PAMELA/ATIC - an Astrophysical point of view or "Anomalous" positrons from very normal sources

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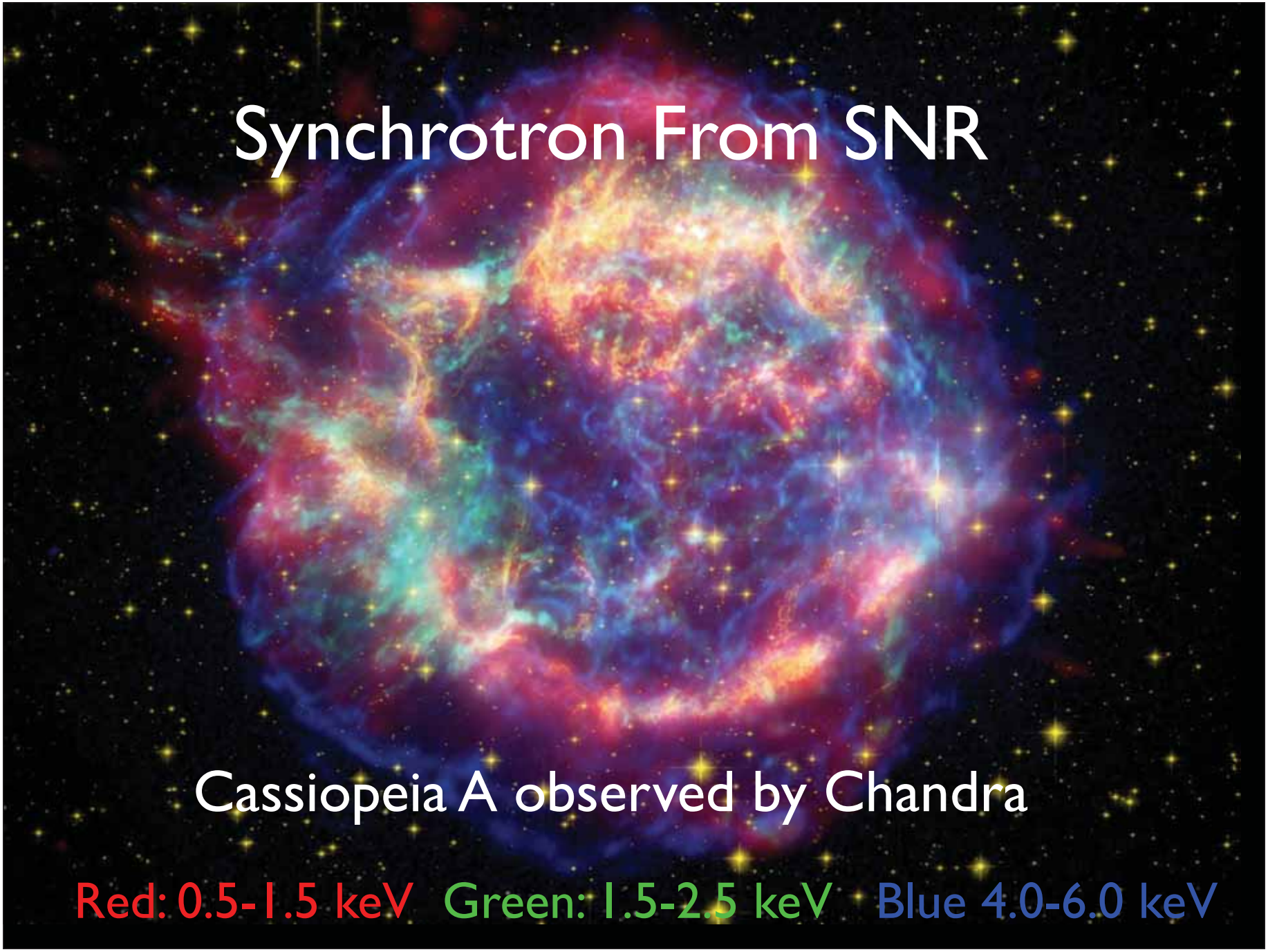
SNR are the canonical sources of CRs

- Mechanism exists (1st order diffusive / shock acceleration)
- Ginzburg & Syrovatskii (1963) - Energy requirements agree with CR density/lifetime (assuming ~ 3% - 10% efficiency)
- Observations of Synchrotron from SNe reveals efficient electron acceleration


Synchrotron From SNR
Cassiopeia A observed by Chandra
Red: 0.5-1.5 keV Green: 1.5-2.5 keV Blue 4.0-6.0 keV

Once formed, Cosmic Rays

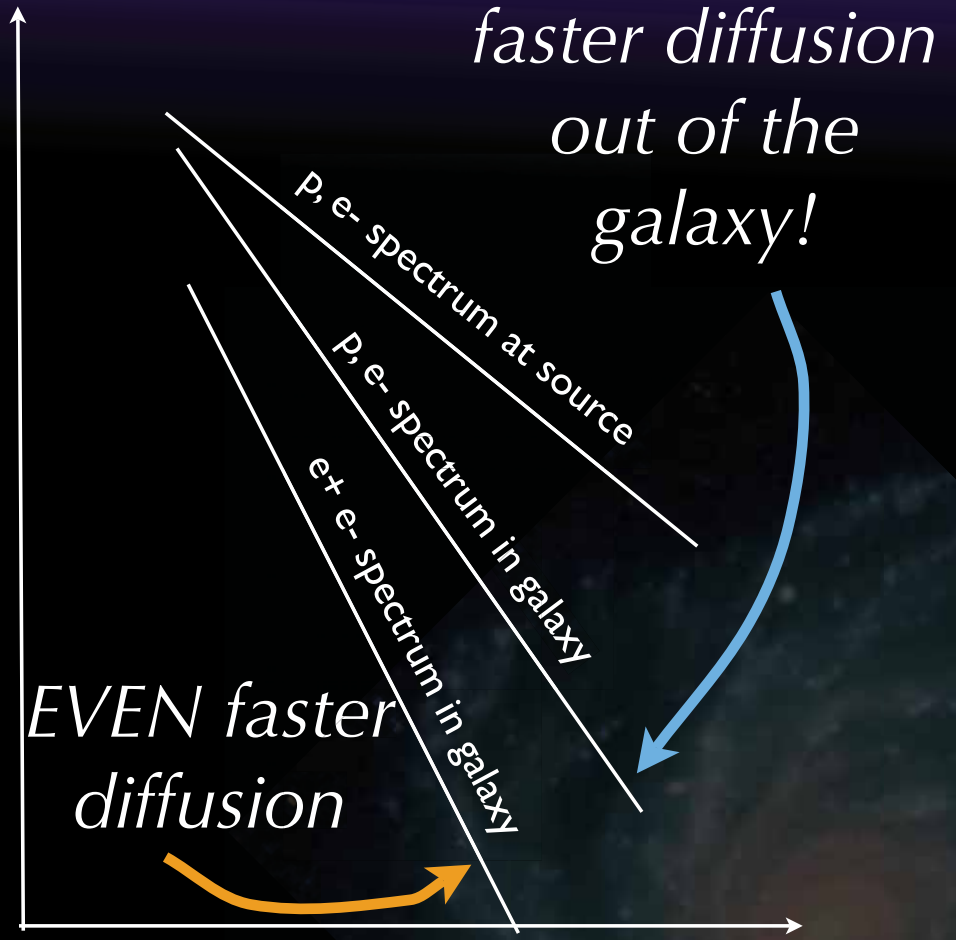
- **Trapped in the Galactic Magnetic field**
- **Diffuse**
- **Escape**

- The protons produce Secondaries p+p → ...
  This is how positrons are produced
  also p+N → N'+...

