FOOT calorimeter

Status Report

Crystals
Photodetector
Readout
Mechanics

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G. Giraudo
N. Pastrone
L. Scavarda
P.P. Trapani

August, 28th, 2018, Roma

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BGO crystals now available

- **As many as we need**

Stored in polystyrol boxes at CERN *(5 crystals/box)*

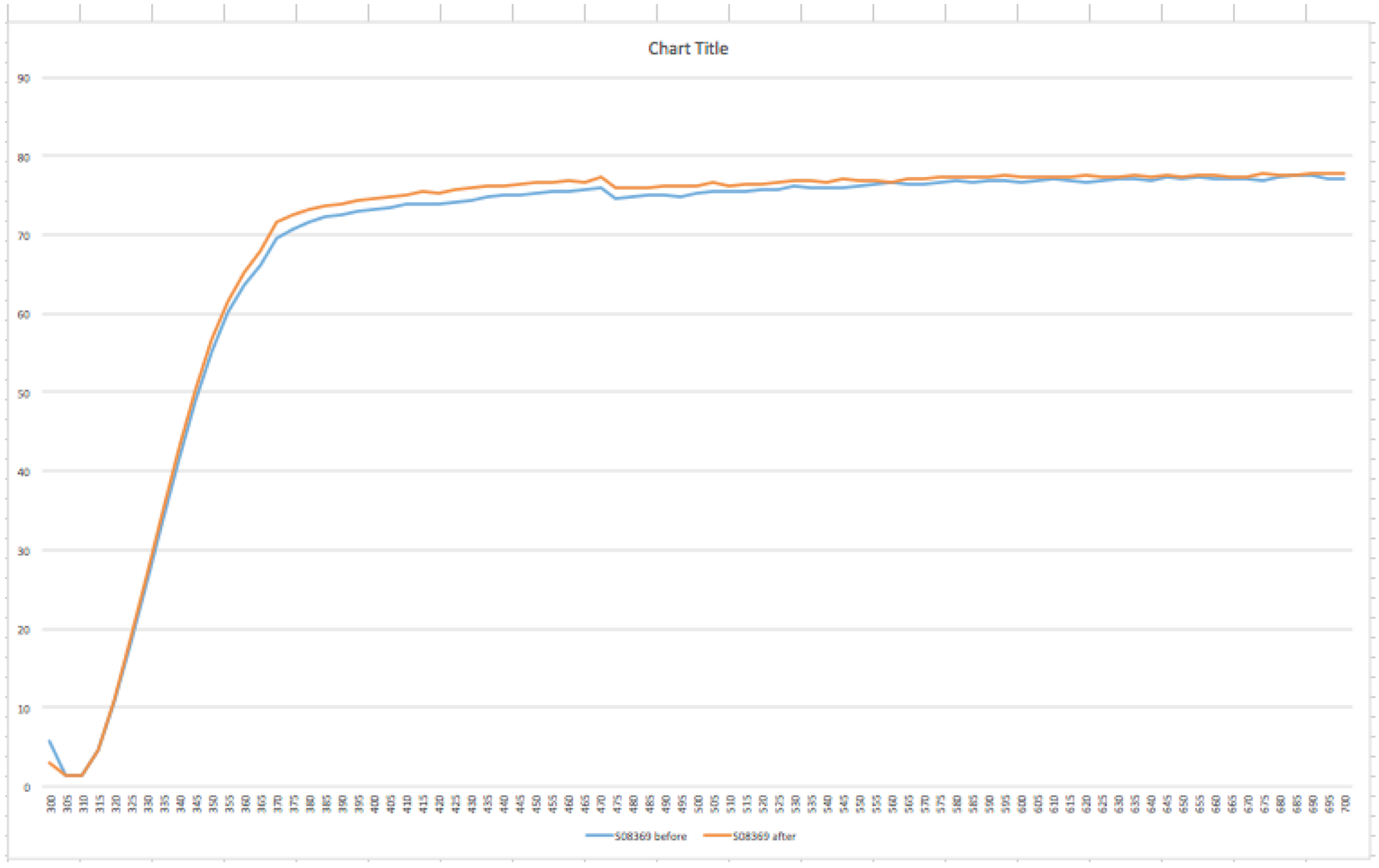
Crystal dimensions:

Approx. 2.0 × 24 × 2.9 cm3

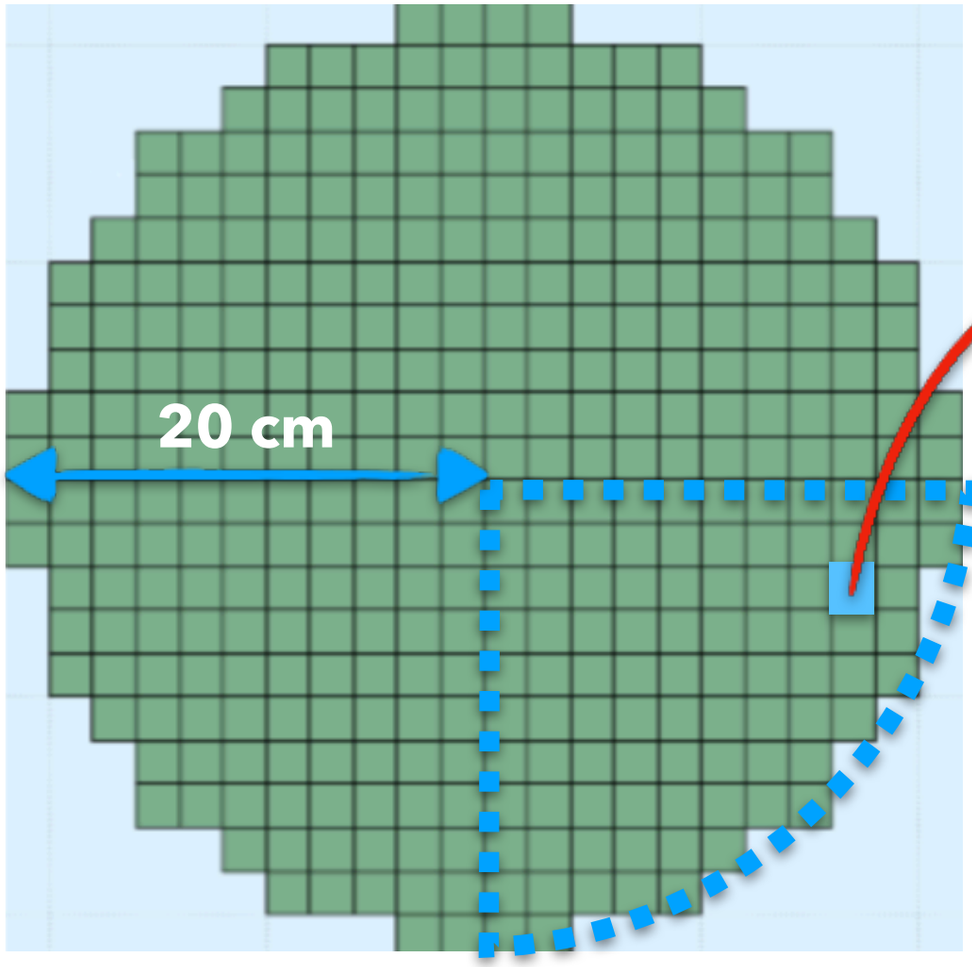
Crystal transmission curves:

- Ongoing Measurements at CERN, will be completed by end of 2018

S08369 Transmission curve – pre/post annealing

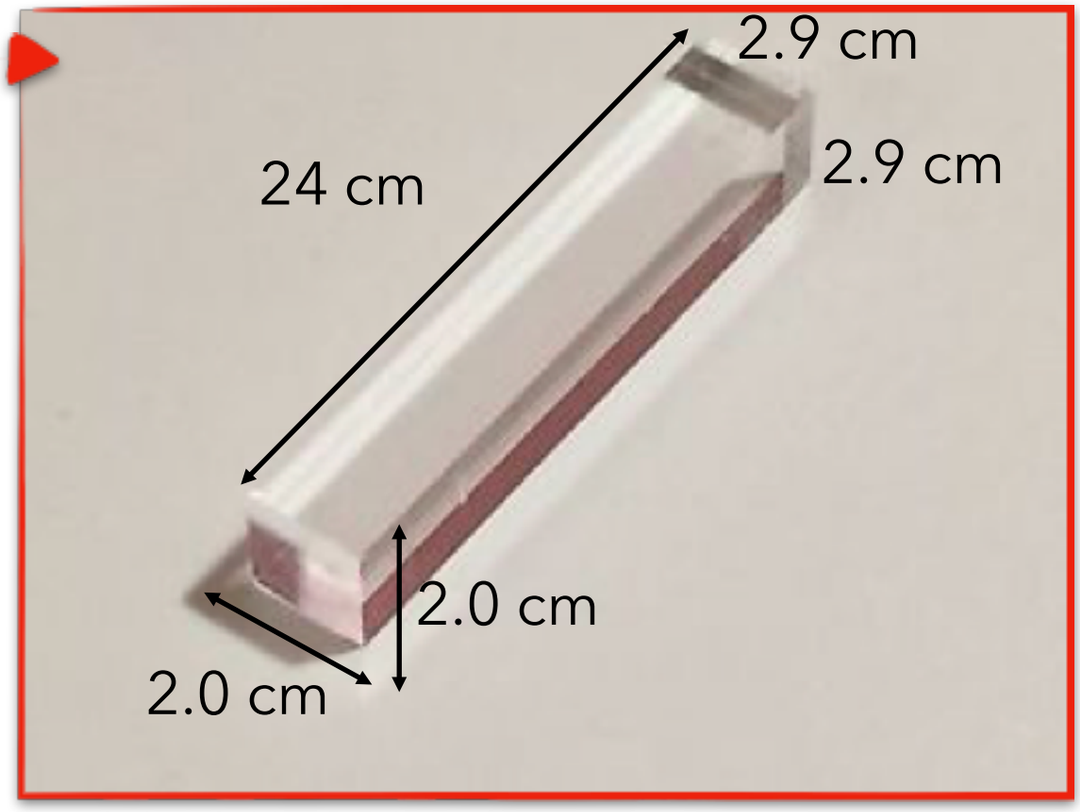


4 quarters of 80 BGO crystals each



$$Z_{Bi} = 83$$

$$\rho_{BGO} = 7.13\ g/cm^3$$



Weight: 1027 g
Total weight: 329 Kg

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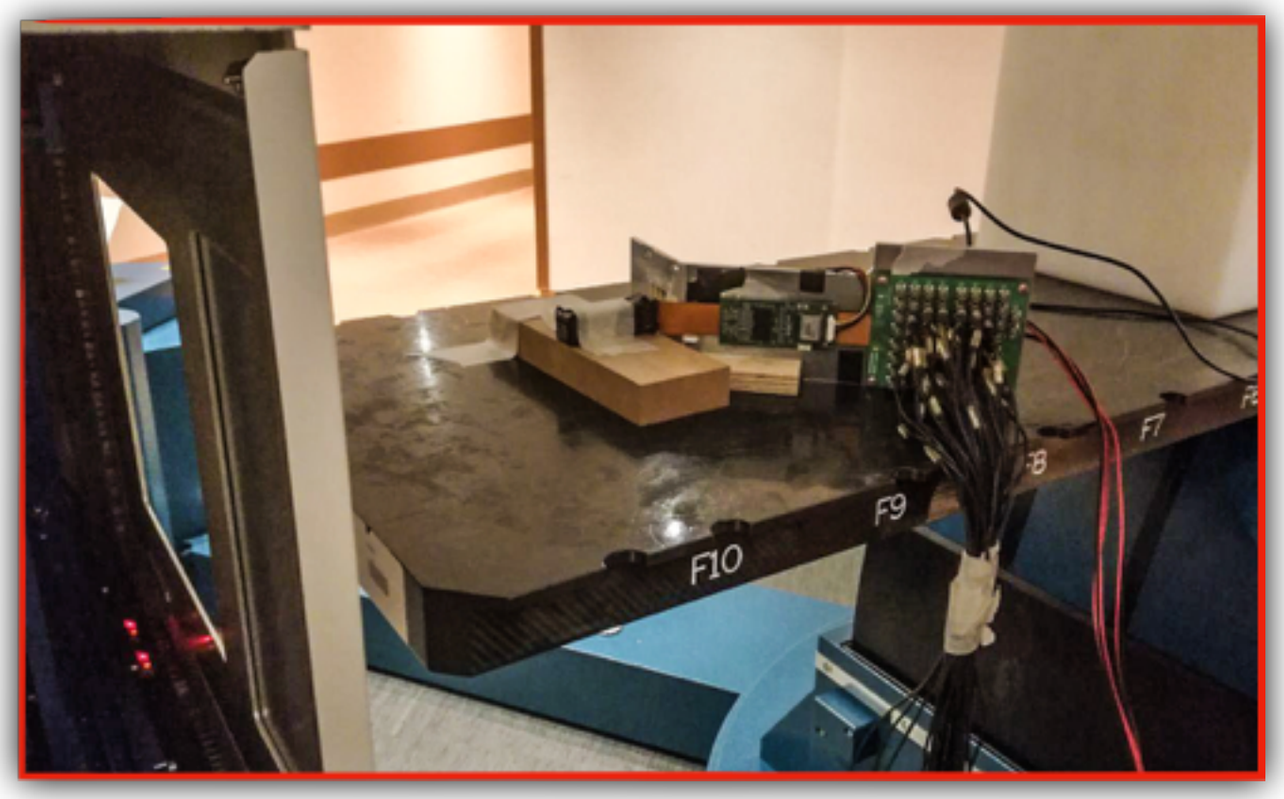
Calorimeter preliminary test at CNAO, March 2018

