Status of the NuPECC Long Range Plan

Angela Bracco - Università di Milano and INFN
San Servolo, Venezia - 29 June 2016
Joint Institute for Nuclear Research Dubna - Recently joined Request from Turkey and Israel

exchanges with

- AnPHA
- NSAC (mutual)
- Canada
- ALAFNA

21 countries – 31 Members

Angela Bracco March 2016
Perspectives of Nuclear Physics in Europe

Long Range Plan 1991-2010

Volume Brochure video


Angela Bracco March 2016
New Facilities and Major upgrades

- FAIR and SPIRAL2 (ESFRI)
- HIE-ISOLDE and SPES
- ALICE at CERN
- Existing Laboratories + Luna
- Instrumentation (AGATA)
- Theory
- Applications
- New ESFRI fac.

Existing Facilities
- ALTO
- COSY
- MAMI
- LNF
- Jyvaskyla
- LNL-LNS
- KVI
- ...

Shifts in time as compared with 2009
After 6 years a new Long range plan is needed

• The plans made in 2009 (published in 2010) are not yet fully realized –

• Changes and delays in the original plans for major facilities are ongoing.

One needs urgently to:

• re-assess programmes at the present conditions and re-affirm the existing great interest on infrastructures under construction

• prepare the instrumentation (including theory) in view of the progress in science and of the changed timeline
LRP - Objectives

• **Review** status of the field

• **Issue recommendations** to advance
  – The science
  – Its applications in Europe

• **Develop action plan** (roadmap) for:
  - Building new large-scale Research Infrastructures
  - Upgrading existing Nuclear Physics facilities
  - Collaborate closely with smaller scale facilities

  – support **EU** projects (IAs, ERA-net ……)

• **Put European Nuclear Physics into global context**

  – NSAC (DoE & NSF) in USA, ANPhA in Asia, ALAFNA in Latin America
  – IUPAP and OECD Global Science Forum -
The 2015 NSAC Long Range Plan
Reaching to the Horizons
Summary for U.S. Long Range Plan

• The U.S. Nuclear Physics efforts are strong and moving forward rapidly.

• Capitalize on recent investments: CEBAF 12 GeV Upgrade, RHIC intensity upgrade and soon electron cooling, NSCL and ATLAS upgrades, and FRIB in the 2020’s. There is exciting science ahead!

• In the U.S. long range plan was created that will allow us to reach new horizons.

From D. Geesaman
LRP 2016 - structure

• One part of the volume on science and Facilities
• Summary and recommendations
• 6 more detailed chapters on the achievements and specific plans concerning the different themes of today Nuclear Physics

1) Hadron Physics
2) Phases of Strongly Interacting Matter
3) Nuclear Structure & Dynamics
4) Nuclear Astrophysics
5) Fundamental Interactions
6) Nuclear Physics Tools & Applications
• Several meeting and workshops are ongoing which are organized by the working group members appointed by NuPECC and by the NuPECC liaisons

1) Hadron Physics  \textit{D Bettoni(Ferrara)} + \textit{H. Wittig(Mainz)}- Mainz 18/19 February

2) Phases of Strongly Interacting Matter  \textit{S Masciocchi(GSI)} + \textit{F Gélis(CEA Saclay)}....\textbf{May 11 CERN}

3) Nuclear Structure & Dynamics  \textit{J Simpson (Daresbury)} + \textit{E Khan (Orsay)}- 5 APRIL ORSAY

4) Nuclear Astrophysics  \textit{G Martinez Pinedo(TU Darmstadt)} + \textit{A Laird (York)}
GSI on 16\textsuperscript{th}/17\textsuperscript{th} February 2016

5) Fundamental Interactions  \textit{K. Kirch (PSI)} + \textit{K Blaum(MPI Heidelberg)} 21-22 APRIL-PSI

6) Nuclear Physics Tools & Applications  \textit{M Durante (TIFPA Trento)} + \textit{D. Letournau (Saclay)}
ECT* 10 March 2016

• NuPECC has organized a special meeting in January to discuss the status of European Facilities
1. **Theory** *(Christian Forssen and Achim Schwenk)*
   Forssen, Gargano, Mora, Schwenk

