The 3rd International Conference on Particle Physics and Astrophysics

The DAMPE experiment:
2 year in orbit (almost)

Fabio Gargano – INFN Bari

on behalf the DAMPE collaboration

The physics goals

- **High energy particle detection in space**
  - Study of the cosmic **electron** and **photon** spectra
  - Study of cosmic ray **protons** and **nuclei**:
    - spectrum and composition
  - 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 (1sr)

Detection of
5 GeV - 10 TeV e/γ
50 GeV - 100 TeV protons and nuclei
Excellent energy resolution
(<1.5%@100GeV e/γ; < 40% @800GeV p)
Very good angular resolution
(<0.2° @ 100GeV γ)

The collaboration

- **CHINA**
  - Purple Mountain Observatory, CAS, Nanjing
    Prof. Jin Chang
  - 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

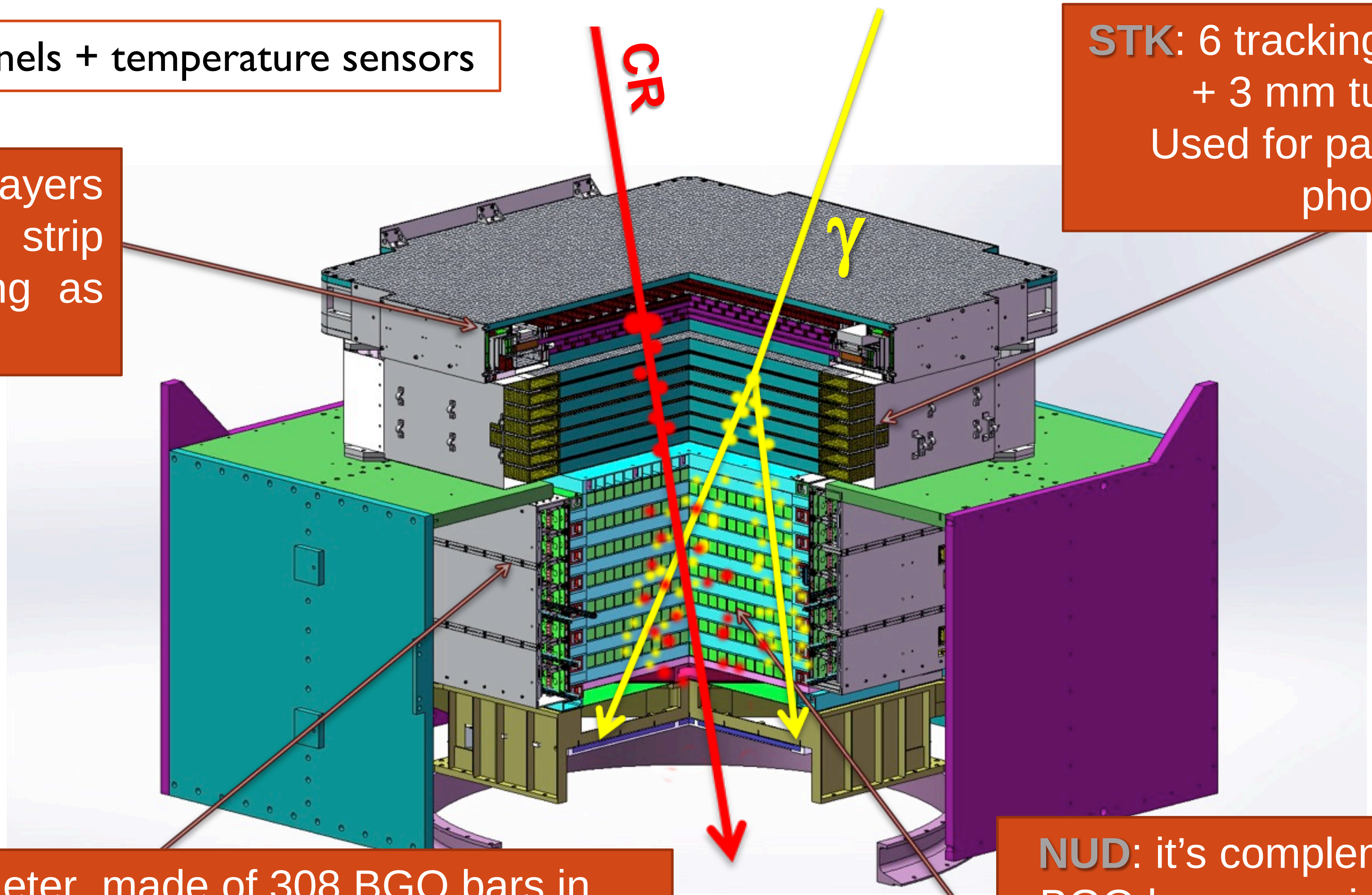
- **SWITZERLAND**
  - University of Geneva

The detector

75k readout channels + temperature sensors

PSD: double layers of scintillating strip detector acting as ACD

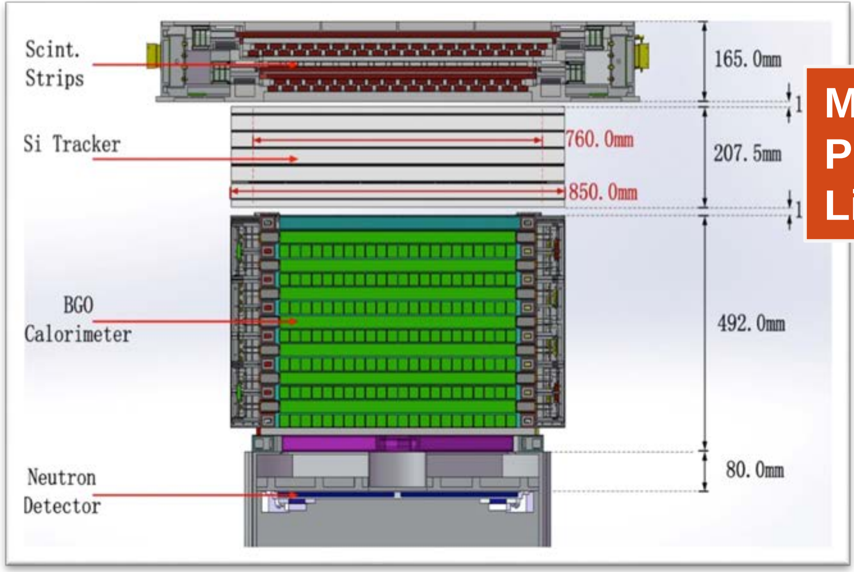
STK: 6 tracking double layers + 3 mm tungsten plates. Used for particle track and photon conversion



BGO: the calorimeter made of 308 BGO bars in hodoscopic arrangement (~32 radiation lengths). Performs both energy measurements and trigger

NUD: it's complementary to the BGO by measuring the thermal neutron shower activity. Made up of boron-doped plastic scintillators

Comparison
DAMPE AMS-02 and FERMI



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

	DAMPE	AMS-02	Fermi LAT
e/γ Energy res.@100 GeV (%)	<1.5	3	10
e/γ Angular res.@100 GeV (deg.)	<0.2	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)	0.3	0.09	1

