« Standard » electron cosmic ray flux

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&

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Collaborators

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- **Turin**
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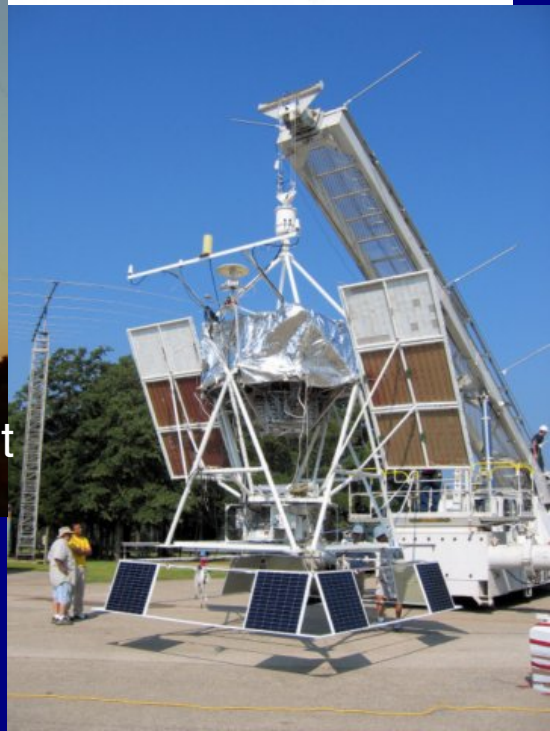
  - Julien Lavalle
  - Nicolao Fornengo
  - Fiorenza Donato

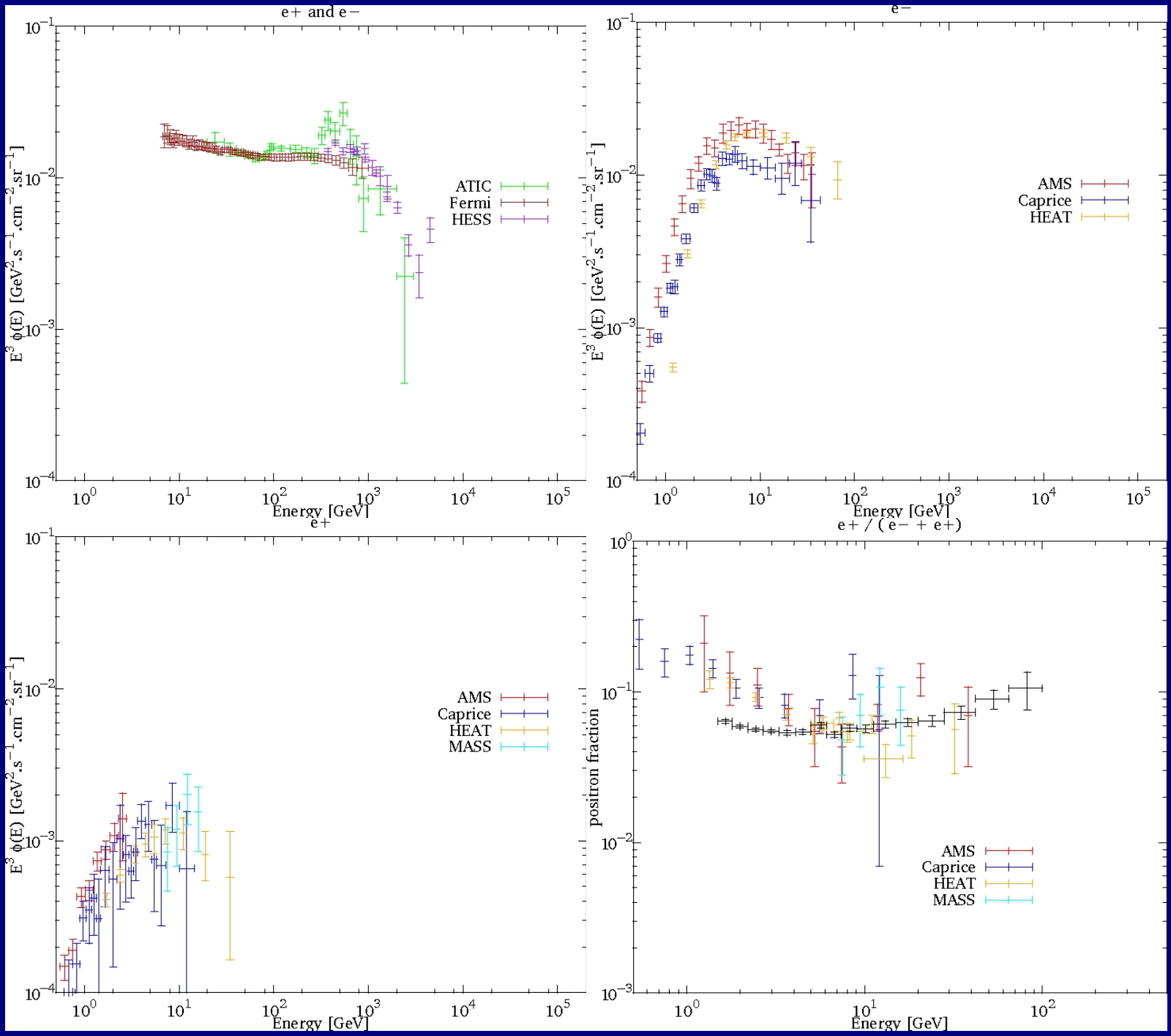
Outline

- Energy losses
- Electrons sources
- Results

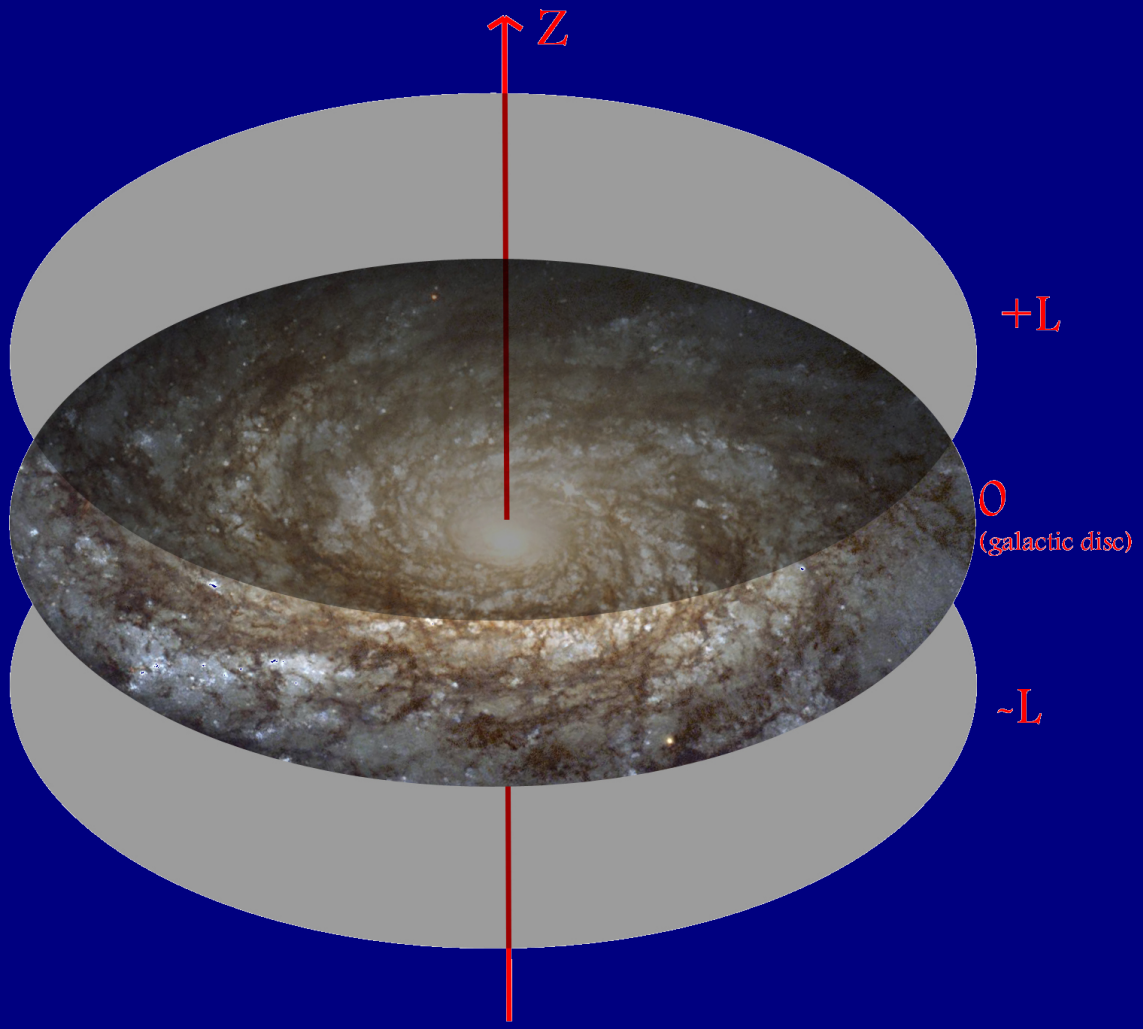
Recent data

With the courtesy of Florent Dubois




e+ and e−
ATIC
Fermi
HESS
E³ ϕ(E) [GeV².s⁻¹.cm⁻².sr⁻¹]
Energy [GeV]
e−
AMS
Caprice
HEAT
e+
MASS
e+ / (e− + e+)
positron fraction

