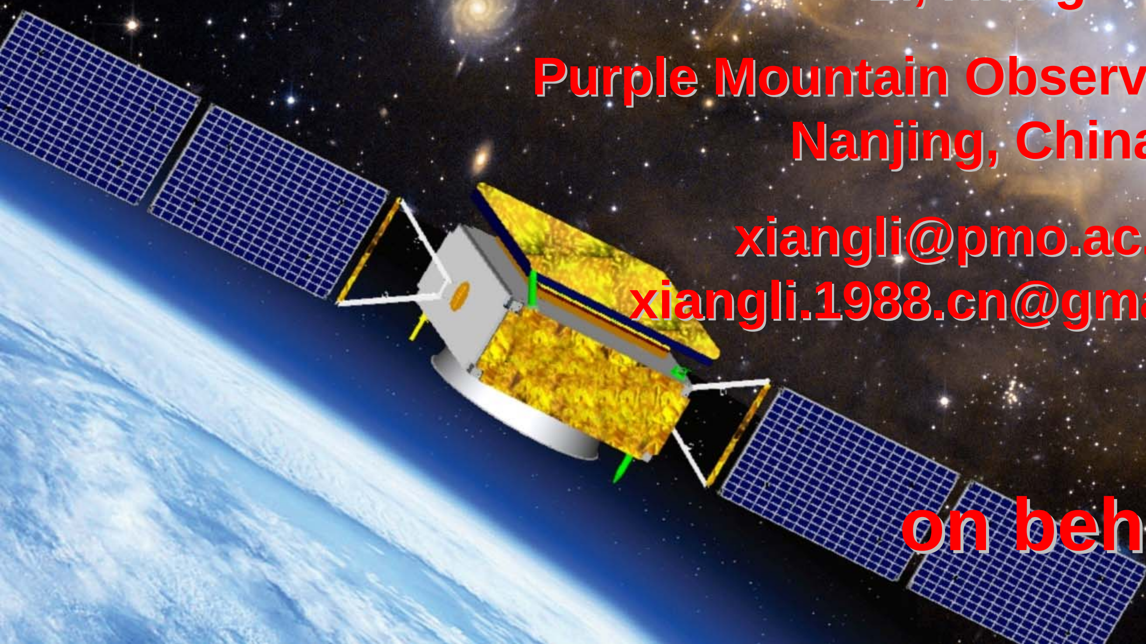
DArk Matter Particle Explorer (DAMPE)

Li, Xiang

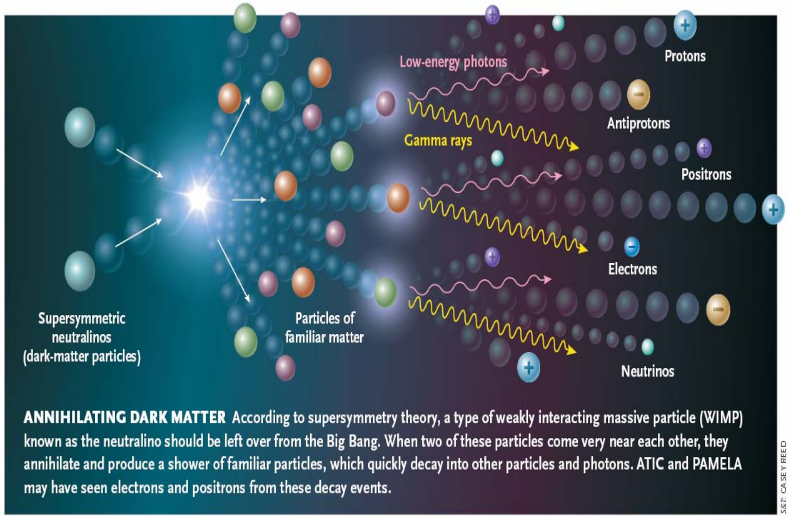
Purple Mountain Observatory, CAS
Nanjing, China

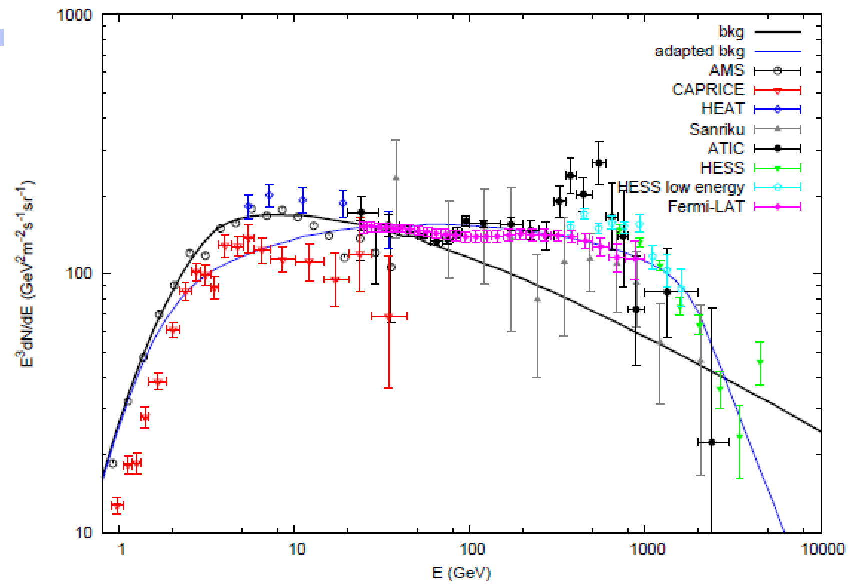
xiangli@pmo.ac.cn
xiangli.1988.cn@gmail.com

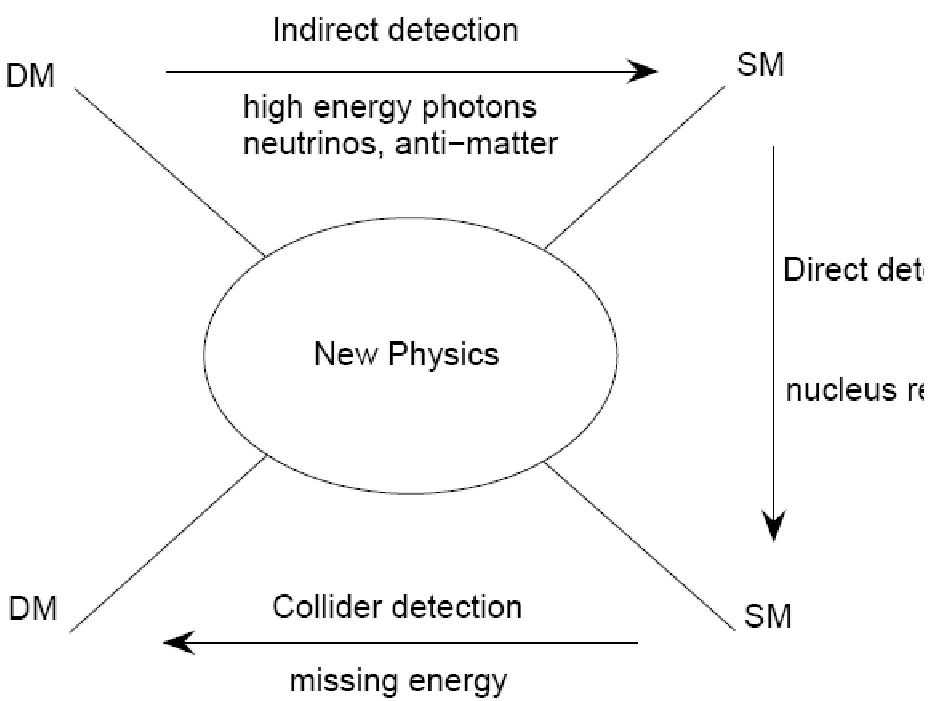


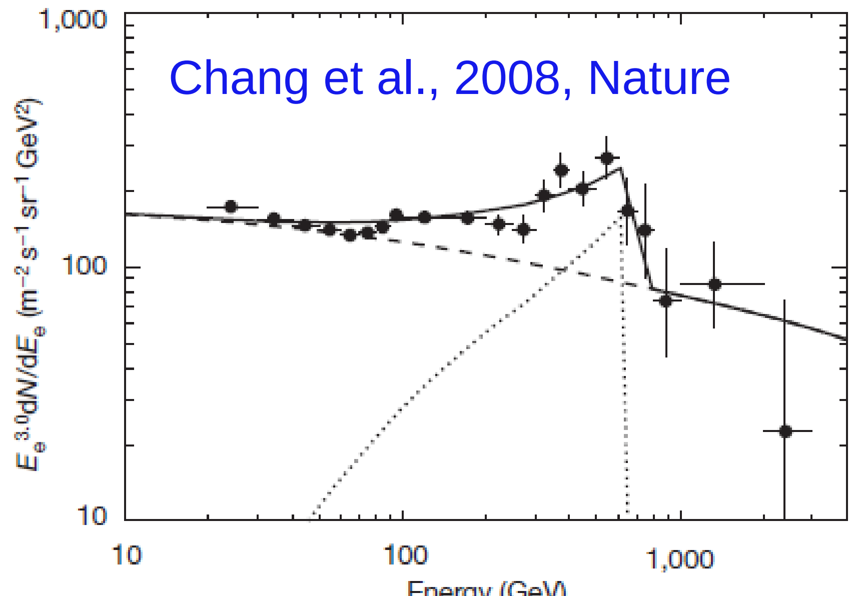
on behalf of DAMPE team

DM indirect detection









We need new accurate and very-high-statistics observation for searching Dark Matter in the sub-TeV to the trans-TeV region with a detector which has large exposure, high energy resolution, high space resolution and low background.

