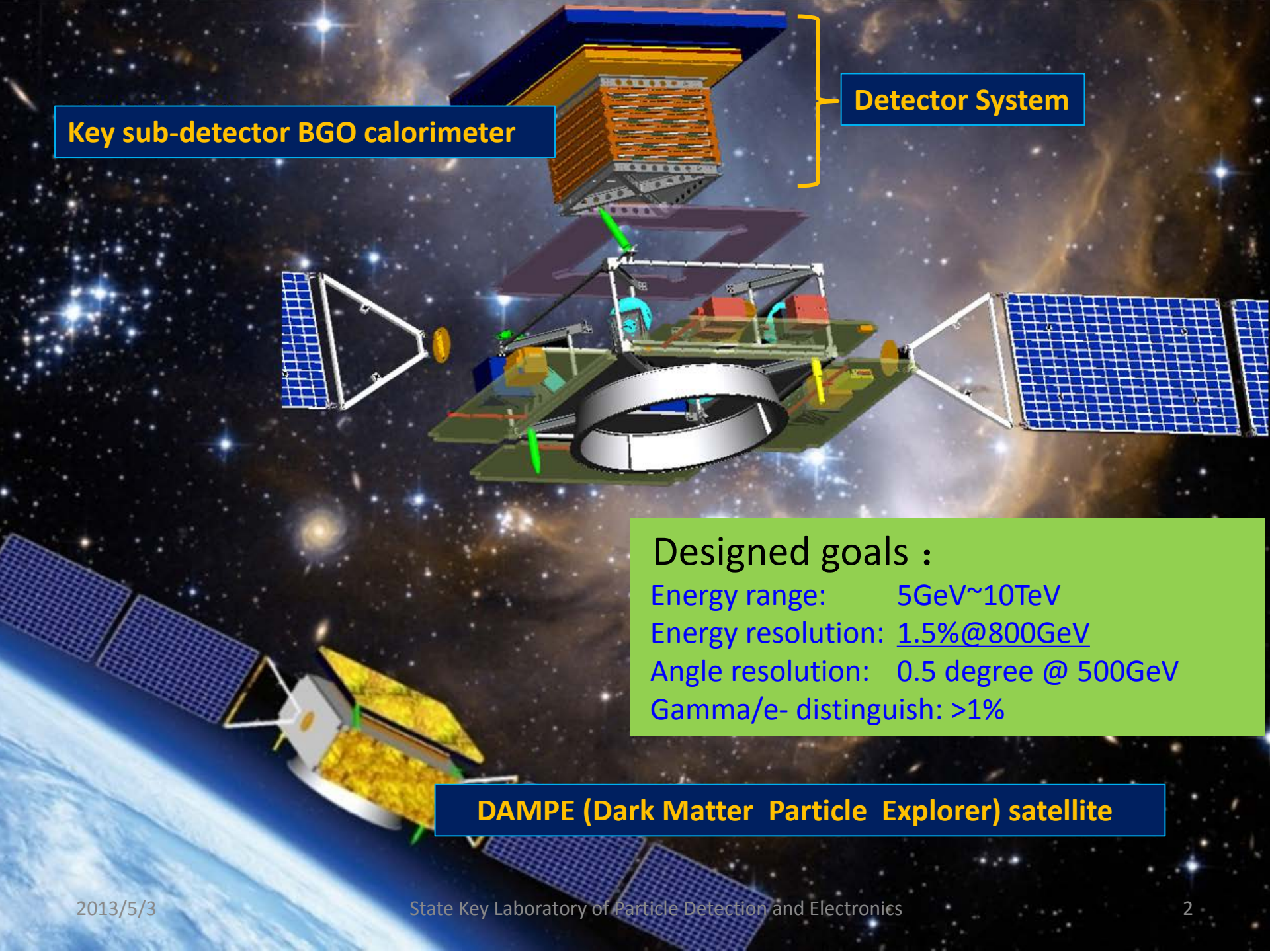
核探测与核电子学国家重点实验室
State Key Laboratory of Particle Detection and Electronics

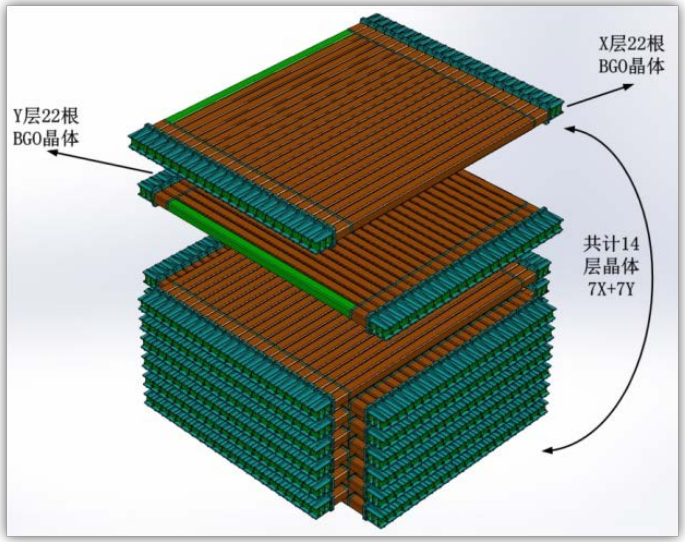
Beam Test Results of Calorimeter of DAMPE

Chi Wang
Department of Modern Physics USTC
Email: chiwang@mail.ustc.edu.cn

on behalf of DAMPE Team

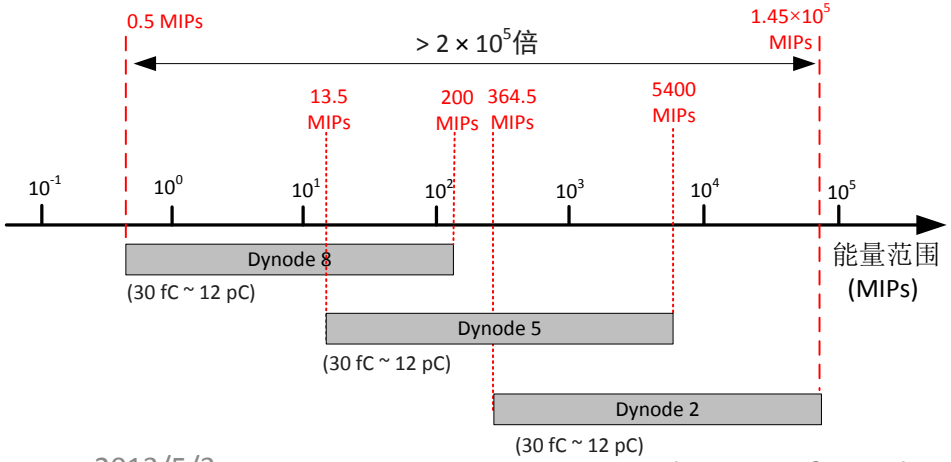

Key sub-detector BGO calorimeter
Detector System
Designed goals：
Energy range: 5GeV~10TeV
Energy resolution: 1.5%@800GeV
Angle resolution: 0.5 degree @ 500GeV
Gamma/e- distinguish: >1%
DAMPE (Dark Matter Particle Explorer) satellite

BGO Calorimeter



Calorimeter Structure

- 7 Planes (1 plane has X , Y Layers)
- 7*2*22 = 308 BGO bars
  - 1 bar measurement: 2.5* 2.5* 60 cm^3
  - Totally： 31.2 Radiation lengths
- Two sides readout
- Readout 3 signals from one PMT

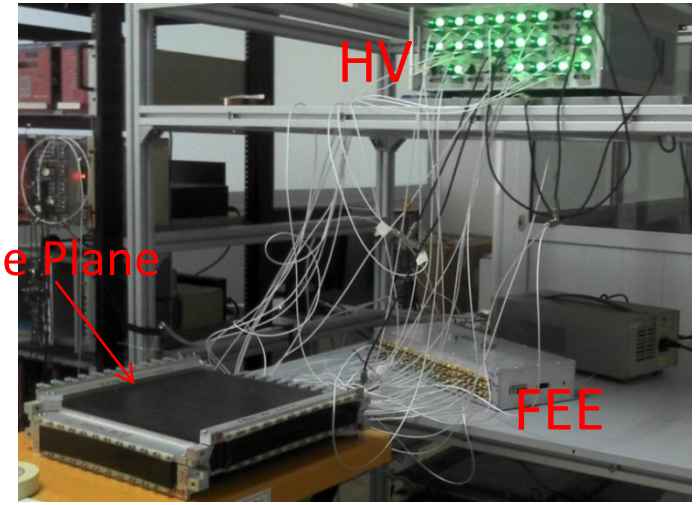


Multi-dynode readout (dynode 2, 5, 8)

- Energy deposit in single bar will reach 2TeV (8.7×10^4MIPs)
- FEE range(one channel)
  30fC~12pC(Dy8： 0.5MIPs~200MIPs)
- One PMT 3 signals

