“DAMPE: a Gamma and Cosmic Ray Observatory in Space"

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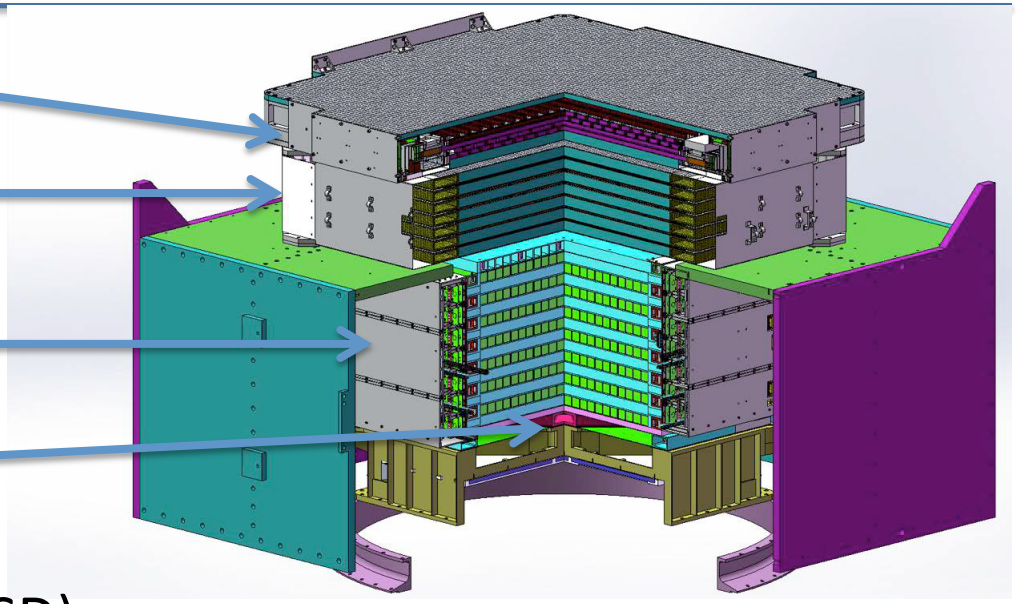
INFN and ASDC
on behalf of the DAMPE Collaboration

SciNeGHE 2016

High Energy gamma-ray experiments at the dawn of gravitational wave astronomy

18-21 October 2016, Pisa, Italy

The DArk Matter Particle Explorer: the detector



Charge measurements (STK, PSD)
Tungsten converters (pair production)
Precise tracking with Si detector (STK)
3D imaging calorimeter of 32 X0 (BGO)
e/hadron discrimination (BGO, NUD)

→ High energy γ-ray, electron and cosmic ray telescope

The Collaboration

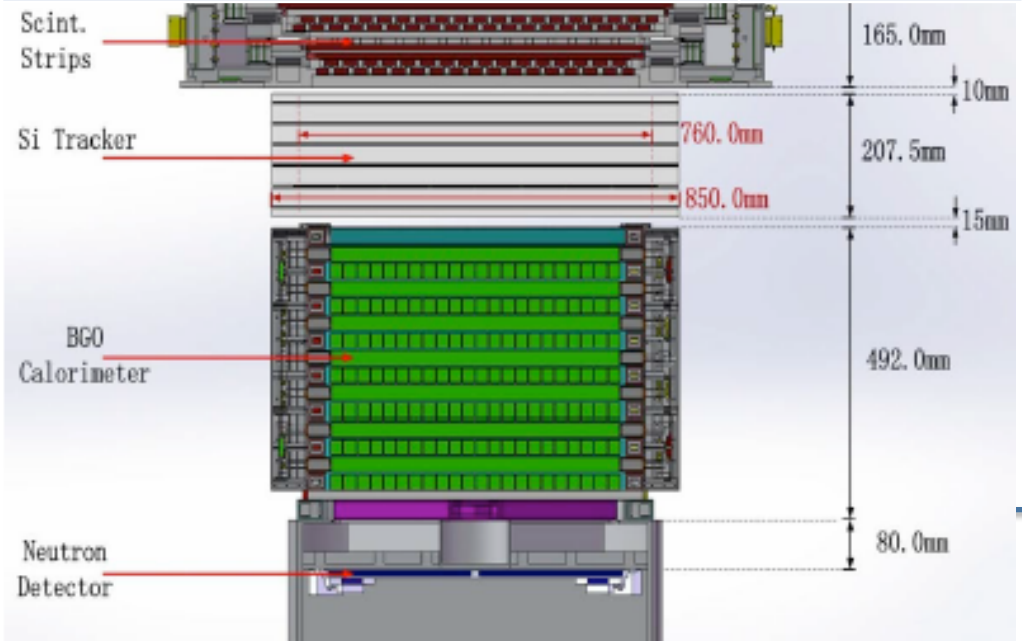
- China
  - **Purple Mountain Observatory, CAS, Nanjing**
  - **Institute of High Energy Physics, CAS, Beijing**
  - **National Space Science Center, CAS, Beijing**
  - **University of Science and Technology of China, Hefei**
  - **Institute of Modern Physics, CAS, Lanzhou**
- Italy
  - **INFN Perugia and University of Perugia**
  - **INFN Bari and University of Bari**
  - **INFN Lecce and University of Salento**
- Switzerland
  - **University of Geneva**

Physics Goals

- Electron and photon spectra (**1 GeV - 10 TeV**)
- Protons and nuclei: spectrum and composition (**50 GeV - 100 TeV**)
- High energy gamma ray astronomy
- Search for dark matter signatures in lepton spectra
- Exotica and “unexpected”, e.g. GW e.m. counterpart in the FoV

Comparison with other Experiments

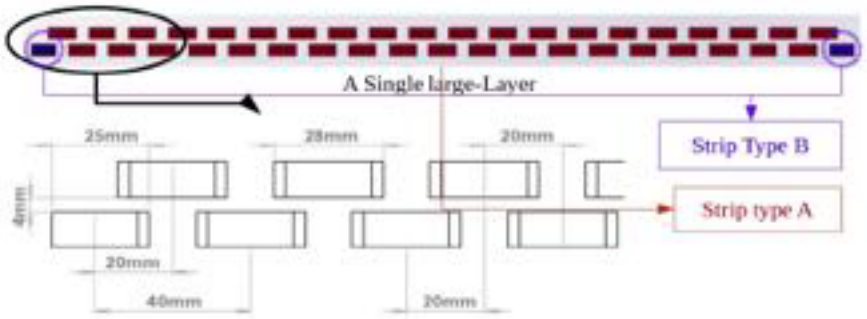
	DAMPE	AMS-02	Fermi LAT
e/γ Energy res.@100 GeV (%)	1.5	3	10
e/γ Angular res.@100 GeV (°)	0.1	0.3	0.1
e/p discrimination	10^5	10^5-10^6	10^3
Calorimeter thickness (X_0)	32	17	8.6
Geometrical accep. (m^2sr)	0.29	0.09	1

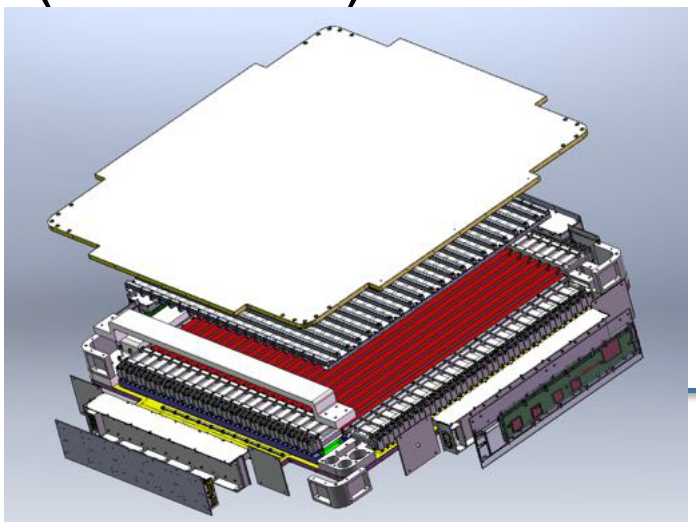


Mass: 1400 Kg
Power: ~ 400 W
Livetime: > 3 years

The PSD

- 2 layers (x, y) of strips 1 cm thick, 2.8 cm wide and 88.4 cm long. Sensitive area 82.5 cm x 82.5 cm, no dead zone
  - ✓ Strip staggered by 0.8 cm
- Readout both ends with PMT, use two dynode signals (factor ~40) to extend the dynamic range



