Valeria Di Felice
INFN Roma Tor Vergata

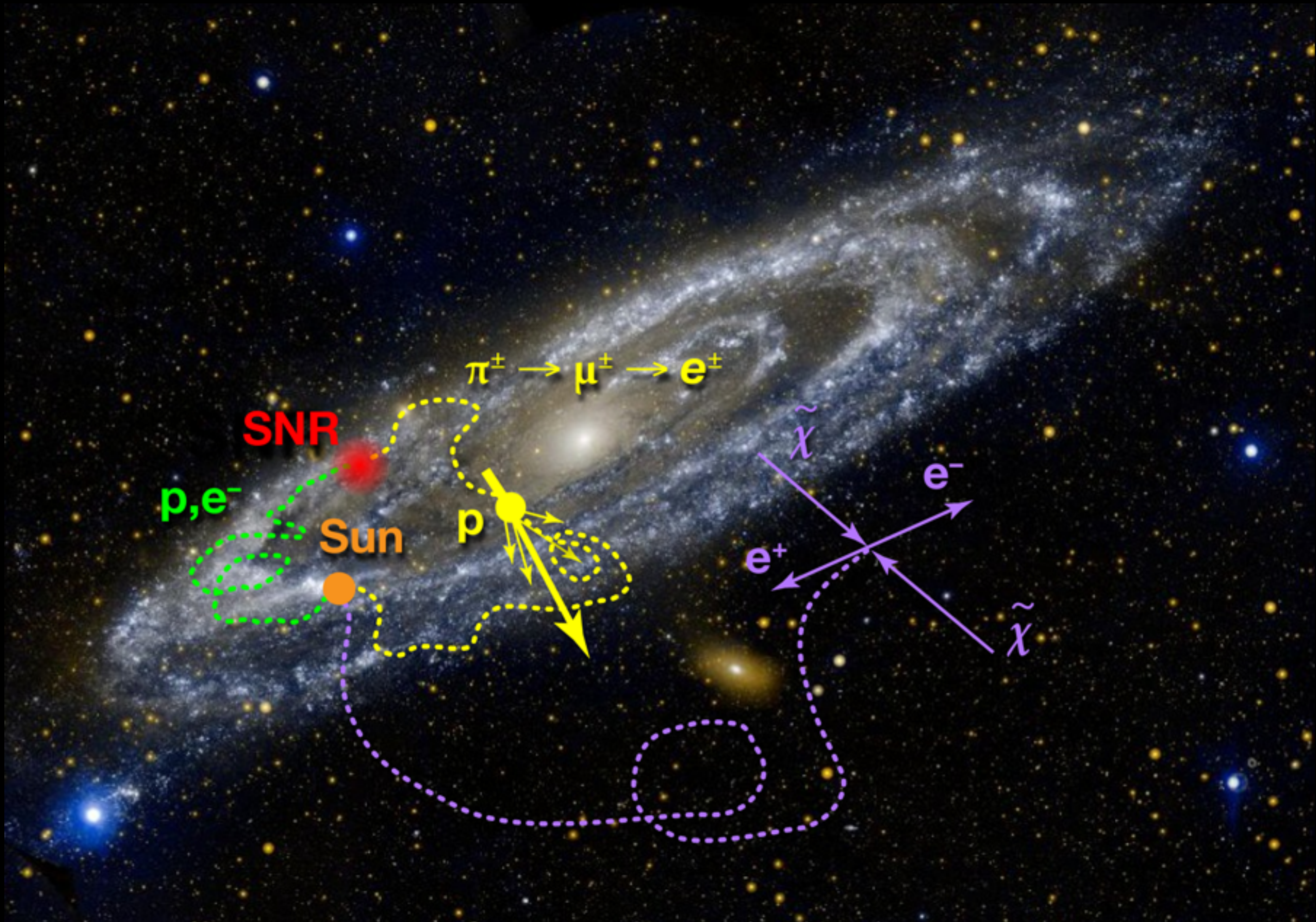


Image: GALEX, JPL-Caltech, NASA; Drawing: APS/Alan Stonebraker

SCIENTIFIC INTERESTS (MAIN)

- Cosmic ray physics
- Indirect dark matter search
- Antimatter-matter detection
- Heliospheric and solar physics

PAMELA MISSION

Space-borne experiment for the precise measure of the matter and antimatter component in cosmic rays.

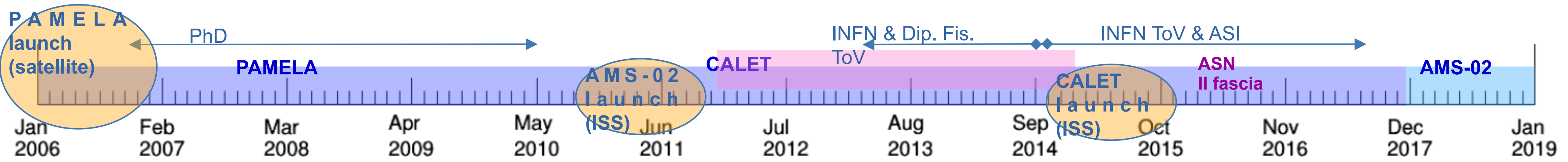
Launched on 15th June 2006. More than 10 years in flight!

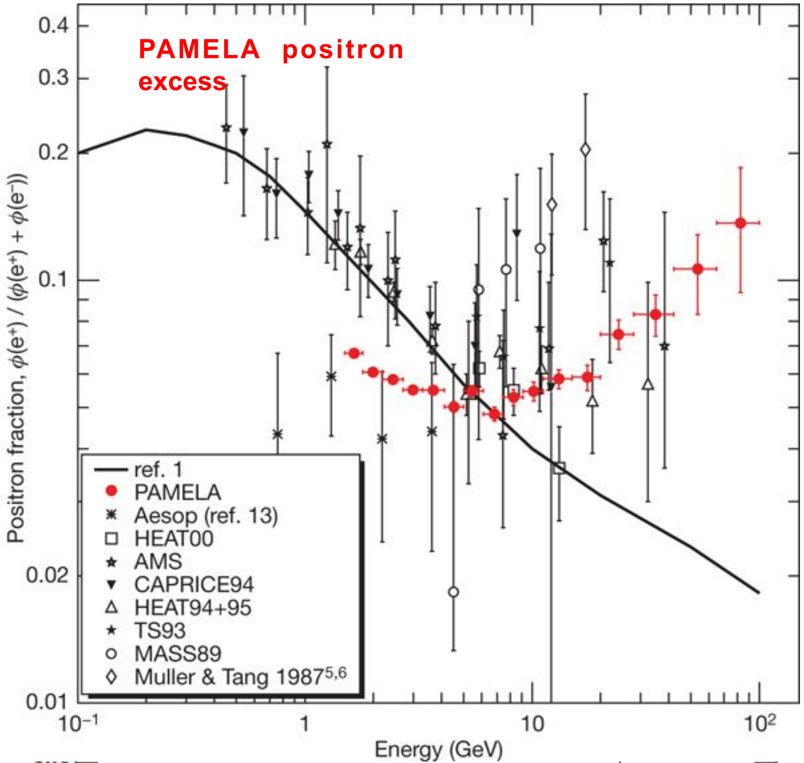
Assembled and tested in **Tor Vergata** clean rooms.
[Prof. Picozza & R. Sparvoli group]





My story





ANTIMATTER MEASUREMENTS

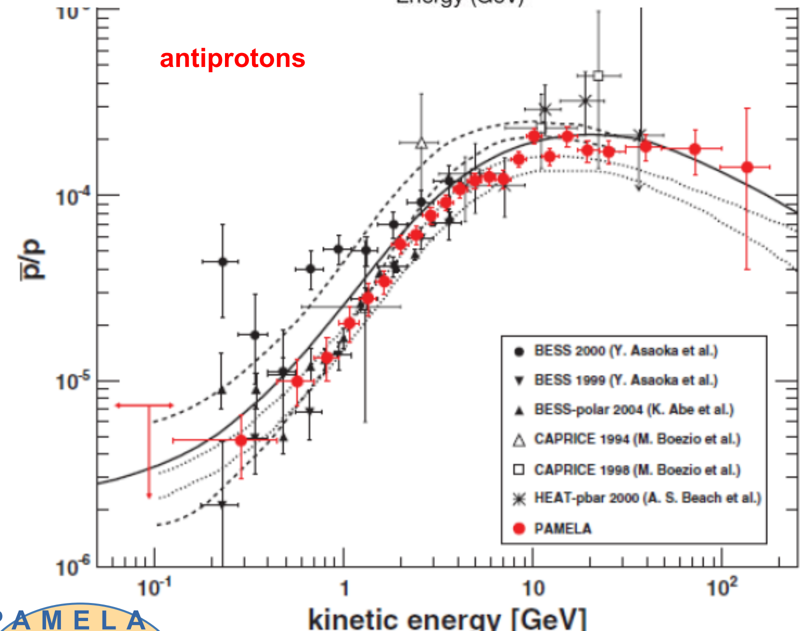
O. Adriani et al. , Nature 458 (2009) 607
O. Adriani et al., AP 34 (2010) 1
O. Adriani et al, Phys. Rep. 544 (2014) 323
O. Adrianiet al. , PRL 111 (2013) 081102
O. Adriani et al, PRL 105 (2010) 121101
O. Adriani et al, Phys. Rep. 544 (2014) 323

