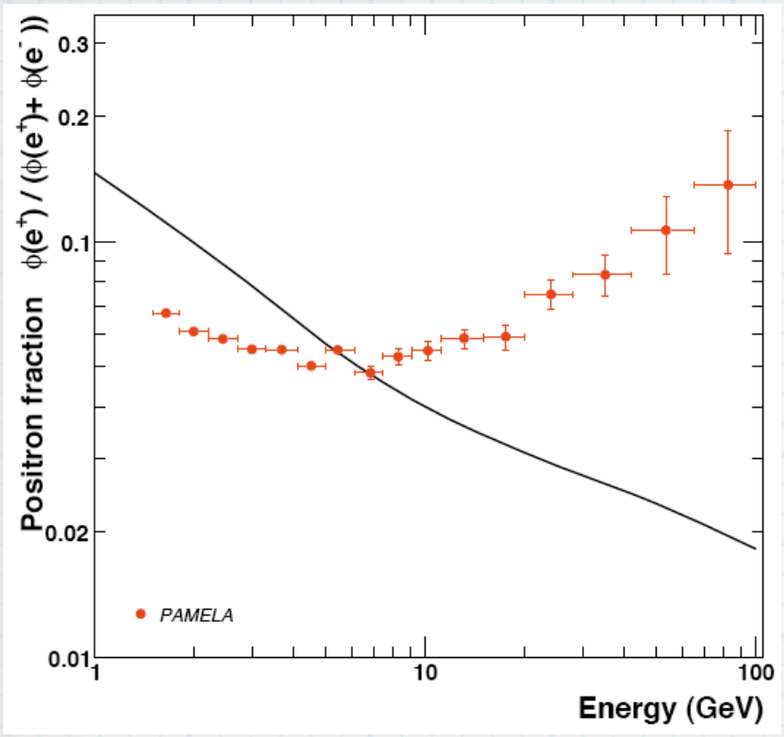
Pulsars as a Source of the WMAP Haze

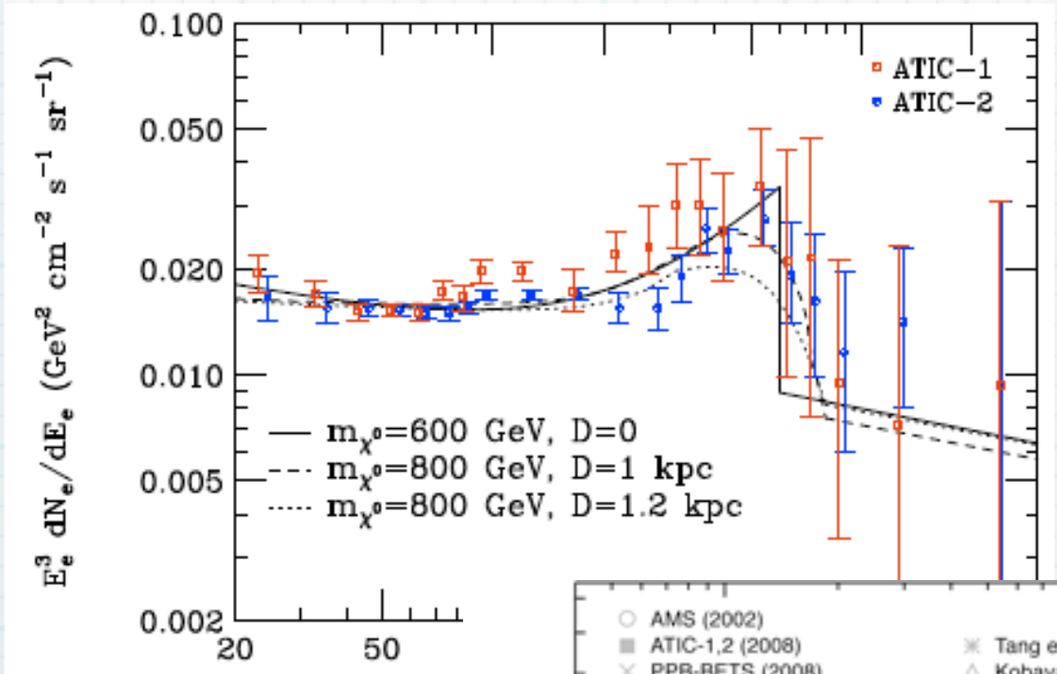
Kathryn Zurek
Fermilab

Kaplinghat, Phalen, KMZ, arXiv: 0905.0487

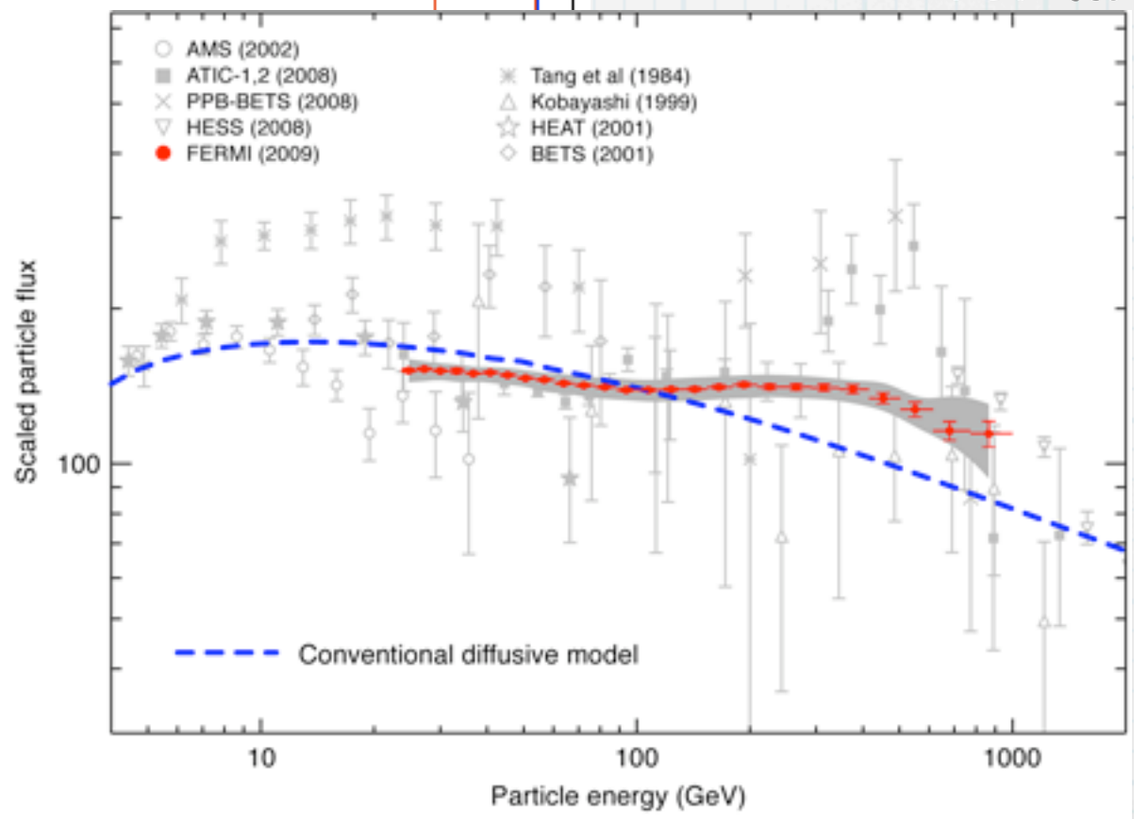
Excess cosmic ray electrons



