



Observations of the Large Magellanic Cloud with Fermi

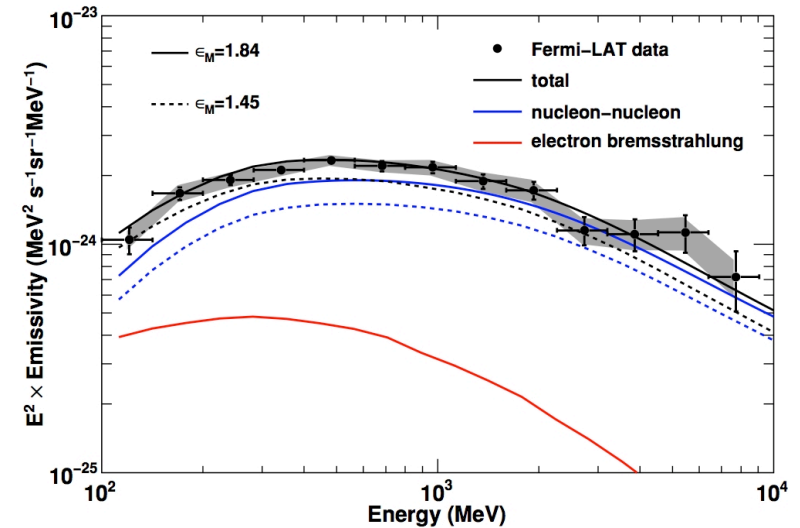
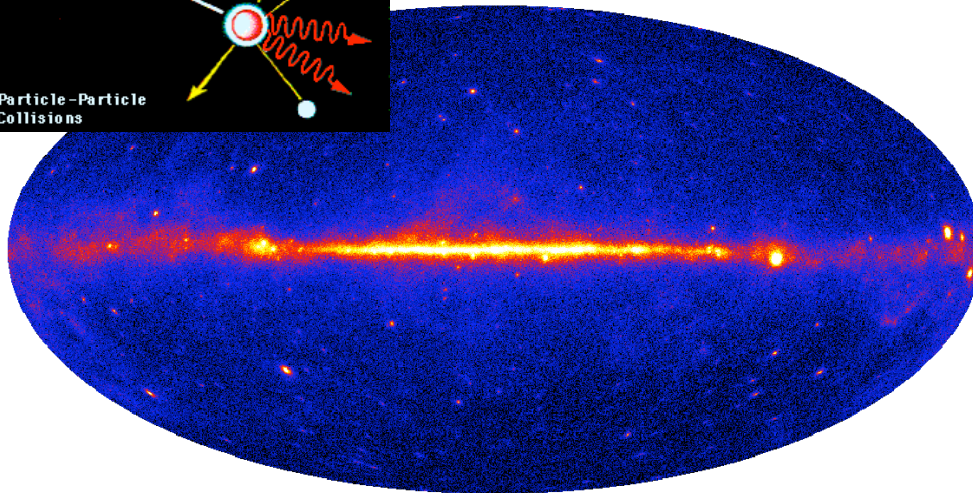
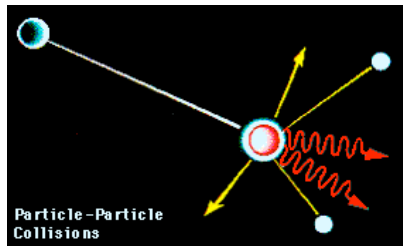
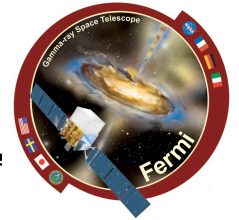
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**On behalf of the
Fermi/LAT collaboration**

Fermi Symposium @ Washington DC
(2009/11/2-5)

