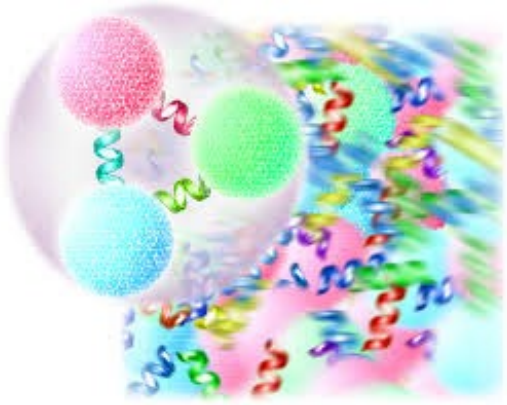
MTP@LNL, 11-12 Aprile 2022

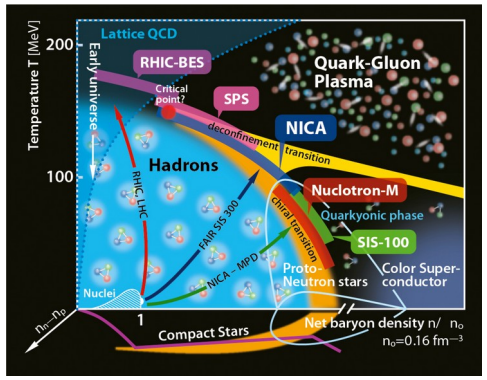
https://agenda.infn.it/event/28738/

Daniele Mengoni
Università e INFN, Padova

INFN - Nuclear Physics Committee

1.**QUARKS AND HADRON DYNAMICS**



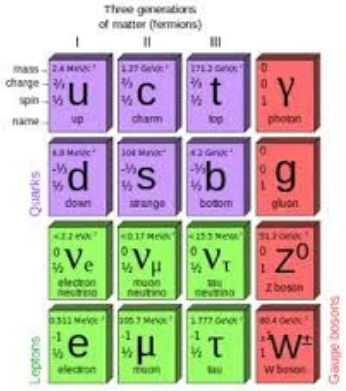


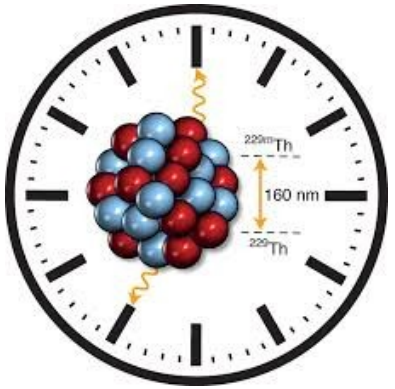
2.**PHASE TRANSITION IN HADRONIC MATTER**

3.**NUCLEAR STRUCTURE AND REACTION MECHANISM**

4 .**NUCLEAR ASTROPHYSICS:**

5.**FUNDAMENTAL INTERACTIONS**





6.**APPLICATIONS AND SOCIETAL BENEFITS:**

INFN is promoting a discussion forum on the future of nuclear physics research in Italy with particular emphasis on INFN laboratories that are preparing important upgrades for the accelerators complexes.

Specific working groups are discussing ideas and topics to be developed in the mid term future with the goal of defining experiments at the upgraded facilities or promoting ad-hoc developments for new setups.

Worldwide researchers interested in joining the working groups are welcome to register and participate to the ongoing discussions as active members of the community.

The working groups will report their activities in four final events, dedicated to each Laboratory:

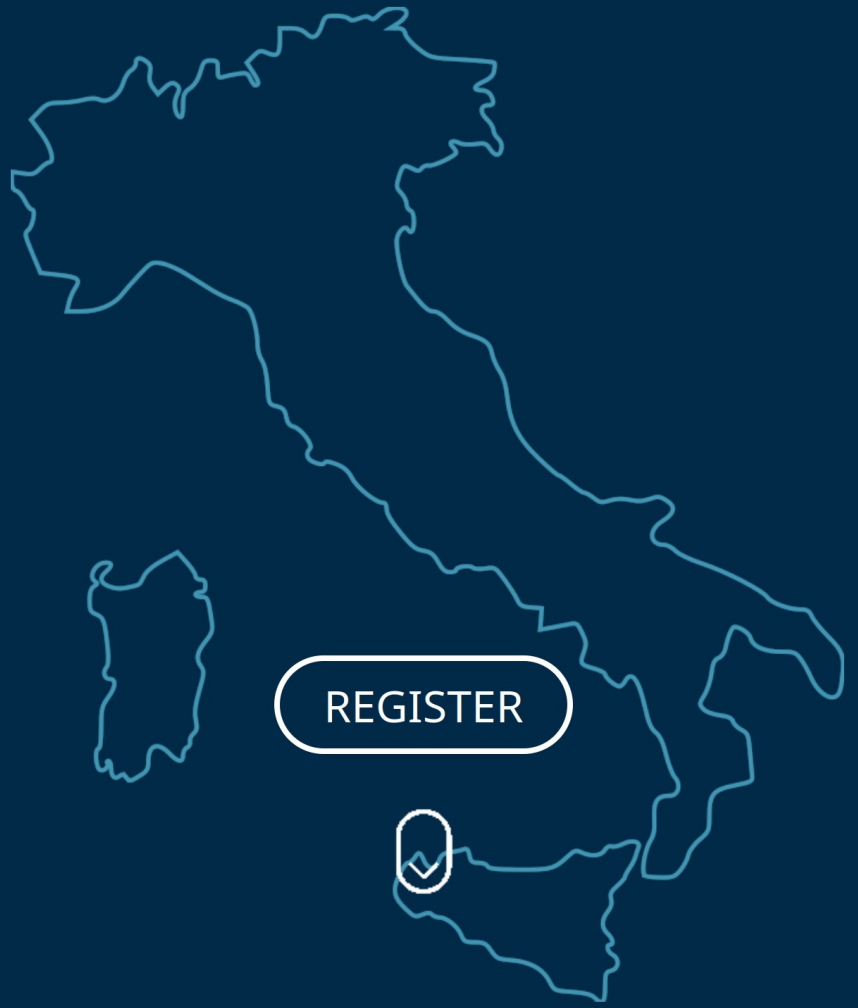
Session 1 – LNS (4-5 April 2022)

