Siam Physics Congress 2016

Earth's Gamma-ray Emission in Geographical Coordinates with *Fermi*-LAT data

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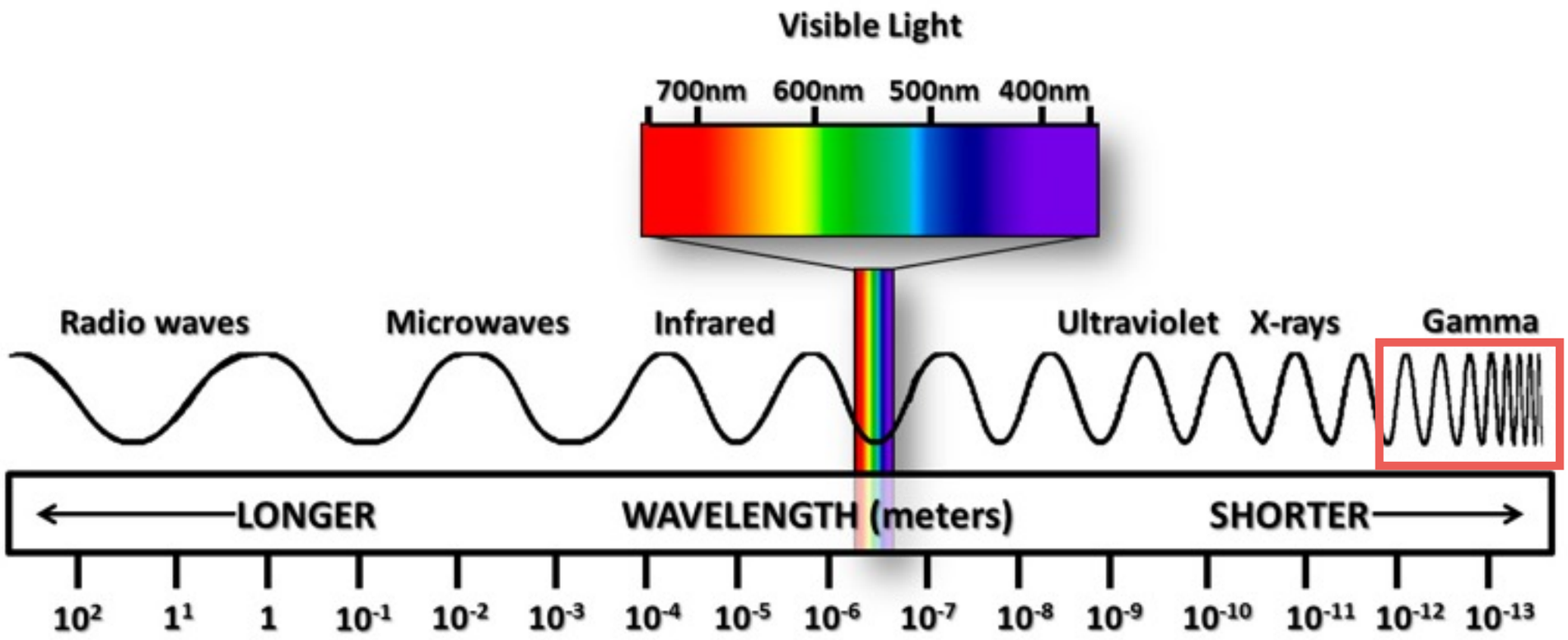
INTRODUCTION

What is gamma ray?

Gamma ray is the highest-energy form of electromagnetic radiation.



http://www.ces.fau.edu/nasa/module-2/radiation-sun.php

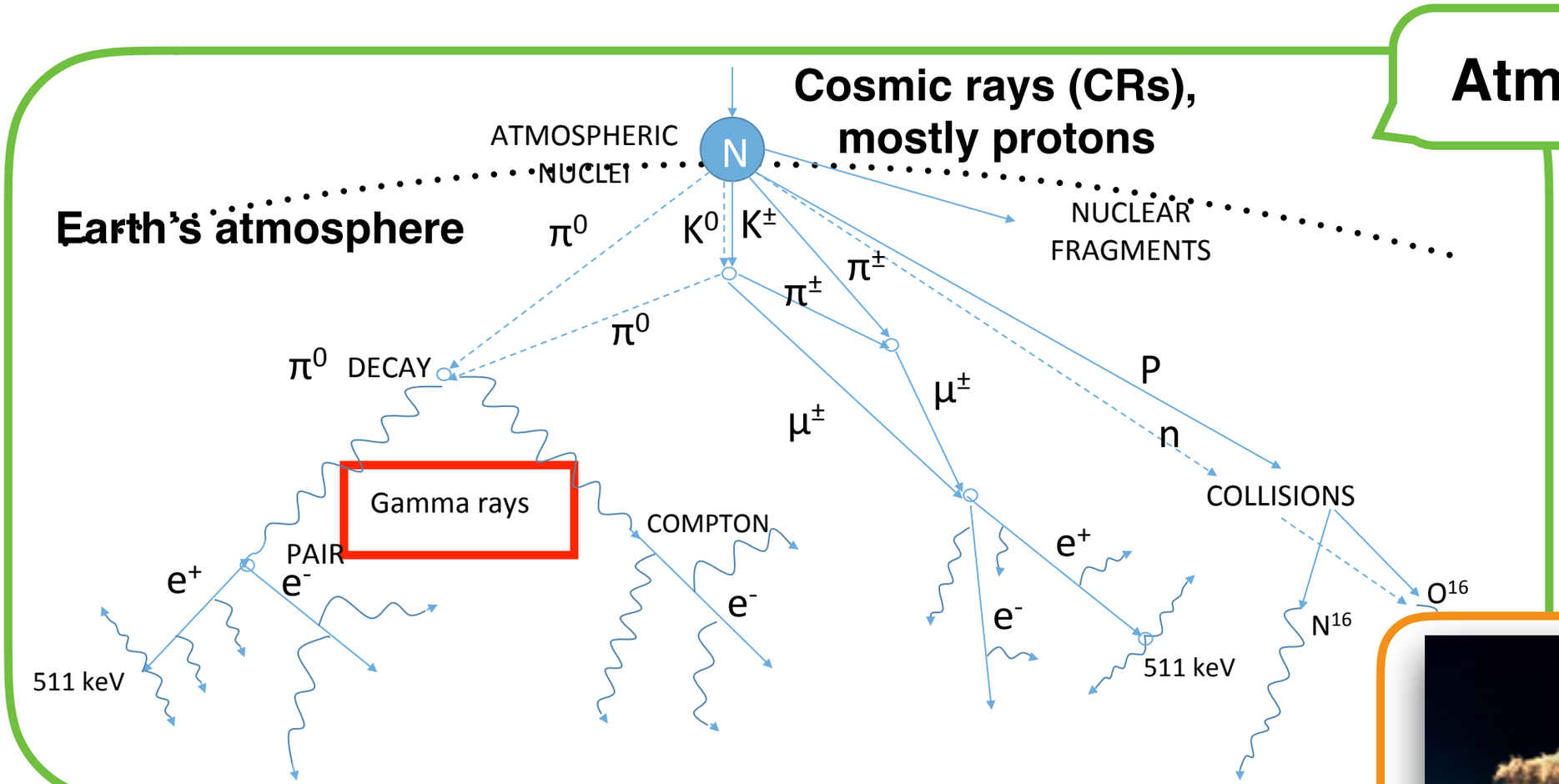
If we can see gamma ray, what does Earth look like?

