



Stato e richieste degli esperimenti di Gruppo III Padova

Daniele Mengoni

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

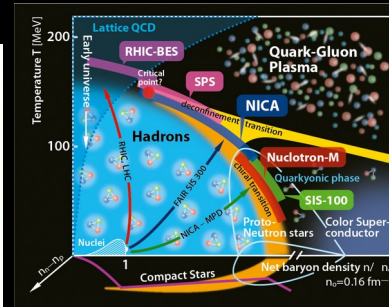
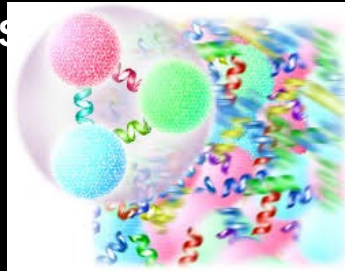
Daniele Mengoni – DFA/INFN Pd
Consiglio di Sezione INFN
Padova
06 Luglio 2023



6 research lines: 26 exps

1. QUARKS AND HADRON DYNAMICS

EIC_NET (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**....)



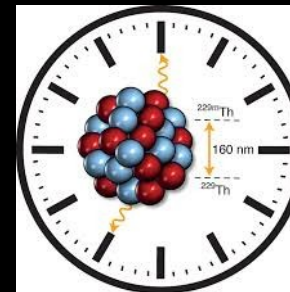
4 .NUCLEAR ASTROPHYSICS:

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)

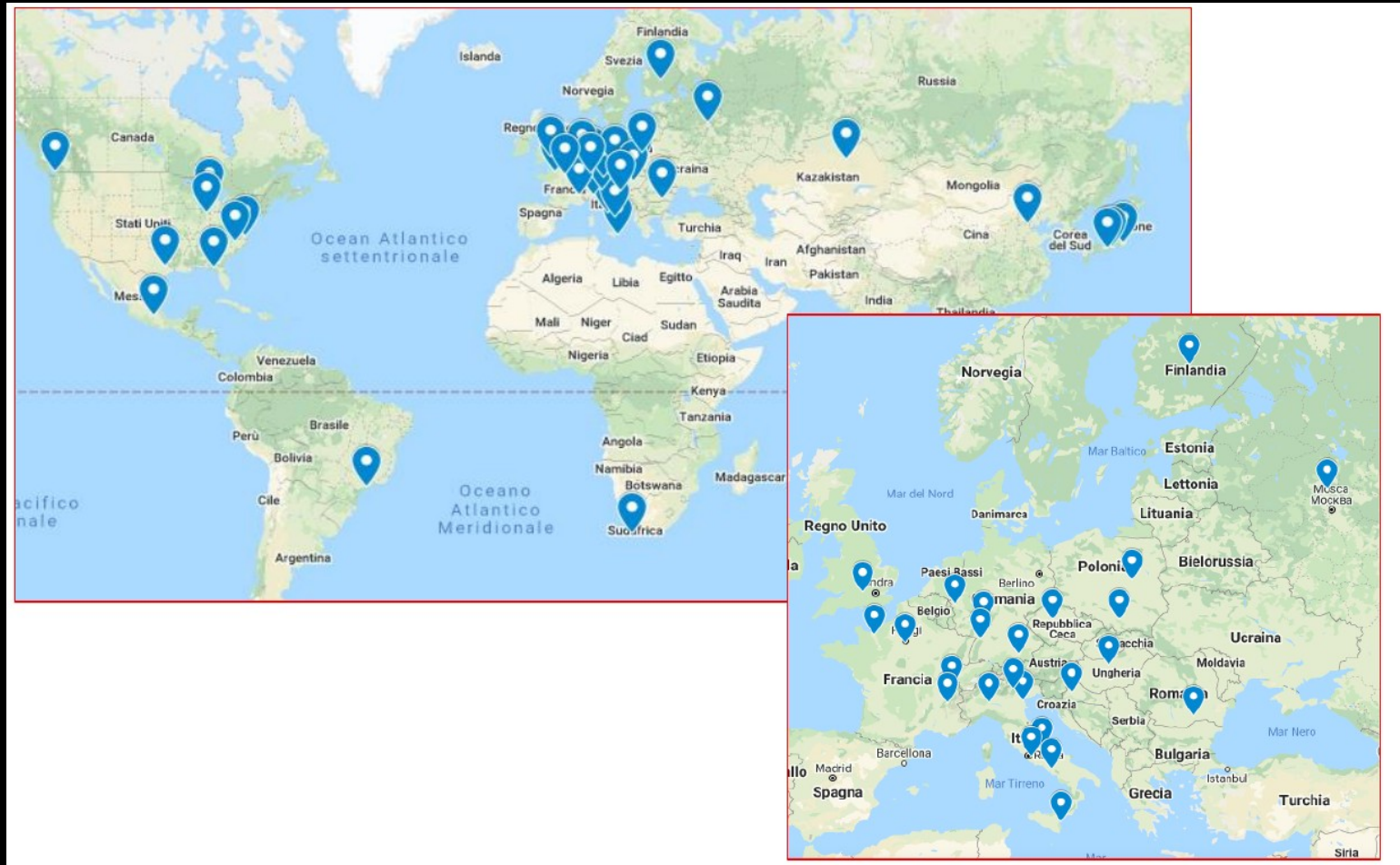
Three generations of matter (fermions)				
	I	II	III	
mass	2.4 MeV/c ²	1.27 GeV/c ²	173.2 GeV/c ²	
charge	2/3	2/3	2/3	
spin	1/2	1/2	1/2	
name				
Quarks	u up	c charm	t top	y photon
	d down	s strange	b bottom	g gluon
Leptons	e electron	μ muon	τ tau	Z ⁰ Z boson
				W [±] W boson



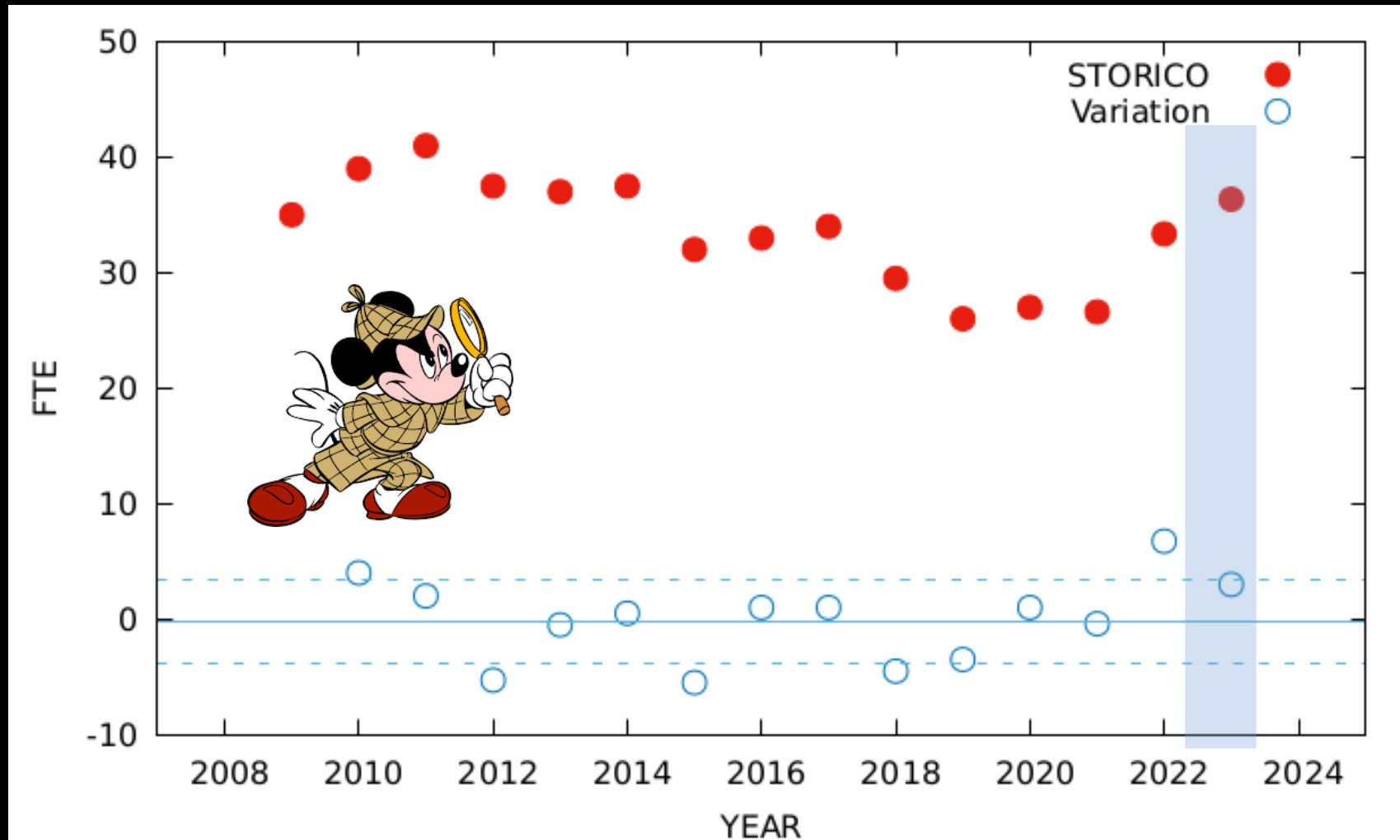
6.APPLICATIONS AND SOCIETAL BENEFITS:

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

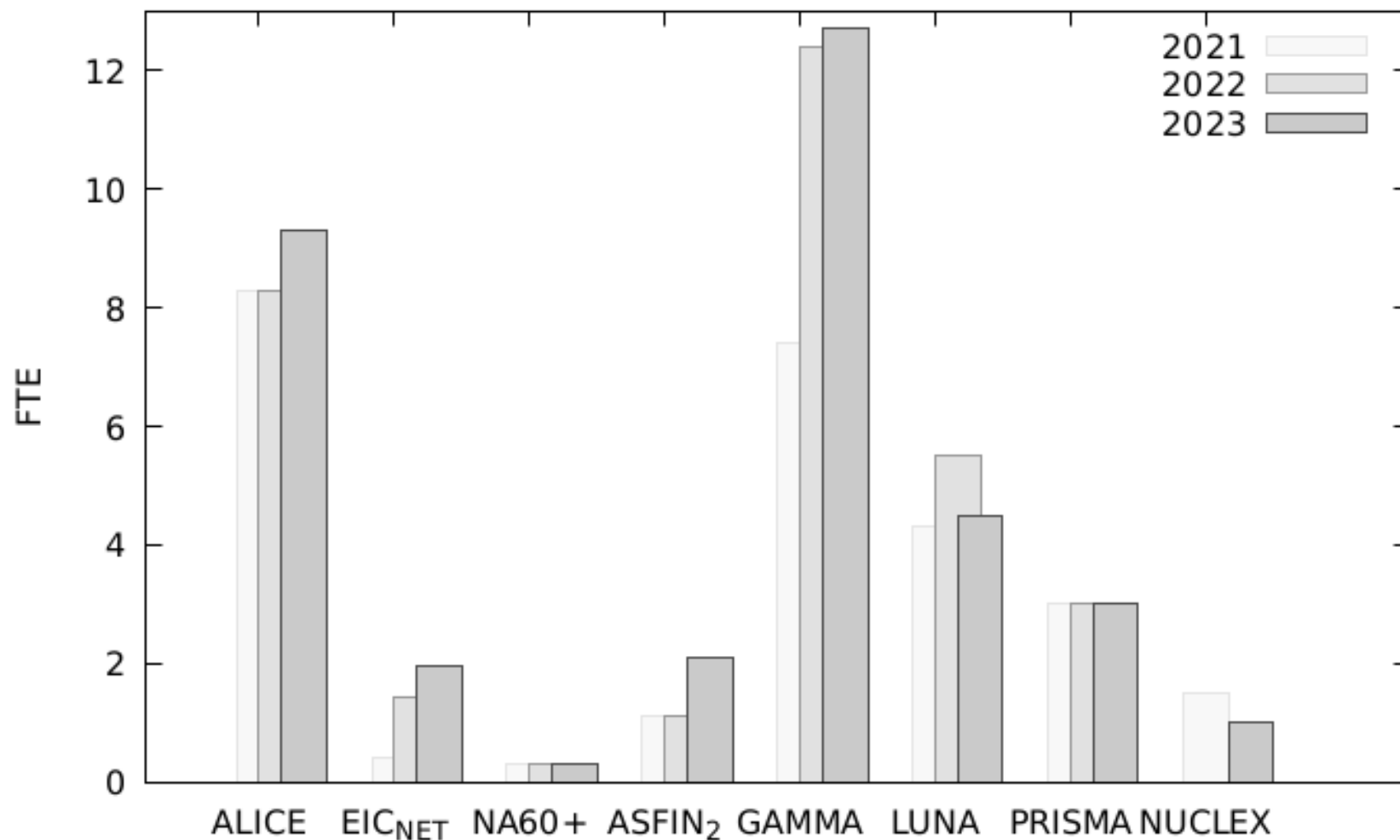
CSN3 National/International activity



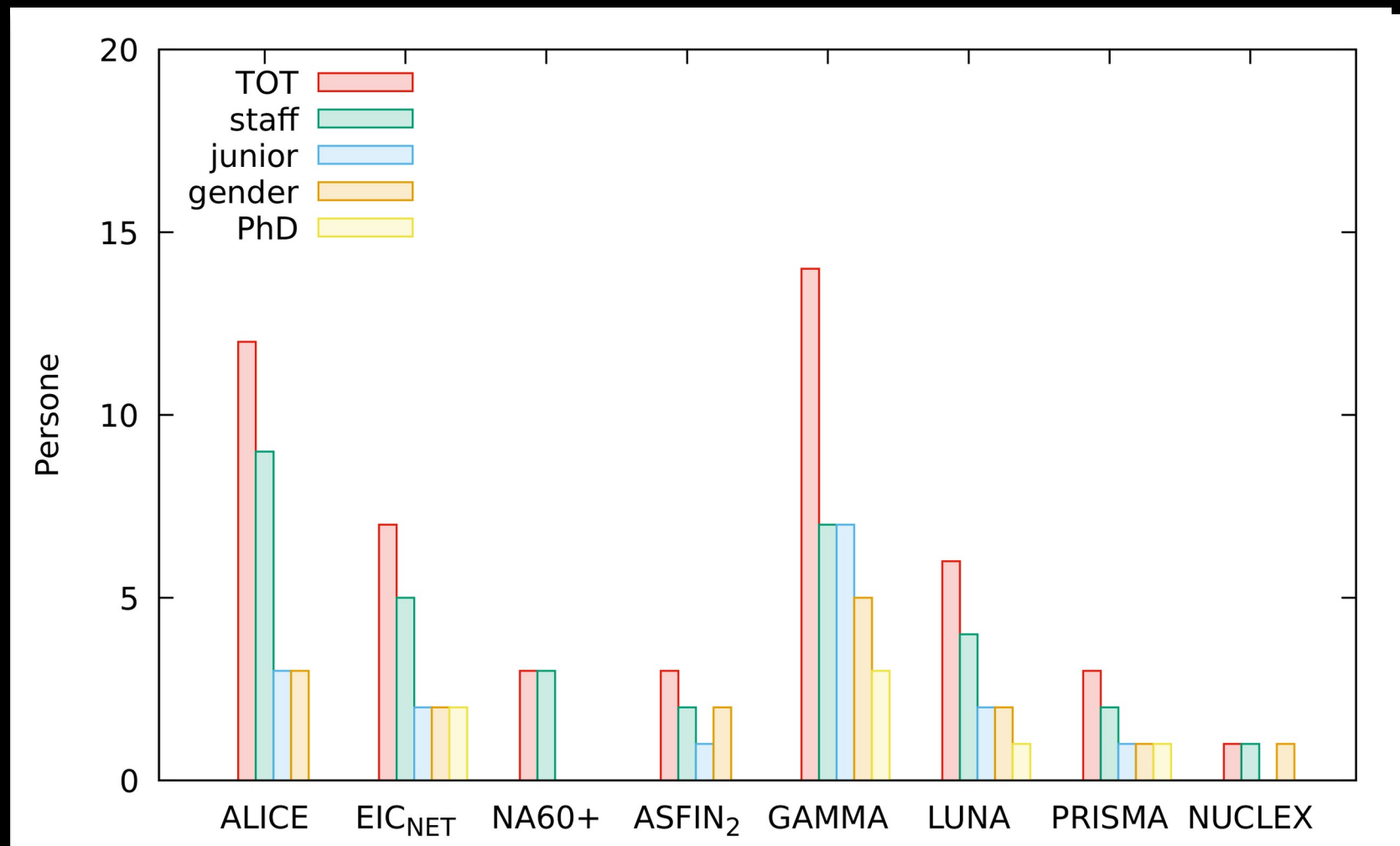
STORICO



Stat (+3 FTE ~10%)

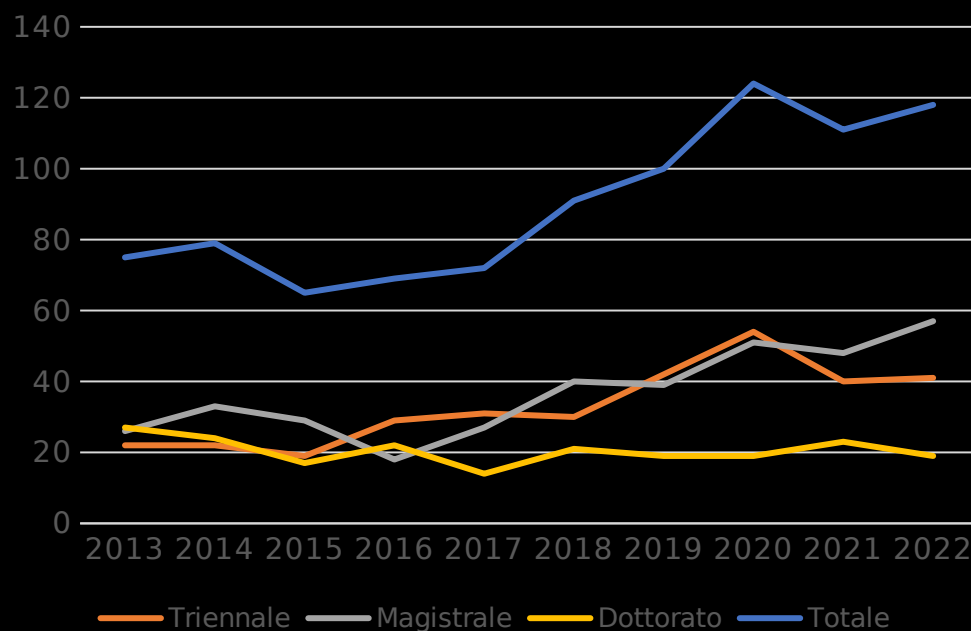


Composizione dei gruppi

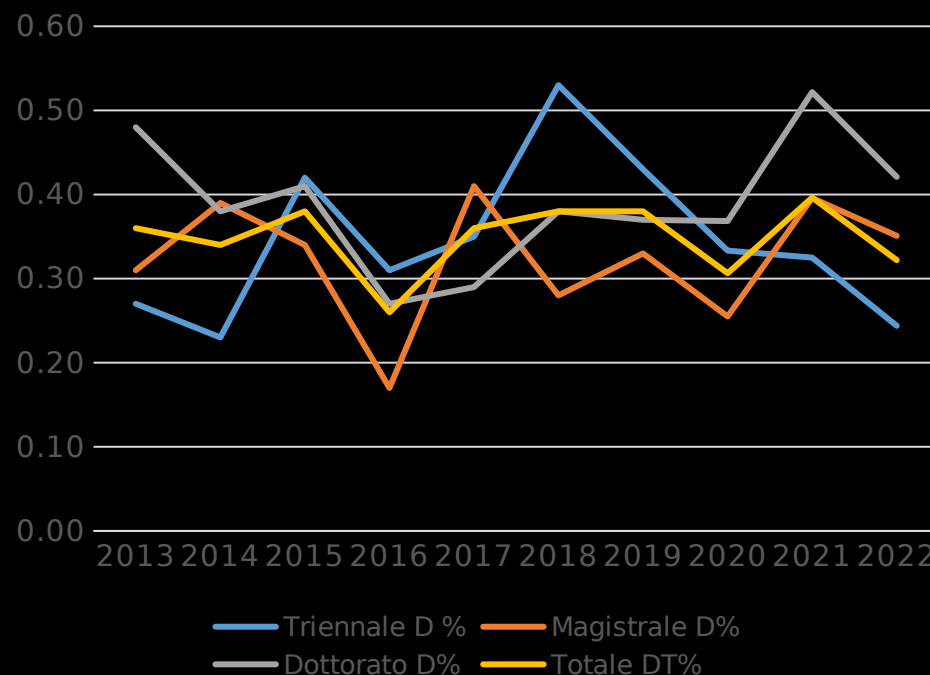


GLV_23 CSN3

Numero Tesi

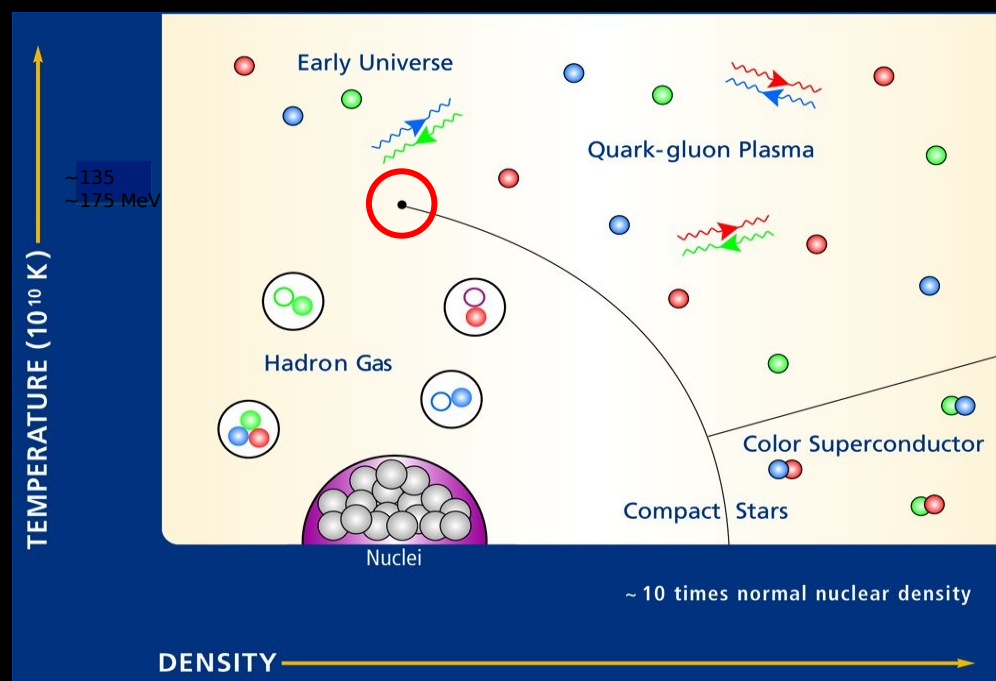


Tesi: componente femminile



1 Quarks and hadron dynamics

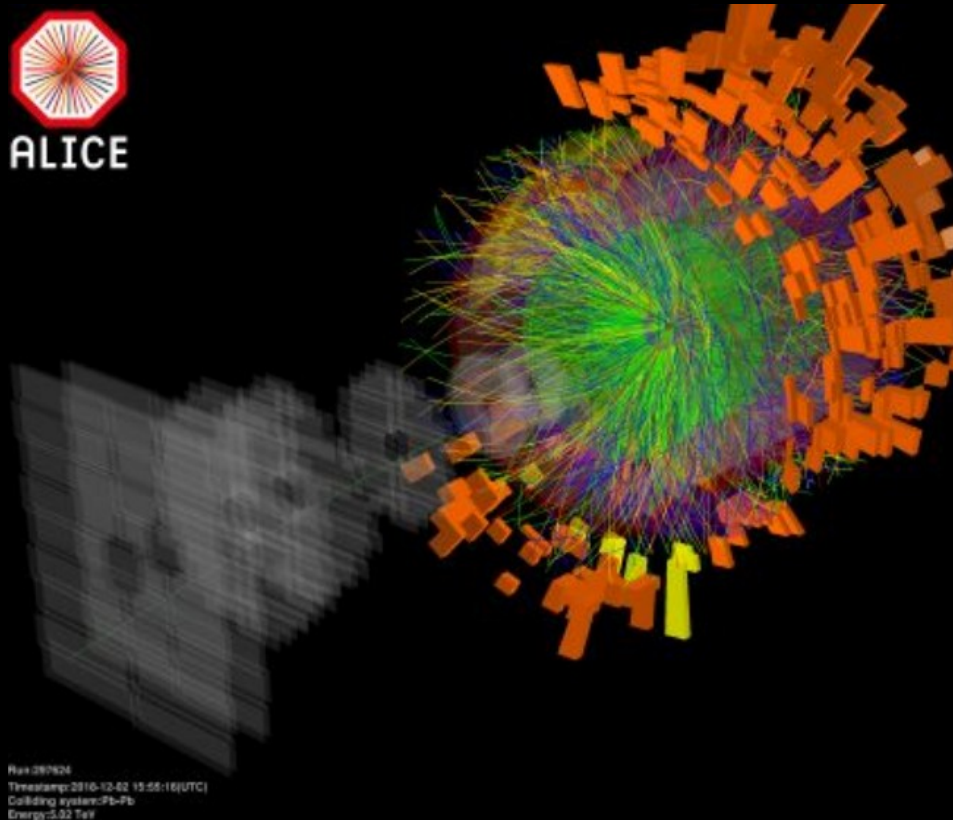
2 Phase transitions of nuclear and hadronic matter



