Hadron energy measurement

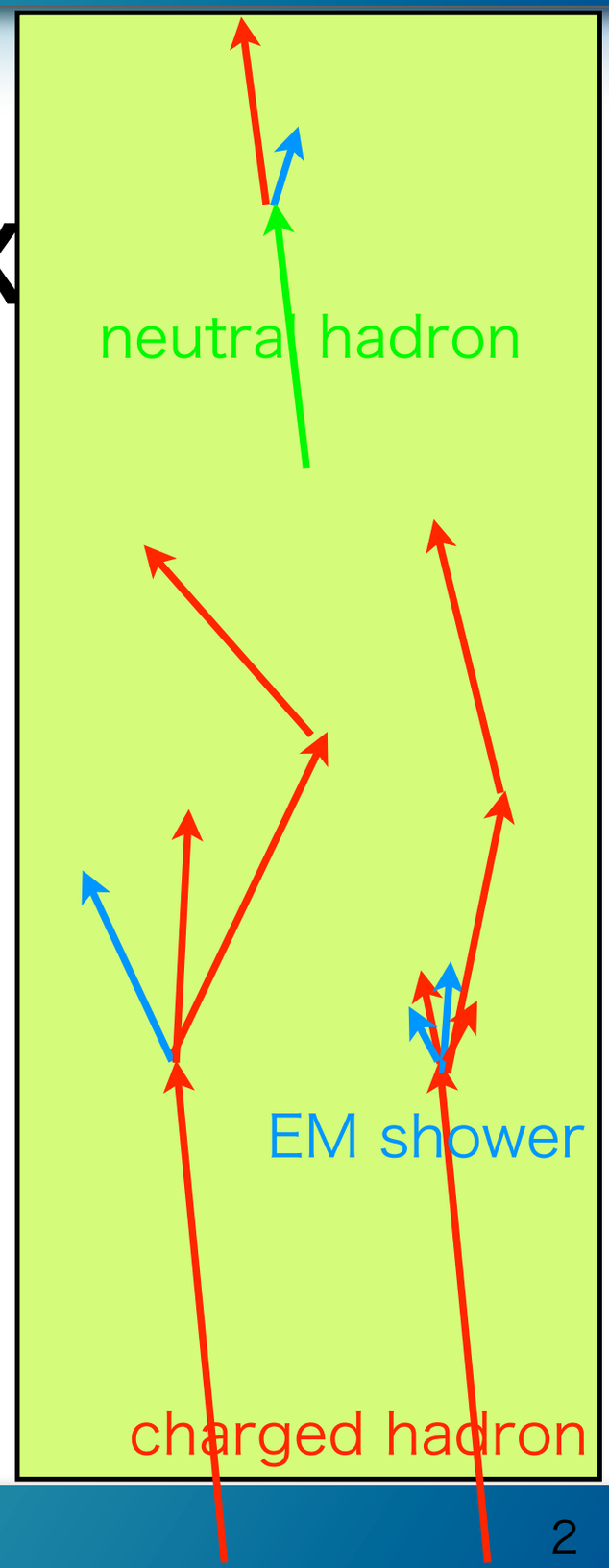
Tohru Takeshita
(Shinshu)

simulation study

Birk's low is not included

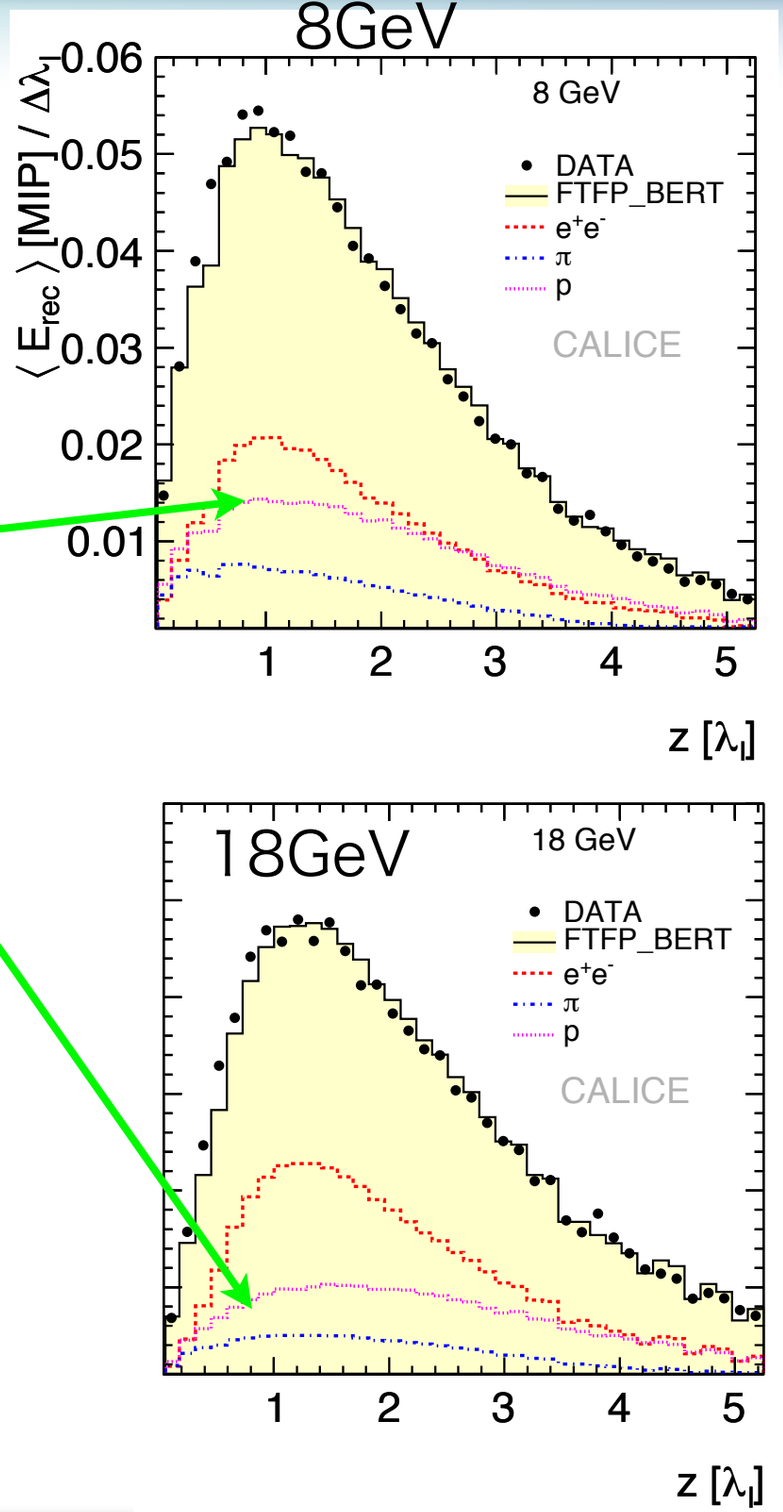
hadron calorimeter

- in HCAL
- **H interaction length ~10cm >> X ~1cm radiation length for EM interaction**
- **once a pi-zero produced EM shower emerges**
- **photons and neutrons**
- **nuclear interactions**



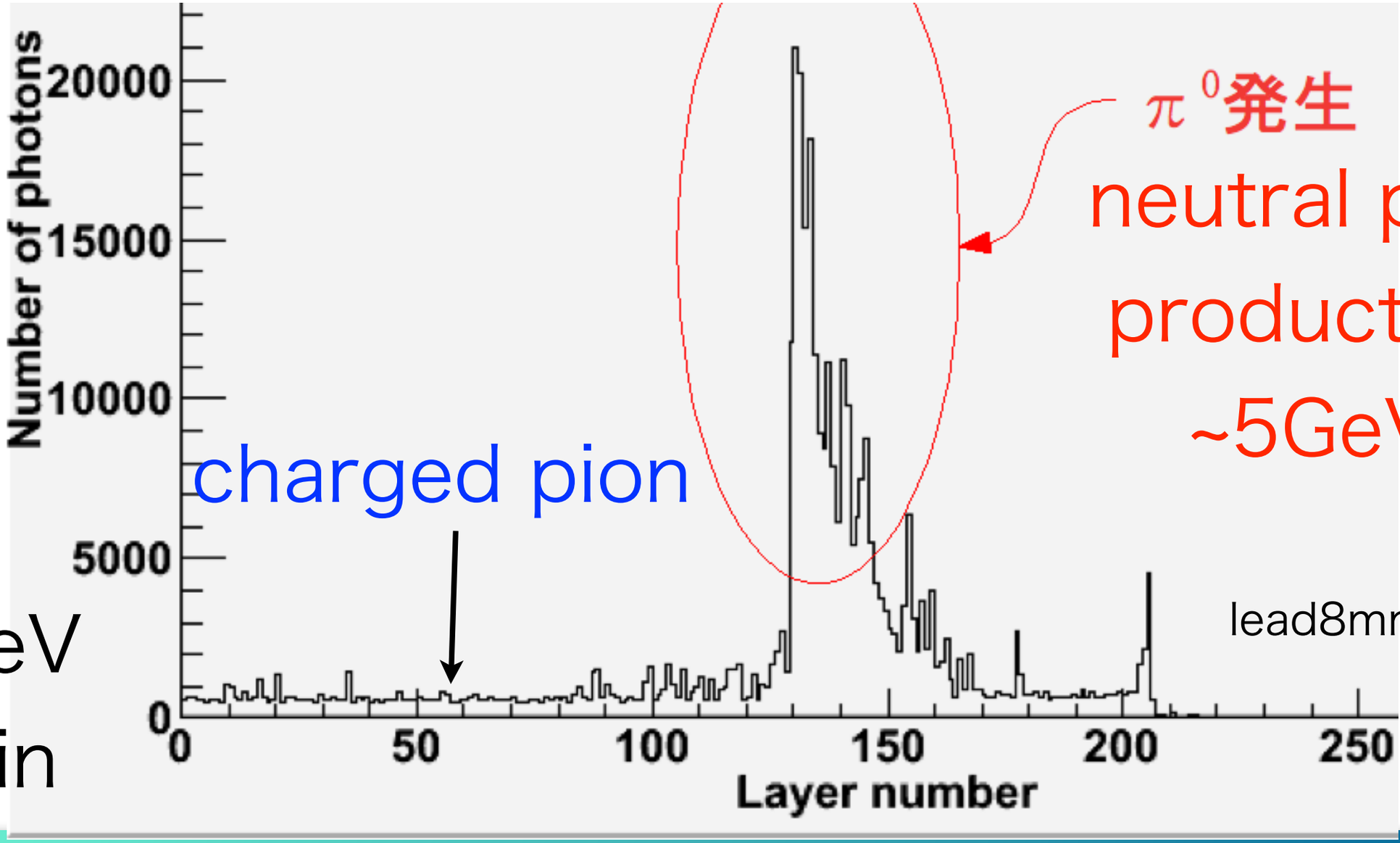
AHCAL results

- pions incident
- longitudinal profile : z
- protons at lower E ~ electrons from π^0
- charged pions ~ MIP



longitudinal profile

- QGSP_BERT model
- longitudinal shower profile



20GeV

π^- in

many events in long.

