







Relazione Coordinatore CSN3@LNF

Consiglio Laboratorio Aperto 4 Luglio 2016

Alessandra Fantoni

 ALICE	CERN	Fisica: QGP	9.6 FTE	
	Jlab	Fisica: adronica	3.7 FTE	
	Bonn/Mainz	Fisica: adronica	1.2 FTE	
	LNF	Fisica: nucleare	10.3 FTE	
 VIP	LNGS	Fisica: nucleare	9.2 FTE	
	CNAO/TIFPA/ LNS/BTF	Fisica: framm. nucleare	1.5 FTE	=> NEW

Totali: 35.5 FTE (Ric.+Tecnol.) + Tecnici

Nuclear Physics Exp. @ LNF in 2016

Funding 2016, SJ 2016 at the level of 0.5 kE

Exp	Res	Tec	FTE	MIS		CON		APP	INV	Other		
ALICE	9.1	1.8	10.9	70.5		3.5		36	7	SPS		
JLAB12	7.3	0.6	7.6	57		8		46	8	7.5	TRA	
KAONNIS	11.6	4.1	15.7	15.5	3	16	15		8	8	13	AltriCON/MA N/TRA/LIC
MAMBO	1.2	0	1.2	8	2	5			7.5			
PANDA (DTZ)	0.3	0	0.3	5 (dtz)								
VIP	8.6	1.1	9.7	22.5	1	9.5			5	18.5		SPS/MAN
DTZ	38.1	7.6	45.7	30 (19+5+6)		13			7	10		MAN/SEM/LIC



ALICE

LNf activities

11 Ricercatori/Tecnologi per 9.6 FTE
Partecipazione media 87%

Ricercatori/Tecnologi (ALICE+MONOPIXEL):

1.	N. Bianchi	1	
2.	L. Calero Diaz	1	
3.	E. Danè	0.5	
4.	P. Di Nezza	1 (0.9+0.1)	<u>Tecnici:</u>
5.	A. Fantoni	1 (0.9+0.1)	M.Matteo
6.	P. Gianotti	0.7	A.Orlandi
7.	S. Liuti	1	L.Passamonti
8.	V. Muccifora	1 (0.7+0.3)	D.Pierluigi
9.	A.R. Reolon	1 (0.9+0.1)	A.Russo
10.	F. Ronchetti	1 (0.9+0.1)	A.Viticchié
11.	E. Spiriti	0.4 (0.3+0.1)	

Personale:

2 Post-doc in arrivo dopo l'estate per 2 anni:

- 1 Post-doc straniero
- 1 AdR (progetto MONOPIXEL-MAECI)

Progetto MONOPIXEL

- Resp. V. Muccifora -

- “Sviluppo di tecnologie integrate per tracciatori a pixel monolitici”
- sottomesso al MAECI nell'ambito di progetti di grande rilevanza in collaborazione con USA
- in collaborazione con Berkeley
- tra i 15 progetti bilaterali selezionati per biennio 2016-2017
- Finanziamento 2016:
 - AdR 14k
 - Consumo 5k
 - Attrezzature/macchinari 3k
 - Altri servizi 5k

The activity of the LNF group: analysis

LNF important contributor to the physics@LHC

1. Contribution in 2015-2016

- *N-subjettiness as a jet shape to study the antenna effect in heavy-ion collisions*
Diploma thesis + Public Note
- *Measurement of the production of high- p_T electrons from heavy-flavour hadron decays in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV*
LNF First author, in circulation within collaboration (Physics Letters B)

2. Phenomenological studies of jet quenching

Collaboration with Santiago de Compostela & LNF theory department

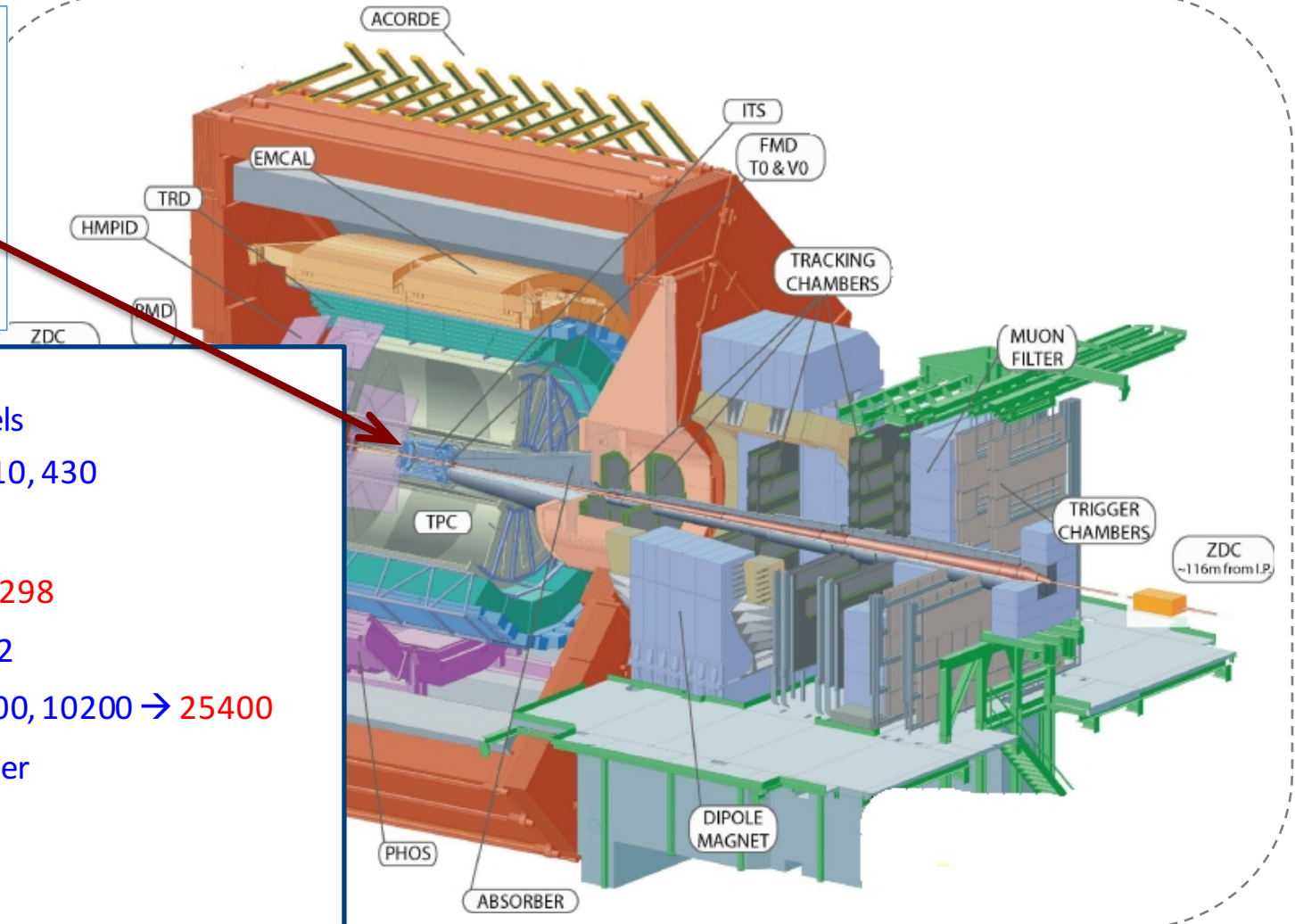
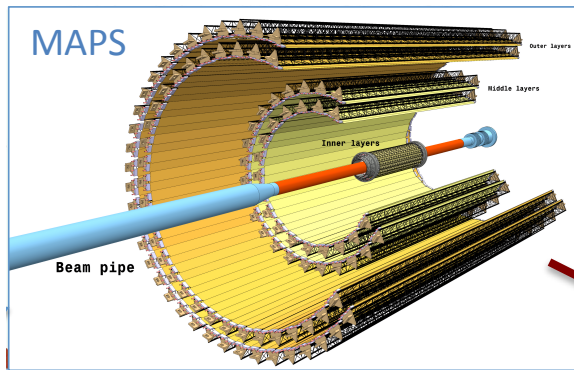
3. Transverse Λ polarization in unpolarized pp scattering

Λ reconstruction globally and in jets \Rightarrow First polarization measurement on TeV scale
First link of GPDs and TMDs with LHC (PhD thesis)

Collaboration with Tufts University and University of Virginia

\rightarrow Workshop at LNF: [3D Parton Distributions: path to the LHC](#) (29 Nov – 2 Dic 2016)

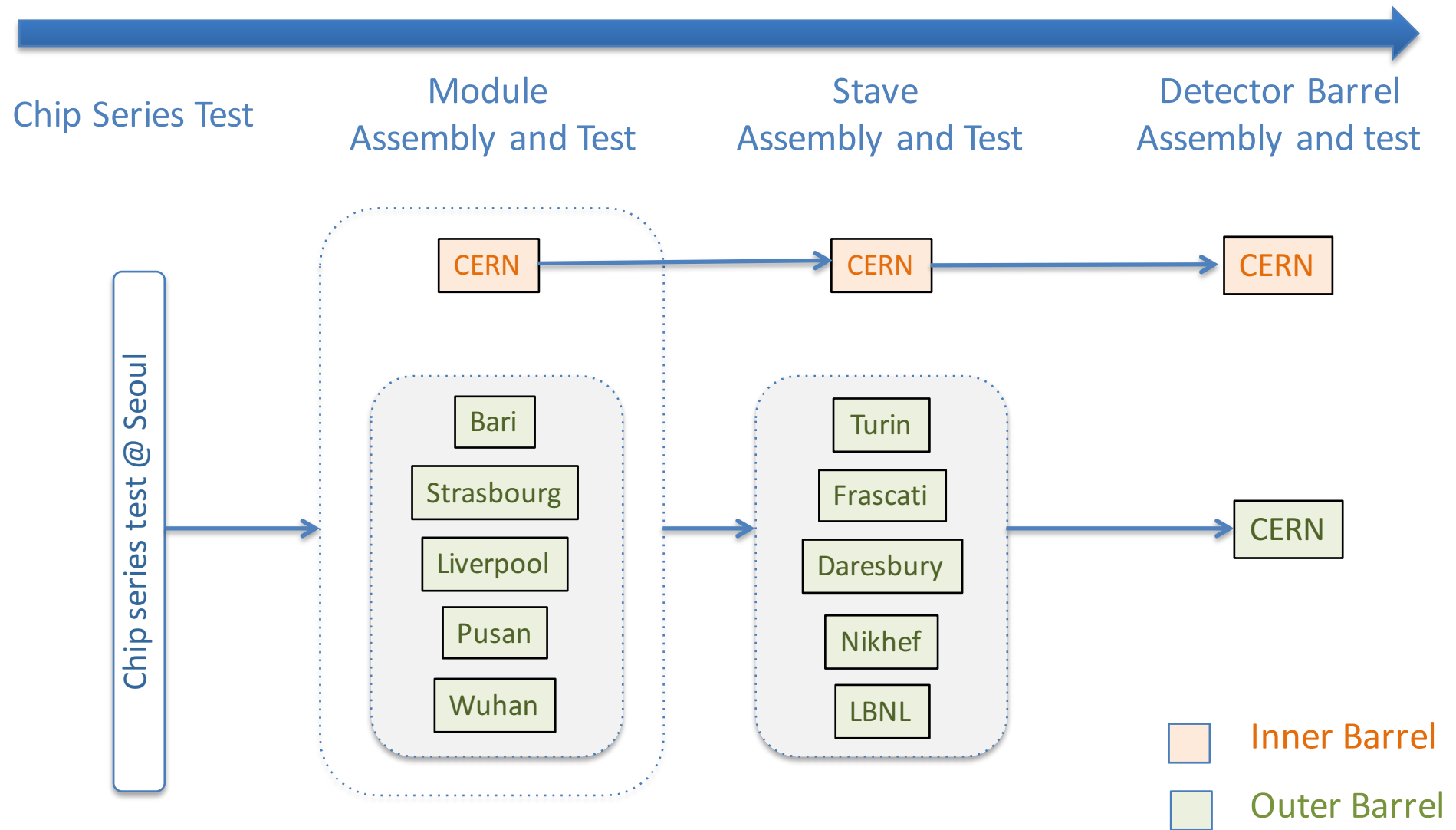
The activity of the LNF group: ITS

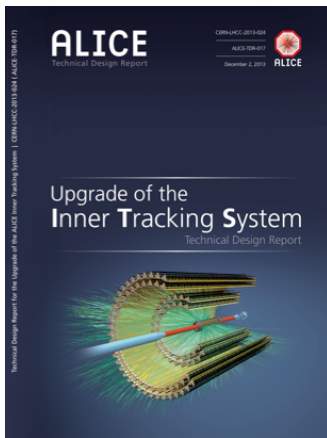


ALICE UPGRADE
ITS Outer Barrel (OB): 4 layers pixels
Radial position (mm): 200, 220, 410, 430
Length in z (mm): 843, 1475
Nr. of modules: 48, 52, 96, 102 → 298
Nr. of chips/module: 28, 28, 52, 52
Nr. of chips/layer: 2688, 2912, 9600, 10200 → 25400
Pixel size: ~ 20 μm x 20 μm or bigger
Material thickness: ~ 0.3% X_0
Throughput: < 6 Mbit / sec·cm²