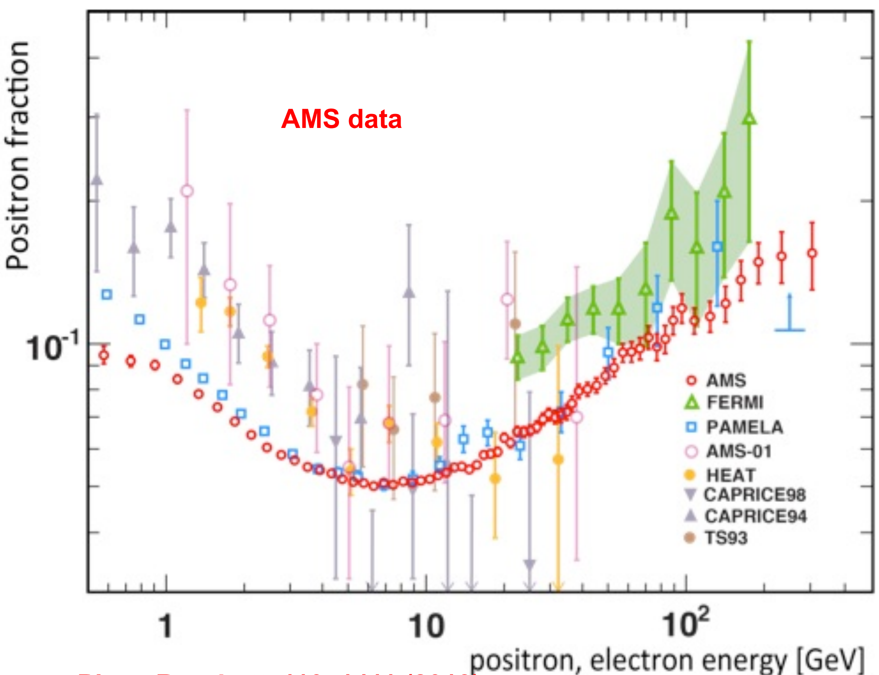
O. Adriani et al, PRL 102 (2009) 051101

....

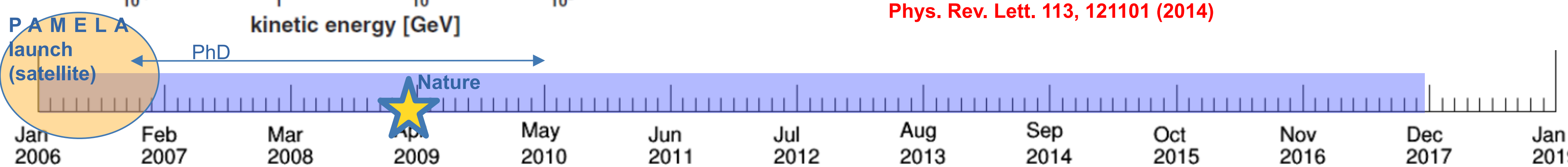
Interpretations:

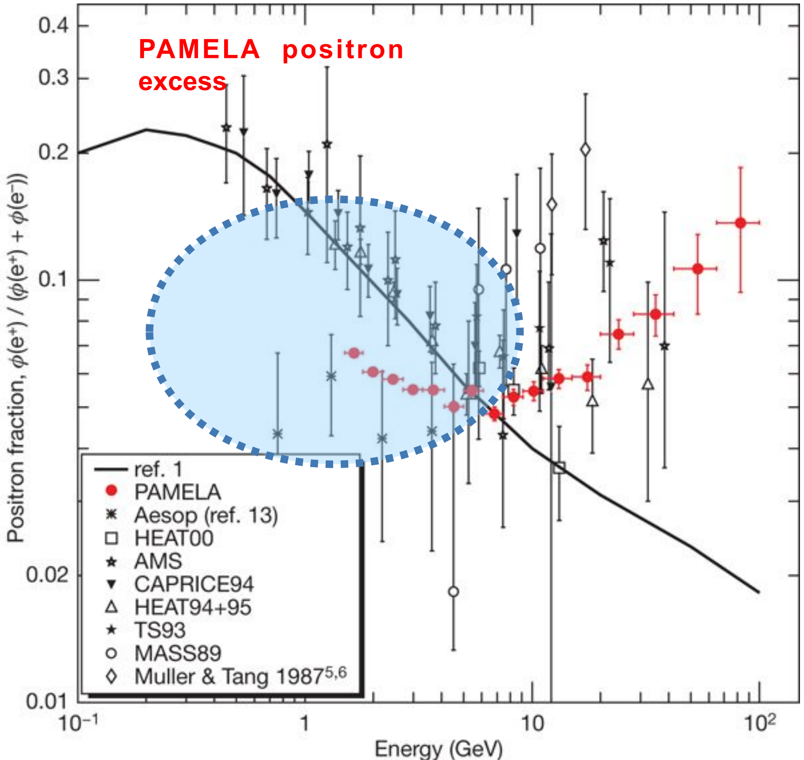
- Dark matter annihilation/decay (>1500 papers)
- Astrophysical origin (~200 papers):
  - SNR shocks
  - Pulsars & pulsar wind nebulae
  - Inhomogeneity of CR sources

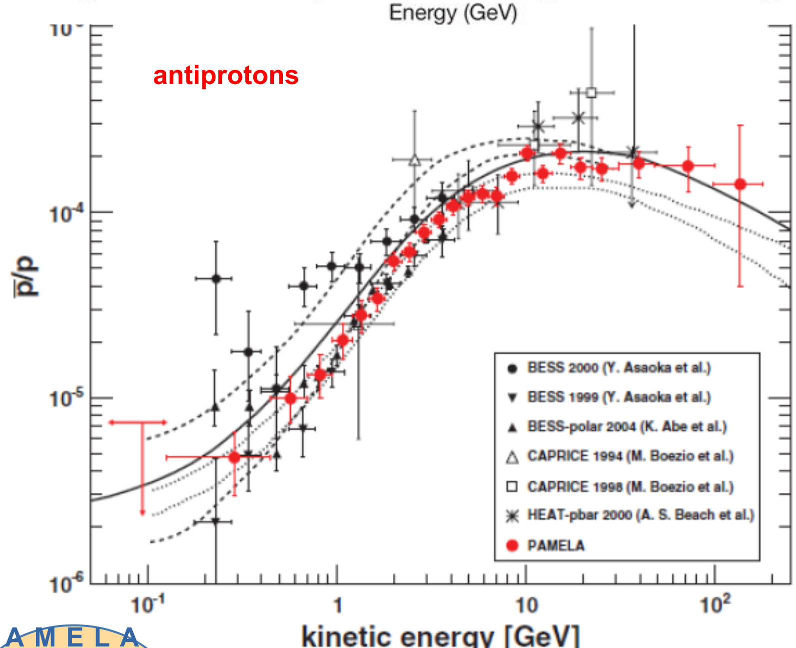




Phys. Rev. Lett. 110, 1411 (2013)
Phys. Rev. Lett. 113, 121101 (2014)







ANTIMATTER RESULTS

O. Adriani et al. , Nature 458 (2009) 607
O. Adriani et al., AP 34 (2010) 1
O. Adriani et al, Phys. Rep. 544 (2014) 323
O. Adrianiet al. , PRL 111 (2013) 081102
O. Adriani et al, PRL 105 (2010) 121101
O. Adriani et al, Phys. Rep. 544 (2014) 323

O. Adriani et al, PRL 102 (2009) 051101

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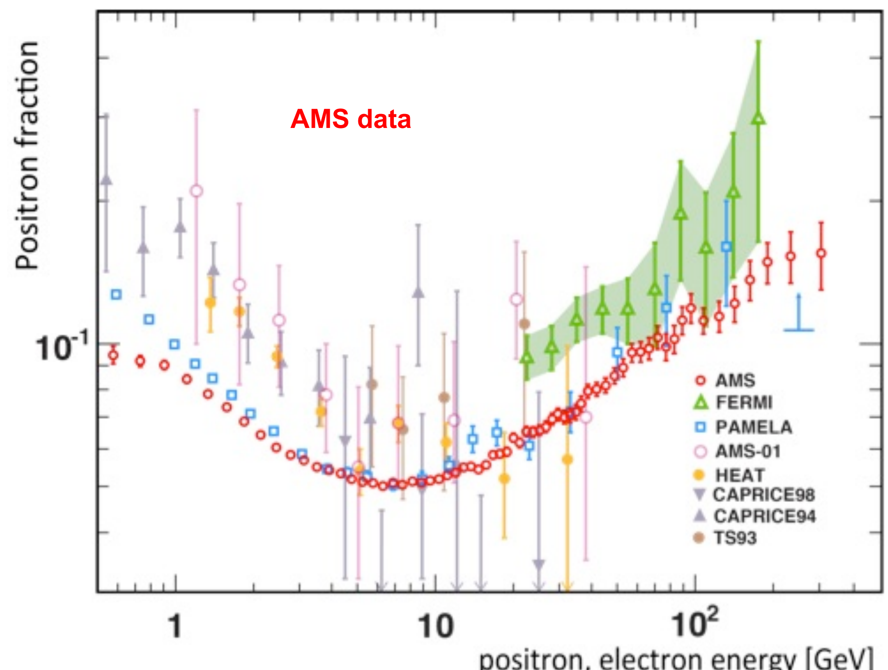