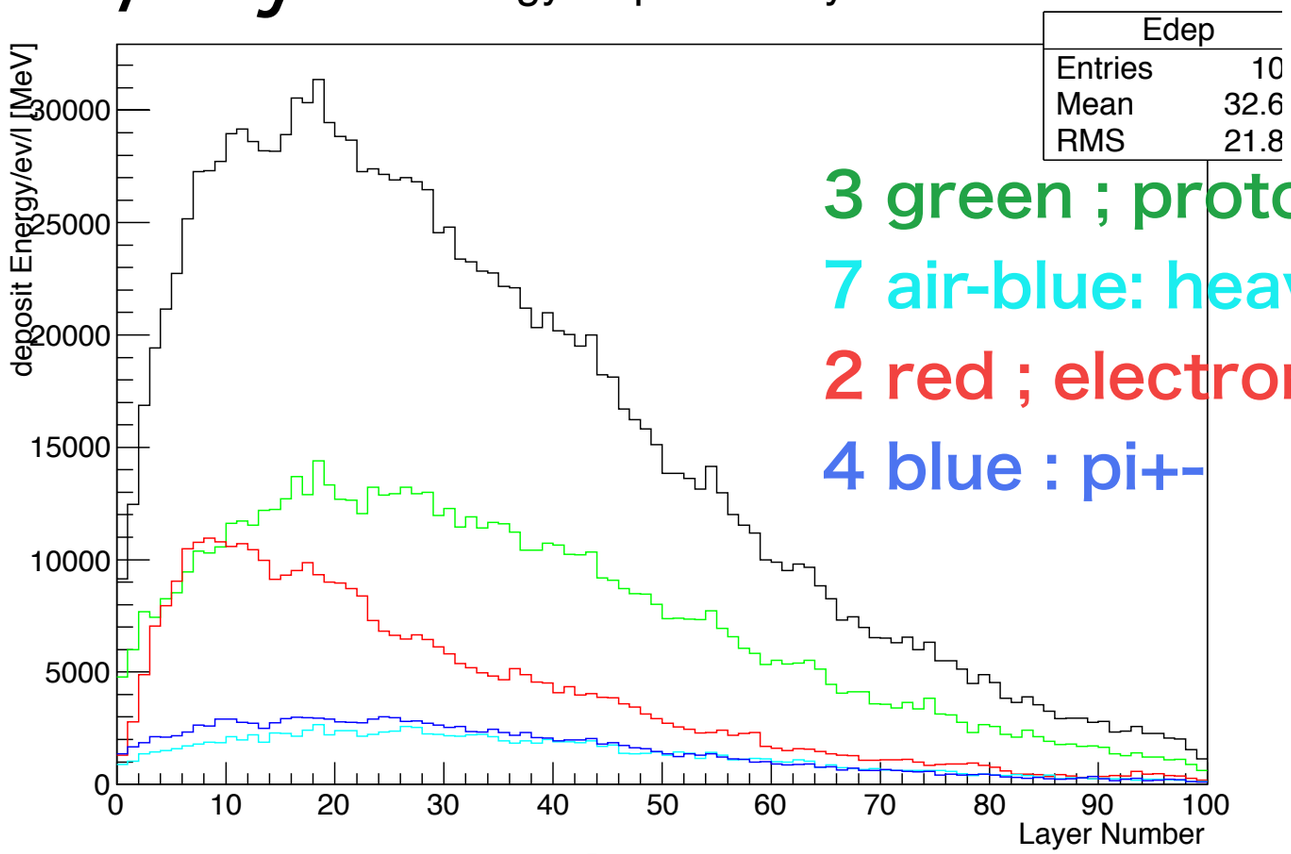
- **summed over 1000 events**
  more protons at low E

lead20mm+sci5mm

5GeV π-

dE/layer

Energy Deposit in layer

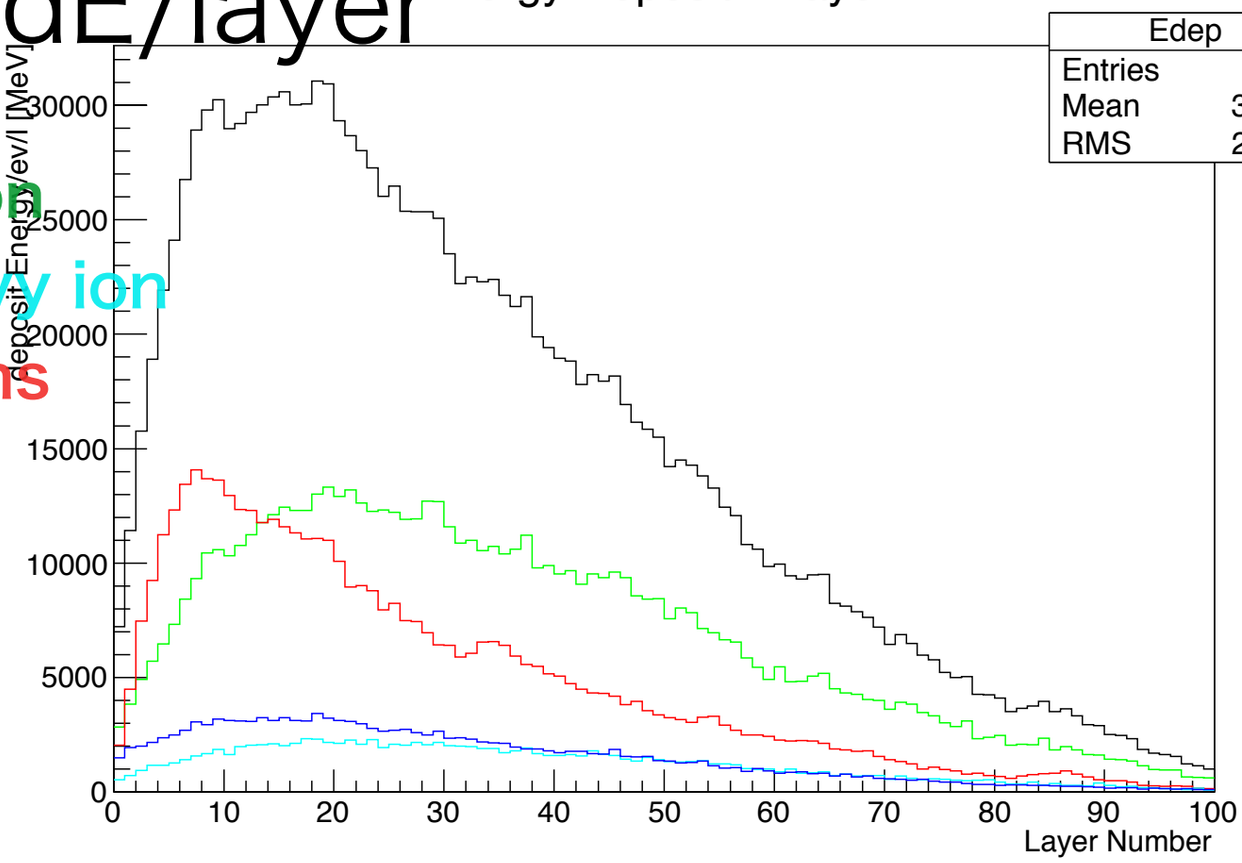


layer num.

20GeV π-

dE/layer

Energy Deposit in layer



layer num.

Birk's low is not included

one event in long.

- **particle type can be found in each hit**

3 green ; proton

7 air-blue: heavy ion

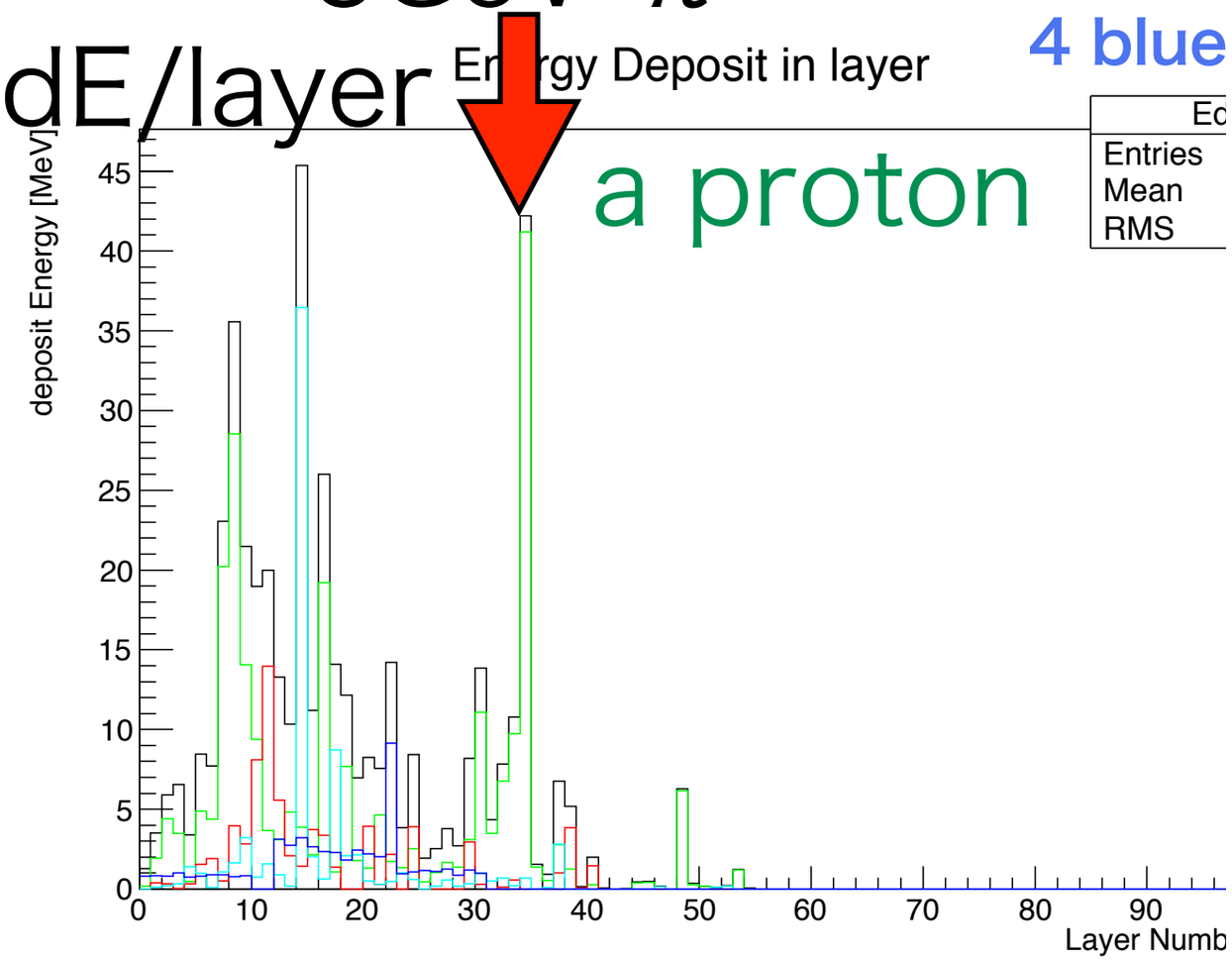
2 red ; electrons

4 blue : pi+-

lead20mm+sci5mm

5GeV π -

dE/layer

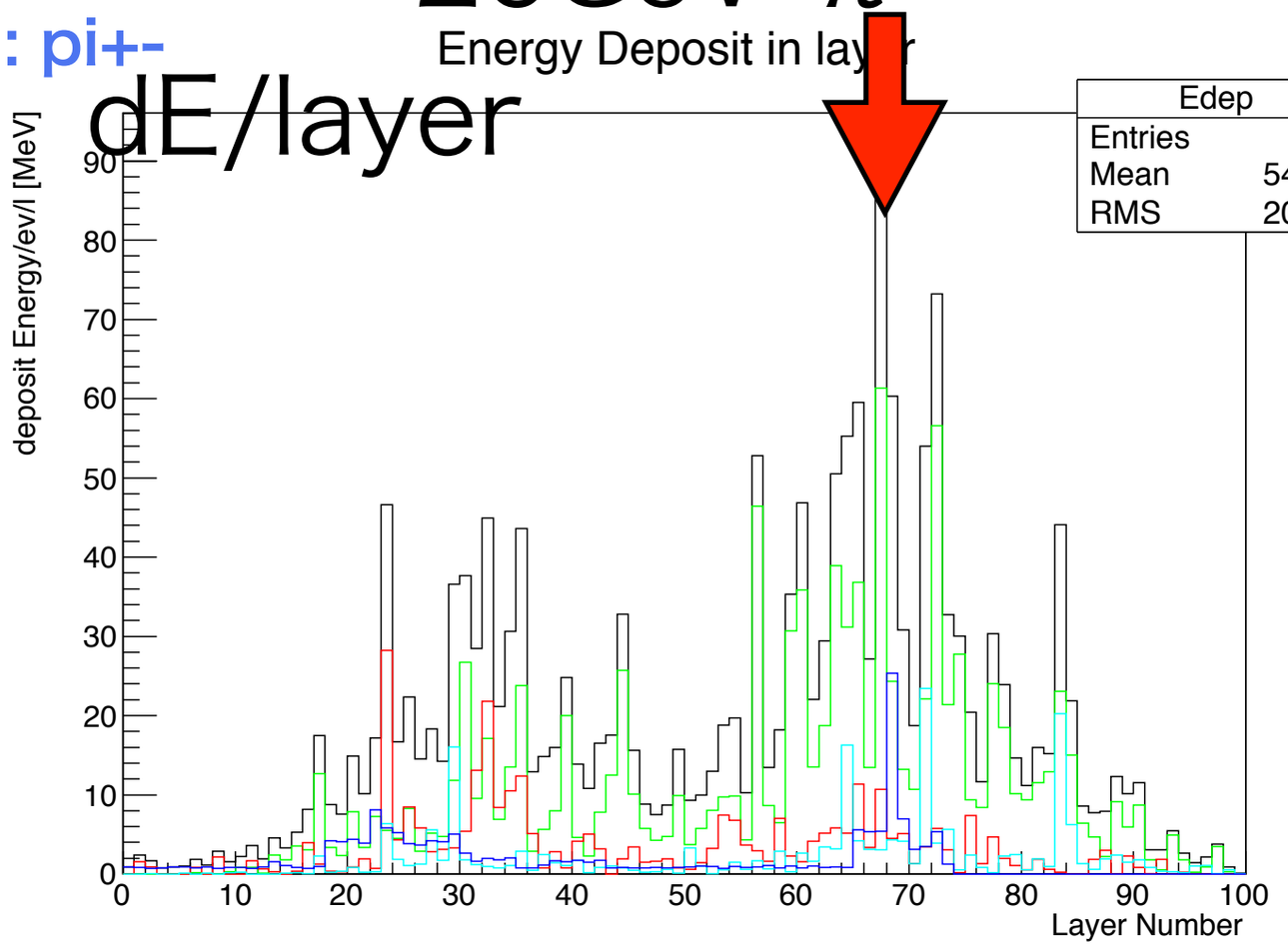


a proton

layer num.