- The electrons and positrons cool

Standard View

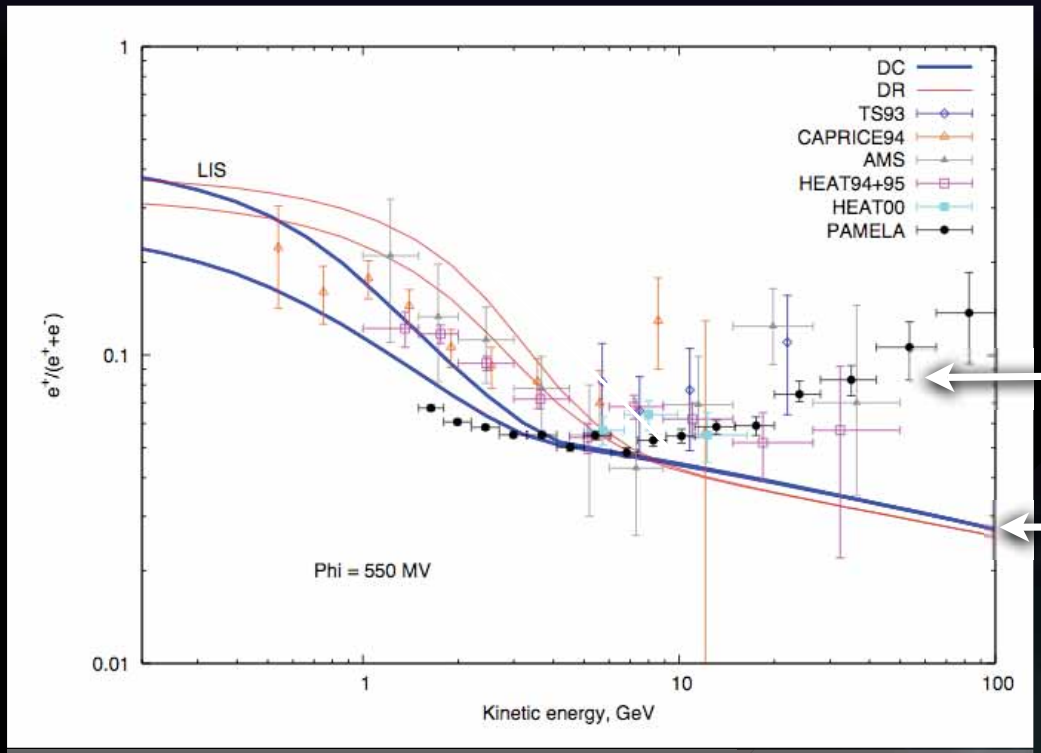
- **Electrons and Protons are mostly accelerated by supernova/ interstellar medium (ISM) shocks.**
- **Pairs (and hence Positrons) are produced by CR protons interacting with the ISM (Positrons are secondaries)**
- **Positron/Electron ratio should decrease with energy!**



What is PAMELA?

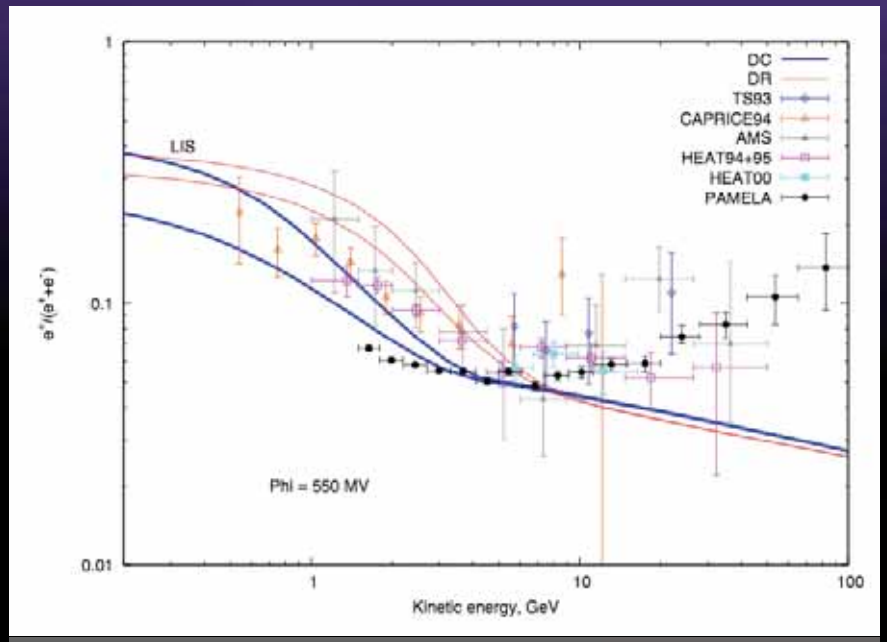
Google: PAMELA images

PAMELA's anomaly:



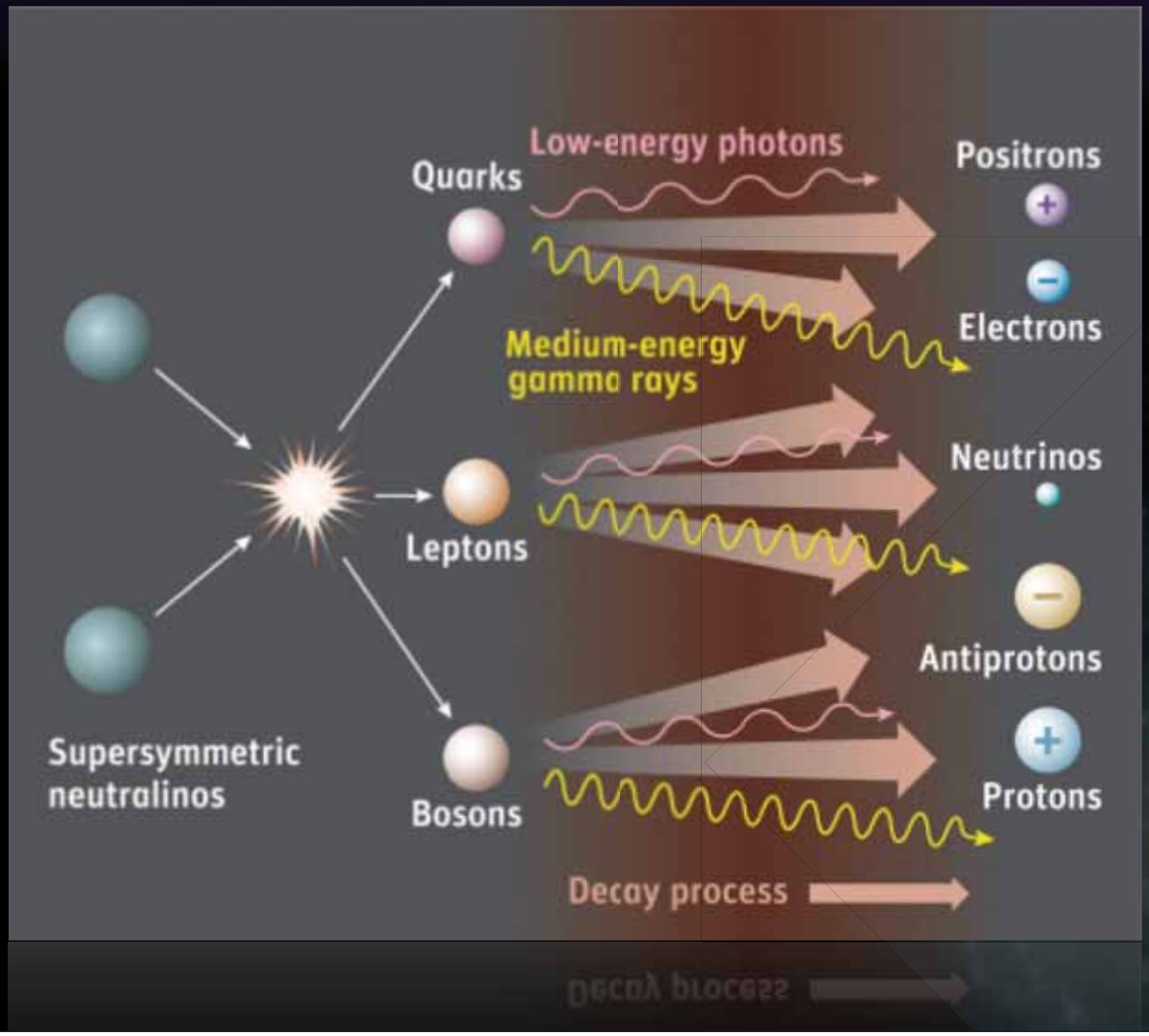
Observations

Models



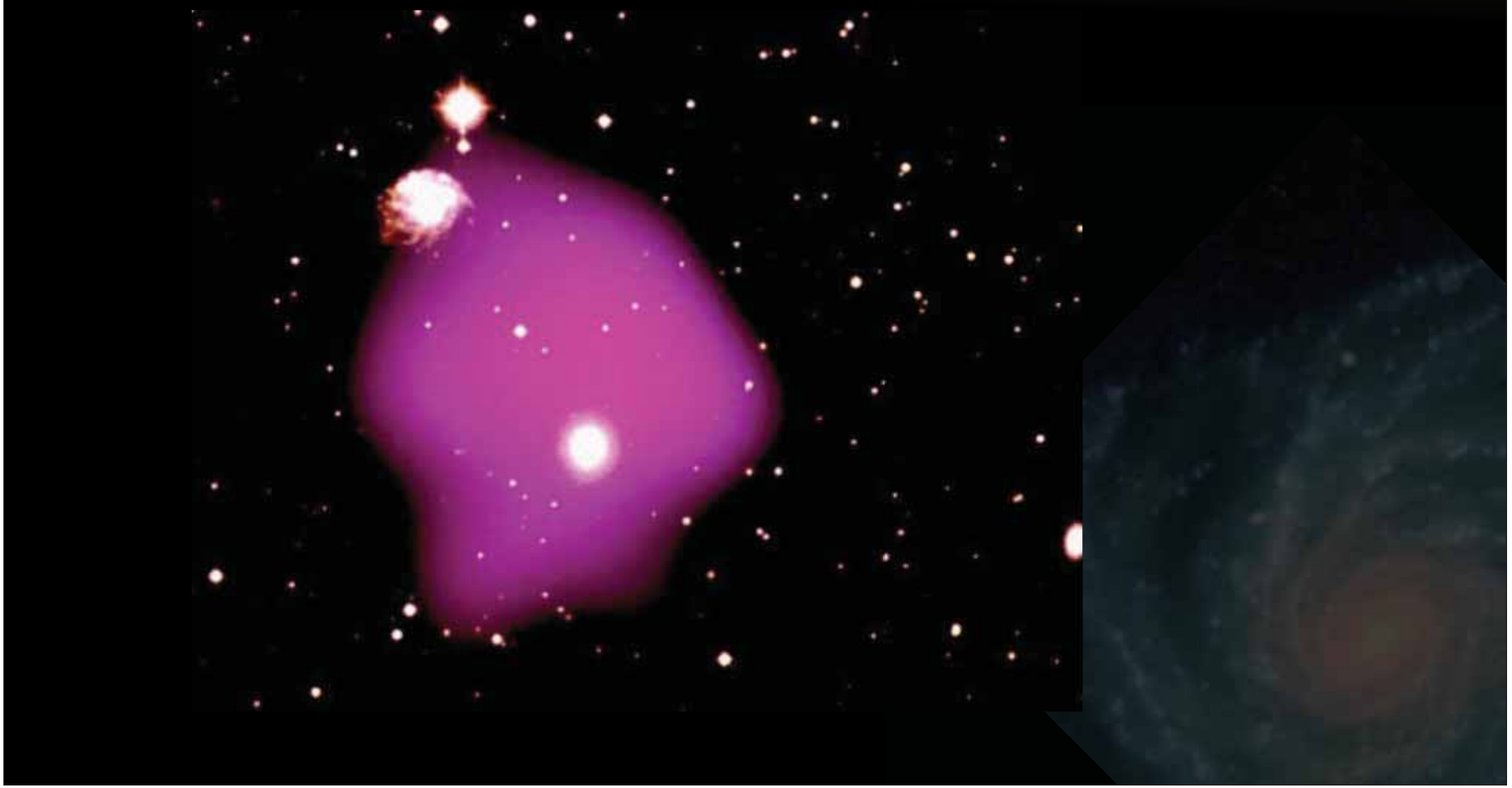
A new source of electrons & positrions that becomes dominant at ~10 GeV

Decay of exotic particles (WIMPs)



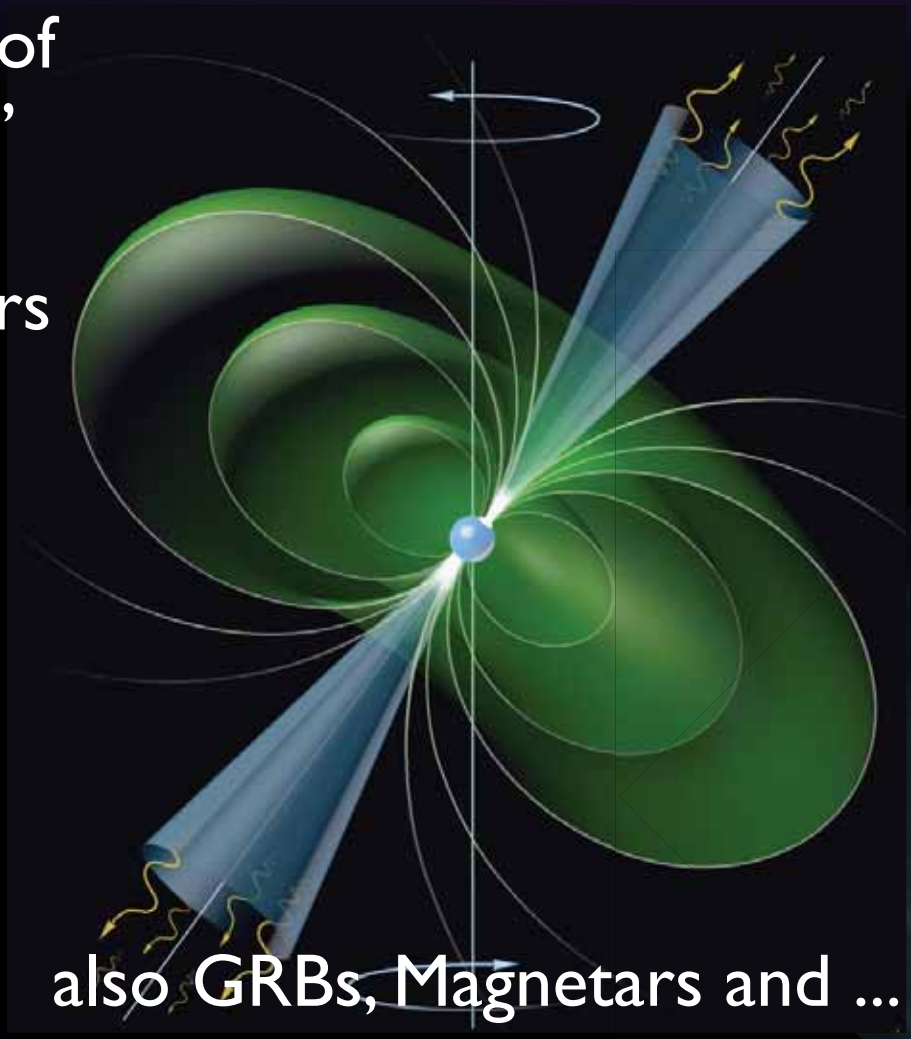
Science News

Pamela picks up 'dark matter' signs



Astrophysical Sources of Pairs: Pulsars

Need ~3% of the pulsars' energy as 100GeV pairs



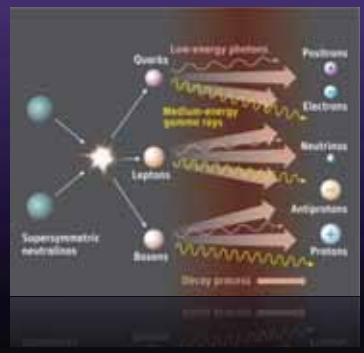
also GRBs, Magnetars and ...

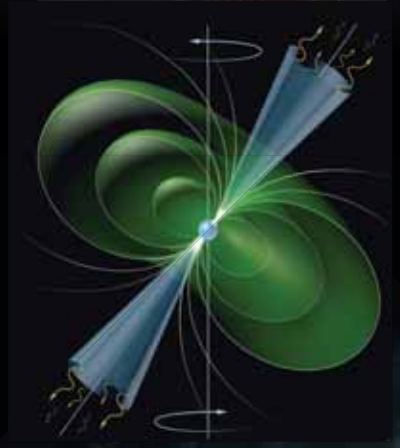
- **These solutions require**

  NEW PHYSICS

  or

  NEW ASTROPHYSICS





- **Okam's razor:**

  Is there a simpler solution?

