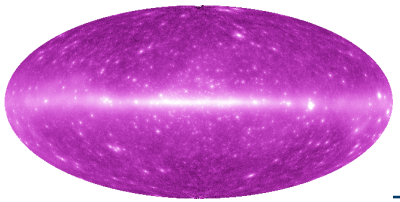
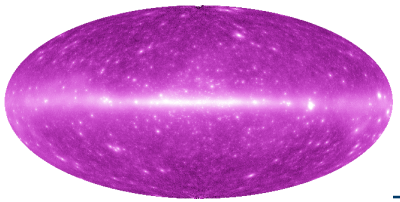
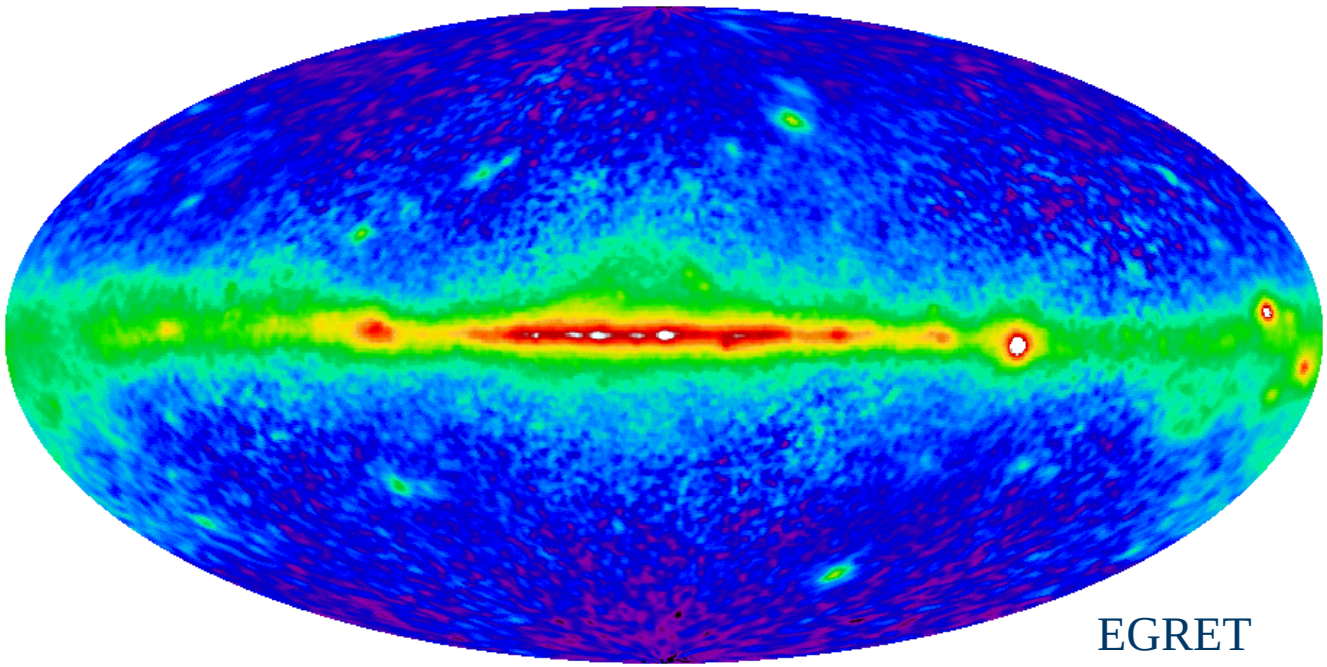


Interstellar Emission Model

- Why have one?
- What are the ingredients?
- Issues for the GLAST interstellar emission model
- Software needed
- How to get there



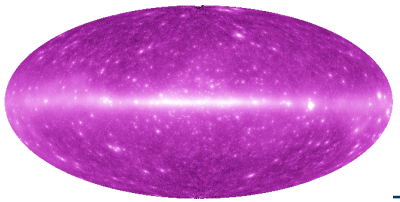
Why Have One?



