Estimate of the Galactic electron and positron fluxes at the Earth

Timur Delahaye

LAPTh(Annecy) & Univ. Turin

On the leave for IFT/UAMadrid

In collaboration with

Julien Lavalle

Roberto Lineros

Fiorenza Donato

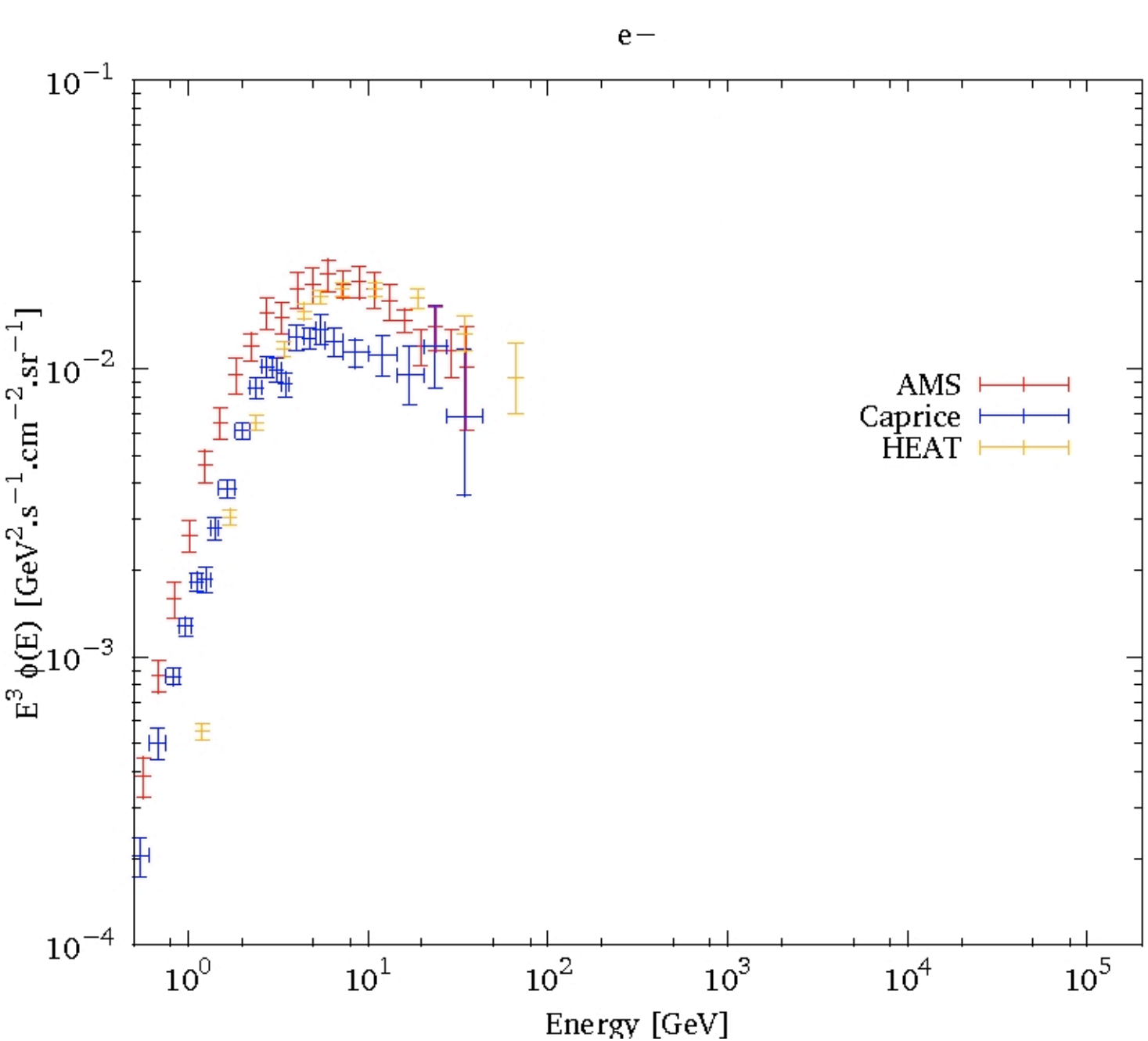
Nicolao Fornengo

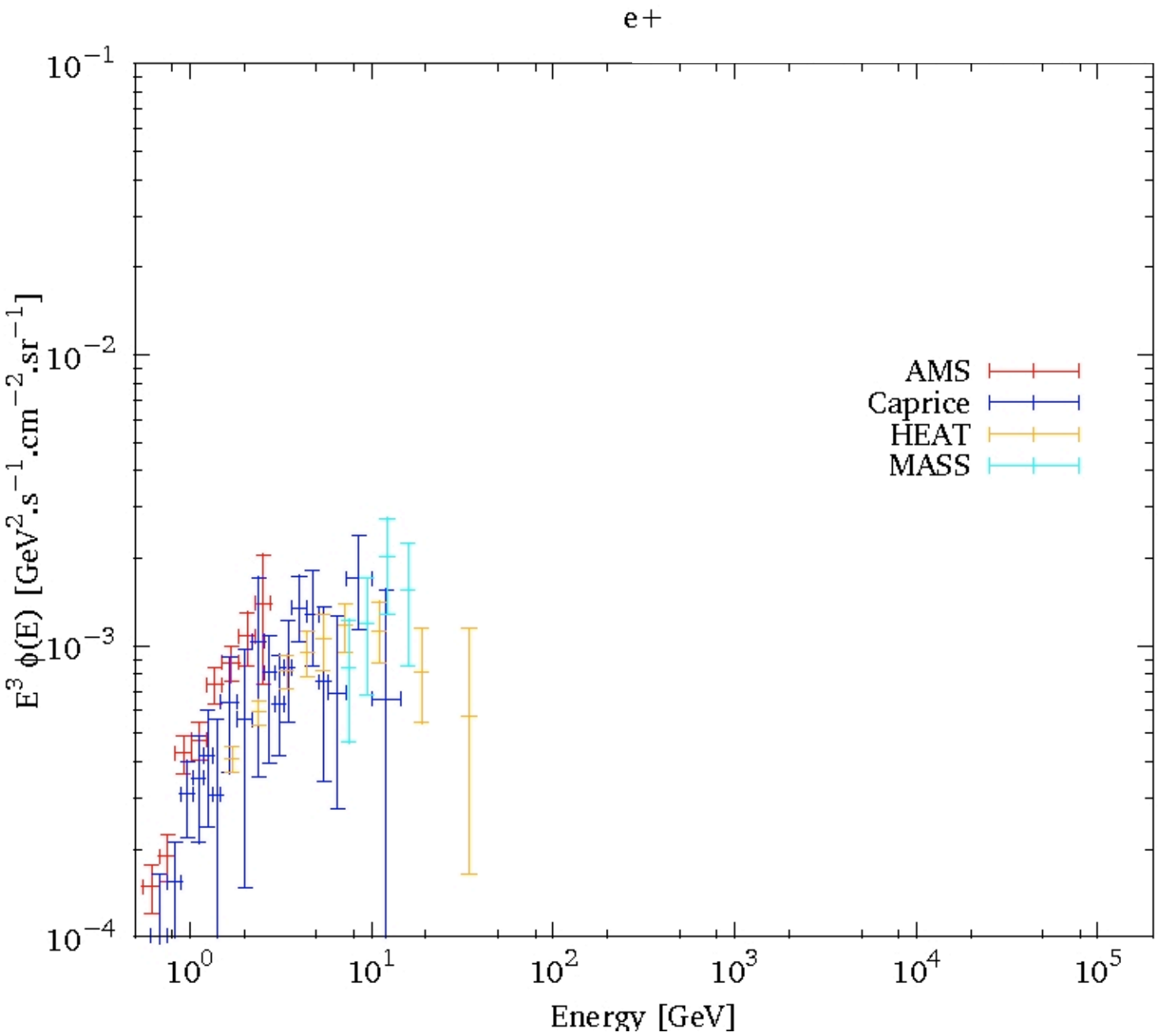
Pierre Salati

arXiv:1002.1910 A&A in press

Outline

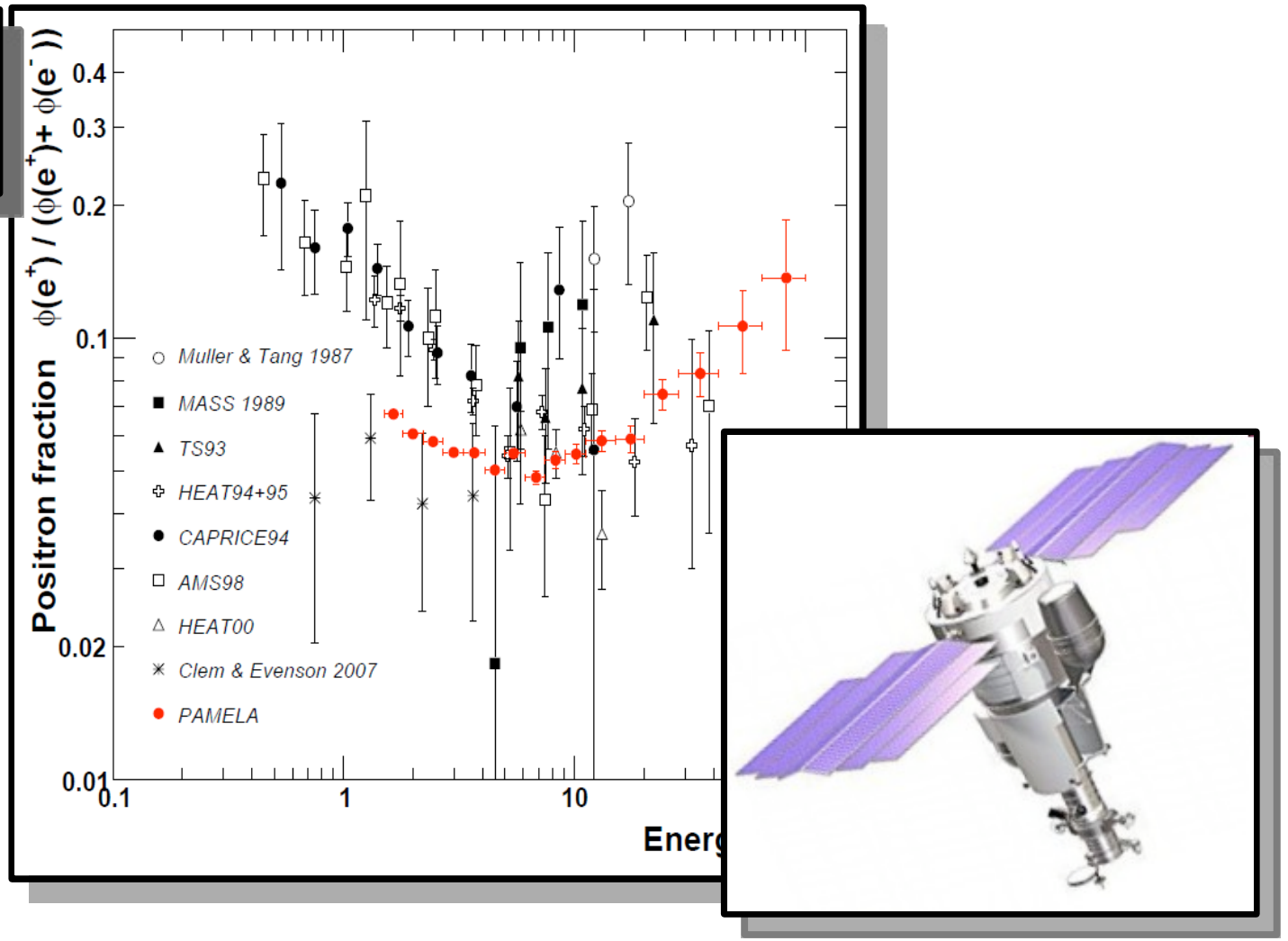
- Recent data
- Cosmic ray model
- Sources
- Results


e−
10^{-1}
10^{-2}
10^{-3}
10^{-4}
$E^3\,\phi(E)$ [$GeV^2.s^{-1}.cm^{-2}.sr^{-1}$]
10^0
10^1
10^2
10^3
10^4
10^5
Energy [GeV]
AMS
Caprice
HEAT


e+
10^{-1}
10^{-2}
10^{-3}
10^{-4}
$E^3\ \phi(E)\ [GeV^2.s^{-1}.cm^{-2}.sr^{-1}]$
AMS
Caprice
HEAT
MASS
10^0
10^1
10^2
10^3
10^4
10^5
Energy [GeV]

Pamela

Adriani et alii
Nature 2009



Fermi & ATIC

$E^3 \cdot J(E)$ (m^{-2} s^{-1} sr^{-1} GeV^2)

