On the status of astrophysical interpretations of PAMELA/Fermi lepton data

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GGI - Firenze- May 2010

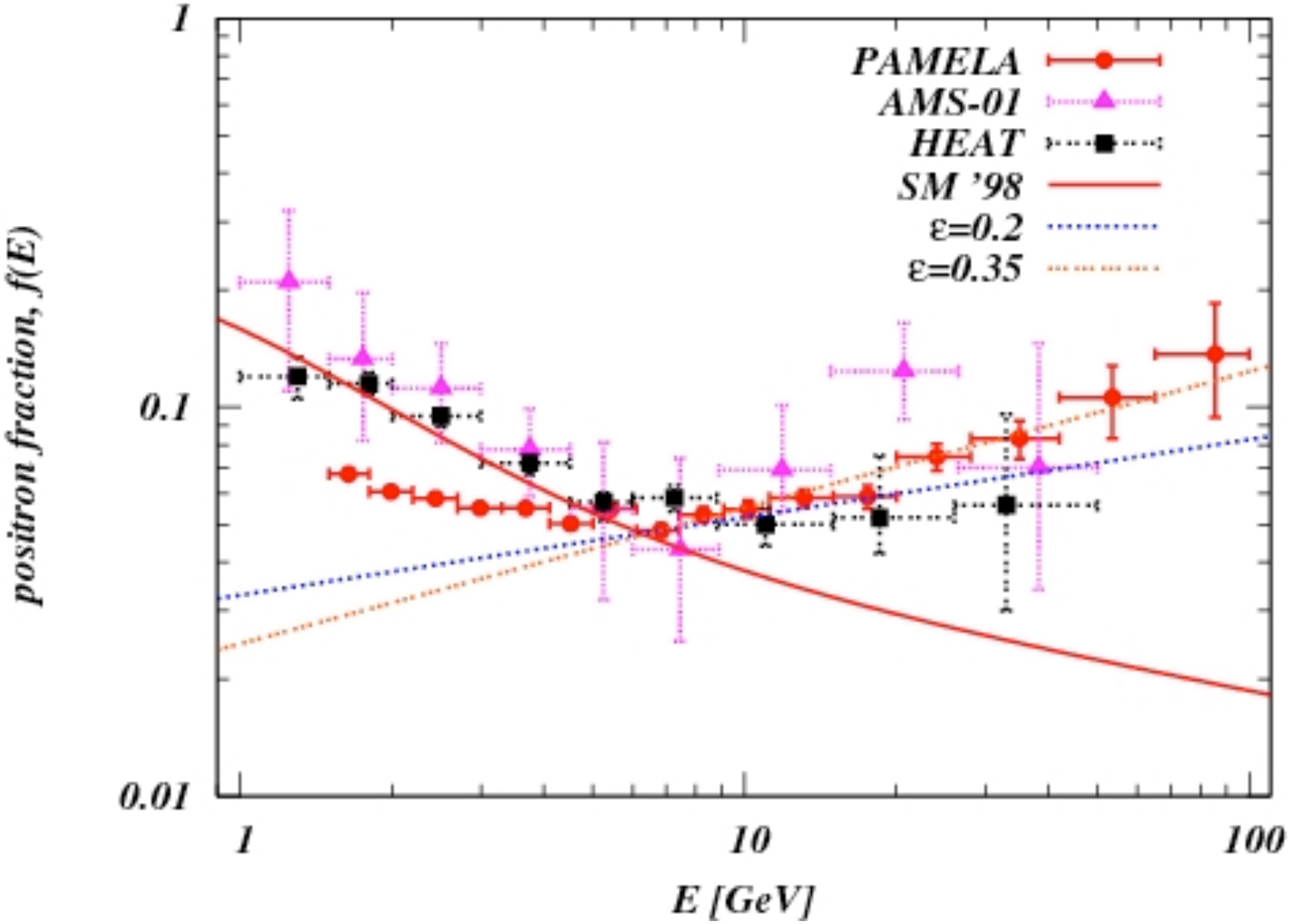
Outline

- Introduction. Why different classes of lepton CR sources are needed

And hopefully clarify some misconceptions…

- Supernova Remnants
- Pulsar Wind Nebulae
- Conclusions

e^+ fraction measurements reveal the following:



Nature 458 (2009) 607

Guaranteed astrophysical sources of antimatter

Spallation of CRs (assume pure matter) on interstellar medium gas

How robustly do we know that?

- ✓ From CR spectra at the Earth, assuming (from known (astro)physics!), that they propagate diffusively in a magnetized region embedding the MW

- ✓ Propagation parameters constrained by assumed secondary/primary elements (B/C), anti-p/p, "chronometers" as ^{10}Be good agreement with properties of the ISM estimated from direct probes.

- ✓ Diffuse gamma-ray data, of course!

