FOOT calorimeter

Status Report

Crystals
Photodetector
Readout
Mechanics

Piergiorgio Cerello

Contributions by:

S. Argiro'
R. Arteche Diaz
N. Bartosik
G. Giraudo
N. Pastrone
L. Scavarda
P.P. Trapani

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BGO crystals now available

- **As many as we need**

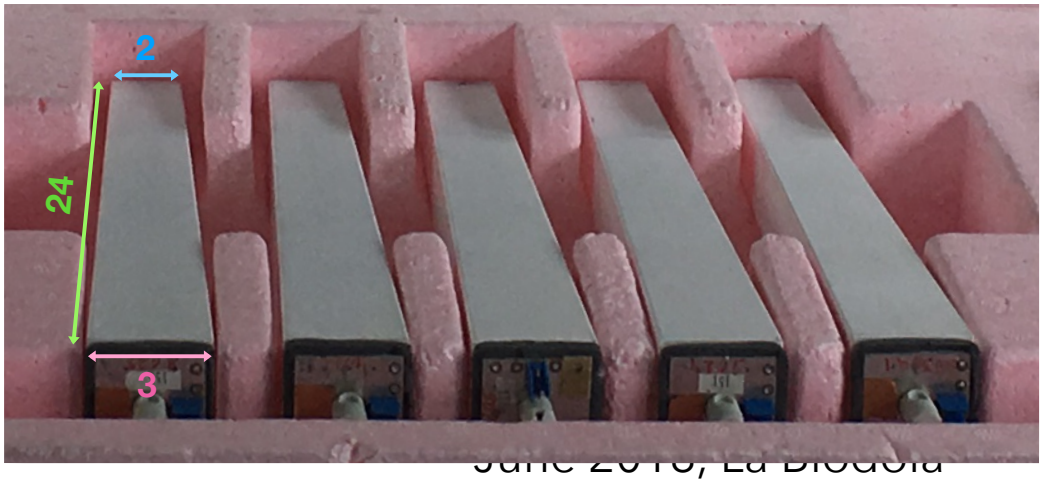
Stored in polystyrol boxes at CERN *(5 crystals/box)*

Crystal dimensions:

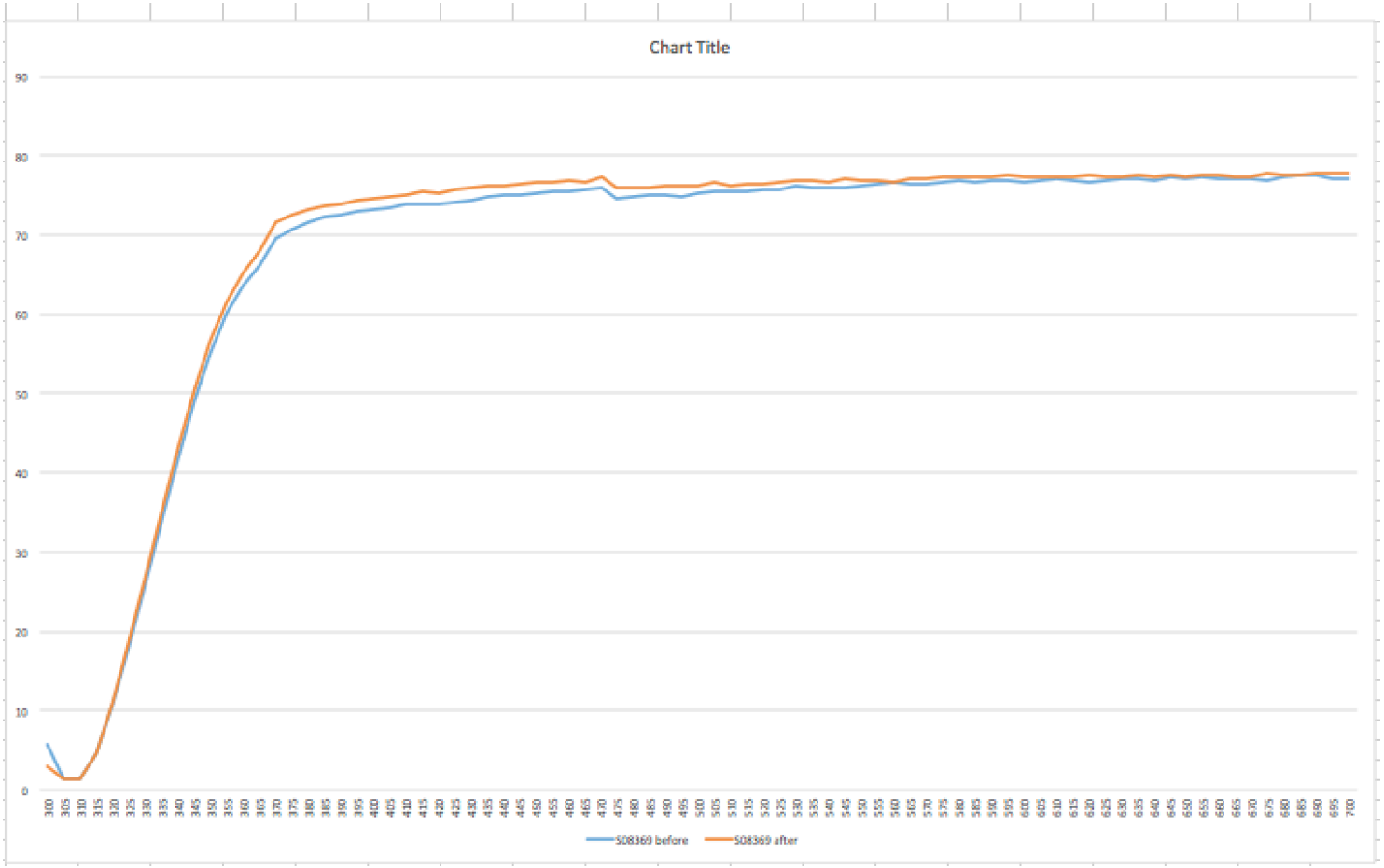
Approx. 2.0 x 24 x 2.9 cm3

Crystal transmission curves:

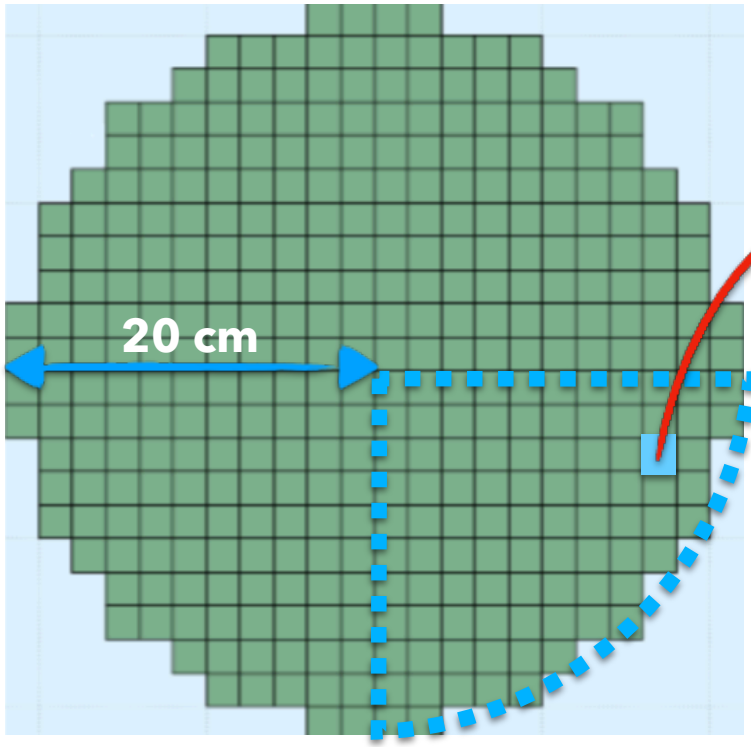
- Ongoing Measurement at CERN



S08369 Transmission curve – pre/post annealing

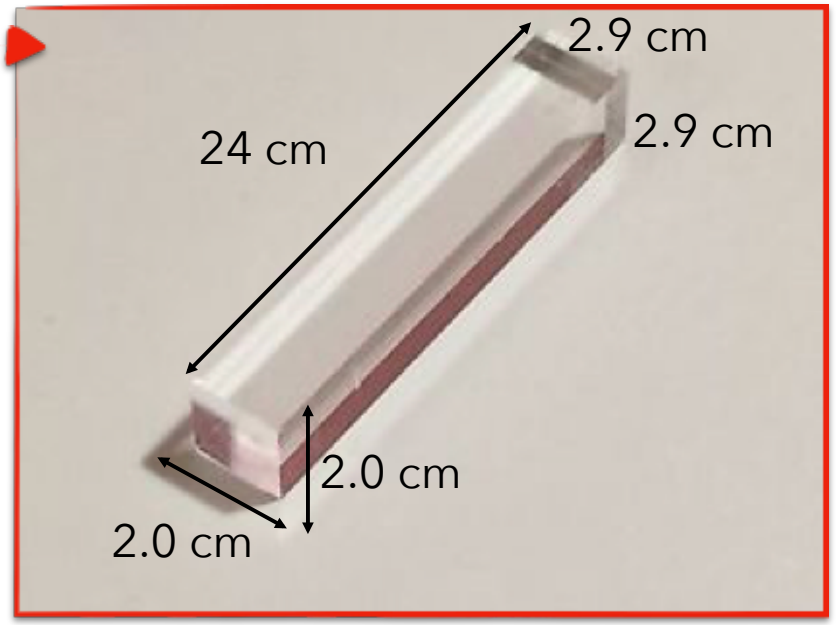


4 quarters of 80 BGO crystals each



$$Z_{Bi} = 83$$

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



Weight: 1027 g
Total weight: 329 Kg

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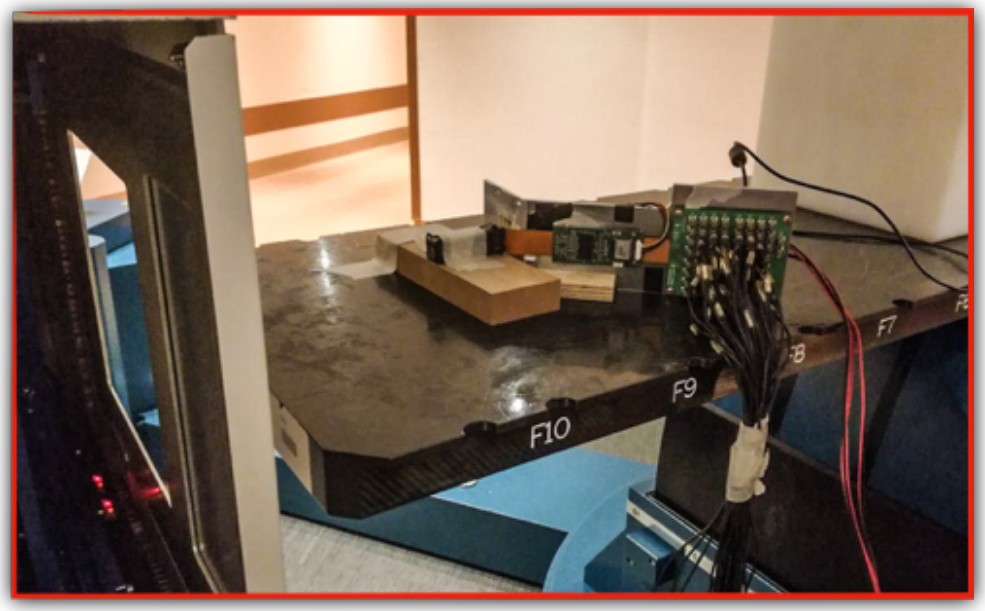
Calorimeter preliminary test at CNAO

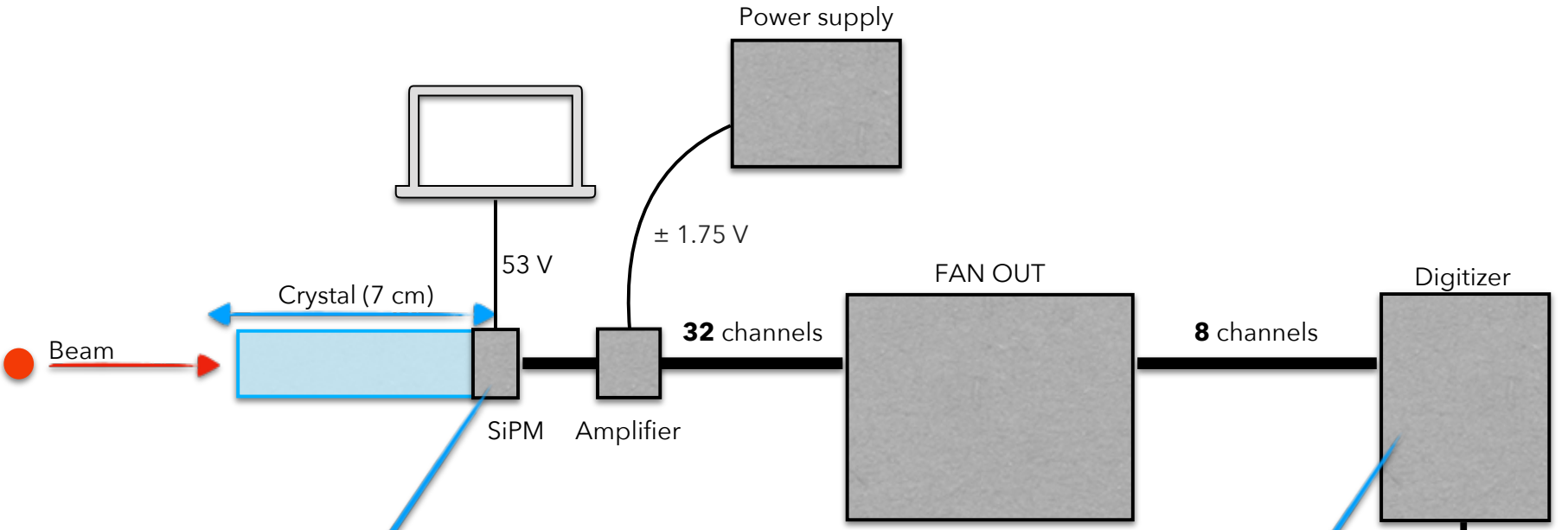
- SiPM
  - Crystal **7 cm** long

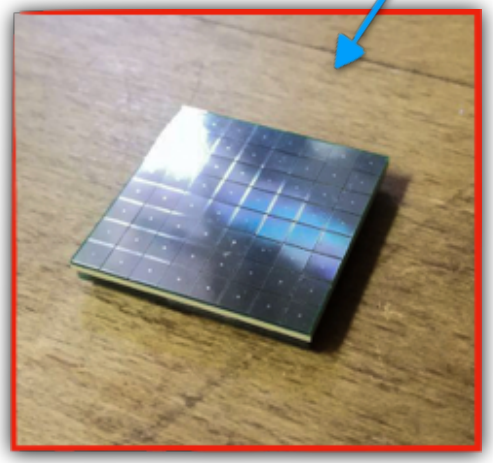
Proton beam
- **70 MeV**
- **120 MeV**
- **170 MeV**
- **400 MeV**

Carbon beam
- **120 MeV/u**
- **190 MeV/u**
- **400 MeV/u**



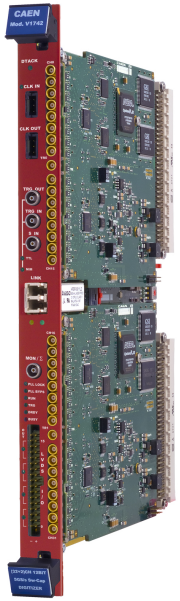
SiPM test setup





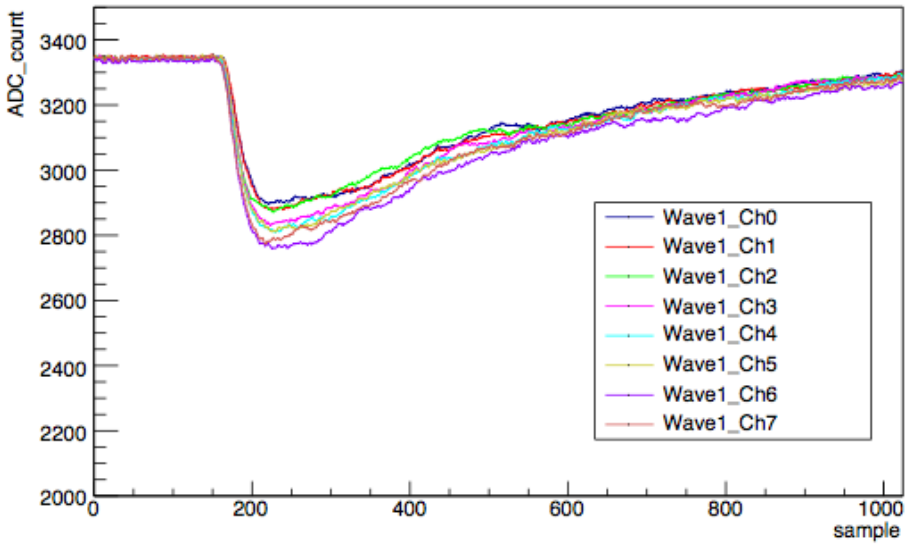
SiPM Hamamatsu
pitch: 50 μm
voltage breakdown: 52 V

Digitizer CAEN V1742



Proton beam, 170 MeV, 7 cm crystal long

Wave Form



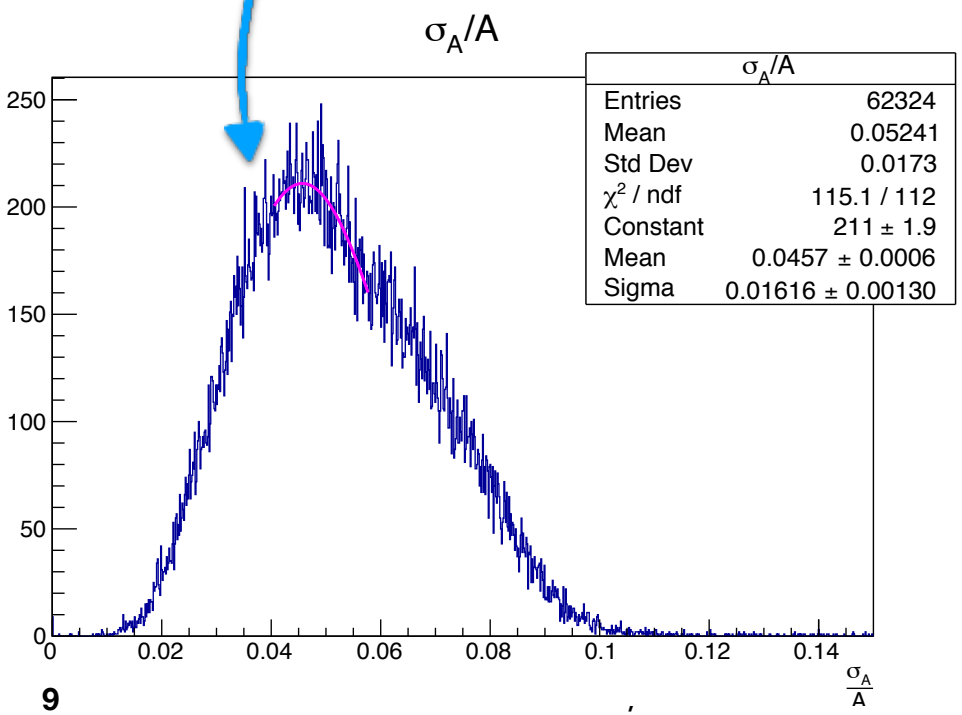
Same event acquired in the 8 channels of Digitizer

