Recent results from the DAMPE space mission

Ivan DE MITRI
Gran Sasso Science Institute (GSSI)
& INFN Laboratori Nazionali del Gran Sasso

ISCRA
Third Internationa Symposium on Cosmic Rays and Astrophysics
Moscow (online) , June, 2021

DAMPE science goals

High energy particle detection in space

- Study of the cosmic electron spectra
- Study of cosmic ray protons and nuclei: spectrum and composition
- High energy gamma ray astronomy
- Search for dark matter signatures in lepton spectra

Detection of
10 GeV - 10 TeV e/γ
50 GeV - 200 TeV protons and nuclei
with excellent energy resolution , tracking precision and particle identification capabilities

- Exotica and “unexpected” , e.g. GW e.m. counterpart in the FoV

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 Bari and University of Bari
  - INFN Lecce and University of Salento
  - INFN LNGS and Gran Sasso Science Institute
  - INFN Perugia and University of Perugia

- **SWITZERLAND**
  - University of Geneva

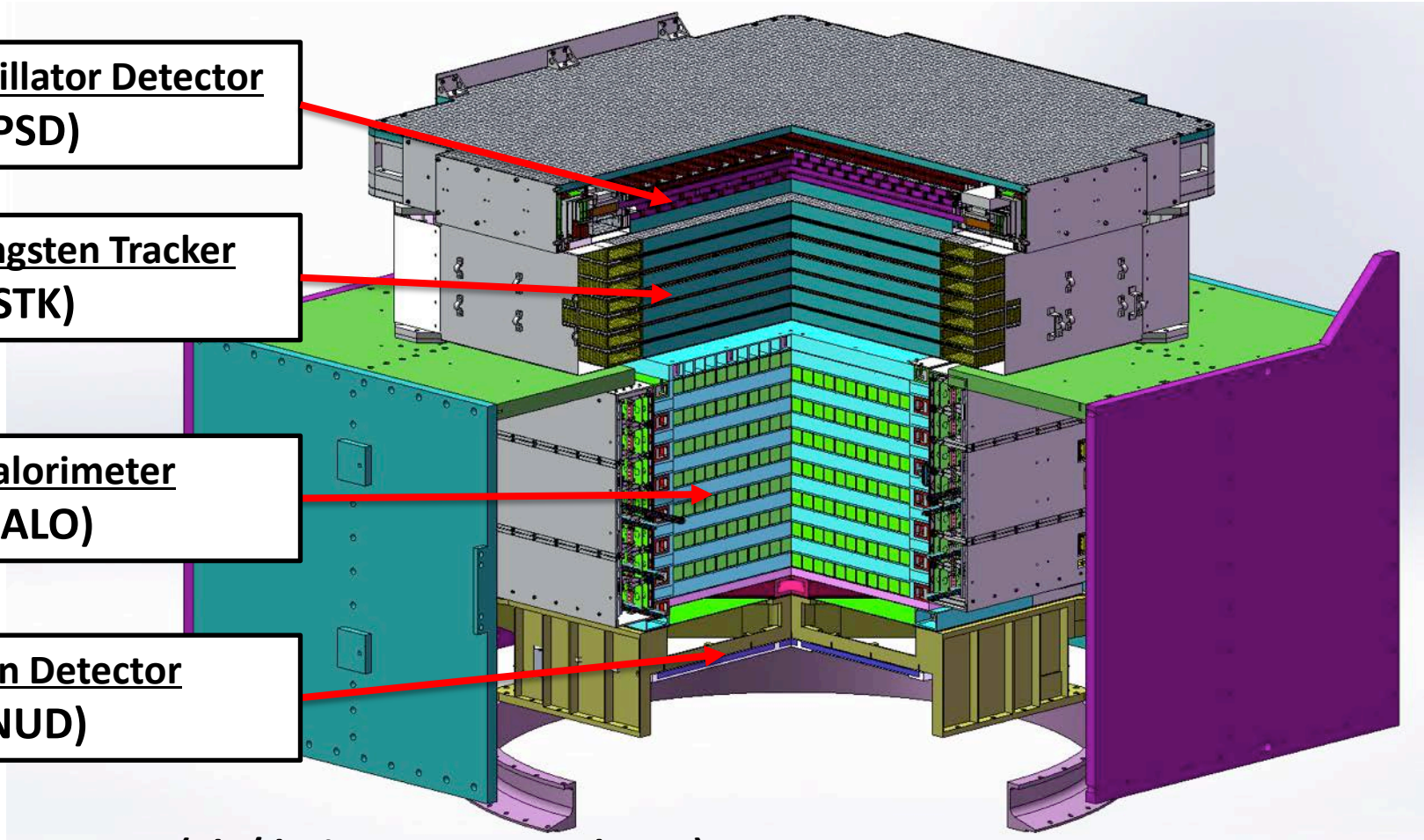
The detector

Plastic Scintillator Detector (PSD)

Silicon-Tungsten Tracker (STK)

BGO Calorimeter (CALO)

Neutron Detector (NUD)

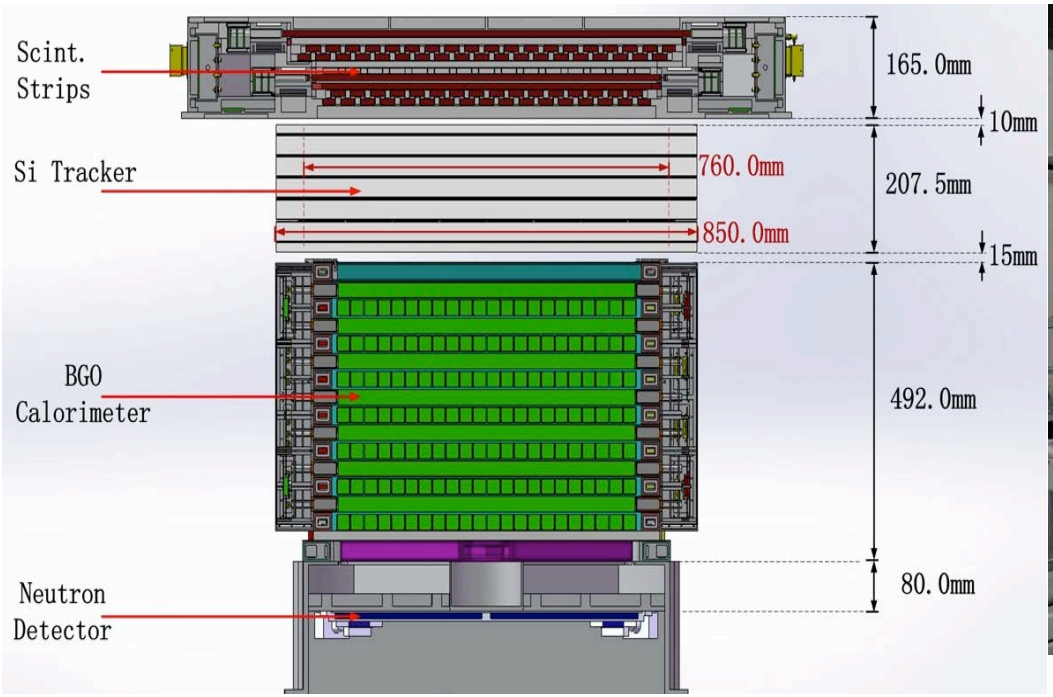


- **Charge measurement (dE/dx in PSD , STK and BGO)**
- **Tungsten converter (pair production)**
- **Precise tracking (silicon strips)**
- **Thick calorimeter (BGO bars)**
- **Hadron rejection (neutron detector)**

high energy
γ-ray, electron and cosmic ray
telescope

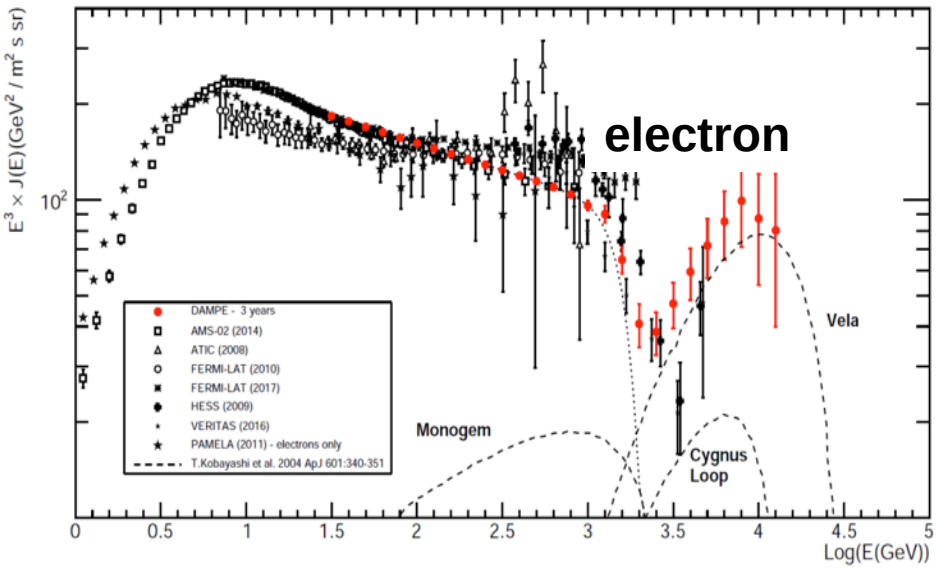
Comparison with AMS-02 and FERMI

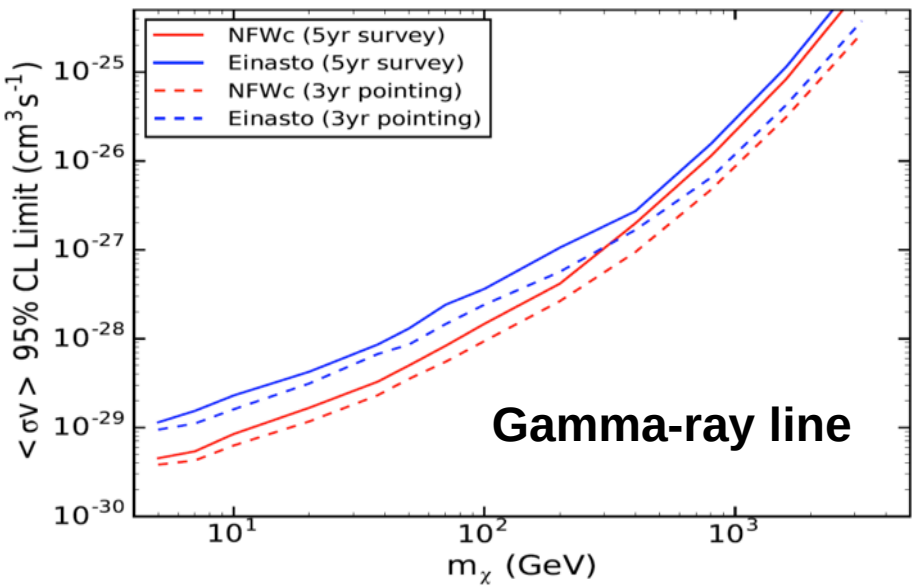
	DAMPE	AMS-02	Fermi LAT
e/γ Energy res.@100 GeV (%)	**1.2**	3	10
e/γ Angular res.@100 GeV (deg)	0.2	0.3	0.1
e/p discrimination	10^5-10^6	10^5 - 10^6	10^3
Calorimeter thickness (X_0)	**32**	17	8.6
Geometrical accep. (m^2sr)	**0.3**	0.09	1

