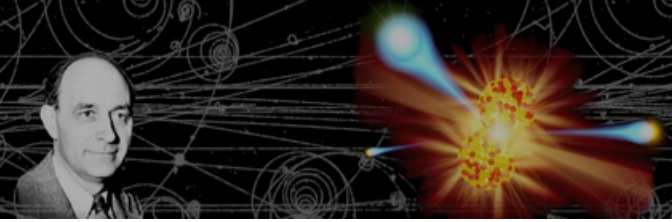


Stato e richieste degli esperimenti di Gruppo III Padova

Daniele Mengoni

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

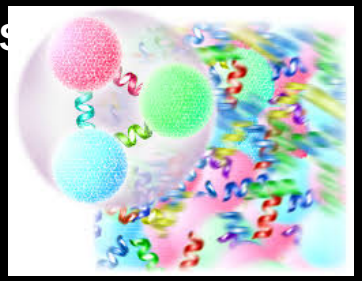
Daniele Mengoni – DFA/INFN Pd
Consiglio di Sezione INFN Padova
08 Luglio 2022

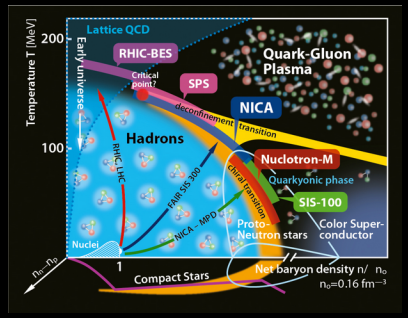
Dipartimento di Fisica e Astronomia Galileo Galilei

INFN PADOVA
Istituto Nazionale di Fisica Nucleare
Sezione di Padova

6 research lines: 26 exps

1.**QUARKS AND HADRON DYNAMICS**
EIC_NET (BNL) , JLAB12 (JLAB), KAONNIS (LNF) MAMBO (Mainz-Bonn), ULYSSES (JPARC)



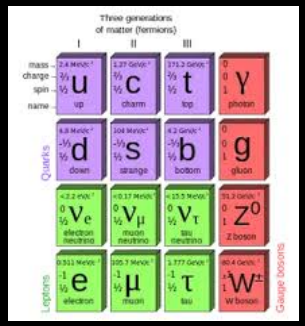


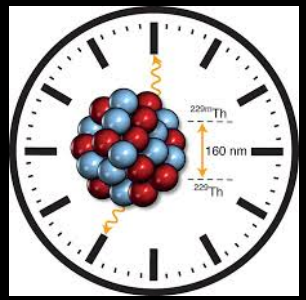
2.**PHASE TRANSITION IN HADRONIC MATTER:**
ALICE (CERN), NA60+_NET(CERN)

3.**NUCLEAR STRUCTURE AND REACTION MECHANISM:**
EXOTIC, FORTE, GAMMA, NEWCHIM, ~~**NUCL-EX,**~~ NUMEN_GR3, **PRISMA_FIDES (LNS, LNL, GANIL, RIKEN....)**

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

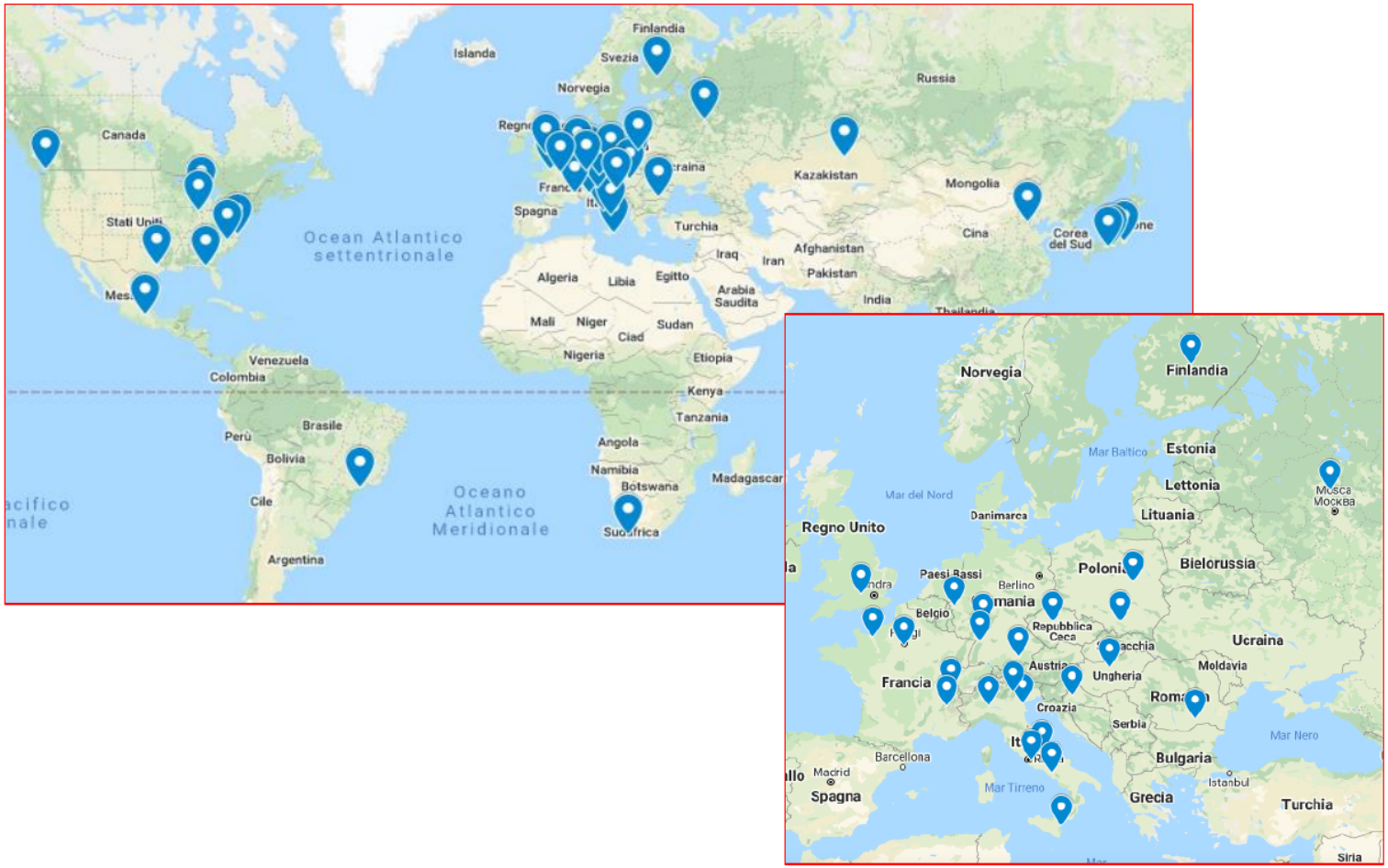
5.**FUNDAMENTAL INTERACTIONS:**
ASACUSA (CERN), ~~**AEgIS**~~ (CERN), JEDI (Bonn),VIP (LNGS), FAMU (RAL)



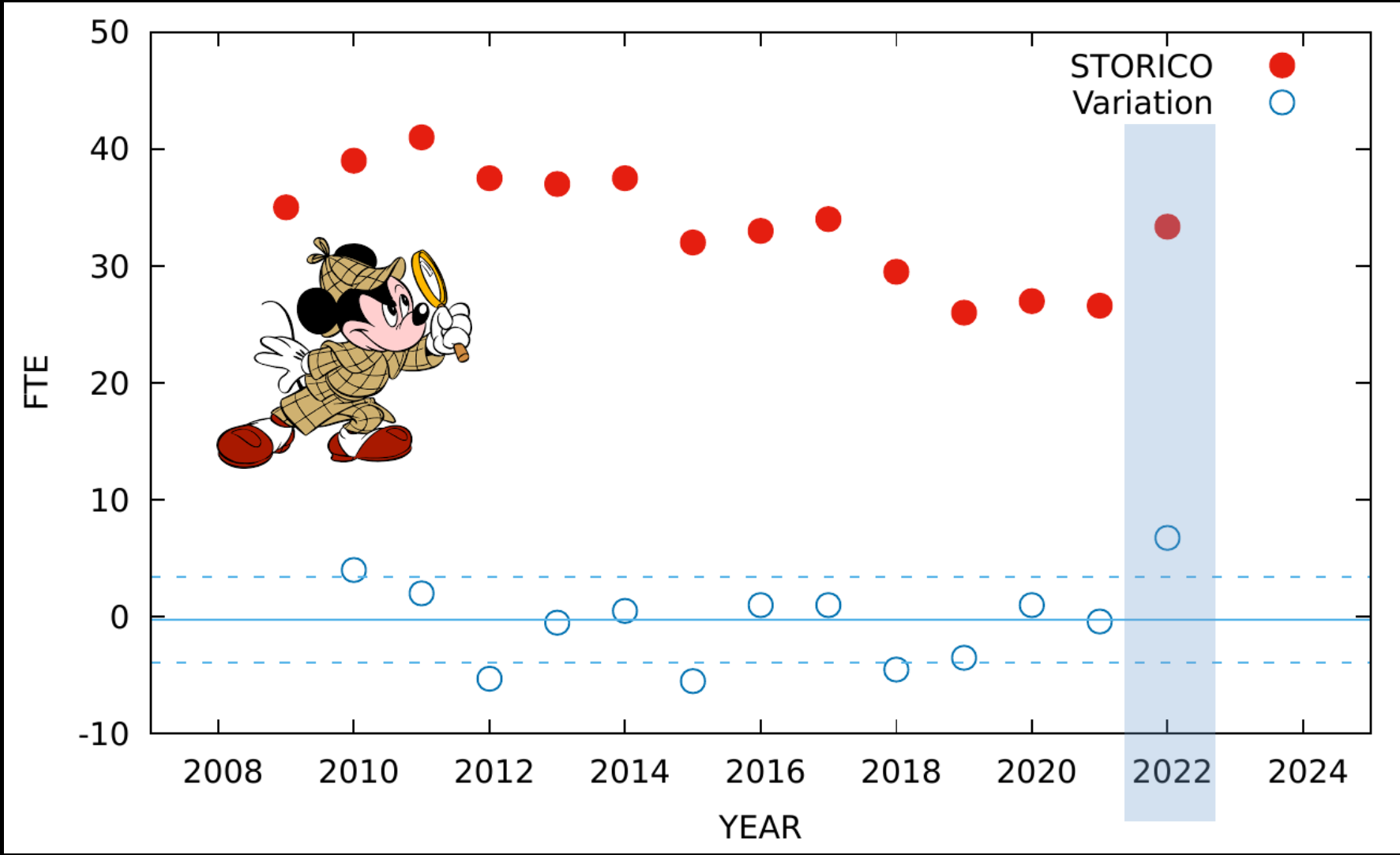


6.**APPLICATIONS AND SOCIETAL BENEFITS:**
TORIO (GE), FOOT (GSI,CNAO,TIFPA)

CSN3 National/International activity



STORICO


STORICO
Variation
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2008
2010
2012
2014
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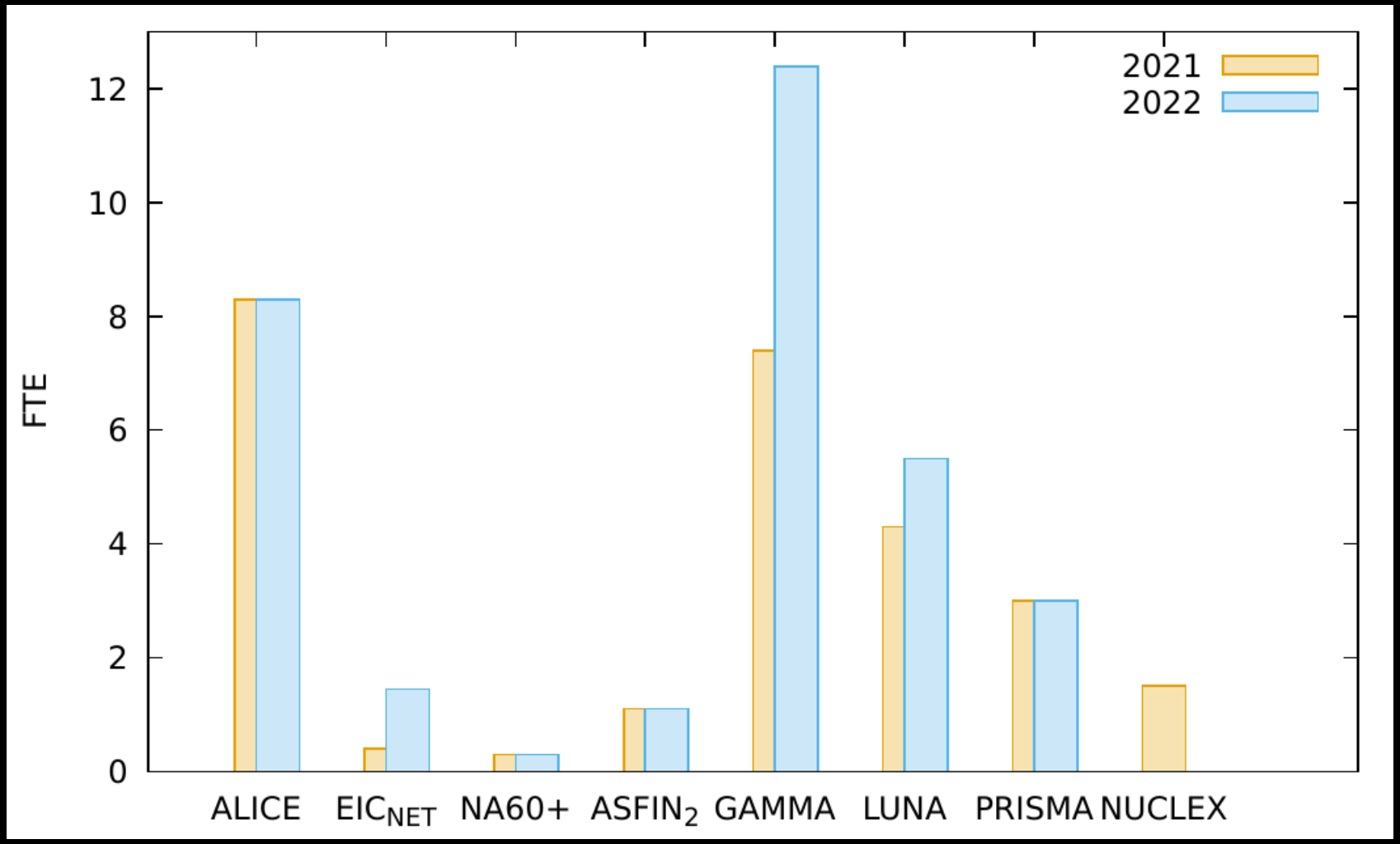
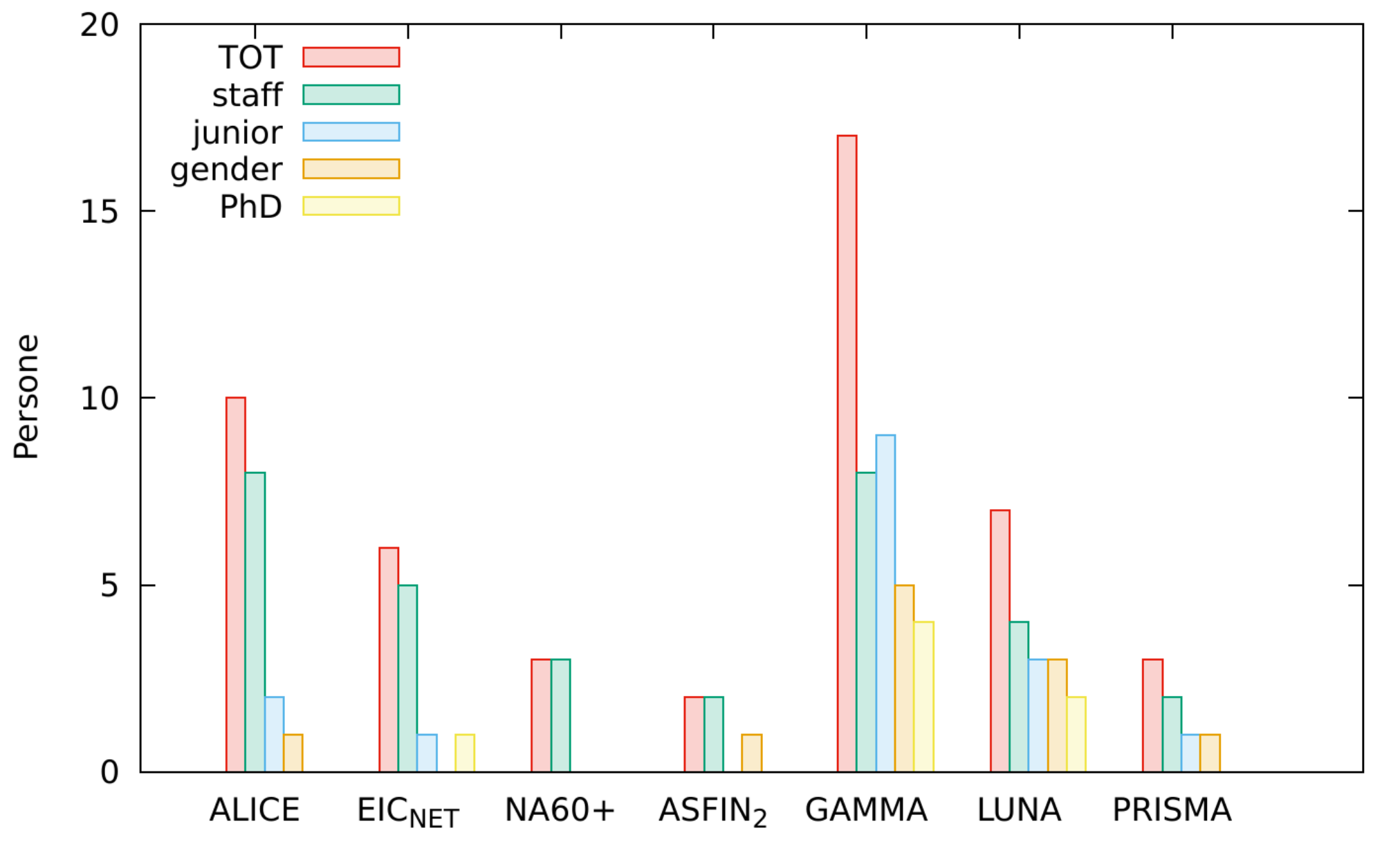
2020
2022
2024