NEWS & ANALYSIS

Science, 20 May, 2011

SPACE SCIENCE

Chinese Academy Takes Space Under Its Wing

LOFTY AMBITIONS

Mission	Chief scientist	Goals	Estimated launch
HXMT	Li Tipei, CAS Institute of High Energy Physics and Tsinghua University	Survey of x-ray sources; detailed observations of known objects	2014
Shijian-10	Hu Wenrui, CAS Institute of Mechanics	Study physical and biological systems in microgravity and strong radiation environment	Early 2015
KuaFu Project	William Liu, Canadian Space Agency and CAS Center for Space Science and Applied Research	Study solar influence on space weather	Mid-2015
Dark Matter Satellite	Chang Jin, CAS Purple Mountain Observatory	Search for dark matter; study cosmic ray acceleration	Late 2015
Quantum Science Satellite	Pan Jianwei, University of Science and Technology of China	Quantum key distribution for secure communication; long-distance quantum entanglement	2016

Strategic Priority Research Program in Space Science

Dark Matter Particle Explorer Satellite

Collaborating institutes

Purple Mountain Observatory (PMO), CAS, Nanjing

University of Science and Technology of China (USTC), Hefei

Institute of Modern Physics (IMP), CAS, Lanzhou

Institute of High Energy Physics (IHEP), CAS, Beijing

National Space Science Center,CAS,Beijing

DPNC, University of Geneva, Geneva

INFN Perugia

Scientific Objectives

- ❑Cosmic ray
- ❑Gamma-ray astronomy
- ❑Dark matter particle

Dark Matter Particle Explorer (DAMPE)

Energy range: 1GeV-10 TeV

Particle: electron, gamma-ray, heavy ions

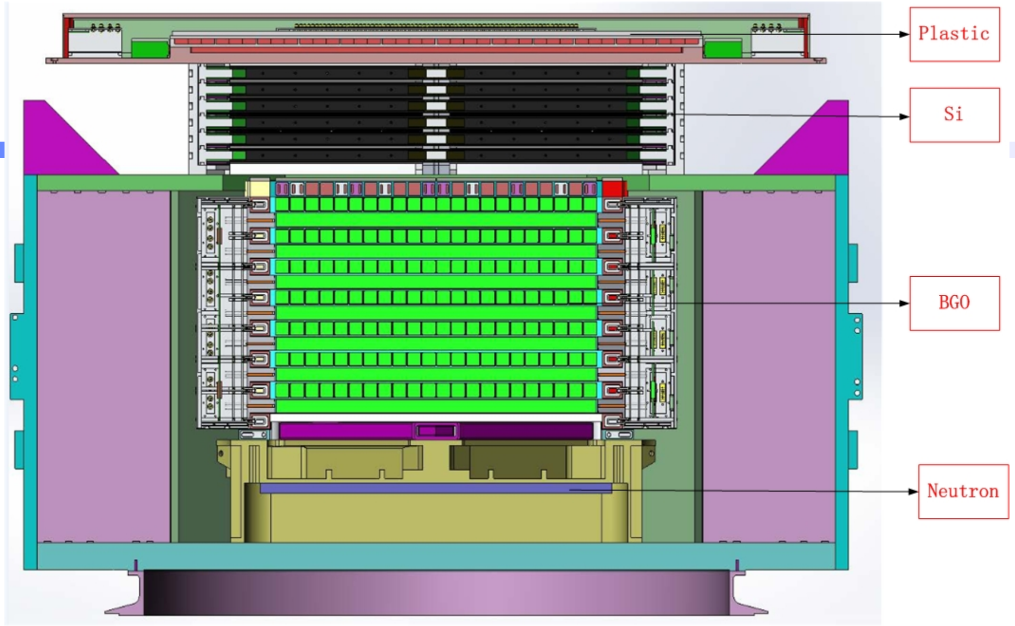
Energy resolution: (1.5%@800GeV)

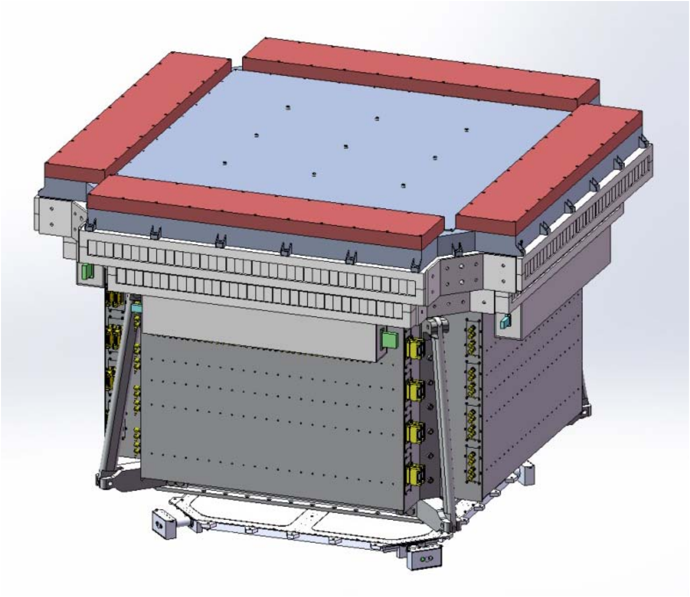
Space resolution: (0.5degree@800GeV)

Background level (<1%@800GeV)

e/p separation: 10^{5-6}

GF: $0.3m^2$.sr

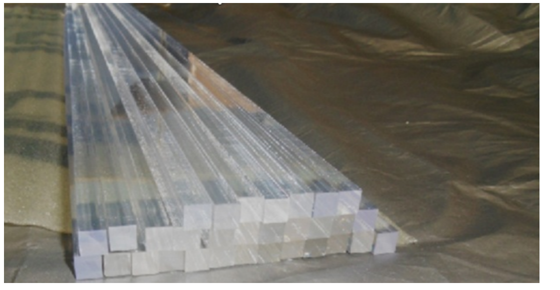




The detector is consisted of 4 parts:
Top plastic scintillators (charge measurement)
Si tracker (6 layers)
BGO calorimeter
Neutron detector

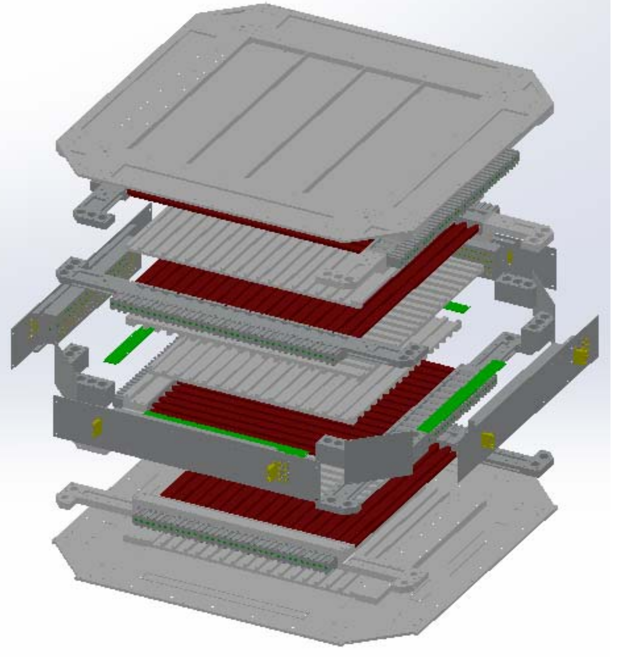
Top hodoscope array

- ❑ Charge measurement (From Z=1 to Z=28)。
- ❑ Anticoincidence (for gamma-ray observation)
- ❑ Cross section: 2.5cm×1cm Length: 82cm
- ❑ Readout: PMT (two dynodes)+VA chip



