CosmicSIG Status and Plans

Cosmic Ray *Science Interest* Group

PhysPAG Town Hall at AAS, January 5, 2014

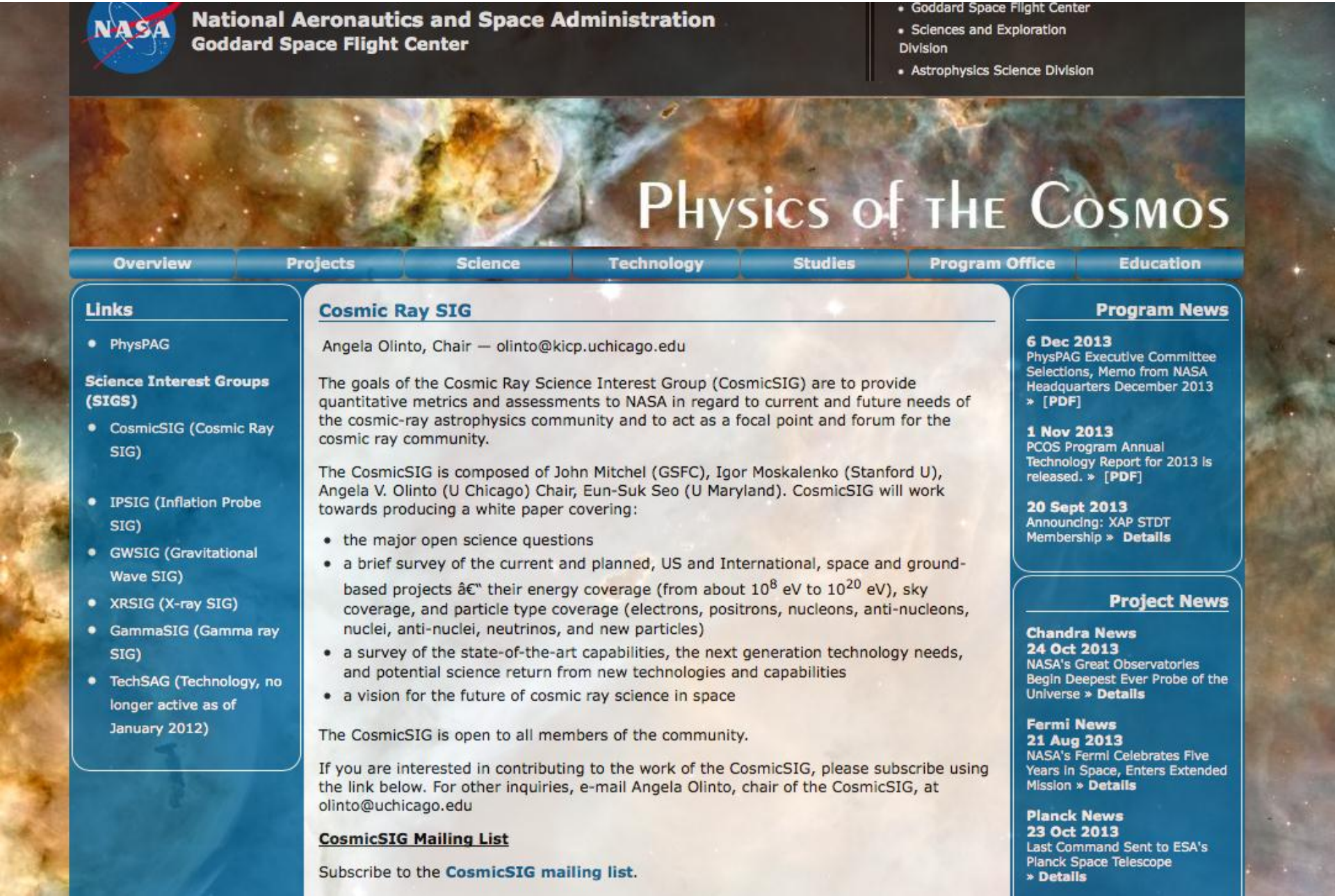
Wireless

- AASMTG
- User: aas
- Pass: aas223

CosmicSIG Activities

- Committee formed April 2013
  - John Mitchel (GSFC), Igor Moskalenko (Stanford U), Angela Olinto (U Chicago) Chair, Eun-Suk Seo (U Maryland)
- Goals of CosmicSIG
  - Provide an assessment to NASA HQ and the PCOS program office of the status and the **current and future** needs of the **cosmic-ray astrophysics** community.
  - Act as a **focal point** and forum for the cosmic ray community.
- White Paper with Cosmic Ray vision for the next decade(s)
  - Gather input from Community
  - Survey current and future projects and missions and their science goals and coverage
  - Survey technology development needs for future progress in the field

http://pcos.gsfc.nasa.gov/sigs/cosmicsig.php



National Aeronautics and Space Administration
Goddard Space Flight Center

- Goddard Space Flight Center
- Sciences and Exploration Division
- Astrophysics Science Division

Physics of the Cosmos

Overview | Projects | Science | Technology | Studies | Program Office | Education

Links

- PhysPAG

Science Interest Groups (SIGS)

- CosmicSIG (Cosmic Ray SIG)
- IPSIG (Inflation Probe SIG)
- GWSIG (Gravitational Wave SIG)
- XRSIG (X-ray SIG)
- GammaSIG (Gamma ray SIG)
- TechSAG (Technology, no longer active as of January 2012)

Cosmic Ray SIG

Angela Olinto, Chair — olinto@kicp.uchicago.edu

The goals of the Cosmic Ray Science Interest Group (CosmicSIG) are to provide quantitative metrics and assessments to NASA in regard to current and future needs of the cosmic-ray astrophysics community and to act as a focal point and forum for the cosmic ray community.

The CosmicSIG is composed of John Mitchel (GSFC), Igor Moskalenko (Stanford U), Angela V. Olinto (U Chicago) Chair, Eun-Suk Seo (U Maryland). CosmicSIG will work towards producing a white paper covering:

- the major open science questions
- a brief survey of the current and planned, US and International, space and ground-based projects â€" their energy coverage (from about 10^8 eV to 10^{20} eV), sky coverage, and particle type coverage (electrons, positrons, nucleons, anti-nucleons, nuclei, anti-nuclei, neutrinos, and new particles)
- a survey of the state-of-the-art capabilities, the next generation technology needs, and potential science return from new technologies and capabilities
- a vision for the future of cosmic ray science in space

The CosmicSIG is open to all members of the community.

If you are interested in contributing to the work of the CosmicSIG, please subscribe using the link below. For other inquiries, e-mail Angela Olinto, chair of the CosmicSIG, at olinto@uchicago.edu

CosmicSIG Mailing List

Subscribe to the **CosmicSIG mailing list**.

Program News

6 Dec 2013
PhysPAG Executive Committee Selections, Memo from NASA Headquarters December 2013 » [PDF]

1 Nov 2013
PCOS Program Annual Technology Report for 2013 is released. » [PDF]

20 Sept 2013
Announcing: XAP STDT Membership » **Details**

Project News

Chandra News
24 Oct 2013
NASA's Great Observatories Begin Deepest Ever Probe of the Universe » **Details**

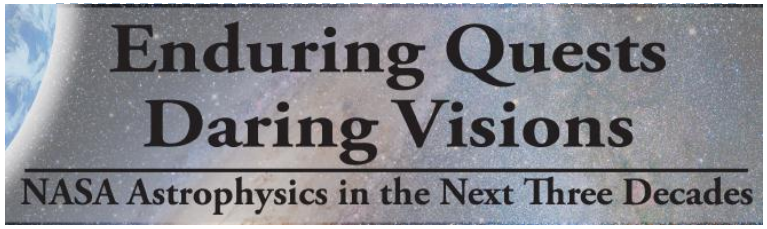
Fermi News
21 Aug 2013
NASA's Fermi Celebrates Five Years in Space, Enters Extended Mission » **Details**

Planck News
23 Oct 2013
Last Command Sent to ESA's Planck Space Telescope » **Details**

CosmicSIG Activities

- Gathering input from Community
  - "June 2012": open meeting at CR2012 requesting input from the community
  - Teleconferences and email input for further information gathering.
  - ICRC 2013
- Fall 2013: compile previous white papers (Astro 2010 prep to NWNH, *Enduring Quests Daring Visions*,…).
- Winter 2014: draft white paper
- April 2014: present white paper draft at APS meeting
- Fall 2014: deliver white paper to PhysPAG (+ NAC)

NASA Astrophys Roadmap



December 20, 2013

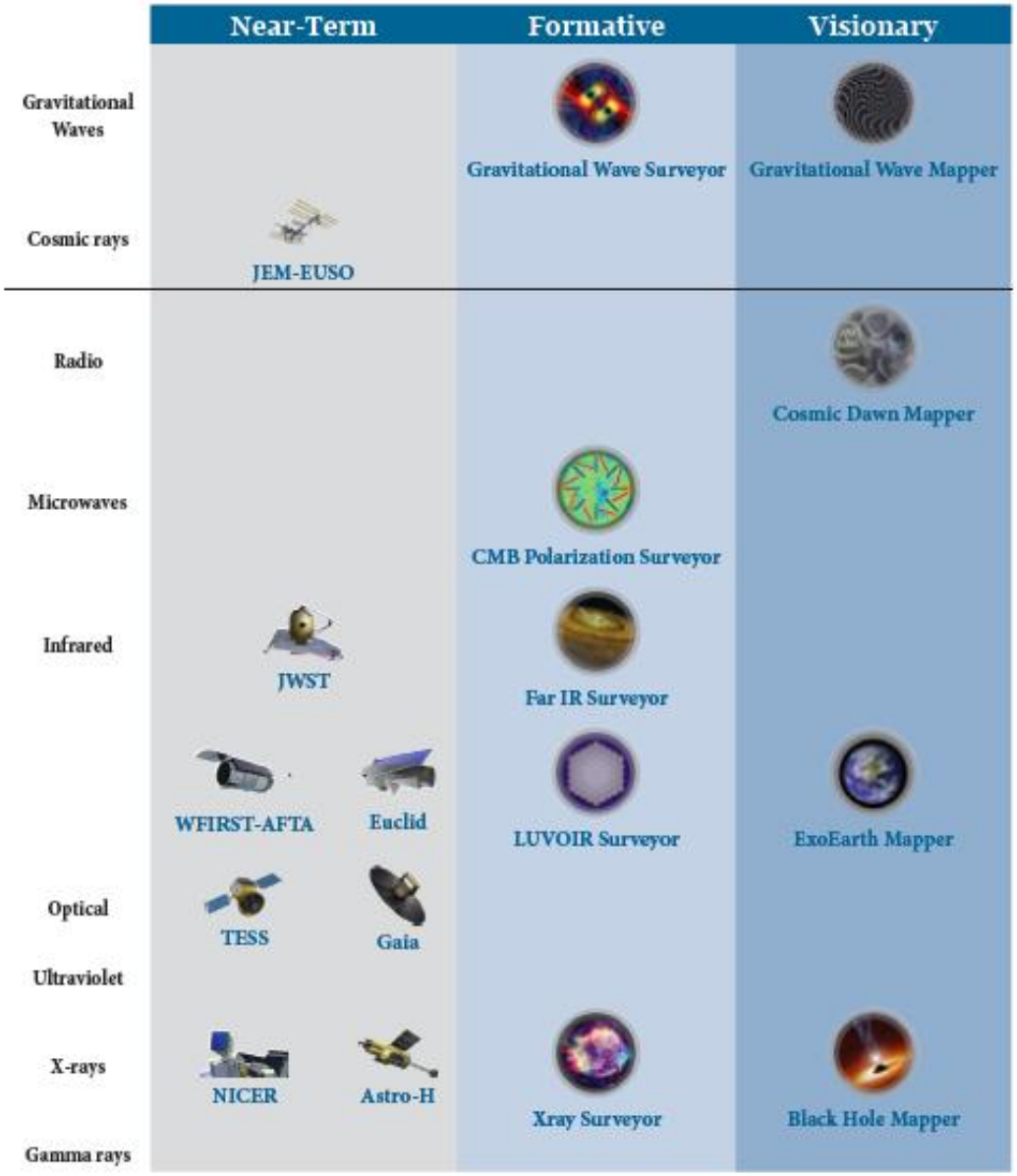
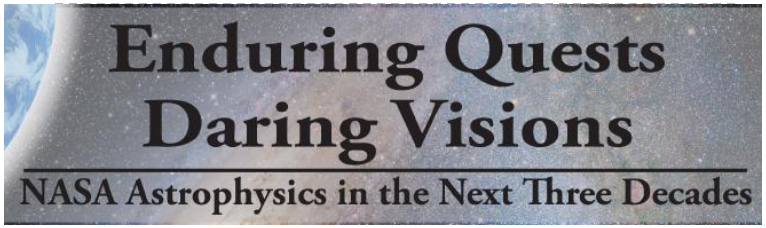


Figure 1.2 Chart of the missions currently planned for launch during the Near-Term Era and of the notional missions of this roadmap for the Formative and Visionary Eras.

