



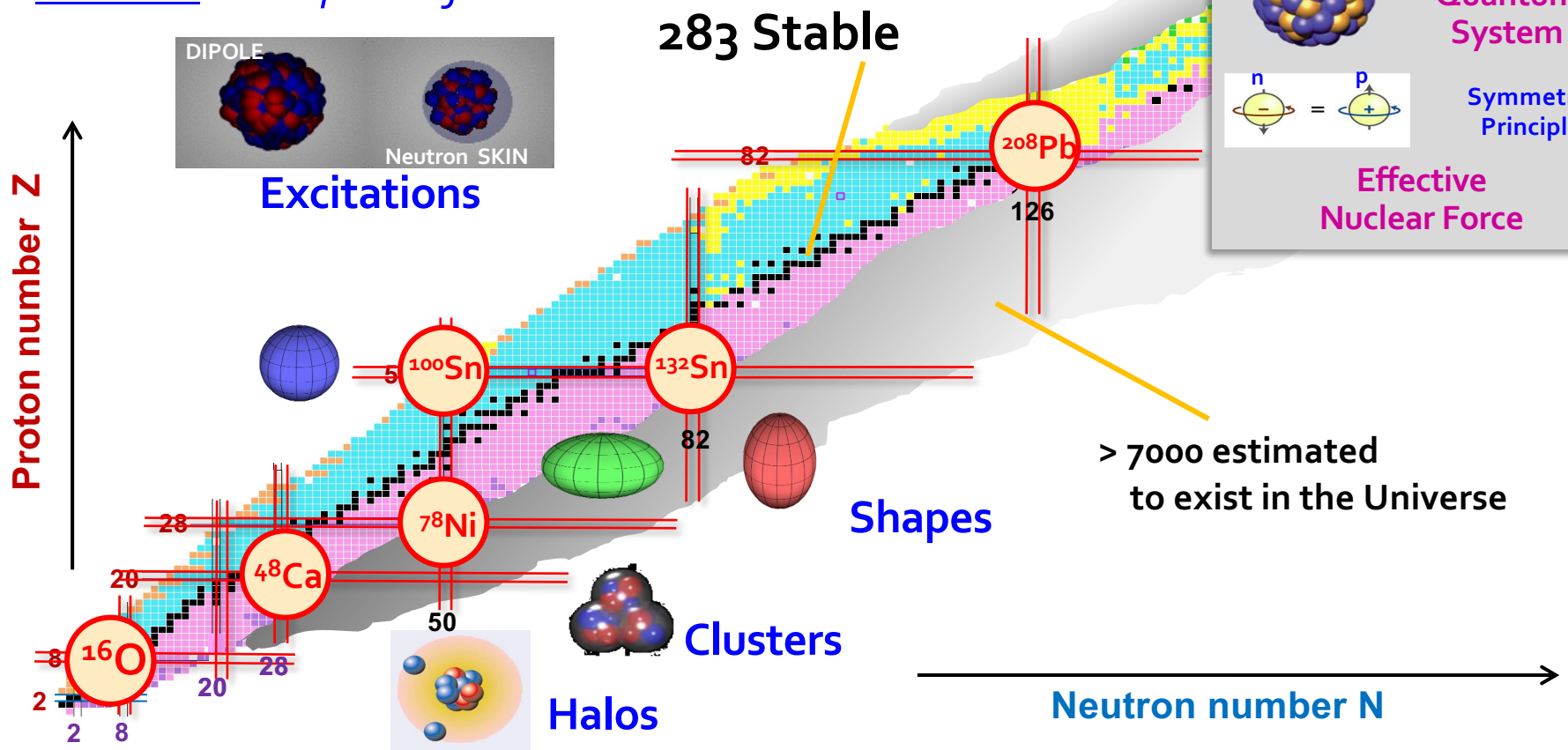
GAMMA: Struttura nucleare con spettroscopia γ



GAMMA: Struttura nucleare con spettroscopia γ

THE CHALLENGE:

a UNIFIED Description of ALL Nuclei in the Universe



GAMMA - Nazionale**FTE: 48.40****Persone: 64****5 Sezioni: FI,LNL,PD,PG, MI****CONSUNTIVI 2020**

93 pubblicazioni ISI

37 Talks

35 Tesi

92 Leadership Roles

**GAMMA - MILANO****FTE: 19****Persone: 24** (79% impegno medio)**Assegnisti/Dottorandi: 7****CONSUNTIVI 2020**

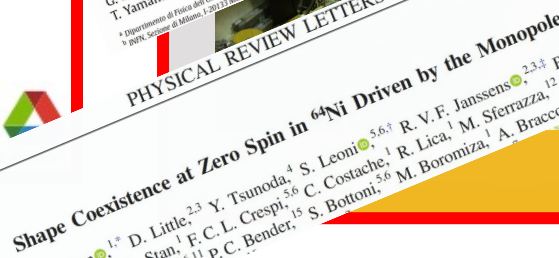
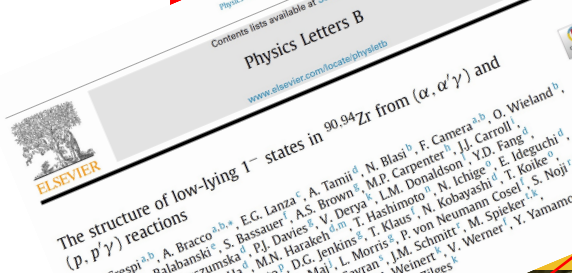
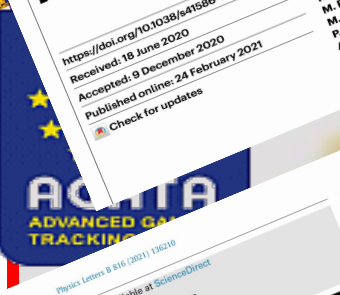
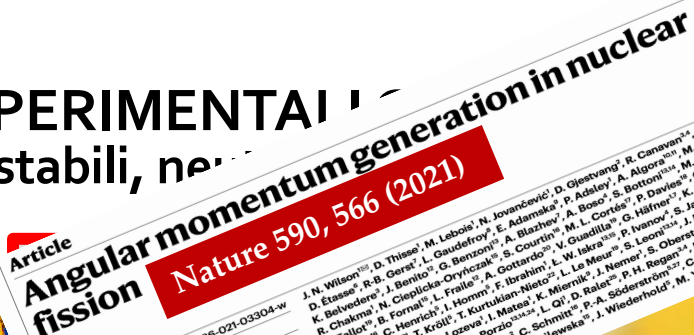
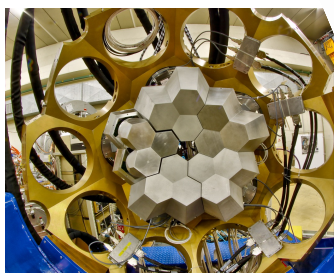
47 pubblicazioni ISI

