

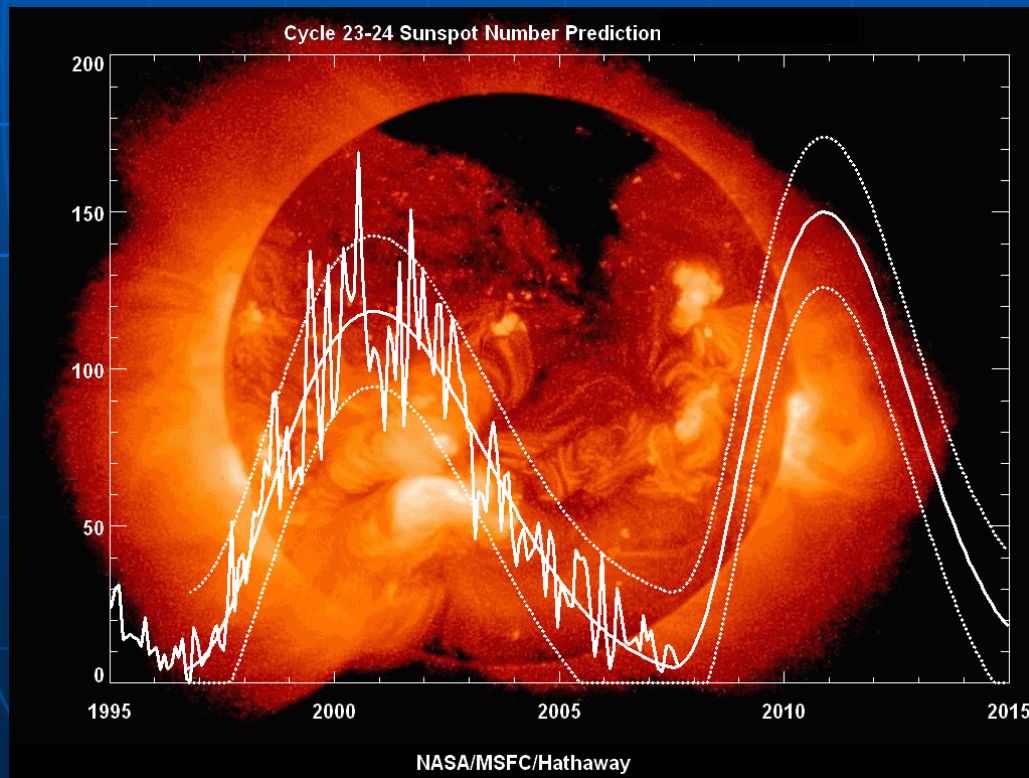
Moon and Quiet Sun Detection with Fermi-LAT Observatory

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Bari University and INFN

on behalf of Solar System
Working group and Fermi LAT
Collaboration

Solar System observation capabilities with Fermi

- Solar Activity expected to peak around 2012
- Fermi will operate for nearly the entire duration of solar cycle 24



Solar System observation capabilities with Fermi (2)

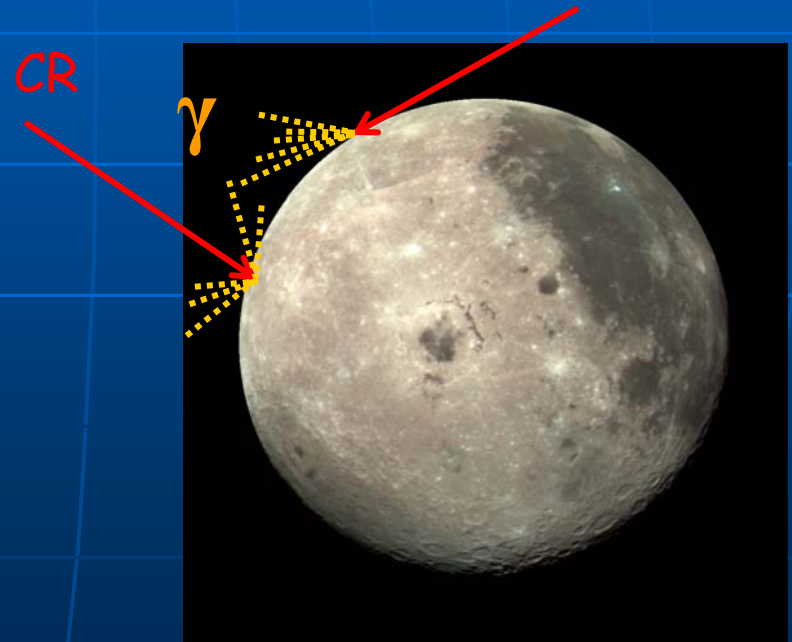
- Fermi is the only satellite capable of making solar observations >100 MeV
- Coordinated measurements between LAT gamma-ray and GBM (10 keV-40 MeV)
- Comparison with RHESSI (1 keV –20 MeV)
- Comparison with energetic solar particle observations (ACE, STEREO, SOHO, WIND) and ground based experiments (Milagro) for flaring Sun alerts
- About ten high-energy flares expected during the FERMI operation period