20GeV π -

dE/layer



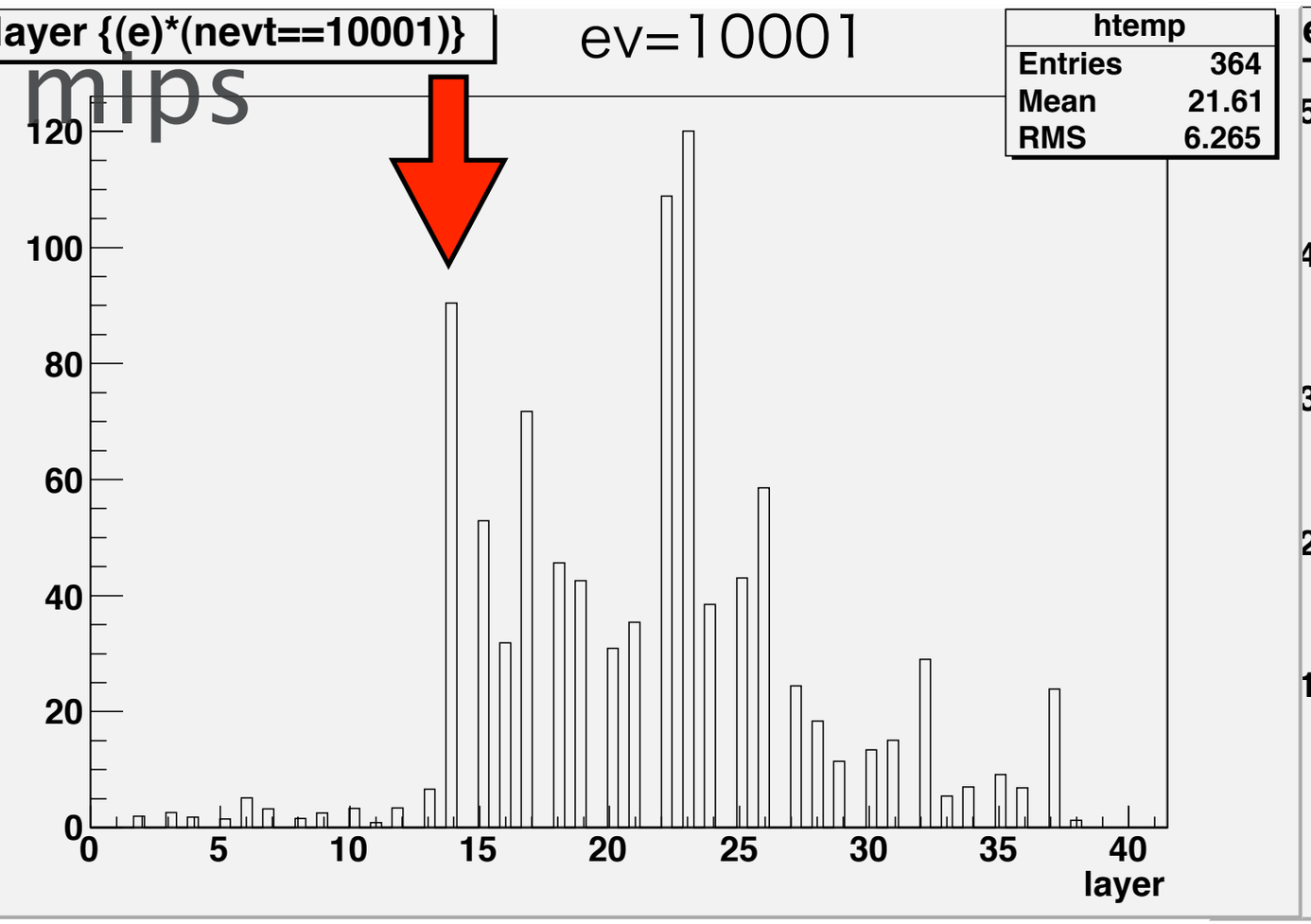
layer num.

Birk's low is not included

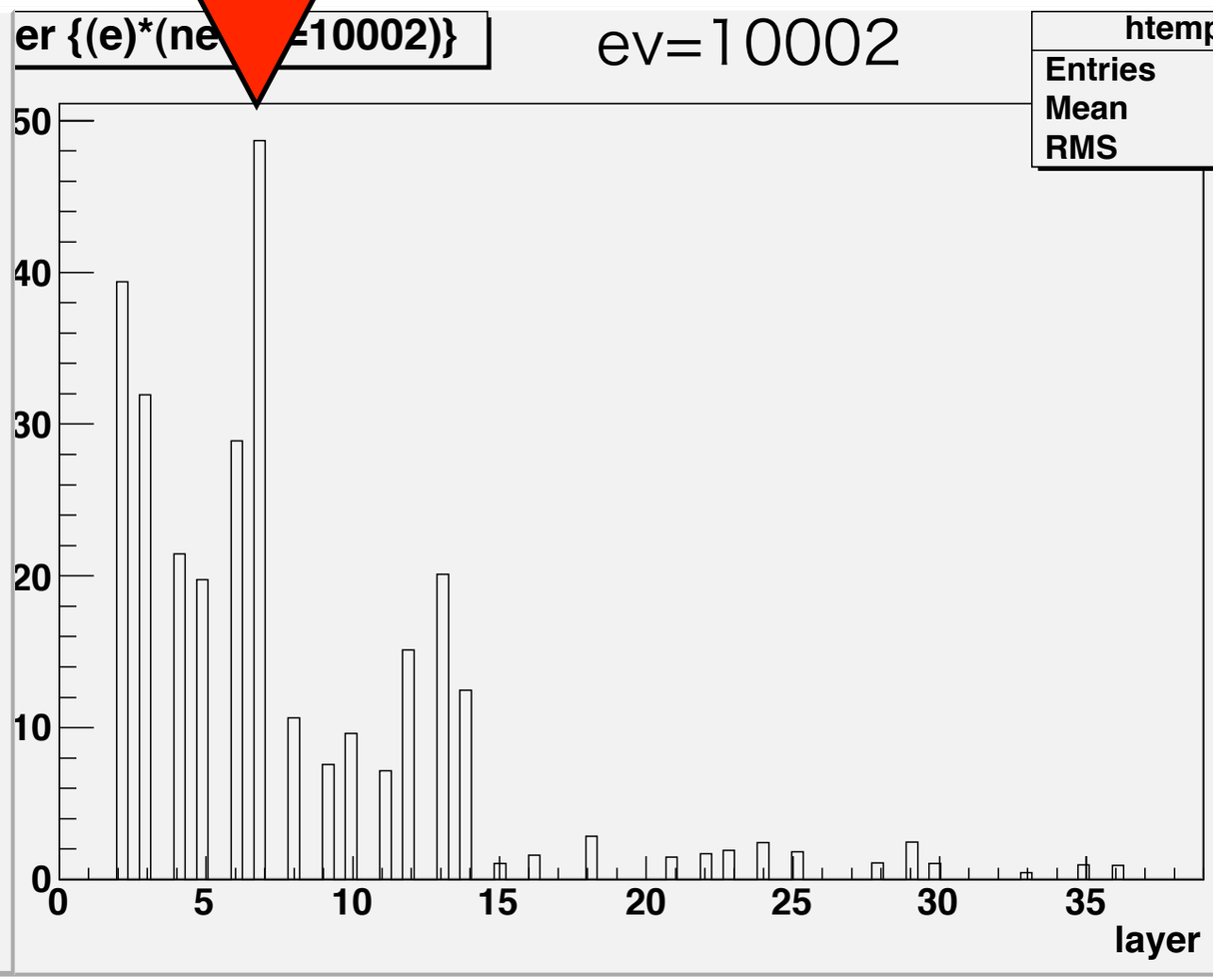
AHCAL data

- Run 560474 32GeV π-
- without any selection

iron20mm+sci5mm



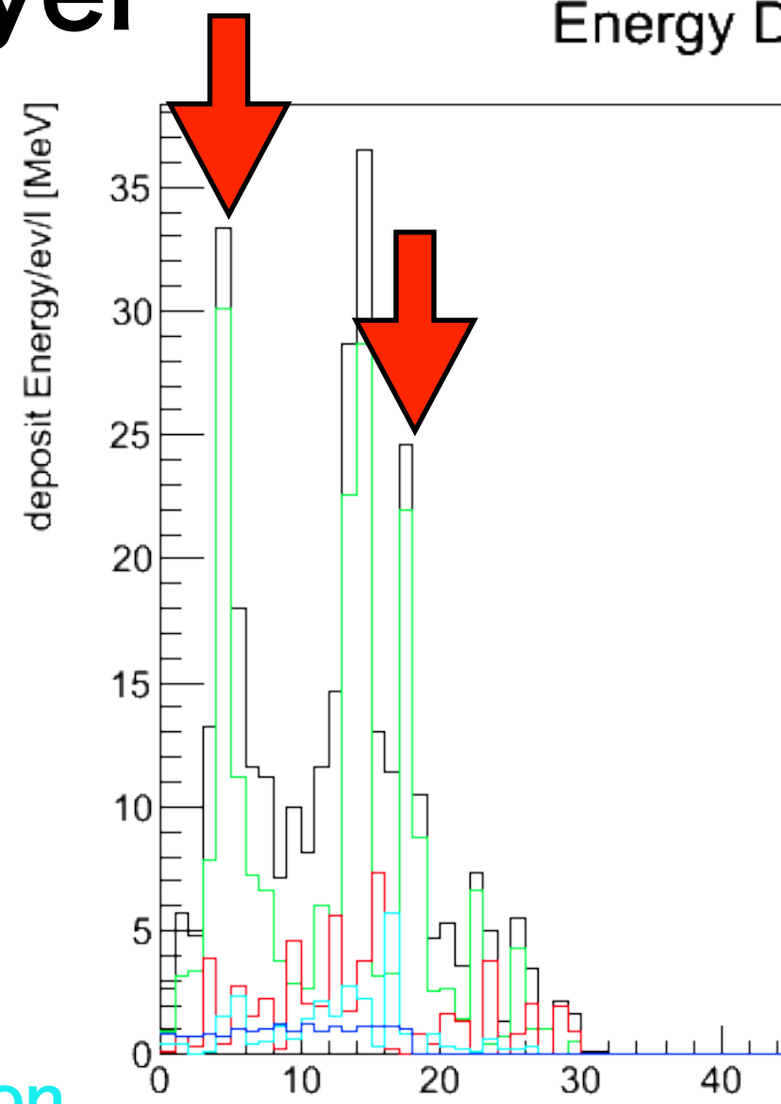
layer num.



layer num.

protons in H int.

- dE is huge in one isolated layer
- slow protons E~50MeV
- confirmed by simulation
- from neutron recoil ?
- from nuclear fragments ?



