FACULTÉ DES SCIENCES

Space Experiments in DPNC

Silvio Orsi

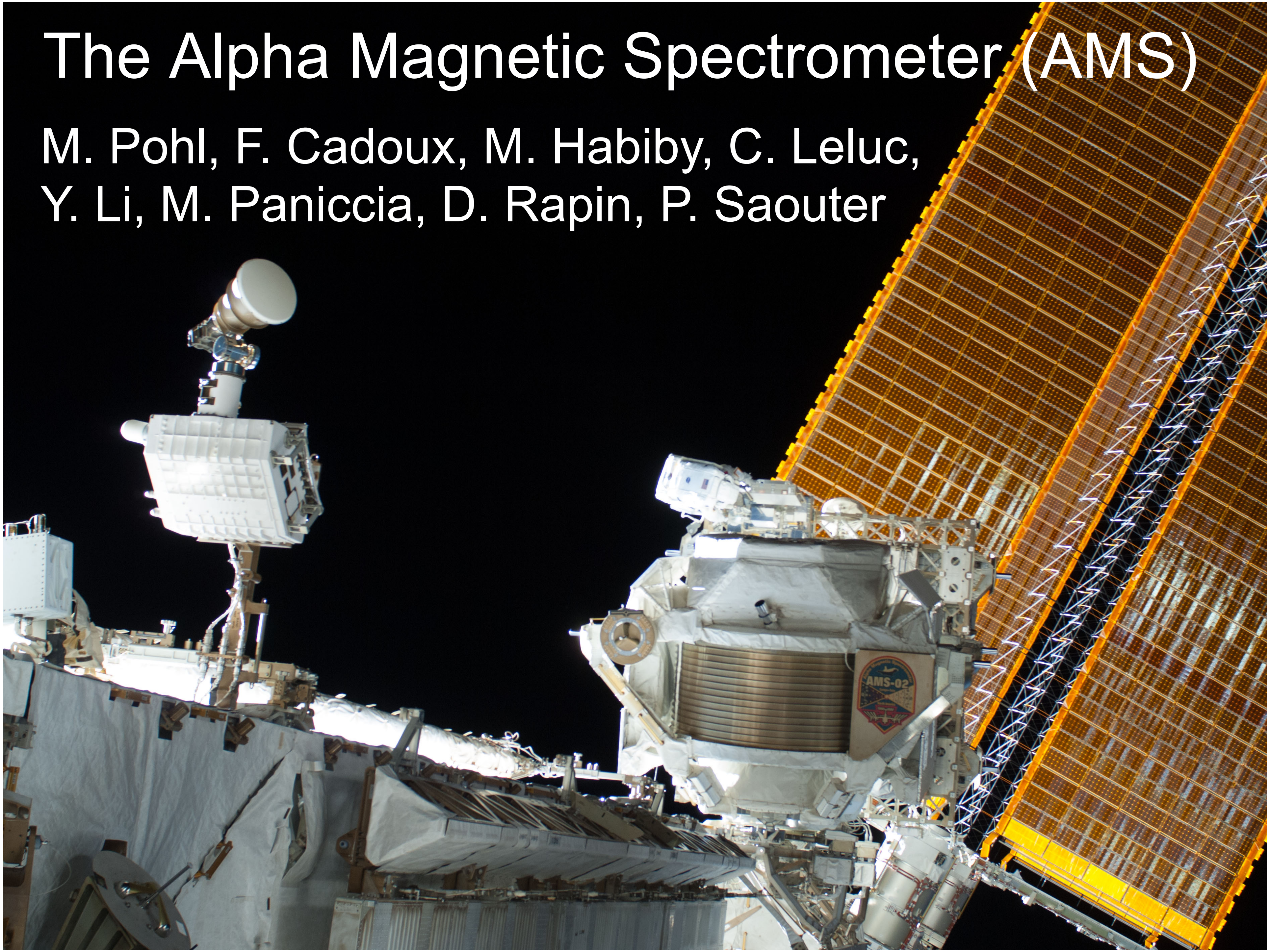
19 December 2013

UNIVERSITÉ DE GENÈVE

DEPARTEMENT DE PHYSIQUE NUCLEAIRE ET CORPUSCULAIRE

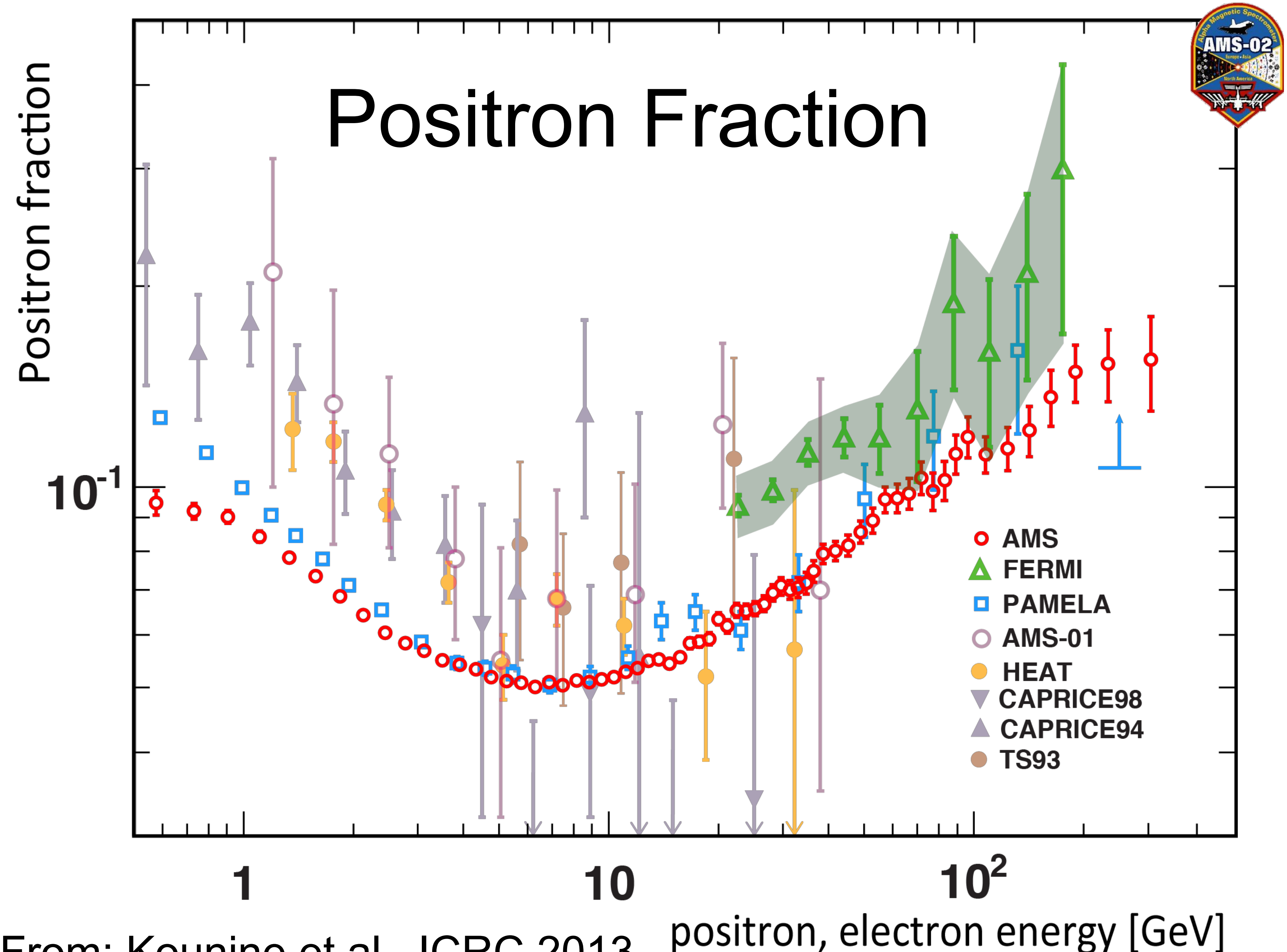
The Alpha Magnetic Spectrometer (AMS)

M. Pohl, F. Cadoux, M. Habiby, C. Leluc,
Y. Li, M. Paniccia, D. Rapin, P. Saouter



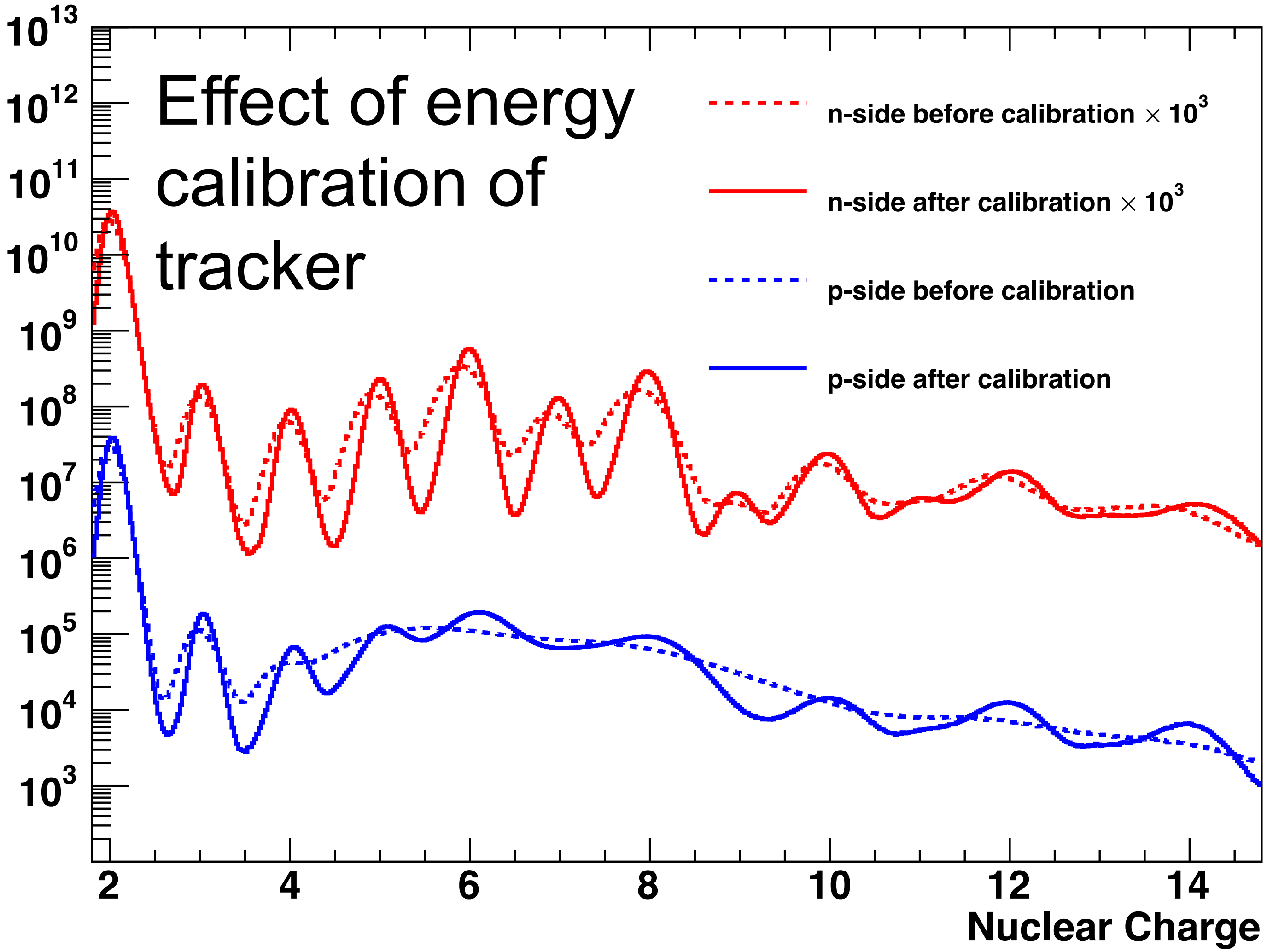
AMS in 2013

- **Presentations at ICRC 2013:**
- Precision measurement of the positron fraction in primary cosmic rays of 0.5−350 GeV
- Precision measurements of the electron spectrum and the positron spectrum with AMS
- Precision measurement of the $e^- + e^+$ spectrum with AMS
- Determination of the positron anisotropy with AMS
- Precision measurement of the proton flux with AMS
- Precision measurement of the Helium flux with AMS
- Precision measurement of the cosmic Boron-to-Carbon ratio with AMS



