







Relazione Coordinatore CSN3@LNF

Consiglio Laboratorio Aperto 30 Giugno 2017

Alessandra Fantoni

 ALICE	CERN	Fisica: QGP	9.5 FTE	F. Ronchetti
	CNAO/TIFPA/ LNS/BTF	Fisica: framm. nucleare	1.9 FTE	
	Jlab	Fisica: adronica	3.7 FTE	
	Bonn/Mainz	Fisica: adronica	1.2 FTE	
	LNF	Fisica: nucleare	11.8 FTE	C. Curceanu
	LNGS	Fisica: nucleare	6.0 FTE	
<u>Totali:</u> 34.1 FTE (Ric.+Tecnol.) + Tecnici				

Nuclear Physics Exp. @ LNF in 2017

Funding 2017, SJ 2017 at the level of 0.5 kE

Exp	Res	Tec	FTE	MIS		CON	APP	INV	Other	
ALICE	7	3	7.6	40		19		14	TRA+SPS	
FOOT	2	3	2	2		3	25	1	TRA	
JLAB12	5	1	3.7	37		2	245	3	7	TRA
KAONNIS	16	2	10.9	14.5		31+ 14.5		17	8	TRA+MAN
MAMBO	2	0	1.2	7.5	2	5				
VIP	12	2	8.8	22	1	9+9		16 2.5	7	MAN+LIC
DTZ	37	4	34.2	32.5		8		16	4.5	MAN+SEM



FOOT

Fragmentation Of Target

An experiment for the measurement of the nuclear fragmentation for Particle Therapy

Experiment with translational approach:

- focus on nuclear physics
- physics applied to medicine
- radioprotection in space

About 50 people for 24 FTE

DATA taking foreseen @ CNAO, TIFPA, LNS, BTF

LNFR & T

1.	Clozza A.	0.2
2.	Sanelli C.	0.5
3.	Sarti A.	0.3
4.	Spiriti E.	0.5
5.	Tomassini S.	0.4

5 Physicists for 1.9 FTE

Average participation of 40%

CSN3:

New experiment in 2017, approved as R&D
Approved last CSN3 meeting, after CDR
Financial plan to be discussed in september



FOOT CDR (Conceptual Design Report)

Delivered 16-06-2017

<https://pandora.infn.it/public/36683d>

FOOT Conceptual Design Report

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U. Weber^y, A. Zoccoli^{e,u}

INFN

Bologna

Frascati

Milano

Napoli

Perugia

(Pavia)

Pisa

Roma1

Roma2

Torino

Trento

INFN: 50 Ricercatori, 24 FTE

+ Centro Fermi, CNAO

+ IPHC (Strasbourg), GSI (Darmstadt), RWTH (Aachen), Nagoja (Japan)

FOOT CDR (Conceptual Design Report)

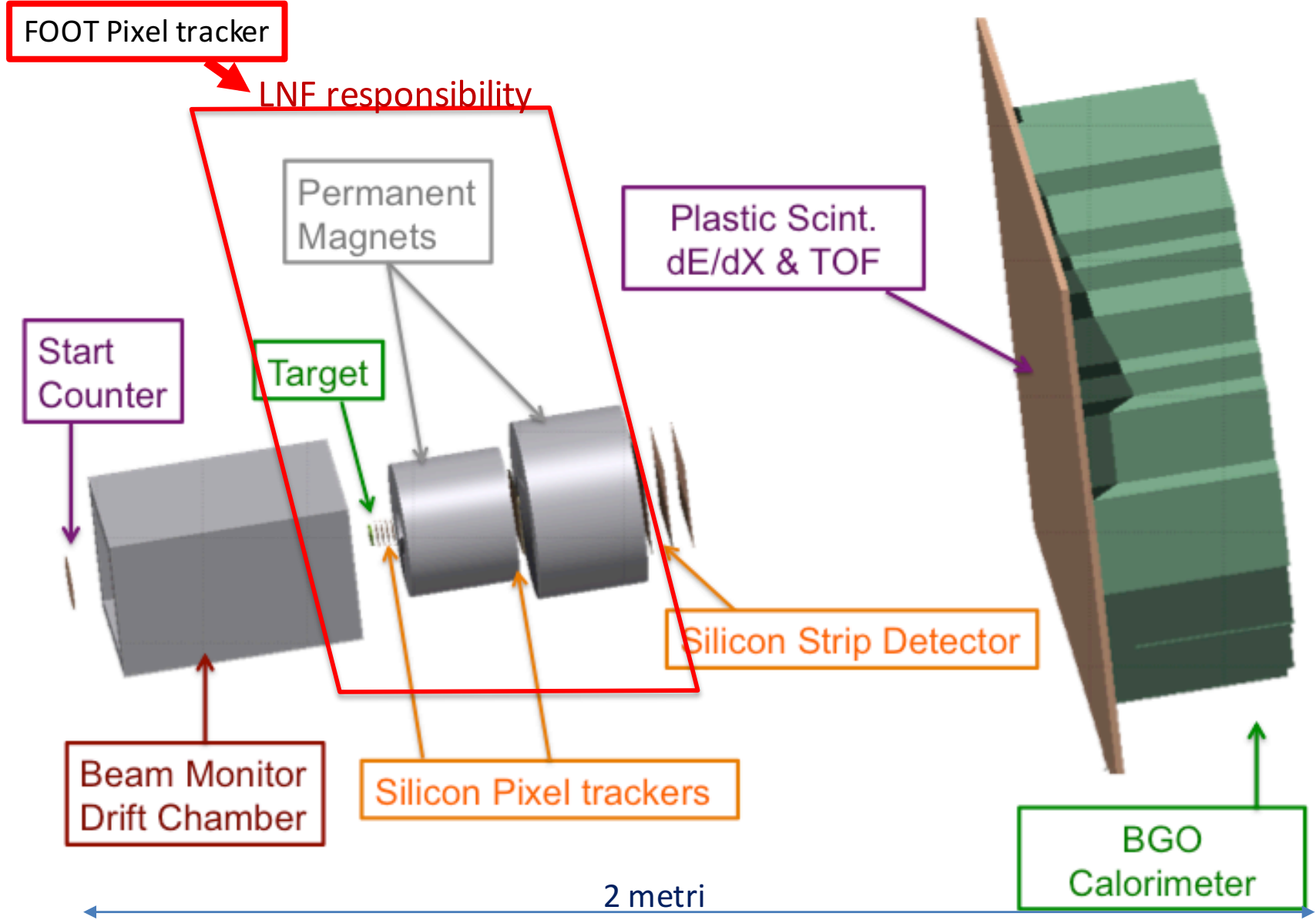
94 pages document



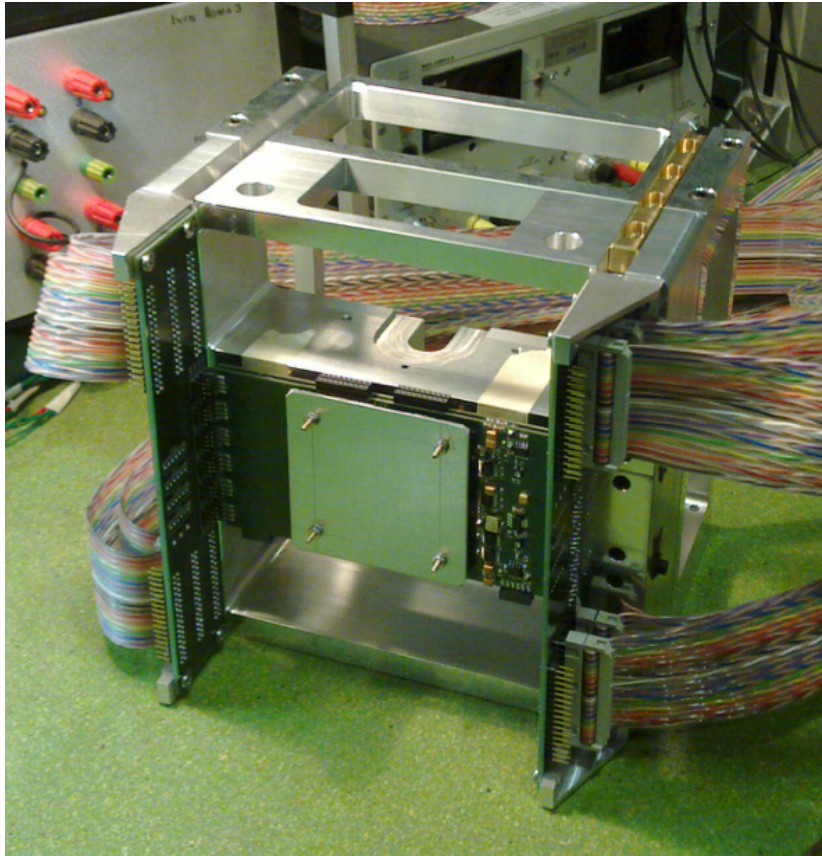
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Description of the Pixel tracking system.
LNF responsibility

