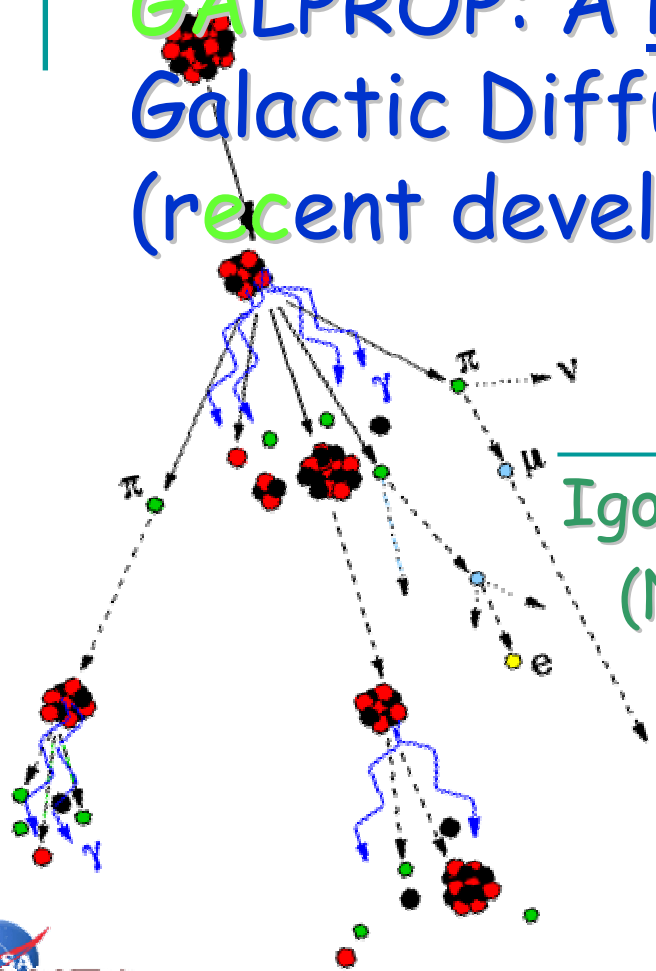
GALPROP: A Physical Model of the Galactic Diffuse Gamma Ray Emission (recent developments and results)