Consider a Local Source of CR electrons

- Above some energy, the electrons don't have enough time to reach us before cooling.

$$t_{cool}(E,d)=t_{diffuse}(E,d)$$

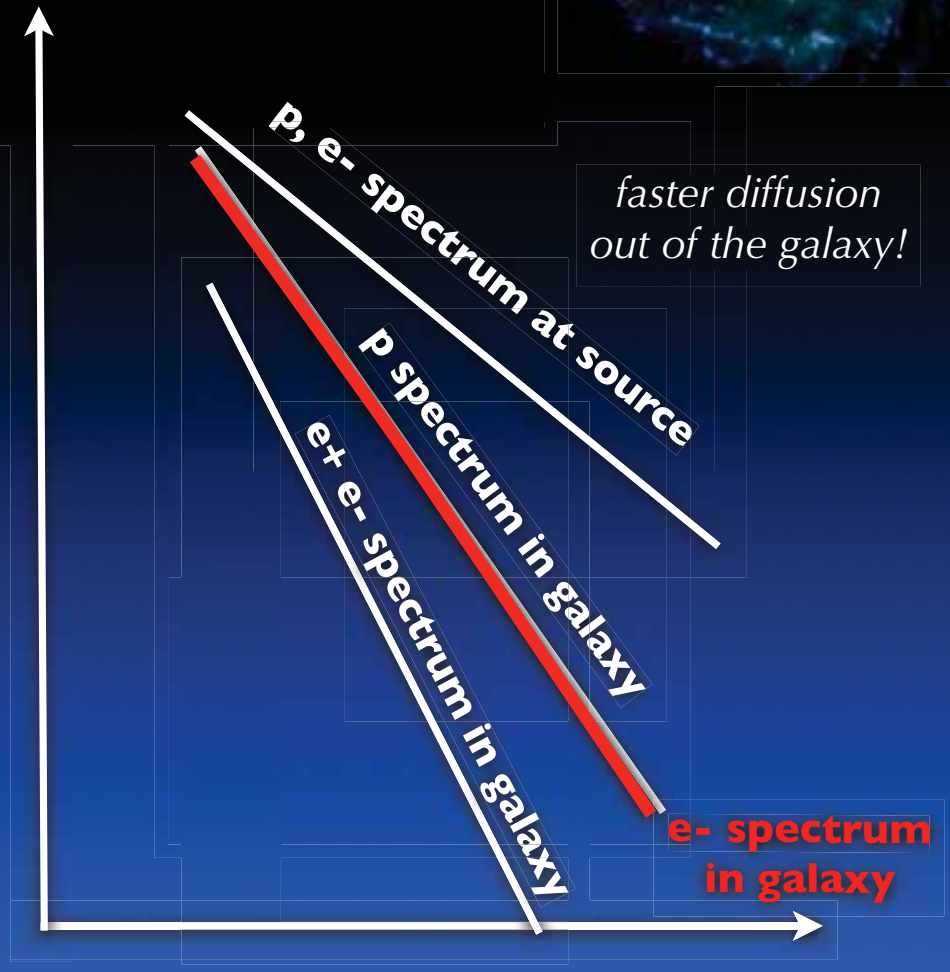
d ≈ 1 kpc for E ≈ 20 GEV

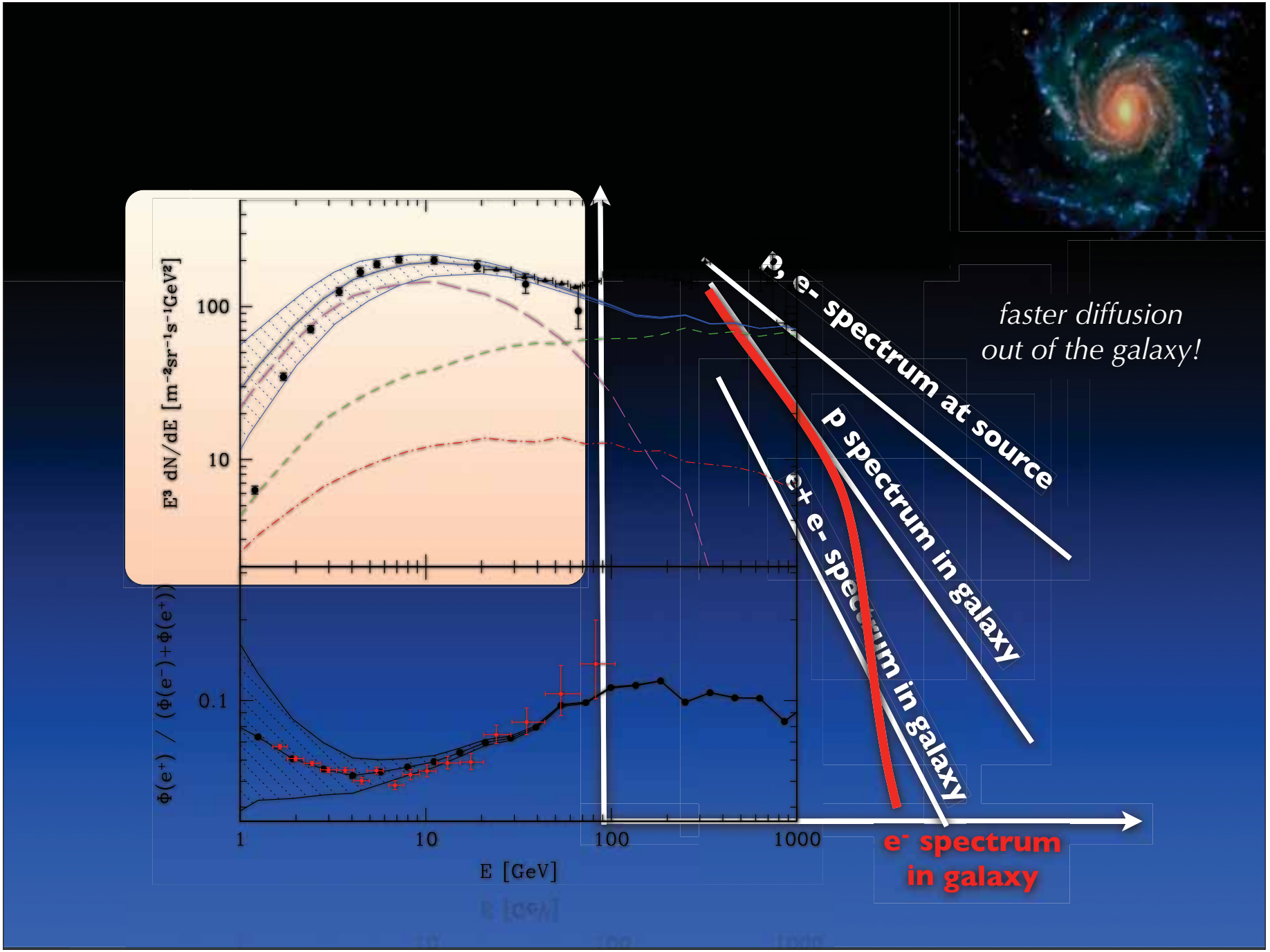
This means that...

- Above $E_b \sim 20$ GeV, the electrons will start cooling and disappear.
- Positrons however, form continousely along the way from proton-ISM interactions.
- **Therefore the positron/electron ratio will increase**

- Primary electron cool and disappear before reaching earth
- Secondary electron/positron form nearer and can reach earth before cooling

- **Electrons from Sprial arms above ~ 20 GeV cool (synchrotron and inverse-Compton) before reaching the solar system!**
- **Protons do not cool, so positron production near us does not care (too much) about cooling.**




E³ dN/dE [m⁻²sr⁻¹s⁻¹GeV²]
100
10
Φ(e⁺) / (Φ(e⁻)+Φ(e⁺))
0.1
1
10
100
1000
E [GeV]
e⁻ spectrum at source
p spectrum in galaxy
e+ e- spectrum in galaxy
e⁻ spectrum in galaxy
faster diffusion
out of the galaxy!

But what is the source?

