EUROPEAN SCIENCE FOUNDATION
SETTING SCIENCE AGENDAS FOR EUROPE

Outline-Proposal for a Forward Look on

Nuclear Physics

Presented by
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Executive Summary

The goal of the Nuclear Physics Forward Look LRP2010 is to bring together the entire Nuclear Physics community in Europe to formulate a coherent plan how best to develop the field in the next decade and beyond.

Objectives

- Review the status of the field in Europe and put it into the worldwide context
- Formulate recommendations for developing the science and its applications
- Agree upon an action plan and suggest a roadmap for the upgrade of existing, or the construction of new, large-scale facilities
- Synchronise above with EU FP7 ERAnet “NuPNET”

Work-plan

- 1st quarter of 1st year: Set up governance structure and working groups, and formulate guidelines for writing Forward Look LRP2010 ✔
- 4th month: Scoping Workshop involving the top-level NP scientists and engineers in Europe
- 2nd and 3rd quarter of 1st year: LRP2010 Steering Committee (SC) and Working Groups (WGs) write LRP2010 draft
- 9th month: NuPECC evaluates 1st draft
- 4th quarter of 1st year: SC and WGs revise 1st draft
- 12th month: Town meeting involving entire NP community in Europe
- 1st quarter of 2nd year: SC and WGs revise 2nd draft
- 16th month: NuPECC evaluates 3rd draft
- 2nd quarter of 2nd year: SC and WGs finalise LRP2010
- 18th month: NuPECC publishes LRP2010

Introduction and Background

Nuclear Physics (NP) is a vibrant area of science in Europe. More than 5000 scientists and engineers perform cutting-edge research at various large-scale (see Figs. 1 and 2 below) and smaller national facilities, and at numerous universities.