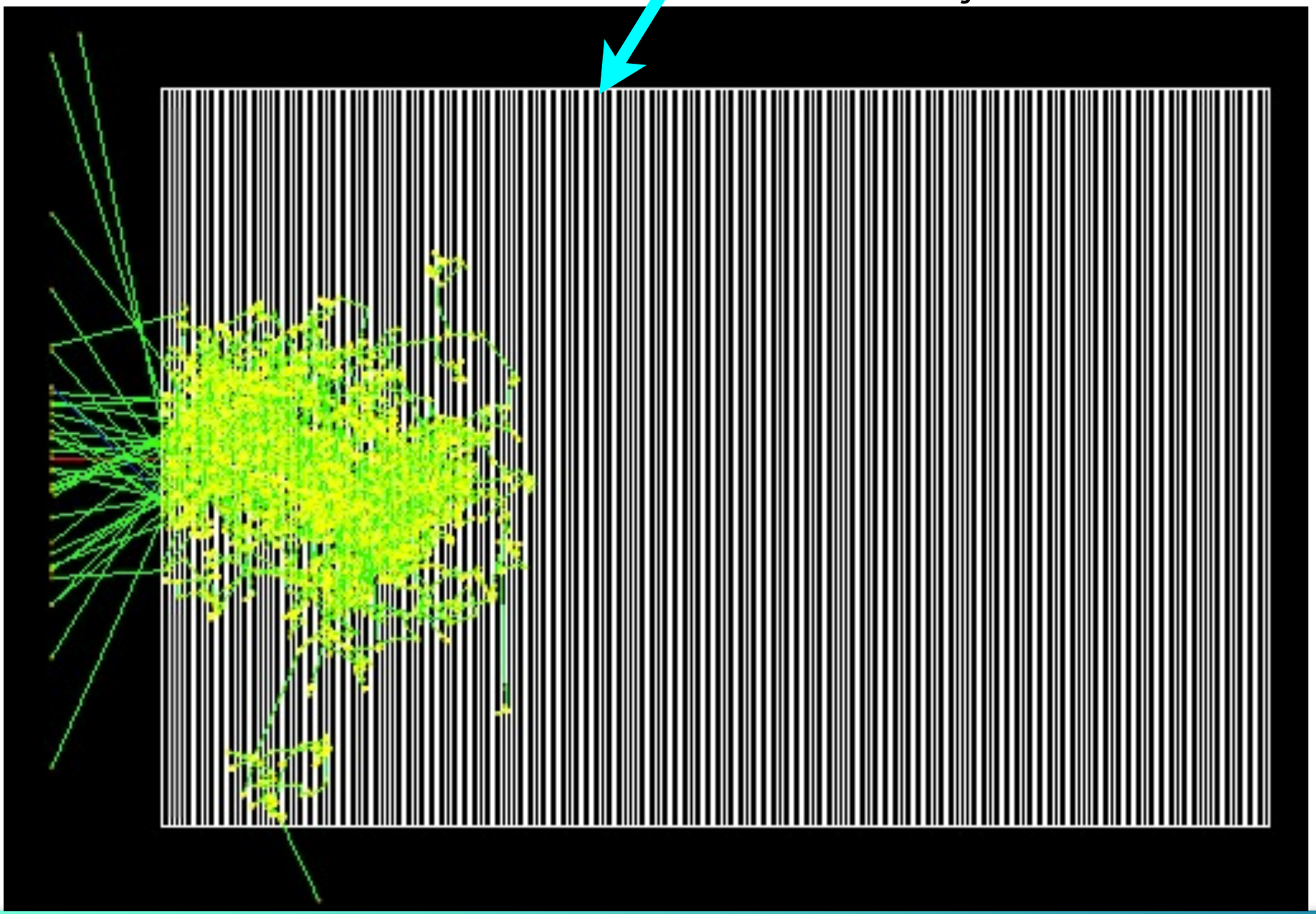
3 green ; proton
7 air-blue: heavy ion
2 red ; electrons
4 blue : pi+-

iron20mm+sci5mm

a hadron event

- 5GeV π-

N interaction at 5th absorber layer



G4 coloring:

red: - charged

bleu : + charged

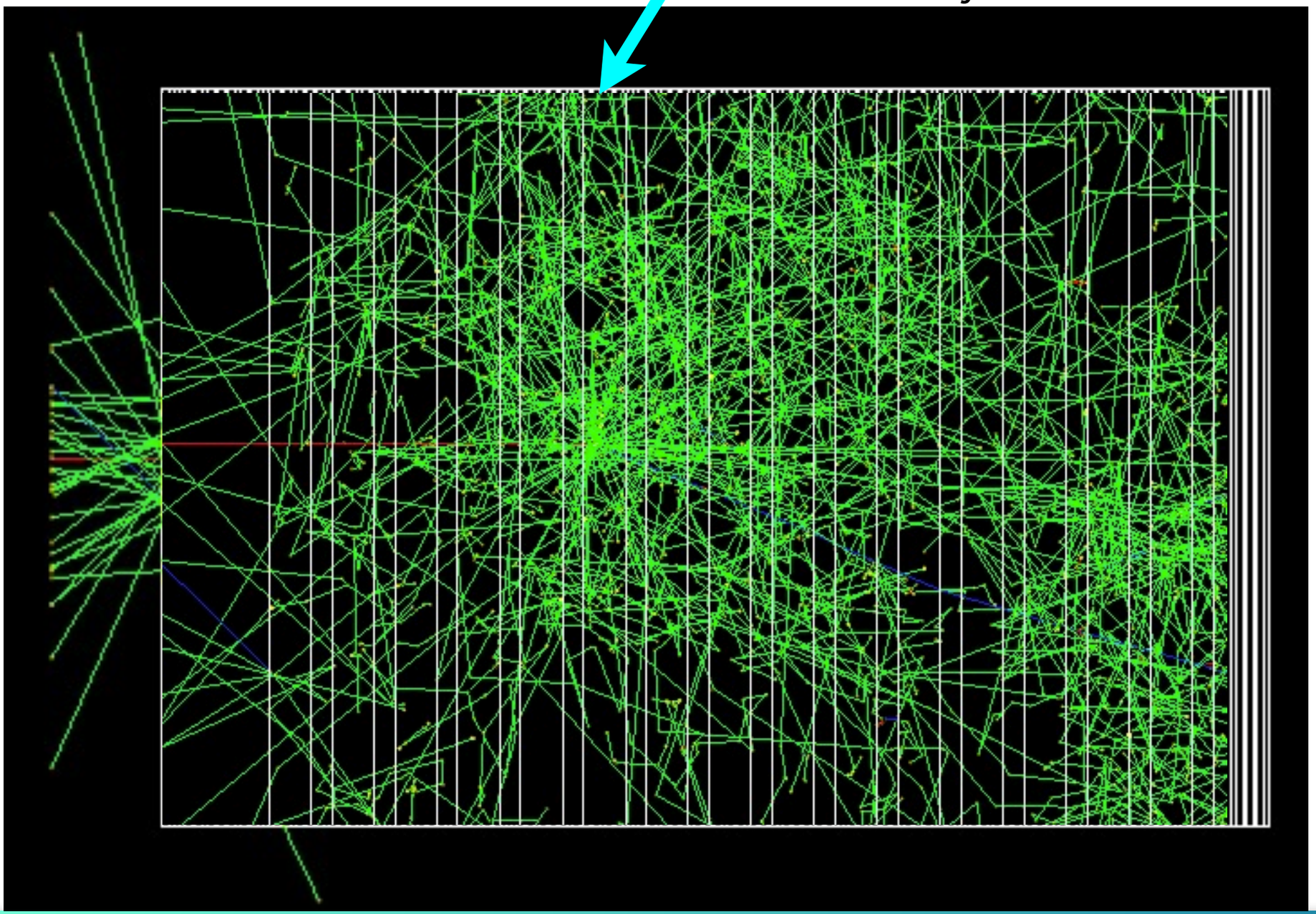
green: neutral

Iron20mm+sci5mm

a hadron event

- 5GeV π-

N interaction at 5th absorber layer



G4 coloring:

red: - charged

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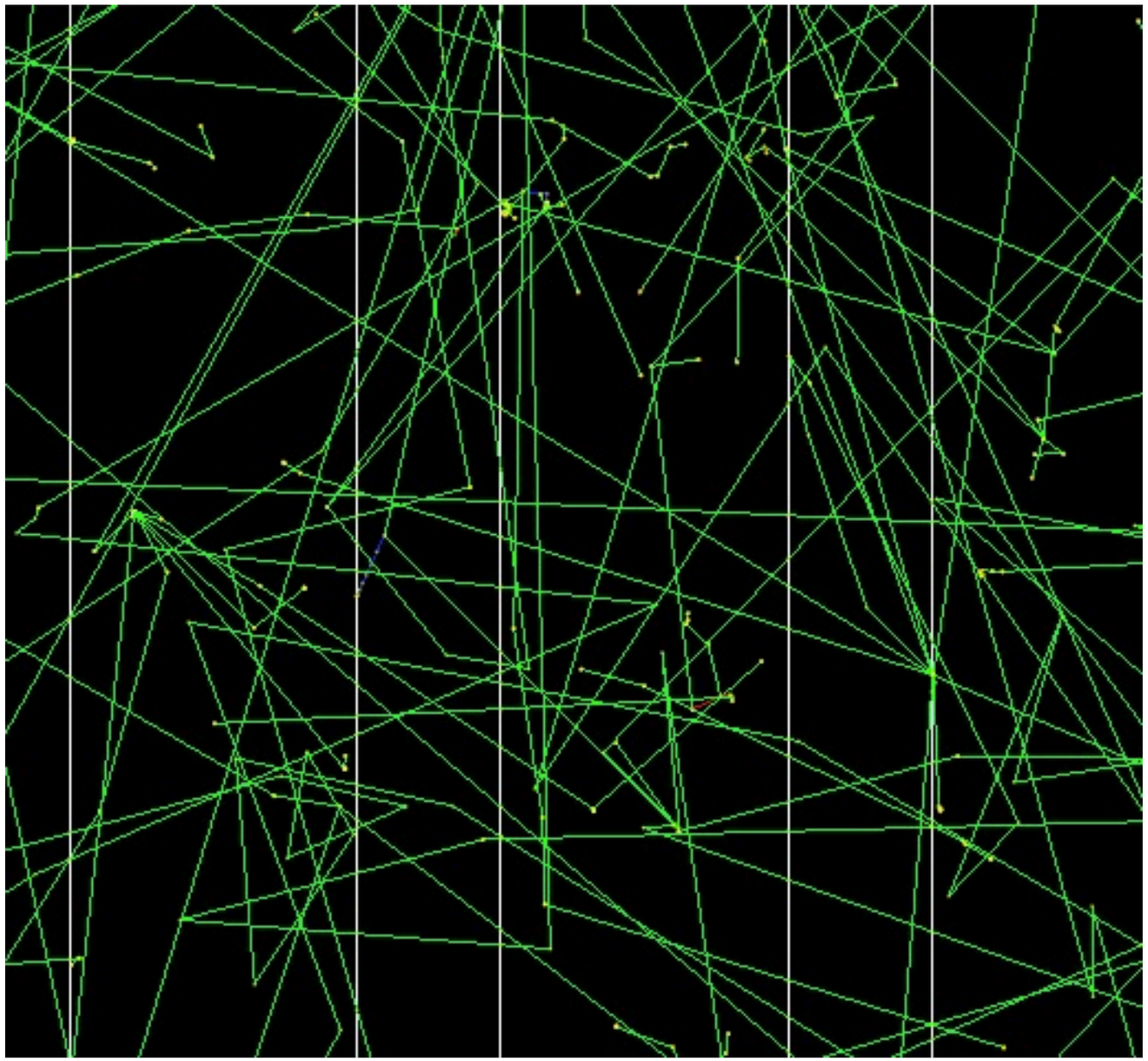
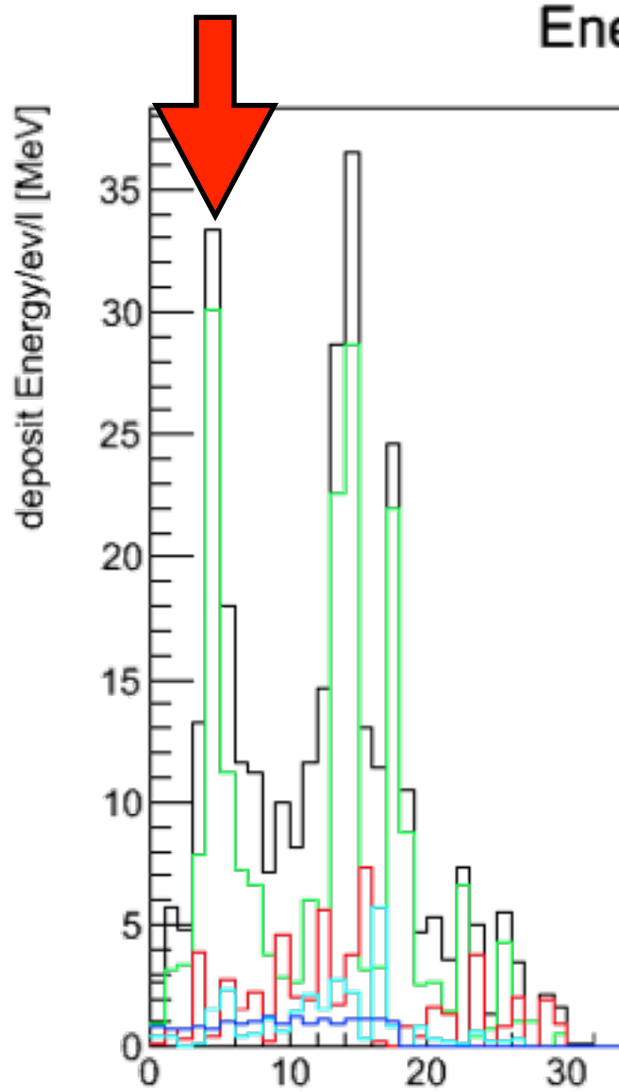
Iron20mm+sci5mm

the hadron event cont.