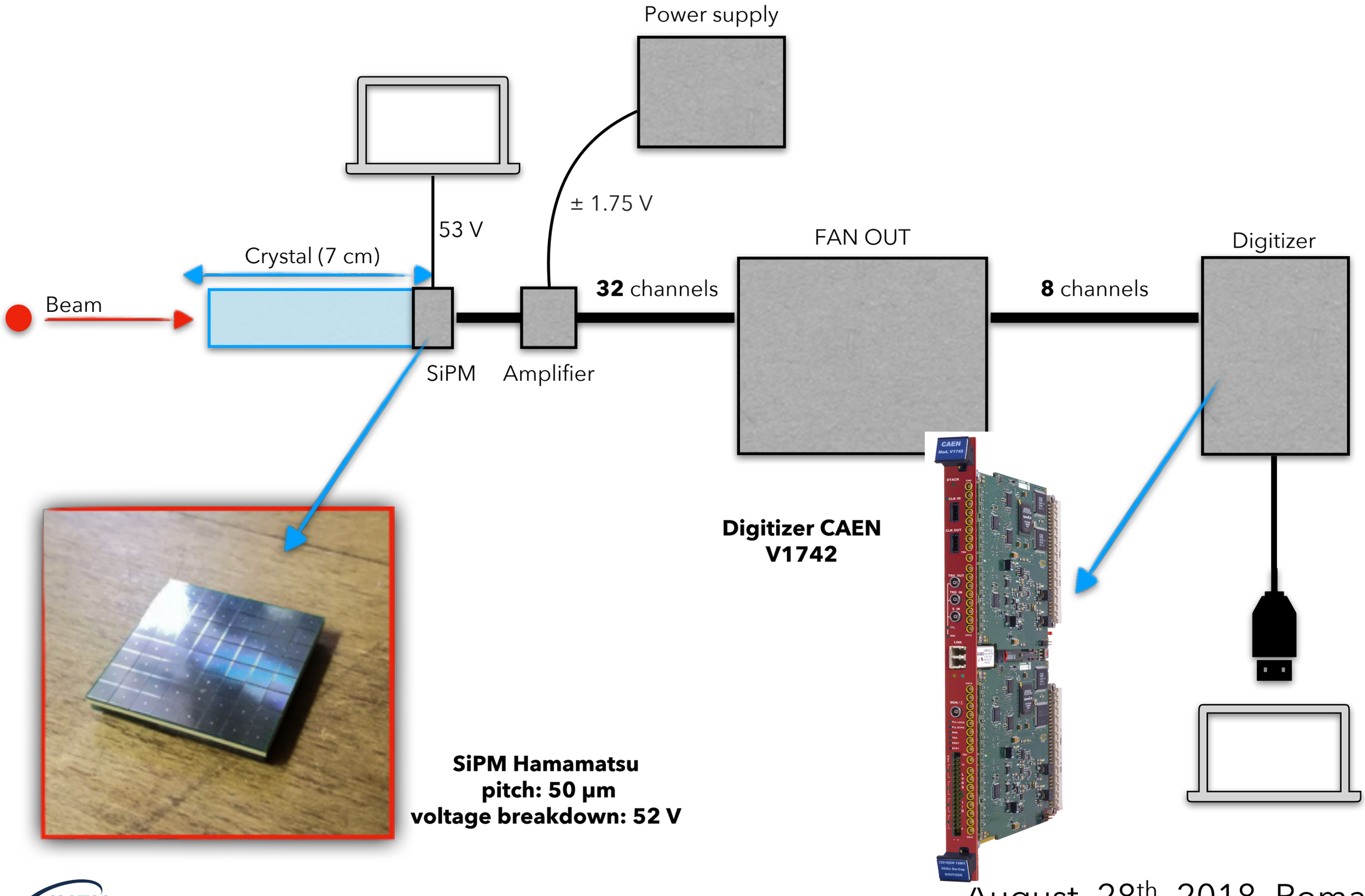
- SiPM
  - Crystal: **7 cm** long

Proton beam → **70 MeV**, **120 MeV**, **170 MeV**, **400 MeV**

Carbon beam → **120 MeV/u**, **190 MeV/u**, **400 MeV/u**



SiPM test setup

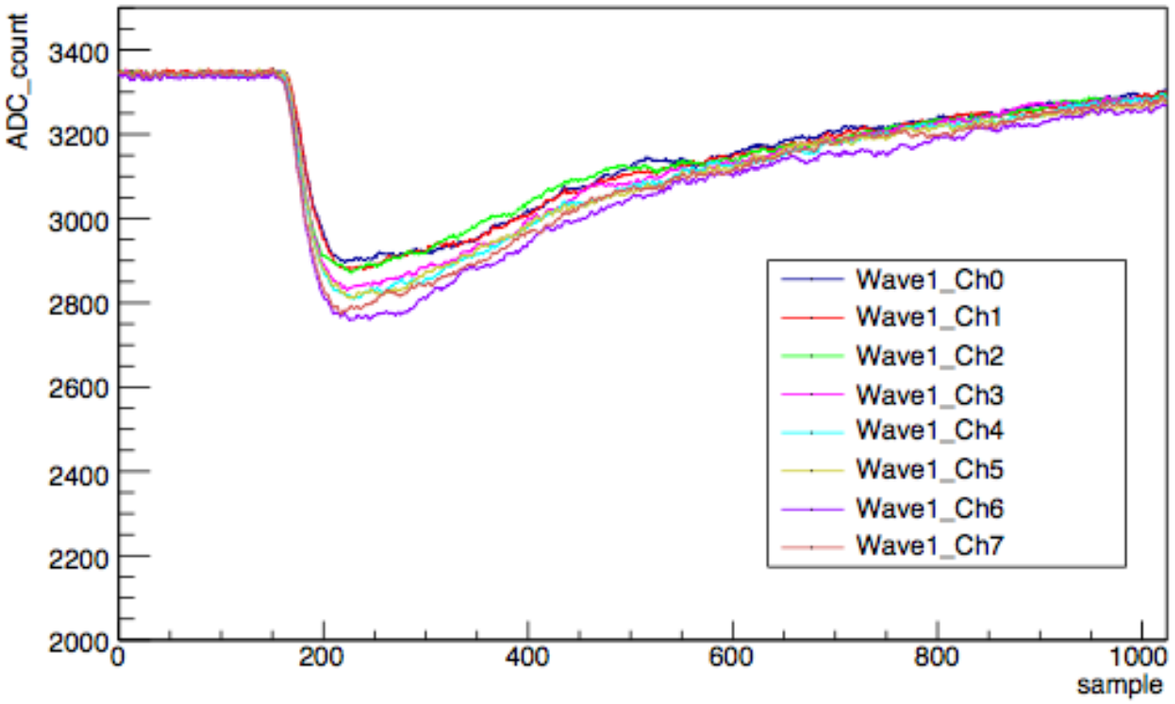


SiPM Hamamatsu
pitch: 50 μm
voltage breakdown: 52 V

Digitizer CAEN V1742

Proton beam, 170 MeV, 7 cm crystal long

Wave Form



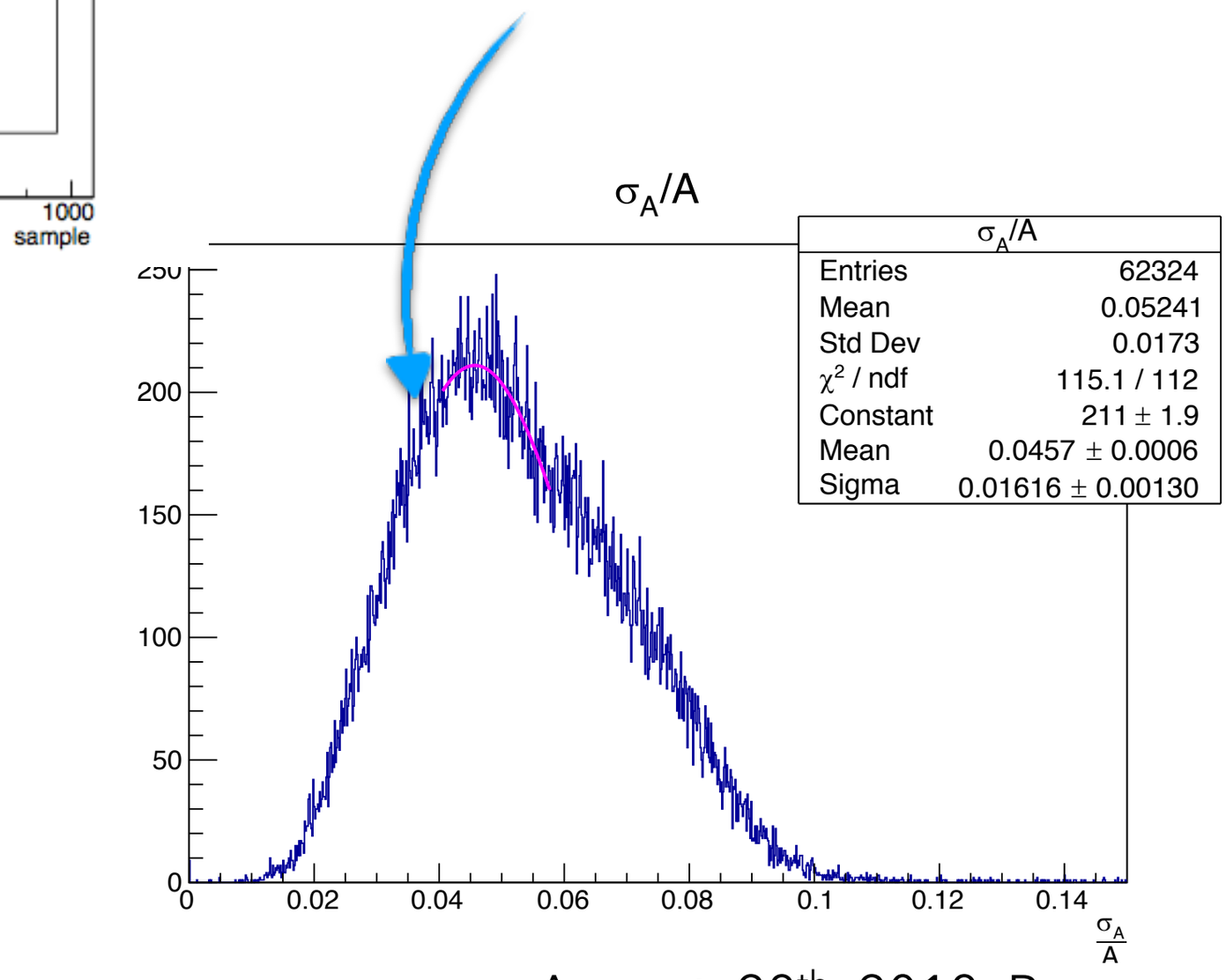
Same event acquired in the 8 channels of Digitizer

Same wave form for all channels

No position dependency

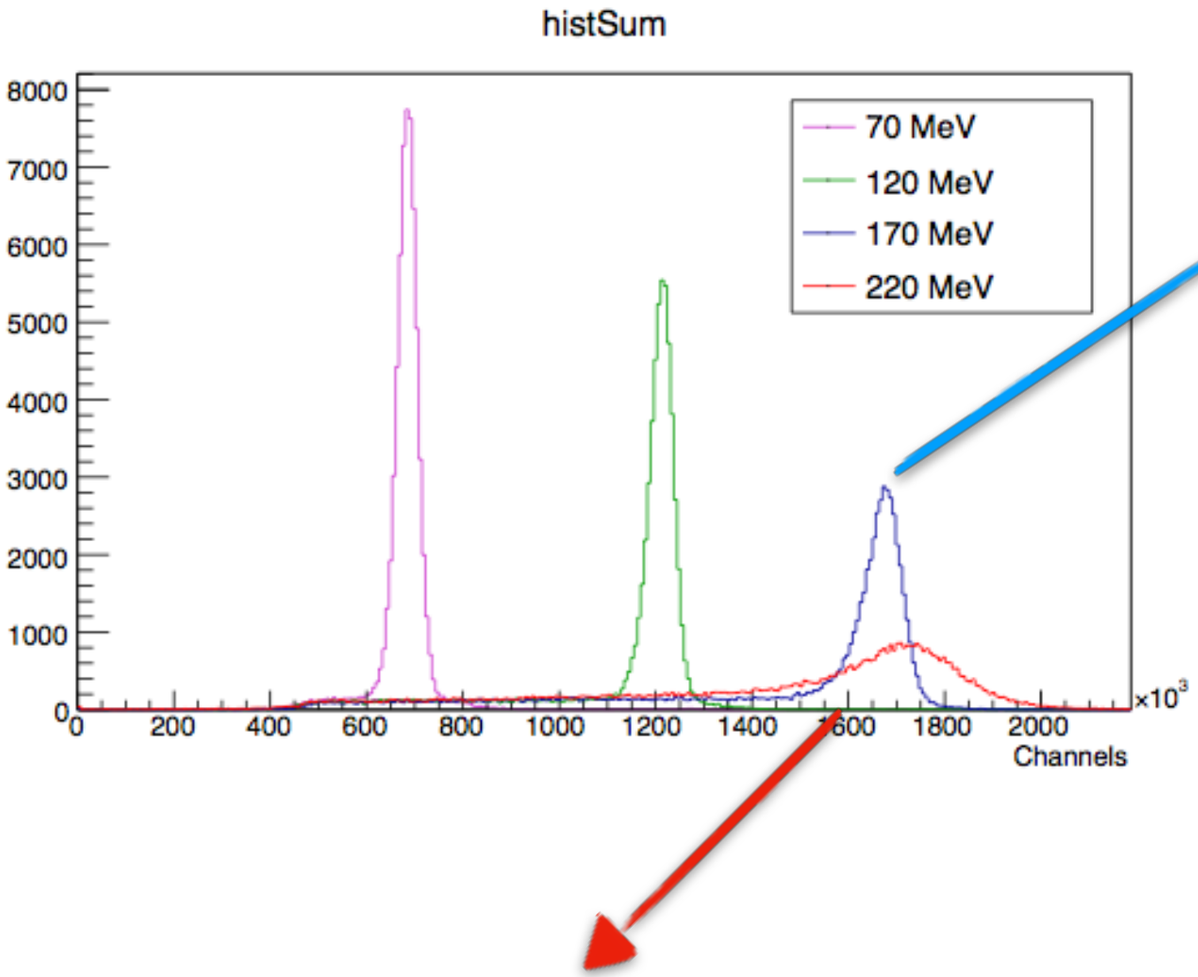
sum over of the whole Tile

Ratio between the sigma and average value of the amplitude distribution of 8 signal channels acquired in one event. Then the distribution is plotted for all events.



Signal Integration

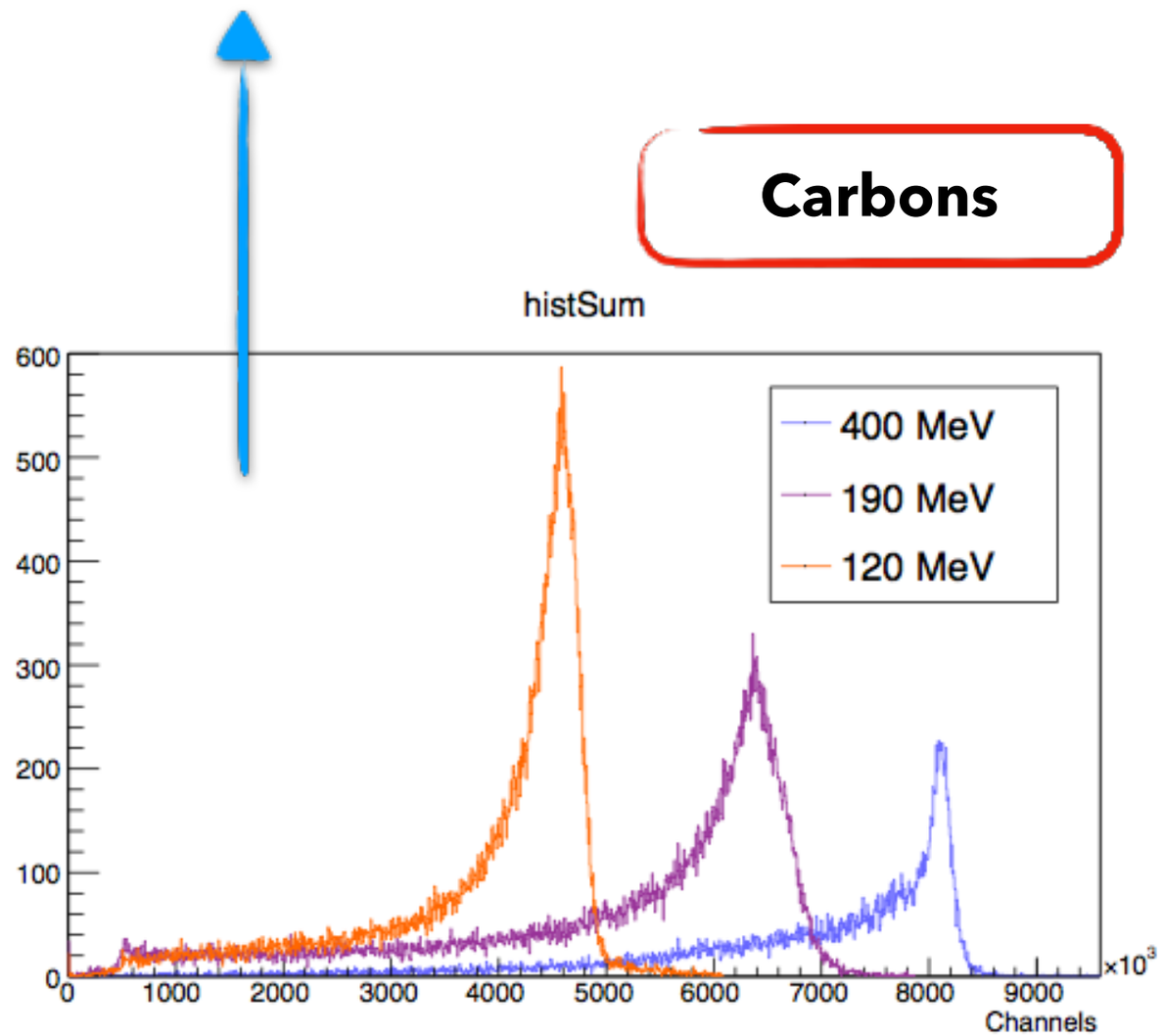
Protons



Anomalous behaviour for proton beams at 220 MeV: what happened?