Session 2 – LNL (11-12 April 2022)

Session 3 – LNGS (11 October 2022)

Session 4 – LNF (1-2 December 2022)

UPDATE: Attendees registration for LNGS Session is now open! Please find the registration form in the INDICO page.



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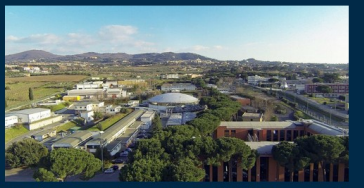
Nuclear Physics
Mid Term Plan in **Italy**


Laboratori Nazionali di Legnaro


Laboratori Nazionali del Sud


Laboratori Nazionali del Gran Sasso


Laboratori Nazionali di Frascati

The event rationale

In the next years the upgrade programs of INFN laboratories will be completed:

SPES at the Laboratori Nazionali di Legnaro (https://web.infn.it/spes/)

POTLNS at the Laboratori Nazionali del Sud (https://potlns.lns.infn.it/en/),

LUNA-MV accelerator of the Bellotti Ion Beam Facility at the Laboratori Nazionali del Gran Sasso (http://l.infn.it/lngs-accel).

Laboratori Nazionali di Frascati and EuPRAXIA (https://w3.lnf.infn.it and https://www.eupraxia-project.eu)

A discussion on the physics to be addressed in the mid-term perspective is timely and beneficial

The workshops

In the preparatory meetings, CSN3 has promoted a discussion forum on the future of nuclear physics research in Italy with particular emphasis on:

- *The role of younger generations of scientists*
- *Developing synergies between infrastructures*
- *Opening dialogue with the theory groups*

Specific working groups have discussed ideas and topics to be developed in the mid term future with the goal of **defining experiments** at the upgraded facilities, promoting ad-hoc **developments for new setups** and **establishing a timeline** for the projects' implementation

Worldwide researchers interested in future research program have joined the working groups and elaborated questions and proposals

The working groups have reported on their activities in four final events, dedicated to each Laboratory

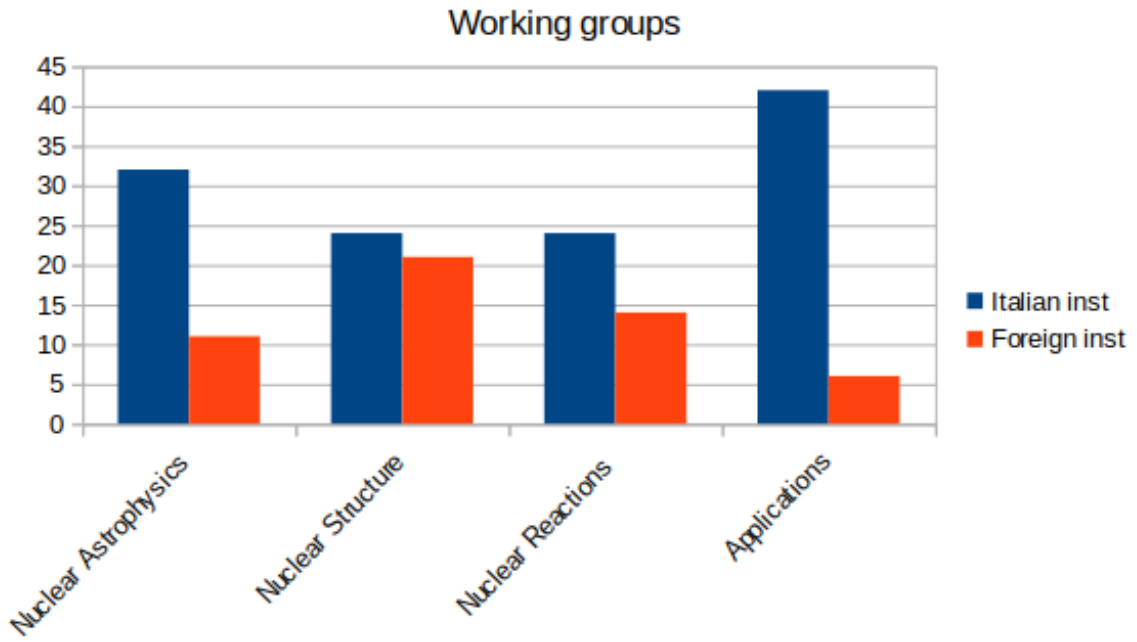
Session 1 – LNS (4-5 April 2022)
Session 2 – LNL (11-12 April 2022)
Session 3 – LNGS (11 October 2022)
Session 4 – LNF (1-2 December 2022)