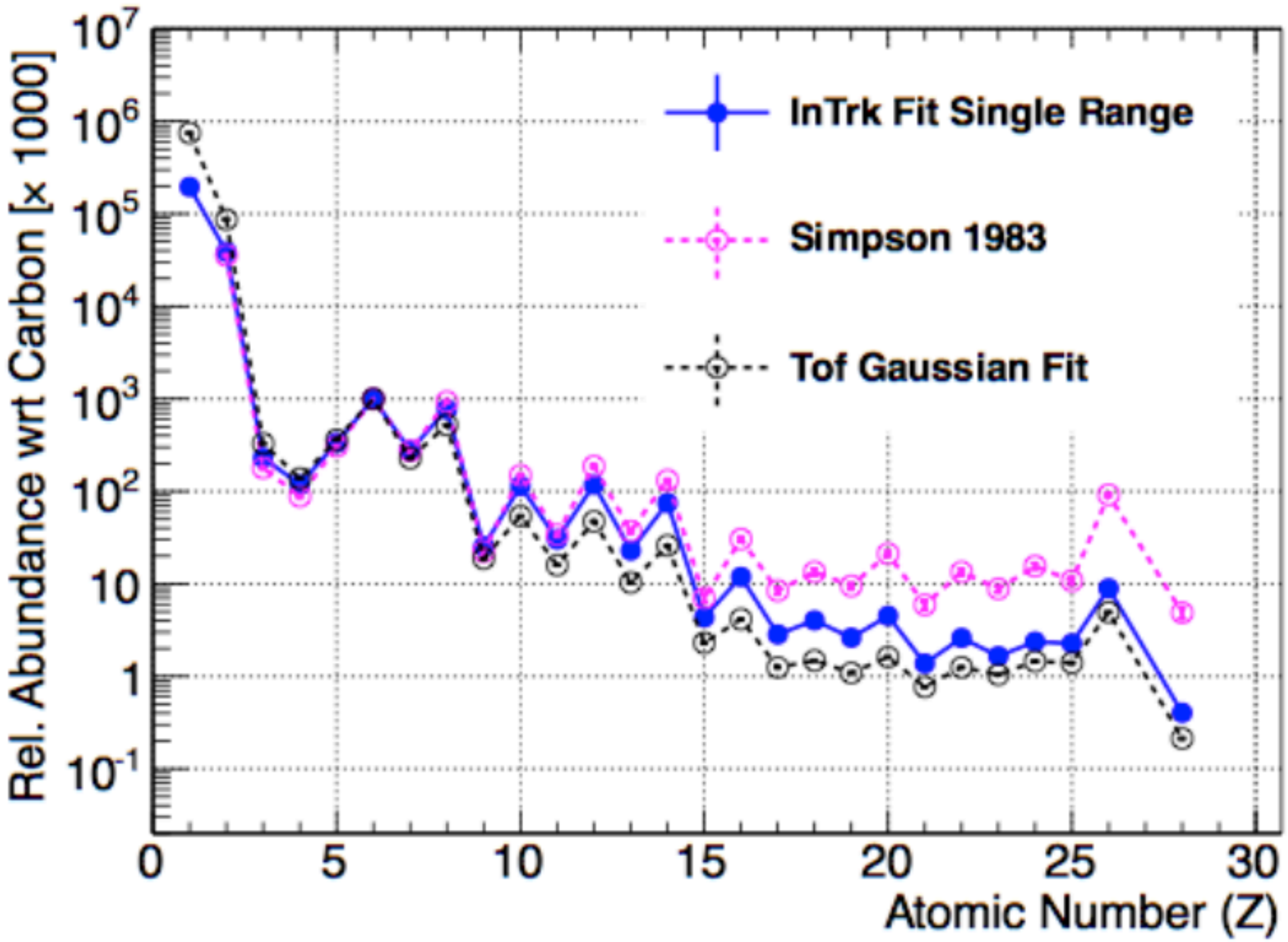
From: Kounine et al., ICRC 2013

Nuclei identification



Pierre Saouter

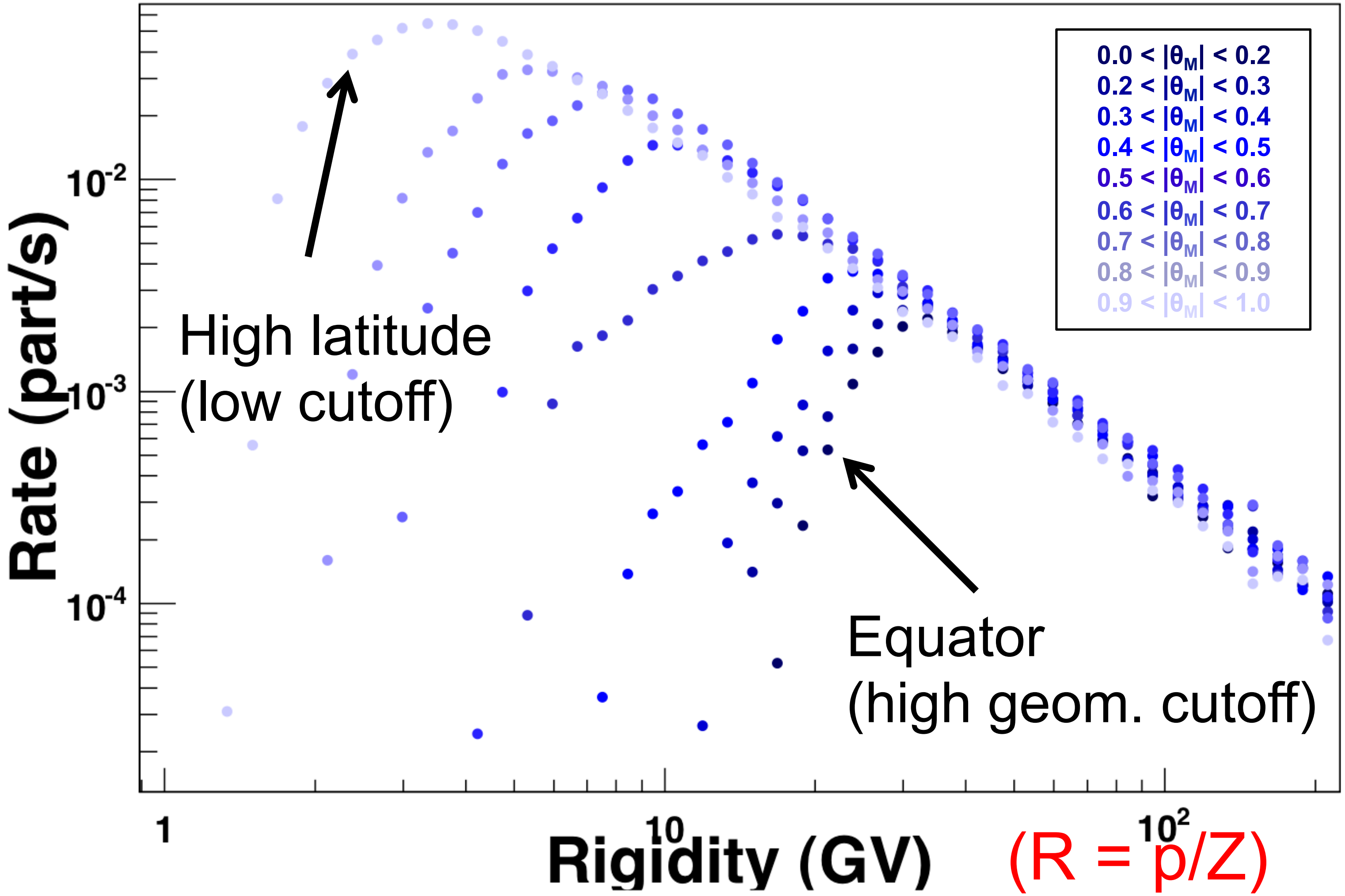
Nuclei: Relative abundance



No correction for fragmentation

Helium Identification

Rate of He nuclei above cutoff, for several geomagnetic locations

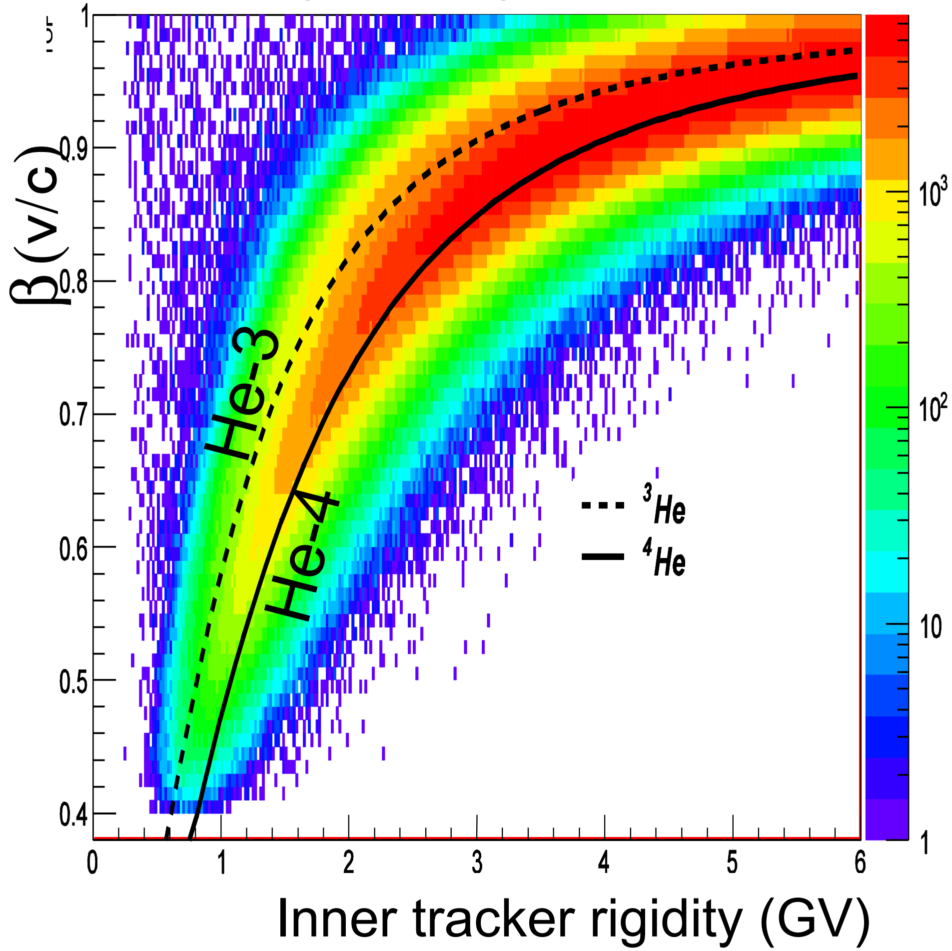


$(R = p/Z)$

Marion Habibi

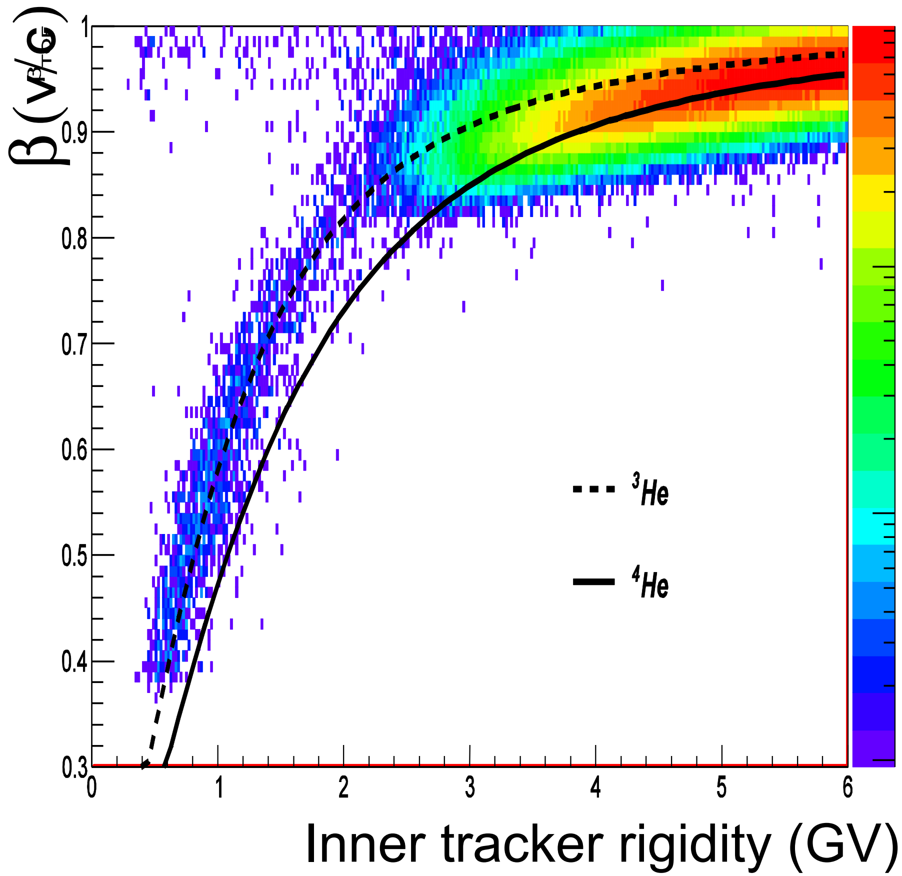
He-3 and He-4 separation

Selection of tracks with Z=2, above geomagnetic cutoff

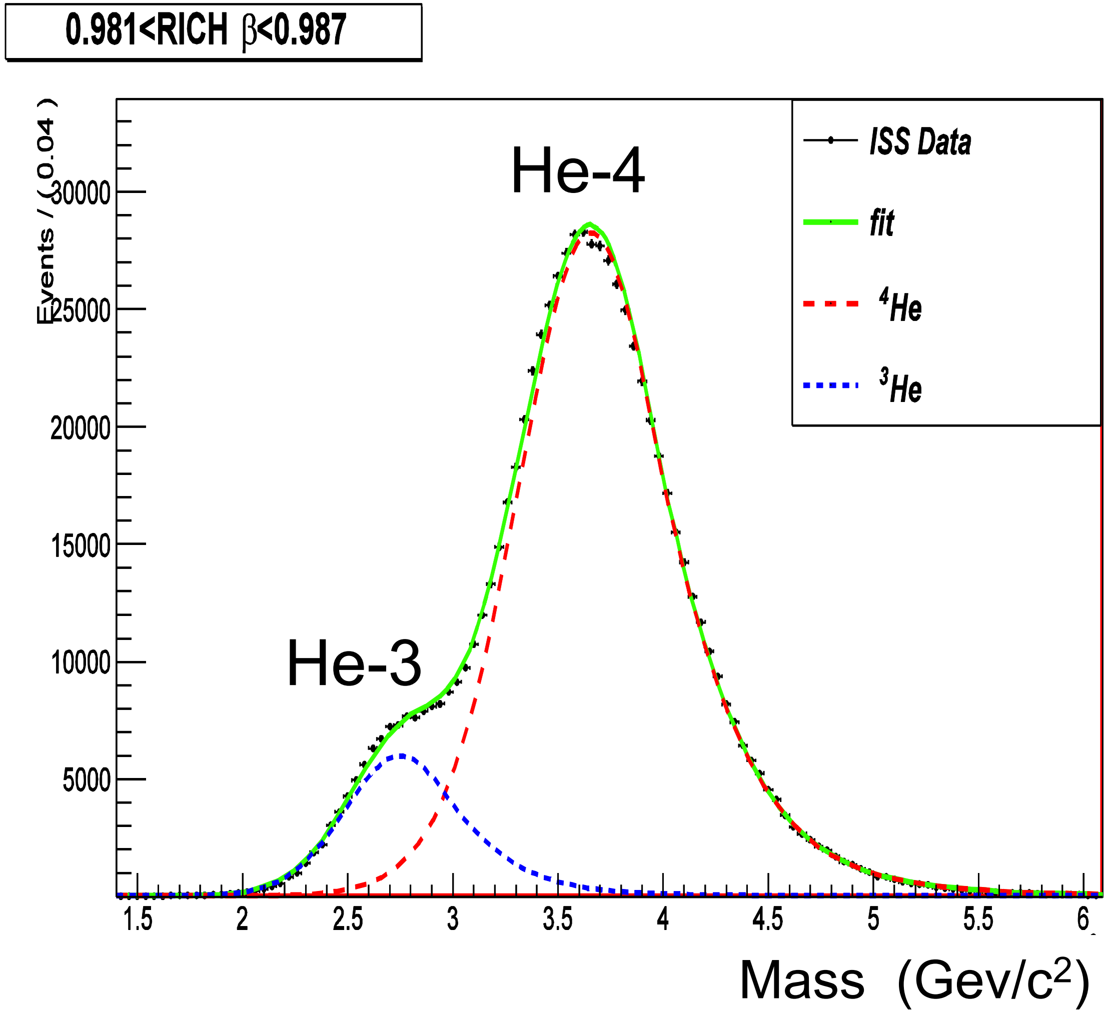


Z=2 particles, below cutoff

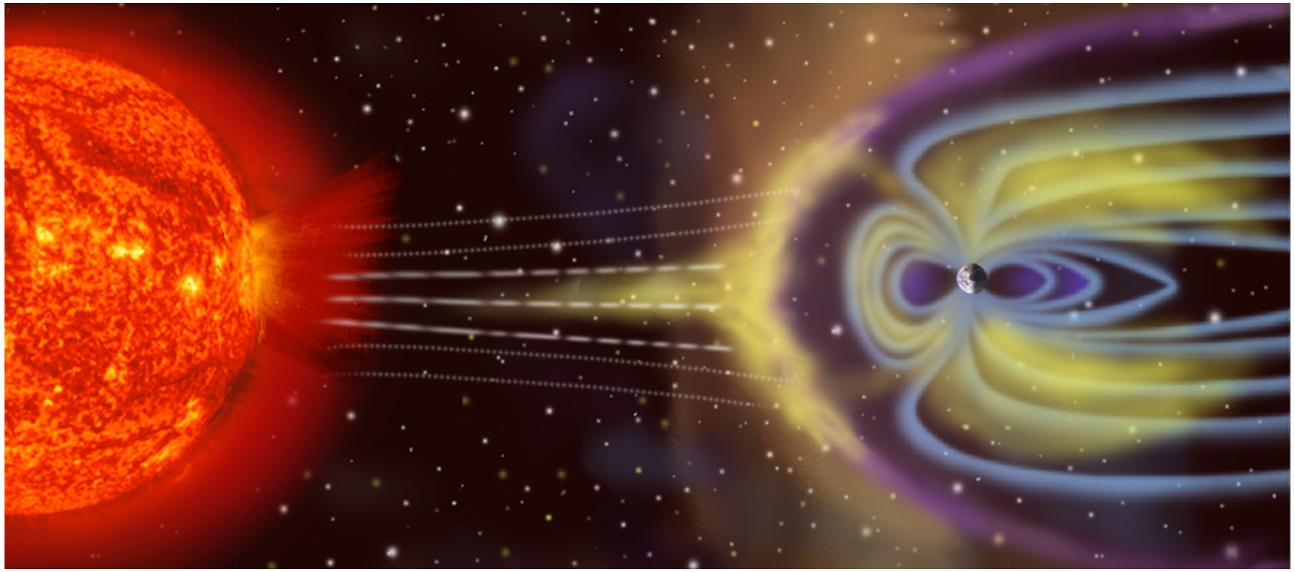
Yang Li



He-3 and He-4 separation



Solar Physics

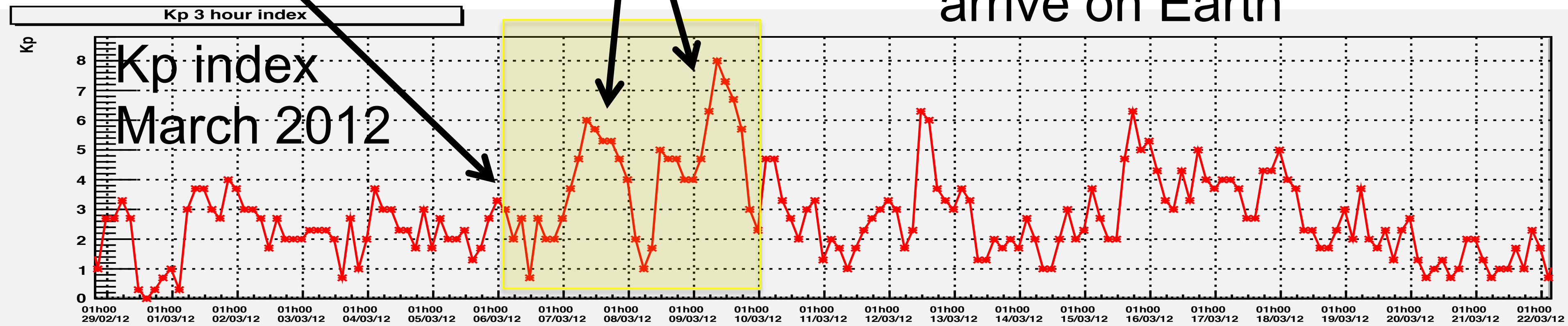


Mercedes Paniccia