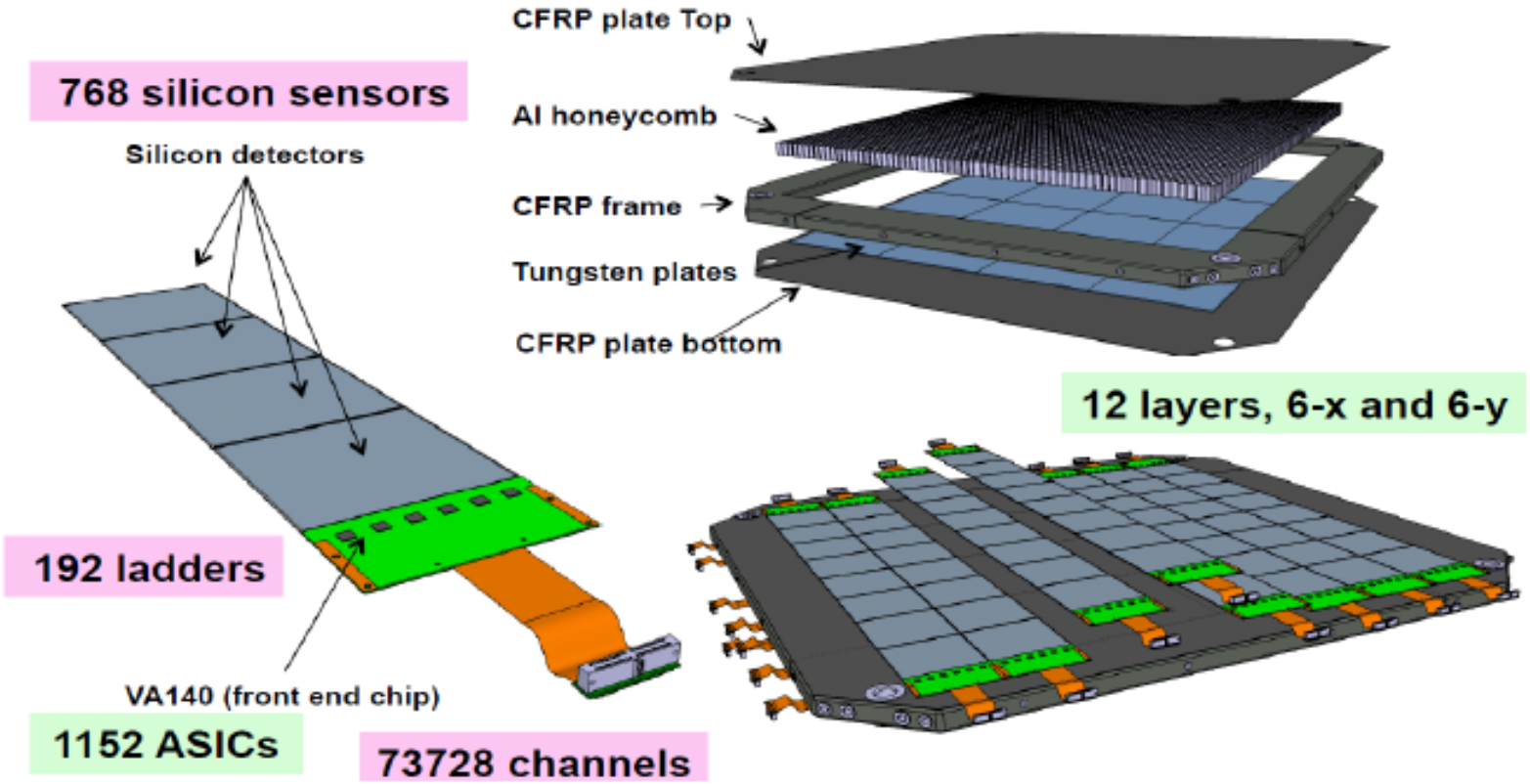


Performance:

- ✓ Position resolution ~6 mm
- ✓ Charge resolution 0.25 (Z=1)
- ✓ Dynamic range Z = 1 – 26
- ✓ Efficiency for MIP: >0.9975

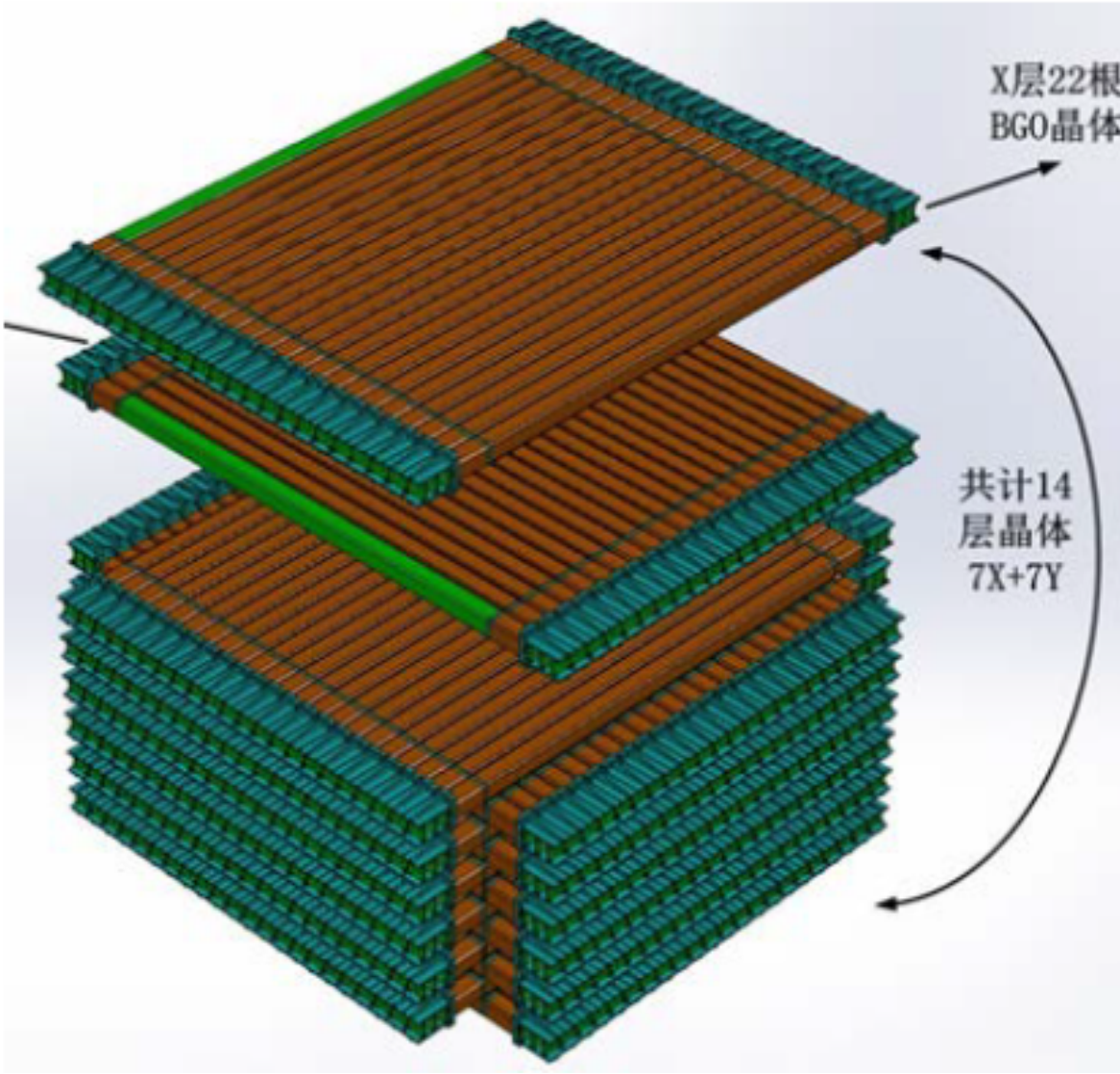
The STK

- 12 layers (6x + 6y) of single-sided Si strips, 16 Ladders per layer (76 × 76 cm^2), 4 Silicon Strip Detectors (SSD) per ladder
- (95 × 95 × 0.32 mm^3) SSD with 768 strips
- 48 μm wide Si strips with 121 μm pitch



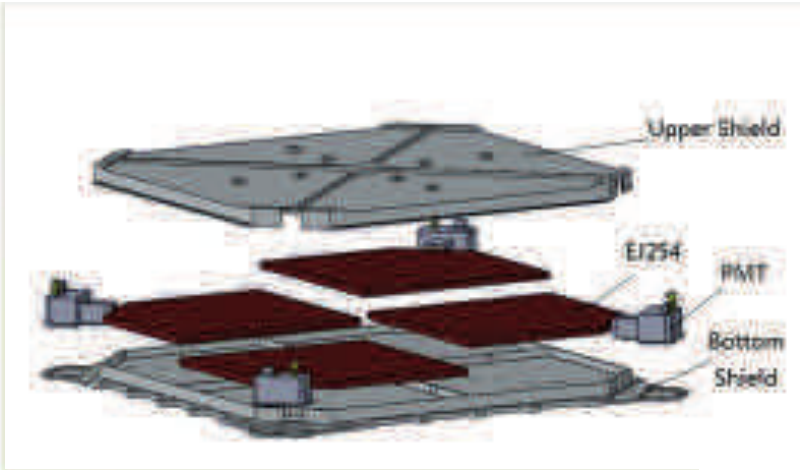
The BGO

- 14 layers of 22 BGO bars (2.5×2.5×60 cm^3)
- Two PMTs coupled with each BGO crystal bar in two ends
  - ✓ Use 3 dynode (2, 5, 8) signals to extend the dynamic range
- Charge readout: VA160 with dynamic range up to 12 pC



THE NUD

- 4 large area boron-doped plastic scintillators (30x30x1 cm^3)
  - ✓ Detect the delayed thermal neutron capture signal to improve the e/h separation
  - ✓ Gating circuit to detect delayed signal with a settable delay (0-20μs) after the BGO trigger