PAMELA



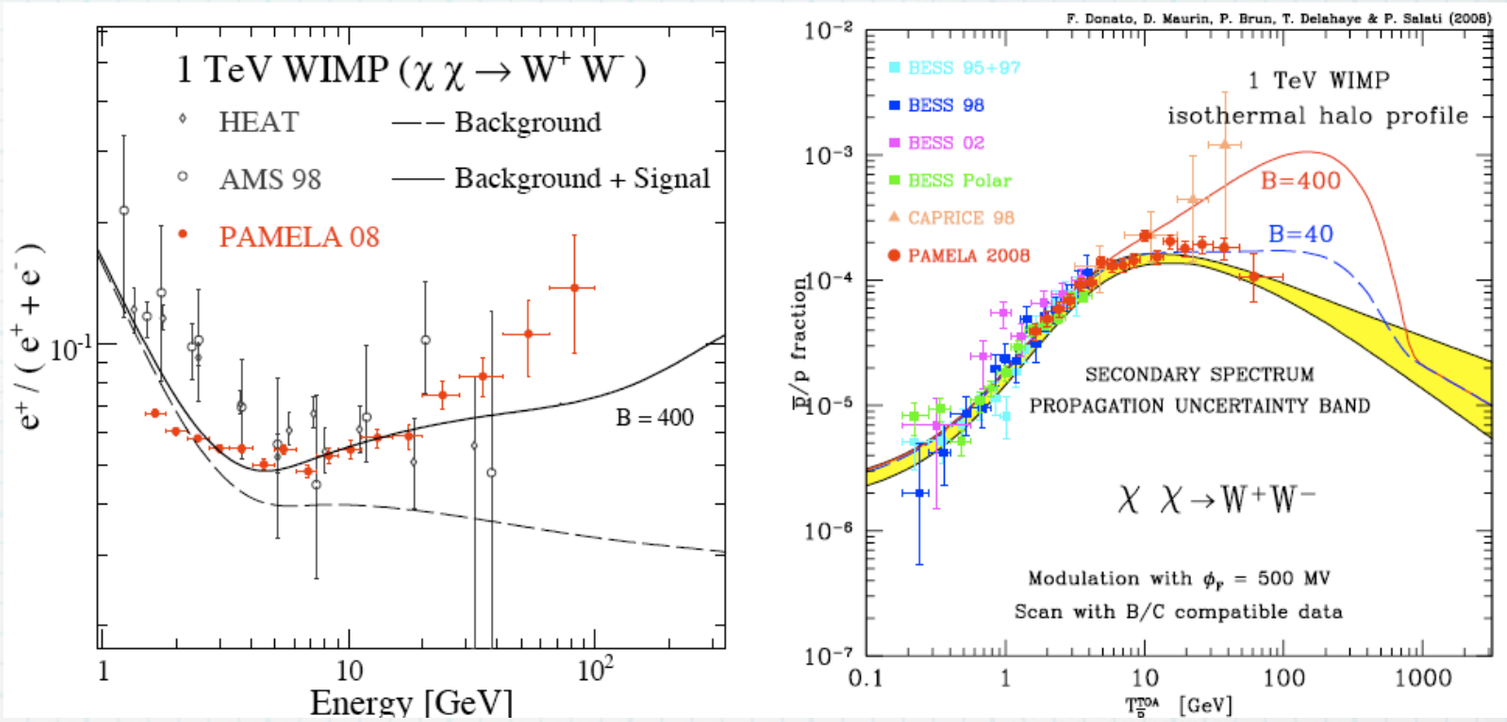
ATIC

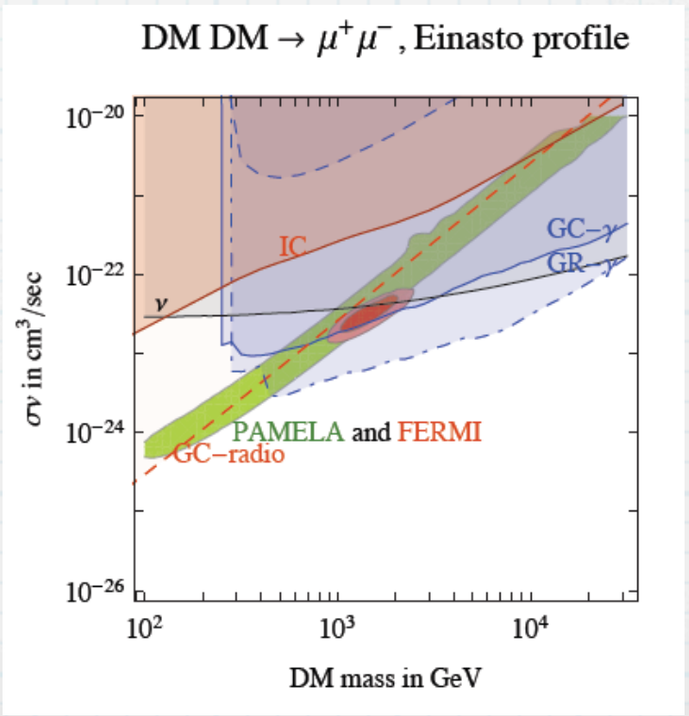


Fermi

DM model building fury

* Problematic with
  * anti-protons
  * gamma rays



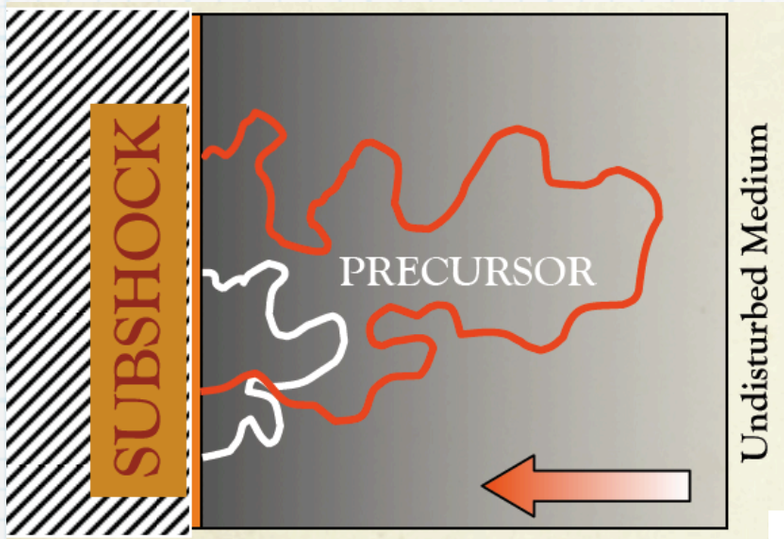


