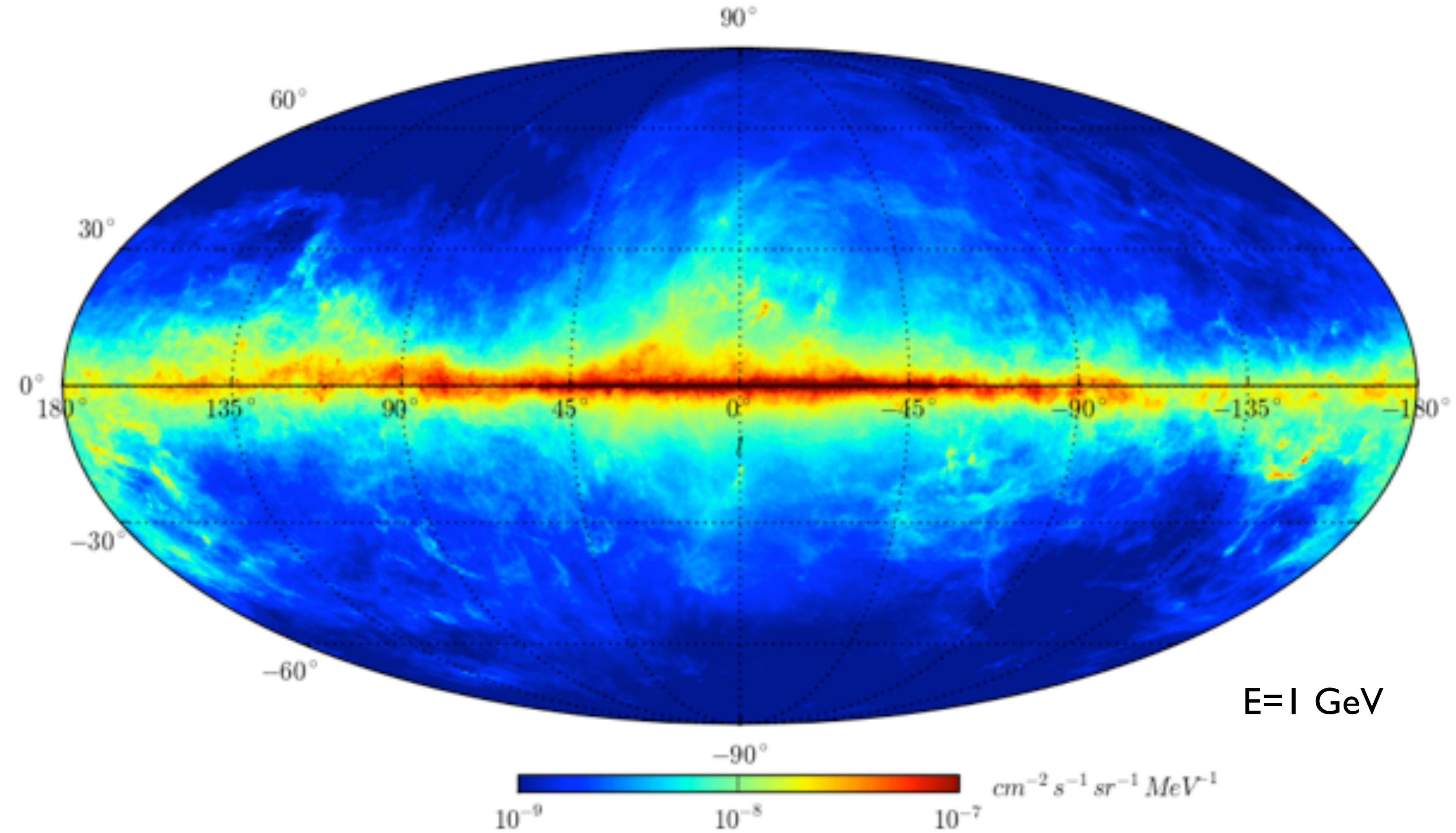
Galactic diffuse emission at MeV Energies

Jean-Marc Casandjian, CEA Saclay



E=1 GeV

diffuse emission = **interstellar emission**
= **emission coming from the Galaxy not associated with point or small-extended sources**
= **not only a background !**

Propagation of the Cosmic Radiation through Intersteller Space

S. Hayakawa

Department of Physics, Osaka City University

November 25, 1952

0.6g cm^{-2}. In the passage through this thickness secondary particles are scarcely produced except photons which are due to the decay of neutral pions. The

SOME PROBLEMS IN GAMMA AND X-RAY ASTRONOMY*

V. L. GINZBURG and S. I. SYROVATSKIJ

P. N. Lebedev Physical Institute, Academy of Sciences, USSR, Moscow

(Received July 30, 1964)

It is also evident that the determination of the intensity and the spectrum of gamma-rays may turn out to be a source of information about cosmic rays themselves. The possibility of studying in this way cosmic rays in the metagalactic space is particularly valuable. The magnetic fields in this case are so weak that relativistic

THE PRODUCTION OF COSMIC GAMMA RAYS IN INTERSTELLAR AND INTERGALACTIC COSMIC-RAY COLLISIONS

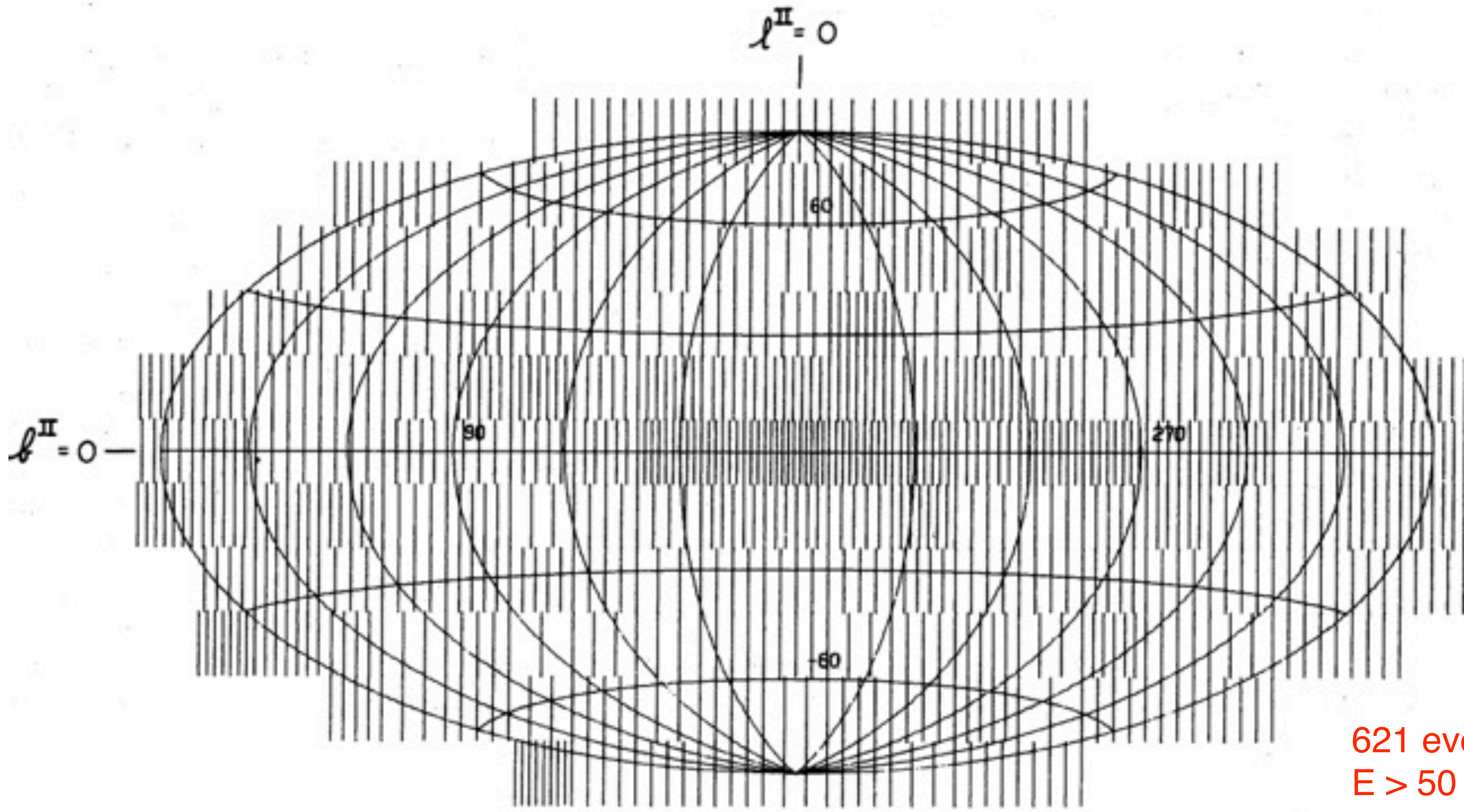
I: THE KINEMATICS OF p-p INTERACTIONS AND SECONDARY MESON AND HYPERON DECAY AND THE COSMIC GAMMA-RAY SPECTRAL SOURCE FUNCTION

F. William Stecker[1]

SAO Special Report #220 (1966) vol. 220

OSO-3 (Third Orbiting Solar Observatory, launched on 1967)
First clear experimental evidence of Galactic diffuse emission

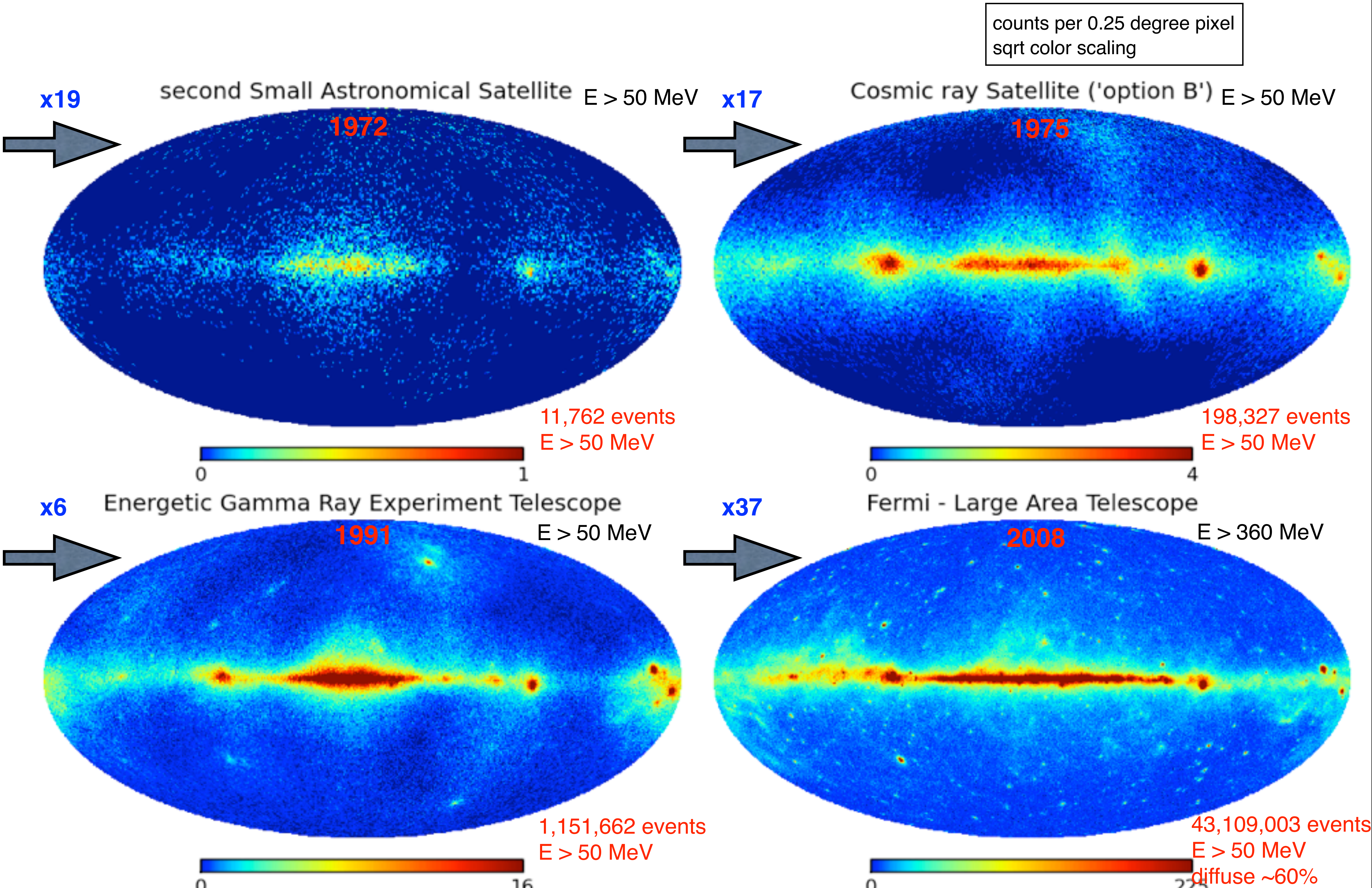
356 W. L. KRAUSHAAR *ET AL.* Vol. 177



621 events
E > 50 MeV

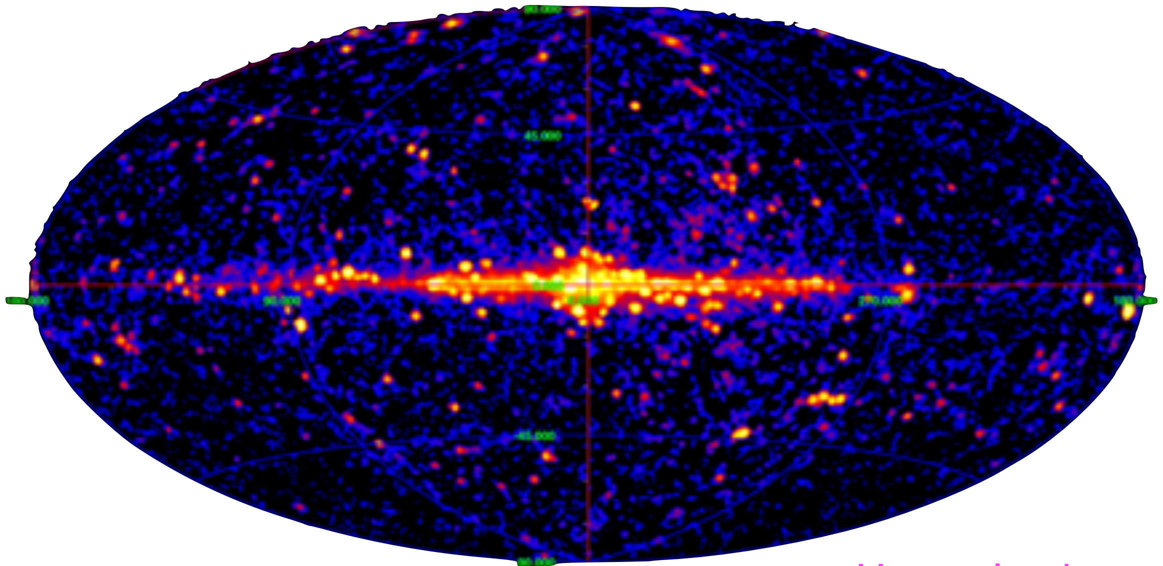
FIG. 8.—Sky map of the γ-ray intensity in galactic coordinates. The element of area on the map to which the formula given in the text applies is approximately 245 square degrees.