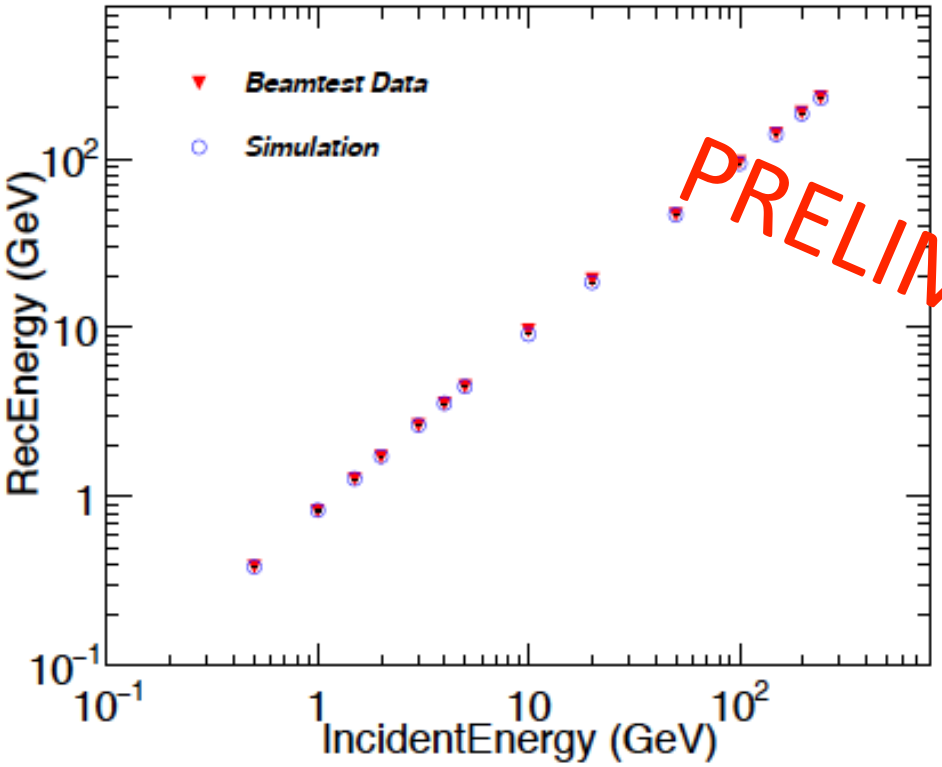


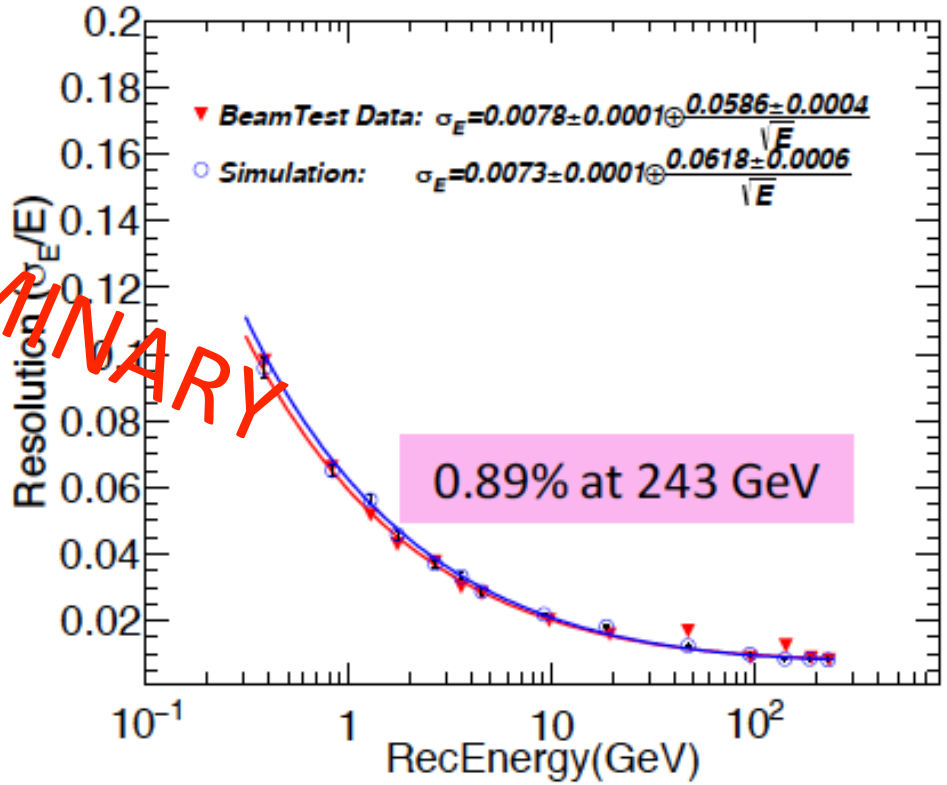
On ground calibration: test beam @ CERN

More then two months of test beam activity

- **14days@PS, 29/10-11/11 2014**
  - ✓ e @ 0.5GeV/c, 1GeV/c, 2GeV/c, 3GeV/c, 4GeV/c, 5GeV/c
  - ✓ p @ 3.5GeV/c, 4GeV/c, 5GeV/c, 6GeV/c, 8GeV/c, 10GeV/c
  - ✓ π-@ 3GeV/c, 10GeV/c
  - ✓ γ @ 0.5-3GeV/c
- **8days@SPS, 12/11-19/11 2014**
  - ✓ e @ 5GeV/c, 10GeV/c, 20GeV/c, 50GeV/c, 100GeV/c, 150GeV/c, 200GeV/c, 250GeV/c
  - ✓ p @ 400GeV/c (SPS primary beam)
  - ✓ γ @ 3-20GeV/c
  - ✓ μ @ 150GeV/c
- **17days@SPS, 16/3-1/4 2015**
  - ✓ Fragments: 66.67-88.89-166.67GeV/c
  - ✓ Argon: 30A- 40A- 75AGeV/c
  - ✓ Proton: 30GeV/c, 40GeV/c
- **21days@SPS, 10/6-1/7 2015**
  - ✓ Primary Proton: 400GeV/c
  - ✓ Electrons @ 20, 100, 150 GeV/c
  - ✓ γ @ 50, 75 , 150 GeV/c
  - ✓ μ @ 150 GeV /c
  - ✓ π+ @10, 20, 50, 100 GeV/c
- **10days@SPS, 11/11-20/11 2015**
  - ✓ Pb 30AGeV/c (and fragments) (HERD)
- **6days@SPS, 20/11-25/11 2015**
  - ✓ Pb 30 AGeV/c (and fragments)