Charge resolution:25%@Z=1
Detection eff. >99%

Weight: 95Kg
Size: 1.18 × 0.89 × 0.12m
Power consumption: 50W

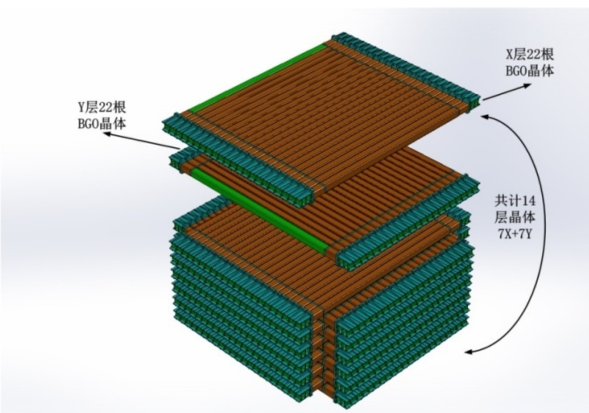


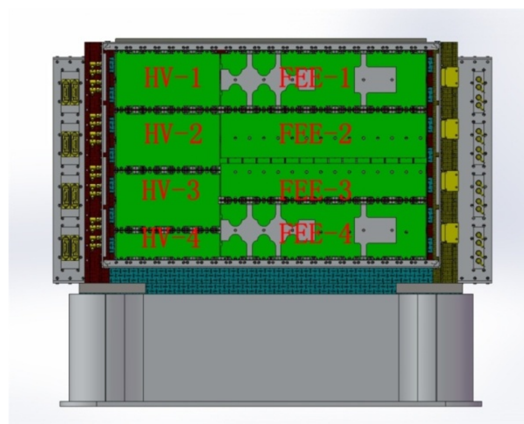
Si tracker

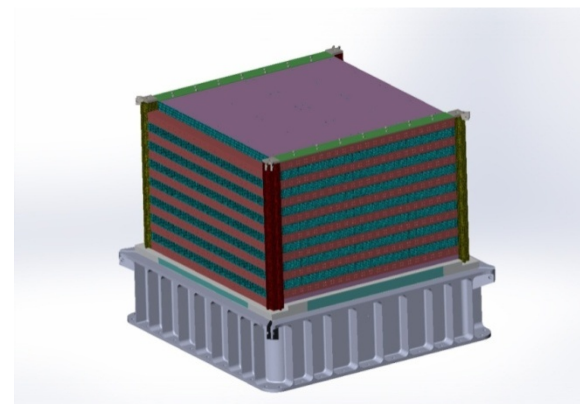
- ❑ 6 layers, 76cmX76cm
- Integrated Tungsten converter plates into a tracker with Si strip detectors
- γ converts in W plate to $e^+e^- \rightarrow$ detected in subsequent Si detectors
  - Unambiguous identification of γ–ray , superior pointing resolution
- ❑ 3 converter layers, total 67 kg of W, thickness 1x1 mm + 2x2 mm = 1.43 X_0
- ❑ A tracking plane is made of 2x8 ladders head to head
- ❑ 7 tray of 4 types: no-W thin tray, no-W thick tray, thin-W tray, thick-W tray
  - Support of thin tray ~ 15 mm, Support of thick tray ~ 30 mm

BGO calorimeter

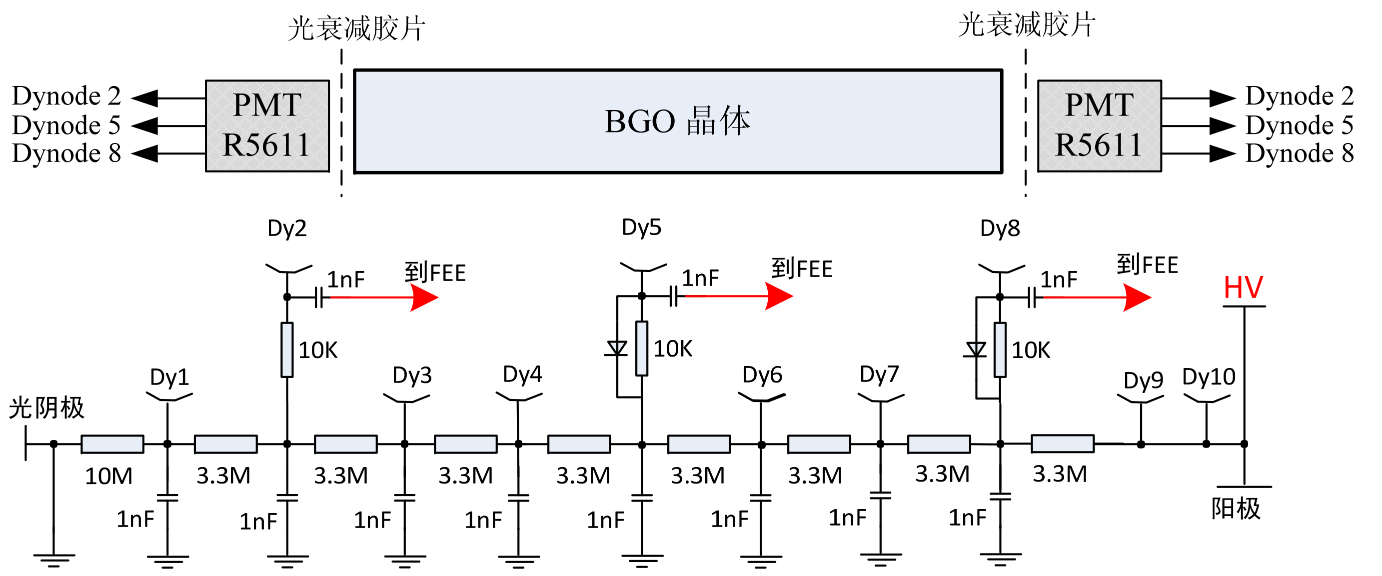
Energy measurement from GeV-100 TeV
e/P seperation 10^4 (31.25 X_0)
308 crystals (2.5cmX2.5cmX60cm)
Readout: PMT from both sides
each PMT: 3 dynodes + VA