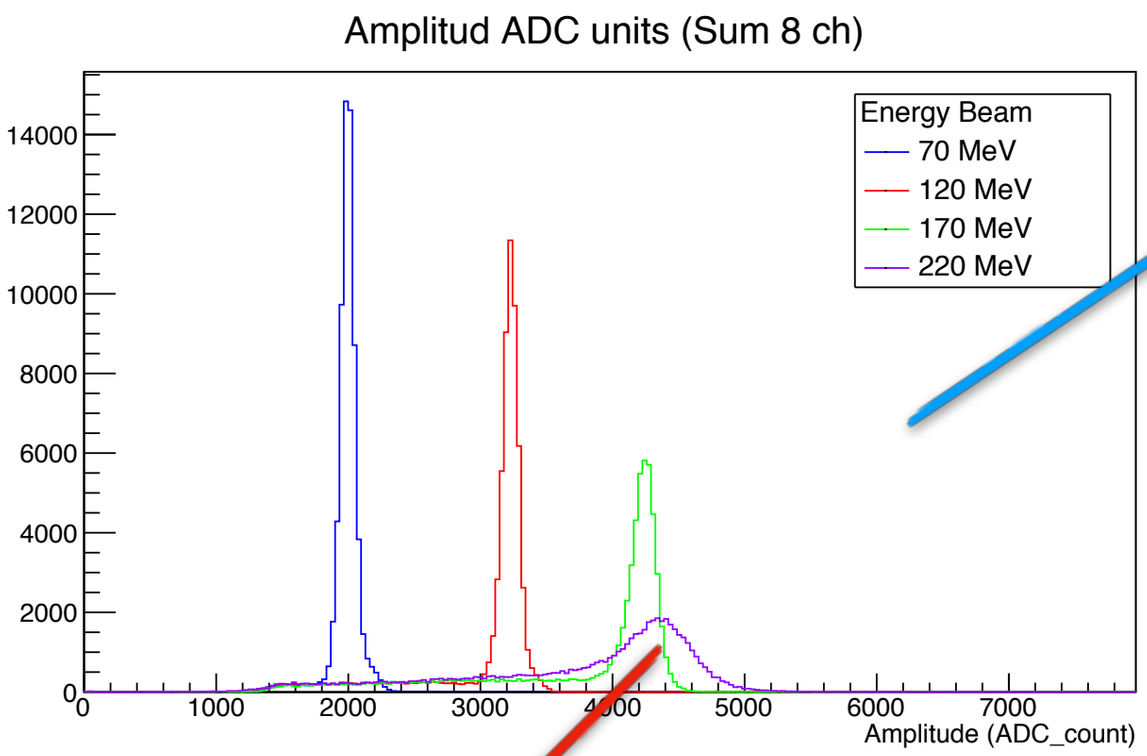
Important result: Mean value of signal integrations increases with energy

Carbons



Signal Amplitude

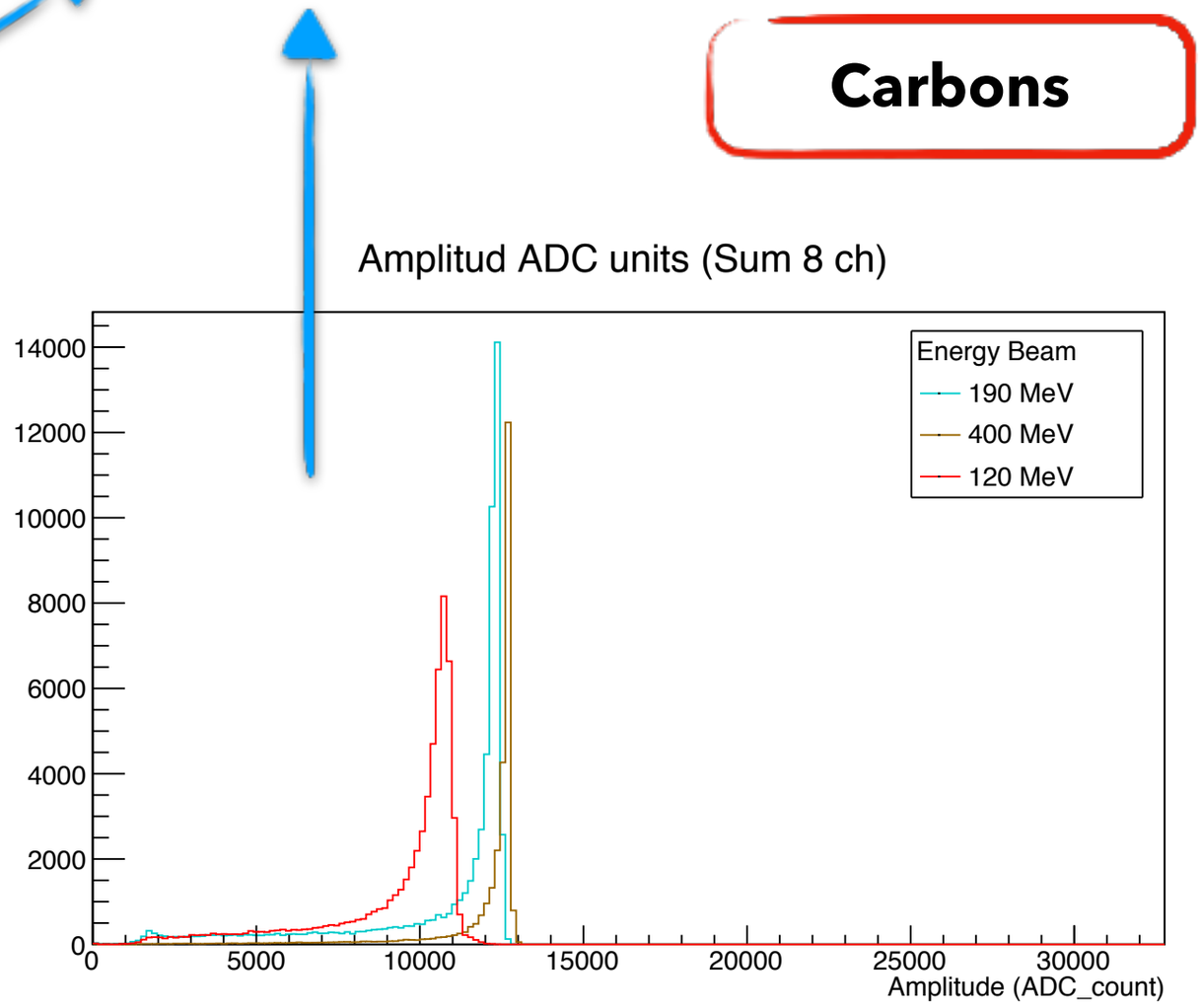
Protons



Anomalous behaviour for proton beams at 220 MeV: what happened?

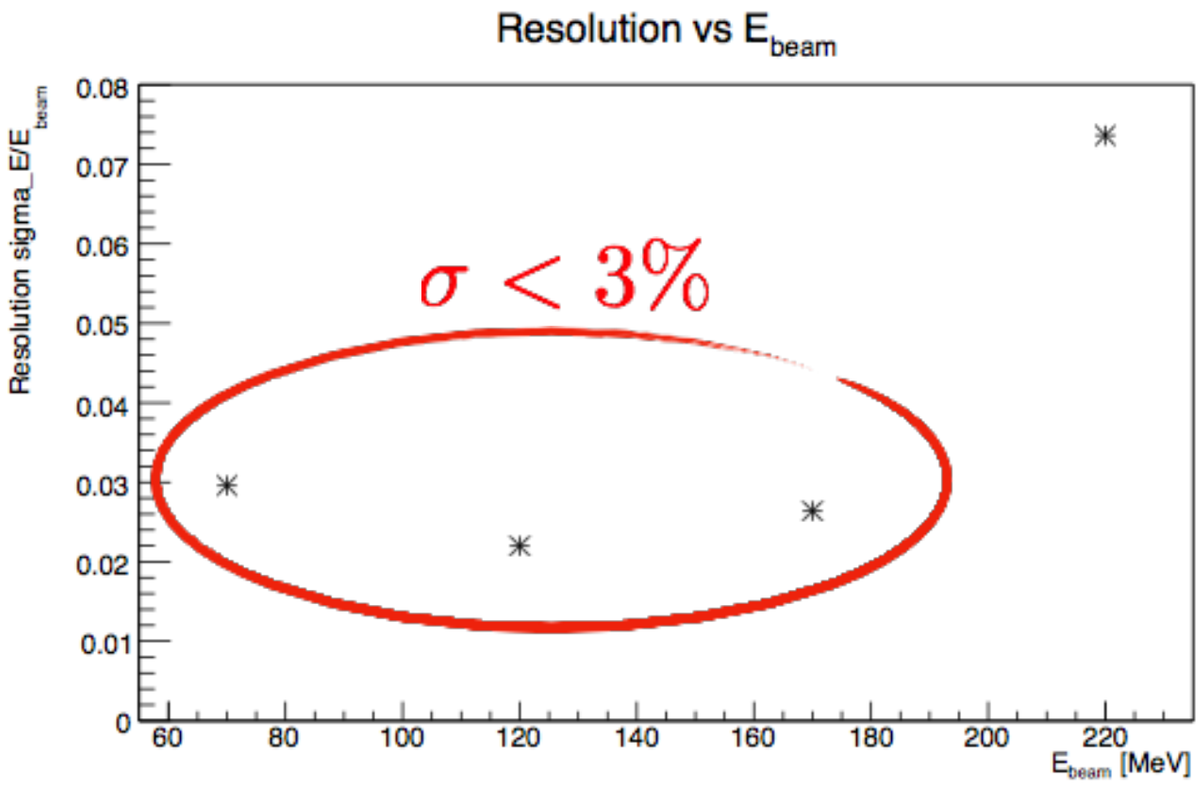
Important result: Mean value of signal amplitude increase with energy up to 120 MeV/A carbon

