



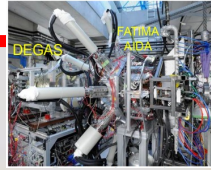
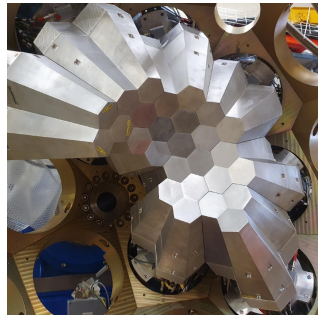
GAMMA @ CSN3: studi di struttura nucleare con tecniche di spettroscopia GAMMA

RL: G.Benzoni

RN: S.Leoni e A.Gottardo

CAMPAGNE SPERIMENTALI COMPLEMENTARI

FASCI (stabili, instabili, neutroni) e APPARATI allo stato dell'arte, ...



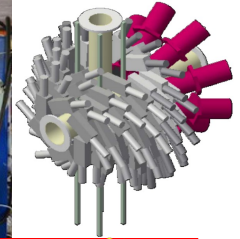
Oslo

JYFL



Separator

DUBNA



GANIL

Orsay

ILL

ISOLDE CERN

Krakow

GSI

LNS

Legnaro

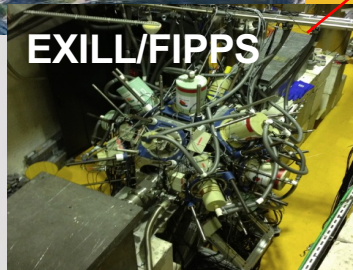
Bucharest



ROSPHERE



OSAKA
RIKEN



EXILL/FIPPS



GALILEO Array at LNL
Working horse for





AGATA: Advanced Gamma Tracking Array based on segmented detectors

Campagna di Fisica @ LNL 2021 → 2026 + ...

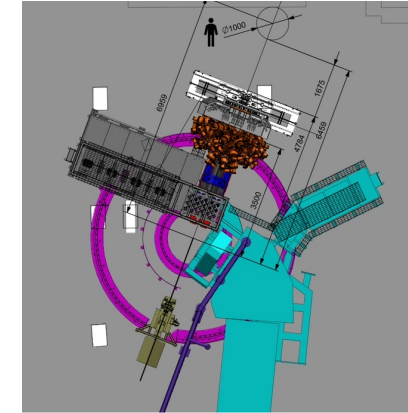
AGATA accoppiata a spettrometro PRISMA

4 campagne di fisica concluse Apr2022 → Lug 2024

Richiesta e uso di ~80% tempo di fascio @ LNL

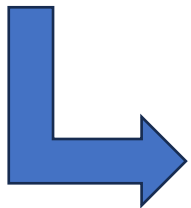
PAC luglio 2024 per prossima campagna

- Impegni nel 2024: supporto per campagna di presa dati
- Presentazione e realizzazione di Proposal a spokes di UniMi e INFN-MI
- Md.S.R.Laskar, assegno di ricercar su AGATA finisce attivita' luglio 2024



2024: Spostamento verso nuova configurazione "stand-alone"

- Progettazione camera di scattering + linea di fascio: ufficio progettazione @INFN-MI, GB
- Nuovo read-out scheme per rivelatori ancillari: S.Brambilla, C.Boiano, S.Capra
- Integrazione con target criogenici: F.Crespi
- Integrazione con Scintillatori: F.Camera e A. Giaz

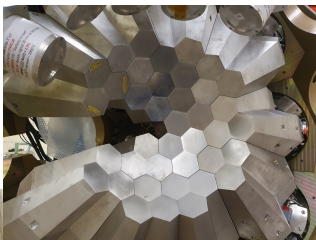


Attivita' sulla nuova configurazione prosegue nel 2025 con pre-installazione
Attivita' di disegno e realizzazione supporti per ancillaries
Test in-beam del nuovo readout system



AGATA: Advanced Gamma Tracking Array based on segmented detectors

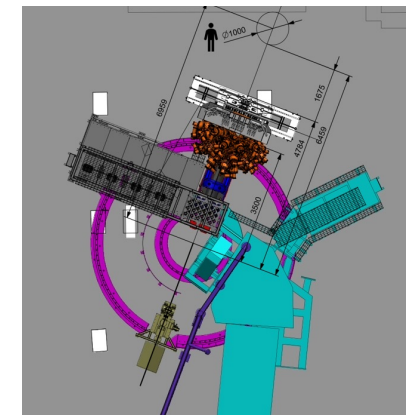
Campagna di Fisica @ LNL 2021 → 2026 + ...



AGATA accoppiata a spettrometro PRISMA

4 campagne di fisica concluse Apr2022 → Lug 2024
Richiesta e uso di ~80% tempo di fascio @ LNL
PAC luglio 2024 per prossima campagna

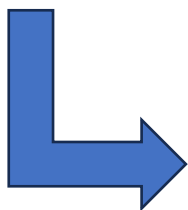
- Impegni nel 2024: supporto per la campagna di fisica
- Presentazione e discussione di nuove proposte di UniMi e INFN-MI
- Md.S.R. L. per la campagna di fisica 2024. AGATA finisce attività' luglio 2024



MOU attivo fino a 2030
Richiesta per 2025: 521 k€ (IVA incl.)
OC 2025: 136 k€ (IVA incl.)

2024: Spostamento della camera di scattering e integrazione "stand-alone"

- Progettazione camera di scattering per il fascio: ufficio progettazione @INFN-MI
- Nuovo read-out scheme per rivelatori ancillari: S.Brambilla, C.Boiano, S.Capra
- Integrazione con target criogenici: F.Crespi
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Attività' sulla nuova configurazione prosegue nel 2025 con pre-installazione
 Attività' di disegno e realizzazione supporti per ancillaries
 Test in-beam del nuovo readout system