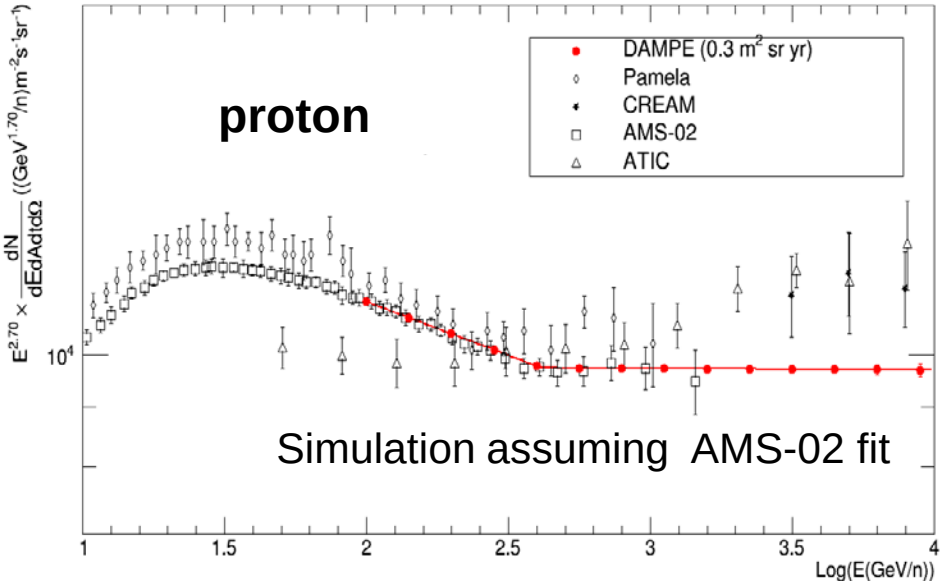


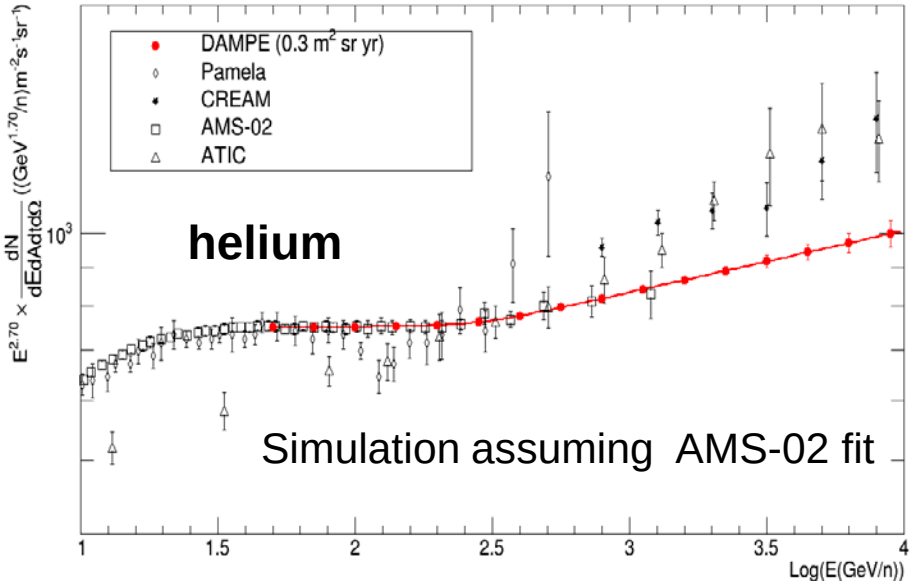
Mass: 1400 Kg
Power: ~ 400 W
Livetime: > 3 years

Expected performances



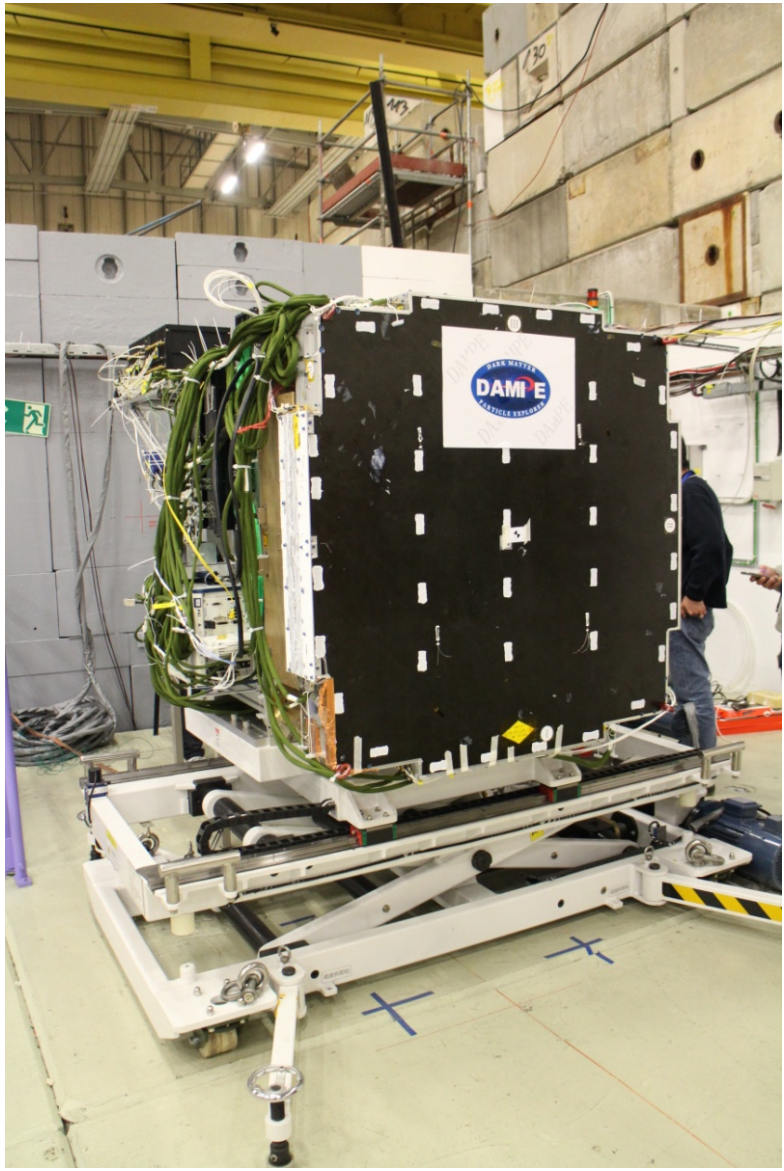




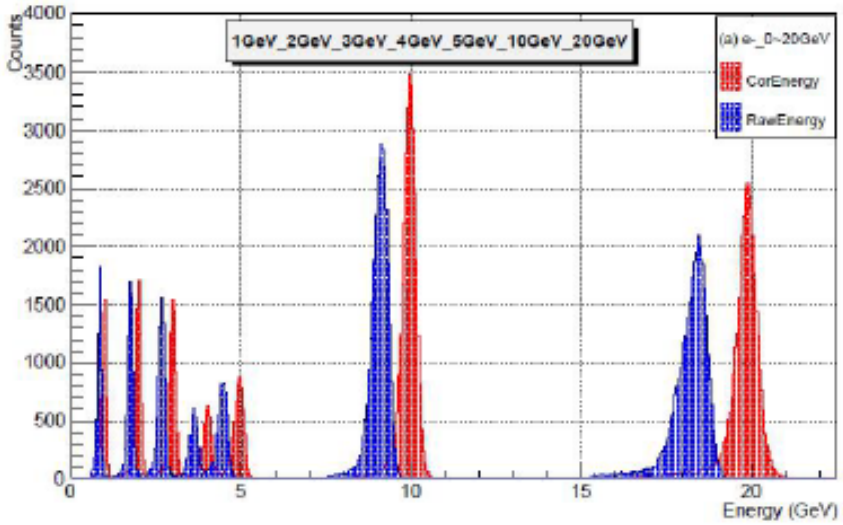


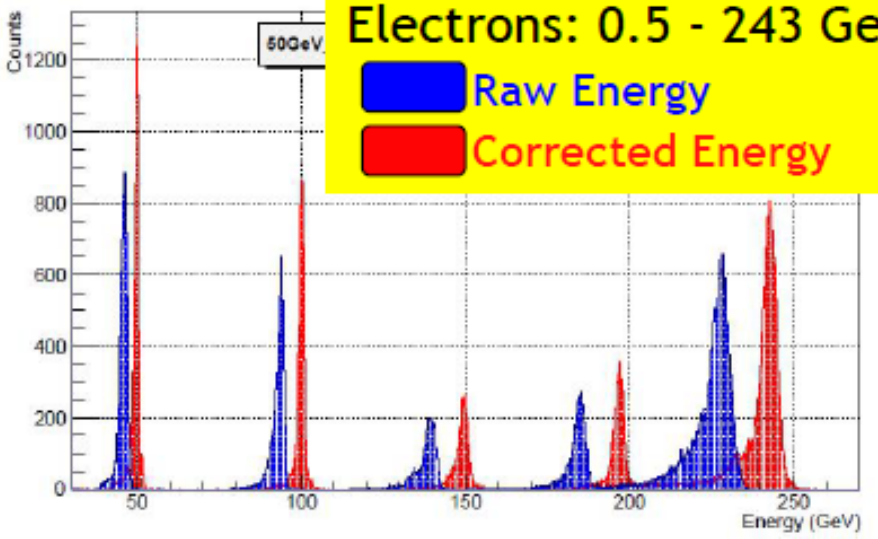
Test beam activity at CERN

- 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 030 AGeV/c (and fragments)



