



Fermi  
Gamma-ray Space Telescope

**SciNeGHE 2009  
Assisi, October 7<sup>th</sup>**

***Fermi* measurements of  
diffuse gamma-ray emission:  
results at the first-year  
milestone**

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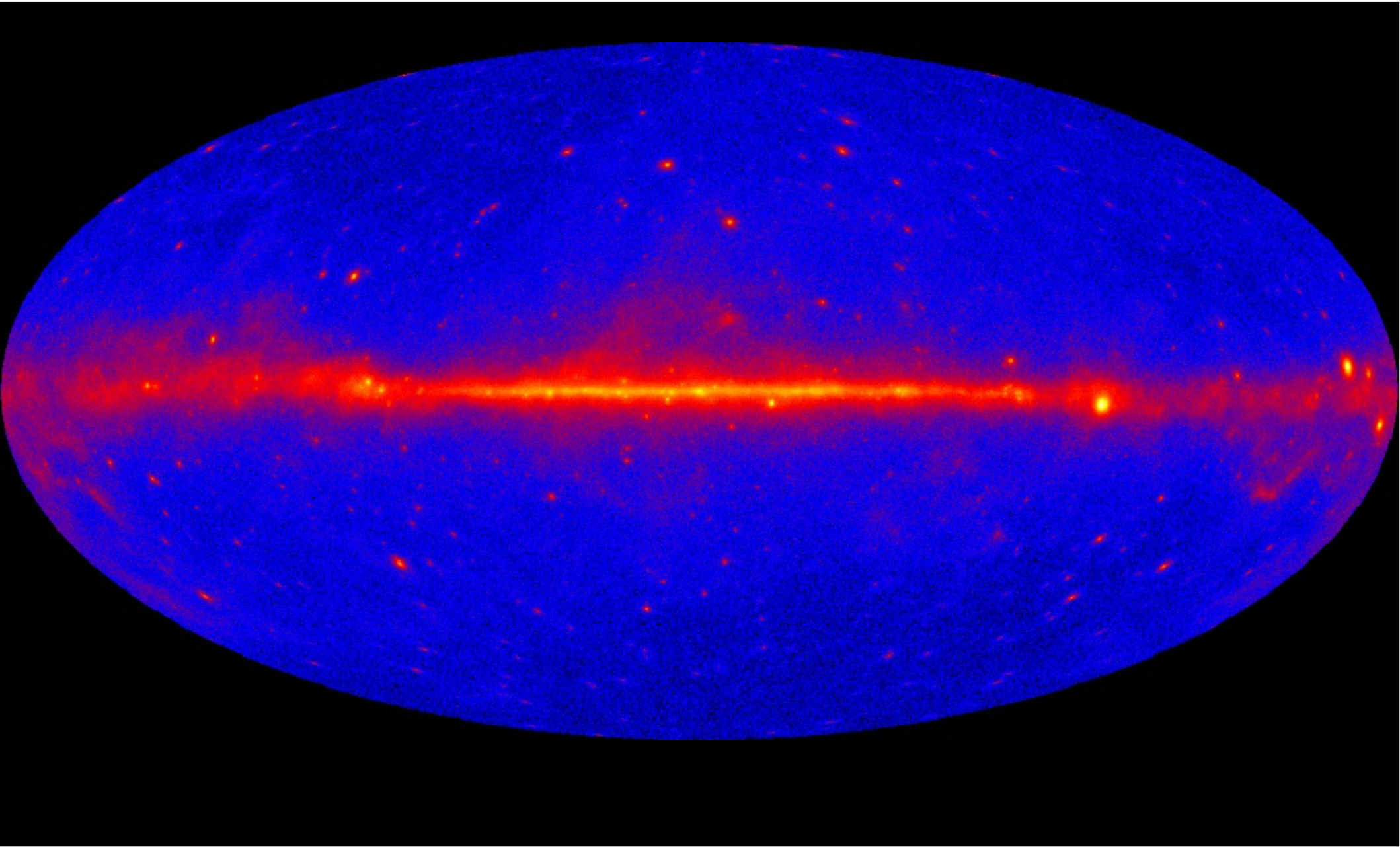
**for the diffuse emission  
working group**

