Simulation of Protons in CEPA[1]: a Pyramide-like Phoswich Array

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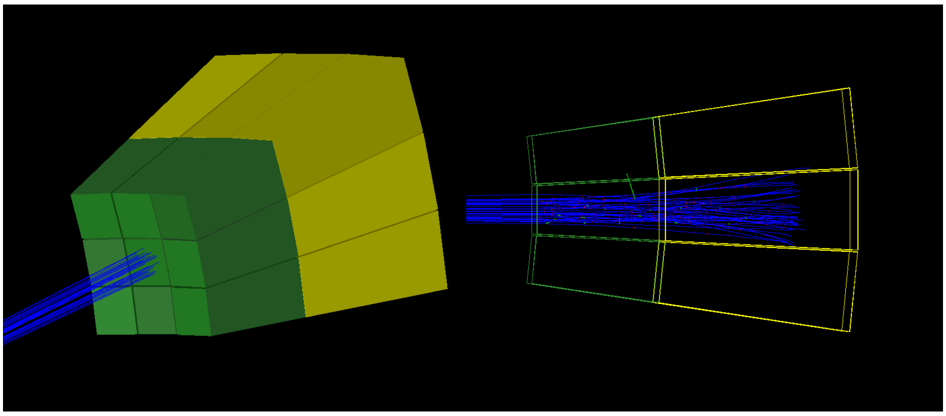
Parameters of the simulation

Geometry:
Array of 3×3 pyramid-like phoswich detectors. Each of them with a square at the entrance face (side: 49.9 cm) and a square at the exit side (side: 80 cm). The diagonal side of each pyramid is 10.2 cm long (the simmetry axis is 10 cm long). Each individual detector is comprised of a $LaBr_3$ crystal 4 cm long opticaly coupled to a $LaCl_3$ crystal 6 cm long.

Primary Generator:
Protons of energies ranging from 20 to 360 MeV have been generated at a distance of 20 cm from the entrance face. They are direceted towards the detector along the z-axis but with an aperture of 0.754^o so that they cover a circle of $\oslash = 1$ cm)



(a) (b)

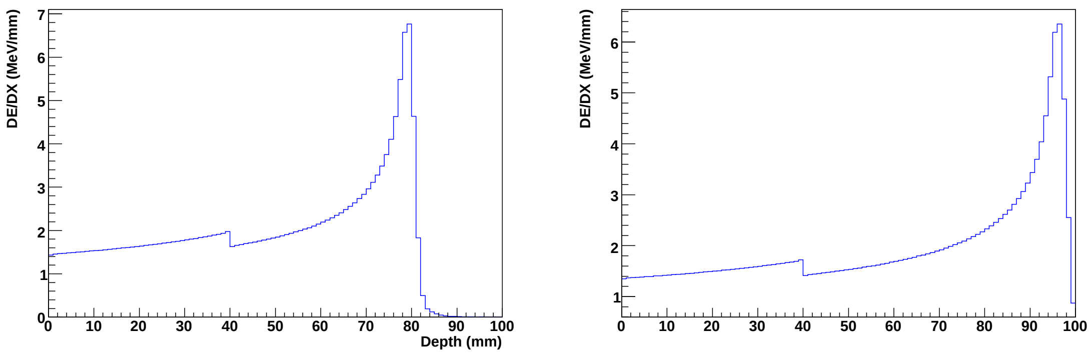
Figure 1: Detail of the geometry simulated and the tracks of the protons (180 MeV) in the central crystal.

[1]CALIFA Endcap Prototype Array

Physics:
Livermore low energy electromagnetic processes for gamma-rays and electrons. Standar Physics for positrons and protons.