Same wave form for all channels

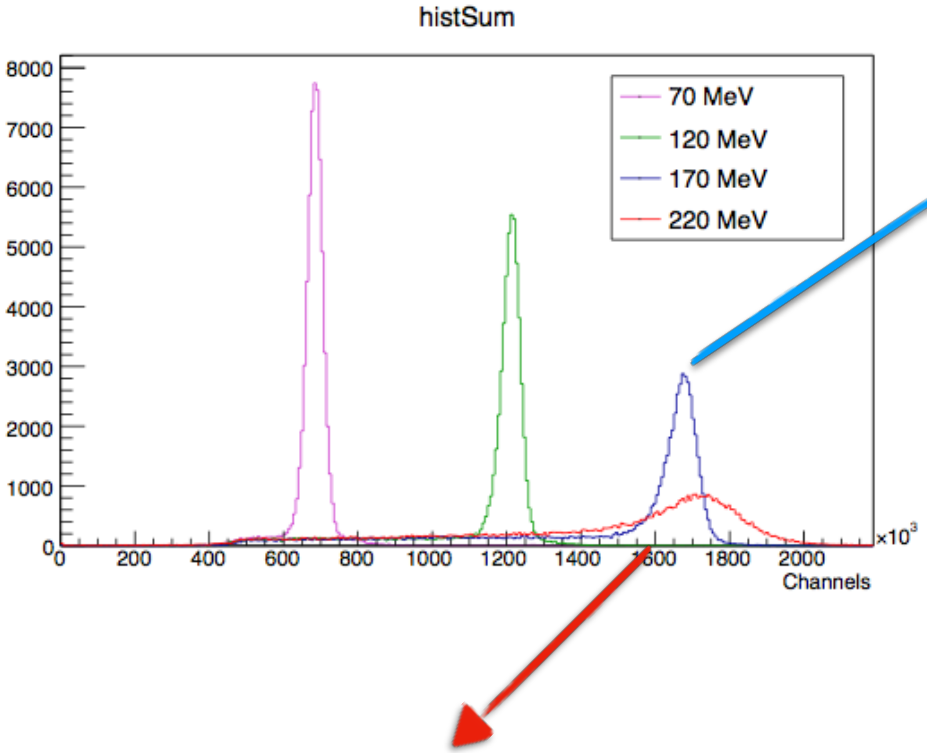
No position dependency

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.



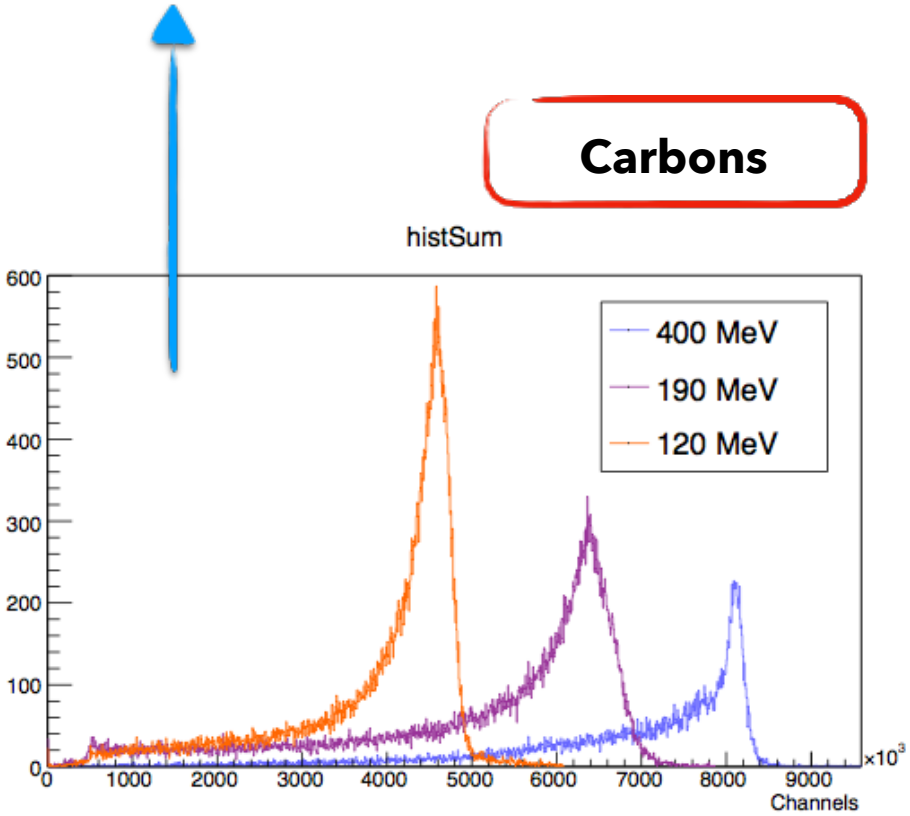
Protons



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

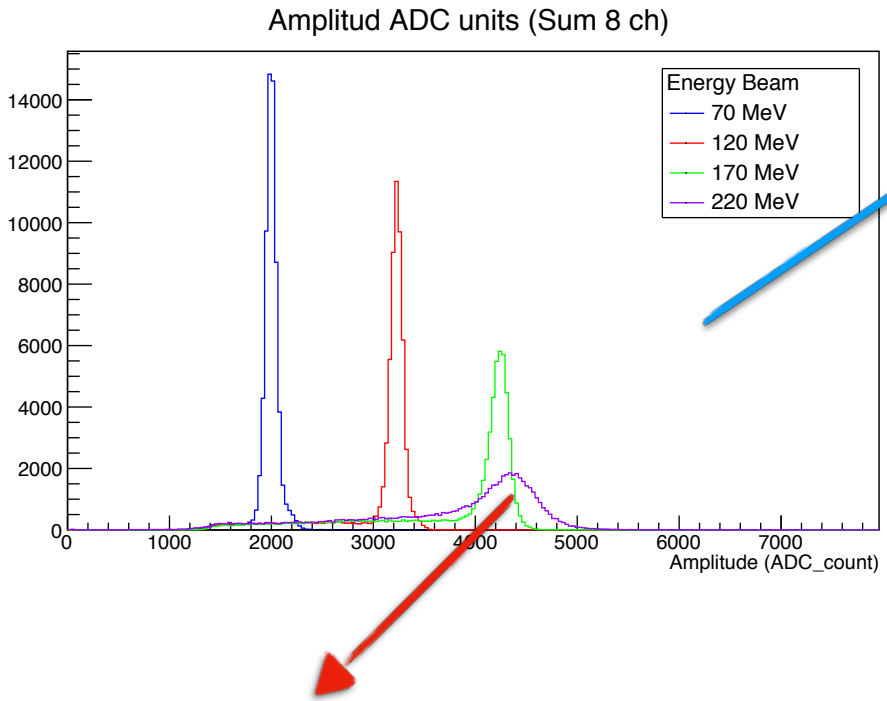
Important result: Mean value of signal integrations increases with energy

Carbons



Signal Amplitude

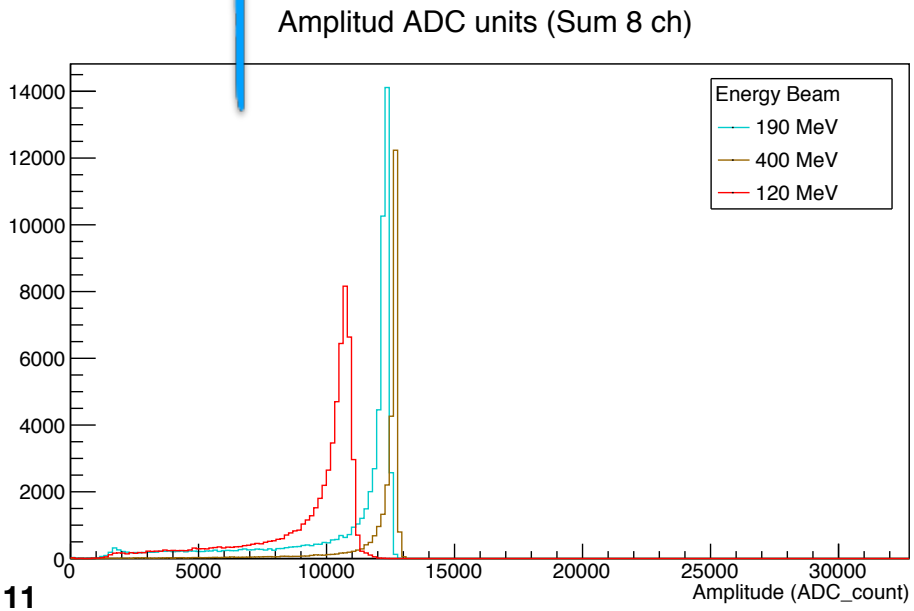
Protons



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

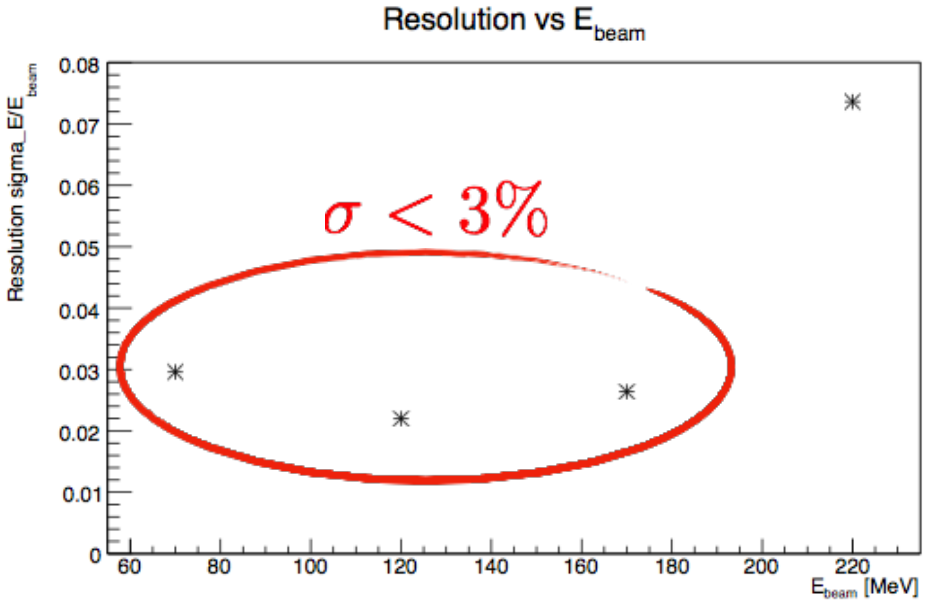
Anomalous behaviour for proton beams at 220 MeV: what happened?