23 Talks

13 Tesi

Resp. Nazionali:**S. Leoni, D. Napoli****Resp. Locali:****A. Nannini (FI)****A. Gottardo (LNL)****O. Wieland (MI)****R. Menegazzo (PD)****S. Simonucci (PG)**

CAMPAGNE SPERIMENTALE

RI
o de

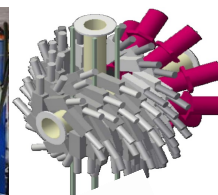
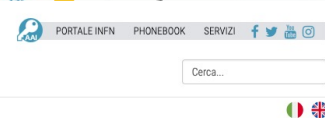
Physics Letters B
Volume 816, 10 May 2021, 136183

Physics Letters B
Volume 816, 10 May 2021, 136001

 ELSEVIER

Manifestation of the Berry phase in the atomic nucleus ²¹³Pb

X. Li^a, J. Benlliure^a, G. Gattardo^a, G. Benzeni^b, A. Gadea^c, S. Lunardi^{d, e}, A. A. Gadea^f, J. Benlliure^g, P. Boutachkov^h, A. Bracco^{b, h}, A. M. Bruce^{b, h}, F. C. C. Crespi^b, A. Corsi^{b, h}, C. Domingo-Pardo^{b, h}



NEWS INFN

03 MARZO 2021

NUOVO STUDIO SUL MECCANISMO DI GENERAZIONE DEL MOMENTO ANGOLARE NELLA FISSIONE NUCLEARE



Un team di ricerca dell'INFN, della collaborazione scientifica GAMMA, ha pubblicato sulla rivista Nature uno studio che contribuisce a far luce su uno dei misteri della fisica nucleare: il meccanismo di formazione del momento angolare dei due frammenti che si generano nel processo di fissione nucleare. Il risultato è stato ottenuto misurando la radiazione gamma emessa dalla fissione di Uranio e Torio.

In una serie di esperimenti condotti presso l'acceleratore ALTO, al laboratorio Irène-Joliot-Curie di Orsay (Francia), i ricercatori hanno osservato che i frammenti emessi durante il processo di fissione acquistano momento angolare dopo la fissione e non prima, come ipotizzato dalla maggior parte delle teorie. Il risultato è stato ottenuto dalla collaborazione internazionale di fisica nucleare NU-BALL, che si occupa di studiare una ampia gamma di nuclei e di investigarne la loro struttura mediante l'impiego di uno spettrometro gamma ad alta granularità, composto da più di 100 rivelatori al germanio iperpuro, appartenenti al network europeo

GAMMAPOOL

La collaborazione NU-BALL include ricercatori da 37 istituzioni e 16 paesi, tra cui fisici nucleari dell'Università e della sezione INFN di Milano, e dei Laboratori Nazionali di Legnaro, che hanno contribuito alla messa a punto dei rivelatori gamma, all'analisi dati e alla interpretazione teorica dei risultati.

Per approfondire leggi la [notizia sul sito della sezione INFN di Milano](#)

Link al paper su Nature: <https://doi.org/10.1038/s41586-021-03304-w>





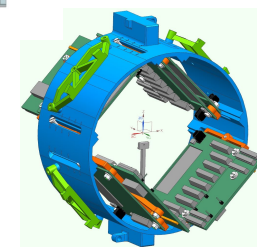
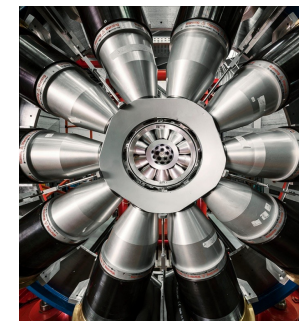
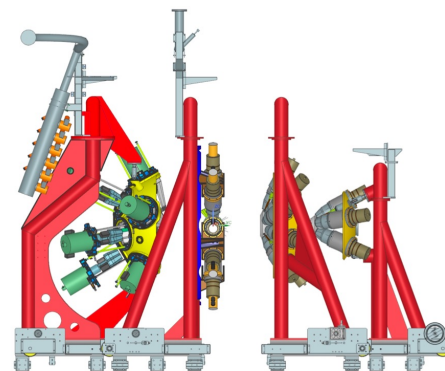
Highlights and flagship for GAMMA-Milano: GALILEO, resident γ array @ LNL

Sez. Milano contributed to mechanics (2014-2019):

- Scattering chamber
- remote handling target system
- Holding structure for ancillary detectors

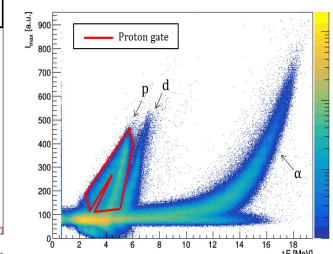
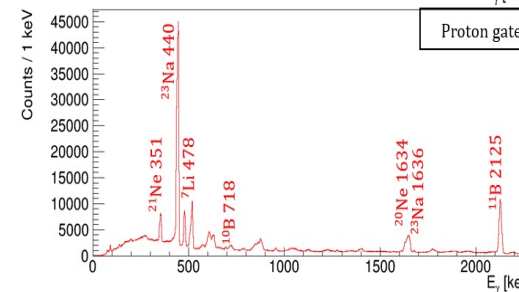
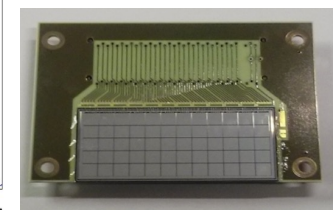
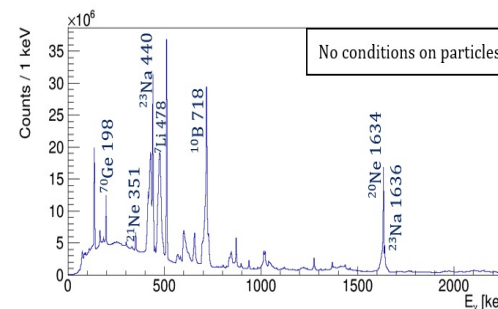
Electronics:

- Pre-amplifiers by A.Pullia
 - Integrated ASIC preamplifiers for **GAL-TRACE** by S. Capra, A. Pullia
- ➔ future development for AGATA with S.Brambilla and C.Boiano



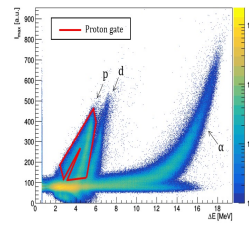
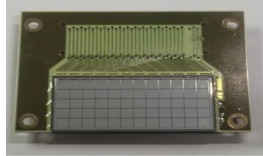
$^6\text{Li}(^6\text{Li},p)^{11}\text{B}$ (S. Ziliani et al., Milano)

- γ -decay from near-threshold resonance in light p-shell
- **GAL-TRACE** to detect the proton at forward angles
(preparatory exp. for **AGATA with stable beams**)
- Performed in Feb. 2021
- Large Remote participation



GAL-TRACE:

Part of a larger state-of-the-art light charged particle detector array based on Si telescopes with digital readout
- E-DE and PSA techniques



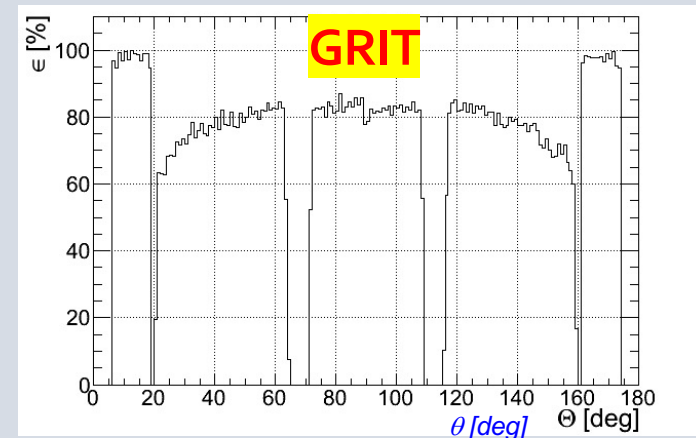
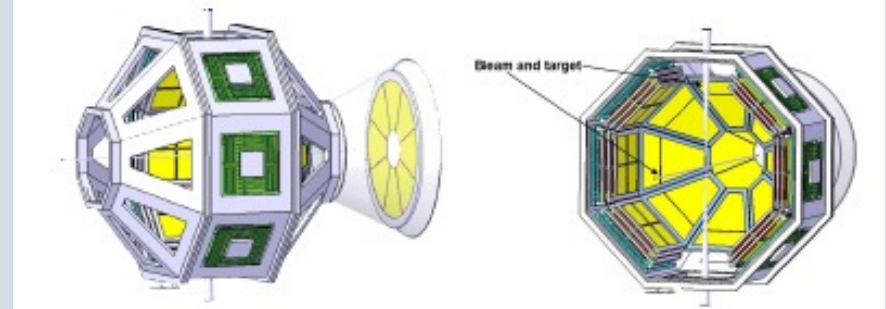
Development of pre-amplifiers by
C.Boiano, S.Capra, A.Pullia, S.Brambilla

Management Board : M.Assié(IPNO), D.Beaumel (IPNO),
D.Mengoni (INFN, Padova), **A.Pullia (INFN Milano)**

Steering Committee : Y.Blumenfeld (IPNO), G.de France (GANIL), W.Catford (Univ. of Surrey), G.De Angelis (LNL),
S.Leoni (INFN, Milano, Italy), A. Shrivastava (BARC, India)

GRIT

State-of-the-art light particle detection setup



D. Mengoni et al., TDR June 2018

LOIs @ GANIL SPIRAL1, LISE and SPES

GRIT MOU (2020-2024) Signed INFN: 74 kE/y



Highlights and flagship for GAMMA-Milano: PARIS and high-energy detectors

Steering Committee

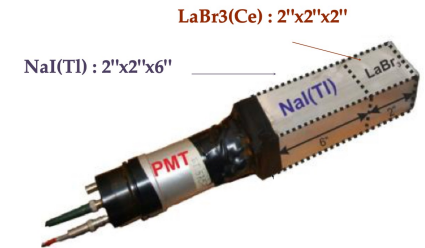
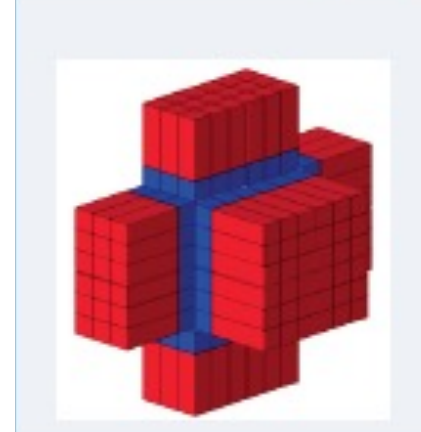
- Marek Lewitowicz (Chair)
- Member: Angela Bracco

Management Board

- Adam Maj (Chair)
- Member: Sergio Brambilla (electronic working group)

Collaboration Council

- Chair: Franco Camera



'PARIS White-Book' completed in 2021

<https://rifj.ifj.edu.pl/handle/item/333?locale-attribute=en>

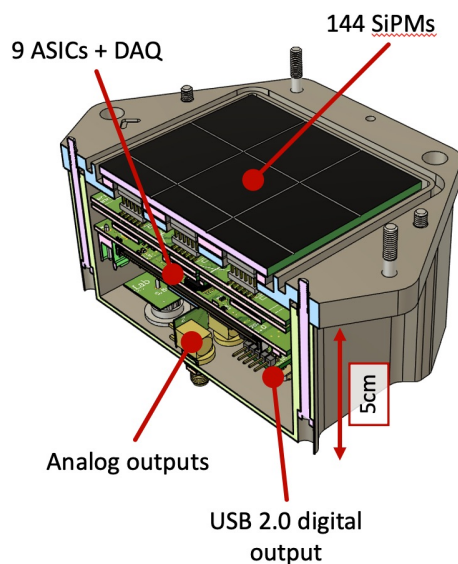
- Introduction (PARIS performances)
- PARIS at GANIL, IJC, LNL, TIFR, GSI, JINR
- The path towards a minicube
- edited by F. Camera, Adam Maj et al.