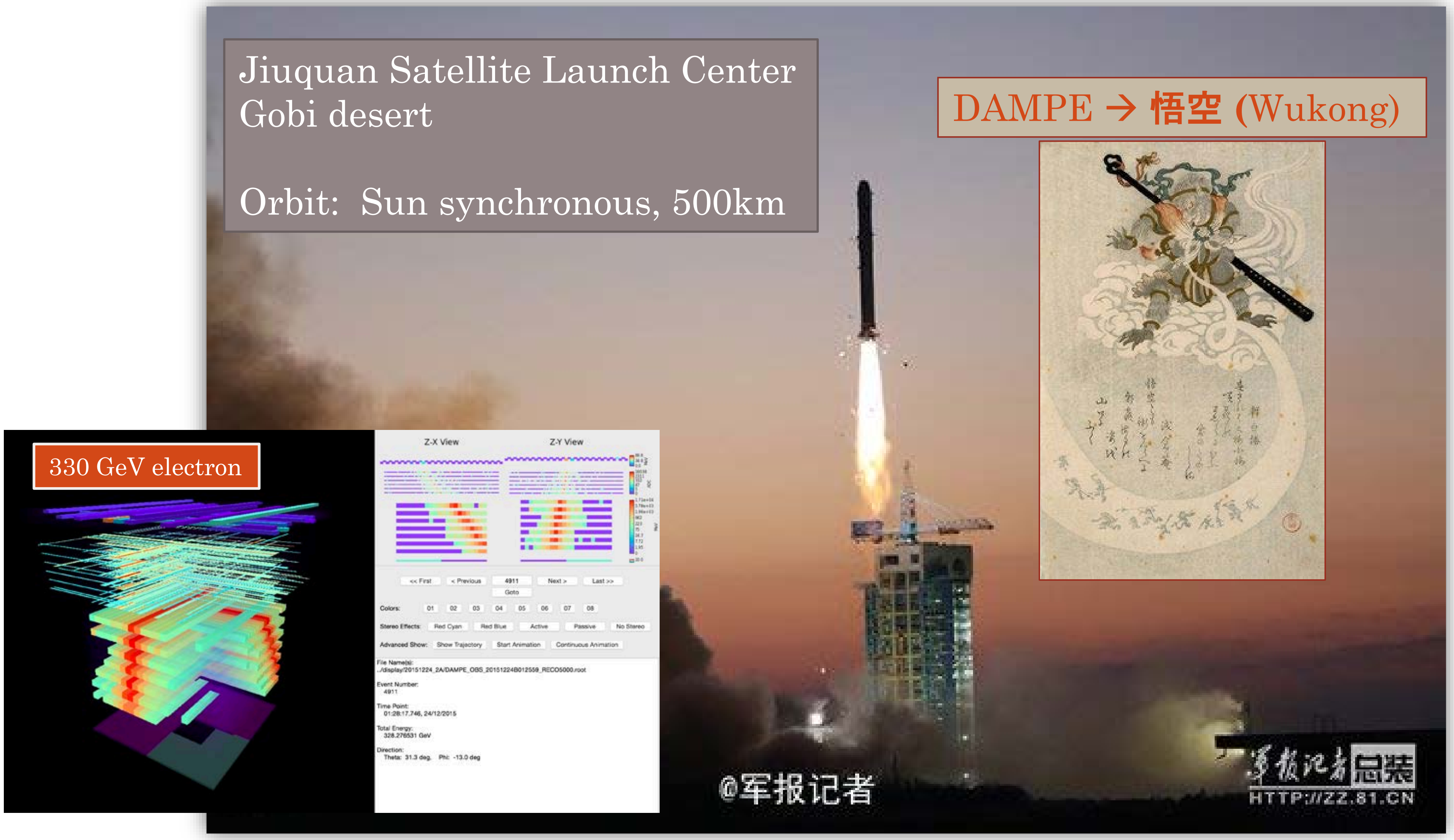
The launch: Dec 17th 2015, 0:12 UTC

Jiuquan Satellite Launch Center
Gobi desert

Orbit: Sun synchronous, 500km

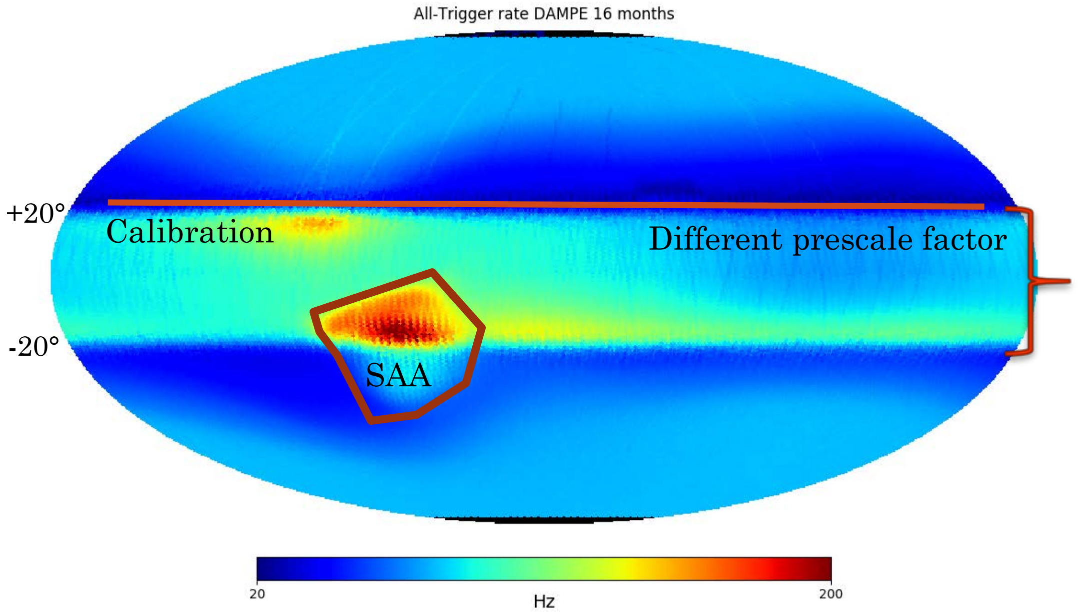
DAMPE → 悟空 (Wukong)

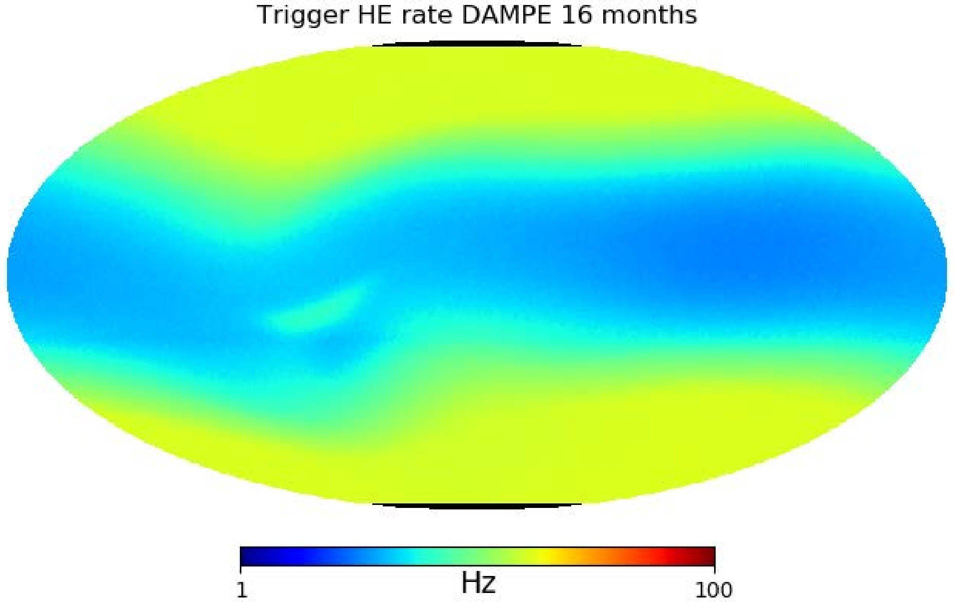
330 GeV electron



Operations 24h/day, 365d/year, since the launch

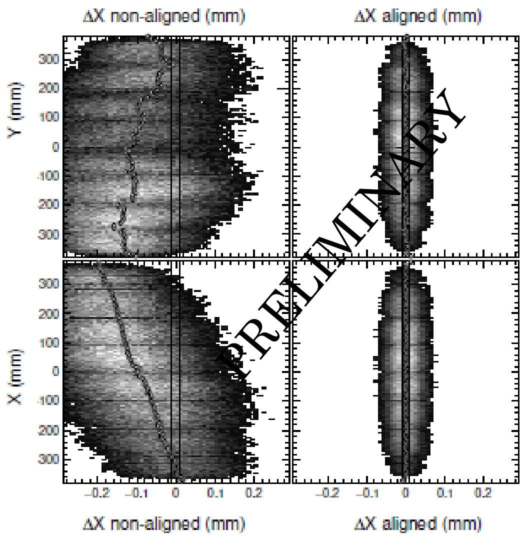
Trigger rate and data transfer



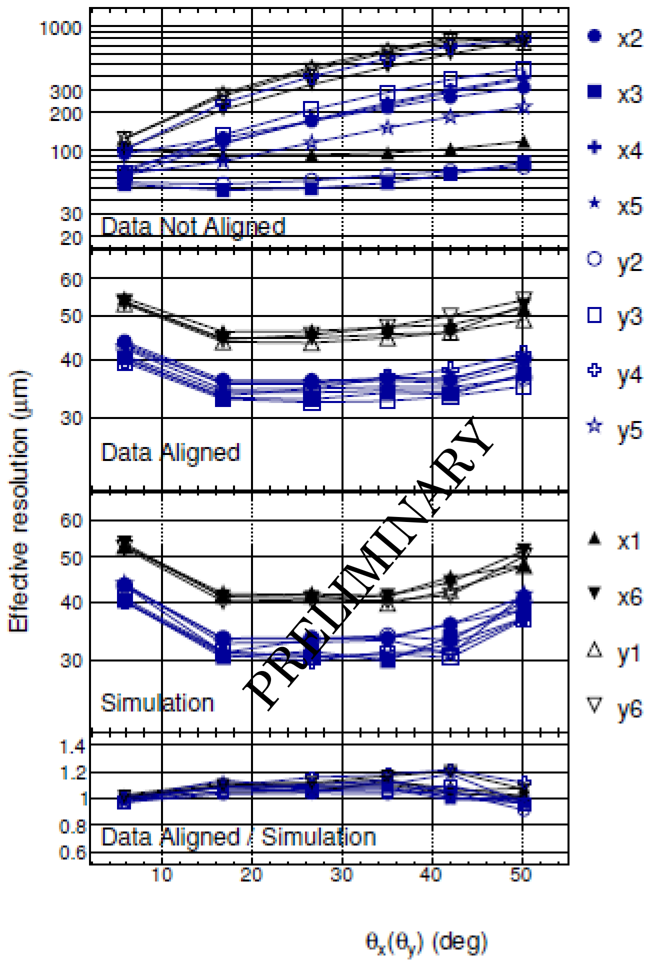


- Acquisition rate up to 200Hz (50 Hz for High Energy Trigger == trigger for physics analysis)
- Data are collected 4 times per day, each time the DAMPE satellite is passing over Chinese ground stations
- 15 GB/day transmitted to ground
  - Raw Data (ROOT format 8GB) + Slow Control + Orbit Information
- 85 GB/day reconstructed data (ROOT format)
- **100 GB/day (35 TB/year) in total**

Some on-orbit performance plots



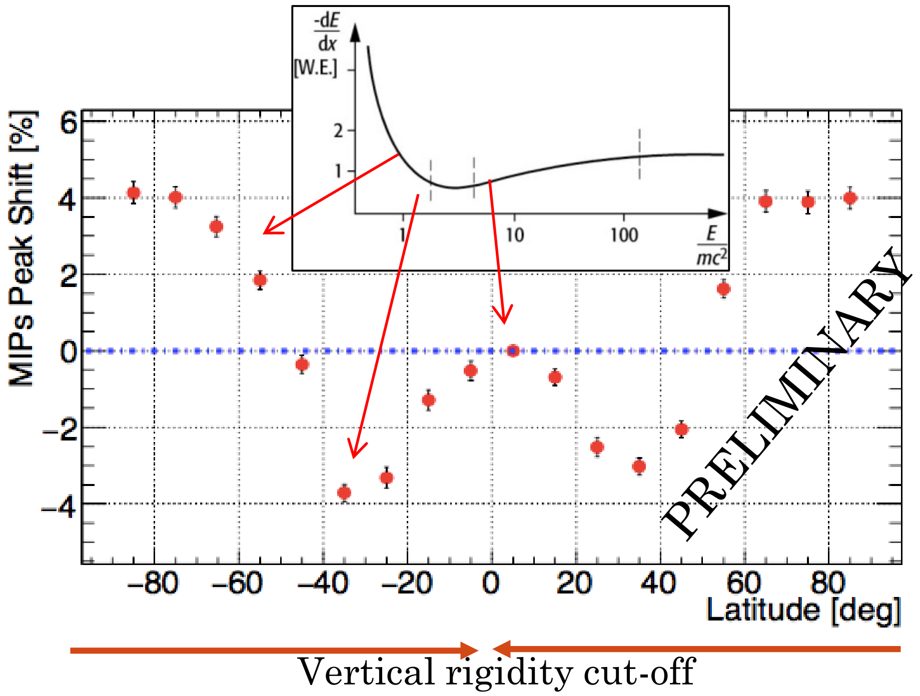
STK



On orbit STK alignment using "mips" (i.e. not showering particle).
The alignment (done every two weeks) allows us to achieve a spatial resolution better than 40μm on central STK planes