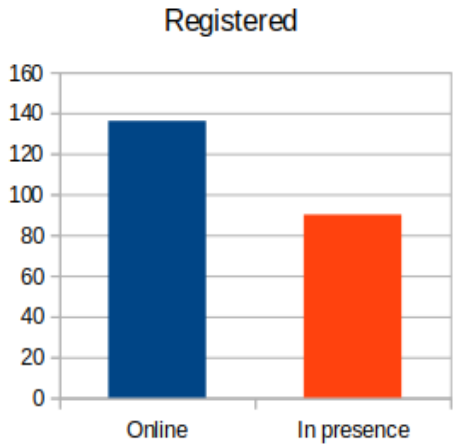
Some Numbers

29 March 2022

Working group registrations					
Working group	Total	Italian inst		Foreign inst	
Nuclear Astrophysics	43	32	74%	11	26%
Nuclear Structure	45	24	53%	21	47%
Nuclear Reactions	38	24	63%	14	37%
Applications	75	69	92%	6	8%
Total	201	149	74%	52	26%

Registered	
226	
Online	In presence
136	90





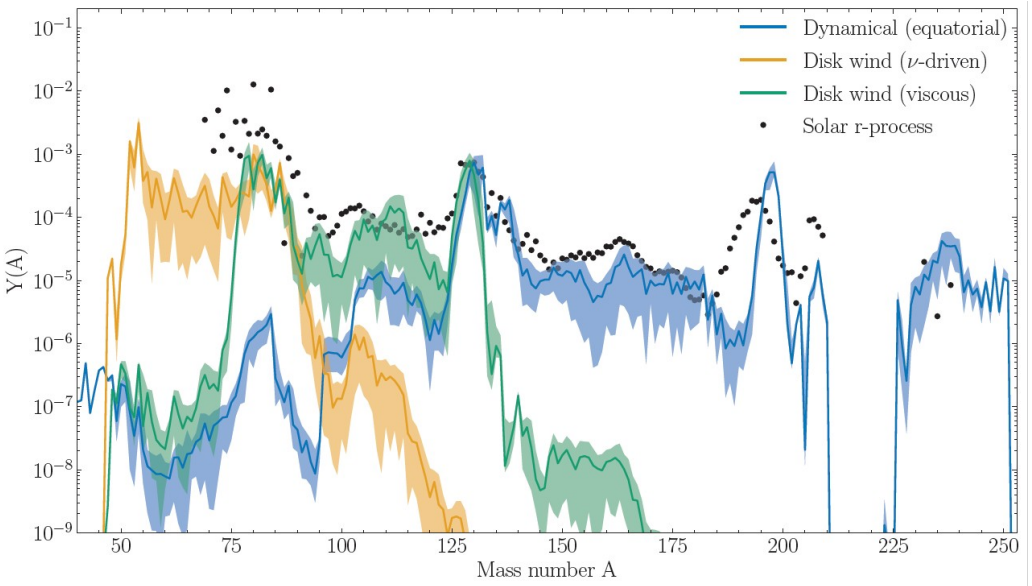
LNL MTP Organization

Working group (Chair)	Topic	Speaker
Nuclear Astrophysics (R. Depalo)	▸ Nucleosynthesis up to the iron peak ▸ Nucleosynthesis of trans-iron elements ▸ Nuclear astrophysics theory	A. Caciolli T. Kurtukian Nieto S. Cristallo
Nuclear Structure (D. Mengoni)	▸ Shell evolution ▸ Light to medium-mass exotic nuclei ▸ N~Z nuclei and isospin symmetry ▸ Deformation and collective states	A. Gottardo S. Bottoni S. M. Lenzi F. C. Crespi
Nuclear Reactions and Dynamics (T. Marchi)	▸ Physics overview: alpha clustering, dynamics and structure, termodynamics, equation of state, collective motions ▸ Mechanisms/Tools: fusion-evaporation and pre-equilibrium emission ▸ Mechanisms/Tools: transfer, particle spectroscopy ▸ Mechanisms/Tools: fission and sub-barrier fusion	F. Gulminelli & D. Dell'Aquila K. Mazurek & M. Cicerchia L. Gasques & F. Galtarossa M. Caamaño-Fresco & I. Zanon
Applications (G. Pupillo)	▸ Nuclear cross sections measurements and modelling for direct radionuclide production and neutron beam lines at SPES ▸ ISOL and laser applications at the SPES facility ▸ Development, characterization and modifications of materials for applied nuclear physics	L. Mou M. Ballan M.Campostrini

