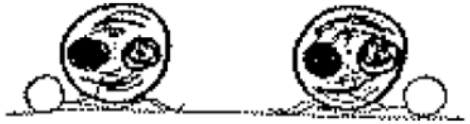
ALICE	CERN	QGP	7.3 FTE	F. Ronchetti
FOOT	CNAO/TIFPA/ LNS/BTF	Framm. Nucleare	2.1 FTE	E. Spiriti
e-JLab12	JLAB	Fisica adronica	2.1 FTE	M. Mirazita
BGOOD	Bonn/Mainz	Fisica adronica	1.2 FTE	P. Levi Sandri
	LNF	Fisica nucleare	16.4 FTE	C. Curceanu
	LNGS	Fisica nucleare	7.3 FTE	C. Curceanu
EIC_net	RHIC	Fisica adronica	0.1 FTE	M. Mirazita
nTOF	CERN	Astrofisica nucleare	1.5 FTE	F. Murtas

INFN
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Presentazione dedicata



Attività in CSNIII@LNF

Silvia Pisano – CSN3 local coordinator
Laboratori Nazionali di Frascati

LNF activities

Researchers and Technologists: **7.3 FTE**

Bianchi N.	1.0
Fantoni A.	1.0
Matuoka P.	0.5
Muccifora V.	1.0
Pisano S.	1.0
Ronchetti F.	1.0
Spiriti E.	0.1
Toppi M.	1.0
Vazquez Doce O.	0.7 (SIDDHARTA)

Technicians: Pierluigi D., Saputi per ITS3

News
P. Larionov got a *similfellow* position @CERN
O. Vazquez Doce got a Fellini position until October 2023

The LNF Group Joined ALICE in 2006

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Responsibilities at CERN

Management Board (AF, 11/2019-in carica)

Collaboration Board (VM, 06/2017-in carica)

Run Coordinator (FR, 2015, 10/2019-in carica fino 2022)

Period Run Coordinator (AF, 2015)

Head of LS1 Consolidation ALICE Task Force (FR, 2013-2014)

Period Run Coordinator (FR, PDN, 2012)

EMCAL Deputy Project Leader (AF, 2013-in carica; NB, 2007-2012)

EMCAL/DCAL Euro-Asian Coordinator (AF, 2008-2012)

EMCAL System Run Coordinator (FR, 2011-2012)

EMCAL High Level Trigger Coordinator (FR, 2009)

ALICE Activities at LNF

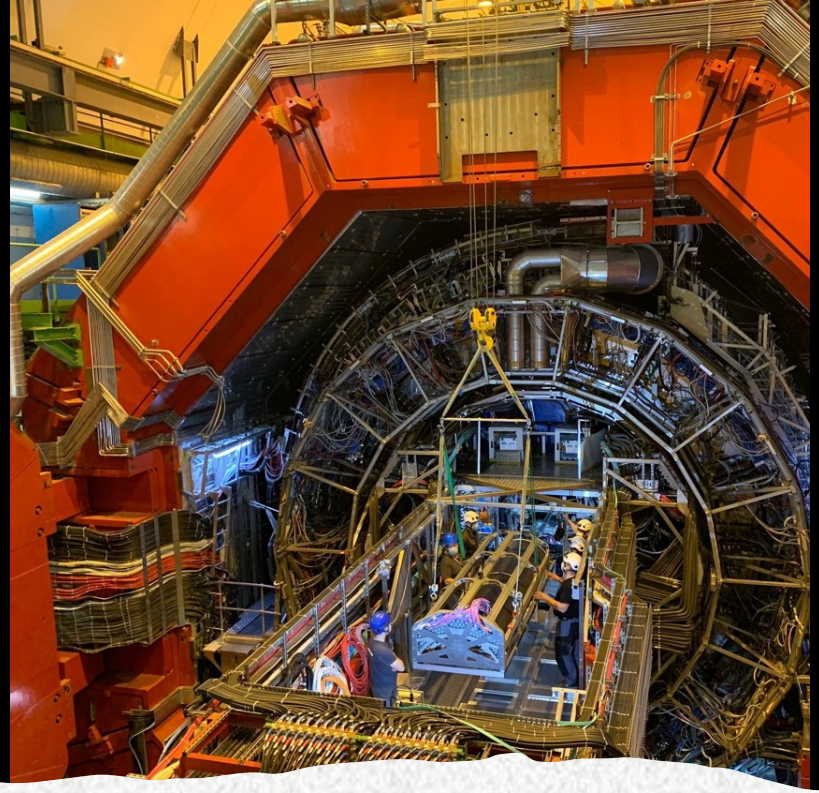
ITS Upgrade production Local Technical Coordinator (FR, 2016-2019)

Physics Analysis Coordinator (SP, 2016-in carica)

EMCAL/DCAL production Local Technical Coordinator (AF, 2010-2011)

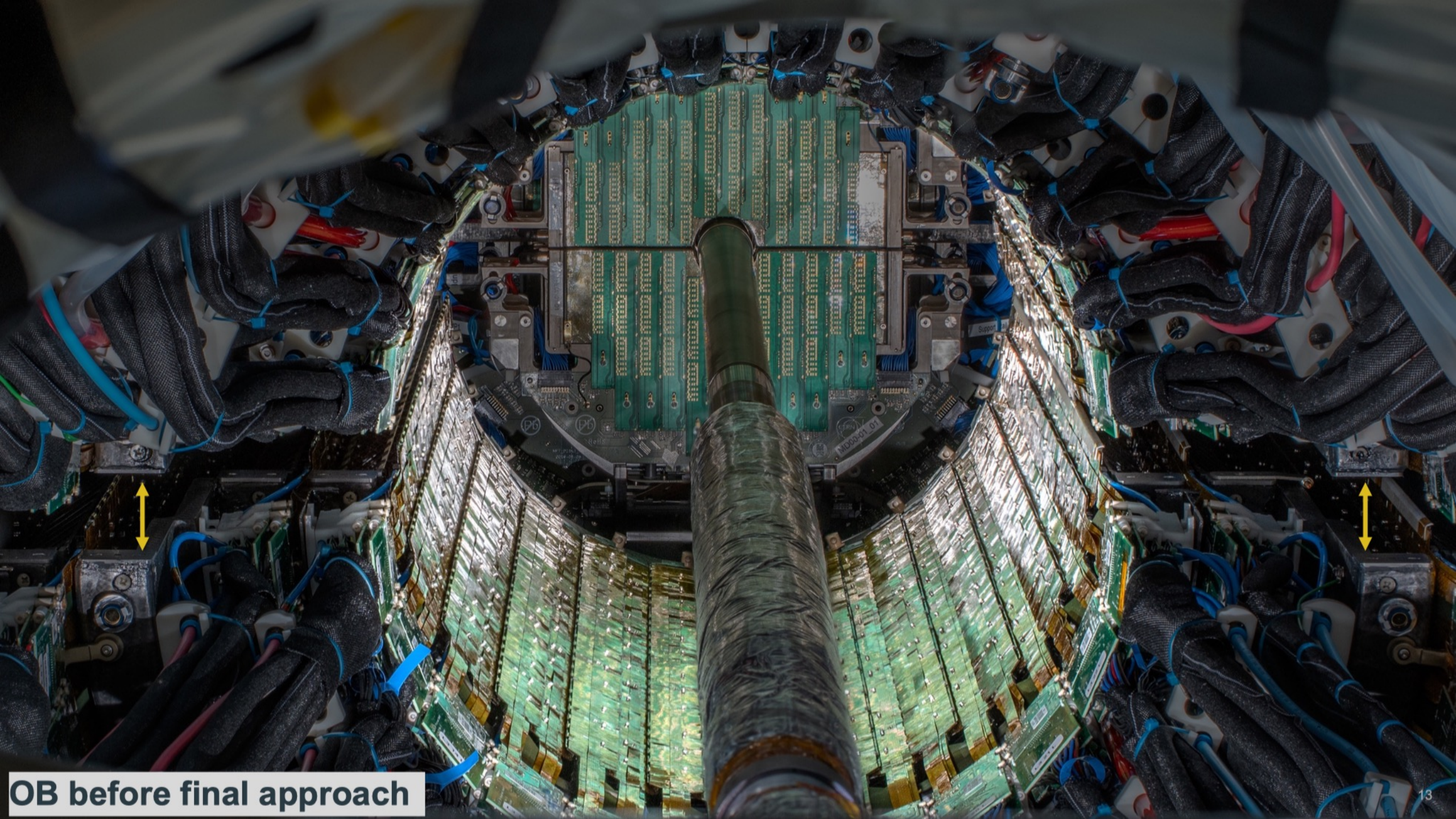
EMCAL production Local Technical Coordinator (FR, 2006-2009)

ITS Commissioning 2020 – ongoing (shifts @CERN and remotely)



ITS OB-top installation: March 18th

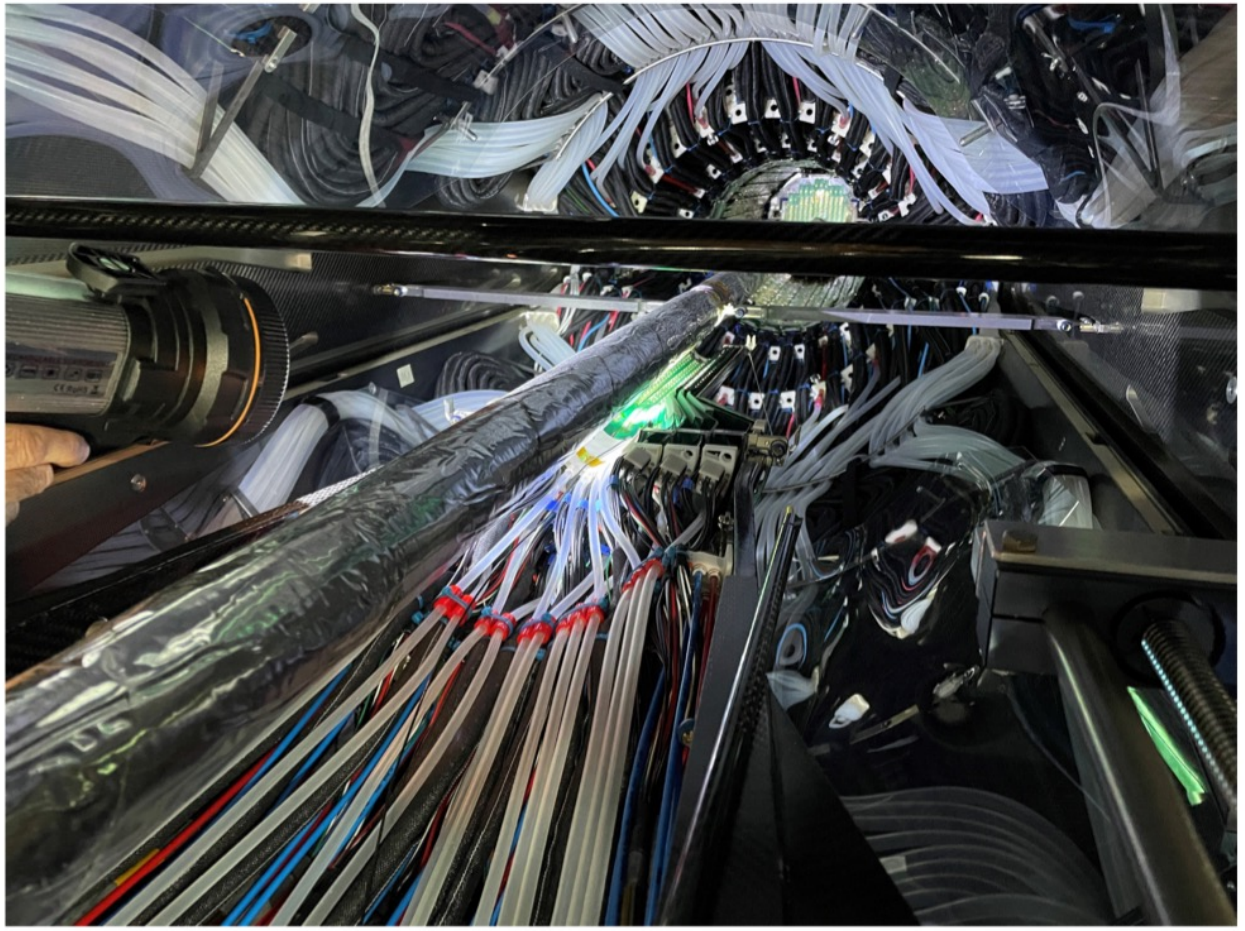
Causa COVID impossibilità di partecipare all'installazione ITS-OB da parte del personale LNF (ricercatori e tecnici)



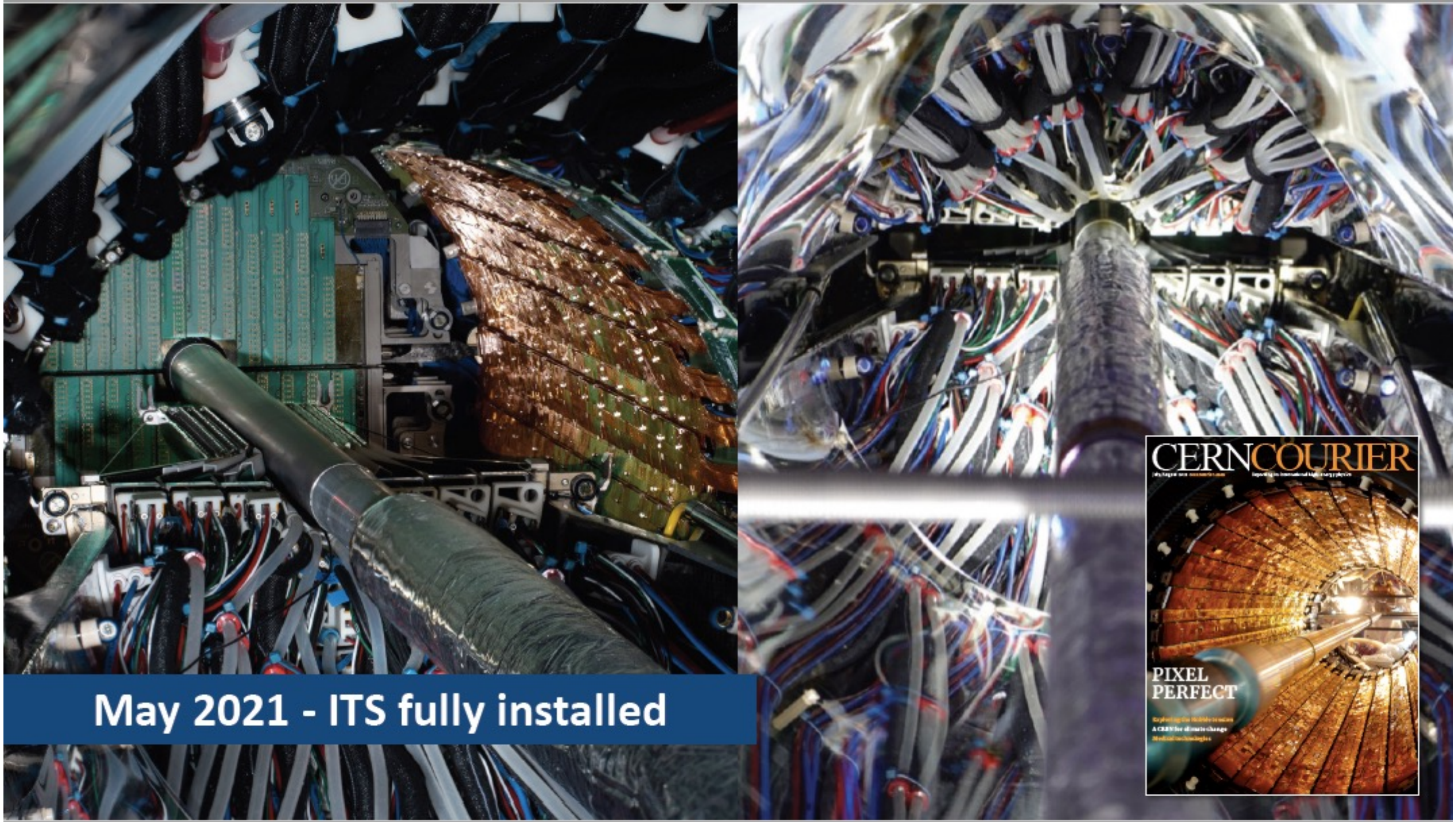
OB before final approach

ITS: IB Installation May 2021

IB Bottom arriving on the Mini-Frame



IB Bottom insertion



May 2021 - ITS fully installed

Analysis activity

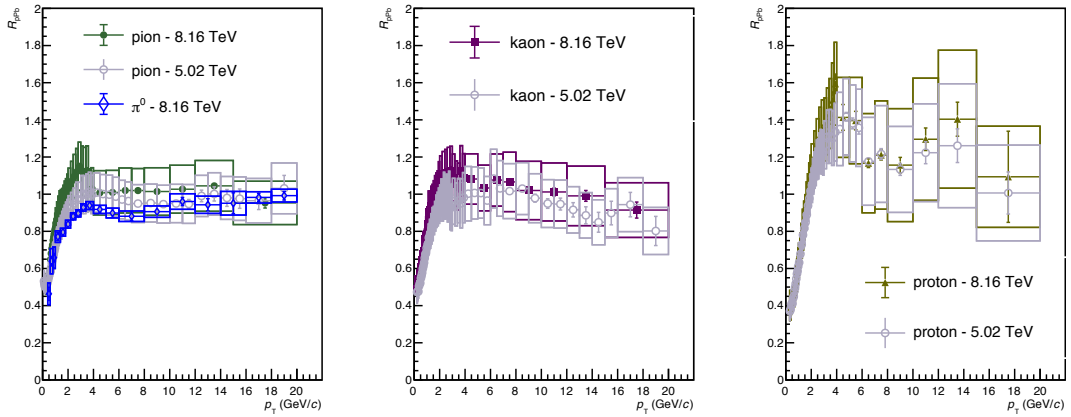
Light-flavour hadron production vs. multiplicity in pp and in p-Pb collisions with ALICE

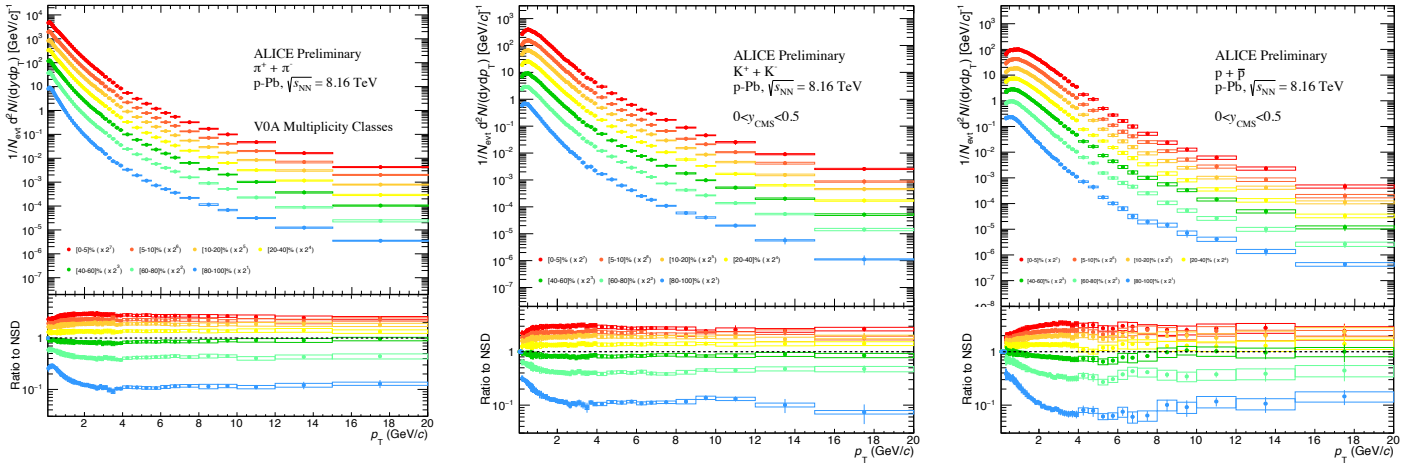
Low-p_{T} hadrons containing light flavours (u, d, s) constitute the bulk of the particle production at LHC (99%)

They allow one to study the whole system, analyzing its thermodynamic properties and exploring the emergence of collective phenomena

Are phenomena typical of QGP such as collectivity, chemical abundances, strangeness enhancement present in small systems?

1. Spectra extraction extended up to 20 GeV thanks to the inclusion of the HMPID and TPCr analysis
2. Measurement of the nuclear modification factor R_{pPb}





P. Larionov (ITSsa), S. Pisano (TPC), M. Toppi (TOF)
+ HMPID (INFN&UniBari)
+ TPCr (Copenaghen)

Combination and extraction of R_{pPb} under LNF responsability.

Paper proposal presented at the Physics Forum on February 2021

Analysis activity

Light-flavour hadron production vs. multiplicity in pp and in p-Pb collisions with ALICE

Low-p_{T} hadrons containing light flavours (u, d, s) constitute the bulk of the particle production at LHC (99%)

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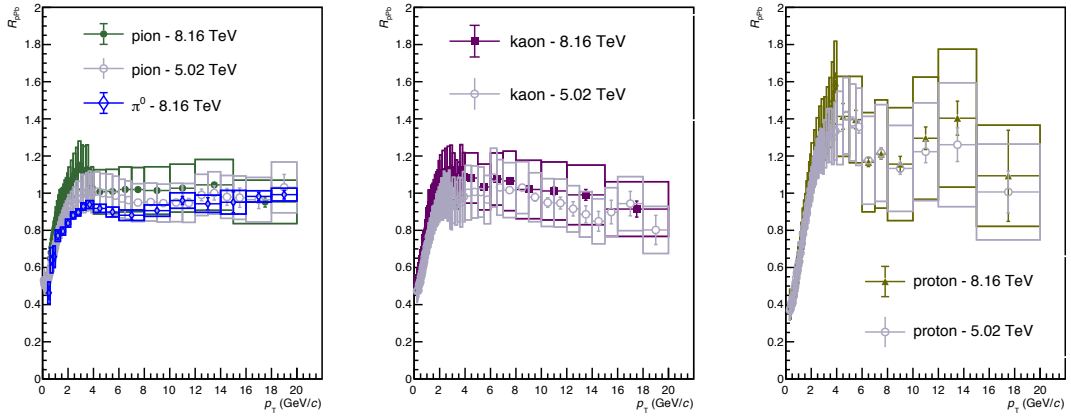
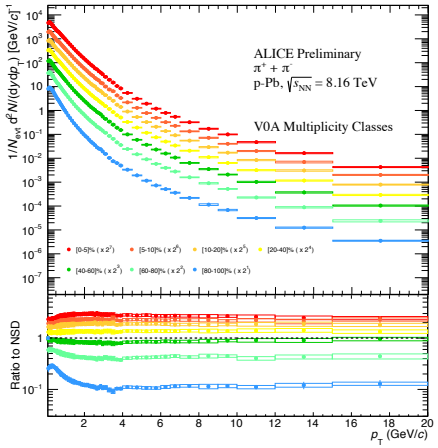
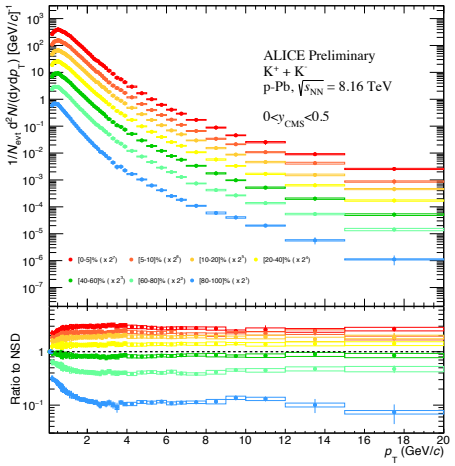
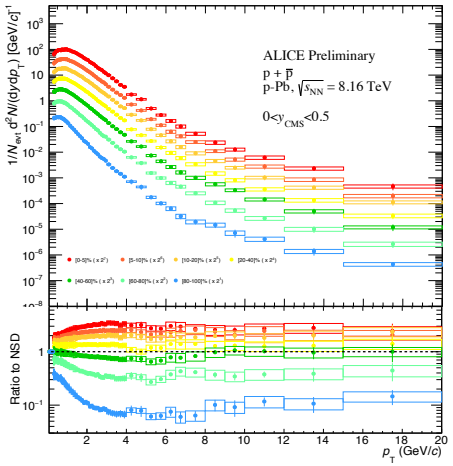








Further activities:

1. Measurement of $\overline{^3He}$ inelastic cross section with ALICE (by P. Larionov)
2. ALICE3 performance studies

Progetto congiunto ALICE-SIDDHARTA

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Fellini Fellow: Otón Vázquez Doce

Program delayed by 12 months due to pandemic

Duration of the fellowship: 28.5 months

1st June 2021 - 15th October 2023

Supervisors:

- ALICE: Alessandra Fantoni (main responsible + administrative duties)
- SIDDHARTA-2: Catalina Curceanu

Fellini Fellowship for Innovation at INFN

H2020 MSCA COFUND
G.A. 754496

Istituto Nazionale di Fisica Nucleare

[Link to Fellini 2nd call]

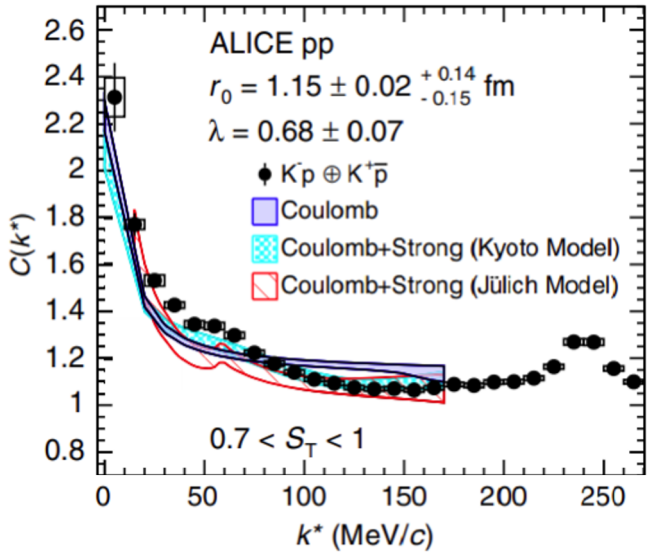
Femto-Strong: "**Antikaon-deuteron femtoscopic correlations with ALICE: A new era of hadron-hadron interaction measurements**" Link to project pdf

- Measurement of the K^--d correlation function in small collision systems with **Run2 (and Run3) ALICE data**
- **Joint-venture** with SIDDHARTA-2: Measurement of the antikaon-nucleon scattering parameters at threshold with SIDDHARTA-2, over threshold at low relative momentum with ALICE.

