ECT*

Annual Report 2008

European Centre for Theoretical Studies in Nuclear Physics and Related Areas
Trento

Institutional Member of the European Science Foundation Expert Committee NuPECC

FONDAZIONE BRUNO KESSLER

Editorial staff:
Barbara Curro' Dossi, Susan Driessen and Gian Maria Ziglio

1 Preface

The year 2008 marked the 15th year of existence of ECT*. This anniversary of the Centre was celebrated on 24-25 September, 2008 with a symposium. A quick glance at the programme of this memorable event on the last page of this Annual Report illustrates that the history, the past, and present role in the wide European Nuclear Physics Research Activity as well as the future perspective of the Centre have been presented by notable speakers and discussed openly with the numerous participants.

The year 2008 is also the year when ECT* officially and legally became an institute within the *Fondazione Bruno Kessler* (FBK). New Regulations-Statutes were signed by President Zanotti of the FBK and the Director of the ECT* on December 19, 2008. This document (posted on the ECT* webpage) updates the former statutes of ECT* in order to make them compatible with the rules of the FBK which now administers the Centre.

With this important step ECT* is entering a new phase with confidence. Its mission, however, is not changed from the one before. The scientific work at the Centre still focuses rigorously on three topics:

- International Workshops and Collaboration Meetings
- International Doctoral Training Programmes
- In-house Research by Postdoctoral Fellows, the Director and the Vice - Director and the Visitors

This Annual Report highlights, similar as its predecessors, the numerous achievements of the year 2008.

With its fifteen Workshops and one Collaboration Meeting in 2008 the ECT* strengthened its international visibility in the scientific community further. The topics again covered a variety of subfields from low energy to high energy nuclear physics. In almost all workshops theorists and experimentalists were actively engaged and some topics discussed were cross disciplinary ones indeed. As a general rule copies of the individual contributions at each workshop were made available on the ECT* website. Altogether about 550 scientists participated in the workshop program in 2008 and spent up to one week at the ECT*.

The success of any research institution depends on the motivation and dedication of young talented scientists. The ECT* thus puts since a number of years a lot of effort into attracting doctoral students from all over the world into its Doctoral Training Programmes. The programme in 2008 on Nuclear Matter under Extreme Conditions lasted three months and was coordinated jointly by a theorist, Urs Wiedemann, and an experimentalist, Hans-Ake Gustafsson, both being great experts in the field. In fact this programme serves also as an example for a very fruitful interaction between experiment and theory for an effective planning, execution and subsequent future experiments at LHC and RHIC. Thanks go also to Georges Ripka who helped supervising the students, organizing tutorials and student seminars. His engagement has thus been an important prerequisite for the great success of the programme.

In the third part of this Annual Report of 2008 the research performed by the scientific personnel (Postdocs, Director and Vice - Director, Visitors) is summarized. The variety of research topics mastered, the listed numerous scientific publications in internationally peer-reviewed journals and the talks presented outside ECT* are another important sign for the great international visibility and recognition ECT* has gained in its 15 years of existence.

In order to operate ECT* on the highest scientific level also in the years to come, the generous support given in 2008 by the FBK and by funding agencies in various European countries - Belgium (Flemish and French speaking part), Czech Republic, Denmark, Finland, France (CEA and CNRS), Germany, Italy, Netherlands, Poland, Romania, Spain and the UK - for which we are extremely grateful must continue. The listed countries (plus Hungary) have all signed a Memorandum of Understanding with the ECT*/FBK securing in most cases financial support in the intermediate future, and ECT* is constantly striving for more countries to sign. We are also thankful for the support in 2008 provided still by EURONS and welcome for 2009 and the following years funds for ECT* Workshops allocated within the Integrated Infrastructure Initiative Hadron Physics 2.

Finally, on November 01, 2008 there has been a changeover in the Directorship of ECT*. This gives me the opportunity to thank Jean-Paul Blaizot warmly for his great effort in his four years of being Director to bring ECT* forward as a strong and professionally operating institution within the FBK and also as an institution of an internationally recognized high standing. Thereby he has served the community in an exemplary way. He has returned to full time research at Saclay and I wish him all the best. Furthermore, with the above mentioned new Regulations-Statutes the ECT* is now fully integrated and operational within the FBK. At the same time, however, a 15 year period of Renzo Leonardi as Scientific Secretary has come to an end. We all know that ECT* owes much of its existence to Renzos early vision, political skillfulness, persistence and tremendous personal commitment. The ECT*, the Board and the whole community are thus very grateful to him for what he has achieved during his 15 years in office. We at ECT* wish him the best and every possible success in his new effort to get the first proton therapy facility in the Autonomous Province of Trento (PAT) built and into operation and at the same time look forward to a good and lasting relation with the Centre.

Achim Richter, Director of ECT*

Contents

2 ECT* Scientific Board, Staff and Researchers

2.1 ECT* Scientific Board, Director, Vice - Director and Scientific Secretary

Wanda Alberico (until September 2008)	University of Torino, Italy
Mauro Anselmino (from September 2008)	University of Torino, Italy
Bengt Friman (from October 2006)	GSI, Darmstadt, Germany
Brian Fulton (until September 2008)	University of York, UK
Hans-Ake Gustafsson (from June 2006)	Lund University, Sweden and CERN, Switzerland
Pawel Haensel (from January 2008)	N. Copernicus Astronomical Center, Poland
Simon Hands (from January 2008)	Swansea University, UK
Wick Haxton (from June 2006)	University of Washington, USA
Paul Hoyer (until June 2008)	University of Helsinki, Finland
Piet Van Isacker (until September 2008)	GANIL, Caen, France

Honorary Member of the Board

Ben Mottelson	NORDITA, Copenhagen, Denmark

ECT* Director:

Jean-Paul Blaizot (until October 2008)	ECT*, Italy and CNRS, France
Achim Richter (from November 2008)	ECT*, Italy and TU Darmstadt, Germany

ECT* Vice – Director

Marco Traini (from October 2004)	ECT* and University of Trento, Italy

ECT* Scientific Secretary

Renzo Leonardi (unitil December 2008)	ECT* and University of Trento, Italy

2.2 ECT* Staff

Ines Campo	Technical Programme Co-ordinator
Corrado Carlin (until May 2008)	Maintenance Support Manager
Cristina Costa	Technical Programme Co-ordinator
Serena Degli Avancini	Technical Programme Co-ordinator
Barbara Currò Dossi	System Manager
Susan Driessen (part time)	Assistant to the Directors
Gianni Fattore (part time)	System Manager
Tiziana Ingrassia (part time)	Accounting Assistant
Mauro Meneghini	Driver and Maintenance Support Manager
Donatella Rosetti (part time)	Secretary Eurons
Luana Slomp	Assistant to the Directors
Gianmaria Ziglio (part time)	Web Manager

2.3 Resident Postdoctoral Researchers

- **ECT* postdocs**

Andrea Beraudo, Italy (until 31 October 2008)

Daniele Binosi, Italy (part time)

Taeko Matsuura, Japan (until 30 January 2008)

Vadim Lensky, Russia

Bingwei Long, China (from 30 September 2008)

Javier Lopez Albacete, Spain (from 31 May 2008)

Michael Schwamb, Germany, Joint position with the Physics Department University of Trento (until 31 May 2008)

Dionysis Triantafyllopoulos, Greece (until 30 September 2008)

- **Research Assistant Professor**

Vladimir Pascalutsa, USA, Joint position with I3 Hadron Physics, (until 30 April 2008)

- **Quantum Computing Group (post-docs)**

Daniele Binosi, Italy (from February 2005)

Tommaso Calarco, Italy (from June 2003)

- **Teraflop Cluster (special Fellow)**

Andrea Nobile, Italy (until 31 October 2008)

Luigi Scorzato, Italy

2.4 Visitors in 2008

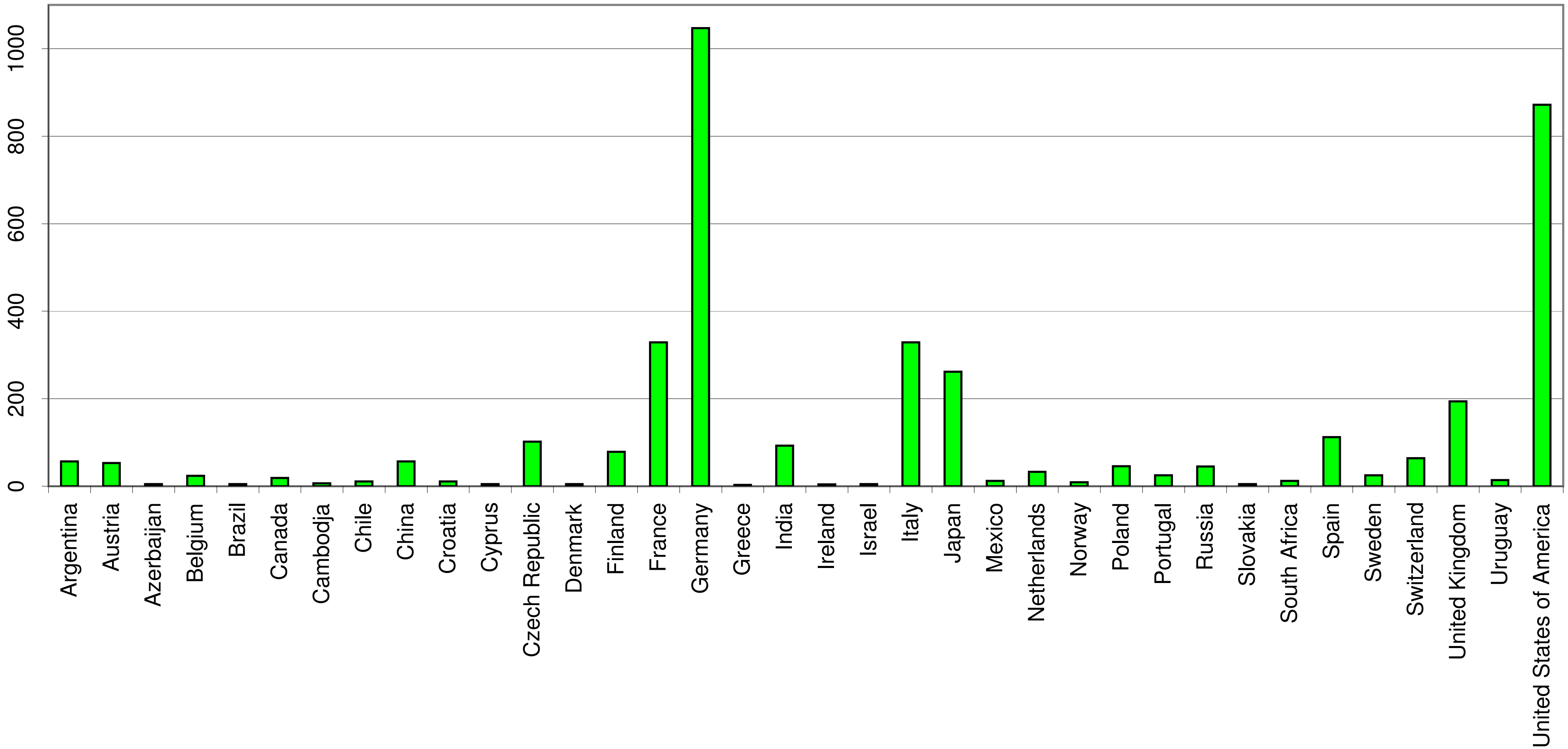
This list includes Visiting Scientists (VS) who typically spent up to several weeks at the Centre, as well as participants and lecturers of the Training Programme (TP).

Kai Hebeler (1/01-31/05)	GSI Darmstadt, Germany (VS)
Tomas Grigera (9/01-6/03)	Universidad Nacional de la Plata, Argentina (VS)
Frédéric Jugeau (3/02-5/02)	INFN Bari, Italy (VS)
Nicolas Wschebor (20/02-5/03)	Universidad de la Republica - Montevideo, Uruguay (VS)
Andreas Ipp (24/02-1/03)	MPI Heidelberg, Germany (VS)
Georges Ripka (1/04-20/07 + 26/10-30/10)	CEA/Saclay, France (VS)
Joseph Butterworth (25/04-20/07)	Creighton University, US (TP)
Clement Gombeaud (25/04-20/07)	CEA/Saclay, France (TP)
David Kettler (25/04-20/07)	University of Washington, US (TP)
Tamal Mukherjee (25/04-20/07)	Bose Institute, India (TP)
Anis Dadi (26/04-6/06)	Universitaet Rostock, Germany (TP)
Raffaele Millo (26/04-20/07)	Università degli Studi di Trento, Italy (TP)
Gang Shen (26/04-20/07)	Indiana University, US (TP)
Jan Kapitan (27/04-20/07)	Nuclear Physics Institute ASCR, Prague, Czech Republic (TP)
Salvatore Plumari (27/04-10/05)	INFN Catania, Italy (TP)
Naoki Yamamoto (27/04-20/07)	University of Tokyo, Japan (TP)
Bengt Friman (27/04-30/04)	GSI, Darmstadt, Germany (TP)
Urs Wiedemann (28/04-30/04 + 17/06-19/06)	CERN, Switzerland (VS)
Peter Senger (29/04-2/05)	GSI, Darmstadt, Germany (TP)
Yukinao Akamatsu (1/05-20/07)	University of Tokio, Japan (TP)
Nestor Armesto Perez (3/05-10/05)	Universidade de Santiago de Compostela, Spain (TP)
Paloma Quiroga (4/05-9/05)	Universidade de Santiago de Compostela, Spain(TP)
Edwin Laermann (13/05-17/05)	Bielefeld University, Germany (TP)
Giacomo Ortona (18/05-11/06)	Università di Torino, Italy (TP)
Enrico Scomparin (18/05-21/05)	INFN Torino, Italy (TP)
Gunther Roland (20/05-24/05)	MIT, Boston, US (TP)
Yaxian Mao (27/05-20/07)	Institute of Particle Physics, China (TP)
Federico Antinori (27/05-30/05)	INFN Padova, Italy (TP)
Jean-Yves Ollitrault (29/05-3/06)	CEA/Saclay, France (VS)
Klaus Goeke (1/06-15/08)	University of Bochum, Germany (VS)
Ralf Rapp (2/06-7/06)	Cyclotron Institute, Texas, US (TP)
Jussi Auvinen (15/06-19/07)	University of Jyvaskyla, Finland (TP)
Axel Drees (16/06-21/06)	SUNY Stony Brook, US (TP)
Maciej Nowak (20/06-25/06)	Jagellonian University Krakow, Poland (VS)
Jorge Casalderrey Solana (22/06-28/06)	LBL Berkeley, US (TP)
Thomas Hell (29/06-6/07)	TUM, Germany (TP)
Anton Rebhan (30/06-4/07)	Technical University, Vienna, Austria (TP)
Carlos Salgado (6/07-15/07)	Universidade de Santiago de Compostela, Spain (TP)
Ulrich Heinz (13/07-18/07)	Ohio State University, US (TP)

Harald Fritzsch (21/07-16/08)	LMU Munich, Germany (VS)
Carlo Ewerz (27/08-11/09)	University of Heidelberg, Germany (VS)

VISITOR DAYS spent at ECT* in 2008

Country



3 Scientific projects run in 2008

3.1 Summary

Altogether, 17 projects have been run at ECT* in 2008: 15 workshops, 1 collaboration meeting and 1 doctoral training programme. This chapter contains the scientific reports prepared by the organizers of each project. Georges Ripka, who assisted the Director in the running of the doctoral training programme, prepared the corresponding report.

3.2 Workshops and Collaboration Meetings in 2008

7 – 11 Jan.	**TNET: The EURONS European Theory Network** Organizers: J. Tostevin (Co-ordinator) (*Univ. Surrey*) J. Vaagen (*Univ. Bergen*) A.C. Sa Fonseca (*Univ. Lisboa*) [p. 12]
25 - 29 Feb.	**Parton Fragmentation Processes: in the Vacuum and in the Medium** Organizers: David d'Enterria (Co-ordinator) (*CERN*) F. Arleo (*CERN LAPTH, Annecy*) [p. 15]
27 - 28 Mar.	**Meeting of the INFN Theory Collaboration PI31 (collaboration meeting)** Organizers: O. Benhar (Co-ordinator) (*INFN Univ. La Sapienza, Roma*) [p. 18]
7 - 11 Apr.	**Quasifree Scattering with Radioactive Ion Beams** Organizers: T. Aumann (Co-ordinator) (*GSI*) R. Lemmon (*Daresbury Lab.*) J. Tostevin (*Univ. Surrey*) H. Lenske (*Univ. Giessen*) [p. 20]
28 Apr. - 18 Jul.	**Nuclear Matter under Extreme Conditions** **(ECT* Doctoral Training Programme)** Organizers: U. Wiedemann (Co-ordinator) (*CERN*) H.A. Gustafsson (Co-organizer) (*CERN Univ. Lund*) [p. 64]

5 - 9 May **Perspectives and Challenges for full QCD Lattice Calculations**
Organizers: L. Scorzato (Co-ordinator) (*ECT**)
F. Farchioni (*ITP Univ. Muenster*)
U. Wenger (*ETH Zuerich*) [p. 22]

12 - 23 May **Hadron Electromagnetic Form Factors**
Organizers: C. Roberts (Co-ordinator) (*Argonne National Lab.*)
A. Constantia (*Univ. Cyprus*)
J. Arrington (*Argonne National Lab.*)
J. Friedrich (*Univ. Mainz*)
F. Maas (*GSI, Darmstadt*) [p. 25]

26 - 30 May **Mass Olympics**
Organizers: T. Buervenich (Co-ordinator) (*Frankfurt Inst. for Adv. Studies*)
C. Scheidenberger (*GSI, Darmstadt*) [p. 30]

3 - 7 Jun. **Nuclear Medium Effects on the Quark and Gluon Structure of Hadrons**
Organizers: S. Liuti (Co-ordinator) (*Univ. Virginia*) [p. 32]

9 - 13 Jun. **Workshop on Hard Exclusive Reactions**
Organizers: R. Kaiser (Co-ordinator) (*Univ. Glasgow*)
P. Kroll (*Univ. Wuppertal*)
N. d'Hose (*CEA-Saclay*) [p. 36]

23 - 27 Jun. **Ultra High-Intensity Laser Nuclear/Particle Physics**
Organizers: T. Heinzl (Co-ordinator) (*Univ. Plymouth*)
B. Kaempfer (*FZ Dresden-Rossendorf*)
K. Ledingham (*Univ. Strathclyde*) [p. 39]

14 - 18 Jul. **Structure of Hadrons and Nuclei at an Electron Ion Collider**
Organizers: R. Venugopalan (Co-ordinator) (*Brookhaven Nat. Lab.*)
F. Gelis (*CERN-Saclay*)
W. Vogelsang (*Brookhaven Nat. Lab.*)
Yuan Feng (*LBNL*) [p. 43]

1 - 5 Sep. **The Statistical Model of Hadron Formation and the Nature of the QCD Hadronization Process**
Organizers: R. Stock (Co-ordinator) (*Univ. Frankfurt*)
F. Becattini (*INFN Firenze and Univ. Firenze*)
P. Braun-Munzinger (*GSI, Darmstadt*) [p. 48]

16 - 18 Sep. **Scaling the Heights of the N=Z Line above 56-Ni**
Organizers: D. Jenkins (Co-ordinator) (*Univ. York*)
I. Moore (*Univ. Jyvaskyla*) [p. 51]

29 Sep. - 3 Oct. **Bound States and Resonances in Effective Field Theories**
Organizers: V. Pascalutsa (Co-ordinator) (*ECT**)
D. Phillips (*Ohio Univ.*) [p. 53]

27 - 31 Oct. **Strangeness Polarization in Semi-inclusive and Exclusive Lambda Production**
Organizers: H. Avakian (Co-ordinator) (*Jefferson Lab.*)
N. Makins (*Illinois Univ.*)
A. Schaefer (*Univ. Regensburg*)
C. Weiss (*Jefferson Lab.*) [p. 57]

17 - 21 Nov. **Neutrinos in Particle, in Nuclear and in Astrophysics**
Organizers: A. Faessler (Co-ordinator) (*Univ. Tuebingen*)
S. Petcov (*Trieste SISSA*)
G. Fogli (*Univ. Bari*)
V. Rodin (*Univ. Tuebingen*) [p. 61]

3.3 Reports on Projects and Collaboration Meetings

3.3.1 TNET: THE EURONS EUROPEAN THEORY NETWORK SECOND WORKSHOP "THEORY NETWORK FOR NUCLEAR STRUCTURE AND REACTIONS"

DATE: January 7 -11, 2008

ORGANISERS:
Jeffrey A. Tostevin (Co-ordinator) (*U-Surrey, UK*),
Antonio Sa Fonseca (*U-Lisboa, PT*),
Jan S Vaagen (*U-Bergen, NO*)

NUMBER OF PARTICIPANTS: 30

MAIN TOPICS:

- Correlations in nuclei: their role, treatment and observation
- Novel reaction methodologies: approaches and new technologies
- Novel phenomena in the study of nuclei far from stability
- Few- and many-body methods, status, opportunities and limitations
- Experimental and theoretical reaction capabilities at new facilities
- Break-up and transfer reaction methods and spectroscopy
- Structure models at the interface with the continuum
- Priorities, future directions and (FP7) opportunities

SPEAKERS:

Ron Johnson (*U-Surrey, UK*)
Pierre Descouvemont (*ULB, BE*)
Winfried Leidemann (*U-Trento, IT*)
Mahir Hussein (*MPI Dresden, DE*)
Raquel Crespo (*IST-Lisboa,PT*)
Antonio Fonseca (*U-Lisboa, PT*)
J Gomez-Camacho (*U-Sevilla, ES*)
Pierre Capel (*ULB, BE*)
Marek Ploszajczak (*GANIL, FR*)
Jimmy Rotureau (*ORNL, USA*)
Sofia Quaglione (*LLNL, USA*)
Gaute Hagen (*ORNL, USA*)
Antonio Moro (*U-Sevilla, ES*)
Markus Stauf (*U-Manchester, UK*)
Paul Stevenson (*U-Surrey, UK*)
Arnau Rios Huguet (*NSCL, USA*)
Hermann Wolter (*U-Munich, DE*)
Marcella Grasso (*Orsay, FR*)
Jeffrey Tostevin (*U-Surrey, UK*)
Giuseppina Orlandini (*U-Trento, IT*)
Haik Simon (*GSI, DE*)
Manuela Rodriguez Gallardo (*U-Lisboa, PT*)
Jim Al-Khalili (*U-Surrey, UK*)

SCIENTIFIC REPORT:

Aim and Purpose

The workshop brought together a specific network of nuclear structure and reactions theorists (TNET within EURONS) with a track record of collaborative activity, plus students. A number of young European scientists presently working overseas also participated.
The aims of the Workshop were primarily:
(1) To share knowledge and foster further research collaboration on topical problems in nuclear reactions, structures, and their interface;
(2) To review most recent theoretical advances and understanding, as driven by new experimental capabilities;
(3) To give exposure to the state-of-the-art theoretical tools and of open questions to young scientists, and to foster younger researcher networking;
(4) To allow assessment of priorities concerning reaction theory and the reactions and structures interface as input into integrated theory themes in FP7.
The latter discussions, that informed the TNET community of future plans within the FP7 I3 proposal (ENSAR) made the workshop particularly timely. Discussions among those active in the theory part of the ENSAR proposal also fine-tuned the current joint research and networking proposals.

Results and Highlights

The workshop format was designed to allow maximum interaction, discussion and questioning. Discussion leaders played an excellent role in staging their presentations to this instruction. The major methodologies, underpinning physics, and challenges to advances in direct nuclear reactions, few-body, (ab-initio) many-body and time-dependent approaches were presented. A particular advance is the practical solution of the Fadeev/AGS equations for few-body dynamical systems in the presence of Coulomb and complex effective interactions, that is permitting assessments of the accuracy of other approximate dynamical theories of breakup and transfer reactions. The enormous efficiency gains resulting from the implementation of the J-scheme within the coupled-cluster approach is also allowing calculations of ground states of medium mass nuclei, to confront experiment. Simon presented new GSI measurements that link strongly with several of the theoretical activities under discussion and stimulated much interest. These included data for nucleon knockout reactions that reveal intriguing differences in residue yields when using a nuclear and a nucleon target. The participation of young European-trained scientists (presently working overseas), Drs. J. Rotureau, G. Hagen (ORNL), Quaglione (LLNL) and Rios Huguet (NSCL) strengthened emerging and fostered new collaborative opportunities. The (upstairs) facilities available at ECT* were ideal for the workshop format. All planned discussion leaders were able to attend (other than Jan Vaagen, who could not attend due a family bereavement). The role of directing FP7 discussions was ably led by Marek Ploszajczak.

Conclusions

The workshop was of immense value in both disseminating recent theoretical advances and in setting out clearly the theoretical foundations of the methodologies used. A number of ongoing collaborations were enlivened and new ones stimulated, by new results, data and theory capabilities. These included, at the time of the workshop, Sevilla-Surrey, Lisboa-Surrey-GSI, ORNL-Trento, Sevilla-Surrey-NSCL, Brussels-Surrey, Bergen-ORNL, and Lisboa-Sevilla-Surrey joint activities. Fonseca, Ploszajczak, Gomez-Camacho and Tostevin were also able to coordinate final input and manpower priorities toward the FP7 ENSAR proposal and discuss future network activity with the ECT*.

Presentations

All presentations from the 24 discussion leaders (minus the associated and extensive discussion) and the full Workshop details are available on the TNET website:
http://www.nucleartheory.net/tnet/presentations.htm
Given the open nature of the workshop, including the sharing of many new (and yet unpublished) results, these presentations have in some cases been edited by the authors prior to their posting on the public website.

