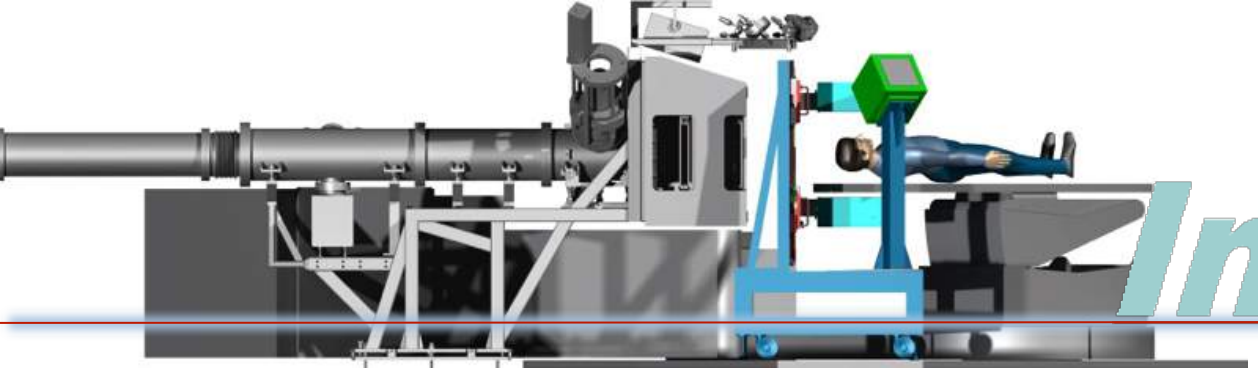
WP5-INSIDE

M. Giuseppina Bisogni
Universita' e INFN Pisa
riunione nazionale RDH - Roma 1/2/2016,



INnovative Solutions for In-beam DosimEtry in Hadrontherapy

-Project supported by Ministero dell'Istruzione, dell'Università e della Ricerca of the Italian government under the program PRIN 2010-2011 project nr. 2010P98A75 - Coordinatore M. G. Bisogni

- finanziamento ministeriale: 1 M Euro
- 5Unita' operative
- 40 ricercatori coinvolti
- durata: 3 anni (end date 1/2/2016)

Sigla INFN Fondi Esterni: PRIN-INSIDE Resp Nazionale G. Battistoni

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F. Cappucci
S. Muraro
P. Sala

partners: CNAO

The InSIDE Project

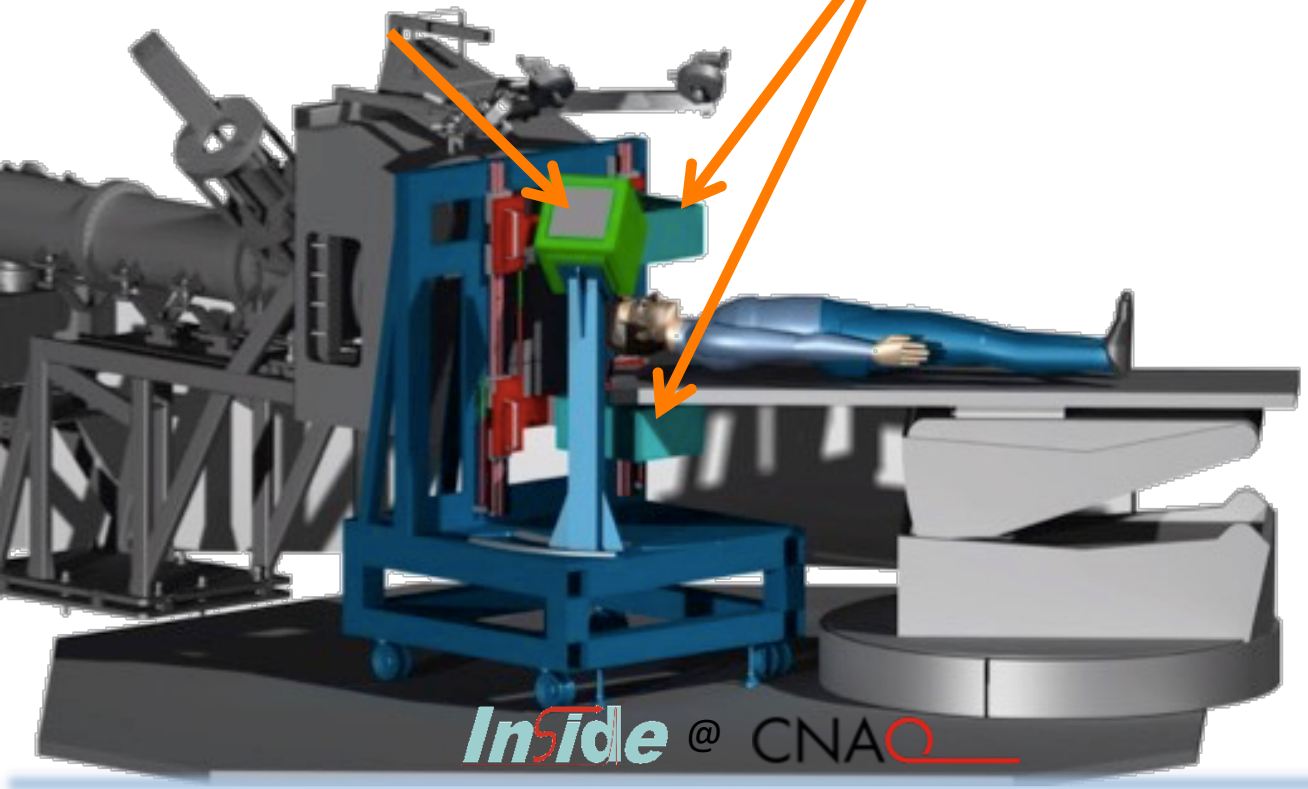
Prompt secondary particles emission

DOSE PROFILER + Tracker + Calorimeter =

β^+ activity distribution

IN-BEAM PET HEADS

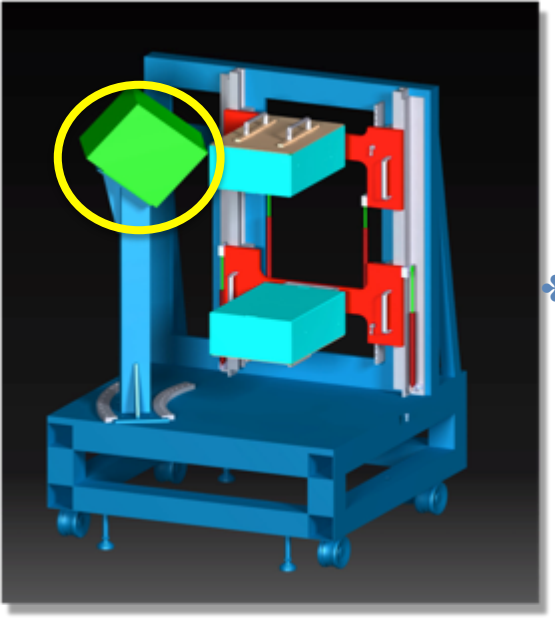
→ **BI-MODAL MONITORING SYSTEM**



Goals:

- To be integrated in the gantry
- To be operated in-beam
- **To provide an IMMEDIATE feedback on the particle range**

More on INSIDE
http://131.114.131.146/insidewiki/



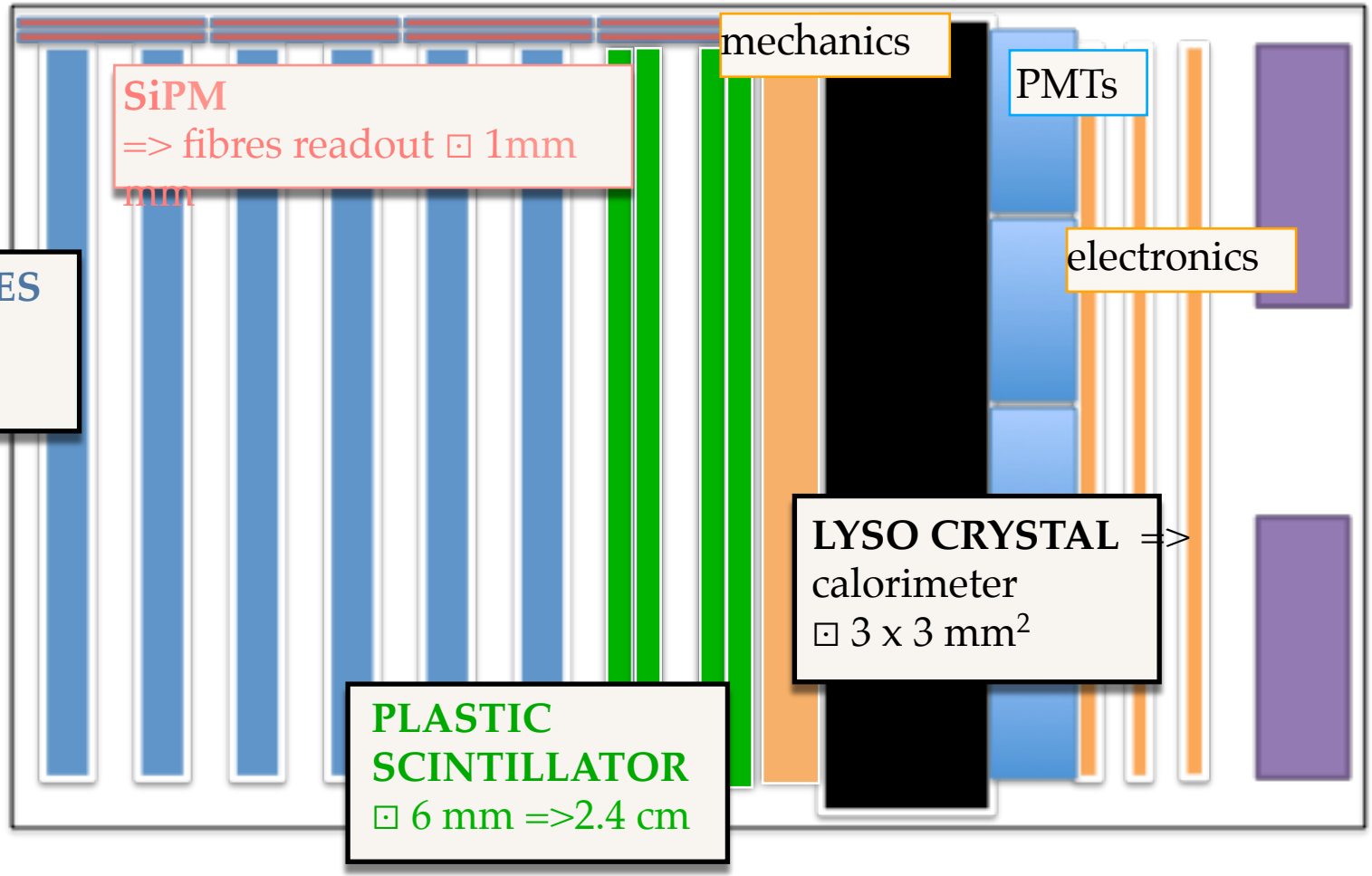
The INSIDE Project: Dose Profiler

- The Dose Profiler aim is to back tracks the secondary particles (p,d,t and prompt photons) and reconstruct their emission point together with their flux.

V. Patera, Roma 1

FIBRES PLANES
=> tracking
⊡ 0.5 mm (UV)

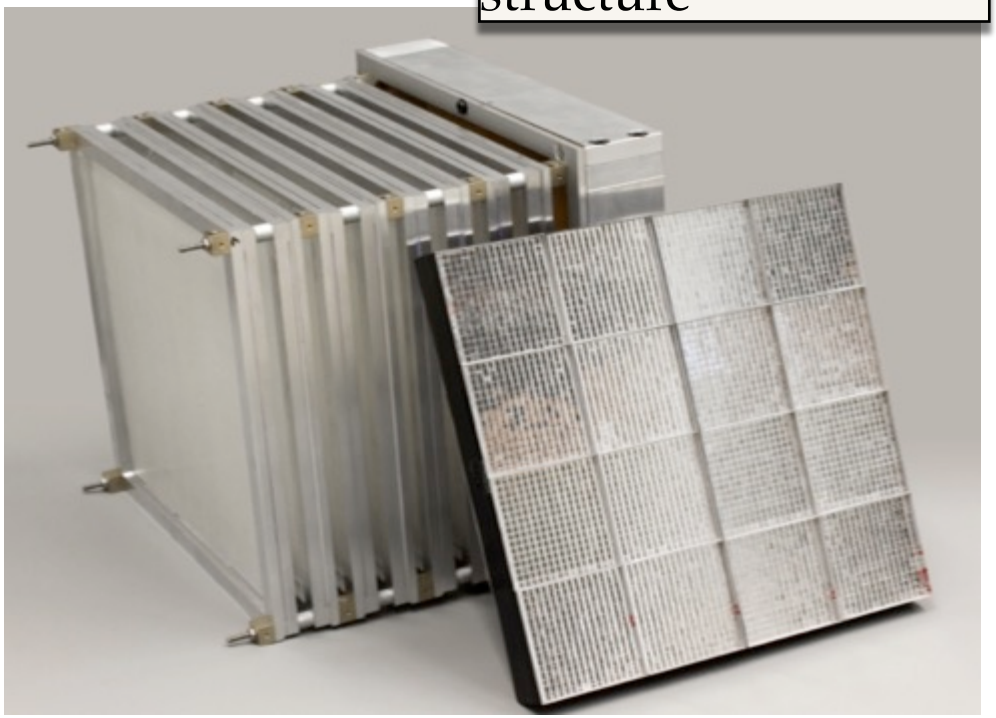
detector at 60° to increase the secondary charged particles rate