⇒ Two-particle correlation studies open new precision era in the hadron-hadron interaction studies ALICE Coll. *Nature* **588**, 232 (2020)

⇒ Improved study following ALICE publication of K^--p femtoscopy in pp collisions ALICE Coll. Phys. Rev. Lett. 124 (2020) 092301

- Comparison with models anchored at threshold to SIDDHARTA data

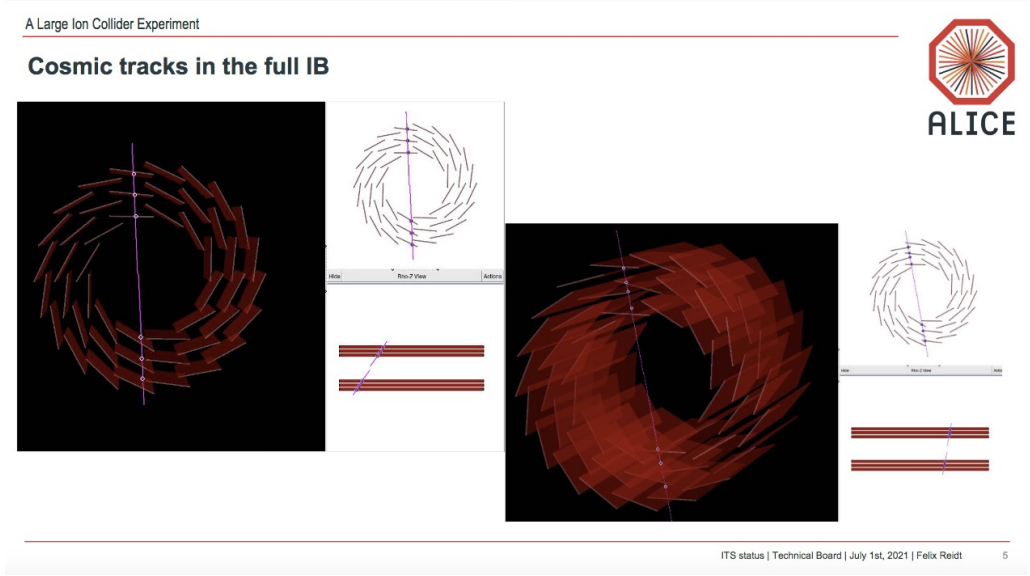


Attività 2021-2022

1. ITS2@CERN: *standalone commissioning* in caverna e global *commissioning* in ALICE da luglio 2021
2. Global *commissioning* (luglio-novembre) maggiormente in presenza da stati EU
3. *Pilot Beam Test Run* (~ 10-20h@few kHz, @450GeV, 10^7– 10^8 eventi) durante la *week 42-43*

Ad oggi: 4 mesi di commissioning globale partendo da luglio 2021 → 3 mesi di contingency rispetto alla chiusura della caverna prevista per il 21/02/22

2022: presa dati + analisi dati & produzione articoli



Contributo tecnici per test silici

Contributo A. Saputi per meccanica (cooling) ITS 3

Nessuna richiesta ai servizi

Richieste economiche principalmente di missioni (circa 60k per 2022):

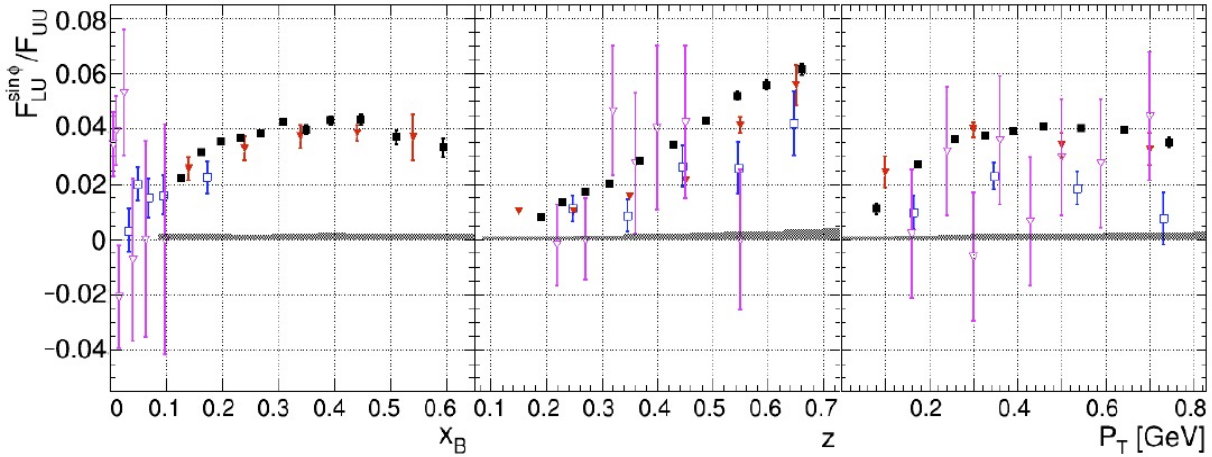
1. turni presa dati ALICE, supporto/oncall ITS2
2. riunioni/discussioni fisica per ITS3
3. riunioni MB, CB, TB e analisi

Physics activity at Jefferson Lab in Hall B with the CLAS12 detector

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

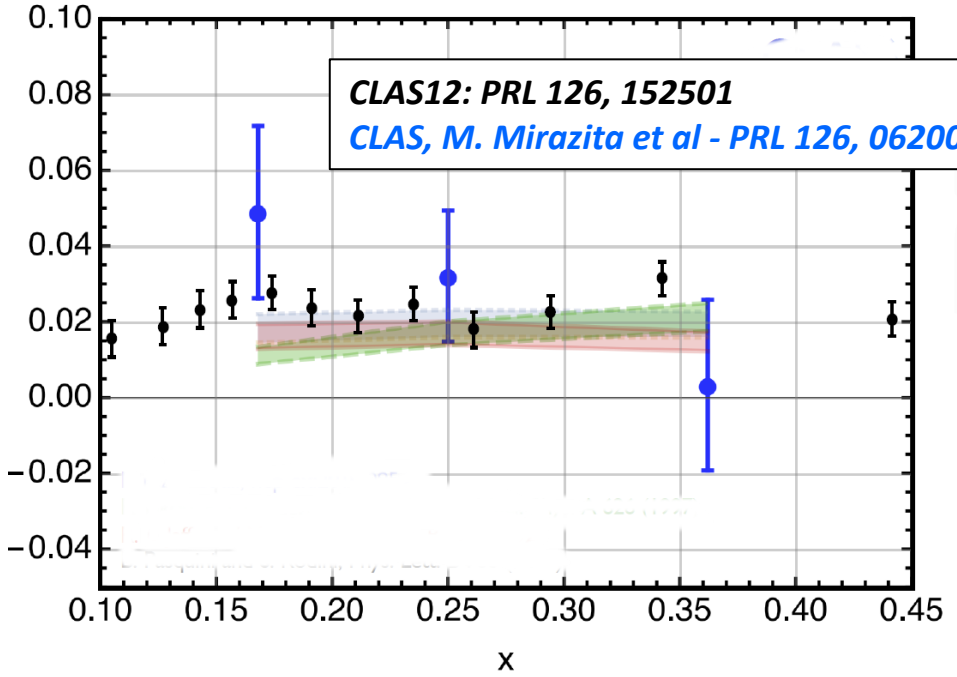
1. study of the 3D structure of the nucleon in eN scattering: semi-inclusive and exclusive measurements in the the Deep Inelastic Scattering region
2. extraction of partonic functions (GPDs, TMDs)

Beam spin asymmetry in single pion semi-inclusive electroproduction



***CLAS12: arXiv:2101.03544 [*hep-ex], under review on PRL**
CLAS **Hermes** **Compass**

Beam spin asymmetry in two pion semi-inclusive electroproduction

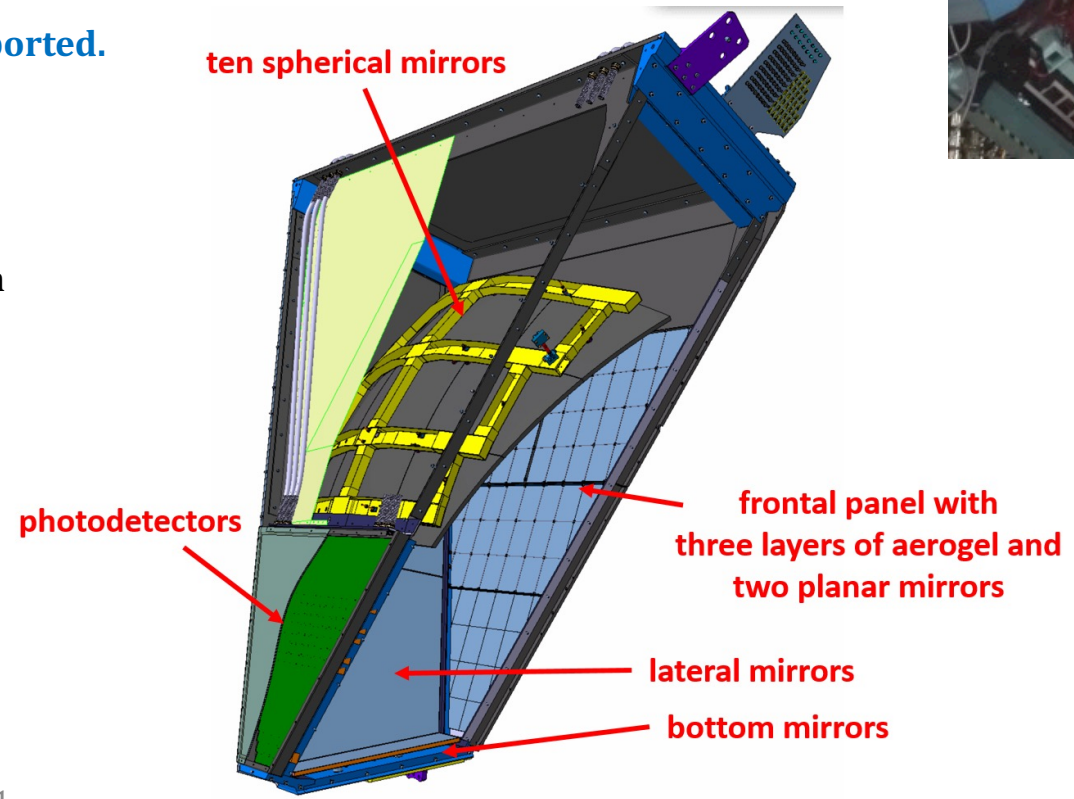


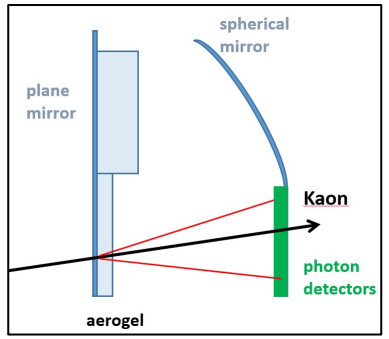
The CLAS12 RICH detector

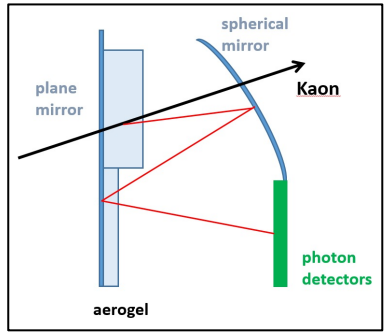
1. **Extend PID capabilities of CLAS12 to kaons in the 3÷8 GeV/c momentum range**
2. **Hybrid solution: proximity gap plus mirror focusing**
3. **First module installed in January 2018 → smoothly operated since then.**
4. **No major hardware problem have been reported.**

System specifications

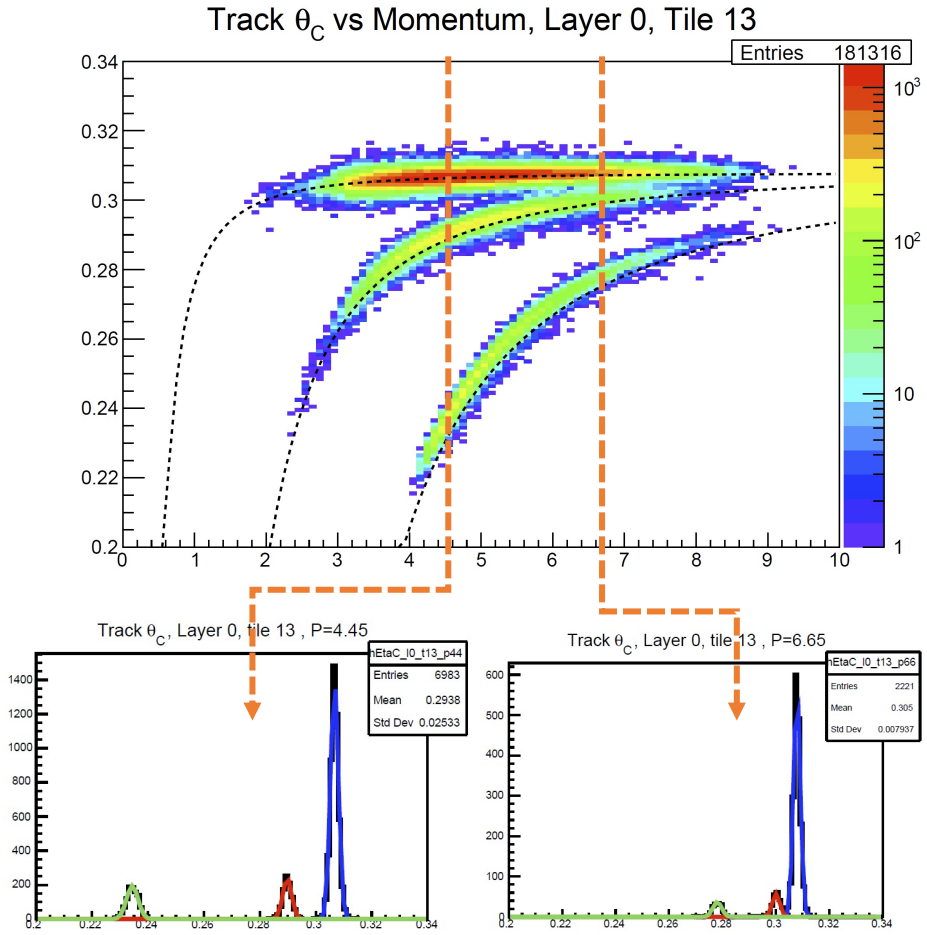
- Time resolution
  - Better than 1 ns to distinguish direct from reflected photons
- Cherenkov angle resolution (spe)
  - Direct photons: 4.5 mrad
  - Reflected photons: 5 mrad
- Particle identification
  - π/K rejection better than 500 for p 3÷8 GeV/c
  - p/K rejection better than 100 for p 3÷8 GeV/c







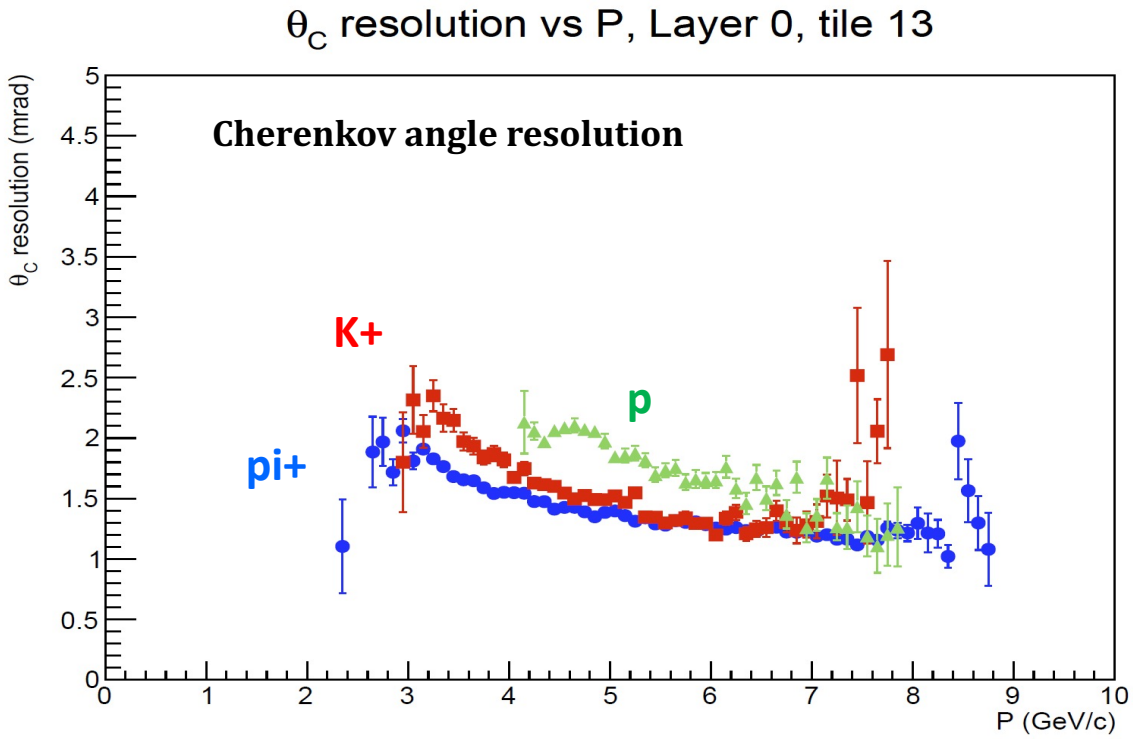
Particle ID with the RICH



4.5 GeV/c **6.7 GeV/c**

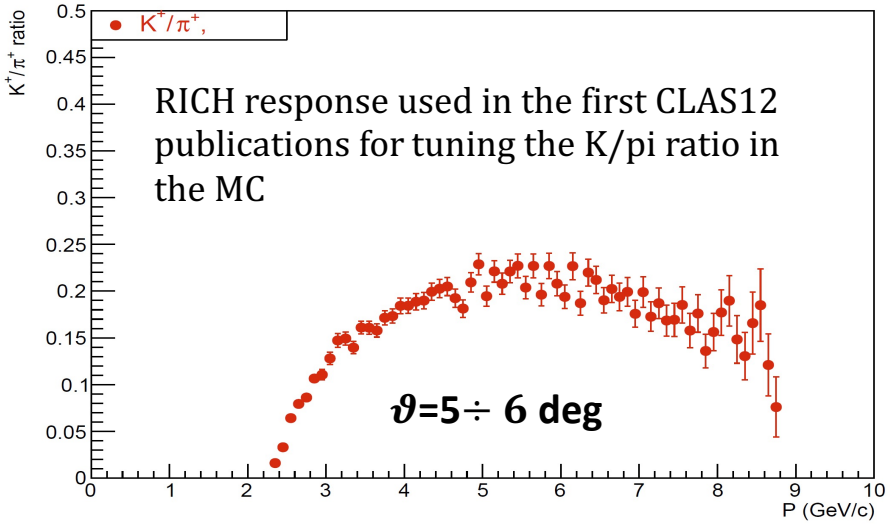
π/K well separated up to 7 GeV/c

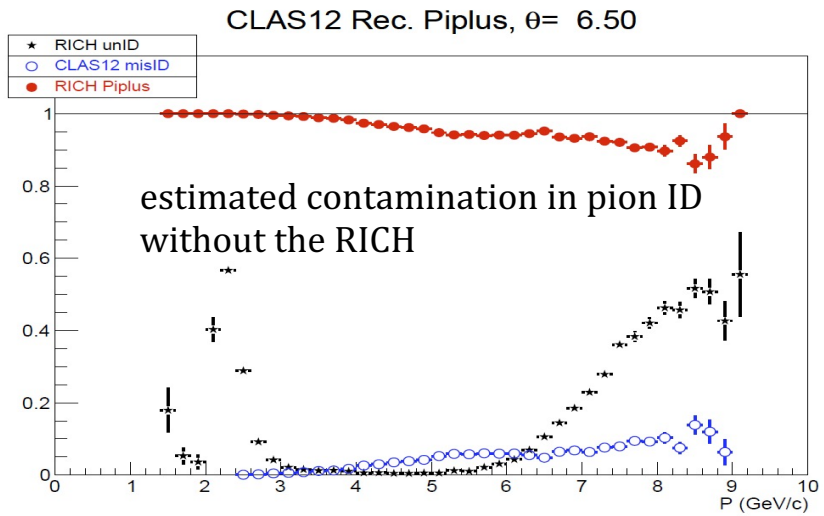
representative plots for one aerogel tile and direct photons
→ working on the alignments for reflected photons



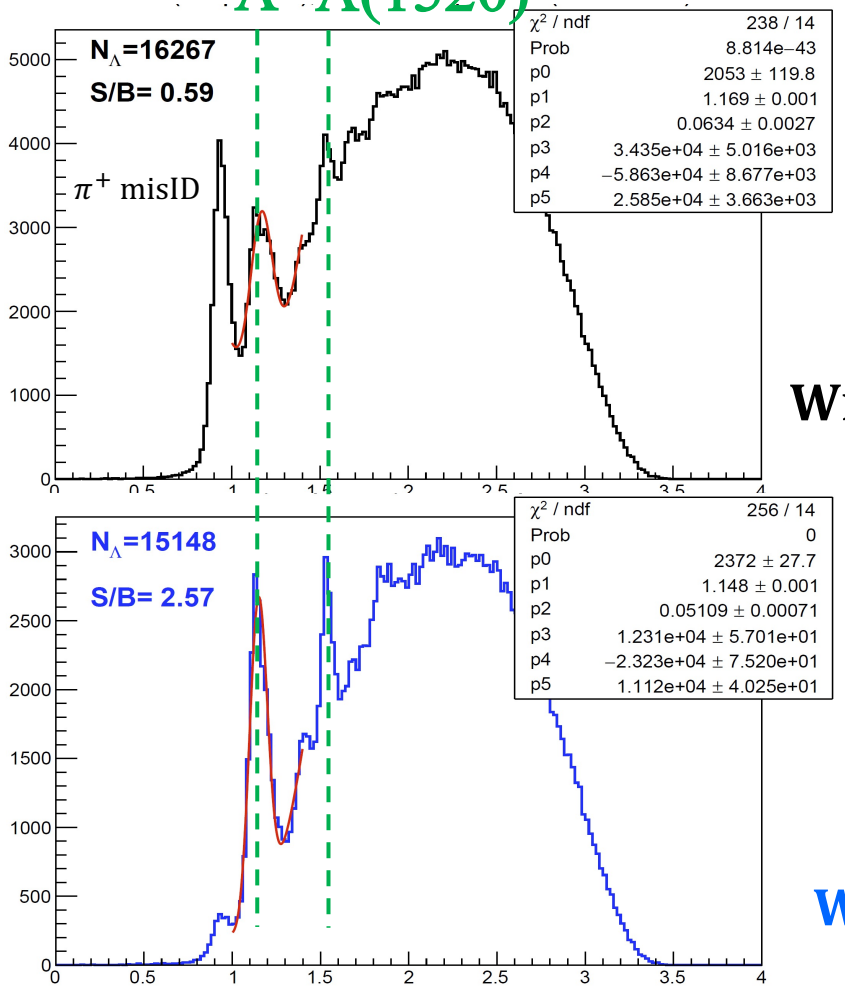
similar resolution for pions and kaons

Kaon ID with the RICH





Λ $\Lambda(1520)$



missing mass in $ep \rightarrow eK^+X$

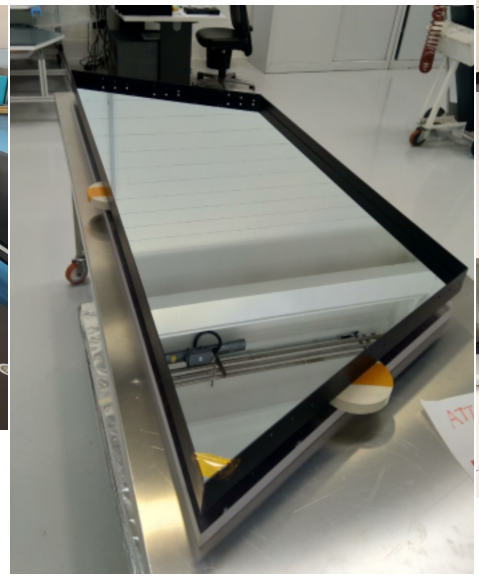
Without RICH

With RICH

Second RICH module

Completion of the production of the components expected by the end of this year. Installation foreseen before May 2022 (starting of polarized target data taking)

- mechanical structure: done
- aerogel: production completed, 20% to be shipped to JLab
- planar mirrors: done
- spherical mirrors: 6/10 mirrors done
  coating of the reflecting surface to be done
  supporting frame in production
- photomultipliers: 374/400 ready (INFN+JLab)
- electronics: FE almost completed (INFN), DAQ in production (JLab)
- services: in production (JLab)



Plans and requests

Attività per il 2022 focalizzata su

1. installazione e commissioning del secondo modulo del RICH nella prima metà del 2021
2. completamento validazione delle performance di PID attese con dati del primo modulo

Le richieste finanziarie per il 2022 sono essenzialmente per

- componenti minori del secondo RICH ancora da acquistare
- spedizione di material al JLab
- metabolismo per maintenance dei due moduli del rivelatore
- missioni al JLab per tecnici/tecnologi/ricercatori
-
  - apparati+consumi+trasporti: ~20 k
  - missioni: 35 k

Richieste da discutere nella riunione nazionale di JLAB12

Richieste ai servizi LNF→ attività di assemblaggio e installazione del RICH

Ricercatori/Tecnologi

1.	**M. Mirazita**	**0.9**
2.	P. Rossi (congedo)	0
3.	O. Soto (postdoc)	1.0
4.	S. Tomassini	0.3

Tecnici

D. Orecchini 0.5

Richieste economiche

- apparati + consume + trasporti: ~ 20 k
- missioni: 35 k

EIC_net: LNF activities

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

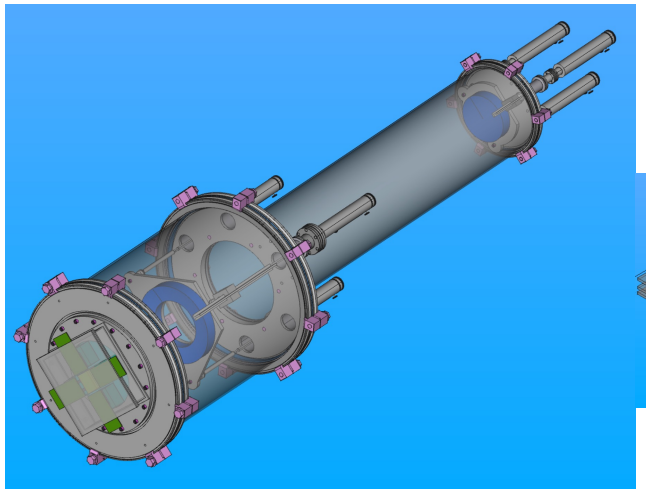
R&D activity on the particle identification detectors: dual RICH (dRICH) for hadron ID from few GeV/c up to 60 GeV/c:

1. aerogel radiator for low momentum region

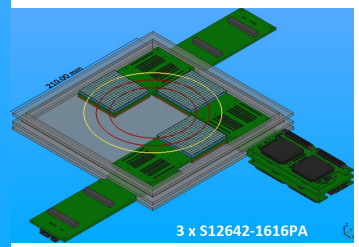
2. gas radiator for high momentum region

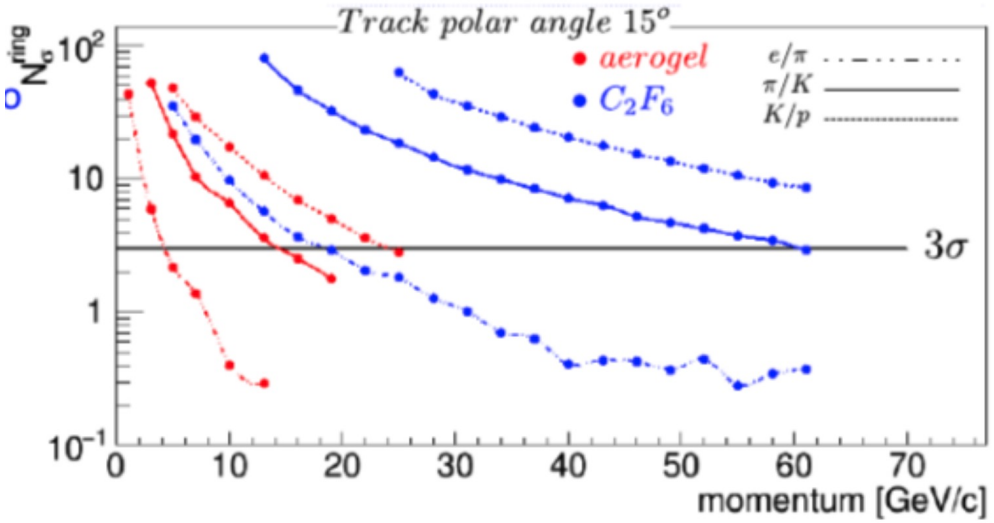
Construction of a prototype for two test beam at CERN in sept/oct 2021:

- validate the dual radiator concept
- compare SiPM with Multi-Anode PMTs
- study the effects of high radiation level on the SiPM response



entrance window to host various photodetectors





Attività 2022:

1. analisi dati test beam
2. eventuale preparazione di un altro test beam al CERN

Ricercatori/Tecnologi
1. M. Mirazita 0.1

Richieste economiche
- missioni: 1 keuro (sotto DTZ)

Open Dipole + BGO calorimeter @Bonn

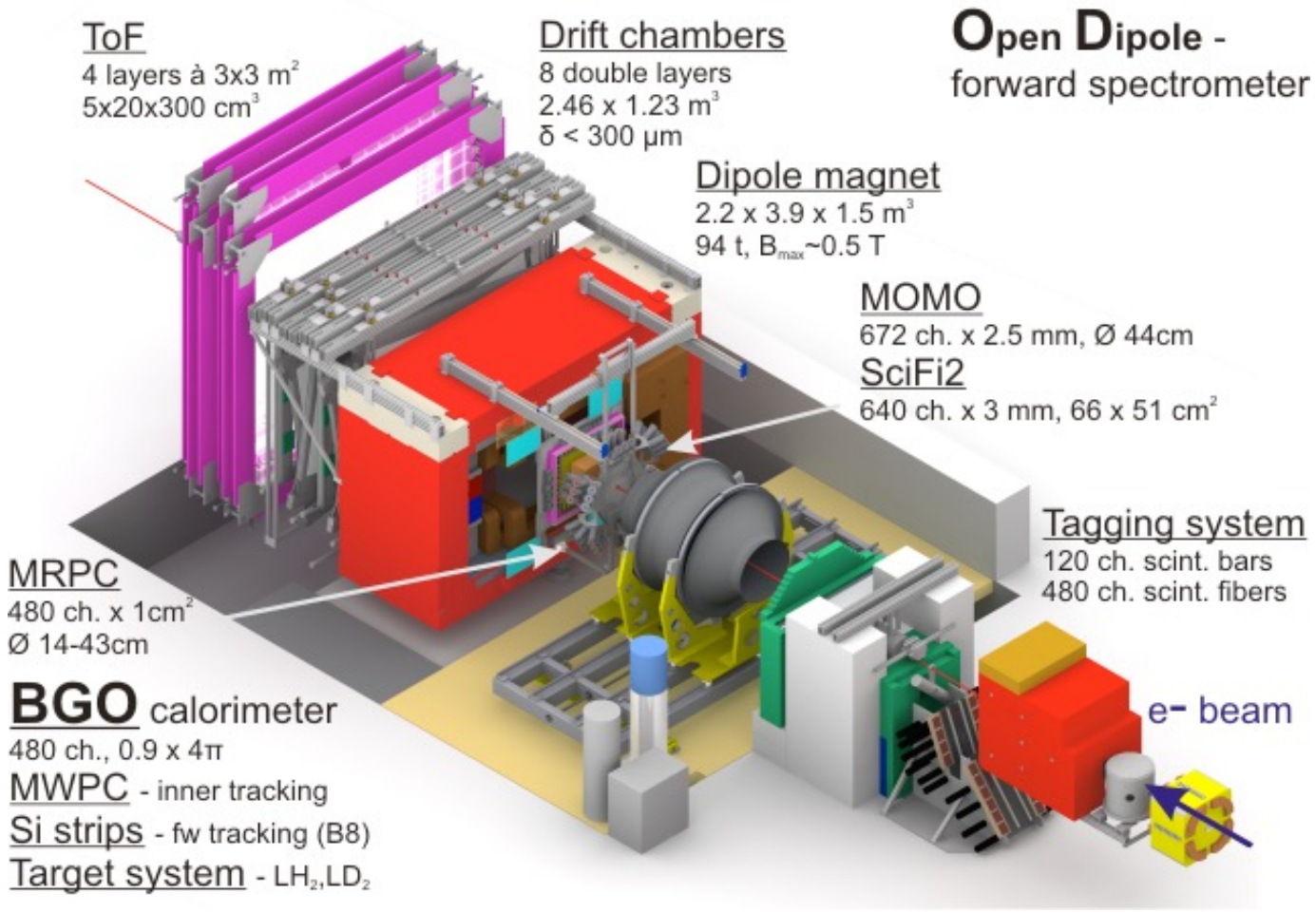
Nucleon excited states via meson photoproduction at MAMIc (A2@Mainz) and ELSA (BGOOD@Bonn)

- Transition form factor
- η' threshold anomaly
- International collaboration: Bonn PI, Bonn HISKP, ISS, LNF, Messina(not INFN), Pavia, Roma2, Torino, Glasgow, Basel, PNPI Gatchina, INR Mosca, IHENP Kharkov, Lamar U. (Texas)

LNF responsibilities (Levi Sandri):

1. **Co-spokesperson BGOOD**
2. **RN**
3. **η' beam asymmetry and x-sect**

hardware responsibilities
- BGO (+ Roma2)
- Barrel (+ ISS)
- MRPC (+ Roma2)



2 researchers for 1.2 FTE
Total INFN ~ 11 FTE

BGOOD status

INFN task status:

All detectors under INFN supervision (Barrel Calorimeter MWPC) are working, but for the MRPC in its final commissioning

MonteCarlo & event generator under development (LNF/Messina/Roma2)

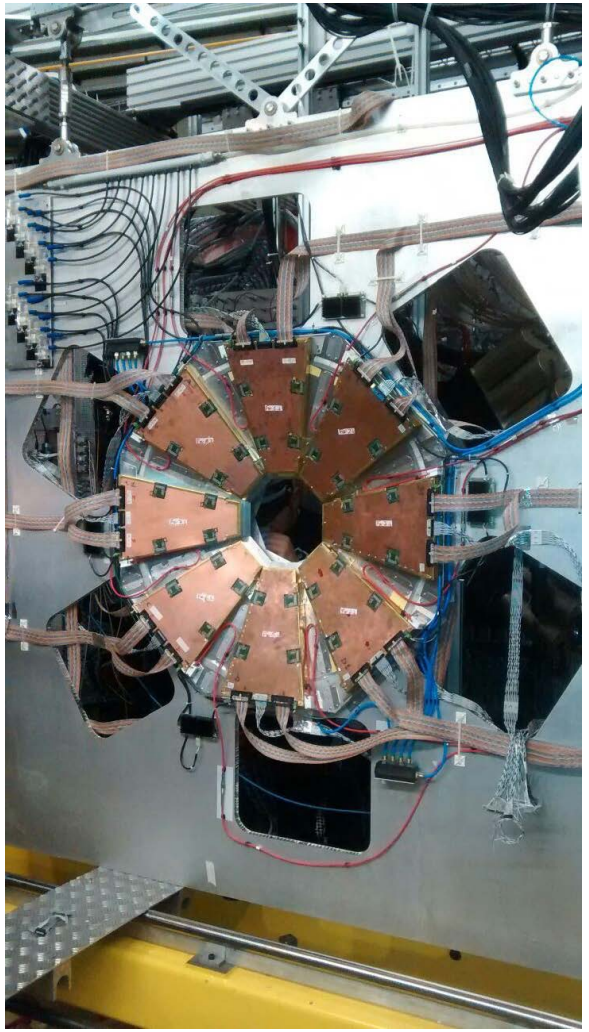
Co-spokespersonship of the BGOOD (LNF)

Spokesperson of the η' photoproduction measurement (LNF).

