Hadron energy measurement in the sampling calorimeter

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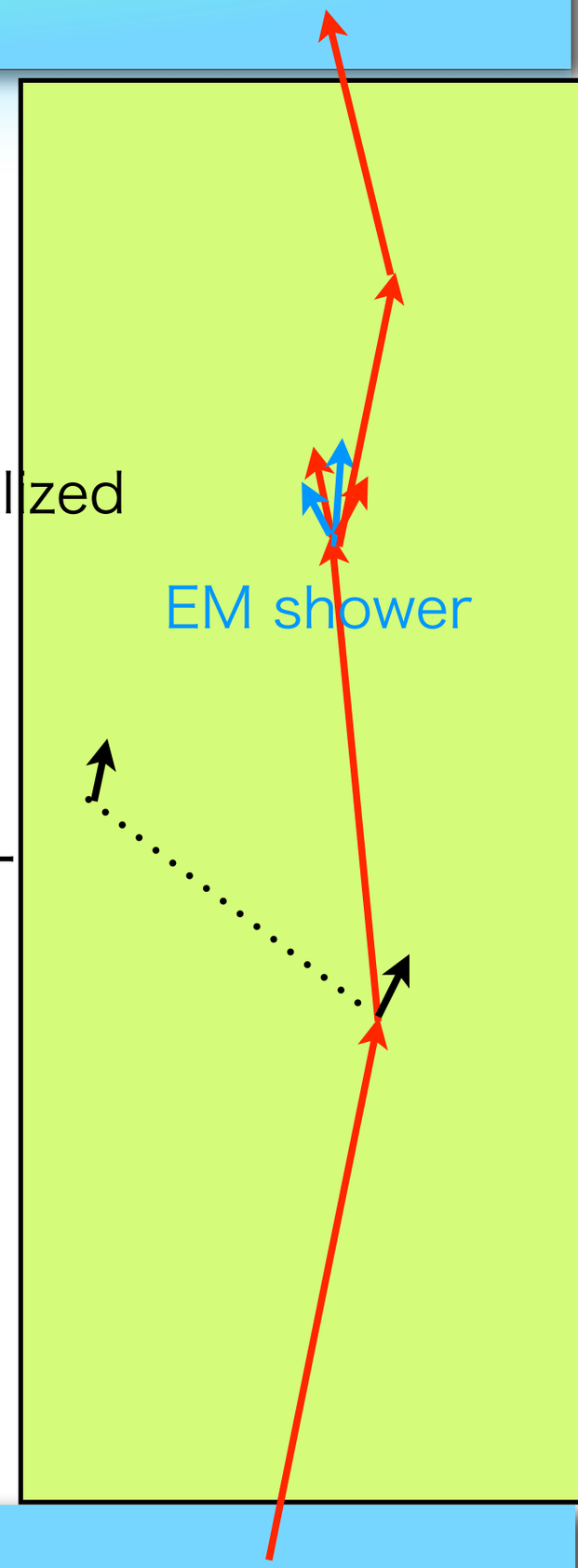
for CALOR2014 @ Giessen

event by event basis analysis

with fine samplings

Hadron measurement

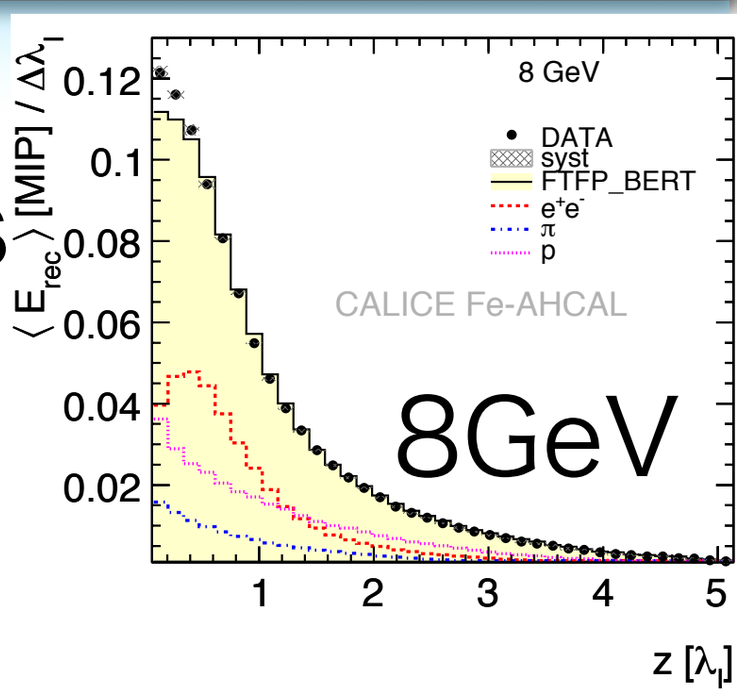
- H interaction length ~10cm
  >> X_0 ~1cm radiation length for EM interaction
  - once a pi-zero produced EM shower emerges $E_{EM} >> E_{pi+-}$
- nuclear interactions
  - photons and neutrons
    e- proton
    evaporation / spallation



CALICE AHCAL

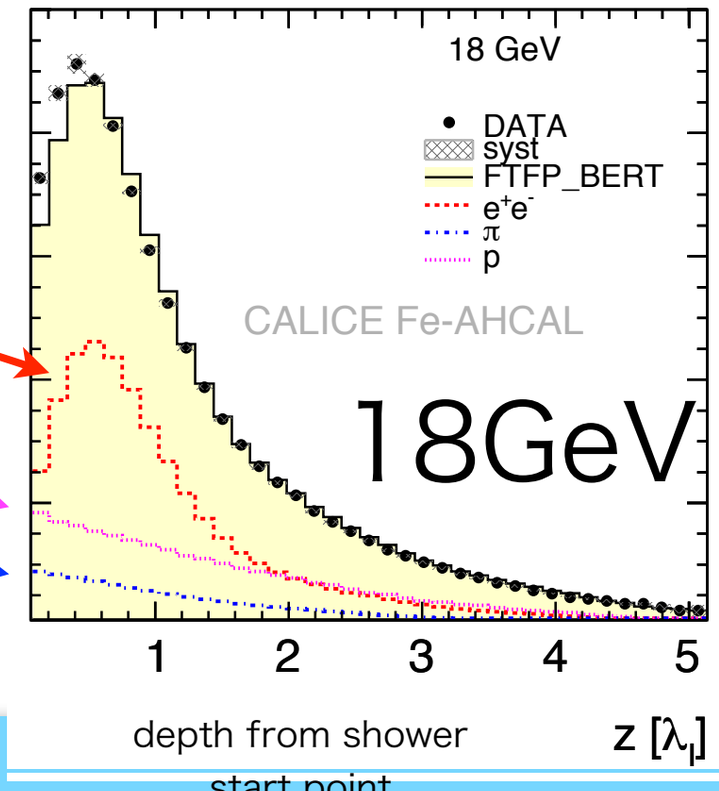
experimental data

- (Fe20mm+sc.5mm) x 40layers
- pions incident: 8 & 18GeV
- longitudinal shower profile : z



