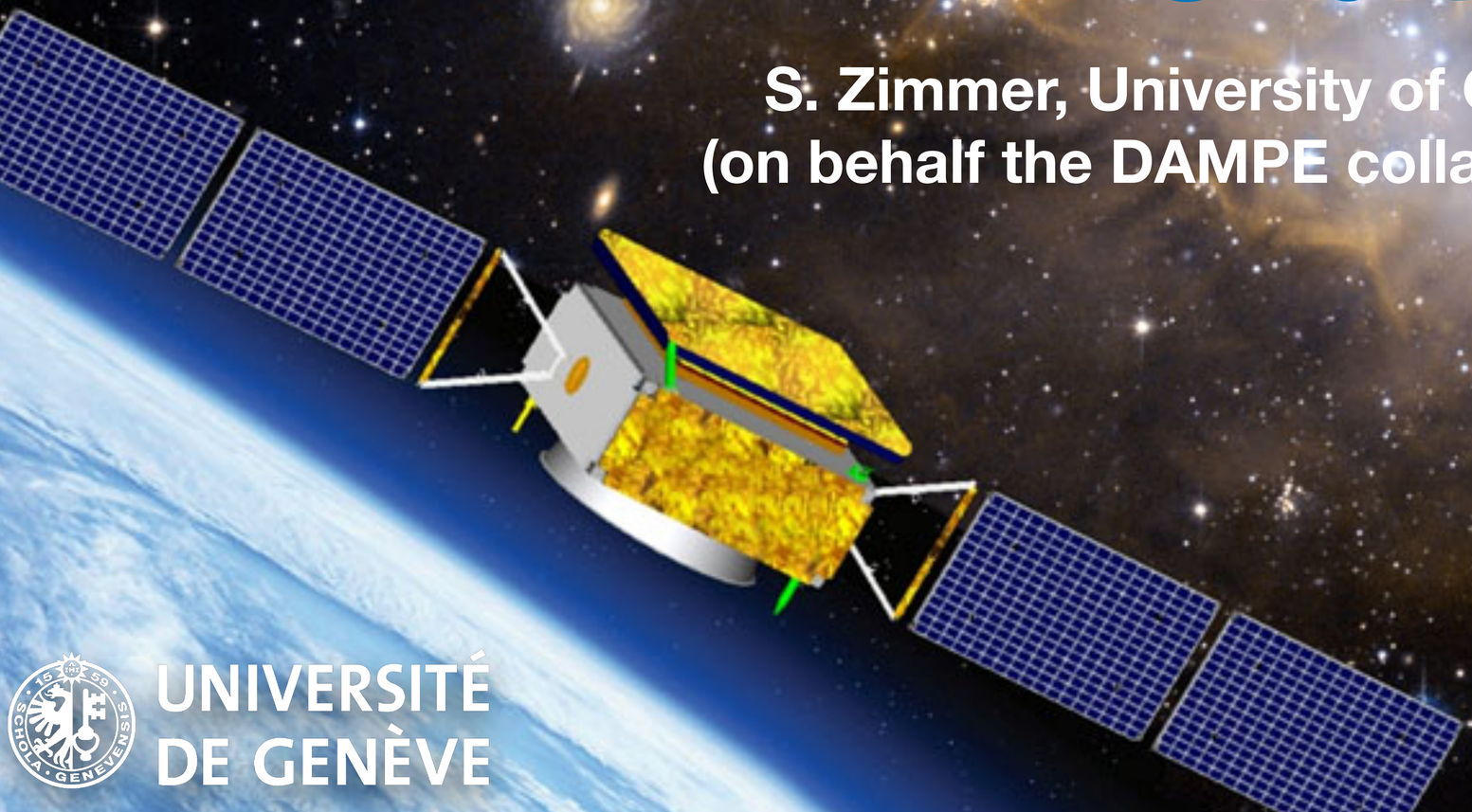
AUGUST 7-11 COLUMBUS, OHIO
TeVPA 2017

DAMPE and its first year in Orbit

S. Zimmer, University of Geneva
(on behalf the DAMPE collaboration)



UNIVERSITÉ DE GENÈVE

Outline

- Intro: Launch, Detector design & Expected Performance
- On-orbit Performance
- Results
  - first light with ɣ-rays
  - p/He spectrum measured with DAMPE

In case you need to go (I hope you can stay):

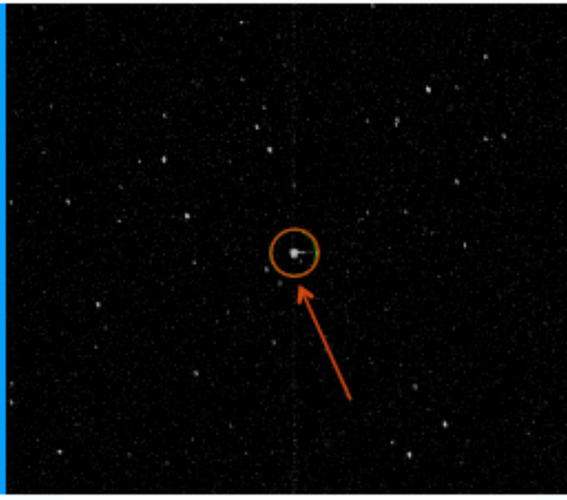
- DAMPE works well & provides new instrument for GeV-TeV ɣ/e/p/ions
- 1st year data confirms results from several different experiments

1. Introduction: Launch, Design & Expected Performance

China's first Astronomical Satellite

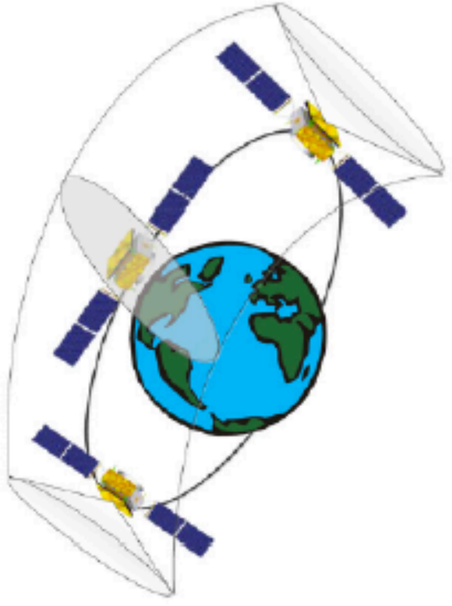

Jiquan Satellite Launch Center, Gobi desert

- **Launch**: December 17th 2015 CZ-2D rocket
  - scientific payload: ~1400 kg, 400 W
- **Lifetime** > 3 years (nominal mission time)

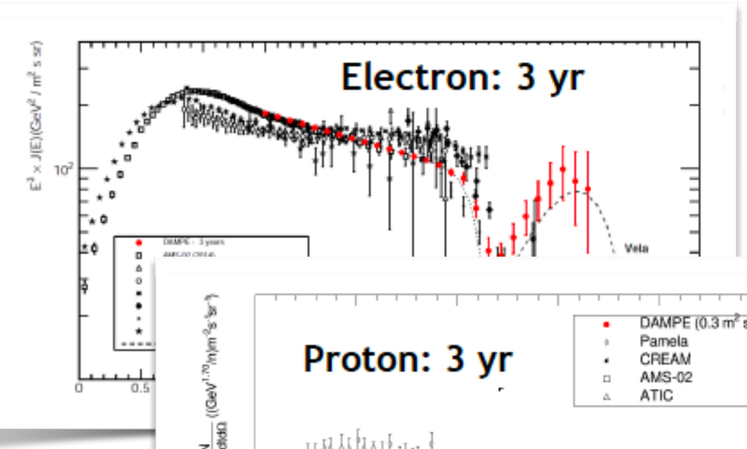


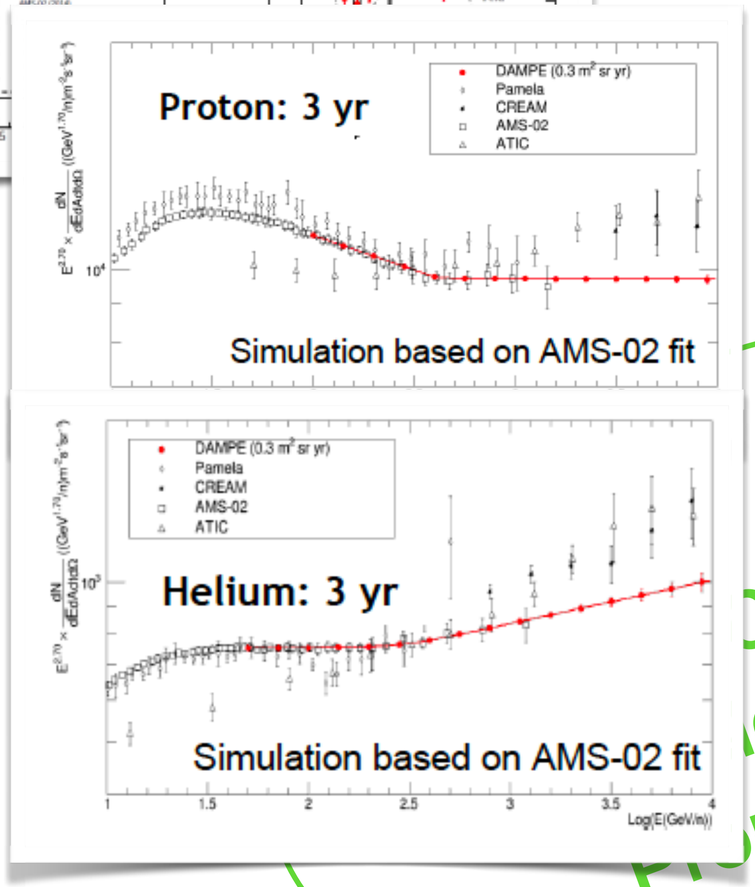

Wukong
"Monkey King"

- **Altitude**: 500 km
- **Inclination**: 97.4065°
- **Period**: 95 minutes
- **Orbit**: sun-synchronous
- **16 GB/day** downlink