- at 5th layer, there is a large dE

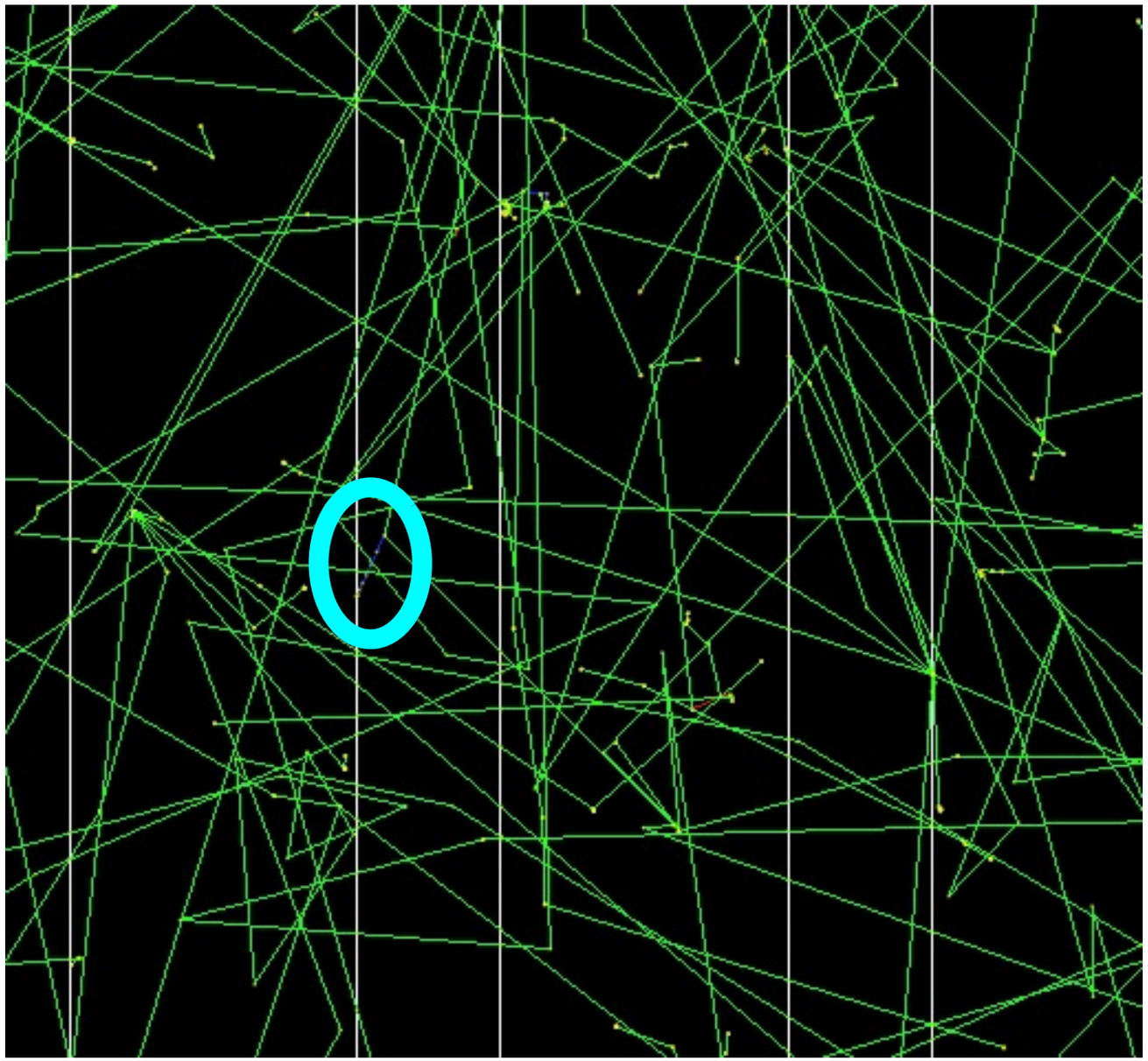


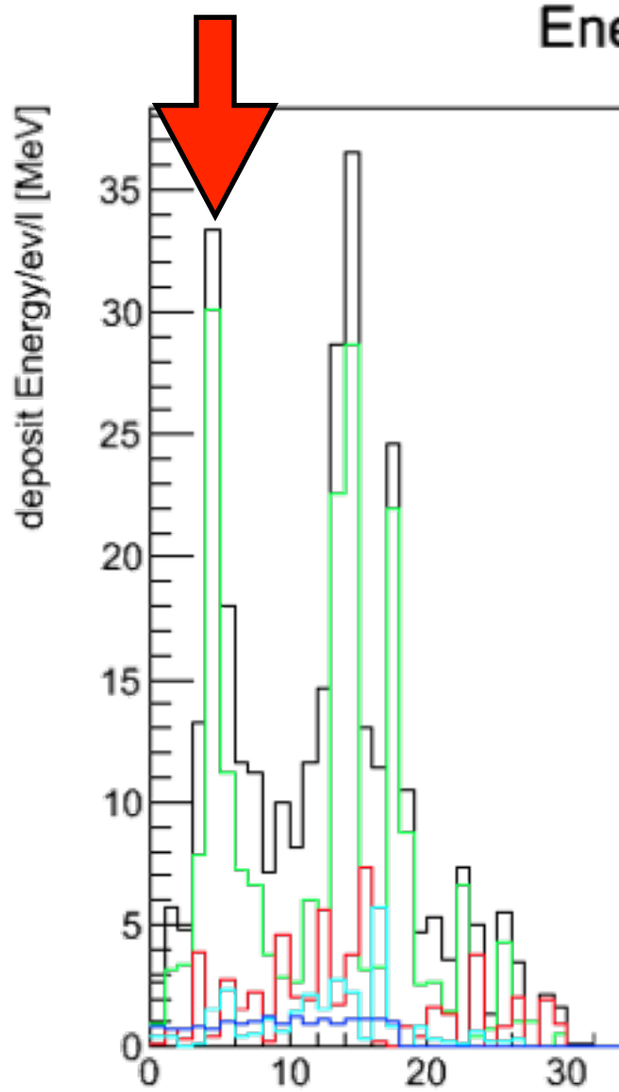


Iron20mm+sci5mm

the hadron event cont.

- at 5th layer, there is a large dE

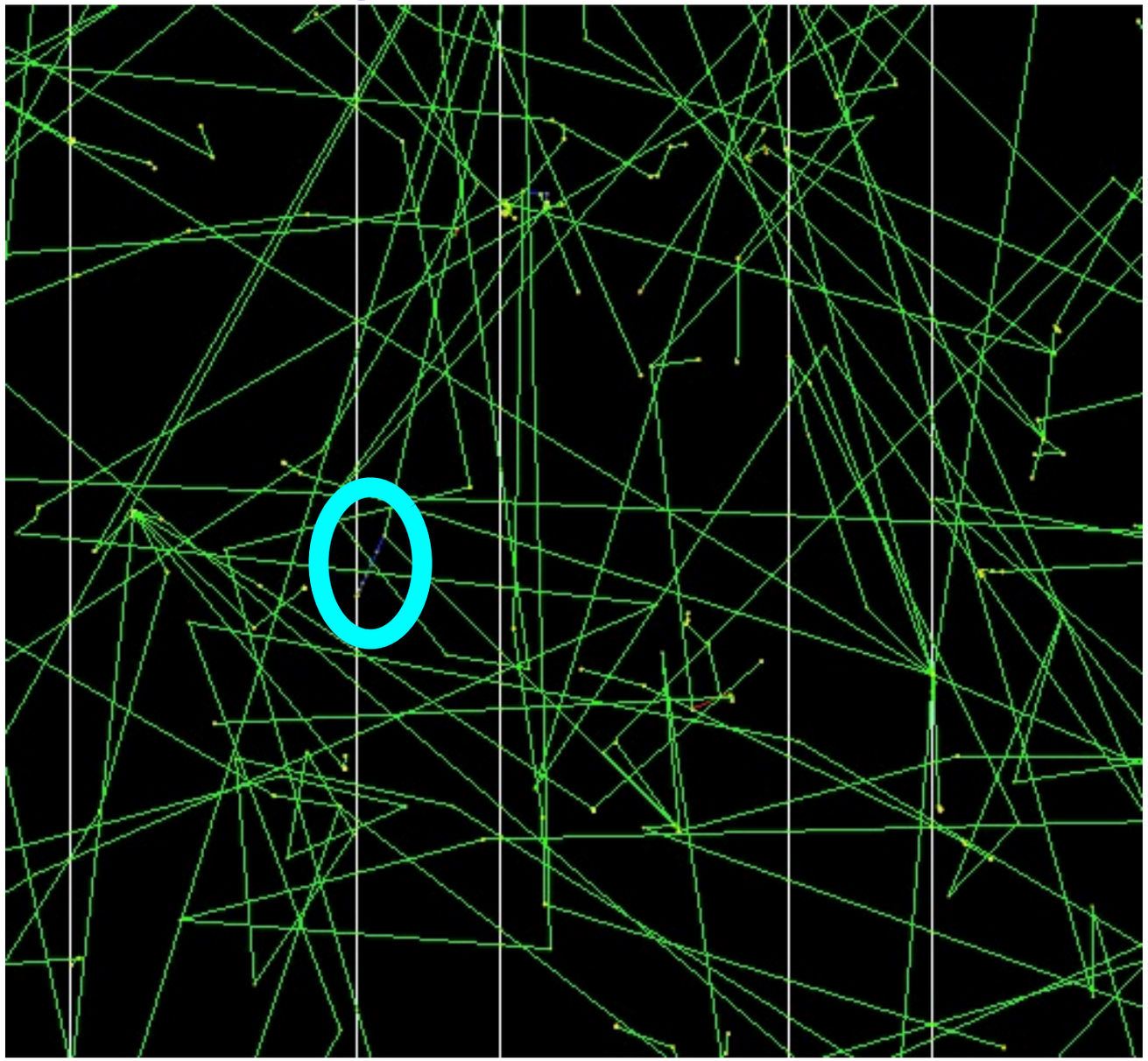


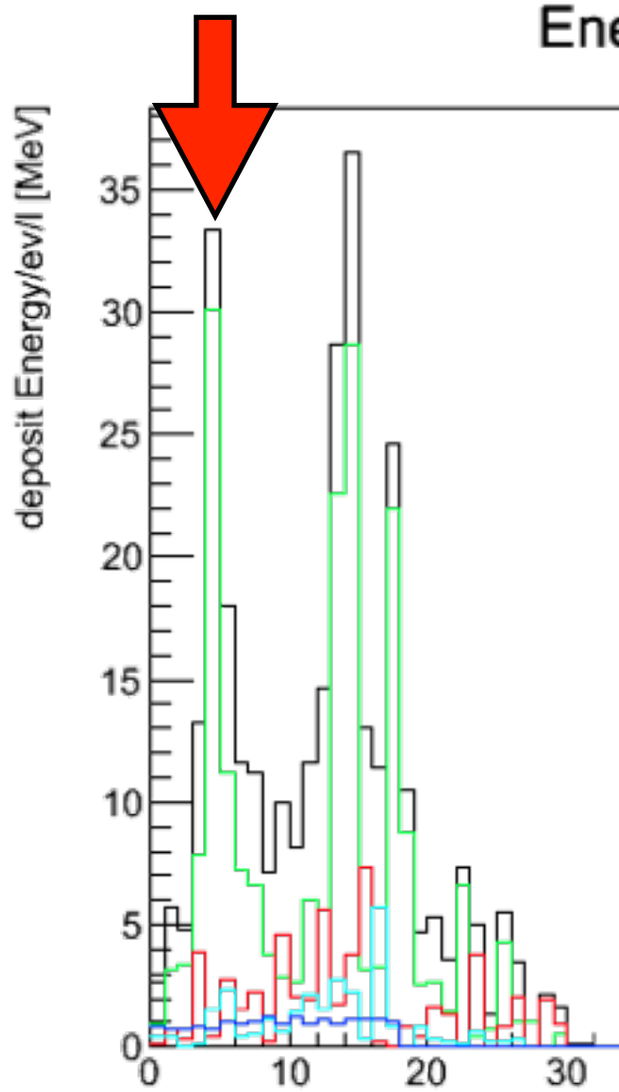


Iron20mm+sci5mm

the hadron event cont.