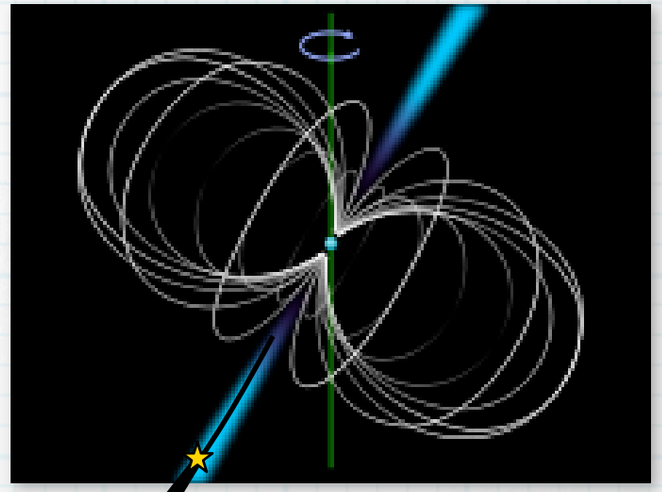
Cirelli et al
Meade et al

But, really just ordinary astrophysics?

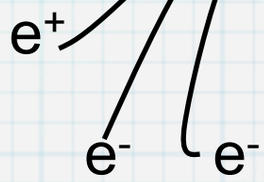
* Possible sources:
  * Pulsars?
  * Secondary production in supernova remnant?
  * New additional acceleration mechanism?