- SNRs in the spiral arm

6946 is similar in shape to that of M33, although the SNRs in NGC 6946 are consistently more luminous than those in M33. This may well be because of the greater mass and higher star formation rate in NGC 6946, leading to a greater steady state population of SNRs. The luminosity functions of both NGC 6946 and M33 have abrupt cutoffs at lower flux densities because of the surface brightness limits of the respective radio surveys.

4. PROGENITOR STARS OF THE RADIO-SELECTED SNRS

In order to investigate which type of SNe is responsible for radio-selected SNRs, and therefore the CR electron acceleration, we have plotted the positions of the radio-selected SNRs on an Hα image of similar resolution and compared the non-thermal radio emission with the Hα emission. Figure 2 illustrates the positions of the radio-selected SNRs relative to the Hα arms in NGC 6946. The spiral arms were defined in Matonick & Fesen (1997), in which they used an optical continuum image of NGC 6946 that

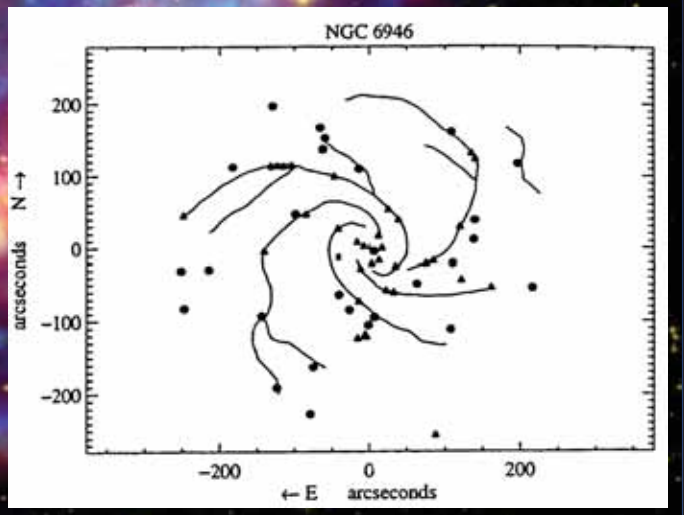
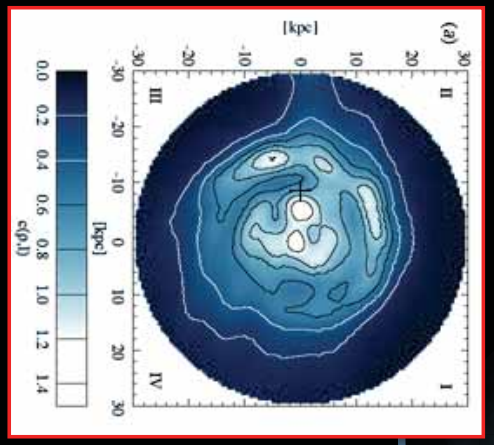
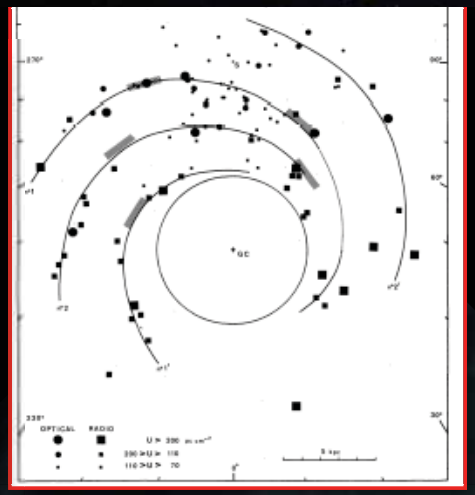


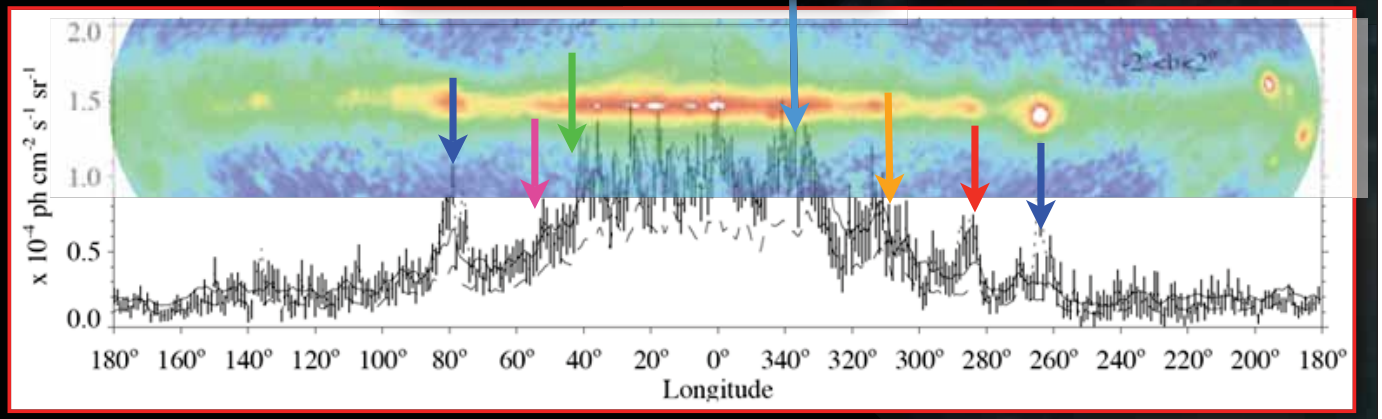
FIG. 3.—Spiral arms of NGC 6946 traced out with the positions of the 25 optically selected SNRs, represented by circles, with 35 radio-selected

Most SNe occur in the spiral arms

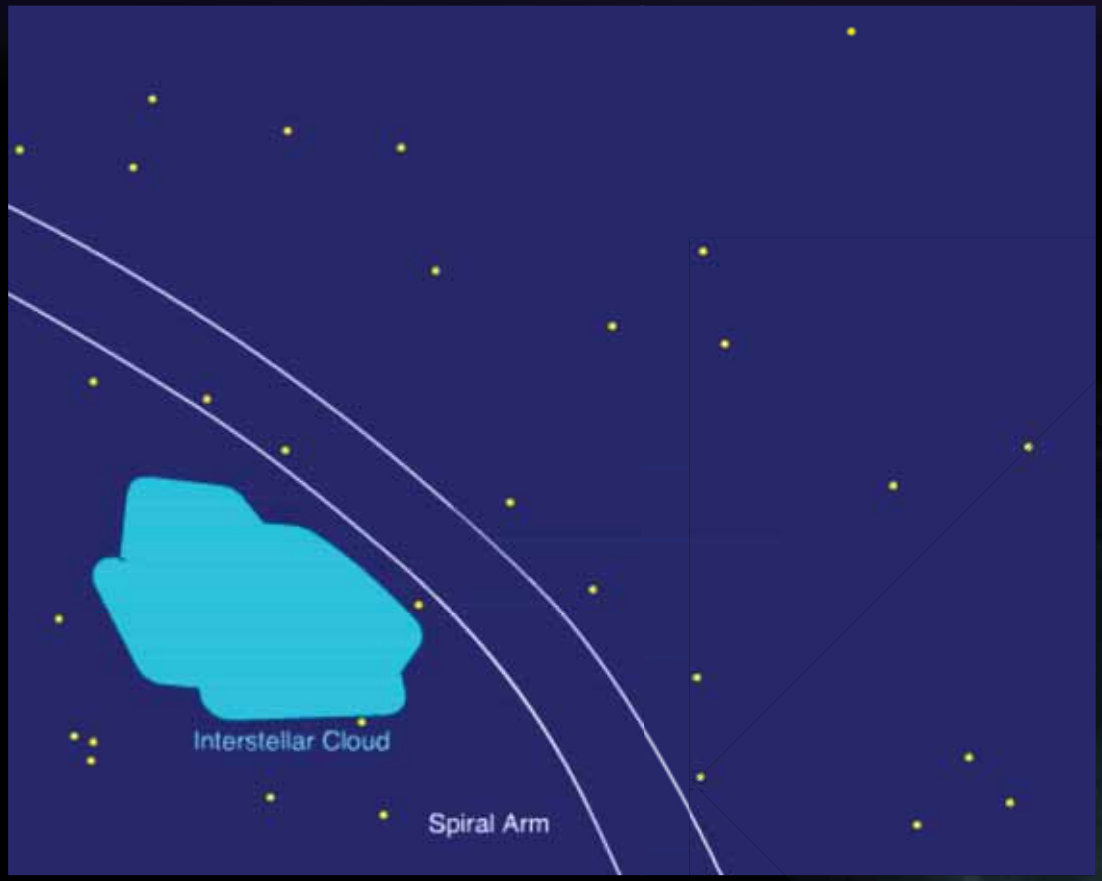
- **In the Milky Way: Almost all SNe are non-Type Ia, and occur where almost all star formation takes place: In the Spiral Arms**
- **Meteorites: Show that density changes by a factor of > 2.5**
- **Deconvolved Synchrotron: Shows arm to inter-arm ratio of ~ 3**