FTFP_Bert model Geant4

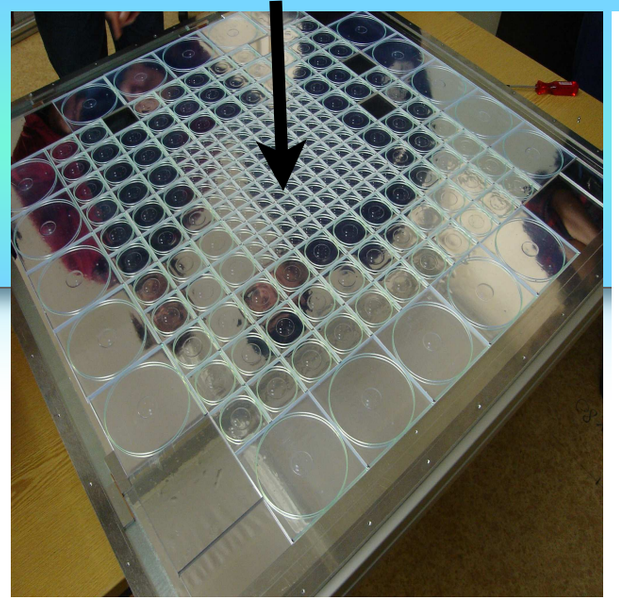
- (1) electrons from π^0
- (2) protons
- (3) charged pions ~ MIP

