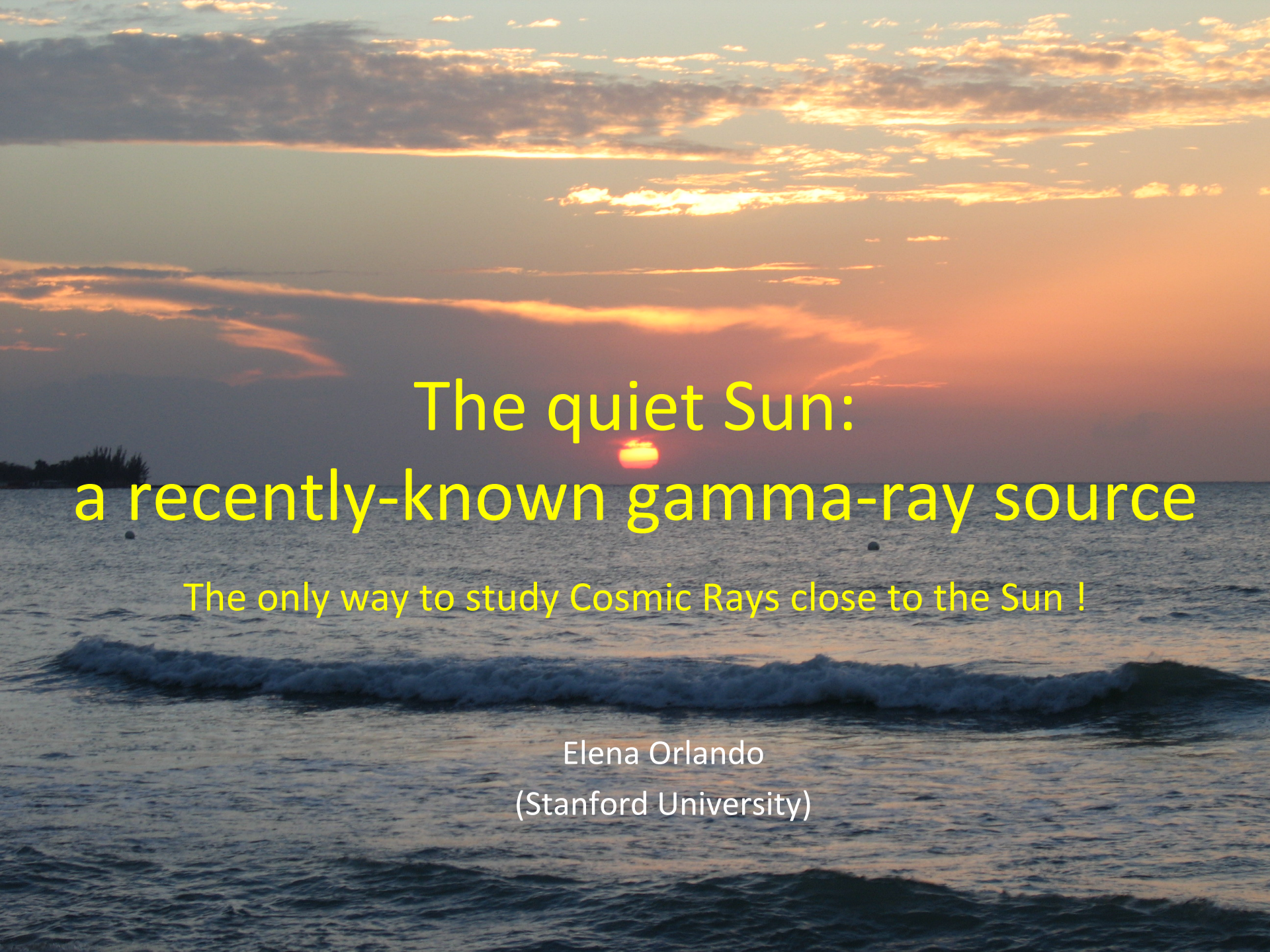


The quiet Sun: a recently-known gamma-ray source

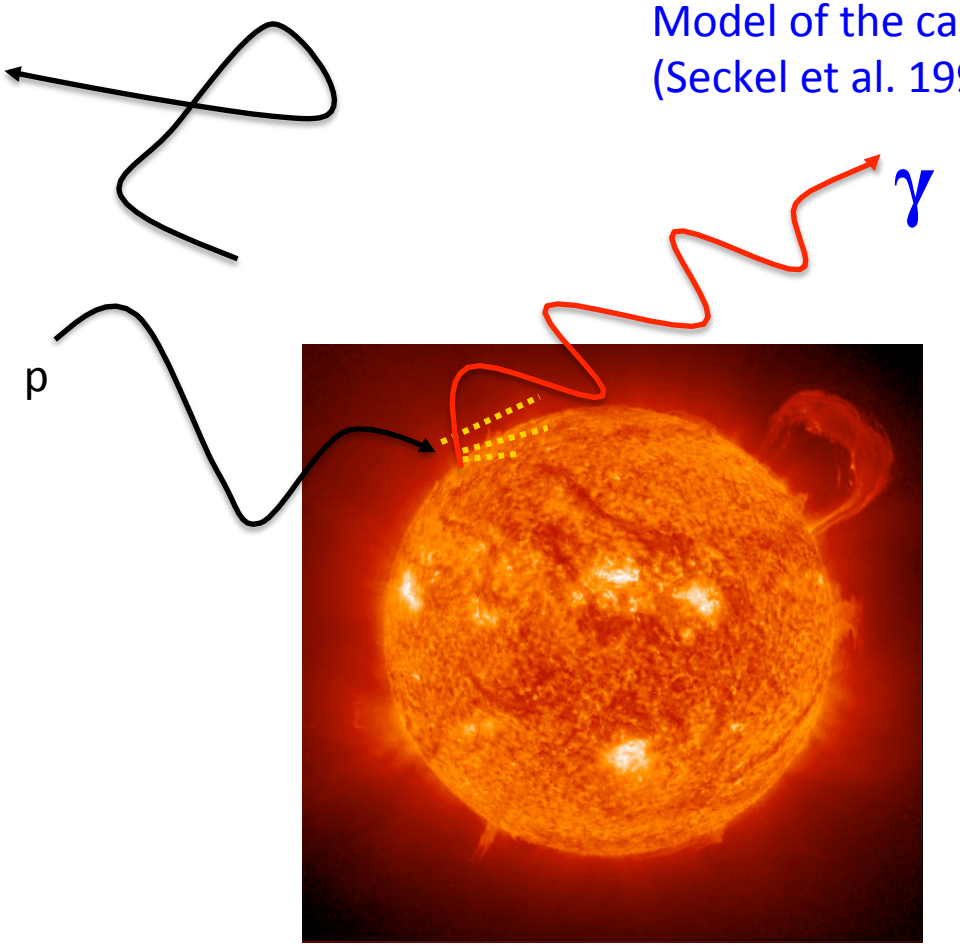
The only way to study Cosmic Rays close to the Sun !

Elena Orlando
(Stanford University)

1) Emission from the disc

Hadronic interactions of cosmic rays with solar atmosphere