Test beam activity at CERN

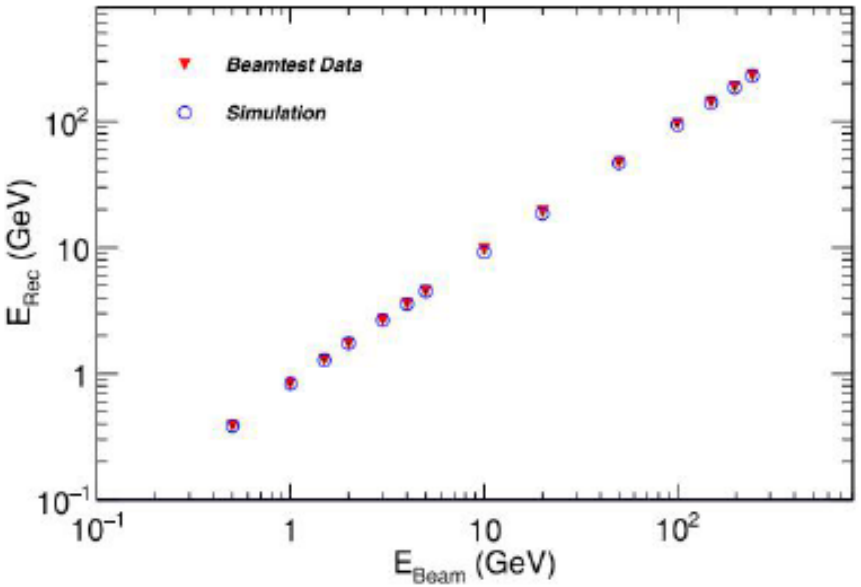


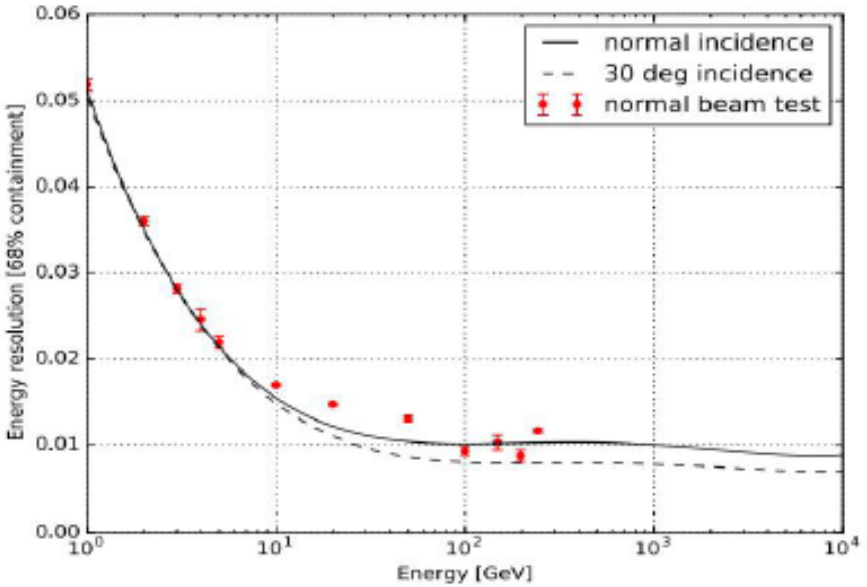


Electrons: 0.5 - 243 GeV

Raw Energy

Corrected Energy



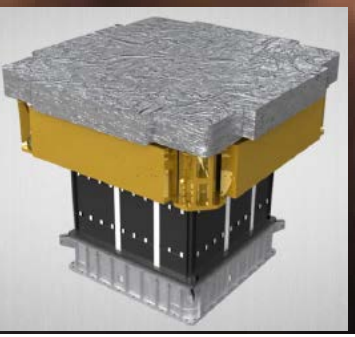


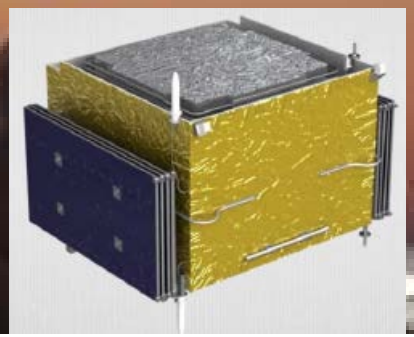
The launch: Dec 17th 2015, 0:12 UTC

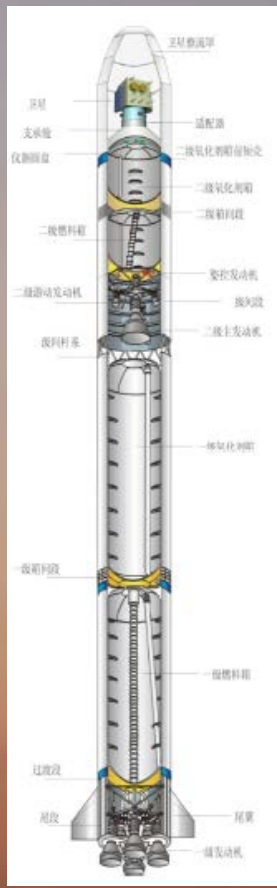
Jiuquan Satellite Launch Center
Gobi desert

CZ-2D rocket

Mass: 1850 kg (scientific payload 1400 kg)
Power : 640 W (scientific payolad 400 W)
Orbit: sun syncronous
Altitude: 500km
Inclination: 97.41˚
Period: 95 minutes
Downlink: 16 GB / day
Lifetime: > 3 years

