



Stato e richieste degli esperimenti di Gruppo III Padova

Daniele Mengoni

<https://www.pd.infn.it/it/gruppo3-fisicanucleare/>

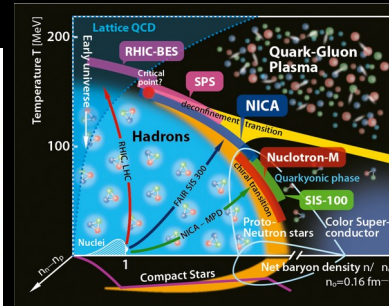
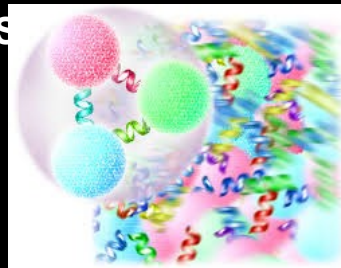
Segreteria: Marina Andreazzo

Daniele Mengoni – DFA/INFN Pd
Consiglio di Sezione INFN
Padova, 04 Luglio 2024

6 research lines: 26 exps

1. QUARKS AND HADRON DYNAMICS

ePIC (BNL), JLAB12 (JLAB), KAONNIS (LNF) MAMBO (Mainz-Bonn), ULYSSES (JPARC)



2. PHASE TRANSITION IN HADRONIC MATTER: ALICE (CERN), NA60+(CERN)

3. NUCLEAR STRUCTURE AND REACTION MECHANISM:

EXOTIC, FORTE, GAMMA, NEWCHIM, NUCL-EX(DTZ), NUMEN_GR3, PRISMA_FIDES (LNS, LNL, GANIL, RIKEN....)

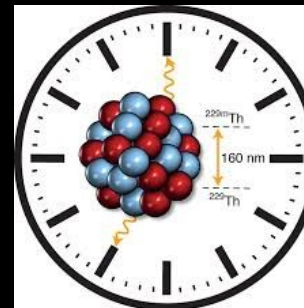


4. NUCLEAR ASTROPHYSICS: ASFIN2, ERNA, LUNA (LNGS), n_TOF, PANDORA (LNS, LNL, LNGS, CIRCE, CERN...)

5. FUNDAMENTAL INTERACTIONS:

ASACUSA (CERN), AEGIS (CERN), LEA (CERN), JEDI (Bonn), VIP (LNGS), FAMU (RAL)

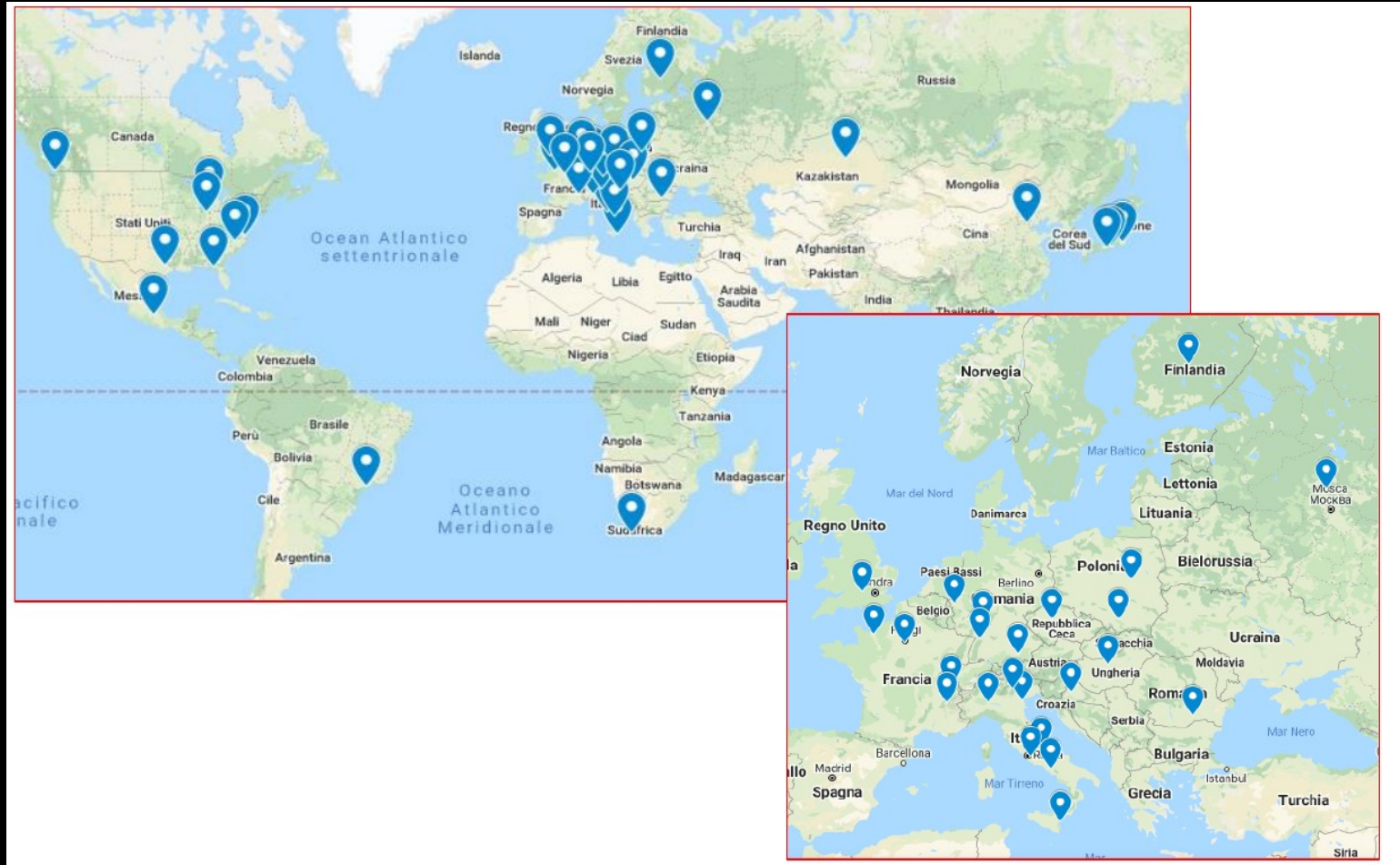
	These generations of matter (fermions)			
	I	II	III	
mass	2.4 MeV/c ²	1.27 GeV/c ²	173.3 GeV/c ²	9.1 GeV/c ²
charge	2/3	2/3	2/3	0
spin	1/2	1/2	1/2	1
name	up	charm	top	photon
	u	c	t	γ
Quarks				
mass	4.8 MeV/c ²	94 MeV/c ²	4.2 GeV/c ²	80.4 GeV/c ²
charge	-1/3	-1/3	-1/3	0
spin	1/2	1/2	1/2	1
name	down	strange	bottom	gluon
	d	s	b	g
Leptons				
mass	0.511 MeV/c ²	105.7 MeV/c ²	1.777 GeV/c ²	81.9 GeV/c ²
charge	-1	-1	-1	0
spin	1/2	1/2	1/2	1
name	electron	muon	tau	Z boson
	e	μ	τ	Z ⁰
				W boson
				W [±]



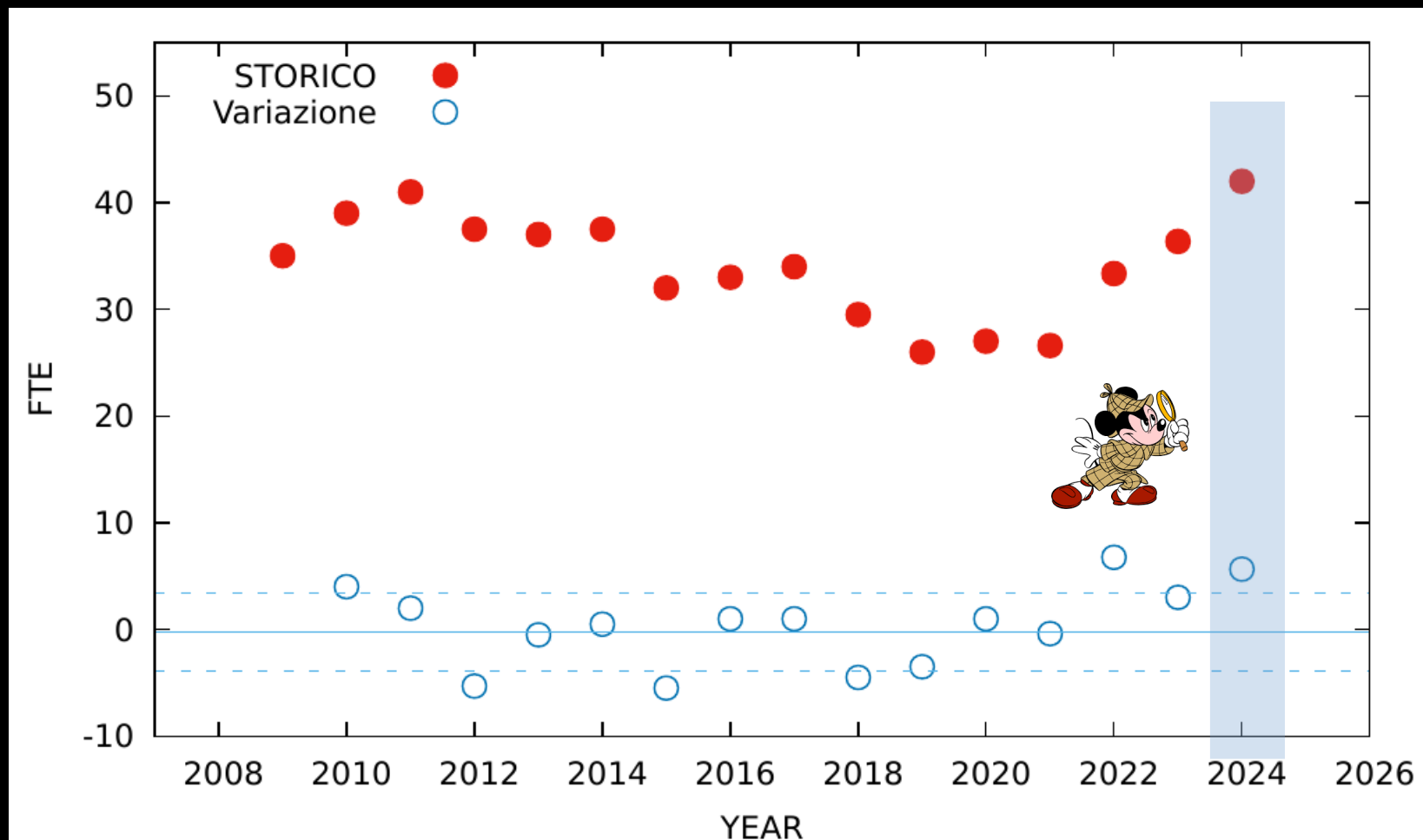
6. APPLICATIONS AND SOCIETAL BENEFITS:

TORIO (GE), FOOT (GSI,CNAO,TIFPA), SPES_MED

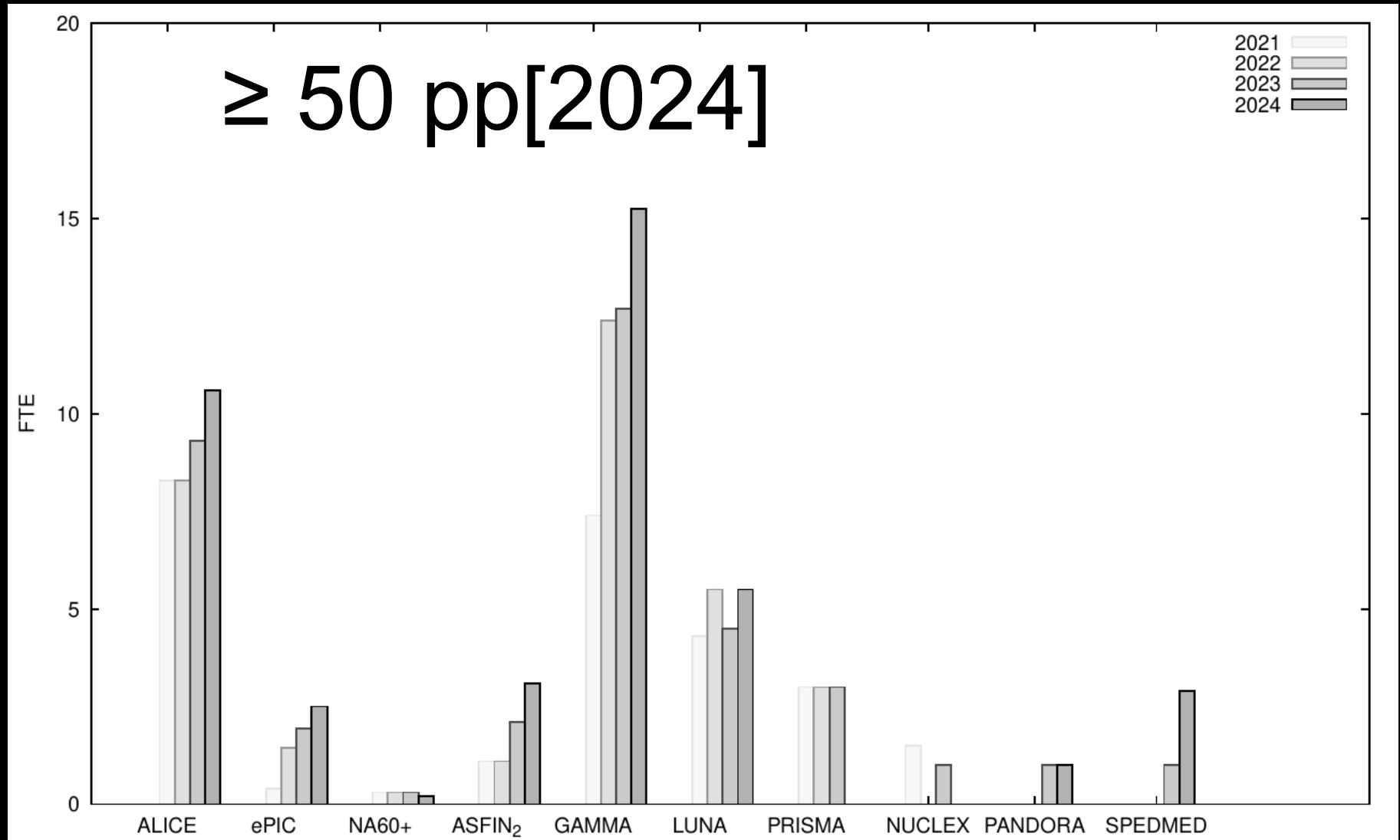
CSN3 National/International activity



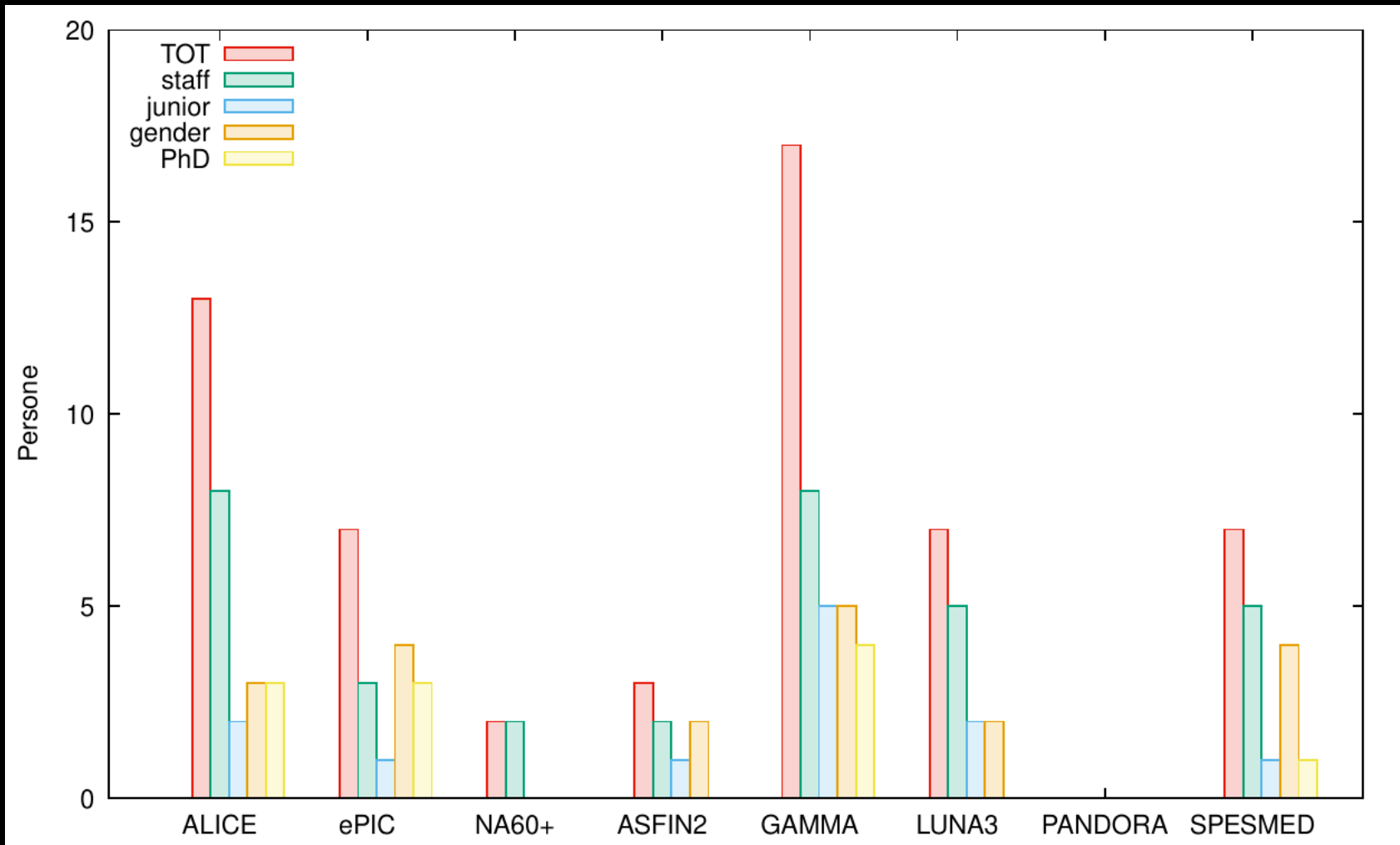
STORICO (da validare, 24/06)



Stat (42 FTE, +5.6 FTE wrt 2023)

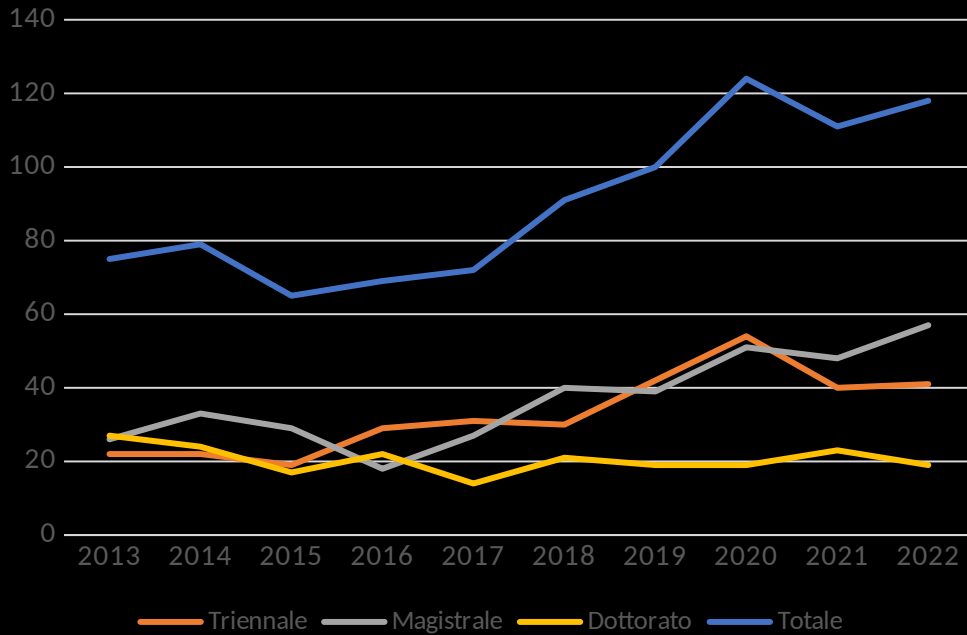


Composizione dei gruppi

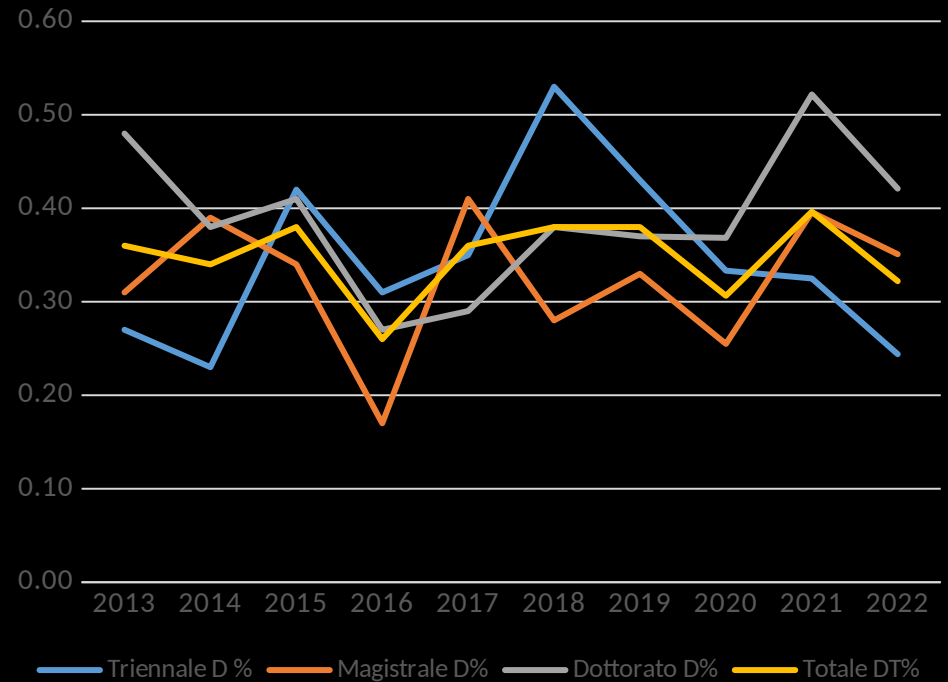


GLV_23 CSN3

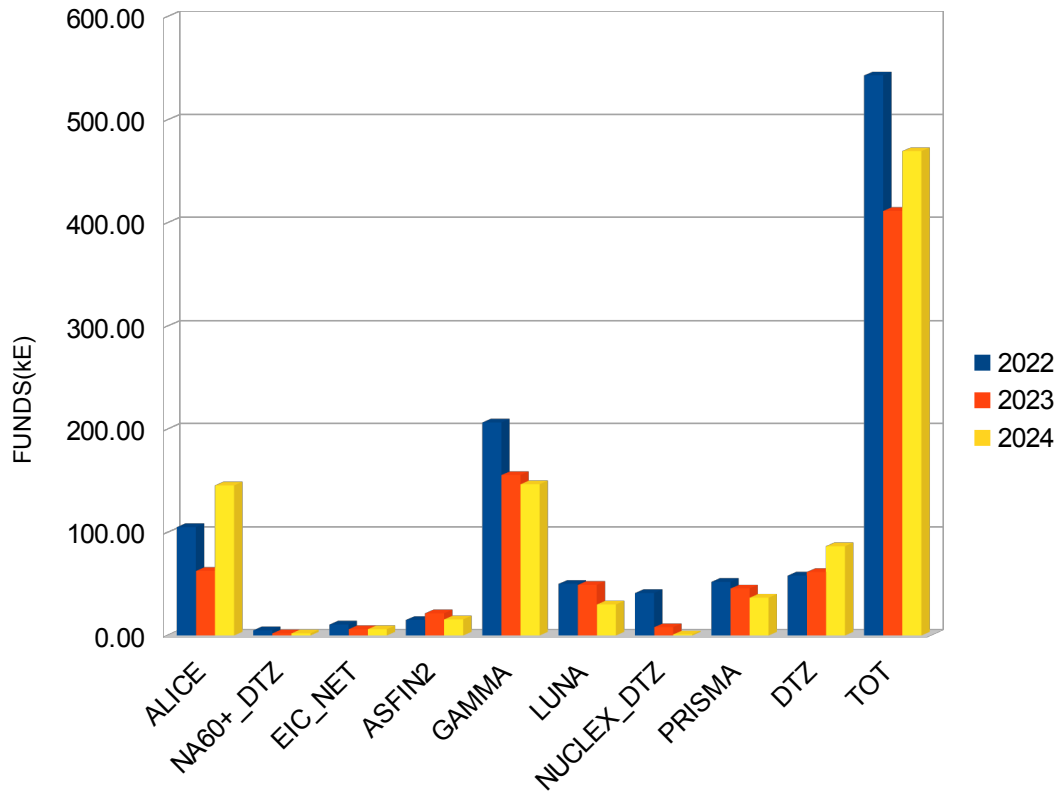
Numero Tesi



Tesi: componente femminile



Fondi



~500 kE/Y

[2024]~50 pp, ~40 FTE

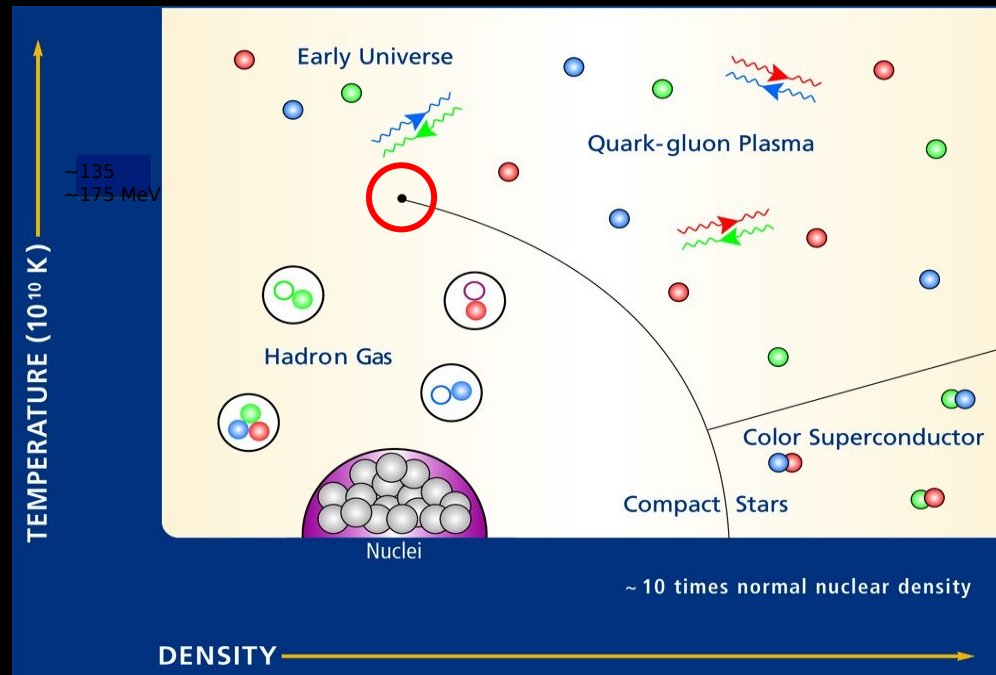
→ ~10 kE/PP

75% sono incaricati/associati
INFN

+Common funds (MoFAB
etc/MoU): ~100 kE ALICE e ~100
kE AGATA (già scalati su PD)