FOOT overall detector schematic picture

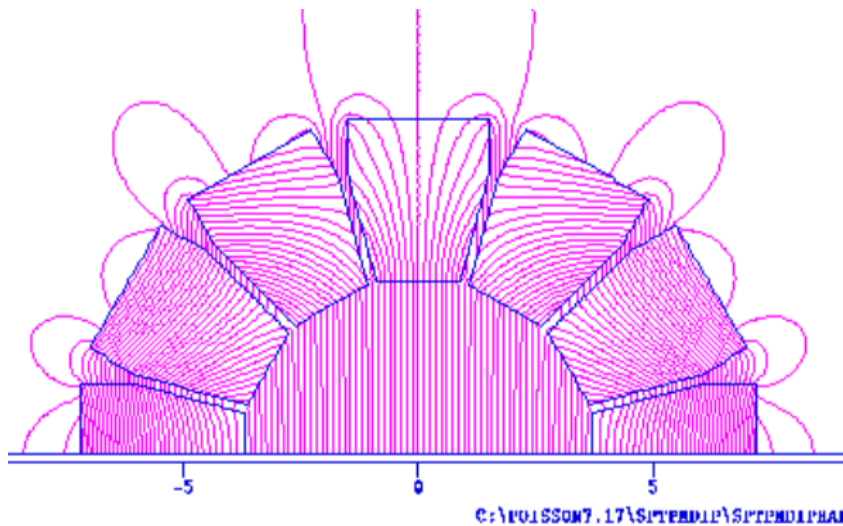
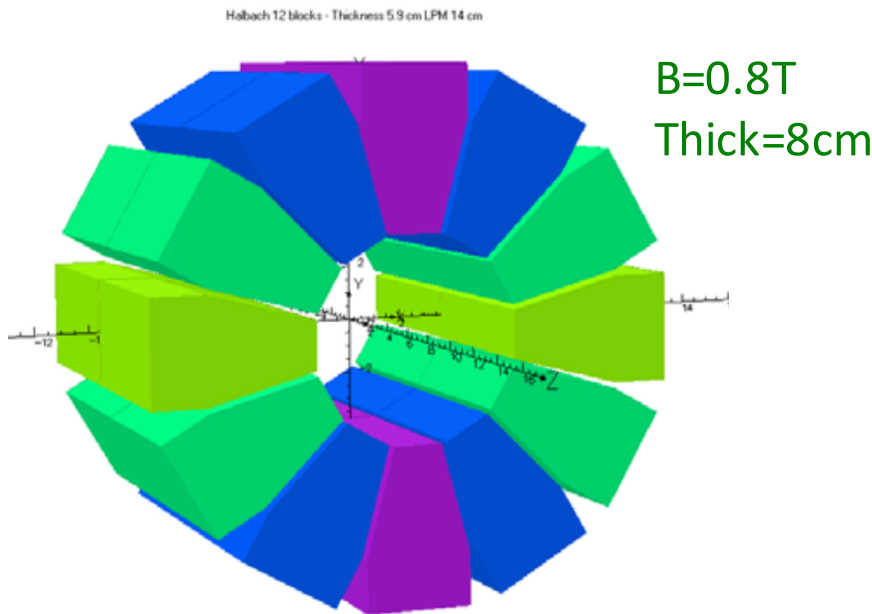


The FIRST target and Vertex setup



Target: system used for the FIRST experiment, equipped with two M26 Mimosa sensors => to be replaced with four new boards redesigned to host one M28 sensors each

The FOOT tracker magnetic region



Halbach geometry provides uniform transverse magnetic field in a cylindrical geometry:
 B field proportional to $\ln(R_{out}/R_{in})$



LABORATORI NAZIONALI DI FRASCATI
 SIDS-Pubblicazioni

LNF-XX/YY(IR)
 May 6, 2017

Studio di fattibilità dei magneti in configurazione “Hallbach” dello spettrometro dell’esperimento FOOT

Claudio Sanelli¹

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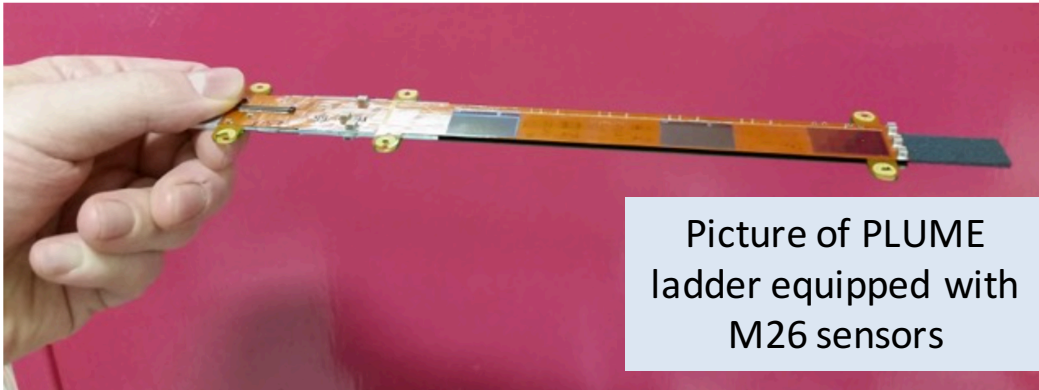
Abstract

Questa nota presenta uno studio di fattibilità per dei magneti permanenti da utilizzare nella costruzione dello spettrometro dell’esperimento FOOT. Vengono presentate simulazioni magnetiche in 2D e 3D per differenti configurazioni dei magneti permanenti in configurazione “Hallbach” facendo una valutazione comparativa delle dimensioni necessarie, in particolare per il materiale magnetico, per ottenere i valori di campo richiesti. Infine si presenta una simulazione di un sistema di due magneti così come al momento si pensa di realizzare il sistema finale dell’esperimento.

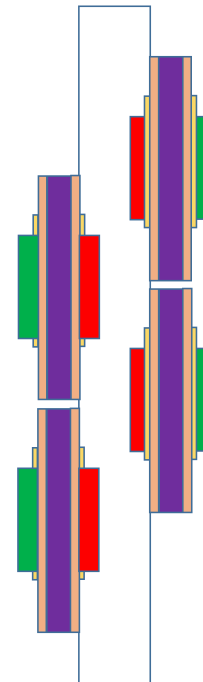
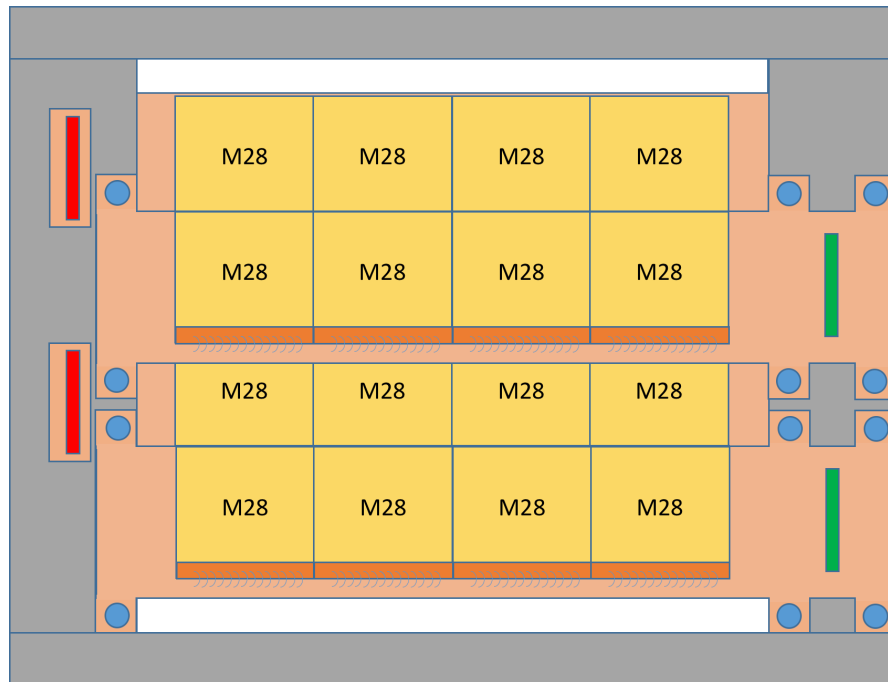
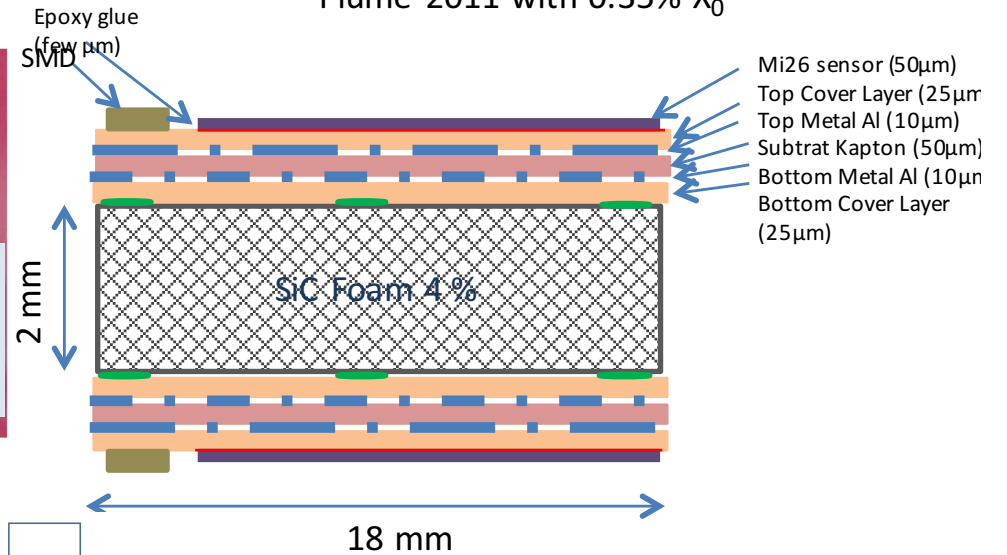
FOOT Inner tracker