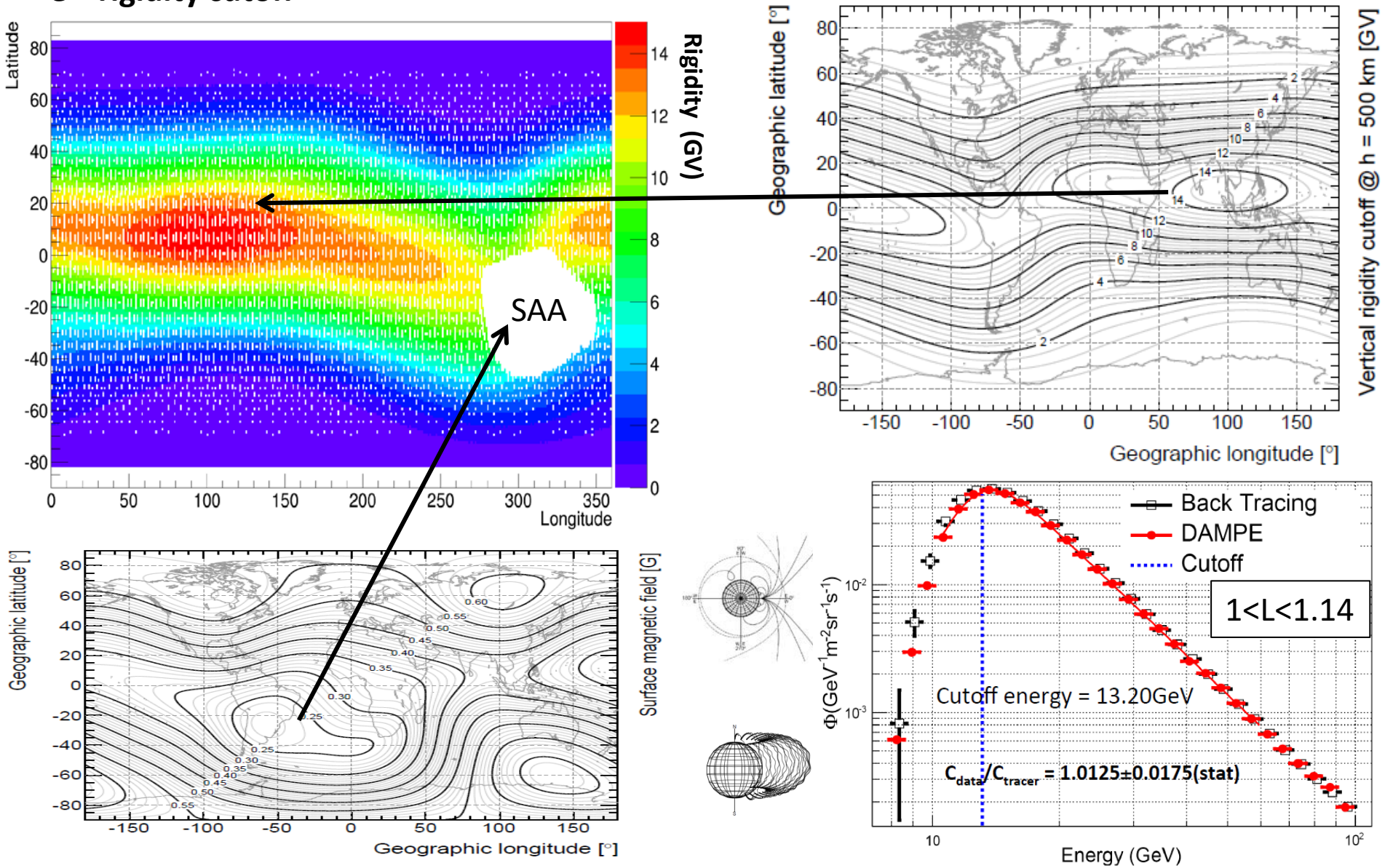






On-orbit energy scale calibration

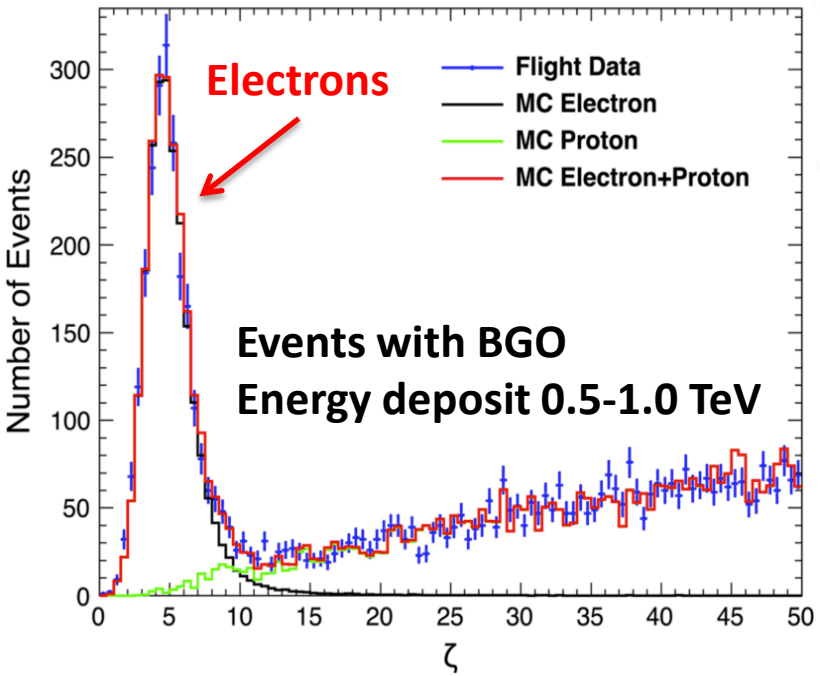
$e^{\pm}$ rigidity cutoff

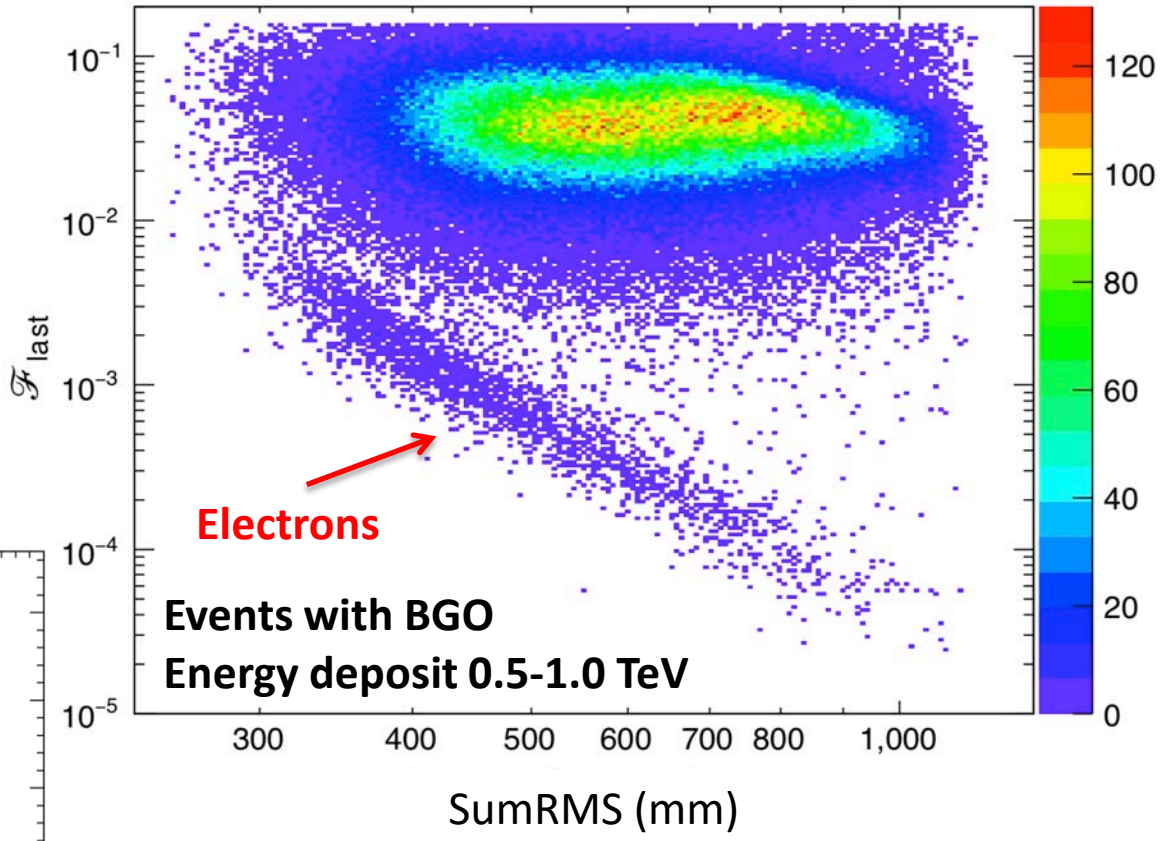


Electron IDentification

$\mathcal{F}_{\text{last}}$ = fraction of energy deposit in the last BGO layer with hits

$$RMS_i = \sqrt{\frac{\sum_j (x_{j,i} - x_{c,i})^2 E_{j,i}}{\sum_j E_{j,i}}}$$





SumRMS = Sum of single layer RMS values

$$\zeta = \mathcal{F}_{\text{last}} \times (\Sigma_i RMS_i/\text{mm})^4/(8 \times 10^6)$$

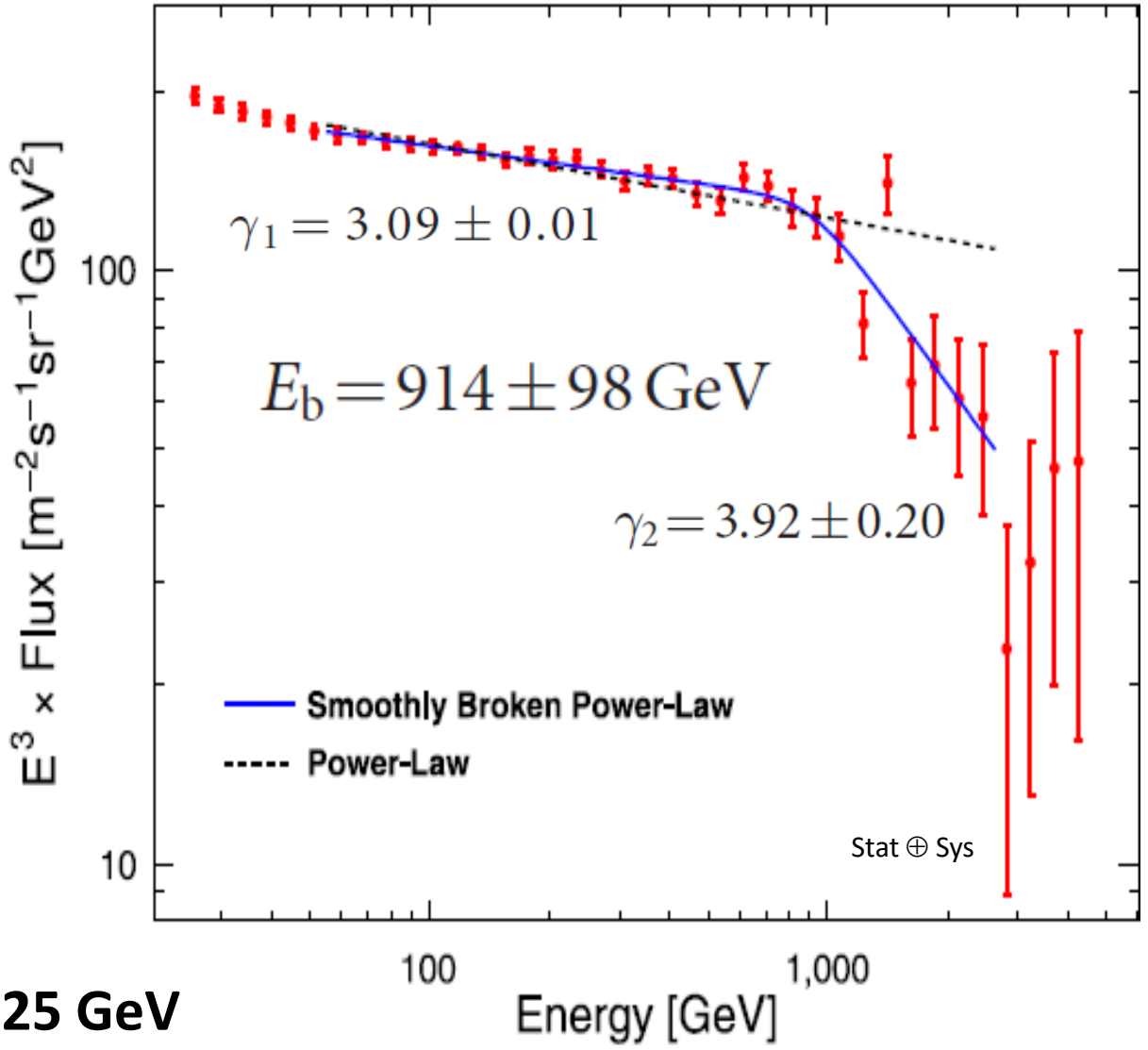
The DAMPE (e^++e^-) spectrum

LETTER nature International weekly journal of science :10.1038/nature24475

Direct detection of a break in the teraelectronvolt cosmic-ray spectrum of electrons and positrons