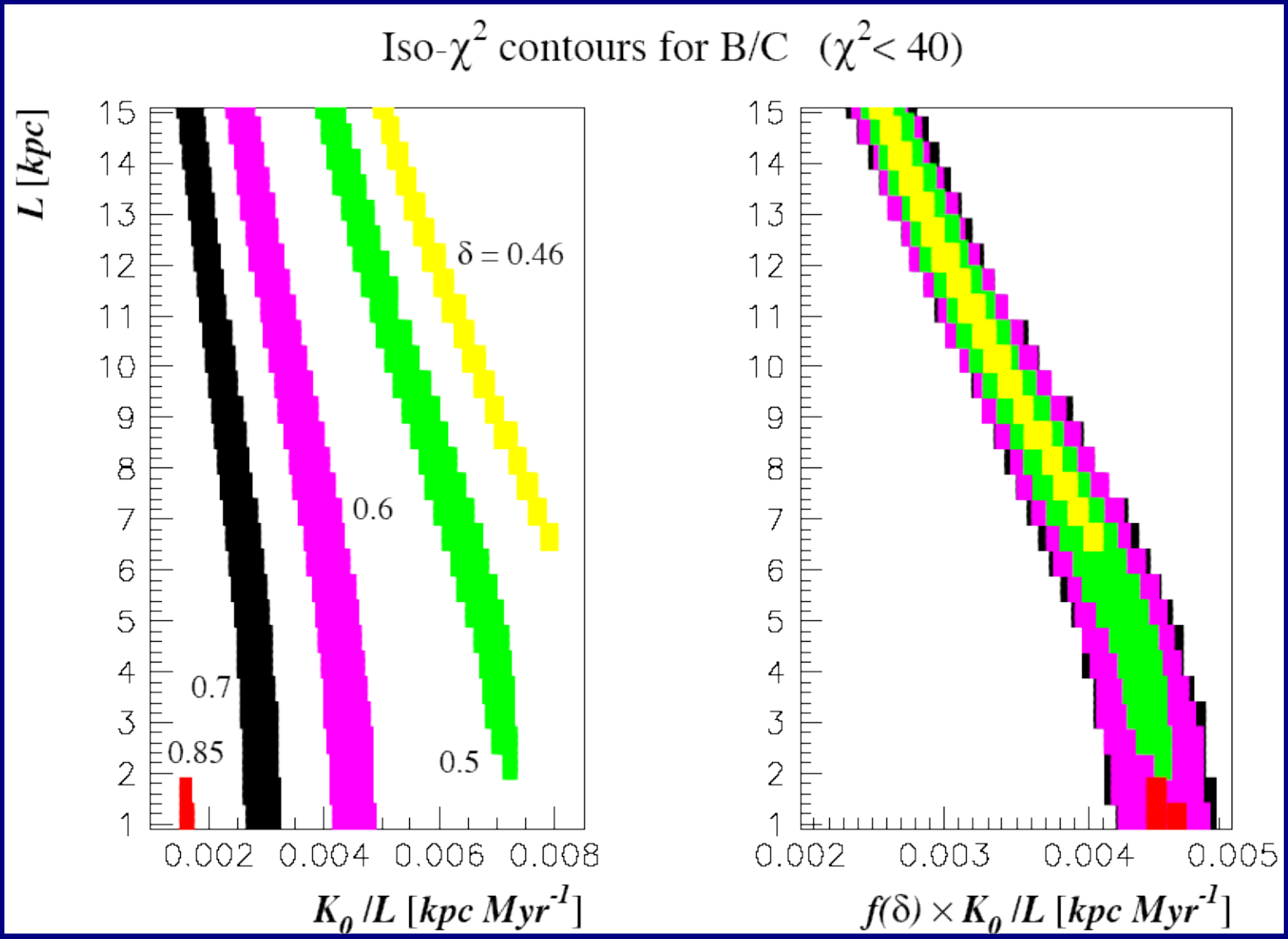
The propagation model



Diffusion equation

$$\partial_t \mathcal{N} - \boldsymbol{\nabla} \cdot \{K(E) \boldsymbol{\nabla} \mathcal{N}\} + \partial_E \left\{ \frac{dE}{dt} \mathcal{N} \right\} = \mathcal{Q}(E, \boldsymbol{x}, t)$$