Sources in Solar System

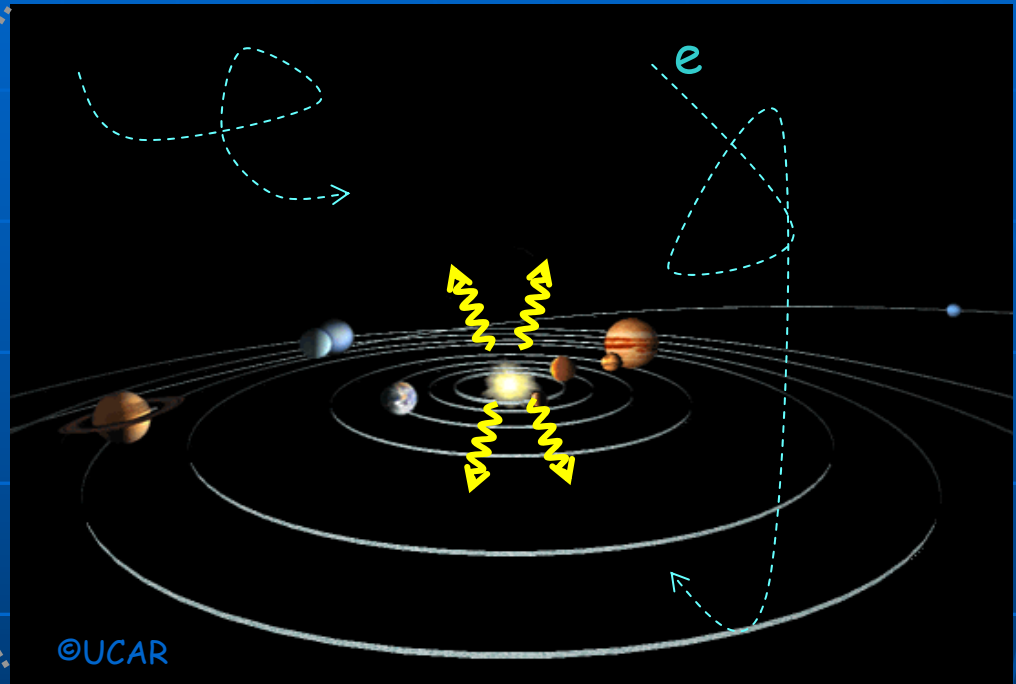
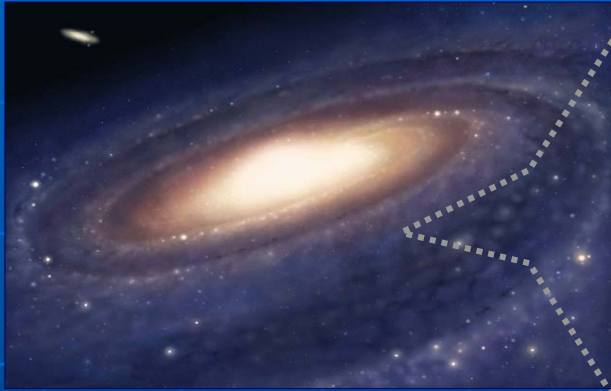
- Moving sources
 - SUN is moving about $1^\circ/\text{day}$
 - MOON is moving about $15^\circ/\text{day}$
- Sources:
 - The Moon
 - The Sun
 - The Earth
- Potential Sources
 - Asteroids in different populations:
 - Main Asteroid Belt (MBAs)
 - Jovian and Neptunian Trojans (Trojans)
 - Kuiper Belt Objects (KBOs)
 - Other planets

Emission Models

- γ -ray albedo" due to CR interactions with surface material:
 - Moon rock
 - Solar atmosphere