http://www.solarsystemscope.com/nexus/textures/tc-earth_texture/

Visible light

Gamma ray

What creates gamma-ray emission from Earth?

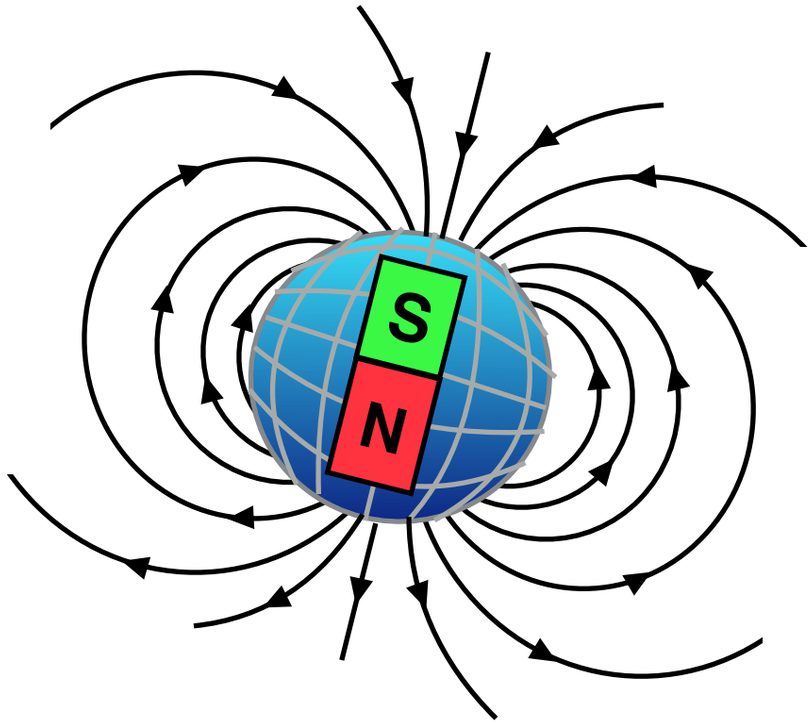


Atmospheric shower

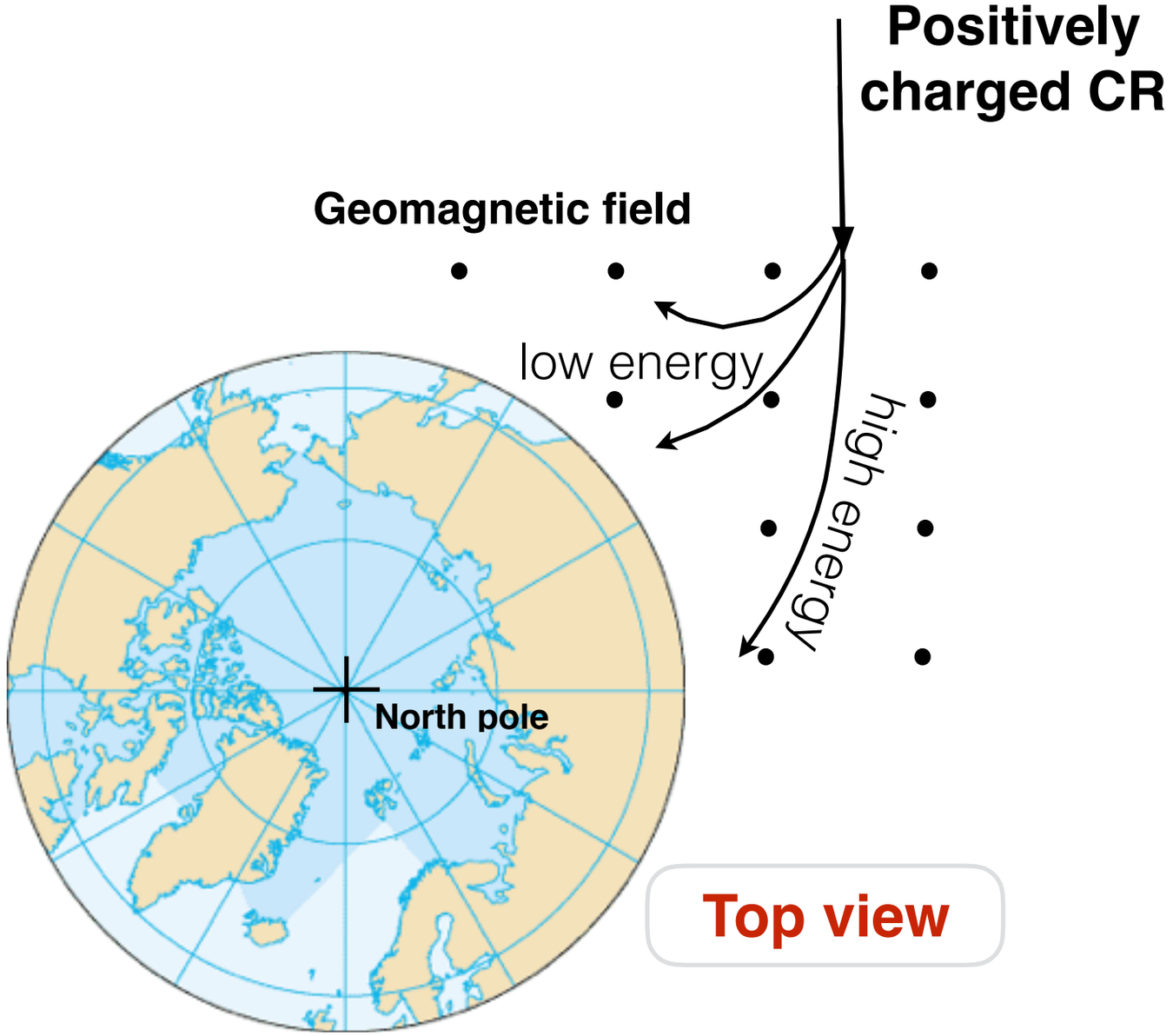
High-altitude nuclear weapon detonation