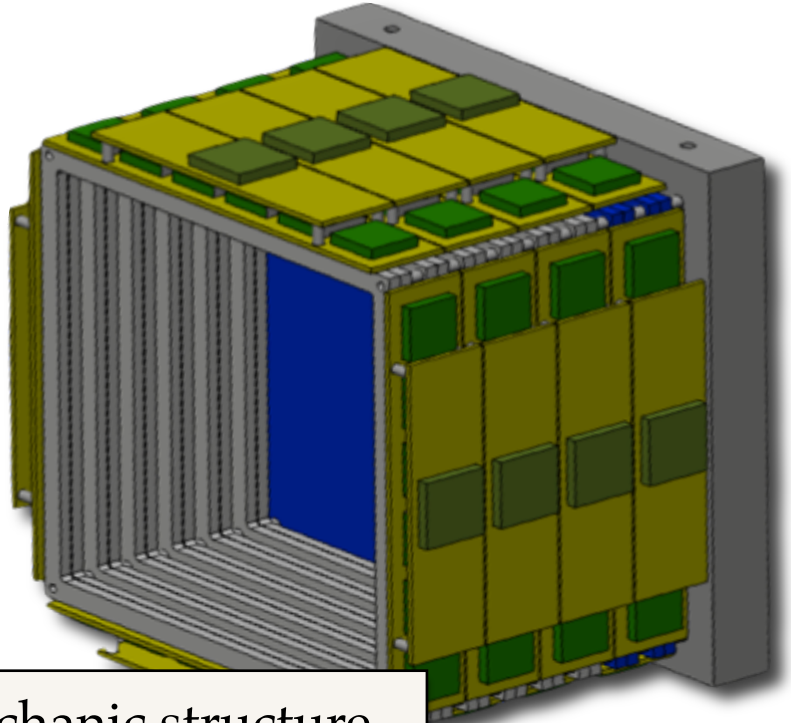


The INSIDE Project: Dose Profiler

- ✓ Expected 3mm accuracy on a slice on ^{12}C beam
- ✓ Calibration at Trento proton beam during 2016
- ✓ Test at CNAO with phantom end 2016- first 2017

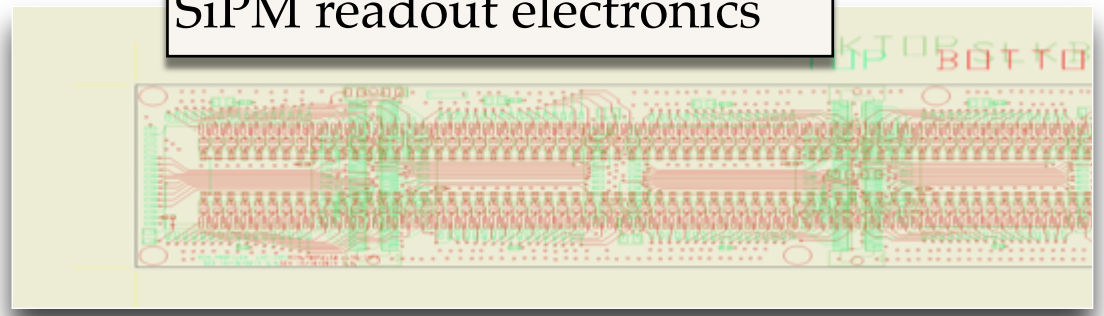
Fiber + calorimeter structure



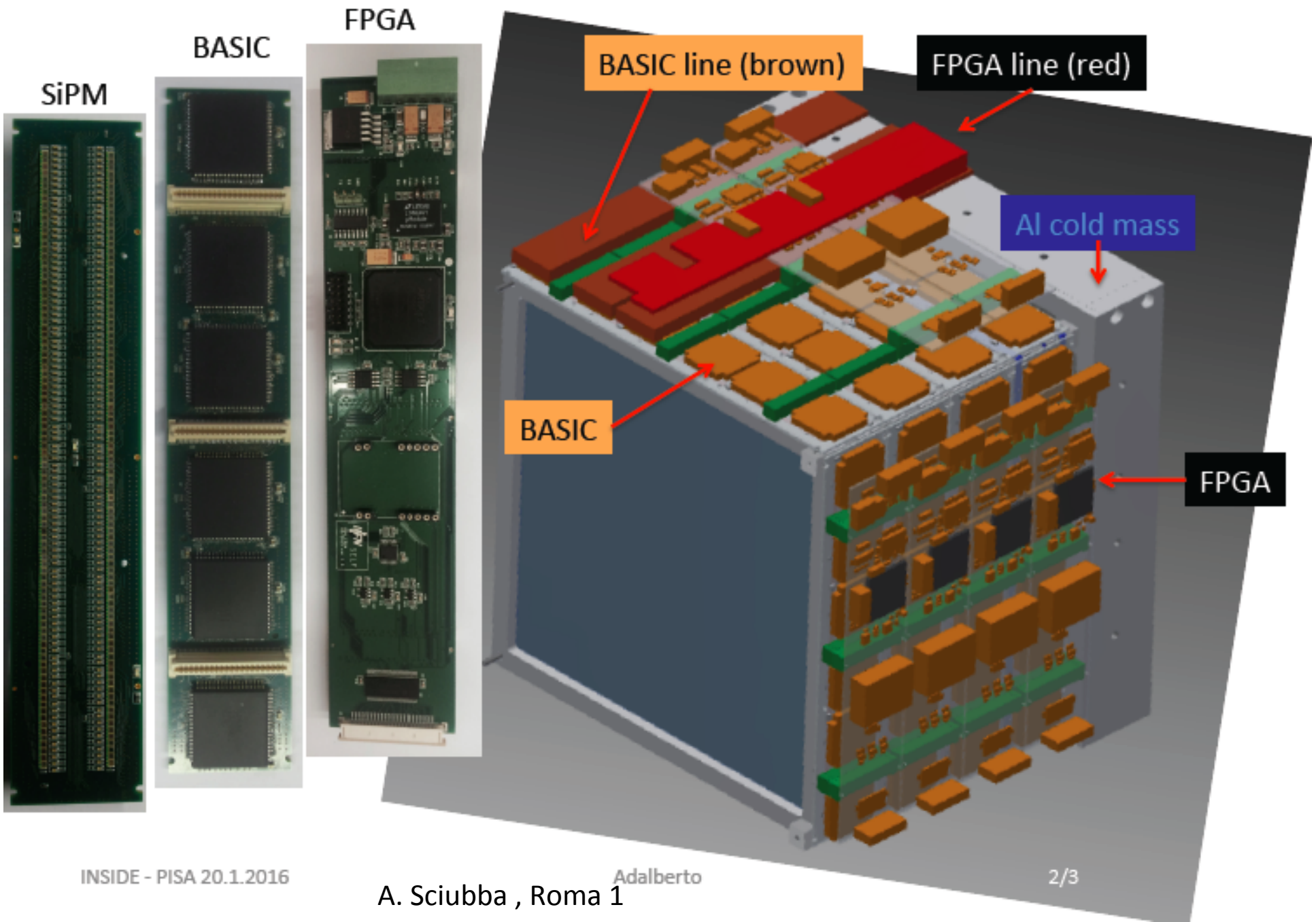


Mechanic structure

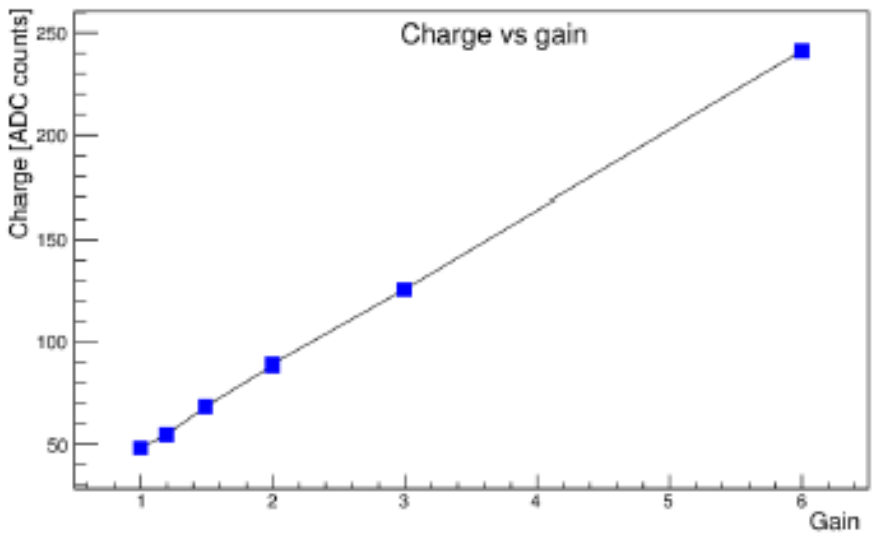
SiPM readout electronics

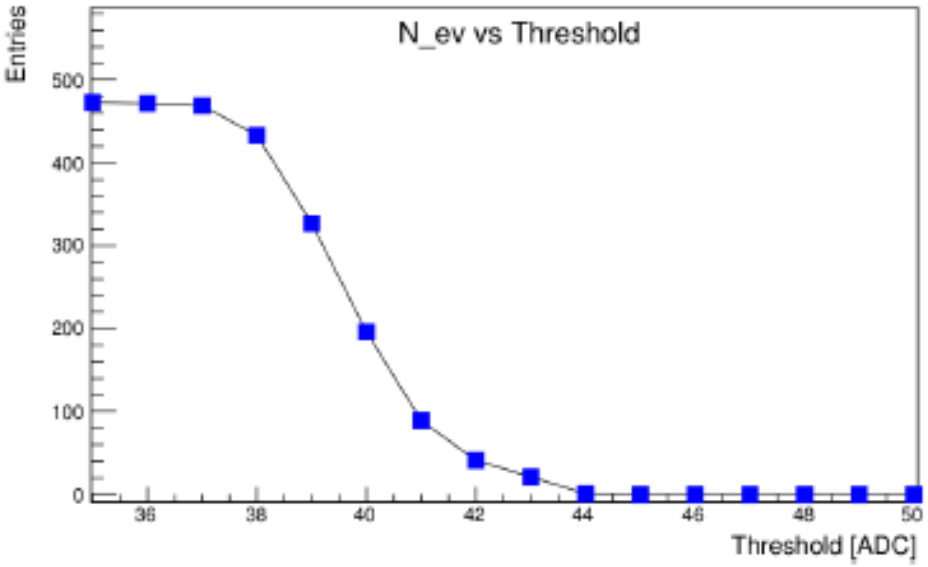


cooling first study with the final electronics dimensions



Results





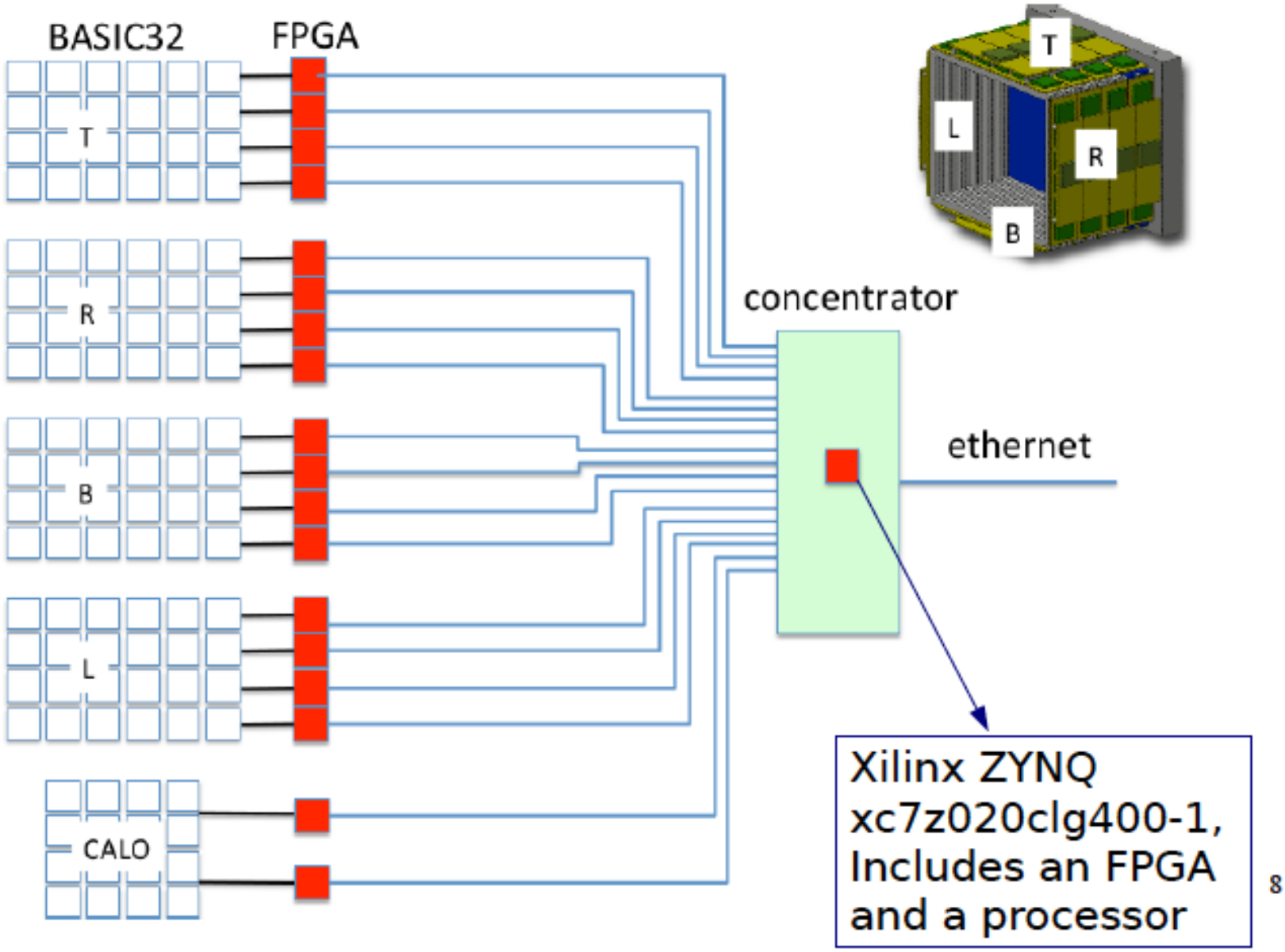
- 6 BASIC show problems on voltage offset
- 3 BASIC shows problems on gain configuration
- 1 BASIC shows problems on read-out
- 1 BASIC show problems on setting configuration
- 150 BASIC can be used with clock up to 10 MHz