Carbons

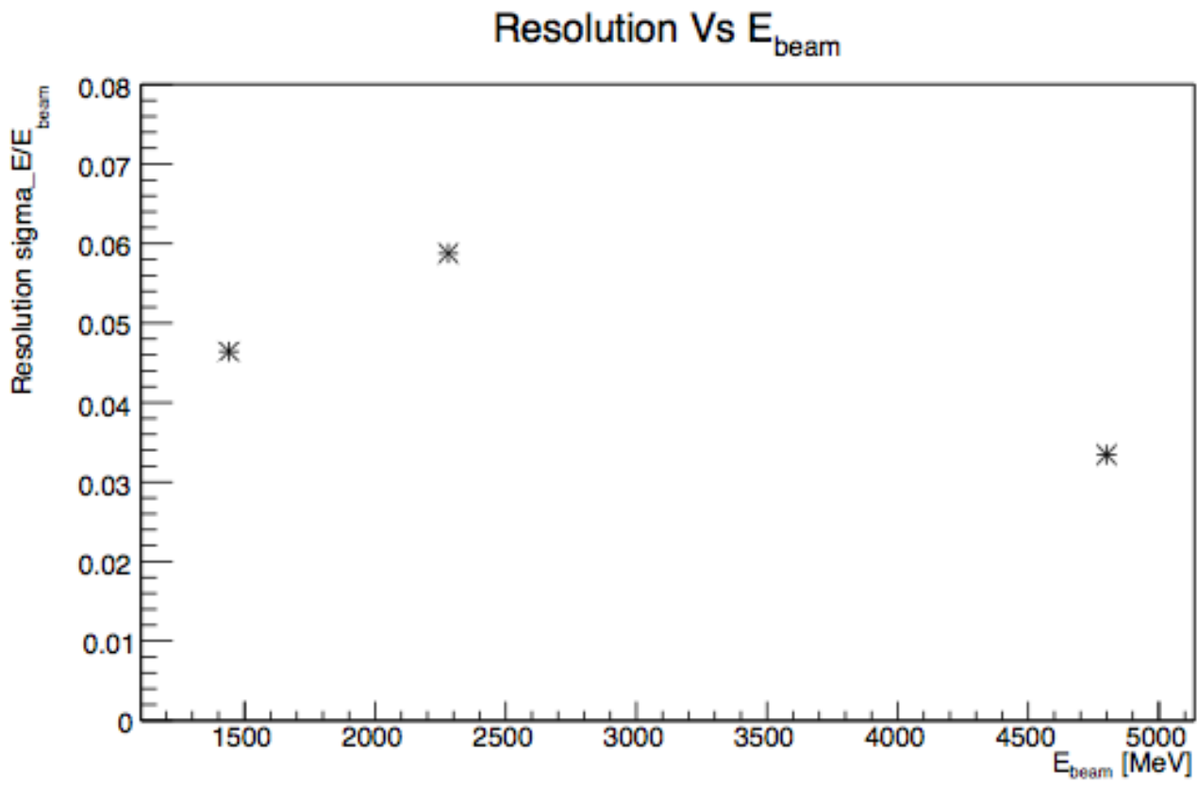


Energy Resolution - Integration

Protons

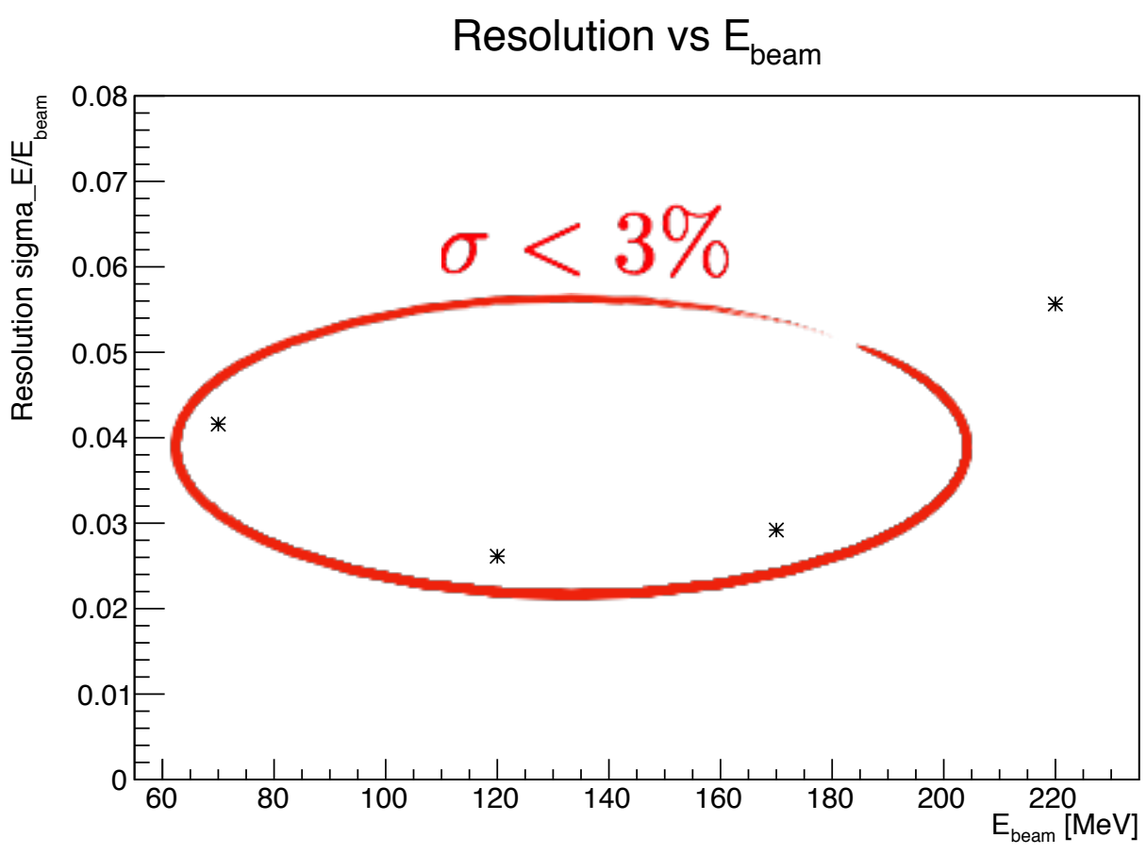


Carbons

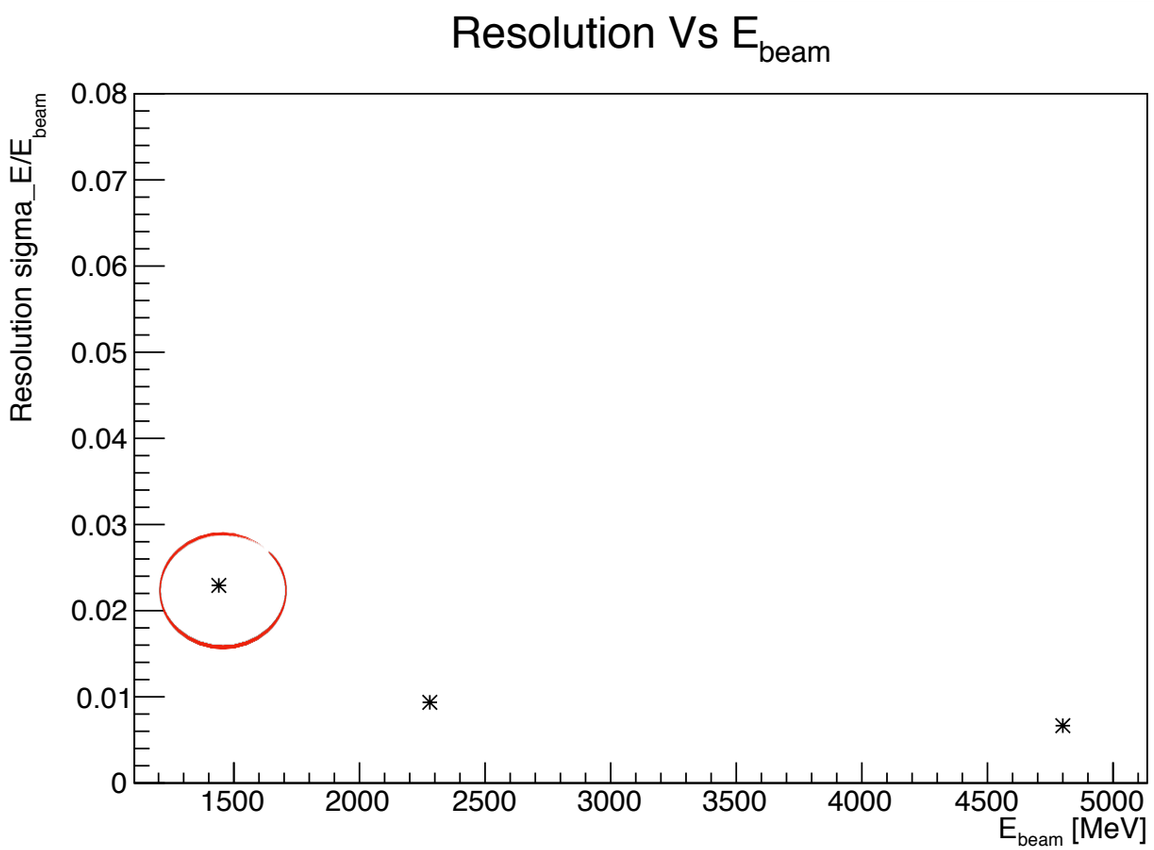


Energy Resolution - Amplitude

Protons



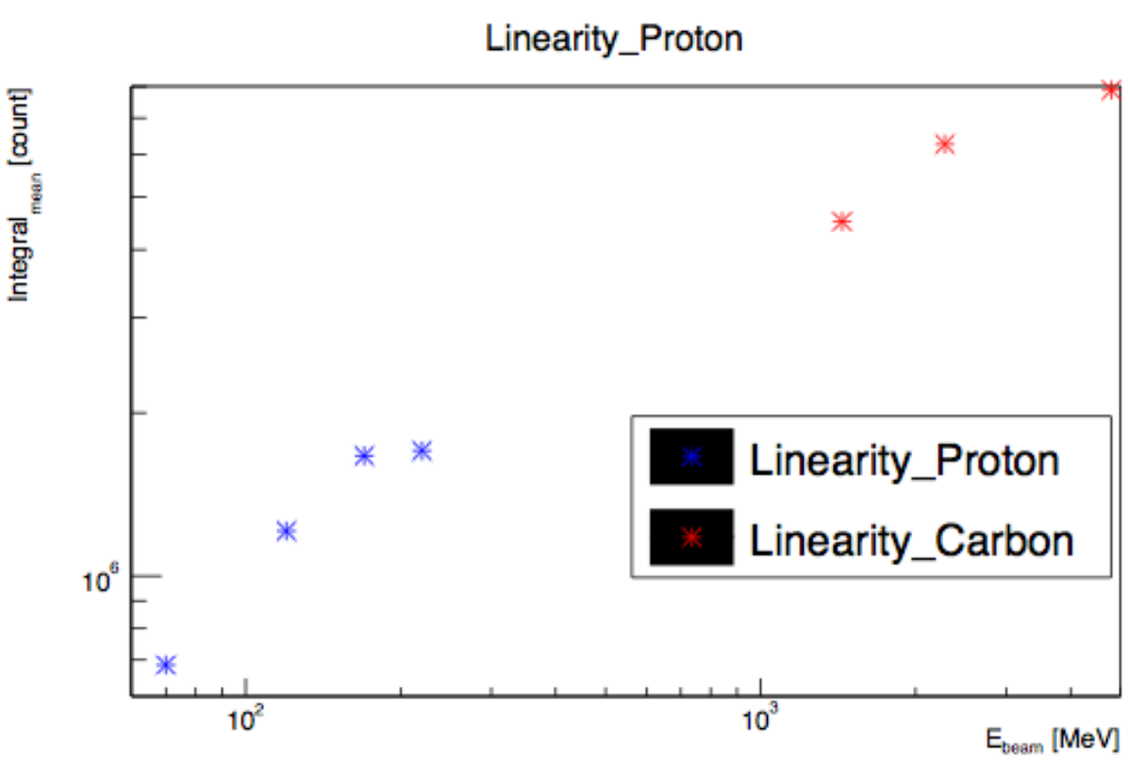
Carbons



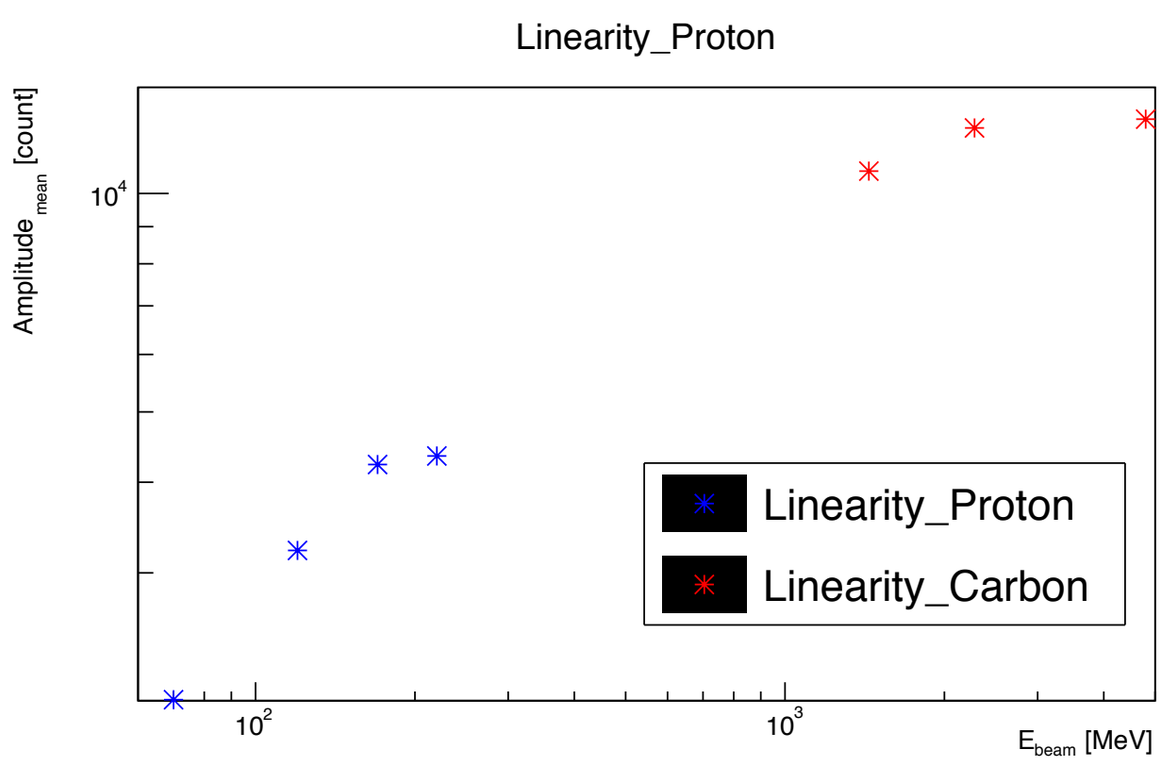
Linearity

Linearity between the beam energy and the mean value of the signal

Integration



Amplitude

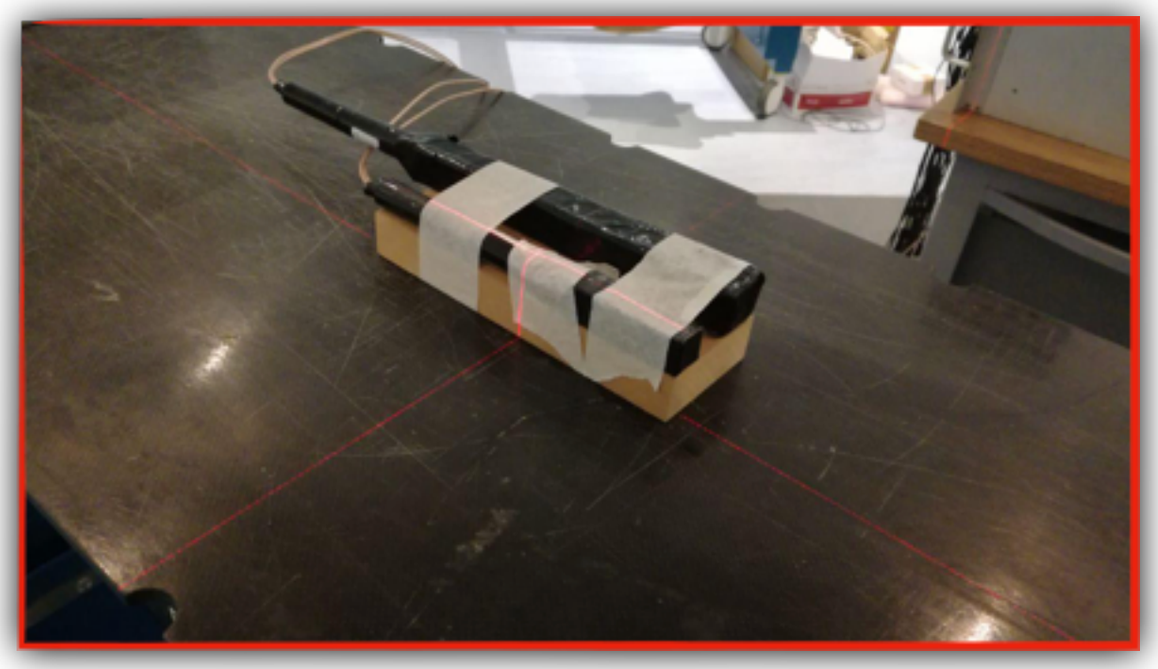


Calorimeter preliminary test at CNAO

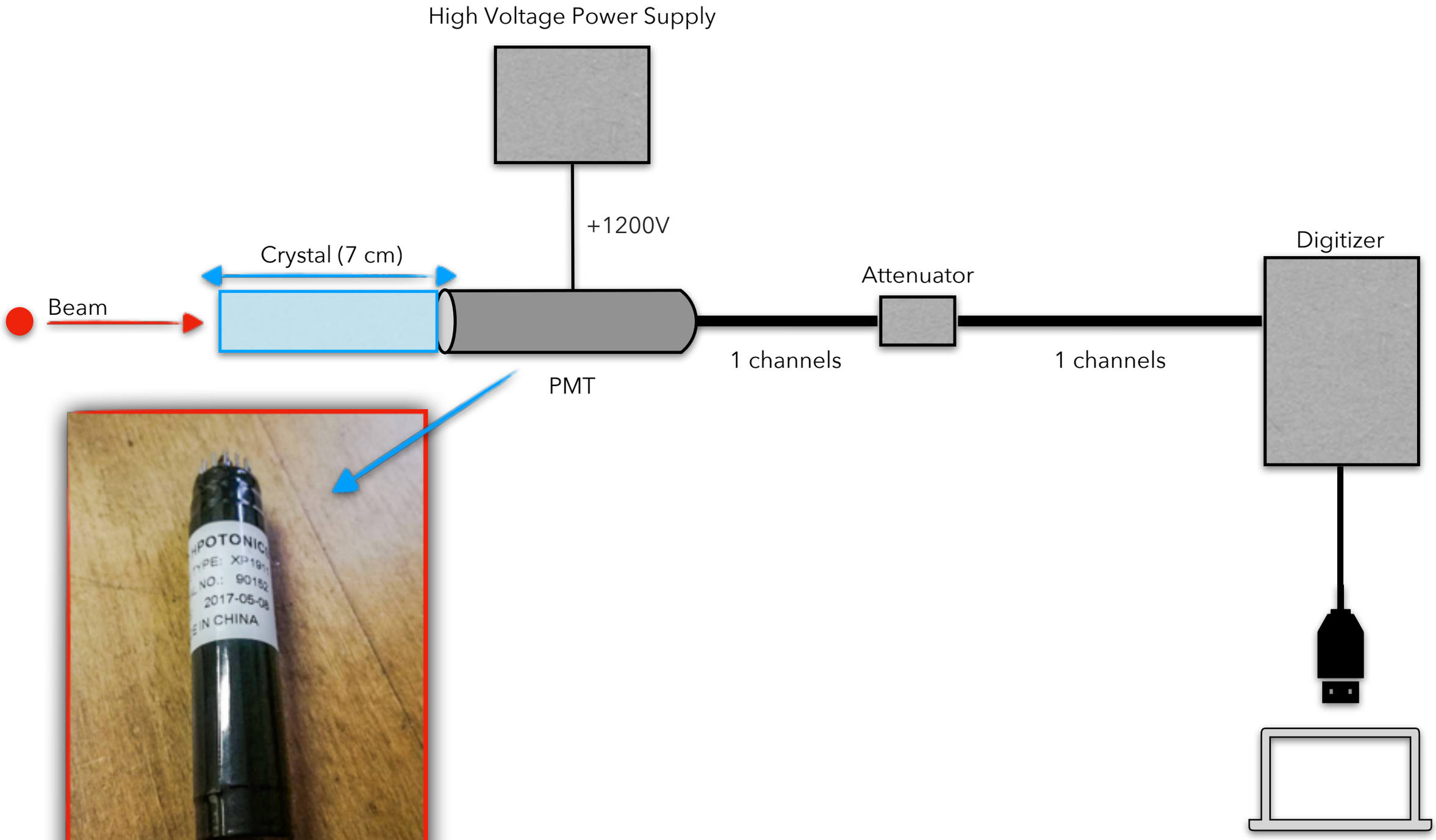
- PMT
  - Crystal **24 cm** long
  - Crystal **7 cm** long