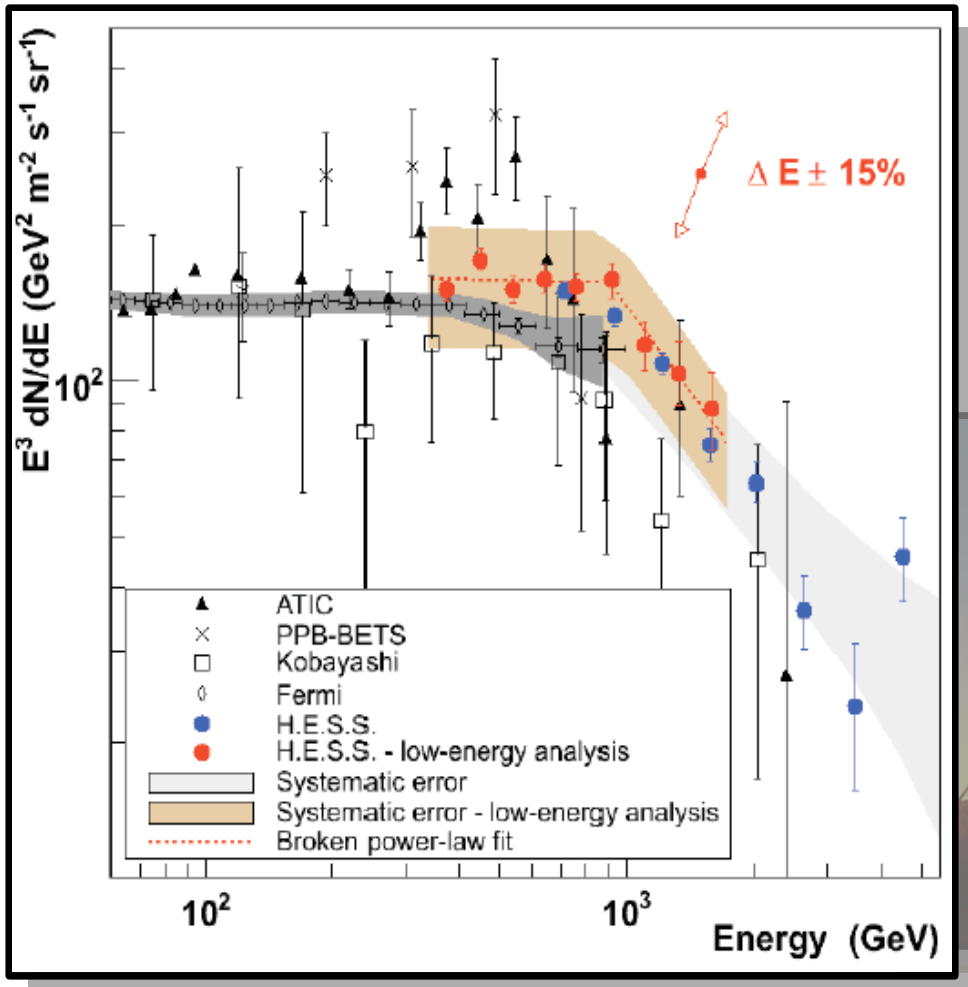
10^2

10 10^2 10^3

Energy (GeV)

AMS (Aguillar et al., 2002)
HEAT (Du Vernois et al., 2001)
Fermi low-energy (PRELIMINARY)
Fermi (Abdo et al, 2009)
ATIC (Chang et al., 2008)
H.E.S.S. (Aharonian et al., 2009)
H.E.S.S. (Aharonian et al., 2008)

HESS


E^3 dN/dE (GeV^2 m^{-2} s^{-1} sr^{-1})
10^2
$\Delta E \pm 15\%$
ATIC
PPB-BETS
Kobayashi
Fermi
H.E.S.S.
H.E.S.S. - low-energy analysis
Systematic error
Systematic error - low-energy analysis
Broken power-law fit
10^2
10^3
Energy (GeV)


With the courtesy
of Florent Dubois

Cosmic ray diffusion model

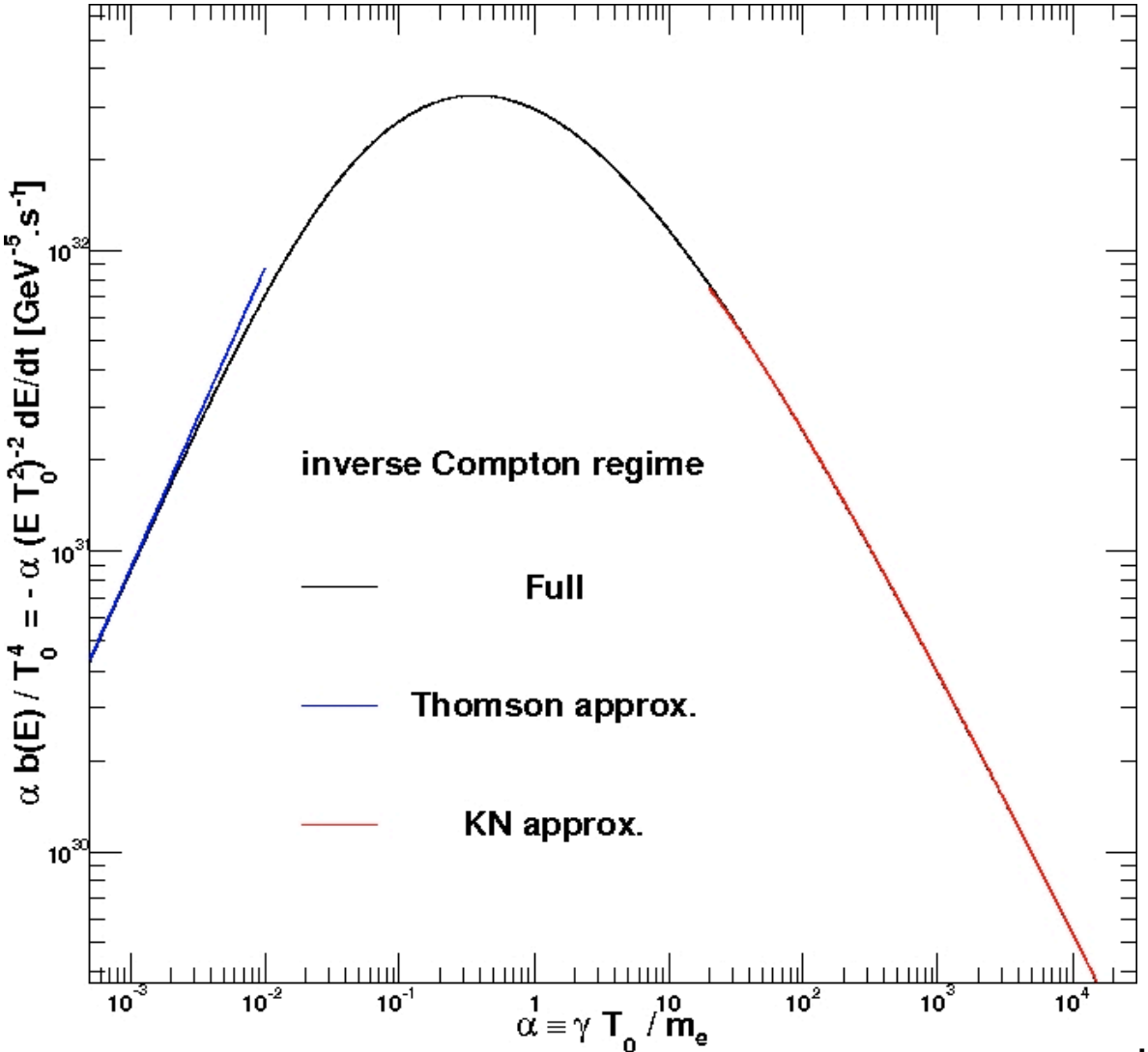
$$\partial_t \Psi - \vec{\nabla} \cdot \left(K \vec{\nabla} \Psi - \vec{V}_c \Psi \right) + \partial_E \left(b_{loss} \Psi - D_{EE} \partial_E \Psi \right) = Q\left(\vec{x}, E, t \right)$$