MTP-LNL. WG 1: Nuclear Astrophysics

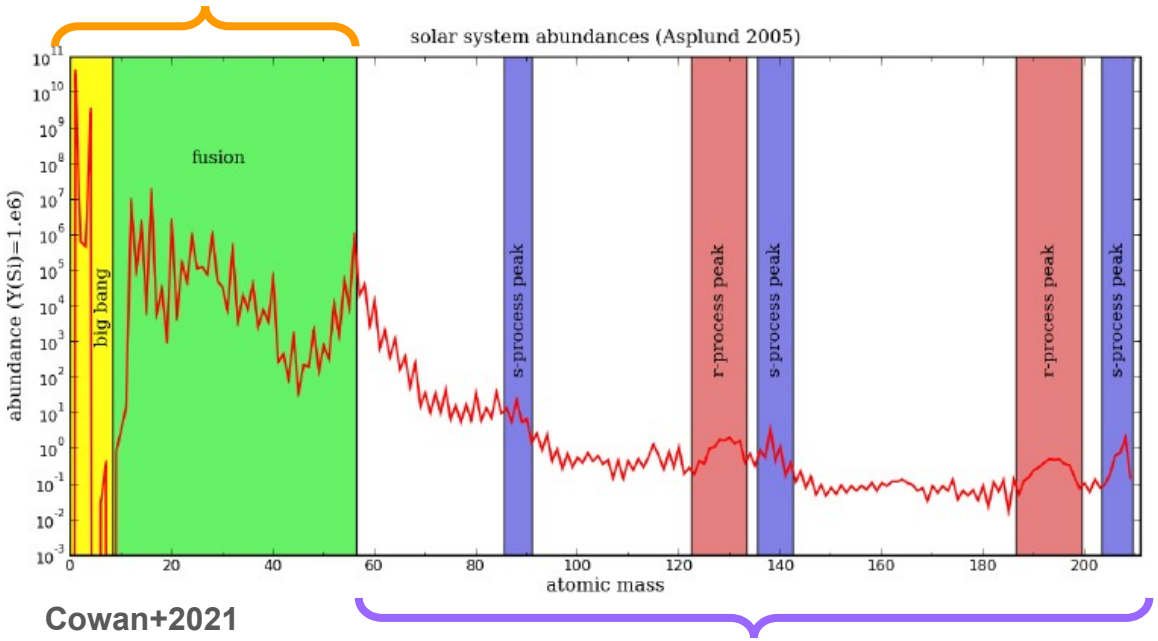
WG1: Nuclear Astrophysics theory

- Sensitivity studies on nuclear inputs needed by stellar models to reproduce observed abundances
- Identify most relevant and interesting science cases



WG2: Nucleosynthesis up to the Fe peak

- Big Bang Nucleosynthesis
- Stellar hydrogen burning
- Formation of ^{12}C and the Hoyle state
- Carbon and Oxygen burning



Cowan+2021

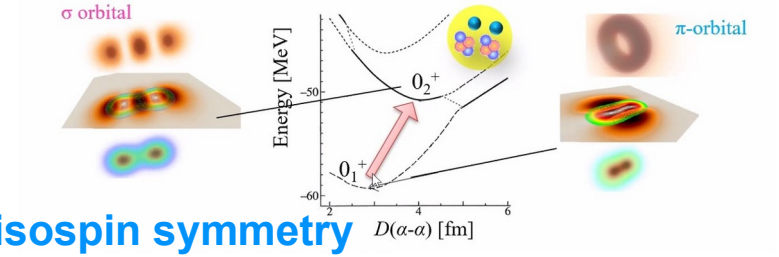
WG3: Nucleosynthesis of trans-iron elements

- Decay properties of neutron-rich nuclei at the first r-process peak
- (α,n) reactions affecting abundances at the first r-process peak
- Direct neutron cross section measurements for the s-process
- Indirect neutron capture cross sections for i- and r-process via surrogate reaction method

MTP-LNL. WG 2: Nuclear Structure

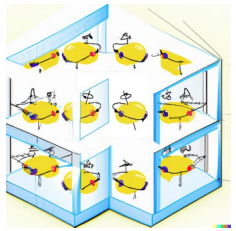
1. Light and medium mass exotic nuclei

- Onset of collectivitazion, clusterization and impact on astrophysics
- Nuclear correlation and nuclear forces (3N forces)
- Structure on neutron-rich medium mass nuclei, proton excitation



