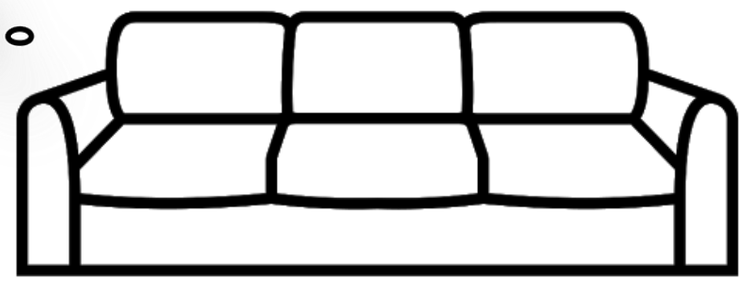
24/05/2021

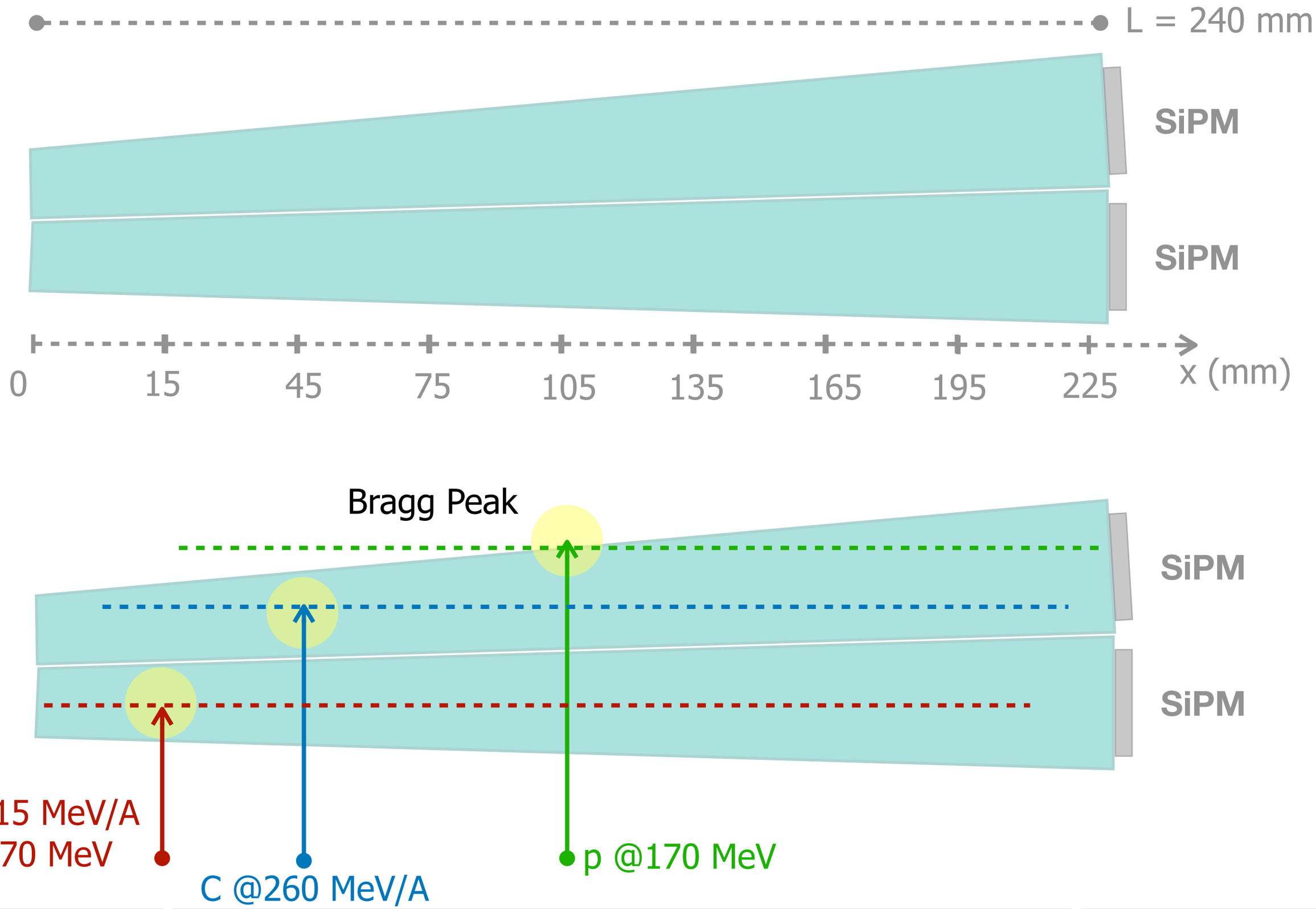
MC simulations of the light absorption in BGO crystals