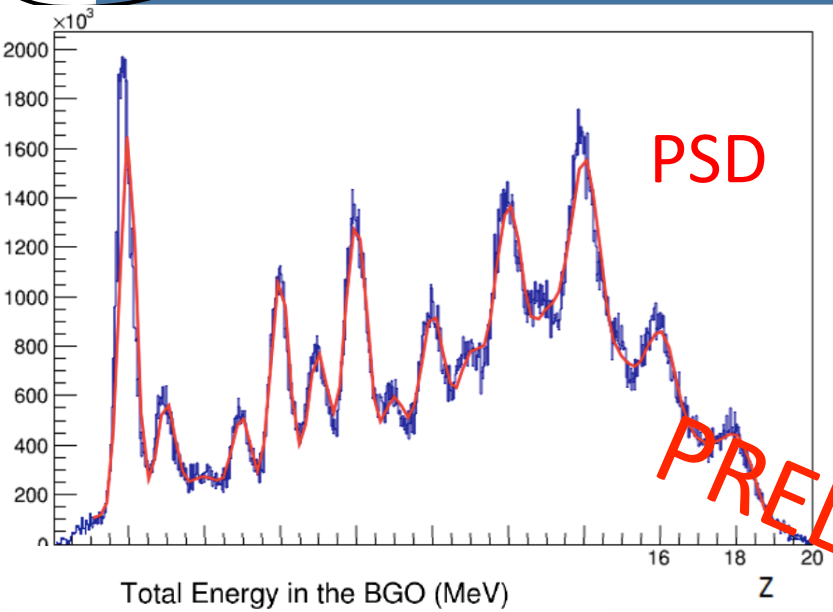
Test beam activity: electrons

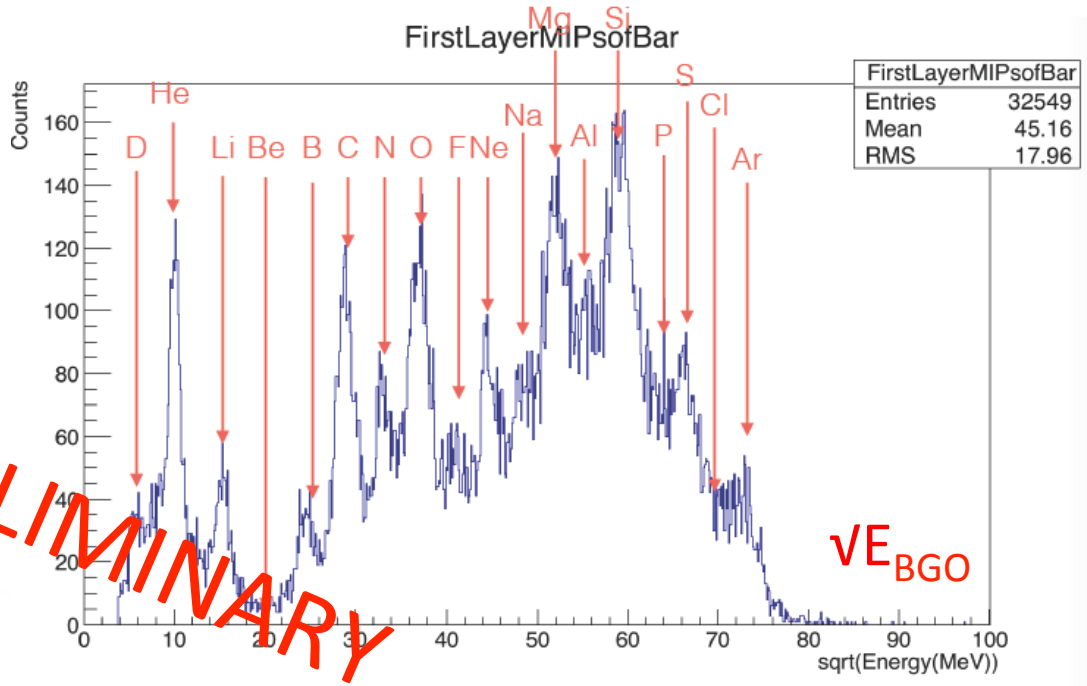




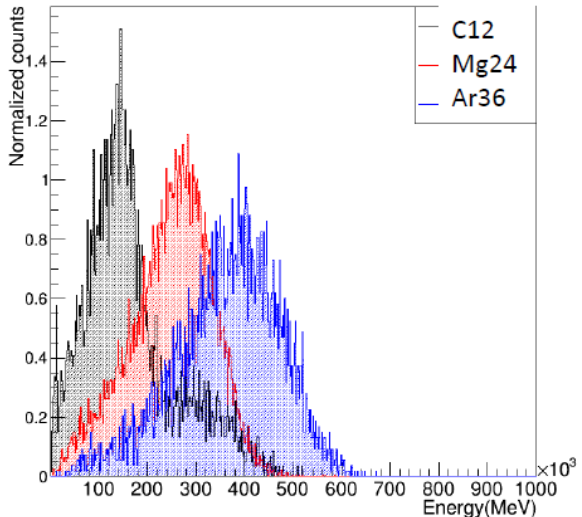
PRELIMINARY

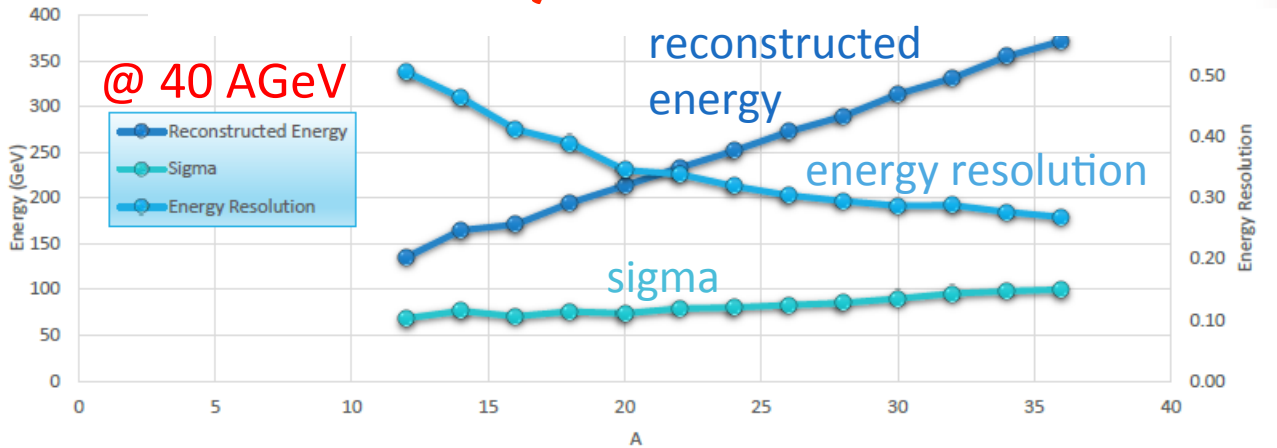
Test beam activity: ions





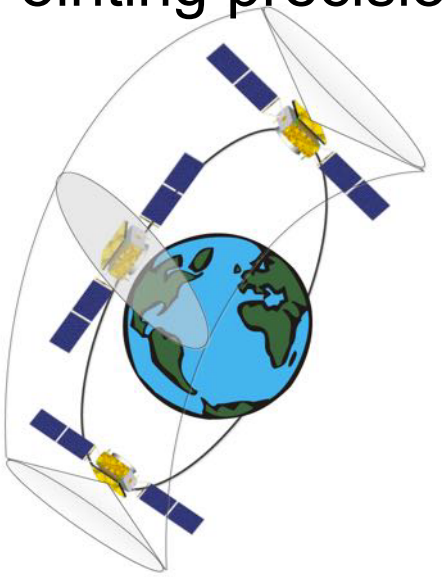
PRELIMINARY





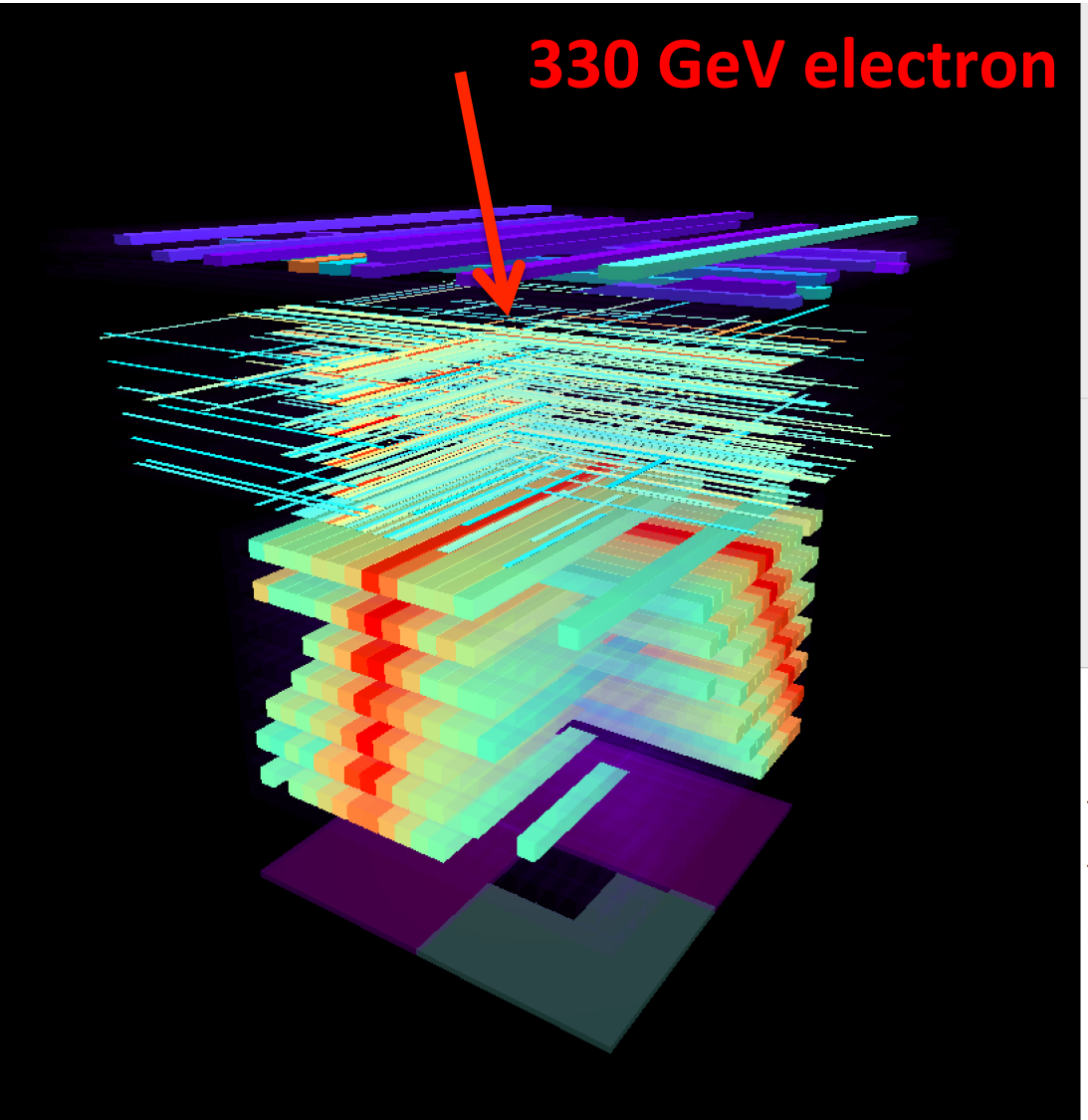
Dec. 17th 2015: the launch!

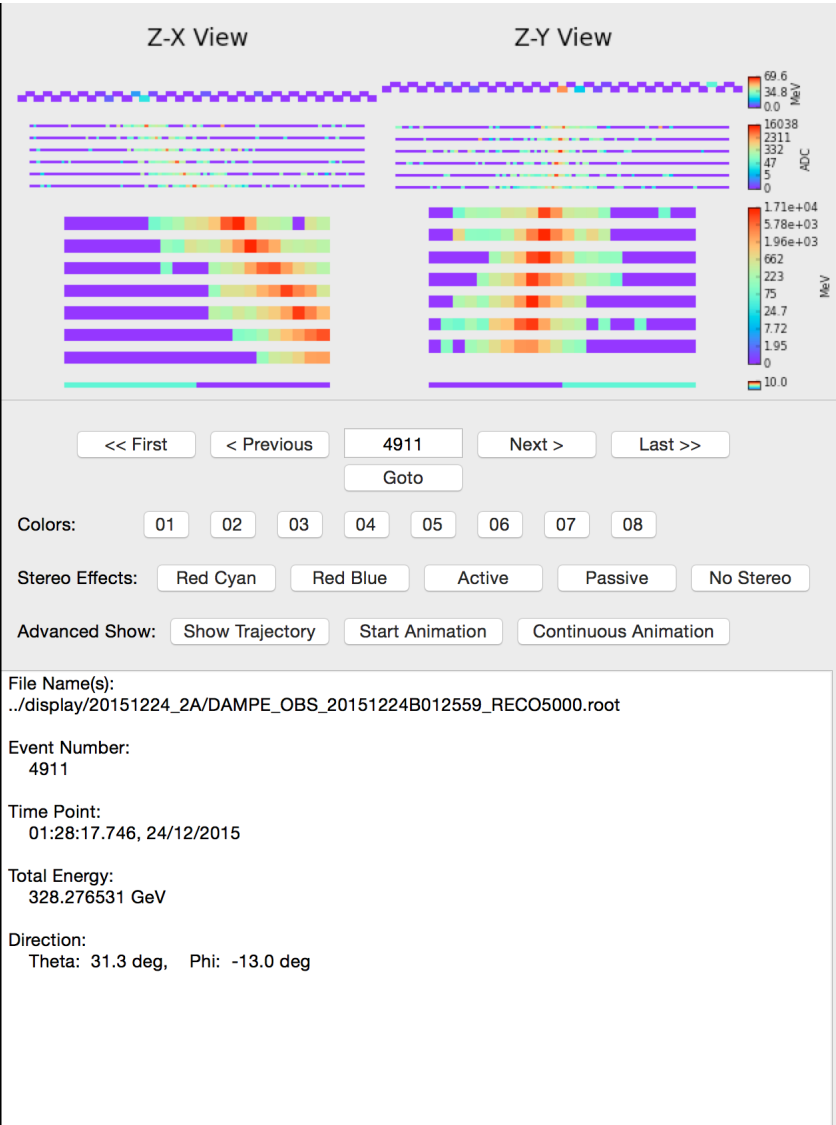
- Altitude: 500 km
- Inclination: 97.4065°
- Period: 95 minutes
- Orbit: sun-synchronous
- Pointing precision 0.005°



