Observations of the Large Magellanic Cloud with Fermi

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• 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 ≈ 50 kpc, i ≈ 20°-35°, diameter ≈ 8°)
• Initial detection by EGRET (no detailed spatial / spectral information)

Abdo et al. (2009), ApJ, 703, 1249
Resolving the LMC in gamma rays

Fermi/LAT

Spitzer

30 Doradus

$N_H = 10^{21} \text{ H cm}^{-2}$

NASA/JPL-Caltech/M. Meixner (STScI)
• 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 (>4σ) with point source emission from PSR J0537-6910, PSR J0540-6919 and R136 (no pulsations)
Neutral 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
• 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?)
Cosmic-ray density

- Considerable cosmic-ray density variations
- Small GeV proton diffusion length

- Spectrum consistent with expectations from $\pi^0$ 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)
Summary

• 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 ≈ 0.2–0.3 that in solar vicinity