X Collaboration Meeting



M. Bisogni, P. Cerello, E. Ciarrocchi, **L. Scavarda**

Test Beam SetUp

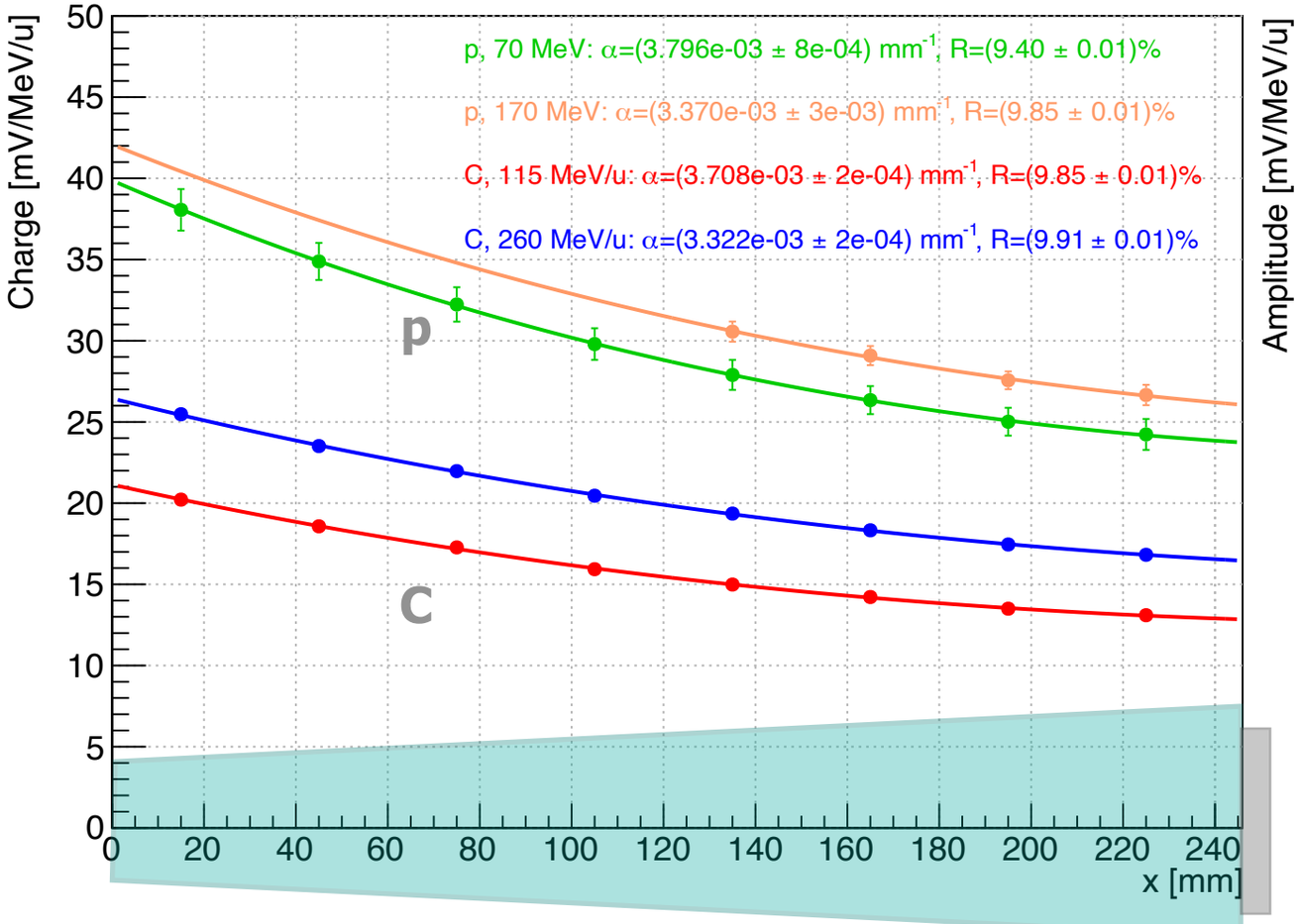


Light absorption

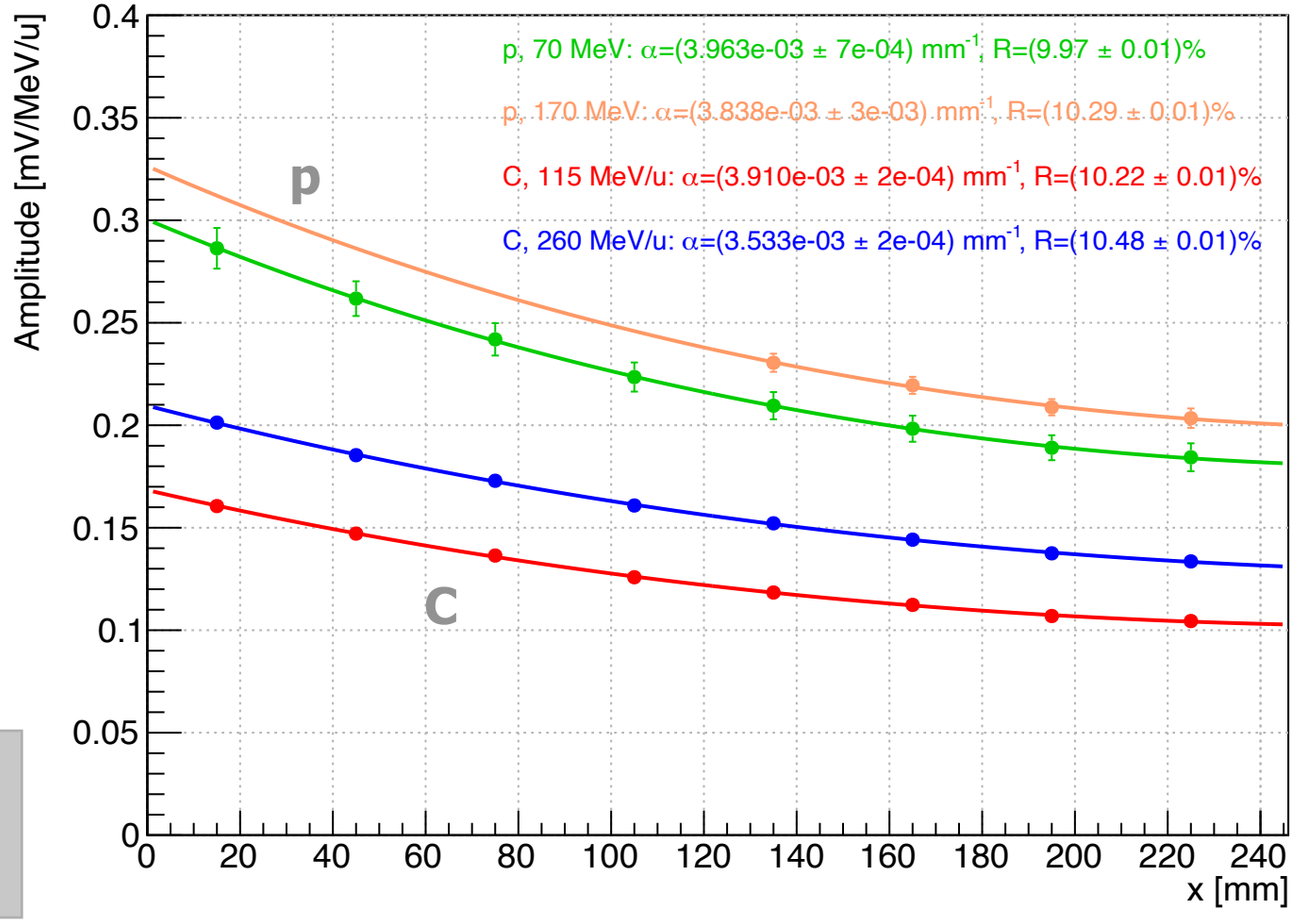
$$f(x) = A \cdot [R \cdot e^{-\alpha \cdot (L-x)} + (1-R) \cdot e^{-\alpha \cdot (L+x)}]$$

- A: normalisation factor
- R: relative weight of the direct component of the light to the SiPM
- α: attenuation factor
- L: length of the crystal