Diffusion parameters



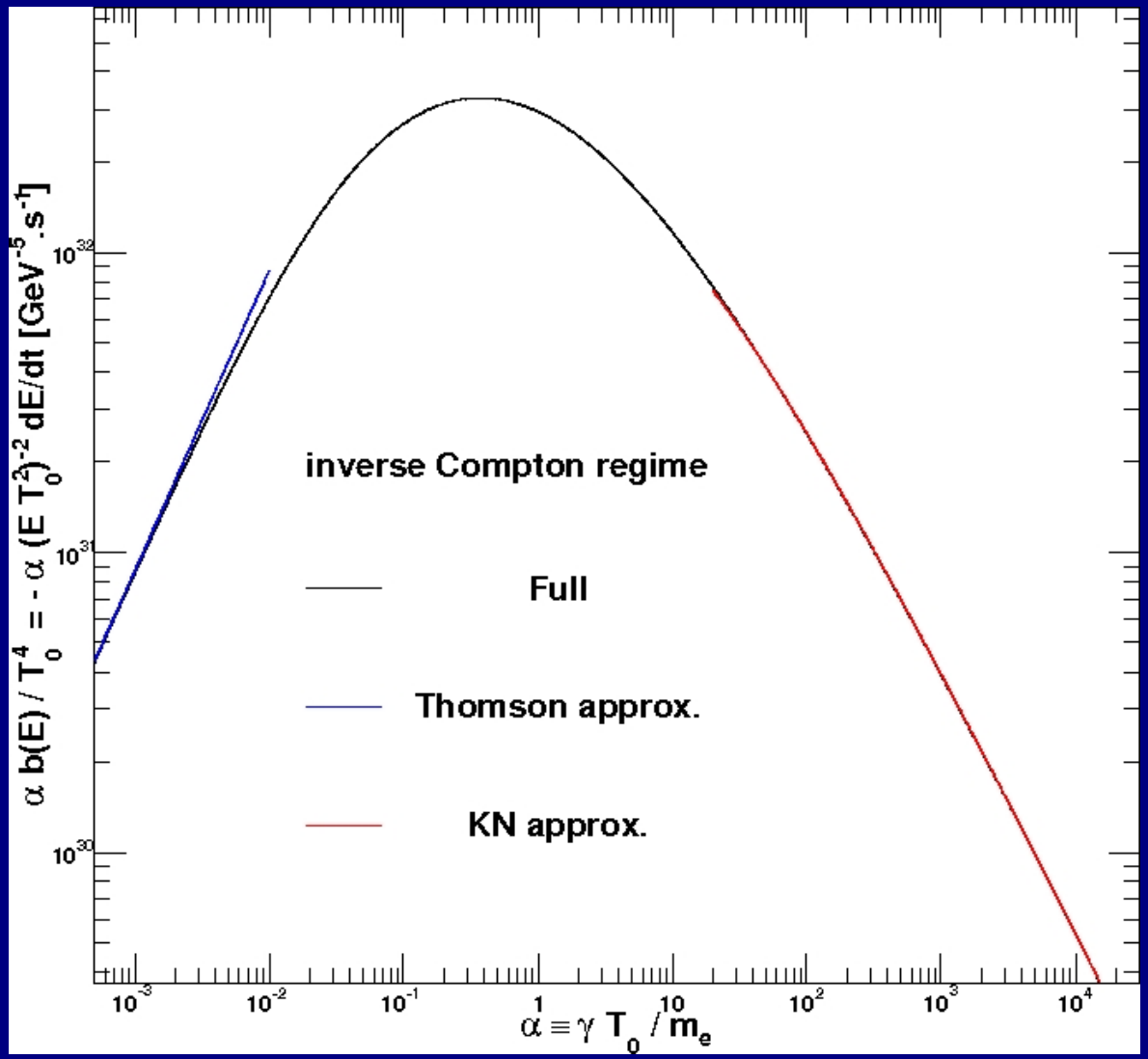
Maurin et alii

ApJ 2001

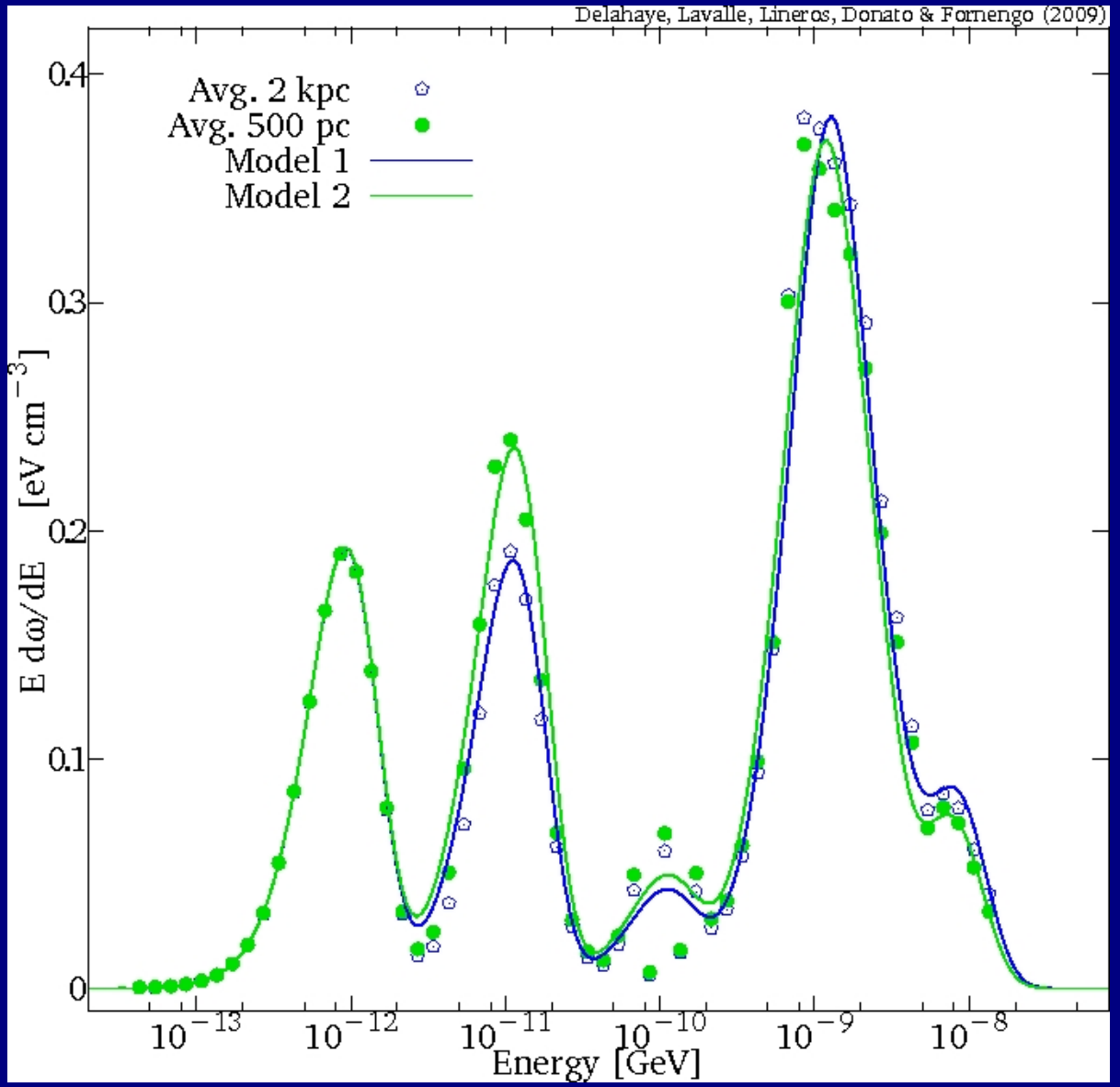
Energy losses

$$-b^{\mathrm{loss}}(\epsilon) = \begin{cases} \dfrac{\epsilon^2}{\tau_E} & \text{Inverse Compton and synchrotron} \\ +\nabla \cdot \mathbf{V}_C \, \dfrac{p^2}{6h\epsilon} & \text{Adiabatic losses} \\ +K_b \, n_H \, \epsilon & \text{Bremsstrahlung} \\ +K_i \, n_H \left\{ 3 \ln\left(\dfrac{E}{m_e}\right) + 19.8 \right\} & \text{Ionisation.} \end{cases}$$