http://www.mirror.co.uk/news/uk-news/world-war-3-how-you--6904856

Motion of CRs in magnetic field

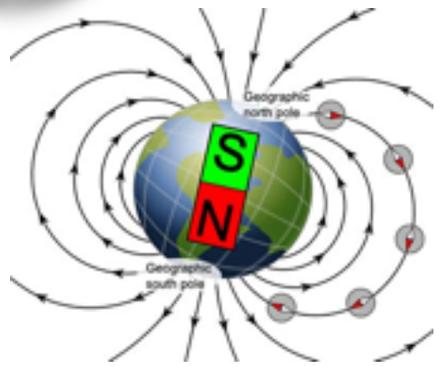


Earth's magnetic field



Top view

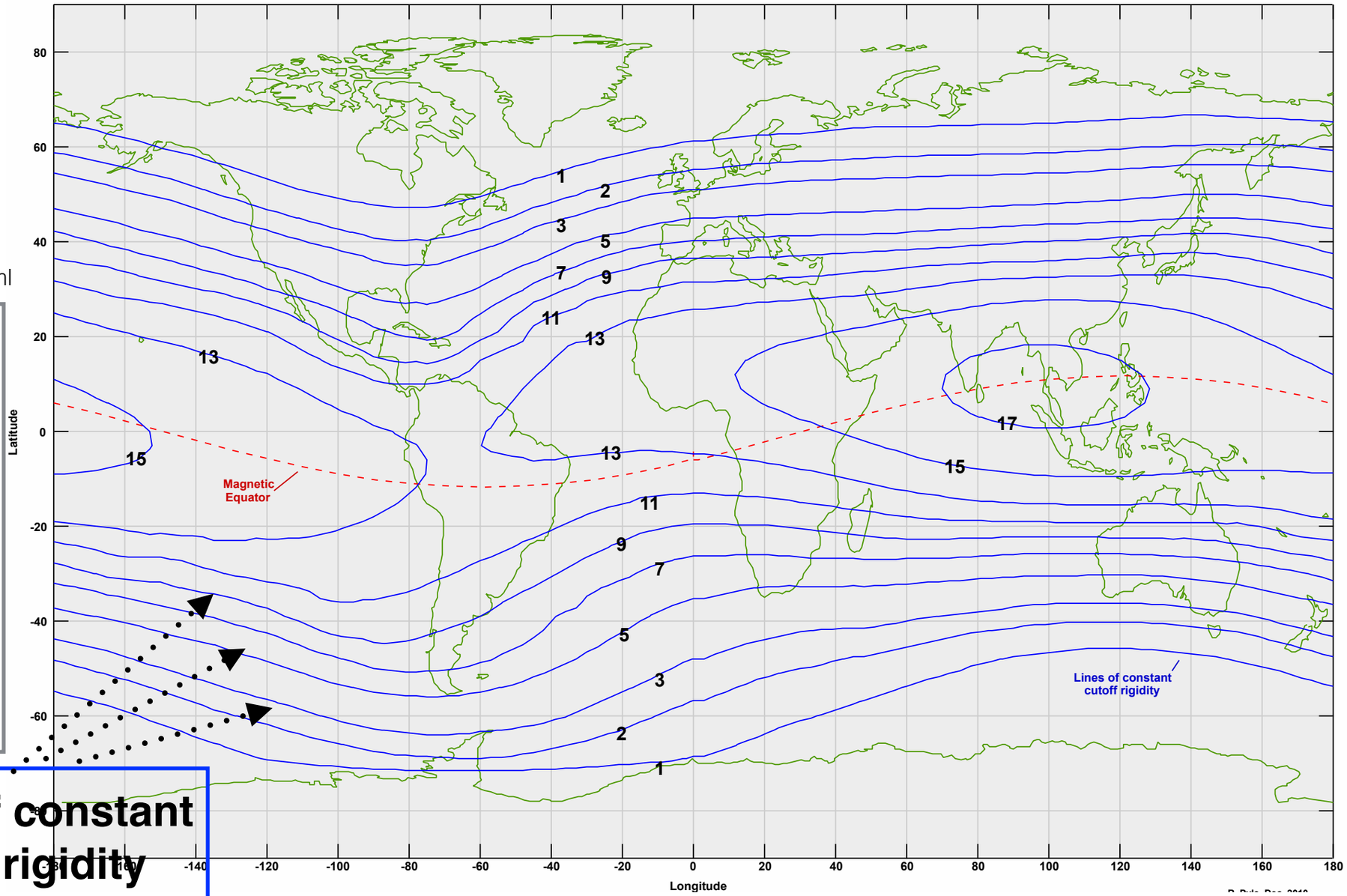
Cutoff Rigidity



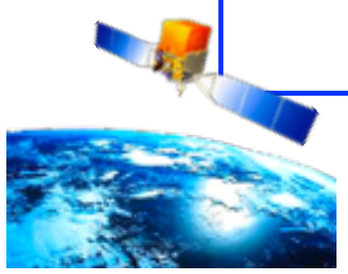