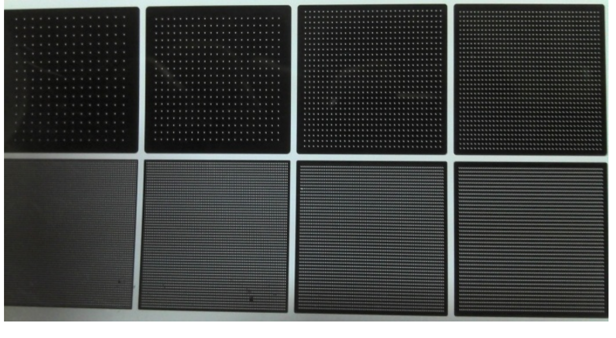


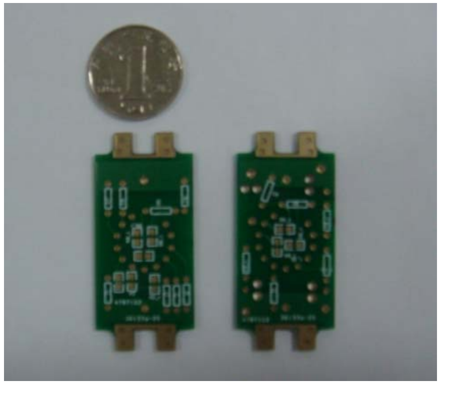


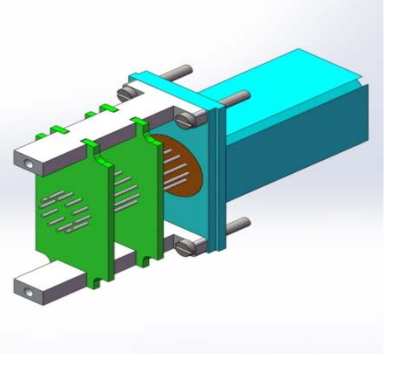
PMT readout

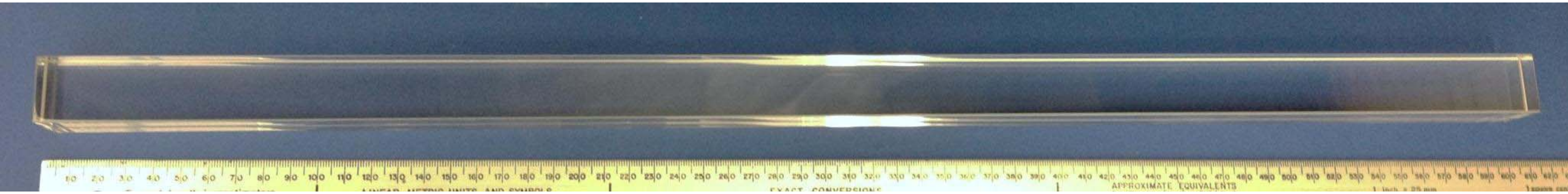


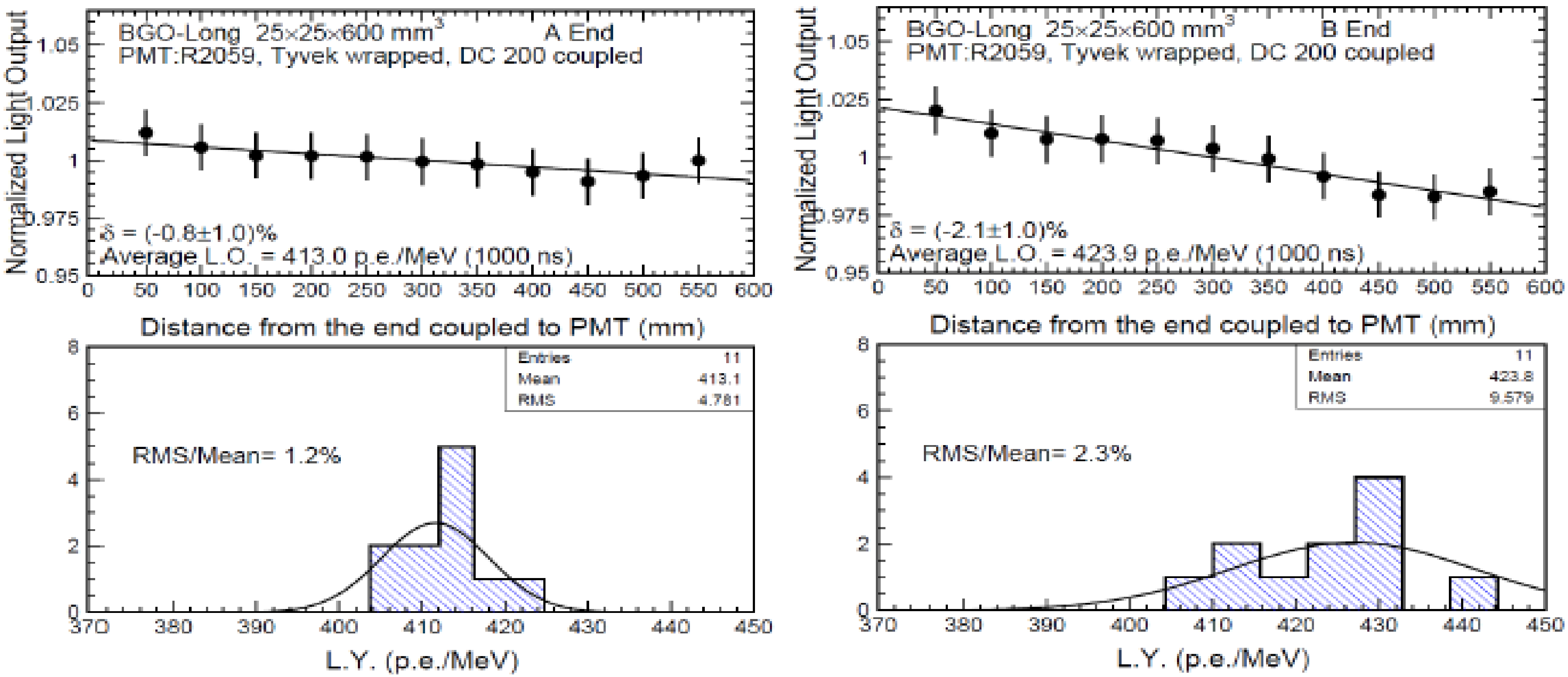
光衰减胶片
光衰减胶片
Dynode 2
Dynode 5
Dynode 8
PMT R5611
BGO 晶体
PMT R5611
Dynode 2
Dynode 5
Dynode 8
Dy2
Dy5
Dy8
1nF
到FEE
HV
10K
光阴极
Dy1
Dy3
Dy4
Dy6
Dy7
Dy9
Dy10
10M
3.3M
阳极











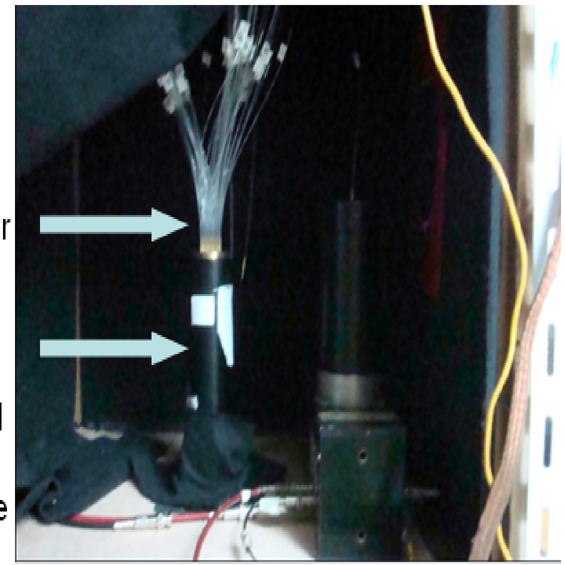
BGO-Long 25×25×600 mm³ A End
PMT:R2059, Tyvek wrapped, DC 200 coupled
δ = (-0.8±1.0)%
Average L.O. = 413.0 p.e./MeV (1000 ns)
Normalized Light Output
Distance from the end coupled to PMT (mm)
BGO-Long 25×25×600 mm³ B End
PMT:R2059, Tyvek wrapped, DC 200 coupled
δ = (-2.1±1.0)%
Average L.O. = 423.9 p.e./MeV (1000 ns)
Normalized Light Output
Distance from the end coupled to PMT (mm)
Entries 11
Mean 413.1
RMS 4.781
RMS/Mean= 1.2%
L.Y. (p.e./MeV)
Entries 11
Mean 423.8
RMS 9.579
RMS/Mean= 2.3%
L.Y. (p.e./MeV)