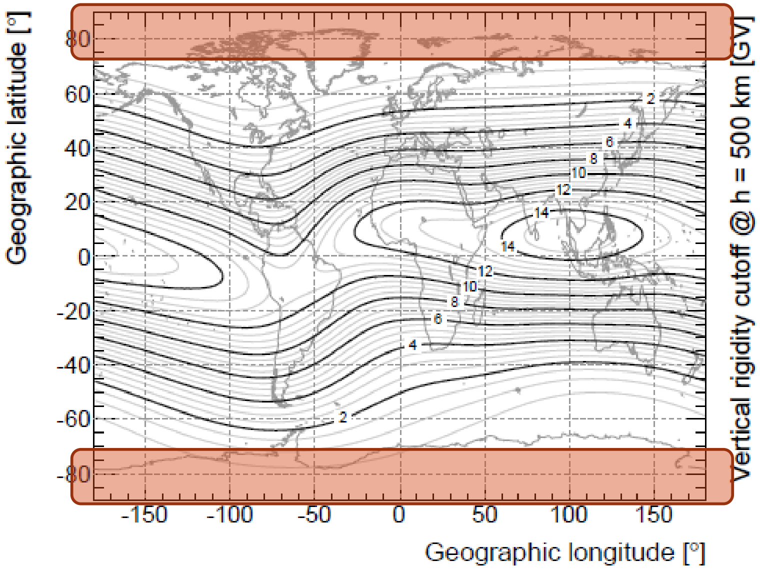
BGO

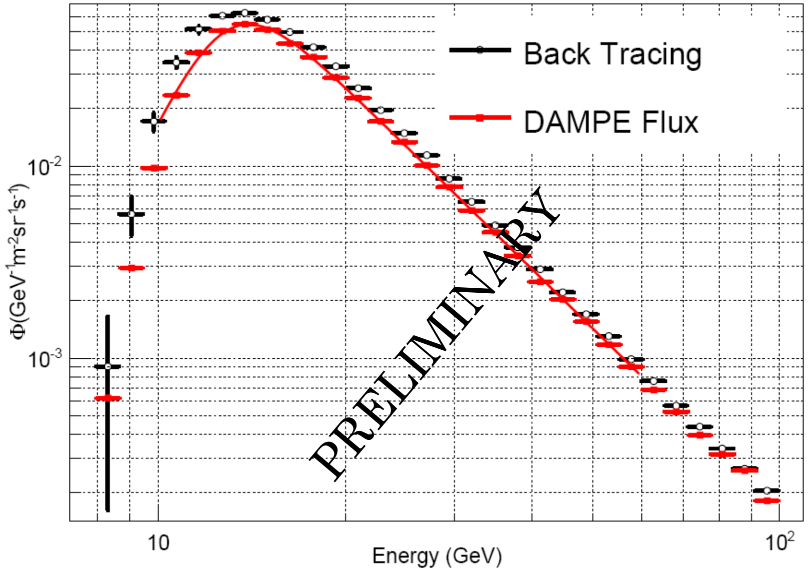
The "mip" (i.e. not showering particles) peak shift with latitude due to the geomagnetic cut-off.

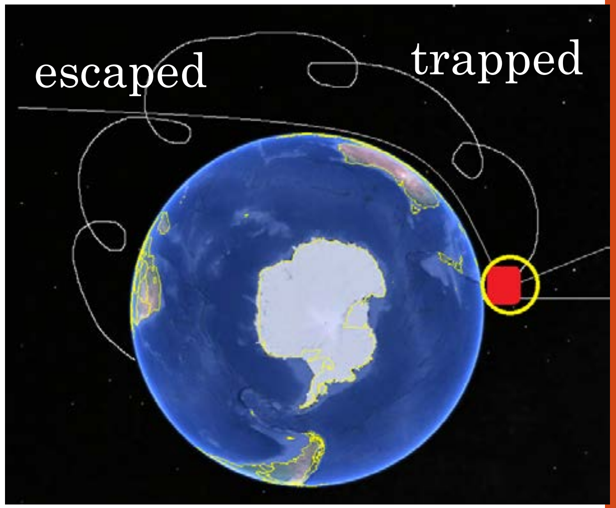


On-orbit absolute energy calibration

- Geomagnetic cut-off on cosmic ray electron spectrum provide a good spectral feature for absolute energy calibration
- Measure low energy CRE flux with 1<L<1.14 in the energy range 8GeV < E < 100GeV
- We made a direct comparison between flight data and MC (with back tracing in Earth magnetic field – IGRF12)







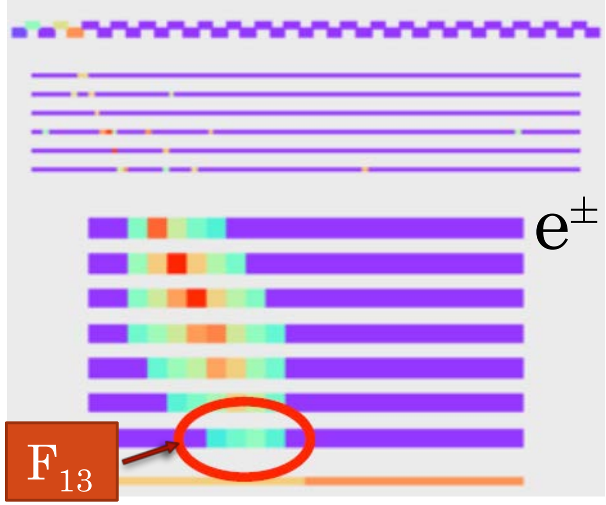
Exp. Cut-off   13.038 GeV
Meas. Cut-off 13.201 GeV

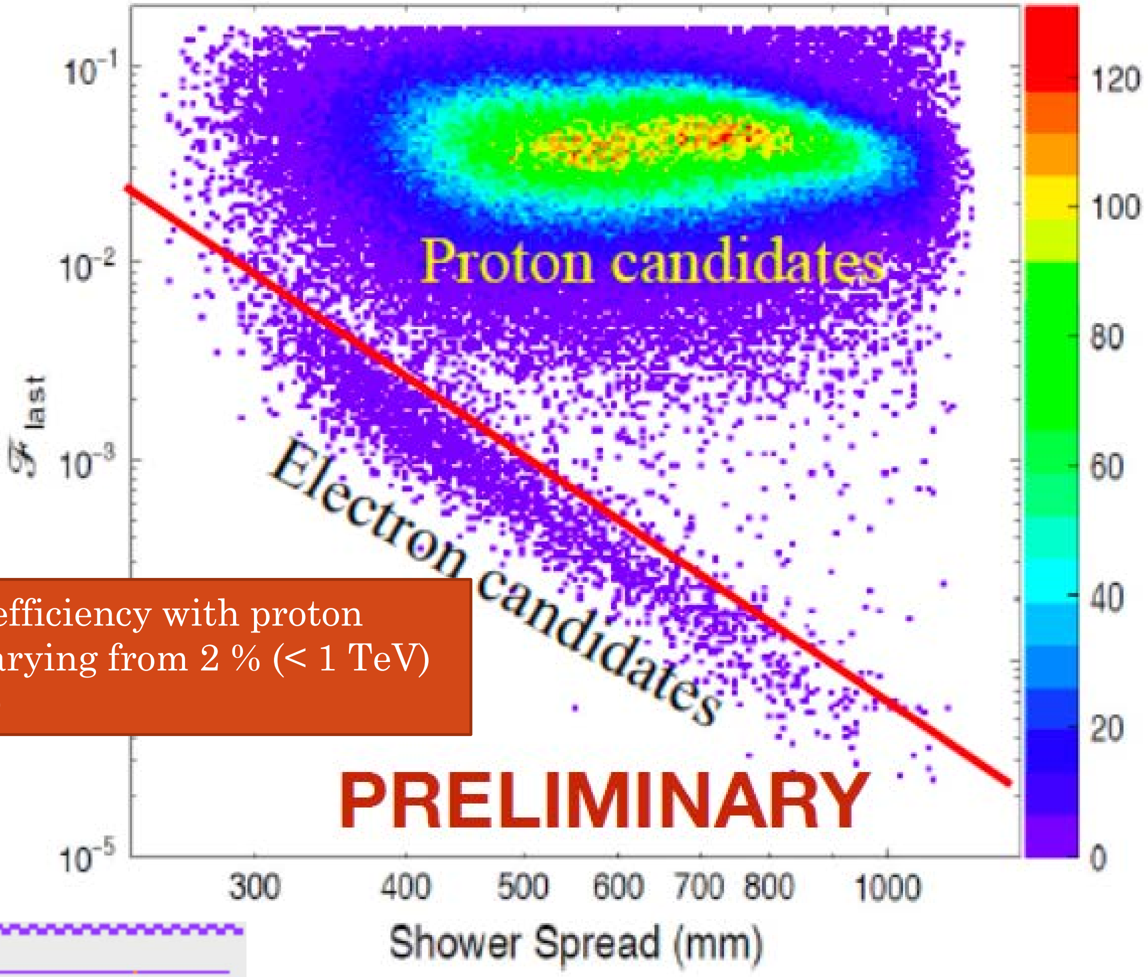
By comparing geomagnetic cut-off on cosmic ray electron and positron fluxes measured from data and MC back tracing, we found DAMPE's absolute energy scale differ from expected by 1.25%

Electrons: identification

One possible "shape parameter"

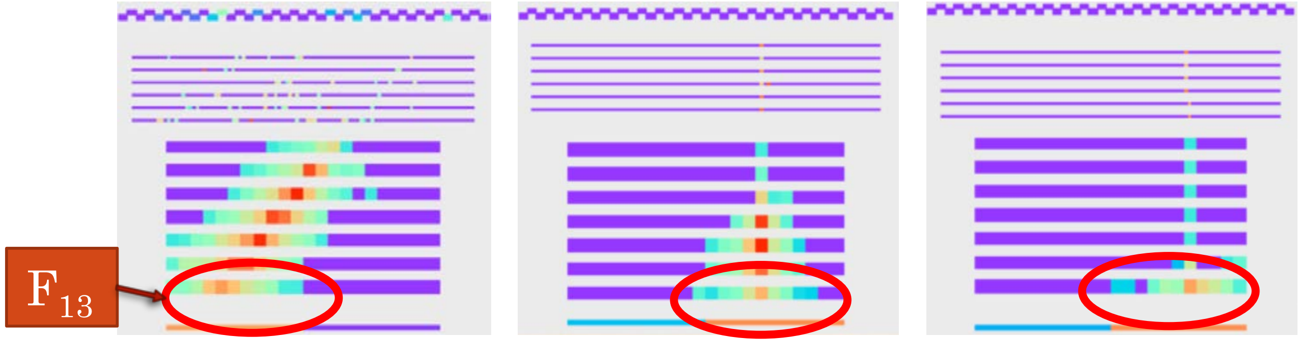
$$F_i = Spread_i \times \frac{E_i}{E_{tot}}$$





> 90% detection efficiency with proton contamination varying from 2 % (< 1 TeV) to 10 % (> 5 TeV)