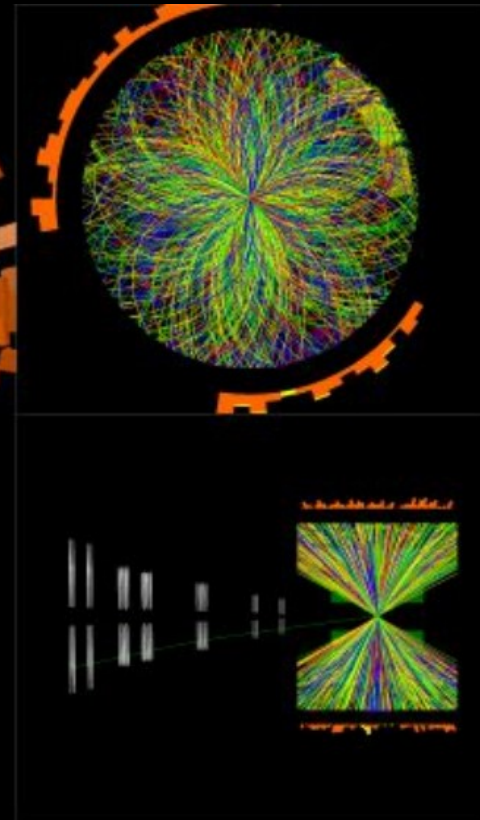
ALICE



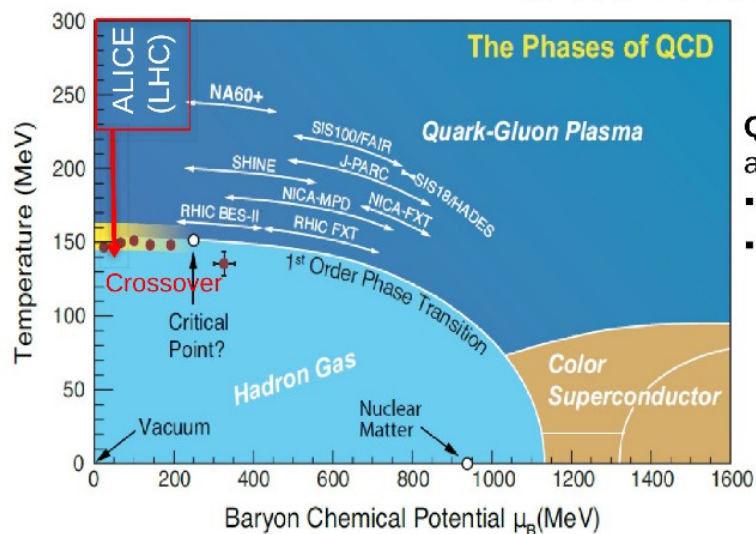
ALICE



Run 287624
Timestamp: 2016-12-02 15:55:16(UTC)
Colliding system: Pb-Pb
Energy: 5.02 TeV



Introduzione

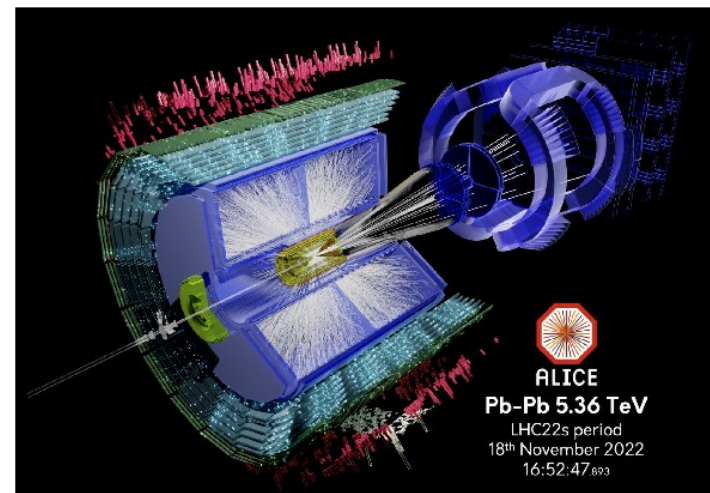


Quark-Gluon Plasma: stato della materia adronica ad alta densità di energia, in cui viene meno il confinamento.

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

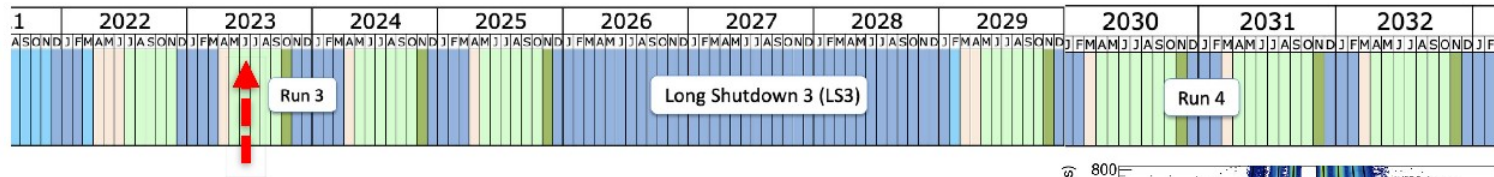
Focus del gruppo ALICE-Padova: studio del QGP attraverso gli effetti che manifesta sui **quark pesanti (c e b)**, prodotti all’inizio della collisione

- 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

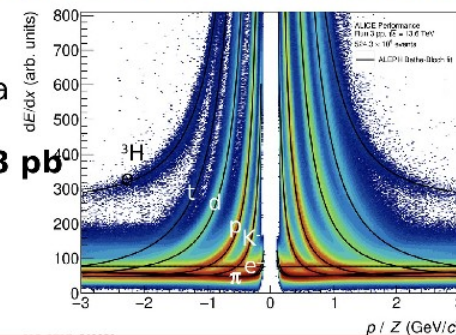


Event display pilot beam Pb-Pb 5.36 TeV, novembre 2022

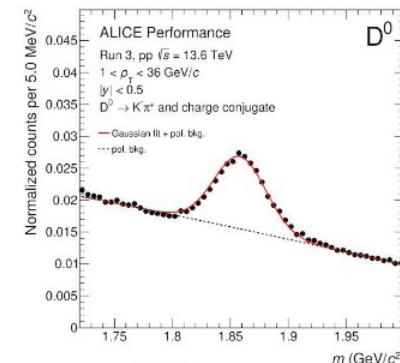
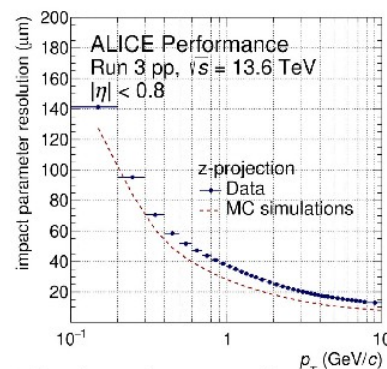
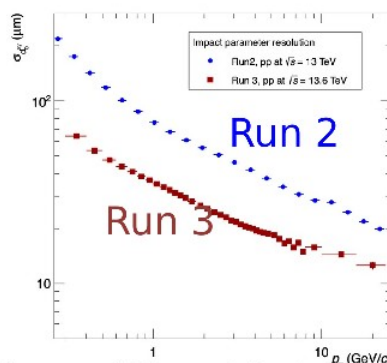
Attività ultimo anno e status attuale



Run Pb-Pb 2022 posticipato al 2023 a causa della crisi energetica
2022 - Giugno 2023: commissioning nuovo detector (**ITS e TPC** upgrade sostanziale durante LS2) + acquisizione campione di $L_{int} \sim 18 \text{ pb}^{-1}$
¹ **a 13.6 TeV 2023 (a più alto rate e triggerless)**: run pp 13.6 TeV in corso. **Ottobre: pp e Pb-Pb a 5 TeV**

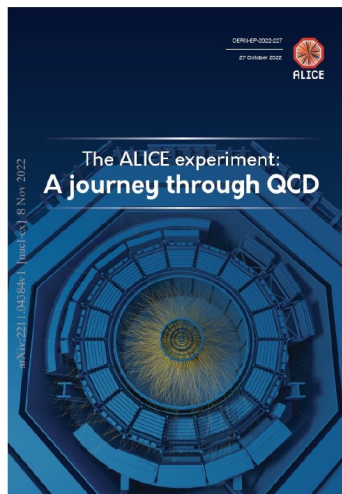


Upgrade: miglioramento risoluzione spaziale di un fattore ~ 2 [5] per $p_T < 1 \text{ GeV/c}$ nel piano trasverso. Risoluzione migliore di $40 \mu\text{m}$ per $p_T > 1 \text{ GeV/c}$ charm e beauty; Studio differenze dati-MC ancora presenti in corso. Ricostruzione mesone D^0

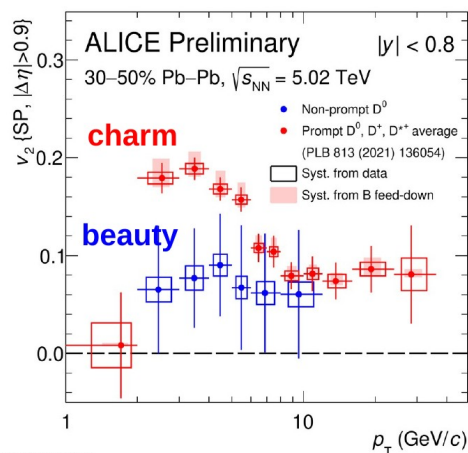


Gruppo PD: contributo importante caratterizzazione performance tracking e segnali HF

Risultati di fisica (focus gruppo PD)



<https://arxiv.org/abs/2211.04384>



Articolo di review (325 pagine) che riassume i risultati dei ~440 articoli prodotti dal 2010 a oggi

Gruppo PD: Andrea Dainese tra i principali editori

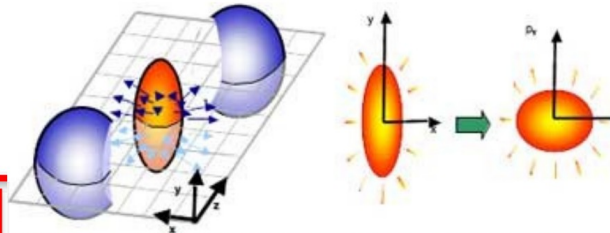
<https://home.cern/news/series/feature/ten-year-journey-through-quark-gluon-plasma-and-beyond>

Esempio: studio anisotropia azimuthale (flusso ellittico)

Collisioni non-centrali $\rightarrow$ simmetria in azimuth della regione di overlap dei nuclei

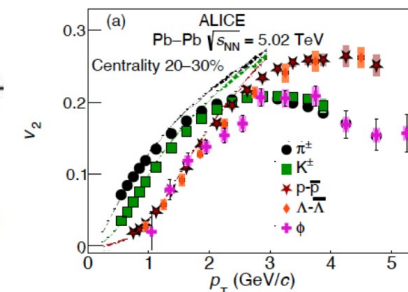
Rapida termalizzazione del mezzo $\rightarrow$ gradiente di pressione anisotropo

Espansione mezzo secondo leggi idrodinamica $\rightarrow$ anisotropia spaziale trasferita nello spazio dei momenti $\rightarrow$ Analisi di Fourier, stima **“flusso ellittico”** ($\equiv v_2$)



Effetto misurato con precisione per particelle leggere Stima viscosità (bassissima $\rightarrow$ QGP = **“perfect fluid”**)

(discussione estesa nel Review paper)



Charm e beauty: connessione **descrizione idrodinamica** del mezzo con modelli dei **processi microscopici** (interazione tra partoni, processi diffusivi)

Tempo di rilassamento dipende da coefficiente di diffusione spaziale del mezzo e da massa particelle $\rightarrow$ importanza del confronto tra charm, beauty e light-flavour

Misura per il beauty da collaborazione Padova - Wuhan

$v_2(\text{beauty}) < v_2(\text{charm}) \rightarrow$ beauty lontano dall'equilibrio cinetico

(in linea con attese teoriche)

Preventivi 2024: anagrafica e ruoli

	2023 (N)	2023 (FTE)	2024 (N)	2024 (FTE)
Ricercatori	10	8.1	11 (12)	7.7 (8.7)
Tecnologi	2	0.2	3	0.8

Nuovi membri, uscite

- **Membri:** Antinori (90%), Dainese (90%), **Faggin (100%, assegnista)**, Giubilato (70%), Lunardon (30%), Mattiazzo (70%), **Guang Meng (60%)**, Rossi (80%), **Himanshu Sharma (100%, assegnista)**, Soramel (70%), Turrisi (70%), Zhu (100%), Benettoni (20%), Sgaravatto (10%)

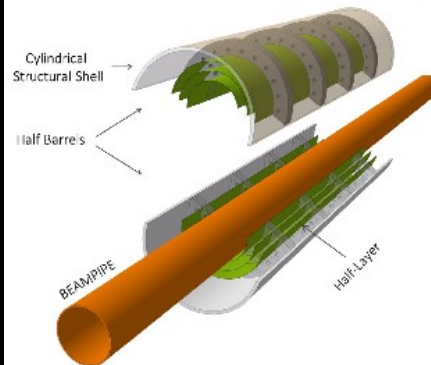
Borsisti: **Davide Chiappara (70%, assegno a breve)**

- **Studenti:** 4 laureandi da Settembre (+ 1 di Trieste) + D. Chiappara (ex-PhD) su lavori legati ad attività silici (MAPS)

Responsabilità nella collaborazione:

- Antinori: Responsabile Nazionale da Ottobre
- Dainese: Upgrade Coordinator
- Rossi: ITS3-upgrade physics performance (coordinatore), Editorial Board (membro), Collaboration Board (membro)
- **Articoli ALICE ultimi 12 mesi ~40**
- **Contributo diretto gruppo di Padova:** 5 (+ 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 ($60 \mu\text{m}$, $x/X_0 \sim 0.05\%$), elettronica ai bordi, basso consumo (20 mW/cm^2), raffreddamento ad aria
- sensori curvati a forma di semi-cilindri

Attività sinergica con NA60+ e EIC Stato del progetto

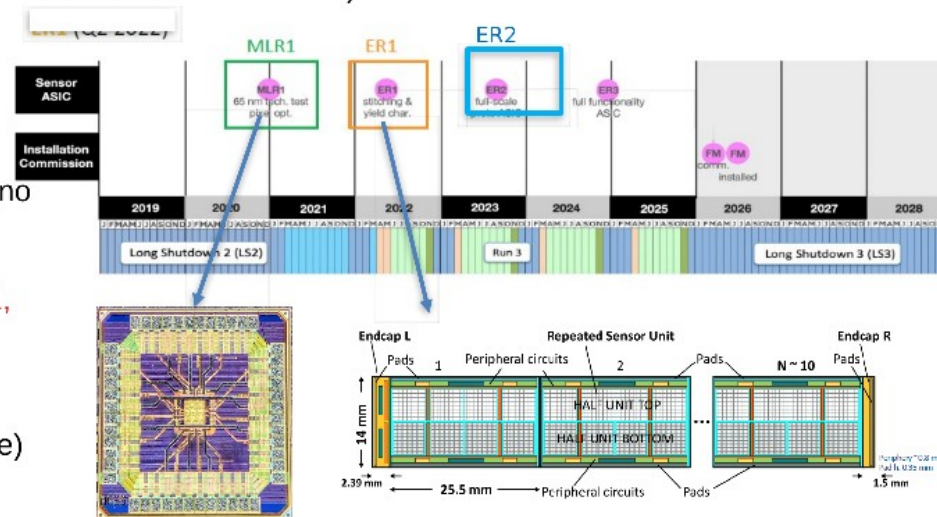
- 2019 Lol (A. Dainese editor): <http://cds.cern.ch/record/2703140>
- Preparazione del TDR avallata da LHCC: obiettivo fine 2023-inizio 2024
- Attività di R&D in corso per sviluppo sensore, bending, meccanica e test (contributo di diverse sedi INFN)

Attività a Padova:

Test in sezione (Giubilato, Mattiazzo) su

- matrici di **piccole** dimensioni da sottomissione **MLR1** (in corso da Giugno 2022, prossima slide)
- **grandi** dimensione (sottomissione **ER1**, **ER2**), test dello stitching (2023-2024)

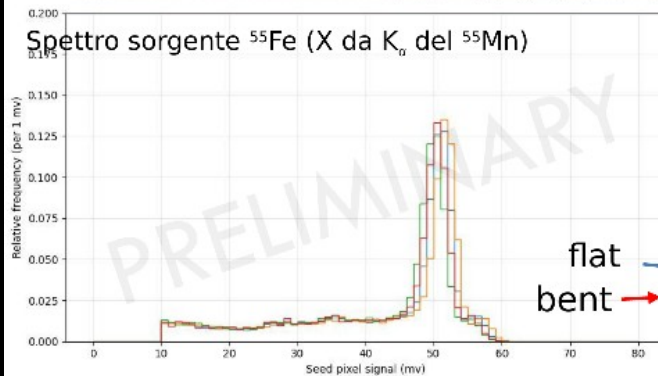
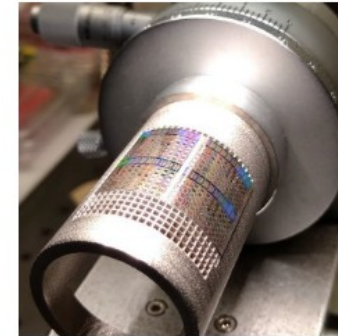
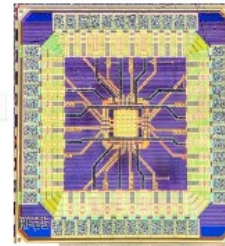
Contributo a preparazione TDR ITS3
(A. Rossi coord. Phys. Perf. Work Package)



Upgrade: ITS3 per run 4



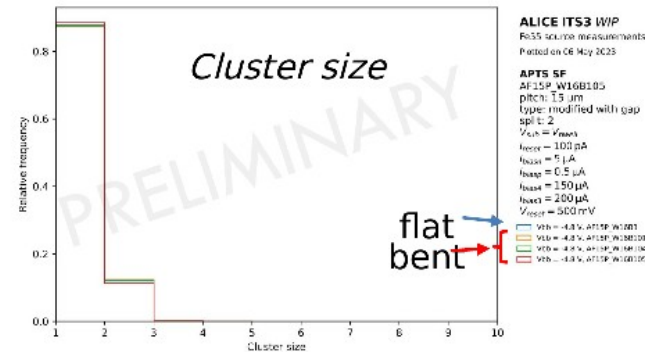
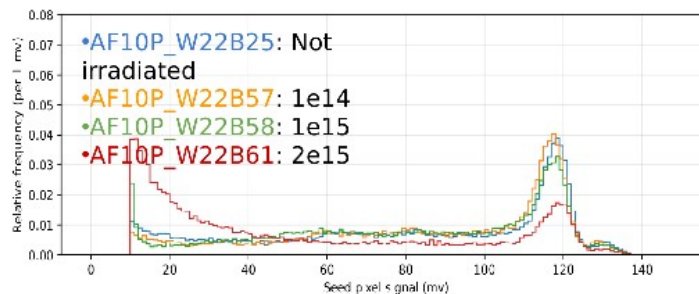
APTS SF (MLR1)
4x4 pixels, lettura analogica



ALICE ITS3 WIP
Fe55 source measurements
Plotted on 18 Apr 2023

APTS SF
AF15P_W16B105
pitch: 15 μm
type: modified with gap
split: 2
 $V_{\text{bias}} = V_{\text{reset}}$
 $I_{\text{bias1}} = 100 \text{ pA}$
 $I_{\text{bias2}} = 5 \text{ pA}$
 $I_{\text{bias3}} = 0.5 \text{ pA}$
 $I_{\text{bias4}} = 150 \text{ pA}$
 $I_{\text{bias5}} = 200 \text{ pA}$
 $V_{\text{reset}} = 500 \text{ mV}$

