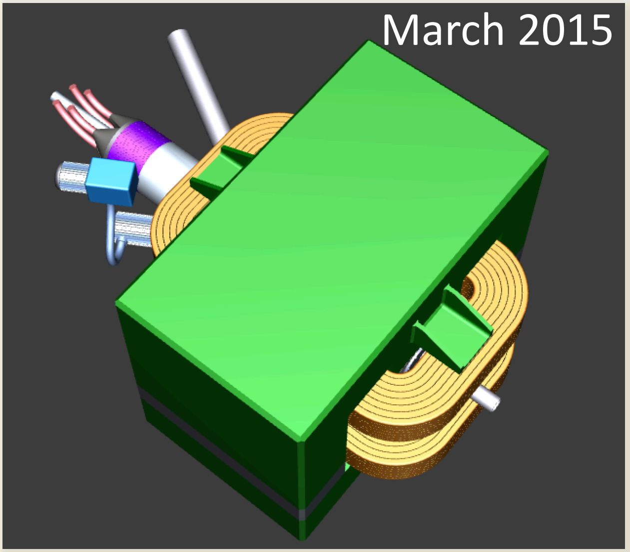
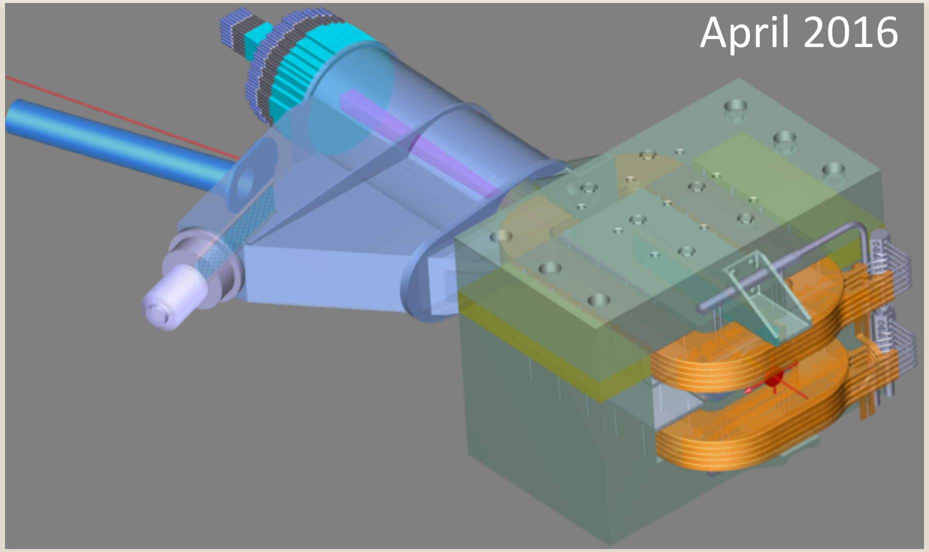
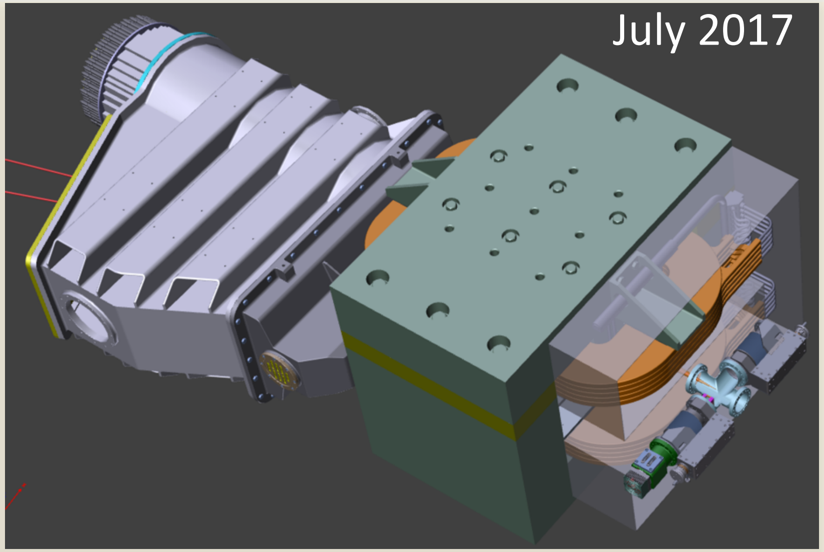
Status of the PADME experiment







Dr. M. Raggi[a,b]

[a]Sapienza Università di Roma, [b]INFN Roma

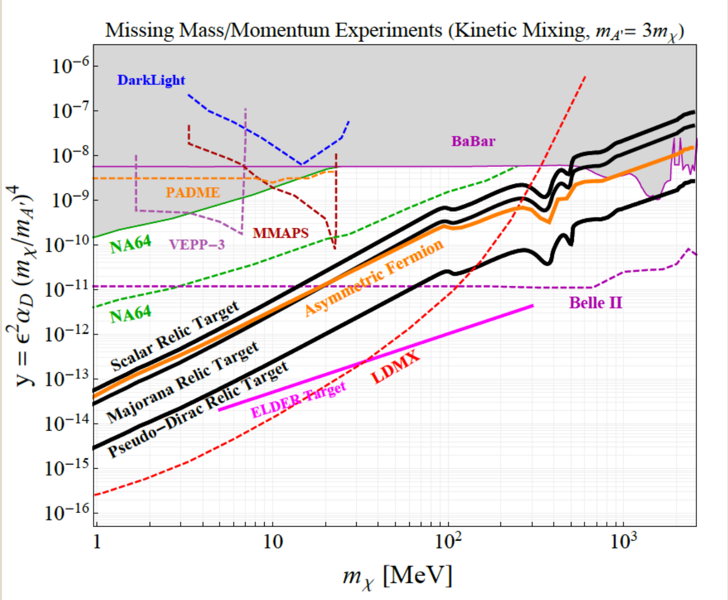
on behalf of the PAMDE collaboration

54Th Meeting of the LNF Scientific Committee

13-14 November 2017 LNF

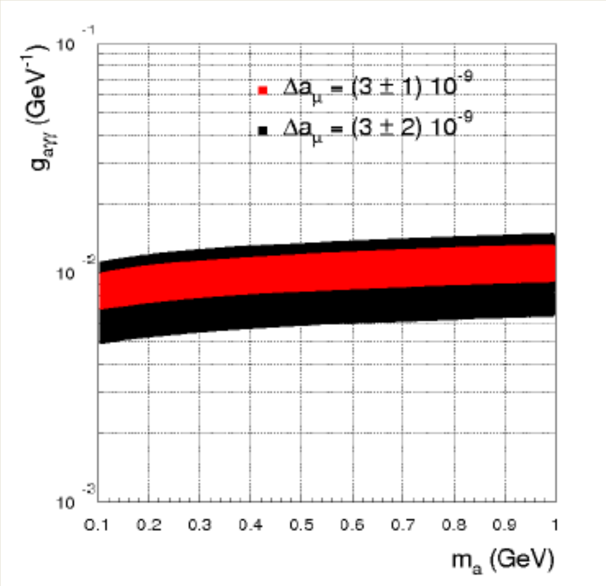
The PADME physics cases

Dark Photon
arXiv:1707.04591v1



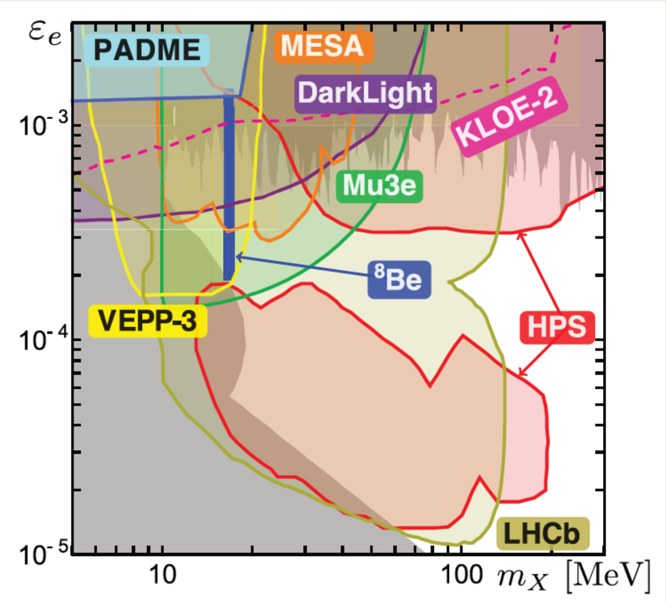
Invisible final state:
$e^+e^- \rightarrow \gamma A'$ and $A' \rightarrow \chi\chi$

ALPs and g-2
Phys. Rev. D 94, 115033 (2016)



ALPs final state $a \rightarrow \gamma\gamma$

BE anomaly- Fifth force
Phys. Rev. D 95, 035017 (2017)



Final state $X \rightarrow ee$

More physics at PADME

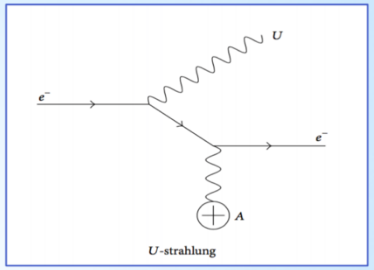
Positron fixed target experiment to search for Dark Photons

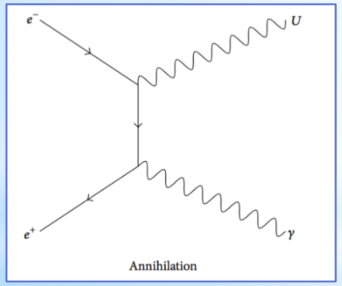
(and test the Atomki ^{8}Be anomaly)

E. Nardi
Perimeter institute

With C.D. Carvajal, A. Ghoshal, D. Meloni, M. Raggi

Electron fixed target experiments:
Electron-nucleon scattering: A' bremsstrahlung
$O(\alpha^3)$ process

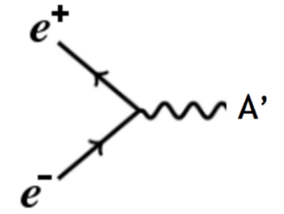




Positron beams: VEPP3 (BINP), PADME (LNF), [MMAPS (Cornell)]

Positron-electron (**non-resonant**) annihilation → A' γ
$O(\alpha^2)$ process

Positron-electron **resonant** annihilation → A'
$O(\alpha)$ process



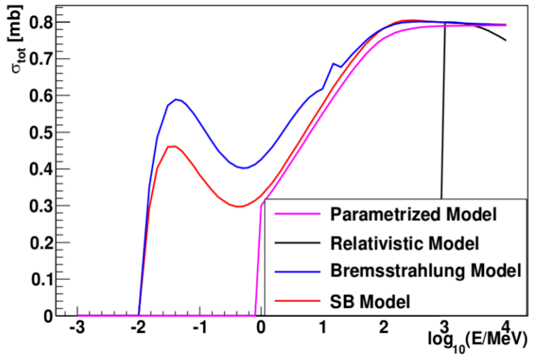
Thanks to the continuous energy loss when propagating in the dump, e^+ will "scan", eventually hitting the resonance

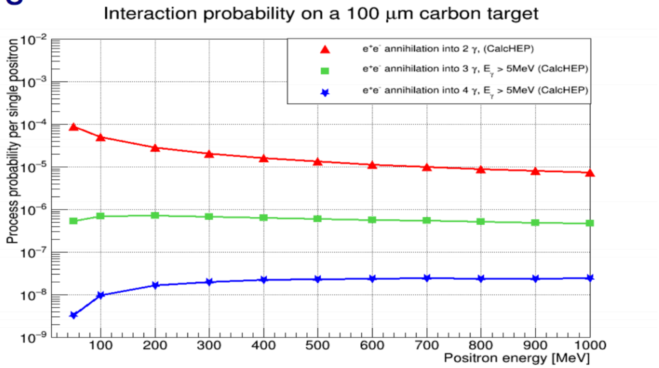
Resonant production of dark photons in positron beam dump experiments

Anish Goshal,[1,2,*] Davide Meloni,[2,†] Enrico Nardi,[1,‡] Mauro Raggi,[3,§] and Cristian D. R. Carvajal[4,1,¶]
[1]*INFN, Laboratori Nazionali di Frascati, C.P. 13, 100044 Frascati, Italy*
[2]*Roma 3 U.*

PADME physics case

- PADME is able to perform measurements of few low energy electromagnetic physics parameters





- GEANT4 model uncertainties on bremsstrahlung
  - Parametric: 4-5 % for E_{e+} > 1 MeV, SB model: 3-5% for E_{e+} > 50 MeV
  - Measurement of differential cross section dσ/dEdθ interesting for PADME

- $\Gamma(\text{annihilation}) = \Gamma(e^+e^- \to \gamma\gamma) + \Gamma(e^+e^- \to \gamma\gamma\gamma) + \Gamma(e^+e^- \to \gamma\gamma\gamma\gamma) + \ldots \approx 1.05 \times \Gamma(e^+e^- \to \gamma\gamma)$

Measurement of $\Gamma(e^+e^- \to \gamma\gamma)$ at the % level

7.05.2017 *Venelin Kozhuharov, LDMA 2017* 27

Producing X boson via resonant production

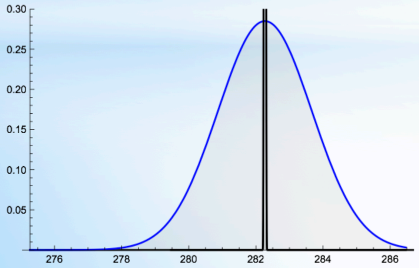
Comparing A' production modes

Frascati DAΦNE BTF: number of $e^{-(+)}$/yr: 10[18] (LNF site authorization limited)
2×10^{20} ($1.2 \times 10^{11} \times 50 \times 3.15 \times 10^{7}$ technically faisable)

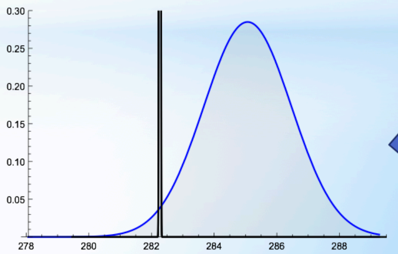
$m_{A'} \leq$ 24 (28) MeV — E_{max} (e^-/e+): 800 MeV/550 MeV (upgrade: 1050 MeV/800 MeV)
$m_{A'} \geq$ 16 MeV — E_{min} (e^-/e+): 250 MeV

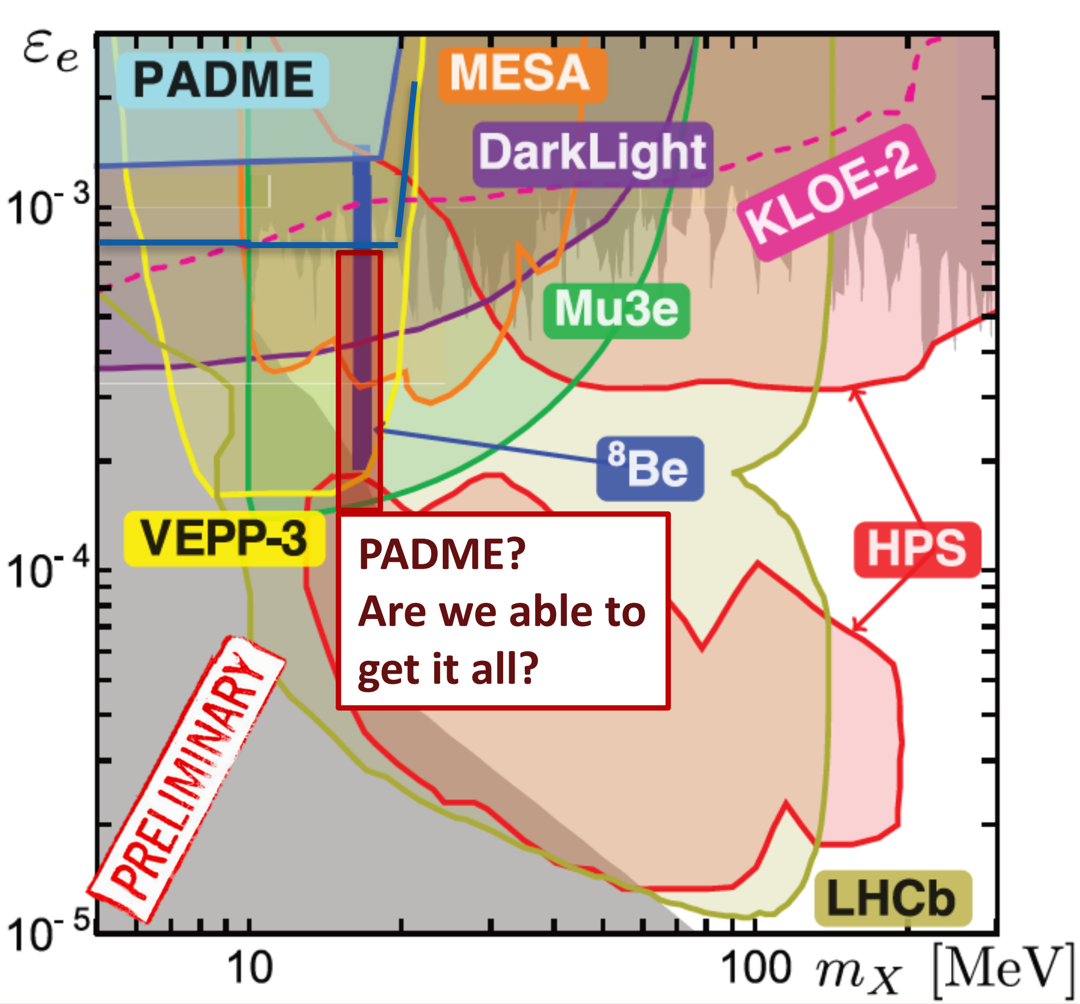
Comparison: A' produced for $m_{A'}$ = 17 MeV; $\varepsilon = \sqrt{\alpha'/\alpha} = 10^{-4}$; E_b = 550 MeV

Production mode	E_{beam} (MeV)	T [integration]	A' produced
Bremsstrahalung (e^-)	550	0.5	4.1×10^7
Annihilation (e^+)	550	0.5	8.7×10^8
Resonant (e^+)	E_{res}=282 MeV	[0 - 0.5]	8.1×10^9
Resonant (e^+)	$E_{res} + 2\sigma_{beam}$	[0 - 0.5]	13.2×10^9



E. Nardi
Perimeter institute

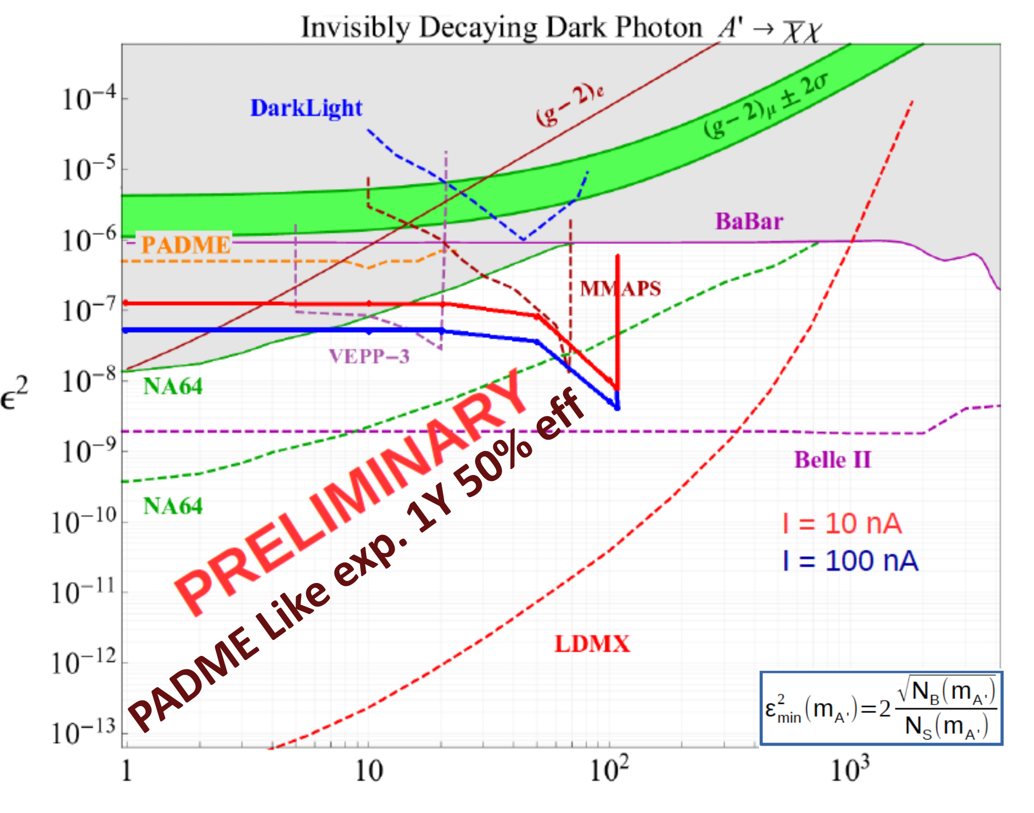




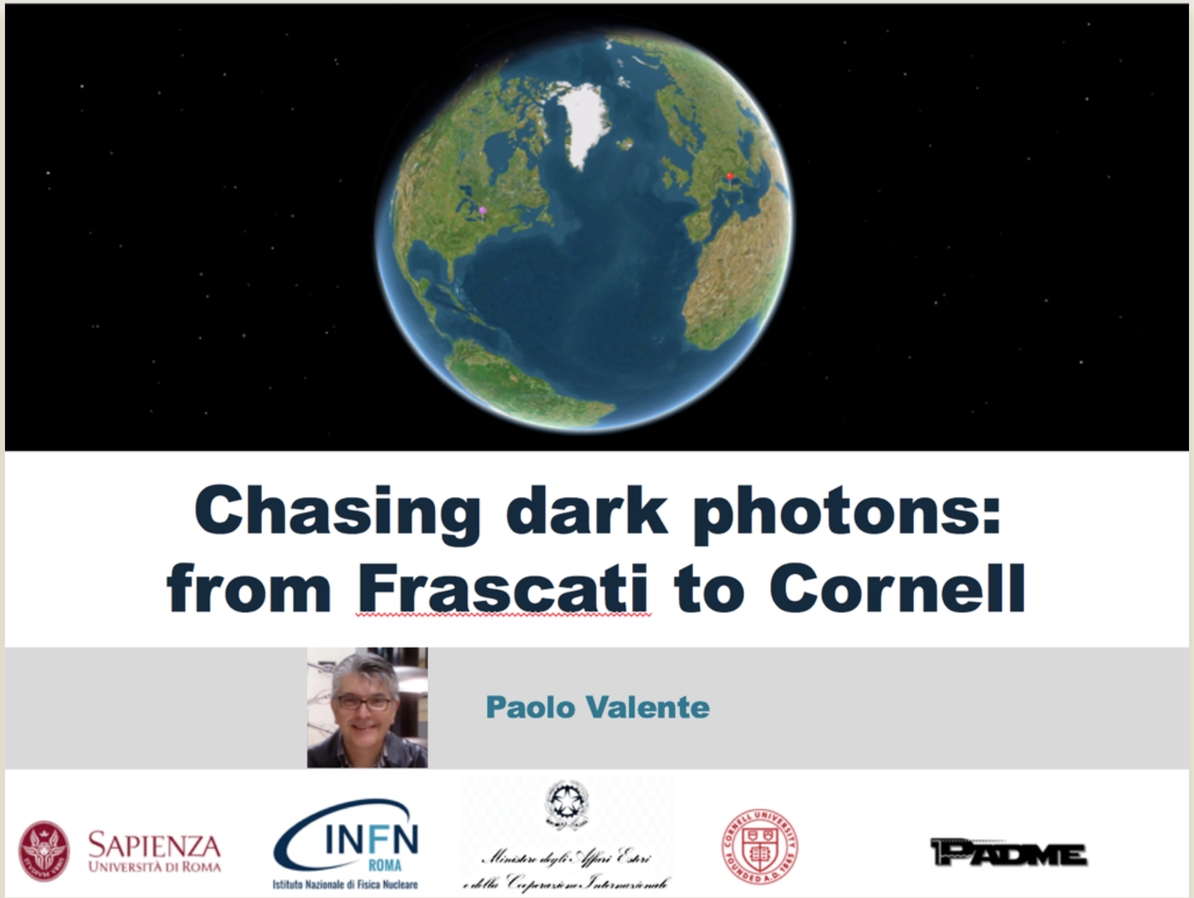
LNF has the only e^+ beam in the world able to produce X boson using resonant production!

