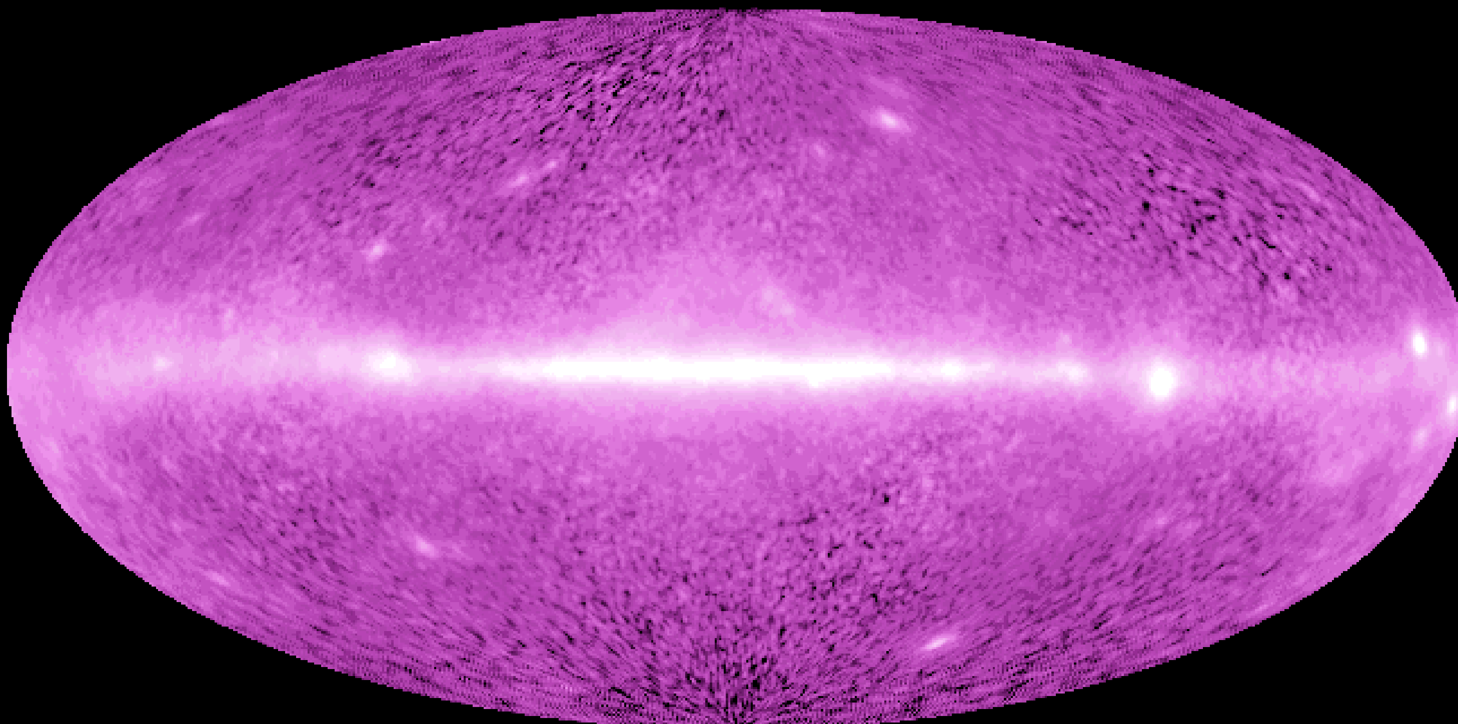
Cosmic Rays, Cosmic Star Formation, and the Gamma-Ray Background



Vasiliki Pavlidou & Brian D. Fields
pavlidou@astro.uiuc.edu , bdfields@astro.uiuc.edu
Department of Astronomy, University of Illinois at Urbana-Champaign

The Guaranteed Gamma Ray Background

Observations (SAS2: Fichtel et al. 1977; EGRET: Sreekumar et al. 1998) reveal:

an isotropic, diffuse, extragalactic γ-ray background

Extragalactic γ-ray sources identified by EGRET (Hartman et al. 1999):