EGRET

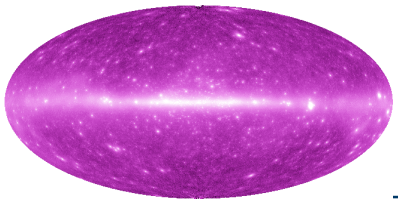
>100 MeV, Phase 1-5

- Angular resolution of GLAST is not all that great, esp. considering the low fluxes of celestial gamma rays
  - Errors in model translate to false detections or at least bad source positions



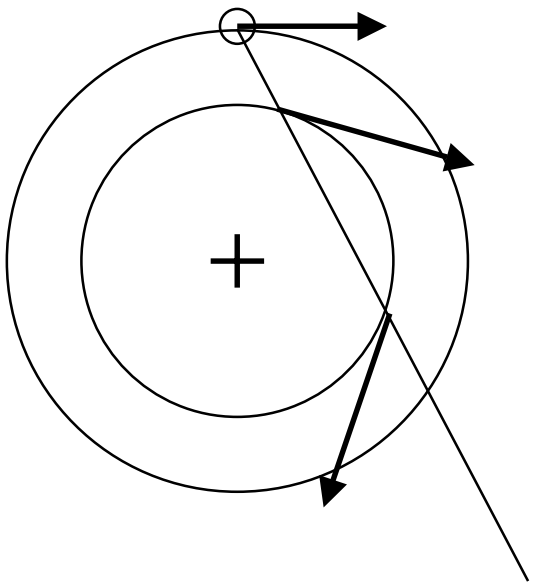
What are the Ingredients?

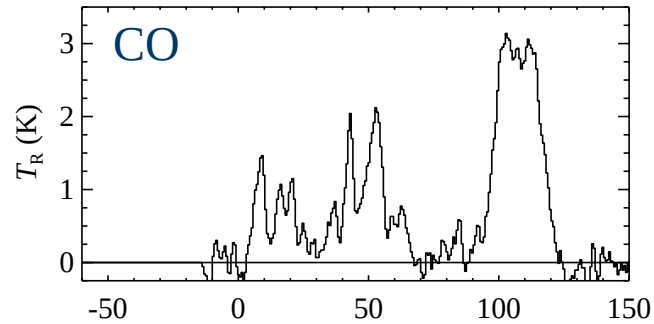
- Interstellar gas
  - Primarily Hydrogen: atomic, molecular, and ionized
  - Spectral shifts (HI & CO) give some idea of spatial dist.
- Interstellar photons
  - Of interest: microwave–optical
- Cosmic rays
  - Measured directly only locally, and modulo solar modulation
- Gamma-ray production mechanisms
  - Bremsstrahlung
  - Pion decay
  - Inverse Compton



Interstellar Gas

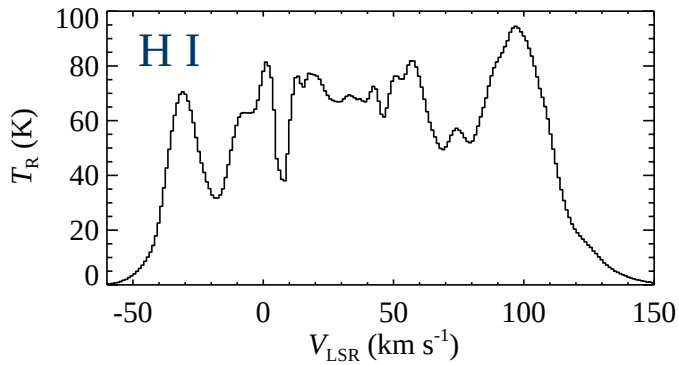
- CO is a stand-in for H_2
- Near-far distance ambiguity



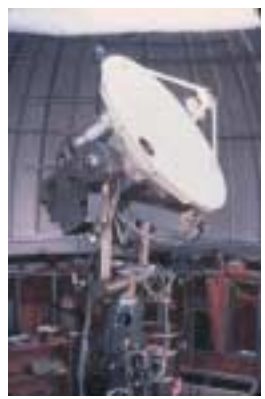


(25°, 0°)

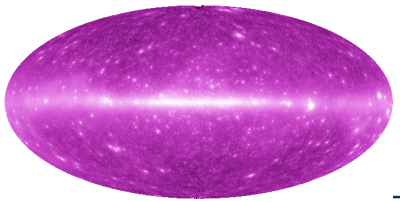
Dame et al. (1987)



Hartmann & Burton (1997)