Charge Analysis



Amplitude Analysis

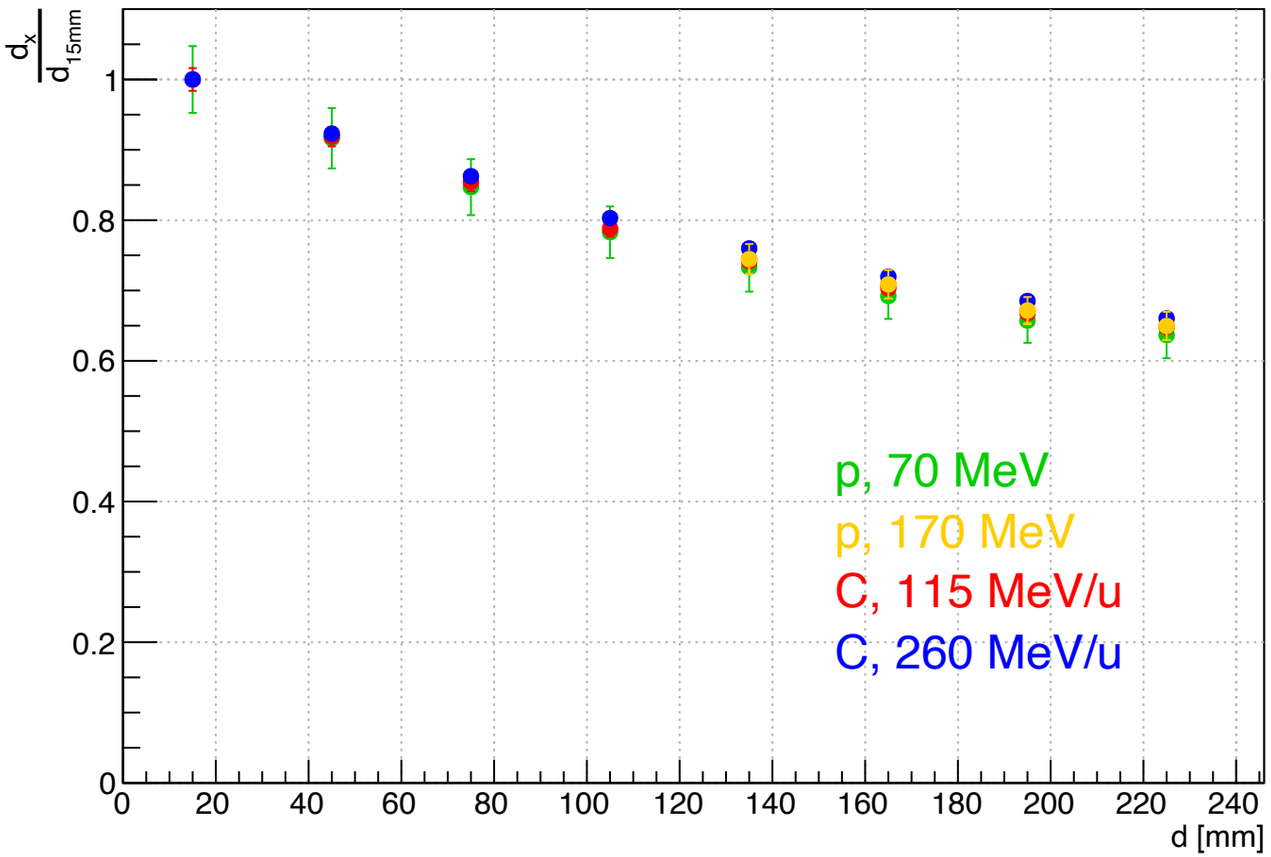


BGO **SiPM**

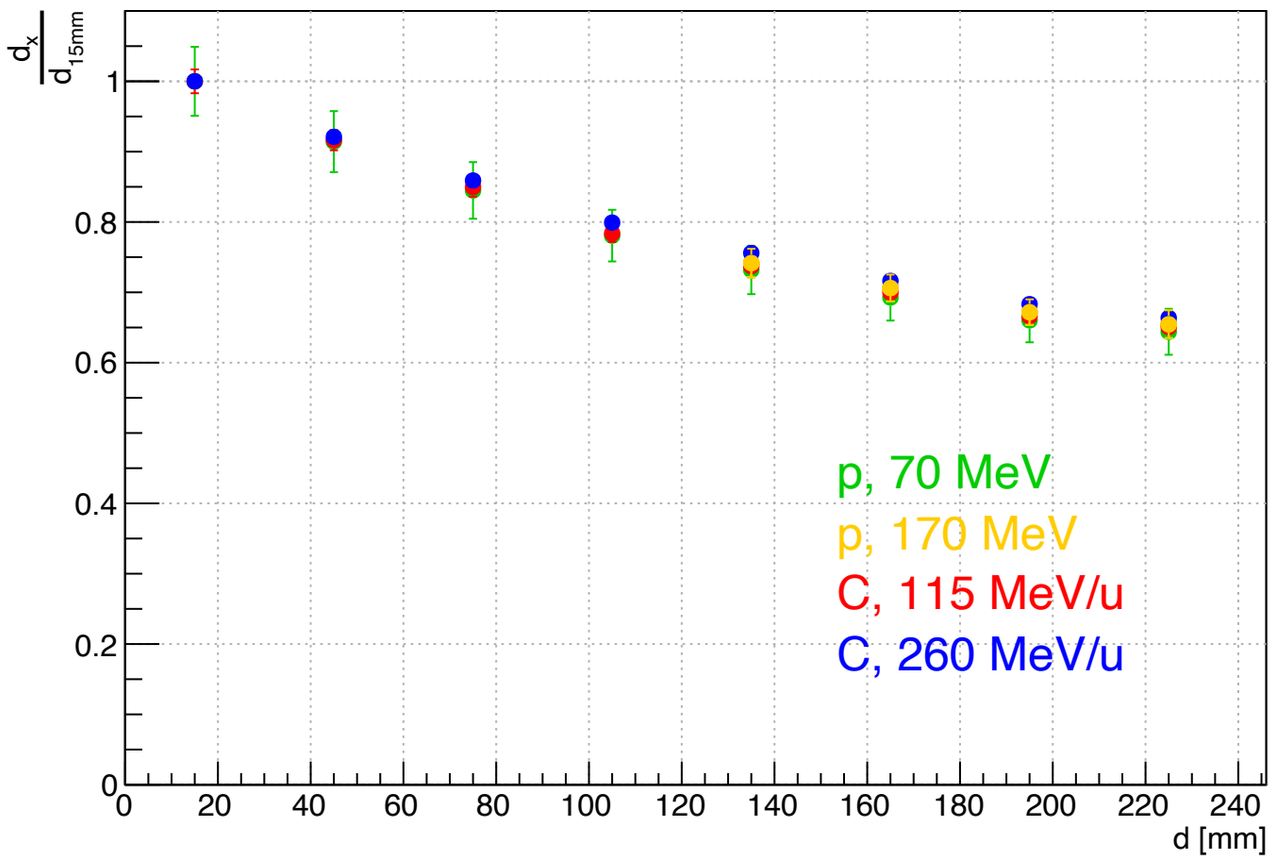
Light absorption

In order to compare better the different particles each set of points normalised to the first point at d=15mm is showed:

Charge Analysis



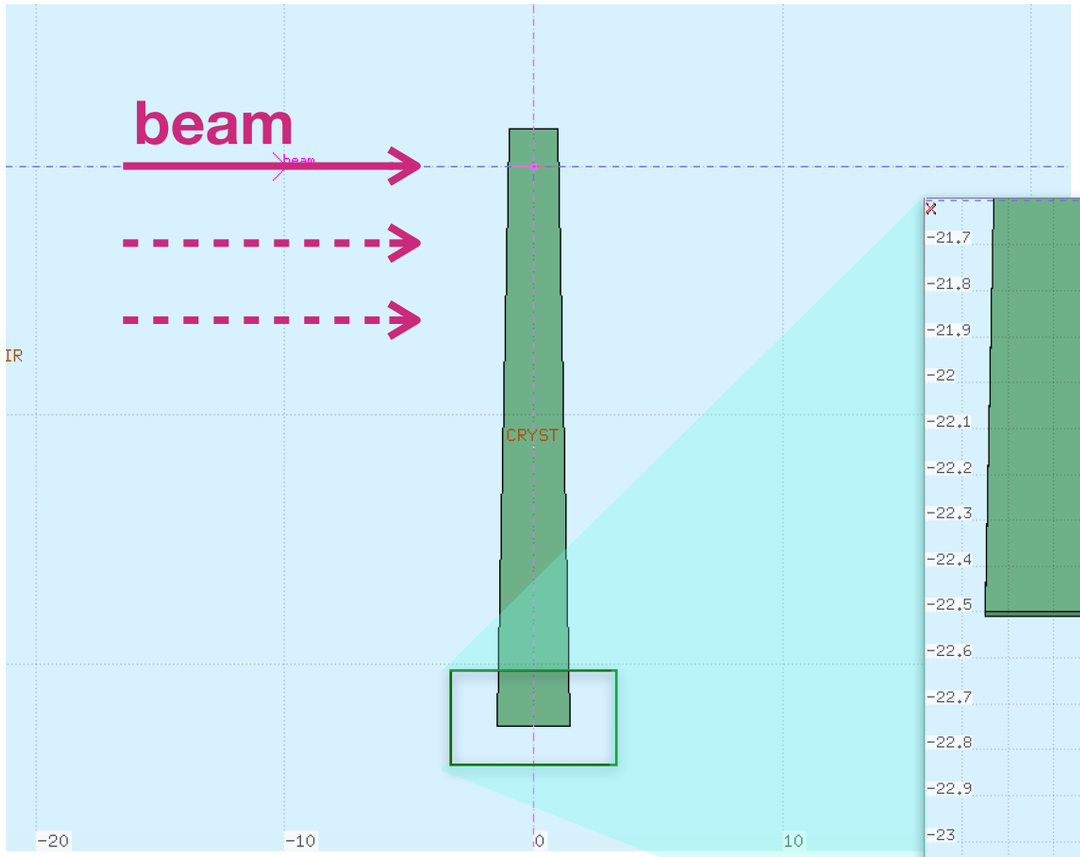
Amplitude Analysis

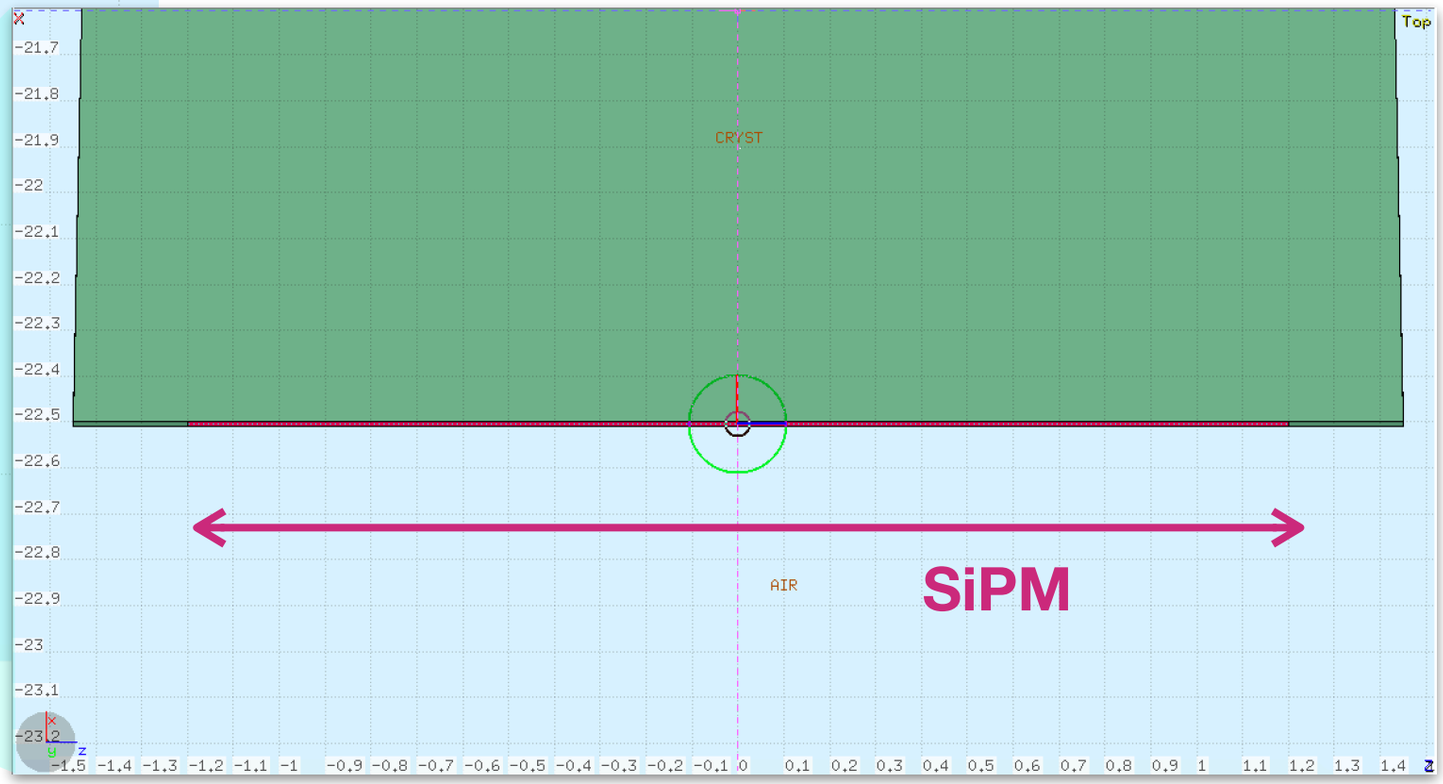


This contribution is not negligible even if it seems to not depend on the particle type and energy

FLUKA simulation geometry

- 1 single BGO crystal rotated 90°
- BGO wrapped with Tyvek
- proton beam @70MeV and carbon @115 MeV/A
- 1 primary proton/event x 100 events
- SiPM area: 22x23 mm^2
- Beam positions: 15, 45, 75, 105, 135, 165, 195, 225 mm
- BGO size:
  - front face 20x20 mm^2
  - back face 30x30 mm^2
  - length 240 mm