Future in the USA?

Luca Marsicano
INFN Genova,Universit. Di Genova

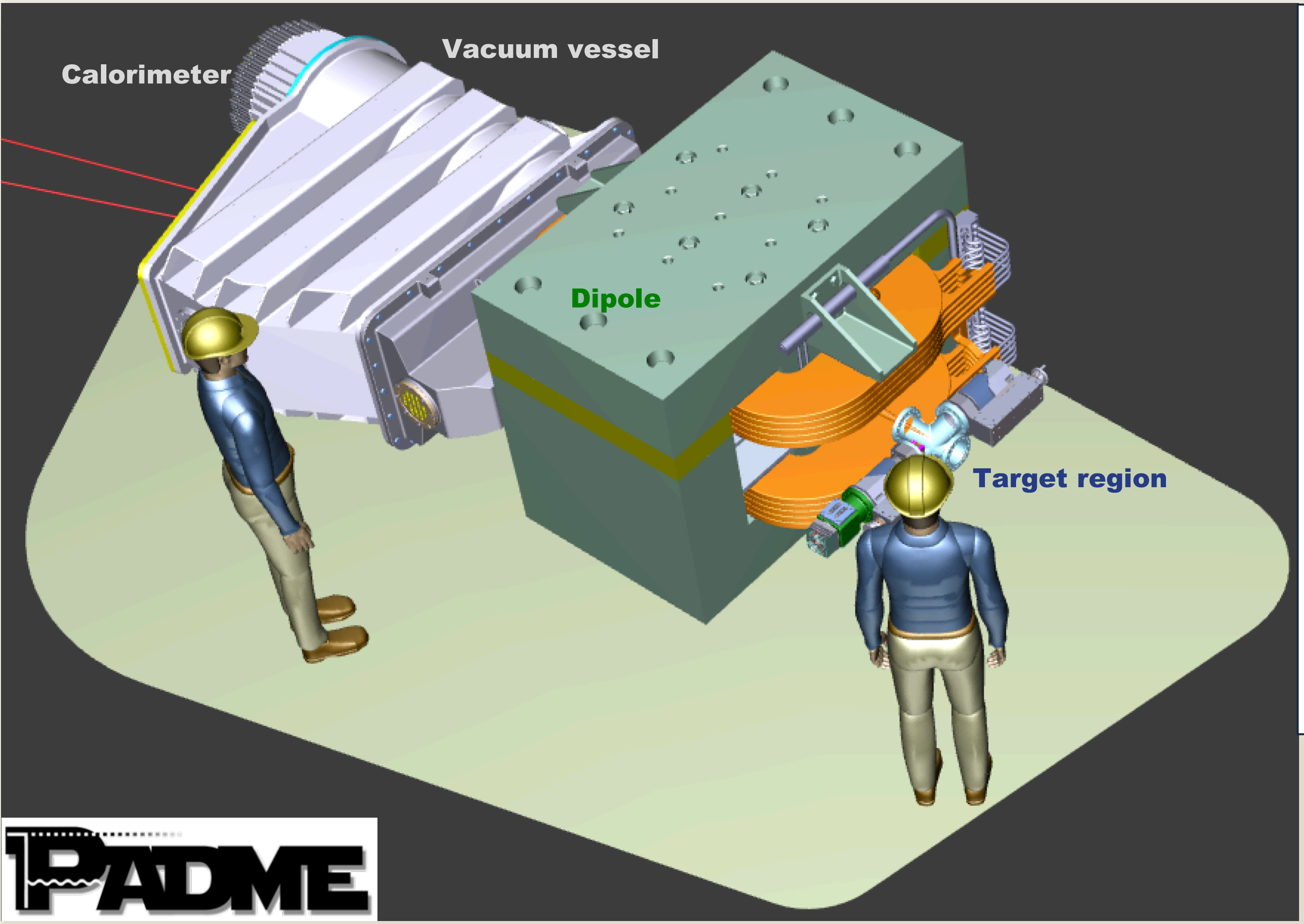


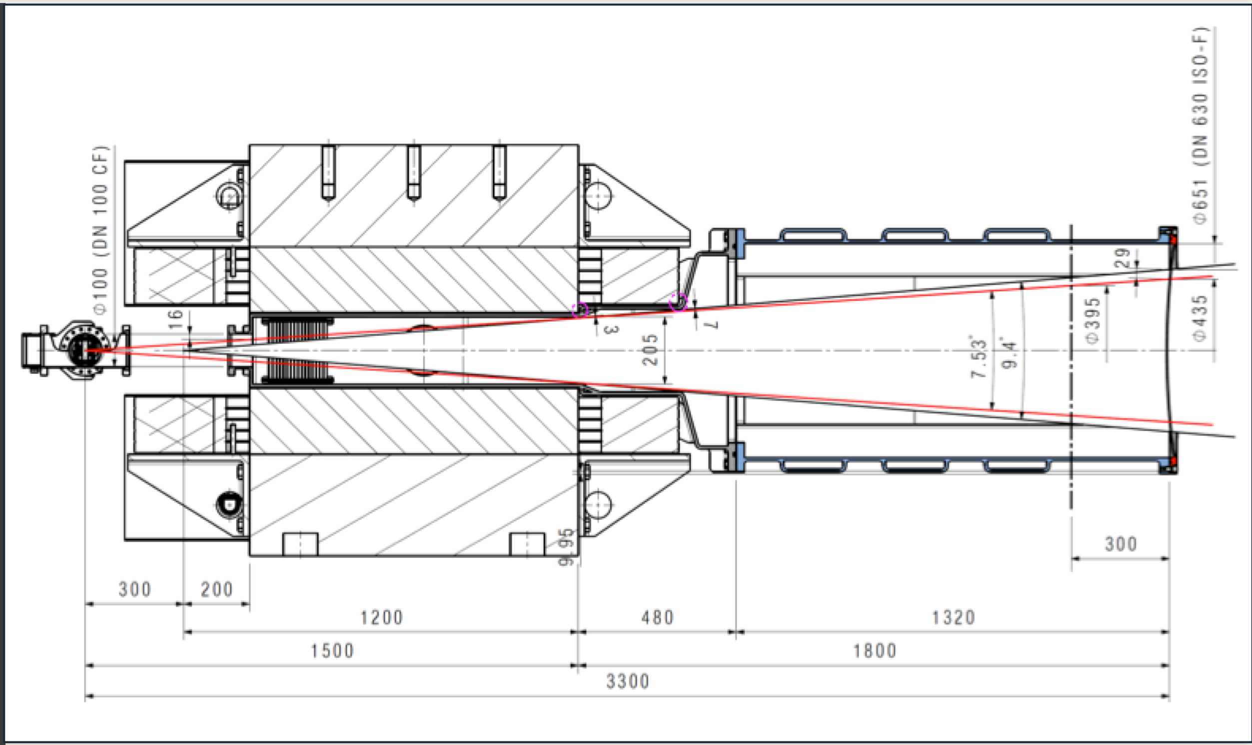
International Workshop on Physics with Positrons at Jefferson Lab
September 12-15, 2017



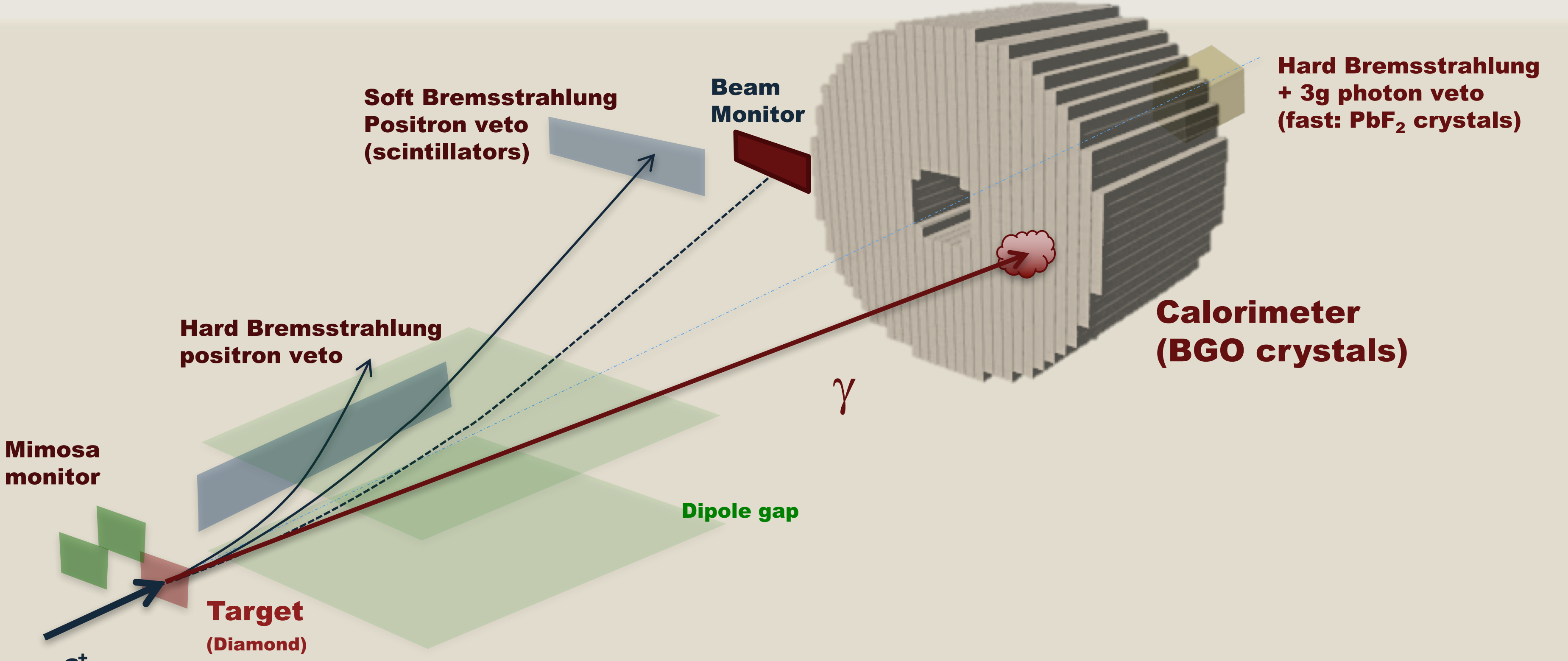
- **Cornell** will apply for NSF grant to participate to PADME
- Cornell will apply to NSF "Major Research Infrastructure" to finance the **6 GeV extracted e^+ line for a Dark Photon**

The PADME detector





The PADME experiment concept



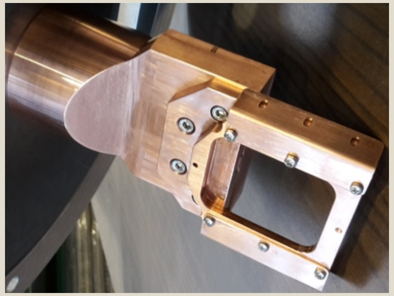
- La misura di PADME si basa sulla massa mancante.
  - $M_{miss}^2 = (P^4_{e-} + P^4_{beam} - P^4_{g})^2$
- La misura di P^4_γ è affidata al calorimetro
- La misura di P^4_e è affidata alla stabilità e alla conoscenza del fascio
  - Il sistema di monitor con il mimosa può misurare i parametri del fascio solo quando non prendiamo dati
  - La targhetta di diamante può fornire informazioni solo sul beam spot

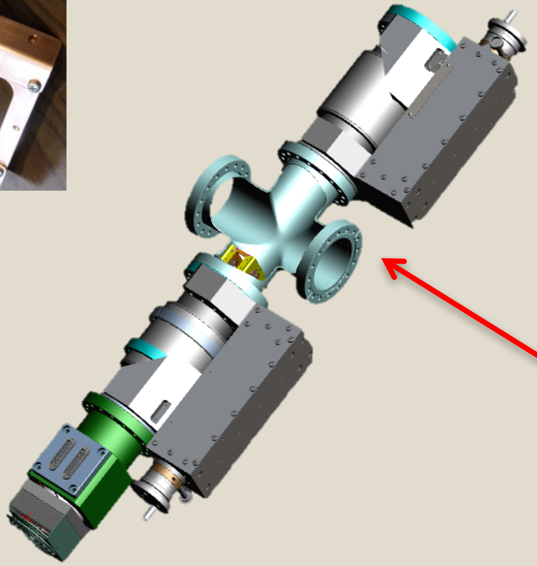
The PADME Target region

Mimosa beam monitor (INFN LNF E. Spiriti)

- **On other side: MIMOSA-28 monolithic pixel tracker for beam monitoring and optimization**
- **20.8 μm pitch, 20.2×22.7 mm² area**

- **Sensors ready, mechanics + cooling in vacuum + carrier board under construction**

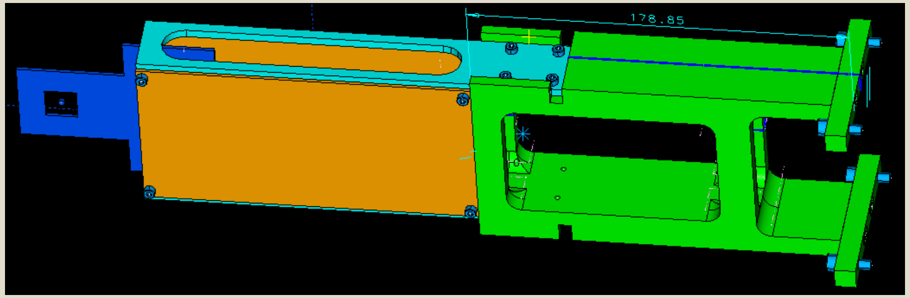


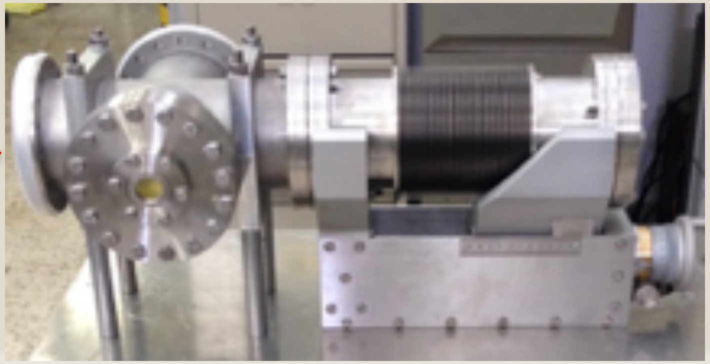


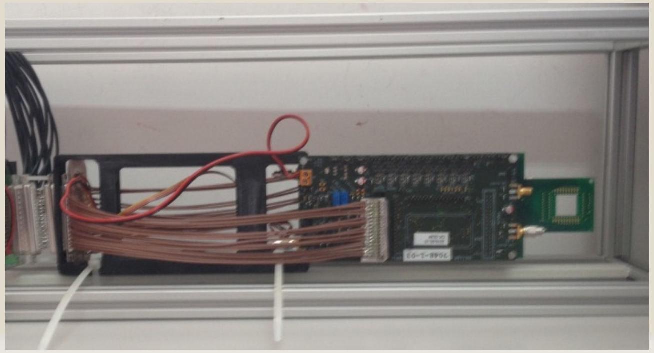
Diamond target (INFN LE)

- **On one side: 0.1 mm CVD target with 15+15 graphite strips + readout electronics + carrier board + mechanics + linear stage, ready to be assembled and installed**

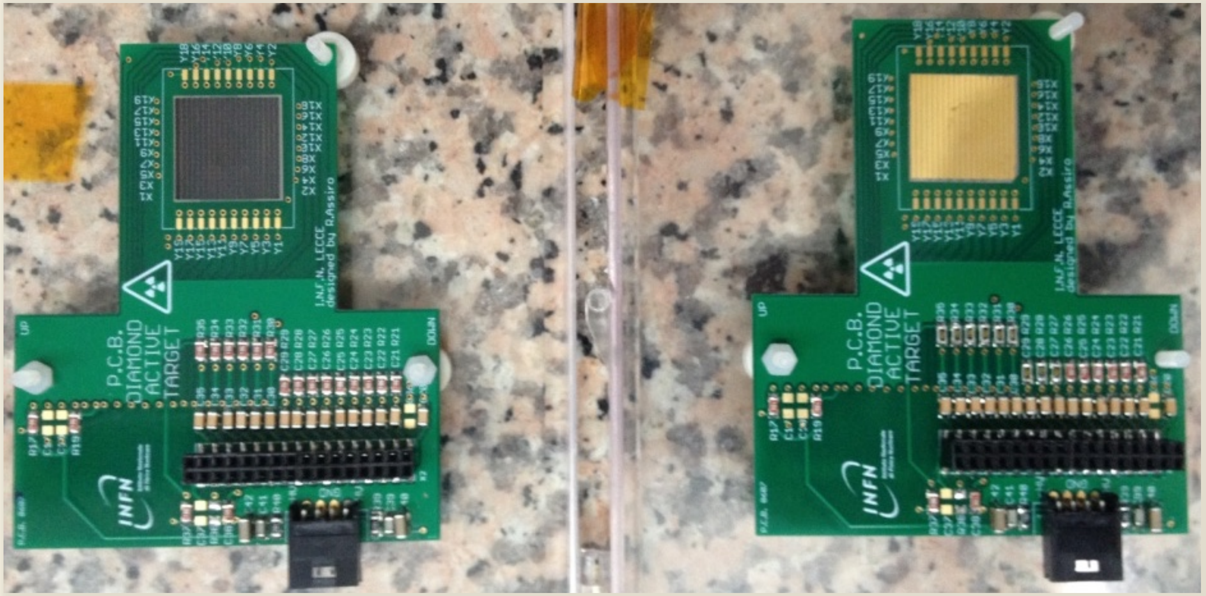
- **0.05 mm CVD, also with metallic strips versions available**





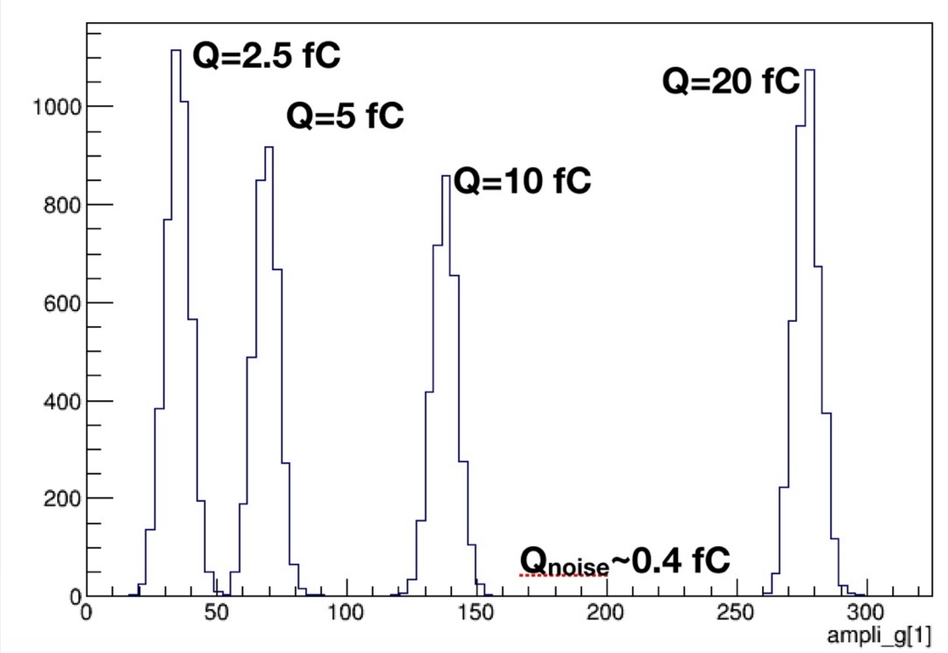


Diamond target electronics status (INFN LE)



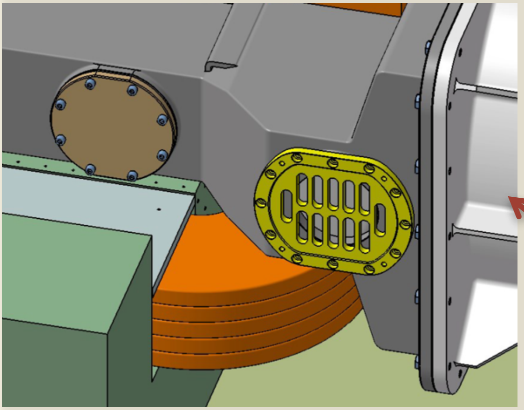
- Two sensors (one with graphitic strips and one with AuCr) mechanically and electrically glued on the populated carrier board.
- Next steps interconnect front strips with wire bonding
- Expected final assembly at the end of Nov 2017
- Test with alfa source in Dec 2017

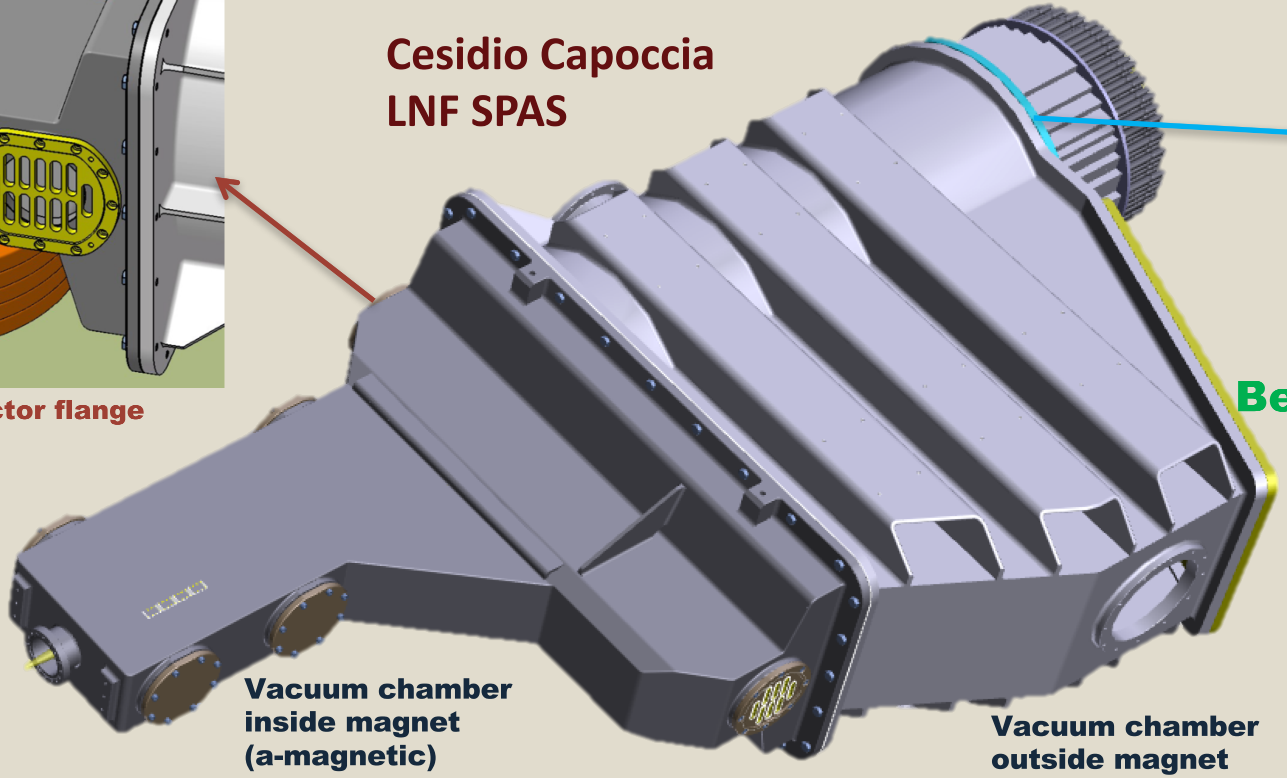
- Tested final electronic chain by injecting charge:
  - sandwich FE board/carrier board/FE board
  - adapter boards
  - connectors
  - cables
  - digitizer