Stat (+6.75 FTE ~20%)




20
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staff
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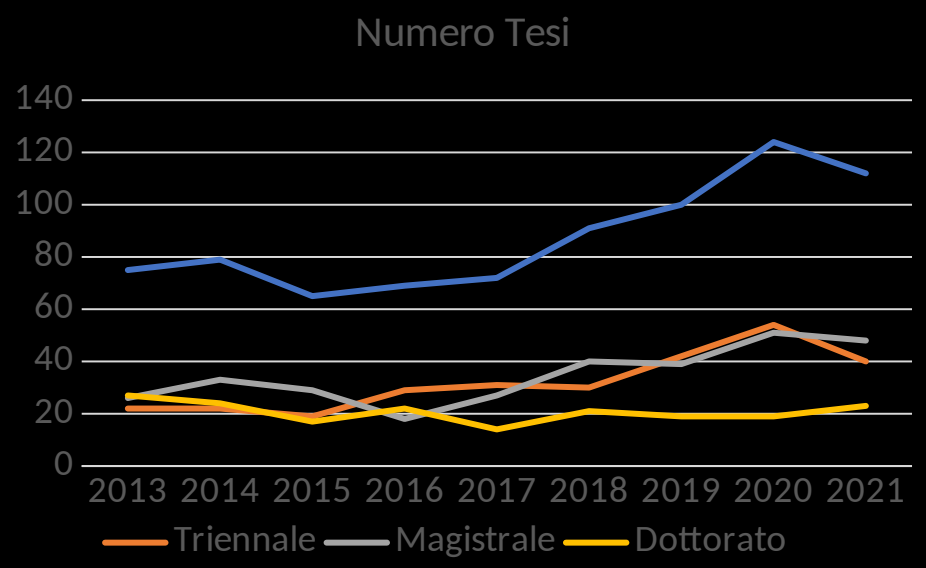
gender
PhD
ALICE
EIC$_{NET}$
NA60+
ASFIN$_2$
GAMMA
LUNA
PRISMA

GLV CSN3


Numero Tesi
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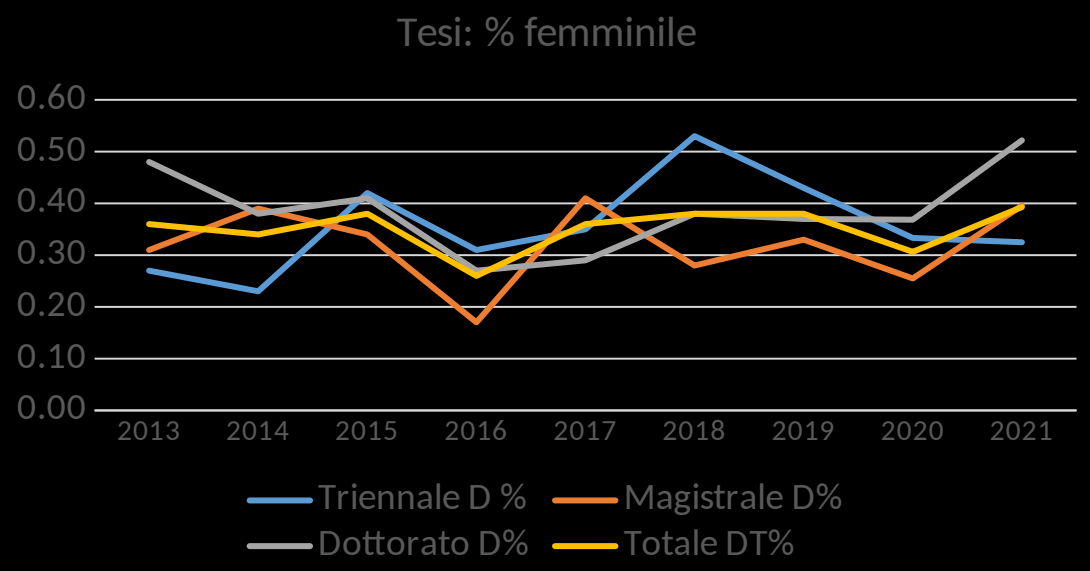
2013 2014 2015 2016 2017 2018 2019 2020 2021
Triennale
Magistrale
Dottorato


Tesi: % femminile
0.60
0.50
0.40
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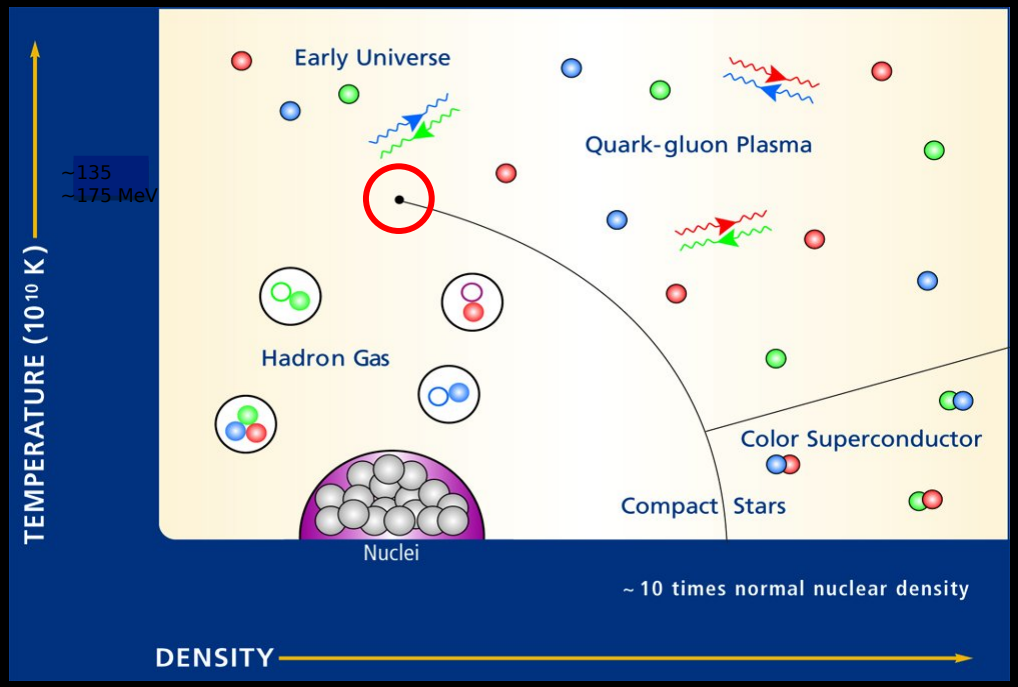
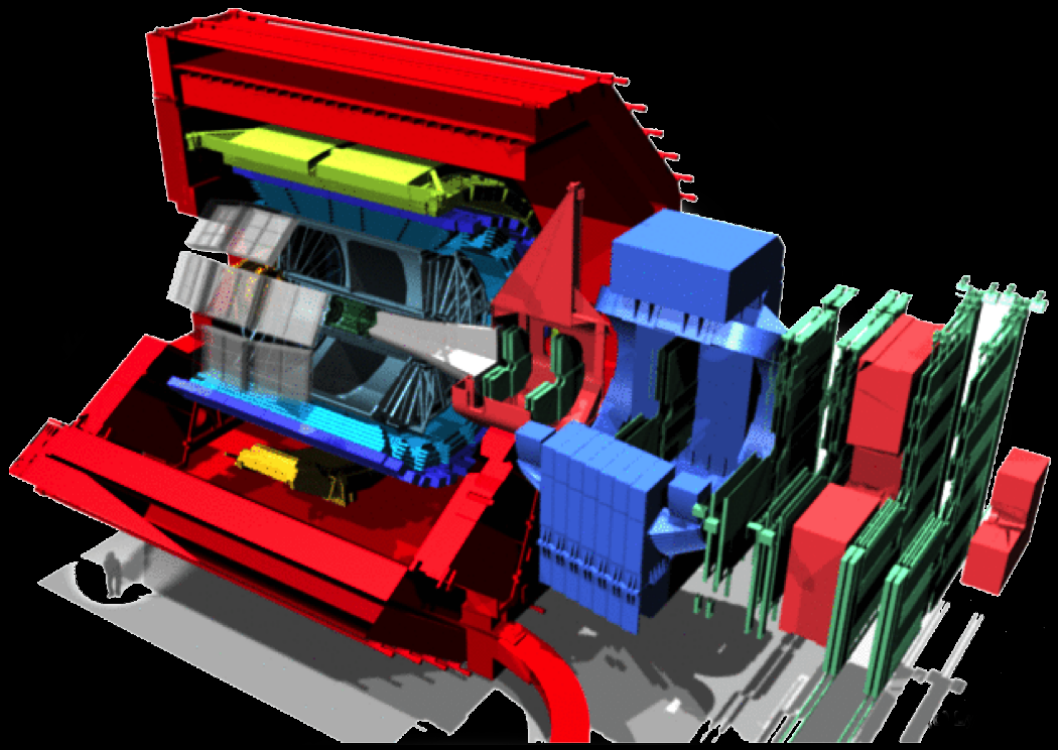
2013 2014 2015 2016 2017 2018 2019 2020 2021
Triennale D %
Magistrale D%
Dottorato D%
Totale DT%

1 Quarks and hadron dynamics

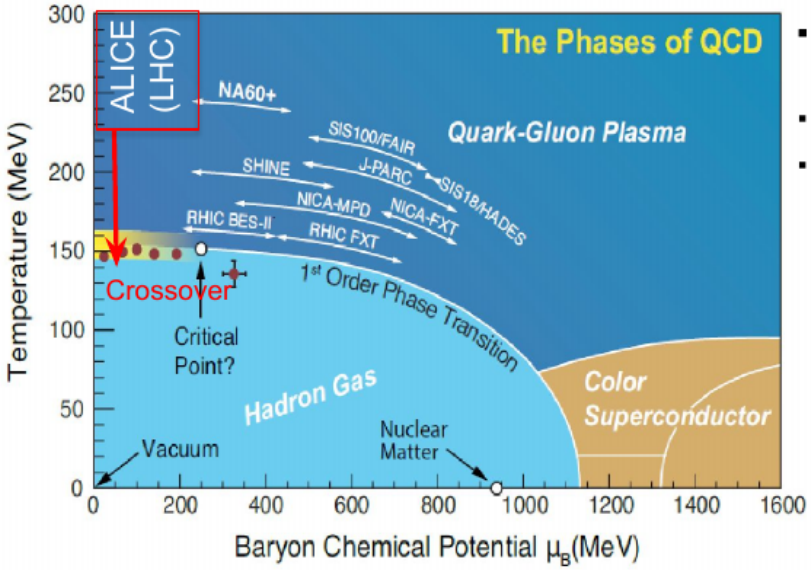
2 Phase transitions of nuclear and hadronic matter



ALICE



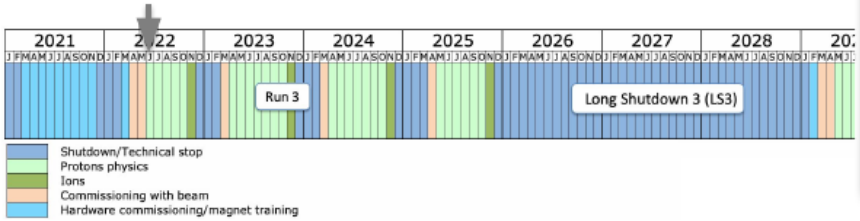
Introduzione

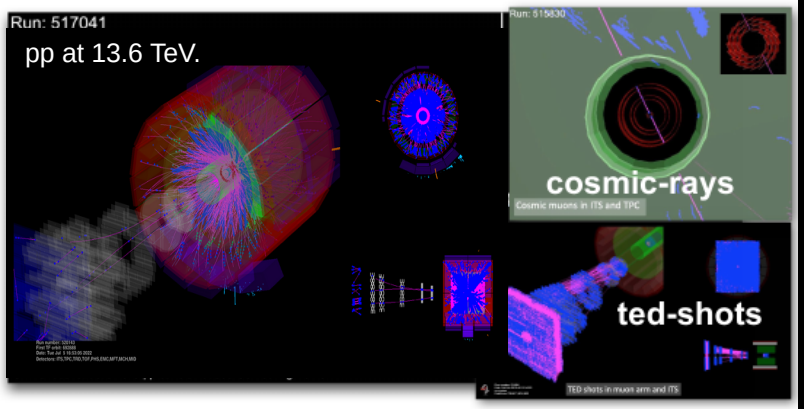


- **Quark-Gluon Plasma**: stato della materia adronica ad alta densità di energia, in cui viene meno il confinamento.
- Sistema "macroscopico" di quark e gluoni interagenti
- Accesso a proprietà fondamentali QCD: confinamento, meccanismi di interazione, origine "dinamica" massa quark costituenti e particelle.
  - **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** □ **SPD, ITS upgrade**

Attività ultimo anno e status attuale

- Nuovi detector installati, major upgrade completato
- >1y commissioning con dati da cosmici, collisioni pp, dati simulati, etc…
- Pronti per run di fisica a massima energia





Preventivi 2023: anagrafica e ruoli

	2022 (N)	2022 (FTE)	**2023 (N)**	**2023 (FTE)**
Ricercatori	7	5.4	**10**	**8.1**
Tecnologi	2	0.2	**2**	**0.2**

Nuovi membri, uscite

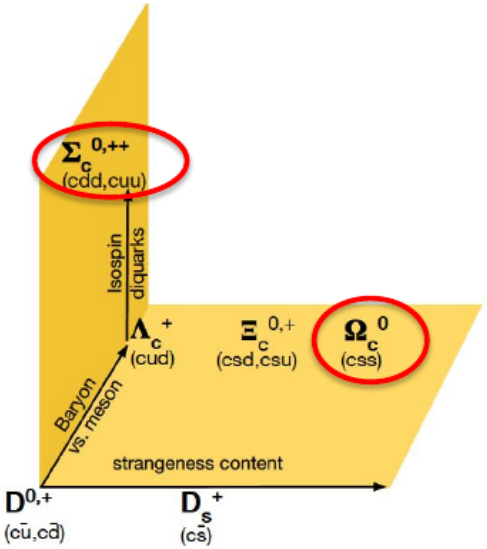
- **Membri**: Antinori (90%), Dainese (90%), Faggin (100%, assegnista), Giubilato (70%), Lunardon (70%), Mattiazzo (70%, RUB), Rossi (80%), Soramel (70%), Turrisi (70%), Zhu (100%, INFN post-doc stranieri), Benettoni (10%), Sgaravatto (10%)
- **PhD**: Faggin (*), Baruffaldi (30%+50%), Cai (in cotut. con Wuhan, dic 2019 - dic 2021)
  *premiato con ALICE Thesis award

Responsabilità nella collaborazione:

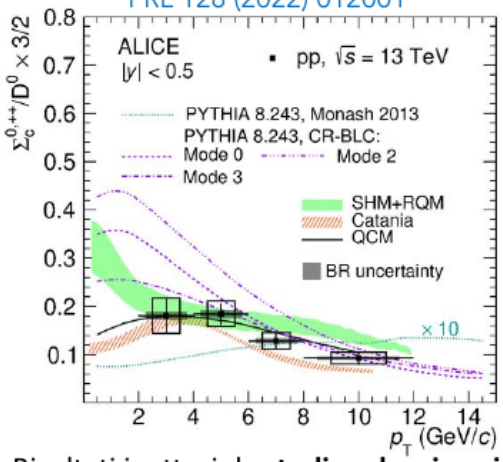
- Antinori: Management Board (membro)
- Dainese: Physics Coordinator (Physics Board)
- Rossi: ITS3-upgrade physics performance (coordinatore), Editorial Board (membro), Collaboration Board (membro), ALICE-Italia Computing Board
- Faggin: coordinatore Data Preparation Group – Analysis Objects and Tools- Tracks

- **Articoli ALICE ultimi 12 mesi ~35**
- **Contributo diretto gruppo di Padova**: 5 (+ 4-5 come coord. o revisione)

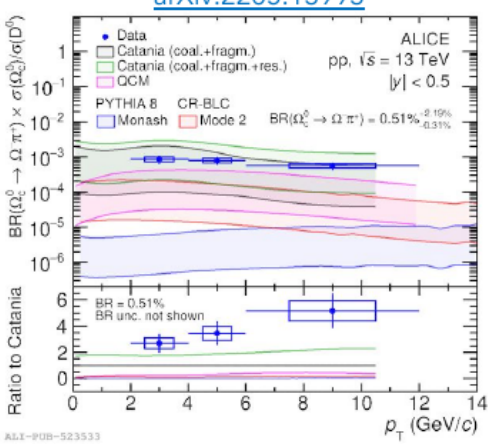
Risultati di fisica (focus gruppo PD)



PRL 128 (2022) 012001

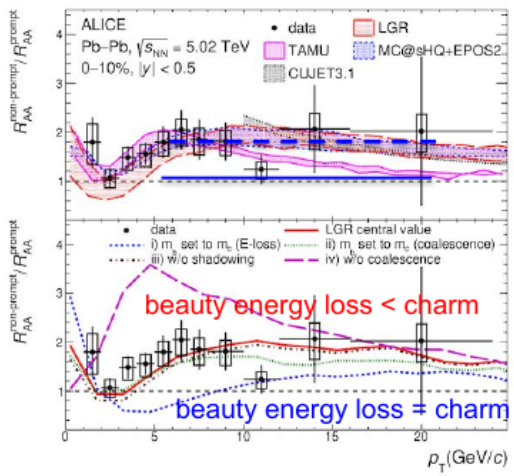


arXiv:2205.13993



Risultati inattesi da **studio adronizzazione del quark charm in protone-protone:**

- Rapporto barioni/mesoni molto più alto di
  - misure in e^+e^- (ordini di grandezza per Ω_c^0)
  - predizioni generatori di eventi (e.g. default PYTHIA8)
- Universalità funzioni di frammentazione violata già in protone-protone

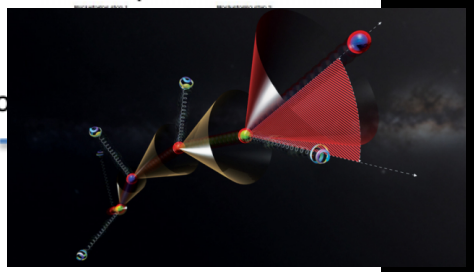


arXiv:2202.00815

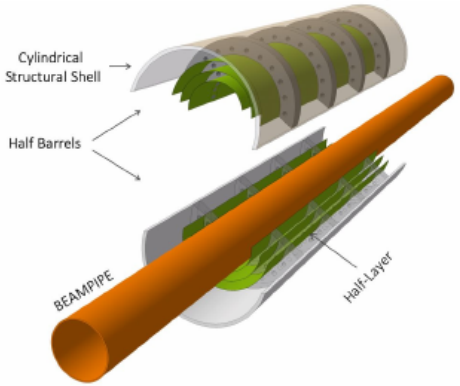
Studio produzione beauty in Pb-Pb □ accesso processi microscopici nel QGP

Alto momento: quark beauty perdono meno energia del charm nel mezzo □ "dead-cone" effect, osservato direttamente da ALICE: *Nature*, 605, 440-446 (2022)
https://www.media.inaf.it/2022/05/20/dead-cone-alice/

Basso momento: diffusione, beauty ~brownian motion marker del QGP



Upgrade: ITS3 per run 4



Design innovativo (evoluzione di ITS2):

- matrice di pixel di silicio delle dimensioni del wafer
- rivelatore curvo □ strati semi-cilindrici
- Ultrasottile, elettronica ai bordi

Attività sinergica con NA60+ e EIC

Tutto sviluppo fatto verrà riutilizzato/sfruttato per NA60+ e EIC

Stato del progetto

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

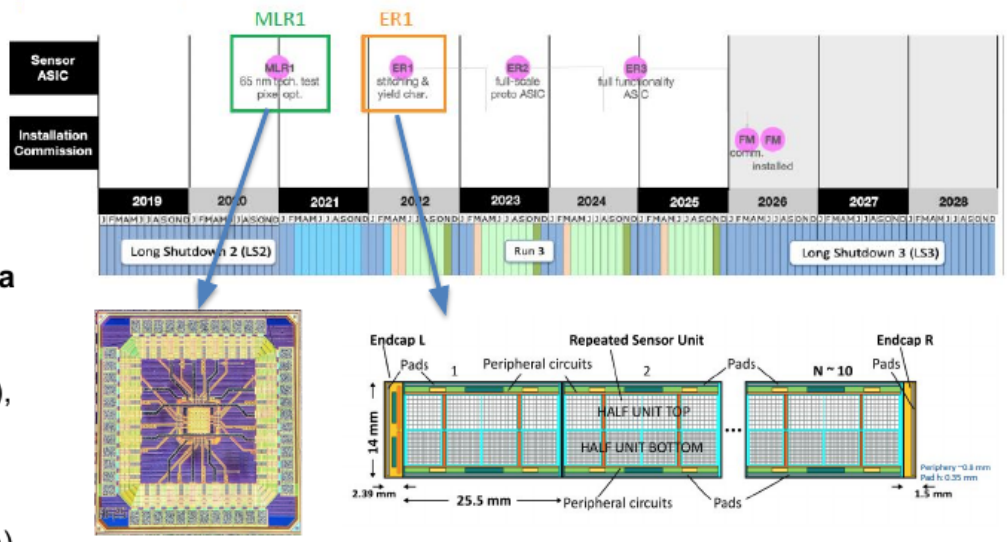
Attività a Padova nel 2023:

Test in sezione (Giubilato, Mattiazzo) su

- matrici di piccole dimensioni da sottomissione MLR1 (tecnologia 65 nm TJ): caratterizzazione parametri (pitch, implant geometry, output driver, etc..). Continuazione attività test **in partenza a Luglio 2022**.

- grandi dimensione (sottomissione ER1), test dello stitching

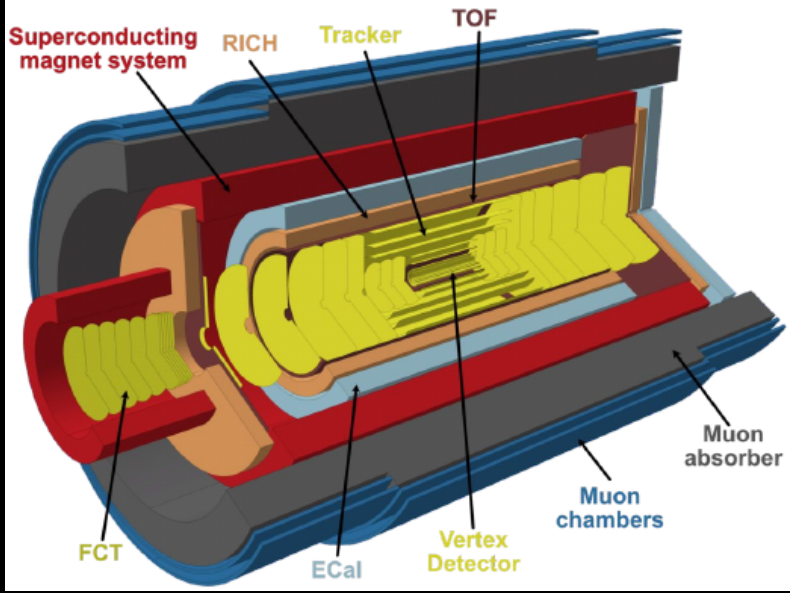
Contributo a preparazione TDR
(A. Rossi coord. Phys. Perf. Work Package)

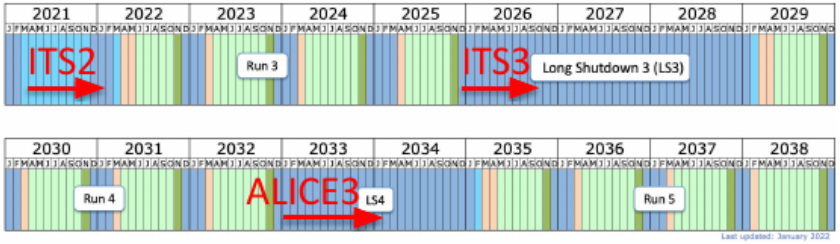


ALICE3

Letter of intent approvata da LHCC a Marzo 2022 (F. Antinori chair editorial board)
"A next generation heavy-ion experiment at the LHC", https://cds.cern.ch/record/2803563.

- Run 5 (2035)
- Interessi principali gruppo di Padova
  - Silicon tracker (central barrel + forward endcaps)
    - MAPS
    - TOF layer
  - Continuazione di R&D per ITS3
  - Meccanica?





The LHCC notes that "the **area of monolithic timing detectors** and monolithic photon sensors is of **general interest for future high-energy physics projects and beyond**, and that a vigorous R&D program is important to bring the technology to the point where it meets the technical specifications required for ALICE3 within the foreseen detector cost."

Richieste per 2023

Capitolo	Richiesta
Trasferte	~90 * k€
Apparati	0 k€
Consumo	15 k€
Trasporti	0 k€

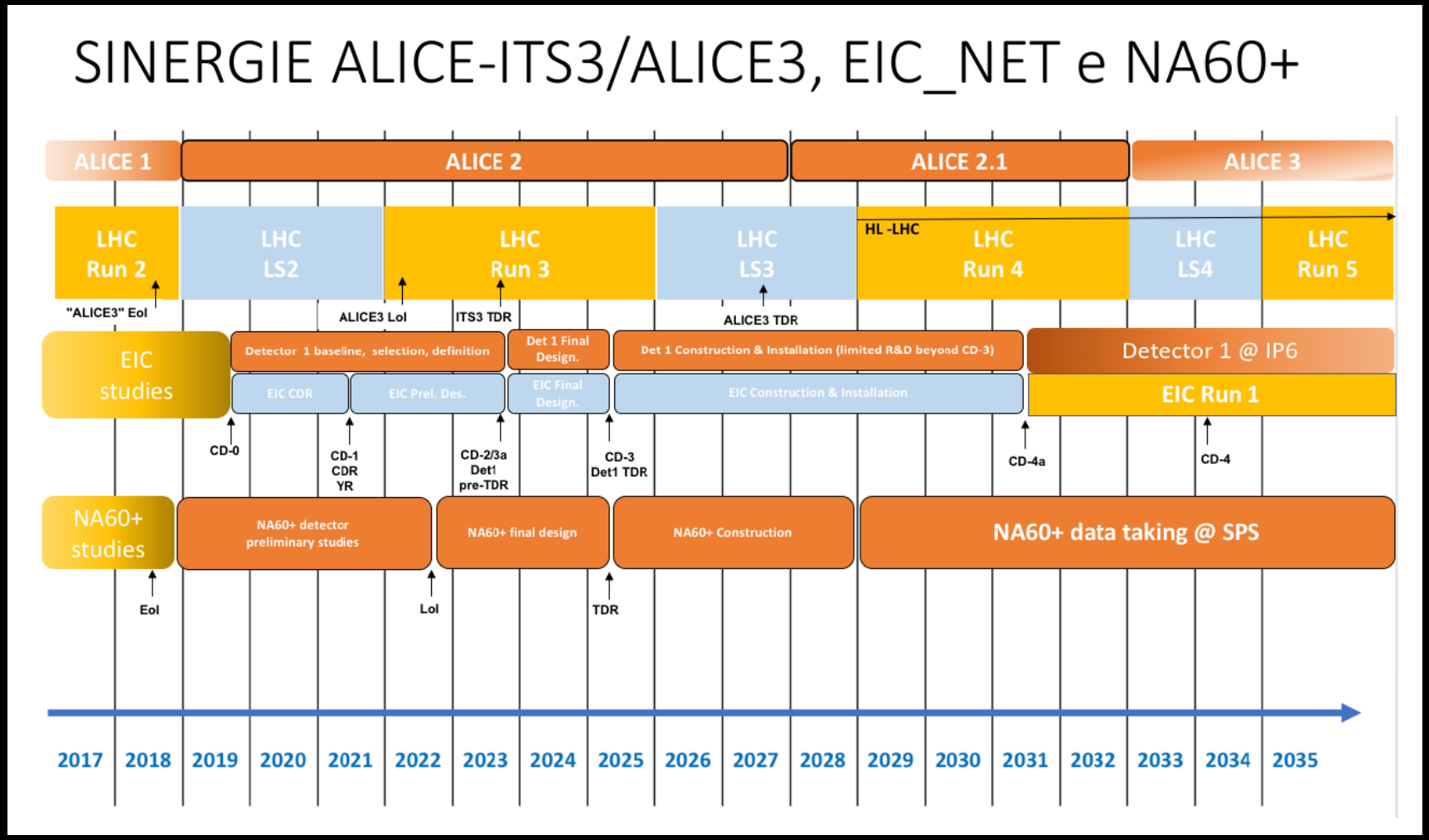
di cui 10 kE per ITS3 (~richiesta 2022)

- 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

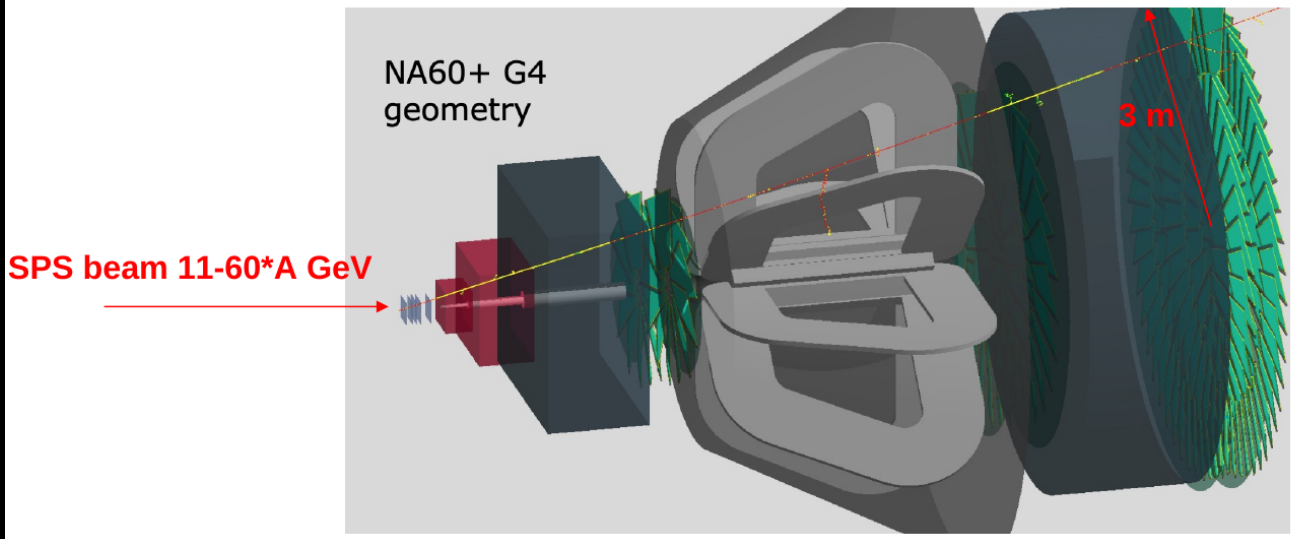
Servizio Sezione	Richiesta
Officina elettronica	6 m.u.