- **at 5th layer, there is a large dE**
  +charged recoils exits

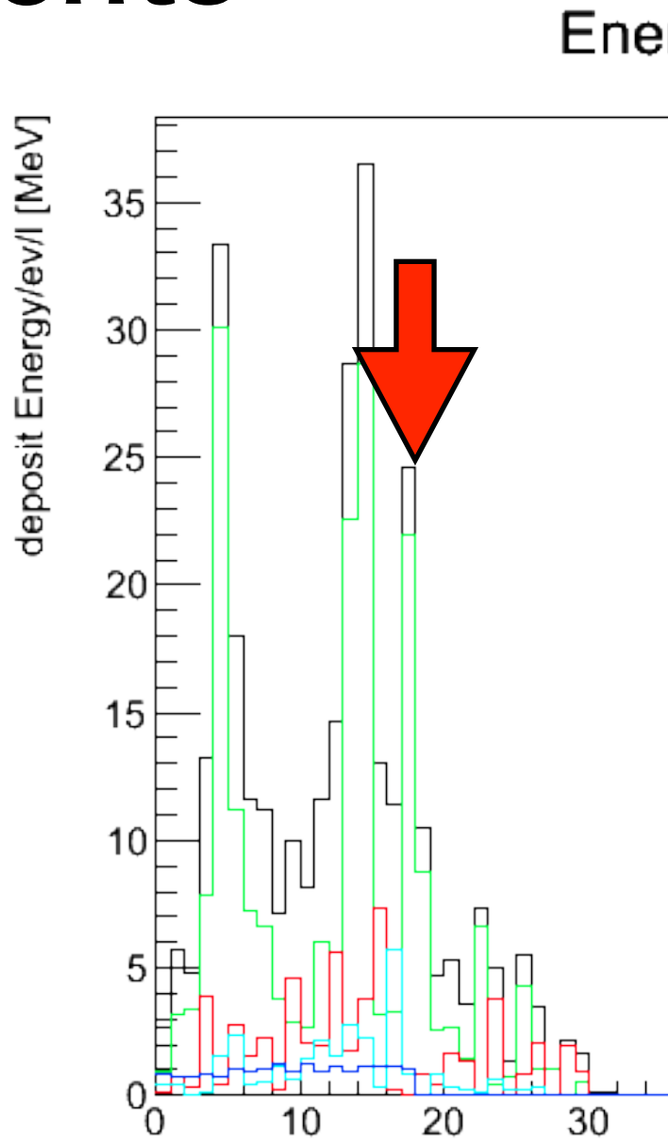




Iron20mm+sci5mm

the hadron event cont.

- at 18th layer : nuclear fragments

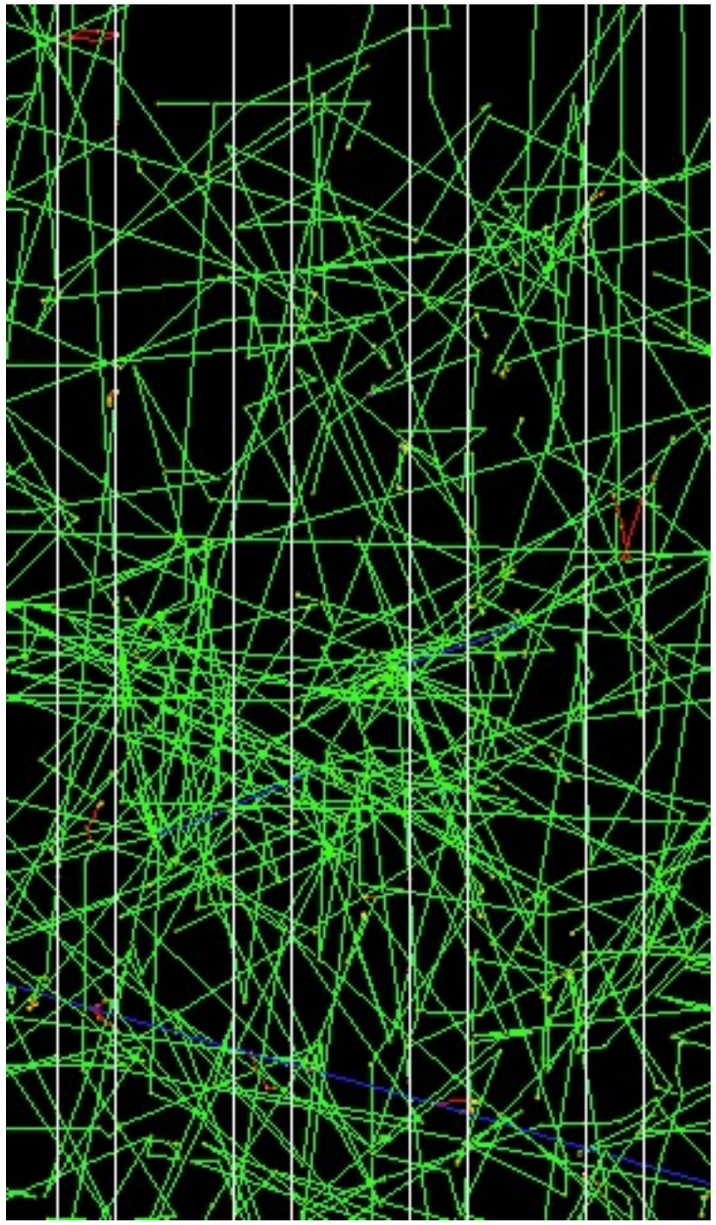


$\pi+$

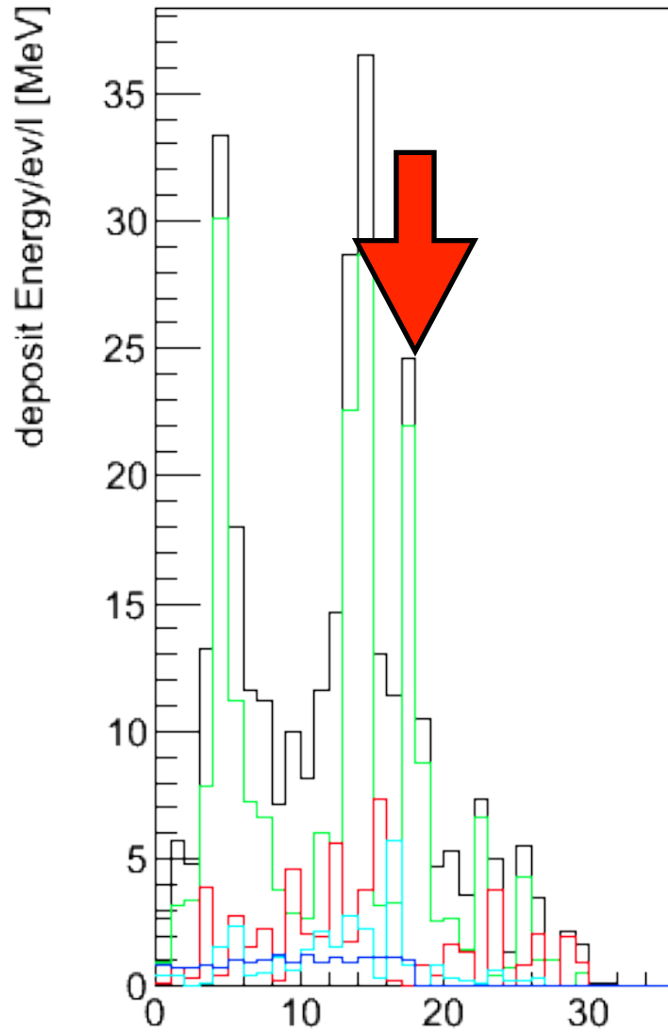
Iron20mm+sci5mm

the hadron event cont.

- at 18th layer : nuclear fragments



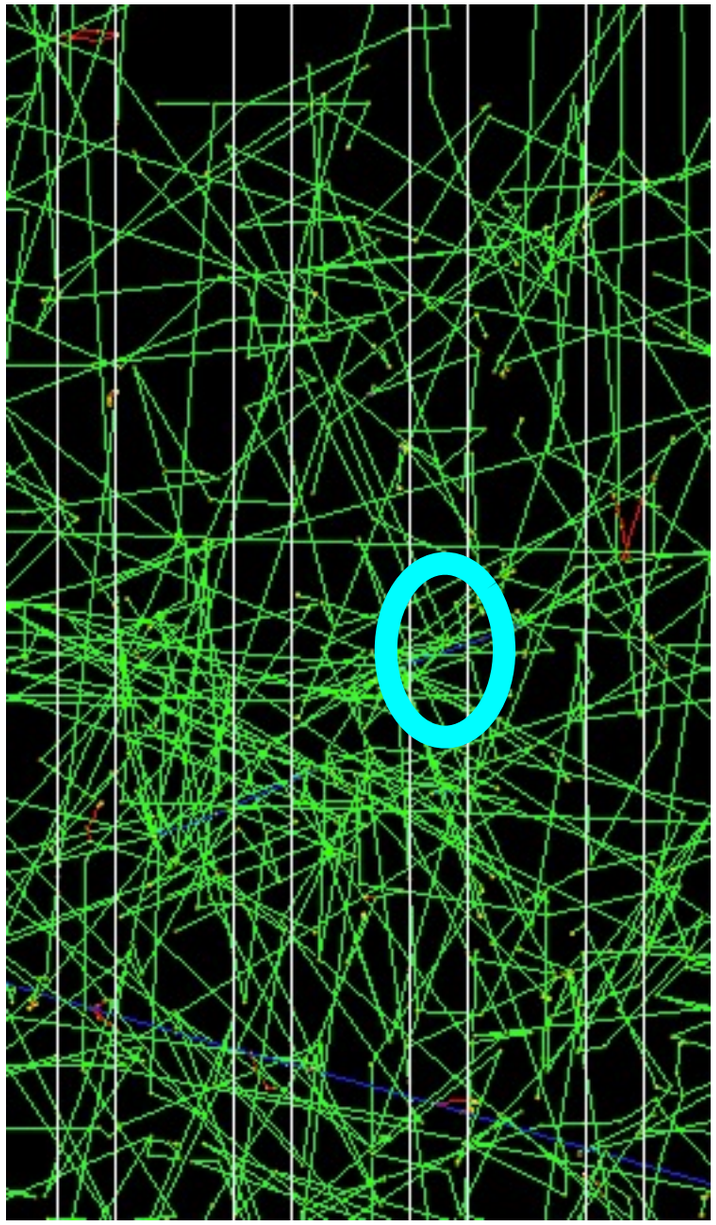
$\pi +$



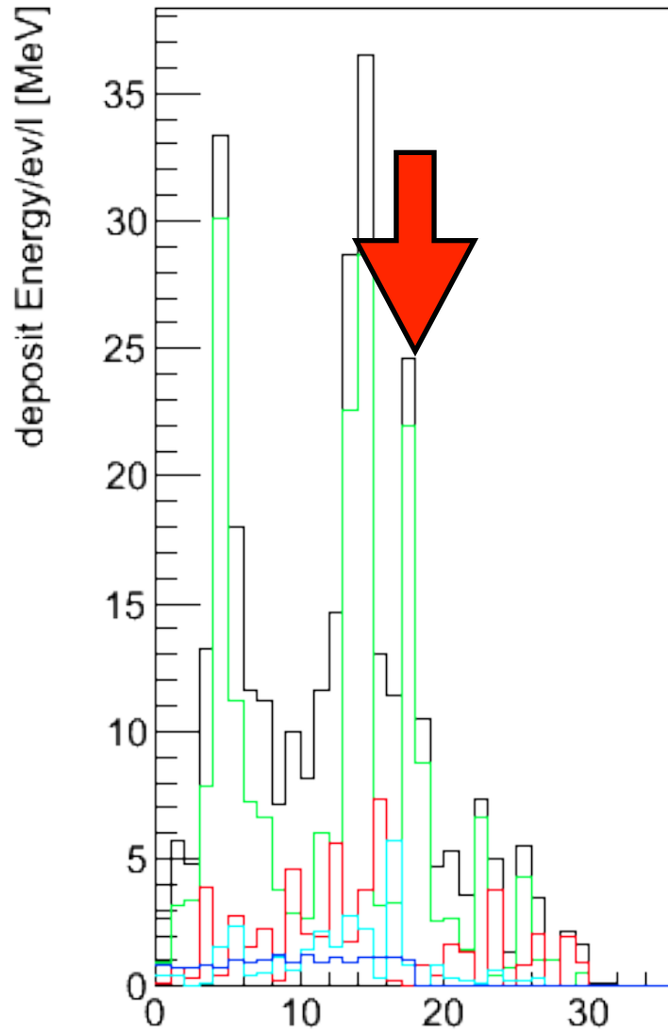
Iron20mm+sci5mm

the hadron event cont.