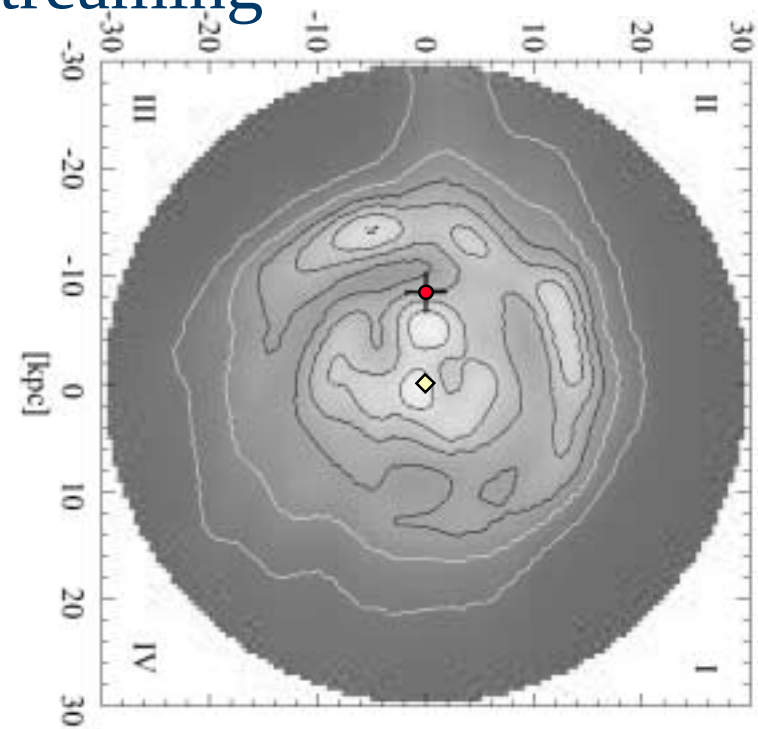


W. Keel

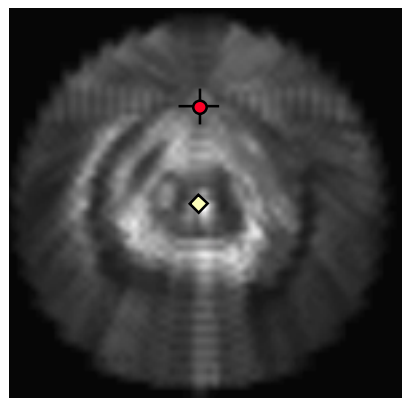


Distribution of Gas

- Velocity-distance ambiguity is hard to resolve, plus streaming



Hunter et al. (1997)

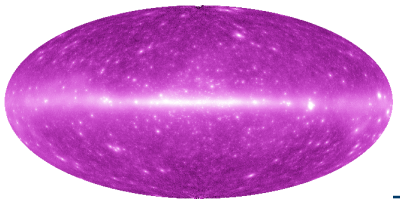


Pohl & Esposito (1998)

Sun

Galactic Center

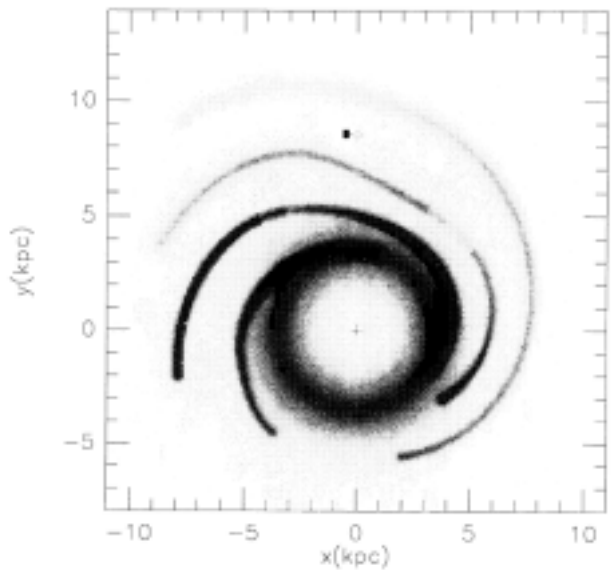
These examples disagree in many details



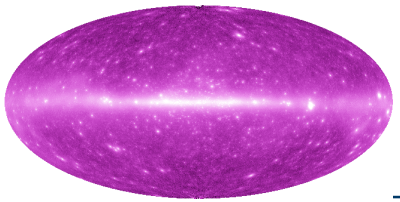
Ionized Hydrogen

- Difficult to observe directly – most detailed models from pulsar dispersion measures, with imposed model that is fit to the data (dispersion measures of 551 pulsars)
- Not a major contributor to the diffuse emission.