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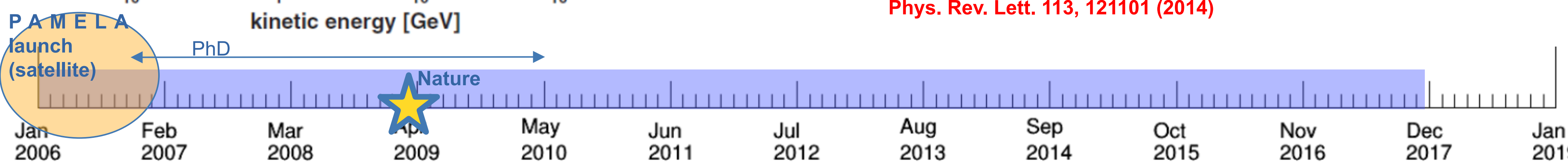
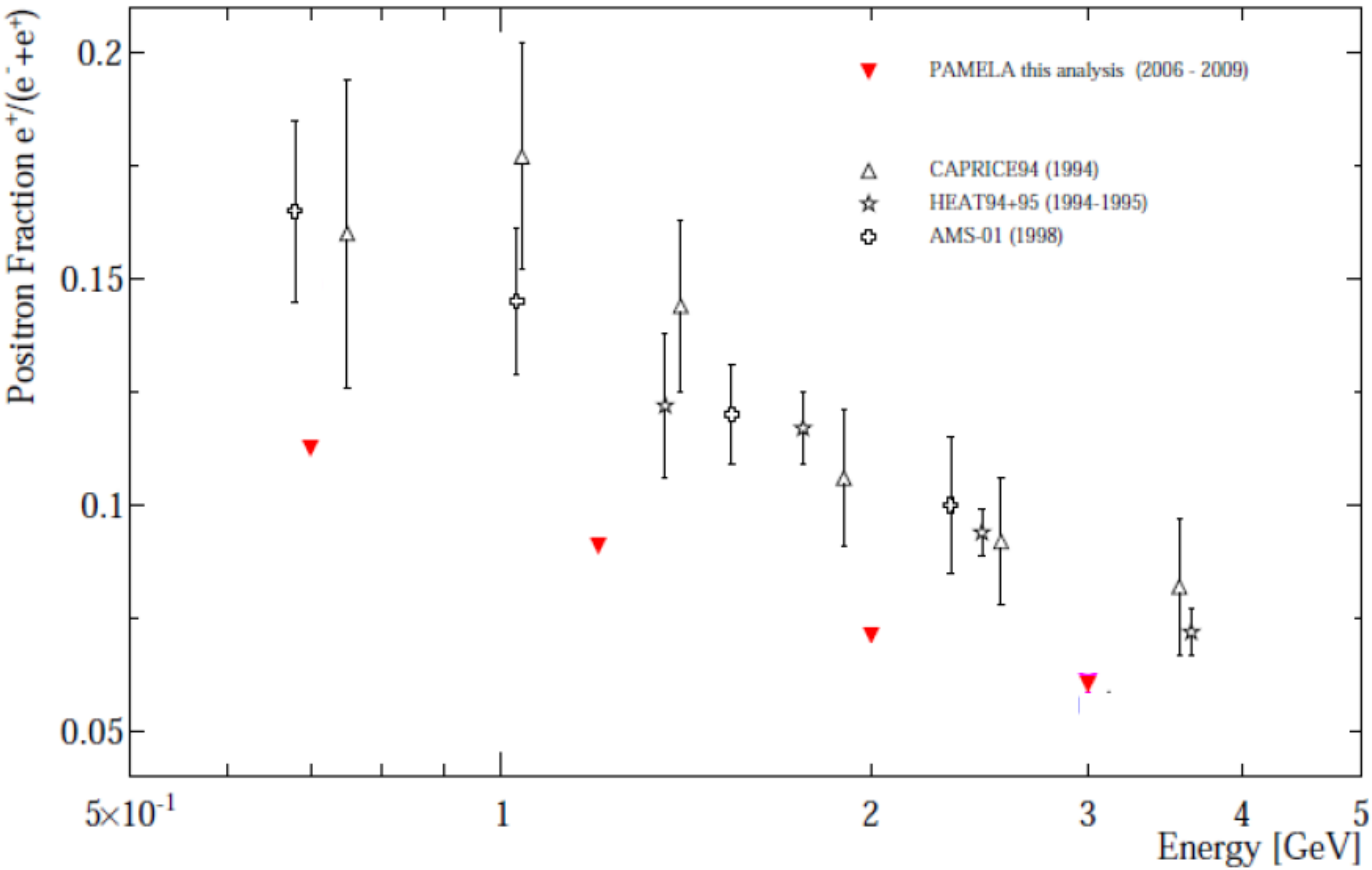
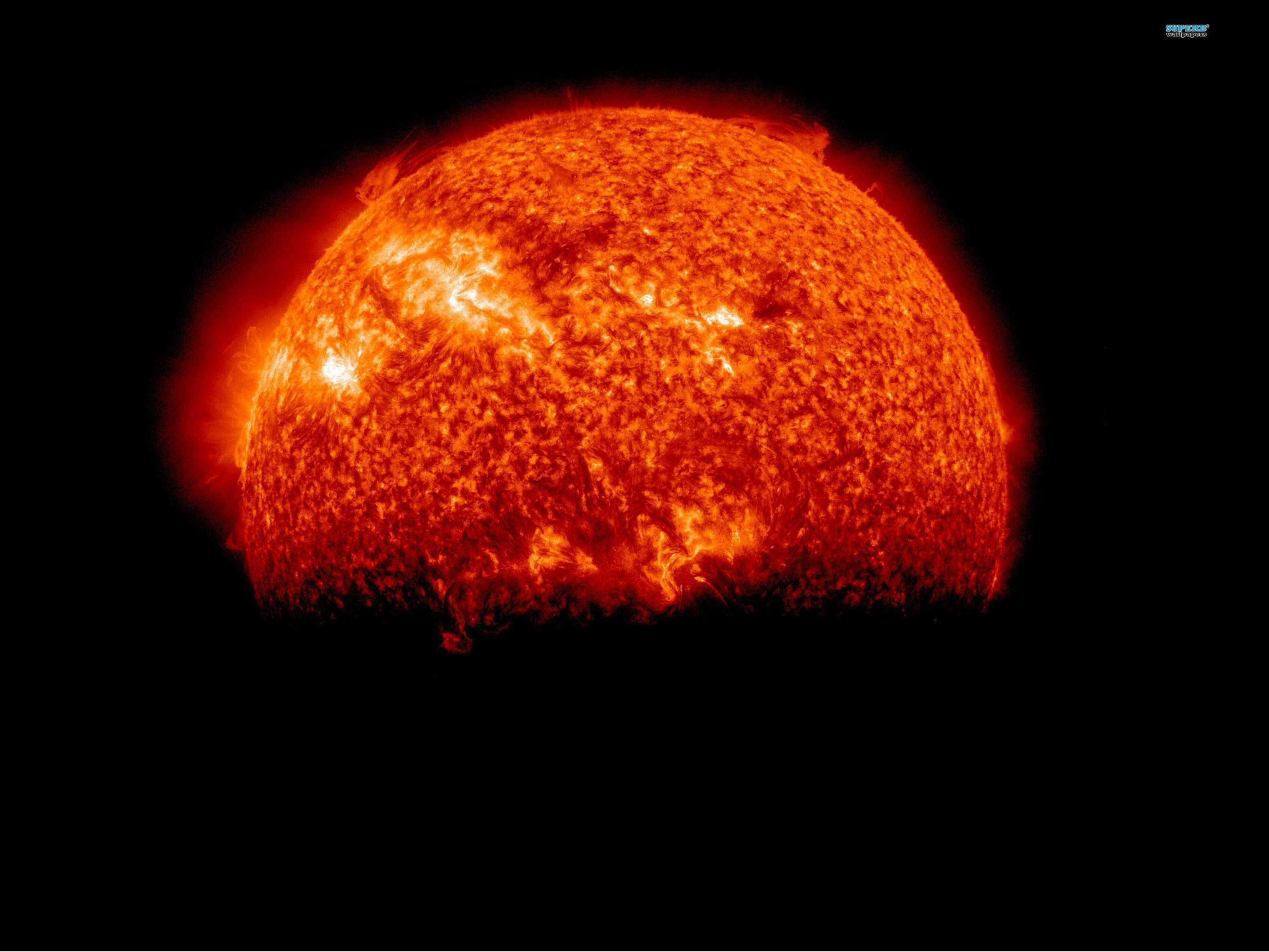
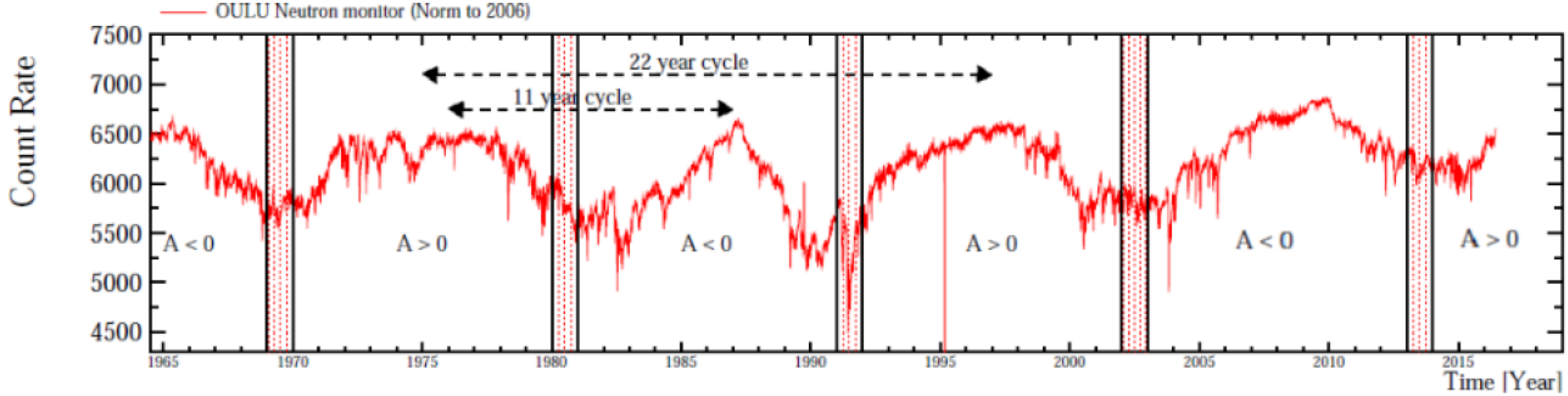