Kraushaar *et al.*, ApJ, 1972,177,341



NASA High Energy Astrophysics Science Archive Research Center (HEASARC)

RXTE-PCA E=3-20 keV

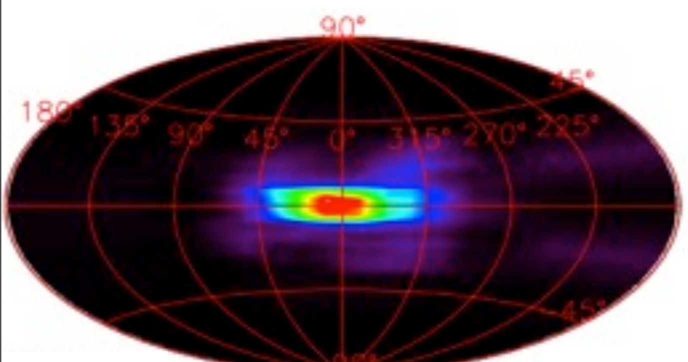


Revnivtsev *et al.,* 2004, A&A 418, 927-936

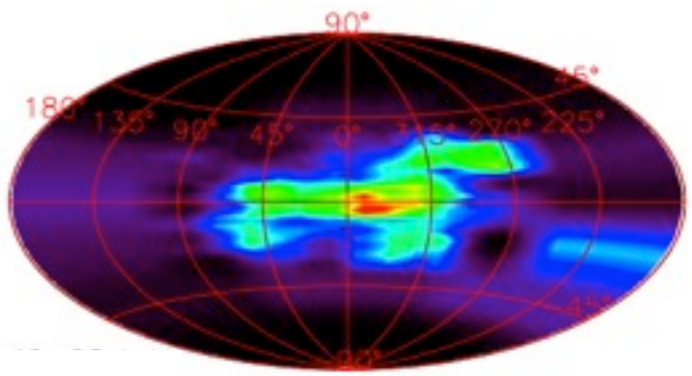
DIRBE, 1.25, 2.2, 3.5 μm

Unresolved sources, not interstellar emission !