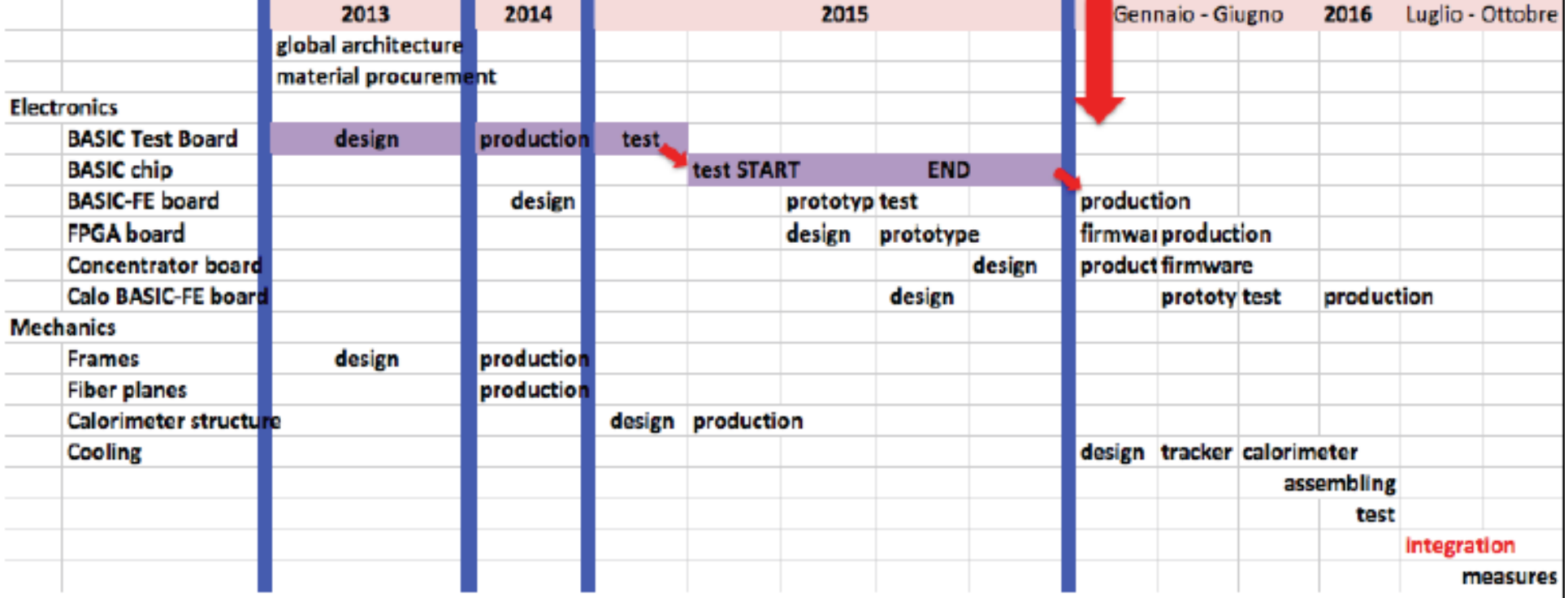
9 BASIC32_ADC have been excluded from the front-end electronics of the tracker

BASIC with only offset malfunctioning can be still used for calorimeter

108 BASIC32_ADC have been delivered to realize 16+2 front-end board for the tracker

Read-out system development





The critical path was the characterization of the 150 BASIC32_ADC chips

Since last week a lot of activities started/restarted:

- BASIC board production
- FPGA and Concentrator firmware
- cooling

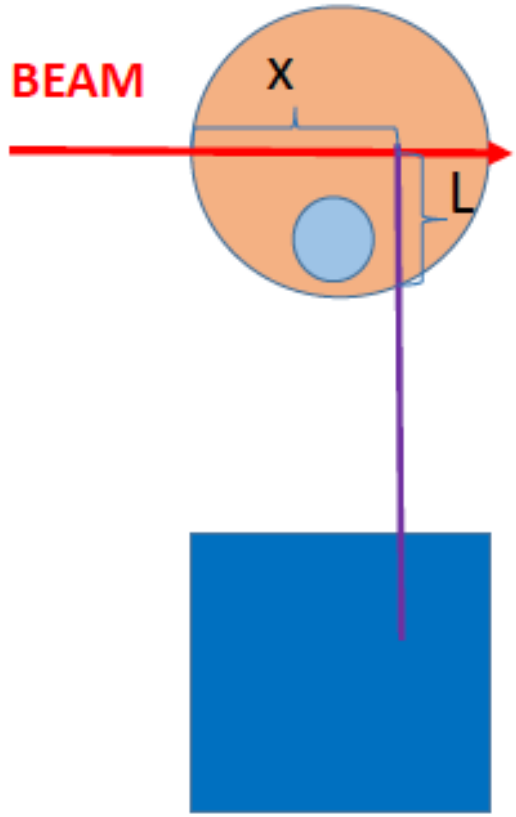
The assembling of the Profiler is expected for the summer; the integration will follow

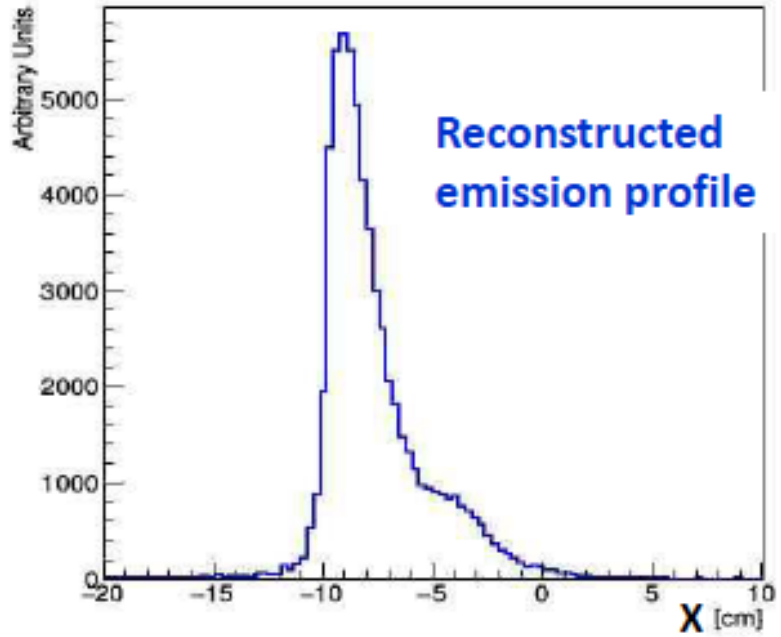
Reconstruction of the emission profile of secondary charged particles for a variable thickness of the material

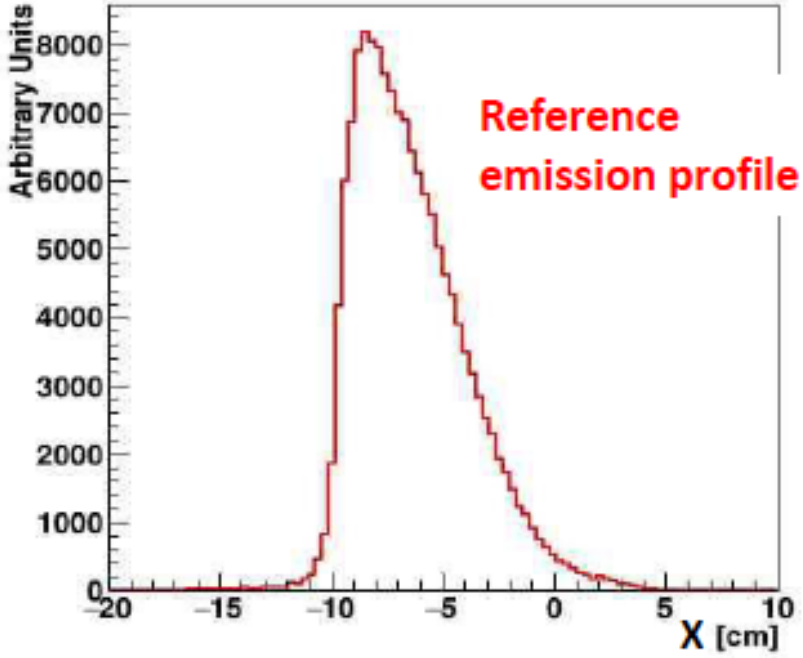
G. Battistoni, S. Muraro, V. Patera, C. Voena

Pisa, 20th January 2016

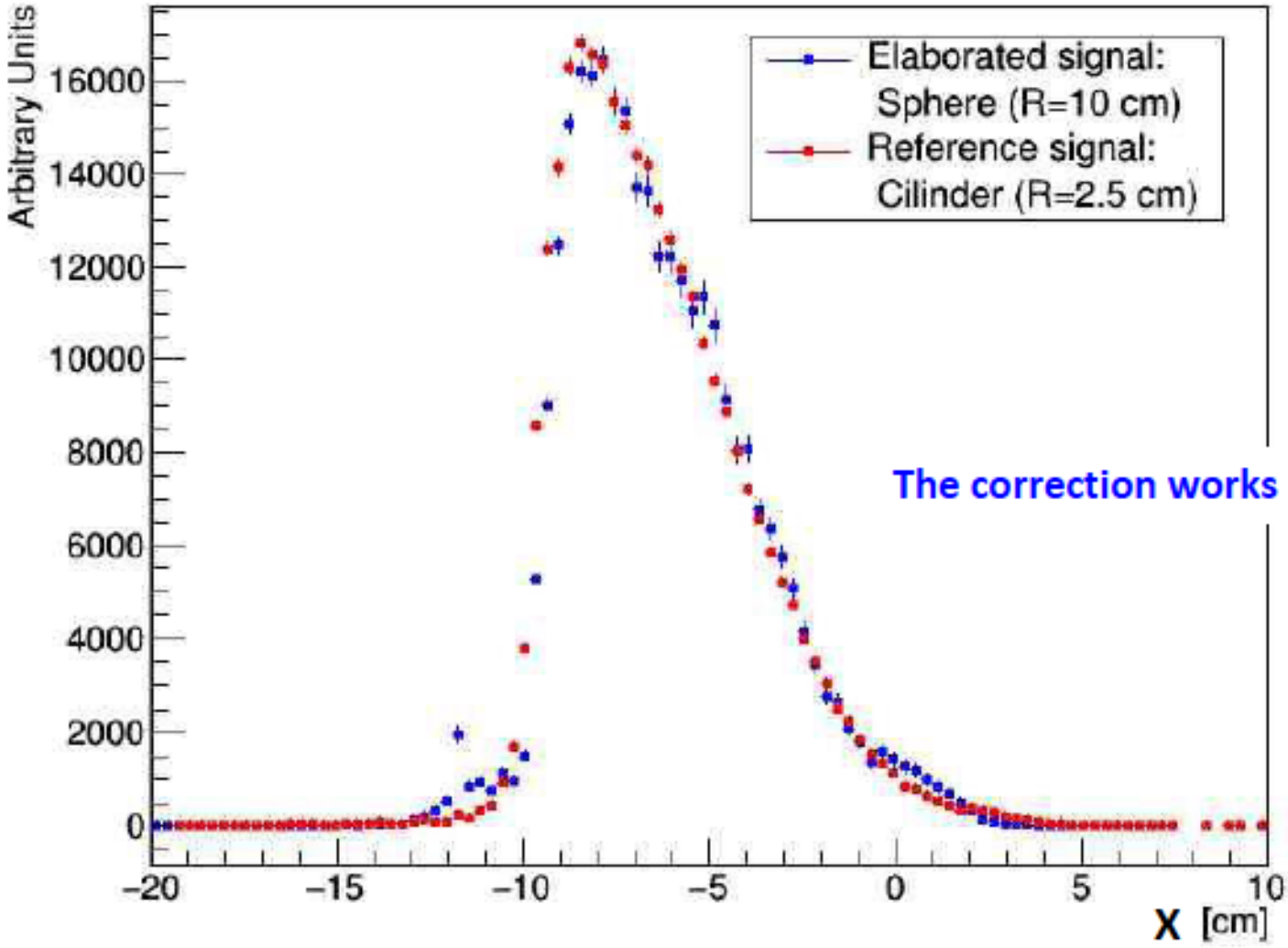
2) inhomgeneous PMMA sphere containing a smaller sphere of "light" PMMA (half density with respect to the standard PMMA)







