Diffuse emission from the Galactic plane and unidentified EGRET sources

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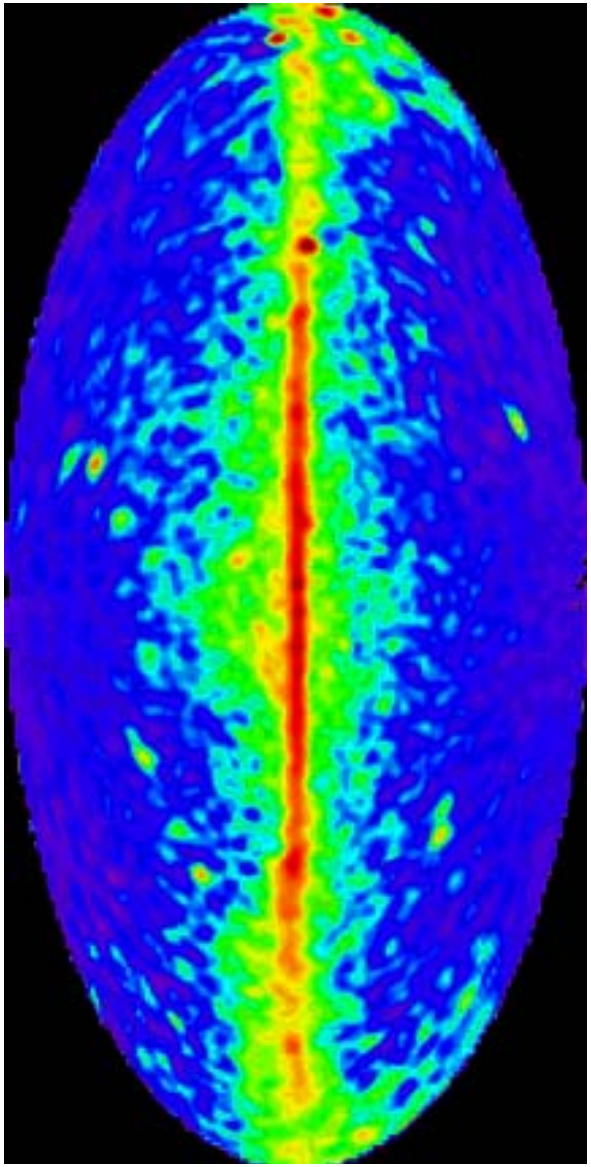
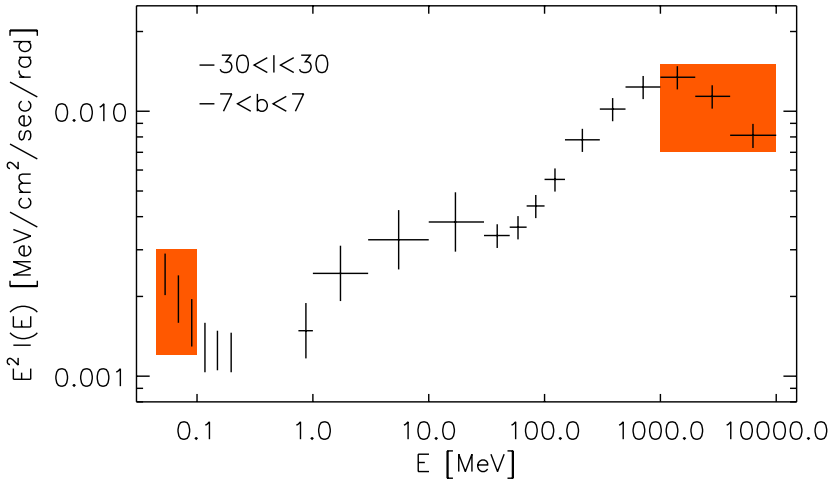
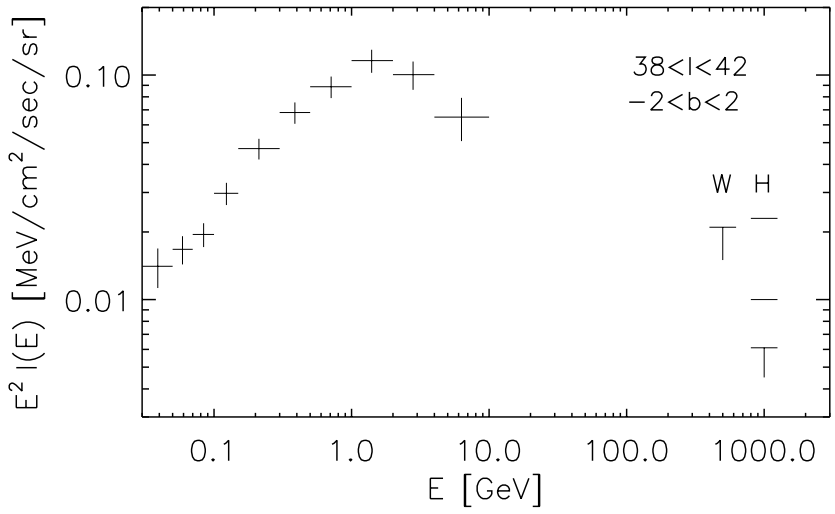
The Questions

- What is the nature of the excesses in diffuse Galactic γ-rays?
- What fraction of the diffuse Galactic emission is caused by unresolved sources?
- What is the nature of the unidentified EGRET sources?
- What is the relation between the γ-ray excesses and the unidentified γ-ray sources?