1 Quarks and hadron dynamics

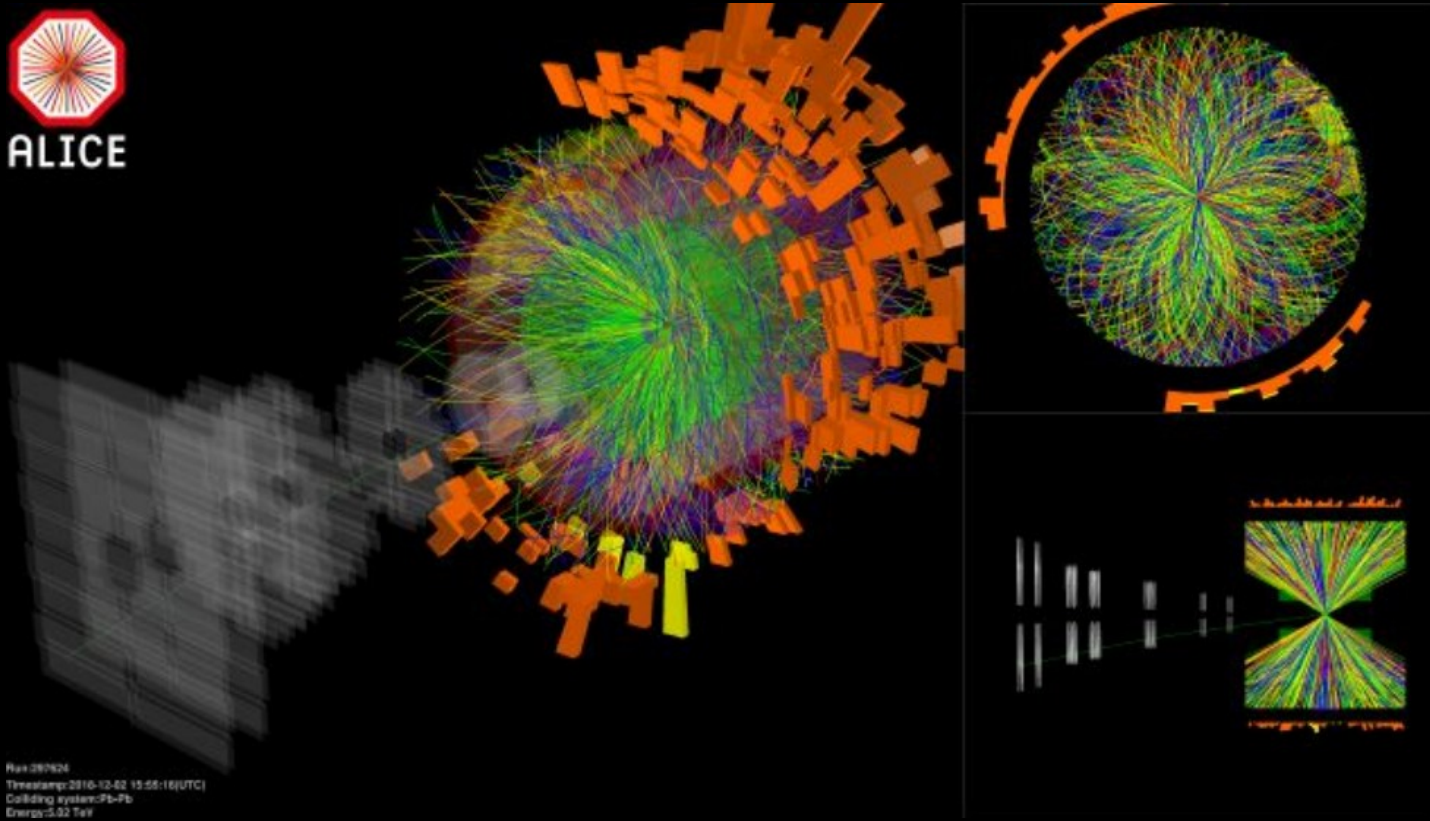
2 Phase transitions of nuclear and hadronic matter



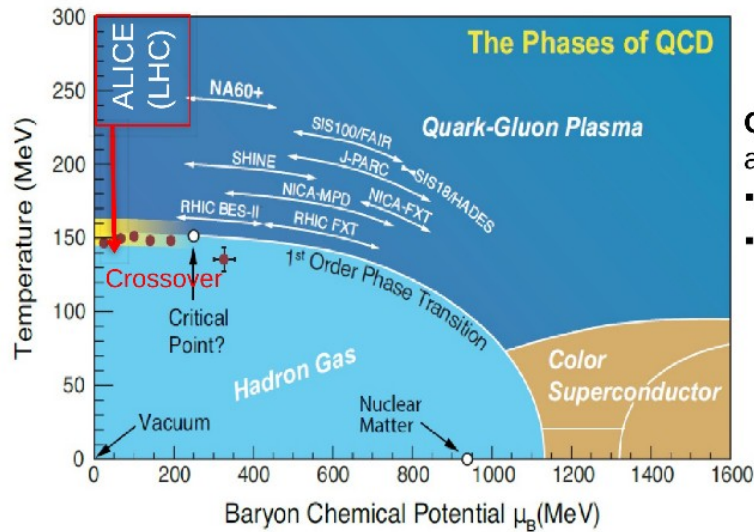
ALICE



Run 2016a
Timestamp: 2016-02-02 15:55:16(UTC)
Colliding system: Pb-Pb
Energy: 5.02 TeV



Introduzione

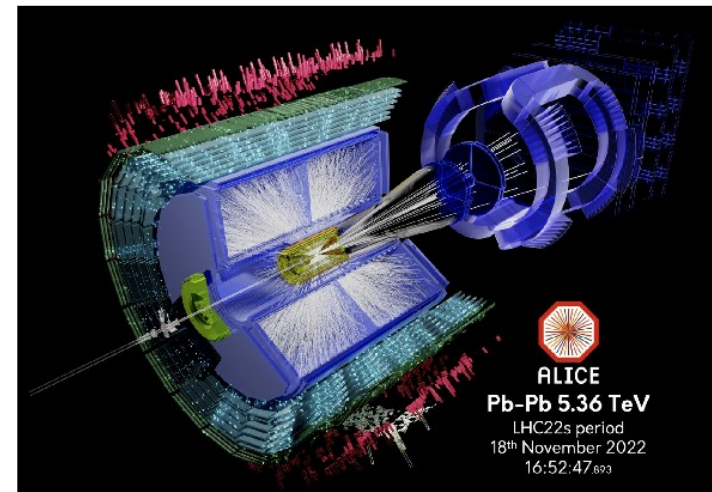


Quark-Gluon Plasma: stato della materia adronica ad alta densità di energia, in cui viene meno il confinamento.

- Sistema “macroscopico” di quark e gluoni interagenti
- Accesso a proprietà fondamentali QCD: confinamento, meccanismi di interazione, origine “dinamica” massa quark costituenti e particelle.

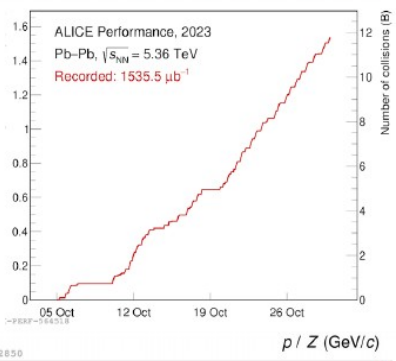
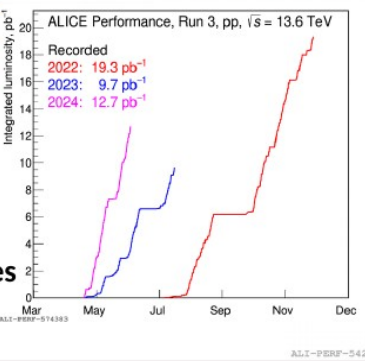
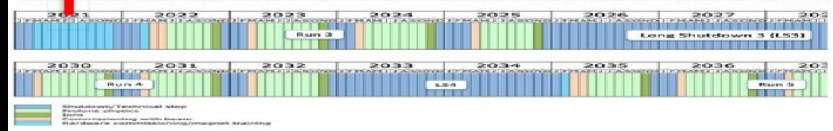
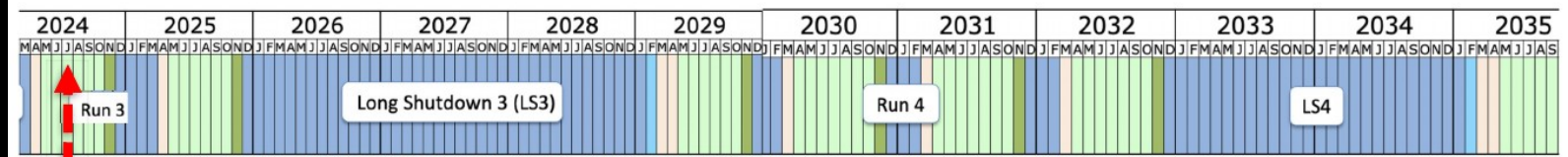
Focus del gruppo ALICE-Padova: studio del QGP attraverso gli effetti che manifesta sui **quark pesanti (c e b)**, prodotti all’inizio della collisione

- attraversano tutte le fasi del sistema e sono chiaramente identificabili nello stato finale
- Ruolo centrale rivelatori “di vertice” a **pixel di silicio** → **SPD, ITS upgrades, ALICE3**



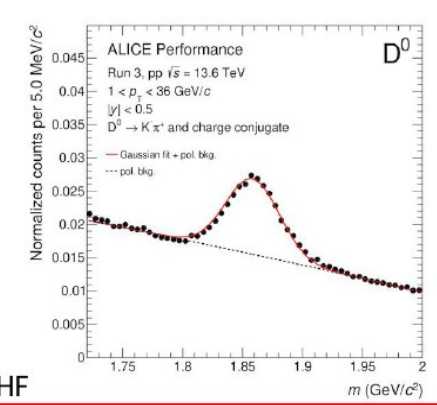
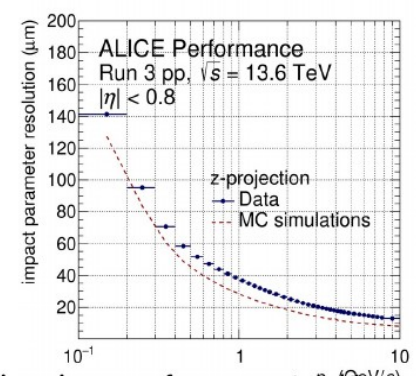
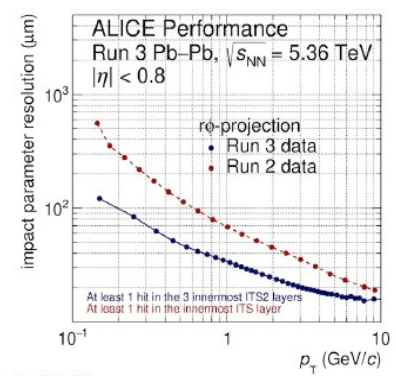
Event display pilot beam Pb-Pb 5.36 TeV, novembre 2022

Attività ultimo anno e status attuale



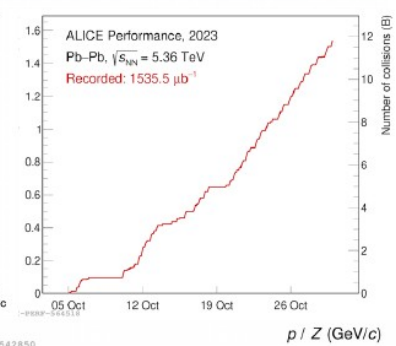
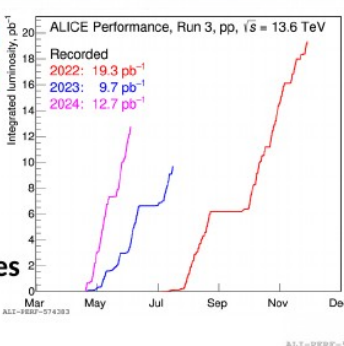
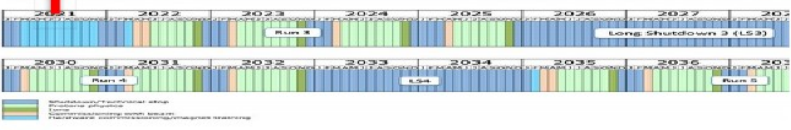
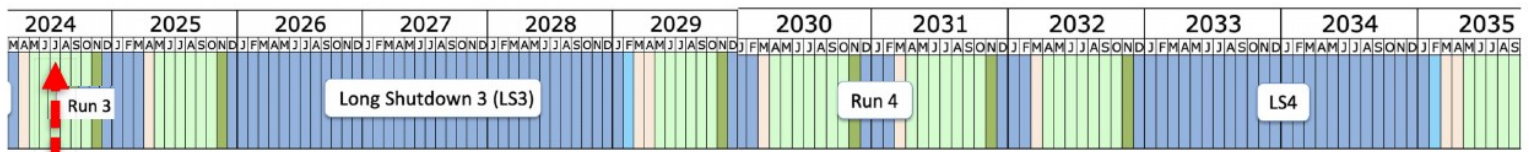
In the middle of Run 3
 Data-taking in continuous (triggerless) readout
2023: run pp 13.6 TeV, primo run Pb-Pb a 5 TeV (1.5 nb⁻¹)
Gain in statistics by ~x1000 (pp) x7 (Pb-Pb) for most observables
2024: run pp 13.6 TeV (in corso) + run pp e Pb-Pb 5 TeV
2025: pp 13.6 TeV, pp, Pb-Pb 5 TeV, O-O e p-O

Upgrade (Run3): miglioramento risoluzione spaziale di un fattore ~2 [5] per $p_T < 1$ GeV/c nel piano trasverso [lungo i fasci]
 Risoluzione migliore di 40 μm per $p_T > 1$ GeV/c -> charm e beauty
 Studio differenze residue dati-MC ancora in corso



Gruppo PD: contributo importante alla caratterizzazione performance tracking e segnali HF

Attività ultimo anno e status attuale

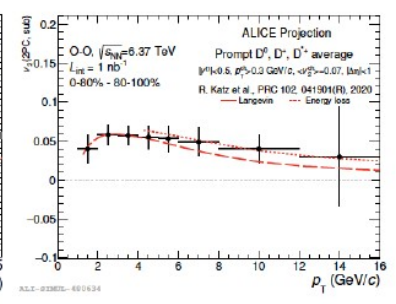
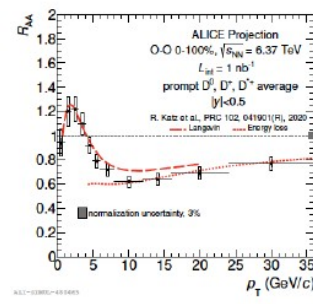


In the middle of Run 3
 Data-taking in continuous (triggerless) readout
 2023: run pp 13.6 TeV, primo run Pb-Pb a 5 TeV (1.5 nb^{-1})
 Gain in statistics by $\sim x1000$ (pp) $x7$ (Pb-Pb) for most observables
 2024: run pp 13.6 TeV (in corso) + run pp e Pb-Pb 5 TeV
 2025: pp 13.6 TeV, pp, Pb-Pb 5 TeV, **O-O e p-O**

Principali motivazioni per O-O e p-O (public note, <https://cds.cern.ch/record/2765973>):

- 1) Capire come mai in “piccoli sistemi” (pp e pA) si osservino valori significativi di anisotropia azimutale, tipici di un sistema fortemente interagente come il QGP ma non segnali di perdita di energia delle particelle energetiche ->O-O sistema intermedio tra p-Pb e Pb-Pb periferico
- 2) Studio sezioni d'urto per fisica dei raggi cosmici

Gruppo PD: contributo a motivazioni di fisica
 (A. Dainese, A. Rossi)



Risultati di fisica (focus gruppo PD)

Separazione J/ψ prompt e J/ψ da decadimenti di B

JHEP 02 (2024) 066 , H. Sharma

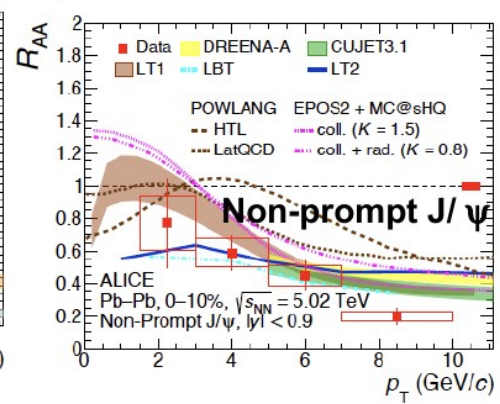
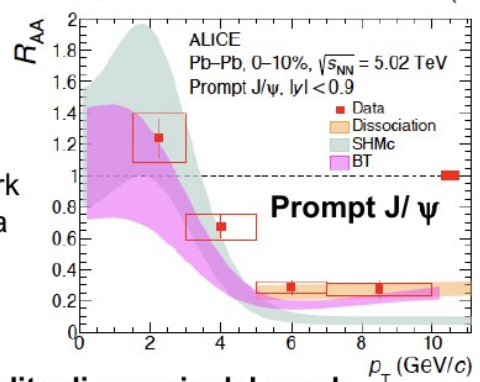
Prompt J/ψ

- dissociazione domina ad alto p_T :
Debye screening del potenziale attrattivo nel QGP -> soppressione
- rigenerazione per coalescenza di quark charm inizialmente scorrelati domina a basso p_T

Conferma 2 evidenze storiche del QGP

Non-prompt J/ψ

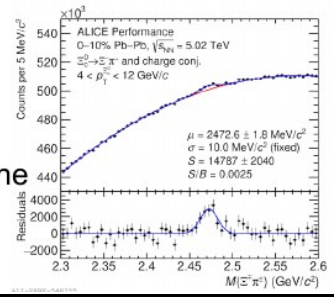
- Vincoli a modelli di trasporto e perdita di energia del quark beauty, prevista minore rispetto a charm, quark leggeri e gluoni



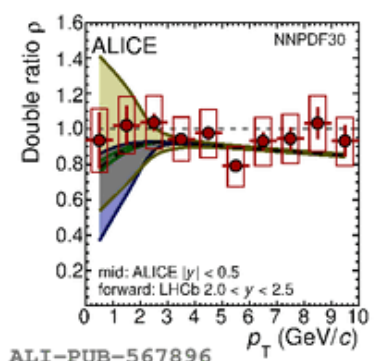
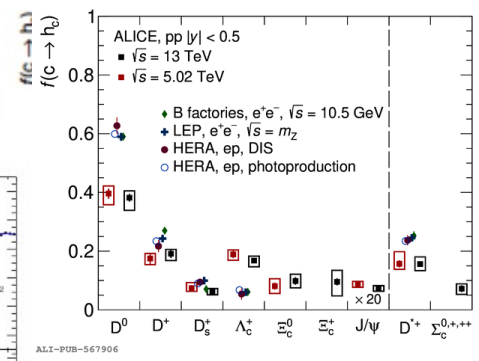
Articolo riassuntivo misure di produzione di mesoni e barioni con charm in Run 2

- molti più barioni in pp:** adronizzazione tramite processi aggiuntivi rispetto alla sola frammentazione che descrive e^+e^-

Studio fenomeno per barioni con charm e stranezza (Ξ_c) in corso in Pb-Pb: prima osservazione di sempre in AA (J. Zhu)



JHEP 12 (2023) 086



- vincoli a PDF tramite "doppio rapporto": mid(ALICE)/forward(LHCb) rapidity a 13/5 TeV

Preventivi 2025: anagrafica e ruoli

Snapshot Luglio 2024

	2024 (N)	2024 (FTE)	2025 (N)	2025 (FTE)
Ricercatori + PhD	11	8.4	13	10.1
Tecnologi	4	0.8	4	0.8

Nuovi membri, uscite (rispetto a Luglio 2024)

• **Ricercatori e assegnisti:** Antinori (90%→100%), Dainese (90%), Chiappara (70%, assegnista), Giubilato (70%), Lunardon (30%), Mattiazzo (70%), Rossi (80%→90%), Sharma (100%, assegnista), Soramel (70%), Turrisi (70% → 50%), Zhu (100% → 0%)

Dottorandi: Pantouvakis (70%), Rignanese (100%), M. Zhang (100%, cotutela Wuhan, attesa conferma)

Tecnologi: Benettoni (20%), Guang Meng (30%), Rebesan (20%), Sgaravatto (10%)

In arrivo dopo Luglio (non conteggiati): Peng, Singh (post-doc bando INFN per stranieri), Wu (PhD Unipd, se conferma CSC)

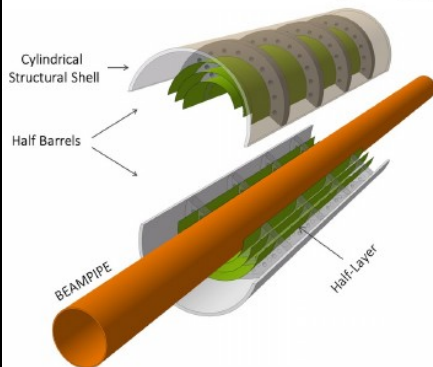
Responsabilità nella collaborazione:

- Antinori: Responsabile Nazionale
- Dainese: Upgrade Coordinator
- Rossi: ITS3-upgrade physics performance (coordinatore), Collaboration Board (membro)
- Turrisi: deputy responsabile nazionale calcolo

Articoli ALICE ultimi 12 mesi ~71 (66 in tutto il 2023, 24 in 2024)

Contributo diretto gruppo di Padova: 4 (+ 4-5 come coord. o revisione)

Upgrade: ITS3 per run 4



Design innovativo (evoluzione di ITS2), nuova tecnologia

- sensori a pixel di silicio delle dimensioni del wafer (⇌ tecnica dello stitching), tecnologia 65 nm TJ, pixel pitch $\sim 22 \times 22 \mu\text{m}^2$
- ultrasottili ($\sim 50 \mu\text{m Si}$, $\langle x/X_0 \rangle_{\text{layer}} \sim 0.07\%$), elettronica ai bordi, basso consumo ($< 40 \text{ mW/cm}^2$), raffreddamento ad aria
- sensori curvati a forma di semi-cilindri

Stato del progetto

- 2019 Lol (Dainese editor): <http://cds.cern.ch/record/2703140>
- 2023 Public Note (Rossi ed.) su Phys. Perf. estende Lol <https://cds.cern.ch/record/2868015?ln=en>
- 2024 Febbraio: TDR avallato da LHCC <https://cds.cern.ch/record/2890181?ln=it>
- Memorandum of Understanding proposto, in fase di approvazione

→ Da R&D a fase di costruzione (costo core tot. $\sim 3800 \text{ kCHF}$ 2024-2027)

- Tecnologia e disegno innovativo → caratterizzazione, sviluppo, e ricerca (specifici per il progetto) anche fase di costruzione

Sviluppi ITS3 cruciali per NA60+ e EPIC

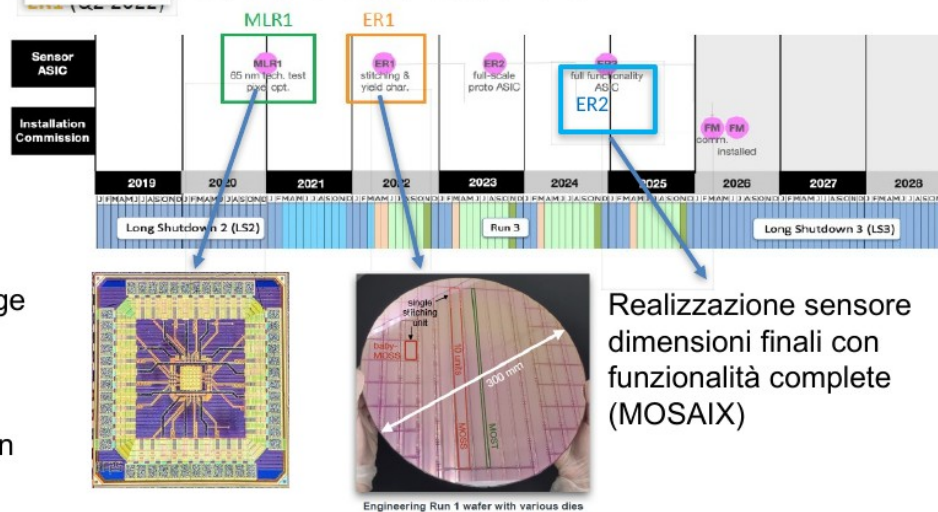
Ancora parziale sinergia

Attività a Padova per 2025:

Test in sezione su matrici di medie dimensioni da sottomissione ER1 (Mattiazzo)

Responsabilità coordinazione work-package sviluppo read-out (Giubilato)

Rossi coord. work-package Physics performance, reconstruction and simulation



Realizzazione sensore dimensioni finali con funzionalità complete (MOSAIX)

ALICE 3

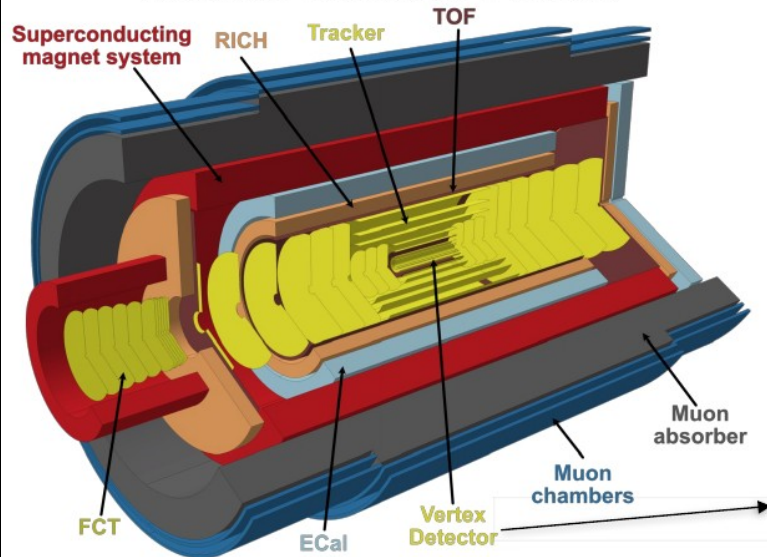
Letter of intent approvata da LHCC a Marzo 2022 (F. Antinori tra i main editors)

“A next generation heavy-ion experiment at the LHC”, <https://cds.cern.ch/record/2803563>.

