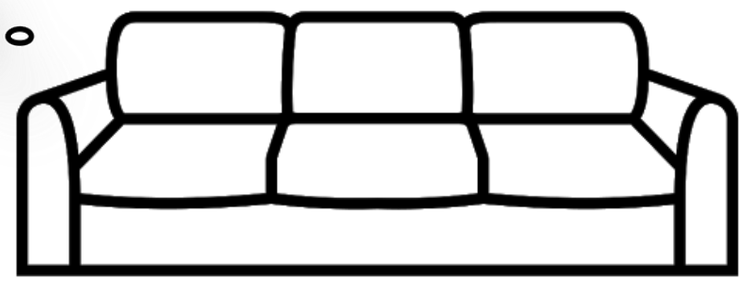
26/05/2020

Temperature compensation: CNAO test beam results

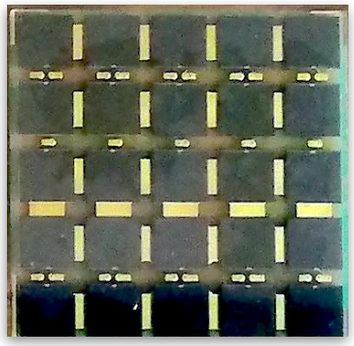
VIII Collaboration Meeting



S. Argirò, N. Bartosik, P. Cerello, G. Giraudo, E. Lopez Torres, M. Mignone, L. Ramello, **L. Scavarda**, M.Sitta

02/2020 Test Beam Setup

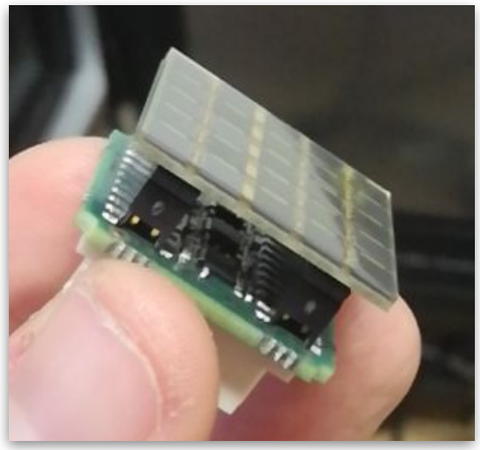
25 SiPM arrays
4x4mm^2 (15 μm)



SiPMs glued to BGOs

1	WhitePainting 2	3
Tyvek 4 NTC	Tyvek 5	Tyvek 6
7	Mylar 8	9

ReadOut Board



- First night:
  - Energy scan in cry 2,4,5,6,8. Angle between module and beam: 0°
  - Energy scan with different temperature T1 on cry4
- Second night:
  - Energy scan with different temperature T2 on cry4
  - Energy scan with different temperature T3 on cry4

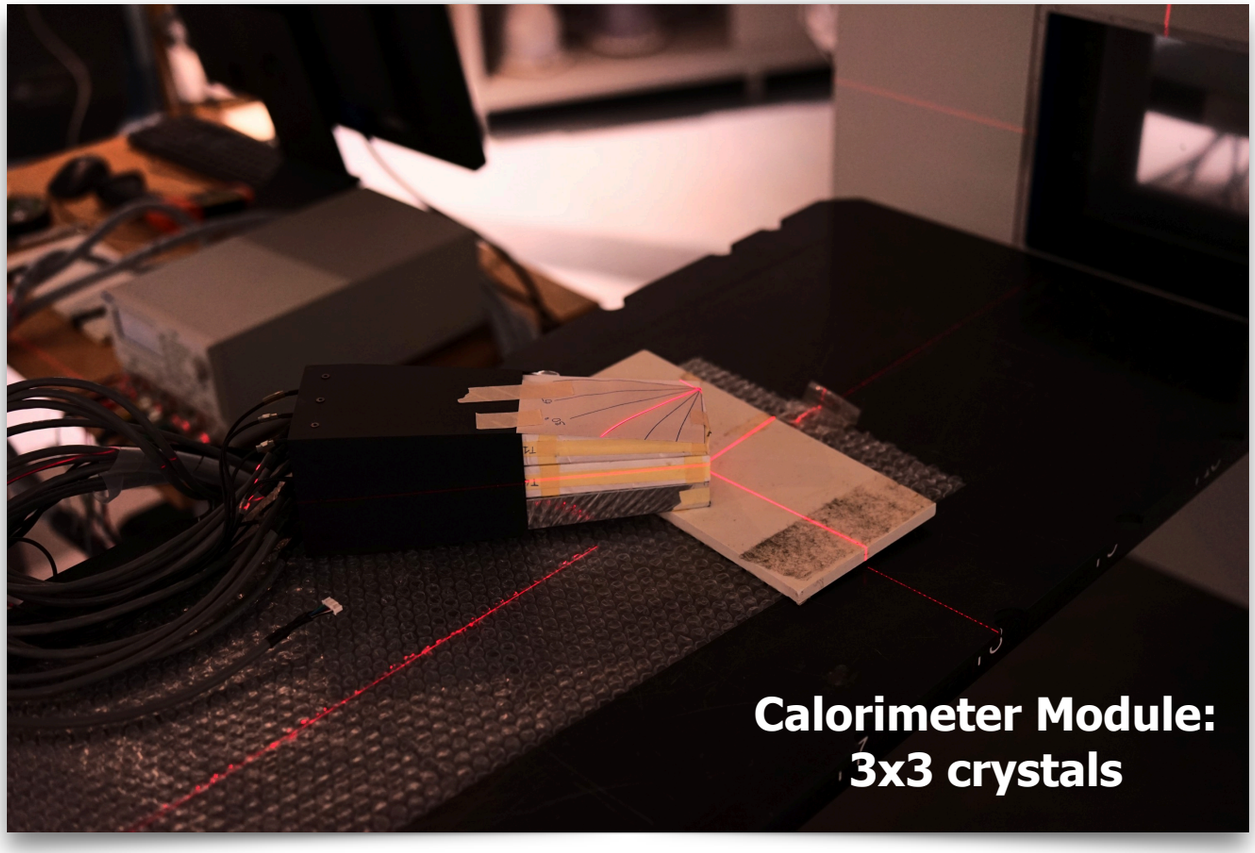
V1740 (2V)

Read SiPM signals

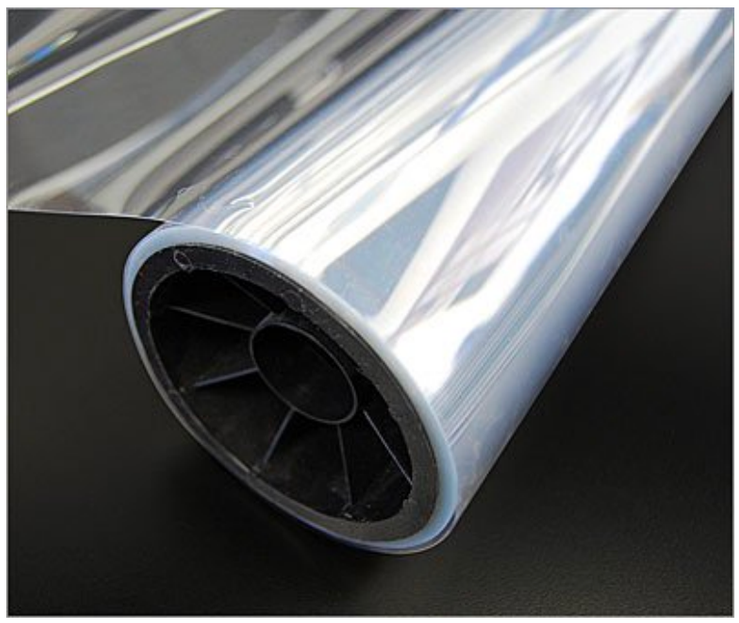
V1740 (10V)