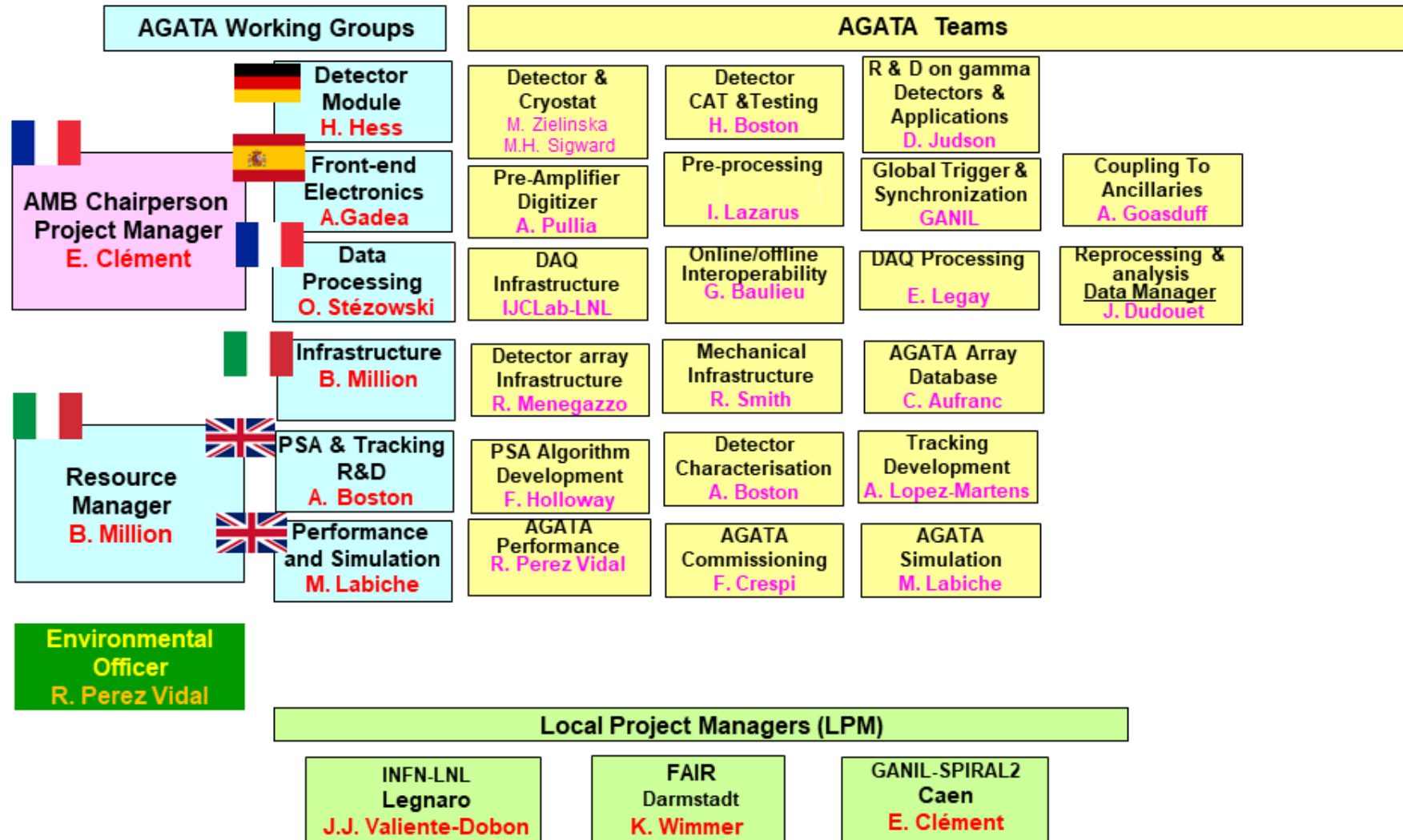
AGATA Management Board and Teams

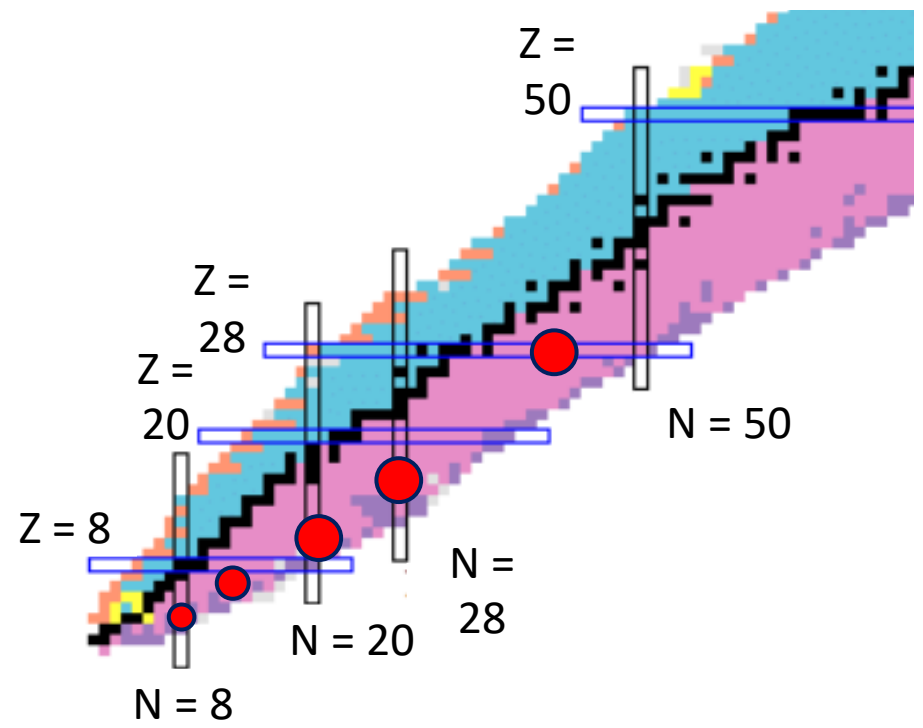
<https://prezi.com/view/6wEXBwIno5QKyLJrBd8H/>

Phase 2

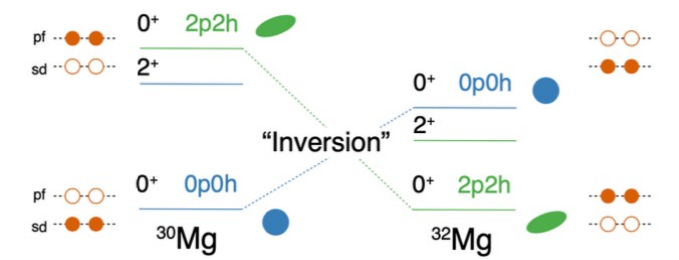
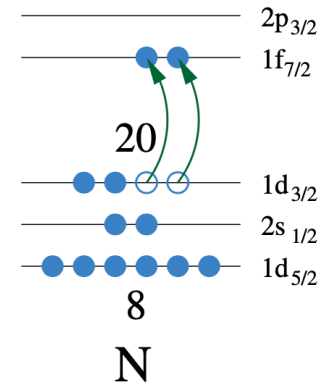
Project Manager / AMB Chairperson

Working Group Chairpersons, ASC Chairperson (A. Bracco) ACC Chairperson (S. Leoni).
LPM-LNL, LPM-GSI, LPM-GANIL J.Nyberg (Dissemination),

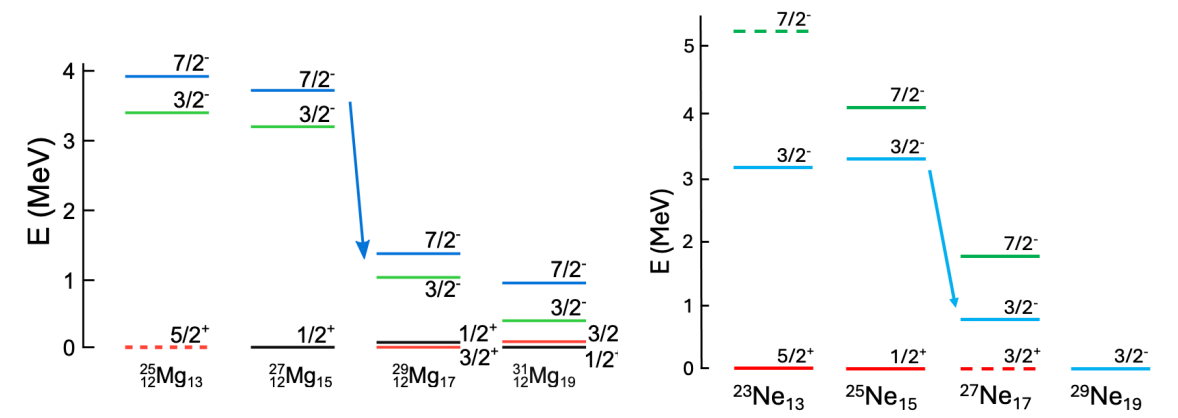




Island of Inversion reduction of the N=20 shell gap



K. Wimmer et al., Phys. Rev. Lett. 105, 252501 (2010)



Eur. Phys. J. Plus (2023) 138:709
<https://doi.org/10.1140/epjp/s13360-023-04249-x>

Regular Article

**THE EUROPEAN
PHYSICAL JOURNAL PLUS**

Nuclear physics midterm plan at Legnaro National Laboratories (LNL)