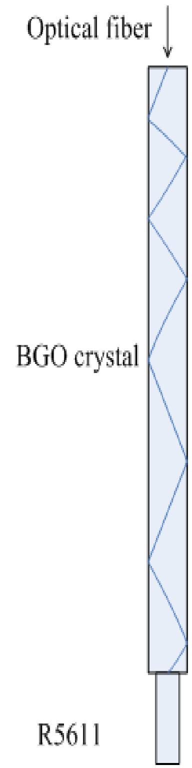
BGO dynamic range test

optical fiber

BGO crystal

It was coupled with R5611 PMT that in the crystal bottom



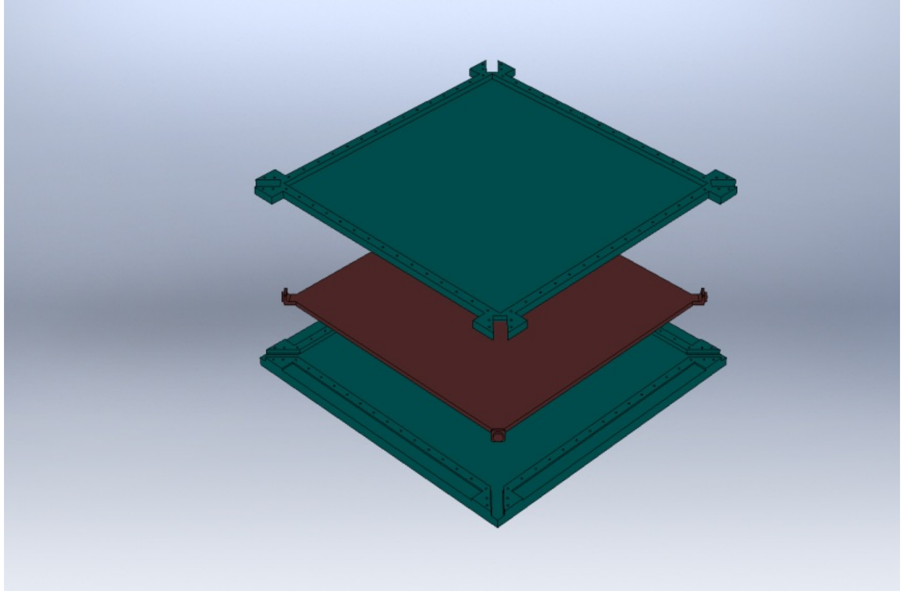


Using one readout: Dynamic range 200,000

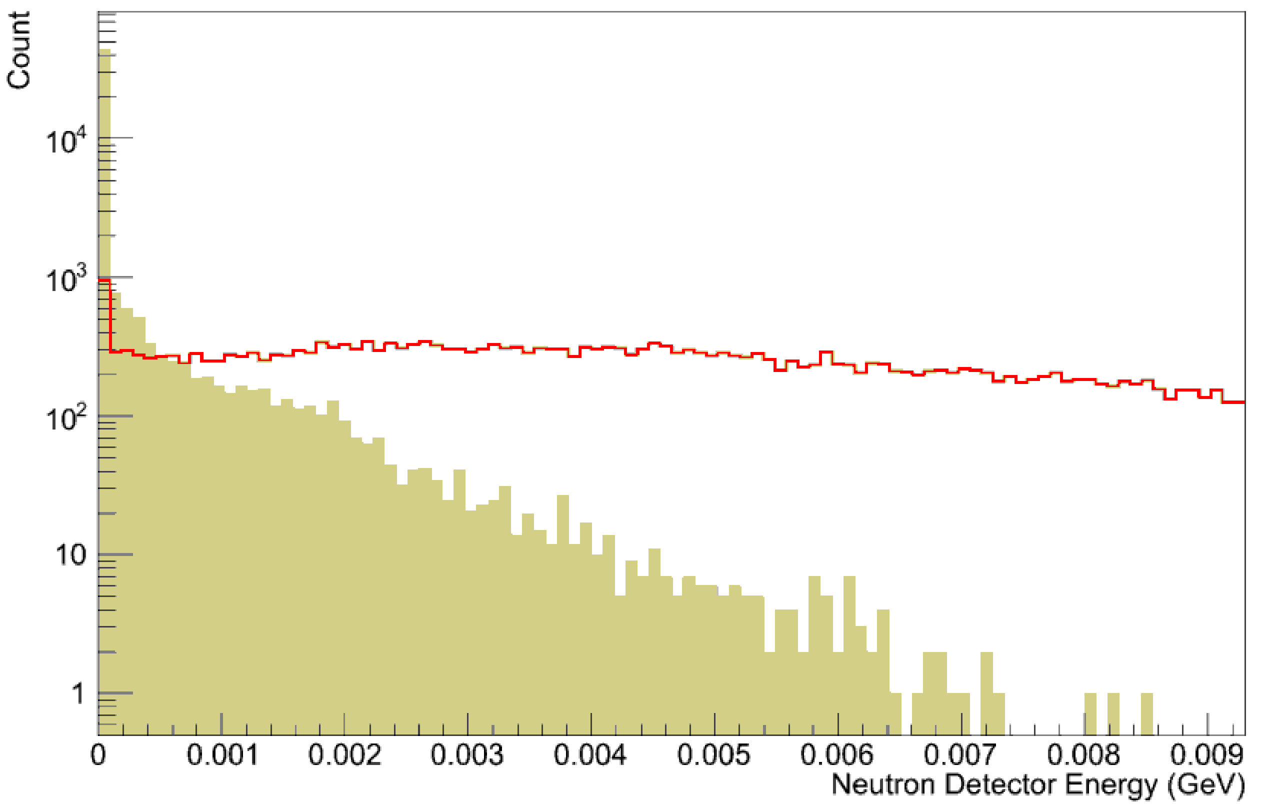
2 end readout: 2,000,000

Neutron Detector

- ❑ Using time window, neutron detector for e/P seperation。
- ❑ BC454 (5% B, size 600mm×600mm×10mm)
- ❑ Read out: PMT
- ❑ Simulation: >10-100 e/P seperation

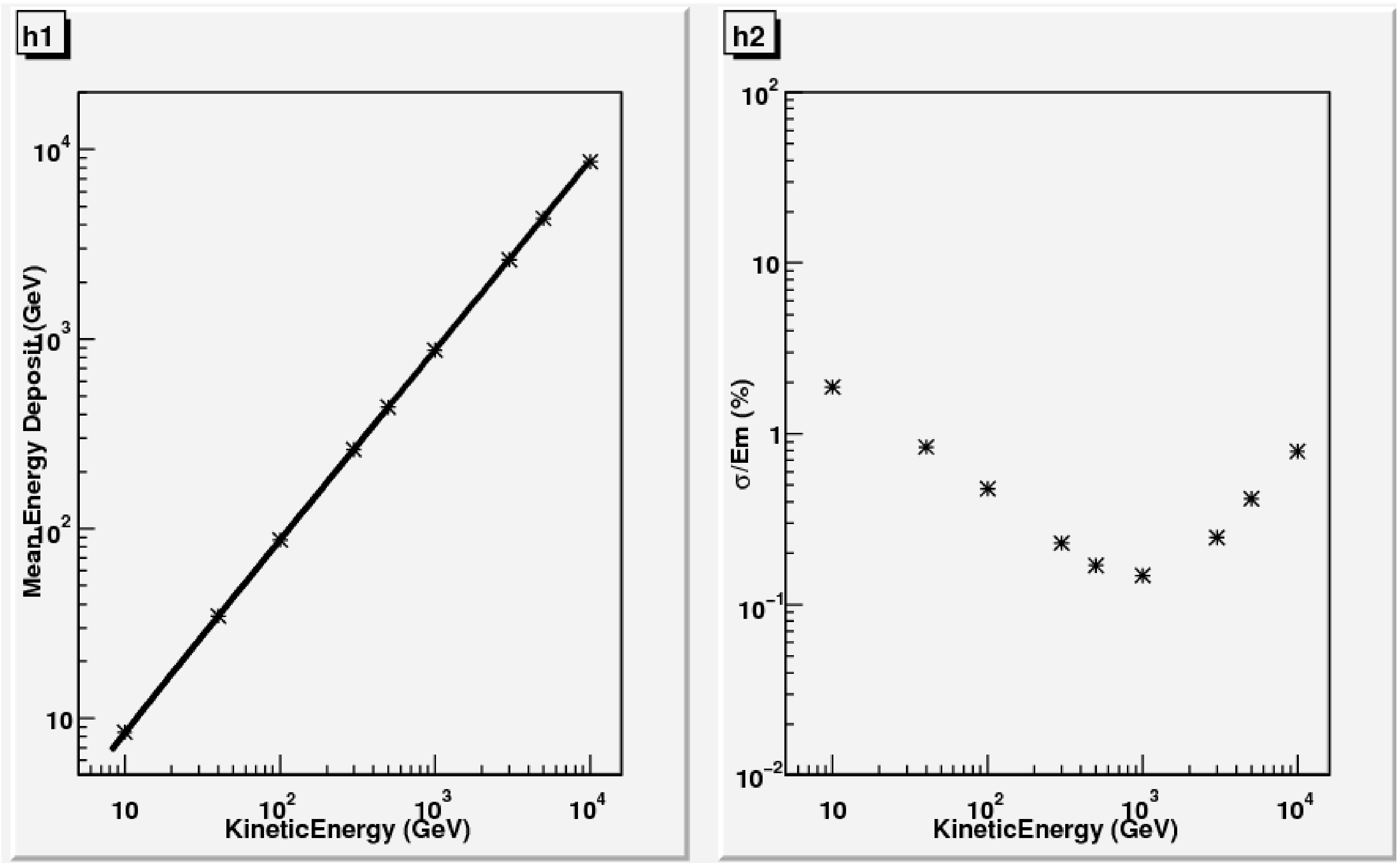


Energy deposit in Neutron detector

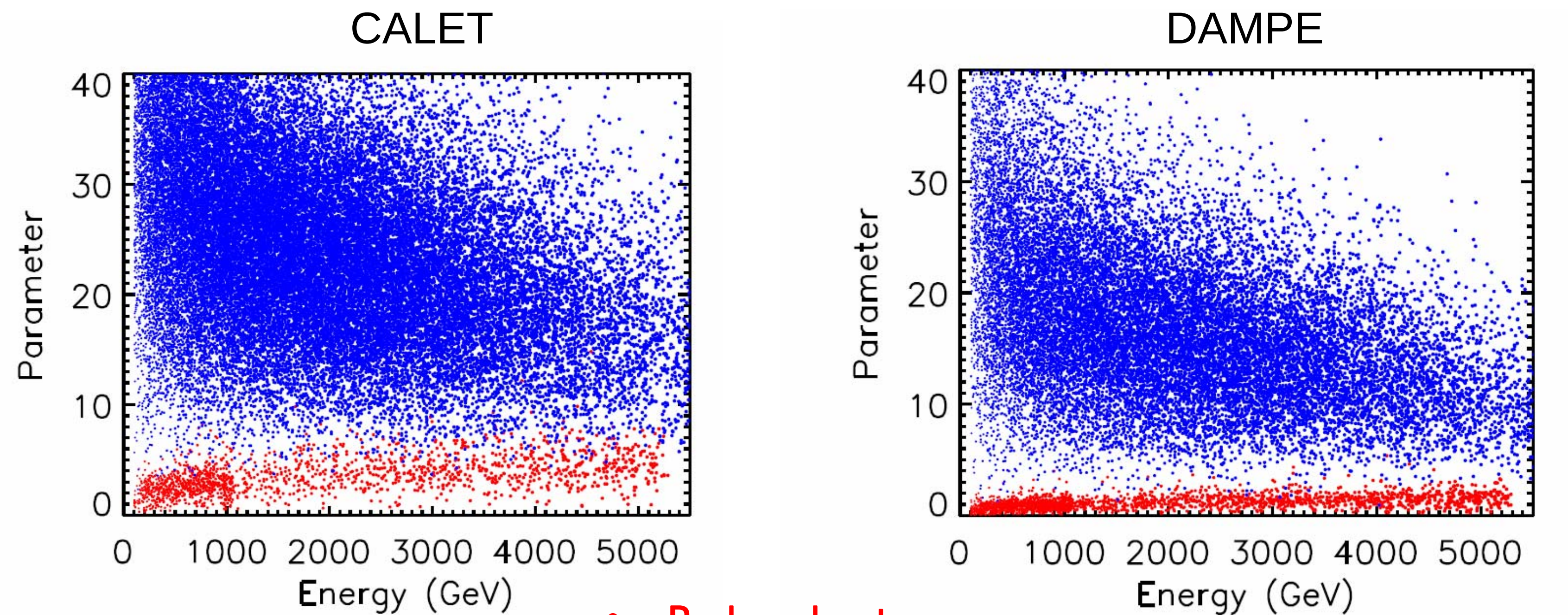


500GeV energy deposit in BGO for electron (yellow) and proton (red)