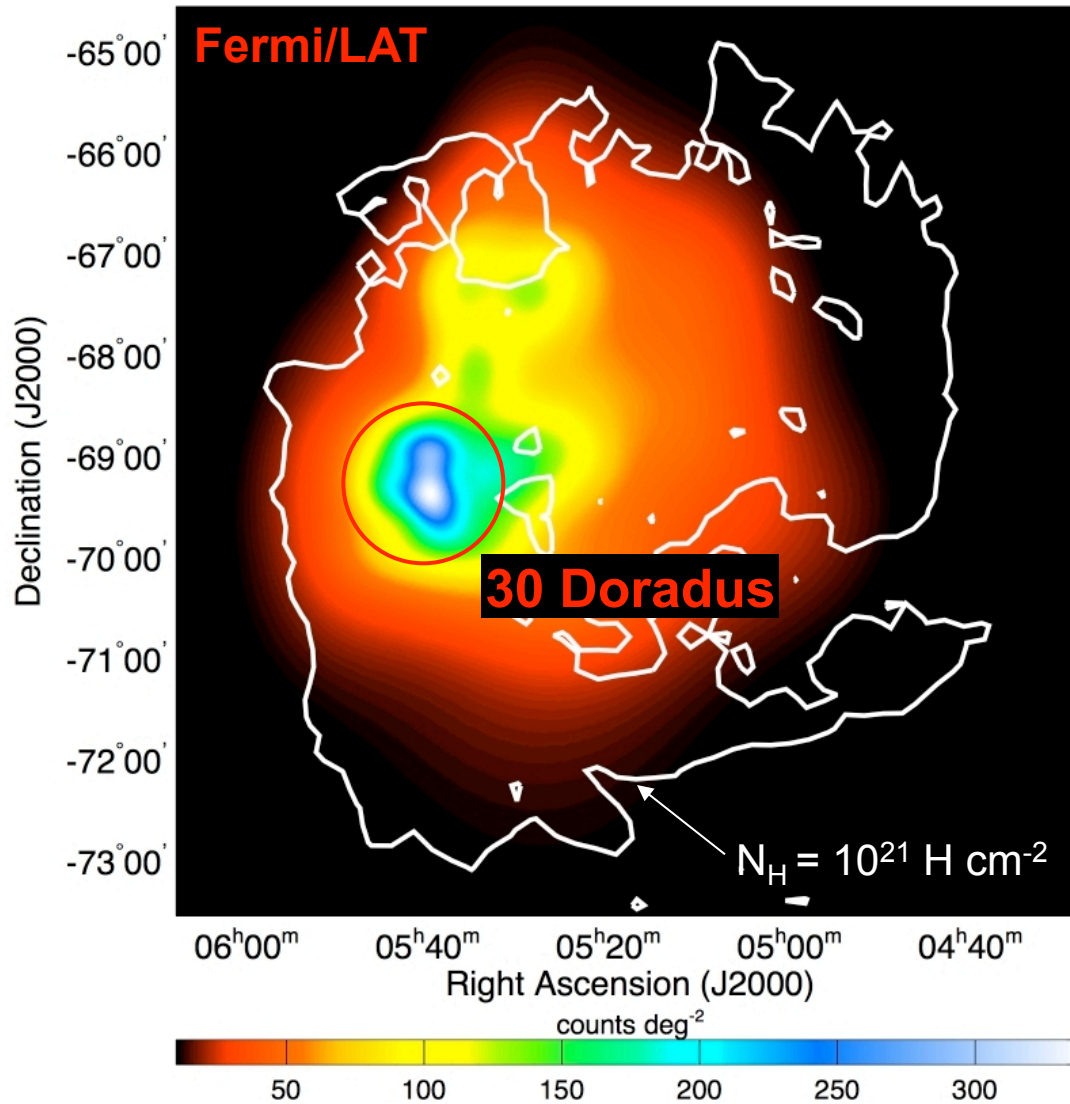
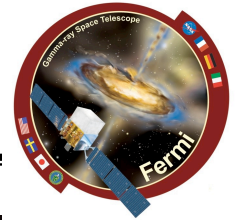
Studying galaxies in gamma rays