Carbon beam

- **120 MeV/u**
- **190 MeV/u**
- **260 MeV/u**
- **330 MeV/u**
- **400 MeV/u**

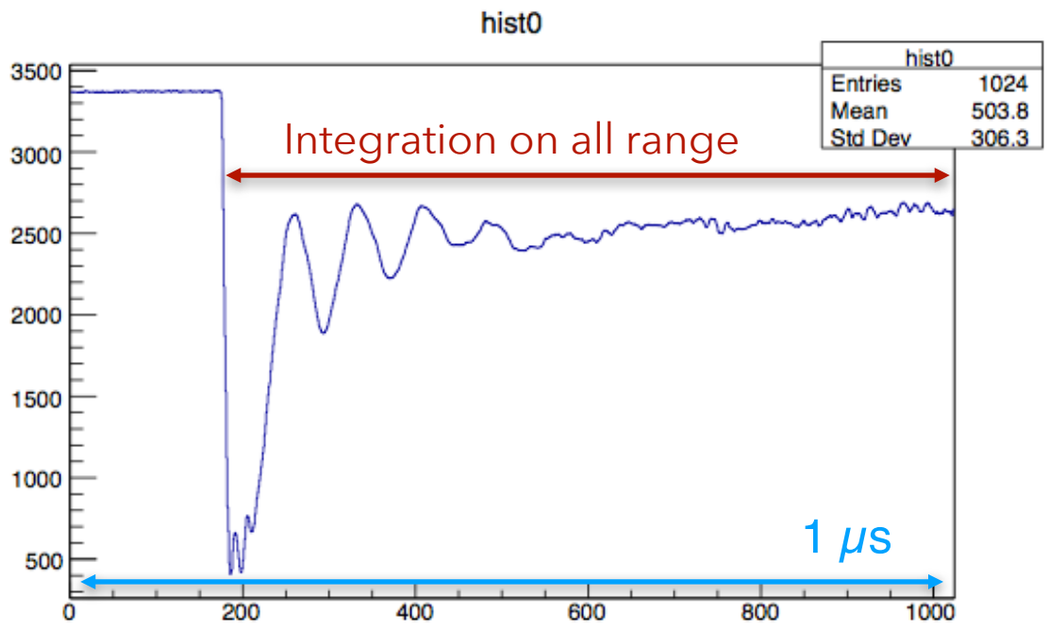


PMT test setup

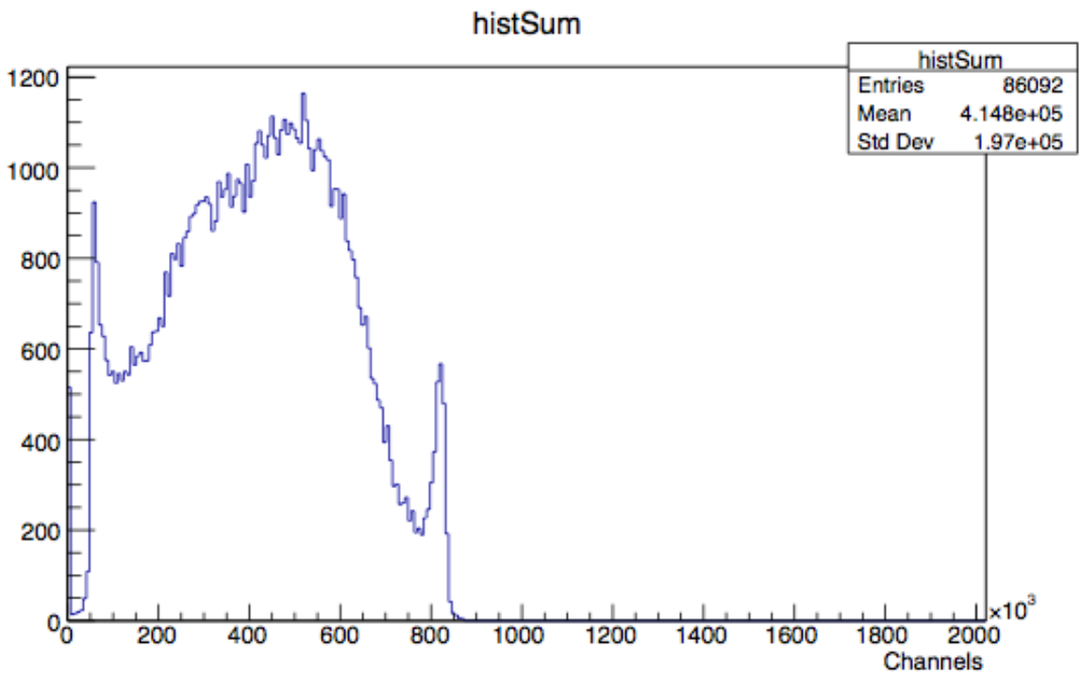


Carbon beam, 120 MeV, Crystal 7 cm long

PMT Signal Integration

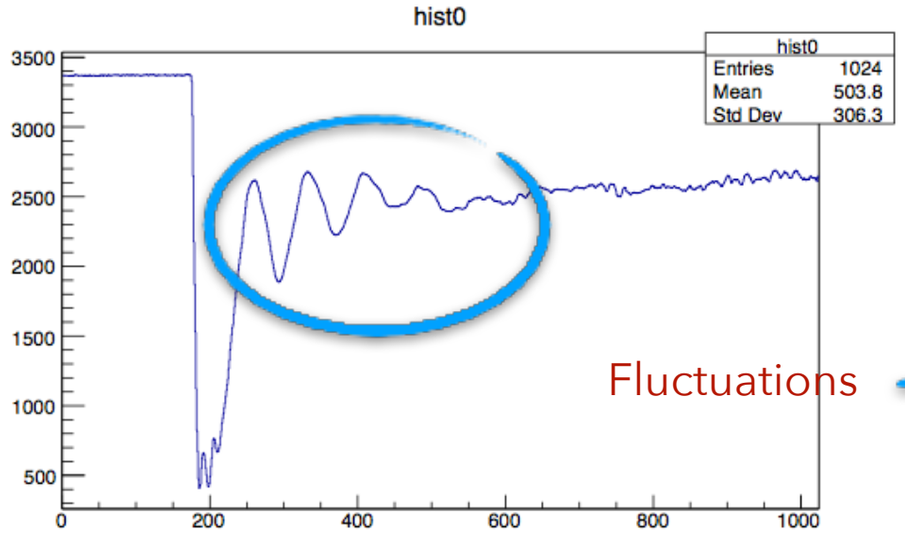


Integration of all signals

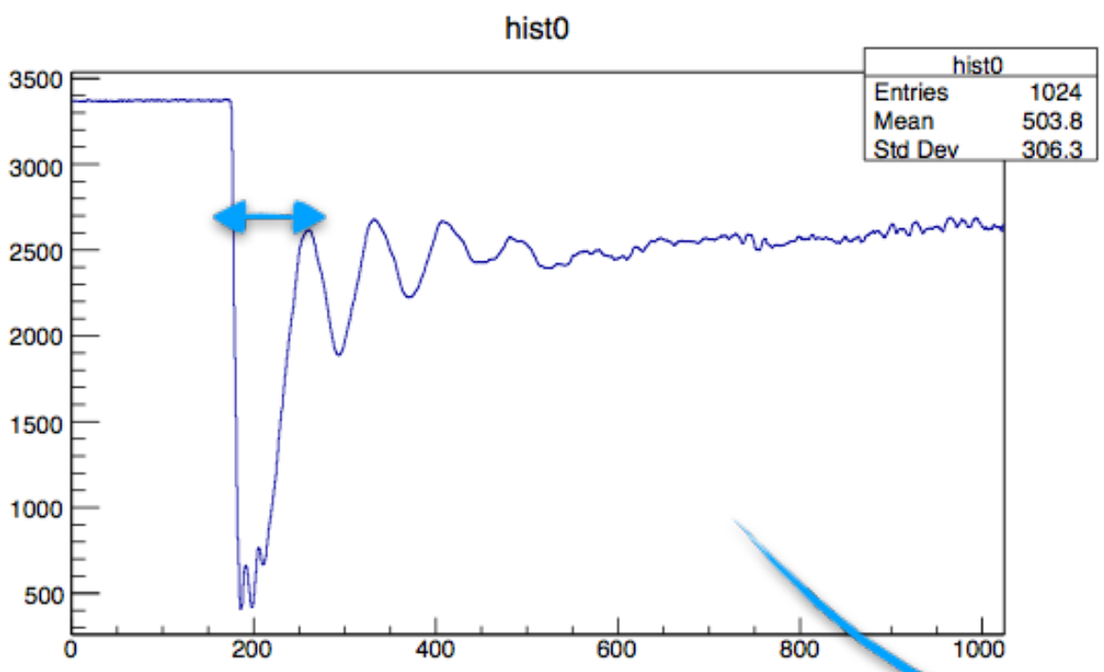


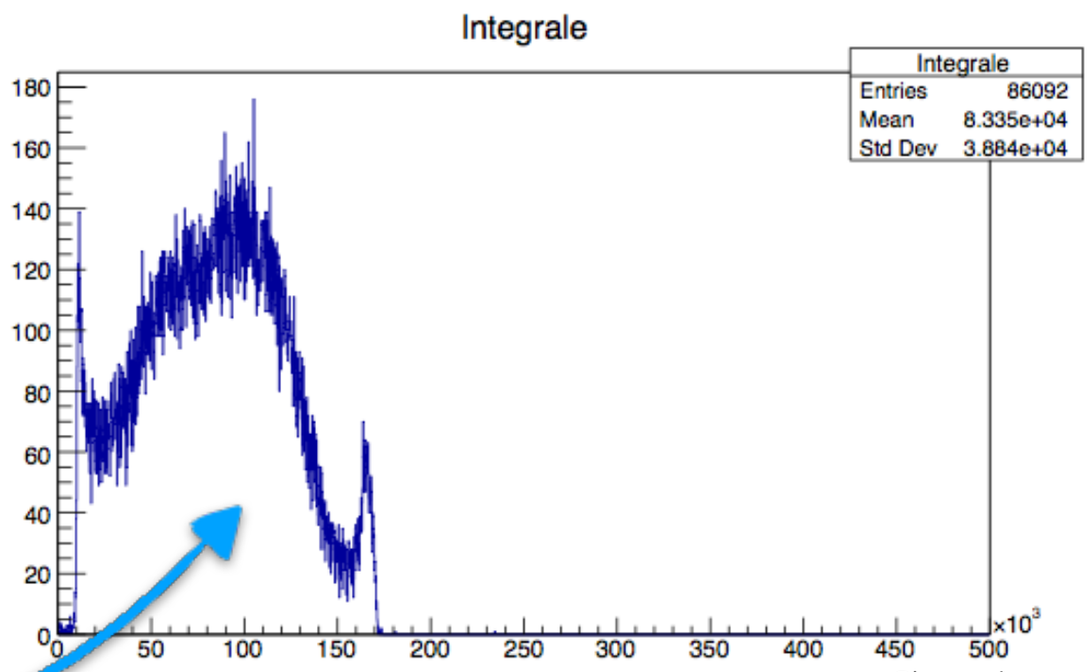
Carbon beam, 120 MeV, Crystal 7 cm long

PMT Signal Integration



Fluctuations → maybe attenuator?



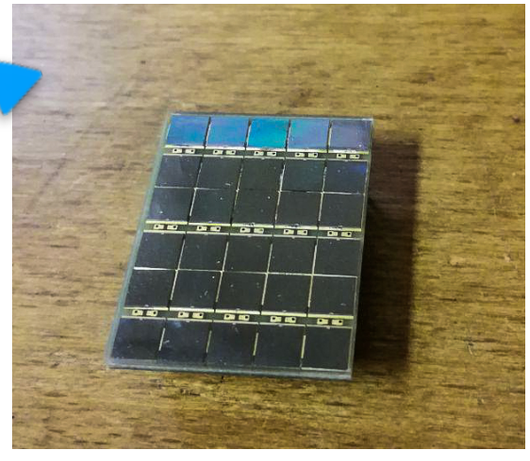


Other tests will have to be performed …

SiPM readout board scheme

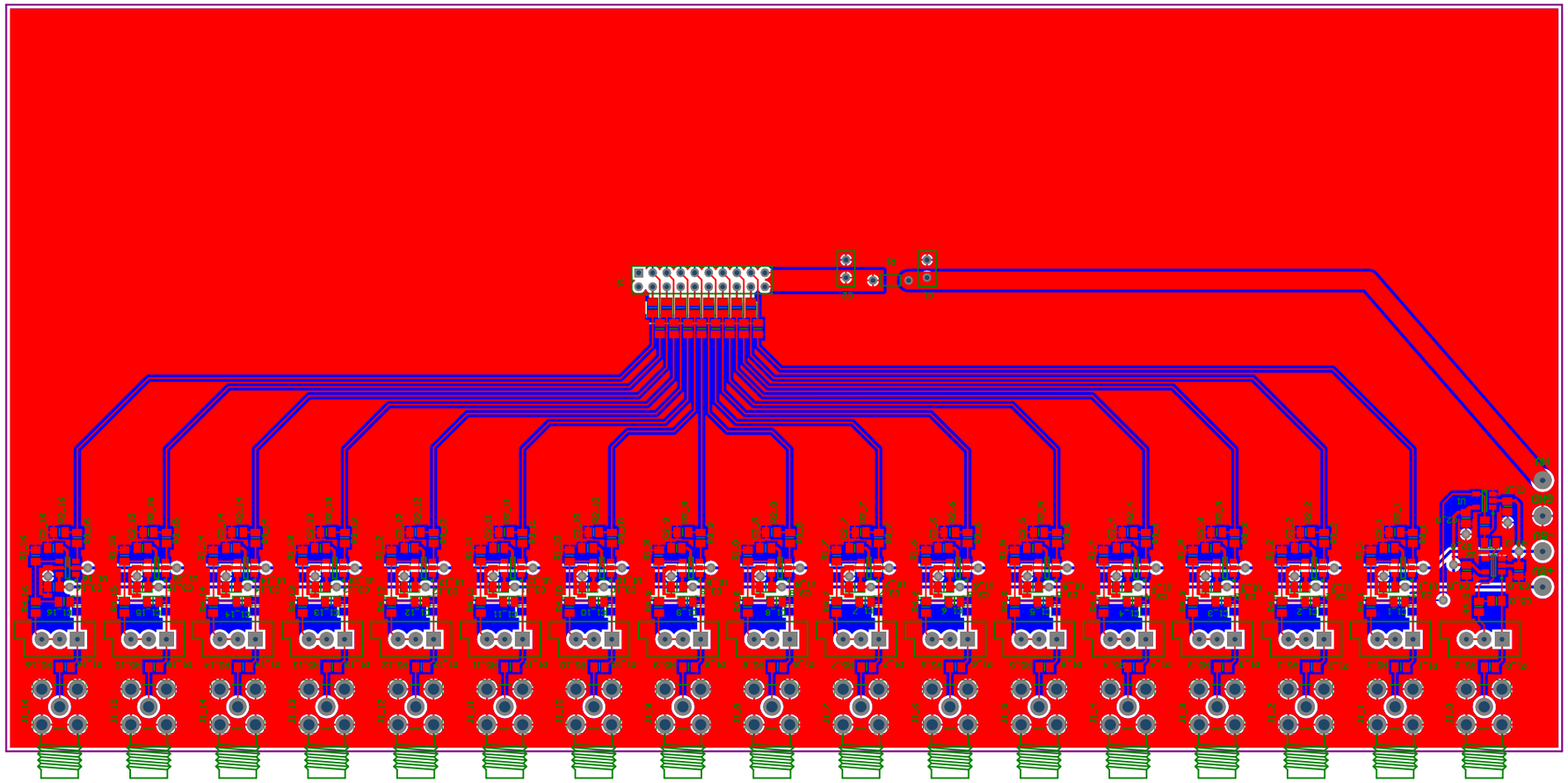
CNAO, July 2018

- Test on SiPMs with 15-20 μm pitch with 15 cm and 24 cm long crystals



Readout board for SiPM with 15 um microcell size

- will be available in about 2 weeks
- Test at CNAO most likely on Jume 24th-25th