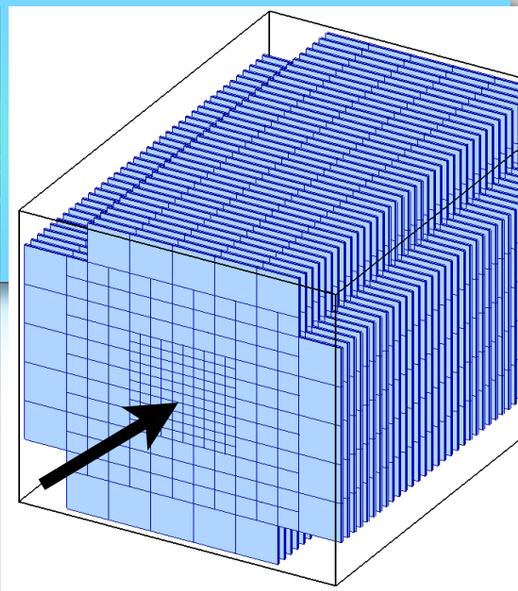


· JINST 8,2013, P07005

event data

- CALICE AHCAL events
- without selection



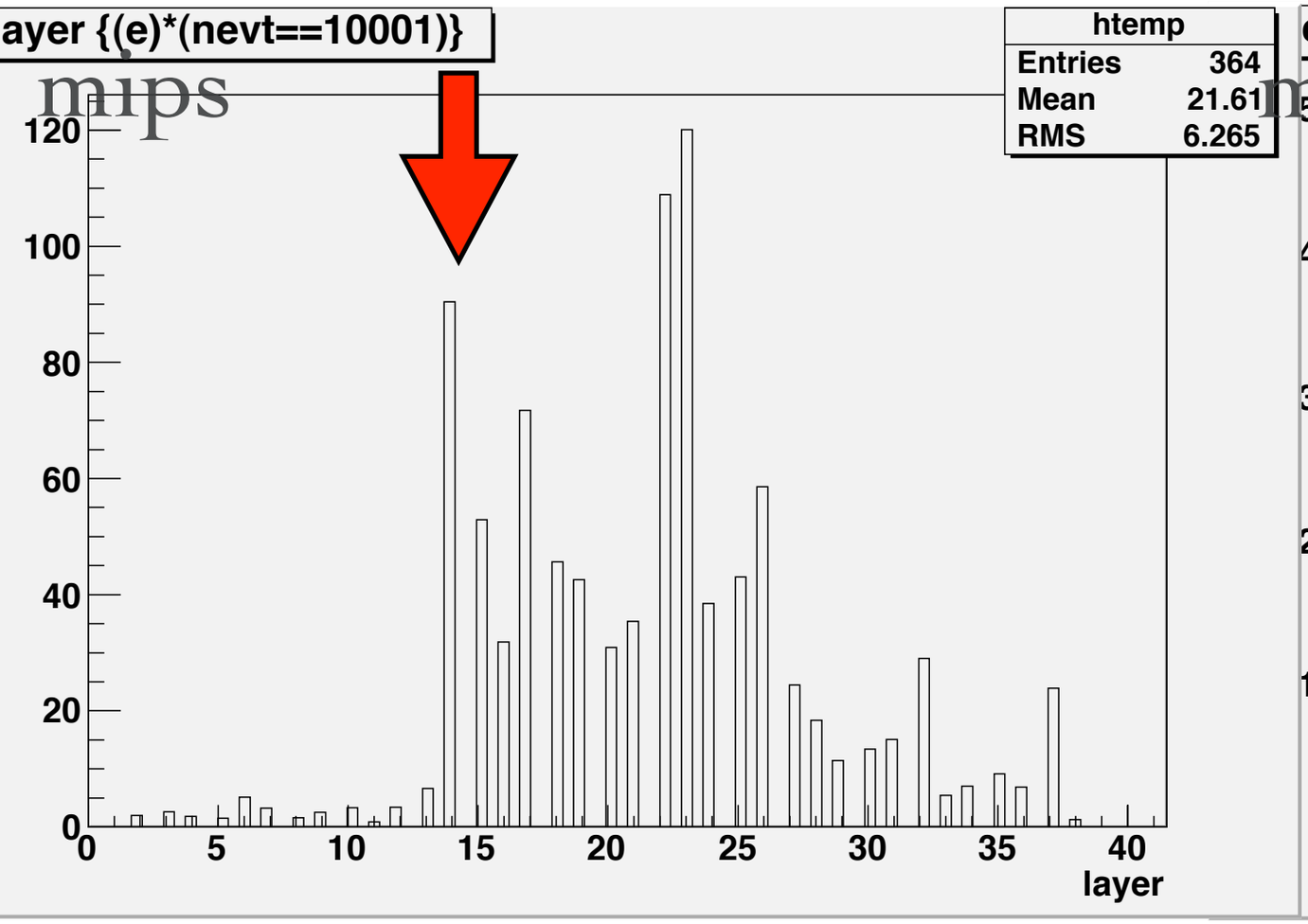