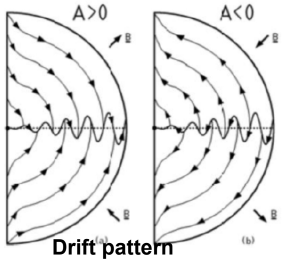
LOW ENERGY CR PARTICLES
(2006-2009) data




SUPERB wallpapers

GALACTIC COSMIC RAY SOLAR MODULATION





Drift pattern positive particles

- The **solar activity cycle** affects low energy cosmic rays.
- Anticorrelation of Crs
- Charge sign dependent effects due to drift effects in the heliospheric magnetic field

- **Observations:**
- Time dependence in low energy charged particles fluxes
- e+/e- varying with time, according to solar activity evolution
- For the same reason, galactic proton and electron fluxes evolve differently at the same rigidity
- Positron fraction results not in tension

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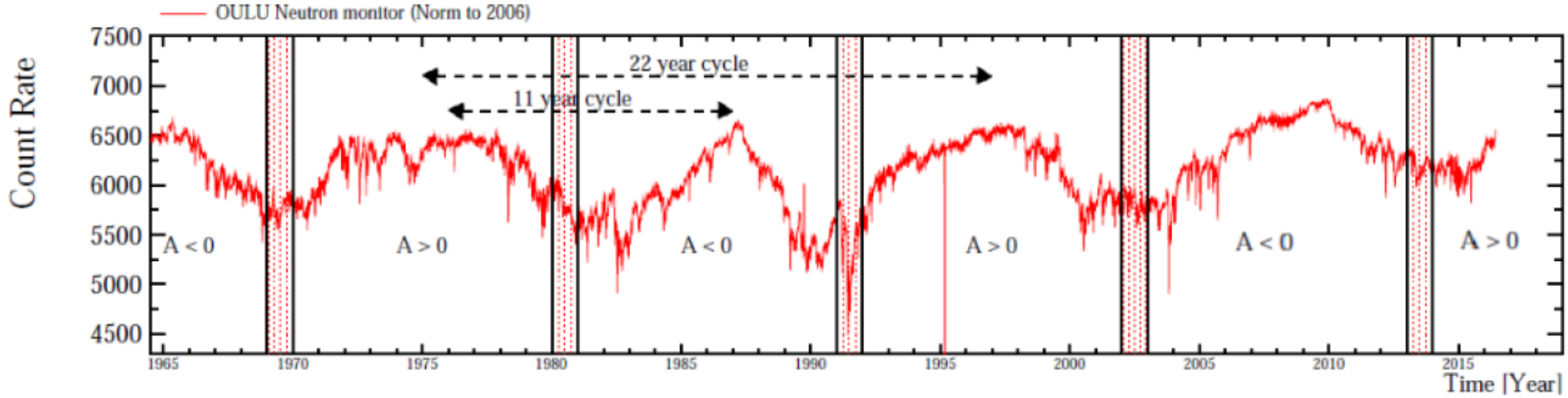

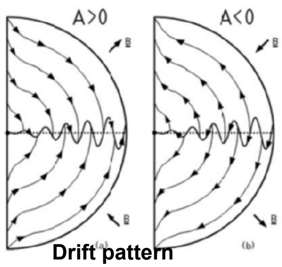

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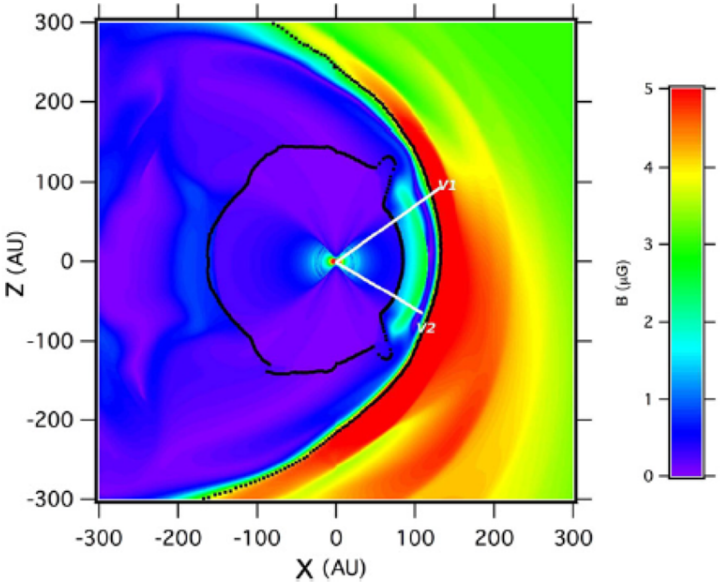

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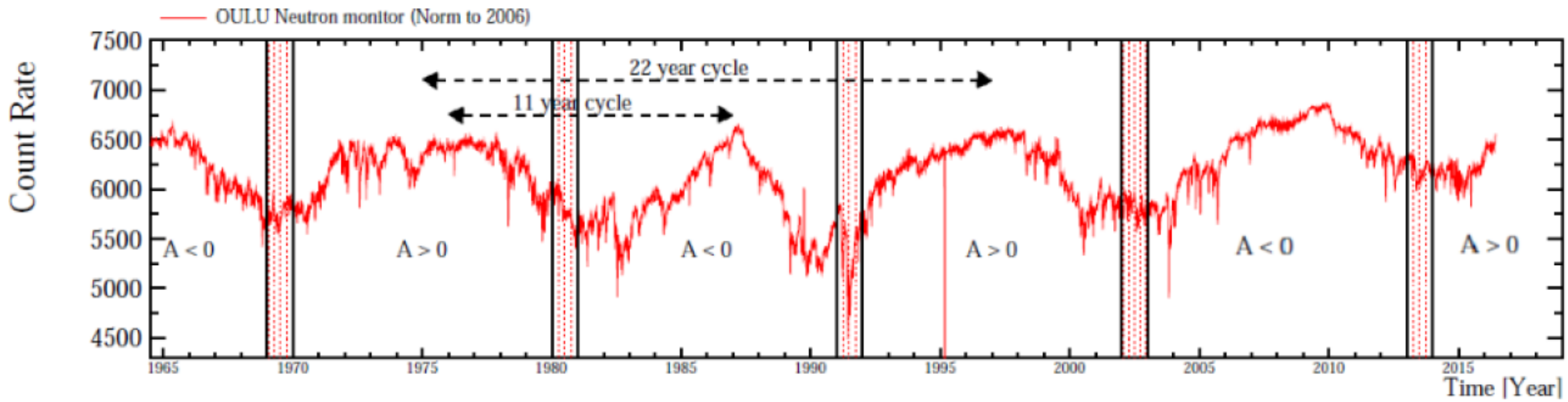

