P17.9 Developing the Galactic Diffuse Emission Model for the GLAST Large Area Telescope

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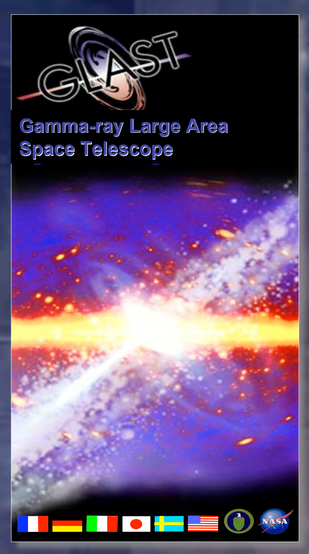
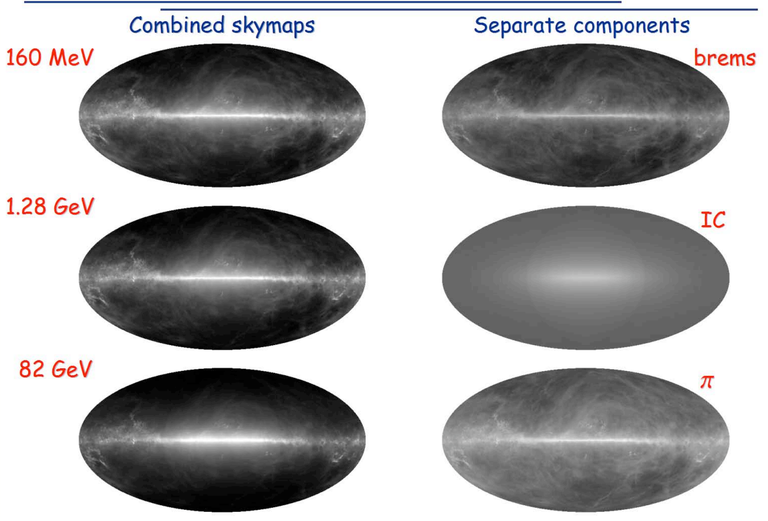
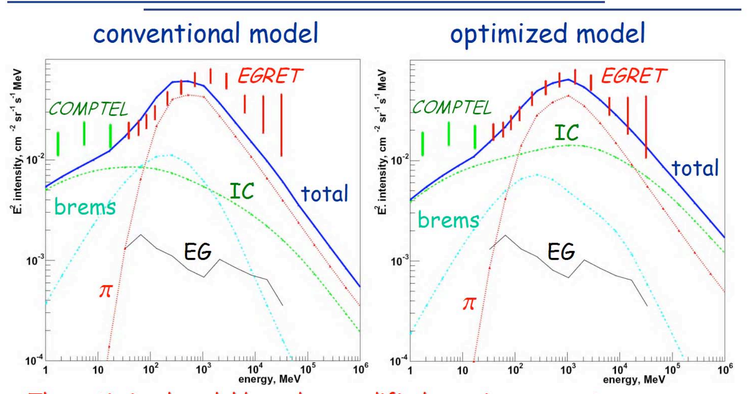


Diffuse emission is produced in energetic cosmic ray interactions, mainly protons and electrons, with the interstellar gas and radiation field and contains the information about particle spectra in distant regions of the Galaxy. It may also contain information about exotic processes such as dark matter annihilation, black hole evaporation etc. Diffuse emission model is important for determination of the source positions and spectra. Calculation of the Galactic diffuse continuum gamma-ray emission requires a model for cosmic ray propagation as the first step. Such a model is based on theory of particle transport in the interstellar medium as well as on many kinds of data provided by different experiments in Astrophysics and Particle and Nuclear Physics. Such data include: secondary particle and isotopic production cross sections, total interaction nuclear cross sections and lifetimes of radioactive species, X-factors and gas distribution in the Galaxy (H_2, HI, HII), interstellar radiation field in every spatial point, cosmic ray source distribution and particle spectra at the sources, magnetic field, energy losses, gamma-ray and synchrotron production mechanisms, and many other issues. We are continuously improving the GALPROP model and the code to keep up with a flow of new data. Improvement in every field may affect the Galactic diffuse continuum gamma-ray emission model used as a background model by the GLAST LAT instrument. Here we report about the latest improvements of the GALPROP and the diffuse emission model.