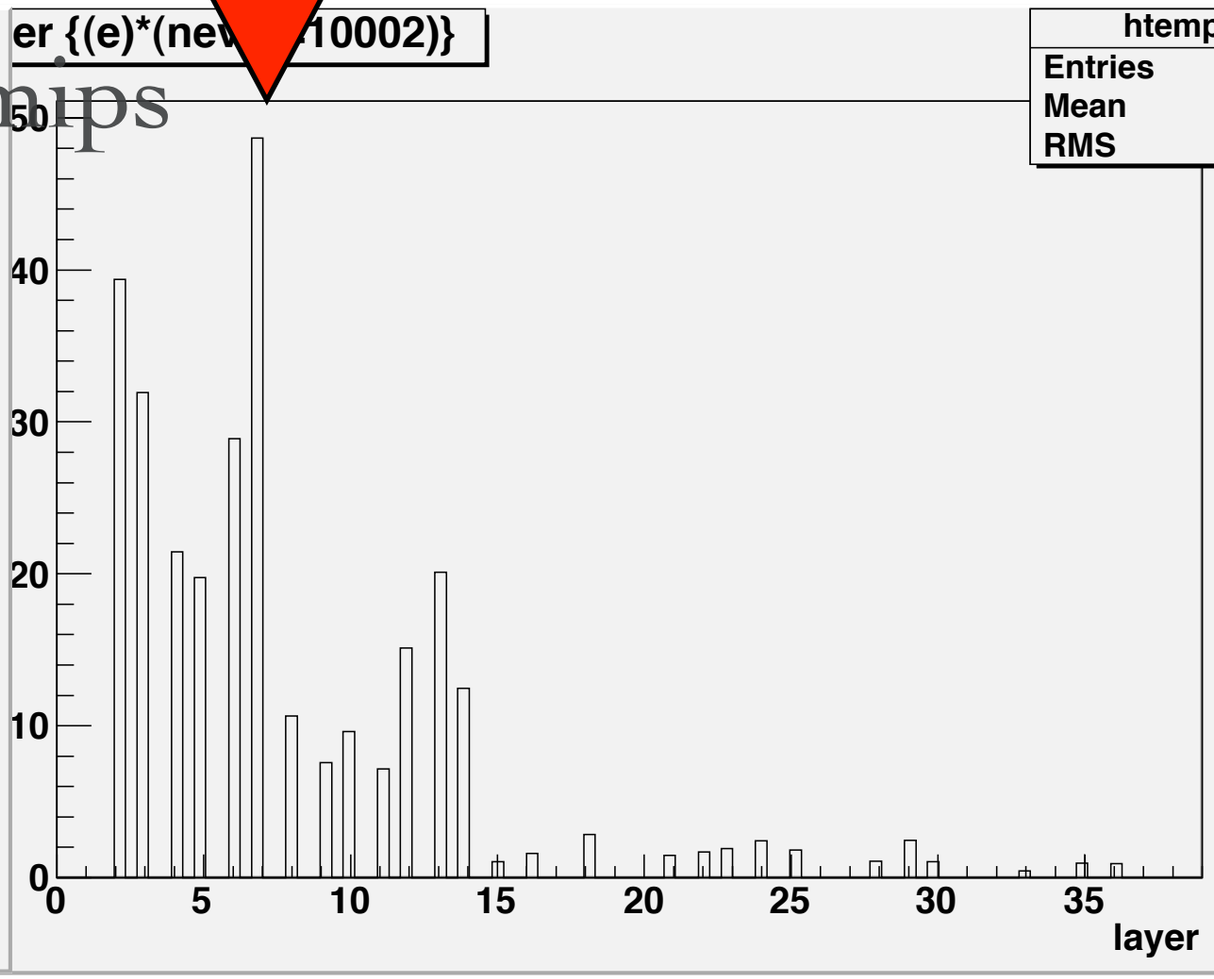
iron20mm+sci5mm

spike

32GeV pi-

spike



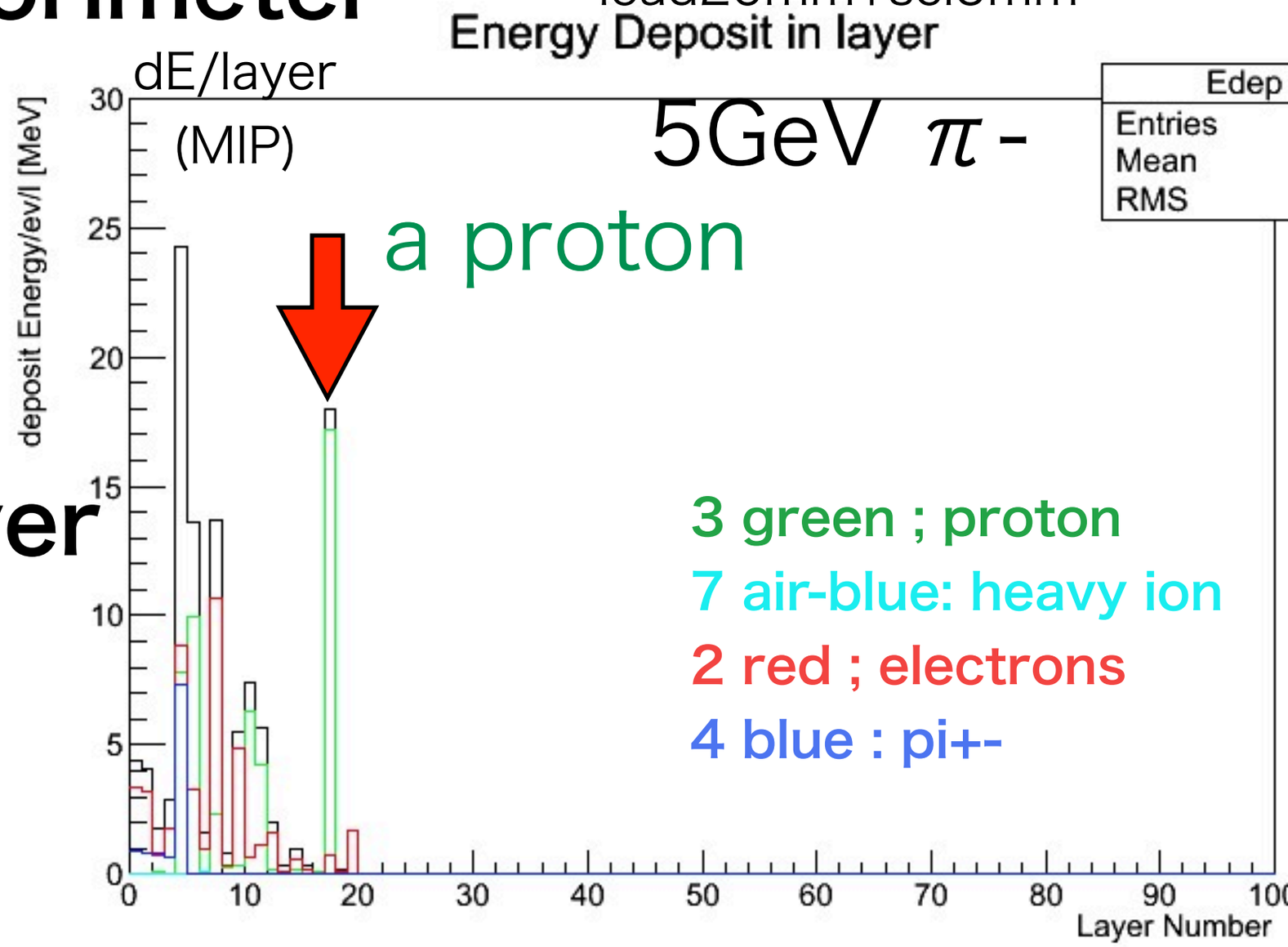


layer num.