Results

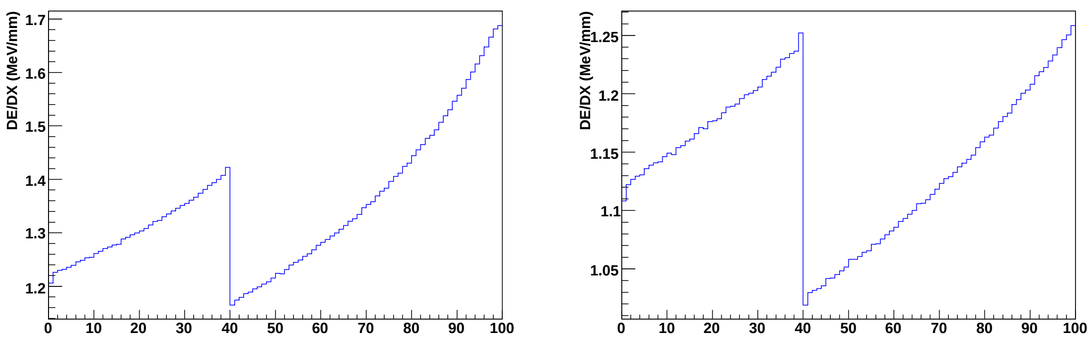
Energy deposited per unit length as a function of the depth in the detector: The Bragg Curve.



(a)

(b)

Figure 2: (a) Proton Energy: 180 MeV. (b) Proton Energy: 200 MeV



(a)

(b)

Figure 3: (a) Proton Energy: 240 MeV. (b) Proton Energy: 280 MeV.

Fig. 4 shows the nergy deposited in the 4 cm of $LaBr_3$ by individual protons of one specific energy from 100 to 320 MeV in steps of 20 MeV. Up to 120 MeV the proton is totally stopped in the $LaBr_3$ and all the counts are in the photopeak at 100 MeV and 120 MeV. For 140 MeV and beyond the $LaBr_3$ crystal acts as a ΔE detector, the proton scapes and all the counts are now in the broad peaks below 100 MeV. Protons of 140 MeV leave about 90 MeV in the $LaBr_3$ crystal, protons of 160 MeV leave about 75 MeV and so on.

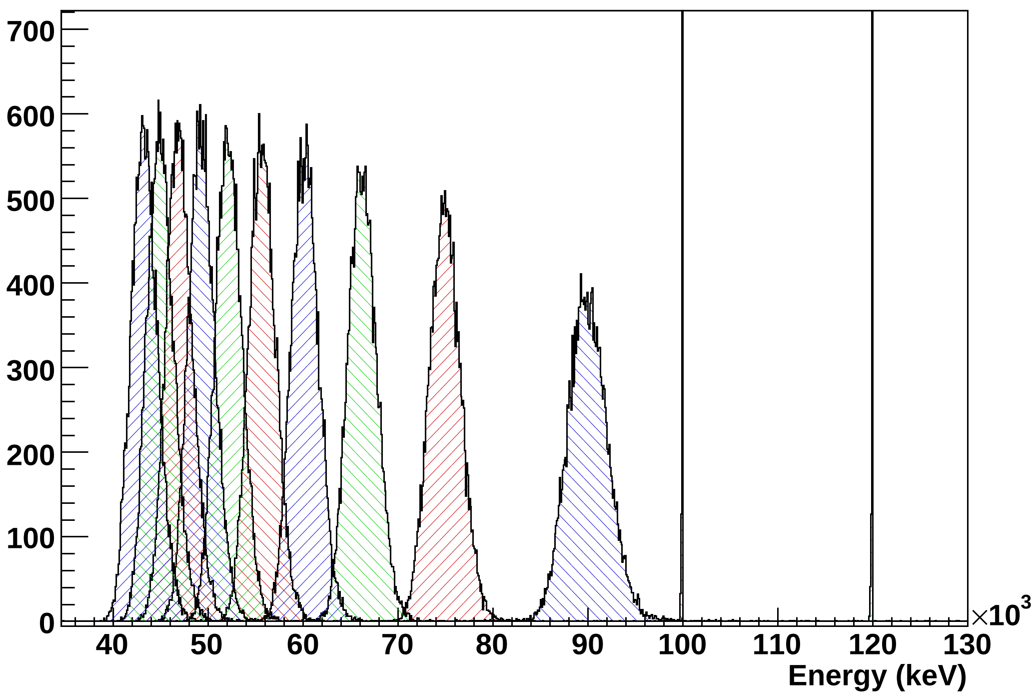


Figure 4: Proton energies from 180 MeV to 320 MeV in steps of 20 MeV.