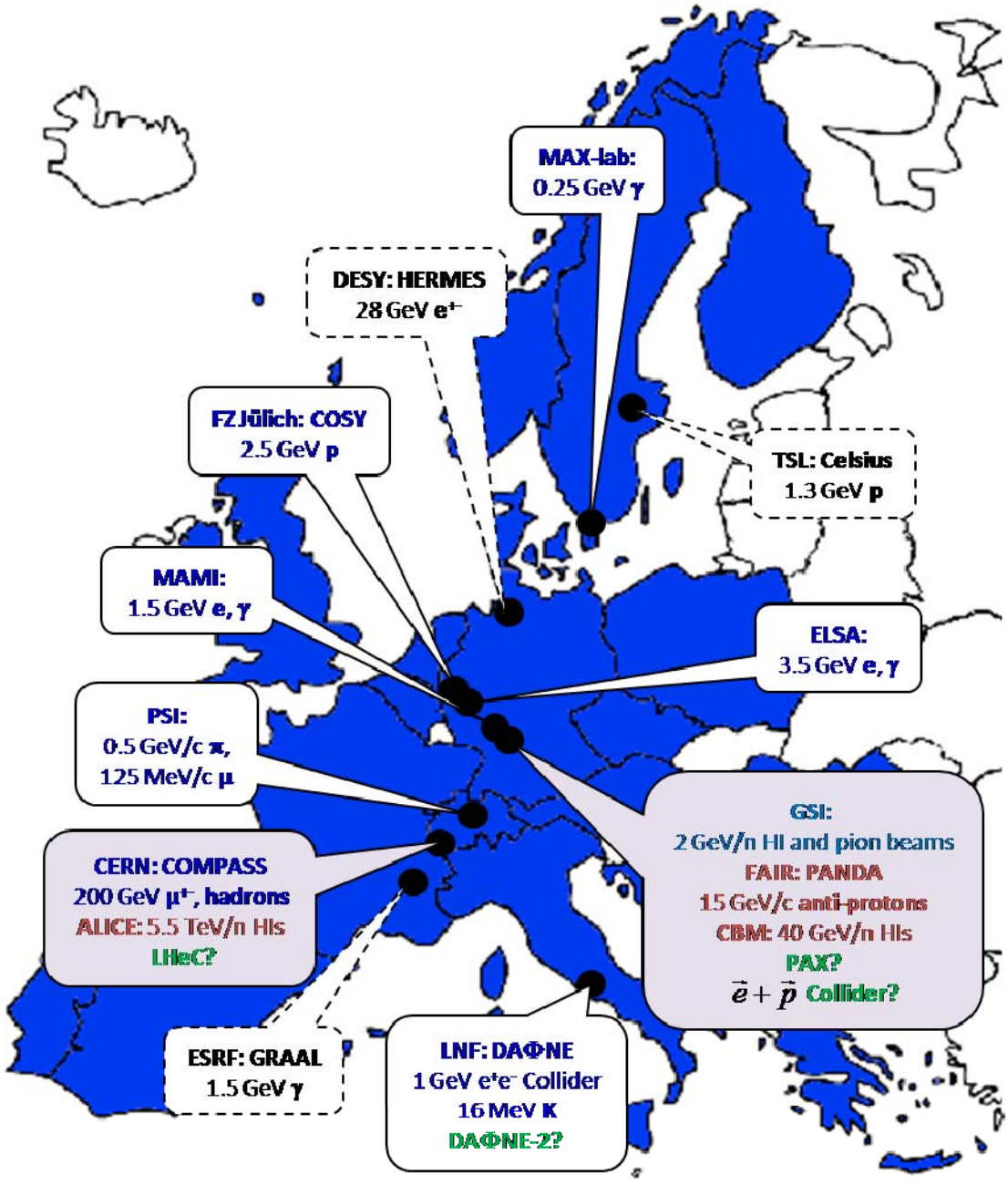

Figure 1: Nuclear Physics large-scale research infrastructures (RIs) in NuPECC member countries: Strong QCD physics with lepton, hadron & heavy ion beams. Black: data taking finished, analysing data; blue: taking data; red: near future facilities; green: longer term projects.

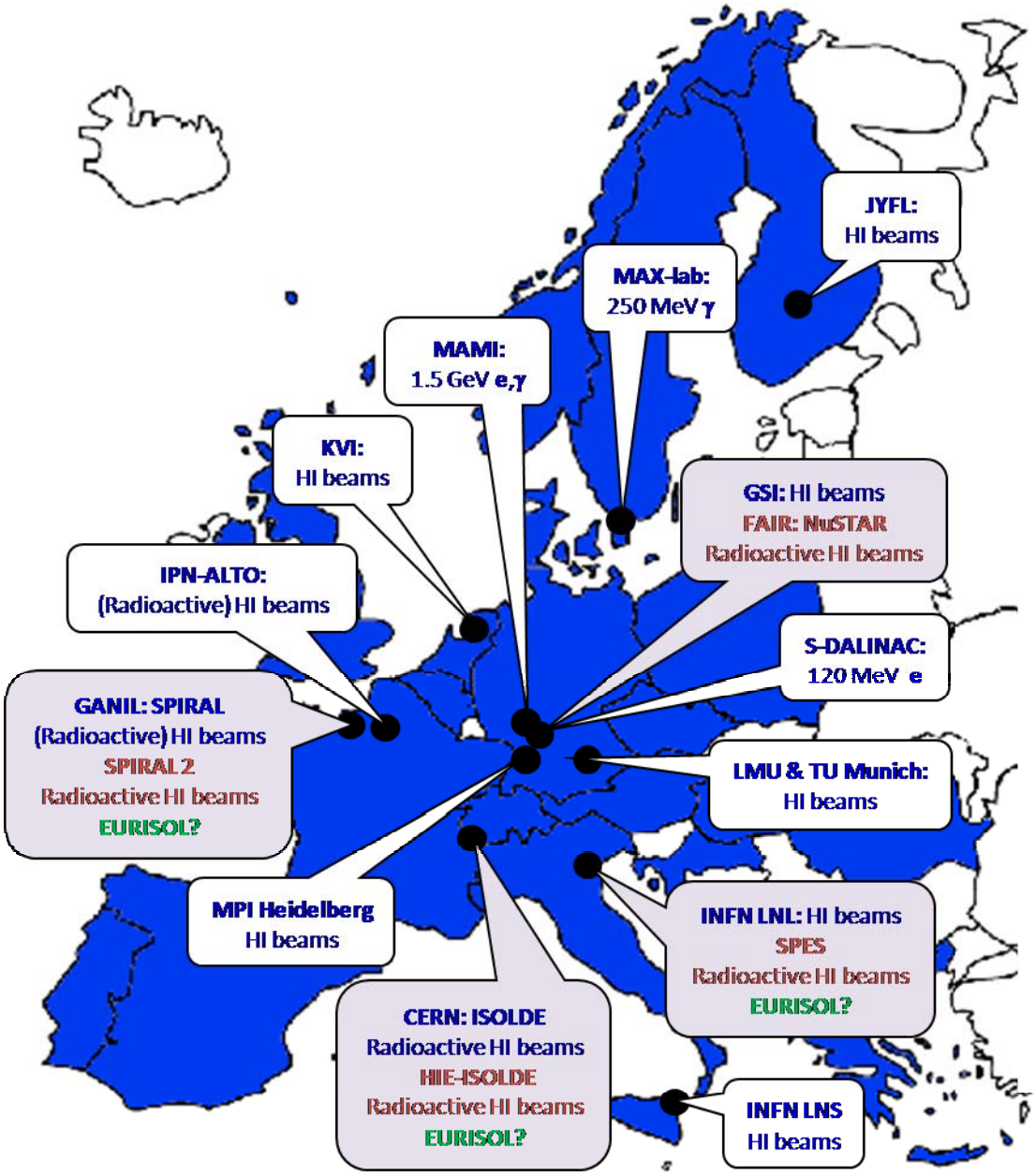

Figure 2: Nuclear Physics large-scale research infrastructures (RIs) in NuPECC member countries: Nuclear Structure Physics with lepton & heavy ion beams. Blue: taking data; red: near future facilities; green: longer term projects

Owing to the complexity of the European landscape, dozens of funding agencies are involved. Some coordination on the European level is needed. This is the task of the Nuclear Physics European Collaboration Committee (NuPECC), which is an expert committee of the European Science Foundation (ESF).