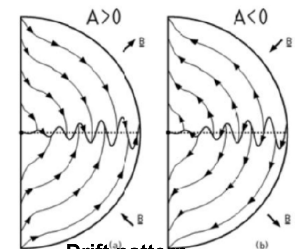

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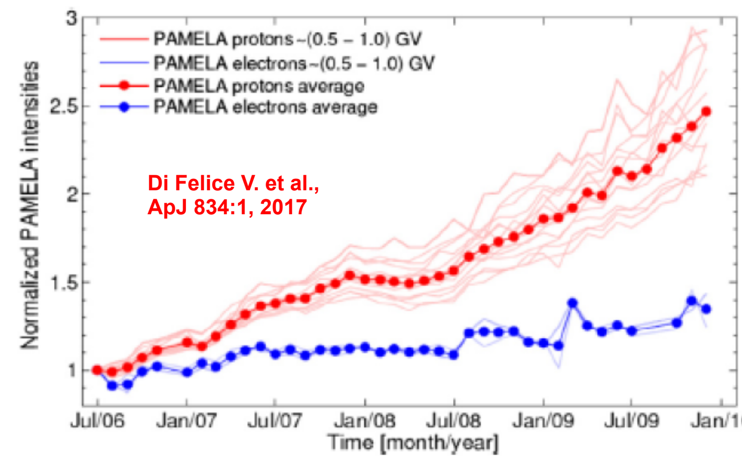
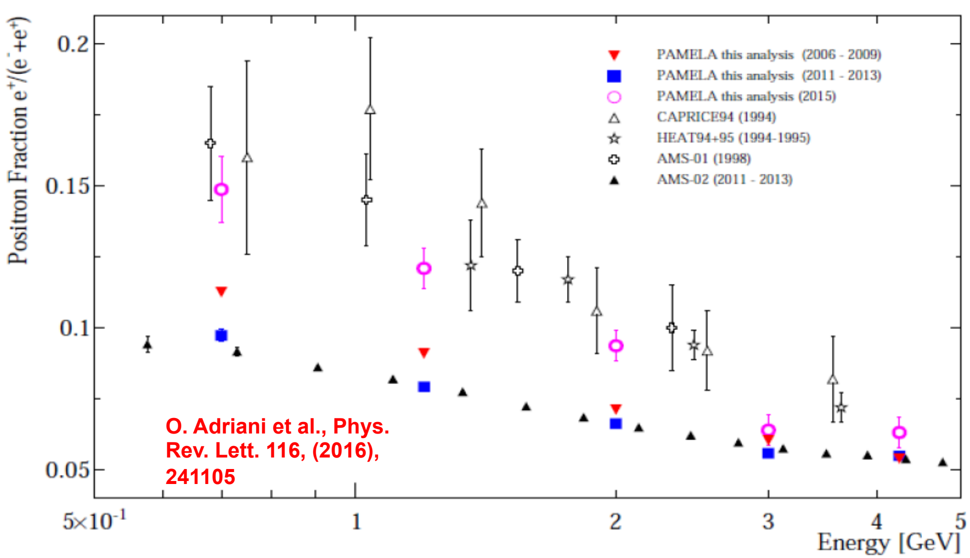
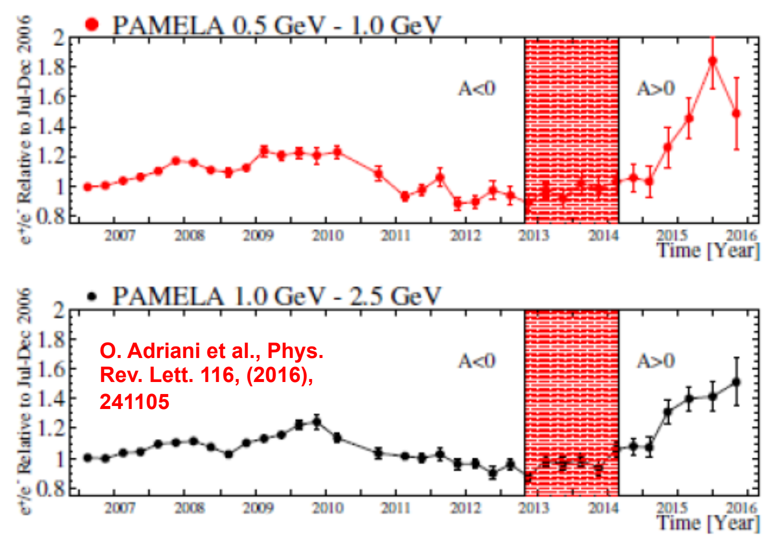
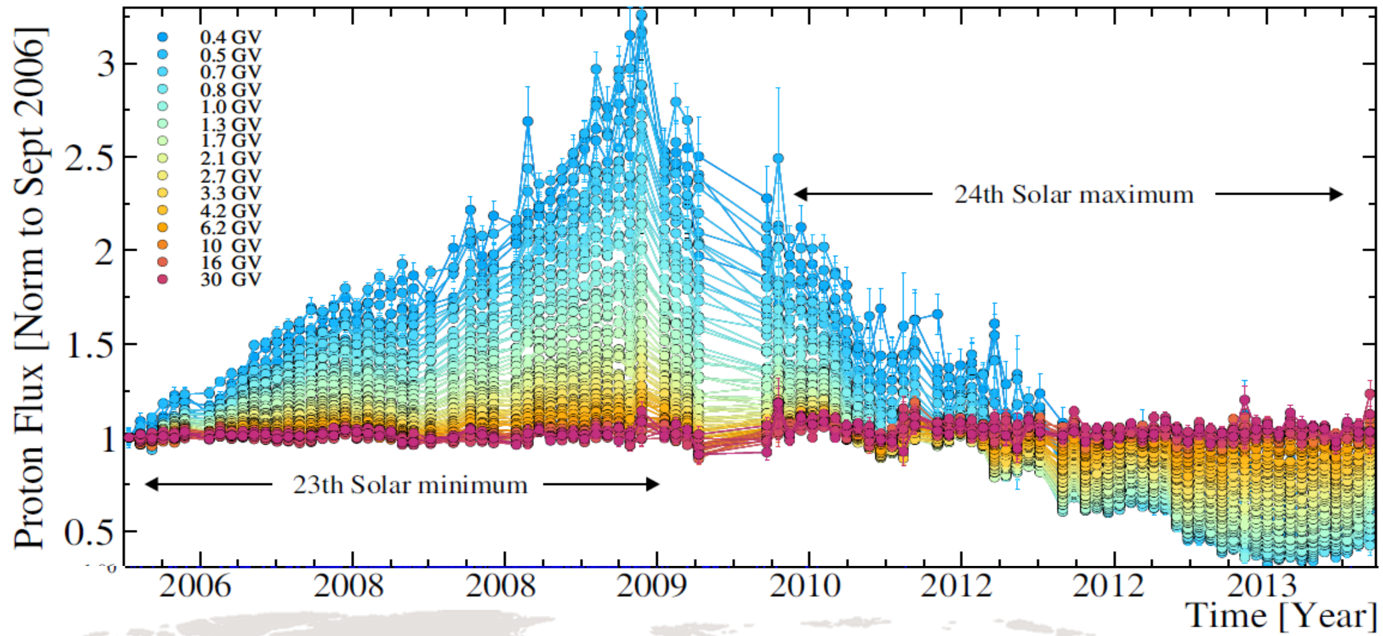
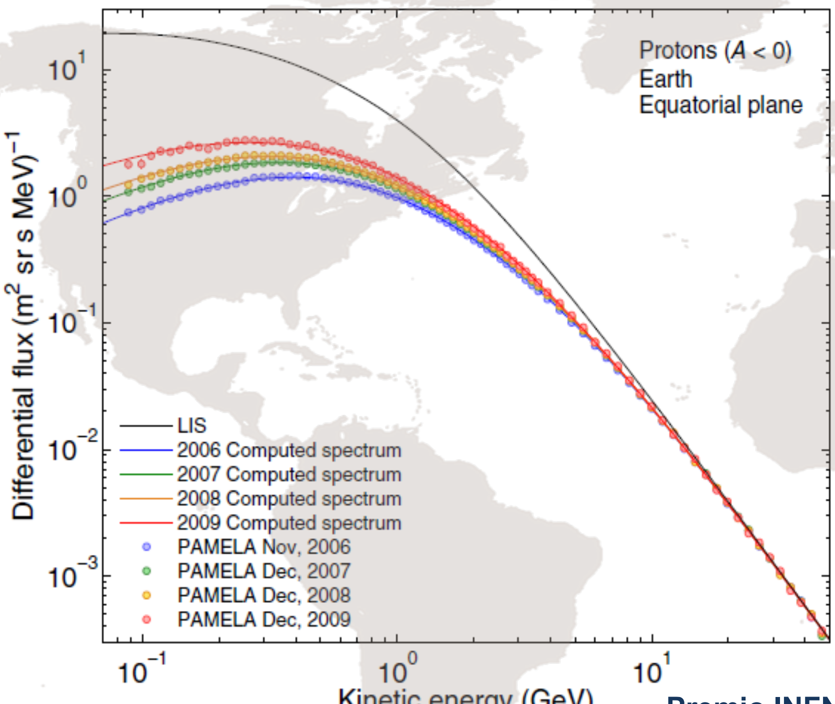










Kiel CAU

CERN

$$\underbrace{\frac{\partial f}{\partial t}}_{a} = -\underbrace{\mathbf{V}\cdot\nabla f}_{b} + \underbrace{\nabla\cdot(\mathbf{K}_s\cdot\nabla f)}_{c} - \underbrace{\langle \mathbf{v}_D\rangle\cdot\nabla f}_{d} + \underbrace{\frac{1}{3}(\nabla\cdot\mathbf{V})\frac{\partial f}{\partial \ln p}}_{e} + \underbrace{Q(\mathbf{x},p,t)}_{f}$$

(a) $f(\mathbf{x},p,t)$, omnidirectional function distribution of CRs; **(b)** convection with solar wind **V**; **(c)** diffusion by magnetic field irregularities; **(d)** drift, curvature and gradient in magnetic field; **(e)** adiabatic energy losses; **(f)** local sources (Jovian electrons);