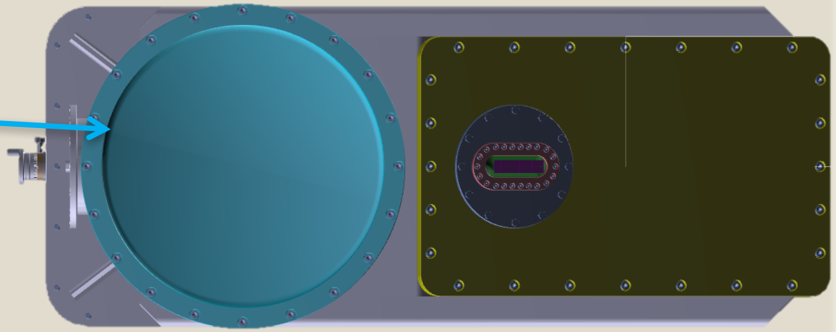


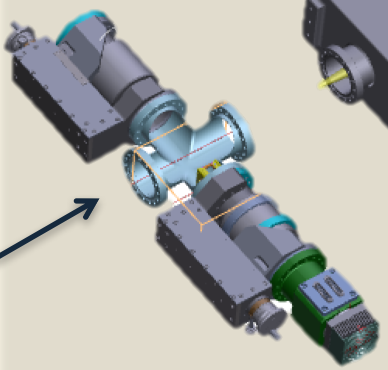
Vacuum Tank

Cesidio Capoccia
LNF SPAS



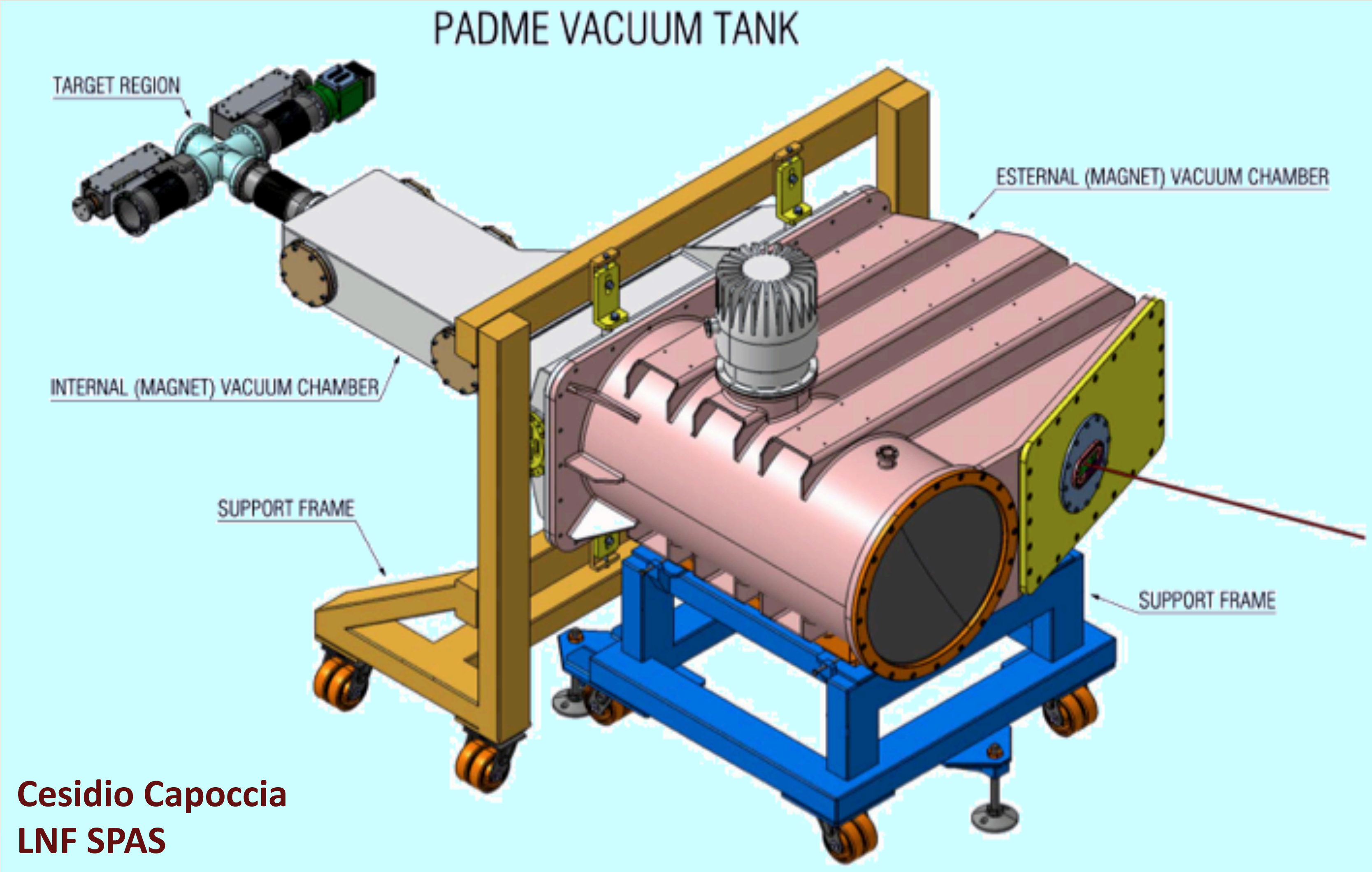






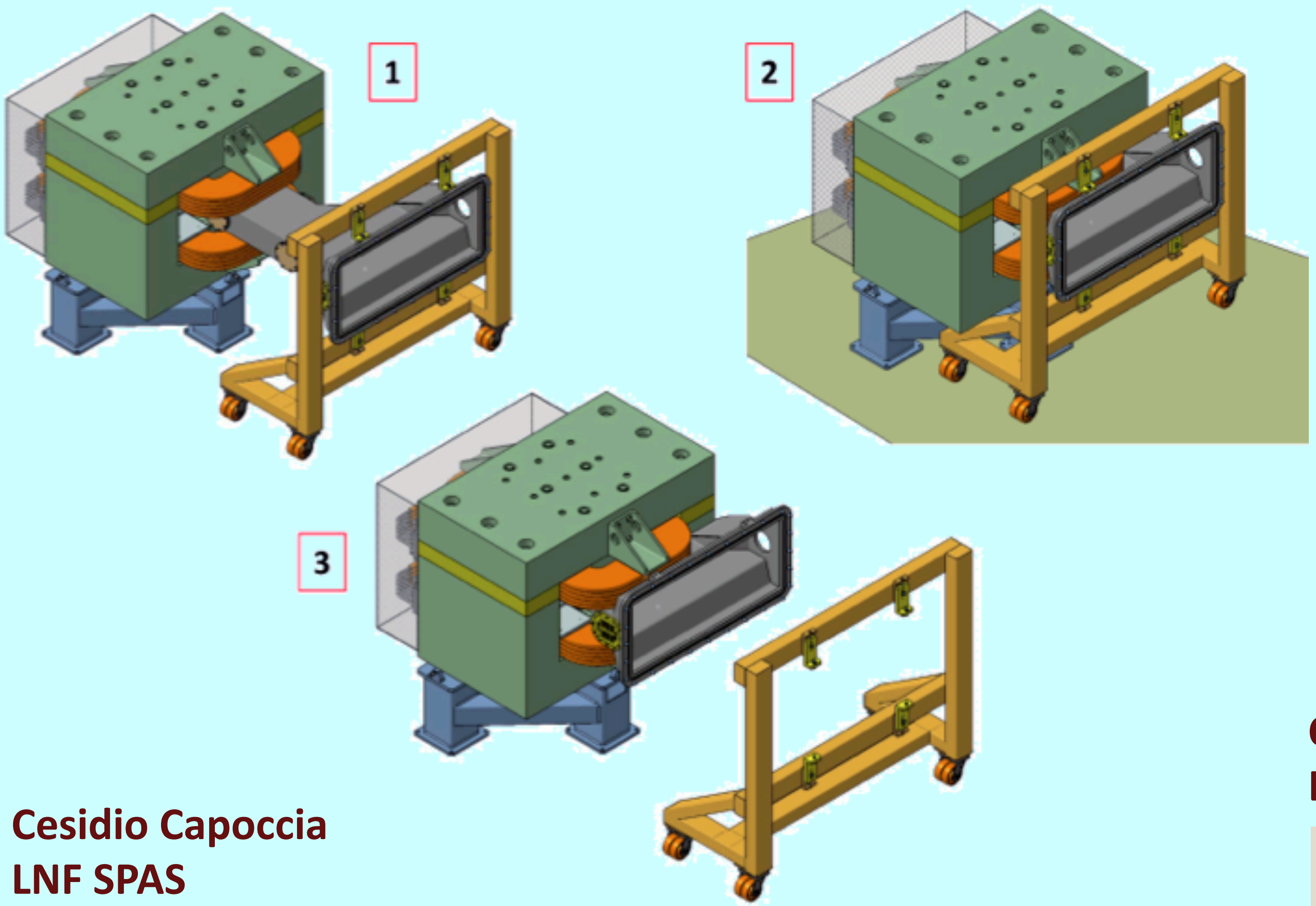
Tender has been issued expected on time delivery

Full vacuum tank assembly view

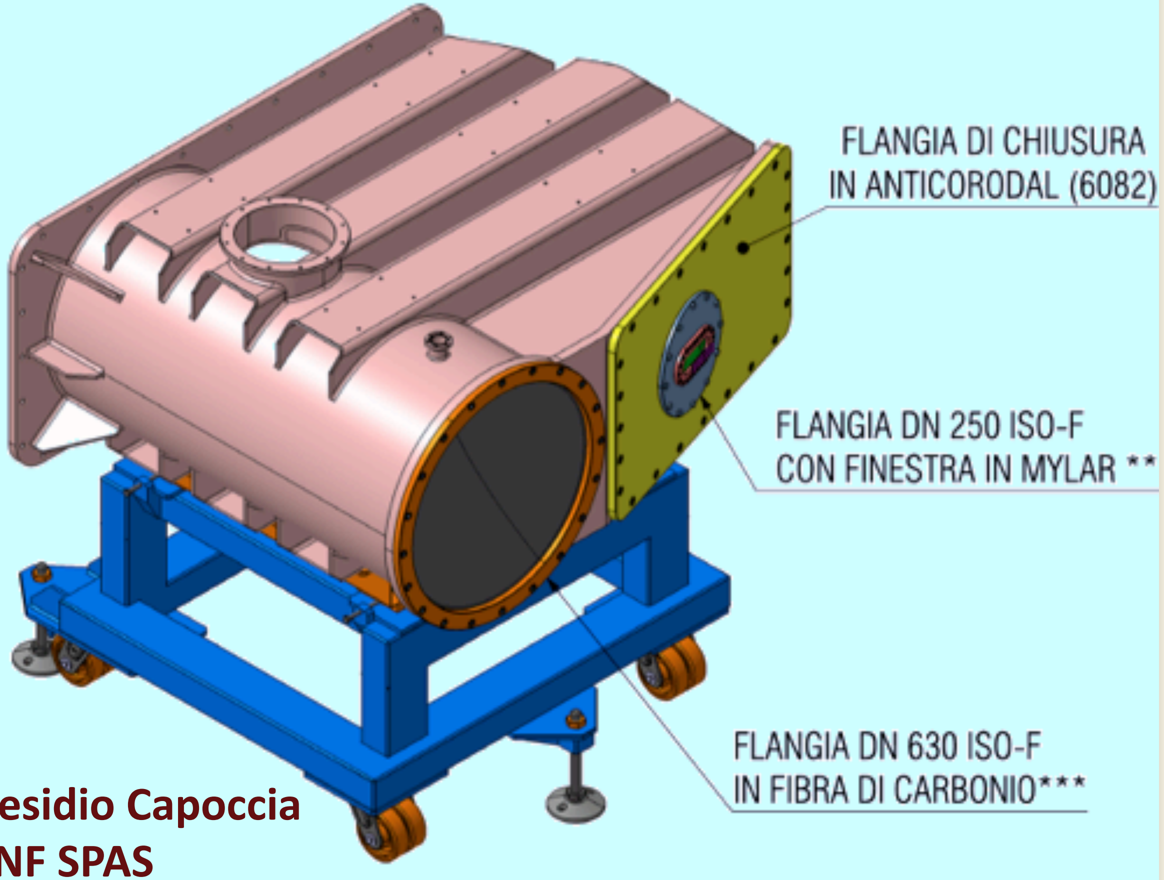


Cesidio Capoccia
LNF SPAS

Vacuum chamber assembly procedure

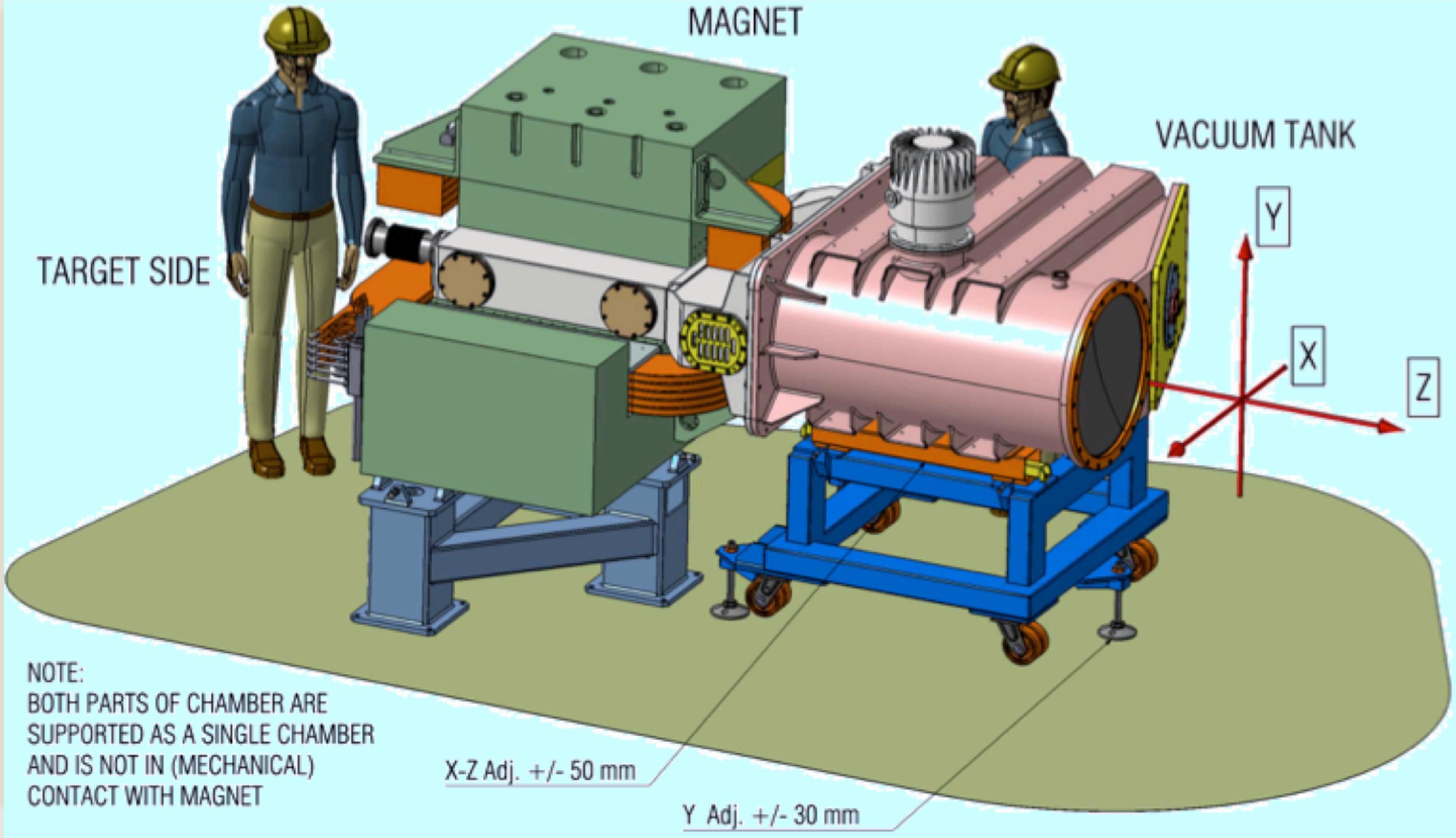


Cesidio Capoccia
LNF SPAS



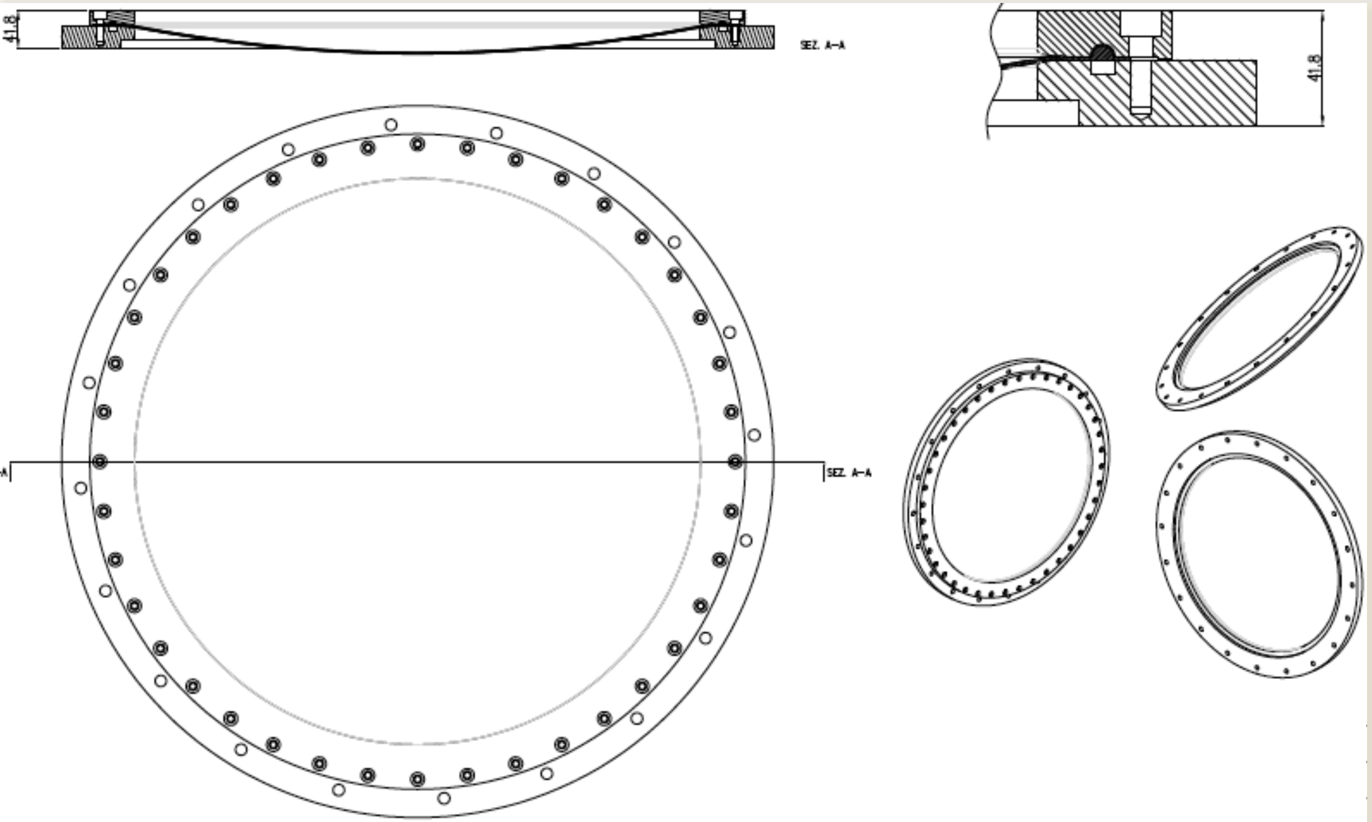
Cesidio Capoccia
LNF SPAS

Vacuum tank assembled



Cesidio Capoccia
LNF SPAS

Ecal Thin window

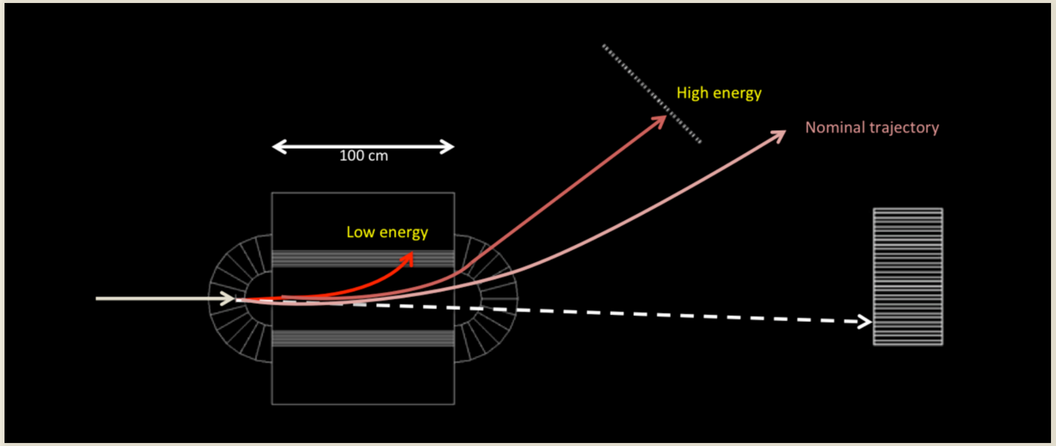


Cesidio Capoccia
LNF SPAS

- PADME Ecal carbon fiber thin window
  - 1.5-2mm carbon fiber
  - 630 mm diameter

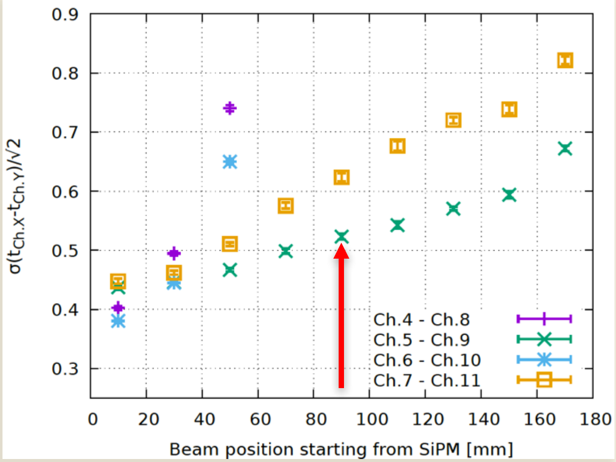
Similar Carbon Fiber built for CNAU

Charged particle Veto (Sofia University)



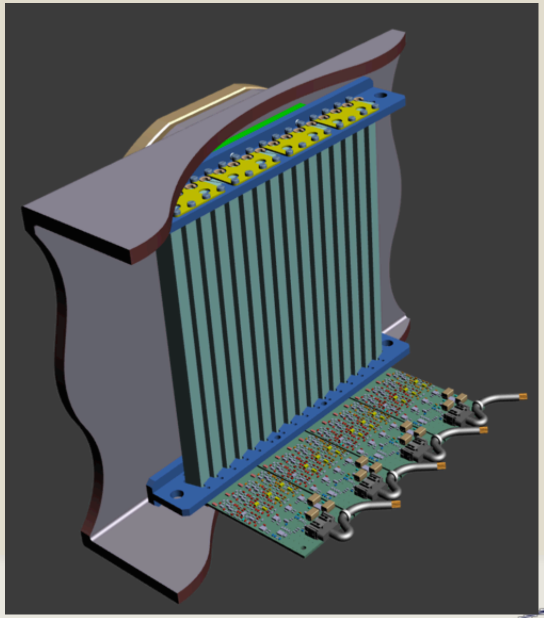
Requirements & performance

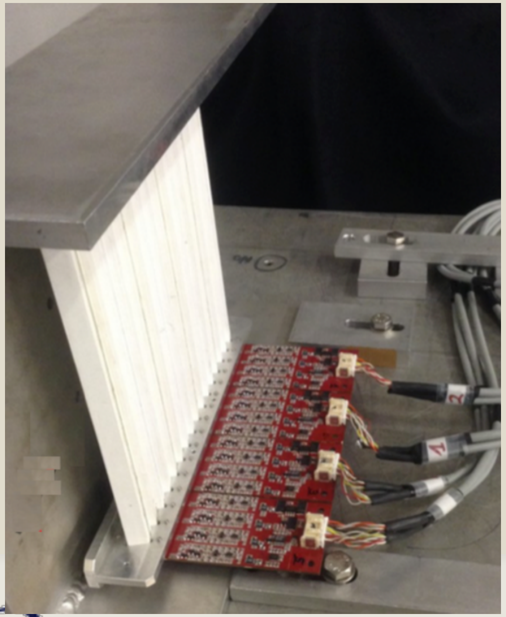
- Time resolution ~ 500 ps
- Momentum resolution of few % based on hit position
- Efficiency better than 99.5% for MIPs
- Low energy part inside the magnet gap
- High energy part close to not interacting beam