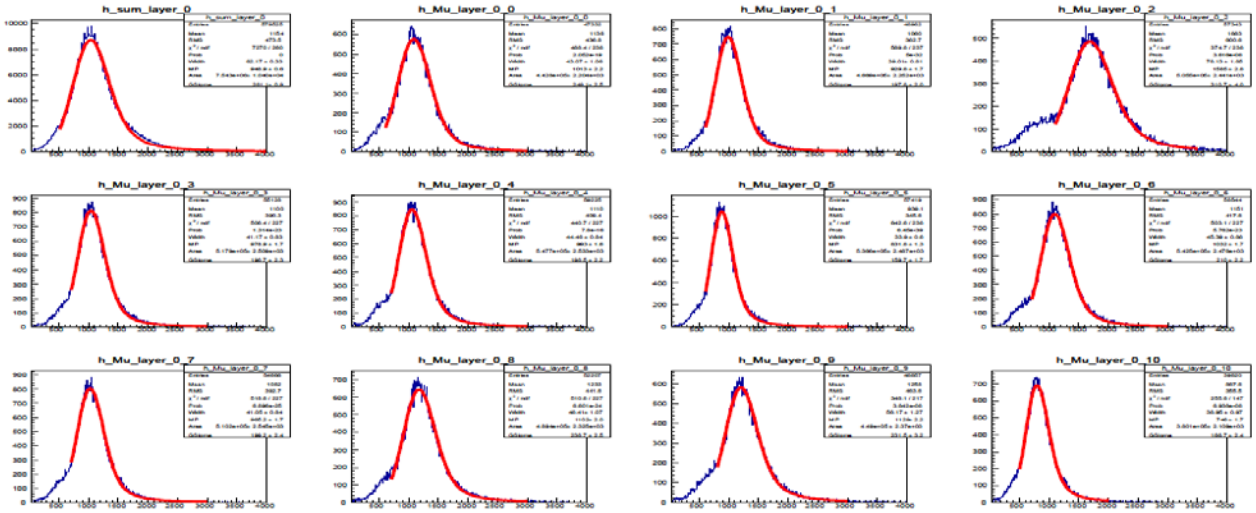
BGO Calorimeter ¼ prototype

- 6 Planes (6*2 = 12 Layers)
- 6*2*11 = 132 BGO bars
  - 1 bar measurement: 2.5* 2.5* 30 cm^3
- One side readout
- 3 Dynode signals