Sun: second component Inverse Compton Scattering

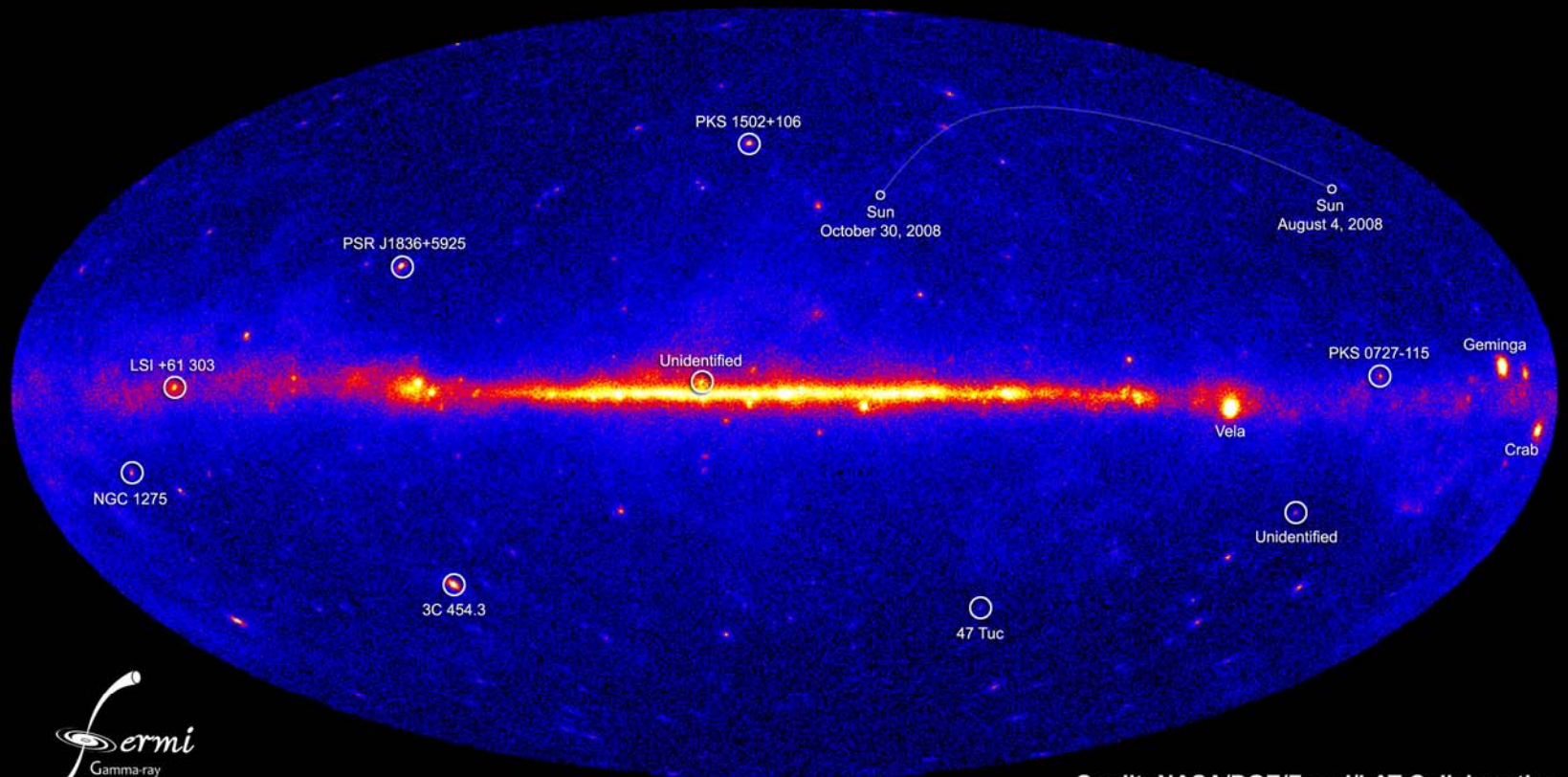


Inverse-Compton scattering of **solar photons** in the heliosphere by **Galactic CR** electrons: the emission is predicted to be extended