Read temperature sensor

Crystal wrappings

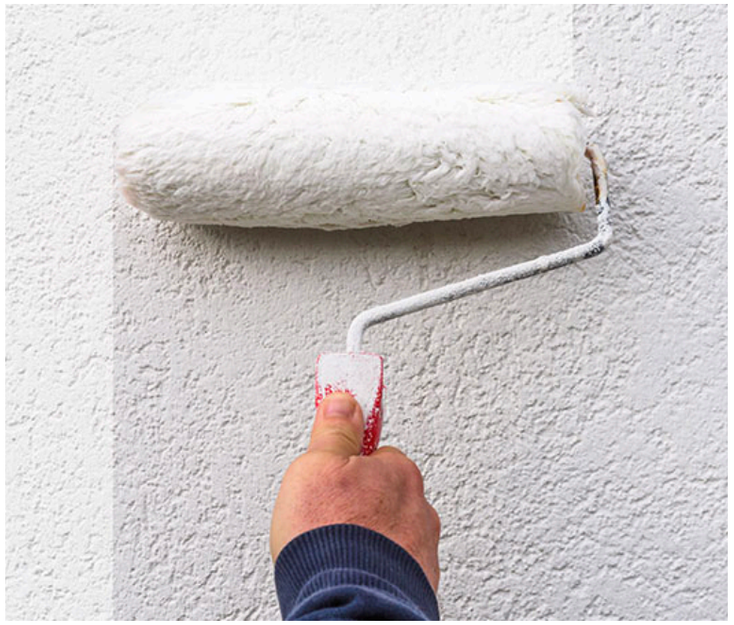


Mylar



Tyvek

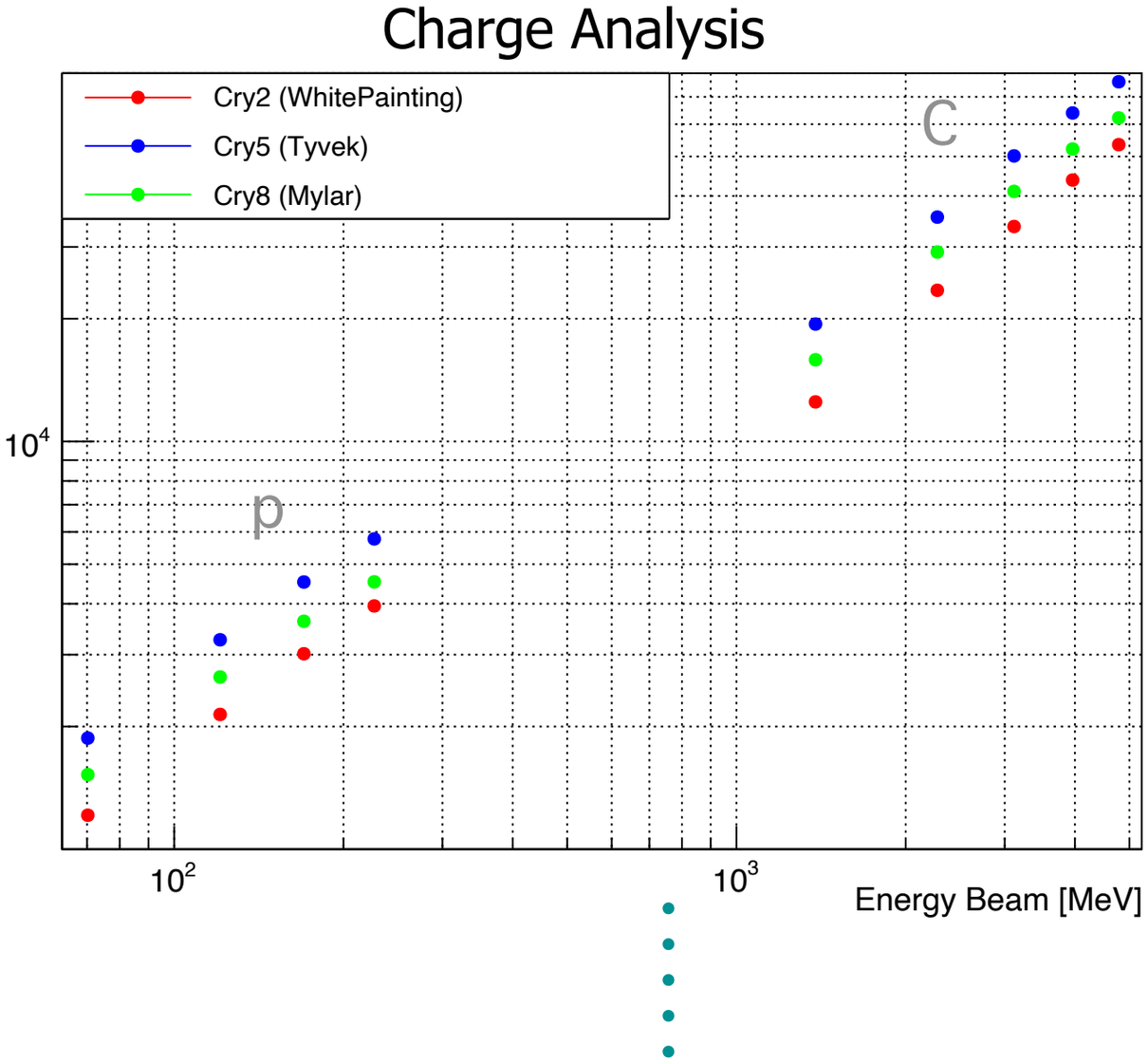
White Painting

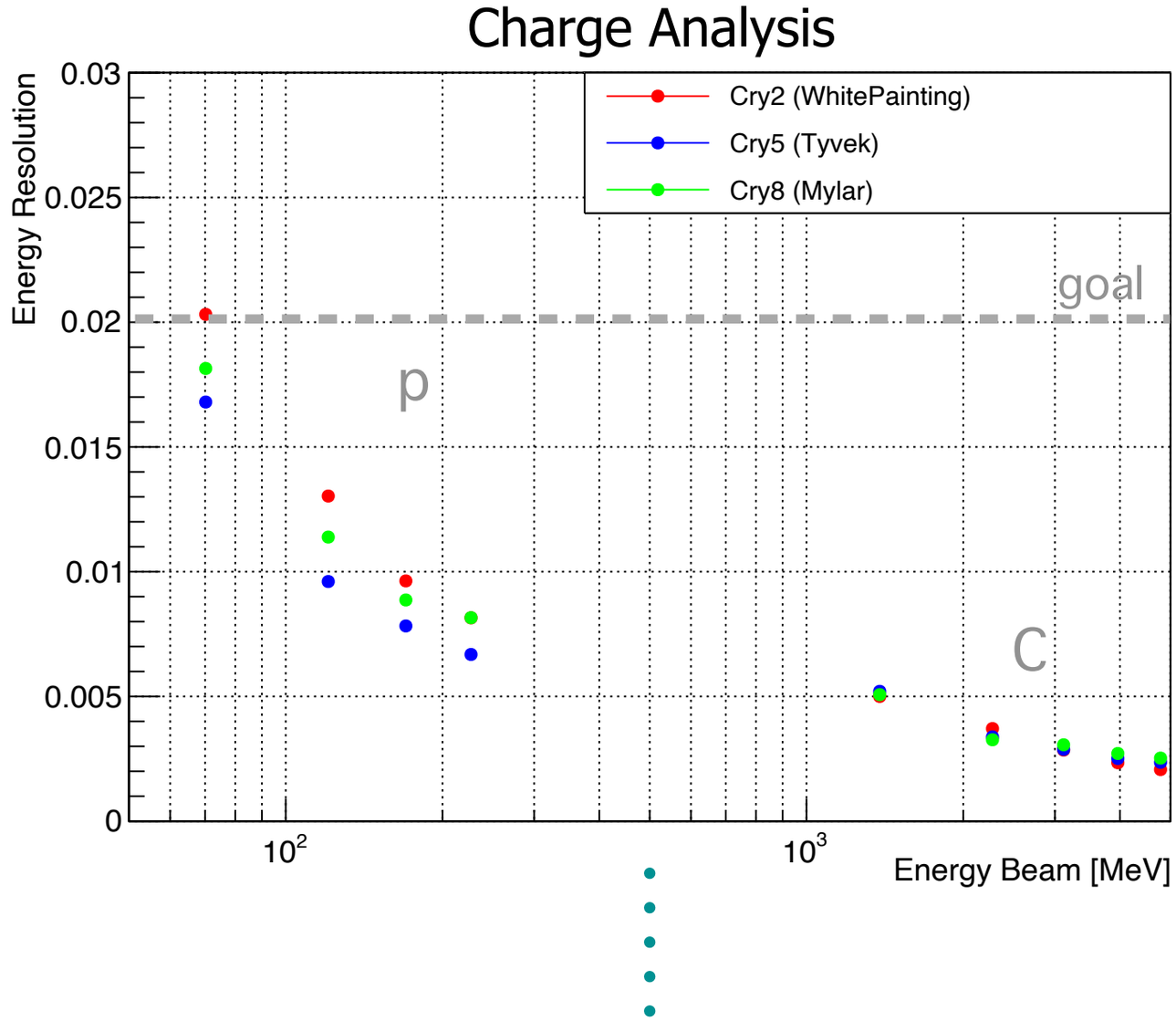


Crystal wrappings (2)

Test beam overview:

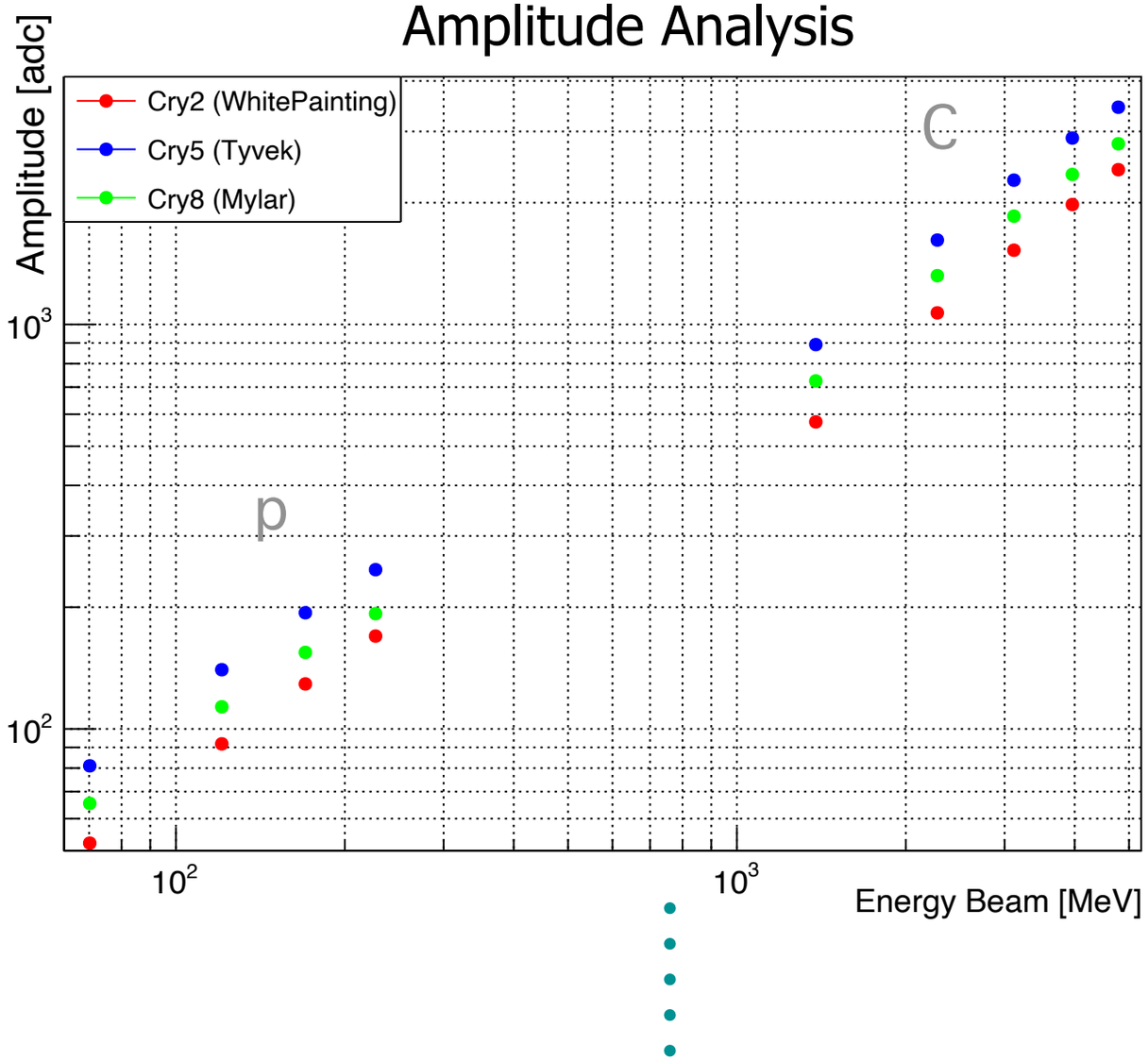
- Proton Energy: 70, 120, 170, 227 MeV
- Carbon Energy: 115, 190, 260, 330, 399 MeV/A