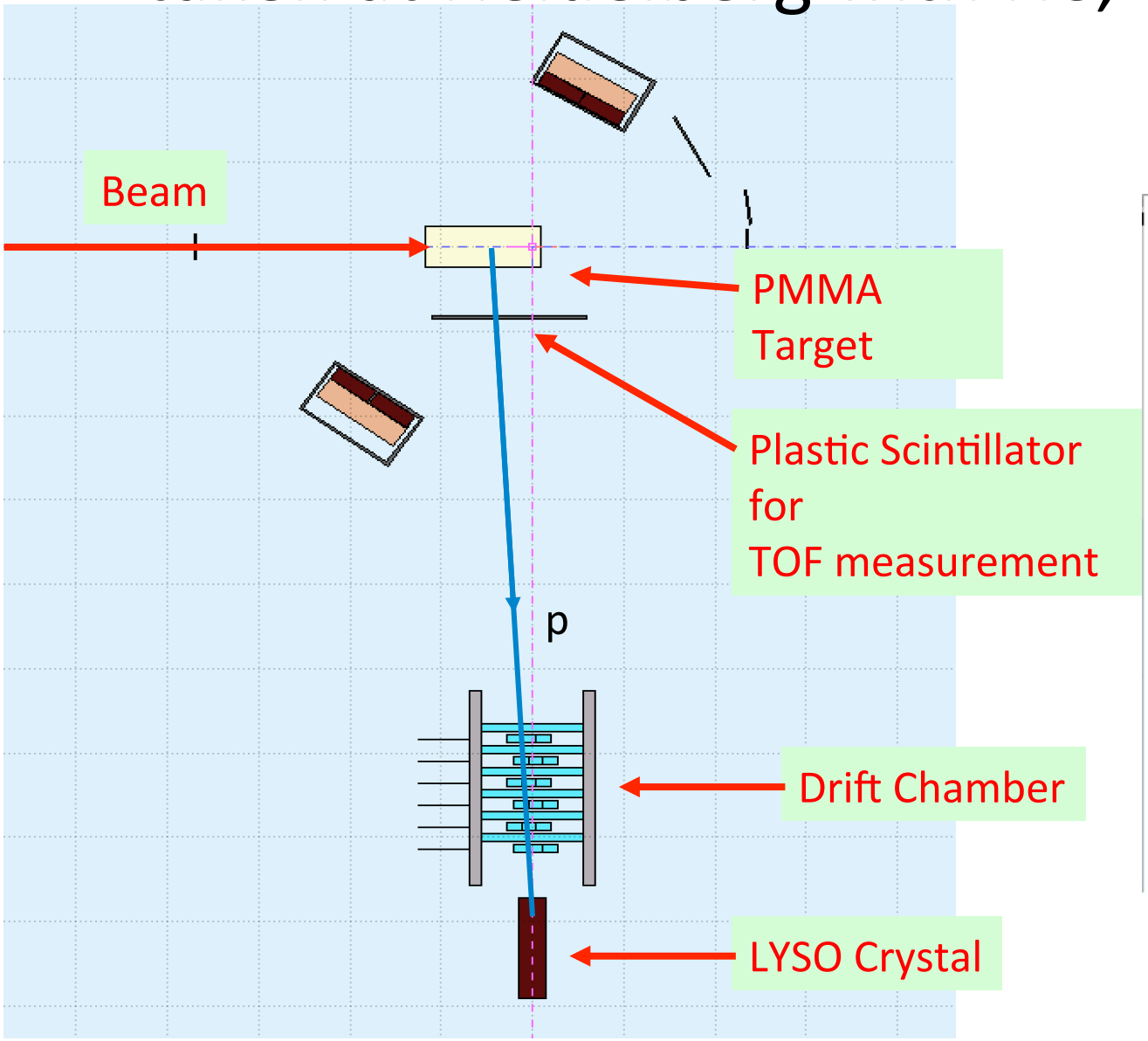
Result of the application of the weighting function

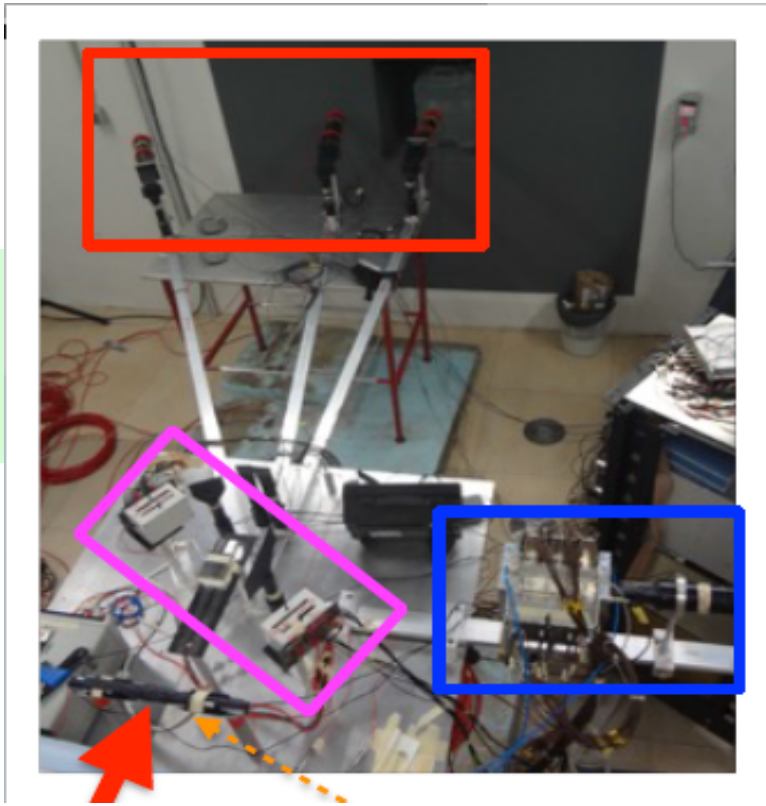


Detection of inhomogeneities with charged particles

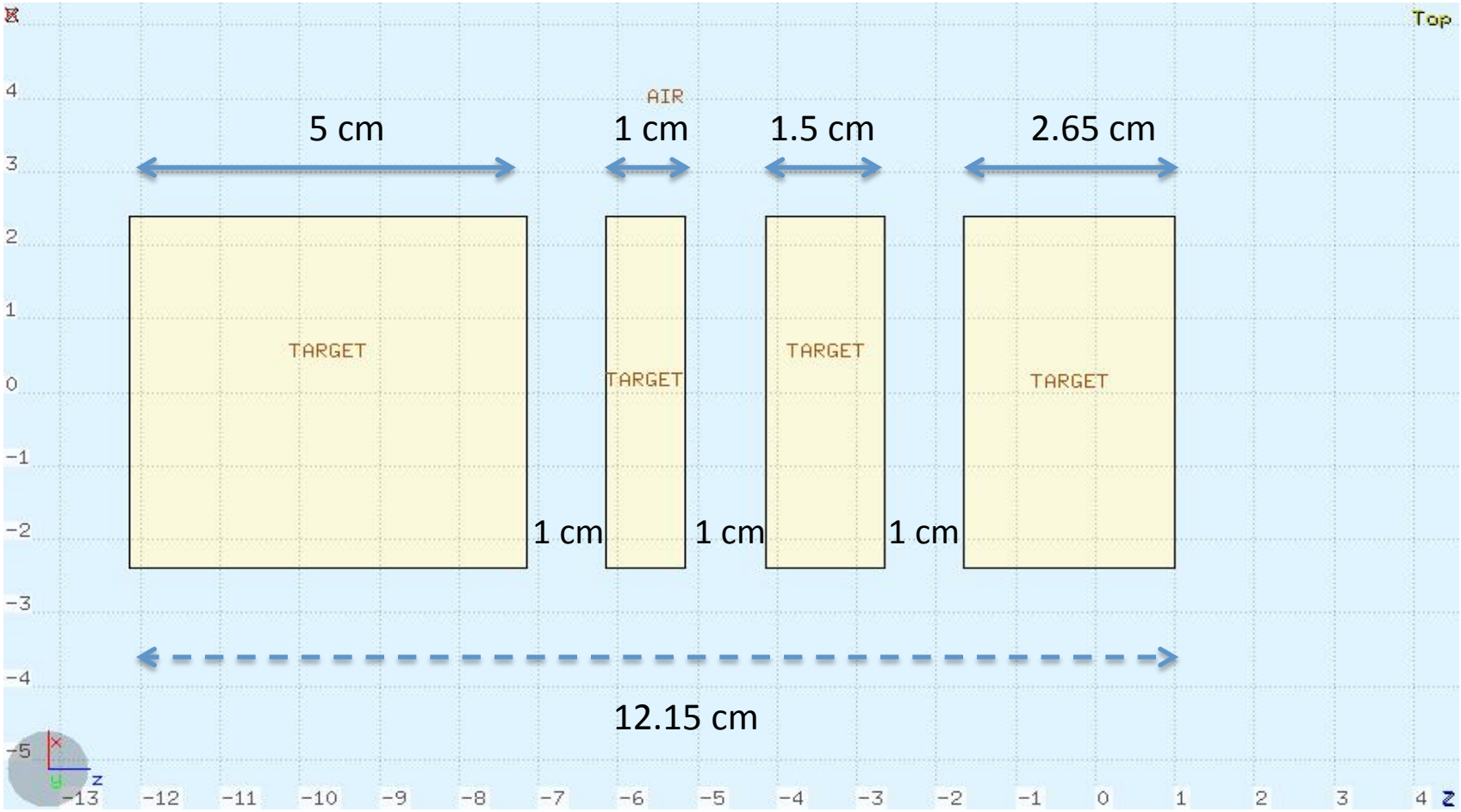
G. Battistoni for the analysis group of HIT test
(with A. Baratto, E. De Lucia, M. Marafini,
I. Mattei, S. Muraro, V. Patera, A. Rucinski,
A. Sarti, M. Toppi, G. Traini et al.)

New recent analysis of charged particle data taken at Heidelberg with He, C and O beams