One of the most important NuPECC activities has been the periodic review and development of the field by producing long range plans (LRP). The last long range plan was pub-

lished in 2004. It formed the basis of the NuPECC Large-Scale Facilities Roadmap submitted to the European Strategy Forum on Research Infrastructures (ESFRI) in 2005. In 2006, ESFRI adopted the NuPECC priorities and identified FAIR and SPIRAL2 as the two top Nuclear Physics projects in Europe, together with three other projects from Astronomy, Astrophysics and Particle Physics. ESFRI reinforced this decision in their European Roadmap on Research Infrastructures Update in Dec. 2008.

Considering the fast progress in the field and the long lead times for constructing NP facilities, we now need to develop a new long-range plan LRP2010 for Nuclear Physics in Europe, which will cover the next ten to fifteen years. This will be done via a bottom-up process involving the entire nuclear physics community in Europe.

At their spring meeting 2009, NuPECC identified six main scientific topics (Themes) to be developed in LRP2010:

- Hadron Structure and Spectroscopy
- Phases of Strongly Interacting Matter
- Nuclear Structure and Dynamics
- Nuclear Astrophysics
- Fundamental Interactions
- Nuclear Physics Tools and Applications

Existing studies and activities

- NuPECC
    - 2006/7 Survey of Resources in Nuclear Physics Research in NuPECC Member States, published 2008
    - High Intensity Stable Ion Beams in Europe, report 2007
    - Roadmap of Construction of Nuclear Physics Research Infrastructures in Europe, 2005
    - Handbook of International Access to Nuclear Physics Facilities in Europe, 2004
    - *NuPECC Long Range Plan 2004*
    - Impact, Application, Interactions of Nuclear Science, report 2003
    - Radioactive Ion Beams, report 2002
    - Report of the NuPECC Working Group on Computational Nuclear Physics, 2002
    - ELFE Physics Motivations, report 2001
    - Report of the NuPECC Working Group on Radioactive Beam Facilities, 2000
    - Handbook of International Access to Nuclear Physics Facilities in Europe, 1998

    - *Nuclear Physics in Europe: Highlights and Opportunities, report 1997*
    - Survey of Nuclear Physics Activities and Resources in NuPECC Member States, 1997
    - Impact and Applications of Nuclear Science in Europe: Opportunities & Perspectives, report 1994
    - European Radioactive Beam Facilities, report 1993
    - *Nuclear Physics in Europe: Opportunities & Perspectives, report published 1991*
- European Commission: Survey of Nuclear Physics Resources in participating EU FP6 ERAnet "NuPNET" countries, submitted to the Commission in summer 2009
- US DoE and NSF NSAC Long Range Plan for Nuclear Physics in the USA, 2007
- International Union of Pure and Applied Physics, IUPAP: Report 41 "Research Facilities in Nuclear Physics" of the Working Group WG.9 on "International Cooperation in Nuclear Physics", ICNP, 2006
- OECD: Global Science Forum, Report of the Working Group on Nuclear Physics, 2008

Analysis of the European landscape

Strengths:

- The European Nuclear Physics community is strong. Since more than a hundred years, it has been contributing very significantly to progress in the field.
- Many smaller groups from different countries have formed strong international collaborations.
- The collaboration between national labs and universities is excellent.
- Experimentalists and theoreticians work hand in hand.

Weaknesses:

- The European funding landscape is rather fragmented. Unlike in the USA for example, nuclear research is supported by dozens of ministries/funding agencies in more than 20 countries and hence, sometimes, lacks coherence.
- There are very large differences in NP funding in various similarly sized European countries.
- Some European research councils discriminate between Nuclear Physics and Nuclear Science (= Nuclear Engineering), which does not facilitate interaction between academia and industry.
- The boundary between Nuclear and Particle Physics differs across Europe, which can cause problems when establishing collaborations.

Opportunities:

- Scientific
    - Novel radioactive heavy ion beam facilities will increase the accessible area of the nuclear chart by roughly one order of magnitude, enabling us to investigate nuclei at their limits of stability, relevant to nuclear structure physics and astrophysics.
    - High energy, intense and precise antiproton beams will enable us to search for new forms of strongly interacting matter such as exotic mesons and glueballs.
    - High energy and high intensity heavy ion beams will create the conditions for breakthroughs in our understanding of nuclear matter at high density or temperature.
    - New electron-nucleon/ion colliders will help us understand the QCD vacuum and the quark-gluon structure of strongly interacting particles.
- Applied
    - NP has made and will be making very significant contributions to medicine regarding the development of diagnostic and therapeutic tools.
    - With a population rising to 10B in the next two decades, and developing countries aspiring to the living standard of industrialised nations, the world's energy consumption will rise dramatically and non-carbon sources of energy will be desperately needed. In this context, nuclear fission and fusion energy generation will likely become indispensable.
    - There are new homeland security issues that can only be tackled by applying nuclear physics methods.
    - Nuclear Physics tools are increasingly used in materials sciences and have a wide range of applications in industry, arts and humanities. The recently approved European Spallation Source will offer new opportunities for applying Nuclear Physics methods.