http://unbonmotgroundswell.blogspot.com/2015/07/what-if-earths-magnetic-field-flipped.html

$$R = pc/z$$

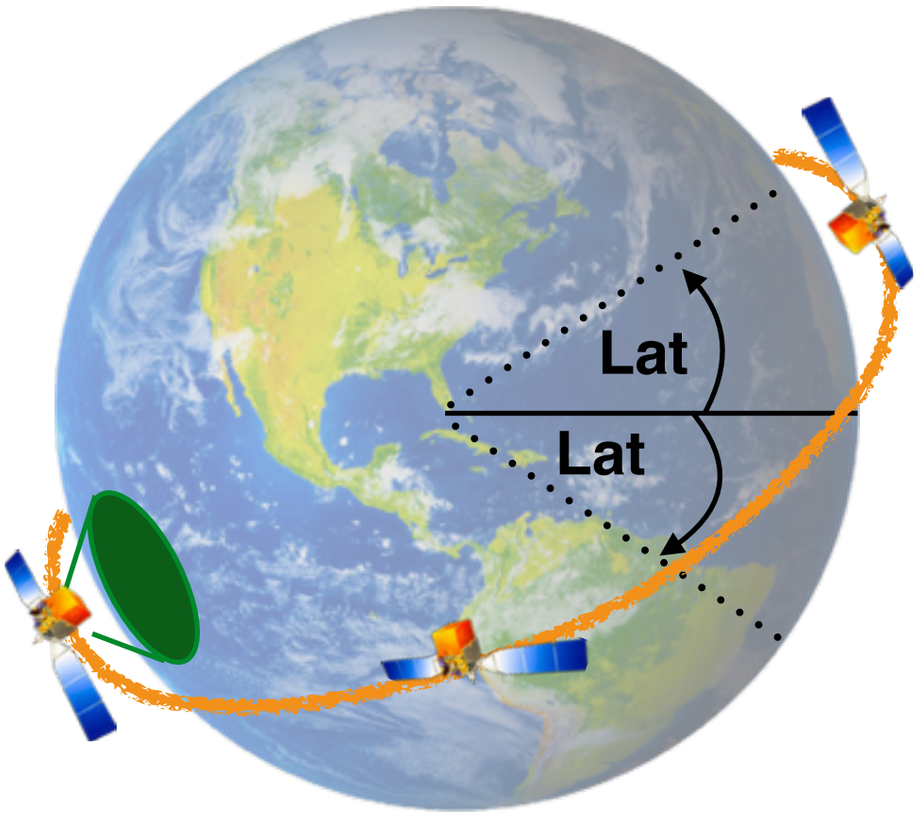
R = rigidity
p = momentum
c = speed of light
z = charge



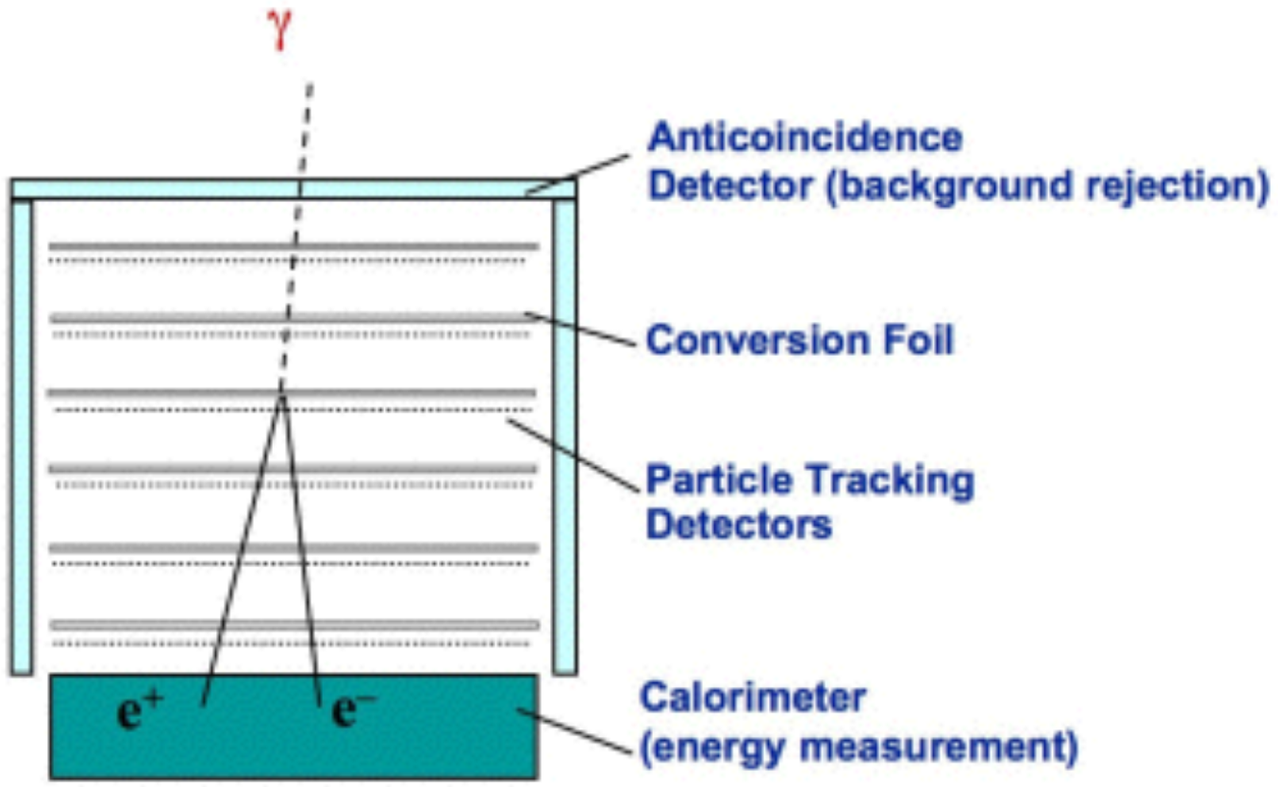
Selected lines of constant vertical cutoff rigidity (Labelled in GV)