**on behalf of the  
*Fermi* LAT Collaboration**

# What is gamma-ray diffuse emission?



# The LAT gamma-ray sky ...

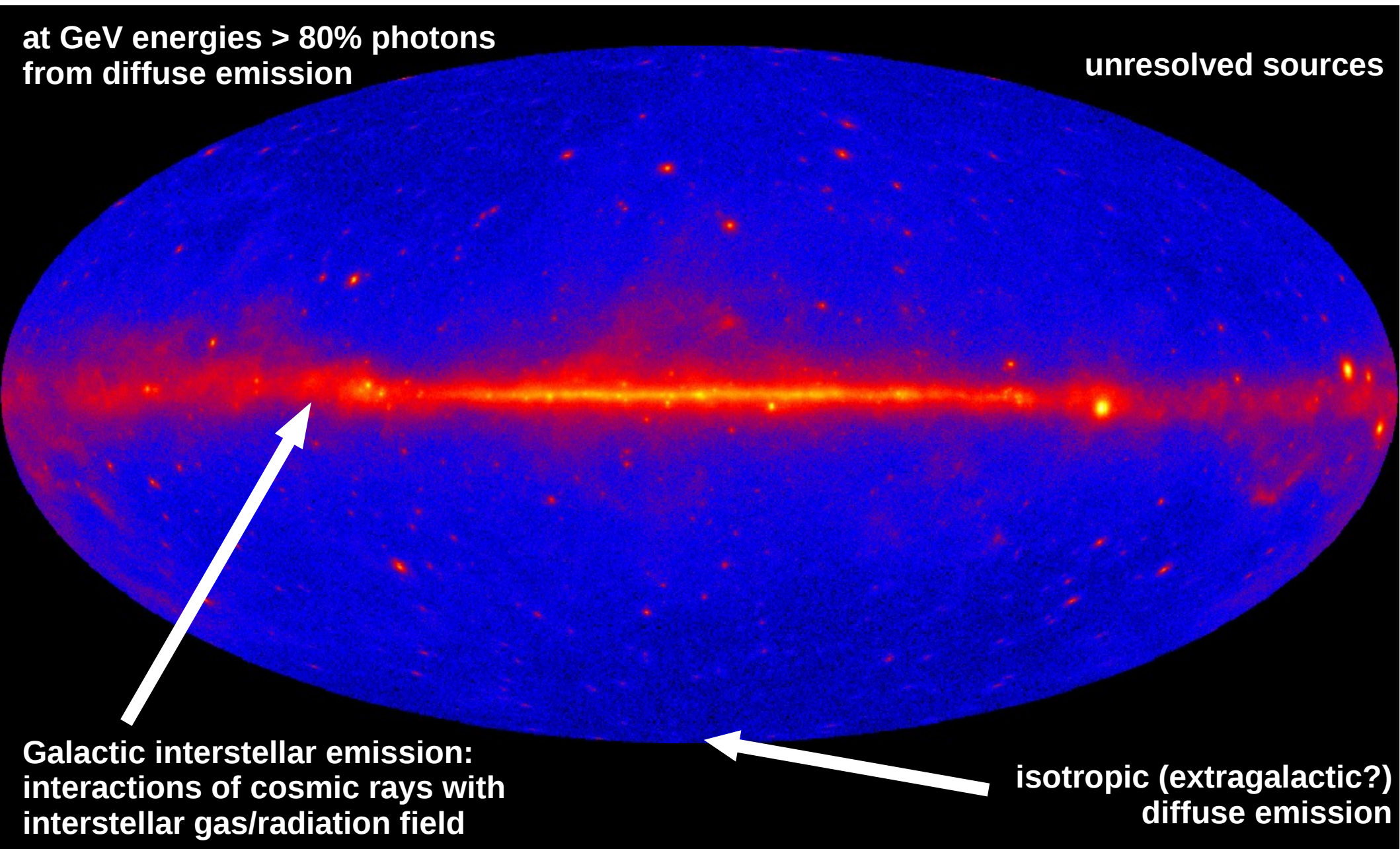




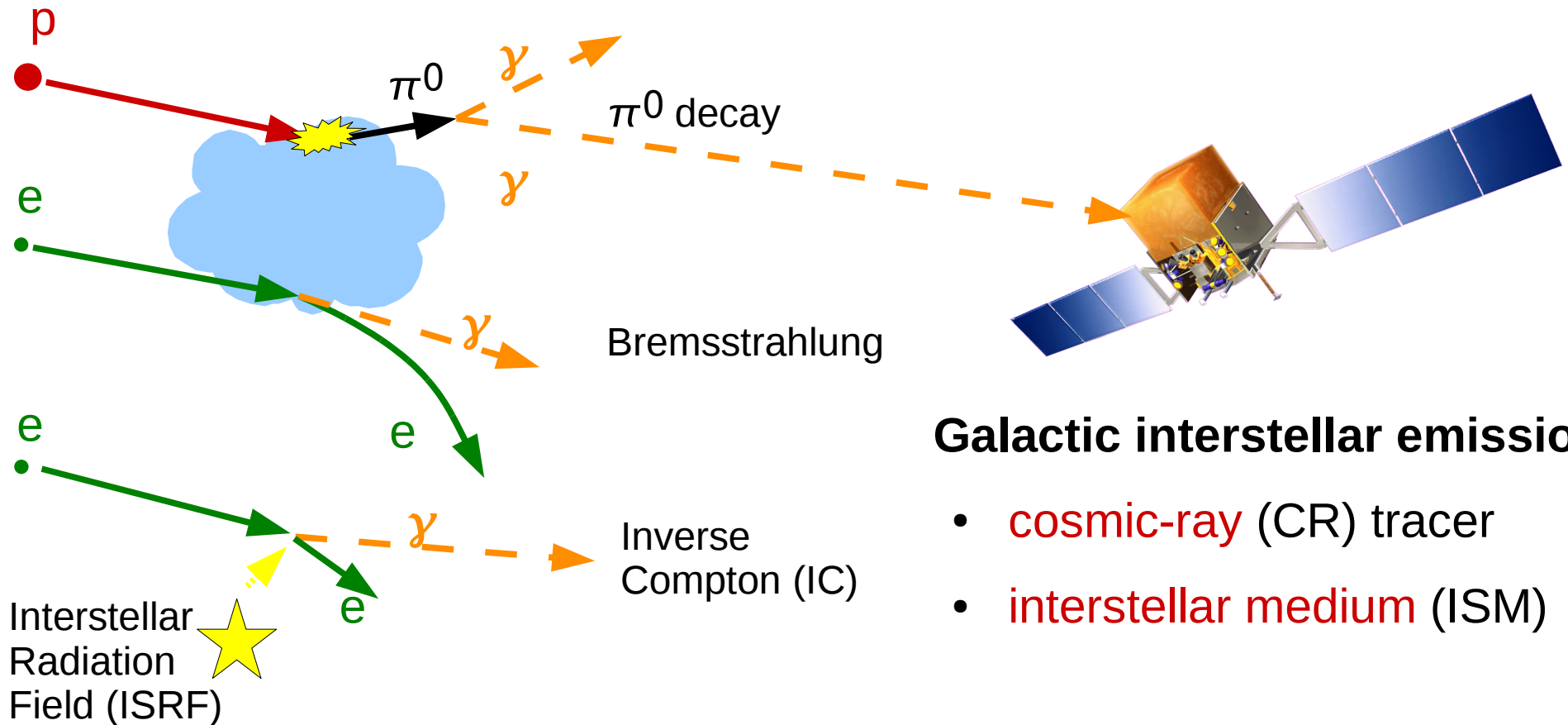
# Diffuse gamma-ray emission

at GeV energies > 80% photons  
from diffuse emission

unresolved sources



# Galactic interstellar gamma-ray emission



## Galactic interstellar emission:

- **cosmic-ray** (CR) tracer
- **interstellar medium** (ISM)

## Galactic interstellar emission:

- background for source detection/characterization
- foreground for isotropic diffuse emission
- hide signals of exotic processes (dark matter)?

# Modelling the Galactic interstellar emission

## Ingredients available:

- CR at Earth
- candidate CR sources
- propagation mechanisms
- cross sections
- interstellar gas
- ISRF
- magnetic field
- ...

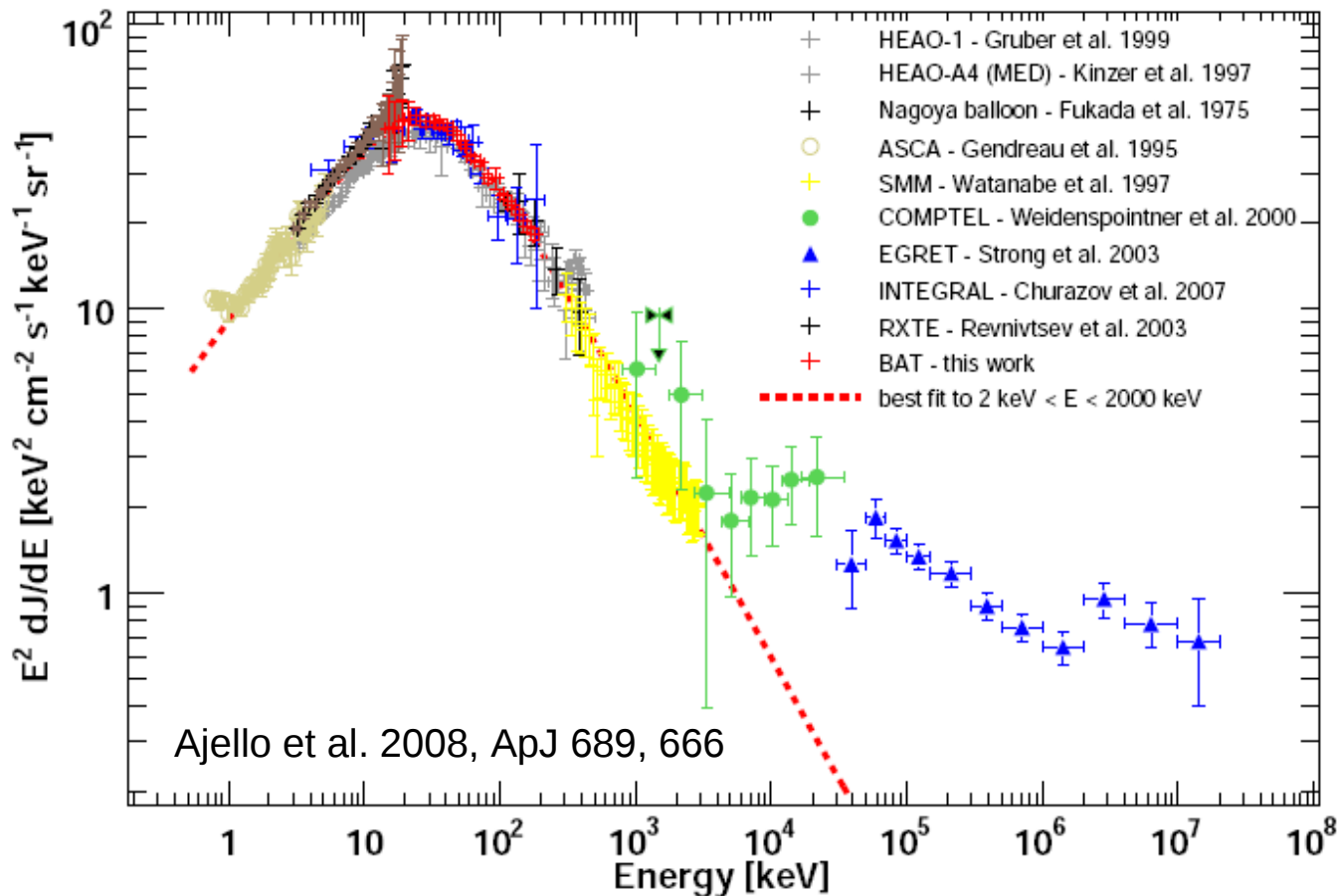


## A possible recipe: GALPROP

(e.g. Strong & Moskalenko 1998, Strong 2007) numerical code for CR propagation in the Galaxy



# Extragalactic Gamma-ray Background (EGB)



## Signals from early Universe???

- baryon-antibaryon
- dark matter
- primordial black-holes
- cosmic structures

Conventional astrophysical processes:

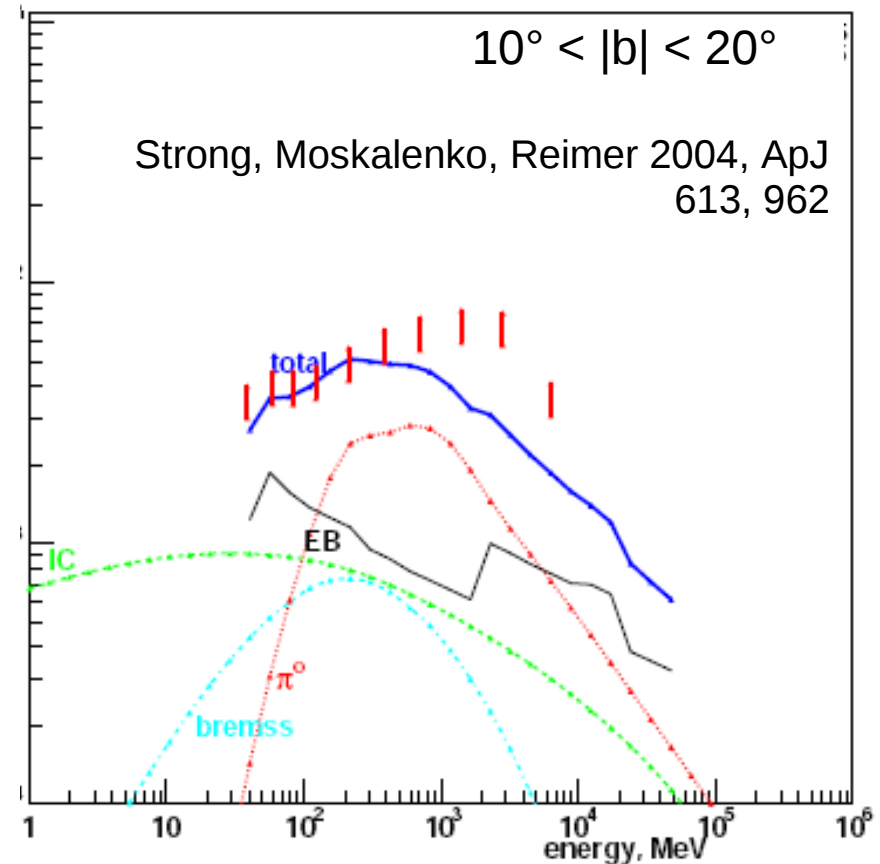
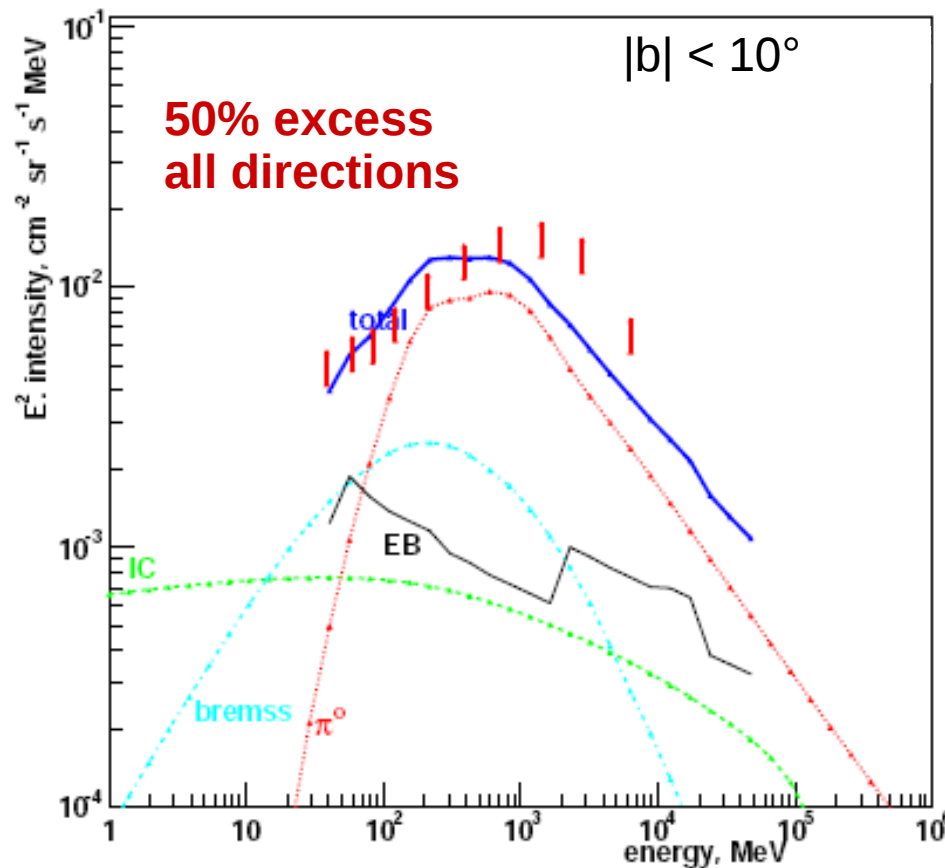
- populations of unresolved sources (AGNs, galaxies, ...)
- debris in the neighborhood of the the Solar system
- distant GRBs ...

# Galactic interstellar emission

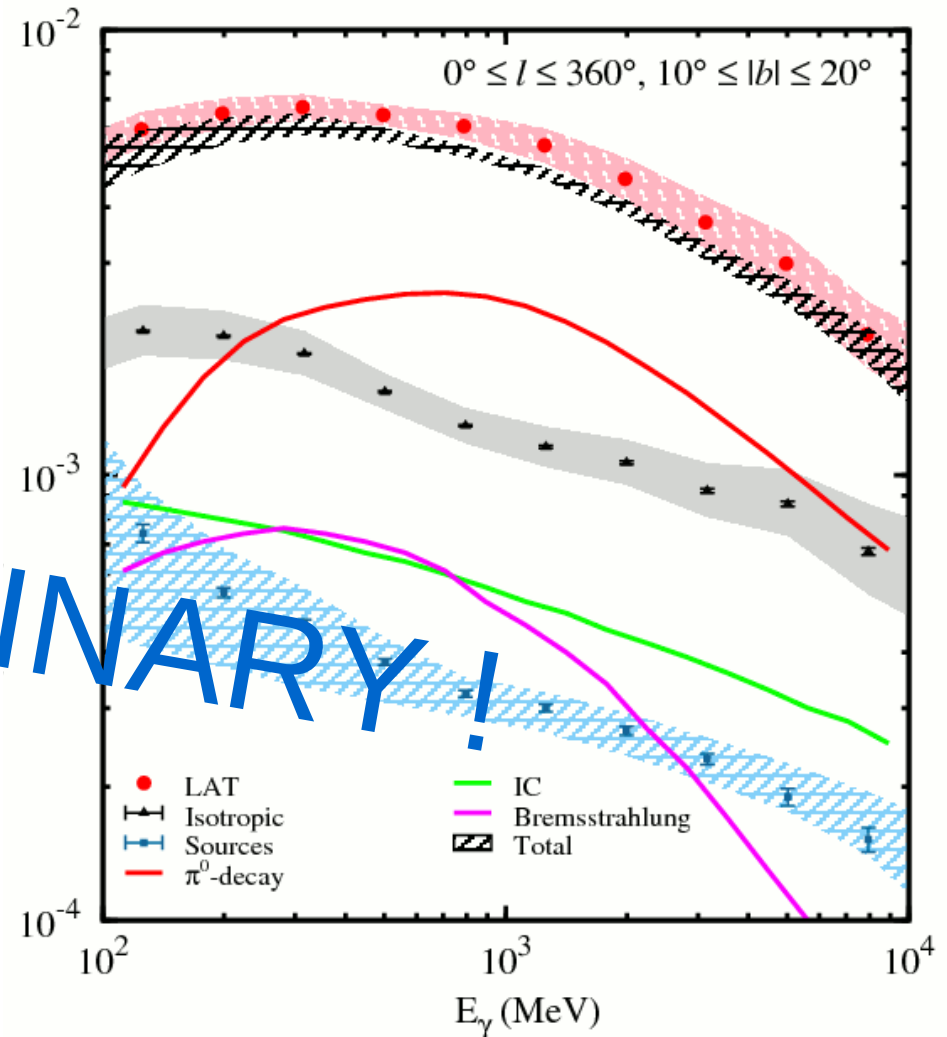
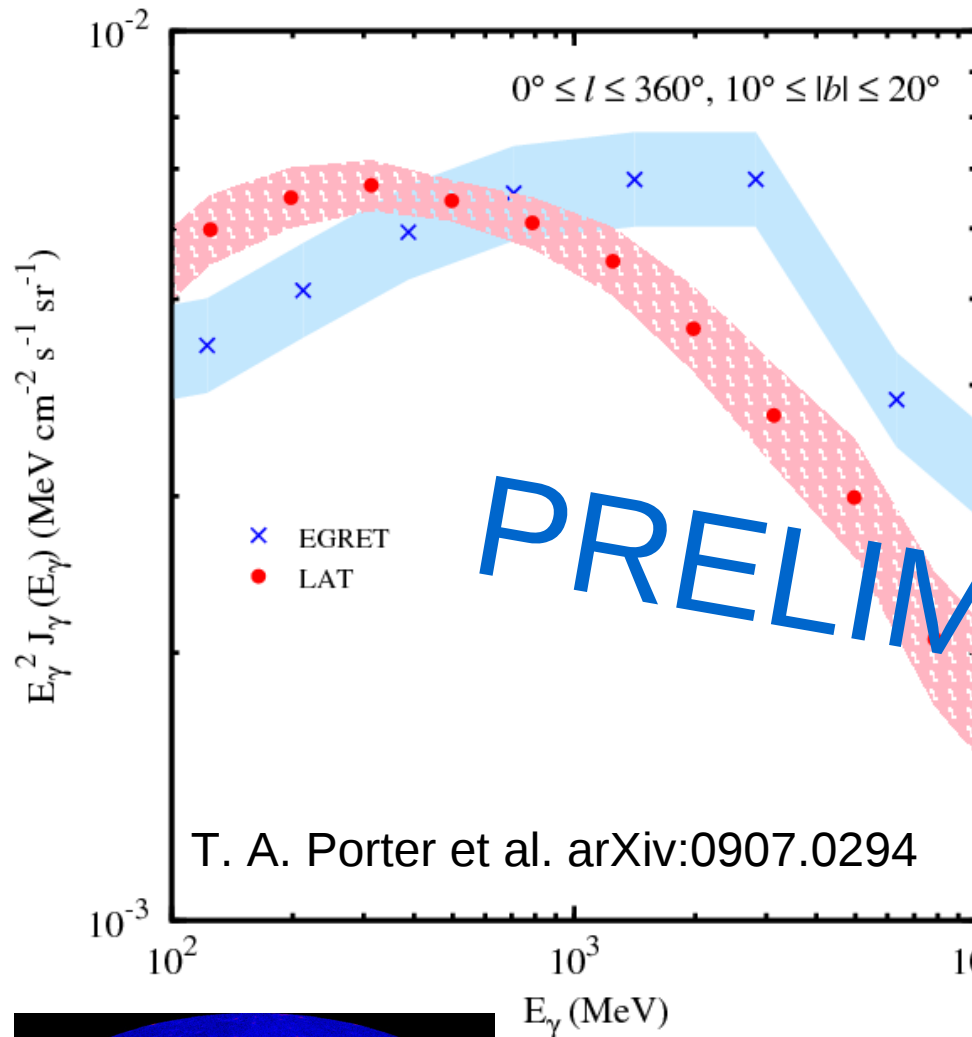


# The EGRET GeV excess

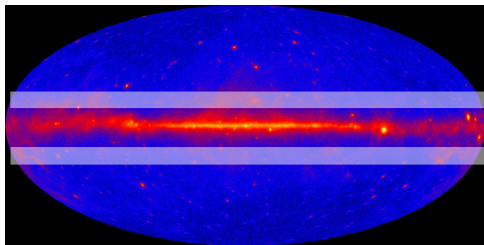
- excess of emission  $> 1$  GeV w.r.t. models based on locally measured CR spectra
- different interpretations: instrument, CRs, dark matter ...