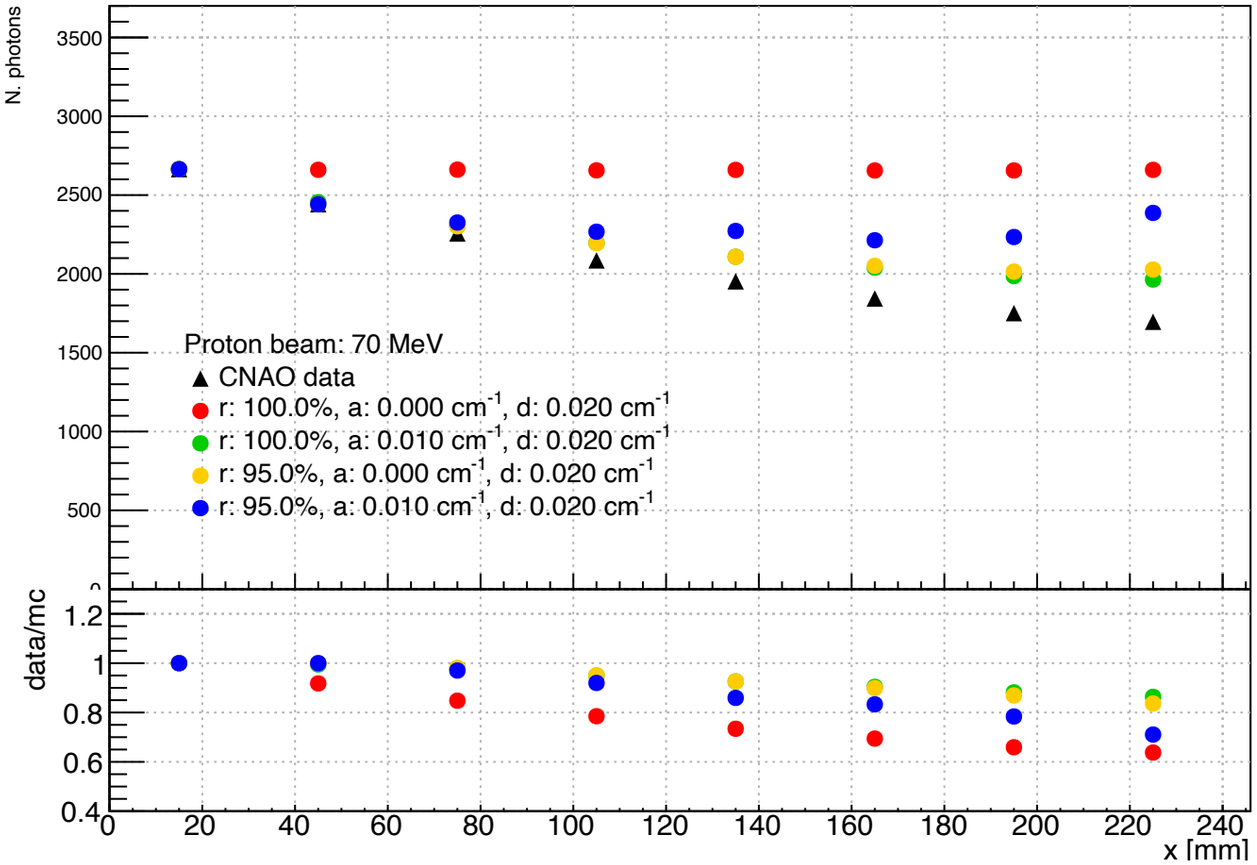


FLUKA simulation results

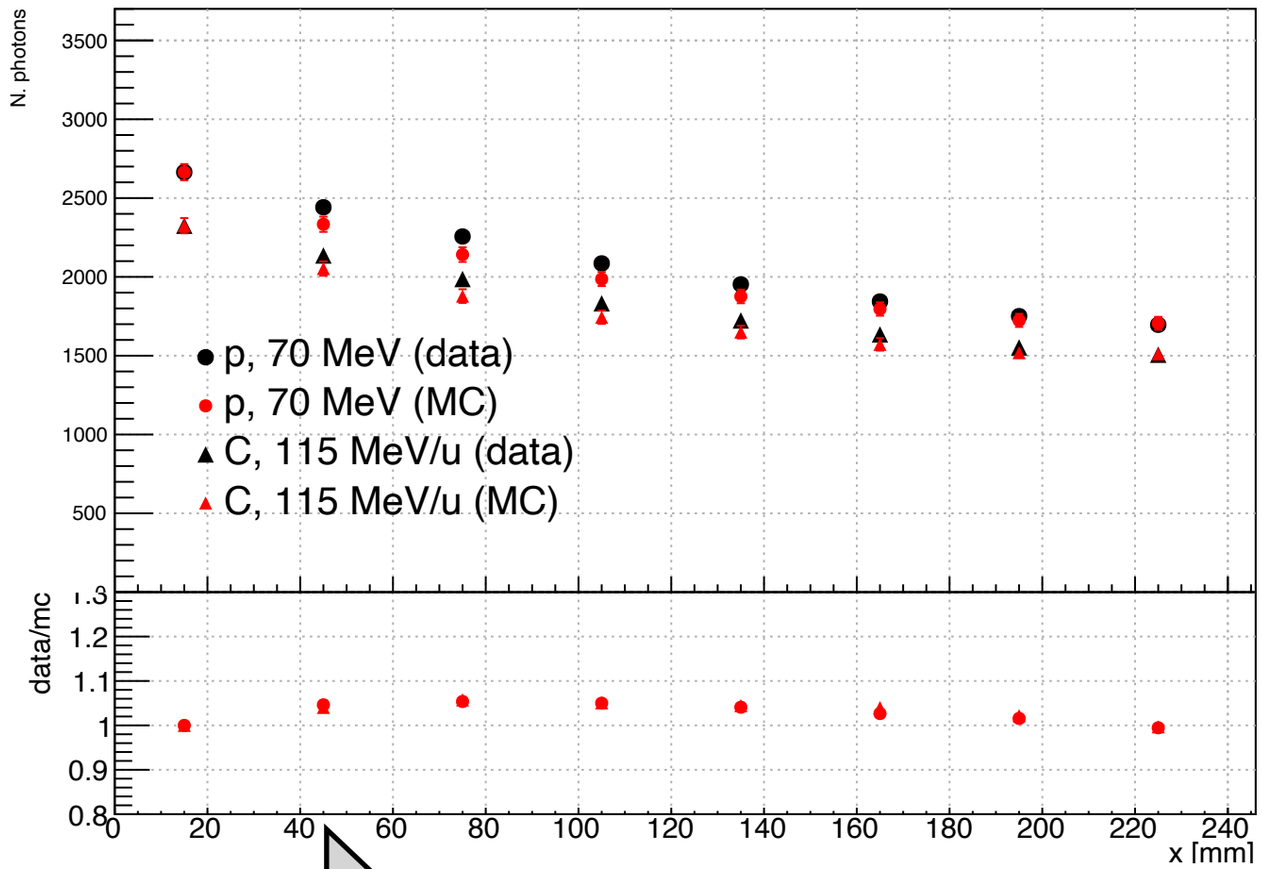
Three parameters were tuned in the simulation: reflectivity index of Tyvek, absorption coefficient and diffusion coefficient (scattering Rayleigh) of the BGO crystal.
The study has been split in 2 phases:

- tuning phase with proton beam @70 MeV
- validation phase with carbon beam @115 MeV