Source & propagation effects

Source term (time, space, momentum dep.)
Includes dec./frag. for heavier nuclei

Diffusion

Energy loss

Convection velocity

$$\frac{\partial \Phi}{\partial t} = Q + \vec{\nabla}\cdot(D_{sp}\vec{\nabla}\Phi) - \frac{\partial}{\partial p}(\dot{p}\Phi) +$$

$$+ \frac{\partial}{\partial p}\left[p^2 D_{mom}\frac{\partial(p^{-2}\Phi)}{\partial p}\right] - \vec{\nabla}\cdot(\vec{V}\Phi) + \frac{\partial}{\partial p}\left[\frac{p}{3}(\vec{\nabla}\cdot\vec{V})\Phi\right] +$$

$$- \frac{\Phi}{\tau_{frag}} - \frac{\Phi}{\tau_{decay}}$$

Adiabatic flow term

Fragmentation and decay terms
(negligible/vanishing for protons)

Diffusive reacceleration

$$\frac{\partial \Phi}{\partial t} = Q - \frac{\Phi}{\tau_{esc}} - \frac{\partial}{\partial p}(\dot{p}\Phi)$$

Diffusion → Leaky box: hadrons

$$\frac{\partial \Phi}{\partial t} = Q - \frac{\Phi}{\tau_{esc}} - \frac{\partial}{\partial p}(\dot{p}\Phi)$$

- For Protons, fair to neglect energy losses and one gets

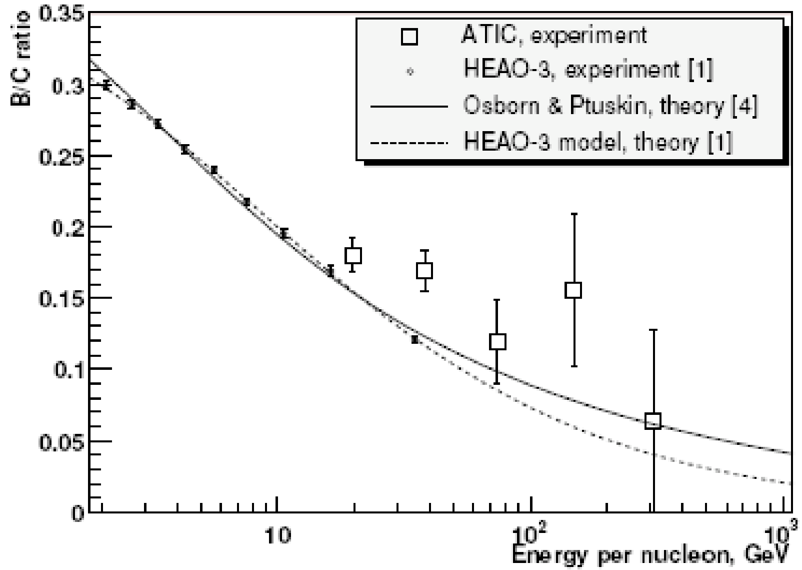
$$Q_p(E) \propto E^{-\gamma_p} \Rightarrow \Phi_p(E) \propto E^{-\gamma_p}\tau_{esc}(E)$$

- For pure secondary nuclei (as Boron, produced from Carbon) one gets

$$Q_{\sec}(E) \propto \sigma\, \Phi_{prim}(E) \Rightarrow \Phi_{\sec}(E) \propto \sigma\, \Phi_{prim}(E)\tau_{esc}(E)$$

$$\tau_{esc}(E) \propto D(E)^{-1} \propto E^{-\delta}$$

At least in the E-range of interest, one infers $\delta \sim 0.5 \pm 0.2$ e.g. from B/C (and other s/p data).



Diffusion → Leaky box: leptons & positron fraction

$$\frac{\partial \Phi}{\partial t} = Q - \frac{\Phi}{\tau_{esc}} - \frac{\partial}{\partial p}(\dot{p}\Phi)$$

- For primary electrons, one can deduce by analogy

$$Q_-(E) \propto E^{-\gamma_-} \Rightarrow \Phi_-(E) \propto E^{-[\gamma_- + \ell(E)]}$$

- Similarly, for secondary positrons (if cross section~E-independent)

$$Q_+(E) \propto \Phi_p(E) \Rightarrow \Phi_+(E) \propto E^{-[\gamma_p + \delta + \ell(E)]}$$

If energy-loss time negligible wrt escape time $\ell(E) \approx \delta$

When radiative energy loss dominate (high energy):
But continous source approximation can break down… $\ell(E) \approx 1$