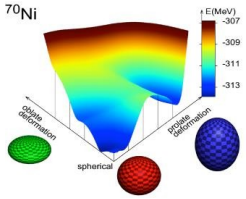
2. N~Z nuclei and isospin symmetry

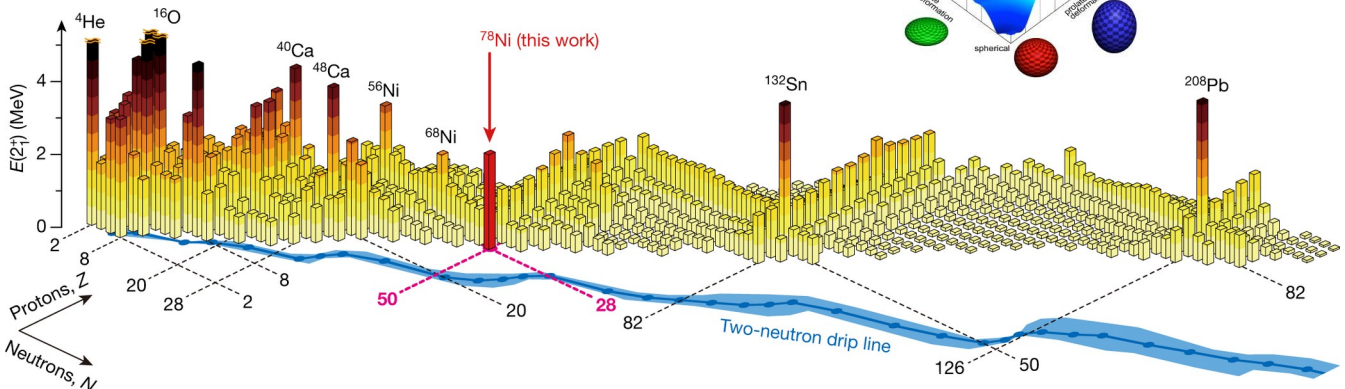
- Quadrupole correlations: shapes and symetries
- Pairing: the role of T=0 pn
- Isospin symmetry (breaking)
- Fundamental interactions



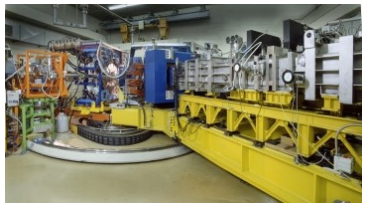
3. Shell evolution

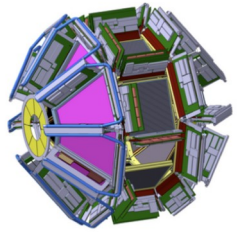
- N=50 (^{78}Ni): intruder states, medium-spin states, single-particle nature
- Shape coexistence
- N=82 (^{132}Sn): single particle nature, n-p multiplets



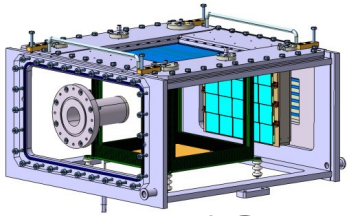


PRISMA
heavy ions

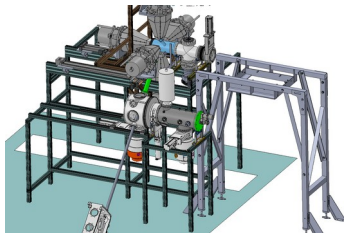




GRIT
charged particles



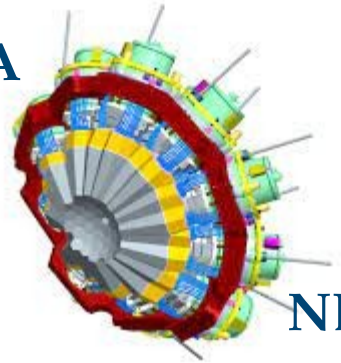
β-decay
station

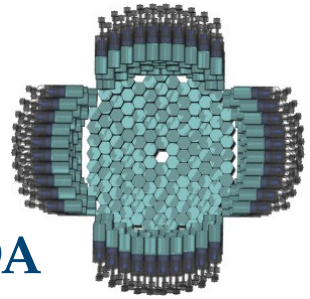


Forefront contemporary nuclear structure needs ground-breaking integrated systems