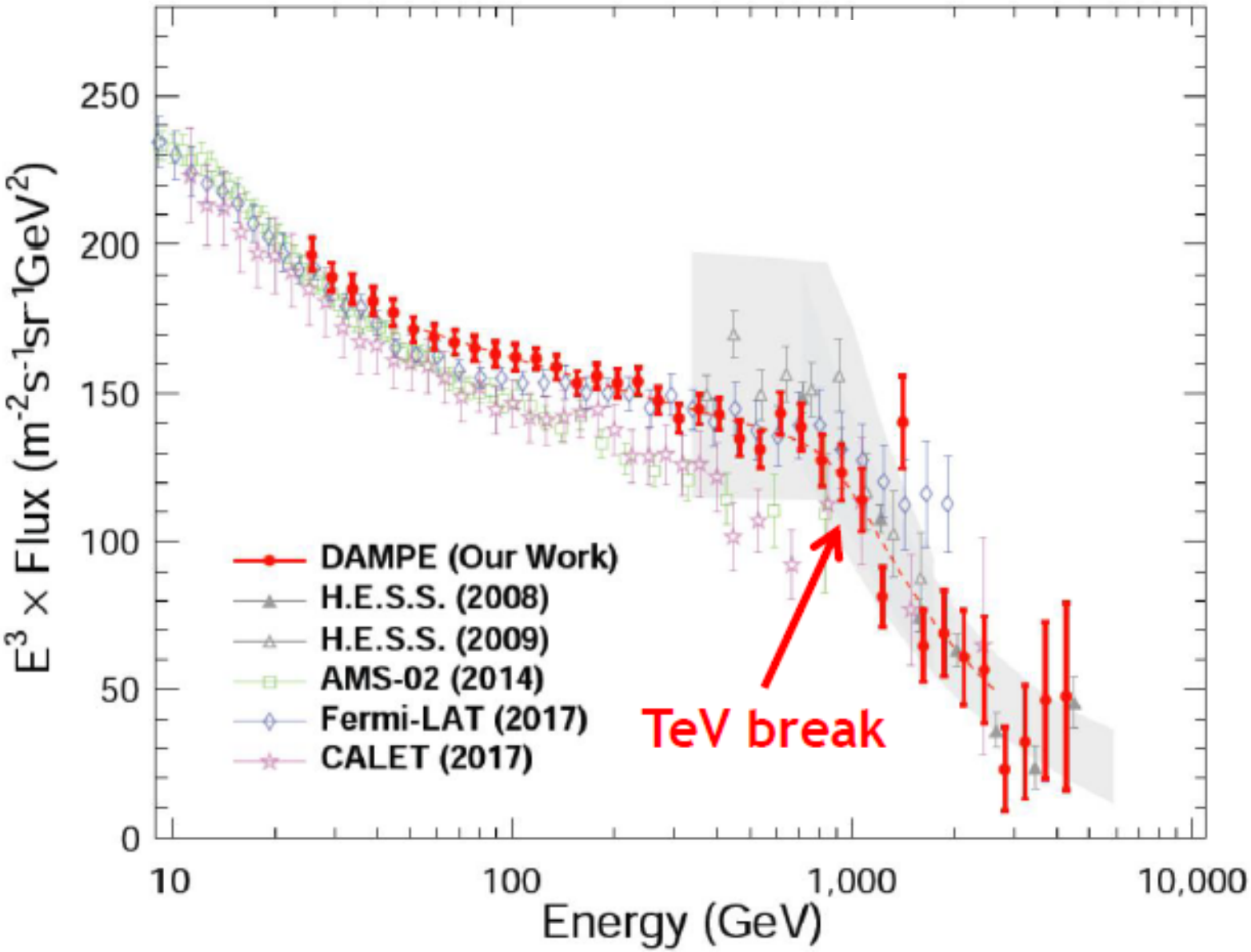
DAMPE Collaboration*

First Direct Evidence for a spectral break in the all-electron spectrum at 0.9 TeV

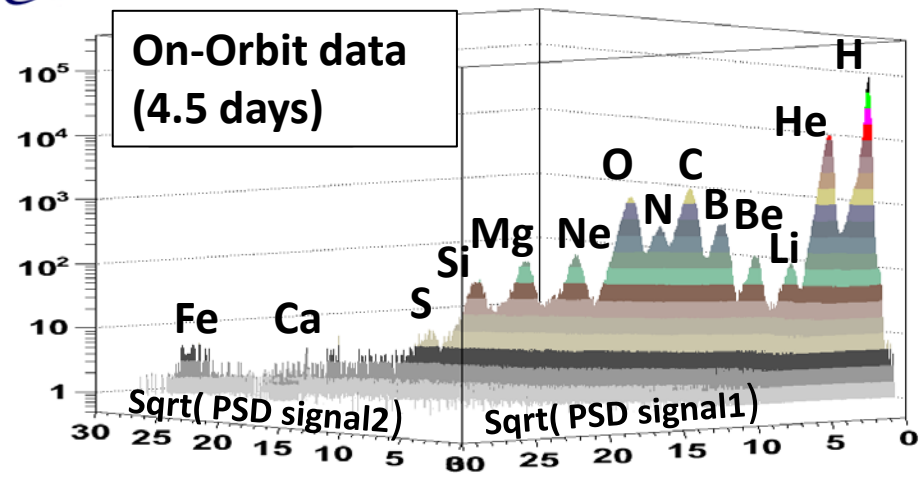


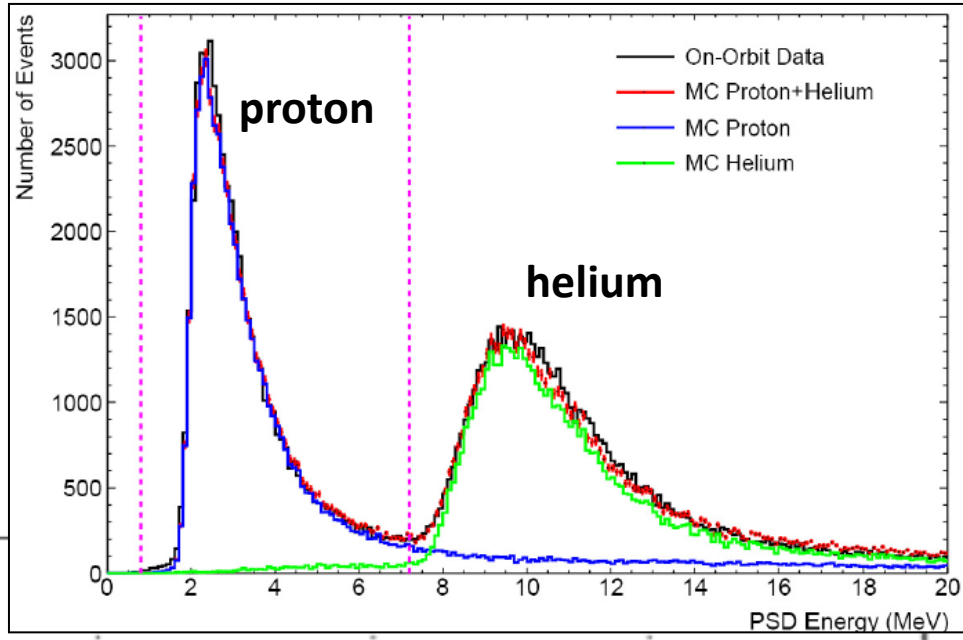
- 530 days
- 2.8 billions CR events
- 1.5 million CREs above 25 GeV

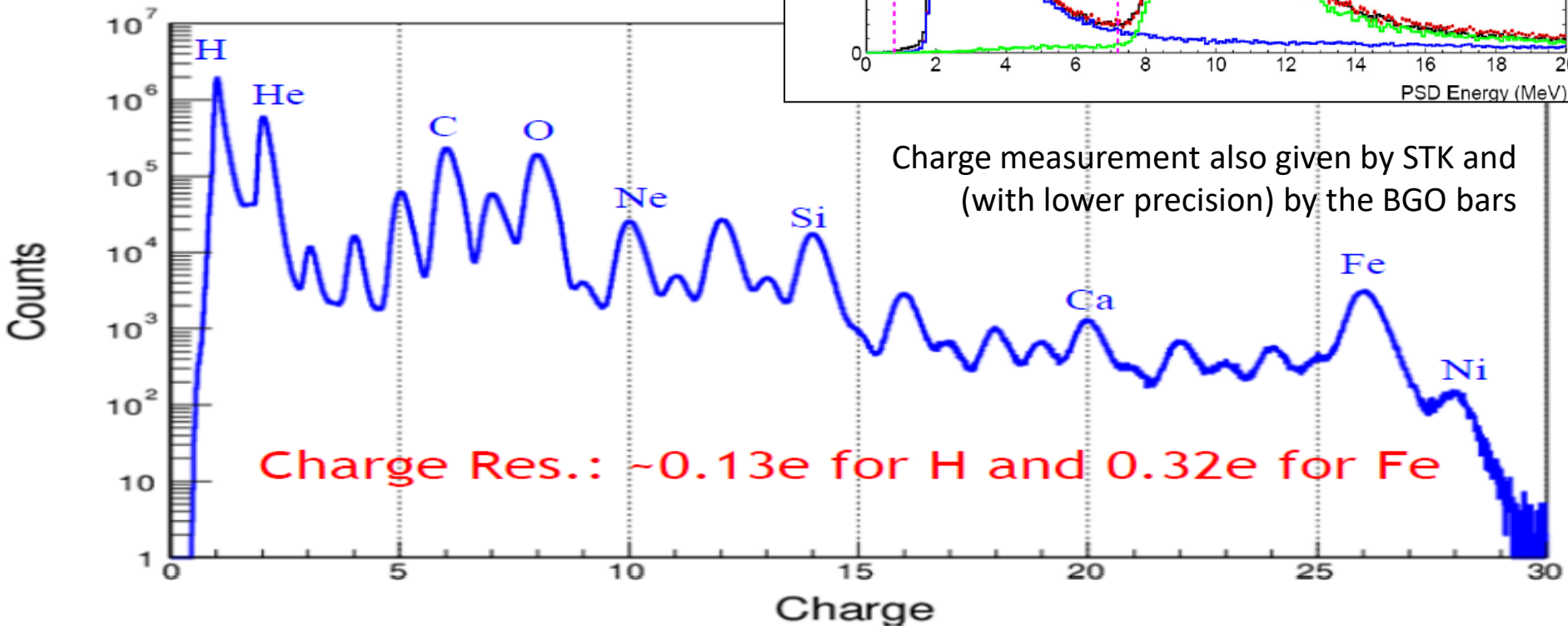
The all-electron spectrum



Nuclei ID with PSD







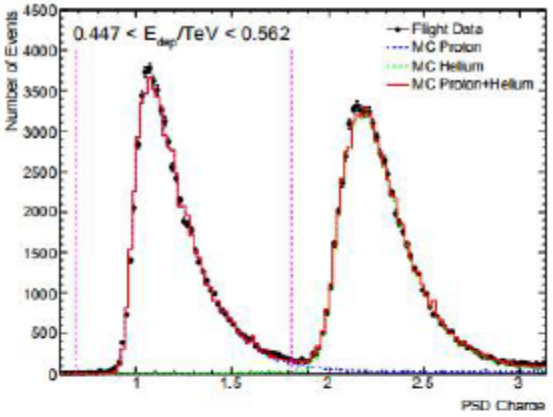
Charge measurement also given by STK and (with lower precision) by the BGO bars