Plume 2011 with 0.35% X_0



Picture of PLUME ladder equipped with M26 sensors

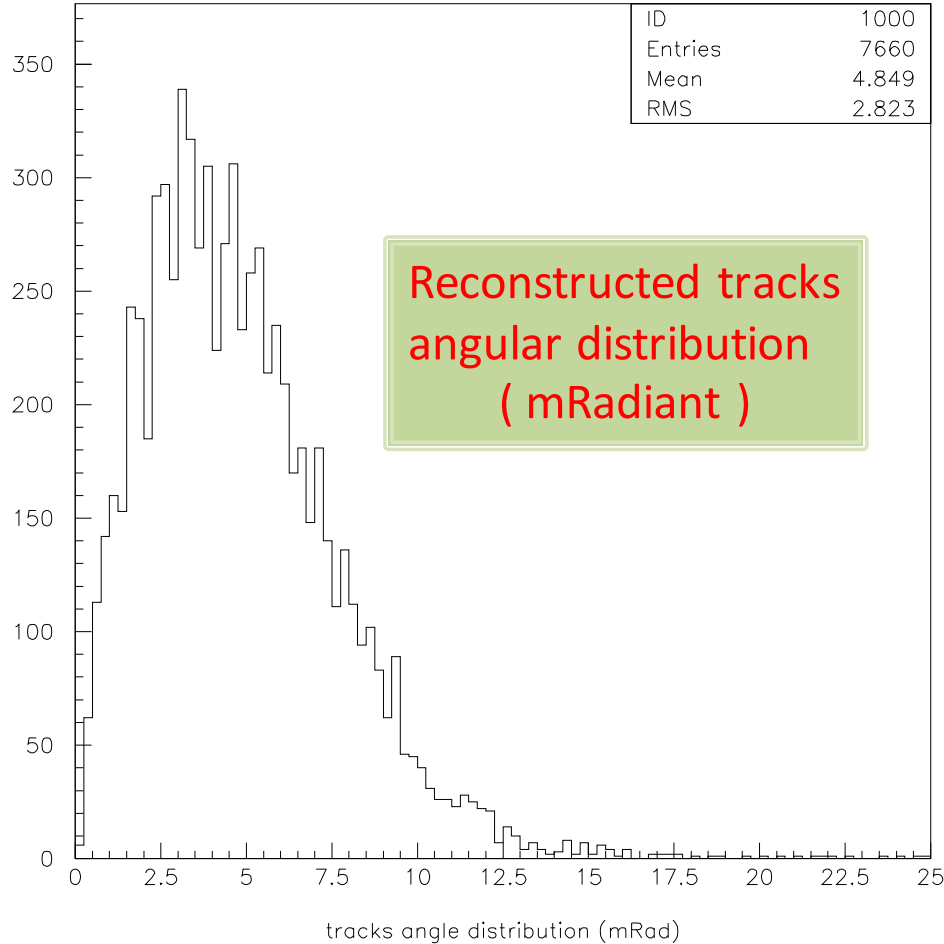
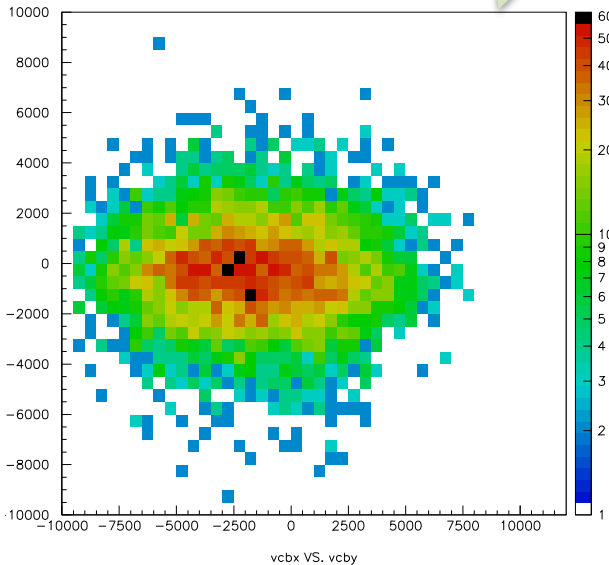
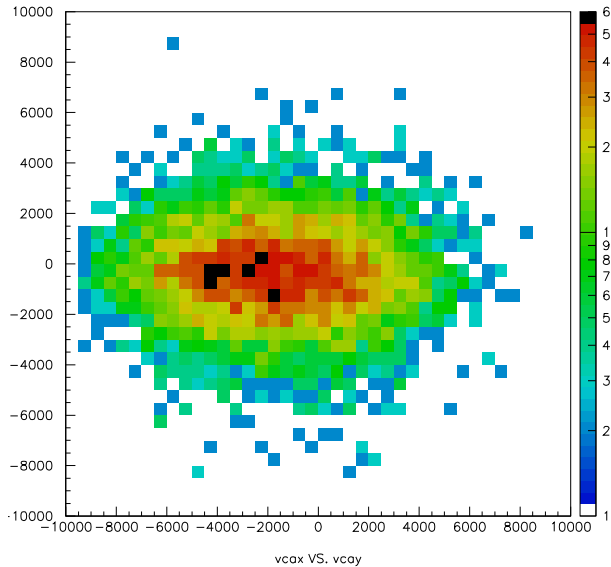


- 1 modulo = 4 sensori
Mimosa M28
- 1 Ladder = 2 moduli
accoppiati
- 1 Layer = 2 Ladder
- Inner tracker = 2 Layer
(4 Ladder)

Two M28 sensors tested at BTF (February, April 2017)



Beam profile in the two sensors
(axis in micrometers)



Reconstructed tracks
angular distribution
(mRadiant)

Attività 2018



Attività 2018 sul tracciatore a pixel di FOOT

- Acquisto secondo batch dei sensori, primo batch nel 2017
- Disegno e realizzazione dell’FPC (Flexible Printed Circuit) per il Tracciatore intermedio (**SEA**)
- Gara per l’acquisto dei magneti permanenti del tracciatore
- Sviluppo di sistemi di assemblaggio dei sensori dell’Inner Tracker (Jigs, incollaggio, bonding) in collaborazione con G&A Engineering
- Realizzazione dei sistemi di DAQ e test da laboratorio/fascio (BTF, LNS)
- Sviluppo di un sistema di readout integrato per il tracciatore intermedio (**SEA** - sviluppo di una scheda con FPGA per lettura integrata di 8 sensori tipo Ultimate)
- Progettazione del sistema di supporto integrato con le readout board del tracciatore intermedio (**SPAS**)
- Disegno e realizzazione della meccanica di supporto del tracciatore composto da: rivelatore di vertice, tracciatore intermedio, magneti (**SPAS**)
- Studio di possibili nuovi sensori a pixel “analogici” (progetto PEGASUS Strasburgo)

Richieste finanziarie:

Missioni	6k
Apparato	115k (secondo wafer + 2 magneti)
Consumo	50k (meccanica supporto, sviluppo scheda readout tracciatore intermedio, tracciatore intermedio)
Trasporto	1 k (per test LNS)

Richieste (indicative) servizi:

SEA	3 mu
SPAS	3 mu
Off. Mecc.	1 mu

Ricercatori/Tecnologi

1. E. De Sanctis 0
2. D. Hasch 0
3. V. Lucherini 1
4. **M. Mirazita 1**
5. P. Rossi 0.3
6. S. Tomassini 0.4
7. M. Turisini 1

Tecnici

- A. Orlandi 0.2
- D. Orecchini 0.8
- A. Viticchié

5 Physicists for 3.7 FTE
Average participation of 74%

Physics activity at JLab in Hall-B:
study of the nucleon structure through eN and eA fixed target experiments