# Fermi view at intermediate latitudes

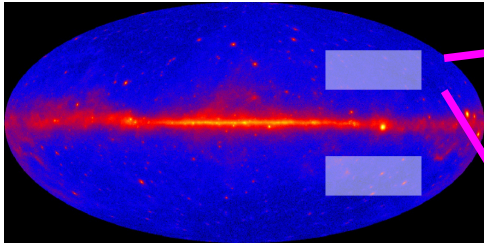


PRELIMINARY!



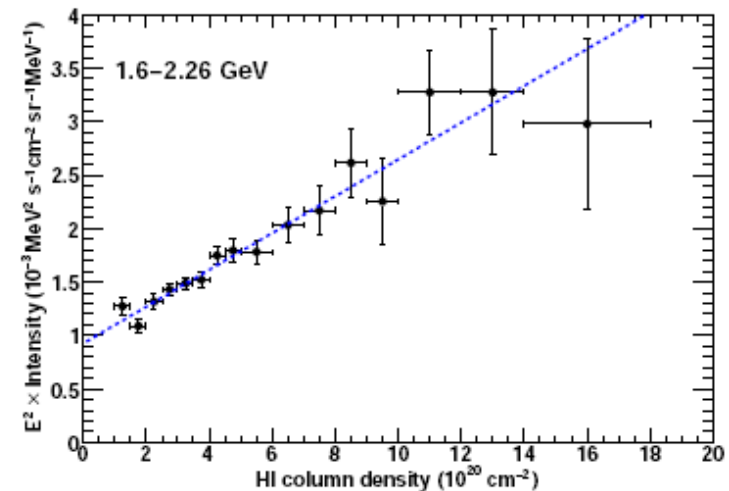
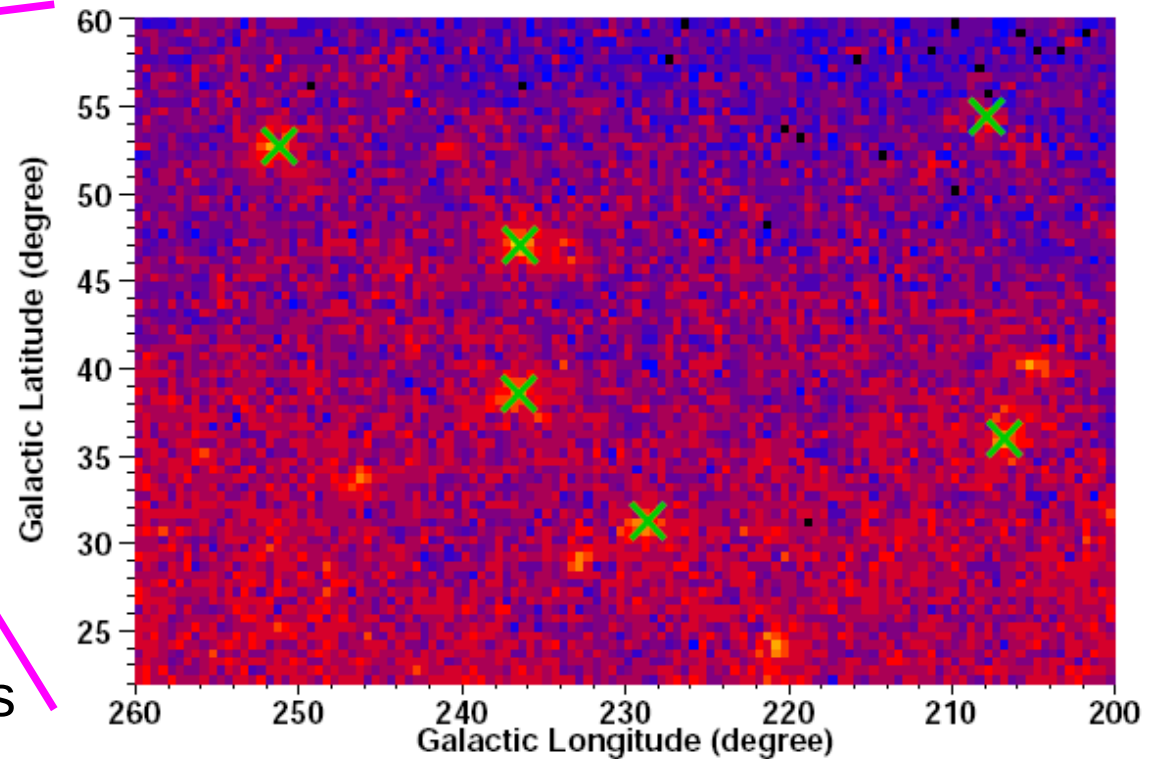
Gamma-ray emission from local interstellar medium APPROXIMATELY explicable on the basis of directly measured CRs.

# Extracting the emissivity of local H I



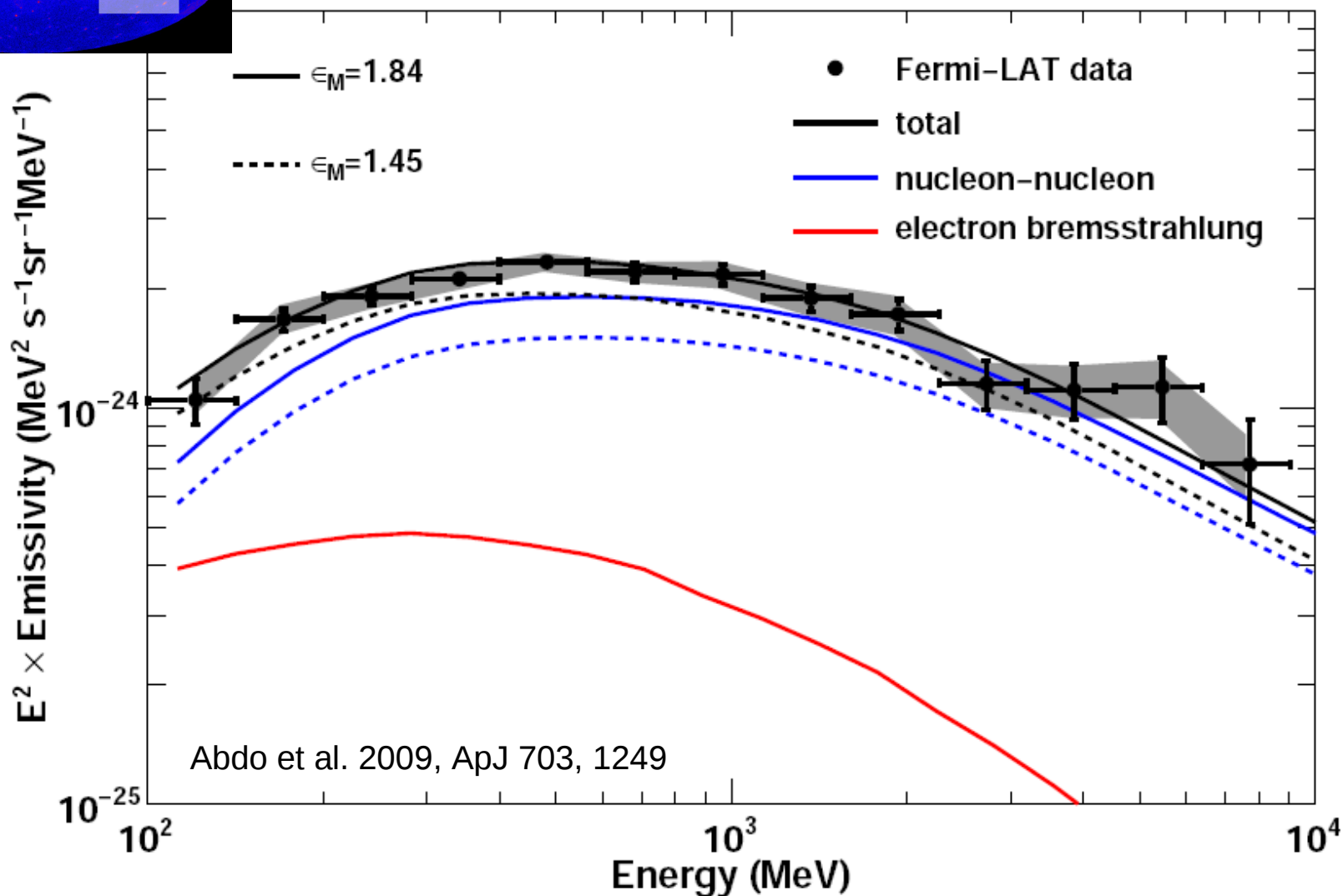
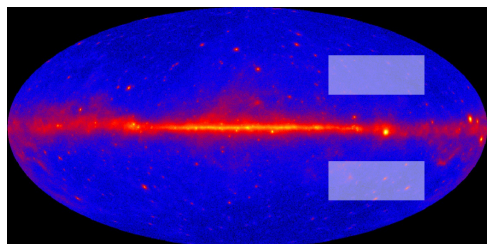
$$200^\circ < l < 260^\circ$$
$$22^\circ < |b| < 60^\circ$$