Surface Density of H II



Taylor & Cordes (1993)

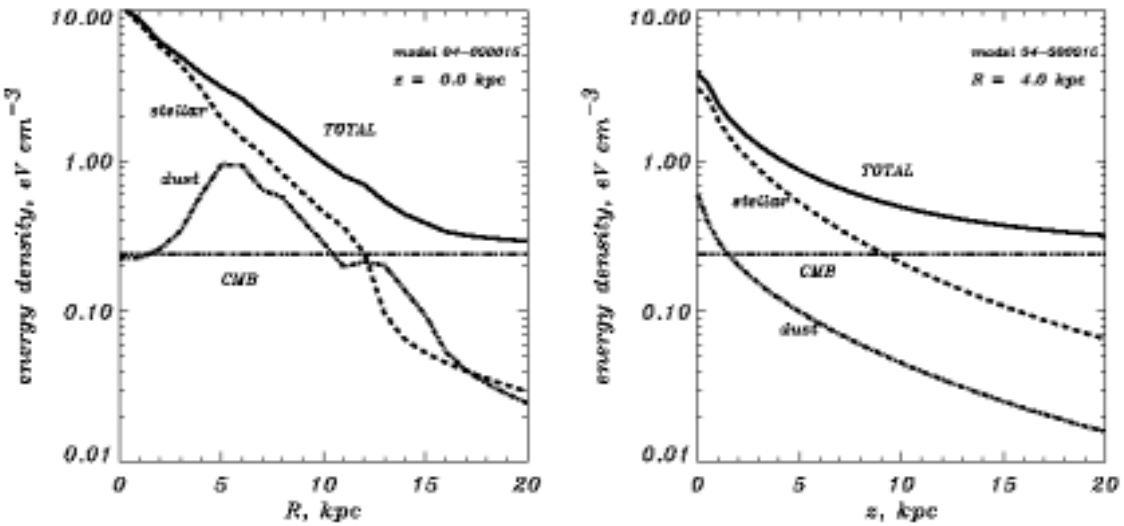


Interstellar Photons

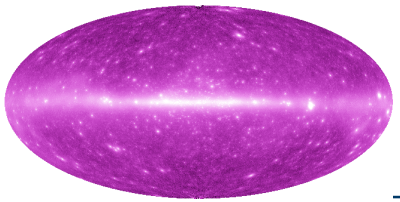
- CMB, star light, and dust emission+extinction

  COBE/DIRBE unfolding (to get radial profile of infrared emissivities), stellar population models

Spatial distribution:



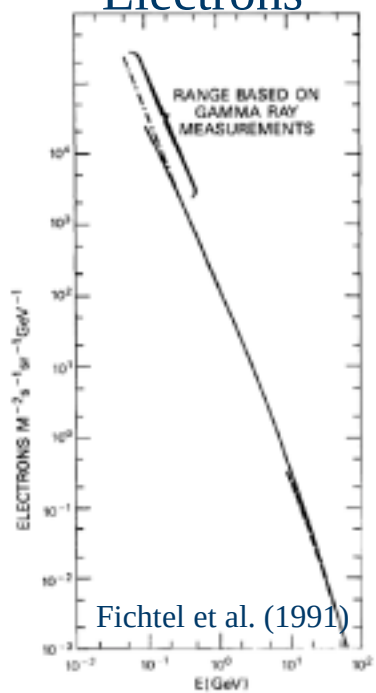
Strong, Moskalenko, & Reimer (2000)