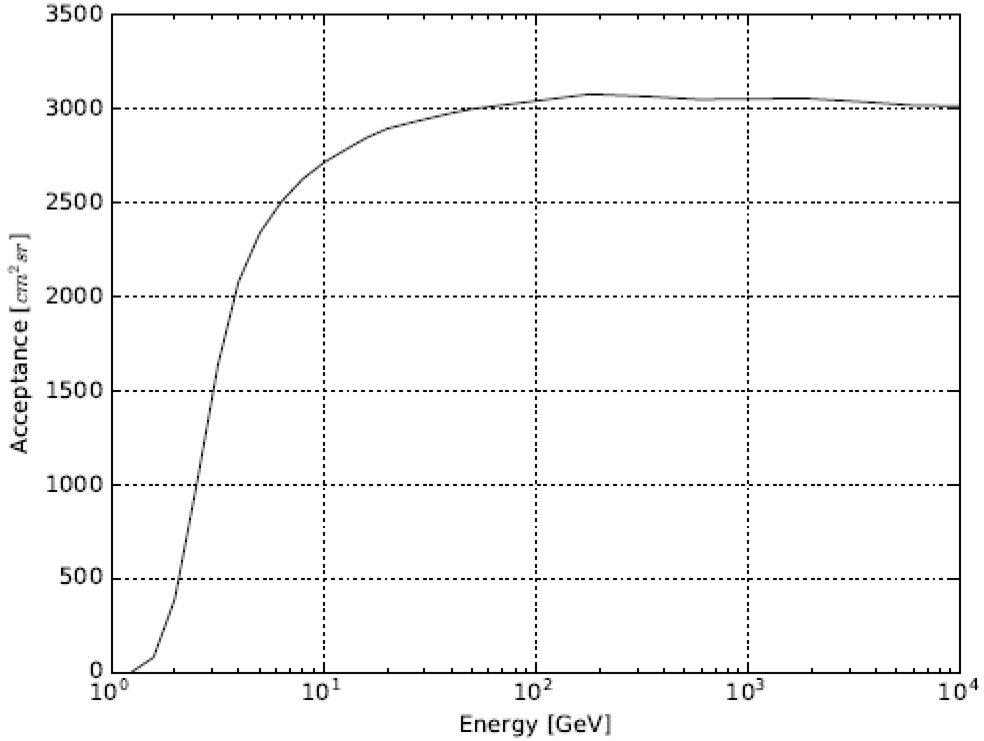
$p\bar{p}$



More PID strategies being investigated (BoostedDecisionTree, RandomForest+ConvolutionalNeuralNetwork, …)

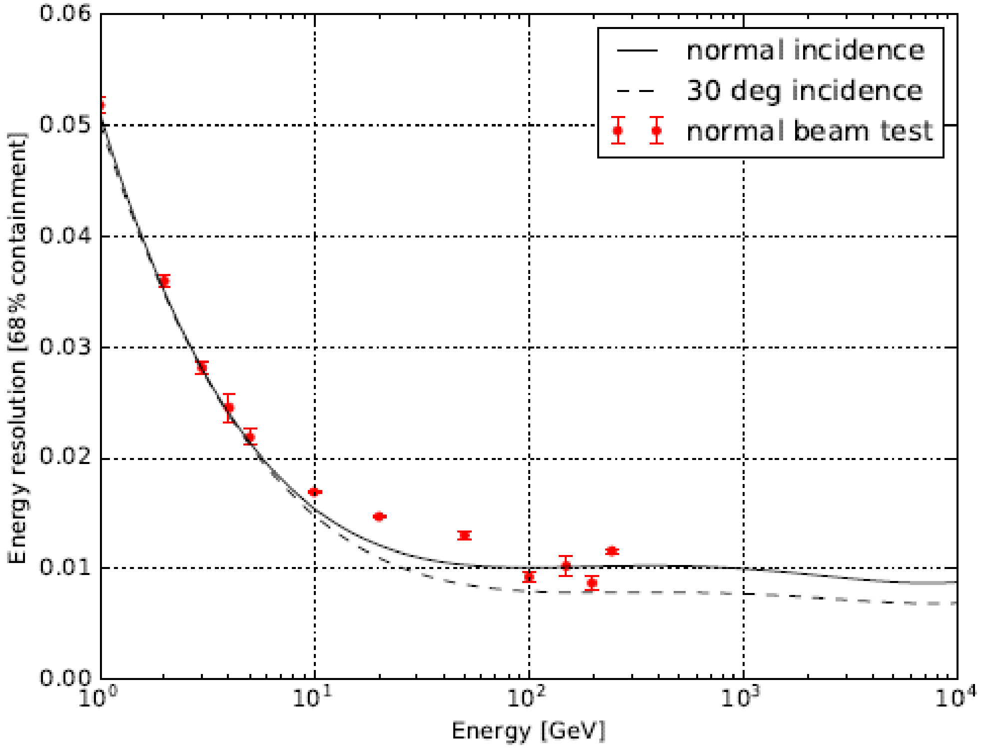
Electrons: performances

Acceptance for electrons and positrons



0.3m^2 sr for E > 100GeV

Energy resolution for E.M. showers



1% for E > 100GeV

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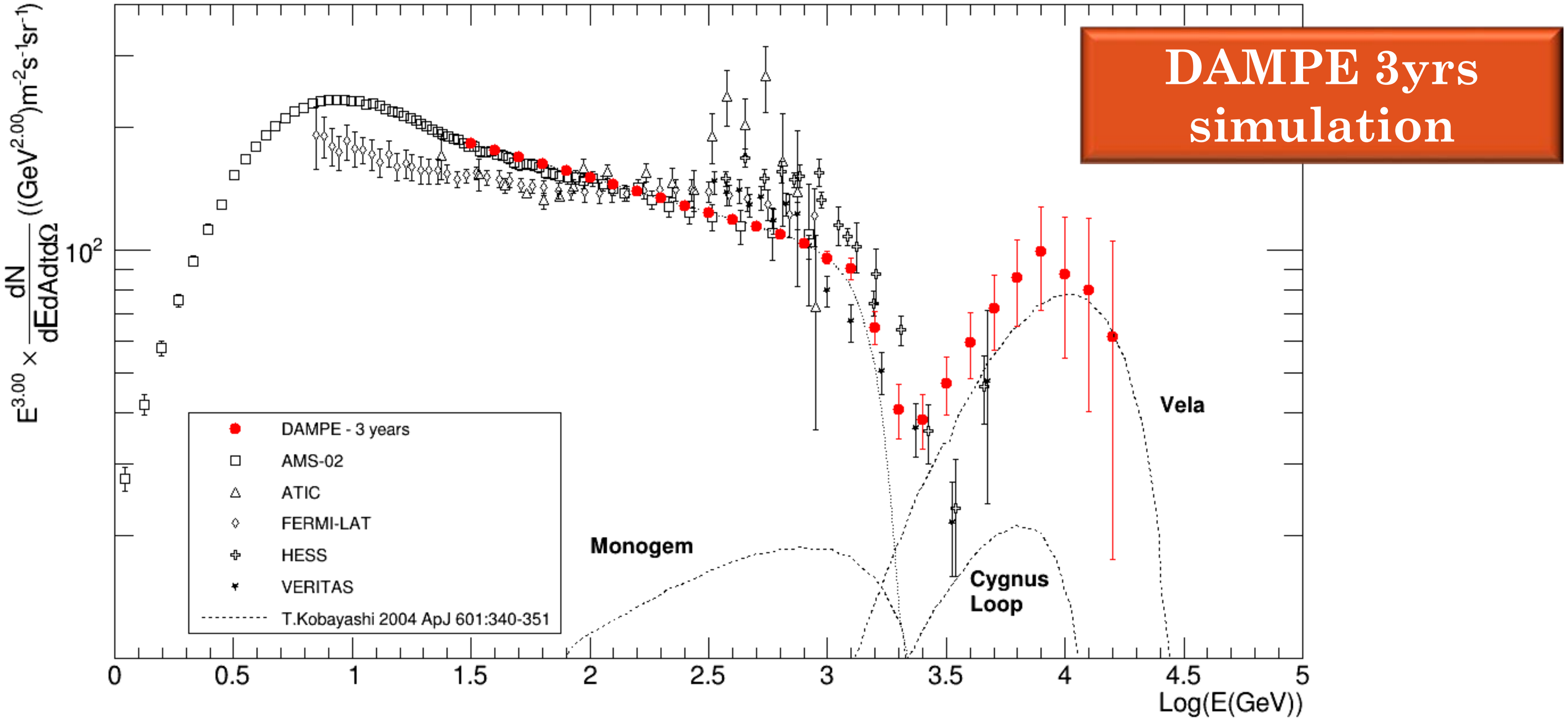
All-electron spectrum

- Measure the all-electron flux up to about 10TeV
- Measure with high accuracy the sub-TeV region and the possible cut-off around 1 TeV
- Detect structures in the spectrum due to nearby sources and/or DM induced excesses
- Detect anisotropies at high energy



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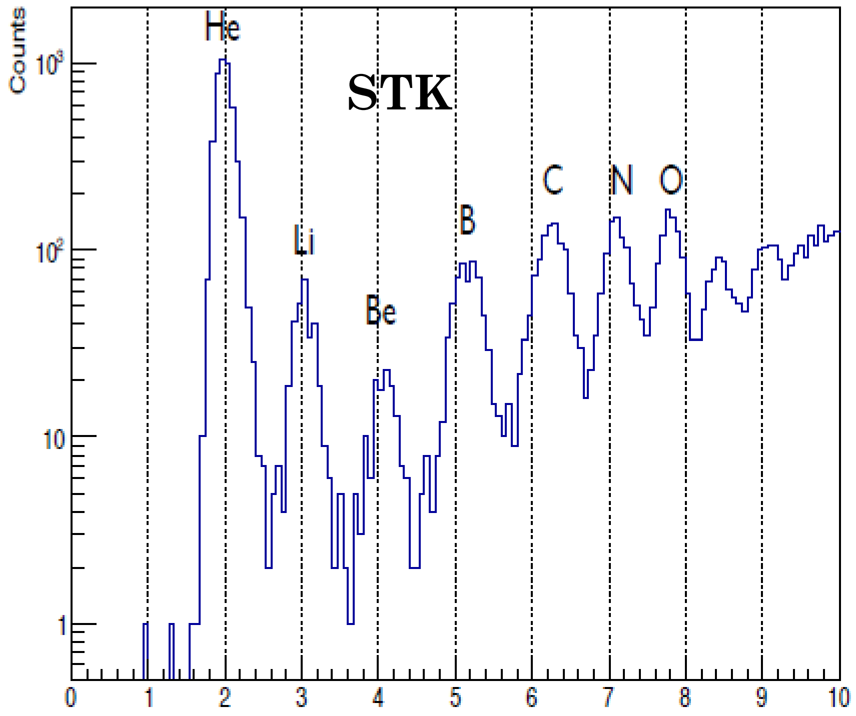
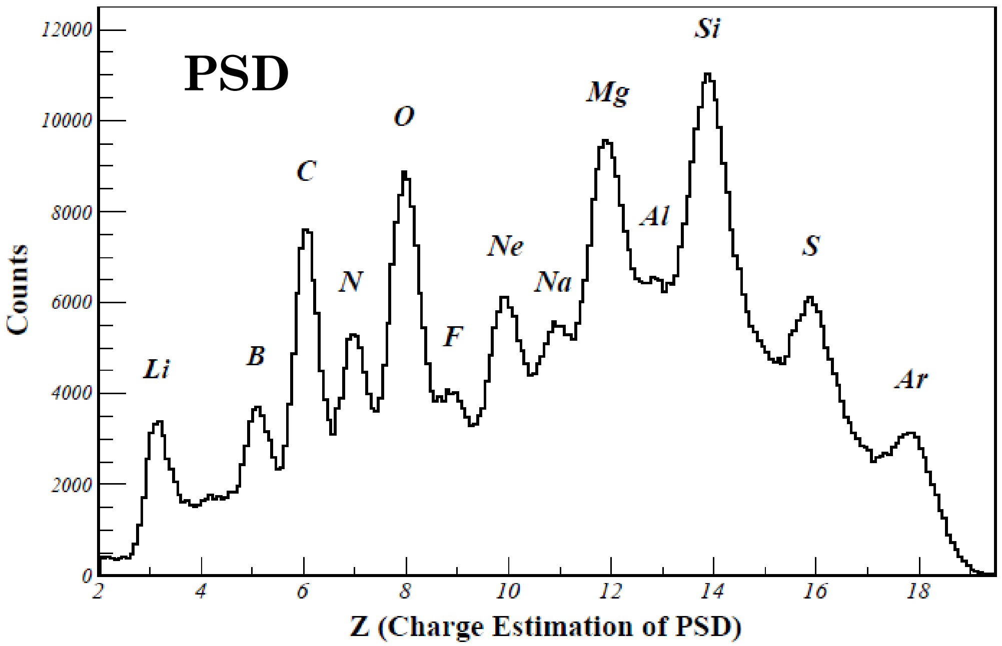
Protons and nuclei – Beam test