Threats:

- The main threat is the negative perception of Nuclear Physics by the public, which roots in the development and past employment of nuclear weapons, nuclear reactor accidents and the nuclear waste problem. This may affect the willingness of governments to fund the field.

Added value of a Forward Look in this area

Nuclear Physics is "big science" that needs the support of potent funding agencies rarely to be found in a single small country. The lead times for designing and building large-scale NP facilities are very long, of order one or even two decades. Hence, in order to promote Nuclear Science the coherent action of a number of countries is needed. ESF is poised to take the lead in securing the prosperity of Nuclear Physics in Europe with regard to both basic science and its applications.

Purpose of the Forward Look

Purpose

The goal of the Forward Look is to bring together the entire Nuclear Physics community in Europe to formulate a coherent plan how best to develop the field in the next decade and beyond. Specifically, we intend to

- Review recent achievements and the current state of the art
- Identify open problems and hot topics
- Develop medium and long-term strategies to tackle them
- Identify synergies with other fields and future applications
- Develop a European perspective and put it into a worldwide context
- Formulate recommendations and suggest an action plan
- Agree upon a roadmap for upgrading existing or building new large-scale NP facilities

Scientific scope

Further develop the case for

- Using antiproton annihilation as a tool for hadron structure studies and spectroscopy, and for the investigation of fundamental symmetries and interactions
- Using radioactive heavy ion beams for nuclear structure studies far off stability, applying
    - In-flight fragmentation and
    - Isotope Separator On-Line (ISOL) techniques
- Understanding the phase-diagram of strongly interacting matter and devising upgrade programmes for relativistic heavy ion beam facilities
- Building a new electron-nucleon/ion collider in Europe for nucleon structure studies and the investigation of the role of gluons in strongly interacting particles (hadrons)
- Building a high-intensity stable beam facility and an underground accelerator for nuclear structure and astrophysics studies
- The further development/improvement of high density ultra-cold neutron sources and underground facilities
- Developing the applied aspects of Nuclear Physics

Societal scope

Paying tribute to its cultural heritage ranging back many thousands of years, Europe should be at the forefront of promoting one of the most fascinating fields in basic science, Nuclear Physics, where the fundamental aspects of strongly interacting particles that constitute nearly 100% of the visible matter in the universe are studied.

With the renewed interest in nuclear technology worldwide (non-carbon energy: nuclear fission and fusion power generation, nuclear medicine: imaging and tumour therapy, homeland security, materials studies with nuclear probes), Europe needs to preserve and enhance its nuclear physics skills basis, i.e. educate young people, in order to, e.g.,

- Acquire new nuclear data for use in novel fission and future fusion reactors
- Develop new particle accelerators for use in cognate fields and cancer therapy
- Design new radiation sources and detector systems for homeland security
- Design new detectors and electronic readout systems for medical imaging
- Develop the nuclear physics tools (particle accelerators, detector systems, simulation codes) for increasingly precise materials studies
- Apply nuclear physics methods in the humanities (archaeology, art analysis, restoration and dating)

Objectives

- Review the status of the field in Europe and put it in a worldwide context
- Formulate recommendations for developing the science and its applications in the next decade and beyond
- Agree upon an action plan and suggest a roadmap for the upgrade of existing or the construction of new large-scale facilities
- Synchronise above with EU FP7 ERAnet “NuPNET”

Working Groups

The Nuclear Physics Forward Look activity LRP2010 so far has been structured as follows.

- A Steering Committee (SC) of six NuPECC members has recently been set up. Each SC member represents one of the six main scientific Themes as identified above. The SC is chaired by NuPECC's Chair.
- Six Working Groups (WGs) have been established by the WG Conveners/ Coordinators in close collaborations with the LRP2010 SC and NuPECC. They again correspond to the six Themes, and are chaired by a prominent non-NuPECC expert in the field.

  Each WG consists of
  - The Coordinator
  - The NuPECC member representing the Theme in the Steering Committee
  - The NuPECC liaison person
  - Approx. one dozen experts representing the European community in that field

Steering Committee (NuPECC)

The Steering Committee members are:

- Theme "Hadron Structure & Spectroscopy": Guenther Rosner (Chair)
- Theme "Phases of Strongly Interacting Matter": Jens Joergen Gaardhoeje
- Theme "Nuclear Structure & Dynamics": Angela Bracco
- Theme "Nuclear Astrophysics": Paul-Henri Heenen
- Theme "Fundamental Interactions": Eberhard Widmann
- Theme "Nuclear Physics Tools & Applications": Philippe Chomaz

The Steering Committee will guide the process of formulating the Forward Look LRP2010. Specifically, they will write the Executive Summary, formulate the recommendations in close collaboration with the Conveners of the six scientific working groups, delineate how to set up the European Network of Nuclear Physics Facilities in close collaboration with the directors of the laboratories and, finally, suggest a roadmap for upgrading existing or building new Nuclear Physics facilities in Europe.