2. **Nuclear structure** *(Alexandre Obertelli)*
   Bruce, Gargano, Dullman, Dombradi, Fornal, Forssen, Guttormsen Greenlees, Grevy, Jungclaus, Karpov, Kalantar, Leoni, Moro, Raabe, Rejmund, Obertelli, Pietralla, Riisager, Schwenk, Scheidenberger, Ur

3. **Reaction Dynamics** *(Antonio Moro)*
   Karpov, Moro, Szilner, Ur

4. **The Nuclear Equation of State** *(Giuseppe Verde)*
   Forssen, Guttormsen, Leoni, Kalantar, Schwenk, Ur, Verdi

5. **Facilities and instrumentation** *(Stéphane Grevy)*
   Grevy, Kalandar, Leoni, Riisager, Scheidenberger, Szilner, Ur, Verde

N.B: i) some are members of several SB’s
    ii) SG1 is has a larger number of members
Box 2. The reach of ab initio methods

In recent years, ab initio computations of nuclei have advanced tremendously. This progress is due to an improved understanding of the strong interaction that binds protons and neutrons into nuclei, the development of new methods to solve the quantum many-body problem, and increasing computer performance. In the early decades, the progress of ab initio methods was approximately linear in the mass number $A$ because the computing power, which increased exponentially according to the Moore’s Law, was applied to exponentially expensive numerical algorithms. In recent years, however, new generation methods, which exhibit polynomial scaling, have dramatically increased the reach. The figures show the chart of nuclei and the reach of ab initio calculations in 2005 (top) and 2015 (bottom). Note for which ab initio calculations exist are highlighted in blue. Note that the figure is for illustrative purposes only and is based on a potentially non-exhaustive survey of the literature.

These recent developments allow employing ab initio many-body methods to perform dedicated tests of nuclear interactions and to answer what input is required to best constrain nuclear forces.
Interfacing structure with reaction observables

- Improvement of structure inputs in reaction frameworks.
- Understanding how structure phenomena (core polarizations, pairing & tensor correlations, etc.) show up in reaction observables.
- Exploring what structure information can be actually extracted from reaction observables: particles correlations, 2N transfer, etc.
Opportunities: ISOL Beams

- Studies relevant to all explosive scenarios
- High quality (energy, time, etc.) radioactive beams for studying reaction cross sections (direct and spectroscopic measurements) at stellar energies
- Measurements away from stability crucial for testing models
Currently, AGATA is being exploited at GANIL (until 2019) using its wide variety of stable and radioactive beams and site-specific spectrometers as well as state-of-the-art ancillary detectors for charged particles, neutrons and high-energy $\gamma$ rays (see figure).

From 2020 the collaboration plans to extend AGATA up to 40 units thus covering two thirds of $4\pi$. This array will be a key instrument at the next-generation facilities NUSTAR at FAIR, SPES at LNL and SPIRAL 2 at GANIL.
Facility for Antiproton and Ion Research

FAIR

• Conception of FAIR
  4 scientific pillars
  • APPA (atomic and plasma)
  • CBM
  • NUSTAR
  • PANDA
Test Facility for SC magnets of NICA and FAIR: excellent collaboration of JINR and Germany (BMBF).

1\textsuperscript{st} cold test of Booster dipole with magnetic measurements in December’14
Cold test of serial quadrupole duplet – Feb-March 2015

Serial production of Booster dipoles and quadrupoles started in Oct 2014

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60 years of JINR Celebration
5 April 2016
High Level Schedule of the MSV

From January 2017
new director
Paolo Giubellino

cc= civil construction
ISOL FACILITIES
Physics with ISOL RIB
Intensity & Energy domains

HI-ISOLDE, SPES, SPIRAL2, ISOL@MYRRHA
EURISOL-DF

EURISOL

Today

INTENSITY (particles/sec)

ENERGY (MeV/u)

Fusion-Fission, Reaction Cross Sections, Coulxex
Two-Nucleon Transfer
One-Nucleon Transfer
Elastic, Inelastic Scattering
Symmetry Studies
Mass and Decay Measurements
Radiative Capture

today

Second generation
EURISOL – Distributed Facility (DF) Initiative

Proposed EURISOL-DF scheme:

- EURISOL Science Case & Experiments
  - Dedicated beamtime for EURISOL-DF experiments
  - Dedicated EURISOL-DF Scientific Council & PAC
- R&D for EURISOL
  - Dedicated Technical Advisory Committee
- Legal entity (ERIC,...)