$V_{\text{th}} (\text{sub}) = -4.8 \text{ V}$ AF15P_W16B105
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 $V_{\text{th}} (\text{sub}) = -4.8 \text{ V}$ AF15P_W16B105



ALICE ITS3 WIP
Fe55 source measurements
Plotted on 06 May 2023

APTS SF
AF15P_W16B105
pitch: 15 μm
type: modified with gap
split: 2
 $V_{\text{bias}} = V_{\text{reset}}$
 $I_{\text{bias1}} = 100 \text{ pA}$
 $I_{\text{bias2}} = 5 \text{ pA}$
 $I_{\text{bias3}} = 0.5 \text{ pA}$
 $I_{\text{bias4}} = 150 \text{ pA}$
 $I_{\text{bias5}} = 200 \text{ pA}$
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Prima evidenza di danno da irradiazione a dosi molto superiori alla richiesta per ITS3/EIC (1e13-1e14)

ALICE3

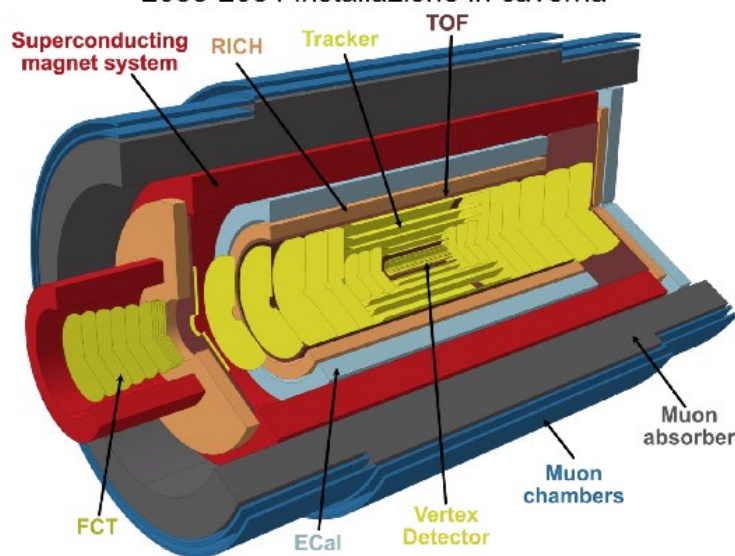
Letter of intent approvata da LHCC a Marzo 2022 (F. Antinori tra i main editors)

“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
- Accettanza grande

Run 5 (2035), timeline

- 2023-2035: 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



2023, 2024:

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

Interessi principali gruppo di Padova

- Silicon tracker: middle layers + vertex detector
- Continuazione di R&D per ITS3
- Meccanica (in via di definizione)

Richieste per 2023

Capitolo	Richiesta
Trasferte	~85* k€
Apparati	0 k€
Consumo	15 k€
Trasporti	0 k€

di cui 10 k€ per ITS3, parte
dei quali potrebbero andare
in Apparati
(totale richiesta ~ al 2023)

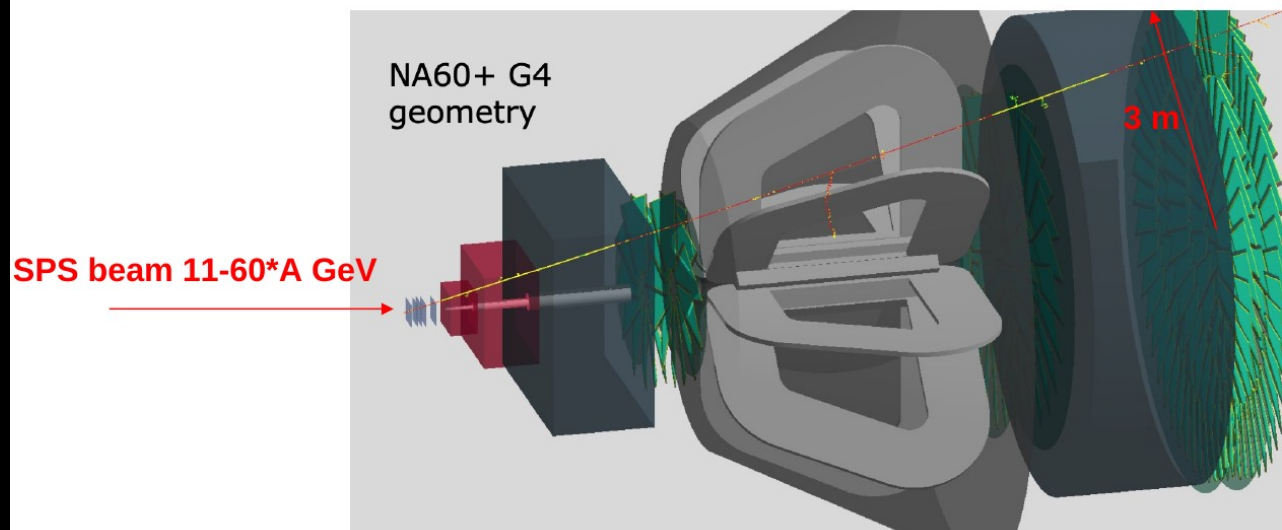
- Ottenuto da parametri ALICE-Italia in base a FTE e responsabilità + attività in ITS (inclusi upgrades)
- Attività ITS3 sinergica con sigle EIC e NA60+

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

Servizio Sezione	Richiesta
Officina elettronica	6 m.u.
Officina meccanica	[3 m.u.] *

* TBC

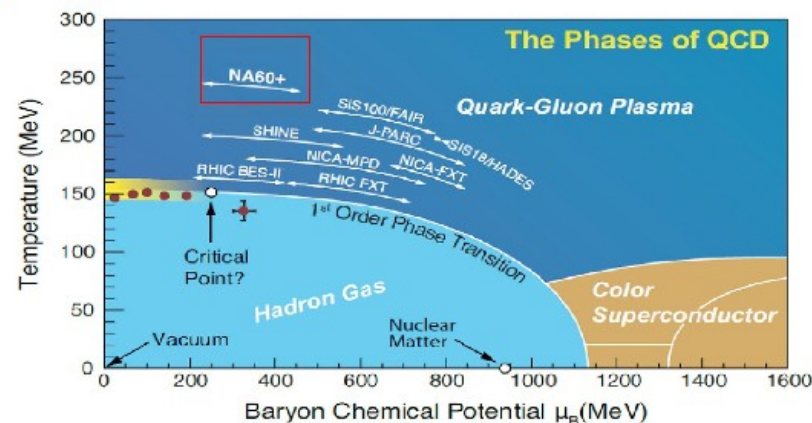
NA60+





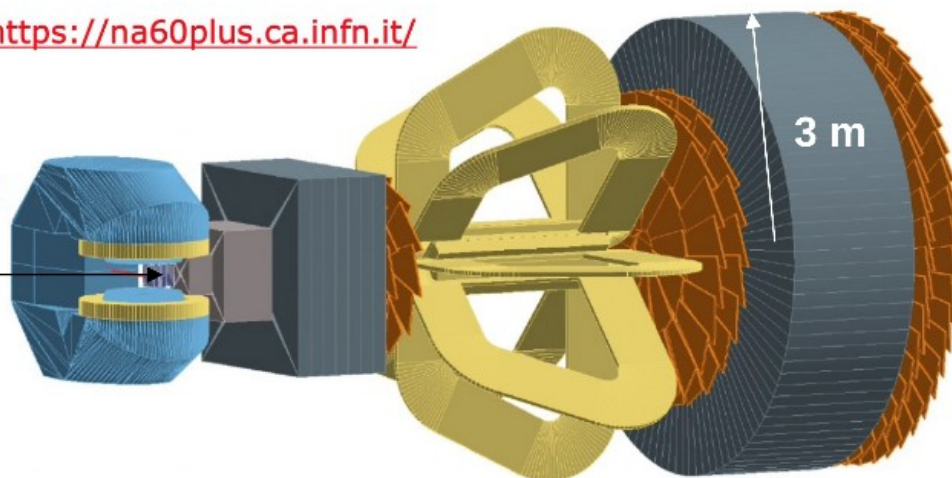
NA60+

- 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 2023 and 2024

- Letter of Intent submitted to SPS Committee (SPSC) in Nov 2022
 - <https://cds.cern.ch/record/2845241>
- Four physics objectives:
 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
- Positive review by SPSC (Feb 2023):

The SPSC **recognizes the fundamental interest of the measurements proposed by the NA60+ collaboration**, which are focused on electromagnetic and hard probes of the quark gluon plasma at high baryochemical potential. In order for the project to proceed with the suggested roadmap (starting construction in 2026 and data taking in 2029), **the SPSC would expect to start examining a proposal by 2024**

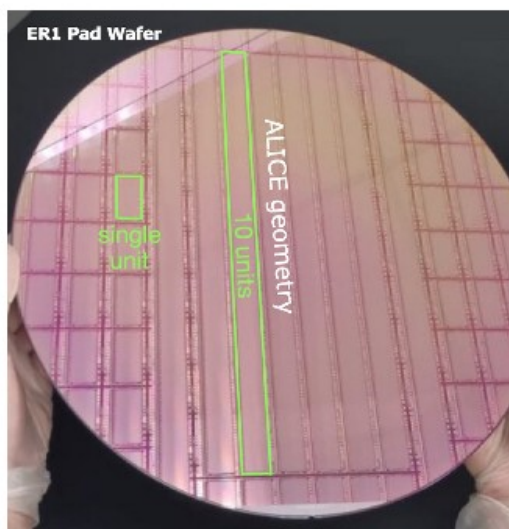
- **Preparation of Technical Proposal has started**



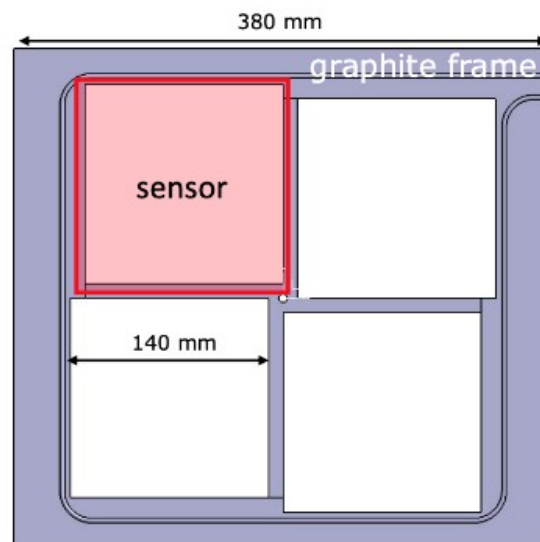
NA60+: activities 2023 and 2024

- 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 as the ALICE ITS3 ☐ R&D in common

First large sensor under test



Goal: 4 large sensors to form a plane



Padova participates in the sensor tests and characterization with radioactive sources
☐ ALICE/ITS3 slides

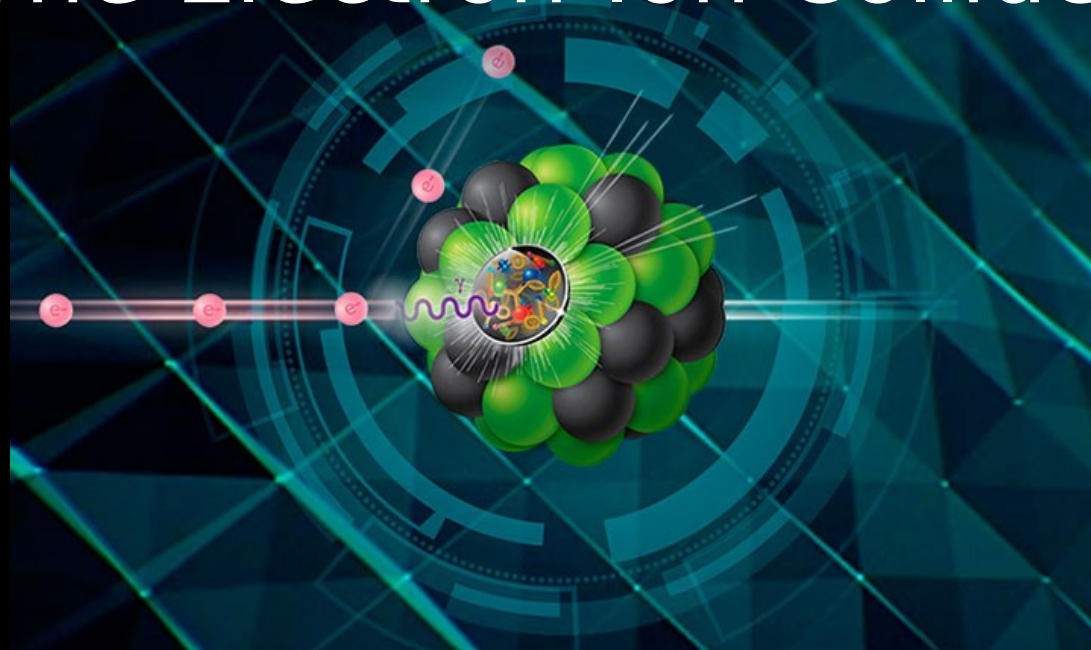


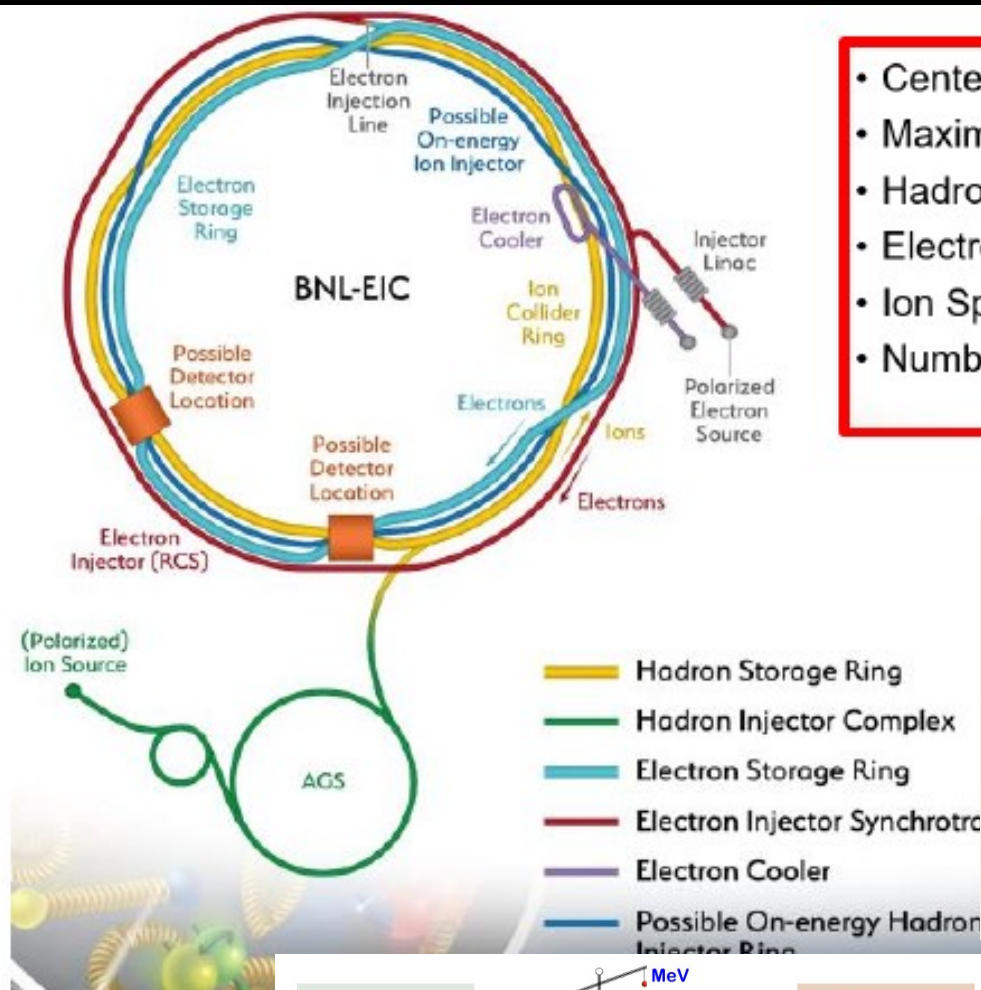
Preventivi 2024 NA60+: anagrafica e richieste

- Sigla “network” dal 2020 in CSN3
 - Resp. nazionali: E. Scomparin, G. Usai
 - ~ 4 FTE: Cagliari+Torino+Padova
- Anagrafica Padova: 0.3 FTE (come 2023)
 - A. Dainese (resp. loc.), F. Antinori, A. Rossi
- Richieste: ~ 2.5 + 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

The Electron-Ion Collider

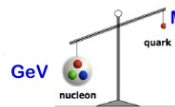




• Center of Mass Energies	20 GeV – 141 GeV
• Maximum Luminosity	$10^{34} \text{ cm}^{-2}\text{s}^{-1}$
• Hadron Beam Polarization	80%
• Electron Beam Polarization	80%
• Ion Species Range	p to Uranium
• Number of interaction regions	up to two



Why #1

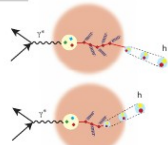


Why #2

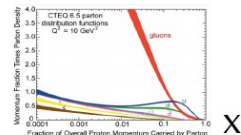
proton
spin 1/2



Why #3



Why #4



News dalla collaborazione

- Completata transizione da ATHENA & ECCE (i due detector a IP6 e IP8 a BNL) a **ePIC**, electron Proton/Ion Collider experiment:
 - nuovi spokes **John Lajoie** (Iowa State Univ., ex ECCE spoke) **Silvia Dalla Torre** (INFN Trieste, deputy, ex ATHENA spoke)



- secondo rivelatore ritenuto necessario ma non finanziato al momento, gruppi di lavoro
- charter (costituzione): https://wiki.bnl.gov/EPIC/index.php?title=File:EPIC_Charter-v1
- working groups attivi sia su fisica che detector
- già due **collaboration meeting** (Stony Brook 7/2022, BNL 1/2023)
- nuovo logo



- Primo **EIC RRB** (resources review board): <https://indico.bnl.gov/event/18452/>
- Detector organizzati in DSC, Detector Subsystem Collaborations, con un leader (DSL) e un technical contact (DSTC):
EIC-SC (Silicon Consortium) confluisce in un DSC con DSL Ernst Sithermann (BNL) e DSTC Laura Gonella (Birmingham Univ.)



EIC_NET e EIC_NET/Pd

- Proposta da Presidente CSN3 fusione sigle EIC_NET, JLAB12, MAMBO in unica sigla “fisica adronica”
 - La collaborazione non ha ritenuto utile/opportuno operare in tal senso
- Passaggio a sigla (non R&D/networking): s.j. alla disponibilità del TDR (anno prossimo, adesso w.i.p.)
- Prima scuola di fisica a EIC! <https://agenda.infn.it/event/33450/>
- ...seguita dalle “Giornate Nazionali EIC_NET”: <https://agenda.infn.it/event/34631/>
 - con un contributo da Padova (S. Mattiazzo, RT)
- **Attività:** test e caratterizzazione rivelatori al silicio in sovrapposizione con ALICE/ITS3 e NA60+ (v. dopo)
- **Anagrafica:** come 20230 a parte inserimento di un(a) PhD con **cofinanziamento di 30k\$ da parte del DoE** tramite progetto R&D eRD111* (local contact RT) - FTE da definire, probabile 0.5
- Richieste **6k€ missioni, 10k€ materiali**
 - Riunioni collaborazione e visite Ts-Ba per test silici
 - Box termostato per test silici irradiati
- Nessuna richiesta specifica ai servizi (v. ALICE)

* dal prossimo anno Padova partecipa a eRD113, più orientato a caratterizzazione e design



Persone		FTE
C. Bonini	PhD	0.5
P. Giubilato	PA	0.3
M. Guang	PT	0.2
S. Mattiazzo	RTDb	0.05
A. Rossi	R	0.1
R. Turrisi (RL)	R	0.3
Nuovo contratto	PhD	0.5?
Totale		1.95

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.

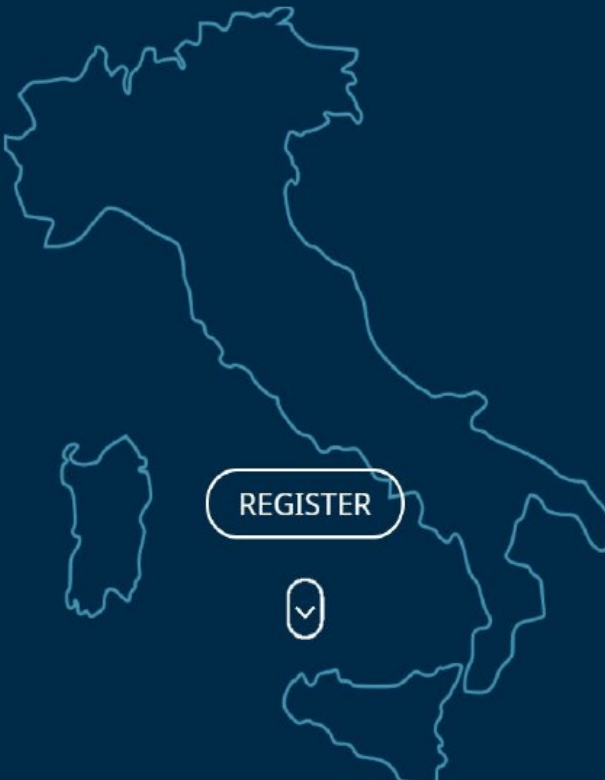
The workshop is divided into three sessions, one for each laboratory:

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.