Selected papers
Martucci M. et al., ApJL 854 (2018) L2
Di Felice V. et al., ApJ 834:1 (2017)
Adriani O. et al, PRL 116 (2016) 241105
Adriani O. et al, ApJ 810 (2015) 142
Potgieter M. S. et al., Solar Phys. 289 (2014) 39
Adriani O. et al., ApJ 765 (2013) 91

Collaborations:
NWU South Africa
CAU Kiel Germany
NASA Goddard
Mephi Moscow

North West University

Premio INFN Bruno Rossi 2010
Premio ARAP 2010

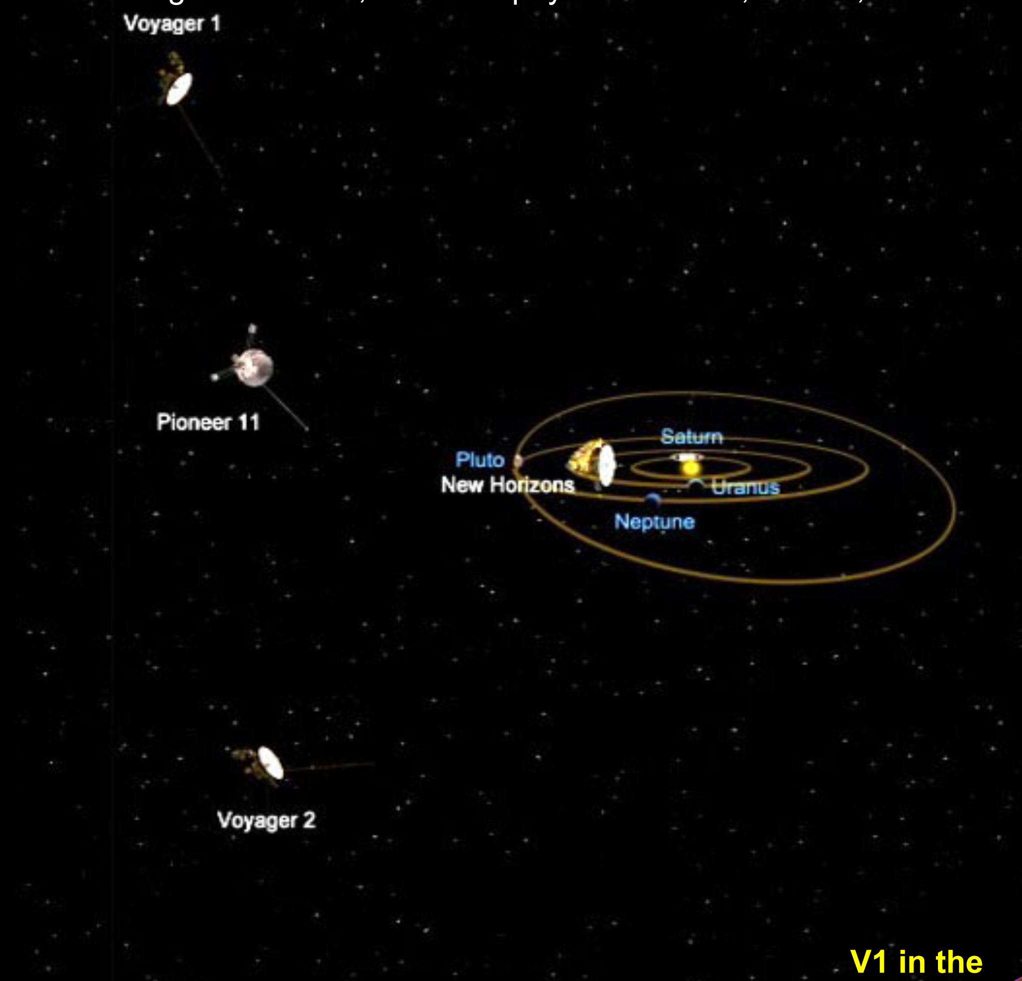
Uncertainties in heliospheric propagation

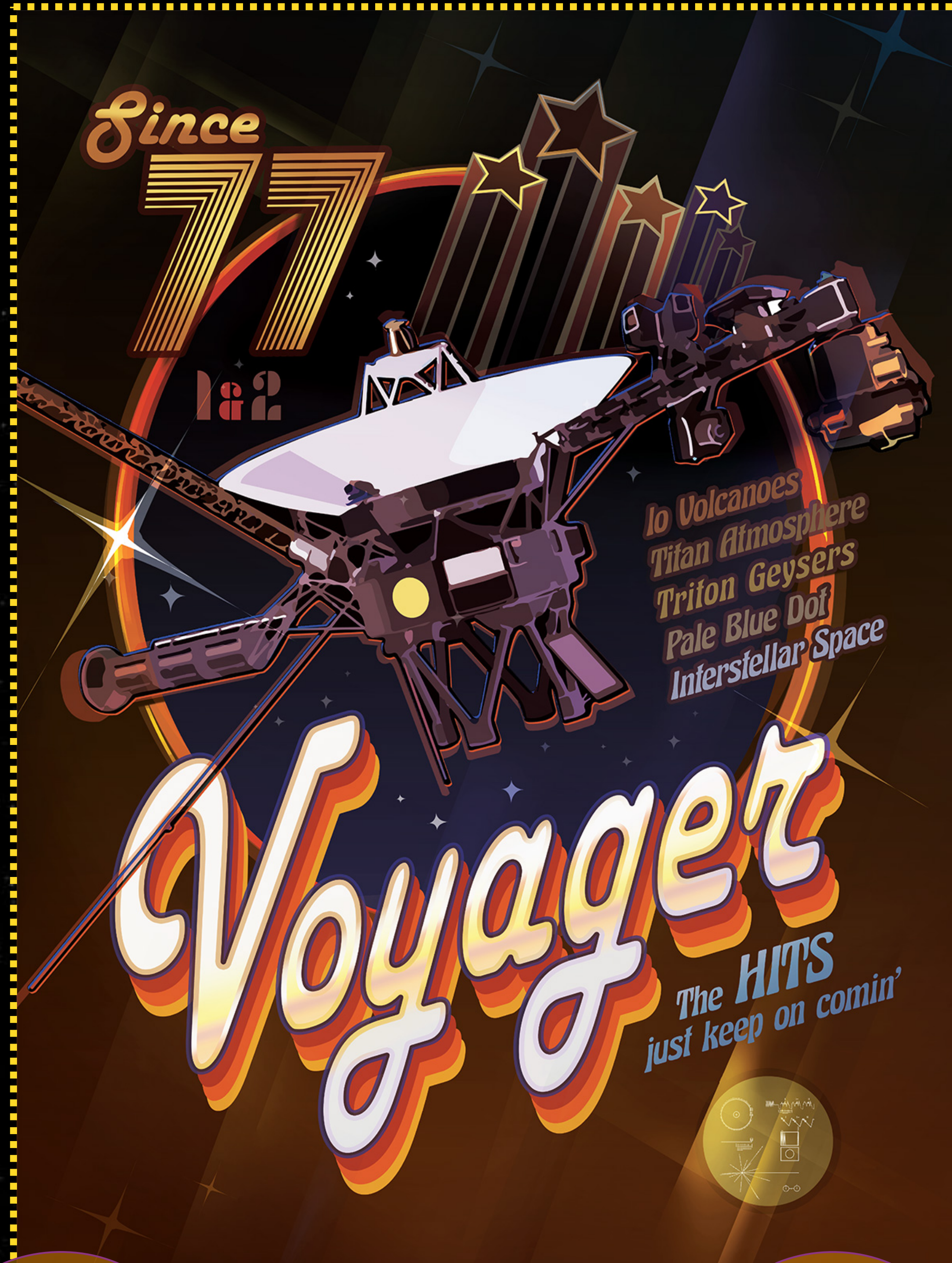
Geometry and physical boundaries of the Heliosphere

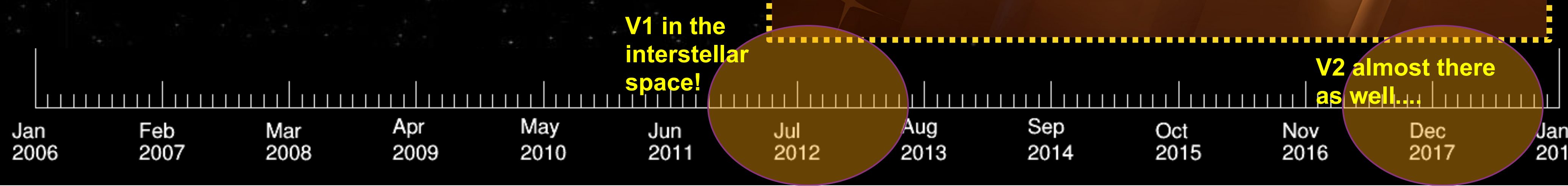
Solar activity parameters (time-varying)

Input Local Interstellar Spectrum (LIS)