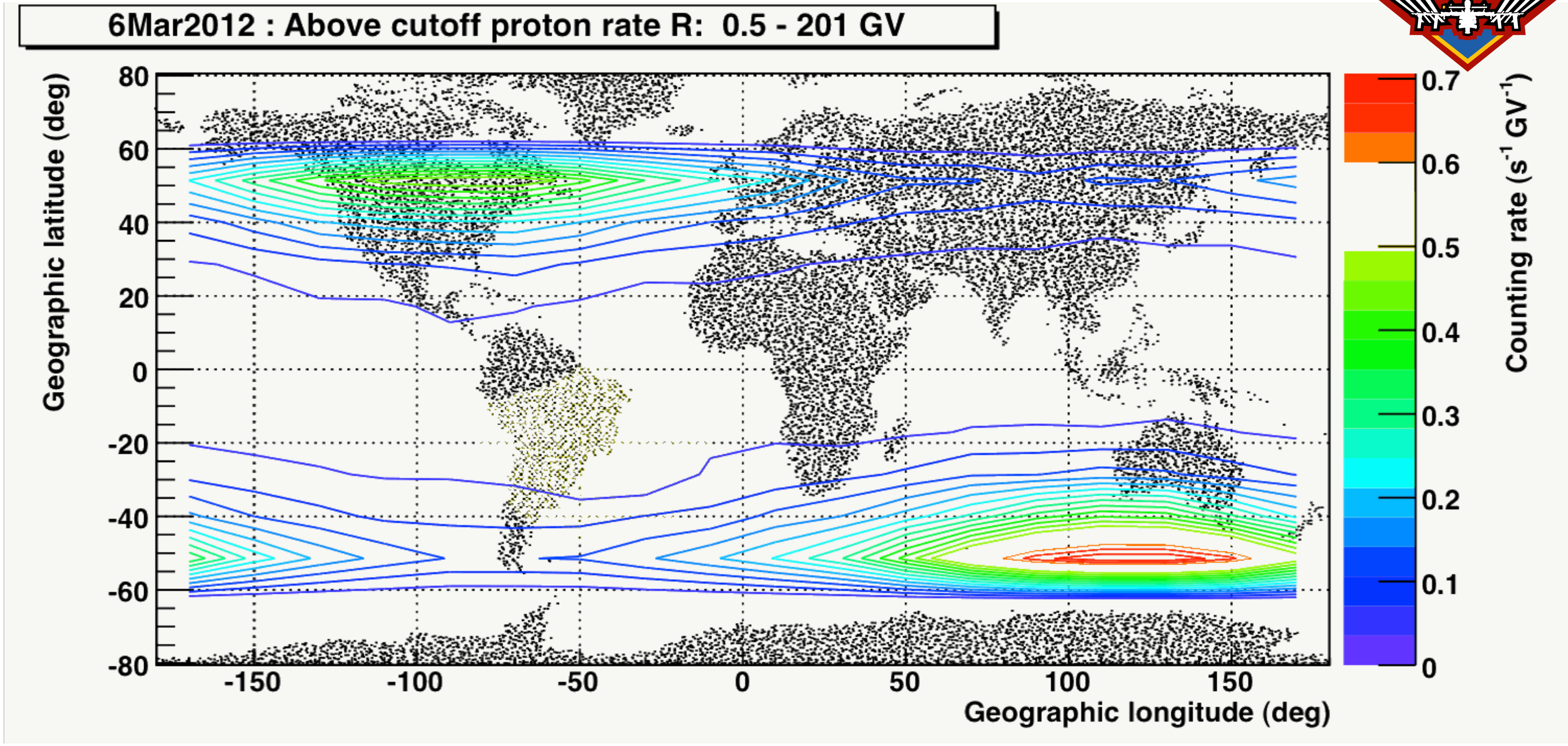
March 6, 2012: quiet day

March 7-9, 2012: active days

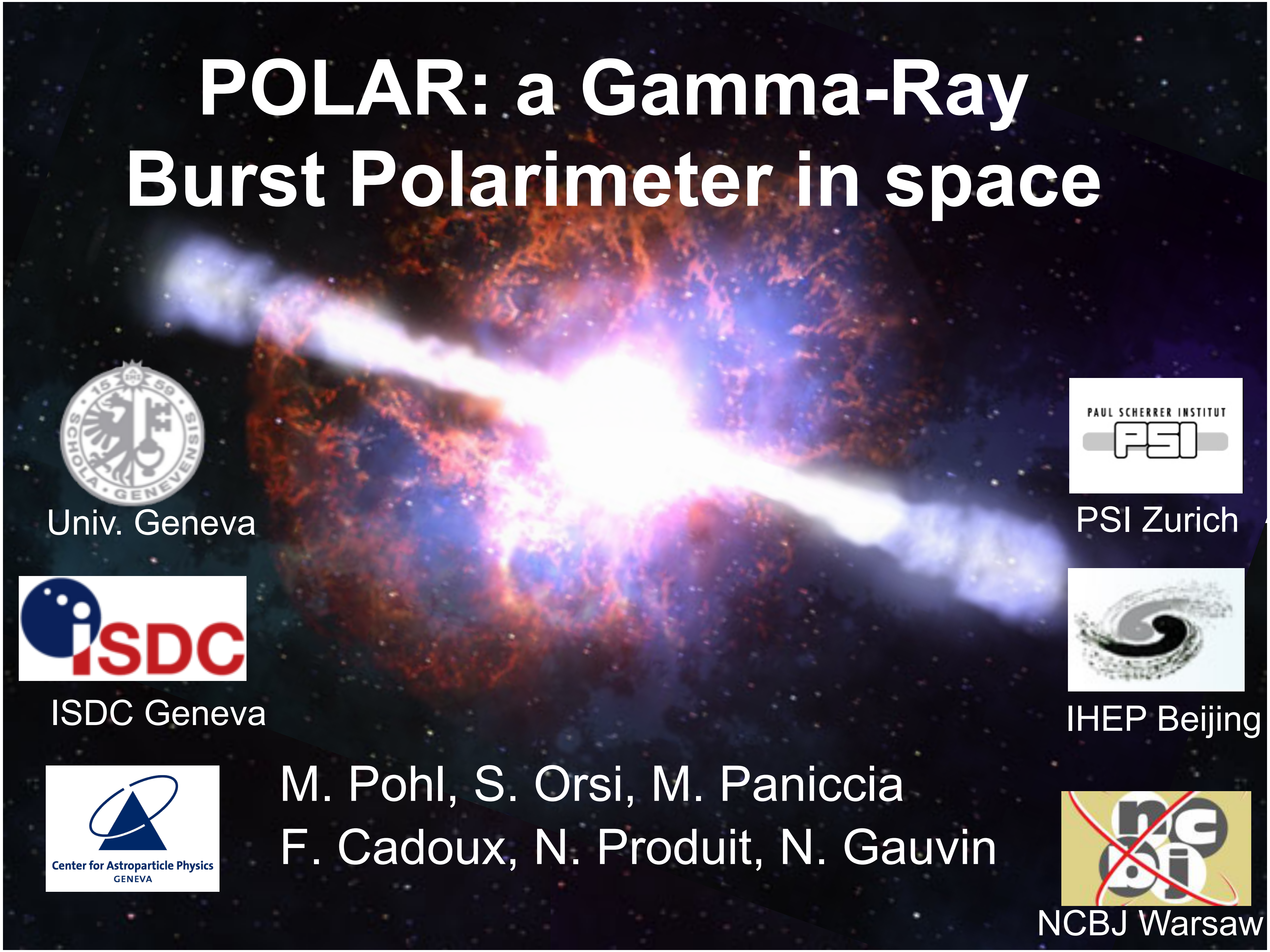
Solar Energetic Particles from Solar Flare/CME arrive on Earth



Modification of geomagnetic field



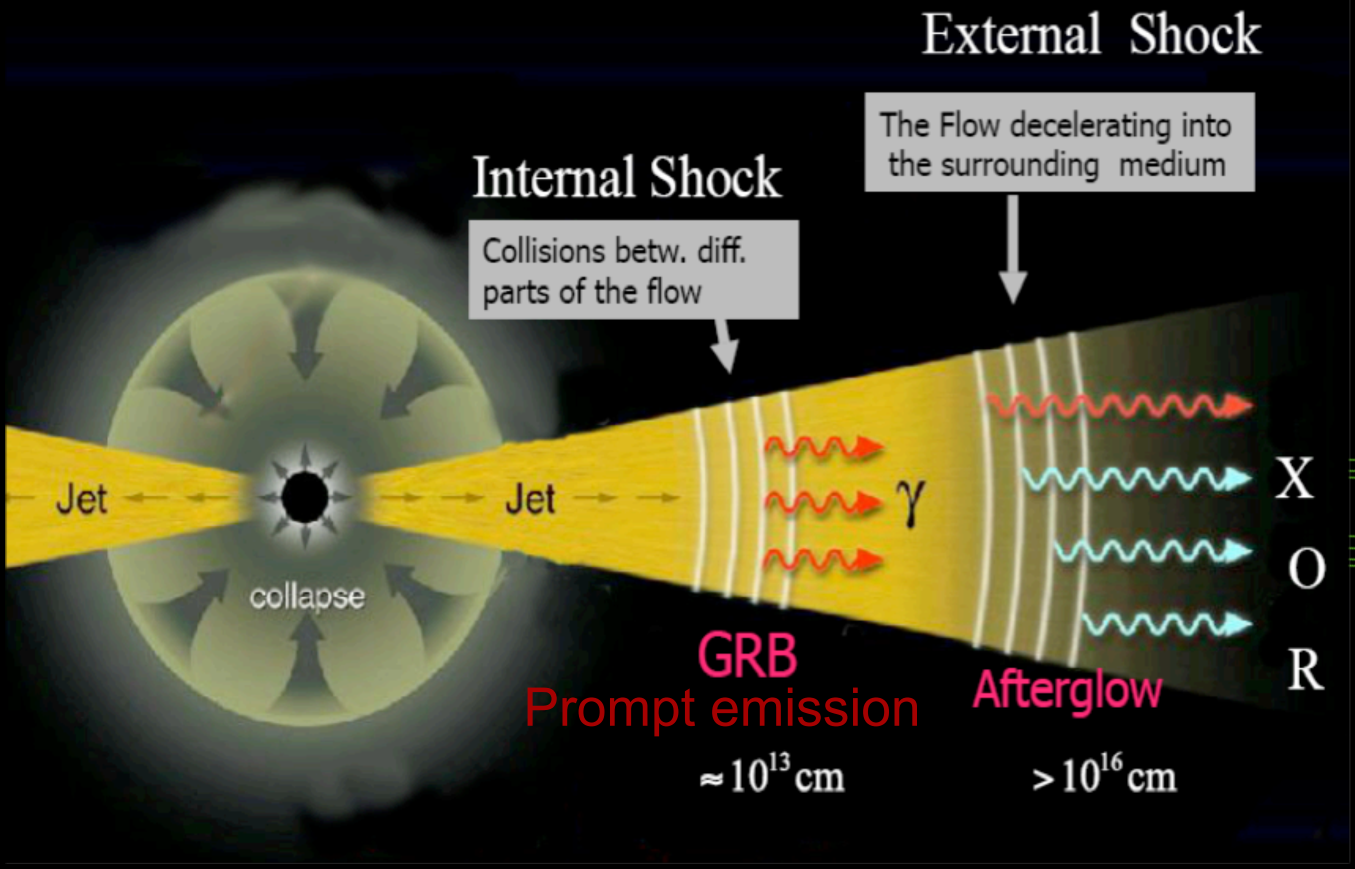
POLAR: a Gamma-Ray Burst Polarimeter in space



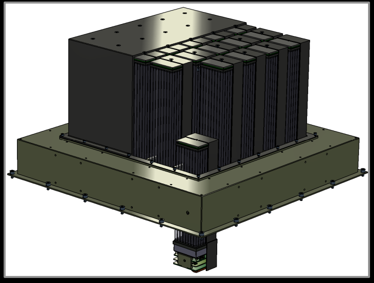
M. Pohl, S. Orsi, M. Paniccia
F. Cadoux, N. Produit, N. Gauvin

Univ. Geneva
ISDC Geneva
Center for Astroparticle Physics GENEVA
PSI Zurich
IHEP Beijing
NCBJ Warsaw

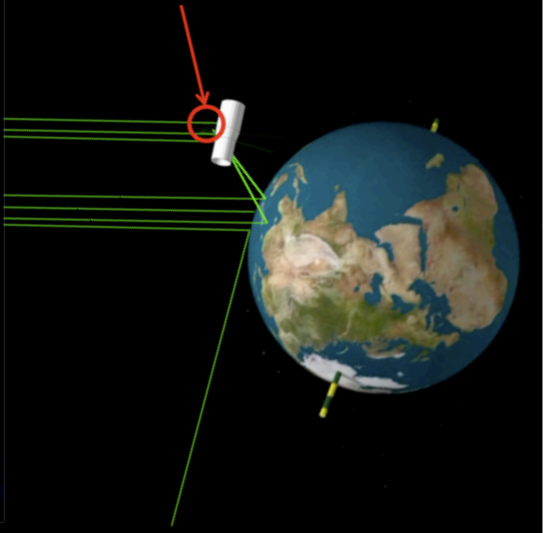
Gamma Ray Bursts



26kg, 40W



POLAR



Launch in 2015 onboard the Chinese Spacelab TG-2


1600 plastic scintillator bars

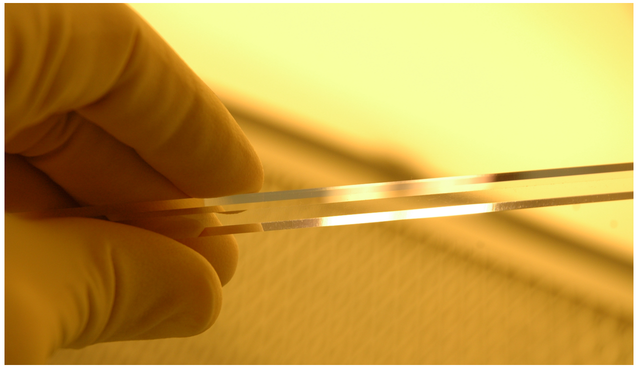
Why polarization?