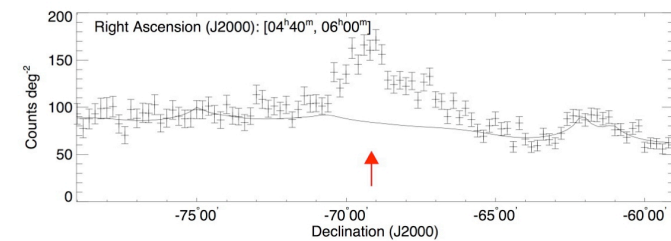
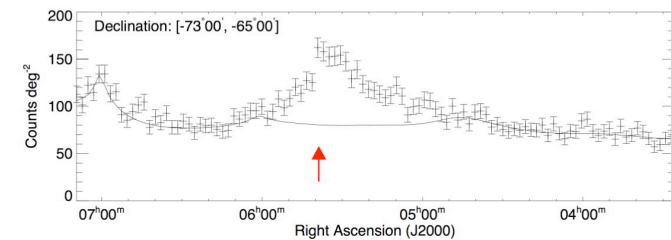
Abdo et al. (2009), ApJ, 703, 1249

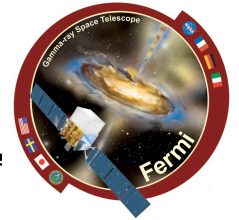
- Galactic gamma rays trace cosmic-ray proton interactions (cosmic-ray acceleration sites & propagation)
- Observations of nearby galaxies provide an outside view
- LMC is prime target ($D \approx 50$ kpc, $i \approx 20^\circ$ - 35° , diameter $\approx 8^\circ$)
- Initial detection by EGRET (no detailed spatial / spectral information)

Resolving the LMC in gamma rays

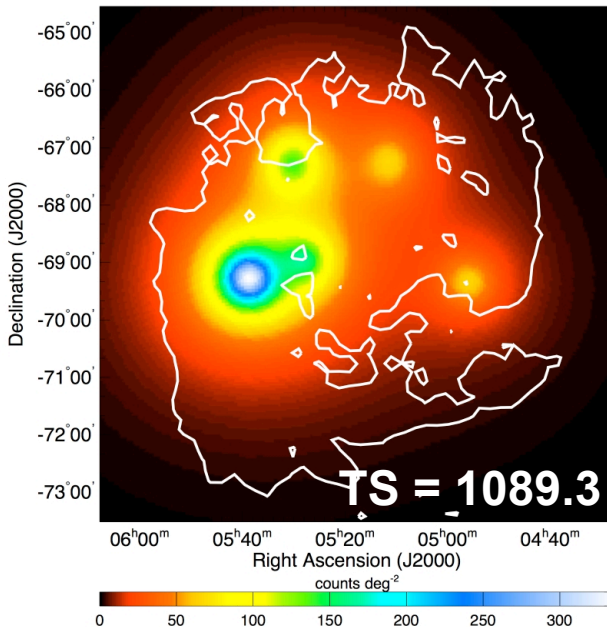


NASA/JPL-Caltech/M. Meixner (STScI)