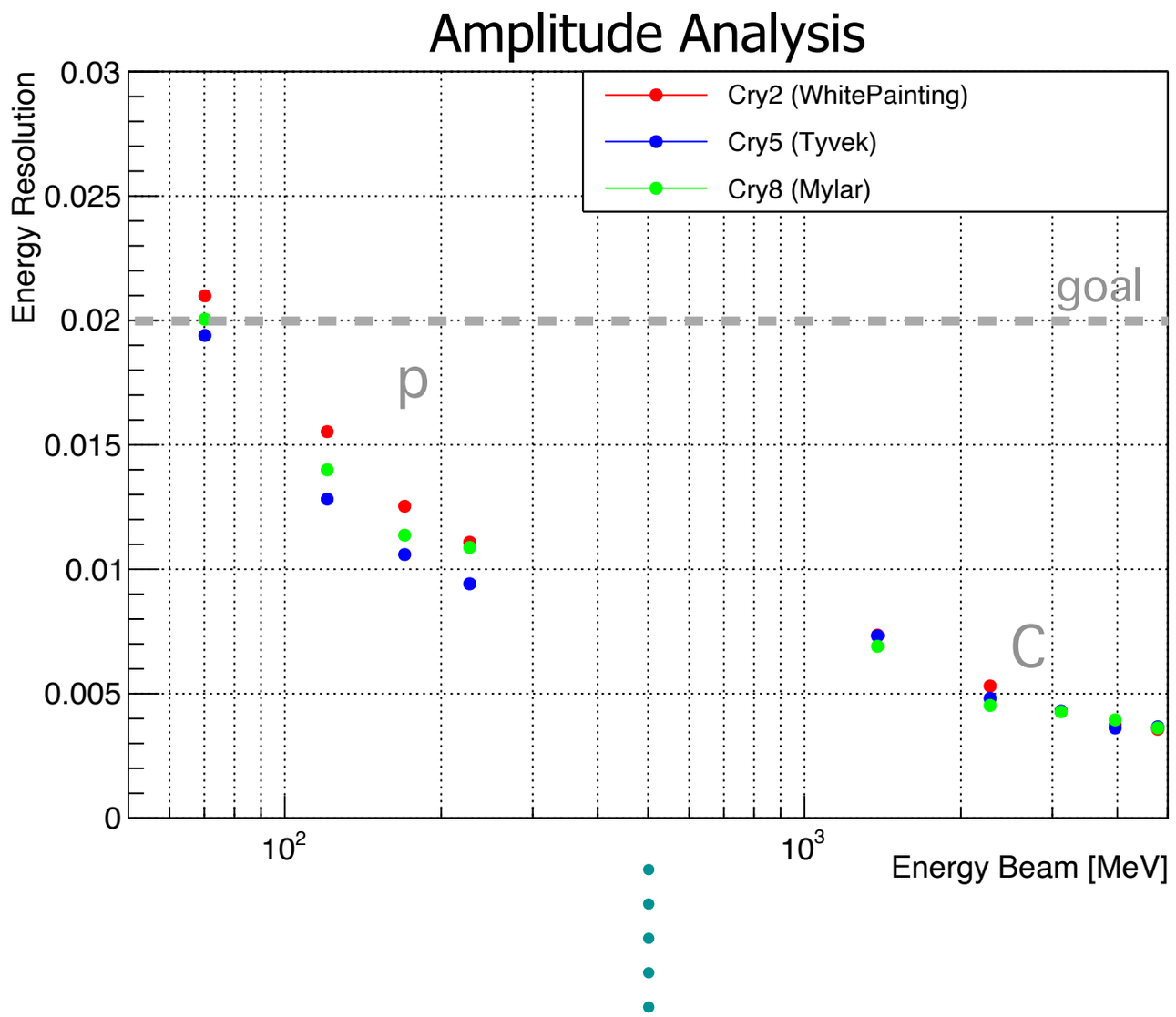




Tyvek reflects more light → better energy resolution

Crystal wrappings (3)





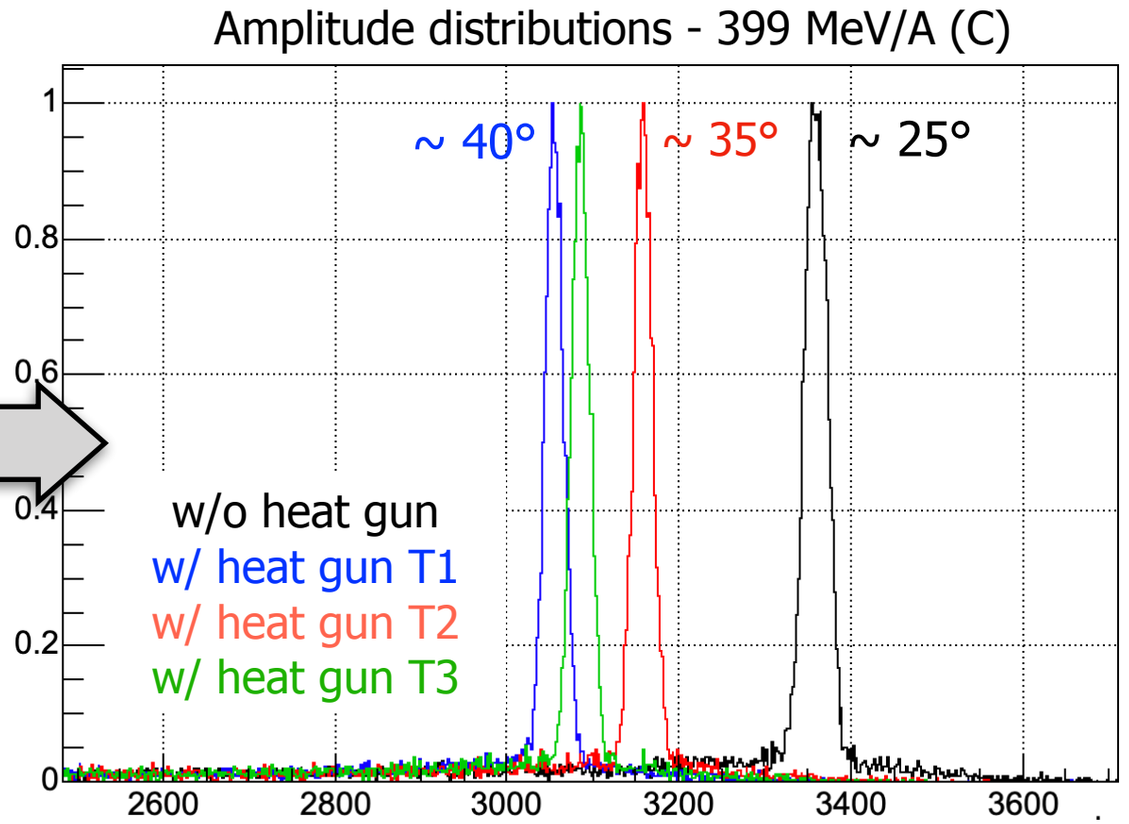
Tyvek reflects more light → better energy resolution

Temperature control system (1)

SiPMs are temperature fluctuations sensitive ⟶ Is a cooling system necessary?

TEST BEAM OVERVIEW:

- For each energy 4 points at different temperature were taken
- Proton Energy: 70, 120, 170, 227 MeV
- Carbon Energy: 115, 190, 260, 330, 399 MeV/A

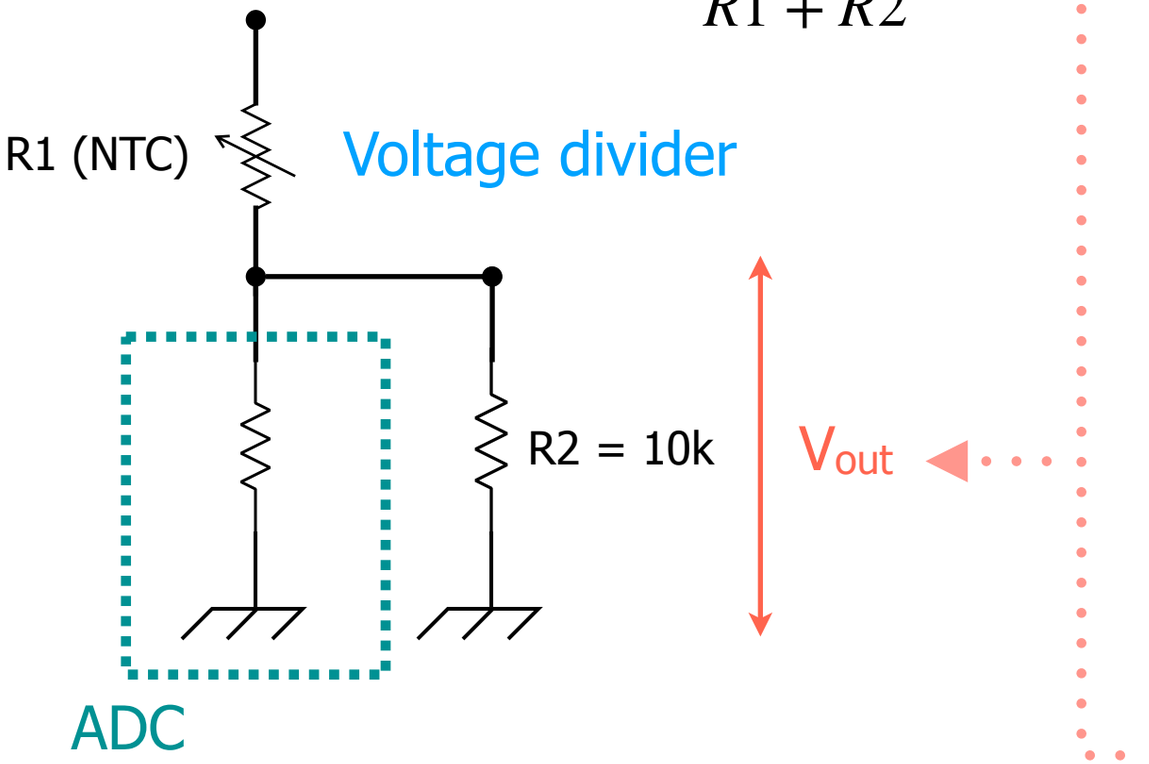


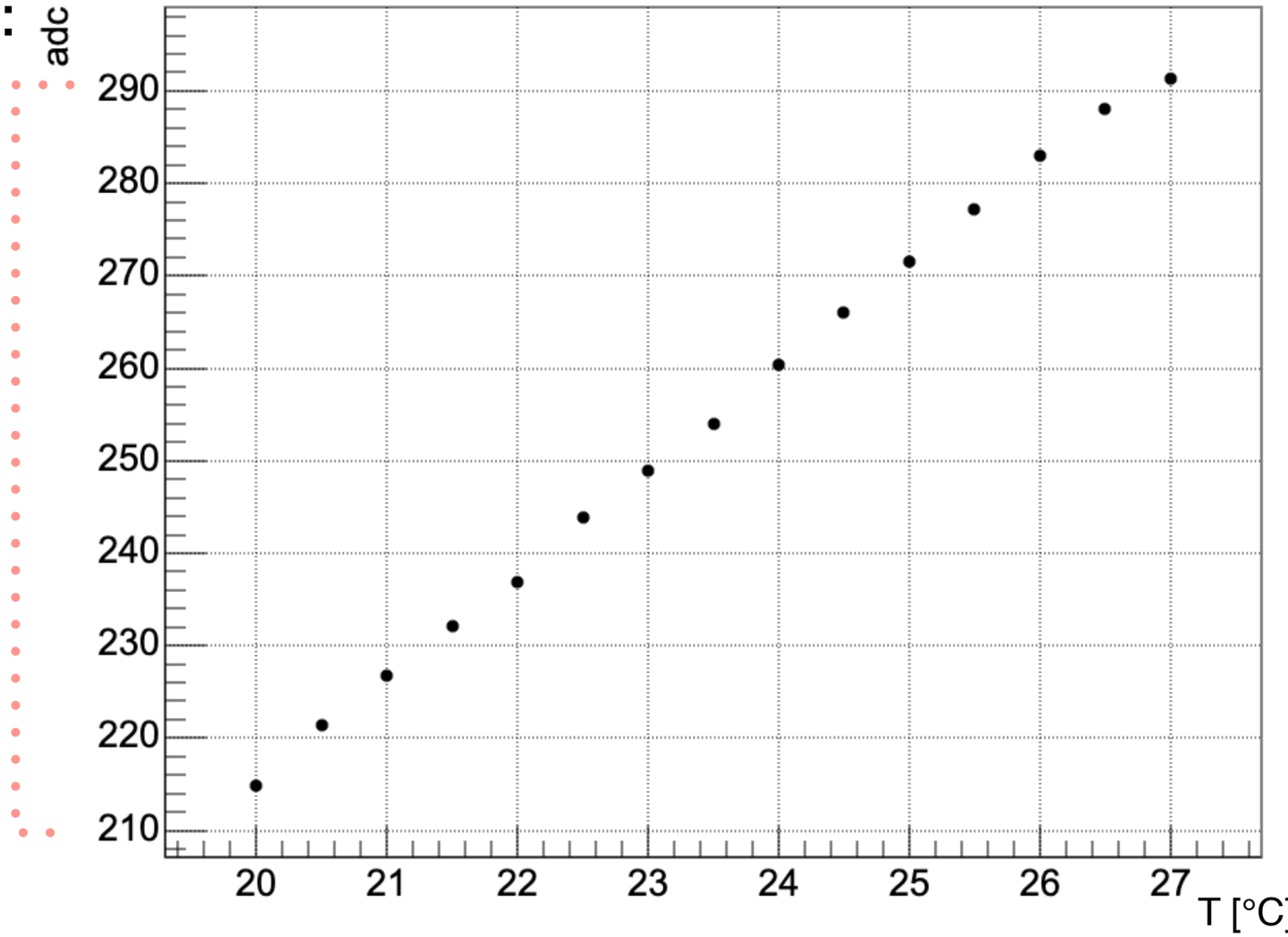
Temperature control system

How to read the temperature sensor:

Vin = 6V

$$V_{out} = \frac{R_2}{R1 + R2} V_{in}$$

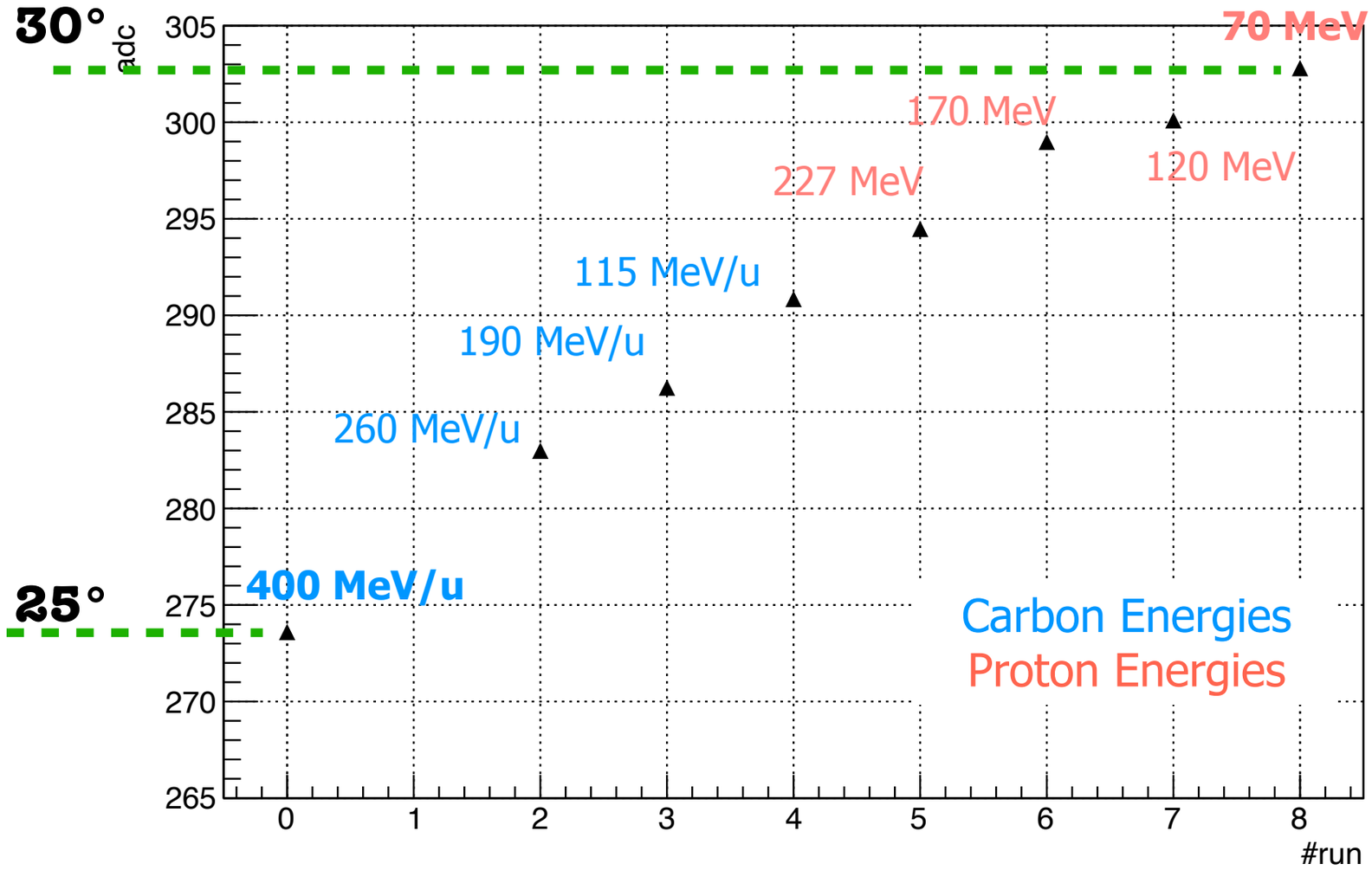




- To monitor the temperature, the voltage of the R1 is read through the digitizer
- The ADC vs T measurements have been taken in a climatic chamber before the test beam
- In the range of temperature 20-27° the trend is linear
- R1↘ T↗ Gain↘

Temperature Analysis

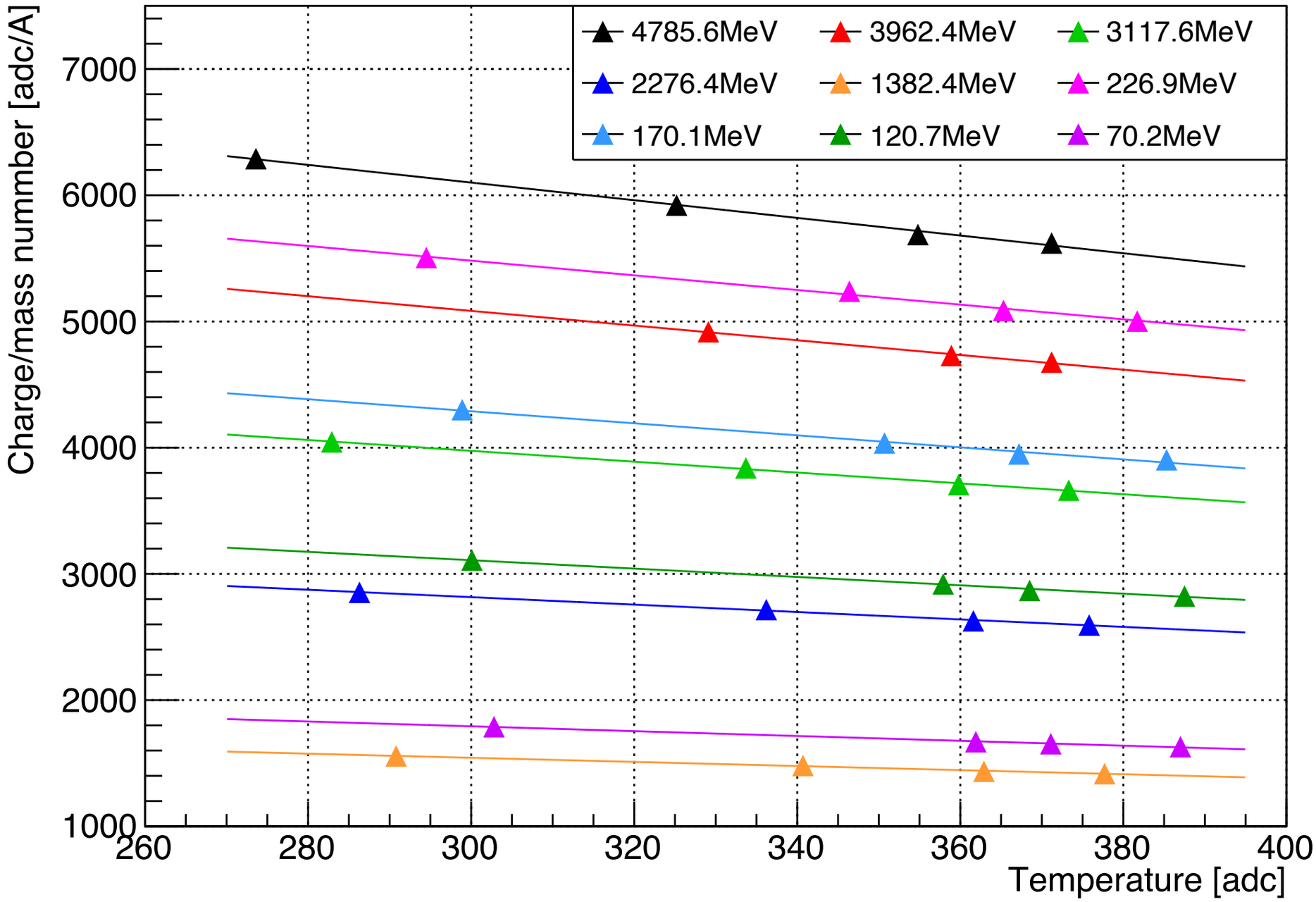
First scan of the first night: **before** putting the heat gun



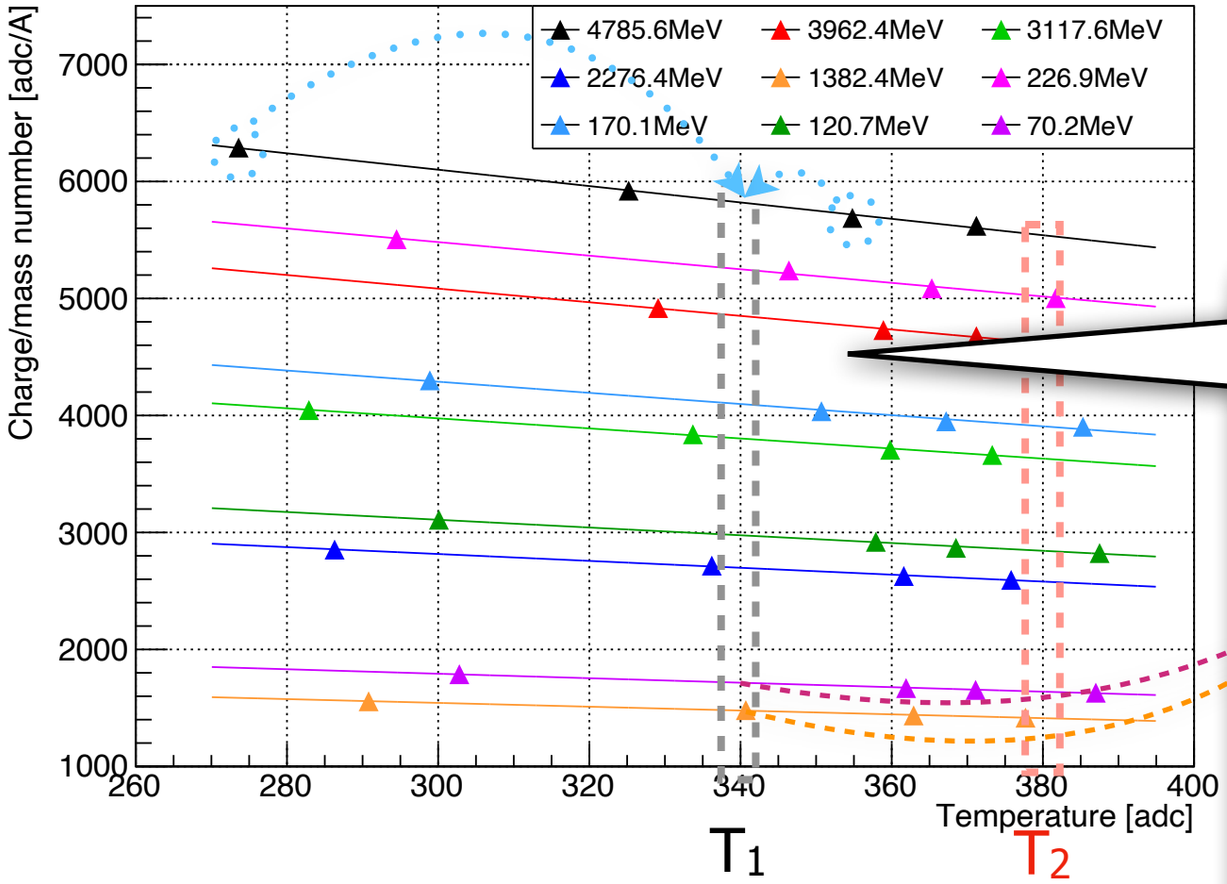
- The temperature is increased about 5°
- The temperature changes are not negligible
- The SiPM and readout board warm up, but the crystal is colder and more time is required to reach a thermal balance