- electrons are isotropic
- photons have a radial angular distribution

Fermi: the Sun track in the sky

NASA's Fermi telescope reveals best-ever view of the gamma-ray sky



Credit: NASA/DOE/Fermi/LAT Collaboration

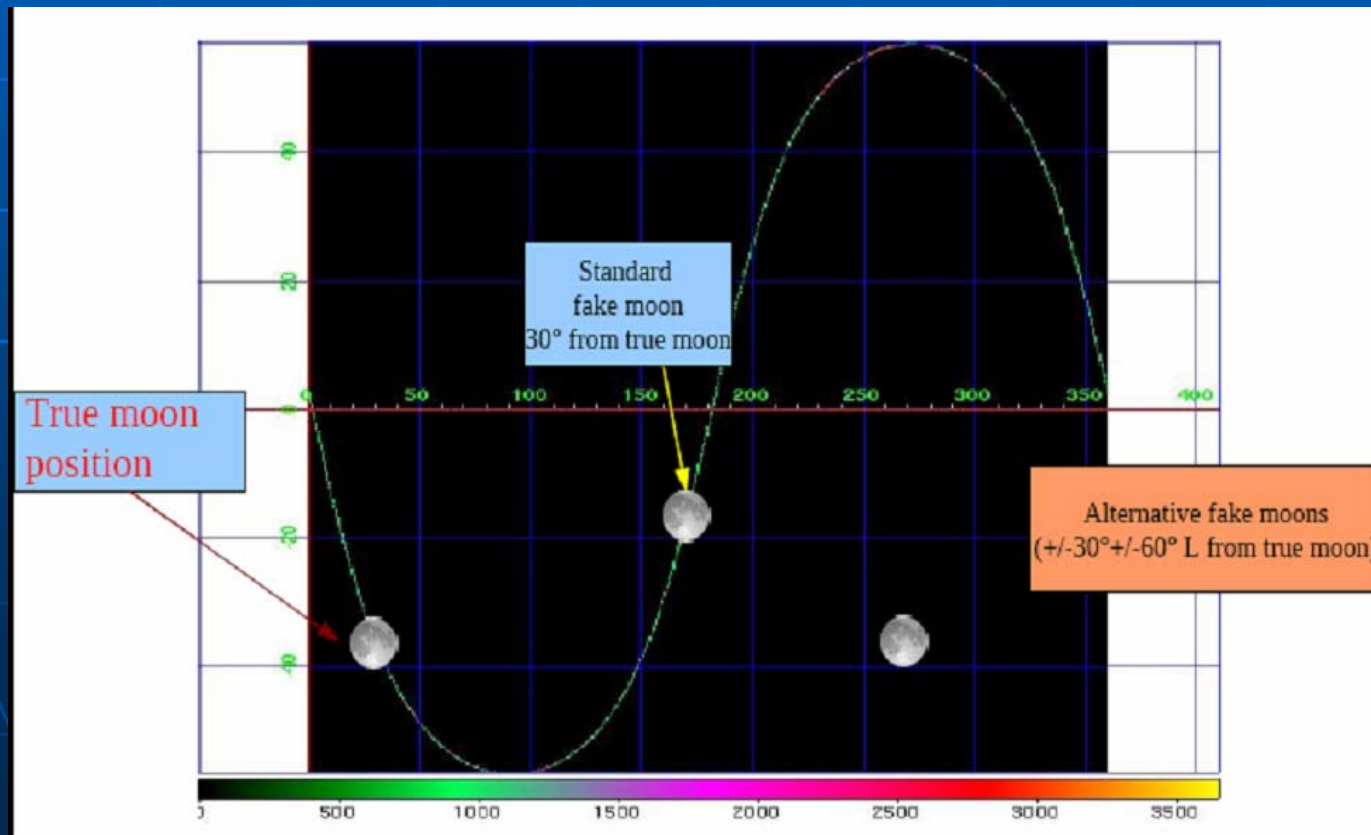
Data selection

- Data from Aug 2, 2008 until March 1, 2009
- Analysis in Moving Coordinates
 - SUN is moving about $1^\circ/\text{day}$
 - MOON is moving about $15^\circ/\text{day}$(Moon and Sun centered data)
- $E > 100\text{MeV}$
- Zenith angle $< 105^\circ$
- Galactic Plane Cut ($>30^\circ$)
- Moon-Sun angular separation $>20^\circ$
- Diffuse Class selected
- **ROI: 10°**

Background estimation approach

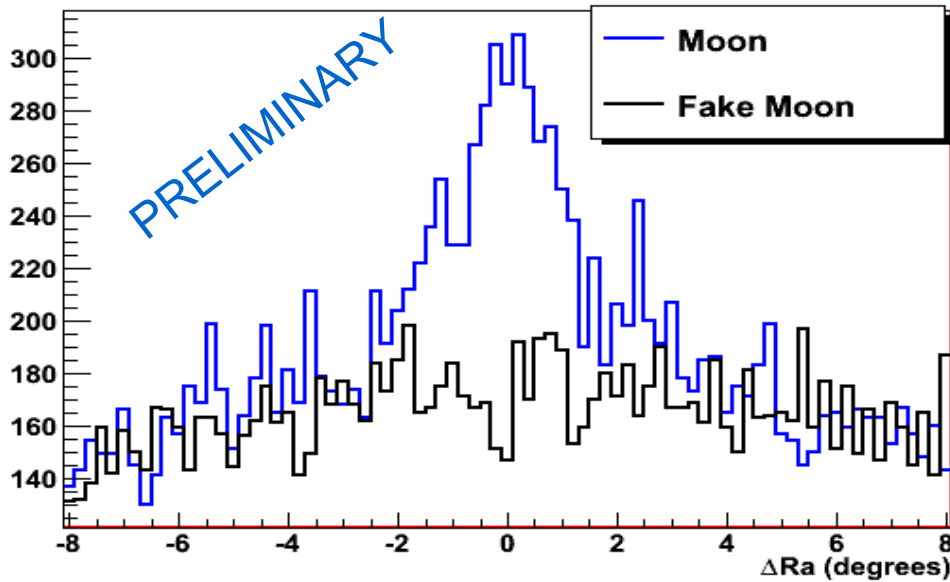
□ The “fake” source method:

A fake source follow the path of the real source but 30 degrees away (passes through the same areas on the sky but at different times)