3.3.2 PARTON FRAGMENTATION: IN THE VACUUM AND IN THE MEDIUM

DATE: February 25-29, 2008

ORGANISERS:
François Arleo (Co-ordinator) (*LAPTH, Annecy-le-Vieux*),
David d'Enterria (*CERN, Geneva*)

NUMBER OF PARTICIPANTS: 49

MAIN TOPICS:

- Light-quark and gluon fragmentation in the vacuum (*p*-*p*, *e*-*p* collisions): global fits analyses and MLLA;
- Strange and heavy-quark fragmentation;
- Parton fragmentation in cold QCD matter;
- Medium-modified fragmentation in hot and dense QCD matter.

SPEAKERS:

S. Albino (*Hamburg*)
F. Anulli (*Roma*)
E. Aschenauer (*Zeuthen*)
F. Arleo (*Annecy*)
D. Besson (*Kansas*)
N. Borghini (*Heidelberg*)
W. Brooks (*Valparaiso*)
B. Buschbeck (*Wien*)
M. Cacciari (*Paris*)
E. Christova (*Sofia*)
G. Corcella (*Roma & Pisa*)
D. d'Enterria (*CERN*)
J. Dolejsi (*Prague*)
S. Domdey (*Heidelberg*)
M. Estienne (*Strasbourg*)
O. Fochler (*Frankfurt*)
T. Gousset (*Nantes*)
K. Hamacher (*Wuppertal*)
M. Heinz (*Yale*)
K. Hicks (*Ohio*)
D. Kettler (*Seattle*)
S. Kumano (*KEK*)
B. Machet (*Paris*)
G. Milhano (*Lisbon*)
S.-O. Moch (*Zeuthen*)
V. Muccifora (*Frascati*)
S. Pacetti (*Frascati*)
R. Pérez-Ramos (*Hamburg*)
H.-J. Pirner (*Heidelberg*)
S. Pronko (*Fermilab*)
J. Putschke (*Yale*)
M. Radici (*Pavia*)
J. Rak (*Jyväskylä*)
C. Roland (*MIT*)
G. Rudolph (*Innsbruck*)
Z. Rurikova (*Hamburg*)
C.A. Salgado (*Santiago de Compostela*)
S. Sapeta (*Cracow*)
D.H. Saxon (*Glasgow*)
R. Seidl (*BEN*)
R. Seuster (*Victoria*)
M. Stratmann (*RIKEN*)
M.J. Tannenbaum (*BEN*)
M. Tasevsky (*Prague*)
T. Trainor (*Seattle*)
D. Traynor (*London*)
M. Werlen (*Annecy*)
C. Zhou (*Montreal*)

SCIENTIFIC REPORT:

Aim and Purpose

The transition from coloured quarks and gluons to colourless hadrons – the so-called fragmentation or hadronization process – is a Quantum Chromodynamics (QCD) phenomenon with many important theoretical and phenomenological implications for the physics at high-energy colliders. At large hadron fractional momenta $z = p_{\rm hadron}/p_{\rm parton}$, the fragmentation functions (FFs) of partons into hadrons or into photons obey DGLAP evolution equations and are obtained from global analyses (fits) of various experimental hadron and photon production data. The FFs are, for example, a basic ingredient for the calculation of the production of high transverse-momentum particles at collider energies within perturbative QCD. At small z, successful QCD resummation techniques (e.g. the Modified Leading Logarithmic Approximation, MLLA) have been developed to understand and describe the evolution of a highly-virtual time-like parton into final hadrons. Most of the available data used in the study of the fragmentation process comes from $q\bar{q}(g)$ production at e^+e^- colliders (LEP, SLC), although data from deep-inelastic e-p scattering (DIS) at HERA has also been used especially in the heavy-quark sector. New high-precision flavour-identified hadron data from the B-factories (BELLE, BABAR), from DIS (HERA), and from hadronic colliders (RHIC, Tevatron), can further help to constrain the FFs and, *in fine*, to improve the calculation of hadron and prompt photon perturbative production at the LHC (in a way similar to the recent developments in improved global-analyses of parton distribution functions). In the near future, the vast kinematical range opened in p-p collisions at LHC energies and luminosities will open up new channels for the study of fragmentation functions.

The study of possible modifications of the parton fragmentation processes in heavy-ion collisions is also an important tool for the determination of the thermodynamical and transport properties of the dense QCD matter produced at RHIC and LHC energies. Since the discovery of the suppression of high-p_T hadrons in central Au-Au collisions at RHIC, a lot of effort has been devoted to the understanding of the propagation of partons in QCD media (cold nuclear matter or quark-gluon-plasma) as well as to understand such a "medium-modified" fragmentation mechanism. These phenomenological studies - which often use techniques originally developed "in the vacuum" (e.g. MLLA) - are well supplemented by a wealth of new data from DIS on nuclear targets (HERMES at HERA, and CLAS at JLab) and in heavy-ion collisions (RHIC).

A few months before the start of the LHC, it seems a timely moment to have a workshop, gathering both theorists and experimentalists, to discuss the current status of investigations concerning the fragmentation mechanisms of gluons, light-quarks and heavy-quarks into hadrons and photons, as well as to discuss their implications for the upcoming p-p and A-A experimental programmes at the LHC. The talks and discussions are organized around the following main topics:

- Light-quark and gluon fragmentation in the vacuum (p-p, e-p collisions): global fits analyses and MLLA.
- Strange and heavy-quark fragmentation.

- Parton fragmentation in cold QCD matter.
- Medium-modified fragmentation in hot and dense QCD matter.

Results and Highlights

The workshop was extremely fruitful as it gathered theorists and experimentalists with different backgrounds, both from the "particle physics" (DIS, *pp* reactions) and "nuclear physics" (*pA*, *AA*) communities, at various facilities (JLab, KEK, LHC, RHIC, SLAC, Tevatron) but a common interest in the study of parton fragmentation processes. Many useful experiences were shared among the participants during and after the talks. New theoretical calculations have been provided to compare with existing data. Continued professional contact exists today among various participants who met for the first time in the meeting. As a result of the workshop, presentations and subsequent discussions were included in a mini-proceedings article to appear on the arXiv server.

Conclusions

The workshop was undoubtedly a success. It was not only very useful as a "status report" on the field of parton fragmentation at current and future facilities but it brought together both theorists and experimentalists, and each got to know better what the state-of-the-art is on both sides, and what can be measured experimentally – especially at the forthcoming LHC. Moreover, another asset of the workshop was the joint participation of the nuclear and particle physics communities working on common aspects of parton fragmentation. We believe that this was only the first workshop of this kind and look forward to similar meetings in the future.

The programme, list of participants and a one-page summary of each talk including a few relevant references are available in the "mini-proceedings" on the conference webpage (and also submitted to the arXiv server):

http://cern.ch/arleo/ff_vacuum_medium_ect08/

In addition, all the talks can also be downloaded from the above address.

3.3.3. MEETING OF THE INFN THEORY COLLABORATION PI31

(Collaboration Meeting)

DATE: March 27-28, 2008

ORGANISERS:
Omar Benhar (Co-ordinator) (*INFN, Roma*), Giampaolo Cò (*University of Lecce*)

NUMBER OF PARTICIPANTS: 15

MAIN TOPICS:

- Many-body theory of nuclear matter and atomic nuclei
- Electroweak nuclear response

SPEAKERS:

M. Valli (*INFN, Roma*)
S. Gandolfi (*SISSA, Trieste*)
M. Barbaro (*Torino*)
G. Cò (*Lecce*)
V. De Donno (*Lecce*)
F. Pederiva (*Trento*)
N. Farina (*Roma*)
K. Graczyk (*Torino*)

SCIENTIFIC REPORT:

Aim and Purpose

The INFN PI31 theory collaboration has carried out research on microscopic theories of strongly-interacting many-body systems for many years.

The collaboration involves eight Physics Departments (Florence, Genoa, Lecce, Pisa, Roma "La Sapienza", Trento, Torino and SISSA, Trieste), contributing a total of eleven faculties, four INFN staff, two postdoctoral fellows and seven Ph.D. students.

The meeting was mainly aimed at circulating the information on the different activities among the participants, so as to stimulate possible new collaborations between differents groups. We believe that this kind of interaction greatly benefits the junior members of the collaboration.

Results and Highlights

The program included presentations from all participating Departments on a wide range of subjects, reflecting the strong interdisciplinary nature of the collaboration. Most talks have been given by Ph.D. students and postdocs, and the large amount of time allotted for questions and discussions allowed for a very lively and effective interaction among the participants.

Conclusions

The meeting turned out to be very fruitful, from both the scientific and the organizational point of view. New collaborative efforts on subjects such as neutrino-nucleus scattering and the effective theories of nuclear matter have been planned. In the final session, devoted to the discussion of organizational issues, it was also decided to explore the possibility of establishing a prize or a scholarship, to be awarded to a young researcher working in the field of many-body theories, in memory of Adelchi Fabrocini (1951-2006), who served for many years as spokesman of the PI31 collaboration.

3.3.4 QUASI-FREE SCATTERING WITH RADIOACTIVE ION BEAMS

DATE: April 7 -11, 2008

ORGANISERS:
Thomas Aumann (Co-ordinator) (*GSI, DE*),
Jeffrey Tostevin (*U-Surrey, UK*),
Horst Lenske (*U-Giessen, DE*)
Roy Lemmon (*Daresbury Laboratory, UK*)

NUMBER OF PARTICIPANTS: 35

MAIN TOPICS:

- Quasi-free scattering reactions with hadron and electron probes
- Achievements with stable nuclei and outstanding problems
- Reaction theory of quasi-free scattering reactions
- Nuclear many-body theory: spectroscopic factors, spectral function and correlations
- In-medium effects in symmetric and asymmetric nuclei and nuclear matter
- Quasi-free scattering with radioactive beams: status and prospects
- Perspectives for a physics programme studying asymmetric nuclei and nuclear matter

SPEAKERS:

H. Lenske (*U-Giessen, DE*)
R. Lemmon (*Daresbury, UK*)
J. Tostevin (*U-Surrey, UK*)
T. Kobayashi (*U-Tohoku, JP*)
O. Benhar (*U-Roma, IT*)
R. Crespo (*IST-Lisboa,PT*)
A. Gade (*NSCL, USA*)
M. Schwamb (*ECT*, IT*)
L. Chulkov (*Kurchatov, RU*)
A. Cowley (*Stellenbosch, SA*)
W. Dickhoff (*St. Louis, USA*)
J. Guillot (*IPN Orsay, FR*)
L. Dieperink (*KVI, NL*)
A. Kisselev (*PNPI, RU*)
T. Noro (*U-Kyushu, JP*)
L. Chen (*Shanghai, CN*)
J. Ryckebusch (*Gent, BE*)
I. Sick (*U-Basel, CH*)
H. Simon (*GSI, DE*)
J. Udias (*U-Madrid, ES*)
P. Konrad (*U-Giessen, DE*)
A. Fedoseew (*U-Giessen, DE*)
C. Bertulani (*Texas, USA*)
T. Uesaka (*CNS-Tokyo, JP*)
C. Barbieri (*GSI, DE*)

SCIENTIFIC REPORT:

Aim and Purpose

The workshop brought together experts working in the field of quasi-free scattering using both proton and electron beams on stable nuclei with those who wish to apply the quasi-free scattering techniques using radioactive beams. The main purpose of the workshop was to review the experimental and theoretical status of the physics studied with quasi-free knockout reactions, including the reaction theory, aiming at a critical assessment on the potential of applying this technique to investigate properties of neutron-proton asymmetric nuclei and nuclear matter.

Results and Highlights

The workshop format was designed to allow maximum interaction, discussion and questioning. Discussion leaders played an excellent role in staging their presentations to this instruction. The different experimental methods for studying quasifree knockout reactions were presented and discussed. The reaction theory describing the knockout process has been reviewed as well as the different physics topics accessible by knockout reactions, e.g., single-particle structure, long and short-range correlations, as well as in-medium effects. First results from experiments utilizing radioactive beams have been presented as well. The applicability to radioactive beam experiments has been discussed and a possible experimental programme was identified.

Conclusions

The workshop has shown that quasifree scattering experiments with radioactive beams have a large scientific potential. A critical discussion of the various aspects lead to the conclusion that the experimental techniques proposed are appropriate and that the precision one will reach will allow a detailed investigation of the single-particle structure of nuclei, long-range correlations, as well as in-medium effects of the nucleon-nucleon interaction as a function of neutron-proton asymmetry. The developments of reaction theory is of outmost importance for a quantitative analysis and understanding of the data.

Presentations

All presentations from the 25 discussion leaders (minus the associated and extensive discussion) and the full Workshop details are available on the QFS website:
http://www.nucleartheory.net/QFS/presentations.htm
Given the open nature of the workshop, including the sharing of many new (and yet unpublished) results, these presentations have in some cases been edited by the authors prior to their posting on this public website.

3.3.5 PERSPECTIVES AND CHALLENGES FOR FULL QCD LATTICE CALCULATIONS

DATE: May 5-9, 2008

ORGANISERS:
Luigi Scorzato (Co-ordinator) (*ECT**),
Federico Farchioni (*Münster U.*),
Urs Wenger (*Bern U.*)

NUMBER OF PARTICIPANTS: 50

MAIN TOPICS:

- Lattice QCD simulations with light quarks, and in particular:
- Physics of the pion and kaon sector
- Nuclear properties
- Chiral symmetry
- Parameters of the Standard Model
- Finite size effects
- Setting of the physical scale and control over scaling violations

SPEAKERS:

A. Kennedy (*Edinburgh*)
S. Schaefer (*HU, Berlin*)
M. Lüscher (*CERN*)
R. Sommer (*DESY, Zeuthen*)
G. von Hippel (*DESY, Zeuthen*)
P. Hasenfratz (*BGR, Bern U.*)
F. Niedermayer (*BGR, Bern U.*)
C. Lang (*BGR, Graz U.*)
G. Schierholz (*QCDSF, DESY*)
P. Rakow (*QCDSF, Liverpool U.*)
Y. Nakamura (*QCDSF, NIC/DESY*)
N. Cundy (*QCDSF, Regensburg U.*)
K. Jansen (*ETMC, DESY*)
G. Herdoiza (*ETMC, DESY*)
M. Brinet (*ETMC, LPSC*)
C. Urbach (*ETMC, HU-Berlin*)
S. Simula (*ETMC, Roma3*)
R. Frezzotti (*ETMC, Roma2*)
F. Palombi (*CERN*)
P. Fritzsch (*Münster U.*)
T. Yamazaki (*UKQCD/RBC, YITP, Kyoto*)
P. Boyle (*UKQCD/RBC, Edinburgh*)
E. Scholz (*UKQCD/RBC, BNL*)
N. Christ (*UKQCD/RBC, Columbia U.*)
R. Edwards (*JLab*)
H.-W. Lin (*JLab*)
S. Cohen (*JLab*)
S. Hashimoto (*JLQCD, KEK*)
S. Aoki (*JLQCD, Tsukuba*)
J. Noaki (*JLQCD, KEK*)
H. Fukaya (*JLQCD, NBI*)
S. Gottlieb (*MILC, Indiana U.*)
C. De Tar (*MILC, Utah U.*)
J. Laiho (*MILC, FNAL*)
Z. Fodor (*Wuppertal U.*)
Y. Kuramashi (*PACS-CS, Tsukuba U.*)
K.-I. Ishikawa (*PACS-CS, Hiroshima U.*)

SCIENTIFIC REPORT:

Aim and Purpose

The perspectives for full QCD simulations have dramatically changed in the past few years. The progress is particularly evident if one compares the pessimism expressed in "panel discussion" at the Berlin 2001 lattice conference with the present situation: by now, there are various algorithms and various lattice regularizations which allow to improve the efficiency of the simulations by orders of magnitude with respect to previous estimates. It is now apparent that Lattice QCD will be able - in the near future - to provide precise answers to fundamental QCD questions with all systematics reasonably under control.

We therefore believed that it was the right moment to put together people from those collaborations that are particularly active in performing full QCD calculations and let them compare their approaches and plans for the future. As opposed to the annual lattice conference, we wanted to concentrate only on the physics aspects that are directly related to the presence of light sea quarks in the QCD dynamics and discuss them under the unifying viewpoint of what is the current status of these calculations, what are their perspectives and challenges for the future.

The physics aspects on which we wanted to focus are in particular:

- **Physics of the pion and kaon sector.** How light should the Up and Down quarks be in order to allow a safe comparison with NLO Chiral Perturbation Theory? What is the effect of including the Strange (or even the Charm) quark in the dynamics of QCD? What are the challenges for the determination of Low Energy Constants in Chiral Perturbation Theory beyond NLO?

- **Nuclear properties.** It is now possible to address the question of how nuclear physics emerges from the underlying theory of strong interactions. A central role in this understanding is played by the ability to perform accurate non-perturbative calculations in low-energy QCD. What are the most recent results in this respect?

- **Chiral symmetry.** Chiral symmetry is a crucial property of the Standard Model (SM) and it can be realized exactly on the lattice, although at very high costs. How do the advantages of exact chiral symmetry compare with the additional costs? In which cases is an exact chiral symmetric approach convenient or necessary?

- **Parameters of the Standard Model.** The parameters in the strong sector of the Standard Model (SM) like the quark masses are rather directly accessible through lattice QCD calculations. However, there are also many parameters in the weak sector of the SM where the hadronic contributions are important, or where the uncertainties from the strong sector limit the theoretical predictivity of the SM. We regard it therefore as mandatory to discuss where full QCD calculations can have the biggest impact on SM phenomenology, and where their present limitations and their future challenges lie.

- **Finite size effects.** Finite size corrections can be very dangerous because they grow exponentially and for very light quarks they are usually the dominant systematic correction. On the other hand, they can be predicted analytically without introducing new parameters, and the crucial question is then how well such predictions work when applied to real lattice calculations.

- **Setting of the physical scale and control over scaling violations.** Most of the lattice regularizations employed at present have lattice artefacts starting with $O(a^2)$. However, in order to make definite QCD predictions in the continuum it is crucial to know how large these lattice artefacts are. These corrections can now be compared for the various lattice regularisations under realistic conditions and it is crucial to assess whether and in which cases they are under good control. Moreover, for the precisions that can be reached in present QCD simulations, the problem of setting the scale starts to become a discerning issue, and we plan to discuss this in the context of controlling scaling violations towards the continuum limit.

Results, Highlights and Conclusions
The workshop produced a coherent picture of the current activity on lattice computations towards a realistic simulation of QCD. The comparison of different approaches allowed to single out the main trends in the field.

The main challenge pointed out by all collaborations in the simulation of QCD in view of small theoretical uncertainties, is the necessity of simulating up and down quarks with light masses nearby the physical point. Two trends emerged clearly during the workshop concerning this issue: the optimization of the simulation algorithms and the use of improved lattice formulations for QCD.

Big advances have been achieved independently of the different collaborations on these two points: the result is a dramatic reduction of the simulation costs for light quark masses. Thanks to these progresses, the lattice activity enters now an exciting new phase, where realistic simulations of QCD with full control over systematic errors are possible and results from different approaches can be compared.

This brings us to the second aspect of the workshop, namely the discussion of the different analysis programs of the various collaborations. The latter discussion was useful in order to single out those aspects in hadron physics where lattice QCD can give a substantial contribution. In particular, progresses have been reported in the determination of the parameters of the standard model (in particular quark masses), the meson and baryon sector, hadron structure, excited-state baryon resonances, exotic (hybrid) mesons.

For all these cases, and in particular for the hadron structure, light quark masses and large simulation volumes resulted to be a very important factor. The application of chiral perturbation theory for the extrapolation in the up and down quark masses, and for the correction of the finite volume effects, was highlighted in this context.

The talks can be browsed from the website:
http://www.ect.it/ → Meetings in 2008 →
"Perspectives and challenges for full QCD lattice calculations".

3.3.6 HADRON ELECTROMAGNETIC FORM FACTORS

DATE: May 12-23, 2008

ORGANISERS:
Craig Roberts (Co-ordinator) (*Argonne National Laboratory*)
Constantia Alexandrou (*University of Cyprus*)
John Arrington (*Argonne National Laboratory*)
Jörg Friedrich (*University of Mainz*)
Frank Maas (*GSI*)

NUMBER OF PARTICIPANTS: 55

MAIN TOPICS:

- Role of pseudoscalar mesons in nucleon electromagnetic structure
- Transition from non-pQCD to pQCD in the pion and nucleon electromagnetic form factors
- Large spacelike-Q^2 behaviour of the proton form factor ratio
- Two-photon exchange contributions to the polarization and Rosenbluth measurements of the proton form factor ratio
- Form factors in the timelike region
- Isospin dependence of the nucleon form factors; strangeness in the nucleon
- Numerical simulations of lattice-regularized QCD

SPEAKERS:

S. Agaev (*Baku State U.*)
C. Alexandrou (*Cyprus U.*)
R. Alkofer (*U. Graz*)
B. Anderson (*Kent State U.*)
J. Arrington (*Argonne Nat. Lab.*)
J. Bernauer (*U. Mainz*)
H. Blok (*Vrije U.*)
P. Blunden (*Manitoba U.*)
A. Bodek (*Rochester U.*)
V. Burkert (*JLab*)
L. Canton (*INFN Padova*)
C. Carlson (*Coll. William & Mary*)
I. Cloët (*Argonne Nat. Lab.*)
K. de Jager (*JLab*)
A. Denig (*U. Mainz*)
G. Eichmann (*U. Graz*)
J. Friedrich (*U. Mainz*)
D. Gaskell (*JLab*)
M. Giannini (*U. Genova*)
R. Gilman (*JLab*)
P. Hoyer (*U. Helsinki*)
H. Kamano (*JLab*)
A. Krassnigg (*U. Graz*)
M. Kohl (*Hampton U.*)
P. Kroll (*U. Wuppertal*)
T.-S.H. Lee (*Argonne Nat. Lab.*)
H.-W. Lin (*JLab*)
A. Lenz (*U. Regensburg*)
F. Maas (*GSI*)
U. Meissner (*U. Bonn*)
T. Melde (*U. Graz*)
G. Miller (*U. Washington*)
Y. Nakamura (*DESY*)
J. Negele (*MIT*)
F. Pacé (*U. Roma*)
S. Pacetti (*INFN Perugia*)
C. Papanicolas (*Athens U.*)
V. Pascalutsa (*U. Mainz*)
L. Pentchev (*Coll. William & Mary*)
J. Ralston (*Kansas U.*)
C. Roberts (*Argonne Nat. Lab.*)
T. Sato (*Osaka U.*)
S. Scherer (*U. Mainz*)
R. Schiel (*Kansas U.*)
G. Schierholz (*DESY*)
P. Tandy (*Kent State U.*)
L. Tiator (*U. Mainz*)
E. Tomasi (*CEA Saclay*)
M. Vanderhaeghen (*U. Mainz*)
T. Walcher (*U. Mainz*)
H. Weigel (*U. Siegen*)
R. Young (*Argonne Nat. Lab.*)
J. Zanotti (*Edinburgh U.*)

SCIENTIFIC REPORT:

Aim and Purpose

The nucleon and pion hold special places in non-perturbative studies of QCD. An explanation of nucleon and pion structure and interactions is central to hadron physics, as they are respectively the archetypes for baryons and mesons. It is also a basis from which a better picture of nuclear physics at-large can be built. Form factors have long been recognised as a basic tool for elucidating bound state properties. They can be studied from very low momentum transfer, the region of non-perturbative QCD, up to a region where perturbative QCD predictions can be tested. Experimental and theoretical studies of nucleon electromagnetic form factors have made rapid and significant progress during the last several years, including new data in the time like region, and material gains have been made in studying the pion form factor. Despite this, however, many urgent questions remain to be answered. Our two-week workshop aimed at exposing theorists to the experimental issues involved in these measurements, as well as the details of form factor extractions that may impact on comparison with calculations. We also wanted to give experimentalists an appreciation for the appropriate and effective uses of contemporary theoretical tools. Furthermore, we aimed to foster improved communication between the experimental and theoretical community to determine where future measurements can most effectively provide additional constraints on theory.

Results and Highlights

The presentations were followed by extensive and often lively discussions. The themes of our proposal were addressed and the following questions discussed in detail.

- What is the role of pion cloud in nucleon electromagnetic structure? Can we understand the pion cloud in a more quantitative and, perhaps, model-independent way?

- Where is the transition from non-pQCD to pQCD in the pion and nucleon electromagnetic form factors?

- Do we understand the high Q^2 behaviour of the proton form factor ratio in the space-like region? Can we make model-independent statements about the role of relativity or orbital angular momentum in the nucleon?

- Can we understand the rich structure of the time like proton form factors in terms of resonances? What do we expect for the proton form factor ratio in the time like region? What is the relation between proton and neutron form factor in the time like region? How do we understand the ratio between time-like and space-like form factors?

- What progress has been made and how far are the results of numerical simulations of lattice-regularized QCD from confronting the experimental measurements?

- What is the role of two-photon exchange contributions in understanding the discrepancy between the polarization and Rosenbluth measurements of the proton form factor ratio? What is the impact of these contributions on other form factor measurements?

- How much does strangeness contribute to nucleon form factors? What are the prospects for new experimental information? Extensive discussion addressed the question of just what would be a reasonable theoretical estimate.

- Are new data precise enough to study the isospin dependence of the nucleon form factors?

- How accurately can the pion form factor be extracted from the $ep \to e'n\pi^+$ reaction? It was emphasized that no calculation of the charged pion form factor can be considered truly reliable unless the framework used can simultaneously describe the neutral pion anomalous form factors.

- Extensive discussions focused on the connection between the Fourier transforms of momentum space form factors and the distribution of charge and current within hadrons. This is relevant, e.g., in connection with providing nuclear physics input to ultra-high precision atomic physics calculations and measurements of charge radii.