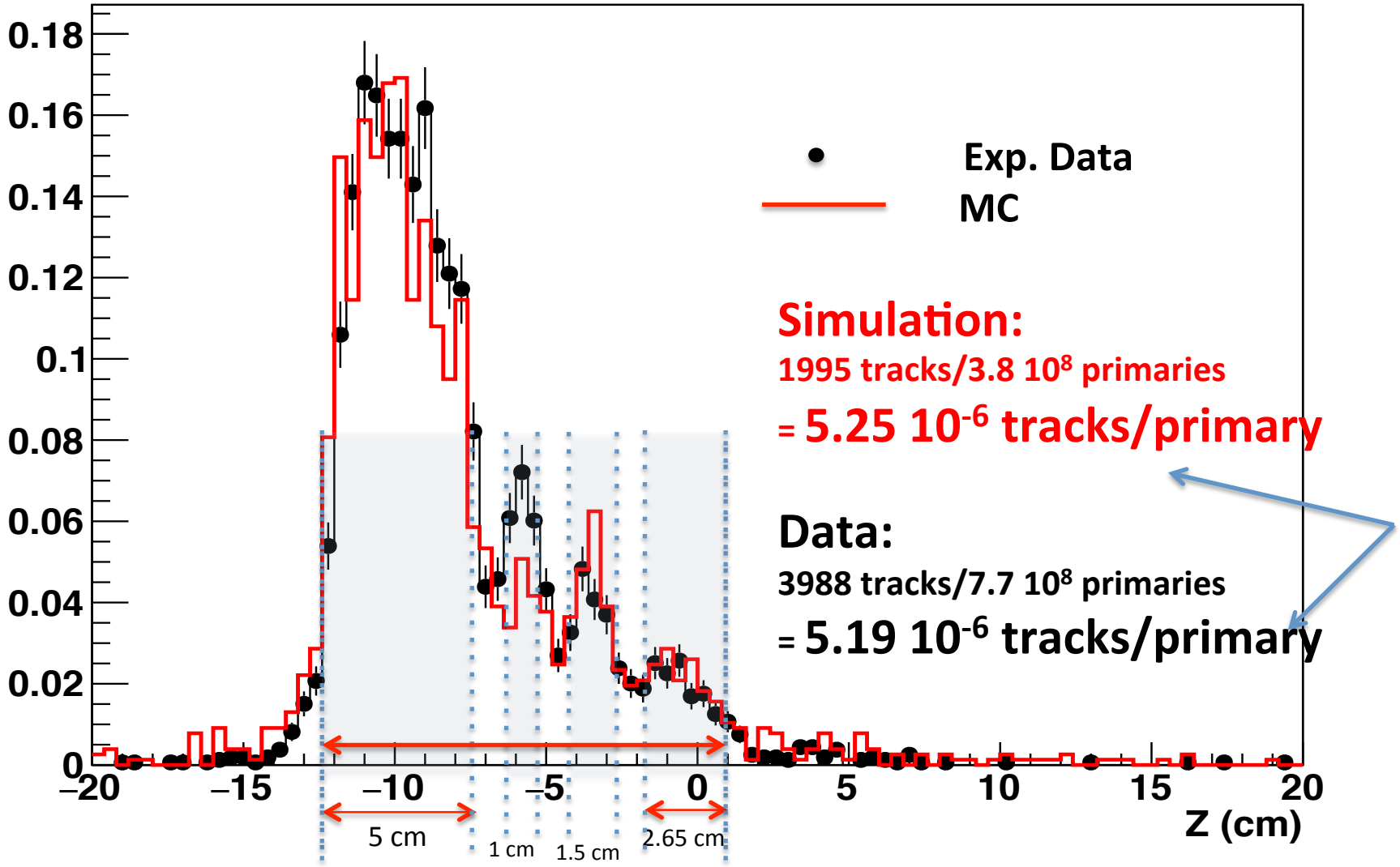




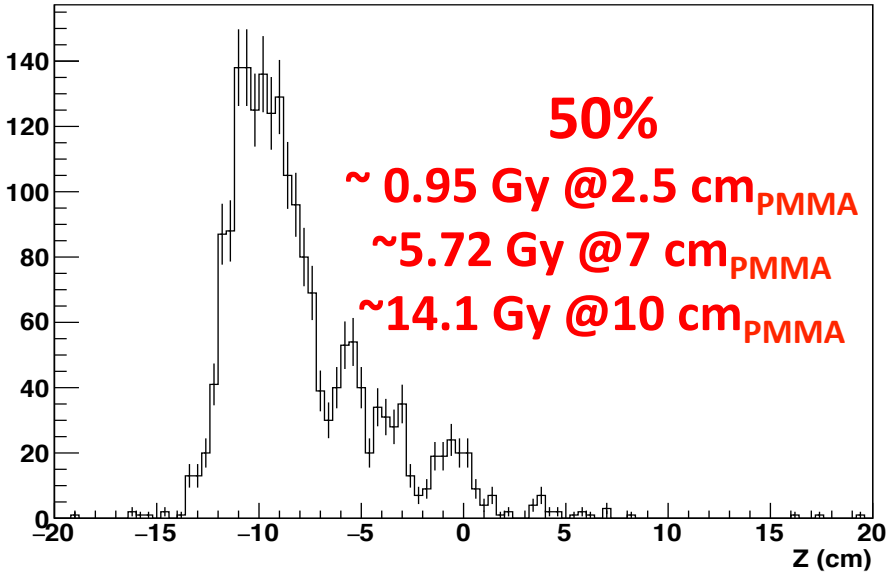
Segmented geometry

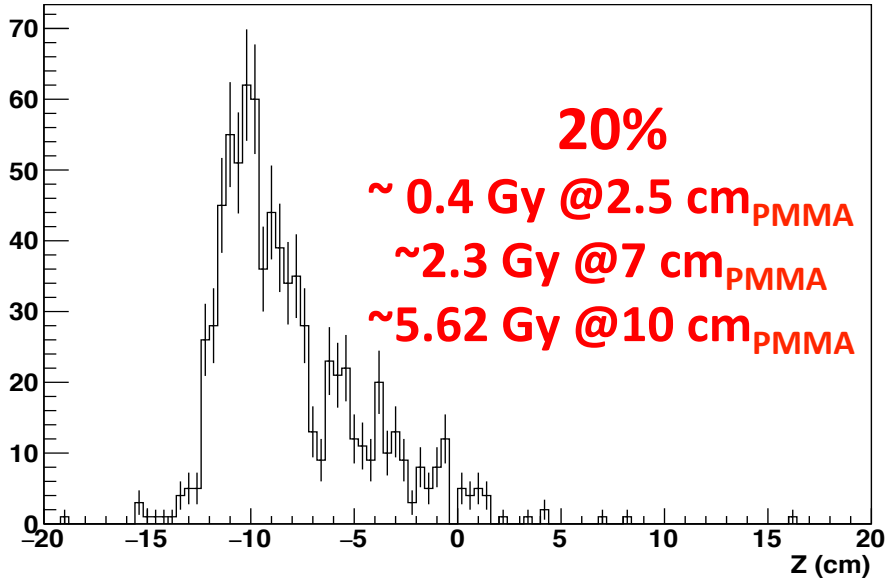


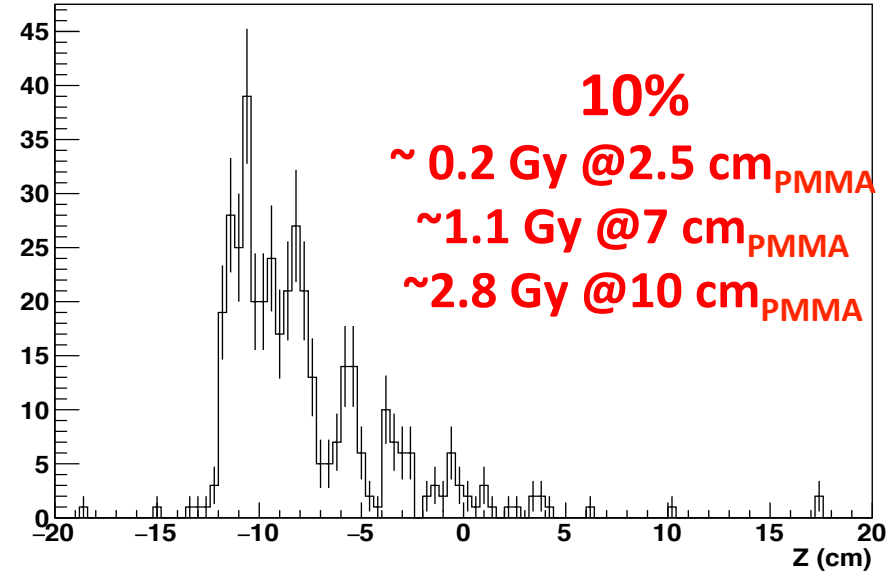
Exp. data + MC


0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
–20
–15
–10
–5
0
5
10
15
20
Z (cm)
Exp. Data
MC
Simulation:
1995 tracks/3.8 10^8 primaries
= 5.25 10^-6 tracks/primary
Data:
3988 tracks/7.7 10^8 primaries
= 5.19 10^-6 tracks/primary
5 cm
1 cm
1.5 cm
2.65 cm

Structures can be spotted with lower statistics



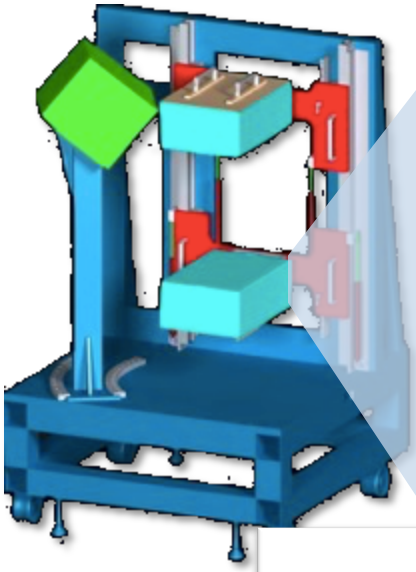


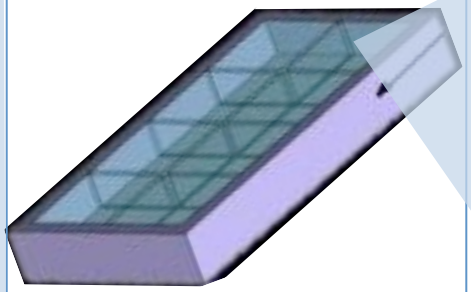


The presence of structures remains distinguishable also for lower doses

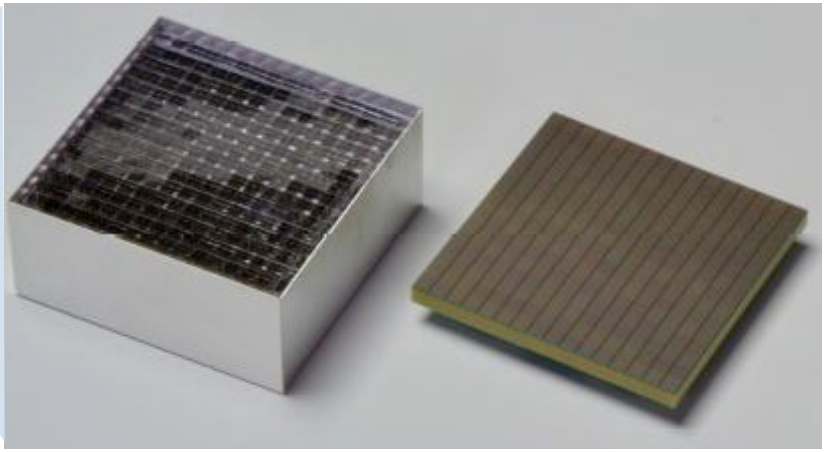
The occurrence of a range larger than expextation at the given energy can in any case be detected at low dose

In-beam PET (ibPET)

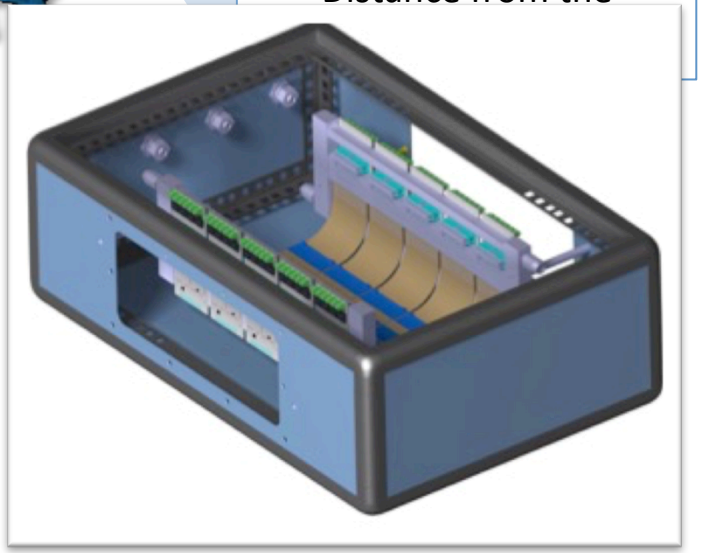




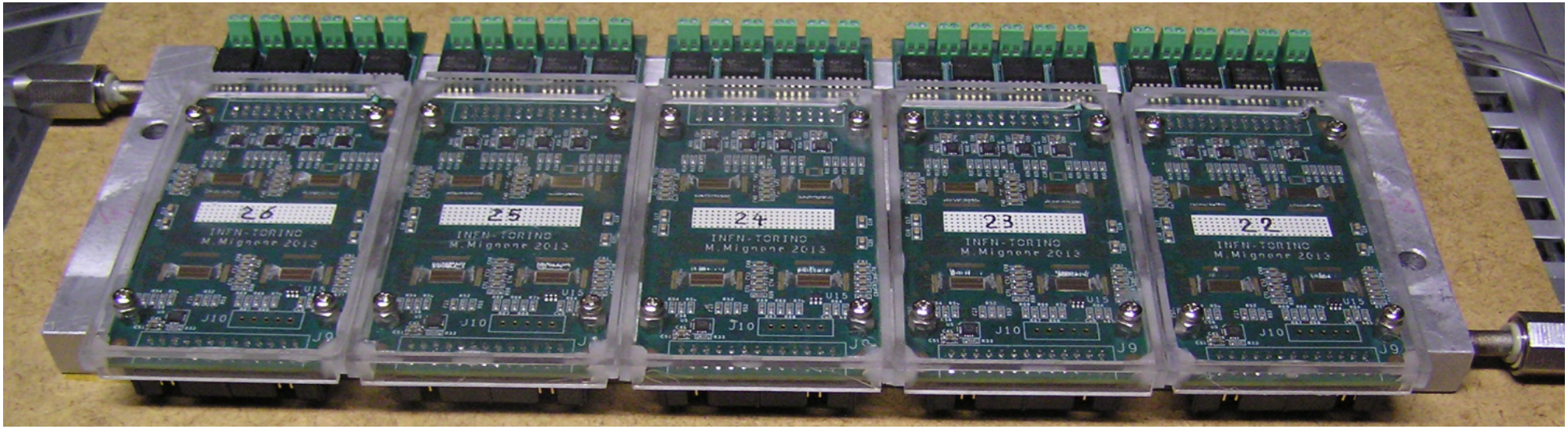
10x 20 x 5 cm^3
Distance from the



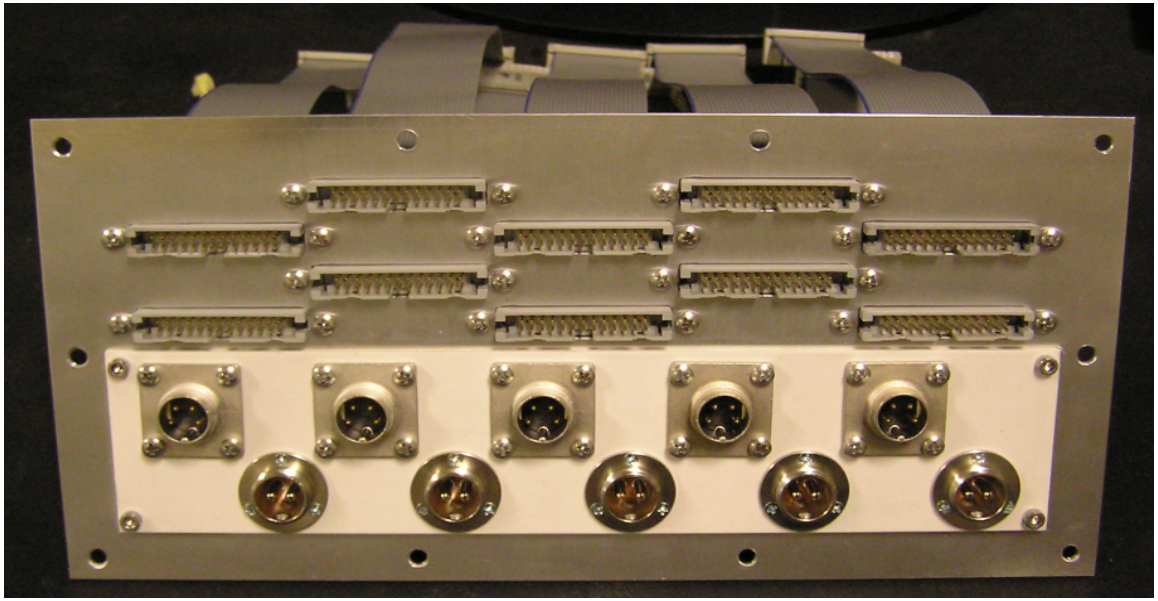
256 LFS pixel crystals (3x3x20mm^3) coupled one to one to MPPCs (Multi Pixel Photon Counters, SiPMs).