Temperature Analysis

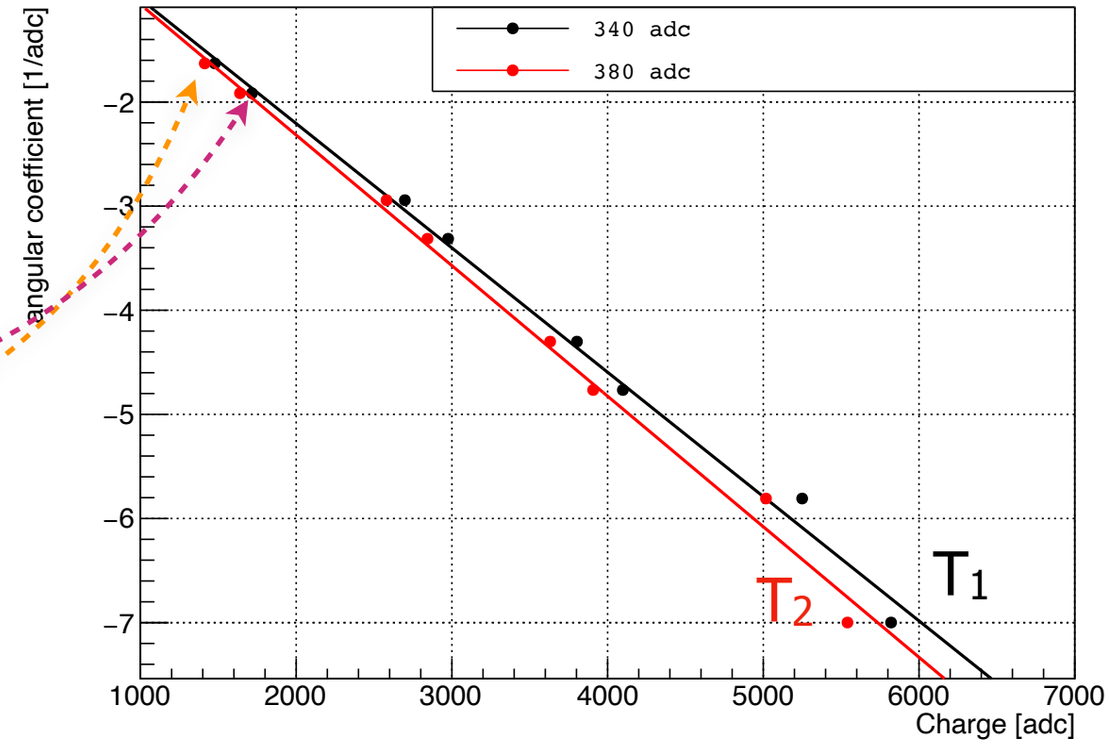
Charge values normalised to mass number versus temperature per each energy



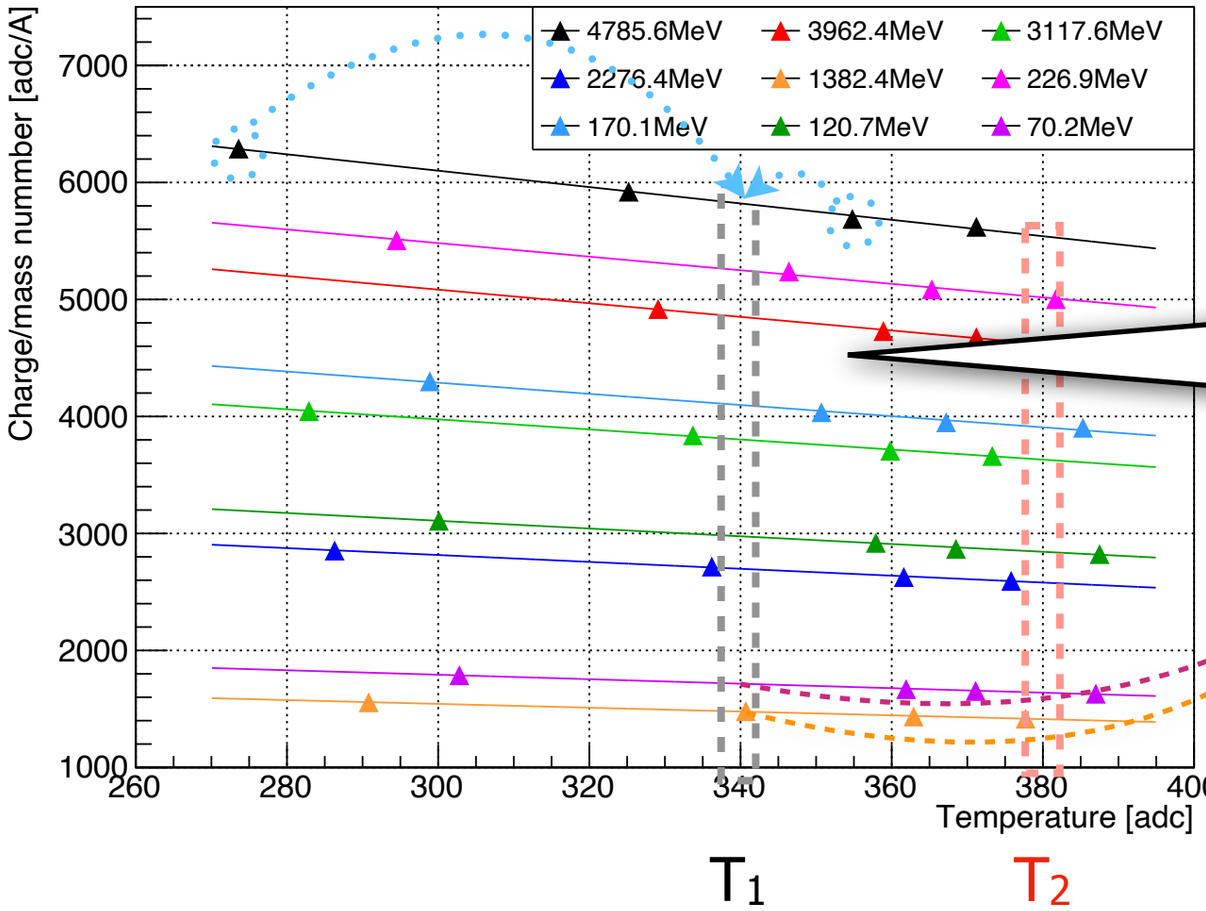
Temperature control system (2)



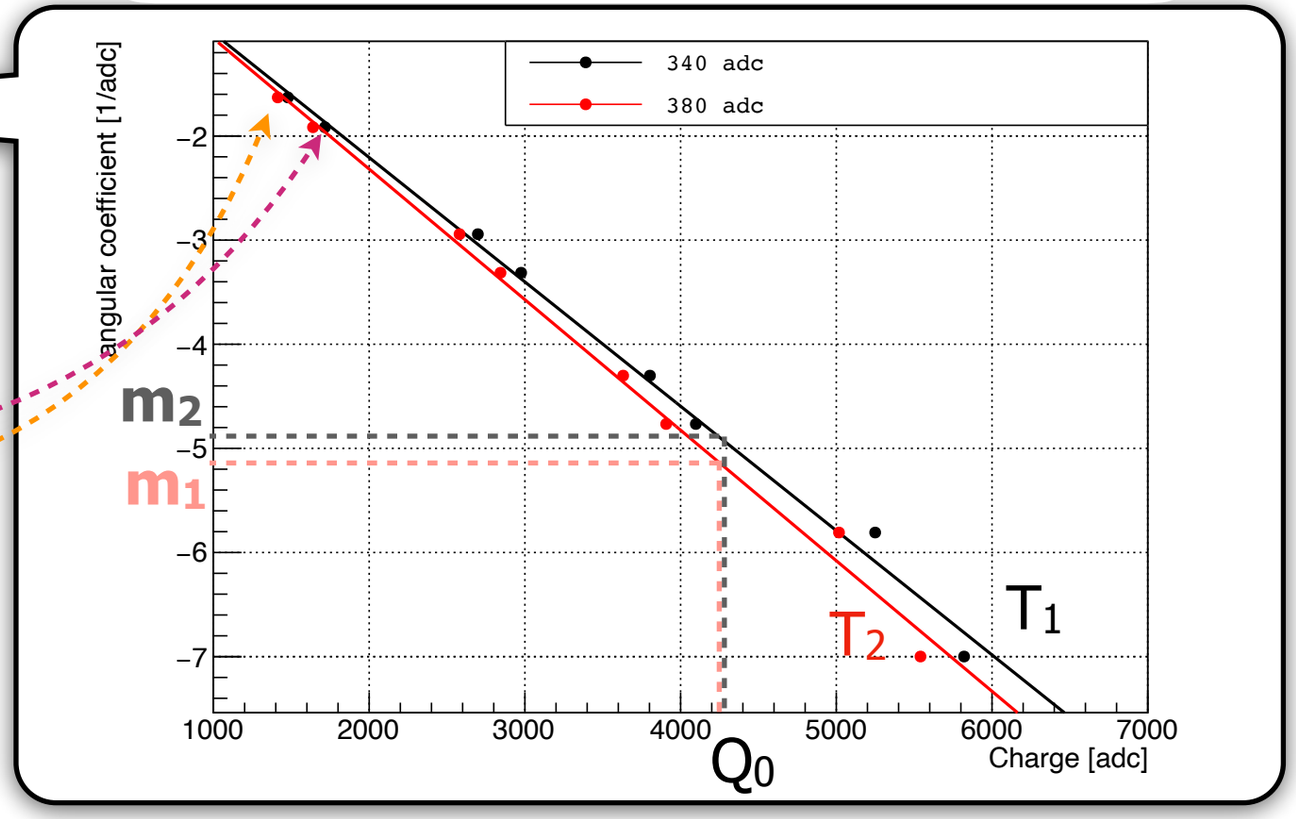
Visible dependency between charge and angular coefficient



Temperature control system (3)



Visible dependency between charge and angular coefficient



Interpolating the slope at T_1 and T_2:

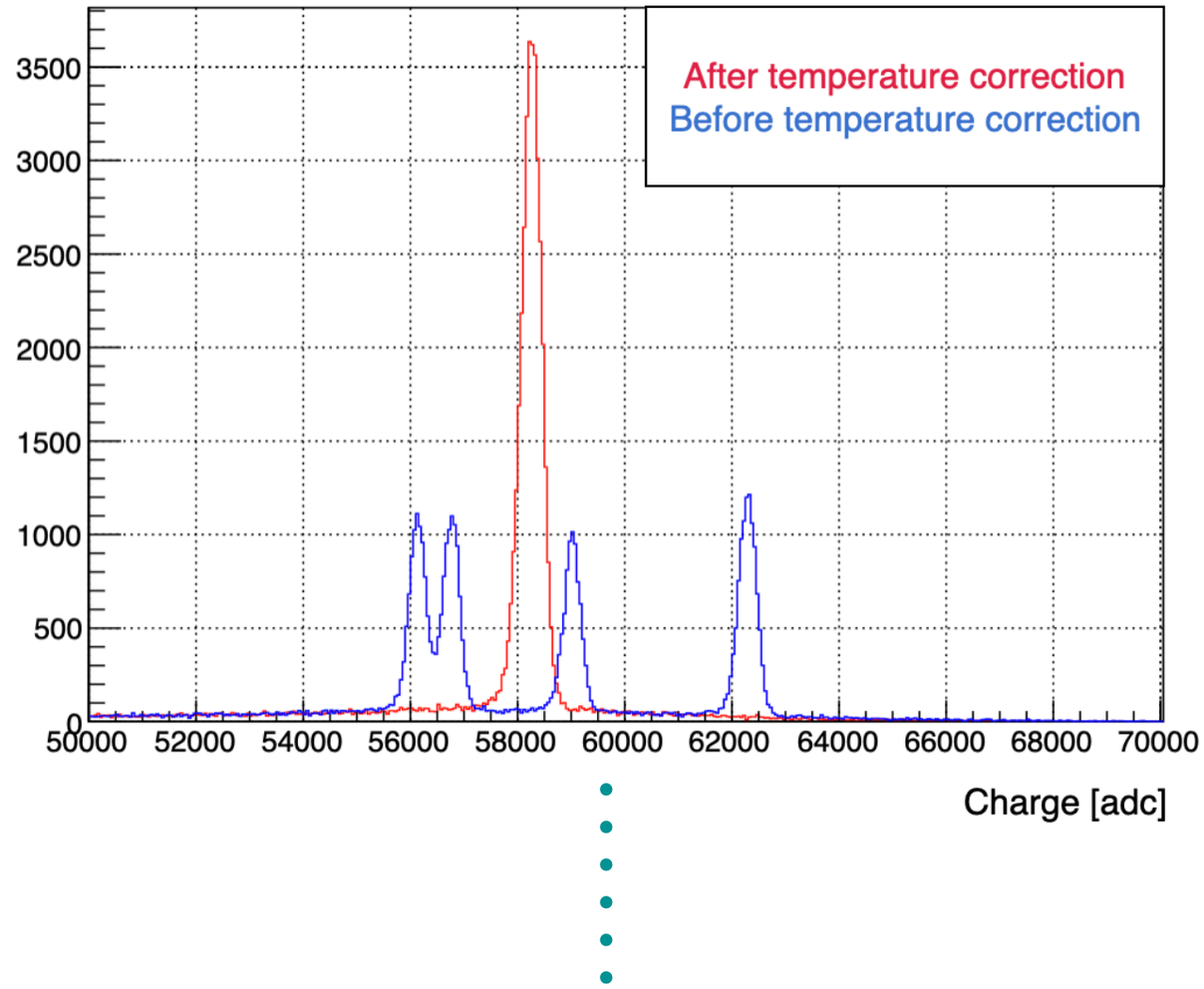
$$m_0 = m_1 + \left(\frac{m_2 - m_1}{T_2 - T_1}\right) \cdot (T_0 + T_1)$$

$$Q_0' = Q_0 + m_0 \cdot (T_1 - T_0)$$

Where:

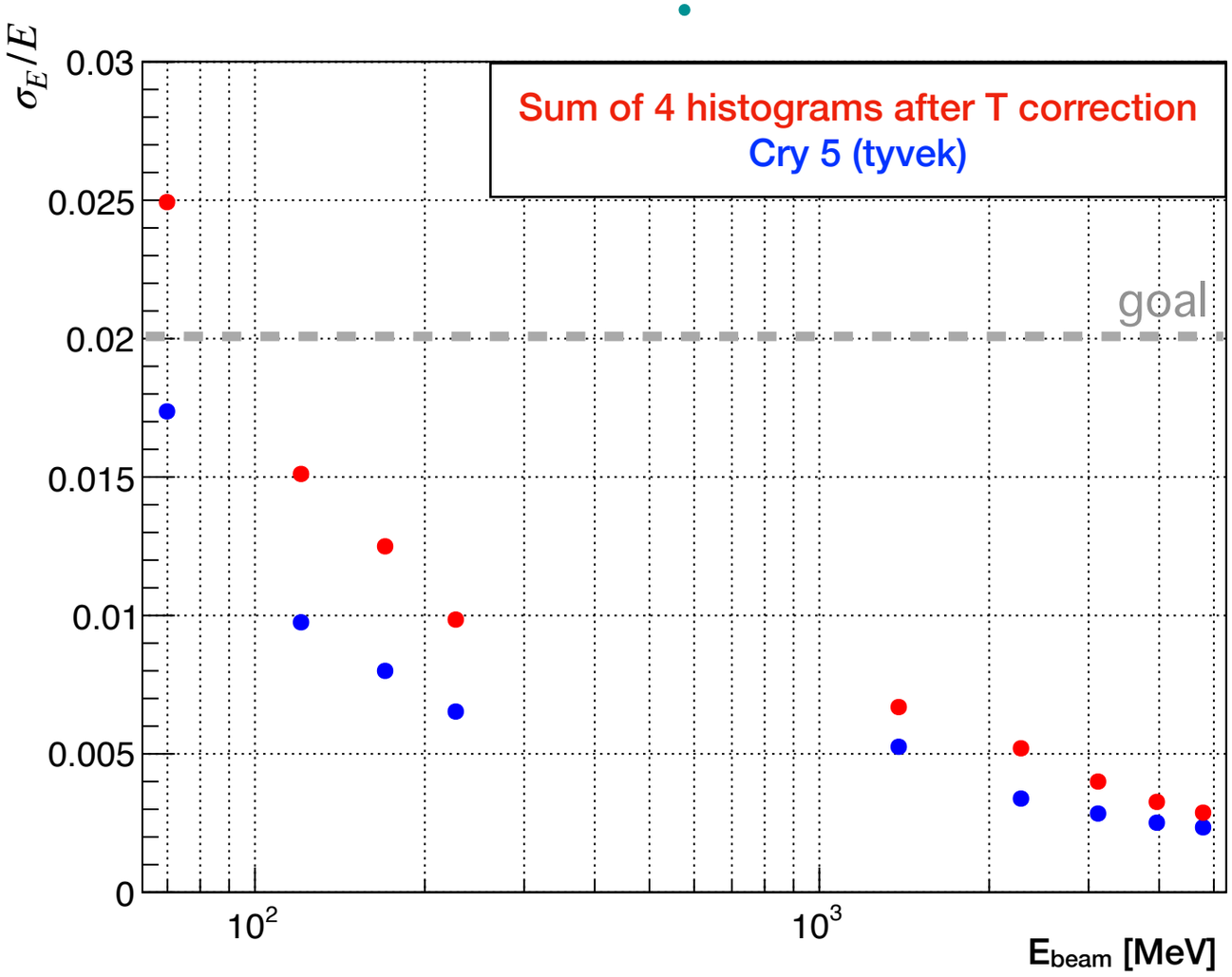
- Q_0: charge must be corrected
- T_0: temperature at which Q_0 has been taken
- m_0: actual angular coefficient to correct Q_0
- m_1 and m_2: the angular coefficients respectively at T_1 and T_2

Temperature control system (4)



In order to prove the validity of the model: sum of the charge distributions at different temperatures

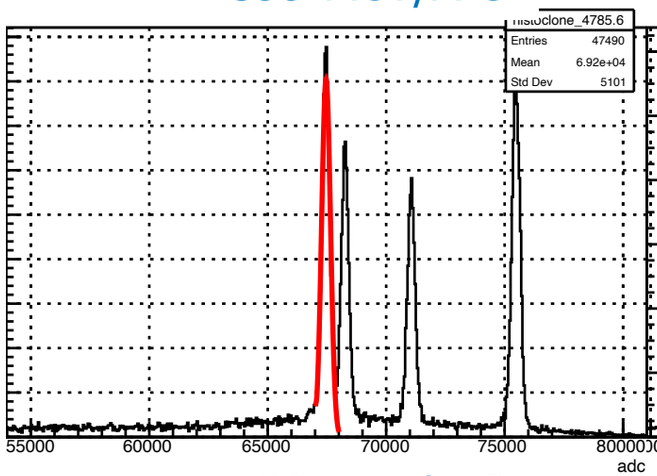
Energy Resolution < 2% after T correction



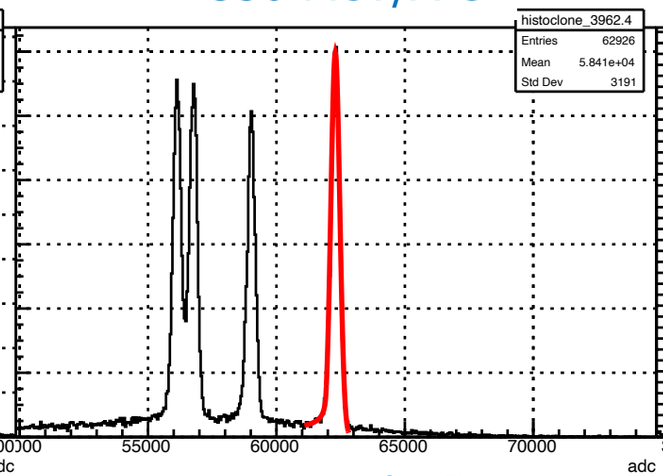
Temperature control system (5)