layer num.

event by event

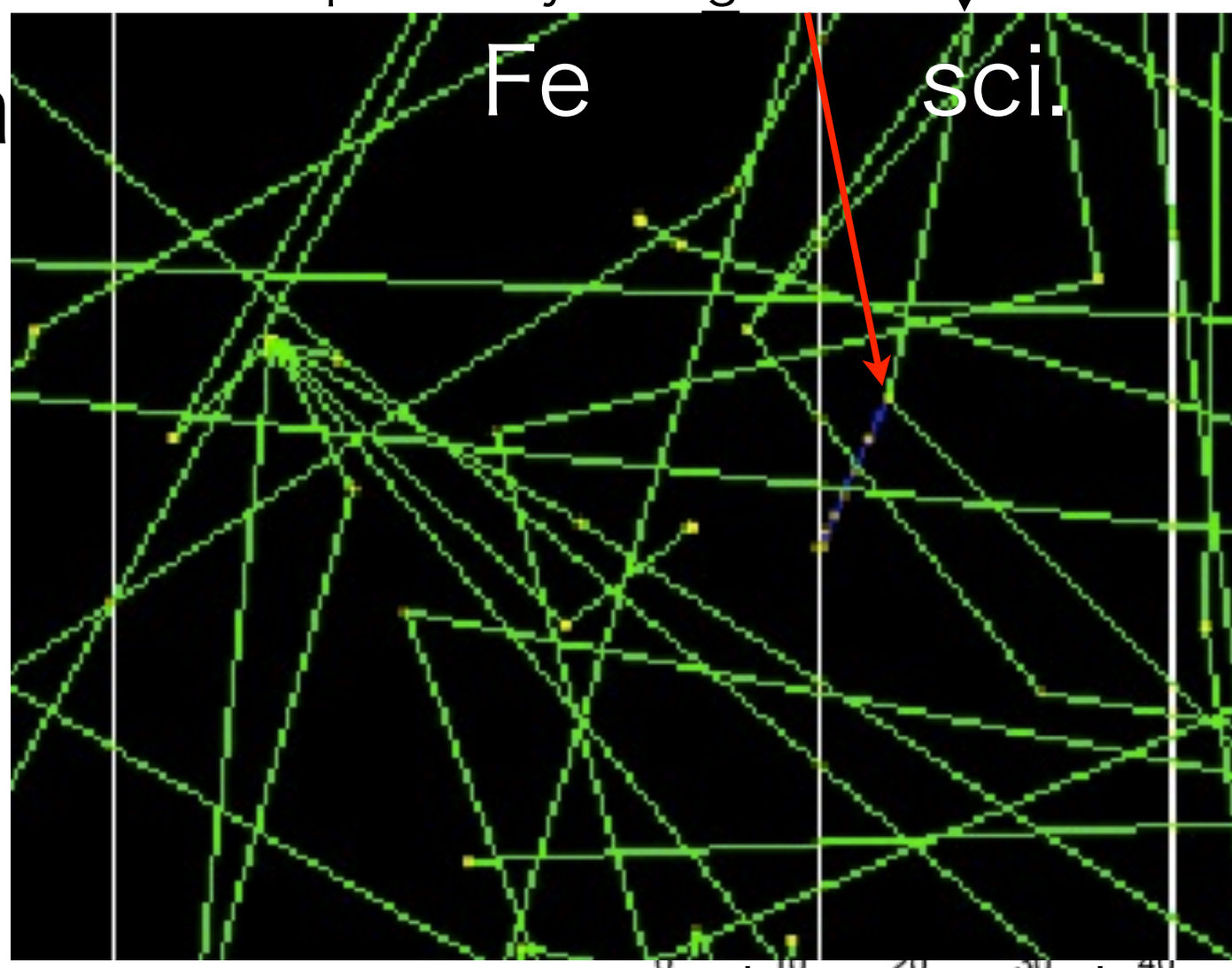
- simulation : longitudinally fine segmented calorimeter
- QGSP_BERT
- found spikes
- high dE in a layer
- due to protons



layer num.

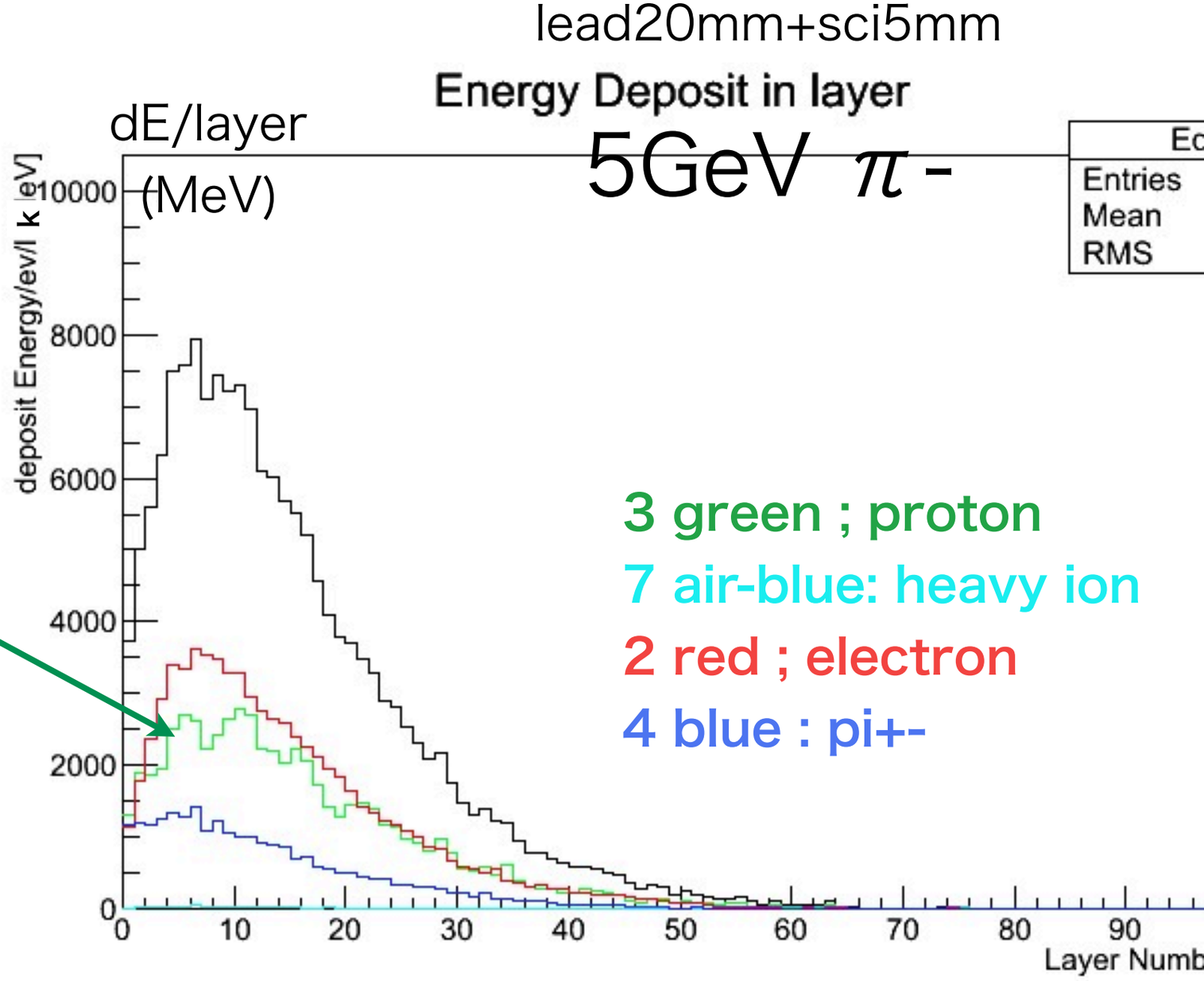
a spike in H-int.