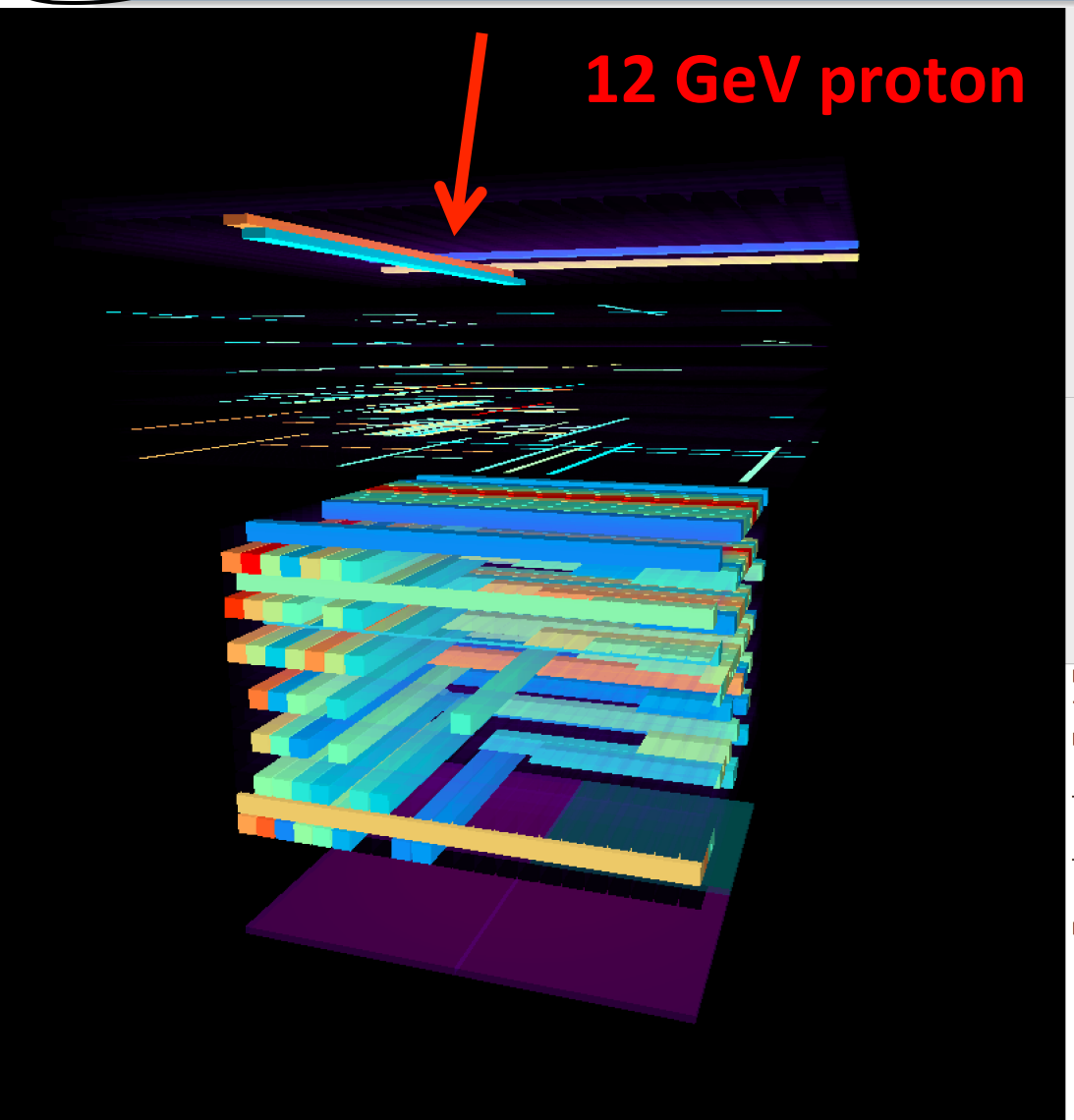
- Dec. 20: all detectors powered on
- except the HV for PMTs
- Dec. 24: HV on!
- Dec. 30: stable trigger condition