- at 18th layer : nuclear fragments



$\pi +$



Iron20mm+sci5mm

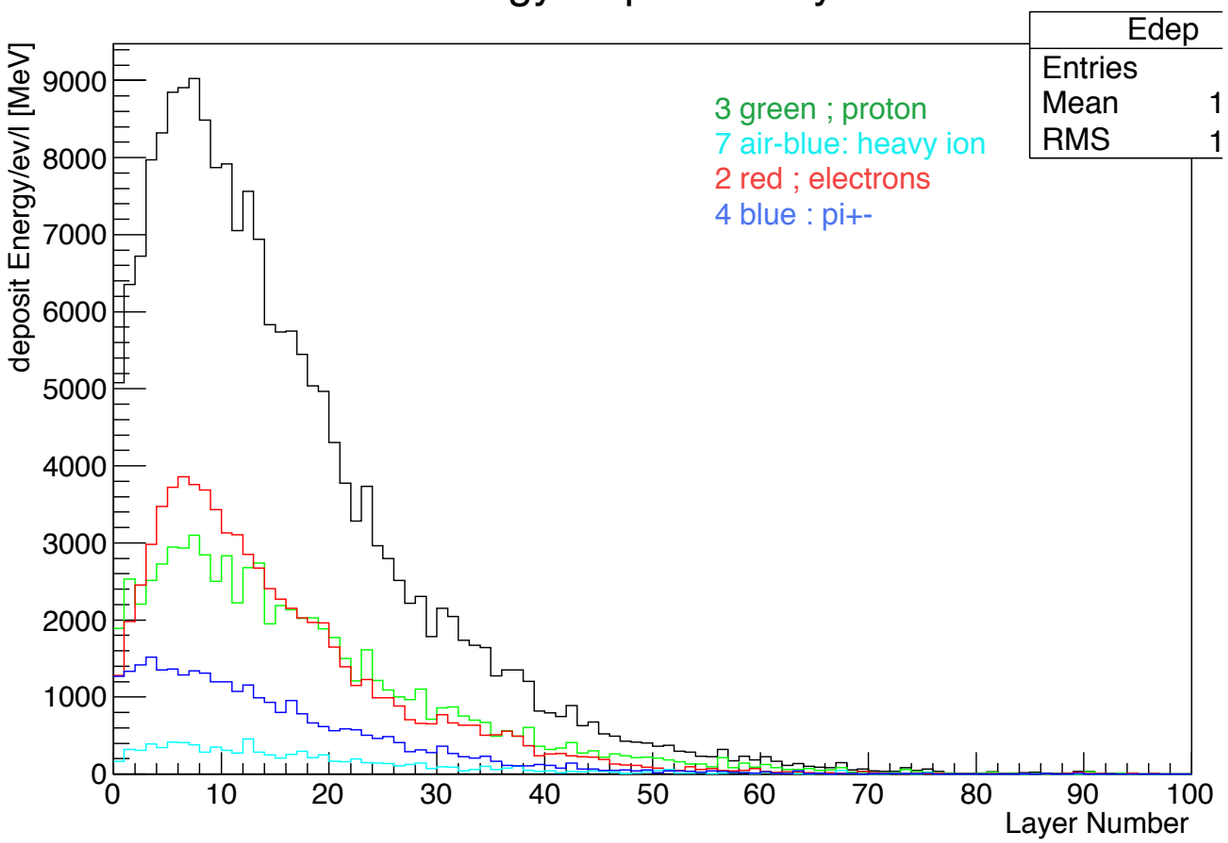
absorber

- iron & lead

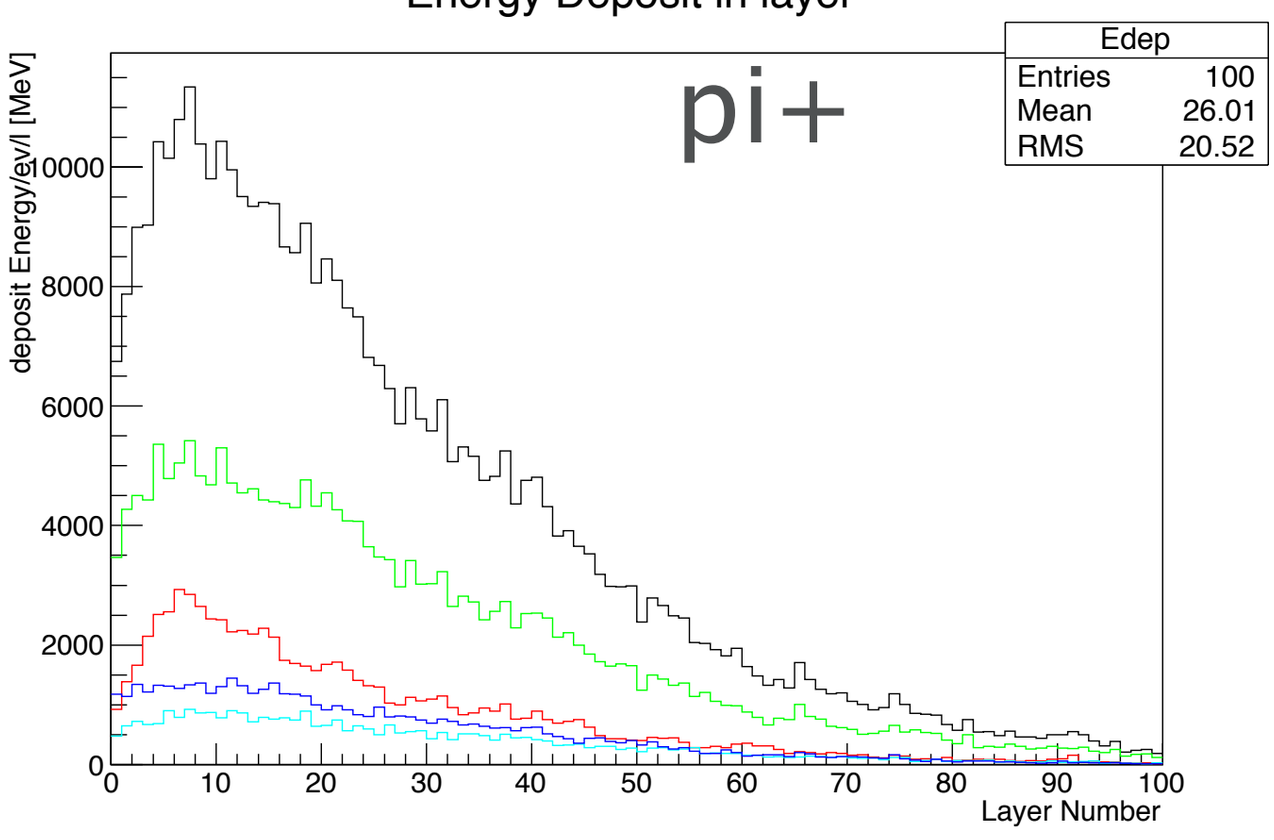
FTF 5GeV pi+

20mm Fe+5mmscint

10mm Pb+5mmscint.



layer num.



layer num.

more protons with lead absorber

gas or scinti.