INTEGRAL-SPI E=27-600 keV

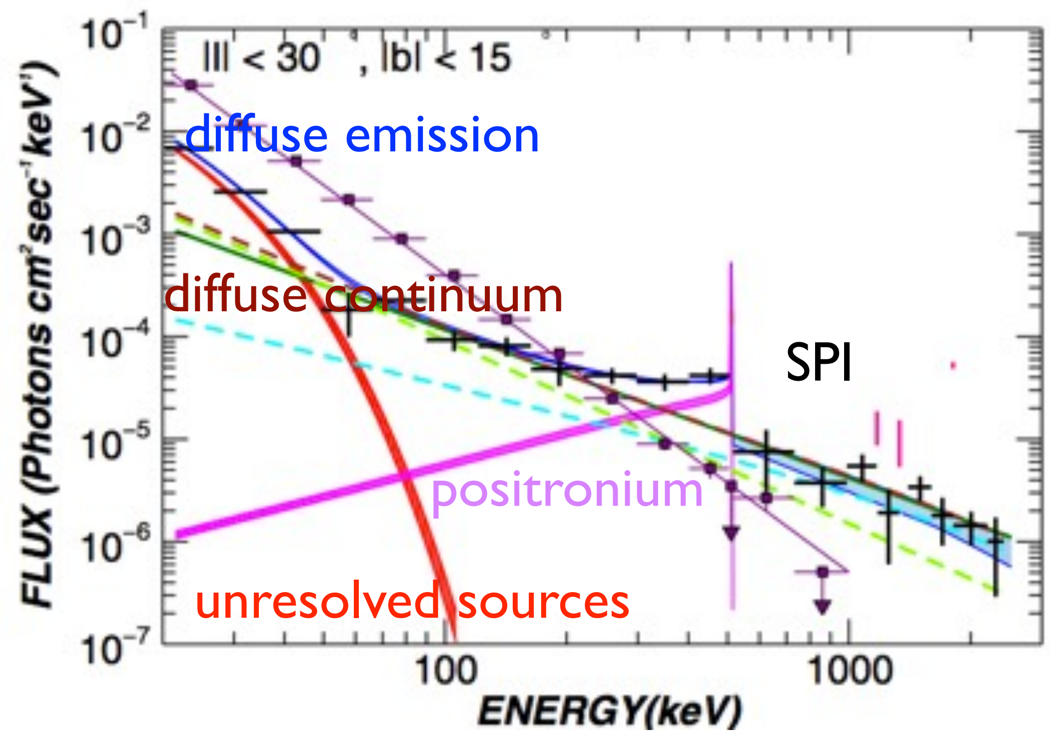


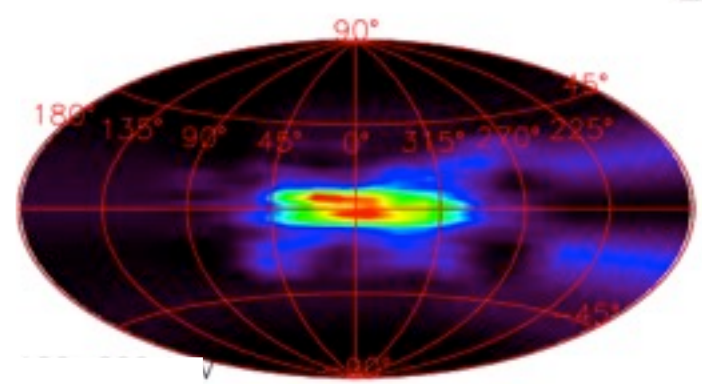
27-49 keV



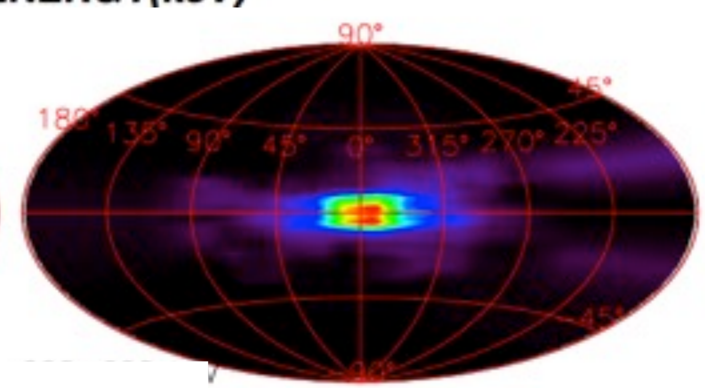
49-90 keV

L. Bouchet *et al.*, ApJ. 2011, 739,29



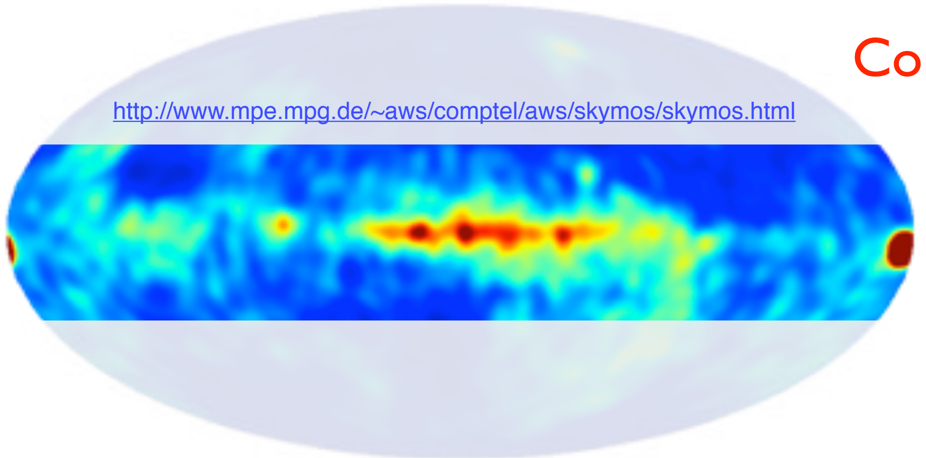


100-200 keV

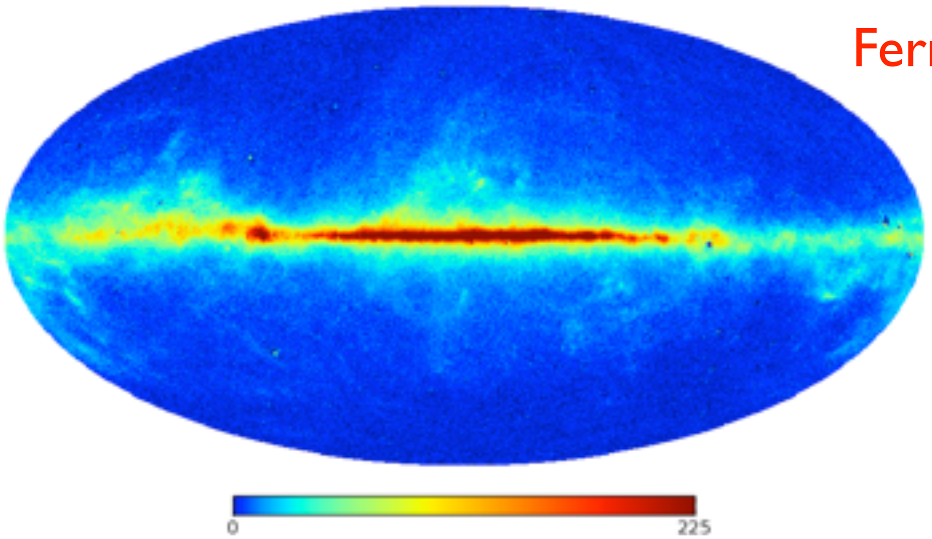


200-600 keV

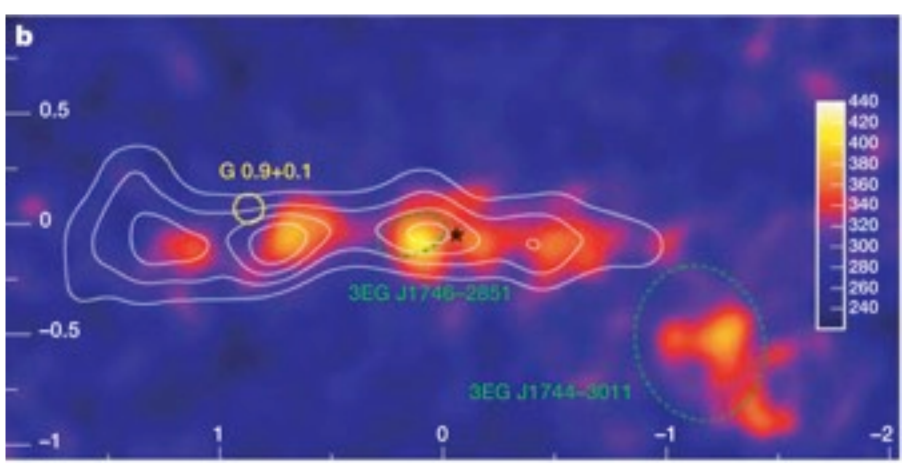
Comptel 1- 30 MeV



Fermi-LAT E>360 MeV

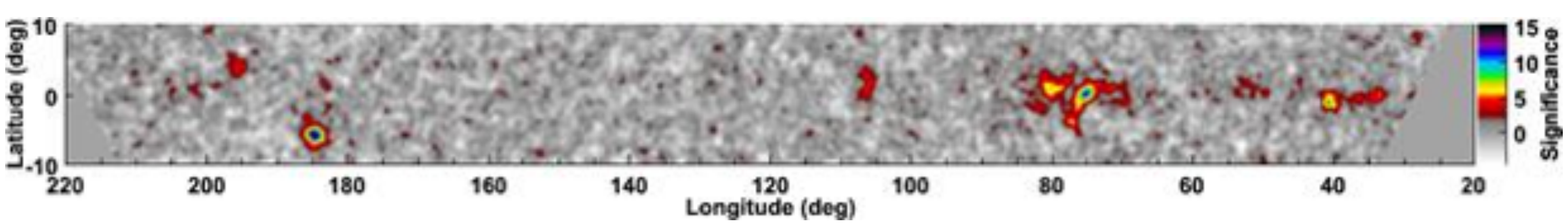


HESS E>380 GeV

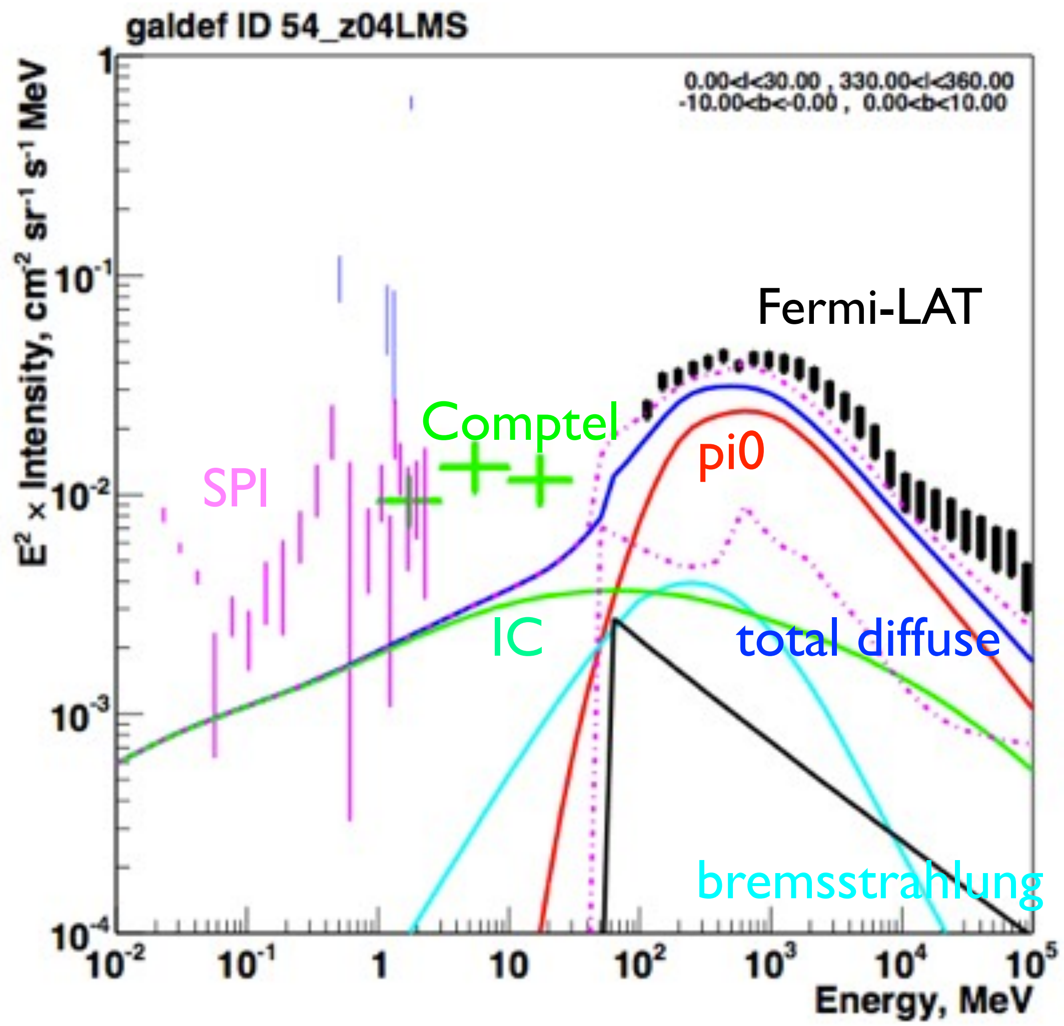


Aharonian *et al.*, 2006, Nature 439, 695

Milagro E>12 TeV

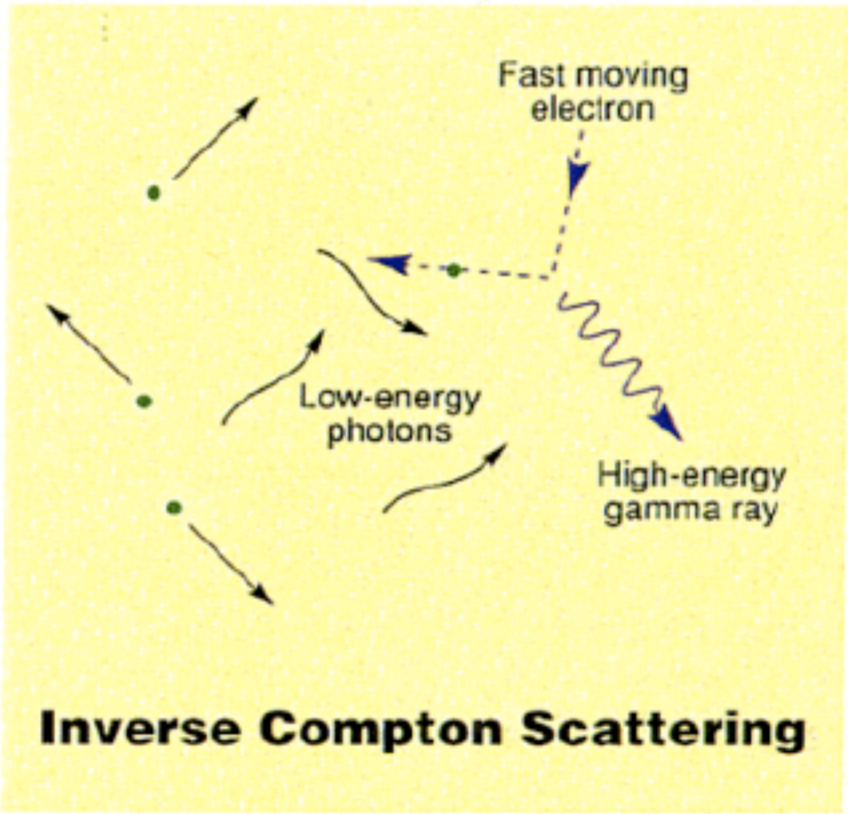


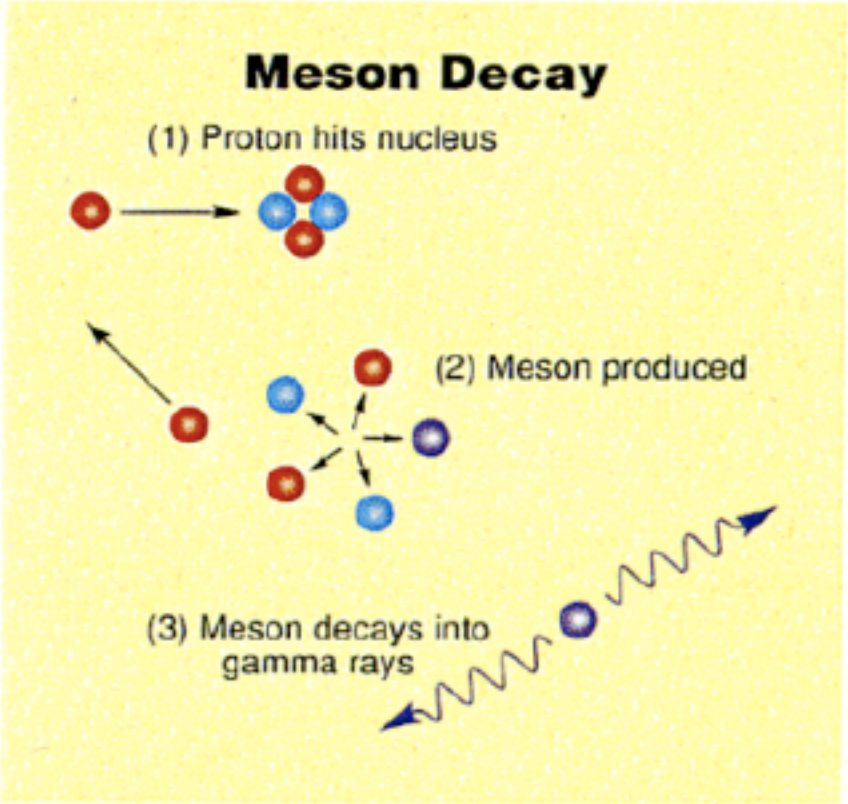
Abdo *et al.*, 2007, ApJ, 658:L33–L36

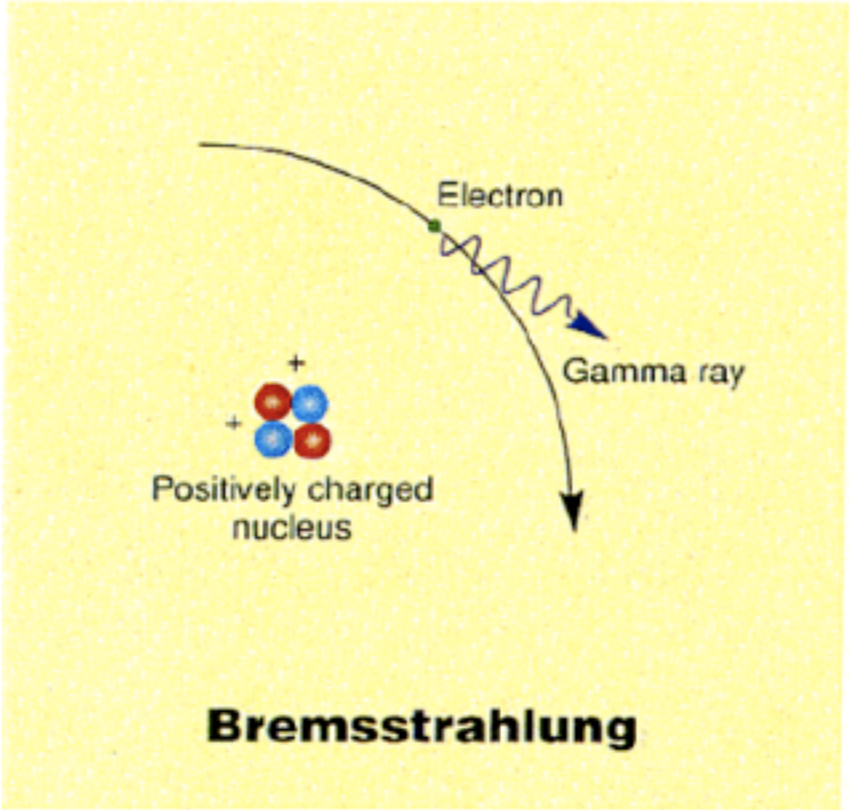


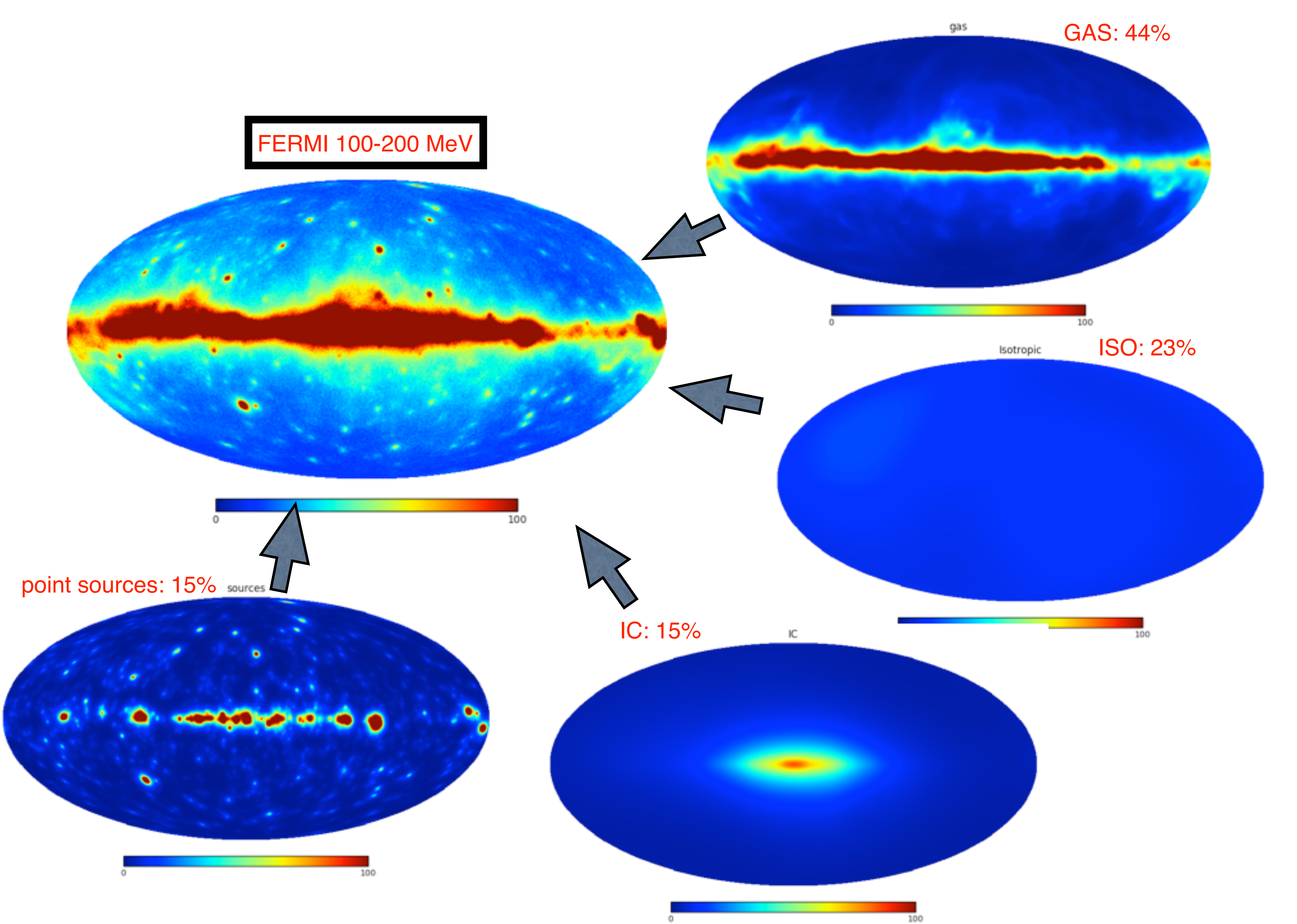
A. Strong, Cosmic Rays for Particle and Astroparticle 2011 Physics. arXiv:1101.1381