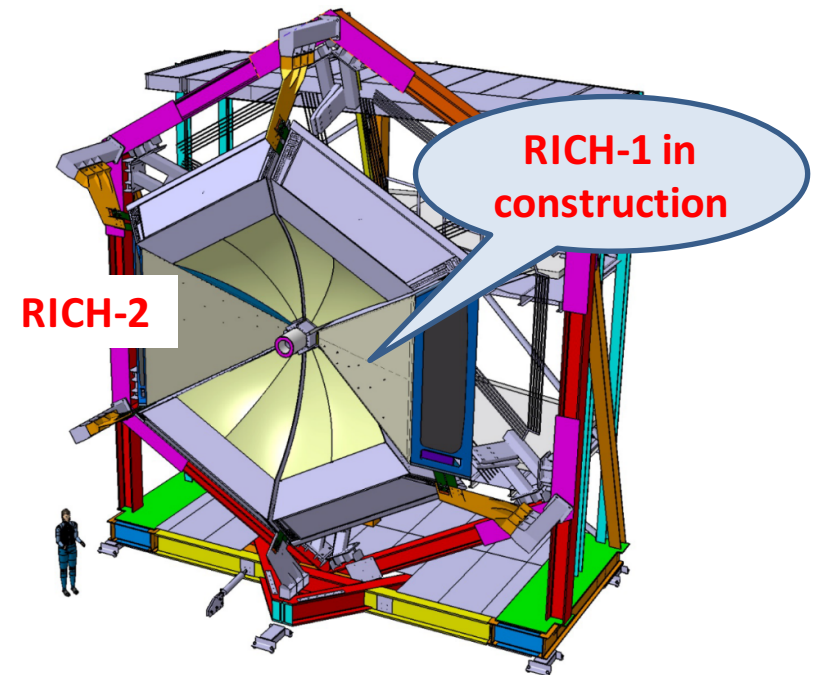
LNF group involved in **RICH for CLAS12:**
Improvement of PID needed to extend TMD measurements to kaons

Goal: ID of kaons vs π and p with $p=3-8$ GeV/c

- Will replace 2 sectors of the thr. Cherenkov counters
- RICH-1 construction started in 2014
 - Beginning of assembly in October 2015
 - Ready in October 2017
- RICH-2 after 2019

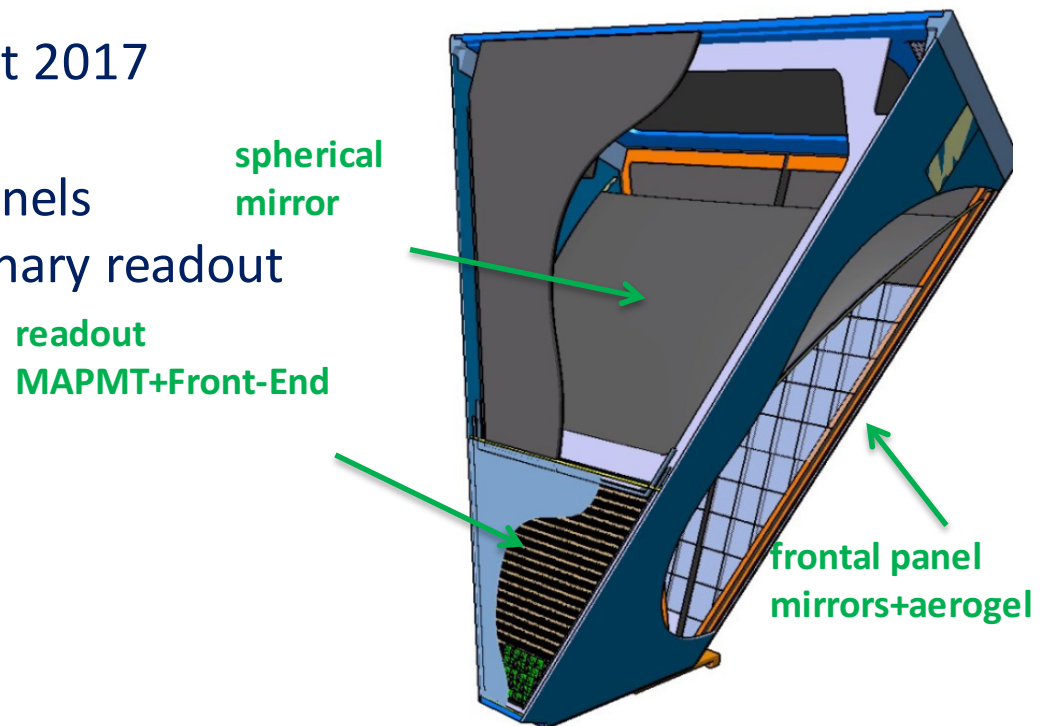
LNF responsibilities:

Design and construction of the mechanical structure
Design of mirrors, support and alignment system



The RICH for CLAS12

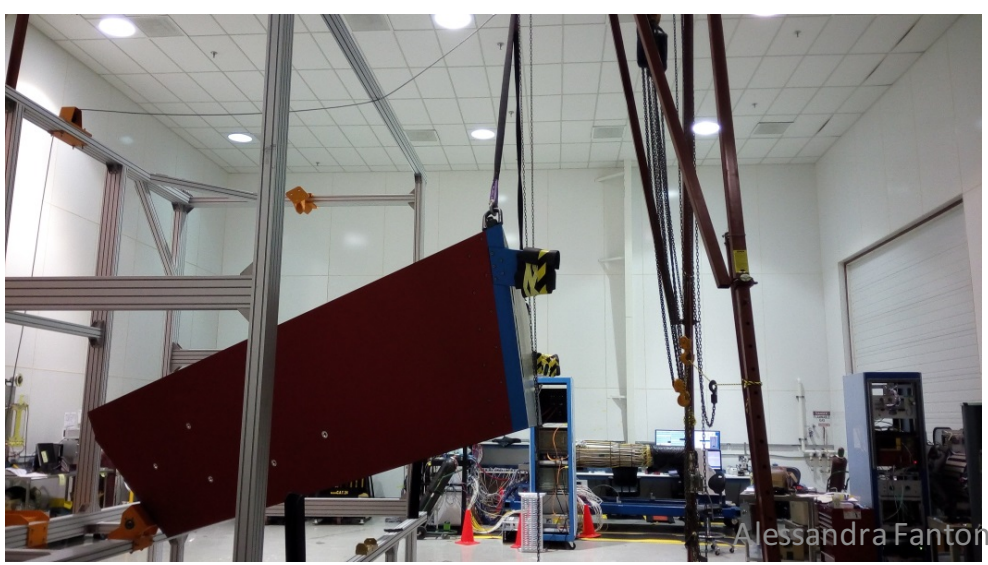
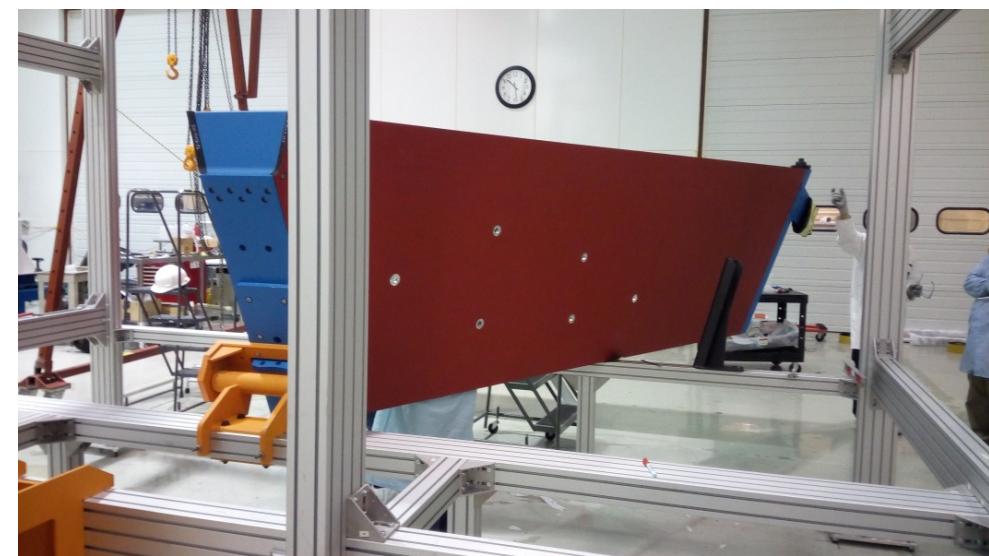
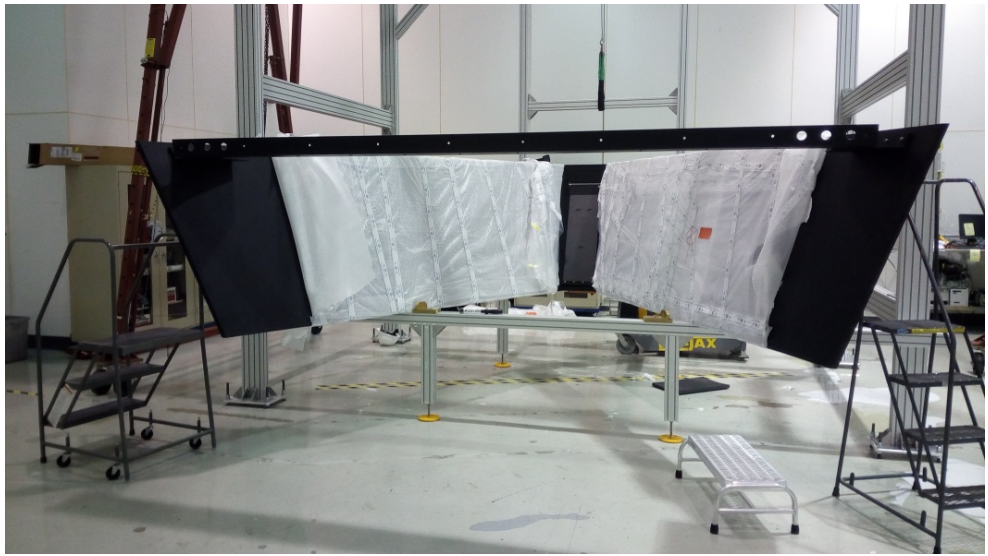
- **Spherical mirrors**
 - 10 carbon fiber mirrors, total area 3.6 m²
 - completion by July 2017
- **Planar mirrors**
 - 7 glass mirrors, total area 3.7 m², very light (~1% X0)
 - completion by July 2017
- **Aerogel radiator**
 - about 120 tiles, 20x20 cm²
 - production completion by August 2017
- **Readout**
 - 391 MultiAnode PMT, 2500 channels
 - FE based on the MAROC chip, binary readout