- Rivelatore compatto e leggero, con tracciatore al silicio e rivelatore di vertice retrattile dentro la beam pipe.
- PID (Si TOF, RICH) + Muoni + ECal
- Accettazione grande

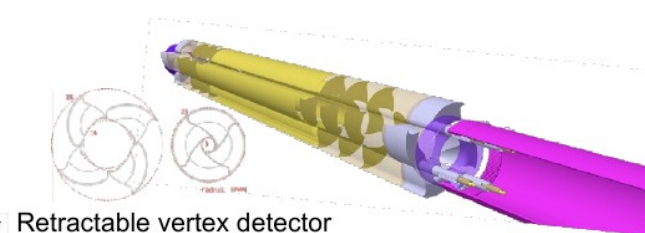
Run 5 (2035), timeline

- 2023-2025: selezione tecnologie prototipi di piccola scala, R&D
- 2026-2027: prototipi di grande scale, TDR
- 2028-2030: costruzione e test
- 2033-2034 installazione in caverna



Ultimo anno/in corso:

- Definizione Work Packages (13 in tutto) (A. Dainese upgrade coord.)
- **Scoping document:** definizione linee R&D, piano delle risorse
- R&D



ALICE3: contributo gruppo PD

Interessi principali gruppo di Padova

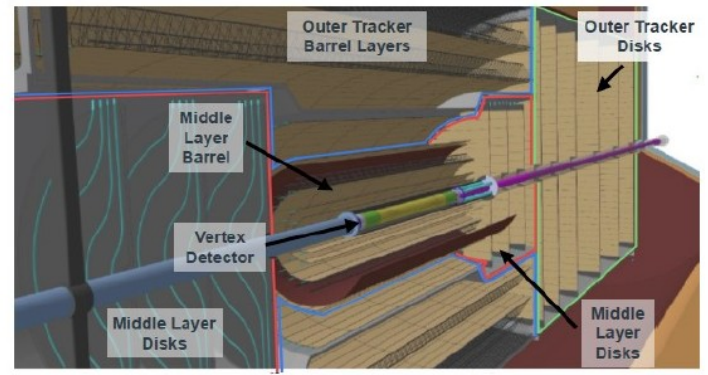
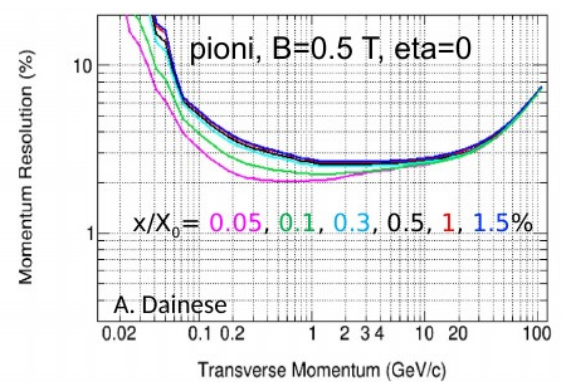
Silicon tracker: middle layers ($7 < R < 20$ cm)
(+ vertex detector)

Continuazione di R&D per ITS3

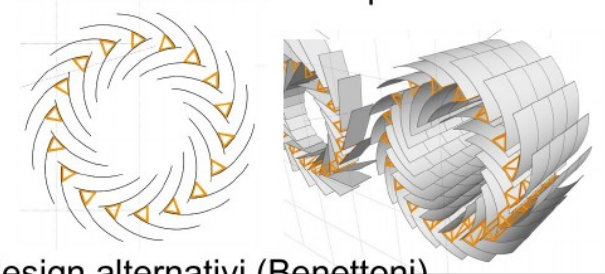
Attività:

1) Valutazione diverse geometrie middle layers

- Base (Lol): standard staves
- Layer curvi (à la ITS3)
→ minor material budget
(risoluzioni spaziali e momento)



- **Proposta e valutazione geometrie alternative e innovative (P. Giubilato)**
- Ricerca compromesso ottimale tra esigenze di
 - Modularità con sensori non troppo grandi (~12 cm)
 - continuità con ITS3 (Low material budget, bending) per coprire accettazione con minor superficie di silicio possibile



2) Meccanica

- in corso valutazioni preliminari (stabilità, cooling, etc.) design alternativi (Benettoni)
- (in via di definizione) contributo ad attività middle layers

Richieste per 2024

Capitolo	Richiesta
Trasferte	~95 k€
Apparati	0 k€
Consumo	15 k€

Missioni:

Valore da parametri ALICE-Italia in base a FTE e responsabilità + attività in ITS (inclusi upgrades)

Essenzialmente trasferte al CERN per riunioni e presa dati + lavori per ITS3

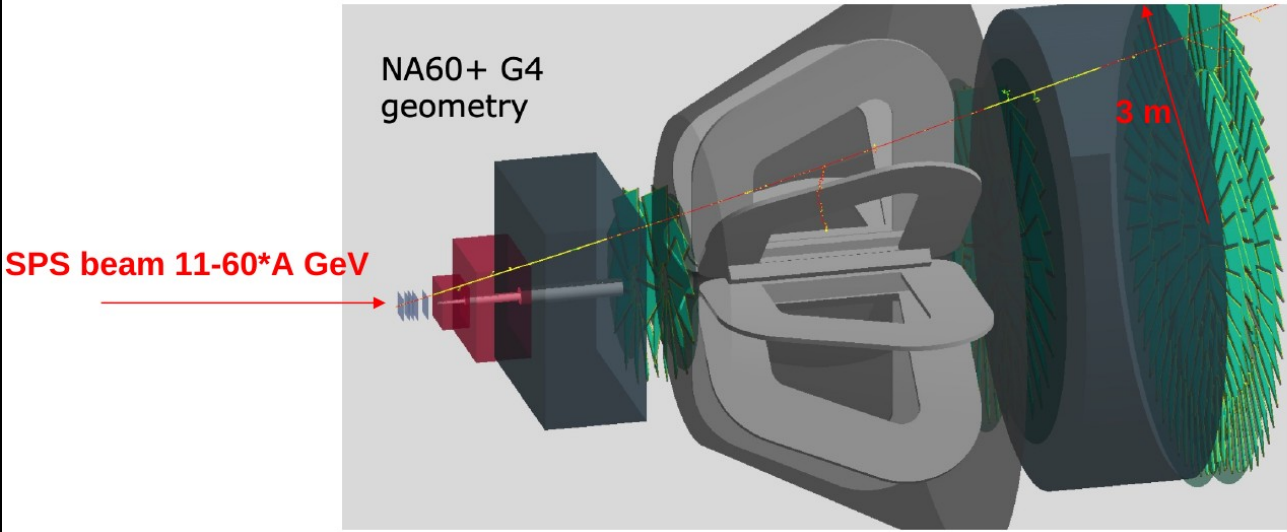
Consumo: ~10 k€ per ALICE3 + 5 kCHF per macchina CERN (turni)

In corso: valutazione richiesta fondi per ITS3, comunque entro envelope già disussa con referee

Servizio Sezione	Richiesta
Officina elettronica	6 m.u.
Officina meccanica	2 m.u.
Ufficio tecnico	2 m.u.



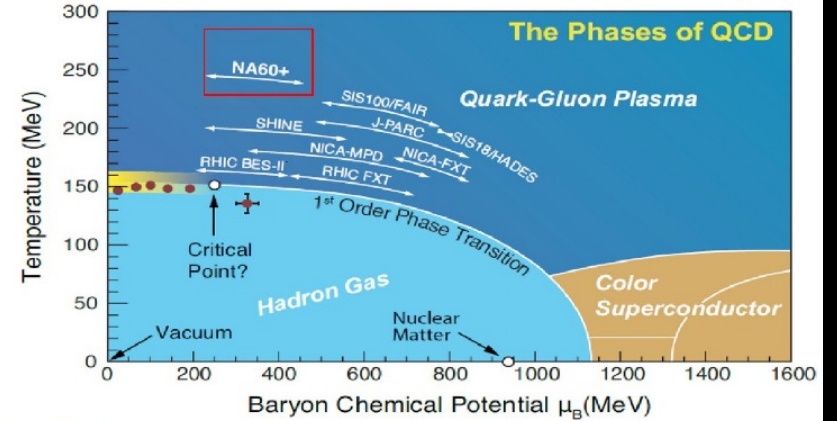
NA60+





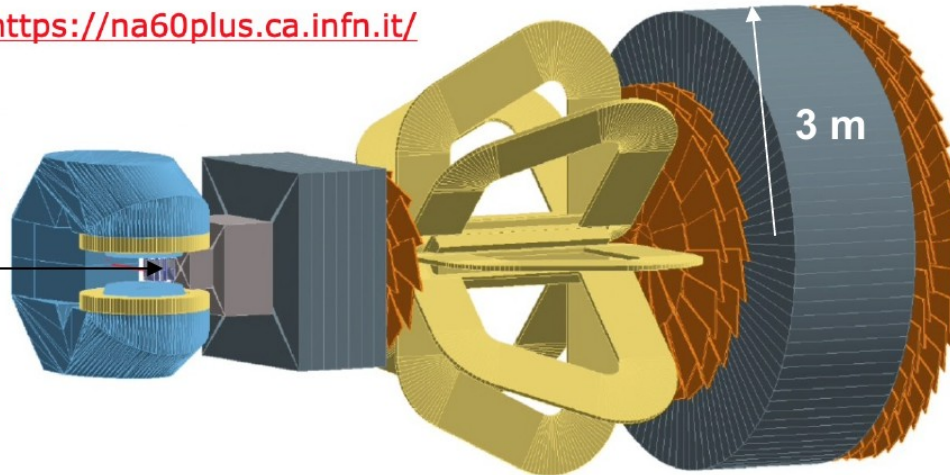
NA60+

- Fixed-target experiment at the CERN SPS
- Dimuon spectrometer with a silicon tracker
- Study QGP properties at lower temperature and higher baryon density than at LHC
- Look for onset of colour deconfinement



<https://na60plus.ca.infn.it/>

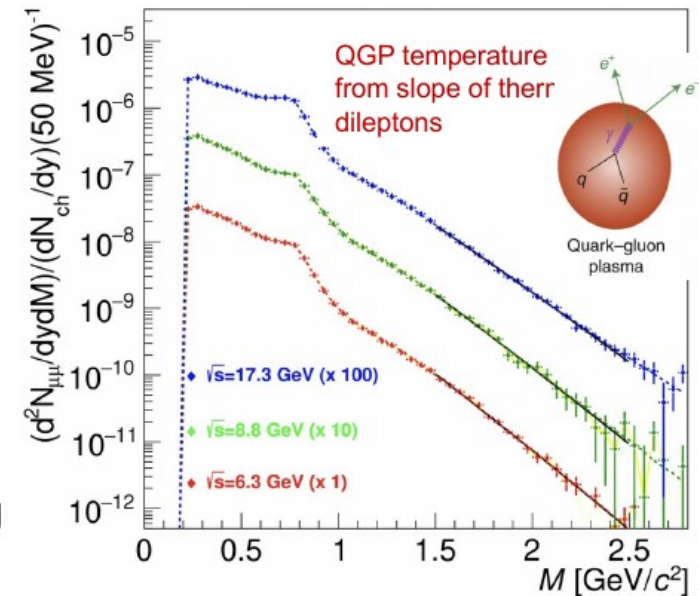
**SPS Pb beam
11-60 A GeV**





NA60+: activities 2024 and 2025

- Letter of Intent approved by SPS Committee in spring 2023
 - <https://cds.cern.ch/record/2845241>
- Main physics goals:
 1. Caloric curve of strongly-interacting matter with thermal radiation (dimuons)
 2. Chiral symmetry restoration with ρ - a_1 meson mixing
 3. Charm production and diffusion coefficient close to critical QCD temperature
 4. Onset of J/ψ suppression due to colour screening
- **Technical Proposal in preparation, submission at the beginning of 2025**

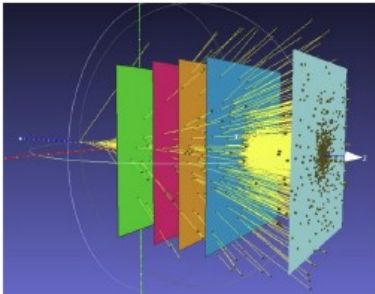


Energy (GeV)	Thermal pairs	T_{slope}
6.3	$3.52 \cdot 10^6$	$166 \pm 4.7 \pm 1$
8.8	$3.56 \cdot 10^6$	$169 \pm 4.4 \pm 1$
17.3	$9.70 \cdot 10^6$	$182 \pm 1.8 \pm 1$

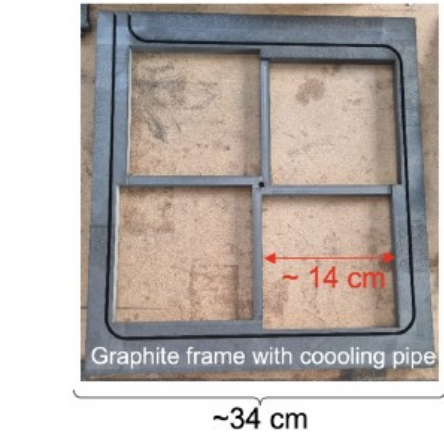


NA60+: activities 2024 and 2025

- R&D on monolithic silicon pixel sensors
- Specs: thickness $\sim 40 \mu\text{m}$, resolution $\sim 5 \mu\text{m}$, few large-area sensors
- NA60+ will use the sensors and readout system developed for the ALICE ITS3



4 large sensors x 5 planes



Padova participates in the sensor tests and readout system design, in coll. with Cagliari \rightarrow ALICE/ITS3 slides

Parallel readout of the 7 segments of full sensor with 7 independent ENCLUSTR boards



ENCLUSTR board



7 MOSAIX segments





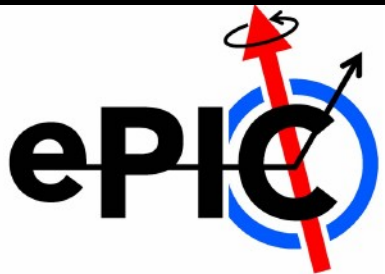
Preventivi 2025 NA60+: anagrafica e richieste

- Sigla “network” dal 2020 in CSN3
 - Resp. nazionali: E. Scomparin, G. Usai
 - ~ 4 FTE: Cagliari+Torino+Padova
- Anagrafica Padova: 0.2 FTE
 - A. Dainese (resp. loc.), A. Rossi; ‘esce’ F. Antinori (ora RN ALICE)
- Richieste: ~ 1.5 + 1.5 s.j. kE, per riunioni di Collaborazione al CERN e eventuale partecipazione test beam per pixel telescope (s.j. a disponibilità prototipi)
- Non ci sono richieste ai servizi

EIC_NET → ePIC

The Electron-Ion Collider





EIC_NET

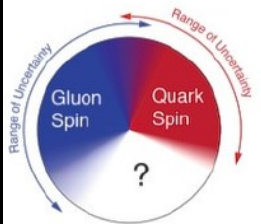
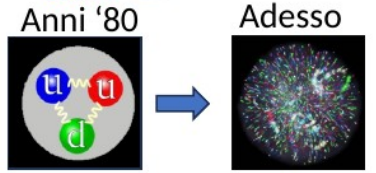
Rosario Turrisi



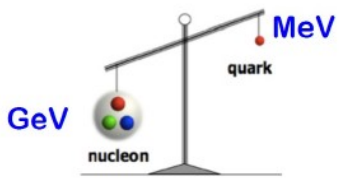
dal 2025 EIC_NET diventa ePIC !
Passaggio a sigla "R&D e costruzione"
Approvato il 18 giugno 2024 in CSN3



Fisica ad EIC con ePIC



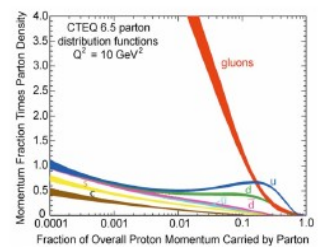
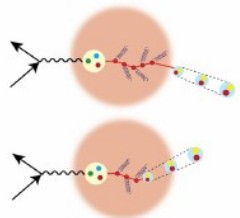
Formazione dello spin di p, n?



Generazione della massa di p, n?

Confinamento?
Struttura in 3D dei nucleoni?

Adronizzazione?
Interazione del colore col mezzo?



Scala e caratteristiche della saturazione gluonica?

INT	Process
1 fb ⁻¹	Inclusive DIS
10 fb ⁻¹	SIDIS
100 fb ⁻¹	Exclusive DIS

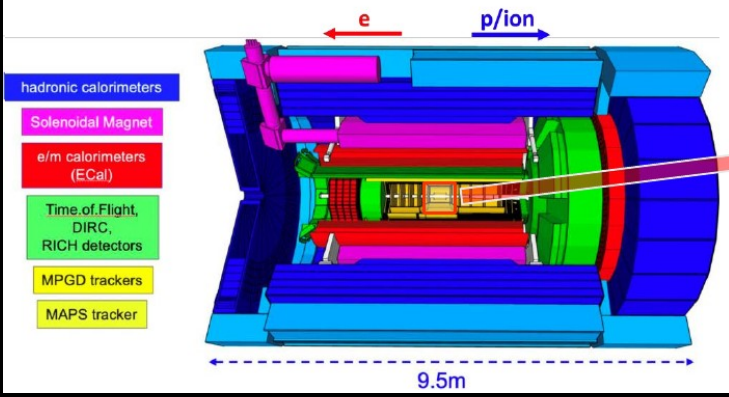
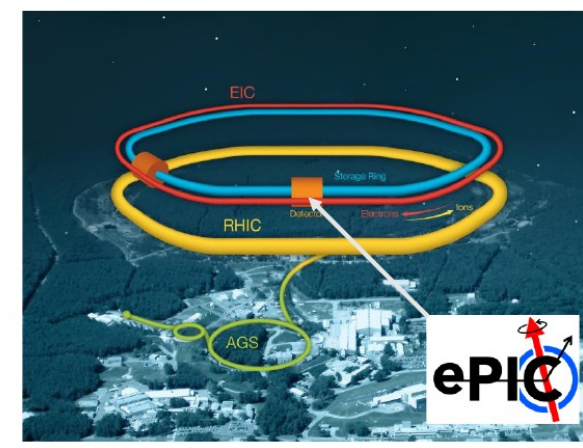
- Parton distributions
- QCD @ high density
- Spin / Flavour structure
- TMD's
- Saturation
- GPD's



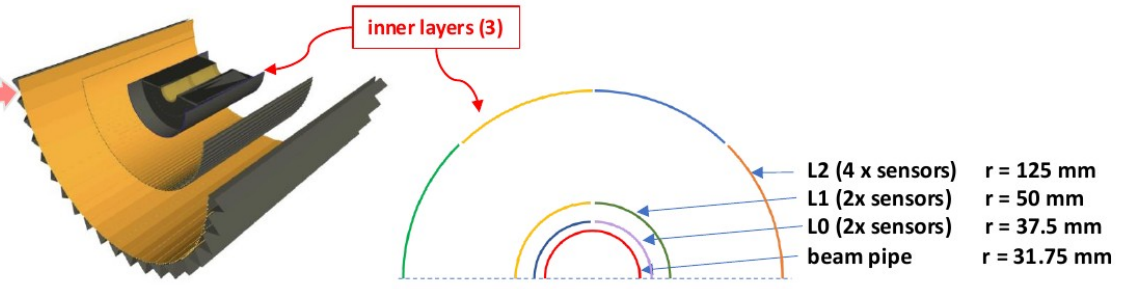
Alcuni punti chiave di EIC ed ePIC

- Electron Ion Collider @ BNL:
 - $100 \times \mathcal{L}$ @ HERA = $\sim 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ (con crab crossing)
 - $E_e \times E_h = 5\text{-}20 \text{ GeV} \times 41\text{-}275 \text{ (A)GeV} \rightarrow \sqrt{s} = 20\text{-}141 \text{ GeV}$
 - Polarizzazione e/p/light nuclei $\sim 70\%$
 - Adroni: H to U
- ePIC
 - Installato in IP6 (dove ora siede STAR)
 - Ottima risoluzione vertice
 - Eccellente calorimetria + PID \rightarrow separazione e/h
 - Buona risoluzione p_T

- Eccellente PID adroni
- Detectors far forward e backward per chiudere cinematica a grandi rapidità (non mostrati)



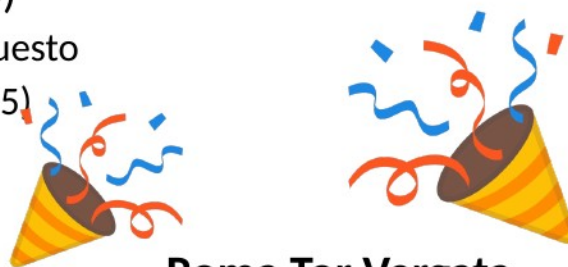
Silicon Vertex Tracker Inner Barrel (SVT IB): i tre layer interni a base di rivelatori MAPS. Col contributo di INFN-Pd!





Ultime notizie rilevanti sulla collaborazione

- CD3-A (inizio finanziamento progetto) approvato in gennaio 2024
- DoE/NSF Nuclear Science Advisory Committee ha posto EIC in categoria "A" → "ready for construction"
- Collaborazione in crescita: 650 partecipanti, 177 istituti, 26 nazioni (survey 2024)
- "CERN Recognized Experiment" parere positivo al Council Meeting 21-22 marzo
 - sinergie significative con esperimenti LHC
- pre EIC/ePIC-TDR prima di CD3-b (fine anno)
 - TDR del progetto EIC, ePIC sarà un capitolo di questo
 - TDR EIC/ePIC finale: prima di CD3 (autunno 2025)
 - pre-TDR=60% readiness, TDR=90% readiness
- gennaio 2025: collaboration meeting a



Roma Tor Vergata
(Villa Mondragone)



EIC_NET/Pd



- Passaggio a sigla "R&D e costruzione" ePIC: approvata alla riunione CSN3 di giugno
- Sigla EPIC già aperta per I preventivi 2025!
- **Anagrafica:** richiesta esplicita dei referee di aumentare il rapporto FTE/pp: abbiamo come obiettivo 0.3 (staff fisici, per sezione):
 - richieste alcune eccezioni in ALICE per scendere fino al 50% mantenendo lo status di componente effettivo (pubblicazioni, service task, etc.) - A Padova solo per RT

- **Attività 2025**

1. test e caratterizzazione rivelatori al silicio in sinergia con ALICE/ITS3 e NA60+
2. costruzione meccanica globale SVT
3. punto produzione layer interni L0, L1 (da confermare, v. dopo)

- Risorse esterne:

- Un contratto PhD cofinanziato al 45% da DoE (C. Pantouvakis)
- Anche quest'anno attratti fondi DoE per R&D:

eRD113 (test and characterization of MAPS) → assegnati ~20 ke
(probabilmente destinati a hardware)

COGNOME	NOME	FTE
Benettoni	Massimo	0.10
Bonini	Chiara	0.50
Chiappara	Davide	0.20
Ciarlantini	Sabrina	0.50
Giubilato	Piero	0.20
Mattiazzo	Serena	0.20
Pantouvakis	Caterina	0.30
Rebesan	Pietro	0.10
Turrisi	Rosario (RL)	0.50
Totale: (9 pp)		2.50
FTE/pp staff fisici: 0.30		FTE/pp totale: 0.29





Dettagli attività - 1

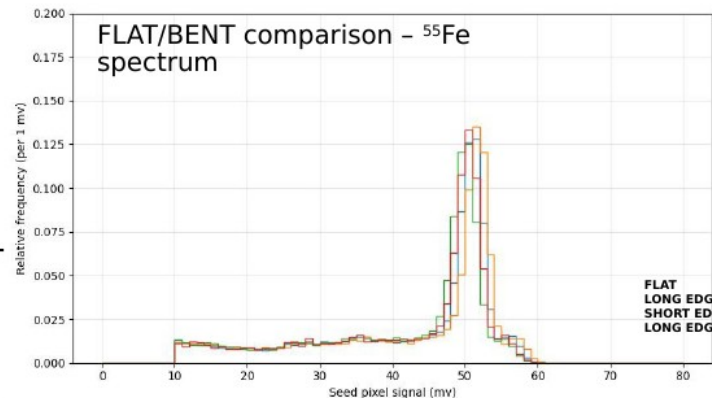


Sviluppo MAPS "ALICE/ITS3-driven". Attività di test e caratterizzazione in (per adesso) completa sovrapposizione con NA60+ ed ePIC.

Personale staff e studenti con esperienza nei test pre-post bending, pre-post irradiazione (partecipazione anche a test-beam e.g. a FNAL)

- Test effettuati su APTS (Analogic Pixel Test Structures) prodotti nel run MLR1 (Multiple Layer Reticle 1) di ITS3, contenente alcune varianti di MAPS per la definizione del *design*, prima sottomissione in tecnologia 65nm a TPSCo
- Sviluppo sistema di test per nuove strutture "stitched" ancora in corso
- 2025: preparazione test sui sensori del prossimo *engineering run*
- V. anche presentazione ALICE

Elettronica per i test dei chip APTS



ALICE ITS3 WIP
Fe55 source measurements
Plotted on 18 Apr 2023

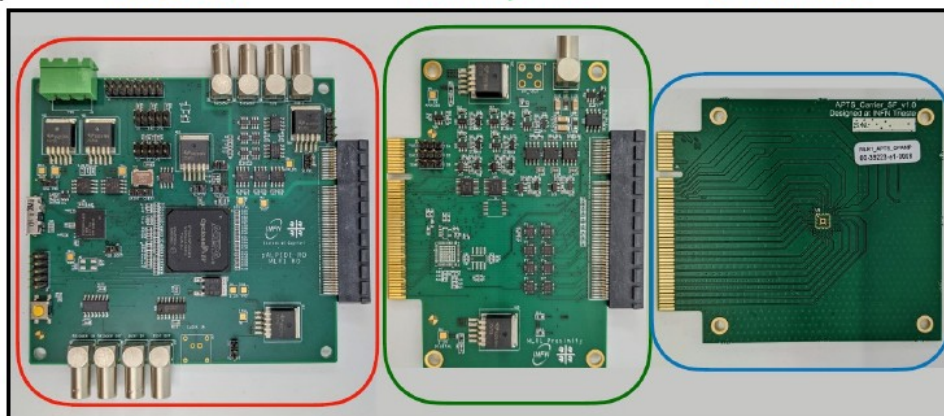
APTS SF
AF15P_WJ168105
pitch: 15 μ m
type: modified with gap
split: 2
 $V_{sub} = V_{pixel}$
 $I_{reset} = 100 \mu$ A
 $I_{bias} = 5 \mu$ A
 $I_{bias} = 0.5 \mu$ A
 $I_{bias} = 150 \mu$ A
 $I_{bias} = 200 \mu$ A
 $V_{reset} = 500$ mV

Legend:
FLAT: $V_{sub} = -4.0$, AF15P_WJ168103
LONG EDGE: $V_{sub} = -4.8$, AF15P_WJ168101
SHORT EDGE: $V_{sub} = -4.8$, AF15P_WJ168104
LONG EDGE: $V_{sub} = -4.8$, AF15P_WJ168105

DAQ board

Proximity board

Carrier board

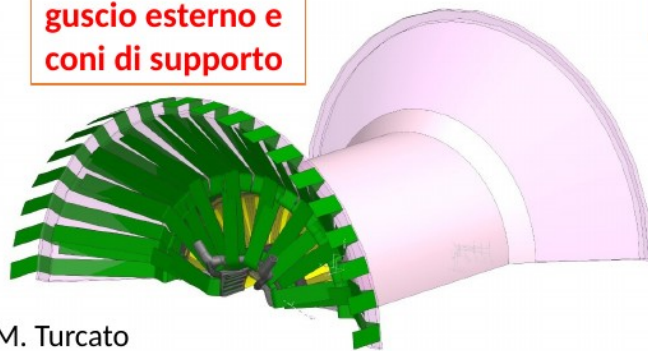


Dettagli attività - 2

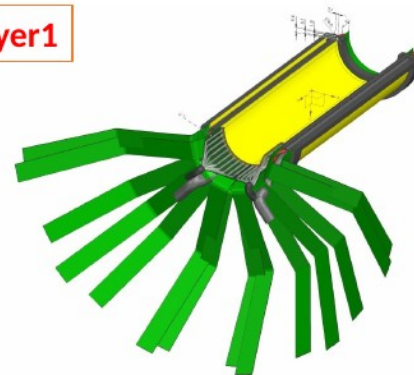
Costruzione meccanica globale SVT

- Responsabilità disegno e realizzazione meccanica globale Inner Barrel SVT
 - Realizzazione mock-up necessari alla qualificazione della procedura di integrazione sensori e servizi
 - Realizzazione supporti (prototipi e finale)
 - Analisi termica FEA
- In fase di indagine:
 - studio vibrazioni indotte da flusso di aria per raffreddamento con sensori confocali cromatici per il rilevamento della posizione (risoluzione sub-micron)

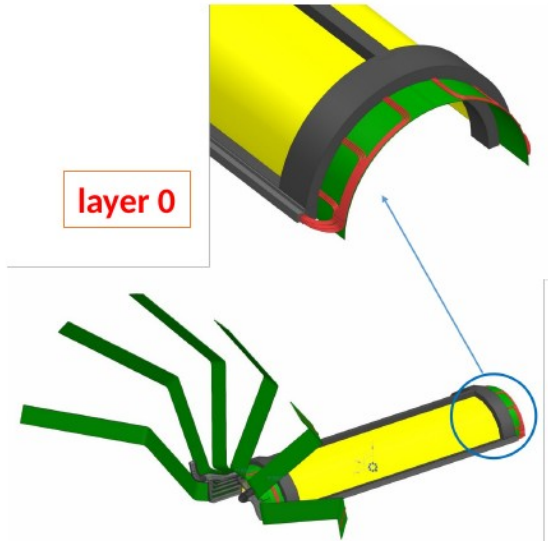
guscio esterno e
coni di supporto



layer1



layer 0



CAD by M. Turcato



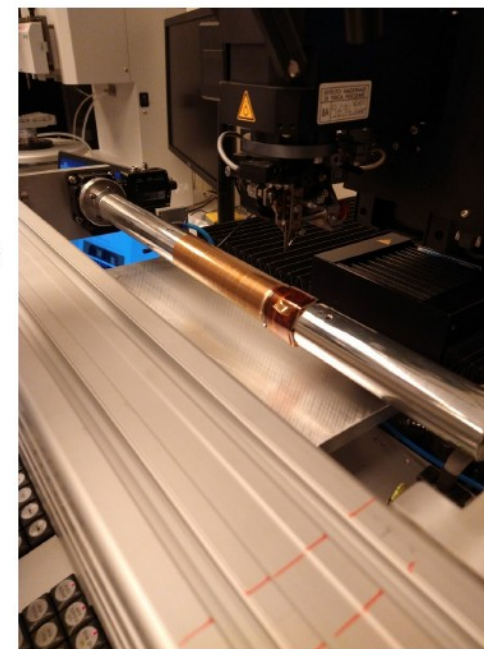
Dettagli attività - 3



Punto produzione layer interni L0, L1 di SVT

- Possibilità di produzione *tooling* per piegamento sensori MAPS
 - mandrini prodotti in OM INFN-Pd
 - lavorazione superficie per rugosità <0.1 ai LNL (electro-polishing) o ditta esterna (rettifica e doratura), da verificare la qualità e convenienza dei due processi
- Processo completo (piegamento, wire-bonding cavi FPC, posa/incollaggio supporto, etc.) dipende da disponibilità macchina wire-bonder (gli FPC devono essere fissati prima di rimuovere il sensore dal mandrino):
 - la particolare operazione (bonding su superficie curva), le dimensioni del supporto e la procedura di fissaggio FPC e fissaggio su supporto definitivo pongono condizioni sul tipo di macchina bondatrice (*bore*, manovrabilità testa, non necessariamente automatica)
 - *market survey* in corso
 - contatti per coinvolgimento altri progetti interessati per acquisto condiviso e contributi da CSN1 e CSN3

Setup per bonding sensori piegati su mandrino presso INFN-Bari





Richieste 2025

Richieste finanziarie CSN3

Missioni	
Riunione SVT (USA) 7gg x 2 pp	5,0
Training e messa a punto procedure per attività in condivisione PD/BA/TS/PV	2,0
Partecipazione a Giornate Nazionali EPIC: 3 gg x 2pp	1,5
Partecipazione a riunione collaborazione o EICUG in USA: 1pp x 7gg	2,5
TOTALE missioni	11,0
Consumo	
Materiale e lavorazioni per assemblaggio mock-up meccanica di supporto IB	5,0
2 Mandrini per piegamento sensori a raggi L0-L1 SVT	2,0
Motorino per rotazione controllata e automatica sensore	1,0
Produzione jig per movimentazione/allineamento sensori grandi dimensioni per procedura di bending e wirebonding	2,0
Sensore confocale cromatico	6,0
Inventario	
Contributo acquisto macchina bondatrice manuale (SJ) - IN FASE DI DEFINIZIONE	20
TOTALE non missioni	36,0

Totale: 47 k€

Richieste servizi INFN-PD (concordati con i responsabili)

Servizio	mesi-persona
Ufficio Tecnico	4
Officina Meccanica	2
Officina Elettronica	2

- Disegno supporto SVT IB, realizzazione mock-up, simulazione termica FEA
- Realizzazione mock-up e mandrini piegamento sensori MAPS
- Piegamento sensori MAPS, wire bonding



Fisica nucleare di bassa energia



Spring – Autumn 2022 Workshops

Nuclear Physics Mid Term Plan in Italy

[About](#)[Organizing Committee](#)[REGISTER](#)

This workshop is dedicated to future nuclear physics research in Italy with particular emphasis on INFN laboratories that are preparing important upgrades for the accelerators complexes.