- region with no molecular gas
- atomic gas within 1 kpc from Sun
- point sources masked, spill-over subtracted
- IC subtracted (GALPROP)
- Emission intensity versus  $N(\text{H I})$



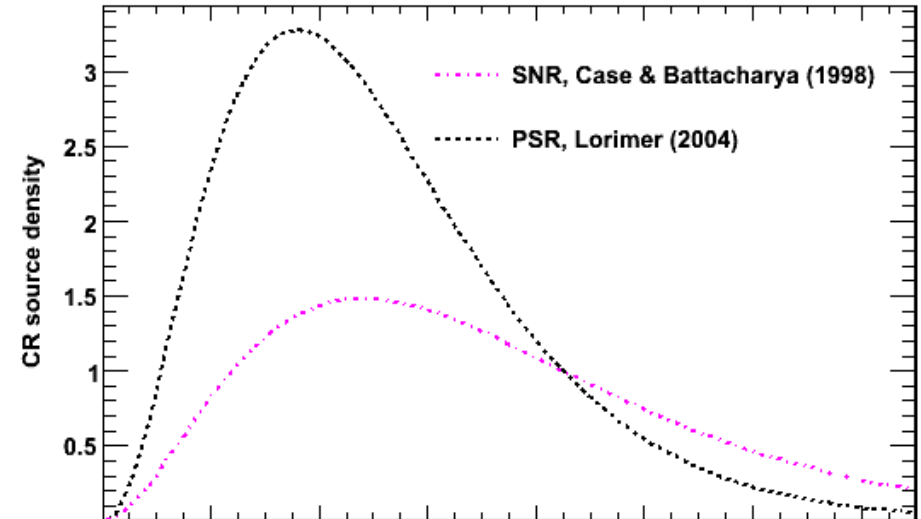


# Local H I emissivity

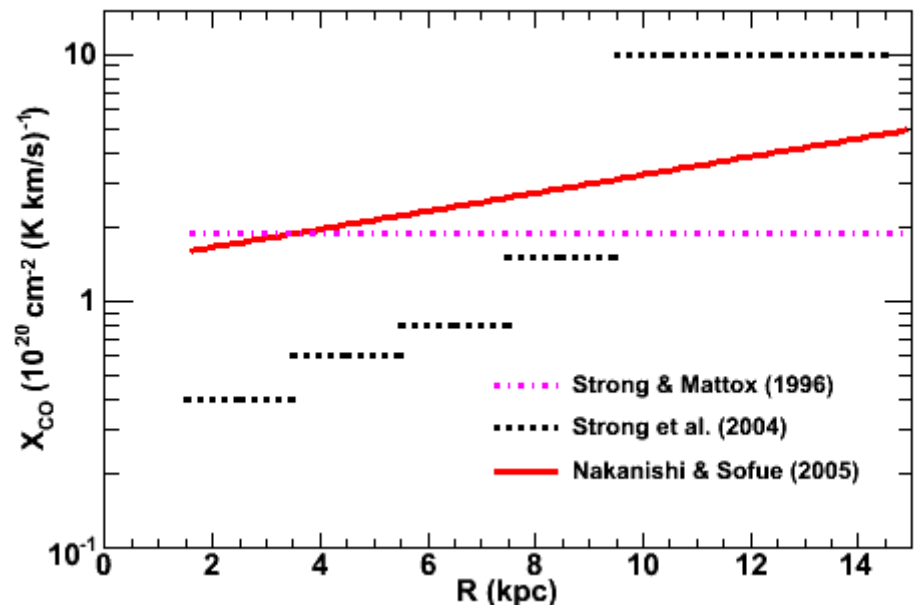


# CR sources and molecular masses

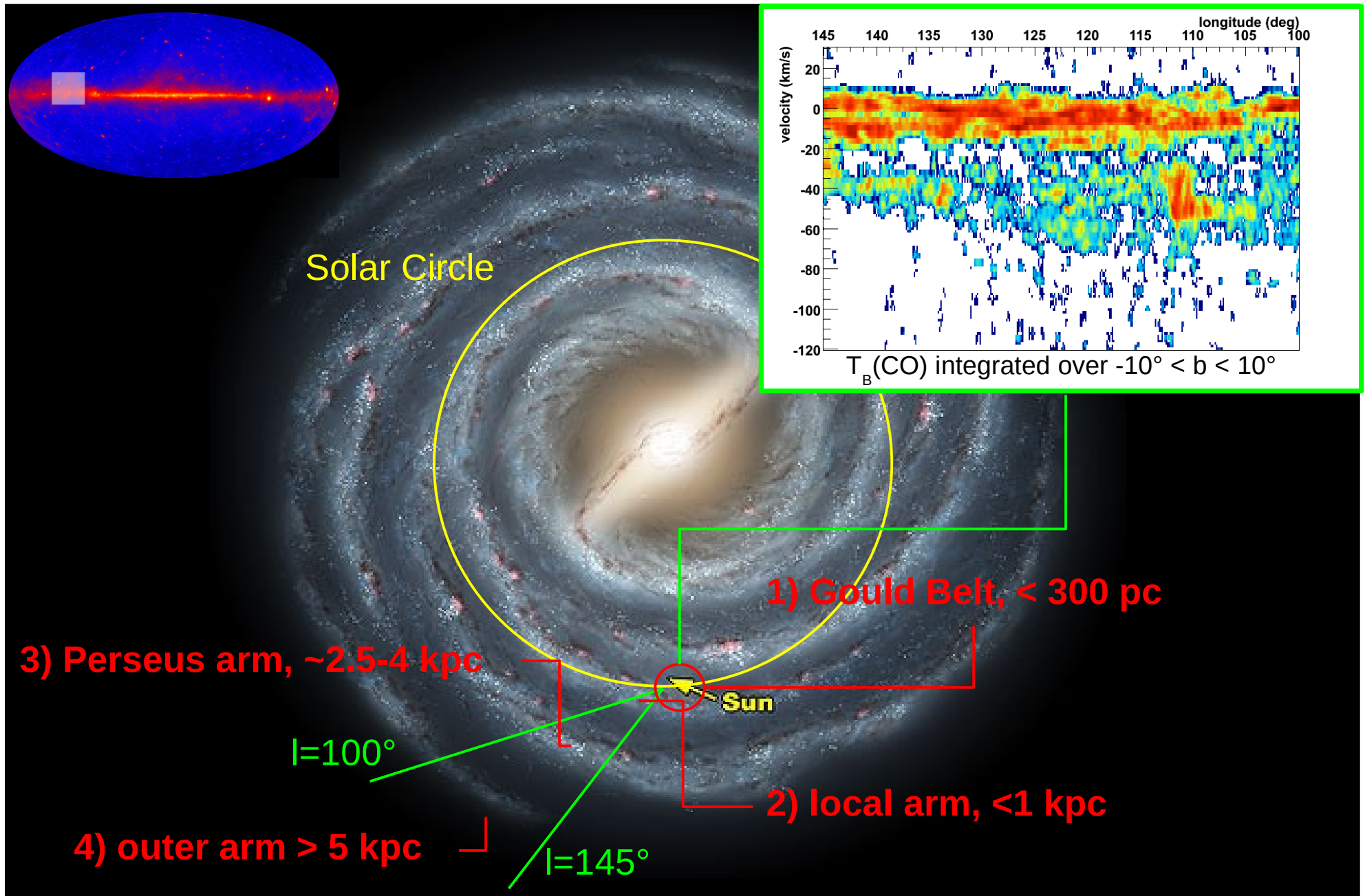
- CR sources:
  - × still mysterious
  - × large uncertainties on SRN distribution
  - × PSR?