- Wide-ranging discussions canvassed the problem of how to best use large experimental data sets, composed from experiments with varying precision and kinematic coverage or with non-uniform sensitivity to different physics effects. Such considerations are generally of concern in connection with global fitting and error analysis. They are particularly relevant to the program at the "Excited Baryon Analysis Center"; and in the context of global form factor fits because, e.g., the quantity and precision of G_M^p data can cloud the inference of G_E^p and G_E^n.

Conclusions
Our immediate goals were met. In the longer term, we anticipate more discussion and collaboration between the participants. This has already begun. There is ample room for more. Moreover, it appears likely that experimental and/or theoretical progress in the following areas will be achieved in the near- to medium-term:

- Quantifying pseudoscalar meson "cloud" effects;

- Locating and explaining the transition from nonp-QCD to p-QCD in the pion and nucleon electromagnetic form factors;

- Explaining the large-Q^2 behavior of the proton form factor ratio in the space-like region;

- Detailing broadly the role of two-photon exchange contributions, and in particular their impact on measurements of parity violating scattering and studies of flavour-dependent contributions to nucleon form factors;

- Explaining the relationship between parton properties on the light-front and rest frame structure of hadrons.

Presentations
Talks from the workshop are available at the following URL:
http://ect08.phy.anl.gov/

3.3.7 MASS OLYMPICS

DATE: May 26-30, 2008

ORGANISERS:
Christoph Scheidenberger (*Gesellschaft für Schwerionenforschung (GSI)*),
Thomas J. Buervenich (*Frankfurt Institute for Advanced Studies (FIAS)*)

NUMBER OF PARTICIPANTS: 35

MAIN TOPICS:

- Nuclear Mass Models
- Theoretical understanding of nuclear ground states
- Applications in nuclear astrophysics
- Elementary particles and cosmology
- Experimental methods and programs
- Mass evaluation and tabulations

SPEAKERS:

J. Aysto (*Univ. Jyvaskyla*)
M. Bender (*CENBG*)
A. Bhagwat (*KTH Stockholm*)
K. Blaum (*MPIK Heidelberg*)
M. Block (*GSI*)
G. Bollen (*NSCL/MSU*)
T. Buervenich (*FIAS*)
A. Bulgac (*Univ. of Washington*)
R. Casten (*Yale Univ.*)
L. Chen (*Univ. Giessen*)
G. Gabrielse (*Harvard Univ.*)
H. Geissel (*GSI*)
S. Goriely (*ULB*)
J. Hardy (*Texas A& M Univ.*)
J. Hirsch (*ICN-UNAM*)
U. Jentschura (*MPIK Heidelberg*)
A. Jokinen (*JYFL*)
J. Ketelaer (*Univ. Mainz*)
H. Koura (*JAEA*)
M. Kowal (*Warsaw Univ.*)
P. Leboeuf (*CNRS*)
Y. Litvinov (*GSI*)
G. Martinez-Pinedo (*GSI*)
P. Moller (*LANL*)
I. Morales (*ICN-UNAM*)
R. Nayak (*Berhampur Univ.*)
J. Pearson (*Univ. de Montreal*)
B. Pfeiffer (*GSI*)
W. Plass (*GSI*)
P. Ring (*TUM*)
C. Scheidenberger (*U. Giessen/GSI*)
M. Smith (*ORNL*)
M. Stoitsov (*UTK-ORNL*)
R. Wyss (*KTH Stockholm*)
T. Yamaguchi (*Saitama Univ.*)

SCIENTIFIC REPORT:

Aim and Purpose

The aim of this workshop has been to bring together leading experts in the field of nuclear masses and to compare and discuss various approaches. The predictive power of certain models was analyzed and their short-comings were discussed. New strategies and ideas on how to improve current mass models - in connection with key nuclei for both theory and experiment - were assessed. Moreover, several applications of nuclear masses in astrophysics, bound-state QED, and tests of fundamental symmetries were presented.

Results and Highlights

The present status of atomic mass evaluation was presented, and future activities were outlined. It became clear that a new evaluation of available experimental masses is urgently needed. First activities in this respect have started recently. Possible ways of sharing and dissemination of nuclear mass tables, both from experiment and from theory, were discussed. A consensus was reached that the website nuclearmasses.org, which already is in operation, could be the seed. On the theoretical side, it became clear that two future directions are desirable: on the one hand the development of a universal energy functional for nuclei (possibly from ab initio principles), on the other hand the improvement of current models to deliver mass predictions for the astrophysical community. However, presently all models exhibit a typical rms deviation of 400...600 keV/c^2 from experimental masses (which are typically known to a precision of better than 100 keV/c^2). The origin of this common limit, possible shortcomings in the physical understanding of nuclear masses, and appropriate measures to overcome this limit are open and thus intriguing questions.

Presentations

Talks from the workshop are available at the following URL:
`http://fias.uni-frankfurt.de/~tbuerven/MassOlympics`

3.3.8 NUCLEAR MEDIUM EFFECTS ON THE QUARK AND GLUON STRUCTURE OF HADRONS

DATE: June 3-7, 2008

ORGANISERS:
Simonetta Liuti (Co-ordinator) (*University of Virginia*), Alessandra Fantoni (*INFN, Laboratori Nazionali di Frascati*), Wally Melnitchouk (*Jefferson Laboratory*), Valeria Muccifora (*INFN, Laboratori Nazionali di Frascati*), Matthias Grosse-Perdekamp (*University of Illinois at Urbana Champaign*)

NUMBER OF PARTICIPANTS: 32

MAIN TOPICS:

- Nuclear effects in parton distribution functions
- Hard exclusive probes
- Nuclear effects in spin structure functions
- h-A, A-A, e-A scattering and nuclear hadronization
- Color transparency and in medium modifications

SPEAKERS:

J. Arrington (*ANL*)
M. Burkardt (*New Mexico U.*)
I. Cloet (*ANL*)
D. Day (*Virginia U.*)
P. Di Nezza (*INFN, LNF*)
R. Ent (*Jefferson Lab*)
H. Gao (*Duke U.*)
G. Goldstein (*Tufts U.*)
D. Hasch (*INFN, LNF*)
S. Kulagin (*INP, Moscow*)
S. Kumano (*KEK*)
P. Lenisa (*INFN, Ferrara*)
A. Majumder (*Duke U.*)
U. Mosel (*Giessen U.*)
V. Muccifora (*INFN, LNF*)
J. Nemchik (*Kosice, IEF*)
K. Ozawa (*Tokyo U.*)
H. Paukkunen (*Jyvaskyla, U.*)
J.C. Peng (*UIUC*)
J.P. Ralston (*Kansas U.*)
A. Rezaeian (*S.Maria U., Valparaiso*)
A. Rinat (*Weizmann*)
S. Scopetta (*Perugia U.*)
P. Solvignon (*ANL*)
S. Strauch (*South Carolina U.*)
A.W. Thomas (*Jefferson Lab*)
J.M. Udias (*Madrid U.*)
E. Voutier (*LPSC, Grenoble*)

SCIENTIFIC REPORT:

Aim and Purpose

Experimental data from high energy lepton-nucleus, hadron-nucleus, and nucleus-nucleus collisions have uncovered striking A-dependent patterns in the quark and gluon structure of nuclei that strongly indicate the presence of in-medium effects at normal nuclear density, beyond conventional, hadronic degrees of freedom based, predictions.

Deep Inelastic Scattering (DIS) measurements of nuclear targets, including the most recent experimental results from both HERMES and Jefferson Lab, have shown unambiguously that the quarks' momentum distributions are modified in a nucleus. Additional, complementary measurements provided by the quasi-elastic nucleon knock-out experiments at Jefferson Lab allow one to determine more precisely the possible modifications of the in medium nucleon form factors through polarization transfer observables. Yet, there exists no clear-cut understanding to date of the mechanisms responsible for the modifications of the quark and gluon structure of nuclei. Furthermore, the understanding of quark propagation in the nuclear medium, its fragmentation into hadrons, and the additional soft processes that may occur before the final is completely formed, are crucial for the interpretation of ultra-relativistic heavy ion collisions, as well as high energy proton-nucleus and lepton-nucleus interactions. In contrast to hadron-nucleus and nucleus-nucleus scattering, in deep inelastic lepton-nucleus collisions no deconvolution of the parton distributions of the projectile and target particles is needed. This allows us to directly relate nuclear effects in quarks propagation and hadronization to the hadron distributions from different nuclei. Recent experiments have been performed at HERMES and JLab, and new measurements are planned for the 12 GeV upgrade in order to clarify many aspects related to the medium modification of the quark fragmentation.

Parallel to $e - A$ experiments, $p - A$ and $A - A$ collisions can be used to detect possible in-medium modifications of hadronic properties. Recent data for hadron suppression in d-Au collisions are available from RHIC, indicating a significant departure from expectations based on reactions with free nucleons. Detailed studies including the Drell Yan process will become possible at RHIC with high luminosity d-Au data samples which will be acquired over the next two years. Dedicated detector upgrades are underway at RHIC to introduce additional capability at low x. Recent high precision measurements of the e^+e^- invariant mass spectra from pA collisions at KEK reported a nuclear dependent mass shift of the ϕ meson.

An electron-ion collider is currently being planned that will allow one to extend measurements at lower x and at larger Q^2, while providing the necessary luminosity to perform deeply inelastic exclusive measurements. The latter will open a whole new dimension in our understanding of nucleons and nuclei as they provide insight on the coordinate space interpretation. Finally, the possibility to study nuclear effects in p-A collisions at the LHC (ALICE, CMS and ATLAS detectors) have been studied in detail with the same high luminosities and energies of precision measurements with charged and neutral reactions.

The aim of the workshop was to assess the present understanding of those nuclear modifications of hadronic properties already appearing in cold nuclear matter. These include both the unpolarized and polarized quark and gluon distribution functions in nuclei, nuclear modifications of the charge and magnetic form factors, nuclear hadronization dynamics, and new observables – the generalized parton distributions – from deeply inelastic exclusive scattering measurements. For this purpose the workshop brought together researchers from different areas of theoretical and experimental hadronic and nuclear physics.

Results and Highlights

At the workshop, talks on several aspects of hard processes in nuclei were presented including nuclear deep inelastic structure functions, both in the unpolarized and polarized cases, hard exclusive experiments using the new formalism of generalized parton distributions, hadron-nucleus and nucleus-nucleus scattering, nuclear hadronization, color transparency, quasi-elastic scattering experiments, and perspectives at future facilities. A summary/open discussion session was purposely organized every day, and it was characterized by often animated discussions. An important underlying theme was the explanation of the puzzle of the EMC effect, namely the deviation from unity of the ratio of the deep inelastic structure function of nuclei divided by the number of nucleons, to the nucleon structure function. The EMC effect was a startling experimental finding more than two decades ago – one of the first on nuclear effects in hard scattering experiments in cold nuclear matter. It still lacks a coherent theoretical explanation, a variety of models being advocated ranging from changes of confinement scales in nuclei, to the role of meson degrees of freedom in effective field theories, to rescattering effects in nuclei. Its discovery stimulated an entire field of research in the subsequent years. On the other side the passage of hadrons through nuclear matter had been proposed almost simultaneously to the EMC findings, as a potential probe of strong interactions dynamics as described by QCD. Four differently oriented communities participate traditionally in these studies, namely the hadron-nucleus and lepton-nucleus experts, from both the experimental and theoretical sides. The workshop succeeded in bringing together the various communities and in creating intersections, and areas of overlapping interests. The atmosphere was relaxed and discussions were facilitated giving space for new, concrete ideas to emerge. An example can be taken from what observed by Prof. J.C. Peng from the UIUC by the end of the workshop: from talks and discussions on polarized scattering one can conclude that although the investigation of a "polarized EMC effect" would be extremely interesting because of its differences with the unpolarized case, the investigation of transversely polarized structure functions such as the Boer-Mulders function that do not require the polarized targets should be considered; or, that it is crucial to simultaneously study semi-inclusive deep inelastic scattering and Drell Yan experiments in order to pin down the parton energy loss in nuclei. Similar new ideas emerged also in the interaction between the "lower energy" community, focused on quasi-elastic scattering experiments, and the high energy one, through the discussion of the unifying concept of generalized parton distributions.

Although the workshop was mainly theoretical, a number of recent and preliminary experimental results were presented, specifically on new precise measurements of the EMC effect on light nuclei, on semi-inclusive and hadron production experiments at both Hermes and Jefferson Lab, on the Bonus experiment at Jefferson Lab, on DVCS experiments in nuclei at Hermes, on large Bjorken x measurements, and finally on searches for nucleons' in medium modifications in polarized ^{4}He(e,e' p)^{3}H at Jlab. New experimental proposals were also presented including DVCS on ^{4}He at Jefferson Lab, as well as the proposed programs at PAX, JPARC and EIC.

Conclusions

The workshop's intense discussions and new ideas represent, in our opinion, one more step towards defining a consistent description of hard processes in nuclei from both the study and comparison of the complementary yet interrelated measurements, approaches, and calculation techniques that were presented. It should be remarked that the workshop had a number of common points with a previous one in 2005 also co-organized by one of us, Drs.Valeria Muccifora, titled "Parton Propagation through Strongly Interacting Matter". A number of the results of the previous workshop were indeed further elaborated on in the present one. For instance, many discussions were held on the concept of hadron formation time and the role of energy loss in cold nuclear matter. A novelty was introduced that a large number of participants from the electroweak probes community was involved thus creating a more diverse level of discussion. We believe that this connection is a very positive one, and we hope to be able to have established a trend to follow in the future.

Finally, we are fully convinced that the workshop succeeded in bringing together researchers from different areas of theoretical and experimental hadronic and nuclear physics, and in facilitating interactions, circulating ideas and fostering new ones to address as one group this exciting field of research.

The talks can be browsed from the website:
http://www.ect.it

3.3.9 WORKSHOP ON HARD EXCLUSIVE REACTIONS

DATE: June 9-13, 2008

ORGANISERS:
R. Kaiser (Co-ordinator) (*U Glasgow*), P. Kroll (*U Wuppertal*), N. D'Hose (*CEA Saclay*)

NUMBER OF PARTICIPANTS: 34

MAIN TOPICS:

- Hard Exclusive Reactions
- Generalized Parton Distributions
- GPD Models

SPEAKERS:

H. Avakian (*JLab*)
S. Brodsky (*SLAC*)
M. Burkhardt (*NMSU*)
N. D'Hose (*CEA Saclay*)
M. Diehl (*DESY*)
A. El Alaoui (*LPSC Grenoble*)
T. Feldmann (*Siegen*)
K. Goeke (*RUB Bochum*)
G. Goldstein (*Tufts U*)
S. Goloskokov (*JINR Dubna*)
A. Goritschnig (*Graz*)
W. Gradl (*Karlsruhe*)
P. Haegler (*TU Muenchen*)
D. Hamilton (*Glasgow*)
G. Hill (*Glasgow*)
P. Hoyer (*Helsinki*)
D. Ivanov (*Novosibirsk*)
G. Jegou (*CEA Saclay*)
R. Kaiser (*Glasgow*)
P. Kroll (*Wuppertal*)
A. Levy (*Tel Aviv*)
S. Liuti (*Virginia*)
A. Martin (*Trieste*)
D. Mueller (*Regensburg*)
P. Mulders (*Amsterdam*)
C. Munoz Camacho (*LPC Clermont-Ferrand*)
S. Niccolai (*IPN Orsay*)
W.-D. Nowak (*DESY*)
L. Pappalardo (*Ferrara*)
K. Passek-Kumericki (*Zagreb*)
D. Robaschik (*TU Cottbus*)
A. Schaefer (*Regensburg*)
P. Stoler (*Rensselaer*)
D. Zeiler (*Erlangen*)

SCIENTIFIC REPORT:

Aim and Purpose

Hard exclusive processes have been shown to factorise into parton-level subprocesses and soft hadronic matrix elements, termed generalized parton distributions (GPDs). The GPDs comprise a wealth of information about the proton. Thus, for instance, they tell us about the orbital angular momenta the partons inside the proton carry and about their transverse localization.

In the last two years an enormous activity could be observed on the theoretical as well as the experimental side, turning the topic of hard exclusive scattering into a rapidly expanding field. Data on many hard exclusive reactions from dedicated experiments at JLab, HERMES and HERA have been published recently and more will come shortly. First attempts to extract the GPDs from data have been published, lattice QCD results on moments of GPDs became more accurate and kinds of 'partial wave expansions' have been developed which provide fitting procedures to the data on, e.g. deeply virtual Compton scattering. The known normalization difficulties of deeply virtual meson electroproduction are now under active investigation. Power corrections to the leading-twist amplitude have been modeled, the NLO correction of perturbative QCD have been calculated and resummations of higher orders have been attempted. Also for wide-angle kinematics where the momentum transfer from the initial to the final proton provides the scale while the photon virtuality is small or even zero, new data are available in the space- and time-like regions probing the GPD approach in many details. There is even speculation about a connection between GPDs and transverse momentum dependent parton distributions although factorization in the latter case has been called into question. Despite these doubts there might be an interesting connection between transversity and hard exclusive scattering.

This progress in the field of exclusive reactions as well as the anticipated progress over the next twelve months, motivated us to plan a workshop on hard exclusive reactions at this point in time.

Results and Highlights
The presentations at the workshop covered experimental results from all experiments in the field of hard exclusive reactions and a broad range of theory presentations, from progress in fundamental questions to GPD model building.

The discussions at the end of each talk were lively and were continued over the lunch and coffee breaks. The central topic of the workshop turned out to be the interface between experimentalists and their data and theorists and their models. Discussions were especially lively where experimental data were interpreted using GPD models.

Conclusions
An ad-hoc opinion poll showed that the participants were very positive about the workshop and that they were glad they had come. There was a general opinion that one should consider a follow-on workshop in the same location in two years time.

In at least one case a new collaboration between experimentalists and theorists was started during this workshop.

The round table discussion on GPD models definitely was one of the highlights of the workshop. The discussion made it clear that GPD models and fits to the experimental data will be one of the key points over the next years, but that the time is not quite right yet for a global collaboration on this issue.

Talks on the Web
The talks of this workshop can be accessed via the workshop website at
http://gpd.gla.ac.uk/gpd2008/ .

3.3.10 ULTRA HIGH-INTENSITY LASER NUCLEAR/PARTICLE PHYSICS

DATE: June 23-27, 2008

ORGANISERS:
Tom Heinzl (Co-ordinator) (*University of Plymouth*), Burkhard Kämpfer (*Forschungszentrum Dresden-Rossendorf*), Ken Ledingham (*Strathclyde University*)

NUMBER OF PARTICIPANTS: 37

MAIN TOPICS:

- High-intensity lasers and their relevance for:
- Plasma physics
- Nuclear/Particle physics

SPEAKERS:

Marie-Madeleine Aleonard (*CENBG, Bordeaux*)
Bob Bingham (*RAL*)
David Blaschke (*Wroclaw*)
Rodolfo Bonifacio (*Milan*)
John Dainton (*Cockcroft Institute and U Liverpool*)
Antonino di Piazza (*MPI Heidelberg*)
Ladislav Drska (*Prague*)
Gerald Dunne (*Storrs*)
Florian Hebenstreit (*Graz*)
Anton Ilderton (*Plymouth*)
Andreas Ipp (*MPI Heidelberg*)
Malte Kaluza (*Jena*)
Stefan Karsch (*MPQ Garching*)
Christoph Keitel (*MPI Heidelberg*)
Victor Malka (*Palaiseau*)
Mattias Marklund (*Umeå*)
Jürgen Meyer-ter-Vehn (*MPQ Garching*)
David Neely (*RAL*)
Alexander Pukhov (*Düsseldorf*)
Andreas Ringwald (*DESY*)
Lorenzo Romagnoni (*Belfast*)
Roland Sauerbrey (*FZD*)
Ulrich Schramm (*FZD*)
Ralf Schützhold (*Duisburg-Essen*)
Daniel Seipt (*FZD*)
Valery Serbo (*Novosibirsk and Russian Academy*)
Klaus Spohr (*U. West of Scotland*)
Valery Telnov (*Novosibirsk*)
Claes-Goran Wahlström (*Lund*)
Oswald Willi (*Düsseldorf*)
Andreas Wipf (*Jena*)

SCIENTIFIC REPORT:

Aim and Purpose
With the intensity of high-power lasers exceeding 10^{22} W/cm^2 new realms of laser-matter interactions become accessible. This allows to address, for the first time, a variety of exciting physics questions the most important of which are listed below.

Basic physics topics to be discussed included:

- laser particle/plasma interactions
- high-intensity (nonlinear) QED
- laser induced QED processes: Schwinger pair production, nonlinear Compton scattering, Unruh radiation etc.
- laser nuclear physics
- laboratory astrophysics
- new physics from photon experiments

Applications to be discussed included:

- laser particle acceleration
- new laser projects: HiPER, ELI etc.
- gamma-gamma colliders
- laser induced fast ignitor fusion
- radiation therapy

The purpose of this interdisciplinary workshop was to gather participants from a wide range of research areas centred around the physics of relativistic laser-matter interactions in order to exchange ideas between the different sub-disciplines. The status of the latter should be assessed (with a unification in mind) and new directions of research identified.

Results and Highlights

Lasers and Plasmas A substantial fraction of the talks was devoted to reporting on progress in laser particle acceleration based on the plasma wake-field mechanism and generalizations thereof like target normal sheet acceleration (Karsch, Malka, Romagnani, Willi). Present challenges are: (i) increasing the energy, in particular of protons and ions, (ii) stability over many shots, (iii) establishing a monochromatic energy profile and (iv) having reliable beam diagnostics (Kaluza). Most promising applications are in radiation therapy (Malka, Wahlström, Karsch) while table-top accelerators for particle physics are still a long way to go. Staging and beam transfer, for instance, are still open questions in this respect (Karsch). Laser induced fusion was reviewed by Neely who also gave an update on the status of the HiPER project. Theoretical contributions suggested methods to achieve still higher intensities (Pukhov, Meyer-ter-Vehn), to enhance pair production due to plasma effects (Keitel, di Piazza) and to develop a quantum free electron laser (Bonifacio).

Nuclear Physics

There were three experimental nuclear physics presentations. Two of these (Aleonard, Drska) dealt with nuclear excitation in laser produced plasmas, particularly laser excitation of low lying isomeric states. The conclusion was that previous published papers on Ta181, U235 and Rb84 were at best questionable. It was suggested that future high power laser systems may be able to shed new 'light' on this field of research and, in addition, to modify internal conversion ratios. High intensity laser systems may also be used to determine the photo-proton and neutron cross sections in the giant dipole resonant region (Spohr) and to test new nuclear reaction codes. Furthermore, laser induced bremsstrahlung spectra could be employed to study neutron skins in neutron rich nuclei like Pb208, with important applications to nuclear astrophysics. Unfortunately, it seems that at present direct laser interaction with the nucleus is some way off, maybe even beyond the intensities available at ELI and HiPER (Keitel, Ledingham).

QED

This was another main focus of the workshop and mostly covered by theorists. One of the most exciting predictions of high-intensity QED is Schwinger pair production, believed to set in above a critical field of about 10^{18} V/m. Below this threshold the effect is supposed to be exponentially suppressed. Presently, pair production can only be treated analytically for a few, somewhat unrealistic, field configurations. The technical difficulties were reviewed (and partly overcome) by Dunne and Hebenstreit. There is an ongoing and intriguing debate as to whether pair production can be even observed below the critical field (Blaschke). Theorists agreed that more research is needed, in particular as the issue is somewhat pressing from an experimental point of view. In addition to the absorptive process of pair creation there are also dispersive effects which below the Sauter/Schwinger threshold are only power-law suppressed, at least for low (optical) energies. Their observation would provide further tests of high-intensity QED (Keitel, di Piazza, Wipf). A process where there is no sub-threshold suppression at all is nonlinear Thomson or Compton scattering. Intensity effects should hence be readily accessible (Ilderton, Schramm, Seipt, Serbo).

Particle Physics

High-intensity lasers may have additional uses for particle physics beyond QED (Dainton, Ipp), for instance, as important components of γ-γ colliders (Ledingham, Telnov). There are even options to test physics beyond the standard model in the low-energy sector (from a particle physics point of view). Laser photons may couple to a variety of weakly interacting sub-eV particles (WISPs) such as milli-charged fermions, axion-like particles and hidden-sector photons (Ringwald, Wipf). First experiments (e.g. 'light shining through walls') are already under way.

Fundamental Physics

There were several talks on fundamental physics topics. Of particular importance was the Unruh effect. This may be viewed as an instance of 'analogue gravity' where the ultra-strong acceleration provided by lasers is employed to mimic Hawking radiation. There seem to be clear experimental signals that distinguish Unruh radiation from the accompanying Larmor spectrum (Marklund, Schützhold). More hypothetical ideas that are certainly worth exploring include laser-based studies of Lorentz violation, ultra-strong magnetic field effects on Landau levels (Marklund) and decoherence of atom beams (Bingham).

Conclusions

The workshop has certainly achieved its goals of facilitating discussions between sub-fields and identifying future research directions. Emphasis has been put on QED experiments ('exploring the quantum vacuum') and on laser acceleration, in particular its medical applications. There will be a direct influence of the workshop outcomes on the science case for the VULCAN 10PW upgrade and the ELI/HiPER fundamental physics programmes. A dedicated meeting on pair production through 'boiling the vacuum' with lasers is currently being discussed.