Blasi

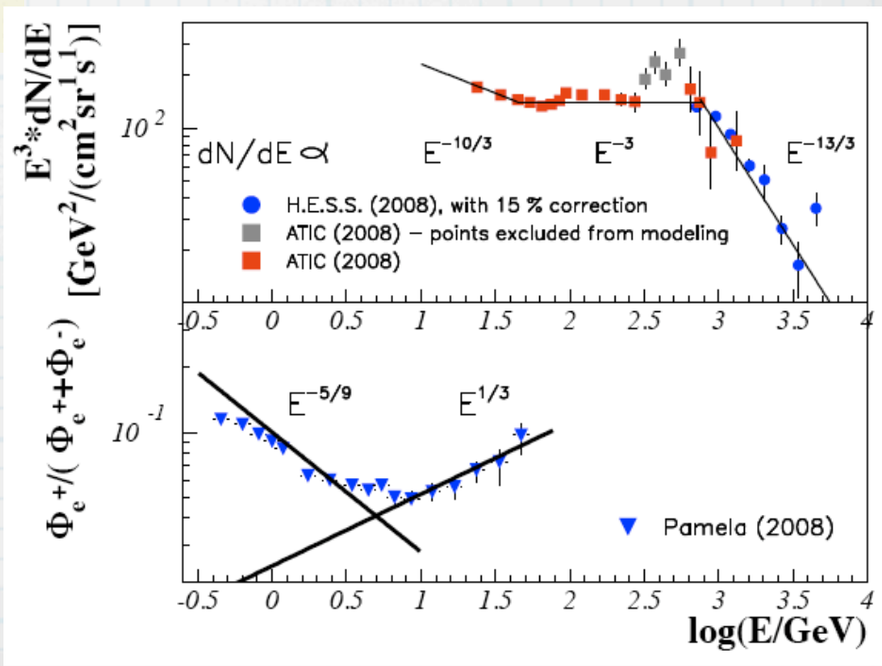




Hooper, Blasi, Serpico

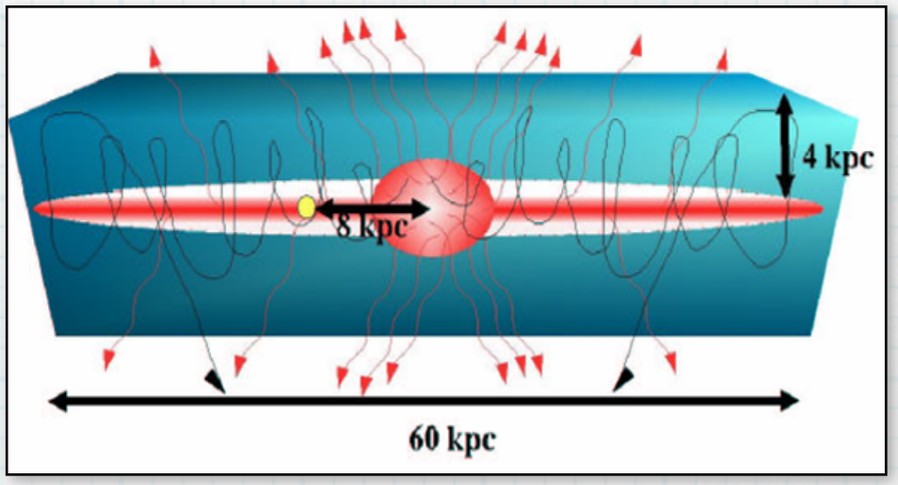


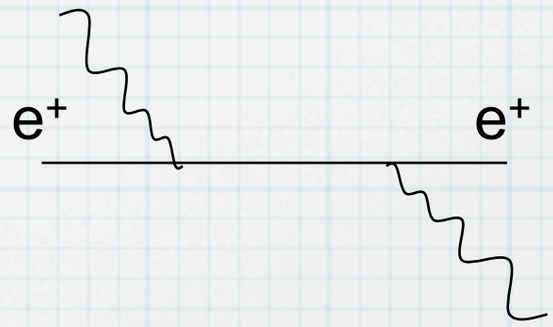
Biermann et al



Excess electrons from astrophysical objects

* Produced at sources
* Diffuse outwards, lose energy
* Radiate in magnetic field
* WMAP Haze?