The RICH mechanical structure

Assembly of the mechanical structure at JLab completed in April 2017

Design of and construction under **LNF** responsibility

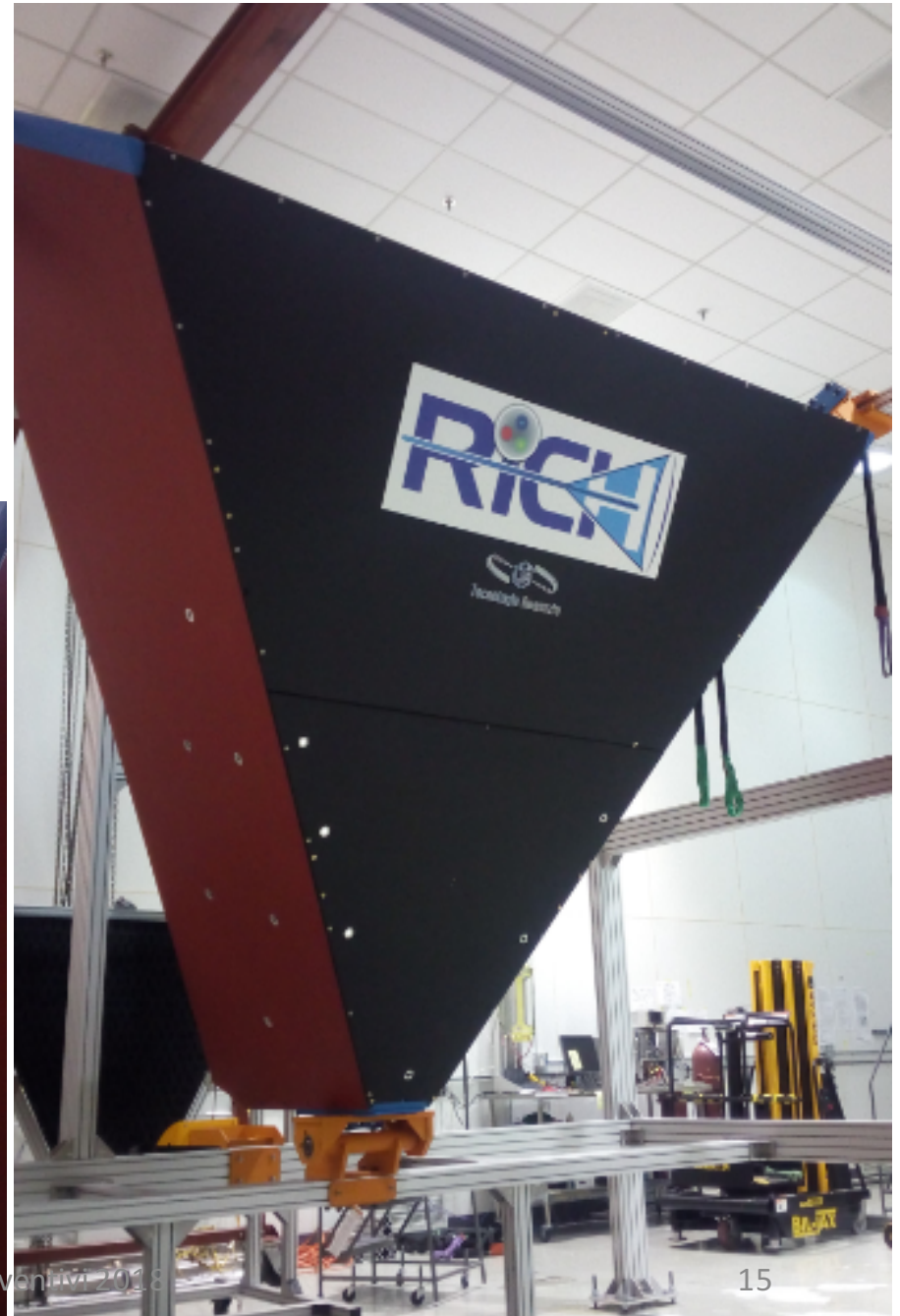


The RICH assembly



Frontal panel

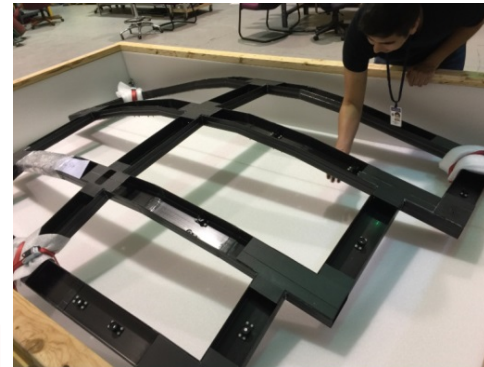
Electronic panel



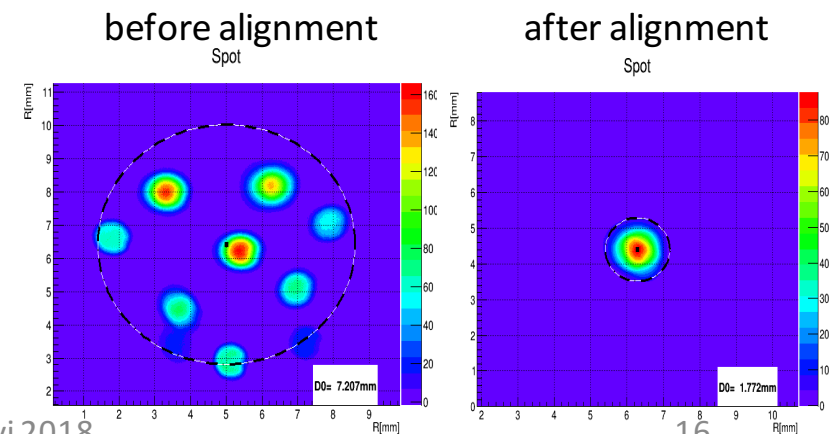
Spherical mirrors

- Mirrors produced in 2016
- Support designed and produced in 2017
- Assembly test performed in April 2017
- Coating of the reflecting layer in progress

Design of the mirrors, the support and the alignment system under **LNf responsibility**

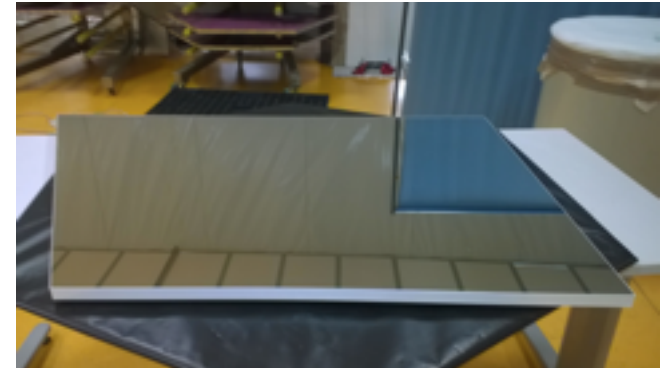


Reflected spot
from a pointlike source:
- alignment procedure ~20 min

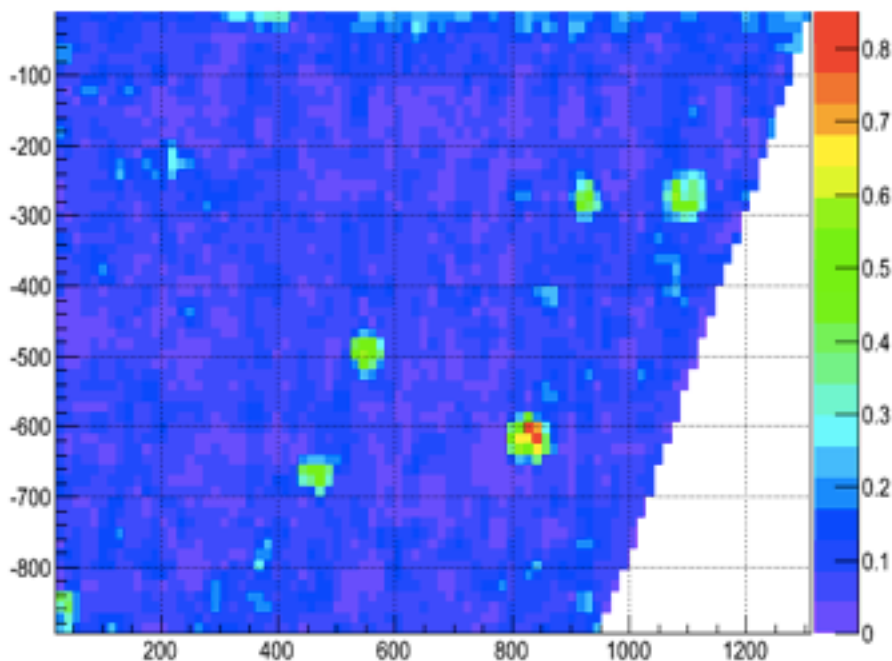


Planar mirrors

- Five lateral mirrors produced (thick skins 1.6 mm)
 - 3 accepted, 2 under verification
- Two frontal mirrors in production (thin skins 0.6 mm)
 - delivery by July 2017
- Assembly test successful