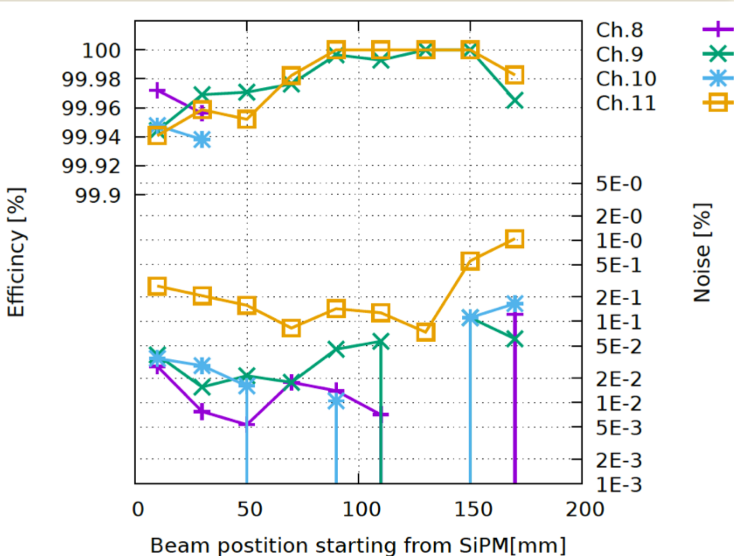


Solution

- 10×10x180 mm^3 scintillator bar with fiber readout
- Hamamatsu Photosensors 3x3mm^2 SiPM
- Prototype electronics designed @LNF SELF, tested
- Read-out by same digitizing system as calorimeter
- All scintillator bars **delivered**





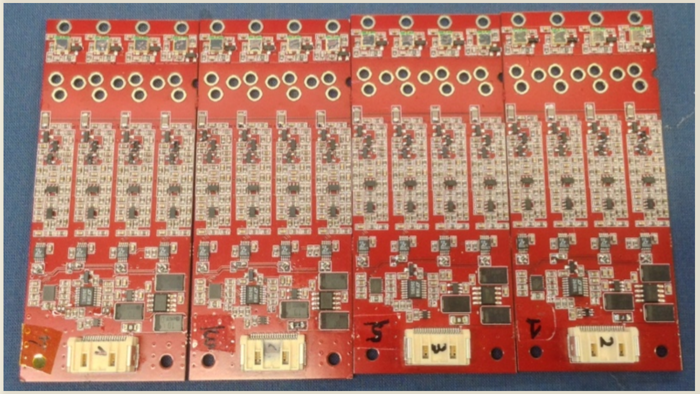


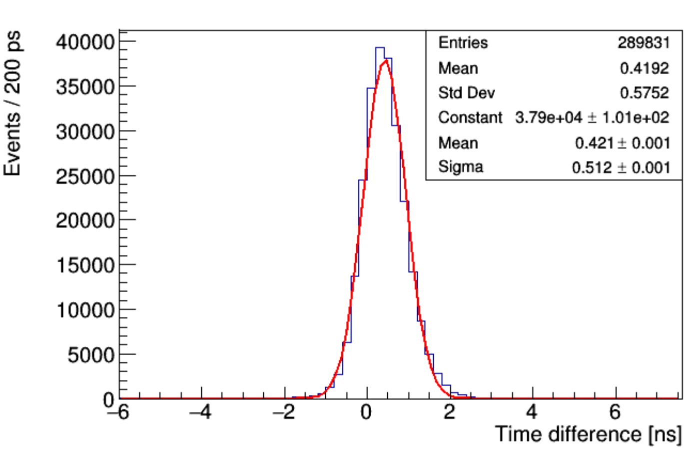
SAPIENZA UNIVERSITÀ DI ROMA

INFN

Veto construction status (Sofia University)

G. Corradi & S. Ceravolo LNF SELF





Test with led driver SiPM σ_T= 360 ps

Status of the Front End Electronics

- Veto FEE Electronics developed by LNF SELF
- SiPMs model defined and procured (250 pcs delivered by Hamamatsu)
- All necessary SiPM FEE cards to be ready by the end of the month

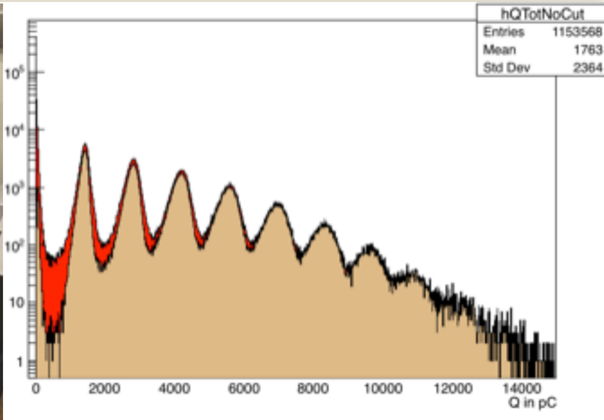
Status of the scintillating bars construction

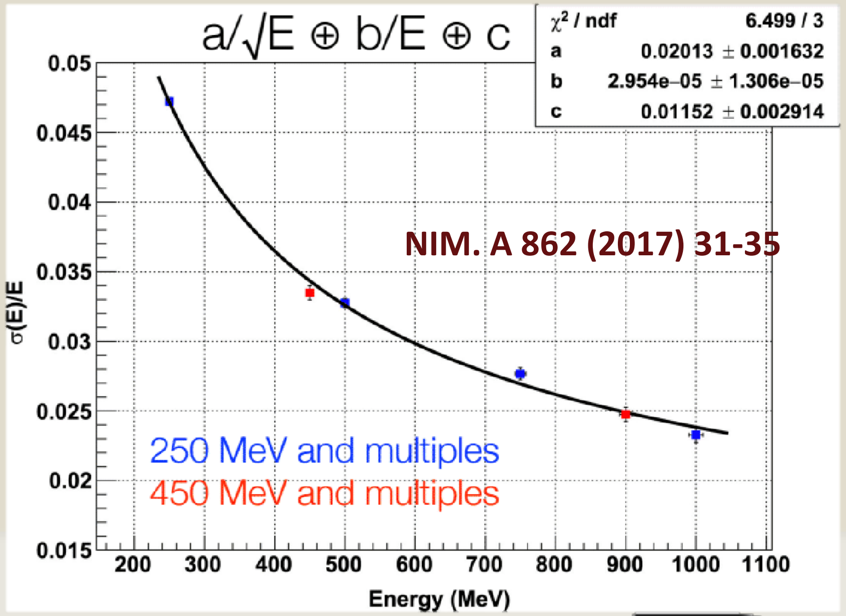
- > 200 bars already with glued fibers in the groove
- Should be sufficient for the full detector construction
- Two steps testing procedure
- After the gluing, using the 20 mm free fiber: longitudinal scan with 90Sr/90Y source, PMT readout
- After the cut and polishing at nominal length:
  - Cosmic ray test in series of 8 (or 16), nominal SiPM RO
- Web database with the parameters for each of the bars designed, implemented, and tested
- Operating with the local DAQ

Ecal performance tests completed

- Several **test-beams** for validating **PMT and divider choices**, **paint, glue, assembly procedure**…
  - Results in line with expectations from L3 experience: **≈2% at 1 GeV**, excellent linearity up to **≈1 GeV**
  - Moreover, **13 pC/MeV**, **0±1.5 pC** pedestal: E threshold well below ~0.3 MeV
- Conclusions:
  - HZC XP1911 PMT's OK; divider type "B" OK
  - 100 μm paint sufficient for light tightness at **few % level**, OK from the mechanical point of view
  - Add TEDLAR foils (50 μm) for dropping optical cross-talk to **zero**
  - Polished surfaces of cut crystals OK
  - **No radiation damage on PMT's**
  - Radiation damage on BGO at the dose level expected from literature **recovered** by high temperature annealing

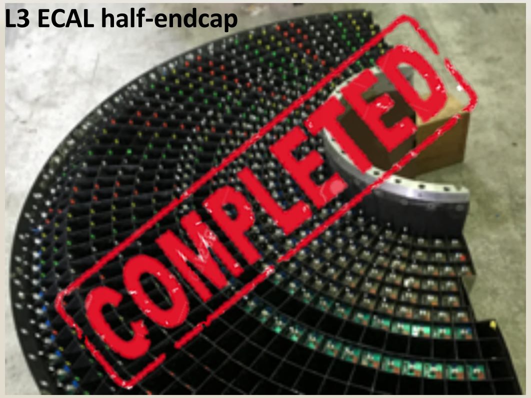
PADME BGO prototype, HZC PMT





Scintillating units production chain

L3 ECAL half-endcap



Dismounting, measure trasmittance before & after **annealing** (LAB27)

Remove foto-diodes, **Cut:** 21×21×230 mm^3

Gestione SILO

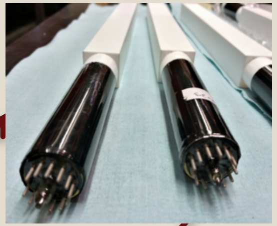
Ecal Team:
G. Piperno, C. Taruggi, G. Giorgiev, F. Ferrarotto, G. Organtini, I. Sarra, E. Capitolo

XP1911 19 mm PMT + base

HZC PHOTONICS

Gestione SILO

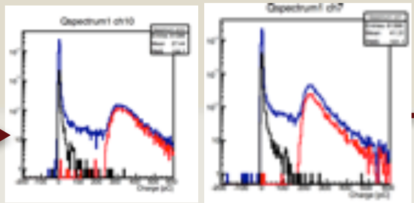
Glue and paint



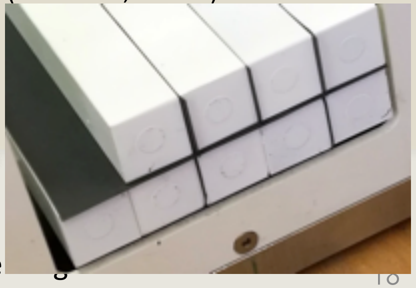
Test with LED (LNF) 80%

INFN LNF

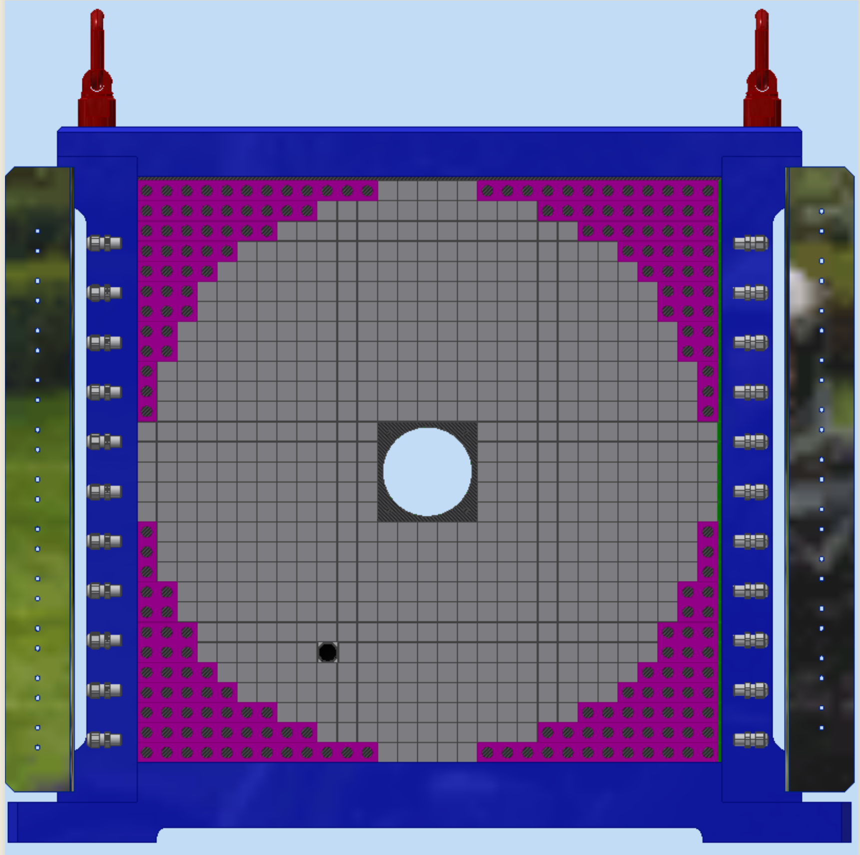
Calibration (source)



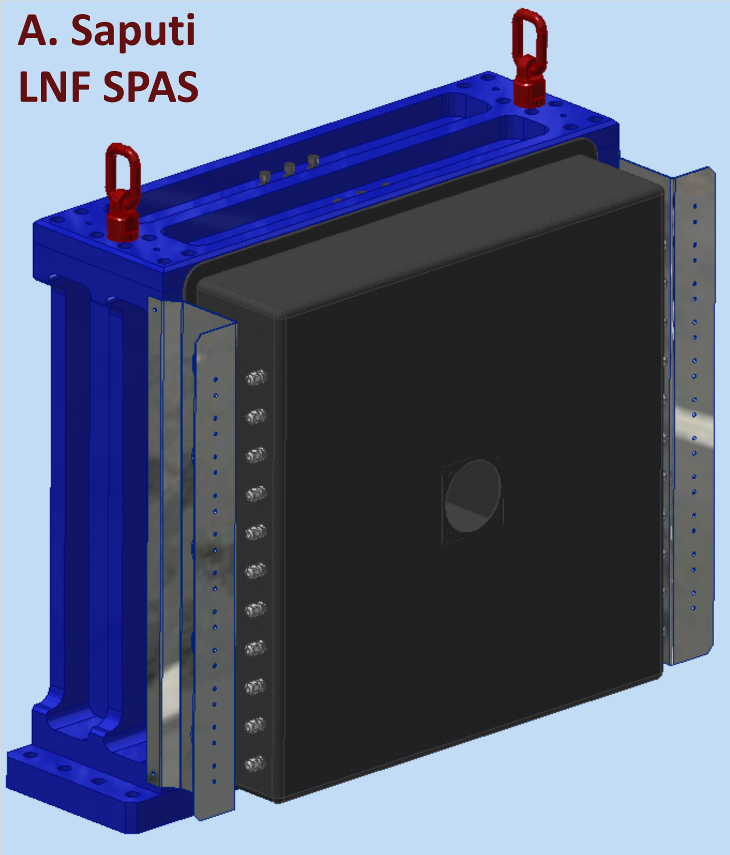
Assembly & Installation
(TEDLAR 0,05 mm)



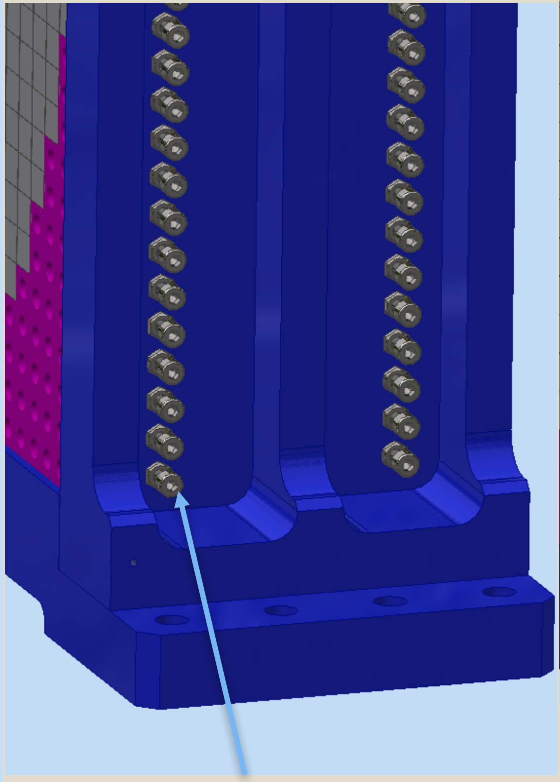
Ecal support mechanics



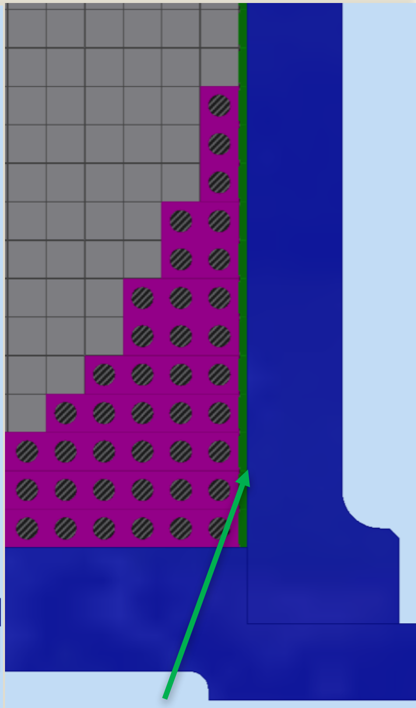
Front view of the Ecal:
Grey crystals
Purple plastic fillers



Rear view of the Ecal with black box



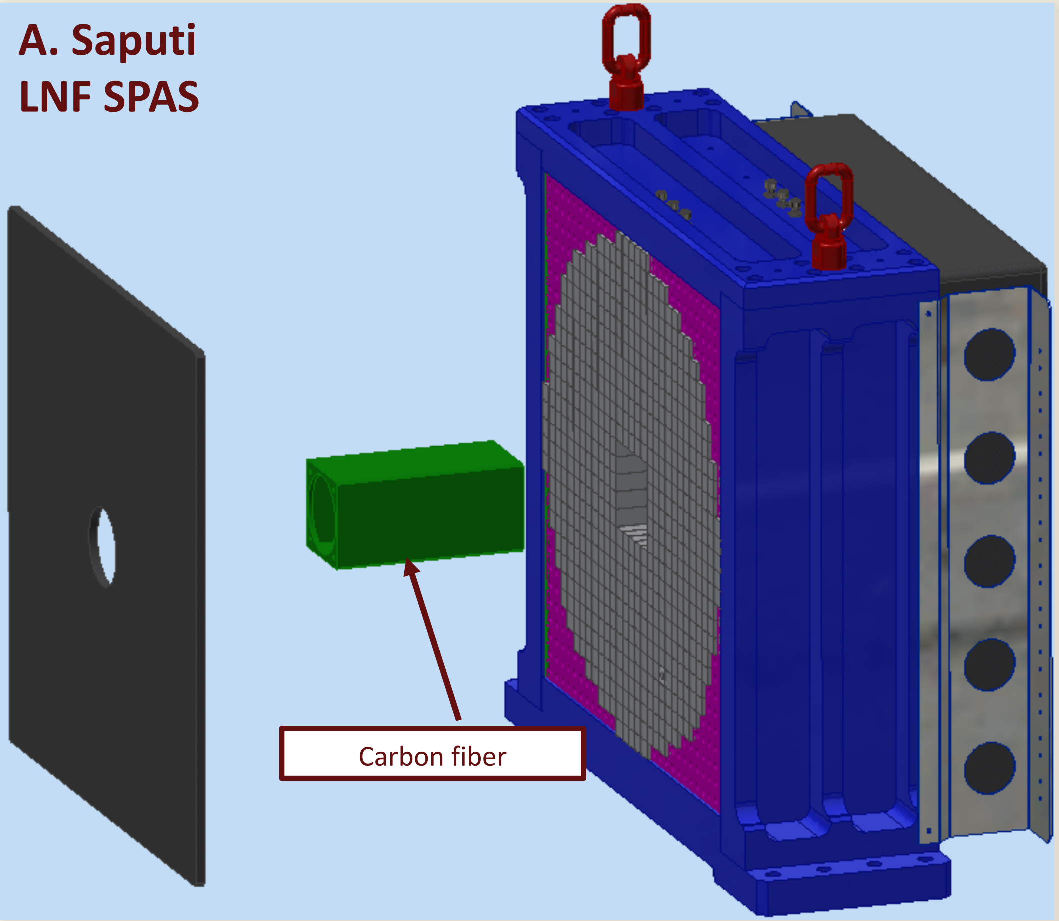
Side view locking screws

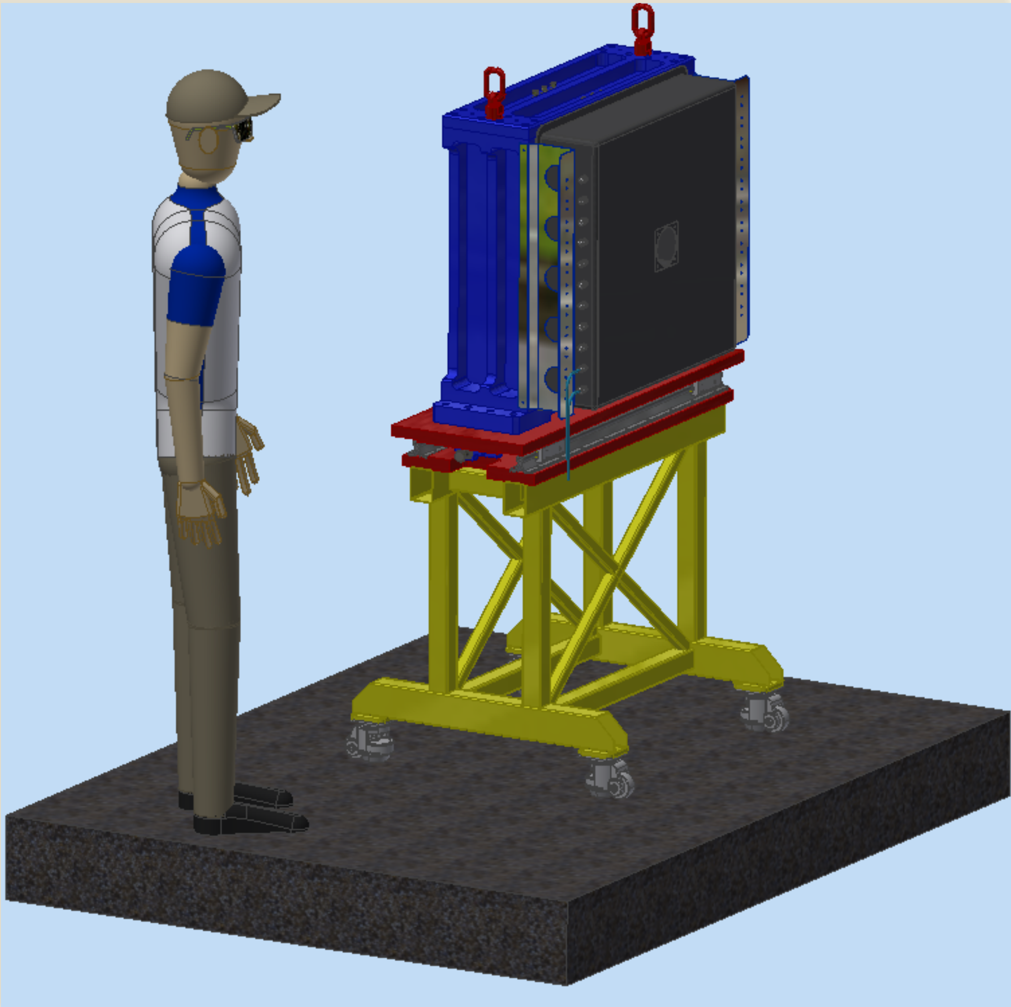


Front view locking spacers

Ecal final assembly view

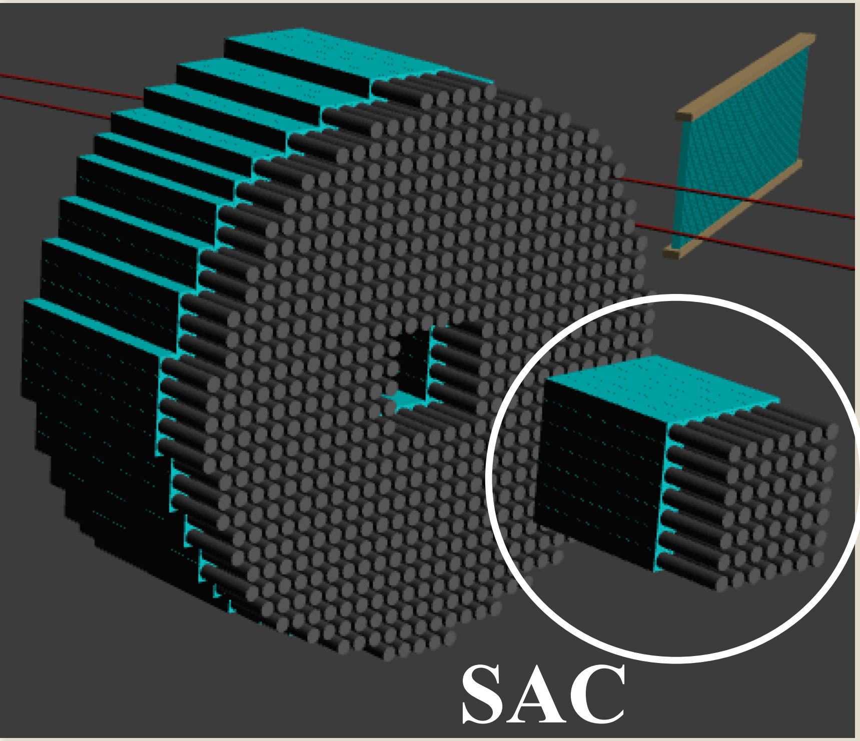
A. Saputi
LNF SPAS

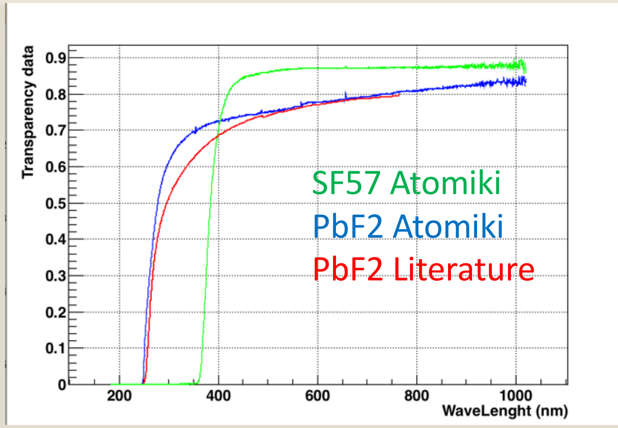




Side view of the Ecal with black box
Front face black panel
Inner hole support

Small angle calorimeter





Fast photon veto system

- Collects γ in the central Ecal hole
- Needs very small dead time and very good time resolution
- Cherenkov radiator + fast PMT