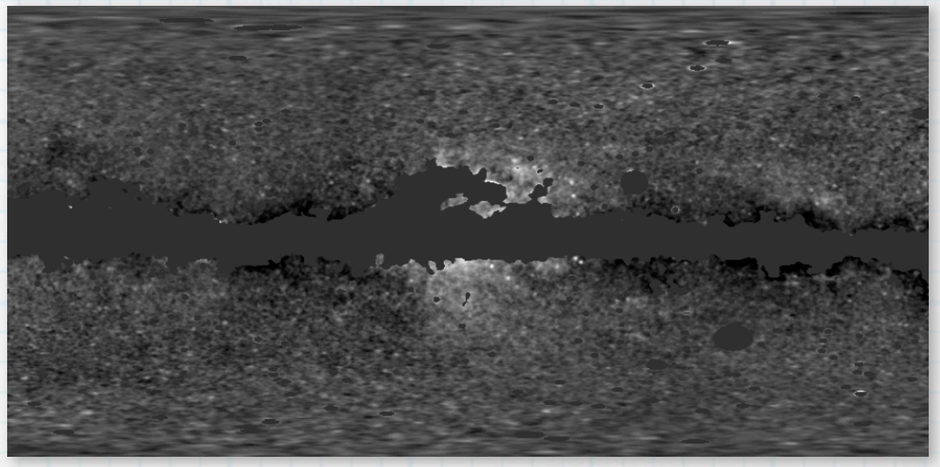


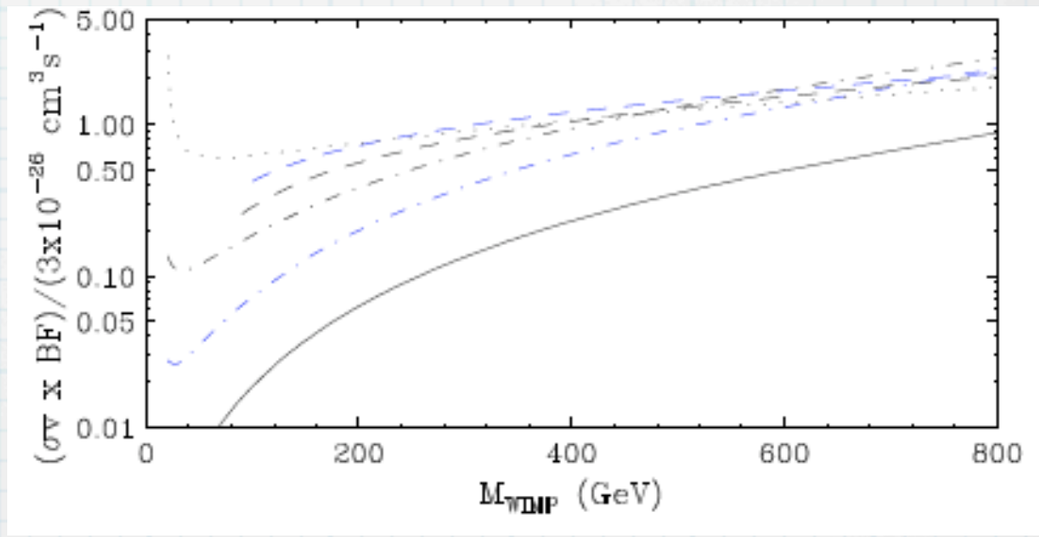
Gamma Rays (Inverse Compton on starlight)
Synchrotron (magnetic field)

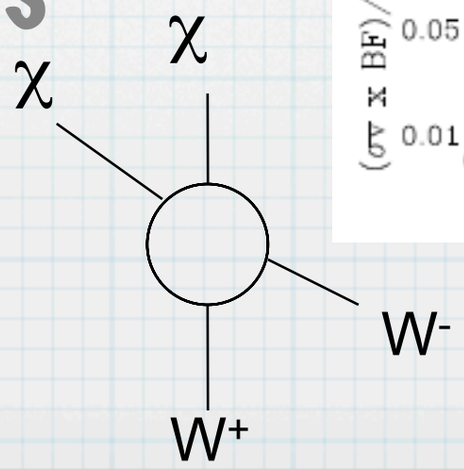
The WMAP Haze

* Is it there?
  * Lots of background synchrotron radiation, from dust
* What causes it?
  * DM annihilation to charged byproducts which radiate in magnetic field?

Finkbeiner
Finkbeiner and Dobler 2007







The WMAP Haze from DM

* Magic thermal annihilation cross-section
  * Gets right relic density
* But annihilation cross-section quite dialable