NB: The workshop talks can be downloaded following URL:
http://www.ect.it/Meetings/ConfsWksAndCollMeetings/ConfWksDocument/2008/talks/14_19_July_08/talks.htm

3.3.11 STRUCTURE OF HADRONS AND NUCLEI AT AN ELECTRON ION COLLIDER

DATE: July 14 -18, 2008

ORGANISERS:
F. Gelis (*CERN and CEA Saclay*), R. Venugopalan (*Brookhaven National Laboratory*), W. Vogelsang (*Brookhaven National Laboratory*), F. Yuan (*Lawrence Berkeley National Laboratory*)

NUMBER OF PARTICIPANTS: 30

MAIN TOPICS:

- Parton Distribution Functions
- Diffraction, Generalized Parton Distributions
- Color Glass Condensate
- Universality and Factorization
- Fundamental Symmetries
- High Energy QCD/Gravity Duality

SPEAKERS:

Mauro Anselmino (Univ. of Torino and INFN)
Nestor Armesto (Univ. Santiago de Compostela)
Antje Bruell (Jefferson Lab)
Allen Caldwell (Max Plank Institute, Munich)
Giovanni Antonio Chirilli (JLab and ODU)
Abhay Deshpande (Stony Brook University)
Markus Diehl (DESY)
Francois Gelis (CERN and CEA Saclay)
Yoshitaka Hatta (University of Tsukuba)
Jamal Jalilian-Marian (Baruch College,CUNY)
Yuji Koike (Niigata University)
Henri Kowalski (DESY)
Krishna Kumar (University of Massachusetts, Amherst)
Matthew Lamont (Brookhaven National Laboratory)
Tuomas Lappi (CEA Saclay)
Yacine Mehtar-Tani (U. Heidelberg)
Stefano Melis (INFN Torino)
Alfred Mueller (Columbia University)
Fernando Navarra (University of Sao Paulo)
Michael Ramsey-Musolf (U. Wisconsin-Madison)
Carlos Salgado (Univ. Santiago de Compostela)
Mark Strikman (Penn State University)

Dionysis Triantafyllopoulos (ECT*)
Raju Venugopalan (Brookhaven National Laboratory)
Werner Vogelsang (Brookhaven National Laboratory)
Andreas Vogt (University of Liverpool)
Xin-Nian Wang (Lawrence Berkeley National Laboratory)
Christian Weiss (Jefferson Laboratory)
Urs Wiedemann (CERN)
Feng Yuan (Lawrence Berkeley National Laboratory/RBRC)

SCIENTIFIC REPORT:

Aim and Purpose

A high luminosity electron ion collider (EIC) has been proposed in the United States and Europe to address the following questions about the fundamental structure of matter:

- determine the spin, flavor and spatial structure of the nucleon by precise imaging of the sea quark and gluon distributions
- understand the universal nature of strong gluon fields by performing deep inelastic scattering of light and heavy nuclei.

The purpose of the ECT* workshop was to address our current understanding of the stated physics issues, to clarify what an EIC can add to our understanding of these topics and to discuss possible new ideas that can be addressed in the future at an EIC.

Spin structure of the Nucleon: few discoveries made in the exploration of the structure of the nucleon have had a bigger impact on the field and its further development than the surprising finding by the EMC that the quarks and anti-quarks together carry only about a quarter of the nucleon's spin. To determine how the constituents of the proton, the fundamental quarks, anti-quarks and gluons of QCD, conspire to provide the spin-1/2 of the nucleon, presents the formidable challenge of understanding a complex composite system in nature and has by now developed into a world-wide quest central to nuclear physics. The proton spin sum-rule,

$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + L_q + \Delta G + L_g \ ,$$

states that the proton spin is the sum of the quark and gluon intrinsic spin ($\Delta\Sigma$, ΔG) and orbital angular momentum (L_q, L_g) contributions. The EIC with its unique high luminosity, highly polarized electron and nucleon capabilities, and its extensive range in center-of-mass energy, will allow to access the quark and gluon spin contributions through deep-inelastic scattering (DIS). The recent results from polarized p+p scattering experiments at RHIC suggesting that the ΔG contribution to the proton's spin is very small has deepened this mystery. By extending the x reach in the proton to significantly smaller x, the EIC will be able to test the robustness of our current small x extrapolations and to determine the role of small x gluons and see quarks in the composition of the nucleon's spin. Measurements of "Generalized parton distributions" (GPDs) in exclusive processes at an EIC would provide unique access to the total, spin plus orbital, angular momentum contributions of quarks and gluons, as well as to many other important aspects of nucleon structure. The aim of the workshop in this regard was to review the state of the art results from the experiments at RHIC, COMPASS and JLab and the latest theoretical analyses, based on these results, of the spin dependent parton distributions based on these experiments. The aim was further to understand the scope of the GPD measurements at the EIC in resolving the "spin crisis".

Nuclei at high energies: the EIC will be the first e+A collider and will perform DIS experiments for a wide range of nuclei. At high energies (or small Feynman x), the structure of hadrons and nuclei is composed primarily of gluons and (to a lesser extent) sea quarks because of the strong enhancement of gluon Bremsstrahlung at small x. Though the gluon distribution in the proton has been measured at HERA and indeed is observed to grow rapidly at small x, gluon distributions in nuclei for $x < 0.01$ are *terra incognita*. A very intriguing possibility is that a universal Color Glass Condensate (CGC), with a characteristic saturation scale $Q_S^A(x)$, controls the properties of hadron and nuclear wavefunctions at small x and provides insight into empirical phenomena such as shadowing, limiting fragmentation, geometric scaling and hard diffraction. Simple arguments based on quantum coherence and relativistic kinematics tell us that the saturation scale is significantly enhanced in large nuclei thereby making e+A collisions an ideal precision probe of this new regime in QCD. The EIC will address the following questions:

- What is the momentum distribution of gluons and sea quarks in nuclei?
- What is the space–time distribution of gluons and sea quarks in nuclei?
- What is the role of color neutral (Pomeron) excitations in scattering off nuclei?
- How do fast probes interact with an extended gluonic medium?

At present, only a limited understanding exists of the answers to these questions. The purpose of the e+A discussion at the workshop was to address the key measurements (and the various theoretical predictions for these) with the aim of answering the above stated open questions. The workshop also addressed questions related to the universality of QCD dynamics extracted in lepton-nucleus collisions relative to that from proton-nucleus and nucleus-nucleus collisions at RHIC and the LHC. This is important both for a conceptual understanding of QCD dynamics as well as the more practical one of interpreting results in p+A and A+A collisions at the LHC, where low x dynamics will play a key role. In terms of probes of the CGC, the EIC and the LHC will have complementary strengths; the former will likely probe the deep saturation regime while the latter will likely be able to map out the geometrical scaling regime where the effects of saturation can still be felt in the QCD evolution of observables.

Results and Highlights

The workshop featured discussions of the state of the art analyses of both spin dependent (Vogelsang) and nuclear parton distributions (Salgado). A highlight of the former was the conclusion that global analyses including RHIC data suggest that ΔG is small–this result suggests that GPD measurements and lattice studies of spin dependent nucleon moments will be important in resolving the spin crisis. The analysis of nuclear parton distributions included, for the first time, data from nuclear collisions at RHIC. The current understanding of nuclear DIS and the many remaining open questions were reviewed by Bruell. Within the collinear factorization framework of the nuclear pdfs, the new global analysis suggests very strong gluon shadowing in nuclei at relatively large x. As these values of x are accessible with the EIC, this result as well as the relation of strong shadowing to the physics of saturation/strong fields provide strong motivation for the EIC.

Crucial to theoretical interpretation of data on structure functions are reliable perturbative computations. Computations of splitting functions and coefficient functions at next-to-next-to leading order (NNLO), for both spin averaged and spin dependent quantities were discussed by Vogt. In the saturation framework, NLO computations are now becoming available–the current status was presented by Chirilli. In the strong coupling regime, perturbative computations are not applicable. Mueller and Hatta discussed how novel theoretical ideas (based on the duality of N=4 Super Yang Mills to $AdS_5 \times S_5$ classical supergravity) may possibly be applied to understand the strong coupling regime in DIS and e^+e^- scattering. Of particular interest to EIC would be testable, hitherto unexpected predictions in this regime, predicted by the (SUSY)QCD/Gravity duality.

Saturation, the Color Glass Condensate and its signatures were discussed by Armesto and Navarra. Hints for these have already been seen in the HERA and RHIC data. Of particular interest here is the extrapolation of results from these accelerators to the LHC. Early measurements at the LHC, if consistent with these, will provide much impetus for detailed studies of saturated gluon matter. QCD factorization in the CGC framework and tests of the universality of saturated gluon "dipole" cross-sections in DIS and heavy ion collisions were discussed by Jalilian-Marian and Mehtar-Tani.

The interaction of fast probes with an extended "hot" and "cold" medium has been a focus of much interest ever since jet quenching was discovered at RHIC. Wang discussed the theoretical framework for this process; an interesting possibility is that the extracted modified fragmentation functions in e+A collisions can help distinguish between different energy loss models. One of the surprises at RHIC was that charm (and likely) bottom mesons are also "quenched". DIS experiments thus far have not had the energy reach to study heavy quark energy loss. A detailed study with EIC can therefore strongly constrain our picture of parton energy loss in cold *and* hot matter.

Diffraction is a promising signature of the onset of a novel regime of strong color fields in QCD. There was a lively afternoon discussion on this topic. The status of the remarkable diffraction results from HERA was reviewed by Caldwell and the predictions for diffractive final states in the saturation and leading twist QCD pictures were discussed by Kowalski and Lappi on the one hand and Strikman on the other. Experimental prospects for diffractive studies at EIC were outlined by Lamont. Deshpande led a discussion on the low energy EIC staged option–the likelihood of an accelerated realization coupled with a strong physics program evoked much interest and discussion.

A fine introduction to the vast new subject of Generalized Parton Distributions was given by Diehl. Exciting possibilities are impact parameter dependent probability distributions. In his talk, Weiss focused on the connection between these distributions and impact parameter dependent final states in p+p collisions at the LHC. GPDs are also closely tied to the Sivers function–prospects for its measurement in semi-inclusive DIS were addressed by Melis. Another interesting spin dependent structure function is Transversity, which was the focus of talks by Anselmino and Koike. All of these talks emphasized the possibility of a more detailed spatial imaging of the proton leading to a better understanding of the orbital motion of quarks and gluons.

A new topic that was introduced at this workshop was the prospect of study fundamental symmetries with an EIC. The theory and experimental aspects were covered by Michael Ramsey-Musolf and Krishna Kumar respectively. An important focus was on the extraction of the running of $\sin^2\theta_W$ with Q^2 in parity violating DIS; this quantity could provide strong hints of beyond the standard model physics. Other interesting possibilities are lepton flavor and number violation in DIS. Preliminary indications suggest that luminosities of at least $10^{34}/\mathrm{cm}^2/\mathrm{sec}$ are needed for these studies.

Conclusions

The workshop on the structure of hadrons and nuclei at an electron ion collider at ECT$\star$ helped clarify the open questions that remain in our understanding of the fundamental partonic structure of matter. This will help in developing the science case for the EIC. A follow up workshop will be held at the INT in Seattle in October 2009.

Interested readers can browse the workshop talks at the website:
http://ipht.cea.fr/Images/Pisp/fgelis/Workshops/Trento2008/

3.3.12 THE STATISTICAL MODEL OF HADRON FORMATION AND THE NATURE OF THE QCD HADRONIZATION PROCESS

DATE: Sept 1-5, 2008

ORGANISERS:
F. Beccatini (*INFN*)
P. Braun-Munzinger (*GSI*)
R. Stock (*Univ. Frankfurt*)

NUMBER OF PARTICIPANTS: 34

SCIENTIFIC REPORT:

The process of hadronization, occurring during the final dynamical evolution of all ultra-relativistic particle collision, actually comprises two distinct but perhaps concurrent phase transformations of non-perturbative QCD: the confinement/deconfinement and the chiral symmetry breaking/restoration transitions. No analytical QCD treatment exists, as of yet, for either of the transitions although there are recent attempts to extend the analysis of QCD simulation on the lattice to such an end. At this moment, even the lattice calculations are limited to a vicinity of zero baryochemical potential where the phase transformations appear to coincide and be of a mere crossover nature. The interpolation to finite baryochem. potential suggests a smooth curve perhaps ending in a QCD "critical point", onward from which a first order transition may be expected. The corresponding domain of baryochemical potential, of up to about 500-600 MeV, is covered by the reaction dynamics of relativistic nucleus-nucleus collisions, and a wealth of experimental observations exists as to the relationship between collisional CM energy, geometry and projectile/target mass on the one hand, and the distribution of hadronization or hadronic freeze-out output over species and phase space, on the other.

In fact it was found that all these data can be strikingly well be accounted for in the framework of the Grand Canonical statistical Gibbs ensemble of the spectrum of hadronic and resonance states up to 2 GeV. This observation, of a hadronization temperature and baryochemical potential systematically related to the conditions of the investigated A+A collisions, i.e. of the viability of an equilibrium description of the bulk hadron/resonance output, is in itself only marginally understood but it provides for a hint about the hadronization process mechanism and, at least, provides for a firm description of its last stage(s). Finally, the observed hadronization systematics merges, at zero baryon potential, with the hadronization systematics of all elementary collisions which can, in turn, be represented by the microcanonical or canonical statistical ensemble, this analysis suggesting a universal hadronization temperature of about 170 MeV which, indeed, coincides with the estimate from lattice QCD as to the critical temperature of QCD.

It was thus tempting to undertake a synopsis of all information available to date, concerning hadronization, both from experiment and theory.

Three topical complexes arise:

1. Early experiences with hadronization made with e^+e^- annihilation to hadrons. A phenomenological model (the code HERWIG) of initial perturbative QCD DGLAP parton shower evolution towards color neutralization was formulated (by Veneziano, Webber et al.) in the late 70s, and later on a configuration space parallel model by Ellis and Geiger, to take account of the a priori fact that partonic evolution has to terminate in a color-neutralization stage. This model, called "colour preconfinement" attempted to exploit perturbative QCD to its absolute end, at cutoff scale 1-2 GeV. The object born here, a color singlet multipartonic cluster, and the corresponding stochastic invariant mass distribution of such pre-hadronic singlet clusters, is then re-interpreted phenomenologically. The initial (partly virtual) inv. mass of the cluster is expected to "dress" with nonperturbative vacuum structure (condensates) as time scale and virtuality slow down/decrease towards 1fm/c. The virtual mass cluster then decays to on-shell hadrons, under dominance of phase space as dictated by the QCD hadron/resonance spectrum. From the end of the perturbative QCD phase one knows that the cluster energy density is now at or below the QCD confinement scale, of about 1GeV/fm^3. Re-interpretation of the output in the statistical model framework introduces the concept of a hadronization temperature, a consequence of the initial energy density, vis a vis the hadronic mass spectrum of QCD. It turns out to be about 170 MeV (as seen everywhere else in hadronization). Can we replace the somewhat ad-hoc-description (which is similarly attempted in the Lund string-model) of hadrogenesis during the first 1fm/c by a modern dynamical theory of hadron structure dynamics? The answer: NOT as of yet. Unfortunately the lattice QCD approach is only indirectly informative about dynamics.

2. Are the above nonperturbative model assumptions congruent with the application (since Hagedorn!) of a quasi-classical interpretation of the on-shell ensemble of hadrons /resonances resulting from singlet cluster quantum mechanical tunnelling decay? Much remains to be clarified (the origin of the "temperature" concept in particular), to explain the remarkable success of the canonical statistical Gibbs ensemble model, but there is recent progress. In particular, the "mysterious" equilibrium property of the final hadronic/resonance species distribution becomes plausible: unlike in former attempts, the pre-hadronic "fireball" cluster does not simply flow apart, with "walls removed", because in this view it still has virtual mass/energy from its pre-history, thus has to decay, not just decompose. There are emerging formulations of the statistical hadronization model,reflecting this fact.

3. From elementary to complex heavy nuclear collisions: what do we learn about the dynamics of the latter from the fact that a.) central heavy A+A collision hadronization is perfectly described by the Grand Canonical version of the Gibbs statistical ensemble, and b.) the A+A data exhibit a smooth transition from canonical hadronization (with strangeness suppression) to the GC case, in order of the net strangeness of the hadronic species considered, as to be expected from the volume dependent GC limit of a canonical system, and c.) at the extreme energy of RHIC the wide rapidity gap permits, for the first time, analysis of the hadron composition as a function of local rapidity. This analysis supports the assumption of an A+A-specific, long delay time occurring inbetween primordial DGLAP shower multiplication and inelastic pileup of quantum

number and energy density along the longitudinal rapidity axis, on the one hand, and final color neutralization to hadrons, on the other: the time extent inbetween being occupied (unlike in elementary collisions!) by a collective partonic medium expansion.

As an extreme of possible scenarios: hadronization in A+A collisions thus occurs at the QCD phase boundary, all expected hadronization implications being in fact observed, including the equilibrium property of hadronization, in GC form for A+A, and the universality of the hadronization temperature derived from statistical model analysis. It appears that the QCD phase boundary is thus localized at T about 170 $\pm$ 10 Mev, for zero baryochemical potential.

The workshop also concluded that first, necessary elements of a final QCD description of the confinement/deconfinement, and chiral restoration transitions (or is it only one such transition?) have been assembled that might allow for a renewed approach (after the 1970/80s models of Marchesini, Veneziano and Webber) toward QCD hadronization. In employing the body of new hadronization data, at near zero, and finite baryochemical potential, as gathered by the A+A experiments. This conclusion was very much helped by the participation of Marchesini and Webber, the pioneers of hadronization. The workshop did, of course, not resolve finally all the posed problems, but was considered inspiring and exciting by all its participants.

The Participants:
10 PhD students and postdoc fellows
7 tenured junior scientists
17 senior scientists
AS INTENDED!

The conditions, preparation, and realization at ECT* of this workshop have been uniquely ideal. ECT* is unmatched in its encouragement and realization of such, already quite complex and ambitious workshops. Thank you!

Reinhard Stock

Workshop Chair

3.3.13 SCALING THE HEIGHTS OF THE N=Z LINE ABOVE ^{56}NI

DATE: September 16-18, 2008

ORGANISERS:
David Jenkins (Co-ordinator) (*University of York, UK*), Iain Moore (*University of Jyvaskyla, Finland*)

NUMBER OF PARTICIPANTS: 25

MAIN TOPICS:

- Neutron-proton pairing
- Isospin symmetry and isospin mixing
- In-beam studies
- Beta decay
- Trapping
- Future programmes with radioactive beams

SPEAKERS:

Piet van Isacker (*GANIL*)
Corina Andreoiu (*Simon Fraser University*)
Zenon Janas (*Warsaw*)
Pedro Sarriguren (*Madrid*)
Emmanuel Clement (*GANIL*)
John Hardy (*Texas AM*)
Ari Jokinen (*University of Jyvaskyla*)
Richard Chasman (*ANL*)
Bob Wadsworth (*University of York*)
Anatoli Afanasjev (*Mississippi State University*)
Giacomo de Angelis (*INFN Legnaro*)
Paul Davies (*University of York*)
Jan Saren (*University of Jyvaskyla*)
Adam Garnsworthy (*TRIUMF*)
Ivan Mukha (*Seville*)
Kazunari Kaneko (*Tokyo*)
Bob Wadsworth (*University of York*)
Phil Woods (*University of Edinburgh*)
Anujh Parikh (*TU Munich*)
Anu Kankainen (*University of Jyvaskyla*)
Darek Seweryniak (*Argonne National Laboratory*)
Bo Cederwall (*KTH Stockholm*)

SCIENTIFIC REPORT:

Aim and Purpose

The aim of the meeting was to bring together experimentalists and theorists interested in the physics of N=Z nuclei. We were conscious that important new results were emerging on N=Z nuclei above ^{56}Ni from a range of different experimental techniques including in-beam studies, trap measurements and beta decay. The intention of the workshop therefore was to bring these different results together to see if important connections could be made between these different approaches, which would cast light on some of the key physics questions relating to N=Z nuclei such as isospin purity, nuclear shapes and nuclear astrophysics.

Results and Highlights

The workshop was very successful in achieving its aims. We were able to bring together most of the principal people working in this area from Europe, North America and Japan. All of the key topics were covered from tests of the CVC hypothesis to nuclear astrophysics. The workshop was deliberately kept small and focussed and with plenty of time for detailed discussion. Some of the sessions were focussed around specific results and issues stemming from them, for example, the discovery of two-proton emission from the isomer in ^{94}Ag. We were pleased to have several of the leading theorists on N=Z physics attending the meeting and this led to a very complete discussion around the topic of neutron-proton pairing.

Conclusions

In summary, the workshop achieved the goals set out from the beginning by bringing together 25 scientists to have a detailed discussion on the physics of N=Z nuclei. The participants commented that the workshop had been very valuable to them and that they had had chance to discuss the issues of interest to them with other experts. It was clear that these discussions are likely to lead to further collaborations and renewed experimental and theoretical interest in these exotic nuclei.

Optional// The talks can be browsed from the website: http://www.ect.it

3.3.14 BOUND STATES AND RESONANCES IN EFFECTIVE FIELD THEORIES

DATE: September 29 - October 3, 2008

ORGANISERS:
Vladimir Pascalutsa (Co-ordinator) (*Mainz, Germany & ECT* Trento, Italy*),
Daniel R. Phillips (*Ohio University, USA & Manchester, UK*)

NUMBER OF PARTICIPANTS: 40

MAIN TOPICS:

- Non-perturbative aspects of EFTs. Resummations and power countings.
- Resonances in the meson sector. The ρ-meson and scalar-isoscalar resonances in χPT description of π-π scattering.
- Resonances in the single-nucleon sector. $\Delta(1232)$ and beyond.
- Convergence and resummations in SU(3) chiral EFT. Role of the $\Lambda(1405)$.
- Light nuclei in chiral EFTs. Deuteron, triton, and alpha particle.
- Nuclear resonances and halo nuclei. ^{5}He, ^{6}He, and others.
- Resonances in lattice QCD and chiral extrapolations.

SPEAKERS:

Shung-ichi Ando (*Manchester, UK*)
Christopher Aubin (*William and Mary, USA*)
Silas Beane (*U. New Hampshire, USA*)
Peter Burns (*Bonn U., Germany*)
Hans Bijnens (*Lund U., Sweden*)
Mike Birse (*Manchester, UK*)
Jorge Martin-Camalich (*Valencia, Spain*)
Gilberto Colangelo (*Bern, Switzerland*)
Evie Downie (*Mainz U., Germany*)
Evgeny Epelbaum (*Bonn/FZ Juelich, Germany*)
Pietro Faccioli (*Trento U., Italy*)
Jambul Gegelia (*Mainz U., Germany*)
Harald Griesshammer (*George Washington, USA*)
Hans-Werner Hammer (*Bonn, Germany*)
Christoph Hanhart (*FZ Juelich, Germany*)
Renato Higa (*Bonn, Germany*)

Naruhito Ishizuka (*Tsukuba, Japan*)
Bruno Julia-Diaz (*Barcelona, Spain*)
Harry Lee (*Argonne, USA*)
Vadim Lensky (*ECT*, Italy*)
Stefan Leupold (*Giessen, Germany*)
Judith McGovern (*Manchester, UK*)
Kostas Orginos (*William and Mary/JLab, USA*)
Assumpta Parreno (*Barcelona, Spain*)
Manuel Pavon Valderrama (*FZ Juelich, Germany*)
Jose Pelaez (*Madrid, Spain*)
Lucas Platter (*Ohio State, USA*)
Luis Roca (*Murcia, Spain*)
Akaki Rusetsky (*Bonn, Germany*)
Matthias Schindler (*Ohio, USA*)
Joan Soto (*Barcelona, Spain*)
Ulrike Thoma (*Bonn, Germany*)
Rob Timmermans (*Groningen/KVI, Netherlands*)
Marc Vanderhaeghen (*Mainz U., Germany*)
Bira van Kolck (*Arizona U., USA*)
Ross Young (*Argonne, USA*)

SCIENTIFIC REPORT:

The primary aim of the workshop was to discuss the issues related with the description of hadron resonances and bound states from the standpoint of chiral effective field theories, lattice QCD, and empirical partial-wave analyses.

The workshop opened with an overview session which saw excellent presentations on meson resonances (G. Colangelo), hadronic atoms (A. Rusetsky), lattice QCD calculations of resonance properties and meson scattering (K. Orginos), and recent developments in the partial-wave and EFT analysis of the nucleon-nucleon interaction (R. Timmermans).

Over the course of the week we then had 6 regular sessions, each consisting of 5 talks and a 30-min discussion, addressing the recent developments and problems in the description of hadron bound states and resonances. Chiral perturbation theory (χPT) has had significant success in describing meson-meson and meson-baryon interactions in the region between threshold and the appearance of the first hadronic resonances — the ρ in the mesonic sector, and $\Delta(1232)$ in the single-baryon sector. Recently, there has been much effort in extending χPT to these and other resonances using effective-field theory (EFT) frameworks. The developments in the meson sector were described in the talks of Bijnens, Roca, Pelaez, Gegelia, while for the developments in the single-nucleon sector see the talks of Schindler, Vanderhaeghen, Lensky, Camalich. Some methods other than EFTs (e.g., large N_c, meson-cloud models, partial-wave analysis) have been discussed by Leupold, Julia-Diaz, and Hanhart.

The EFT framework also facilitates the extrapolation of lattice QCD results at unphysical quark masses and finite volumes to the physical world that is probed at these laboratories. In this connection we discussed the recent progress in chiral extrapolation of resonance properties and addressed the problem of obtaining the scattering and resonance properties in lattice simulations by means of studying the volume dependencies of the spectrum and current operators (see talks of Beane, Ishizuka, Parreño, Aubin, Young).

The low-energy EFTs of the strong interaction are being used to calculate the properties of nuclear bound states. To even generate these states, some part of the NN interaction must be iterated to infinite order, thus also going beyond the perturbative expansion in powers of momenta and light-quark masses. While this resummation is reasonably well understood in a simple EFT without explicit pion fields (see talks of Van Kolck, Birse, Griesshammer, Hammer, Platter), the organization of power-counting in the chiral EFT description of light nuclei is not yet well established. Several interesting ideas to solve this problem were demonstrated in the presentations of Epelbaum, Soto, Beane, Birse.