High energy Resolution



High e/p seperation



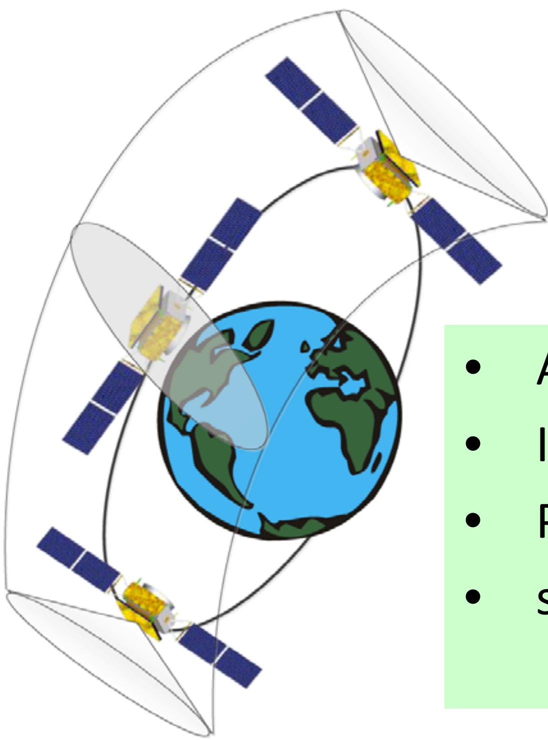
- Red: electron
- Blue: Proton

Mission	ATIC	FERMI	AMS	CALET	DAMPE
Depth	24	10.1	17	30	34

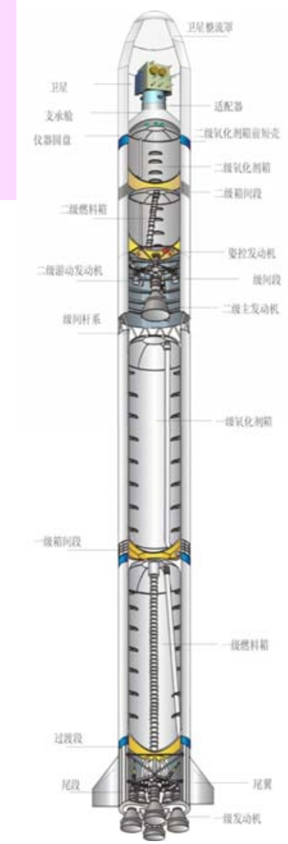
DAMPE Mission

- Approved for construction (phase C/D) in Dec. 2011
- Scheduled launch date 2015

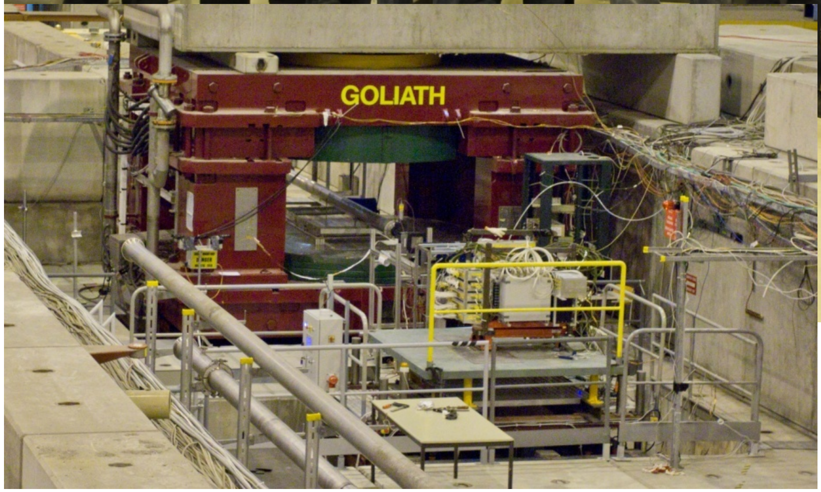
- Satellite < 1900 kg, payload ~1340kg
- Power consumption 840W
- Lifetime > 3 years
- Launched by CZ-2D rockets

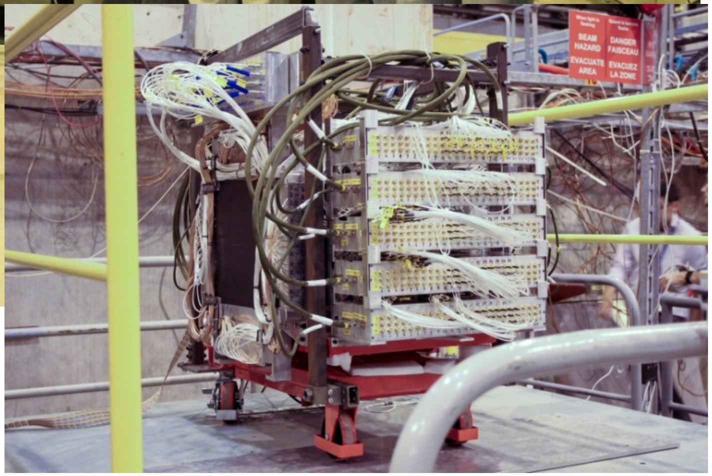


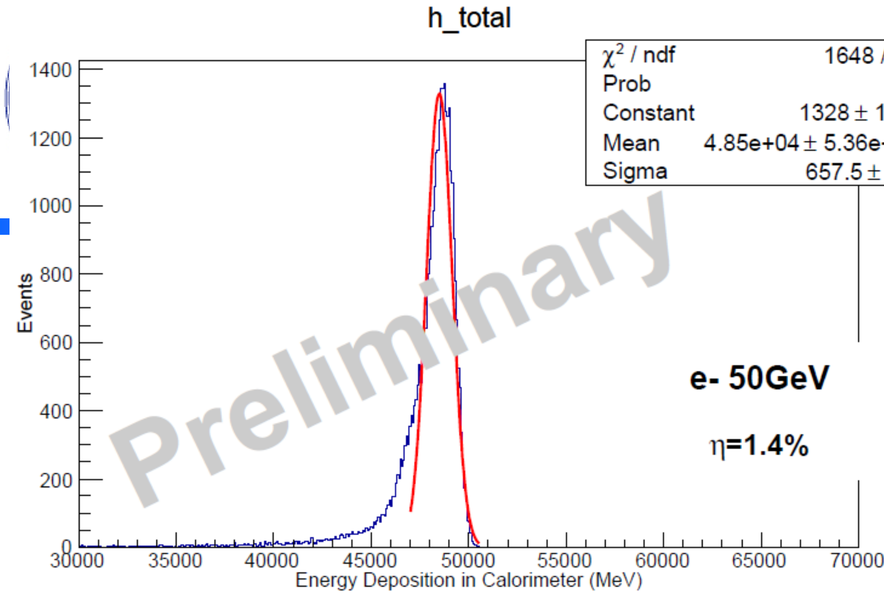
- Altitude 500 km
- Inclination 97.4065°
- Period 90 minutes
- sun-synchronous orbit