**Preparation for the new Inner Tracking System construction
LNF as one of the 5 international production centers**

Module and Stave Production Flow Chart





CDR → Dec '12
LHCC Upgrade Cost Group rev. 03/03/2014

Research Board approval 12/03/2014

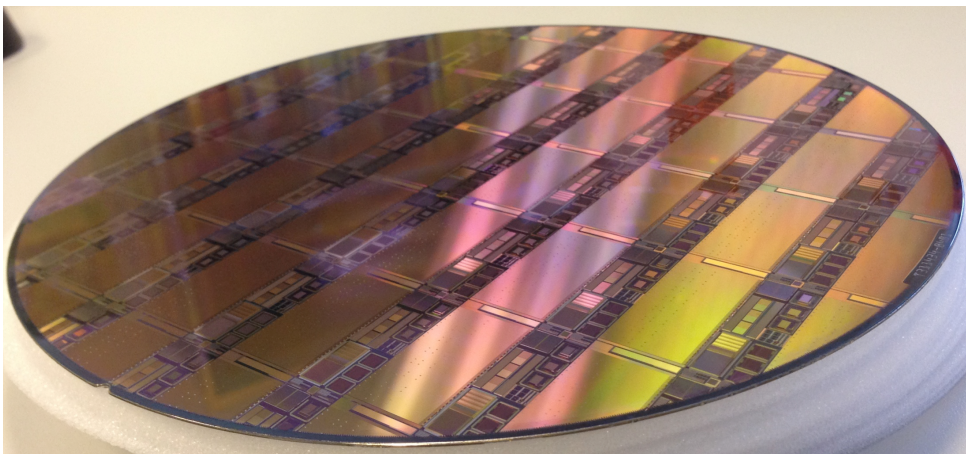
MOU due to the RRB → Oct '14



Contributo INFN	2013	2014	2015	2016	2017	2018	2019	Total
R&D (kEUR)	258	337+136	222					953
CORE (kEUR)			445	1040	935	400	80	2900

Institute	Responsibilities
Bari	<ul style="list-style-type: none"> OB Module development and construction <ul style="list-style-type: none"> R&D, Module 0, Production Design of the End of Stave services Module and Stave test system (*) Power distribution and supply system (pro-tempore)
Cagliari	<ul style="list-style-type: none"> Chip design and characterization Chip characterization system (*)
LNF	<ul style="list-style-type: none"> LNF Beam Test Facility OB Stave production
Padua	<ul style="list-style-type: none"> Outer Layers End-wheels and Half-layer Integration
Turin/Alessandria	<ul style="list-style-type: none"> Chip design and characterization OB FPC and PB OB Stave development and construction <ul style="list-style-type: none"> R&D, Stave 0

Intensive test beam campaign at the BTF

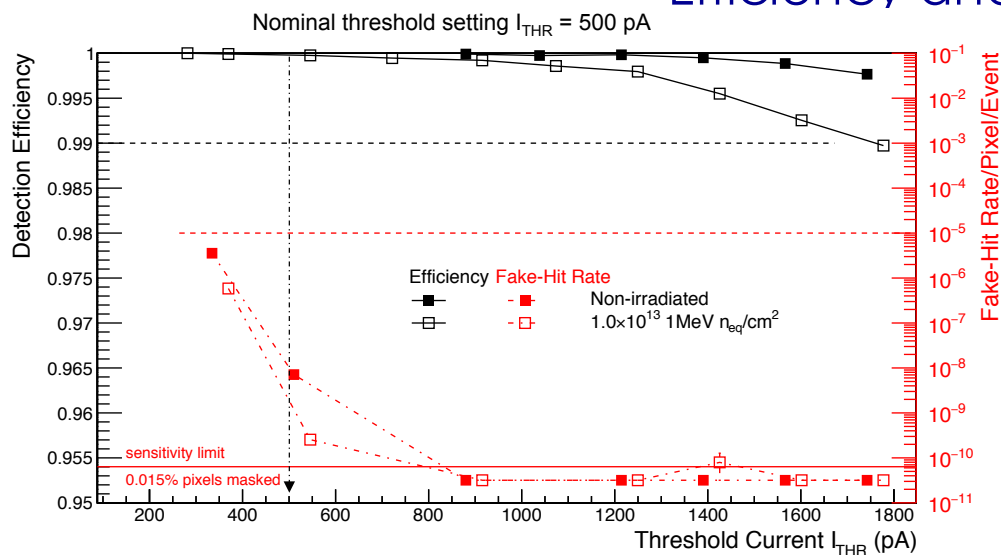


- $\lambda_{\text{fake}} \ll 10^{-5}$ / event/pixel and $\varepsilon_{\text{det}} > 99\%$ over a wide threshold range
- Chip of 50 μm thick: 3 non irradiated and 3 irradiate with neutrons to 10^{13} (1MeV n_{eq})/ cm^2
- \rightarrow excellent performance also after the irradiation

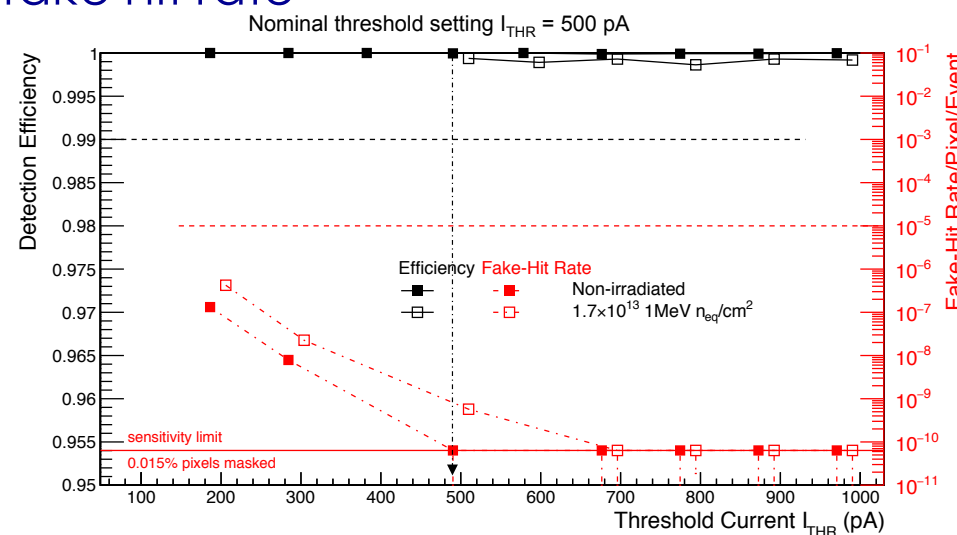
epi=25 μm , $V_{\text{BB}}=-3\text{V}$, spacing=2 μm

epi=30 μm , $V_{\text{BB}}=-6\text{V}$, spacing=4 μm

Efficiency and fake hit rate

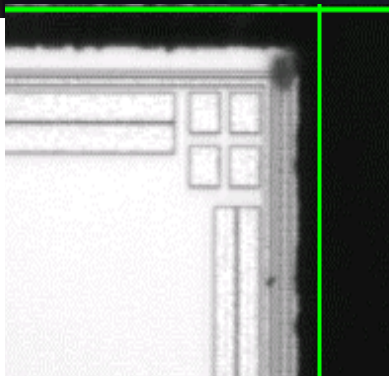
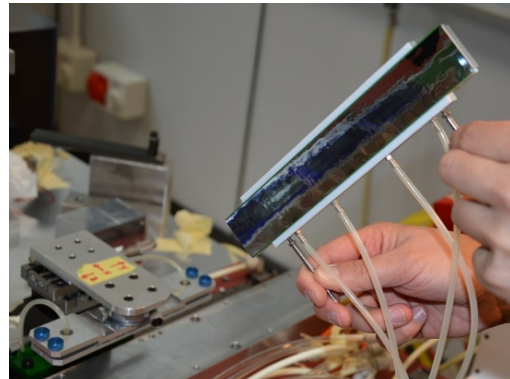
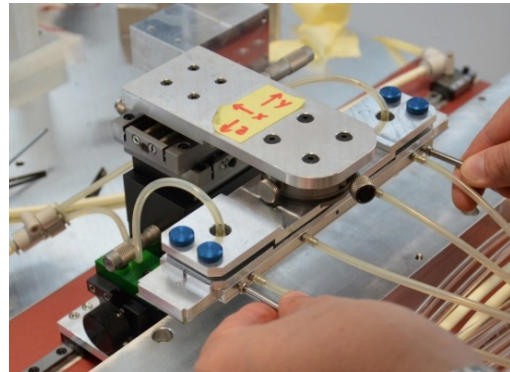
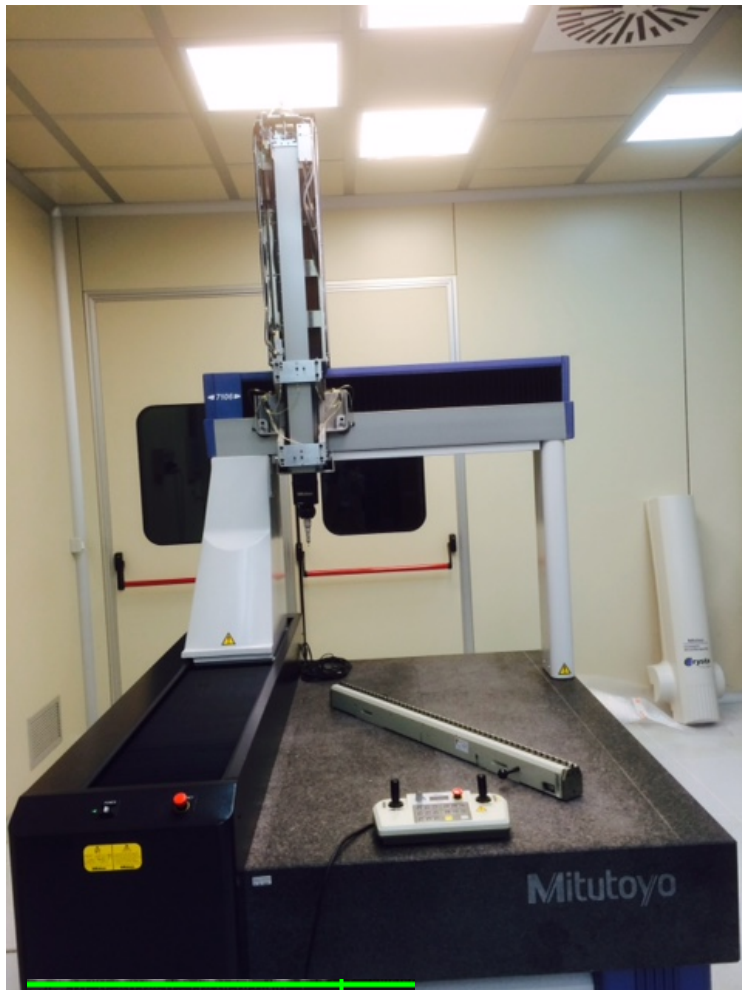