Meanwhile, EFT methods have recently been applied to the description of "halo nuclei" and nuclear resonances in the p-shell (see the talks of Van Kolck and Higa). The energy scales involved in the EFTs for these systems are different to those in chiral EFTs, but the issues associated with the need to resum classes of diagrams in order to generate nuclear resonances, are very similar to those encountered within chiral EFT treatments of states such as the $\Delta(1232)$.

It is this sort of overlap between disparate strong-interaction EFTs that we were exploring in this workshop. We have identified some universal and unique features in the EFT description of the above-mentioned hadronic/nuclear states, namely: resonances in the meson sector, resonances in the single-baryon sector, light nuclear bound states, such as the deuteron and the trinucleons, and nuclear resonances, such as ^{5}He. In each case we discussed how to establish a consistent power-counting that can be used to compute properties of the bound-state/resonance from the EFT description of QCD. The results can be confronted with the wealth of experimental data on these resonances and bound states, coming from facilities such as Jefferson Lab, MAMI, ELSA, and, in the future, GSI. Some new experimental results have been presented by E. Downie and U. Thoma on the second day of the workshop.

On the last day of the workshop we have seen two more presentations (Ando, Burns) of 'late-breaking' developments and finally 15-min presentations from the chairmen of each of the sessions (Bijnens, McGovern, Lee, Vanderhaeghen, Phillips, Beane), which highlighted and summarized many of the points raised during the week.

The talks and chairmen highlights can be found on-line at the ECT* web site, www.ect.it → Meetings → Conferences... → Past years ... → 2008 → 29 Sept 3 Oct... Talks.

3.3.15 STRANGENESS POLARIZATION IN SEMI-INCLUSIVE AND EXCLUSIVE LAMBDA PRODUCTION

DATE: October 27-31, 2008

ORGANISERS:
Harut Avakian (*Jefferson Lab*)
Naomi C.R. Makins (*Univ. of Illinois at Urbana–Champaign*)
Andreas Schäfer (*Regensburg Univ.*)
Christian Weiss (*Jefferson Lab*)

NUMBER OF PARTICIPANTS: 30

MAIN TOPICS:

- Strangeness polarization and nucleon structure: Ideas, current status
- Semi-inclusive Λ production in ep : Experiments, QCD analysis, distribution and fragmentation functions
- Λ polarization in pp : Experiments, reaction models, phenomenology
- Target fragmentation in deep–inelastic scattering: QCD factorization, fracture functions, experimental status and prospects
- Exclusive channels in deep–inelastic scattering: Generalized parton distributions, phenomenology, experimental prospects
- Λ production with future facilities: JLab 12 GeV, GSI FAIR, Electron-Ion Collider (EIC).

SPEAKERS:

Alberg, Mary (*Seattle U.*)
Alexakhin, Vadim (*JINR Dubna*)
Anselmino, Mauro (*Torino U.*)
Belostotski, Stanislav (*St. Petersburg NPI*)
Ceccopieri, Federico (*Parma U.*)
Ent, Rolf (*Jefferson Lab*)
Gamberg, Leonard (*Penn State U.*)
Johansson, Tord (*Uppsala U.*)
Joo Kyungseon (*U. Connecticut*)
Kaskulov, Murat (*Giessen U.*)
Kotzinian, Aram (*CEA Saclay*)
Kroll, Peter (*Wuppertal U.*)
Liang, Zuo-tang (*Shandong U.*)
Mirazita, Marco (*LNF-INFN*)
Mulders, Piet (*Amsterdam VU*)
Naumov, Dmitri (*JINR Dubna*)
Polyakov, Maxim (*Bochum U.*)
Ryckebusch, Jan (*Gent U.*)
Samoylov, Oleg (*JINR Dubna*)
Sapozhnikov, Mikhail (*JINR Dubna*)
Stratmann Marco (*Würzburg U.*)
Teryaev, Oleg (*JINR Dubna*)
Trentadue, Luca (*Parma U.*)
Schäfer Andreas (*Regensburg U.*)
Weiss, Christian (*Jefferson Lab*)
Xu Qinghua (*Shandong U.*)

SCIENTIFIC REPORT:

Aim and Purpose

Hyperon production in *ep* and *pp* scattering provides a direct way of probing the strange quark content of the nucleon, including its polarization. Most experimental and theoretical efforts so far have focused on semi-inclusive production of Λ through fragmentation of the strange quarks/antiquarks participating in a DIS process (current fragmentation). During the last years two promising new methods of studying Λ production have emerged: (a) Semi-inclusive production through hadronization of the target remnants in the DIS process (target fragmentation), described by the so-called nucleon fracture functions; (b) Exclusive electroproduction of $K\Lambda$ states, in which the target structure is described by generalized parton distributions (GPDs). These new approaches complement and extend the reach of traditional semi-inclusive Lambda production in the current fragmentation region and offer new ways of accessing strangeness in the nucleon. They can also be used to explore the physics of spin-orbit interactions in QCD using the recoil Λ polarization as a new observable.

While considerable expertise has now been gathered with these new methods in other channels, there has not been much exchange between these emergent fields and "traditional" approaches to Λ production. The aim of this workshop was to bring together experimentalists from the *ep* (HERMES, COMPASS, JLab, future Electro–Ion Collider or EIC) and *pp* (RHIC, JPARC, GSI FAIR) scattering communities, as well as theorists working on semi-inclusive and exclusive particle production in different kinematic regions, in order to (a) review our present knowledge of the strangeness content of the nucleon; (b) summarize the data and status of Λ production experiments; (c) discuss theoretical approaches to Λ production in different kinematic regions; (d) assess the potential of target fragmentation and exclusive Λ electroproduction to probe the strangeness content of the nucleon and spin-orbit interactions of quarks; (e) identify areas for further study and the prospects for future experimental facilities (JLab 12 GeV Upgrade, EIC, GSI FAIR).

Results and Highlights
The broader purpose of the meeting was to exchange information between experts in different areas of particle production and foster a common understanding of the status and prospects of Λ production. This was fully achieved and represents certainly the main result of the workshop. Most of the presentations had a pedagogical introduction and took ample time to explain the basic concepts, which was greatly appreciated by the audience and enabled several extensive "interdisciplinary" discussions (global analysis of parton structure, fragmentation functions vs. Monte–Carlo generators, target fragmentation vs. semi-inclusive and exclusive production).

More specifically, the presentations and discussions produced the following main results:

- Understanding of the nucleon's partonic structure has made substantial progress with the recently completed global analysis of inclusive and semi-inclusive DIS data. Even within this "global" framework, semi-inclusive kaon production, particularly K^-, remains the main source of information about strangeness in the nucleon. Further study of the K^- fragmentation functions were encouraged in order to reduce its uncertainties.

- Universal QCD fragmentation functions and the Lund string–breaking model are two different methods to describe properties of the hadronic final state in Λ production. The conceptual relation between the two was clarified. It was found that no satisfactory theoretical framework exists to describe empirically observed non–universal effects in the QCD fragmentation function approach, and further investigation of this problem was discussed.

- Fracture functions represent a new method to describe particle production in the target fragmentation region in the context of QCD factorization. The new method was explained to a wider audience, and its potential for Λ production was assessed. The limits of applicability of the fracture function approach were discussed, and it was found that they need to be quantified by further theoretical and experimental study (COMPASS, JLab 12 GeV, EIC).

- Exclusive channels represent another interesting option for Λ production studies. While the theory and phenomenology have made great progress, a number of puzzling observations remain and require further study. Present GPD–based calculations reproduce the data well at energies $W > 4\,\mathrm{GeV}$ but fail at lower energies for yet unknown reasons. Conversely, the Lund model for inclusive fragmentation describes the transverse cross section even in the exclusive limit, although there is no theoretical basis for it. The implications of these results were discussed, and strategies for further studies were outlined.

Conclusions
The main conclusions of the workshop are as follows:

- Λ production in various kinematic regions remains one of the most effective methods for studying the strange quark/antiquark content of the nucleon and its polarization.

- In traditional semi–inclusive Λ production experiments, there is still considerable room for improvement of the analysis (polarization transfer to Λ, K^- fragmentation functions, non–universal effects in quark fragmentation).
- Target fragmentation and exclusive Λ production could contribute extremely valuable information if the theoretical methods are developed further and their applicability is demonstrated by exploratory experimental studies.
- The planned future facilities (JLab 12 GeV, GSI FAIR, EIC) offer exciting opportunities for further experimental studies of Λ production, and researchers are encouraged to formulate specific proposals.

We think that our meeting was a major step toward creating an "interdisciplinary" community of researchers interested in Λ production, as will be needed to fully exploit the potential of the planned future facilities. Many of the participants did not know each other before the meeting, and our workshop has produced many new contacts and enabled future collaborations. The participants universally appreciated the relaxed format of the meeting (long presentations, ample time for discussion, flexible schedule), the professional handling of all organizational matters by the ECT* staff, and the unique atmosphere in Trento.

3.3.16. NEUTRINOS IN PARTICLE, IN NUCLEAR AND IN ASTROPHYSICS (FIFTH ANNUAL MEETING OF ILIAS N6/WP1)

(Collaboration Meeting)

DATE: November 16-21, 2008

ORGANISERS:
Amand Faessler (Co-ordinator) (*Tuebingen DE*)
Serguey Petcov (*SISSA Trieste IT*)
Gianluigi Fogli (*Bari and INFN - Bari IT*)
Vadim Rodin (*Tuebingen DE*)

NUMBER OF PARTICIPANTS: 55

MAIN TOPICS:

- Neutrinos in Grand Unified Theories and in Supersymmetric Models
- Neutrino Oscillations and their Global Analysis (including the GSI oscillations)
- Double Beta Decay and the absolute Neutrino Mass
- Physics and Realization of a Neutrino factory
- Neutrinos in Cosmology and Astrophysics

SPEAKERS:
M. Acero Ortega (*Torino IT*)
S. Antusch (*MPIP Munich DE*)
D. Aristizabal (*INFN/LNF IT*)
F. Avignone (*SC USA*)
S. Bilenky (*JINR Dubna RU*)
A. Caciolli (*Padova IT*)
F. Deppisch (*Manchester UK*)
A. Faessler (*Tuebingen DE*)
F. Feruglio (*Padova IT*)
E. Fiorini (*Milano IT*)
G. Fogli (*INFN Bari IT*)
D. Frekers (*Muenster DE*)
S. Geer (*FNAL USA*)
A. Giuliani (*Insubria IT*)
C. Giunti (*INFN Torino IT*)
P. Grabmayr (*Tuebingen DE*)
S. Hannestad (*Aarhus DK*)
A. Ivanov (*TU Wien AUT*)
S. King (*Southampton UK*)
J. Kopp (*MPIK Heidelberg DE*)
Th. Kosmas (*Ioannina GR*)
S. Lavignac (*IPhT, Saclay FR*)
L. Lavoura (*TU Lisbon PT*)
M. Lindner (*MPIK Heidelberg DE*)
Yu. Litvinov (*GSI DE*)
X. Liu (*MPIP Munich DE*)
F. Lucarelli (*Roma IT*)
A. Marrone (*Bari IT*)
A. Merle (*MPIK Heidelberg DE*)
B. Metcalf (*MPIA Garching DE*)
O. Micu (*TU-Dortmund DE*)
S. Morisi (*IFIC ES*)
E. Moya de Guerra (*UCM ES*)
E. Otten (*Mainz DE*)
S. Petcov (*SISSA IT*)
F. Plentinger (*Wuerzburg DE*)
W. Rodejohann (*MPIK Heidelberg DE*)

SPEAKERS:

(ctnd.)

V. Rodin (*U-Tuebingen DE*)
A. Romanino (*SISSA IT*)
P. Serpico (*CERN SUI*)
G. Sigl (*U-Hamburg DE*)
F. Simkovic (*Comenius Univ. SLO*)
H. Sugiyama (*SISSA IT*)
I. Tamborra (*INFN Bari IT*)
M. Tortola (*U-Hamburg DE*)
J.D. Vergados (*U-Ioannina GR*)
S. Wiesenfeldt (*U-Karlsruhe DE*)
W. Winter (*U-Wuerzburg DE*)

SCIENTIFIC REPORT:

Aim and Purpose

Recently, the progress in no other field of particle physics has been so fast and interesting as in the neutrino sector. Thus, the topic "Neutrinos in Cosmology, in Astro, Particle and Nuclear Physics" is a very timely one.

The neutrino has always been an interesting particle since it was invented by Wolfgang Pauli in 1930 and finally detected experimentally by Reines and Cowan in 1956. The standard model postulates the neutrino to be a massless left-handed particle, and parity is maximally violated in the weak interaction.

Neutrino flavor oscillations observed in experiments with atmospheric (Super-Kamiokande), solar (chlorine [Nobel prize for Ray Davis, 2002] and SNO experiments) and reactor (KAMLAND) neutrinos have unambiguously proven that neutrinos are massive particles. However, the extreme smallness of their masses (with the upper bound more than five orders of magnitude smaller than the electron mass) still remains a puzzle. In any case, an extension of the Standard Model is needed to accommodate the non-vanishing neutrino mass.

While the standard model assumes neutrino to be a Dirac particle and therefore different from its antiparticle, Ettore Majorana proposed in 1937 a theory in which the neutrino can be its own antiparticle (Majorana neutrinos). For Majorana neutrinos an elegant see-saw mechanism exists which allows to explain why neutrino masses are so small.

The Workshop "Neutrinos in Particle, in Nuclear and in Astrophysics" was devoted to discussion of the following questions:

What are the masses of the three neutrinos?

Why are neutrino masses so small? What is the origin of the neutrino mass?

What can neutrinos tell us about the Grand Unification and Supersymmetry?

How can we determine if neutrino is a Dirac or a Majorana particle?

The neutrinoless double beta decay is the experimentum crucis to answer this question.

Can (or even has) the neutrinoless double beta decay been detected? What is the limit for the Majorana neutrino mass of the next generation of double beta decay experiments?

What are the best upper limits which one can obtain by measuring the electron neutrino mass directly from the tritium decay?

What is the role of neutrinos in evolution of the universe and in astrophysical processes such as supernova explosions?

Results and Highlights

The workshop brought together international experts in these fields who gave invited talks in the morning sessions and younger scientists who spoke in afternoon seminars. Ample time for discussions and questioning was provided. The current status of theories of neutrino masses and mass models beyond the Standard Model, neutrino flavor oscillations, theoretical and experimental aspects of the neutrinoless double beta decay, direct neutrino mass search experiments, neutrino mass from/for cosmology were reported.

Conclusions

Participants of the conference benefited from the synergy of experimental and theoretical considerations of problems of neutrino physics. Further experimental and theoretical developments are of utmost importance for better understanding of neutrinos.

Workshop program and presentations

The full workshop program with links to the presentations can be found at the website:
http://www.uni-tuebingen.de/ilias-dbd/Trento08/src/program.html

3.4 Doctoral Training Programme 2008: Nuclear matter under extreme conditions

Preface

The 2008 ECT* Doctoral Training Programme on "Nuclear matter under extreme conditions" lasted 12 weeks, from April 28 to July 18. The coordinators of the programme were Urs Wiedemann and Hans-Ake Gustafsson.

It was attended by 10 full time and 6 part time students. (The list of students is given below.) The students were lodged in the guest house in San Doná, an apartment which ECT* rents year round, and four students were in an apartment in Gardolo.

Four of the attending students were experimentalists, a high number compared to the previous Doctoral Training Programmes. Also several lecturers were experimentalists. This is due to the fact that the present Doctoral Training Programme concentrated on future experiments to be performed at the LHC and RHIC. Several lectures were devoted to simulations of future experiments.

The students were given each a desk to work on and those who did not use their personal laptop were given ECT* desk computers, running either on Unix or on Windows. They all had access to Internet as well as to an ECT* Wiki page, from which they could download the lecture notes delivered by the lecturers.

List of participants:

Akamatsu Yukinao	University of Tokyo, Japan
Auvinen Jussi	University of Jyvaskyla, Finland
Butterworth Joseph	Creighton University, US
Dadi Anis	Universitaet Rostock, Germany
Gombeaud Clement	CEA/Saclay, France
Hell Thomas	TUM, Germany
Kapitan Jan	Nuclear Physics Institute ASCR, Prague, Czech Republic
Mao Yaxian	Institute of Particle Physics, China
Millo Raffaele	Università degli studi di Trento, Italy
Mukherjee Tamal Kr	Bose Institute, India
Ortona Giacomo	Università di Torino, Italy
Plumari Salvatore	INFN Catania, Italy
Quiroga Paloma	Universidade de Santiago de Compostela, Spain
Shen Gang	Indiana University, US
Yamamoto Naoki	University of Tokio, Japan

3.4.1 Doctoral Training Programme Lectures

- Experimental and theoretical topics in the study of dense matter with the CBM experiment at FAIR
  (28 April - 2 May)
  Lecturer: Bengt Friman and Peter Senger (GSI Darmstadt)

- Testing the Color Glass Condensate at RHIC and at the LHC
  (5 - 9 May)
  Lecturer: Nestor Armesto Perez (Universidade de Santiago de Compostela)

- Lattice QCD at finite temperature
  (14 - 16 May)
  Lecturer: Edwin Laermann (Bielefeld University)

- The LHC heavy ion program of ALICE and CMS
  (19 - 23 May)
  Lecturer: Gunther Roland (MIT Boston) and Enrico Scomparin (INFN Torino)

- Heavy Quarks and Quarkonium at the LHC
  (28 - 30 May)
  Lecturer: Federico Antinori (INFN Padova and CERN Geneva)

- Electromagnetic Probes in heavy ion collisions - theory
  (3 - 6 June)
  Lecturer: Ralf Rapp (Cyclotron Institute, Texas A-M University Texas)

- Electromagnetic Probes in heavy ion collisions - experiment
  (17 - 20 June)
  Lecturer: Axel Drees (SUNY Stony Brook)

- String theory techniques in the study of hot plasmas
  (23 - 27 June)
  Lecturer: Jorge Casalderrey-Solana (LBL Berkeley)

- Finite temperature field theory
  (1 - 4 July)
  Lecturer: Anton Rebhan (Technical University Vienna)

- Hard Probes at RHIC and at the LHC
  (7 - 11 July)
  Lecturer: Carlos Salgado (Università di Roma, INFN Roma and Universidade de Santiago de Compostela)

- Soft Probes and hydrodynamics at RHIC and at the LHC
  (14 - 18 July)
  Lecturer: Ulrich Heinz (Ohio State University and CERN Geneva)

3.4.2 Seminars given at ECT* by the students

J. Kapitan: 1st of May, 2008, “Open charm measurement with HFT at STAR ”.

T. Mukherjee: 7th of May, 2008, “Model study of QCD thermodynamics ”.

P. Quiroga: 8th of May, 2008, “Studying high-energy QCD evolution via reaction-diffusion processes at zero transverse momentum”.

D. Kettler: 14th of May, 2008, “Correlation analysis at the STAR experiment at RHIC ”.

J. Butterworth: 21th of May, 2008, “Modeling ultra-peripheral collisions”.

C. Gombeaud: 4th of June, 2008, “Collective effects in heavy ion collisions”.

Y. Mao: 11th of June, 2008, “Hadron correlation measurement in ALICE at LHC ”.

G. Ortona: 18th of June, 2008, “Fast simulation tool for charm v2”.

R. Millo: 24th of June, 2008, “Strong CP violation in external magnetic fields”.

A. Dadi: 26th of June, 2008, “Equation of state for nuclear matter in a non-local field theory model”.

G. Shen: 3th of July, 2008, “Study of a hadronic theory at finite temperature and density”.

S. Plumari: 1st of July, 2008, “Application of the Polyakov-Nambu-Jona Lasinio model to elliptic flow”.

Y. Akamatsu: 8th of July, 2008, “Heavy quark phenomenology in relativistic heavy ion collisions”.

N. Yamamoto: 10th of July, 2008, “New critical point and continuity of hadrons in dense QCD”.

4 Research at ECT*

In this chapter the activities of the scientific researchers at ECT* in 2008, i.e. of the Postdoctoral Fellows, the Director, the Vice - Director and the Visitors, are briefly summarized. The different contributions are listed in alphabetical order of the researchers. It can be seen that on the one hand there existed strong collaborations within the researchers at the ECT*, but on the other hand several of the Postdocs collaborated also with colleagues outside ECT*. The main reason for the latter is of course the particular structure of ECT* with few senior scientists present. Vladimir Pascalutsa, hired in 2006 as a senior scientist, has been very essential, however, for creating a remarkable scientific life amongst the hadron physicists of the in-house group, and his leaving for a permanent position at the University of Mainz by the end of April 2008 presented a loss to the research group. As before, Andrea Nobile, who left ECT* at the end of October 2008, and Luigi Scorzato have held special INFN fellowships. Besides their scientific work mainly on lattice QCD they were responsible for the efficient running of the Teraflop cluster BEN at ECT* and also for preparing a scientific proposal of the so-called AURORA project for future Petascale computing for science and engineering. Finally, Daniele Binosi besides his scientific activity in QCD continued his efforts on coordinating a large European project on quantum information processing and communication for which ECT* has been and will also be in the future a special host.

4.1 Projects of ECT* Researchers

Andrea Beraudo

Study of the behavior of heavy quarks and quarkonia in a hot medium, like the Quark Gluon Plasma.

In collaboration with J–P. Blaizot (ECT), C. Ratti (Stony Brook),*
P. Faccioli and G. Garberoglio (Trento University)

- Static case:
  Description in terms of an effective potential accounting for screening and collisional damping.

- Dynamical case:
  Study of the single particle spectrum (thermal mass corrections and width) within a path-integral approach, with the HTL resummed gluon propagator playing the role of an effective non-local potential. Possible extension to the two-particle case.

Study of transport properties (energy loss, momentum diffusion) of heavy quarks and quarkonia.

In collaboration with A. De Pace, W.M. Alberico
and A. Molinari (Torino University and INFN)

Calculation of transport coefficients for heavy quarks in the GP and study of their Langevin dynamics.

Daniele Binosi

Non-perturbative Quantum Chromodynamics

During 2008 my research activity has focussed on exploring the properties of a new truncation scheme for the Schwinger-Dyson equations of QCD that has been developed recently. In February 2008 I have also signed the contract with Cambridge University Press for the publication of a monograph on the subject of the so-called Pinch Technique, written in collaboration with Prof. J. Cornwall (Emeritus Professor of Physics at UCLA, USA) and Dr J. Papavassiliou (University of Valencia). The expected delivery date is March 2010.
The main results reached this year include:

- **Infrared finite effective charge of QCD**

  In collaboration with A. C. Aguilar
  and J. Papavassiliou (University of Valencia)
  `arXiv:0810.2333 [hep-ph], PoS to appear.`

  In this paper we show that the gauge invariant treatment of the Schwinger-Dyson equations of QCD leads to an infrared finite gluon propagator, signaling the dynamical generation of an effective gluon mass, and a non-enhanced ghost propagator, in qualitative agreement with recent lattice data. The truncation scheme employed is based on the synergy between the pinch technique and the background field method. One of its most powerful features is that the transversality of the gluon self-energy is manifestly preserved, exactly as dictated by the BRST symmetry of the theory. We then explain, for the first time in the literature, how to construct non-perturbatively a renormalization group invariant quantity out of the conventional gluon propagator. This newly constructed quantity serves as the natural starting point for defining a non-perturbative effective charge for QCD, which constitutes, in all respects, the generalization in a non-Abelian context of the universal QED effective charge. This strong effective charge displays asymptotic freedom in the ultraviolet, while in the low-energy regime it freezes at a finite value, giving rise to an infrared fixed point for QCD. Some possible pitfalls related to the extraction of such an effective charge from infrared finite gluon propagators, such as those found on the lattice, are also briefly discussed.

- **New Schwinger-Dyson equations for non-Abelian gauge theories**

In collaboration with J. Papavassiliou (University of Valencia)
JHEP **11**, 063 (2008), `arXiv:0805.3994 [hep-ph]`

In this paper we show that the application of the pinch technique to the conventional Schwinger-Dyson equations for the gluon propagator, gluon-quark vertex, and three-gluon vertex, gives rise to new equations endowed with special properties. The new series coincides with the one obtained in the Feynman gauge of the background field method, thus capturing the extensive gauge cancellations implemented by the pinch technique at the level of individual Green's functions. Its building blocks are the fully dressed pinch technique Green's functions obeying Abelian all-order Ward identities instead of the Slavnov-Taylor identites satisfied by their conventional counterparts. As a result, and contrary to the standard case, the new series can be truncated gauge invariantly at any order in the dressed loop expansion. The construction is streamlined by resorting to the Batalin-Vilkovisky formalism which allows for a concise treatment of all the quantities appearing in the intermediate steps. The theoretical and phenomenological implications of this novel non-perturbative framework are discussed in detail.

- **Gluon and ghost propagators in the Landau gauge: Deriving lattice results from Schwinger-Dyson equations**

In collaboration with A. C. Aguilar and J. Papavassiliou (University of Valencia)
Phys. Rev. **D78**, 025010 (2008), `arXiv:0802.1870 [hep-ph]`

In this paper we show that the application of a novel gauge invariant truncation scheme to the Schwinger-Dyson equations of QCD leads, in the Landau gauge, to an infrared finite gluon propagator and a divergent ghost propagator, in qualitative agreement with recent lattice data.