Fig. 5 represents the same as Fig. 4 but with all counts coming from all different energies added up. It looks like it is not possible to distinguish protons of 220 MeV from the ones with higher energy.

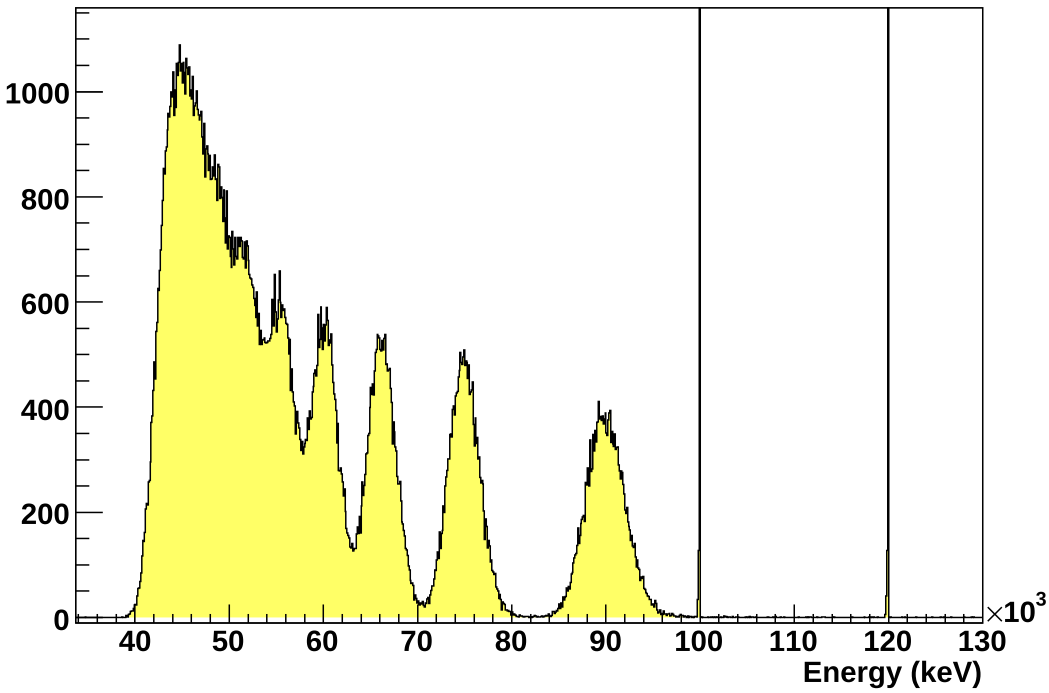


Figure 5: Proton energies from 180 MeV to 320 MeV in steps of 20 MeV.

A different approach to separate different proton energies is to represent the energy deposited in the first crystal (4 cm of $LaBr_3$) as a function of the total energy deposited in the whole detector. This is shown in Fig. 6.