DArk Matter Particle Explorer

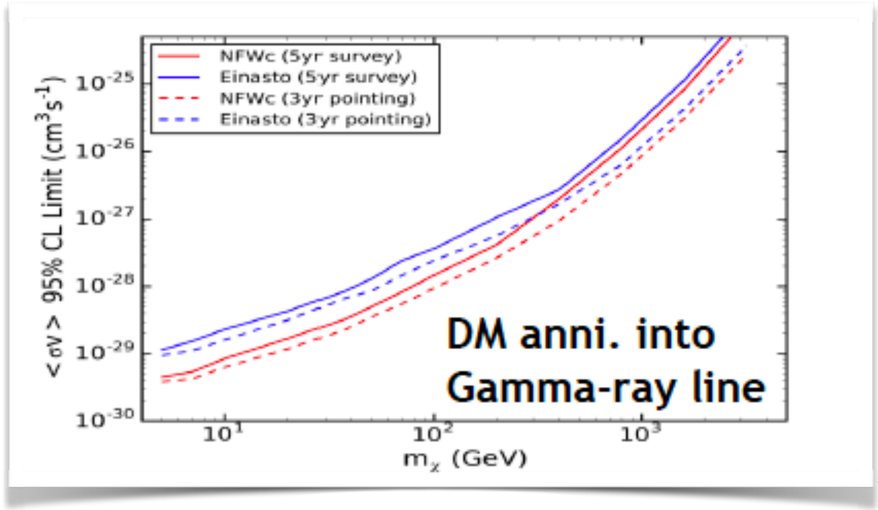


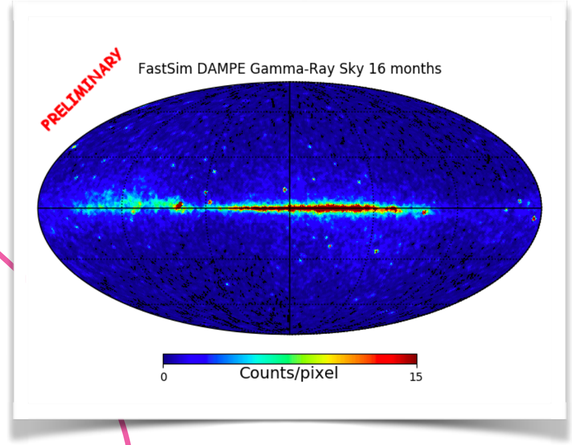


Particle Dark Matter ID

CR Generation & Propagation

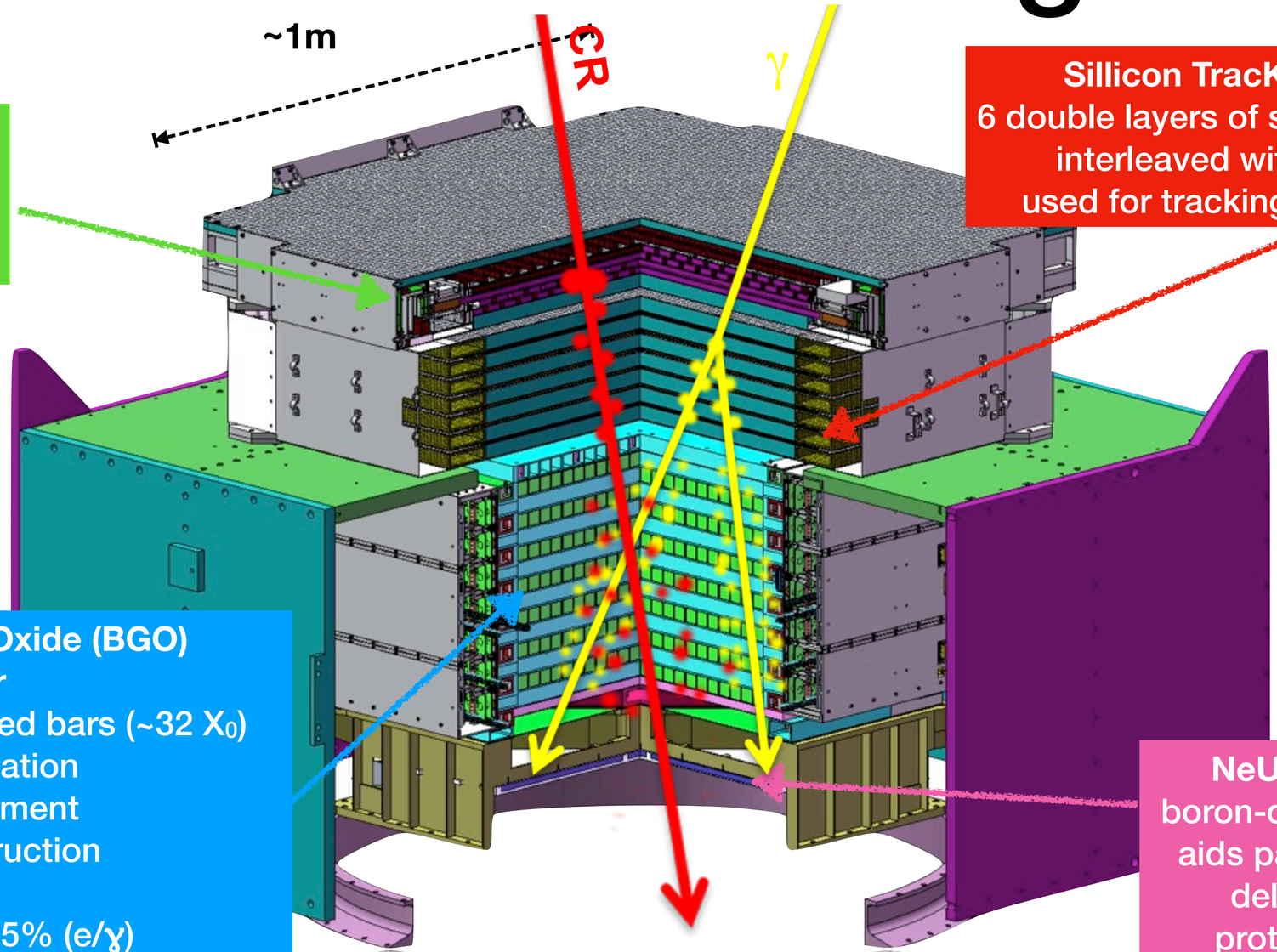
Gamma Ray Astrophysics





DAMPE Coll. [arXiv:1706.08453]

Instrument Design



Plastic Scintillator Detector (PSD)
double layers of scintillating strips acting as top ACD

Sillicon TracKer converter (STK)
6 double layers of single sided-silicon strips interleaved with 3 mm of tungsten
used for tracking & photon conversion

Bismuth-Germanium Oxide (BGO) calorimeter
308 hodoscopically arranged bars (~32 X_0)
particle identification
energy measurement
direction reconstruction
trigger
$\Delta E/E$ (>10 GeV) ≲ 1.5% (e/ɣ)

NeUtron Detector (NUD)
boron-doped plastic scintillator
aids particle ID by measuring delayed neutrons from proton-induced showers

Expected Performance

The DArk Matter Particle Explorer mission **[astro-ph/1706.08453, Astropart. Phys. submitted]**

The DAMPE collabo

(Submitted on 26 Jun 2

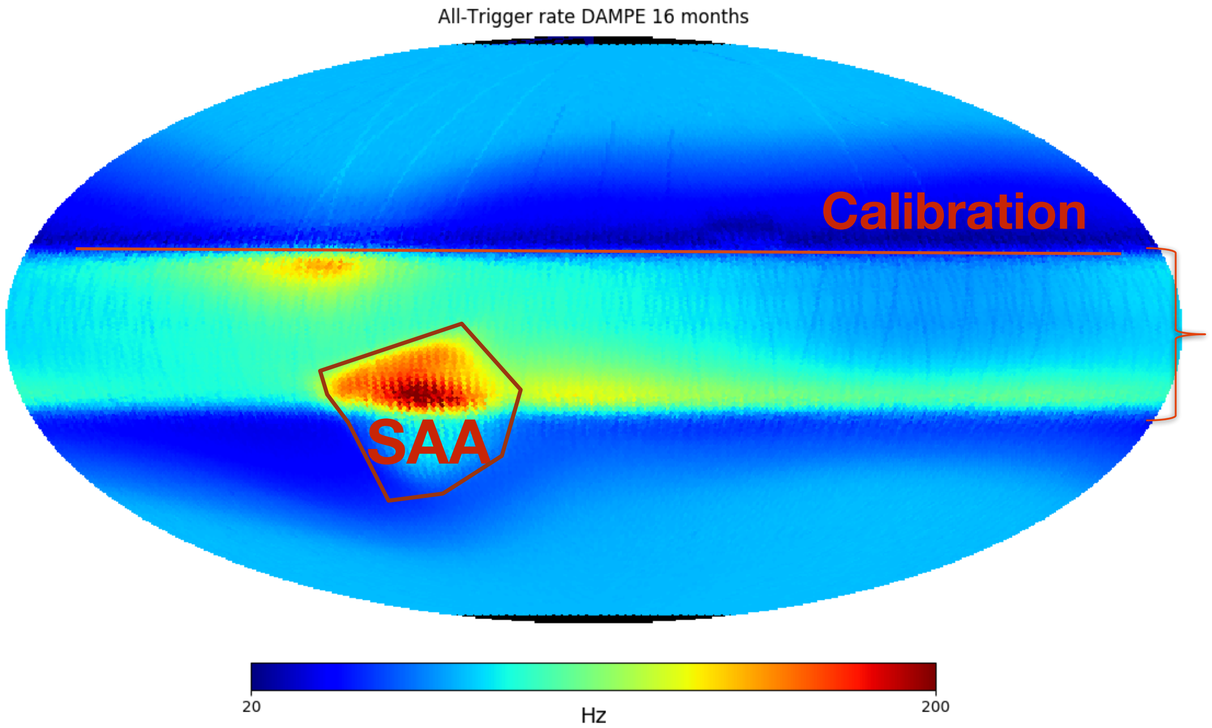
The DArk Matter P
of the Chinese Aca
2015 from the Jiuc
electrons/gammas
and discuss the re
mission key scient

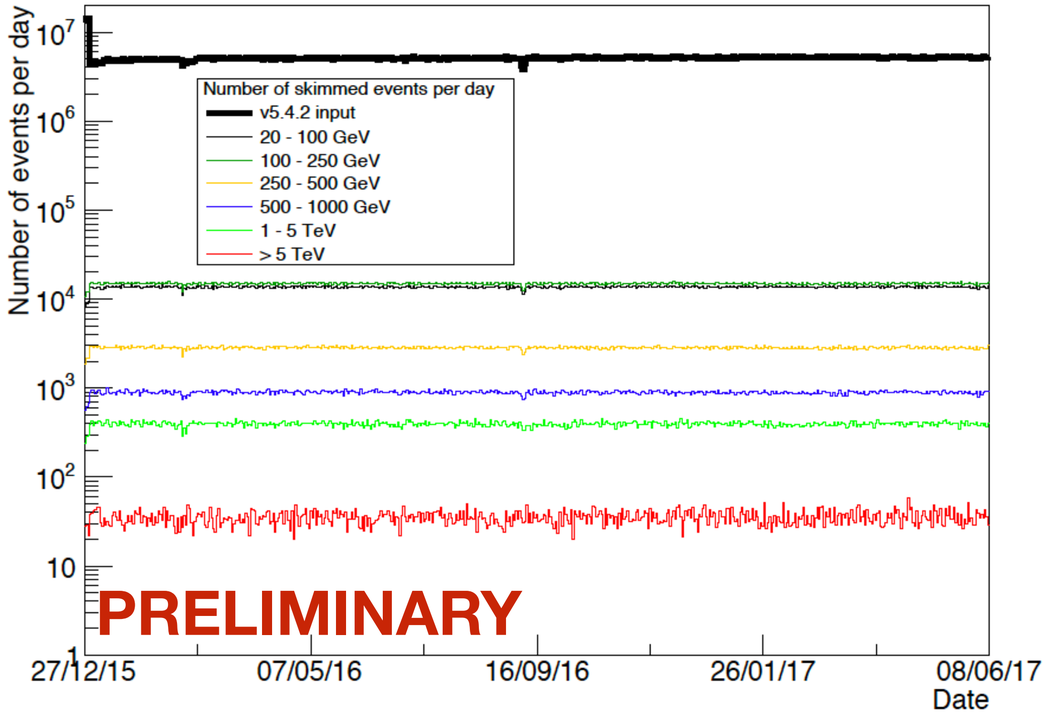
Parameter	Value
Energy range of gamma-rays/electrons	5 GeV to 10 TeV
Energy resolution (electron and gamma)	<1.5% at 800 GeV
Energy range of protons/heavy nuclei	50 GeV to 100 TeV
Energy resolution of protons	<40% at 800 GeV
Eff. area at normal incidence (gamma)	1100 cm^2 at 100 GeV
Geometric factor for electrons	0.3 m^2 sr above 30 GeV
Photon angular resolution	<0.2 degree at 100 GeV
Field of View	1.0 sr

m on Space Science
on December 17th,
dreds of TeV for
DAMPE instrument,
verview of the

2. On-Orbit Performance

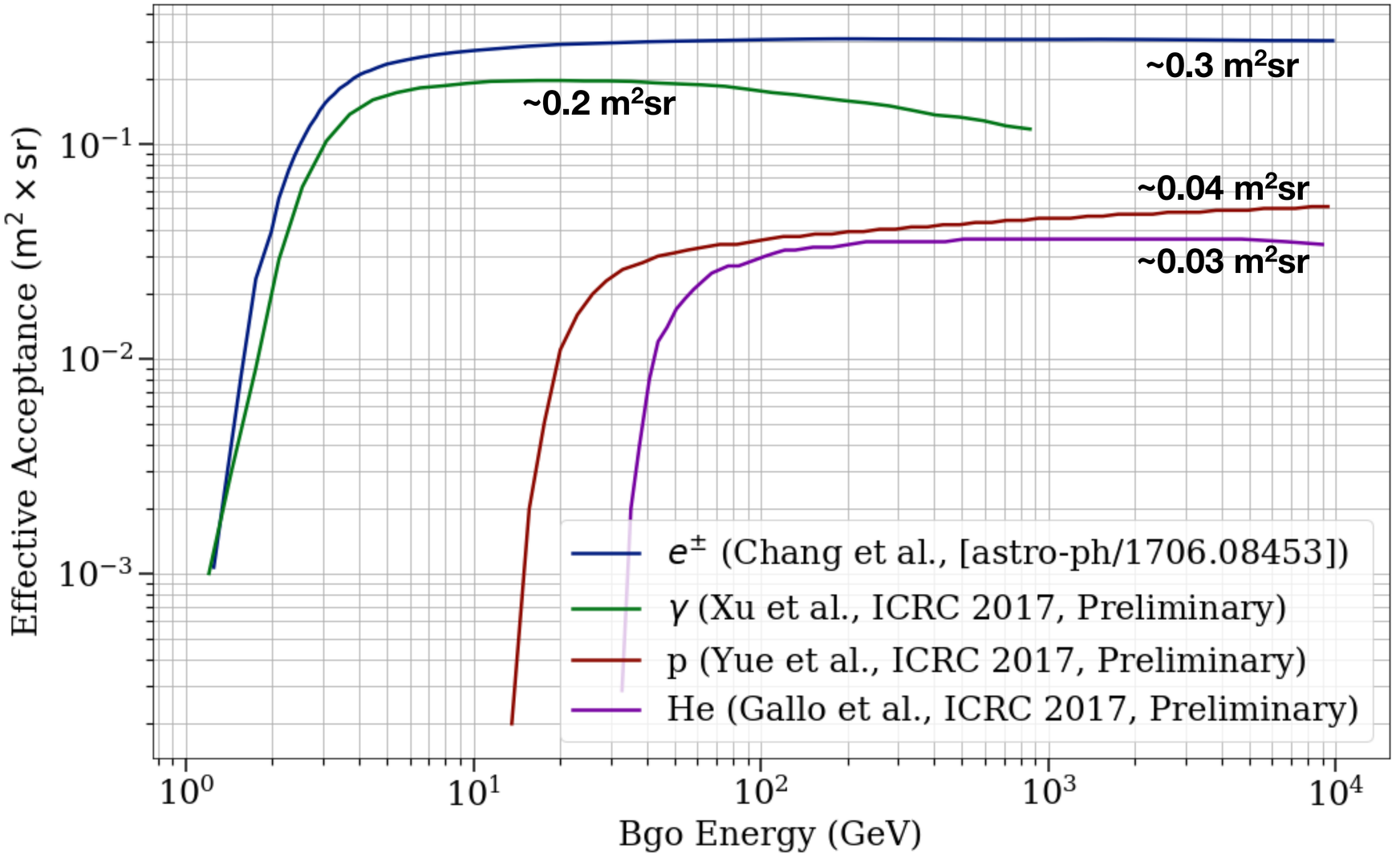
Trigger Rate & DAQ





- Acquisition rate up to 200 Hz (50 Hz for HE trigger, pre-scaled during calibration & for LE trigger)
- live-time: 18.4 hours / day (incl. SAA), 3 ms dead time after each event
- 100 GB/day orbit data (observation & calibration runs); calibration run at b +20 deg