+ boundary conditions

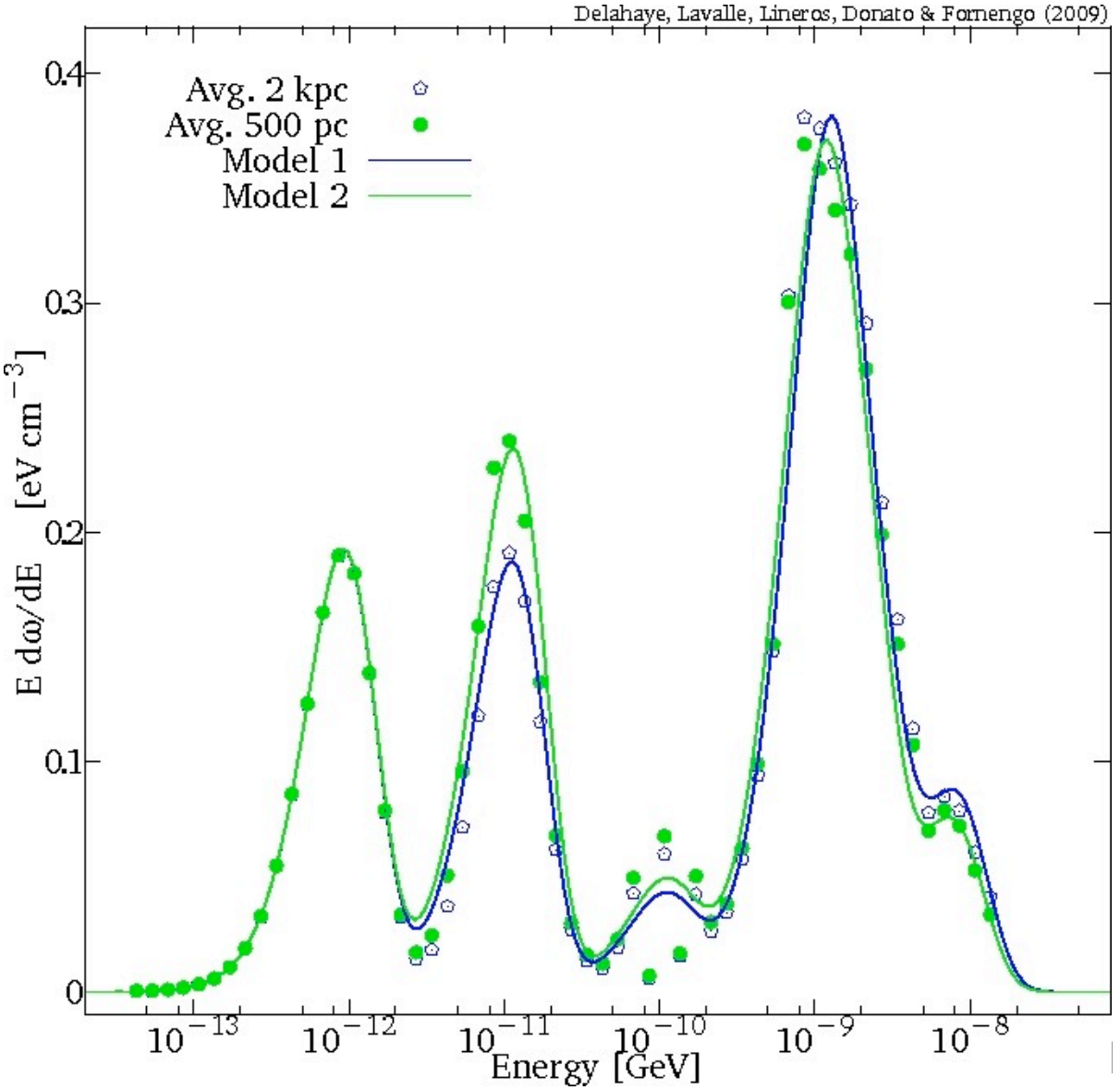
Energy losses

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

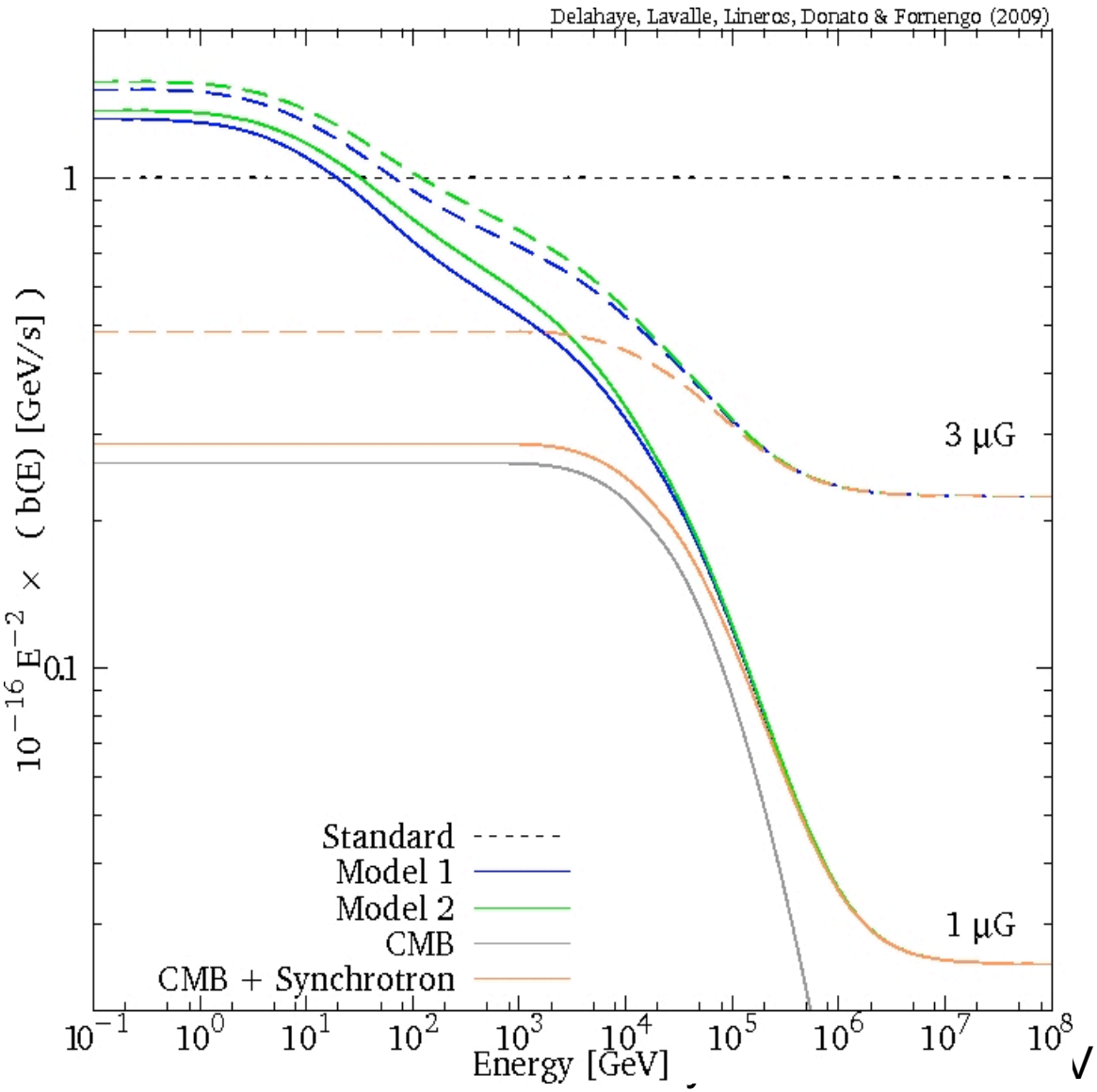
Inverse Compton