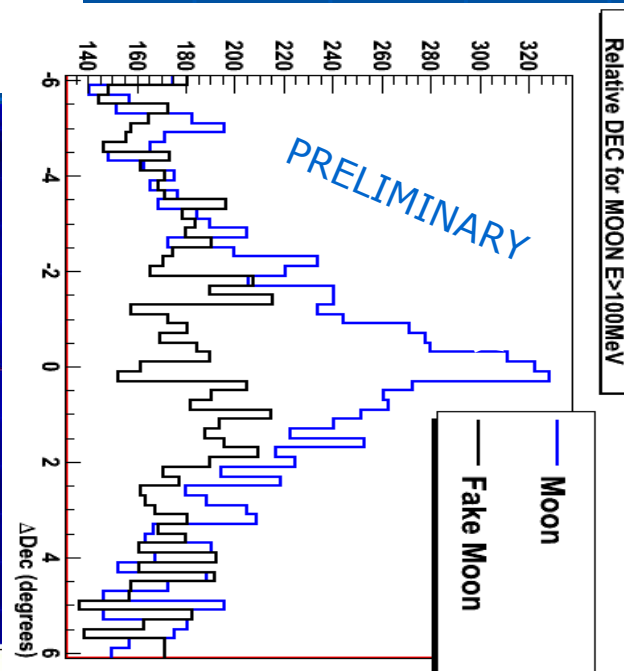
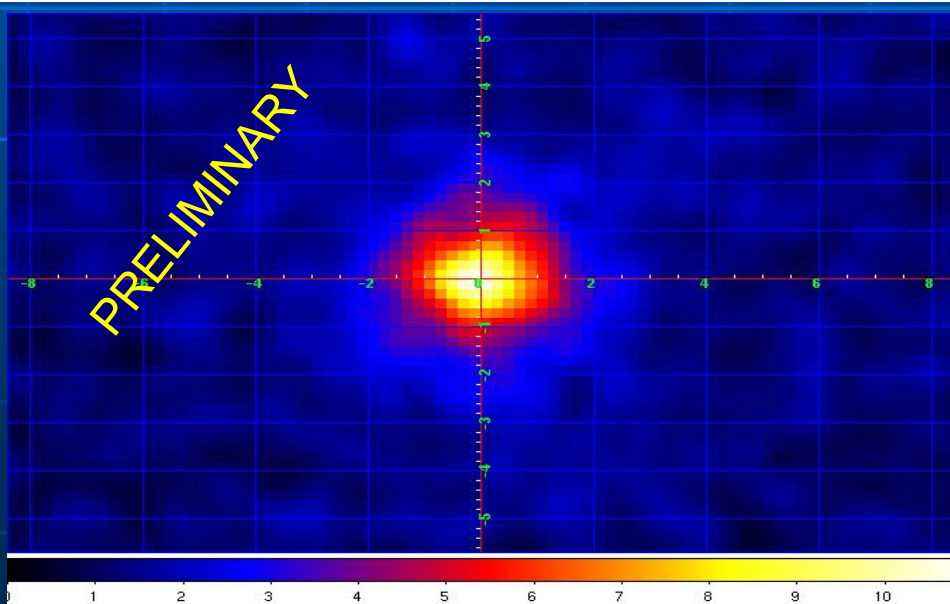
The Moon: first 7 months

Relative RA for MOON $E > 100\text{MeV}$



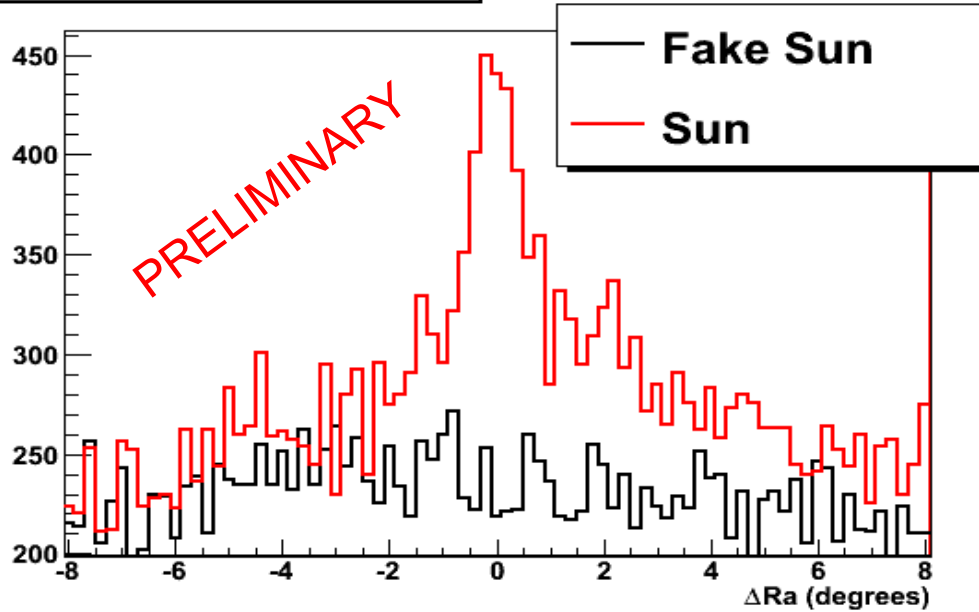
Moon count map and projections in RA and DEC axes centered on Moon position.