**MOU is expired in 2020,
New MOU (or amendment)
in preparation (ready by end
2021)**

**In 2022: GANIL Campaign (first half 2022)
IJC (ALTO) Campaign (second half 2022)**

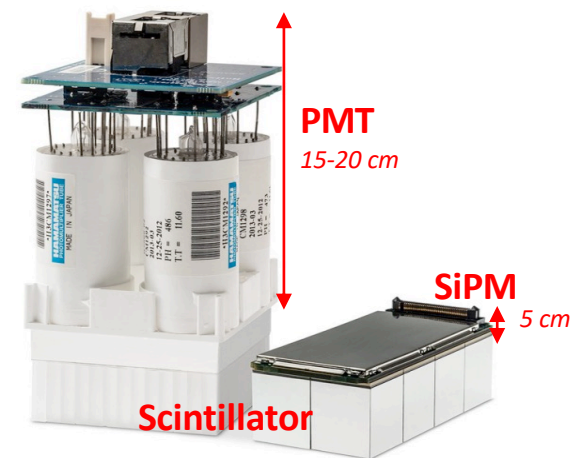
Development of SiPMs-based readout for **large** LaBr_3 scintillators



Full-scale range of **40 MeV** (lowest ASIC gain)
< 3% resolution at 662 keV (highest ASIC gain)
 state-of-the-art: similar performance of PMT

4 PREMI internazionali
interesse da altre collaborazioni

- 9x16-ch **GAMMA ASICs** for a total of 144 readout channels
- Each SiPM is read by an ASIC channel (no merging)
- FPGA-based data processing and acquisition system
- Temperature gain drift compensation
- USB 2.0 communication for both control and data transfer
- Analog outputs (trigger, signal amplitude, interaction position)

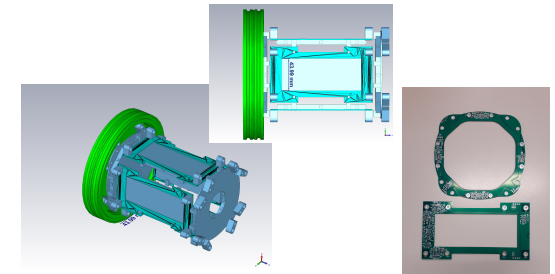
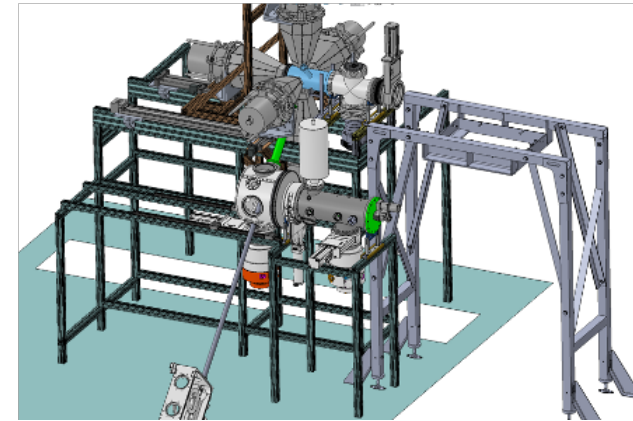
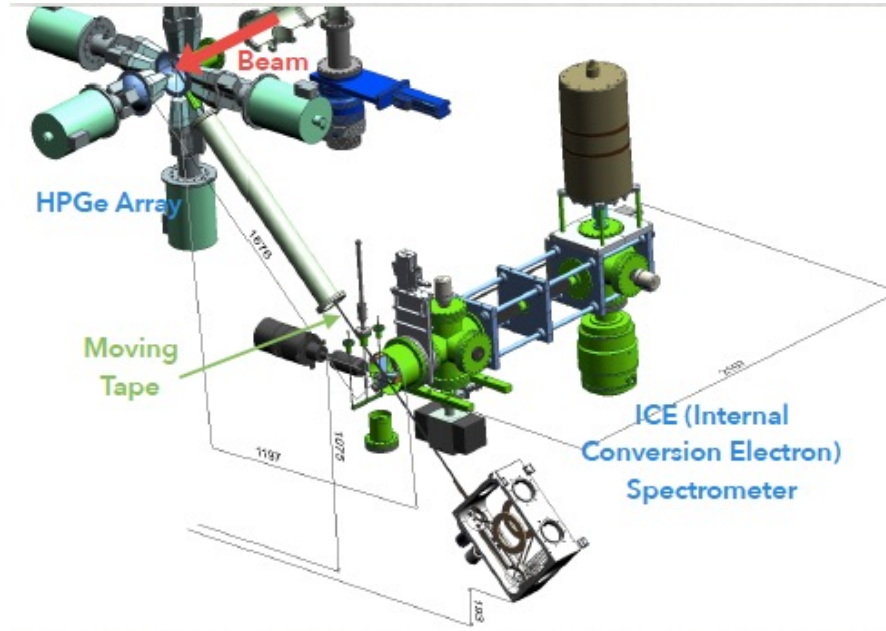


Sez. Milano contributes to realisation of detectors' and SiPMs' cases → new elements to be produced

Highlights and flagship for GAMMA-Milano: BETA TAPE DECAY STATION ed ELECTRON CONVERSION SETUP (@SPES-1+)

Punto Misura Gamma e beta

- (1) Struttura di sostegno progettata ordini a breve
- (2) Rivelatori da Installare:
Plastici e HPGE