Model of the cascade
(Seckel et al. 1991 ApJ, 382, 652)



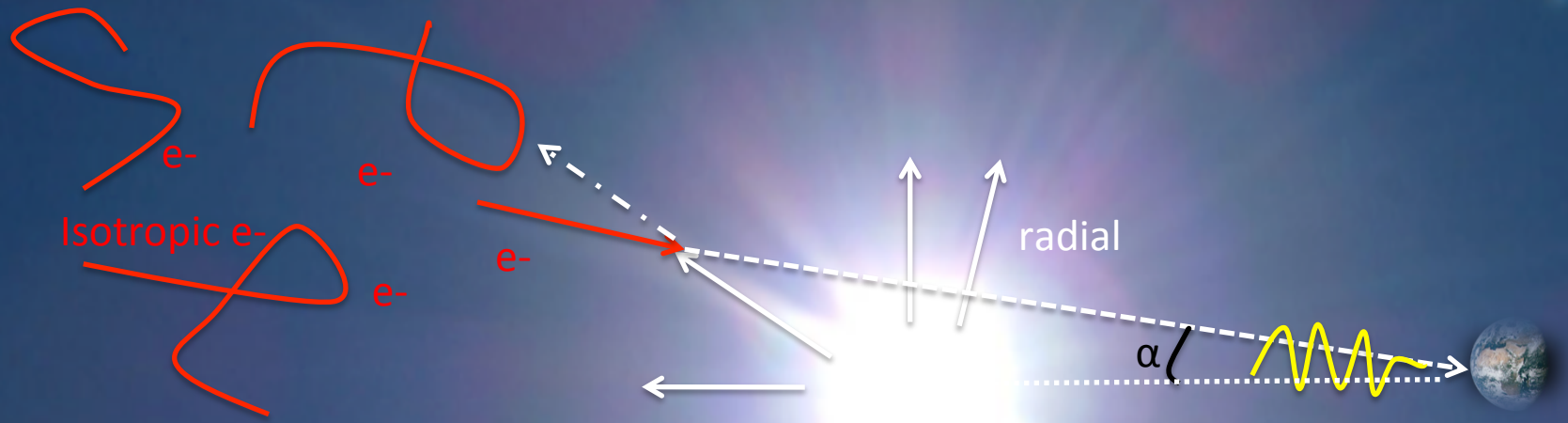
Thompson et al.
1997 JGR, 102, 1473
-> upper limit with EGRET

2) Extended Inverse Compton (IC) emission

GeV electrons (CR) + eV photon (solar photons)→ gamma rays

First theory:

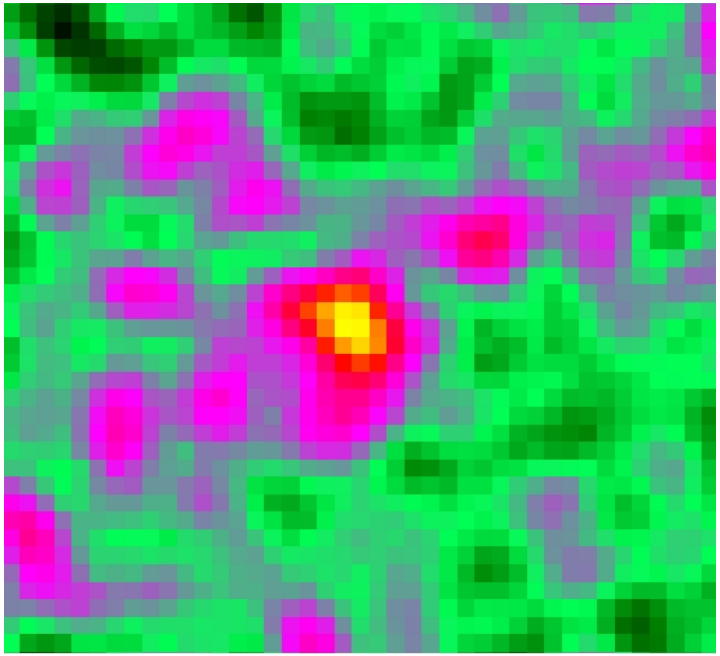
Orlando & Strong, 2006 arXiv:astro-ph/0607563; 2007 Ap&SS, 309, 59;
Moskalenko, Porter & Digel, 2006 ApJ 652, L65



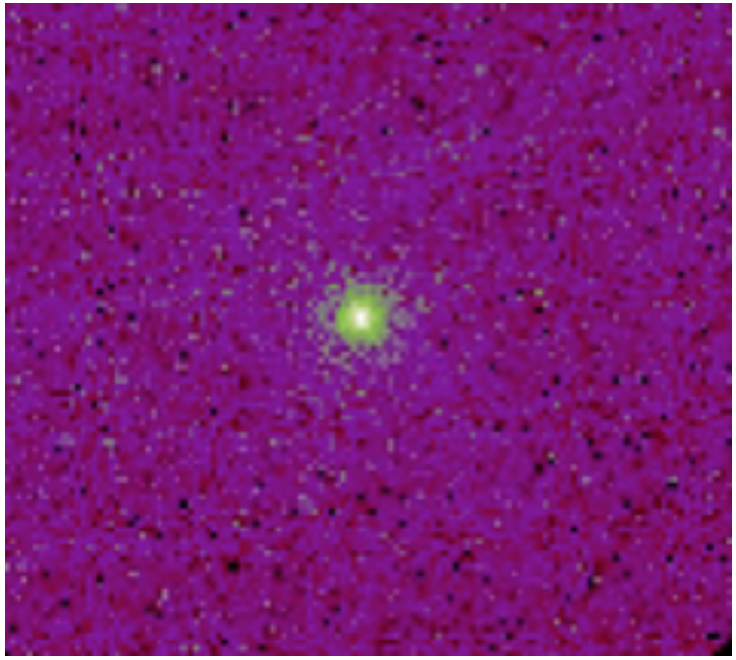
Detection of the quiet sun in gamma rays and of its extended inverse Compton (IC) emission

Orlando & Strong (2008) A&A, 480, 847,
with EGRET: FIRST DETECTION !

Abdo et al. ApJ. (2011) 734, 116,
with FERMI LAT



Count maps
>100 MeV
in sun-centred
system

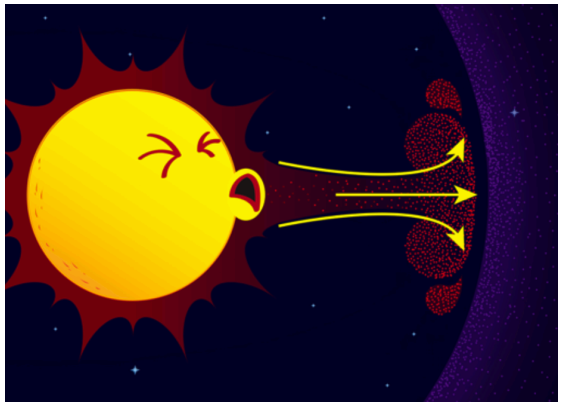


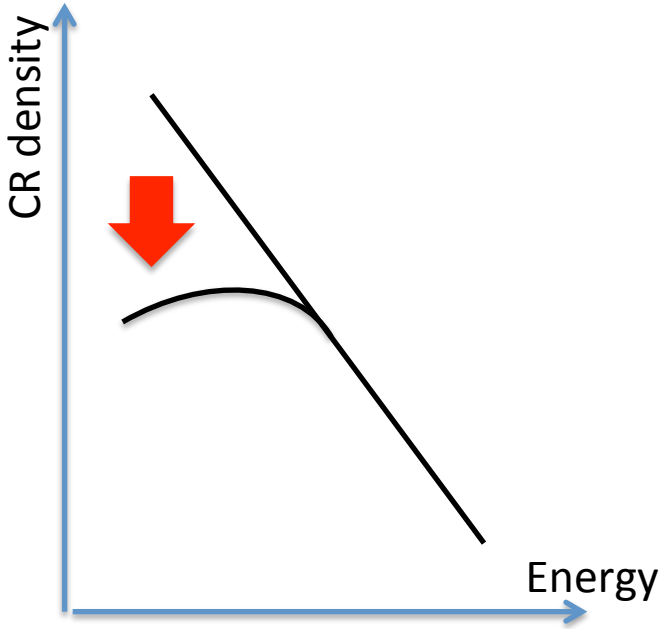
Entire mission of EGRET including both solar minimum and maximum activity