Cosmic Rays

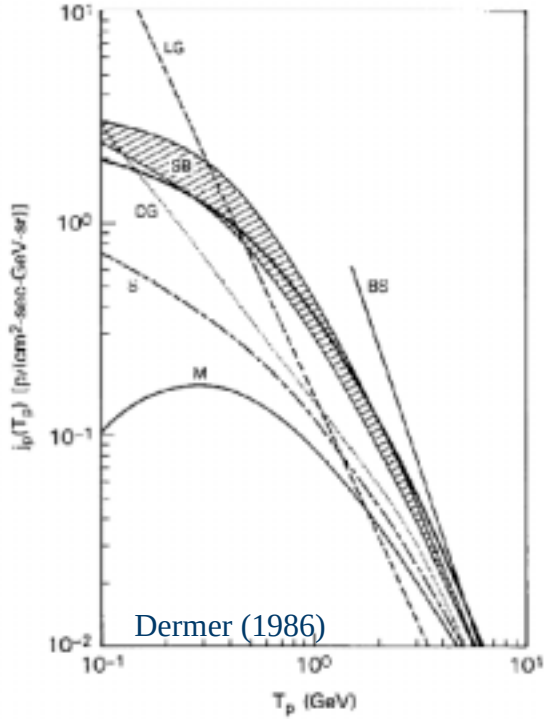
- State of the art also includes
  - heavier CRs, reaction network (e.g., Strong & Moskalenko 2001)
  - more than e, p local spectra as constraints

Electrons



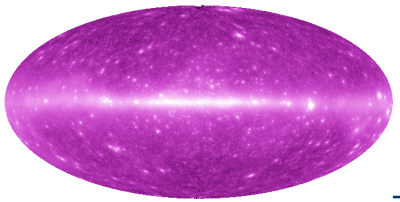
Fichtel et al. (1991)

Protons



Dermer (1986)

- Extensive effort is toward models of CR propagation
  - Strong, Moskalenko, & Reimer (viewgraphs)
  - Pohl et al.



Gamma-Ray Production Mechanisms

- Bremsstrahlung – no surprises

  $\Gamma_\gamma = \Gamma_e$, $E_\gamma <\sim E_e$

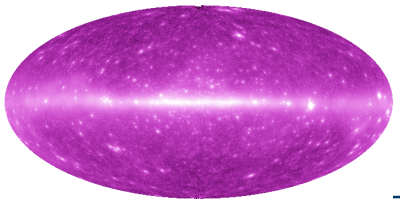
- Pion decay

  peak at $M_{\pi^0}/2$, $\Gamma_\gamma \sim \Gamma_p$, $E_\gamma << E_p$

- Inverse Compton

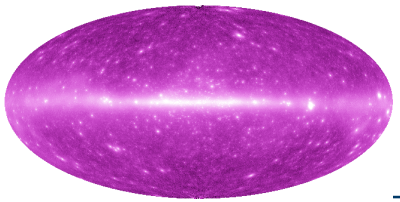
  Also no surprises, although recent recognition of the importance of the anisotropy of the interstellar radiation field (Moskalenko & Strong 2000)

  $\Gamma_\gamma = (\Gamma_e + 1)/2$, $E_\gamma << E_e$



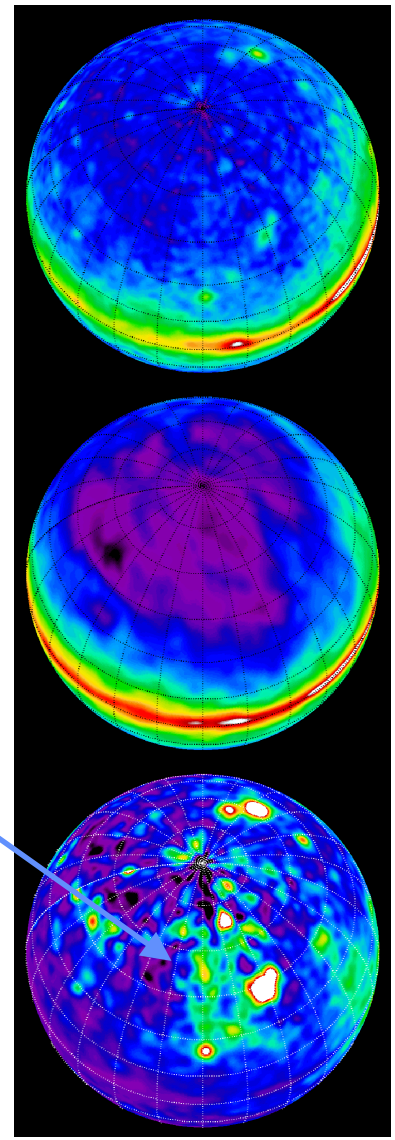
Issues to be Resolved

- Some surprises from EGRET
- Are additional radio data needed?
- Is a detailed model of ISRF in massive star-forming regions needed?
- 3-dim distribution of cosmic rays - converge on model (with feedback from gamma rays)
- Can gamma-ray data help resolve the distance ambiguity for distributions of gas? How should the Galactic center and anticenter be modelled?
- Pion decay production function understood?
- What adjustable parameters will the model have?