Final solution 30x30x140mm^3 PbF_2

- PbF_2: extended transparency at shorter wave-lenghts (higher Cherenkov yield +50%)
- Hamamatsu R13478: fast 2.54mm diameter PMT (x8 area coverage)
- Scale 1-2 p.e./MeV expected
- Black wrapping.
- Readout by CAEN V1742 digitizer

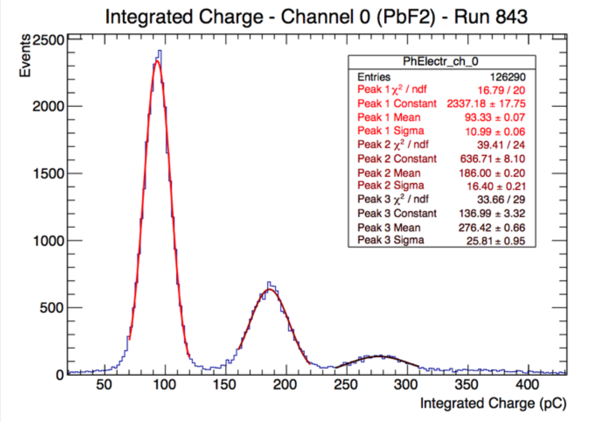
Detector project status

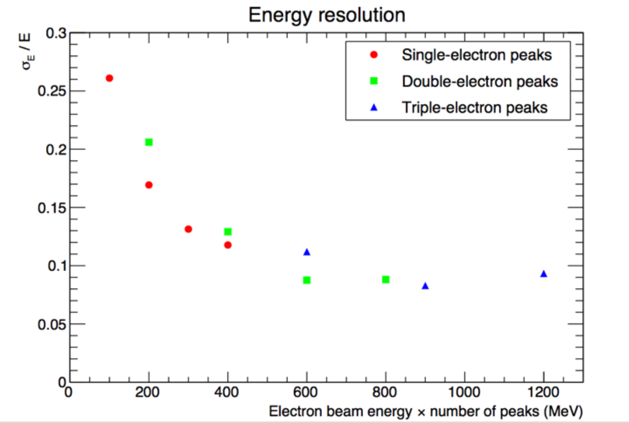
- Geometry: 5x5 matrix of 30x30 mm^2 crystals
- Order placed for 25xPbF_2 Siccas only producer
- 26xHamamatsu R13478 ordered already in July

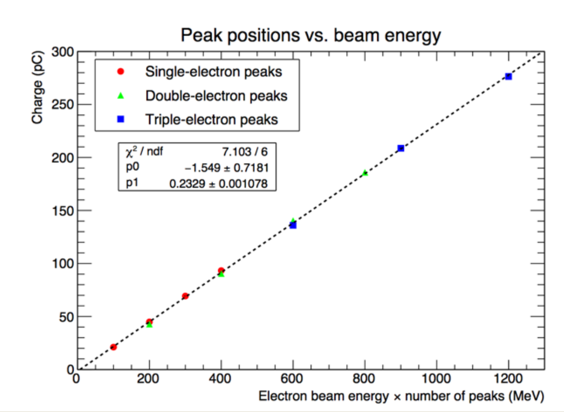
PbF$_2$ Single Crystal Performance at BTF

Energy resolution and linearity (single crystal !)

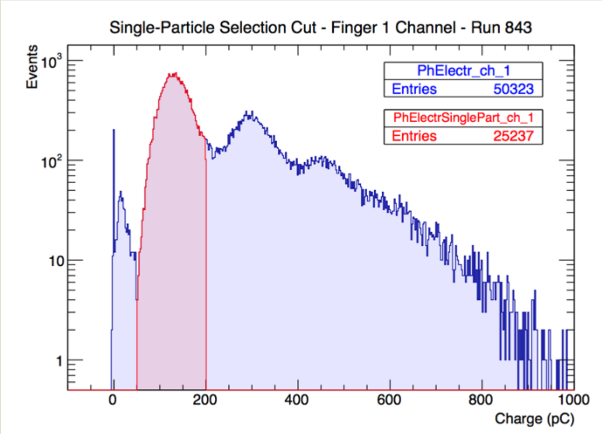
Analysis by A. Frankenthal
PHD Cornell U.



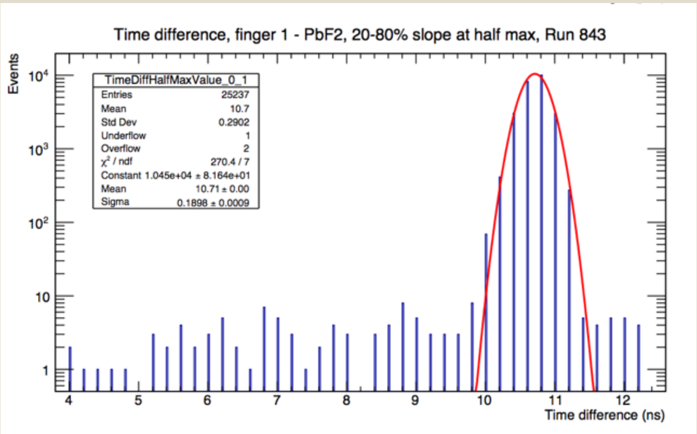


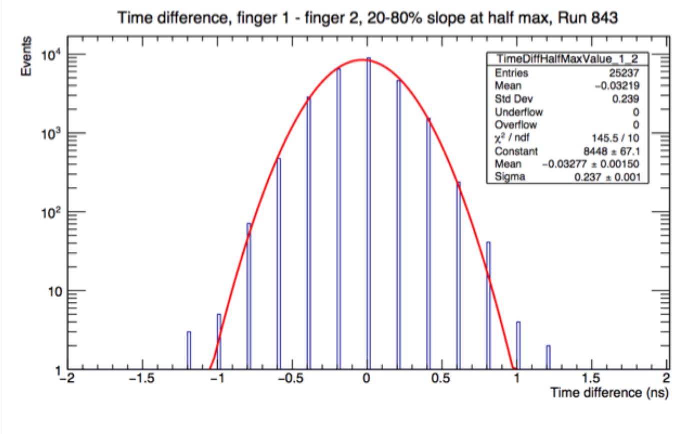


Select single electrons…



…for measuring the time resolution



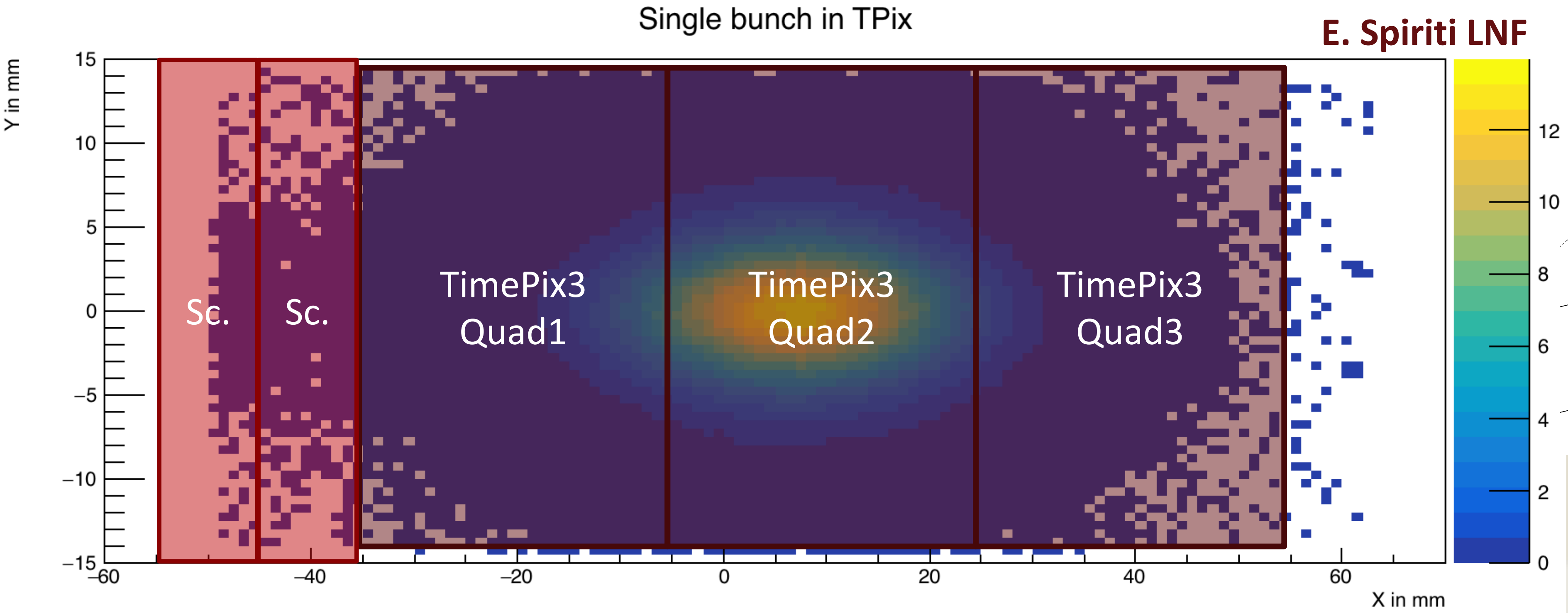


Very preliminary: <100 ps

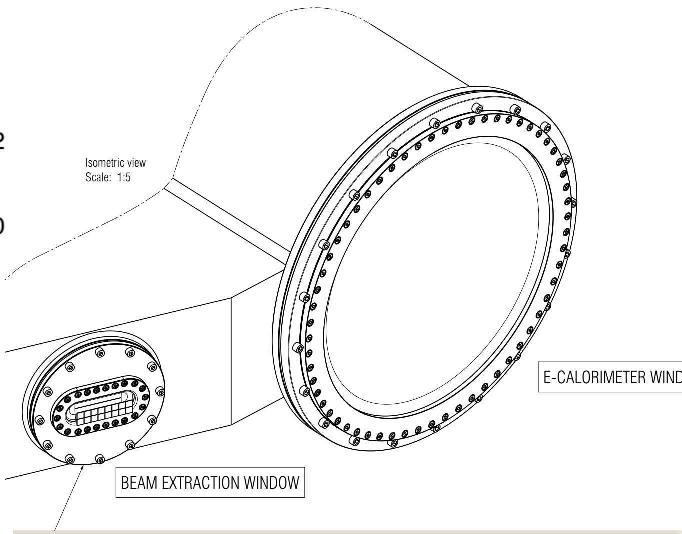
Reference scintillators: ≈150 ps

TimePix3 array as PADME beam monitor

- To obtain a reliable missing mass measurement we need to monitor the beam parameters to high precision
  - Beam divergence and its time dependence (better than 1mrad)
  - Bunch time structure (~1ns bins)
  - Beam exit coordinate (Total beam deflection in magnetic field)
  - Total number of particles/bunch (better than 1% for precision cross section measurements)
- All of this measurement will be obtained by using an array 2x6 TimePix3 sensors
- Unique device to be developed in collaboration with ADVACAM



E. Spiriti LNF

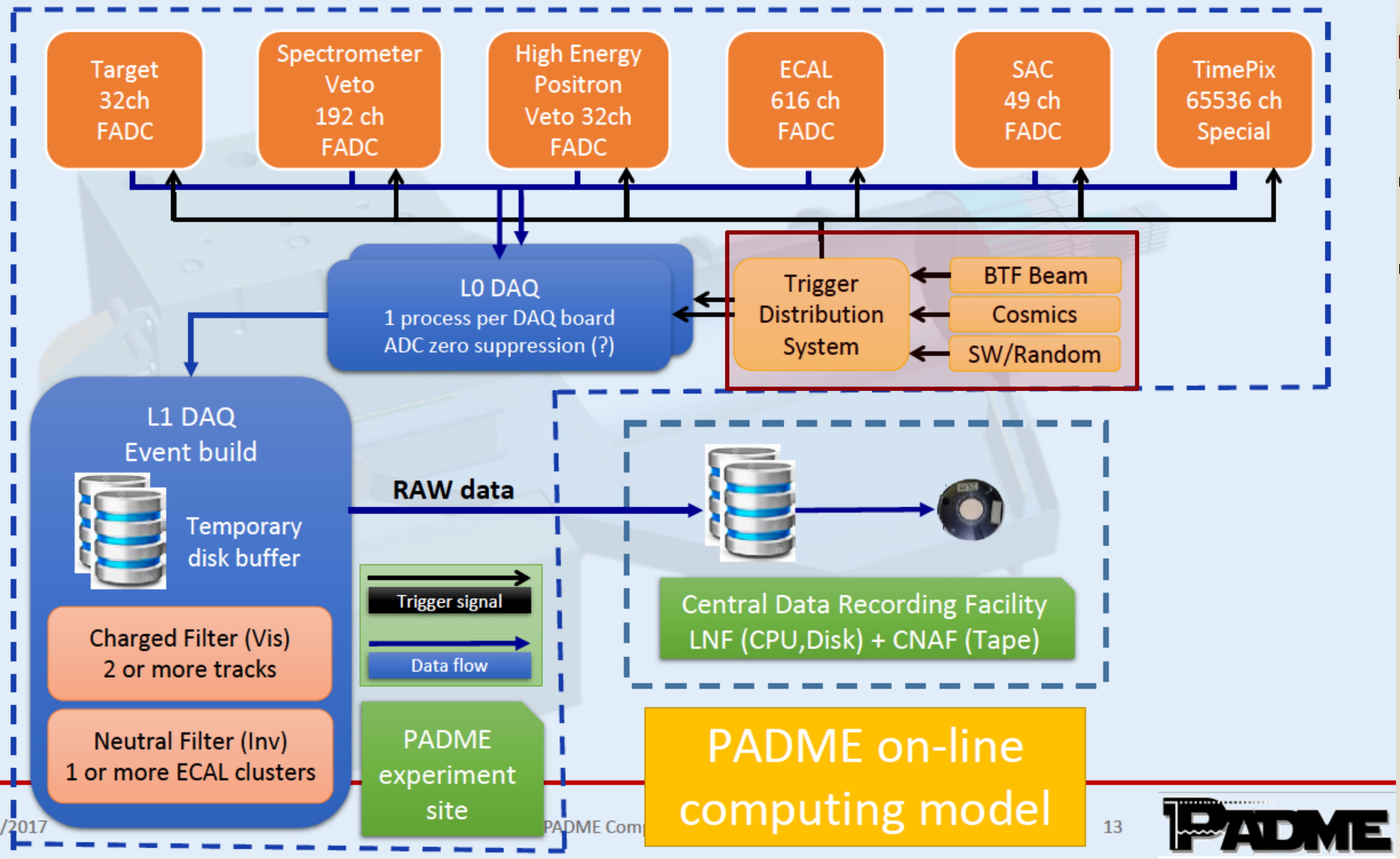


ADVACAM
Imaging the Unseen

SAPIENZA UNIVERSITÀ DI ROMA
INFN

PADME

PADME Trigger and readout model

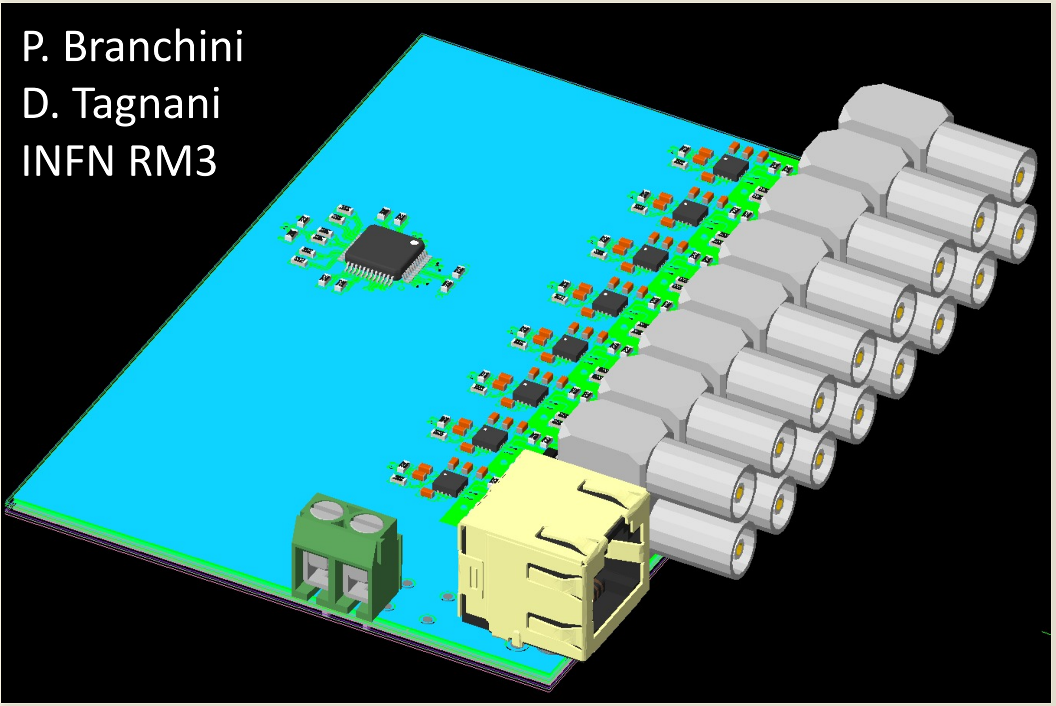


PADME L0 Trigger Processor

- Collects the beam, cosmic and random triggers
- Distribute a synchronous trigger signal to all the CAEN V1742 digitizers
- Two main components:
  - Trigger logic unit
  - Trigger Fan out

L0 trigger fan out board

P. Branchini
D. Tagnani
INFN RM3

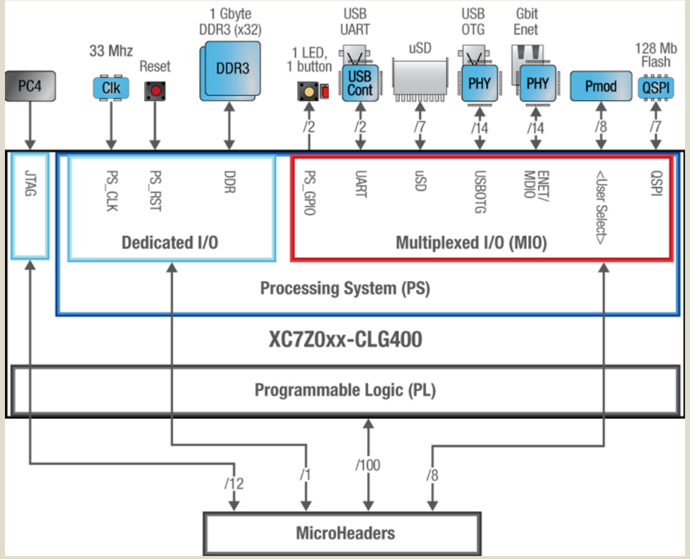


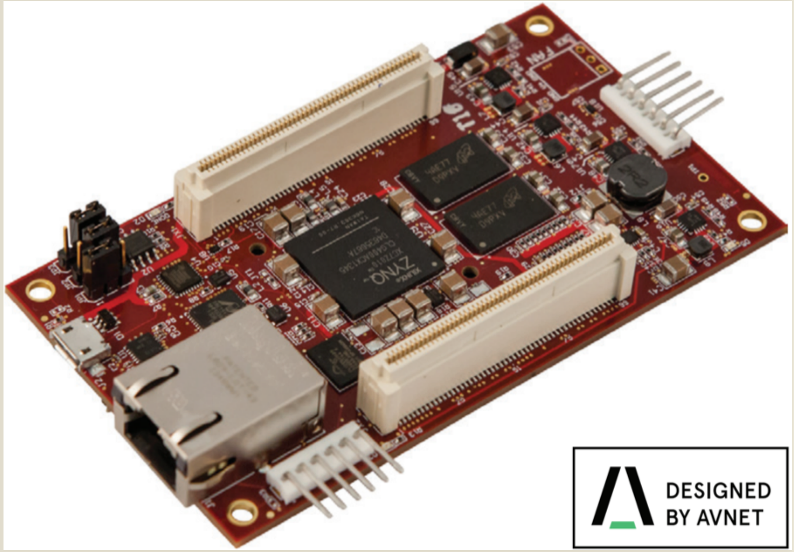
Trigger Fan out Unit

- Prototype trigger fan out 1/16 board designed in Roma3
  - NIM module very low jitter (<150ps) logic fanout
- Prototype ordered delivery expected by the end of the year.