- ✓ AGN (blazars)
- ✓ normal galaxies

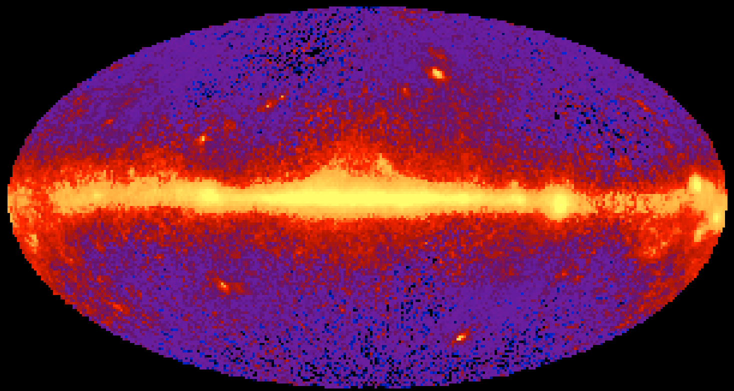
Unresolved sources of same class contribute to diffuse background

guaranteed γ-ray background ≡ the sum of γ-ray emission from all unresolved identified sources (unresolved blazars + unresolved normal galaxies)

Other proposed sources (e.g.: structure formation cosmic rays, decaying dark matter) *constrained* by difference between observed and guaranteed γ-ray background

Gamma rays from Normal Galaxies

γ- rays in normal galaxies produced through cosmic ray - interstellar gas collisions:



EGRET γ-ray sky. Disk of MW obvious, traces CR+ISM collisions

γ-ray flux of a typical galaxy *higher* in the past because:

1. Star formation rate higher
   → more cosmic rays accelerated by supernovae
   → larger cosmic ray flux
2. More targets available
   (less gas locked up in stars)

• use observations of *cosmic star formation rate* to calculate both effects.

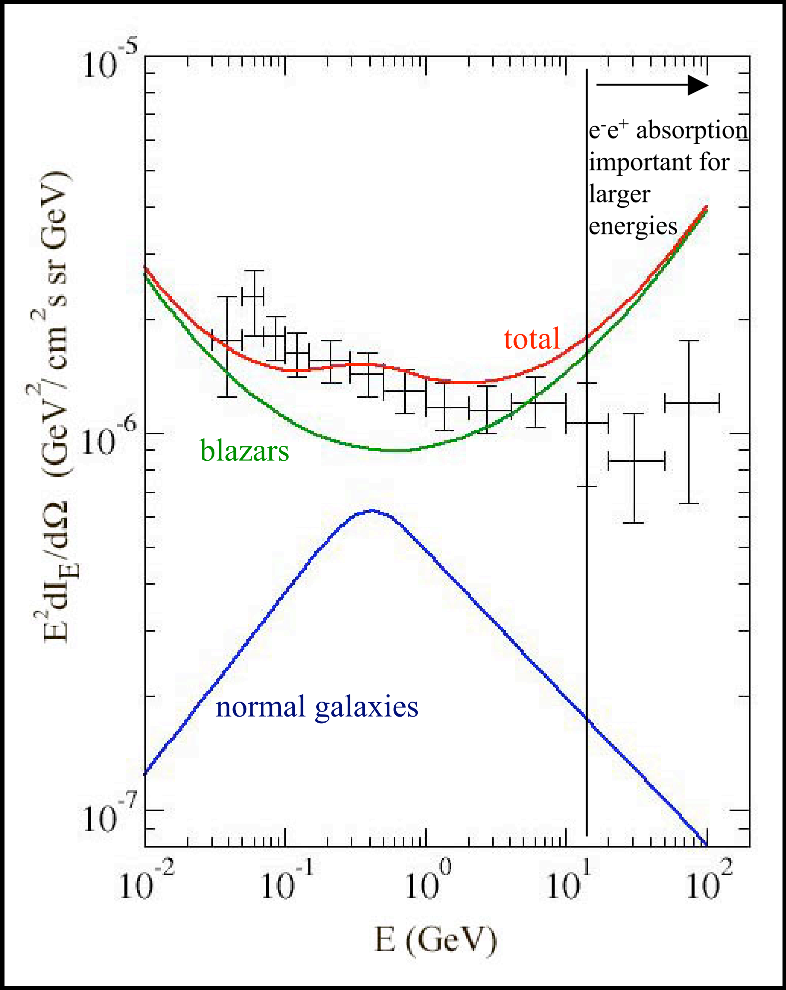
• normalize γ-ray luminosity and spectrum produced per star formation rate unit to Milky Way