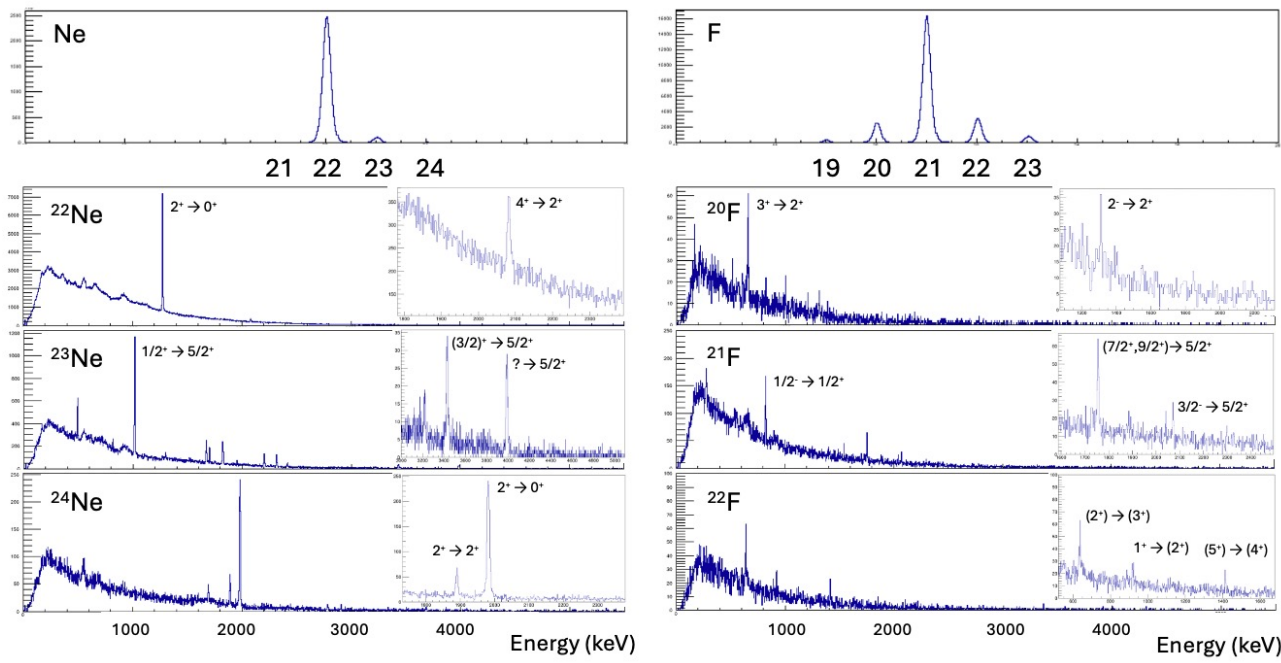
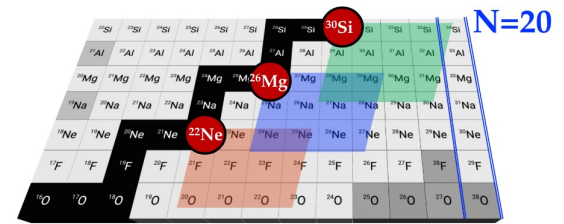
Experimental campaign discussed
in the LNL Mid Term Plan (Phase A)

Working group: Light to medium mass exotic nuclei
Convener: S. Bottoni



Multi-nucleon transfer reactions

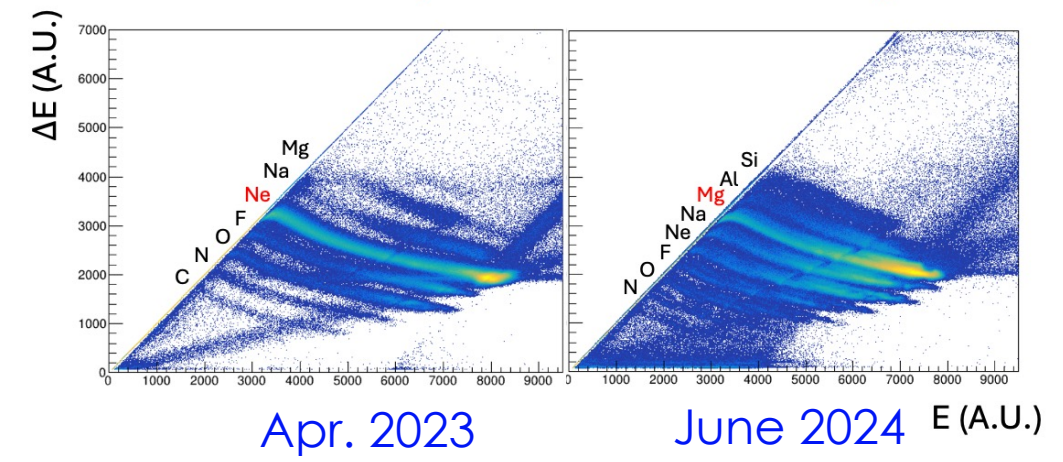
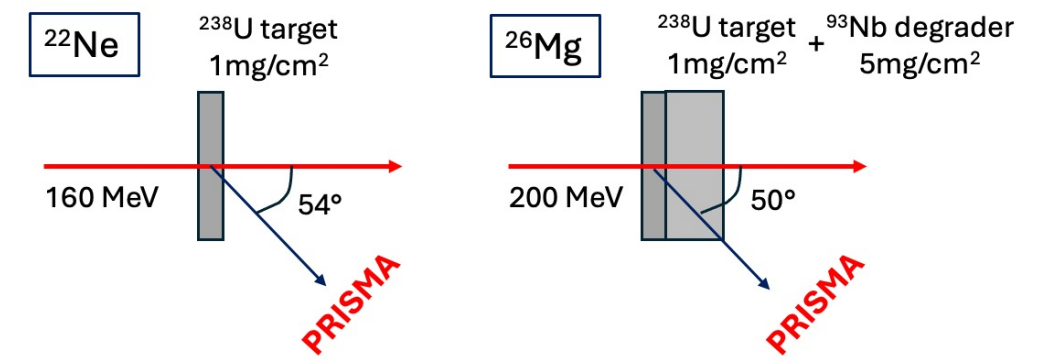
light beams and ^{235}U target



AGATA-PRISMA coincidences
mass reconstruction and Doppler correction

2 experiments performed

K. Wimmer, S. Bottoni, G. Benzoni, P. Aguilera, F. Recchia



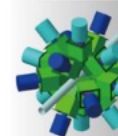
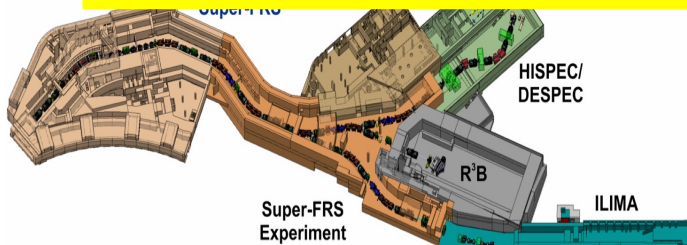
Analysis by F. Drent (GSI), P. Aguilera (UNIPD), **D. Genna (UNIMI)**

HIGHLIGHTS GAMMA 2023: Campaigns at International Labs.