$$\Omega_c h^2 = 0.114 \pm 0.003$$

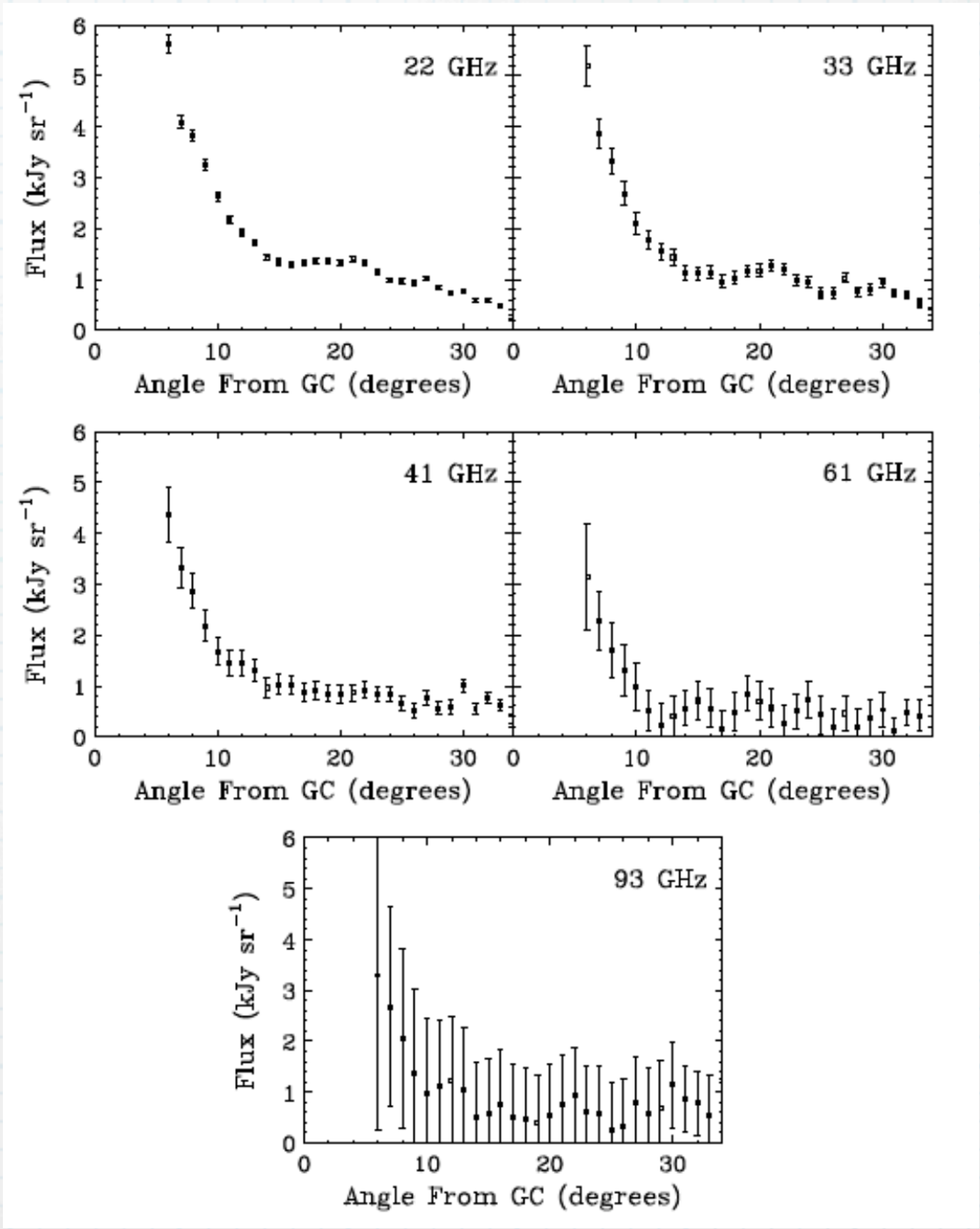
$$\Omega h^2 \approx \frac{2 \times 10^{-10} \mathrm{GeV}^{-2}}{\langle \sigma v \rangle}$$

$$\sigma v \approx \frac{g^4}{1\ \mathrm{TeV}^2} \approx 3 \times 10^{-26} \frac{\mathrm{cm}^3}{\mathrm{s}}$$

* Density profile, Magnetic field profile, ratio of energy lost by inverse Compton to synchrotron
* Several orders of magnitude in cross-section

WMAP Haze from Astrophysical Electrons?

* Total flux of synchrotron
* Angular profile from galactic center
* Frequency band dependence $\frac{dn_e}{dE_e} \propto E_e^{-\alpha}$
* Morphology -- approximately spherical



WMAP Haze from Astrophysical Electrons?

* Total flux of synchrotron
* Angular profile from galactic center
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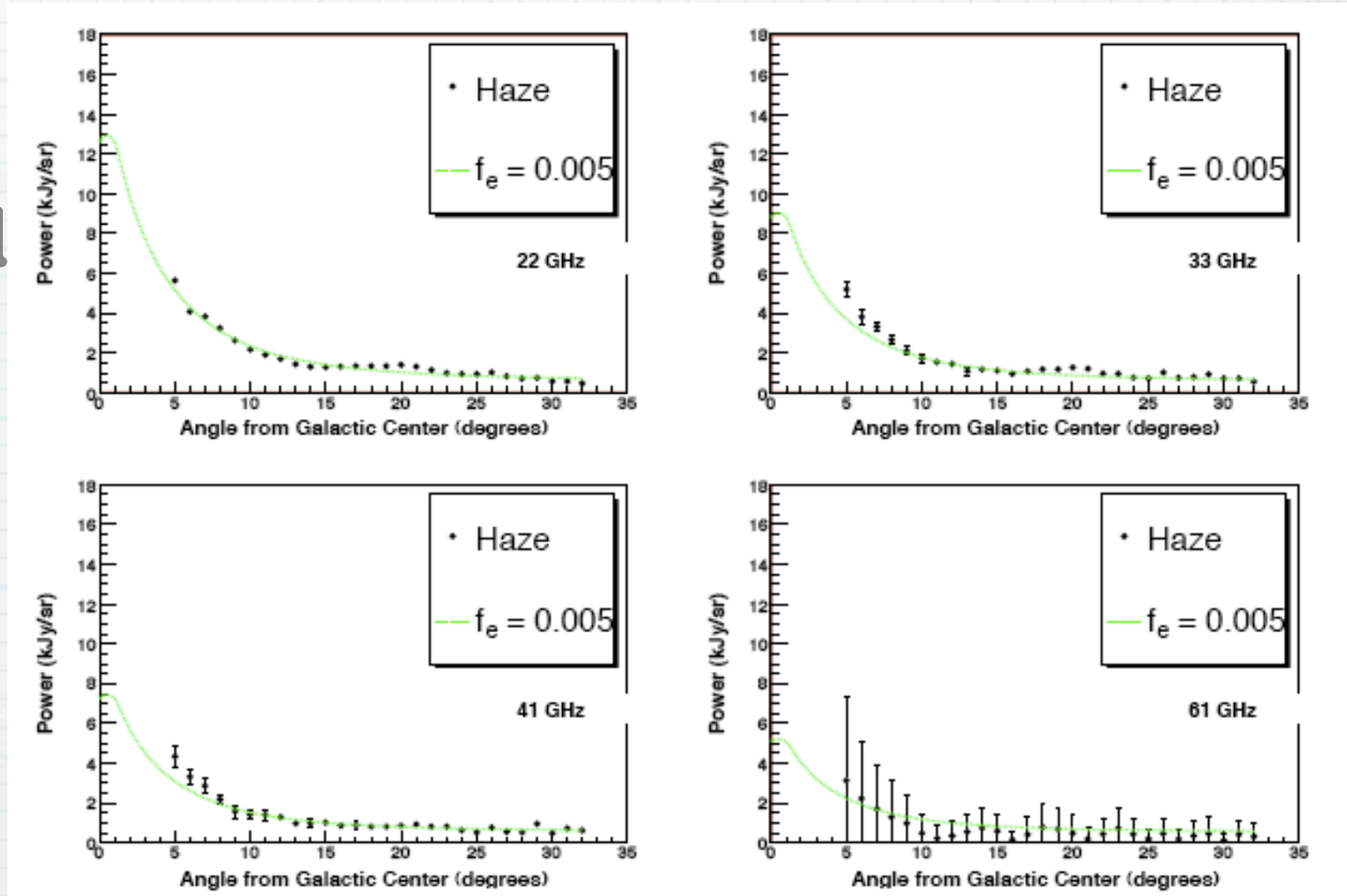
* Morphology -- approximately spherical
* Pulsar contribution