Design of the mirrors, the support and the alignment system under **LNf responsibility**



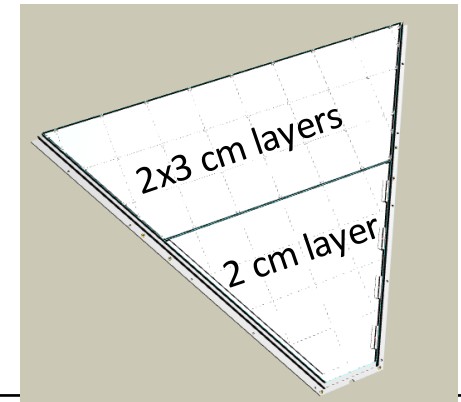
- Characterization of the prototypes at LNf using the **ALICE CMM machine**
- profile of the mirror measured in a 5x5 mm² grid
 - Local slope of the surface reconstructed

The RICH radiator: Aerogel

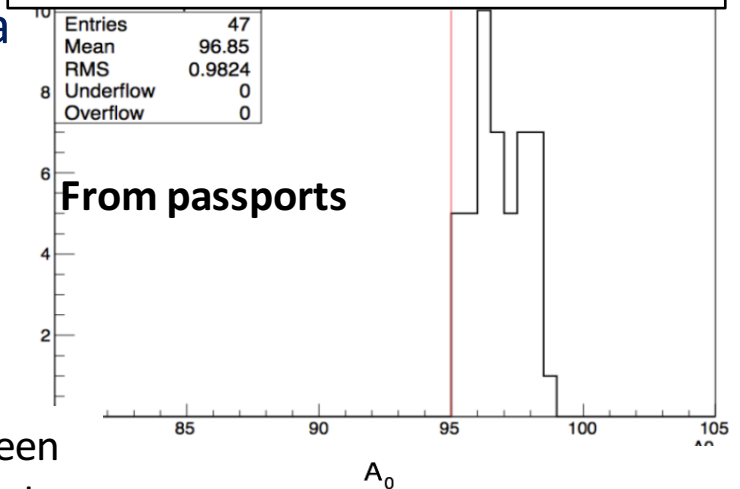
Large 20x20 cm² tiles produced by the Budker Institute (Novosibirsk, Russia)

- Production of the 3 cm layers almost completed
- Production of the 2 cm layer in progress, expected completion by August 2017

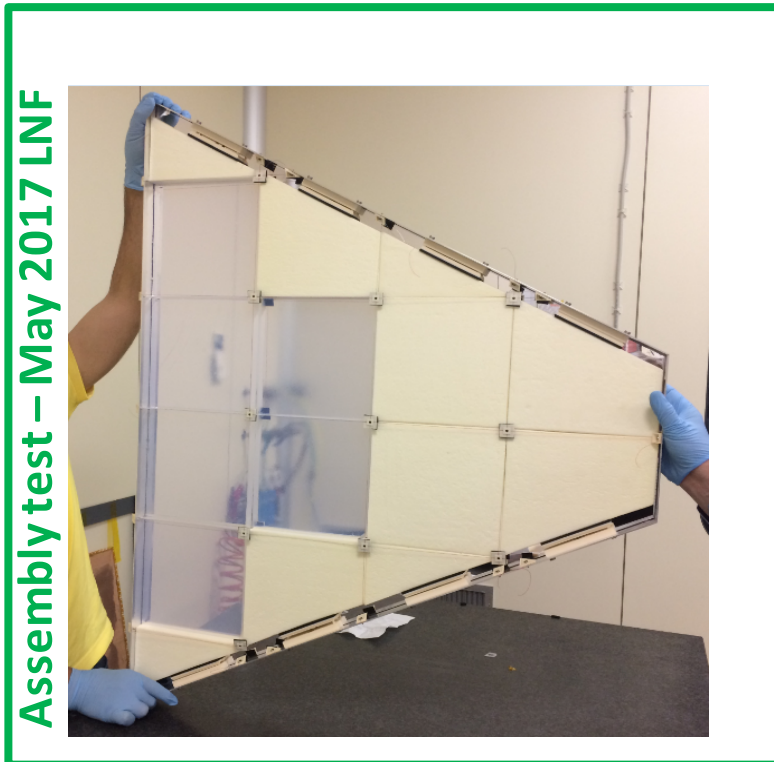
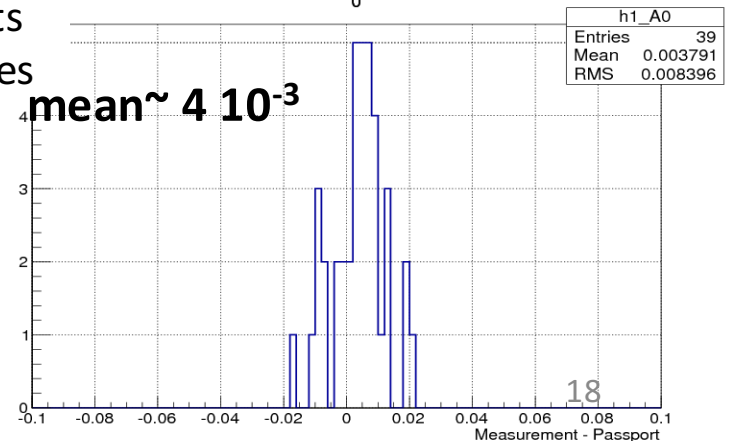
All delivered tiles are measured at the Catholic University (Washington) => results in agreement with vendor data



Transparency coefficient A₀



Difference between LNF measurements and passport values



Richieste 2018

Richieste finanziarie

Apparati	150k (aerogel secondo settore RICH)
Consumo	10k
Trasporti	10k
Missioni	38k

Richieste ai servizi

Progettazione 4 m.u. costruzioni meccaniche secondo settore RICH

Officina meccanica

+ prototipazione rapida (3D) 1 m.u. prototipi studi fotorivelatori
+ test di specchi

NOTA:

Premiale CLAS-MED 2013: 2.1M

Accordo con GE: finanziamento 600k in 3 anni (200k/y) da Sett 2015

+ finanziamento secondo modulo RICH da CSN3



LNF activities

2 researchers for 1.2 FTE
Average participation of 60%
Total INFN ~12 FTE

- 1. P. Levi Sandri 0.8
- 2. D. Pietreanu 0.4

- Nucleon excited states via meson photoproduction at MAMIc (Mainz) and ELSA (Bonn)
- Transition form factor
- η' threshold anomaly
- International collaboration: Bonn PI, Bonn HSKP, (Gießen), ISS, LNF, Messina, Pavia, Roma2, Torino, Glasgow, Basel, PNPI Gatchina, INR Mosca, IHENP Kharkov (Iowa State U)