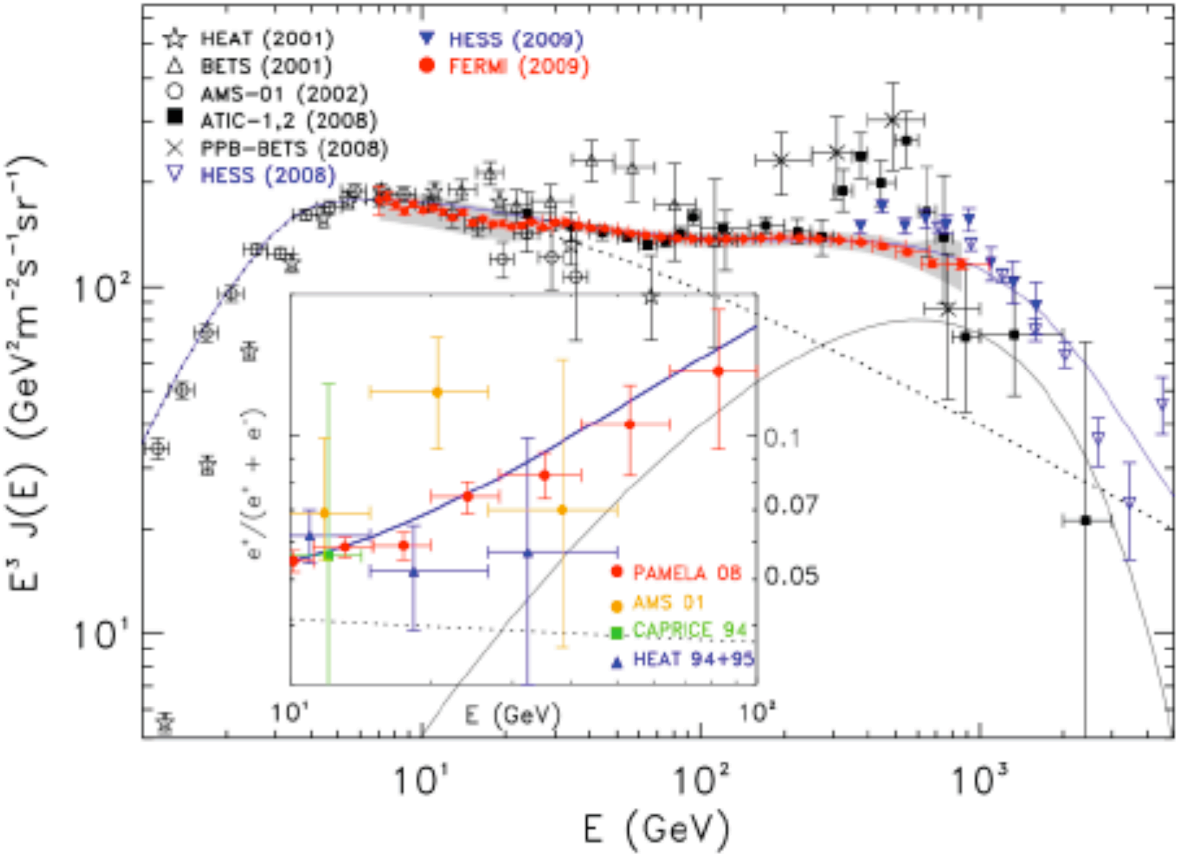
$$f(E) \equiv \frac{\Phi_+}{\Phi_+ + \Phi_-} = \frac{1}{1 + (\Phi_- / \Phi_+)} \approx \frac{1}{1 + kE^{\rho}}$$

$$\rho = \delta + \gamma_p - \gamma_-$$

Can this be ~ -0.3?

Not without additional sources!!!

The measured slopes are γ_e'~ 3.05 (Fermi), it is known that γ_p' ~2.75.
The measured rise implies e^+ spectrum at Earth very similar to the p one.
All indicators (B/C, antiprotons,…) require δ>0.33: even forgetting that e spectra steepened also by E-losses, rising f_{e+} can' t be obtained with ISM yield only



Latronico, Fermi Symposium 2009

PRL 102 (2009) 181101

"Firm" Conclusion:

Barring

- major systematics, like p-contamination at least ~10 times worst than evaluated from in-flight data (final check by AMS-02, hopefully!)
- and/or fundamental flaw in our understanding of CR propagation

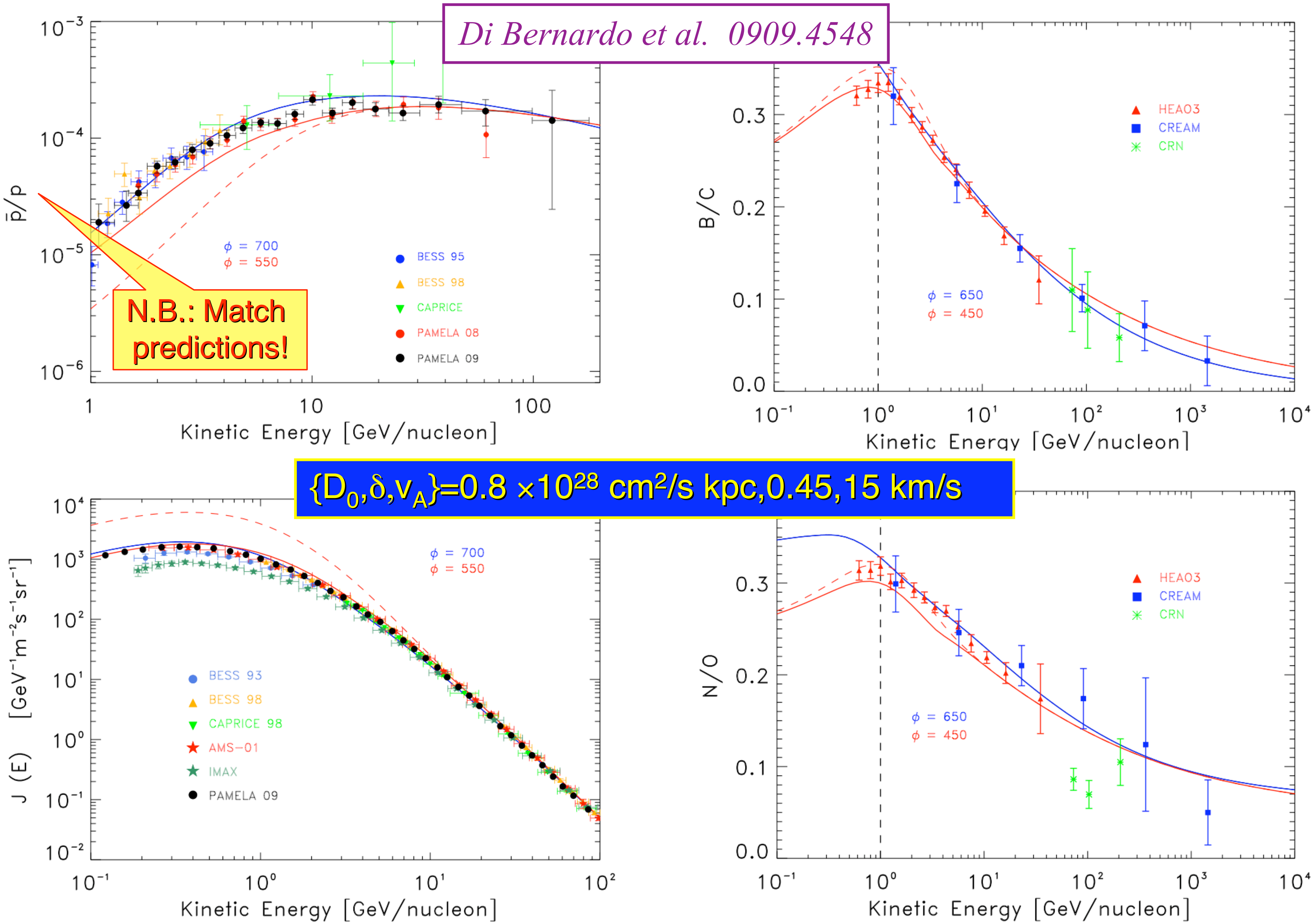
We need different components in the primary lepton spectrum!