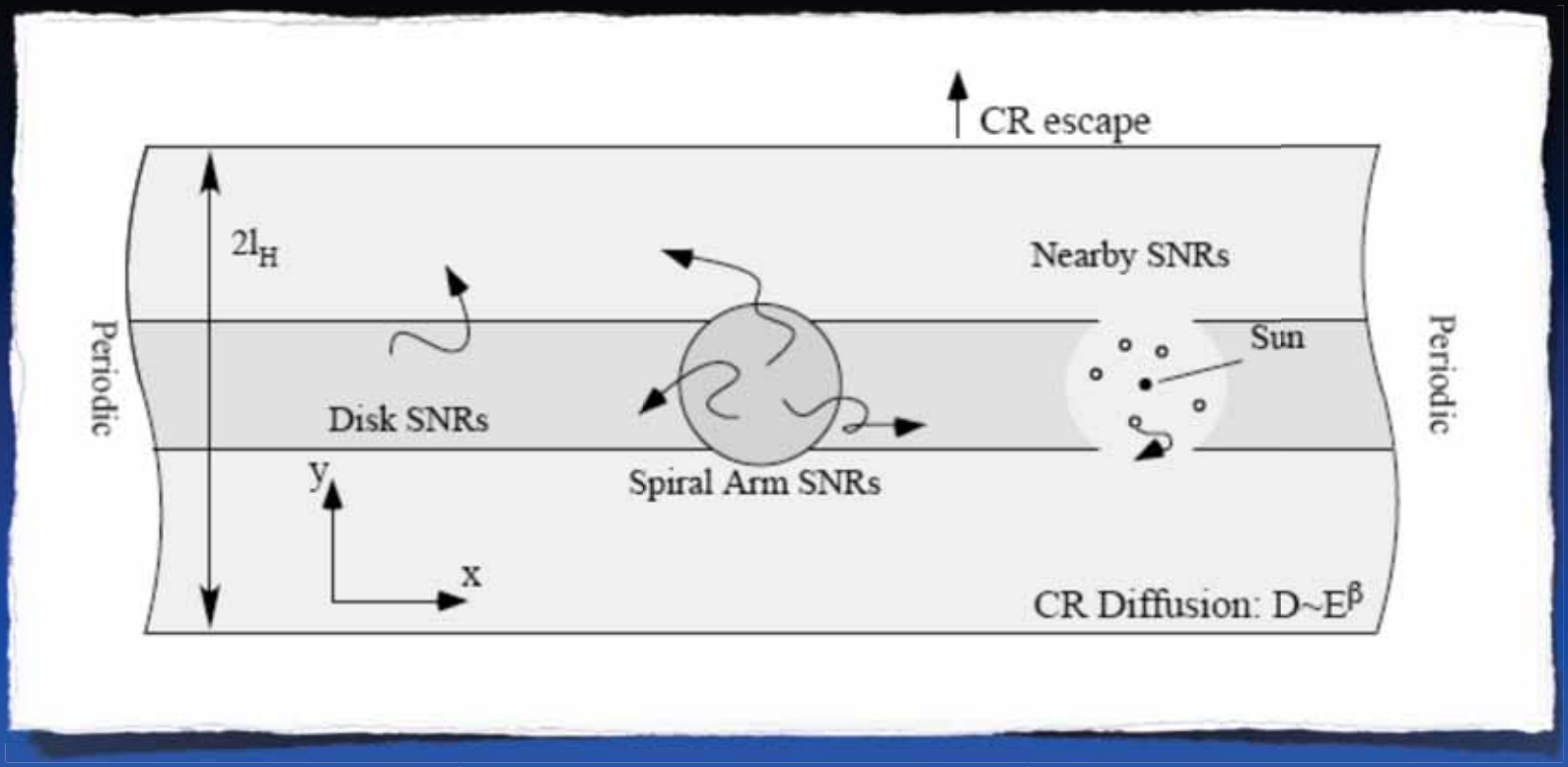




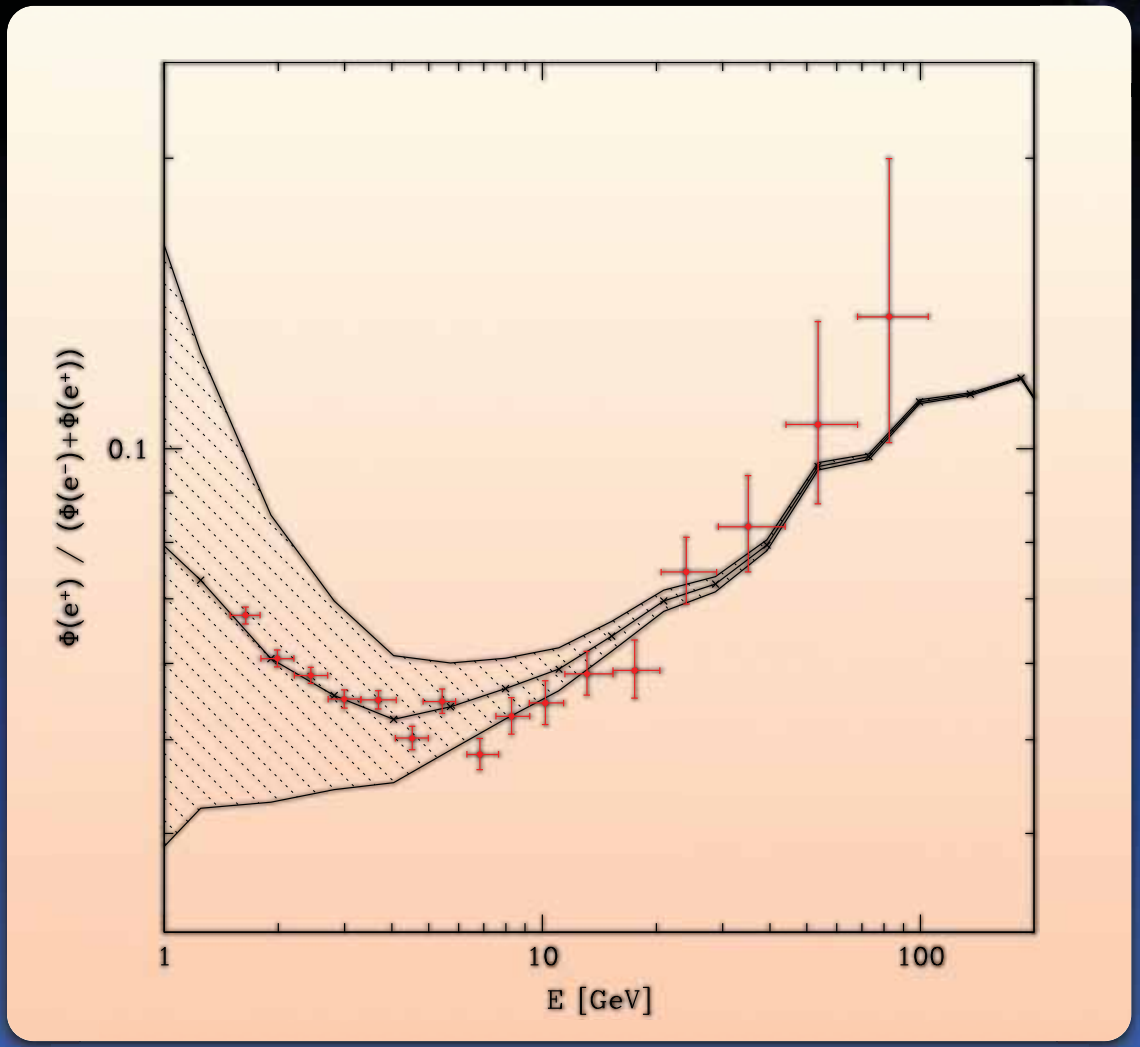
Why Primarily Spiral Arms?