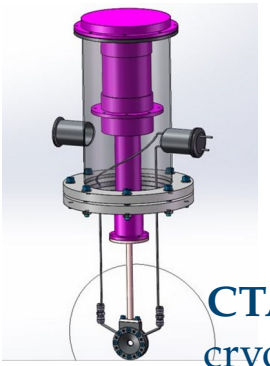
ACTIVE TARGETS

AGATA
γ-rays





NEDA
neutrons

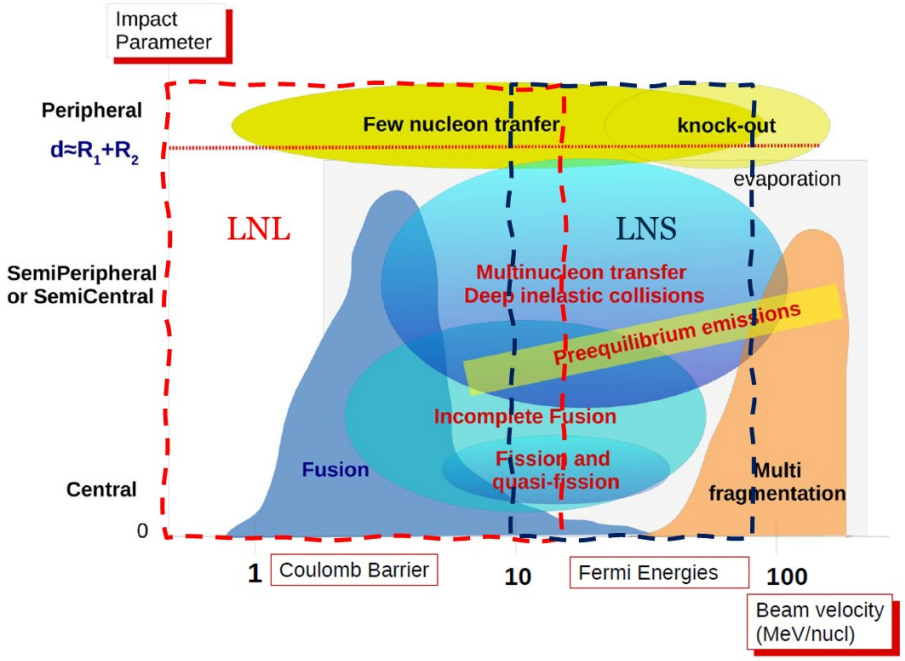


CTADIR
cryogenic target

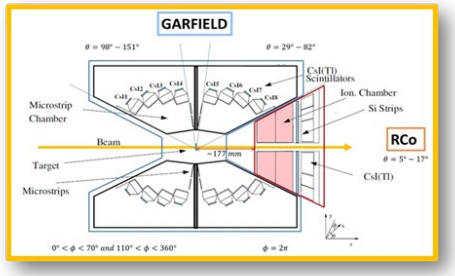
4. Deformation and collective modes

- Pygmy dipole and quadrupole resonances (PDR,PQR)
- Giant dipole and quadrupole resonances(GDR,GQR)
- Isospin mixing, hot PDR
- Jacoby shapes

MTP-LNL. WG 3: Nuclear Reactions and Dynamics



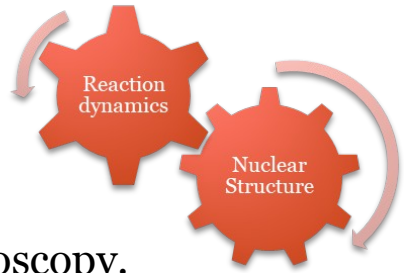
WG1. Fusion-evaporation and pre-equilibrium emission.



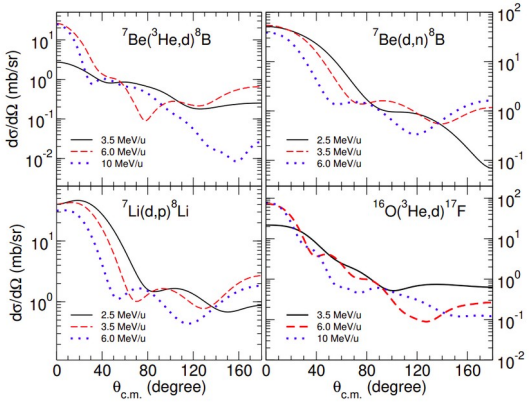
High angular coverage particle detectors with good PID performances and low thresholds. Many ancillaries: Rco, FARCOS, FAZIA, ...

The challenge: **provide absolute cross-sections!**

Coupling with high-efficiency gamma-ray detectors will provide profitable information.



WG2. Direct processes, transfer and particle spectroscopy.



Study of the reaction mechanism

Multinucleon transfer at near- ad sub-barrier energies

- Production of neutron-rich heavy nuclei
- Nucleon-nucleon correlations

Competition between transfer and near-barrier fusion

Applications of transfer to structure and astrophysics

Asymptotic Normalization Constants

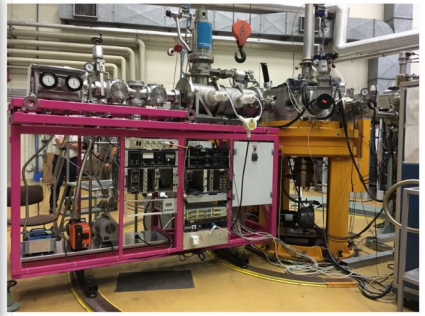
The problem of ^{12}C and the ^{6}He elastic breakup

WG3. Fission and sub barrier fusion.

- With the upcoming ^{238}U beam and the increase of beam energy, **transfer-induced fission is at hand** for a good set of beam especies.
- Transfer-induced fission can produce **a number of systems with a wide distribution of excitation energy** with a single target and beam combination.