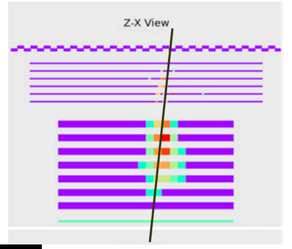
Acceptance Estimates



3. Results

Gamma Rays: First Light

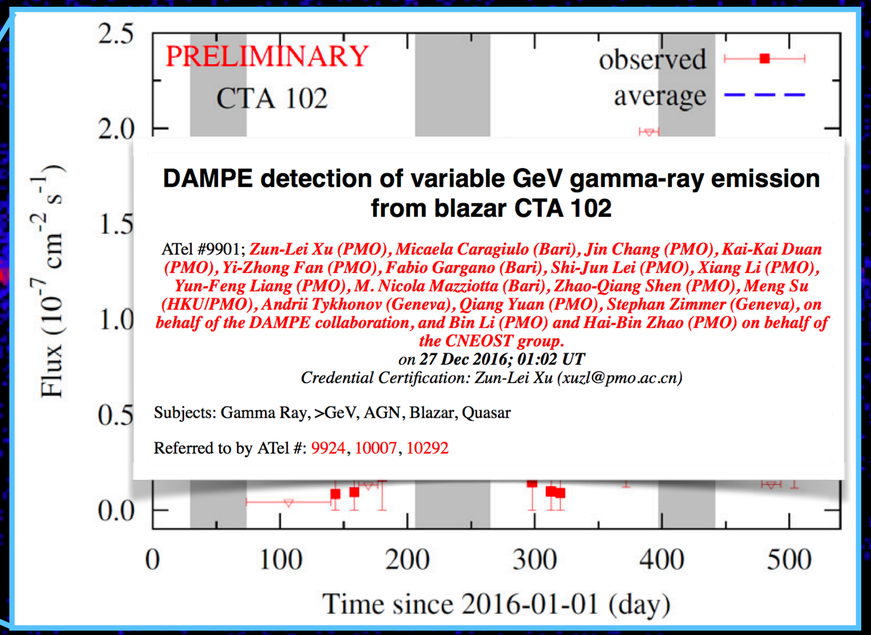
gamma



[Xu et al. / Lei et al. / Muñoz-Salinas et al. (DAMPE), ICRC 2017]

PRELIMINARY

DAMPE 510 days
E > 2GeV



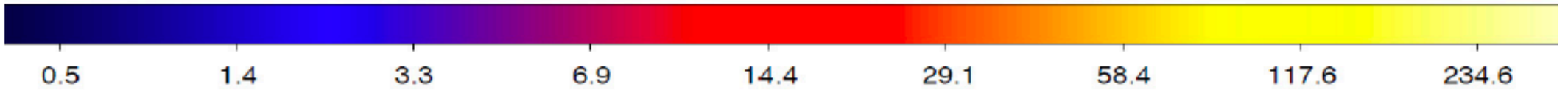
DAMPE detection of variable GeV gamma-ray emission from blazar CTA 102

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)

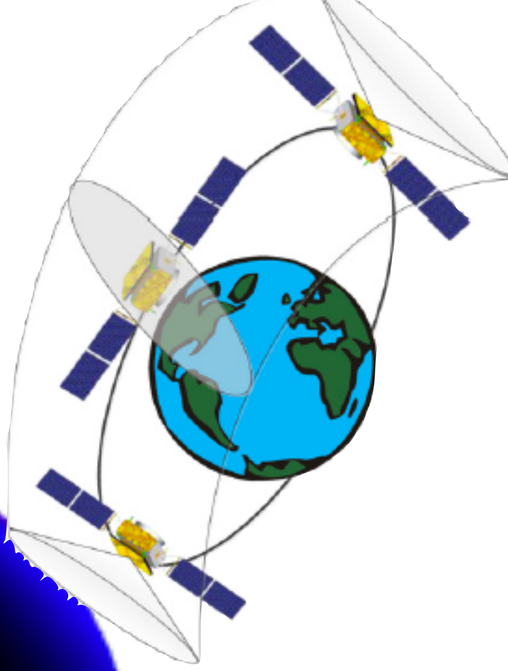
Subjects: Gamma Ray, >GeV, AGN, Blazar, Quasar

Referred to by ATel #: 9924, 10007, 10292

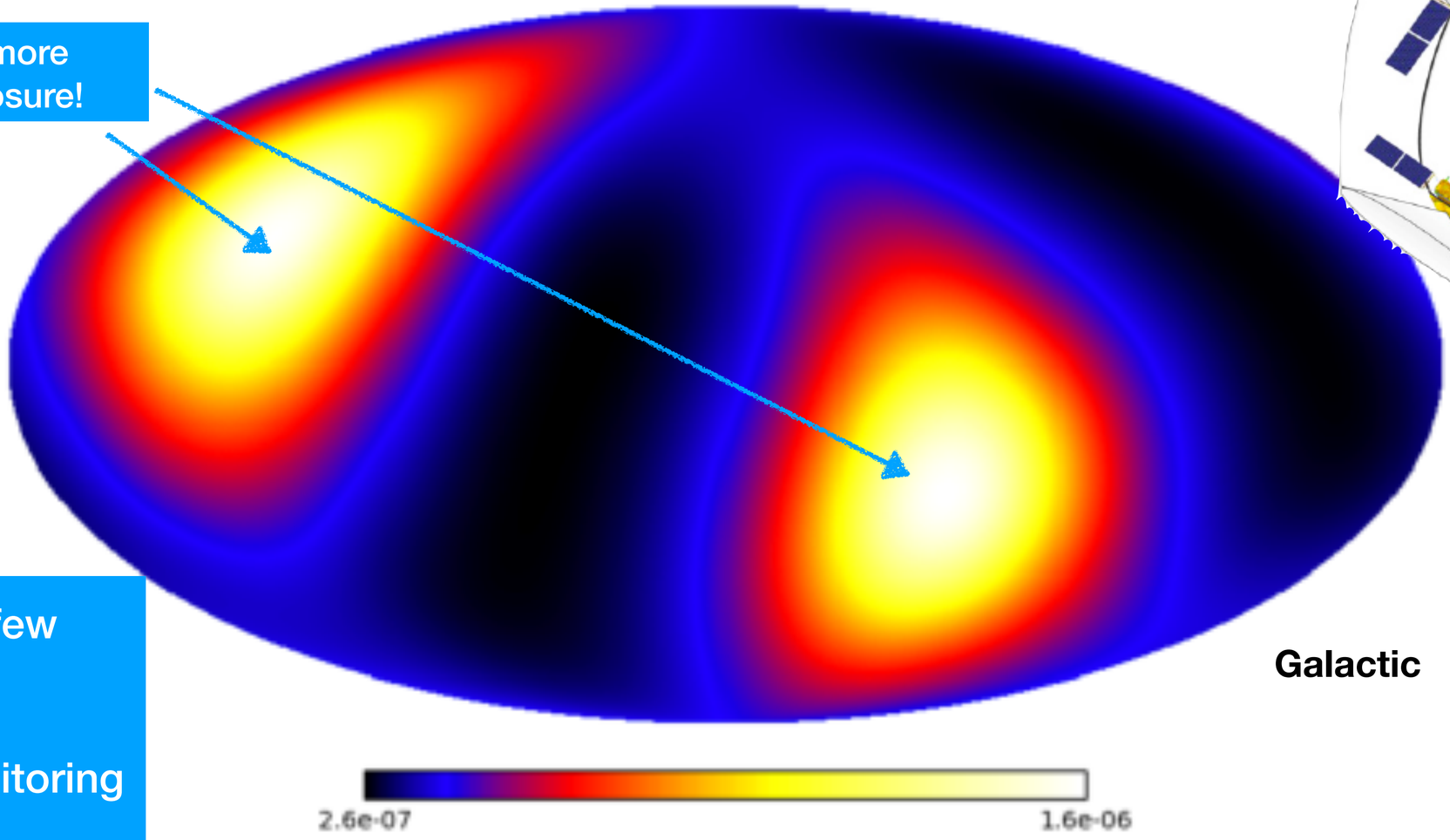
roughly: ~200 ɣ/day



Exposure Map



6x more exposure!

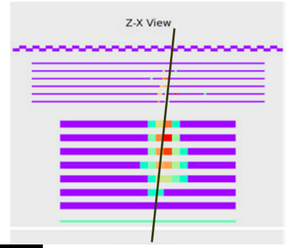


Galactic

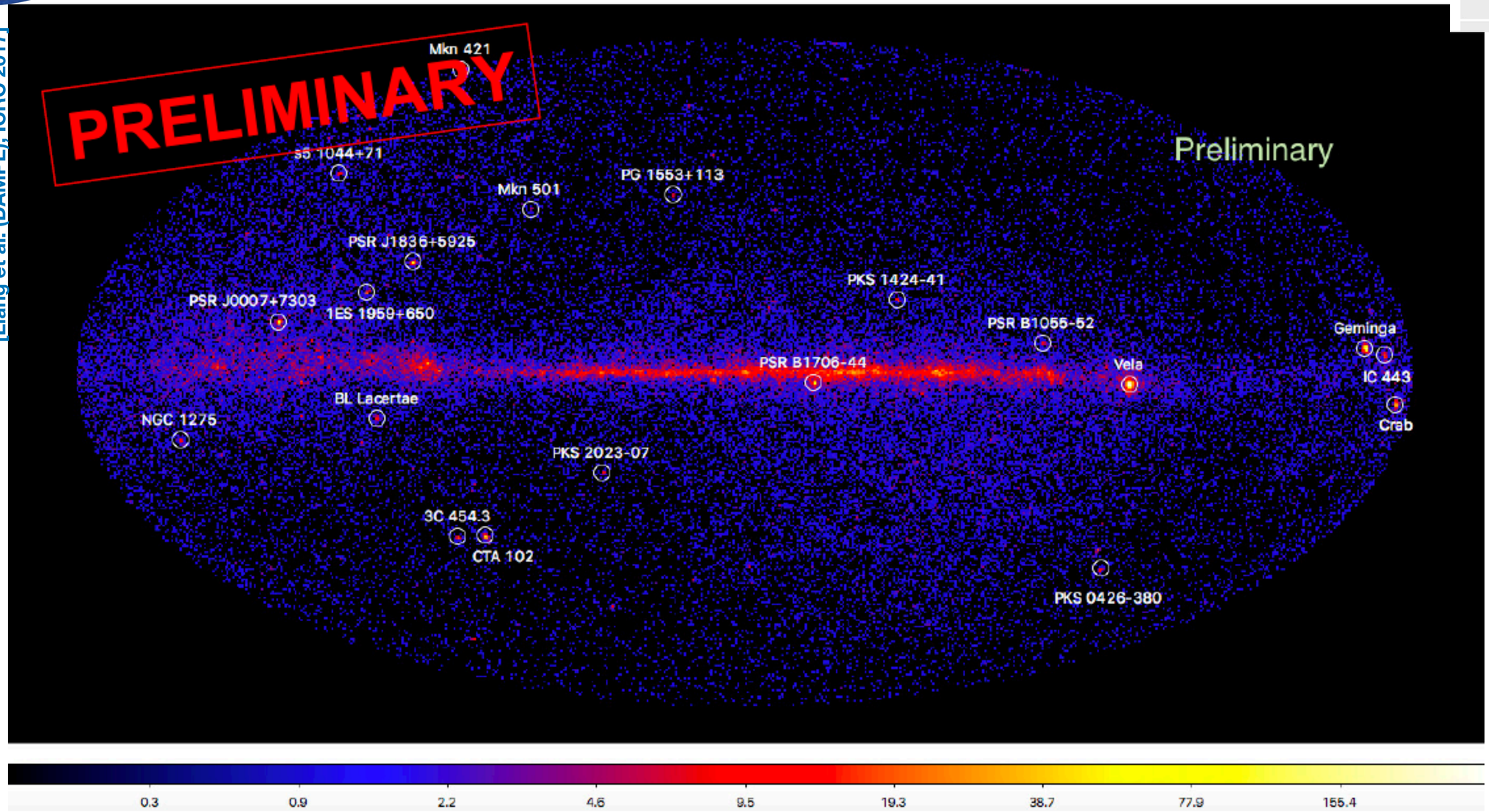
- full sky coverage ~few times per year
- highly non-uniform (limited all-sky monitoring capabilities)

(Re)discovering the γ-Ray Sky

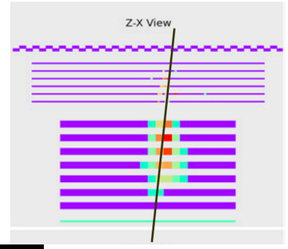
gamma



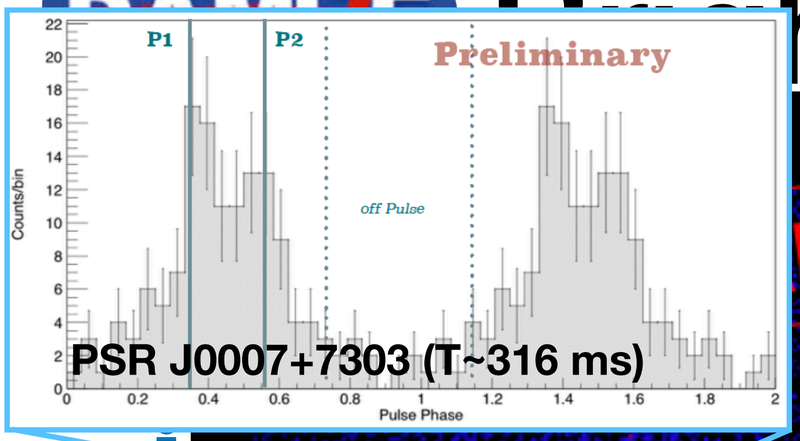
[Liang et al. (DAMPE), ICRC 2017]