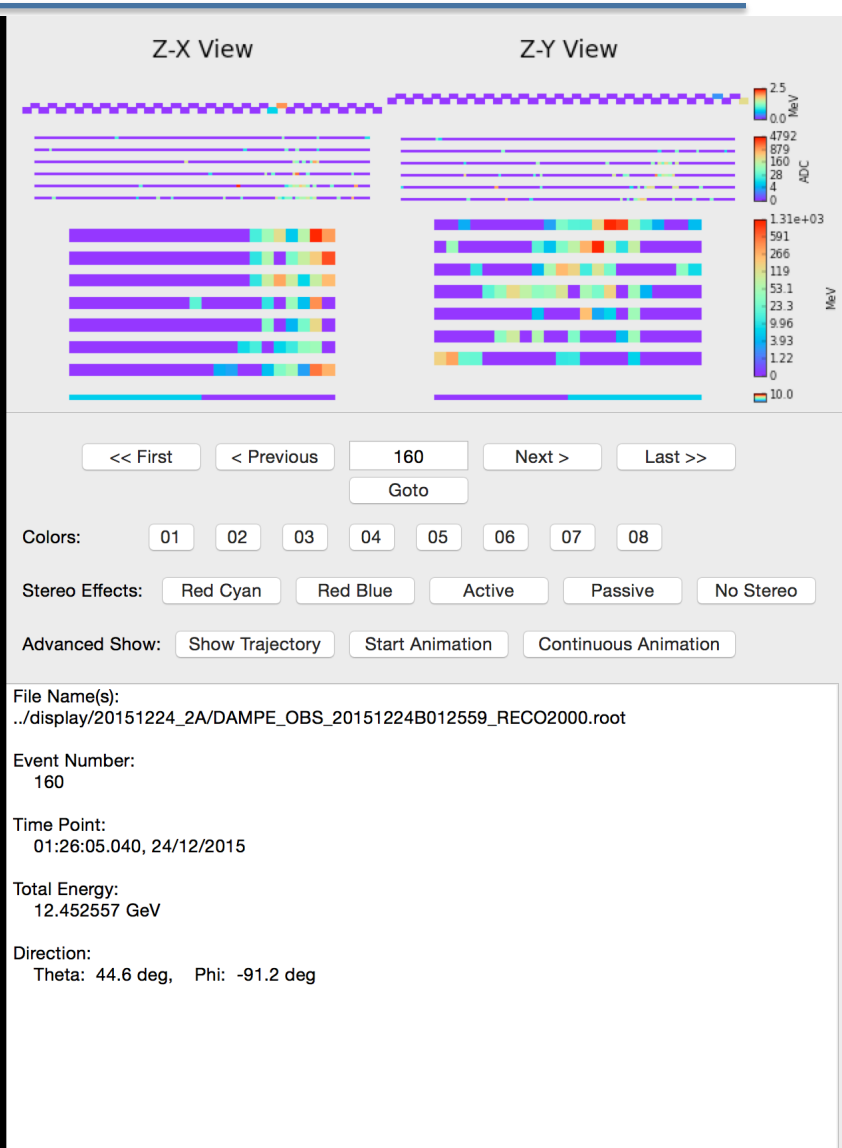
Dec 24, 2015: HV on



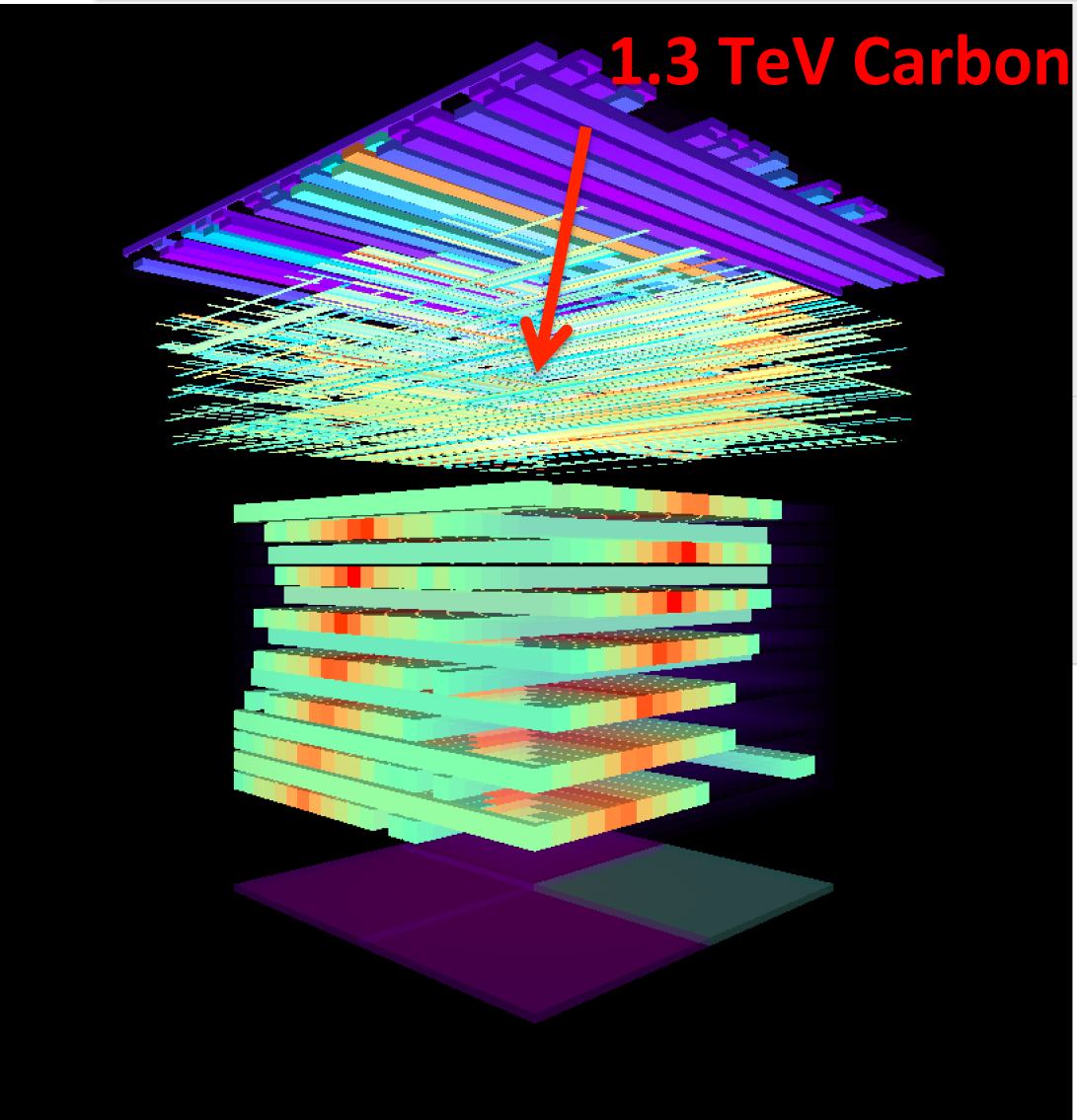


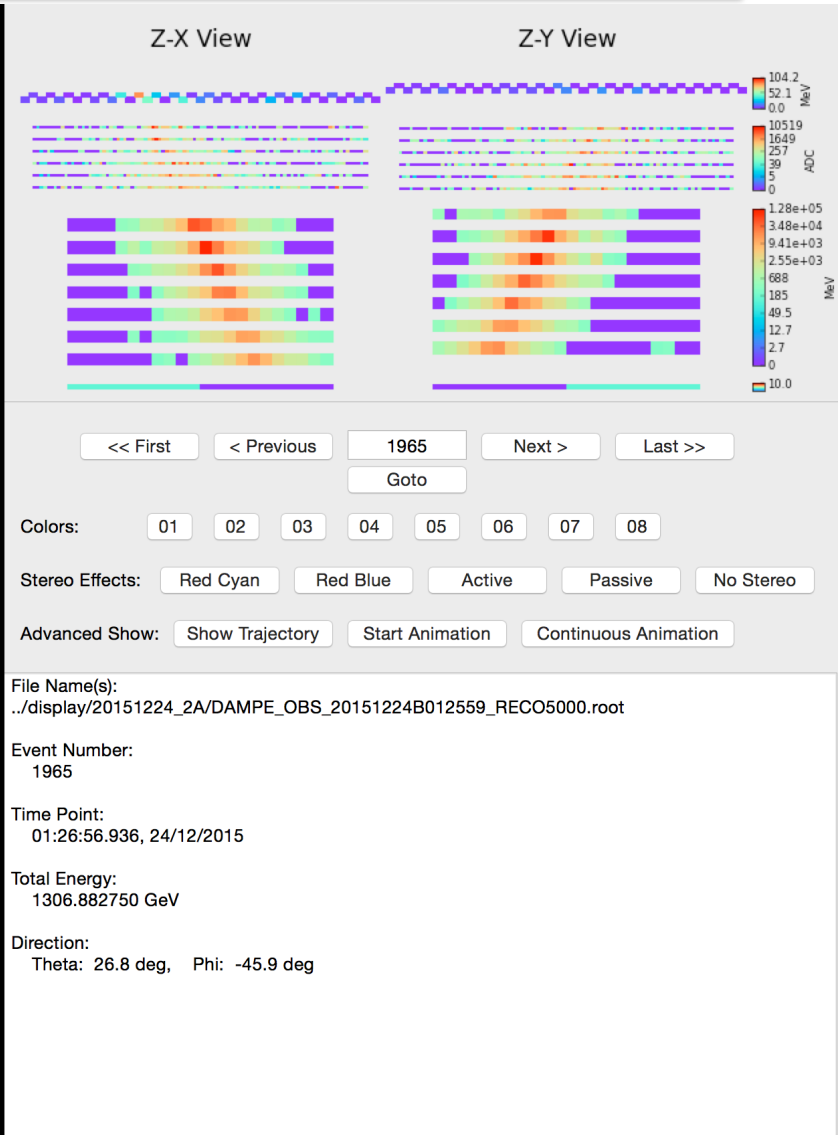
Dec 24, 2015: HV on



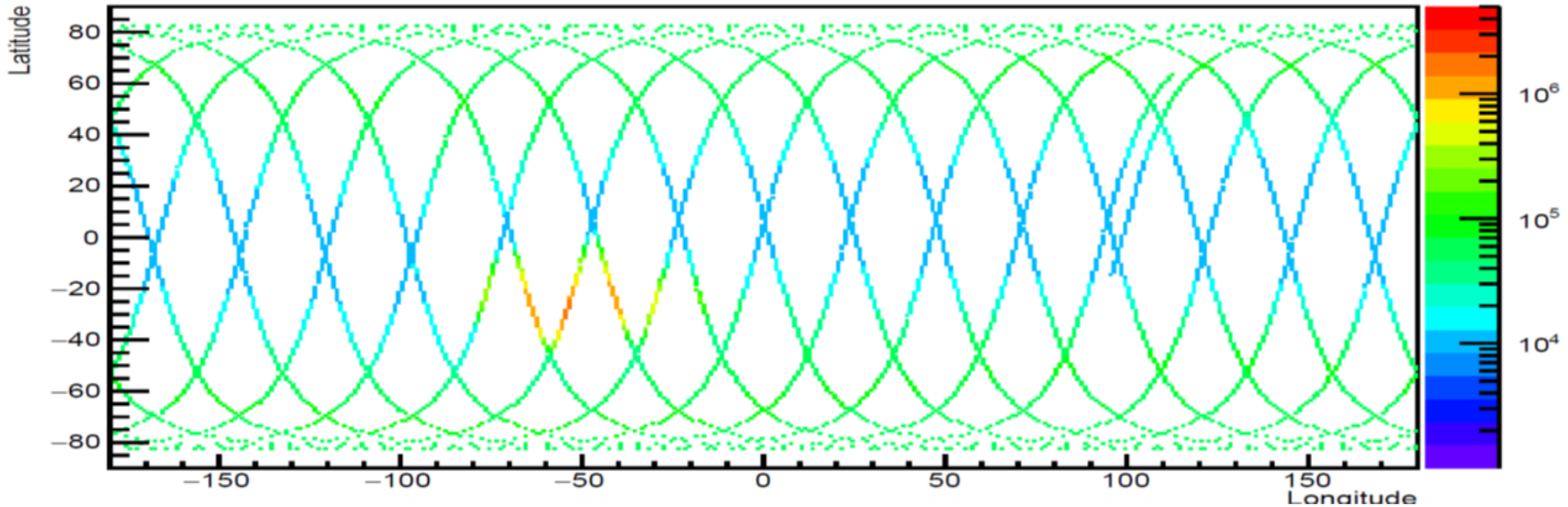


Dec 24, 2015: HV on



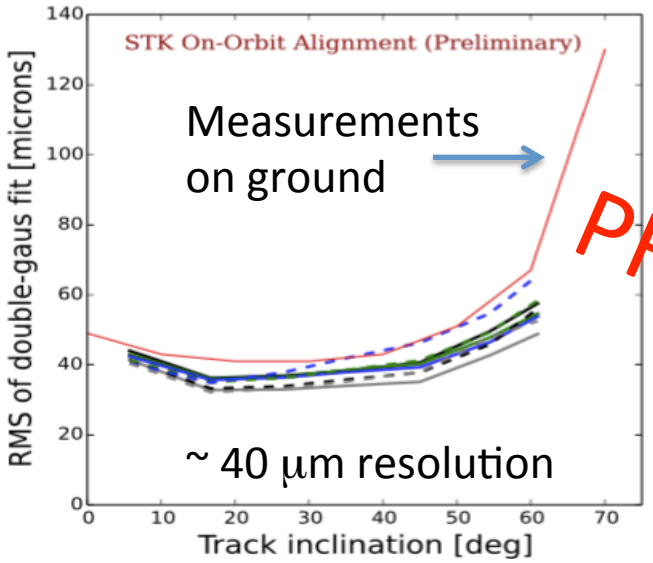


Trigger rate

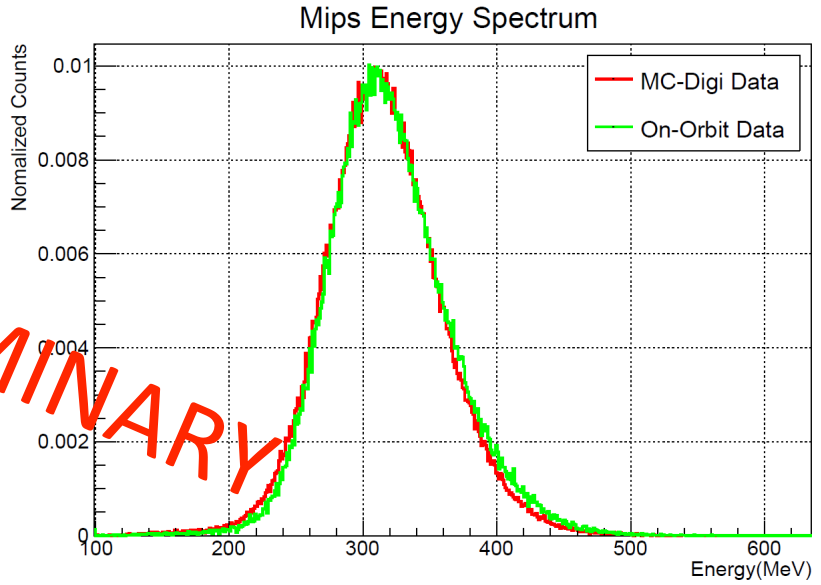


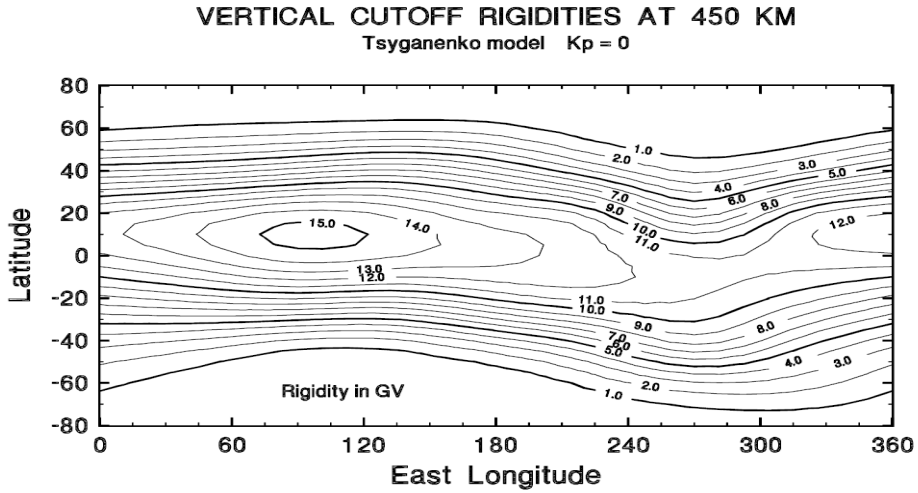
- average trigger rate: ~ 50 Hz
  - 100 GB/day on ground (~ 4M events)