- **JaxoDraw: A graphical user interface for drawing Feynman diagrams. Version 2.0 release notes**

In collaboration with J. Collins (Penn State University, USA),
C. Kaufhold and L. Theussl (Niels Bohr Institute, Copenhagen)
`arXiv:0811.4113 [hep-ph]`, submitted to *Comput. Phys. Commun.*

In this paper we describe the new version of the Feynman graph plotting tool JaxoDraw. Version `2.0` is a fundamental re-write of most of the `JaxoDraw` core and some functionalities, in particular importing graphs, are not backward-compatible with the `1.x` branch. The most prominent new features include: drawing of Bezier curves for all particle modes, on-the-fly update of edited objects, multiple undo/redo functionality, the addition of a plugin infrastructure, and a general improved memory performance. A new LaTeX style file is presented that has been written specifically on top of the original `axodraw.sty` to meet the needs of this this new version.

- **Pinch Technique: Theory and Applications**

In collaboration with J. Papavassiliou (University of Valencia)
prepared for Physics Reports

We review the theoretical foundations and the most important physical applications of the Pinch Technique (PT). This general method allows the generation of off-shell Green's functions in non-Abelian gauge theories that are independent of the gauge-fixing parameter and satisfy ghost-free Ward identities. We first present the diagrammatic formulation of the technique in QCD, deriving at one loop the gauge independent gluon self-energy, quark-quark-gluon vertex, and three-gluon vertex, together with their Abelian Ward identities. The generalization of the PT to theories with spontaneous symmetry breaking is carried out in detail, and the profound connection with the optical theorem and the dispersion relations are explained within the electroweak sector of the Standard Model. The equivalence between the PT and the Feynman gauge of the Background Field Method (BFM) is elaborated, and the crucial differences between the two methods are critically scrutinized. A variety of field theoretic techniques needed for the generalization of the PT to all orders are introduced, with particular emphasis on the Batalin-Vilkovisky quantization method and the general formalism of algebraic renormalization. The main conceptual and technical issues related to the extension of the technique beyond one loop are described, using the two-loop construction as a concrete example. Then the all-order generalization is thoroughly examined, making extensive use of the field theoretic machinery previously introduced; of central importance in this analysis is the demonstration that the PT-BFM correspondence persists to all orders in perturbation theory. The extension of the PT to the non-perturbative domain of the QCD Schwinger-Dyson equations is presented systematically, and the main advantages of the resulting self-consistent truncation scheme are discussed. A plethora of physical applications relying on the PT are finally reviewed, with special emphasis on the definition of gauge-independent off-shell form-factors, the construction of non-Abelian effective charges, the gauge-invariant treatment of resonant transition amplitudes and unstable particles, and finally the dynamical generation of an effective gluon mass.

Quantum Information Processing and Communication

(For a general introduction to the Quantum Information Processing and Communication group at ECT* see Section 5 p.101)

During the first six months of 2008 I have been on a leave of absence to work in the European Commission (Brussels) as a help to project officers in the Future and Emerging Technologies (FET) Unit F1(*FET Proactive*), in the Directorate F (*Information Society and Media*). However I have been continuing the activity related to the European project QUROPE. In particular the Trento node of this coordination action is involved in the following two work-packages:

- **WP2: Develop a common vision, strategy and goals**

  WP leaders: T. Calarco (Ulm) and P. Zoller (Innsbruck);
  WP members: D. Binosi (Trento)

  WP2 is designed to develop a common European vision, strategy and goals. It formally takes over the development and regular updates of the European QIPC Strategic Report from the ERA-Pilot QIST WP1 described earlier. Other reports and position papers are also within the scope of work. The goal is to provide input for the preparation of the upcoming 7th Framework Program, and of other strategy/policy documents which could help the EC to shape the research programme in the field of IST. The organization of working Expert groups in various sub-fields, their interaction and integration is also an important part of the work.

- **WP4: Electronic Information Infrastructure and Information Exchange**

  WP leaders: E. Polzik (Copenhagen) and D. Binosi (Trento);
  WP members: L. Theussl (Copenhagen)

  QUROPE WP4 is in charge of establishing and maintaining an Electronic Information Infrastructure to support the efficient service of all the coordination action objectives. The centerpiece is a comprehensive website constituting (*i*) the project portal through which all the relevant information are distributed, exchanged and disseminated, and (*ii*) the feedback channel that the QIPC community uses to provide direct input to the QUROPE members thus influencing on the fly the future actions taken by the coordination action.
  The QUROPE website `http://www.qurope.net` is hosted at the Niels Bohr Institute in Copenhagen with part of the database infrastructure hosted in the ECT* servers.

Finally, the past November the European Commission has open an FP7 call in Quantum Information Foundations and Technologies (Call 4: FP7-ICT-2009-4, Objective ICT-2009.8.2). I am currently actively involved in the writing of three projects (two coordination actions and one integrated project) to be submitted to this call.

Jean-Paul Blaizot

Large N(c) confinement and turbulence

In collaboration with M. Nowak (Jagellonian University)

We suggest that the transition that occurs at large N_c in the eigenvalue distribution of a Wilson loop may have a turbulent origin. We arrived at this conclusion by studying the complex-valued inviscid Burgers-Hopf equation that corresponds to the Makeenko-Migdal loop equation, and we demonstrate the appearance of a shock in the spectral flow of the Wilson loop eigenvalues. This picture supplements that of the Durhuus-Olesen transition with a particular realization of disorder. The critical behavior at the formation of the shock allows us to infer exponents that have been measured recently in lattice simulations by Narayanan and Neuberger in $d = 2$ and $d = 3$. Our analysis leads us to speculate that the universal behavior observed in these lattice simulations might be a generic feature of confinement, also in $d = 4$ Yang-Mills theory.

The classical field created in early stages of high energy nucleus-nucleus collisions

In collaboration with Yacine Mehtar-Tani (Heidelberg)

We show that a special choice of light-cone gauge can greatly simplify the calculation of the classical color field created in the initial stages of nucleus-nucleus collisions. Within this gauge, we can in particular construct explicitly the conserved color current and calculate exactly the gauge field immediately after the collision. This field is used as a boundary condition in an iterative solution of the Yang-Mills equations in the forward light-cone. In leading order, which corresponds to a linearization of the Yang-Mills equation in the forward light-cone, we obtain a simple formula for the spectrum of gluons produced in nucleus-nucleus collisions. This formula reproduces exactly the known formula for proton-nucleus collisions, where k_t-factorization is recovered, while the latter property apparently breaks down in the case of nucleus-nucleus collisions.

Tommaso Calarco

Quantum Information Processing and Communication

During 2008 my research activity has focussed on four main lines:

- the application of quantum optimal control methods to quantum information processing systems;

- the investigation of novel search-based quantum optimization algorithms;
- the study of ion chains, their phase transitions and their coherence properties.

The main results reached this year include:

Optimal control of atom transport for quantum gates in optical lattices

In collaboration with the group of W. D. Phillips at NIST
Phys. Rev. A **77**, 052333 (2008)

By means of optimal control techniques we model and optimize the manipulation of the external quantum state (center-of-mass motion) of atoms trapped in adjustable optical potentials. We consider in detail the cases of both noninteracting and interacting atoms moving between neighboring sites in a lattice of a double-well optical potentials. Such a lattice can perform interaction-mediated entanglement of atom pairs and can realize two-qubit quantum gates. The optimized control sequences for the optical potential allow transport faster and with significantly larger fidelity than is possible with processes based on adiabatic transport.

Quantum genetic optimization

In collaboration with A. Malossini and E. Blanzieri
IEEE Transactions on Evolutionary Computation **12**, 231 (2008)

The complexity of the selection procedure of a genetic algorithm that requires reordering, if we restrict the class of the possible fitness functions to varying fitness functions, is $O(N \log N)$, where N is the size of the population. The quantum genetic optimization algorithm (QGOA) we developed exploits the power of quantum computation in order to speed up genetic procedures. In QGOA, the classical fitness evaluation and selection procedures are replaced by a single quantum procedure. While the quantum and classical genetic algorithms use the same number of generations, the QGOA requires fewer operations to identify the high-fitness subpopulation at each generation. We show that the complexity of our QGOA is in terms of number of oracle calls in the selection procedure. Such theoretical results are confirmed by the simulations of the algorithm.

Ramsey interferometry with a spin embedded in a Coulomb chain

In collaboration with G. De Chiara, S. Fishman and G. Morigi
Phys. Rev. A **78**, 043414 (2008).

In this work we showed that the statistical properties of a Coulomb crystal can be measured by means of a standard interferometric procedure performed on the spin of one ion in the chain. The ion spin, constituted by two internal levels of the ion, couples to the crystal modes via spatial displacement induced by photon absorption. The loss of contrast in the interferometric signal allows one to measure the autocorrelation function of the crystal observables. Close to the critical point, where the chain undergoes a second-order phase transition to a zigzag structure, the signal gives the behavior of the correlation function at the critical point.

Vadim Lensky

Nucleon Compton Scattering in Covariant ChPT with $\Delta(1232)$

In collaboration with V. Pascalutsa (ECT and Universität Mainz)*

In our work [1], where we calculated the nucleon Compton scattering amplitudes within the covariant baryon ChPT up to $\mathcal{O}(p^3)$, we argued that the contribution of the $\Delta(1232)$ can be more naturally accommodated within the covariant formulation of ChPT than with the commonly used heavy baryon framework. In the subsequent work [2], which is currently being prepared for publication, we show that indeed the inclusion of the $\Delta(1232)$ in the covariant baryon ChPT gives reasonable values for the nucleon polarizabilities, and at the same time allows to describe the Compton scattering observables. In this connection, it is very interesting to see whether a similar improvement can be reached within the covariant baryon ChPT for other reactions in one–nucleon sector (or if the agreement can be at least as good as with the HBChPT). Such a study would allow to test the ChPT and to understand the reasons why the covariant baryon ChPT gives in some cases better description of the experimental data than HBChPT, and we are planning to perform it in the near future.

Pion Production in Nucleon–Nucleon Collisions

In collaboration with V. Baru, C. Hanhart, J. Haidenbauer,
U.-G. Meißner (Forschungszentrum Jülich), A. Kudryavtsev (ITEP)

We are now performing a calculation for the p-wave pion production in the reaction $NN \to NN\pi$ [3], which is aimed at a comparison of the experimental data on pion production in nucleon–nucleon collisions with theoretical results. Such a comparison could give us a lot of information about dynamics of pion production in $NN \to NN\pi$. This calculation will serve as a test of whether we are able to consistently describe the data in the three reaction channels $pp \to pn\pi^+$, $pp \to d\pi^+$, $pn \to pp\pi^-$ within the same framework, and it will shed a new light to the apparent inconsistency between the values of the three–nucleon force contact terms extracted from tritium beta decay and from the reaction $pp \to pn\pi^+$ [4]. This will also serve as a starting point for the calculation of the charge symmetry breaking observables, for these observables show up as an interference between the charge symmetric and charge symmetry breaking amplitudes [5]. A calculation of the charge symmetry breaking observables would be especially interesting given the fact that some of these observables have already been measured, for instance, the forward–backward asymmetry in the reaction $pn \to d\pi^0$ was found to be rather significant [6].

References

[1] V. Lensky, V. Pascalutsa, `arXiv:0803.4115`[nucl-th]

[2] V. Lensky, V. Pascalutsa, *in preparation*

[3] V. Baru, J. Haidenbauer, C. Hanhart, A. E. Kudryavtsev, V. Lensky, and U.-G. Meißner, *in preparation*

[4] S. X. Nakamura, Phys. Rev. C **77**, 054001 (2008)

[5] U. van Kolck, J. Niskanen, G. A. Miller, Phys. Lett. B **493**, 65-72 (2000)

[6] A. K. Opper et al., Phys. Rev. Lett. **91**, 212302 (2003)

Bingwei Long

Pion-nucleon scattering around $\Delta(1232)$

In collaboration with U. van Kolck (University of Arizona)

The focus of my work has been pion-nucleon scattering around the delta isobar resonances. Due to its perturbative nature, the standard power counting scheme of chiral perturbation theory (ChPT) is not adequate to describe the physics in the kinematic region around the delta. In addition to introducing the delta as explicit degrees of freedom, I apply a new power counting to pion-nucleon scattering so that the delta peak in this process can be studied in the manner of effective field theory. As a result, we establish a model-dependent, consistent-with-QCD calculation of low-energy pion-nucleon scattering, which improves over a simple model-dependent Breit-Wigner representation widely used in partial wave analyses. Confrontation with data can determine the pion-nucleon-delta couplings, which are important in many nuclear and hadronic reactions.

Javier López Albacete

Fits to proton F2 at small Bjorken-x using non-linear QCD evolution

In collaboration with N. Armesto, C. A. Salgado (Universidade de Santiago de Compostela) and J. G. Milhano (IST-Centra, Lisbon).

DESCRIPTION: In this work we are exploring the ability of the BK-JIMWLK non-linear QCD evolution including next-to-leading order effects in the form of running coupling corrections, [1, 2, 3] to account for the small Bjorken-x dependence of the structure functions, F_2, measured in Deeply Inelastic proton-electron collisions performed in HERA (DESY, Hamburg). The DIS cross-section is calculated in the framework of the dipole model, and a global fit with 3 to 4 free parameters (in order to characterize the initial condition for the evolution and to model the infrared dynamics) has been devised . The numerical method to solve the evolution equation was developed in [3] and successfully applied to describe the energy and rapidity dependence of the hadron multiplicities in heavy ion collisions in [4].

Energy-momentum tensor in heavy ion collisions in AdS/CFT

In collaboration with Y. V. Kovchegov and A. Taliotis (The Ohio State University)

DESCRIPTION: The goal of this work is to model heavy ion collision at strong coupling and to calculate the energy-momentum tensor (EMT) of the matter produced in such collisions. Due to the scarcity of analytical methods in QCD to tackle such problem, we resort to the Anti de Sitter / Conformal Field Theory correspondence [5, 6, 7], which allows to study non-perturbative problems in real time dynamics in a QCD-like theory as N=4 Super Yang-Mills. Under the correspondence, the EMT is dual to the metric in the five dimensional space, so its calculation amounts to solving Einstein equations with appropriate initial conditions. The modellization of a ultra-relativistic nuclei is done, along the lines of [8], via a shock wave metric. Then, Einstein equations are solved perturbatively in powers of the shock wave scale. Due to the intricacy of the problem, a combination of analytical and numerical methods is being used.

References

[1] Y. V. Kovchegov and H. Weigert, "Triumvirate of running couplings in small-x evolution," Nucl. Phys. A **784** (2007) 188 [arXiv:hep-ph/0609090].

[2] I. Balitsky, "Quark contribution to the small-x evolution of color dipole," Phys. Rev. D **75** (2007) 014001 [arXiv:hep-ph/0609105].

[3] J. L. Albacete and Y. V. Kovchegov, "Solving High Energy Evolution Equation Including Running Coupling Corrections," Phys. Rev. D **75** (2007) 125021 [arXiv:0704.0612 [hep-ph]].

[4] J. L. Albacete, "Particle multiplicities in Lead-Lead collisions at the LHC from non-linear evolution with running coupling," Phys. Rev. Lett. **99** (2007) 262301 [arXiv:0707.2545 [hep-ph]].

[5] J. M. Maldacena, *The large n limit of superconformal field theories and supergravity*, *Adv. Theor. Math. Phys.* **2** (1998) 231–252, `hep-th/9711200`.

[6] S. S. Gubser, I. R. Klebanov, and A. M. Polyakov, *Gauge theory correlators from non-critical string theory*, *Phys. Lett.* **B428** (1998) 105–114, `hep-th/9802109`.

[7] E. Witten, *Anti-de sitter space and holography*, *Adv. Theor. Math. Phys.* **2** (1998) 253–291, `hep-th/9802150`.

[8] J. L. Albacete, Y. V. Kovchegov and A. Taliotis, “Modeling Heavy Ion Collisions in AdS/CFT,” JHEP **0807** (2008) 100 [arXiv:0805.2927 [hep-th]].

Andrea Nobile

Optimization of LQCD kernels on the Cell BE architechture

In collaboration with H. Simma (University of Milano Bicocca)

We developed a method to analyze and model the performance of computational kernels and apply it to Lattice QCD. In the particular case of the Cell BE architechture we developed a schedules and allocation schemes for relevant LQCD application kernels which are optimal for the range of lattice sizes considered.

QPACE :QCD Parallel Computing on the Cell

In collaboration with U. Regensburg, U. Wuppertal, DESY Zeuthen,
U. Milano Bicocca, U. Ferrara, IBM

We are developing a massively parallel computer architechture optimized for Lattice QCD calculations based on the IBM PowerXCell8i processor and a custom 3D network interconnect.

BEN Cluster Administration

In collaboration with L. Scorzato (ECT)*

We ensured the continued functionality of the ECT* computational facility

References

[1] M. Creutz, *Quarks, Gluons, and Lattices*, Cambridge University Press, 1983.

[2] *Quantum Fields on the Computer*, Ed. M. Creutz, World Sc ientific, 1992.

[3] I. Montvay and G. Münster, *Quantum Fields on a Lattice* , Cambridge University Press, 1994.

[4] H. J. Rothe, *Quantum Gauge Theories: An Introduction*, Worl d Scientific, 1997.

[5] *Improved continuum limit lattice action for QCD with wilson fermions* B. Sheikholeslami and R. Wohlert, 259 (1985) 572.

[6] R. Wohlert, DESY 87/069; M. Lüscher and P. Weisz, 479 (1996) 429.

[7] K. Wilson, *Confinement of quarks* 10 (1974) 2445.

[8] K. G. Wilson, in *New Phenomena in Subnuclear Physics*, ed. A. Zichichi (Plenum Press, 1977).

[9] Y. Saad. *Iterative Methods for Sparse Linear System.* PWS Publishing Company, Boston, 1996.

[10] H. A. van der Vorst, *A fast and smoothly converging variant of Bi-CG for the solution of non-symmetric linear systems* SIAM J. Sci. Stat. Comput. 13 (1992) 631

[11] A. Frommer, V. Hannemann, B. Nöckel, T. Lippert, K. Schilling, *Accelerating Wilson Fermion Matrix Inversions by means of the Stabilized Biconjugate Gradient Algorithm* Int. J. Mod. Phys. C5 (1994) 1073

[12] H. A. van der Vorst, C. Vuik, *A family of nested GMRES methods* Num. Lin. Alg. Appl. 1 (1994) 369

[13] C. Vuik, *New insights in GMRES-like methods with variable preconditioners* J. Comput. Appl. Math. 61 (1995) 189

[14] S. Duane, A. D. Kennedy, B. J. Pendleton, D. Roweth, *Hybrid Monte Carlo* Phys. Lett. **B195** (1987) 216.

[15] T. A. DeGrand and P. Rossi, *Conditioning techniques for dynamical fermions* Comput. Phys. Commun. **60** (1990) 211.

[16] J. C. Sexton, D. H. Weingarten, *Hamiltonian evolution for the hybrid monte carlo algorithm* Nucl. Phys. **B380** (1992) 665.

[17] M. Hasenbusch, *Speeding up the Hybrid-Monte-Carlo algorithm for dynamical fermions* Phys. Lett. **B519** (2001) 177 [hep-lat/0107019].

[18] M. A. Clark, *The rational hybrid Monte Carlo algorithm*, PoS **LAT2006** (2006) 004

[19] G. Bilardi et al., *The Potential of On-Chip Multiprocessing for QCD Machines*, http://dx.doi.org/10.1007/11602569$_4$1 $SpringerLectureNotesinComputerScience$**3769**(2005)386

[20] H. Simma., *Analysis and modeling of the performance of LQCD kernels*, Talk at Lattice Practices 2006 https://indico.desy.de/materialDisplay.py?contribId=4&materialId=slides&confId=132

[21] N. Meyer, A. Nobile and H. Simma, *Performance Estimates on Cell*, internal reports and talk at Cell Cluster Meeting, Jülich 2007, http://www.fz-juelich.de/zam/datapool/cell/Lattice_QCD_on_Cell.pdf

[22] F. Belletti et al. (APE Collaboration), *Computing for LQCD: apeNEXT* Computing in Science and Engineering 8 (2006) 18 (IEEE Computer Society)

[23] A. Nobile, F. Belletti et al., *QCD on the Cell Broadband Engine*, PoS (LAT2007) 039

[24] A. Nobile, H. Baier et al. *QPACE: QCD parallel computing on the Cell Broadband Engine* Computing in Science and Engineering, in press.

[25] J. A. Kahle et al., *Introduction to the Cell multiprocessor* [http://researchweb.watson.ibm.com/journal/rd/494/kahle.html]

[26] T. W. Ainsworth, T.M. Pinkston *Characterizing the Cell EIB On-Chip Network* IEEE Micro (Vol. 27, No. 5) pp. 6-14

[27] J. Spray, J. Hill and A. Trew *Performance of a Lattice Quantum Chromodynamics Kernel on the Cell Processor* arXiv:0804.3654 [hep-lat]

[28] S. Motoki and A. Nakamura *QCD on the Cell Broadband Engine*, PoS(LATTICE 2007)040

[29] B. Bunk and R. Sommer, *An Eight Parameter Representation Of Su(3) Matrices And Its Application For Simulating Lattice Qcd.* Comput.Phys.Commun.**40**:229-232,1986.

[30] M. Lüscher, *Solution of the Dirac equation in lattice QCD using a domain decomposition method* Comput. Phys. Commun. **156** (2004) 209 [hep-lat/0310048].

[31] M. Lüscher, *Schwarz-preconditioned HMC algorithm for two-flavour lattice QCD*, Comput. Phys. Commun. **165** (2005) 199 [hep-lat/0409106].

[32] F. Bodin et al., *The apeNEXT Project* Nuclear Physics B (proceedings supplement), vol. 140, 2005, pp. 176-182

[33] R. Ammendola, M. Guagnelli, G. Mazza, F. Palombi, R. Petronzio, D. Rossetti, A. Salamon, and P. Vicini. Apenet: a high speed, low latency 3d interconnect network. In *CLUSTER '04: Proceedings of the 2004 IEEE International Conference on Cluster Computing*, page 481, Washington, DC, USA, 2004. IEEE Computer Society.

[34] **QCDOC** Collaboration, P. A. Boyle, C. Jung, and T. Wettig, *The QCDOC supercomputer: Hardware, software, and performance*, *ECONF* **C0303241** (2003) THIT003, [http://xxx.lanl.gov/abs/hep-lat/0306023`hep-lat/0306023`].

[35] A. Ukawa, (Proc. Suppl.) 106 (2002) 195-196

[36] M. Hasenbusch. *Speeding up the Hybrid-Monte-Carlo algorithm for dynamical fermions. Phys. Lett.*, B519:177–182, 2001 (hep-lat/0107019).

Vladimir Pascalutsa

Chiral perturbation theory of nucleon Compton scattering

In collaboration with Vadim Lensky (ECT, Italy)*

We have investigated the process of Compton scattering off the proton in the framework of chiral perturbation theory (ChPT) . This fundamental process was poorly understood in ChPT, in the sense that none of the calculations could, in any natural way, describe the experimental cross-sections both below and above the pion production threshold. The calculations based on nucleon and pion degrees of freedom alone [1], without explicit Delta(1232) resonance, failed above the pion-production threshold (≈ 140 MeV), while the calculations with the Delta degrees of freedom [2, 3] failed below the threshold due to a large contribution of the Delta to nucleon polarizabilities. In our investigations we have followed-up on the claim of Lvov [4] and others [5], saying that recoil corrections cancel out the effect of the Delta in polarizabilities. This led us to refrain from using the heavy-baryon (semi-relativistic) expansion that had normally been used in ChPT with baryons. We have thus performed all the one-loop calculations in a manifestly-covariant fashion. The results have to some extent confirmed the Lvovs claim. The heavy-baryon results were giving too large of a contribution, compared to the exact (non-expanded) result. We have therefore quantified the physics that prevented the inclusion of the Delta in a natural way and showed that the nucleon Compton scattering can consistently be described in ChPT with Deltas. A letter describing this work has recently been published in JETP Letters [6] and a more detailed paper is in preparation.

Magnetic moments of Δ and Ω^- in full lattice QCD

In collaboration with C. Aubin, K. Orginos (Jefferson Lab, USA) ,
and M. Vanderhaeghen (Mainz Uni, Germany)

We have calculated the magnetic dipole moment of the $\Delta(1232)$ and Ω^- baryons with 2+1-flavors of clover fermions on anisotropic lattices using a background magnetic field. This is the first dynamical calculation of these magnetic moments using a background field technique. The calculation for Ω^- is done at the physical strange quark mass, with the result in units of the physical nuclear magneton $\mu_{\Omega^-} = -1.93(8)(12)$ (where the first error is statistical and the second is systematic) compared to the experimental number: $-2.02(5)$. The Δ has been studied at three unphysical quark masses, corresponding to pion mass $m_\pi = 366, 438$, and 548 MeV. The pion mass dependence is compared with the behavior obtained from chiral effective field theory [7]. More details can be found in Refs. [9, 10].

The form factors and transverse densities of the Δ baryon

In collaboration with
C. Alexandrou, T. Korzec, G. Koutsou, Th. Leontiou (Nicosia, Cyprus),
C. Lorcé, M. Vanderhaeghen (Mainz Uni, Germany)
J. W. Negele (MIT, USA), A. Tsapalis (Athens, Greece)

We are developing the techniques to calculate the four Δ electromagnetic form factors using lattice QCD, with particular emphasis on the sub-dominant electric quadrupole form factor that probes deformation of the Δ. Results are presented for pion masses down to approximately 350 MeV for three cases: quenched QCD, two flavors of dynamical Wilson quarks, and three flavors of quarks described by a mixed action combining domain wall valence quarks and dynamical staggered sea quarks. The magnetic moment of the Δ is compared with chiral effective field theory calculations and the Δ charge density distributions are briefly discussed in Ref. [11]. A more detailed manuscript is in preparation.

References

[1] J. A. McGovern, Phys. Rev. C **63**, 064608 (2001) [Erratum-ibid. C **66**, 039902 (2002)]; S. R. Beane, M. Malheiro, J. A. McGovern, D. R. Phillips and U. van Kolck, Phys. Lett. B **567**, 200 (2003) [Erratum-ibid. B **607**, 320 (2005)]; Nucl. Phys. A **747**, 311 (2005).