The six Scientific WGs are structured as follows.

Working Group 1: Hadron Structure & Spectroscopy

Coordinator: Ulrich Wiedner (Germany)

SC member: Guenther Rosner

NuPECC liaison: Jochen Wambach

Experts: Constantia Alexandrou (Cyprus), Mauro Anselmino (Italy), Reinhard Beck (Germany), Mike Birse (United Kingdom), Tullio Bressani (Italy), Michel Guidal (France), Thierry Hennino (France), Frank Maas (Germany), Ulf Meissner (Germany), Klaus Peters (Germany), Andreas Schäfer (Germany), Madeleine Soyeur (France), Antoni Szczurek (Poland), Marc Vanderhaeghen (Germany)

WG1 Key items
(to be finalised at Scoping Workshop at FIAS, Frankfurt on 12-13/10/2009)

- Nucleon structure
    - Form factors, structure functions, transverse momentum distributions
    - Generalised parton distributions and distribution amplitudes
    - Nucleon spin puzzle
    - New facilities
        - Antiproton annihilation facility (PANDA at FAIR)
        - JLab 12 GeV upgrade (CLAS12 and Hall A)
        - Polarised antiproton – polarised proton collider (PAX at FAIR)
        - Electron-nucleon/ion colliders (ENC at FAIR, ELIC at JLab, eRHIC at BNL, LHeC at CERN)
- Baryon spectroscopy
    - Search for missing nucleon resonances
    - Search for exotic multi-quark states and quark molecules
- Meson structure and spectroscopy
    - Search for exotic mesons (hybrids)
    - Search for glueballs
    - New facilities
        - Antiproton annihilation facility (PANDA at FAIR)
        - High energy linearly polarised photon beams (GlueX at JLab)
- Hypernuclei
    - Doubly strange hypernuclei
    - Strange baryon interaction
    - New facility
        - Antiproton annihilation facility (PANDA at FAIR)
- Lattice QCD
- Effective field theories

- European and international context

WG1 Key questions
(cf. key items above, and to be concretised at Scoping Workshop at FIAS, Frankfurt on 12-13/10/2009)

- What is the fundamental structure of the visible matter in the universe?
    - What is the mechanism of confining quarks and gluons in strongly interacting particles (hadrons)?
    - What is the structure of the nucleon and how do hadrons get their mass and spin?
    - How can we understand the excitation spectra of hadrons from the quark-quark interaction?
- Do exotic hadrons (multiquark states, quark molecules, hybrid mesons and glue-balls) exist?
- How are hadrons modified in the strong colour fields of nuclei? (cf. WG2)
- How do nuclear forces arise from QCD (cf. WG3)?

WG1 Activities
(to be finally decided upon at Scoping Workshop at FIAS, Frankfurt on 12-13/10/2009)

- Review recent achievements and the current state of the art
- Identify open problems and hot topics in the field
- Develop medium and long-term strategies to tackle them
- Optimise interplay between experiment and theory
- Develop the European and worldwide perspective of the field, identifying synergies
- Formulate recommendations and suggest action plan

Working Group 2: Phases of Strongly Interacting Matter

Coordinator: Paolo Giubellino (Italy)

SC member: Jens Joergen Gaardhoeje

NuPECC liaison: Thomas Peitzmann

Experts: U. Wiedemann (Switzerland), R. Snellings (The Netherlands), M. Petrovici (Romania), J. Wessels (Germany), A. Kugler (Czech Republic), J.-Y. Ollitrault (France), F. Gulminelli (France), P. Senger (Germany), J. Nystrand (Norway), K. Redlich (Poland), G. Cardella (Italy)

WG2 Key items

(to be finalised at Scoping Workshop at FIAS, Frankfurt on 12-13/10/2009)

- Dynamics of (ultra) relativistic heavy ion collisions
- Properties of the quark-gluon plasma
- Search for the critical point in the phase diagram of strongly interacting matter
- Quark superconductivity and neutron stars
- Electron-ion colliders and gluon density saturation (cf. WG1)
- Lattice QCD at finite temperature and chemical potential (cf. WG1)
- European and international context
- New facilities
    - ALICE at CERN
    - CBM at FAIR
    - LHeC at CERN

WG2 Key questions

(cf. key items above, and to be concretised at Scoping Workshop at FIAS, Frankfurt on 12-13/10/2009)

- What is the property of strongly interacting matter at the highest temperatures and densities?
- What is the QCD equation of state? How can we test it?
- What are the dominant microscopic mechanisms of QCD non-equilibrium dynamics and thermalisation?
- How does hadronisation proceed dynamically? How is this process changed in dense QCD matter?
- How can the QCD phase diagram be efficiently explored?
- How can we understand the structure of nucleons and nuclei at very small parton momentum fractions (Bjoerken-x)?