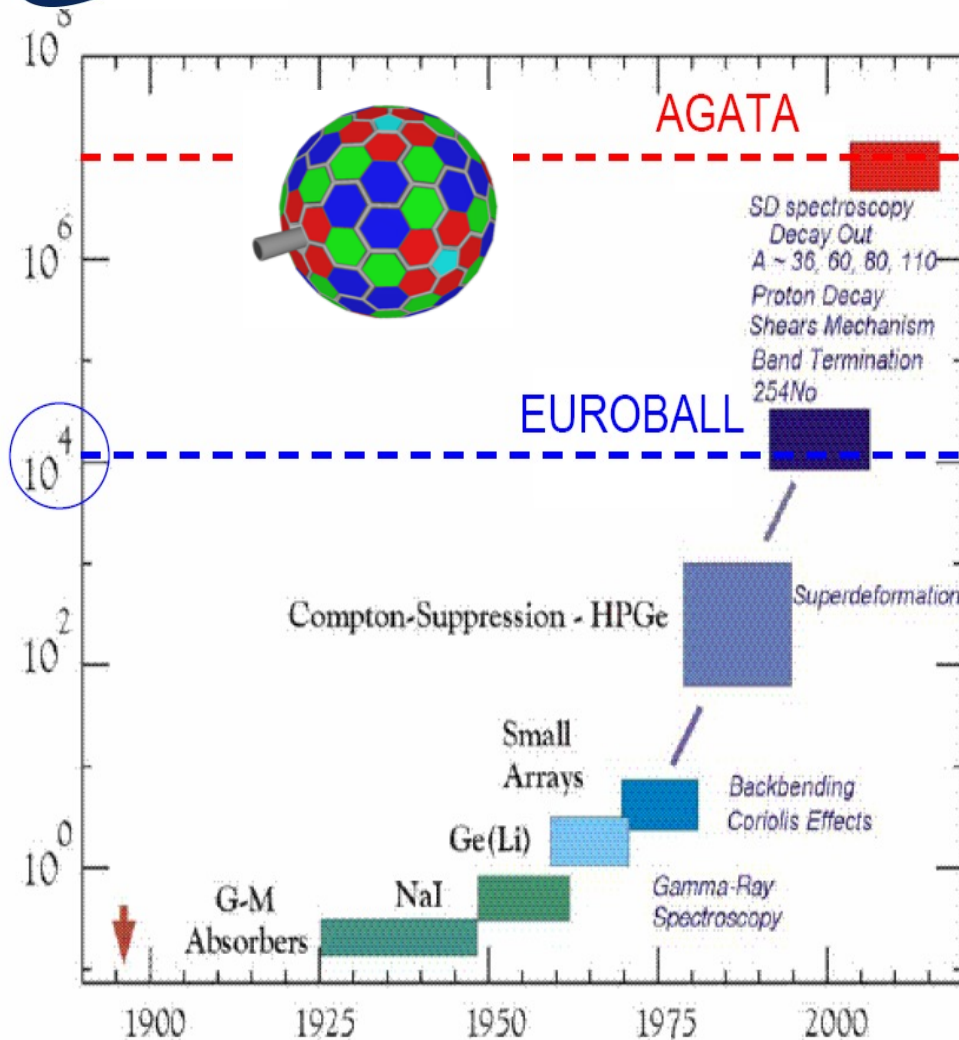


Sez. Milano contributed to mechanics (2018) for the tape cassette
Holding structure designed at INFN-Fi
Electronics and Read-out:

- PCB boards for SiPM readout of Plastic by C.Boiano
- Implementation of signals from HPGe and Plastics into digital DAQ system S.Brambilla
- Help to produce small mechanical holding elements foreseen

PRIMI FASCI SPES@LNL
2023

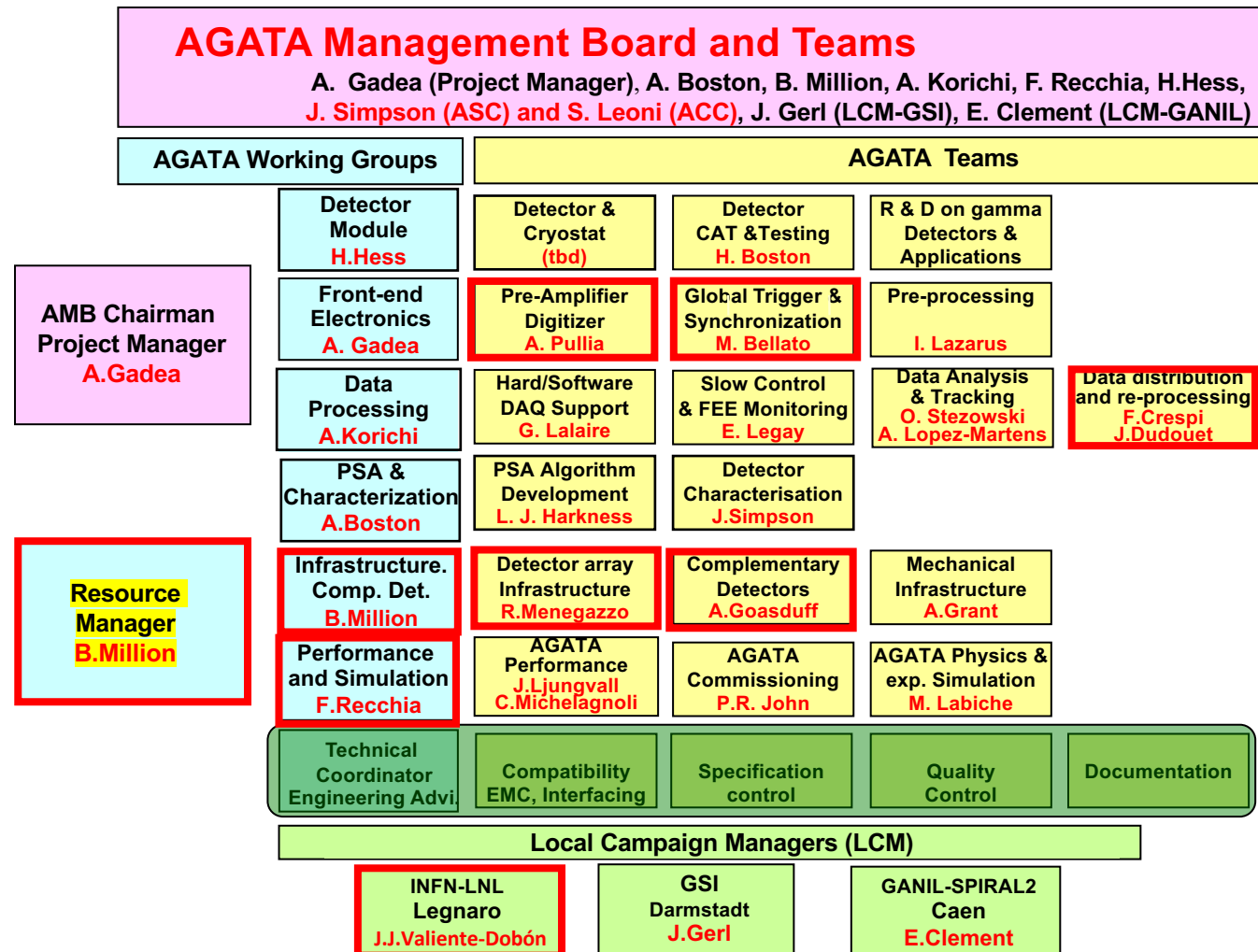
**Increase in sensitivity
for gamma-arrays
over the years**