Identifying protons and nuclei with PSD and STK

Lead beam 40 GeV/n



Argon beam 40 GeV/n



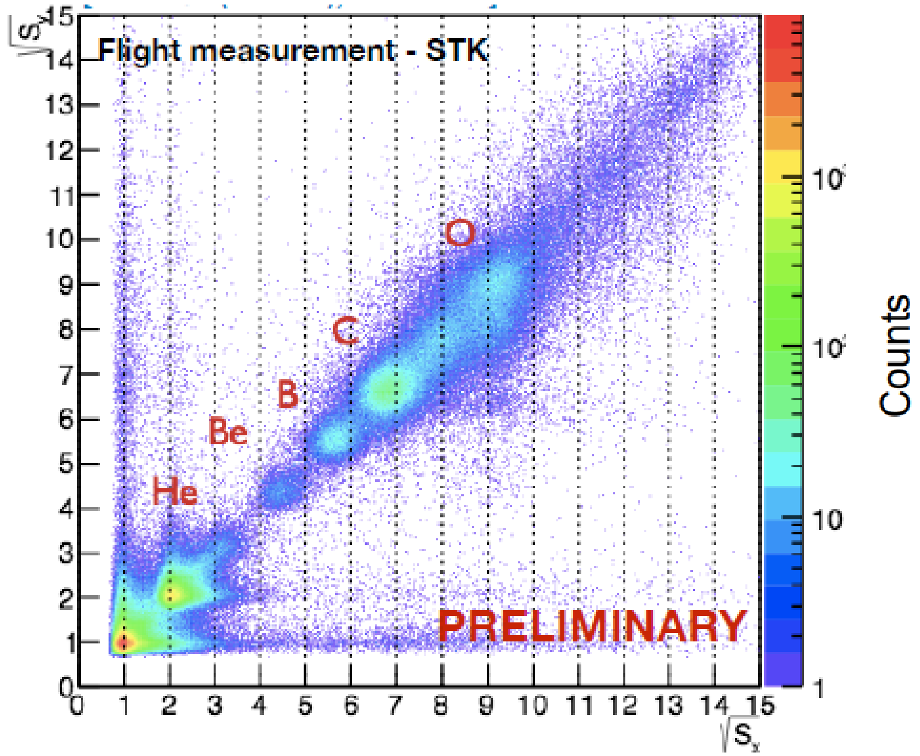
Charge measurement is done with **STK** up to Oxigen and with PSD from protons up to Iron