NASA Astrophys Roadmap



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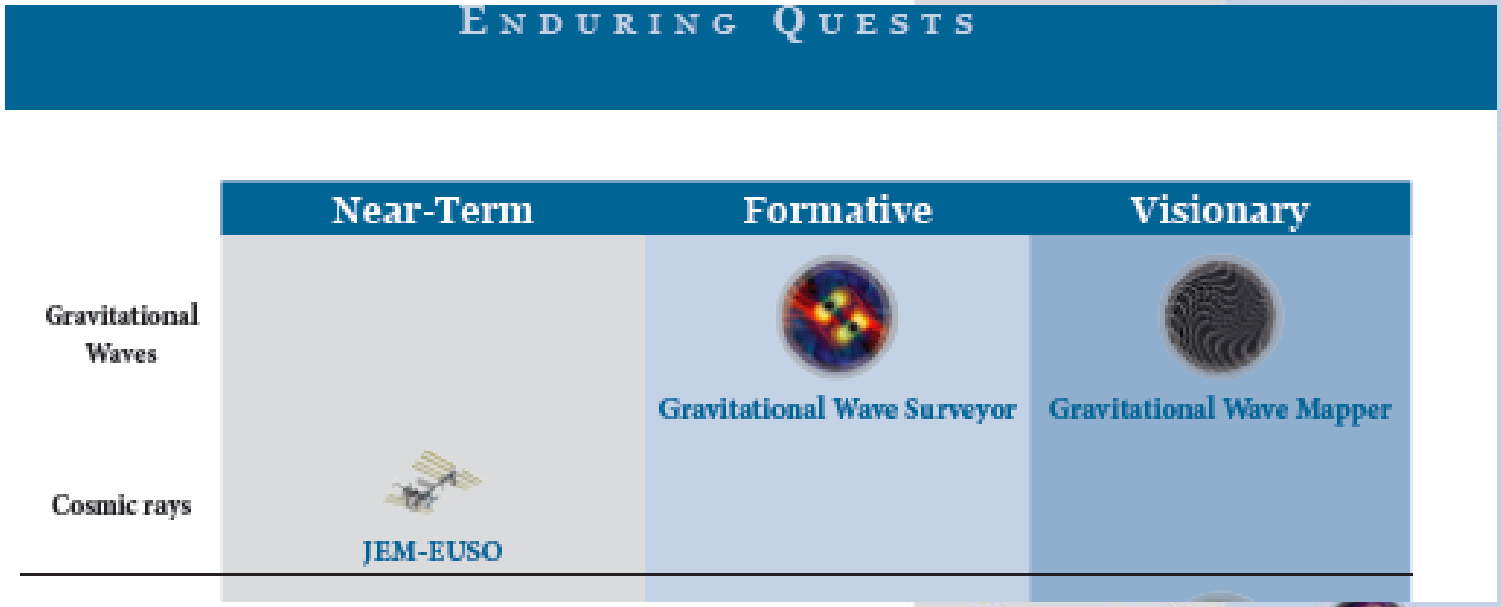


Figure 1.2 Chart of the missions currently planned for launch during the Near-Term Era and of the notional missions of this roadmap for the Formative and Visionary Eras.

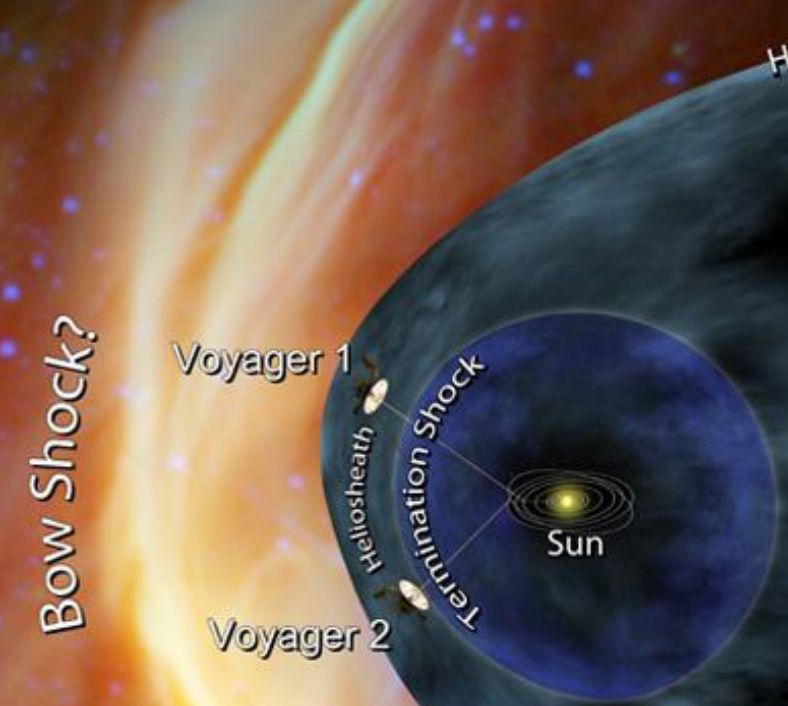
Particle Accelerators

THERE is yet another, less apparent component of galaxies: high-energy particles (cosmic rays). A century ago, Victor Hess discovered via high-altitude balloons a background of high-energy charged particles, which we now know pervades the ISM, providing about a third of its energy density. This dynamically important gas of particles requires efficient acceleration, which is now believed to take place in the strong shock waves of supernova remnants. Only recently did gamma-ray observations in the GeV regime (from space) and the TeV regime (from the ground) yield convincing data supporting this paradigm. About half a dozen stars are born every year in the Milky Way; those with sufficiently high mass ultimately end their lives as supernovae, resulting in a few supernova explosions per century. Due to their large energy per explosion, this rate is sufficient to maintain a significant fraction of the ISM in a hot and ionized state, emitting characteristic line radiation in the ultraviolet and X-ray bands. The study of galactic cosmic rays with space based detectors (e.g., Fermi, AMS) and ground-based facilities, such as the Auger array in Argentina (and indirectly through ground-based observations of very high-energy gamma rays), can be advanced with dedicated detectors on the International Space Station such as JEM-EUSO, which will utilize Earth's atmosphere as a particle detector. The study of cosmic ray particle acceleration is an important physics question in its own right, but this high-energy particle component of any actively star-forming galaxy is also responsible for the creation of some crucial elements (lithium, beryllium, and boron). It bathes the galaxy in a diffuse glow of high-energy gamma rays, which represents a significant fraction of its total energy output; the presence of the cosmic ray component can even play a substantial role in the self-regulation of the star-formation rate. The motion of the Sun-Earth system in the galactic potential causes changes to the cosmic ray environment on timescales on the order of 100 million years, which could potentially be linked to extinction cycles on Earth.