Carbons

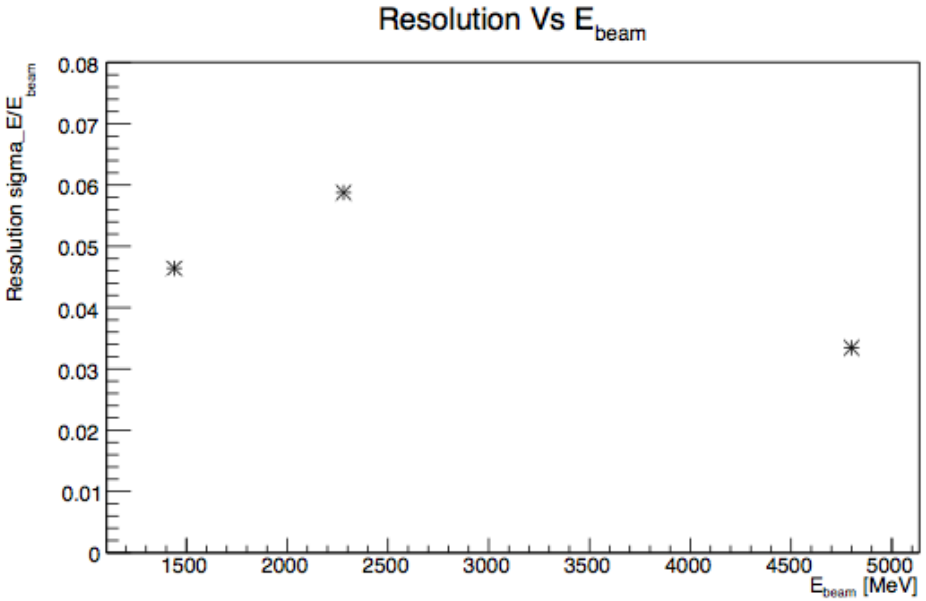


Energy Resolution - Integration

Protons

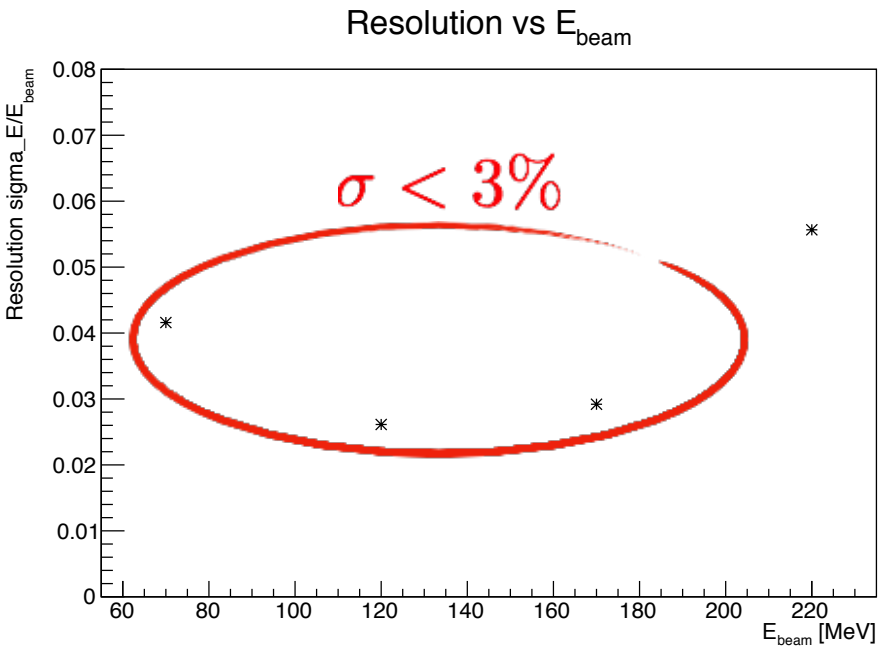


Carbons

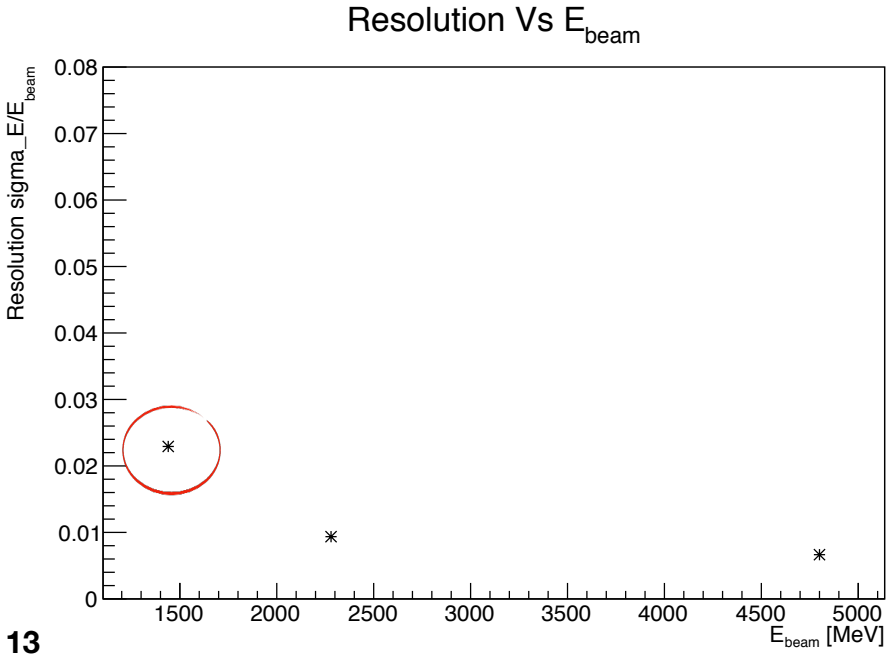


Energy Resolution - Amplitude

Protons



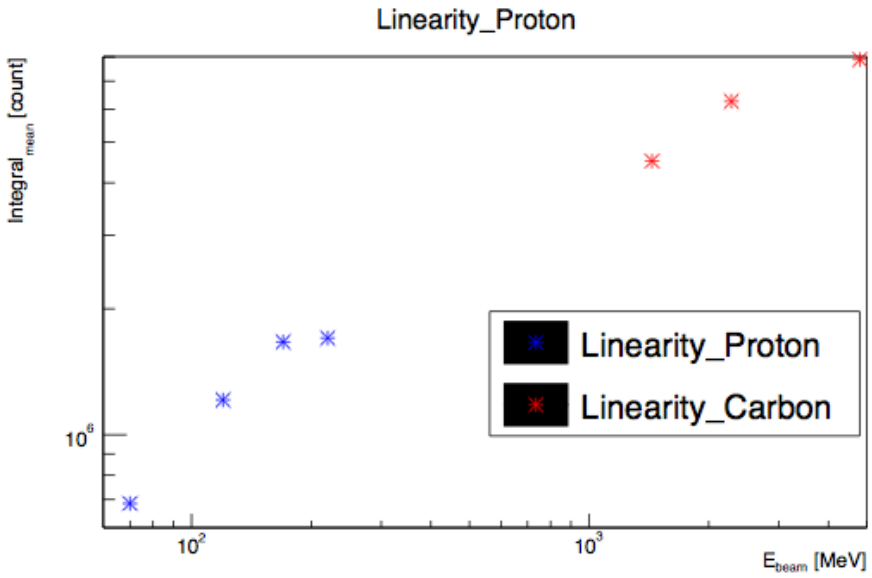
Carbons



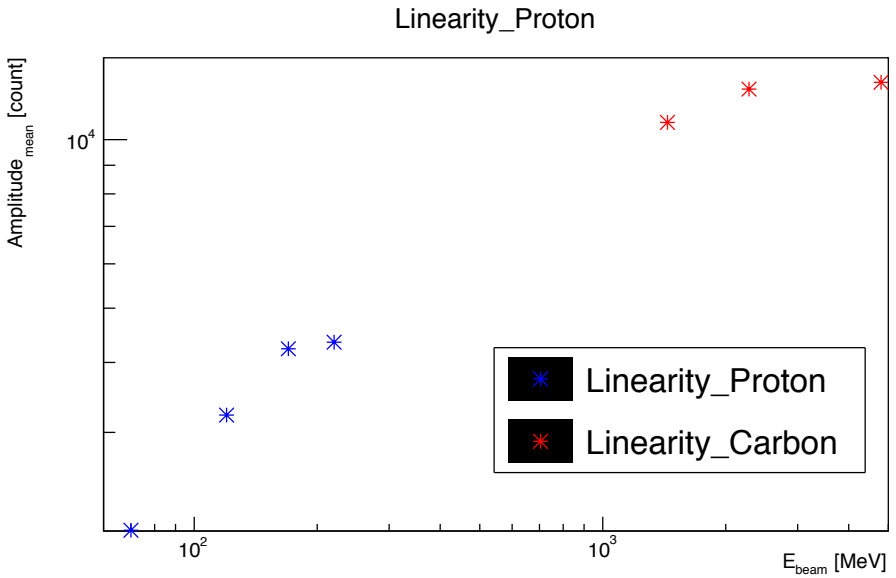
Linearity

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

Integration



Amplitude

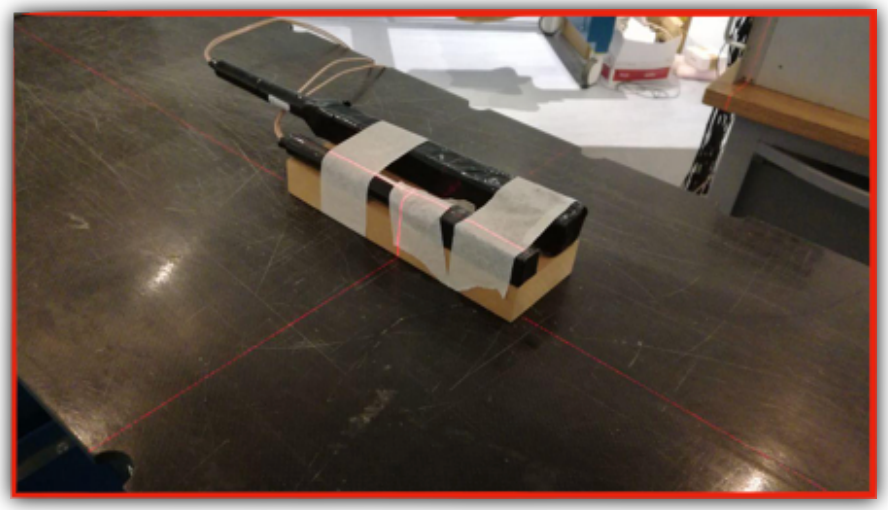


Calorimeter preliminary test at CNAO

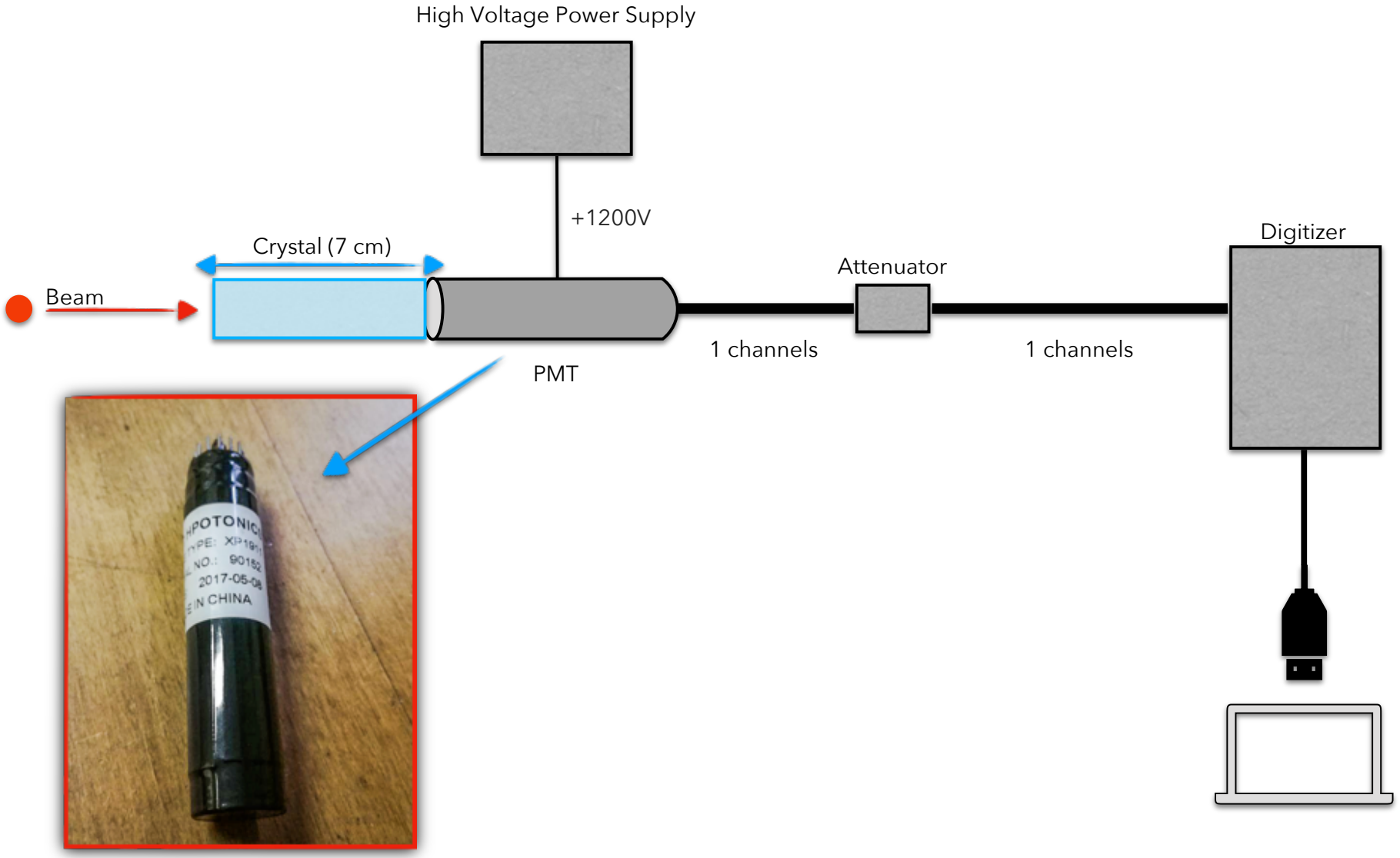
- PMT
  - Crystal **24 cm** long
  - Crystal **7 cm** long