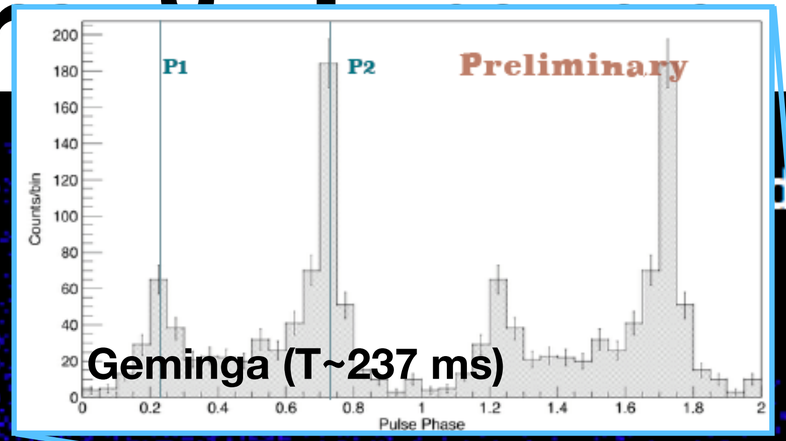


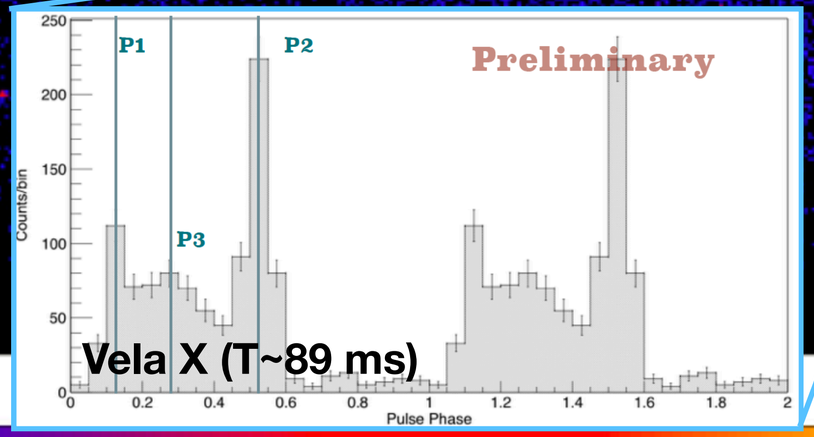
gamma



Bright Pulsar & Ti







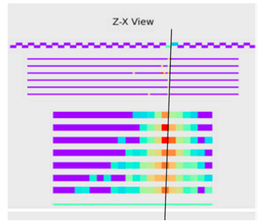
days

[Xu et al. / Lei et al. / Muñoz-Salinas et al. (DAMPE),

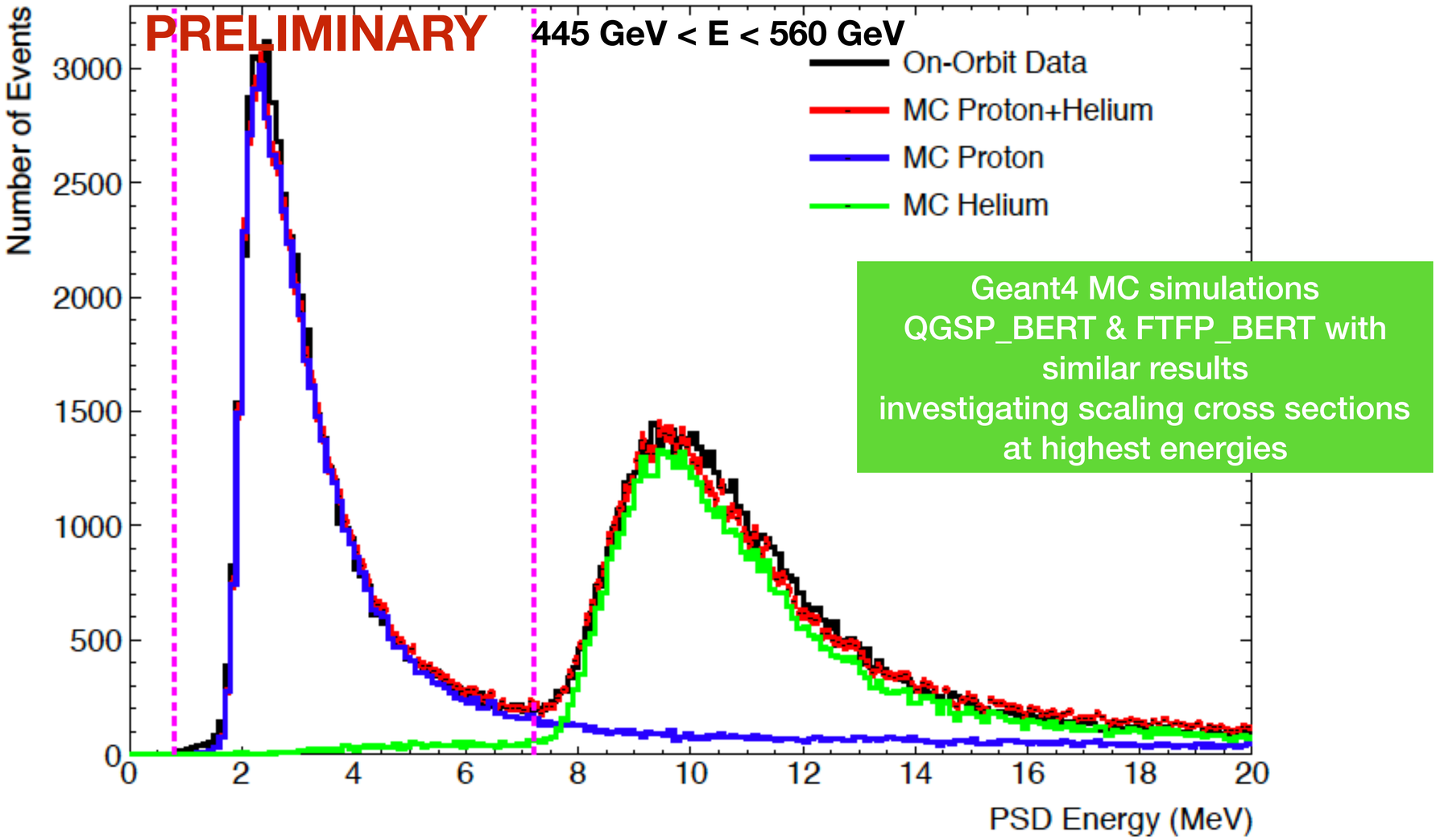
0.5 1.4 3.3 6.9 14.4 29.1 58.4 117.6 234.6

Protons & Ions

proton



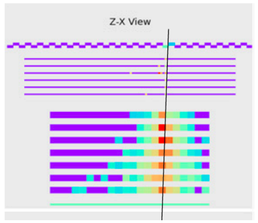
[Yue et al. (DAMPE), ICRC 2017]

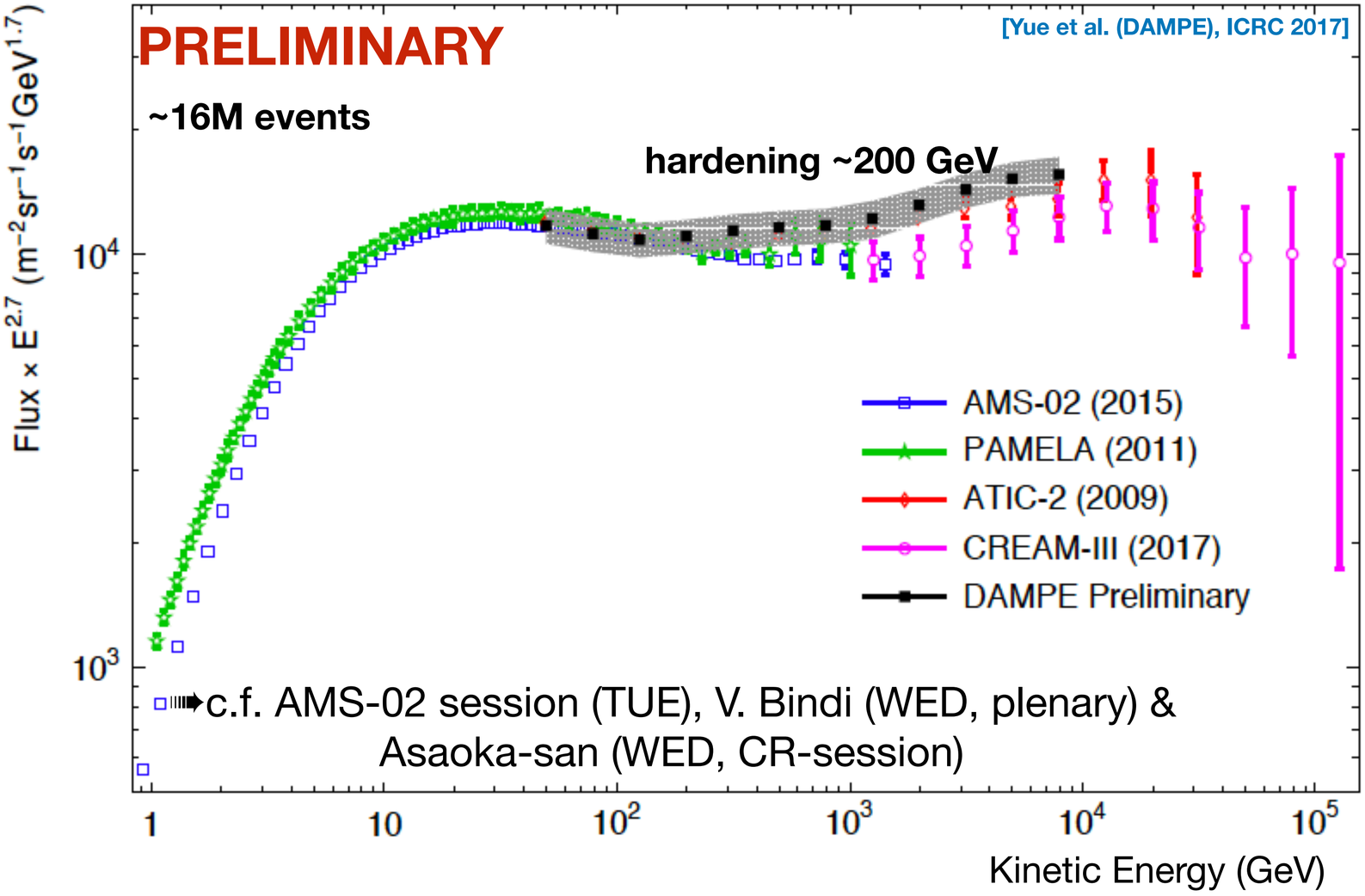


Geant4 MC simulations
QGSP_BERT & FTFP_BERT with similar results
investigating scaling cross sections at highest energies