70
1951
2021
inf

Nuclear Physics Mid Term Plan in Italy



Laboratori Nazionali di Legnaro



Laboratori Nazionali del Sud



Laboratori Nazionali del Gran Sasso



Laboratori Nazionali di Frascati

GAMMA



GAMMA



- Commissione Scientifica Nazionale III

- Linea 3: Nuclear Structure and Reaction Dynamics

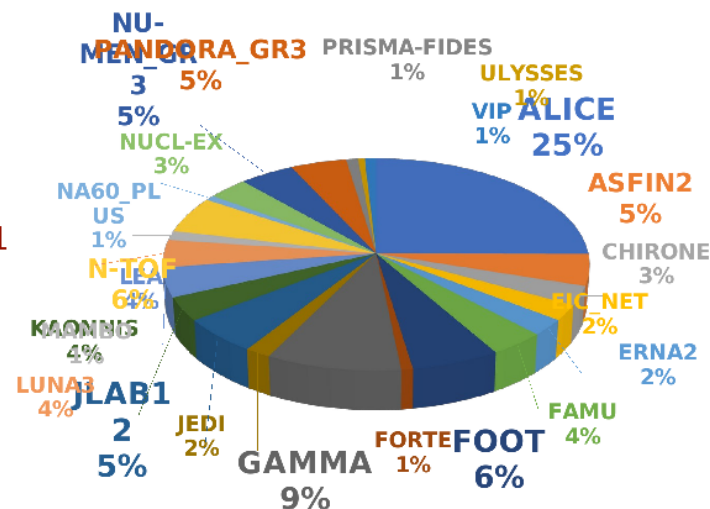
- Fission and fusion reaction mechanisms**
 - Production and study of very exotic nuclei far from the stability region**
 - Structure of nuclei from gamma spectroscopy**
 - Radioactive ion beams**

- GAMMA

- Sezioni di Padova, Milano, Firenze, Perugia e Laboratori Nazionali di Legnaro
 - 67 persone (55R + 12T) = 46.5 FTE su 501 della CSN III
 - 73 pubblicazioni, 101 contributi a conferenze, 24 Tesi

- GAMMA - PD nel 2022/2023

- 15 Ricercatori (12.7 FTE)
 - 31 pubblicazioni (5 come primo autore), 20 contributi a conferenze, 4 Tesi (3T + 1S)
 - Richieste finanziarie: 116 k€ (+ 108.5 di missioni) → Assegnazioni 88 k€ (+ 52.5 di missioni)



AGATA installation: first configuration

Ground breaking 10/3/2021



26/11/2021



Commissioning 26/4/2022



~one year of
data taking!!

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

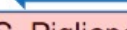
- **PRISMA**: L.Corradi, F.Galtarossa
- **GAL-TRACE**: S.Capra, **G.Zhang**
- **EUCLIDES**: J.Pellumaj, D.Brugnara
- **SPIDER**: M.Rocchini, M.Balogh
- **DANTE**: **K.Rezynkina**
- **Scintillators**: E.Gamba, **S.Pigliapoco**
- **Plunger**: I.Zanon

Complementary detectors

First PACs

commissioned

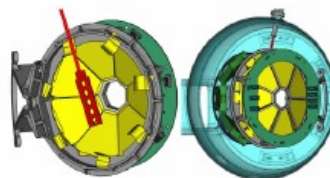
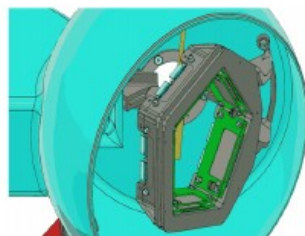
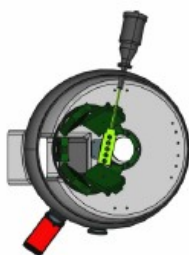
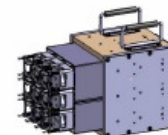
- PRISMA : L. Corradi, F. Galtarossa
- GAL-TRACE : S. Capra, **G. Zhang**
- EUCLIDES: J. Pellumaj, D. Brugnara
- SPIDER: M. Rocchini, M. Balogh
- DANTE: **K. Rezyunkina, J. Benito**
- Gamma-ray scintillators: E. Gamba, **S. Pigliapoco**
- Plunger: I. Zanon



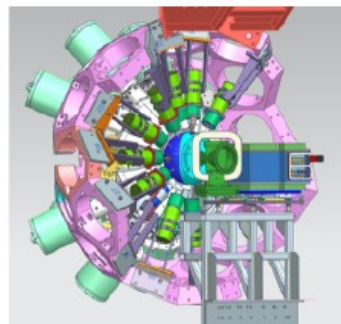
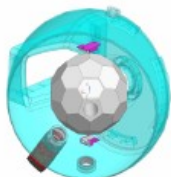
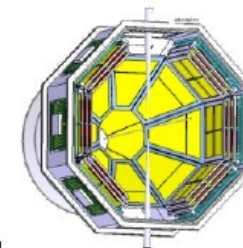
Targets: CTADIR + SUGAR



PARIS



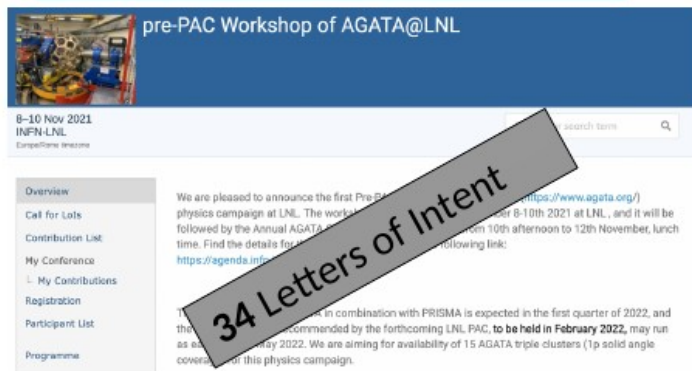
GRIT
GASPARD+TRACE



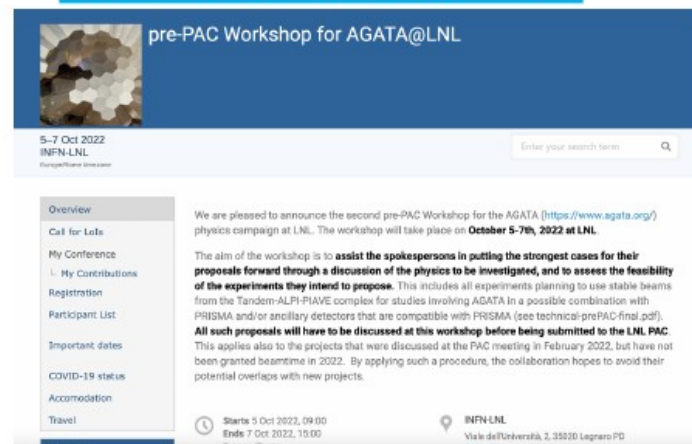
NEDA

AGATA scientific program

PrePAC 8-10 November 2021



PrePAC 5-7 October 2022



PAC@LNL 21-23 February 2022

Submitted **28** proposals

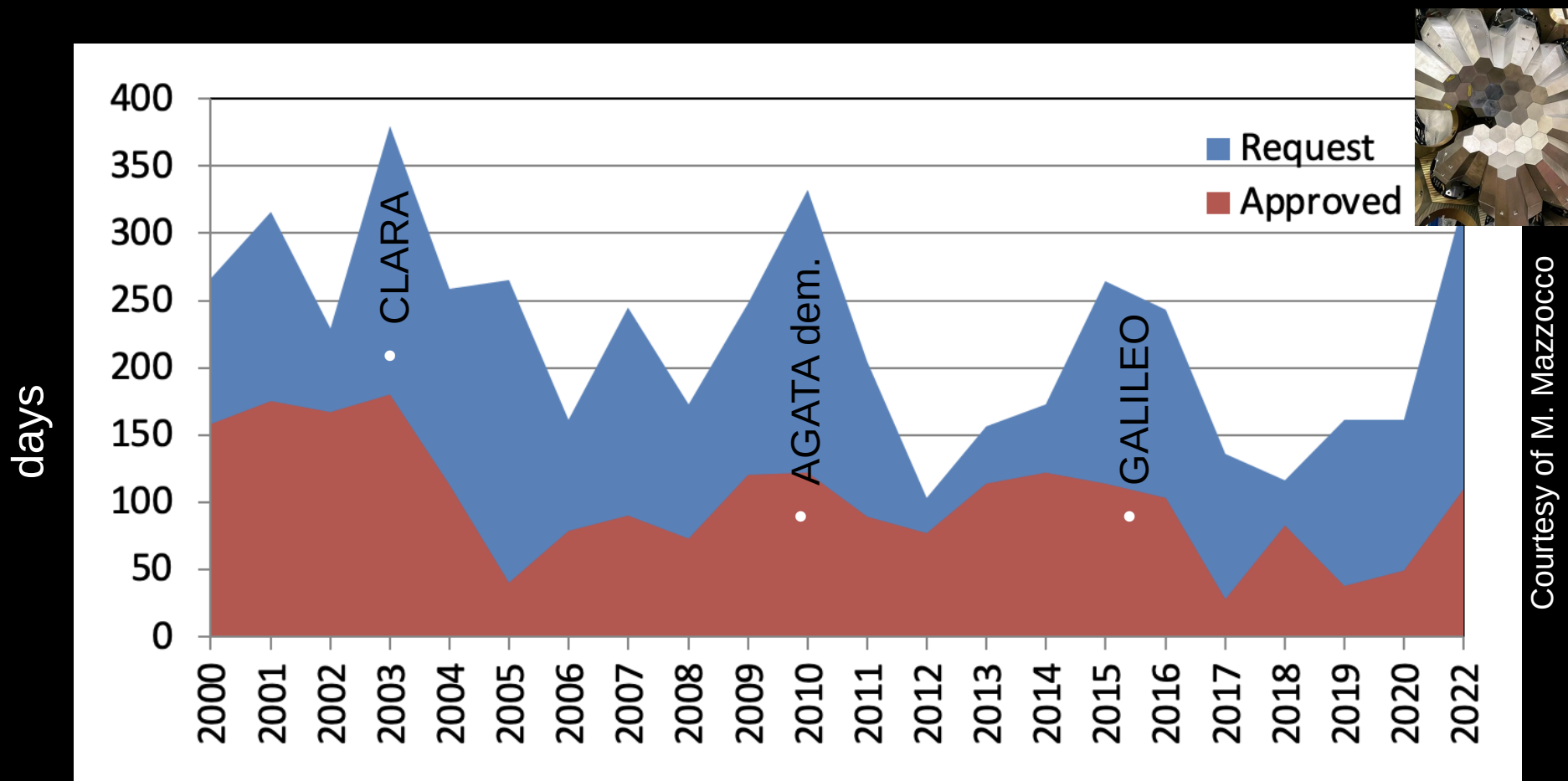
Approved experiments:

- **10** (3 commissioning) priority A
- **5** priority B

Nuclear Physics (330)



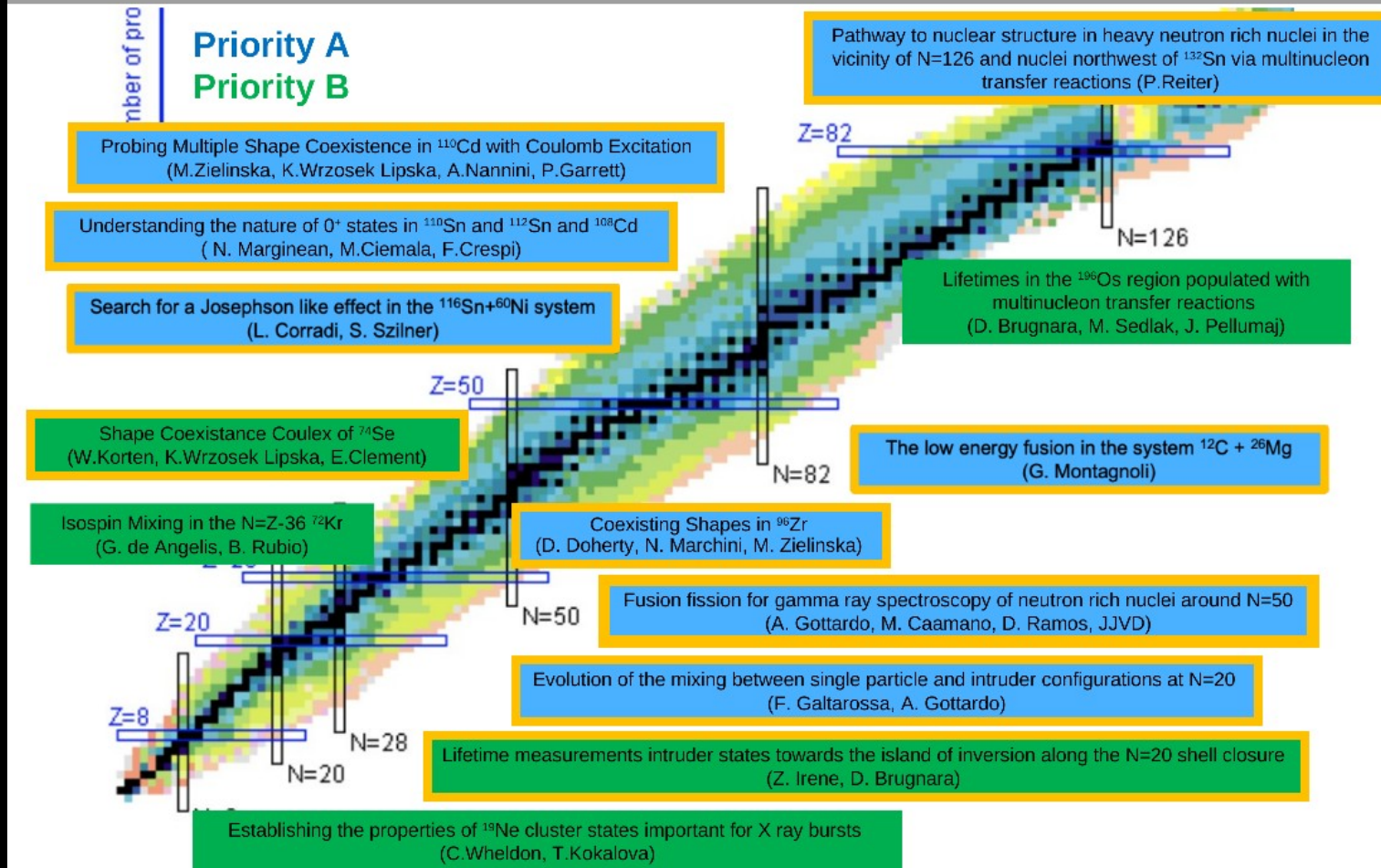
- AGATA (120)
- AGATA+PRISMA (173.5)
- PRISMA (14)
- PISOLO (17.5)
- GALILEO Ch. (4)



- Next week July 2023 PAC – probably December 2023
 - There will be two PACs per year

17 exp/y

First AGATA physics campaign



Two different configurations

Nuclear Inst. and Methods in Physics Research, A 1049 (2023) 168040



Contents lists available at ScienceDirect

Nuclear Inst. and Methods in Physics Research, A

journal homepage: www.elsevier.com/locate/nima

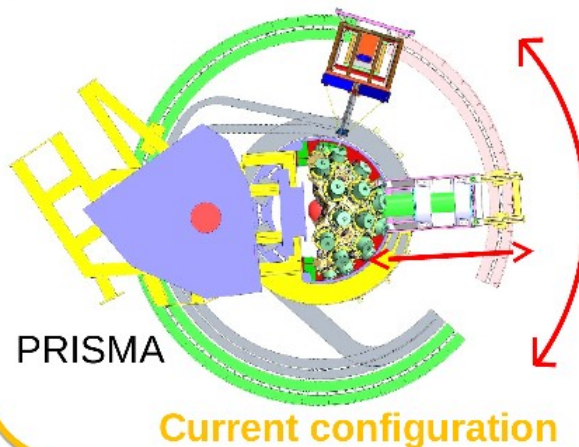


Full Length Article

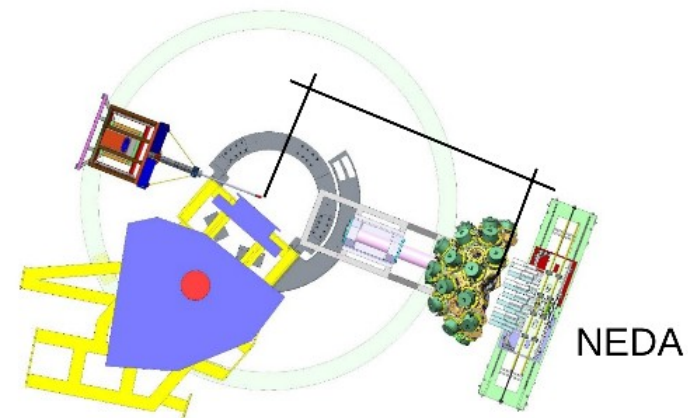
Conceptual design of the AGATA 2π array at LNL



AGATA coupled with PRISMA



AGATA zero degrees



PrePAC + Workshop zero degrees



AGATA Campaign at LNL Third Pre-PAC Workshop and Zero-Degree Campaign Workshop

LNL, April 19th-21st, 2023

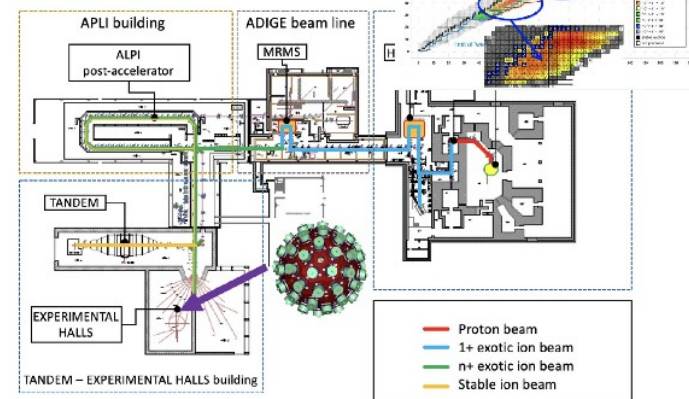
Meeting devoted to the discussion of the future campaign involving AGATA at zero degrees □ preliminary information about **DayOne SPES beams**

List of possible first SPES beams:

Primary target	Beam	Intensity (pps)	Max energy (MeV/A)
TiC	43Sc	2,40E+07	10
TiC	44Sc	2,25E+08	10
TiC	42K	3,70E+07	10
UCx	130Sn	3,95E+06	10
UCx	132Sn	7,70E+05	10
UCx	132Te	2,11E+07	10
UCx	132Sb	9,50E+05	10
UCx	134Te	1,50E+04	10
UCx	94Rb	6,80E+06	10
UCx	75Ga	1,10E+05	10

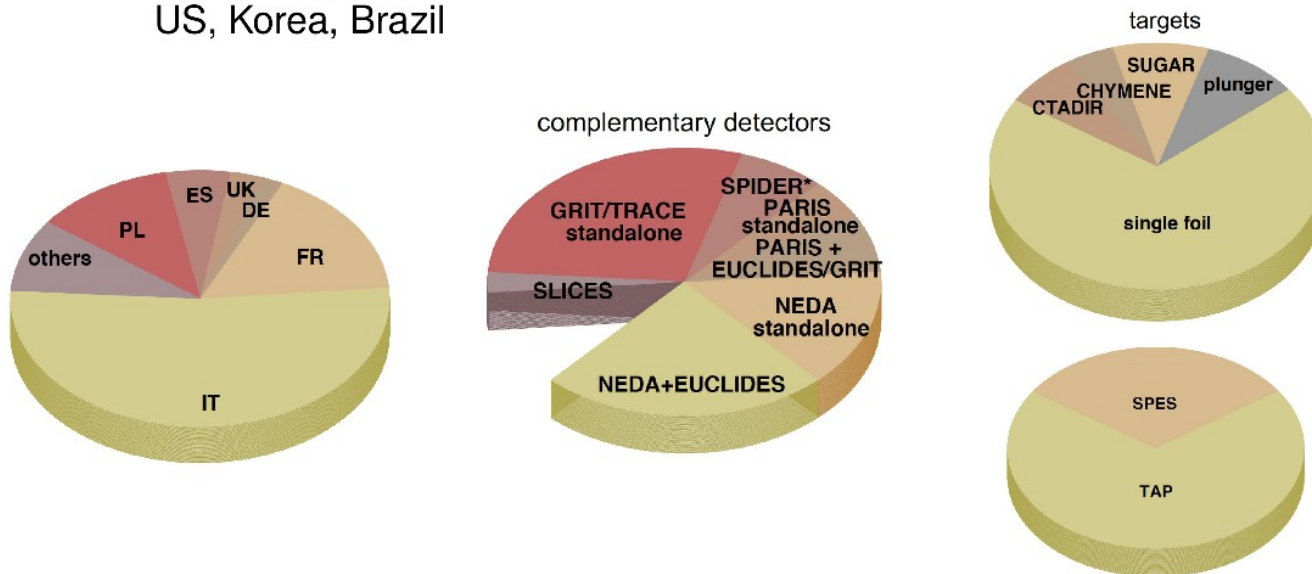
The intensities are to be considered at the target position.