Synergy



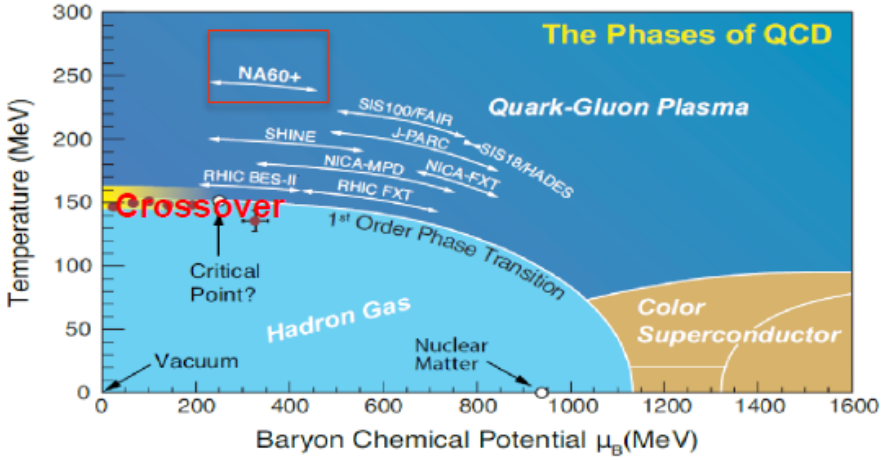
Razionalizzazione delle risorse, valutazione degli FTE in comune

NA60+

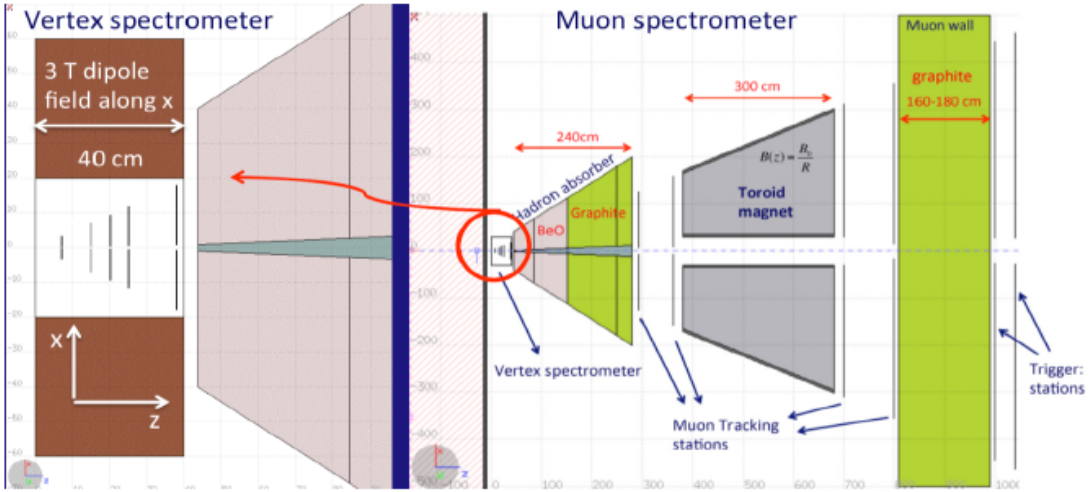


NA60+: goals and concept

- Fixed-target experiment at the CERN SPS
- High-rate 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



- Vertex spectrometer with Monolithic Active Pixel Sensors (MAPS)
- MAPS optimized by ALICE for ITS Upgrade and now developed towards large-size sensors (~15x15 cm^2)
  - Development common to future ALICE projects



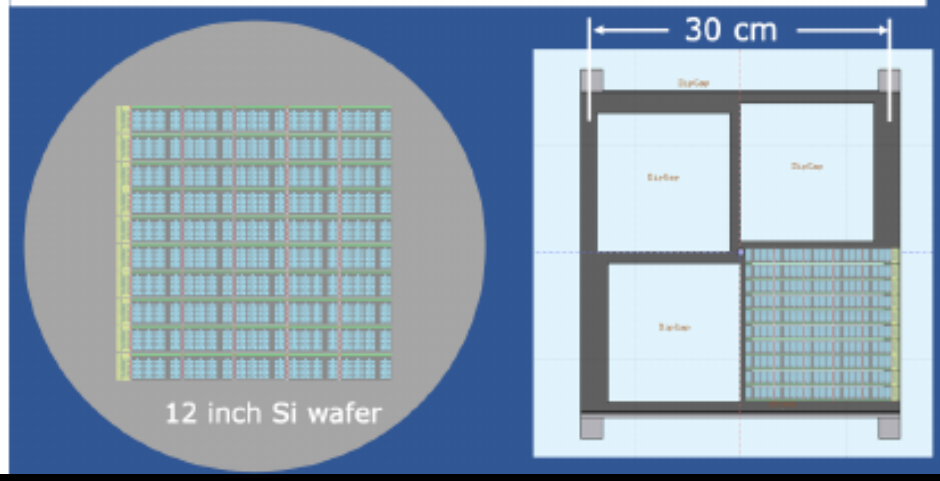
NA60+: activities 2022 and 2023

- Expression of Interest submitted to SPS Committee (SPSC)
  - http://cds.cern.ch/record/2673280
- Four physics objectives:
  1. Unique measurement of 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

- **Preparation of Letter of Intent for SPSC now ongoing**

NA60+: activities 2022 and 2023

- R&D on monolithic silicon pixel sensors (ALPIDE)
- Strong synergy with ALICE and EIC R&D programs
- Document on common developments submitted to CSN3
  - Covering all detector R&D, not only pixel sensors



R&D in progress
Common development
ALICE ←→ NA60+

State-of-the-art imaging technology
TowerJazz 65 nm

Sensor thickness:
few tens of microns of silicon
→ material budget **<0.1% X_0**

Spatial resolution ≤ **5 μm**

Cooling studies (NA60+ geometry)
in progress

Complete NA60+ station → 4 sensors

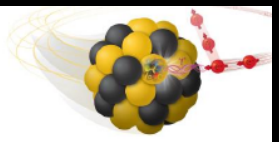
Preventivi 2023 NA60+: anagrafica e richieste

- Sigla “network” dal 2020 in CSN3
  - Resp. nazionali: E. Scomparin, G. Usai
  - ~ 3 FTE: Cagliari+Torino+Padova
- Anagrafica Padova: 0.3 FTE (come 2022)
  - A. Dainese (resp. loc.), F. Antinori, A. Rossi
- Richieste: ~ 3 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

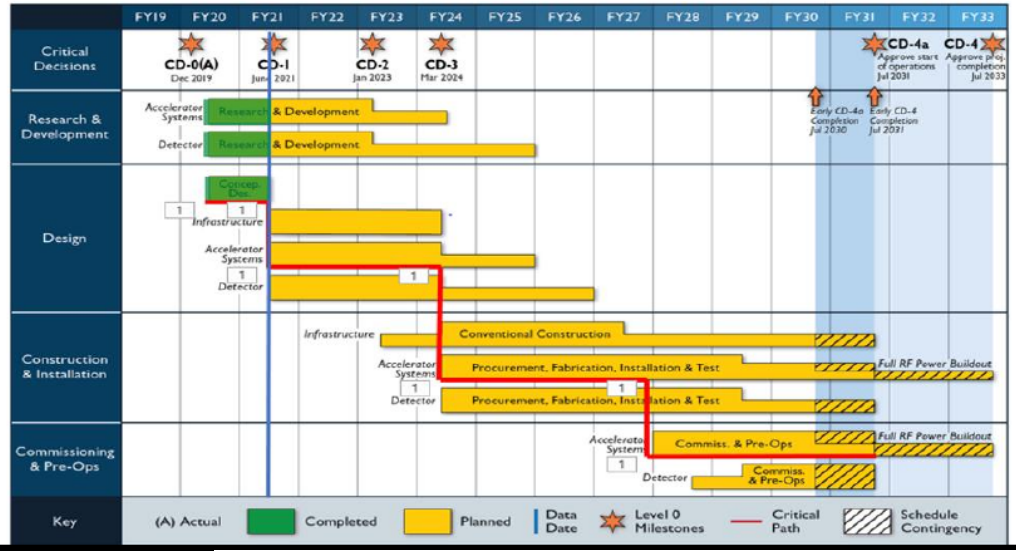
EIC_NET



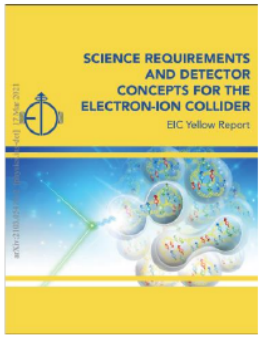
News:
Time schedule (in aggiornamento): CD3 (inizio costruzione) atteso nel 2024, CD4 (inizio operatività) atteso nel 2031
(reminder - sito approvato a gennaio 2020: Brookhaven National Laboratory)

Le due collaborazioni, ATHENA (''main'' project, in IP6) ed ECCE (''secondo'' detector in IP8) in fase di fusione (per adesso si chiama Detector 1) a seguito delle raccomandazioni del DPAP (EIC Detector Proposal Advisory Panel, closing meeting tenuto in data 8/3/2022) – in fase di definizione un gruppo di lavoro per proposal di un secondo rivelatore.

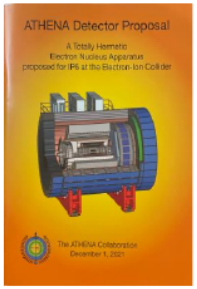
Componenti sigla EIC_NET: 59, ~11 FTE (sigla networking)
Probabile passaggio a sigla ''full'' il prossimo anno



Documenti importanti:
Yellow Report – 17/03/2021 (**57/414** autori INFN/Univ.)
ATHENA detector proposal – 1/12/2021

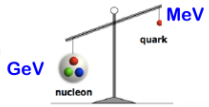


arXiv:2103.05419v2



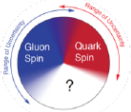
Tbp su JINST

Why #1

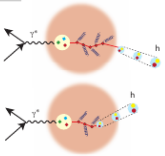


Why #2

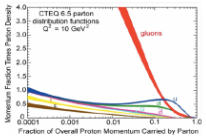
proton spin 1/2



Why #3



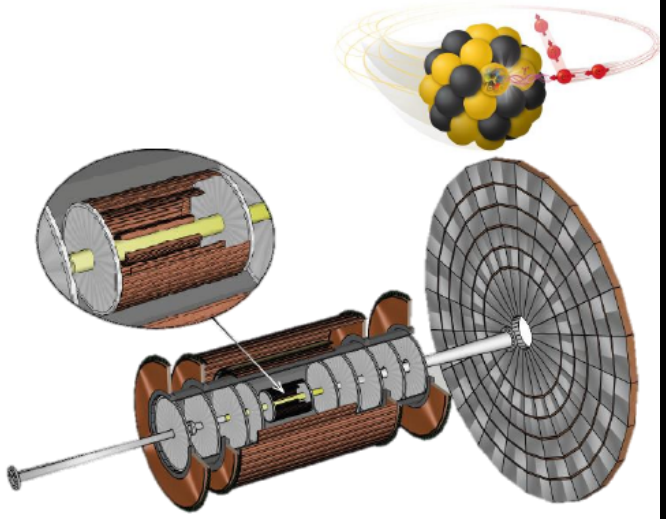
Why #4



x

EIC_NET – Attività a Padova

Rivelatore di vertice per EIC-Detector 1:
Stessa tecnologia di ALICE per ITS3 (2025-2026): **MAPS 65 nm**
(*fallback plans* previsti in caso di sviluppo non soddisfacente)
Perfetta sovrapposizione di esigenze fino alla eventuale definizione di un diverso stitching, sarà chiaro fra uno-due anni.
Transizione a sigla effettiva (non ''networking'') probabile con le richieste del 2023.
Per adesso tutte le richieste riguardanti il tracciatore sono in ALICE (riportate in EIC per sottolineare l'interesse comune).
A Padova: 6 unità (4 con percentuali sia in ALICE che EIC)



ATHENA baseline hybrid tracking system comprising MAPS vertex and barrel layers and forward/backward MAPS disks complemented by large-area Micromegas detectors in the outer barrel layers and forward/backward GEM and μRWell disks.

Attività:
- test e caratterizzazione MAPS
- Interessi fisica: heavy flavours (pdf gluoniche), SIDIS (attività nel software soggetta a disponibilità manpower)

Richieste finanziarie/servizi:
- Missioni: attività networking e training (partecipazione a riunioni di collaborazione, EIC Silicon Consortium, scuola nazionale EIC, scambi tra sedi di caratterizzazione e test chips MAPS) TOT 10.5 k€
- Servizi da EIC: nessuna per OM/OE, qualche VM su cloud in previsione di attività sul software.

Anagrafica (salvo piccole variazioni)

Nome	Frazione FTE
R. Turrisi	0.3 (R.L.)
C. Bonini	0.5
P. Giubilato	0.3
M. Guang	0.2
S. Mattiazzo	0.05 *
A. Rossi	0.1
TOT (FTE)	1.45

Fisica nucleare di bassa energia

Spring – Autumn 2022 Workshops
Nuclear Physics Mid Term Plan in Italy

More information soon on the CSN3 web page:
https://web.infn.it/csn3/index.php/it/

ASFIN2

ASFIN2 (38 ricercatori, 24.75 FTE)

LNS (18.05 FTE) + NA (2.9 FTE) + PG (2.7 FTE) + PD (1.1 FTE): M. Mazzocco (0.8), F. Soramel (0.3)

Studio delle reazioni nucleari di interesse astrofisico mediante i metodi indiretti

La reazione di interesse astrofisico **x+A → c+d** viene studiata mediante la reazione Cavallo di Troia **a+A → 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

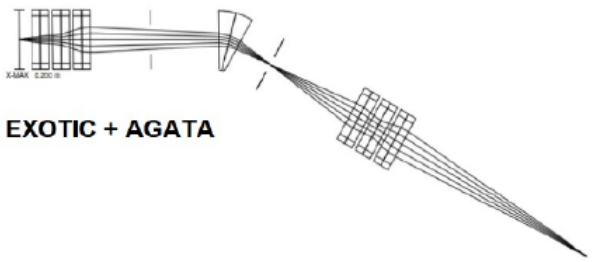
LOI for Coupling EXOTIC to AGATA (Feb. 2022)

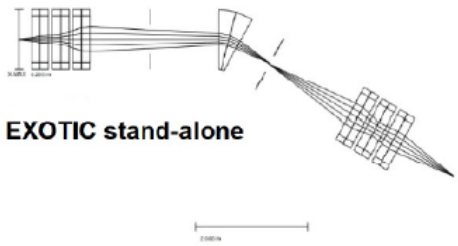
Letter of Intent: Coupling the In-Flight Radioactive Ion Beam Facility EXOTIC to the γ-Ray Spectrometer AGATA

Spokespersons: M. Mazzocco[1], D. Pierroutsakou[2], J.J. Valiente-Dobon[3]

P. Aguilera[1], M. Balogh[3], D. Bazzacco[1], J. Benito Garcia[1], G. Benzoni[4], S. Bottoni[4], D. Brugnara[3], S. Carollo[1], S. Cherubini[5], M. Costa[5], F.C.L. Crespi[4], G. D'Agata[5] G. De Angelis[3], A. Di Nitto[2], A. Di Pietro[5], A. Ertoprak[3], R. Escudeiro[1], P. Figuera[5], F. Galtarossa[3], A. Goasduff[3], B. Gongora[3], A. Gottardo[3], G.L. Guardo[5], M. Gulino[6], M. La Cognata[5], M. La Commara[2], L. Lamia[5], G. La Rana[2], D. Lattuada[6], S.M. Lenzi[1], S. Leoni[4], I. Lombardo[7], G. Maniciò[5], T. Marchi[3], M. Mazzocco[1], R. Menegazzo[1], D. Mengoni[1], A. Musumarra[7], A. Nannini[8], D.R. Napoli[3], A.A. Oliva[5], S. Palmerini[9], J. Pellumaj[3], R.M. Pérez-Vidal[3], D. Pierroutsakou[2], S. Pigliapoco[1], E. Pilotto[1], R.G. Pizzone[5], M.L. Pumo[5], G.G. Rapisarda[5], F. Recchia[1], K. Rezynkina[1], S. Romano[5], D. Santonocito[5] M. Sedlak[3], M.L. Sergi[5], F. Soramel[1], R. Spartà[5], D. Torresi[5], A. Tumino[6], J.J. Valiente-Dobón[3], E. Vardaci[2], L. Zago[3], I. Zanon[3], G. Zhang[1]

[1] *Università di Padova and INFN, Sezione di Padova, Padova, Italy*
[2] *Università di Napoli and INFN, Sezione di Napoli, Napoli, Italy*
[3] *INFN, Laboratori Nazionali di Legnaro, Legnaro, Italy*
[4] *Università di Milano and INFN, Sezione di Milano, Milano, Italy*
[5] *Università di Catania and INFN, Laboratori Nazionali del Sud, Catania, Italy*
[6] *Università di Enna and INFN, Laboratori Nazionali del Sud, Catania, Italy*
[7] *Università di Catania and INFN, Sezione di Catania, Catania, Italy*
[8] *INFN, Sezione di Firenze, Firenze, Italy*
[9] *Università di Perugia and INFN, Sezione di Perugia, Perugia, Italy*





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.