large margin over design requirements

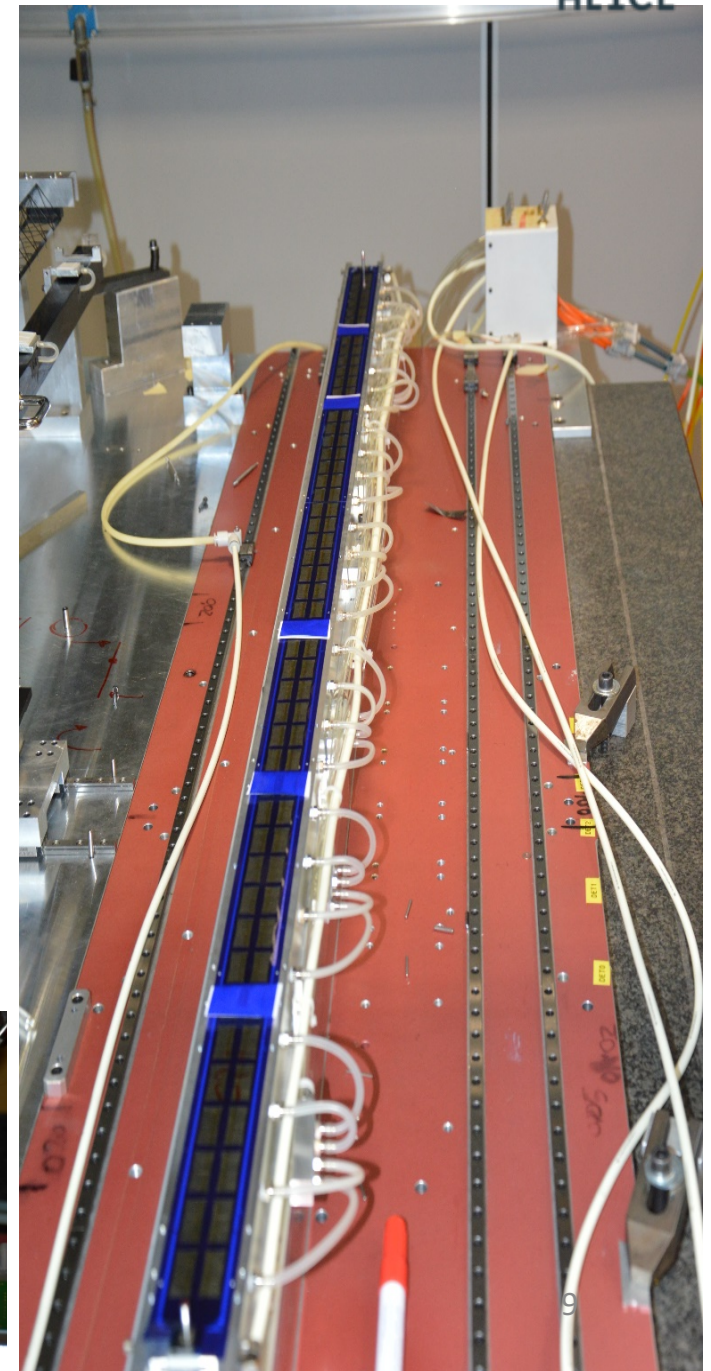


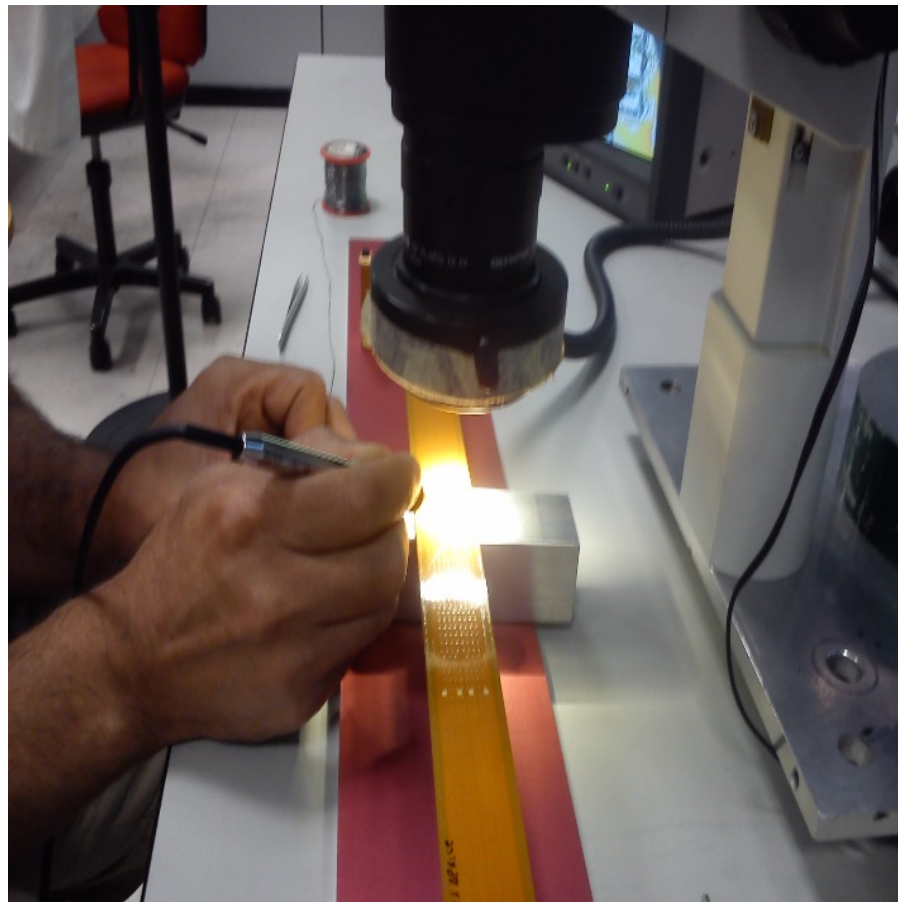
operation margin significantly increased by increasing epi layer and reverse bias voltage

R&D at the end stage (CP @ ASTRA)



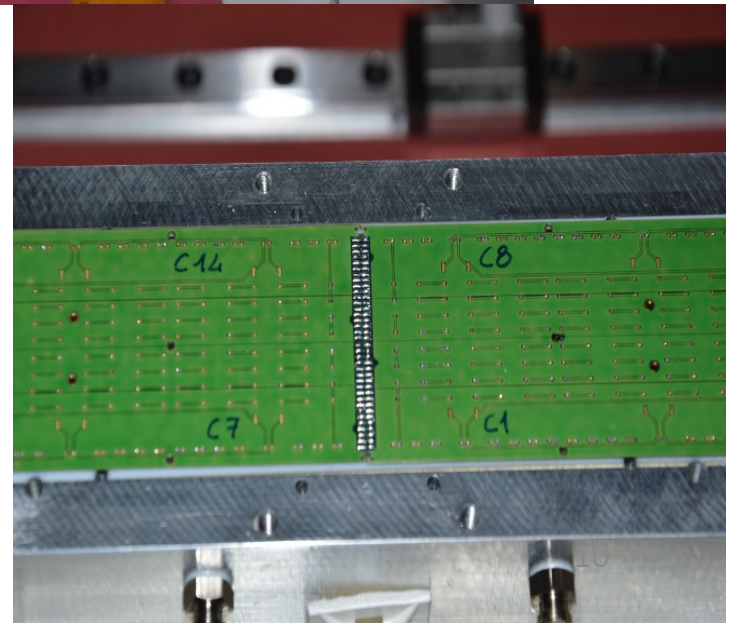
Alessandra Fantoni / Convegni 2017



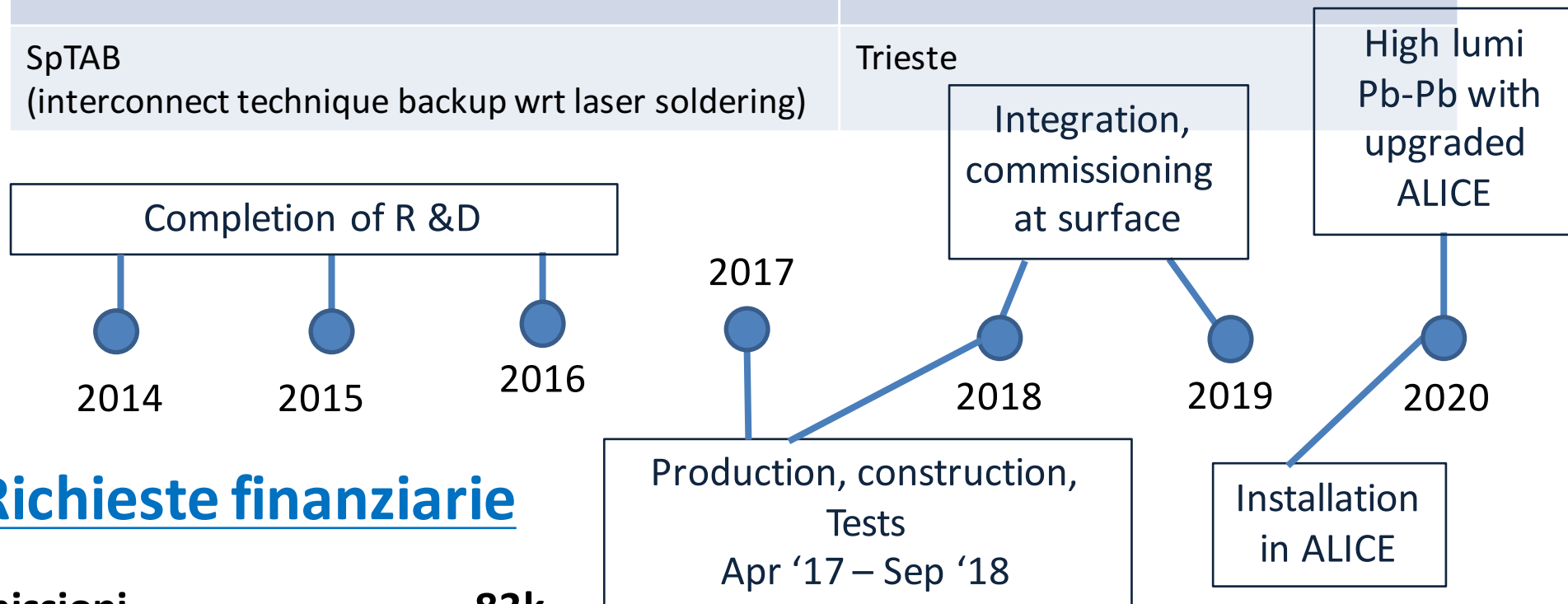


July 7th – 8th: assembly of the first mechanical (not working) module.