Cosmic Rays 2013 Highlights - Space

The Great Voyage

1977 to now and onwards…



Voyager 1 and 2 in 2012 Voyager 'leave' the Heliosphere in the

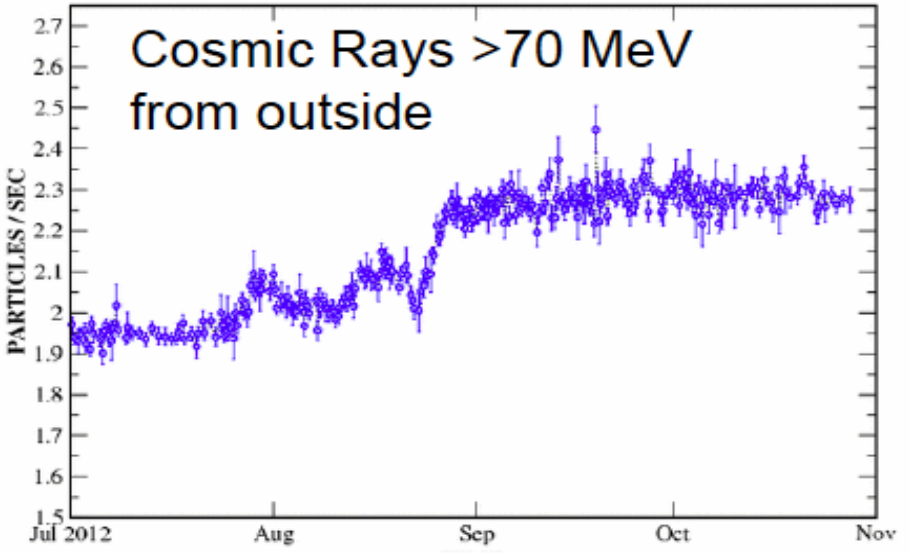
Moving at **17.26 km/s**

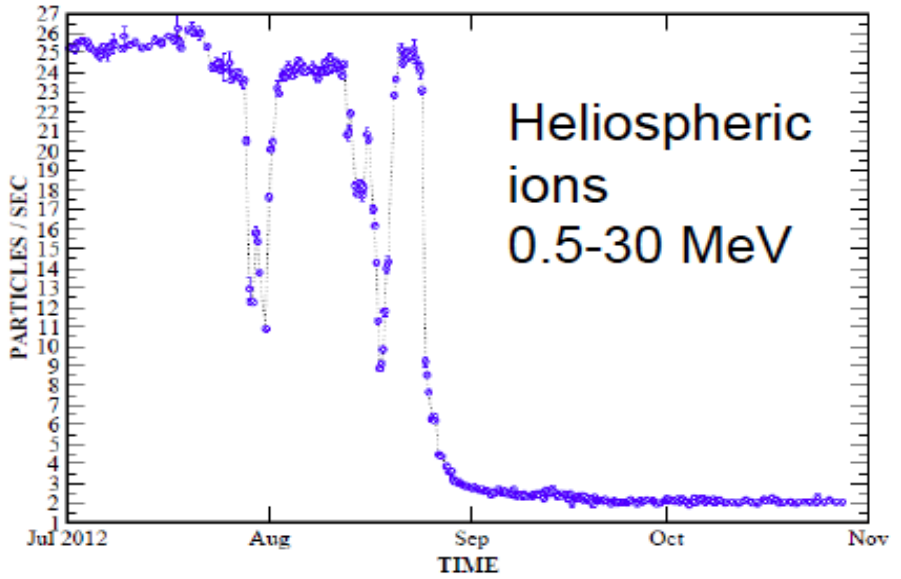
Heliosphere

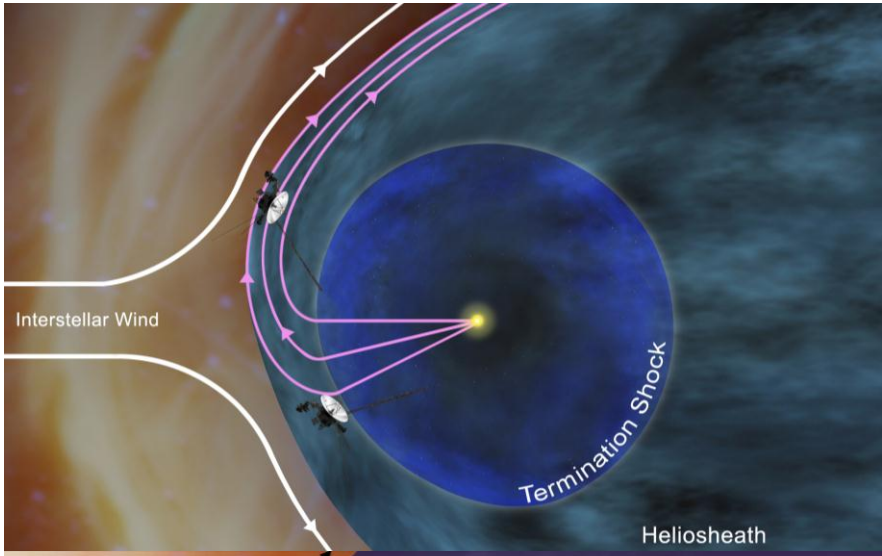
Ed Stone & Voyager

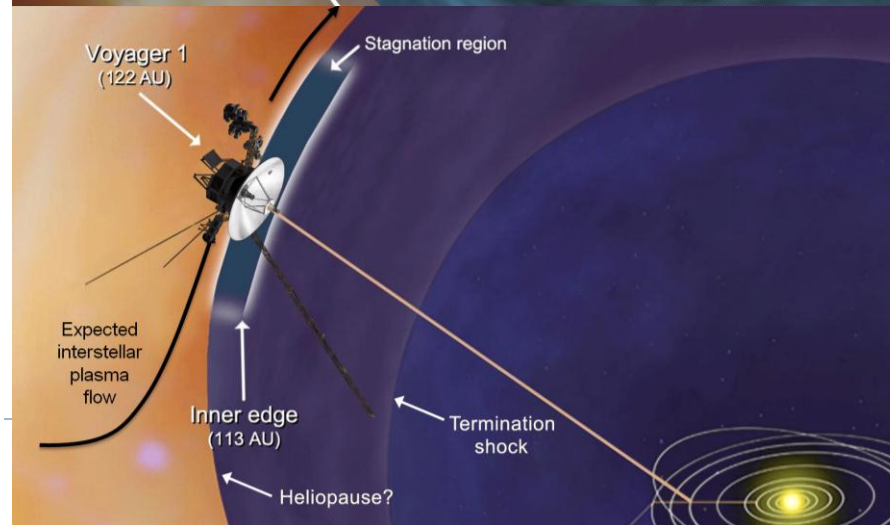
Cosmic Rays Recent Highlights

- Voyager 1 reaches Interstellar Space (Aug/Sep 2012)

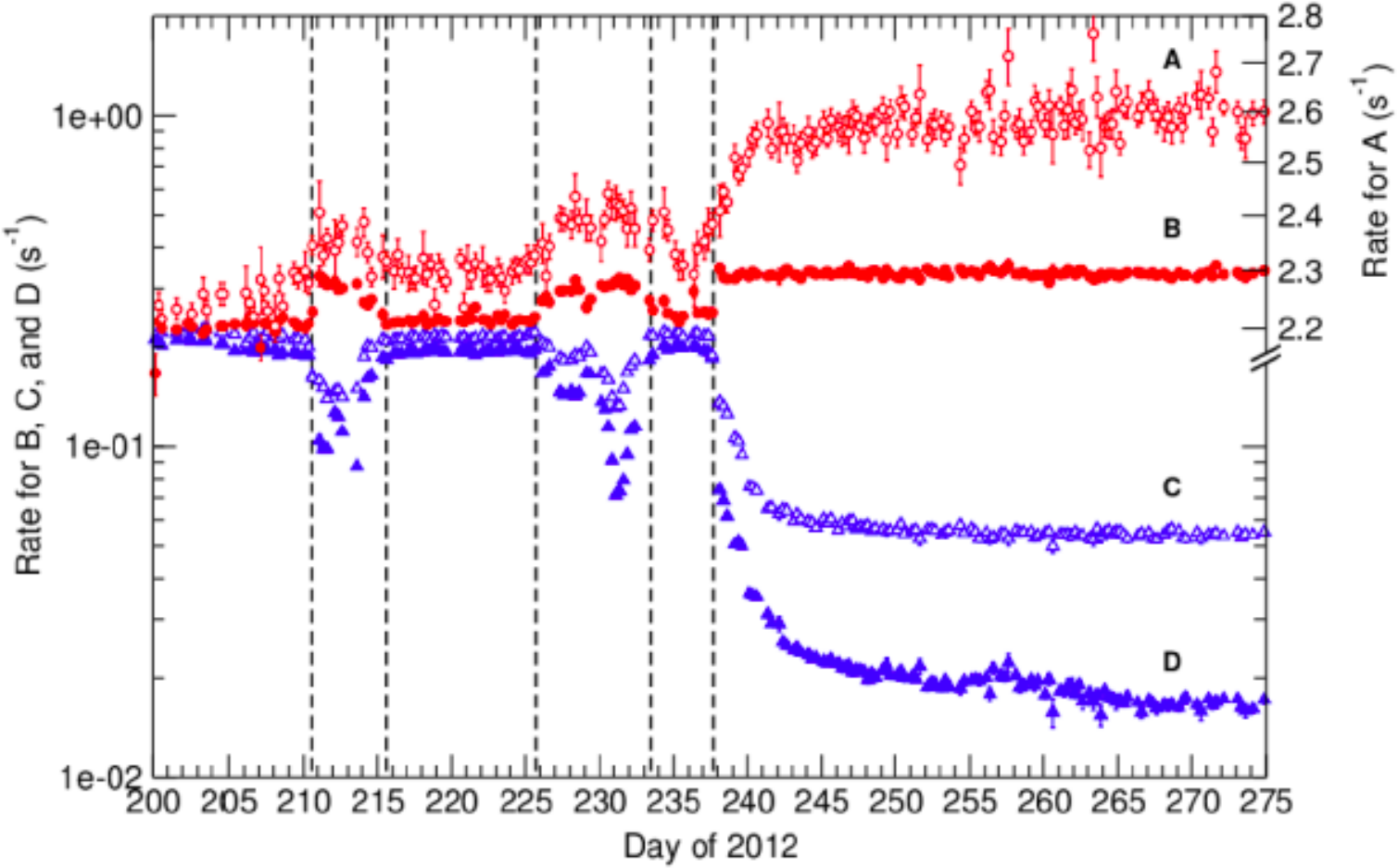








Galactic CRs ↑ Heliospheric CRs ↓



From outside:

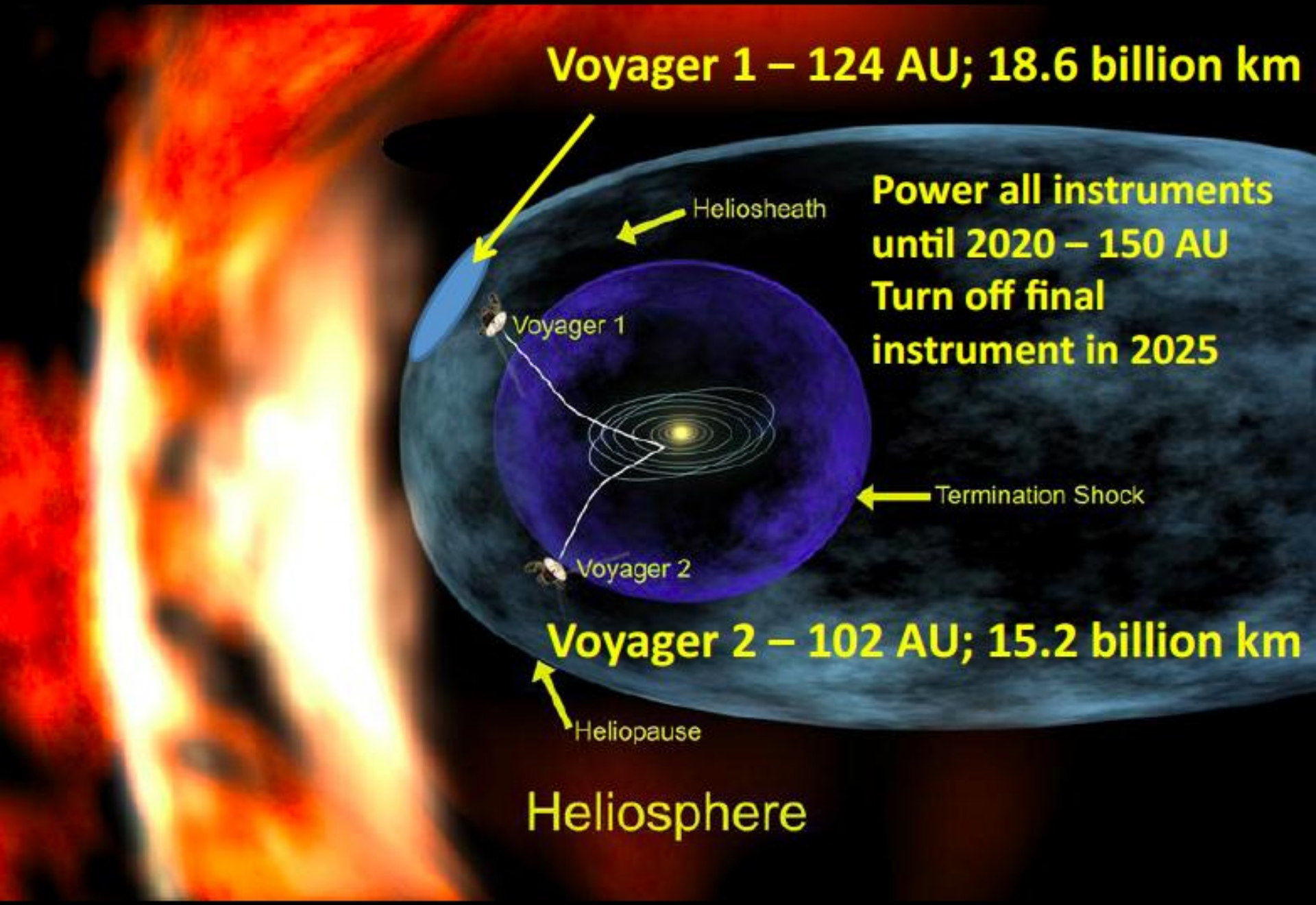
GCR protons
>70 MeV

GCR electrons
7 to ~100 MeV

From inside:

ACR protons
7 to 60 MeV

TSPs
0.5 to 30 MeV


Voyager 1 – 124 AU; 18.6 billion km
Heliosheath
Power all instruments until 2020 – 150 AU
Turn off final instrument in 2025
Voyager 1
Termination Shock
Voyager 2
Voyager 2 – 102 AU; 15.2 billion km
Heliopause
Heliosphere

Cosmic Rays 2013 Highlights (Mar'13)