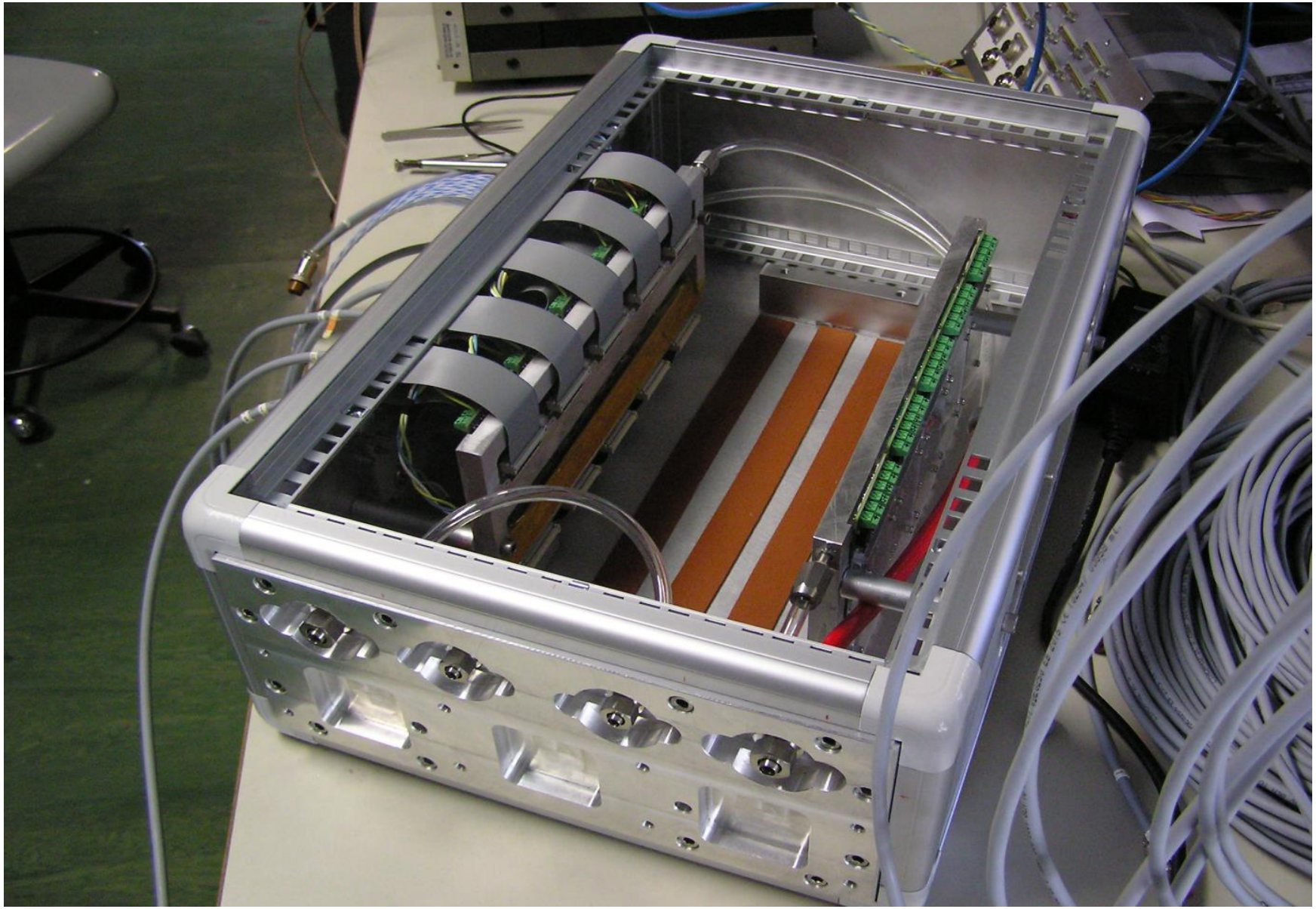
Solid model
Of the PET
head



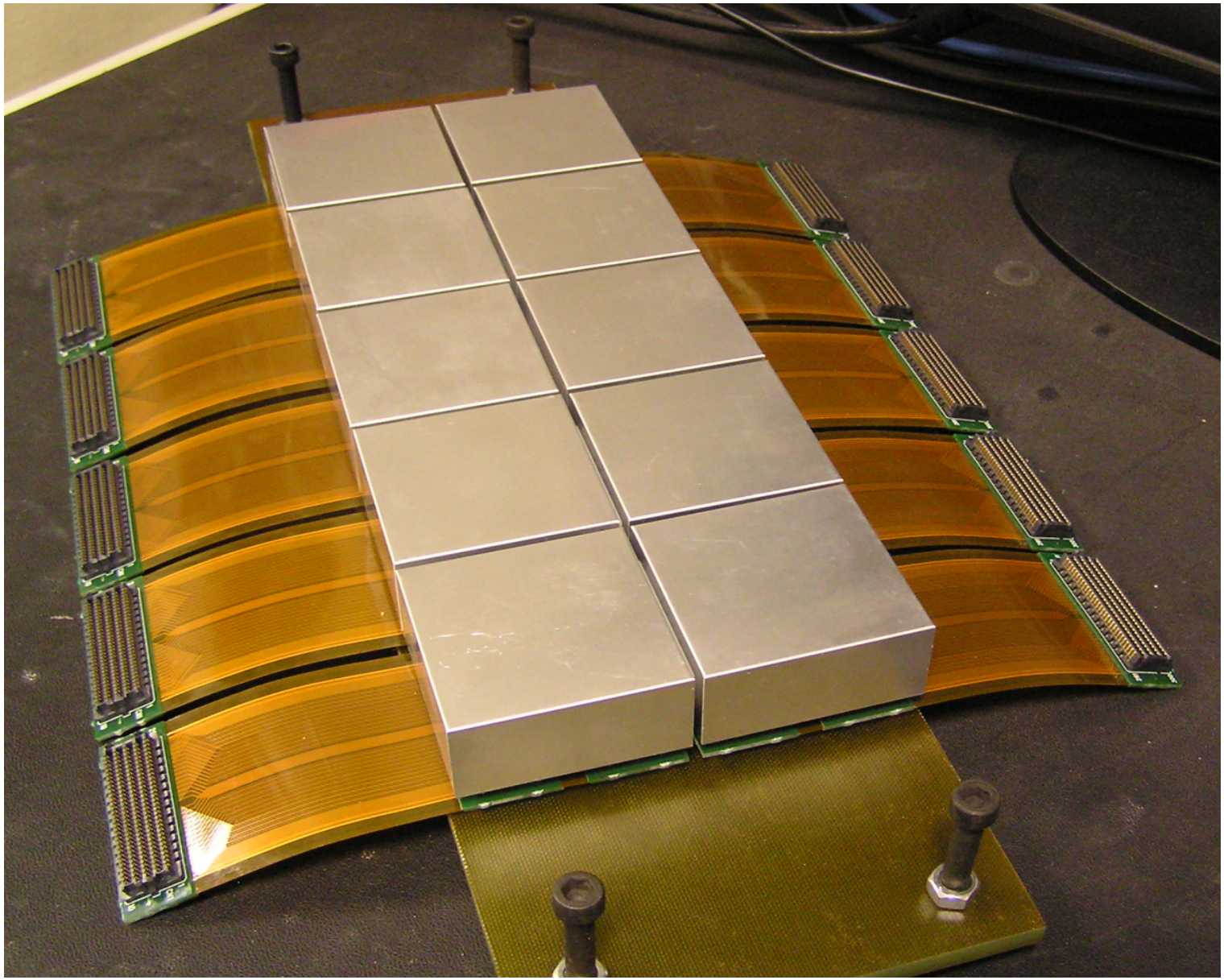
FE boards on cooling support



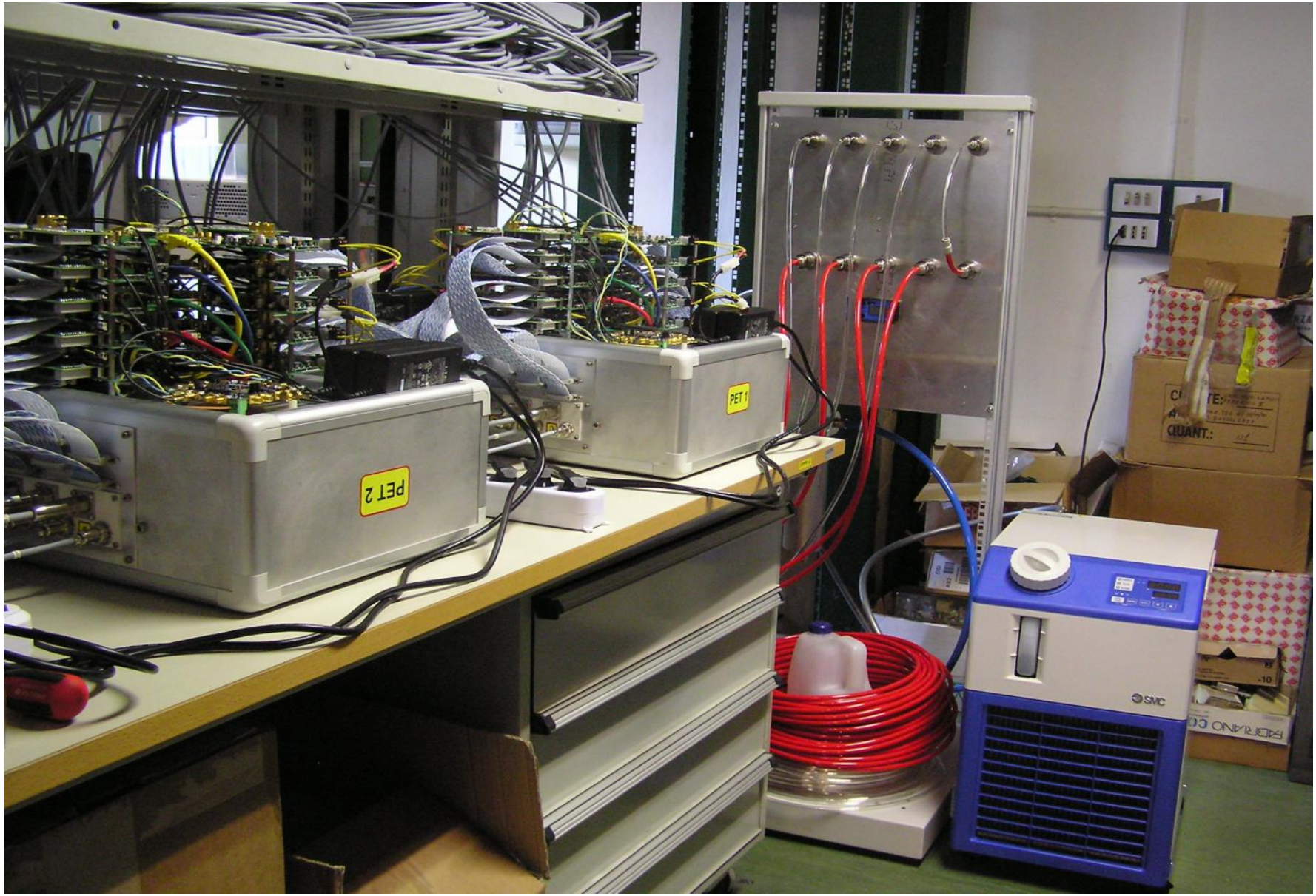
Connector panel



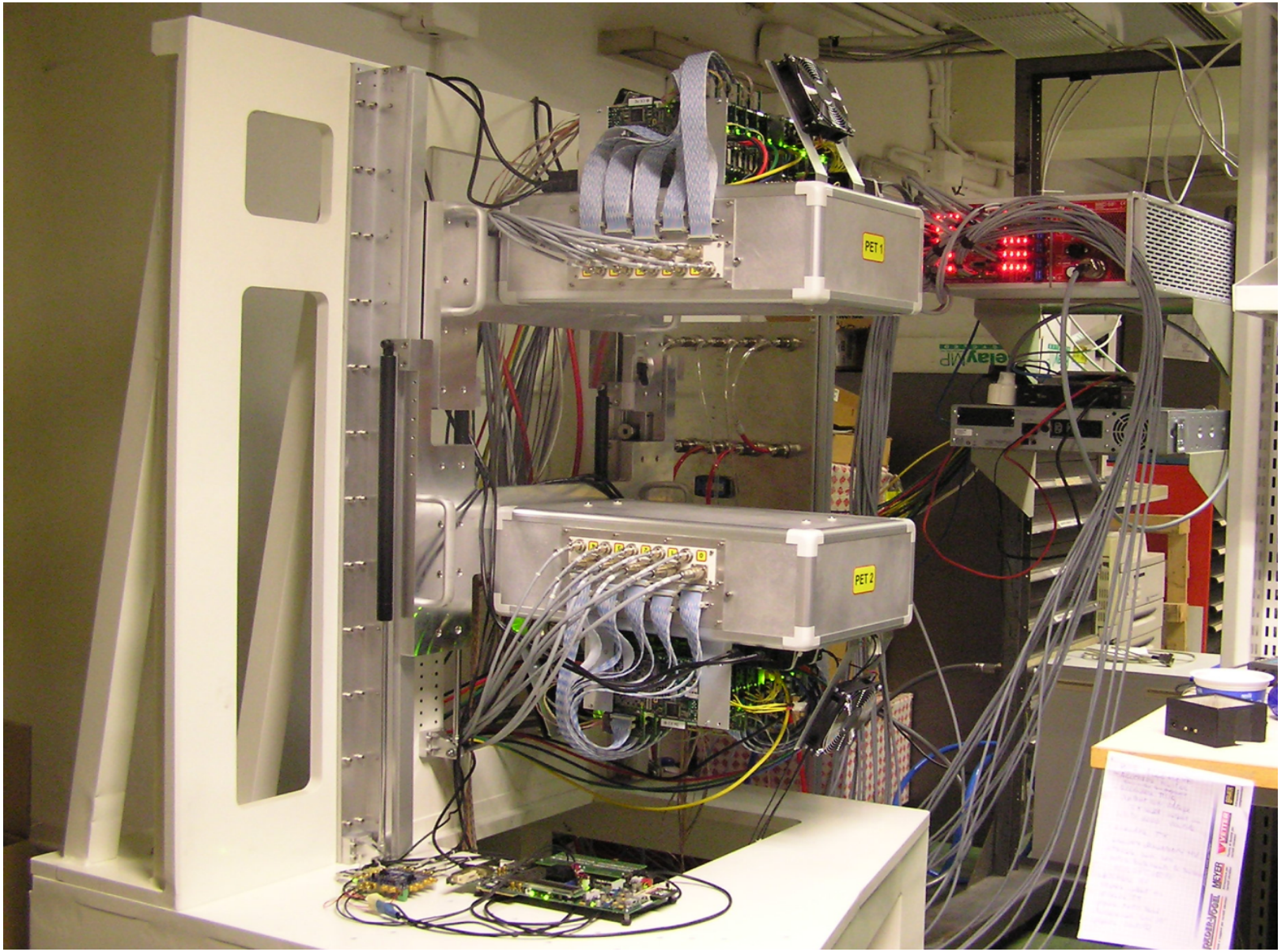
FE boards mounted and cabled in PET box



Detector blocks on glass-fibre support

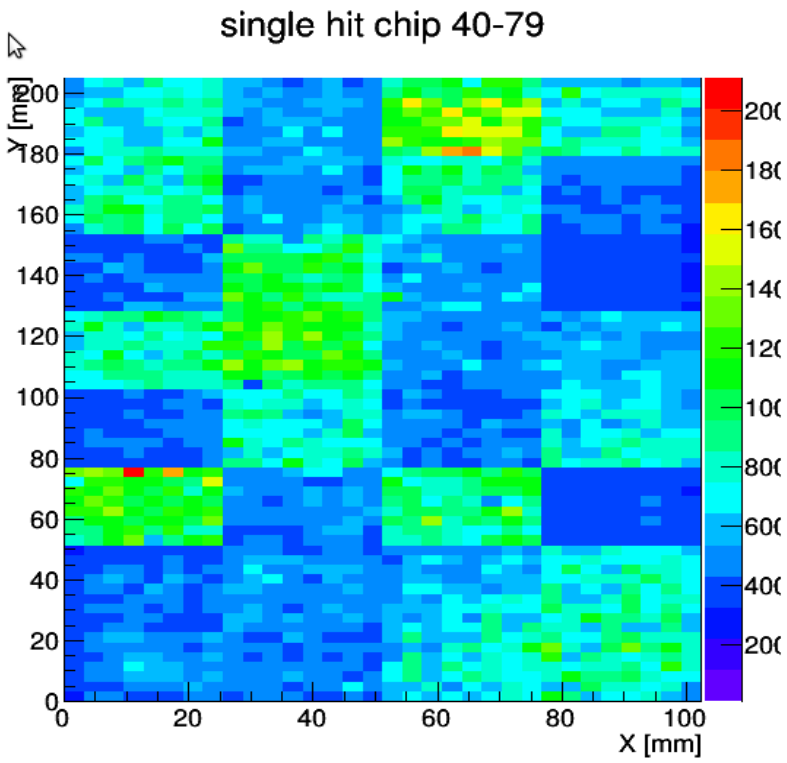


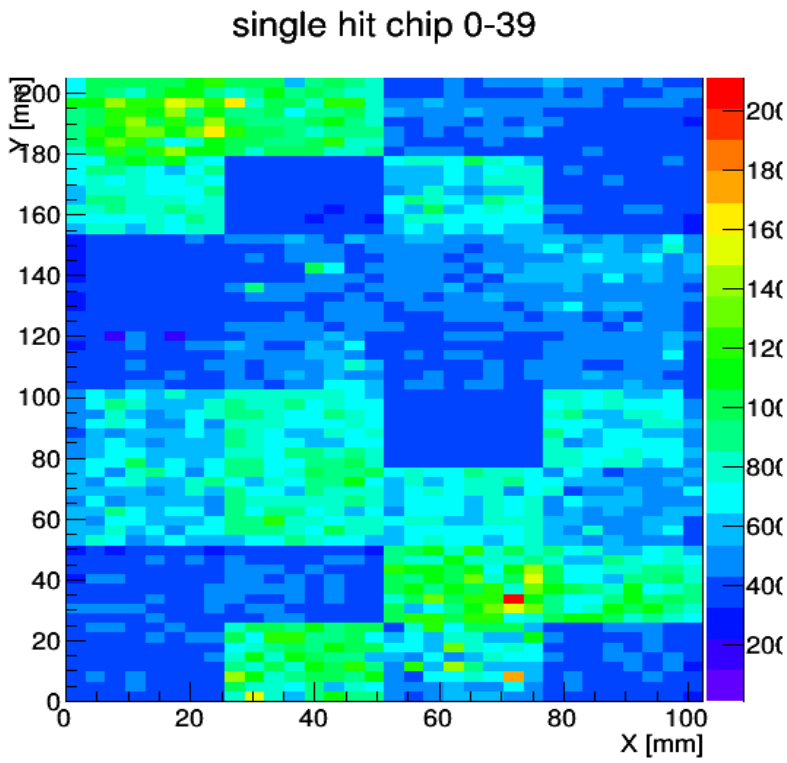
Ready for test with Tx boards and chiller connected



Completed PET detector (running)- January 15

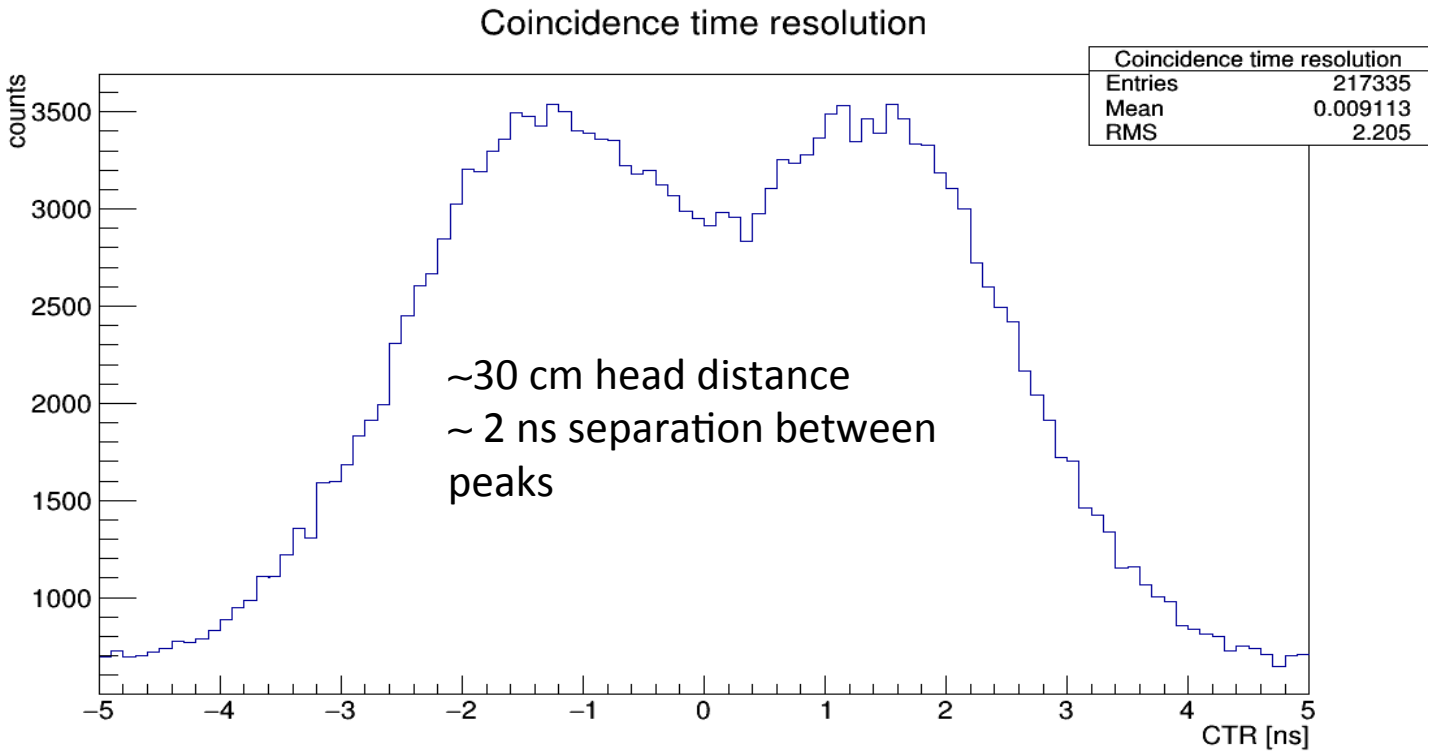
Background single events