In absolute the first 3 modules (2 Torino + 1 LNF) will be mounted on the support structure in Padova



Activity	Contributing INFN teams
Chip test and characterization	Bari, Cagliari, Catania, LNF, Padova, Roma, Alessandria/Torino, Trieste
Mechanics for Stave Construction	Cagliari
Pixel chip, FPC and PB qualification and selection	Catania, Trieste
SpTAB (interconnect technique backup wrt laser soldering)	Trieste



Richieste finanziarie

missioni **83k**

consumo (rich. ITS-Italia) **55k**

apparati (richieste globali CORE per ITS-It)

Richieste ai servizi

- SPCM: 4 mesi/uomo
- SEA: 2 mesi/uomo



LNF activities

Ricercatori/Tecnologi

1. D. Hasch 0.3
2. V. Lucherini 1
3. **M. Mirazita 1**
4. S. Pisano 1
5. S. Tomassini 0.4
- + P. Rossi

Tecnici

- A. Orlandi
D. Orecchini
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

Research activity & Responsibilities

1. Proposal for new 12 GeV experiment - submitted to Jlab PAC44 (July 2016)

- DVCS on the n with a longitudinally polarized D target (Co-spokesperson S. Pisano)

2. Papers

- S. Pisano and M. Radici, "Di-hadron fragmentation and mapping of the nucleon structure", EPJ A52 (2016) no.6, 155
- S. Anefalos Pereira *et al.*, "Test of the CLAS12 RICH large scale prototype in the direct proximity focusing configuration", EPJ A52 (2016) no.2, 23

3. Thesis

- J. Phillips, "Semi-Inclusive Λ Electroproduction in the Target Fragmentation Region at CLAS" PhD thesis, Glasgow University, October 2015 (supervisor M. Mirazita)

The RICH project for CLAS12

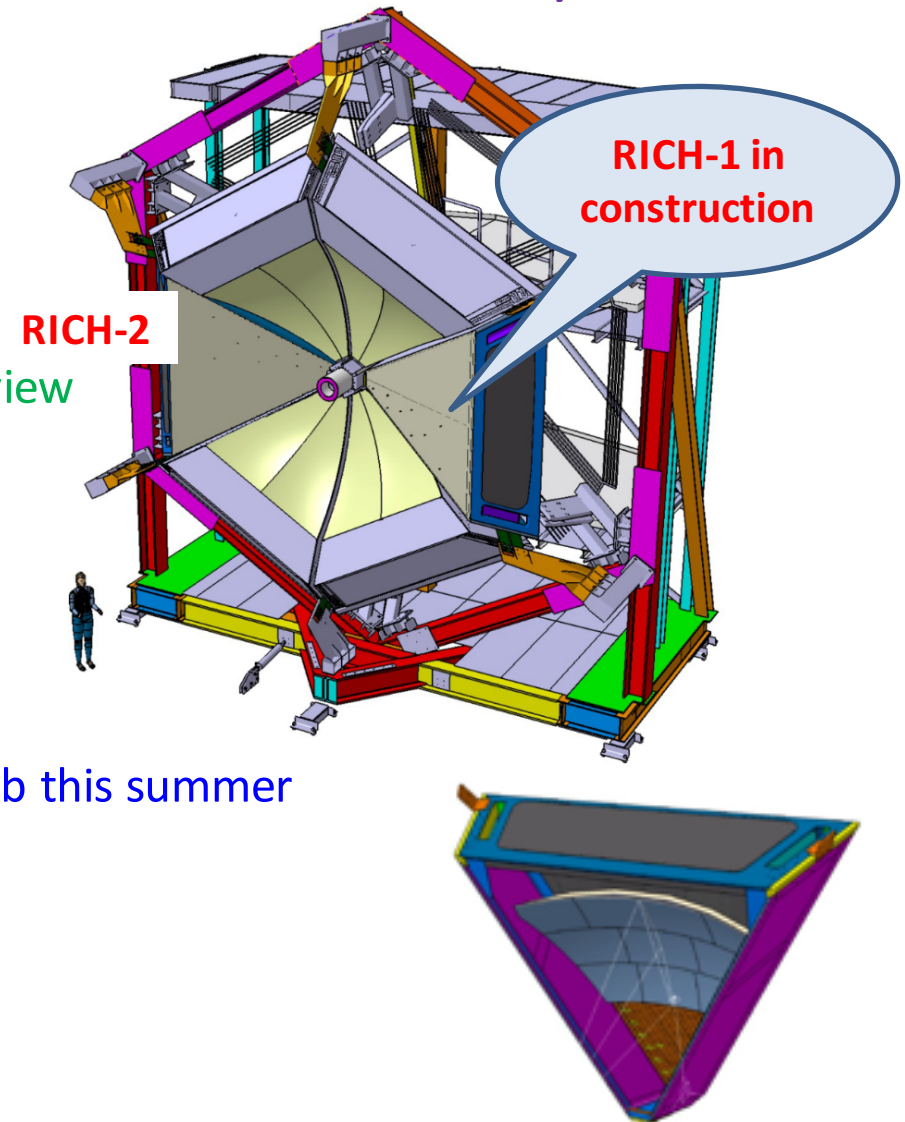
Improvement of PID needed to extend TMD measurements to kaons

Goal: ID of kaons vs π and p with momentum 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
- JLab+DOE, October 2015: mid-term review
 - the DOE relaxed the supervision
- JLab, 13-14 June 2016: Experiment Readiness Review
 - final approval for installation
 - waiting for the Committee Report

Project schedule:

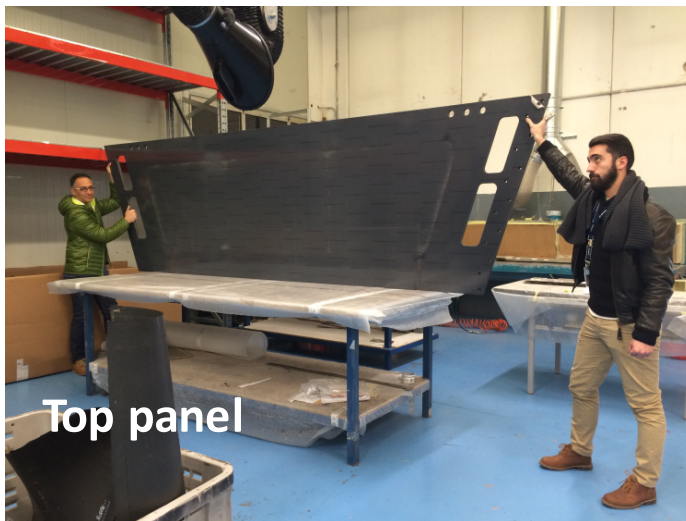
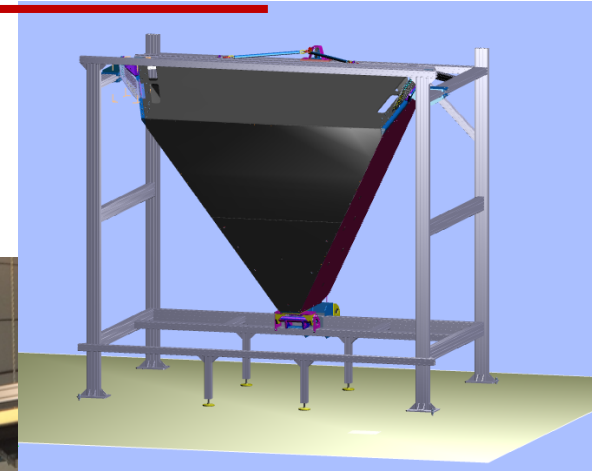
- Delivery of the components in progress
 - mechanical structure, mirrors, aerogel
- Mechanics assembly test ongoing, shipping to JLab this summer
- Start of assembly at JLab in October 2016
- Completion of the assembly by summer 2017
- Installation in CLAS12 September 2017
- Parallel work on the second sector is started



The RICH mechanical structure

Carbon fiber structure with corner elements in Aluminum and steel attaching elements to CLAS12

Tecnologie Avanzate s.r.l. (Veroli)



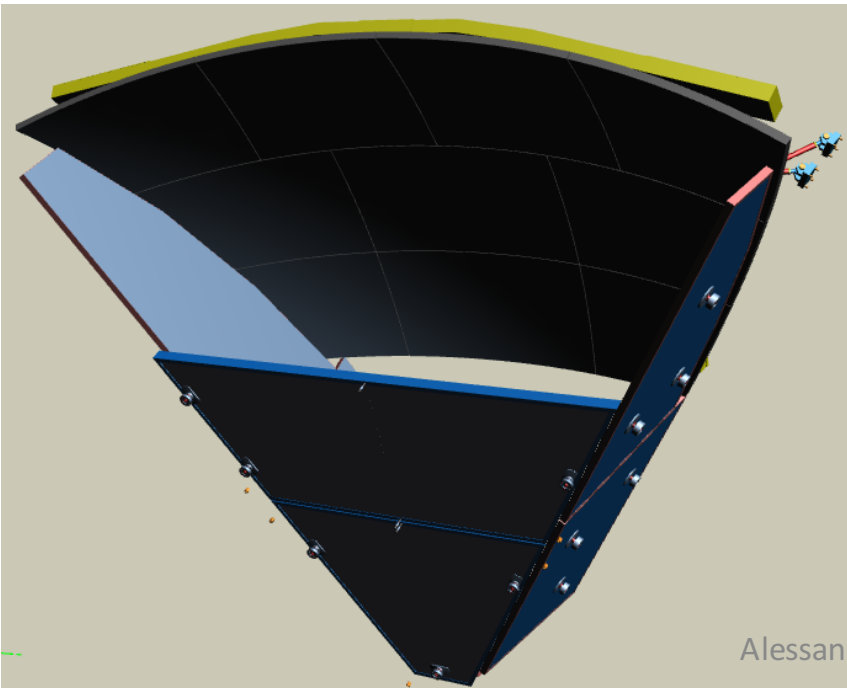
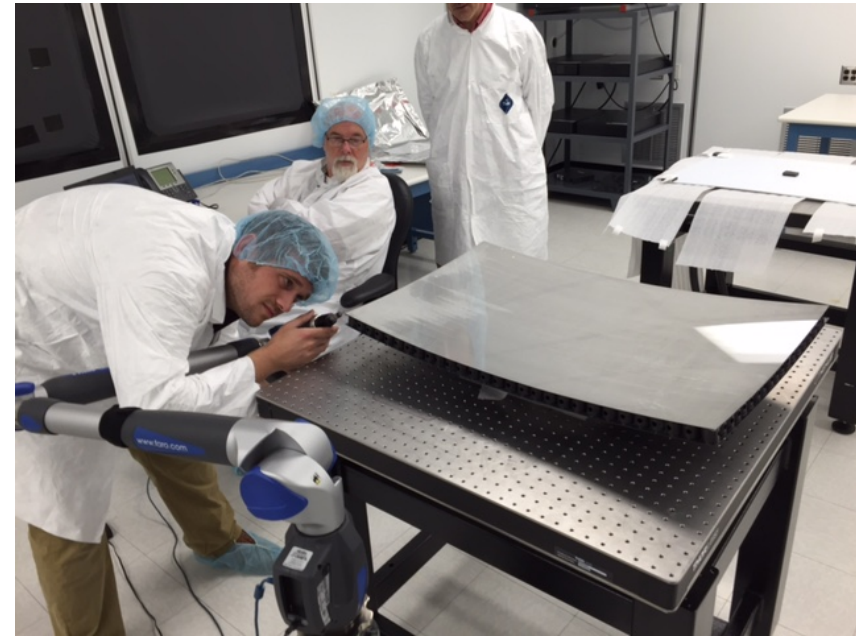
The RICH mirrors

Spherical mirror testing

High surface accuracy to preserve the photon emission direction, high reflectivity

- 10 carbon fiber spherical mirrors made by CMA (USA) - Area $\sim 3.6 \text{ m}^2$ - 4 produced/delivered to JLab
- 7 frontal/lateral/bottom glass (2 frontal, 2+2 lateral, 1 bottom) planar mirrors made by MediaLario (IT) - Area $\sim 3.6 \text{ m}^2$ - 2 produced