- an event
- positive charged recoil
- proton from np>pn
- spallation neutron
- timing ~0
- Tn~Tp~50MeV



dE vs layer

- simulation dE/layer
- QGSP_BERT
- proton contribution
- makes spikes



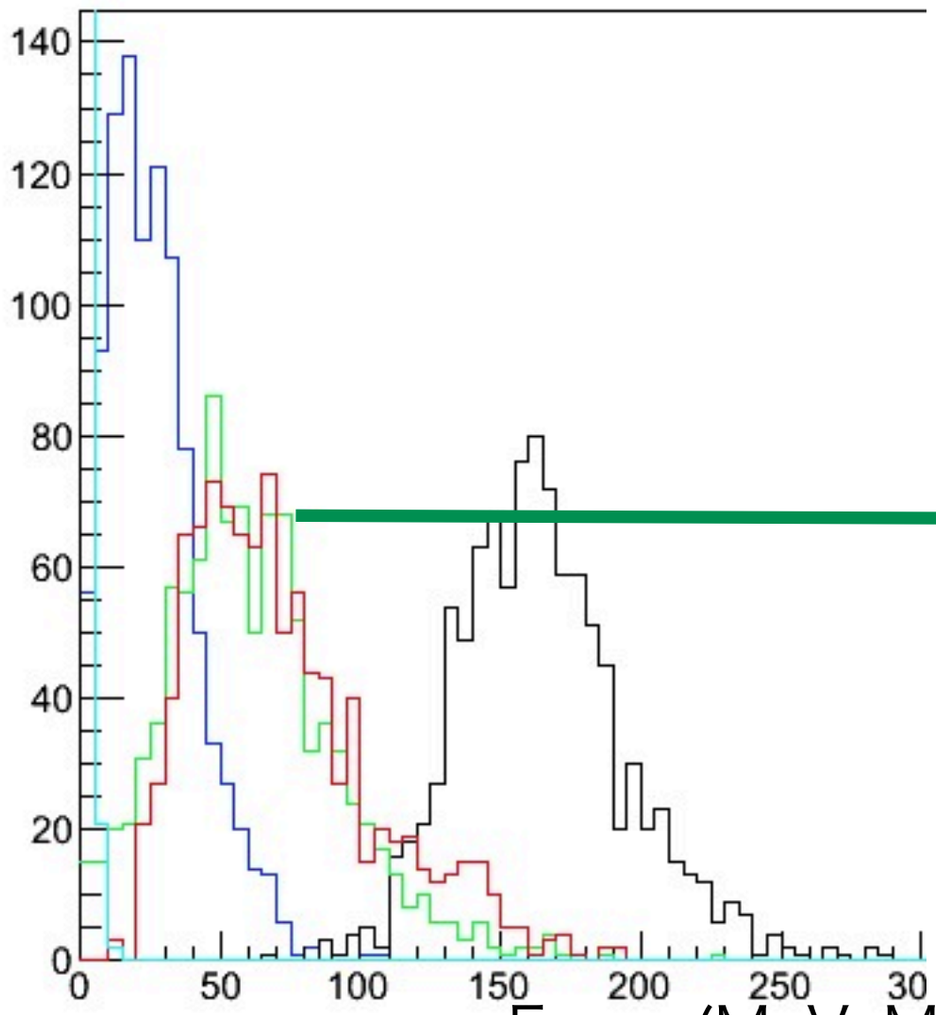
proton energies

- E_{proton} cut applied
- most of spikes are low E from spallation

lead20mm+sci5mm

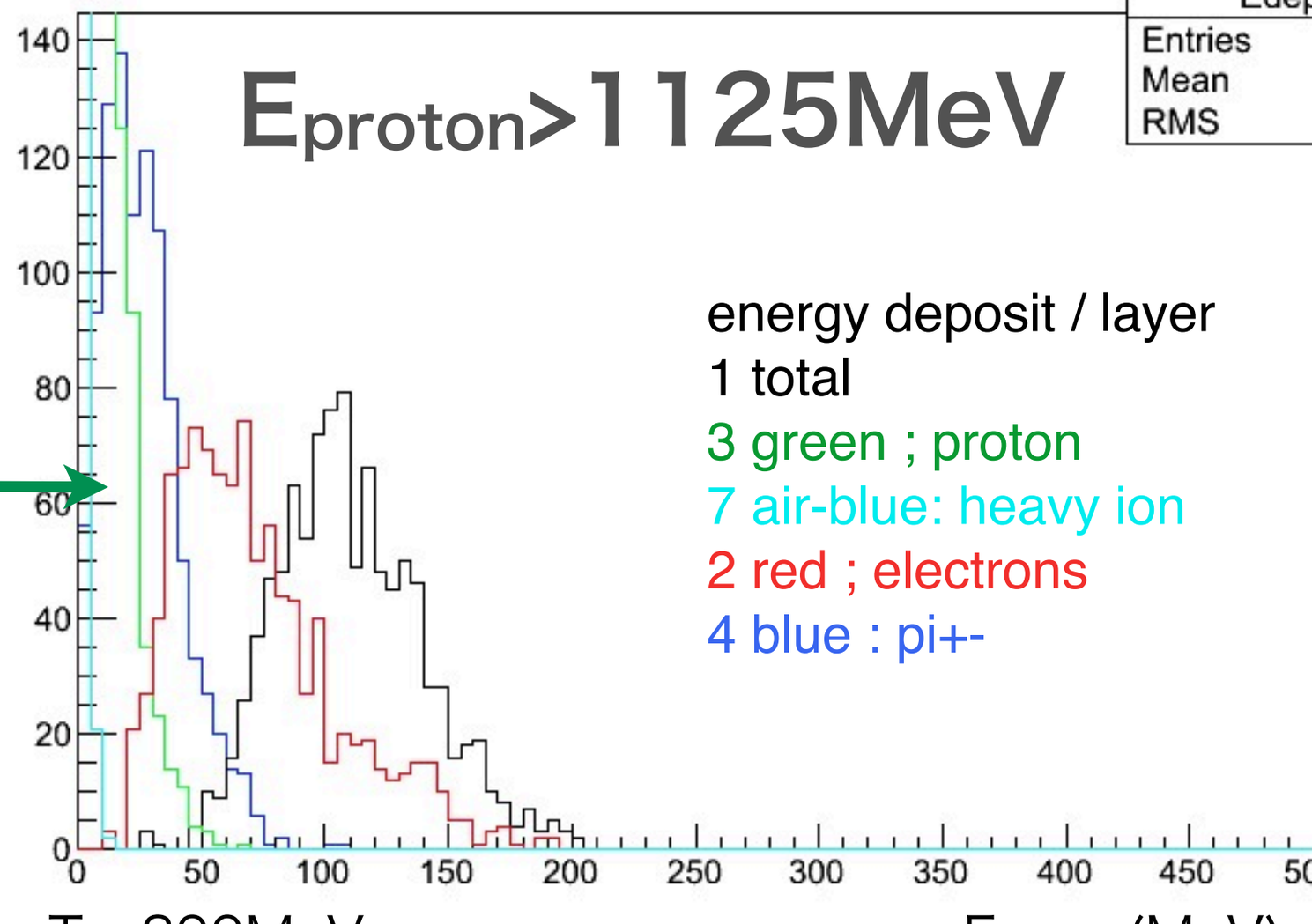
5GeV π-

Esum in a event for particles



Esum (MeV~MIP) Tp>200MeV

Energy Deposit



E_{proton}>1125MeV

energy deposit / layer
1 total
3 green ; proton
7 air-blue: heavy ion
2 red ; electrons
4 blue : pi+-

Esum (MeV)