Charge distributions SUM before T correction

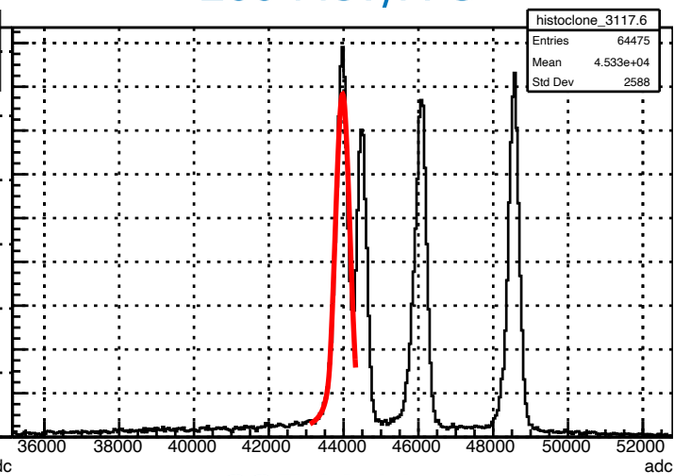
399 MeV/A C



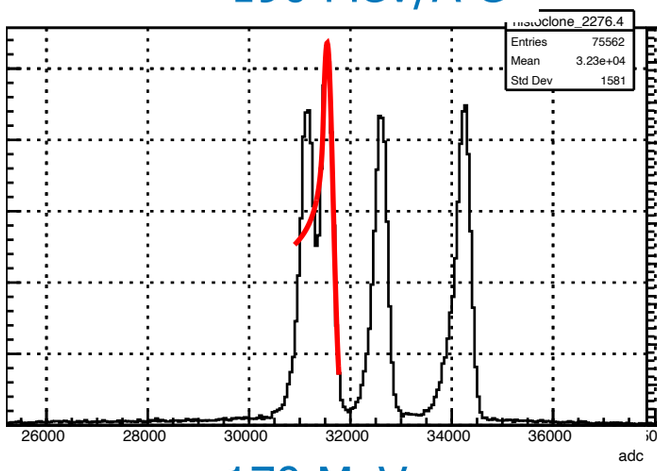
330 MeV/A C



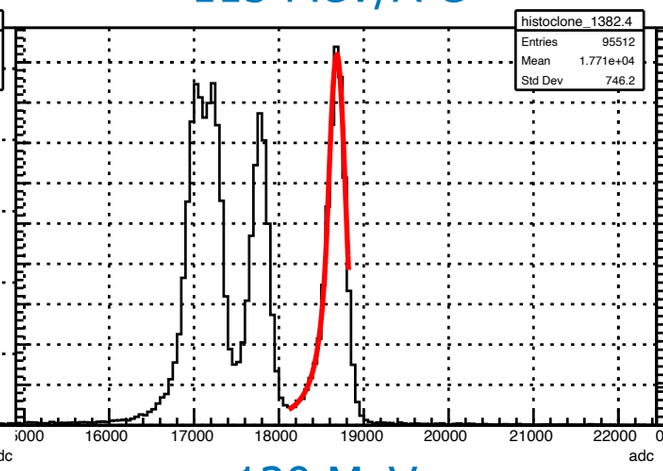
260 MeV/A C



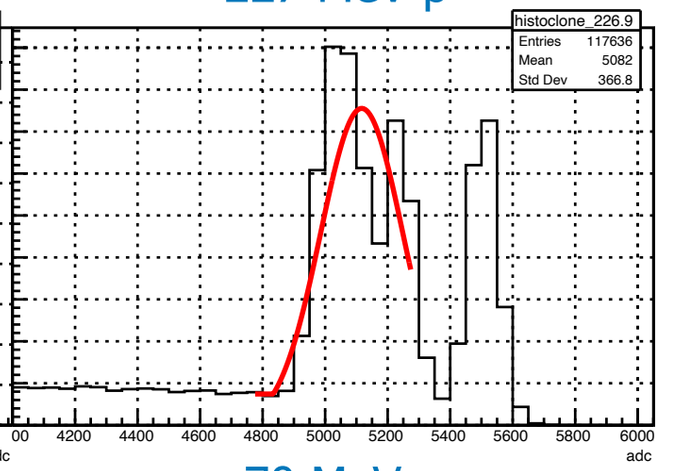
190 MeV/A C



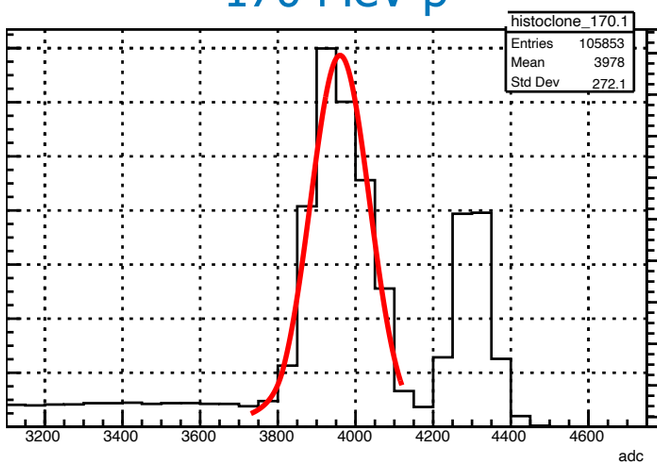
115 MeV/A C



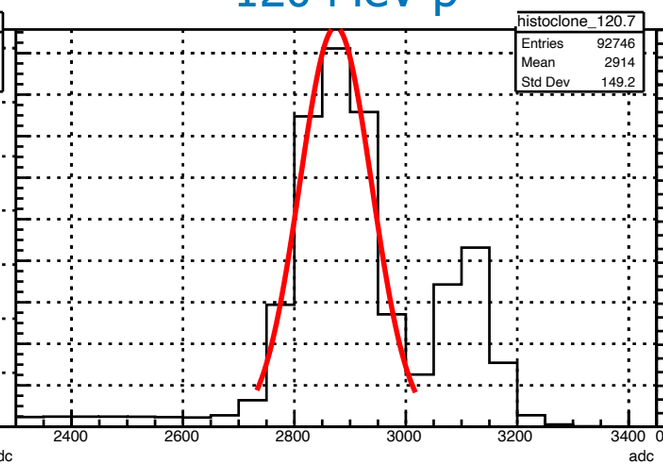
227 MeV p



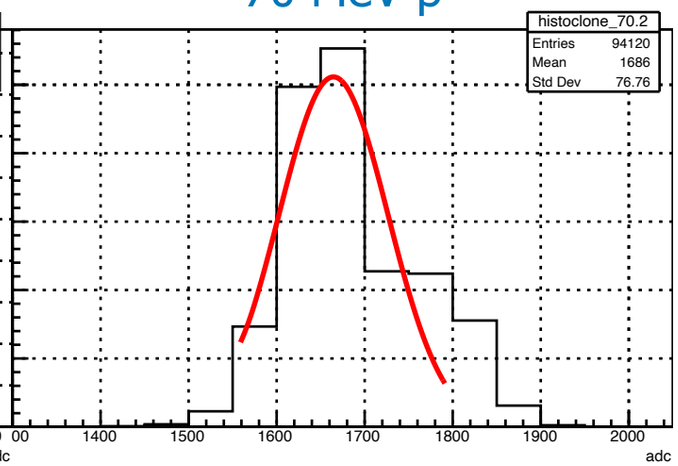
170 MeV p



120 MeV p



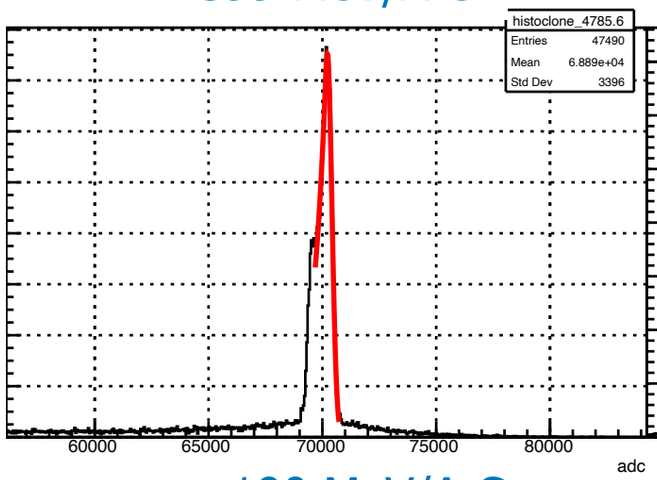
70 MeV p



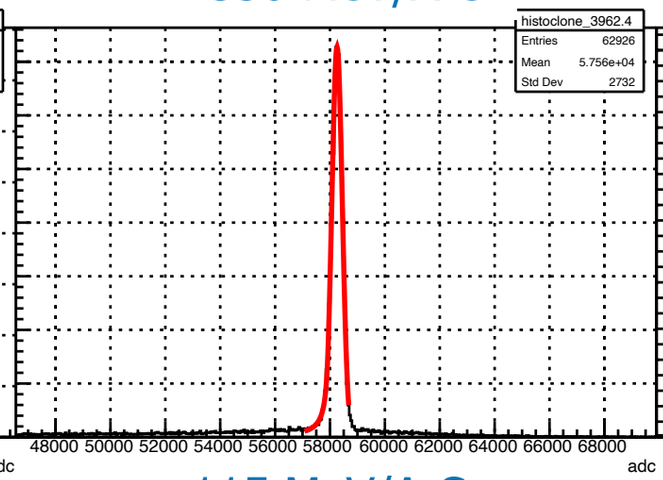
Temperature control system (6)