$E > 100\text{MeV}$
0.2deg/bin
gaussian smoothed



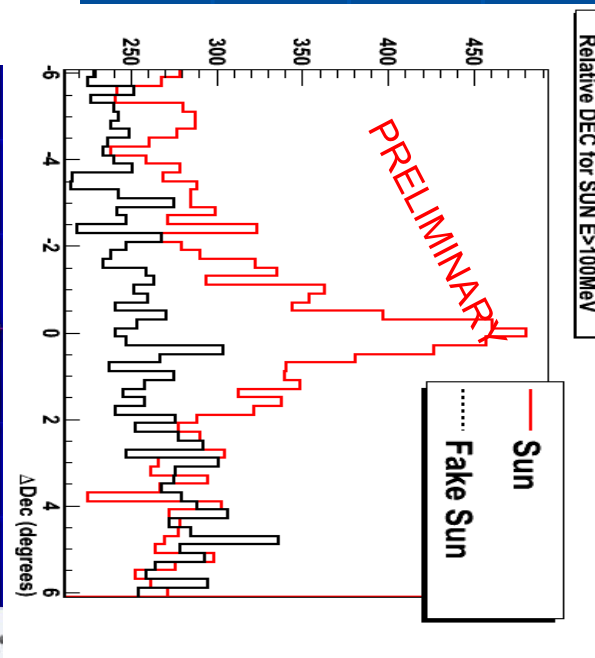
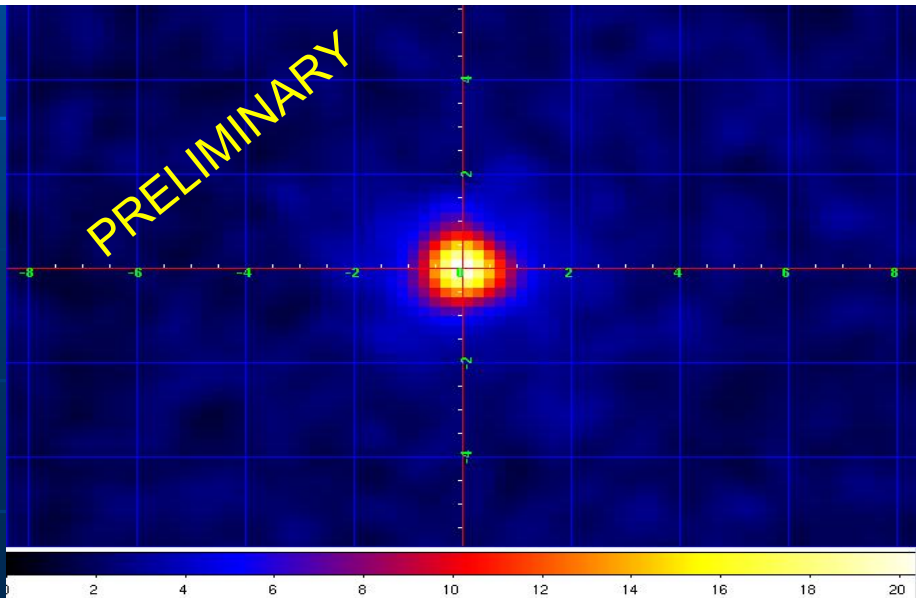
The Quiet Sun: first 7 months