WMAP Haze from Astrophysical Electrons?

* Total flux of synchrotron ✓
* Angular profile from galactic center ✓
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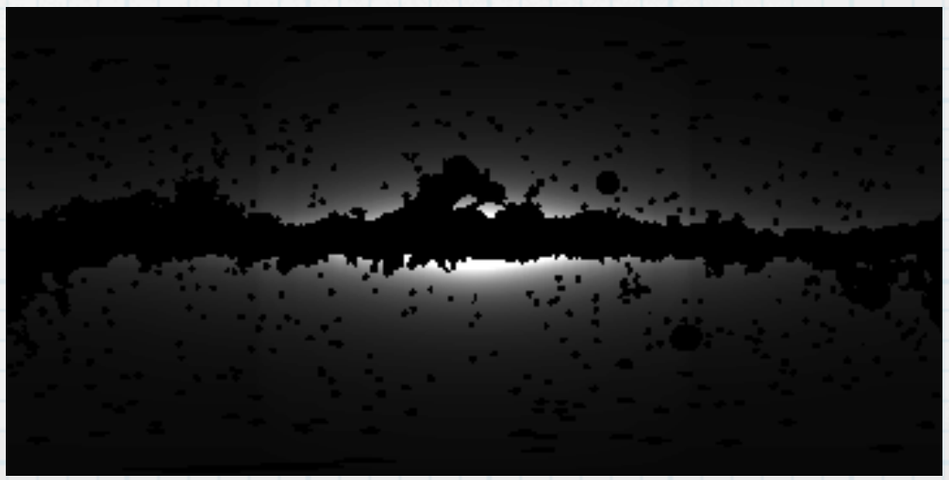
* Morphology -- approximately spherical

* Pulsar contribution

$$\int Q_0 \left(\frac{E_e}{GeV}\right)^{-\alpha} e^{-E_e/E_{cut}} E_e dE_e = W_0.$$

$$B(r,z) = B_0 e^{-r/r_0 - |z|/z_0}$$

$$Q(E_e) = Q_0 f_e \left(\frac{E_e}{GeV}\right)^{-\alpha} e^{-E_e/E_{cut}}$$



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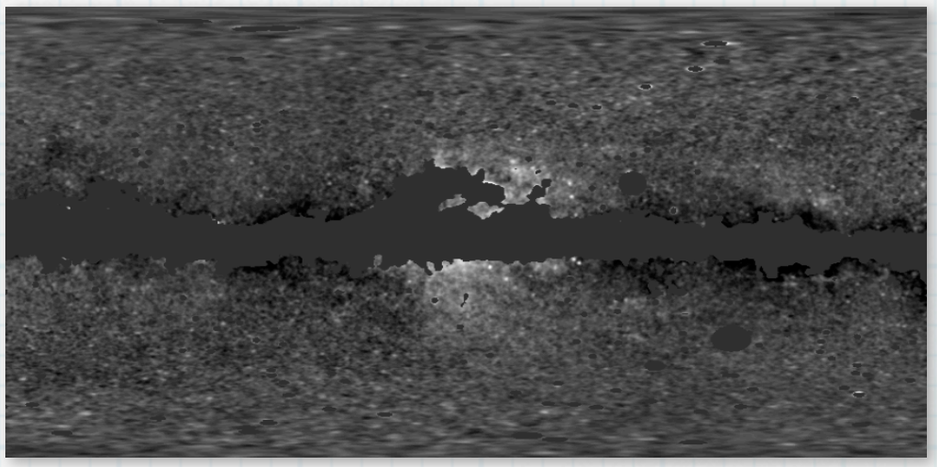
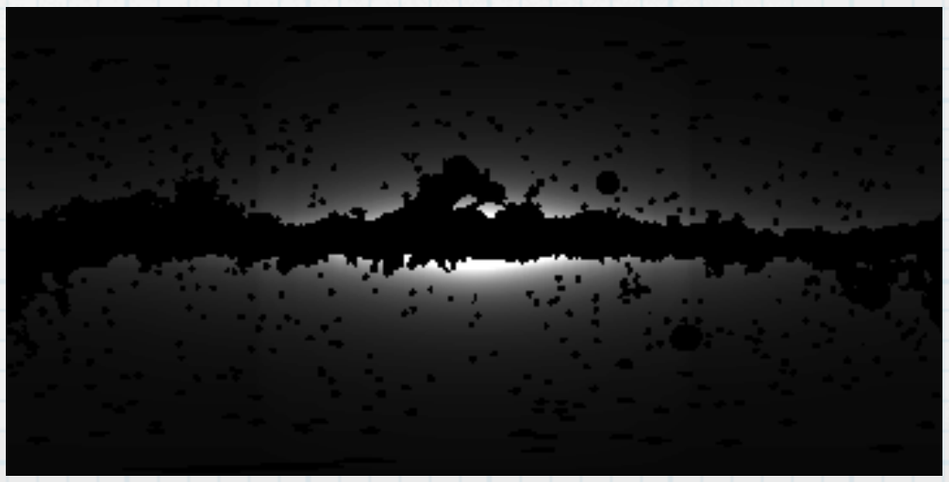