All the mirrors met the specifications



Planar mirror testing

Alessandra Baccetti - CUP, November 2015

Production will be completed by end of the year

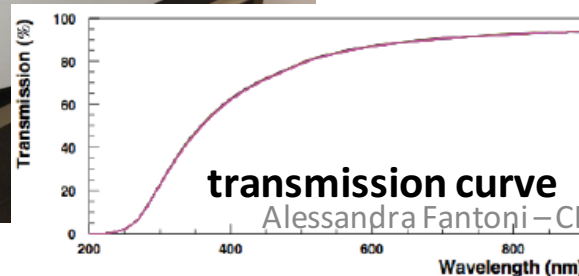
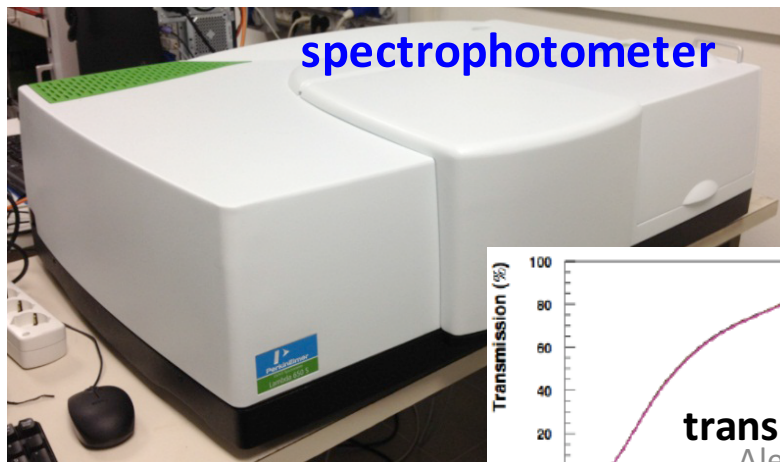
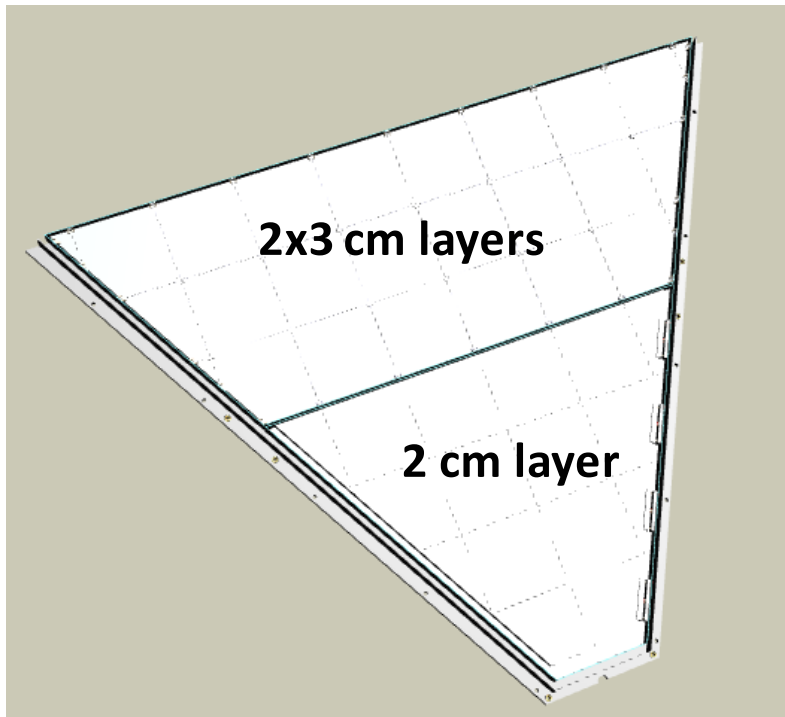
The RICH radiator

Large 20x20 cm² aerogel tiles produced by Budker Institute for Nuclear Physics (Russia)

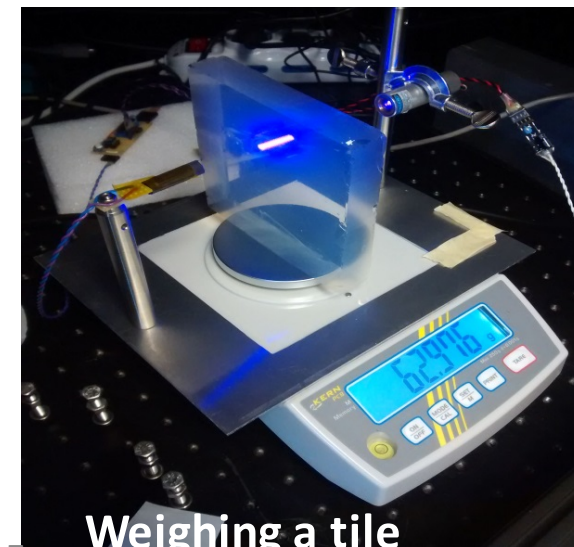
- production of the first 3 cm layer completed
- completion of the full production expected by the spring 2017

- 10% of the production delivered to Ferrara for full characterization, 90% directly to JLab
- Acceptance tests performed at JLab (scale) and Washington (spectrophotometer)

- All the tiles met the specifications
- Our results in agreement with vendor's



Alessandra Fantoni - CL preventivi 2017



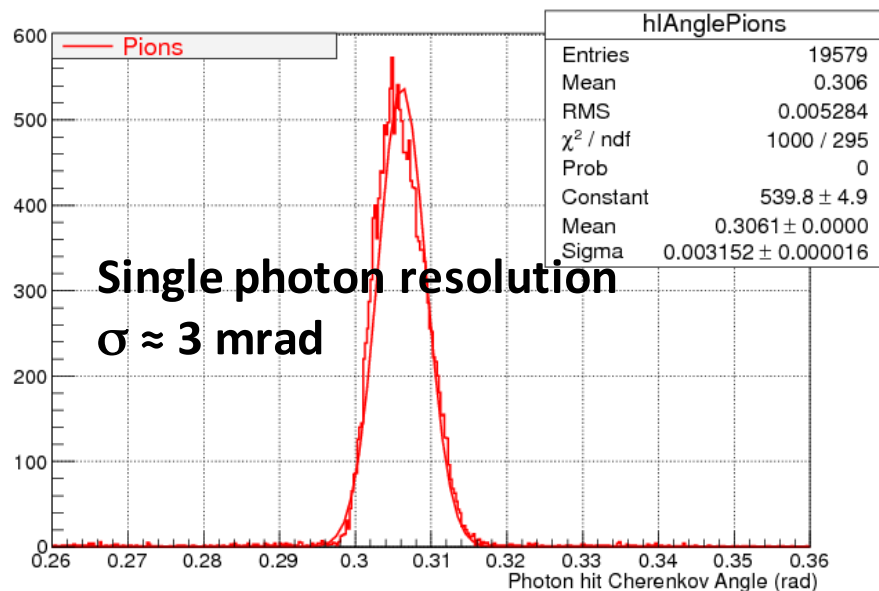
The RICH software

RICH software under development

- GEANT4 simulation
- Event reconstruction and PID
- Monitor

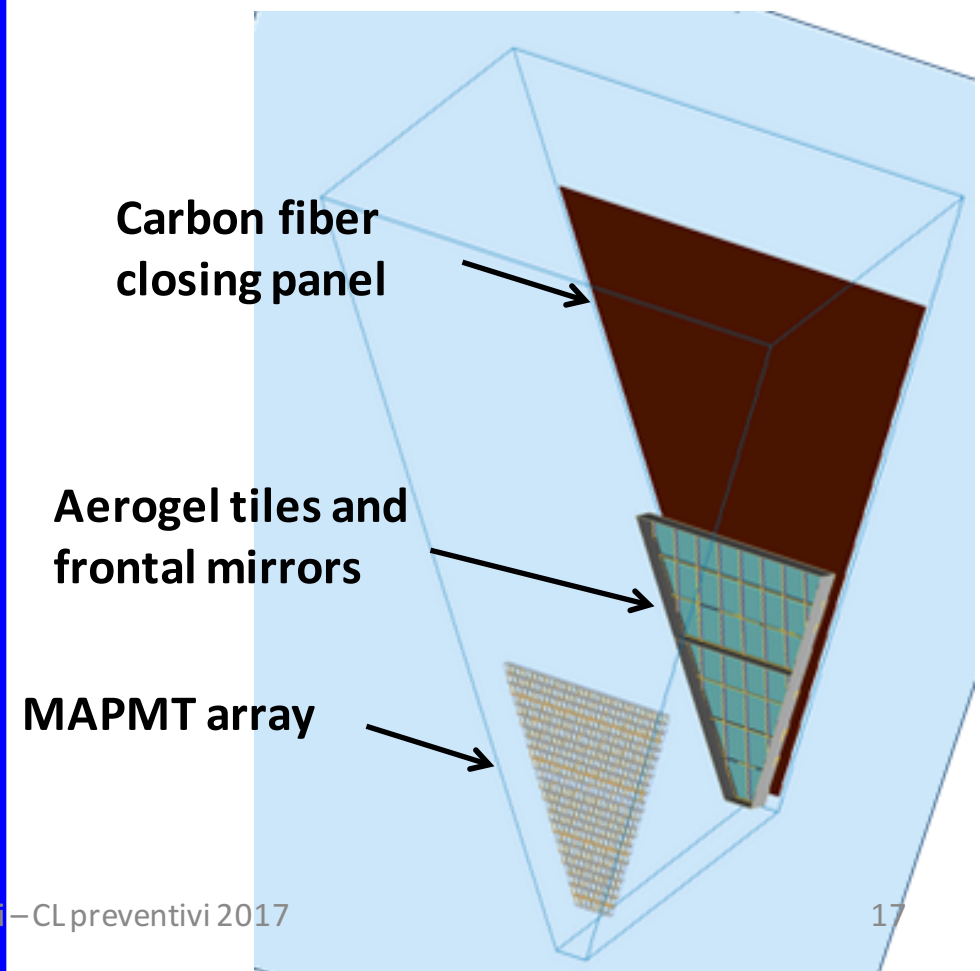
Test of Cherenkov angle reconstruction for directly imaged photons

- 8 GeV/c pions
- ideal tracks



The RICH in GEANT4, active elements

- full digitization of the photodetector array (MAPMTs & pixels)
- segmentation of the aerogel wall and mirrors
- detailed optical properties



Richieste

Richieste finanziarie

App+Cons+Inv.	300k (di cui 200k premiale CLAS-MED 2013)
Missioni	50k

Richieste ai servizi

Progettazione	10 mesi/u	Installazione RICH
Officina meccanica	1 mese/u	Supporti per assemblaggio del RICH

NOTA:

Premiale CLAS-MED 2013 => 600k in 3 anni (200k/y) da Sett 2015



LNF activities

2 researchers for 1.2 FTE
Average participation of 60%
Total INFN ~11 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 HISKP, (Gießen), ISS, LNF, Messina, Pavia, Roma2, Torino, Glasgow, Basel, PNPI Gatchina, INR Mosca, IHENP Kharkov (Iowa State U)