[2] V. Pascalutsa and D. R. Phillips, Phys. Rev. C **67**, 055202 (2003).

[3] R. P. Hildebrandt, H. W. Griesshammer, T. R. Hemmert and B. Pasquini, Eur. Phys. J. A **20**, 293 (2004).

[4] A. I. L'vov, Phys. Lett. B **304**, 29 (1993).

[5] B. R. Holstein, V. Pascalutsa and M. Vanderhaeghen, Phys. Rev. D **72**, 094014 (2005).

[6] V. Lensky and V. Pascalutsa, JETP Lett. (in press), arXiv:0803.4115 [nucl-th].

[7] V. Pascalutsa and M. Vanderhaeghen, Phys. Rev. Lett. **94**, 102003 (2005); Phys. Rev. D **77**, 014027 (2008).

[8] M. Kotulla *et al.*, Phys. Rev. Lett. **89**, 272001 (2002).

[9] C. Aubin, K. Orginos, V. Pascalutsa and M. Vanderhaeghen, arXiv:0809.1629 [hep-lat], to appear in Proceedings of Science (Lattice 2008).

[10] C. Aubin, K. Orginos, V. Pascalutsa and M. Vanderhaeghen, "Magnetic Moments of Δ and Ω^- Baryons with Dynamical Clover Fermions," arXiv:0811.2440 [hep-lat], submitted to Phys. Rev. D.

[11] C. Alexandrou *et al.*, Phys. Rev. D (in press), arXiv:0810.3976 [hep-lat].

Achim Richter

Since my arrival at ECT in November 01, 2008, I have continued working closely with my research group and colleagues at the Technical University of Darmstadt and elsewhere on both, problems in nuclear structure and nuclear astrophysics and in quantum chaos.*

Nuclear Structure Physics

In nuclear structure physics we have pursued the method of wavelet transforms in the analysis of the fine structure of the isoscalar giant quadrupole resonance (ISGQR) which is common to most nuclei. The deduced scales from the experimental data were compared to predictions from various model calculations within the random-phase approximation (RPA) including two-particle two-hole excitations, the quasi-particle phonon model (QPM) and the extended theory of finite Fermi systems (ETTFS). While the calculations agree with qualitative features of these scales, considerable differences are found between the model results and in the comparison to experiments. It is clear, however, that the characteristic scales of the fine structure mainly arise from the coupling of the ISGQR to low-lying collective surface vibrations. An article on this work is in press in PRC. Furthermore, wavelet analysis methods have also been applied to the fine structure of magnetic dipole strength distributions in medium-heavy nuclei within a shell-model approach. In particular the influence of the number of Lanczos iterations on the development and stability of scales and the role of the model space in terms of the truncation level, the differences in scales of the spin and orbital parts, the use of different effective interactions and the effect of pairing and of the quadrupole part of the interaction has been examined. The results of these investigations have been prepared for publication in PRC. Finally, the excitation and strength of the pygmy dipole resonance (PDR) in stable tin isotypes has been studied both experimentally and also within the quasiparticle-phonon model. The experimental PDR centroid excitation energies and summed strengths are in reasonable agreement with QPM calculations based on a nonrelativistic description of the mean field but disagree with predictions from a relativistic quasiparticle RPA. The results are submitted for publication in PLB.

Nuclear Astrophysics

In nuclear astrophysics, high-resolution inelastic electron scattering at the superconducting Darmstadt electron linear accelerator (S-DALINAC) off the Hoyle state in 12C has been measured recently and its pair decay width determined. Discrepancies between previous results were resolved. A precise knowledge of this width is mandatory for quantitative studies of some key issues in the modeling of supernovae and of asymptotic giant branch stars as a source of the slow-neutron nucleosynthesis process. Furthermore, none of the existing nuclear structure models also not the ones with newly developed interactions like UCOM is able to describe the experimental data. The results will be submitted for publication in PRL.

Quantum Chaos

In quantum chaos the main scientific activity has been a thorough understanding of experiments on chaotic scattering in microwave billiards in the regime of overlapping resonances. Particular emphasis has been put on modeling the experimental observables S-matrix elements and their phases as well as two-point correlation functions in terms of random matrix theory (RMT). We have tested this approach for both time-reversal (T) invariant (GOE) and (GUE) systems. For the latter we were able to determine the degree of T-violation and other parameters of the theory by fitting scattering data with high precision. A goodness-of-fit test and the successful prediction of elastic enhancement factors confirm the RMT approach. The results are accepted for publication in PRL.

Michael Schwamb

The spin asymmetry on the deuteron

My major research activities deal with the construction of a *unified* approach for the various possible reactions on few-nucleon systems up to the first resonance region. In consequence, not only nucleons, but also mesons and the Δ-resonance have to be taken into account in a consistent, nonperturbative manner.

In the two-nucleon sector, this aim has already been realized in previous studies for not less than seven reactions, namely elastic nucleon-nucleon scattering, pionic disintegration of the deuteron, pion production in nucleon-nucleon collisions, deuteron photo- and electrodisintegration as well as coherent and incoherent pion photoproduction on the deuteron [1, 2].

Recently, for pion photoproduction on the deuteron, precise experimental data became available not only for the unpolarized cross section, but furthermore also for the spin asymmetry $\sigma_P - \sigma_A$ [3, 4]. The latter enters into the Gerasimov-Drell-Hearn sum rule which links the anomalous magnetic moment of a particle to its complete excitation spectrum. Its experimental and theoretical check for various targets constitutes an important test of our present understanding of nuclear dynamics.

In this project performed in 2008, I supplied theoretical support for the interpretation of new precise experimental data of $\sigma_P - \sigma_A$ at MAMI [5, 6]. It turns out that the description of the data still needs to be improved, motivating strongly further research in this field.

Study of inclusive reactions on the three-nucleon system with the LIT approach

In collaboration with W. Leidemann and G. Orlandini (University of Trento and INFN, Trento)

The unified approach mentioned above is presently extended from the two- to the three-nucleon sector. In a first step, inclusive hadronic and electromagnetic reactions are studied up to the Δ-region. Since, due to pion-production, the number of particles is not fixed beyond pion-threshold, these studies go conceptually far beyond standard Faddeev approaches. The explicit calculations are performed within the Lorentz integral transform approach [7], which requires only bound state techniques for the calculation of observables in scattering processes. Despite this conceptual simplification, this ambitious project is far from being trivial from a numerical point of view. Therefore, the major time of research at ECT* in 2008 has been devoted to further progress in the numerical realization of this project.

Two-nucleon knockout off ^{16}O

In collaboration with C. Giusti and F.D. Pacati (University of Pavia and INFN, Pavia)

In collaboration with the Pavia group, electromagnetic two-nucleon knockout off ^{16}O has been studied. The most refined version of our theoretical approach considers important improvements, e.g. with respect to the role of center-of-mass effects in the electromagnetic current operator. It allows an at least qualitative description of experimental data for proton-proton knockout [8].

References

[1] M. Schwamb, to be published in Few-Body Systems, ECT* preprint number ECT*-07-26.

[2] M. Schwamb, submitted to Phys. Rep.

[3] J. Ahrens *et al.*, Phys. Rev. Lett. **97**, 202303 (2006).

[4] S. Hoblit *et al.*, arXiv:0808.2183 [hep-ex].

[5] M. Martinez, Dissertation, University of Mainz (2007).

[6] J. Ahrens *et al.*, submitted to Phys. Lett. B.

[7] V.D. Efros, W. Leidemann, G. Orlandini and N. Barnea, J. Phys. G: Nucl. Part. Phys. **34**, R459 (2007).

[8] C. Giusti, F.D. Pacati and M. Schwamb, arXiv:0801.2304 [nucl-th].

Luigi Scorzato

Aurora

In collaboration with INFN, IASMA, ATreP, Padova U., Eurotech, Intel

We are currently carrying out the preliminary studies of a project that aims at developing a new computational system optimized for scientific applications. The collaboration includes experts of various fields, from hardware development to optimization of scientific application software.

Instantons Liquid Model and Stochastic PT

In collaboration with P.Faccioli, R.Millo (Trento U.) and F.Di Renzo (Parma U.)

By means of Stochastic Perturbation Theory we are computing the quantum corrections around a background of diluted Instantons and/or Instantons pairs. This would allow to promote the Instantons Liquid Model into a systematic expansion, where QCD corrections are computed in PT via NSPT.

Numerical Stochastic Perturbation Theory

In collaboration with F. Di Renzo and M. Brambilla (Parma U.)

I am computing renormalization factors and improvement coefficients in Lattice Perturbation Theory. These quantities are needed to improve the precision of phenomenological predictions that can be extracted from Non-perturbative QCD Lattice calculations.

Unquenched Lattice QCD

In collaboration with ETM Collaboration

I am doing Lattice QCD calculation of hadron masses and decay constants. We use the "twisted mass" regularization for the sea quarks and also the "overlap" regularization for the valence quarks. This choice is done in order to optimize symmetry properties and computational cost. Computations are done, in part, also on the ECT* BEN cluster.

Ben cluster with APE3D

In collaboration with A.Nobile (ECT), INFN-APE group in Roma 2 and Eurotech*

We have ported and tested on the BEN Cluster the software and firmware tools necessary to interface the APE3D cards with a general MPI program.

Marco Traini

Radiative partons from quark models

In collaboration with P. Faccioli (University of Trento)
and M. Cristoforetti (Technische Universität, München)

A radiative parton model starting from low-resolution scale has been presented [1, 2] and implemented up to Next-to-Leading-Order (NLO). The model has as low resolution scale the structure functions (twist-2 part) calculated within a relativistic quark model of the nucleon. It has been demonstrated that the approach can be implemented for unpolarizaed [1] and polarized [2] partons, including longitudinal and transverse partons, as well as off diagonal responses (Generalized parton Distributions (GPDs)) [3]. The recent calculations of Next-to-Next-Leading-Order (NNLO) of coefficient and splitting functions [4], challenges the approach to demonstrate the convergence of the procedure. The present research intends to accept such a challenge. We are implementing a new code for the calculation of unpolarized NNLO partons starting from the response of a light-cone quark model [5] and instanton model for nucleons [6]

Sum rule approach to the electric polarizability of neutral atoms, ions and clusters

In collaboration with R. Leonardi (University of Trento)

The electric polarizability of atoms and ions is calculated within a sum rule approach which can constrain the actual values of the polarizabilty in a self-consistent and stringent way. The approach has been applied to nuclei and nucleons [7], the atomic application is a severe test of the method [8].

References

[1] M. Traini, A. Mair, A. Zambarda and V. Vento, Nucl. Phys. **A614**, 472 (1997).

[2] P. Faccioli, M. Traini and V. Vento, Nucl.Phys.**A656**, (1999).

[3] S. Boffi, B. Pasquini and M. Traini, Nucl. Phys. **B649**, 243 (2003).

[4] S. Moch, J.A.M. Vermaseren, A. Vogt, Nucl. Phys. **B688**, 101 (2004).

[5] M. Traini, P. Faccioli and M. Cristoforetti, *in preparation.*

[6] M. Cristoforetti, P. Faccioli, M. Traini and J.W. Negele, Phys.Rev.D **75**, 034008 (2007).

[7] F. Cano and M. Traini, Phys. Rev. C **61**, 065202 (2001); E. Biasioli, M. Traini and R. Leonardi, Few Body Syst. **26**, (1999).

[8] M. Traini and R. Leonardi, *in preparation.*

4.2 Publications of ECT* Researchers

A. Beraudo, J.P. Blaizot and C. Ratti
Real and imaginary-time Q anti-Q correlators in a thermal medium
*Nucl. Phys. A***806***, 312 (2008)* [*arXiv:0712.4394 [nucl-th]*]

A. Beraudo, J.P. Blaizot and C. Ratti
Real and imaginary-time quarkonium correlators in a hot plasma
arXiv:0812.1130 [hep-ph]

D. Binosi, J. Collins, C. Kaufhold and L. Theussl
JaxoDraw: A graphical user interface for drawing Feynman diagrams. Version 2.0 release notes
submitted to Comput. Phys. Commun., e-Print: arXiv:0811.4113 [*[hep-ph]*]

A. C. Aguilar, D. Binosi and J. Papavassiliou
Infrared nite effective charge of QCD
to appear in PoS, e-Print: arXiv:0810.2333 [*[hep-ph]*]

D. Binosi and J. Papavassiliou
New Schwinger-Dyson equations for non-Abelian gauge theories
JHEP 11, 063 (2008), e-Print: arXiv:0805.3994 [*[hep-ph]*]

A. C. Aguilar, D. Binosi and J. Papavassiliou
Gluon and ghost propagators in the Landau gauge: Deriving lattice results from Schwinger- Dyson equations
Phys. Rev. D 78, 025010 (2008) e-Print: arXiv:0802.1870 [*[hep-ph]*]

D. Binosi and J. Papavassiliou
Pinch Technique: Theory and Applications
prepared for Physics Reports [*ECT*-08-07*]

T. Calarco, P. Grangier, A. Wallraff, P. Zoller and D. Binosi
Small steps that will lead to quantum leaps
eStrategies Projects, Issue 7 (October 2008) [*ECT*-08-08*]

Jean-Paul Blaizot, Yacine Mehtar-Tani
The Classical field created in early stages of high energy nucleus-nucleus collisions
Nucl.Phys.A818:97-119,2009 [*ECT* 08-06, arXiv: 0806.1422 [hep-ph]*]

Jean-Paul Blaizot and Maciej Nowak
Large N(c) confinement and turbulence
Phys.Rev.Lett.101:102001,2008 [*arXiv: 0801.1859 [hep-th]*]

Jean-Paul Blaizot
Non Perturbative Renormalization Group and Bose-Einstein Condensation
e-Print: arXiv:0801.0009 [cond-mat.stat-mech] [Lectures given at ECT School on Renormalization Group and Effective Field Theory Approaches to Many-Body Systems, Trento, Italy, 27 Feb - 10 Mar 2006]*

J.L. Albacete, Y. V. Kovchegov and A. Taliotis
DIS in AdS
e-Print arXiv:08011.0818[hep-th].

V. Lensky, V. Pascalutsa
Manifestly-covariant p^3 calculation of nucleon Compton scattering
Submitted to JETP Letters, e-Print: arXiv:0803:4115[nucl-th] [ECT-08-03]*

H. Baier[1], H. Boettiger[1], M. Drochner[2], N. Eicker[2,3], U. Fischer[1], Z. Fodor[3], G. Goldrian[1], S. Heybrock[4], D. Hierl[4], T. Huth[1], B. Krill[1], J. Lauritsen[1], T. Lippert[2,3], T. Maurer[4], J. McFadden[1], N. Meyer[4], A. Nobile[5,6], I. Ouda[7], M. Pivanti[4,6], D. Pleiter[8], A. Schäfer[4], H. Schick[1], F. Schifano[9], H. Simma[10,8], S. Solbrig[4], T. Streuer[4], K.-H. Sulanke[8], R. Tripiccione[9], T. Wettig[4], F. Winter[8]
Status of the QPACE Project
Ref. [Proceeding of the International Symposium on Lattice Field Theory, 2008]

H. Baier[1], H. Boettiger[1], M. Drochner[2], N. Eicker[2,3], U. Fischer[1], Z. Fodor[3], G. Goldrian[1], S. Heybrock[4], D. Hierl[4], T. Huth[1], B. Krill[1], J. Lauritsen[1], T. Lippert[2,3], T. Maurer[4], J. McFadden[1], N. Meyer[4], A. Nobile[5,6], I. Ouda[7], M. Pivanti[4,6], D. Pleiter[8], A. Schäfer[4], H. Schick[1], F. Schifano[9], H. Simma[10,8], S. Solbrig[4], T. Streuer[4], K.-H. Sulanke[8], R. Tripiccione[9], T. Wettig[4], F. Winter[8]
QPACE: Quantum Chromodynamics Parallel Computing on the Cell Broadband Engine
Ref. [Computing in Science and Engineering, Vol 10, no. 6 pp 46-54]

V. Pascalutsa
The Delta(1232) Resonance in Chiral Effective Field Theory
Prog. Part. Nucl. Phys. **61***, 27 (2008)*

V. Pascalutsa and M. Vanderhaeghen
Chiral effective-field theory in the Delta(1232) region: II. radiative pion photoproduction
Phys. Rev. D **77***, 014027 (2008)*

V. Lensky and V. Pascalutsa
Manifestly-covariant chiral PT calculation of nucleon Compton scattering
JETP Lett. (in press), arXiv:0803.4115 [nucl-th]

C. Aubin, K. Orginos, V. Pascalutsa and M. Vanderhaeghen
Magnetic Moments of Δ and Ω^- Baryons with Dynamical Clover Fermions
to appear in Phys. Rev. D, arXiv:0811.2440 [hep-lat].

C. Alexandrou, T. Korzec, G. Koutsou, Th. Leontiou, C. Lorcé, J. W. Negele, V. Pascalutsa, A. Tsapalis, and M. Vanderhaeghen
Delta-baryon electromagnetic form factors in lattice QCD
Phys. Rev. D (in press), arXiv:0810.3976 [hep-lat]

Ph. Boucaud, P. Dimopoulos, F. Farchioni, R. Frezzotti, V. Gimenez, G. Herdoiza, K. Jansen, V. Lubicz, Christopher Michael, G. Munster, D. Palao, G.C. Rossi, L. Scorzato, A. Shindler, S. Simula, T. Sudmann, C. Urbach, U. Wenger
Dynamical Twisted Mass Fermions with Light Quarks: Simulation and Analysis Details
Comput.Phys.Commun.179:695-715,2008. [*arXiv:0803.0224 [hep-lat]*]

A. Shevchenko, J. Carter, G.R.J. Cooper, R.W. Fearick, Y. Kalmykov, P. von Neumann-Cosel, V.Yu Ponomarev, A. Richter, I. Usman and J. Wambach
Analysis of fine structure in the nuclear continuum
Phys. Rev. C77, (2008) 024302

N. Ryezayeva, H. Arenhövel, O. Burda, A. Byelikov, M. Chernykh, J. Enders, H.W. Grießhammer, Y. Kalmykov, P. von Neumann-Cosel, B. Özel, I. Poltoratska, I. Pymenetska, C. Rangacharyulu, S. Rathi, A. Richter, G. Schrieder, A. Shevchenko and O. Yevetska
Measurement of the reaction $^2H\,(e,e')$ at 180^o close to breakup threshold
Phys. Rev. Letters 100, (2008) 172501

E.G. Altmann, T. Friedrich, A.E. Motter, H. Kantz and A. Richter
Prevalence of marginally unstable periodic orbits in chaotic billiards
Phys. Rev. E77, (2008) 016205

A.Richter
Supercars, doorway states and nodal domains in a barrier billiard
Workshop on Nuclei and Mesoscopic Physics (WNMP 2007)
Eds. P. Danielewicz et al. AIP Conference Proceedings 995, (2008) 202

A.Y. Abul-Magd, B. Dietz, T.Friedrich and A. Richter
Spectral fluctuations of billiards with mixed dynamics: from time series to superstatistics
Phys. Rev. E77, (2008) 046202

B. Dietz, B. Mößner, T. Papenbrock, U. Reif and A. Richter
Bouncing ball orbits and symmetry breaking effects in a three-dimensional chaotic billiard
Phys. Rev. E77, (2008) 046221

S. Åberg, T Guhr, M. Miski-Oglu and A. Richter
Supercars in billiards - a model for doorway states in quantum spectra
Phys. Rev. Letters 100, (2008) 204101

B. Dietz, T. Friedrich, M. Miski-Oglu, A. Richter, and F. Schäfer
Properties of nodal domains in a pseudointegrable barrier billiard
Phys. Rev. E78, (2008) 045201

B. Dietz, T. Friedrich, H.L. Harney, M. Miski-Oglu, A. Richter, F. Schäfer and H.A. Weidenmüller
Chaotic scattering in the regime of weakly overlapping resonances
Phys. Rev. E78, (2008) 055204

Y. Aksyutina, H.T. Johansson, P. Adrich, F. Aksouh, T. Aumann, K. Boretzky, M.J.G. Borge, A. Chatillon, L.V. Chulkov, D. Cortina-Gil, U. Datta Pramanik, H. Emling, C. Forssén, H.O.U. Fynbo, H. Geissel, M. Hellström, G. Ickert, K.L. Jonson, A. Kliemkiewicz, J.V. Kratz, R. Kulessa, M. Lantz, T. LeBleis, A.O. Lindahl, K. Mahata, M. Matos, M. Meister, G. Münzenberg, T. Nilsson, G. Nyman, R. Palit, M. Pantea, S. Paschalis, W. Prokopowicz, R. Reifarth, A. Richter, K. Riisager, G. Schrieder, H. Simon, K. Sümmerer, O. Tengblad, W. Walus, H. Weick, M.V. Zhukov
Lithium isotopes beyond the drip line
Phys. Letters B666, (2008) 430

4.3 Seminars and Presentations at International Conferences by ECT* researchers

- ### Andrea Beraudo

QQbar correlators in a hot medium
Talk given at the school “Hadronic collisions at the LHC and QCD at high density”.
March 2008, Les Houches, France

Real and Imaginary Time Correlators of a Q-Bar Pair in a Thermal Medium
Invited talk at the workshop “Understanding GP through Spectral Functions and Euclidean Correlators”.
April 2008, BEN, US

Real and imaginary-time quarkonium correlators in a hot plasma
Invited talk at the 8-th Conference “Quark Confinement and the Hadron Spectrum”.
September 2008, Mainz, Germany

- ### Jean-Paul Blaizot

The LHC and the physics of high density QCD
Quark-Matter 2008
February 2008, Jaipur, India

Large N(c) confinement and turbulence
New Frontiers in QCD: Fundamental problems in hot and/or dense matter
March 2008, Kyoto, Japan

Real and imaginary-time quarkonium correlators in a hot plasma
New Frontiers in QCD: Fundamental problems in hot and/or dense matter
March 2008, Kyoto, Japan

QCD Thermodynamics
Hadronic collisions at the LHC and QCD at high density
March 2008, Les Houches, France

Large N(c) confinement and turbulence

May 2008, Paris, France

Correlation functions at finite momentum within the exact Renormalization Group
Exact Renormalization Group 2008
July 2008, Heidelberg, Germany

Wilson Loops and Random Matrix Theory
Extra Strong Quark Gluon Plasma (ESQGP)
October 2008, Stony Brook, USA

- **Tommaso Calarco**

Fast and ultrafast quantum gates via optimal control of ultracold systems
Batsheva De Rothschild Seminar on Ultrafast-ultracold processes
February 2008, Ein Gedi (IL)

The consultation workshop on QIPC and other Quantum Technologies
QIPC Cluster Review Conference
March 2008, Paris (F)

Optimal control theory and quantum information systems
Applied Physics Colloquium
May 2008, Darmstadt (D)

Fast and ultrafast quantum gates via optimal control of atoms and photons
Quantum 2008: IV workshop ad memoriam of Carlo Novero
May 2008, Turin (I)

Optimal control theory and quantum information systems
APS Division of Atomic, Molecular and Optical Physics Conference 2008
May 2008, State College (USA)

Quanteninformationstechnologien fr die IKT
BMBF-Fachgesprch Quanteninformationstechnologien
June 2008, Bonn (D)

Optimal control theory and quantum information systems
Physics Colloquium, Freie Universität
June 2008, Berlin (D)

Ultracold atom-ion collisions
Institute for Theoretical Atomic, Molecular and Optical Physics Harvard
July 2008, Cambridge (USA)

Optimal control theory and quantum information systems
Workshop Quantum/Classical Control in Quantum Information 2008
September 2008, Otranto (I)

Quantum information foundations and technologies
Seminar Qubit pour le calcul: létat des lieux
October 2008, Grenoble (F)

Optimal control theory and quantum information systems
Italian Quantum Information Science Conference 2008
October 2008, Camerino (I)

- **Vadim Lensky**

Chiral EFT in One- and Two-Nucleon Sectors
Theoretical Nuclear Physics Group Seminar, University of Mainz
July 2008, Mainz, Germany

Covariant Baryon ChPT Calculation of Nucleon Compton Scattering
25th Students' Workshop on Electromagnetic Interactions, Bosen
September 2008, Bosen (Saar), Germany

Nucleon Compton Scattering in Chiral EFT
ECT* Workshop on Bound States and Resonances in Effective Field Theories
September 2008, Trento, Italy

- **Javier López Albacete**

DIS in AdS
DIS in AdS, invited seminar
December 2nd 2008, Department of Physics, University of Washington, Seattle (WA), USA

- **Andrea Nobile**

Lattice 2008: Status of the QPACE Project
Status of the QPACE Project
July 2008, Williamsburg, Virginia

- **Achim Richter**

Chaotic Scattering of Microwaves in Billiards: Introduced Time-Reversal Symmetry Breaking and Fluctuations in GOE and GUE Systems
Chaos and Collectivity in Many-Body Systems Conference
March 2008, MPIPKS Dresden, Germany

Playing Billiards with Microwaves - Quantum Manifestations of Classical Chaos
Nuclear Structure at the Extremes Conference
May 2008, University of the West of Scotland

Chaotic Scattering in Microwave Billiards
Random Matrix Theory and Applications: from Number Theory to Mesoscopic Physics Conference
June 2008, University Paris-Sud, Orsay, France

Overview on the Research Program in Quantum Chaos at the TU Darmstadt
CONACYT/DFG, Workshop for the Preparation of Joint Projects between German and Mexican Researchers
August 2008, Cuernavaca, Mexico

Collective Excitations and Superfluidity in Nuclei
CNS-EFES08 Summer School
August 2008, University of Tokyo, Japan