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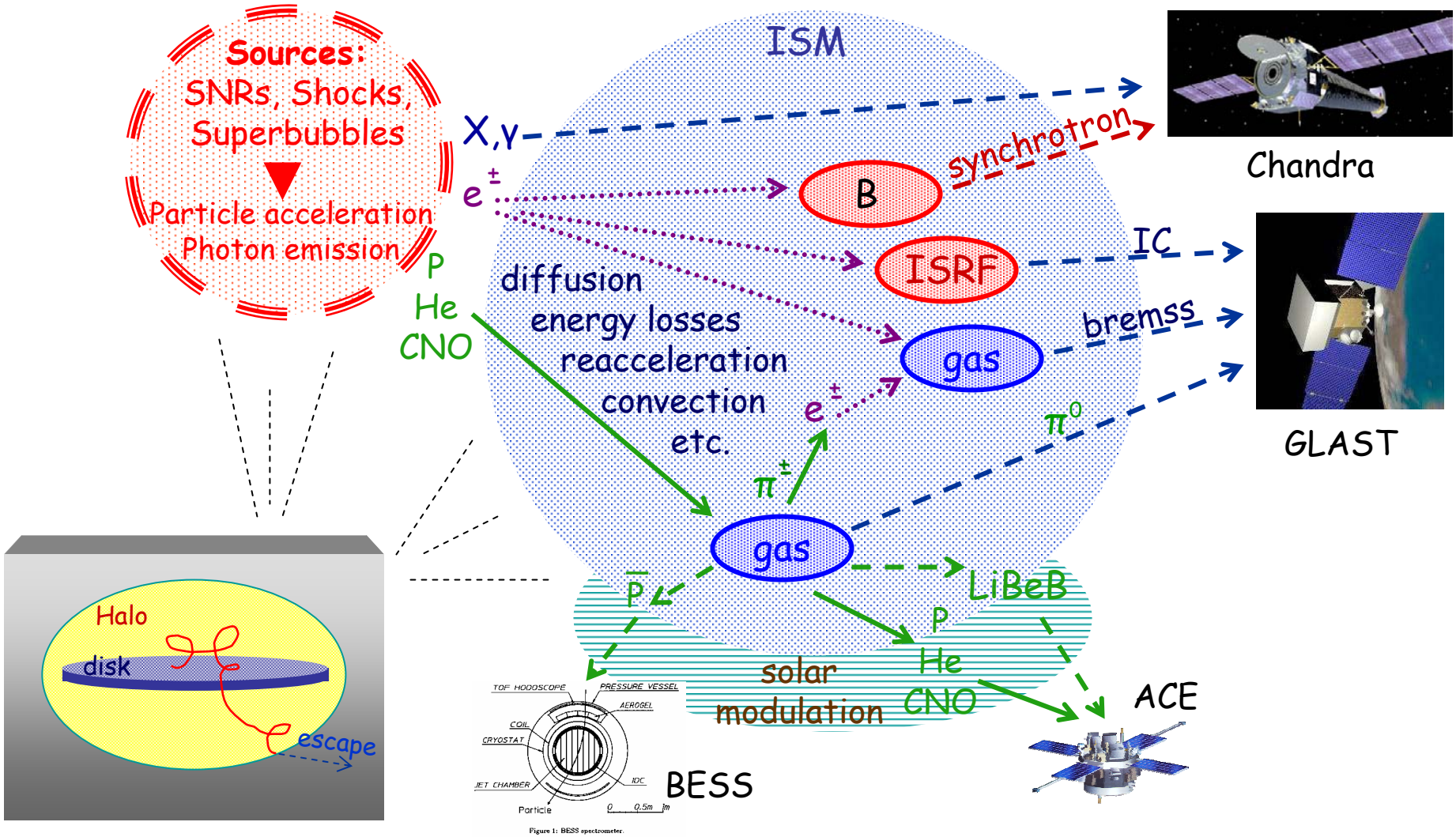
(NASA/GSFC) (MPE)

Processes in the ISM



Probes of CR propagation

Nuclei:

- Stable secondaries: Diffusion coefficient
- Radioactive secondaries: Effective CR volume
- K capture isotopes: Diffusive reacceleration

Protons:

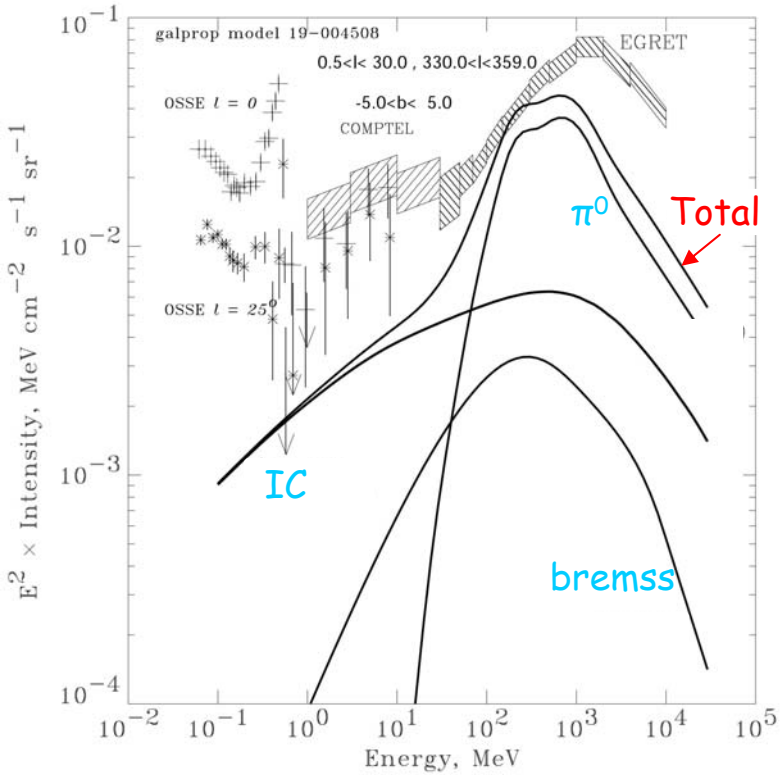
- Gamma rays: Direct probe of the spectrum (π^0)
  - Unknown part is produced by e^- (bremss, IC), and point sources
- Secondary antiprotons
  - \+ Can be calculated accurately
  - \+ Unique spectrum
- Secondary positrons
  - Possible primary sources
  - Large energy losses