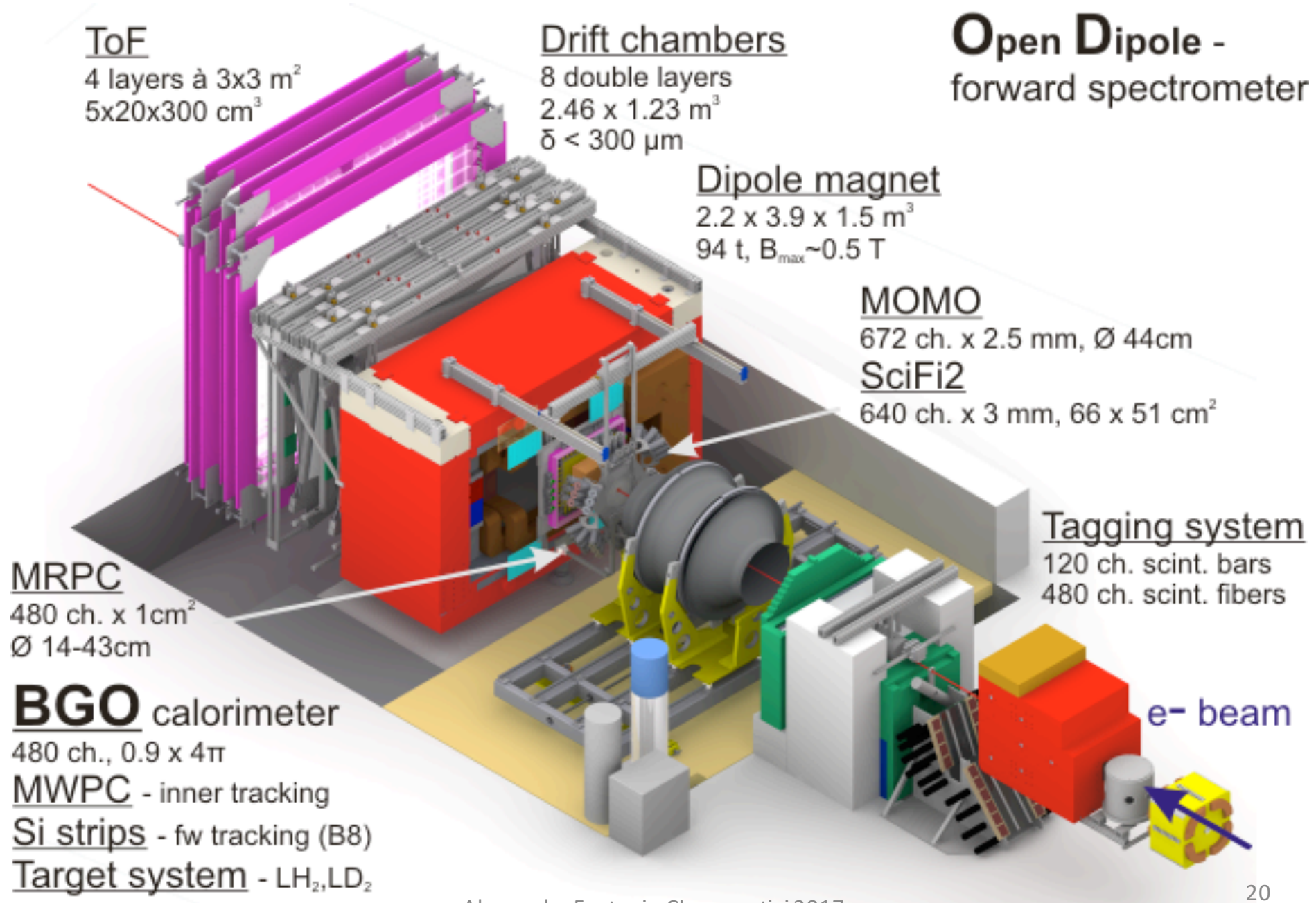
Collaboration Responsibilities:

- Co-spokesperson BGO-OD
- Analysis and MC coordinator
- Spokesperson η' beam asymmetry and x-sect
- Next INFN RN (2017)

Hardware responsibilities:

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

Open Dipole + BGO calorimeter @ Bonn



ELSA (Bonn) beamline S - Status



Rivelatori & Software:

- MWPC: Commissioning
- MRPC: Commissioning (BTF test beam ok => $\sigma \sim 60\text{ps}$)
- Calorimetro e barrel in funzione
- MonteCarlo in continuo sviluppo, generatore di eventi (LNF, Messina, Roma2)

Raccolta dati 2015:

- Due run di presa dati in configurazione ridotta con bersaglio H (+ alcuni giorni D, C)

Attività 2016 – 2017 e oltre:

- giugno 2016: termine finanziamento SFB (parte importante del contributo di Bonn PI)
- Nuova richiesta DFG (necessari circa 9 mesi per risposta)
- Forza lavoro ridotta in questo periodo
- => solo un'altra presa dati a fine 2016 (~5-6 settimane)
- 2017: richieste solo 1000h per completare misura H
- 2018-2019: bersaglio D
- 2020: shutdown

Richieste finanziarie

missioni

15k

consumo

10k

Richieste ai servizi

Nessuna salvo problemi



LNF activities

17 researchers for 10.3 FTE
Average participation of 60%
Total INFN ~14.8 FTE

1. C. Berucci	1
2. M. Cargnelli	0.5
3. A. Clozza	0.3
4. C. Curceanu	0.6
5. R. Del Grande	1
6. M. Donari	1
7. P. Levi Sandri	0.2
8. M. Merafina	1
9. M. Miliucci	1
10. D. Pietreanu	0.6
11. A. Scordo	0.1
12. H. Shi	0.4
13. D. Sirghi	0.3
14. A. Spallone	1
15. S. Tomassini	0.2
16. O. Vazquez D.	0.3
17. J. Zmeskal	0.5
Y. Bravo	1
Tecnici:	
G. Basso	1
L. Karavania (bors.)	1

+ C. Guaraldo

- KAONNIS= Low energy kaons interaction studies at DaΦne
- 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 (Germany); RIKEN, Tokyo U. (Japan); Victoria U. (Canada); Zagreb U. (Croatia)

Spokesperson + ALL Responsibilities in LNF

Recent Publications (2016):

- *K⁻ absorption on two nucleons and ppK⁻ bound state search in the Σ⁰p final state* PLB 758 (2016) 134;
- *Structure near K⁻+pp threshold in the in-flight ³He(K⁻,Λp)n reaction*, PTEP 2016 (2016) no.5, 051D01
- *K⁻ series, X-ray yield measurement of kaonic H atoms in a gaseous target*, NPA, nuclphysa.2016.03.047
- *On the KHe₄ → Λp-He³ resonant and non-resonant processes*, NPA, nuclphysa.2016.05.007, in press
- *Absolute energy calibration of X-ray TESs with 0.04 eV uncertainty at 6.4 keV in a hadron environment*, J. Low Temp. Phys. DOI 10.1007/s10909-016-1491-2
- *SIDDHARTA results and implications of the results on antikaon-nucleon interaction*, AIP Conf.Proc. 1735 (2016) 080014
- *Precision X-ray spectroscopy of kaonic atoms as a probe of low-energy kaon-nucleus interaction*, Conference: C15-08-23, arXiv:1601.02236

SIDDHARTA: important training for young researchers => 10 PhDs

Alessandra Fantoni – CL preventivi 2017

KAONNIS (Integrated Initiative):



Unprecedented precision measurements of low-energy kaon-nucleon/nuclei interactions

Relevant to: non-perturbative QCD in strangeness sector

- **SIDDHARTA data analyses and SIDDHARTA-2 experiment: kaonic atoms measurements**
- **AMADEUS : kaon-nuclei interaction studies at low energies**
- **collaboration in experiments in strangeness physics at JPARC (Japan)**

WhatNext LNF (10-11/11/2014) => Kaon-nucleon/nuclei interaction studies

Workshop

- **“Frontiers in hadron and nuclear physics with strangeness and charm”, ECT* 18-23/10/2015**
- **“Strangeness, gravitational waves and neutron stars”, LNF 10/06/2016**

SIDDHARTA-2 program



1) Kaonic deuterium measurement - 1st measurement and R&D for other measurements

2) Kaonic helium transitions to the 1s level – 2nd measurement, R&D

3) Other light kaonic atoms (KO, KC,...)

4) Heavier kaonic atoms measurement (Si, Pb...)

5) Kaon radiative capture – $\Lambda(1405)$ study

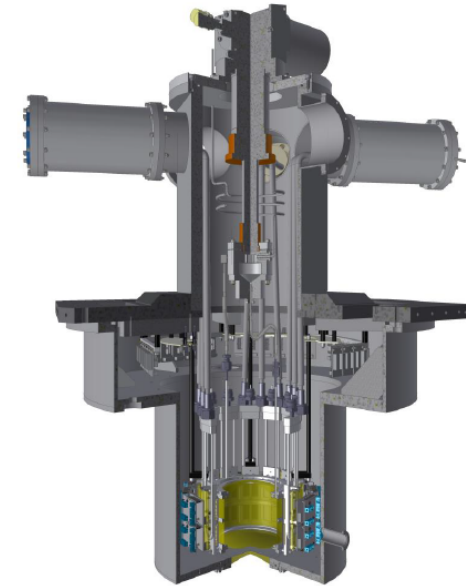
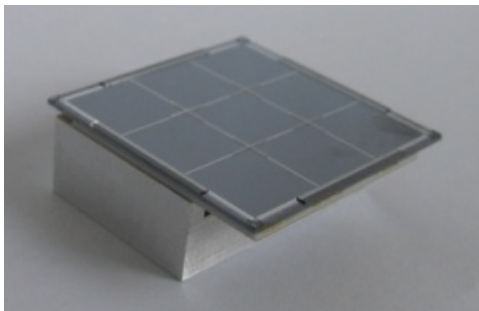
6) Investigate the possibility of the measurement of other types of hadronic exotic atoms (sigmonic hydrogen ?)

7) Kaon mass precision measurement at the level of <10 keV

SIDDHARTA-2 setup (vs SIDDHARTA)



- new target cell
- new vacuum chamber
- new cooling system
- new kaon monitor/trigger
- two veto systems
- K⁺ induced background discriminator
- new shielding structure
- new SDD detectors 64mm² (FBK)



TECHNICAL REPORT

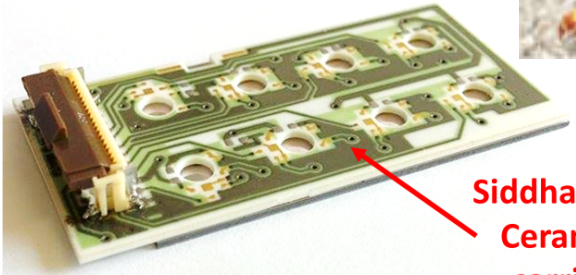
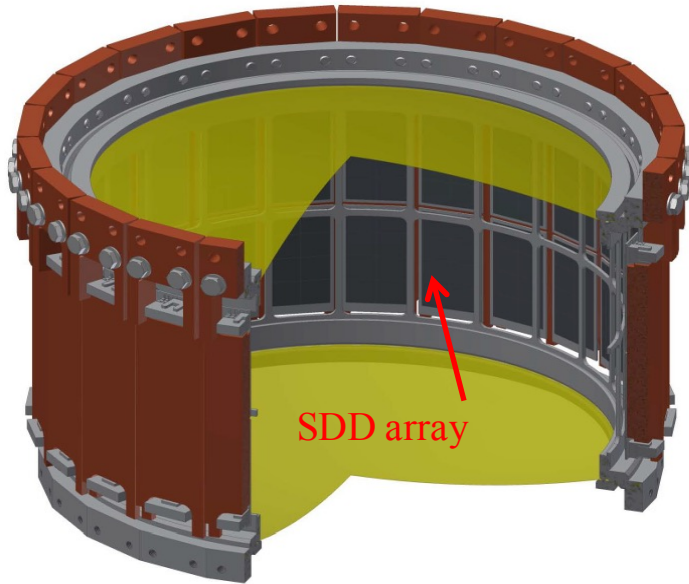
SIDDHARTA-2 – kaonic deuterium measurement

May 2016

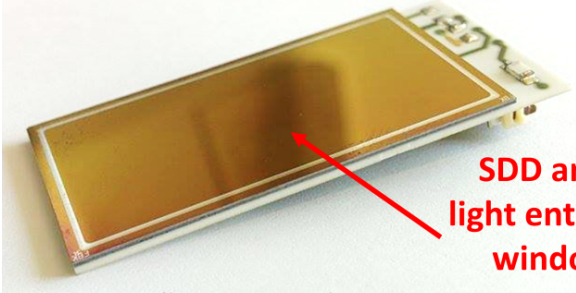
The SIDDHARTA-2 Collaboration:

LNF- INFN, Frascati, Italy; SMI- ÖAW, Vienna, Austria; IFIN – HH, Bucharest, Romania; Politecnico and INFN, Milano, Italy; TUM Muenchen, Germany; RIKEN, Japan; Univ. Tokyo, Japan; Victoria Univ., Canada; Univ. Zagreb, Croatia