WG2 Activities

(to be finally decided upon at Scoping Workshop at FIAS, Frankfurt on 12-13/10/2009)

- Review recent achievements and the current state of the field in light of the most recent advances achieved both in Europe and worldwide, with particular reference to the RHIC results in the USA.
- Identify the most important open problems in the field and the areas where the currently planned experiments and facilities will have the largest impact.
- Develop a strategy to address the potential medium and long-term progress in the field, the necessary new research infrastructures and lines of activity needed to arrive at a coherent scientific program in the long run.
- Optimise the interplay between experiment and theory
- Develop the European and worldwide perspective of the field, identifying synergies

Working Group 3: Nuclear Structure & Dynamics

Coordinator: Rauno Julin (Finland)

SC member: Angela Bracco

NuPECC liaison: Maria Borge

Experts: Navin Alahari (France), Thomas Aumann (Germany), Yorick Blumenfeld (France), Peter Butler (UK), Hans Fynbo (Denmark), Andres Gadea (Spain), Wolfram Korten (France), Adam Maj (Poland), Gerda Neyens (Belgium), Thomas Nilsson (Sweden), Robert Roth (Germany), Patricia Roussel-Chomaz (France), Christoph Scheidenberger (Germany), Andrea Vitturi (Italy), Dario Vretenar (Croatia)

WG3 Key items
(to be finalised at Scoping Workshop at FIAS, Frankfurt on 12-13/10/2009)

- Dynamics of nuclear reactions
- Few body systems and light nuclei
- Ground state properties
- Nuclear spectroscopy
    - Evolution of shell structure and collective behaviour
    - Symmetry of nuclear matter
- Nuclear theory
- Development of radioactive beams towards the neutron and proton drip-lines by
    - In-flight fragmentation (NuSTAR at FAIR)
    - Isotope separation online (ISOL) and postacceleration (SPIRAL2 at GANIL, HIE-ISOLDE at CERN and SPES at LNL)
    - Large-scale new research infrastructure EURISOL
- Development of high-intensity stable-ion beams
- European/international context

WG3 Key questions
(cf. key items above, and to be agreed upon at Scoping Workshop at FIAS, Frankfurt on 12-13/10/2009)

- Understanding the nuclear force – a unified description of bulk properties, nuclear excitations and reactions
- Nuclear structure far-off stability - shell structure, symmetry of nuclear matter, collective behaviour
- Multipole response of unstable nuclei - new exotic modes of excitation
- Limits of existence of nuclei - limits of stability, heaviest elements, highest spin states

- Nuclear structure and reactions of astrophysical interest

WG3 Activities
(to be finally decided upon at Scoping Workshop at FIAS, Frankfurt on 12-13/10/2009)

- Review recent achievements and highlights, especially with respect to the NuPECC Long Range Plan 2004
- Write short text on selected hot topics concentrating on medium and long term ideas as well as on new facilities and instruments needed
- Collect additional ideas from European community, especially from key laboratories
- Conduct a critical discussion on the WG3 Forward Look (FL) draft during the Scoping Meeting
- Formulate recommendations and suggest an action plan
- Compile a new draft in accord with the general layout of the FL
- Distribute the draft to the community for comments
- Present the FL for Nuclear Structure and Dynamics (WG3) during the Town Meeting
- Revise the WG3 FL for NuPECC

Working Group 4: Nuclear Astrophysics

Coordinator: Brian Fulton (UK)

SC member: Paul-Henri Heenen

NuPECC liaison: Sotirios Harissopulos

Experts: Nicholas Chamel (Belgium), Zsolt Fülöp (Hungary), Fairouz Hammache (France), Michael Heil (Germany), Jordi José (Spain), Francois de Oliveira (France), Paolo Prati (Italy), Thomas Rauscher (Switzerland), Stefano Romano (Italy), Kerstin Sonnabend (Germany), Christof Vockenhuber (Switzerland), Phil Woods (UK)

WG4 Key items
(to be finalised at Scoping Workshop at FIAS, Frankfurt on 12-13/10/2009)

- Stellar physics: hydrostatic burning and s-process
- Cataclysmic astrophysical events, r-process and nucleosynthesis
- Explosive thermonuclear burning and the p-process
- Nuclear abundances in the universe
- Neutron stars and the nuclear equation of state
- Neutrino astrophysics
- Astrophysical modelling

- European/international context

WG4 Key questions
(cf. key items above, and to be agreed upon at Scoping Workshop at FIAS, Frankfurt on 12-13/10/2009)

- How, and where, were the heavy elements made?
- What are the key reactions that drive explosive nucleosynthesis in objects like Novae, X-ray Bursters and Supernovae?
- What is the equation of state for the compact matter in a neutron star?
- What are the sites, and what are the nuclear processes, that produce the gamma-ray emissions observed by new satellite missions?
- How do nuclear reactions influence the evolution of massive stars?
- What role do neutrino induced reactions play in astrophysical sites?