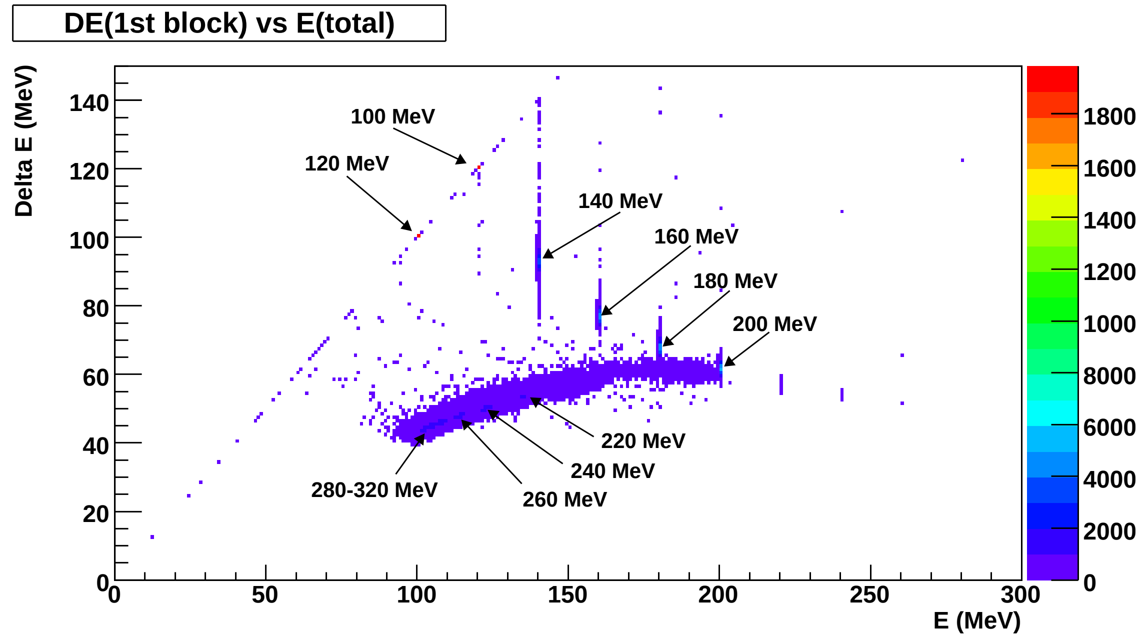


Figure 6: ΔE - E scatter plot for protons with energies from 180 MeV to 320 MeV in steps of 20 MeV.

The same figure but in a 3-dimensional view:

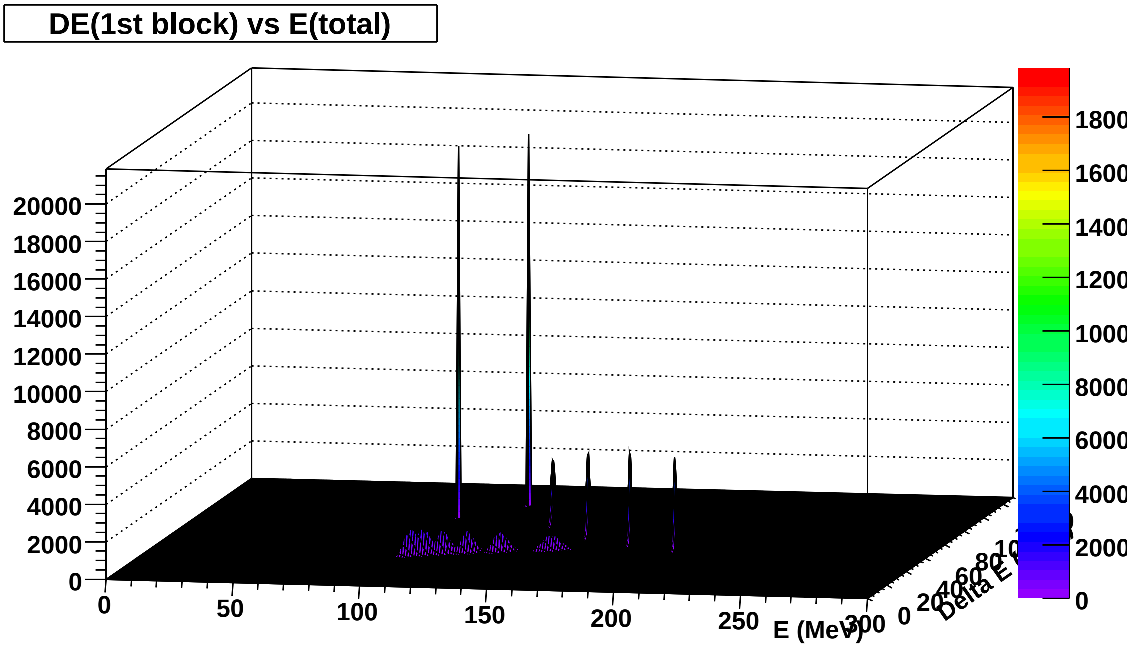


Figure 7: ΔE - E 3D plot for protons with energies from 180 MeV to 320 MeV in steps of 20 MeV.