Phase-0 Campaign @GSI started in 2020 (3 exps./year)

- 3 experiments Italian leadership (PhD projects):
 - 1 exp. Run by Italian Gamma Coll. in 2024

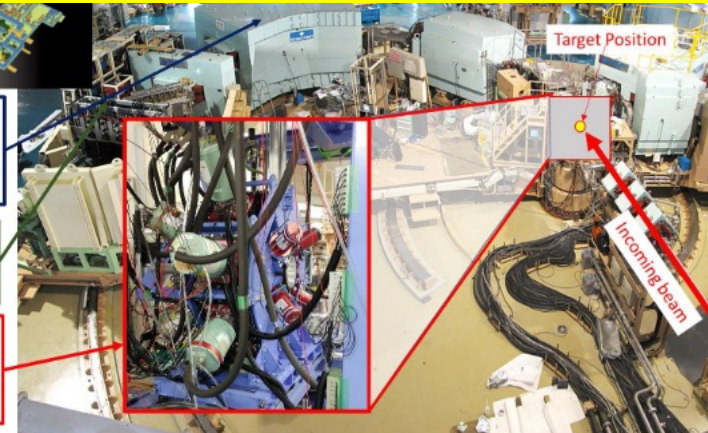


Experimental campaign in Osaka Autumn 2023-24-25
Use of our $\text{LaBr}_3(\text{Ce})$ detectors as part of in-house array

Grand Raiden Spectrometer
Resolution: 37,000
Momentum Byte: 1.05
Acceptance: 5.6 msr

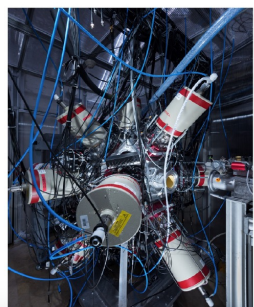
Focal Plane Detector
2 VDC Systems
2 Trigger Scintillators

Gamma Detection System
CAGRA
- 12 CLOVERS
- 4 $\text{LaBr}_3:\text{Ce}$ 3,5"x8"



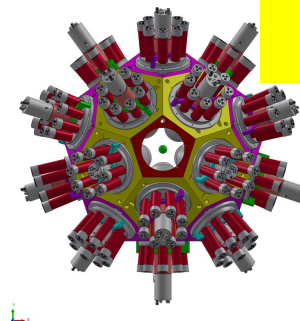
FIPPS

8 Clovers (ILL)
8 Clovers (IFIN-HH)

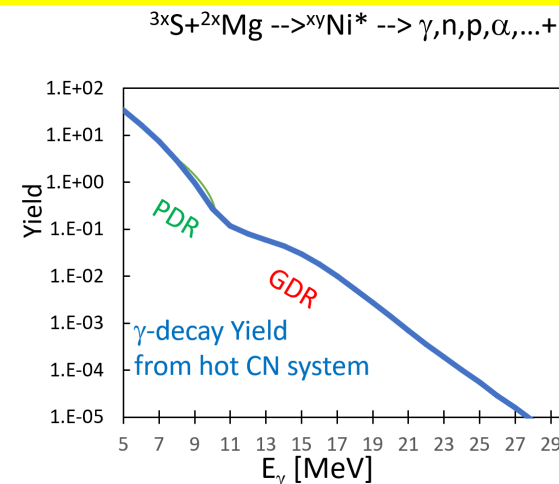


Studies of (n,g) or fission fragments at ILL
Several isotopic chains
 ^{83}Se studies using target developed with CUPID coll. (CSN2)
Program on-going in 2024-25

Studies of Pygmy Resonance states built on hot compound nucleus:
First ever experimental measurement



ELIFANT-GG@IFIN Bucharest
11 3x3 inch $\text{LaBr}_3:\text{Ce}$
10 3x3 inch CeBr_3



LOHENGRIN ^{131}Sb

PHYSICAL REVIEW C 107, 014322 (2023)

Testing the predictive power of realistic shell model calculations via lifetime measurement of the $11/2^+$ state in ^{131}Sb

S. Bottoni^{1,2,*}, E. R. Gamba^{1,2}, G. De Gregorio^{3,4}, A. Gargano⁵, S. Leoni^{6,7}, B. Fornal⁸, N. Brancadori⁹, G. Ciconali^{1,2}, F. C. L. Crespi^{1,2}, N. Cieplicka-Oryńczak⁵, E. W. Iskra⁵, G. Colombi^{1,2,6}, Y. H. Kim^{6,1}, U. Köster⁶, C. Michelagnoli⁵, F. Dunkel⁷, A. Esmaylzadeh⁷, L. Gerhard⁷, J. Jolie⁷, L. Knafle⁷, M. Ley⁷, J.-M. Régis⁷, K. Schomaker⁷ and M. Sferrazza⁸

complementary experiments at LNL, IFIN-HH, ILL

Analysis ongoing in Ni A=60 Region:

(n,γ) at ILL: $^{62,64}\text{Ni}$

1n, 2n, 1p transfer at IFIN-HH with ROSPHERE: $^{62,64,66}\text{Ni}$

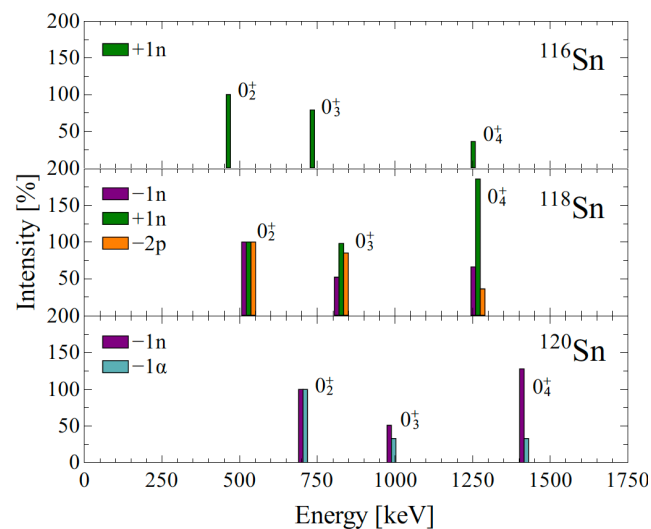
Performed/planned experiments in Ca and Sn A=100 Region:

$^{18}\text{O} + ^{112}\text{Sn} \rightarrow ^{114}\text{Sn}$: lifetime (DSAM and Plunger), ROSPHERE (2022)

$^{32}\text{S} + ^{110}\text{Cd} \rightarrow ^{112}\text{Sn}$: lifetime (Plunger), AGATA+PRISMA (2022)

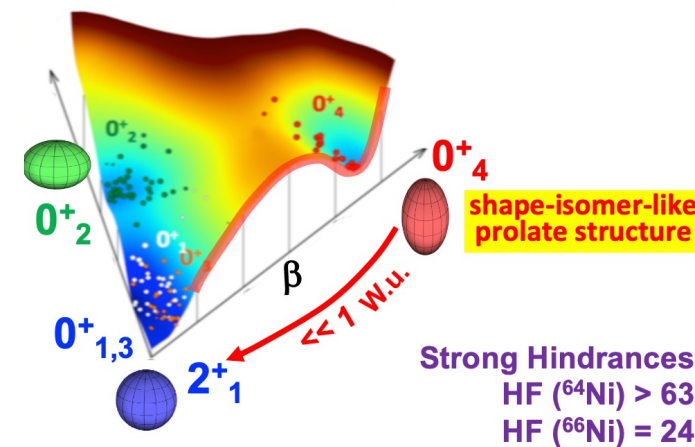
1n, 2n, 2p, (alpha) transfer $\rightarrow ^{114,116,118,120}\text{Sn}$: DSAM, ROSPHERE (2023)

1n transfer $\rightarrow ^{114,116,118,120}\text{Sn}$: lifetime (Plunger), ROSPHERE (2024)