Firmware-decoded events
Lutetium background spectrum
Good background rate uniformity

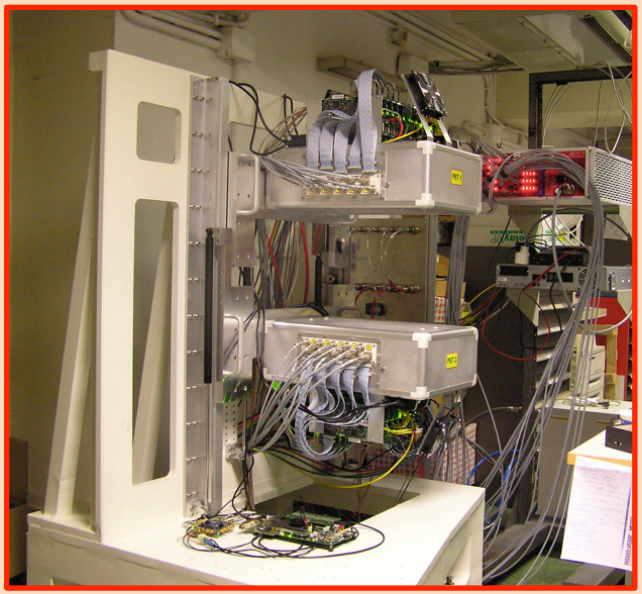
…and what about the CTR?



Firmware-decoded TOT
Lutetium background spectrum
CTR with 5 ns window
-> calibration software (already tested for 2 boards) works, source needed to perform actual calibration

Torino Group's SW Tasks

INSIDE in-beam PET
10vs10 modules
was built!



JANUARY 2016

Data AcQuisition (DAQ)

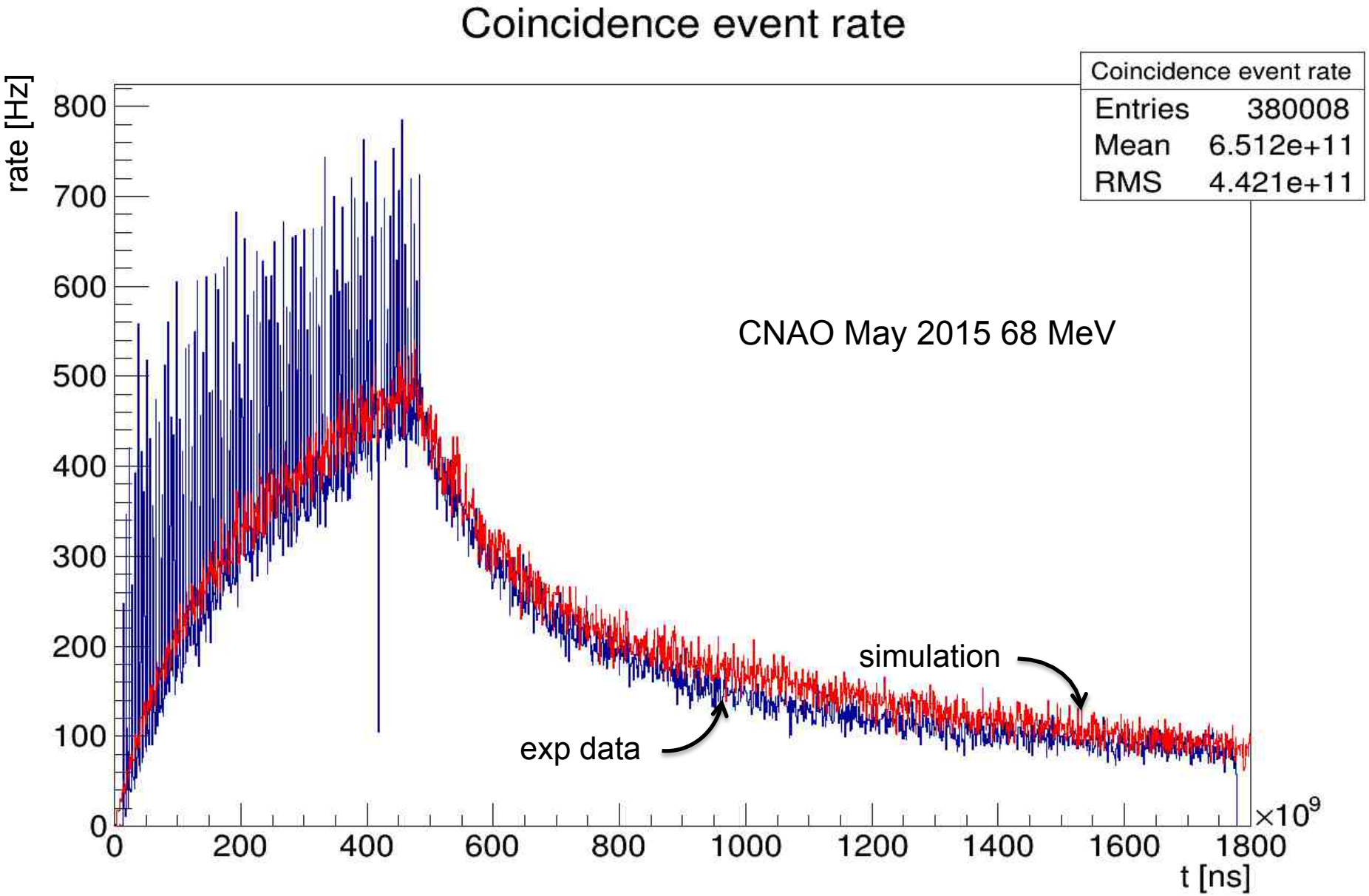
- ✓ Decoded data format
- ✓ Multi-threading DAQ software
- ✓ Online data analysis
- ✓ Monitoring via UDP protocol