Carbon beam

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

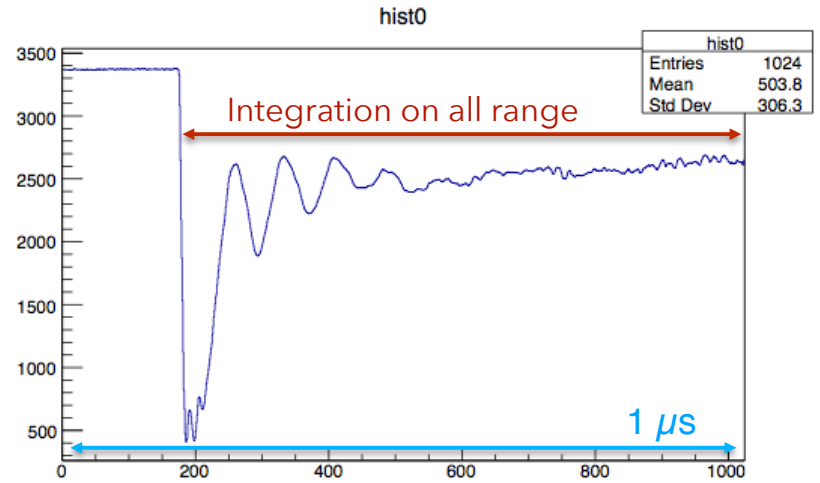


PMT test setup

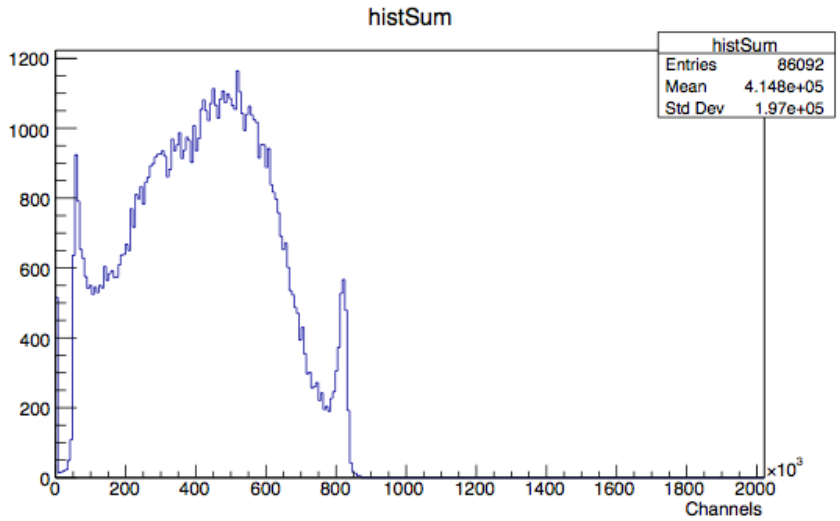


Carbon beam, 120 MeV, Crystal 7 cm long

PMT Signal Integration

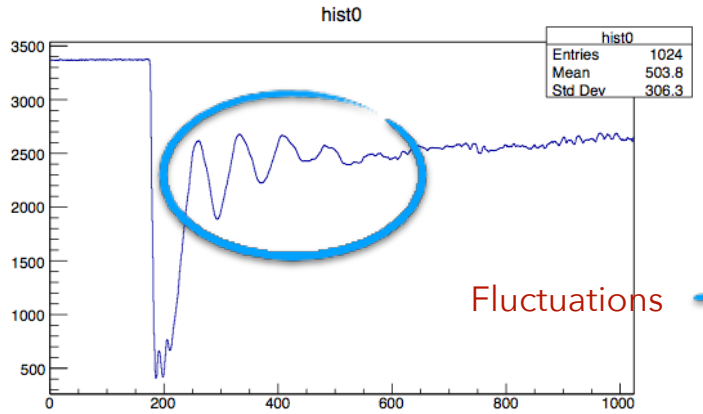


Integration of all signals

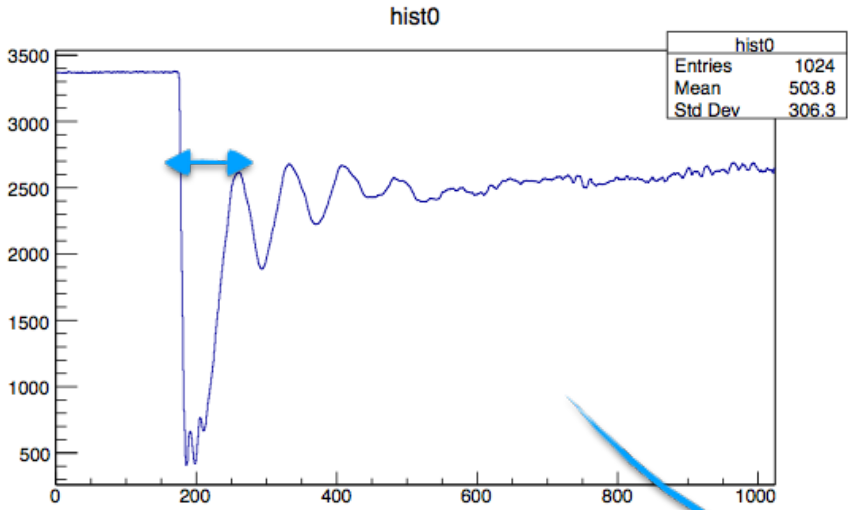


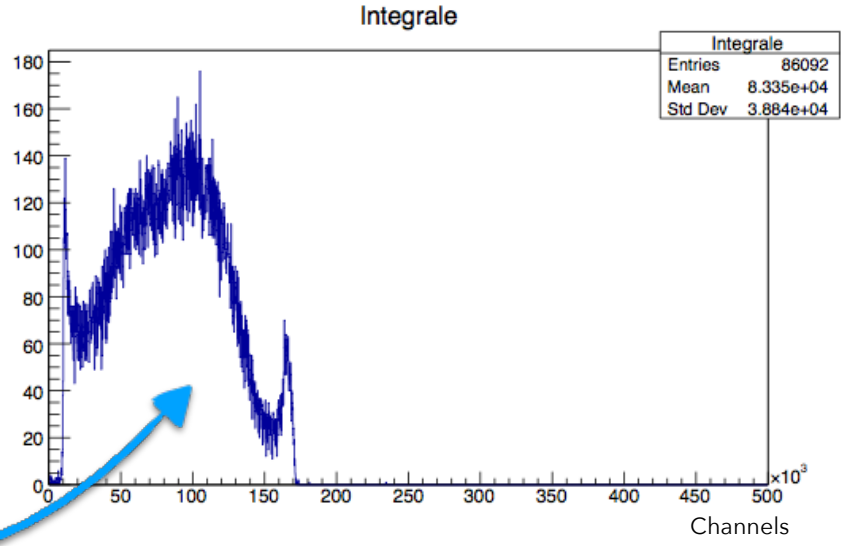
Carbon beam, 120 MeV, Crystal 7 cm long

PMT Signal Integration



Fluctuations → maybe attenuator?

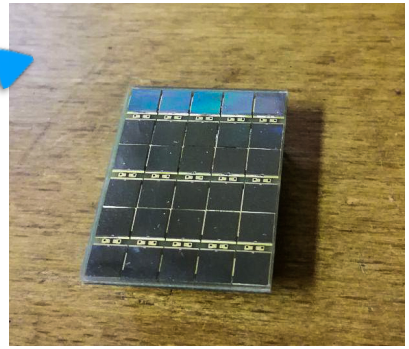




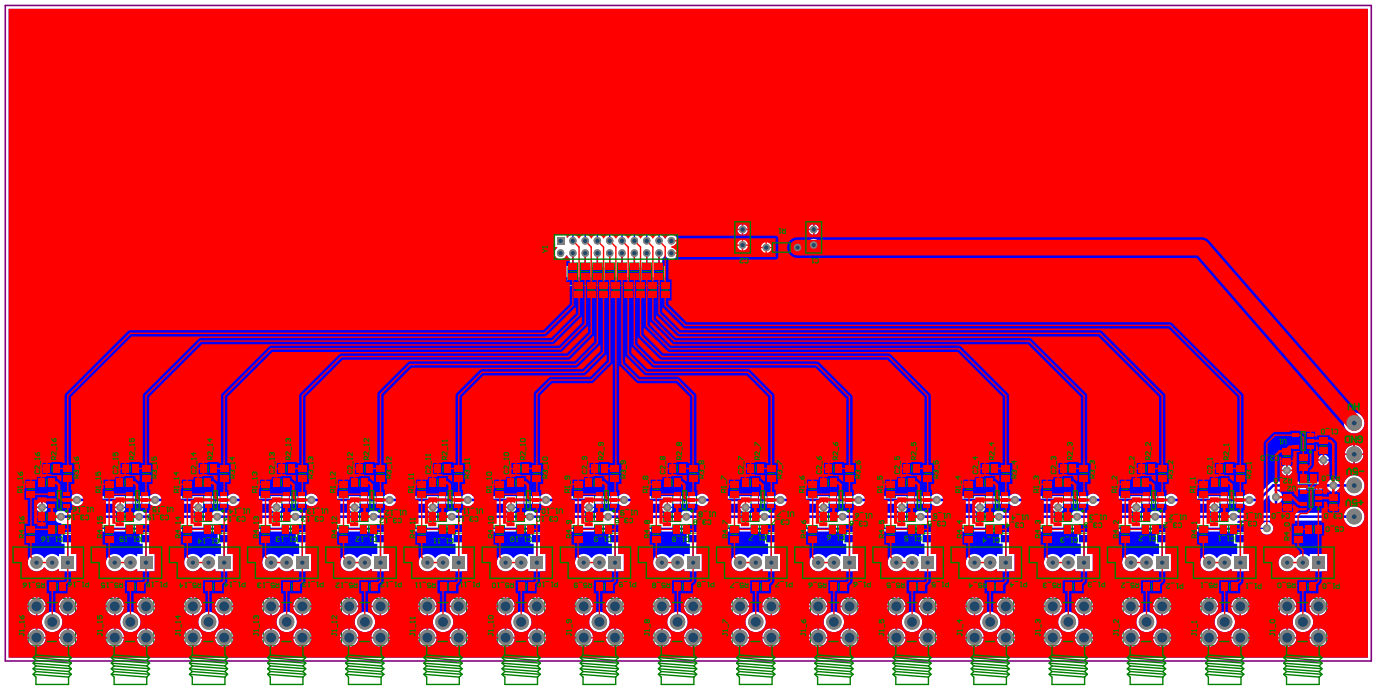
Other tests will have to be performed …

Next tests at CNAO:

- 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

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Readout

Likely readout scheme, if 15 μm SiPM prove to be linear – as expected

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

It's the simplest solution

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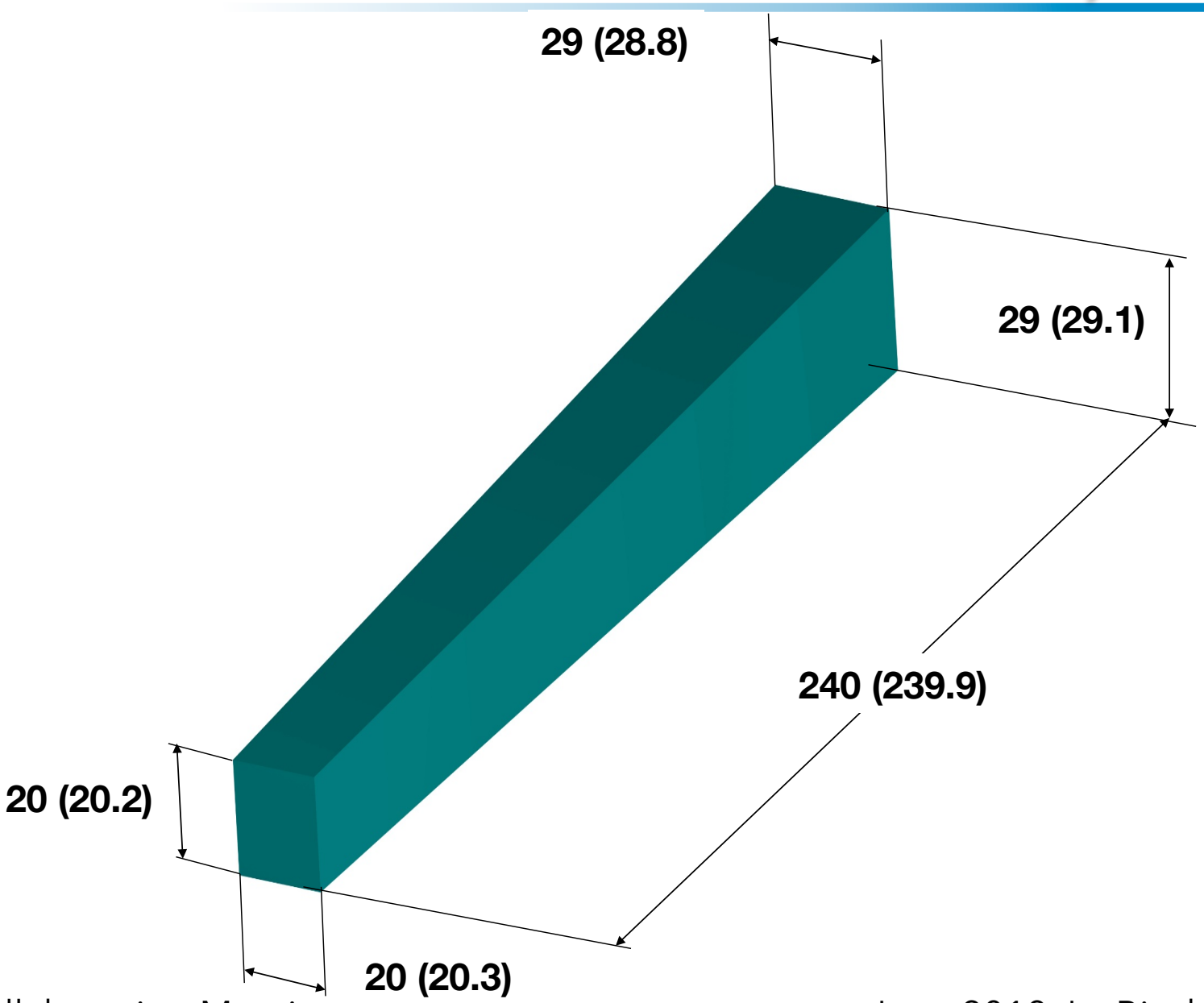
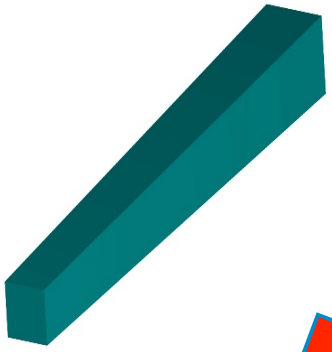
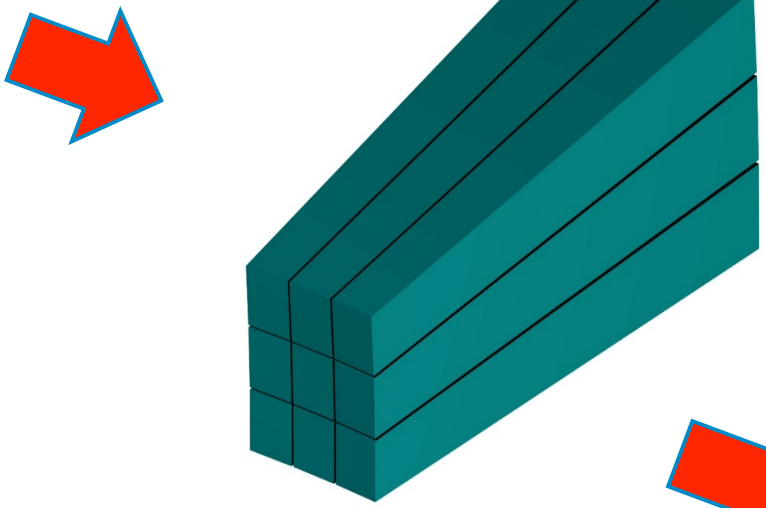
The crystals