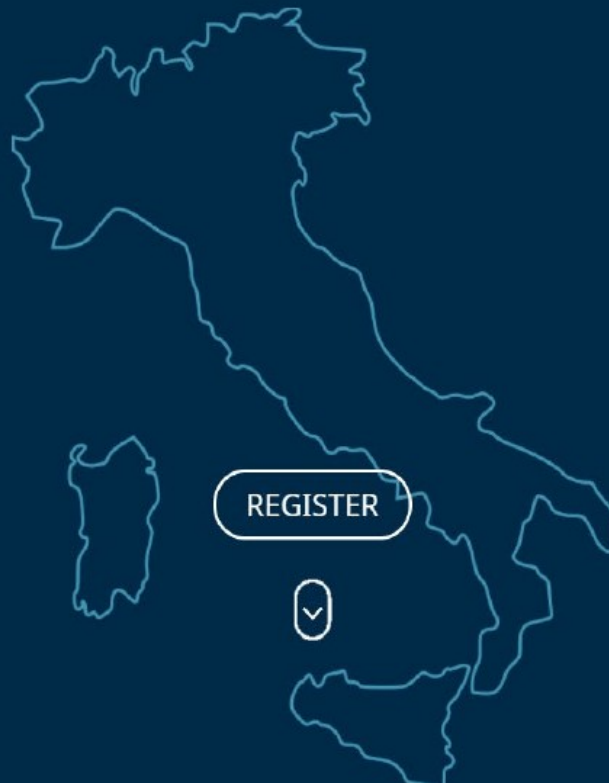
The workshop is divided into three sessions, one for each laboratory:

Session 1 – LNS (April 2022)

Session 2 – LNL (April/May 2022)

Session 3 – LNGS/LNF (date to be announced)

The workshop will be prepared by researchers participating to specific working groups that will report their activities in the final events. These working groups will address the various research possibilities of the future experimental campaigns in the laboratories.



Nuclear Physics Mid Term Plan in Italy



Laboratori Nazionali di Legnaro



Laboratori Nazionali del Sud



Laboratori Nazionali del Gran



Laboratori Nazionali di Frascati

GAMMA



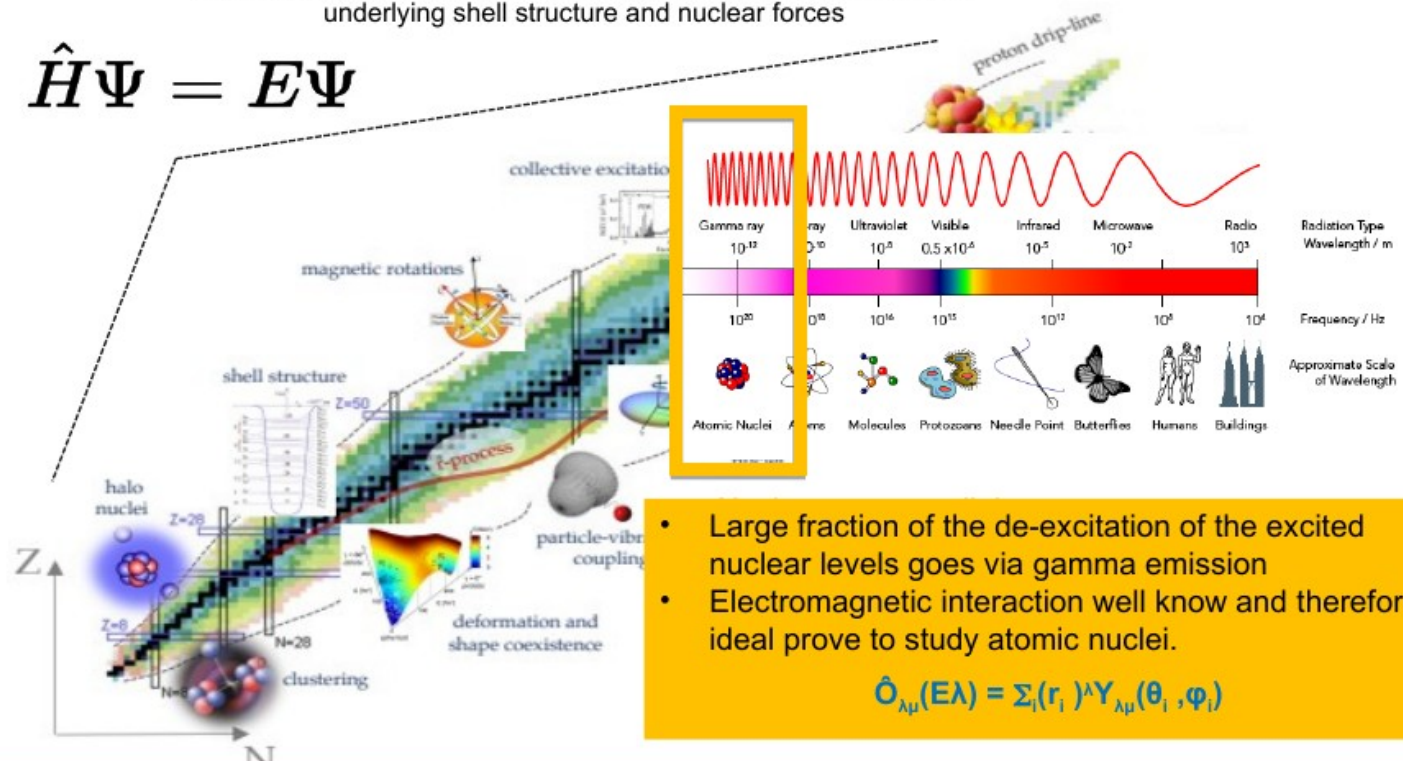
Unraveling the nuclear many-body problem

Three fundamental forces in nuclei: strong, weak and electromagnetic

Emergent phenomena from the same Hamiltonian

underlying shell structure and nuclear forces

$$\hat{H}\Psi = E\Psi$$



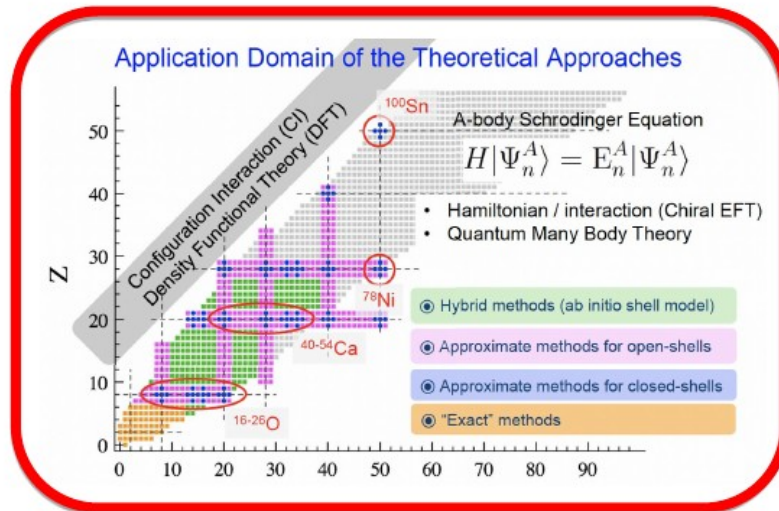
Variety of quantum phenomena, with an energy domain that goes from **few eV to GeV**.

Required a **comprehensive theory** that *describes quantitatively and predicts* the properties of the entire nuclear landscape
→ Gamma spectroscopy can contribute to this endeavour

How to approach such endeavour?

The nuclear structure is not an observable. The nucleus is a many body object → need to measure in the laboratory various observables to constrain the nuclear models

The progress in the understanding of nuclei is driven by major advances of **theoretical** and **experimental** tools.

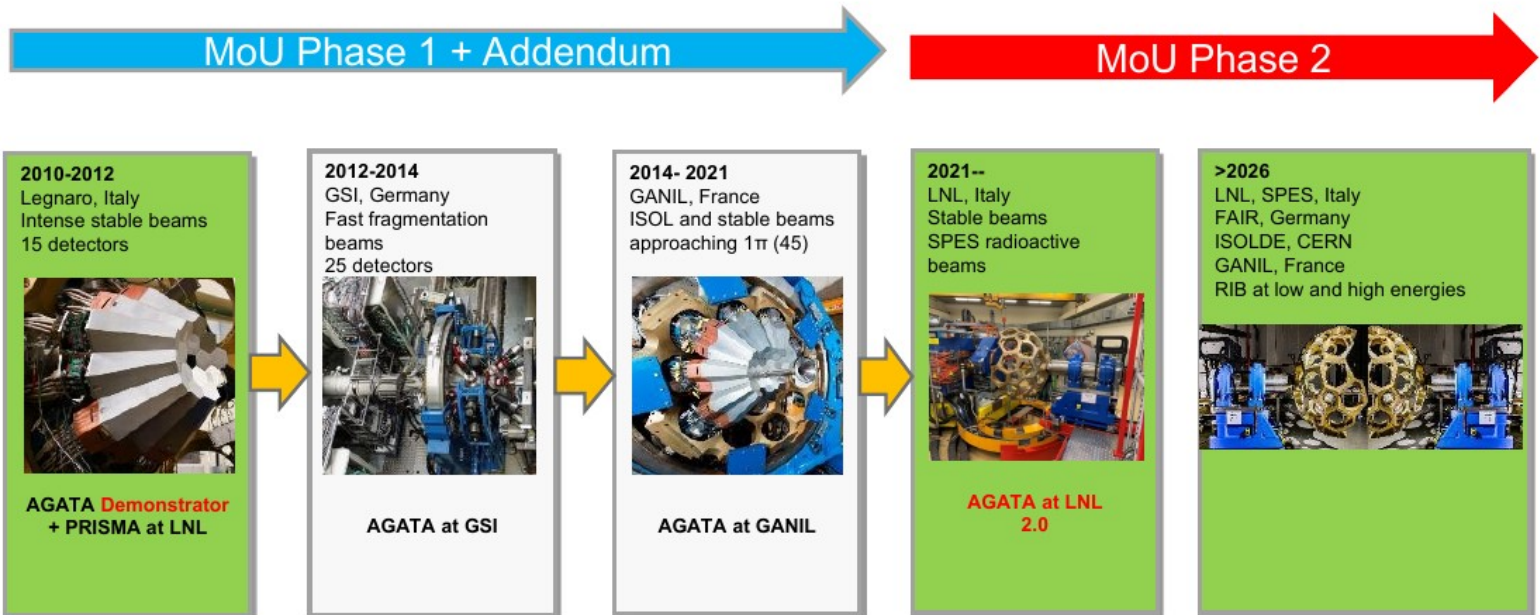


Theory development



Experimental apparatus and facilities

The AGATA time line



AGATA installation: first configuration



AGATA @ LNL: Italian collaboration

The italian working groups

Task 1, Infrastructure: [Roberto Menegazzo](#)

Task 2, AGATA Mechanics: [Nicola Bez](#), [Loris Ramina](#), [Mirco Rampazzo](#), [Marco Scarcioffolo](#), Diego Giora

Task 3, Experimentation mechanics: Giovanna Benzoni

Task 4, Safety and Quality: Maria Luisa Allegrini, Daniela Benini, Luca de Ruvo

Task 5, Computing and network infrastructures: Michele Gulmini, Massimo Biasotto, Sergio Fantinel

Task 6, Surveyor: Daniele Scarpa

Task 7, Detectors: Walter Raniero, Davide Rosso

Task 8, DAQ-Electronics: Alain Goasduff, Nicola Toniolo

Task 9, Complementary instrumentation: [Daniele Mengoni](#)

Task 10, Performance: Fabio Crespi, Simone Bottoni

Task 11, Exploitation: Andrea Gottardo, Oliver Wieland

Task 12, Data Analysis: [Francesco Recchia](#), [S.M.Lenzi](#)

Task 13, Logistics: Paolo Cocconi

Task 14, Documentation and data base: Vincenzo Volpe

Task 15, Public exposure of AGATA activities: Andrea Gozzelino

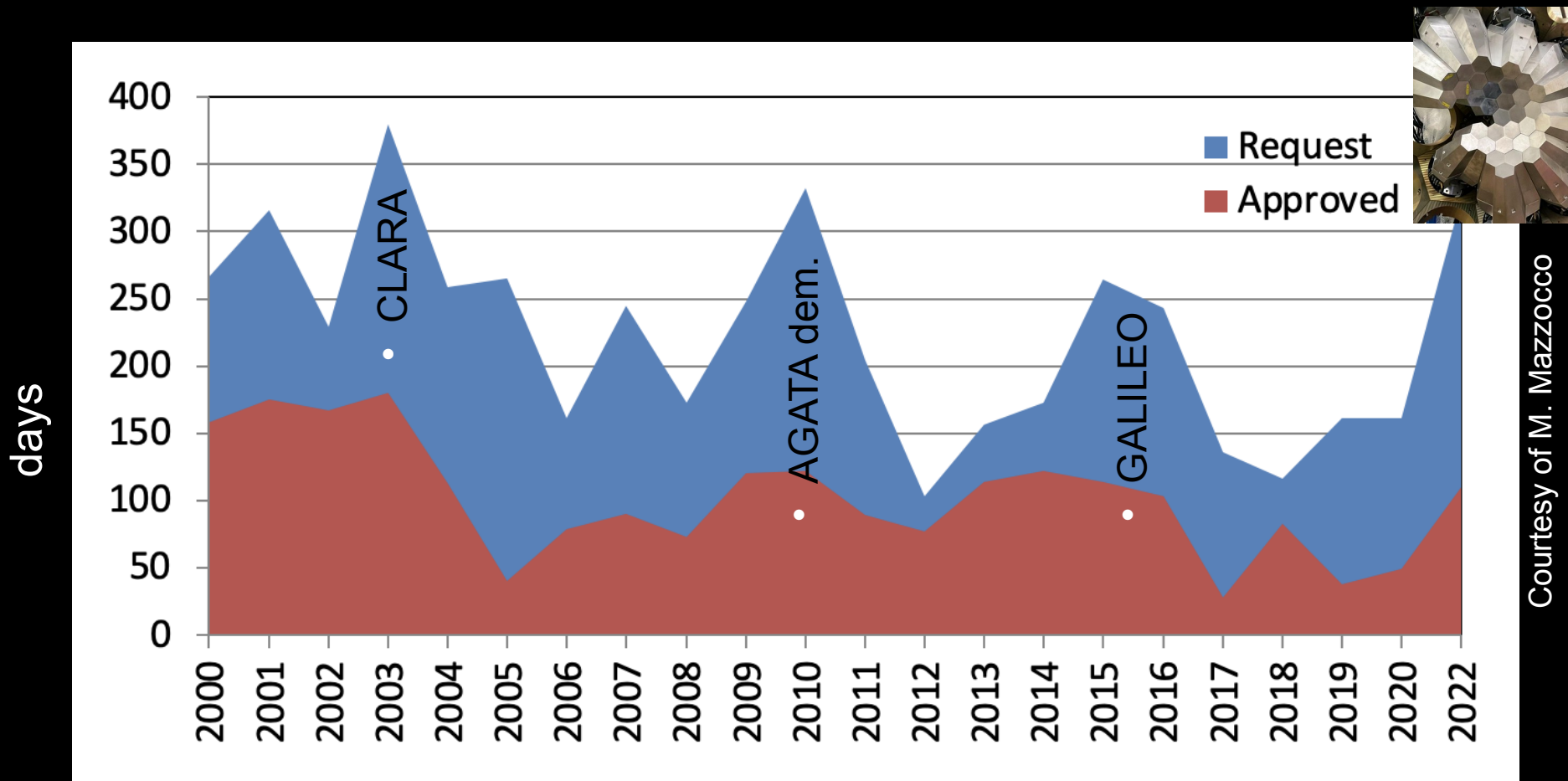
Local project manager: J.J. Valiente Dobón (LNL)

Technical coordinator: [R. Menegazzo](#) (Padova)



Complementary detectors

- **PRISMA:** L.Corradi, F.Galtarossa
- **GAL-TRACE:** S.Capra, [G.Zhang](#)
- **EUCLIDES:** J.Pellumaj, D.Brugnara
- **SPIDER:** M.Rocchini, M.Balogh
- **DANTE:** [K.Rezynkina](#)
- **Scintillators:** E.Gamba, [S.Pigliapoco](#)
- **Plunger:** I.Zanon



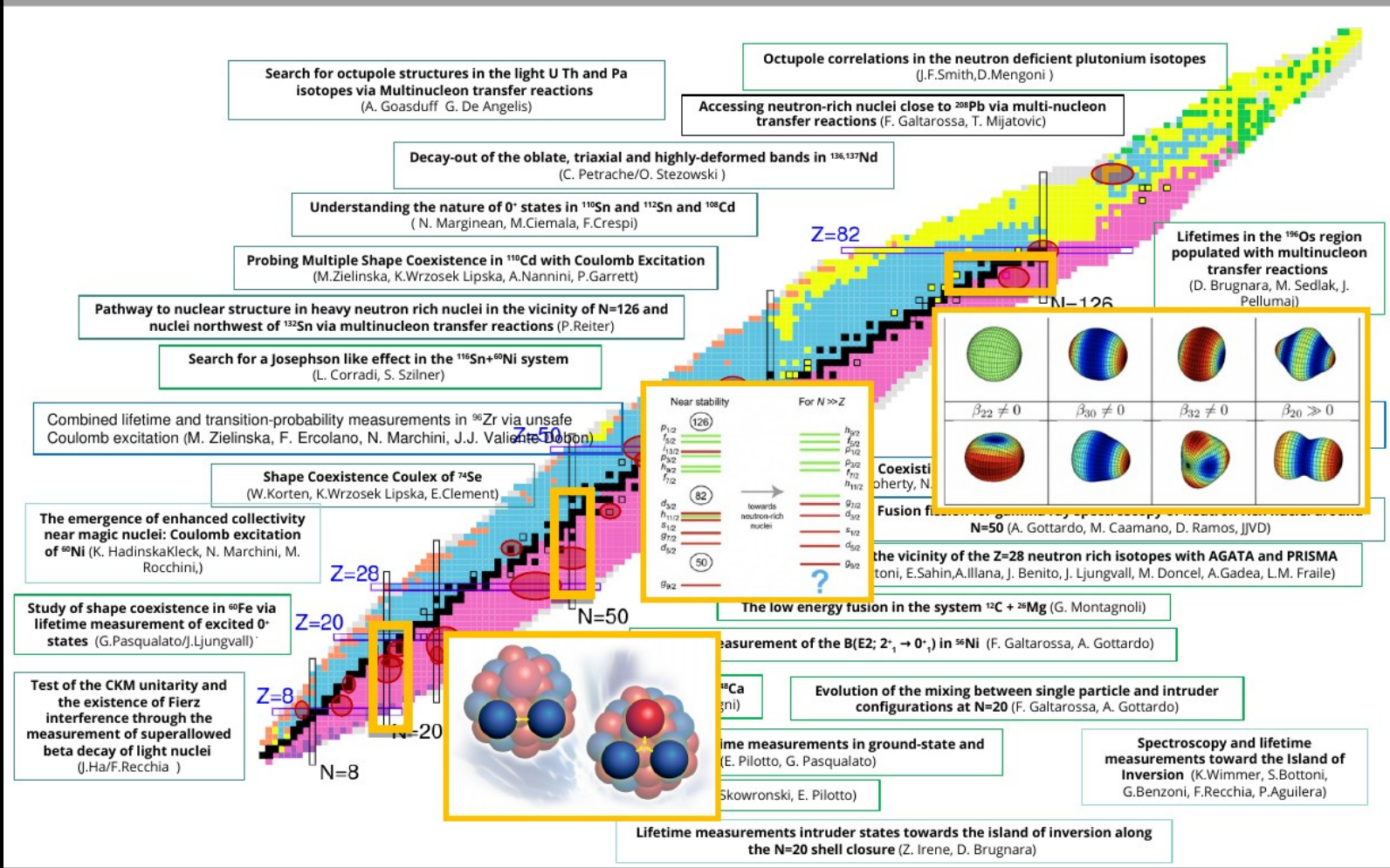
Courtesy of M. Mazzocco

- Coming week July 2024 PAC – probably December 2024
 - There will be two PACs per year

33 exp

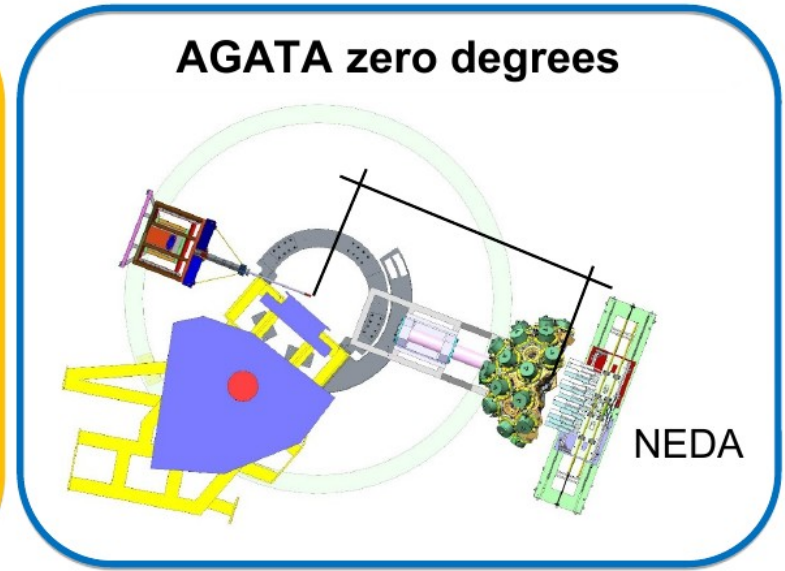
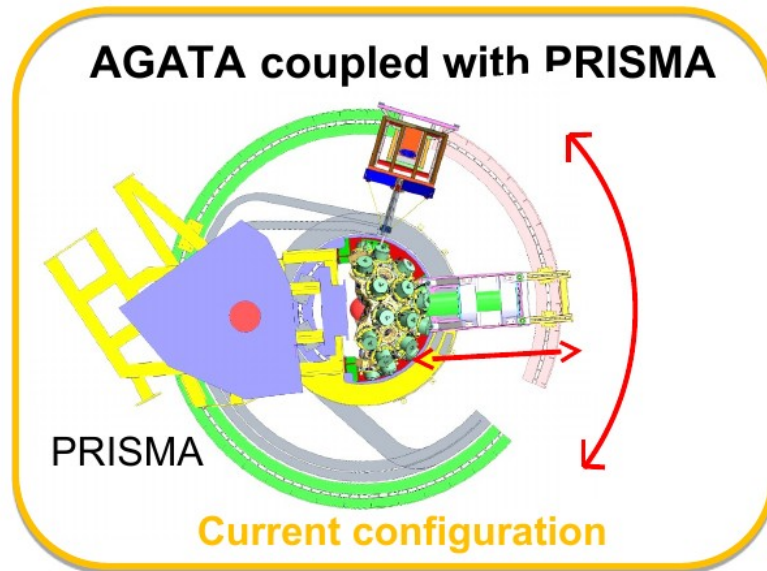
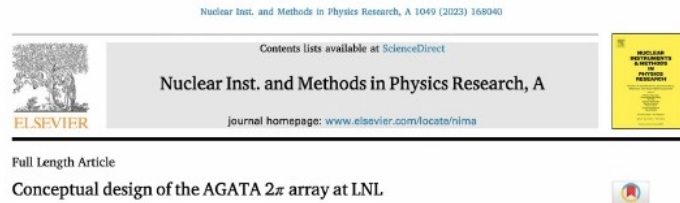
AGATA physics campaign

Priority A: 31
Priority B: 23



Two different configurations

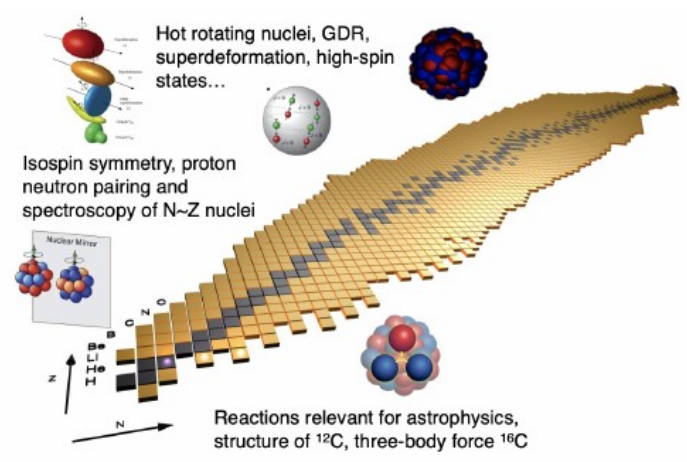
LNL: new data centre, new targets ^9Be , ^{232}Th , ^{238}U
and new ^{238}U beam



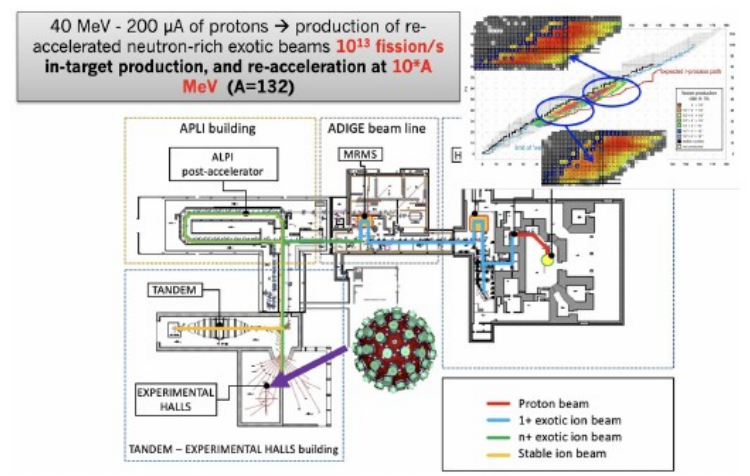
Future of AGATA@LNL

- Campaign with Uranium beams
- Zero degrees campaign → configuration change of AGATA
- In the future: SPES beams