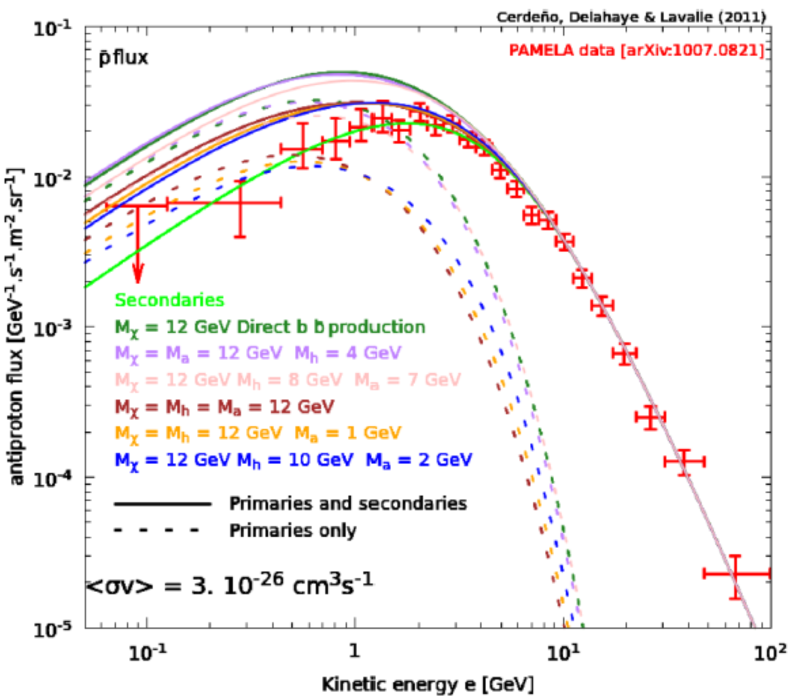
Webber W. R. and F. B. McDonald, Geoph. Res. Lett., 40, 2013
Stone E. C. et al., Science, 341 (6142), 2013
Cummings A. C. et al., The Astrophysical Journal, 831:18, 2016



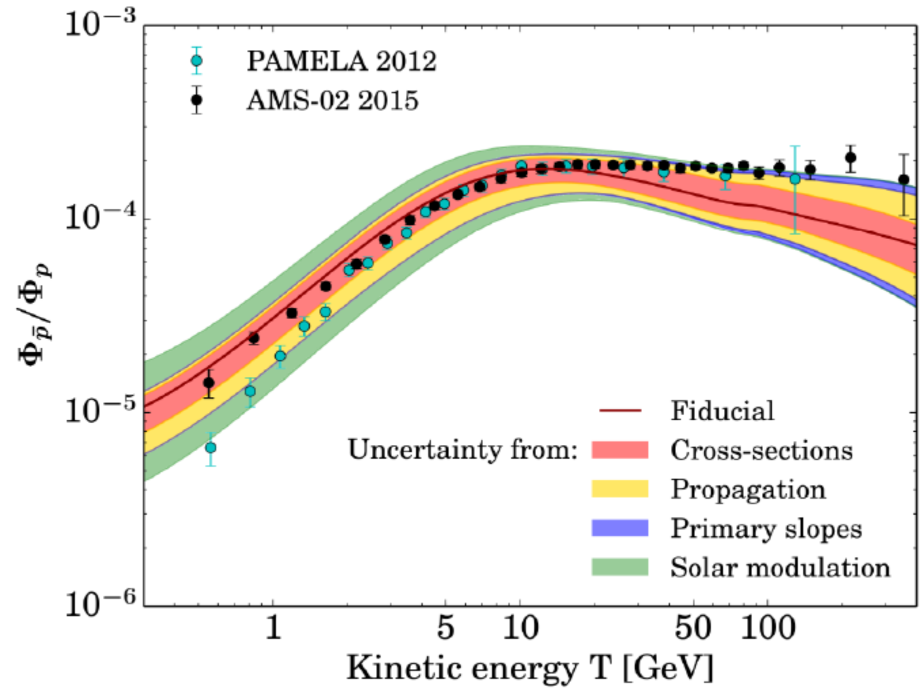




MOTIVATION



D. G. Cerdeno, T. Delahaye, J. Lavalle, Nucl. Phys. B 854 (2012) 738

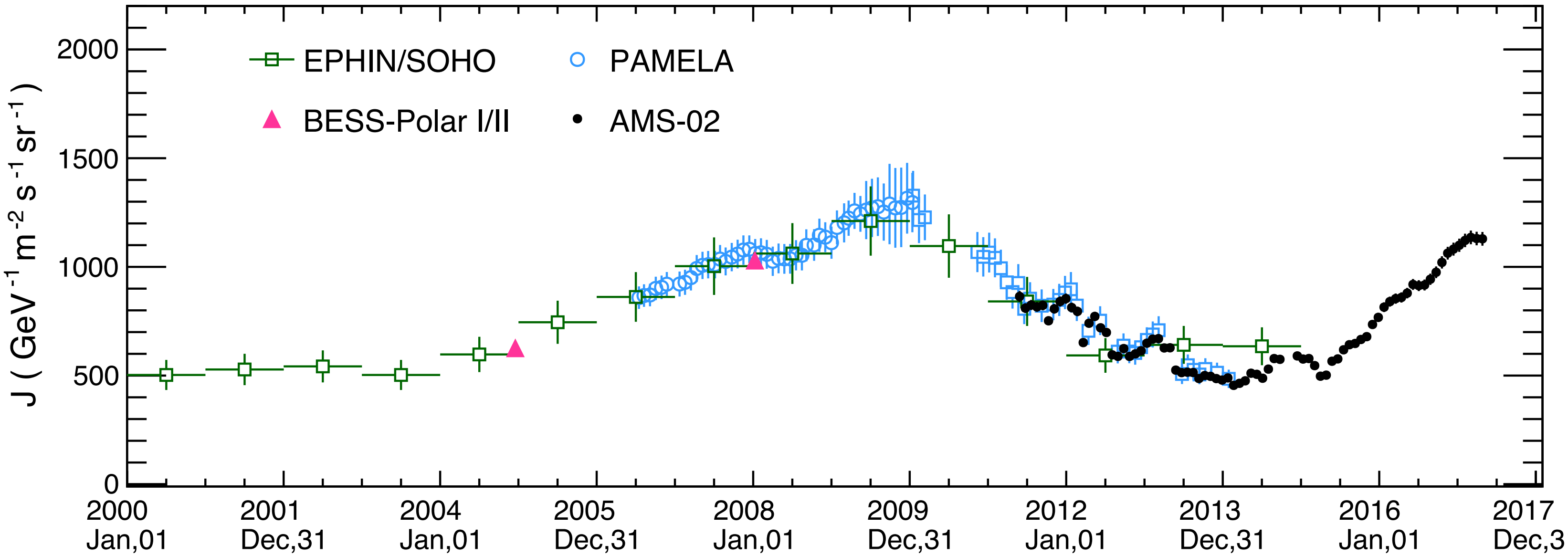


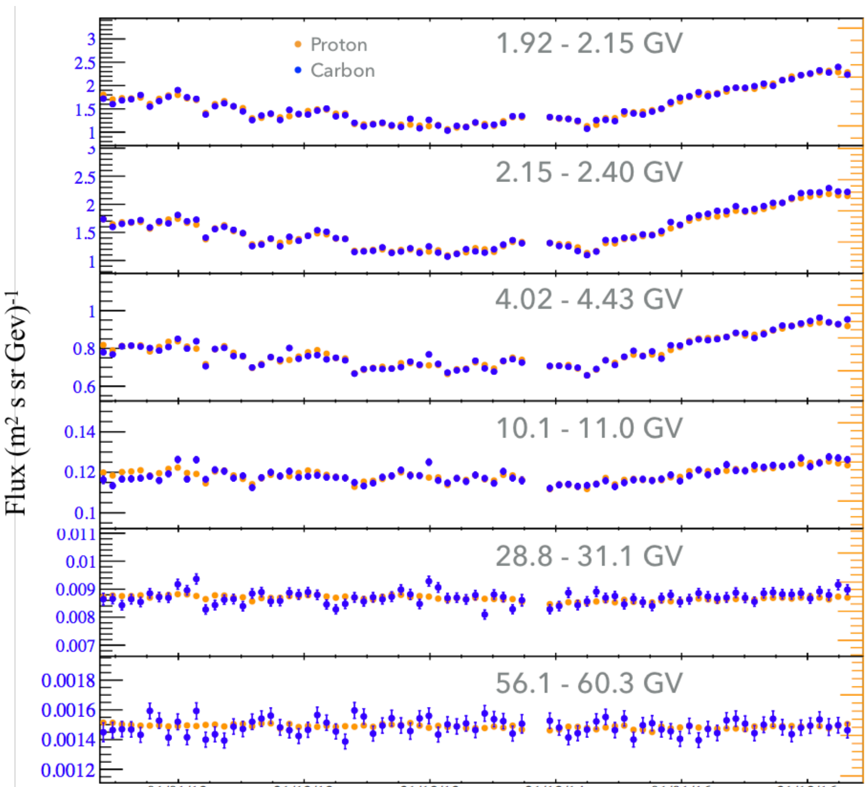
G. Giesen et al., JCAP 1509 (2015) 023, arXiv:1504:04276

Precise measurements of the time-dependent GCRs spectra are important for:

- Understanding the propagation of GCRs in the heliosphere, and contribution from the various modulation mechanisms
- Refining models, reduce uncertainties on free parameters
- Constraining uncertainties on secondary CR prediction at low energy
- Useful in low energy dark matter indirect detection improving the evaluation of the secondary background.