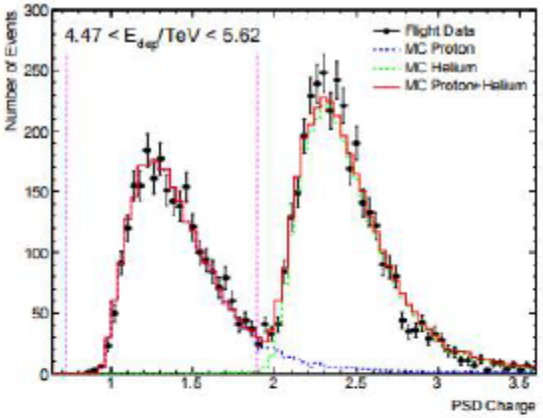
The DAMPE proton spectrum

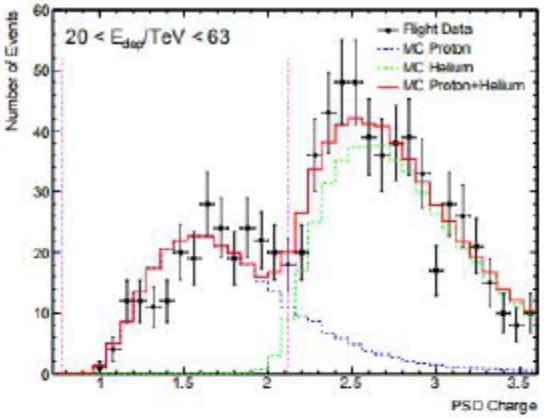
SCIENCE ADVANCES | RESEARCH ARTICLE

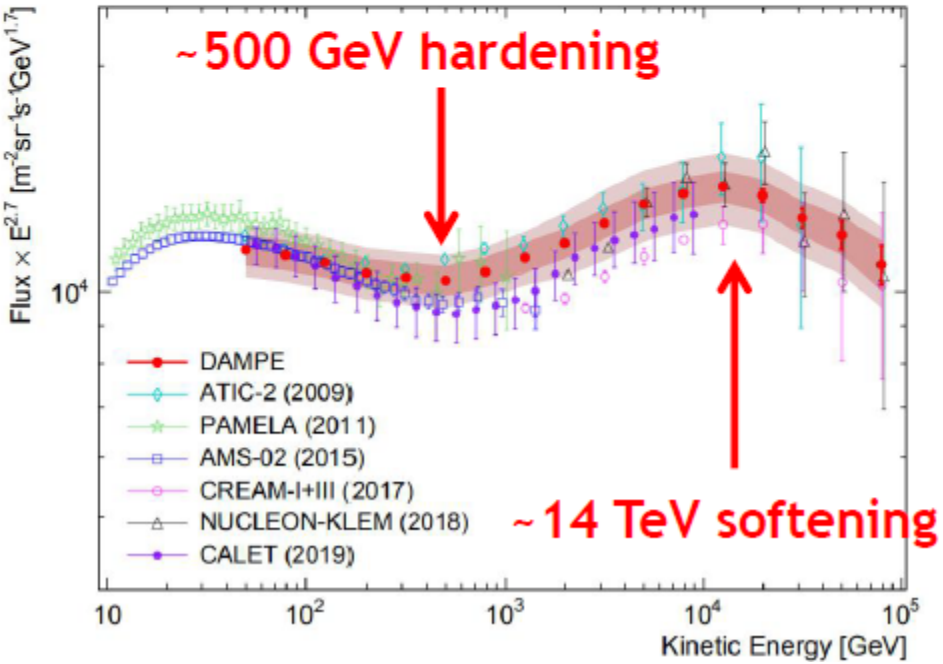
PHYSICS

Measurement of the cosmic ray proton spectrum from 40 GeV to 100 TeV with the DAMPE satellite



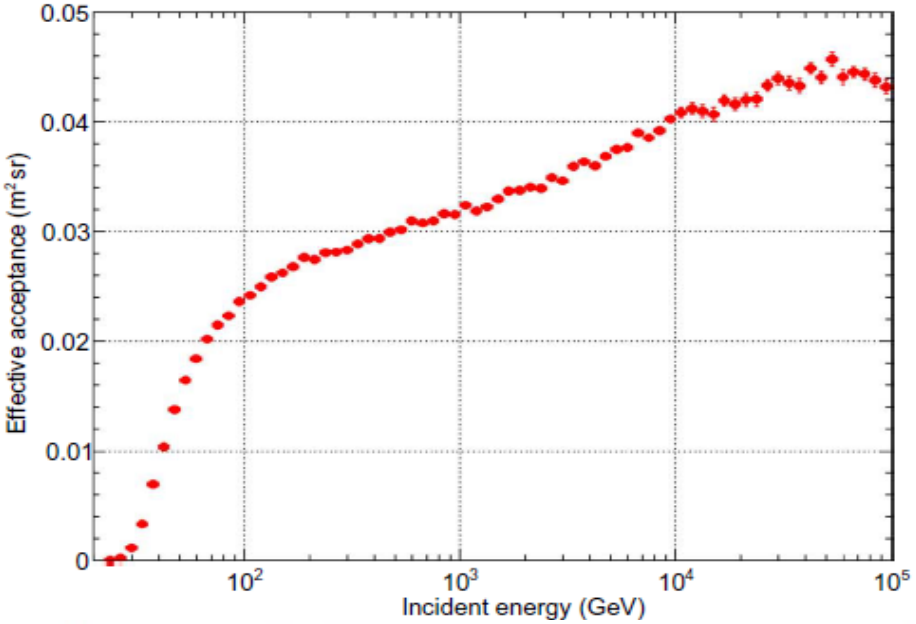


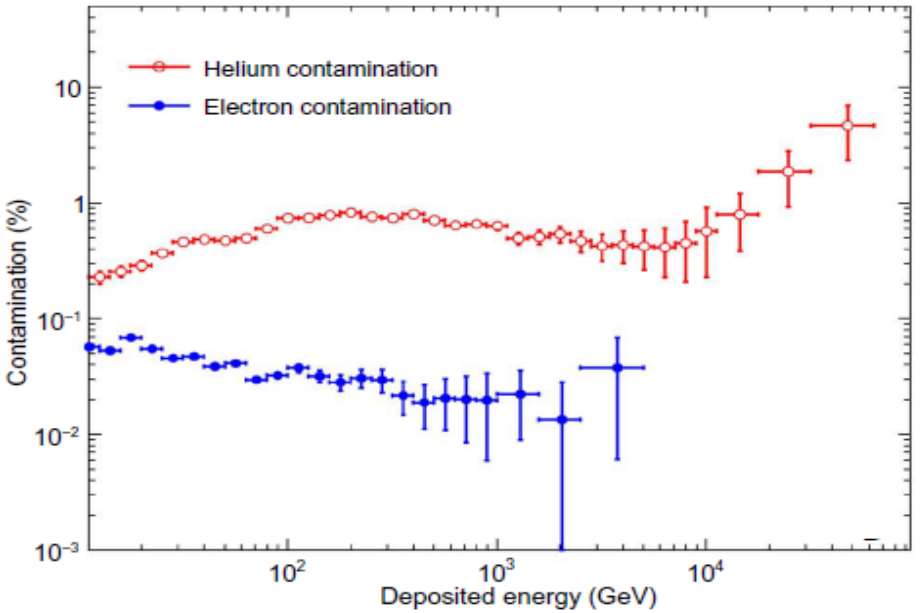


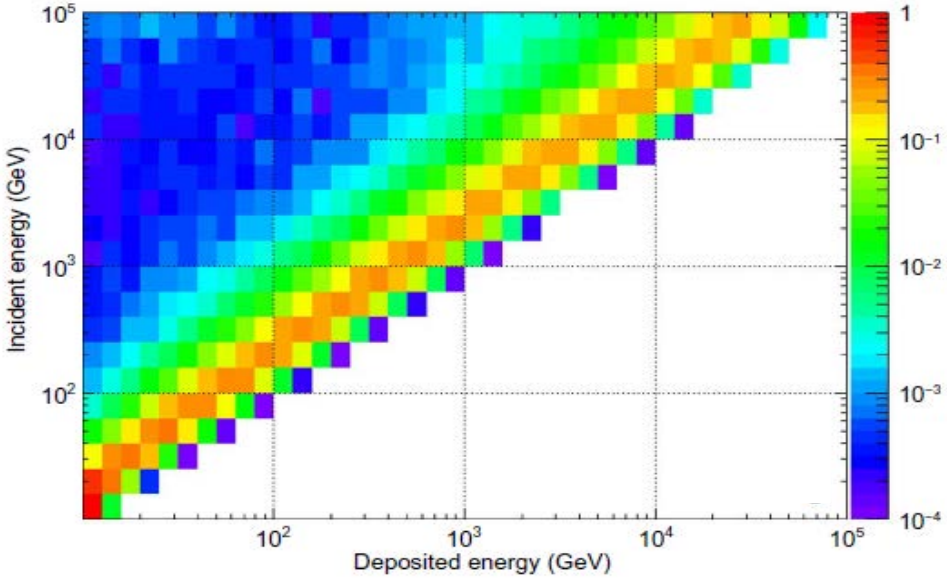


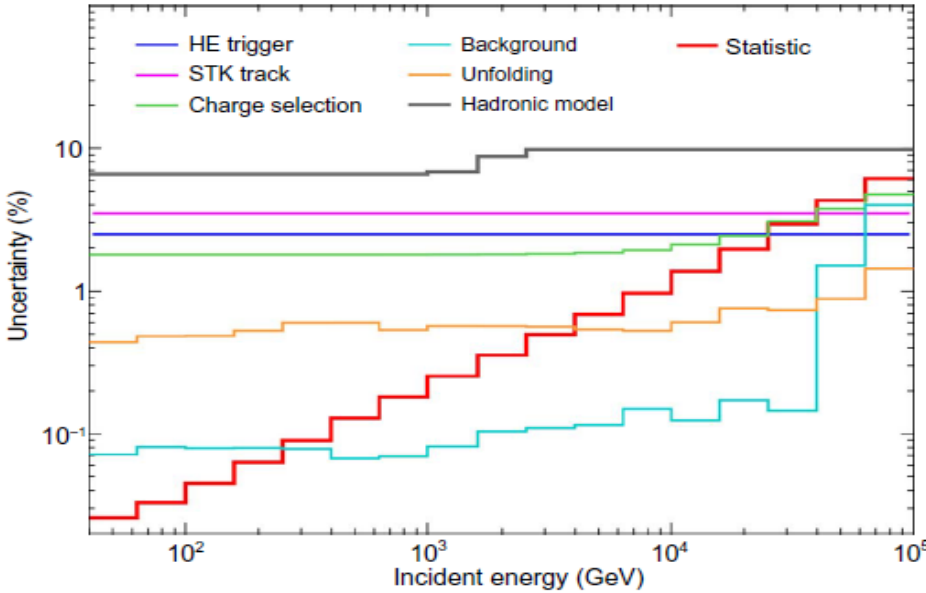
- Confirms the hundreds of GeV hardening
- Detecting a softening at ~14 TeV with high significance