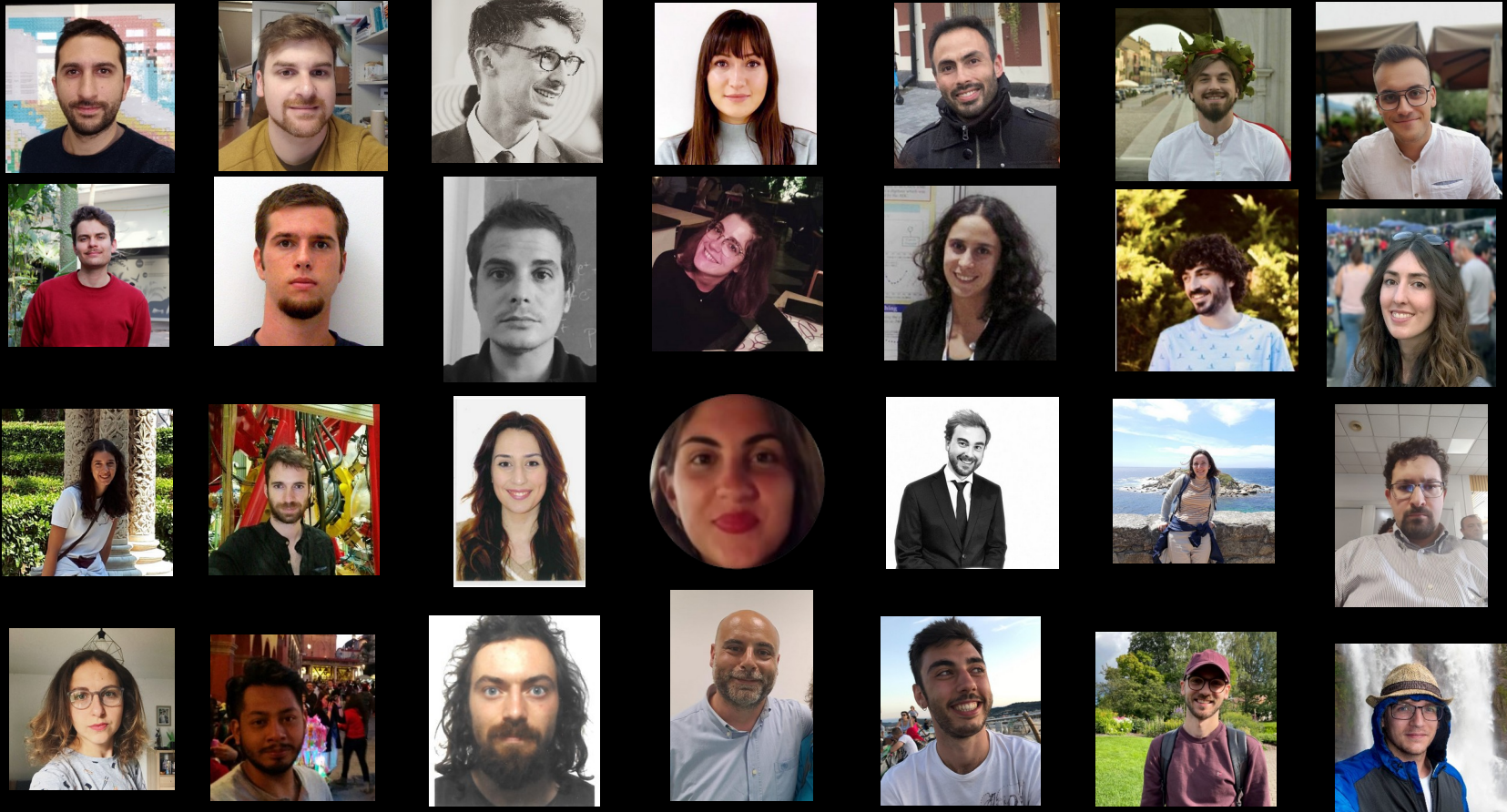
AGATA zero degrees

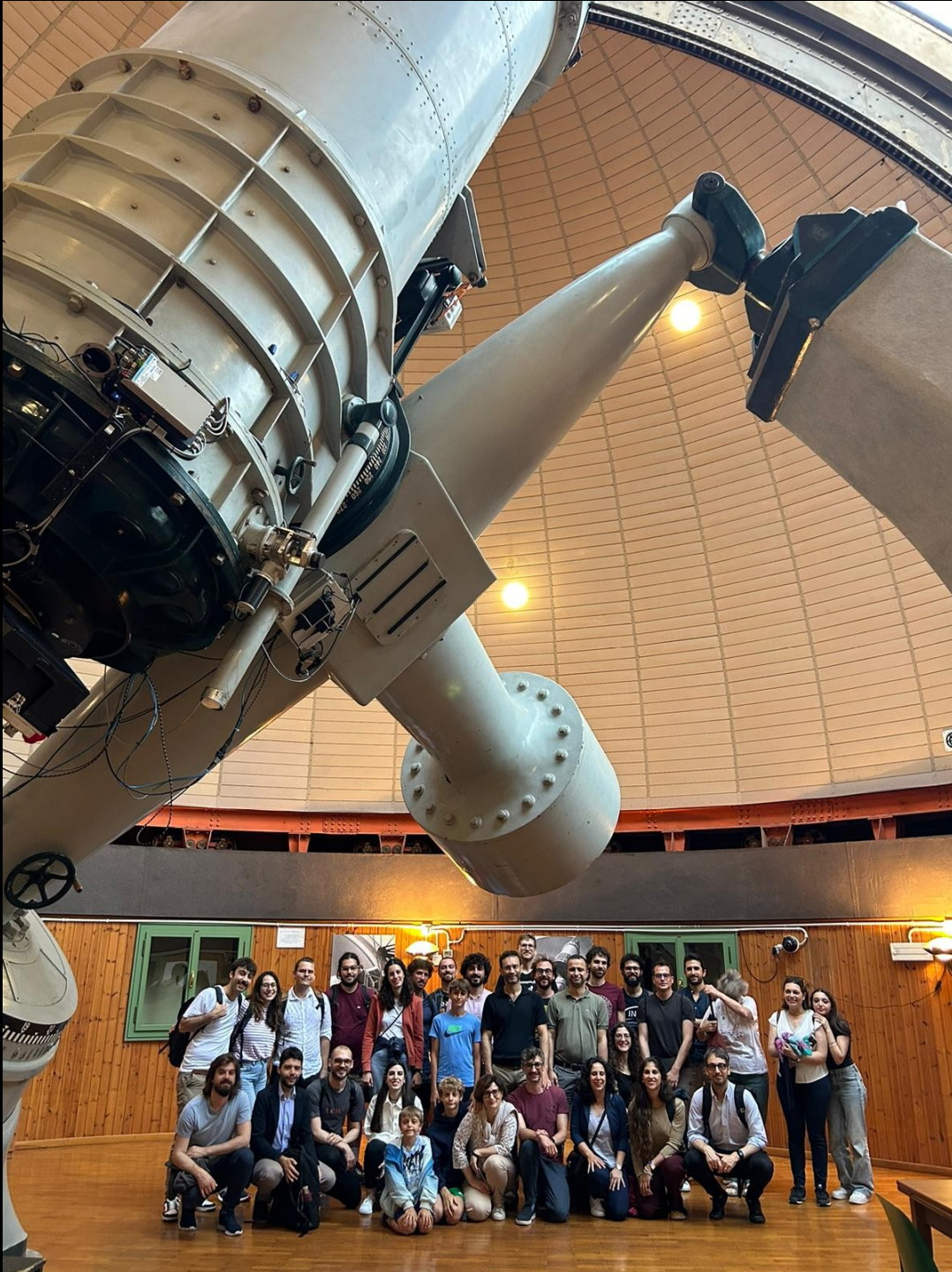


SPES beams



Babel tower: 10 nationalities





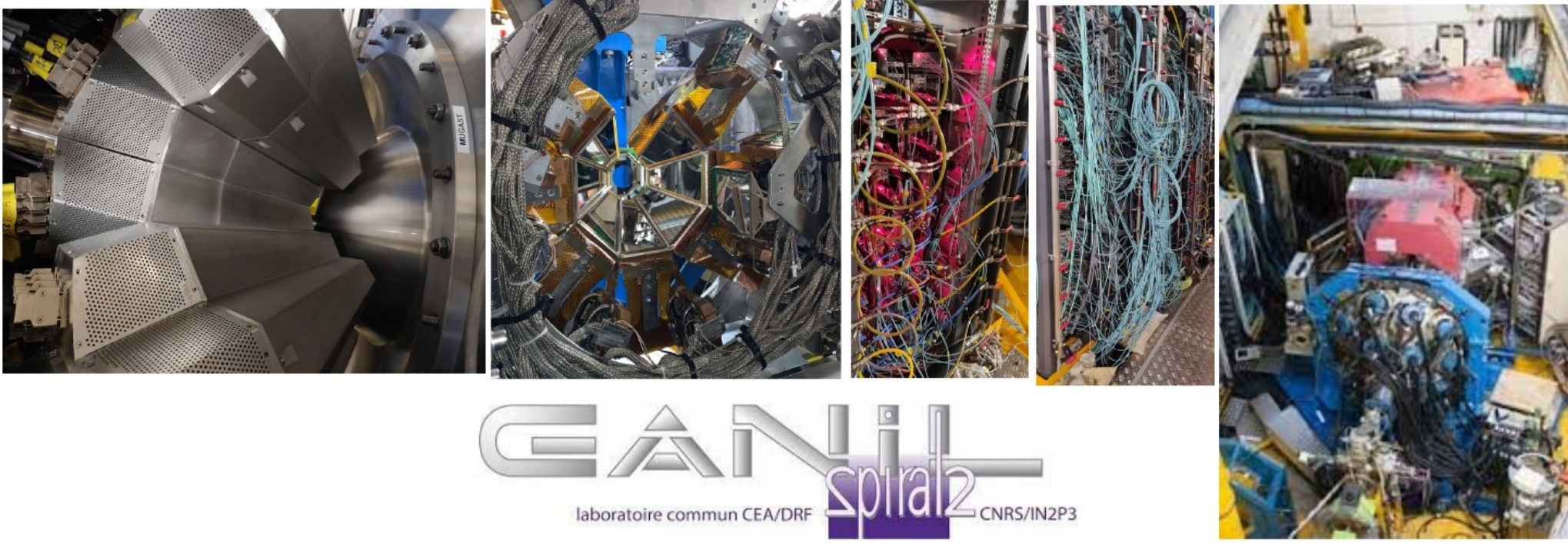
First young
GAMMA meeting

Osservatorio
Asiago

reventivi 04 Luglio 2024



AGATA+MUGAST+VAMOS setup



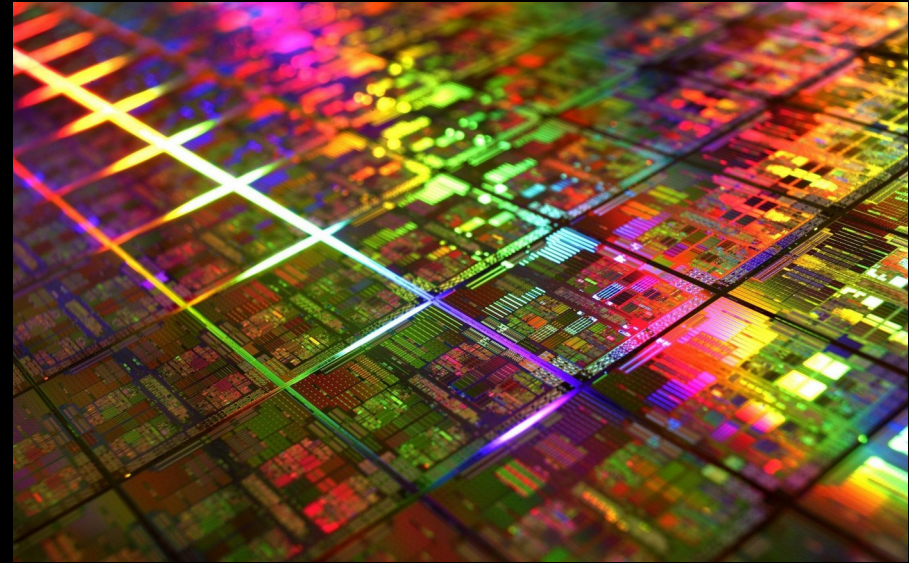
DM et al. "Advances in nuclear structure via charged particle reaction with AGATA" EPJA 2023
M.Assié et al., "MUGAST-AGATA-VAMOS campaign: setup and performances" NIMA 2021

Review esterna elettronica 02/2024 (CEA Saclay/Daresbury)

[..] critical element is the front-end board for which the schedule can be affected by manufacturing delays associated with the production of the very high-density flex-rigid printed circuit boards.

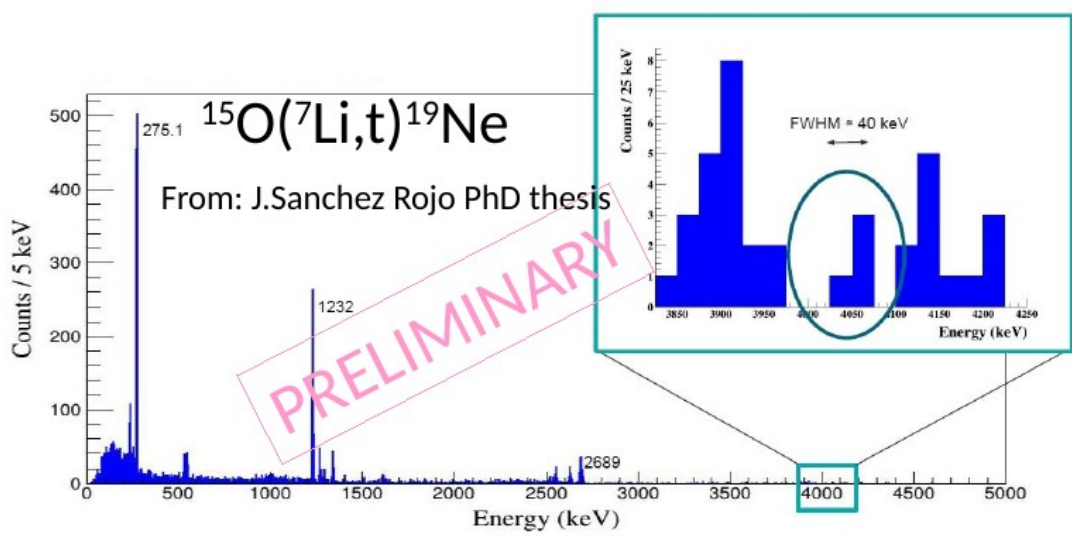
We also noticed that the same persons are sometimes allocated to several critical tasks at the same time.

In case of impossibility to house the components on the front-end cards due to lack of space, the option of using more aggressive packages for ASICs will necessarily lead to a delay



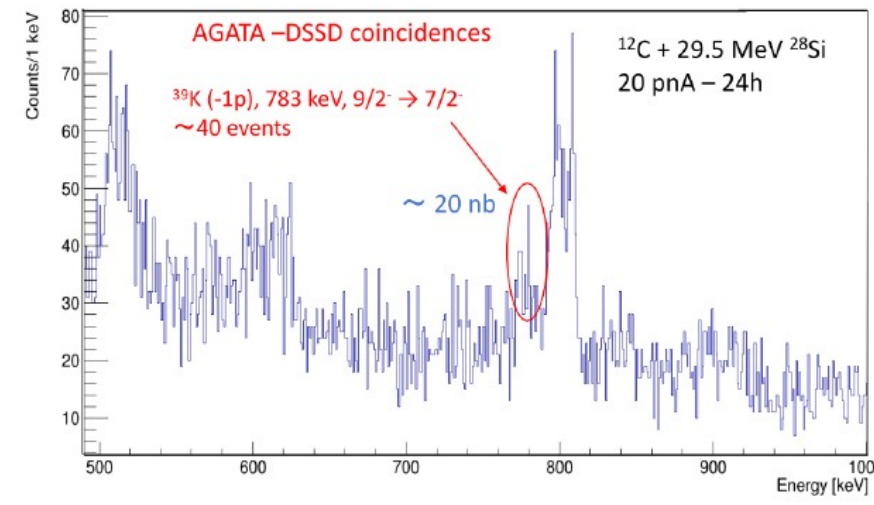
→ 4 MU SPE/OE

Pushing the limit of sensitivity



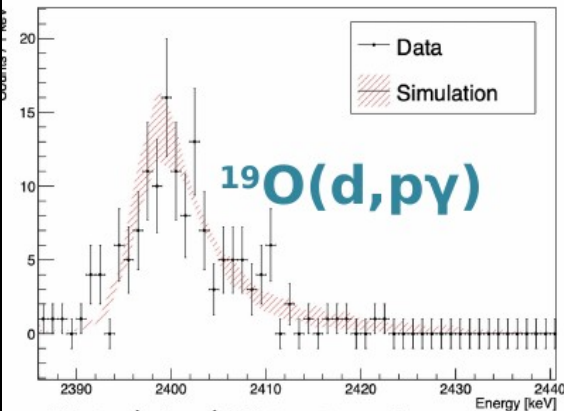
- $^{15}\text{O}(\alpha,\gamma)^{19}\text{Ne} \leftarrow ^{15}\text{O}(^7\text{Li},t)^{19}\text{Ne}$
- Beam rate : $\sim 10^7$ pps and triple coincidence: $\gamma+t+^{19}\text{Ne}$
- Minimum detection limit: **cross section few $\mu\text{b}/\text{sr}$**

G.Montagnoli at this conference



Fusion far below the barrier: $^{12}\text{C}+^{28}\text{Si}$
Stable beams, particle-gamma coinc.
Estimated **cross section $\sim 20 \text{ nb}$**

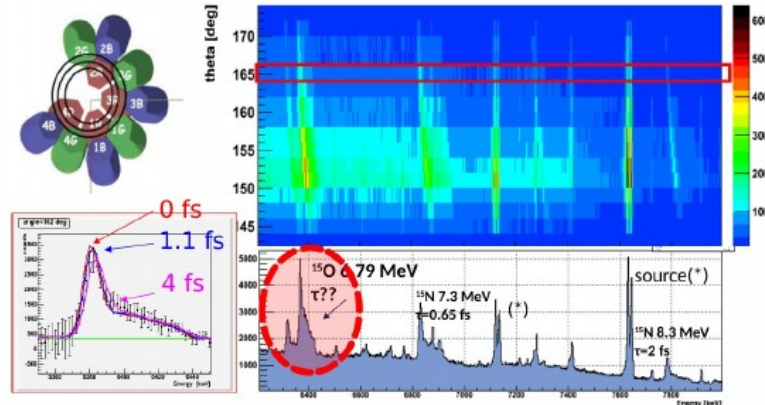
Lifetime arrow



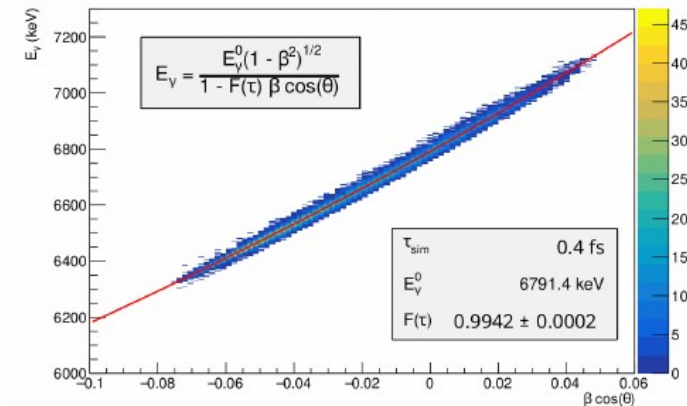
$^{19}\text{O} (d,p)^{20}\text{O}$, 3N forces

τ_{2+} : 63^{+29}_{-16} fs

I.Zanon et al., Phys. Rev. Lett. 131 (2023) 262501



$^{14}\text{N}(^2\text{H},n)^{15}\text{O}$ for CNO cycle
Estimated lifetime **limit <1 fs**
(unpub)
No particle detection



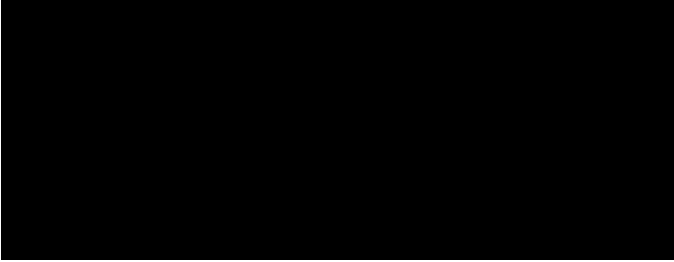
$^{16}\text{O}(^3\text{He},^4\text{He})^{15}\text{O}$ for CNO cycle
Estimated lifetime value **<1 fs**
(sim.), particle detection

Analysis on-going
RUN LAST November '23





Daniele Brugnara



nature physics

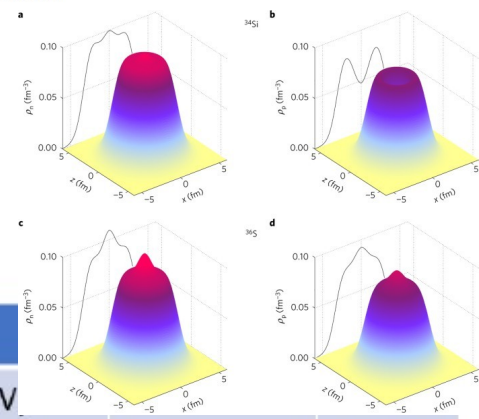
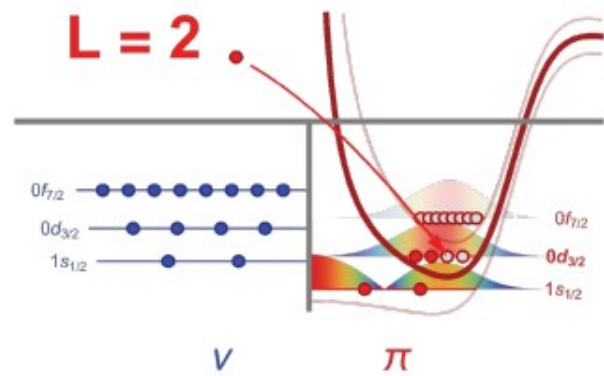
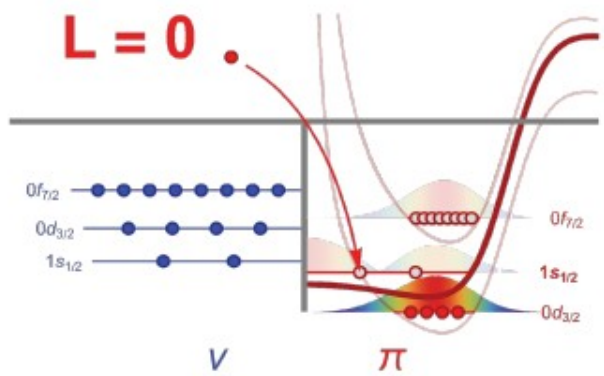
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nature > nature physics > articles > article

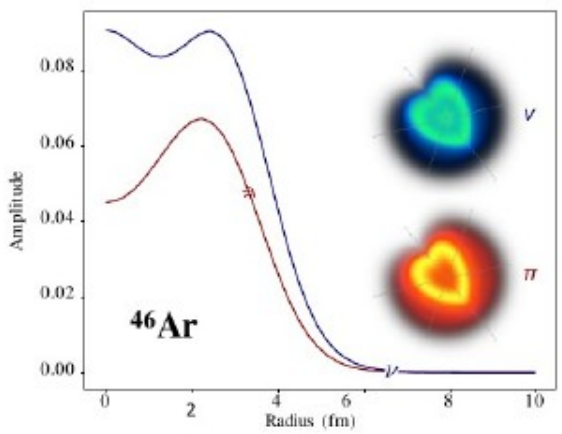
Published: 24 October 2016

A proton density bubble in the doubly magic ³⁴Si nucleus

Central density depletion



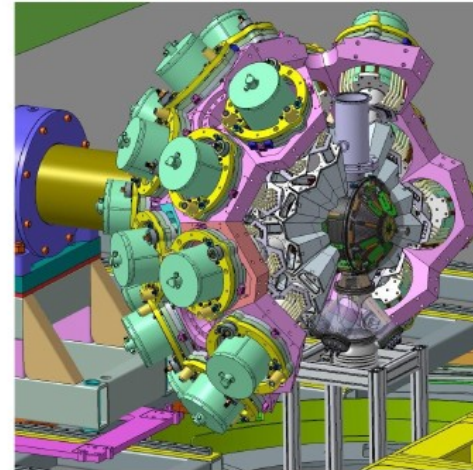
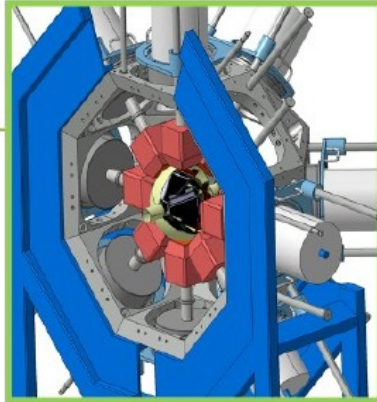
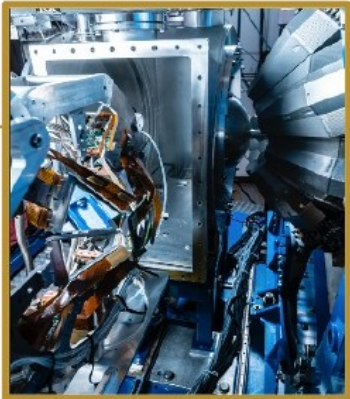
BE exp. (MeV)		
BE NNLO _{sat} (MeV)	414.67	384.18
r _{ch} exp. (fm)	3.4771 (20)	
r _{ch} NNLO _{sat} (fm)	3.478	



- Results indicate a reduced L=2 transfer at odds with large-scale shell-model calculations but consistent with new ab-initio results
- The s_{1/2} proton orbit dominates at small radii so that a lack in its occupation results in a charge bubble.
- The reduced transfer represents the first experimental indication of a central depletion in the proton density of ⁴⁶Ar and the second experimental evidence of this phenomenon (at first observed in ³⁴Si with a knockout reaction)



LISE Campaign @ GANIL [EXOGAM+MUGAST+ZDD]



MUGAST-
AGATA-VAMOS
@GANIL

MUGAST-
EXOGAM-LISE
@GANIL

2021

2023-2024

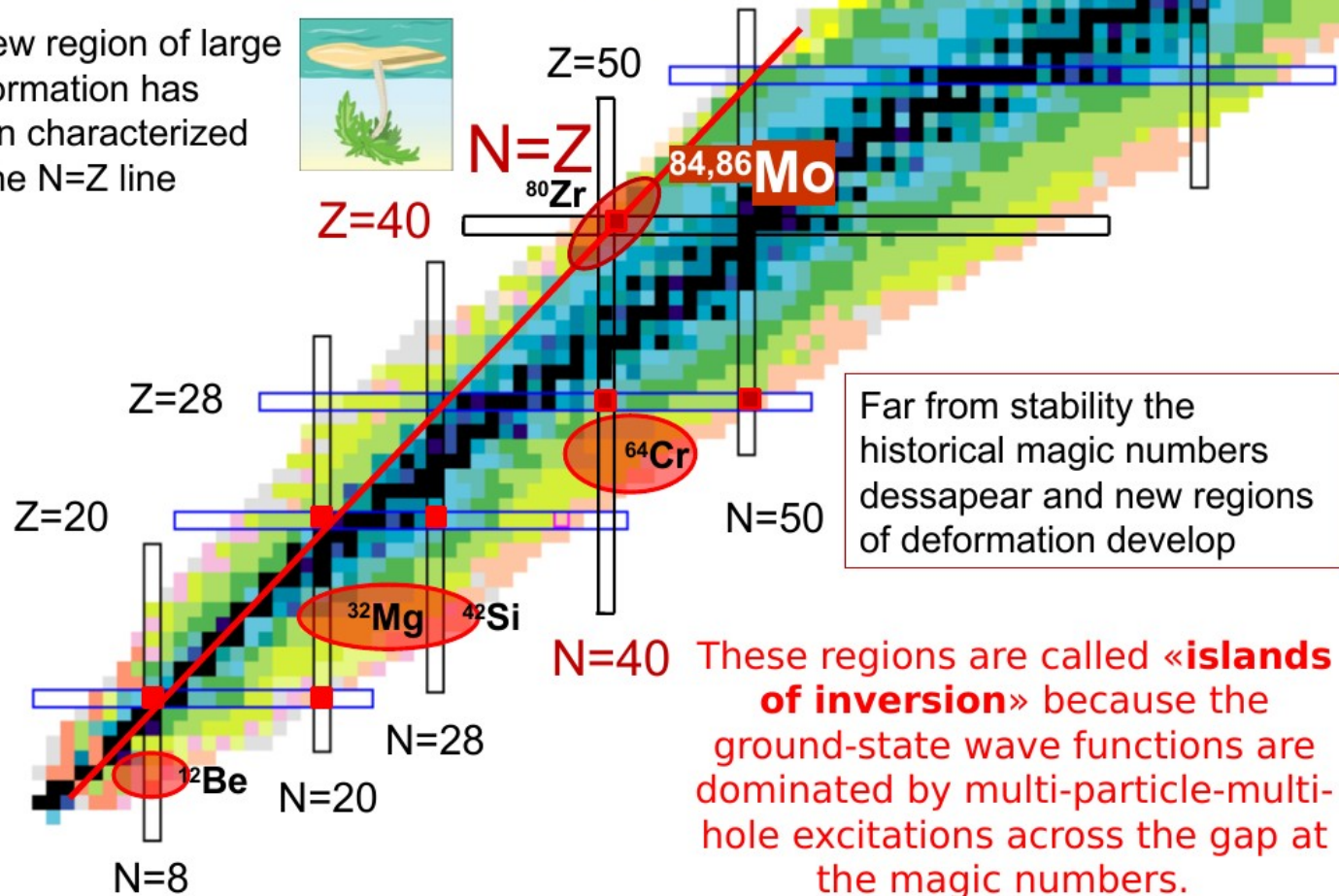
2025

2026

and SPES@LNL

New Island of inversion at the N~Z line

A new region of large deformation has been characterized at the N=Z line



Far from stability the historical magic numbers disappear and new regions of deformation develop

N=40 These regions are called «**islands of inversion**» because the ground-state wave functions are dominated by multi-particle-multi-hole excitations across the gap at the magic numbers.