Interstellar Radiation Field



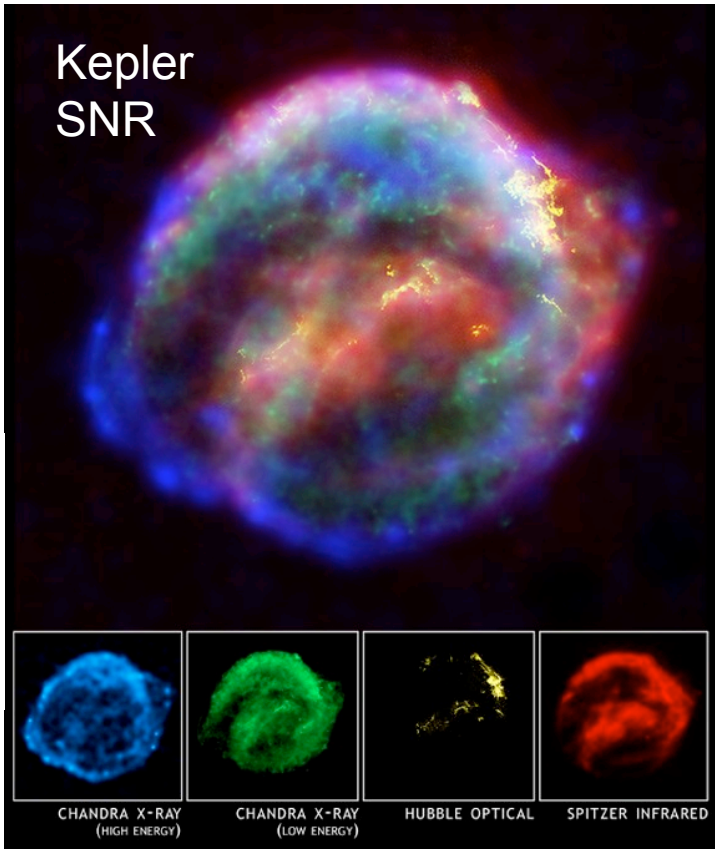
Energy losses



Sources

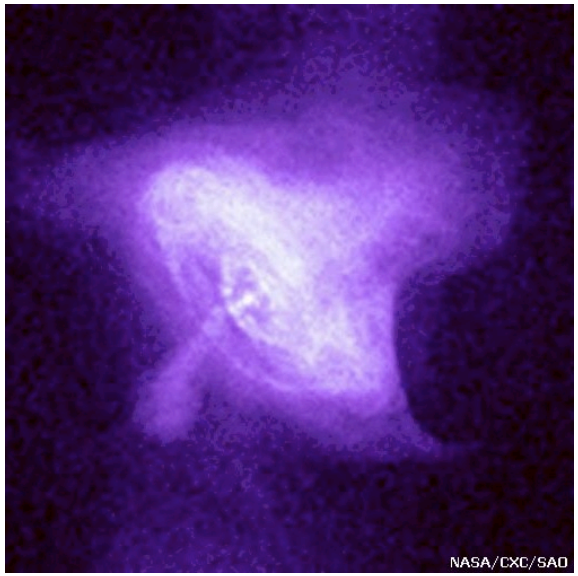
- Supernova remnants

$$Q_0 E^{-\gamma} e^{-E/E_c}$$