Of course, there are some mild theoretical assumptions.
If one claims a mechanism for which the propagation of leptons has a $\delta_e<0$ (i.e. low energy particles escape more easily…) while at the same time baryons feel a $\delta>0$, you can make without.

Katz et al., arXiv:0907.1686

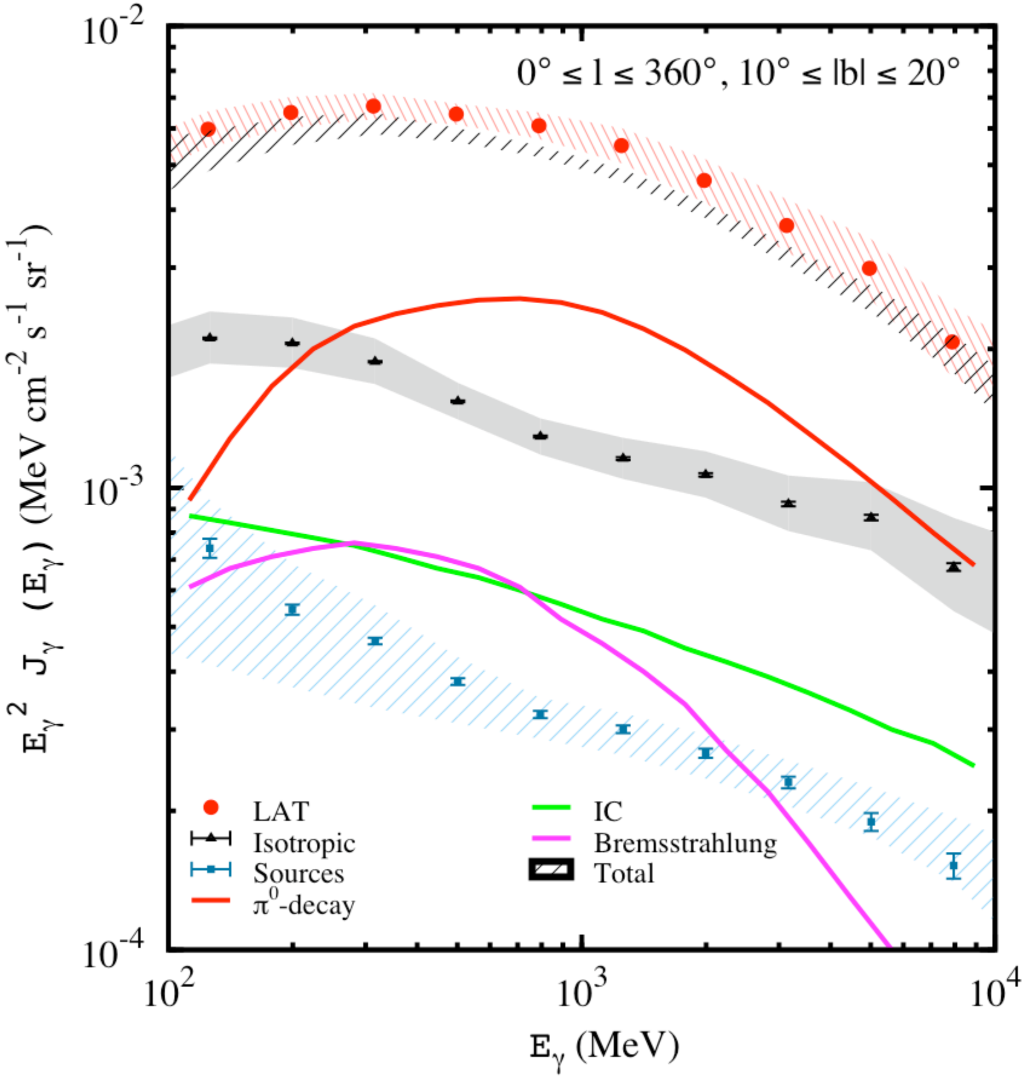
At the moment, such a "radical alternative" model has not been built. Its eventual consistency with a wealth of other observations (e.g. gamma rays) is another task unproven. Needless to say, if you accept such a skeptical point of view, the last thing you can do is to even think using CRs for DM searches…

We do have a consistent framework, at leading order!