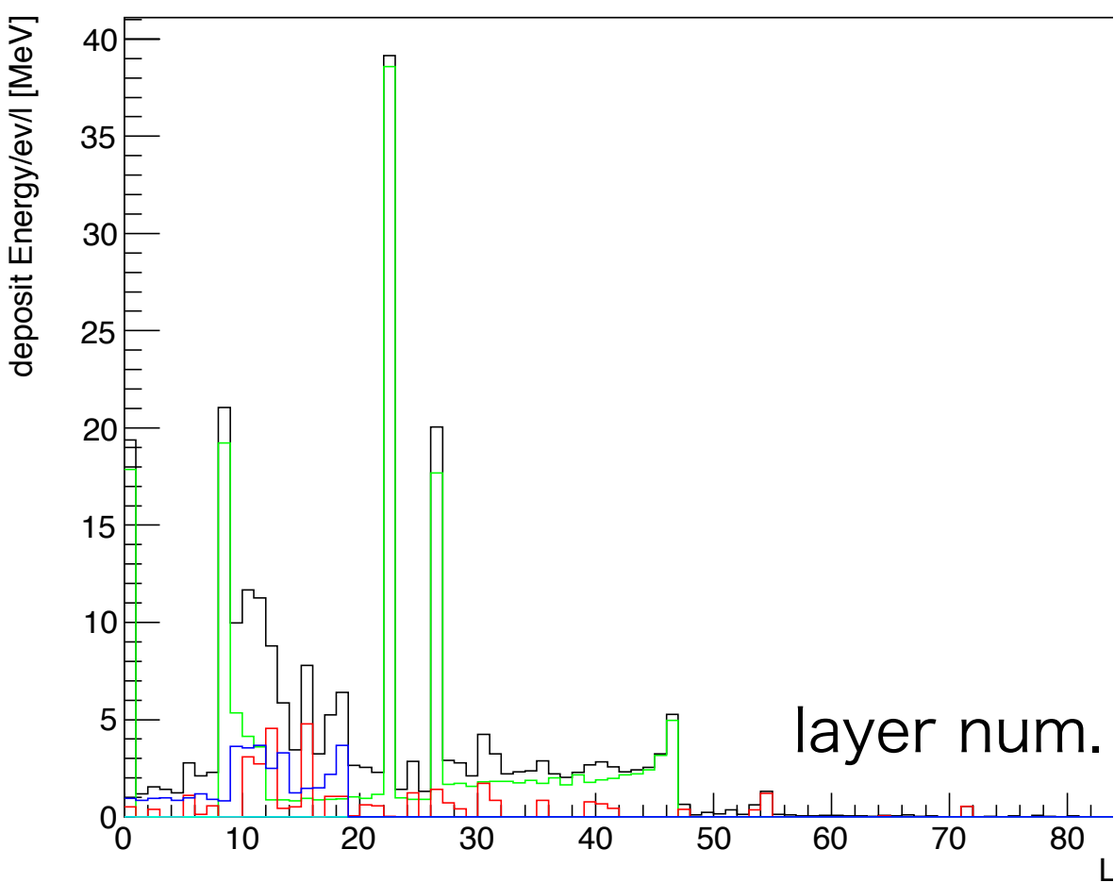
- sensitive material

32GeV pi-

- gas is mostly measuring EMshower

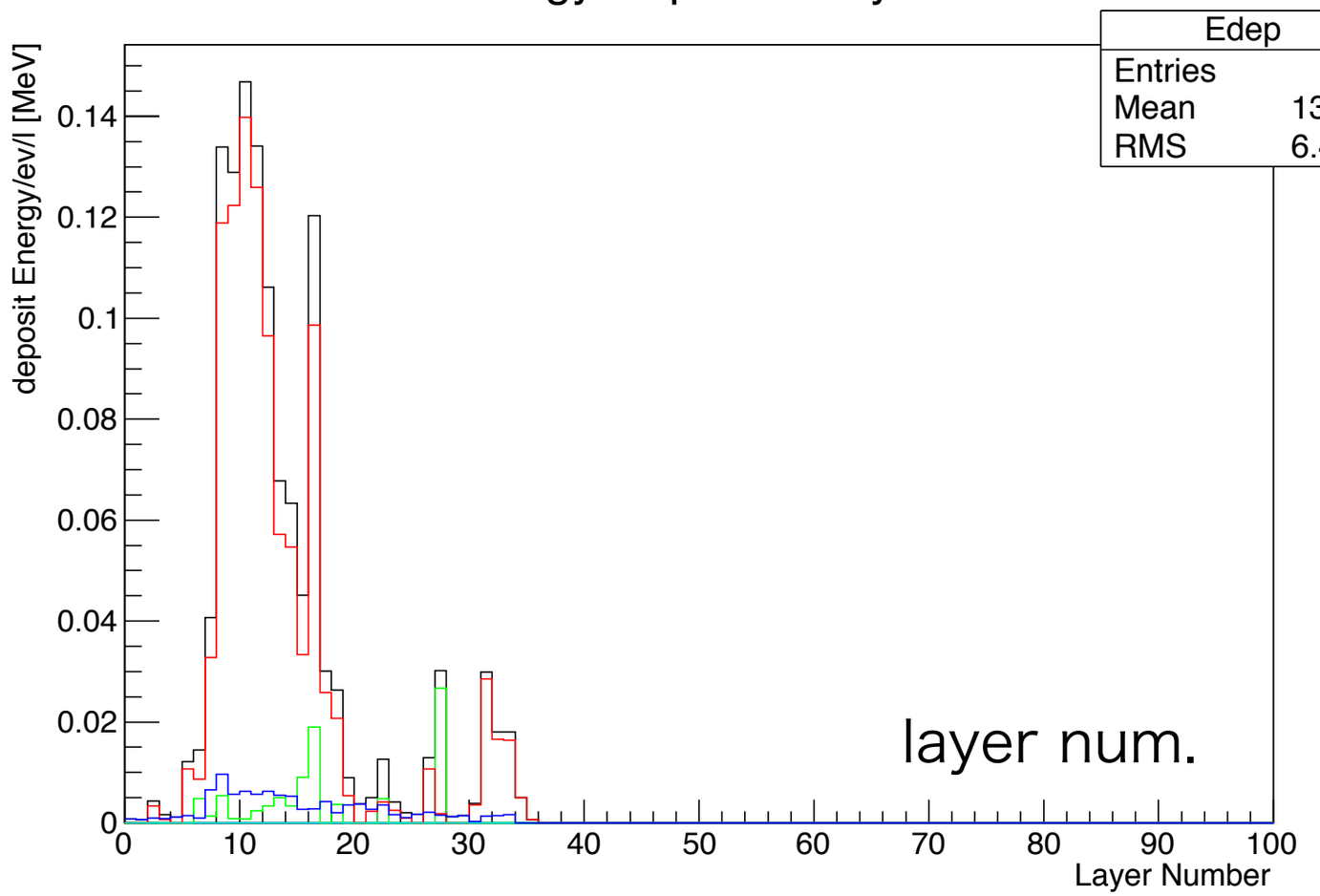
Pb10+LiqAr5

Energy Deposit in layer



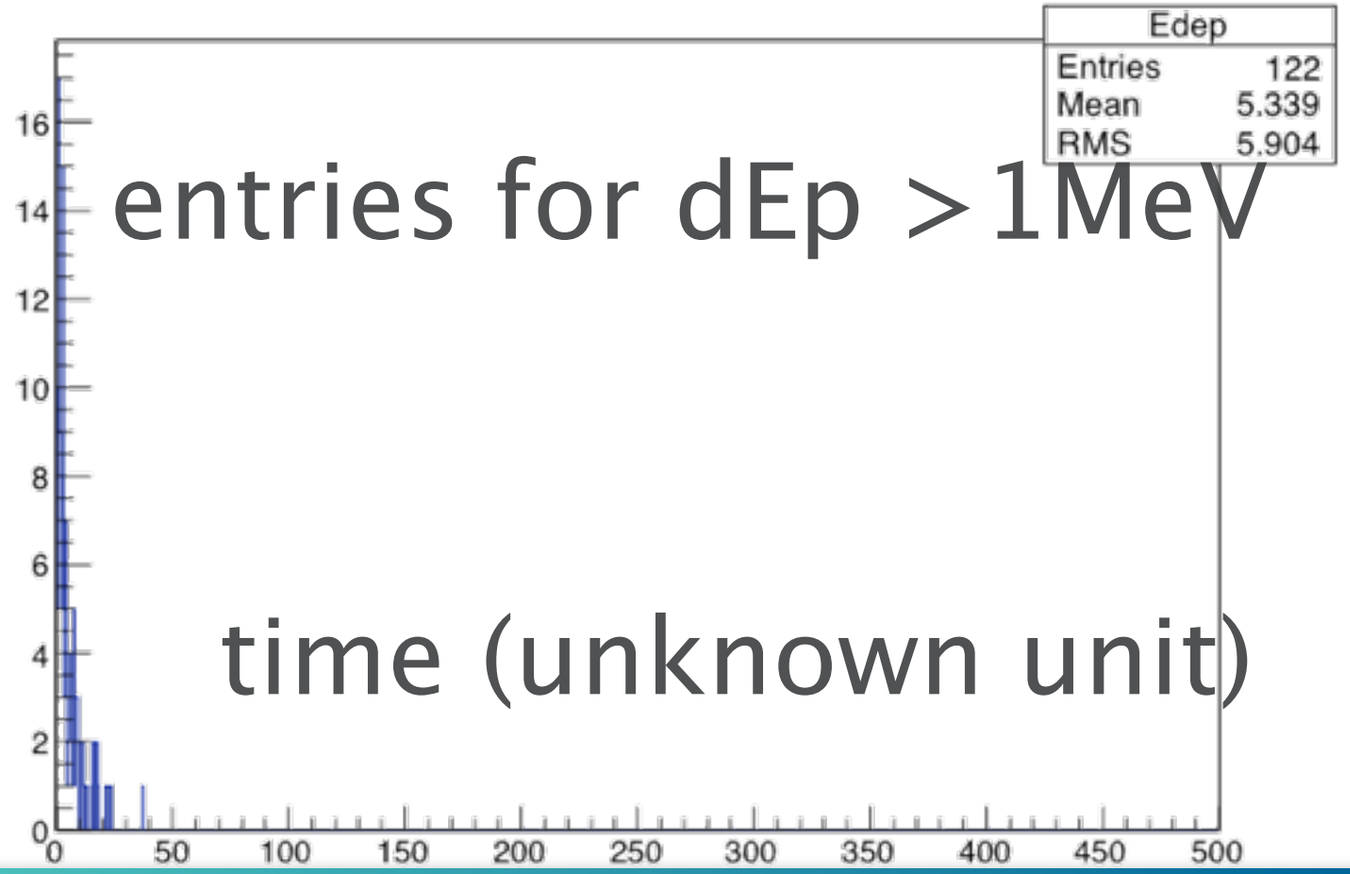
Fe25+gasAr5

Energy Deposit in layer



timing

- where come from those conspicuous protons ?
- not from slow neutron elastic scattering
- timing of protons are in short from injection

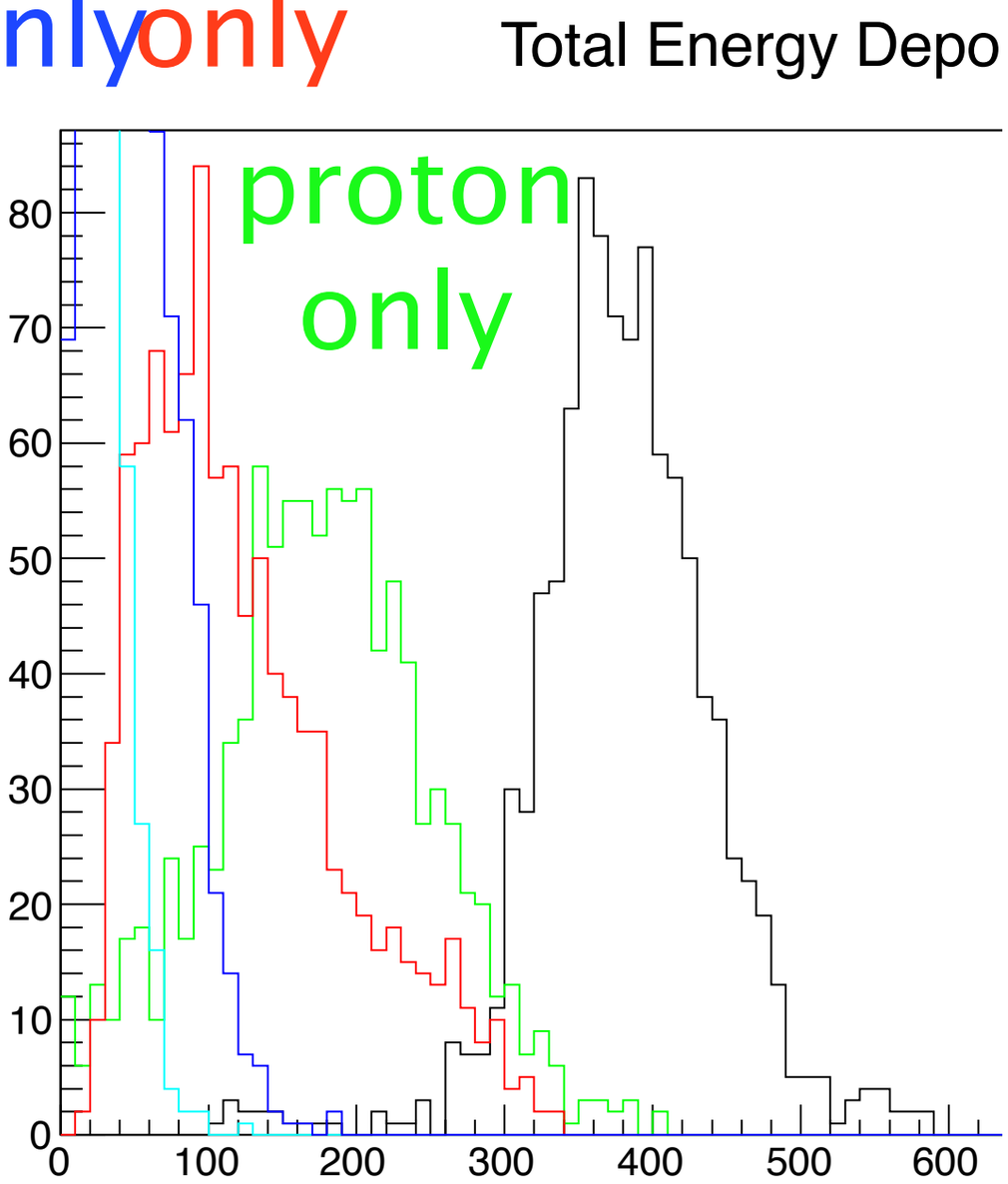


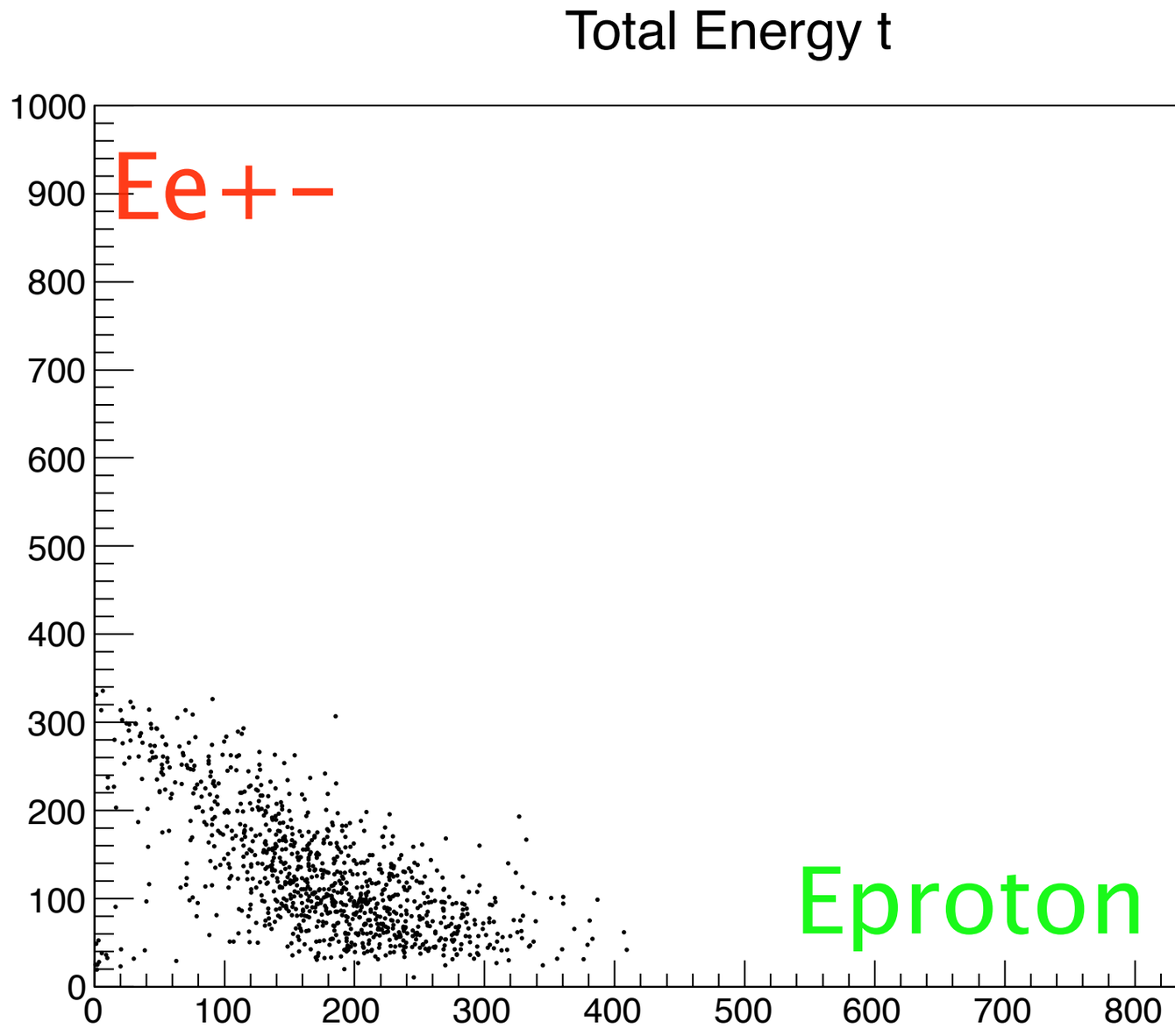
energy resolutions

- how can we improve it ?

π+−e+−

only only





summary

- HCAL is measuring either
  - EM shower from neutral pion prod.
    - gas sensor
    - nuclear fragments energy from π^{+-} / neutrons via slow protons
    - scintillator sensor
- how can be improved the resolution ?

suffer big fluctuation