Gamma Ray Background – the Minimal Model

- ✓ Add normal galaxy contribution + blazar contribution as calculated by Stecker & Salamon (1996) to get a minimal 2-component model for the γ-ray background.

- ✓ Blazar spectrum: concave
  Normal galaxy spectrum: convex.
  Summed spectrum: flatter than either
  ⇒ better fit to observations

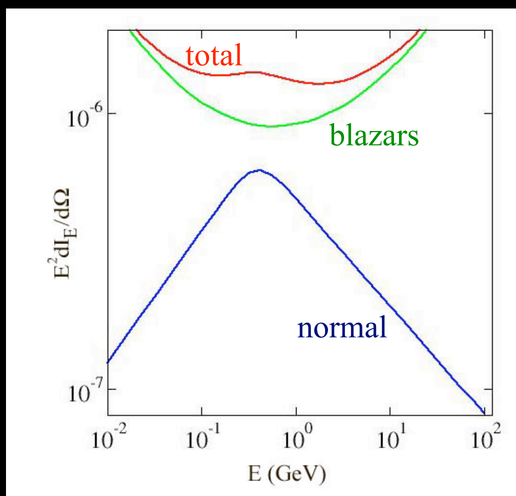
- ✓ Relative normal galaxy contribution: highest at ~ 1GeV
  (about 1/3 of summed spectrum)



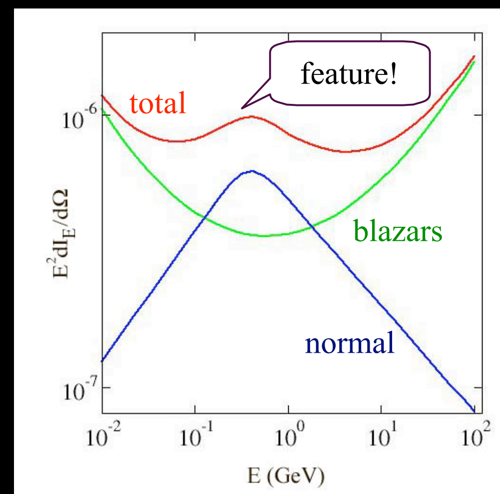
Observational Tests

γ-ray observatory GLAST (launch: 2006) will *test the minimal model*:

- will resolve many more blazars (Stecker & Salamon 99)
  but at most 3 new normal galaxies (Pavlidou & Fields 01)
  ⇒ relative blazar contribution reduced ⇒ will detect normal galaxy peak at ~ 1 GeV



EGRET



GLAST

- will improve observational inputs for both blazar and normal galaxy models

If both guaranteed components well understood,
can better constrain other components & new physics generating them

References

- <u>For more information on this work:</u>
  "The Guaranteed Gamma-Ray Background", V. Pavlidou & B.D. Fields 2002, ApJL 575, 5 ***(astro-ph/0207253)***

- Other references
  - Stecker-Salamon model for the blazar contribution to the γ-ray background:
    Stecker, F.W. & Salamon, M.H. 1996, ApJ, 464, 600
  - Observations of the gamma-ray background:
    Sreekumar, P. et al. 1998, ApJ, 494, 523
  - Detectability of Local Group galaxies by GLAST:
    Pavlidou, V. & Fields, B.D. 2001, ApJ, 558, 63