Main and Satellite facility structure

Interaction with EURISOL JRA in ENSAR 2 and EURISOL User group

http://www.eurisol.org/eurisol_df/

Project to be submitted for the 2018 update of the ESFRI roadmap
Landmark Facilities
– FAIR \(\rightarrow\) synergies with NICA at JINR
– SPIRAL2
– ELI_NP

In 2018 the list will be updated – a proposal from NP is in preparation.

European Strategic Forum Research Infrastructures

• NuPECC, APECC, CERN … are observers and gave inputs for STRATEGY REPORT ON RESEARCH INFRASTRUCTURES - March 10 2016
http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri
Next meetings of ESFRI to update the list in 2018

• The procedure will be launched in October 2016 at Cape Town (South Africa) during the ICRI conference.
For the Distributed-Facility

Important aspects to be considered:

- Maturity of the project
- Common developments and specific features and roles of each site
- Why we need in Europe such an organization to progress in this science
.... the worldwide situation .... and Eurisol_DF

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PS Conference: Towards EURISOL Distributed Facility

EURISOL DF 2016

- 18-21 October 2016
- Leuven
- Expected attendance: ≥ 200 participants

Promotiezaal KU Leuven
(385 places)

Jubileumzaal: coffee breaks, reception, lunch and poster session(s)
• The inclusion of Nuclear Physics programmes at the multi-purpose facilities ELI and ESS.

Bucharest-Magurele National Physics Institutes

Extreme Light Infrastructure - Nuclear Physics (ELI-NP) - Phase I

Project co-financed by the European Regional Development Fund
Large equipments:

- **Ultra-short pulse high power laser system**, 2 x 10PW maximum power
  - 0.5% band width $10^4$ photons/eVs.
- **Gamma beam**, high intensity, tunable energy up to 20MeV, produced by Compton scattering of a laser beam on a 700 MeV electron beam produced by a warm LINAC

Buildings: 33000sqm total

Experiments:

- 8 experimental areas,
  - Interaction chambers, Beam transportation
- 8 auxiliary laboratories
- **Nuclear Structure- Nuclear Astrophysics and Applications**
Small scale facilities
European Small-scale Accelerator Facilities

Specific role in
• Education
• R&D
• Applications

30 small scale facilities
LUNA site

- **LUNA 1**
  - (1992-2001)
  - 50 kV

- **LUNA 2**
  - (2000 – …)
  - $U_{\text{terminal}} = 50 - 400\text{kV}$
  - $I_{\text{max}} = 500\mu\text{A (on target)}$
  - $\Delta E = 0.07\text{keV}$
  - Allowed beams: $H^+, 4\text{He}, 12\text{C}$

- **LUNA MV**
  - (approved)
  - $U_{\text{terminal}} = 350 - 3500\text{kV}$
  - $I_{\text{max}} = 500\mu\text{A (on target)}$
  - $\Delta E = 0.7\text{keV}$
  - Allowed beams: $H^+, 4\text{He}, 12\text{C}$

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Nuclear reactions at stellar energies for nucleosynthesis-star evolution, energy production

At the position of ICARUS
Start with beams of the new accelerator in 2018
ALICE at CERN

– Upgrade the nuclear beams and the detector to expand physics reach
Final remarks....

Nuclear Physics is in general a very vital field

The new facilities under constructions for nuclear physics will engage the community for several years-

Delays in the construction !!!
The community needs to push for the realization of the scientific objectives with no further delays and to update and reformulate them when needed

NuPECC has launched the LRP
This will play a role for Nuclear science in giving it the deserved visibility towards the funding agencies and towards other communities in the international general landscape
Town meeting for LRP of NuPECC
at GSI
11-13 January 2017