Charge resolution is Z dependent and ranges from 0.2 to 0.4

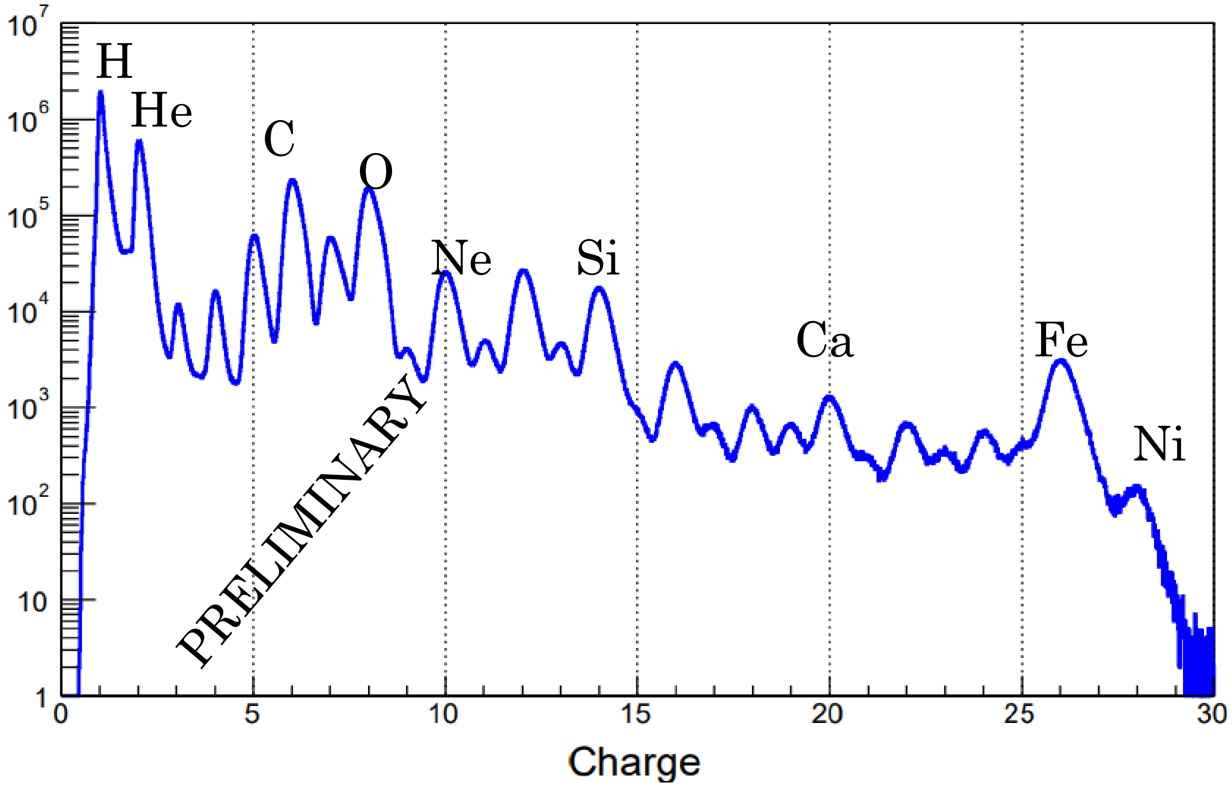
Protons and nuclei – Flight data

Identifying protons and nuclei with PSD and STK

STK

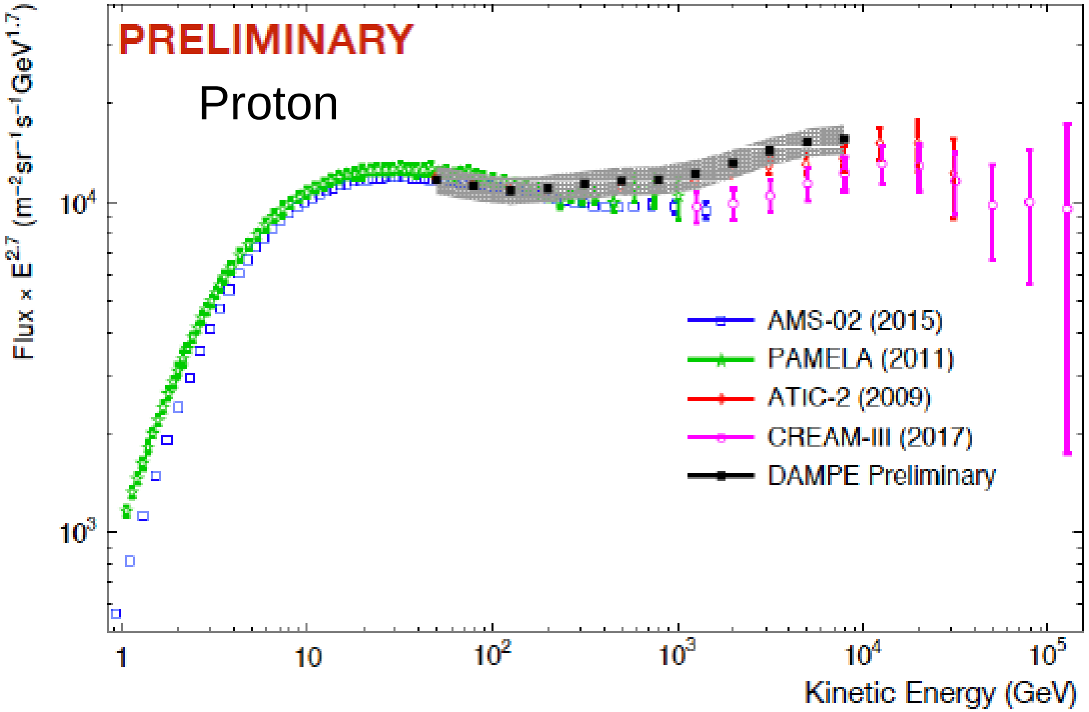


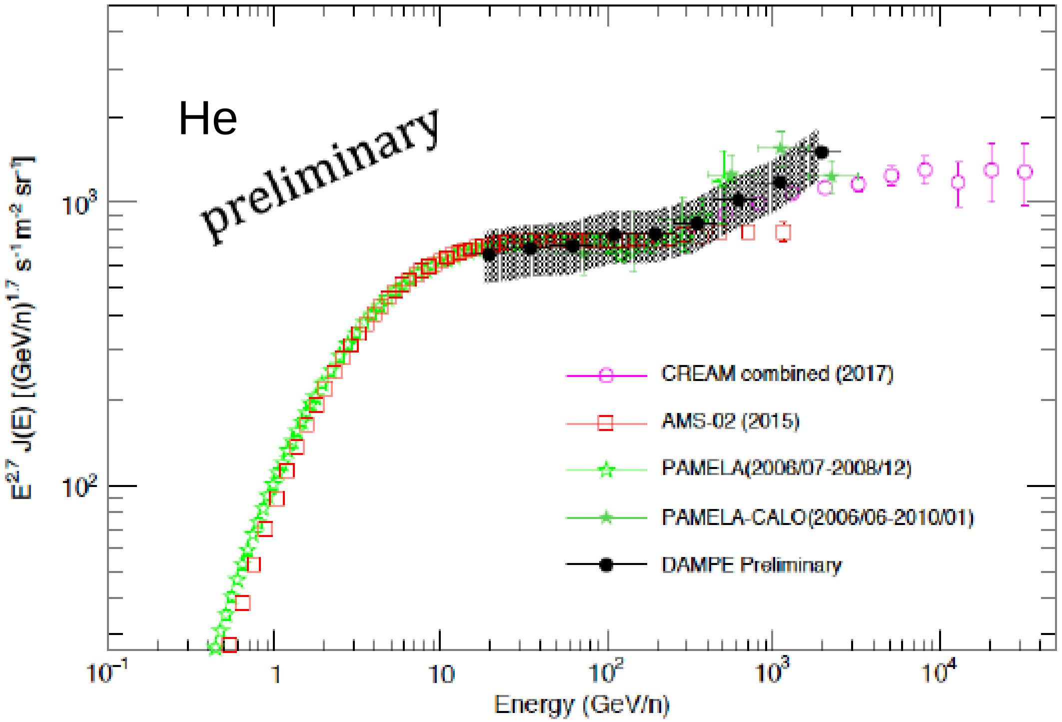
PSD



Charge resolution
H 0.13
Fe 0.32

Protons and nuclei – First spectra



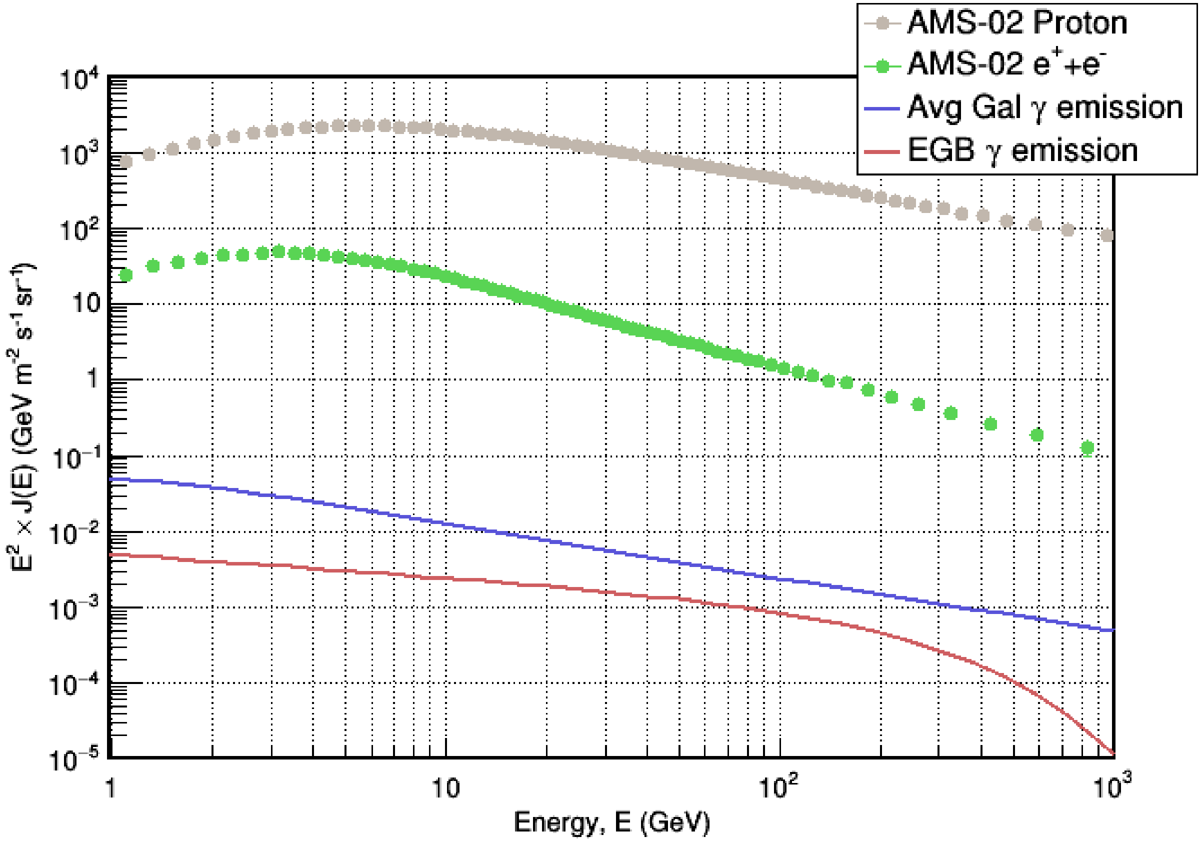


- template fits to account for He background
- spectral hardening at E>200 GeV

- well in agreement with previous experiments
- currently extending analysis to higher energies

Photons: Selection

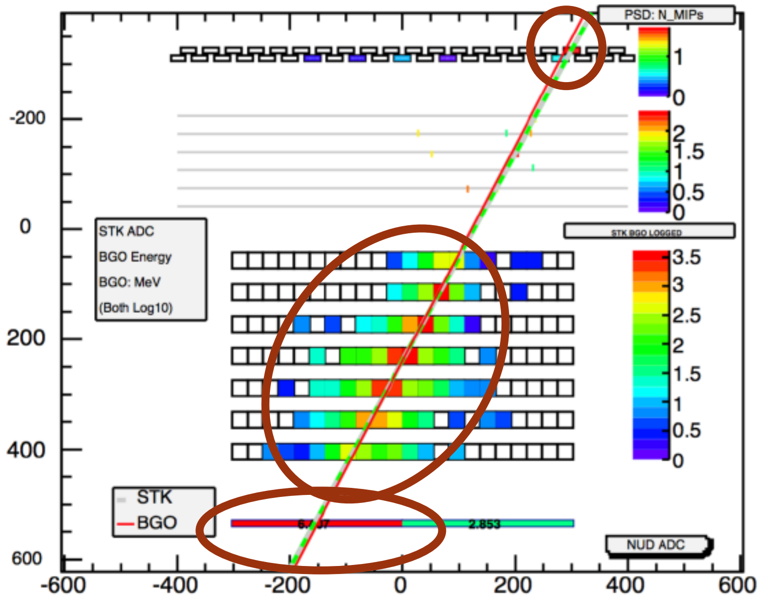
- The main background sources are protons and electrons
  - Protons: 10^5 @ E > 100GeV
  - Electrons: 10^3 @ E > 100GeV
- Protons
  - Are mainly rejected using the shower profile and the onboard trigger
- Electrons
  - Are mainly rejected using the PSD and 1st layer of STK
  - Main problem is back scattering at high energy



Photons: Selection

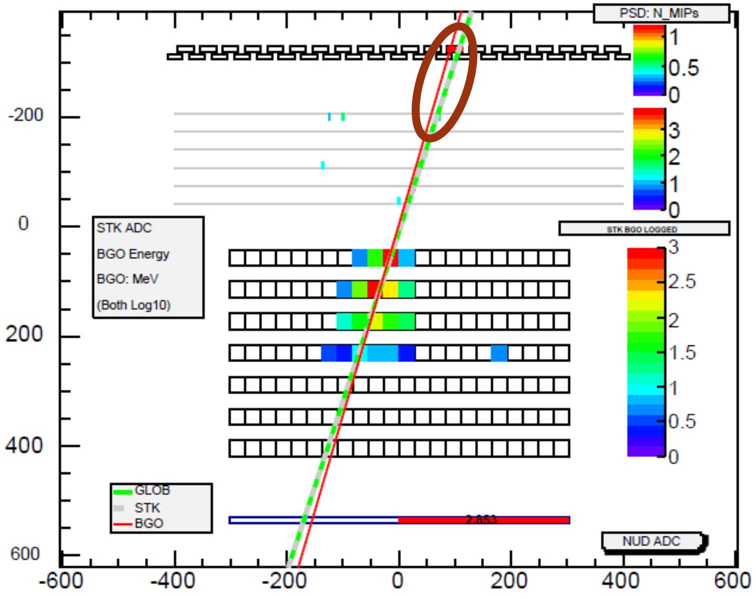
proton

Y [No. 32: 49.132GeV]



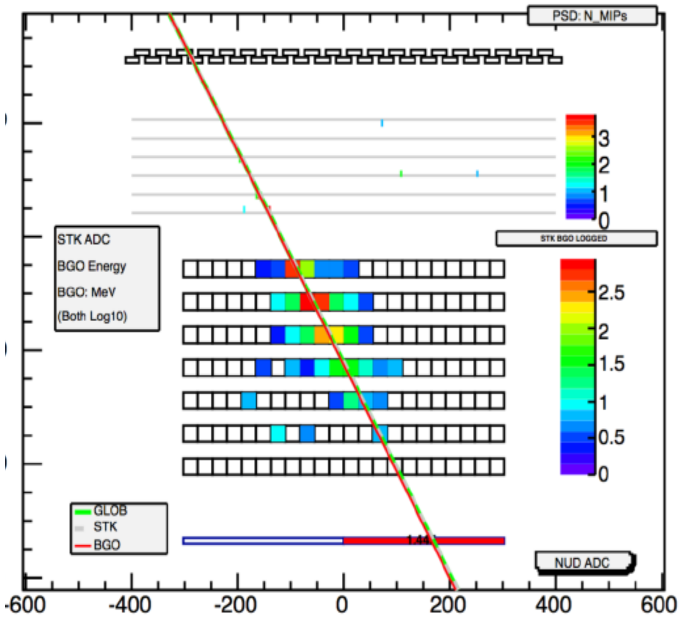
electron

Y [No. 40: 5.034GeV]



gamma

Y [No. 61: 5.559GeV]