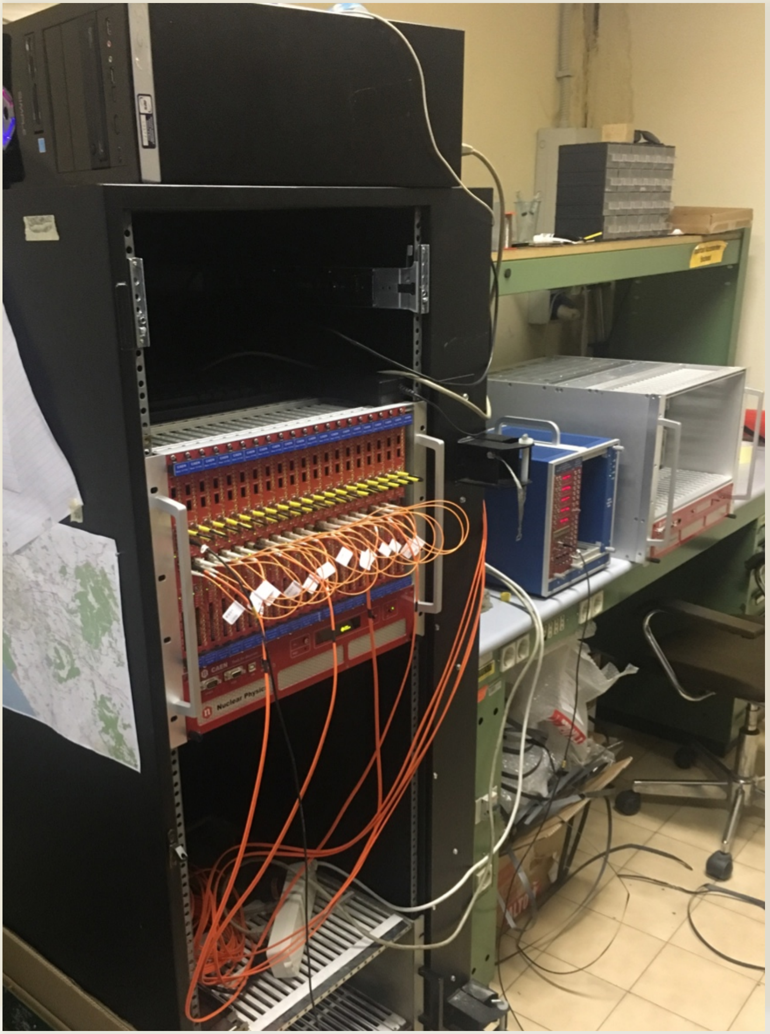
Trigger logic unit

- **Trigger logic unit based on AES-Z7MB-7Z020-SBC-I-G**
- Wide range of possible input and output connections
  - Internal 33MHz clock source.





PADME DAQ and readout test setup



- A DAQ test setup is being implemented
  - 20 ADC boards connected to the system
  - Run a realistic full data acquisition
  - Data throughput identical to final experiment
- Use a temporary (low precision) trigger signal
  - Final trigger board added to the system when ready
- Develop and test final Run Control software
  - A working prototype in use since 2015
- A Detector Control System is being implemented to:
  - Control and monitor all HV systems
  - Control target area stepping motors
  - Collect information from environmental probes
  - Control VME and NIM crates

E. Leonardi
F. Safai-Tehrani
G. Georgiev

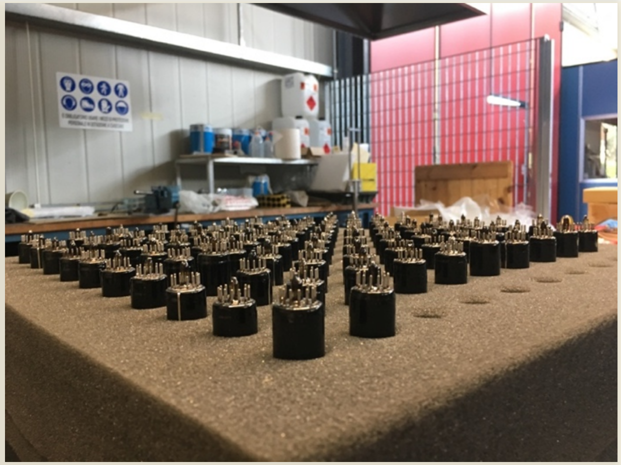
Resources and schedule

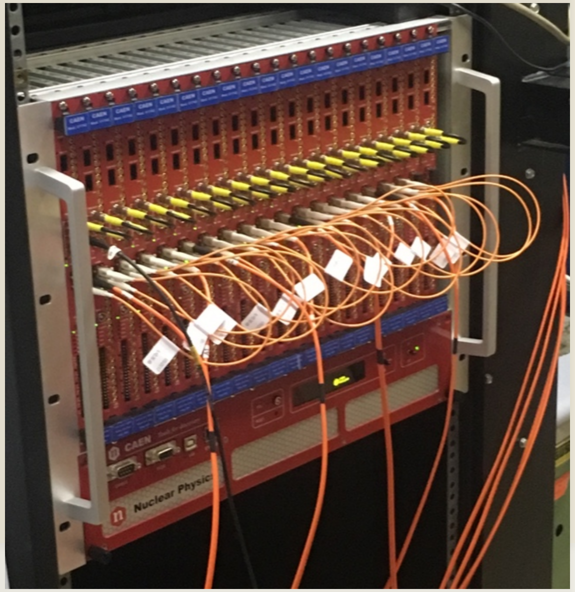
CSN1 opproval
November 2015

RUN
1 April 2018

Hardware delivery status: electronics

Material type	Status	Delivery	Note
Ecal and SAC HV system	Delivered	100%	
Readout system V1742 digitizers	Delivered	100%	
A3818 optical receivers	Delivered	100%	
VME64 8U crates	Delivered	100%	
ECAL R648 SHV distribution system	Ordered	7%	Delivery foreseen end of Jan. 2018
Positron and electron veto FEE	Ordered	80%	Delivery foreseen by end of November
Hamamatsu SiPM Charged Veto	Delivered	100%	
SAC PMTs Hamamatsu	Ordered	50%	Delivery foreseen by mid of December
ECAL PMT HZC photonics	Delivered	100%	





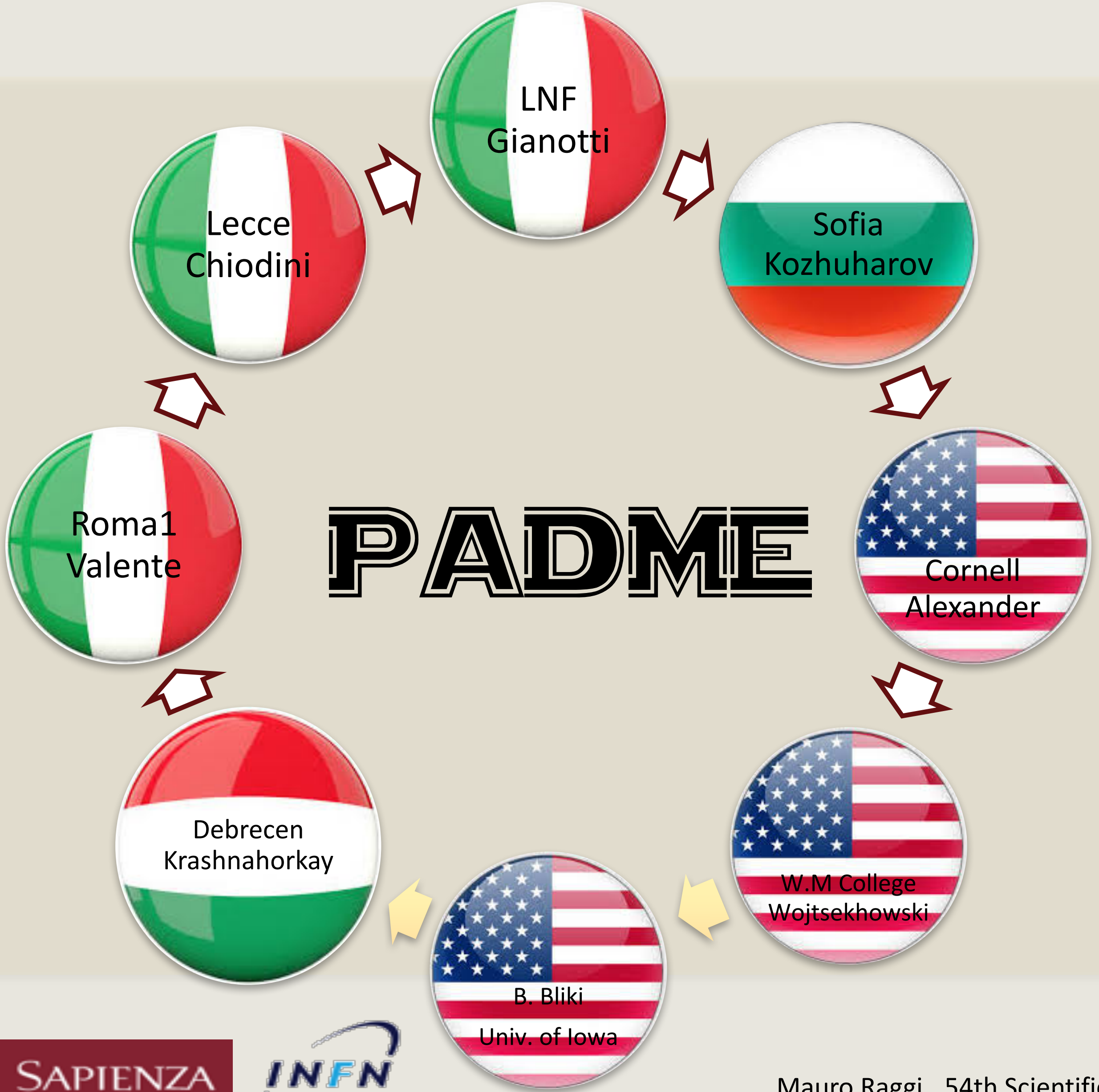
Hardware delivery status: Computing

Material type	Status	Delivery	Note
L0 Servers: 3 DELL power edge 630	Delivered	100%	
L1 Servers: 2 DELL power edge	Delivered	100%	
80TB disk in LNF Tier2 Storage System	Delivered	100%	
10 TB added in CNAF Storage System	Delivered	100%	
Tape: 100 TB on the CNAF tape library	Delivered	100%	

L0 servers

L1 servers

PADME Collaboration 2017



PADME Institutions:

Europe

Sofia Univ. Ass. : Prof. Venelin Kozhuharov
Atomiki Lab. Debrecem : Dott. A. Krashnahorkay

USA

Cornell Univ. : Prof. J. Alexander
William and Mary college : Prof. B. Wojtsekhowski
The university of Iowa: : Prof. B. Bilki

Italy

INFN Lecce : Dott. G. Chiodini
INFN LNF : Dott. P. Gianotti
INFN Roma1 : Dott. P. Valente
INFN Roma3 : Dott. P. Branchini

Conference talk list… and first papers

Talks a Conferenze

- IPRD 2016 (Siena) - Ottobre 2016 , “The PADME experiment for dark mediator searches at the Frascati BTF”, G. Chiodini
- KLOE-2 Workshop on e+e- collision physics at 1 GeV - Ottobre 2016, “Status and prospects for the PADME experiment at LNF”, P. Gianotti
- CHEP 2016 - Ottobre 2016 -”GEANT4-based full simulation of the PADME experiment at the DAFNE BTF”, E.Leonardi
- La Thuile 2017 - Feb 2017 - “The PADME experiment for dark mediator searches at the Frascati BTF”, V. Kozhuharov
- International Workshop on Light Dark Matter @ Accelerators (LDMA) 24-28 May 2017"The PADME experiment at LNF”, V. Kozhuharov
- 13th AxionWIMP conference (Patras workshop), Maggio 2017, “Search for the Dark Photon with the PADME experiment at LNF”, V. Scherini
- EPS-2017 Venezia (Aug 2017) “Search for the gauge boson of a secluded sector with the PADME experiment at LNF”, P. Gianotti
- PANIC 2017 - settembre 2017 “Dark Photon search with PADME at LNF”, G. Piperno
- IFAE 2017 - Aprile 2017 - G. Piperno / SIF 2017 C. Taruggi

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ELSEVIER

Performance of the PADME Calorimeter prototype at the DAΦNE BTF

CrossMark

M. Raggi [c,d,*], V. Kozhuharov [a,b], P. Valente [d], F. Ferrarotto [d], E. Leonardi [d], G. Organtini [c,d], L. Tsankov [b], G. Georgiev [a,b], J. Alexander [e], B. Buonomo [a], C. Di Giulio [a], L. Foggetta [a], G. Piperno [a]

[a] Laboratori Nazionali di Frascati, Frascati (RM) 00044 Italy
[b] Faculty of Physics, University of Sofia “St. Kl. Ohridski”, 5 J. Bourchier Blvd., Sofia 1164, Bulgaria
[c] Sapienza Università di Roma, Piazzale Aldo Moro 5, Rome 00185, Italy
[d] INFN sezione di Roma, Piazzale Aldo Moro 5, Rome 00185, Italy
[e] Cornell University, Ithaca, NY 14853, USA

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Received in revised form 4 May 2017
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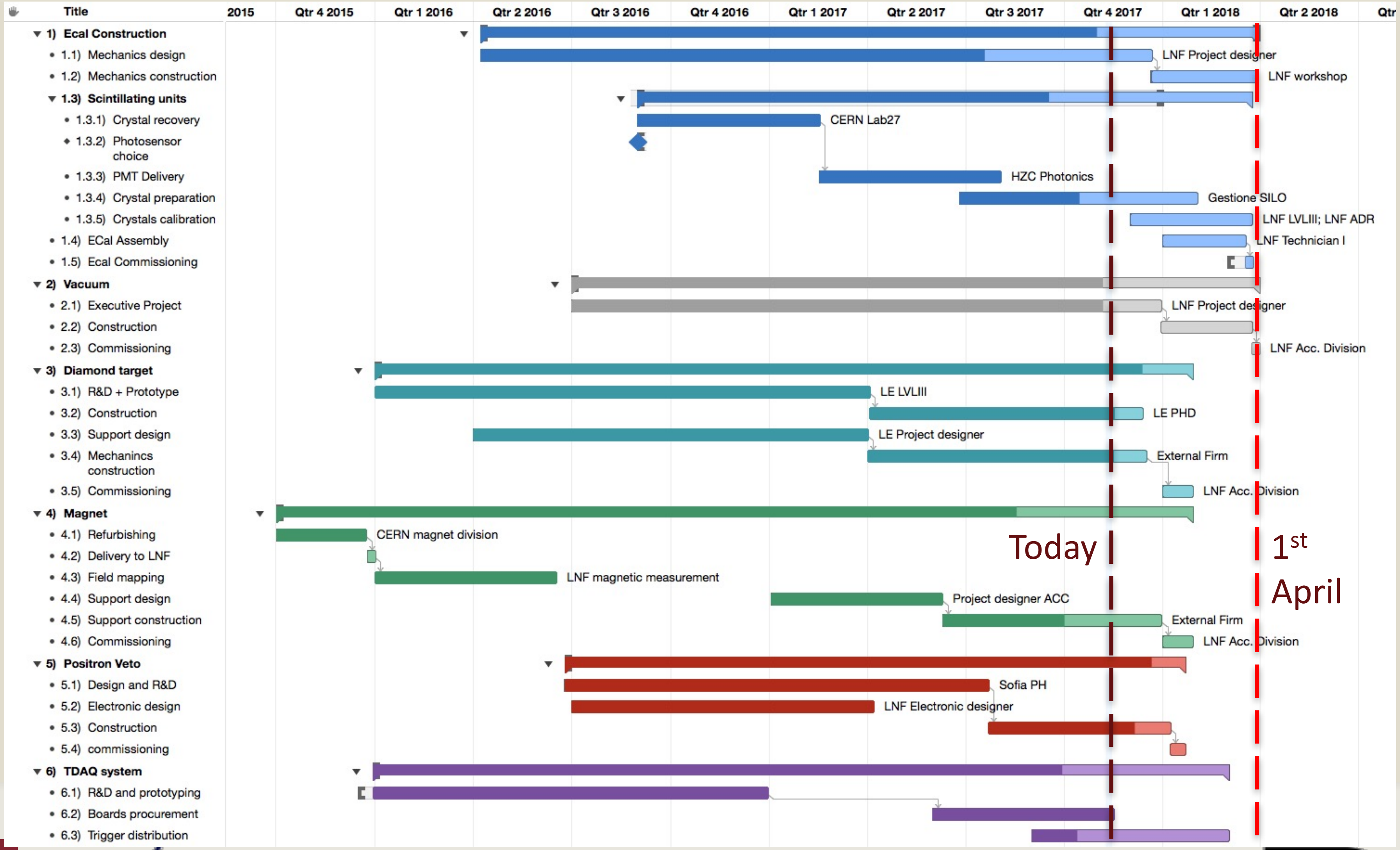
BGO calorimeter
Energy resolution
Photon detector
PADME

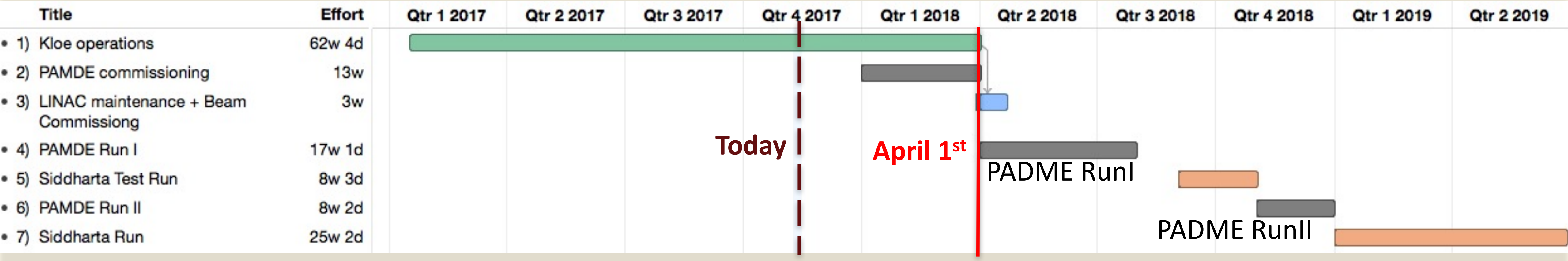
ABSTRACT

The PADME experiment at the DAΦNE Beam-Test Facility (BTF) aims at searching for invisible decays of the dark photon by measuring the final state missing mass in the process $e^+e^- \to \gamma + A'$, with A' undetected. The measurement requires the determination of the 4-momentum of the recoil photon, performed using a homogeneous, highly segmented BGO crystals calorimeter. We report the results of the test of a 5×5 crystals prototype performed with an electron beam at the BTF in July 2016.

PADME roadmap to data taking



LNF beam schedule 2018



- 2018 PADME running time:
  - 6 months with the aim of collecting 1E13 POT (using 200 ns bunch)
- 2-3 weeks during April devoted to LINAC maintenance and beam commissioning
  - Incompatible with running KLOE or PADME
  - Delay in first beam for physics at PADME by ~3 weeks
- Additional delays in the start of PADME physics will impact on the quality of 2018 data set.

Conclusions

- **PADME construction**
  - The experiment is now designed in full details.
  - All component's orders have been issued or will be issued during this week.
  - The **support of LNF workshop** is **crucial in January-March 2018** to complete PADME construction
    - Ecal mechanics construction.
    - Charged veto supports construction.
  - Trigger and readout systems in advanced state.
  - The experiment will be able to take data at the beginning during April 2018.

- **Manpower and cost to completion**
  - The cost of the experiment seems in the predicted envelop (few components need to be postponed to 2018)
  - The manpower is increased +18% FTE in Italy + 1 new American university joined.
    - Still some concern due to small number of PHD and Post Doc (just 1+1) of fundamental importance for data analysis

Let me thank all the PADME runners

CSN1 approval
November 2015

INFN LNF
(Divisione Ricerca)
P. Albicocco
F. Bossi
D. Domenici
R. De Sangro
G. Finocchiaro
P. Gianotti Group Leader
B. Liberti 30% (INFN Tor Vergata)
G. Piperno
I. Sarra
B. Sciascia
T. Spadaro
E. Spiriti
C. Taruggi (Ph.D. Tor Vergata)
E. Vilucchi
V. Kozhuharov (Università Sofia &LNF)
G. Georgiev (Università Sofia & LNF)

(Divisione Acceleratori)
B. Buonomo
L. Foggetta
A. Ghigo

PADME physics RUN
1 April 2018

LNF Officina:
T. Napolitano
F. Angeloni

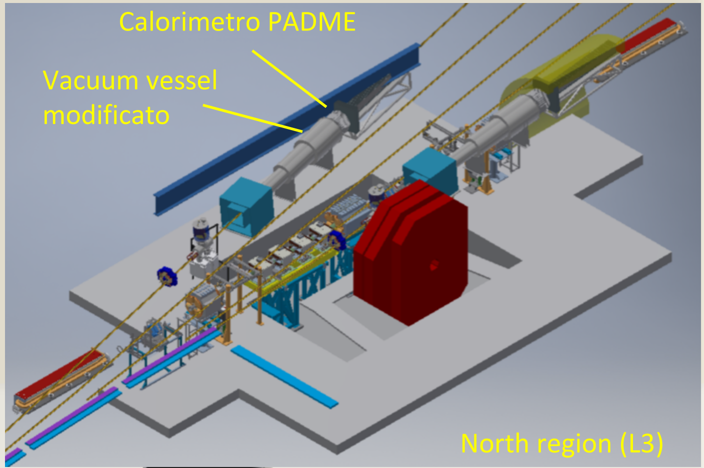
LNF Servizi Elettronica:
G. Corradi
S. Ceravolo
R. Lenci

LNF Servizio progettazione:
C. Capoccia
A. Saputi
E. Capitolo

Spare Slides

Fondi esterni MAECI PGR00026

- Il gruppo di **Cornell Laboratory for Accelerator-based Sciences and Education** (Ithaca, NY) si è unito alla collaborazione
  - J. Alexander, P. Wittich, M. Perelstein + A. Frankenthal PHD + laureandi
- Richiesta di grant a NSF (**EPP**) per il 2018 per poter contribuire fattivamente alla preparazione, presa dati e analisi dei dati
- Partecipazione **attiva ai test-beam anche nel 2017**:
  - BTF: scintillatori di veto e PbF_2 (risultato preliminare di Andre: σ(t)=90 ps)
  - Fermilab: risoluzione temporale dei diamanti (parassitaggio a test CMS)
- Ora in corso: simulazione del nuovo setup con il calorimetro di PADME per ottimizzare la distanza (vs. fondi e accettanza) e verificare le modifiche necessarie alla geometria per operare tra 4.5 e 6 GeV
- Al gruppo di fisici HEP vanno aggiunti coloro che lavorano sulla linea di estrazione di positroni
  - D. Rubin ha completato il lavoro preparatorio per l'estrazione risonante dal sincrotrone di Cornell
  - Il gruppo acceleratori sta lavorando sul posizionamento della linea nel complesso del Wilson Lab, cioè sincrotrone+anello di accumulazione (CESR)+linee di luce (CHESS): K. Smolenski e D. Kelly
- La direttrice, R. Patterson, stimola la richiesta di grant NSF per **Major Research Infrastructure**
  - Entro ottobre: competizione interna a Cornell University
  - Invio a NSF a fine 2017
  - Eventuale finanziamento fino a 2,5 M$ dall'anno fiscale 2019
- Al **College of William & Mary** (Williamsburg, VA):
  - Bodgan Wojtsekhowski +Todd Averett
  - Opzione fascio di **positroni da CEBAF** in fase di studio

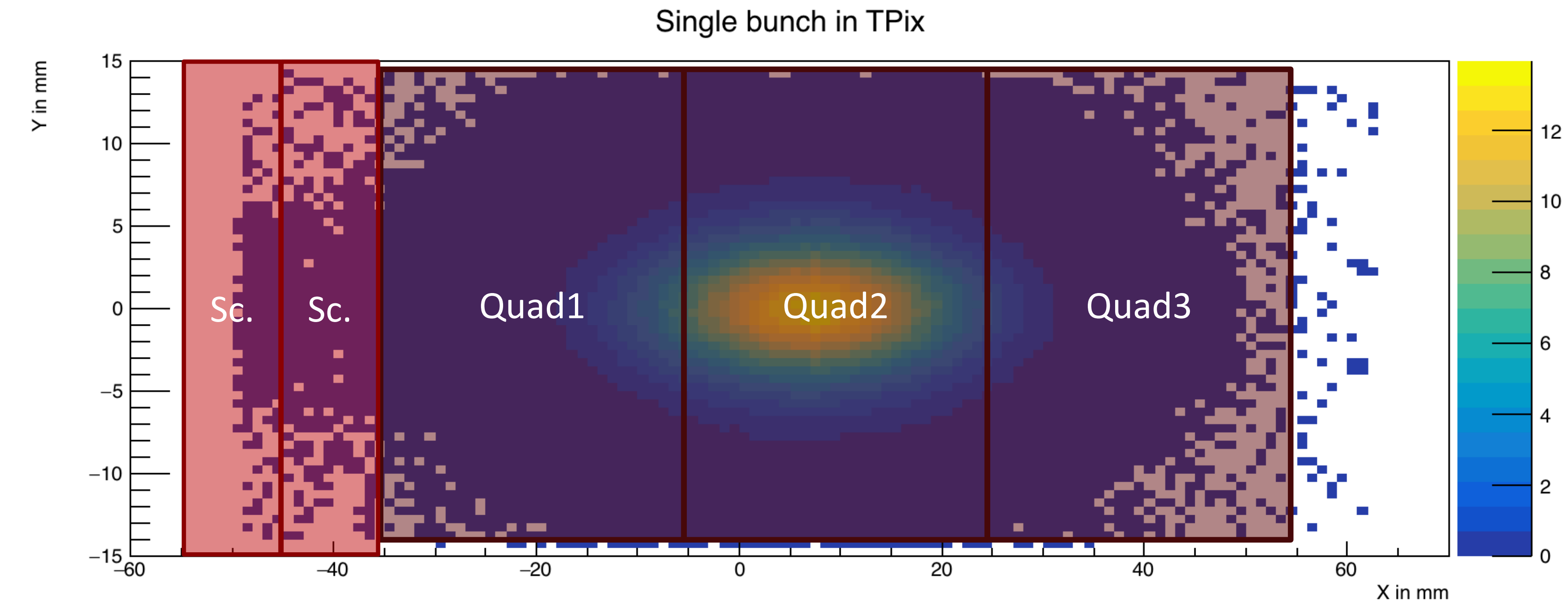


Misure di sezione d'urto a PADME

- Buco nelle misure di cross section elettromagnetiche alla scala dei ~100 MeV
- PADME e' in grado di analizzare stati finali del tipo:
  - $e^+N \to e^+N\gamma$
  - $e^+e^- \to \gamma\gamma$, $e+e^- \to \gamma\gamma\gamma$,
- PADME possiede targhette di C e di Si
  - Possono essere fatte misure sui due differenti materiali
- PADME ha la possibilità di cambiare l'energia tra 100-500 MeV
- PADME ha la possibilità di cambiare e^- e^+
- PADME ha la possibilità di fornire cross section differenziali in angolo e in energia.
- Possiamo raggiungere precisioni al di sotto del %
  - Nel caso del C le misure sono parassite alla misura principale di PADME.