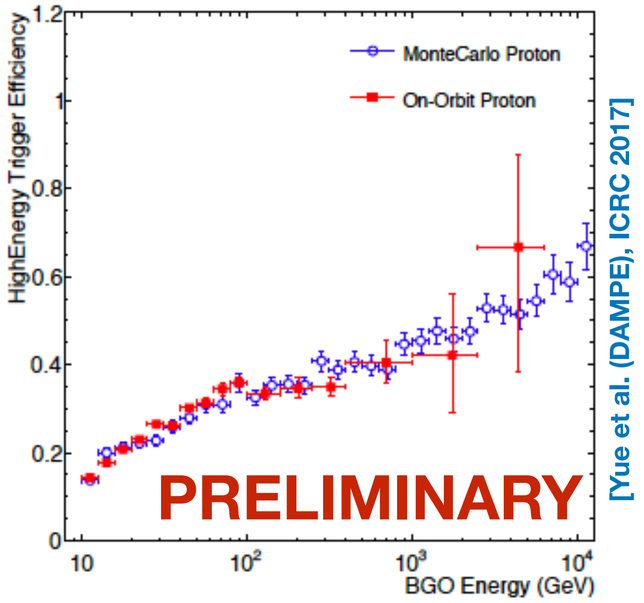
Proton Flux Measurement

proton

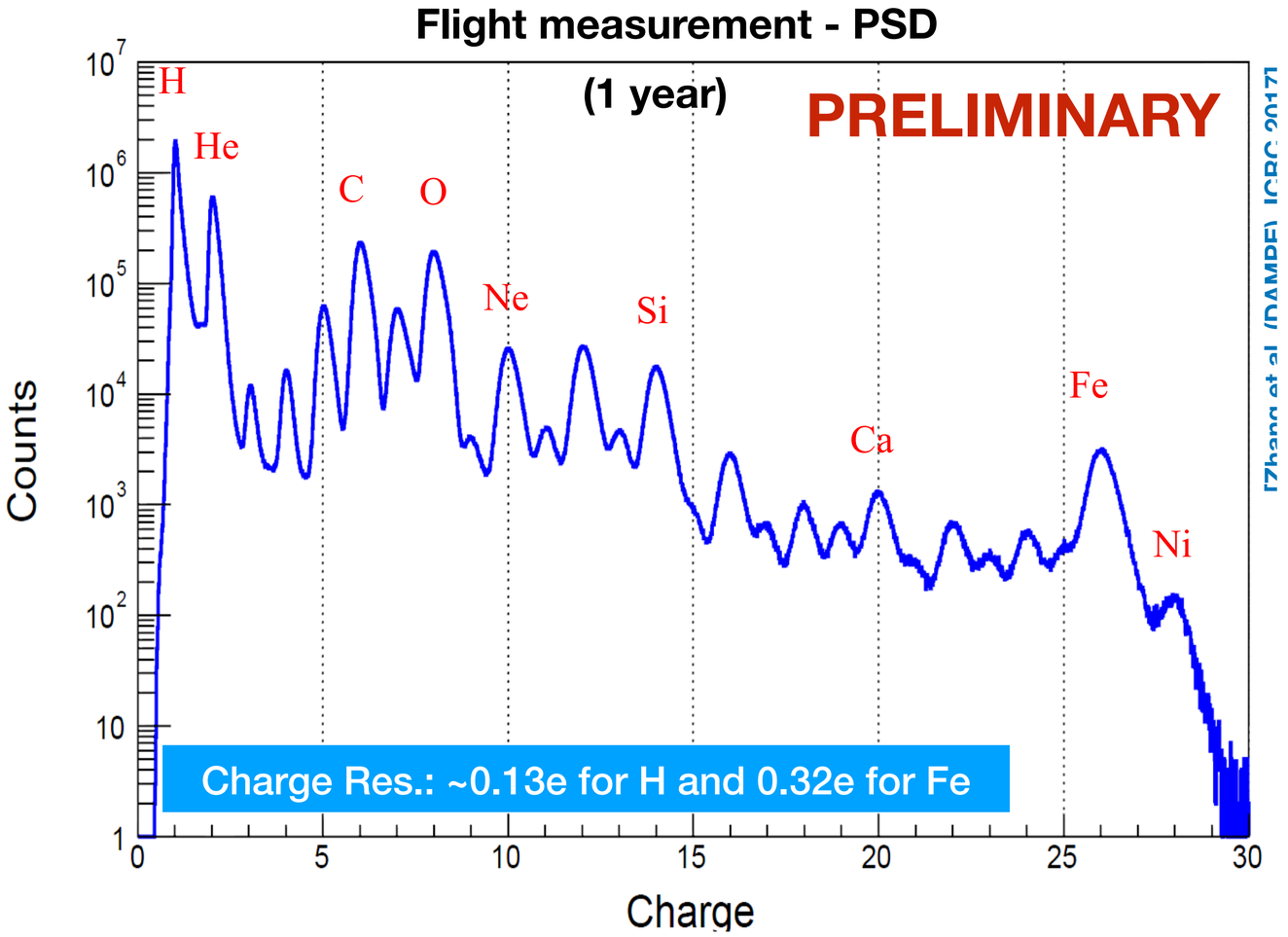




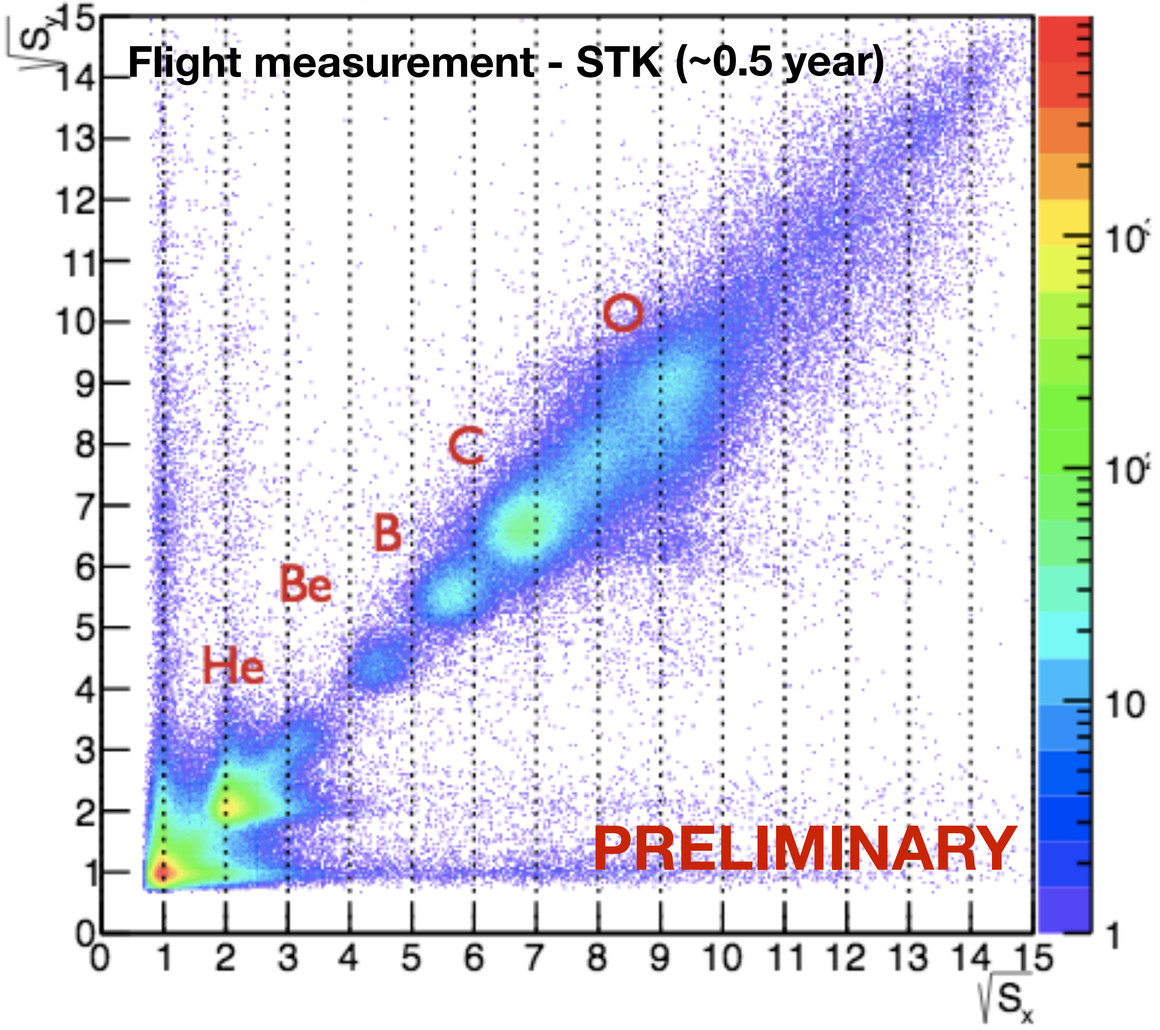
- template fits to account for He background
- main uncertainty trigger efficiency



Charge ID - Flight Data

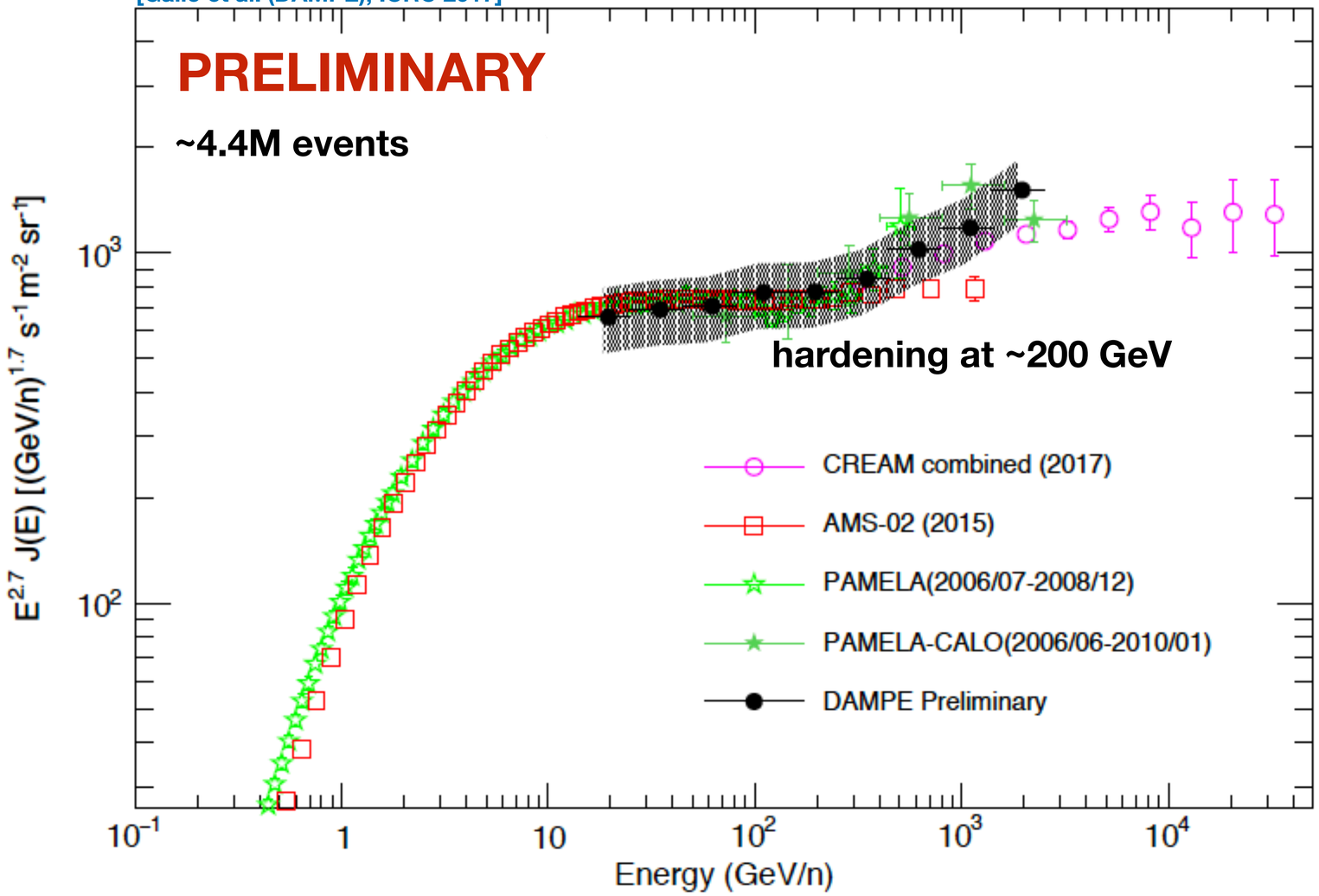


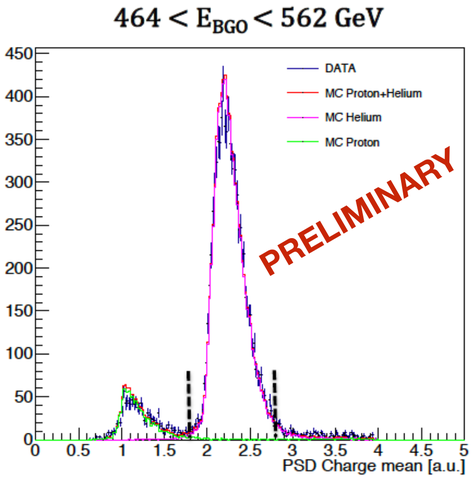
[Gallo et al. (DAMPE), VERTEX 2016]



Helium Flux

[Gallo et al. (DAMPE), ICRC 2017]



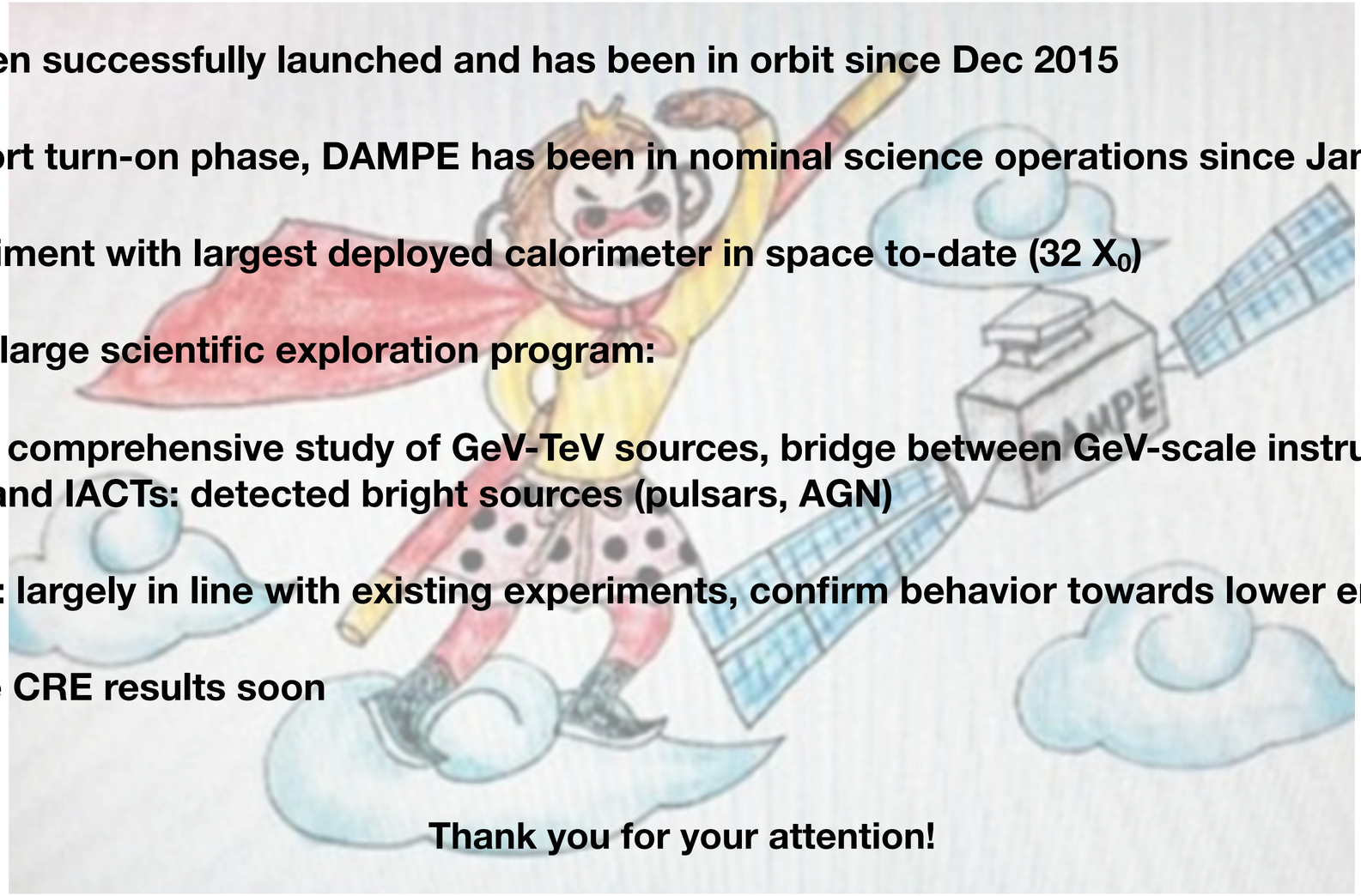


- p & Li contamination negligible
- systematic uncertainty ~21 % (dominated by trigger efficiency)

➠c.f. AMS-02 session (TUE), V. Bindi (WED, plenary) & Asaoka-san (WED, CR-session)

Summary

- DAMPE has been successfully launched and has been in orbit since Dec 2015
  - after very short turn-on phase, DAMPE has been in nominal science operations since January 2016
  - unique experiment with largest deployed calorimeter in space to-date (32 X_0)
- DAMPE covers large scientific exploration program:
  - gamma-rays: comprehensive study of GeV-TeV sources, bridge between GeV-scale instruments (Fermi-LAT & Agile) and IACTs: detected bright sources (pulsars, AGN)
  - protons & He: largely in line with existing experiments, confirm behavior towards lower energies
  - expect to see CRE results soon



Thank you for your attention!