- molecular gas:
  - ×  $H_2$  does not have emission lines we can observe
  - × CO indirect tracer
  - ×  $X_{CO} = N(H_2)/W_{CO}$

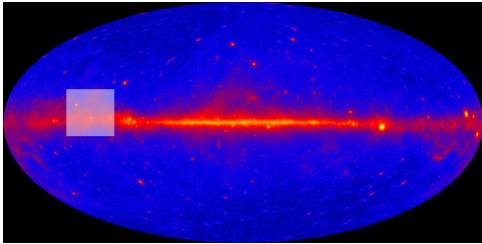


# Exploring the outer Galaxy: Cas & Cep





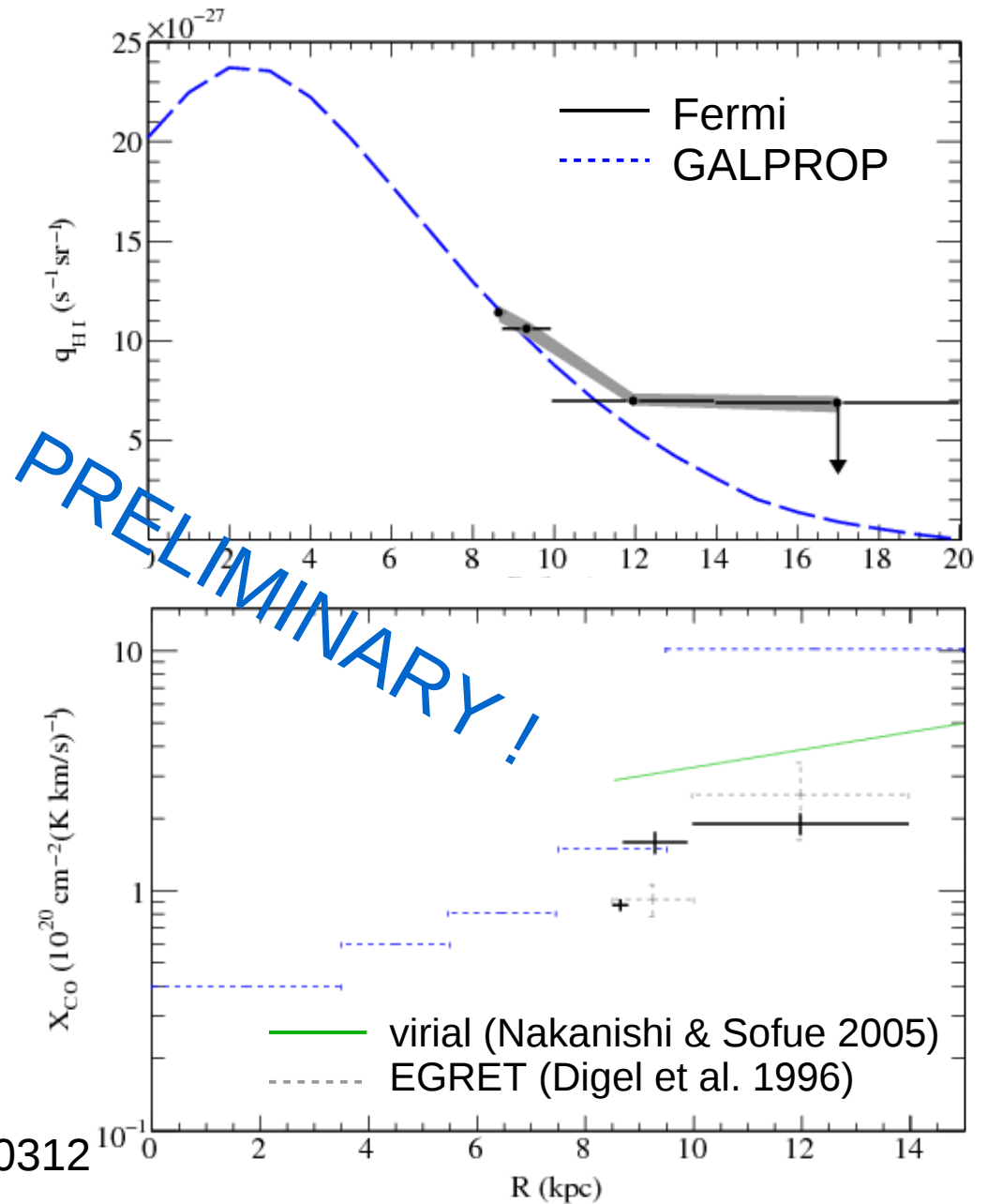
# CRs and molecular clouds in the outer Galaxy



- Decrease of CR densities, but gradient flatter than expectations for SNR sources (as traced by PSR)

- Increase of  $X_{\text{CO}}$  by a factor  $\sim 2$  from Gould Belt to Perseus arm

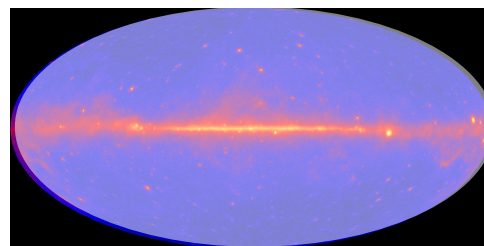
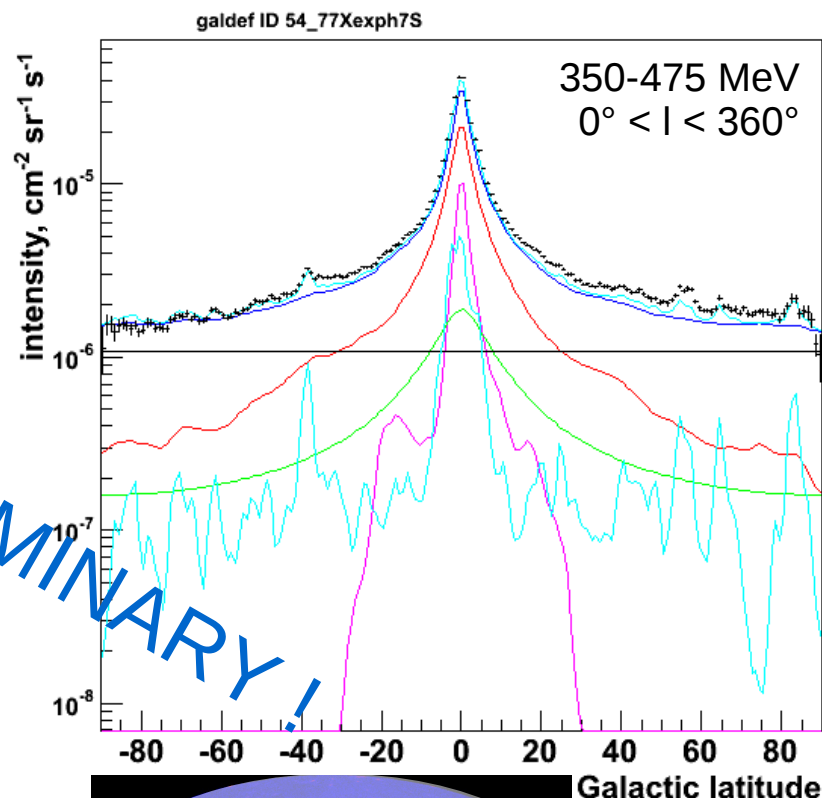
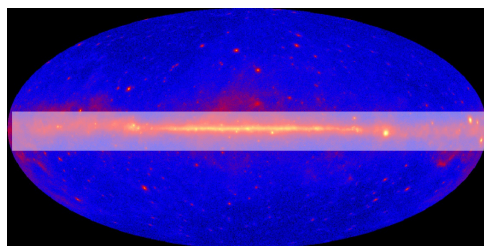
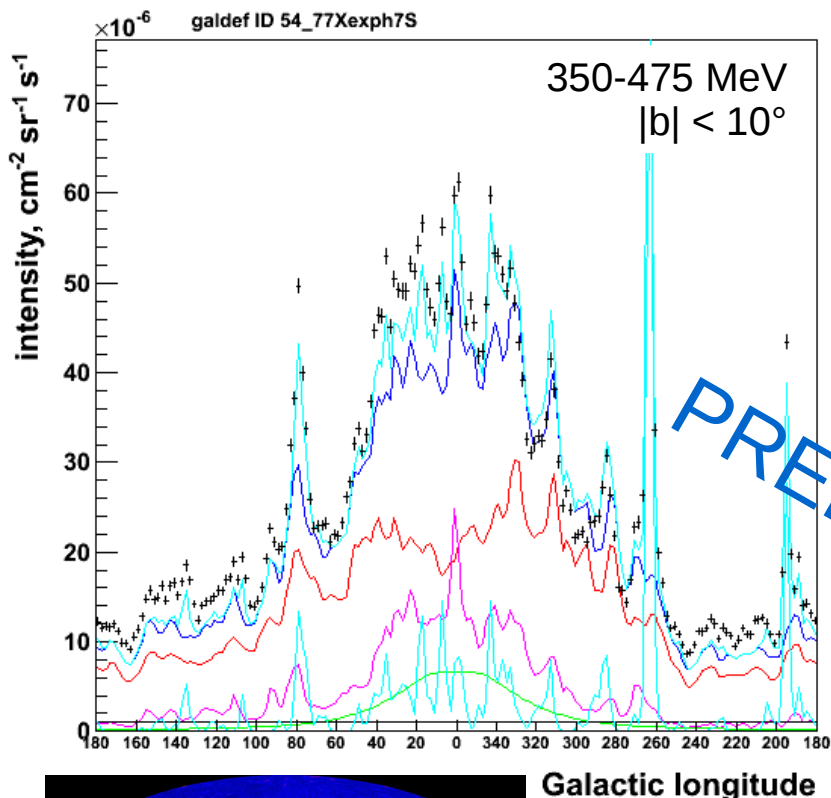
Analysis method described in  
L. Tibaldo, I. A. Grenier et al. arXiv:0907.0312



# Toward a large-scale model ...

- putting together what we have learnt
- still ongoing work!