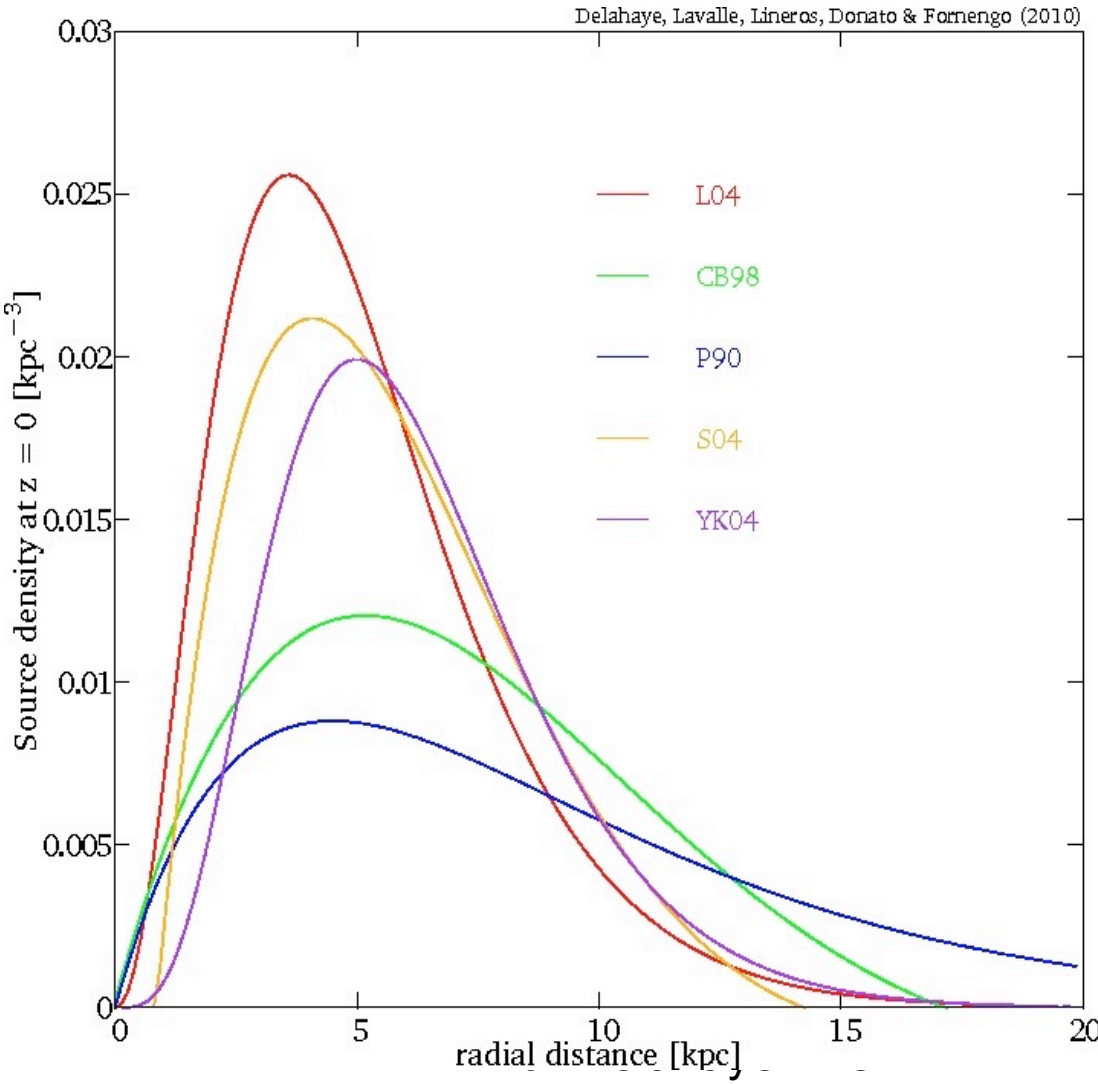
Sources

- Supernova remnants
- Pulsars

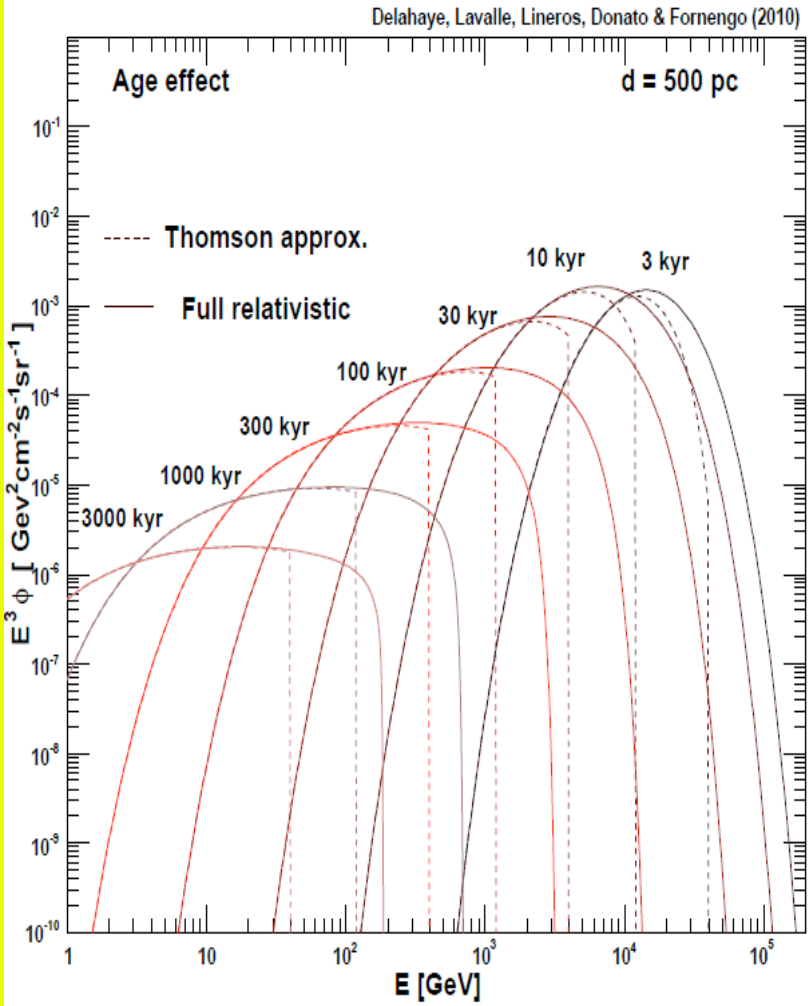


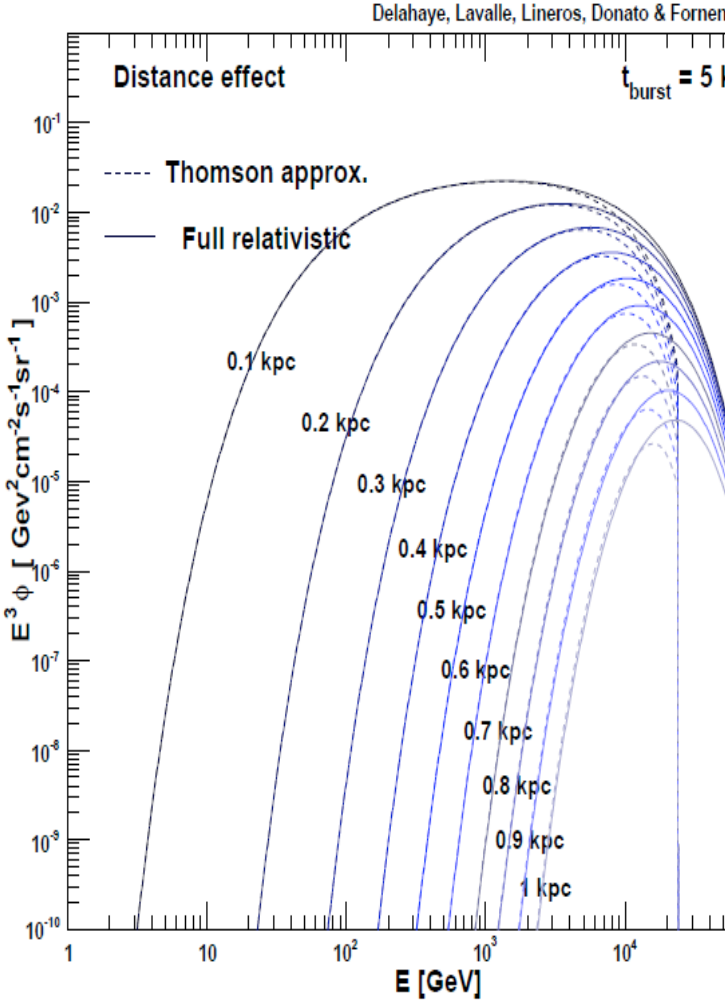
$$Q_0 E^{-\gamma} e^{-E/E_c}$$

Source distribution