G. Corbari PhD Thesis (Sn Region)
M. Luciani PhD Thesis (Ca Region)

High Potential Energy Barrier



Review

Multifaceted character of shape coexistence phenomena in atomic nuclei

S. Leoni^{a,b,c}, B. Fornal^c, A. Bracco^{a,b}, Y. Tsunoda^d, T. Otsuka^{e,f}

^a Dipartimento di Fisica dell'Università degli Studi di Milano, Italy

^b INFN, Sezione di Milano, Italy

^c Institute of Nuclear Physics PAN, Krakow, Poland

^d Center for Nuclear Study, The University of Tokyo, 7-3-1 Hongo, Bunkyo, Tokyo 113-0033, Japan

^e Department of Physics, The University of Tokyo, 7-3-1 Hongo, Bunkyo, Tokyo 113-0033, Japan

^f RIKEN Nishina Center, 2-1 Hirosawa, Wako, Saitama 351-0198, Japan

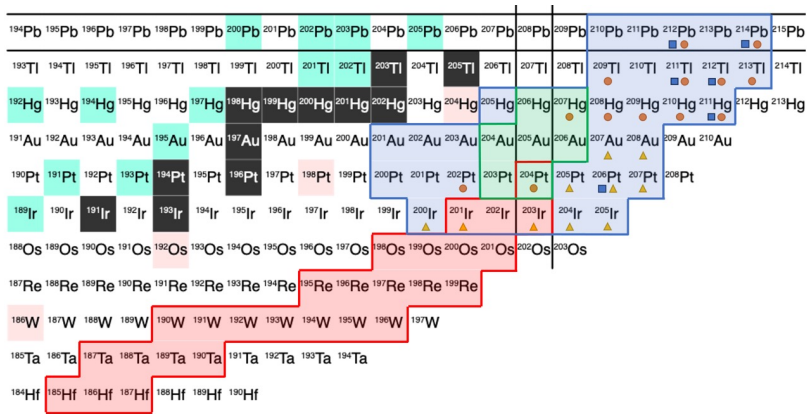
review paper in print

ARTICLE INFO

Keywords:
Nuclear structure
Shape coexistence
Shape isomers
Superdeformed bands

ABSTRACT

This article is devoted to a review of decay properties of excited 0⁺ states in regions of the nuclear chart well known for shape coexistence phenomena. Even-even isotopes around the Z=20 (Ca), 28 (Ni), 50 (Sn), 82 (Pb) proton shell closures and along the Z=36 (Kr), Z=38 (Sr) and Z=40 (Zr) isotopic chains are mainly discussed. The aim is to identify examples of extreme shape coexistence, namely highly deformed structures, well localized in the Potential Energy Surface in the deformation space, which could lead to γ decays substantially hindered. This is in analogy to the 0⁺ fission shape isomers in the actinides region and to the superdeformed (SD) states at the decay-out spin in medium/heavy mass systems. In this survey, the Hindrance Factor (HF) of the E2 transitions de-exciting 0⁺ states or SD decay-out states is a primary quantity which is used to differentiate between types of shape coexistence. The 0⁺ states, examined with the help of the hindrance factor, reveal a multifaceted scenario of shape coexistence. A limited number of 0⁺ excitations (in the Ni, Sr, Zr and Cd regions) exhibit large HF values (>10), some of which are associated with the clear separation of coexisting wave functions, while in most cases the decay is not hindered, due to the mixing between different configurations. Comparisons with theory predictions based on various models are also presented, some of which shed light on the microscopic structure of the considered states and the origin of the observed hindrances. The impact of shape ensembles at finite temperature on the decay properties of highly-excited states (Giant Dipole Resonances) is also discussed. This research area offers a complementary approach for identifying regions where extreme shape coexistence phenomena may appear.

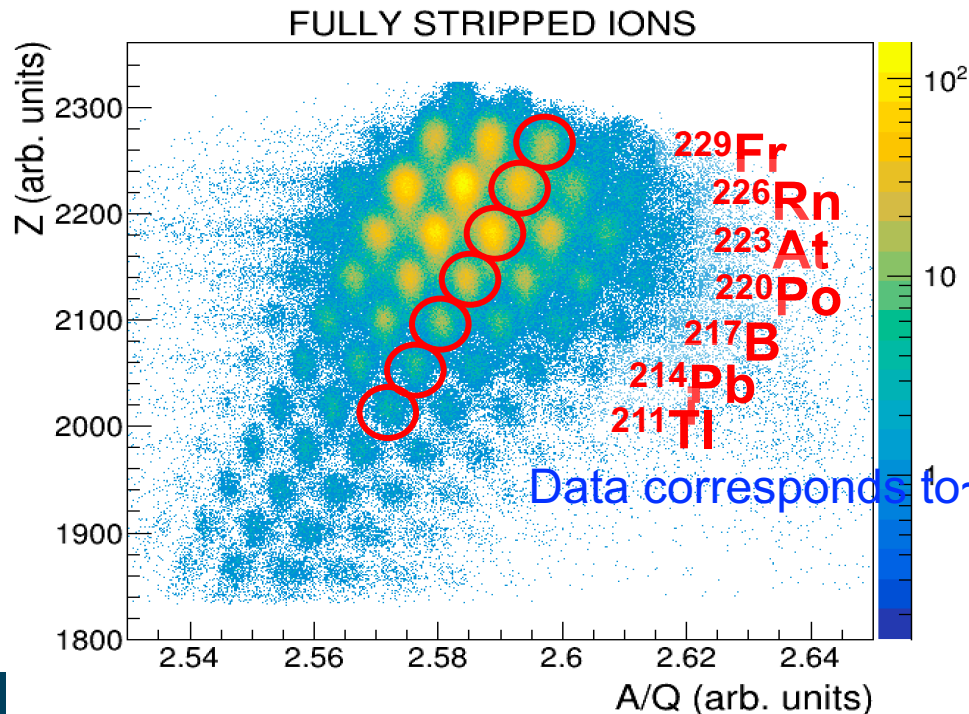


Main goals:

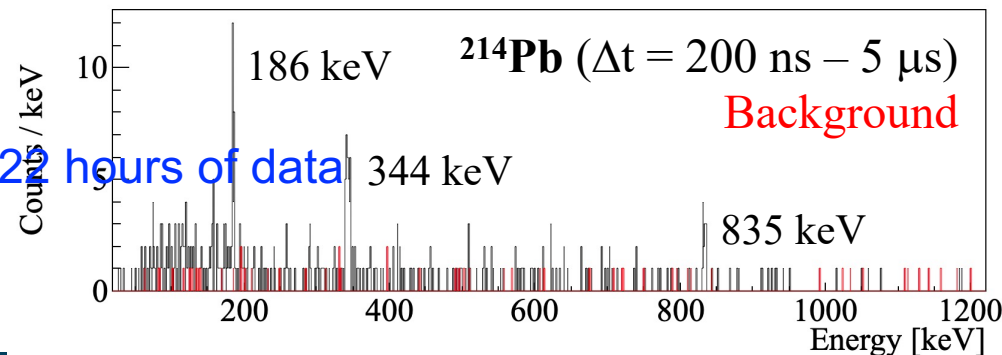
- ⇒ Obtain nuclear properties used as inputs into r-process network calculations
- ⇒ Provide new data to test nuclear models

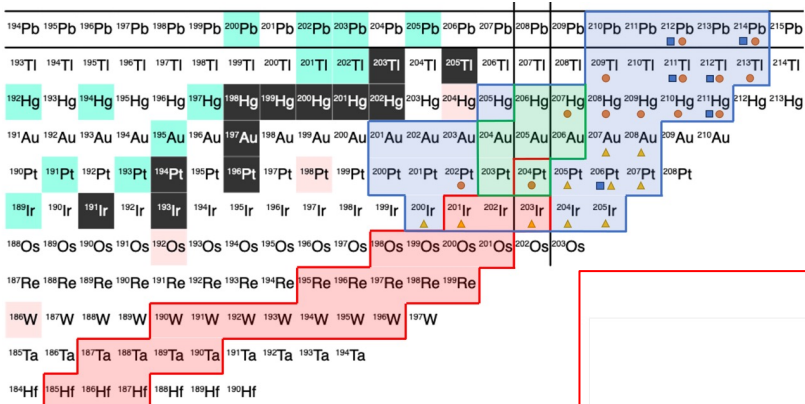
Focus on the Pt isotopic chain:

- Trace the evolution of **decay schemes** between N=122 and N=129
- Search for a **seniority isomer** in ^{206}Pt
- New **β -decay half-lives** measurements in $^{205,206,207}\text{Pt}$ and $^{207,208}\text{Au}$



Experiment performed mid-June 2024
Data analysis to be started





Main goals:

⇒ Obtain nuclear properties used as inputs into r-process network calculations

⇒ Provide new data to test nuclear models

Focus on the Pt isotopic chain:



Marta Poletti ha vinto il Premio Villi per la migliore tesi di dottorato in fisica...