Relative RA for SUN E>100MeV

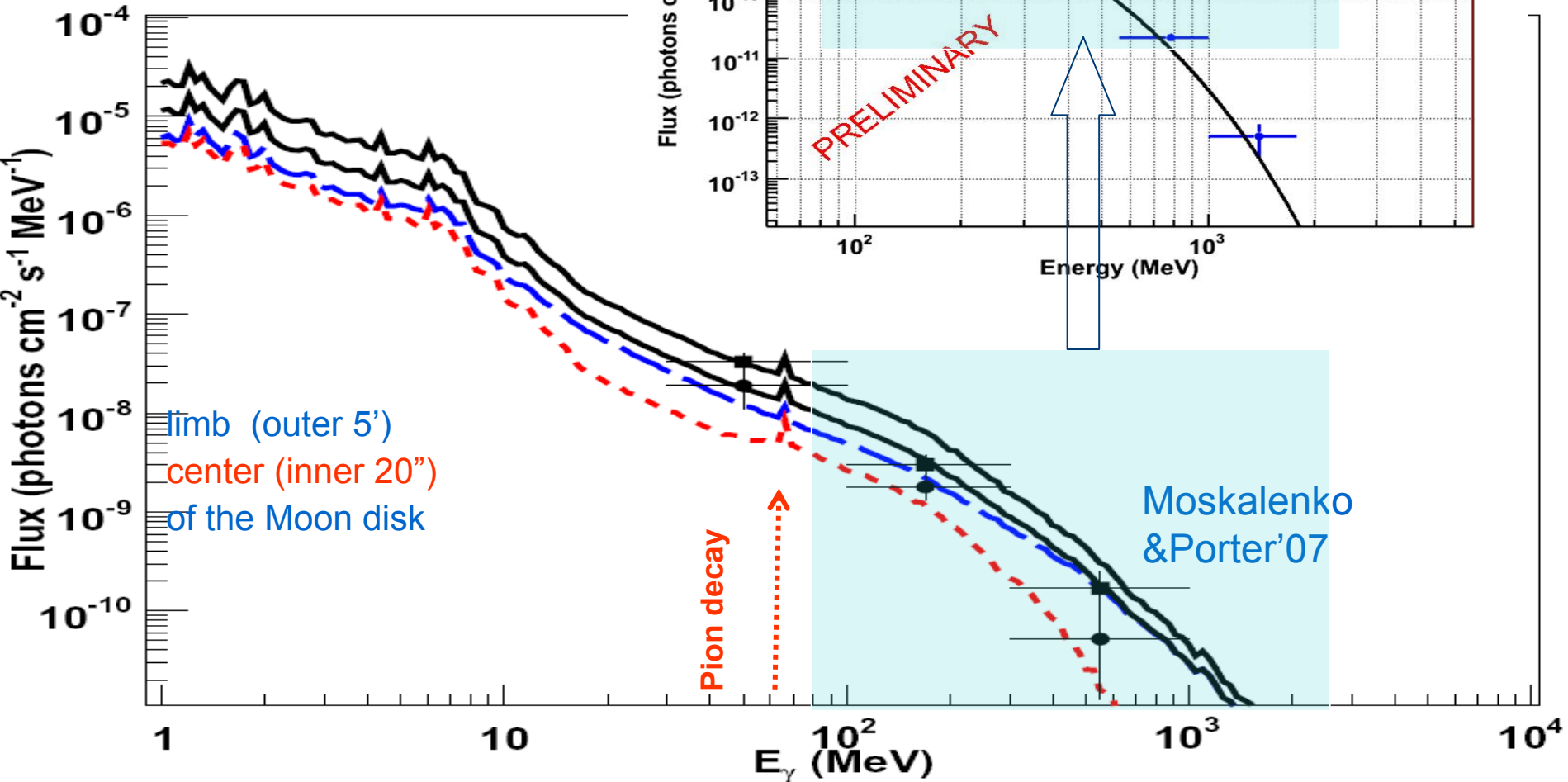


Sun count map and projections
in RA and DEC axes centered
on Sun position.
E>100MeV
0.2deg/bin
gaussian smothed

PRELIMINARY

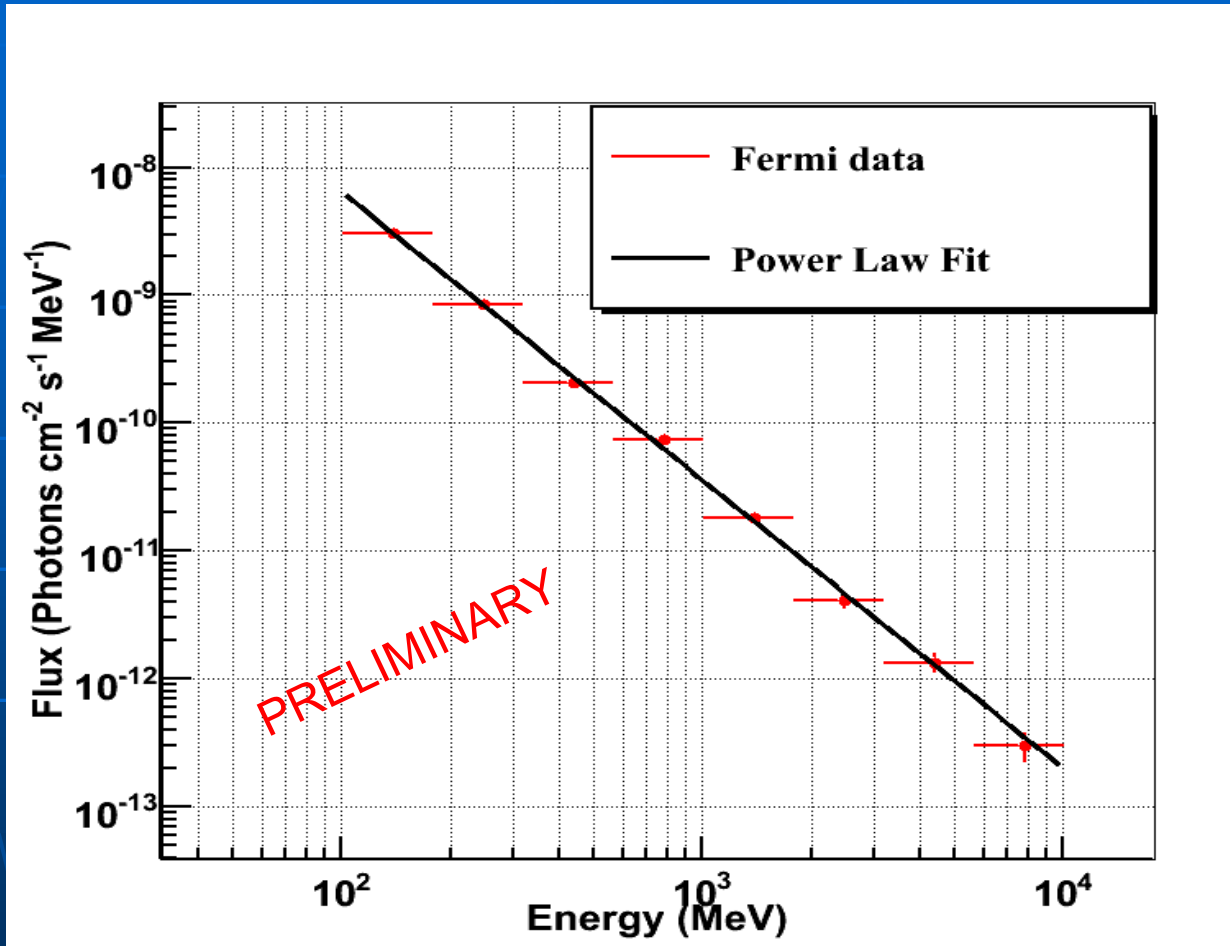


Moon Spectra



**Flux ($E > 100 \text{ MeV}$) = $(1.06 \pm 0.20) \times 10^{-6} \text{ ph cm}^{-2} \text{ s}^{-1}$
(statistical + 20% systematic error)**