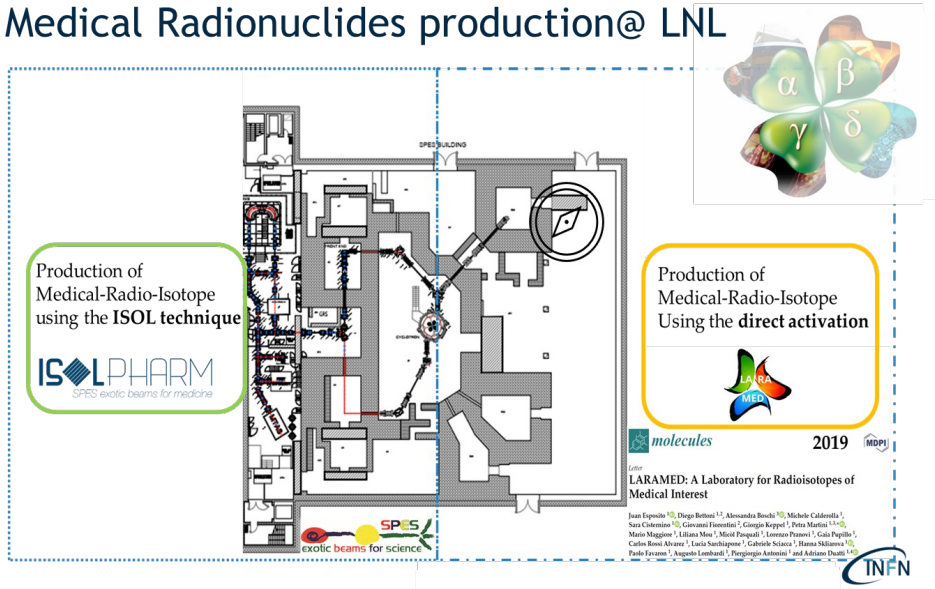
The opportunity with PRISMA

The present PISOLO set-up for sub-barrier fusion measurements at LNL



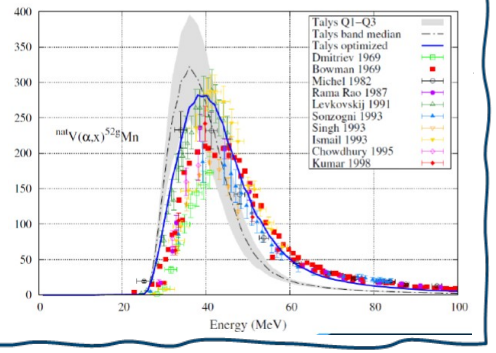
MTP-LNL. WG 4: Applications

Medical Radionuclides production@ LNL

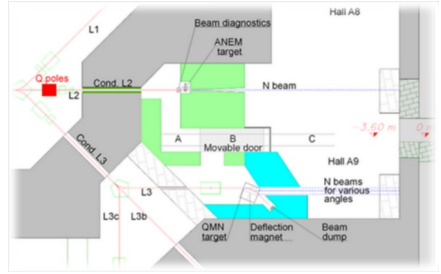


WG1. Nuclear cross sections measurements and modelling for direct radionuclide production and neutron beam lines at SPES.

- **Development of emerging RNs in Nuclear Medicine** (^{67}Cu, ^{47}Sc, ^{xx}Tb and future RNs: ^{117m}Sn, ^{119}Sb,^{133,135}La..)
- **Modeling of nuclear xs**

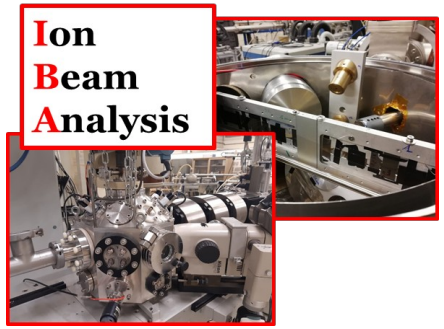


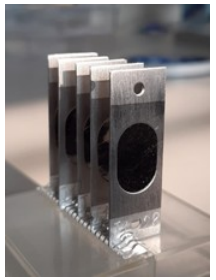
- **Neutron facility @ SPES**

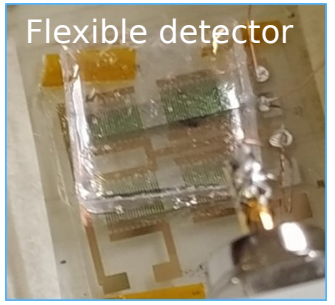


WG3. Development, characterization and modifications of materials for applied nuclear physics.

- **Ion beam micro-analysis for nuclear targets development and cross section measurements** for applied nuclear physics
- **Ion-solid interaction and radiation damage of materials, detectors and devices**
- **Novel detectors development and test**