Processes for HE γ production

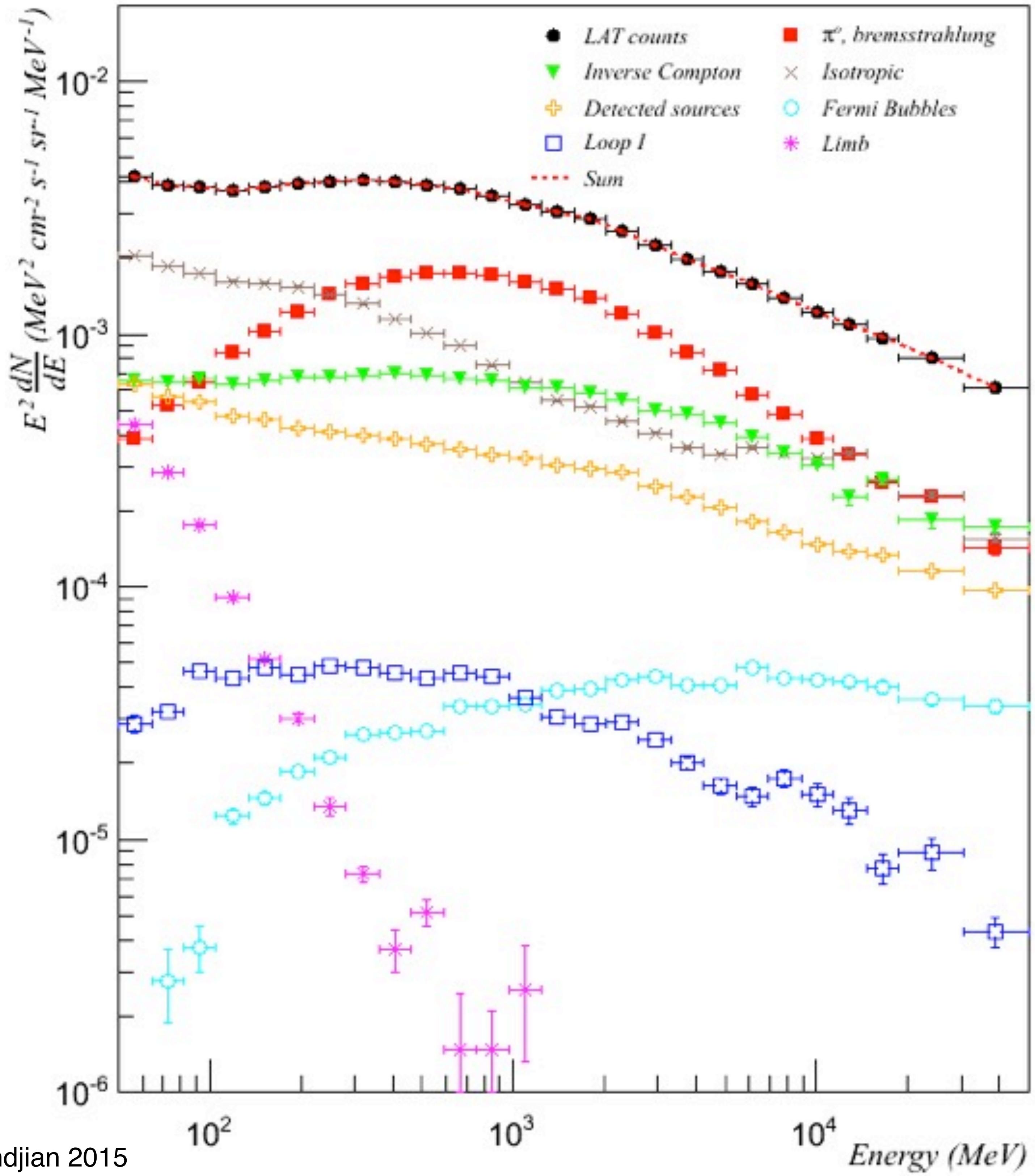







FERMI 100-200 MeV
0
100
gas
GAS: 44%
0
100
Isotropic
ISO: 23%
100
point sources: 15%
sources
0
100
IC: 15%
IC
0
100