- pion decay
- Bremsstrahlung
- IC
- total diffuse
- sources (total+sources)

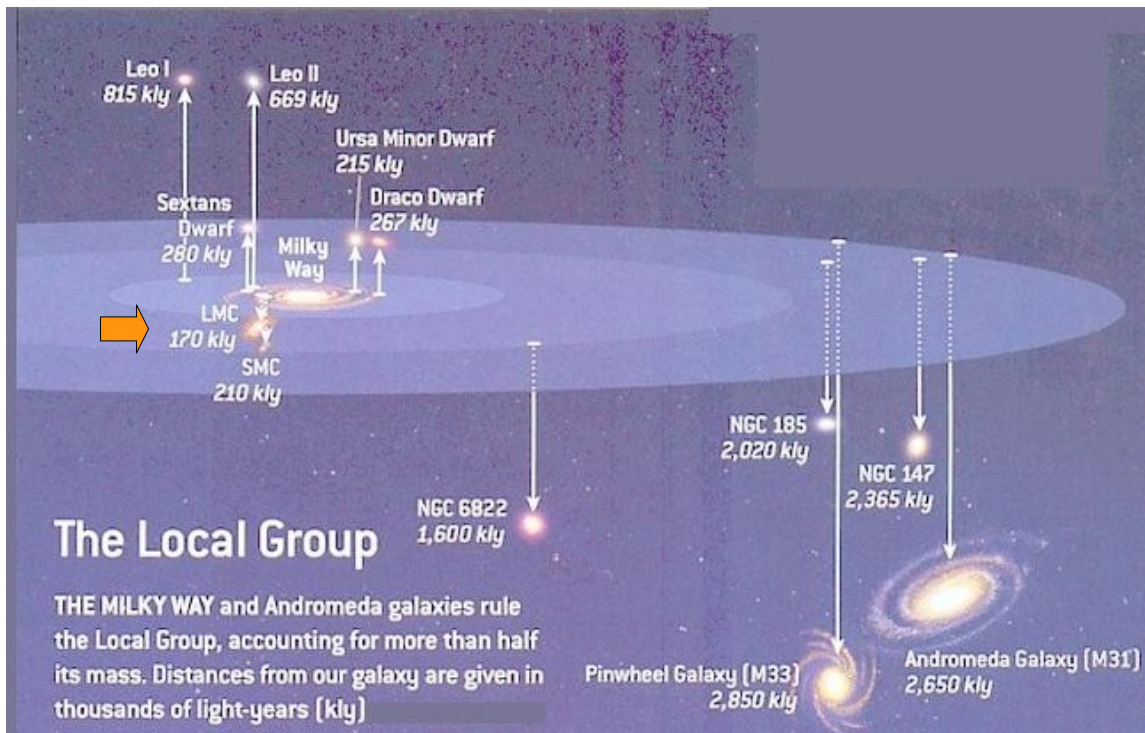


PRELIMINARY!

# Beyond the Milky Way



# The local group of Galaxies

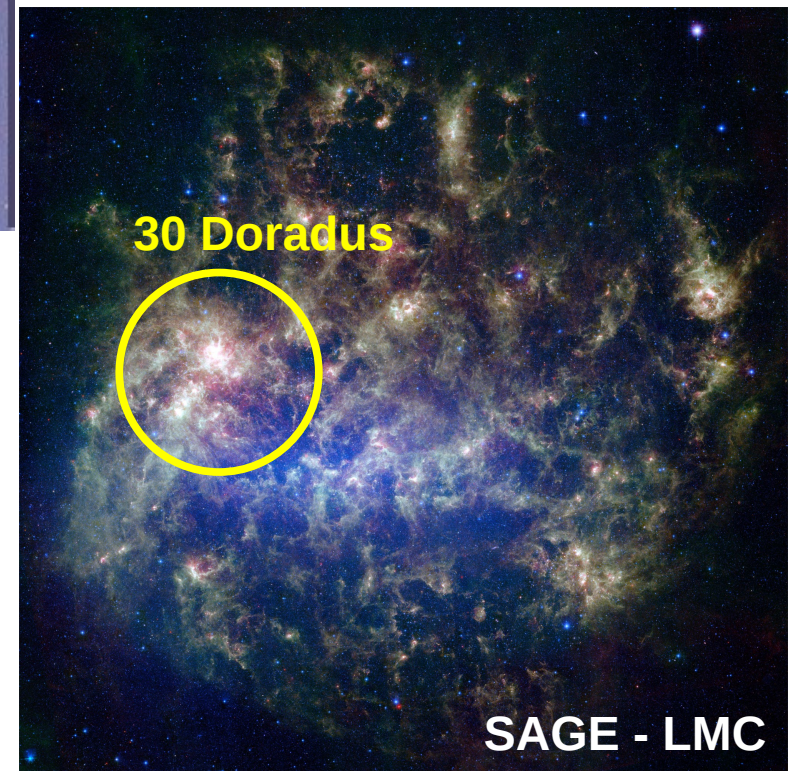


LMC:

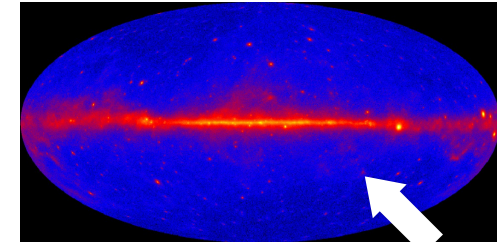
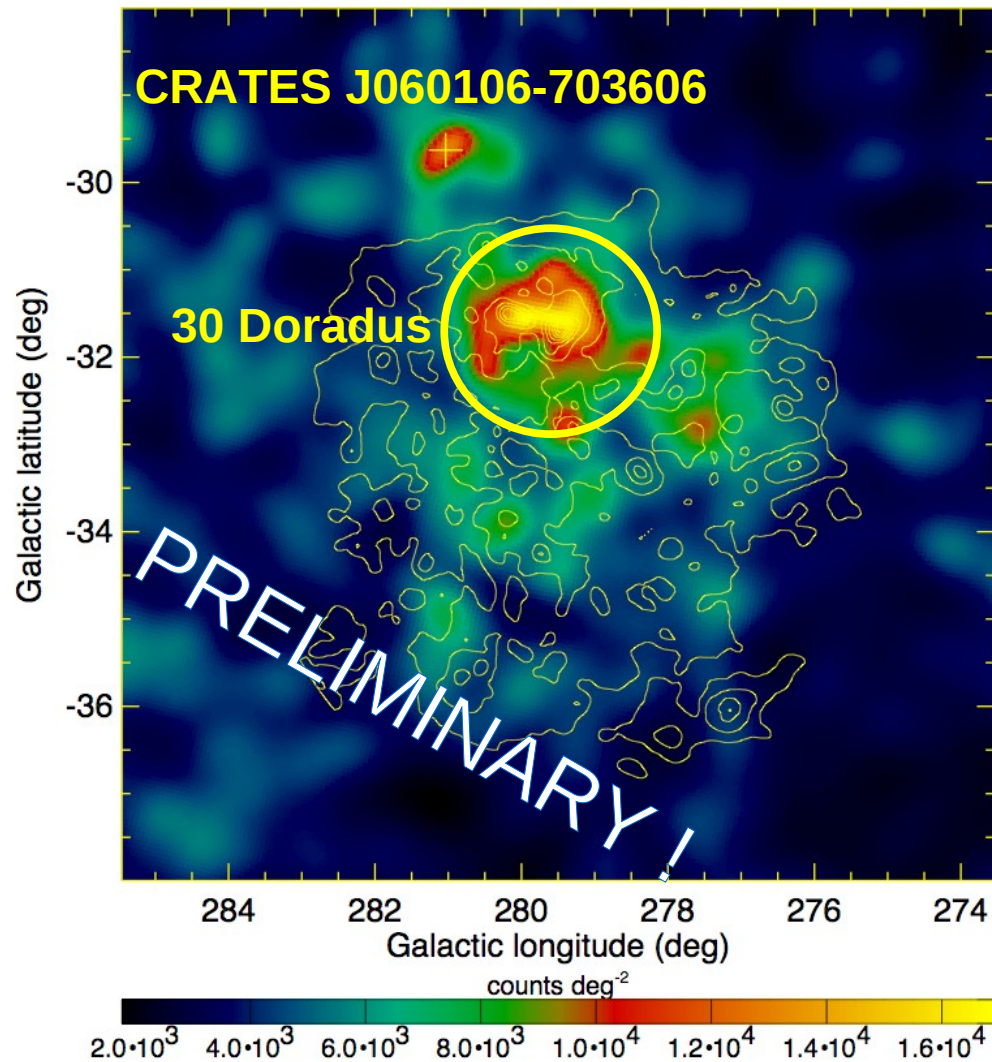
- seen by face ( $27^\circ$ )
- 50 kpc far away
- star formation

EGRET:

- detection of LMC
- non detection of SMC (for CRs at Earth expected flux  $2.4 \cdot 10^{-7} \text{ cm}^{-2} \text{ s}^{-1}$ )  
⇒ evidence that CR are Galactic, not universal