Cosmic test of Single Plane ¼ prototype

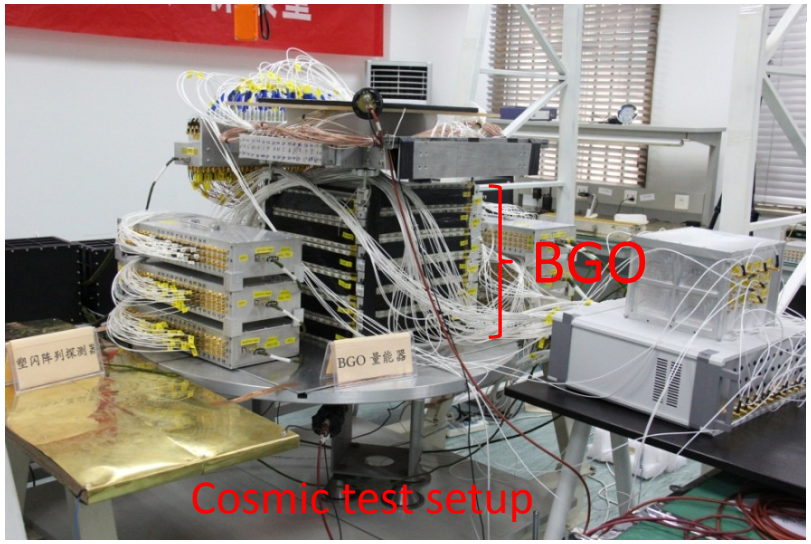
MIPs spectrum of dynode 8 of each Bar

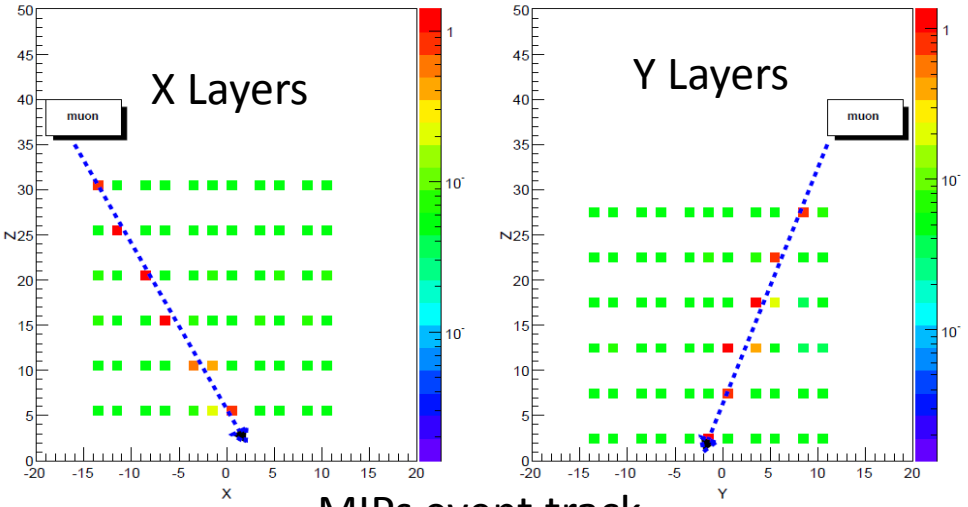


Tested each plane at USTC for tuning uniformity of MIPs ADC in one Layer

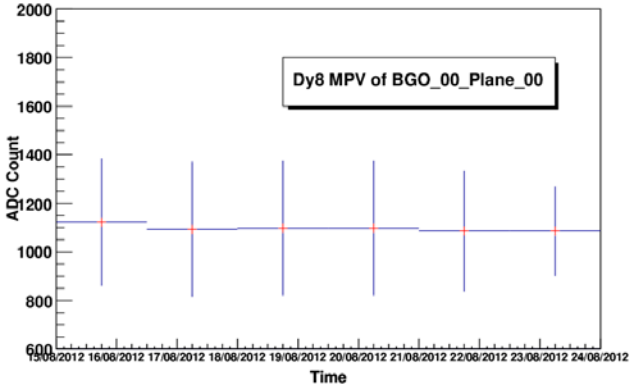
Cosmic Test

At PMO 2012.7~2012.8, 2013.1, 2013.3

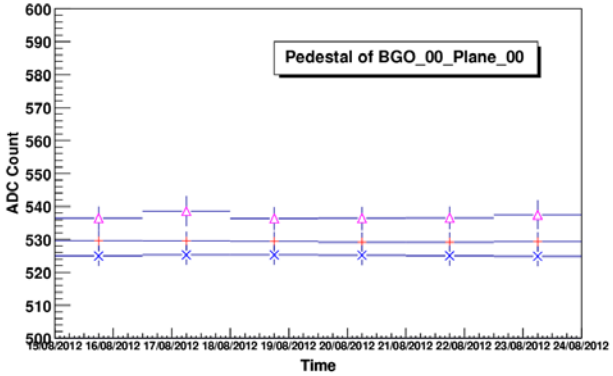




MIPs event track



Stability of MIPs value

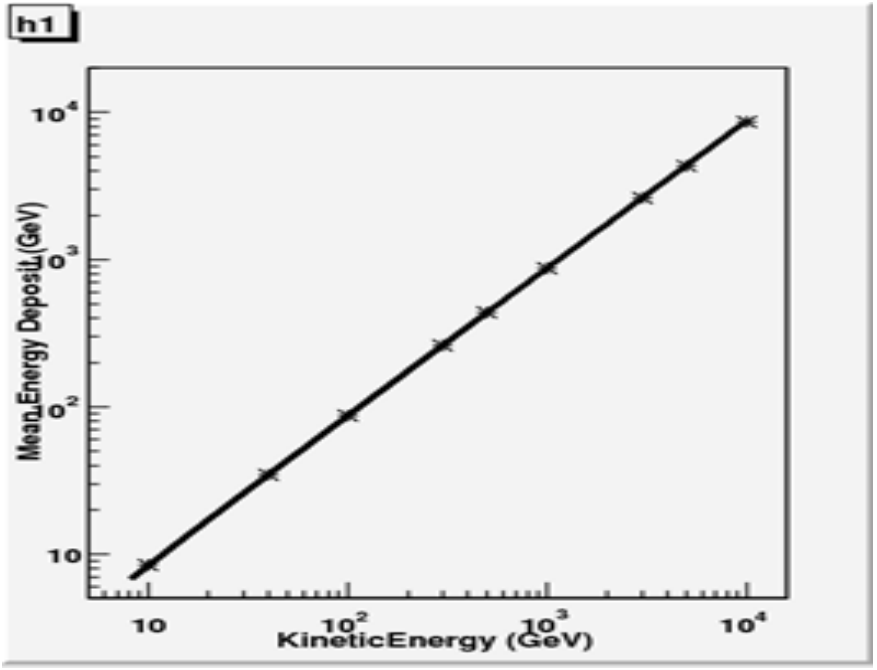


Stability of Pedestal value

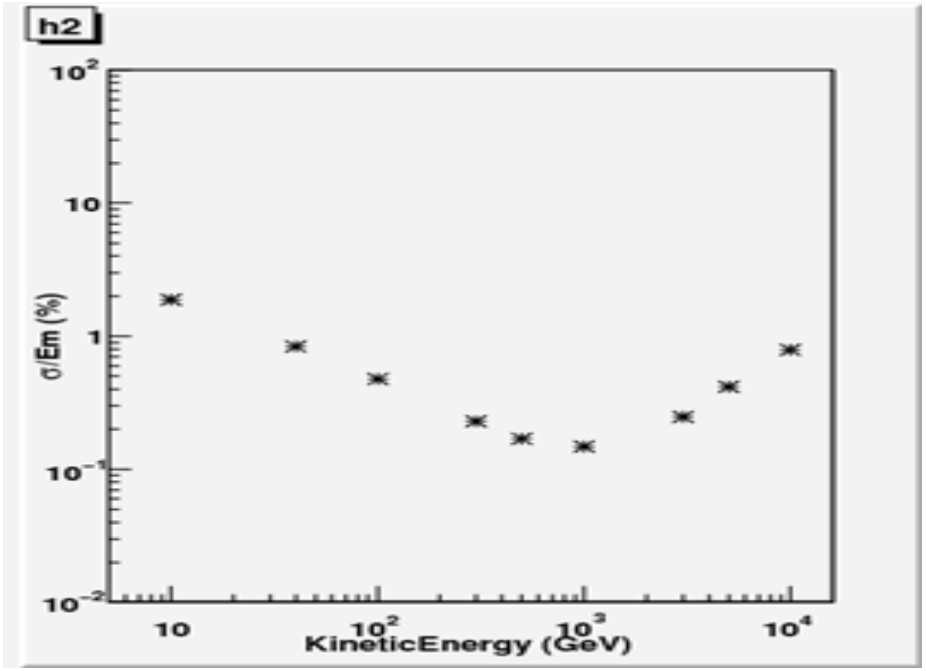
- ✓ Detector and FEE work well
- ✓ Data communicate with other parts of DAMPE correct
- ✓ Stable during long time test
- ✓ Need test beam to verify properties of detector at high energy

MC Results

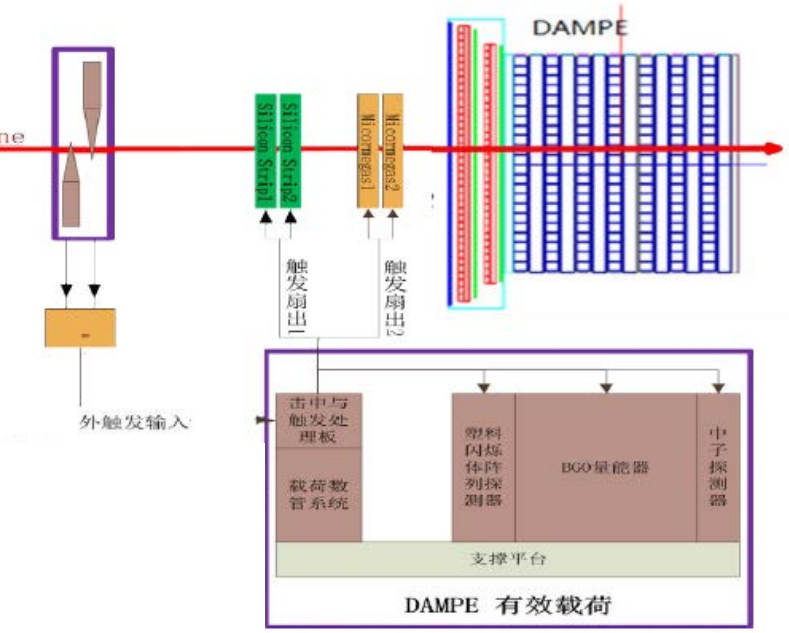
Energy Linearity

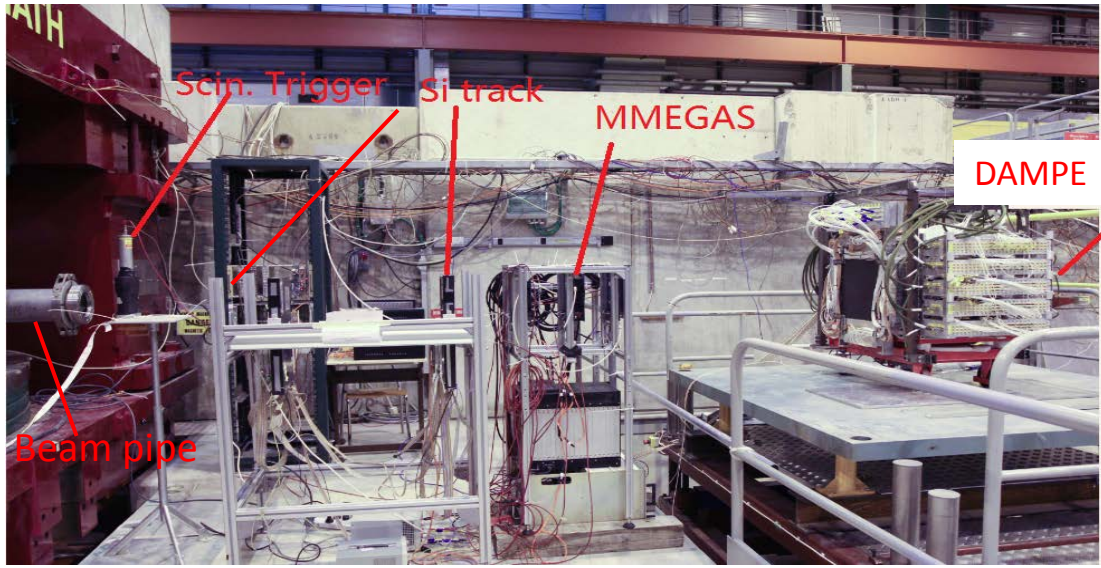


Energy Resolution



Beam Test Setup





At SPS/H4 area CERN
from 10.1.2013 to 10.8.2013

Mainly Involved:

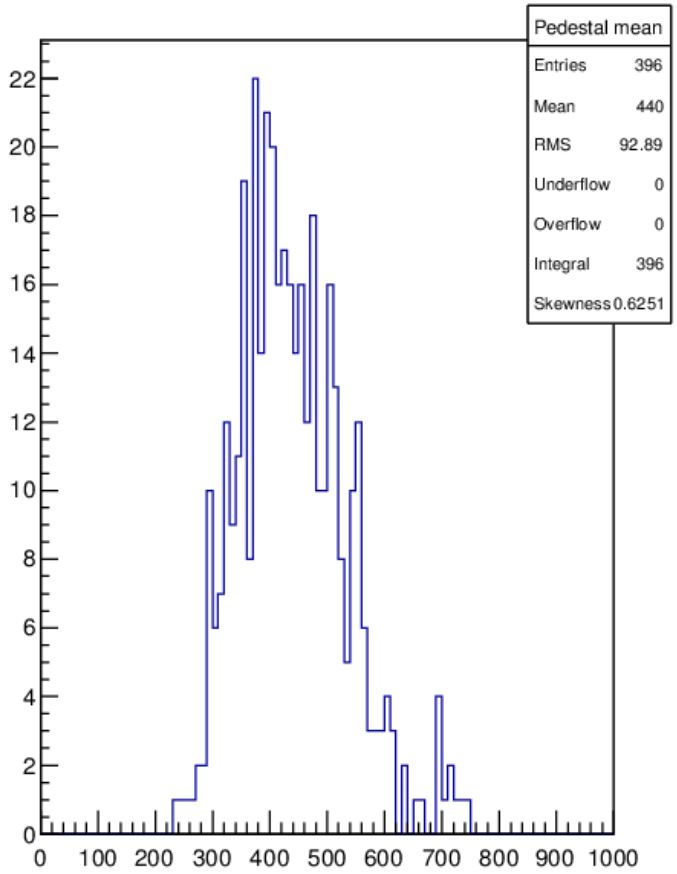
Purple Mountain Observatory
University of Science and Technology China
Institute of Modern Physics, CAS
National Space Science Center, CAS
University of Geneva

—e @ 5,20,50,100,120,149,173,200,245,290 GeV
High energy response,
Energy linearity and resolution,
Calibration dynode relations
—p @ 50,150,300 GeV
Calibration ADC,
Dynode relations
—mu @ 150 GeV
Calibration MIPs