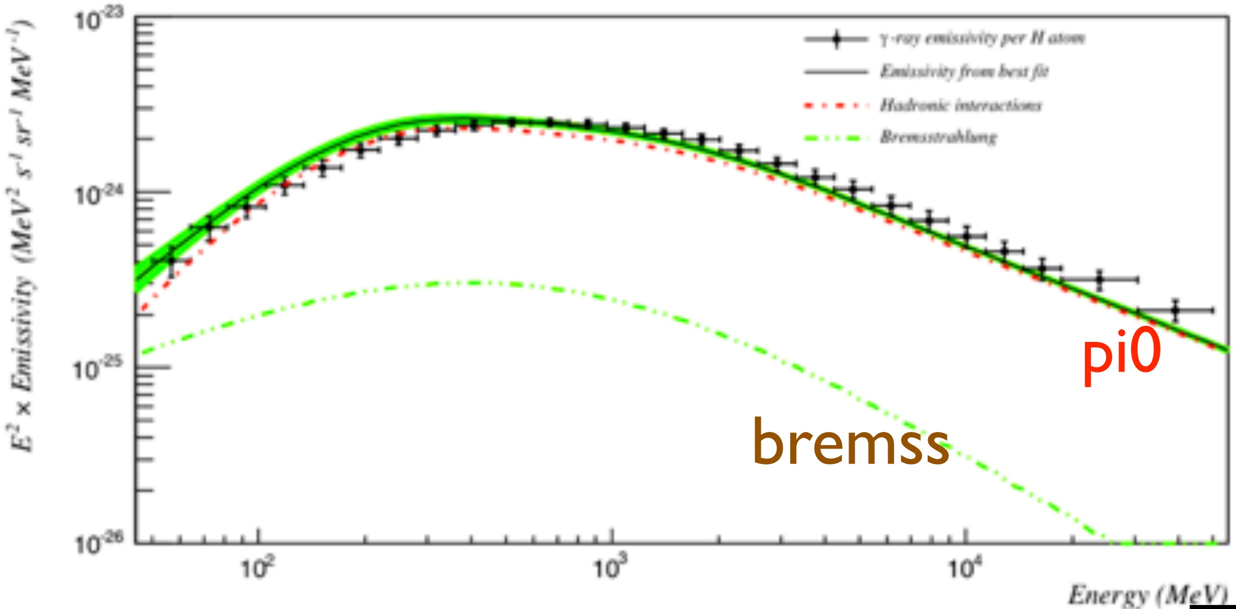
FERMI |b|>10 deg

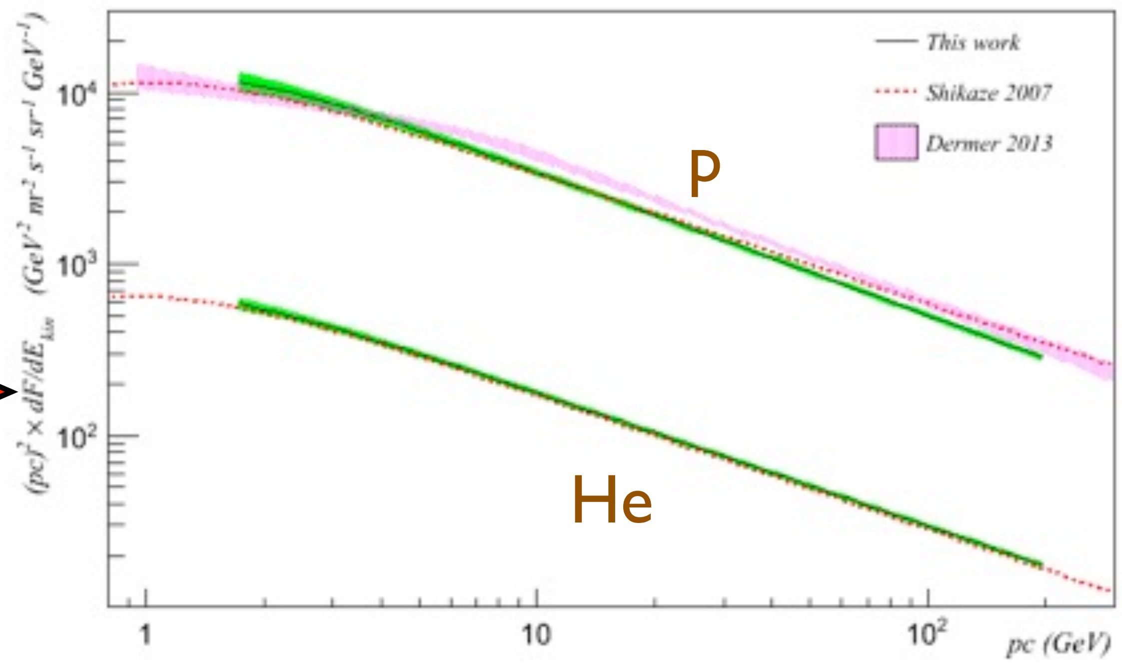


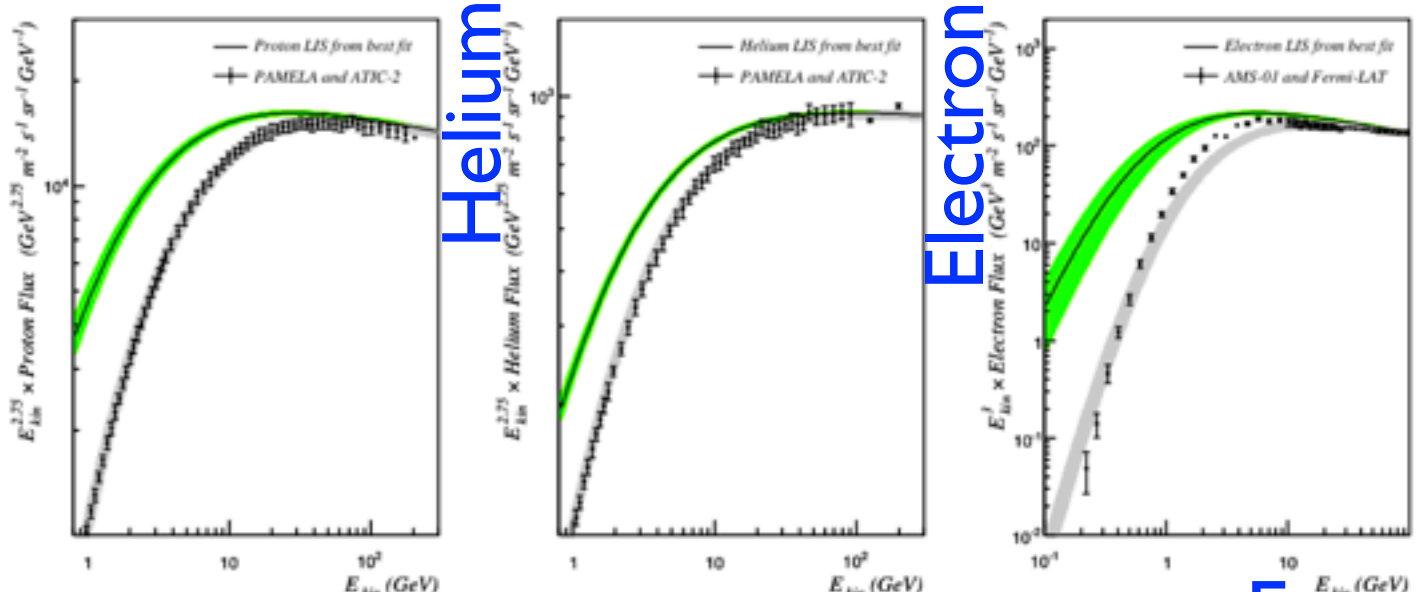
Casandjian 2015

$$N_\gamma(l,b) = q_{HI} N_{HI}(l,b) + q_{CO} W_{CO}(l,b) + IC + ..$$

$$q_{HI} \propto F_{CR} \times \sigma_{pp\to\gamma}$$







Casandjian 2015

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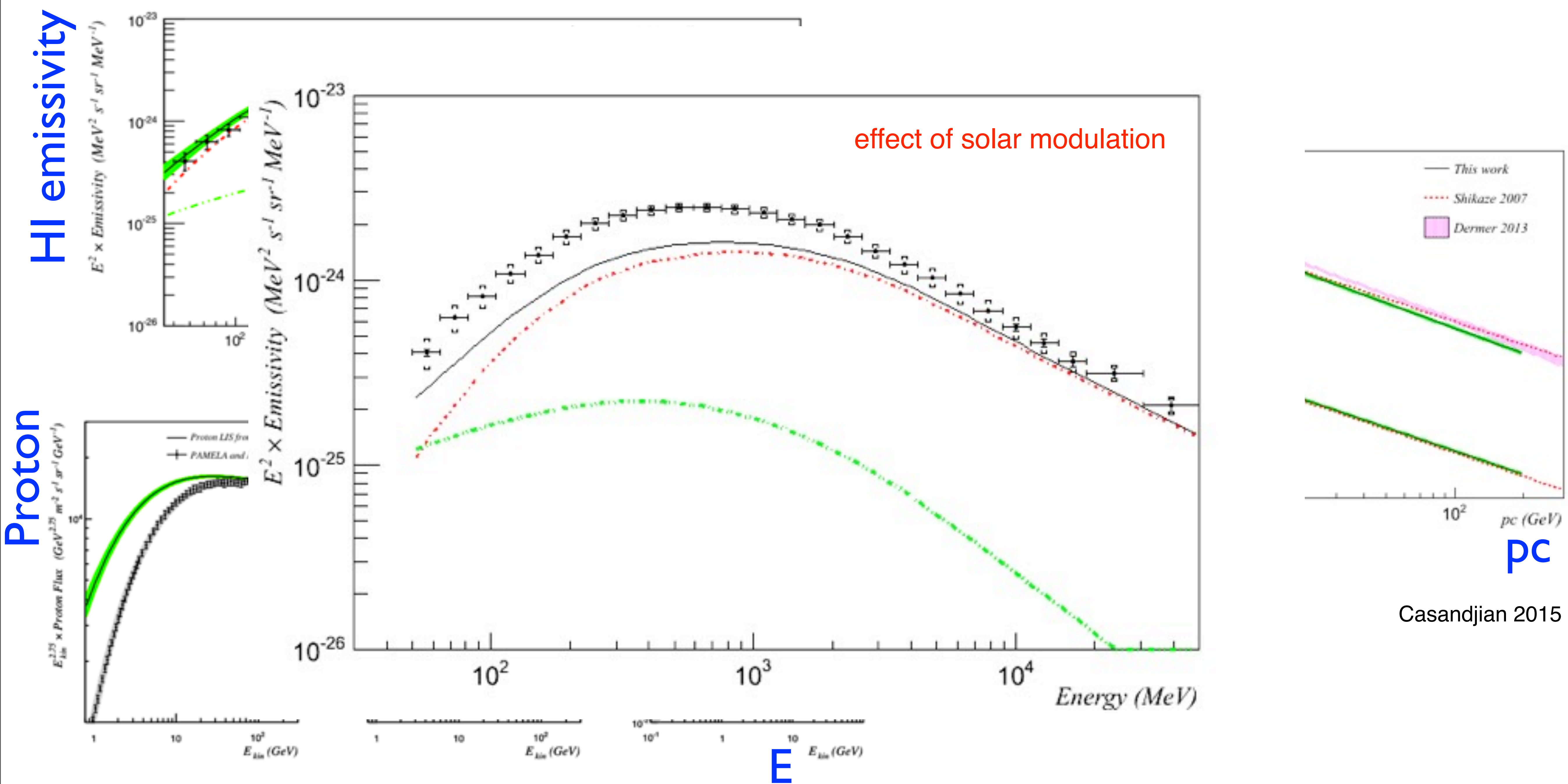
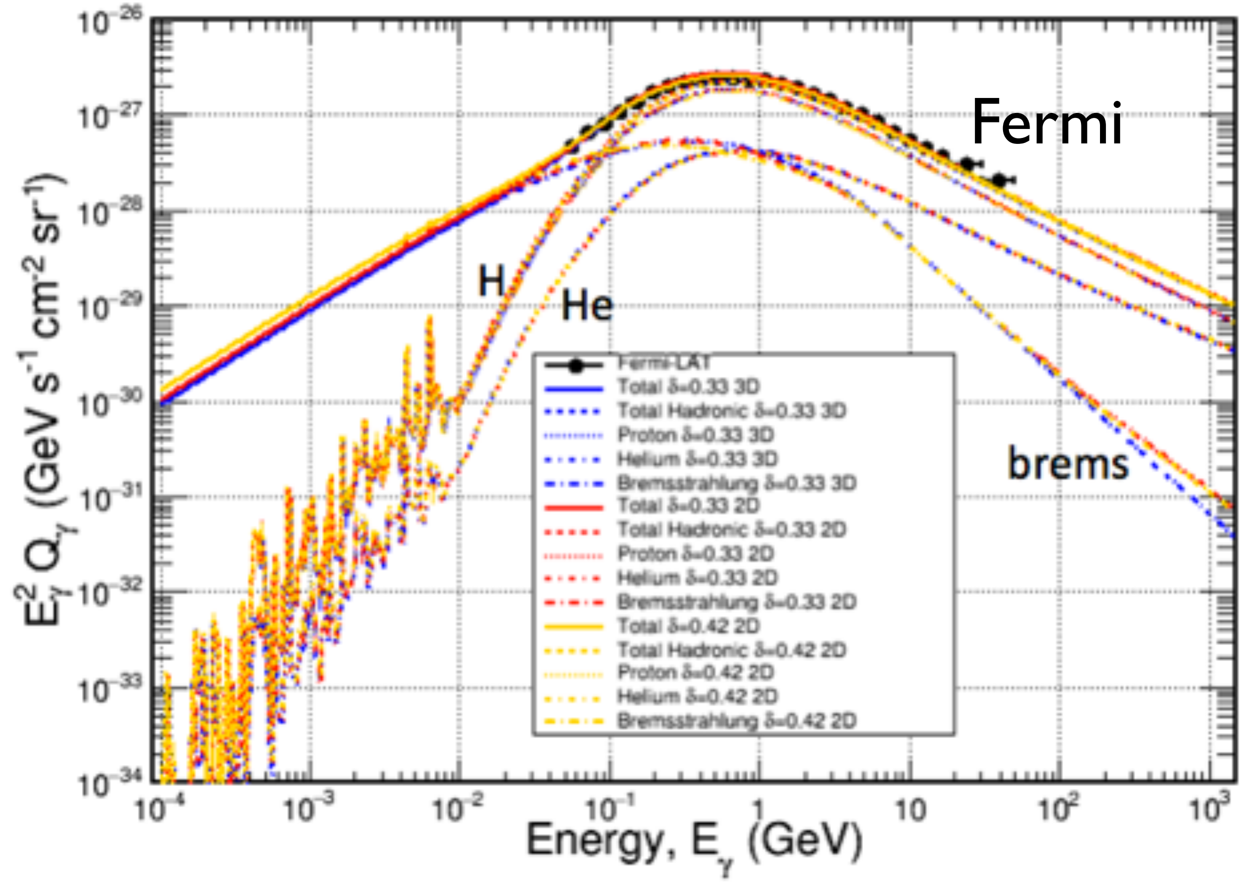


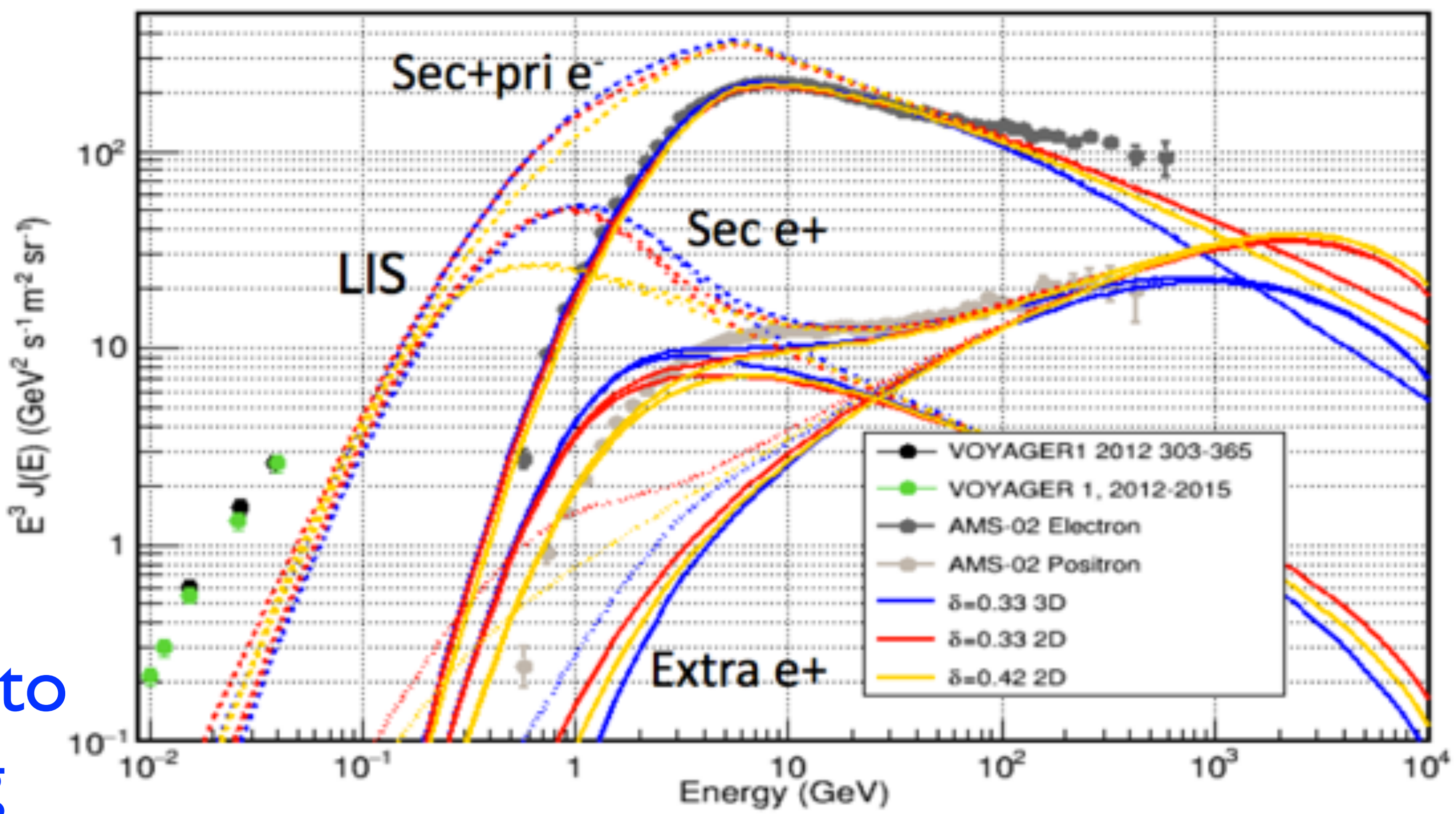
Casandjian 2015



M. Nicola Mazziotta - XSCR CERN Mar 30, 2017

Study of emissivities with LIS from Dragon
and production cross-section from FLUKA

Incompatibility with Voyager :