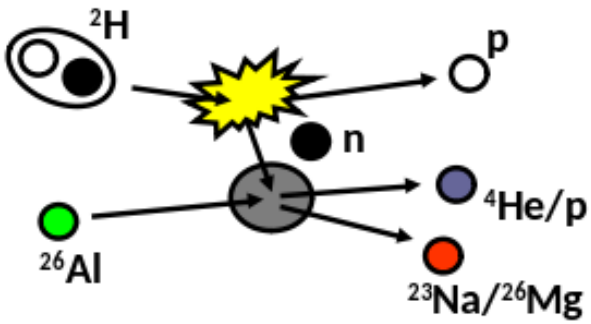
ASFIN2_PD: Highlights Attività 2021-2022

TDR AGATA-EXOTIC

RIB	EXOTIC Conf. (pps)	AGATA Conf. (pps)
$^{8}Li^{3+}$	10^5	5×10^4
$^{7}Be^{4+}$	10^6	5×10^5
$^{8}B^{5+}$	10^3	4×10^2
$^{10}C^{6+}$	5×10^3	2×10^3
$^{11}C^{6+}$	2×10^5	10^5
$^{15}O^{8+}$	4×10^4	2×10^5
$^{17}F^{9+}$	10^5	4×10^4
$^{18}Ne^{10+}$	10^3	4×10^2

First draft of the **TDR ready**. A **reduction** of approximately **50%** is expected (according to the calculations) between the **present RIB intensity** and that in the **AGATA configuration**.

n(^{26}Al,p/α) (TRIUMF, Canada, 2022)



^{26}Al nucleo-synthesis scenario: investigation of the ^{26}Al production and destruction mechanisms both for **ground** and **metastable** states at at 228 keV via the THM.
Spokesperson: A. Caciolli, M. La Cognata, D. Mengoni (joint-venture ASFIN2, GAMMA e LUNA_PD).
APPROVED with high priority.

Richieste Finanziarie e Richieste ai Servizi PD

Richieste Finanziare – ASFIN2 Sez. Padova

Missioni: TUNL, USA, 1pp * 15gg (1 k€ viaggio + 130 €/die) = **3 k€**
UJF – Praga, Rep. Ceca, 1pp * 10gg (500 € viaggio + 130 €/die) = **2 k€**
TRIUMF, Canada: 1p * 15gg (1 k€ viaggio + 130 €/die) = **3 k€**
RIKEN, Giappone, 1pp * 15gg (1k€ viaggio + 130 €/die) = **3 k€**
LNS – Collaboration Meeting, 2pp * 3gg (300 € viaggio + 50€/die) = **1 k€**
LNS – Detector Test, 2pp * 3gg (300 € viaggio + 50€/die) = **1 k€**
LNL – Attività di Manutenzione, 2 pp (500 € anno per persona) = **1 k€**
Consumo: **2 k€**: Piccole Spese di Manutenzione Linea di Fascio EXOTIC (sostituzione cavi, connettori per ricablaggio, acquisto gas e target)
Totale: 15.5 k€ (Missioni 13.5, Consumo 2)

Richieste ai Servizi della Sezione INFN di Padova

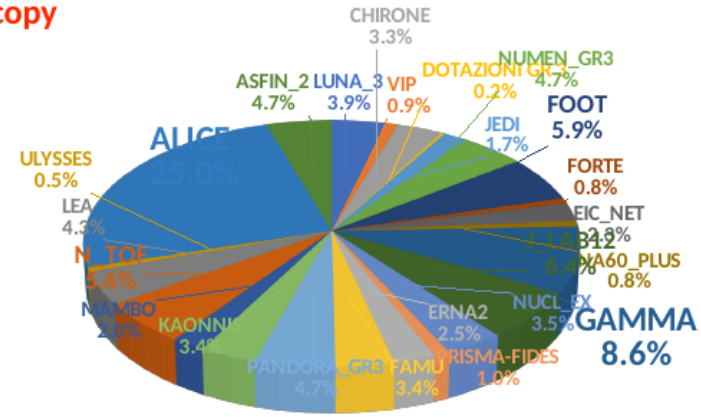
Officina Meccanica: **2 mesi/uomo** (lavorazione delle parti meccaniche per linea di connessione EXOTIC-AGATA, allineamento meccanico della linea, installazione delle crociere e dei soffietti)
Progettazione: **2 mesi/uomo** (progettazione delle componenti della linea di connessione EXOTIC-AGATA e della collocazione delle crociere e dei soffietti della linea di collegamento tra l'acceleratore e il bersaglio gassoso)

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**

Distribuzione FTE 2022
CSN III



- GAMMA
  - Sezioni di Padova, Milano, Firenze, Perugia e Laboratori Nazionali di Legnaro
  - 67 persone (54R + 13T) = 45 FTE su 522 della CSN III
  - 80 pubblicazioni, 58 contributi a conferenze, 26 Tesi

- GAMMA - PD nel 2021/2022
  - 16 Ricercatori (11.4 FTE)
  - 32 pubblicazioni, 4 come primo autore, 8 contributi a conferenze, 6 Tesi (5T + 1S)
  - Richieste finanziarie: 83 k€ (+ 72 di missioni) → Assegnazioni 60 k€ (+ 46 di missioni, in parte restituite)

GALILEO Phase II

Physics campaigns and results

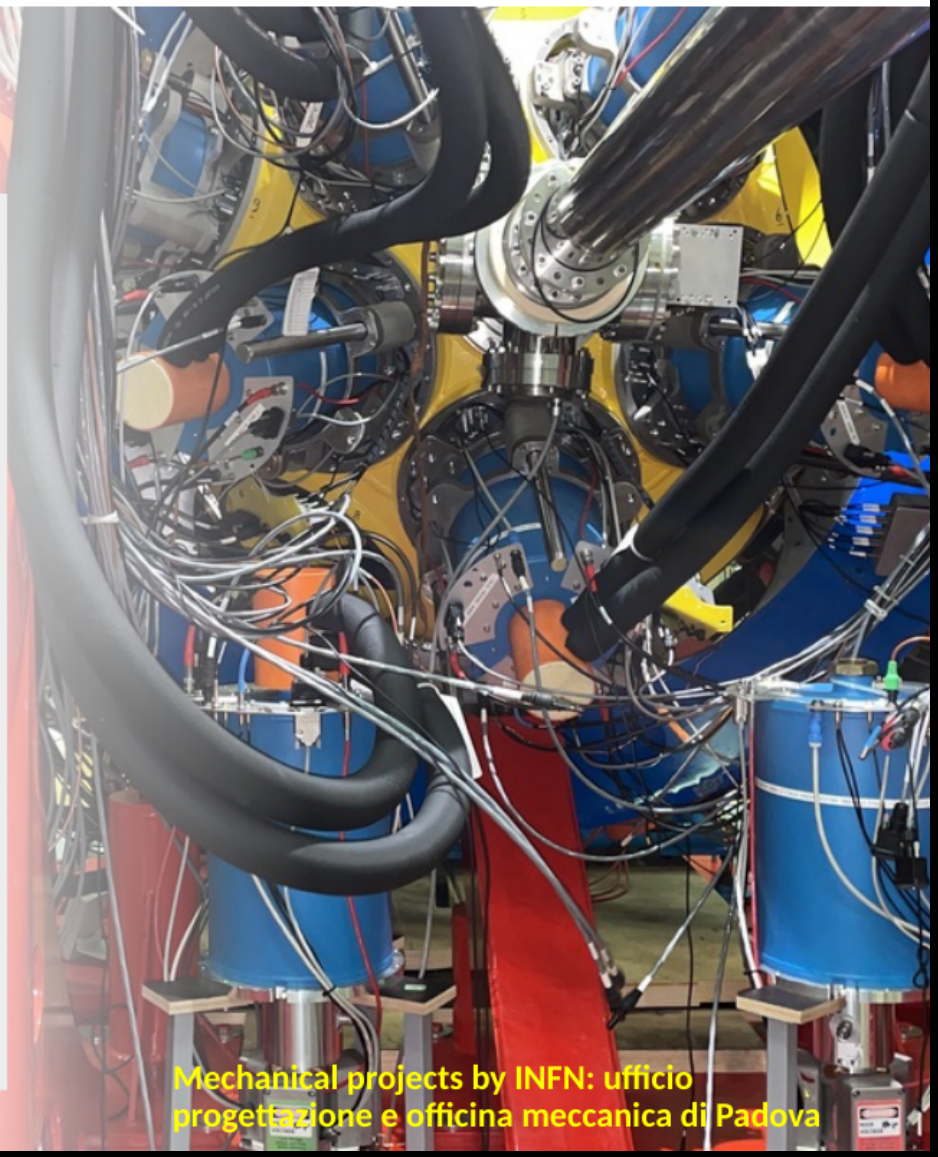
- **30 experiments** performed (4 in the campaign 2021/2022)
- **End of experiments: April 2021**
  - **Infrastructure** *used to support AGATA detectors*
  - **HPGe detectors in different projects**: *PANDORA, β-decay station @ SPES, LUNA*
  - **Ancillaries:** *refurbished/improved and used with AGATA*

Publications

- Technical: **7**
- Scientific: **12 + 1 in preparation**

Thesis

- **8 PhD, 12 Master, 10 Bachelor**



Mechanical projects by INFN: ufficio progettazione e officina meccanica di Padova

AGATA @ LNL

AGATA at **LNL 3 years** (*2022-2024*)

- Six months of **stable beams in 2022**
- Six months stable beams + six months **RIB from SPES**, when available
- Installation during **one year shut-down** of LNL accelerators (April 2021 – March 2022)

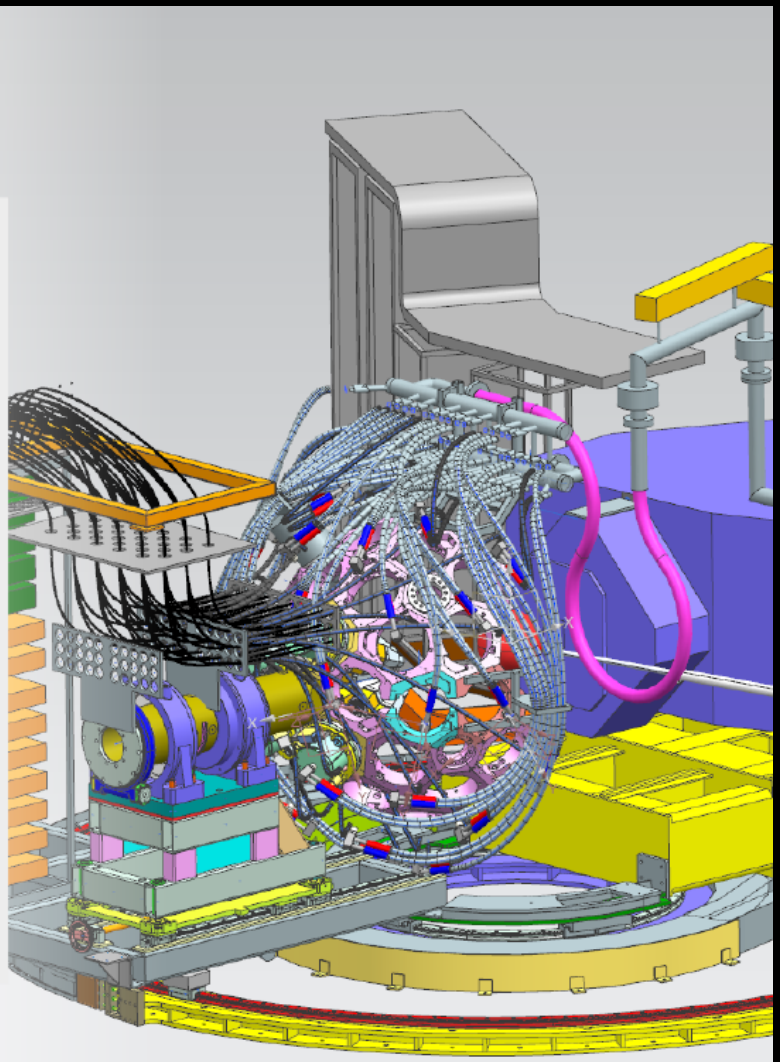
Timeline

- ✓ 9.2021: Transport of AGATA from GANIL and honeycomb from Daresbury
- ✓ 4.2022: Commissioning I: **AGATA (9 ATCs) + PRISMA + DANTE**
- ✓ 5.2022: Commissioning II: **AGATA (11 ATC) + SPIDER + DANTE**
- ✓ 6.2022: Commissioning III: **AGATA + Reverse Plunger**

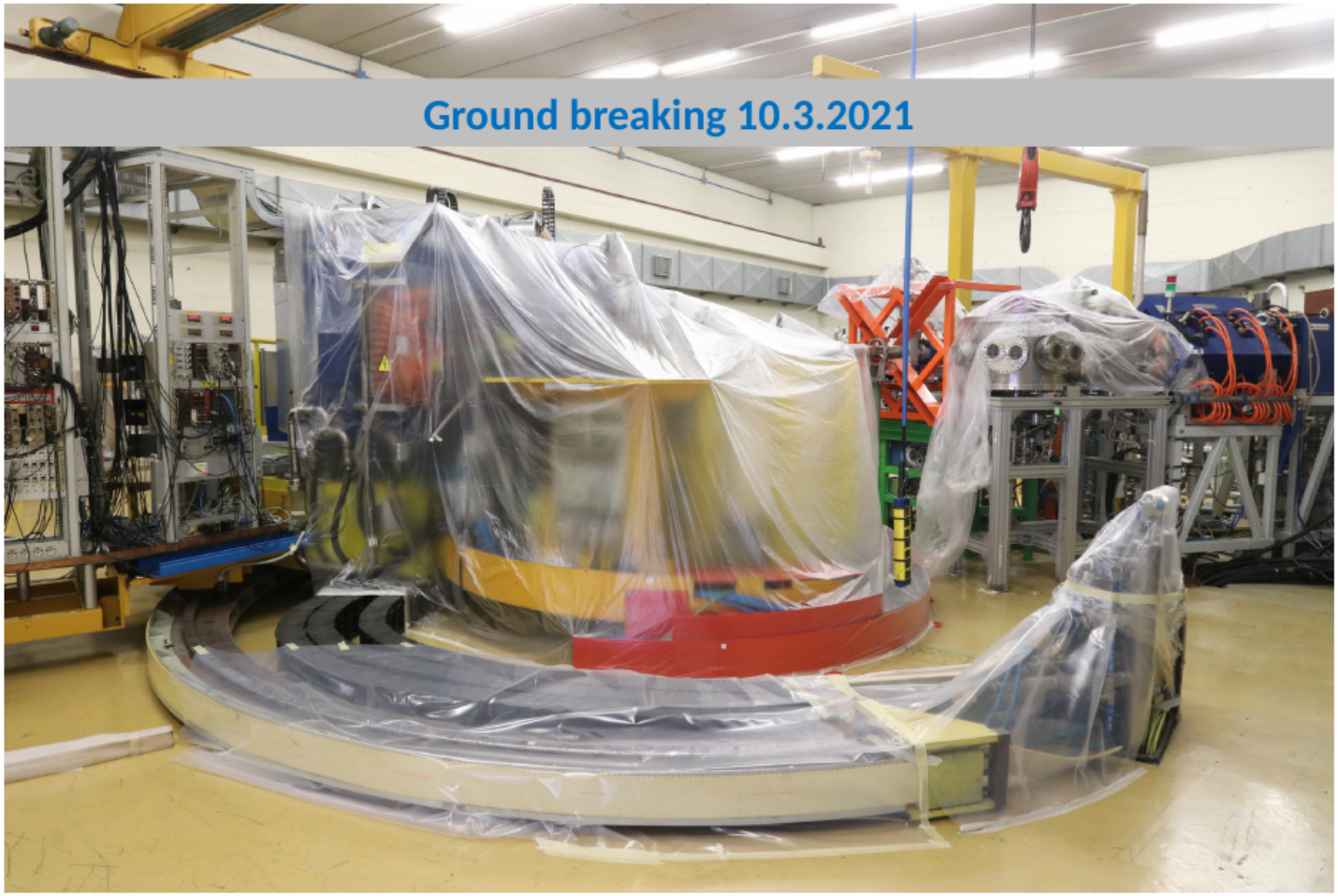
Physics campaign started on May 28, 2022