Diffuse γ-ray emission model



Diffuse γ-ray spectrum of the inner Galaxy

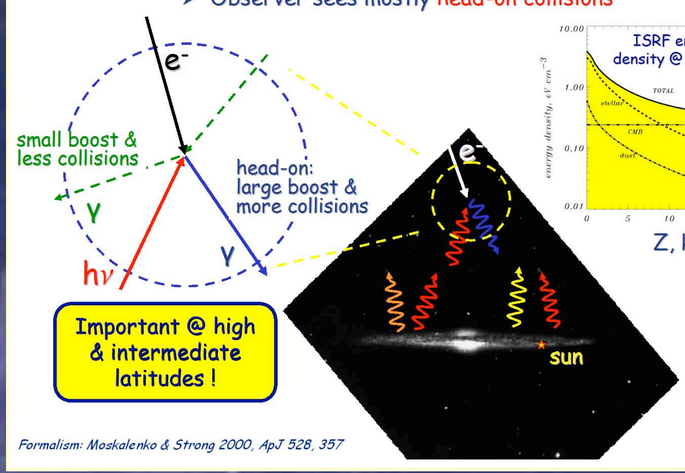


The optimized model based on modified cosmic ray spectra reproduces the EGRET skymaps. GLAST data on diffuse emission are critical to distinguish between the models and to provide valuable information on cosmic ray spectra in distant regions of the Galaxy.

Strong+ 2007, Ann.Rev. 57, in press (astro-ph/0701517)

Anisotropic Inverse Compton Scattering in the Galaxy

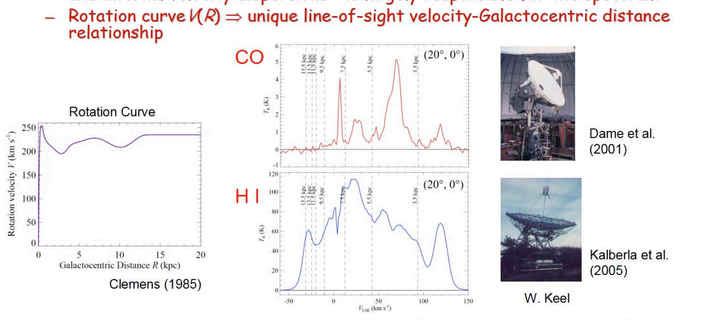
- Electrons in the halo see anisotropic radiation
- Observer sees mostly head-on collisions



Formalism: Moskalenko & Strong 2000, ApJ 528, 357

Distribution of interstellar gas

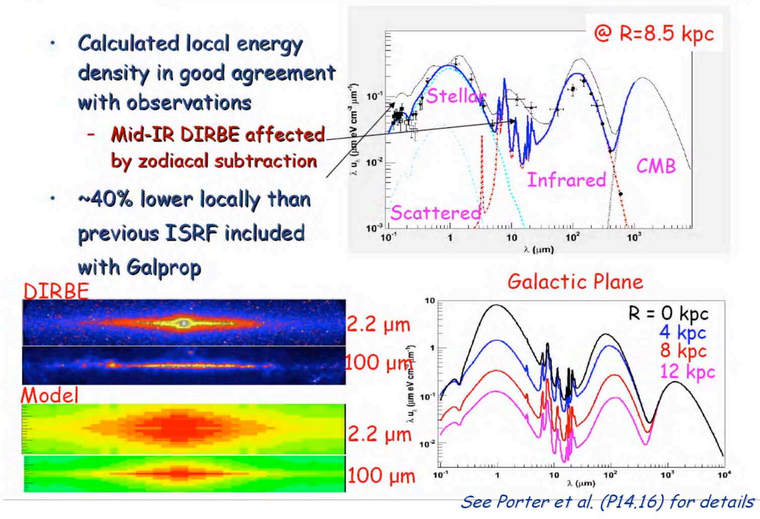
- Neutral interstellar medium – most of the interstellar gas mass
  - 21-cm H I & 2.6-mm CO (surrogate for H_2)
  - Differential rotation of the Milky Way – plus random motions, streaming, and internal velocity dispersions – is largely responsible for the spectrum
  - Rotation curve $V(R) \Rightarrow$ unique line-of-sight velocity-Galactocentric distance relationship