Calorimeter preliminary test at CNAO, July 2018

- SiPM
  - Crystal: **24 cm** long

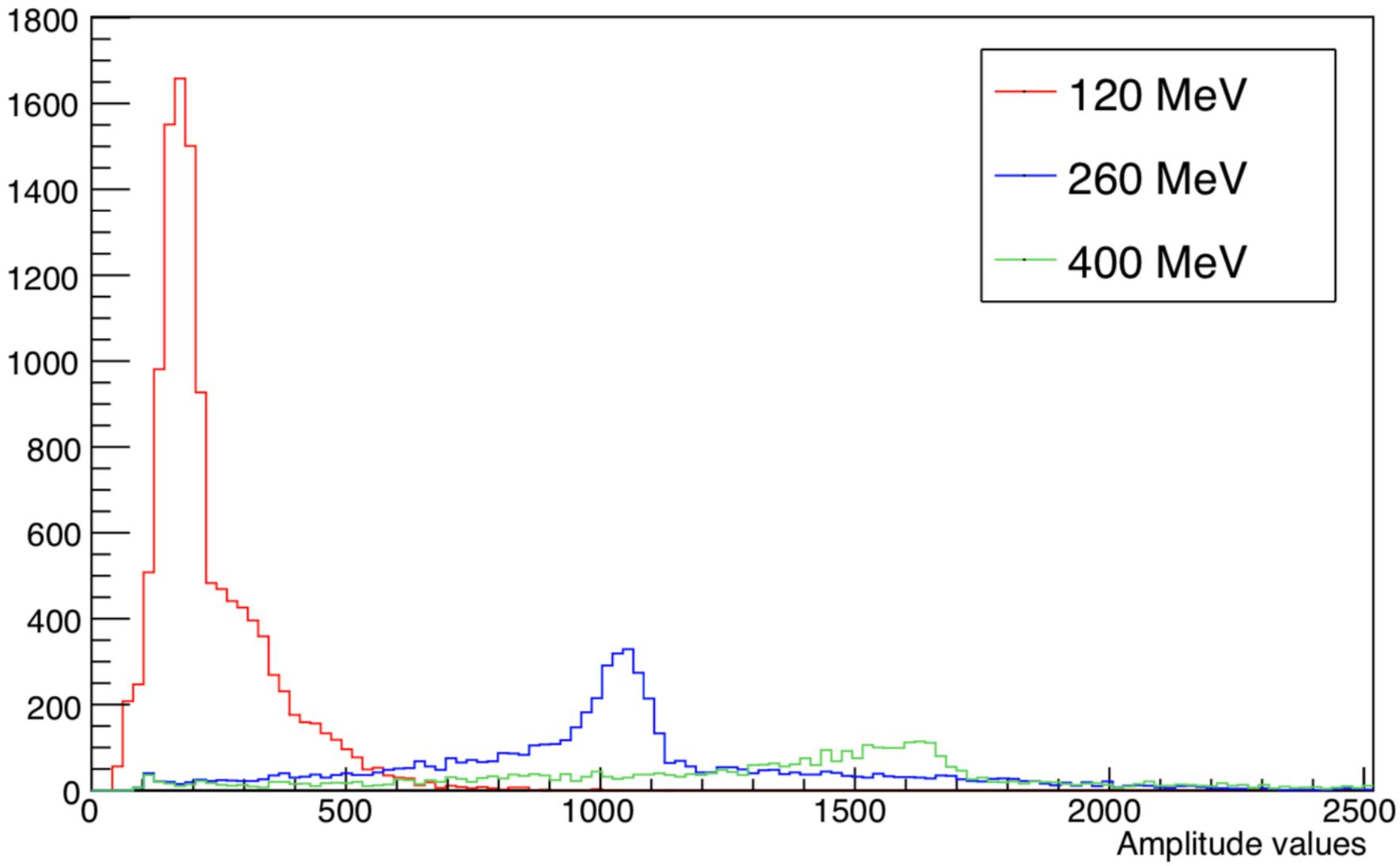
Proton beam → **70 MeV**, **120 MeV**

Carbon beam → **120 MeV/u**, **260 MeV/u**, **400 MeV/u**

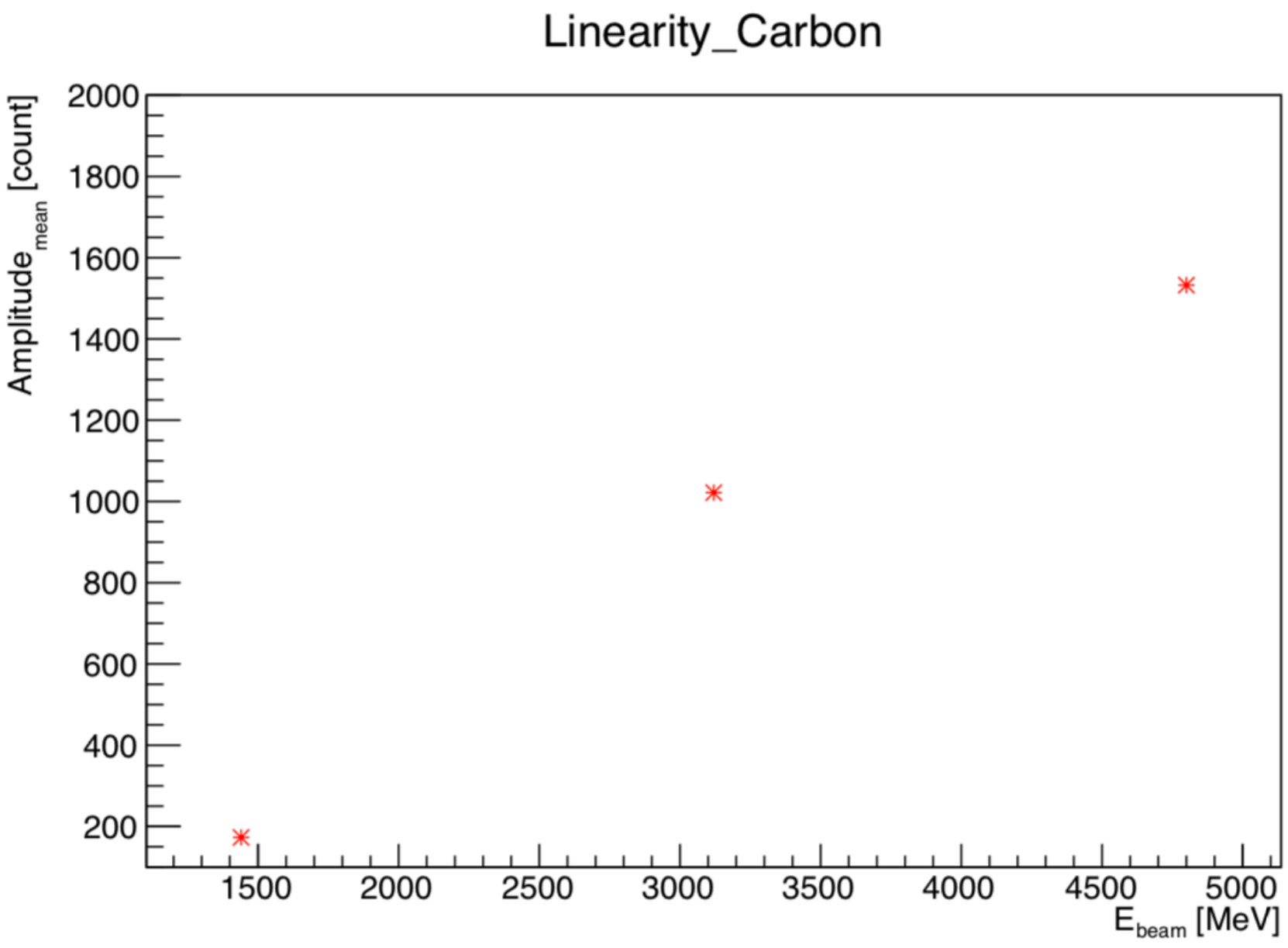
CNAO, July 2018

Carbon Beam

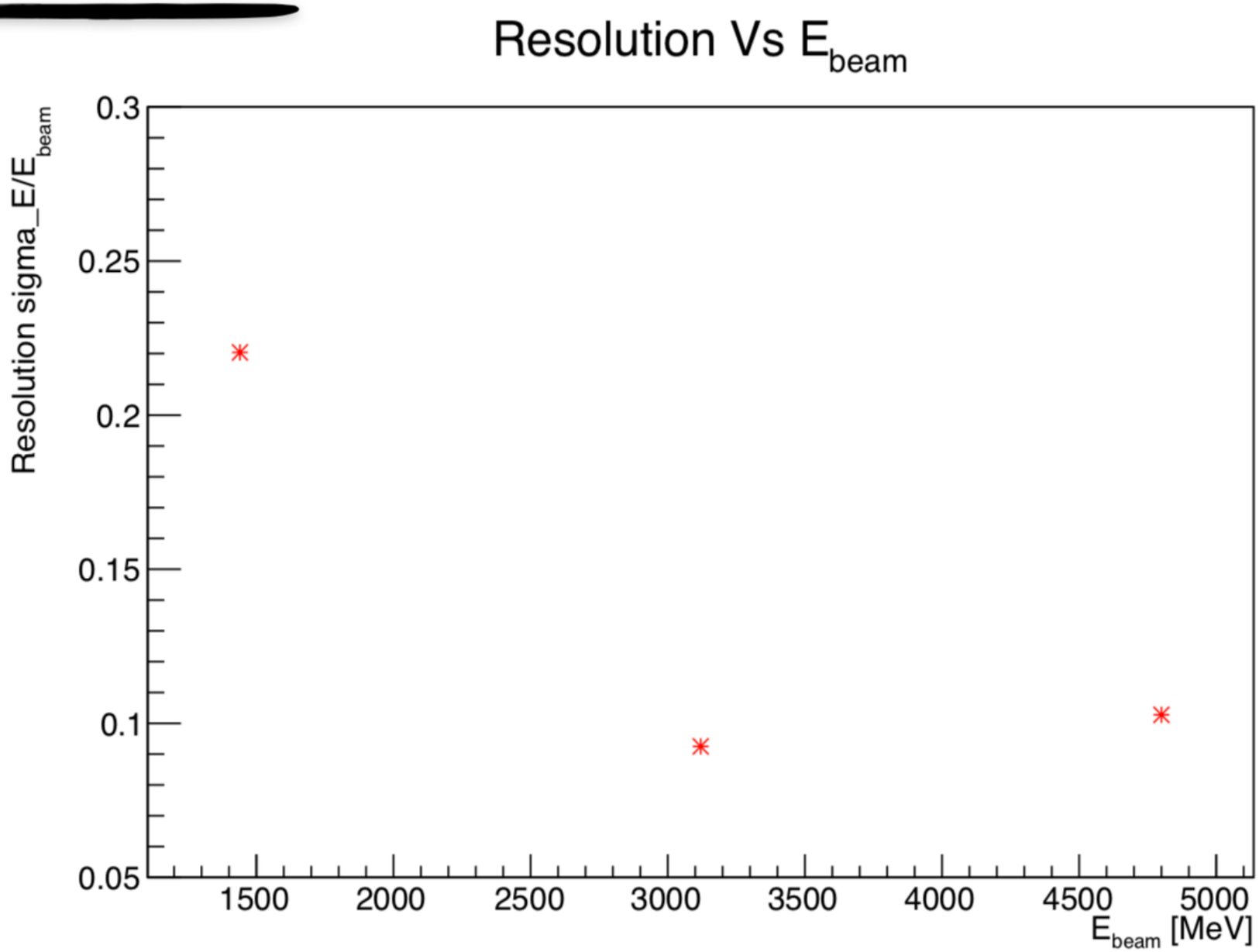
Amplitude distribution for channel 0 with different energy beams



Carbon Beam

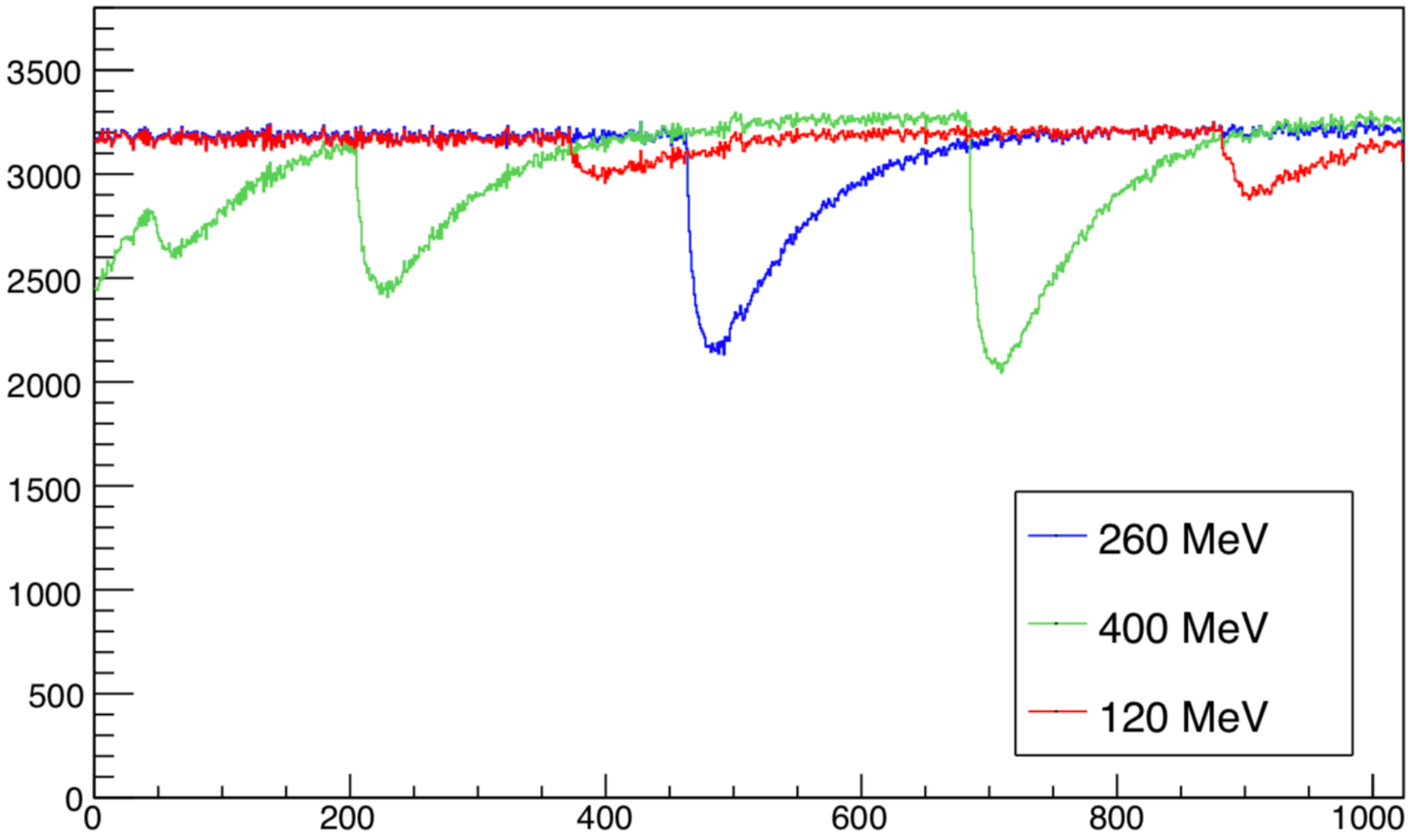

Linearity_Carbon
Amplitude_mean [count]
2000
1800
1600
1400
1200
1000
800
600
400
200
1500
2000
2500
3000
3500
4000
4500
5000
E_beam [MeV]

Carbon Beam


Resolution Vs E_{beam}
Resolution sigma_E/E_{beam}
0.3
0.25
0.2
0.15
0.1
0.05
1500
2000
2500
3000
3500
4000
4500
5000
E_{beam} [MeV]