Fermi Large Area Telescope (LAT)



The LAT is a pair-conversion telescope, gamma-ray photon is converted to e^+e^- pair for detection.

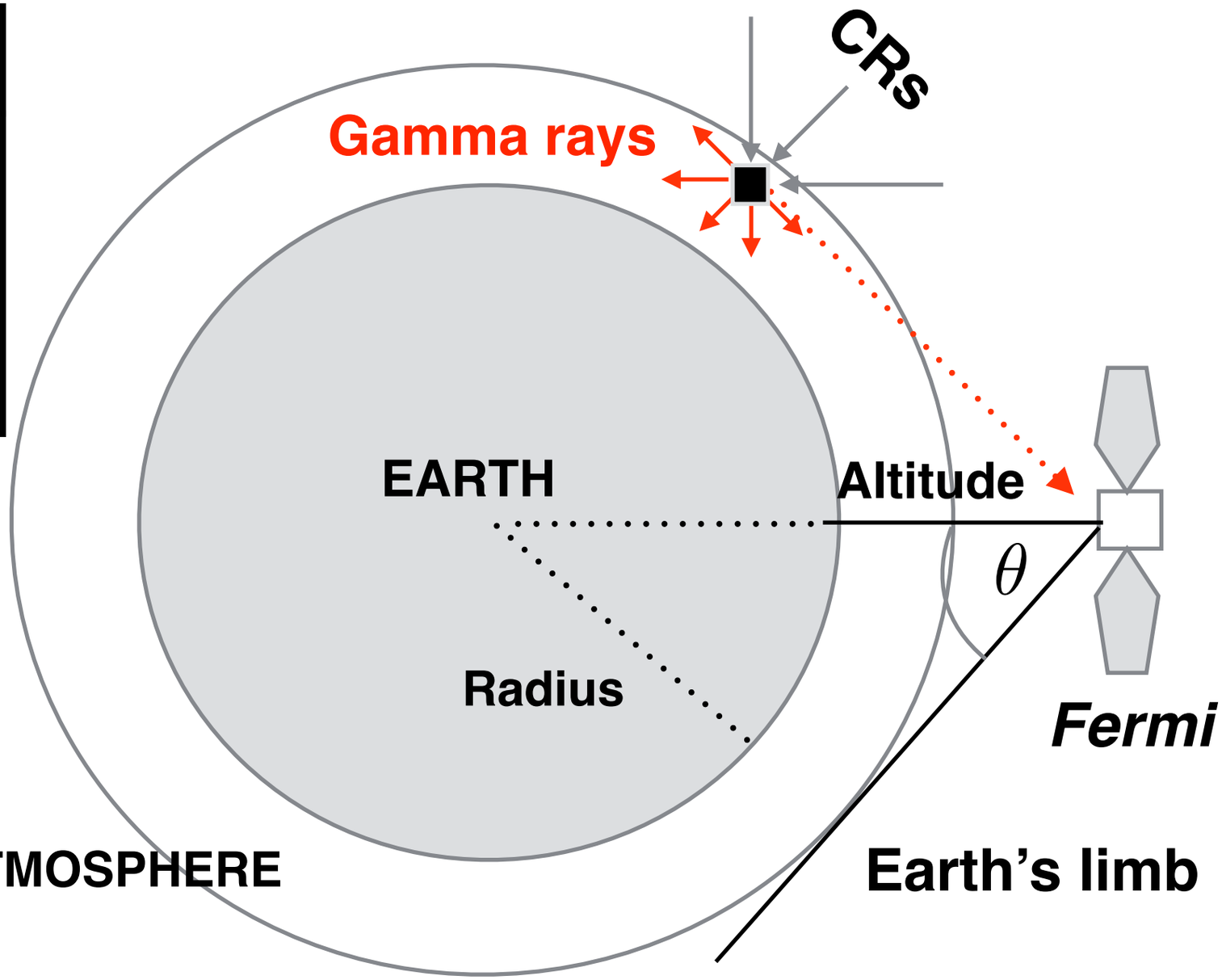


https://www-glast.stanford.edu/instrument.html

Earth's gamma-ray detection

Info

Altitude = ~550 - ~565 km
Earth's Radius = ~6371 km
Atmospheric thickness = ~45 km
θ_{limb} = ~68 deg