And also gammas and leptons fit in that…

Fermi-LAT Collaboration, Phys.Rev.Lett.103, 251101 (2009)



Additional information e.g. from radio consistent with ISM e spectra similar to local ones

Some misconceptions about astrophysical electron spectra

I. One does not expect a power-law spectrum

Even assuming pure power-laws at injection, features expected!

Pure Energy-loss effects

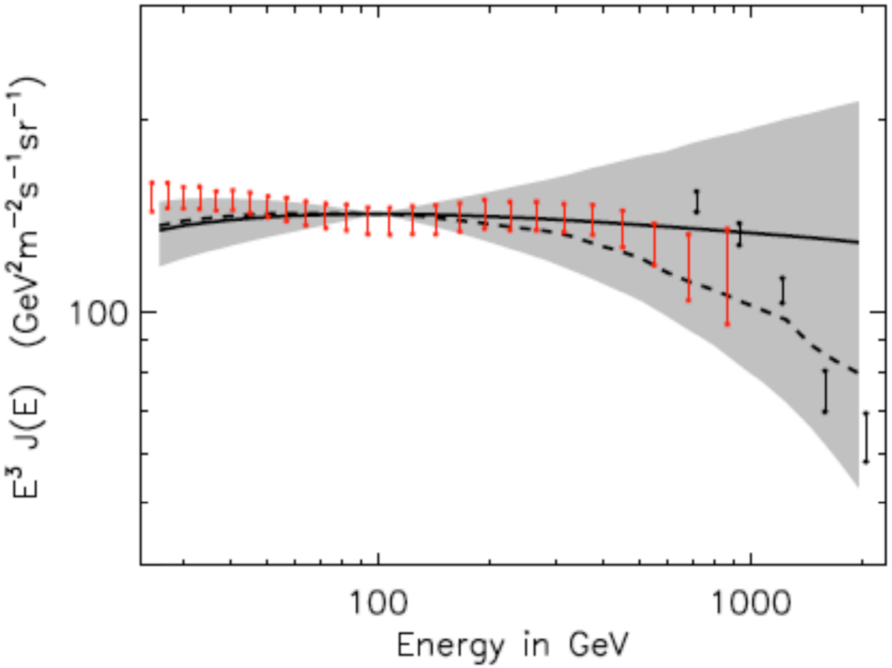
e.g. Klein-Nishina suppression of the IC cooling rate, important at E~TeV.

Stawarz, Petrosian, & Blandford, arXiv:0908.1094

Inhomogeneities

- Stochasticity (rms distance <~ E-loss volume)
- Inhomogeneous distribution of sources, e.g. large arm/interarm difference in SN rate

D. Grasso et al. arXiv:0905.0636;
Shaviv, Nakar, Piran PRL 103, 111302 (2009)



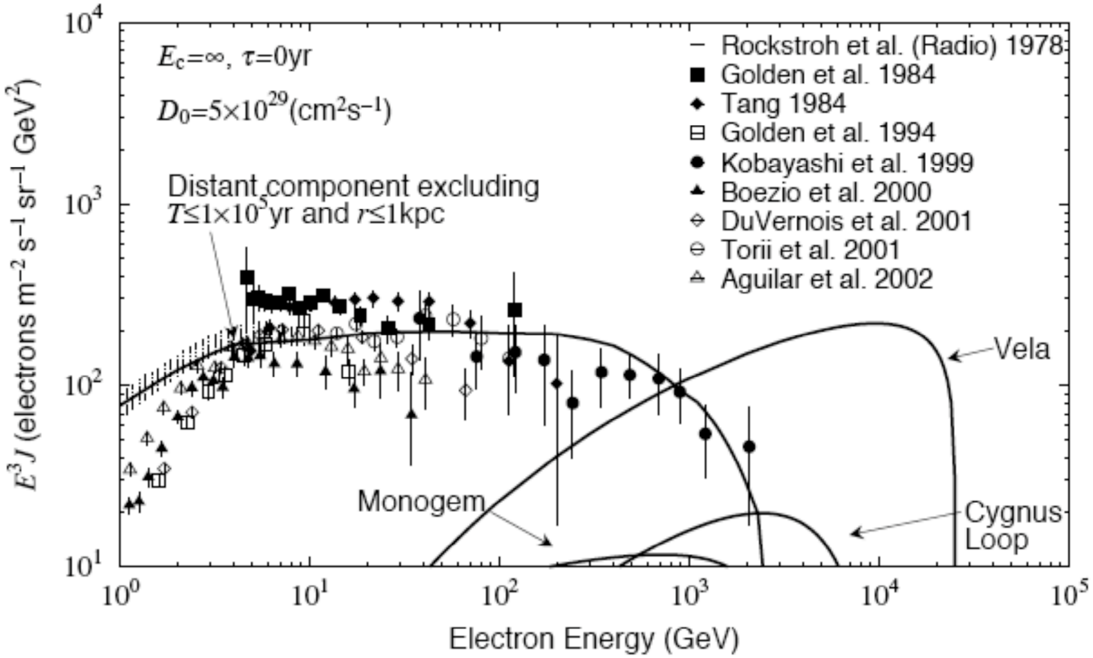
Many Sources and source types are known!

Virtually any HE astrophysics object sources relativistic e^-. Many spectra measured, at some level their overlap must yield spectral features.