−30<l<30
−7<b<7
0.010
0.001
E² I(E) [MeV/cm²/sec/rad]
0.1
1.0
10.0
100.0
1000.0
10000.0
E [MeV]


38<l<42
−2<b<2
W H
0.10
0.01
E² I(E) [MeV/cm²/sec/sr]
0.1
1.0
10.0
100.0
1000.0
E [GeV]

The excess at 100 keV

• If truly diffuse, a very high source power in radiating particles would be needed.

• point source contamination unknown (→ INTEGRAL).

The GeV excess

• Unlikely to be an instrumental effect.

• Spectral extent towards higher energies is marginally constrained.

• Apparently visible also at high latitudes!

(Observation of extragalactic emission, Sreekumar et al. 1998)

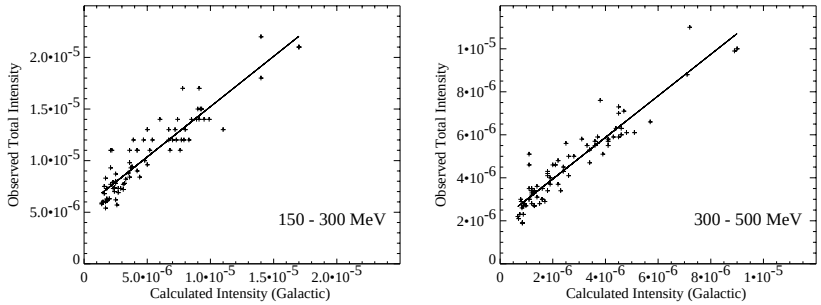


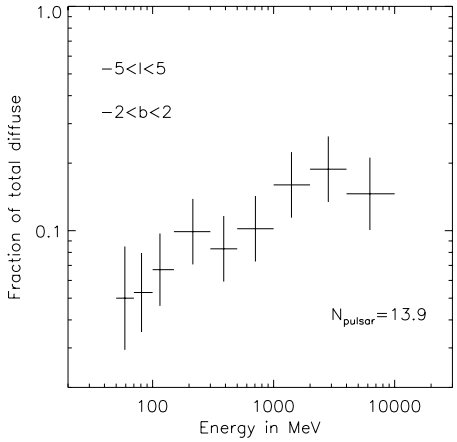
Table 1. Results from the all-sky correlation analysis

Energy (MeV)	Normalization(B)	A
30–50	1.14	(1.20±0.32)E-06
50–70	1.04	(6.56±0.96)E-07
70–100	1.09	(2.59±0.09)E-07
100–150	1.05	(1.09±0.04)E-07
150–300	0.97	(3.53±0.14)E-08
300–500	0.97	(9.56±0.47)E-9
500–1000	1.09	(2.59±0.14)E-9
1000–2000	1.34	(6.69±0.36)E-10
2000–4000	1.85	(2.03±0.14)E-10
4000–10000	1.56	(3.10±0.28)E-11

$$\frac{\text{Data}}{\text{Model}} = B \simeq 1.3 - 1.8 \qquad \text{for} \quad E > 1 \text{ GeV} , \quad |b| > 10^\circ$$

Suggests existence of GeV excess at high latitudes!

Unresolved sources in the diffuse emission

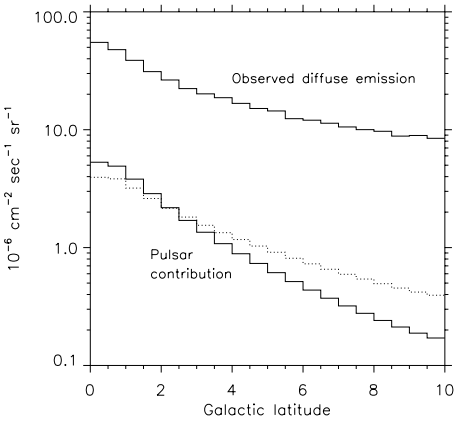


Pulsars, Pohl et al. 1997

Based on

six identified

EGRET pulsars



E > 1 GeV

N=13.9

T=1.6 million years

The contribution of known sources is small!

But see also McLaughlin & Cordes (2000)

The nature of unidentified sources

- How do we know they're Galactic?

  – Can't tell for HEGRA source in Cygnus.

  – Spatial distribution of EGRET sources

  $\Rightarrow$ $\sim$100 unidentified EGRET sources are Galactic

- EGRET systematics influence the population studies:

  – Flat-spectrum sources are more easily found in region of high background.

  – Backward-folding in EGRET standard analysis can cause "false" variability of Galactic plane sources.

  – Correlation studies with known classes of sources are hampered by the large number of objects.

What to expect from different source classes?