Online Monitoring - GUI

- ✓ Updated GUI sw (10vs10)
- ✓ Improved automatic calibrations
- ✓ Online monitoring on singles
- ✓ Online monitoring on true coincidence data

Simulation

- ✓ Coincidence rate validation


Coincidence event rate
Coincidence event rate
Entries 380008
Mean 6.512e+11
RMS 4.421e+11
rate [Hz]
800
700
600
500
400
300
200
100
0
CNAO May 2015 68 MeV
simulation
exp data
0
200
400
600
800
1000
1200
1400
1600
1800
×10^9
t [ns]

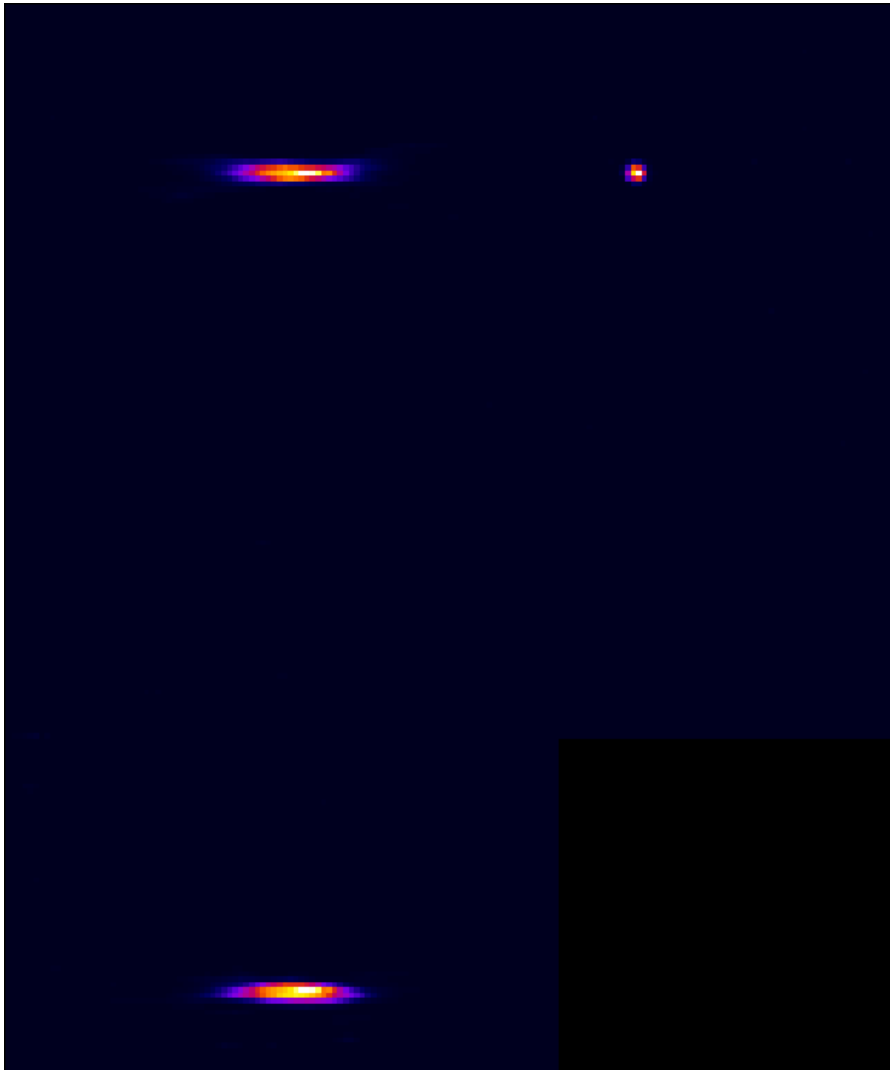
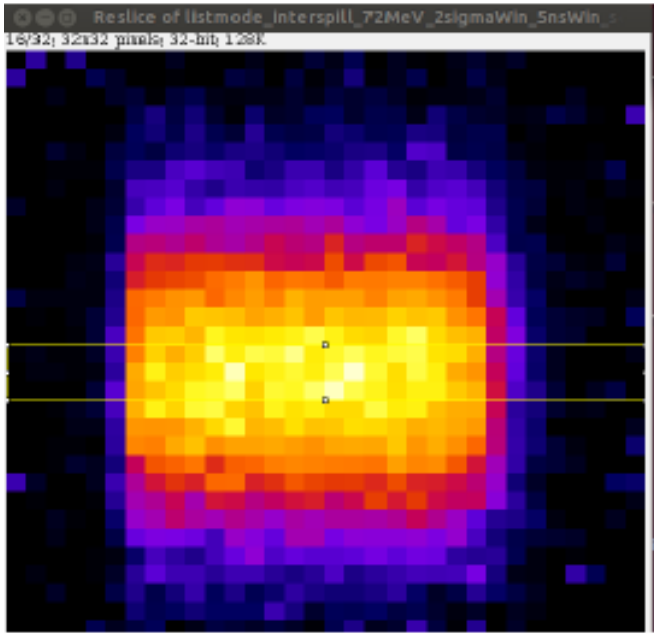


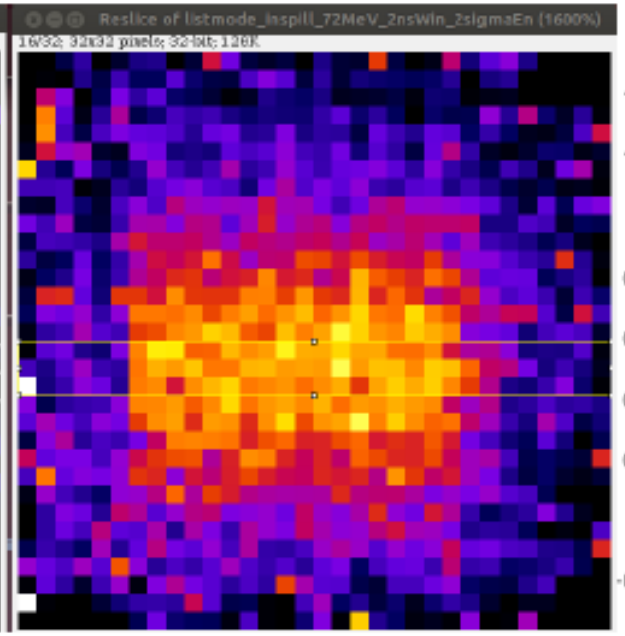
Image of a FDG source, activity about 0.5 MBq
Source size < 0.5 cm
5 min acquisition time
Image acquired on 29/1/2016

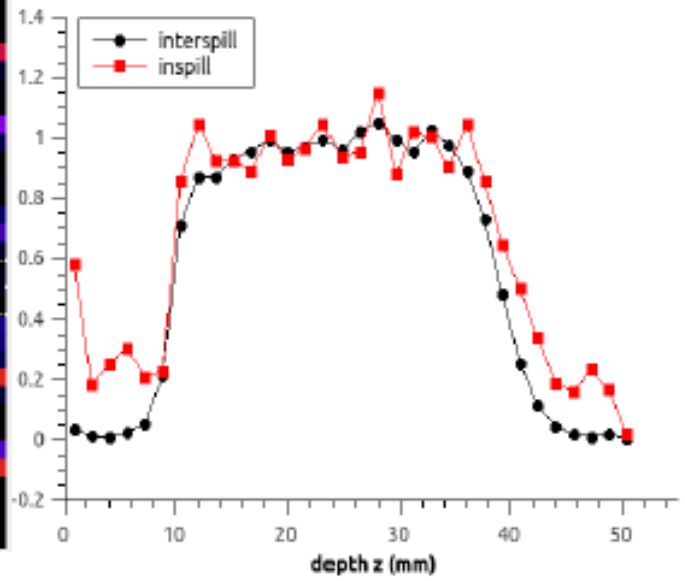
Misure sperimentali: protoni 72 MeV

Interspill



Inspill





A cosa sono dovuti gli eventi intorno alla zona irraggiata?

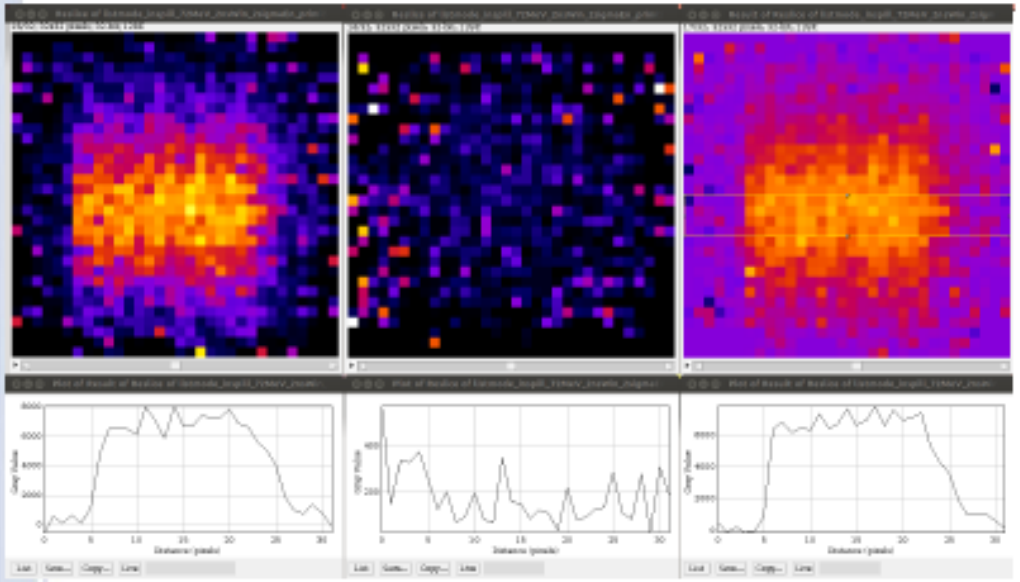
- Produzione di coppie?
- Coincidenze random?
- Isotopi a breve vita media tipo ^{12}N, ^{8}B?

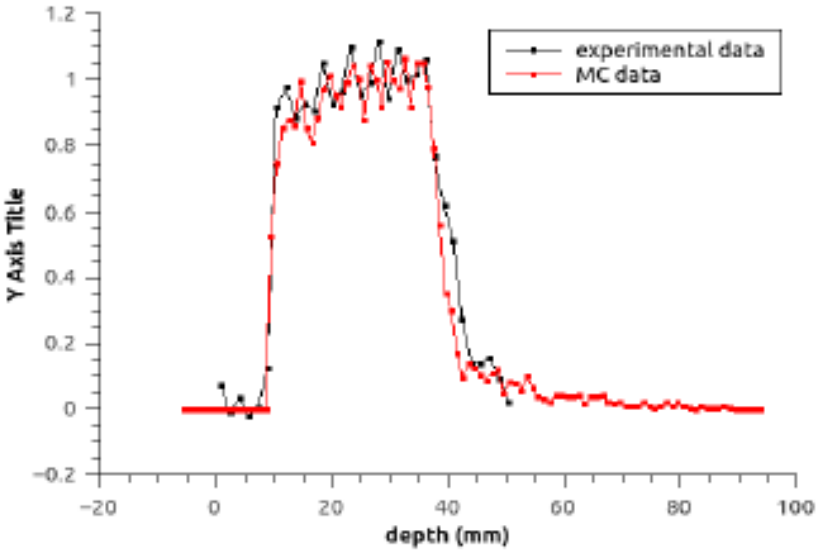
Profilo inspill con sottrazione dell'immagine delle random

Immagine originale

Immagine delle coincidenze random

Immagine originale - random





A. Kraan, simulazioni

15

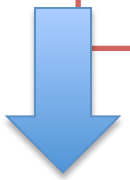
INSIDE activities in 2016

In-beam PET

- global device test & characterization (Uni and INFN Pisa & To)
  - Performance Assessment w Sources @Pisa, To
  - Installation at CNAO treatment room (3/2/2016)
  - Commissioning with Proton/Carbon Beams (7/2/2016)

Dose profiler

- global device test & characterization (LNF, MI & RM1)
  - Cosmic ray test @RM1
  - Proton beam calibration @ LNS/TIFPA
  - Installation at CNAO treatment room
  - Commissioning with Proton/Carbon Beams



INSIDE

Commissioning of the bi-modal system w Carbon Beams
Protocol definition for clinical validation