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RESULTS

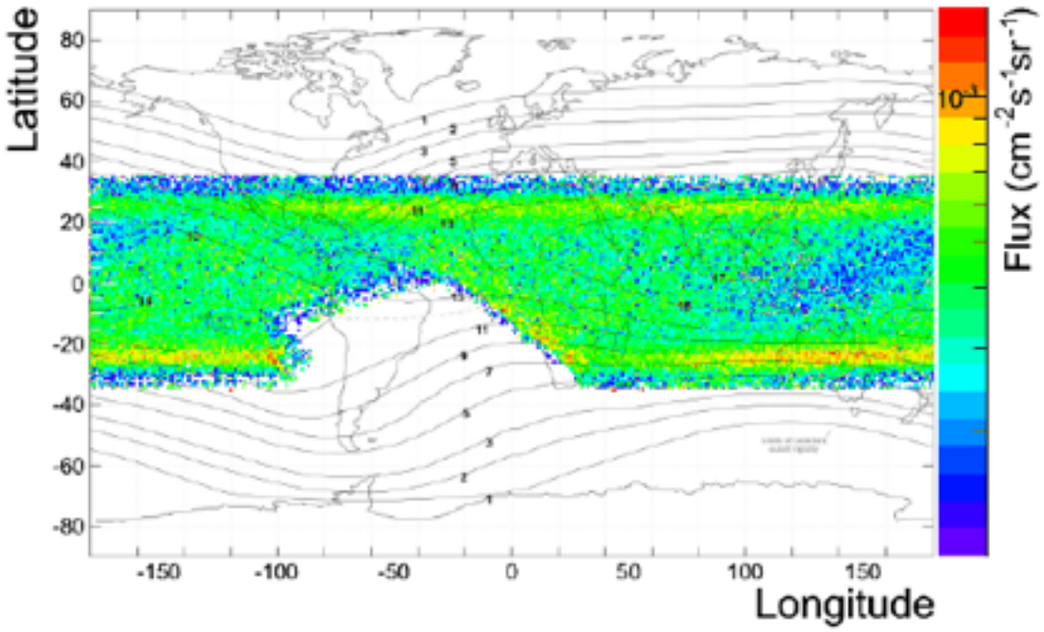
Data set

- Data from 07/08/2008 to 21/01/2016 (~93 months)
- ~7.7x10^5 photons above 1 GeV
- Latest version of instrument response function and photon selection (Pass8 Source class)
- Zenith angle cut = 120°
- Incidence angle cut = 70°
- 1° x 1° binning in latitude and longitude below 5 GeV, 5° x 5° above 5 GeV