- Pulsars
  - constant flux
  - wide latitude distribution

Few sources have the "typical" hard spectrum!

Off-beam emission in polar-cap model (Harding & Zhang 2001)

→ low luminosity with soft spectrum.

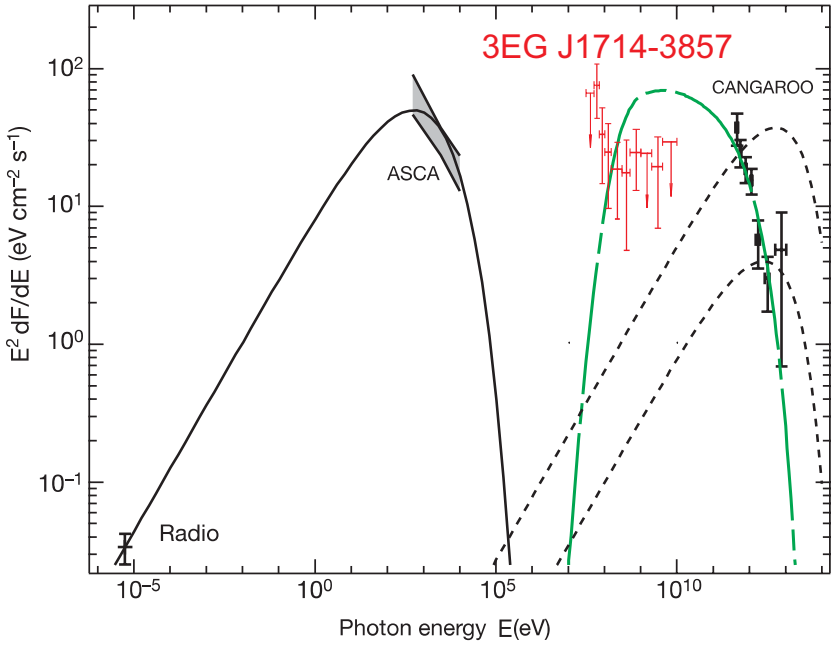
- Supernova remnants
  - constant flux
  - narrow latitude distribution

TeV detection of only three SNR.

→ no clear evidence for hadronic emission.

Extrapolations from TeV behaviour to GeV appearance are difficult.

Example: RX J1713.7-3946



Enomoto et al., 2002:

IC interpretation is in conflict with the data.

Reimer & Pohl, 2002:

π^0-decay interpretation is in conflict with the data.

- Relative νF_ν-sensitivity of EGRET and ACTs

- Expected γ-ray spectra from SNR

$\Rightarrow$ At most a few SNR can be EGRET sources.

Or

SNR do not accelerate cosmic rays to more than ~ 10 TeV.

What about unresolved SNRs?

– Could contribute significantly at TeV energies (by π^0-decay).
(Berezhko & Völk 2000)

– Presumably a minor contribution at GeV energies.
(compare with B/C ratio)

– This would not explain the GeV excess.

What about the Swiss Cheese model?

The hard IC interpretation of the GeV excess requires an SNR origin of CR electrons.

Pohl & Esposito 1998
Strong, Moskalenko, & Reimer 2000

It was assumed that accelerated electrons are instantly released, but produced over 10^5 years.

Then for TeV electrons with $\tau_l \simeq 10^5$ years

$\Rightarrow$ Enhancements with radius 200 pc

$\Rightarrow$ IC Enhancements with radius 2.3deg for D=5 kpc.

$\Rightarrow$ Nearby enhancements wouldn't not be point sources!

Is that realistic?

CR's are NOT instantly released!

SNR radius is ~ 50 pc or 0.6deg for D=5 kpc

Close to a point source?

BUT: The precursor thickness increases!

$$\delta r \simeq \frac{\kappa}{V} \simeq 0.2\,\eta \text{ pc} \qquad \text{with} \quad \kappa = \eta\,\kappa_{\rm Bohm}$$

$$\Rightarrow \delta r \gg 1 \text{ pc} \qquad \text{for} \quad \eta \gg 1$$

No strong conflict with non-detection of SNR!

Have still ∼100 unidentified sources!

Torres et al, 2001:

• ∼ 40 UnIds are not positionally coincident with any known class of potential γ-ray emitters in the Galaxy.

• Many are variable (like AGN)

• The spectra are soft with $<\gamma>=2.4\pm0.2$

⇒ **Must be a new class of objects!**

• They can't contribute to the GeV excess

• The luminosity should be $\gtrsim 10^{34}$ ergs/sec in the EGRET band.

⇒ **No evidence**

for a point source origin of the GeV excess!

Summary and conclusions

• About 100 EGRET UnId's seem to be Galactic.

• A small fraction of them will be Pulsars and SNR.

• The majority of them comes from a other classes of objects.

• Diffuse γ-ray excesses are observed at 100 keV and a few GeV.

• INTEGRAL will tell the point source fraction at100 keV.

• The GeV excess is probably not caused by unresolved sources.

• Hard IC models of the GeV excess are not in strong conflict with non-detection of SNR or SNR halos by EGRET.