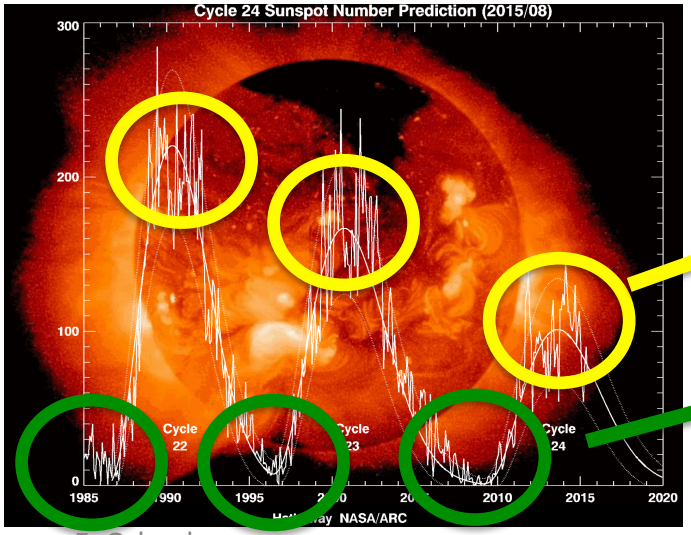
First 18 months of the LAT mission during solar minimum activity

Observations are in general agreement with predictions, but some discrepancies still remain