- This is the best – but far from perfect – distance measure available
- Column densities: $N(H_2)/W_{CO}$ ratio assumed; a simple approximate correction for optical depth is made for N(H I); self-absorption of H I remains

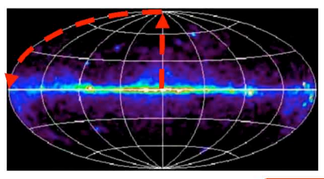
New Interstellar Radiation Field: Spectra & Skymaps

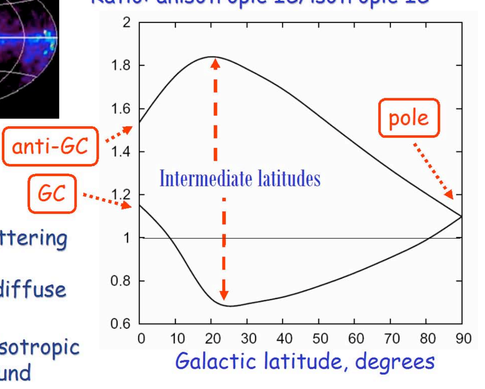
- Calculated local energy density in good agreement with observations
  - Mid-IR DIRBE affected by zodiacal subtraction
- ~40% lower locally than previous ISRF included with Galprop



See Porter et al. (P14.16) for details

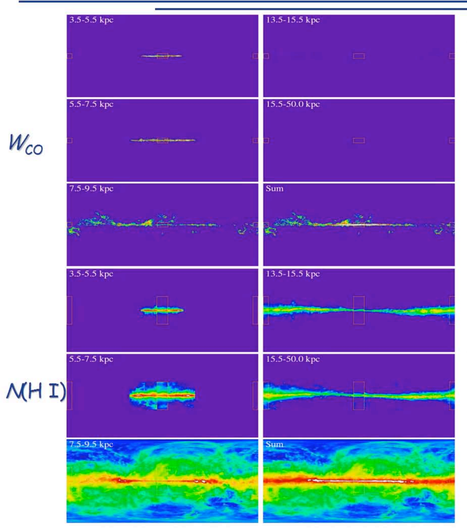
Effect of anisotropic IC scattering (first proper calculation)





- The anisotropic IC scattering plays important role in modeling the Galactic diffuse emission
- Affects estimates of isotropic extragalactic background

Column densities of gas



- Here are examples of the resulting 'rings'
- For the local (7.5-9.5 kpc) annulus we are incorporating new intermediate latitude CO survey data (Dame 2007) and additional coverage from the NANTEN survey in the south (Onishi, Mizuno, & Fukui 2004)
- We are also investigating incorporating a 'dark' component of molecular gas not traced by CO (Grenier, Casandjian, & Terrier 2005)