PSD, BGO shower profile and NUD allow to reach a rejection > 10^7 for hadrons

PSD and STK allow to reach a rejection of 10^3 for electrons

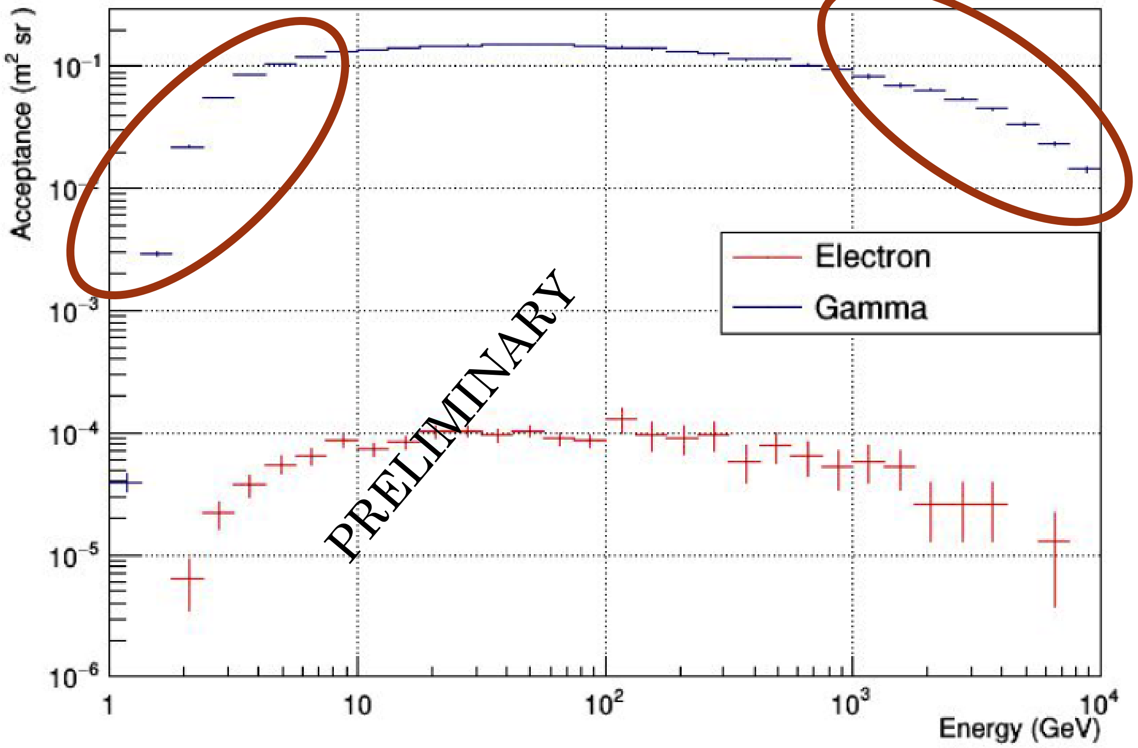
Random **F**orest + **C**onvolutional **N**eural **N**etwork are used for PID

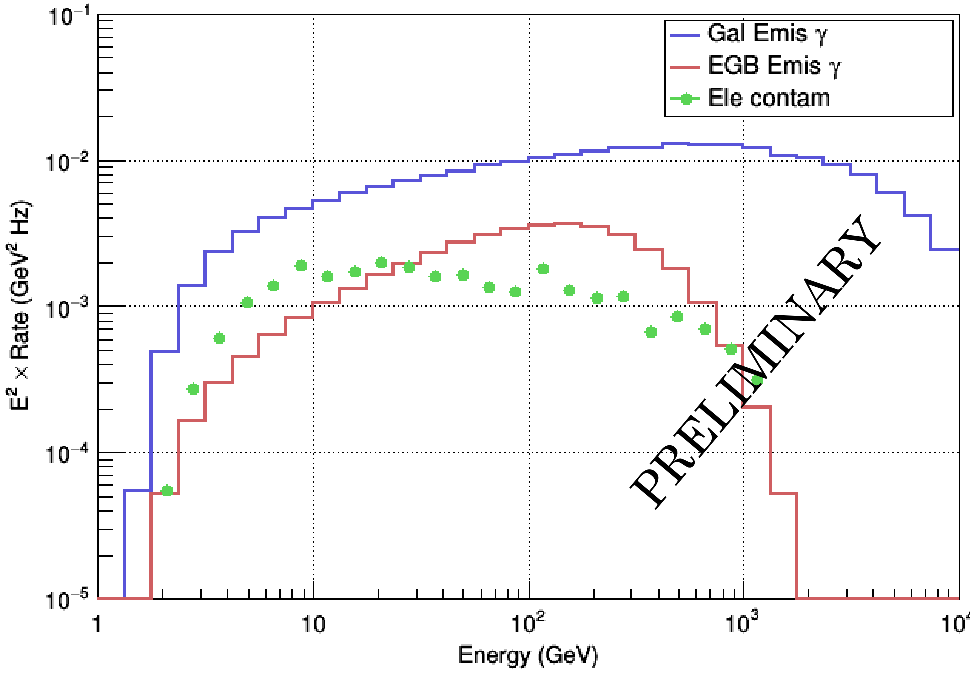
Photons: Selection

- Acceptance after the selection criteria applied to reject protons and electrons

Trigger effect

Backscattering effect

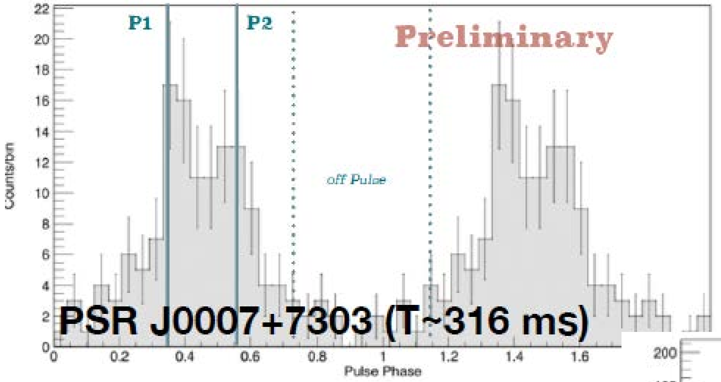




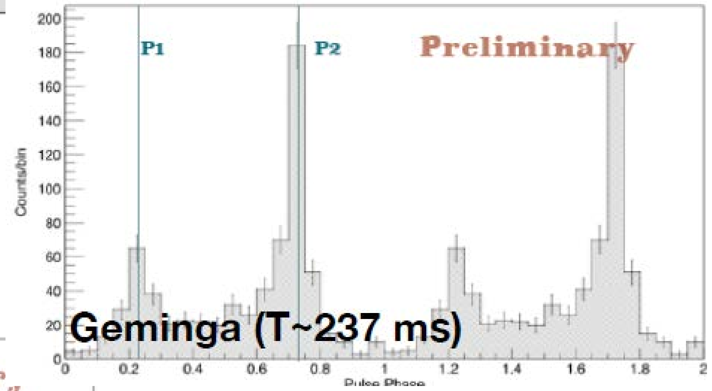
Expected rate w/ selection criteria applied

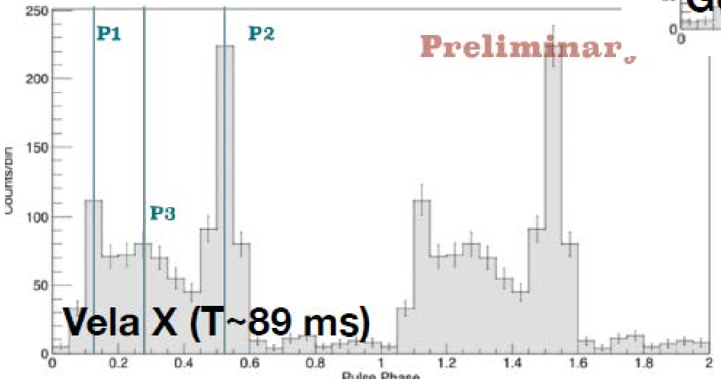
Other PID algorithm are under study to further decrease the electrons contamination at a level below the Extra Galactic Background emission

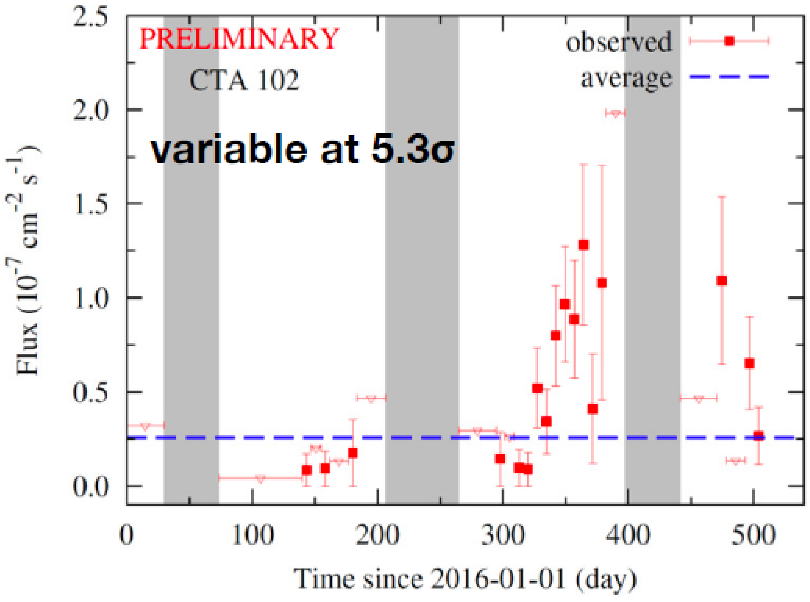
Photons: First results on timing
Pulsars and variability



Very good agreement with Fermi and Agile data







DAMPE detection of variable GeV gamma-ray emission from blazar CTA 102

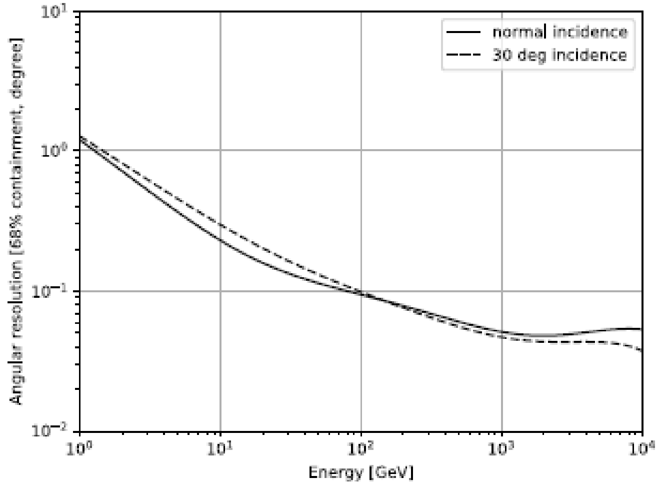
ATel #9901; *Zun-Lei Xu (PMO), Micaela Caragiulo (Bari), Jin Chang (PMO), Kai-Kai Duan (PMO), Yi-Zhong Fan (PMO), Fabio Gargano (Bari), Shi-Jun Lei (PMO), Xiang Li (PMO), Yun-Feng Liang (PMO), M. Nicola Mazziotta (Bari), Zhao-Qiang Shen (PMO), Meng Su (HKU/PMO), Andrii Tykhonov (Geneva), Qiang Yuan (PMO), Stephan Zimmer (Geneva), on behalf of the DAMPE collaboration, and Bin Li (PMO) and Hai-Bin Zhao (PMO) on behalf of the CNEOST group.*
on 27 Dec 2016; 01:02 UT
Credential Certification: Zun-Lei Xu (xuzl@pmo.ac.cn)