Tuning Phase



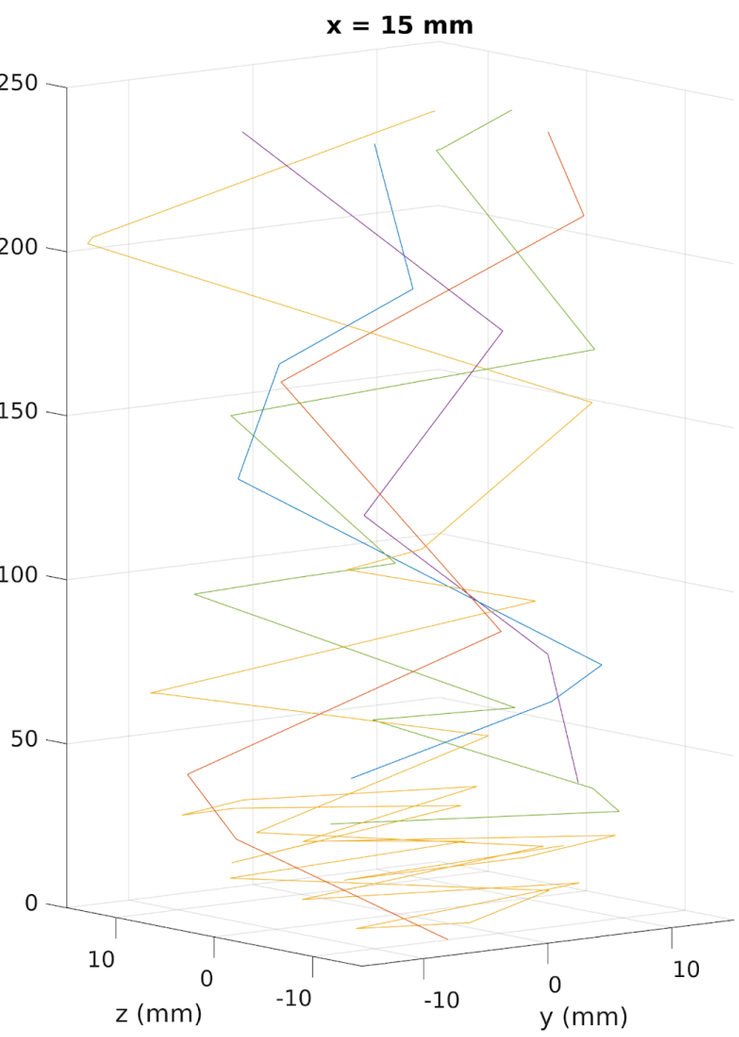
Validation Phase

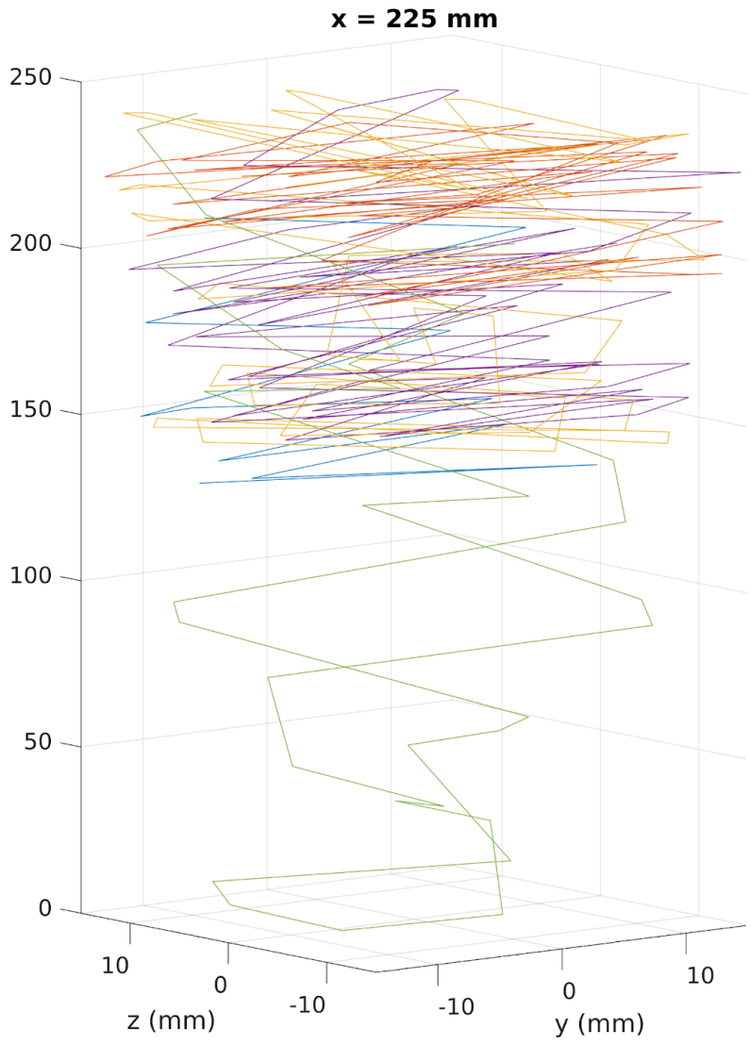


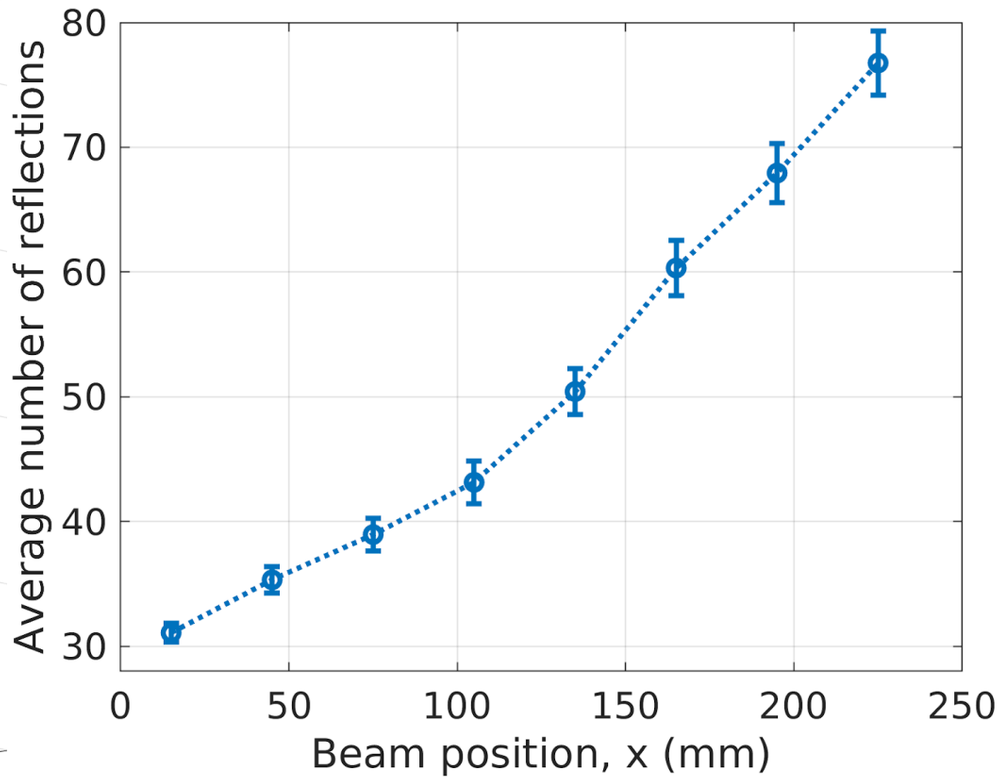
k_a=0.01 cm^{-1}, k_d=0.01 cm^{-1}, k_r = 97%

GEANT4 simulation results

Example paths for 5 scintillation photons in the BGO for the two extreme positions (15mm and 225 mm) and the average number of reflections as a function of their production position.