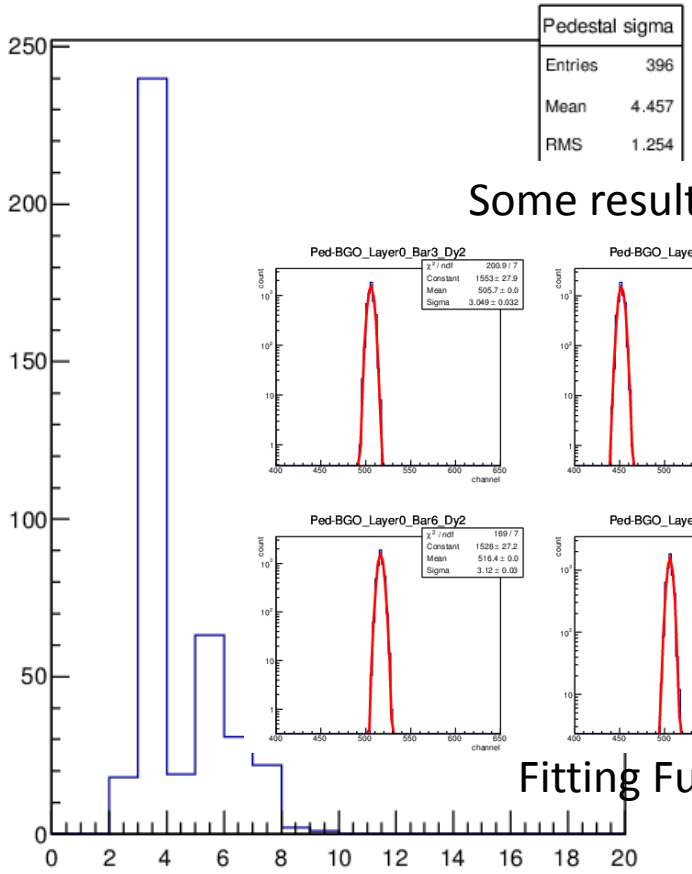
Calibration: Pedestal

2012.10.01 random trigger to calibration each channels' pedestal

Distribution of Pedestal means



Distribution of Pedestal sigmas



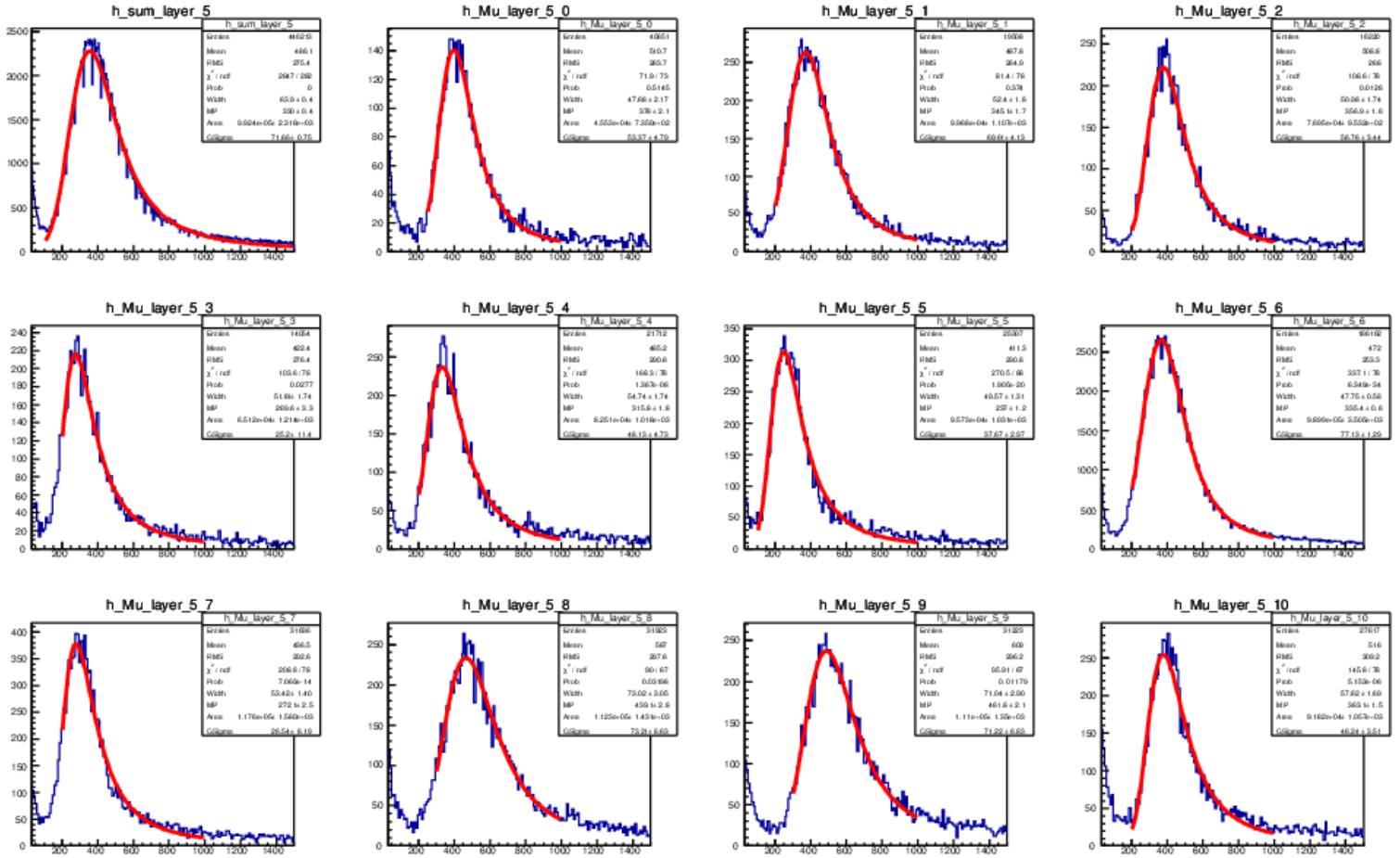
Some results of the 1st Layer

Fitting Function: Gaussian

Calibration: MIPs ADC

50GeV proton to calibrate MIPs ADC of dynode 8 of each BGO Bar

The 5th Layer results

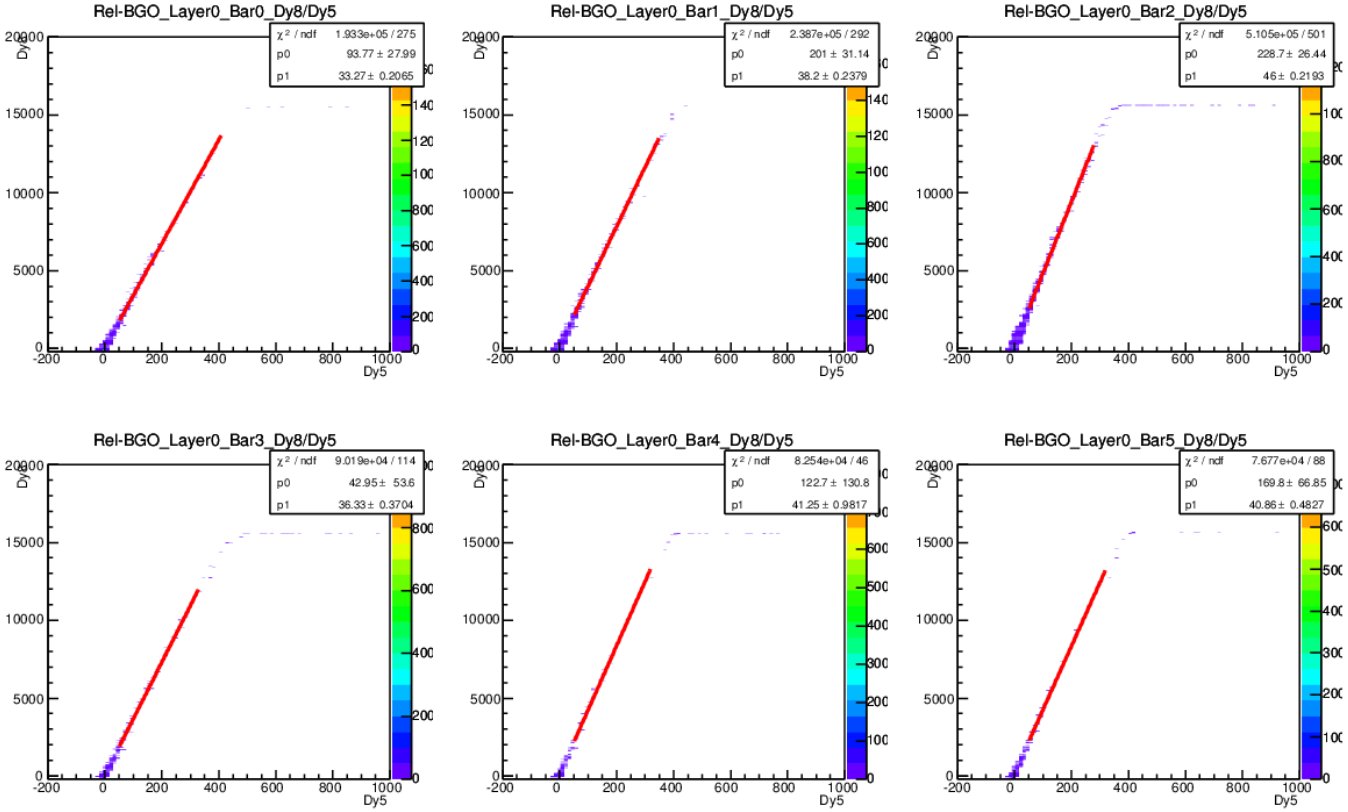


Fitting Function: Gaussian convolution landau

Calibration: Dynode Relations

All electron data to calibrate Dynode Relations

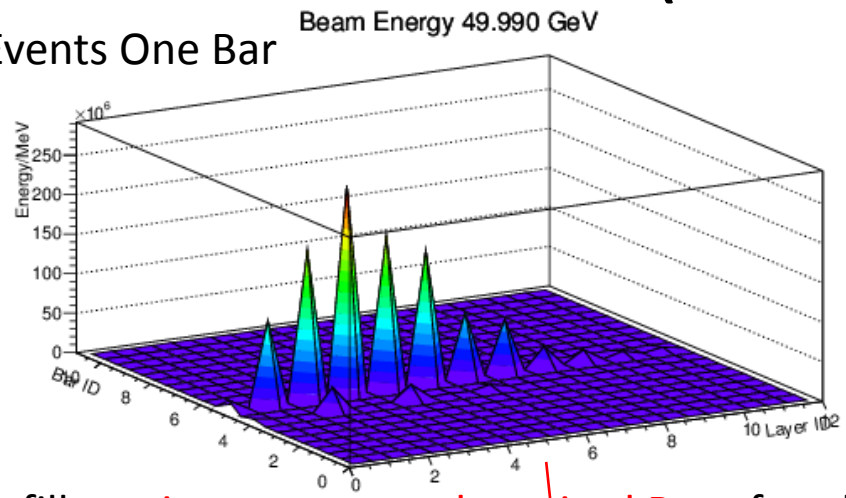