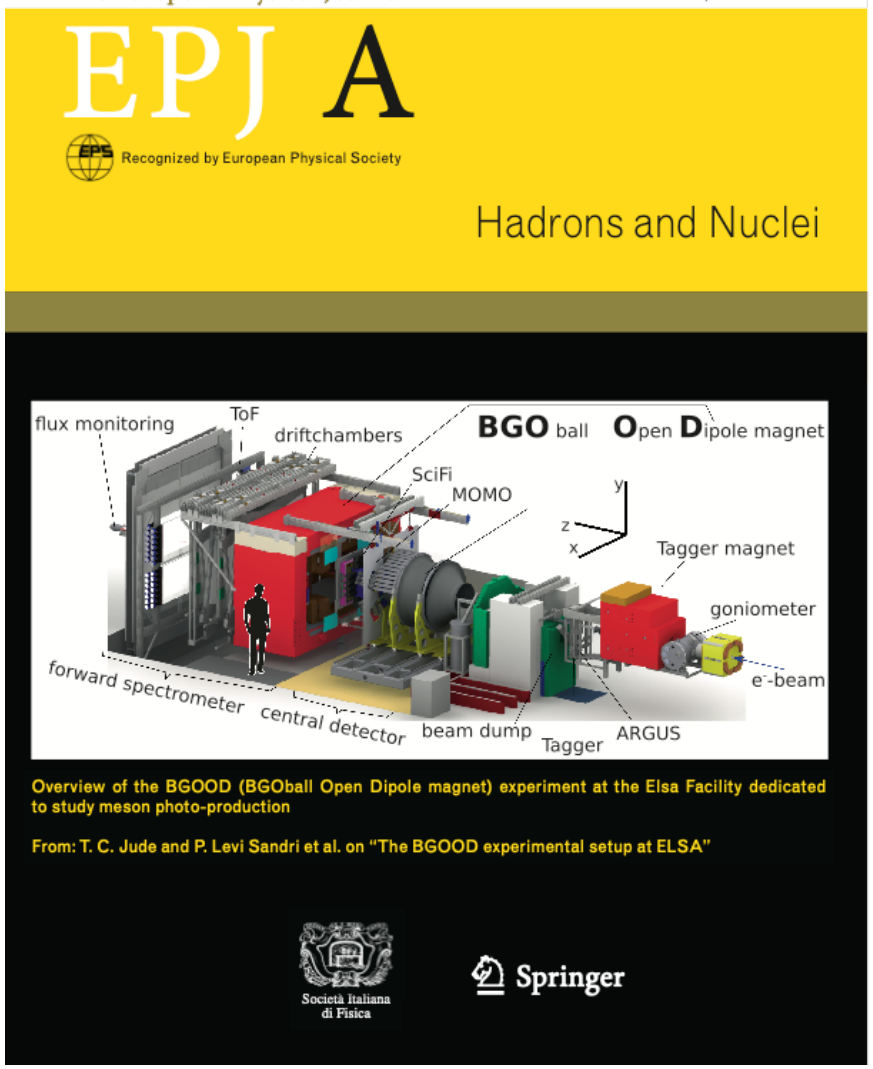
RN (LNF)

December 2018: Klystron issue → no beam in 2019

No data-taking in 2020



LNF activities



Eur. Phys. J. A (2020) 56:104

$K^+\Lambda$ photoproduction at forward angles and low momentum transfer

S. Alef[1], P. Bauer[1], D. Bayadilov[2,3], R. Beck[2], A. Bella[1,a], J. Bieling[2,a], A. Braghieri[4], P.L. Cole[5], D. Elsner[1], R. Di Salvo[6], A. Fantini[6,7], O. Freyermuth[1], F. Frommberger[1], F. Ghio[8,9], S. Goertz[1], A. Gridnev[3], D. Hammann[1,a], J. Hannappel[1,b], T.C. Jude[1,c], K. Kohl[1], N. Kozlenko[3], A. Lapik[10], P. Levi Sandri[11], V. Lisin[10], G. Mandaglio[12,13], F. Messi[1,a], R. Messi[6,7], D. Moricciani[11], V. Nedorezov[10], V.A Nikonov[2,3,d], D. Novinskiy[3], P. Pedroni[4], A. Polonskiy[10], B.-E. Reitz[1,a], M. Romaniuk[6,14], A.V Sarantsev[2,3], G. Scheluchin[1], H. Schmieden[1], A. Stuglev[3], V. Sumachev[3,d], V. Vegna[1,a], V. Tarakanov[3], and T. Zimmermann[1,a]

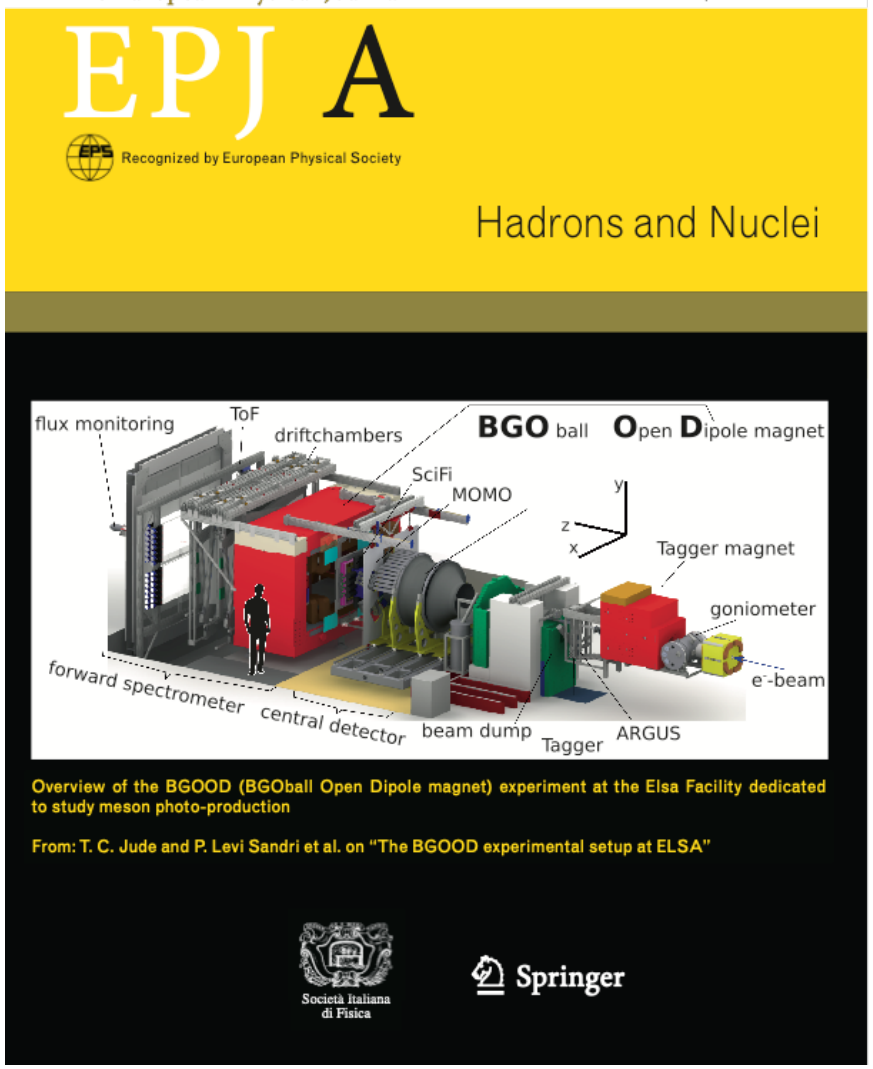
Eur. Phys. J. A (2021) 57:80 ($\gamma p \rightarrow K^+\Sigma^0$)

Observation of a cusp-like structure in the $\gamma p \rightarrow K^+\Sigma^0$ cross section at forward angles and low momentum transfer

T.C. Jude[a,*], S. Alef[a], P. Bauer[a], D. Bayadilov[b,c], R. Beck[b], A. Bella[a,1], J. Bieling[b,1], A. Braghieri[d], P.L. Cole[e], D. Elsner[a], R. Di Salvo[f], A. Fantini[f,g], O. Freyermuth[a], F. Frommberger[a], F. Ghio[h,i], S. Goertz[a], A. Gridnev[c], D. Hammann[a,1], J. Hannappel[a,2], K. Kohl[a], N. Kozlenko[c], A. Lapik[j], P. Levi Sandri[k], V. Lisin[j], G. Mandaglio[l,m], F. Messi[a,1], R. Messi[f,g], D. Moricciani[k], V. Nedorezov[j], V.A Nikonov[b,c,3], D. Novinskiy[c], P. Pedroni[d], A. Polonskiy[j], B.-E. Reitz[a,1], M. Romaniuk[f,n], A.V Sarantsev[b,c], G. Scheluchin[a], H. Schmieden[a], A. Stuglev[c], V. Sumachev[c,3], V. Vegna[a,1], V. Tarakanov[c], T. Zimmermann[a,1]

arXiv:2006.12350v1 ($\gamma p \rightarrow K^+\Lambda$)

LNF activities



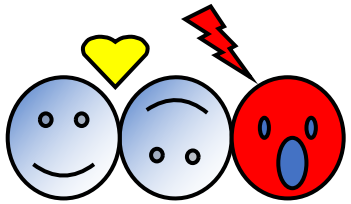
Eur. Phys. J. A (2020) 56:104

Causa guasto ed emergenza COVID PI e Università di Bonn garantiscono il funzionamento di ELSA per esperimenti fino a tutto il 2022 (#2 Finanziamenti DFG approvati). ELSA ha ripreso il normale funzionamento per esperimenti di fisica adronica

Chiesto e ottenuto il prolungamento della sigla per altri 4 anni in CSN3:

1. 2022: richieste 1500 ore di *beam-time* per completare la raccolta dati su bersaglio di idrogeno e di deuterio
2. 2023: misure su Li-6, C-12
3. 2024: possibile estensione per completamento statistiche.

Richieste finanziarie 25k€		**2 Ricercatori e Tecnologi, 1.2 FTE**
Consumo	10 k€	**Richieste ai servizi**
Inventariabile	0 k€	
Manutenzione	0 k€	Nessuna salvo imprevisti
Missioni	15 k€	



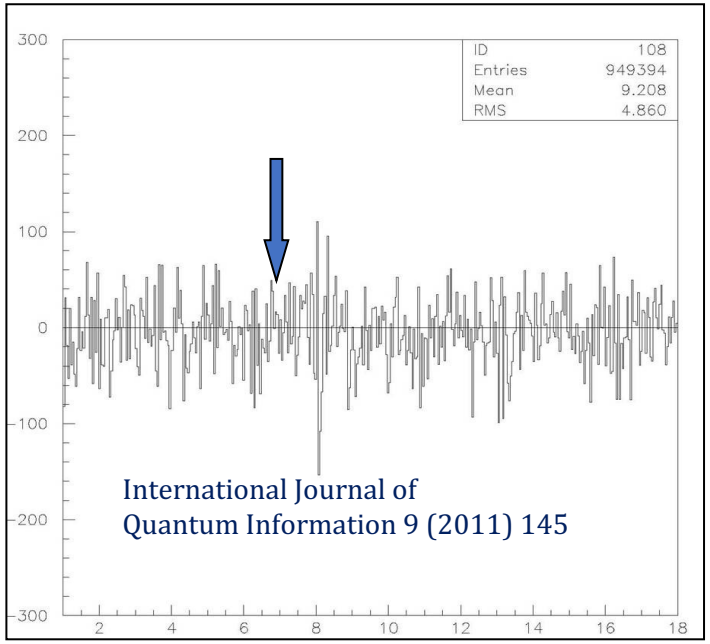
VIP: LNF activities

14 researchers for **7.3 FTE**
Average participation of 52%

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

VIP=Violation Pauli Exclusion Principle (PEP)

- Perform experimental test of PEP for e- at LNGS to reduce X-ray background
- International collaboration: LNF, LNGS, Ts Univ. and INFN; SMI-OAW (Austria); IFIN-HH (Romania); Neuchatel U. (Switzerland); Uni & INFN BO; Fudan Univ. (China), Chengdu Univ. (China); IAS Princeton; Wigner Institute
- **VIP already established a probability of PEP violation b2/2<4x10-29** → previous limit <1.7x10-26 PLB 328 (1990) 438 ⇒ **VIP-2 aims at an improvement of at least 2 orders of magnitude**
- VIP upgrade (CCD detectors replaced by SDD) : VIP-2 in data taking at LNGS
- Other tests of Quantum Mechanics (collapse models) and quantum applications → collaboration with Roger Penrose, Steve Adler



1.	M. Bazzi	0.3
2.	M. Benfatto	0.5
3.	A. Clozza	0.3
4.	**C. Curceanu**	**0.3**
5.	R. Del Grande	1.0
6.	J. Marton	0.5
7.	M. Miliucci	0.3
8.	E. Pace	0.8
9.	**K. Piscicchia**	**1.0**
10.	D. Sirghi	0.3
11.	A. Addazi	0.5
12.	M. Bragadireanu	0.5
13.	F. Napolitano	0.8
14.	A. Marciano	0.5
+	C. Guaraldo	0

VIP-2 ⇒ new detectors SDD:

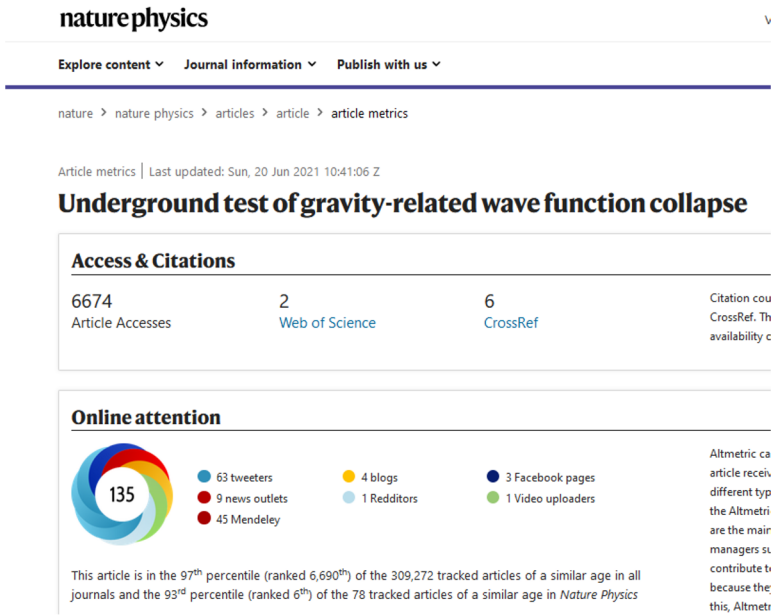
1. higher resolution: 190eV (fwhm)
2. faster (triggerable) ⇒ VETO system
3. higher acceptance
4. higher current ⇒ low background
5. higher efficiency

ALL Responsabilities @LNF
Spokeperson: C. Curceanu, RN: K. Piscicchia

16 Publications (2020-2021) – *Nature Physics 17 (2021) 1, 74-78*
External projects: *EU FET – TEQ, Centro Fermi, Foundational Questions Institute FQXi, John Templeton Foundation*

Main publications & conferences

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati



Copertina SAPERE
C. Curceanu, K. Piscicchia

TOP 10 mondiale per

1. Our favorite science news stories of 2020:

Science - sciencemag.org (al numero 2 subito dopo una ricerca su virus):

https://www.sciencemag.org/news/2020/12/our-favorite-science-news-stories-2020-non-covid-19-edition

2. puorlascience.org (Les 10 articles que vous avez prfrs en 2020) al numero 9:

https://www.pourlascience.fr/sr/actualites/les-10-articles-que-vous-avez-preferes-en-2020-20609.php

Main publications & conferences

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Exploring Quantum Boundaries

Workshop: Is Quantum Theory exact? Exploring Quantum Boundaries.

10-11 December 2020
Europe/Rome timezone

https://agenda.infn.it/event/24187/overview, **with over 150 participants**

Nobel Laureate R. Penrose Guest Lecture

TOP 10 mondiale per

1. Our favorite science news stories of 2020:

Science - sciencemag.org (al numero 2 subito dopo una ricerca su virus):

https://www.sciencemag.org/news/2020/12/our-favorite-science-news-stories-2020-non-covid-19-edition

2. puorlascience.org (Les 10 articles que vous avez prfrs en 2020) al numero 9:

https://www.pourlascience.fr/sr/actualites/les-10-articles-que-vous-avez-preferes-en-2020-20609.php

Copertina SAPERE
C. Curceanu, K. Piscicchia

VIP-2 setup at LNGS and status

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

1. VIP-2 version 1 with 6 SDDs (SIDDHARTA type) installed at LNGS end of 2015 – data taking (no shielding) till end of 2017 (**Eur. Phys. J. C (2018) 78: 319**)

2. VIP-2 with upgraded SDDs (4 arrays of 2x4 SDD detectors) installed at LNGS in April 2018; tests and data taking without shielding till November 2018

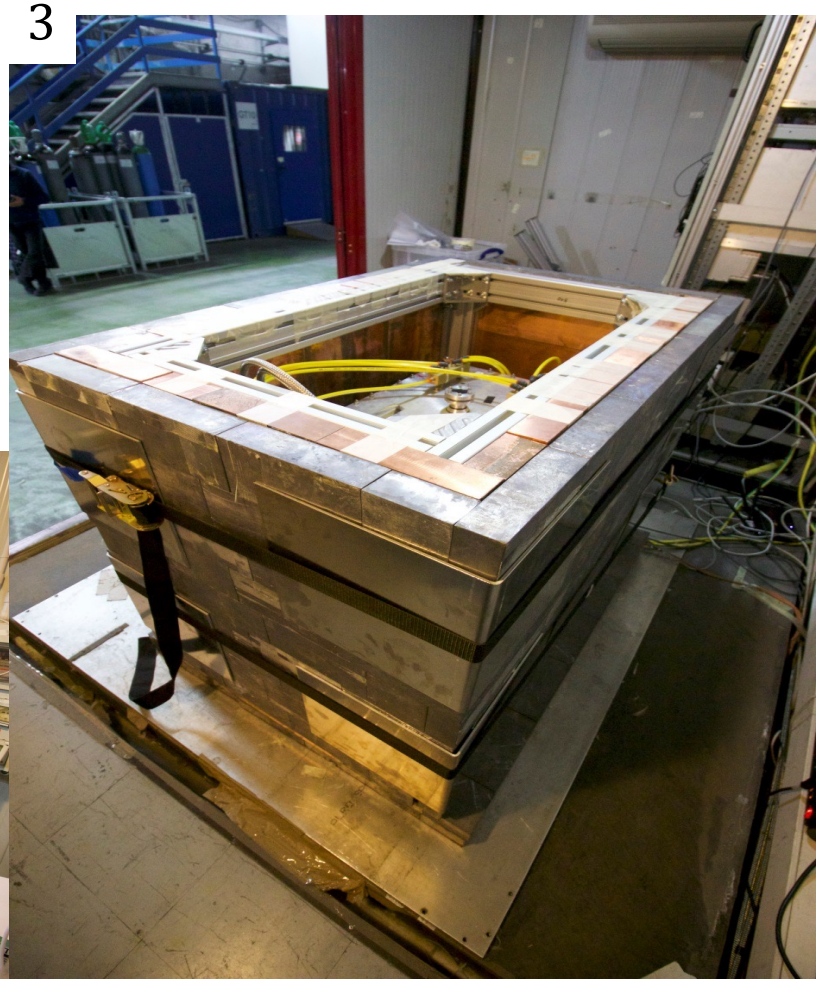
3. Shielding (Cu and Pb) installed in November 2018 – **data taking ongoing** (with and without current) thanks to the slow-control remote system

4. Optimization of the shielding ongoing (MC, veto system); strategy of data taking optimization

1

2

3



October2019 – present: data analysis (shielding)

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Laboratori Nazionali di Frascati

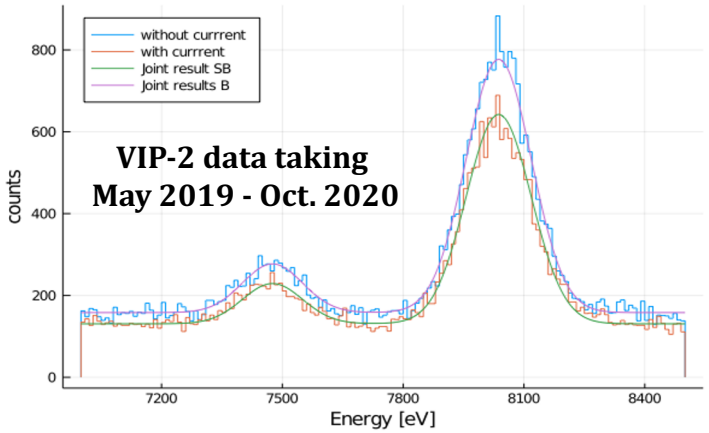
Simultaneous Bayesian of the two spectra, accounts for uncertainties on the parameters of the signal and background shapes, and normalization of the current on/off spectra

$$\mathcal{L} = P(\text{data}_{wc}, \text{data}_{woc}|S, B, s, \theta_S, \theta_B) = P(\text{data}_{wc}|S, B, \theta_S, \theta_B) \cdot P(\text{data}_{woc}|B, s, \theta_B)$$

$$P(\text{data}_{wc}|S, B, \theta_S\theta_B) = \prod_{i=1}^{N} \frac{\lambda_i(S, B, \theta_S\theta_B)^{nwc}_i e^{-\lambda_i(S,B,\theta_S\theta_B)}}{n_i^{wc}!} \qquad P(\text{data}_{woc}|B, s, \theta_B) = \prod_{i=1}^{N} \frac{\lambda_i(B, s, \theta_B)^{nwoc}_i e^{-\lambda_i(S,B,\theta_S,\theta_B)}}{n_i^{woc}!}$$

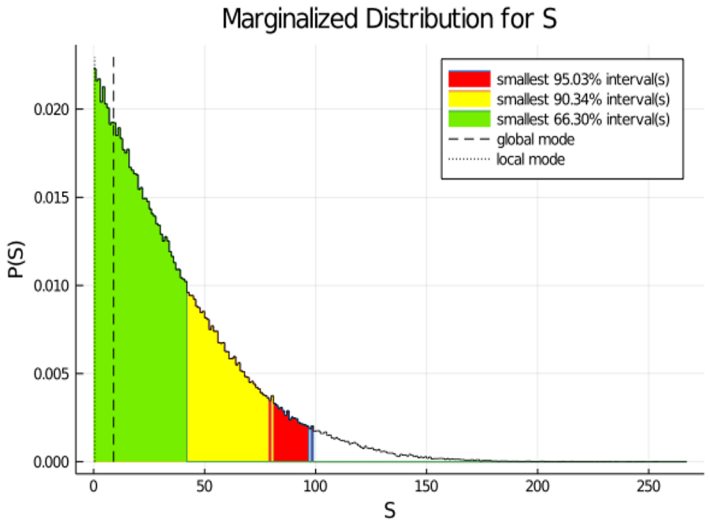
ϑ_S, ϑ_B: vectors of parameters of the signal and bkg shapes; s = scale parameter.

$$P(S, B, s, \theta_S, \theta_B|\text{data}_{wc}, \text{data}_{woc}) = \frac{\mathcal{L}}{N} P_0(S) \cdot P_0(B) \cdot P_0(s) \cdot P_0(\theta_S) \cdot P_0(\theta_B)$$



Upper limit on the PEP violation probability (90% CL): $\beta^2/_2 < 6 \times 10^{-31}$

Two orders of magnitude improvement w.r.t. VIP

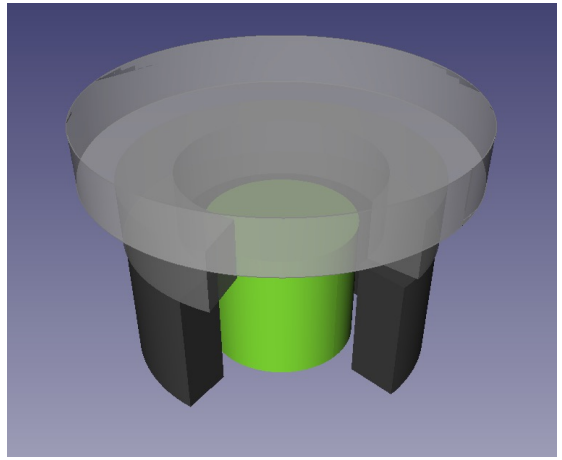


VIP Lead (closed systems)

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

High purity Ge detector measurement (M. Laubenstein):

- Ge detector surrounded by roman lead target + complex electrolytic Cu + Pb shielding
- 10B-polyethylene plates reduce the neutron flux towards the detector
- Shield + cryostat enclosed in airtight steel housing flushed with nitrogen to avoid contact with external air (and thus radon)



Extremely low bkg in the two regions of interest, compatible with the mean bkg: b = 3 counts/0.5 keV

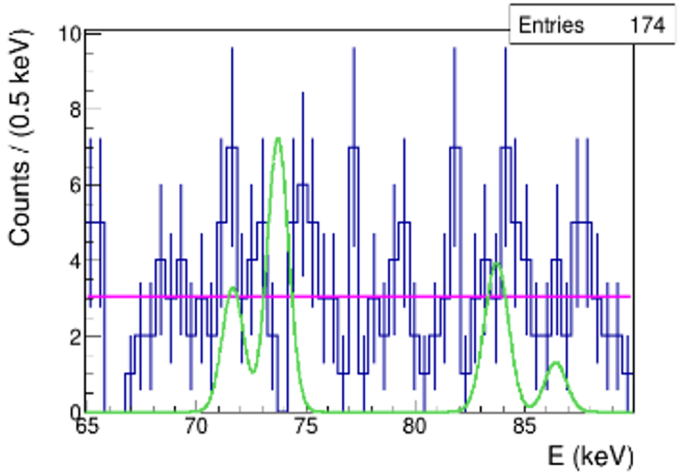
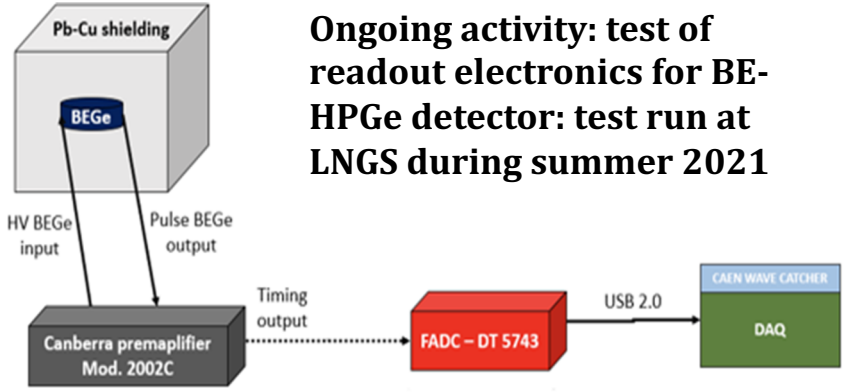


FIG. 1. The measured X-ray spectrum, in the region of the K_α and K_β standard and violating transitions in Pb, is shown in blue; the magenta line represents the fit of the background distribution. The green line corresponds to the shape of the expected signal distribution (with arbitrary normalization) for the A_3 analysis and the M_3 parametrization.