Upgrade the apparatus with new SDD detectors

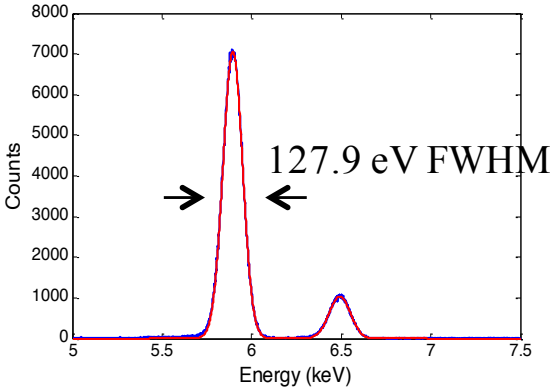


Siddharta-II Ceramic carrier

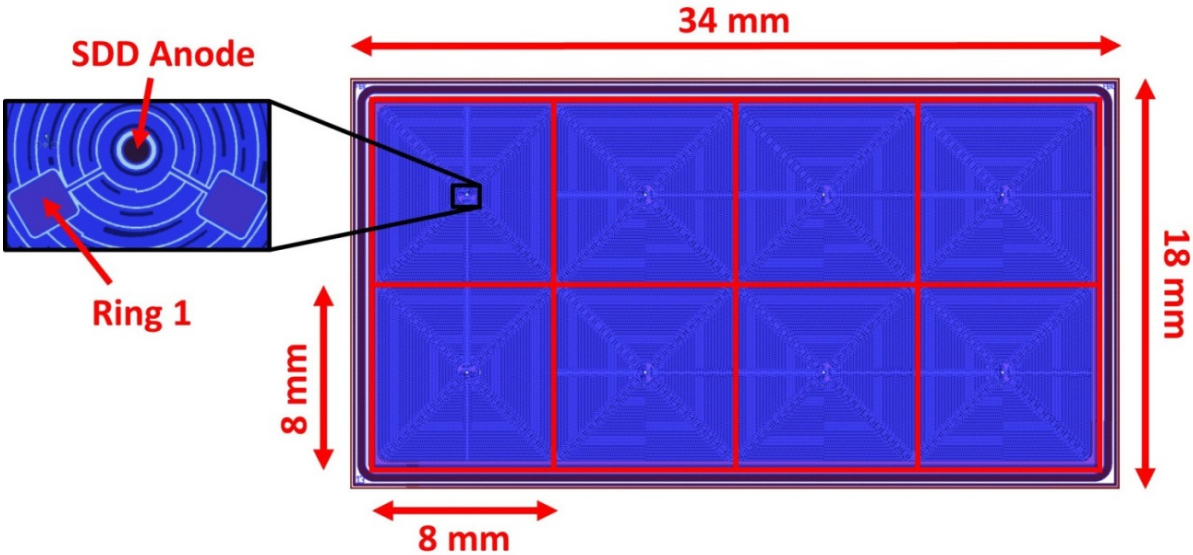


SDD array light entrance window

first ceramic prototype (final design in production)



- single SDD
- $T = -35^{\circ}\text{C}$
- $T_{sh} = 2\mu\text{s}$



Siddharta-II SDD array (Average $I_{Leakage} = 200 \text{ pA/cm}^2$ @room temperature)

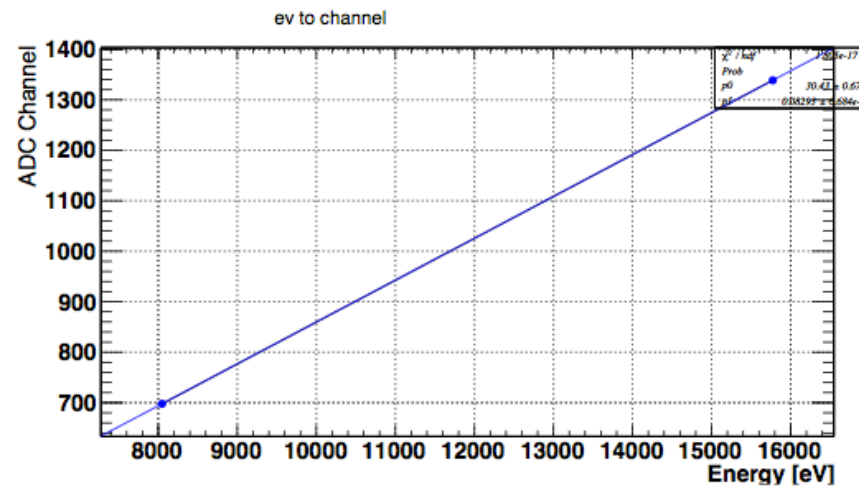
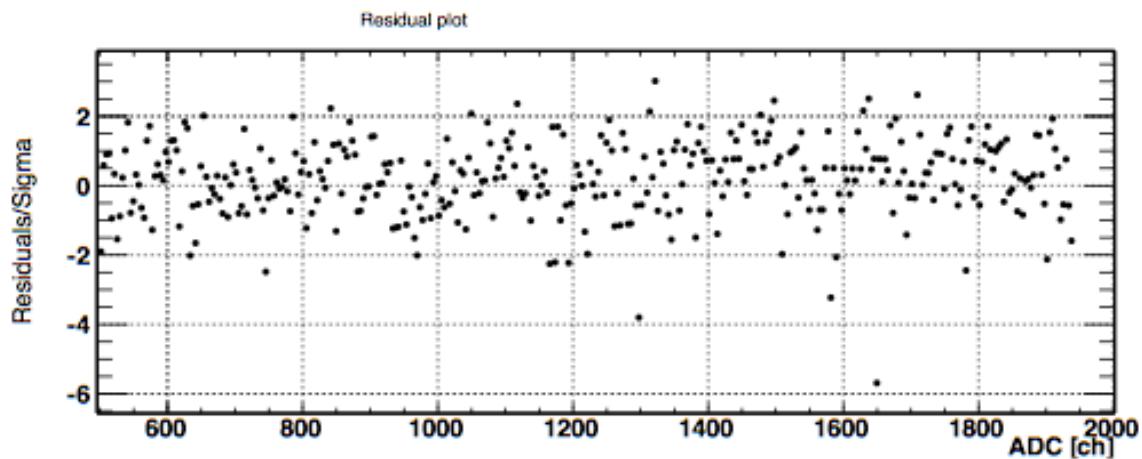
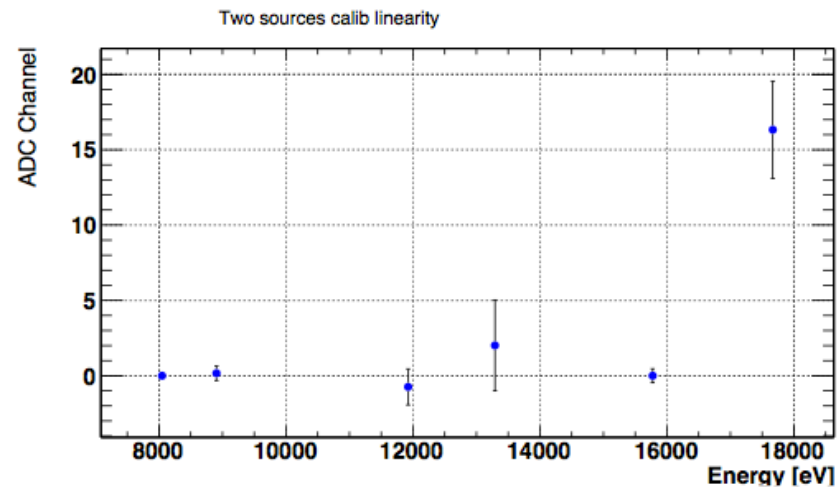
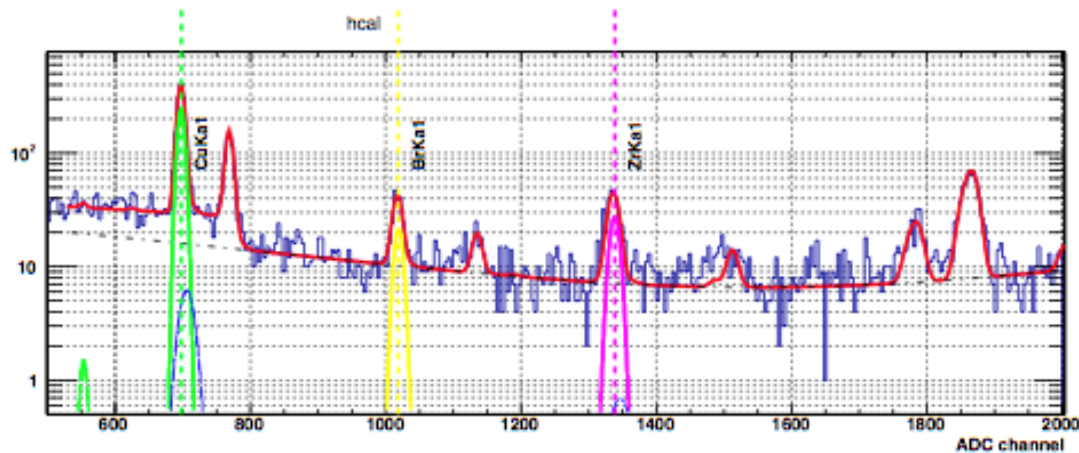
Energy calibration



sdd1-11-2015_02_19_29.txt

- 165 °C

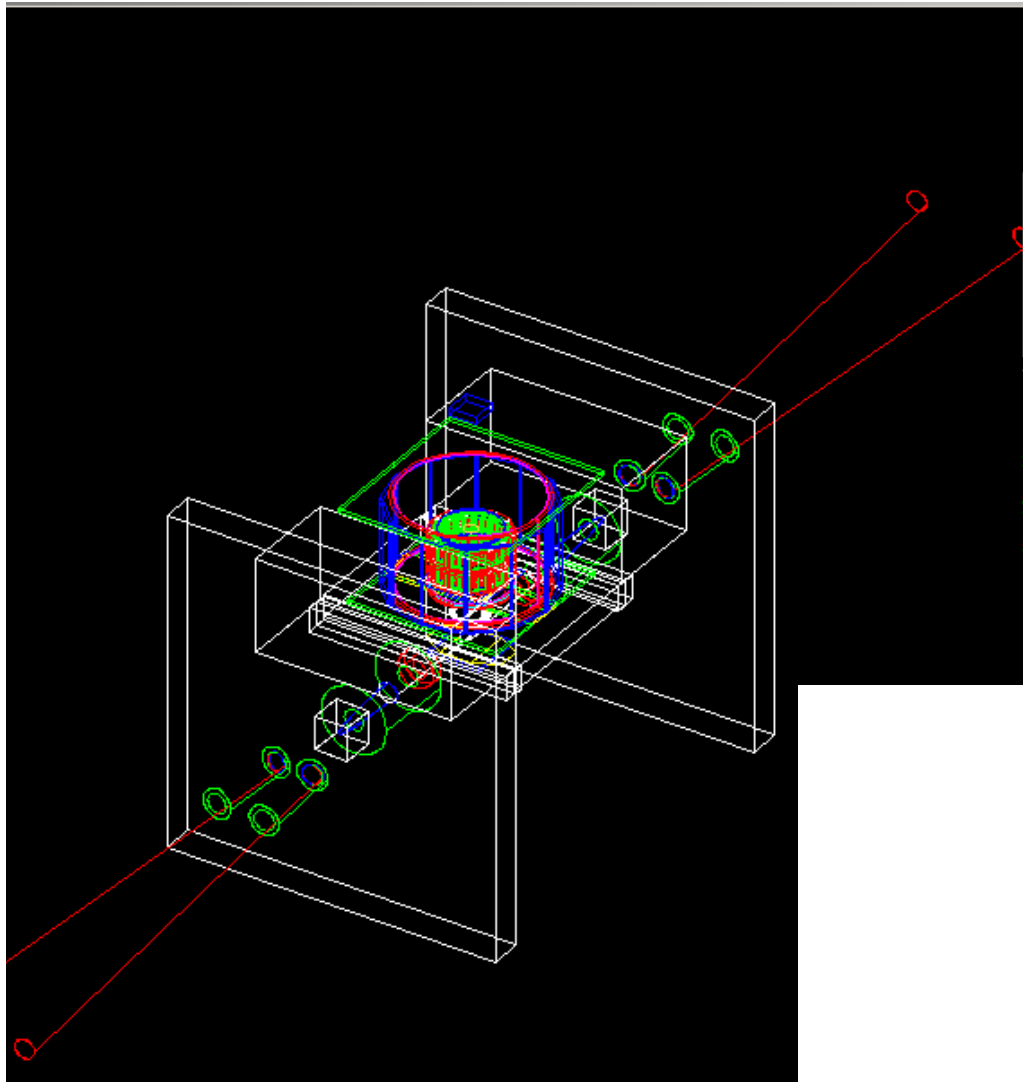
FWHM @ 6 keV: 131 eV



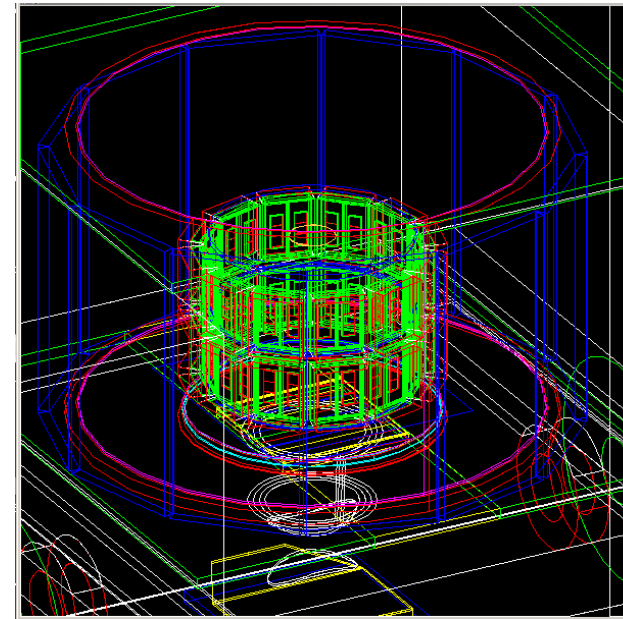
SIDDHARTA-2 (GEANT4 MC, M. Iliescu & C. Berucci)