- AMS (Alpha Magnetic Spectrometer) on the ISS announces first results

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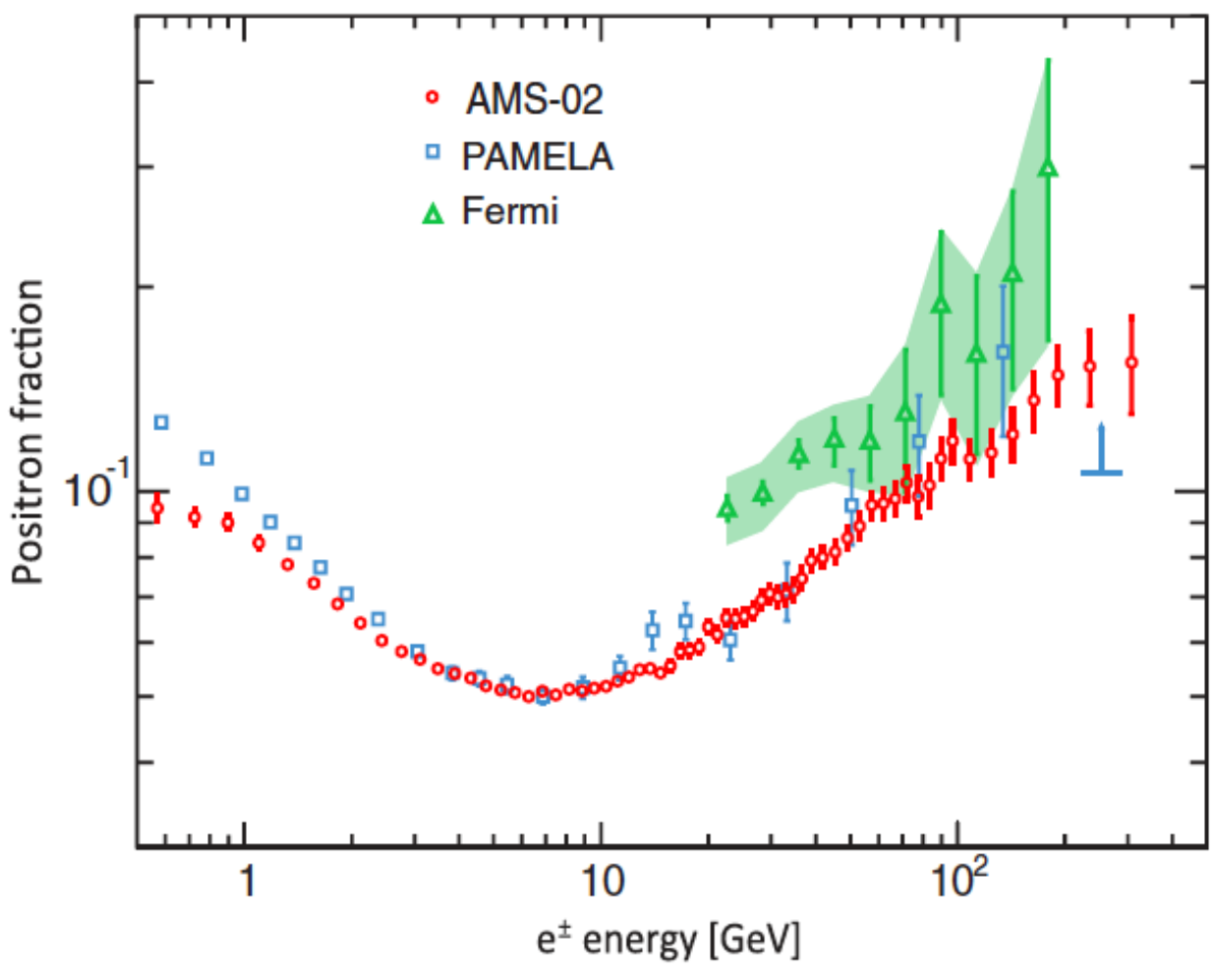
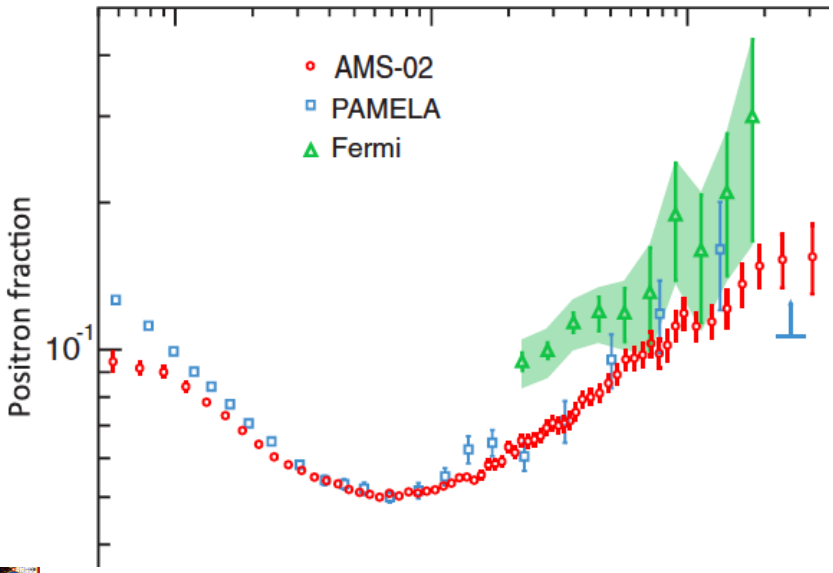
PRL 110, 141102 (2013)

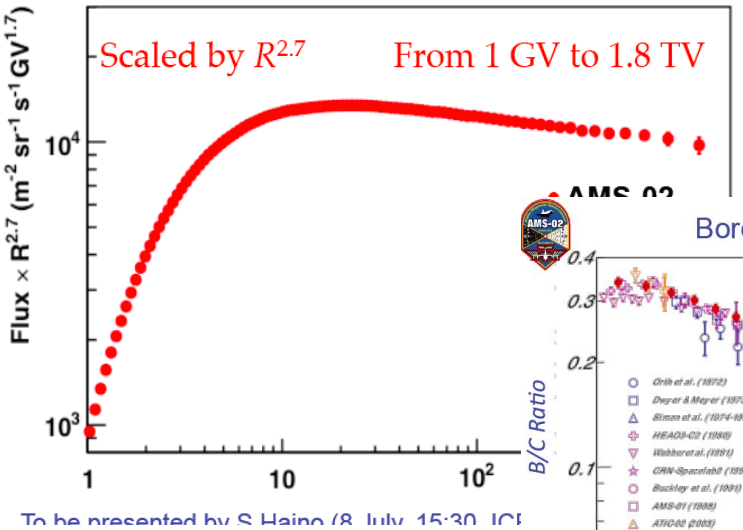


Cosmic Rays 2013 Highlights (Jul'13)

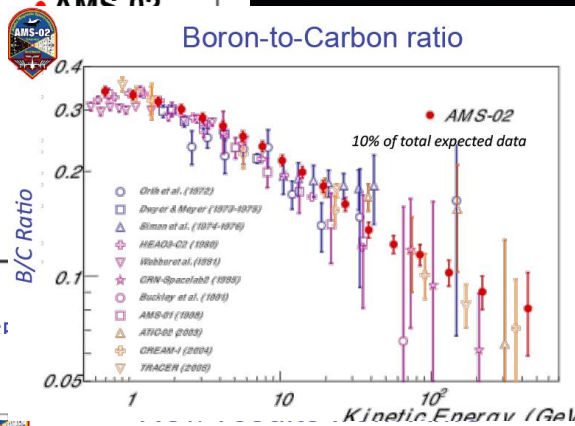
- AMS (Alpha Magnetic Spectrometer) on the ISS



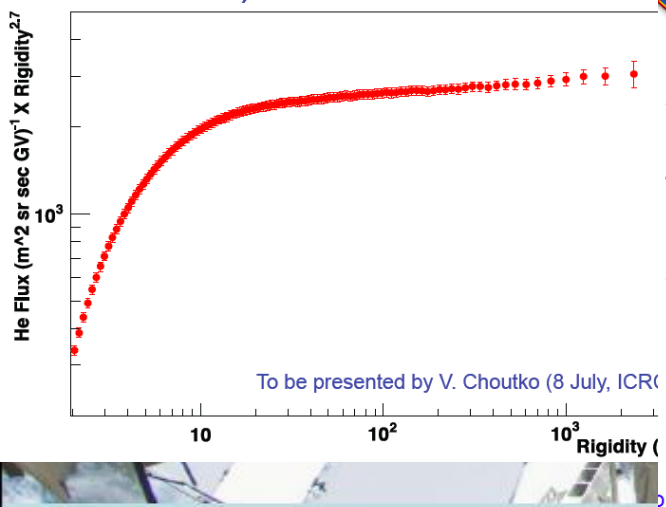
2) Proton flux



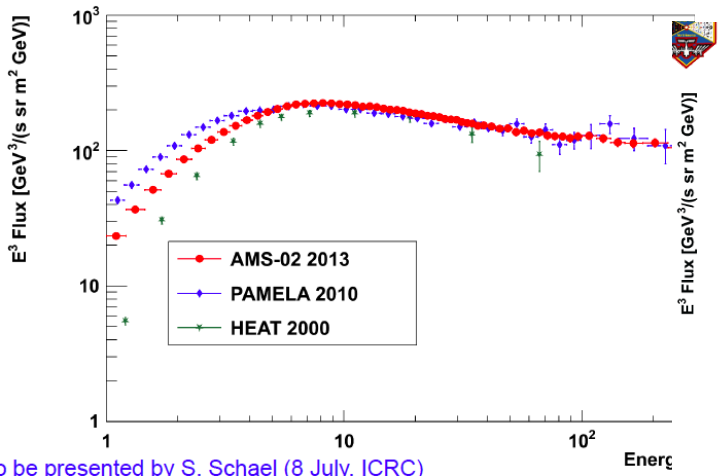
41102 (2013)



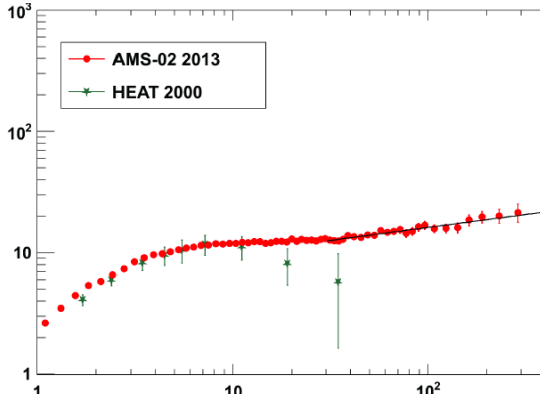
3) Helium flux



4) Electron Spectrum

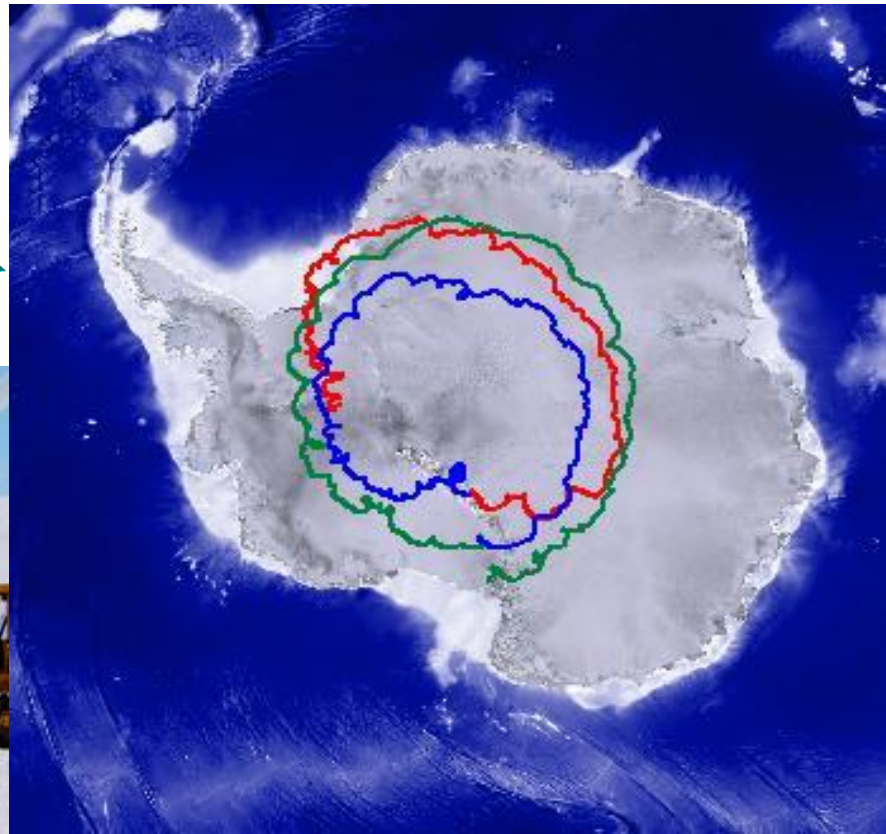


5) Positron Spectrum



Cosmic Rays 2013 Highlights (Feb' 13)