Inverse Compton

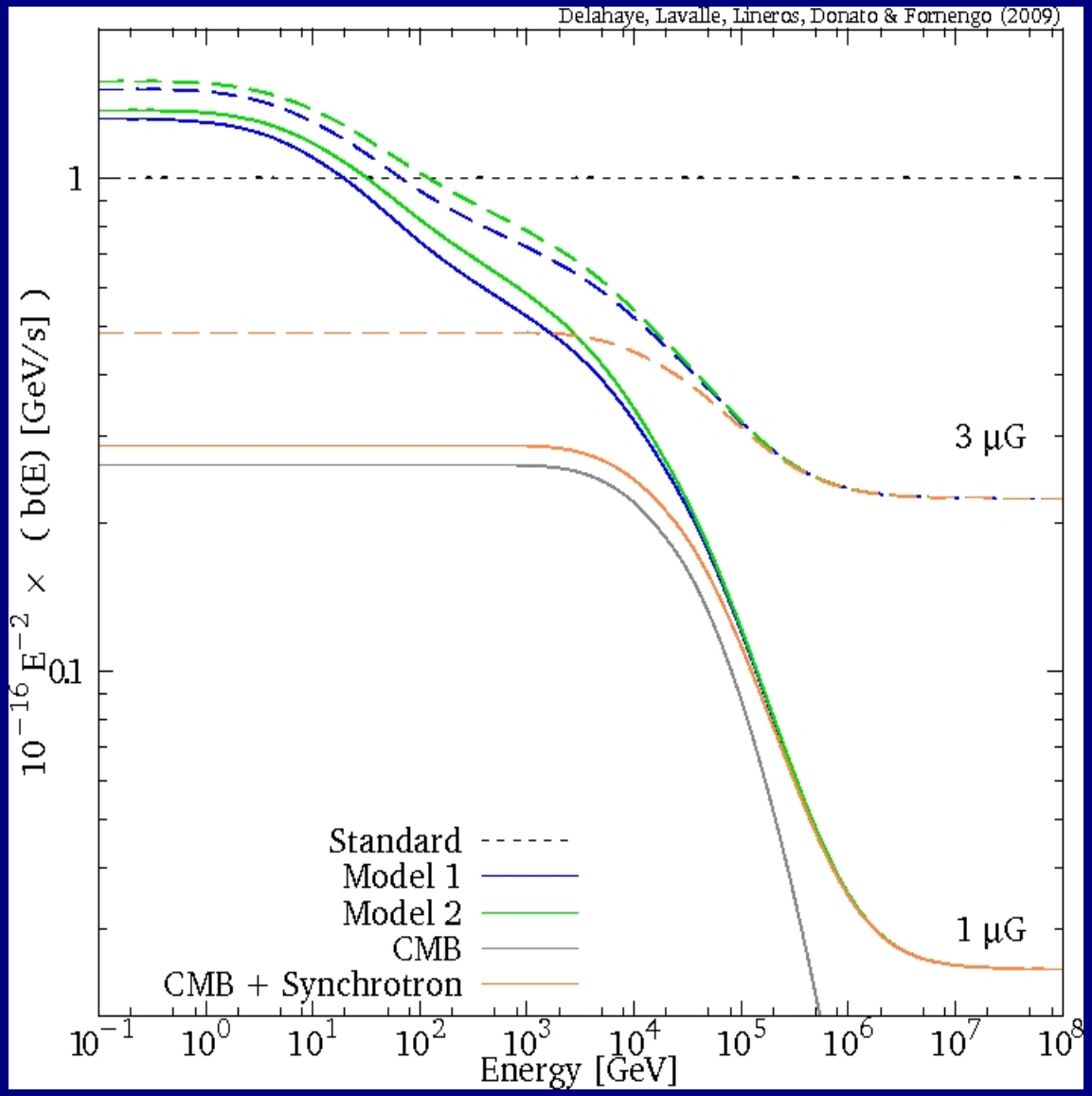


Interstellar Radiation Field

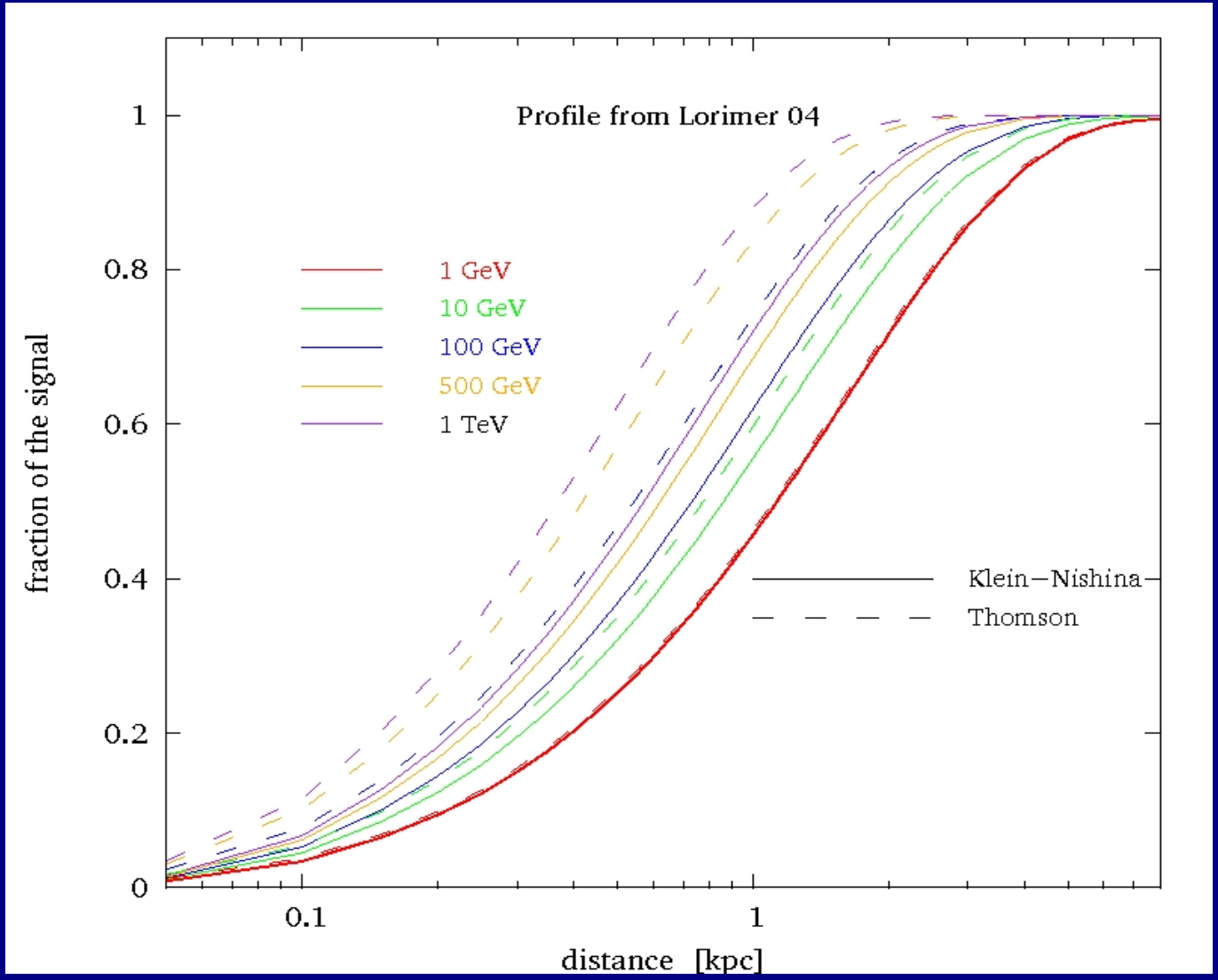


Porter & GALPROP

Energy losses



Energy losses



Electron flux

The Torinese contribution

Soon on the ArXiv

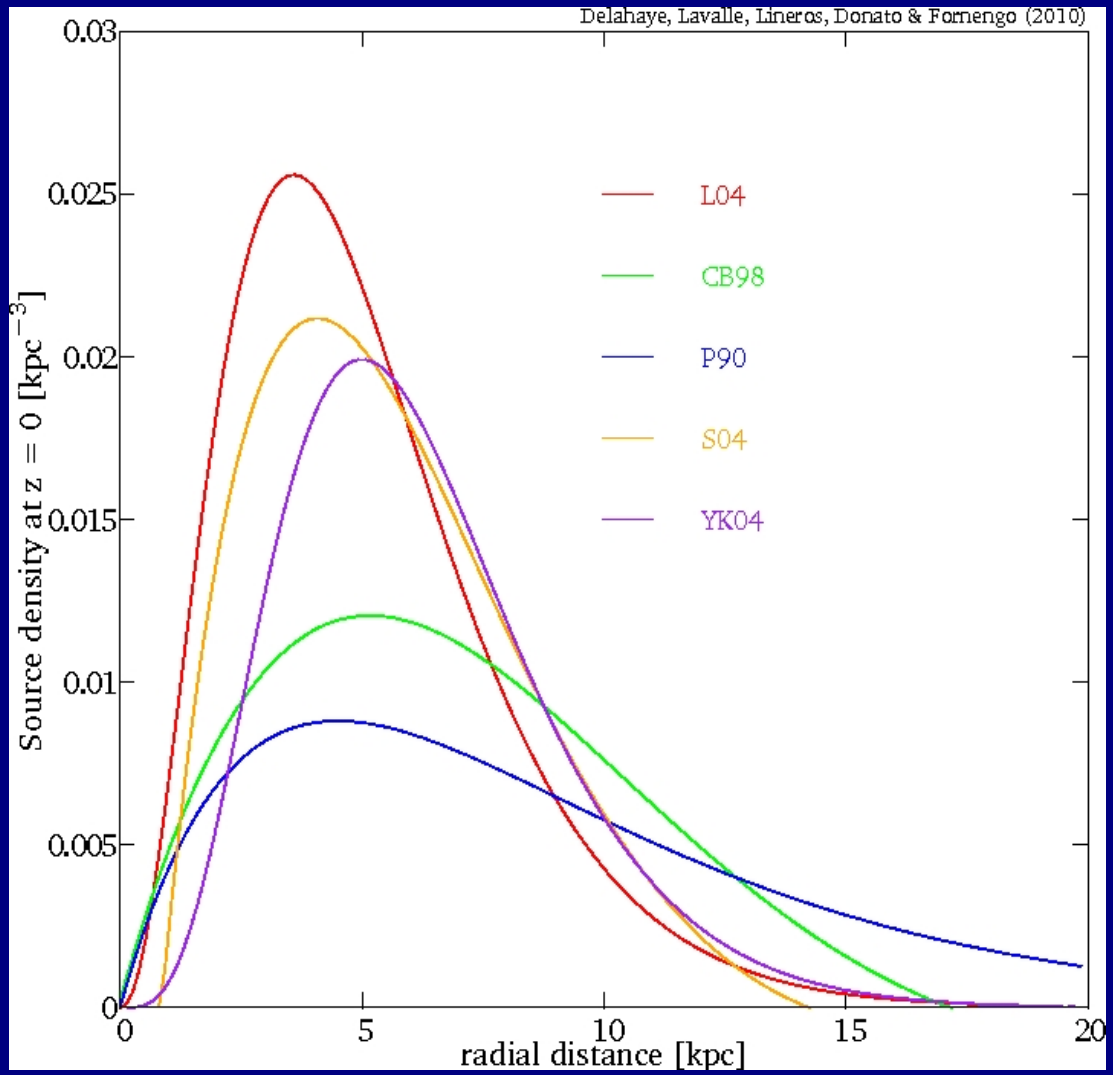
Secondary contribution

- Nothing new: uncertainties due to cross-sections, proton flux at the Earth, propagation...
- Even lower than the positron contribution

« Normal » primary contribution

- Supernova remnants: the « Standard Model »
  - Spatial distribution**?**
  - Injection spectrum**?** $\approx A\, \varepsilon^{-\gamma} \exp(-\varepsilon/\varepsilon_0)$
  - Other sources**?**