Discreteness



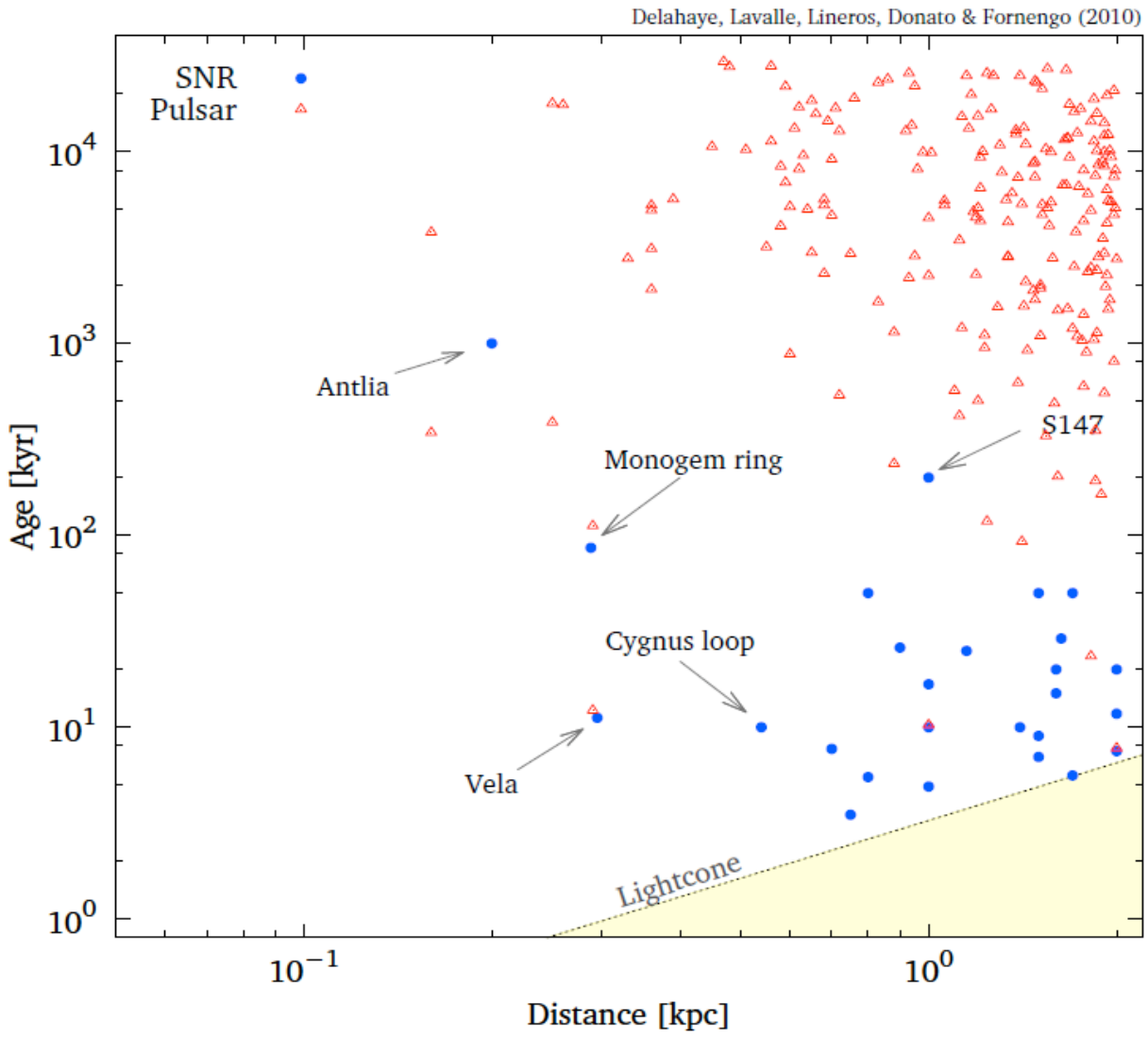


Source catalogues

Green SNR catalogue http://goo.gl/Srbr

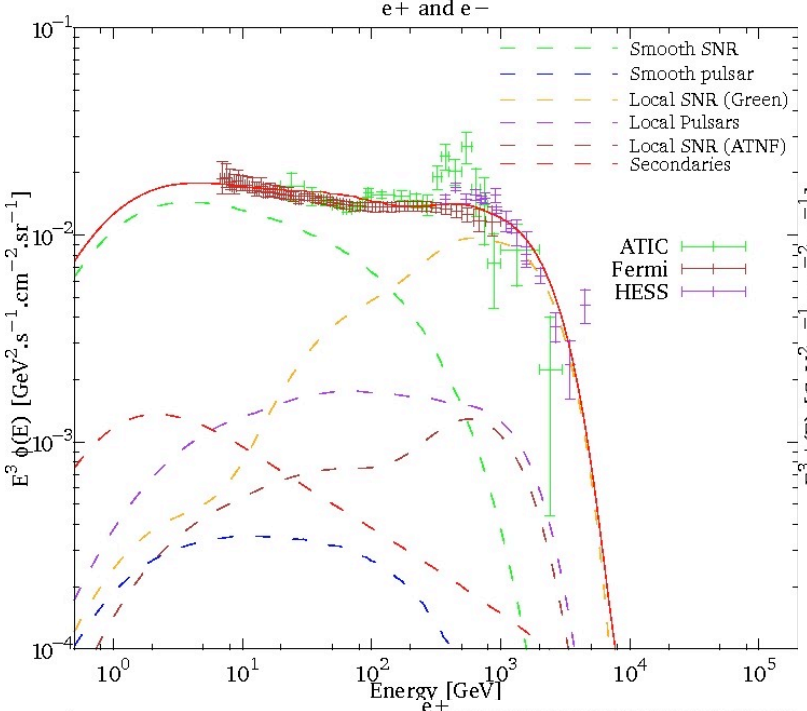
ATNF pulsar catalogue http://goo.gl/fpEK