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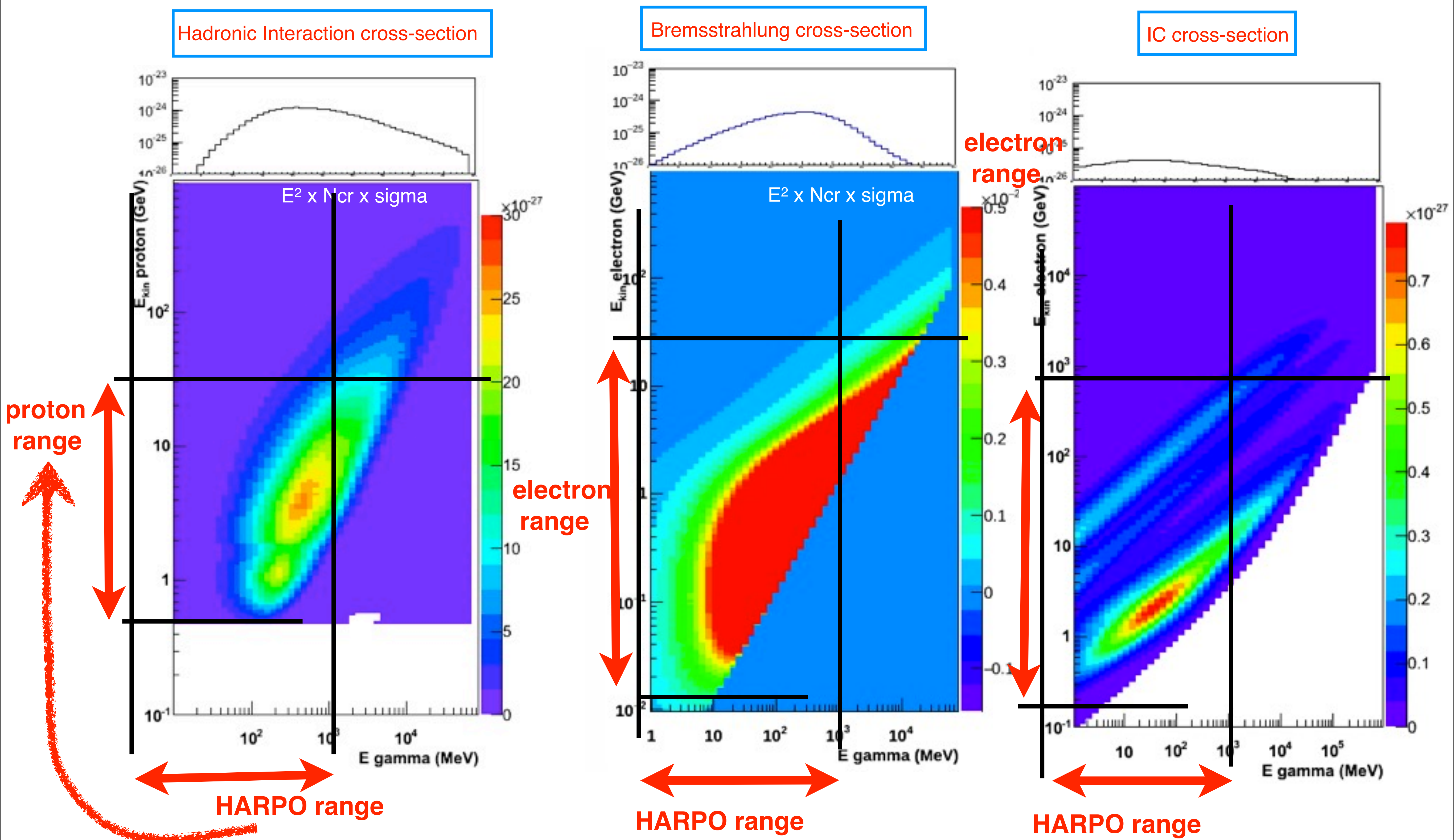
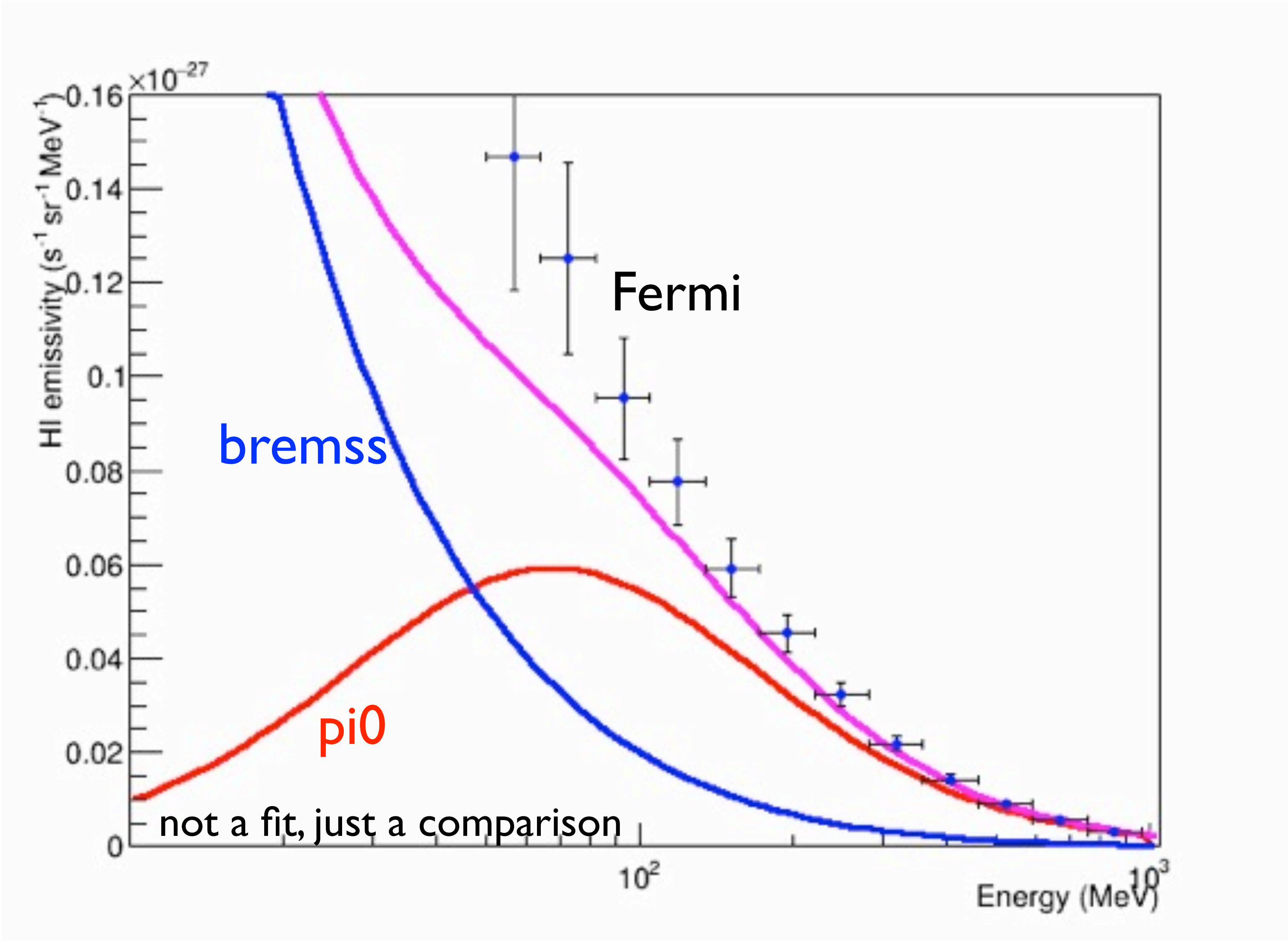
We need lower energy gamma-ray to constrain e- from bremsstrahlung

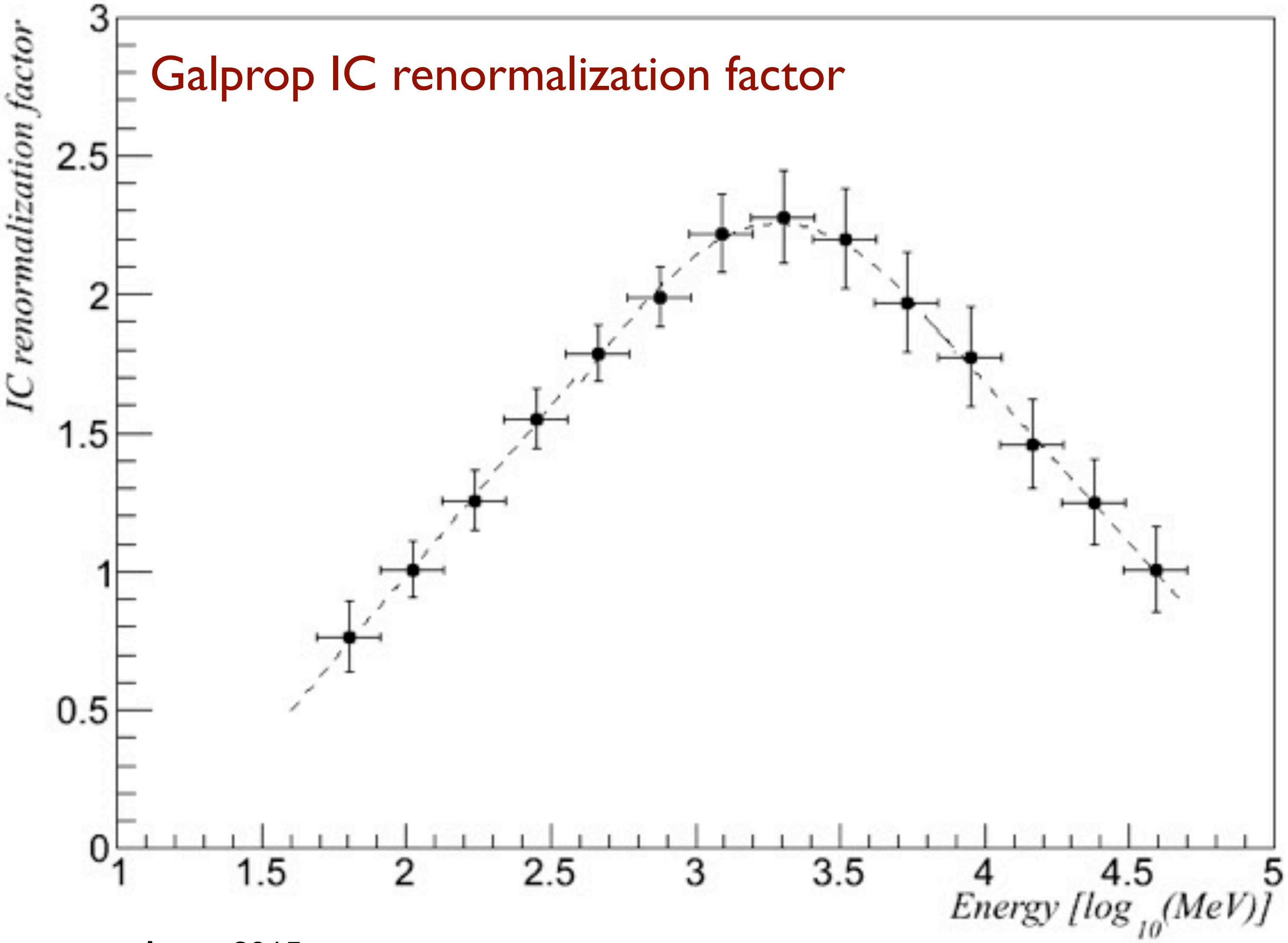
At MeV energies



Bremsstrahlung makes the real pi0 bump very challenging to observe (see presentation from Martina Cardillo)



IC probe the Galaxy bulge and halo



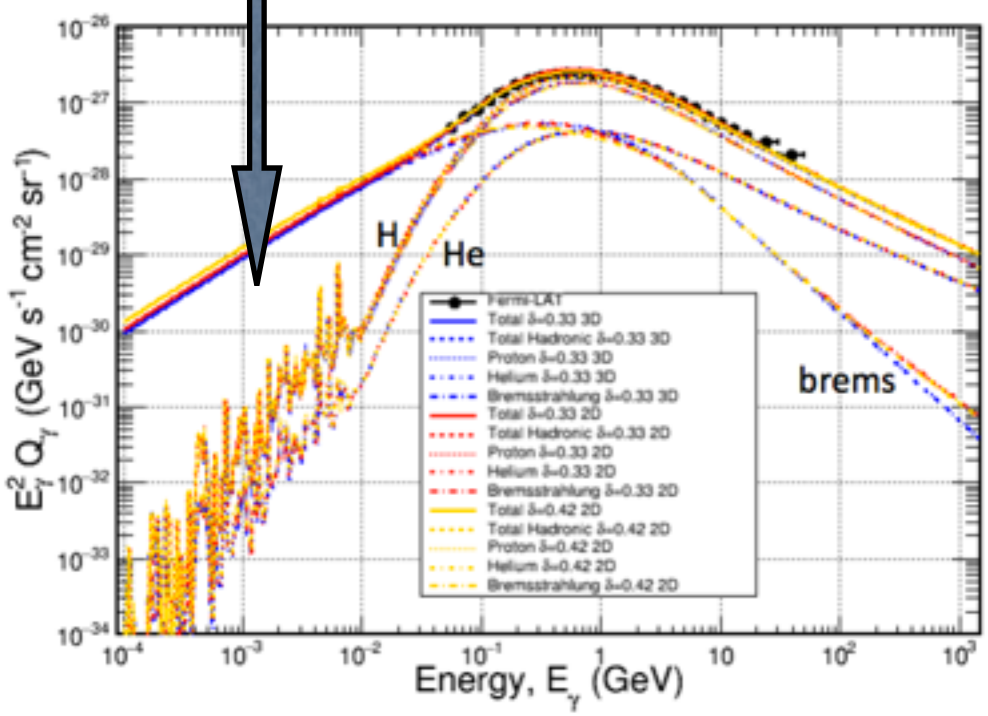
Acero 2015

- Wrong electron density ?
- Incorrect ISRF ?
- DM signal (see talk by Marco Cirelli) ?