WG4 Activities
(to be finally decided upon at Scoping Workshop at FIAS, Frankfurt on 12-13/10/2009)

- Review recent achievements and the current state of the art
- Identify open problems and growth areas
- Develop medium and long term strategies to tackle these
- Optimise the interaction of nuclear physics, astrophysical modelling and observation required to progress the field
- Explore how these European efforts link to the worldwide development of the field
- Formulate recommendations and an action plan

Working Group 5: Fundamental Interactions

Coordinator: Nathal Severijns (Belgium)

SC member: Eberhard Widmann

NuPECC liaison: Klaus Jungmann

Experts: Roberto Calabrese (Italy), Guido Drexlin (Germany), Dezso Horvath (Hungary), Klaus Kirch (Switzerland), Krzystof Pachuki (Poland), Fabrice Piquemal (France), Stefan Schönert (Germany), Rob Timmermans (The Netherlands), Cristina Volpe (France), Oliver Zimmer (France)

WG5 Key items
(to be finalised at Scoping Workshop at FIAS, Frankfurt on 12-13/10/2009)

- Fundamental Fermions

    - Neutrino oscillations and the neutrino mixing matrix
    - Neutrino masses (direct measurements and neutrino-less double beta decay)
    - Quarks (CKM matrix, unitarity)
    - Rare decays (baryon and lepton number/flavour violation)
    - New (time reversal invariant) interactions in nuclear and muon beta decays
- Discrete symmetries
    - Parity (atomic systems, electron scattering, hadronic systems)
    - Time reversal and CP violation in the quark sector (electric dipole moments; R & D correlation coefficients in beta decay)
    - CPT invariance
- Properties of known basic interactions
    - QED and fundamental constants (g-2, fine structure constant, H-like ions, antihydrogen, exotic atoms)
    - QCD (exotic atoms)
    - Gravity (matter vs. antimatter behaviour, $1/r^2$ law tests / extra dimensions)
    - Tests of Lorentz invariance (searching for asymmetry in space)
- European/international context

<u>WG5 Key questions</u>

(cf. key items above, and to be finally agreed upon at Scoping Workshop at FIAS, Frankfurt on 12-13/10/2009)

- What is the origin of the matter dominance in the universe?
- Which fundamental symmetries are conserved in nature?
- What is the nature of the neutrino (Dirac or Majorana)?
- What are the absolute values of the neutrino masses?
- What is the mass hierarchy of neutrinos?
- Are there new sources of CP violation?
- Is there physics beyond the standard model?
- Are there other fundamental forces than the four known ones?
- Are there new particles?
- What are the symmetries behind the conservation laws?
- What are the precise values of the fundamental constants?
- Is the CKM matrix unitary?

<u>WG5 Activities</u>

(to be finally decided upon at Scoping Workshop at FIAS, Frankfurt on 12-13/10/2009)

- Review recent achievements and the current state of the art
- Identify open problems and new issues
- Develop medium and long-term strategies to tackle them
- Optimise interplay between experiment and theory

- Develop the European and worldwide perspective of the field, identifying synergies
- Formulate recommendations and suggest an action plan

Working Group 6: Nuclear Physics Tools & Applications

Coordinator: Sylvie Leray (France)

SC member: Philippe Chomaz

NuPECC liaison: Eugenio Nappi

Experts: José Benlliure (Spain), Andrew Boston (UK), Marco Durante (Germany), Santo Gammino (Italy), Joaquim Gomez Camacho (Spain), Mark Huyse (Belgium), Jan Kucera (Czech Republic), Rolf Michel (Germany), Philippe Moretto (France), Christina Trautmann (Germany)

WG6 Key items
(to be finalised at Scoping Workshop at FIAS, Frankfurt on 12-13/10/2009)

- Nuclear energy
    - Fission: Generation IV reactors, transmutation of nuclear waste, accelerator-driven sub-critical reactors
    - Fusion: Activation data, inertial confinement
- Nuclear medicine
    - Imaging (NMR, SPECT, PET)
    - Photon and charged particle tumour therapy
- Dosimetry, radioprotection, radioecology, modelling, space applications
- Homeland security, radiation sources and detector systems
- Materials sciences and study of materials for industry
    - Neutron scattering
    - Ion beam analysis
    - Spallation sources
- Cultural heritage, arts and archaeology
- European/international context

WG6 Key questions
(cf. key items above, and to be agreed upon at Scoping Workshop at FIAS, Frankfurt on 12-13/10/2009)

- How can the nuclear physics community help increase the sustainability of nuclear energy generation and thus improve public acceptance?
    - Fission: help solve the problem of nuclear waste disposal, help design nuclear power plants with further reduced risk of accidents

    - Fusion: help solve the issue of material damage and activation, help develop a feasible and cost effective technology for nuclear fusion power plants
- What is needed for major advances in particle accelerator and radiation detector technology?
    - High-intensity accelerators for Accelerator Driven Subcritical Reactors (ADSRs) and Spallation Neutron Sources (ESS)
    - Development of the technologies for building polarized electron-ion colliders
- New directions in Nuclear Medicine
    - More reliable assessment of long term effects in hadron therapy
    - Improvement of the precision of surgical procedures by exploiting pre-, intra- and post-operative molecular imaging technologies based on nuclear methods.
- Which new, or modifications of existing, nuclear physics tools are needed to cope with new requirements, in particular regarding homeland security?