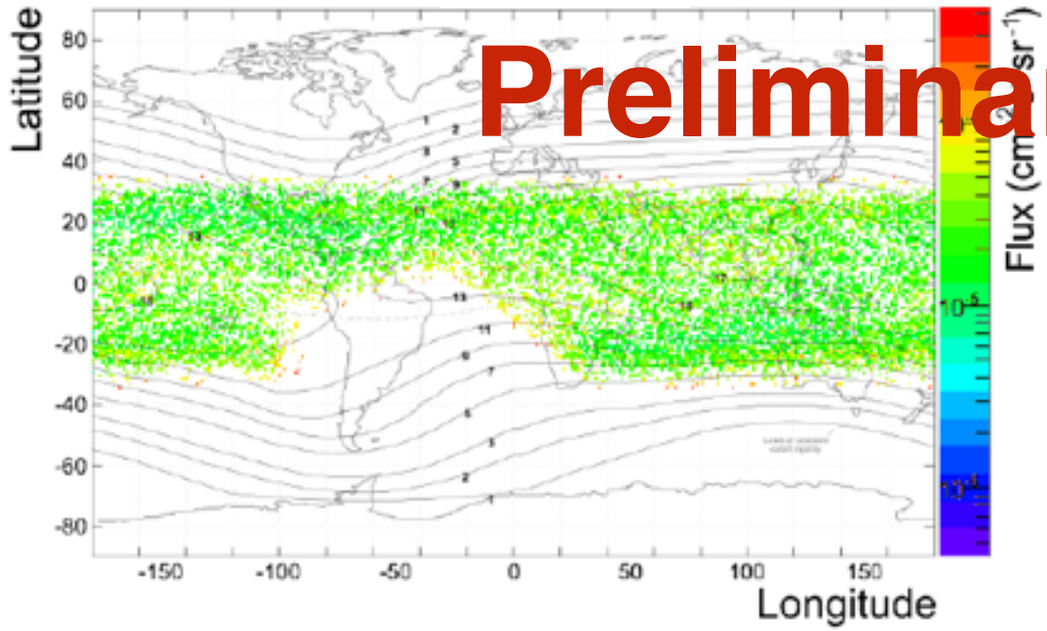
Results

Preliminary

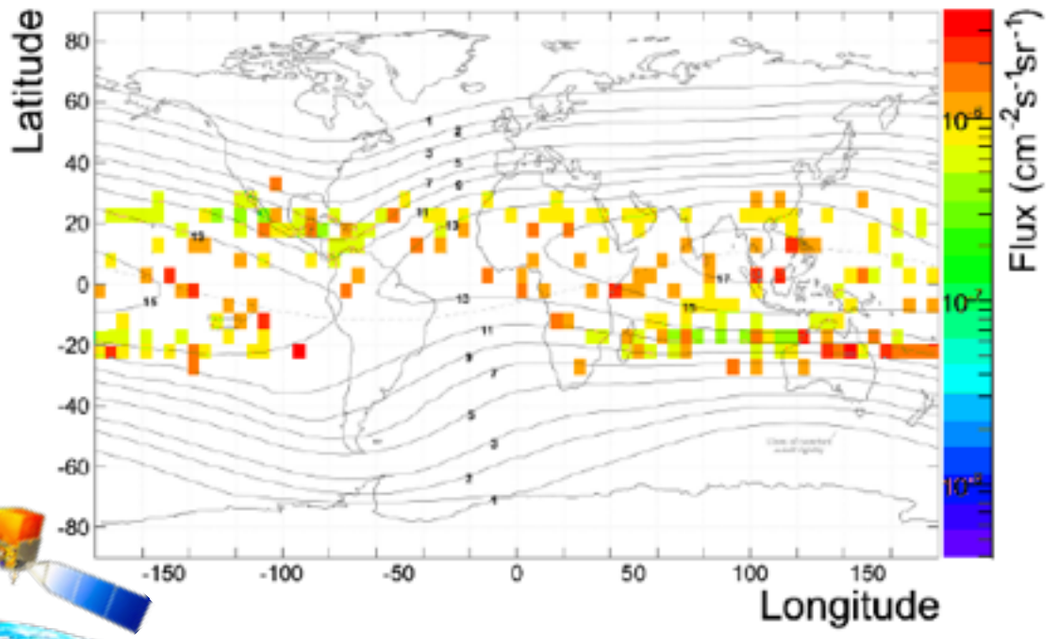
1-2 GeV



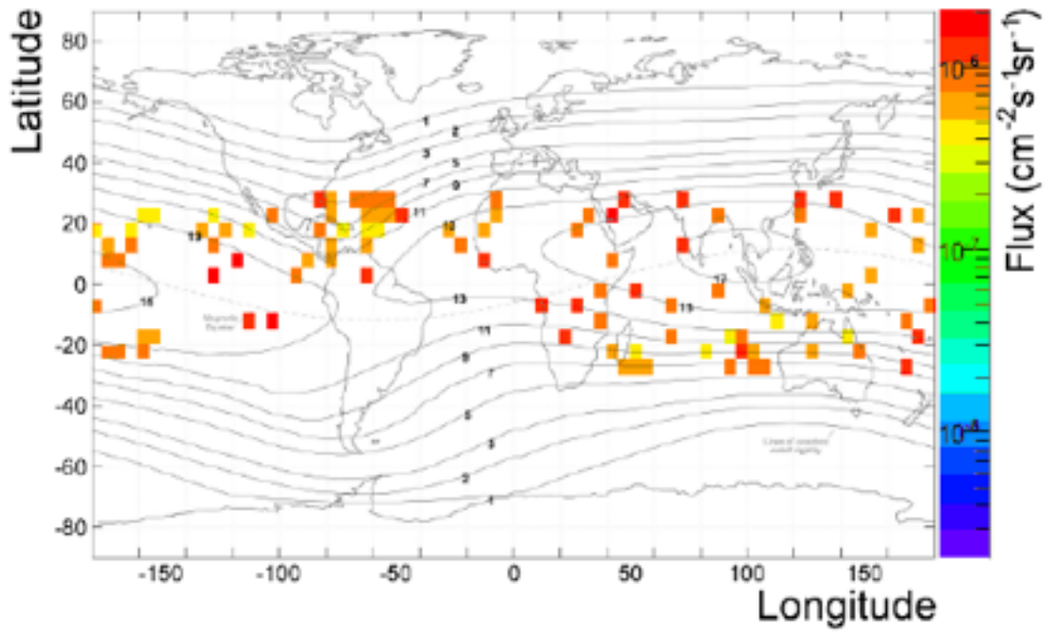
2-5 GeV

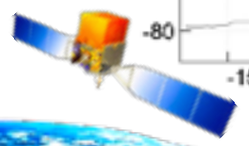


5-10 GeV



>10 GeV





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CONCLUSIONS

Conclusions

- Gamma-ray emission from Earth is produced by interactions between cosmic rays and Earth's atmosphere.
- We have obtained preliminary pictures of Earth in gamma ray but more checks are required.

Acknowledgement

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References

[1] V. L. Ginzburg., “The origin of the cosmic rays (past, present, future)”, P. N. Lebedev Physics Institute, USSR Academy of Sciences, Usp. Fiz. Nauk. 124, 307-331 (February 1978).

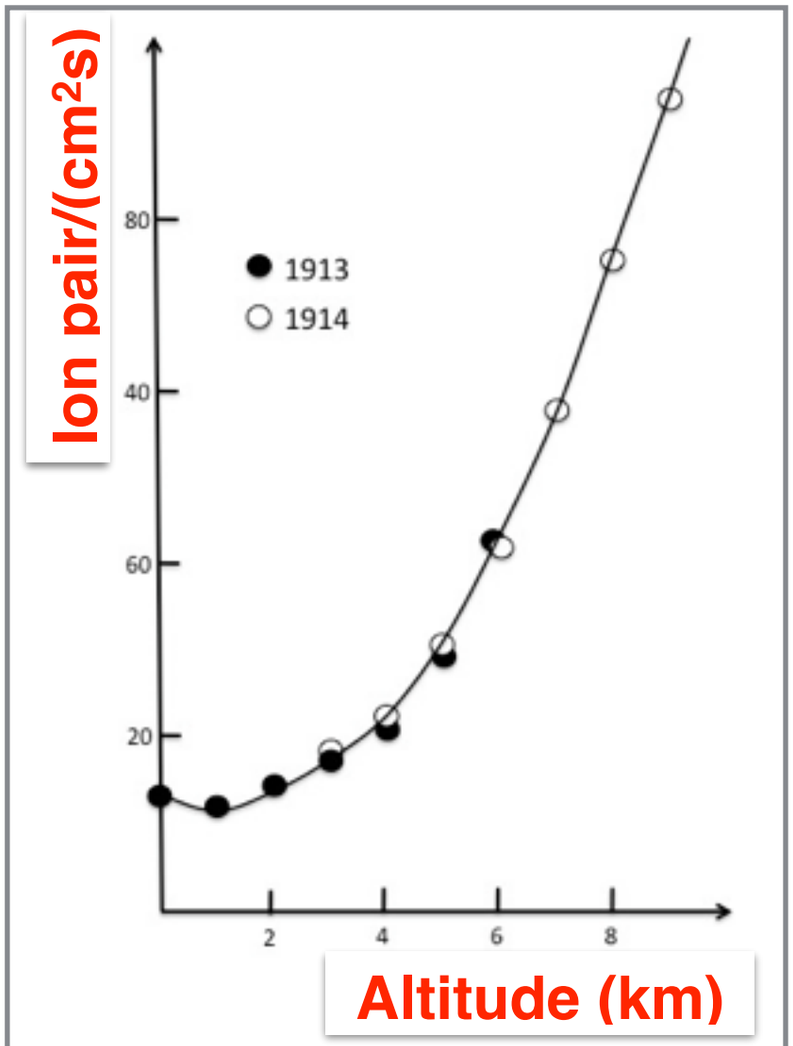
[2] A. A. Abdo et al., “Fermi large area telescope observations of the cosmic-rays induced γ-ray emission of the Earth’s atmosphere”, Physical review, D 80, 122004 (2009).