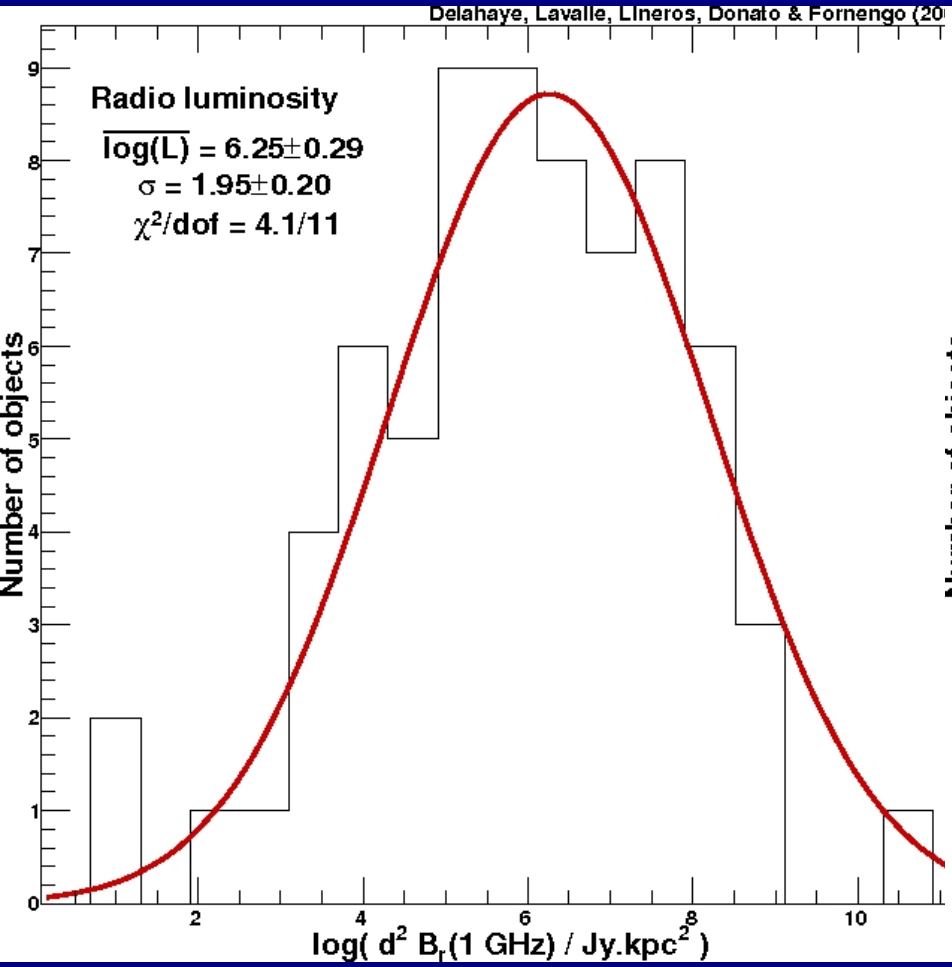
Source distribution

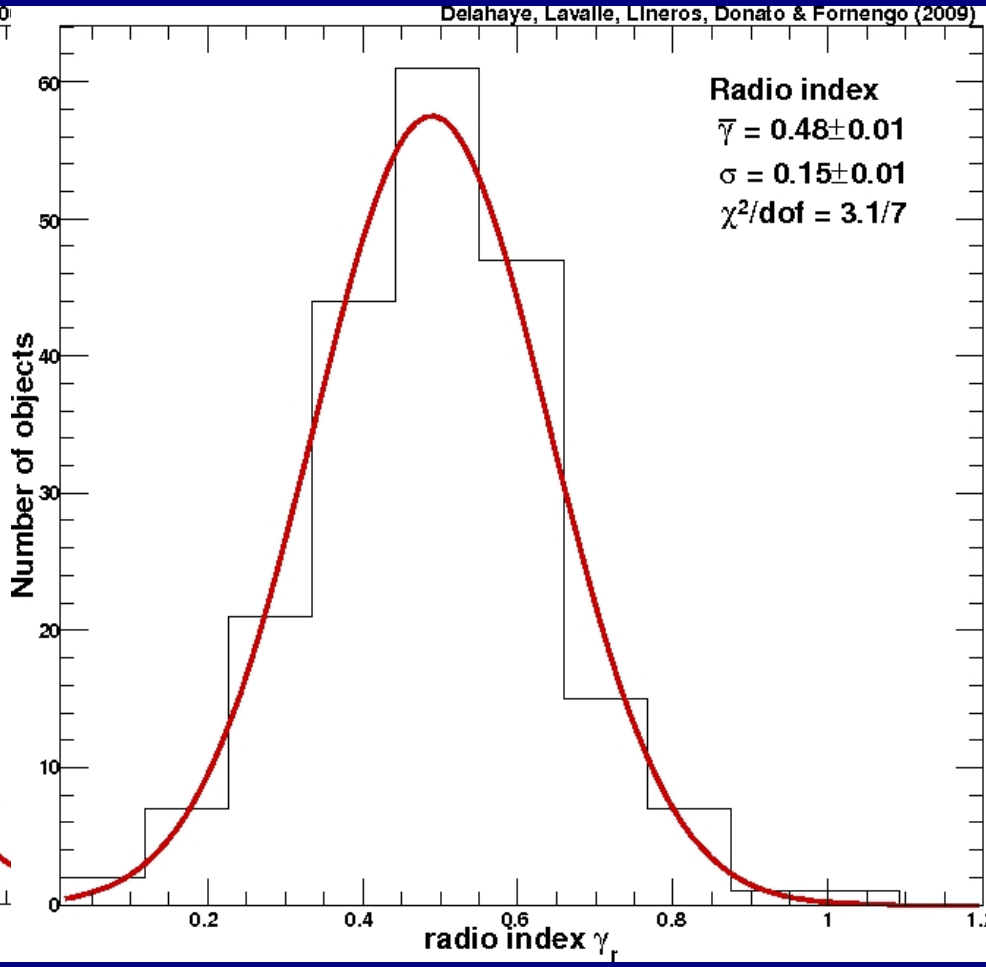


Super Nova Remnant catalogues

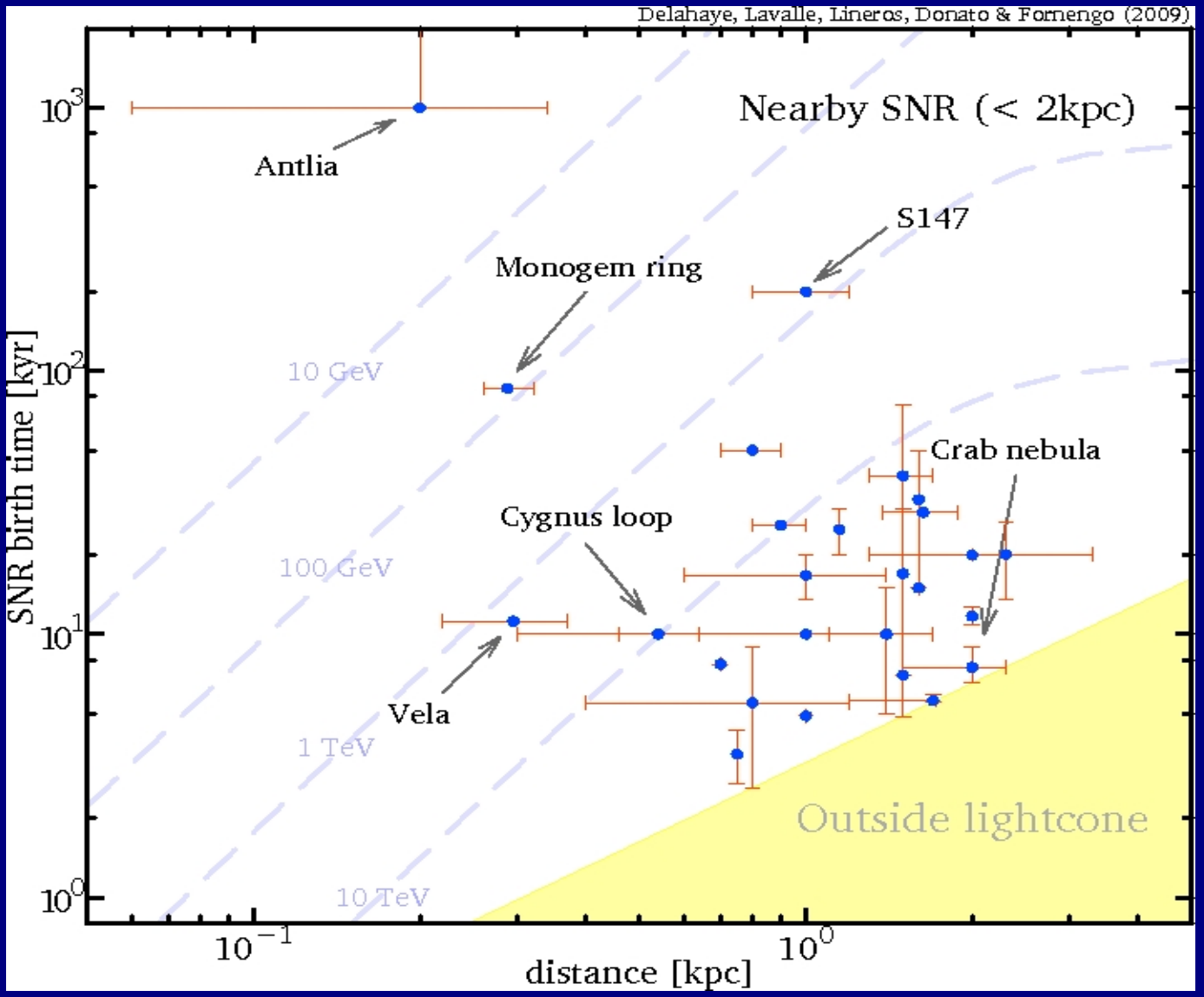
- Green catalogue http://www.mrao.cam.ac.uk/surveys/snrs/
- About 275 known Galactical remnants with: coordinates, distance, luminosity at 1GHz, spectral index.
- Some bibliography provides the age.