40 MeV - 200 μ A of protons $\rightarrow$ production of re-accelerated neutron-rich exotic beams **10^{13} fission/s in-target production, and re-acceleration at 10*MeV (A=132)**

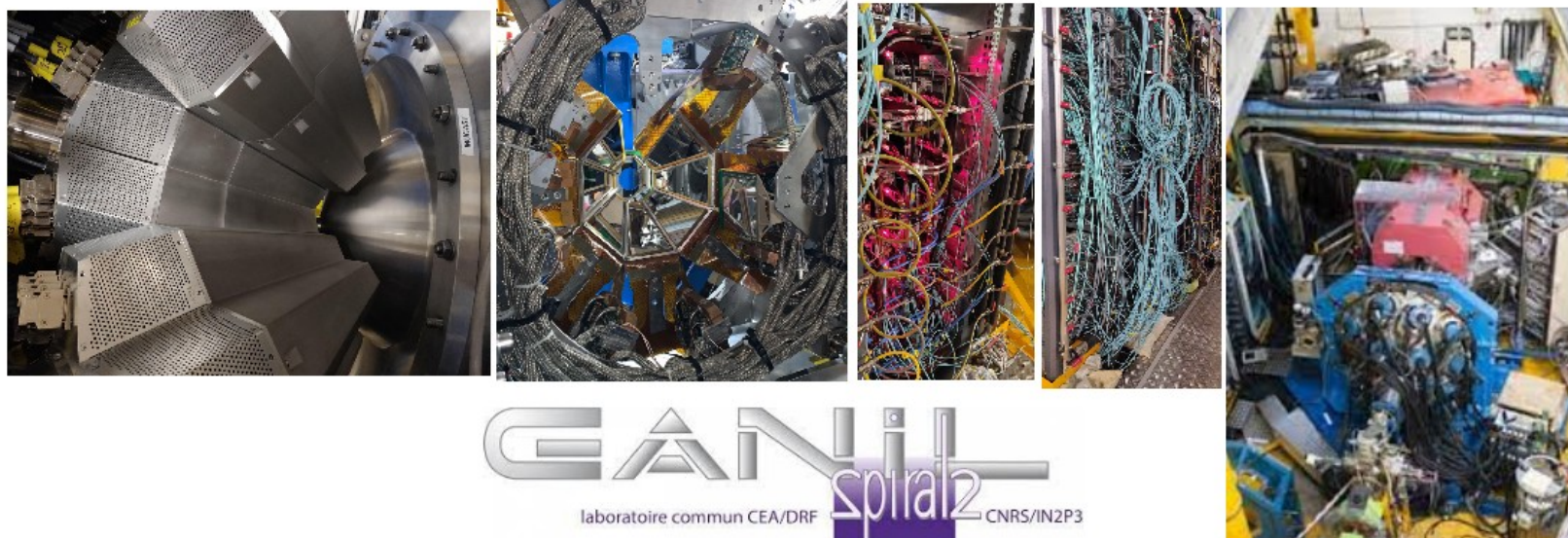


Statistiche del WS

- overwhelming response from the community: 42 “physics” Lols + 4 umbrella proposals
- large majority (33) with at least one Italian spokesperson; percentage of Italian co-spokesperson consistent with earlier AGATA Pre-PACs at LNL
- particularly strong representation of France and Poland
- co-spokespersons from outside the AGATA collaboration: Mexico, US, Korea, Brazil



AGATA+MUGAST+VAMOS setup



GANIL
laboratoire commun CEA/DRF **spiral2** CNRS/IN2P3

- Campaign **2019-21 at GANIL** (1+5, 2 PhD thesis, 1 Master thesis). Two more proposals approved but not yet scheduled
- Analysis ongoing and for some of them close to be finalized. Commissioning paper published, cryo target paper published, first science paper published, 3 more science paper ongoing, 2 PhD thesis, 1 MSc thesis, 1 premio SIF
- **Campaigns at LISE (2023) and SPES (...)**

Italian contribution 2022/2023:

Milano: PLAS v3 prototype or PLAS v2 series

Padova: Serial thick if prototype is proven to be successful + serial production of thin detectors (2 trapezoid + 2 square)

MUGAST-AGATA-VAMOS-Spiral1 campaigns : an overview

2019	UNBOUND STATES Above barrier narrow resonances in ^{15}F <i>I. Stefan (IPN), F. de Oliveira (GANIL)</i> $^{14}\text{O}(p,p')$ with few 10^5 pps	NUCLEAR ASTROPHY. Determining the $\alpha+^{15}\text{O}$ radiative capture rate <i>C. Diget (York), N De Séréville (IPN)</i> $^{15}\text{O}(^7\text{Li},t)^{19}\text{Ne}$ with $4\cdot 10^7$ pps	SHELL MODEL Is there a problem with protons in N=28 nucleus ^{46}Ar ? <i>A. Gottardo INFN, M. Assié IPN</i> <i>D. Mengoni, INFN</i> $^{46}\text{Ar}(^3\text{He},d\gamma)^{47}\text{K}$ with $4\cdot 10^4$ pps
2020	SHELL MODEL Lifetime measurements of 2_2^+ and 3_1^+ of ^{20}O by direct nucleon transfer <i>E. Clément (GANIL), A. Goasduff (INFN)</i> $^{19}\text{O}(d,p\gamma)$ + DSAM with $4\cdot 10^5$ pps		
2021	SHELL MODEL Proton-neutron interactions across the N = 28 shell closure via $^{47}\text{K}(d,p)^{48}\text{K}$ <i>W. Catford (Surrey), A. Matta (LPC)</i> $^{47}\text{K}(d,p\gamma)^{48}\text{K}$ with $5\cdot 10^5$ pps		

COMMON FEATURES

- SPIRAL 1 radioactive beams from ~ 5 to ~ 10 MeV/u and intensity between few 10^4 and 10^8 pps.
- Direct transfer reactions such as (d,p), (^3He ,d), (^7Li ,t)...
- γ -particle coincidence.

Italian contribution 2021/2022:

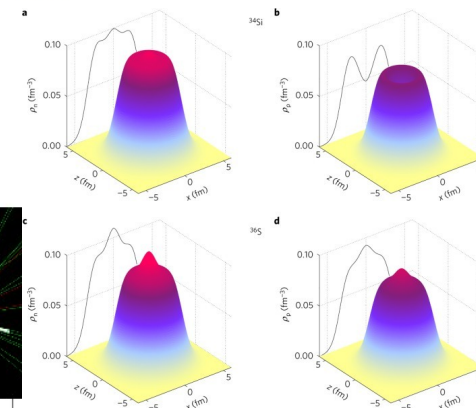
Milano: PLAS V2 under test at LPC Caer  PLAS v3 prototype or PLAS v2 series

Padova: Ongoing production of thick prototype  Serial thick if prototype is proven to be successful + serial production of thin detectors (2 trapezoid + 2 square)

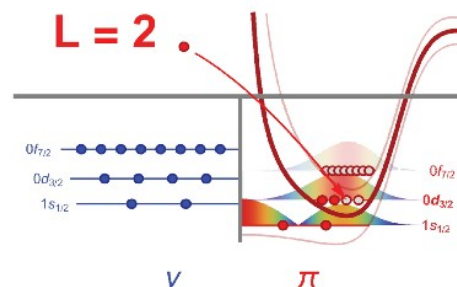
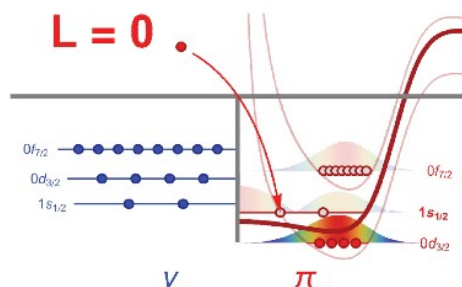
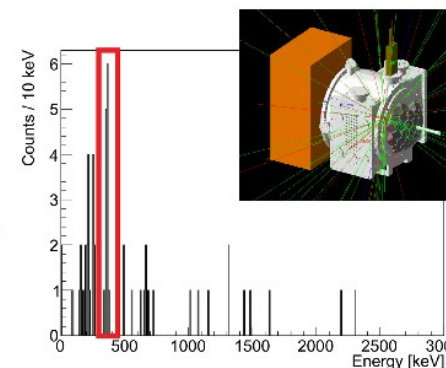
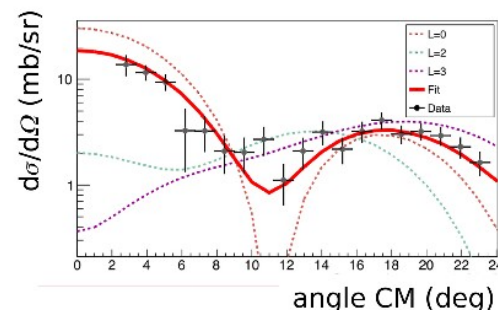
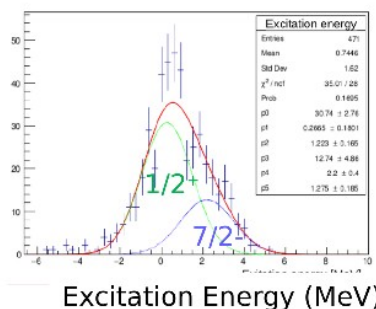


Is there a problem with protons in $N=28$ ^{46}Ar ?

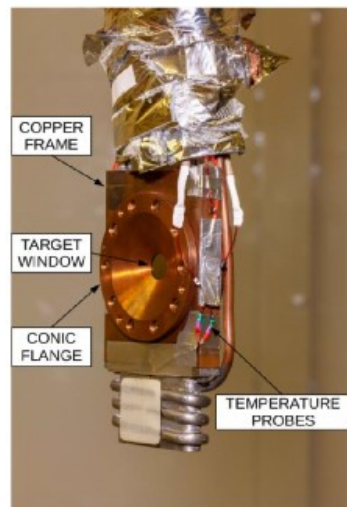
A proton density bubble in the doubly magic ^{34}Si nucleus



Triple coinc and simulation confirm the $L=0$ dominance



- $L=2$ transfer very much reduced !
- No direct gamma from $3/2^+$ observed from AGATA+VAMOS
- Reduced transfer to $3/2^+$
- High degree of occupancy of $\pi d_{3/2}$ in ^{46}Ar inconsistent with SM calculations

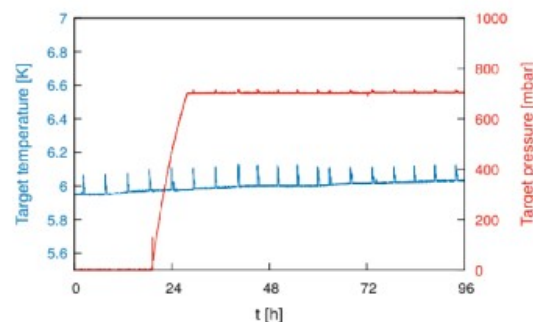
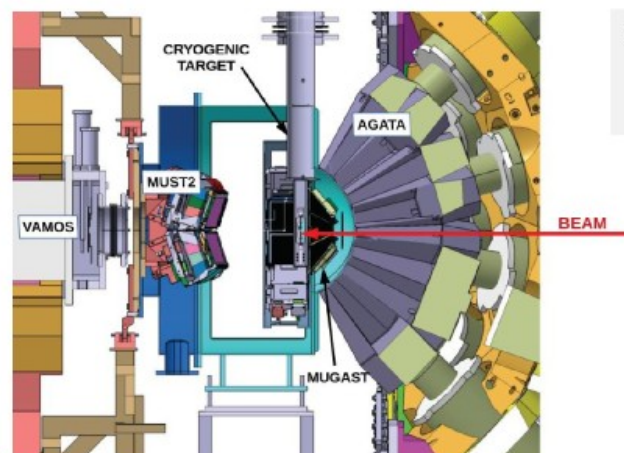


- Ø 16 mm
- Opening angle: 130 deg.
- Havar windows: 3.8µm
- T ~ 6-7 K. / P up to 1 bar
- Equivalent thickness 2 mg/cm²
- ³He recycling
- LHe open circuit

M. Pierens, V. Delpech,
F. Galet, H. Saugnac (IJCLab)
A. Giret & J. Goupil (GANIL)

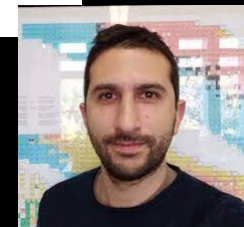
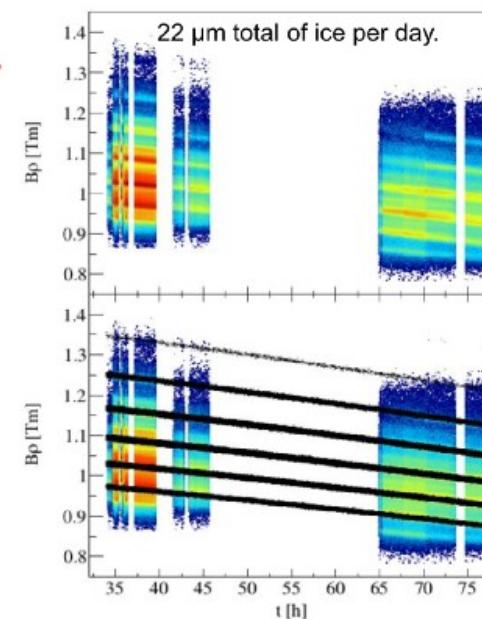
The HECTOR cryogenic ³He target

F. Galtarossa et al, NIMA (2021)



Monitoring of target with VAMOS :

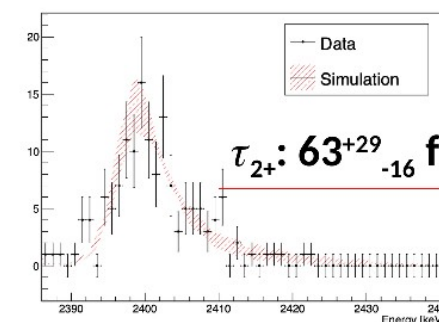
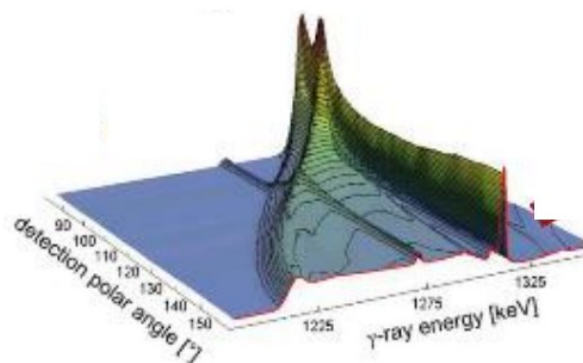
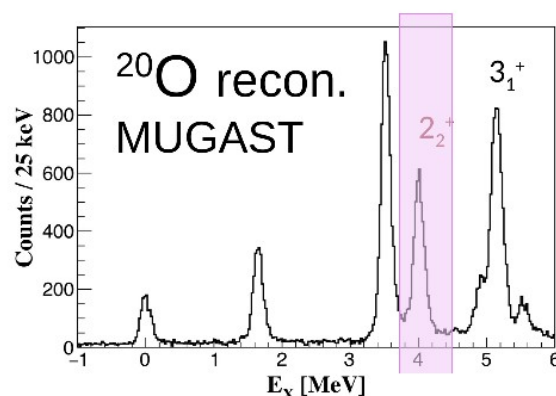
- Target **pressure & temperature stable**
- **Ice formation** on the target with time





$^{19}\text{O}(\text{d},\text{p}\gamma)$

Role of 3-body forces



- Triple coincidences: reconstructed entry point (MUGAST) through transfer reaction to avoid top feeding + continuous-angle line shape (AGATA)+ channel selection (VAMOS)
- Lifetimes measured significantly shorter than predictions for the 2^+ , theoretical interpretation ongoing
- First lifetime measurement in the tens of femto-sec. scale (DSAM) using transfer reaction in inverse kinematics

Altre attività del gruppo GAMMA: 2022 - 2023

Highlights on $N = Z$ experiments

- ❑ **Mirror energy differences with radioactive beams@ Riken-Nishina Center (Tokyo):** First gamma-ray spectroscopy of the exotic proton-rich nuclei Cu and Zn Best candidates to study isospin non-conserving interactions and the nuclear structure at the drip-lines, **Ph.D thesis Sara Pigliapoco (Padova)**
- ❑ **JYFL: mirror nuclei $^{43}\text{Ti} - ^{43}\text{Sc}$:** Testing the $T=0$ vs $T=1$ nucleon-nucleon interaction through the comparison of excitation energies between isobaric nuclei, **Draft in preparation, by K. Rezykina (INFN-Padova)**
- ❑ **Lifetime measurements with Radioactive beams@NSCL-MSU:** Evolution of nuclear structure along the $N=Z$ line: Lifetime measurement for the low-lying states in ^{84}Mo and its vicinity, **Draft in preparation by J. Ha (formerly in Padova), P.Aguilera took over the analysis.**

Other experiments

- ❑ **DESPEC @ GSI** several experiments with Italian spokespersons, **Data analysis in progress by G. Zhang (Padova)**
- ❑ **AGATA @ GANIL: MUGAST** (D.Mengoni cospeks) was the principal ancillary detector in the campaign 2019/2020: 3 experiments in 2019, 3 in 2020 and 1 in 2021

Approved several experiments at JYFL

- ❑ **^{71}Kr :** population for the first time of excited states. Interesting to study coincidences between transitions above and below the isomeric intruder $9/2^+$ state. Estimated cross section: 1 microbarn. **Spokespersons: F. Recchia, A. Boso et al.. Analysis by K. Rezykina (INFN-Padova)**
- ❑ **^{91}Pd :** no excited states known so far: disentangling the claim of $p-n$ $T=0$ pairs at low excitation energy in ^{92}Pd . **Spokesperson: F. Recchia et al.**
- ❑ **Isospin symmetry towards the proton dripline:** Isobaric analogue states in the $A = 29$ quartet. **Spokespersons: J. Ha, S.M. Lenzi, P. Ruotsalainen et al.**
- ❑ **^{114}Ba :** Octupole collectivity in the $N = Z = 56$ region: identification of excited states in ^{114}Ba using recoil-decay tagging. **Spokespersons: J.J. Valiente-Dobon, A. Illana, J.F. Smith**
- ❑ **Quantal Rotation and pn interaction:** lifetime measurements in the $N=Z=31$ ^{62}Ga . **Spokespersons: G. de Angelis, D.Mengoni et al.**
Approved experiments at GANIL (D.Mengoni), Argonne (S.M.Lenzi, F.Recchia, D.Mengoni), TRIUMF (D.Mengoni) GSI, ISOLDE, JYFL and Riken. Other proposals will be presented in 2022

CONTRIBUTO PANDORA

frontiers | Frontiers in Physics

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

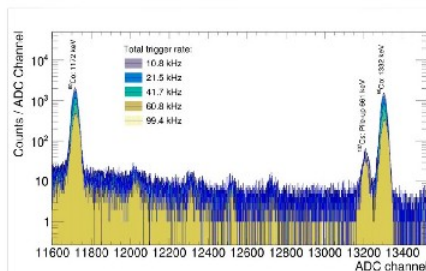


FIGURE 7
Stacked spectra obtained for five different total counting rates. The peak lying close to the 1332-keV line (13220 ADC channels) is due to the pile-up peak of the intense ^{137}Cs source.

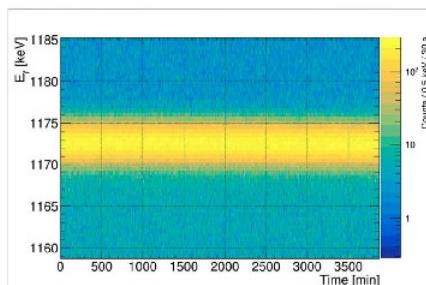


FIGURE 8
Energy vs. Time measured of 60 h using the multi-source with a total rate of 50 kHz. The energy axis has been zoomed on the 1172-keV transition coming from the ^{60}Co source.

Check for updates

OPEN ACCESS

EDITED BY
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United Kingdom

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Institute of Nuclear Research (ATOMKI),
Hungary
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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

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

STATUS OF THE CNAF COMPUTING SOLUTION

Working Group:

- G. Benzoni (Mi) – Group Leader
- A. Goasduff (LNL) – Group Leader
- S. Bottoni (Mi) – Local coordinator INFN-MI
- M. Rocchini (Fi) – Local coordinator INFN-FI
- F. Galtarossa (Pd) – Local coordinator INFN-PD

Programs already installed:	geant	prismafilters
adpc	gosia	ptolemy
AgataSelector	grain	radware
AgataSimulation	grazing	reaction
AgataSoftware	GretinaSoftware	root
angcor	GRSISort	rosphere
fipps	kshell	shell_model
fresco	lib	twofnr
fresco_rel	NAG	
fresco_SB	napatau	
GASPware	nptool	
	pgi	

Anagrafica GAMMA-PD 2024

Nome	Tipo	Qualifica prof.	% FTE
Aguilera Pablo Antonio	Associato	Assegnista UniPD	100
Carmen Altana	-	Ricercatrice A UniPD	0
Dino Bazzacco	Associato	Ass. Senior	0
Benito Garcia Jaime	Associato	Ricercatore straniero	100
Brignolo Giacomo	Associato	Laureando Magistrale	0
Carollo Sara	Associata	Dottoranda	100
Rafael Escudeiro	-	Assegnista INFN	100
Franco Galtarossa	Dipendente	Ricercatore	100
Huang Zhen	-	Ricercatrice straniera	0
Silvia M. Lenzi	Associata	Prof. Ordinario	80
Santo Lunardi	-	Ass. Senior	0
Marco Mazzocco	Associato	Prof. Associato	20
Roberto Menegazzo	Dipendente	Ricercatore	70
Daniele Mengoni	Associato	Prof. Associato	100
Raquel Nicolàs Del Àlamo	Associata	Laureanda magistrale	0
Sara Pigliapoco	Associata	Dottoranda	100
Pilotto Elia	Associato	Dottorando	100
Polettini Marta	Associata	Assegnista	100
Francesco Recchia	Associato	Ricercatore B UniPD	100
Kseniia Rezyunkina	Associata	Borsa post-doc stranieri	100
Giuseppe Andreetta	Associato	Laureando Magistrale	0
TOTALE	15	Ricercatori	1270

Richieste GAMMA-PD 2024

Apparato	Descrizione	Richieste [k€]
AGATA	Meccanica, elettronica ancillari, computers	20
GRIT	MoU	55
Altre spese ricerca	Isotopi, consumo e manutenzioni	10
Missioni		107*
TOTALE		192

**) Inclusi 21 k€ per installazioni, manutenzioni e turni di misura a Legnaro: GAMMA + UPM + OM*

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

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

NUCL-EX



Riapertura della sigla sotto DTZ



ESPERIMENTO NUCLEX: Ambito di indagine e strumenti

NUCLEX esiste dal 2003

(dati 2021)

Ricercatori: 34 (22.7 FTE)

Tecnologi: 3 (1.0 FTE)

R.N.: S. Barlini, T. Marchi

Collaborazioni Internazionali:

- FAZIA (MoU)
- ACTAR
- LEA-COLLIGA e POLITA
- USP (MoU in via di definizione)

Contatti di collaborazione con:

USA (MSU), Brasile (Univ San Paolo), Francia (GANIL, IN2P3, CEA), Spagna (Univ Santiago De Compostela), Polonia (IFJ-PAN, COPIN), Turchia (Univ. Nevsehir), Russia (Moscow Univ.)

< 5 MeV/n

Struttura Nucleare e
sezioni d'urto tramite
spettroscopia di particelle

LNL: CN, AN200

LNS: Tandem



OSCAR

5-20 MeV/n

Fusione-evaporazione
Decadimento (non) statistico
Emissione di pre-equilibrio

LNL: Tandem, Alpi, **SPES**



ATS

20-50 MeV/n

(Multi)frammentazione
Isospin transport
Eq. di stato Nucleare

LNS: CS

GANIL



GARFIELD



FAZIA



ESPERIMENTO NUCL-EX

- ❖ **ATS:** Sviluppo di rivelatori ancillari per Neutroni/ γ e studio dell'accoppiamento con ATS (**responsabilità Padova**)

Sistema versatile ed innovativo con discriminazione Neutroni/ γ
-> **Scintillatori Plastici con PSD e SiPM**

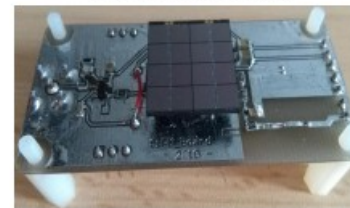
Test Finali:

- PCB prodotto per matrice 4x4 mm² SiPM AdvanSID RGB e NUV con Preamplificatore Veloce
- Scintillatori con PSD usati:
 - EJ-276G 1" Plastico
 - EJ-299 2" Plastico
 - EJ-309 2" Liquido

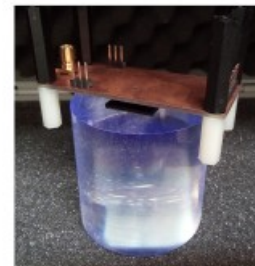


ATS

Preamplifier board with 4 x 4 AdvanSid SiPM array



SiPM preamplifier board with EJ-276G scintillator



EJ-299 2" scintillator



❖ **ATS: Sviluppo di rivelatori ancillari per Neutroni/ γ e studio dell'accoppiamento con ATS (responsabilità Padova)**



Sistema innovativo di array **SiPM** accoppiati a **Scintillatori Plastici** con discriminazione **PSD**

Studio comparativo di due arrays SiPM:

- ❖ **AdvanSiD-NUV** hybrid array ASD-NUV4S-P-4x4TD (17x17 mm²)
- ❖ **MPPC Hamamatsu** S14161-6050HS-04 (25x25 mm²)



Progettazione schede di lettura dei SiPM:
singoli segnali sommati e amplificati con preamplificatore veloce

Servizio di Progettazione Elettronica Padova
(M. Bellato, D. Corti, A. Griggio)

Next:

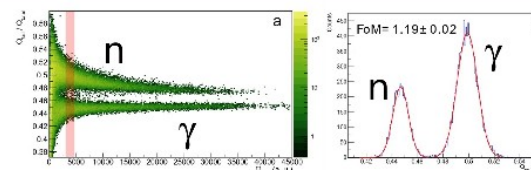
- ☐ **Revisione PCB per SiPM Ketek**
- ☐ **Nuovo PCB per lettura di 2 matrici SiPM Hamamatsu SOMMATE**

Accoppiati a due Scintillatori organici con discriminazione n/ γ :

- ❖ Liquid scintillator **EJ-309** (50 mm diam. x 50 mm thick.)
- ❖ Plastic scintillator **EJ-276G** (25 mm diam. x 25 mm thick.)