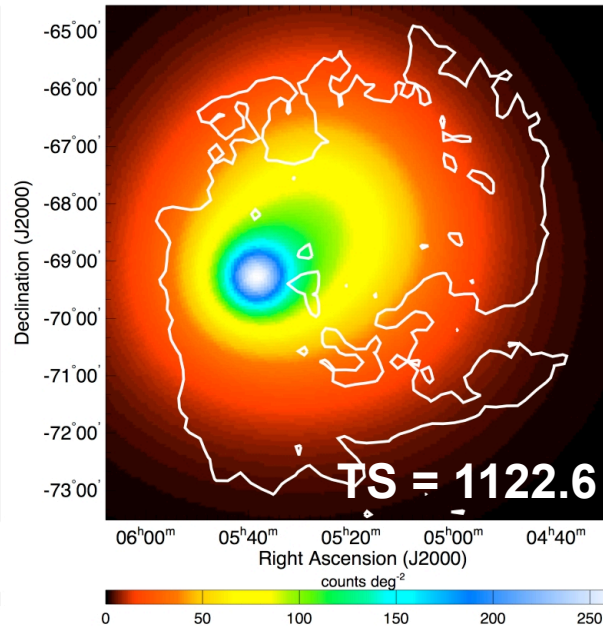




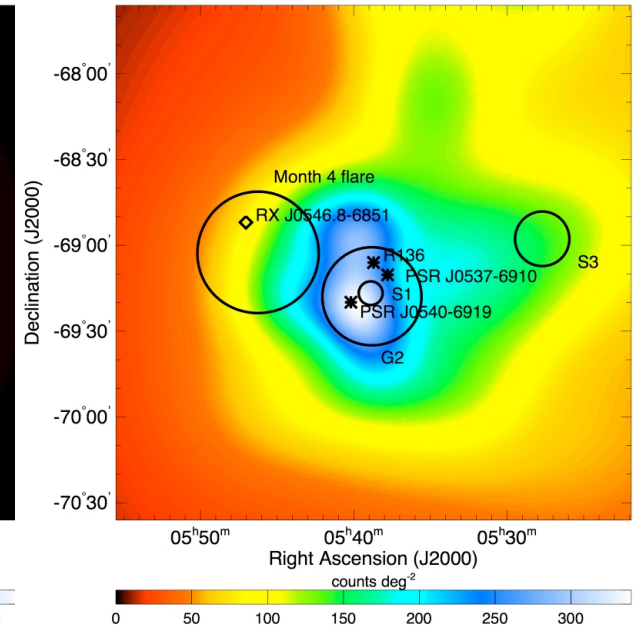
5 point sources



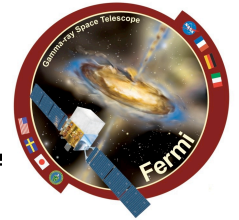
2 Gaussians



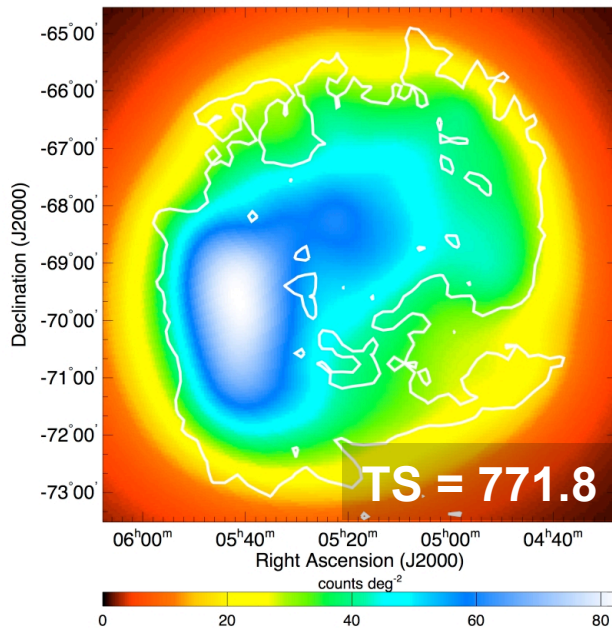
Zoom into 30 Doradus



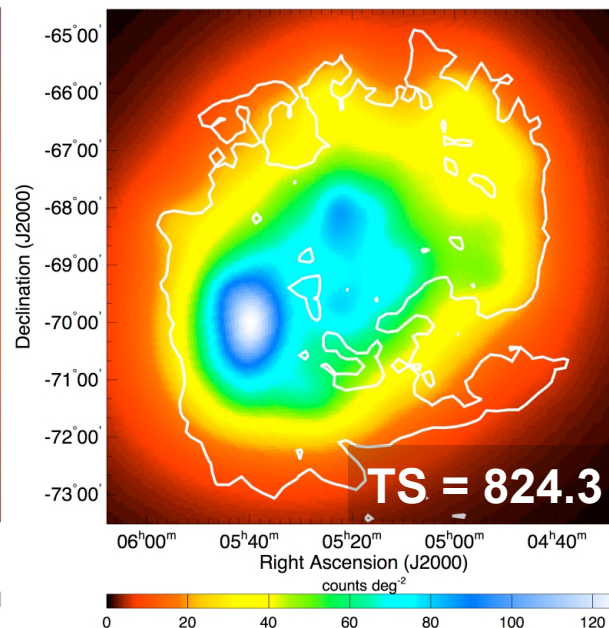
- Successive addition of sources until TS improvement < 25
- 2 Gaussians fit better than 5 point sources despite smaller number of parameters
- 30 Doradus feature incompatible ($>4\sigma$) with point source emission from PSR J0537-6910, PSR J0540-6919 and R136 (no pulsations)