II. Interest for TeV electrons is astrophysical!

- A plethora of suitable candidates exist to explain “bumps” in the electron flux: SNRs, pulsars, X-ray binaries, etc. (γ,X-ray & radio objects)
- The astrophysical motivation for “TeV” e^- studies is to explore a range where all but one/few local objects account for the flux

Possibly Fermi hint for a “bump” welcome & interesting, not unexpected



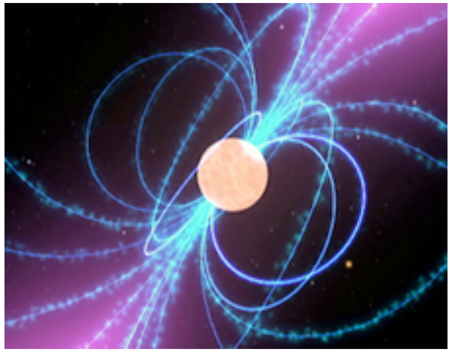
Kobayashi, Komori, Yoshida, Nishimura, “The Most Likely Sources of High Energy Cosmic-Ray Electrons in Supernova Remnants,” APJ 601, 340 (2004)

What causes the rise?

Exceptional object

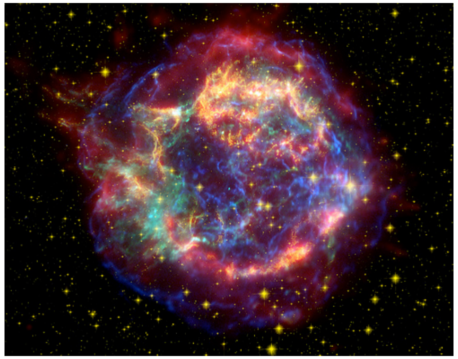
Pulsars

- Complex astrophysics, no “robust predictions”
- “Natural” normalization; shape of the signal (?)
- ‘Purely’ e.m. cascade, explains why no anti-p & no ν



Mature SNRs *(standard source of CRs!!!)*

- In situ production is certain at some level.
- How large hard to calculate reliably a priori,
most likely must be answered observationally.
- Prediction of high-energy feature in anti-p, nuclei



What causes the f_{e+} rise? "Anticopernican" option

Exceptional object(s) or position: elsewhere or at another time in the Galaxy we would not see something similar very easily. E.g.:

collisions of CRs from a SNR in a near dense cloud
Y. Fujita, K. Kohri, R. Yamazaki and K. Ioka, arXiv:0903.5298, see also Dogiel, V. A et al (1987), MNRAS, 228, 843

GRB (or μ–quasar event?) happening in our Galactic neighborhood in the last ~ 10^5 yr (~1% chance probability?)
K. Ioka, arXiv:0812.4851

Single pulsar? *Many papers…*

Predict specific features in total e flux, not (yet?) confirmed

Consistency with other probes, like pbar,γ...?

- certainly "logical possibilities": but also a killing argument (generic conclusions would hardly be reached)

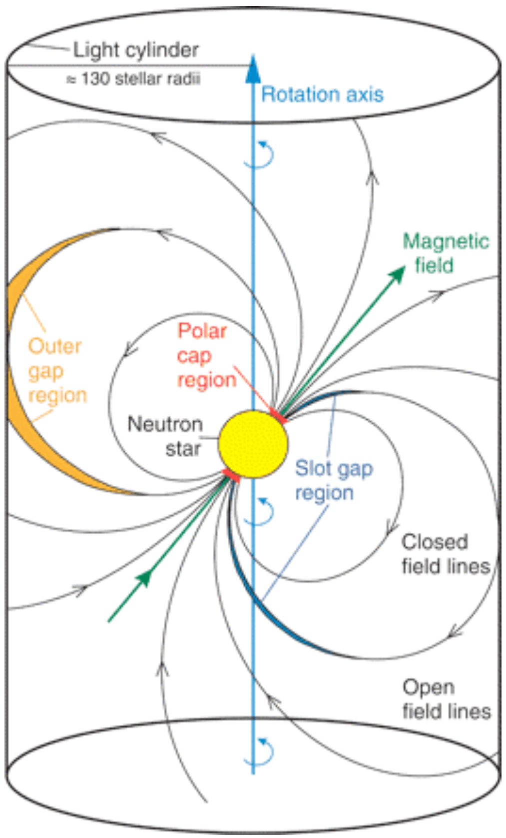
- Are we sure we *need* this? For example, for the known distribution in space & time of 'standard' sources and targets, are these contributions really dominant over "diffuse" contributions from all other (known) sources?

Pulsars

Pulsars

➢ Magnetized NS with non-aligned rotation and magnetic axes, remnants of core-collapse supernovae: *Pacini, Gold 1967-68.*

➢ They lose rotational energy and spin-down through e.m. torques due to large-scale currents in their magnetospheres: the induced E-fields are so strong that charges are stripped from the surface & populate a "corotating" plasma up to $R_L \sim c/\Omega$



▪ Regions exist connecting the NS surface to ∞, along which develop potential drops of the order

$$\Delta\phi \simeq \frac{\Omega B_0 R^2}{2c}\frac{R}{R_L}$$
$$\sim 6 \times 10^{12} B_{12} P_s^{-2} V$$