The DAMPE proton spectrum

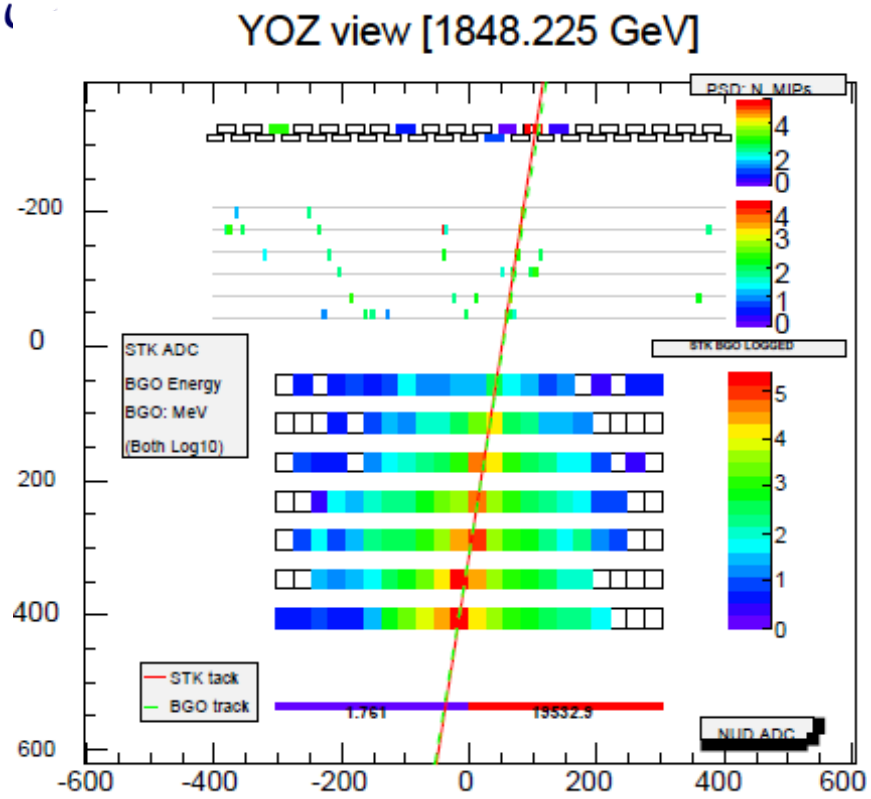


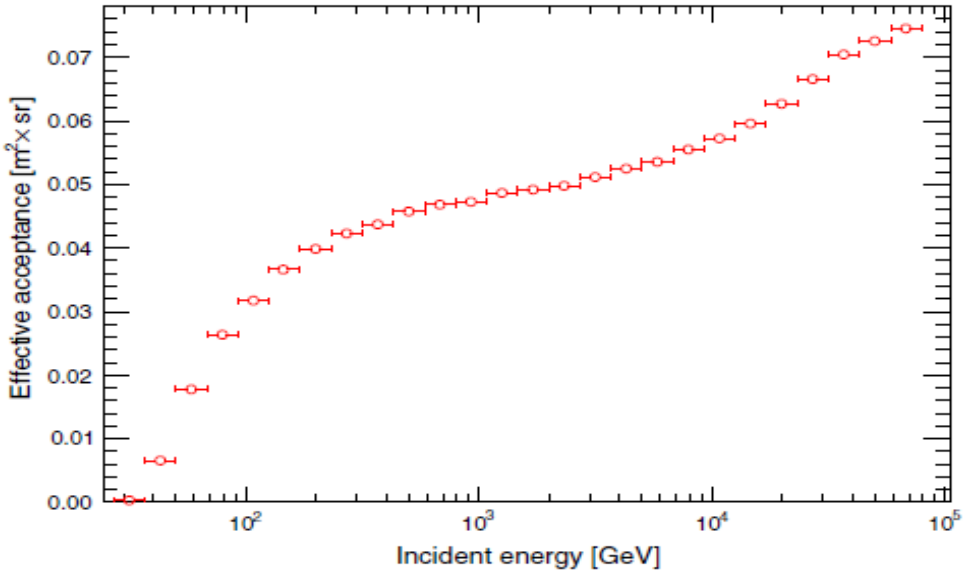


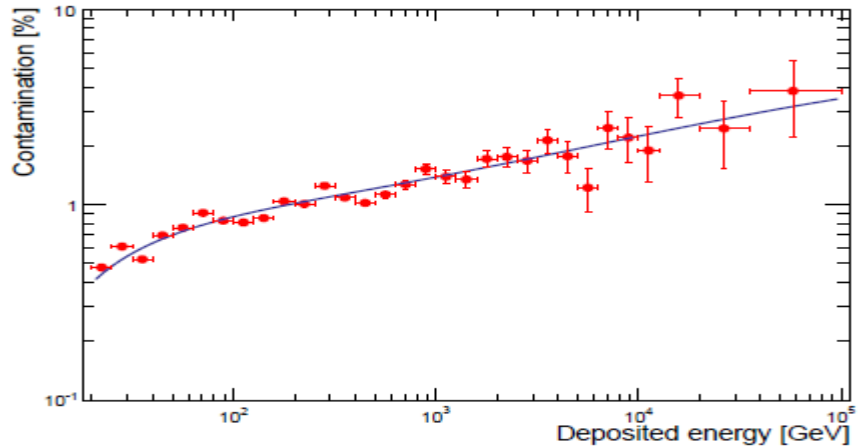


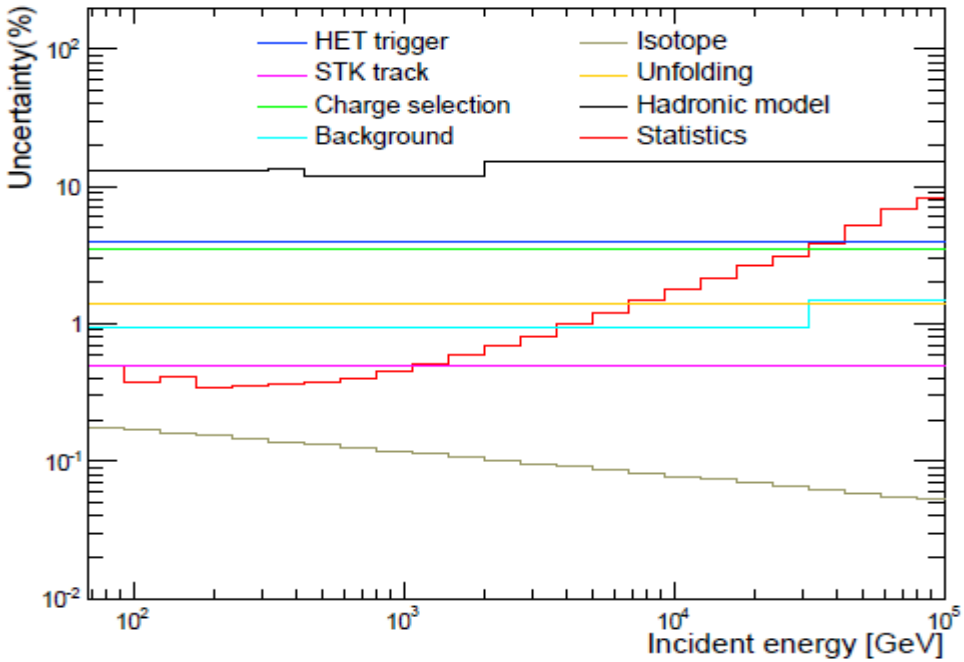


The DAMPE helium spectrum









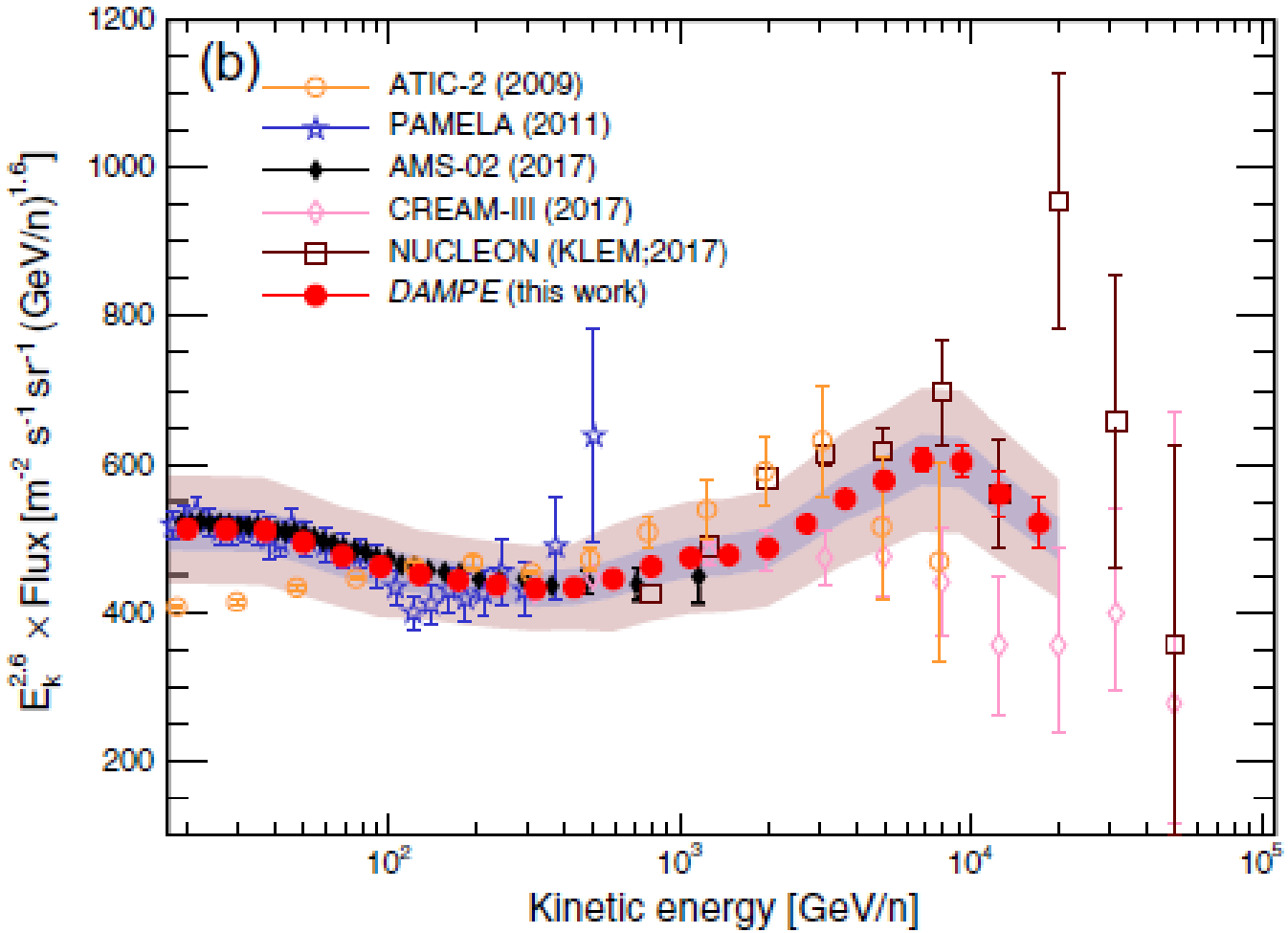
The DAMPE helium spectrum

PHYSICAL REVIEW LETTERS **126,** 201102 (2021)