Neutron/ γ -ray discrimination con Am-Be source



Plots di EJ-276G accoppiato ad array SiPM Hamamatsu

Scintillator/SiPM array	Energy Resolution (@480keVee)	Time resolution (ns)	FoM (@480keVee +/- 10%)
EJ-276G/AdvanSiD-NUV	29.0% $\pm$ 0.002	1.84 $\pm$ 0.01	0.76 $\pm$ 0.02
EJ-276G/Hamamatsu	18.8% $\pm$ 0.004	1.09 $\pm$ 0.01	1.19 $\pm$ 0.02
EJ-309/AdvanSiD-NUV	20% $\pm$ 0.02	1.30 $\pm$ 0.01	1.15 $\pm$ 0.01
EJ-309/Hamamatsu	10.8% $\pm$ 0.004	0.599 $\pm$ 0.004	2.04 $\pm$ 0.01

Best SiPM Performance
HAMAMATSU

J. Delgado et al., ANIMMA 2023 - Lucca, 12-16 Giugno 2023



ESPERIMENTO NUCLE-EX

❖ Progetto 8Be-X17: Studio dell'anomalia nel decadimento del ⁸Be

Presentato nel luglio 2020 alla CSN3 è stato finanziato nell'ambito dell'esperimento NUCLEX per il 2021, con lo scopo di sviluppare un apparato sperimentale per una nuova misura.

PRL **116**, 042501 (2016)

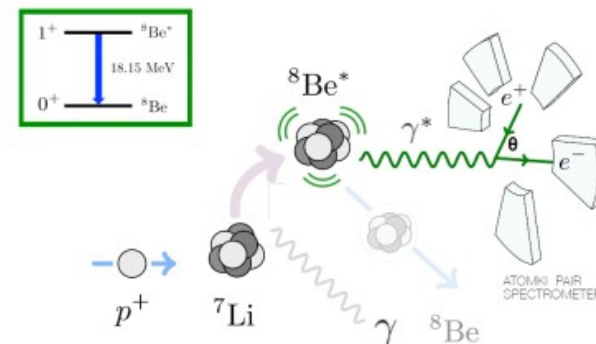
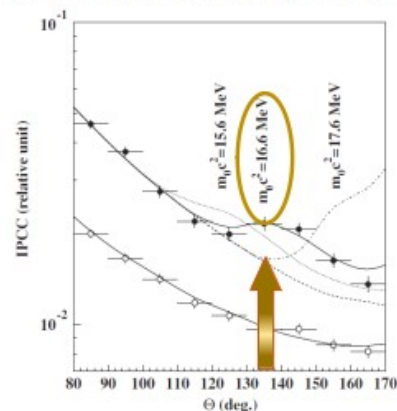
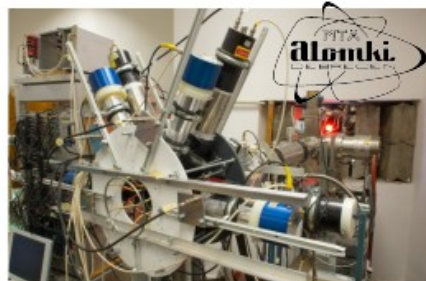
PHYSICAL REVIEW LETTERS

week ending
29 JANUARY 2016

Observation of Anomalous Internal Pair Creation in ⁸Be: A Possible Indication of a Light, Neutral Boson

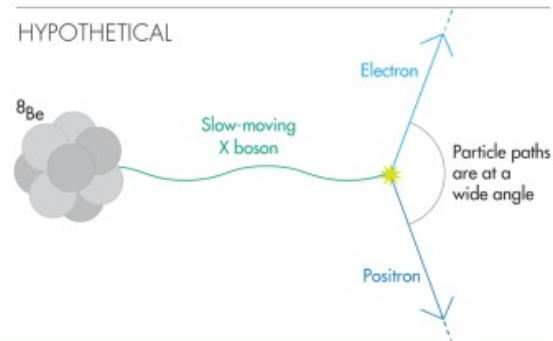
A. J. Krasznahorkay,^{*} M. Csatlós, L. Csige, Z. Gácsi, I. Gulyás, M. Horvádi, I. Kuti, R. M. Niszká, I. Stohl, I. Tóth,

⁷Li(p,e⁺e⁻)⁸Be @ E_p = 1.10 MeV



Calcoli teorici hanno ipotizzato nuovo bosone: la particella **X17**

HYPOTHETICAL



J.L. Feng et al., Phys Rev. Lett. 117 (2016) 071803

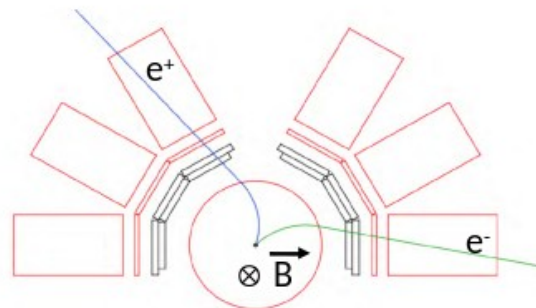
J.L. Feng et al., Phys Rev D 102 (2020) 036016



ESPERIMENTO NUCL-EX

Nuova misura all'acceleratore AN2000 dei LNL

- ☐ Migliorare risoluzione angolare riducendo material budget
- ☐ Migliorare copertura angolare e misurare correlazioni out-of-plane
- ☐ Migliorare la purezza del bersaglio
- ☐ Prevedere un futuro accoppiamento con campo magnetico

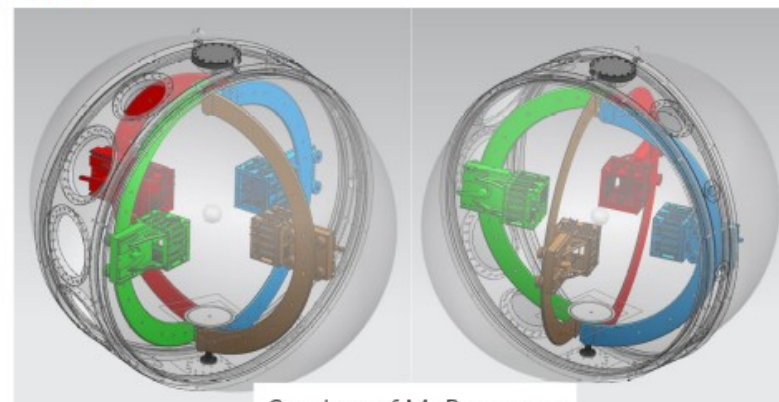
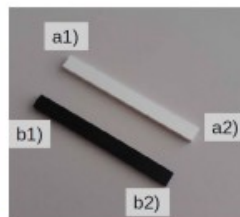
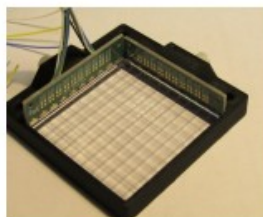


➤ **Progettazione supporti rivelatori e porta target** **Progettazione Meccanica Padova (M. Benettoni, M. Rampazzo)**
e collaborazione **G. Cogo**



Prototipo rivelatore

- Prototipo: EJ-200 + 2 layers XY position
- 1 blocco -> 4 moduli (max 10 blocchi)
- Read-out: SiPM (FBK Trento)

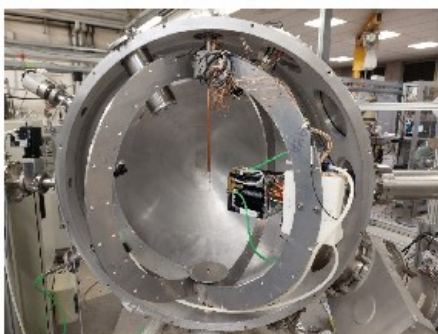
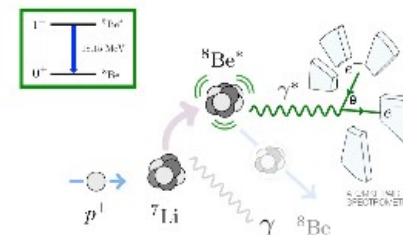


Courtesy of M. Rampazzo



❖ Progetto 8Be-X17: Studio dell'anomalia nel decadimento del ^8Be

Per spiegare l'anomalia nella correlazione angolare delle coppie e+e- prodotte nel decadimento del ^8Be , alcuni **calcoli teorici hanno ipotizzato l'esistenza di un nuovo bosone: la particella X17**



Il Progetto è stato finanziato nell'ambito dell'esperimento NUCLEX con lo scopo di sviluppare un apparato sperimentale per una nuova misura.

➤ Progettazione e Realizzazione dei supporti rivelatori e porta target

Servizio Progettazione Meccanica Padova (M. Benettoni, M. Rampazzo, M. Turcato)

Servizio Officina Meccanica Padova (L. Ramina, D. Agguiaro, A. Benato)

- ✓ Modifica camera di scattering esistente
- ✓ Realizzazione porta target con raffreddamento
- ✓ Realizzazione struttura di supporto della camera scattering
- ✓ Installazione nuovo punto misura all'acceleratore AN2000 dei LNL

- ☐ Realizzato nuovo punto misura all'AN2000 e trasportato un fascio di protoni di 500 nA a Marzo 2023
- ☐ Next: presa dati a fine Luglio 2023



Altre Attività:

- ❖ **Supporto alle attività di NUCLEX principalmente presso i LNL: *GARFIELD, OSCAR, X17, ATS***
- ❖ **Analisi Dati esp. ACLUST** - *Pre-equilibrium and statistical mechanisms in cluster production*

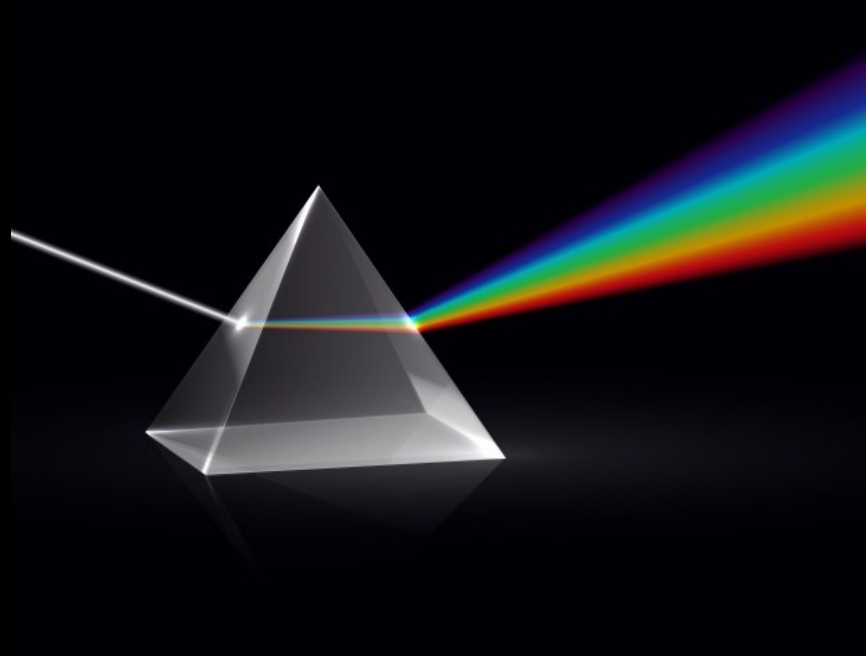
(v. **NucleX LoI** presentata per rinnovo sigla nazionale)

Anagrafica e Richieste 2024

- ❑ **Riapertura sigla NUCLEX sotto DTZ3 - D. Fabris 1 FTE**
- ❑ **MISSIONI** : 0.5 KE - Viaggi a LNL
0.5 KE - Trasferte per discussione analisi dati
- ❑ **Servizio Progettazione Elettronica:** 1 mese/uomo -
Revisione scheda PCB per lettura matrice SiPM Ketek
Progettazione e Produzione PCB per somma e lettura di 2 matrici SiPM

Hamamatsu

PRISMA-FIDES



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



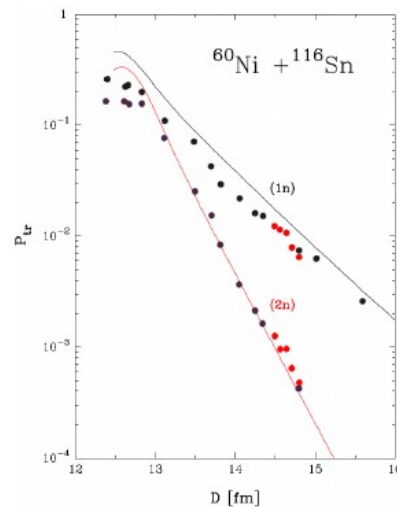
Heavy-ion fusion reactions
near V_B and at $E \ll V_B$
using the set-up **PISOLO** based on
an electrostatic beam separator



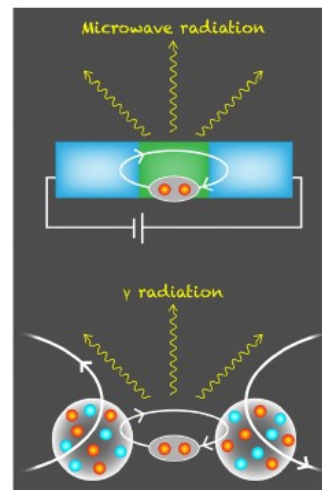
Quasi-elastic reactions
nucleon-nucleon correlations, sub-
barrier transfer, coupling to fusion,
n-rich isotope production and
nuclear structure studies
using the magnetic spectrometer
PRISMA

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:

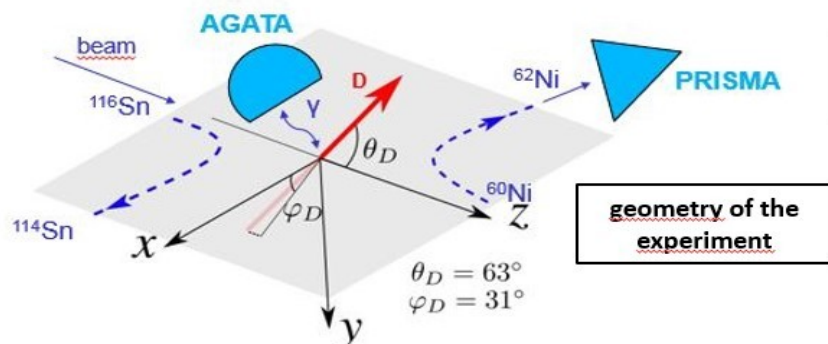
- Tiniest superfluid circuit in nature
- Superconductivity valid for macroscopic phenomena in solids may be applicable to the much smaller scale (femtometer nuclear scale)
- Pairing description is appropriate for a small number of particles

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

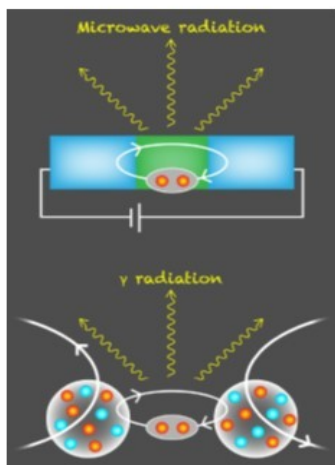


Search for a nuclear Josephson effect - PRISMA-AGATA experiment Feb. 2023

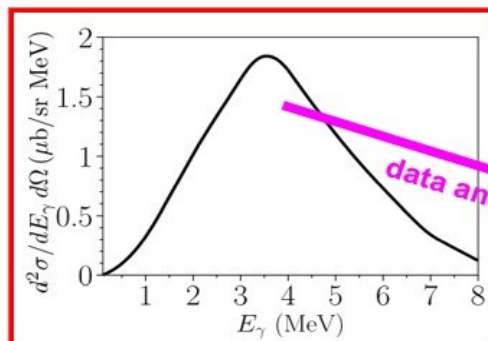


^{116}Sn beam PIAVE+ALPI, $E_{\text{lab}} = 452.5$ MeV, $I = 3$ pA
target thickness $300 \mu\text{g}/\text{cm}^2$, Prisma $\theta_{\text{lab}} = 20^\circ$

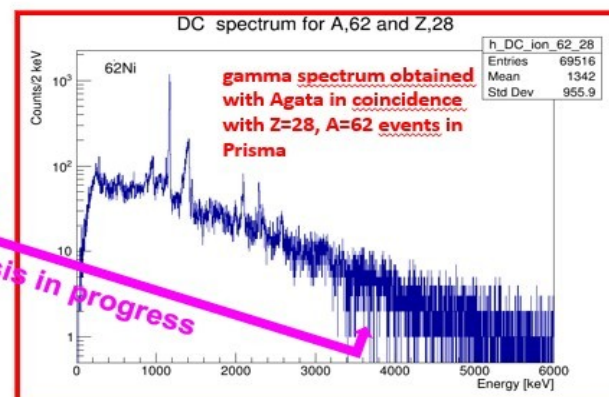
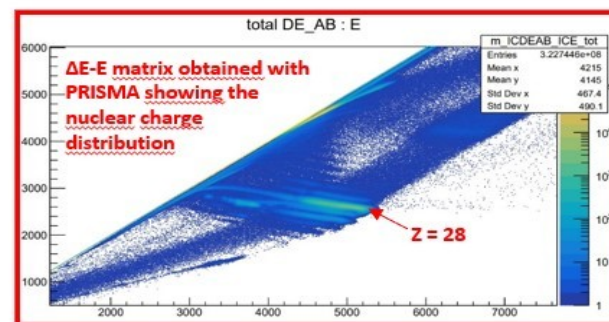
A first challenging experiment has been carried out at LNL looking at the possible existence of a gamma radiation emitted via a **dipole oscillation D** generated by the two neutron transfer process in the $^{116}\text{Sn}+^{60}\text{Ni}$ reaction at energies below the Coulomb barrier. This would evidence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



gamma ray strength function
predicted by Broglia et al.



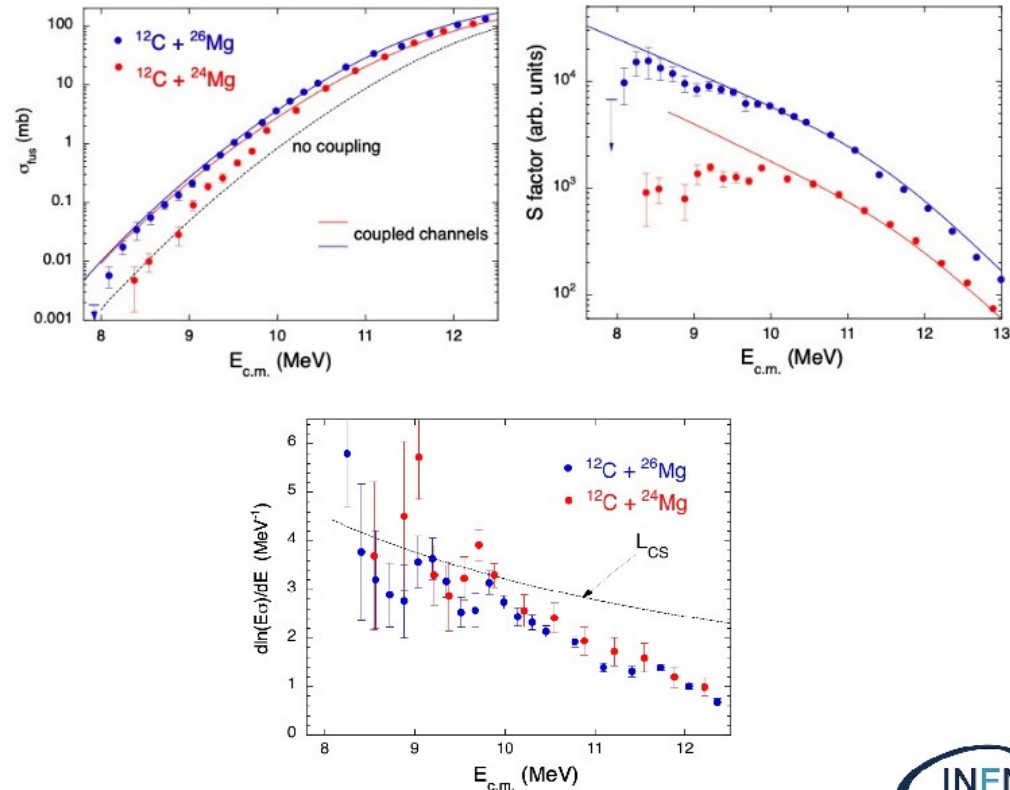
examples of preliminary data



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

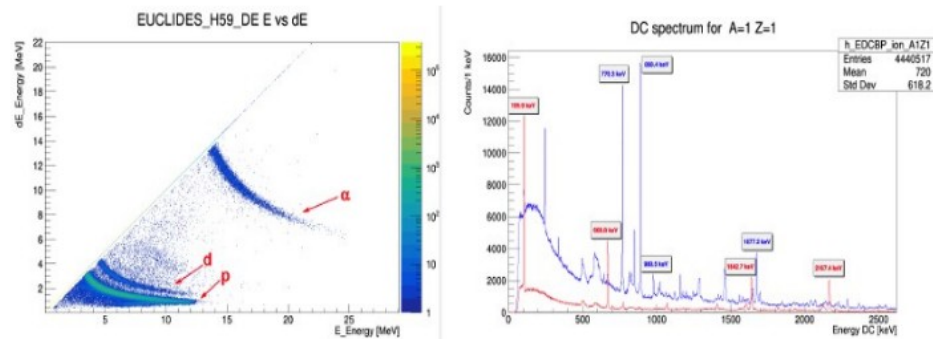
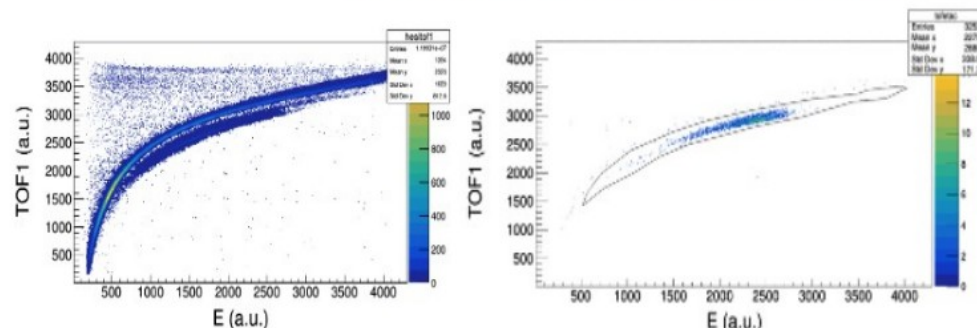
HIGHLIGHTS: SUB-BARRIER FUSION