Some results of the 1st Layer



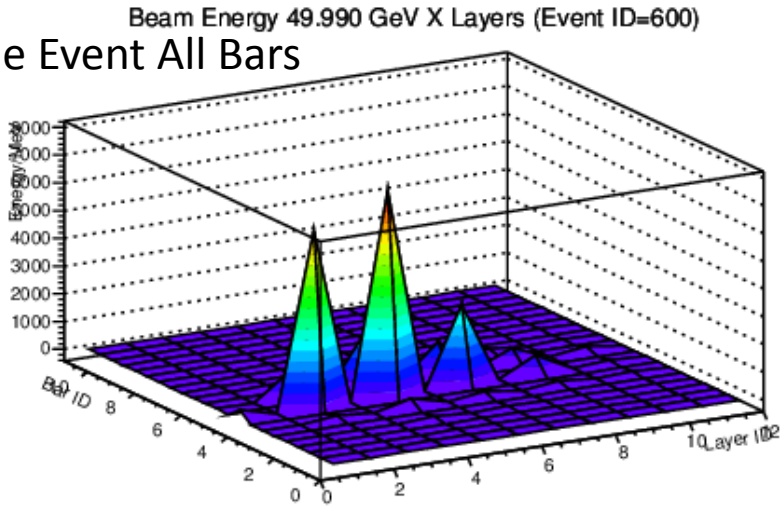
Dynode relations and MIPs ADC of dynode 8 to reconstruct of deposited energy when high energy particle incident

Energy Reconstruction (50GeV e-)

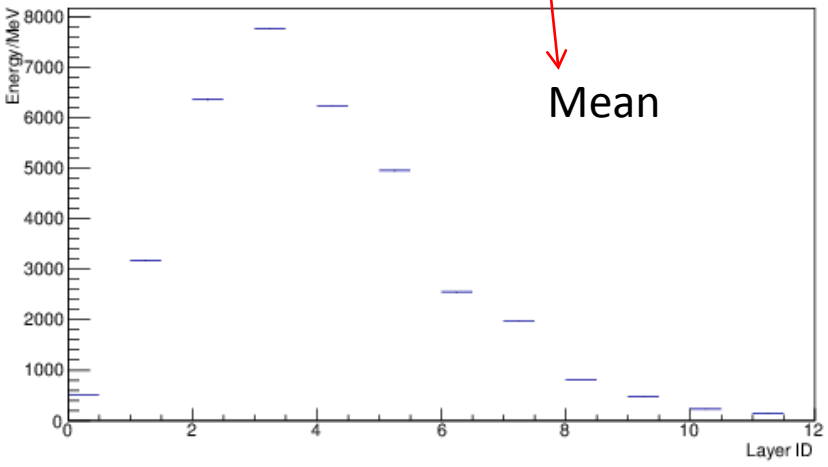
All Events One Bar



One Event All Bars

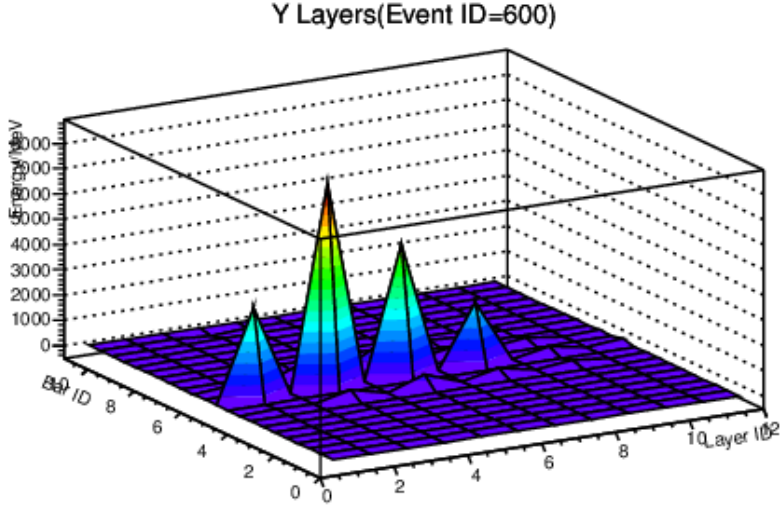


Only fill maximum energy deposited Bar of each Layer

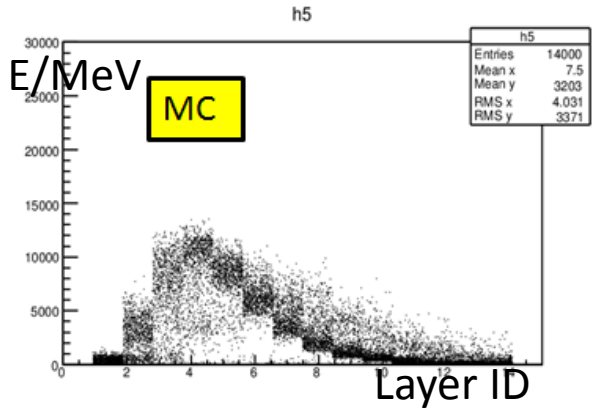


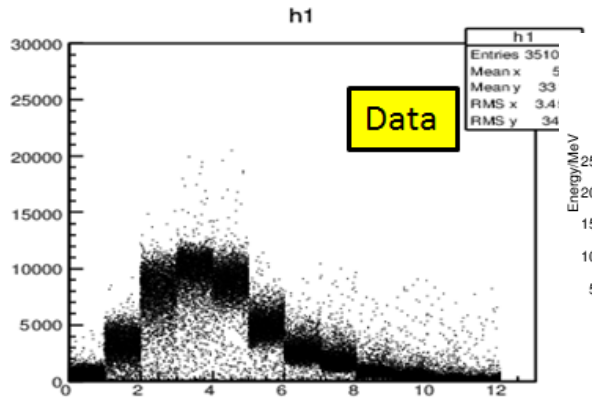
Mean

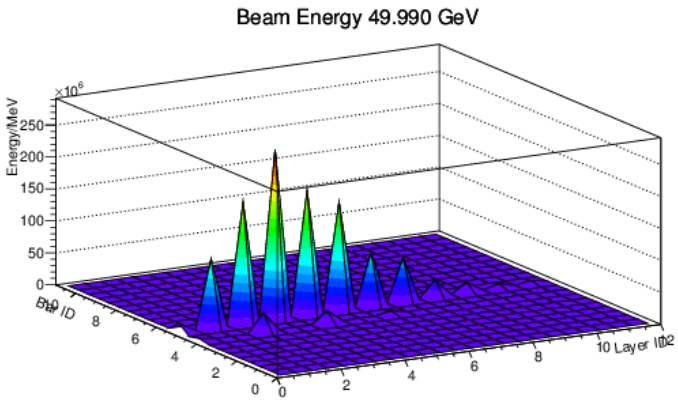
Event ID=600: E total = 48.111GeV



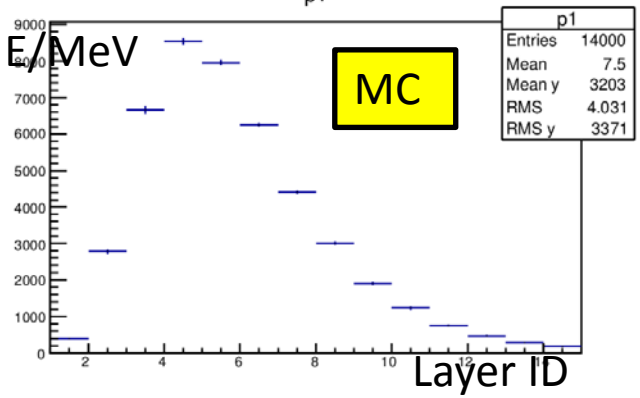
Energy Reconstruction (50GeV e-)