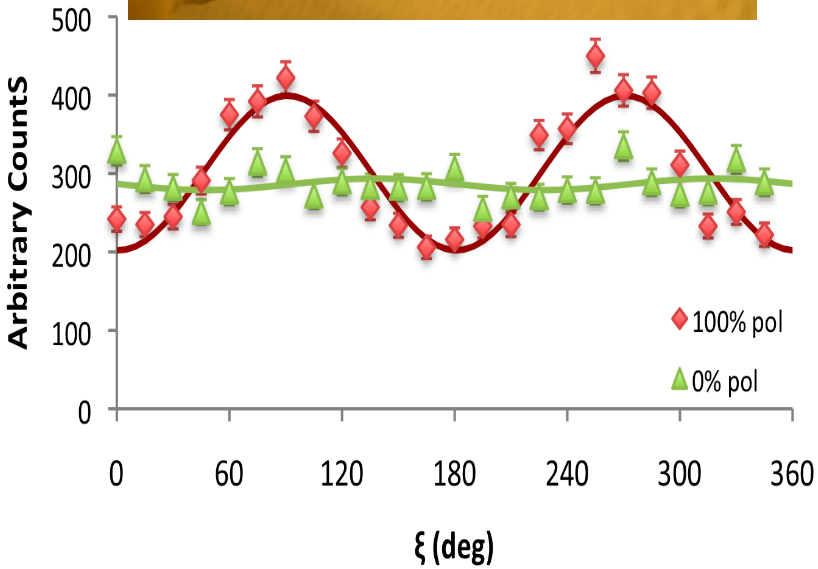
Visible light

Horizontal polarizer

Vertical polarizer

X-Rays

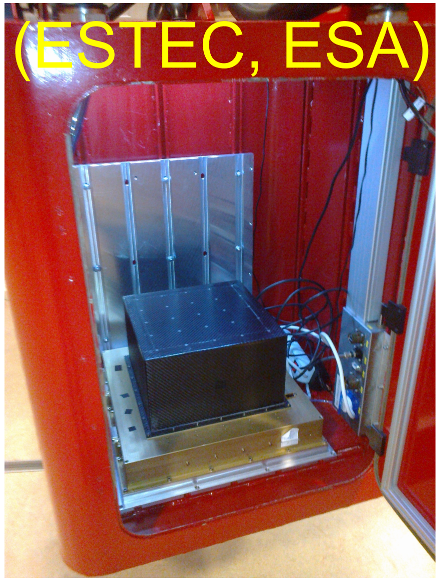




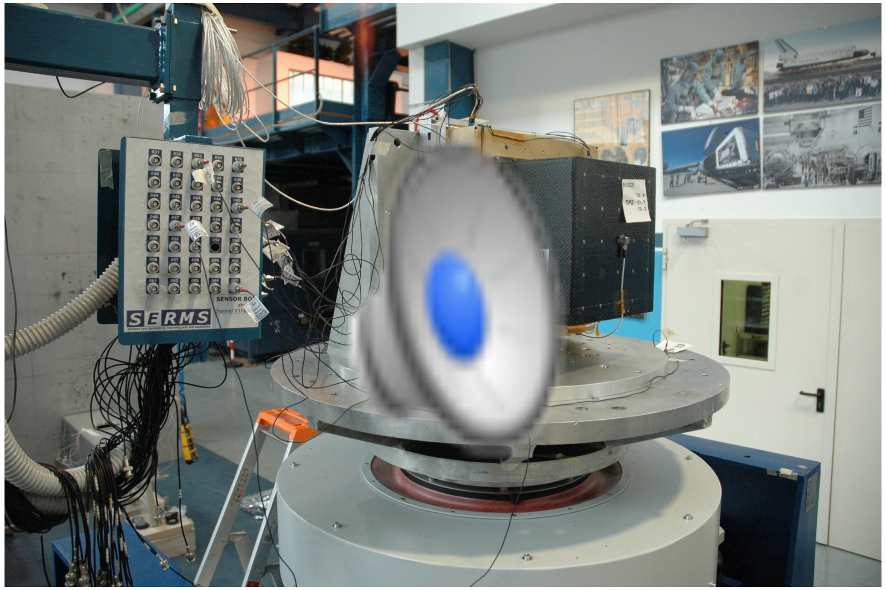
Space Qualification 2013

Static accel.

(ESTEC, ESA)

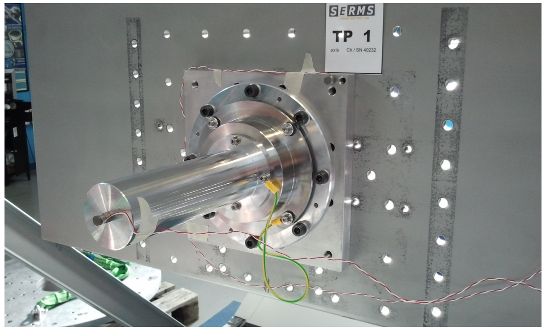


Vibration (Terni, Italy)



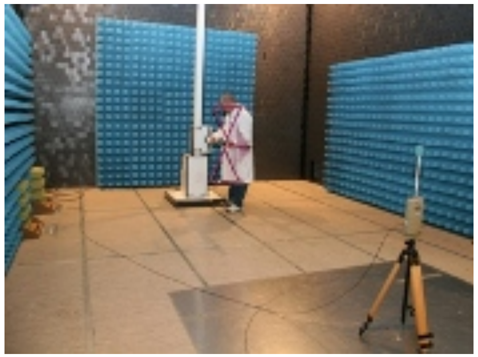
TVT(Terni)

Shock 3 (Terni)

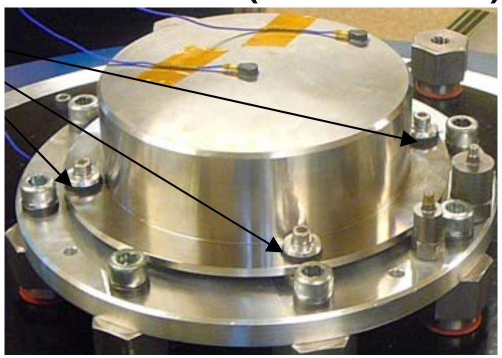


Shock 1 (Terni)

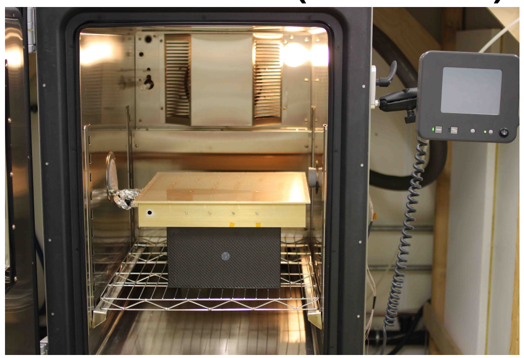
EMC (Terni)

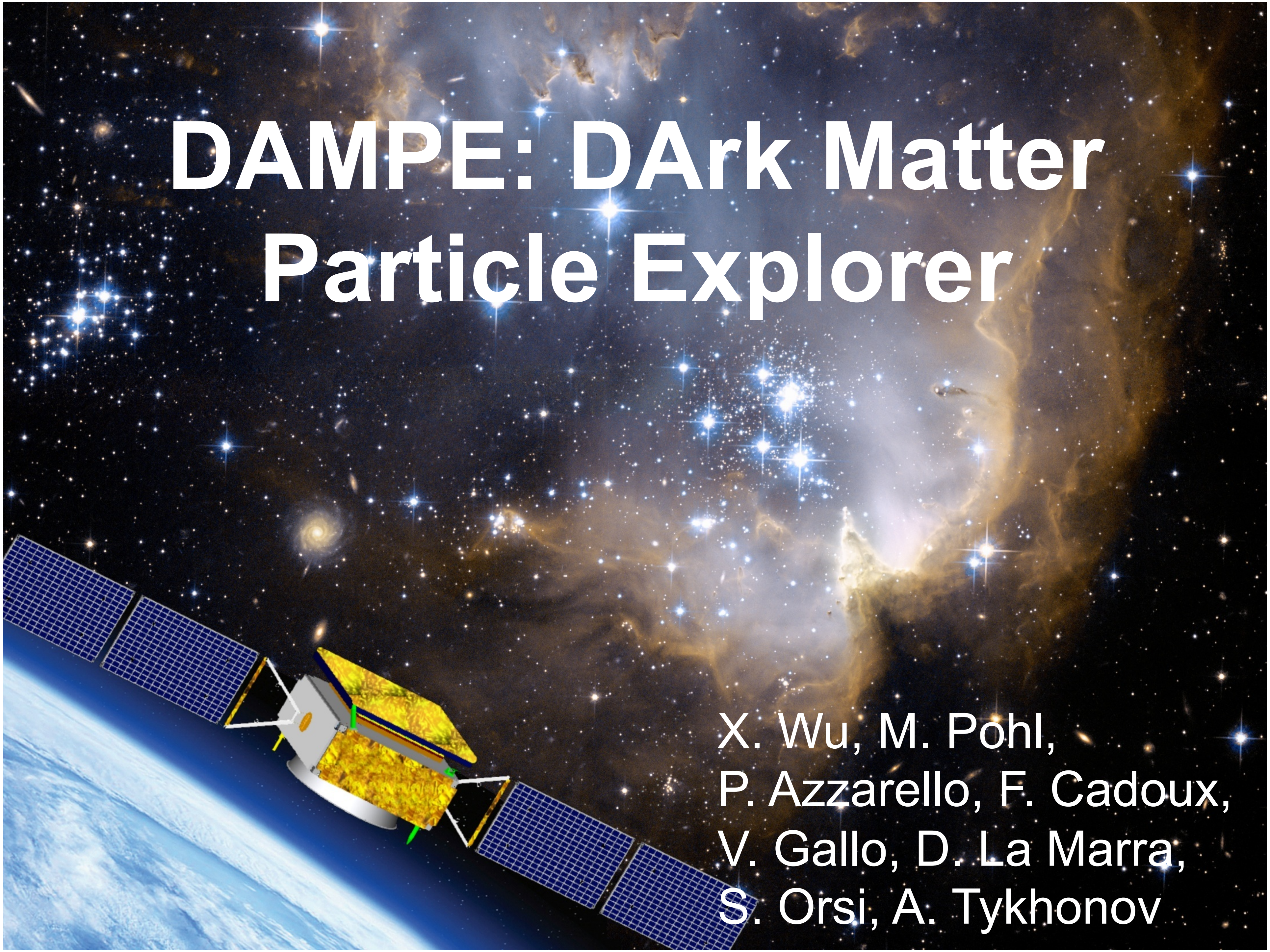


Shock 2 (Valence)



Thermal (CERN)