Supernova remnants properties

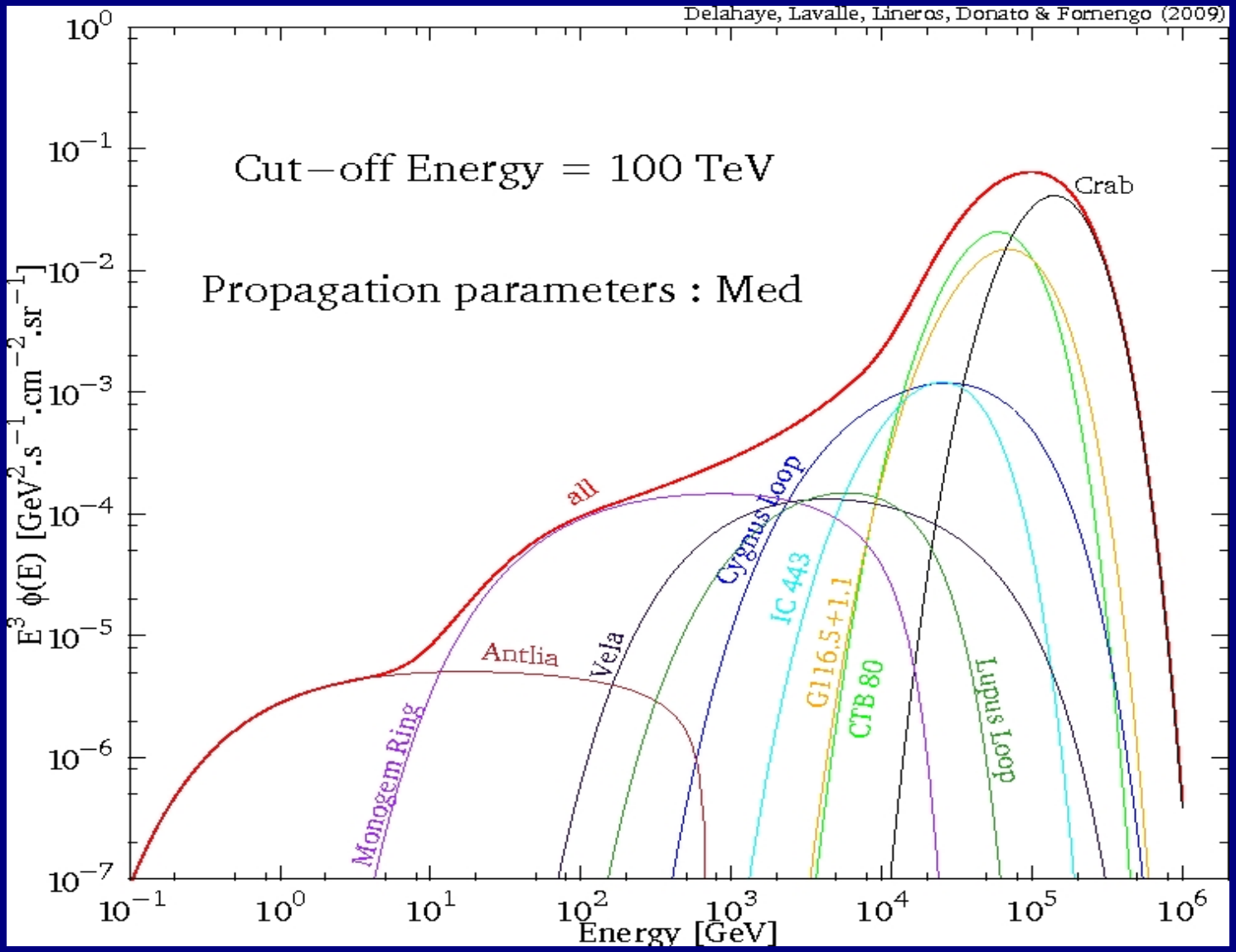




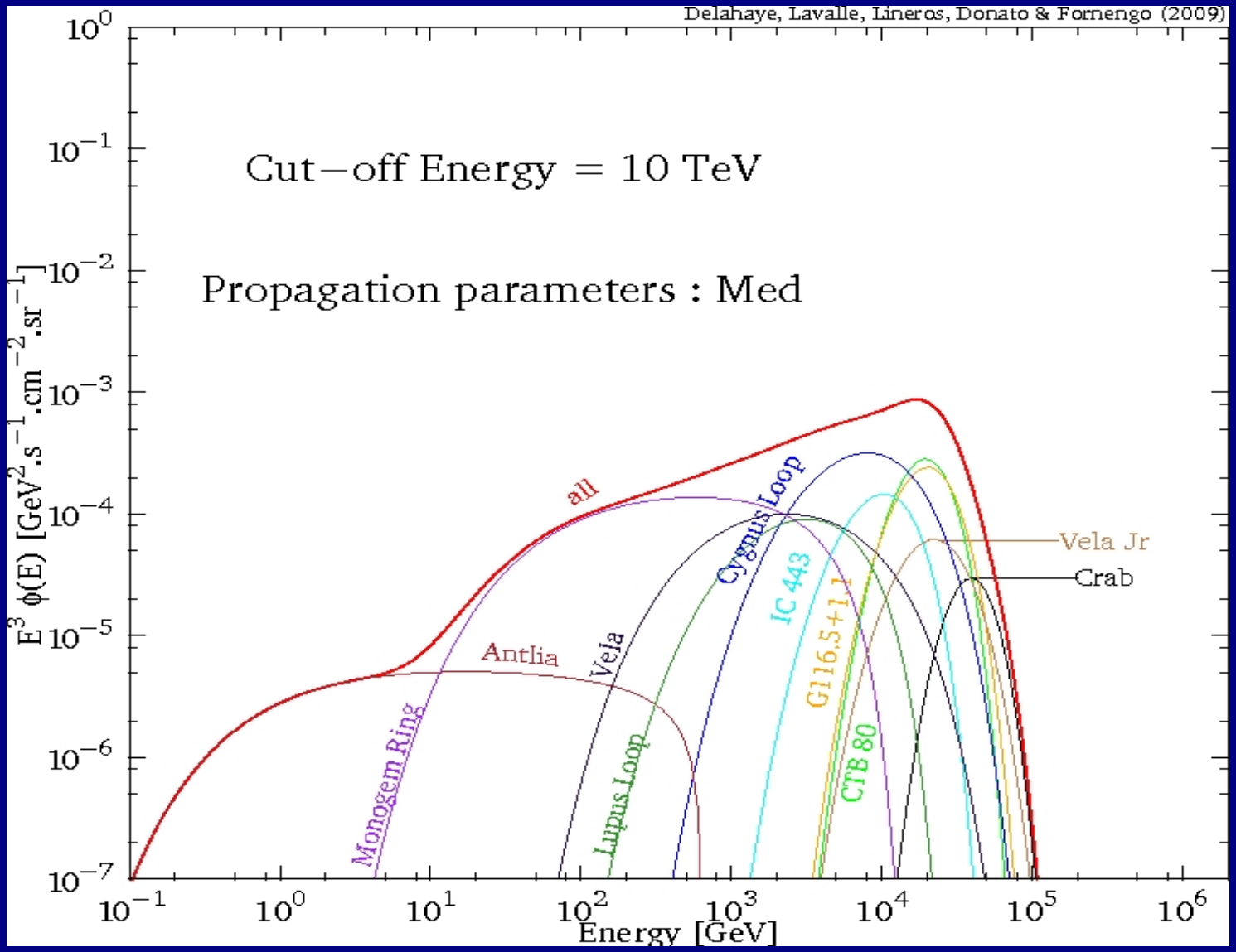
Local sources



Local sources



Local sources



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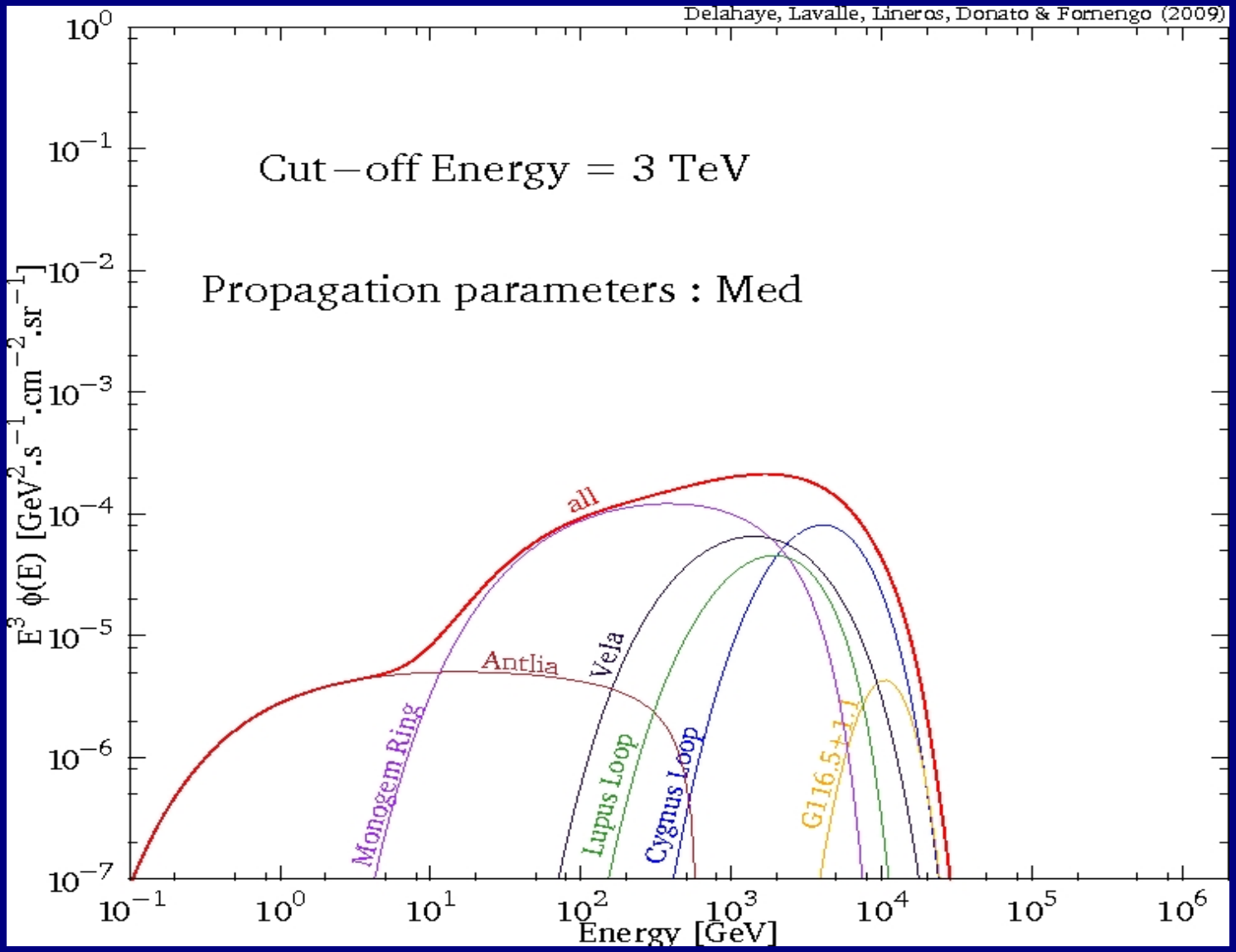