**AGATA
the “Ultimate” Ge Array**

- ✧ **EFFICIENCY:**
43% $M_\gamma = 1$ and 28% $M_\gamma = 30$ (@ 1 MeV, FULL BALL)
- ✧ **COUNT RATE** capabilities (100s KHz)
- ✧ **ANGULAR RESOLUTION**
of the γ interaction point ($\theta \sim 1^\circ$)
- ✧ **“PERFECT” DOPPLER CORRECTION**
(6 keV @ 1 MeV, $\beta=50\%$)

AGATA Steering Committee Italian Members: A. Bracco, G. De Angelis → **A. Bracco next CHAIR (April 22)**
AGATA Collaboration Council Italian Members: **S. Leoni (CHAIR)**, S. Lenzi, B. Million, A. Nannini, D. Napoli



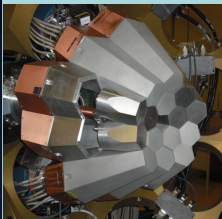
Status June 2021

AGATA MoU towards 3π configuration submitted to INFN to be signed

The AGATA Evolution Towards 2π

**LNL
2009**

9 crystals
Eff. ~3.5%



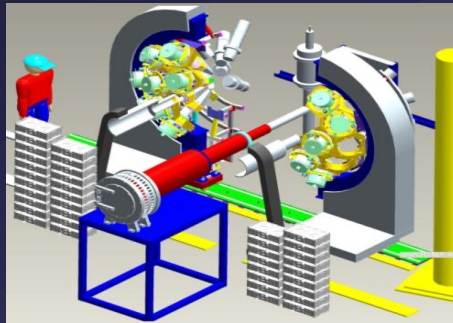
AGATA
“Demonstrator”

LNL: 2010-2011
15 crystals
Total Eff. ~6%



AGATA + PRISMA
“backward”
*STABLE
BEAMS*
20 experiments

GSI: 2012-2014
22 crystals
Total Eff. ~10%



AGATA + Hector⁺ + FRS
“forward”
*RELATIVISTIC
EXOTIC BEAMS*
7 experiments

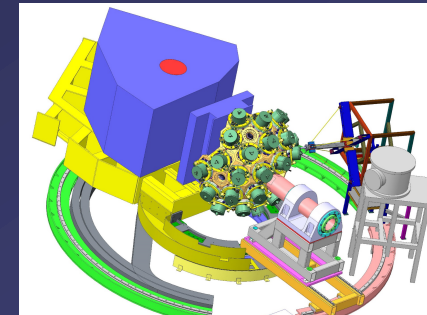
GANIL: 2015 - 2021
up to 45 crystals
Total Eff. ~22%



AGATA+VAMOS+ ...
AGATA+NEDA+...
AGATA+PARIS+...
*STABLE BEAMS &
EXOTIC (ISOL)*
30 experiments

MAJOR UPGRADE
Ready for 4π

LNL: 2022- 2025
up to 90 crystals (2π)



AGATA+PRISMA+ ...
AGATA+NEDA+...
AGATA+PARIS+...
AGATA+MUGAST+...
*STABLE BEAMS &
SPES BEAMS*

AGATA+MUGAST in 2019-2021
AGATA+VAMOS in 2021

WG AGATA@LNL

General WG meetings:

- First 24/9/2020
- Second 28/1/2021
- Third 8/6/2021

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. Rezyunkina
- Gamma-ray scintillators: E. Gamba, S. Pigliapoco
- Plunger: I. Zanon

Task 1, Infrastructure: Roberto Menegazzo

Task 2, AGATA Mechanics: Nicola Bez, Loris Ramina, Mirco Rampazzo, Marco Scarcia

Task 3, Experimentation mechanics: Giovanna Benzoni

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

Task 5, Computing and network infrastructures: Michele Gulmini, M

Task 6, Surveyor: Daniele Scarpa

Task 7, Detectors: Walter Raniero, Davide Rosso

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

Task 9, Complementary instrumentation: D

Task 10, Performance: Fabio Crespi

Task 11, Exploitation: Andrea

Task 12, Data Analysis: F

Task 13, Logistics: F

Task 14, Doc: Vincenzo Volpe

Task 15, AGATA activities: Andrea Gozzelino

INFN ADR position opening in Milano ("Installazione e Campagna Sperimentale con lo spettrometro AGATA@LNL" (deadline 12/07)