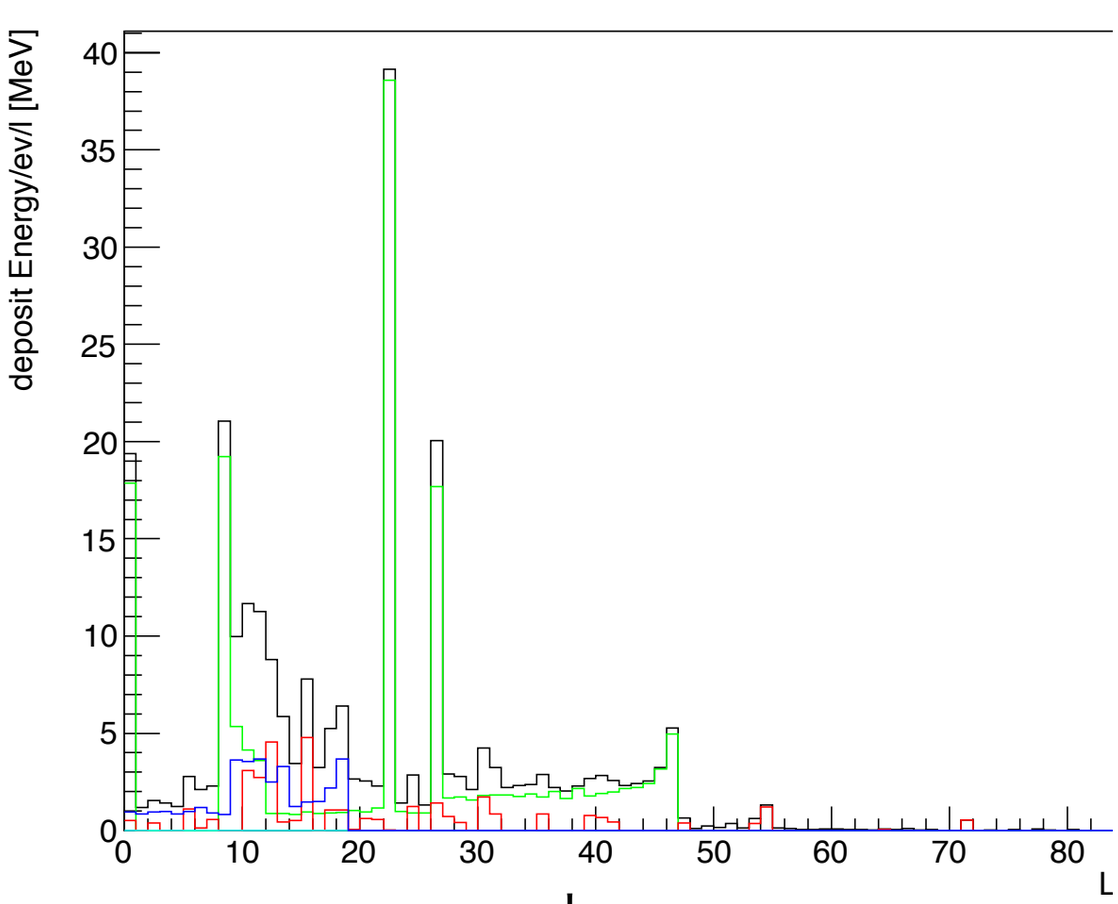
spikes in liq./gas

- liq. Ar has spikes: spallation protons
- no spikes in gas detector

5GeV π -

Pb10+LiqAr5

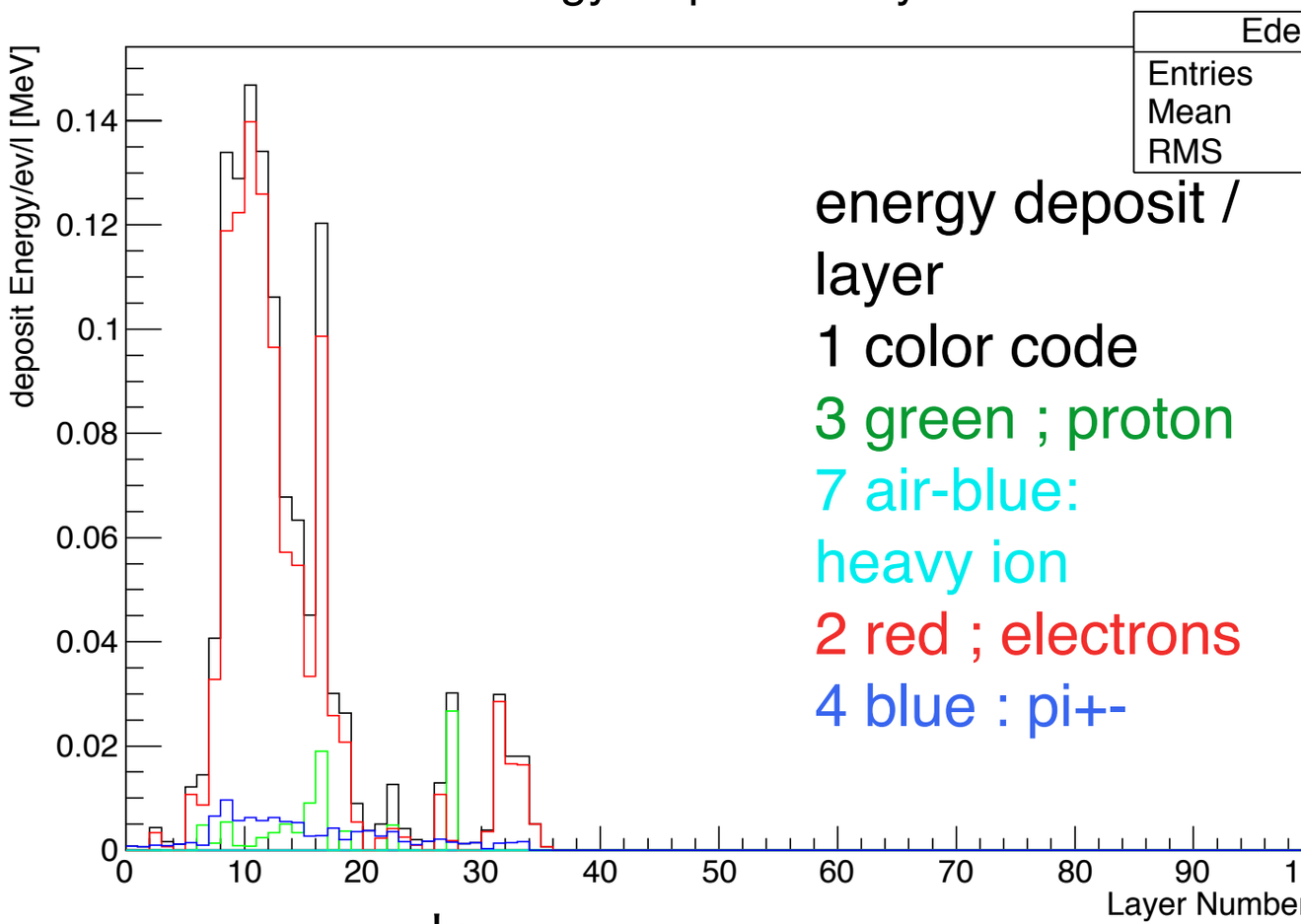
Energy Deposit in layer



layer num.

Fe25+gasAr5

Energy Deposit in layer



energy deposit / layer

1 color code

3 green ; proton

7 air-blue: heavy ion

2 red ; electrons

4 blue : pi+-

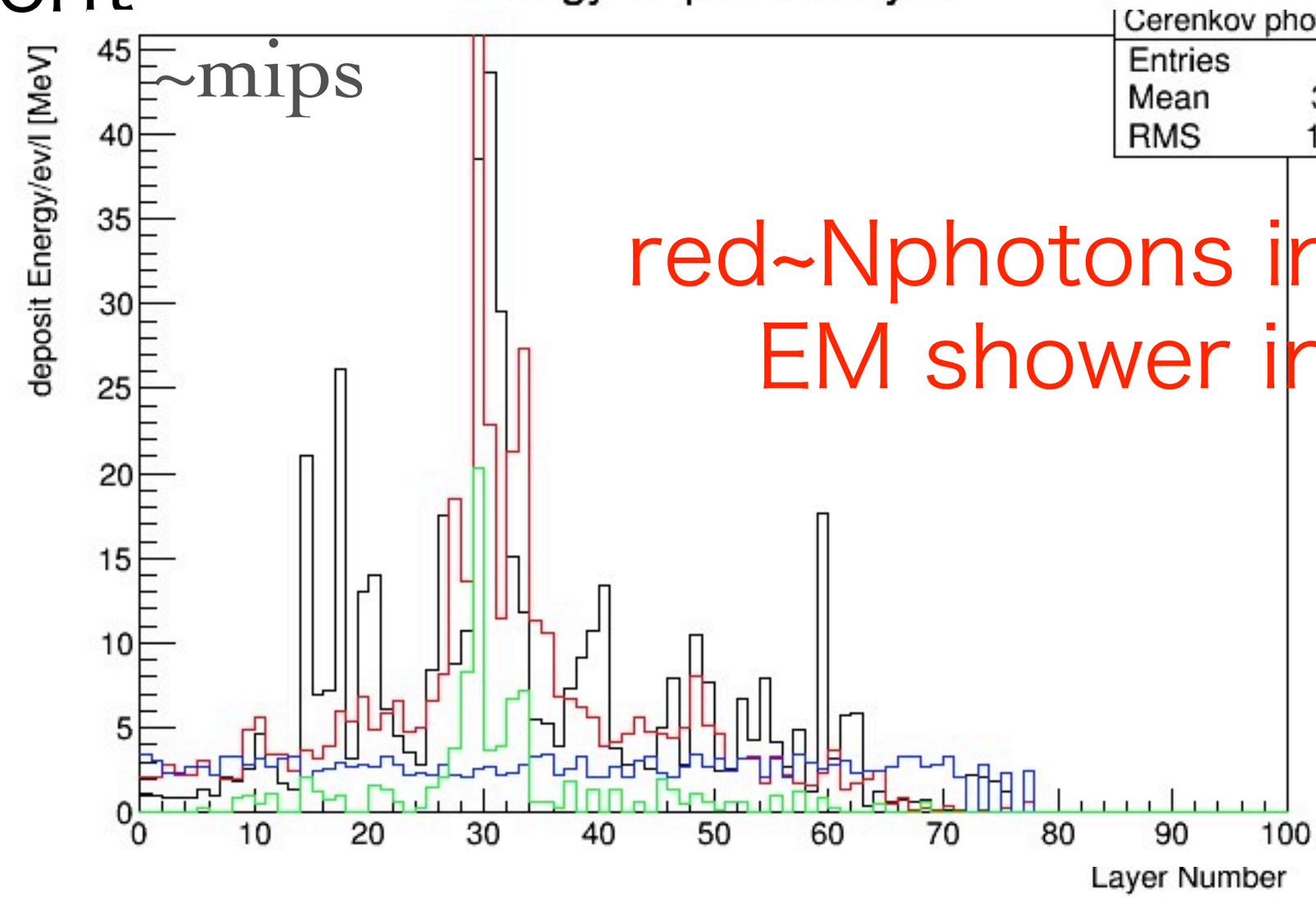
layer num.