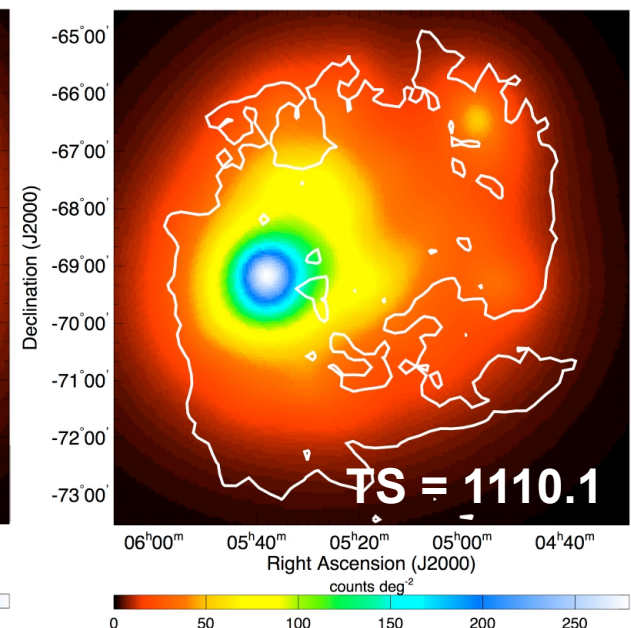
Neutral hydrogen



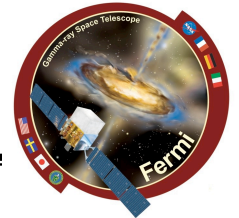
Molecular hydrogen



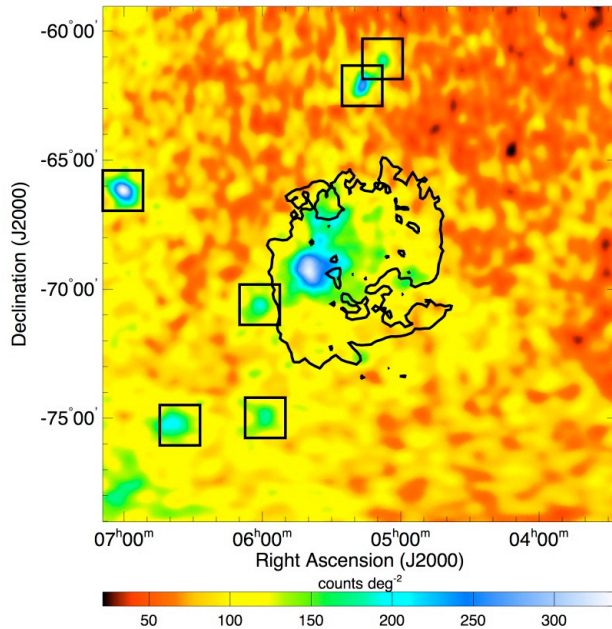
Ionized hydrogen



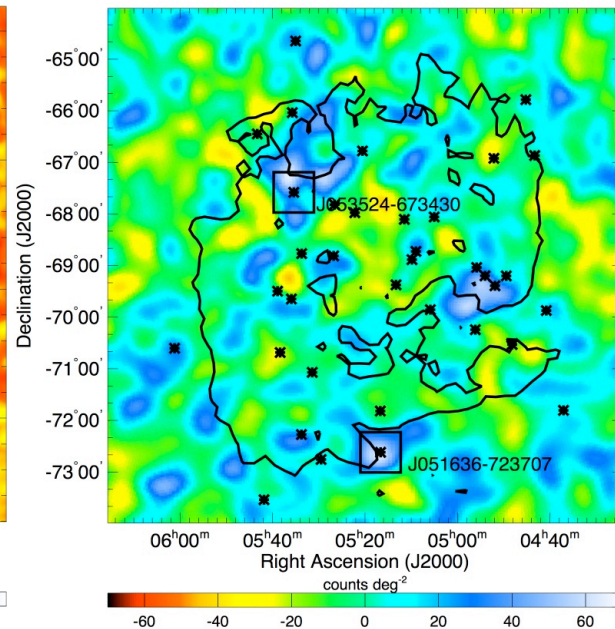
- Neutral & molecular hydrogen templates poorly fit the data