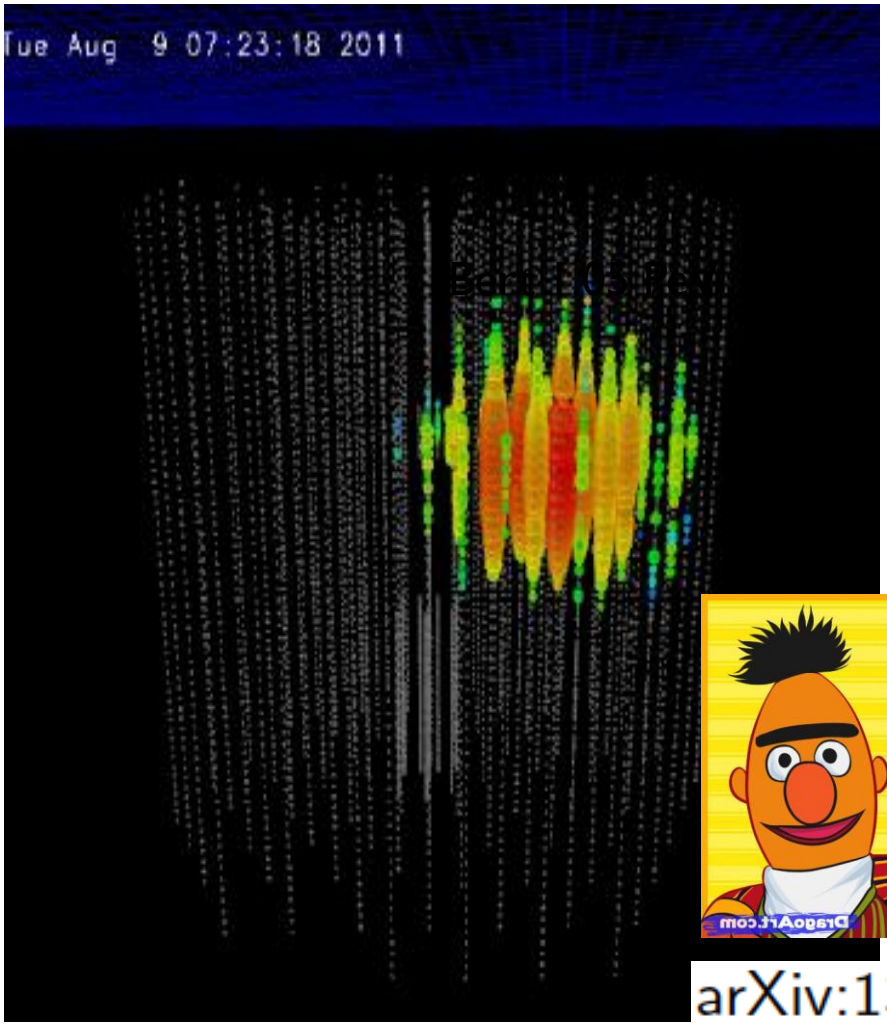
- Super-TIGER (Trans-Iron Galactic Element Recorder) breaks flight duration record: 55 days at 127,000 feet
  - Increase on UltraHeavy Nuclei data by 1 o.o.m. to study composition and origin of Galactic Cosmic Rays

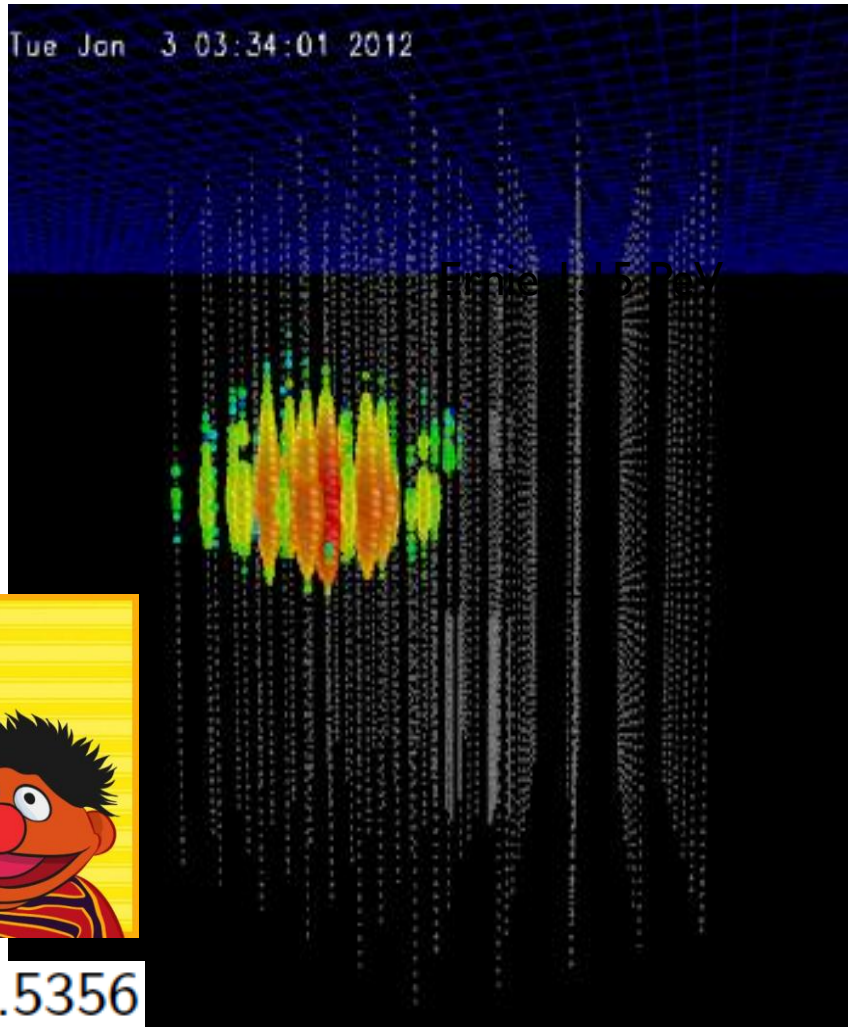


Cosmic Rays 2013 Highlights - Ground

Neutrino Astronomy Begins

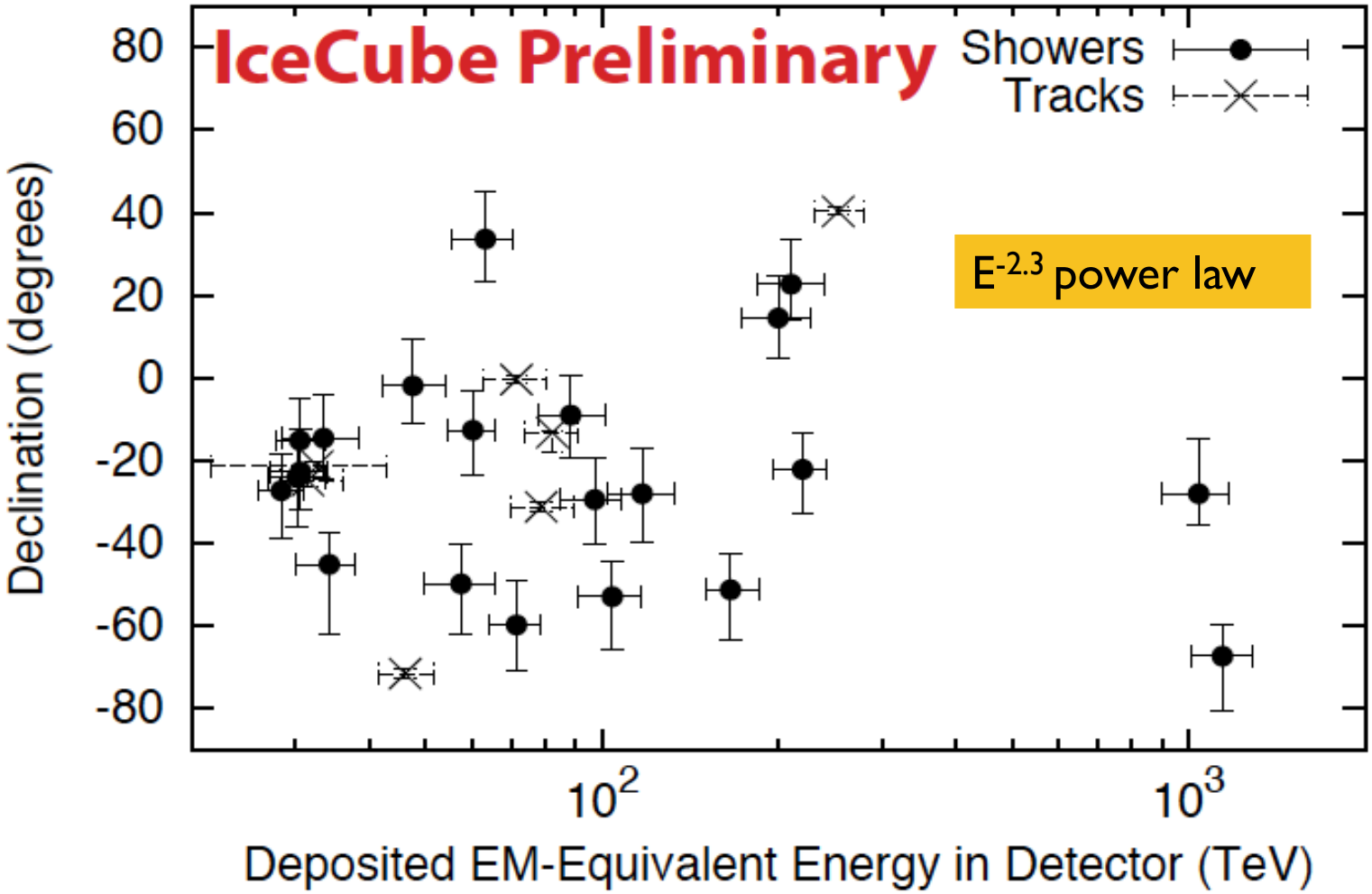
- PeV neutrinos first observed by **IceCube** (Apr'13)





arXiv:1304.5356

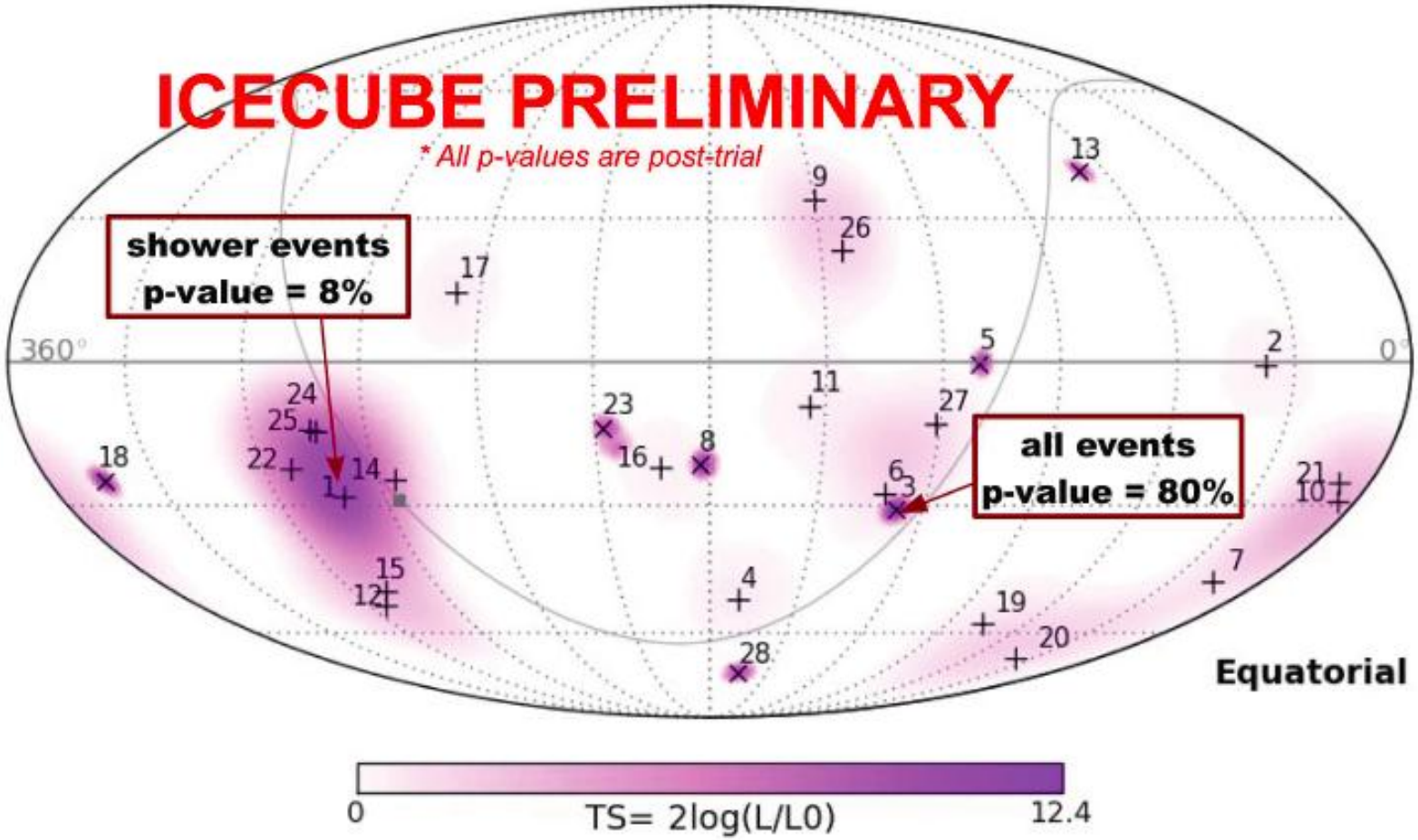
Results of Contained Vertex Event Search (4.3σ)