- ✓ **2 experiments performed + 1 in progress**

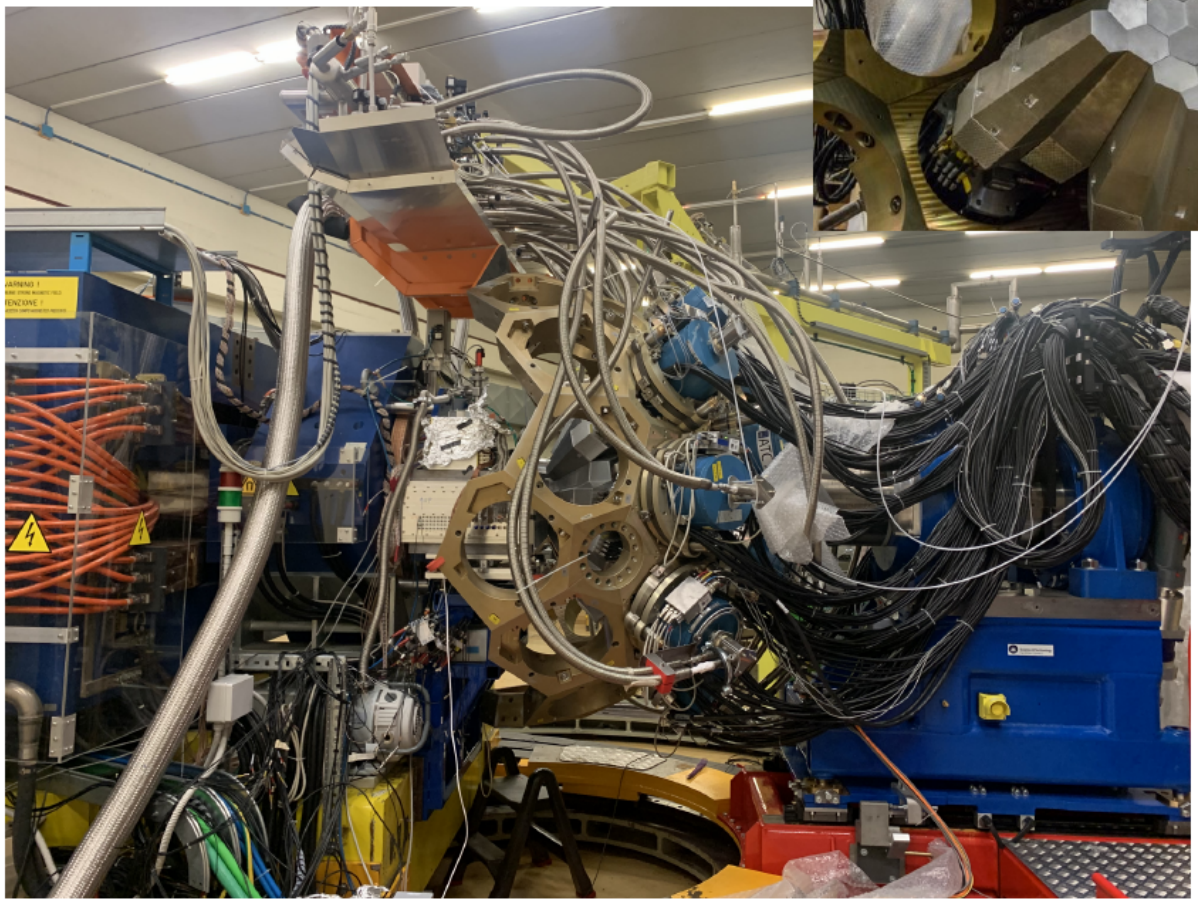
Mechanical projects by SFTC - Daresbury and INFN - ufficio progettazione e officina meccanica di Padova

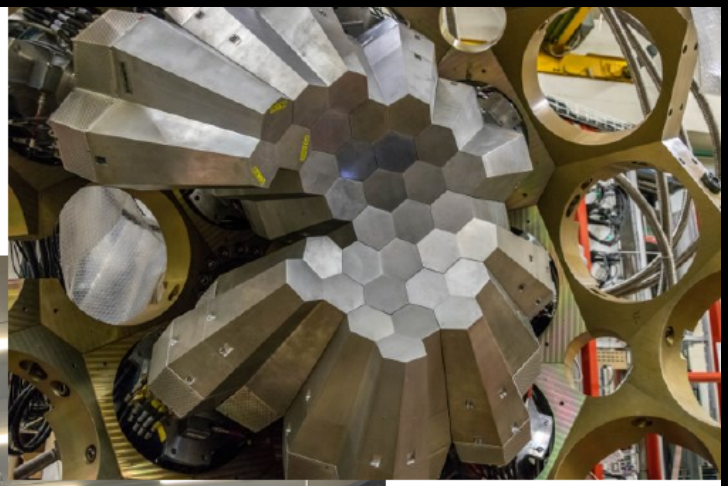


AGATA @ LNL: Experimental Hall

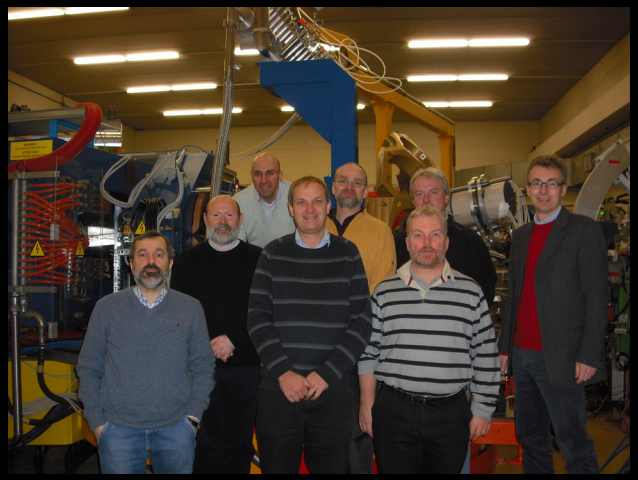


AGATA: Present configuration





10+2 celebration

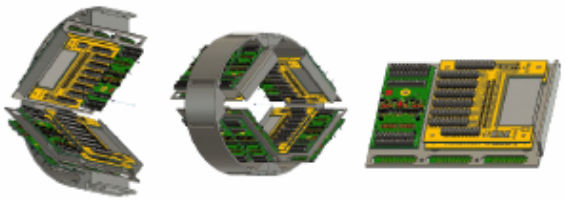


AGATA @ LNL: Italian collaboration

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

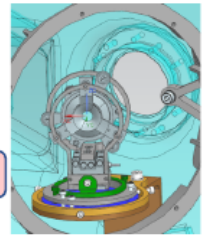
- **PRISMA:** L.Corradi, F.Galtarossa
- **GAL-TRACE:** S.Capra, G.Zhang
- **EUCLIDES:** J.Pellumaj, D.Brugnara
- **SPIDER:** M.Rocchini, M.Balogh
- **DANTE:** K.Rezynkina
- **Scintillators:** E.Gamba, S.Pigliapoco
- **Plunger:** I.Zanon

Complementary detectors

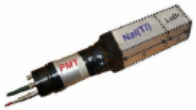
… to come

First PACs **commissioned**

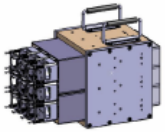
- PRISMA : L. Corradi, F. Galtarossa
- GAL-TRACE : S. Capra, G. Zhang
- EUCLIDES: J. Pellumaj, D. Brugnara
- SPIDER: M. Rocchini, M. Balogh
- DANTE: K. Rezynkina, J. Benito
- Gamma-ray scintillators: E. Gamba, S. Pigliapoco
- Plunger: I. Zanon

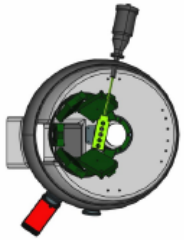


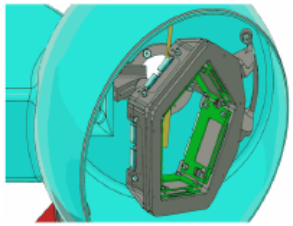
Targets: CTADIR + SUGAR

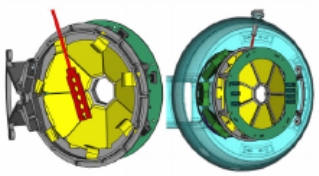


PARIS

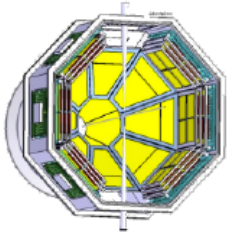


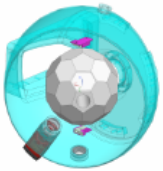


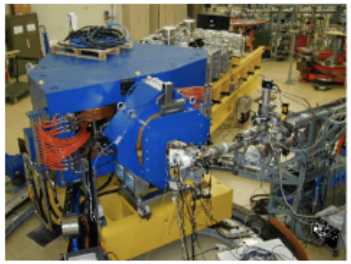


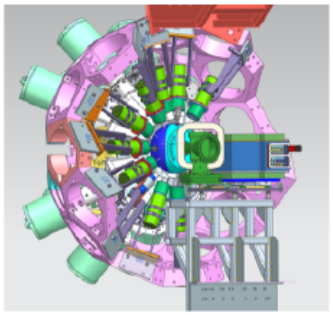


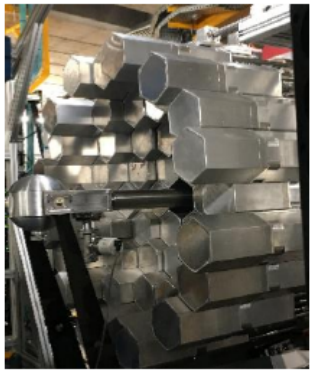
GRIT
GASPARD+TRACE







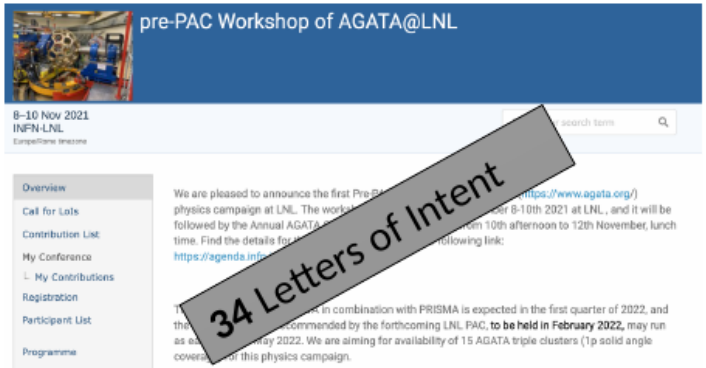




NEDA

AGATA scientific program

PrePAC 8-10 November 2021



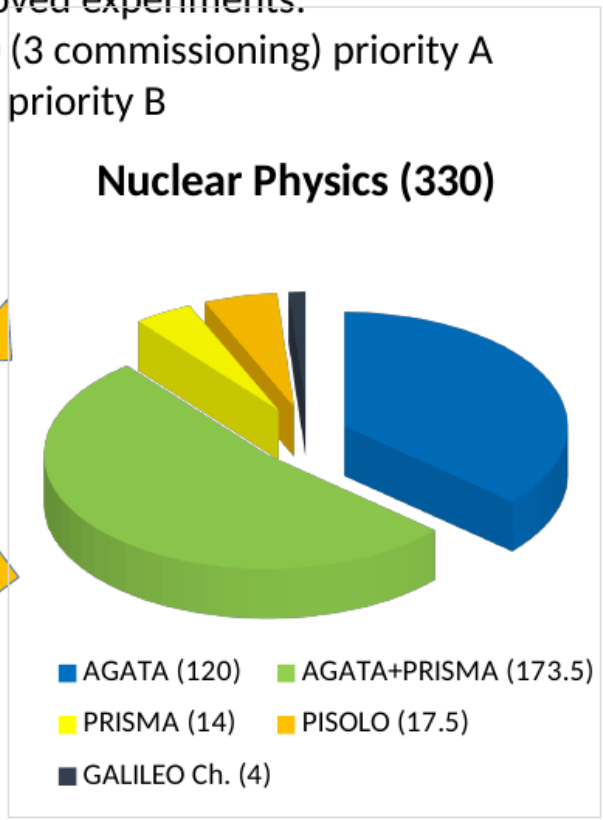
PrePAC 5-7 October 2022

PAC@LNL 21-23February 2022

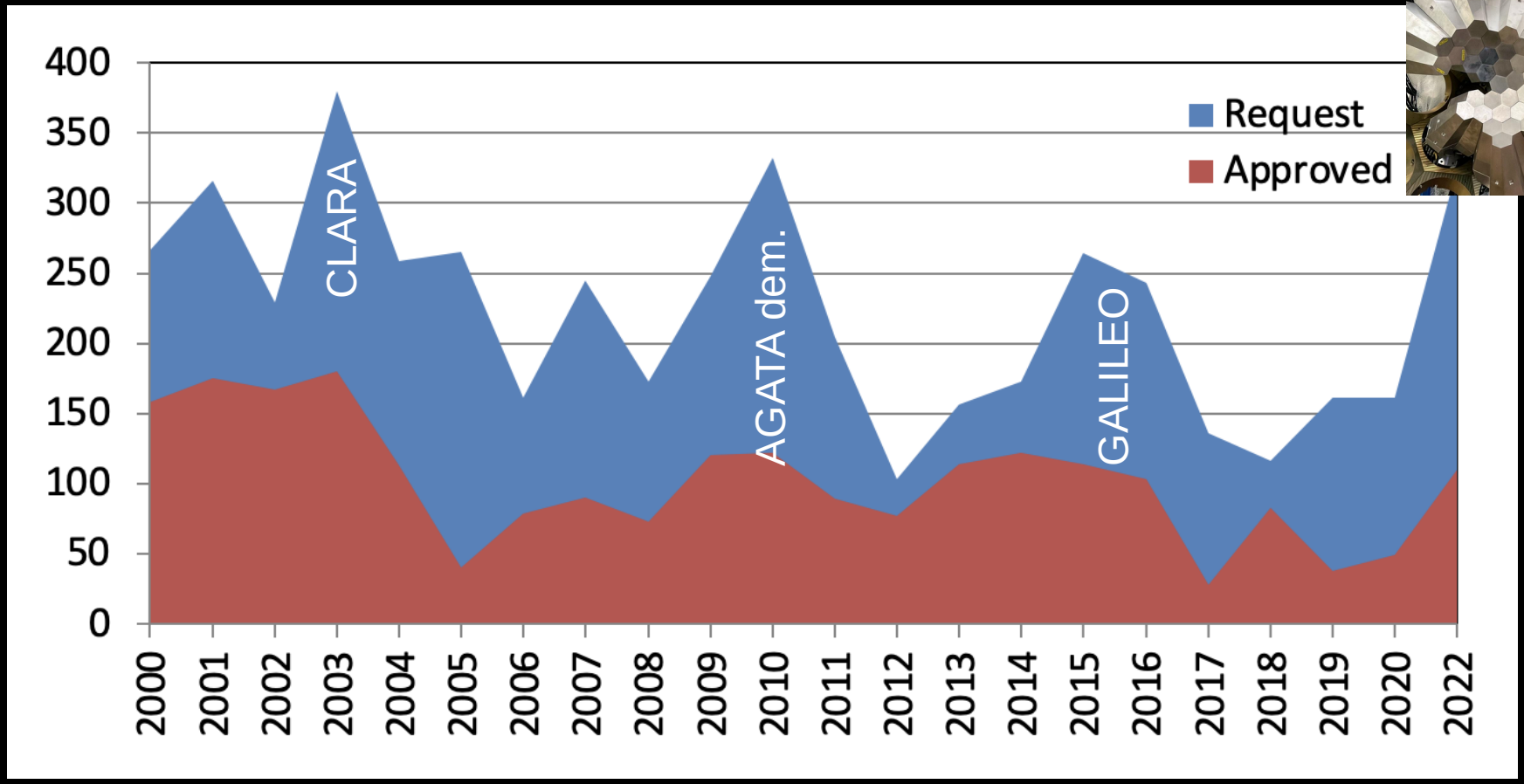
Submitted **28** proposals

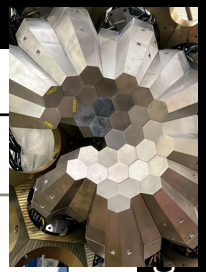
Approved experiments:

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



Gamma peaks

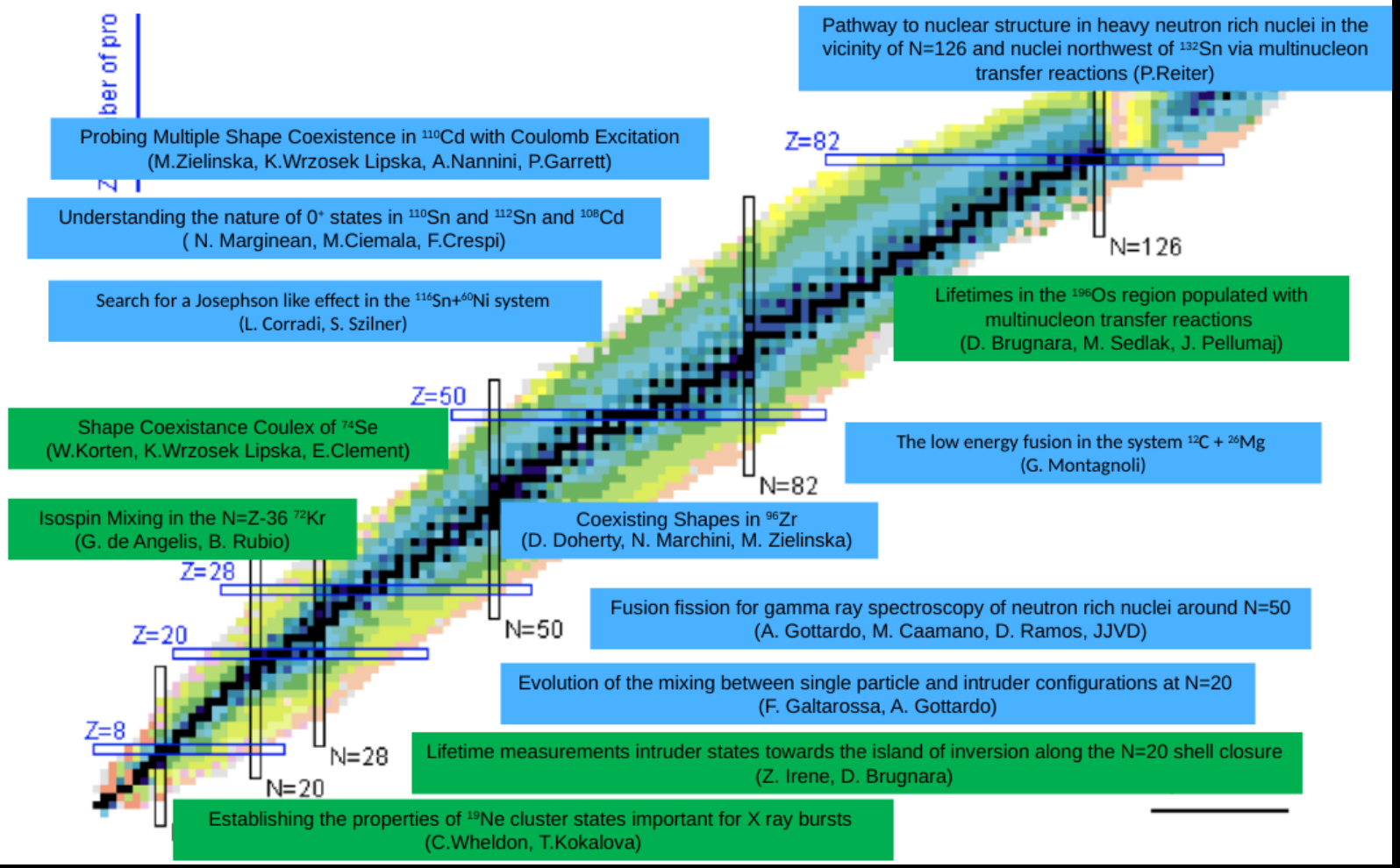




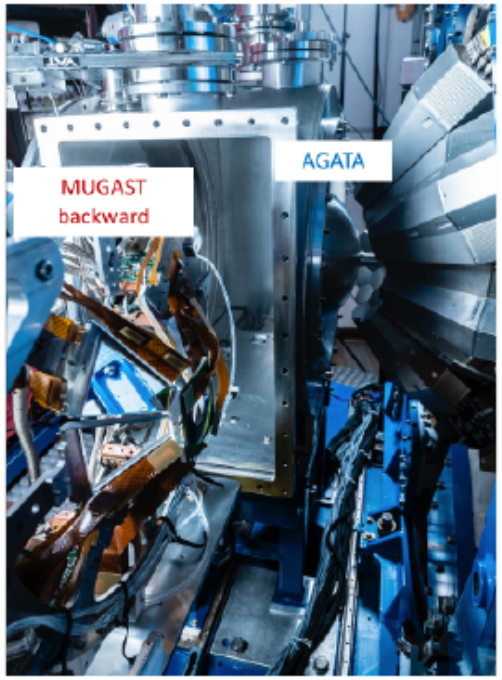
Courtesy of M. Mazzoc

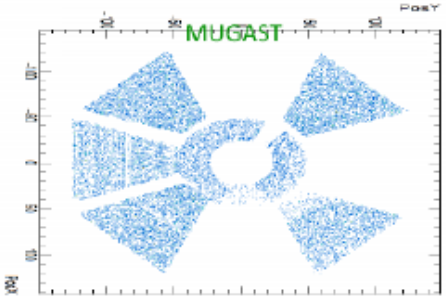
21-23 February 2022 PAC – next 5-7 December 2022.
There will be two PACs fixed per year

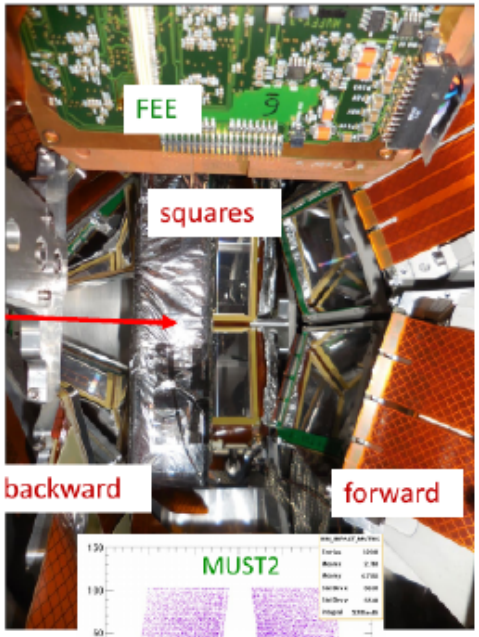
First AGATA physics campaign

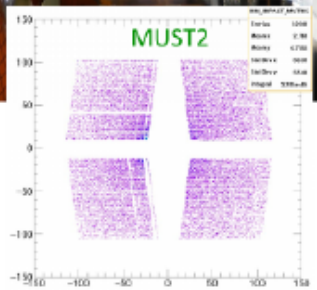


MUGAST in pictures









- 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. Stefan (IPN), F. de Oliveira (GANIL)
^{14}O(p,p') with few 10^5 pps

NUCLEAR ASTROPHY.
Determining the α+^{15}O radiative capture rate
C. Diget (York), N De Séréville (IPN)
^{15}O(^{7}Li,tγ)^{19}Ne with $4\cdot10^7$ pps

SHELL MODEL
Is there a problem with protons in N=28 nucleus ^{46}Ar ?
A. Gottardo INFN, M. Assié IPN)
D.Mengoni, INFN
^{46}Ar(^{3}He,dγ)^{47}K with $4\cdot10^4$ pps

2020

SHELL MODEL
Lifetime measurements of 2_2^+ and 3_1^+ of ^{20}O by direct nucleon transfer
E. Clément (GANIL), A. Goasduff (INFN)
^{19}O(d,pγ) + DSAM with $4\cdot10^5$ pps

2021

SHELL MODEL
Proton-neutron interactions across the N = 28 shell closure via ^{47}K(d,p)^{48}K
W. Catford (Surrey), A. Matta (LPC)
^{47}K(d,pγ)^{48}K with $5\cdot10^5$ 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), (^{3}He,d), (^{7}Li,t)…
- γ-particle coincidence.

Italian contribution 2021/2022:

Milano: PLAS V2 under test at LPC Caen → 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)

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 43Ti – 43Sc:** *Testing the T=0 vs T=1 nucleon-nucleon interaction through the comparison of excitation energies between isobaric nuclei,* **Draft in preparation, by K. Rezynkina (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 84Mo and its vicinity,* **Draft in preparation by J. Ha (formerly in Padova), P.Aguilera took over the analsys.**

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

- **71Kr:** *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. Rezynkina (INFN-Padova)**
- **91Pd:** *no excited states known so far: disentangling the claim of p-n T=0 pairs at low excitat ion energy in 92Pd.* **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.**
- **114Ba:** *Octupole collectivity in the N = Z = 56 region: identification of excited states in 114Ba 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 62Ga.* **Spokespersons: G. de Angelis, D.Mengoni et al.**

Approved experiments at GANIL (D.Mengoni) , Argonne (SM.Lenzi, F.Recchia, D.Mengoni) , TRIUMF (D.Mengoni) GSI, ISOLDE, JYFL and Riken. Other proposals will be presented in 2022

Richieste GAMMA-PD 2023

Apparato	Descrizione	Richieste [k€]
GALILEO	*Manutenzione rivelatori ed elettronica*	*7*
AGATA	*Meccanica, elettronica ancillari, computers*	*26*
MUGAST	*MoU*	*55*
Altre spese ricerca	*Isotopi, consumo e manutenzioni*	30
Missioni		95*
TOTALE		**118 + 95**

**) Approved experiments at GANIL, Argonne, GSI, ISOLDE, JYFL and Riken. Other proposals will be presented in 2022*

Divisione - Servizio	Attività	Richiesta
Progettazione elettronica	*Aggiornamento elettronica GALILEO. Manutenzione e test schede di produzione locale*	4 mesi uomo
Elettronica	*Assistenza produzione elettronica ancillari AGATA. Riparazioni elettronica e sviluppo sistemi di controllo ß-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) all'attività a Legnaro

Anagrafica GAMMA-PD 2023

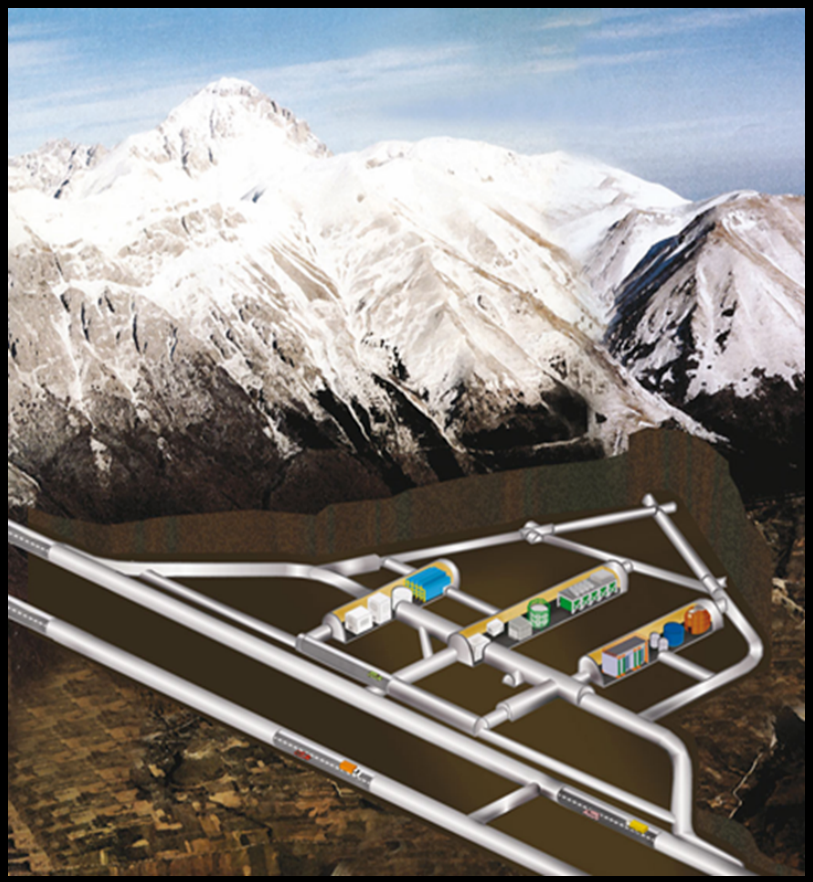
Nome	Tipo	Qualifica prof.	% FTE
Aguilera Pablo Antonio	Associato	Assegnista UniPD	100
Altana Carmen	Associata	Ricercatrice A UniPD	100
Dino Bazzacco	Associato	Ass. Senior	0
Benito Garcia Jaime	Associato	Ricercatore straniero	100
Carollo Sara	Associata	Dottoranda	100
Rafael Escudeiro	Associato	Assegnista UniPD	10*
Huang Zhen	Associata	Ricercatrice straniera	100
Silvia M. Lenzi	Associata	Prof. Ordinario	80
Santo Lunardi	Associato	Ass. Senior	0
Marco Mazzocco	Associato	Prof. Associato	20
Roberto Menegazzo	Dipendente	Ricercatore	70
Daniele Mengoni	Associato	Prof. Associato	90*
Sara Pigliapoco	Associata	Dottoranda	100
Pilotto Elia	Associato	Dottorando**	100
Francesco Recchia	Associato	Ricercatore B UniPD	70*
Kseniia Rezynkina	Associata	Borsa per stranieri	100
Guangxin Zhang	Associato	Assegnista UniPD	100
TOTALE	17	Ricercatori	1240

*) Attività (*130 % FTE*) nel progetto N3G della CSN V, interamente riconducibile a GAMMA
**) da Settembre 2022

Un solo dipendente INFN
Guangxin Zhang: borsa per stranieri INFN (D.Mengoni)
Nuovo assegnista entro la fine dell'anno con cofinanziamento INFN – DFA (D.Mengoni)
Dottorando entro fine anno (D.Mengoni)

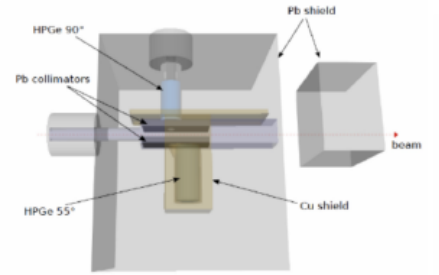
Fondi esterni
PRIN 2018: Cryogenic Targets for Direct Reactions with Exotic Beams (RN e INFN: A.Gottardo, UniPD: F.Recchia).
Finanziamento > 700 k€ (208 k€ a Padova)

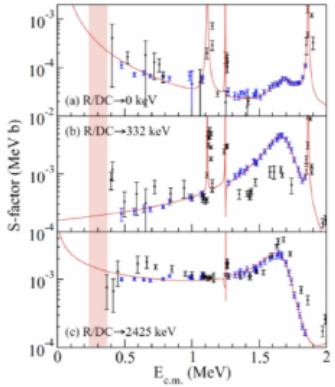
LUNA3



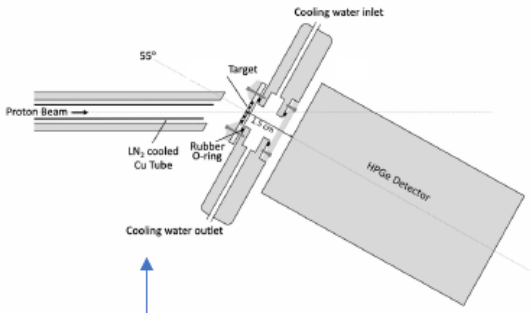
LUNA: ATTIVITÀ 2022 GRUPPO PD

$^{20}Ne(p,\gamma)^{21}Na$





$^{12/13}C(p,\gamma)^{13/14}N$

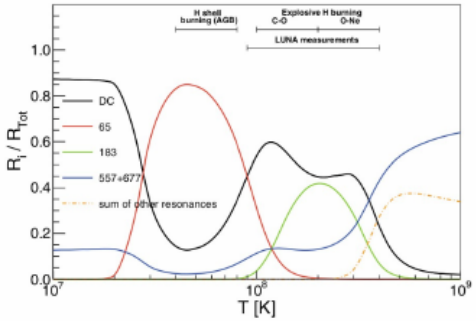


data taking and analysis ended

Scientific and technical papers under preparation
For 20Ne WG experimental data at energies never reached before in literature

For 12/13C S-factor is lower than what reported in literature with interesting outcome on astrophysical scenarios

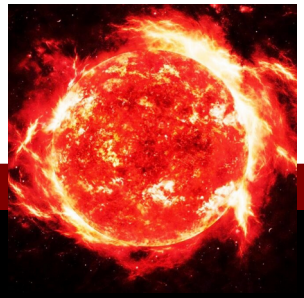
$^{17}O(p,\gamma)^{18}F$



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



LUNA: ATTIVITÀ 2022 GRUPPO PD

- Data taking and analysis for $^{20}Ne(p,\gamma)^{21}Na$ reaction. Coordinatore A. Caciolli. Master thesis student in Padua: Lucia Barbieri
- Data taking and analysis $^{12/13}C(p,\gamma)^{13/14}N$ at LUNA. PhD thesis at UNIPD (J. Skowronski). Data takig in the Felsenkeller Laboratory. Coordinators: Denise Piatti and Jakub Skowronski
- Development of DAQ for MV accelerator at LNGS. Coordinator R. Menegazzo
- Characterization of the new HPGe for $^{12}C+^{12}C$ study at LUNA Coordinators: R. Menegazzo and Antonio Caciolli
- Study of the 65 keV resonance for the $^{17}O(p,\gamma)^{18}F$ reaction. Coordinator: D. Piatti.
- Study of the $^{16}O(p,\gamma)^{17}F$ with activation method. Master student at Padua, Marvin Axness Ferrando (supervisor A. Caciolli)
- Measurements of the carbon targets for LUNA at HEAT in LNL. Coordinator: D. Piatti
- **Collaboration with ASFIN and GAMMA group for nuclear astrophysics experiments at LNL and TRIUMF**
- Dissemination projects on Nuclear Astrophysics with high school students
- The LUNA activity is also correlated with the CHETEC-INFRA EU project and the General Assembly of the network has been organised by LUNA Padova group