The Sun: spectra

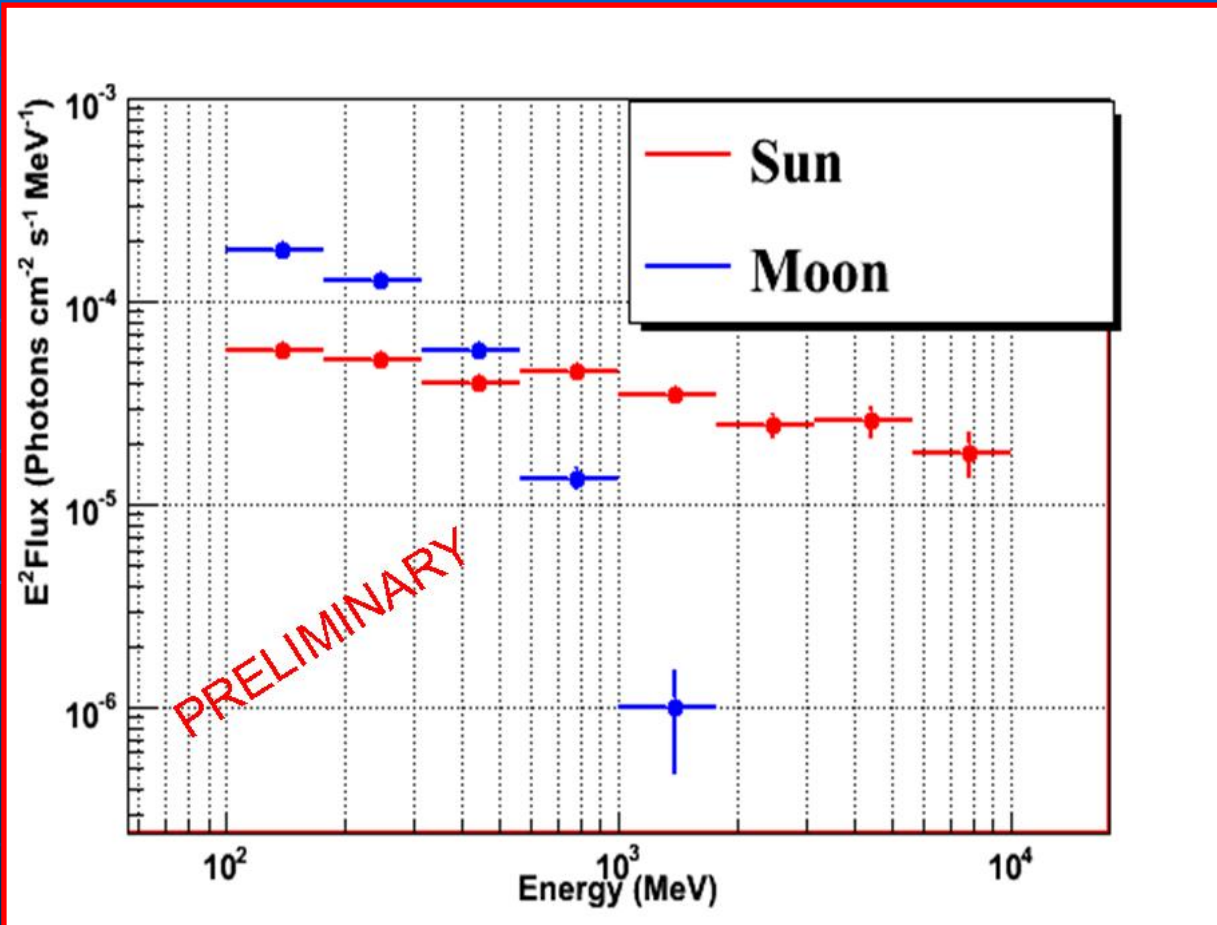


**Flux($E > 100 \text{ MeV}$) = $(4.59 \pm 0.89) \times 10^{-7} \text{ ph cm}^{-2} \text{ s}^{-1}$
(statistical + 20% systematic error)**

Sun: the flux

P6V3 IRF ROI: 10 deg	Flux ($\times 10^{-7}$ ph cm$^{-2}$ s$^{-1}$)
Fermi	($E > 100$ MeV) = 4.59 +/- 0.89
Expected (Moskalenko '06 Orlando&Strong '07)	(>100 MeV) = 4.30 (@ solar min)
EGRET Flux	not observed by EGRET (Thompson '97) (>100 MeV) = 4.44 ± 2.03 New analysis by Orlando&Strong'08

Sun and Moon spectra: a comparison



Moon and Sun
Spectra Compared

Conclusions

- During the first months of data taking Fermi has observed the quiet Sun and the Moon
- Preliminary Spectra and Fluxes has been reported for both sources
- The Fermi preliminary results are consistent with predictions