Solar modulation of CRs in the heliosphere





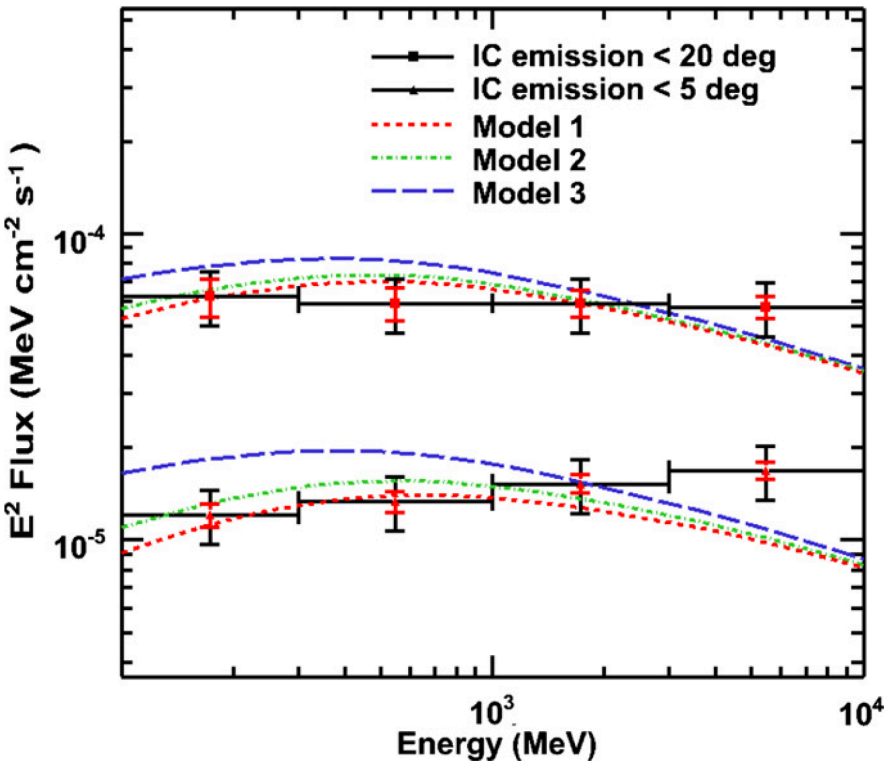


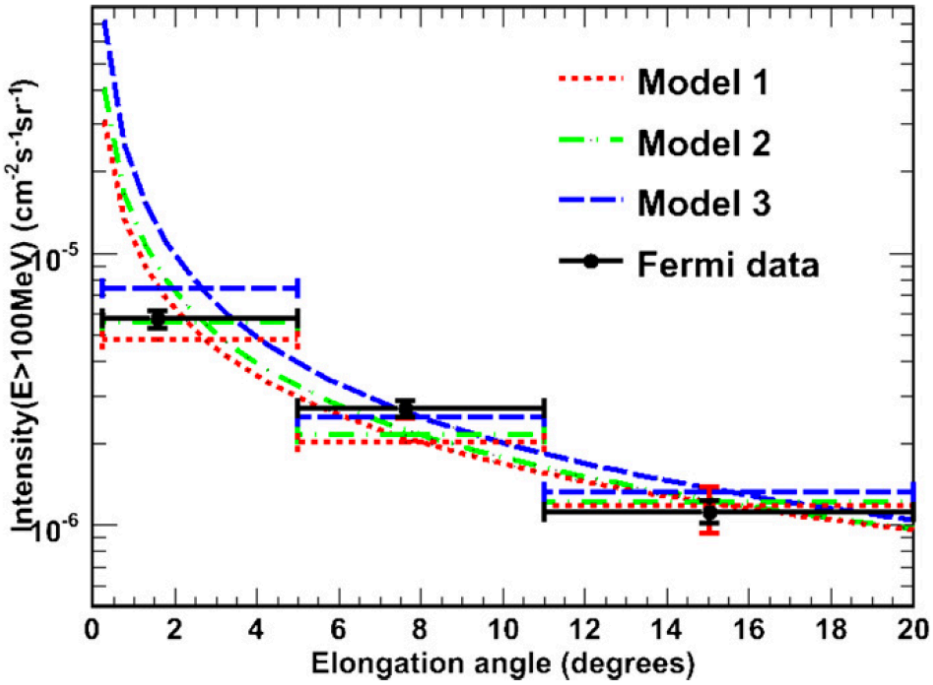
Lower CR flux → Lower gamma-ray flux

Higher CR flux → Higher gamma-ray flux

Observations of the IC emission with Fermi

Abdo et al. (2011) Apj 734, 116





No best model found.