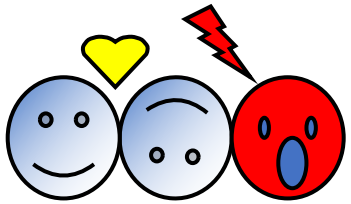
Strong implications on QG models:

- **k-Poncaré excluded far above the Planck scale**
- **θ-Poincaré - excluded up to 0.2 Planck scale**

Test of the Continuous Spontaneous Localization and gravity-related collapse models. Collaboration with: Lajos Diosi and Roger Penrose
FQXi and JTF grants



Ongoing activity: test of readout electronics for BE-HPGe detector: test run at LNGS during summer 2021



Future plans

Richieste finanziarie

Consumo	40 k€
Inventariabile	20 k€
Manutenzione	10 k€
Missioni	25 k€

Richieste ai servizi

Progettazione: 2 m.u. per supporteria/schermature; BEGe setup per future misure collasso

Officina meccanica: 2 m.u. per costruzioni supporterie, schermature, setup BEGe

Tecnici: 0.5 FTE installazioni e costruzioni varie

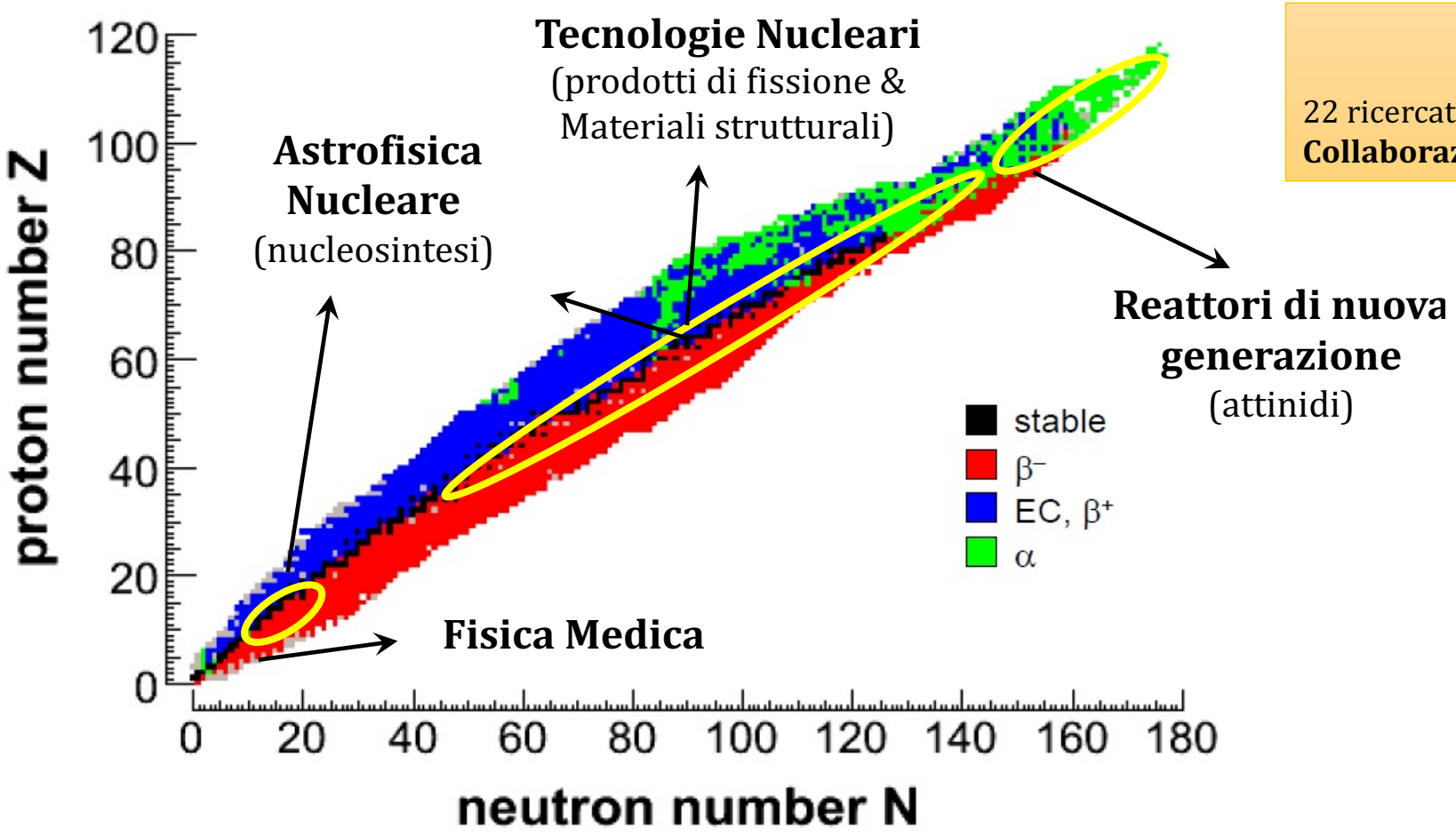
VIP-2 setup (open system)

- Finalize and submit for publication the papers on data analyses (at least 1 paper)
- Study and optimization of the shielding and data taking strategy
- Refined statistical data analyses continued
- Refined calculation electrons path inside bulk material
- Continuation of Monte Carlo simulations and studies for optimization of the run
- New SDD 1-mm setup preparation

VIP-Lead or other materials (closed system)

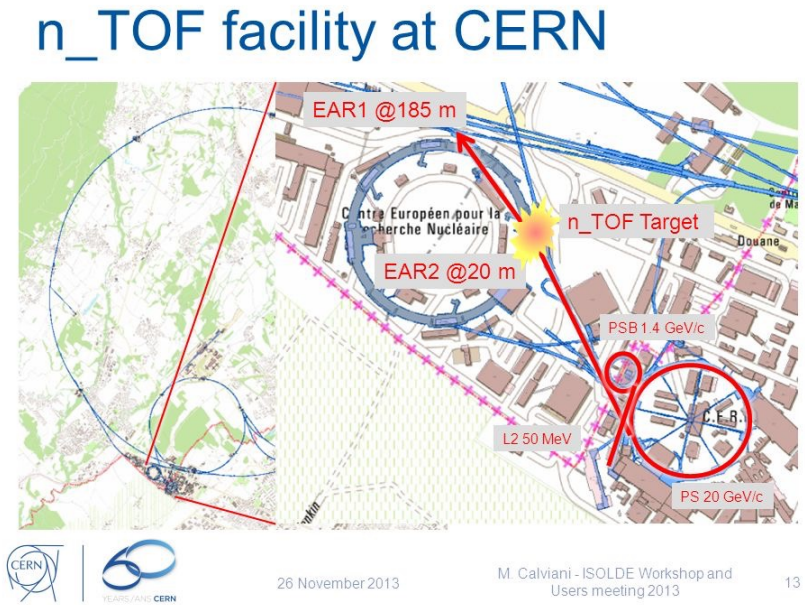
1. Finalize and submit for publication the paper on theoretical interpretation and VIP-lead results (*k-Poncaré excluded far above the Planck scale and θ-Poincaré - excluded up to 0.2 Planck scale*)
2. Refined data analyses for additional targets: V, Pt, Hf, Ta and study of the limit of PEP-violation on various materials
3. Intensive collaboration with theoreticians (in particular with Addazi and Marcianò) for the interpretation of the VIP-results and with Roger Penrose
4. Studies in Frascati laboratory of a possible setup to test anisotropy effects – quantum-gravity tests
5. Preparation of a new setup with a Broad Energy Ge detector
6. Dissemination activities: presentation of the VIP-2 results in at least 3 events (Workshops/conferences) and in dissemination events – such as Open Labs and in talks/seminars at schools.

Misura di precisione di sezioni d'urto di reazioni indotte da neutroni

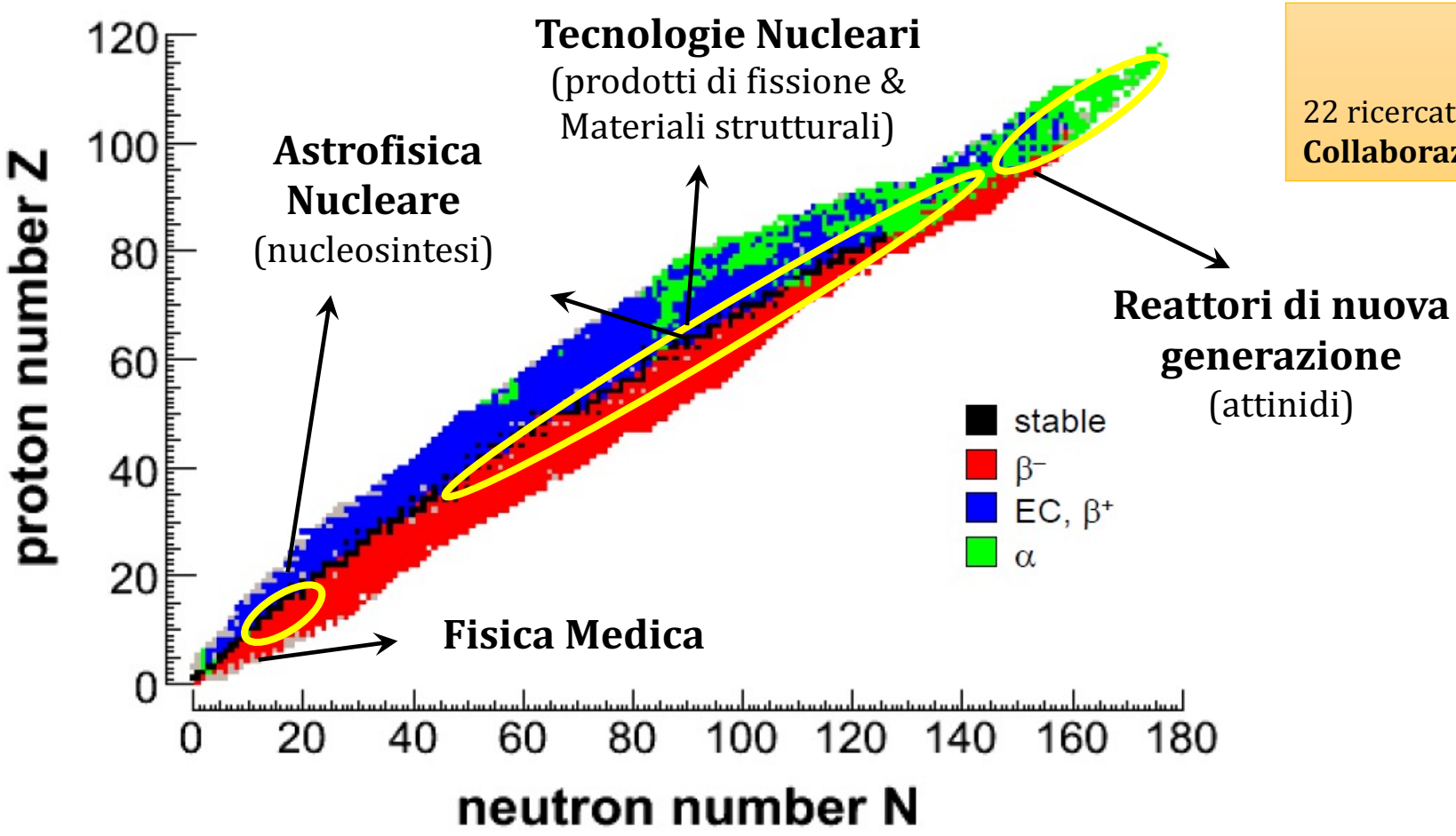


n_TOF Italia

22 ricercatori (INFN, Università), 15.5 FTE su 6 sedi INFN
Collaborazioni con ENEA-Bologna, INAF-Teramo, CNR-Bari



Misura di precisione di sezioni d'urto di reazioni indotte da neutroni



n_TOF Italia

22 ricercatori (INFN, Università), 15.5 FTE su 6 sedi INFN
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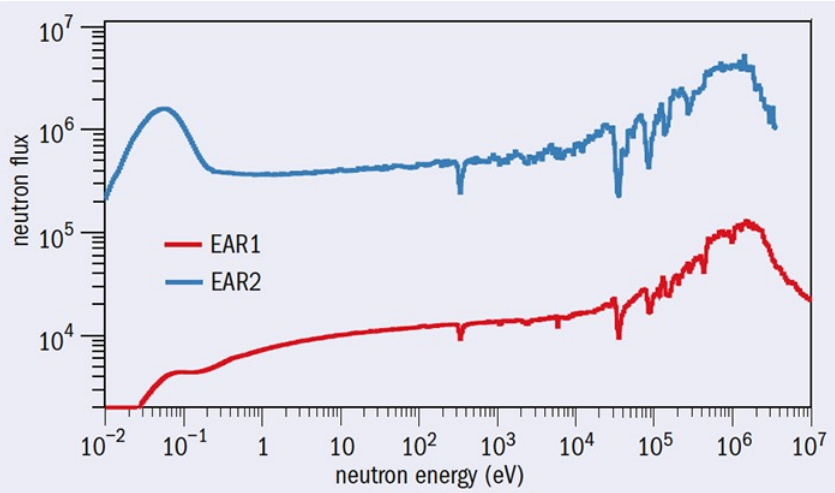


LNF per:

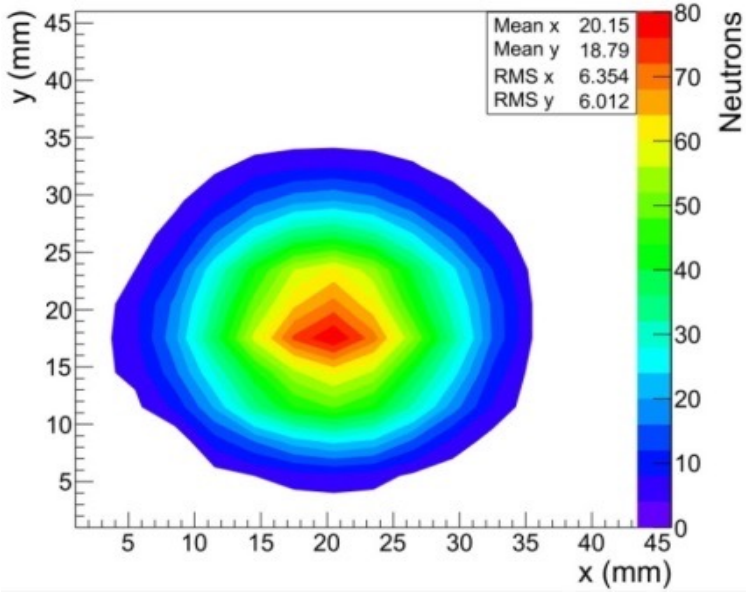
- **Beam monitor (area beam dump)**
- **nuovi rivelatori neutroni basati su GEM (Beam4Fusion)**

nTOF@LNF: GEM detector for neutrons

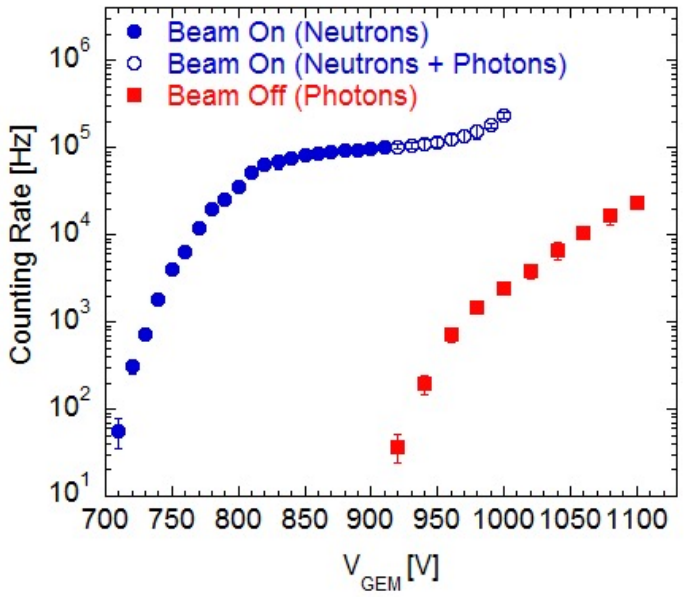
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

LNF has developed GEM detectors for thermal neutrons, based on the conversion on Boron coated cathode ($^{10}B(n,\alpha)\ ^{7}Li$) → good candidate for He^3 detector replacement:

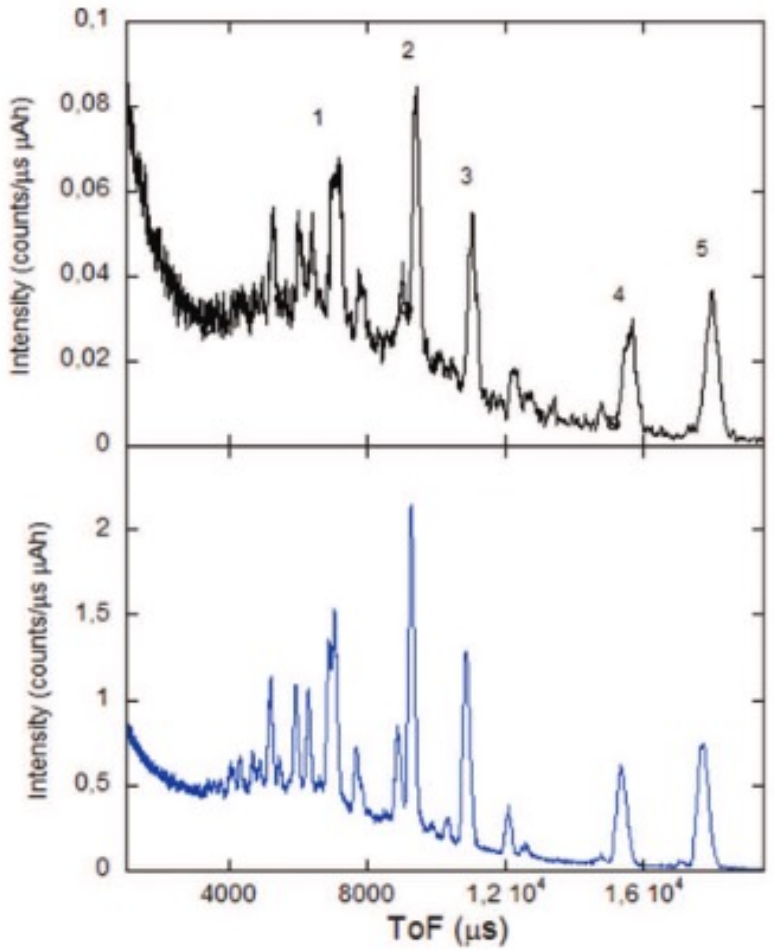
1. Imaging capability
2. good time resolution (5 ns),
3. high gamma rejection ($>10^5$)
4. high-rate capability O(10 MHz/cm^2)
5. good spatial resolution O(mm)



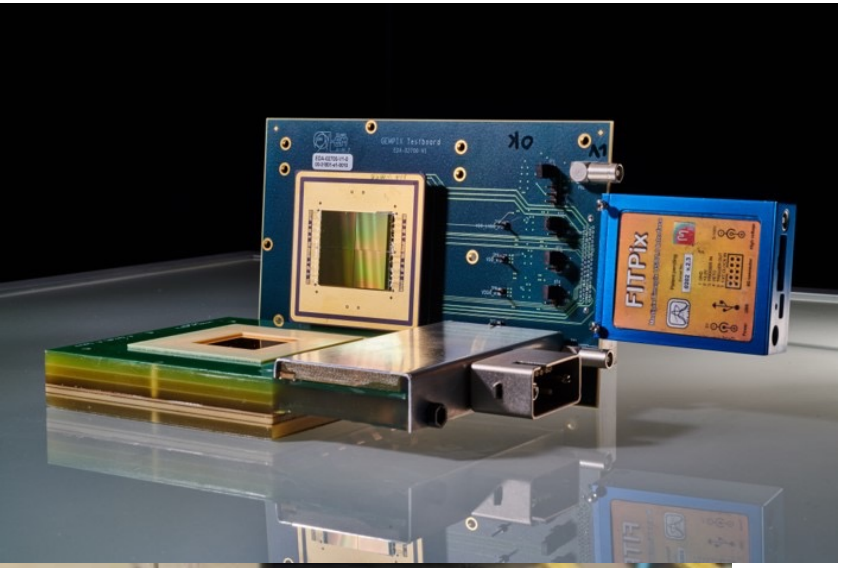
Gamma neutron rejection

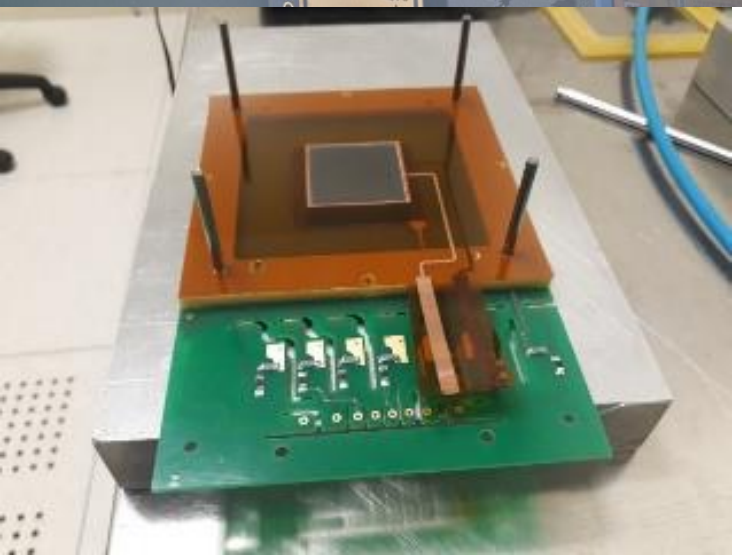


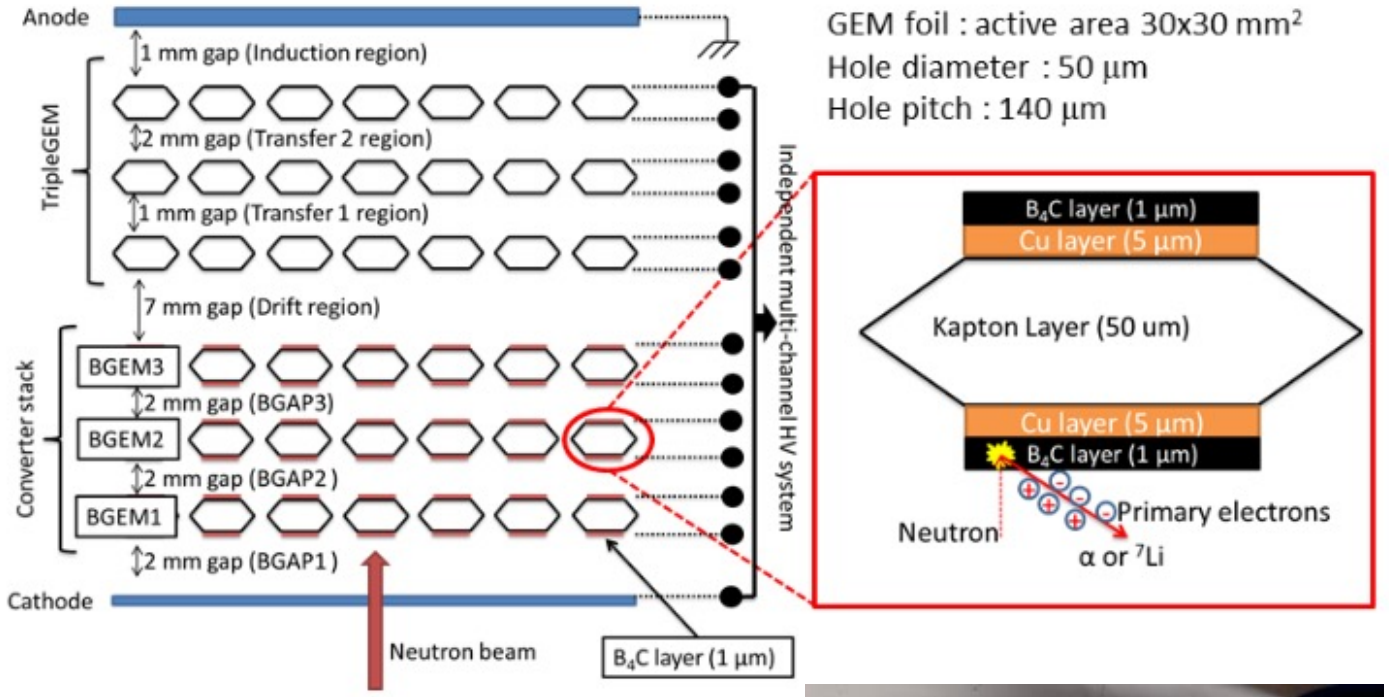
Diffraction Measurement at ISIS



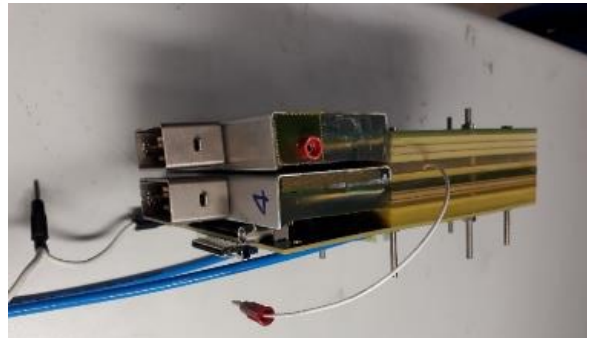
MBGEM Detector assembly







Assembling done in Frascati of two detectors with 2- and 3-mm gap between borated gem foils



MBGEM characterization published on EPJ+

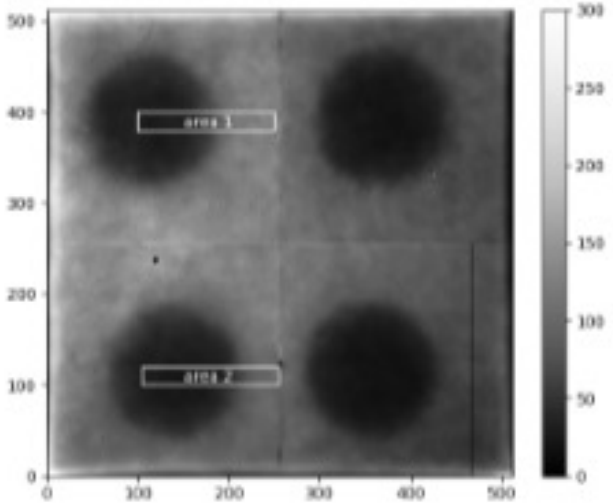
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

MBGEM : a stack of Borated GEM detector for high efficiency thermal neutron detection

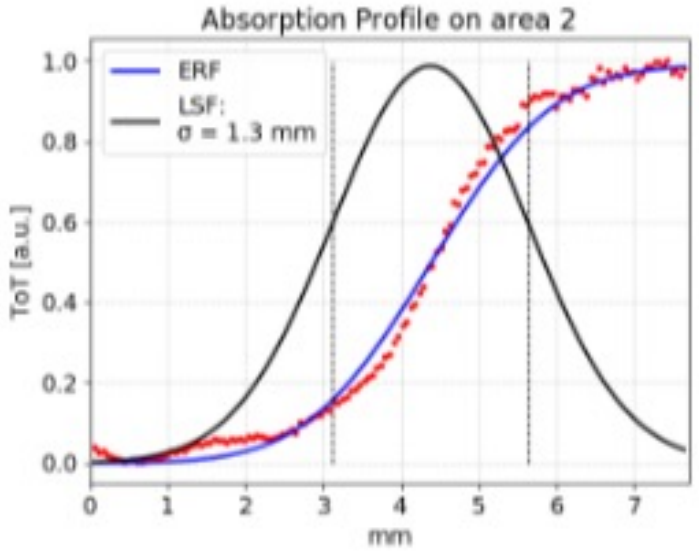
Published on EPJ Plus : EPJP-D-21-01206R2