- Ionized hydrogen template provides best fit
- Gamma-ray emission correlates little with gas (90-95% H I, 5-10% H₂, 1% H II)
- Exclusion of 30 Doradus region from fit does not change these findings



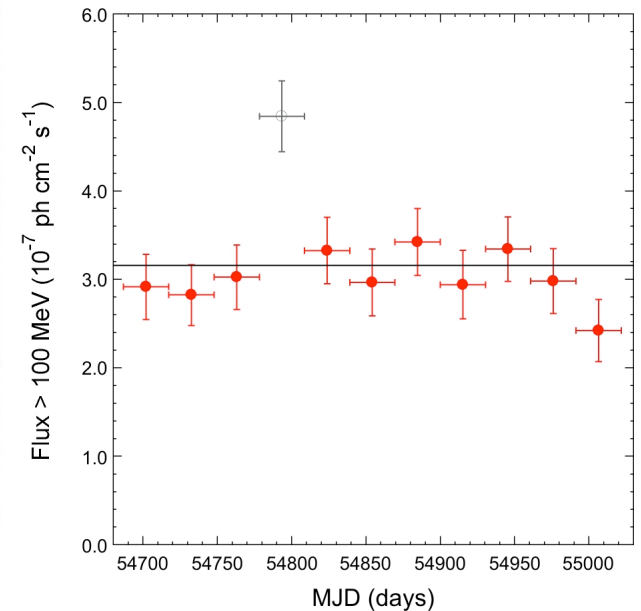
Total counts map



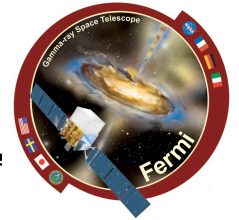
Residuals (2 Gaussians)