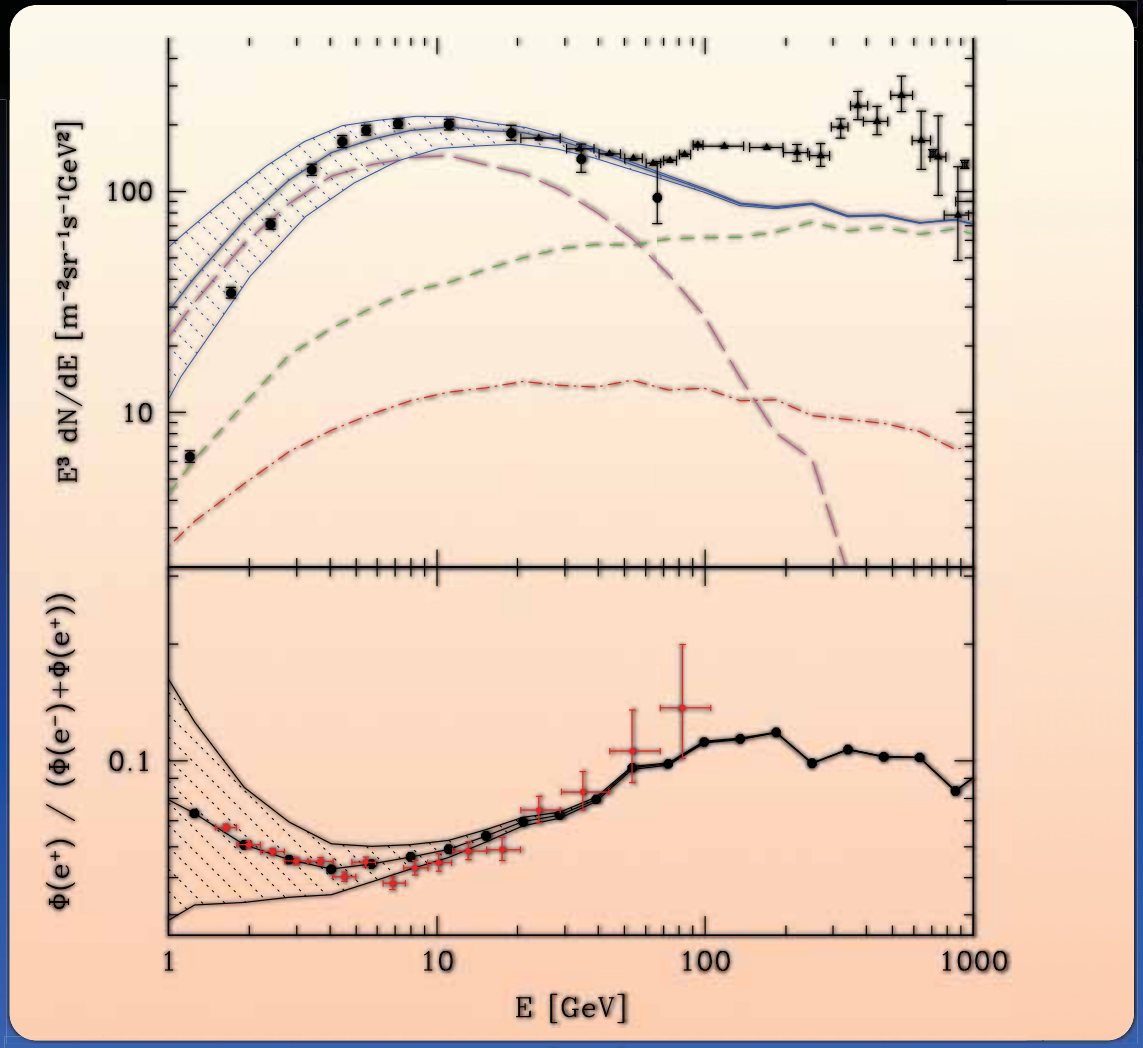
A simplied Model

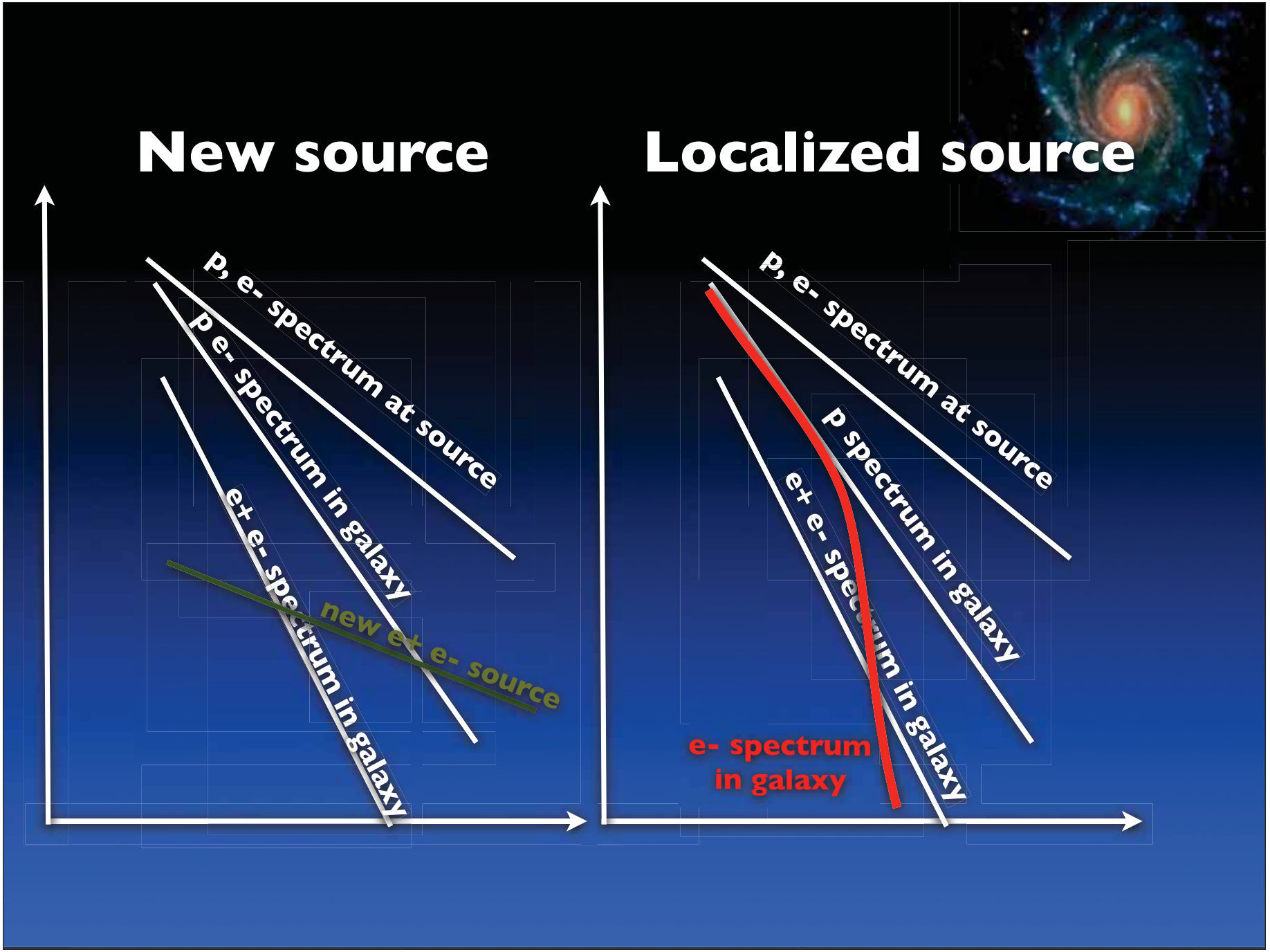


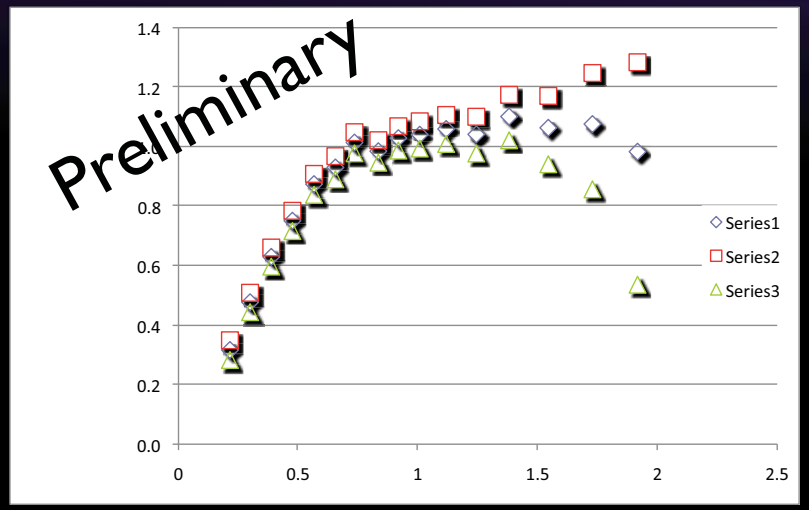
The Resulting $e^+/(e^+ + e^-)$ ratio

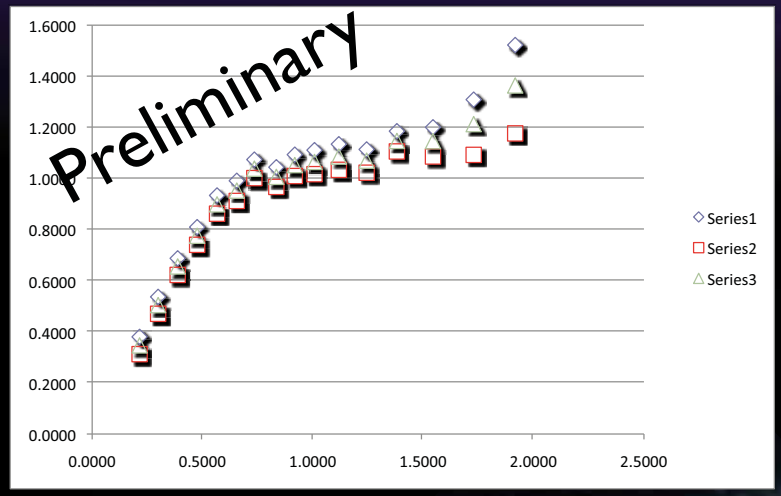


$e^+/(e^+ + e^-)$ ratio and e^- spectrum




New source
p, e- spectrum at source
p e- spectrum in galaxy
e+ e- spectrum in galaxy
new e+ e- source
Localized source
p, e- spectrum at source
p spectrum in galaxy
e+ e- spectrum in galaxy
e- spectrum in galaxy

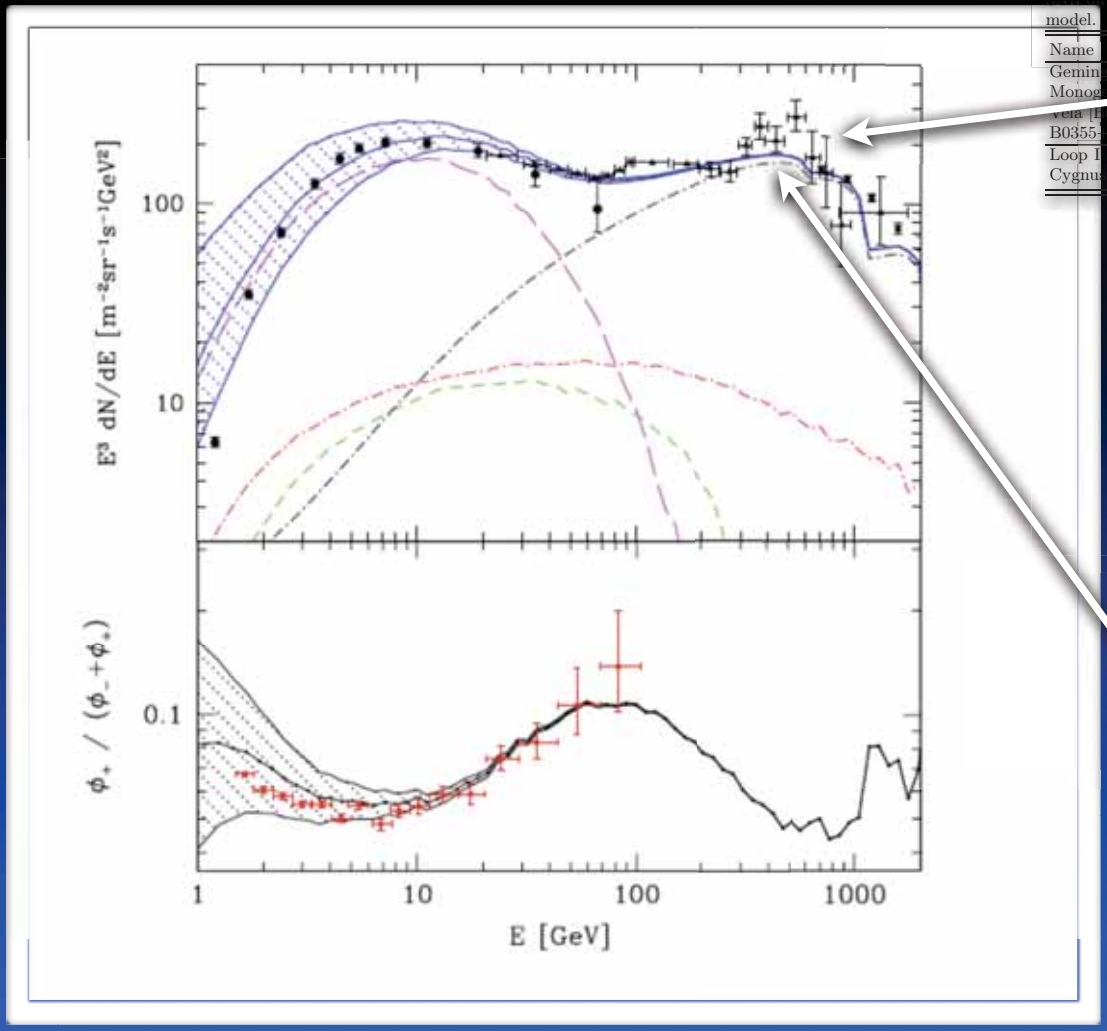




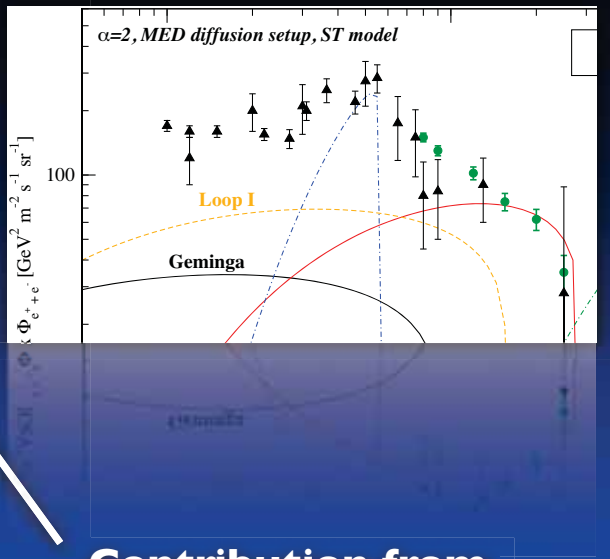
$E^3\ N(E)\ |_{e+} = E^3\ N(E)\ |_{e-}\ (e^+/e^-)$

HEAT+ATIC PAMELA

What about ATIC?



These electrons did not cool yet



Contribution from nearby KNOWN young SNRs: Geminga, Monogem, Gela LoopI and Cygnus Loop

Conclusions

- Taking the *real* distribution of SNRs gives the correct positron/electron energy behavior.
- No free parameters give the correct break energy.
- Nearby young known SNRs explain ATIC
- Predictions:
  - e^+/e_{tot} ratio should saturate < 50%
  - At higher energies the ratio should decrease! (due to fresh electrons)


The End ?