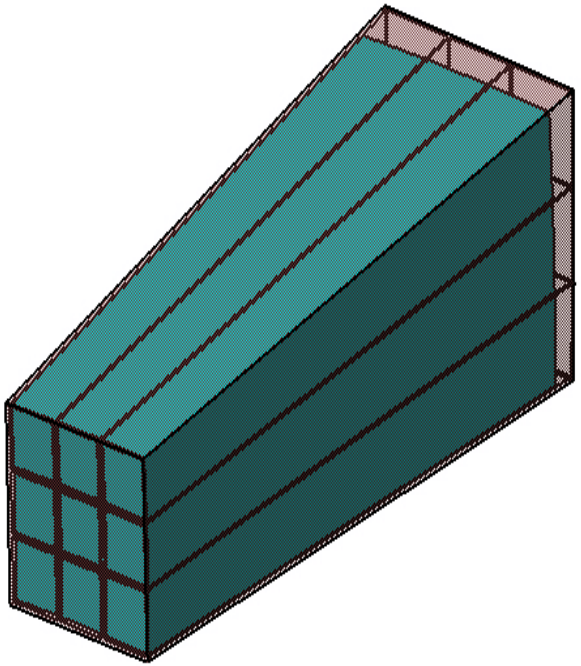
Module definition

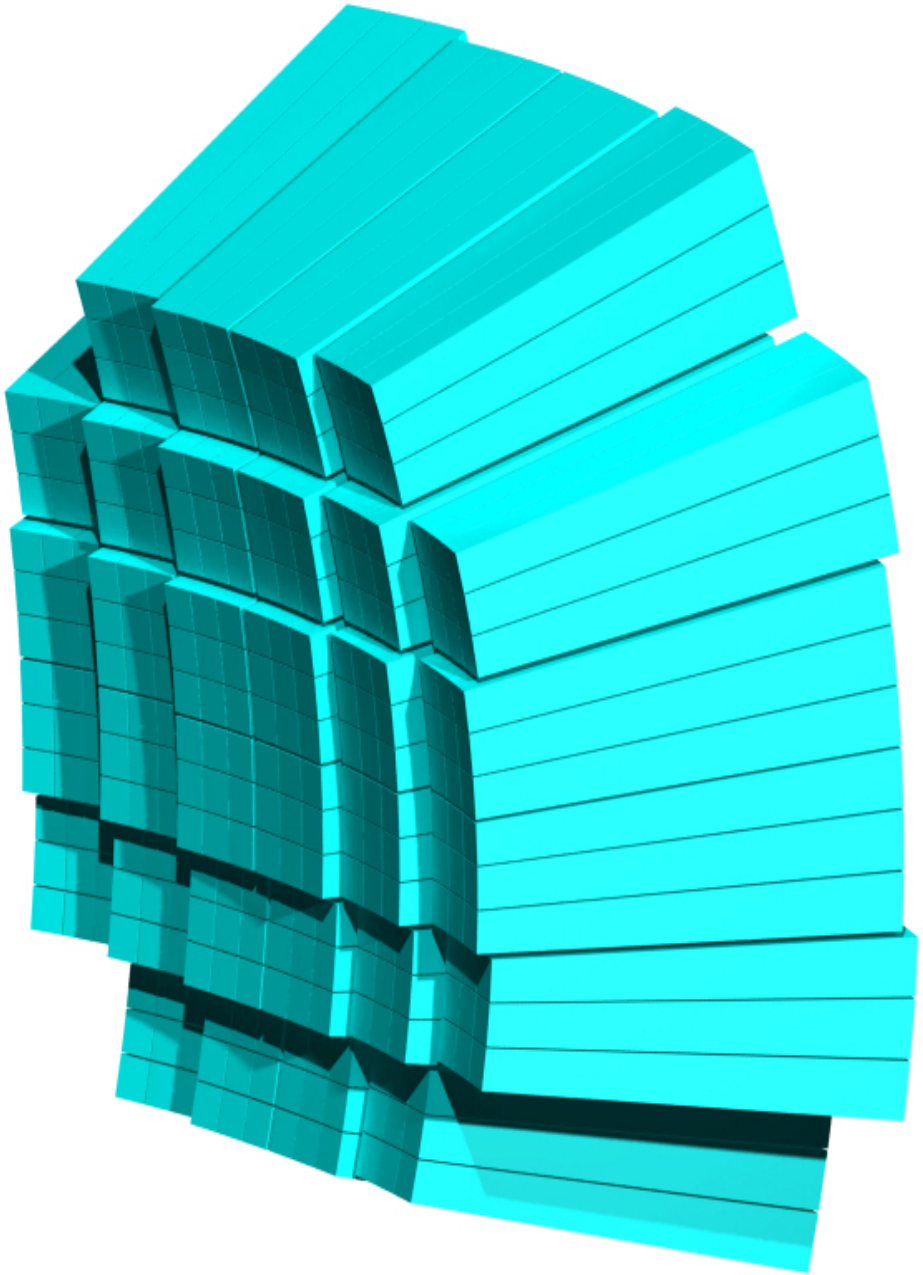




Matrix 3x3 crystals

Plastic box

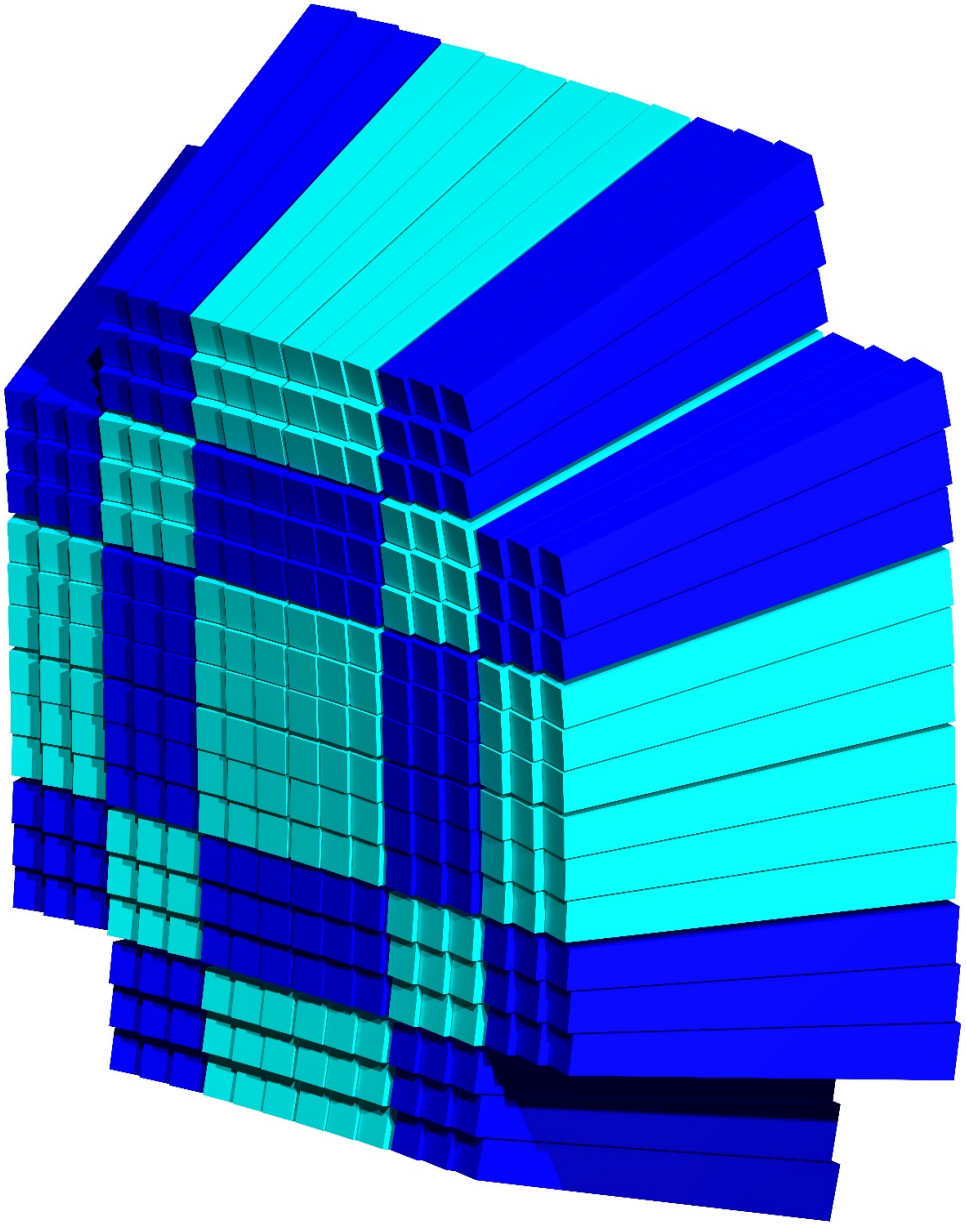




Modules layout – option 1

arrangement of 32 modules
1 plastic box design

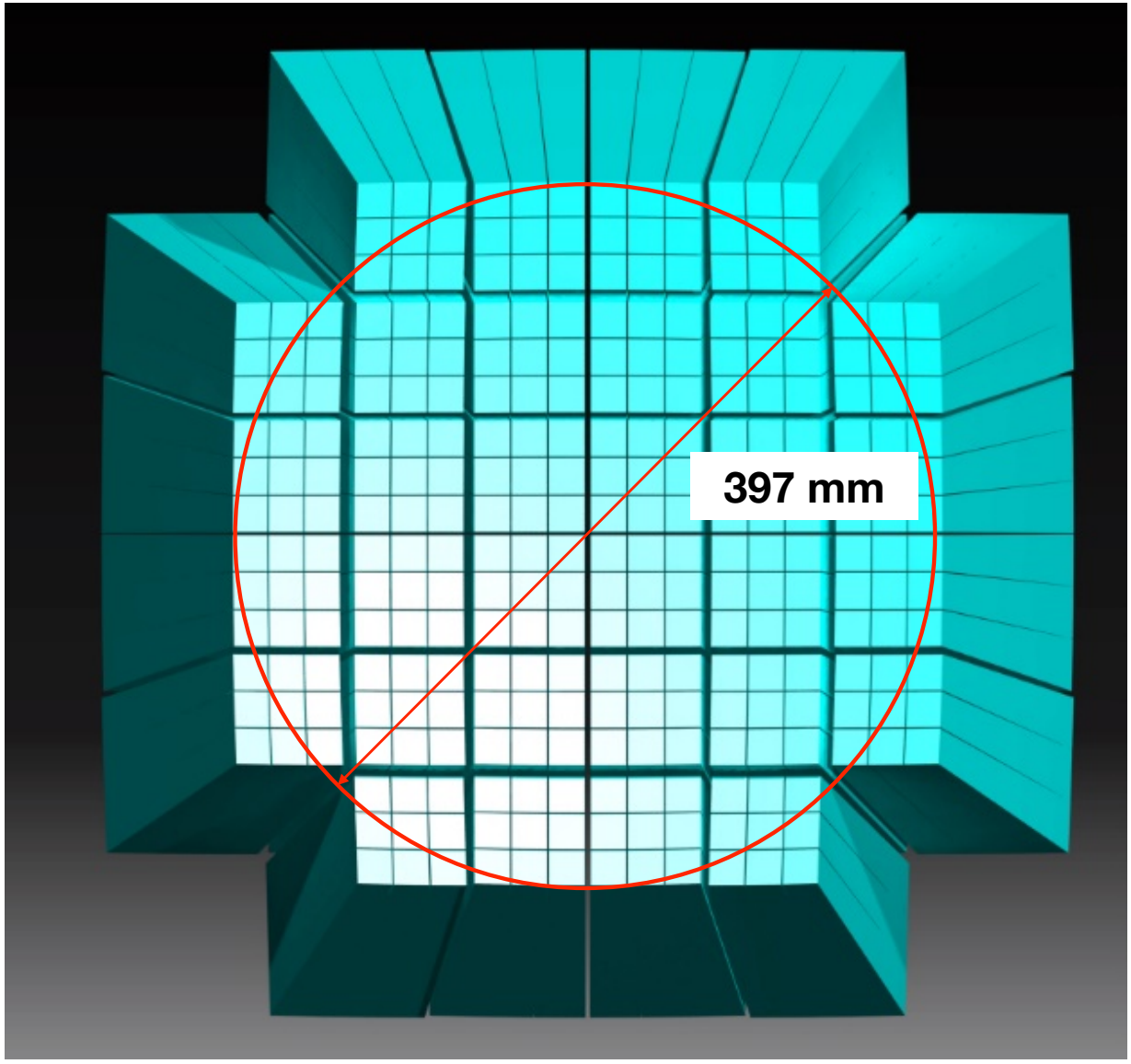
Modules layout – option 2



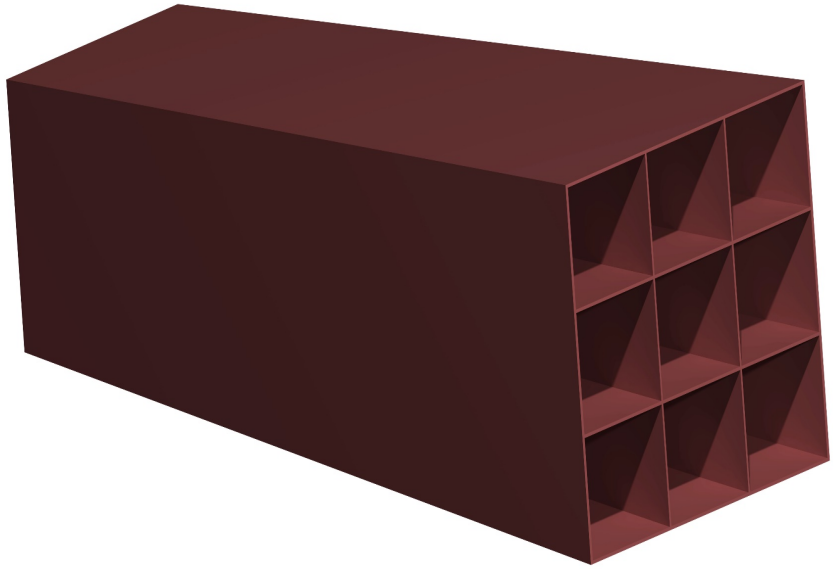