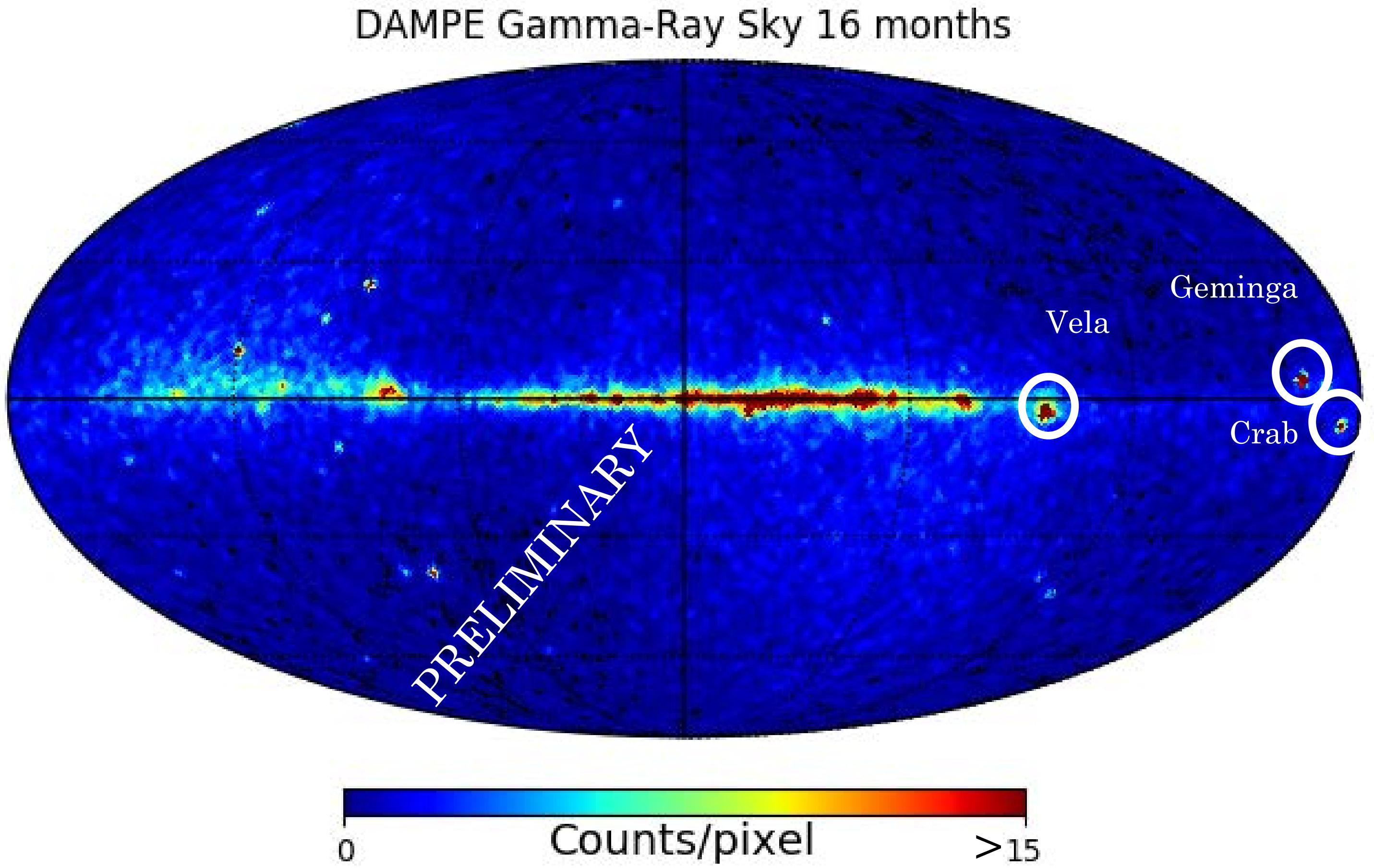
Subjects: Gamma Ray, >GeV, AGN, Blazar, Quasar

Referred to by ATel #: 9924, 10007, 10292

DAMPE Counts map

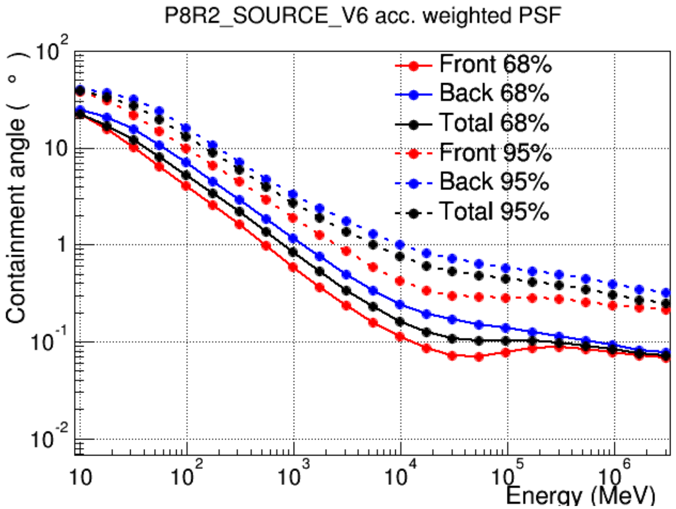
E > 1GeV
16 months

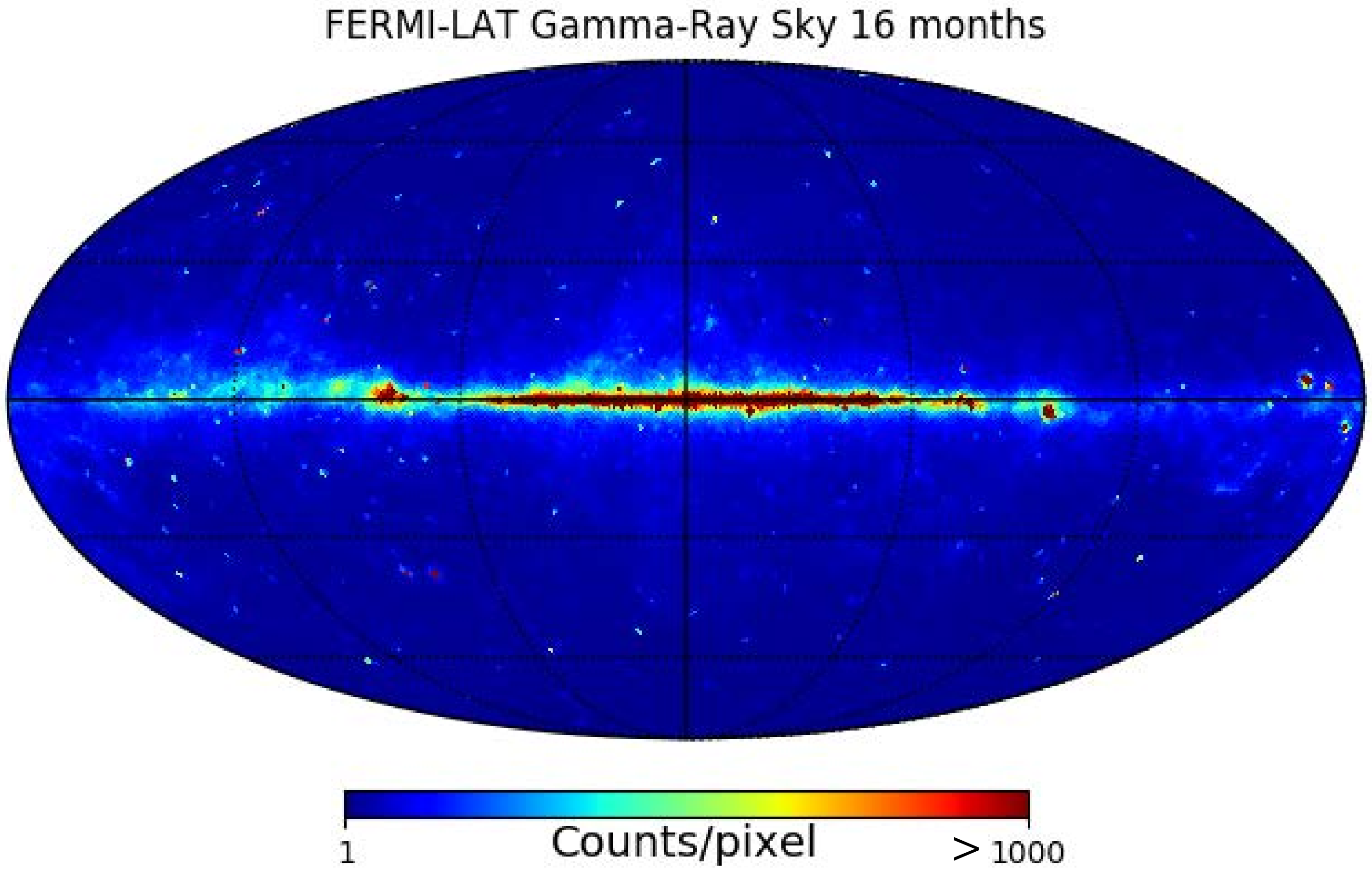




FERMI Counts map

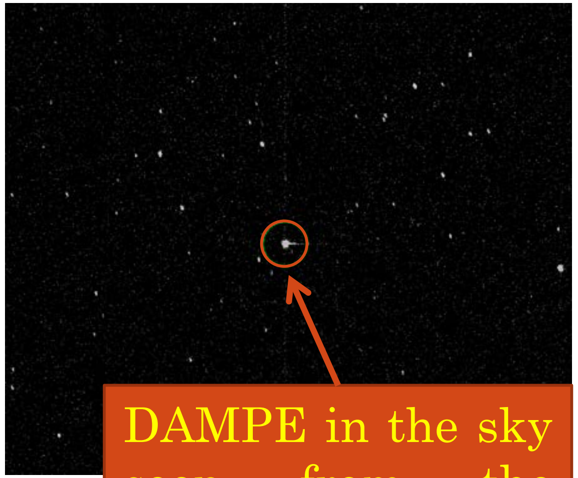
E > 1GeV
16 months





Summary

- **The detector**
  - Large geometric factor (0.3 m^2 sr for electrons)
  - Precision Si-W tracker (40μm spatial resolution, 0.15° angular resolution)
  - Thick calorimeter (32 X_0 , σ_E/E 1% above 100 GeV for e/γ , ~40% for hadrons)
  - "Multiple" charge measurements (20%-40% energy resolution)
  - e/p rejection power > 10^5 (topology alone, plus neutron detector)
- **Launch and performances**
  - Successful launch on Dec 17, 2015
  - On orbit operation steady and with high efficiencies
  - Absolute energy calibration by using the geomagnetic cut-off
  - Absolute pointing cross check by use of the photon map
- **Physics goals**
  - Study of the cosmic electron and photon spectra
  - Study of electron anisotropy and nearby sources contribution
  - Study of cosmic ray protons and nuclei: spectrum and composition
  - Precise measurement of CR discrepant hardenings and spectral indexes
    - Preliminary results well in agreement with other experiments
  - High energy gamma ray astronomy
  - Search for dark matter signatures in lepton spectra
  - The "unexpected": GW electromagnetic follow up in FoV and in the observable energy range



DAMPE in the sky seen from the Earth (China)