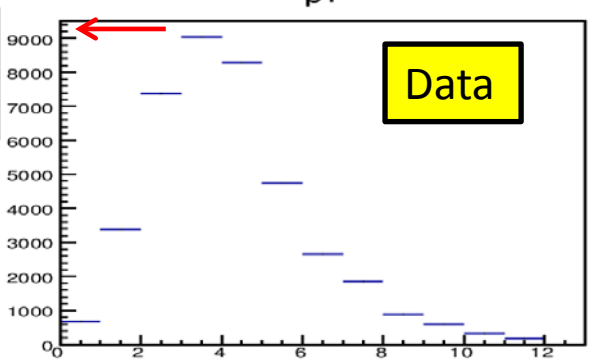


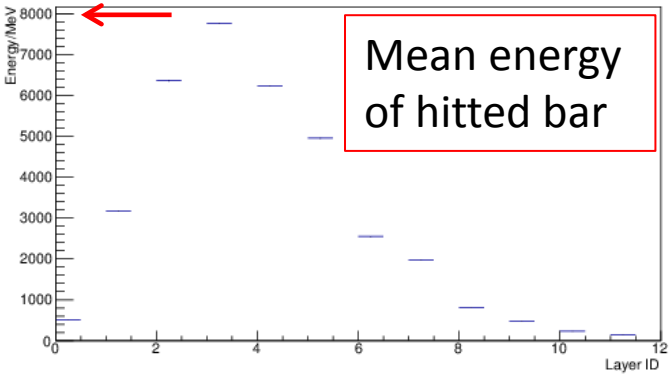




Total energy deposited in each layer



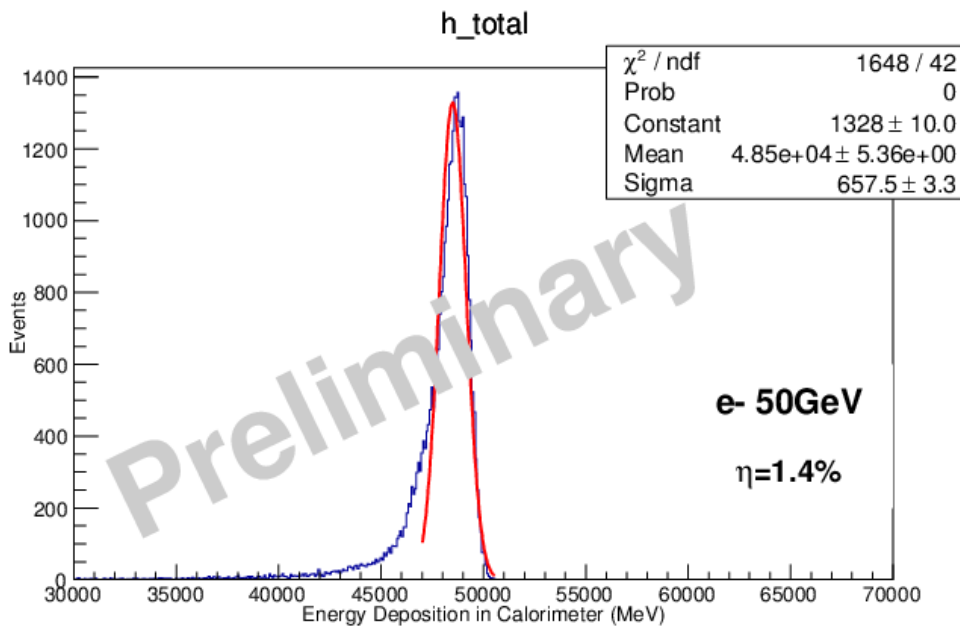


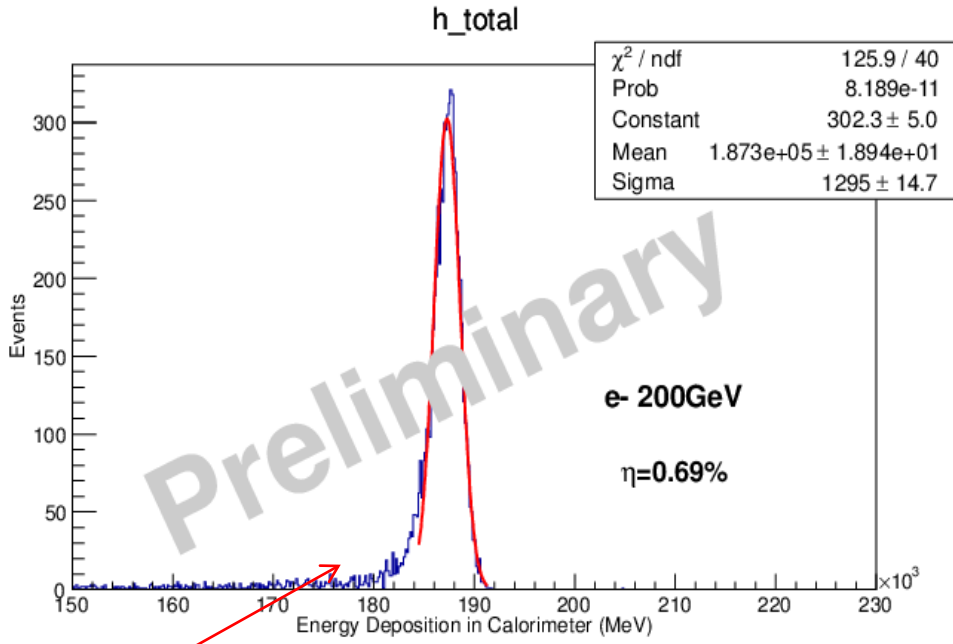


In maximum energy deposited Layer:

about 88.8% energy deposited in hitted bar (50GeV)

Energy Deposited in BGO Calorimeter

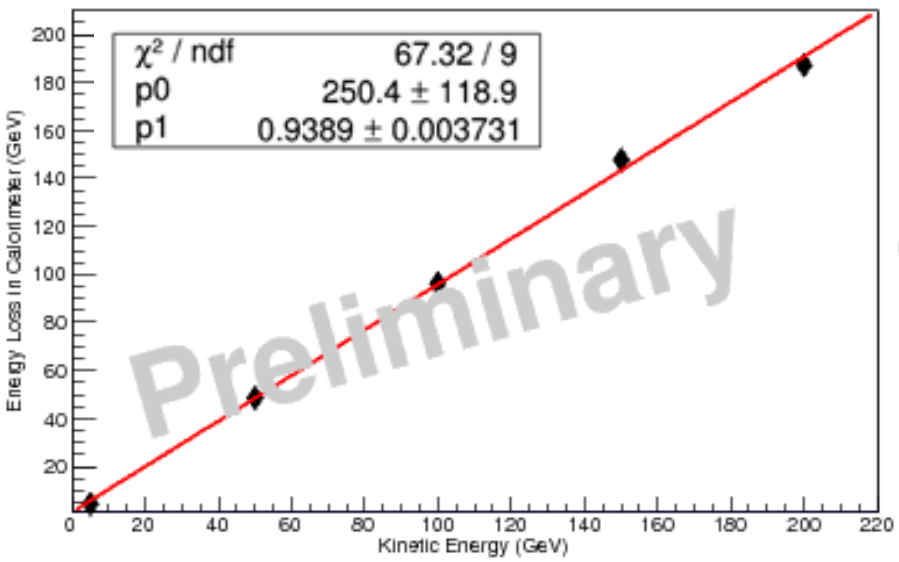




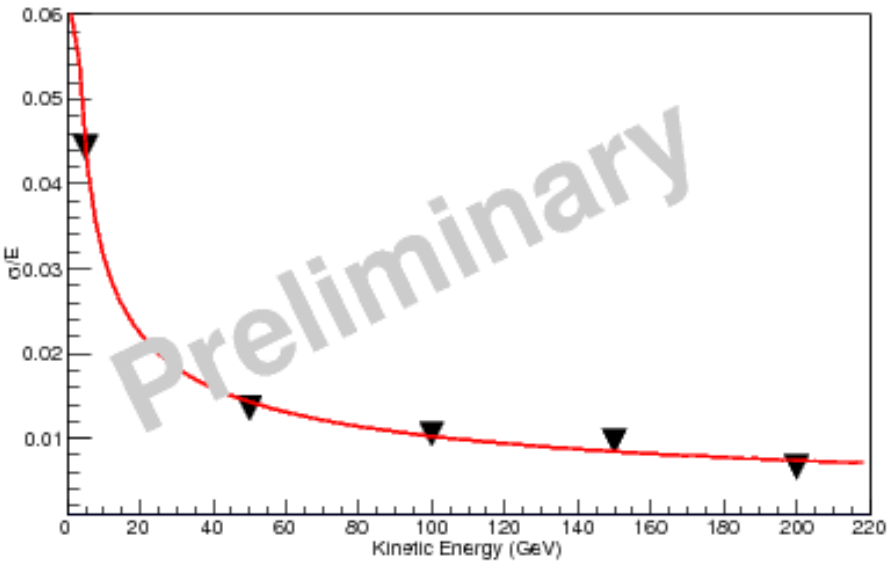
Caused by energy leak and beam particle contamination