→ Joined IC and bremsstrahlung analysis at low gamma-ray energy

Nuclear lines

deexcitation of the first levels in 12C, 16O, 20Ne, 24Mg, 28Si, 56Fe



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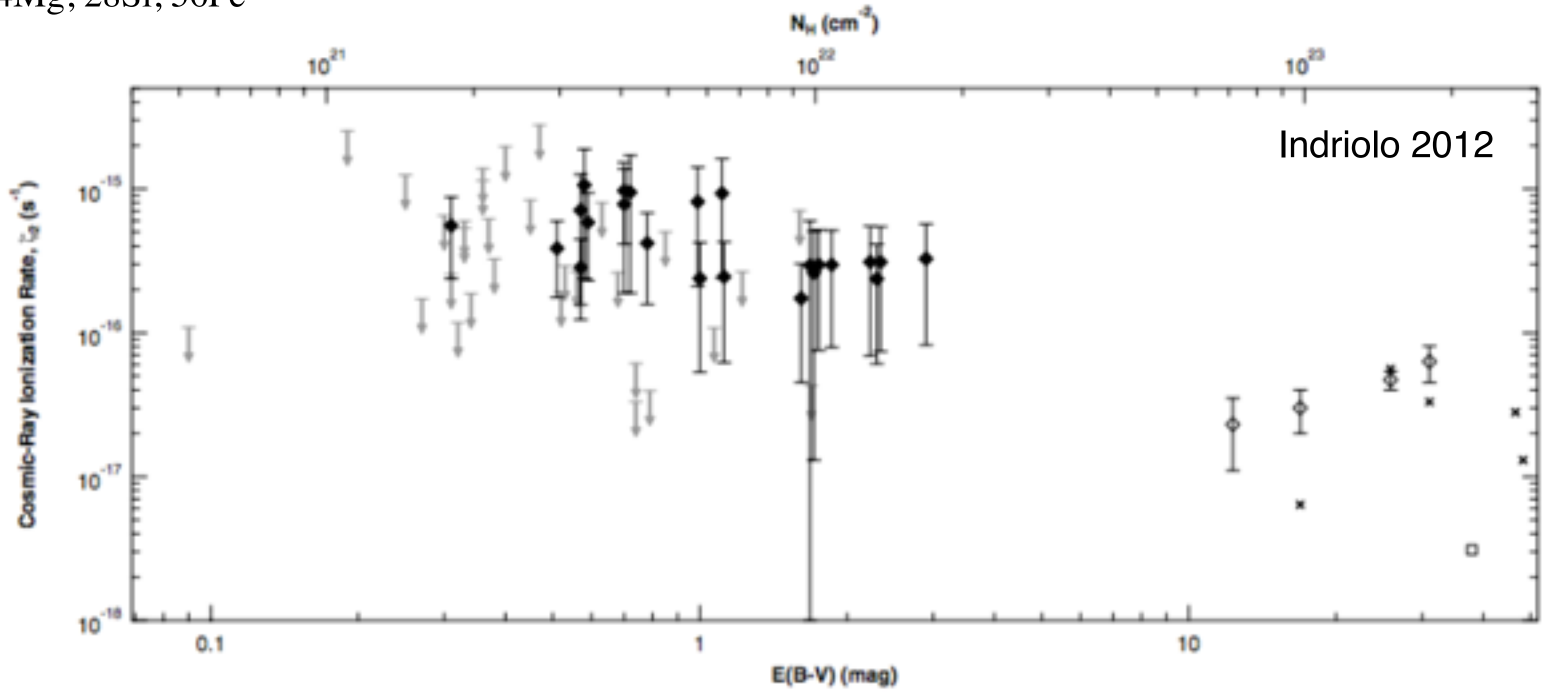
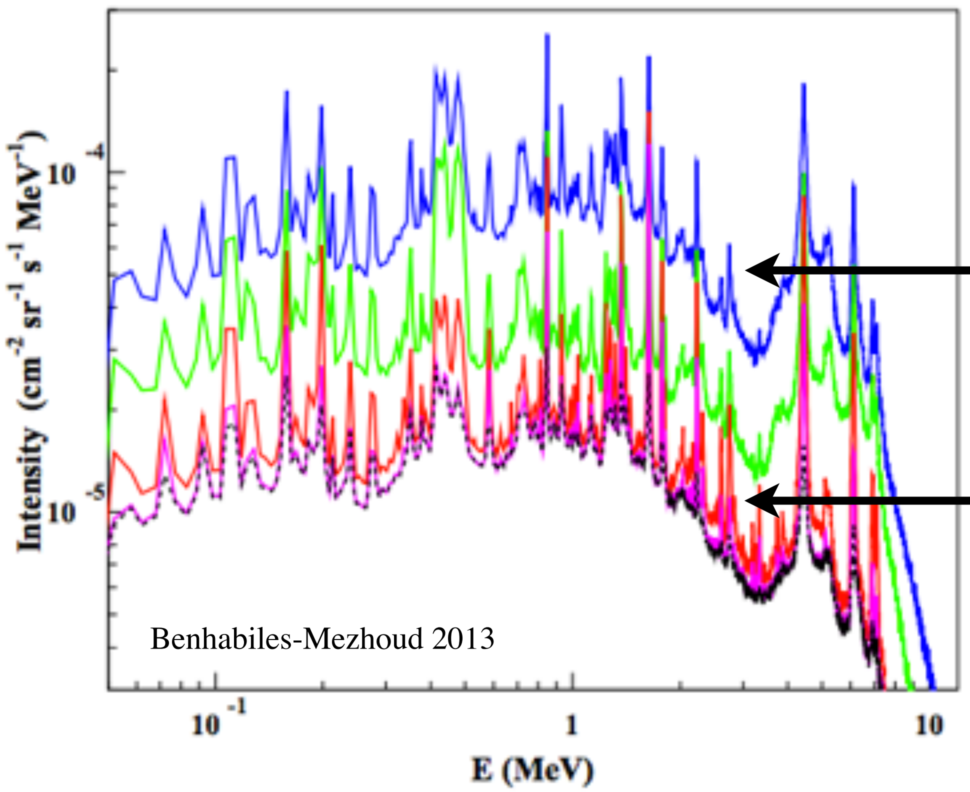
H_3^+: cosmic-ray ionization rate



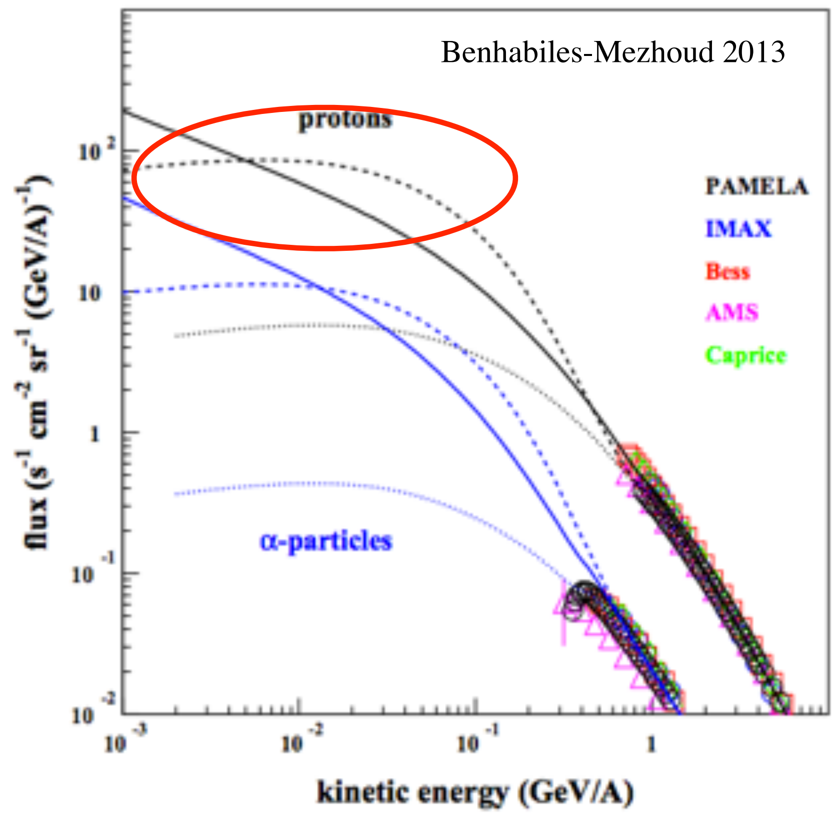
The cosmic-ray ionization rate (ζ2) is about one order of magnitude larger than previously thought.



extra low E CR

standard CR

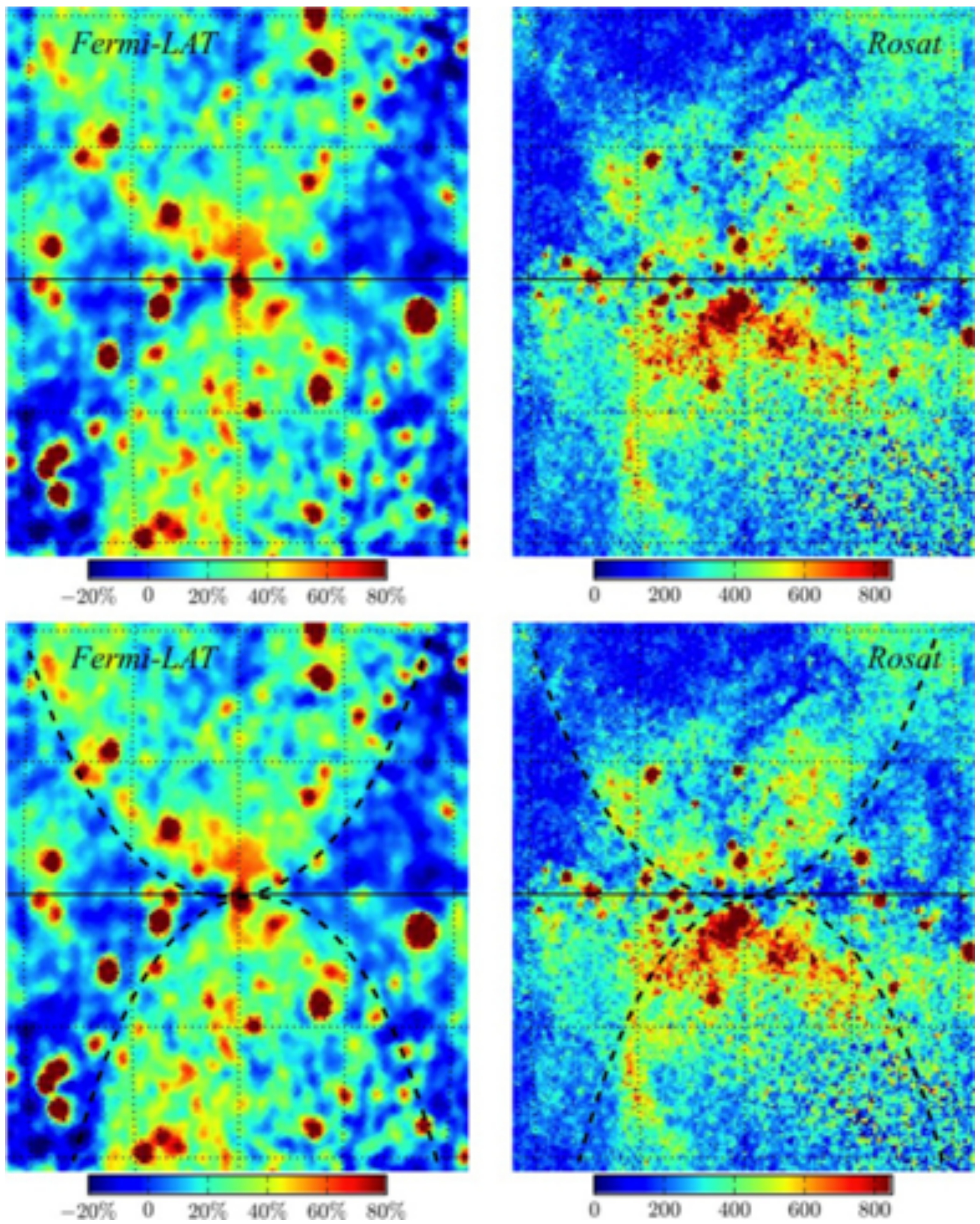
Low-energy extra component of the proton spectra.