Single arrangement of
288 crystals

16 plastic box designs

Modules layout – front view

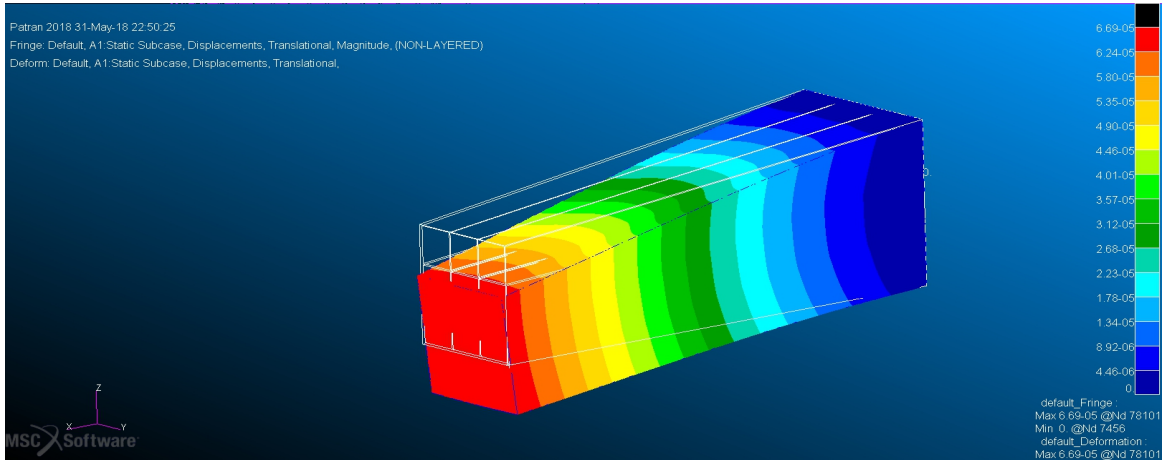


Module case



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

Max displacement ≈ 70μm
Max stress $9{,}5 \cdot 10^5$ Pa
(ABS Tensile strength ≈ $25 \cdot 10^6$)



Plans

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