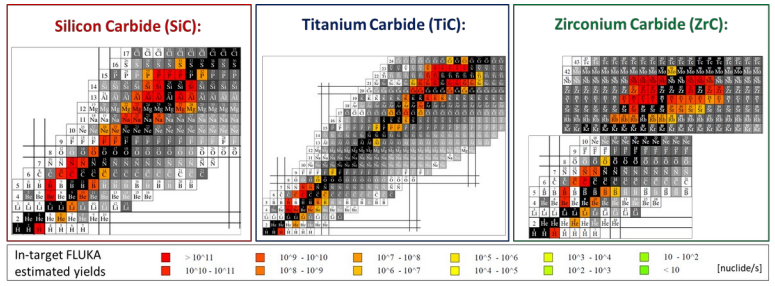


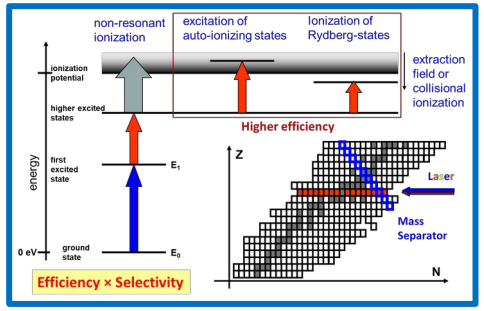




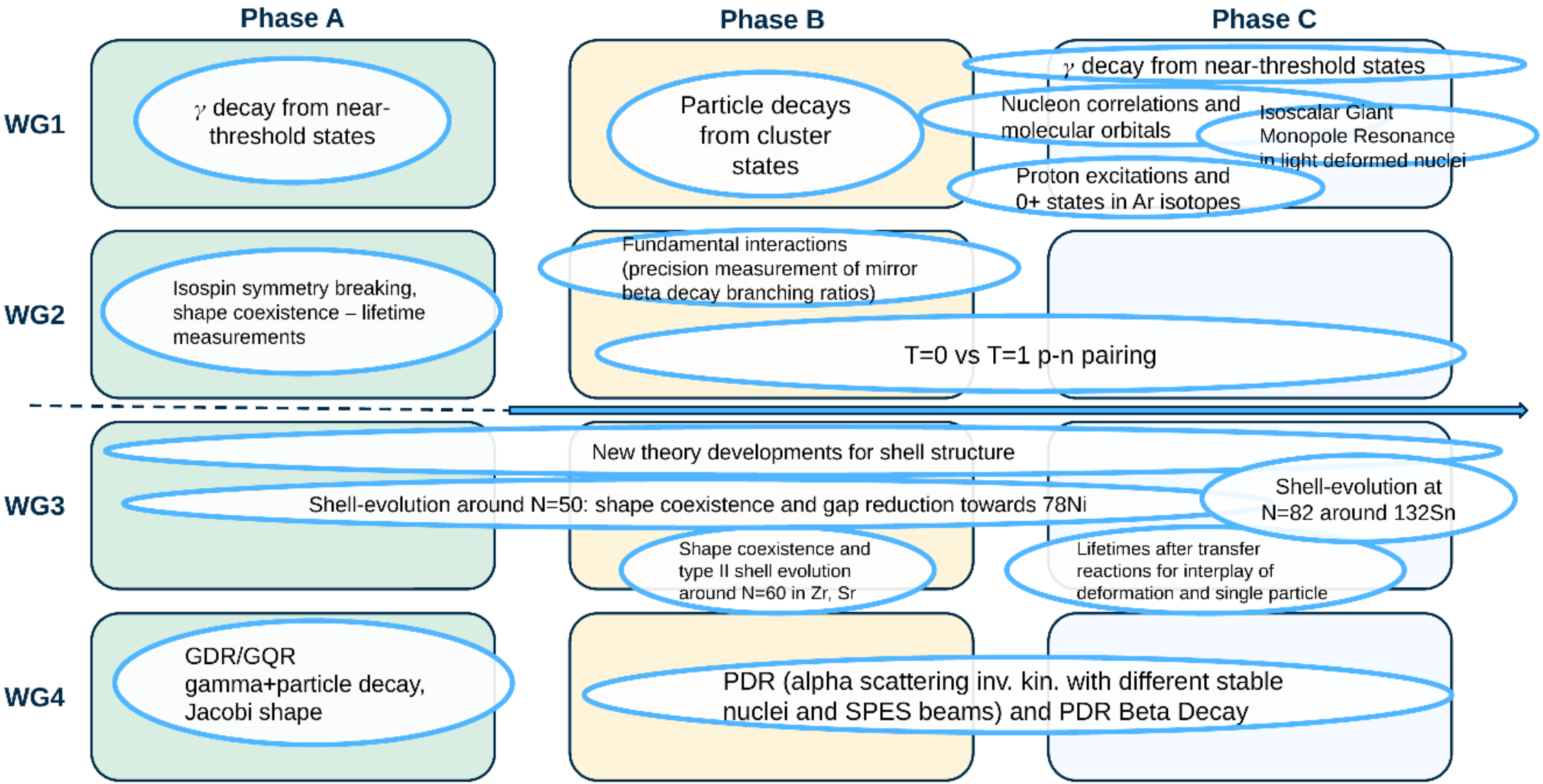
WG2. ISOL and laser applications at the SPES facility.

- **Laser spectroscopy** and applications
- **Nuclide production with ISOL** for medicine and nuclear physics
- **Decay spectroscopy** of nuclides of medical interest





Timeline, an example



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THE EUROPEAN PHYSICAL JOURNAL PLUS

Regular Article

Nuclear physics midterm plan at Legnaro National Laboratories (LNL)

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Abstract The next years will see the completion of the radioactive ion beam facility SPES (Selective Production of Exotic Species) and the upgrade of the accelerators complex at Istituto Nazionale di Fisica Nucleare – Legnaro National Laboratories (LNL) opening up new possibilities in the fields of nuclear structure, nuclear dynamics, nuclear astrophysics, and applications. The nuclear physics community has organised a workshop to discuss the new physics opportunities that will be possible in the near future by employing state-of-the-art detection systems. A detailed discussion of the outcome from the workshop is presented in this report.

Summary and Conclusions

- Material/talks available at the event website
- Review published on EPJ Topical issue
- Physics ideas developed within midterm plan was also collected in the NUPECC long-range plan
- Attraction of the International collaboration towards LNL, now and in the future with SPES → new users, new proposals already now
- SPES + TAP + “small machines” → great asset for the lab

Ta -daaa ....


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