28 events (7 with visible muons, 21 without) on background of $10.6^{+4.5}_{-3.9}$ (12.1 ± 3.4 with reference charm model)

Anchordoqui et al '13

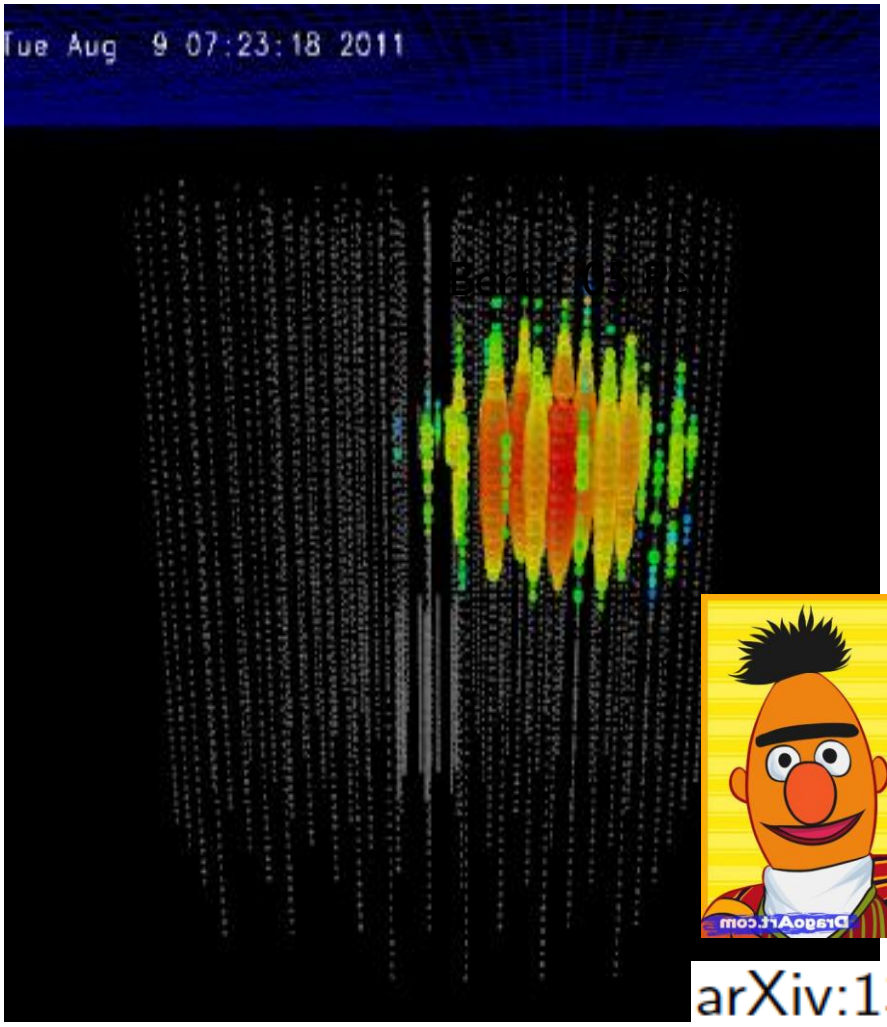
Skymap: No Significant Clustering

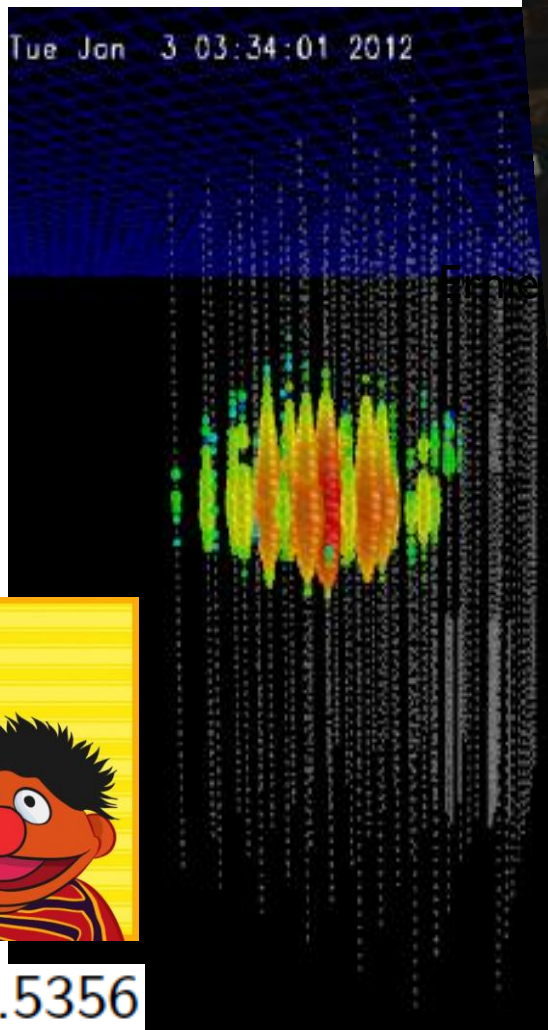


See: talk by Naoko Kurahashi Neilson

Neutrino Astronomy Begins

- PeV neutrinos first observed by **IceCube** (Apr'13)