# Fermi view of LMC

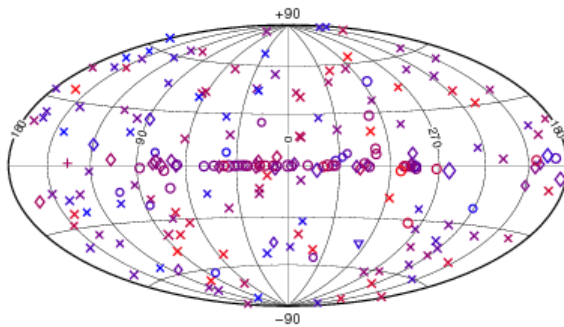
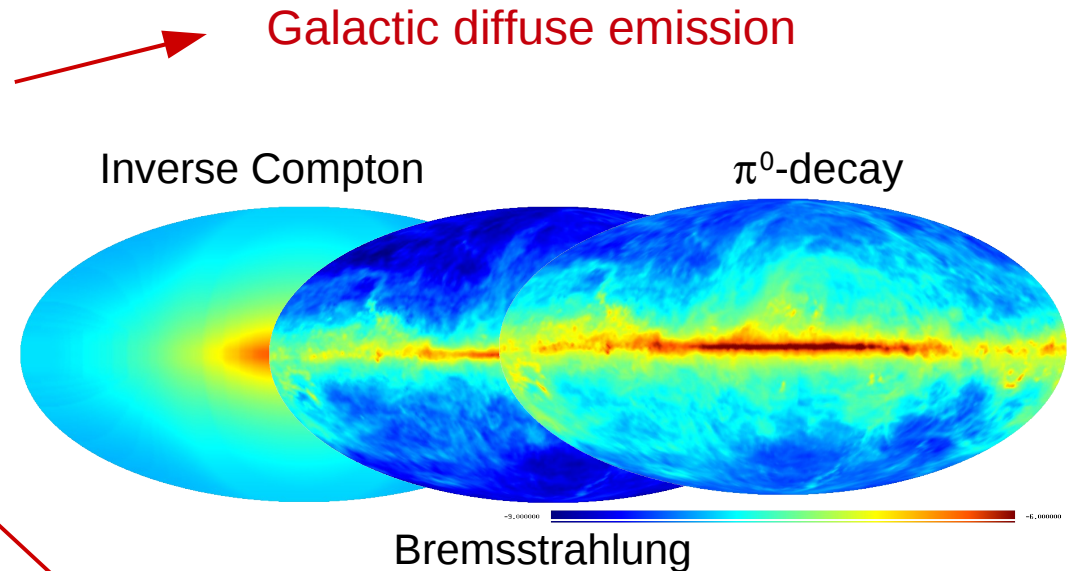
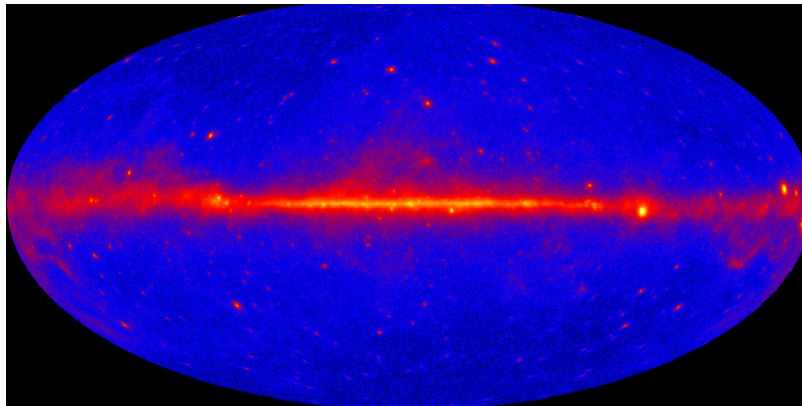


- 212 days of survey data
- first extragalactic object ever resolved in high-energy gamma rays
- 30 Doradus + interaction of CRs with gas

adaptively smoothed 100 MeV - 10 GeV counts map



# Hunting isotropic emission



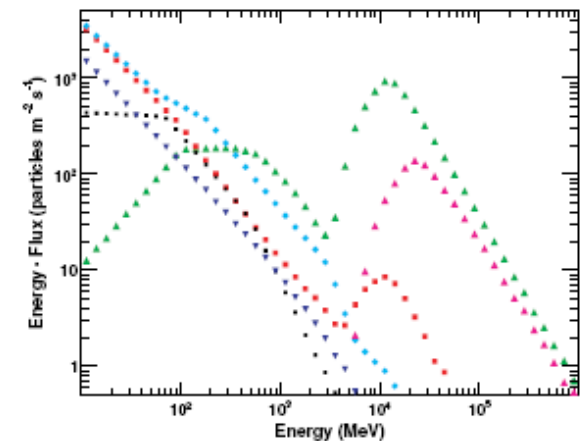
Resolved sources

What's left  
isotropic?

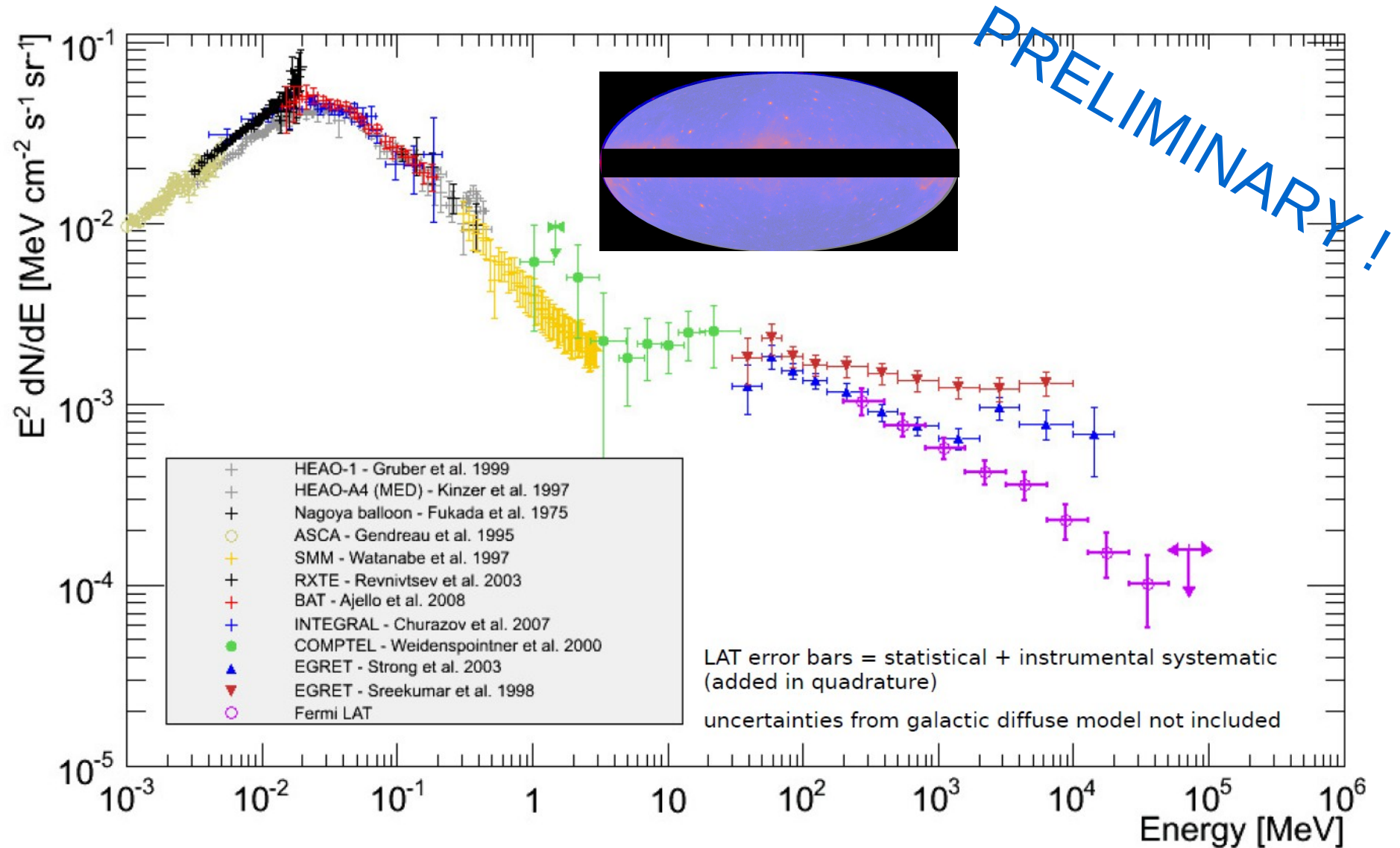
Residual background CRs  
misclassified as gamma-rays

misreconstructed gamma-rays  
from Earth albedo

Dedicated background  
rejection developed for EGB!



# Fermi EGB



**Stay tuned!**



# Concluding remarks

The poster features the Fermi satellite in space against a starry background. At the top, the word "Fermi" is written in a large, stylized font, with "Gamma-ray Space Telescope" underneath. Logos for NASA and the University of Maryland are in the top right. A curved banner at the bottom left shows flags of France, Germany, Italy, Japan, Sweden, and the USA, with the text "Fermi Symposium, 2-5 November 2009". In the center right, it says "The Symposium is being held at the Hyatt Regency on Capitol Hill in Washington DC". The bottom section is divided into two columns of names for the organizing committees.

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<http://fermi.gsfc.nasa.gov/science/symposium/2009/>

- local emission explicable in terms of CRs at Earth
- improved constraints for CRs and ISM on Galactic scale
- CRs in external Galaxies!
- new determination of EGB
- other studies (Orion clouds, outer Galaxy in the 3<sup>rd</sup> quadrant)
- more coming soon ...