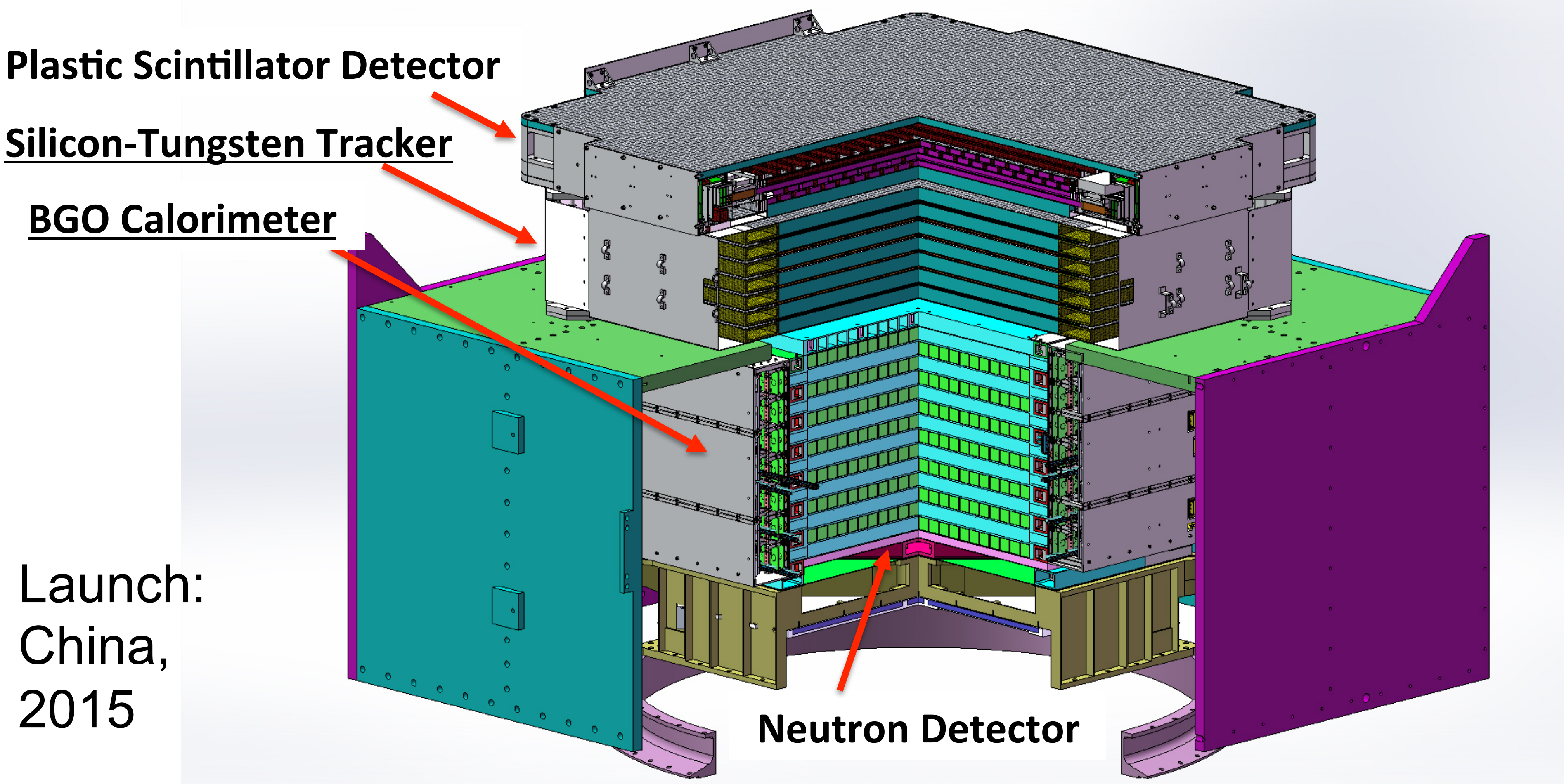
DAMPE: DArk Matter Particle Explorer

X. Wu, M. Pohl,
P. Azzarello, F. Cadoux,
V. Gallo, D. La Marra,
S. Orsi, A. Tykhonov

The DAMPE Detector

High energy particle detection in space

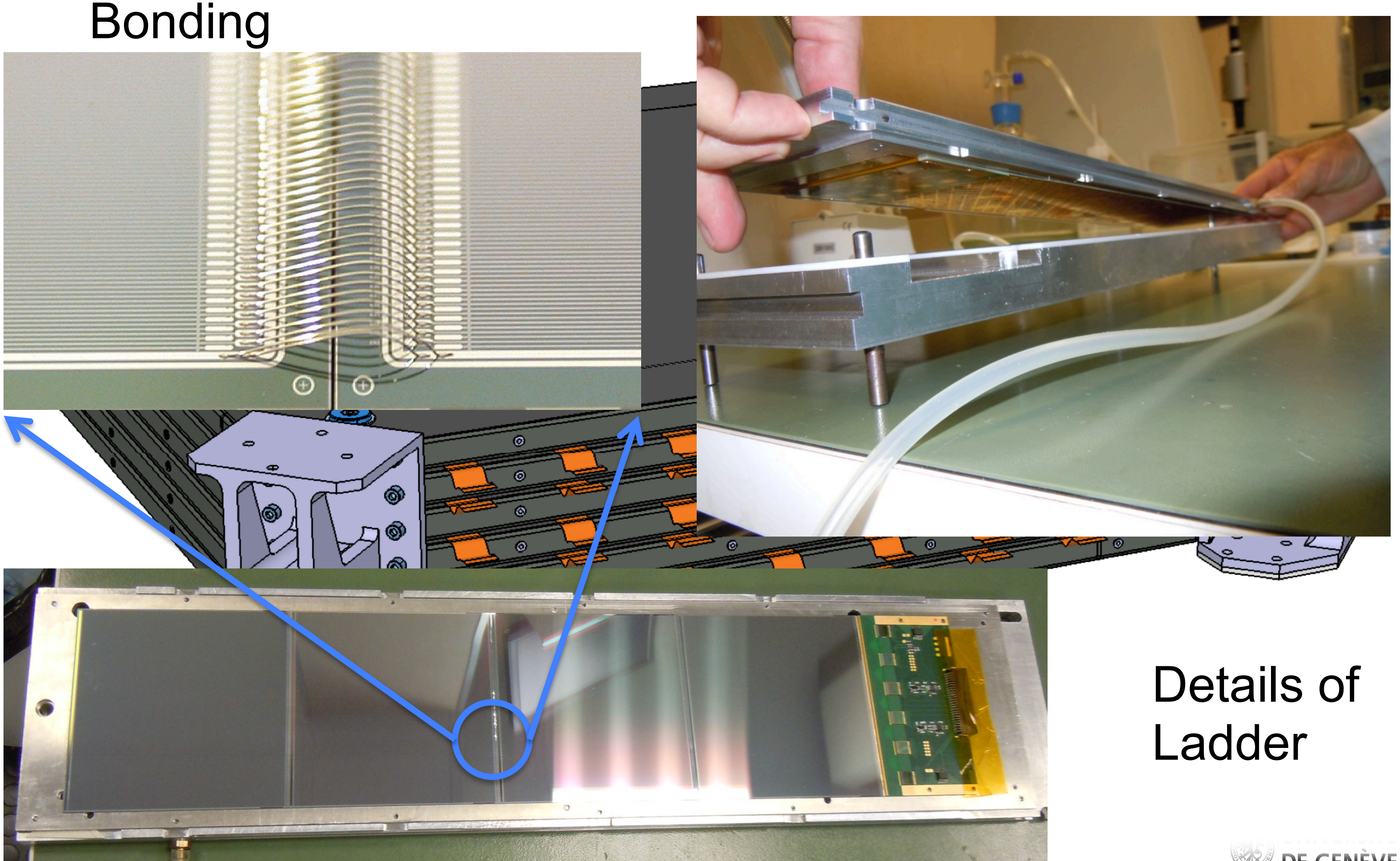
- **Search for Dark Matter signatures with e, g**
- **Study of cosmic ray spectrum and composition**
- **High energy gamma ray astronomy**



Launch: China, 2015

Silicon Tracker (STK)

Bonding

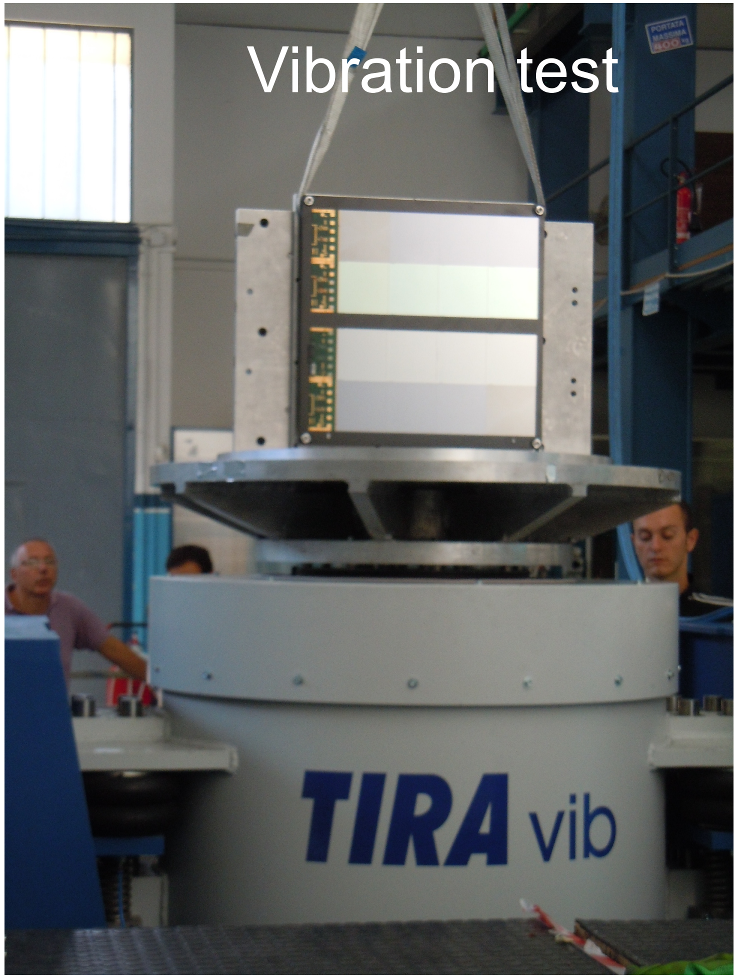


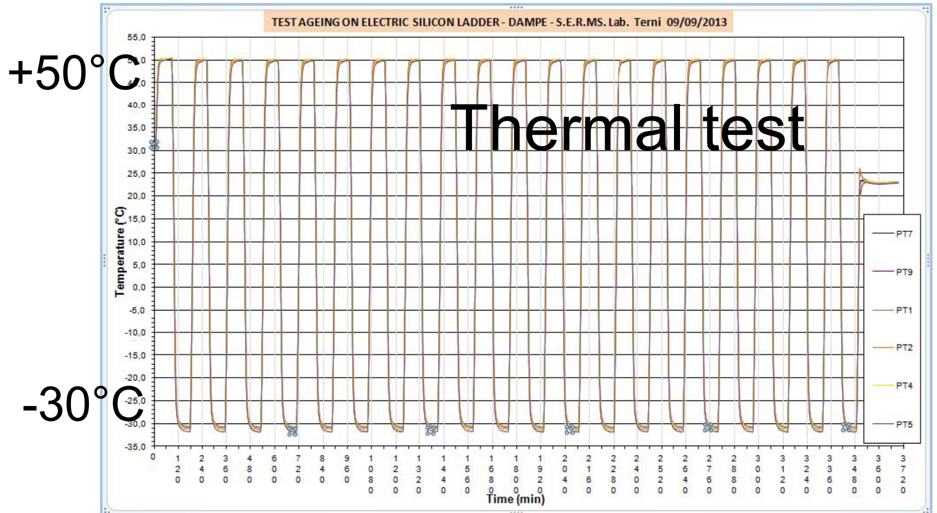
Details of Ladder

DAMPE: Qualification Tests

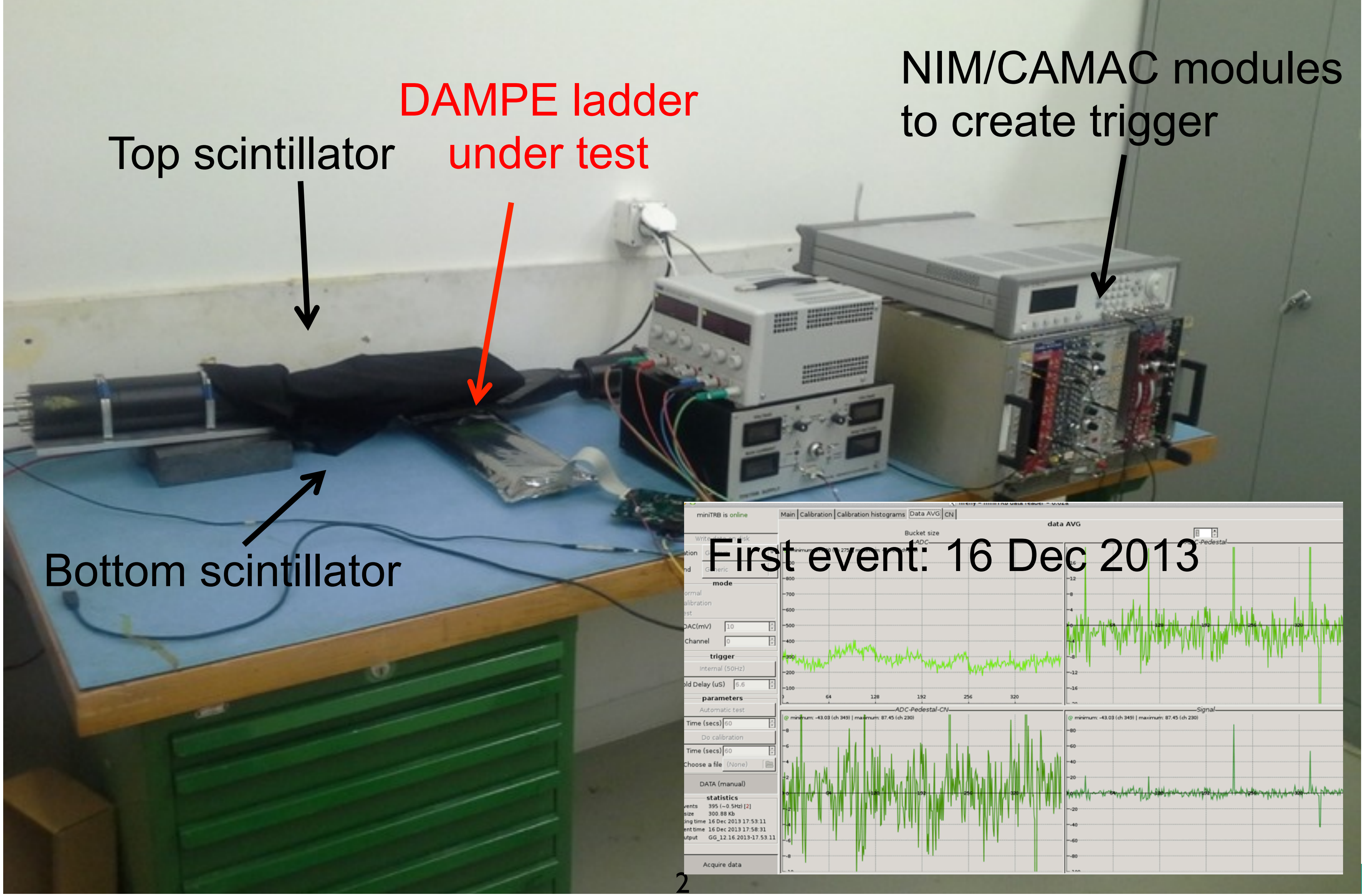
All tests performed at:

SERMS laboratory in Terni (Italy)