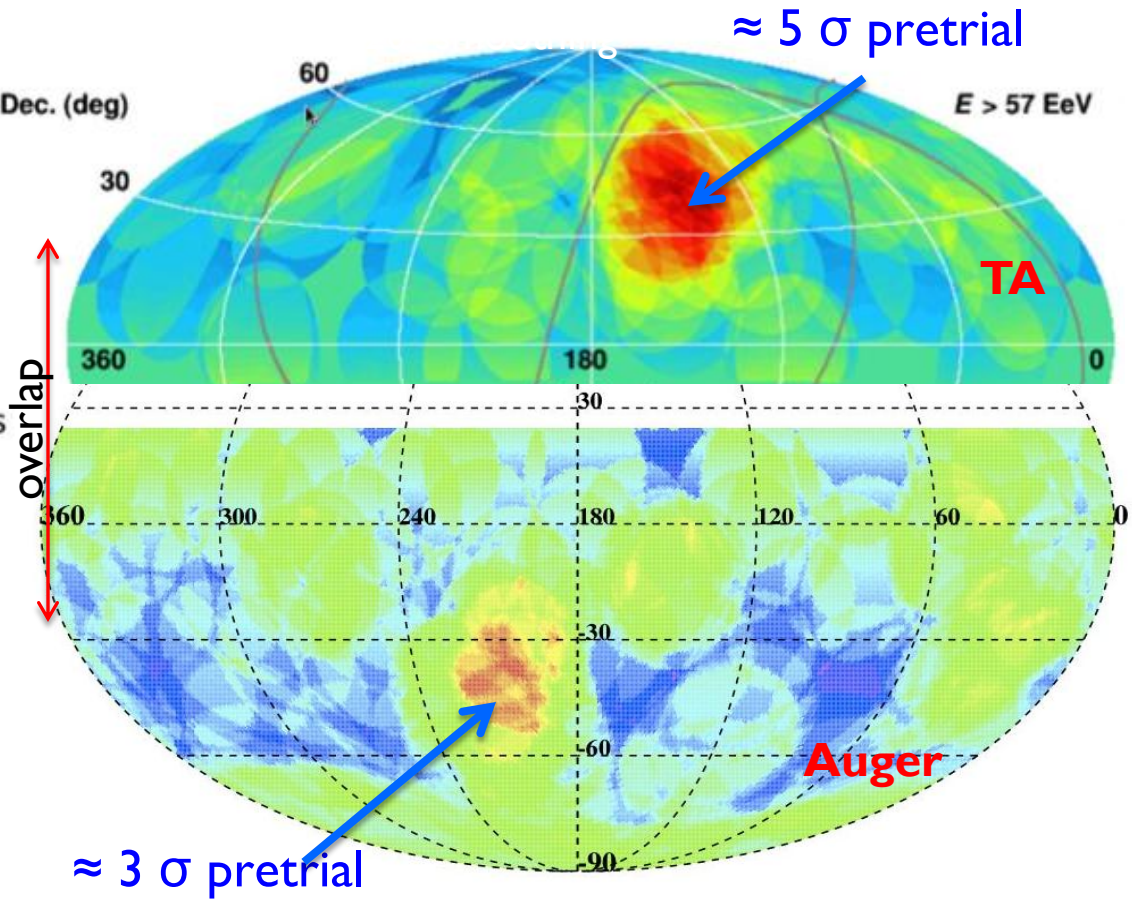




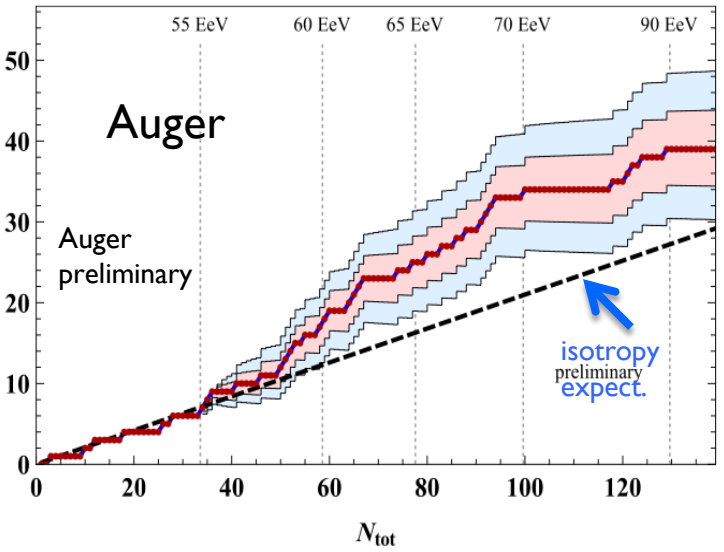
arXiv:1304.5356

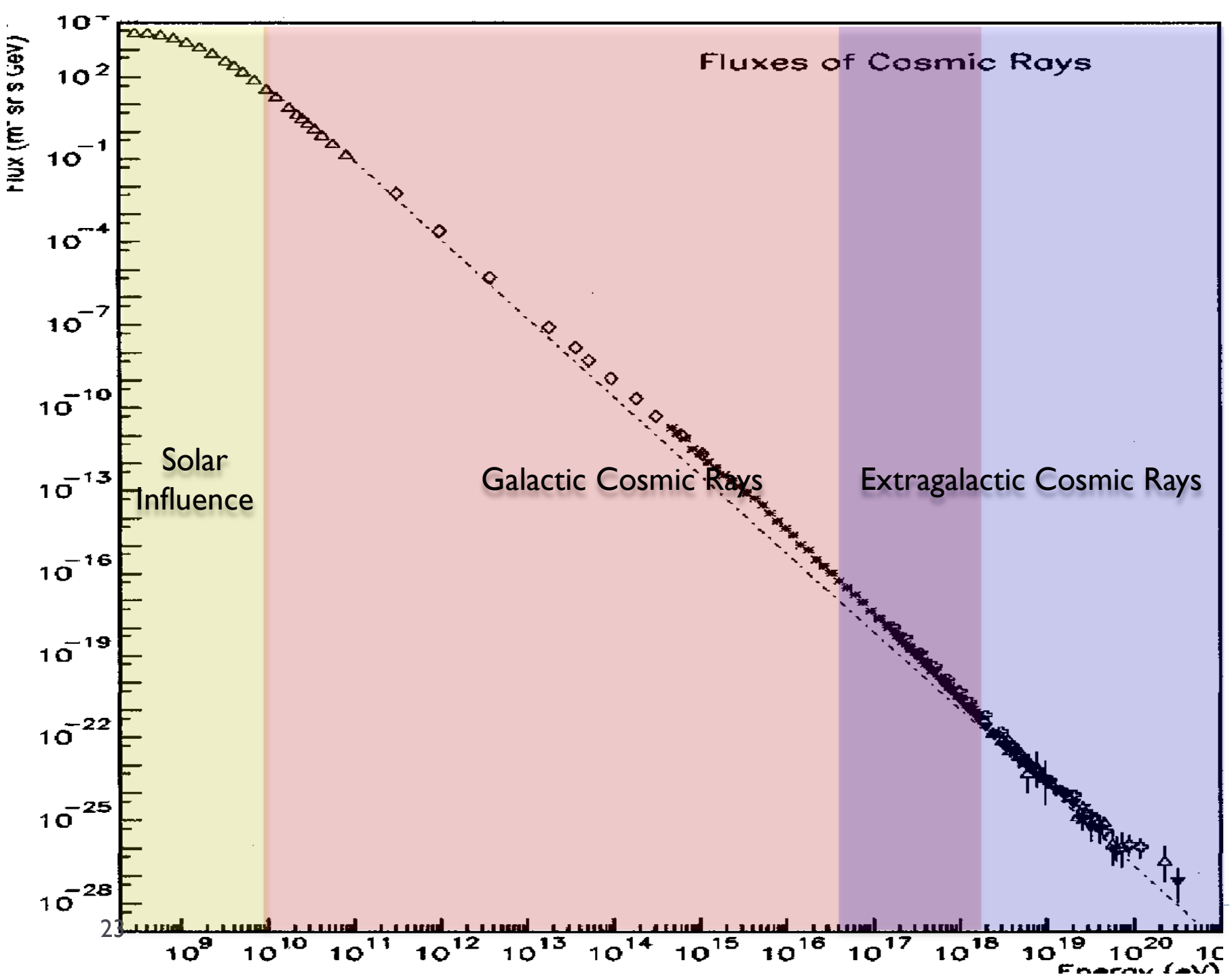
UHECR Anisotropy Hints >60 EeV

Statistically limited evidence for Comic Ray Anisotropy above 5.7x 10^{19} eV in the North and South



# of events correlating with AGN, ordered in energy (integral plot)




Fluxes of Cosmic Rays
Solar Influence
Galactic Cosmic Rays
Extragalactic Cosmic Rays

Open Questions in CR Science

- Origin of Galactic Cosmic Rays (GCR):
  - What are the accelerators?
  - What are they accelerating?
  - How do they propagate in the Galaxy?
  - Where is the Transition between Galactic & ExtraGalactic CRs?
- Origin of ExtraGalactic Cosmic Rays (XGCR):
  - What are the accelerators?
  - What are they accelerating?
  - How do they propagate to Earth?
  - At what Energy COSMIC RAY ASTRONOMY begins?
- How do Cosmic Rays Affect the Earth, the Solar System, the Galaxy, other Galaxies, and the formation of Stars and Galaxies?

Open Questions in CR Science

- Origin of Galactic Cosmic Rays (GCR):
  - **What are the accelerators? (**CosmicSIG + GammaSIG)
  - What are they accelerating?
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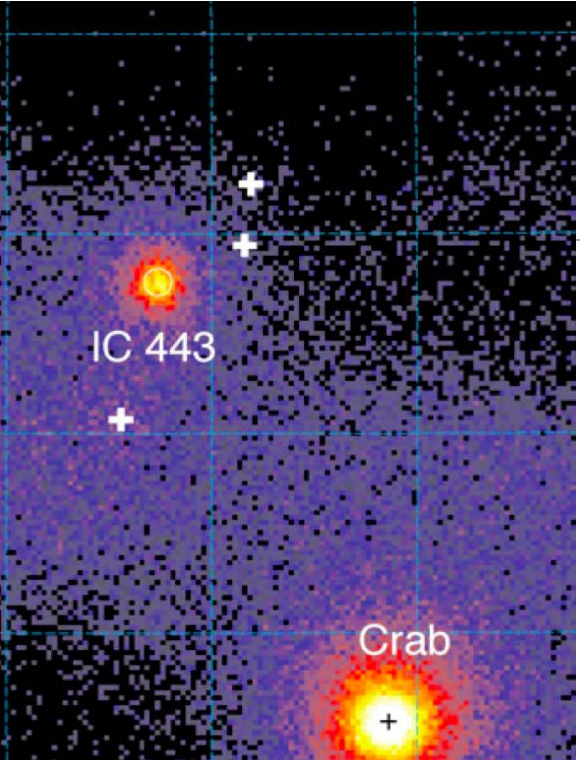
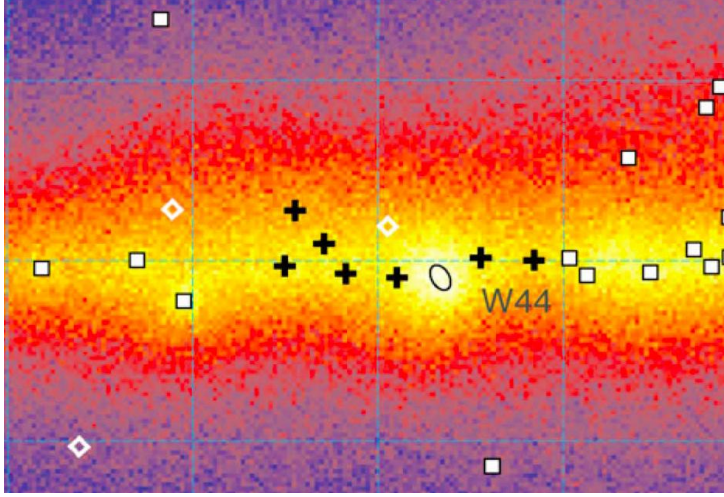
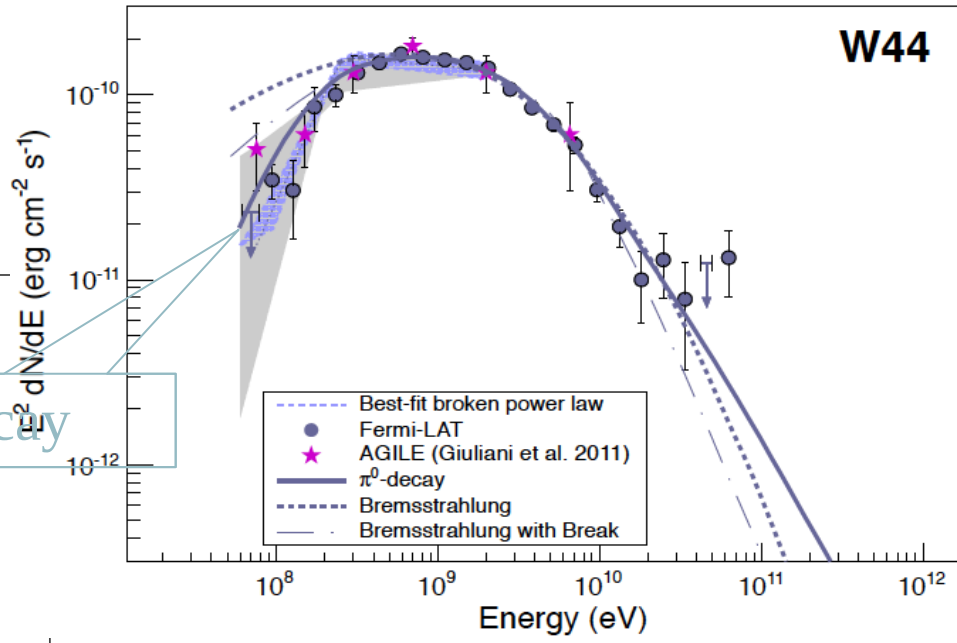
π^0 decay!