[3] W. B. Atwood et al., “The Large Area Telescope on the Fermi Gamma-ray Space Telescope Mission”, Astrophysics. J., 697, 1071 (2009).

[4] Gelvam A. Hartmann and Igor G. Pacca., “Time Evolution of the South Atlantic Magnetic Anomaly”, An Acad Bras Cienc 81(2), 243-255 (2009).

THANKS FOR YOUR ATTENTIONS !!

Discovery of Cosmic Rays



Increase of ionisation with altitude as measured by Hess

On a ballon at an altitude of 5 kilometers, Victor Hess, the father of cosmic ray research,discovered "penetrating radiation" coming from space.

Victor Hess aboard his balloon

http://www.telescopearray.org/index.php/history/introduction-to-cosmic-rays?showall=&start=1

Cosmic Rays (CRs)

Cosmic rays (CRs) are high-energy particles (~10^7 - ~10^{20} eV) from space.

The composition of CRs

- ~90% protons
- ~9% alpha particles
- ~1% other particles such as electrons (e^-), positrons (e^+), gamma rays, and other ions

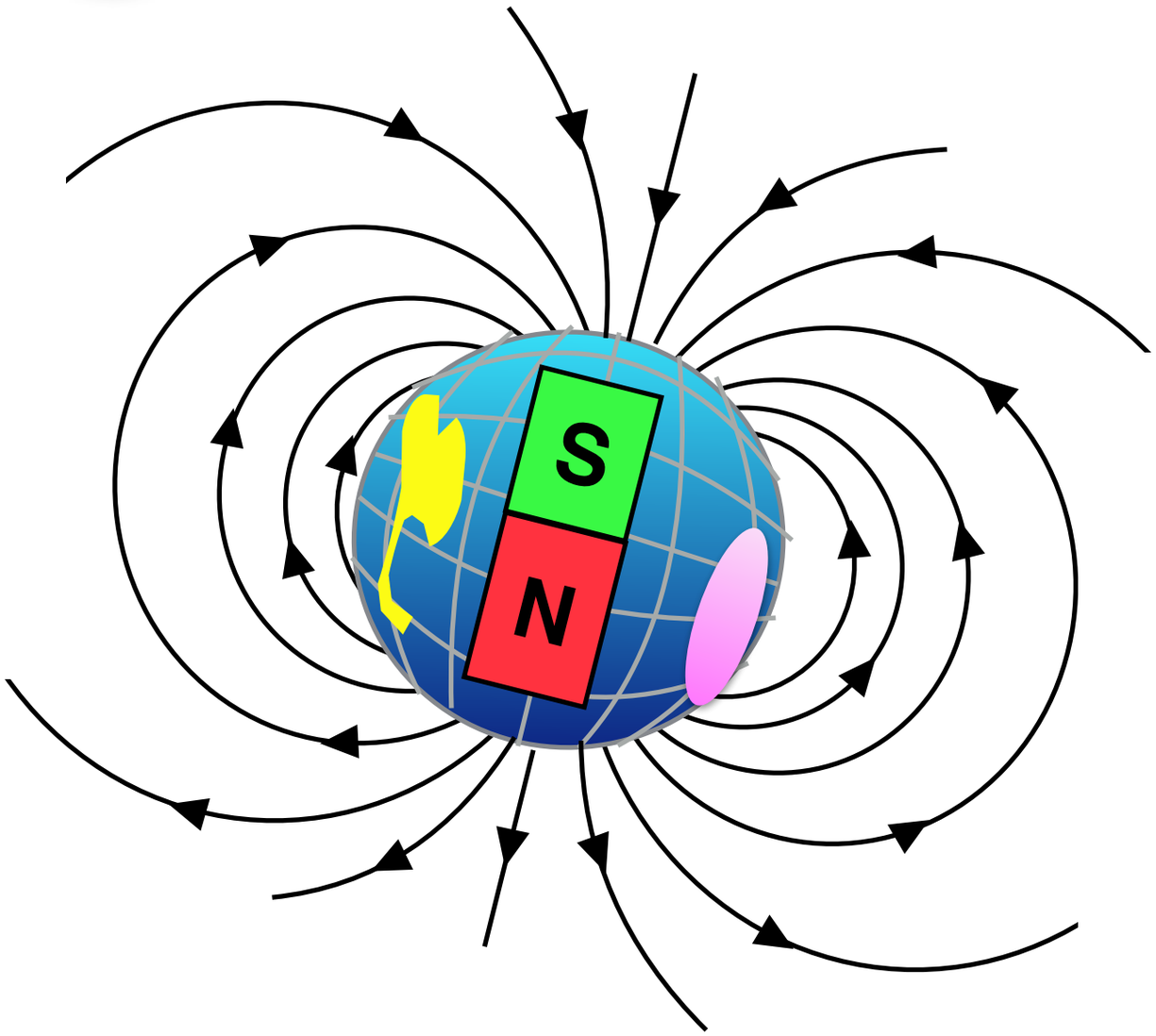
Fermi

Fermi Gamma ray Space Telescope (*Fermi*) was launched into a near-earth orbit (about 565 km) on June 2008.

- The Large Area Telescope (LAT): sensitive to photons energy range from 30 MeV to > 300 GeV
- The *Fermi* Gamma ray Burst Monitor (GBM): sensitive at 10 keV < E < 30 MeV

http://www-conf.slac.stanford.edu/fermiLAT/spring2011/

South Atlantic Anomaly (SAA)



The SAA is a region where the geomagnetic field is weakest compared to other region at the same altitude.