Fermi GC emission

Fermi and ROSAT

Fermi residuals in %



Rosat

E > 1.7 GeV

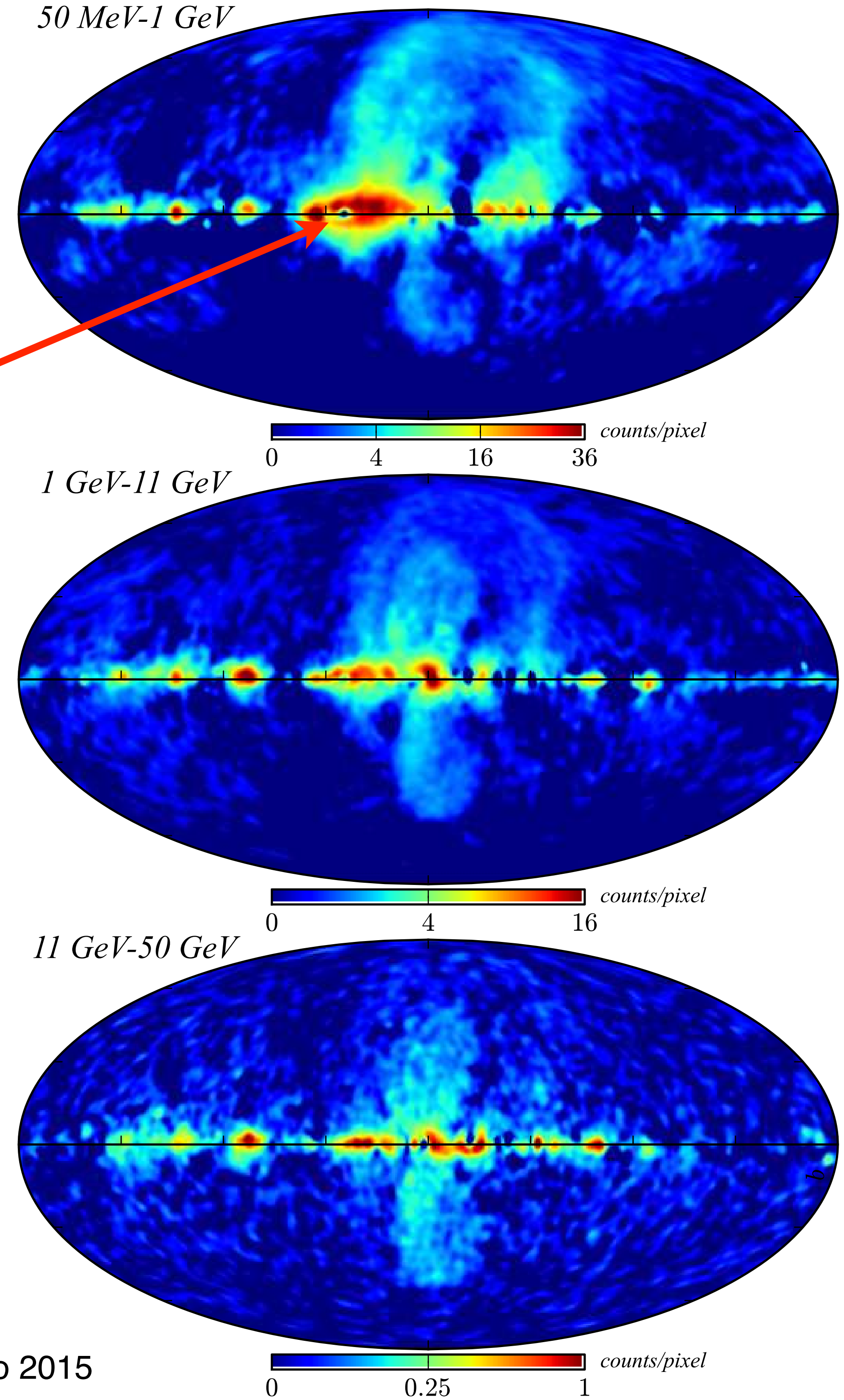
Acero 2015

→ Joined IC and bremsstrahlung analysis at low gamma-ray energy

casandjian arXiv:1502.07210

“un-modeled” Fermi emission

complicates faint point source studies

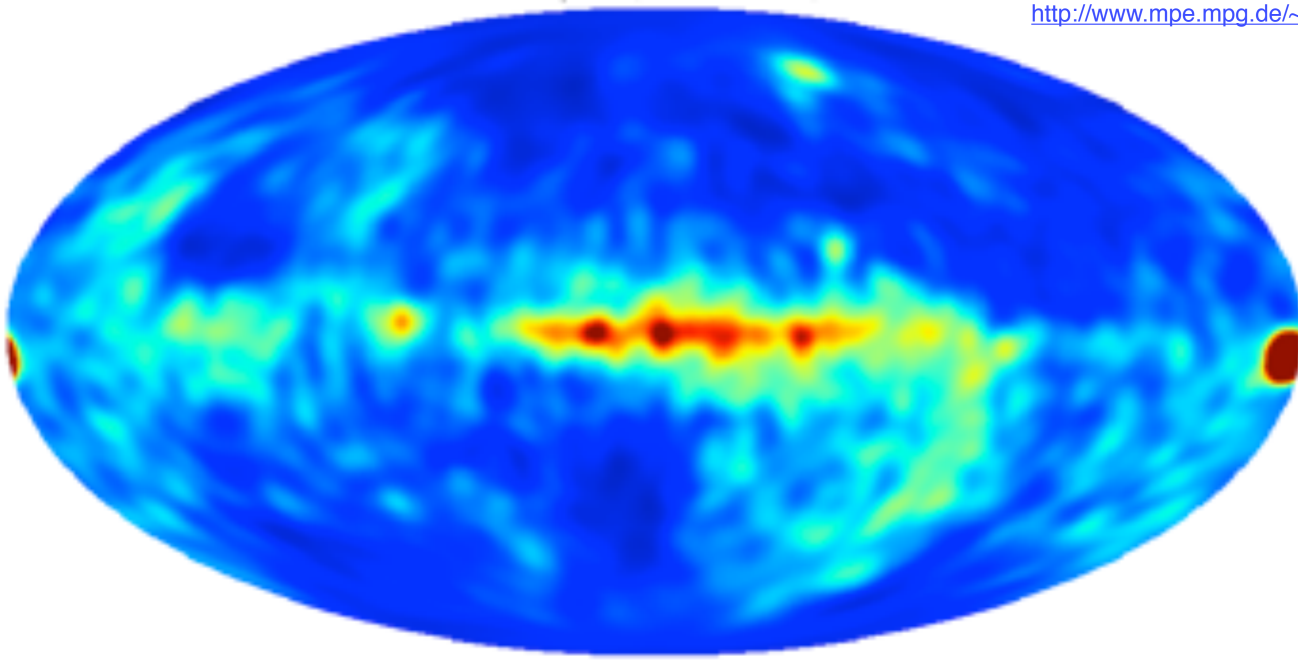


Acero 2015

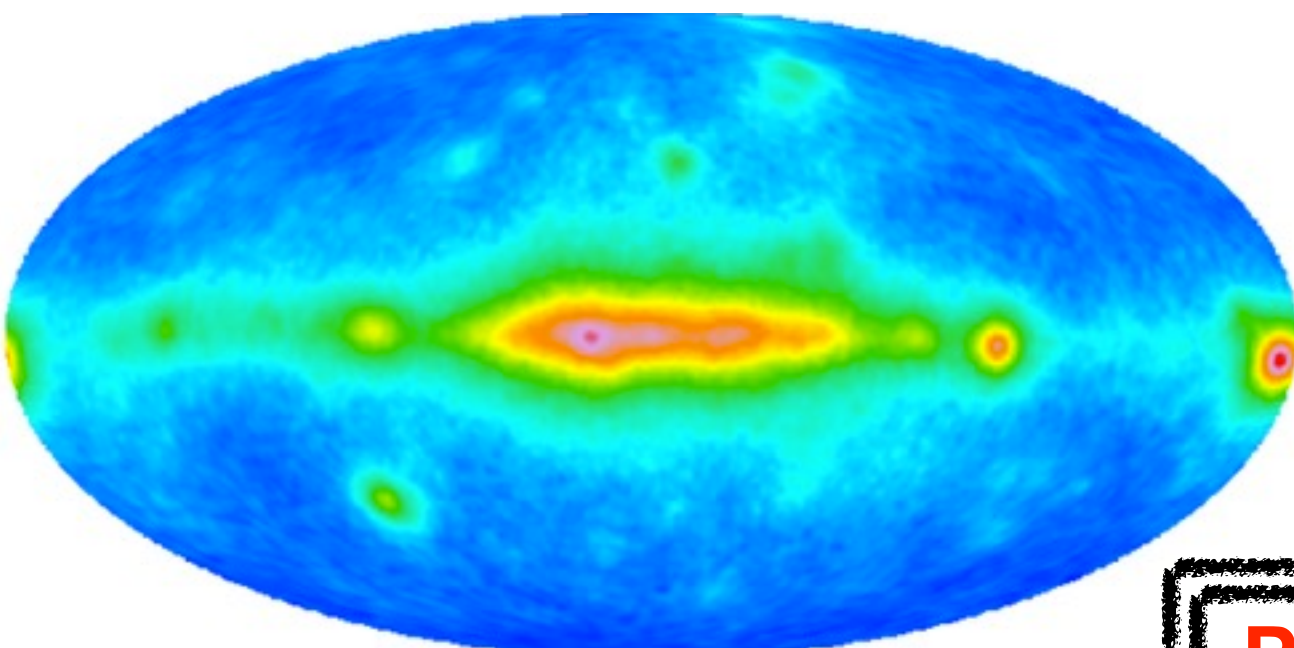
PSF versus Aeff

Comptel 1- 30 MeV, linear scaling

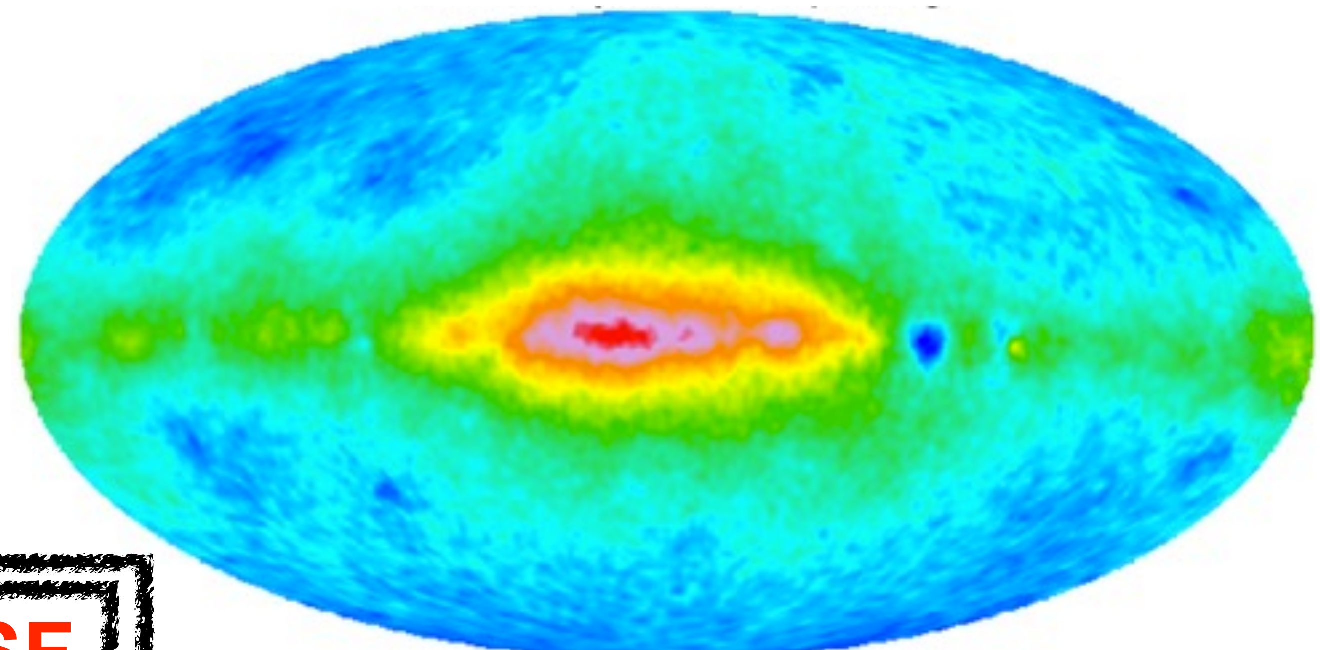
http://www.mpe.mpg.de/~aws/comptel/aws/skymos/skymos.html



Fermi-LAT counts, E=30-50 MeV, sqrt scaling



Fermi-LAT counts minus sources
E=30-50 MeV, sqrt scaling

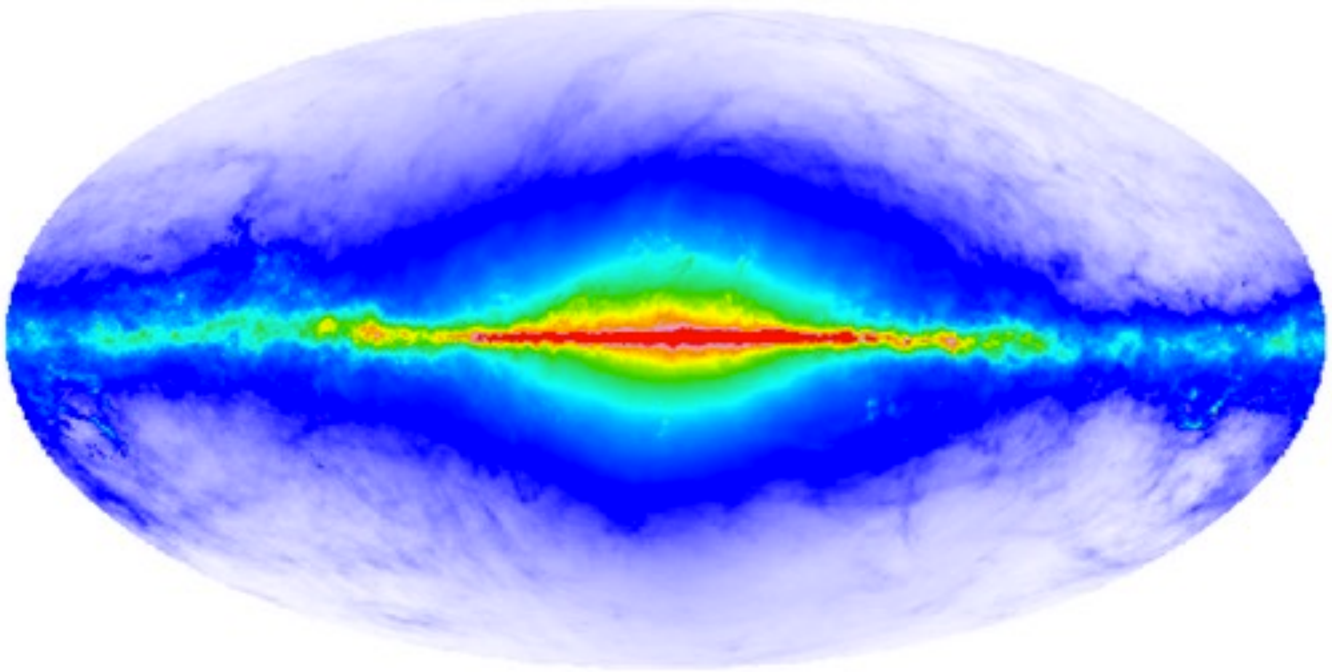


PSF

Extragalactic Gamma-ray Background

(see talk by Nachiketa Chakraborty)

Tentative of diffuse model at ~40 MeV:
large IC contribution



It will be very challenging to disentangle EGB and IC at high latitude !

Conclusions

Lot's of astrophysics can be done at low energy gamma-ray

We did learn a lot about ISM and CRs with Fermi.

MeV will give us access to the electrons and positions density in the local and outer Galaxy and clouds.

It should be possible to model the diffuse emission for point-source extraction.

IC has a smooth spatial structure, it is difficult to model, it should be ok for point sources but a problematic background for extended sources.

From Fermi we know a good PSF helps a lot to study the interstellar emission.