DAMPE @ ICRC2017

www.icrc2017.org

The Astroparticle Physics Conference
35th International Cosmic Ray Conference

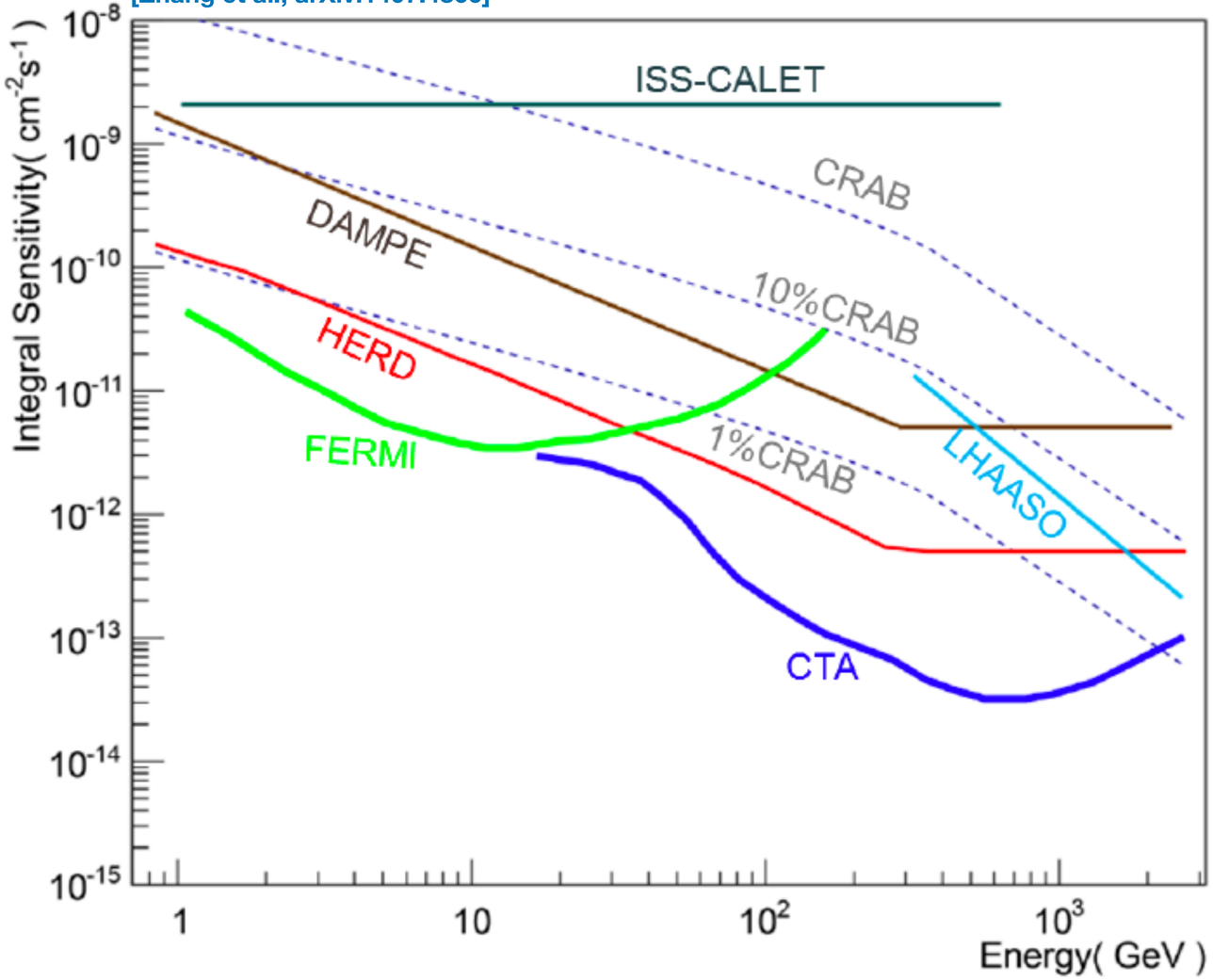
LINK TO ABSTRACTS

[CRD153] The first results from DAMPE
[DM030] In-orbit Performance of the Silicon-Tungsten Tracker of the DAMPE Mission
[CRD051] Measurement of absolute energy scale of ECAL of DAMPE with geomagnetic rigidity cutoff
[CRD082] Studies on cosmic-ray proton flux with DAMPE
[CRD096] Studies on Helium flux with DAMPE
[CRD097] Measurement of cosmic ray charge with DAMPE Silicon-Tungsten Tracker
[CRD098] PSD performance and charge reconstruction with DAMPE
[CRD117] The On-orbit Performance of DAMPE Trigger System
[CRD124] Determination of the South Atlantic Anomaly from DAMPE data
[DM032] Readout Electronics of DAMPE BGO Calorimeter and the Status during the First Year In Orbit
[DM041] Study of E/P separation for the DAMPE experiment with the TMVA BDT method
[DM042] Validation of GEANT4 Monte Carlo Models with a three dimensional BGO Calorimeter of DAMPE
[DM043] Acceptance research and electron/proton characteristic investigation in the DAMPE experiment
[DM044] Energy calibration of DAMPE in space
[DM045] The Performance of a 3D Imaging Calorimeter of DAMPE for Cosmic Ray Physics in Orbit
[GA183] First observations of Pulsars with the DArk Matter Particle Explorer
[GA184] Gamma-ray selection of DAMPE
[GA204] The variable sky of DAMPE
[GA206] Gamma-ray Astronomy with DAMPE
[GA248] The performance of DAMPE for gamma-ray detection
[GA268] Calibration of the point-spread function of DAMPE with bright pulsars and AGNs
[GA271] Bright gamma-ray sources observed by DArk Matter Particle Explorer
[GA282] A Machine Learning classifier for photon selection with the DAMPE detector

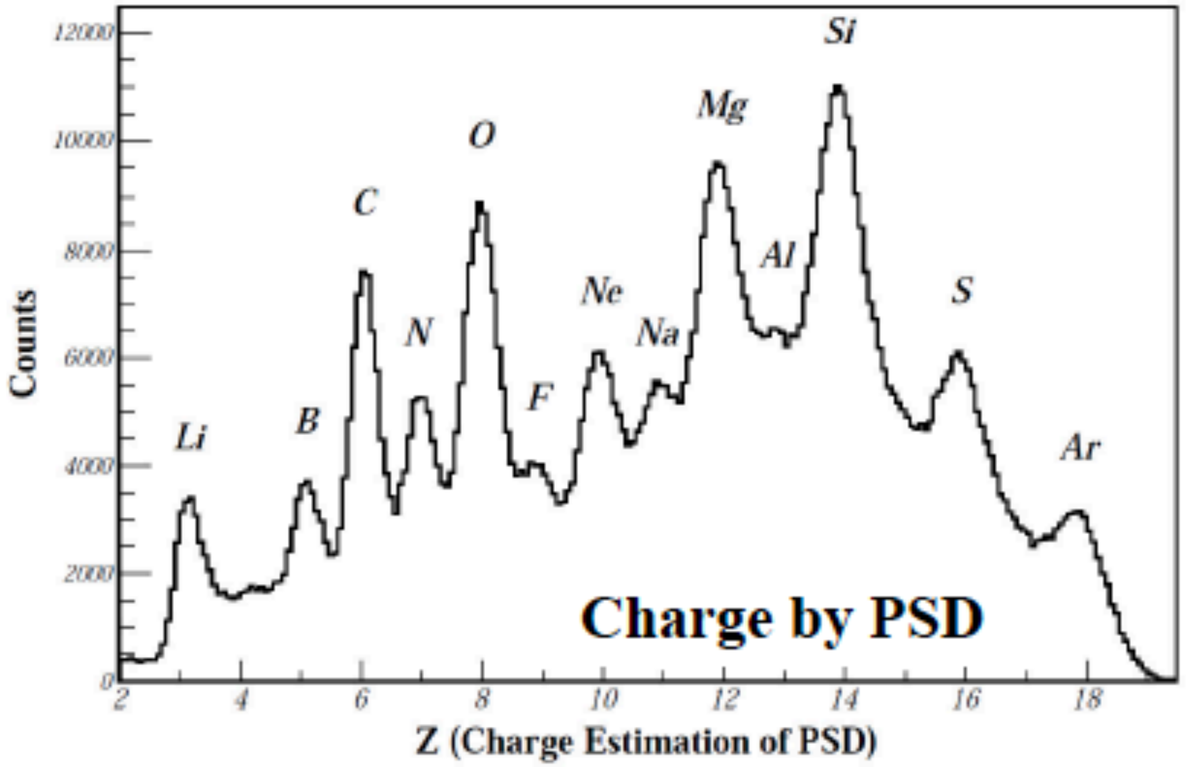
EXTRA

DAMPE Integral Sensitivity

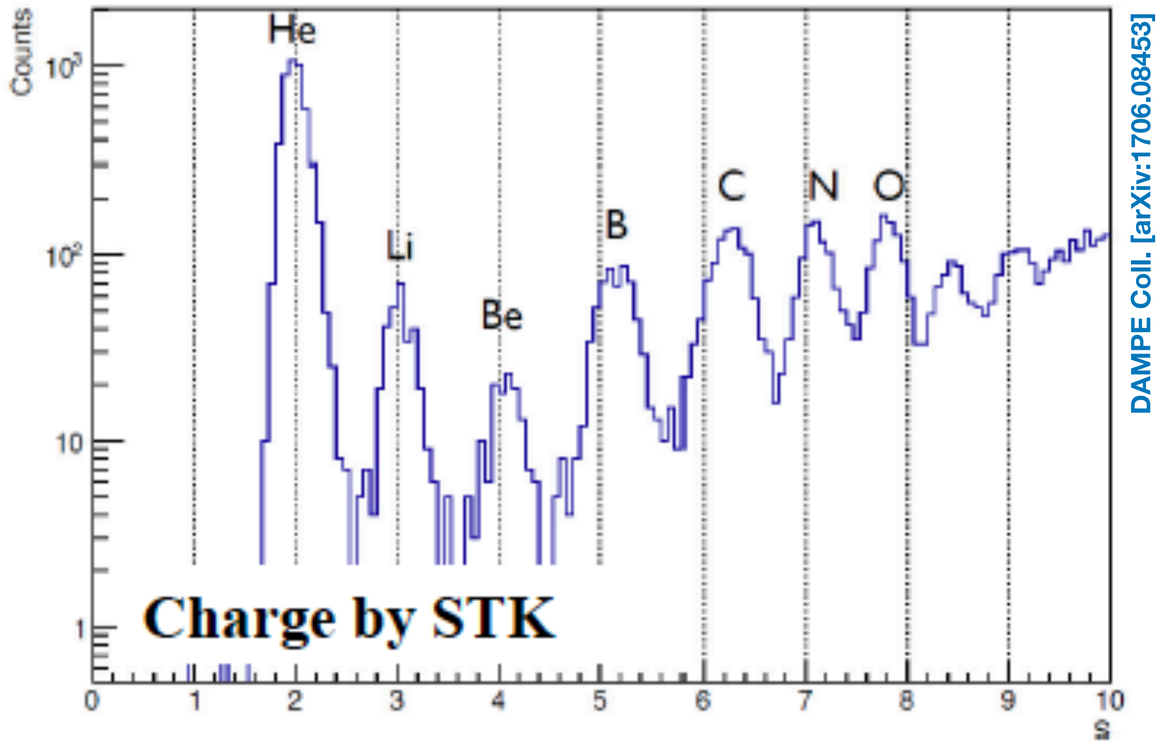
[Zhang et al., arXiv:1407.4866]