PUBBLICAZIONI ULTIMO ANNO

- *Direct Measurement of the C-13(alpha,n)O-16 Cross Section into the s-Process Gamow Peak*. Phys Rev Lett 127(2021)152701
- *Low-energy resonances in the O-18(p, gamma)F-19 reaction*. Phys Rev C 104(2021)025802
- *First Direct Measurement of* $^{22}Ne(\alpha,\gamma)^{26}Mg$ *Er = 334 keV Resonance at LUNA*, sottomesso ad EPJA
- *Study of three low energy resonances for the* $^{22}Ne(p,\gamma)^{23}Na$ *reaction*. In preparazione per sottomissione a PRC
- *Study of the proton induced reaction on carbon isotopes at LUNA*. In preparazione per sottomissione a PRL
- *Advances in Radiative capture studies at LUNA with a segnented BGO Detector*. In preparazione per JPG

ATTIVITÀ PER 2023

- Studio della reazione $^{21}Ne(p,\gamma)^{22}Na$. Tesista magistrale a Padova su questo lavoro
- Analisi dati misure svolte a esperimento a Dresda nell'ambito di CHETEC-INFRA su reazioni $^{12/13}C(p,\gamma)^{13/14}N$ ad alte energie
- Studio reazione $^{16}O(p,\gamma)^{17}F$ con nuovo setup per distribuzioni angolari con detector schermati
- Test su bersagli di carbonio con setup sperimentale HEAT a LNL (il setup è stato in riparazione per lunga parte del 2022 e tornato a LNL durante il mese di Giugno)

ATTIVITÀ PER ACCELERATORE MV

- Implementazione segnali di slow control nella DAQ
- **Caratterizzazione nuovo HPGe** a bassissimo fondo e studio per setup sperimentale per studio reazione $^{12}C+^{12}C$
- Design del setup per lo studio della reazione $^{12}C+^{12}C$. Padova avrà la **coordinazione della fase gamma per lo studio di questa reazione**

GRUPPO LUNA3 (~ 5.3 FTE)

C. Broggini (100%), A. Caciolli (100%), P. Marigo (20%), R. Menegazzo (30%), Denise Piatti (100%), Jakub Skowronski (100%) + 3 master thesis students

RICHIESTE FINANZIARIE LUNA3 @ PD PER 2023

- Missioni: 28 k€ turni LNGS, 2 k€ misure a LNL. Totale 30 k€
- Attività a LNL su facility HEAT: 8k€ (Gate vale, faraday cup e una flangia isolante per sistema pompaggio, bersagli HEAT)
- Attività a LNGS: 16k€ (beam line telescopica 12C+12C)

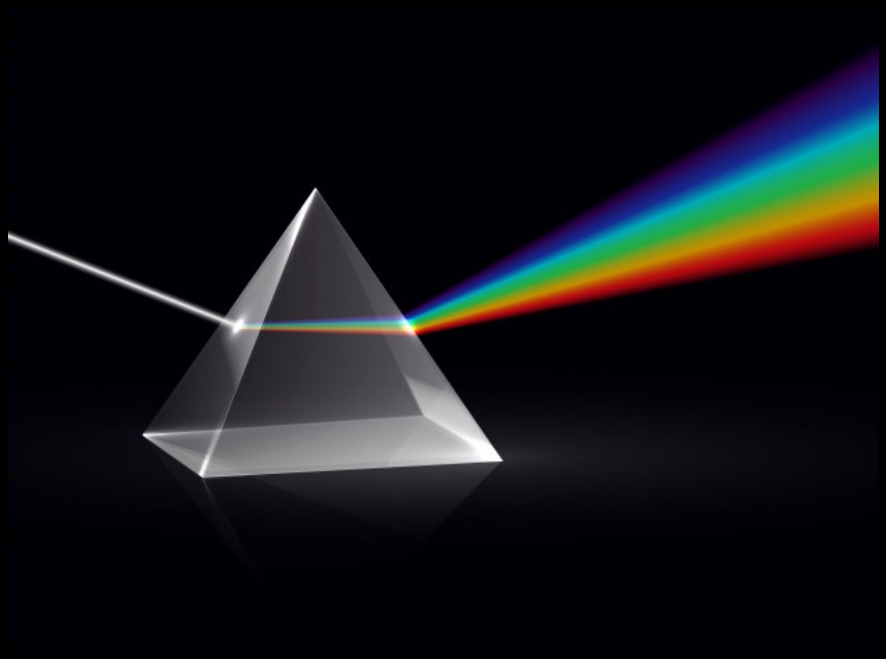
  1 mese uomo elettronica (OE)
  1 mese uomo progettazione (SPM)
  2 mesi uomo officina meccanica (OM)

NUCL-EX

NUCL-EX

Daniela Fabris, ringrazia e sottolinea il supporto della sezione e dei servizi in tutti questi anni

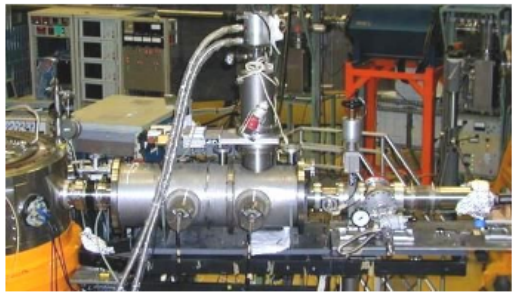
PRISMA-FIDES



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 $E << V_B$
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**

INFN

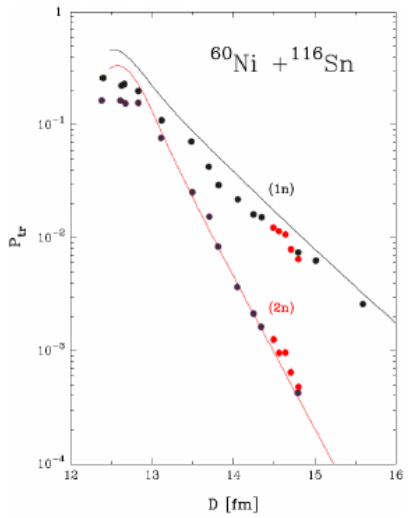
PRISMA- FIDES

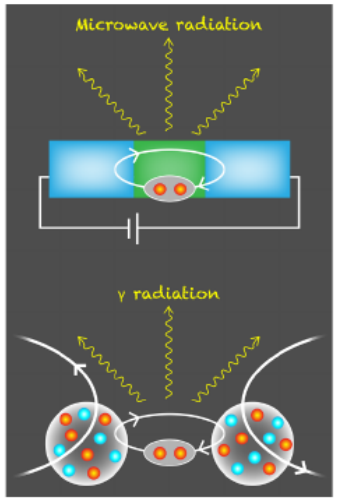
INFN

Two-nucleon transfer reaction

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.





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)

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

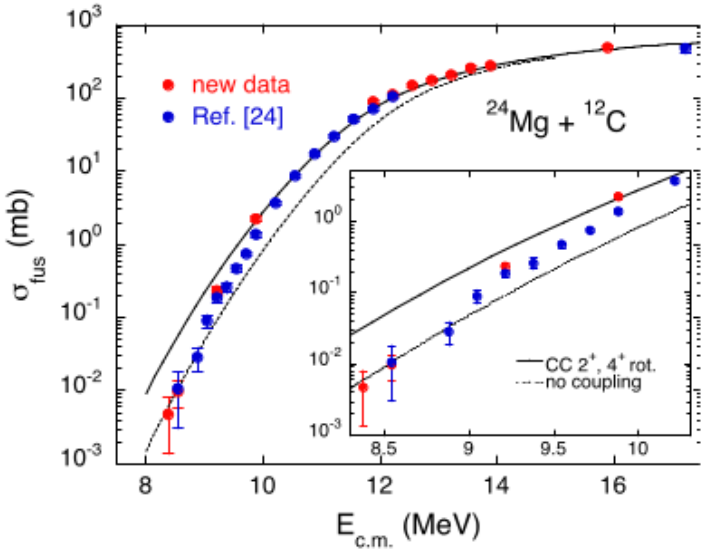
result from AGATA demo+PRISMA exp in 2011
AGATA campaign at LNL is awaited soon

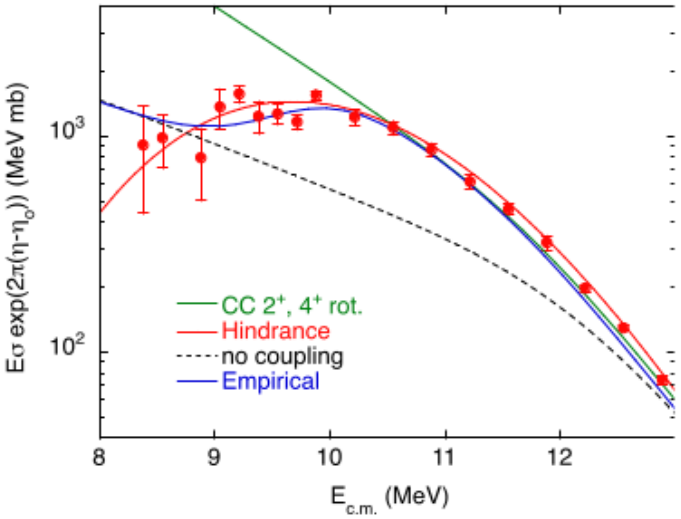
HIGHLIGHTS: SUB-BARRIER FUSION

Measurements of **fusion cross sections** for **^{24}Mg+^{12}C** have been extended down to 4μb, confirming the presence of hindrance already at ~0.75mb.

The S-factor develops a clear maximum that is nicely fitted using both an empirical interpolation in the spirit of the adiabatic model, and the hindrance parametrisation

These results serve as a base for the understanding of the astrophysics reaction networks responsible for the energy production and elemental synthesis in **stellar environments**.





G. Montagnoli et al., J.of Phys.G, accepted PLB

PRISMA- FIDES

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

DANFYSIK

SYSTEM 8500
Model 859
Magnet Power Supply

ISTITUTO NAZIONALE DI FISICA NUCLEARE

GIUNTA ESECUTIVA

DELIBERAZIONE N. 13108

D E L I B E R A

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;

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 2023 (in Keuro)

	Cons	Inv	Miss	TOT
PD	29	17	6	52

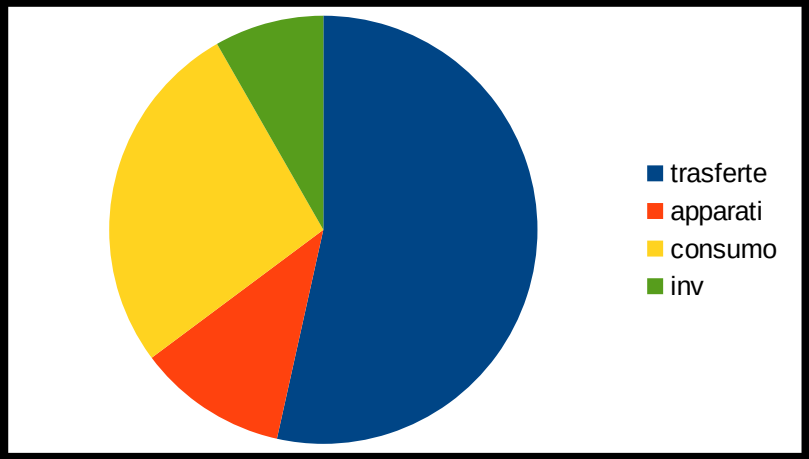
RICHIESTE DI SERVIZI PER IL 2023

SERVIZIO	LAVORO RICHIESTO	MESI UOMO
Officina meccanica	Assistenza durante gli esperimenti di Pisolo e Prisma con Agata	2
SPE/OE	Possibile sviluppi di elettronica per esperimenti Pisolo in coincidenza con silici	2+2

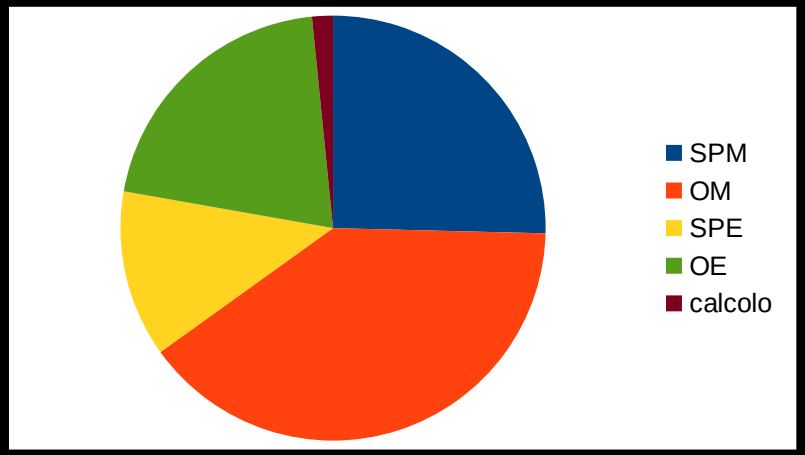
RECAP

2022

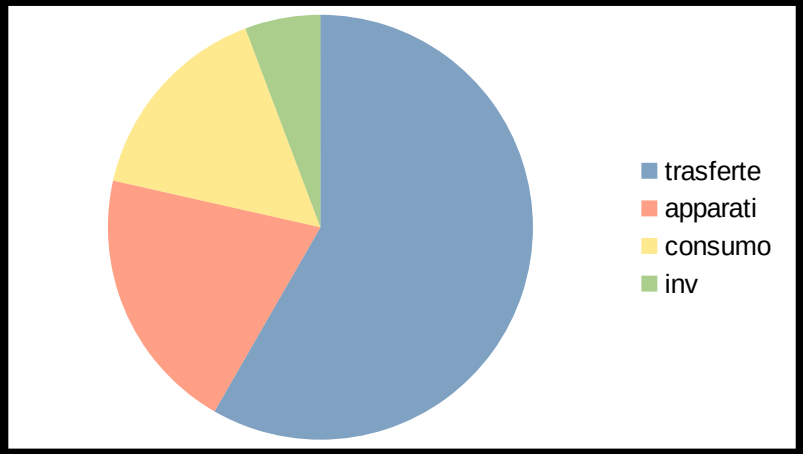
FONDI

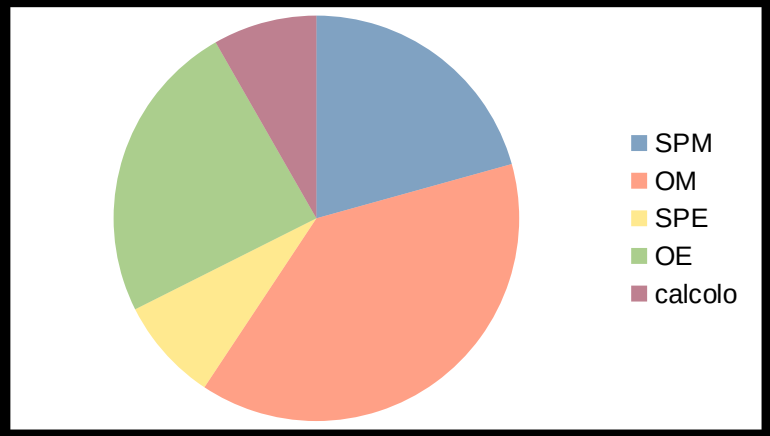


SERVIZI



2021





Summary

2022	pp	FTE	trasferte	apparati	consumo	inv	SPM	OM	SPE	OE	calcolo
ALICE	10.00	8.30	90.00		15.00					6.00	
NA60+	3.00	0.30	5.00								
EIC_NET	6.00	1.45	10.50								
ASFIN2	2.00	1.10	13.00		2.00		2.00	2.00			
GAMMA	17.00	12.40	94.80	54.90	50.60	6.10	10.00	18.00	4.00	6.00	1.00
LUNA	7.00	5.50	30.00		10.00	10.00	1.00	2.00	1.00		
PRISMA	3.00	3.00	6.00	-	29.00	17.00		2.00	2.00	2.00	
tot	48.00	33.55	259.30	54.90	130.60	40.10	16.00	26.00	9.00	14.00	1.00

N3G (Gr5) = 0.3 FTE GAMMA
FEROCE (Gr5) = 0.1 FTE GAMMA
+1 AdR entro fine anno= 1 FTE GAMMA
2 associati senior in GAMMA

Grazie per
l’attenzione