Unexpected EGRET Findings

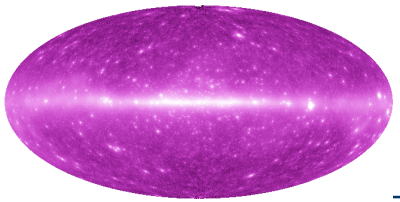
- Chen, Dwyer, & Kaaret (1995) pointed out excess *emissivity* in a large region at high latitude
- Reminds that cosmic-ray modelling may be art + science



Intensity (>100 MeV) EGRET

N(H I), Dickey & Lockman (1990)

Emissivity ($\gamma\ s^{-1}$ H-atom^{-1})



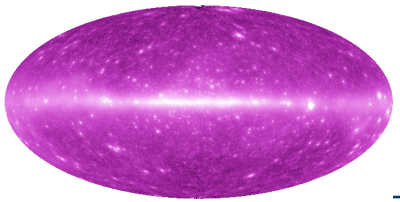
Are additional data needed?

- Not because GLAST has high angular resolution

Angular *radii* of 'effective PSFs' above 1 GeV

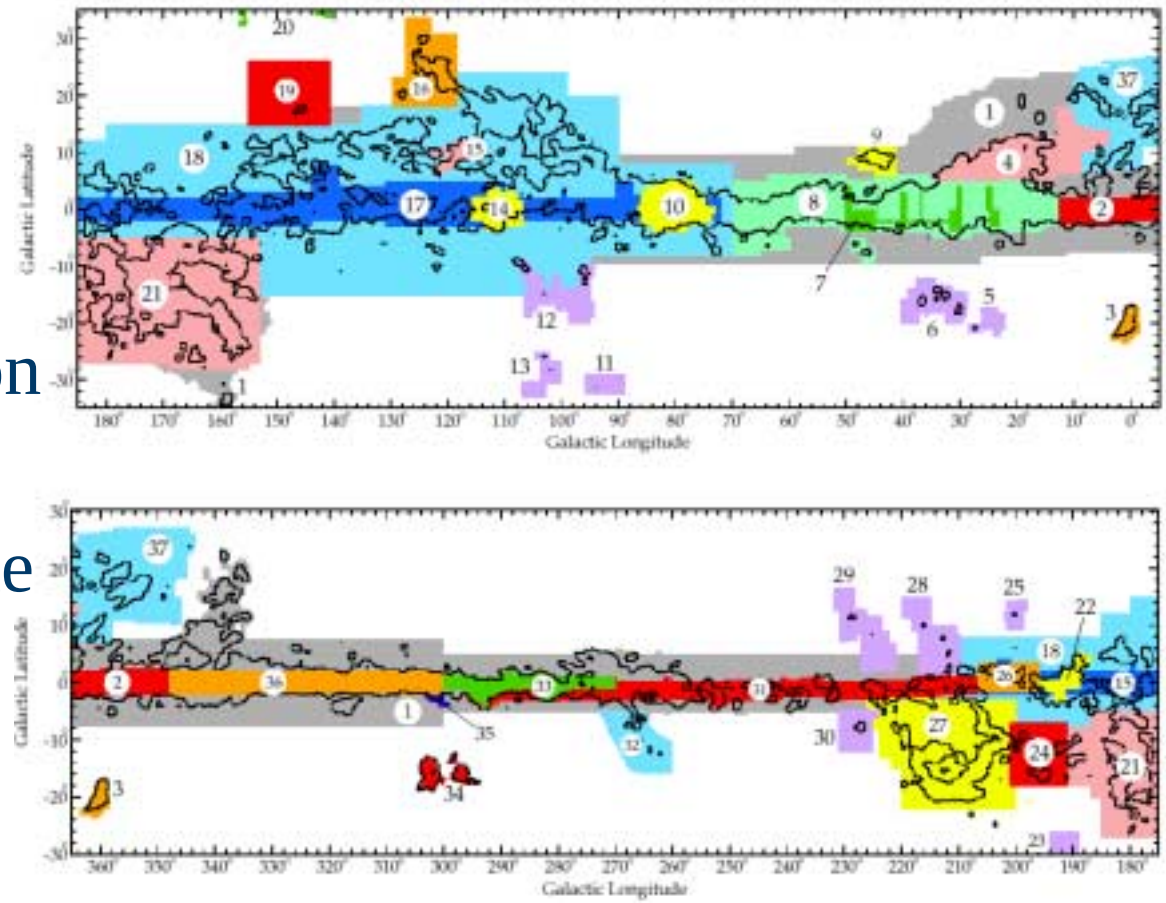
	EGRET	GLAST
68%	0.7°	0.35°
95%	3.5°	1.2°