MOST RECENT ACTIVITY





Preliminary data – low energy C
PostDocs: F. Donnini, B. Khiali

Towards understanding the origin of cosmic-ray positrons

M. Aguilar,[26] L. Ali Cavasonza,[1] G. Ambrosi,[31] L. Arruda,[24] N. Attig,[21] P. Azzarello,[15]
A. Bachlechner,[1] F. Barao,[24] A. Barrau,[16] L. Barrin,[14] A. Bartoloni,[36] L. Basara,[34]

Origin of Cosmic Electrons

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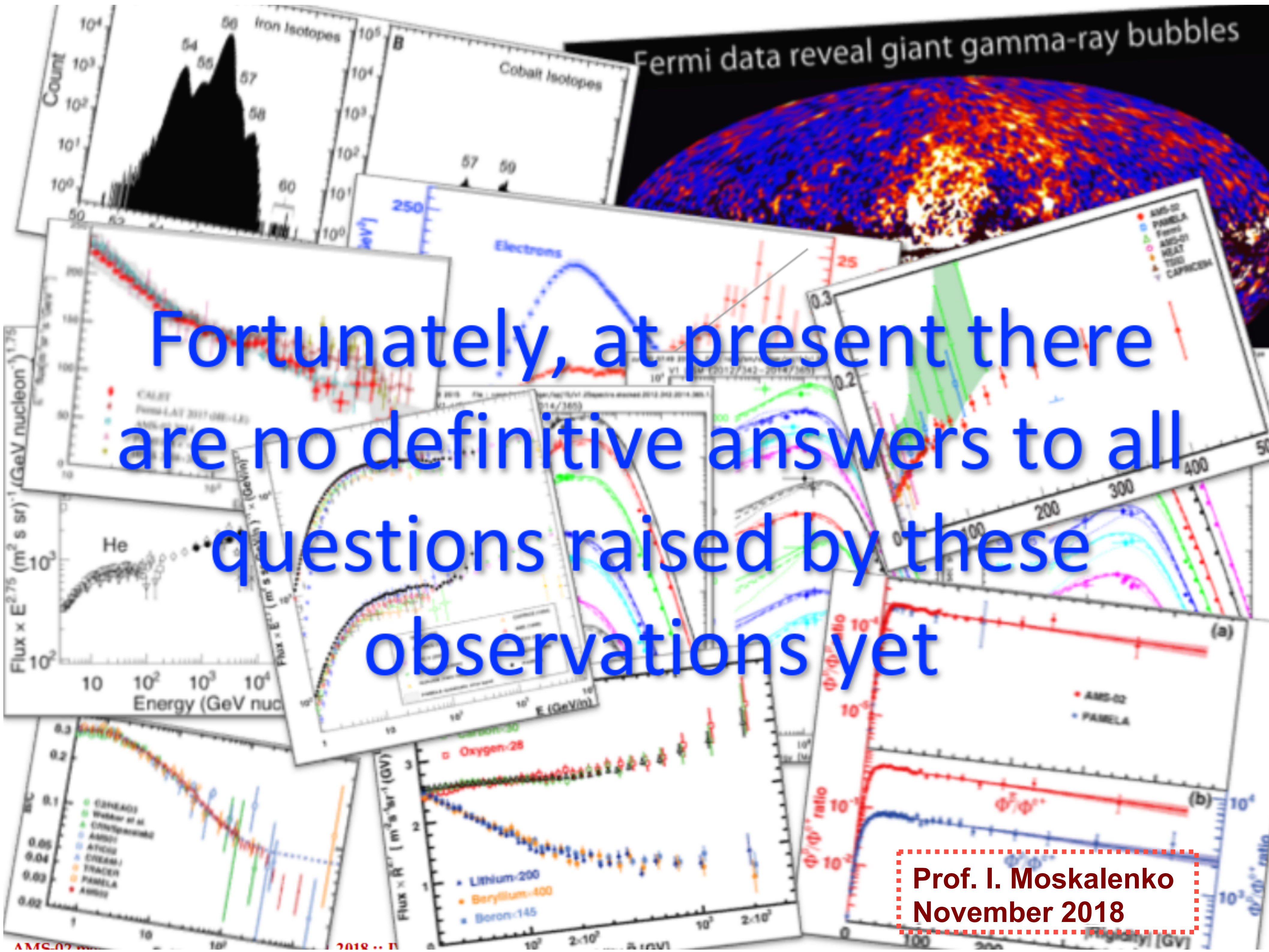
- **Many on-going analysis by instruments in space:**
- Precise antimatter-matter measurements in cosmic rays.
- Indirect dark matter searches.
- Cosmic ray physics
- Connections with solar physics and space weather
- Related to projects as Limadou, GAPS, LIDAL…

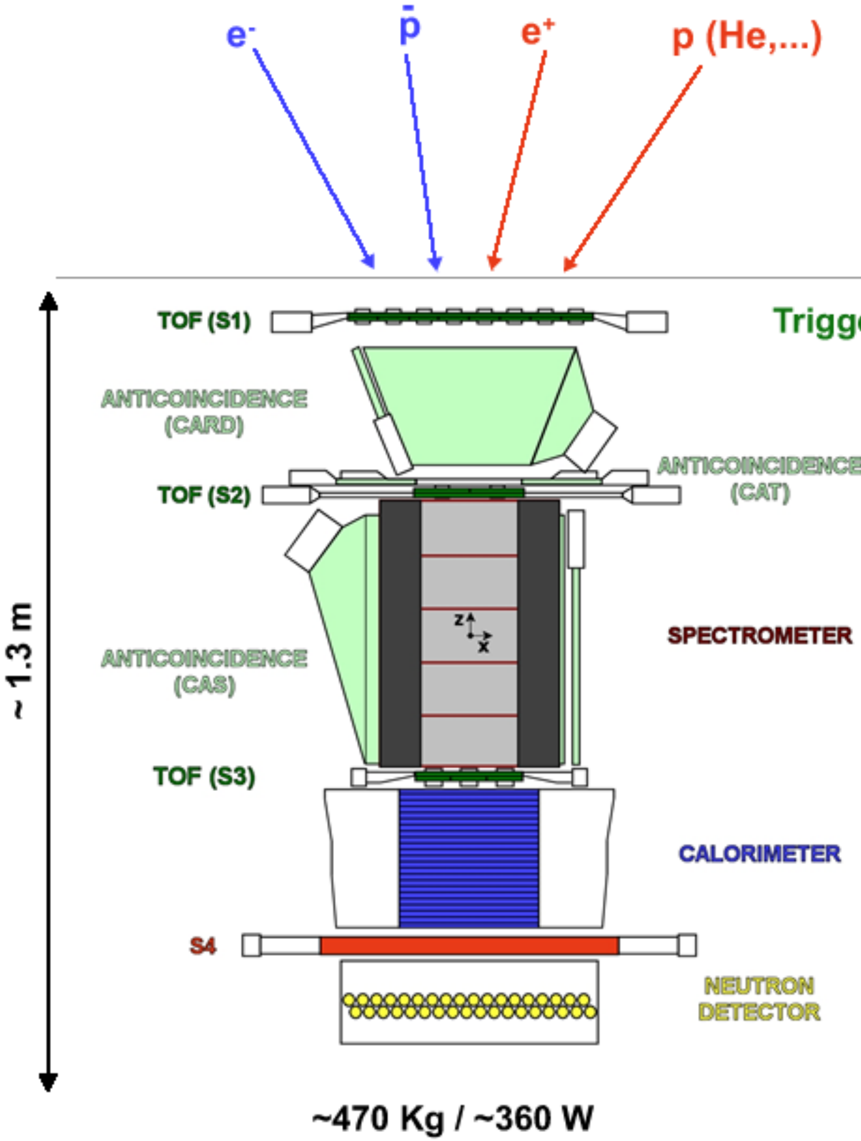


Fortunately, at present there are no definitive answers to all questions raised by these observations yet

Prof. I. Moskalenko
November 2018

backup

PAMELA INSTRUMENT



Trigger, ToF, dE/dx

- S1, S2, S3; double layers, x-y
- plastic scintillator (8mm)
- ToF resolution ~300 ps (S1-3 ToF >3 ns)
- lepton-hadron separation < 1 GeV/c
- S1.S2.S3 (low rate) / S2.S3 (high rate)

Sign of charge, rigidity, dE/dx

- Permanent magnet, 0.43 T
- 21.5 cm^2 sr
- 6 planes double-sided silicon strip detectors (300 μm)
- 3 μm resolution in bending view → MDR ~800 GV (6 plane) ~500 GV (5 plane)

Electron energy, dE/dx, lepton-hadron separation

- 44 Si-x / W / Si-y planes (380)
- 16.3 X0 / 0.6 L
- dE/E ~5.5 % (10 - 300 GeV)
- Self trigger > 300 GeV / 600 cm^2 sr

- 36 ^3He counters
- $^3He(n,p)T$; E_p = 780 keV
- 1 cm thick poly + Cd moderator
- 200 μs collection