Electrons:

- Gamma rays: Direct probe of the spectrum (bremss, IC)
  - Unknown interstellar radiation field
  - Injection spectrum may be different from that of nucleons
  - Large energy losses
- Synchrotron emission

Diffuse Galactic gamma ray emission

Conventional model: local proton & electron spectra



Possible reasons for discrepancy:

- Harder nucleon spectrum *and/or*
- Harder electron spectrum

  In the ISM and/or near the sources
- Unresolved sources
- …

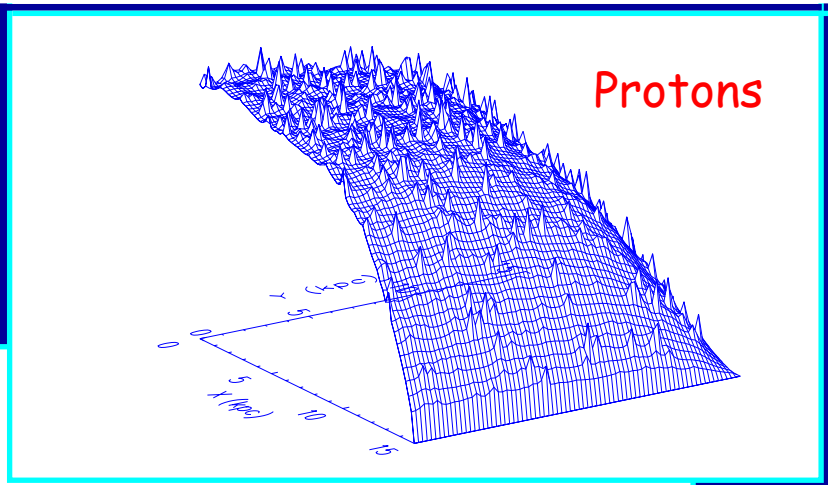
GALPROP model

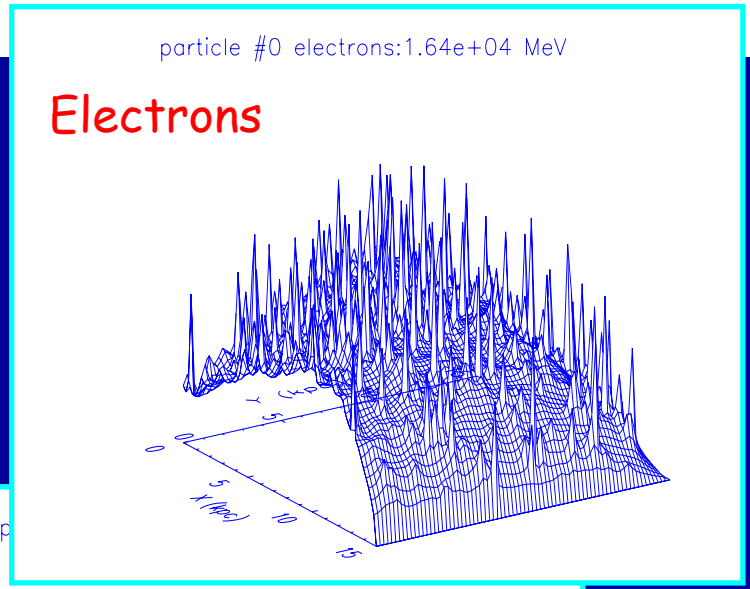
Try to be as much realistic as possible:

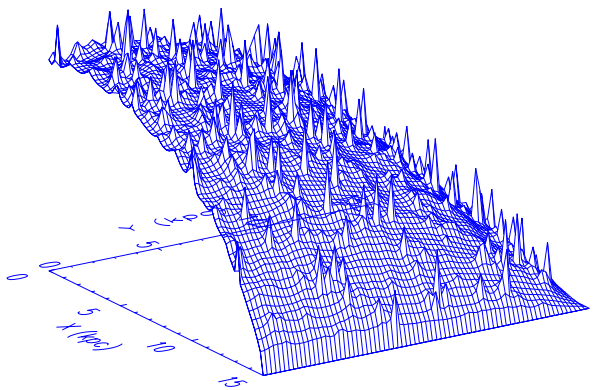
- ✓ 3D or 2D (cylindrical) geometry
- ✓ 2D (cyl) Galactic gas distribution: H_2, HI, HII
- ✓ 2D (cyl) radiation fields: stars, dust, CMB
- ✓ Diffusion, reacceleration, convection…
- ✓ Energy losses: ionization, Coulomb, bremss, Compton, synchrotron
- ✓ Nuclei H-Ni, antiprotons, electrons, positrons
- ✓ Nuclear reaction network + cross sections (best to date)
- ✓ Radioactive decay, electron capture, and stripping
- ✓ Explicit time-dependence with stochastic and known SN events in 3D mode
- ✓ Gamma rays (neutral pions, IC, bremss), synchrotron
- ✓ Generation of gamma-ray skymaps (FITS format)
- ✓ Implemented in C++

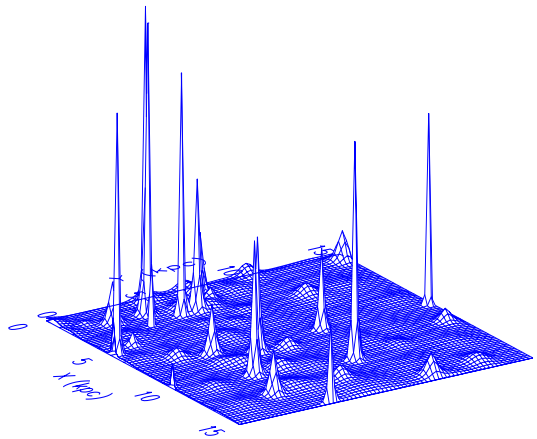
Particle sources in 3D

Protons and electrons:









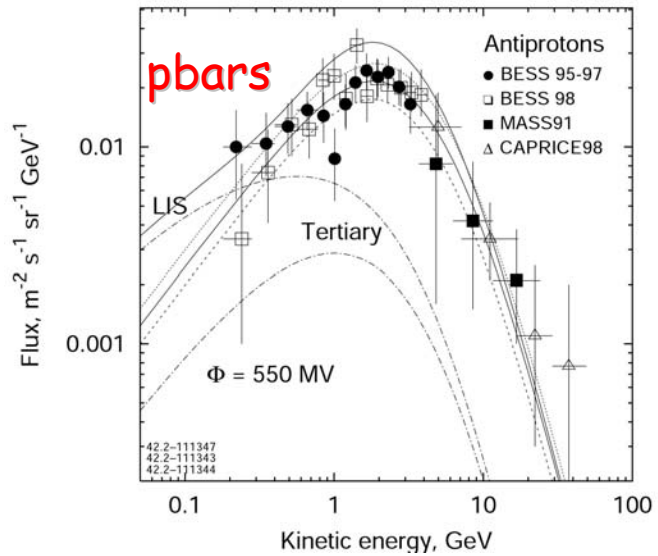
Recent developments

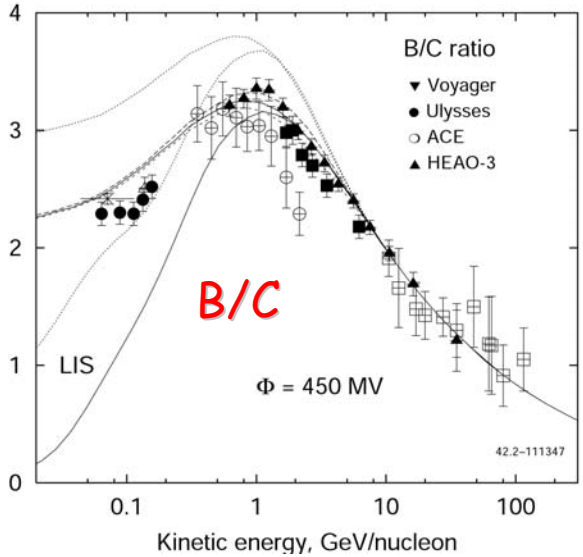
Nucleons:

- More accurate nuclear cross sections (LANL database + modern nuc-codes)
- More accurate CR data (ACE, Ulysses), pbars (BESS), p, He (BESS, AMS)
- More restrictions on propagation models (pbars vs. nucleons), new ideas:
  - + Local Bubble contribution
  - + Damping of interstellar turbulence on small scale
  - + …

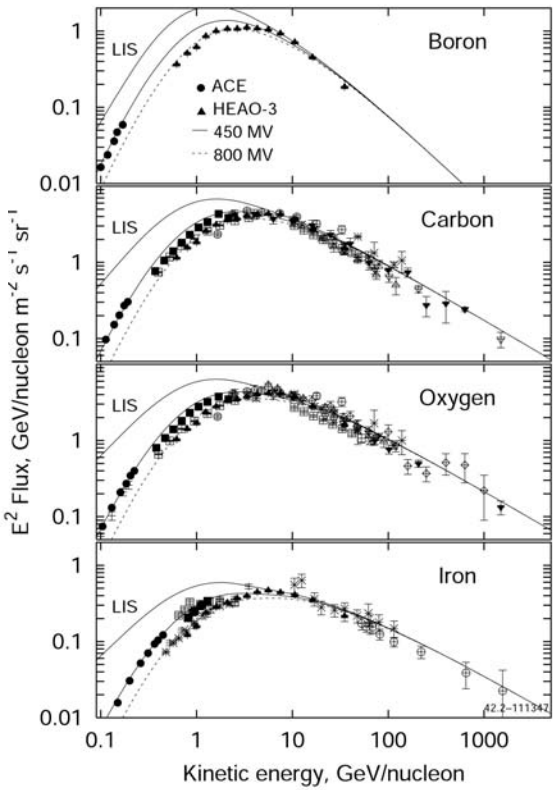
Influences propagation (diffusion coefficient etc.)