A.Muraro[5,6,10], G.Claps[1,4], G.Croci[5,6,10], C.C. Lai[8,3], R.De Oliveira[2], S.Altieri[7], S.Cancelli[5,6], G.Gorini[5,6,10], R.Hall-Wilton[8,6], C.Höglund[8,9], E.Perelli Cippo[5], L.Robinson[8], P.Svensson[8], and F.Murtas[1,2]

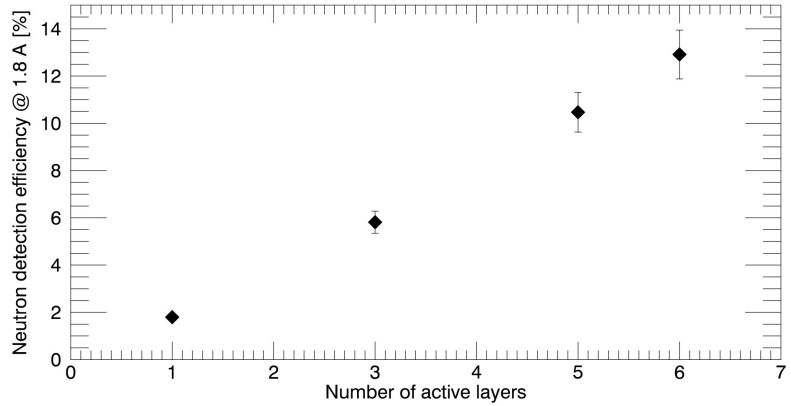
Spatial resolution ranging between 2.0 to 2.6 mm

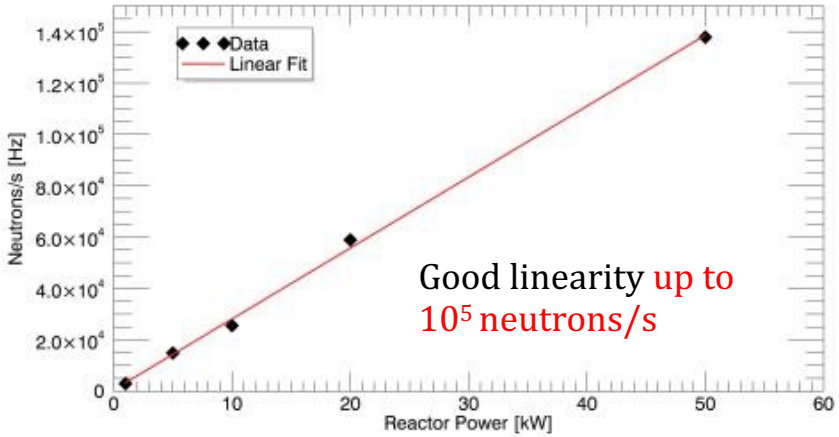


Cadmium disks (diameter of 8 mm)



Clear evidence of the contribution of **all 6 borated layers** → final preliminary detector efficiency **= 9%**

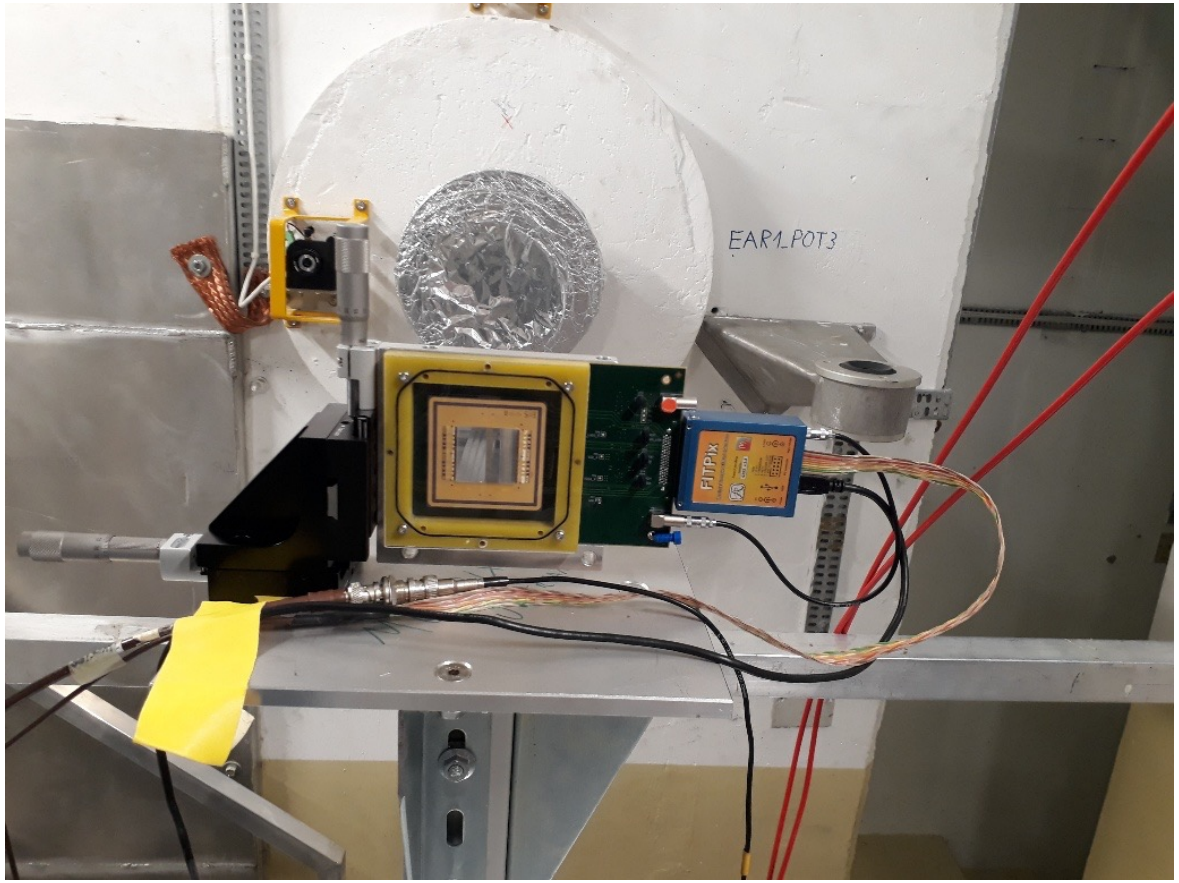


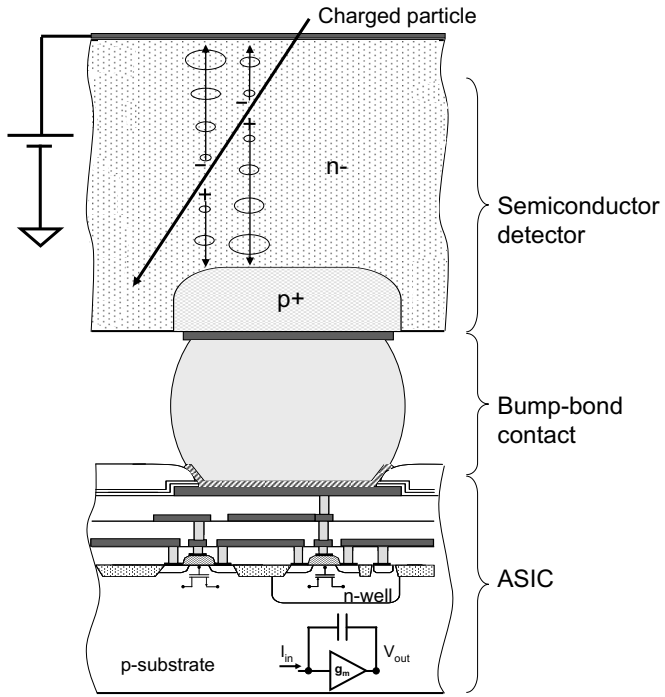


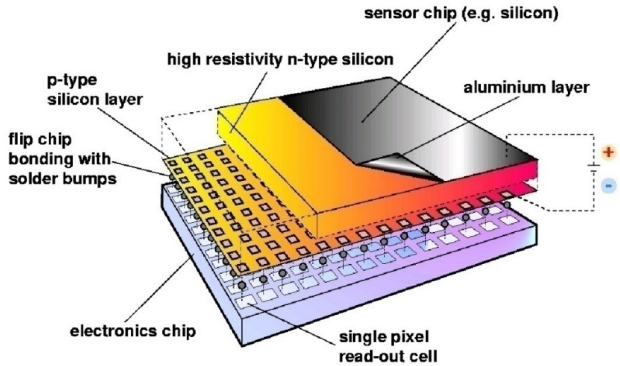
The 10x10 cm_2 detector will be test in nTOF starting from September 2021

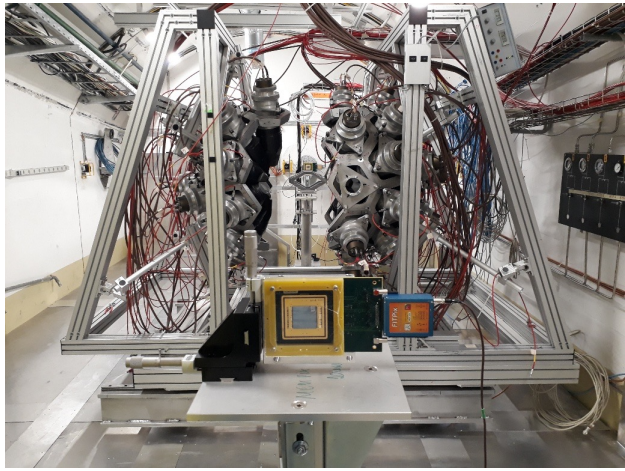
Applied Nuclear Energy Laboratory (LENA) of Pavia University

Timepix Installation in EAR1 for the beam/laser alignement



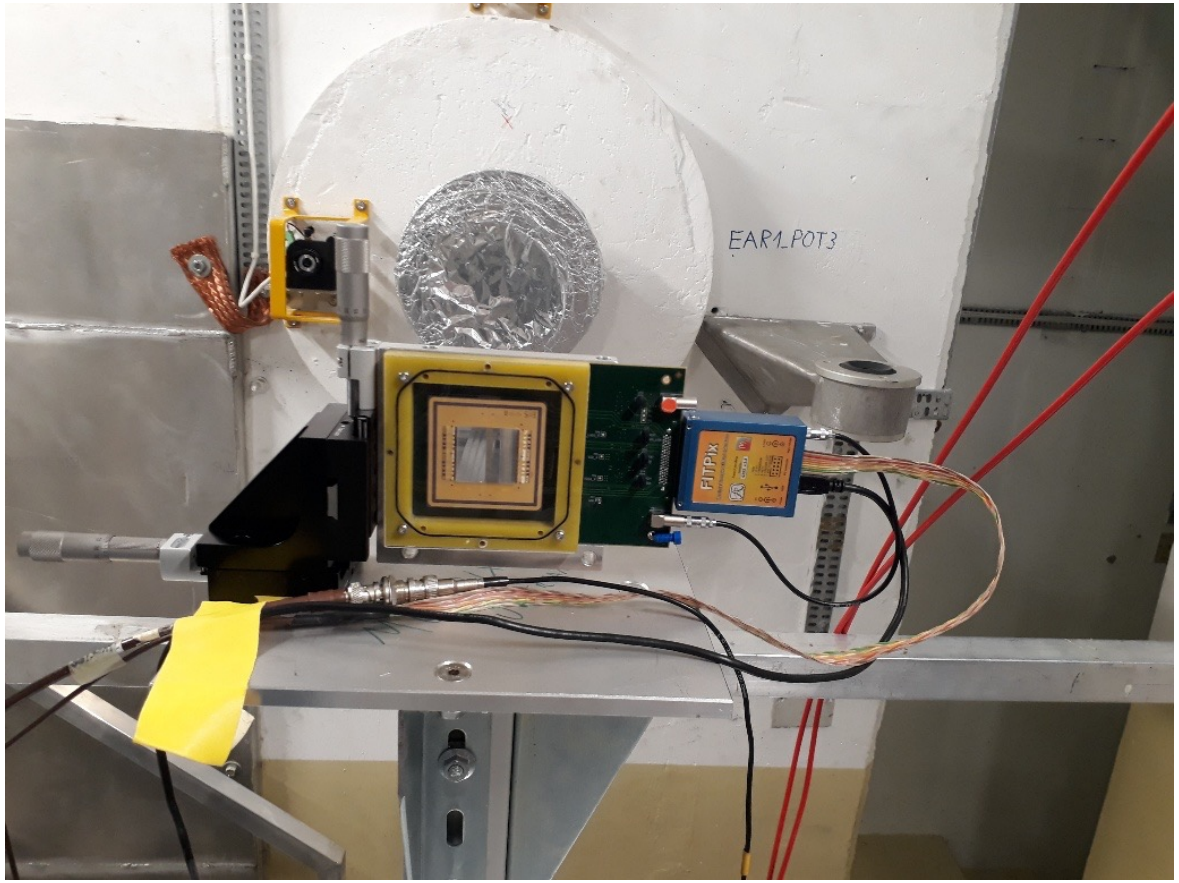


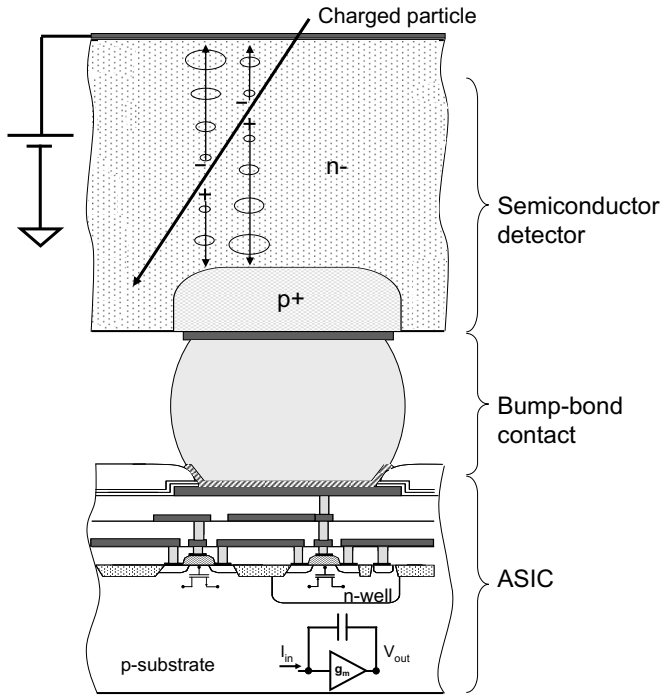


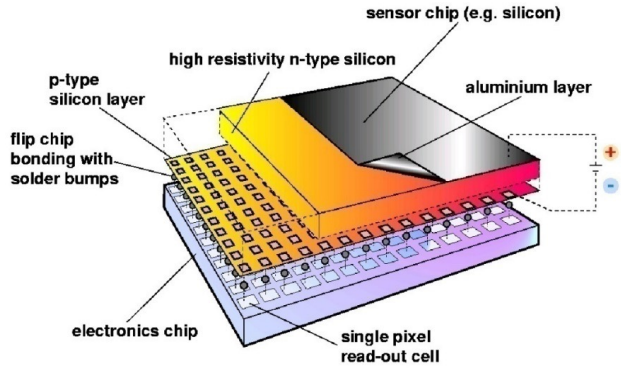


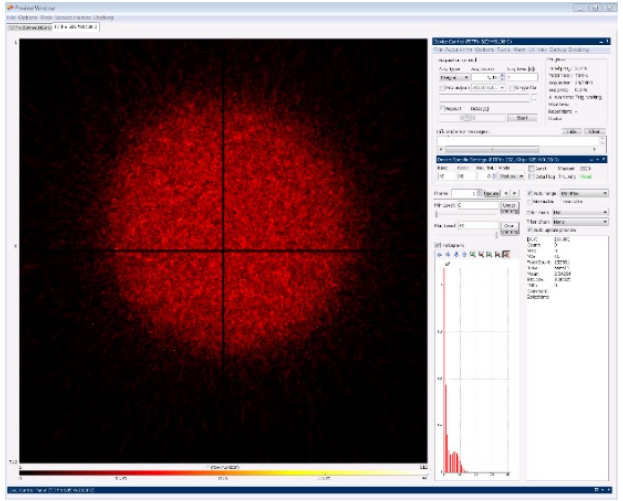
Installation in EAR2 ongoing with the two Timpixquad bought in 2020

Timepix Installation in EAR1 for the beam/laser alignement





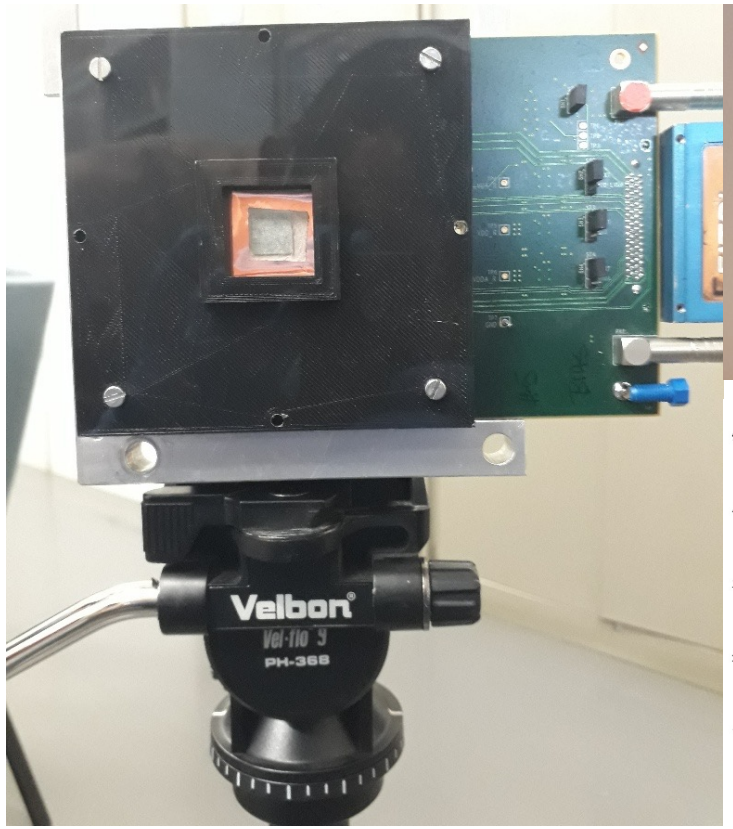


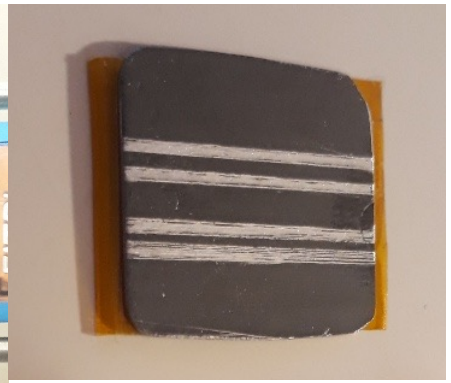


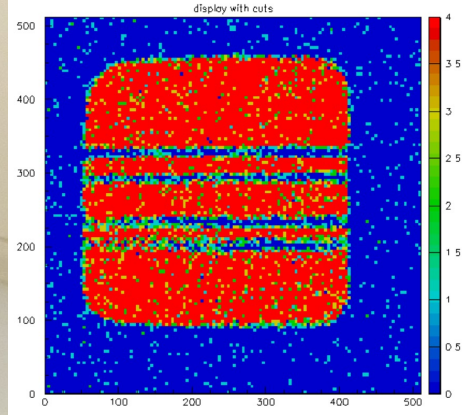
Installation in EAR2 ongoing with the two Timpixquad bought in 2020

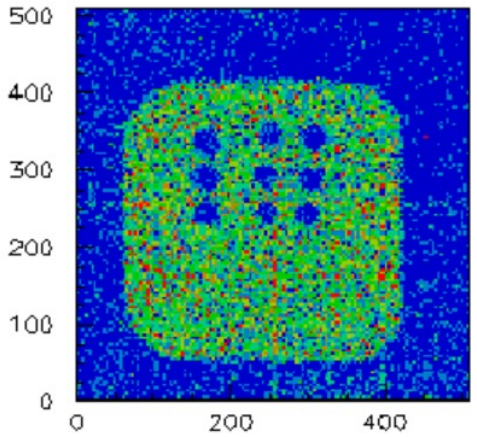
Timpix3 quad for boron distribution measurements

The Timepix-quad can be used also to measure the Boron distribution on a surface placed in front of the silicon sensor .

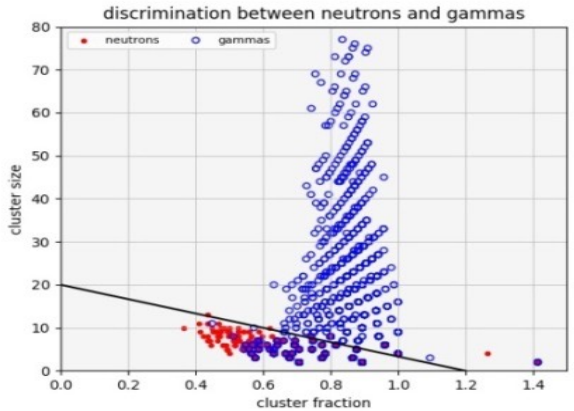








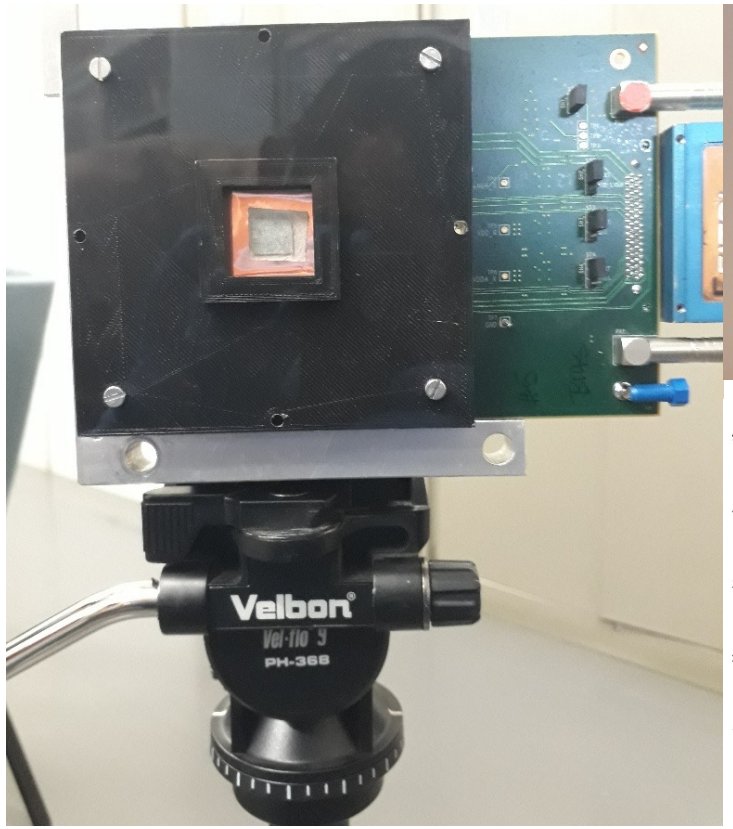
Measurements performed @LENA with two Boron Carbide samples.
Active area 3x3 cm^2 with 50x50 μm^2 pixels.

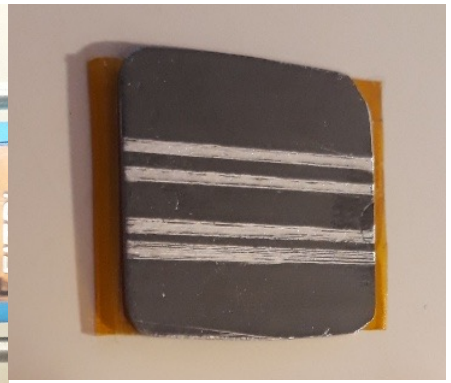


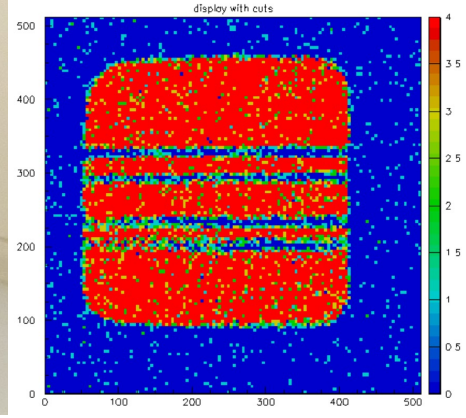
For a better discrimination between Neutrons and Gammas the Timepix3 is the best Asic! We ask to buy a new timepix3 quad for this type of measurement for 2022.

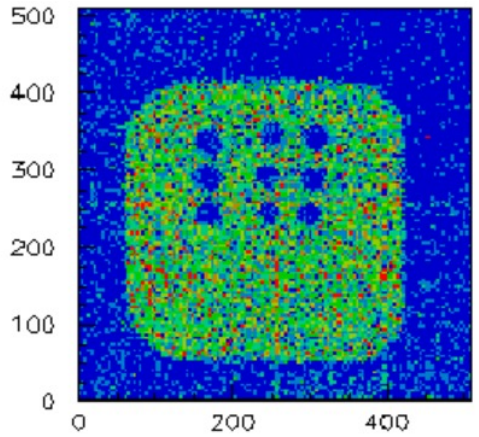
Timpix3 quad for boron distribution measurements

The Timepix-quad can be used also to measure the Boron distribution on a surface placed in front of the silicon sensor .