The experiment @NSCL - MSU

Radioactive beam ^{86}Mo at 103 MeV/A

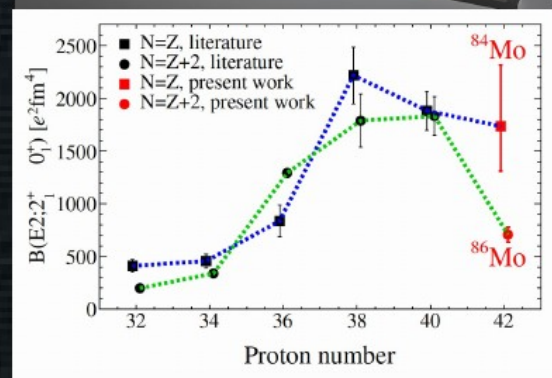
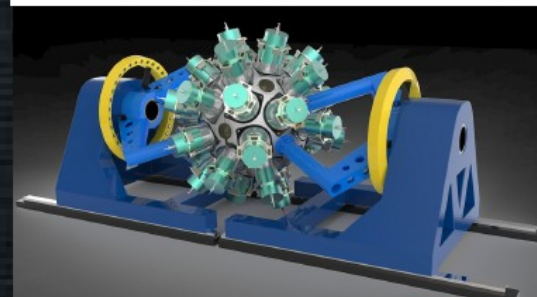
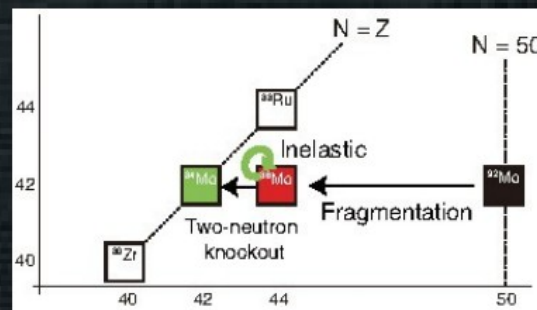
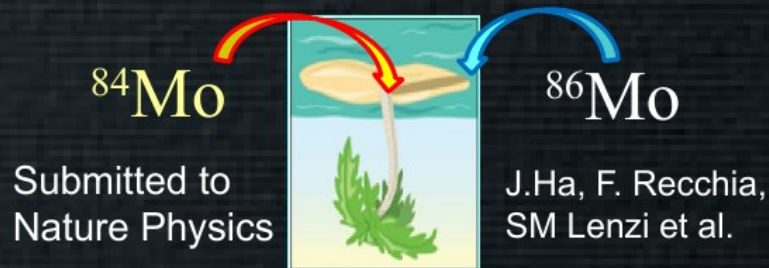
Identification event-by-event
B – Rho, TOF

^{84}Mo produced in a 2n-
knockout reaction

GRETINA : gamma-ray array of
48 HPGe detectors 36-fold
segmented each

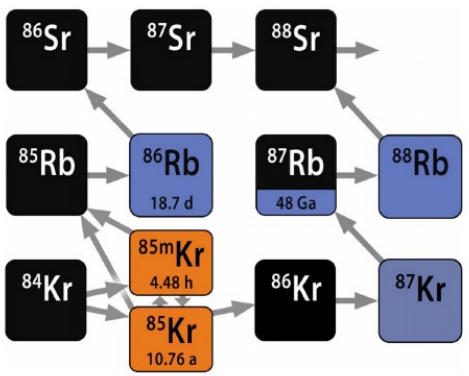
TRIPLEX plunger → lifetime
measurement

Unexpected large deformation in ^{84}Mo
 $N=Z=42$, decreasing abruptly with +2n



STellar ARcheology with Solenoidal spectrometer

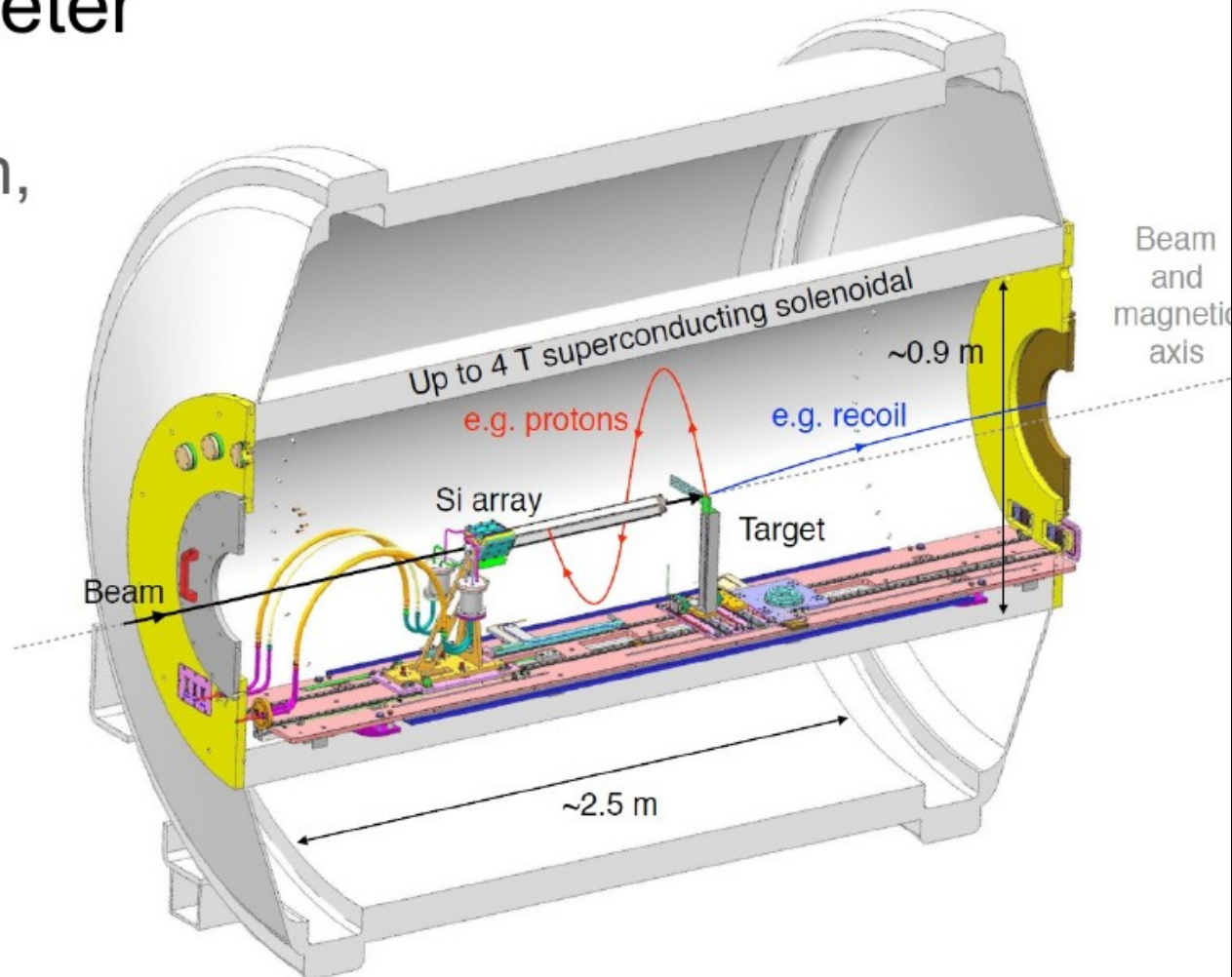
WARNING
Pinch Hazard
Use handles to
move cover



Solenoidal spectrometer

- **Simple** configuration, few detectors
 - Max 150 acquisition channel
- All commercial solutions

→ 2 MU SPM



CONTRIBUTO PANDORA

frontiers | Frontiers in Physics

TYPE Original Research
PUBLISHED 07 October 2022
DOI 10.3389/fphy.2022.936081

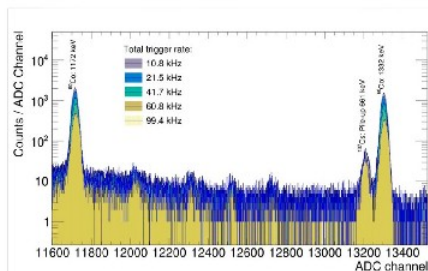


FIGURE 7
Stacked spectra obtained for five different total counting rates. The peak lying close to the 1332-keV line (13220 ADC channels) is due to the pile-up peak of the intense ^{137}Cs source.

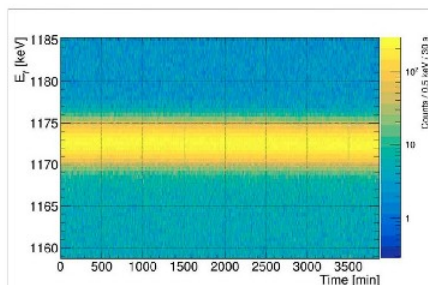


FIGURE 8
Energy vs. Time measured of 60 h using the multi-source with a total rate of 50 kHz. The energy axis has been zoomed on the 1172-keV transition coming from the ^{60}Co source.

Check for updates

OPEN ACCESS

EDITED BY
Marialisa Aliotta,
University of Edinburgh,
United Kingdom

REVIEWED BY
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Institute of Nuclear Research (ATOMKI),
Hungary
Jack Henderson,
University of Surrey, United Kingdom

*CORRESPONDENCE
D. Santonocito,

A high resolution γ -ray array for the pandora plasma trap

A. Goasduff¹, D. Santonocito^{2*}, R. Menegazzo³, S. Capra^{4,5},
A. Pullia^{4,5}, W. Raniero¹, D. Rosso¹, N. Toniolo¹, L. Zago^{1,6},
E. Naselli² and D. R. Napoli¹

¹Laboratori Nazionali di Legnaro, INFN, Legnaro, Italy, ²Laboratori Nazionali del Sud, INFN, Catania, Italy, ³Sezione di Padova, INFN, Padova, Italy, ⁴Dipartimento di Fisica, Università degli Studi di Milano, Milano, Italy, ⁵Sezione di Milano, INFN, Milano, Italy, ⁶Dipartimento di Fisica e Astronomia, Università degli Studi di Padova, Padova, Italy

Per 2023:

- Produzione pre-amplificatori (disegno UniMI/INFN MI)
- Test prestazioni ad alto rate: fino a 100 kHz
- Annealing riv. GASP (da programmare)
- Modifica mother-board GASP (passaggio 12V -- > 24V)
- Studente magistrale condiviso tra GAMMA/PANDORA



Commissione trasferimento tecnologico INFN – trattative per accordi con la Mirion

N3G : Next Generation Germanium Gamma Detectors

D. De Salvador^{1,2}

Responsabile Nazionale

¹ INFN-LNL

² Università di Padova

CALL 2021-2023

Laboratori di Legnaro

D.R. Napoli

Sezione Milano

S. Capra

Sezione Ferrara

A. Mazzolari

Sezione Padova

F. Recchia

GAMMA – richieste 2025

Apparato	Descrizione	Richieste [k€]
AGATA	<i>Meccanica, elettronica ancillari, computers</i>	20
GRIT	<i>MoU</i>	55
Altre spese	<i>Isotopi, consumo e manutenzioni</i>	10
Missioni		108
TOTALE		193

Divisione - Servizio	Attività	Richiesta
Progettazione elettronica	Manutenzione e test schede di produzione locale. Progettazione PCB GRIT	6 mesi uomo
Elettronica	Assistenza produzione elettronica ancillari AGATA. Riparazioni elettronica e sviluppo sistemi di controllo β -DS @ SPES. Bonding Silici GRIT	8 mesi uomo
Ufficio progettazione meccanica	Progettazione componenti meccaniche nuovo setup a 0° AGATA e PRISMA @ LNL. Supporto disegni STARS @ LNL	10 mesi uomo
Officina meccanica	Supporto all'installazione rivelatori e manutenzione componenti meccaniche AGATA @ LNL. Secondo braccio PRISMA	6 + 12* uomo
Calcolo	Gestione server e storage. Supporto Cloud	4 settimane uomo

*) Supporto di M. Scarcioffolo (UniPD) e F. Veronese a Legnaro

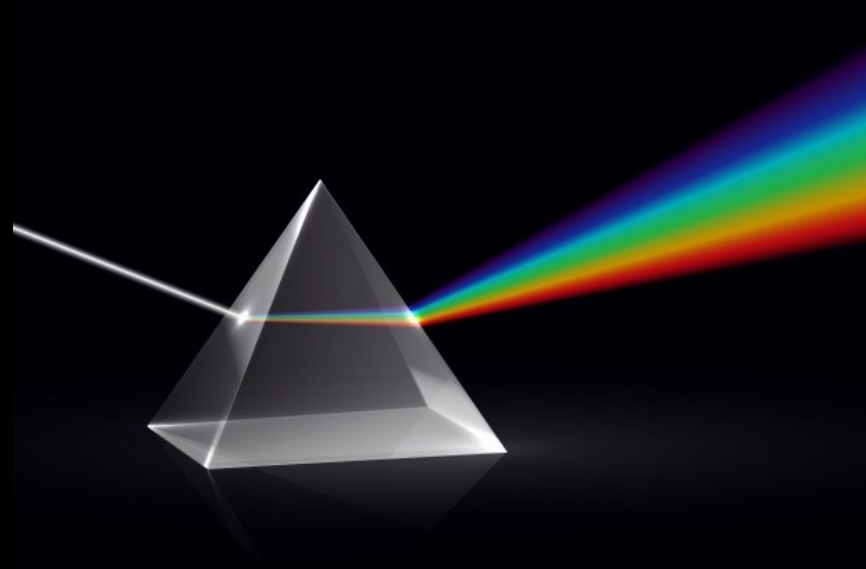
GAMMA - Anagrafica

Nome	Tipo	Qualifica prof.	% FTE
Aguilera Pablo Antonio	Dipendente	<i>Assegnista</i>	100
Bazzacco Dino	Associato	<i>Affiliato</i>	0
Benito Garcia Jaime	Associato	<i>Ricercatore straniero</i>	100
Carollo Sara	Associata	<i>Dottoranda</i>	100
Lenzi Silvia M.	Associata	<i>Prof. Ordinario</i>	80
Galtarossa F.	Dipendente	<i>Ricercatore</i>	100
Mazzocco Marco	Associato	<i>Prof. Associato</i>	20
Menegazzo Roberto	Dipendente	<i>Primo Ricercatore</i>	70
Mengoni Daniele	Associato	<i>Prof. Associato</i>	90*
Nicolàs Del Àlamo Raquel	Associata	<i>Dottoranda</i>	100
Pigliapoco Sara	Associata	<i>Assegnista UniPD</i>	100
Pilotto Elia	Associato	<i>Dottorando</i>	100
Polettini Marta	Associata	<i>Assegnista UniPD</i>	100
Francesco Recchia	Associato	<i>Prof. Associato</i>	100
Kseniia Rezyunkina	Dipendente	<i>Assegnista</i>	100
TOTALE	15	Ricercatori	1260

*) 10% FEROCÉ (CSNV)

3 AdR +RTT +1 PHD
Fondi esterni: PRIN22

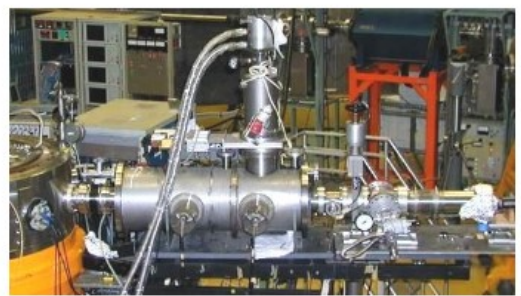
PRISMA-FIDES → GAMMA



PRISMA-FIDES
"Heavy-ion reactions from grazing collisions to complete fusion"
Report 2021 and plan for 2022-2024



The PRISMA-FIDES experiment at LNL includes 2 lines of research



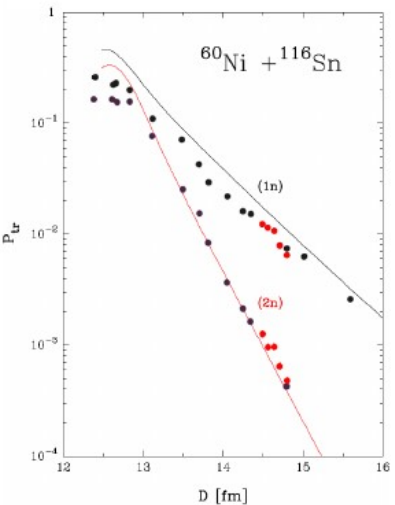
Heavy-ion fusion reactions
near V_B and at $E \ll V_B$
using the set-up **PISOLO** based on
an electrostatic beam separator



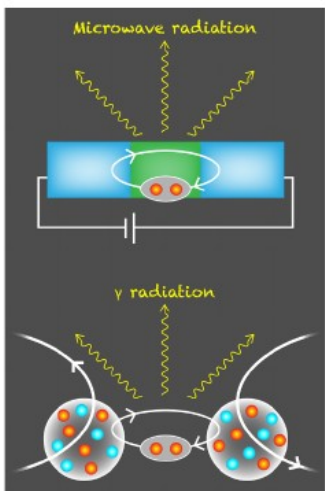
Quasi-elastic reactions
nucleon-nucleon correlations, sub-
barrier transfer, coupling to fusion,
n-rich isotope production and
nuclear structure studies
using the magnetic spectrometer
PRISMA

Colliding nuclei: Josephson junction?

A new analysis of heavy-ion collision experiments uncovers evidence that two colliding nuclei behave like a Josephson junction, in which Cooper pairs tunnel through a barrier between two superfluids.



D.Montanari, et al., PRL113(2014)052501;
and PRC93(2016)054623



Physics Viewpoint:

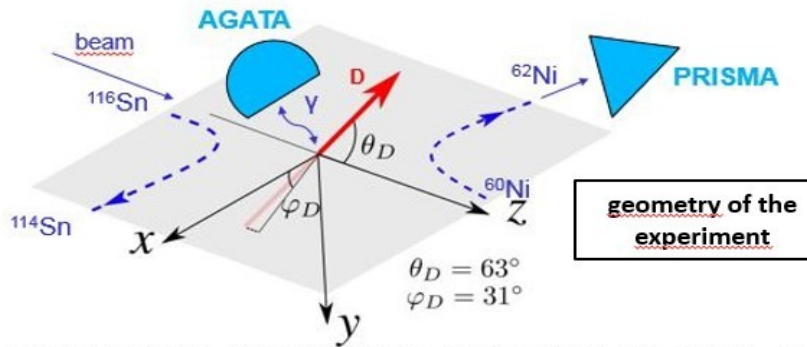
- Tiniest superfluid circuit in nature
- Superconductivity valid for macroscopic phenomena in solids may be applicable to the much smaller scale (femtometer nuclear scale)
- Pairing description is appropriate for a small number of particles

G. Potel, F. Barranco, E. Vigezzi, and R. A. Broglia,
Phys. Rev. C 103, L021601 (2021)

result from AGATA demo+PRISMA exp in 2011
AGATA campaign at LNL is awaited soon



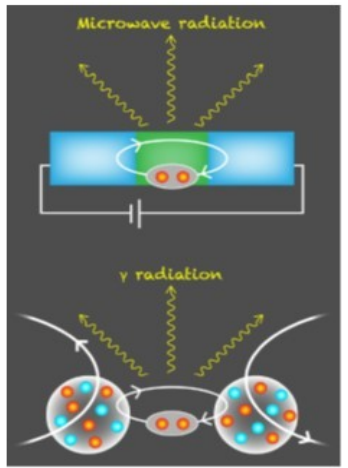
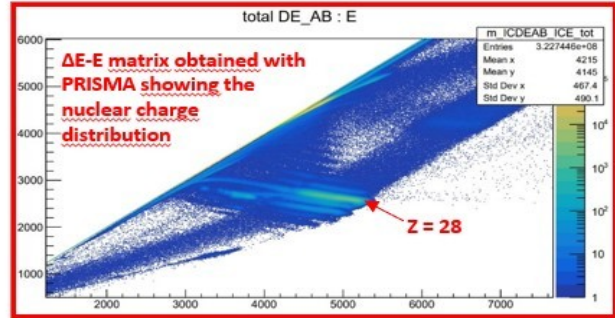
Search for a nuclear Josephson effect - PRISMA-AGATA experiment Feb. 2023



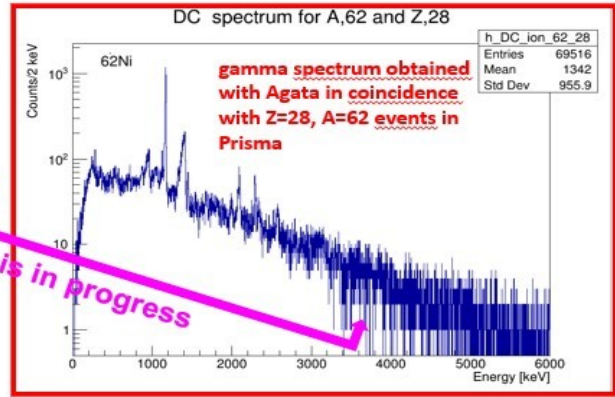
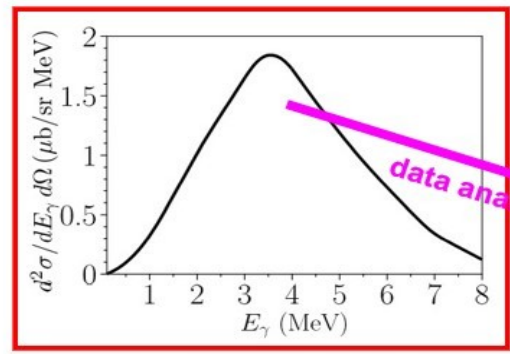
^{116}Sn beam PIAVE+ALPI, $E_{\text{lab}} = 452.5$ MeV, $I = 3$ pA
target thickness $300 \mu\text{g}/\text{cm}^2$, Prisma $\theta_{\text{lab}} = 20^\circ$

A first challenging experiment has been carried out at LNL looking at the possible existence of a gamma radiation emitted via a **dipole oscillation D** generated by the two neutron transfer process in the $^{116}\text{Sn}+^{60}\text{Ni}$ reaction at energies below the Coulomb barrier. This would evidence that two colliding nuclei behave like a Josephson junction, a device in which **Cooper pairs tunnel through a barrier between two superfluids**

examples of preliminary data



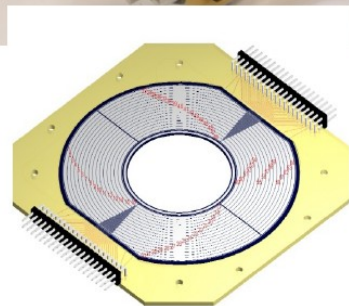
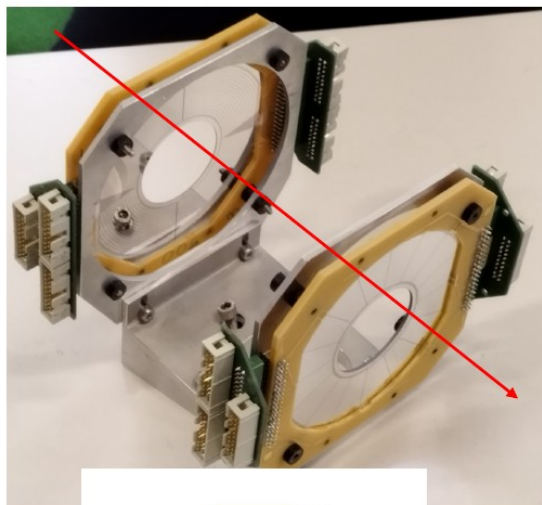
gamma ray strength function predicted by Broglia et al.



data analysis in progress

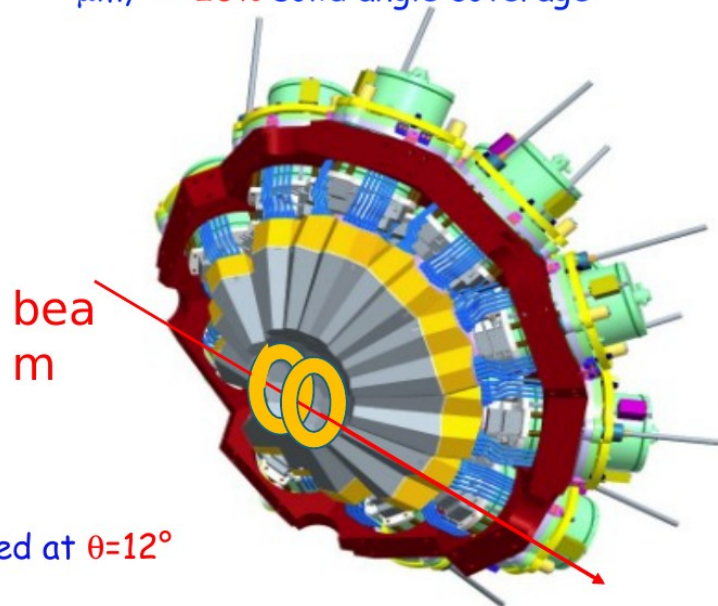
Data taken at INFN – Laboratori Nazionali di Legnaro Spokespersons L.Corradi, S.Szilner

Low-energy fusion hindrance in medium-light systems: AGATA + DSSD set-up



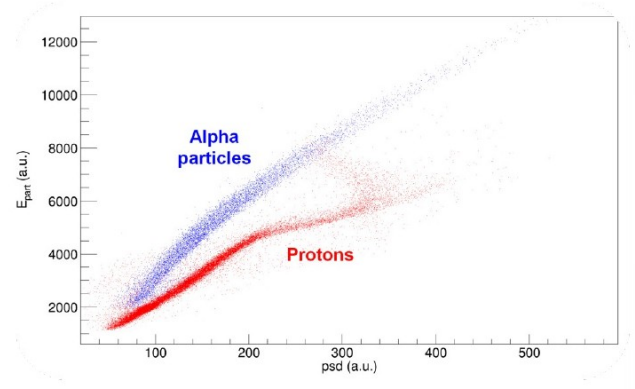
→ Two monitor detectors installed at $\theta=12^\circ$ to normalize the fusion yield

- S1 detectors (Micron), $\varnothing = 4''$, at 5 cm from the target, upstream and downstream of the target
- thicknesses of 1500 μm and 1000 μm , $\sim 20\%$ solid angle coverage

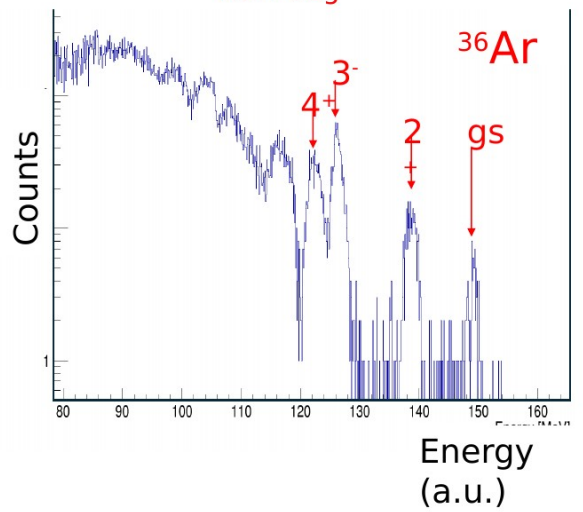


50 MeV $^{28}\text{Si} + ^{12}\text{C}$

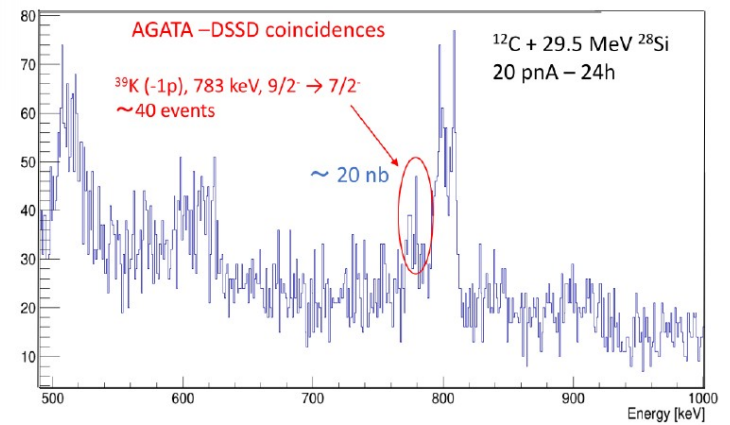
Identification of evaporated particles: Energy spectrum of α particles at $\Delta\theta = 27.0\text{-}28.4$ deg



Light-charged particles detected by the DSSD are identified through pulse shape analysis, using their energy E_{part} vs the rise time (psd)



γ -spectrum in coincidence with one DSSD at 29.5 MeV



Coincident γ -spectrum at the energy $E_{\text{lab}} = 29.5$ MeV, where the total fusion cross section is estimated ≈ 100 nb. The $9/2^- \rightarrow 7/2^-$ transition of the $1p$ evaporation channel (^{39}K) can be observed.