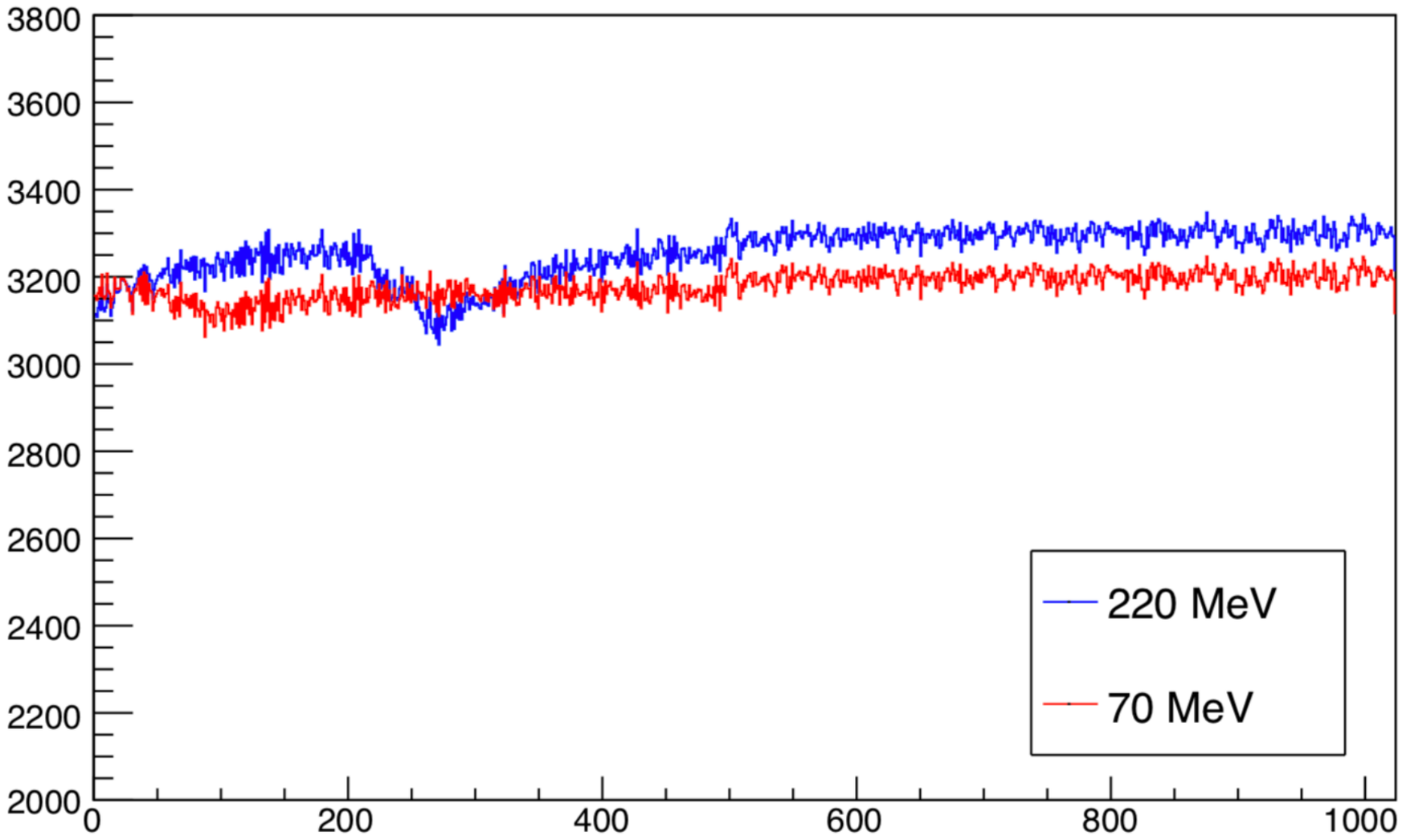
Carbon Beam

Wave Shapes



Proton Beam

Wave Shapes



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August, 28th, 2018, Roma

15 μm SiPM prove to be linear – as expected

Next test at CNAO (probably in September):

- **20 and 30 μm SiPM validation**
- **with all the channels**
- **validate energy resolution**

3x3 (4x4) readout boards with 9 (16) output channels (1/crystal)
Amplification factor to be defined
Output to Digitizers

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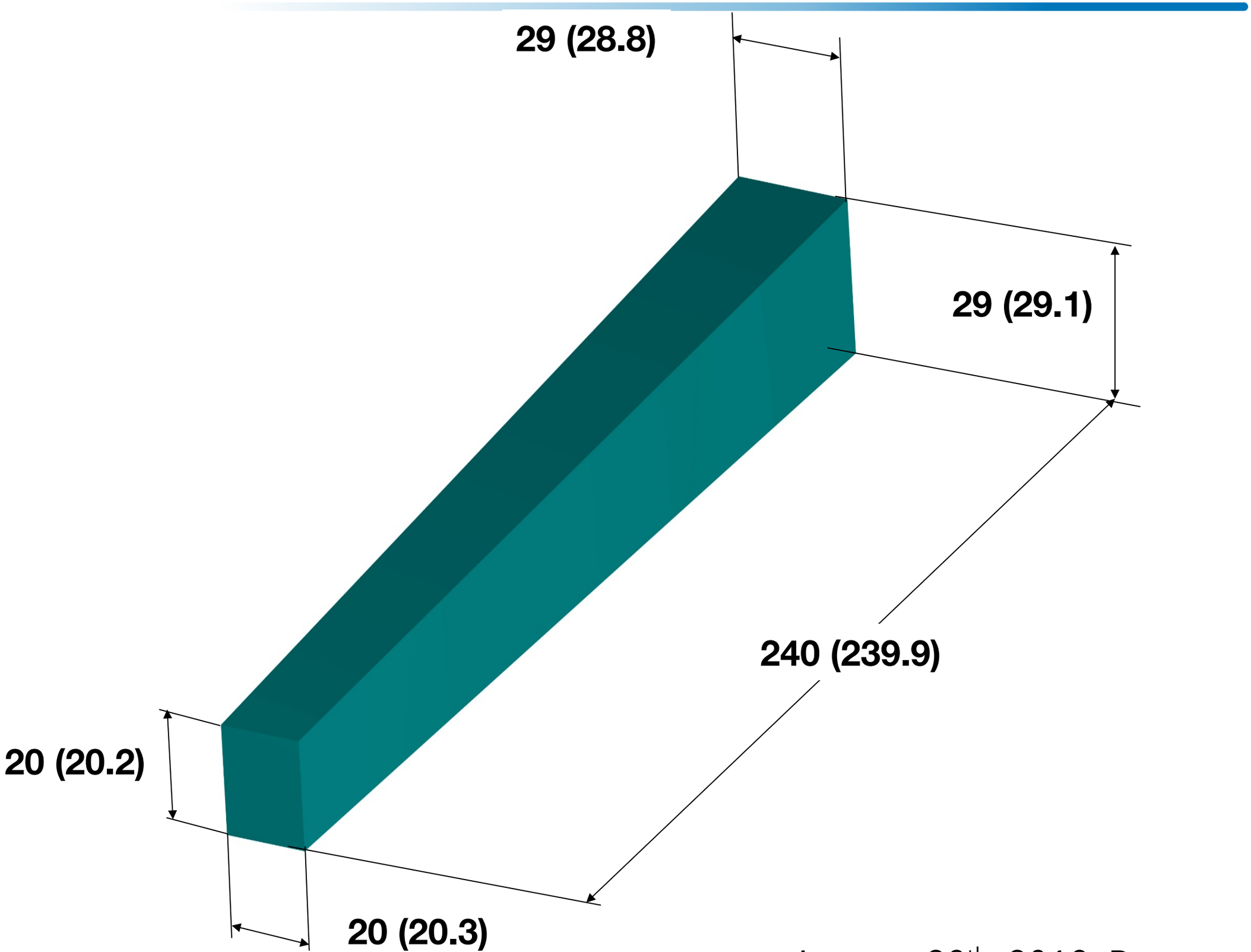
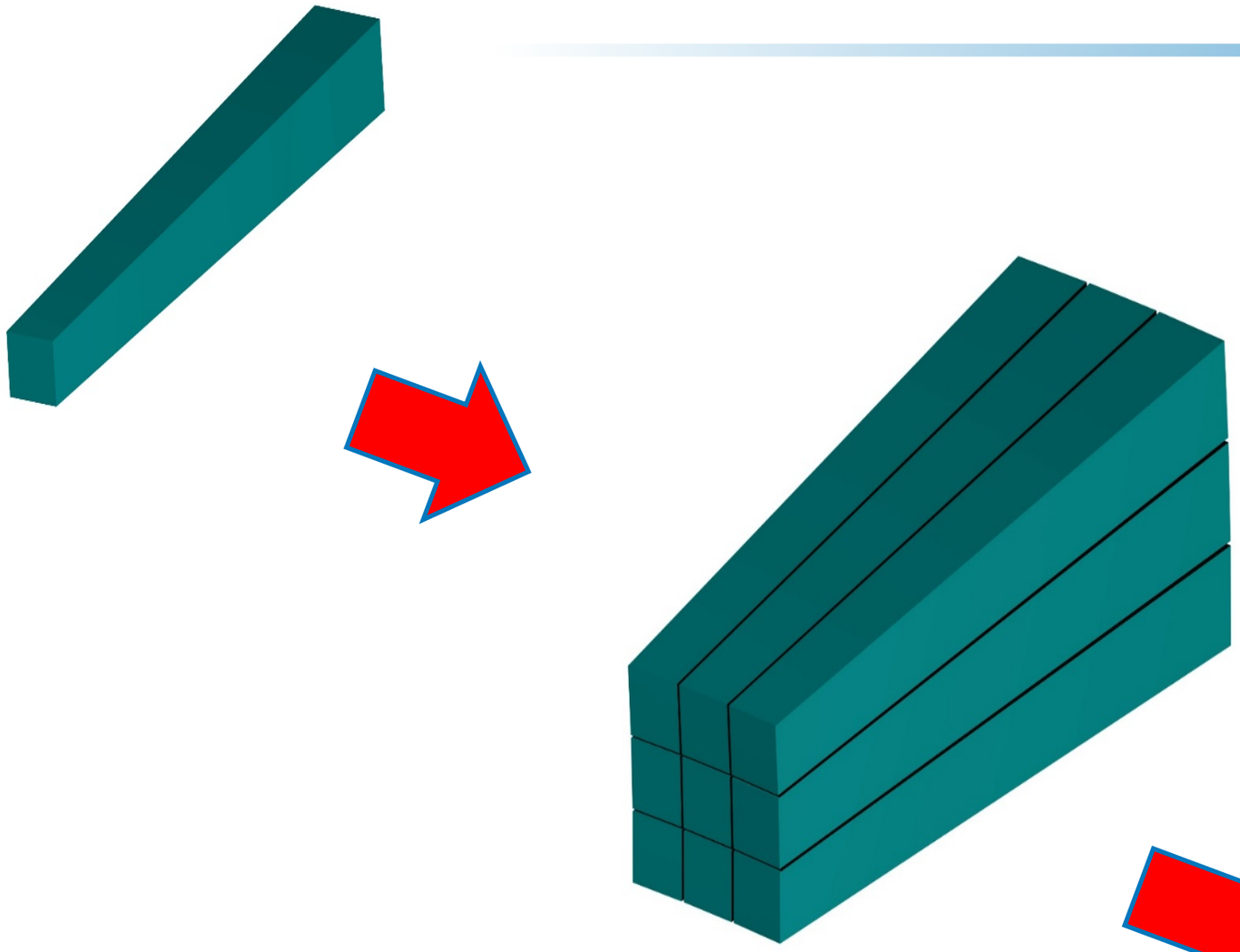
The crystals