- For atomic hydrogen, resolution of large area surveys is ~36´. Canadian Galactic Plane synthesis survey data (1´) are becoming available – see whether need better angular resolution in 21-cm. Larger issue is likely stray light (calibration), which seems to be under control, and perhaps self absorption



Additional Data? (2)

- Coverage map of composite CO survey (in press)
- Entire plane, and many high |*b*| regions surveyed with ~9´ resolution
- Likely very little CO missed outside borders

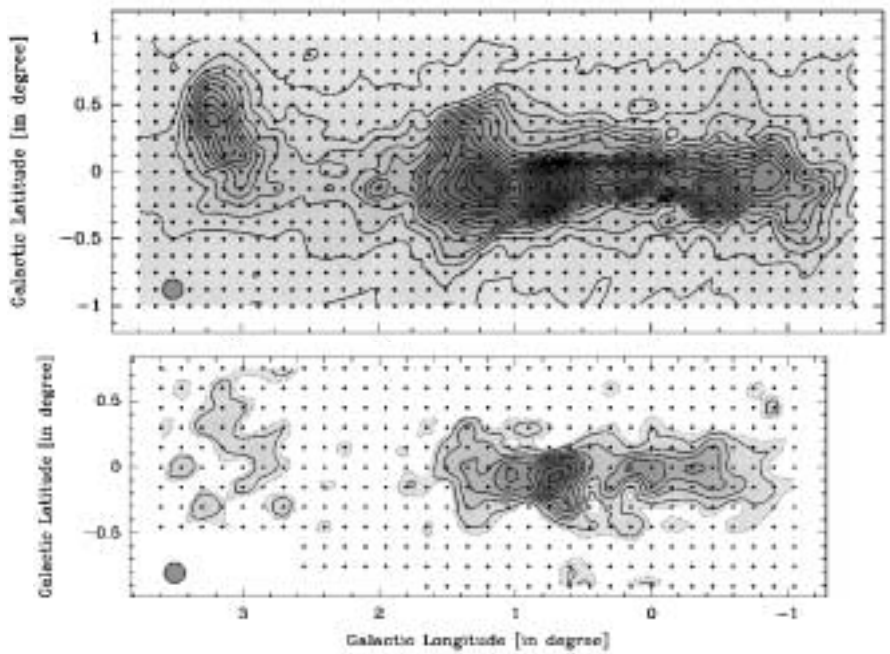


Dame, Hartmann, & Thaddeus (2001)

Additional data? (3)

- High-*z* molecular gas?
- Tracers of molecular hydrogen in the Galactic center?

  HC_3N?

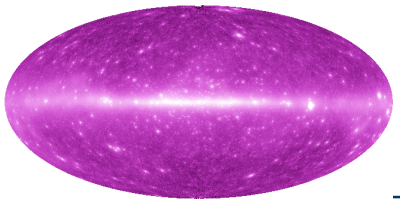


CO (J = 1–0)

vs.

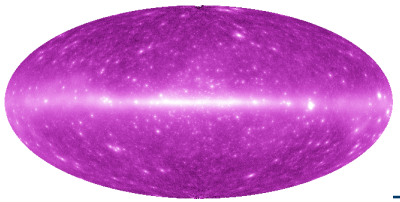
$C^{18}O$ (J = 1–0)

Bitran (1987)
Dahmen et al. (1998)



Software Needed

- This is a software workshop after all
- Model will have some adjustable parameters
  - These parameters should not be adjusted for every point-source search
  - Will want to fit the model to the EGRET, and eventually GLAST, data, and not suffer from point source contamination
- Note that the model will not be standard analysis software – documented but not run by the general GI



Plan for Progress

- Establish working group, milestones, assignments
- Have a jump start with EGRET data and collective experience studying it