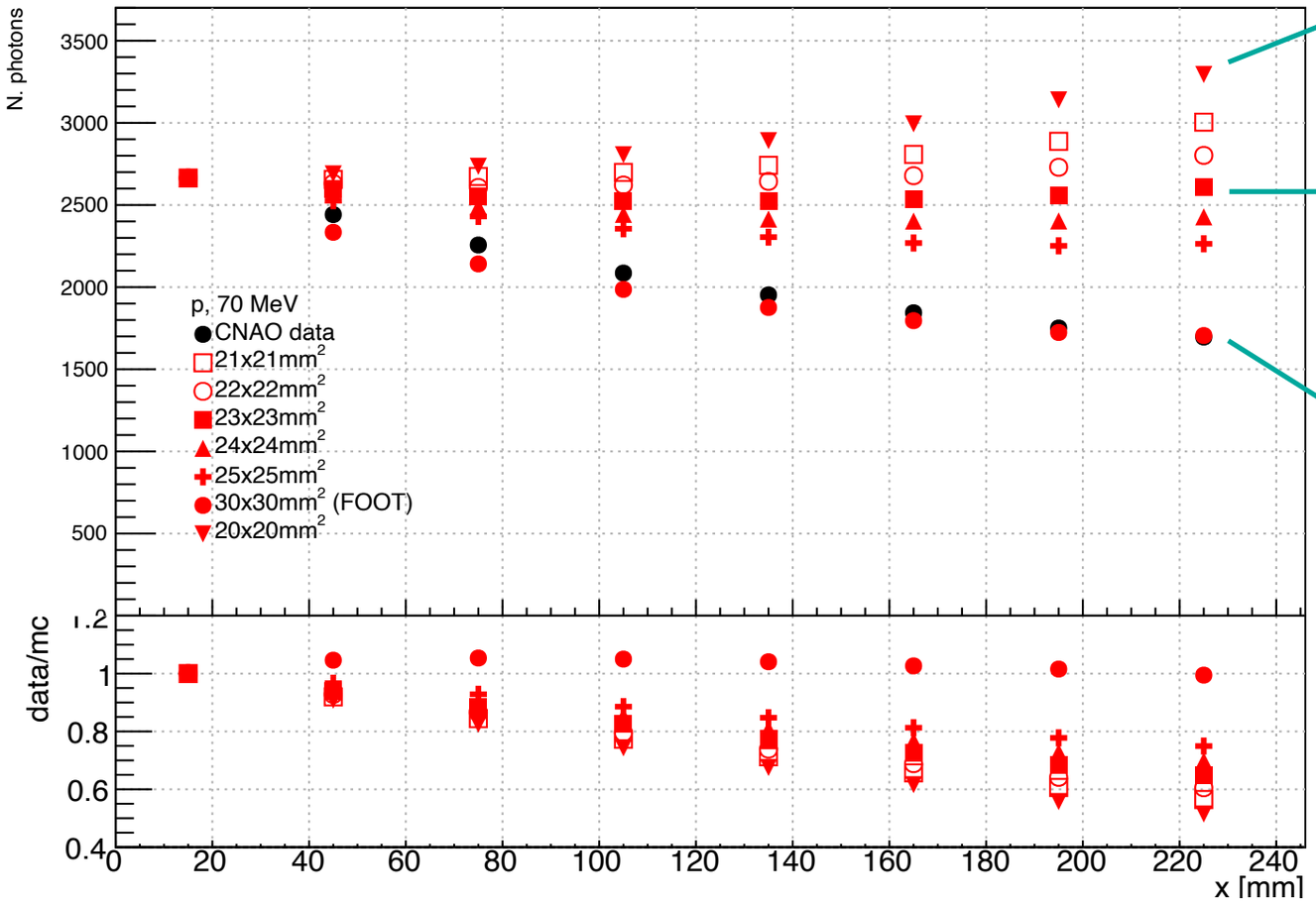


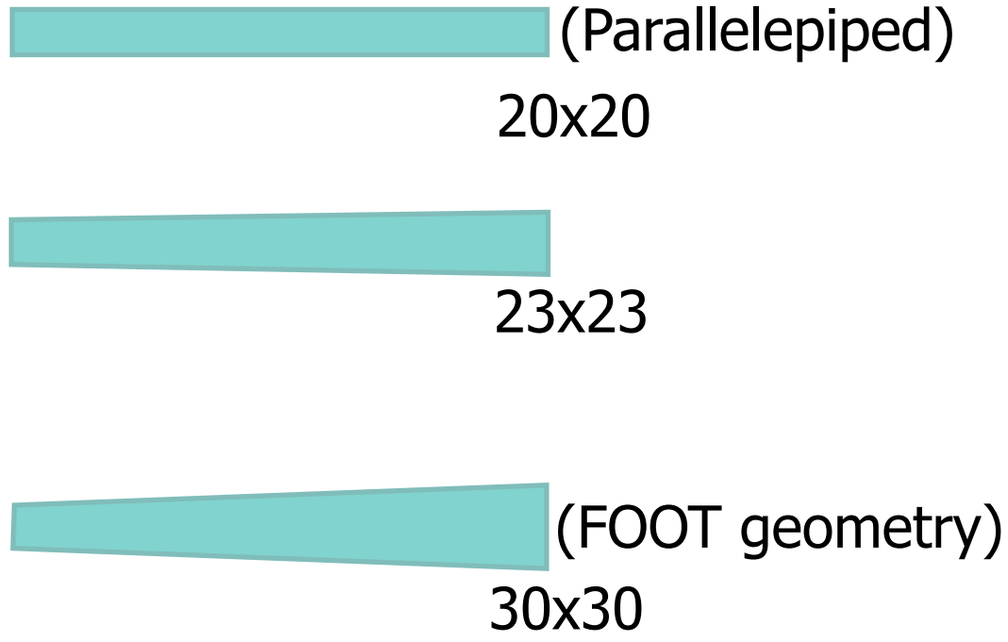




[by Esther's GEANT4 simulation]

Which should be the crystal geometry in order to compensate the optical absorption? Several FLUKA simulations with different size of the back face were performed

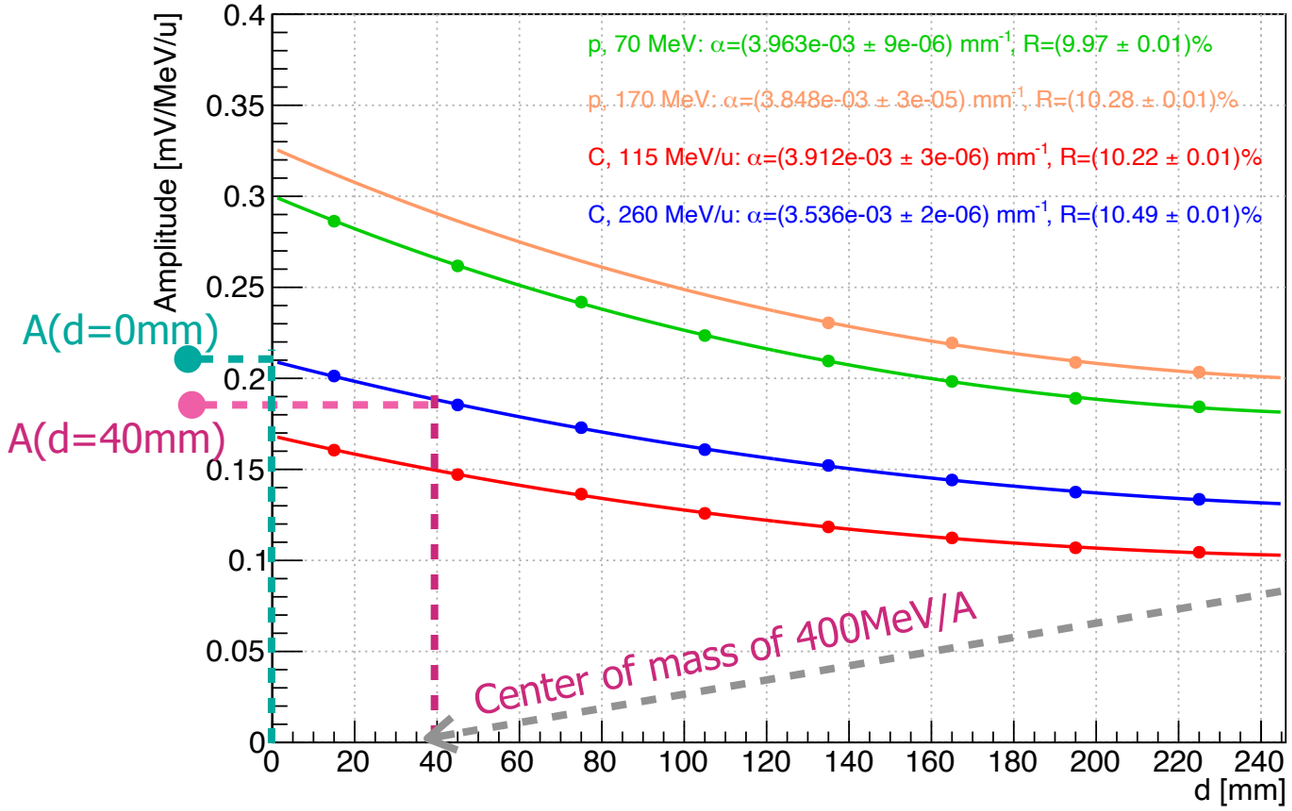


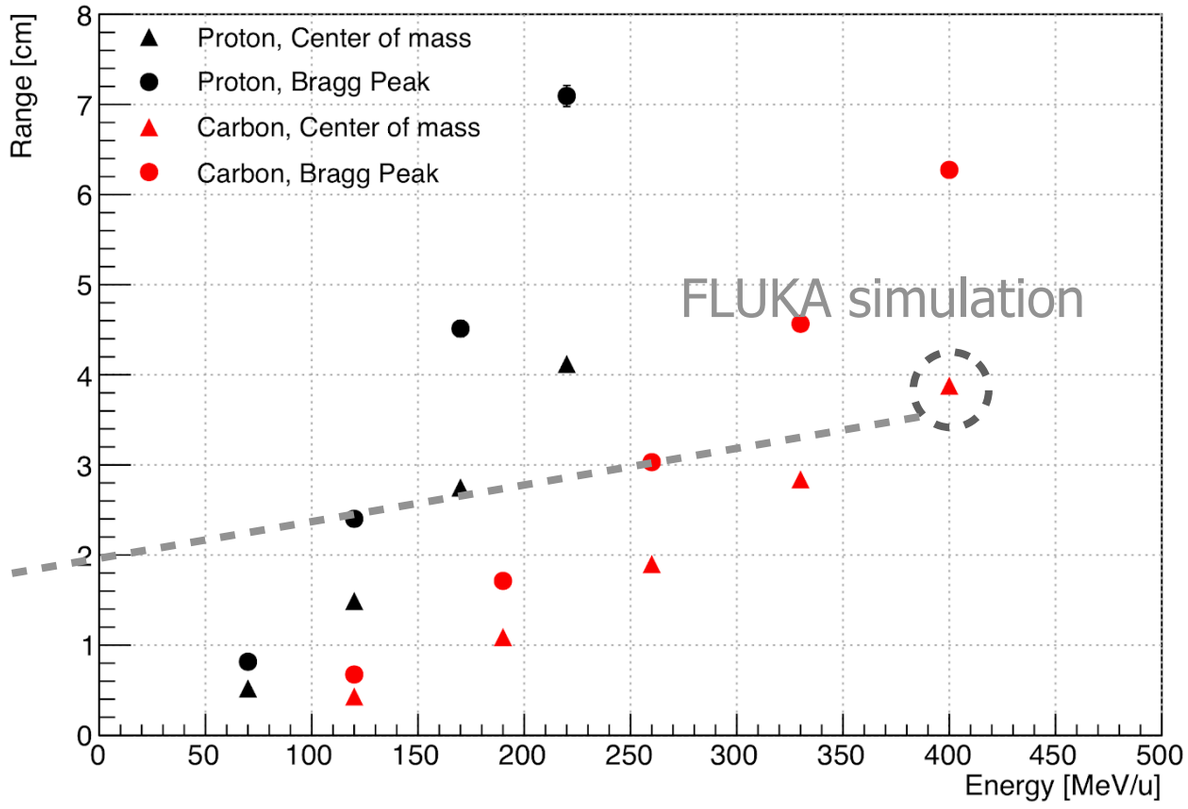


The simulation results show that with truncated pyramid crystal of 20x20 (front face) and 23x23 (rear face) the optical absorption effect is almost completely compensated (~5%).