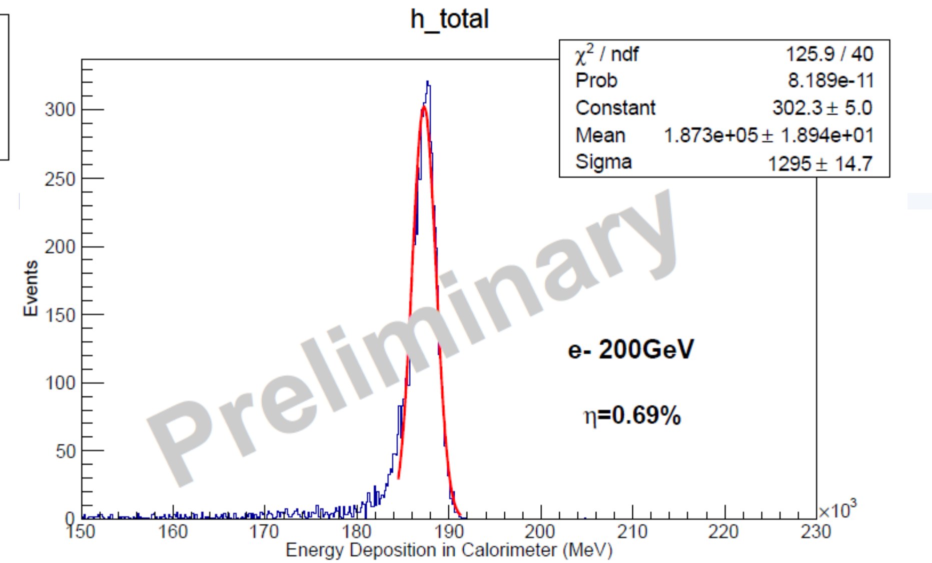


Beam Test in CERN

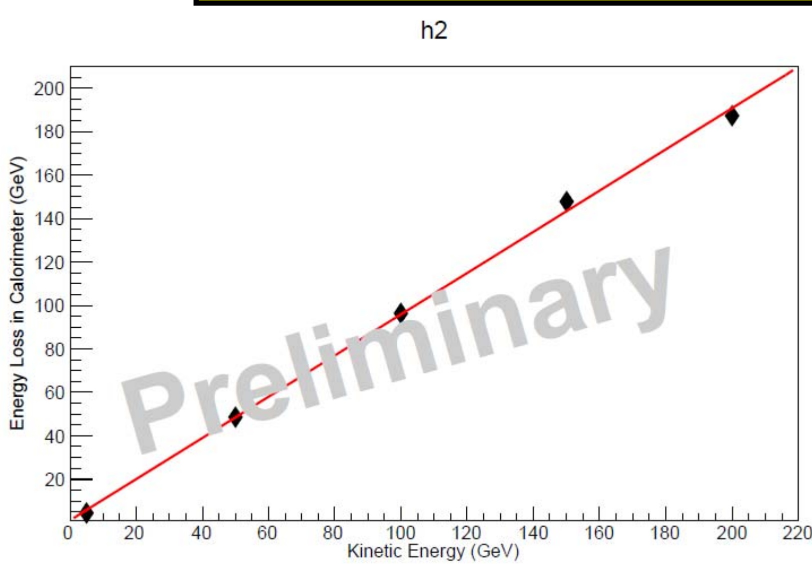


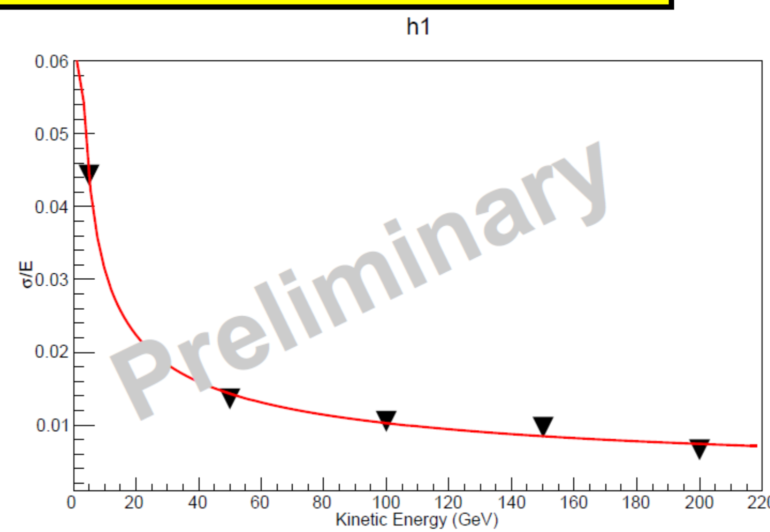




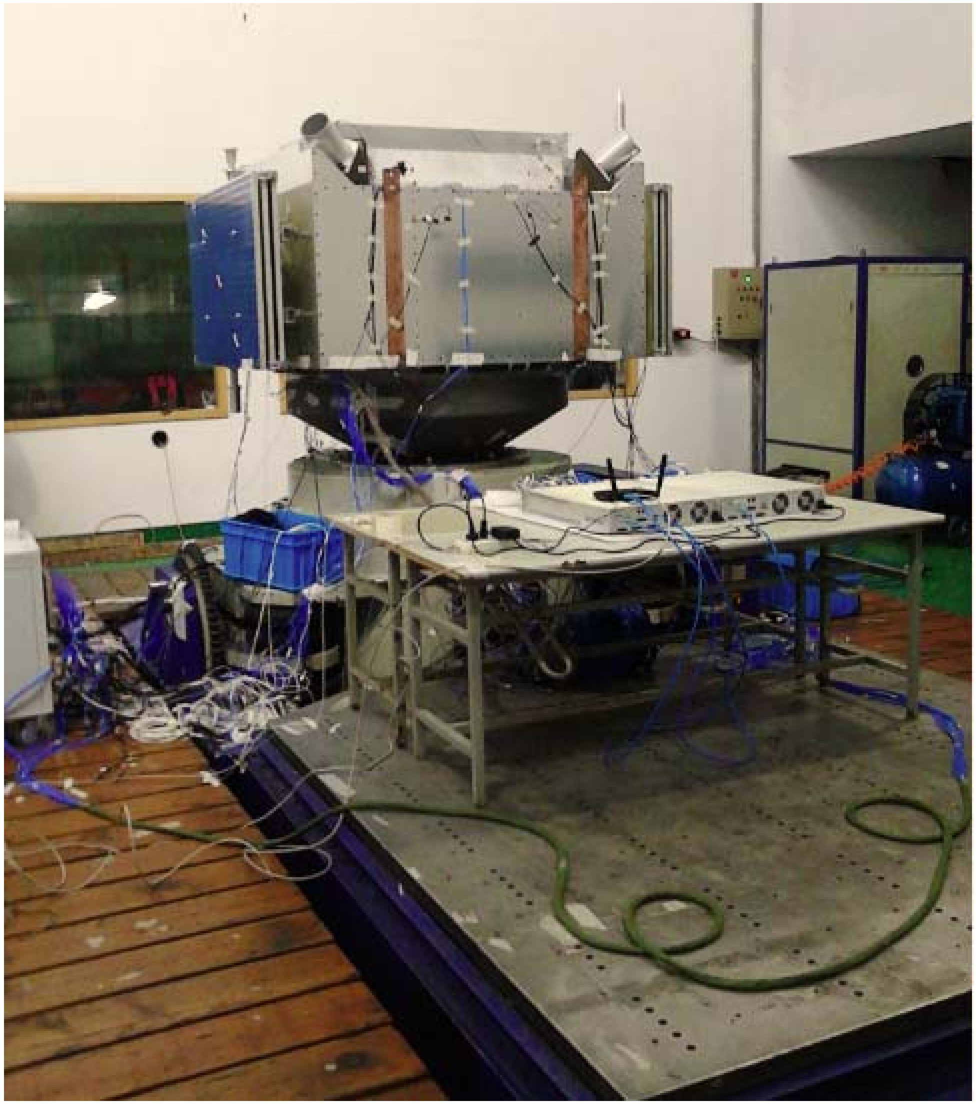


These results agree with simulation very well





Test for structrue of whole detector



2013-02-27

Comparison of Detector Performance for Electrons

DAMPE is optimized for the electron observation in the trans-TeV region, and the performance is best also in 10-1000 GeV.

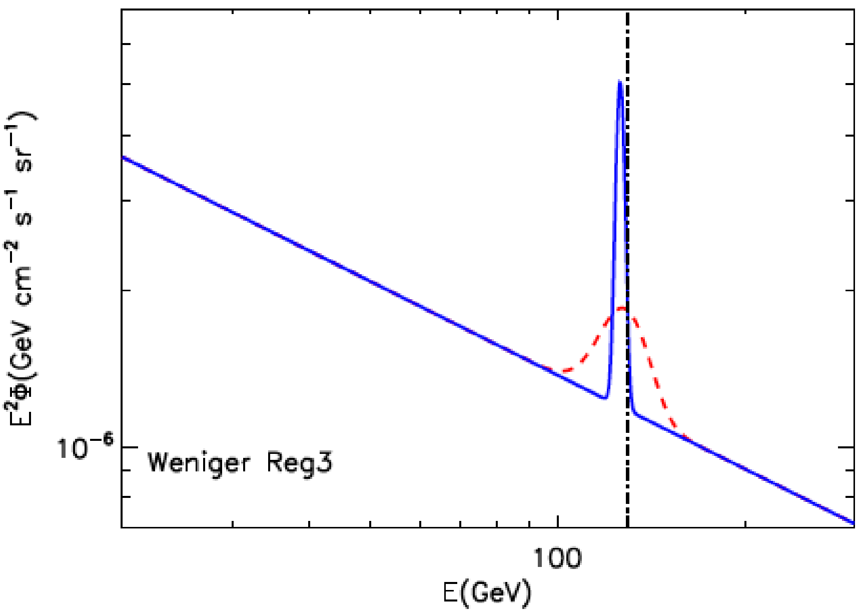
Detector	Energy Range (GeV)	Energy Resolution	e/p Selection Power	Key Instrument (Thickness of CAL)	SΩT (m^2srday)
ATIC1+2 (+ ATIC4)	10 - a few 1000	<3% (>100 GeV)	~10,000	Thick Seg. CAL (BGO: 22 X_0) + C Targets	3.08
PAMELA	1-700	5% @200 GeV	10^5	Magnet+IMC (W:16 X_0)	~1.4 (2 years)
FERMI-LAT	20-1,000	5-20 % (20-1000 GeV)	10^3-10^4 (20-1000GeV) Energy dep. GF	Tracker+ACD + Thin Seg. CAL (W:1.5X_0+CsI:8.6X_0)	60@TeV (1 year)
AMS	1-1,000 (Due to Magnet)	～2-4% @100 GeV	10^4 (x 10^2 by TRD)	Magnet+IMC +TRD+RICH (Lead: 17X_0)	~50(?) (1year)
CALET	1-10,000	~2-3% (>100 GeV)	～10^5	IMC+CAL (W: 3 X_0+ PWO : 27 X_0)	44 (1years)
DAMPE	1-10,000	~1% (>100 GeV)	～10^5-10^6	IMC+CAL+Neutron (W: 2 X_0+ BGO: 32 X_0)	180 (1 years)