- Queste competenze sono presenti in commissione IV
  - Sarebbe molto utile avere indicazioni dai teorici su precisioni e cosa misurare

Possibile configurazione a 3 quad



3 quad (12 timePix) potrebbero coprire tutta la regione interessante e fornire tutte le informazioni necessarie sul fascio e al veto per positroni.
La parte restante delle code potrebbe essere coperta avvicinando gli scintillatori ~40 mm dal punto d'impatto del fascio.

Anagrafica PADME ITALIA 2018

Researchers

INFN Lecce **6 Ric 2.3+0.3 FTE**
G. Chiodini 30%
S. Spagnolo 30%

Viviana Scherini ass INFN 30%
F. Oliva 100% (Specializzanda. Lecce)

INFN Lecce and Università Salento
A. Caricato (ric) 20%
M. Martino (Professore) 20%

INFN LNF **19 Ric, 6.2+1.3 FTE**
(Divisione Ricerca)
P. Albicocco 30%
F. Bossi 40%
D. Domenici 10%
R. De Sangro 20%
G. Finocchiaro 20%
P. Gianotti 30%
B. Liberti 30% (INFN tor Vergata)
G. Piperno (A.d.R.) 100%
I. Sarra (A.d.r) 20%
B. Sciascia 20%
T. Spadaro 20%
E. Spiriti 10 %
C. Taruggi 100% (Ph.D. Tor Vergata)
E. Vilucchi 10%
V. Kozhuharov (Università Sofia) 50%
G. Georgiev (Università Sofia) 50%
(Divisione Acceleratori)
B. Buonomo (20%)
L. Foggetta (20%)
A. Ghigo (10%)

INFN Roma **7 Ric, 2.8 FTE +0.1**
P. Valente 50%
F. Ferrarotto 50%
E. Leonardi 50% (Tecnologo)
S. Fiore (ENEA) 20%
Safai Tehrani Francesco 30% (Tecnologo)

INFN Roma and Università Sapienza
G. Organtini (Professore) 30%
M. Raggi (RTDb) 50%

Total 11.3 FTE
32 researchers
2 PHD + 1PostDoc
+1.7 FTE wrt 2017 +1 Ric.
+ 1 LNF summer student (2mesi)

Supporto tecnico

INFN Lecce
G. Fiore (Tecnico e progettista) 30%

INFN Lecce and Università Salento
M. Corrado (Tecnico) 20%
C. Pinto (Tecnico elettronico) 20%

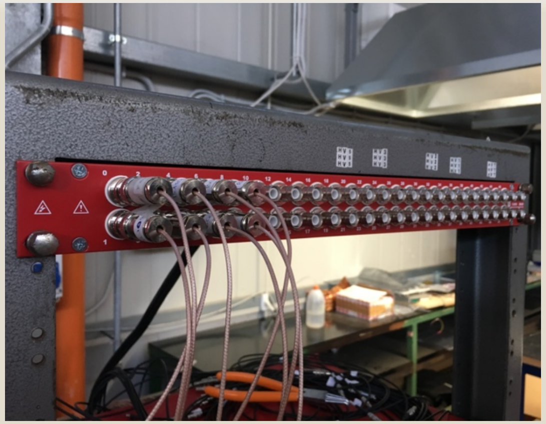
INFN LNF
(SPAS)
C. Capoccia (Progettista meccanico) 50%
E. Capitolo (Progettista meccanico) 50%
(SELF)
G. Corradi (Progettista Elettronico) 30%
Frascati Officina meccanica
2 mesi uomo II sem (2016)

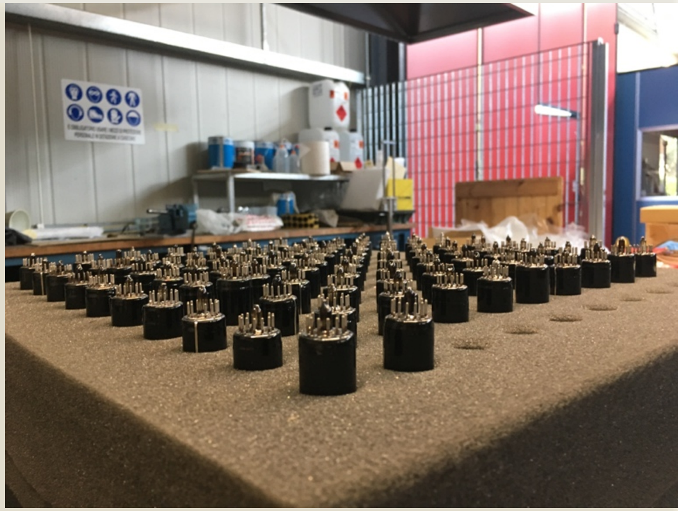
INFN Roma
M. Nuccetelli (20%)
D. D'Angelo (20%)

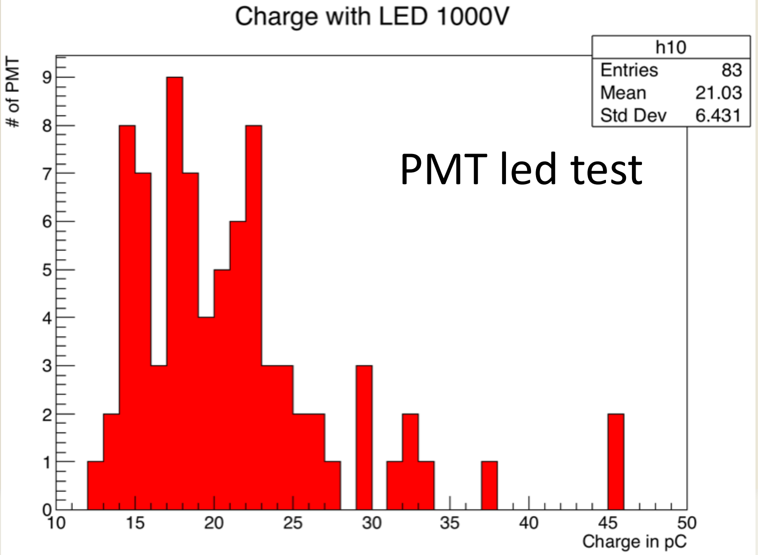
Calorimeter status

Beginning of Sep. 2017:

- All 650 PMT's + dividers delivered by HZC
  - ~ 480 PMT tested with no surprise
- Quality check, calibration and assembly at Frascati Nov.-Dec.
- HV for all channels already delivered by CAEN under test



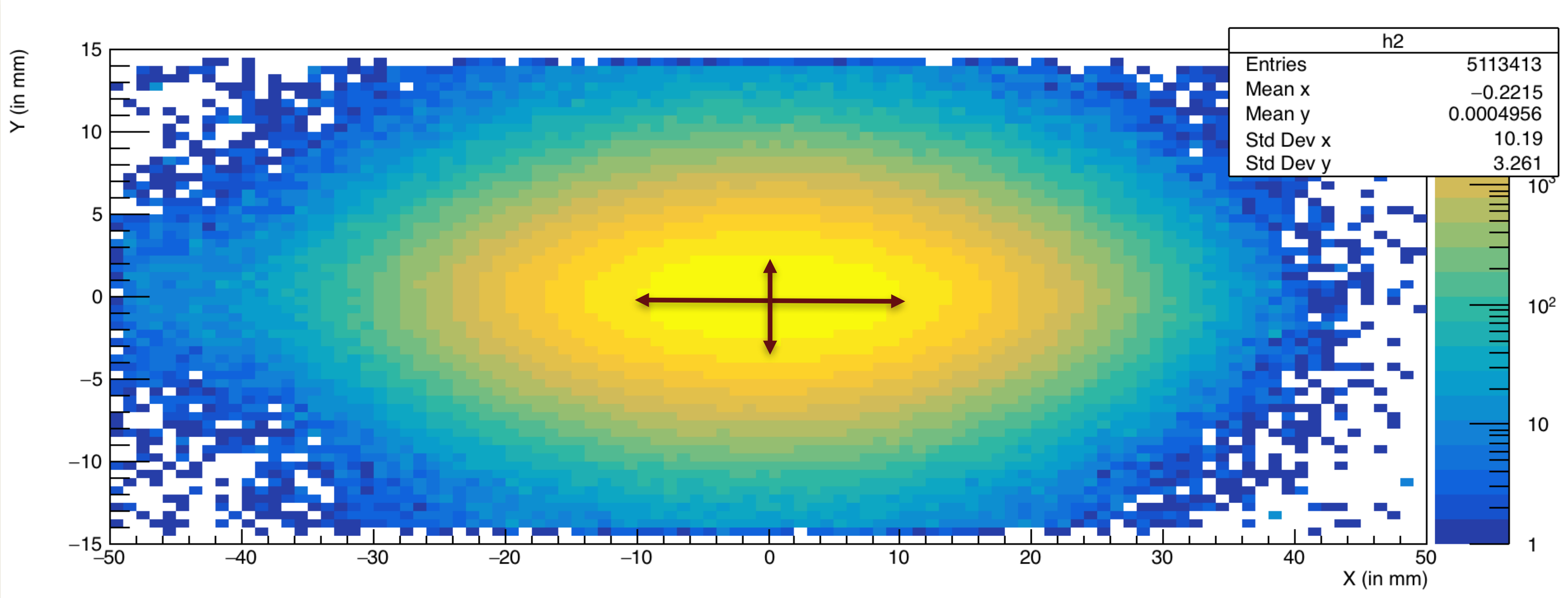




Il monitor di fascio in PADME

- Per avere un’affidabile interpretazione dei risultati di PADME abbiamo bisogno di
  - Misura della divergenza del fascio e sua evoluzione temporale
  - Misura della struttura temporale del bunch e sua evoluzione temporale.
  - Calibrazione della deflessione del campo magnetico (posizione esatta d’uscita del fascio)
  - Numero totale di particelle (misure di sezioni d’urto richiedono meglio del %)
- Un monitor di fascio costruito con la tecnologia TimePix3 potrebbe fornire tutte queste informazioni grazie a:
  - Altissima granularità (n particelle, posizione del fascio)
  - Risoluzione temporale scala del ns (struttura del fascio)
  - Tempo sopra soglia (n di particelle)
  - Fondo molto basso (pochi hit di rumore che verrebbero contati come positroni)

Beam monitoring e shifters

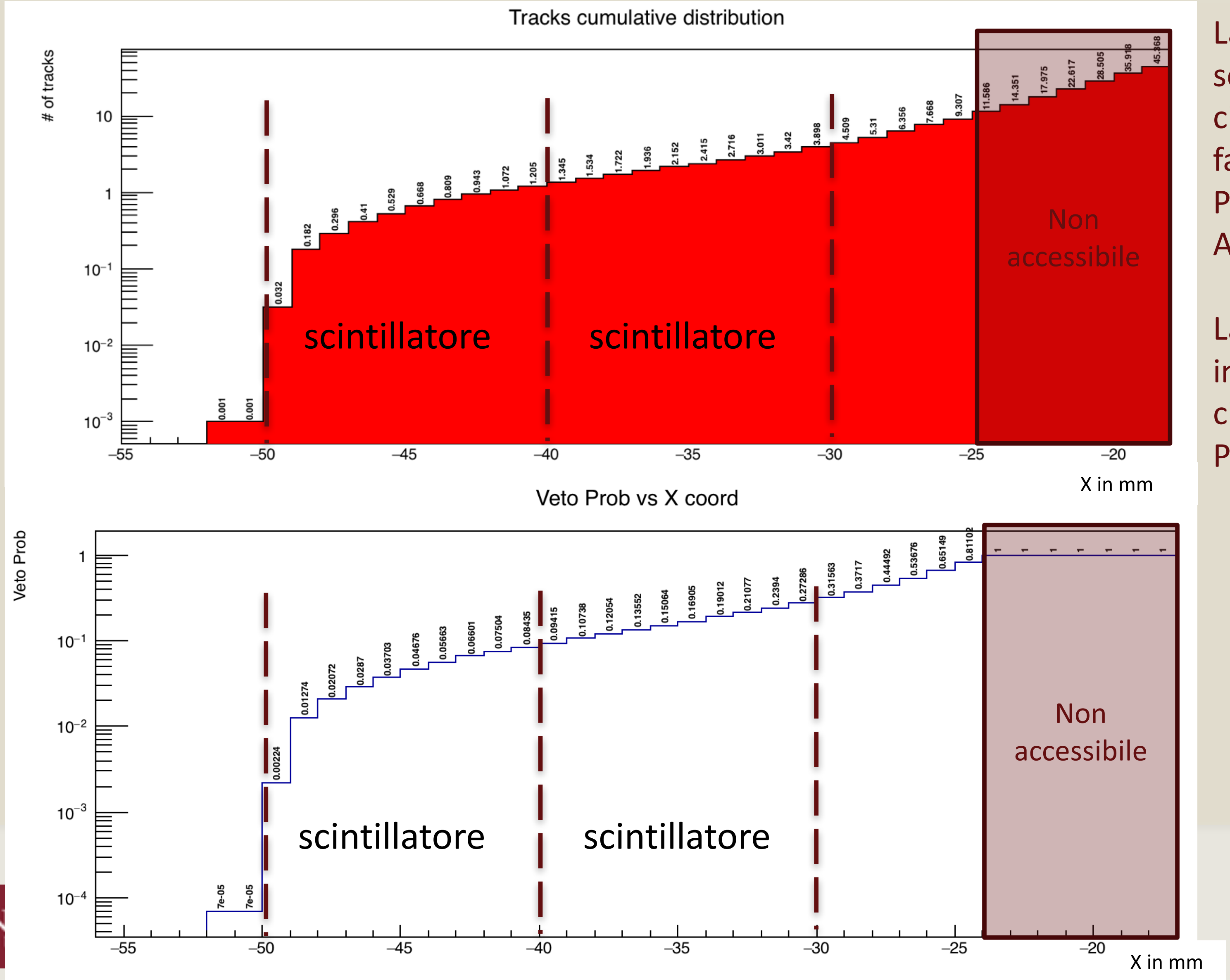


Il beam monitor sarebbe l'unico strumento a poter dare online informazioni certe sulla qualità del fascio e quindi dei dati:

- Numero di pixels accesi ⇒ nparticles
- MeanX e MeanY ⇒ posizione del fascio
- RMSx ⇒ risoluzione in energia del fascio
- RMSy ⇒ divergenza angolare in Y (e quindi anche in X)

1 secondo di fascio integra dell'ordine di 250K-1M di hit fornendo buone determinazioni di tutte le grandezze richieste

Detail in the region of interest



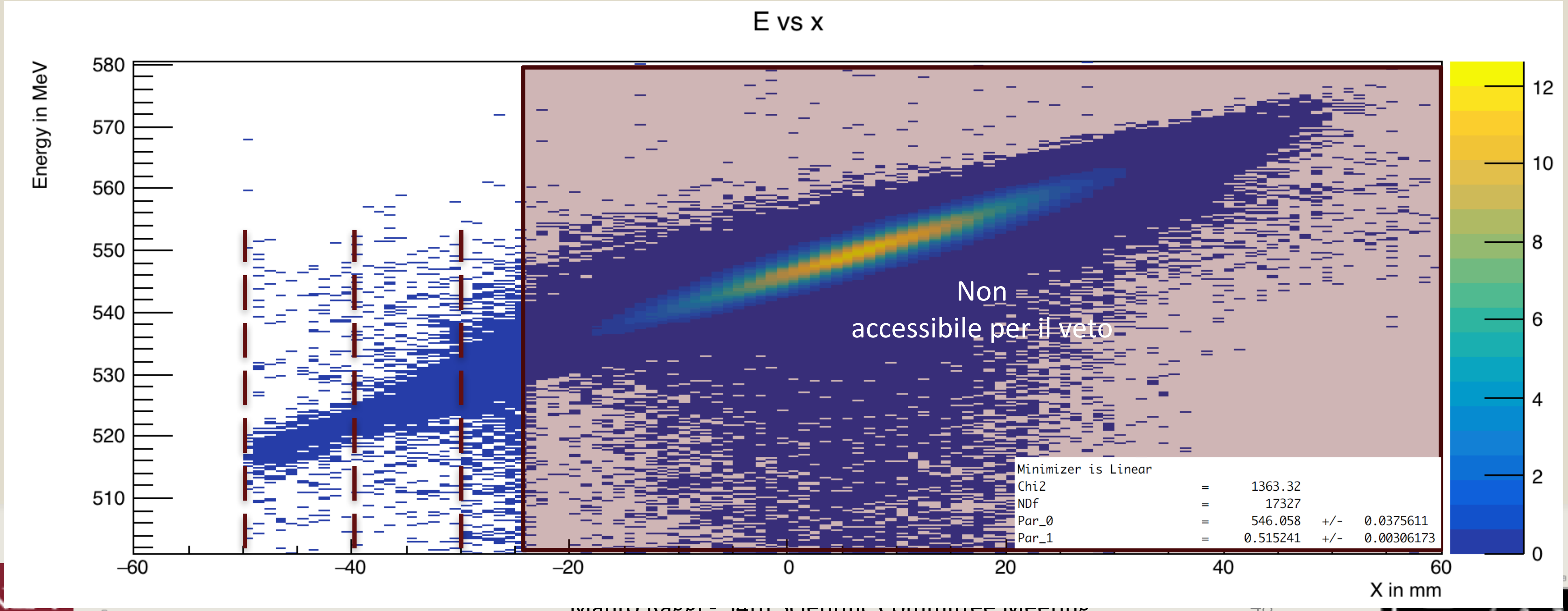
La zona accessibile agli scintillatori termina a circa 35-mm dal core del fascio.
Prob random veto ~30%
Assumendo σ_T=700ps

La zona totalmente inaccessibile comincia a circa 25 mm dal fascio
Prob random veto ~100%

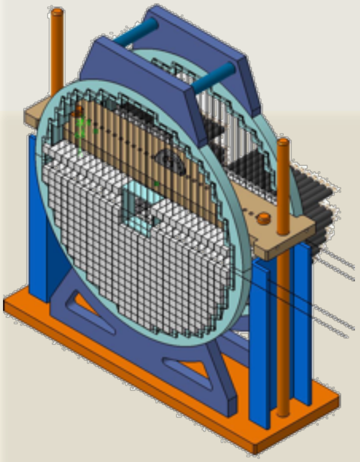
SAPIEN
UNIVERSITÀ DI

Momentum vs position

La regione recuperabile con i TimePix è di circa 10MeV in momento della traccia
In cui si potrebbe sopprimere il fondo di un fattore 20 (eff veto 95%) al prezzo di circa un fattore di riduzione 3 nell’accettanza (veto random)