Domenica, 21 Aprile 2024

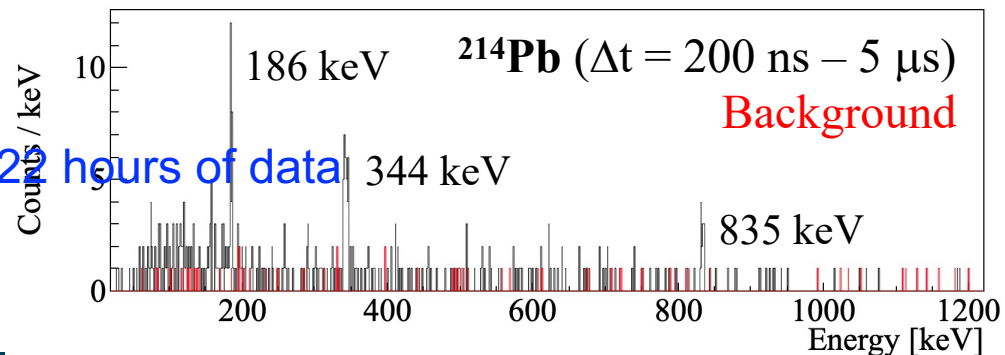
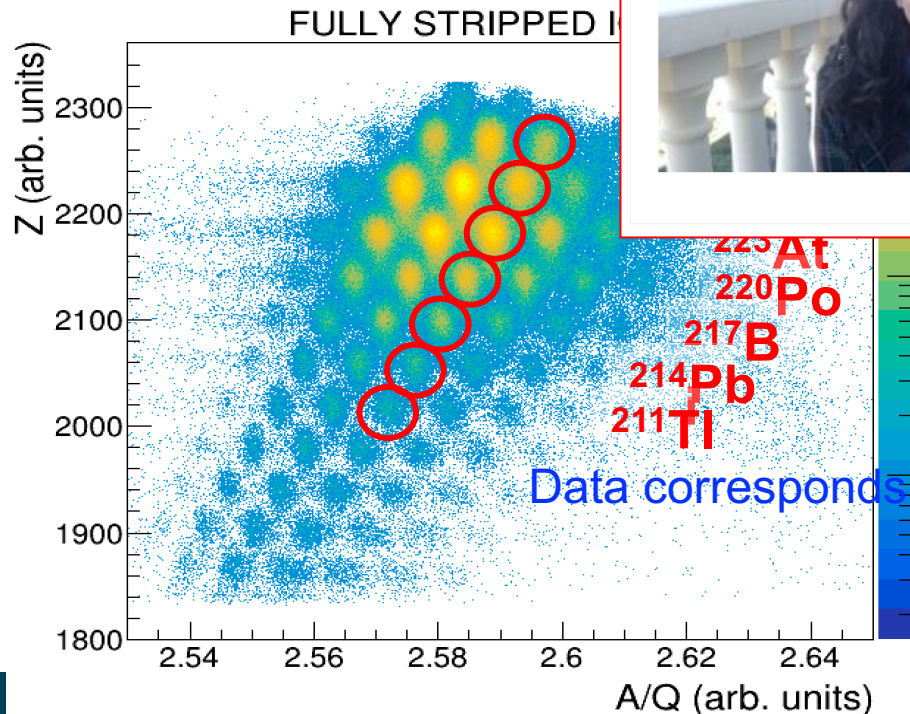
La nostra studentessa Marta Poletti e' stata selezionata come vincitrice del Premio Villi, assegnato annualmente dalla CSN3 dell'INFN, per la migliore tesi

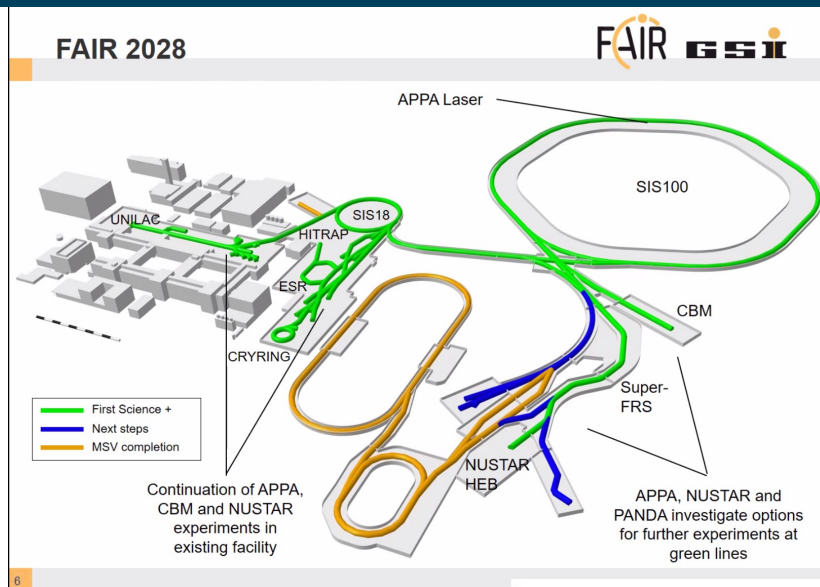
2024

[1](#) [2](#) [3](#) [4](#) [5](#)

between N=122 and N=129

205,206,207Pt and 207,208Au

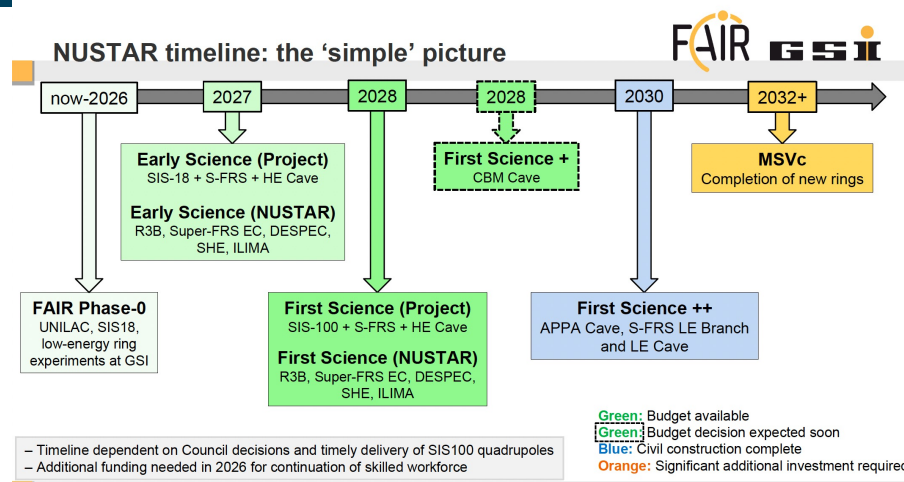




6



- **HISPEC/DESPEC** (High-Resolution in-flight Spectroscopy/Decay Spectroscopy)
- **R³B** (Reactions with Relativistic Radioactive Beams)
- **MATS** (Precision Measurements of very short-lived nuclei using an Advanced Trapping System)
- **LaSpec** (Laser Spectroscopy)
- **ILIMA** (Isomeric Beams, Lifetimes and Masses)
- AIC
- **ELISe** (Electron-Ion Scattering in a Storage Ring)
- **EXL** (Exotic nuclei studied in light-ion induced reactions at the NESR storage ring)
- **Super-FRS Experiments**
- **SHE** (Super-Heavy Element Research)