Fine-structure of Pygmy and Giant Resonances, Scales and Level Densities
CNS-EFES08 Summer School
August 2008, University of Tokyo, Japan

Nuclear Structure in Astrophysics
CNS-EFES08 Summer School
August 2008, University of Tokyo, Japan

Quantum Chaos in Billiards and Nuclei
CNS-EFES08 Summer School
August 2008, University of Tokyo, Japan

Giant Resonances, Wavelets, Scales and Level Densities - A Scientific and Personal Tribute to Björn Jonson
Journey towards and beyond the drip lines Conference
October 2008, Chalmers University Göteborg, Sweden

Nuclear Structure in Astrophysics – Recent Examples from the S – DALINAC
Physics Colloquium
November 2008, University of Bonn, Germany

- **Michael Schwamb**

Unified description of hadronic and electromagnetic reactions on the two-nucelon system beyond pion-threshold
Seminar
January 2008, Tübingen, Germany

Physics on the two-nucleon system: past achievements and future challenges
Seminar
February 2008, Pavia, Italy

Electromagnetic two-nucleon knockout: a tool to study NN-correlations?
1st international workshop on quasi-free scattering with radioactive ion beams
April 2008, ECT, Trento, Italy*

- **Luigi Scorzato**

The SAE-2 project
INFN - PAT meeting
7 February 2008, Trento, Italy

Status of the SAE project
Meeting of the scientific commission of the Provincia Autonoma di Trento
11 March 2008, Trento, Italy

Status of the Project
INFN - PAT Collaboration Meeting
11 April 2008, Padova, Italy

Lattice QCD: Analysis of computational requirements
Aurora Meeting
14-15 May 2008, Trento-Ferrara, Italy

Aurora Applications
Aurora workshop
30 July 2008, Amaro (UD), Italy

Computing Kernels of Scientific Applications
Aurora workshop
4 November 2008, München, Deutschland

- **Marco Traini**

Light Hadron Spectrum in the Instanton Liquid Model
Talk given at "Hadron 07", XII International Conference on Hadron Spectroscopy
October 2007, Frascati, Italy

Exploring the transition into the Chiral Regime of QCD using the Interacting Instanton Liquid Model
Talk given at XXV International Symposium on Lattice Field Theory, July 2007, Regensburg
July 2007, Regensburg, Germany

4.4 Lectures and Seminars at ECT*

4.4.1 Lectures

(also listed under the DTP 3.4.1, p.65)

- Experimental and theoretical topics in the study of dense matter with the CBM experiment at FAIR
  (28 April - 2 May)
  Lecturer: Bengt Friman and Peter Senger (GSI Darmstadt)

- Testing the Color Glass Condensate at RHIC and at the LHC
  (5 - 9 May)
  Lecturer: Nestor Armesto Perez (Universidade de Santiago de Compostela)

- Lattice QCD at finite temperature
  (14 - 16 May)
  Lecturer: Edwin Laermann (Bielefeld University)

- The LHC heavy ion program of ALICE and CMS
  (19 - 23 May)
  Lecturer: Gunther Roland (MIT Boston) and Enrico Scomparin (INFN Torino)

- Heavy Quarks and Quarkonium at the LHC
  (28 - 30 May)
  Lecturer: Federico Antinori (INFN Padova and CERN Geneva)

- Electromagnetic Probes in heavy ion collisions - theory
  (3 - 6 June)
  Lecturer: Ralf Rapp (Cyclotron Institute, Texas A-M University Texas)

- Electromagnetic Probes in heavy ion collisions - experiment
  (17 - 20 June)
  Lecturer: Axel Drees (SUNY Stony Brook)

- String theory techniques in the study of hot plasmas
  (23 - 27 June)
  Lecturer: Jorge Casalderrey-Solana (LBL Berkeley)

- Finite temperature field theory
  (1 - 4 July)
  Lecturer: Anton Rebhan (Technical University Vienna)

- Hard Probes at RHIC and at the LHC
  (7 - 11 July)
  Lecturer: Carlos Salgado (Università di Roma, INFN Roma and Universidade de Santiago de Compostela)

- Soft Probes and hydrodynamics at RHIC and at the LHC
  (14 - 18 July)
  Lecturer: Ulrich Heinz (Ohio State University and CERN Geneva)

4.4.2 Seminars

(also listed under the DTP 3.4.2, p.66)

09.01
Effective Field Theories of the Standard Model (Part 1)
Vladimir Pascalutsa (*ECT**)

16.01
Effective Field Theories of the Standard Model (Part 2)
Vladimir Pascalutsa (*ECT**)

21.01
Effective Field Theories of the Standard Model (Part 3)
Vladimir Pascalutsa (*ECT**)

23.01
Effective Field Theories of the Standard Model (Part 4)
Vladimir Pascalutsa (*ECT**)

28.01
Effective Field Theories of the Standard Model (Part 5)
Vladimir Pascalutsa (*ECT**)

25.01
Peculiar thermodynamics of supercooled liquids
Tomas Grigera (*Instituto de Investigaciones Fisicoqumicas Teoricas y Aplicadas, INIFTA*)

30.01
Effective Field Theories of the Standard Model (Part 6)
Vladimir Pascalutsa (*ECT**)

04.02
Effective Field Theories of the Standard Model (Part 7)
Vladimir Pascalutsa (*ECT**)

04.02
The AdS/QCD duality and the light glueball spectrum
Frederic Jugeau (*INFN, Bari*)

06.02
Effective Field Theories of the Standard Model (Part 8)
Vladimir Pascalutsa (*ECT**)

18.02
Effective Field Theories of the Standard Model (Part 9)
Vladimir Pascalutsa (*ECT**)

02.04
Spinning atoms with light: a new twist on coherent deBroglie-wave optics
William D. Phillips (*Department of Physics, University of Maryland*)

23.08
Large Nc confinement and turbulence
Maciej A. Nowak (*Jagiellonian University*)

06.10
Monte-Carlo simulations of QCD thermodynamics in the PNJL model
Marco Cristoforetti (*University of Trento*)

5 The Quantum Information Processing Group at ECT*

ECT*, owing to its institutional goals, is interested in research on computing technologies for the simulation of complex quantum many-body systems. On a normal (super)computer this requires exponential computational resources; this would not be the case, should the computer itself obey the laws of quantum mechanics. These basic considerations have started some 20 years ago the new research field of Quantum Information Processing (QIP). In this context the Future and Emerging Technologies Unit in DG Information Society and Media of the European Commission acted as a pathfinder and played a crucial role in the development and structuring of this strategic field in Europe by quickly recognizing its potential. In particular, QIP has been a FET Proactive Initiative (PI) in the Framework Programme FP5 (1999-2002) and FP6 (2003-2006).

Since the beginning, the ECT* has been a constant presence in QIP research consortia, through the activity of T. Calarco and later on of D. Binosi. In particular

- In 2000 ECT* has been coordinating the theoretical research of the FP5 Research and Technology Development Network ACQUIRE (Atom Chips for QUantum Information REsearch; start: 1/1/2000, end: 31/12/2002; funding: 75k), aiming at the implementation of an elementary quantum processor on an atom chip (based on an idea of T. Calarco, J.-I. Cirac and P. Zoller);

- ECT* has been a node of the FP5 European QIPC Network of Excellence QUIPROCONE (QUantum Information PROcessing and COmmunication Network of Excellence; start: 1/1/2000, end: 31/12/2003);

- ACQUIRE has continued under the name ACQP (Atom Chip Quantum Processor; start: 1/1/2003, end:31/12/2005) with ECT* as a consortium member (funding: 150k);

- In FP6, ECT* has been a partner of the FET Integrating Project SCALA (SCAlable quantum computing with Light and Atoms; start: 1/11/2005, end: 31/10/2009; funding: 135k).

Over the course of these projects, a fruitful collaboration has been established with the University of Trento and with the INFM BEC Centre, including the supervision of several Ph. D. and Laurea theses (including one in collaboration with the Computer Science Department in Povo, which yielded one of the 2008 publications), several joint papers on various aspects of QIP implementations using cold neutral atoms, and two one-day workshops, held at ECT* in December 2004 and December 2005. Along this line, T. Calarco has been appointed first as an INFM Researcher (since November 1st, 2004) and later as a Senior Researcher (since March 2005) - while office space for a few members of the QIP group has been provided at the BEC Centre in Povo. Computing resources are a key asset in this context, as they are used quite intensively for simulation of quantum processes relevant for QIP; hence, the purchase of two new state-of-the-art computing workstations has been realized whose cost has been equally shared among the ECT* general budget and the ACQP project.

Furthermore, T. Calarco has been appointed also as the responsible of the European QIP Roadmap, in the framework of ERA-Pilot QIST Project, in a joint effort be tween INFM and the Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences. Since then, T. Calarco collaborates with the ECT* researcher D. Binosi. In particular, they have written together the application for the Coordination Action QUROPE (Quantum Information Processing and Communication in Europe; start: 1/9/2006, end: 31/8/2009; funding 220k) in which ECT* leads the Work-Package 4, in charge of establishing and maintaining an Electronic Information Infrastructure to support the efficient service of all the coordination action objectives. ECT* is also deeply engaged in Work-Package 2 which is designed to develop a common European vision, strategy and goals, formally taking over the development and regular updates of the European QIPC Strategic Report from the ERA-Pilot QIST Work-Package 1 described earlier.

It is the early support and long-term vision offered by the ECT* that has allowed T. Calarco to build a career in QIP physics and get an offer for a full professorship from the University of Ulm that he took up in September 2007.

This did not weaken the strong link of T. Calarco with the ECT* in general and D. Binosi in particular. In fact, T. Calarco and D. Binosi, while planning a joint line of research in Density Matrix Renormalization Group techniques applied to QIP, have been involved in the preparation and/or directly participating to several high profile meeting held at the European Commission in Brussels, intended to shape the future of the QIP field in Europe. In addition, T. Calarco has contributed in the writing of the German roadmap for Quantum Communication, while D. Binosi has participated in the working group of the Italian roadmap for QIP lead by M. Inguscio and written the final document presented to the MIUR (Ministero Italiano dell'Universitá e della Ricerca).

As a result of all these activities (carried out under the QUROPE flagship) and the constant input gathered from the research community and conveyed by the QUROPE Work-Package 2 to the Commission in the preparation process of the Seventh Framework-Programme, QIP is a FET Proactive Initiative also in FP7, under the objective ICT 2009.8.2: Quantum Information Foundations and Technologies. The call for projects (FP7-ICT-2009-4) is funded for 15M, and has been opened in November 2008 with a deadline on the 1/4/2009.

T. Calarco and D. Binosi have jointly applied for two projects:

- The Integrating Project AQUTE (Atomic QUantum TEchnologies) involving a Consortium of 24 partners including two Nobel Prize winners (Theodor W. Hänsch and William Phillips), and of which T. Calarco is the coordinator (based in Ulm) and D. Binosi the Project Office leader;

- The Coordination Action QUIE^{2}T (QUantum Information Entanglement-Enabled Technologies) representing the successor of the currently running QUROPE. In QUIE^{2}T, T. Calarco is the leader of Work-Package 2 (Strategy, vision and sustainability), while D. Binosi, in addition to having laid the foundations of this new enterprise and contributing to Work-Package 2 and 3 (Dissemination activities), will act as QUIE^{2}T Executive Secretary. The funding requested for the ECT* node is 89k.

Finally they have been involved in the preparation of an ERA-NET initiative (CHIST-ERA) led by the French funding agency ANR, that has as one of its main deliverables a joint transnational call in the QIP field funded by the Austrian, German, Italian and Polish governments.

6 BEN, the ECT* teraflop cluster

This section provides a detailed technical status of the machine, as well as the list of the projects that have been running in 2008.

6.1 Report of the cluster management

6.1.1 Status of the computing nodes

The table shows the resources used by the jobs running under the queue system (i.e. excluding APE3D) in 2008 (from 1/1/2008 to 31/12/2008). It also compares the granted CPU time with the one actually used until now (in thousands of CPU hours). This should also be compared with the total ideally available CPU hours which amount to 1682k per year. Because of many reasons (optimal parallel jobs use 1CPU/node; uptime of the machine; queueing of larg jobs) a more realistic figure is about the half. In 2008 the machine was used mainly by the following projects: AFDMC[1], thermqcd[2], NLMCHPF[3], molcp[4], NSPT[5], lattham[6], Giorgini[7].

[1] F.Pederiva and S.Gandolfi. Study of ground state properties of light nuclei and neutron matter with the Auxiliary Field Diffusion Monte Carlo (AFDMC) method.

[2] F.Karsch and M.Kitazawa. First principle calculation for spectral properties of quarks in the quark-gluon plasma.

[3] P.Verocchio. Non-local Monte Carlo algorithm for highly polydisperse fluids

[4] V.Minicozzi et al. The role of metals on protein aggregation processes. Prion protein and beta-Amyloids

[5] C.Torrero et al. NSPT for 3d gauge theories.

[6] P.Faccioli, F.Pederiva, S.Gandolfi. Nuclear Physics in Lattice Hamiltonian Effective Field.

[7] S.Giorgini, S.Pilati. Disorder in Bose Gases

Group	No. jobs	days	Percent	Average No. nodes	kCPUh used
AFDMC	9714	3437.79	25.37	3.87	165.0
NLMCHPF	641786	3016.22	22.26	1.00	144.8
NSPT	20520	1960.82	14.47	3.87	94.1
lattham	4090	1743.38	12.87	3.80	83.7
giorgini	11806	1593.13	11.76	1.00	76.5
molcp	198	805.91	5.95	16.12	38.7
Ambrosetti	681740	503.91	3.72	1.16	24.2
garberog	930	314.91	2.32	2.48	15.1
TwoColQCD	83	153.56	1.13	9.36	7.2

Table 1: Granted CPU time refers to the whole year. All the other figures refer to the period 1/1/08 - 31/12/08. Total ideal available CPU time for one year is 1682k CPUh.

6.2 Technical status of the machine

6.2.1 Network connection with the external world

The network band available with the external world amounts presently at 4Mb/sec. Although this is still not optimal for the large amount of data that are expected to be exchanged in a cluster like BEN, it seems that this is currently sufficient.

6.2.2 Cooling system

We had four further high temperature pre-alarms on 2008. Precisely on 29/1, 9/5, 5/9, 7/11. The first two cases were true failures of the cooling system for the well known reasons explained in previous reports. The second two cases were false alarms, which are not completely understood, since they only happened in two occasions.

6.2.3 Storage hard disks

In 2008 we had a couple of failuers of Hard Disks of the main storage system and the corresponding disks have been replaced. Although the RAID 5 system, which is in use, should mask single failures to the user, we did have problem in the system and even a (small) data loss. The reason is not completely understood.

6.2.4 Queue system

This year the behaviours of the queue system was quite stable, except for occasional crashes of the scheduler program, which was readly restored without consequences. The reason for that is now understood and should not happen frequently anymore.

6.2.5 Front-end machine

The front-end machine experienced a few unexpected crashes. If this phenomenon should be more frequent we will have to consider the substitution of the front-end.

6.2.6 New users approved by the Borad in October 2008

The projects approved in 2008 involve mainly old users except for the projects of Giorgini, the one of Watanabe and the one of Gandolfi (that invloved new users). The users were assisted in the usage of the cluster.

6.2.7 New software

No new software was installed in 2008.

6.3 Overview of the projects running in 2008

the table above shows the resources used by the jobs running under the queue system (i.e. excluding APE3D). The machine was used mainly by 9 groups: AFDMC, thermqcd, NSPT, NLMCHPF, molcp, pH2wave, BECPCF, qnsu and lattham. The others are mainly test runs. I report below some informations about each of these groups.

6.3.1 Group: AFDMC

People: Francesco Pederiva, Stefano Gandolfi

Title: Study of ground state properties of light nuclei and neutron matter with the Auxiliary Field Diffusion Monte Carlo (AFDMC) method.

Abstract: we perform calculations of nuclear systems with the Auxiliary Field Diffusion Monte Carlo method. The aim of AFDMC technique is to solve the many-body Schrodinger equation for A nucleons interacting with realistic NN-potential (of the Argonne-type). In particular, we studied the equation of state of symmetric nuclear matter with the Argonne v_6' interaction (Phys.Rev.Lett. 98 (2007) 102503) and the properties of several nuclei. We also performed calculations to study properties of neutron rich isotopes of calcium (nucl-th/0605064 to be published in EPJA). At present we are working to include three-body and spin-orbit forces in the nuclear Hamiltonian, and we are studing properties of three-body forces in pure-neutron systems (neutron drops).

6.3.2 Group: NSPT

People: Y. Schroeder , F. Di Renzo, M. Laine, C. Torrero, V. Miccio

Title: NSPT for 3d gauge theories.

Abstract: three-dimensional (3d) gauge theories are interesting for several independent reasons. Theoretically, they are simpler than four-dimensional (4d) theories in that they are superrenormalisable, yet equally non-trivial in that they display confinement and other nonperturbative phenomena. Phenomenologically, they describe the thermodynamic properties of 4d physical theories, particularly QCD, at very high temperatures. Motivated by the latter aspect, namely the reliable determination of the pressure of hot QCD at very high temperatures, we wish to make use of the former aspect, namely the possibility to obtain non-perturbative results from lattice Monte Carlo simulations of 3d gauge theories, if the perturbative ultraviolet divergences are computed up to a sufficient loop order. More precisely, we wish to determine the renormalisation constants needed for certain effective gluon condensates, by using numerical stochastic perturbation theory (NSPT). Part I of the project has been completed, and it has demonstrated that BEN meets the demands of this project in an optimal way. In Part II we wish to determine the renormalisation constants for the remaining effective gluon condensates. With the help of BEN, we have published a proof-of-concept of our strategy. For precision results, we would need to run our codes for a larger set of parameters.

6.3.3 Group: NLMCHPF

People: Paolo Verrocchio.

Title: Non-local Monte Carlo algorithm for highly polydisperse fluids.

Abstract: we aim to study the freezing transition in a polydisperse model which is well suited to describe both colloids and glass-formers. The numeric simulation will be based on the local swap Monte Carlo algorithm, which turned out to reduce dramatically both the relaxation time and the freezing time. Focusing on the frozen phase, we shall investigate the structural differences between the solid with small polydispersity and the highly polydisperse one.

6.3.4 Group: molcp

People: V. Minicozzi, F.Stellato, G. La Penna, S. Morante, G.C. Rossi

Title: Study of aggregation processes in proteins: Prion Protein and beta-Amyloid peptides

Abstract: by using first principle ab initio Molecular Dynamics simulations of the Car-Parrinello type, the coordination modes of Cu and Zn to the binding sites of the prion and $\beta-$Amyloid proteins are investigated. Despite the large amount of available experimental data, many details of structural modifications involved in the aggregation process in the presence of metals are still unclear. *Ab initio* quantum mechanical simulations are a unique tool for a parameter-free investigation of such problems. Since large numbers of atoms with many electrons are involved, investigations of this type are well suited for a Linux Cluster architecture, owing to the existence of high-performance libraries and well adapted codes.

6.3.5 Group: lattham

People: P.Faccioli, S.Gandolfi, F.Pederiva.

Title: Nuclear Physics in Lattice Hamiltonian Effective Field Theory.

Abstract: the goal of this research line is to develop an ab-initio theoretical and computational framework to determine ground-state properties of nuclei and nuclear matter directly from the low-energy chiral Effective Field Theory (EFT) of QCD, using Montecarlo techniques. At present, calculations of nuclear binding energies based on the EFT framework are extremely challenging and therefore limited to very light nuclei. For example, lattice calculations of Borasoy and collaborators of the He-4 binding energy required a huge computational time on $\mathcal{O}(10^3)$ parallel CPUs.

6.3.6 Group: Giorgini

People: S.Giorgini, S.Pilati

Title: Disorder in Bose Gases

Abstract: we plan to investigate the effect of disorder on the superfluid transition temperature of dilute Bose gases. The method used is based on Path-Integral Monte-Carlo simulations in continuum space implementing the worm algorithm, which allows for an efficient calculation of the superfluid density and of the condensate fraction for very large systems. This technique has been recently applied by the proponents to the calculation of the critical temperature in homogeneous Bose systems in three and two dimensions [Phys. Rev. Lett. 100, 140405 (2008)].

6.4 Presentation of the AURORA project

Computer simulations have revolutionised both fundamental and applied scientific research in the last half century. High Performance Computing (HPC) is now an essential research tool for very many scientific fields and HPC related investments are consequently growing.

Aurora is an interdisciplinary research project (with a proposed duration of 3 years) to develop a high-performance computing system optimised for a limited number of highly relevant scientific computing applications. The architecture should be scalable up to Pflops performance, have a manageable electrical power consumption, and offer an excellent ratio between price and (sustained) performance. The target application fields for this system include theoretical particle and nuclear physics, molecualar dynamics, biology, genomics, and radiation therapy.

The overall computing efficiency of such applications is determined by a complex interplay between machine architecture, system software, and application algorithms. Therefore, the project goals cover not only the development of an adequate hardware and software architecture of the computer system itself, but also the implementation of optimised application codes, and algorithmic research to improve the efficiency of the scientific computations.

A key element for the possibility to realize a cost and power efficient computer system with huge floating-point performance is the availability of commercial multi- or many-core processors, like some latest processor lines of IBM and Intel. Moreover, the previous experience of some of the partners in the development of dedicated HPC system with fast and scalable communication network will be crucial to obtain an efficient parallel machine architecture.

On the other hand, the additional level of parallelism between the cores within multi-core processors, and their more complex memory hierarchy represent a novel challenge for the adequate choice of the application algorithms and for the optimised implementation of them. A goal of the current project is also to contribute improved solutions for this problem, which is an open research field in computer science.

The scientific program of this project is driven by research groups from various institutions and universities in or in the vicinity of the Trento region. Under the leadership of ECT*/FBK the collaboration include the Nuclear Theory group at the University of Trento, the Bioinformatics group at FEM, the medical physics group at ATreP, INFN groups at Ferrara, Parma and Milan and the Computer Science group at the University of Padova. These groups have an excellent and internationally recognized expertise in their respective scientific research fields. Moreover, some of the groups have collected during the last decades a unique knowhow from the successful development of several dedicated high-performance machines (in particular the APE projects).

The realisation of prototype machines within this project or subsequent large-scale production machines requires crucial know-how and services from industry. Informal contacts have been estabilished with a world-leading processor chip manufacturer (Intel) and a computer system manufacturer with significant experience in HPC systems (Eurotech), whose industrial plans are well suited to provide industrial support to tis project.

Apart from the technical and scientific results, the project is also expected to have a significant impact on the local scientific community by training junior researchers at the forefront of scientific and technological problems, and by providing the basis to create and exploit a leading HPC infrastructure.

The first informal meetings among the partners and the first feasibility study started in 2007. A project proposal was prepared and submitted as a joint collaboration of PAT, FBK and INFN. The project proposal was positively evaluated by the INFN scientific commission in March 2008, by the ECT*-FBK scientific commission in September 2008 and by the PAT scientific commission in January 2009. A first general agreement between PAT and INFN has been signed in October 2008. In the meantime (July 2009) the first phase of the project has been approved.

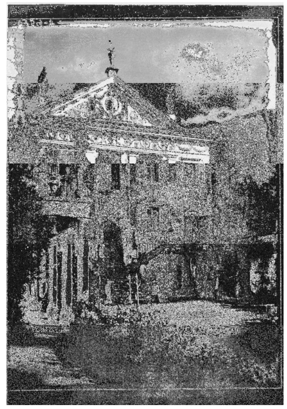
7 ECT* Computing Facilities

7.1 Available computing resources

2 license servers:	2 PC (Mathematica) [10 concurrent users] 1 PC (MATLAB) [2 concurrent users]
server:	6 Dell Intel Xeon 3GHz
computation servers:	1 Dell Intel Xeon 3GHz 1 AMD Opteron 2GHz
26 PC for staff and local research:	Pentium III up to 866 MHz Pentium IV up to 2.8 GHz BI-PROC. Pentium III up to 1 GHz BI-PROC. Pentium IV up to 1.6 GHz RACK
31 PC for users:	Pentium III up to 866 MHz Pentium IV up to 3 GHz BI-PROC. Pentium III up to 650 MHz Workstation Dell Optiplex GX280 Workstation Dell Optiplex GX620
1 Supercomputer EXADRON:	1 Front/End and 99 computers Communication Band width Gbit/second
1 cluster ALPS:	1 Front/End and 36 CPU Communication Band width Gbit/second
1 DELL:	Power Edge 1850 Bi-Processore Xeon 3 GHz

ECT* - A fifteen year perspective

24-25 September, 2008



Villa Tambosi, Villazzano (TN)

Wednesday, September 24 (OPEN SESSION)

14.00 Registration

14.30 Welcome
Chairman: W. Weise
14.35 A. Zanotti (President FBK): "The Bruno Kessler Foundation"

15.00 B. Mottelson (Nobel Prize Laureate and First Director of ECT*)

15.45 B. Fulton (Chairman of NuPECC): "ECT*'s role in the wider European Nuclear Physics Research Activity"

16.30 Coffee Break

Chairman: P. Hoyer
17.00 J.P. Blaizot (Director ECT*): "*ECT* - A fifteen year perspective*"

17.45 Open discussion with participants

18.45 S. Gales (Scientific Coordinator of NUPNET): "*NUPNET: Toward a Transnational Funding Plan for Nuclear Physics in Europe*"

19.30 DINNER in Villa Tambosi (after dinner a bus will bring participants downtown)

Thursday, September 25 (CLOSED SESSION 9.30 – 11.30)

A bus will bring participants of the closed session from Piazza Dante to ECT*

09.30 Chairman: B. Fulton

- Introduction: G. Salvatori (Minister of Research of the Province of Trento)
- ECT* within FP6 and FP7 (Alex Muller, Carlo Guaraldo and Muhsin Harakeh)
- The new MoU
- General discussion