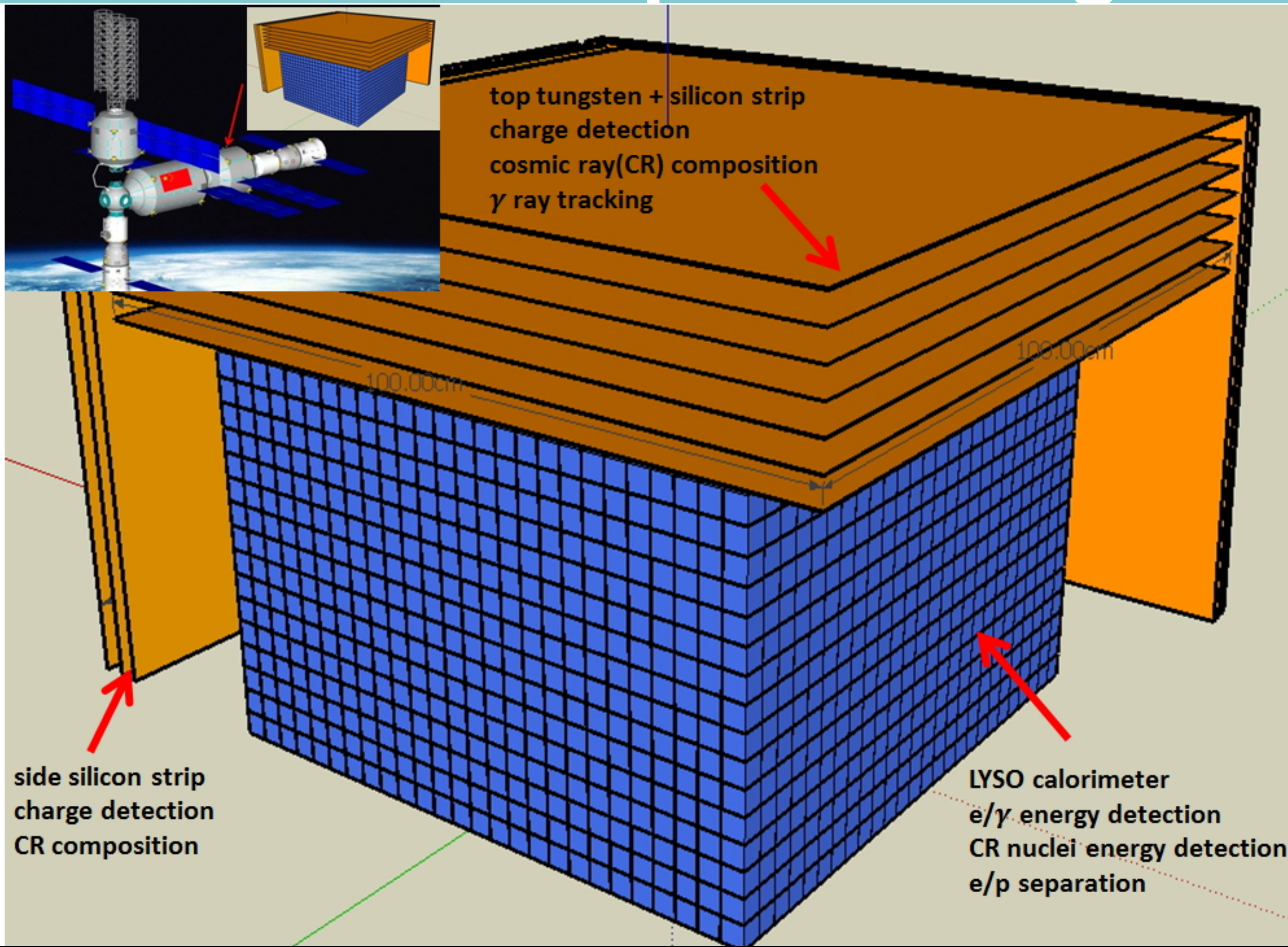


Setup to test DAMPE ladders with cosmic rays in DPNC

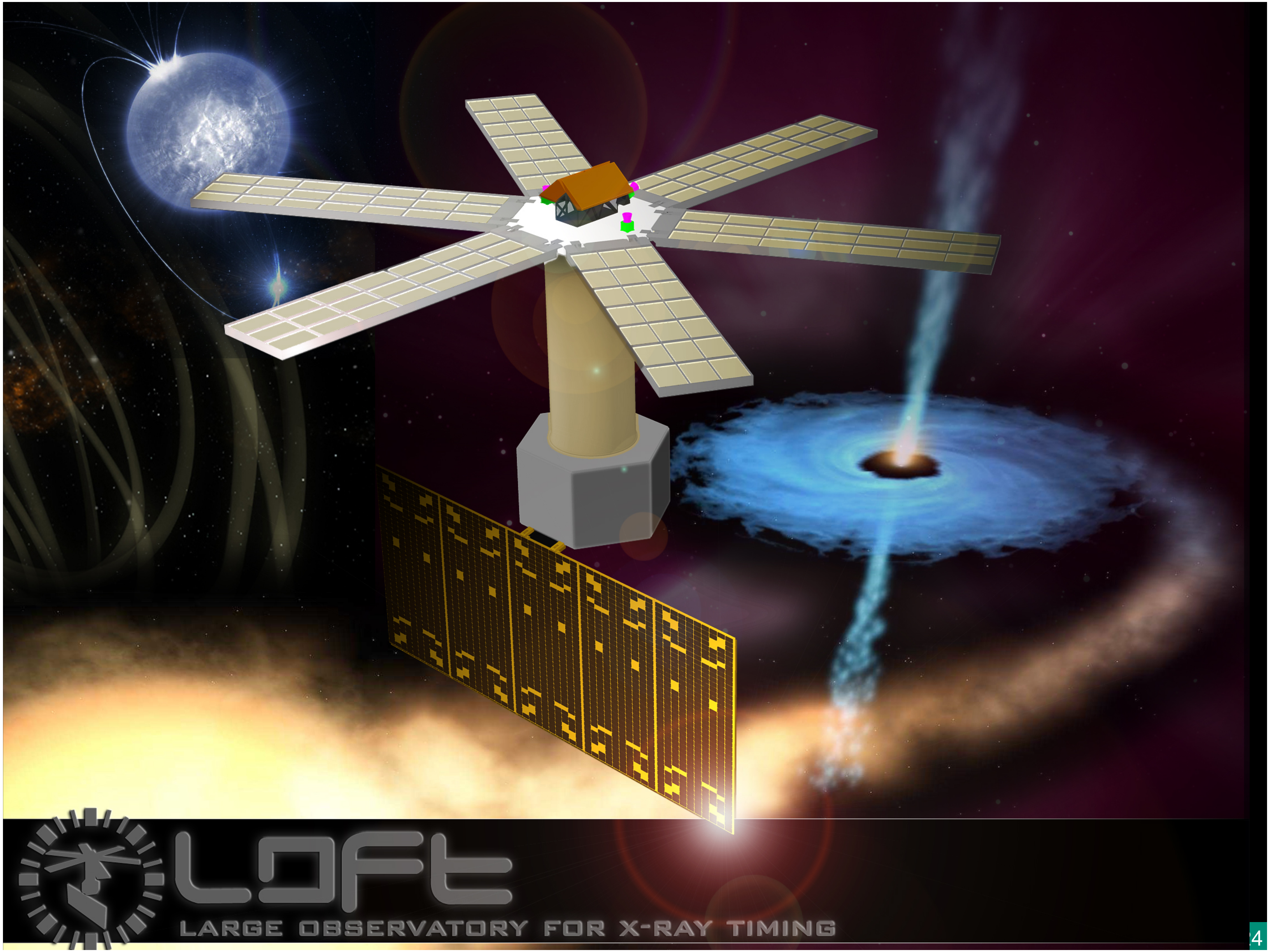


The High Energy cosmic Radiation Detection (HERD) facility onboard China's Space Station

HERD Conceptual Design



Silicon-Tungsten Tracker + LYSO Calorimeter


LOFT
LARGE OBSERVATORY FOR X-RAY TIMING

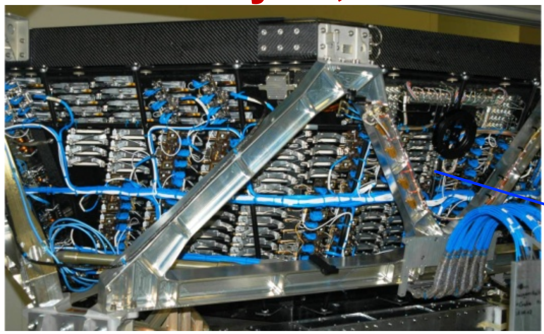
Conclusions and Outlook

- AMS:
  - Data taking; first scientific results in 2013
- POLAR: (flight in 2015)
  - Qualification in 2013, to be ended soon
  - Ongoing construction of flight model
- DAMPE: (flight in 2015)
  - Geneva responsible for silicon tracker
  - Qualification ongoing
- HERD: (flight in ~2020)
  - Conceptual design
- LOFT: (flight ~2022)
- Other projects: Astro-H, JEM-EUSO, …

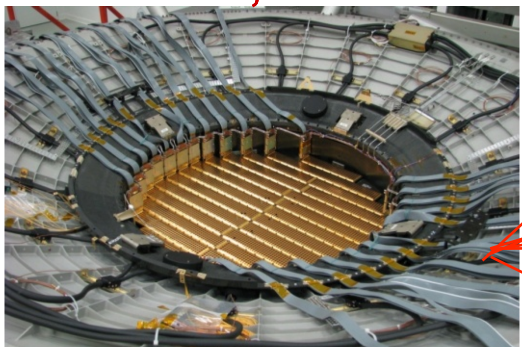

Thank you!
AMS-02

AMS: A TeV precision, multipurpose spectrometer

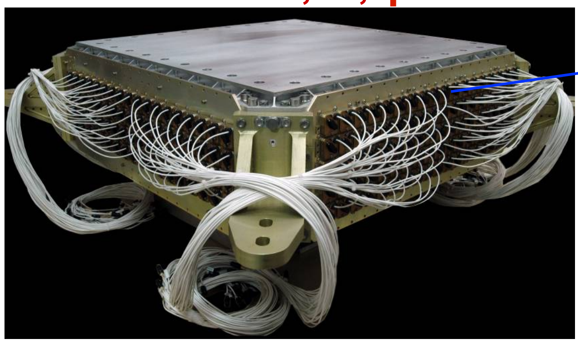
TRD
Identify e^+, e^-



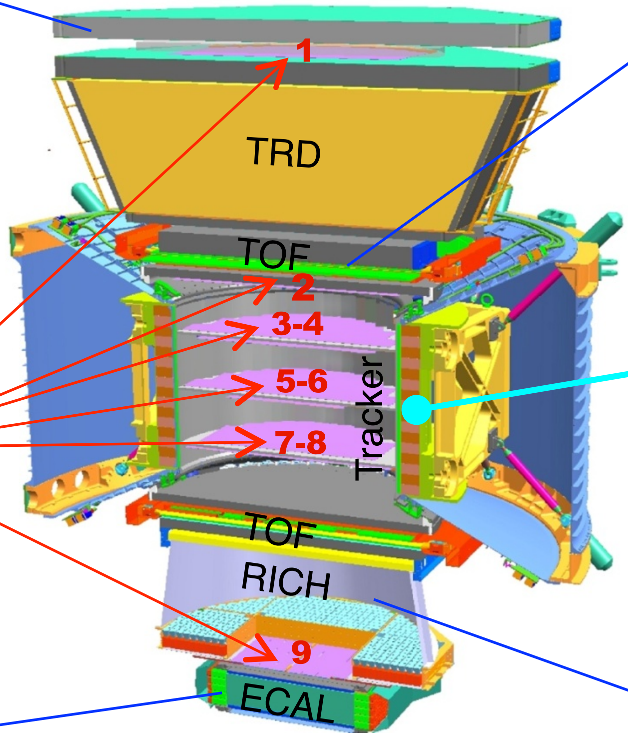
Silicon Tracker
Z, P



ECAL
E of e^+, e^-, γ



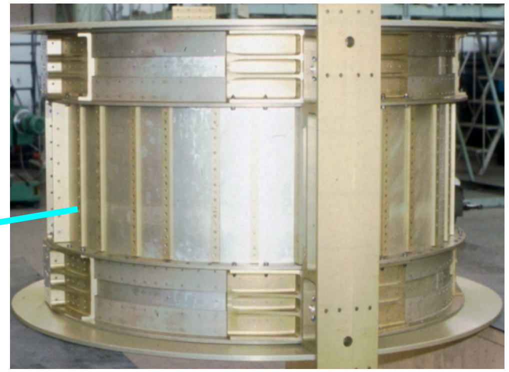
Particles and nuclei are defined by their charge (Z) and energy (E ~ P)



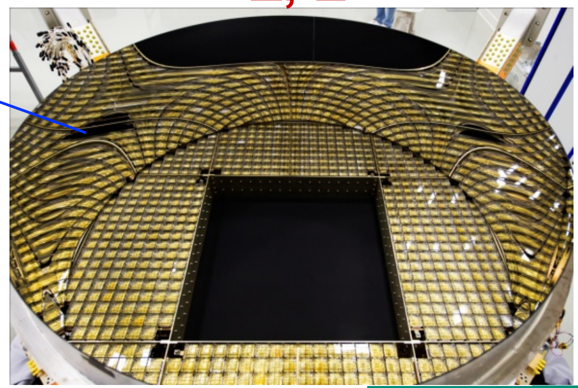
Z, P are measured independently by the Tracker, RICH, TOF and ECAL

TOF
Z, E

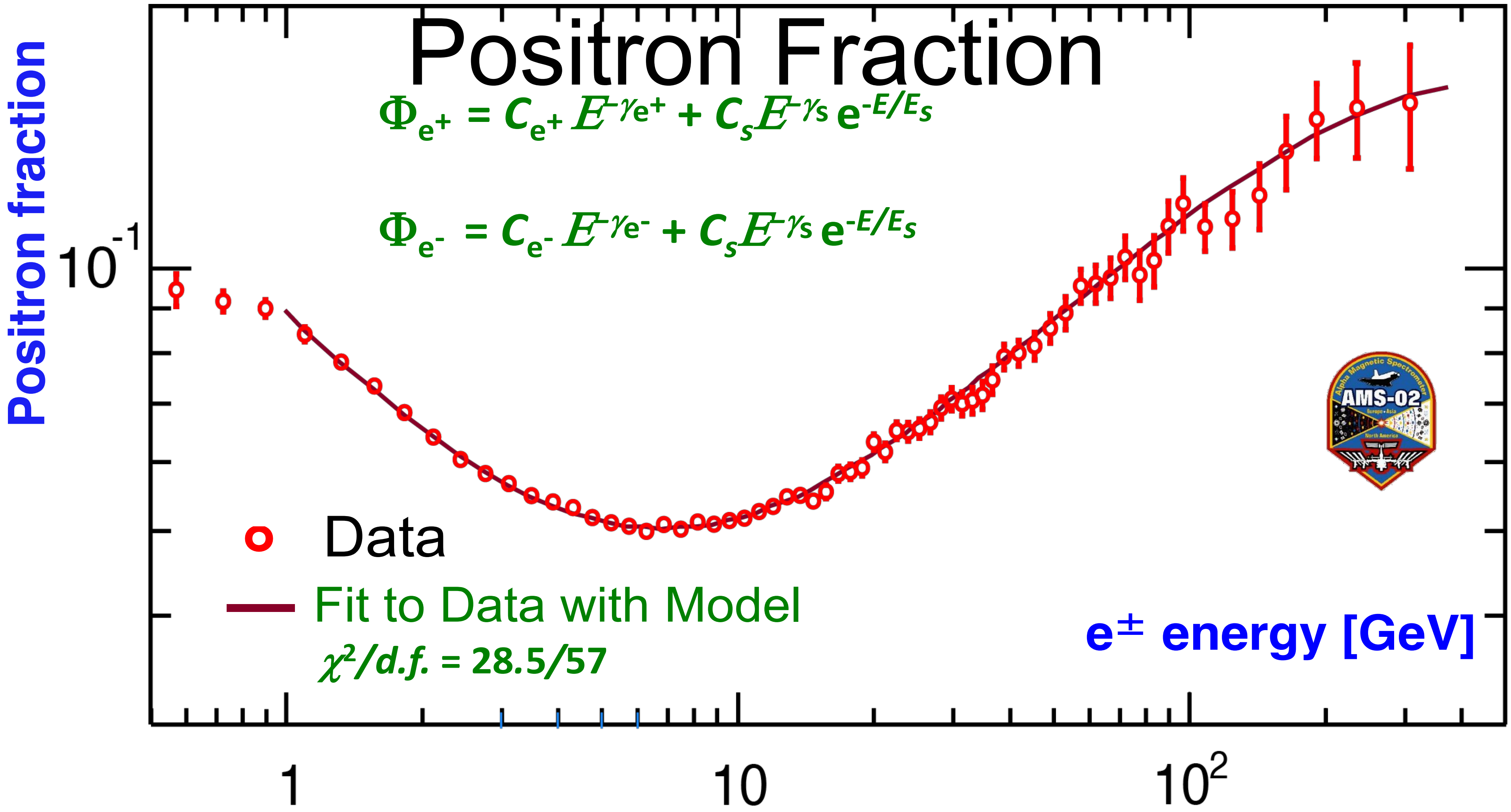
Magnet
±Z



RICH
Z, E



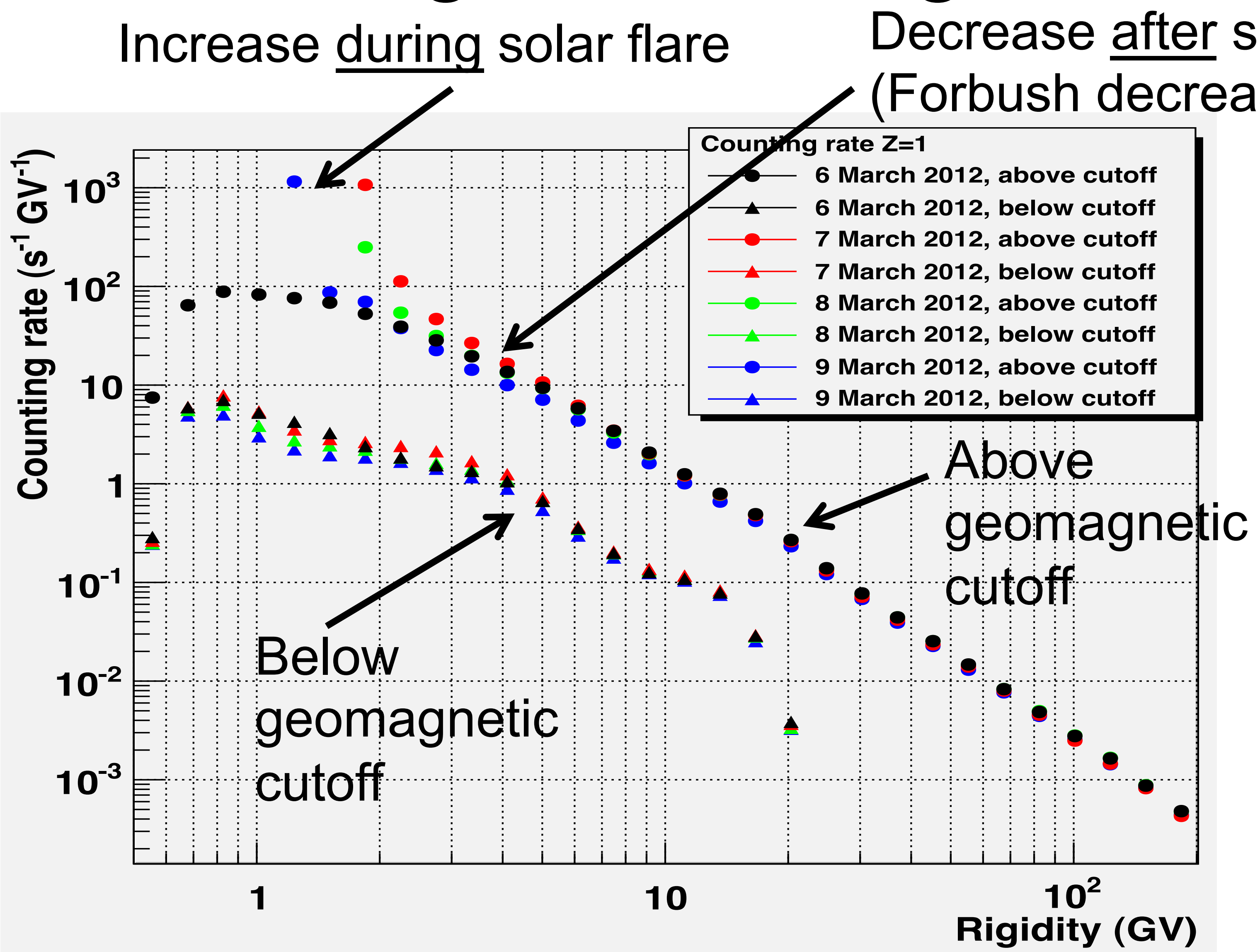
Physics Example: Comparing data with a minimal model.