Predictions at MeV – fundamental effect of solar modulation

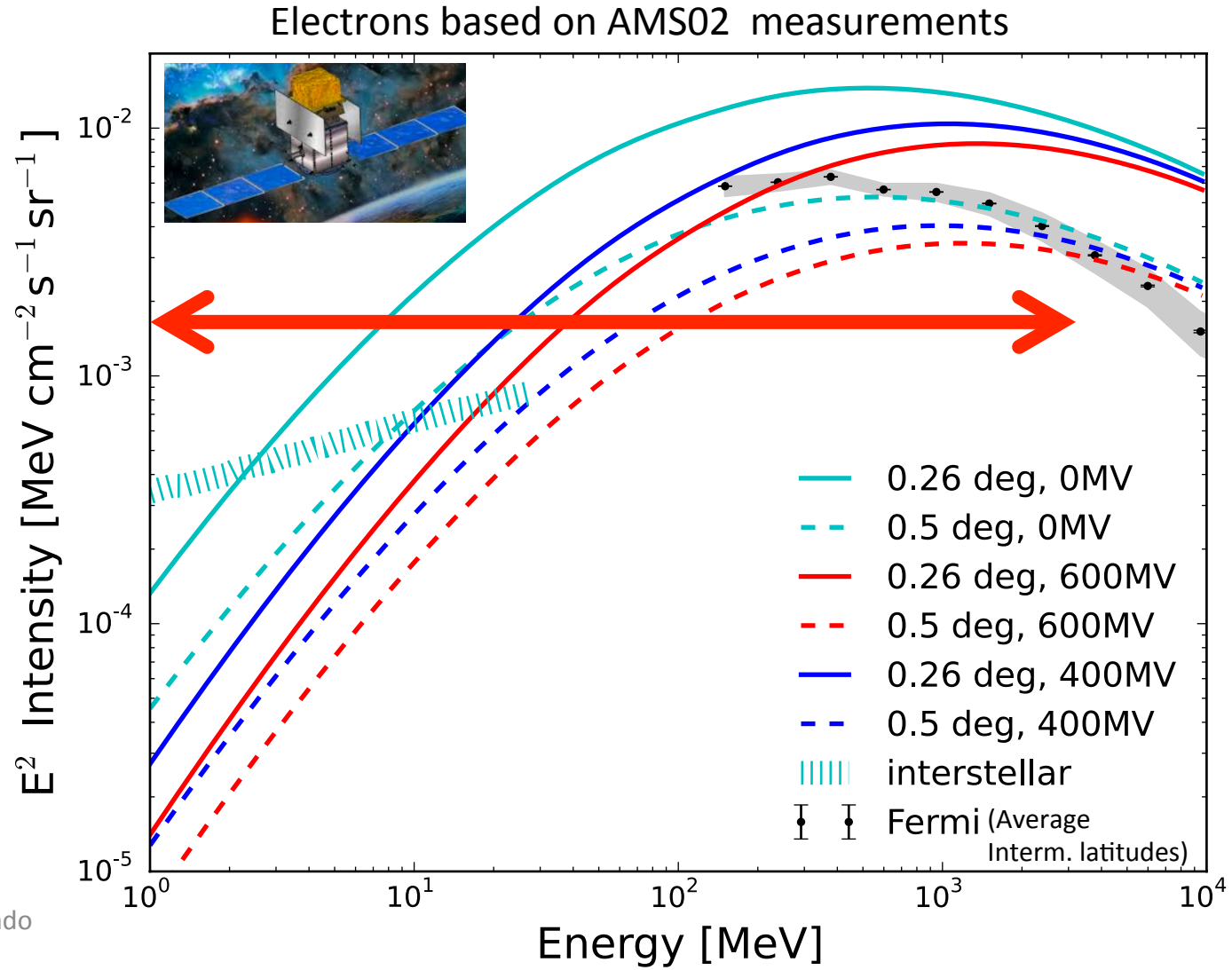
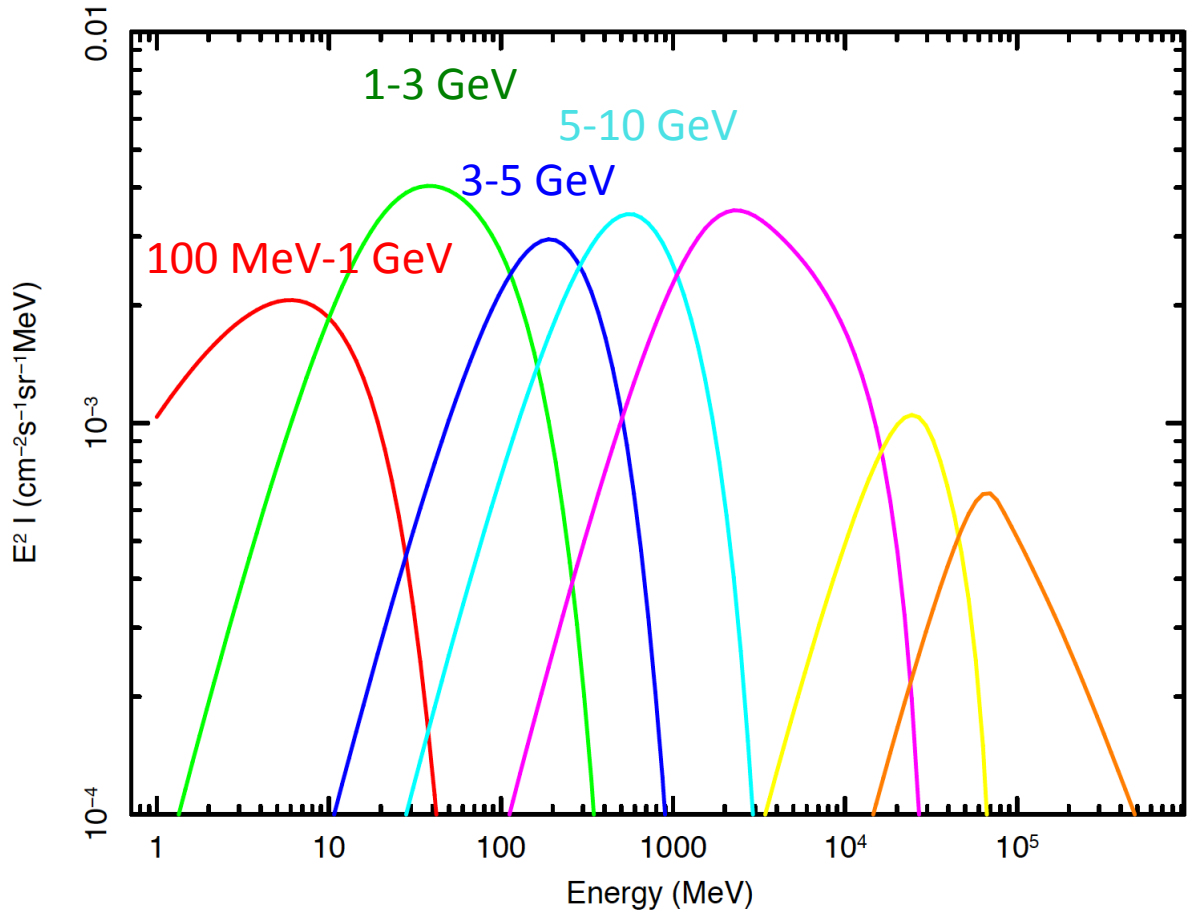