<u>WG6 Activities</u>

(to be finally decided upon at Scoping Workshop at FIAS, Frankfurt on 12-13/10/2009)

- Review recent achievements in the field and the current state of the art
- Identify open problems and new issues
- Develop medium and long-term strategies to tackle them
- Optimise interplay between fundamental physics and application end-users
- Develop the European and worldwide perspective of the field, identifying synergies
- Formulate recommendations and suggest action plan

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Schedule of Activities

Date	Task	Deliverables
Month 1	NuPECC defines Themes, establishes LRP Steering Committee, appoints liaison persons for WGs 1-6 and allocates start-up funds.	Lists of • Themes ✔ • SC members ✔ • Liaison persons ✔
Month 2	NuPECC nominates, SC selects and appoints conveners/coordinators for WG 1-6	List of WG 1-6 coordinators ✔
Month 3	WG 1-6 coordinators, SC and liaison persons nominate WG 1-6 experts. NuPECC discusses composition of WGs 1-6. WG 1-6 conveners contact experts and appoint them. SC issues guidelines for work of WGs and drafts Outline Forward Look Proposal. SC organises and WGs prepare Scoping Workshop.	Lists of WG 1-6 experts ✔ Outline FL Proposal ✔
Month 4	Scoping Workshop	Final lists of • Key items • Key questions • Activities FL Proposal
Month 5-8	SC and WGs draft Forward Look LRP2010.	
Month 9	NuPECC discusses Forward Look LRP2010 draft.	
Month 10-11	SC and WGs revise their drafts according to NuPECC's recommendations and prepare the Town Meeting.	
Month 12	Town Meeting (Consensus Conference)	
Month 13-15	SC and WGs revise their drafts according to the decisions at the Town Meeting.	
Month 16	NuPECC evaluates revised LRP2010 draft.	
Month 17	SC and WGs finalise LRP2010.	
Month 18	SC prepares publication and dissemination.	Forward Look LRP2010

Contributors to the Forward Look

Contributors from Academia

- NuPECC
- All European Universities that have an active Nuclear Physics research programme
- All major Nuclear Physics National Labs in Europe
- European Lab CERN
- International Lab FAIR

Other participants

- FP7 HadronPhysics2 and ENSAR IAs
- FP7 ERAnet “NuPNET” of ministries or research councils who fund Nuclear Physics research in Europe
- SMEs participating in HadronPhysics2 and ENSAR IAs

Relevant International Organisations

- The European Commission
- The European Strategy Forum on Research Infrastructures
- The European Research Council
- The European Science Foundation and its Member Organisations
- The International Union of Pure and Applied Physics
- The OECD

Participants in the Preparatory Workshops

Scoping Workshop at FIAS in Frankfurt on 12-13/10/2009

Participants (ca. 200-250):

- NuPECC
- WGs 1-6
- Directors/ top management of European Nuclear Physics labs
- EU FP7 Nuclear Physics Integrating Activities
    - HadronPhysics2 IA Management Board and task leaders
    - ENSAR IA top management and task leaders
- Senior European Nuclear Scientists and Engineers
- ESF representatives (PESC Unit)
- EU FP7 ERAnet "NuPNET" Governing Council
- Representatives of non-European Nuclear Physics policy bodies such as NSAC (US DoE and NSF), the Asian ANPhA and IUPAP C12 and WG.9 ICNP

Town Meeting at CSIC in Madrid on 31/5-2/6/2010

Participants (ca. 500-700):

- NuPECC
- WGs 1-6
- Directors/ top management of European Nuclear Physics labs
- EU FP7 Nuclear Physics Integrating Activities
    - HadronPhysics2 IA Management Board and task leaders
    - ENSAR IA top management and task leaders
- European Nuclear Scientists and Engineers
- ESF representatives (PESC Unit)
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- Representatives of non-European Nuclear Physics policy bodies such as NSAC (US DoE and NSF), the Asian ANPhA and IUPAP C12 and WG.9 ICNP

2 WGs 1-6 meetings before and 1 WGs 1-6 meeting after the Town Meeting

Participants (ca.12 members from each WG plus invited experts at each occasion = 3 x 6 x (12 + ?) >> 216 participants in total)

2 SC meetings before and 2 SC meetings after the Town Meeting

Participants (6 SC members plus NuPECC Scientific Secretary plus invited experts at each occasion = 4 x (7 + ?) >> 28 participants in total)

Dissemination Plan

The Nuclear Physics Forward Look LRP2010 will be printed and distributed at the end of the 18 months' preparation period.

Consideration will be given to launching the Forward Look at a special event that could, for example, be related to a prominent ESF or EU event, or to one of the large European Nuclear Physics conferences, e.g. that organised by the European Physical Society.

The publication of LRP2010 will also be announced via the Nuclear Physics News International, which is a European, US American, Canadian and Japanese journal issued by NuPECC.

In addition, LRP2010 will be published on ESF's and NuPECC's websites and circulated to the community, funding agencies, lab directors, ESFRI, and national and European decision makers.