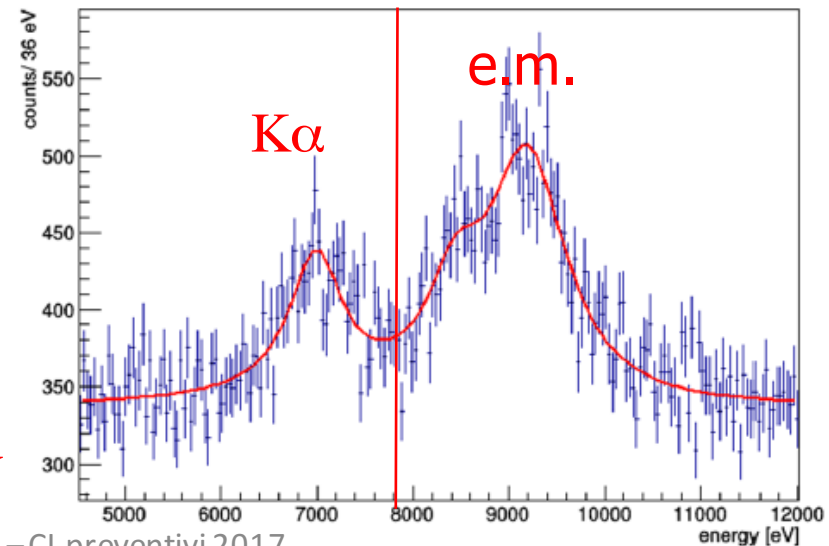
SIDDHARTA2 setup



Setup detail



$$\Delta\varepsilon(1s) = 30 \text{ eV and } \Delta\Gamma(1s) = 70 \text{ eV}$$



Alessandra Fantoni – CL preventivi 2017

Figure 21: The simulated spectrum of K^d for SIDDHARTA-2 for 800 pb^{-1} (the $K\alpha$ line is at 7.8 keV , while from 8 to 10 keV there is the K-complex)

SIDDHARTA-2 plan for 2016:



- 1) New SDDs ready by summer 2016 (27 arrays already delivered)
- 2) Mounting and bonding new SDDs -> end of 2016
- 3) New readout ASIC electronic -> end of 2016
- 4) New SDDs assembly and test -> spring 2017
- 5) New veto system (veto-2) -> spring 2017
- 6) All other elements realized -> OK

⇒ SIDDHARTA-2 setup with new SDDs will be mounted and tested by summer 2017

- SIDDHARTA-2 setup ready to be installed on DAΦNE from summer 2017
- Data taking with kaonic deuterium: 800pb^{-1}
- Interaction with DAFNE to define the strategy for installation - ongoing

Experimental program of AMADEUS

Unprecedented studies of the low-energy charged kaons interactions in nuclear matter: solid and gaseous targets (d, He³, He⁴) in order to obtain unique quality information about:

AMADEUS collaboration:

119 scientists from 13 Countries and 34 Institutes

- Nature of the (elusive) $\Lambda(1405)$
- Possible existence of kaonic nuclei clusters (deeply bound kaonic nuclei states)
- Interaction of K^- with one and two nucleons
- Low-energy charged kaons cross sections for K^- momenta lower than 100 MeV/c (missing today)
- Many other processes of interest in the low-energy QCD in strangeness sector -> implications from particle and nuclear physics to astrophysics
- PhD Thesis at Tor Vergata (2015): *Studies of the Λ -triton correlations in the low-energy kaon-nuclei interactions at DAΦNE with the KLOE detector (I. Tucakovic)*
- **PLB 758 (2016) 134**: *K^- absorption on two nucleons and ppK^- bound state search in the $\Sigma^0 p$ final state*



AMADEUS status:

- analyses of the 2002-2005 KLOE data -> publications
 - Step 0 : Pure Carbon Target inside KLOE data taking in 2012, under analyses -> publ.
 - R&D for more refined setup: trigger and active target
 - in 2014: collaboration AMADEUS+KLOE for KLOE2 data taking and studies of **future possible scenario and additions (hypernuclear...)**
 - AMADEUS dedicated setup: formation of a strong collaboration; technical proposal – ongoing (EU projects....) – interest from: Vienna; Heidelberg; Giessen; TUM; GSI; Varsavia; IFIN-HH; Moscow ITEP; Cracovia; Zagreb; RIKEN
-



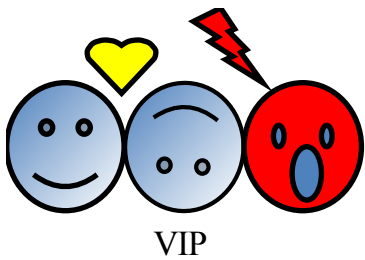
Richieste KAONNIS

Richieste finanziarie

missioni	15k
consumo	30k
inventario	20k
altri consumi	20k
manutenzioni	8k

Richieste ai servizi

SEA: 6 mesi/uomo
SPAS: 6 mesi/uomo
SPCM: 8 mesi/uomo



LNF activities

13 researchers for 9.2 FTE
 Average participation of 70%
 Total INFN 9.5 FTE

- | | |
|-----------------------|------------|
| 1. S. Bartalucci | 1 |
| 2. M Bazzi | 1 |
| 3. M. Benfatto | 0.2 |
| 4. G. Modestino | 1 |
| 5. A. Clozza | 0.3 |
| 6. C. Curceanu | 0.4 |
| 7. M. Iliescu | 0.8 |
| 8. J. Marton | 0.5 |
| 9. A. Pichler | 1 |
| 10. K. Piscicchia | 1 |
| 11. H. Shi | 0.3 |
| 12. L. Sperandio | 1 |
| 13. O. Vazquez Doce | 0.7 |

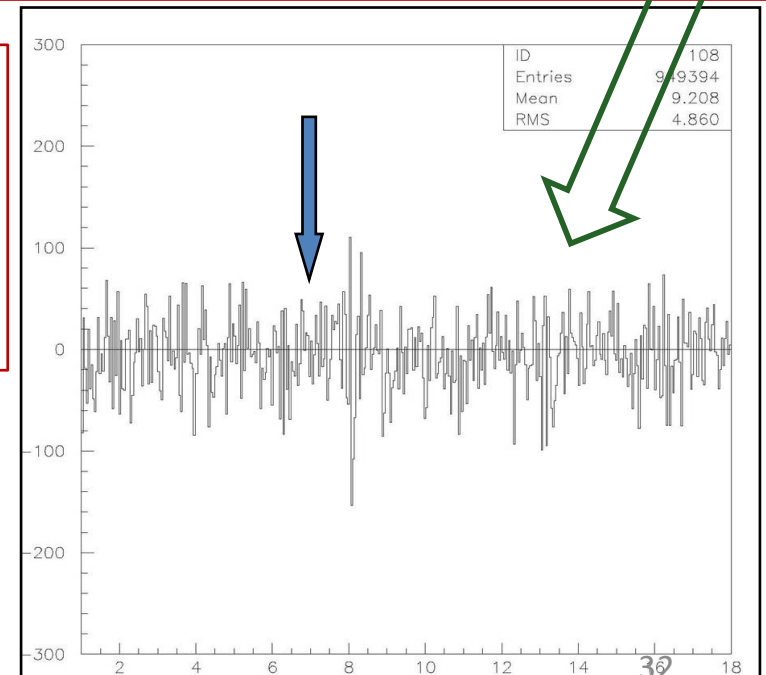
- **VIP=Violation Pauli Exclusion Principle (PEP)**
- Perform experimental test of PEP for e^- with a clean method
- Located at LNGS to reduce X-ray background
- International collaboration: LNF, LNGS, Ts INFN; SMI-OAW (Austria); IFIN-HH (Romania); Neuchatel U. (Switzerland)
- VIP already established 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

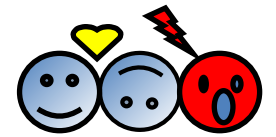
- new detectors (triggerable SDD)
- Resolution: $300 \mu\text{m}$, more efficient in a broader energy range
- new setup, much more compact: higher acceptance (present one 2.8%) and lower background

ALL Responsibilities @ LNF

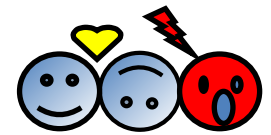
Previous limit improved by 3 orders of magnitude
 International Journal of Quantum Information 9 (2011) 145



VIP2 Installation at LNGS –Nov. 2015



VIP-related recent results (2016)



- *Spontaneously emitted X-rays: an experimental signature of the dynamical reduction models*, Found.Phys. 46 (2016) 263
- *Potential of the J-PET detector for studies of discrete symmetries in decays of positronium atom - a purely leptonic system*, Acta Phys.Polon. B47 (2016) 509
- *Macroscopic Quantum Resonators (MAQRO): 2015 update*, EPJ Quantum Technology, DOI: 10.1140/epjqt/s40507-016-0043-7
- *Application of photon detectors in the VIP2 experiment to test the Pauli Exclusion Principle*, Journal of Physics: Conference Series 718 (2016) 052030
- *Searches for the violation of Pauli exclusion principle at LNGS in VIP(-2) experiment*, Journal of Physics: Conference Series 718 (2016) 042055

Workshop

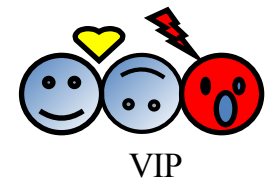
- *Is Quantum Theory exact? The endeavour for the theory beyond standard quantum mechanics Second Edition*, 23-25/09/2015 LNF-INFN
- *Testing the limits of the quantum superposition principle in nuclear, atomic and optomechanical systems*, 11-16/09/2016, ECT* Trento

Awards (2015) – 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 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 other type quantum mechanics tests
(collapse model predictions, quantum technologies in space...)*

Richieste

Richieste finanziarie

missioni
consumo
inventario
manutenzioni

20k
20k
12k
5k

Richieste ai servizi LNF

SEA: 2 mesi/uomo
SPAS: 2 mesi/uomo
SPCM: 4 mesi/uomo

Summary

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



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 (2015/2016):

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

Comitato Scientifico

Consiglio di Laboratorio Preventivi

9/6 Seminari gruppo 3

90/18 ordini

2 Workshop 2015 (FQT2015, ISU2015)

5 Workshop 2016 (INFN2016, 3DPDF, FQT2016 fine anno)

1 Riunione CSN3