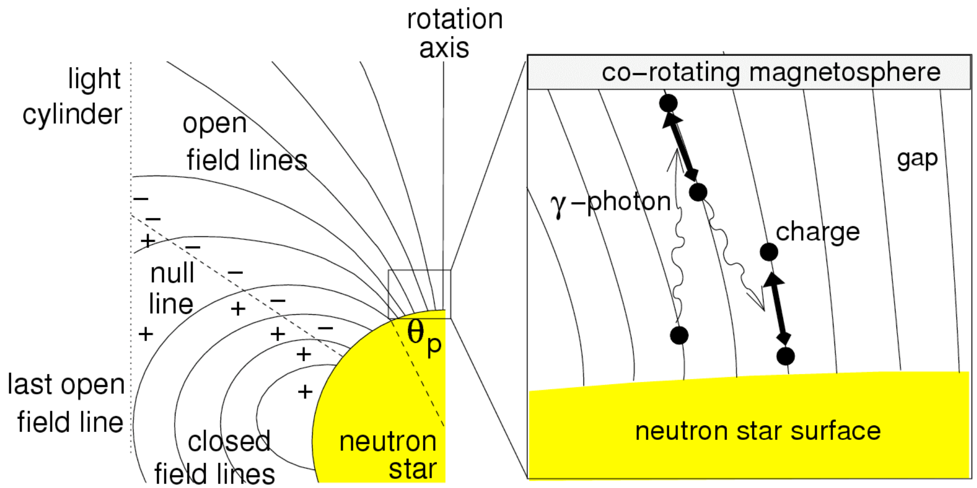
which can accelerate e.g. electrons to E>TeV

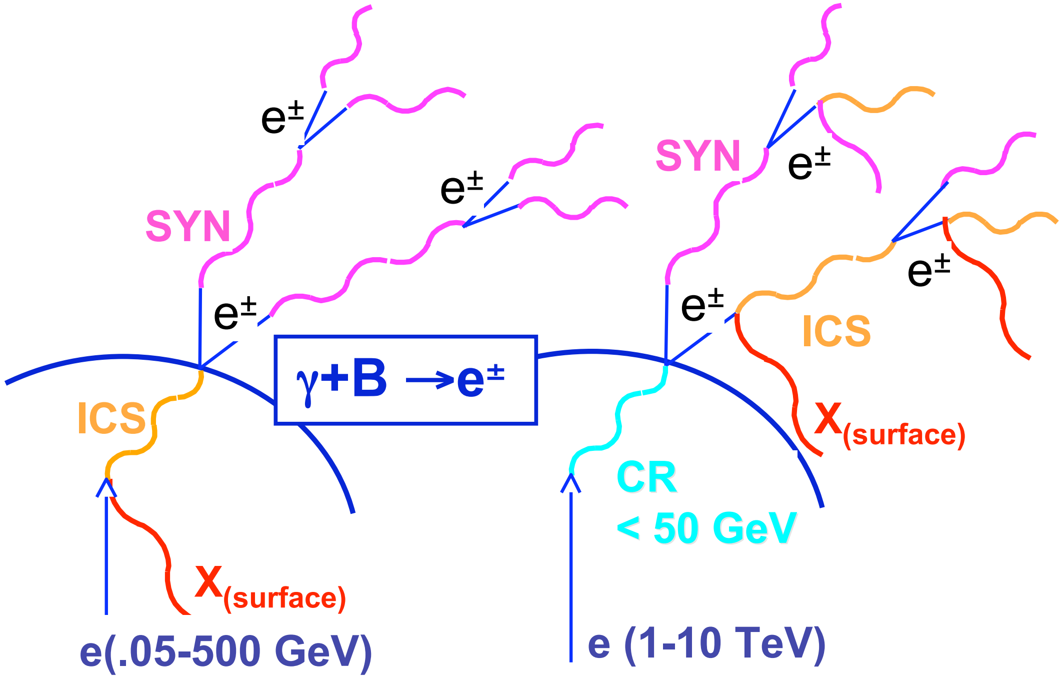
▪ But interactions with the medium important! Losses and particle production take place
→ e.m. cascades develop

High energy particle production

Particles accelerated in "gaps" (=regions without saturated plasma configuration), e.g.:

- Where open field lines attach to the polar surface & stripped particles escape to ∞
- In regions joining null-charge surfaces (no efficient "refilling" can take place) to ∞





High-E spectra shaped by conditions @ different locations via:

- Synchrotron & curvature radiation
- Inverse Compton
- pair production in the intense B-field
- pair production on γ backgrounds
- triplet pair production
- …

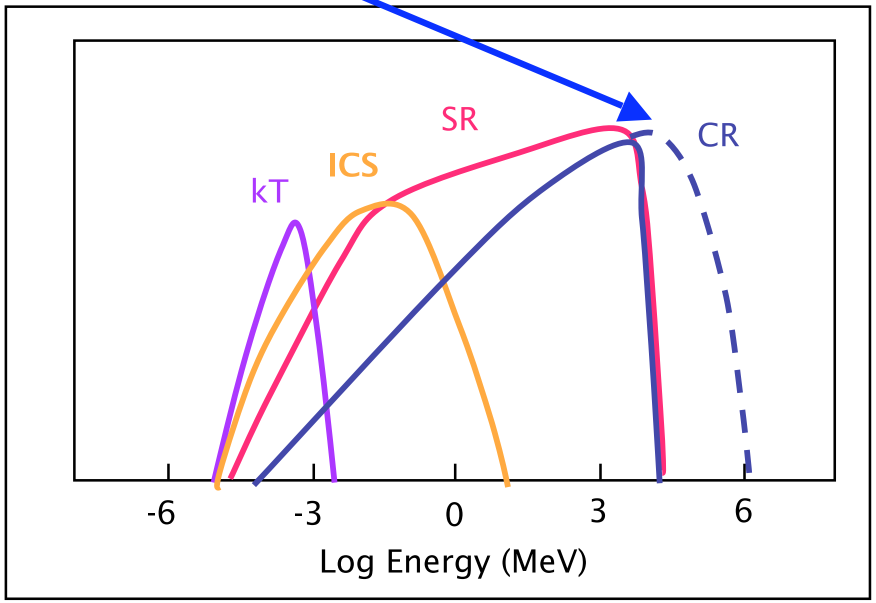
How to distinguish among acceleration models?