Recent developments/nucleons

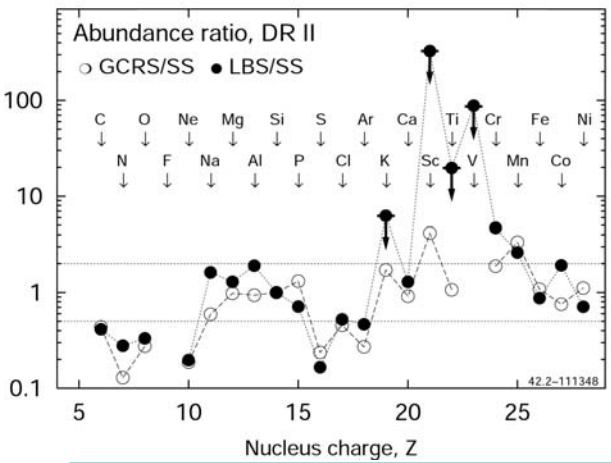


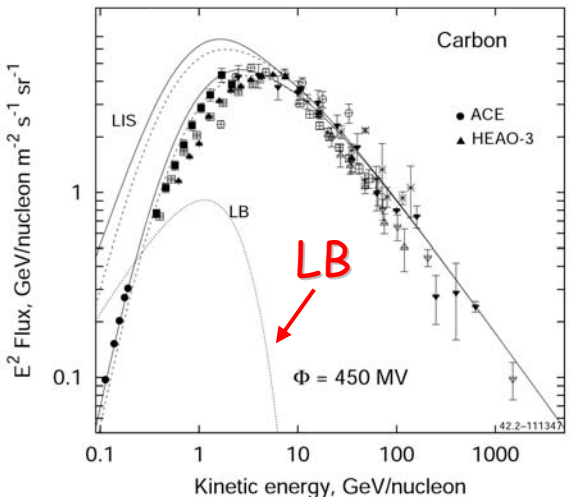


Spectra



Abundance ratio





Recent developments

Gammas:

- Full 3D geometry
- Optional explicit time-dependence with stochastic SN events
- Generates gamma-ray skymaps as a function of energy (FITS format) using the computed CR distribution and gas survey data (by S.Digel)
- Visualization tool (started) using the classes of CERN ROOT package (images, profiles, and spectra from GALPROP to be directly compared with data)

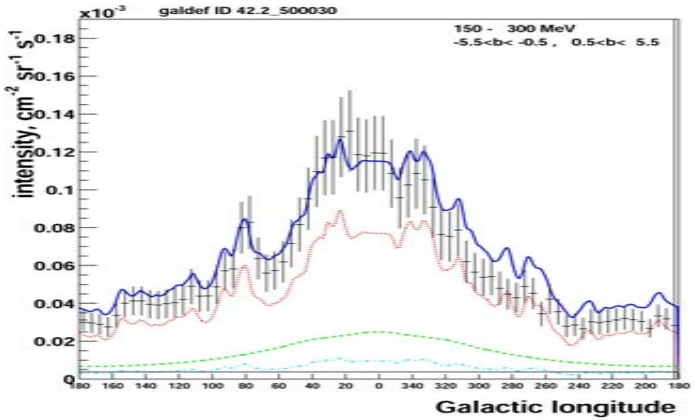
New analysis:

- Point sources (3EG catalogue) removed (O.Reimer) – little effect
- Predicted skymaps convolved with EGRET PS-function
- Excludes the Galactic plane – better defined EG background
- Based on a model of CR propagation (consistent with CR data).

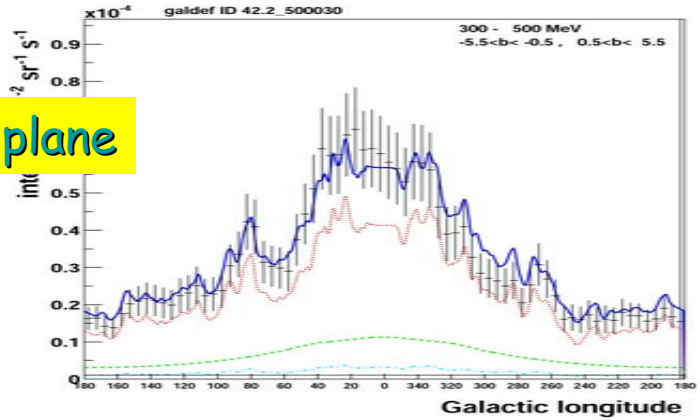
[Hunter et al. (1997) approach – CR-gas coupling, a small IC component]