The new PRISMA power supplies (approval on 13-4-2022)

the tender specifications started to be worked out just after we got financial support by the CSN3 (300 keuro) in Sept. 2021

the bid deadline was fixed by end of Feb. 2022

the final approval by INFN was on 13-4-2022



SYSTEM 8500

Model 859

Magnet Power Supply

ISTITUTO NAZIONALE DI FISICA NUCLEARE

GIUNTA ESECUTIVA

DELIBERAZIONE N. 13108

DELIBERA

1. di approvare la procedura negoziata illustrata in narrativa e di affidare alla DANFYSIK A/S la fornitura di due alimentatori per lo spettrometro magnetico PRISMA, per la Sezione di Padova dell'INFN, per un importo di € 270.000,00, oltre IVA al 22%, pari ad € 59.400,00 per un totale di € 329.400,00;

ASFIN2 (44 ricercatori, 29.6 FTE)

LNS (19.60 FTE) + NA (2.9 FTE) + PG (4.0 FTE) + PD (3.1 FTE):
M. Mazzocco (0.8), S. Pigliapoco (1.0), F. Soramel (0.3), F. Andreis (1.0)

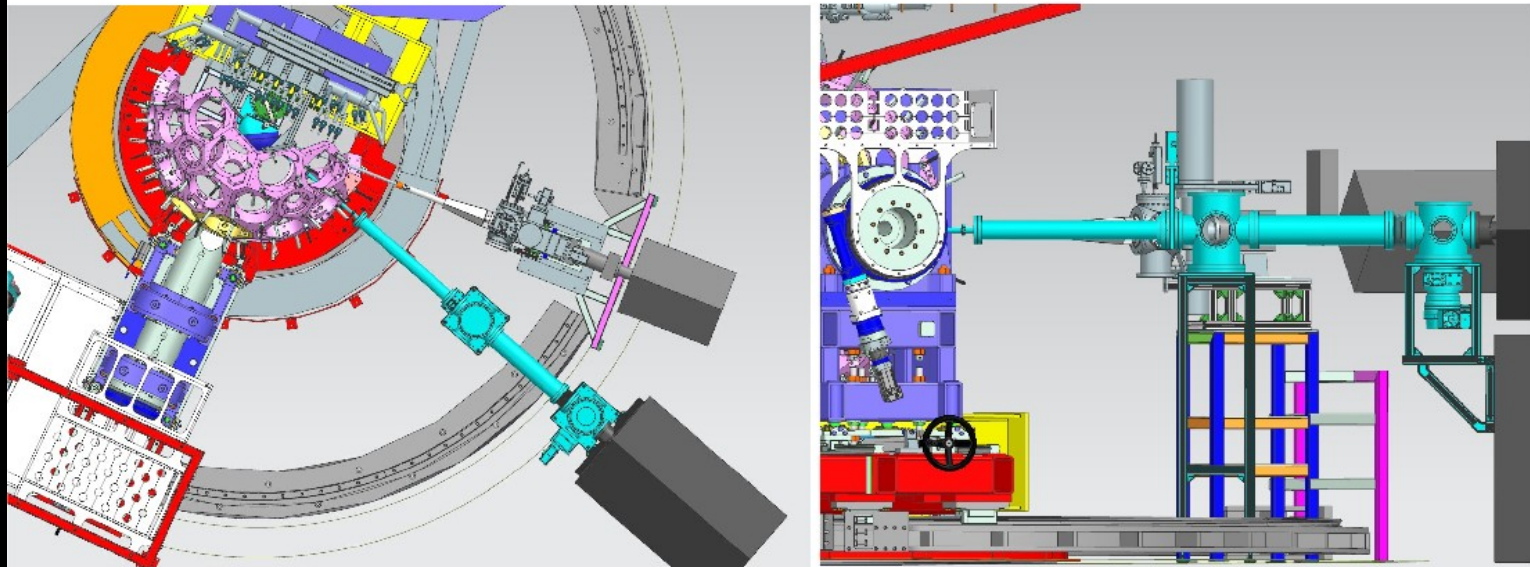
Studio delle reazioni nucleari di interesse astrofisico mediante i metodi indiretti



La reazione di interesse astrofisico $x+A \rightarrow c+d$ viene studiata mediante la reazione Cavallo di Troia $a+A \rightarrow c+d+s$, nell'ipotesi che a abbia una pronunciata struttura a cluster $a = x+s$ ed s rimanga **spettatore** durante l'interazione.

ASFIN2_PD: Highlights Attività 2022-23

Connection Beam-Line between EXOTIC and AGATA

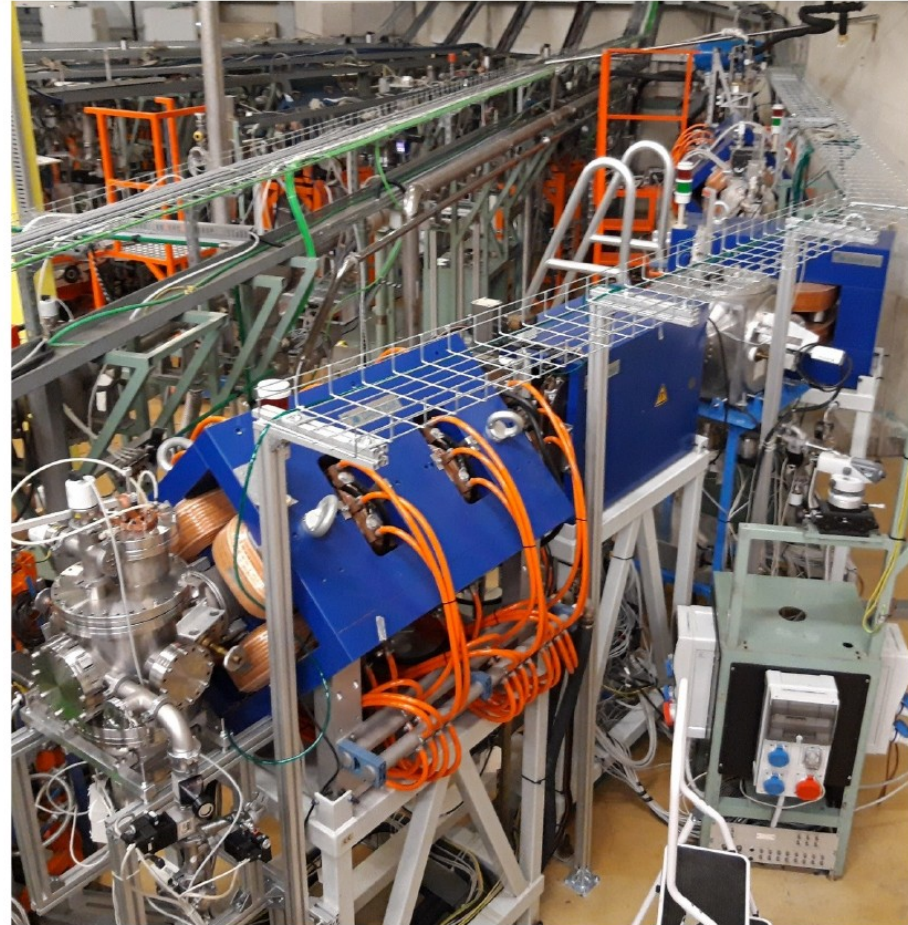


Ufficio Tecnico – INFN Padova

ASFIN2_PD: Highlights Attività 2023-24

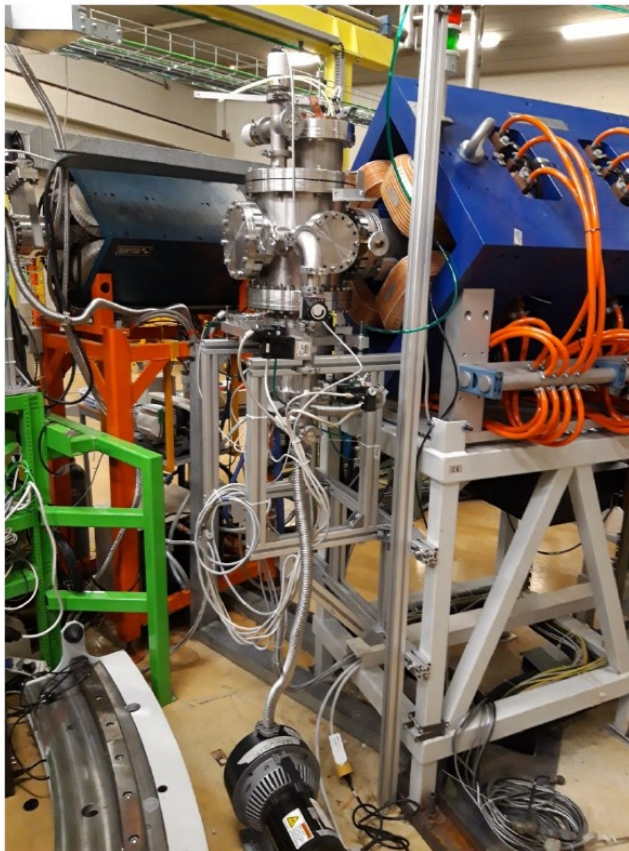
Upgrade of EXOTIC

- Power lines
- Signal cables
- Beam diagnostics
- Vacuum control
- Gas target control
- LN₂ pile-line insulation
- Water collector and pipelines for cooling the magnets
- Magnets and Wien Filter remote control
- Slit remote control
- Teslameters
- Compressed air
- Tracking detectors



ASFIN2_PD: Highlights Attività 2023-24

First (Re-)commissioning Run (October 28-29, 2023)



- First experimental run with EXOTIC after nearly 4 years of inactivity.
- **Beam:** ${}^7\text{Li}^{3+}$, 48 MeV, 1-35 pA
- **Target:** ${}^1\text{H}_2$, 1 bar, -184°C
- **RIB:** ${}^7\text{Be}^{4+}$, ~ 42 MeV

- Reoptimization of the **primary beam focussing procedure.**
- Quickly reproduced the **secondary beam production conditions** of November 2013.
- **Tuning** of the ion optical elements of the beamline.
- Test of the **AGATA performance** and **neutron flux** on the detectors.

ASFIN2_PD: Highlights Attività 2023-24

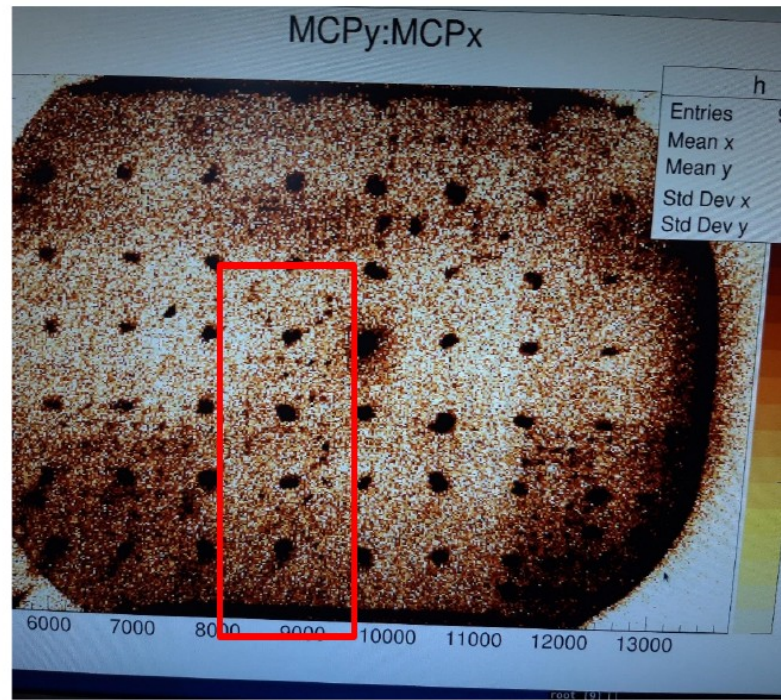
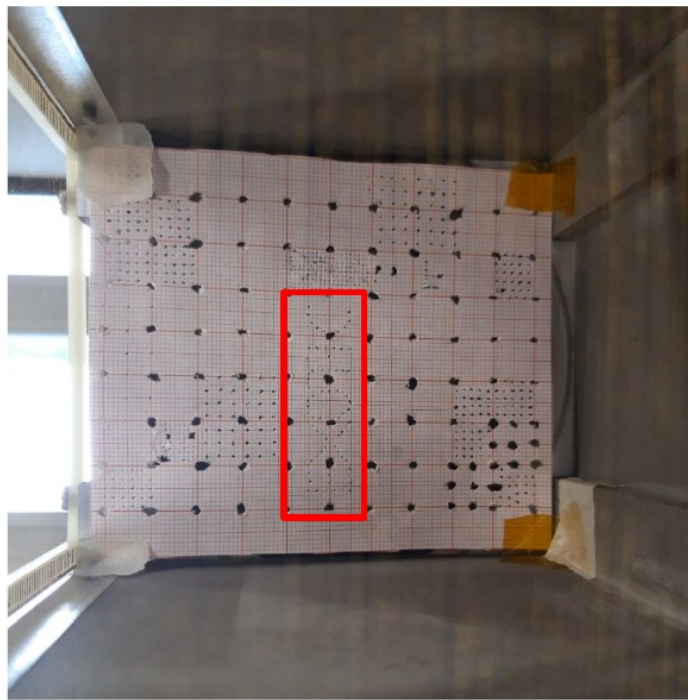
Building the new MCP

- MCPs from RoentDek (Hamamatsu) delivered at the **end of July 2023**.
- **Circular shape** with a diameter of **104 mm** (active area).
- Lay-out of the mechanical support and electronics based on the MCP of **PRISMA** (rectangular shape of 100 mm x 80 mm).



ASFIN2_PD: Highlights Attività 2023-24

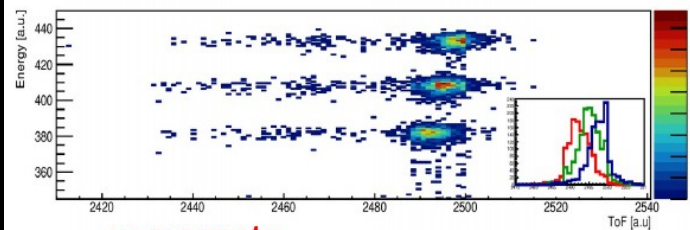
First Tests with Alpha Particles



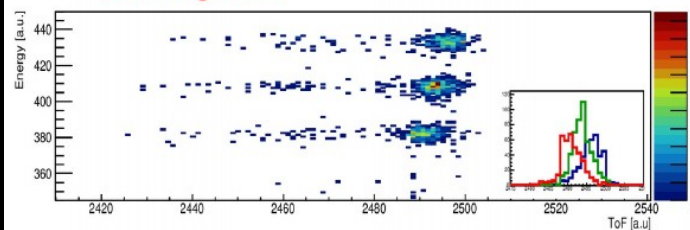
ASFIN2_PD: Highlights Attività 2023-24

Second Commissioning Run (December 4-5, 2023)

w/o magnets

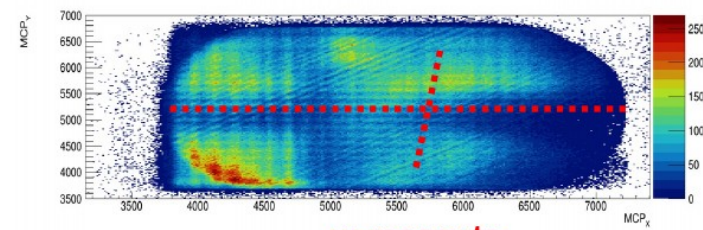


w magnets

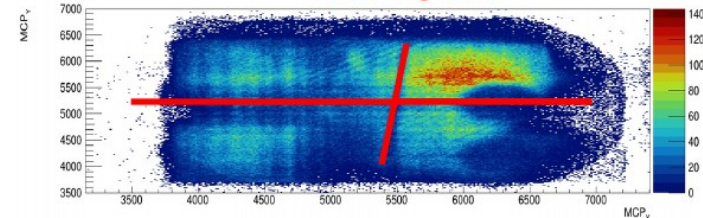


TOF resolution **better than 600 ps**

w/o magnets



w magnets



Position resolution: **~ 2 mm**

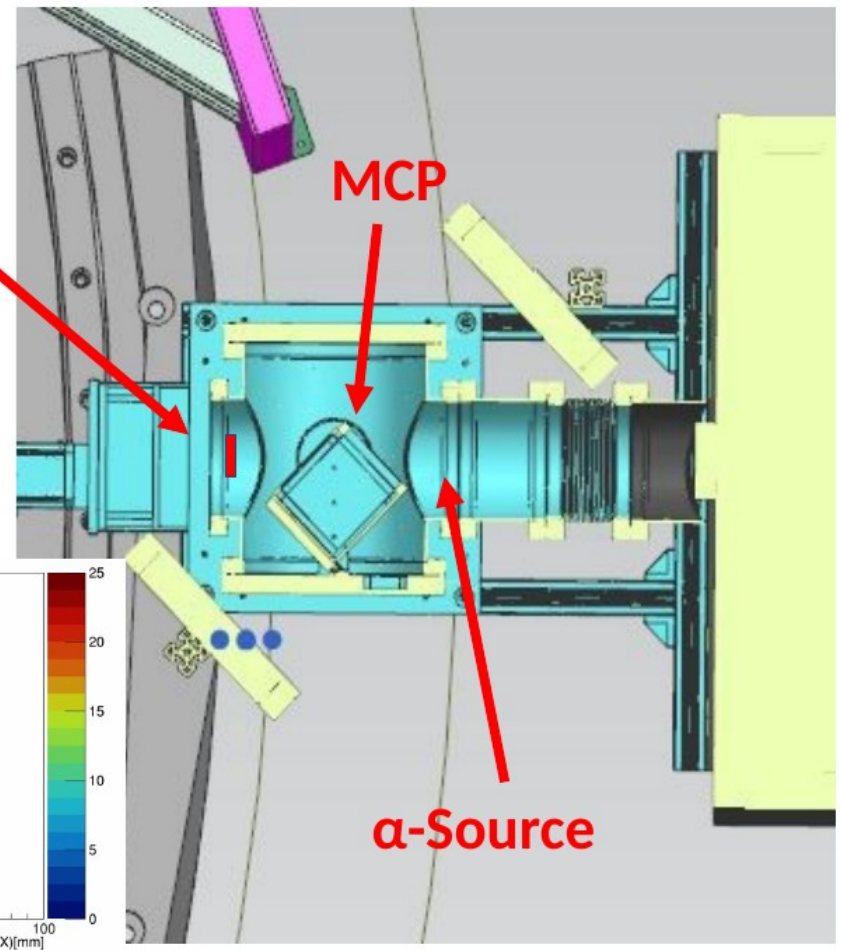
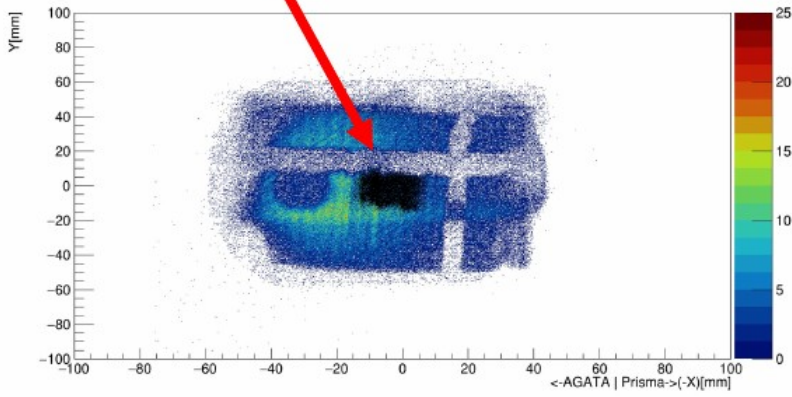
ASFIN2_PD: Highlights Attività 2023-24

Off-line Test of the Tracking Algorithm

EXotic Silicon Strip Detector (EXSSiDe)
Area: 64 mm x 64 mm
Thickness: 1 mm
Strip: 32 vertical x 32 horizontal
Position Resolution: 2 mm x 2 mm

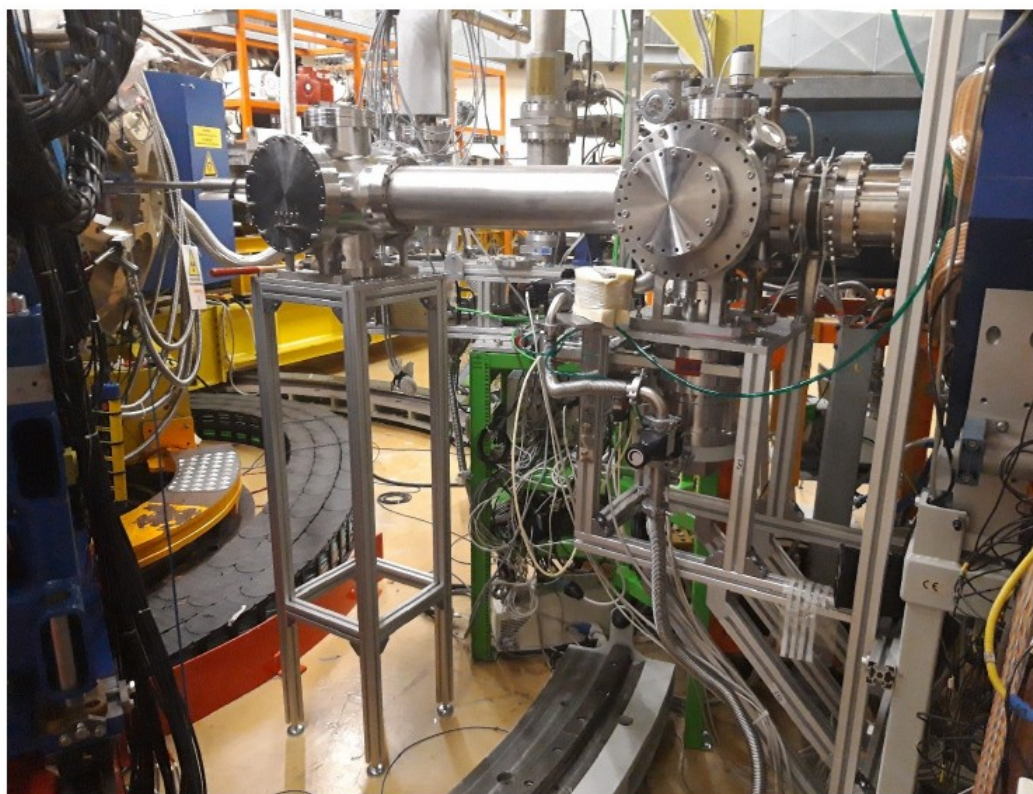
EXSSiDe

Gate on EXSSiDe



ASFIN2_PD: Attività Prevista 2024-25

Third Commissioning Run (July 5-6, 2024)



Development and installation of a second MCP in a dedicated chamber.
Test of the performances of the event-by-event tracking algorithm.

Richieste Finanziarie e Richieste ai Servizi PD

Richieste Finanziarie - ASFIN2 Sez. Padova

TO UPDATE

Consumo:
Costituzione Apparat:
Total

STILL TO BE DISCUSSED

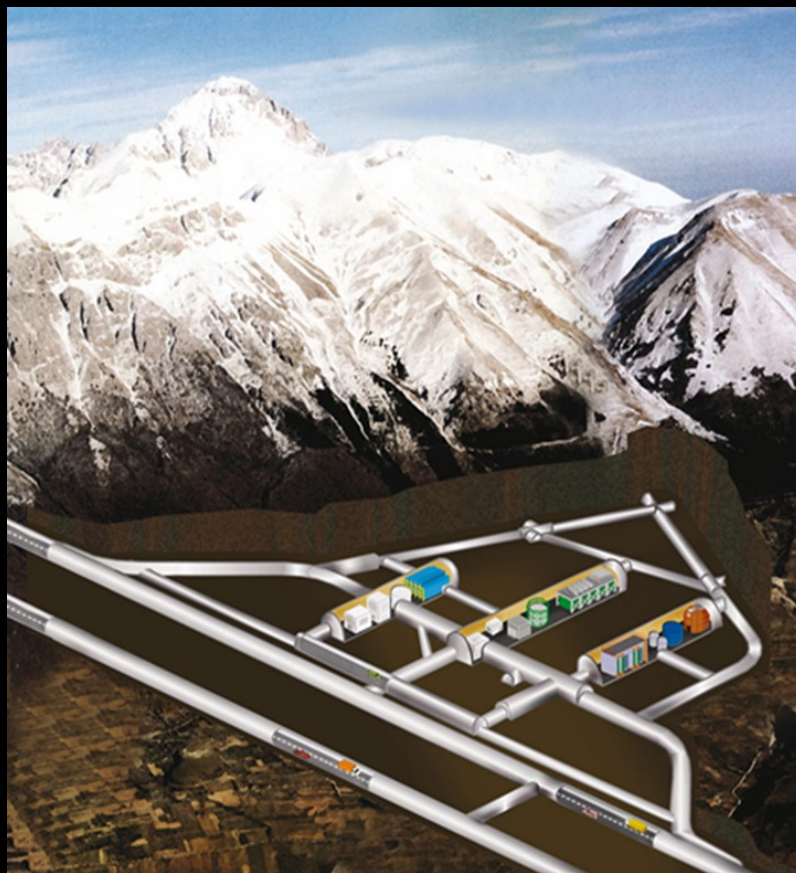
Richieste ai Servizi della Sezione INFN di Padova

Officina Meccanica: 2 mese/uomo (piccole lavorazioni delle parti meccaniche per il sistema di collimazione EXOTIC-AGATA ed installazione).