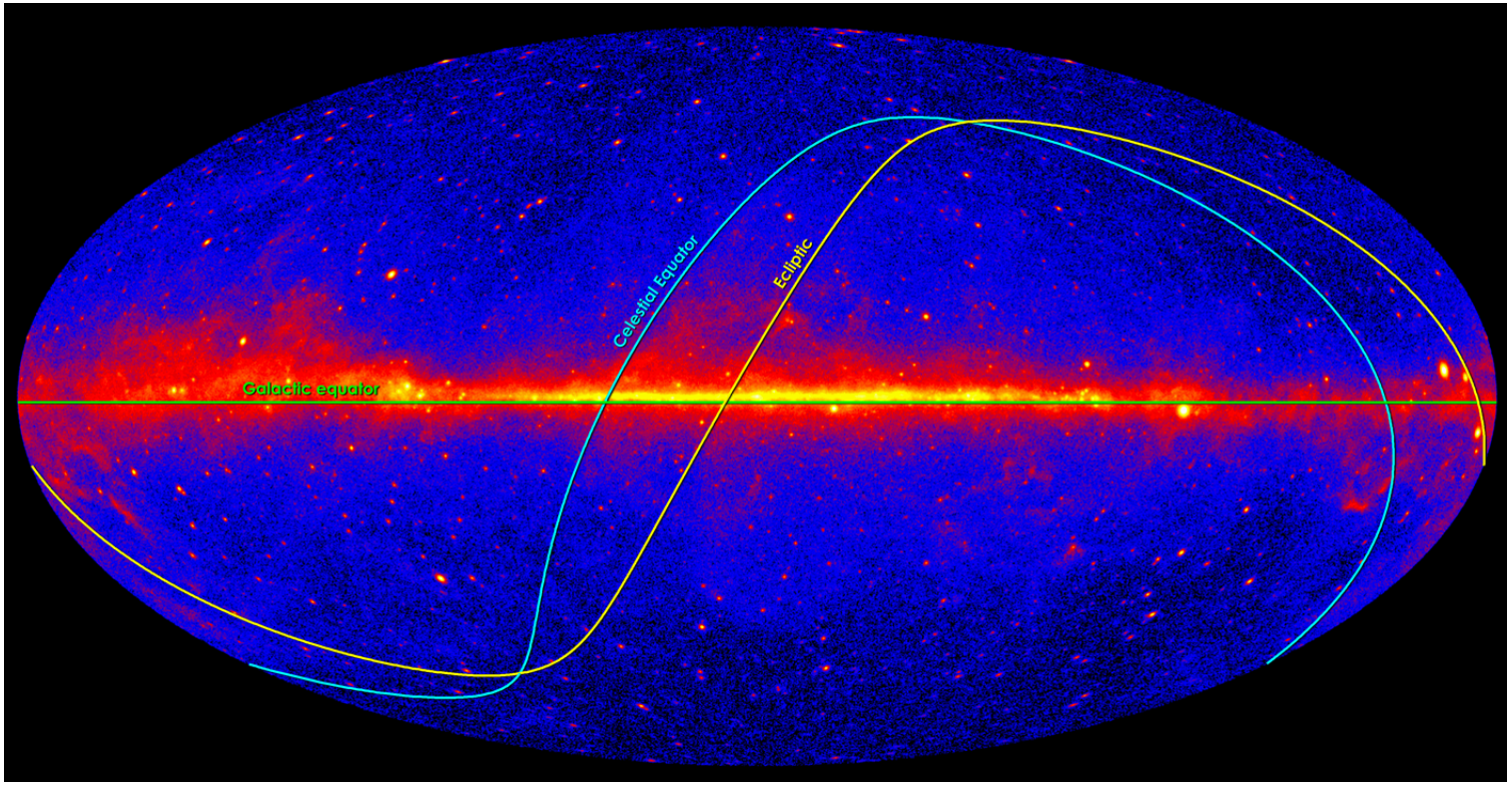
Figure in the contribution

Solar IC emission and electrons



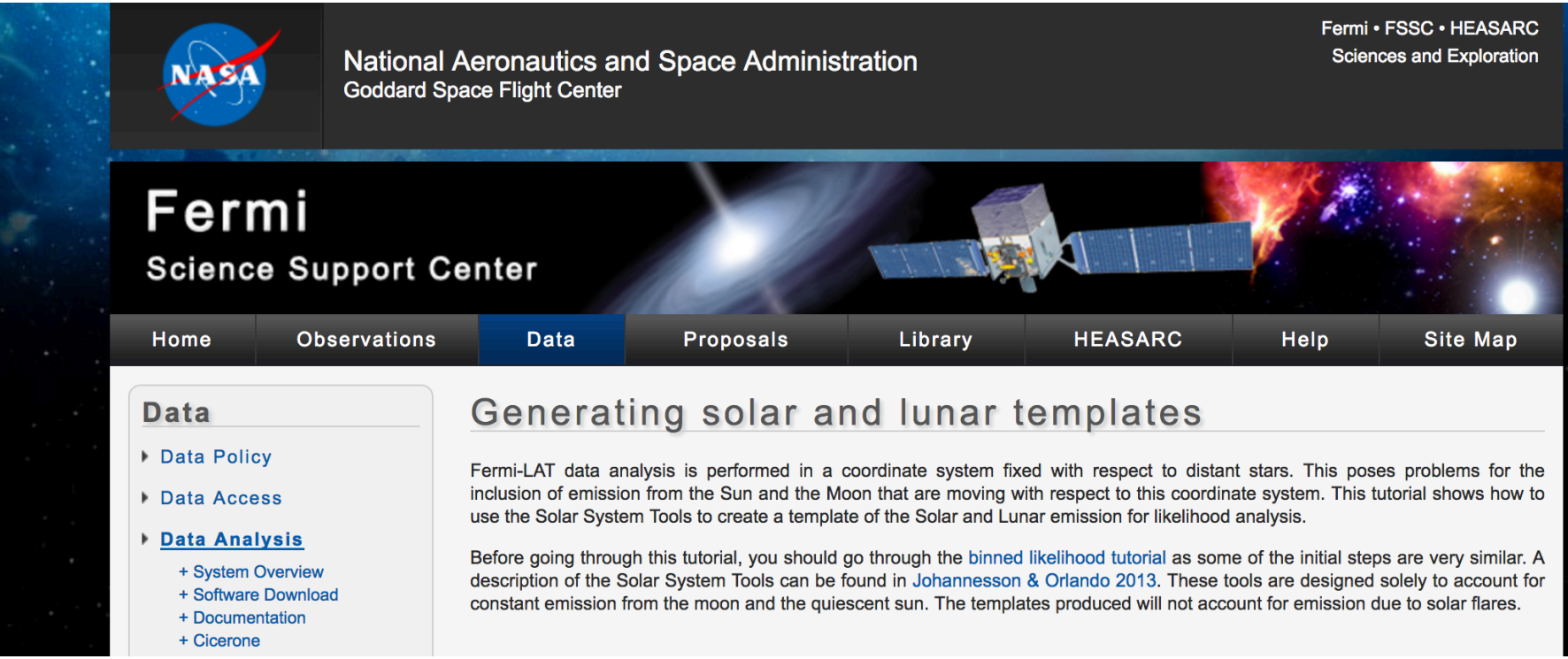
Orlando & Strong (2008) A&A, 480, 847

Solar emission as confusing background for other studies



In Fermi LAT we need to account for it for both short and long exposure !
And we will need at MeV energies as well !

Accounting for the quiet sun in Fermi LAT analyses



1) Dedicated Fermi Science Tools to generate the template

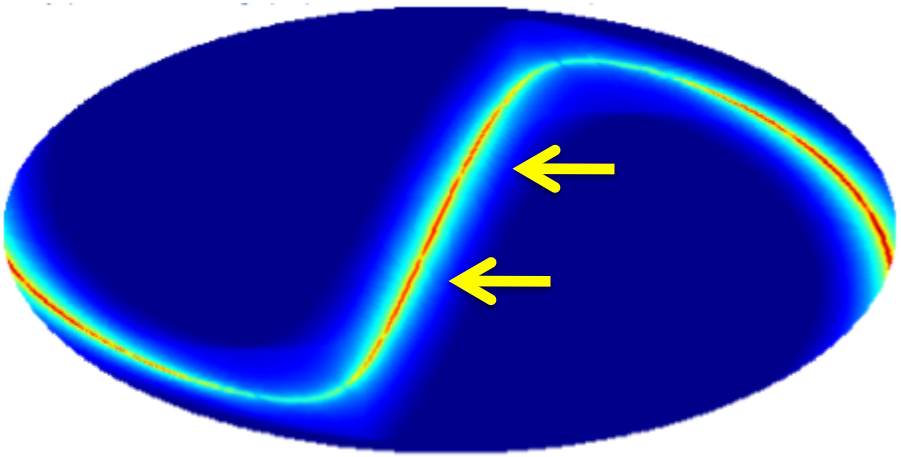
(Johannesson & Orlando 2013, Proc. 33rd International Cosmic Ray Conference, p.0957, arXiv:1307.0197)

2) Input IC models for the Science Tools from the StellarICs code