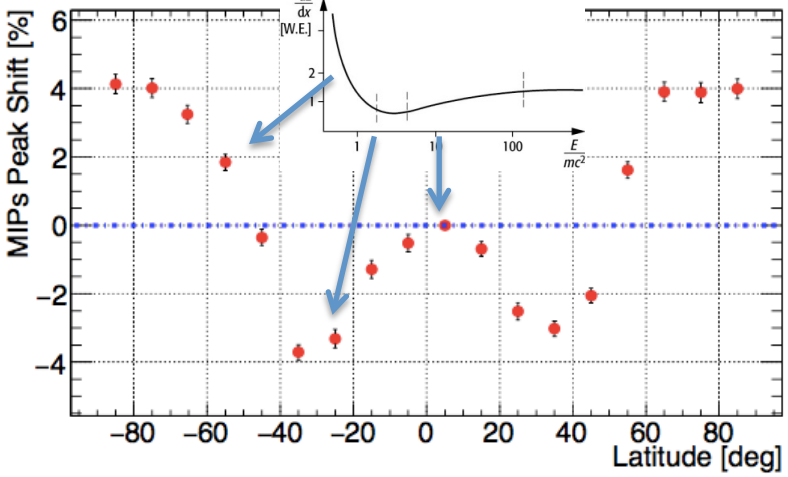
Orbit Performances



PRELIMINARY

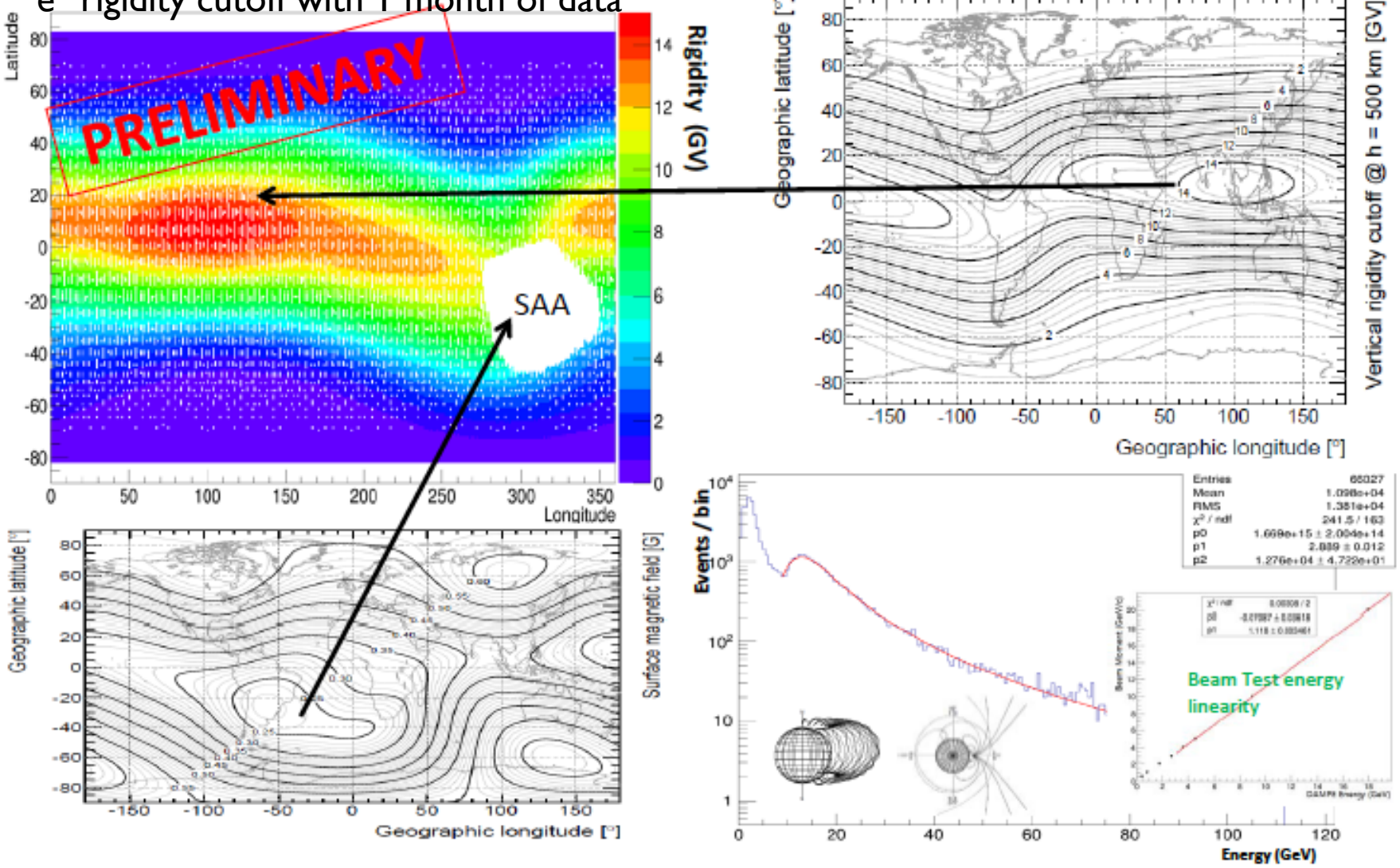




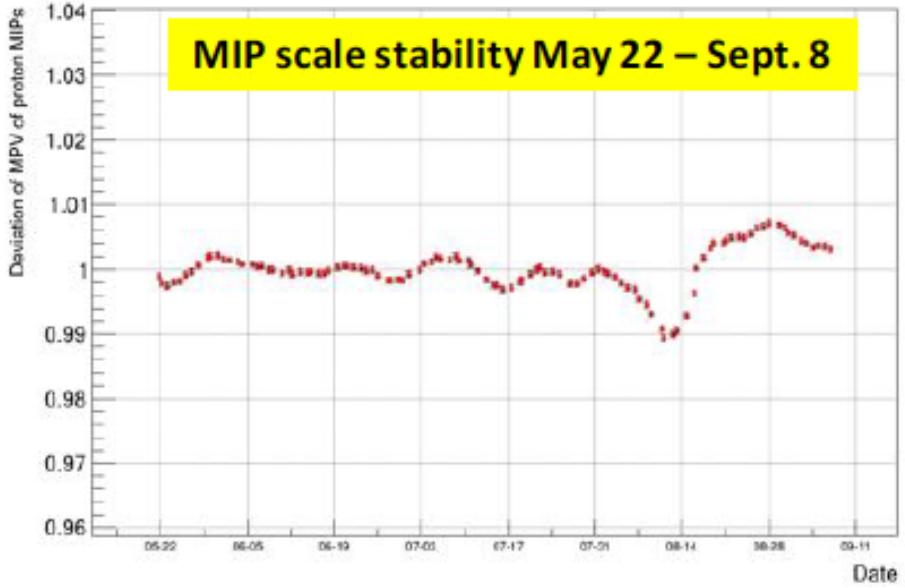


On orbit energy calibration

e± rigidity cutoff with 1 month of data



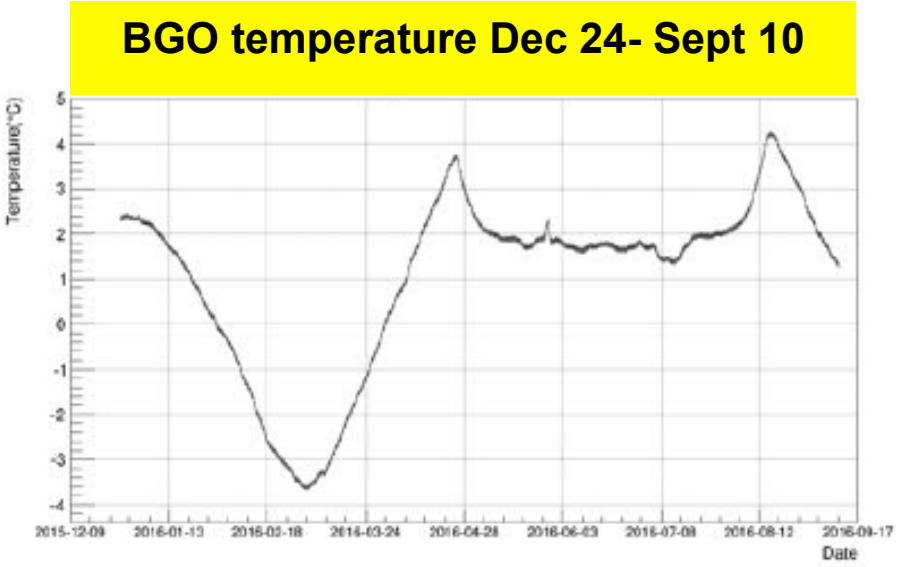
BGO Temperature Effects



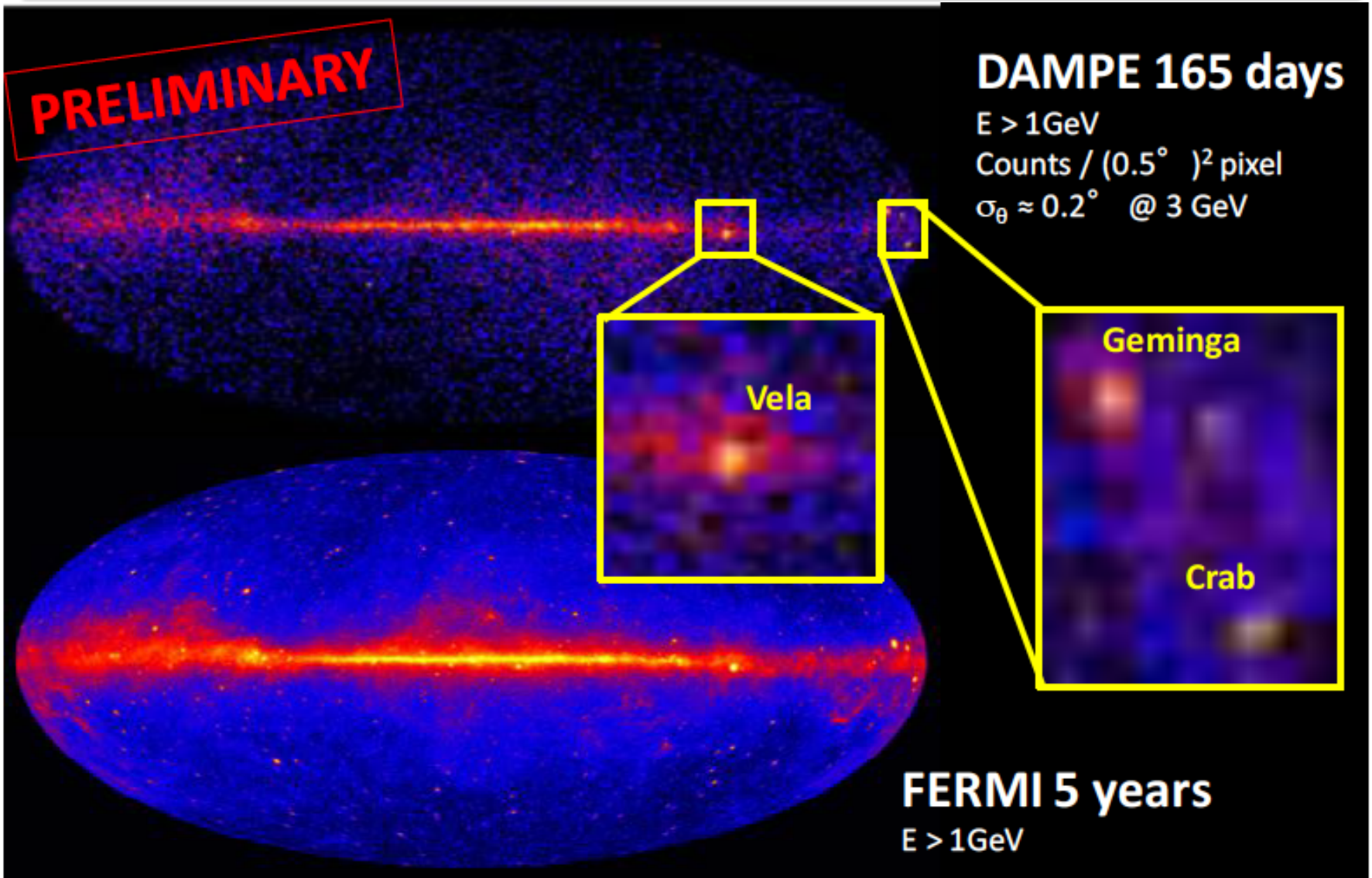
- Temperature variation:
  - ✓ day to day << 1°C
  - ✓ ~8 °C since Dec 2015

Mip scale stability ~1% without temperature correction

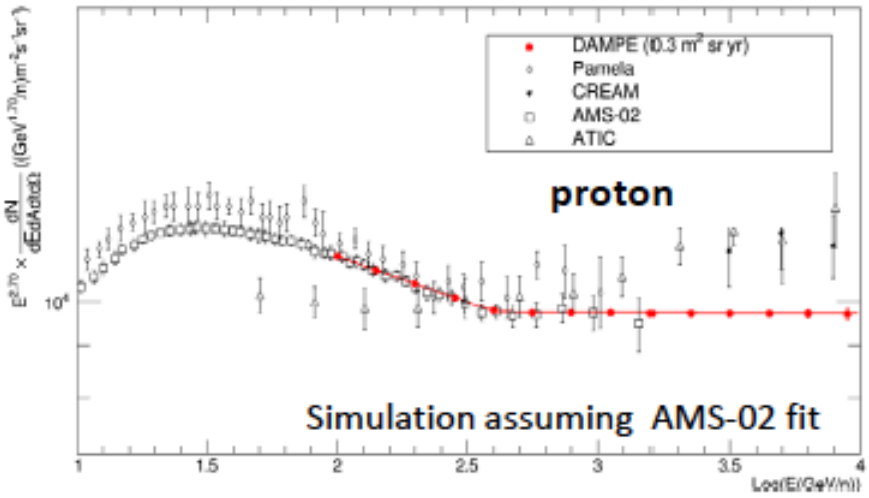
Possible to achieve 0.5% stability taking into account temperature effects

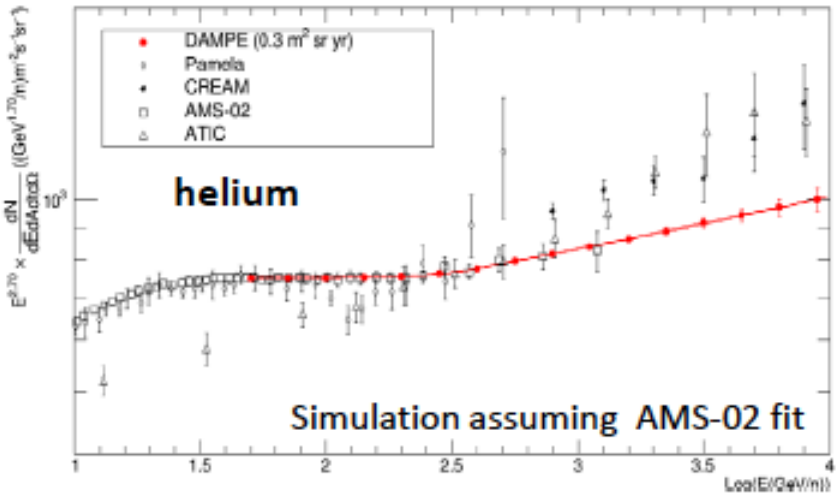


Photons

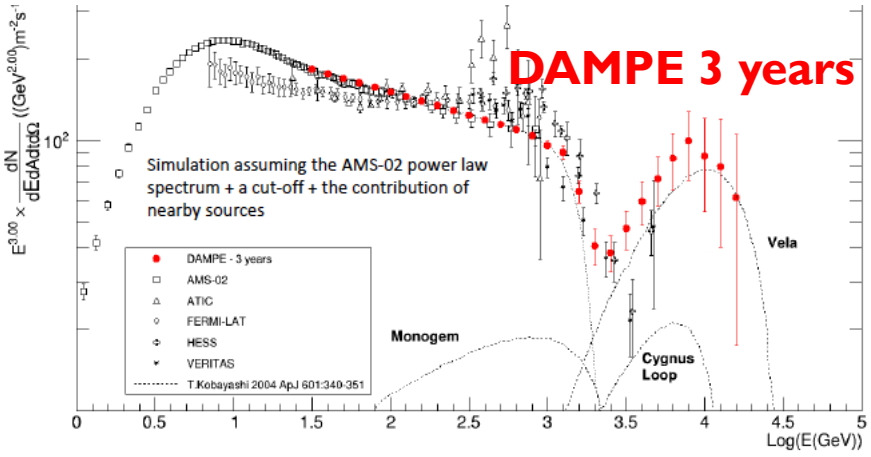

PRELIMINARY
DAMPE 165 days
E > 1GeV
Counts / (0.5°)² pixel
σθ ≈ 0.2° @ 3 GeV
Vela
Geminga
Crab
FERMI 5 years
E > 1GeV

Expected measurements





- Proton and nuclei up to 100Tev
- Electron Spectrum up to 10 TeV
  - ✓ Detect the possible cutoff around 1TeV
  - ✓ Detect possible spectrum structures and anisotropies (DM signals)



Summary

- DAMPE is a powerful telescope for high energy electrons, γ−rays and cosmic rays:
  - ✓ intensive calibration campaign before launch (more then 2 months)
  - ✓ large geometrical aperture (0.3 m^2 sr)
  - ✓ Precision STK measurements (0.1°, 40 μm)
  - ✓ Thick calorimeter (32 X_0)
- On orbit commissioning completed
  - ✓ operations are smooth and with high efficiency (4M events/day)
- Calibration, optimization of reconstruction and of particle identification algorithms on going

Stay tuned for first physics results!