Editors' Suggestion | Featured in Physics

Measurement of the Cosmic Ray Helium Energy Spectrum from 70 GeV to 80 TeV with the DAMPE Space Mission

May 18, 2021

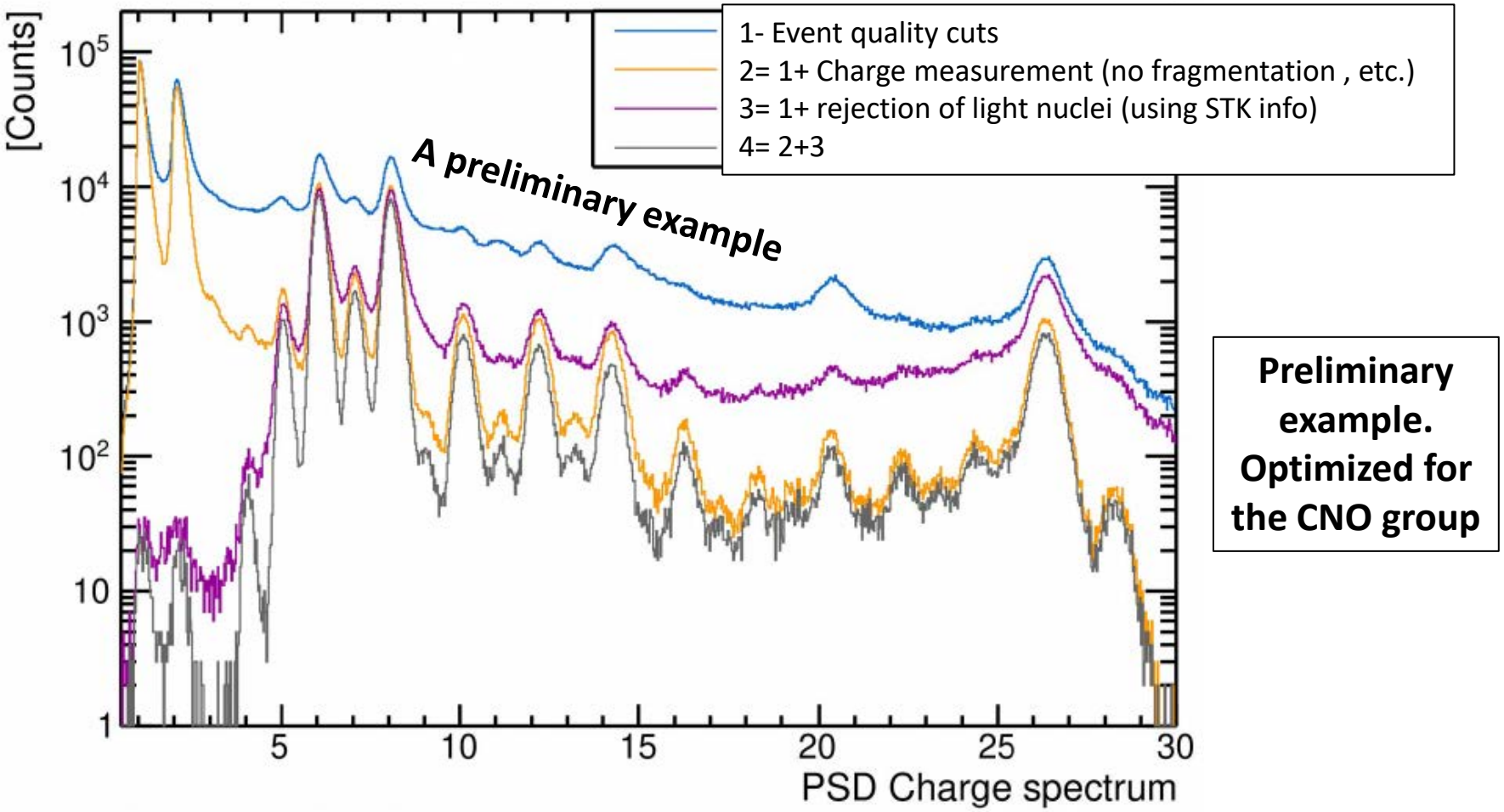


First clear evidence for a softening at about 34 TeV

Suggesting a Z dependent softening energy (~ 14 TeV for protons)

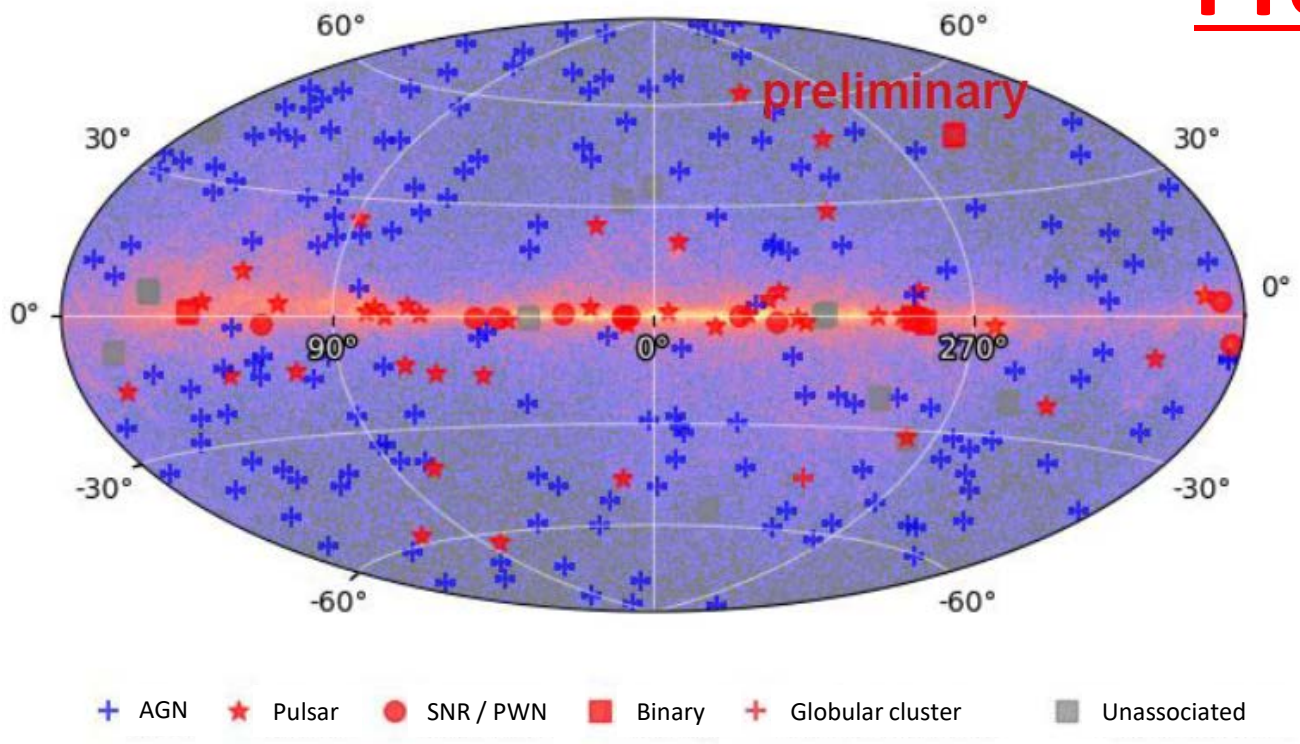
DAMPE: heavier nuclei

Several independent analyses are ongoing.
Different selection criteria to reject light nuclei and avoid charge misidentification

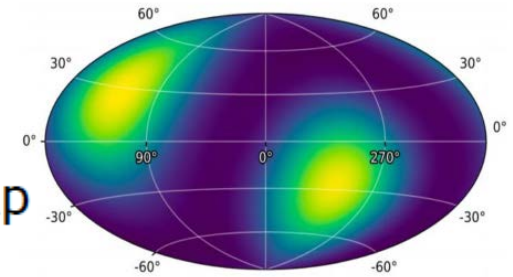


DAMPE: bright sources

Preliminary



DAMPE 5 year exposure map



Source Type	Number
AGN	175
Pulsar	45
SNR/PWN	11
Binary	4
Globular cluster	1
Unassociated	13
Total	249

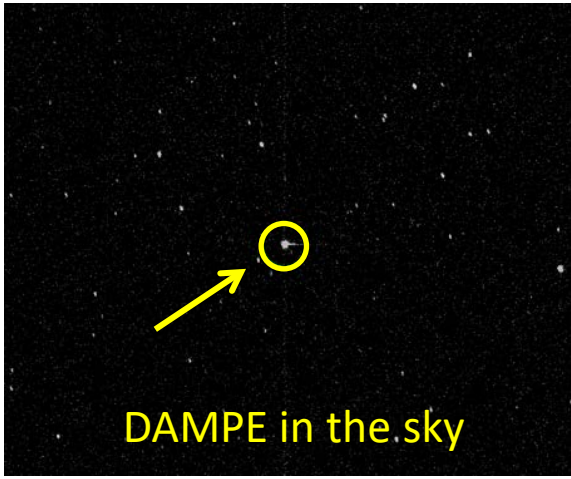
Summary

The detector

- Large geometric factor instrument (0.3 m^2 sr for p and nuclei)
- Precision Si-W tracker (40μm , 0.2°)
- Thick calorimeter (32 X_0 , σ_E/E better than 1% above 50 GeV for e/γ , ~35% for hadrons)
- "Mutiple" charge measurements (0.2-0.3 e resolution)
- e/p rejection power > 10^5 (topology alone, plus neutron detector)

Launch and performances

- Succesfull 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:

- Evidence for a cutoff at ~1 TeV in the all electron spectrum
- Evidence for a softening in the proton spectrum at ~ 14 TeV
- Evidence for a softening in the helium spectrum at ~ 34 TeV (suggesting Z dependence)
- Undergoing spectral measurements of heavier nuclei
- Preliminary studies of gamma ray sources (~250 sources, Fermi bubble, …)
- Detected new features in Forbush decrease
- Search for dark matter signatures (gamma line searches,…)
- Be ready for the "unexpected": GW electromagnetic follow up in FoV, ……

More info here:
https://inspirehep.net/jobs/1854147

PhD at GRAN SASSO SCIENCE INSTITUTE

The GSSI is an international PhD school and a center for research and higher education

The PhD program for the academic year 2021-2022 includes four courses:

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- COMPUTER SCIENCE
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Application deadline: June 14 2021

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