ra





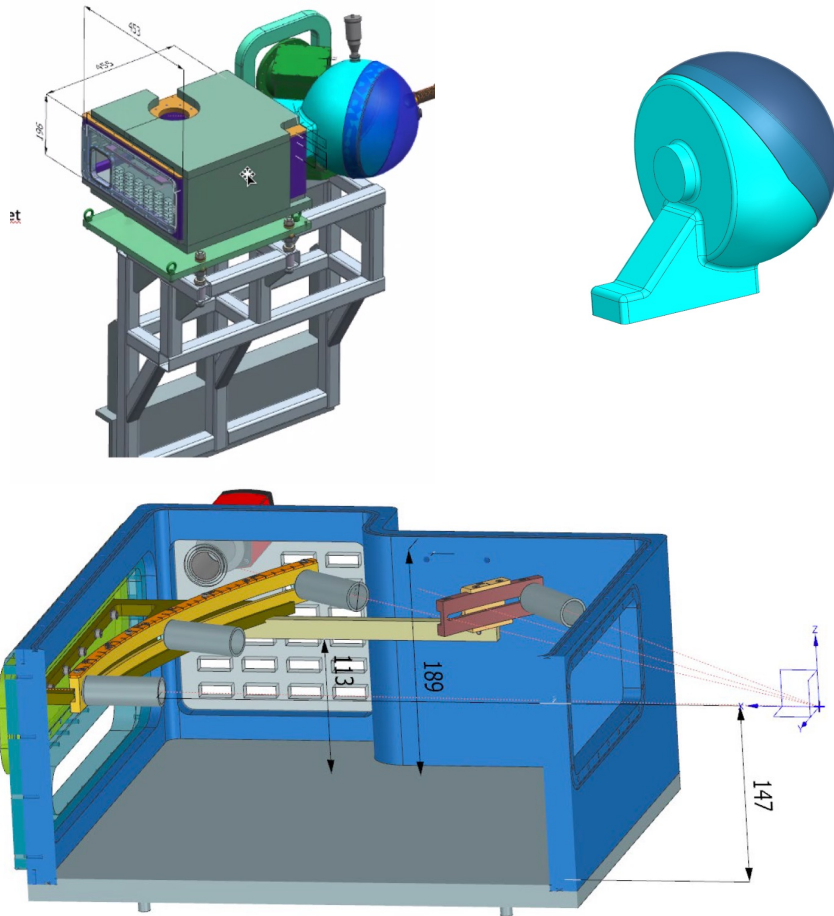
pre-PAC Workshop of AGATA@LNL

8-10 November 2021
INFN-LNL

AGATA Collaboration Meeting 2021

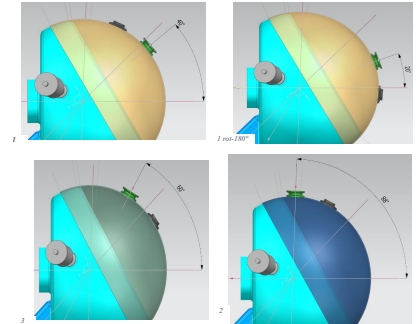
10-11 November 2021
Legnaro National Laboratory

Highlights and flagship for GAMMA-Milano: AGATA, γ -ray tracking array



Scattering chamber made of two shells
Outer radius 170 mm
Thickness 2 mm

3 removable shells help covering
angles btw ~ 7 -88 deg
Each shell can slide ± 13 deg from
central position



Sept 2020- June 2021: designing of scattering
chamber+ service chamber + holding structure and
aligning mechanisms

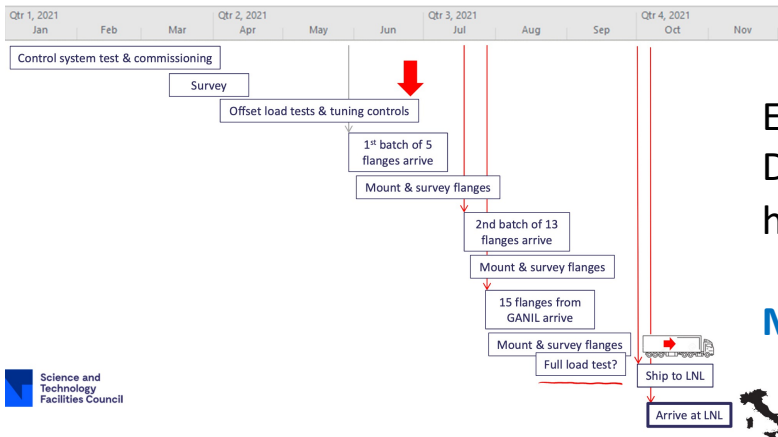
INFN-MI design office:

S.Coelli, [F. Tomasi](#), E. Viscione, A. Capsoni, D. Vigano'

progettazione conclusa, concluso affidamento a ditte
(camere da vuoto+ coperture+ telaio + movimentazione)

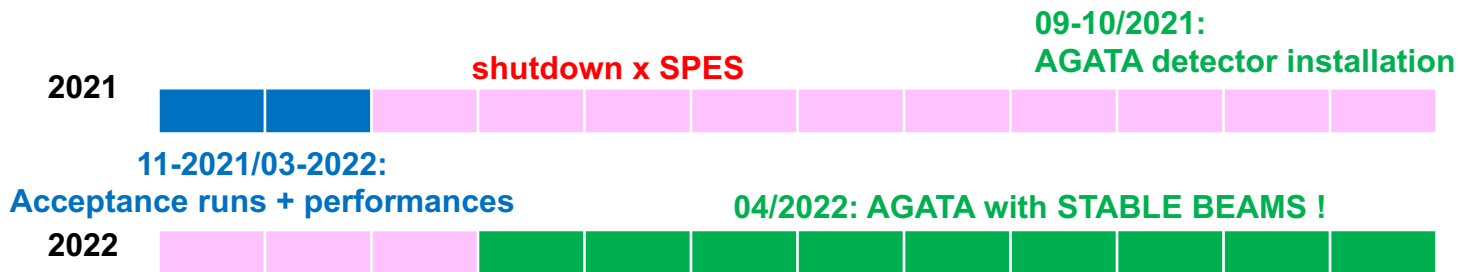
Highlights and flagship for GAMMA-Milano: AGATA, g-ray tracking array

Ground breaking 10/3/2021



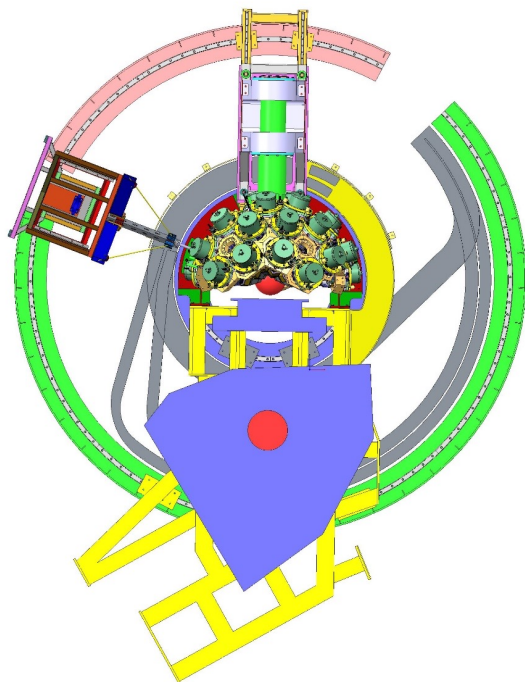
Expected delivery at LNL:
Detectors → end of July
holding structure of detectors → Early October