C-MOU:

- final version to be released end of June
- Already got approval from INFN legal office → INFN ready to sign
- 31 Senior members from 6 divisions (Mi-Pd-LNL-Ct-LNS-Na)
- Covering years 2025-2028

Total 207 k€ → **annual FEE of 51.75 k€**

HISPEC-DESPEC Collaboration Agreement:

- Signed by INFN on 06/06/2024
- 26 Senior Members from 3 divisions (Mi-Pd-LNL)
- **Yearly Fee of 14.4 k€**

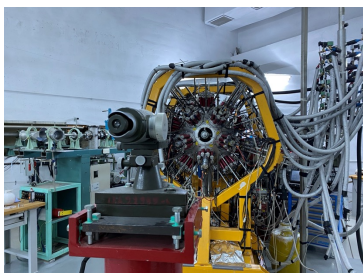
Activity on Pygmy and Giant Resonances

Spokespersons:

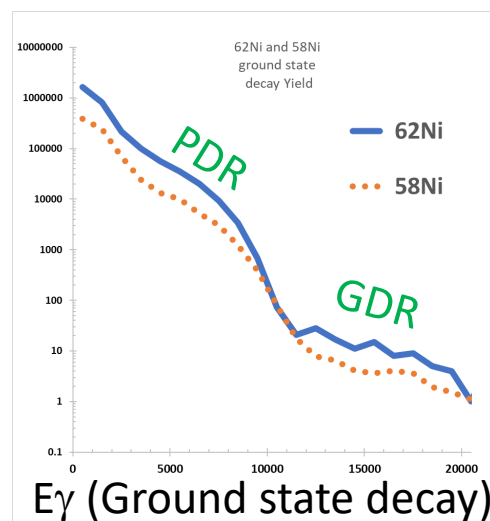
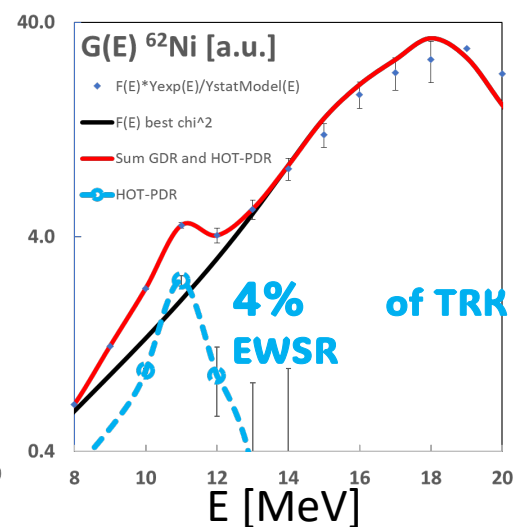
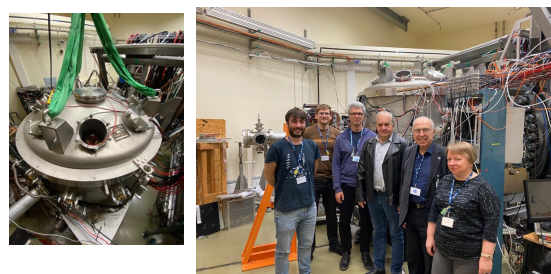
O.Wieland & A.Giaz, F.Crespi, F.Camera

- Pygmy states: oscillation of neutron excess against core
- Important to follow at increasing N/Z
- Proved existence at T=0 by several techniques in several systems
- **Population of Pygmy states at increasing T in Ni isotopic chain**
- **Comparison of data-sets at 2 locations**

ELIGANT @ IFIN-HH (T>0)



KRATTA+PARIS+LABr3@Cracovia



Activity on Pygmy and Giant Resonances

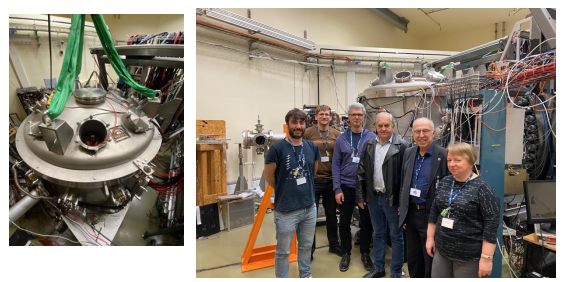


- Pygmy states: oscillation of neutron excess against core
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ELIGANT @ IFIN-HH (T>0)



KRATTA+PARIS+LABr3@Cracovia



Spokespersons:

O.Wieland & A.Giaz, F.Crespi, F.Camera

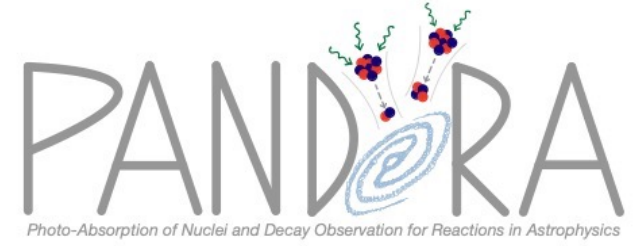
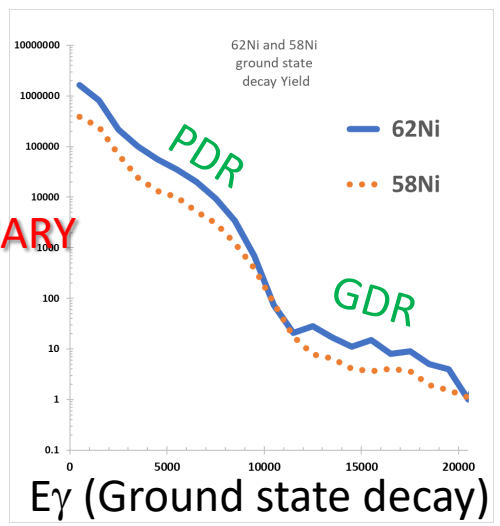
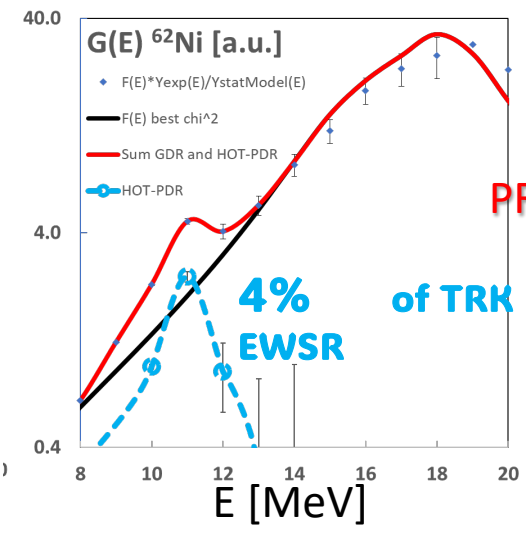