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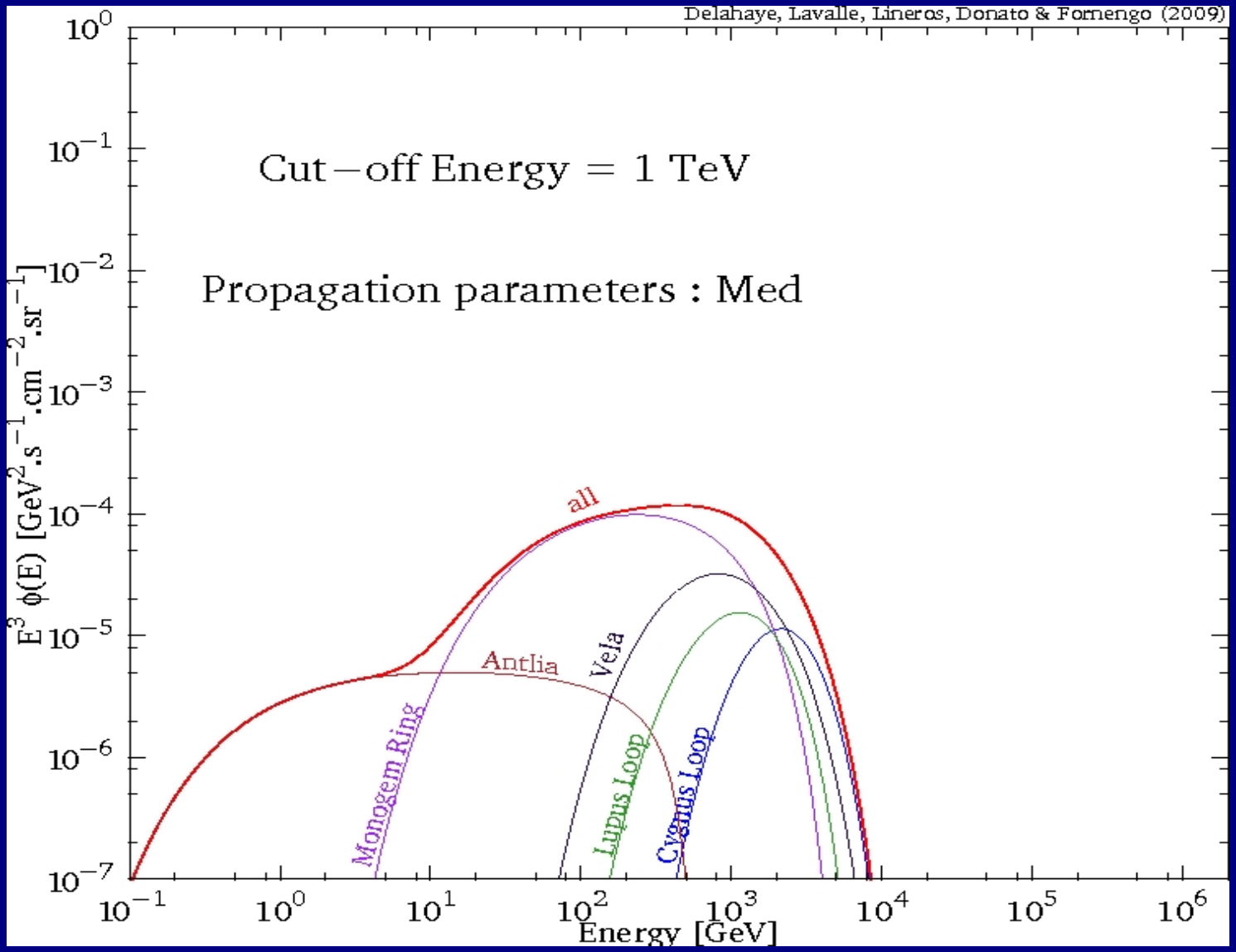
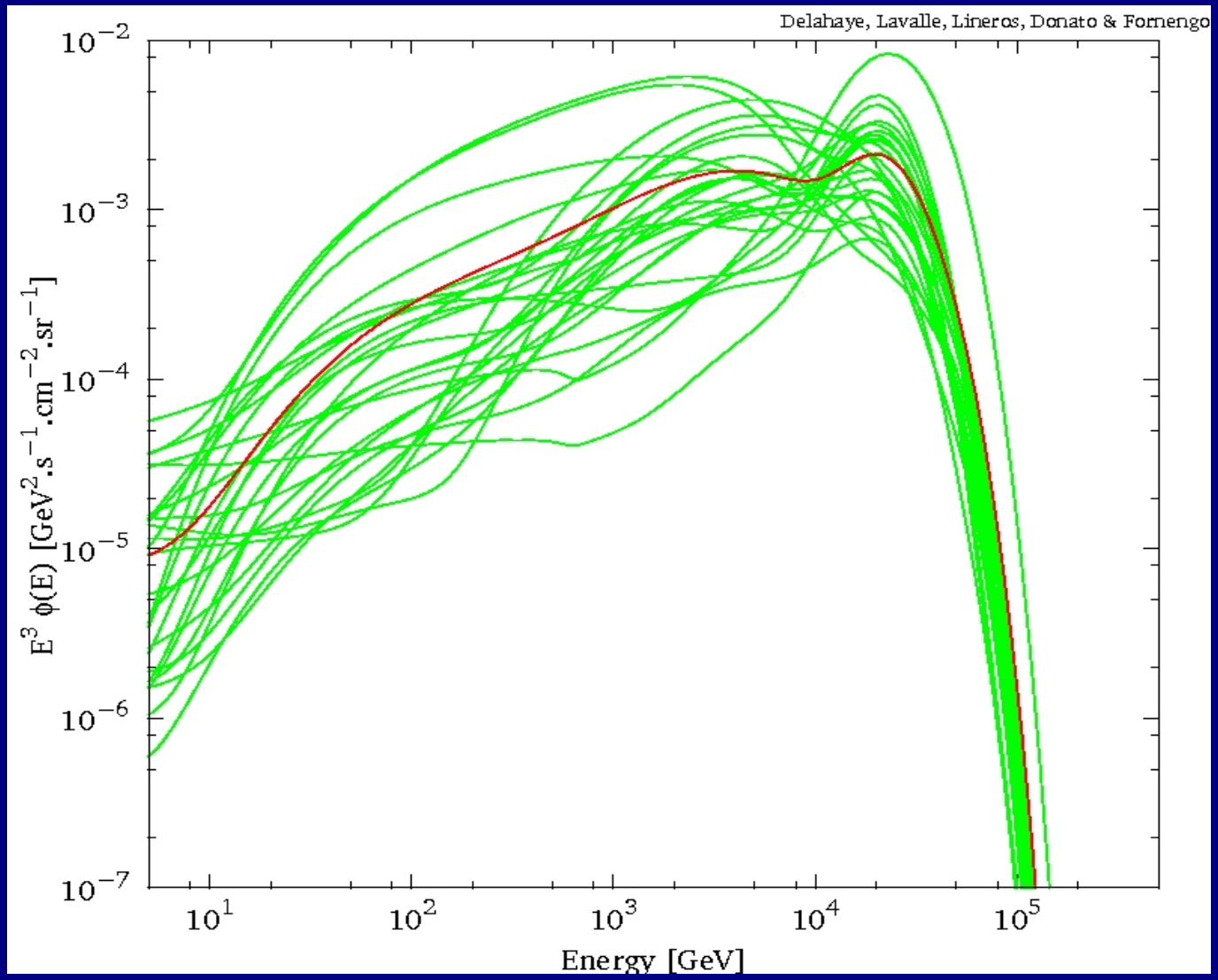