Mounting of scattering chamber and its holding structure in September



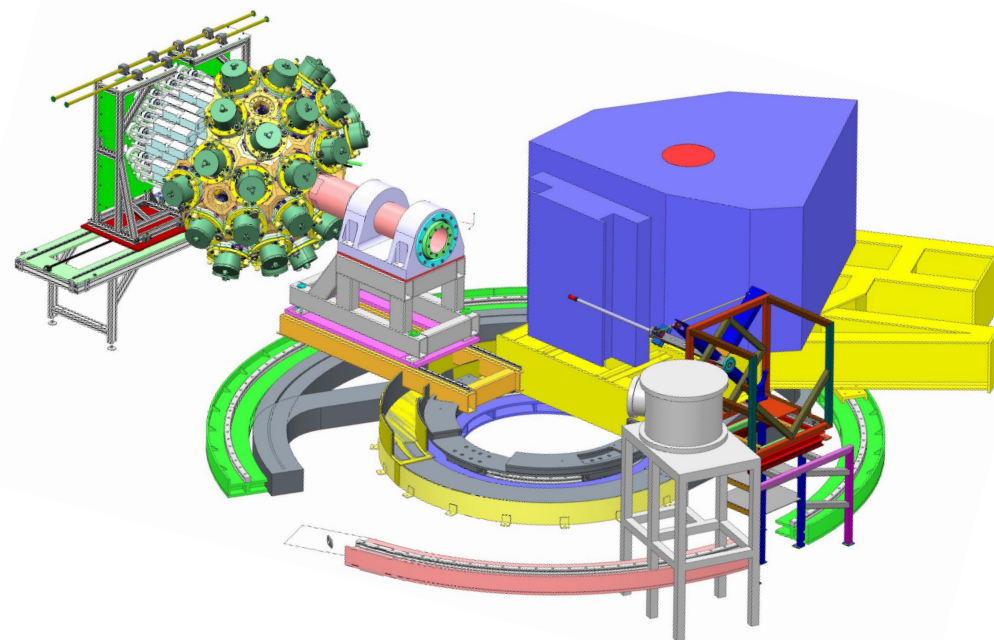
Two Configurations

I° Setup 2022-2023

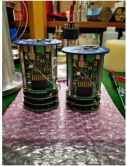


Coupling with PRISMA

II° Setup 2023-2024



Configuration at 0°

Richieste per officina meccanica e ufficio progettazione	Ore progettazione	Ore officina
AGATA: Nuova camera di scattering + beam dump + struttura portante per configurazione stand-alone (2023-2024) Design simile a GALILEO, con possibilita' di adattare targets criogenico	12 mesi/uomo	6 mesi/uomo
Adattatori per installazione rivelatori LaBr3(Ce) 3x3 inch su AGATA		
B-DS: Struttura di sostegno dei rivelatori plastici nella camera di decadimento; aiuto per costruire piccole parti: Aste e Adattatori (piccole L)		1 mese/uomo
Housing per rivelatori		
modifica e produzione seriale di housing per Labr3 3x3 inch con lettura da SiPm (Camera – Fiorini Politecnico) Totale di 4 moduli in due anni (2021-2022)		2 mesi/uomo
Modifica housing per lettura usando I Spector: alto circa 30-35 cm ed ha un diametro di circa 10-20 cm. cilindri di Al-Cu (Camera) Quantita': 1 o 2 pezzi		1 mese/uomo
Housing per rivelatori piccoli 1x1 inch (pending request dal 2021) (Camera) 1-2 pezzi		1 mese/uomo
TOTALE	13	11

Richieste per Servizio di Elettronica: 12 mesi/uomo, Ciro Boiano 100%

- continuazione dello sviluppo di read-out con SiPM dei rivelatori di PARIS
- sviluppo di preamplificatori e supporto alla sperimentazione di TRACE array di Silici
- supporto alla sperimentazione con AGATA, GALILEO e rivelatori ancillary
- supporto per readout con SiPM per scintillatori beta decay Tape Station
- supporto sperimentazione CRACOVIA e ILL

Richieste economiche:

Preventivi 2022

Consumo	55 k€	di cui	5 k€	s.j.
Trasporti	2.0 k€	di cui	2.0 k€	s.j.
Inventariabile	8.5 k€	di cui	55 k€	s.j.
Apparati*	762 k€	di cui	0 k€	s.j.
Σ	<u>827.5 k€</u>	di cui	62 k€	s.j.

Missioni	<u>144 k€</u>	di cui	19 k€	s.j.
-----------------	----------------------	---------------	--------------	-------------

GAMMA - MILANO

FTE: 19

Persone: 24 (79 % impegno medio)

Assegnisti/Dottorandi: 7

CONSUNTIVI 2020

47 pubblicazioni ISI

23 Talks

13 Tesi

**** su APPARATI Milano: PARIS MoU (50.5 k€), GRIT MoU (37 k€),
AGATA MoU (in firma) 551 k€ in 2022 (gare in preparazione),
3 π configuration in 10 years (total investment: 5.5 M€))**

Mid-term plan of the nuclear physics research at INFN national labs

- * 3 WS collegati per fisica 2022-2027 ai laboratory nazionali
- LNL e LNS a breve distanza in febbraio/marzo 2022
- una per LNF e LNGS maggio/giugno 2022

* Per LNL e LNS si prevedono 4 gruppi di lavoro:

- # Struttura nucleare
- # Dinamica di reazione
- # Astrofisica nucleare
- # Applicazioni (più vicine alla fisica CSN3)

* Outcome: pubblicazione di un lavoro di rivista/libro bianco che firmato dai membri dello steering committee, da tutti gli speaker, dai conveners e dai ricercatori partecipanti ai sottogruppi **EPJ Focus Point**

Steering committee:

LNL: F. Gramegna, E. Fioretto, G. Benzoni, F. Soramel, L. Fortunato, J. J. Valiente-Dobon
LNS: S. Gammino, S. Romano, I. Lombardo, P. Russotto, M. Colonna, M. La Cognata
R. Nania, D. Bettoni, F. Bossi, E. Previtali + colleghi da LNF e LNGS