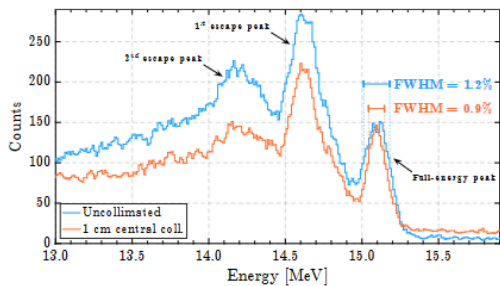
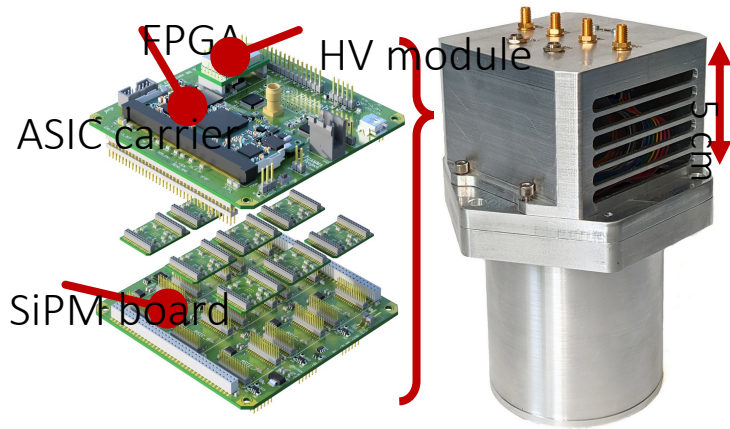
Photo-Absorption of Nuclei and Decay Observations for Reaction in Astrophysics



- ~ Extragalactic propagation of ultra-high energy cosmic rays (UHECRs)
- ~ Nuclear Structure = electric dipole strength distribution: PDR, GDR, EDP

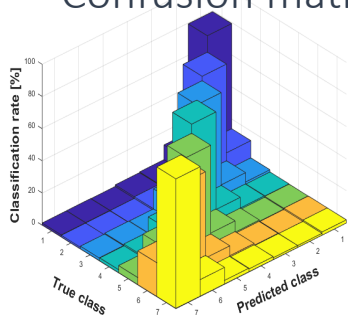


Test sotto fascio per scintillatore $\text{LaBr}_3:\text{Ce}:\text{Sr}$ letto da SiPM



ML algorithms to derive position sensitivity

Confusion matrix (1D)

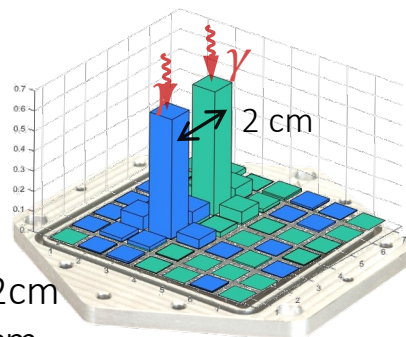


Decision Tree

- Mean error: 0.47cm
- RMS error: 1.08cm

Neural Network

- Mean error: 0.42cm
- RMS error: 1.02cm



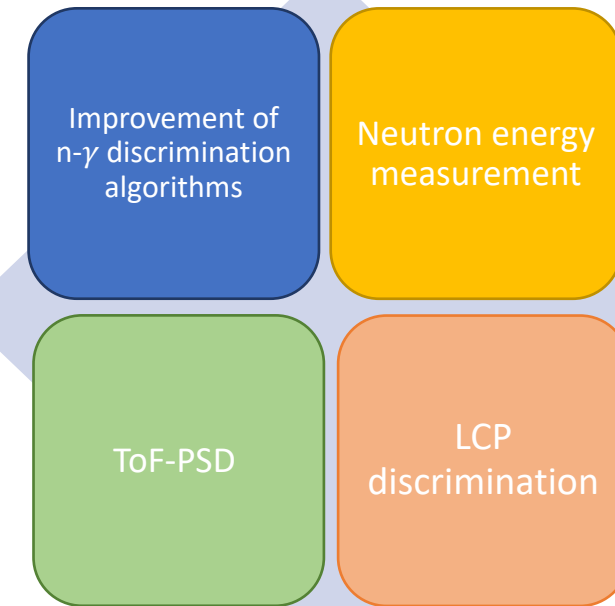
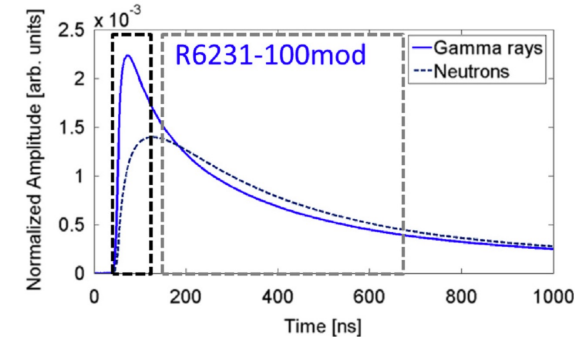
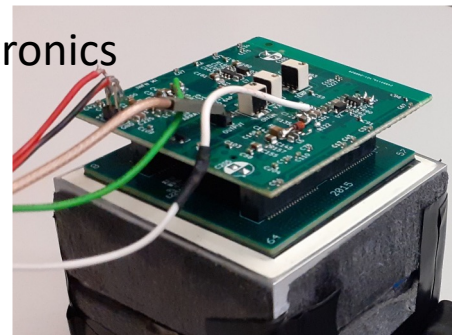
Attività' di R&D di rivelatori / readout / DAQ

New activity on ClyC detectors for g-n discrimination

SiPM readout for PARIS phoswich det.

→ test sotto fascio @ AGATA

- 2" x 2" x 2" LaBr_3 (first part of the crystal)
- 2 inch sensL matrix, signal as a sum of 64 SiPM (6x6 mm)
- Thermal compensation
- Dedicated electronics



Consuntivi 2023:

Budget : **1276.50 KE**

Researchers: **46.22 FTE (61 people)**

Technologists: **5.25 FTE (12 people)**

5 INFN divisions (MI-Pd-LNL-Fi-Pg)

MI: **27 persone / 19.4 FTE**

➔ aumento in 2024 per N3G

Budget Mi: **796 (+25 SJ) KE**

96 publications (DOI indexed)

31 Thesis (BT/MT/PhD)

~130 talks to Conferences

Consuntivi attivita' 2023:

ITALIA

Budget : **1276.50 KE**

Researchers: **46.22 FTE (61 people)**

Technologists: **5.25 FTE (12 people)**

5 INFN divisions (MI-Pd-LNL-Fi-Pg)

MILANO

27 persone / 19.4 FTE

→ aumento in 2024 per N3G

Budget Mi: **821 KE**

96 publications (DOI indexed)

31 Thesis (BT/MT/PhD)

~130 talks to Conferences

Richieste economiche 2025:

Consumo	45 k€	di cui	7 k€	s.j.
Trasporti	0 k€	di cui	0 k€	s.j.
Inventariabile	14.5 k€	di cui	0 k€	s.j.
SPServizi	151 k€	di cui	0 k€	s.j.
Apparati**	649 k€	di cui	20 k€	s.j.
Riparazioni/licenze	5 k€	di cui	0 k€	s.j.
Σ		<u>864.5 k€</u>	di cui 7 k€	s.j.

Missioni **125 k€**

**** su APPARATI Milano: PARIS MoU (48 k€), GRIT MoU (30 k€), AGATA MoU (551 k€) 3π configuration in 10 years (total investment: 5.5 M€)**

Richieste di Servizi:

- Officina meccanica: 10 mesi/uomo
- Servizio Progettazione: 12 mesi/uomo
- Elettronica: 12 mesi/uomo (C.Boiano)