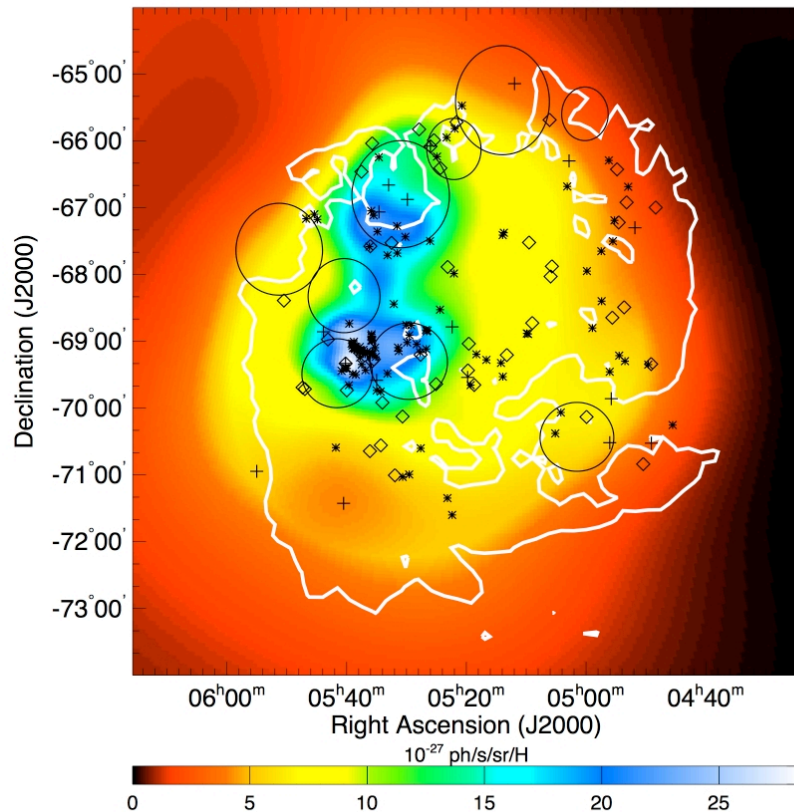
Monthly lightcurve



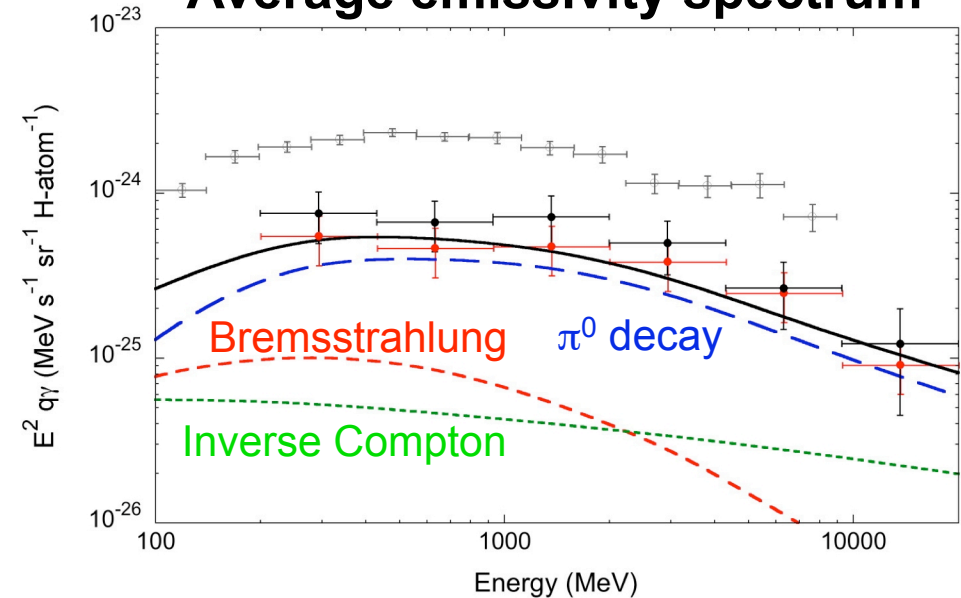
- About 10 background blazars expected in 20° x 20° field
- 6 CRATES sources associated with LAT sources outside LMC
- 1 CRATES source associated within LMC boundaries
- 1 flaring source near 30 Doradus during month 4 (RX J0546.8-6851?)



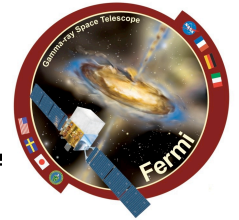
LMC emissivity map



Average emissivity spectrum



- Considerable cosmic-ray density variations
- Small GeV proton diffusion length
- Spectrum consistent with expectations from π^0 decay (using local galactic p, e⁻, e⁺ spectral shapes)
- Average cosmic-ray density about 0.2-0.3 times that in solar vicinity (consistent with difference between galactic and LMC SN rate)



- **LMC for the first time resolved in gamma rays**
- **30 Doradus star forming region is a bright source of gamma rays and very likely a powerful cosmic-ray accelerator**
- **No significant point source contribution (no pulsations from PSRs J0540-6919 and J0537-6910)**
- **Gamma-ray emission correlates well with massive star forming regions and little with the gas distribution**
- **Compactness of emission regions suggests little CR diffusion**
- **Average CR density $\approx 0.2-0.3$ that in solar vicinity**