Not published for fits



Courtesy of G. Dobler

WMAP Haze from Astrophysical Electrons?

* Total flux of synchrotron ✓

* Angular profile from galactic center ✓

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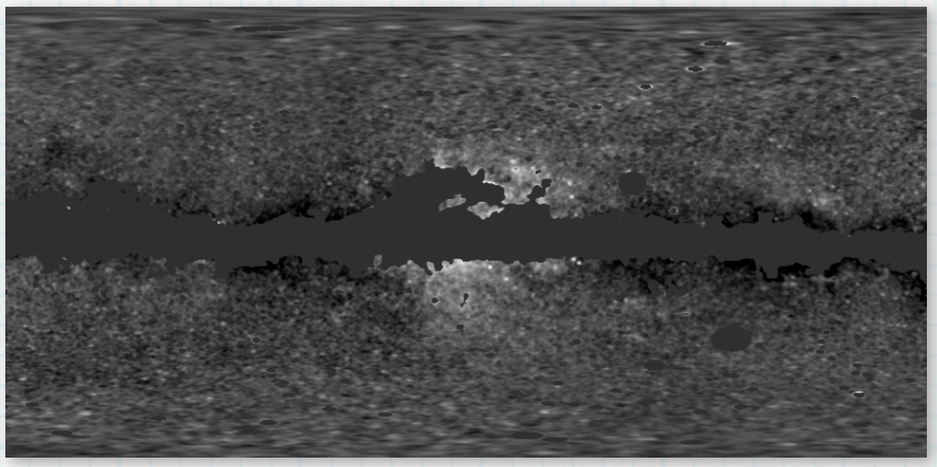
* Pulsar contribution

$$B(r,z) = B_0 e^{-r/r_0 - |z|/z_0} \rightarrow B(r,z) = B_0 e^{-r/r_0' - |z|/z_0} + B_1$$

$$r_0' << r_0$$



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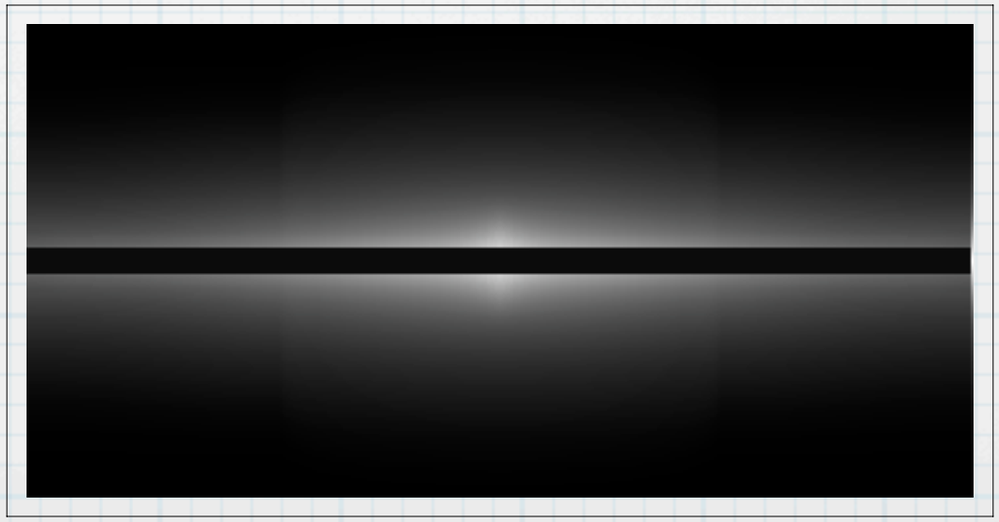

Roughly spherical?

Summary

* Pulsars are a good possible source of the positron excesses observed by PAMELA and Fermi
* The electron flux and energy distribution from pulsar production well produces Haze flux and spectrum
* Morphology needs to be further studied; subject to many astrophysical uncertainties such as B-field and pulsar distribution