Financial requests

1.5 FTE

50% FM	INFN
20% Tonino Pietropaolo	ENEA
30% Gerardo Claps	ENEA
50% Nicholas Terranova	ENEA

Financial requests:

10 k€ Timepix3 quad for thermal neutron high precision measurements

5 k€ Katerine series 2 for DAQ

Missions:

5 k€ for installations and collaboration meetings

LNF Facility: clean room

LNF activities

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Spokesperson + ALL Responsabilities in LNF

KAONNIS= Low energy kaons interaction studies at Dafne

- Integrated initiative (SIDDHARTA + AMADEUS)
- Precise measurement of kaonic atoms X-ray transitions and of the charged kaons nuclear interaction processes
- International collaboration: INFN; SMI-OAW (Austria); IFIN-HH (Romania); Politecnico MI; TUM, Helmholtz I. (Germany); RIKEN, Tokyo U. (Japan); Jagellonian U. (Poland); Victoria U. (Canada); Zagreb U. (Croatia) + ELPH Tohoku University & CERN

20 Publications (2020-2021)
Characterization of the SIDDHARTA-2 luminosity monitor, JINST 15 (2020) 10, P10010

- **STRONG2020: WP8-JRA, WP16-NA, TA3-LNF**
- **Bando regionale SICURA**
- **Croatian Science Foundation research project 8570**

Prog. di grande rilevanza MAECI:
"Strangeness in the compact stars?"
Italy-Japan 2017-2019

Events (2020-2021)
Workshop: Investigating the Universe with exotic atomic and nuclear matter, online LNF-INFN, 28-30 September 2020.
STRANU Workshop ECT: 24-28 May 2021*

25 researchers for 15.3 FTE
Average participation of 61%

1. M . Bragadireanu	1.0
2. M. Bazzi	0.7
3. F. Sgaramella	1.0
4. A. Clozza	0.5
5. C. Curceanu	**0.7**
6. S. Dabagov	0.2
7. L. De Paolis	1.0
8. D. Hampai	0.2
9. M. Iliescu	1.0
10. P. Levi Sandri	0.2
11. A. Khreptak	0.5
12. M. Merafina	0.6
13. C. Milardi	0.1
14. M. Miliucci	0.7
15. M. Tuechler	1.0
16. E. Pace	0.2
17. A. Scordo	1.0
18. D. Sirghi	0.7
19. F. Sirghi	1.0
20. M. Skurzok	0.5
21. A. Spallone	1.0
22. O. Vazquez D.	0.3
23. J. Zmeskal	0.5
24. F. Napolitano	0.2
25. H. Shi	0.5
26 C. Guaraldo	

Main activity: SIDDHARTA-2 - aim and goal

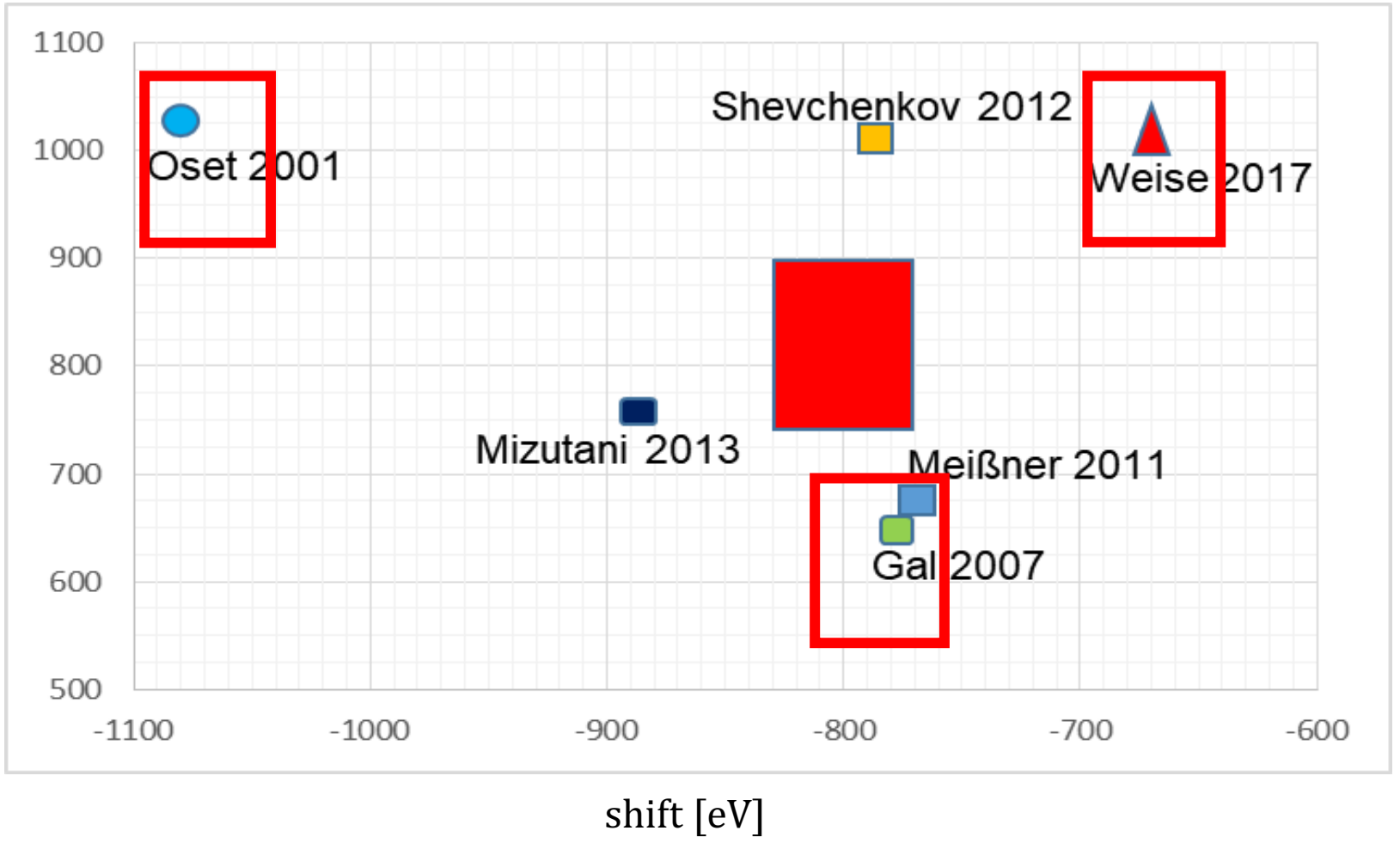
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Perform precision measurement of kaonic atoms X-ray transitions

Precision measurement of the shift and of the width of the 1*s* level of kaonic deuterium and of the other types of kaonic atoms

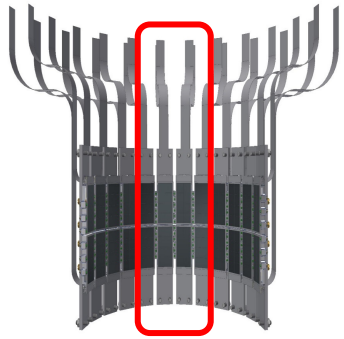
→ unique info about the QCD in non-perturbative regime in the strangeness sector not obtainable otherwise; impact in astrophysics (EOS neutron stars)

Comparison with various theoretical models



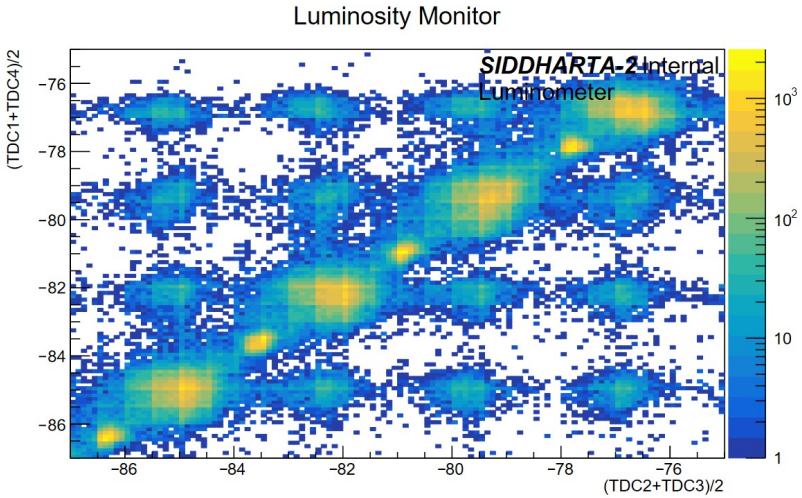
SIDDHARTA-2: phase 1 (SIDDHARTINO)

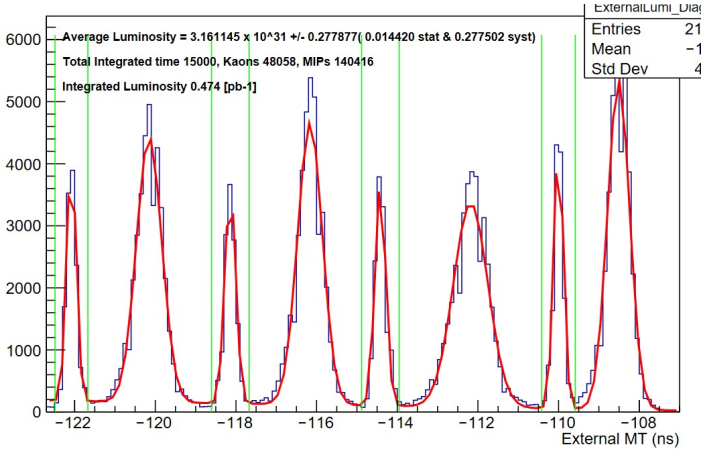
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati



Phase 1 with SIDDHARTINO (8 SDDs KHe)

- Technical run (2020; stopped early March and moved to 2021; now ongoing)
- target position 100 mm higher in order to install the DAΦNE luminosity monitor for optimal beam tuning!
- with 8 SDDs (one DAQ bus subsystem)
- SIDDHARTA-2 luminosity monitor
- Goal: reach a similar beam/background conditions as in SIDDHARTA run (S/B>100) ⇒ tested with SDD background and kaonic helium indicators





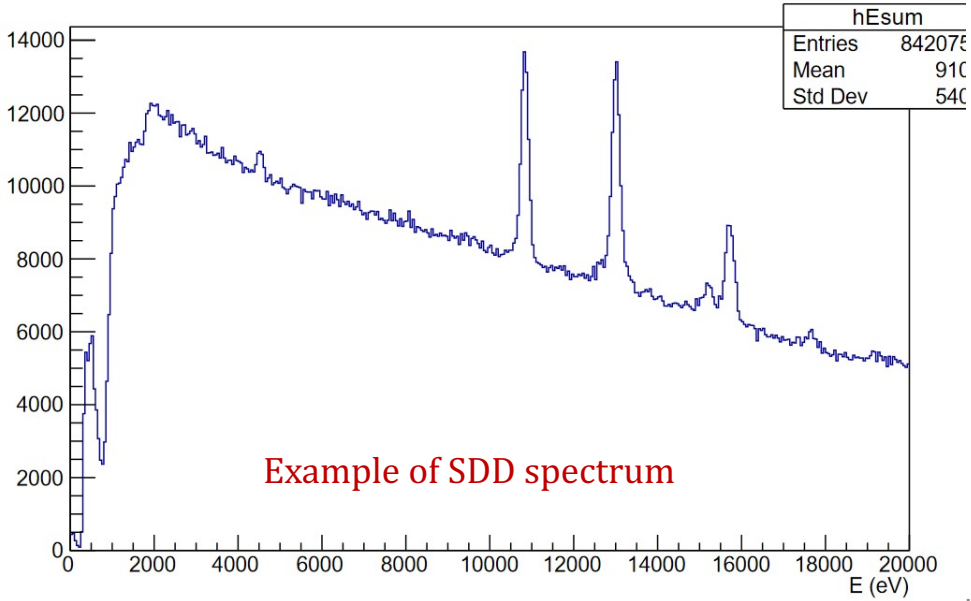
SIDDHARTA-2: phase 1 (SIDDHARTINO)

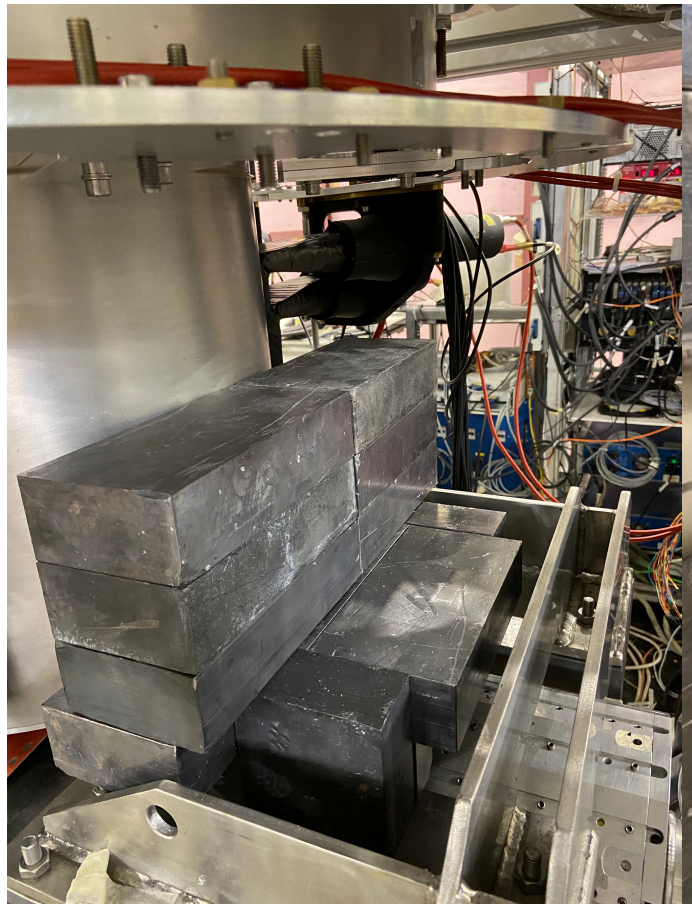
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

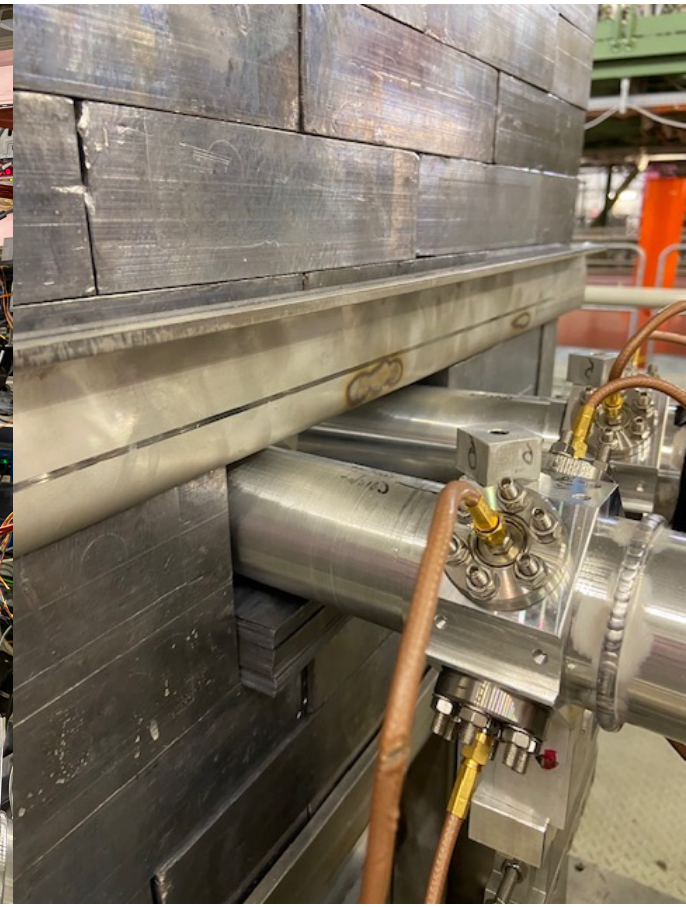
DAFNE optimization & shielding optimization ongoing
Run SIDDHARTINO: till 18 July 2021

Background characterization: we went from about 15-16 X rays/cm2/pb (5-10 keV region) to:**

- 14 by preliminary scrapers
- 8 by shielding
- Goal (SIDDHARTA-like): gain another factor about 3 (shielding, machine)







SIDDHARTINO: observation of first kaonic atoms!

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

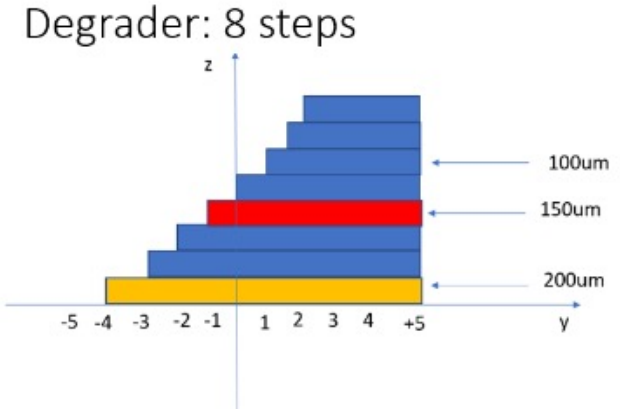
SIDDHARTINO – elio kaonico
Ottimizzazione della misura e del degrader

DEGRADER 8 steps

Files analysed: **29.06.2021 (21:36) – 05.07.2021(10:35)**

Lumi int from luminosity detector = 6,785 pb-1

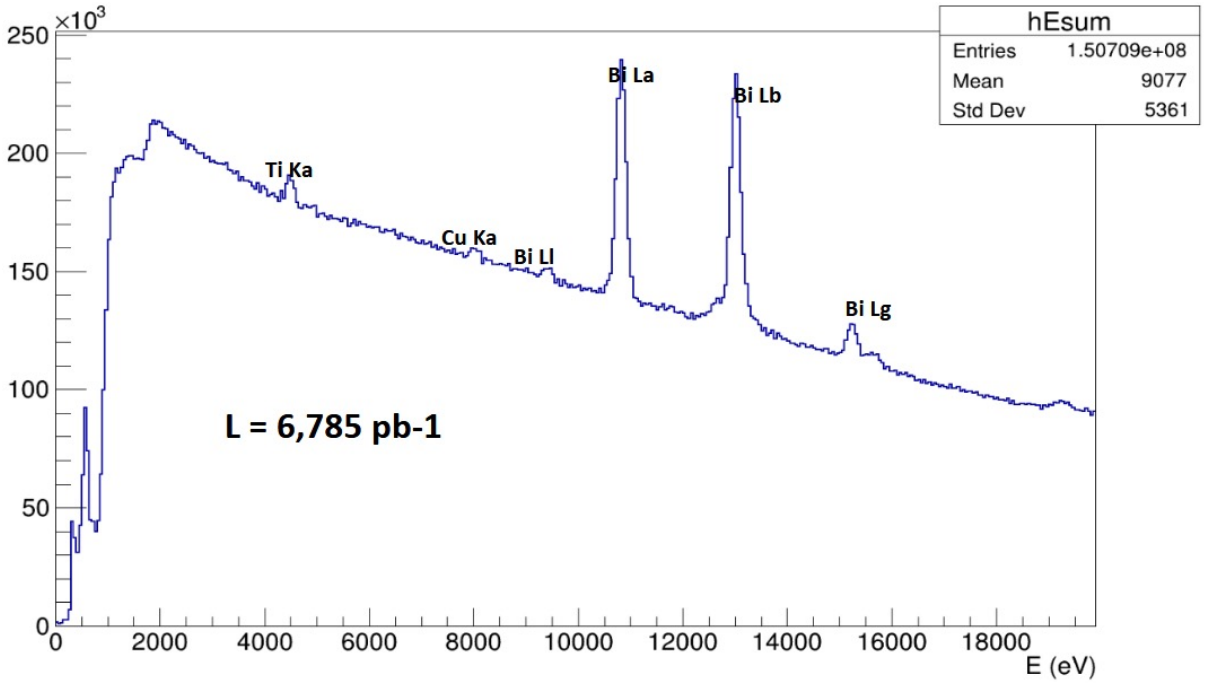
39 SDDs



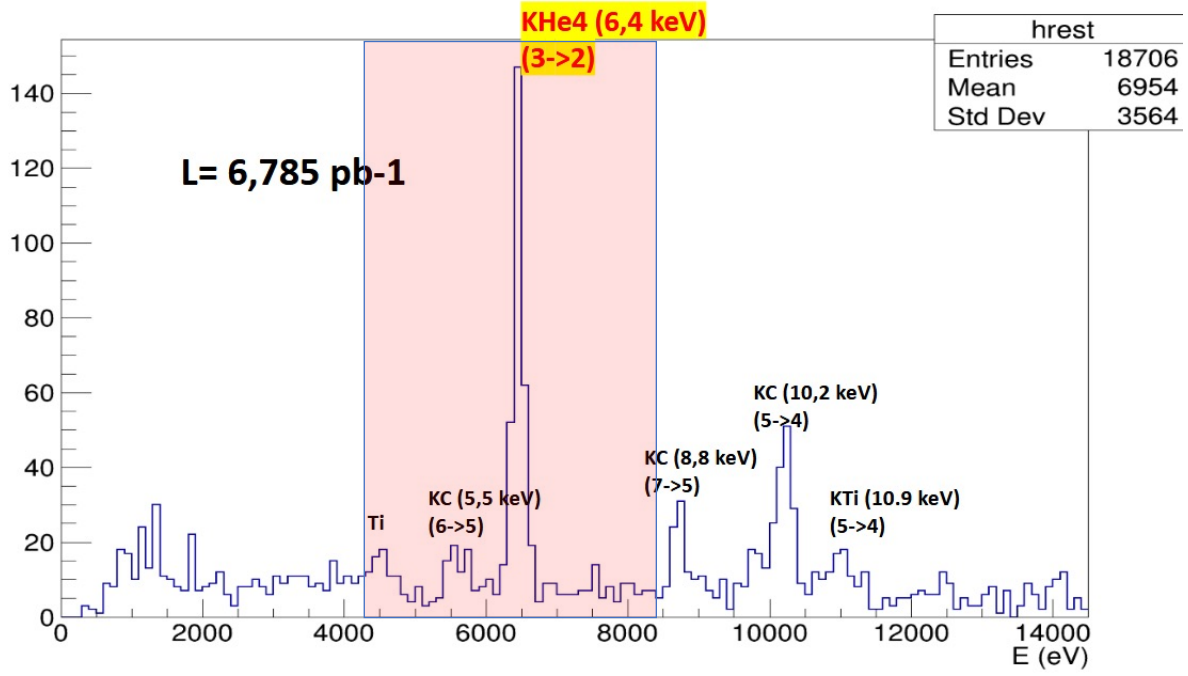
SIDDHARTINO: observation of first kaonic atoms!

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Spettro raw – senza trigger:



Spettro raw – con trigger:

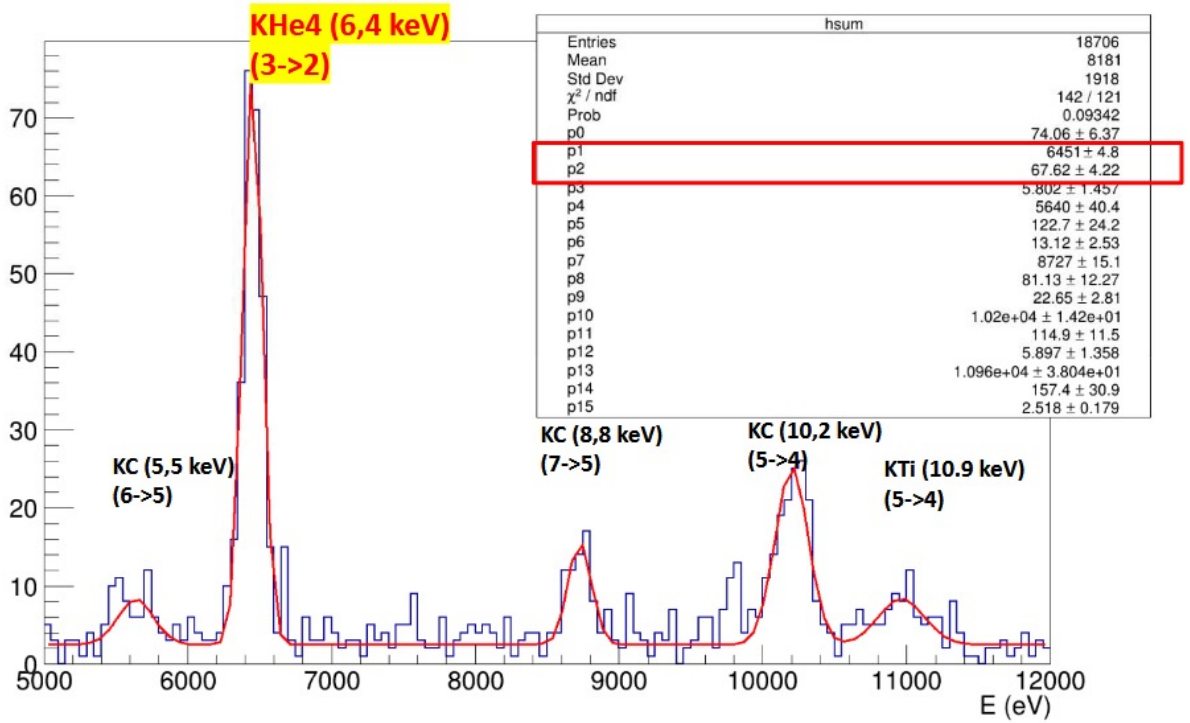


Stiamo procedendo con vari degrader - ottimizzazione

SIDDHARTINO: observation of first kaonic atoms!

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Fit dello spettro dell'elio kaonico



hsum	
Entries	18706
Mean	8181
Std Dev	1918
χ^2 / ndf	142 / 121
Prob	0.09342
p0	74.06 ± 6.37
p1	6451 ± 4.8
p2	67.62 ± 4.22
p3	5.802 ± 1.457
p4	5640 ± 40.4
p5	122.7 ± 24.2
p6	13.12 ± 2.53
p7	8727 ± 15.1
p8	81.13 ± 12.27
p9	22.65 ± 2.81
p10	1.02e+04 ± 1.42e+01
p11	114.9 ± 11.5
p12	5.897 ± 1.358
p13	1.096e+04 ± 3.804e+01
p14	157.4 ± 30.9
p15	2.518 ± 0.179

Precisione: 4.8 eV

Fine run: 18 Luglio 2021

Precisione intorno a 2-3 eV

→ pubblicazione scientifica

Peak/back.: circa 30; we are in business…miglioramenti fattibili

SIDDHARTA 2: phase-2 (48 SDDs KD)

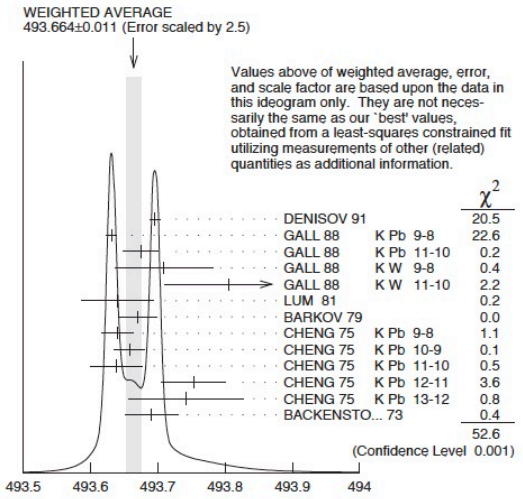
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

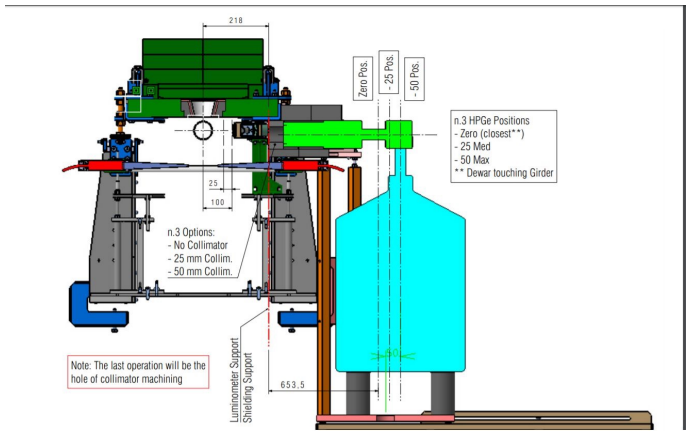
Physics run: kaonic deuterium run in 2021 and 2022

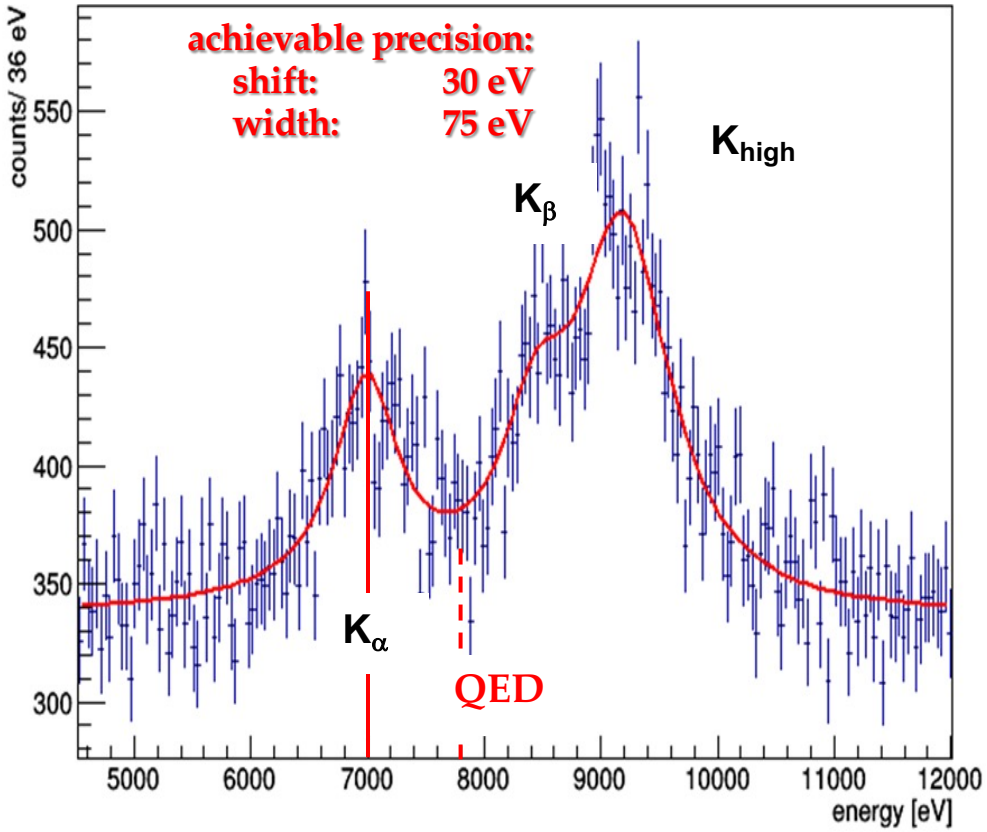
1. Final installation in Dafne in summer 2021, restart of the data taking in October 2021
2. request of 800 pb^{-1} on tape to perform the first measurement of the strong interaction induced energy shift and width of the K_d ground state (similar precision as $K-p$)
3. Kaonic lithium measurement

In parallel with SIDDHARTA-2 K_d measurement: feasibility tests for future measurements with Ge and VOXES detectors:

- Kaon mass puzzle (C vs. Pb), QCD
- High precision tests QED (P. Indelicato) – exploring possible dark sector effects



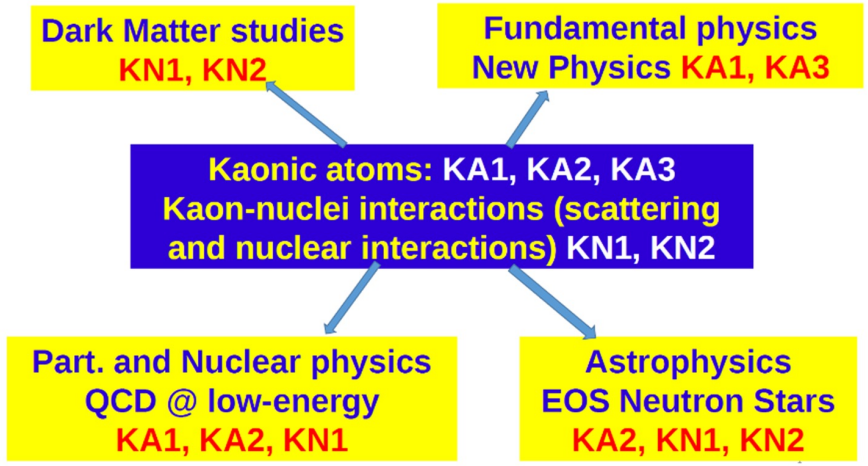




Proposal for Future measurements at DAFNE

Kaonic atoms and kaon-nuclei interaction studies (FFF and SC)