how to avoid spikes

- **a 5GeV pion event : 3 spikes from proton Pb10+sc5mm**

EMshower at layer=30

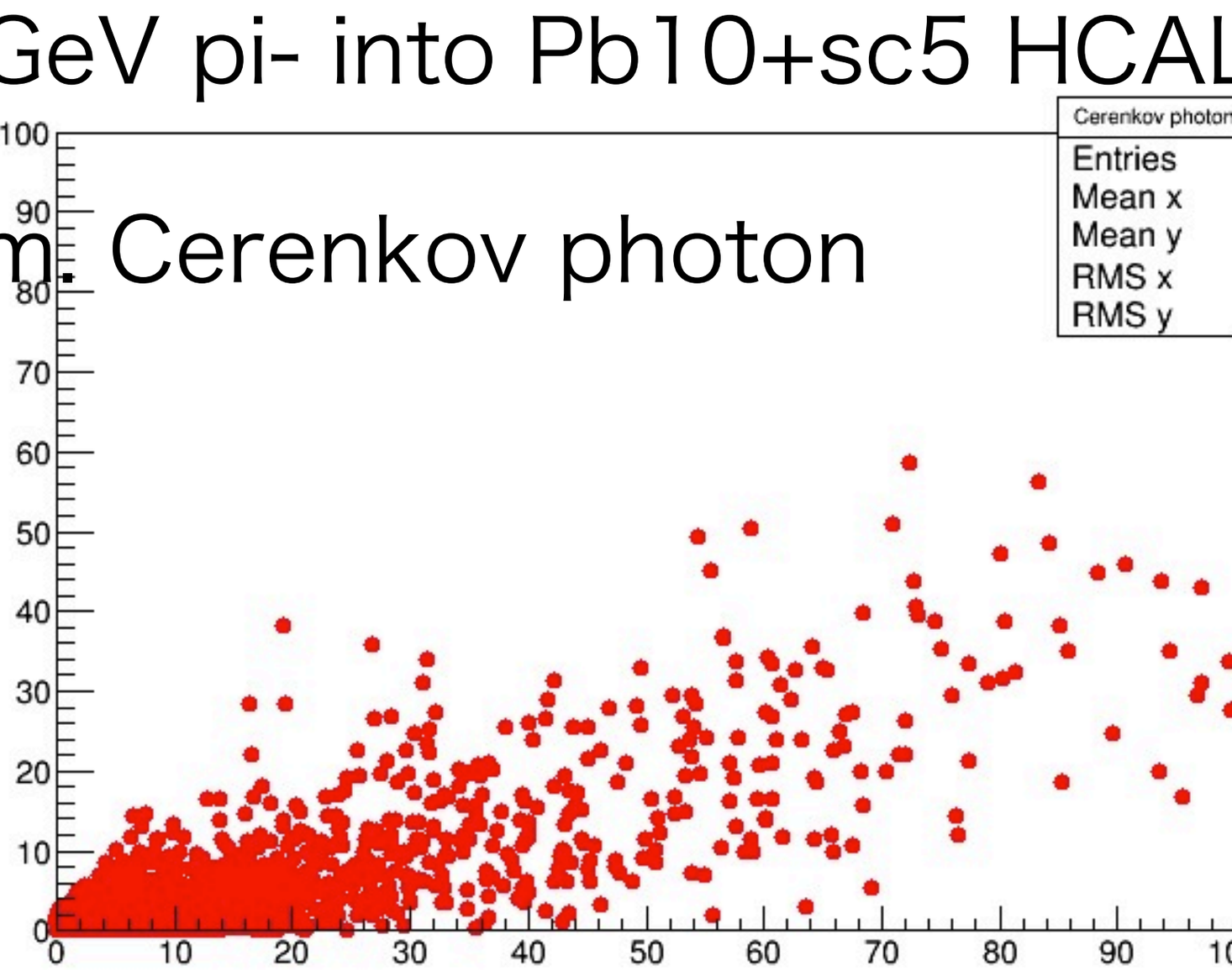
an event



layer num.

Cerenkov light

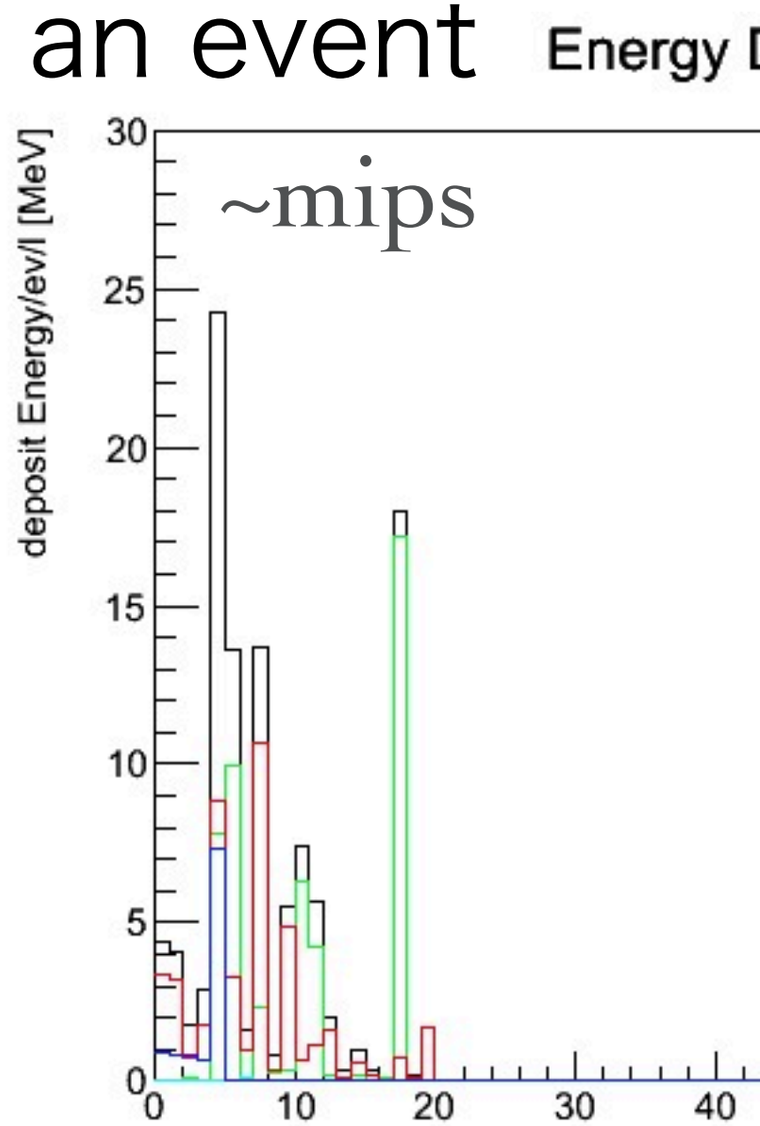
- EM shower detection in absorber
- utilizing Cerenkov light det.
- good correlation



prob. low

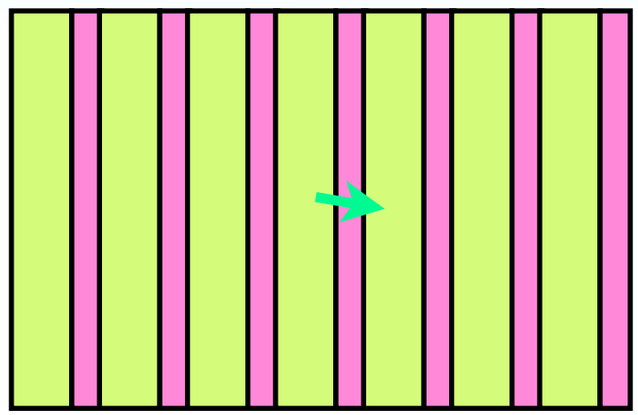
summary & outlook

- hadrons make spikes in the sampling calorimeter
  - by low energy protons
    due to Bragg peak
  - makes large fluctuation in energy measurement
- to avoid them, Cerenkov in absorber can help
- need to develop technique to measure in sampling CAL.



spike rejection

- spikes could be avoided by
- fine lateral segmentation
- localized in a small unit



- find & remove a spike hit
- little effect to total energy measurement