Charge ID - Beamtest*



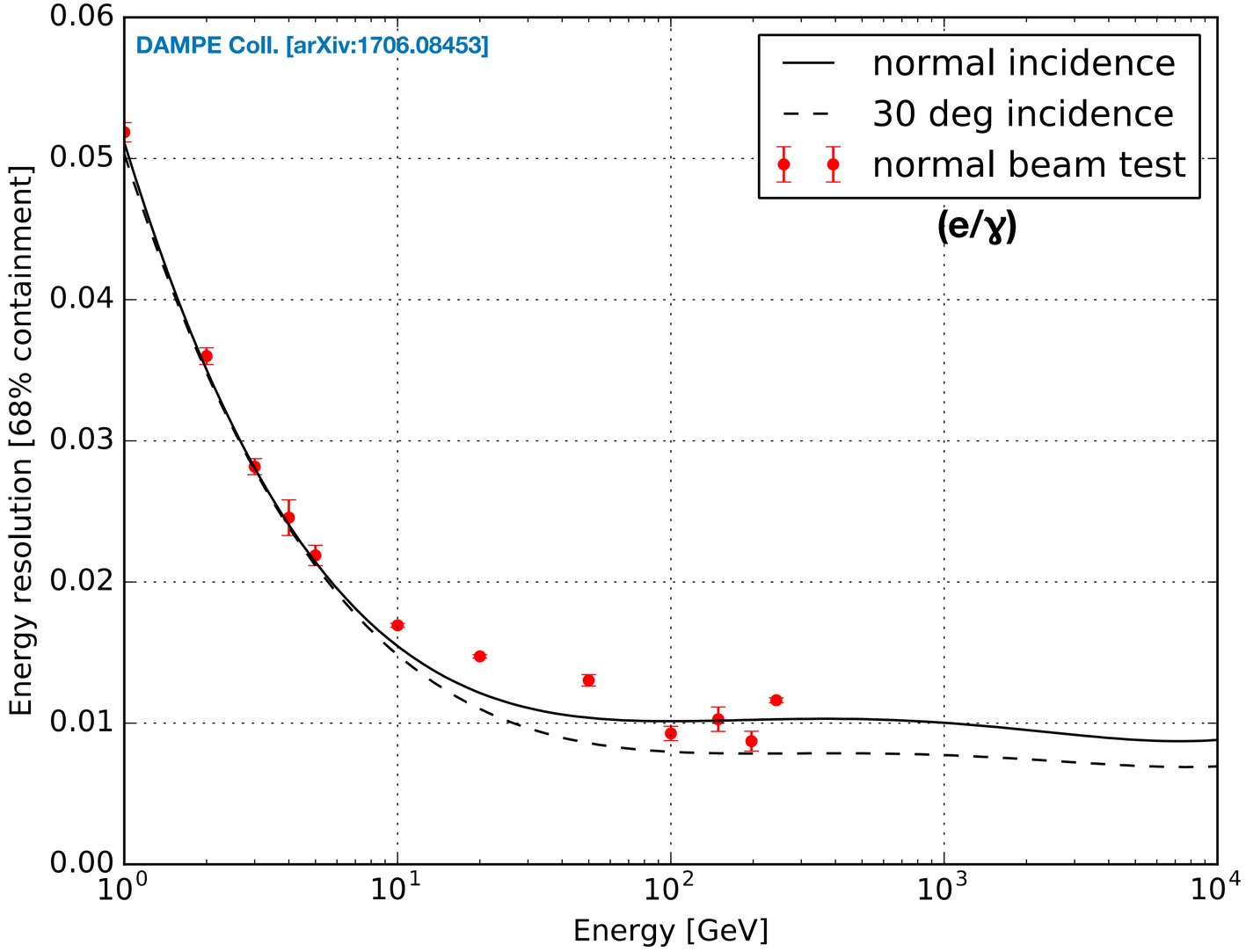
DAMPE Coll. [arXiv:1706.08453]



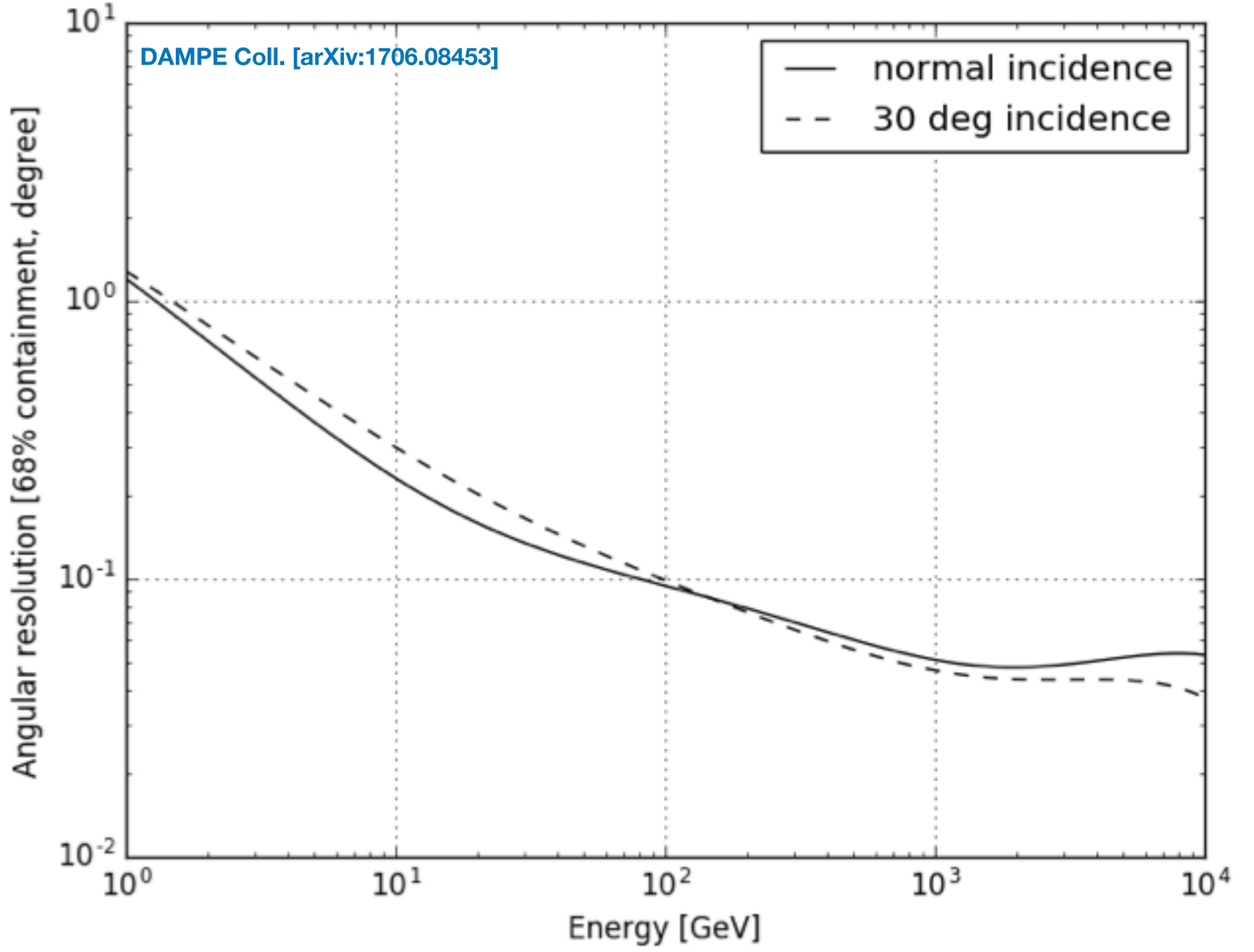
DAMPE Coll. [arXiv:1706.08453]

*Argon beam at CERN SPS

A new instrument to find lines & spectral features



Good Angular Resolution for HE γ-rays



The DAMPE collaboration

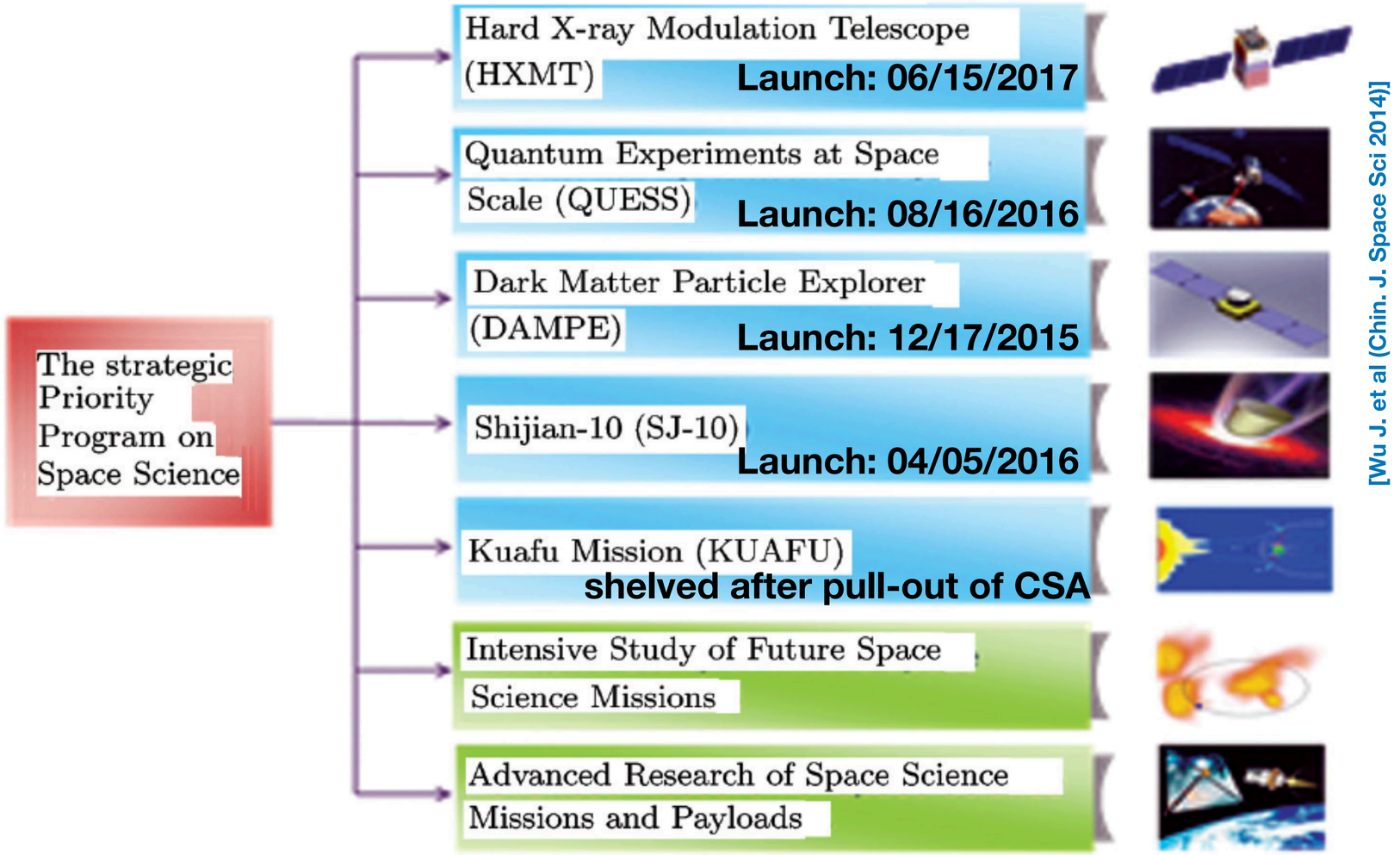
PI: Prof. Jin Chang (PMO)

- Purple Mountain Observatory, CAS, Nanjing
- Institute of High Energy Physics, CAS, Bejing
- National Space Science Center, CAS, Being
- University of Science and Technology of China, Hefei
- Institute of Modern Physics, CAS, Lanzhou

- INFN Perugia & University of Perugia
- INFN Bari & University of Bari
- INFN Lecce & University of Salento

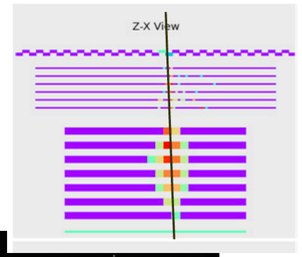
- University of Geneva

Strategic Priority Program on Space Science (2011 - 2016)



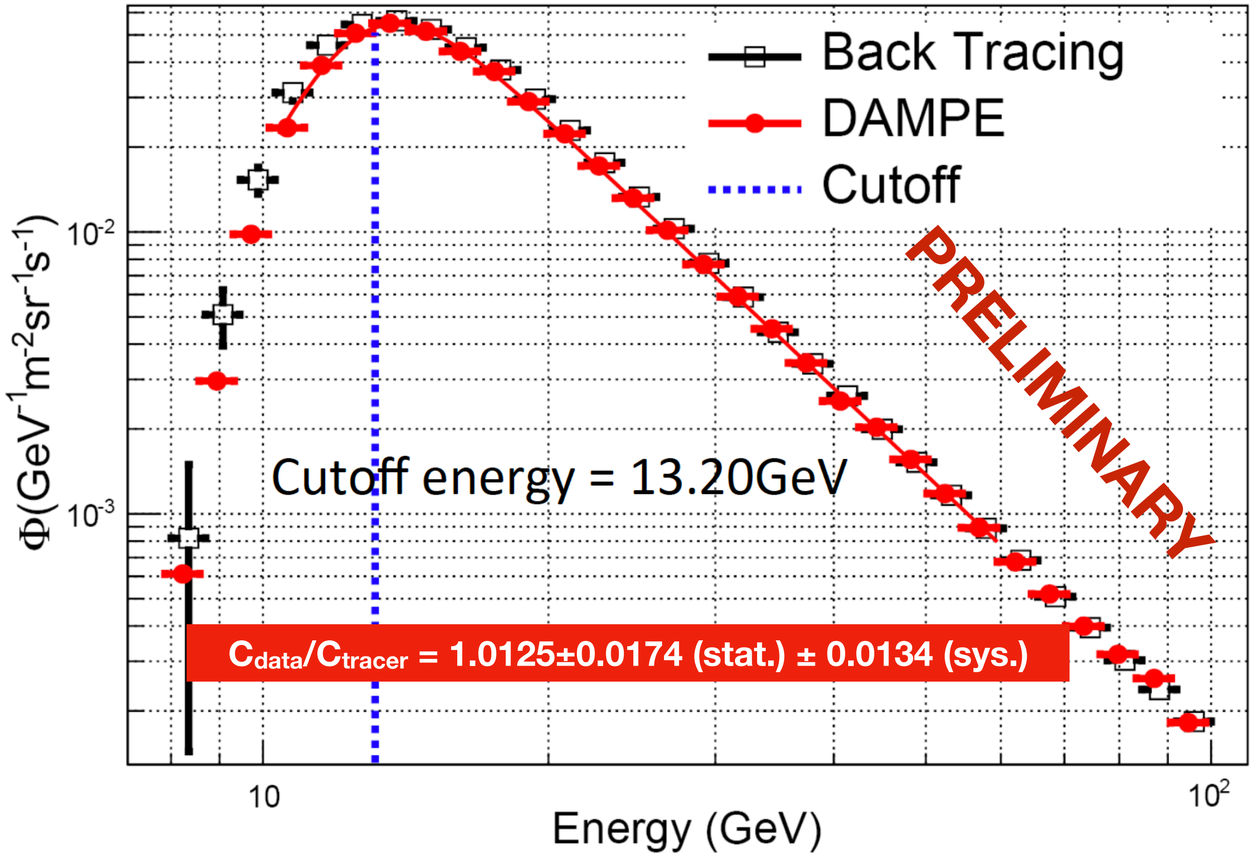
[Wu J. et al (Chin. J. Space Sci 2014)]