Energy Resolution

Energy Linearity



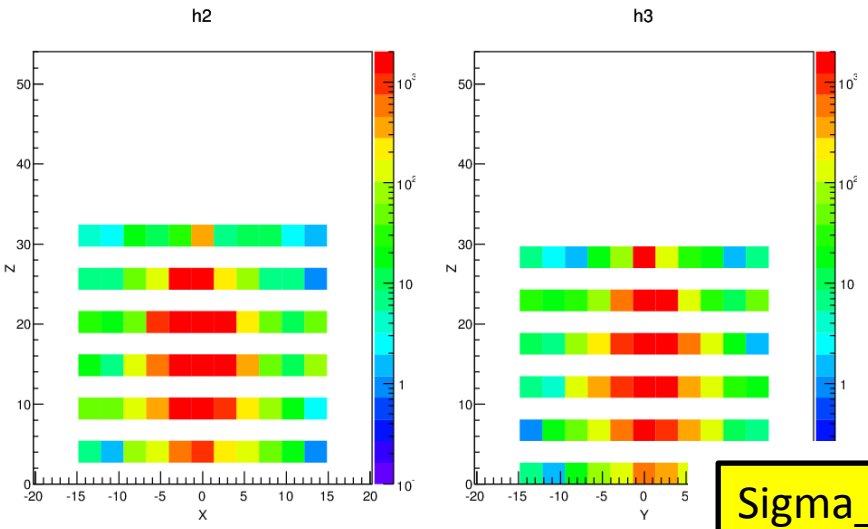
Energy Resolution



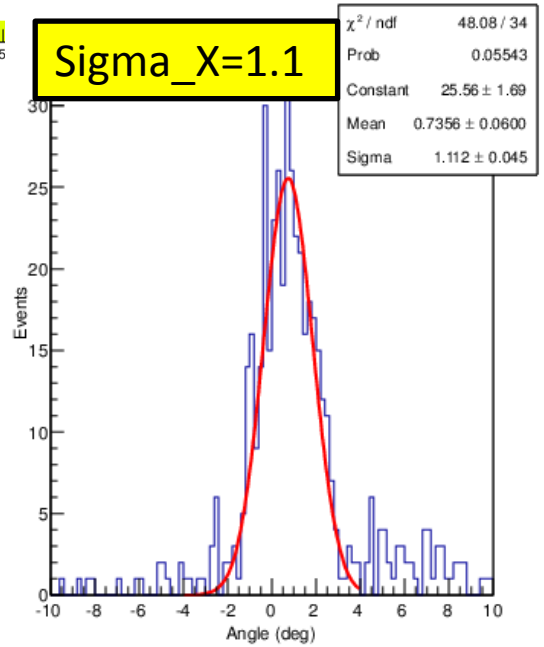
The gradient != 1:
energy deposited in structure material

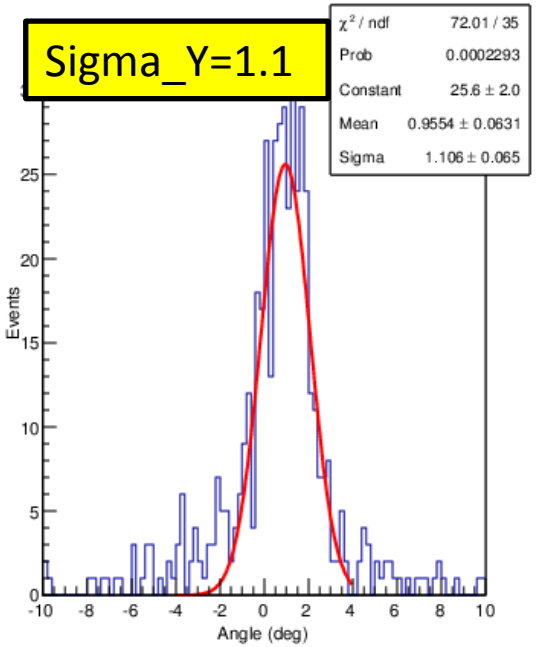
Energy leakage correction can give better resolution

Angle Resolution



Shower of one event (50GeV e-)





Conclusion

- The first time of beam test of DAMPE
- Calibrated of DAMPE by using high energy particles(e-, p, muon)
- Well response in high energy range
- Good energy linear, and energy resolution is nearly 1% ~ 200GeV
- Angle resolution can reach ~1 degree
- Detailed analysis is in progress

Thanks~

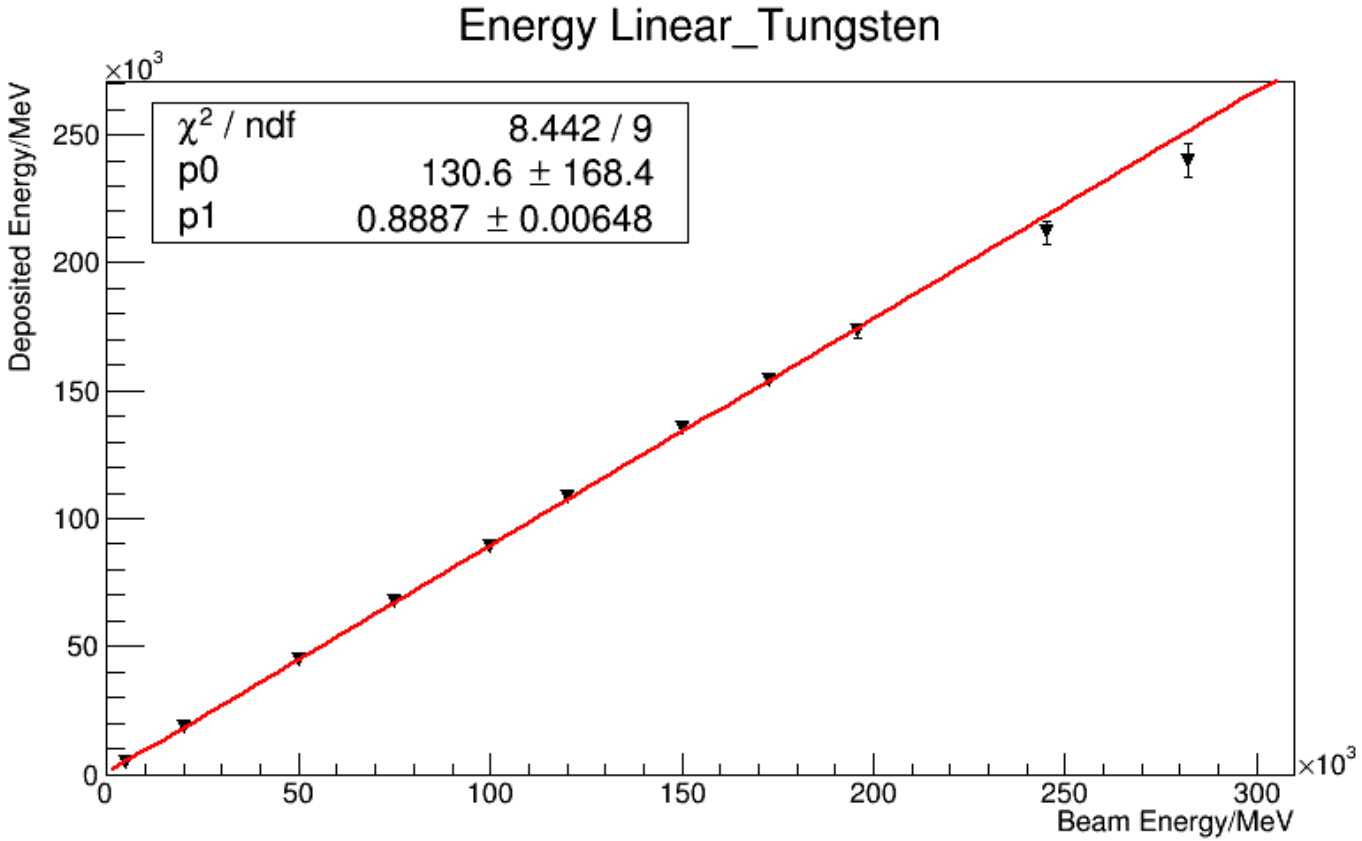
Mainly involved：

Purple Mountain Observatory
Institute of Modern Physics, CAS
University of Geneva
University of Science and Technology China
National Space Science Center, CAS
CERN