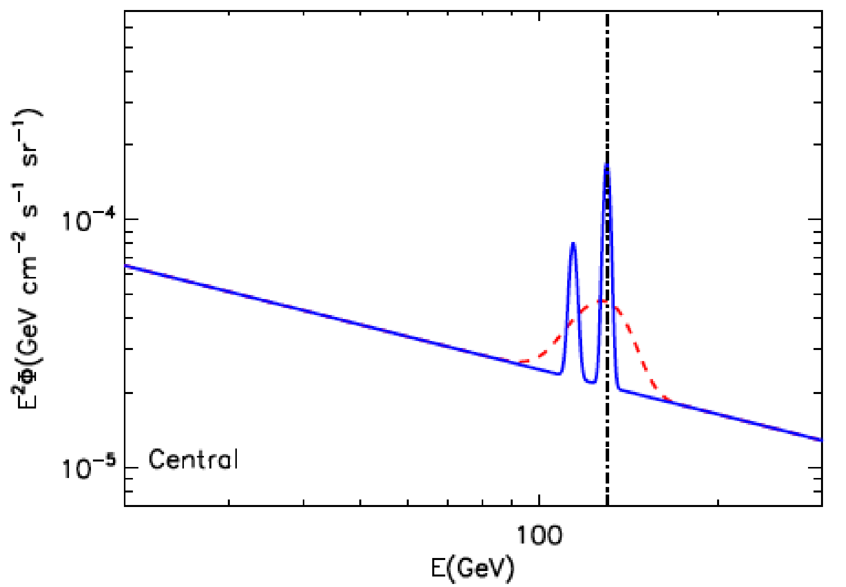
More detailed and accurate description about DAMPE is to be represented in the 33rd International Cosmic Ray Conference (ICRC2013) next month by our technical experts.

High energy resolution for line searching

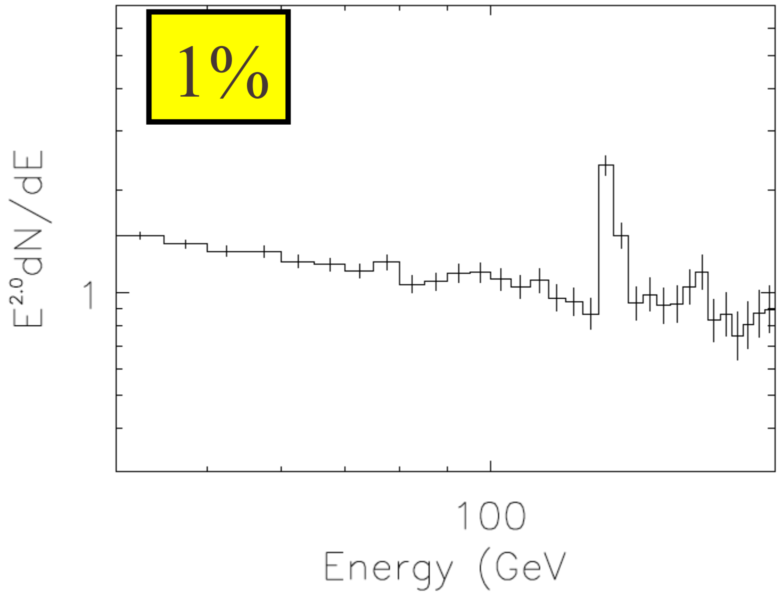
Region	E_0 GeV	Fermi-LAT $N_{\rm sig}/N_{\rm bkg}$	Fermi-LAT significance	Fermi-LAT $t(5\sigma)$	DAMPE $N_{\rm sig}/N_{\rm bkg}$ [a]	DAMPE significance[a]	DAMPE $t(5\sigma)$[b]
Weniger Reg3	126.2	24.2/52.5	3.3	8.6	24.2/8.8	8.2	2.8
Central	130.4	17.1/13.5	4.7	4.2	17.1/2.2	11.4	1.4
West	129.8	11.8/12.0	3.4	8.1	11.8/2.0	8.4	2.6

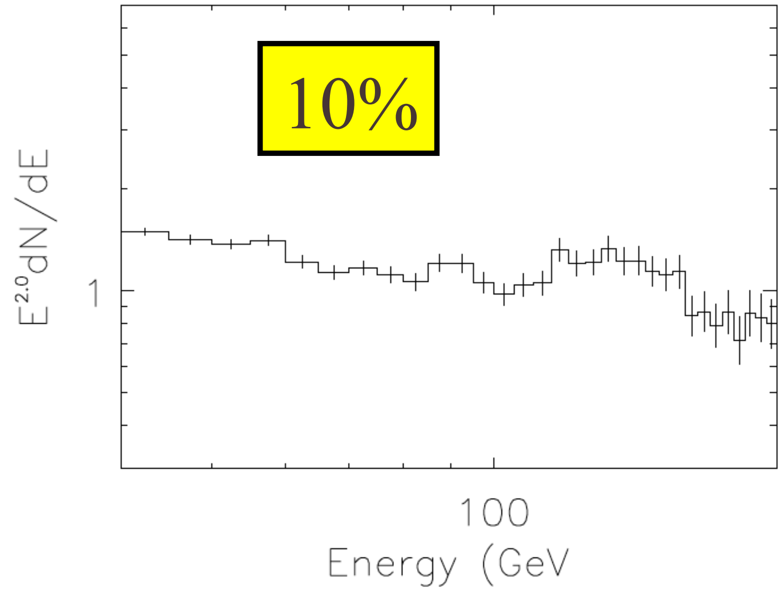
[a] Assuming the same exposure of Fermi-LAT and DAMPE;
[b] The geometry factor of DAMPE is adopted to be half of that of Fermi-LAT.

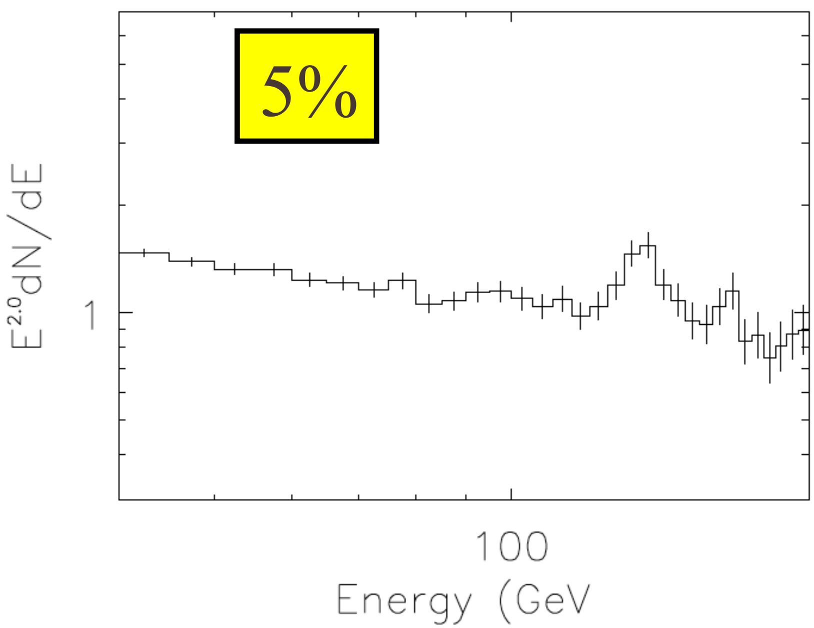


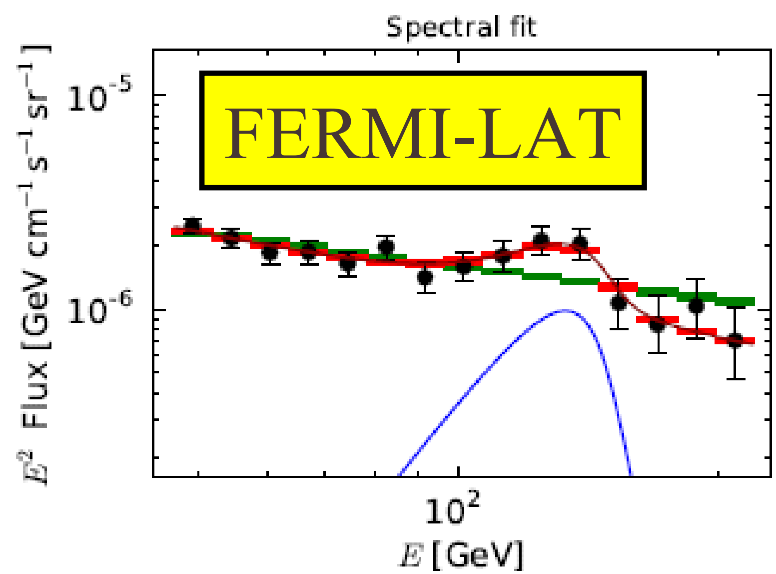


Li & Yuan (2012, Phys. Lett. B, 715, 35)


1%
E^2.0dN/dE
1
100
Energy (GeV


10%
E^2.0dN/dE
1
100
Energy (GeV


5%
E^2.0dN/dE
1
100
Energy (GeV


Spectral fit
FERMI-LAT
E^2 Flux [GeV cm^-1 s^-1 sr^-1]
10^-5
10^-6
10^2
E [GeV]

Thanks for your attention !