Conclusions

- The study of the absorbed light along the crystal showed that the effect is not negligible but it is constant between different particles and energies.
- FLUKA and GEANT4 simulations reproduced correctly the effect within 5% and 15% respectively.
- The experimental and simulation results were interpreted as the convolution of several physical effects, related to the Tyvek reflectivity, the photon absorption and diffusion, the crystal shape, and the geometrical acceptance.
- A method to compensate this effect and correct the experimental data for the particle ranges has been developed:





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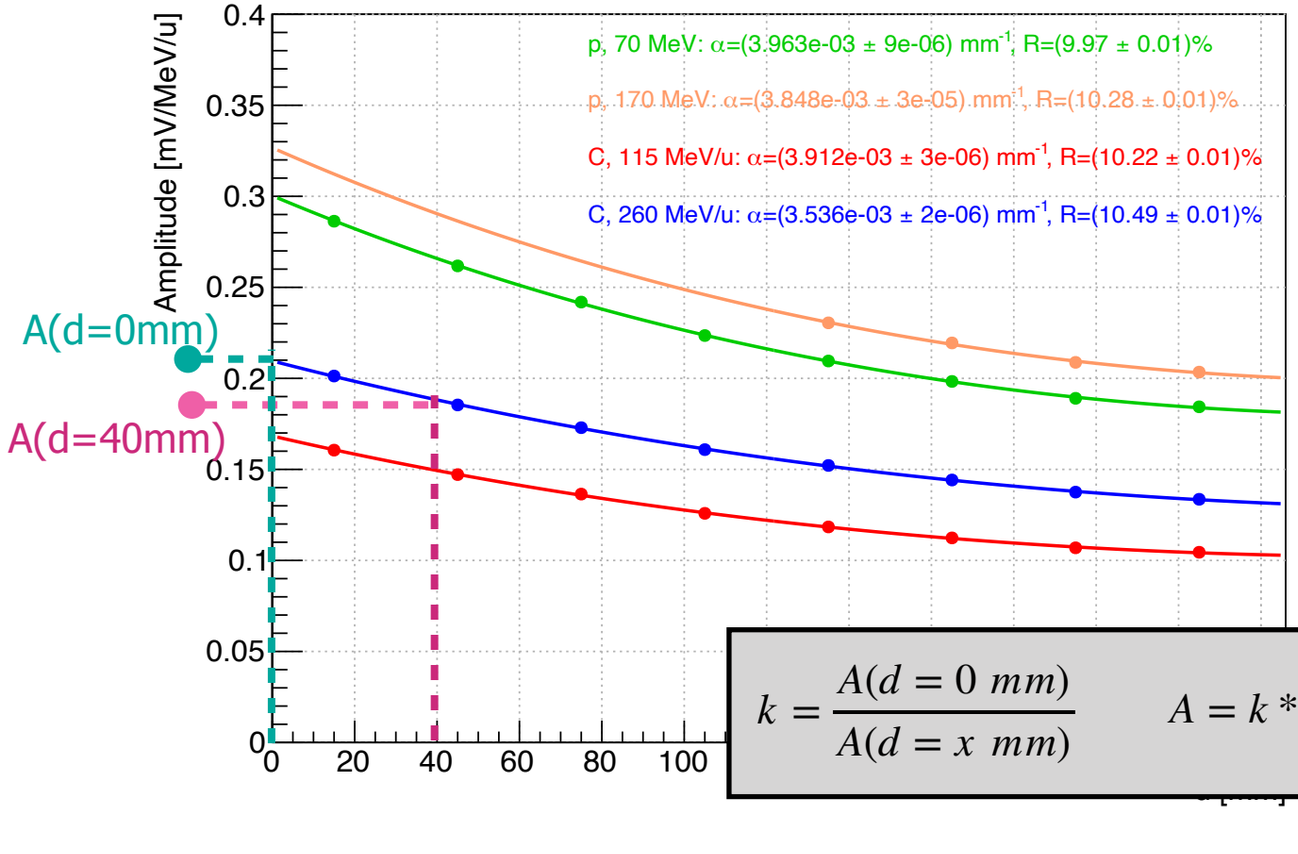

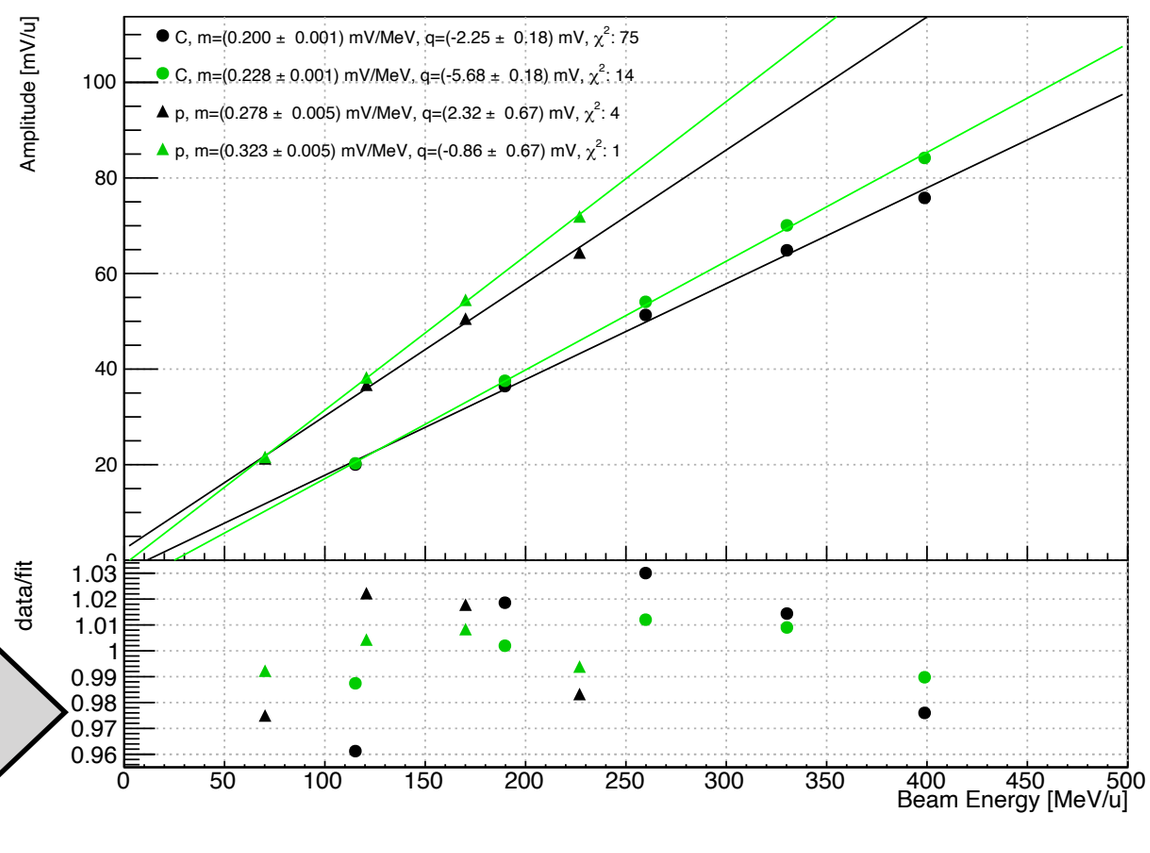

The results have been summarised in a paper and already sent to the Editorial Board!!