Progettazione Meccanica: 1 mese/uomo (progettazione di piccole componenti meccaniche per la collimazione del fascio secondario)

Progettazione Elettronica: 2 mesi/uomo (realizzazione delle griglie per i MCP, se non realizzate entro il 2024)

LUNA3





GRUPPO LUNA3

C. Brogginì (30%), A. Cacioli (100%), P. Marigo (20%), R. Menegazzo (30%), Denise Piatti (70%), Jakub Skowronski (100%), Steffen Turkat (100%) – 4.5 FTE

FONDI ESTERNI LEGATI AD ATTIVITÀ LUNA

- CHETEC-INFRA: 85k€ at UNIPD (local coordinator A. Cacioli)
- PRIN2020: 65k€ at UNIPD (local coordinator A. Cacioli)
- Progetto Terza Missione 2023: 50k€ (coordinator A. Cacioli)

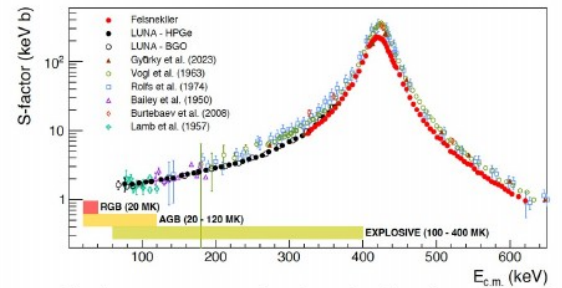
PAPER LUNA NELL'ULTIMO ANNO

- Skowronski et al., published in PRL
- Mid Term Plan LNL (Cacioli convener² for Nuclear Astrophysics)
- Mid Term Plan LNGS
- Skowronski et al., published in PRC (Piatti Corr. Author)
- Masha, Barbieri, Skowronski et al., published in PRC (Cacioli Corr. Author)
- Ananna et al., published on Universe (Piatti corr. Author)
- Ananna et al., published on Frontiers
- Gesuè et al., accepted to PRL (Piatti Corr. Author)
- Takacs et al., accepted to PRC (Piatti Corr. Author)
- Stockel, Mozumdar et al., under review on PRC
- Csedreki et al., under review on PRC
- Skowronski et al., on R-Matrix development under internal review



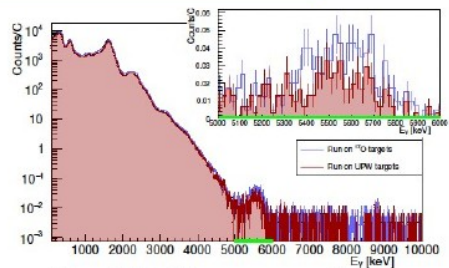
PRINCIPALI RISULTATI COORDINATI DA LUNA-PD 2023-2024

Proton capture on 12C and 13C



Studied at LUNA and Felsenkeller (Germany)
4 papers published, 3 in preparation

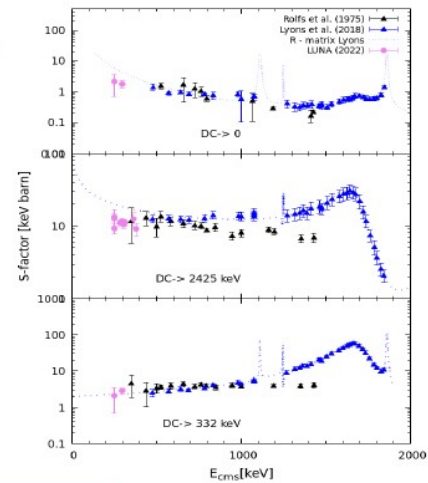
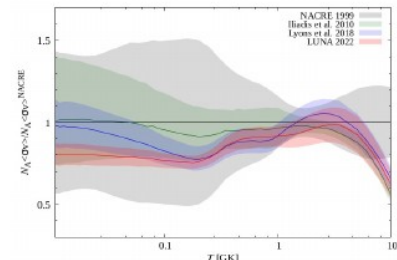
Proton capture on 17O



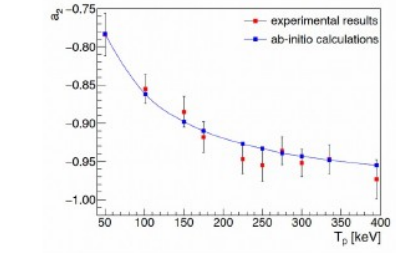
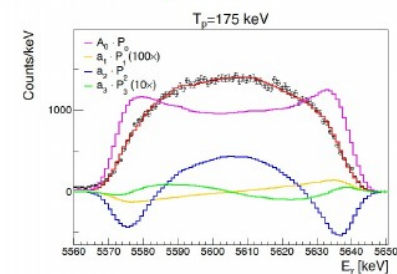
Measured the 65 keV resonance in the gamma channel
Up to now the lowest resonance strength value ever measured with direct approaches
Coordinated by Denise Piatti

Proton capture on 20Ne

First direct data lower than 400 keV
New rate lower by 20% with respect NACRE
A. Cacioli - corresponding author



p+d -> 3He+gamma



Extremely important for BBN and new results for angular distribution (follow up of the Nature paper Mozumdar (master student Nucphys) as second author

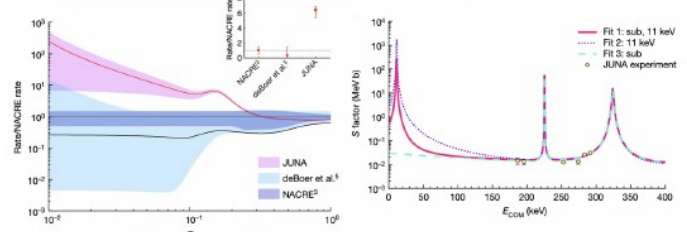




PRINCIPALI ATTIVITÀ LUNA-PD 2024-2025

LUNA-400kV

Proton capture on 19F



The rate of the $^{19}\text{F}(p,\gamma)^{20}\text{Ne}$ reaction can challenge, depending on its value, the traditional view that the bulk abundances of elements heavier than fluorine are only produced in late burning stages

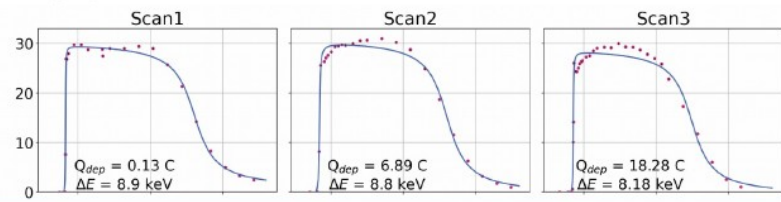
Recent results by JUNA reporting a rate higher by a factor of 7 more than literature

Goals: overlap and extend to low energies the JUNA results

LUNA-PD will coordinate the study

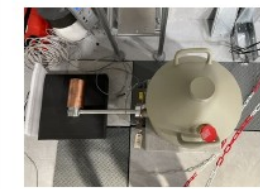
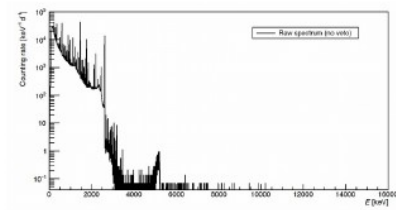
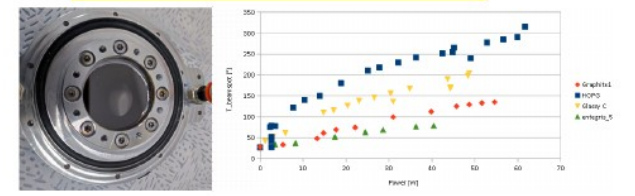
Proton capture on 23Na

Target production and characterization



Bellotti IBF

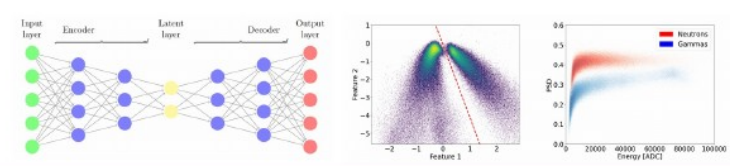
12C+12C reaction study



Characterization of the setup (target and detector) to be installed in autumn 2024. S. Turkat responsible of the data analysis

Neutron detector PSD analysis with NN

Devoted to the characterization of the SHADES liquid scintillators



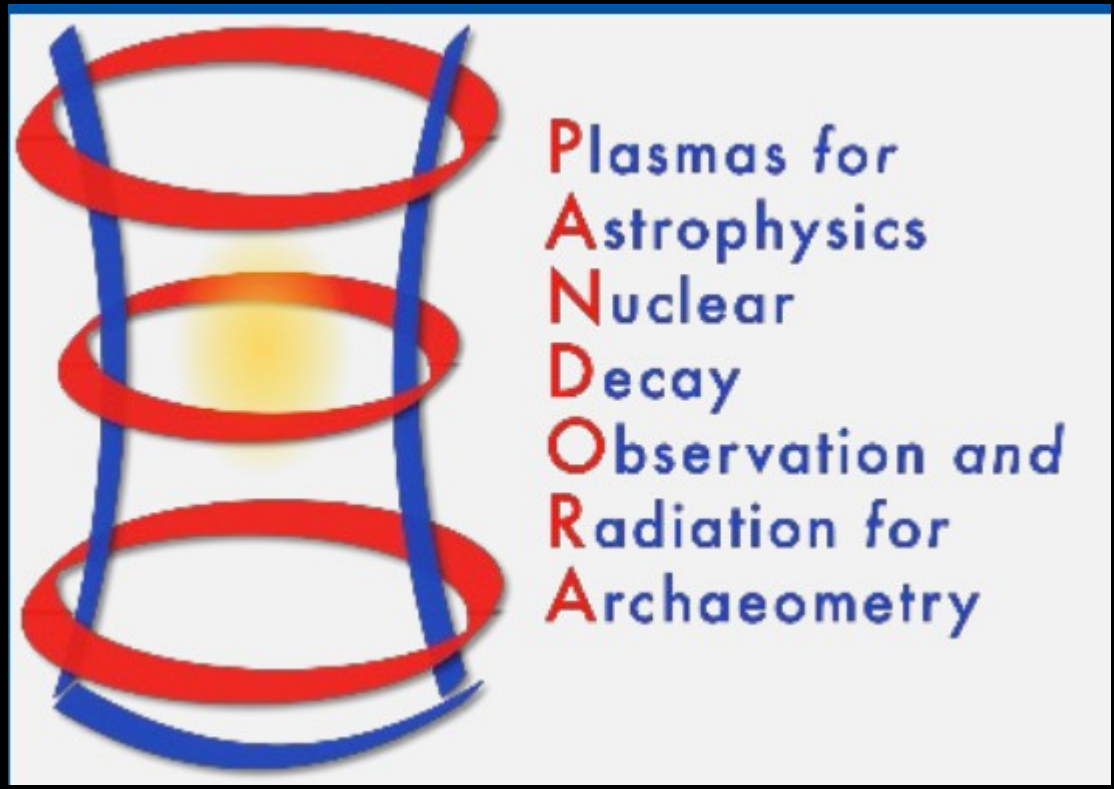


RICHIESTE FINANZIARIE LUNA3 @ PD PER 2025

- Missioni: 32 k€ turni LNGS, 3 k€ misure a LNL. Totale 35 k€
- Acquisto Faraday cup per linea di fascio a LUNA-400: 30 k€
 - 1 mese uomo elettronica
 - 1 mese uomo progettazione
 - 2 mesi uomo officina meccanica

1MU SPM + 2MU OM: Officina meccanica e progettazione per realizzazione camera di scattering sulla base di una già realizzata al gran sasso

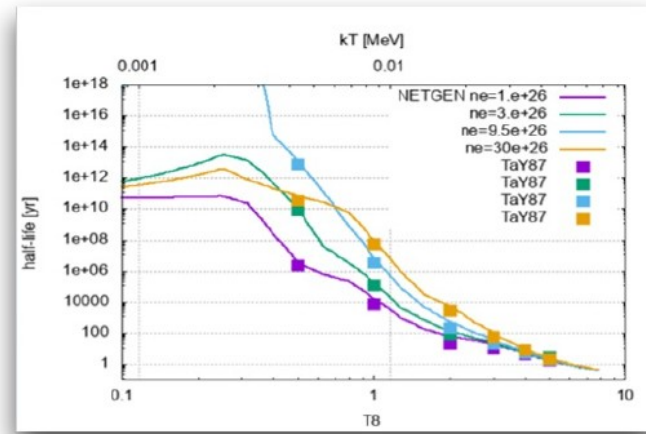
1MU Officina elettronica per aiuto in riparazione di moduli per wobblers a LNGS



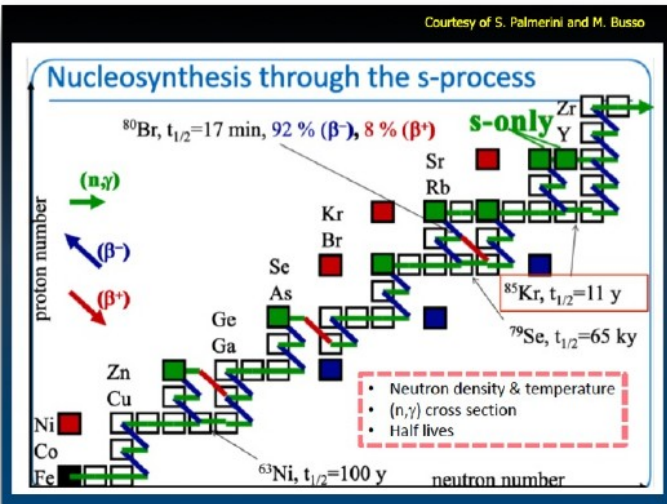
PANDORA main goal: Investigating β -radioactivity in a «stellar» environment

Make β -decay measurements in plasmas of astrophysical interest: **many isotopes can change their lifetime of several order of magnitude when ionized!!**

The effect is mainly driven by the opening of a new decay channel: the bound state beta decay



Takahashi et al. 1987, Phys Rev C 36, 1522.



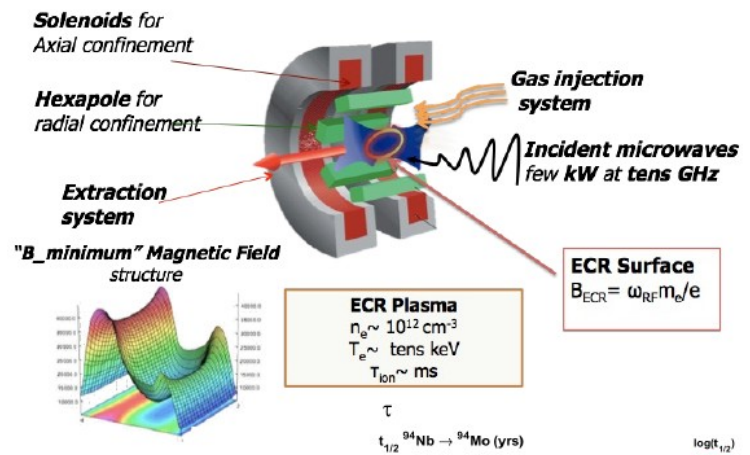
Direct implication on branching points in s-process nucleosynthesis chain competition of neutron capture vs β -decay

Isotope	$T_{1/2}$ (yr)	E_γ (keV)
^{176}Lu	3.78×10^{10}	88-400
^{134}Cs	2.06	>600
^{94}Nb	2.03×10^4	>700

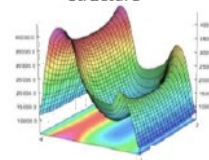
➔ COSMO-CHRONOMETER
reproduction of ^{134}Ba , ^{136}Ba s-only isotope yields

➔ Solving the puzzle about the contribution of s-processing to ^{94}Mo : β -decay or binary stars

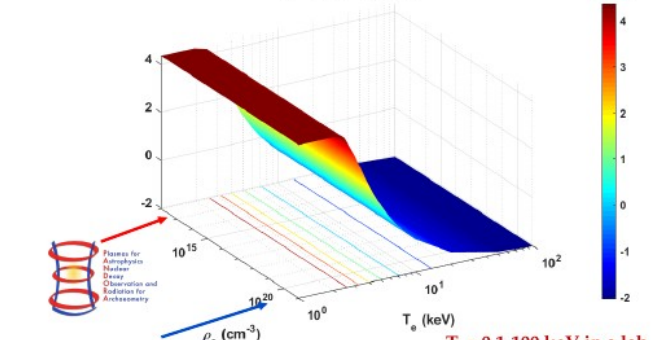
PANDORA: A New ECRIT – ECR Ion Trap for β -decay measurements in plasmas



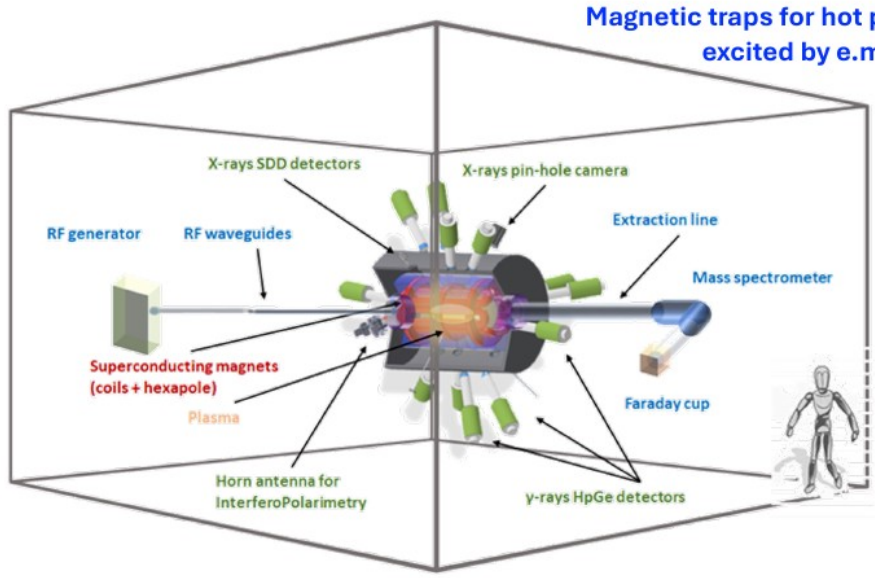
ECR Plasma
 $n_e \sim 10^{12} \text{ cm}^{-3}$
 $T_e \sim \text{tens keV}$
 $T_{ion} \sim \text{ms}$



τ
 $t_{1/2} \text{ } ^{94}\text{Nb} \rightarrow \text{}^{94}\text{Mo} \text{ (yrs)}$



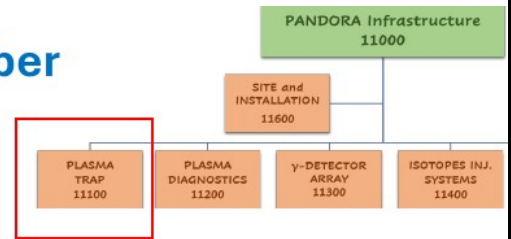
Variation with T_e stronger than with ρ so "stellar effect" can be modelled in ECR plasmas



Additional Goal

- Measuring plasma opacity relevant for compact binary ejecta (Kilonovae)

MAIN SUBSYSTEMS UPDATES: plasma chamber (LNS + PD ACTIVITY)



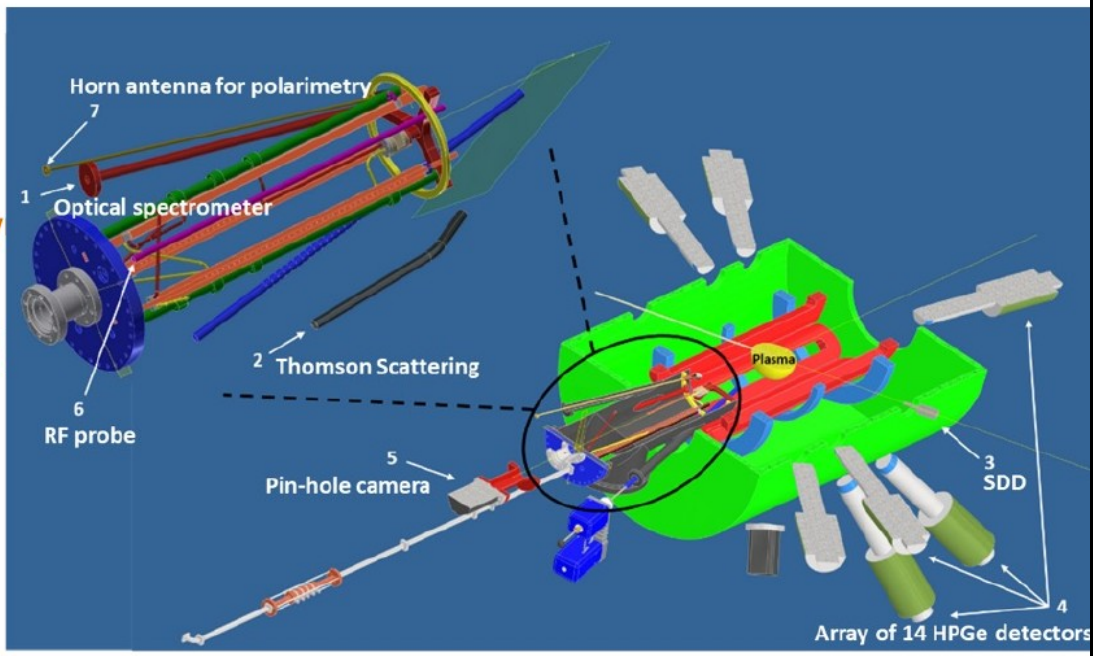
The design of the main plasma chamber is ongoing

The end caps, through several flanges and feedthroughs, allow to connect the vacuum pipe, the RF injection waveguides, the gas inlet, the oven, and several diagnostic devices.

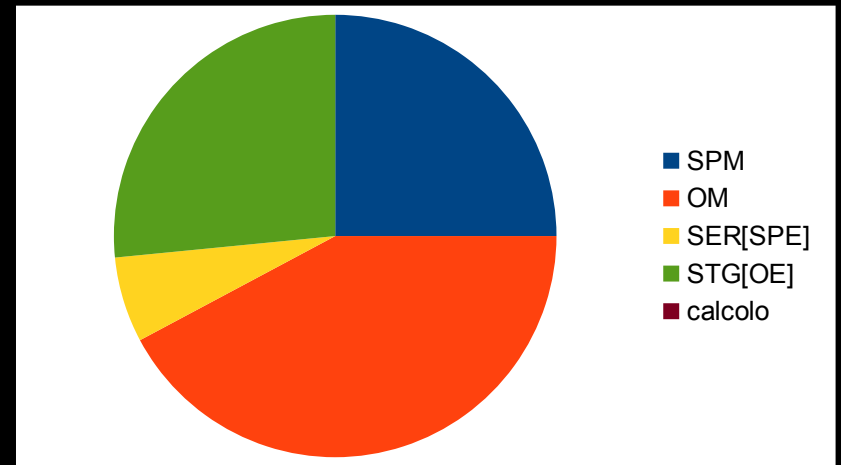
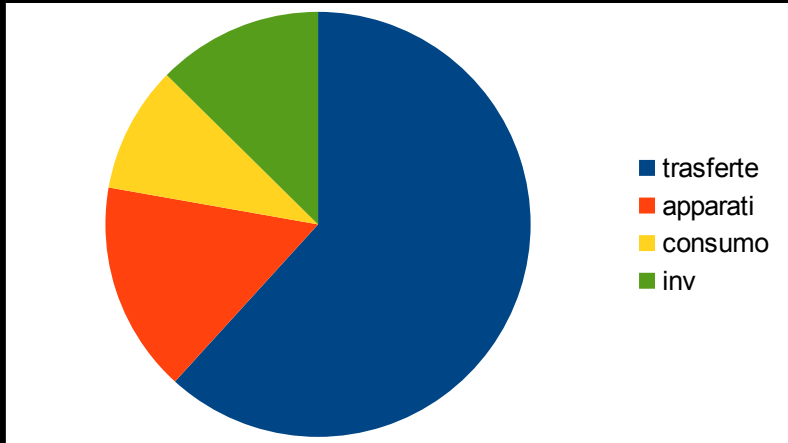
Many aspects concerning the positioning of different diagnostic tools on the injection side of the chamber were defined but still work needs to be done to complete the design.

The completion of the design will be possible only when the technical specifications (dimensions) of the magnetic trap will be known

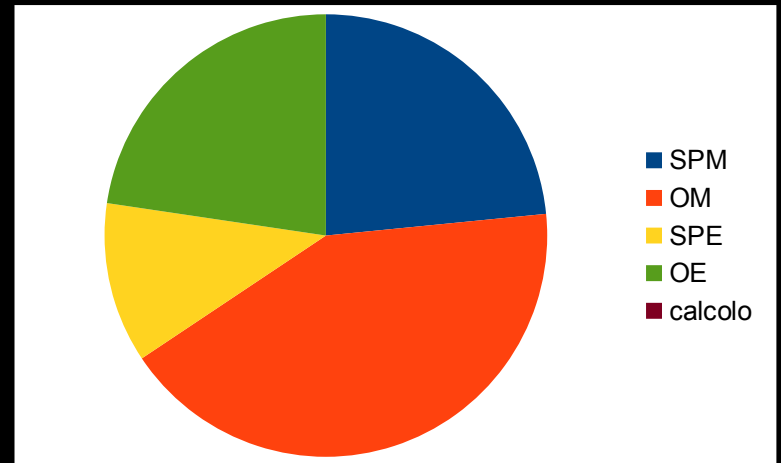
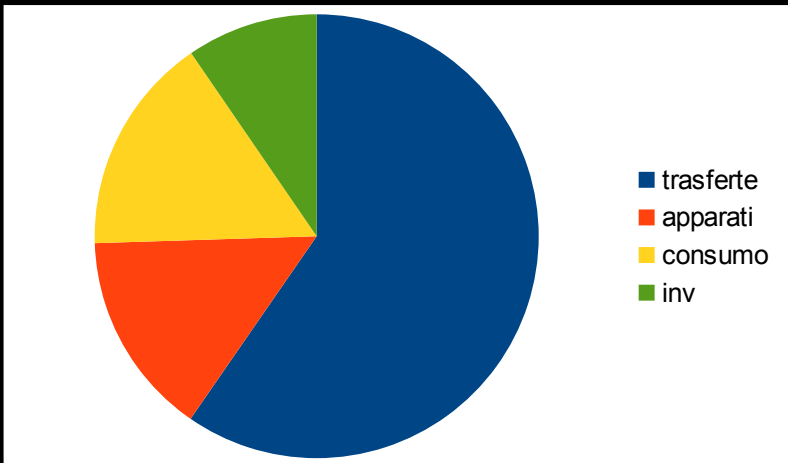
With INFN-PD we have already ordered 120 kg of Inconel (Nickel alloy) for the chamber fabrication by Additive Manufacturing - Dec. 2023
Delivery at INFN-PD in April 2024



2024



2023



Sommario preliminare

	>= PhD									
2024	pp	FTE	trasferte	apparati	consumo	inv	SPM	OM	SER[SPE]	STG[OE]
ALICE	13.00	10.60	95.00		15.00			3.00		6.00
NA60+	2.00	0.20	4.00							
ePIC	7.00	2.50	11.00		16.00	20.00	4.00	2.00		2.00
ASFIN2	3.00	3.10	20.50		1.00	5.00	1.00	2.00		2.00
GAMMA	17.00	15.25	100.00	70.00	10.00		10.00	18.00	4.00	6.00
LUNA3	7.00	5.50	35.00			30.00	1.00	2.00		1.00
PANDORA	4.00	1.00	4.00							
SPES_MED	7.00	2.90								
tot	60.00	41.05	269.50	70.00	42.00	55.00	16.00	27.00	4.00	17.00
Δ	12.00	4.70	-11.00	0.00	-33.00	10.00	0.00	2.00	-4.00	0.00

FEROCE (Gr5) = 0.1 FTE AFFINI GAMMA
1 associati senior in GAMMA

Non in anagrafica entro scadenza
GAMMA: 3 AdR +RTT +1 PHD
ALICE: 1-2 PhD, 1 AdR



**Fine
della
Presentazione**

Grazie per l'attenzione

Andrea Vitturi, WS Fiera di Primiero 2019