- The difference between $^{12}\text{C} + ^{24,26}\text{Mg}$ might (only qualitatively) be attributed to the α -like structure of ^{24}Mg .
- In overall systematics, the different behaviours of $^{12}\text{C} + ^{24,26}\text{Mg}$ make the situation more complex and call into question the extrapolation procedure toward the lighter systems of astrophysical interest.
- The logarithmic derivatives of the two excitation functions are very similar to each other and are characterized by oscillations in the sub-barrier energy region, whose nature needs to be investigated



HIGHLIGHTS: SUB-BARRIER FUSION

Measuring very small cross sections: recent tests



- The fusion events have been measured with **PISOLO + one Si detector (of the whole Euclides array)**.
- The two-dimensional **spectrum E-ToF, without** (left) and **with** (right) the coincidence show that the most of the beam-like and background events have been rejected.
- Test of particle- γ coincidences with **AGATA + Euclides** for fusion measurement of $^{12}\text{C} + ^{30}\text{Si}$
- The aim is to measure in the nano-barn range using the combined set-up of **AGATA with the DSSD** for further experiments will be proposed for 2023

PRISMA-FIDES
"Heavy-ion reactions from grazing collisions to complete fusion"
Continuation experiment 2022-2024



GROUP COMPOSITION				
G.Montagnoli (100%, Resp. Loc.), M.Dal Fabbro (100%), F.Scarlassara (100%) (Univ. and INFN – Padova) 3.0 FTE				
L. Corradi (100%, Resp. Naz.), E.Fioretto (100%), A.M. Stefanini (ass. senior) (INFN – LNL) 2.0 FTE				
PREVISIONE DI SPESA PER IL 2024 (in Keuro)				
	Cons	Inv	Miss	TOT
PD	14	10	12	36

RICHIESTE DI SERVIZI PER IL 2024		
SERVIZIO	LAVORO RICHIESTO	MESI UOMO
Officina meccanica	Meccanica di supporto per rivelatori al silicio ad AGATA e PISOLO	2
SPE/OE	Possibili test e sviluppi di elettronica per esperimenti Pisolo/Agata in coincidenza con silici	2

ASFIN2

ASFIN2 (43 ricercatori, 28.6 FTE)

LNS (19.60 FTE) + NA (2.9 FTE) + PG (4.0 FTE)
+ PD (2.1 FTE): M. Mazzocco (0.8), F. Soramel (0.3) + X. Su (1.0)

Studio delle reazioni nucleari di interesse astrofisico mediante i
metodi indiretti



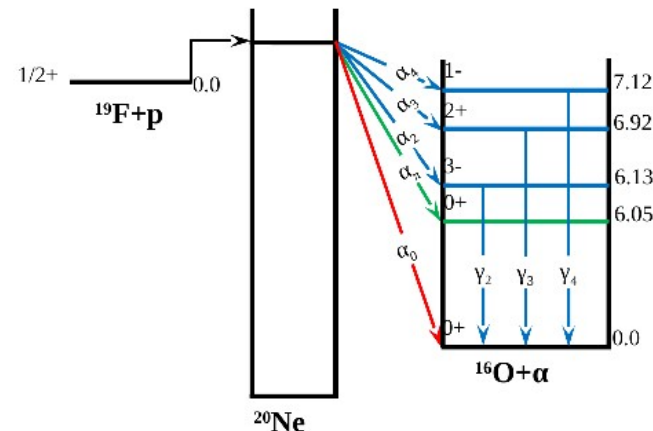
La reazione di interesse
astrofisico $x+A \rightarrow c+d$
viene studiata
mediante la reazione
Cavallo di Troia $a+A \rightarrow$
 $c+d+s$, nell'ipotesi che
a abbia una pronunciata
struttura a cluster $a =$
 $x+s$ ed s rimanga
spettatore durante
l'interazione.

ASFIN2_PD: Highlights Attività 2022-23

Study of the reaction $^{19}\text{F} + \text{p} \rightarrow ^{16}\text{O} + \alpha$ (Xuedou Su)

$^{19}\text{F}(\text{p}, \alpha_0)^{16}\text{O}$

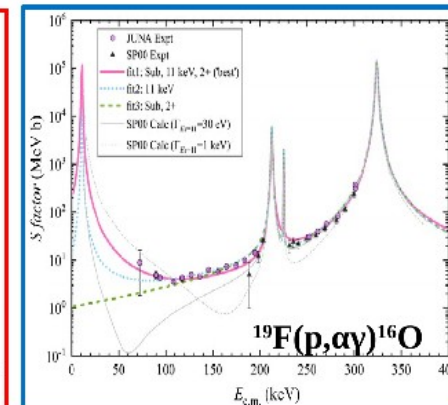
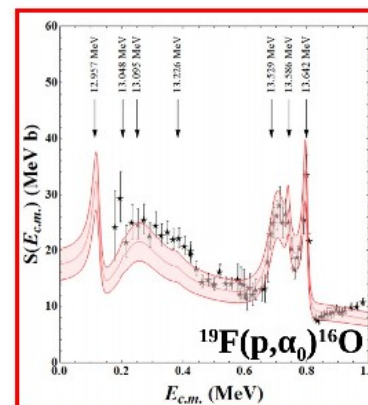
Trojan Horse Method (THM)
measurement in the energy region $0 < E_{\text{cm}} < 1$ MeV (La Cognata et al. 2011, La Cognata et al. 2015, Indelicato et al. 2017). Direct measurement in the energy region $0.2 < E_{\text{cm}} < 1$ MeV (Lombardo et al. 2013, Lombardo et al. 2015).



$^{19}\text{F}(\text{p}, \alpha\gamma)^{16}\text{O}$

Direct measurement in the energy region $72.4 < E_{\text{cm}} < 344$ keV (Zhang et al. 2021).

The $^{19}\text{F}(\text{p}, \alpha)^{16}\text{O}$ reaction rate is the sum over the rate for the (p, α_0) , (p, α_n) and $(\text{p}, \alpha\gamma)$ channels, but the (p, α_n) channel has never been measured experimentally in the energy range of interest.



ASFIN2_PD: Highlights Attività 2022-23

Study of the reaction $^{19}\text{F} + p \rightarrow ^{16}\text{O} + \alpha$ (Xuedou Su)

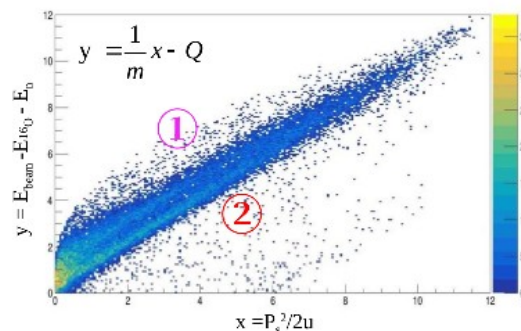
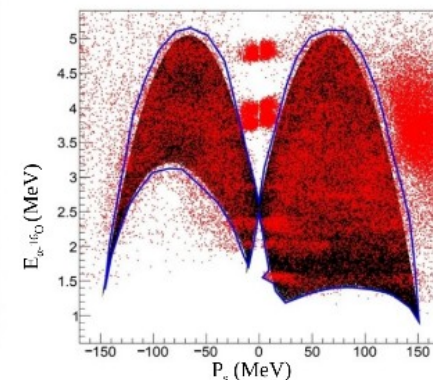
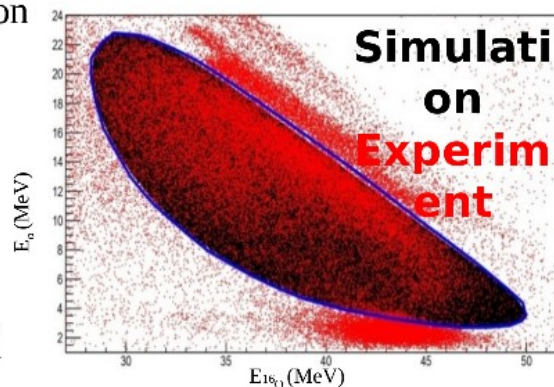
Comparison with the simulation

Selection in $E_\alpha - E_{^{16}\text{O}}$ and

$$E_{\alpha-^{16}\text{O}} - P_s$$



To select the three-body
reaction channel of interest
and to reduce the background

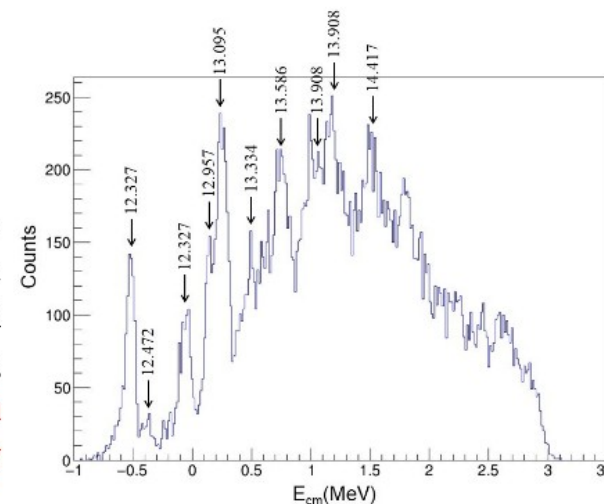


① (p, α_3) and (p, α_4) channels

② (p, α_π) and (p, α_2) channels

Q-value
Reconstruction

E_{cm}
Reconstruction
and
corresponding
 $^{20}\text{Ne}^*$ Excitation
Energy



ASFIN2_PD: Highlights Attività

LOI for Coupling EXOTIC to AGATA (Feb. 2022)

Letter of Intent: Coupling the In-Flight Radioactive Ion Beam Facility EXOTIC to the γ -Ray Spectrometer AGATA

Spokespersons: M. Mazzocco¹, D. Pierrousakou², J.J. Valiente-Dobón³

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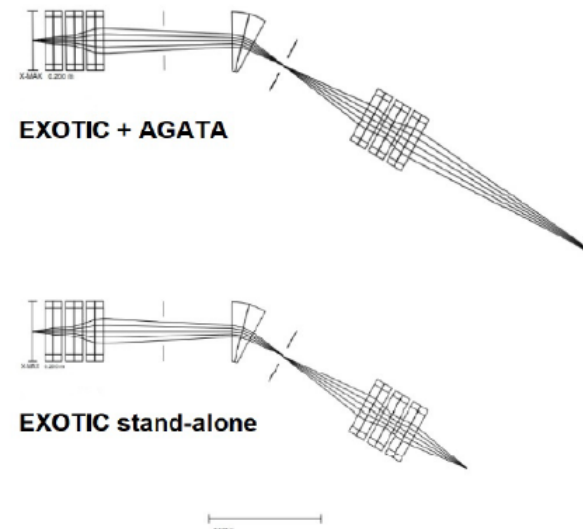
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⁸ INFN, Sezione di Firenze, Firenze, Italy

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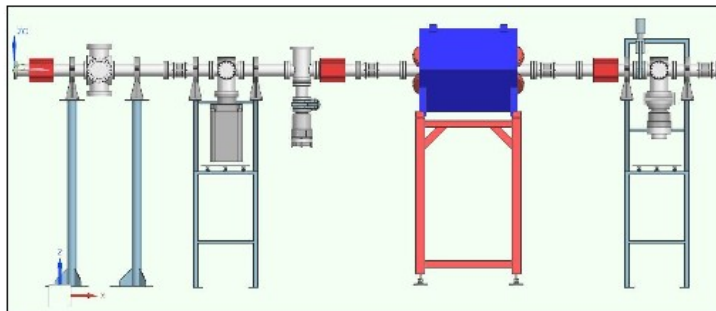


The proposal suggests the coupling of the EXOTIC beam line to the AGATA gamma-ray spectrometer. The EXOTIC facility can produce moderately exotic light nuclei of interest for astrophysics and aspects of nuclear structure physics and would thus enhance the potential of the LNL laboratory in terms of experiments with light radioactive beams as shown by the few examples presented. This coupling does not at all affect the rest of the AGATA program and is thus an interesting extension to the capabilities at, presumably, relatively low costs. As outlined in the LOI, it is possible to envisage competitive experimental proposals that would exploit EXOTIC beams with AGATA. The PAC therefore strongly recommends this coupling to be performed and suggests expanding the list of possible future proposals of interest to both the EXOTIC and AGATA communities.

ASFIN2_PD: Highlights Attività 2022-23

Upstream the Production Target

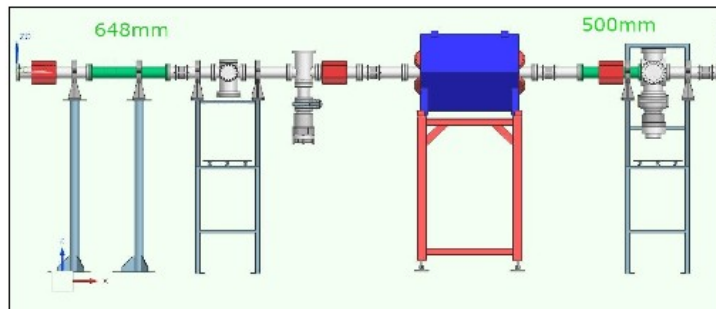
Before



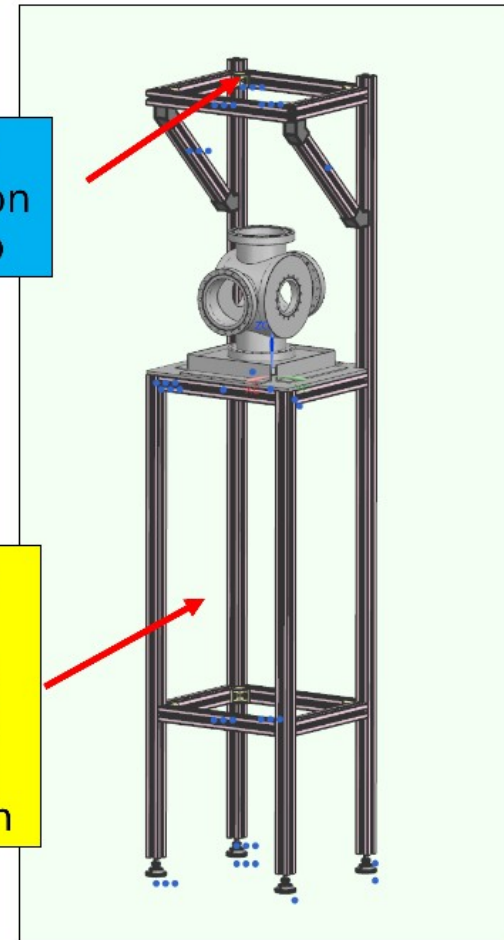
After

To host the
"compensation
lung" on top

After



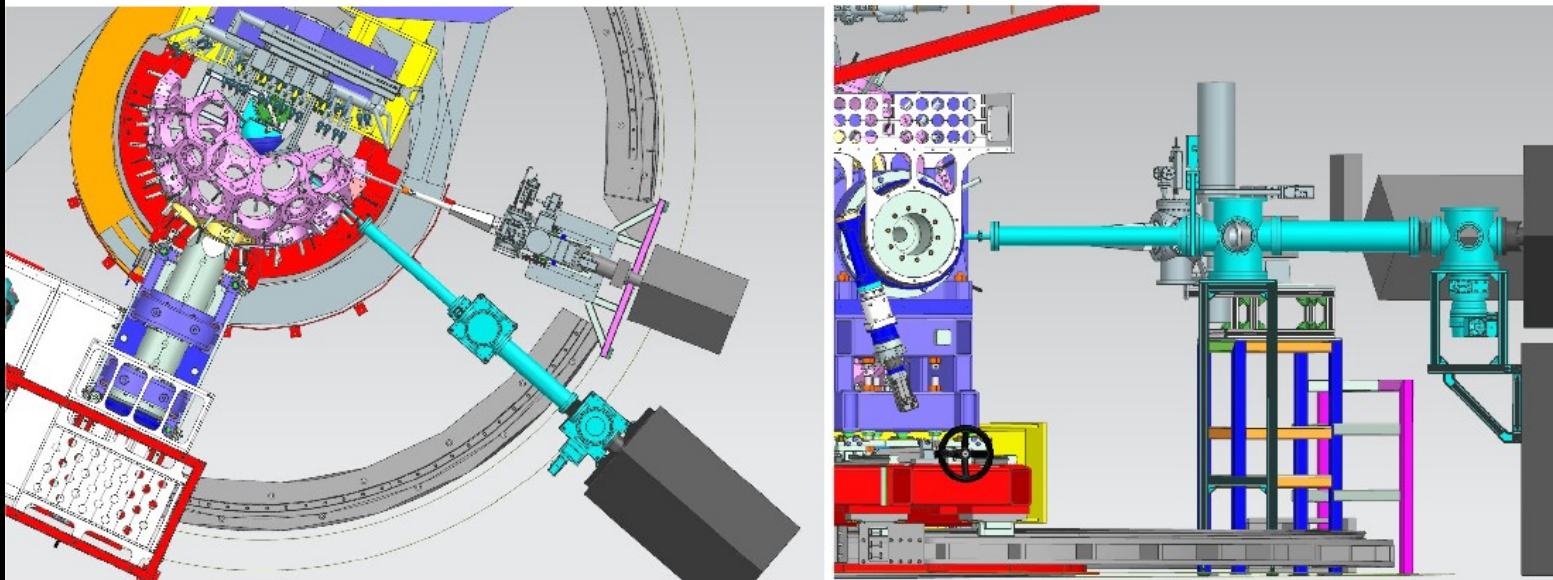
To house
the
repository
of the gas
cylinders
underneath



Ufficio Tecnico – INFN Padova

ASFIN2_PD: Highlights Attività 2022-23

Connection Beam-Line between EXOTIC and AGATA



Ufficio Tecnico - INFN Padova

ASFIN2_PD: Attività Prevista 2023-24

Time-Line of the Facility Refurbishment

Before the Summer Break 2023, with the collaboration of the LNL Accelerator Division and the LNL Users Service, we expect:

1. to **replace** the **pipelines** for cooling the power supplies and the magnets (July 2023);
2. to **upgrade** the **remote control system** of the **power supplies** (under the EPICS platform, July 2023);
3. to **upgrade** the **remote control system** of the **slits** (on-going);
4. to **perform** the **laser-assisted alignment** of the facility (September 2023).

ASFIN2_PD: Attività Prevista 2023-24

Commissioning of the Connection

We expect: (i) to **complete** the **maintenance** of the facility before the summer break, (ii) to **test** the new **remote control systems**, at latest, in September and (iii) to **assembly** and **test** the **MCPs** (with delay lines built in-house) in September.

We plan to request **three two-day commissioning runs** with a ${}^7\text{Be}$ secondary beam (most intense RIB delivered by EXOTIC).

- 1. October 2023:** in-beam test of the remote control system of the magnets and of the performances of the first MCP;
- 2. November 2023:** in-beam test of the second MCP and development of the secondary beam tracking algorithm;
- 3. December 2023:** in-beam test for delivering the RIB up to the PRISMA-AGATA reaction chamber.

Primary Beam Request: ${}^7\text{Li}$ at 48 MeV, intensity: ~ 30 pA.



Experiments with EXOTIC+AGATA

In case of successful commissioning, we should be able to accept proposals for experiments with secondary beams delivered by EXOTIC in the **PAC meeting** at the **end of 2023**.

${}^7\text{Be} + {}^{208}\text{Pb}$

Quasi-elastic scattering and **projectile fragments (${}^3,{}^4\text{He}$)** production measured at LNL.

${}^7\text{Be} + \gamma$ (0.429 MeV): inelastic scattering contribution to the quasi-elastic process.

${}^3,{}^4\text{He} + \gamma$ coincidences: information on the target-like nuclei produced.

${}^{11}\text{C}(\text{d},\text{p}){}^{12}\text{C}$

${}^{11}\text{C}(\text{d},\text{p}){}^{12}\text{C}$ ${}^{11}\text{B}(\text{d},\text{n}){}^{12}\text{C}$

Same final wave function (ex. states ${}^{12}\text{C}$)

Same reaction in Isospin Symmetry
Same initial w.f. in Isospin Symmetry

Isospin Symmetry is obviously **violated** by **Coulomb interaction**, are there **nuclear** sources?

Ab-initio calculations possible for $A=11$!

Richieste Finanziarie e Richieste ai Servizi PD

Richieste Finanziarie - ASFIN2 Sez. Padova

Missioni: LNL - Preparazione Esperimenti con linea di fascio EXOTIC e Turni di Misura, 3 pp (1 k€/anno per persona) = **3 k€**

TRIUMF, Canada, ^{16}C exp: 1p * 15gg (0.9 k€ viaggio + 130 €/die) = **3 k€**

RIKEN, Giappone, ^6He exp: 1pp * 15gg (1 k€ viaggio + 130 €/die) = **3 k€**

Corea del Sud, laser exp: 1pp * 21gg (0.9 k€ viaggio + 130 €/die) = **3.5 k€**

TRIUMF, Canada, ^{26}Al exp: 1p * 15gg (0.9 k€ viaggio + 130 €/die) = **3 k€**

LANF, Brasile, $^{12,13}\text{C}$ exp: 1p * 10gg (0.9 k€ viaggio + 130 €/die) = **2.5 k€**

LNS - ^{23}Na exp: 1pp * 15gg (0.5 k€ viaggio + 130 €/die) = **2.5 k€**

Consumo: 1 k€: acquisto gas compressi per il bersaglio di produzione

Costruzione Apparati: 5 k€: servo-maccanismi per controllo remoto slitte

Totale: 26.5 k€ (Missioni 12.5 + 8 sj, Consumo 1, Costr. App. 5)

Richieste ai Servizi della Sezione INFN di Padova

Officina Meccanica: 1 mese/uomo (piccole lavorazioni delle parti meccaniche per linea di connessione EXOTIC-AGATA ed installazione).