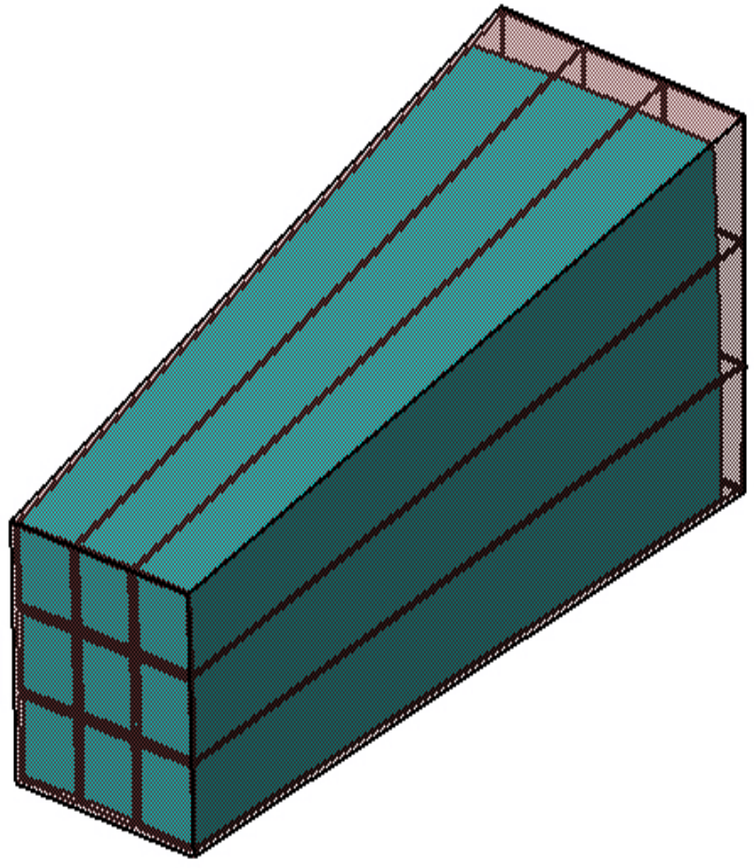


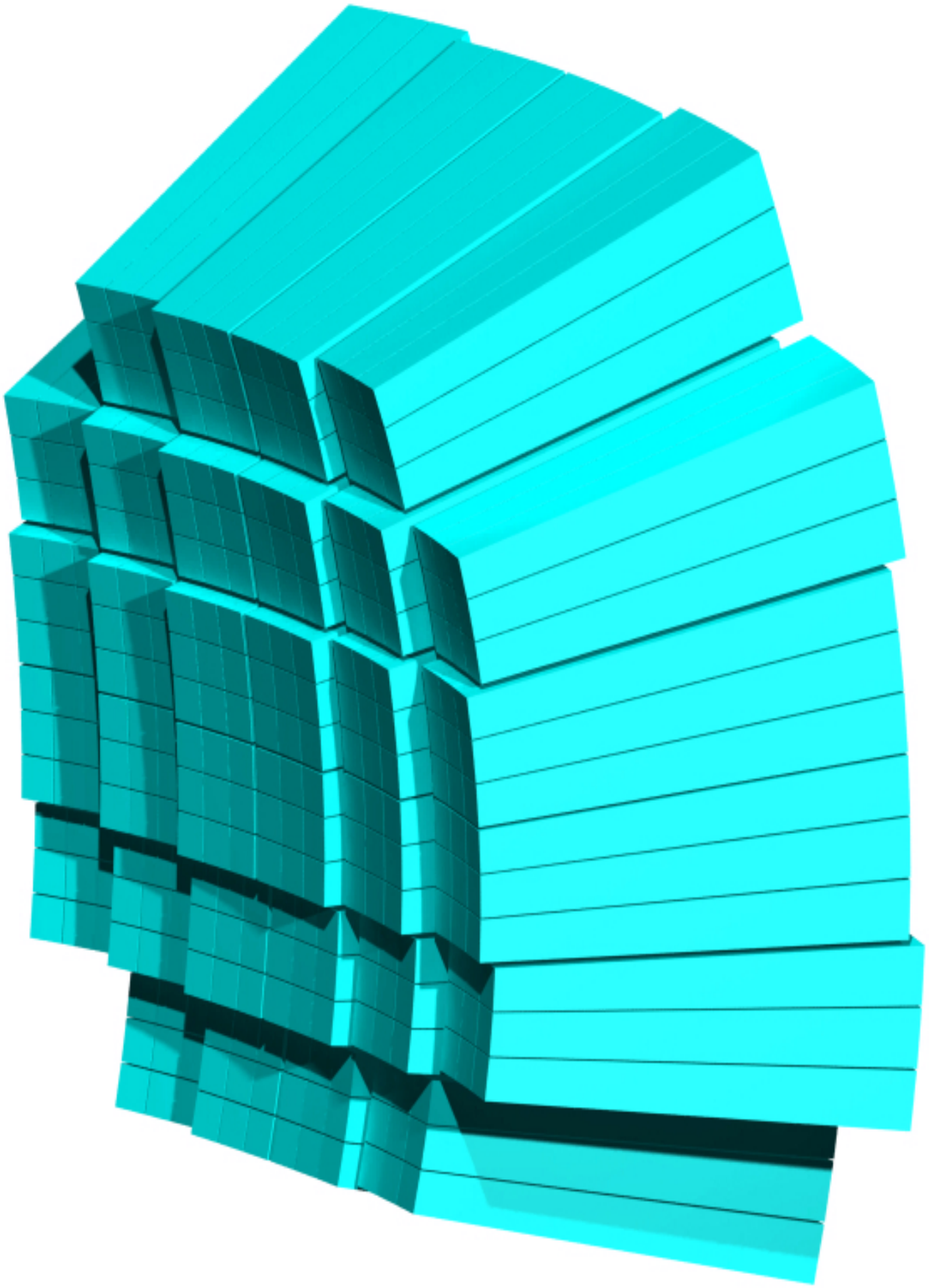
Module definition



Matrix 3x3 crystals

Plastic box

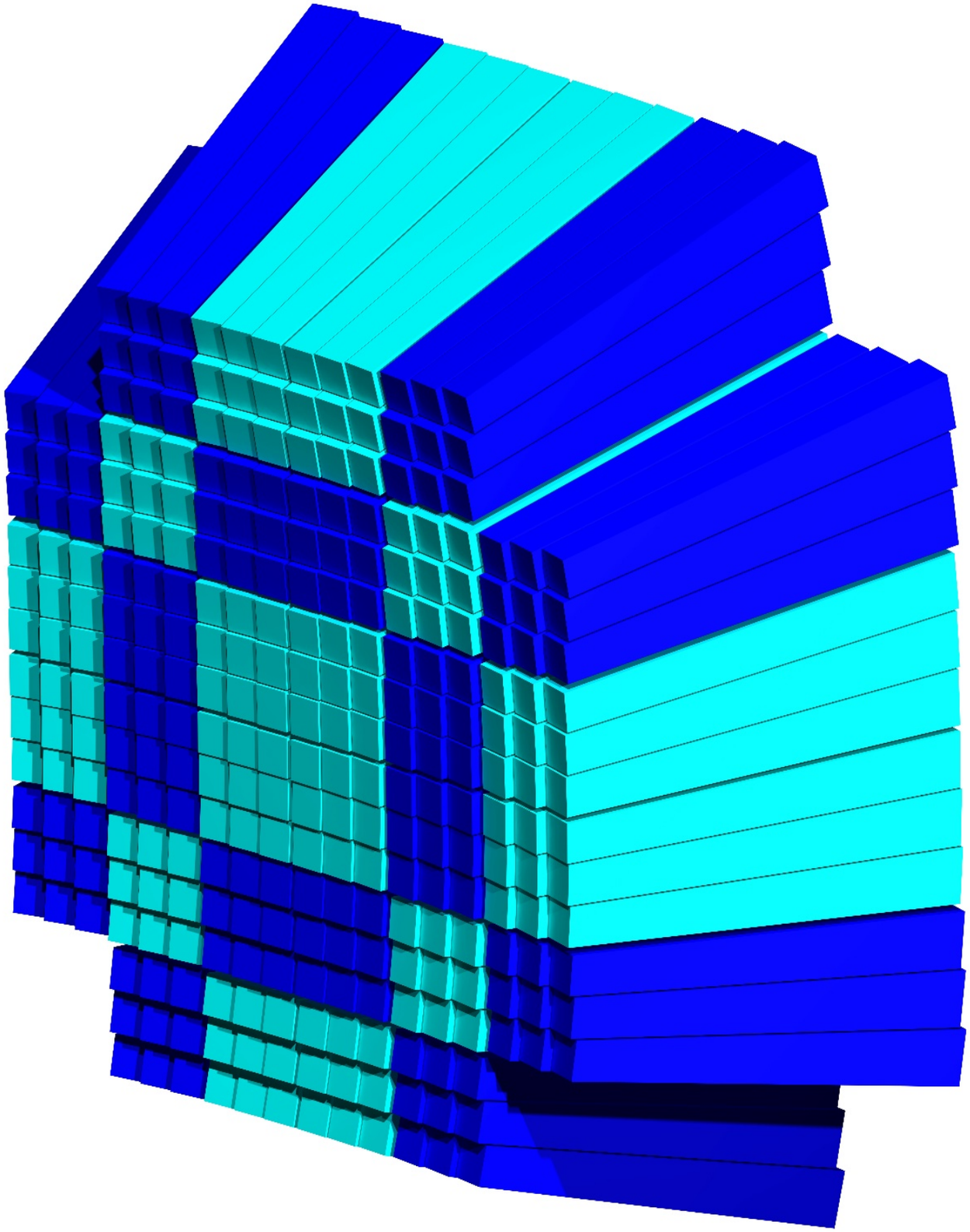




Modules layout – option 1

arrangement of 32 modules
1 plastic box design

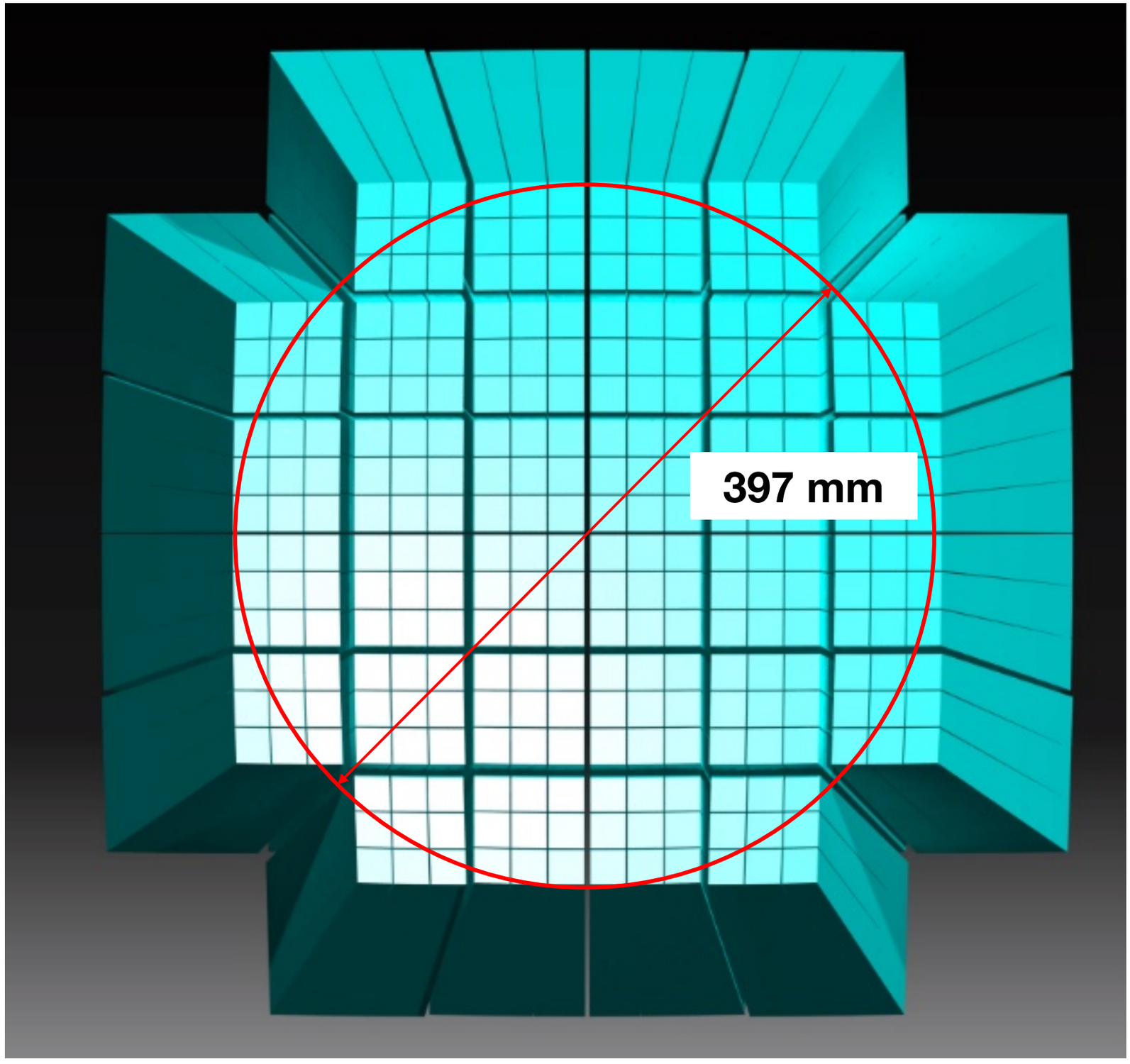
Modules layout – option 2

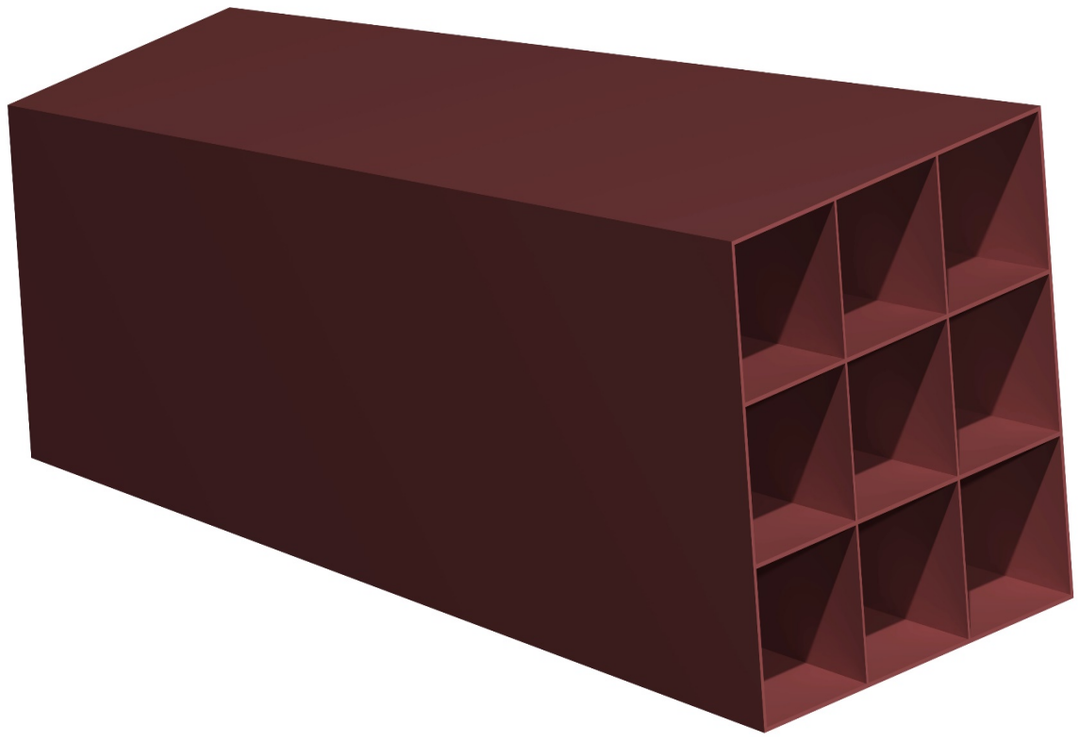


Single arrangement of 288 crystals

16 plastic box designs

Modules layout – front view

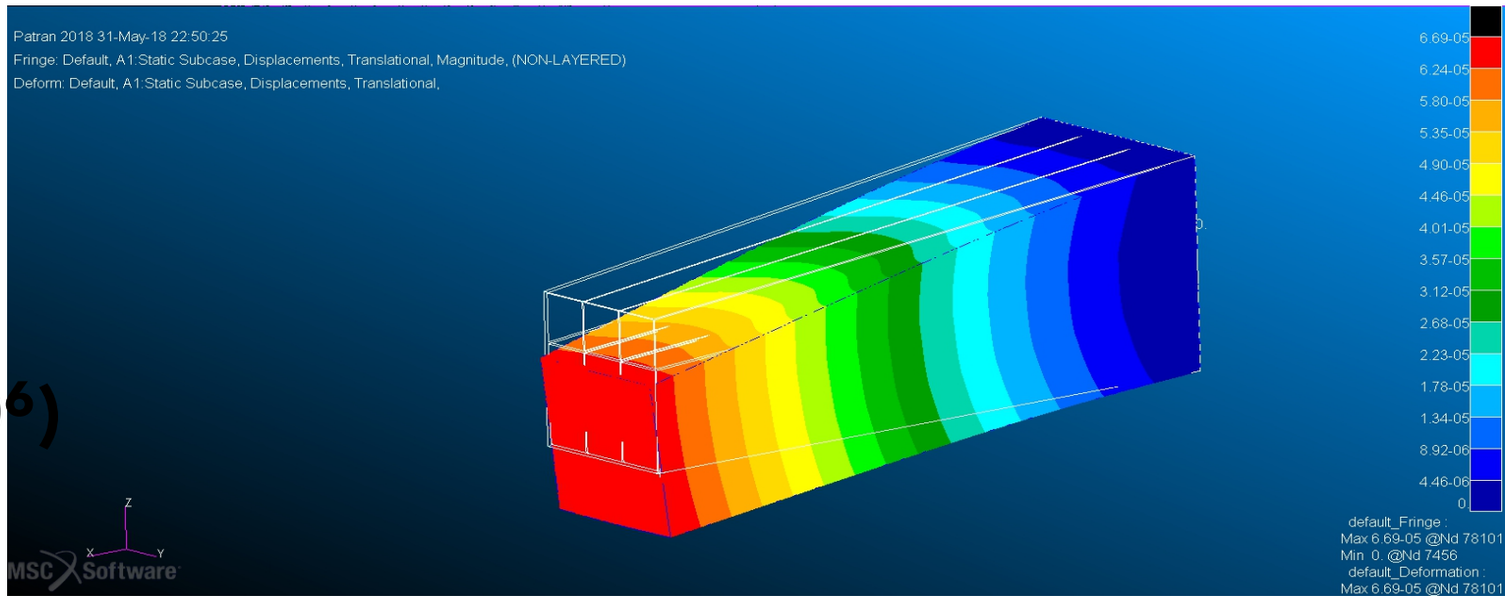




Module case

The box houses 9 crystals
ABS reinforced or similar material
E≈4 GPa
3D printing (?)

Max displacement ≈ 70μm
Max stress 9,5·10^5 Pa
(ABS Tensile strength ≈ 25·10^6)



Plans

- **complete crystal transparency measurements (end 2018)**
- **test at CNAO with 15/20/30 um SiPM (resolution)**
- **build prototype of 9 modules case**
- **freeze readout chain**
- **start procurement**
- **start crystal calibration**
- **R/O + calibration sw development**

Richieste 2019

MISSIONI	1. 5 giorni di presa dati al GSI per 3 persone	3.50
	2. Collaboration Meeting 5 p x 3 gg x 2	6.50
	3. Calibrazioni cristalli CNAO (3 p x 15 n)	10.00
CONSUMO	1. metabolismo	1.00
INVENTARIO	1. 10 Digitizers CAEN V1742	103.00
	2. 40 A654 KIT8 - 8 MCX TO LEMO Cable Adapter	12.00
APPARATI	1. SiPM (produzione), nell'ipotesi di accesso a convenzione INFN-FBK	22.00
	2. SiPM (packaging)	78.00
	3. Verniciatura e incollaggio cristalli	52.00
	4. Readout boards	15.00
	5. Meccanica del calorimetro	20.00