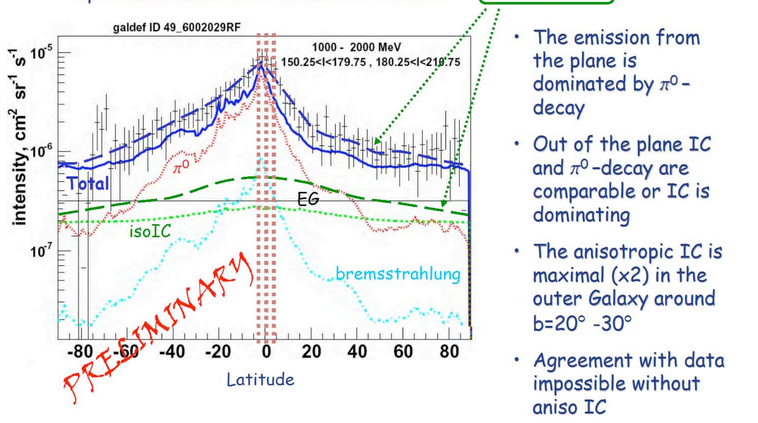
GALPROP Web-site

galprop.stanford.edu

- This Web site is dedicated to research in astrophysics of cosmic rays and diffuse gamma rays. It is designed to be a communication forum between researchers in different disciplines.
- Systematic work on evaluation of the codes and data posted on the Web-site, cross tests of different propagation models and approaches, should make the calculations of propagation in the interstellar space and in the heliosphere more reliable.

Latitude profile of the outer Galaxy

Optimized model with variable X-factors

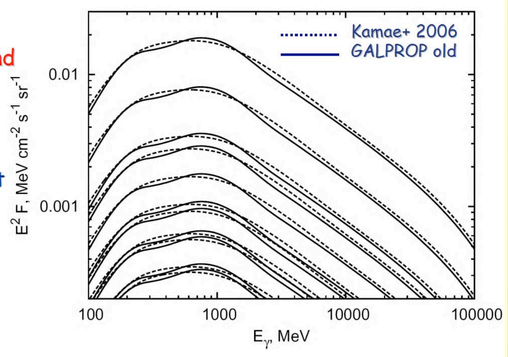


- The emission from the plane is dominated by π^0-decay
- Out of the plane IC and π^0-decay are comparable or IC is dominating
- The anisotropic IC is maximal (x2) in the outer Galaxy around b=20° -30°
- Agreement with data impossible without aniso IC

Gammas from neutral pion decay $pp \rightarrow \pi^0$

- New parameterization (Kamae+ 2005, 2006) is based on Pythia Monte Carlo event generator and includes diffraction dissociation
- New parameterization shows some improvement over the old formalism employed in GALPROP
- Galprop now has a parameter to choose a formalism

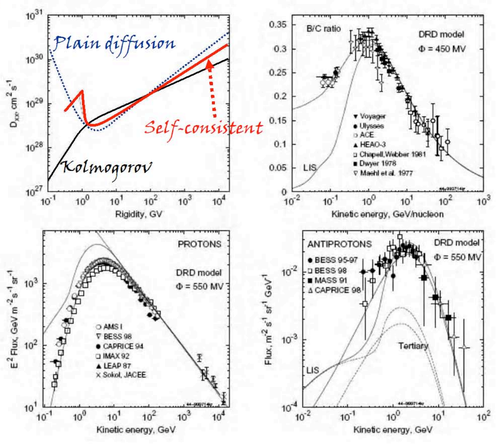
Pion decay γ-ray spectra for different regions on the sky



Particle – MHD wave interactions (reacceleration with damping)

- A self-consistent approach includes particle-wave interactions (damping)
- The diffusion coefficient and the proton spectrum are derived in iterations
- Figures show B/C ratio, proton and antiproton spectra calculated in this model
- Different diffusion coefficients (models) may change the relationship between the components of the diffuse emission (IC, pion-decay)

LIS = local interstellar spectrum
DRD = diffuse reacceleration with damping



Ptuskin+ 2006, ApJ 642, 902

Dark Matter package & DarkSUSY

- DM package is now a part of the GALPROP distribution
  - Allows a user to define the DM density profile and spectra for annihilation products (pbar, $e^{\pm}$, γ) and propagate them throughout the Galaxy, calculate the skymaps of γ-rays produced in DM annihilation

DarkSUSY – GALPROP interface (Baltz—Moskalenko, available soon)
  - GALPROP can now be called from the DarkSUSY to calculate the Green's functions of particle propagation in the Galaxy

- Can work down to 1 keV in electron kinetic energy (not in the public version yet, sorry)
  - Allows particle propagation down to very low energies