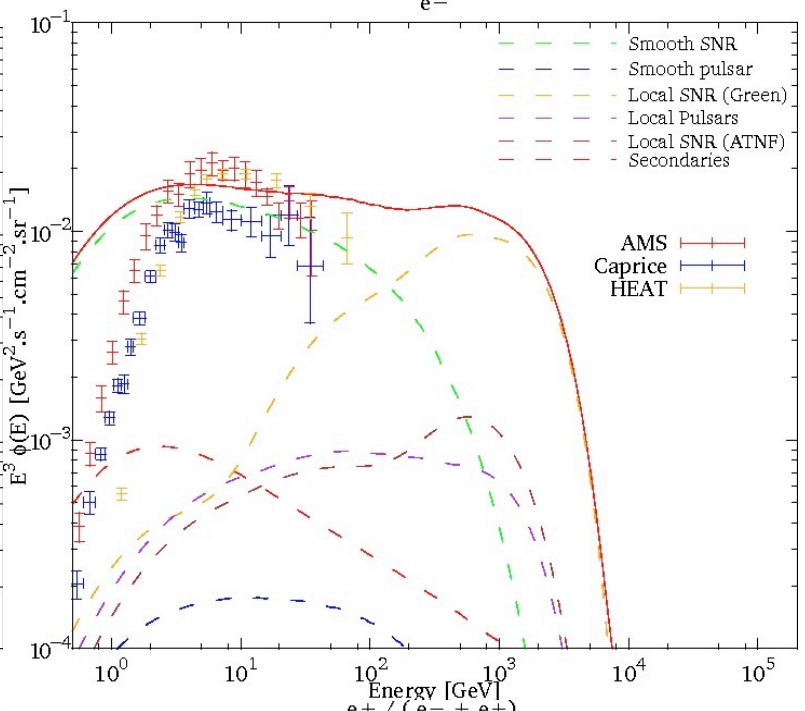
Local sources

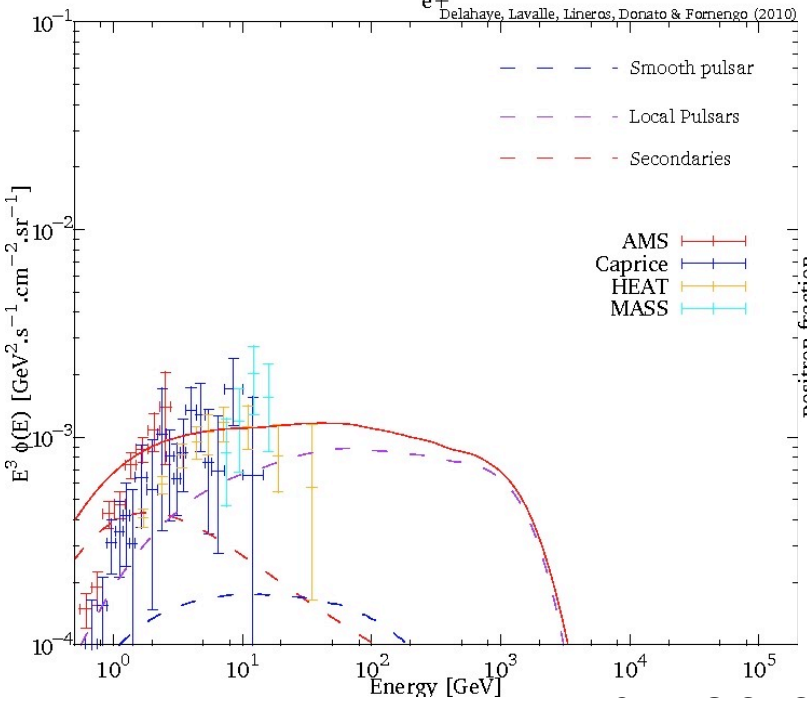


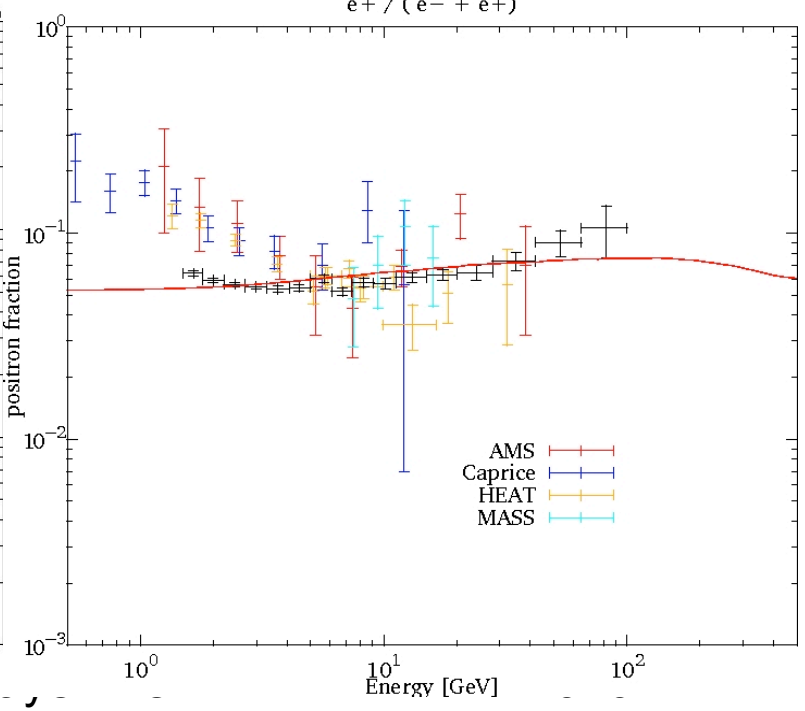
The ingredients : summary

- Smooth distribution of far away SNR
- Local known SNR
- Local SNR inferred from known pulsars
- Smooth distribution of far away pulsars
- Local known pulsars


e+ and e−
Smooth SNR
Smooth pulsar
Local SNR (Green)
Local Pulsars
Local SNR (ATNF)
Secondaries
ATIC
Fermi
HESS
$E^3 \phi(E)$ [GeV^2.s^{-1}.cm^{-2}.sr^{-1}]
Energy [GeV]


e−
Smooth SNR
Smooth pulsar
Local SNR (Green)
Local Pulsars
Local SNR (ATNF)
Secondaries
AMS
Caprice
HEAT
$E^3 \phi(E)$ [GeV^2.s^{-1}.cm^{-2}.sr^{-1}]
Energy [GeV]


e+
Delahaye, Lavalle, Lineros, Donato & Fornengo (2010)
Smooth pulsar
Local Pulsars
Secondaries
AMS
Caprice
HEAT
MASS
$E^3 \phi(E)$ [GeV^2.s^{-1}.cm^{-2}.sr^{-1}]
Energy [GeV]


e+ / (e− + e+)
AMS
Caprice
HEAT
MASS
positron fraction
Energy [GeV]

Conclusions

- No need for Dark Matter to explain current data
  =>Does not mean that it is not there !

- Semi-analytical methods allow to fully take into account the energy losses, the discreteness of sources and to quickly scan over the parameters.
- Because sources are discrete, it is expected to have deviation from a powerlaw.