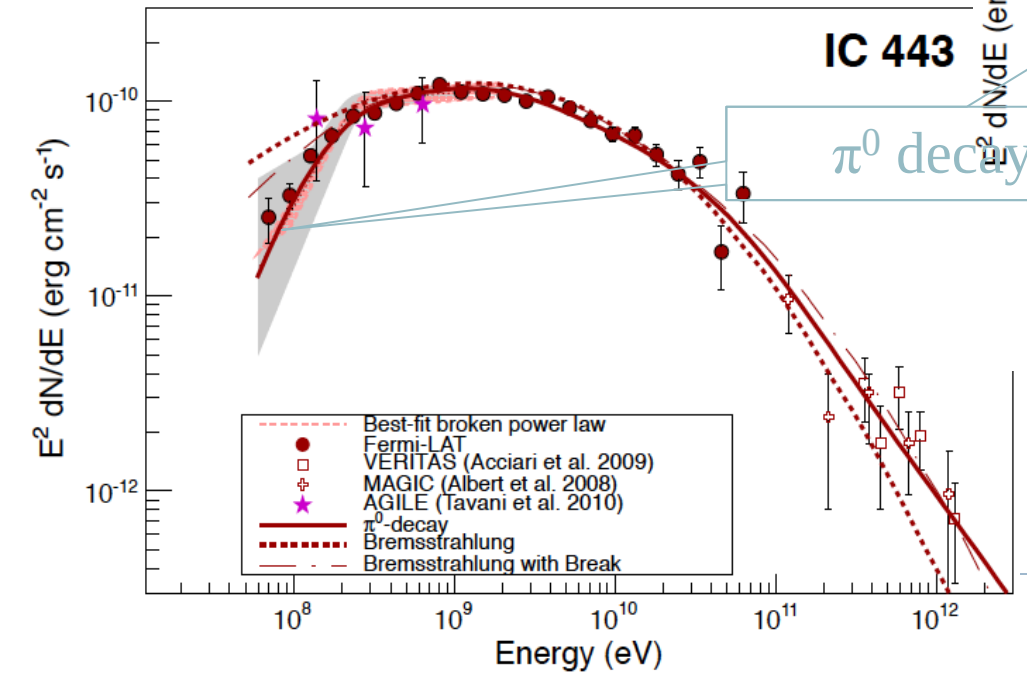
IC 443 & W44

Fermi & AGILE





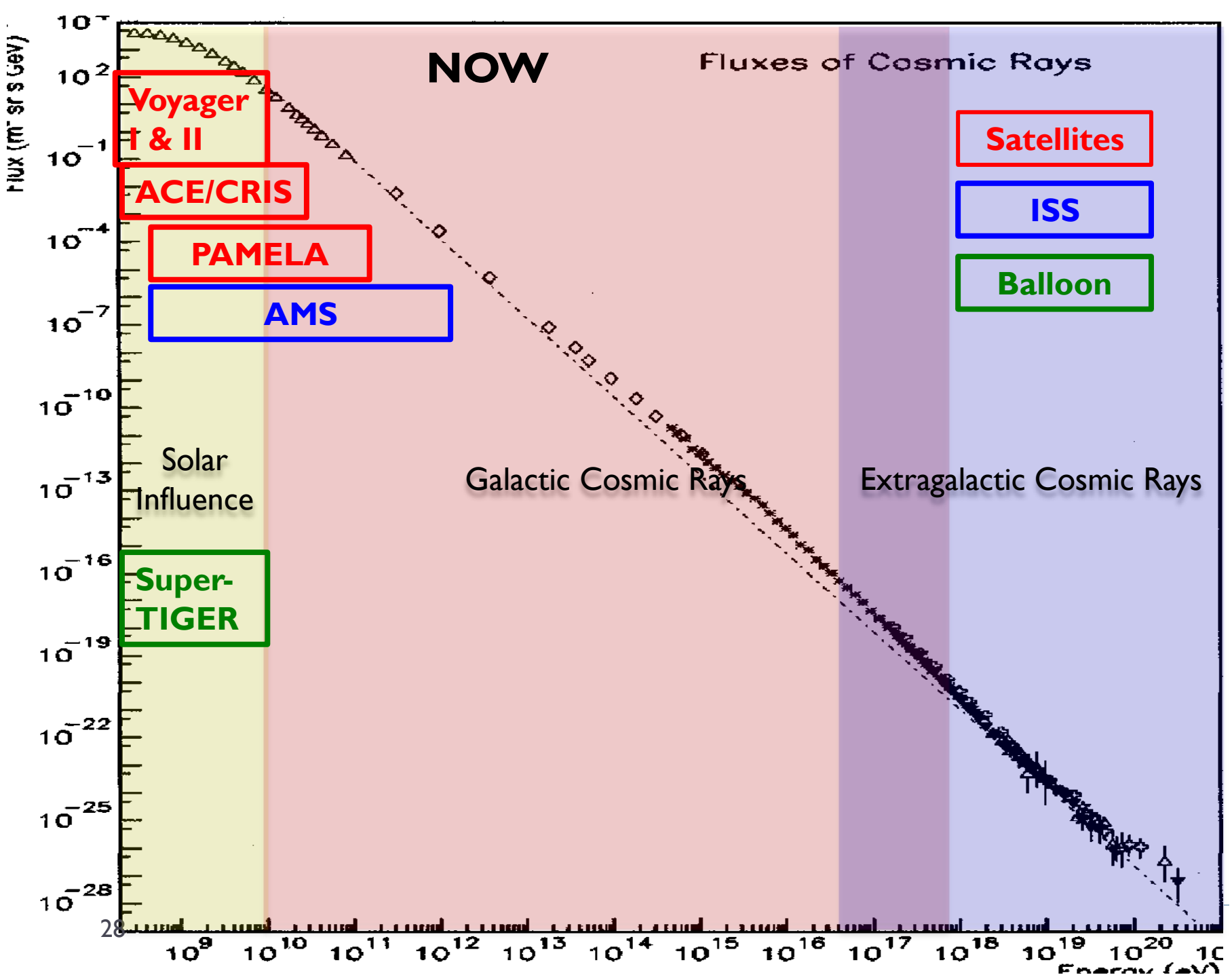


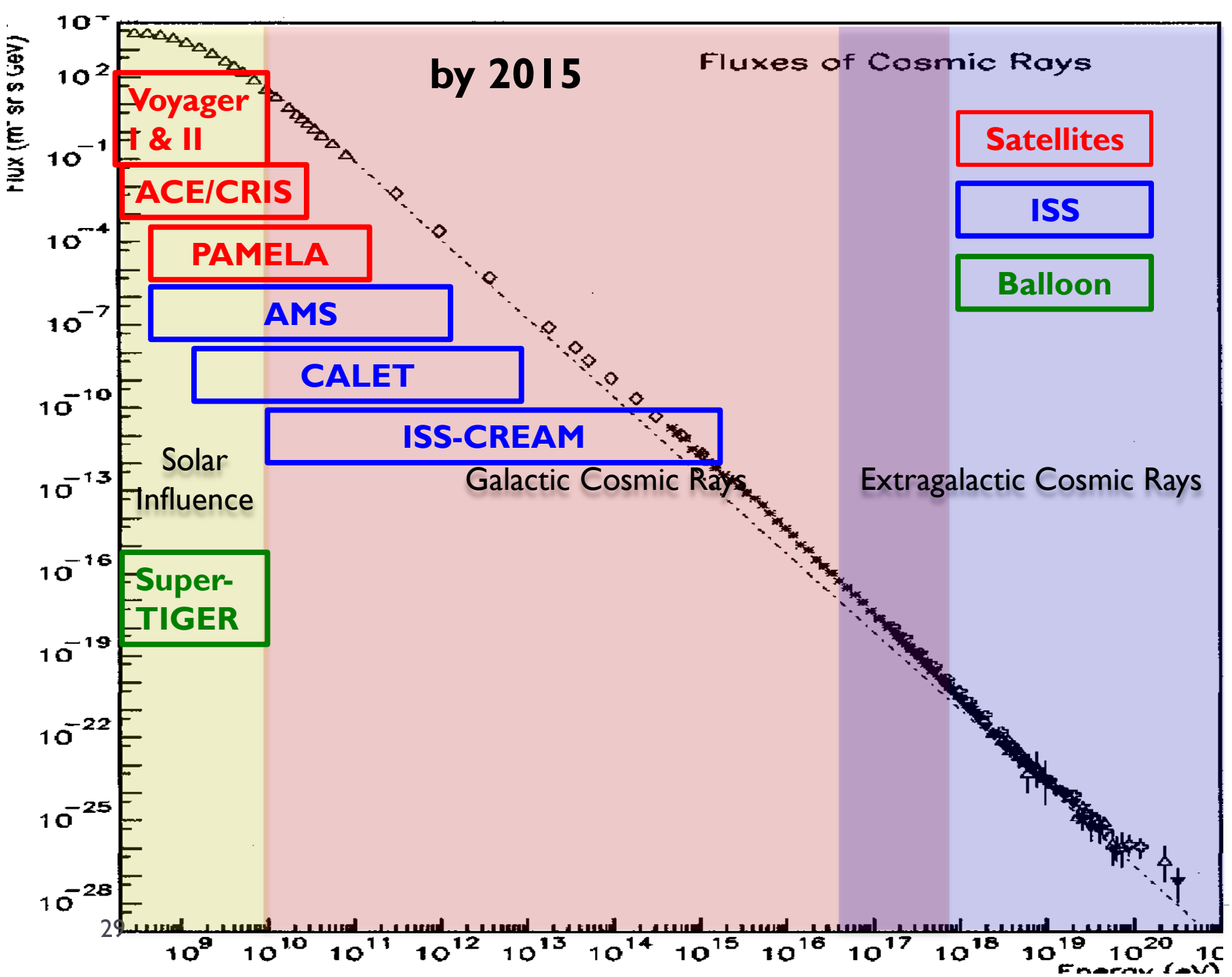


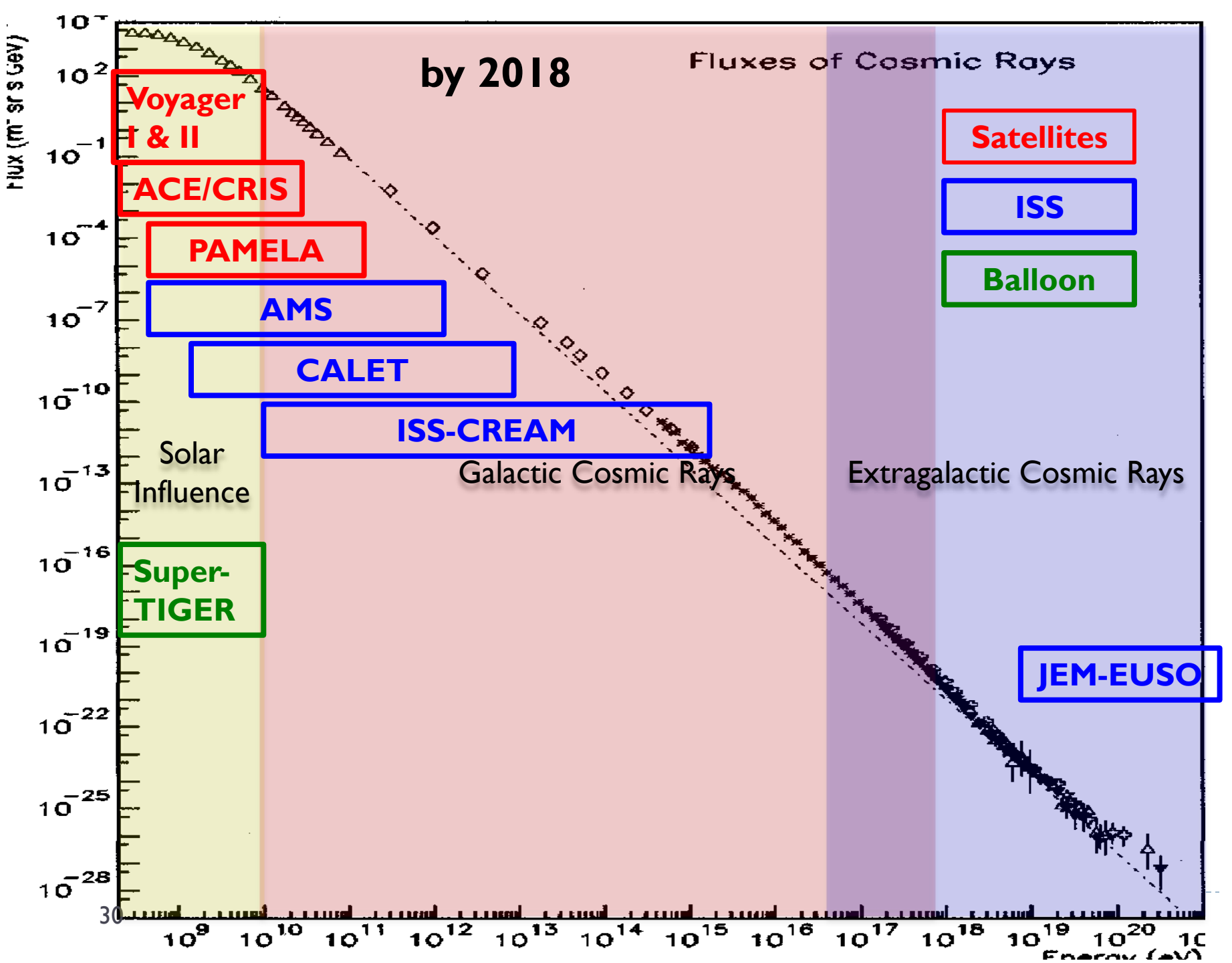
Ackermann et al (Fermi Collab) '13
arXiv:1302.3307

Questions Related to CR Science

- Origin of PeV neutrinos
- Indirect Dark Matter Searches
  - WIMP in the Galactic Halo: e+, e-; p, anti-p, γ, ν...
- Probe of Particle Interactions above LHC energies
  - Ultrahigh Energy Cosmic Rays (UHECR) E_{cm} > 100 TeV
  - Ultrahigh Energy Neutrinos
- Searches for Exotic Components of Matter:
  - antinuclei
  - Magnetic Monopoles
  - Strangelets
  - Qballs
  - Primordial Black Holes


NOW
Fluxes of Cosmic Rays
Voyager I & II
ACE/CRIS
PAMELA
AMS
Satellites
ISS
Balloon
Solar Influence
Galactic Cosmic Rays
Extragalactic Cosmic Rays
Super-TIGER
Flux (m² sr s GeV)
Energy (eV)

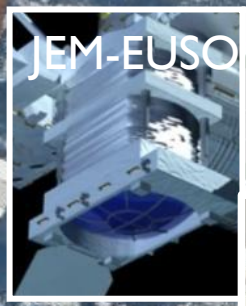

by 2015
Fluxes of Cosmic Rays
Voyager I & II
ACE/CRIS
PAMELA
AMS
CALET
ISS-CREAM
Super-TIGER
Satellites
ISS
Balloon
Solar Influence
Galactic Cosmic Rays
Extragalactic Cosmic Rays
Flux (m² sr s GeV)
Energy (eV)

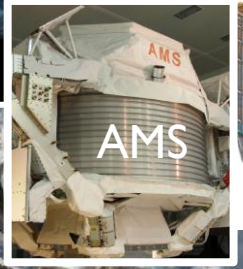

by 2018
Fluxes of Cosmic Rays
Voyager I & II
ACE/CRIS
PAMELA
AMS
CALET
ISS-CREAM
Super-TIGER
Satellites
ISS
Balloon
JEM-EUSO
Solar Influence
Galactic Cosmic Rays
Extragalactic Cosmic Rays

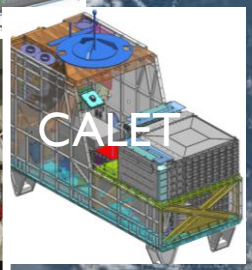
Opportunities in Space

- In Situ Measurements of Solar System
  - Voyager I & II
- Ultra Heavy Nuclei
  - ACE/CRIS
  - Super-TIGER
- Precise Measurements from GeV to TeV
  - PAMELA
  - AMS
  - CALET
- Galactic Cosmic Rays up to the knee
  - CREAM, TRACER
  - ISS-CREAM
- Extragalactic Cosmic Rays
  - JEM-EUSO
  - OWL/PATEL

Space Opportunities for Cosmic Ray Science







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