Fundamental Physics at the strangeness frontier, next 5 years



https://arxiv.org/pdf/2104.06076.pdf
Towards a LoI (authors: Editorial Board only)

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Richieste finanziarie 115k

Consumo	70 kE
Inventariabile	30 kE
Manutenzione	15 kE
Missioni	25 kE

Richieste ai servizi

Progettazione: 6 m.u.
supporteria/schermature più nuovo rivelatore veto; misure test Ge e VOXES

Officina meccanica: 6 m.u. per costruzioni supporterie, schermature, frame nuovo veto2 layer, test setup Ge, VOXES

Tecnici: 2 x 0.5 FTE installazioni e costruzioni varie

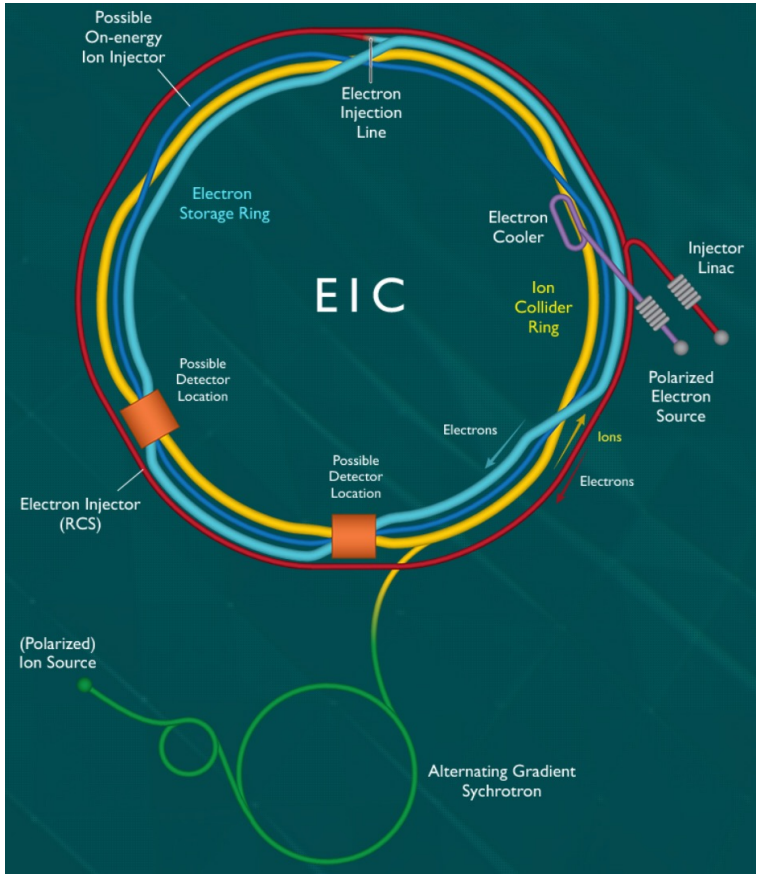
Conclusioni

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

ALICE

EIC_net

1. Attività proseguita nonostante la pandemia → riprogrammata verso attività di analisi e preparazione *paper*
2. SIDDHARTA data taking will start soon!
3. Coinvolgimento nei diversi ambiti racchiusi nella CSN3
4. Progetti futuri



Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

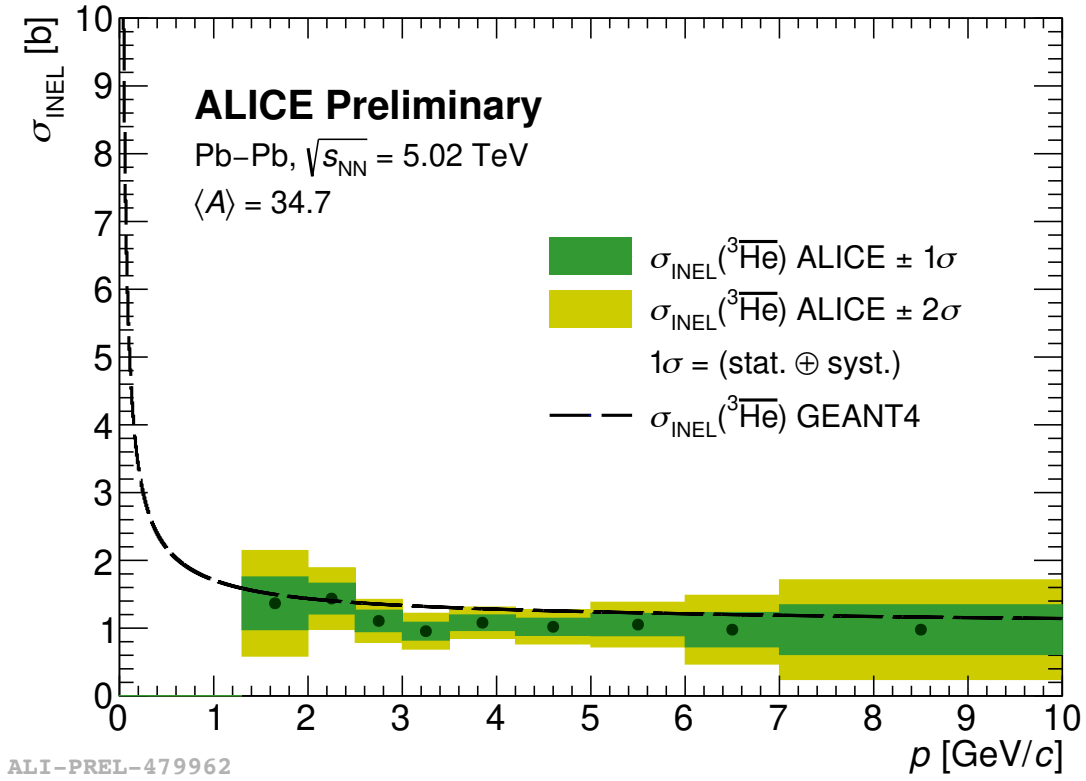
backup

Funding for the current year
Assegnazioni 2020 (k€)

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

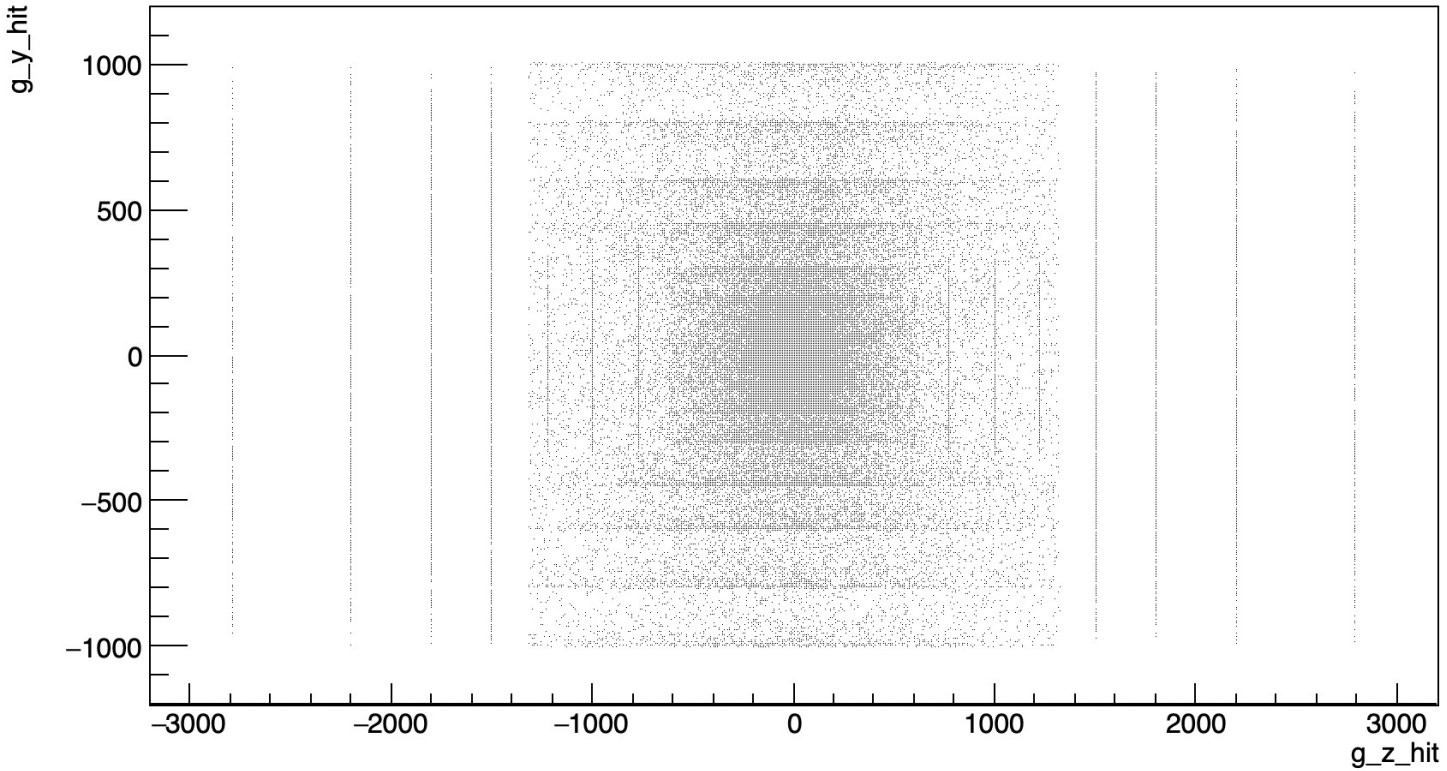
Exp	Ricercatori	Tecnici	FTE	Missioni	Consumo	Apparati	Inventario	Altri consumi
ALICE	9	3	7.3	60	0			0
FOOT	3	2	2.1	7 4	8.5	15	1	
JLAB	4	1	2.2	35	0	20		
KAONNIS	21	2	16.3	13	21		21.5	16 2
MAMBO	2		1.2	15	10			
N_TOF	3		1.0	5	6	9		
VIP	11	2	7.3	16.5 6	3		21.5	9
DTZ (1.5 per EIC_net + 1)				30.5	15		20	7

Measurement of $\overline{^3He}$ inelastic cross section with ALICE



- ^3He is a promising probe for Dark Matter searches near Earth
- Its inelastic cross section is an essential input for calculating the propagation of within the interstellar medium
- Data sample: 147.9M Pb-Pb collisions at 5.02 TeV recorded with ALICE
- TPC/TOF matching method: ratio of antinuclei identified with the TPC and TOF detectors and comparison with dedicated Monte Carlo simulation with scaled inelastic cross section

ALICE3 performance studies



- ALICE3 will replace the current ALICE experiment after Run 4
- Studies of the detector performance and layout optimization
- Preparation for the Letter of Intent
- Studies with Fast Analytical Tool (FAT) and ACTS tracking and reconstruction software

ITS3 work packages

	ATTIVITA'	CONSUMO/licenze/manutenzioni	Richiesta (k€)	INVENTARIABILE	Richiesta (k€)	MISSIONI	Richiesta (k€)
WP1						partecipazione a riunioni	DA DEFINIRE (VEDI TABELLA COMUNE)
WP2							
WP3	Test e caratterizzazione	manutenzione camere pulite aggiornamento sistemi test DAQ board (adattare MOSAIC?)	1			Partecipazione a beam test: 5 beam test anno/7 gg per test/ no. shifter? ogni sede fornisce numero di shifter x BT	DA DEFINIRE (VEDI TABELLA COMUNE)
WP4	Interconnessioni						
WP5	Saputi, sistema di cooling					missioni specifiche per Saputi	
ITS2						partecipazione a riunioni - shift commissioning ITS - global commissioning - ruoli di coordinamento ecc....	DA DEFINIRE (VEDI TABELLA COMUNE)

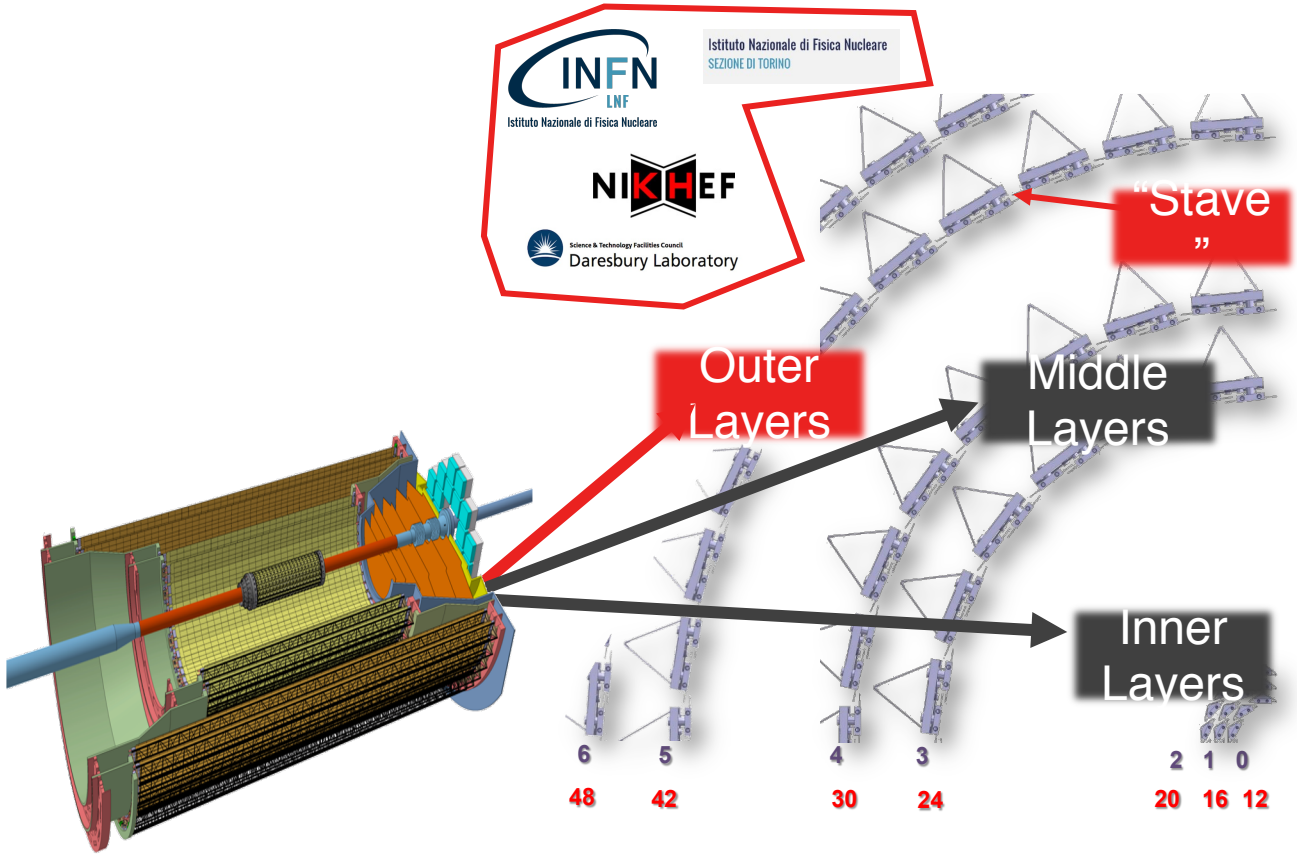
LNF production summary

Full production at LNF started in Feb 2018 and ended in June 2019 + extra staves + rework:

- LNF quota (27+2 staves) was fully produced in time
- Very long preparation and development phase: 2016-17

The LNF group also contributed to the development and debug of the procedures

- Debug of the readout system
- Development of wire bond repairs using conductive glues
- Development of mechanical procedures and tooling to rework finished staves

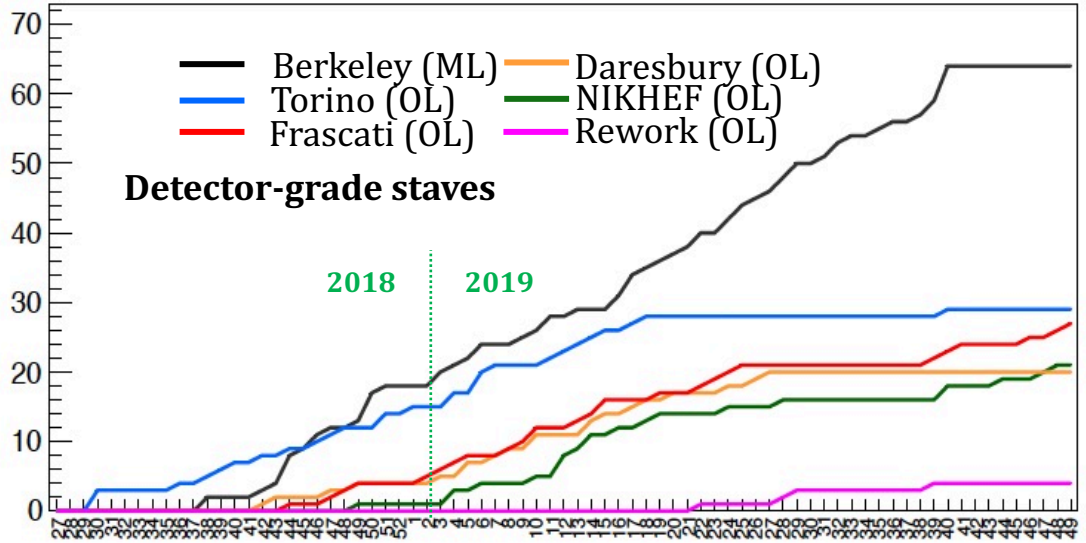


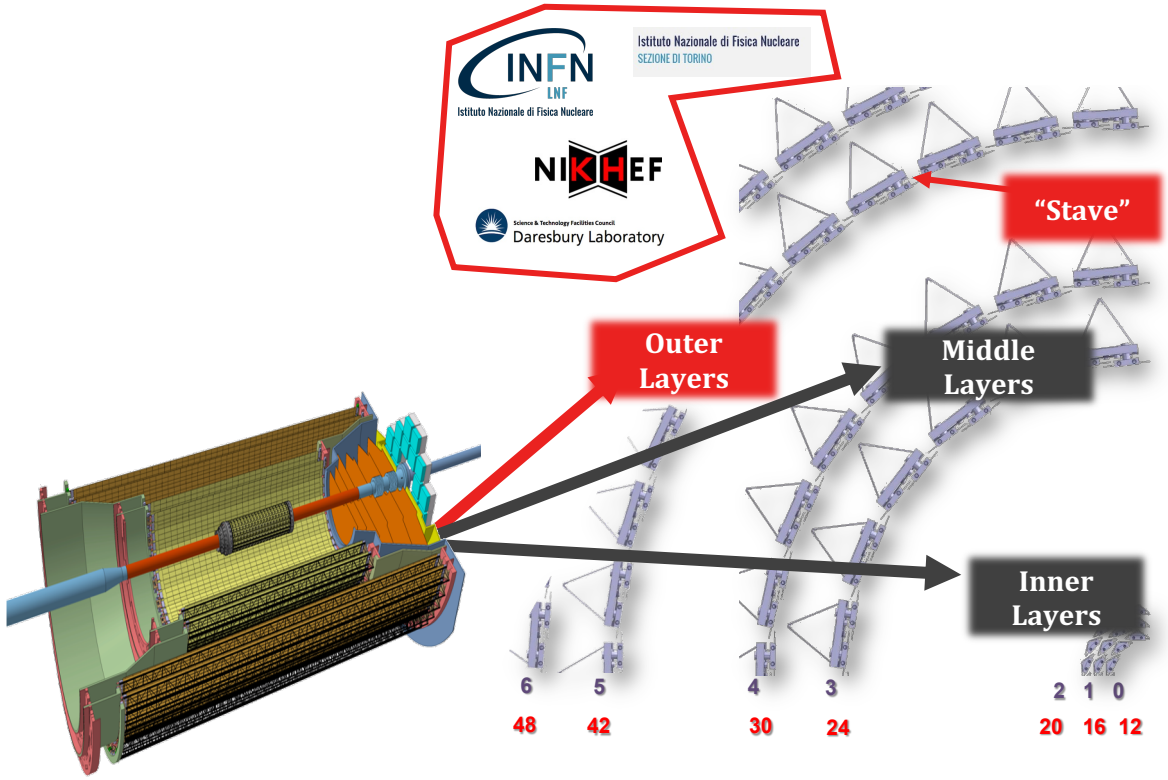
LNF production summary – ITS2

Full production at LNF started in Feb 2018 and ended in June 2019.

The LNF group also contributed to the development and debug of the procedures

- Debug of the readout system
- Development of wire bond repairs using conductive glues
- Development of mechanical procedures and tooling to rework finished staves





ML Staves Total: 64

- ML completed in August
- Spares completed in September

OL Staves Total: **101**

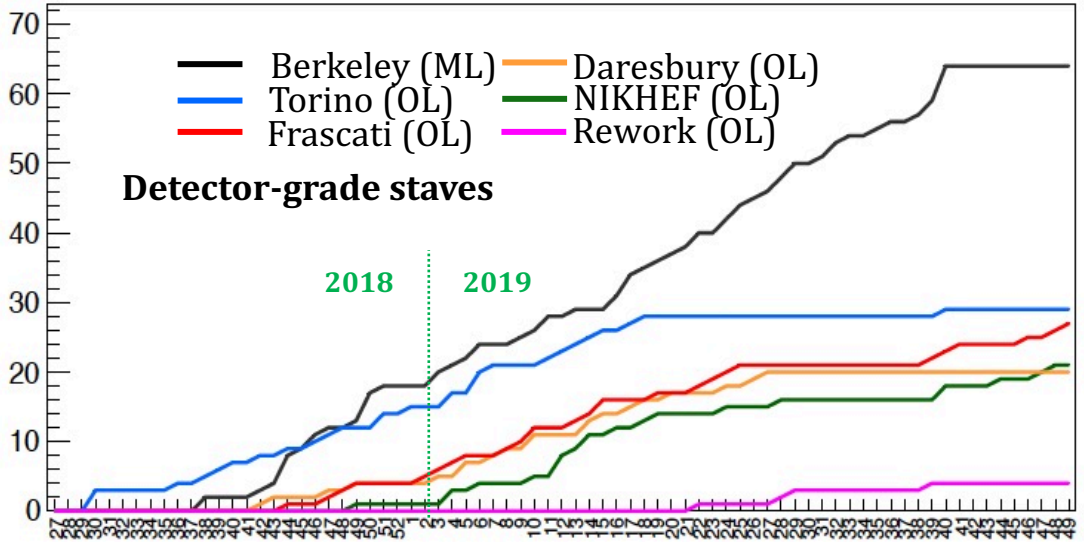
- OL completed in September
  a Spares followed in December (ITS.14)

LNF production summary

Full production at LNF started in Feb 2018 and ended in June 2019.

The LNF group also contributed to the development and debug of the procedures

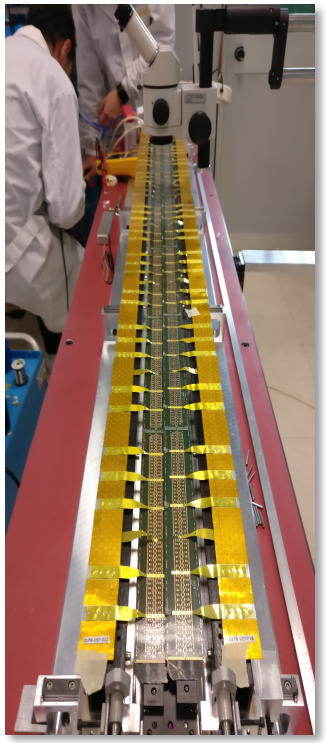
- Debug of the readout system
- Development of wire bond repairs using conductive glues
- Development of mechanical procedures and tooling to rework finished staves



Production@LNF: 29 (27+2)

It served as the only remaining site for spare production, hard rework

97% yield



ML Staves Total: 64

- ML completed in August
- Spares completed in September

OL Staves Total: **101**

- OL completed in September a Spares followed in December (ITS.14)

LS2 milestones

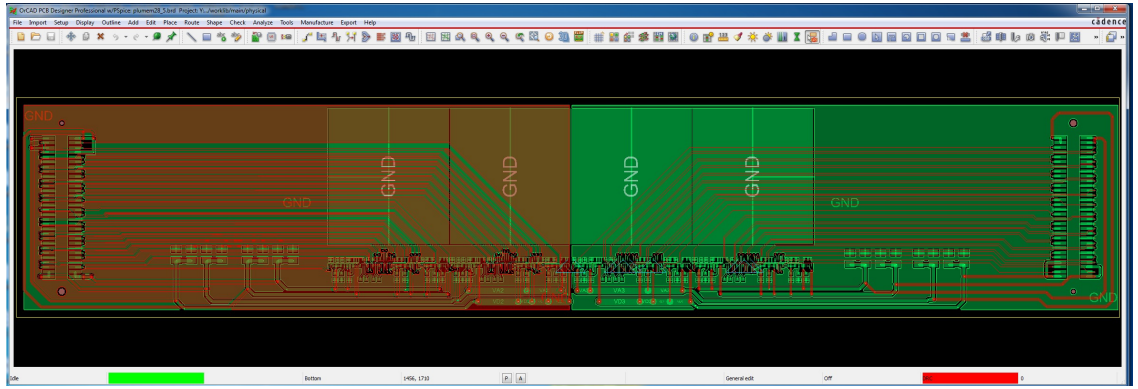
Activity	v47
ITS	**25 Jan – 12 May** OB: 16 Mar – 23 Apr IB: 6 May – 12 May
ITS standalone commissioning	**13 May – 18 Jun**
FIT-A	**21 – 25 Jun** Transport. to P2: 18 Jun
RB24 beampipe	**28 Jun – 9 Jul**
BCM-A	**13 Jul**
BLMs	**14 Jul**
ZEM	**15 Jul**
FDD-A	**12 – 16 Jul**
Close L3 doors	**28 – 30 Jul**
ITS & MFT commissioning time	**2w**
LHC pilot beam test	**w42-43**
ALICE global commissioning time	**4 months (18w)**
End of LS2 – stop UX25 access (contingency from end of global commissioning)	**21 Feb 2022 (3 months)**

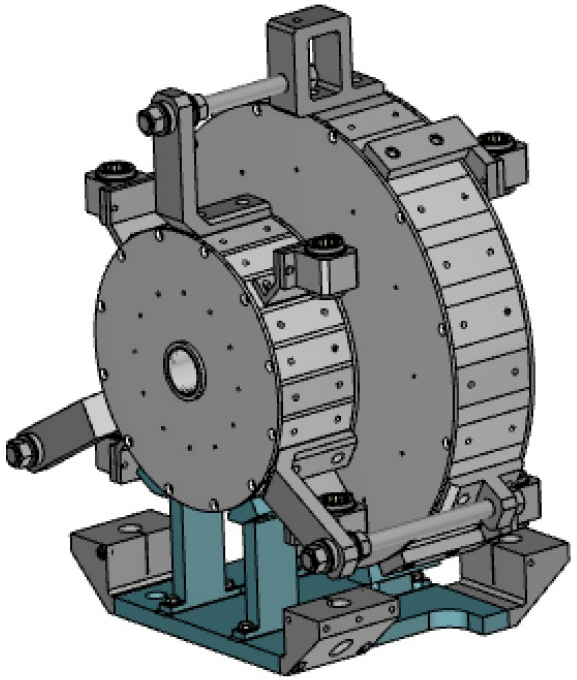
LNF activities:
Inner Tracker, magneti, setup meccanico

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Inner Tracker

- module Kapton PCB in production
- G&A company (take care of module assembly) waiting to start working on ladders
- Two more boards needed (delayed by learning a new electronic CAD system)



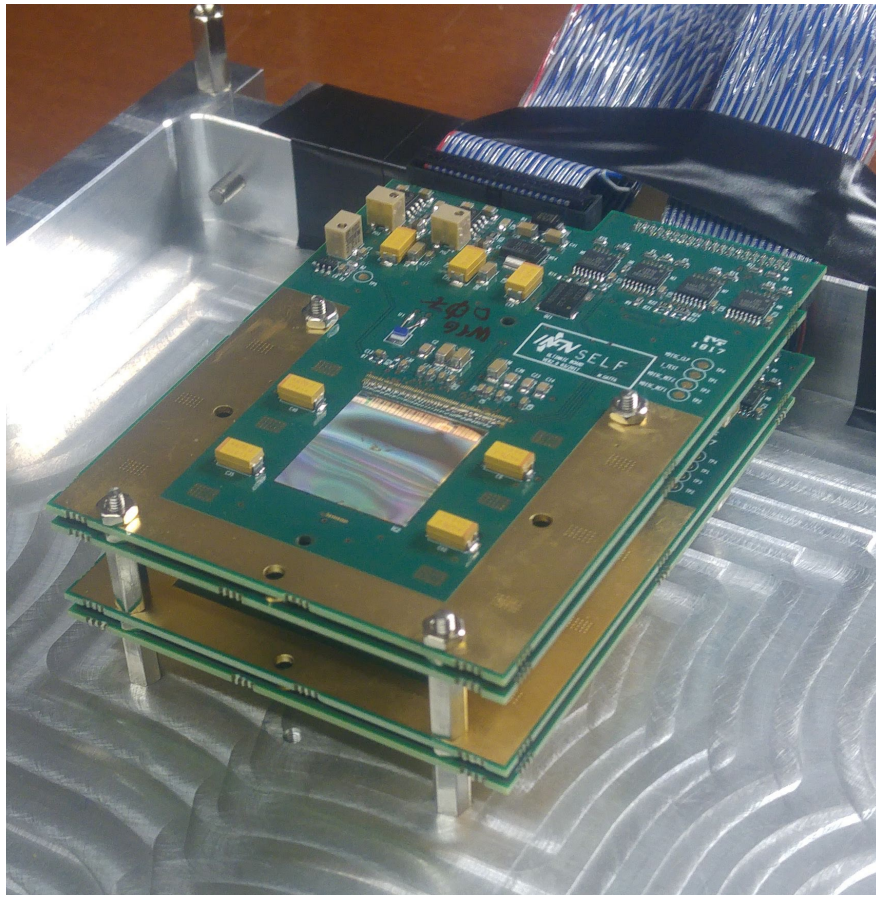


Mechanical setup waiting to be finalized by:

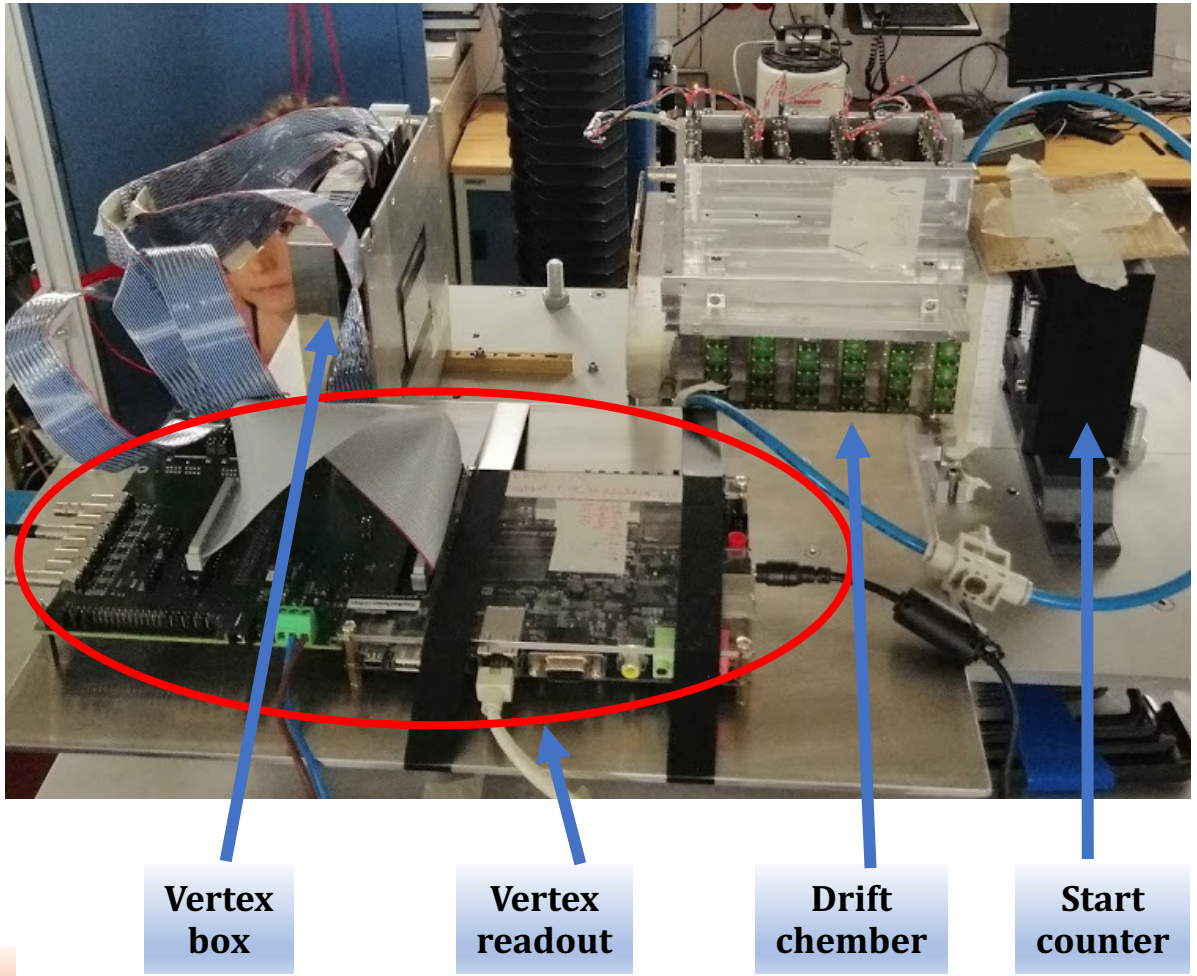
- Final magnet design (after new magnet bid)
- Inner Tracker ladder assembly procedure definition by G&A company. Delayed by kapton PlumeM28 PCB availability.

Acquisto magneti problematico.
La gara è partita recentemente,

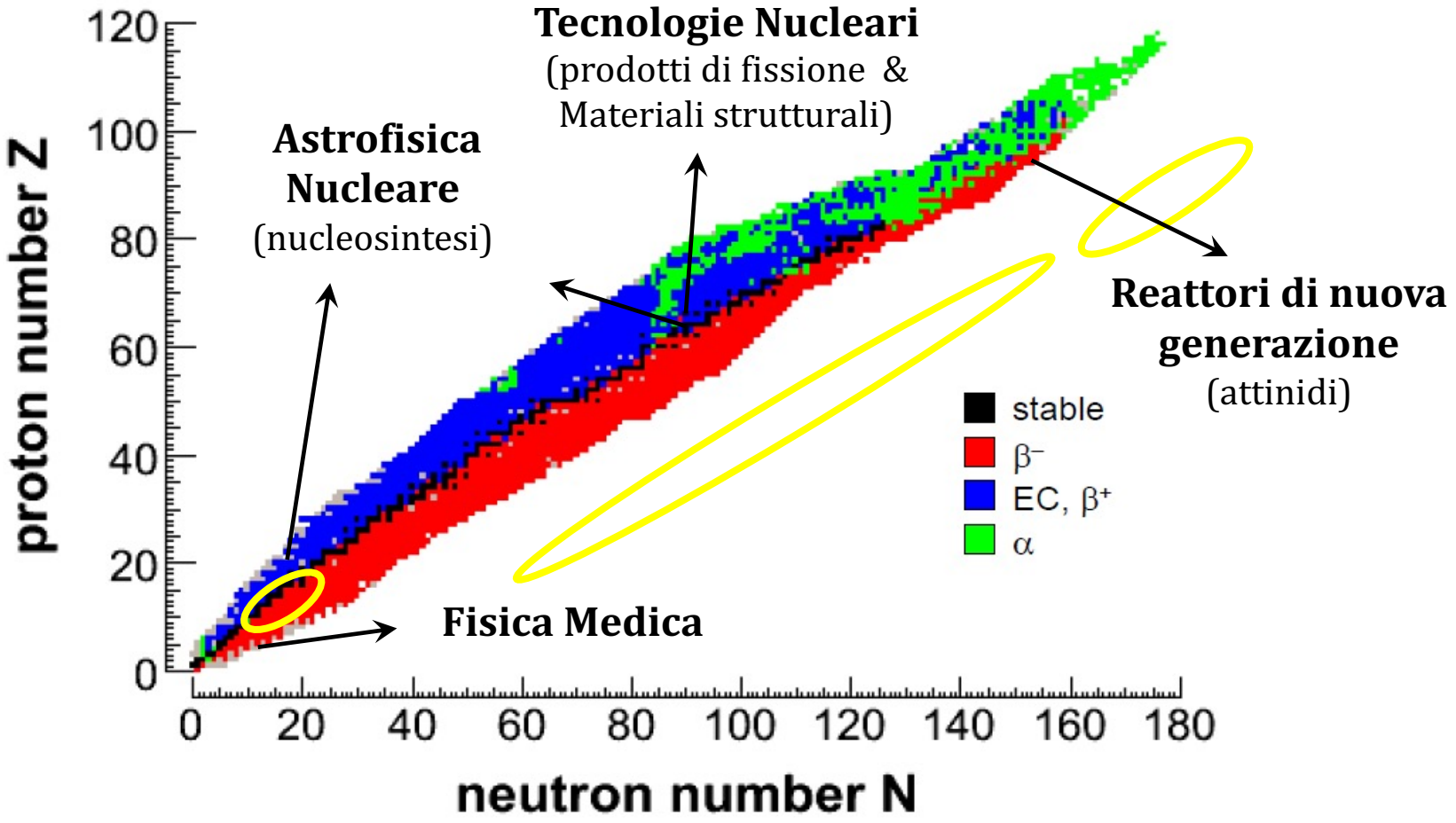
LNF activities:
Inner Tracker, magneti, setup meccanico



Pixel Vertex: 4 planes of M28 sensor, 50μm thick



Misura di precisione di sezioni d'urto di reazioni indotte da neutroni



n_TOF Italia

22 ricercatori (INFN, Università)
15.5 FTE su 6 sedi INFN

Collaborazioni con ENEA-Bologna, INAF-Teramo, CNR-Bari

LNF per:

- Beam monitor (area beam dump)
- nuovi rivelatori neutroni basati su GEM (Beam4Fusion)

FOOT: FragmentatiOn Of Target

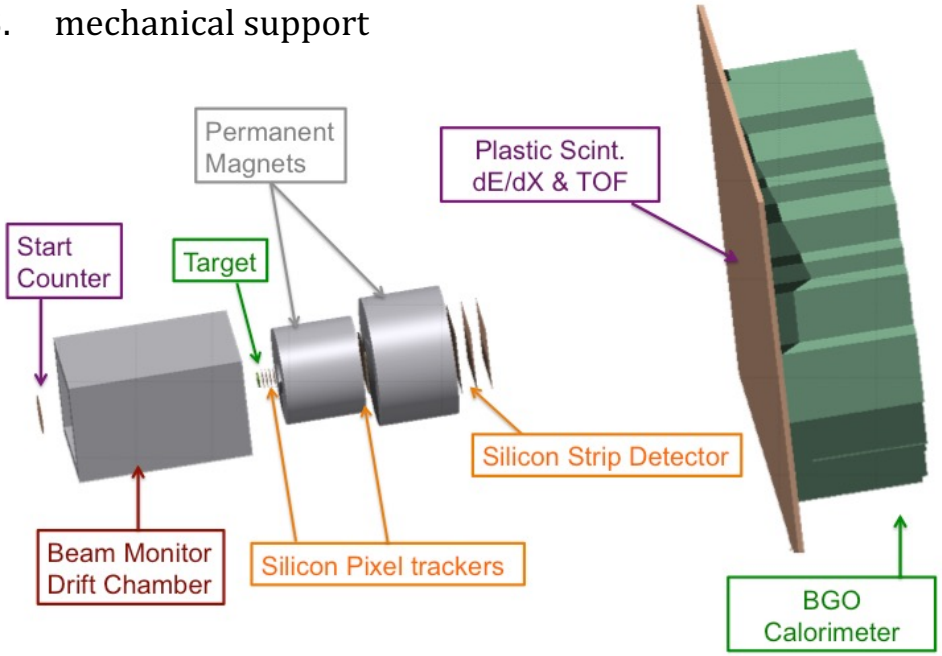
Approved as R&D in CSN3 in 2017

5 Physicists for 2.1 FTE
Average participation of 42%

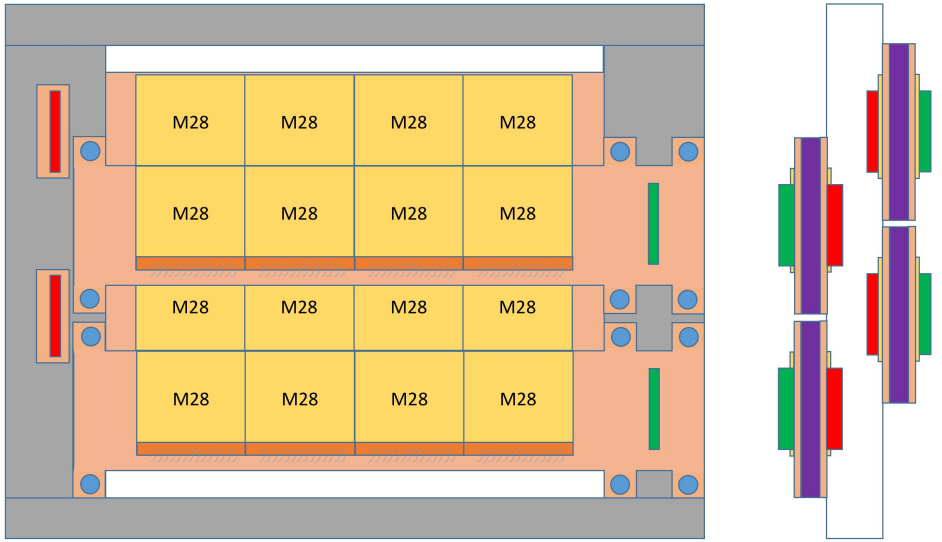
Study of the target fragmentation to improve the nuclear fragment description in the next generation Treatment Planning Systems

Main LNF responsabilities:

1. vertex tracker
2. inner tracker
3. mechanical support



Inner (pixel) tracking system



1 module = 4 Mimosa sensors M28
1 Ladder = 2 modules
1 Layer = 2 Ladder
Inner tracker = 2 Layer (4 Ladder)

Attività 2021

Due to two issues, part of the 2020 activity was postponed to 2021:

1. **The company for the ladder assembly procedure (Ultimate sensors) for the Inner Tracker cannot accomplish the task → new strategy under definition**
2. **Bid for magnets started only recently – it should be over by mid July**

- Finalization and test for the FPC (Flexible Printed Circuit) for the middle tracker (SEA)
- Magnet bid finalization and test@**Laboratorio Misure Magnetiche (**LNF)
- Construction and test of the Inner Tracker (SEA)
- Development of an integrated redout system for the middle tracker (SEA)
- Design of the support system integrated on the readout board of the middle tracker (SPAS)
- Desing finalization and construction of the mechanical structure for the whole tracking system - *start counter, beam monitor, vertex detector, middle tracker, magnets, MSD* (SPAS)
- First data taking RUN@CNAO
- R&D of new «analog» pixel sensors (STRONG2020 project involving LNF, Trento, Bari, Strasburgo, GSI, DMKZ)

LNF ricercatori&tecnologi		
1.	Raffone G.	0.5
2.	Sanelli C.	0.0
3.	Sciubba A.	0.9
4.	**Spiriti E.**	**0.6**
5.	Tomassini S.	0.1
Totale		**2.1**

Richieste finanziarie:

Missioni	12 k€	(riunioni collaborazione, presa dati)
Apparato	10 k€	(Meccanica, Inner Tracker, Read Out)
Consumo	10 k€	(Materiali per test magnetici, meccanica)
Trasporto	2 k€	(per test GSI, CNAO)

Richieste (indicative) servizi:	
SEA	4 mu
SPAS	3 mu
Off. Mecc.	3 mu
Lab. Mis. Magnetiche	3 mu

Le richieste finanziarie presuppongono un possibile riutilizzo come residui di parte dei fondi del 2020 (vedi ritardi citati)

KAONNIS future perspectives

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Plans for the **extension of the scientific program**:

4 proposals submitted at ICFA mini-workshop on DAFNE as Open Accel Test Facility (LNF December 2018):

- **GeKA ⇒ selected Kaonic Atoms with High Purity Germanium detectors**
- **Knscat ⇒ Low-energy kaon-nucleon scattering**
- **WiKAMP ⇒ kaonic atoms with ultra-high energy resolution detectors (VOXES)**
- **KAHEL ⇒ QCD with strangeness**

Kaon mass - precision measurement at the level < 7 keV
Kaonic helium transitions to the 1s level

Other light kaonic atoms (K^-O, K^-C,…)
Heavier kaonic atoms (K^-Si, K^-Pb…)

Radiative kaon capture – Λ(1405) study

Investigate the possibility of the measurement of other types of hadronic exotic atoms (sigmonic hydrogen?)

Richieste finanziarie 115k

Consumo	50 kE
Inventariabile	25 kE
Manutenzione	15 kE
Missioni	25 kE

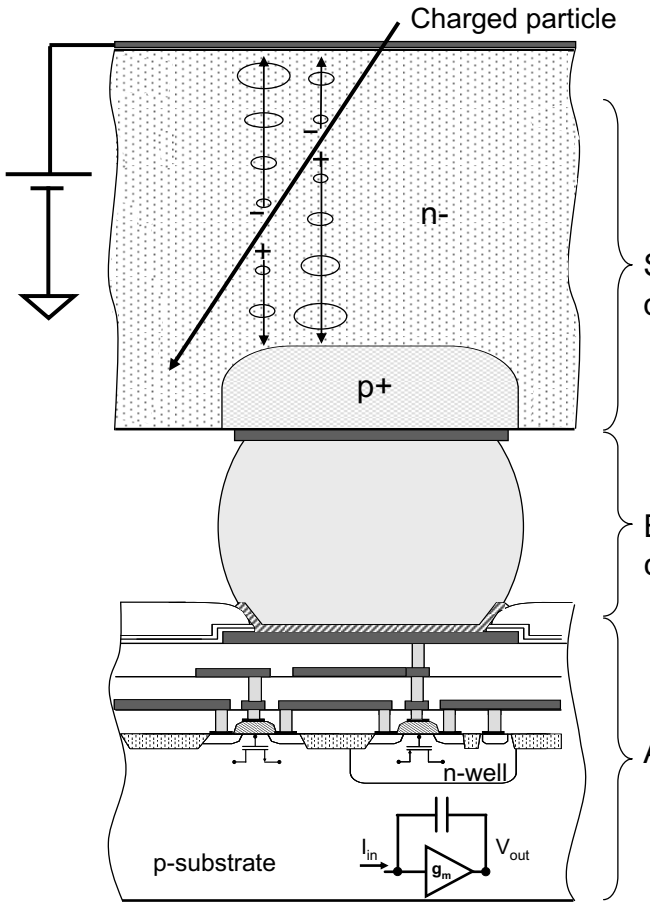
Richieste ai servizi

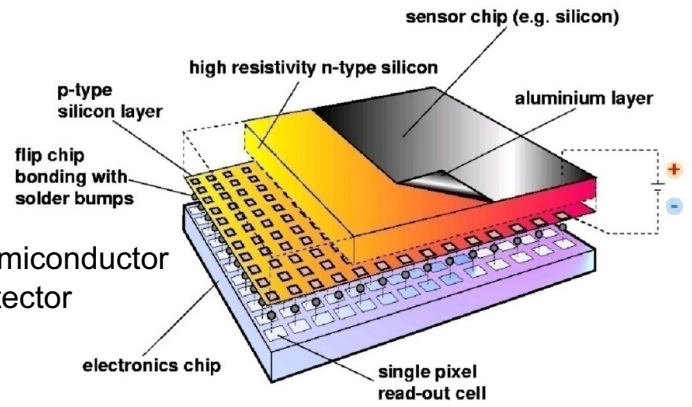
Progettazione: 6 m.u.
supporteria/schermature più nuovo rivelatore veto; misure test Ge e VOXES

Officina meccanica: 6 m.u. per costruzioni supporterie, schermature, frame nuovo veto2 layer, test setup Ge, VOXES

Tecnici: 2 x 0.5 FTE installazioni e costruzioni varie

Timepix





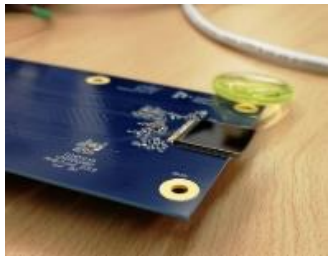
Standard CMOS can be used allowing on-pixel signal processing
Sensor material can be changed according to the application you need : Silicon, GaAs, CdTe, Diamond … and gas → GEMPix detector)

Timepix : Time frame oriented
- ○ Counting mode or
- ○ Time of arrival or
- ○ Charge
- ☹ Dead Time
- ☹ Evis> 5 keV
- ☹ 10 ns resolution
- ☺ kB/s

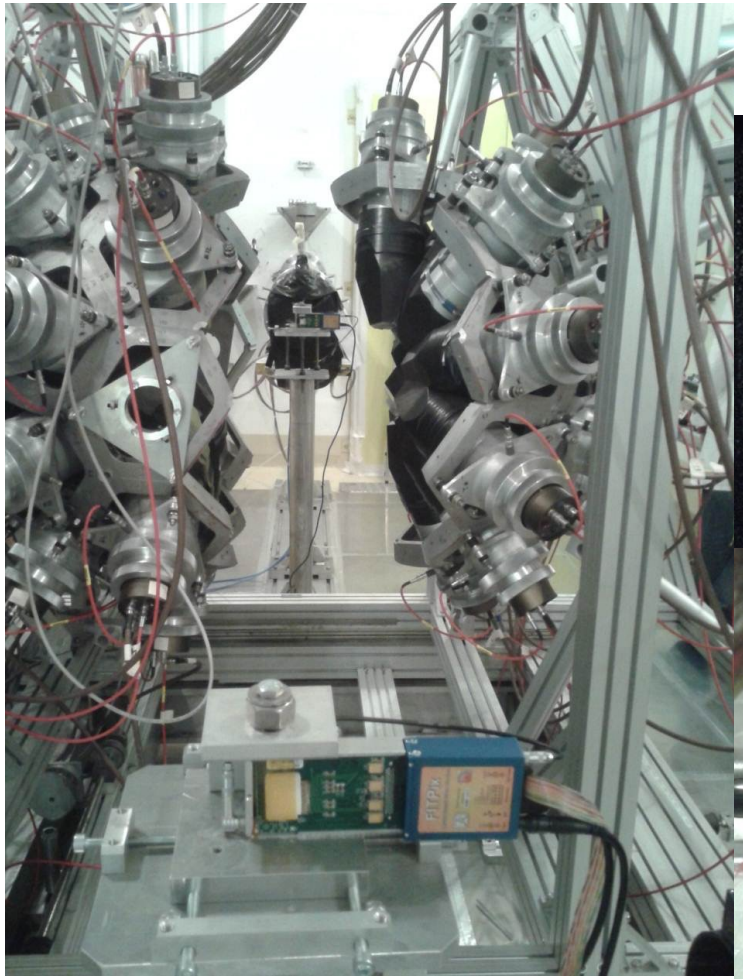
Timepix3: Pixel oriented AND Time frame oriented
- ○ Counting mode and
- ○ Time of arrival and
- ○ Charge
- ☺ Continous measurement
- ☺ Evis> 3 keV
- ☺ 1.5 ns resoution
- ☹ MB/s
- ☹ High Temperature

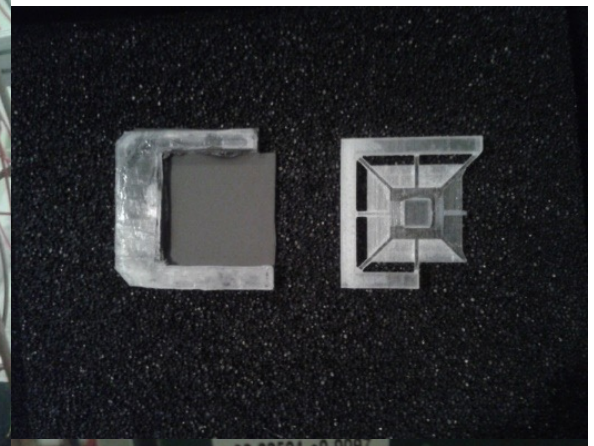
Timepix4_ Pixel oriented
Time frame oriented
4 x active area

…eventually INFN re-enter in Medipix collaboration !



Timepix in EAR1





First measurements were done also with Timepix detectors in 2014 in EAR1

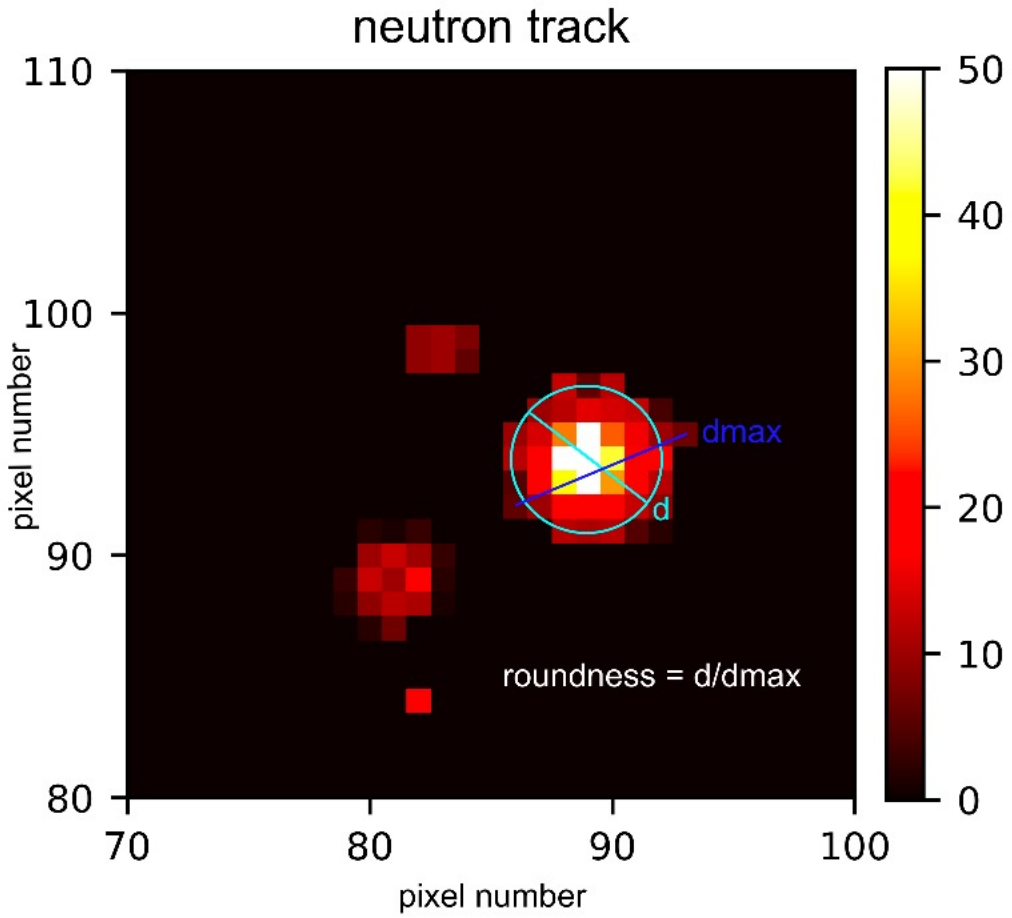
A converter can be placed on top of the silicon sensor (15x15 mm^2 x 300 micron)

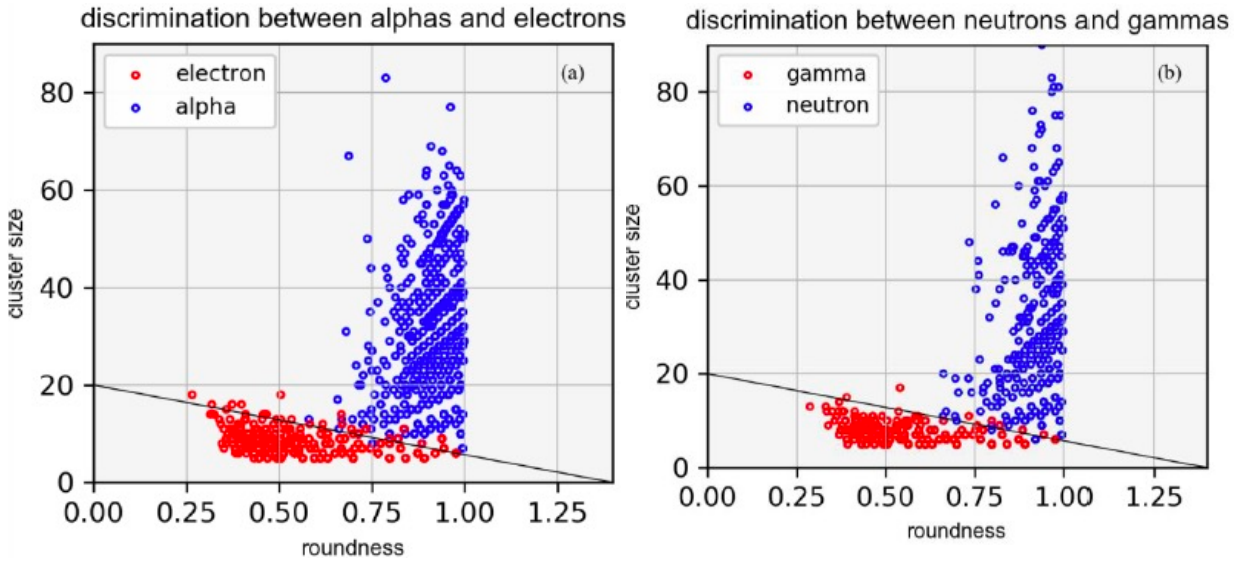
- Boron layer (1 micron)
- PE layer (2 mm)
- Machined PMMA

The converter can be replaced with the detector in position

The sensitivity to thermal or fast neutrons can be changed easily

n/γ discrimination with timepix





For a selected track, *CV* is the sum of the ToT counts on all the pixels belonging to the track, *CS* is the total number of pixels in a track. The *CR* parameter, instead, is defined as the ratio between the diameter of the circumference having the same cluster area and the length separating the two most distant pixels in the cluster [16].

CR parameter can range from 0 (very bad roundness) to 1 (optimal roundness). CS and CR can be used to discriminate the alpha (or neutron) tracks from the gamma (or electron) tracks. Fig 10a shows a plot of CS versus CR for ^{241}Am and ^{90}Sr sources.

title