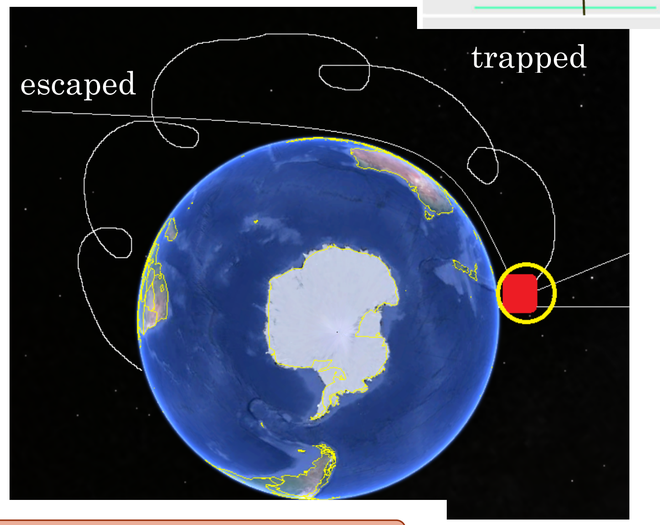
Absolute Energy Scale

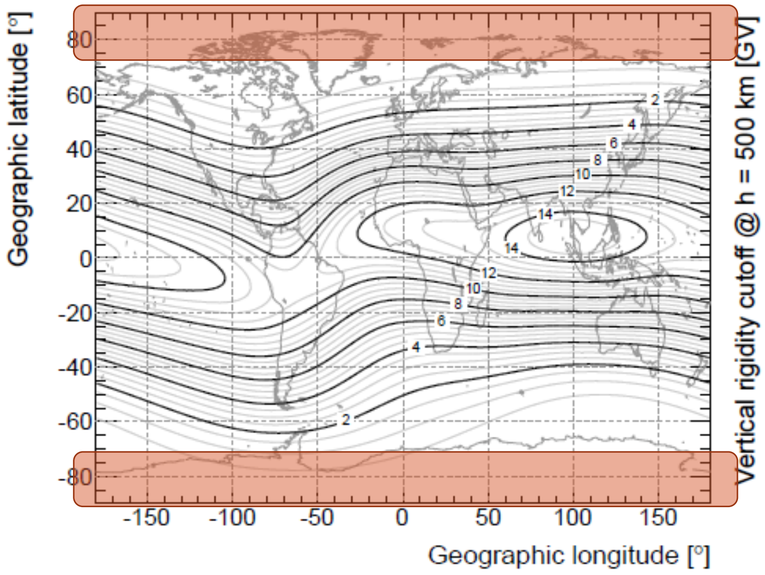


- use LE spectral cut-off of CRE to test absolute energy scale (1 < L < 1.14 & 8 GeV < E < 100 GeV)
- direct comparison between back-tracing code (IGRF12) and data
- 2.15B triggered events between Jan 2016 and Feb 2017, after selection ~40M events left

[Zang et al. (DAMPE), ICRC 2017]







Particle Identification

Distinctly different signature in BGO

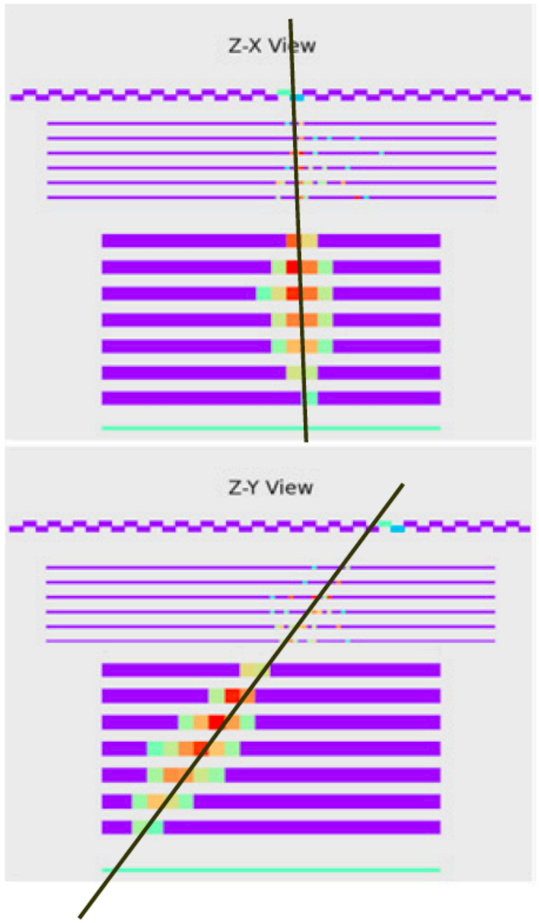
PSD

STK

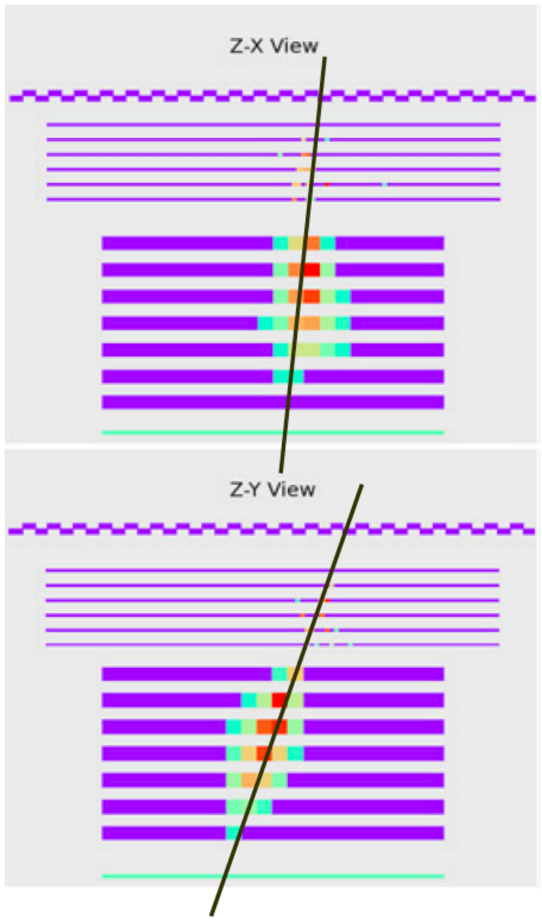
BGO

NUD

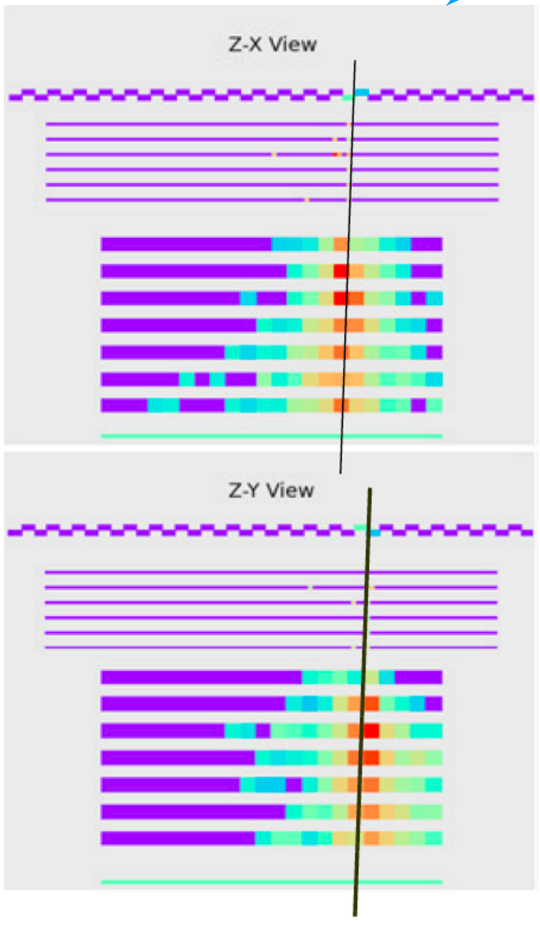
electron



gamma

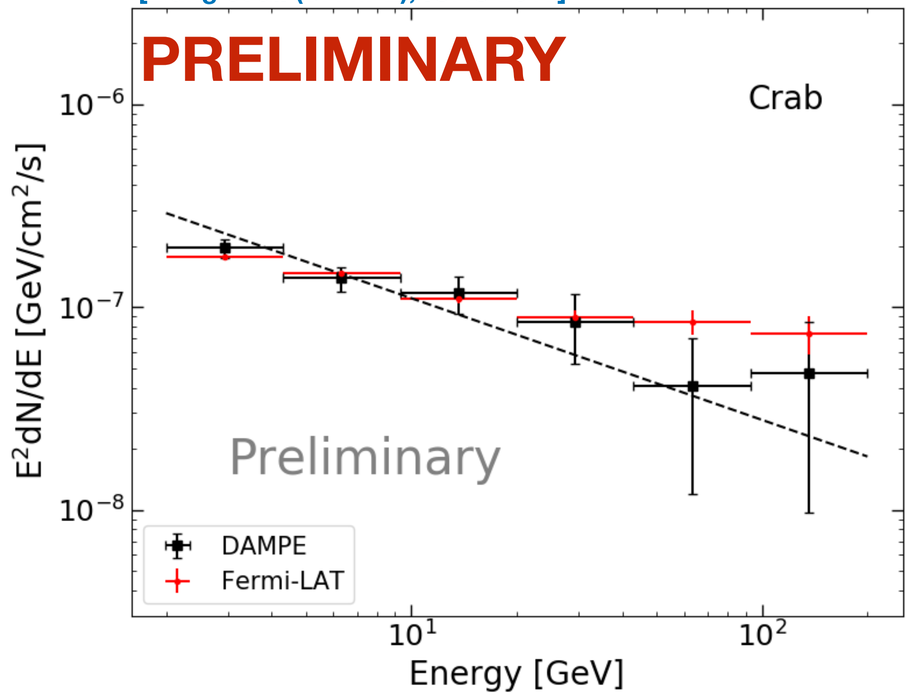


proton

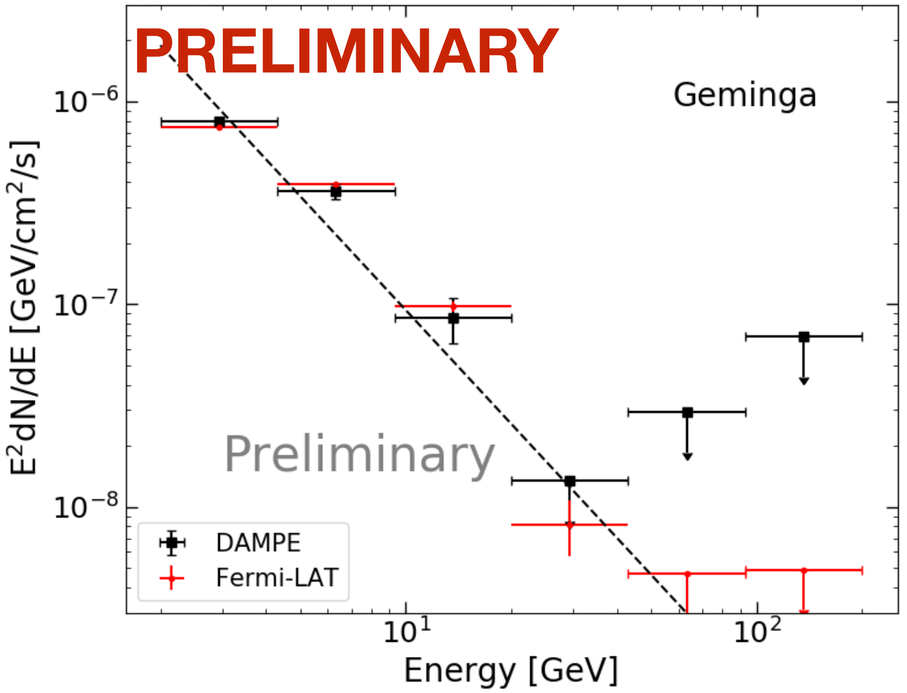


Bright Sources

[Liang et al. (DAMPE), ICRC 2017]



[Liang et al. (DAMPE), ICRC 2017]



Comparison with AMS-02 & Fermi-LAT

	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 acceptance (m^2sr)	0.3	0.09	1