Recent developments/gammas

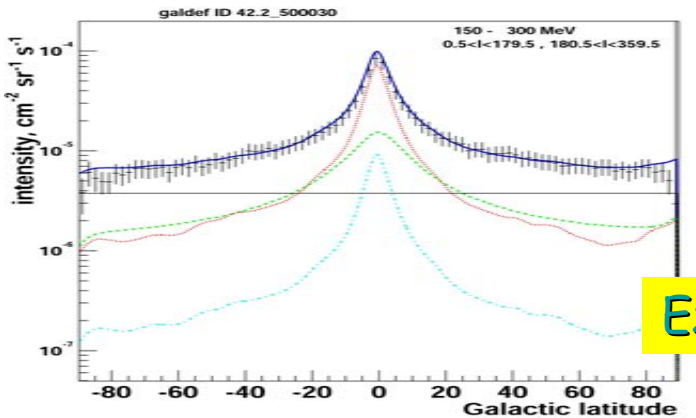
150—300 MeV Longitude profile 300—500 MeV



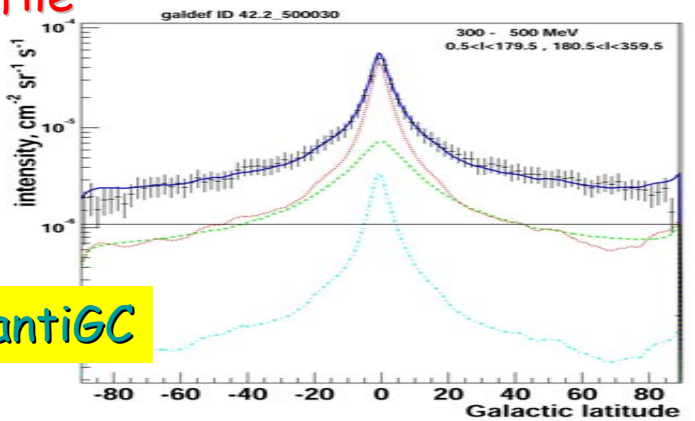
luding the plane



Latitude profile

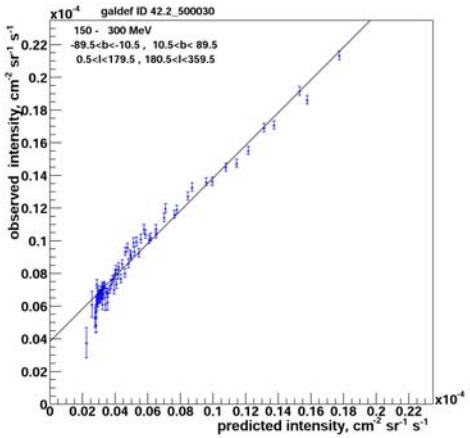


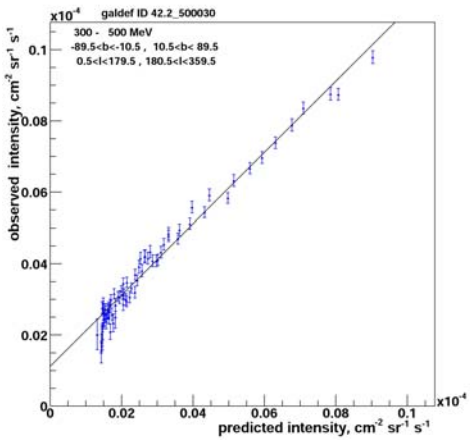
Excluding GC/antiGC



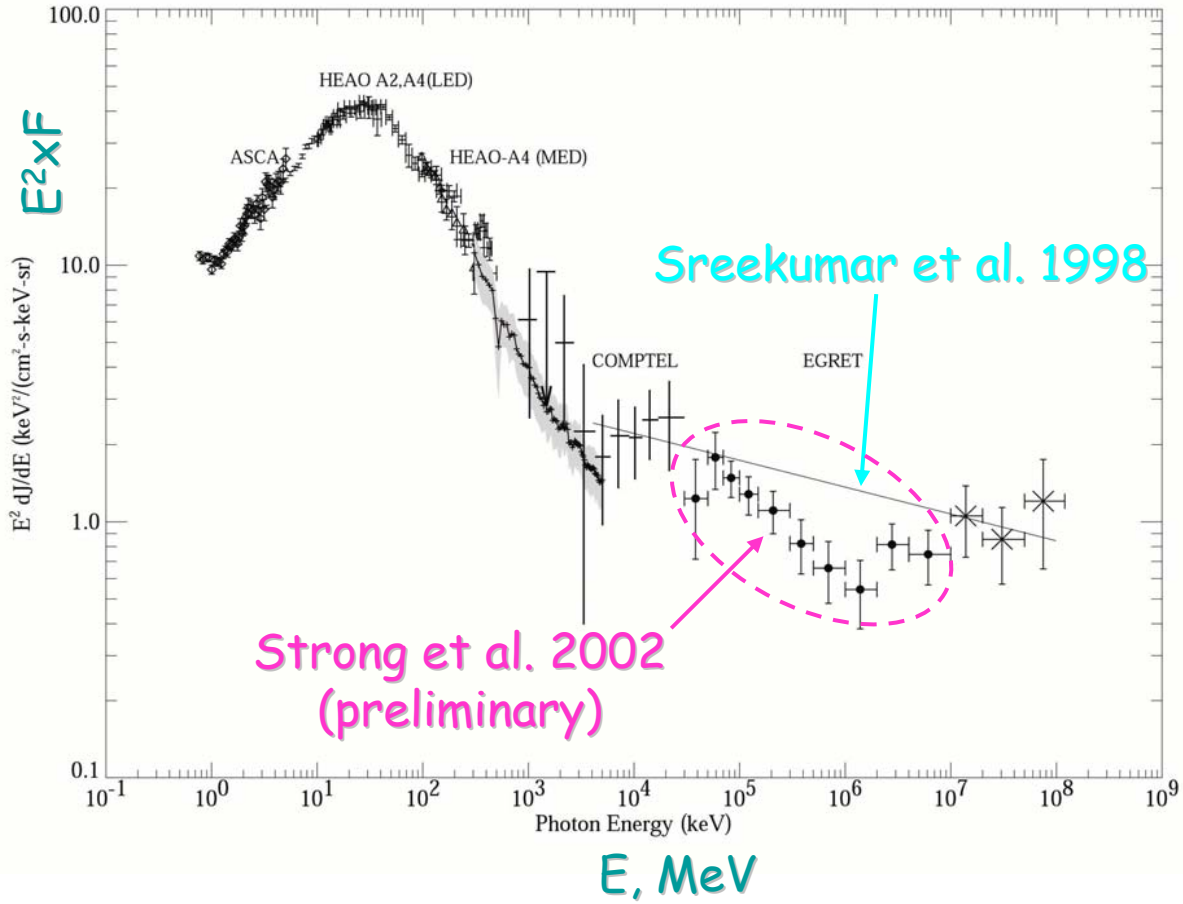
Recent developments/gammas

Predicted vs. observed





Extragalactic background



More developments to come…

- Integrated research tool for the study of diffuse gamma rays…
- Work on user friendly plotting interface…
- New interstellar radiation field…
- New gas distribution…
- …

Conclusion

Many things to test with GLAST:

- GeV excess (confirm ?)
- Diffuse emission @ HE – tests of models
- Extragalactic emission (not the last word yet)
- Dark matter signals (& test vs. CR data)
- …

GALPROP – a ready instrument to play before/after the GLAST launch:

+ Only physical model of the Galactic diffuse emission
+ Available from the authors @ http://www.gamma.mpe–garching.mpg.de/~aws/aws.html