Many effects

- Age~distance of the Supernova remnants
- Spectral index
- Normalisation

Local sources

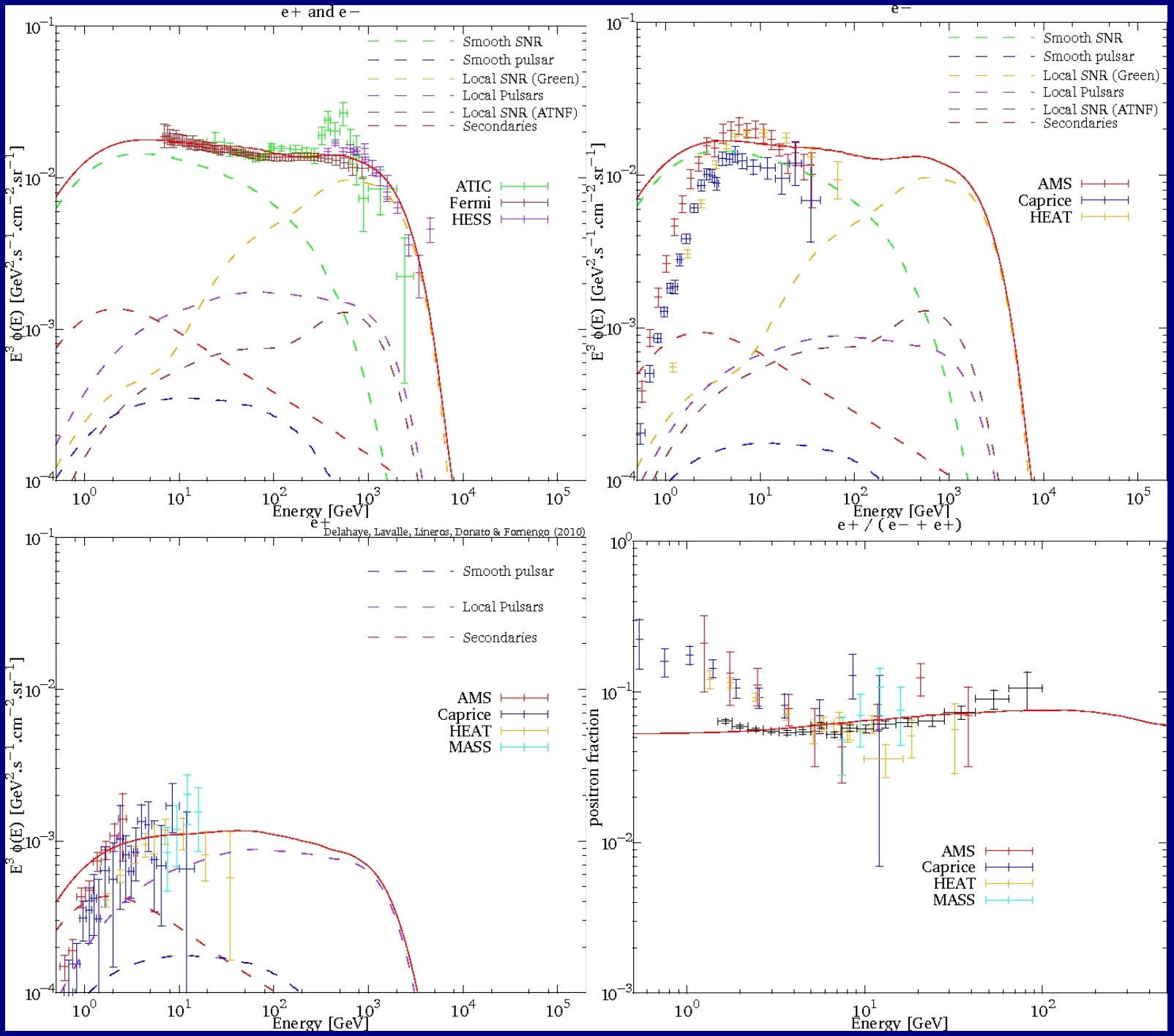


Pulsars?

- Pulsar catalogues are more crowded than SNR catalogues.
- Parameters : age, distance, magnetic energy
- Each pulsar was born from a supernova explosion.

Summary of sources

- Smooth distribution of distant SNR
- Local known SNR (Green)
- Smooth distribution of distant pulsars
- Local known pulsars
- Local putative SNR (ATNF)
- Secondaries


e+ and e−
Smooth SNR
Smooth pulsar
Local SNR (Green)
Local Pulsars
Local SNR (ATNF)
Secondaries
ATIC
Fermi
HESS
E³ ϕ(E) [GeV².s⁻¹.cm⁻².sr⁻¹]
Energy [GeV]
e−
AMS
Caprice
HEAT
e+
Delahaye, Lavalle, Lineros, Donato & Fornengo (2010)
MASS
e+ / (e− + e+)
positron fraction

Conclusions

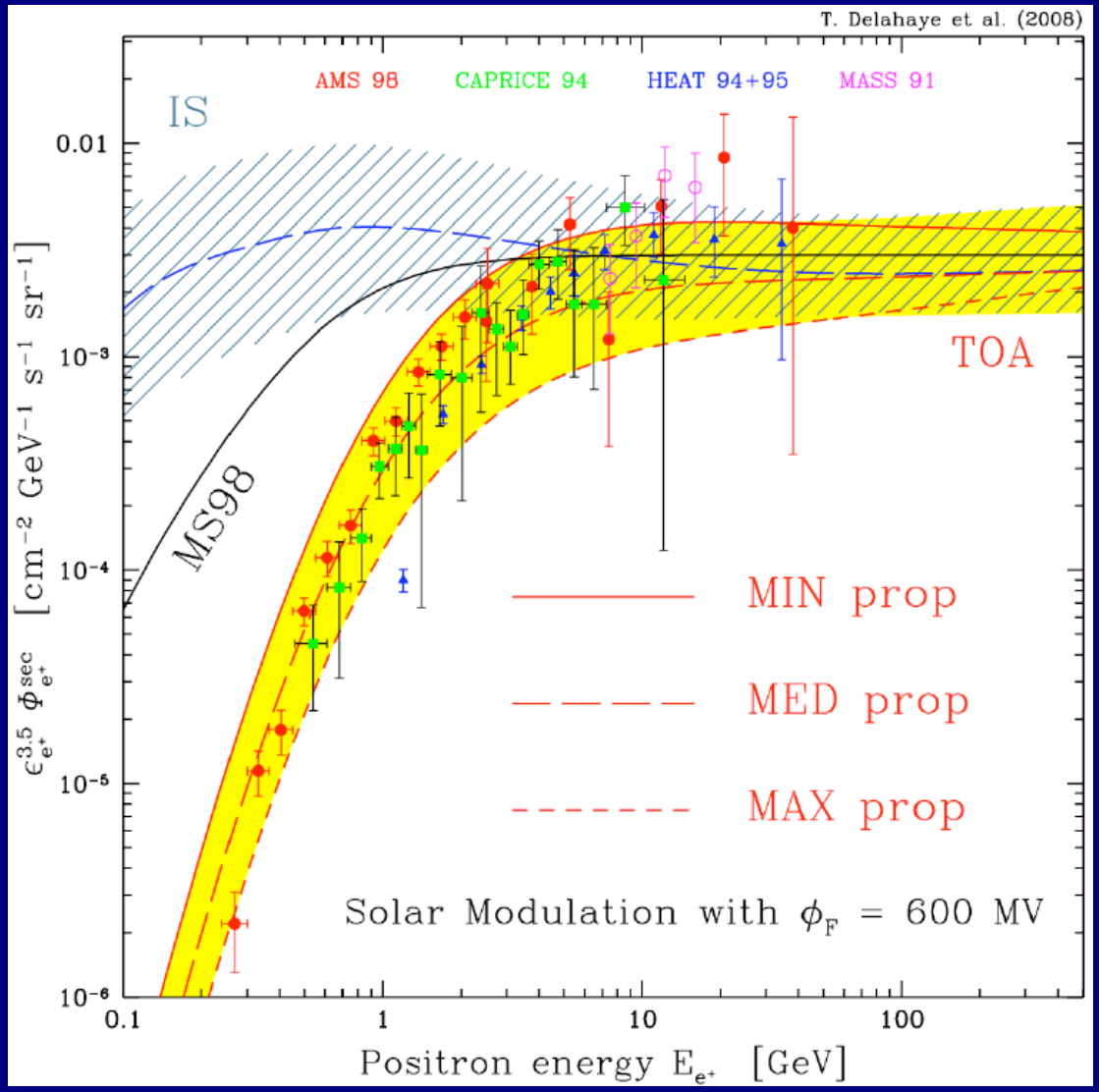
- There is standard paradigm of Galactical cosmic ray sources and diffusion

BUT

- There is no standard model of cosmic ray leptons.

Secondaries

Positrons: the background



Astron.Astrophys. 501:821-833, 2009

Positron fraction