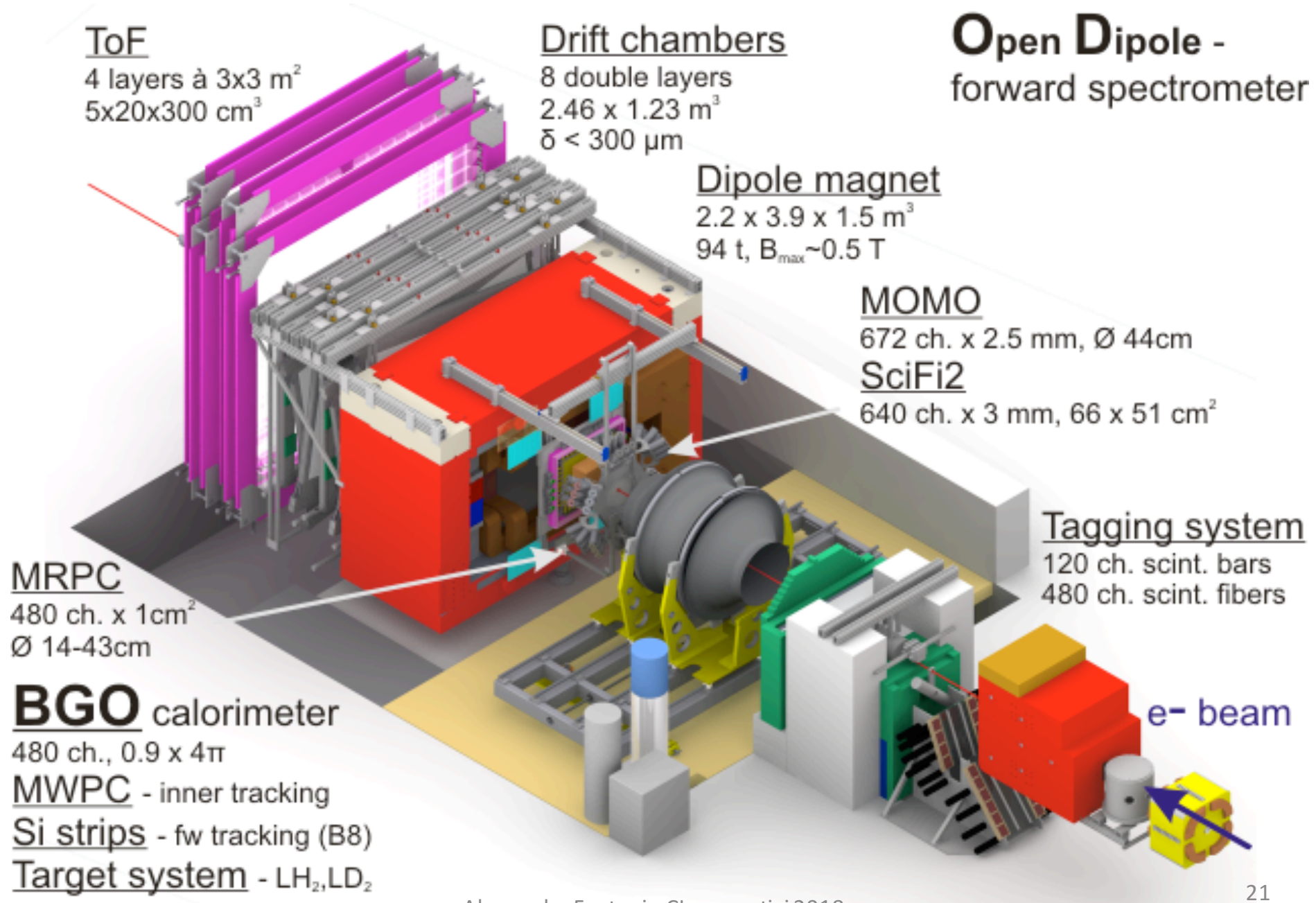
Collaboration Responsibilities:

- Co-spokesperson BGO-OD
- Responsabile Nazionale INFN
- MC coordinator
- Spokesperson η' beam asymmetry and x-sect

Hardware responsibilities:

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

Open Dipole + BGO calorimeter @ Bonn



ToF

4 layers à 3x3 m²
5x20x300 cm³

Drift chambers

8 double layers
2.46 x 1.23 m³
 $\delta < 300 \mu\text{m}$

Open Dipole - forward spectrometer

Dipole magnet

2.2 x 3.9 x 1.5 m³
94 t, $B_{\text{max}} \sim 0.5 \text{ T}$

MOMO

672 ch. x 2.5 mm, $\varnothing 44\text{cm}$

SciFi2

640 ch. x 3 mm, 66 x 51 cm²

Tagging system

120 ch. scint. bars
480 ch. scint. fibers

MRPC

480 ch. x 1cm²
 $\varnothing 14\text{-}43\text{cm}$

BGO calorimeter

480 ch., 0.9 x 4 π

MWPC - inner tracking

Si strips - fw tracking (B8)

Target system - LH₂, LD₂

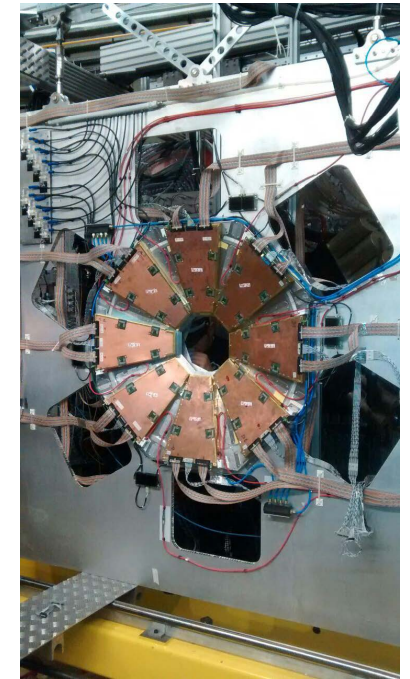
e⁻ beam

ELSA (Bonn) beamline S - Status



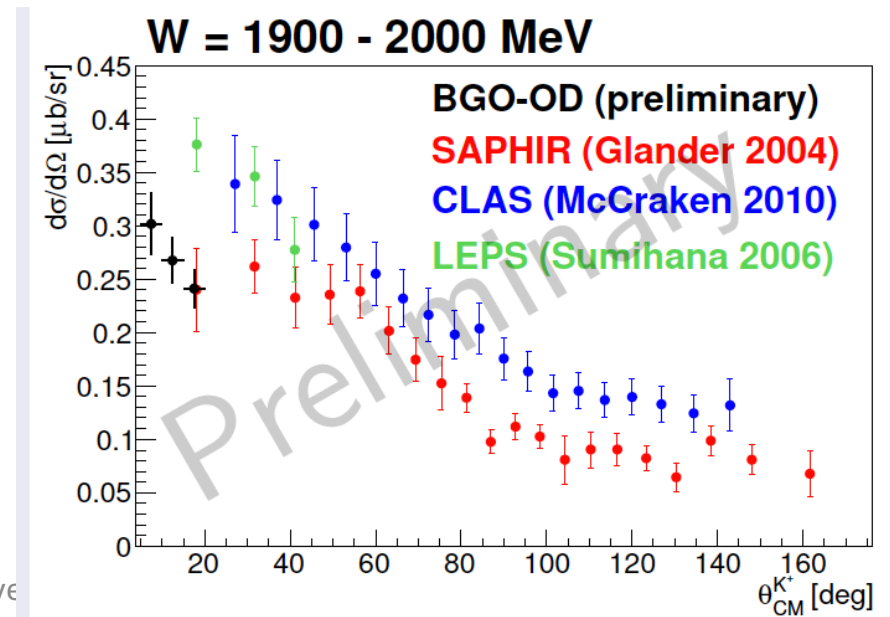
Rivelatori & Software:

- MWPC: Commissioned
- MRPC: Final commissioning
- Calorimetro e barrel in funzione
- MonteCarlo in continuo sviluppo, generatore di eventi (LNF, Messina Roma2)



Raccolta dati 2016-2017:

- Un run di presa dati in configurazione ridotta con bersaglio H nel 2016
- Un run di produzione ad aprile 2017 + possibile run in autunno
- Analisi in corso
- Primi risultati preliminari



Attività 2017 – 2018 e oltre:

- Nuova richiesta DFG presentata a marzo 2017
risposta entro fine anno
- Analisi dati raccolti + eventuale presa dati in autunno
- 2018: richieste 2000h fascio per:
 - completamento misura H
 - inizio misura D
- 2019: bersaglio D
- 2020: ${}^6\text{Li}$, ${}^{12}\text{C}$

Richieste finanziarie

missioni

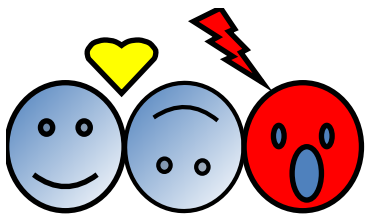
15k

consumo

10k

Richieste ai servizi

Nessuna salvo imprevisti



VIP

LNF activities

9 researchers for 6.0 FTE
Average participation of 67%

1. S. Bartalucci	0.4
2. M. Benfatto	0.4
3. A. Clozza	0.3
4. C. Curceanu	0.4
5. J. Marton	0.5
6. A. Pichler	1
7. K. Piscicchia	1
8. H. Shi	1
9. L. Sperandio	1