Backup

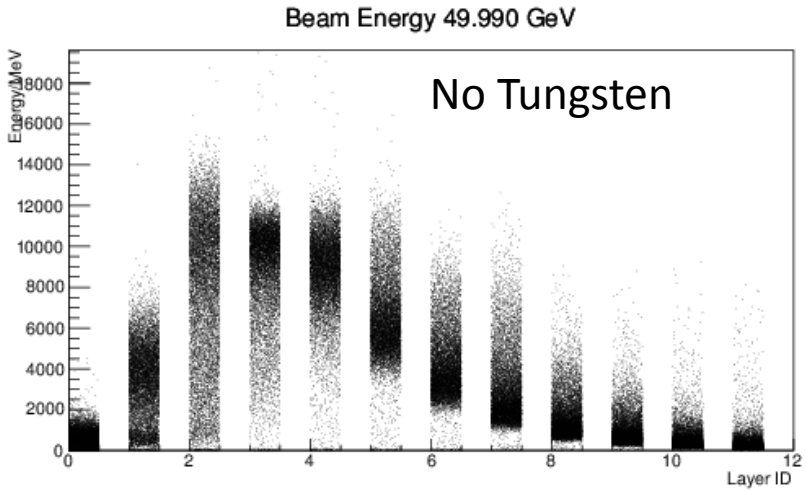
Energy Linearity

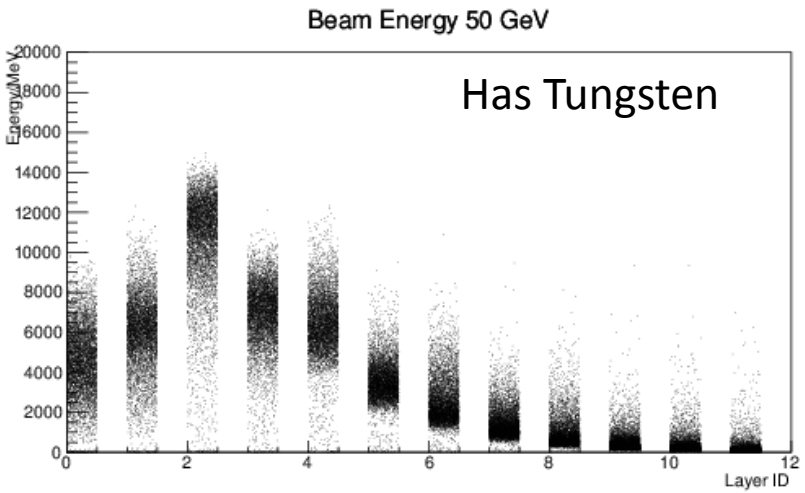
With Tungsten

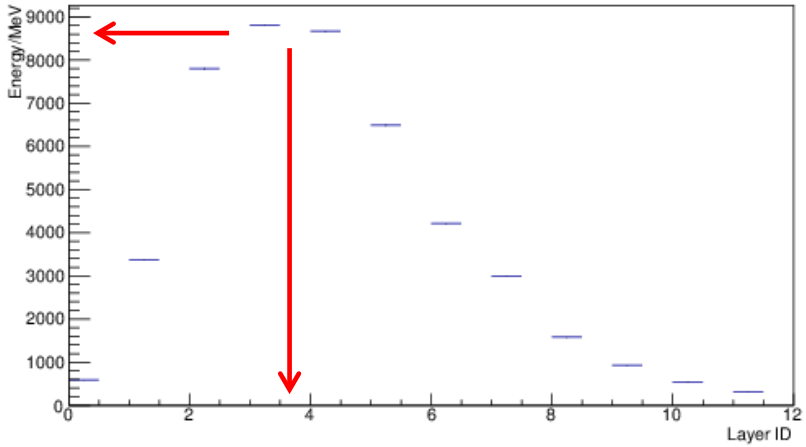


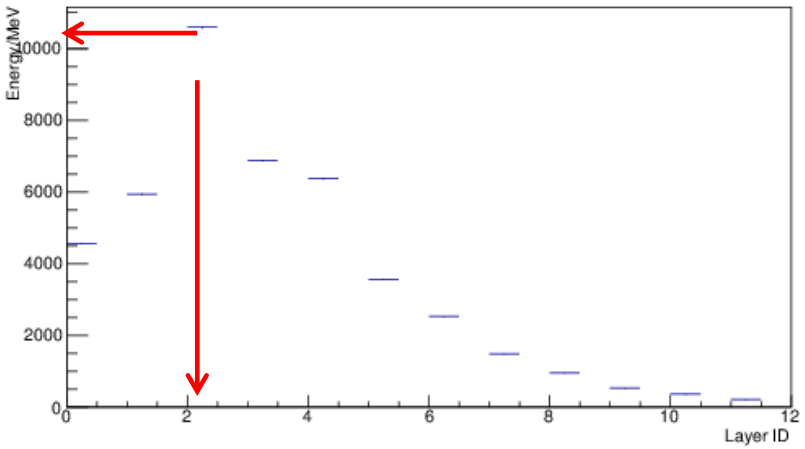
Gradient decrease with tungsten

Electron 50GeV



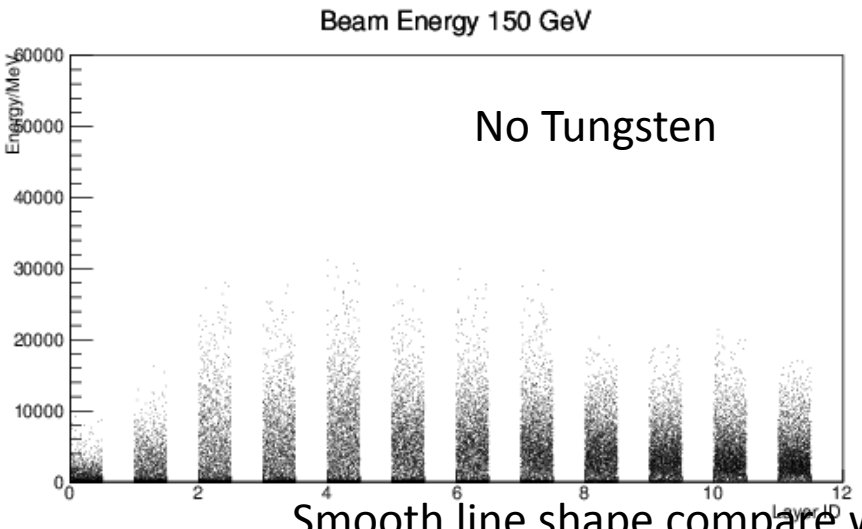


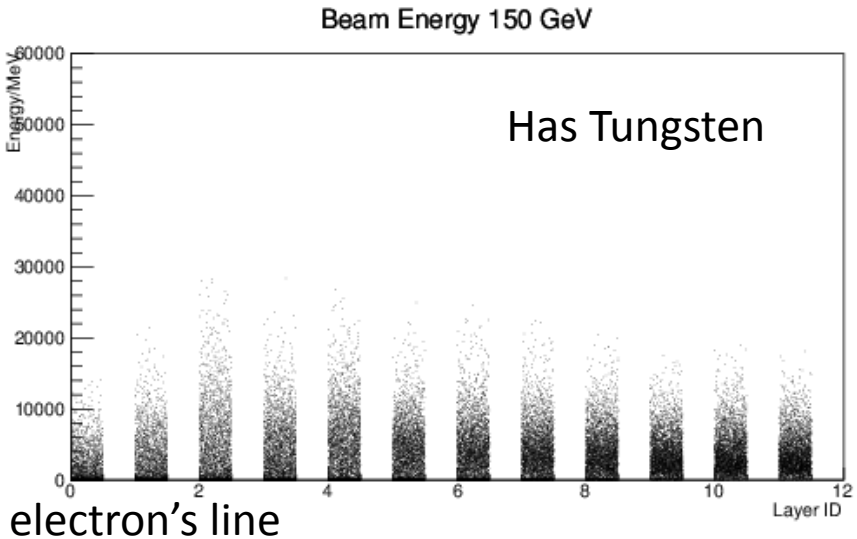




Shower max position forward, and more energy deposited in max. E Layer

Proton 150GeV





Smooth line shape compare with electron's line

Less energy deposited in maximum energy layer if has Tungsten