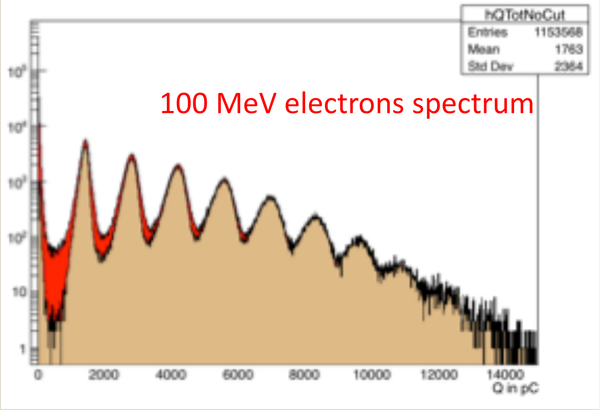


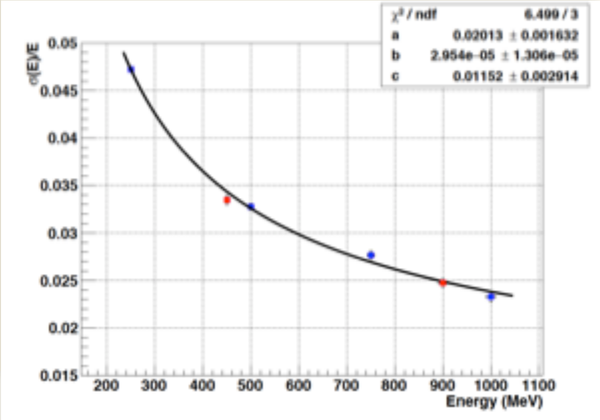
Calorimetro



~616 cristalli BGO
60 cm di diametro

Nucl.Instrum.Meth. A862 (2017) 31-35





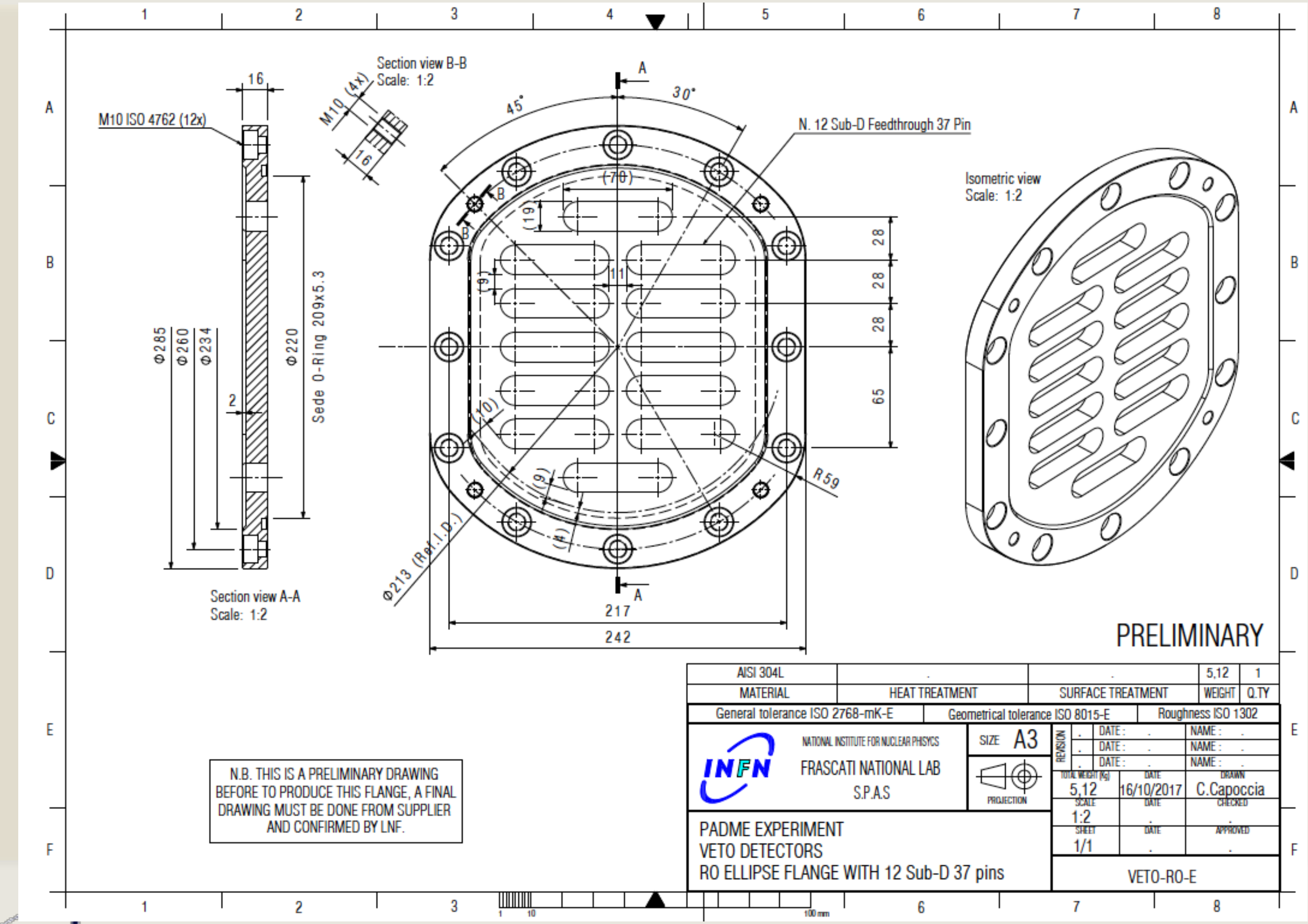
- Several **test-beams** for validating **PMT and divider choices**, **paint, glue, assembly procedure**…
  - Results in line with expectations from L3 experience**: ≈2% at 1 GeV**, excellent linearity up to **≈1 GeV**
  - Moreover, **13 pC/MeV**, **0±1.5 pC** pedestal: threshold well below 1 MeV
- Conclusions:
  - HZC XP1911 PMT’s OK; divider type “B” OK
  - 80 μm paint sufficient for light tightness at **few % level**, OK from the mechanical point of view
  - Add TEDLAR foils (50 μm) for dropping optical cross-talk to **zero**
    - **Recuperati alcuni mq (sufficienti a tutto il calorimetro) a costo e tempo zero da LHCb: GRAZIE!**
  - Polished surfaces of cut crystals OK
  - **No radiation damage on PMT’s**
  - Radiation damage on BGO at the dose level expected from literature **recovered** by high temperature annealing
- **All tenders completed:** crystal machining, gluing & paiting (Gestione SILO), PMT’s+dividers (HZC Photonics), HV system (CAEN), waveform digitizers (CAEN)

DP panorama 2018

Experiment	Machine	Type	E_{beam} (GeV)	Detection	Mass range (GeV)	Sensitivity	First beam	Ref.
Future US initiatives								
BDX	CEBAF @ JLab	electron BD	2.1-11	DM scatter	$0.001 < m_\chi < 0.1$	$y \gtrsim 10^{-13}$	2019+	[211, 212]
COHERENT	SNS @ ORNL	proton BD	1	DM scatter	$m_\chi < 0.06$	$y \gtrsim 10^{-13}$	started	[213, 214]
DarkLight	LERF @ JLab	electron FT	0.17	MMass (& vis.)	$0.01 < m_{A'} < 0.08$	$\epsilon^2 \gtrsim 10^{-6}$	started	[215]
LDMX	DASEL @ SLAC	electron FT	4 (8)*	MMomentum	$m_\chi < 0.4$	$\epsilon^2 \gtrsim 10^{-14}$	2020+	[216]
MMAPS	Synchr @ Cornell	positron FT	6	MMass	$0.02 < m_{A'} < 0.075$	$\epsilon^2 \gtrsim 10^{-8}$	2020+	[217]
SBN	BNB @ FNAL	proton BD	8	DM scatter	$m_\chi < 0.4$	$y \sim 10^{-12}$	2018+	[218, 219]
SeaQuest	MI @ FNAL	proton FT	120	vis. prompt vis. disp.	$0.22 < m_{A'} < 9$ $m_{A'} < 2$	$\epsilon^2 \gtrsim 10^{-8}$ $\epsilon^2 \sim 10^{-14} - 10^{-8}$	2017	[220]
Future international initiatives								
Belle II	SuperKEKB @ KEK	e^+e^- collider	~ 5.3	MMass (& vis.)	$0 < m_\chi < 10$	$\epsilon^2 \gtrsim 10^{-9}$	2018	[203]
MAGIX	MESA @ Mami	electron FT	0.105	vis.	$0.01 < m_{A'} < 0.060$	$\epsilon^2 \gtrsim 10^{-9}$	2021-2022	[205]
PADME	DAΦNE @ Frascati	positron FT	0.550	MMass	$m_{A'} < 0.024$	$\epsilon^2 \gtrsim 10^{-7}$	2018	[206, 207]
SHIP	SPS @ CERN	proton BD	400	DM scatter	$m_\chi < 0.4$	$y \gtrsim 10^{-12}$	2026+	[208, 209]
VEPP3	VEPP3 @ BINP	positron FT	0.500	MMass	$0.005 < m_{A'} < 0.022$	$\epsilon^2 \gtrsim 10^{-8}$	2019-2020	[210]
Current and completed initiatives								
APEX	CEBAF @ JLab	electron FT	1.1-4.5	vis.	$0.06 < m_{A'} < 0.55$	$\epsilon^2 \gtrsim 10^{-7}$	2018-2019	[197, 198]
BABAR	PEP-II @ SLAC	e^+e^- collider	~ 5.3	vis.	$0.02 < m_{A'} < 10$	$\epsilon^2 \gtrsim 10^{-7}$	done	[191, 229, 230]
Belle	KEKB @ KEK	e^+e^- collider	~ 5.3	vis.	$0.1 < m_{A'} < 10.5$	$\epsilon^2 \gtrsim 10^{-7}$	done	[231]
HPS	CEBAF @ JLab	electron FT	1.1-4.5	vis.	$0.015 < m_{A'} < 0.5$	$\epsilon^2 \sim 10^{-7}$**	2018-2020	[232]
NA/64	SPS @ CERN	electron FT	100	MEnergy	$m_{A'} < 1$	$\epsilon^2 \gtrsim 10^{-10}$	started	[186]
MiniBooNE	BNB @ FNAL	proton BD	8	DM scatter	$m_\chi < 0.4$	$y \gtrsim 10^{-9}$	done	[188]
TREK	K^+ beam @ J-PARC	K decays	0.240	vis.	N/A	N/A	done	[201, 202]

TABLE II: Summary table of current light DM experiments and future proposals. The sensitivities are quoted either for the kinetic mixing or the variable y, whichever is most relevant (see the text and the corresponding figures for more detailed predictions). The range quoted for experiments sensitive to both visible and invisible decays refers to the invisible case. Starting dates are subject to variations. *Legend:* beam dump (BD), fixed target (FT), dark matter scattering (DM scatter), missing mass (MMass), missing momentum (MMomentum), missing energy (MEnergy), prompt/displaced visible decays (vis). *Notes:* *LDMX beam energy is 4 GeV for phase I, and could be upgraded to 8 GeV for phase II. **Sensitivity to displaced vertices under study.

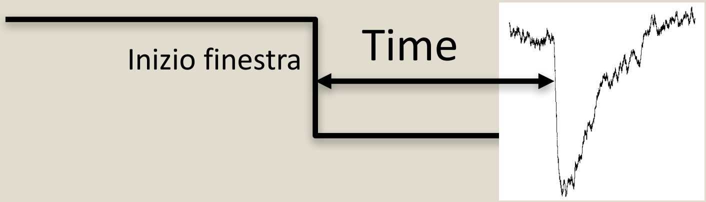
Veto readout flange



PADME L0 trigger timing

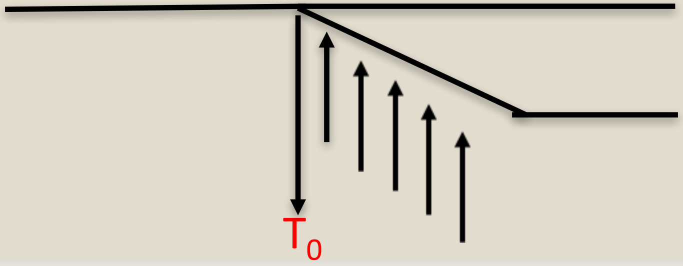
Ogni board misura il tempo rispetto al suo trigger

Tempo del segnale singola board

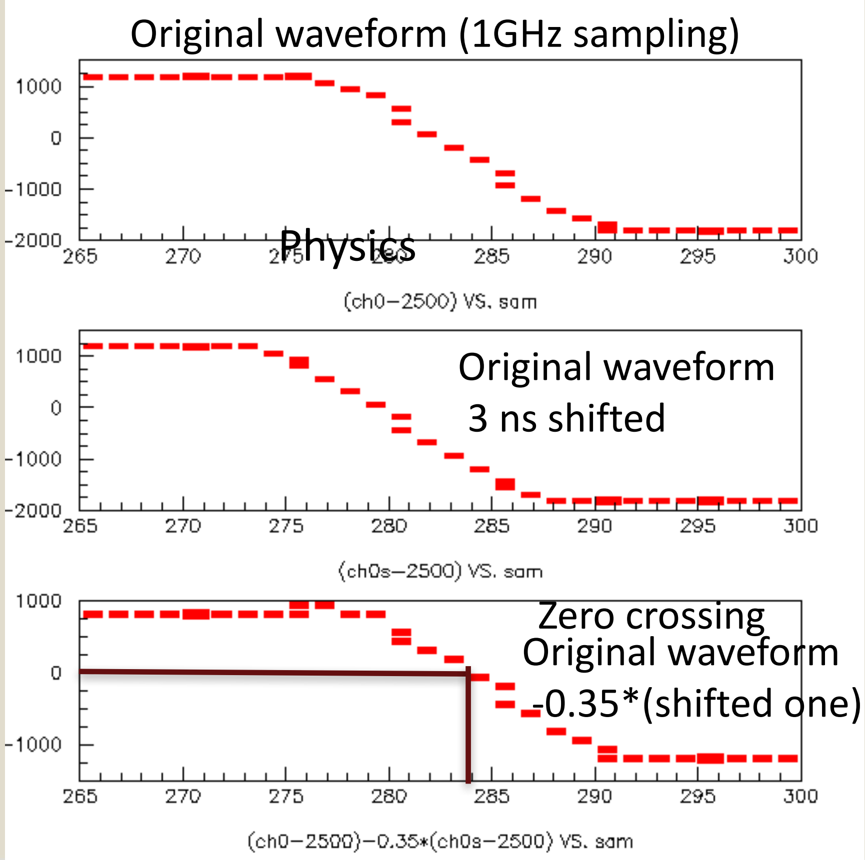


Ogni board si sincronizza con le altre usando il tempo del trigger digitizzato

Tempo del trigger singola board



I trigger vengono digitizzati assieme ai segnali per fine time alignement



Tipici sampling rates a PADME:
- Ecal 1 GHz
- Veto e SAC 2.5 GHz

B1 sampling	B2 sampling	$S(T_{B1}-T_{B2})$
1 GHz	1GHz	188 ps
2.5 GHz	1GHz	141 ps
5 GHz	1GHz	142 ps
2.5 GHz	2.5 GHz	66 ps
5 GHz	2.5 GHz	64 ps
5 GHz	5 GHz	65 ps

Contributi attesi dalla sincornizzazione
- Ecal-Veti <150 ps
- Veto-SAC <70 ps

P. Branchini, D. Tagnani INFN RM3

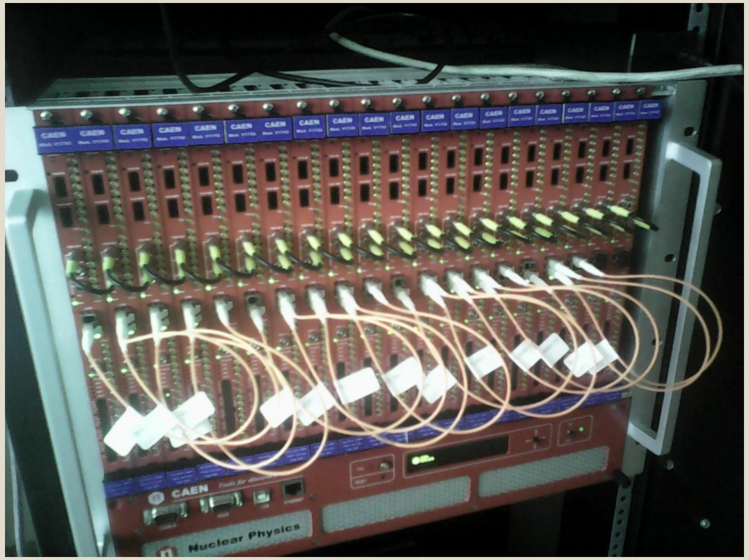
Status of DAQ and Computing

DAQ and On-line Computing

- All 2017 acquisitions are complete
  - Electronics: V1742 ADC boards, HV modules, A3818 optical boards (CAEN)
  - L0 servers: 3 Dell R630 servers
  - L1 servers and disk buffers: 2 Dell R730xd with 22TB of RID storage each.
- Compatibility problem between Dell R630 servers and the CAEN A3818 optical data acquisition board
  - Use the 3 Dell R630 for additional on-line services (on-line monitor, DB, DCS): i.e. anticipate the acquisitions financed for 2018.
  - Buy new L0 servers at the very beginning of 2018.
  - Use temporary (existing) nodes for the current DAQ development phase

DAQ setup

- A DAQ test setup is being implemented
- All ADC boards connected to the system
- Run a realistic full data acquisition
  - Data throughput identical to final experiment
- Use a temporary (low precision) trigger signal
  - Final trigger board added to the system when ready
- Develop and test final Run Control software
  - A working prototype in use since 2015
- A Detector Control System is being implemented to:
  - Control and monitor all HV systems
  - Control target area stepping motors
  - Collect information from environmental probes
  - Control VME and NIM crates



Off-line computing - Hardware

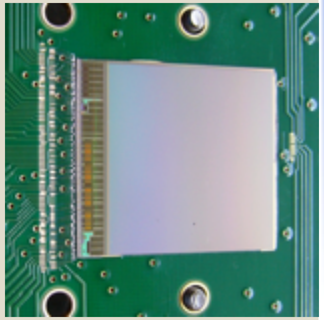
- CPU: 1 kHEPSpec included in the latest INFN-wide tender (just completed). Will be added to the LNF Tier2 Batch System.
- Disk: 80 TB full RAID box included in the LNF Tier2 Storage System.
- Disk: 10 TB added to the CNAF Storage System.
- Tape: 100 TB on the CNAF tape library
- Financed for 2018:
  - CPU: 2 kHS @ LNF, 1 kHS @ CNAF
  - Tape: 400 TB @ CNAF, 300 TB @ LNF (KLOE2 tape library: full copy of data)

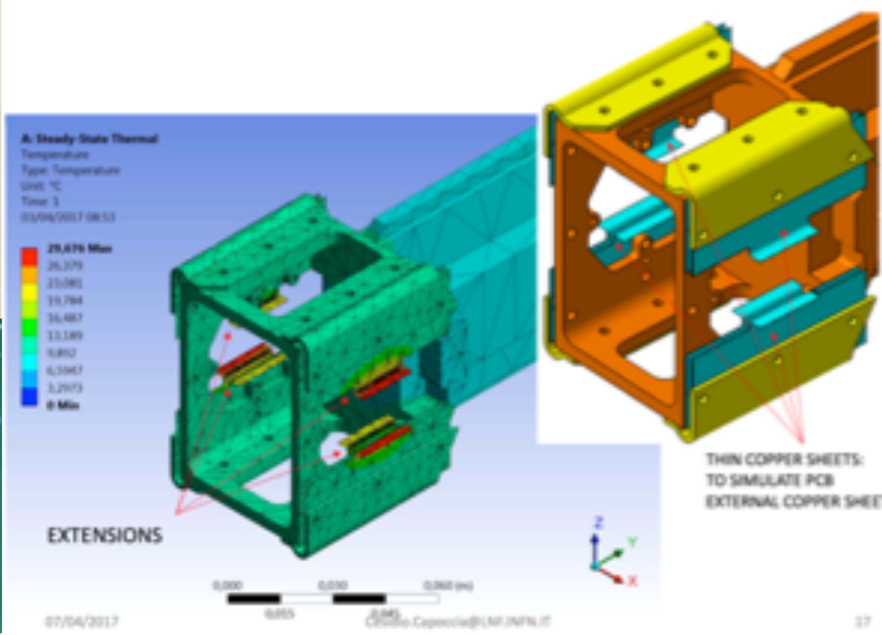
Off-line computing: Software

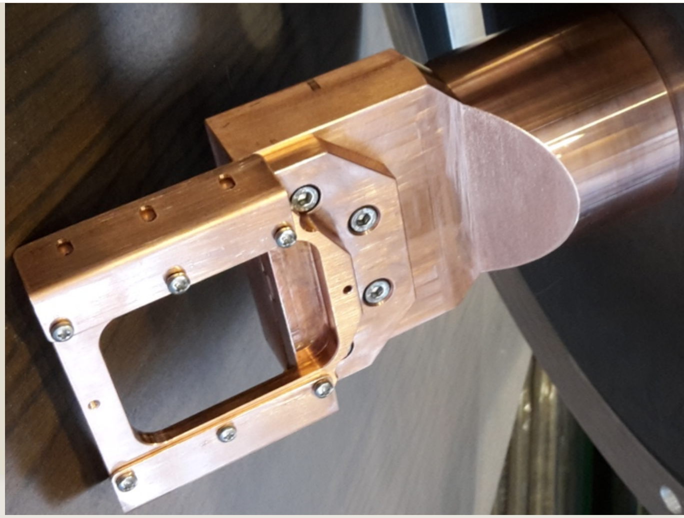
- All GRID services for PADME are active
  - VO: vo.padme.org. VOMS based at CNAF.
  - CVMFS area: /cvmfs/padme.infn.it created at CNAF to distribute the software
- Central Data Recording facility
  - Service running on a T2 UI @ LNF.
  - Data are «pulled» from the PADME DAQ system (scp) and copied to the LNF Disk Storage System, to the CNAF Tape Library, and (later) to the KLOE2 Tape Library.
- GRID-based MC Production Manager
  - Automatic jobs generation and submission
  - Automatic copy of produced data to the CNAF tape library

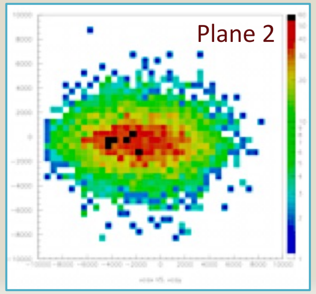
MIMOSA tracking

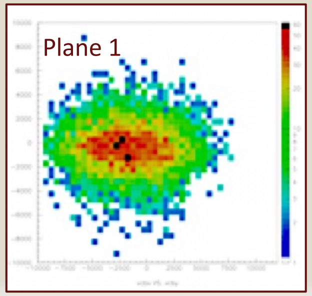
- Based on MIMOSA M28 (monolithic active pixel, 0.35 μm technology), by IPHC Strasbourg, but **in vacuum** (never implemented, so far)
  - 20.8 μm pitch, 20.2×22.7 mm^2 area
  - 50 μm thickness
- Mechanics and cooling for in vacuum operation
  - Linear stage mirrored from the diamond side
  - New board, support and cooling structure prototype constructed
  - In vaccum test setup almost ready test expected in July
- Sensors: OK
- DAQ, software
  - In advanced development: **April 2017 test-beam successful**







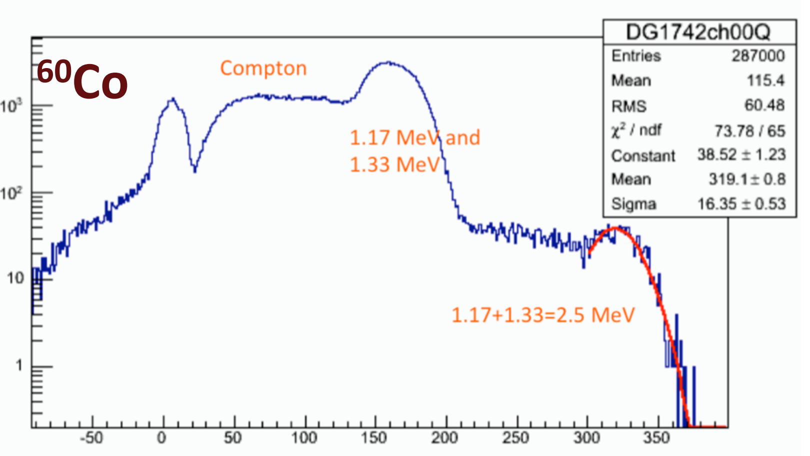


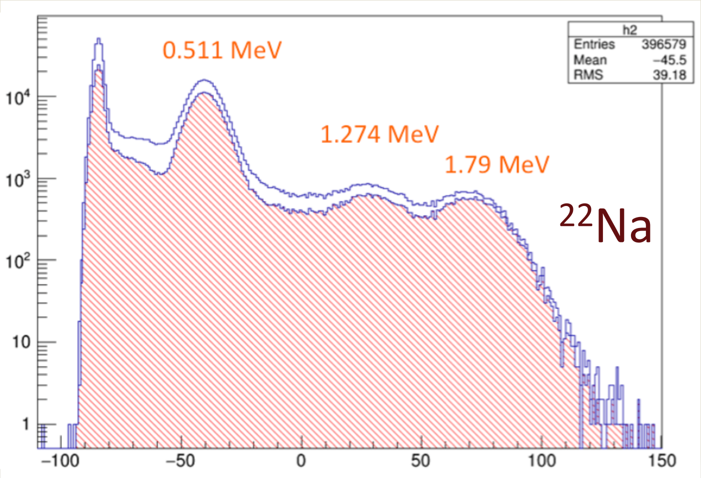


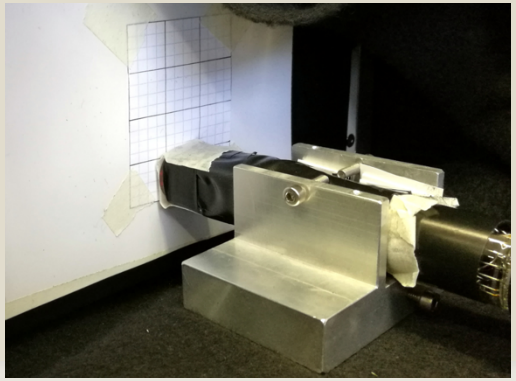
Calorimetro QA/QC

Belle-II lab, ed. 29

- Quality assurance/control & calibration:
  - LED pulsing for **PMT QA/QC** and gain measurement
  - Cosmic rays/radio-active source test-stand for finished crystal+PMT **assemblies calibration**
- Few hundreds KeV sensitivity obtained with HZC PMT very promising!







Thanks to R. De Sangro and G. Finocchiaro