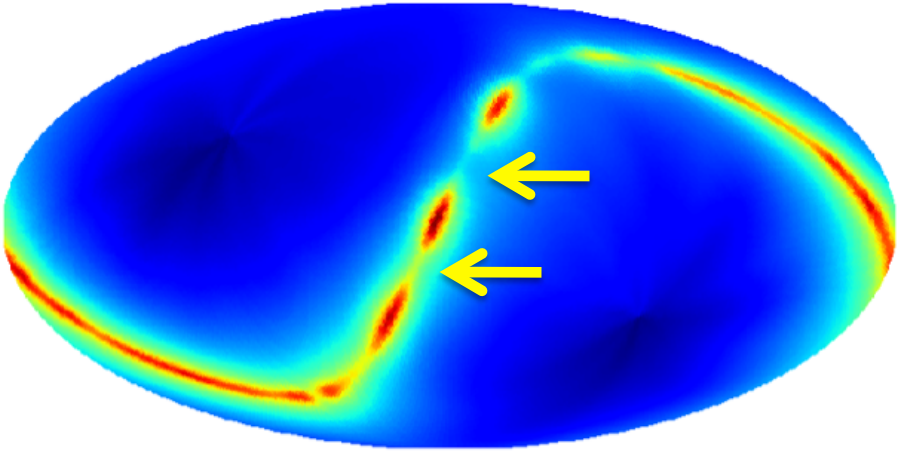
(Orlando, E., & Strong, A. 2013, Nuclear Physics B Proceedings Supplements, 239, 266)

Example of solar template for long exposure

With an average exposure



Appropriate, accouting for istantaneous temporal variation of the exposure



Summary

The quiet Sun is among the Fermi LAT science cases (the only way to study CRs in the inner Heliosphere)

Predictions at MeV suggests that this energy range will be very important to study CRs close to the Sun and their heliospheric propagation for different solar activity !

The Sun acts as a confusing background source for other studies, need to account for it for missions at MeV energies