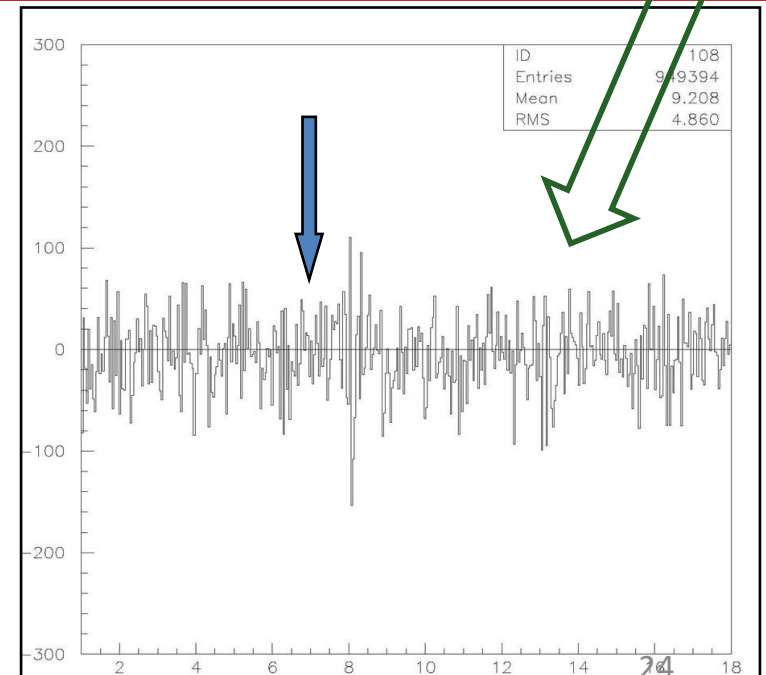
- **VIP=Violation Pauli Exclusion Principle (PEP)**
- Perform experimental test of PEP for e^- with a clean method
- Located at LNGS to reduce X-ray background
- International collaboration: LNF, LNGS, Ts INFN; SMI-OAW (Austria); IFIN-HH (Romania); Neuchatel U. (Switzerland); Rennes U. (France); Uni & INFN BO
- VIP already established a probability of PEP violation $\beta^2/2 < 4 \times 10^{-29}$
previous limit $< 1.7 \times 10^{-26}$ PLB 328 (1990) 438
- **VIP upgrade (CCD detectors replaced by SDD) : VIP-2 in data taking at LNGS**
- **Other tests of Quantum Mechanics (collapse models)**

VIP-2

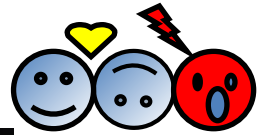
- new detectors (triggerable SDD)
- Resolution: $300 \mu\text{m}$, more efficient in a broader energy range
- new setup, much more compact:
 - higher acceptance (present one 2.8%)
 - lower background

ALL Responsibilities @ LNF

Previous limit improved by 3 orders of magnitude
International Journal of Quantum Information 9 (2011) 145

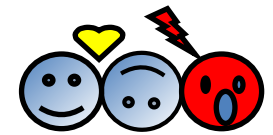


VIP-2 Installed at LNGS in Nov. 2015



Data taking since summer 2016

VIP-related recent results (2016-2017)



Workshop

- **Testing the limits of the quantum superposition principle in nuclear, atomic and optomechanical systems**, 11-16/09/2016, ECT* Trento

Organizers: M. Paternostro (Belfast), C. Curceanu (LNF), A. Bassi (Trieste), H. Ulbricht (Southampton)

- **Quantum Foundations: The physics of “what happens” and the measurement problem**, 20-24/05/2017, LNF

Training school

- **Are spin statistics connection and quantum theory exact?**

The endeavor for the theory beyond the standard quantum mechanics, 21-23/12/2016, LNF

School for graduating students, PhD students and young researchers

External funds (Awards) – PI: C. Curceanu

- John Templeton Foundation Award *“**Hunt for the “impossible atoms”: the quest for a tiny violation of the Pauli Exclusion Principle. Implications for physics, cosmology and philosophy**”*

- Foundational Question Institute FQXi Award *“**Events' as we see them: experimental test of the collapse models as a solution of the measurement-problem**”*

EU projects: COST Action CA15220, Quantum Technologies in Space (2016 – 2020)

VIP-2 preliminary results (2017)

Paper submitted and accepted by Entropy

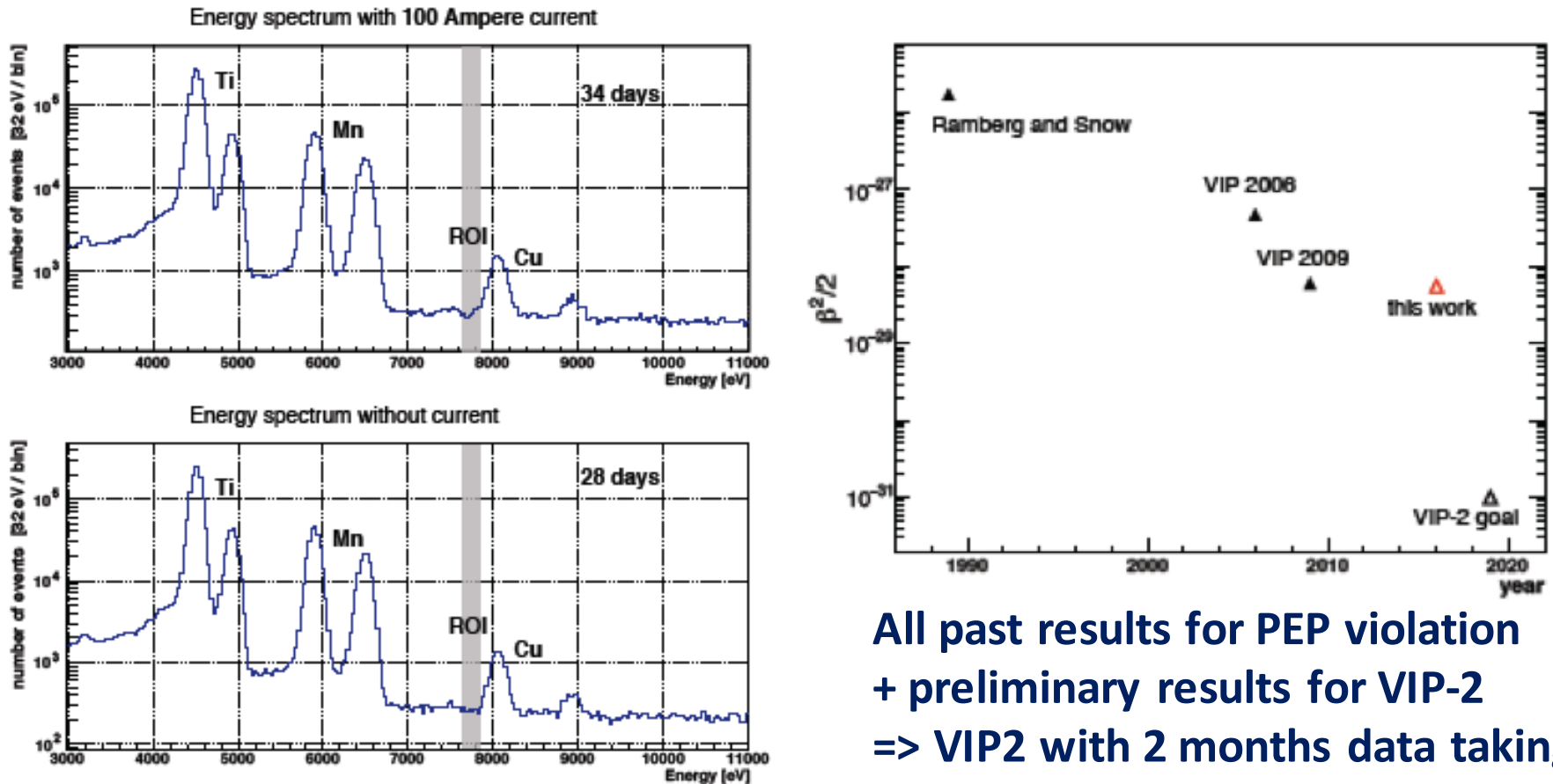


Figure 2. The energy spectra from all the SDDs, for data with and without applied DC current to the copper strip, taken during the physics run in late 2016 at the LNGS.

All past results for PEP violation
+ preliminary results for VIP-2
=> VIP2 with 2 months data taking
already reached VIP limit (3y data
taking)

$$\frac{\beta^2}{2} \leq \frac{3 \times 66}{4.7 \times 10^{30}} = 4.2 \times 10^{-29}.$$

VIP-2 plans



- Data taking at LNGS: next 3-4 years
- Expectation either to find a small violation or to be able to bound the probability that PEP is violated by electrons pushing it from about $4 \cdot 10^{-29}$ to 10^{-31}

Explore other type of measurements related to quantum mechanics tests (collapse model predictions, quantum technologies in space...)

Richieste

Richieste finanziarie

missioni
consumo
inventario
manutenzioni

Richieste ai servizi LNF

20k SEA: 1 m.u. (supporto alimentazione SSD)
20k SPAS: 2 m.u. (progettazione supporto shielding tra fine 2017-2018)
10k
5k SPCM: 2 m.u. (costruzioni supporto + camera da vuoto)

Summary

- Nuclear physics group involved in 5 international collaborations, inside LNF and outside + 1 new experiment recently approved in CSN3



ALICE



- Big LNF contributions in all collaborations
- Several national and/or international responsibilities
- LNF Support for design and construction
- Relevant contribution of LNF technicians for construction and for upgrades

Ringraziamenti (2016/2017):

- *Servizi LNF*
- *Tecnici*
- *Segreteria:*

14/3 Seminari gruppo 3

70/25 ordini

4 Workshop 2016 (Strangeness g waves n stars.INFN2016, 3DPDF, FQT2016)

1 Riunione ALICE ITS Italia

Assenza di segreteria dedicata ☹️ lavoro svolto con supporto e pazienza di tanti