The agreement between the data and the model shows that the positron fraction spectrum is consistent with e± fluxes each of which is the sum of its diffuse spectrum and a single common power law source.

From: Kounine et al., ICRC 2013

Counting rate during solar flare



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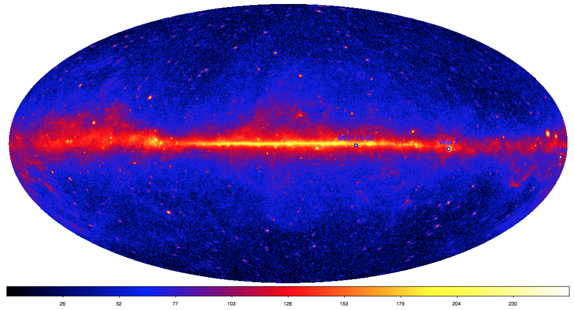
Scientific Objectives of DAMPE

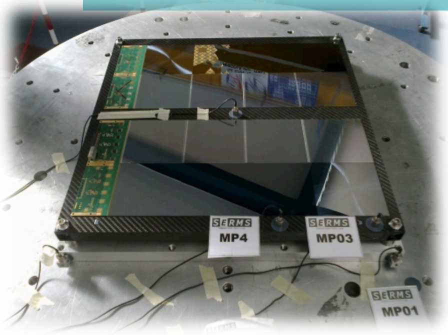
High energy particle detection in space

- **Search for Dark Matter signatures with e, g**
- **Study of cosmic ray spectrum and composition**
- **High energy gamma ray astronomy**



Detection of 5 GeV - 10 TeV e/g, 100 GeV - 100 TeV CR
Excellent energy resolution and tracking precision
Complementary to Fermi, AMS-02, CALET, ISS-CREAM, …

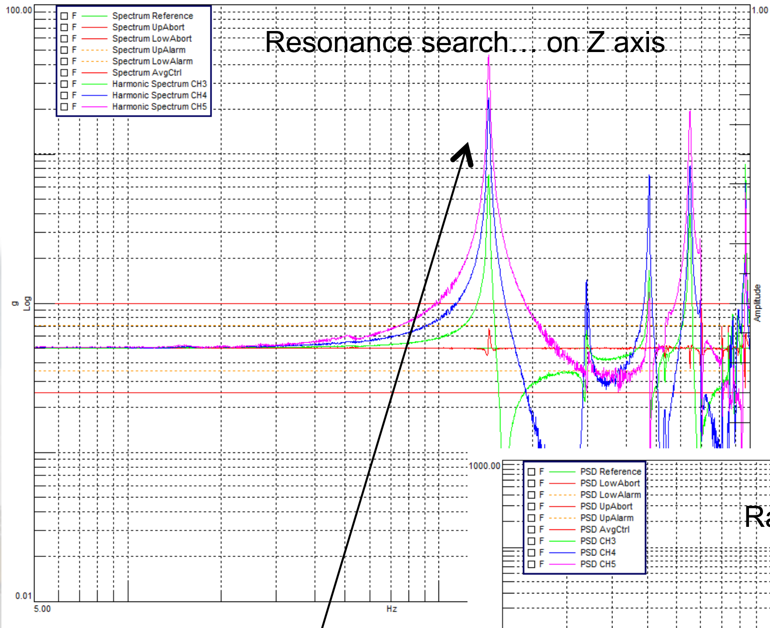
STK: Quarter Plane Test (2)



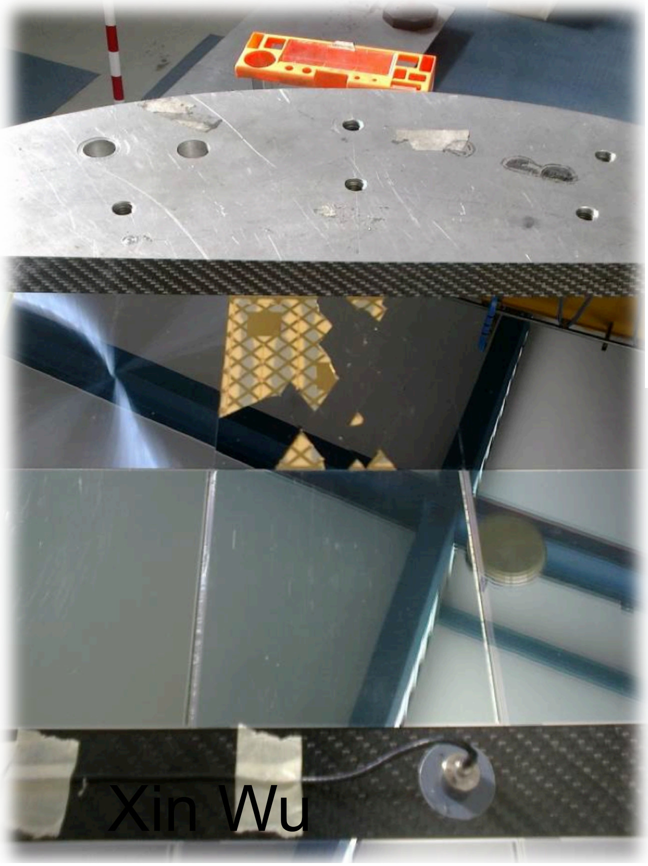
Test on Z axis (worst case)

-Resonance search confirm some big Q factors (amplification at resonance peak)

-Random VIB at full load showed some failures on Si Wafer (due to wrong gluing!)



First frequency at **144 Hz**

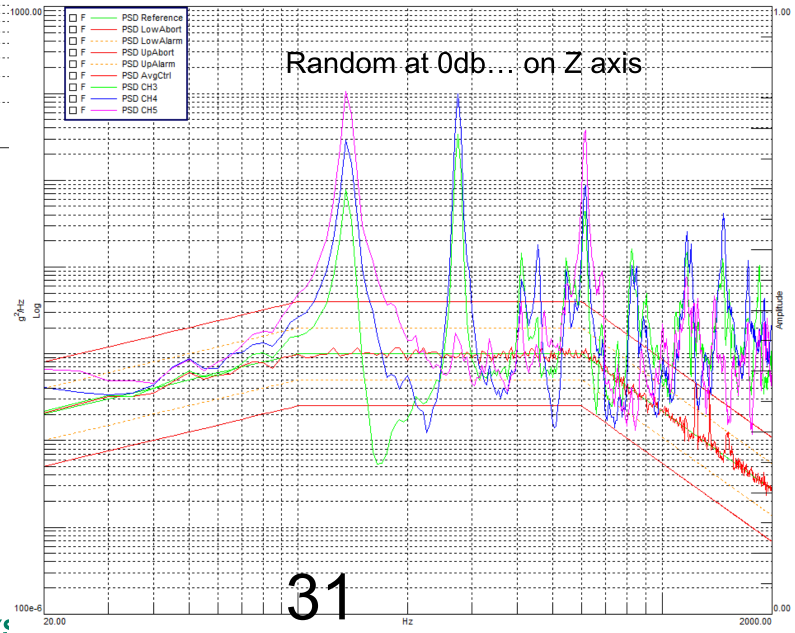


Big amplification at resonance (typical from CFRP structures)

Input: 0.5g

Output: about 45g!

→ **Important to estimate the deflection**




background
Gamma-ray
HERD
electron
proton
He
Dark matter particle
Slide from Shuang Nan Zhang, 2013

Detector Characteristics

	type	size	X_0,λ	unit	main functions
tracker (top)	Si strips	70 cm × 70 cm	2 X_0	7 x-y (W foils)	Charge Photon conversion
tracker 4 sides	Si strips	65 cm × 50 cm	--	3 x-y	Nucleon Track Charge
CALO	~10K LYSO cubes	63 cm × 63 cm × 63 cm	55 X_0 3 λ	3 cm × 3 cm × 3 cm	e/γ energy nucleon energy e/p separation

Total detector weight: ~2000 kg

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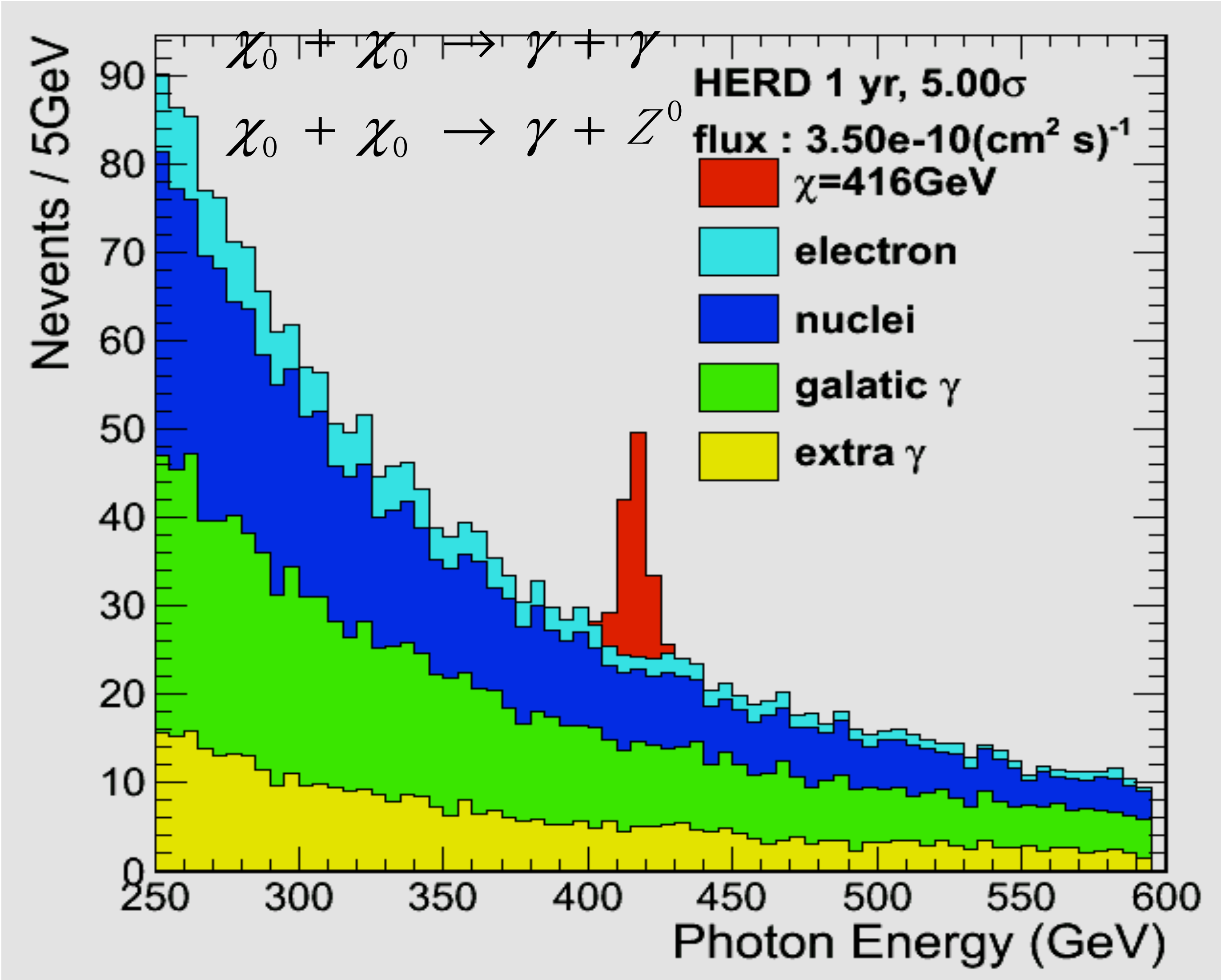
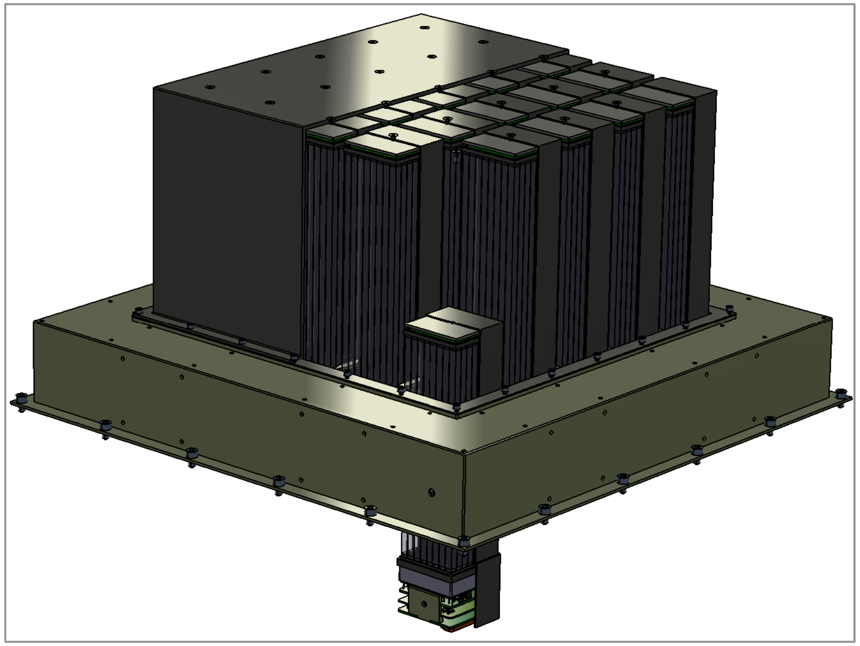
Expected performance of HERD

γ/e energy range (CALO)	tens of GeV-10TeV
nucleon energy range (CALO)	up to PeV
γ/e angular resol. (top Si-strips)	0.1°
nucleon charge resol. (all Si-strips)	0.1-0.15 c.u
γ/e energy resolution (CALO)	<1%@200GeV
proton energy resolution (CALO)	20%
e/p separation power (CALO)	$<10^{-5}$
electron eff. geometrical factor (CALO)	3.7 m^2sr@600 GeV
proton eff. geometrical factor (CALO)	2.6 m^2sr@400 TeV