Charge distributions SUM after T correction

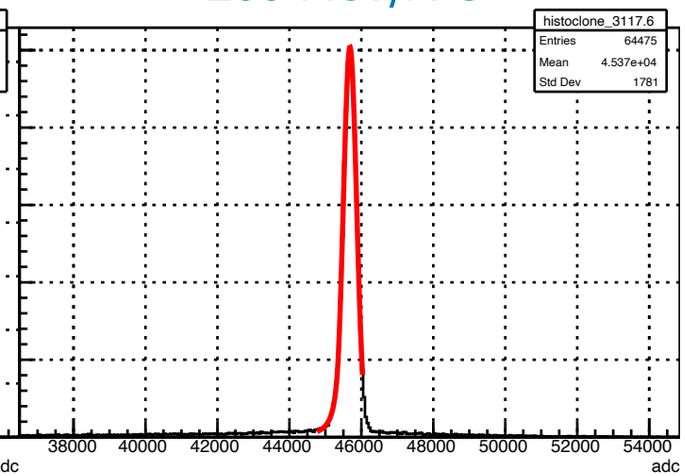
399 MeV/A C



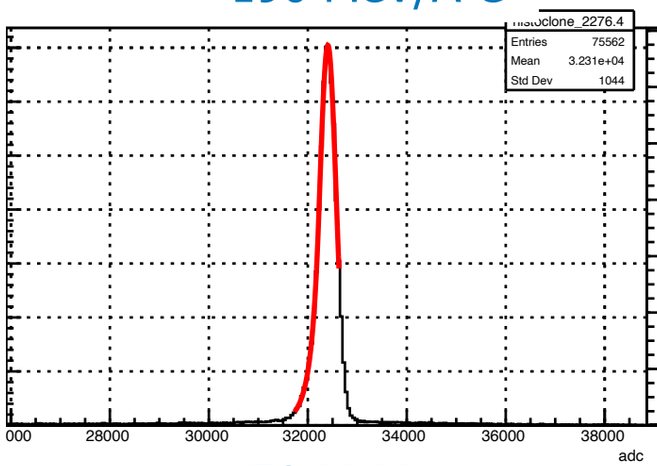
330 MeV/A C



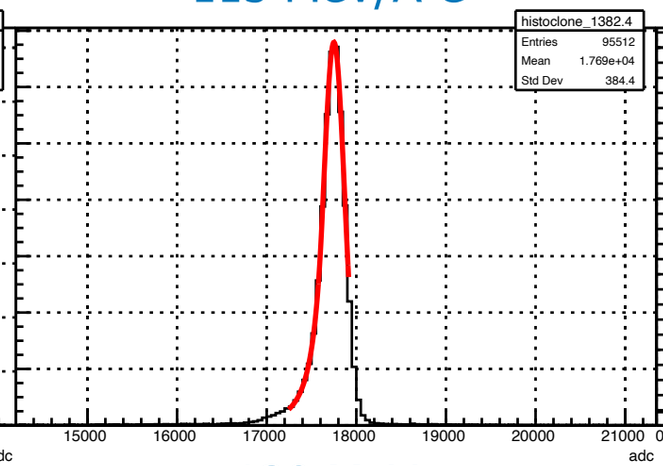
260 MeV/A C



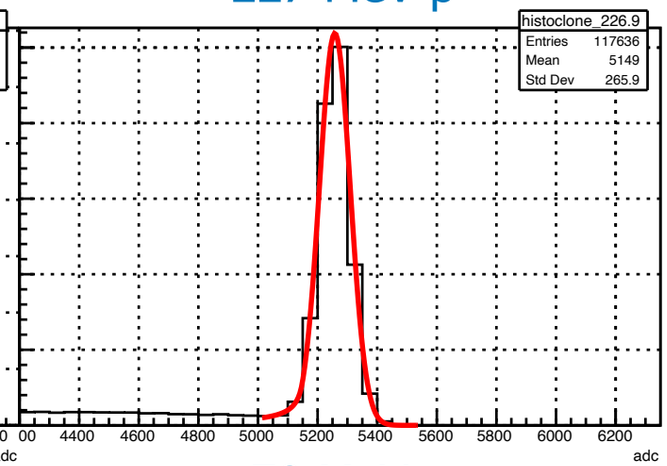
190 MeV/A C



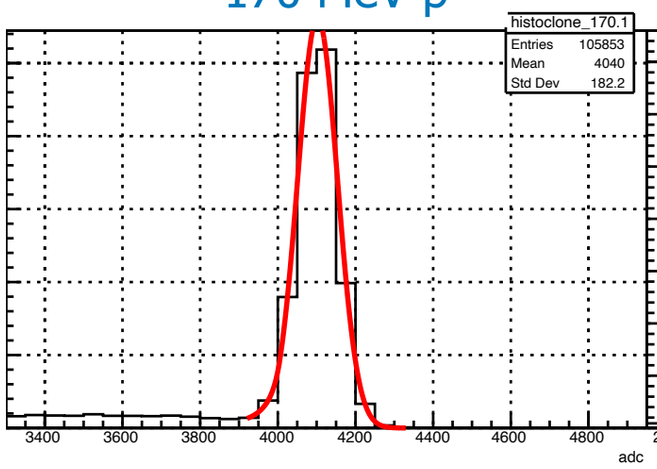
115 MeV/A C



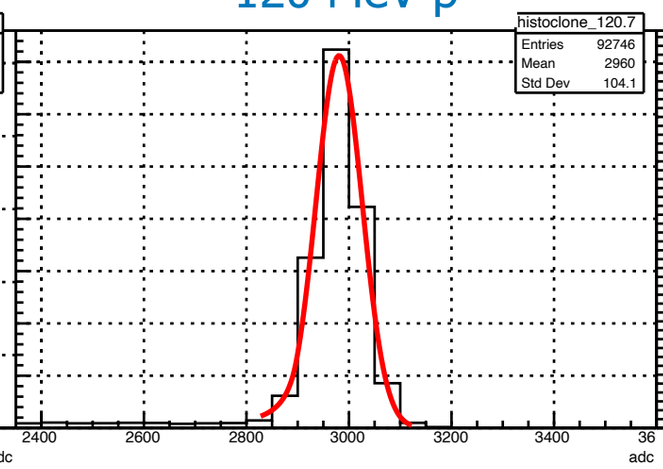
227 MeV p



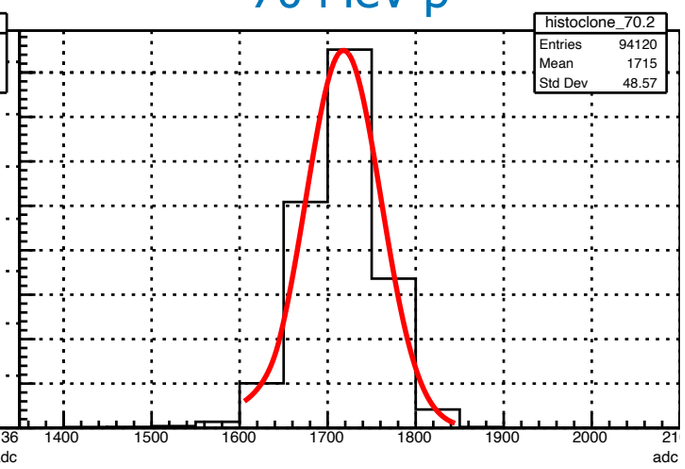
170 MeV p



120 MeV p

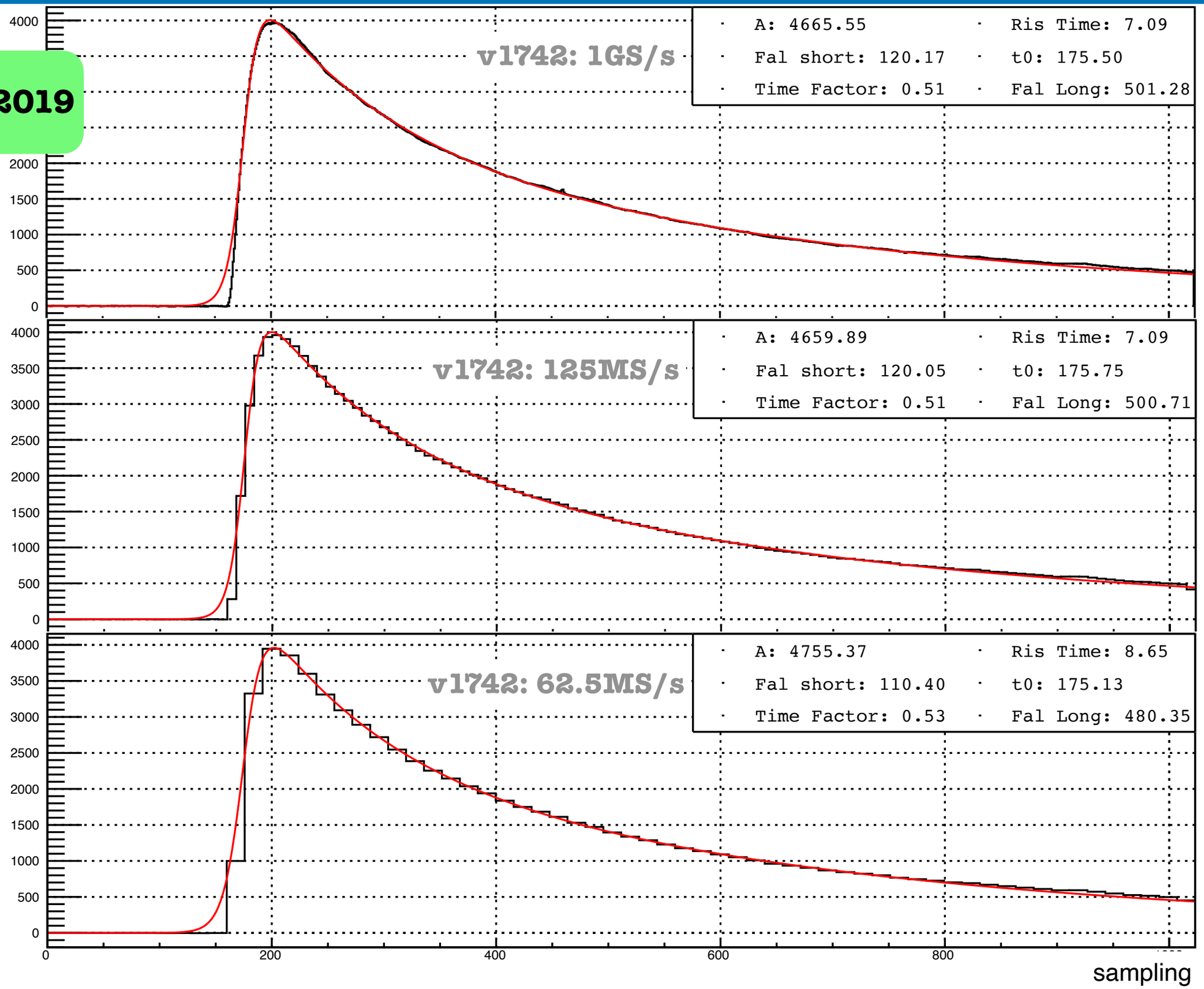


70 MeV p



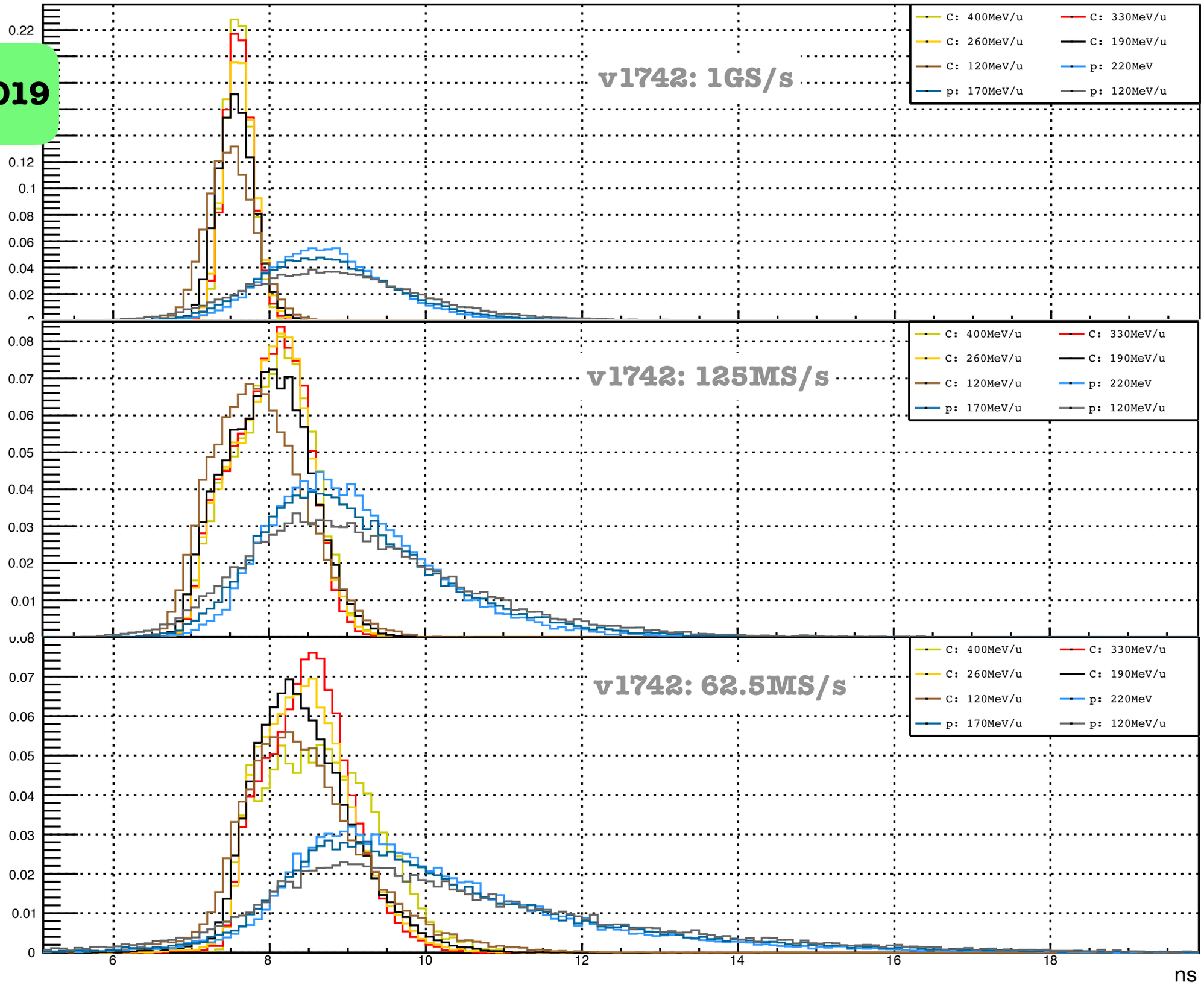
Downscaling simulation - Pulse Shape

11/11/2019



Downscaling simulation - Rising Time

11/11/2019



Conclusion & Future plans

Another parameter of the calorimeter design has been fixed: the wrapping

We have collected enough information to start the calorimeter construction:

- crystal size
- wrapping
- photodetector type and configuration
- readout parameters
- temperature variation compensation

Future plans:

- Test beam at Heidelberg Ion-Beam Therapy Center (HIT) in order to measure the crystal response function with different ions (H, He, C, O). Study the "quenching effect" in the BGO crystals
- DAQ
- Mechanics
- More studies on the temperature fluctuations with the climatic chamber