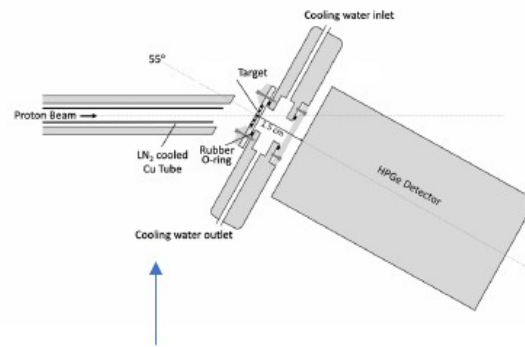
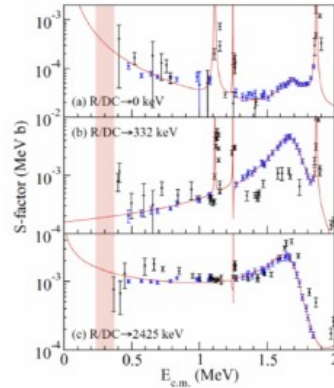
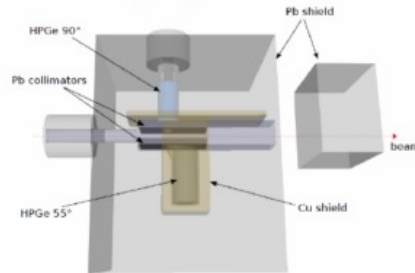
Progettazione Meccanica: 1 mesi/uomo (progettazione di piccole componenti meccaniche per il supporto dei MCP)

Progettazione Elettronica: 2? mesi/uomo (progettazione e realizzazione dell'elettronica di readout dei MCP)

LUNA3



LUNA: ATTIVITÀ 2022 GRUPPO PD

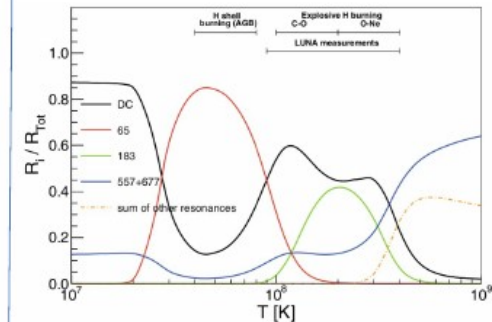


data taking and analysis ended

Scientific and technical papers under preparation

For ^{20}Ne WG experimental data at energies never reached before in literature

For $^{12/13}\text{C}$ S-factor is lower than what reported in literature with interesting outcome on astrophysical scenarios



Study of the 65 keV Resonance → never observed before with experimental data

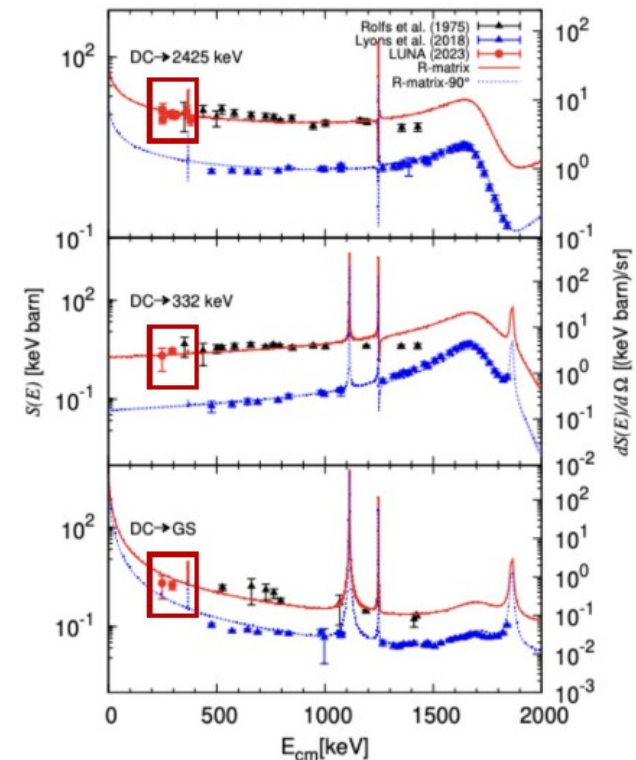
Data taking completed
Technical paper under preparation

Preliminary: signature of the resonance signal

Study of the $^{20}\text{Ne}(p,\gamma)^{21}\text{Na}$ reaction

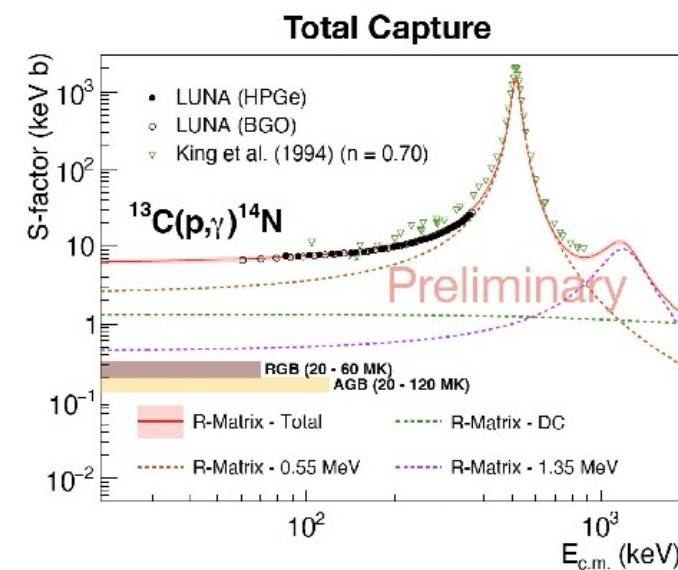
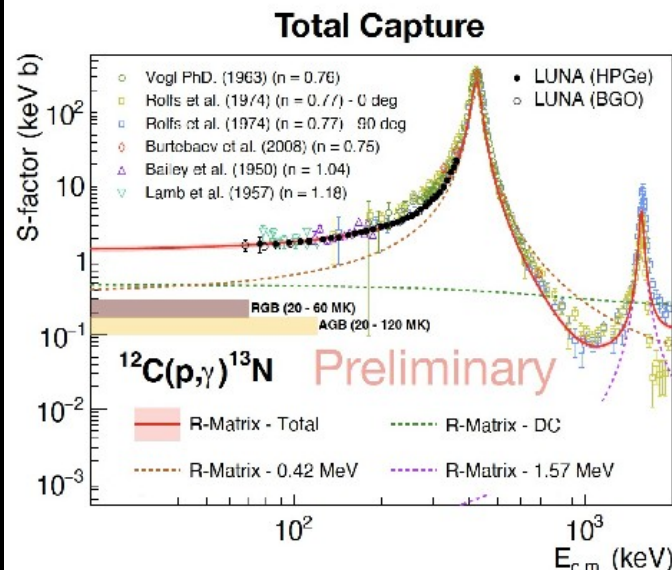
Coordinatore A. Cacioli

- $^{20}\text{Ne}+p$ è la **reazione più lenta del ciclo neo sodio** e quindi controlla la velocità del ciclo e la produzione di isotopi. È importante per stelle AGB e nova dove il rate impatta direttamente sulla nucleosintesi degli isotopi in modo.
- Attività svolta da LUNA-PD:
data taking and analysis (**Master thesis** student in Padua: Lucia Barbieri)
- LUNA raggiunge per la prima volta dati sotto 37 keV ($\sim$ Gamow) e i nuovi dati condizionano fortemente le estrapolazioni alle energie di interesse astrofisico
- Articolo scientifico sui risultati sottomesso a PRL under review. A. Cacioli as corresponding autho



The study of the $^{12/13}\text{C}(p,\gamma)^{13/14}\text{N}$ reactions at LUNA

- Le reazioni di cattura protonica su isotopi del carbonio sono interessanti perché lo studio delle **abbondanze di ^{12}C e ^{13}C** aiutano a comprendere i **modelli di trasporto convettivo** nelle stelle RGB e AGB.
- PhD thesis** at UNIPD (J. Skowronski), Attività svolta da LUNA-PD data taking and analysis; articolo scientifico sottomesso a PRL (under review)



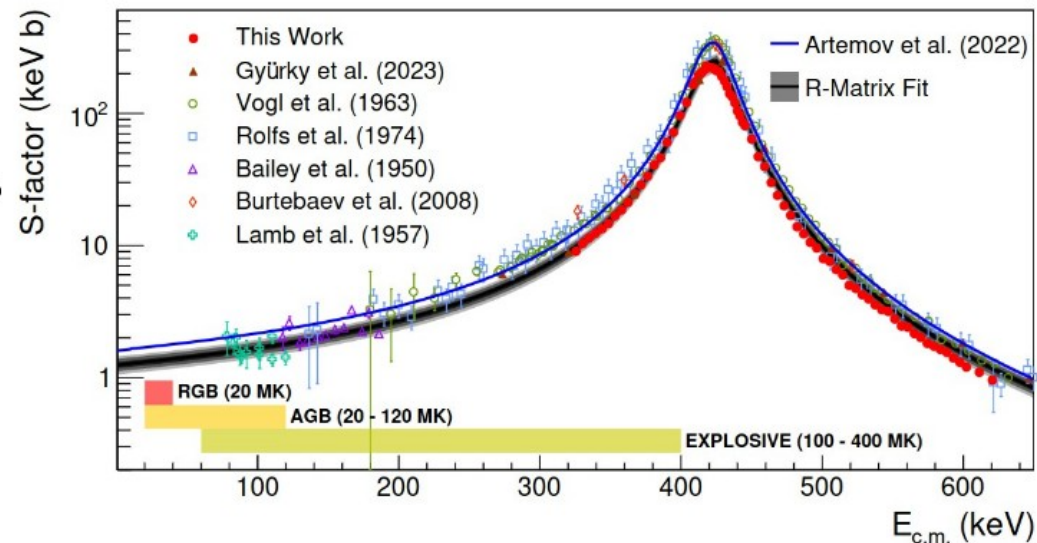
I nuovi risultati LUNA sono $\sim 20\%-30\%$ inferiori rispetto ai valori in letteratura e con più alta precisione $\rightarrow$ implicazioni su stelle AGB e RGB.

The study of the $^{12}\text{C}(p,\gamma)^{13}\text{N}$ reactions at Felsenkeller (HZDR)

Coordinators: Denise Piatti and Jakub Skowronski

- PhD thesis at UNIPD (J. Skowronski) – Master Student: HarshitBabu
- Attività svolta da LUNA-PD data taking and analysis
- Articolo scientifico sui risultati pubblicato su PRC Letter (Skowronski et al.), Denise Piatti as corresponding author

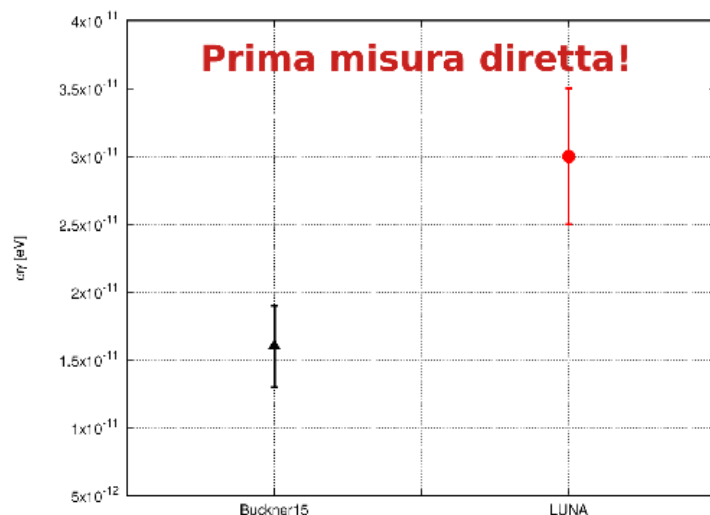
- Esperimento supportato da progetto EU CHETEC-INFRA
- Incertezza totale inferior a 9%
- **S-factor 25% più basso della letteratura** in forte accordo con quanto trovato da LUNA
- **Nuovo valore più preciso dell'energia della risonanza** ad energie maggiori di quelle raggiungibili a LUNA



The study of the 65 keV resonance in the $^{17}\text{O}(p,\gamma)^{18}\text{F}$ reaction at LUNA

Coordinator: Denise Piatti

- La reazione di cattura protonica capture su ^{17}O è importante per le stelle AGB e RGB. **Prima misura diretta** della risonanza a 64 keV che domina il rate alle basse energie.
- Setup “spinto” come schermatura che sfrutta un sistema di coincidenze tra cristalli del rivelatore BGO ottenendo un valore maggiore di quello presente in letteratura (basato su metodi indiretti)
- Attività svolta da LUNA-PD data taking and analysis; Articolo scientifico in preparazione per PRL



- Setup upgrades: technical paper published on JPG (Skowronski et al 2023)
- I risultati preliminari suggeriscono che la risonanza abbia un valore due volte maggiore rispetto alla letteratura (misure indirette)



LUNA: ATTIVITÀ ULTIMO ANNO GRUPPO PD

- Sviluppo **DAQ** per acceleratore MV a LNGS. Coordinatore R. Menegazzo
- Caratterizzazione **nuovo HPGe** for $^{12}\text{C}+^{12}\text{C}$ study at LUNA Coordinatori: R. Menegazzo and Antonio Cacioli
- Misure bersagli carbonio per LUNA con **HEAT** ai LNL e al Felsenkeller. Coordinatrice: D. Piatti
- **Collaborazione con ASFIN e GAMMA** per nuclear astrophysics experiments a LNL e TRIUMF
- Proposal per lo studio della reazione $^{13}\text{C}(p,\gamma)^{14}\text{N}$ al Felsenkeller
- **Dissemination projects** on Nuclear Astrophysics with high school students

L'attività di LUNA-PD è fortemente correlata con il progetto EU **CHETEC-INFRA** project (Cacioli UNIPD local responsible):

- Partecipazione ad una **nuova proposta INFRASTRUCTURE** sottomessa nel 2023 (under evaluation)
- **Denise Piatti ha ricevuto il premio «Horst Wenninger» ad Erice**
- **PRIN2022** on $^{12}\text{C}+^{12}\text{C}$ finanziato (Cacioli local responsible per UNIPD)



ATTIVITÀ PREVISTA 2023-2024

Lavoro per Acceleratore LUNA400

- Studio della reazione $^{21}\text{Ne}(p,\gamma)^{22}\text{Na}$. Tesista magistrale a Padova su questo lavoro
- Studio reazione $^{16}\text{O}(p,\gamma)^{17}\text{F}$ con nuovo setup per distribuzioni angolari con detector schermati
- Studio reazione $^{23}\text{Na}(p,\alpha)^{20}\text{Ne}$ con bersaglio solido. Bersagli prodotti a LNL e testati a LUNA e LNL
- Studio reazione $^{14}\text{N}(p,\gamma)^{15}\text{O}$ a basse energie con rivelatore BOG segmentato (con anche fondi PRIN2022)

Lavoro per Acceleratore MV

- Implementazione segnali di slow control nella DAQ
- Caratterizzazione nuovo HPGe a bassissimo fondo e studio per setup sperimentale per studio reazione $^{12}\text{C}+^{12}\text{C}$
- Design del setup per lo studio della reazione $^{12}\text{C}+^{12}\text{C}$
- Test su bersagli di carbonio con setup sperimentale HEAT a LNL (il setup è stato in riparazione per lunga parte del 2022-2023 e tornato operativo a Maggio)
-

In aggiunta

- 1 esperimento presentato a AGATA per studio livello eccitato ^{15}O
- 2 esperimenti presentati per misure presso Felsenkeller facility



GRUPPO LUNA3: 4.5 FTE

C. Brogginì (100%), A. Caciolli (100%), P. Marigo (20%), R. Menegazzo (30%), Denise Piatti (100%), Jakub Skowronski (100%) + 5 master thesis students [forte attrattività studenti]

RICHIESTE FINANZIARIE LUNA3 @ PD PER 2024

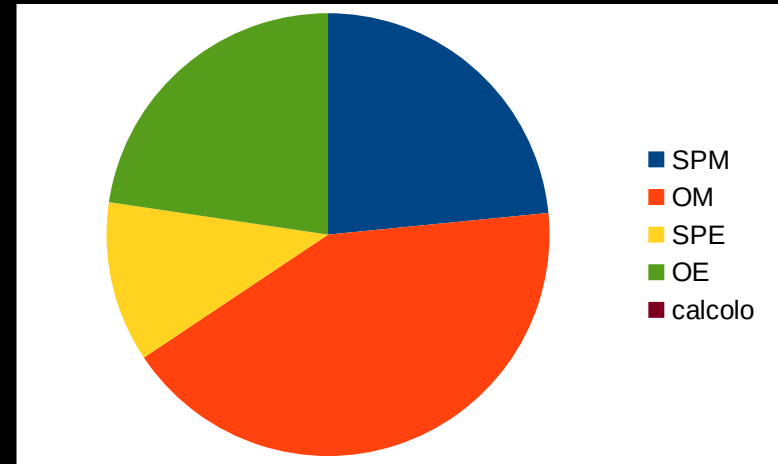
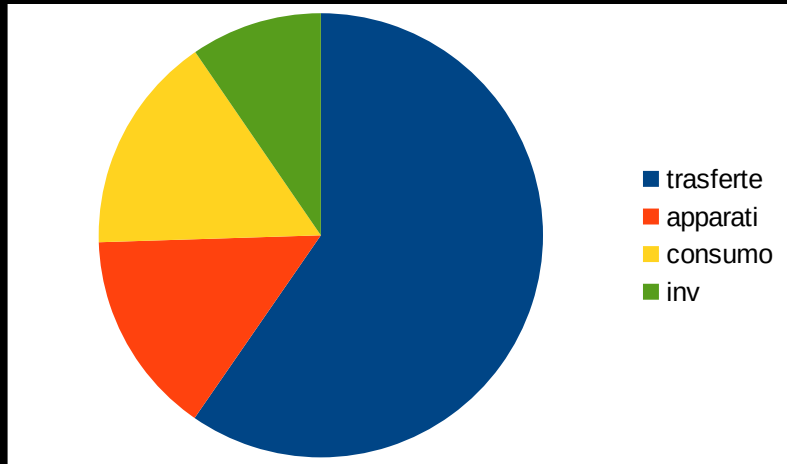
- Missioni: 32 k€ turni LNGS, 3 k€ misure a LNL. Totale 35 k€
- Attività a LNL su facility HEAT: 6k€ (acquisto materiale per bersagli)
- Attività a LNGS: 18k€ (sistema di acquisizione per SiPM che sono accoppiati a rivelatori NaI per lo studio della reazione $^{12}\text{C}+^{12}\text{C}$)

1 mese uomo OE: design/produzione basette lettura rivelatori

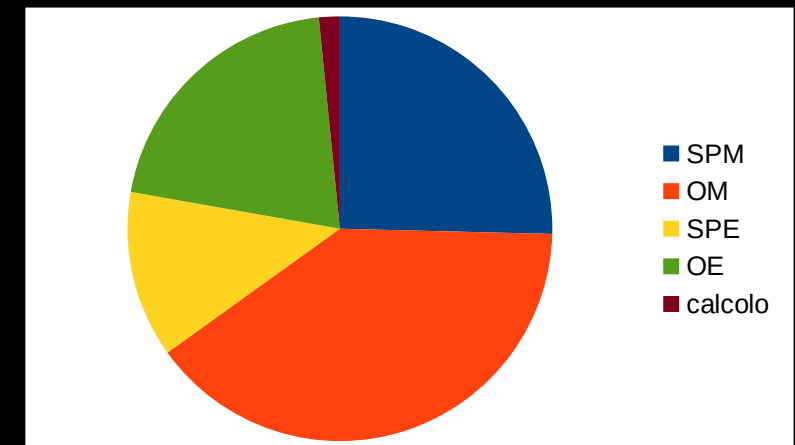
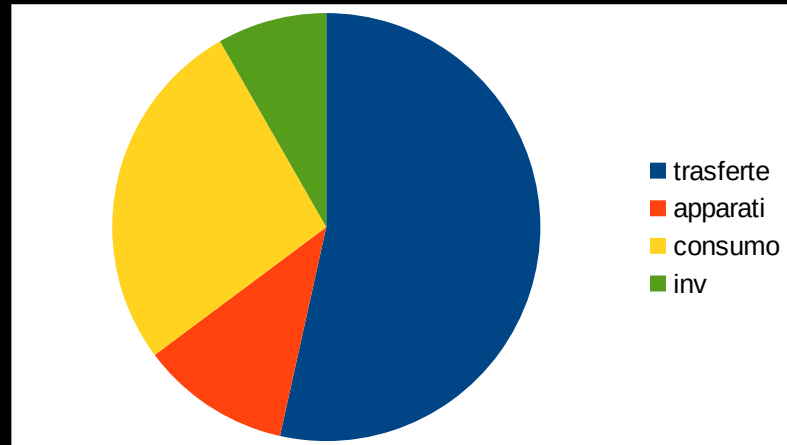
1 mese uomo SPM: progettazione camera reazione $^{12}\text{C}+^{12}\text{C}$

2 mesi uomo OM: realizz. camera

2023



2022



Summary

2023	pp	FTE	trasferte	apparati	consumo	inv	SPM	OM	SPR[SPE]	STG[OE]	calcolo
ALICE	12.00	9.30	85.00		15.00			3.00		6.00	-
NA60+	3.00	0.30	4.00								
EIC_NET	7.00	1.95	6.00		5.00	5.00					
ASFIN2	3.00	2.10	20.50		1.00	5.00	1.00	2.50		1.00	
GAMMA	14.00	12.70	107.00	70.00	10.00		10.00	18.00	4.00	6.00	1.00
LUNA	6.00	4.50	35.00		6.00	18.00	1.00	1.00	0.50	0.50	
PRISMA	3.00	3.00	12.00		14.00	10.00		2.00	1.00	1.00	
NUCLEX	1.00	1.00	1.00								
tot	48.00	36.35	280.50	70.00	75.00	45.00	15.00	28.50	7.50	14.50	1.00

FEROCCE (Gr5) = 0.1 FTE AFFINI GAMMA
 +2 AdR [ASFIN2, LUNA in Settembre]
 1 associati senior in GAMMA

An abstract black and white image featuring a dense network of thin, white, curved lines that resemble a spider web or a complex fiber structure. A bright, circular light source is visible in the upper right, creating a strong glow and casting long, soft shadows across the web-like pattern.

**Fine
della
Presentazione**

Grazie per l'attenzione