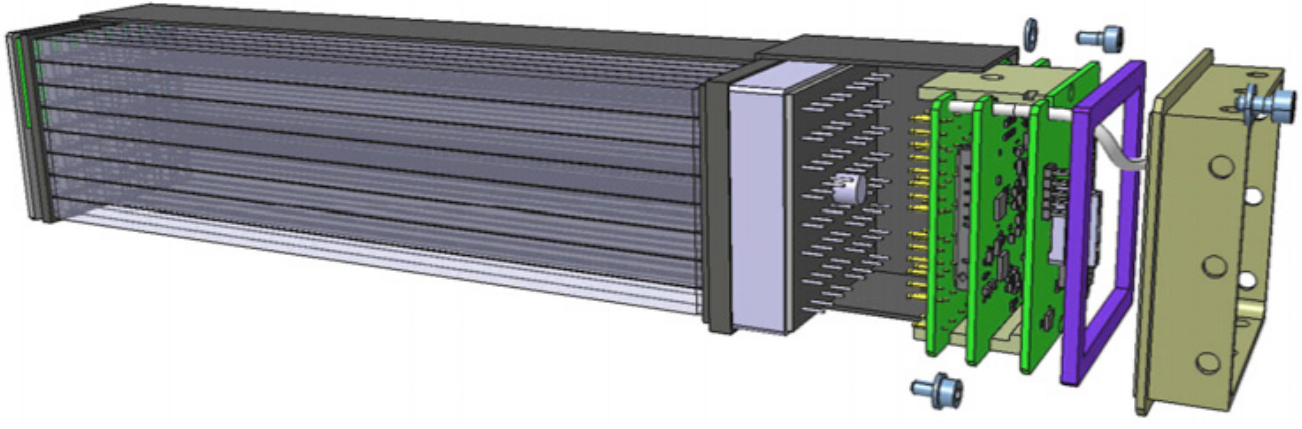
DM annihilation line of HERD

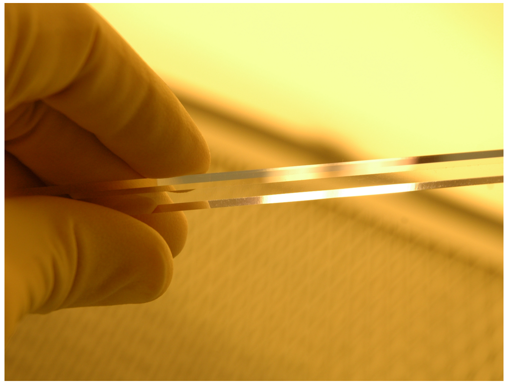


The POLAR Detector



- Compton polarimeter
- 26 kg / 40 W
- 25 Flat panel multi anode PMT
- ASIC readout
- 1600 scintillating bars





Polarization & Modulation

- Photons tend to Compton scatter at right angles to the incident polarisation direction (Klein-Nishina formula)

$$\frac{d\sigma}{d\Omega}(\theta,\eta) = \frac{r_0^2}{2}\left(\frac{E'}{E}\right)^2 \cdot \left(\frac{E'}{E} + \frac{E}{E'} - 2\sin^2\vartheta \cdot \cos^2\eta\right)$$

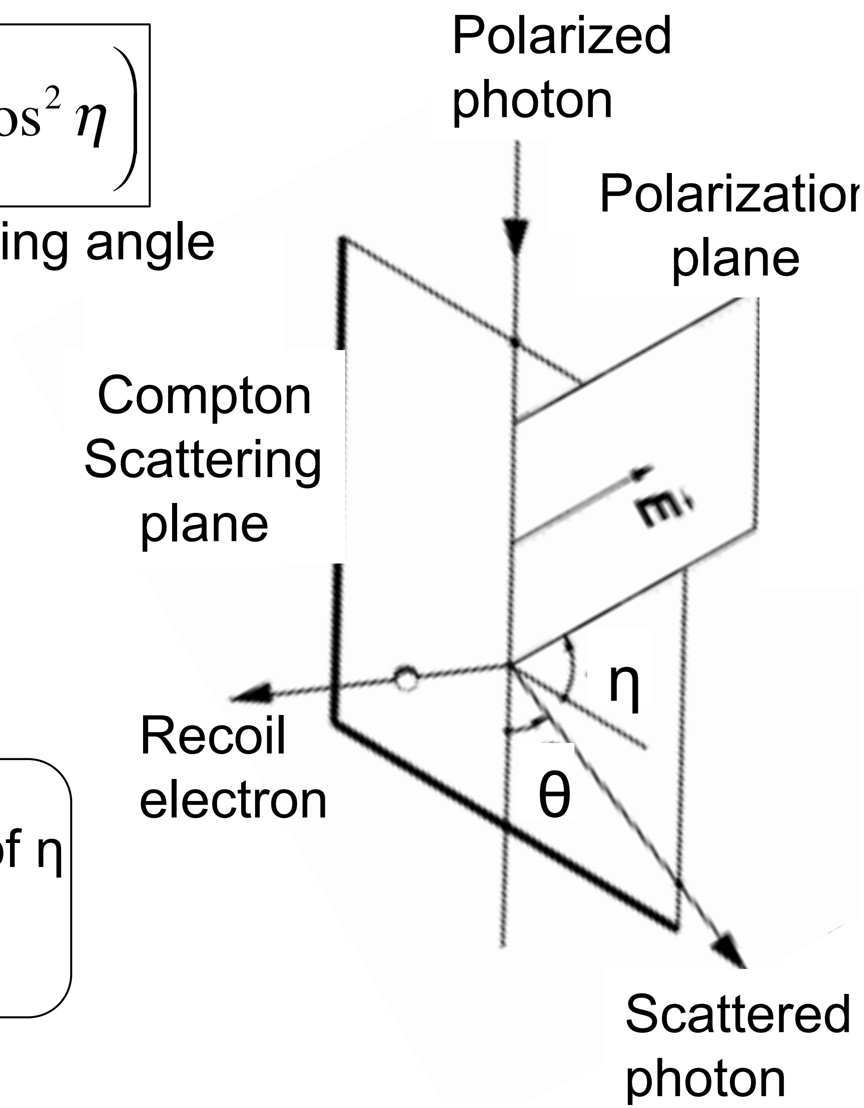
θ: Compton scattering angle
η: Azimuthal angle

$$\frac{d\sigma}{d\Omega}(\theta,\eta) = \frac{r_0^2}{2}\left(\frac{E'}{E}\right)^2 \cdot \alpha \cdot \left(1 - \frac{\sin^2\vartheta}{\alpha} \cdot \cos 2\eta\right)$$

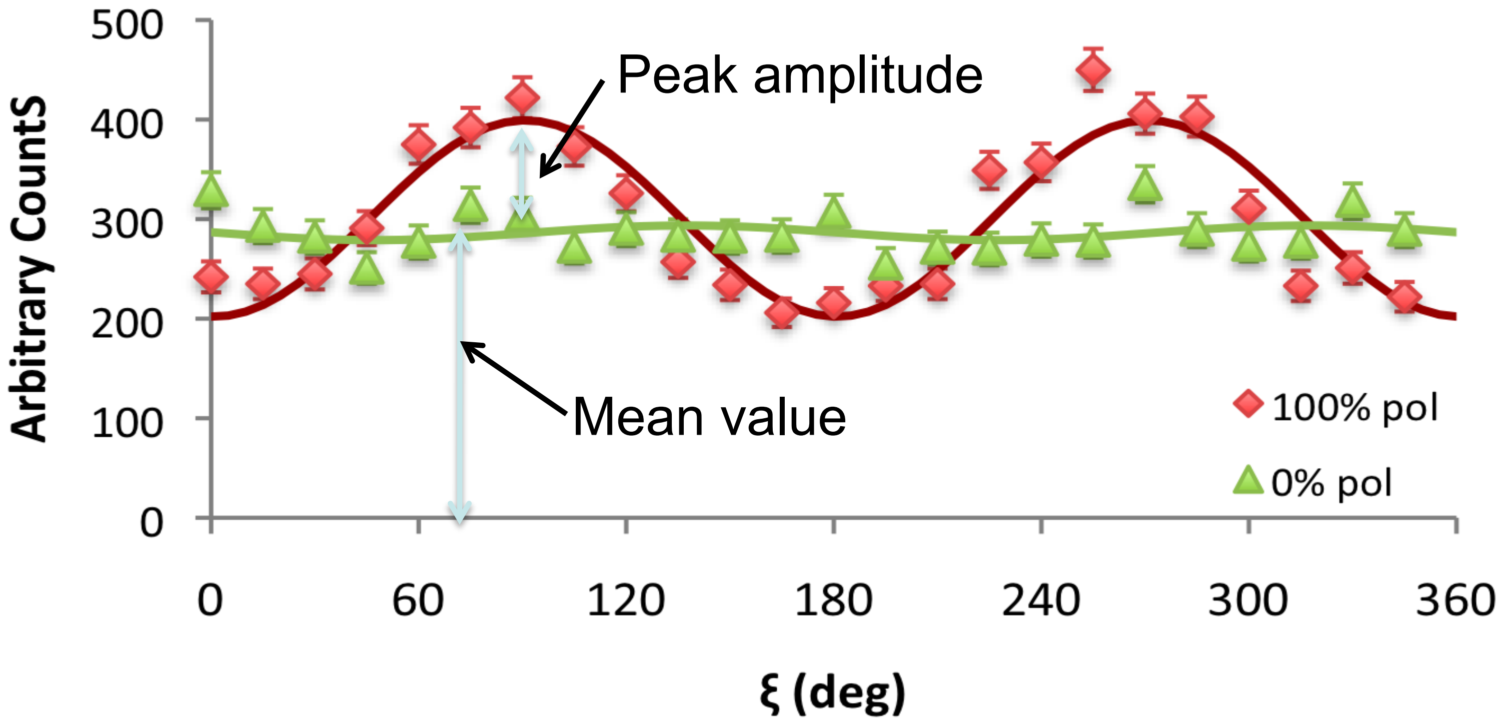
$$\alpha = \left(\frac{E'}{E} + \frac{E}{E'} - \sin^2\vartheta\right)$$

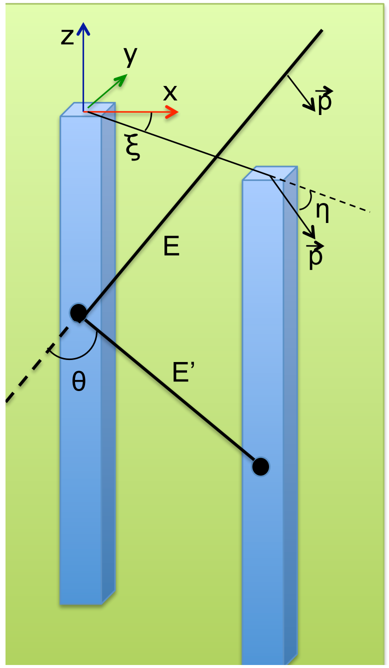
$$\frac{d\sigma}{d\Omega}(\eta) = A \cdot (1 - B \cdot \cos 2\eta)$$

Modulation of η (period π)



Modulation Curves





Fit function: $f(x) = A\left\{1 + \mu_{100} \cdot cos\left[2(\xi - \xi_0) + \pi\right]\right\}$

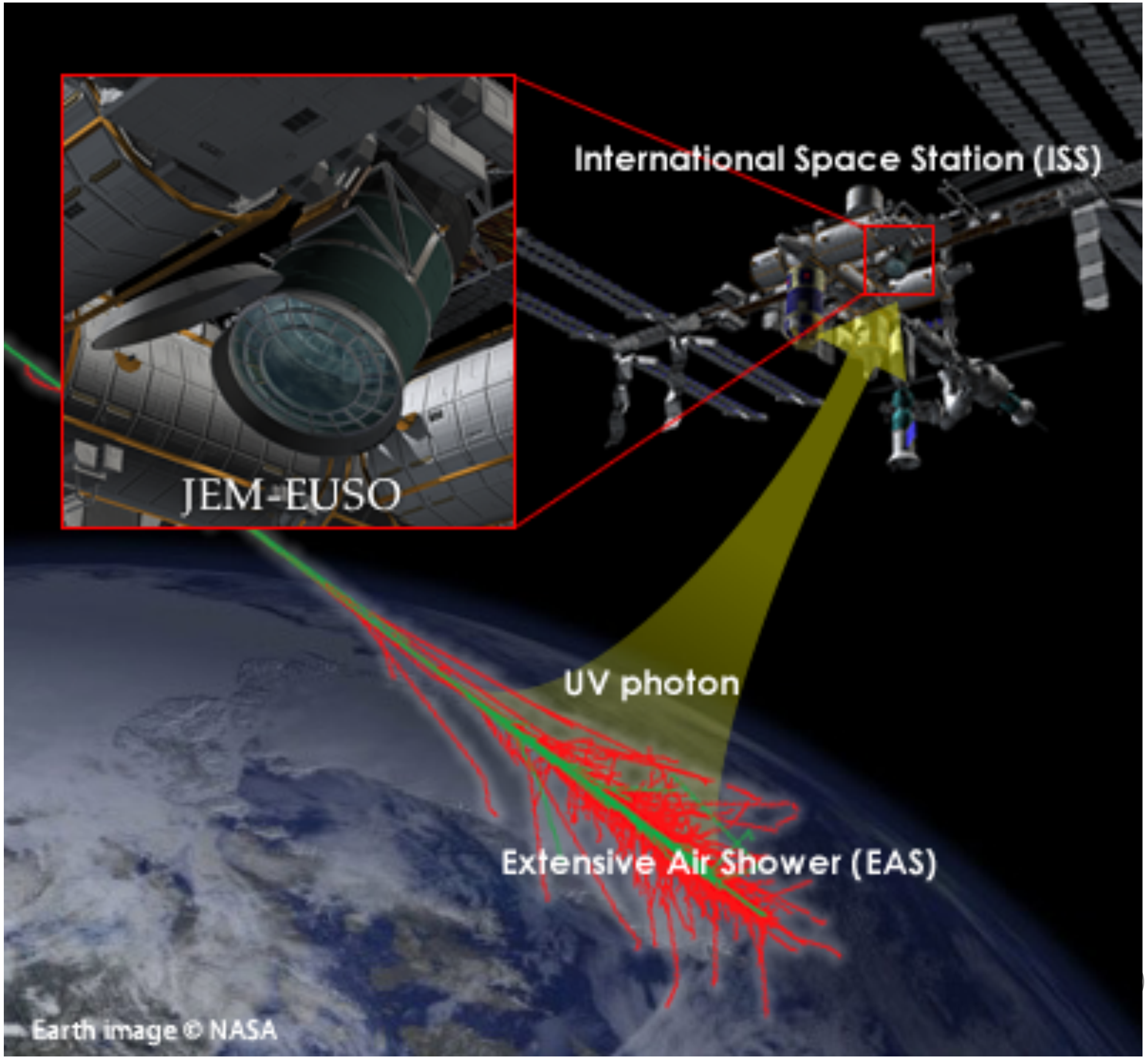
Modulation factor: $\mu = \frac{\text{Peak amplitude}}{\text{Mean value}}$

Polarization: $\Pi = \frac{\mu}{\mu_{100}}$

Mod. angle : ξ_0

where μ_{100} is the modulation factor for 100% polarized photons

JEM-EUSO


International Space Station (ISS)
JEM-EUSO
UV photon
Extensive Air Shower (EAS)
Earth image © NASA