- Different models exist depending on location & geometry of “gaps”
- Constrained via γ-ray spectra (possibly high-energy cutoff!), phase-profile, multi-wavelength (radio to γ) constraints.

For example, interactions with B dominate in the PC model
→ superexponential cutoff at relatively low energies (few GeV).

γ–γ prevail in outer magnetosphere ($d \sim R_L$)
→ milder (exponential) cutoff & at higher E.

“Fermi” region!

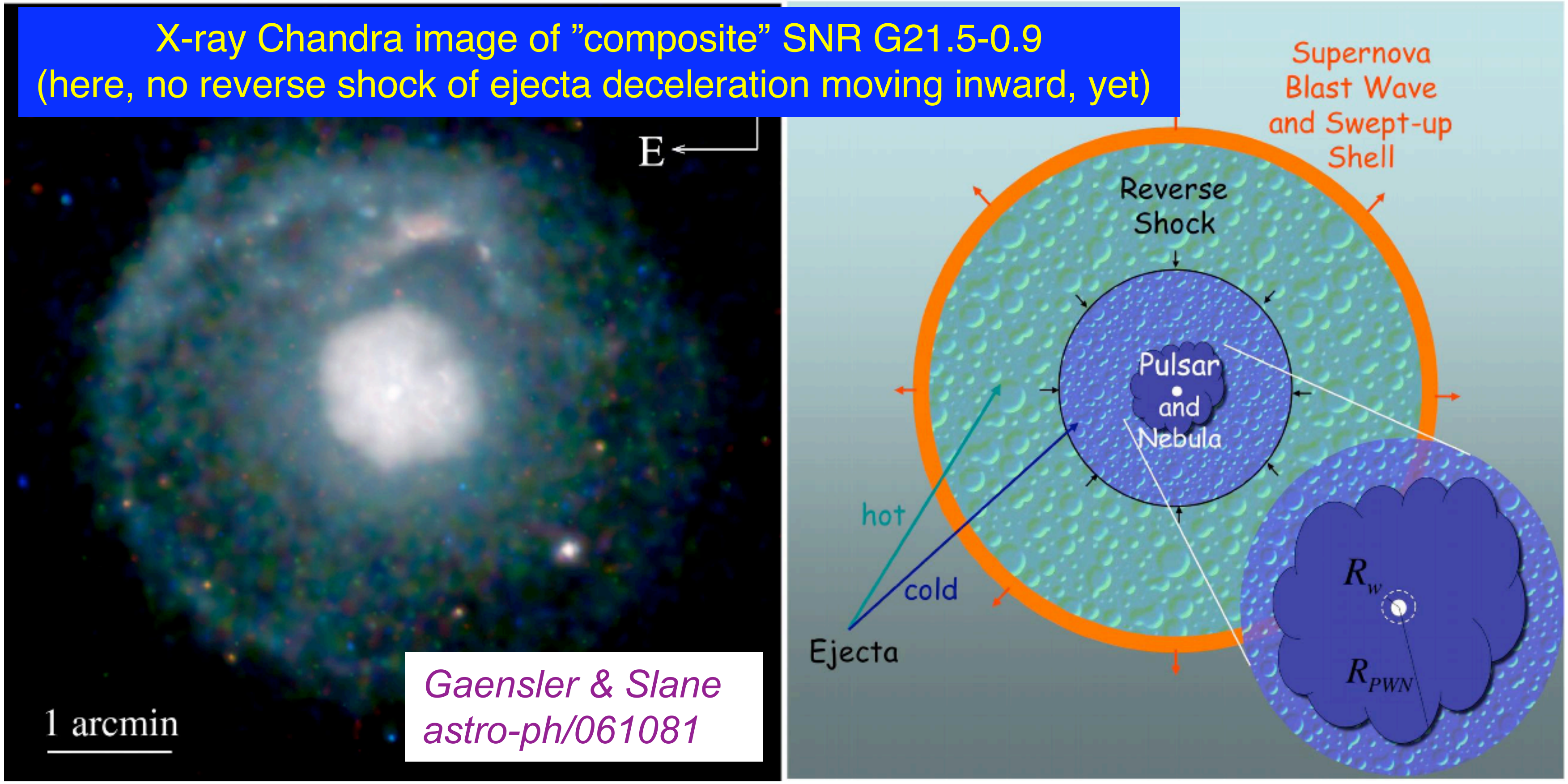


In general, pulsar spectra [observed by Fermi in γ-rays] are consistent with simple exponential cutoffs, indicative of absence of magnetic pair attenuation.

L. Guillemot, Fermi Symposium,
2 November 2009

But there's more than the 'initial' injection!

X-ray Chandra image of "composite" SNR G21.5-0.9
(here, no reverse shock of ejecta deceleration moving inward, yet)



- Forward shock in the ISM (which is heated)
- Reverse shock propagates inwards, decelerating the SNR ejecta
- The Pulsar launches a relativistic wind (fields plus pairs) called nebula, which forms a "termination shock" when hitting the slower ejecta

Emission at magnetosphere is not the whole story!

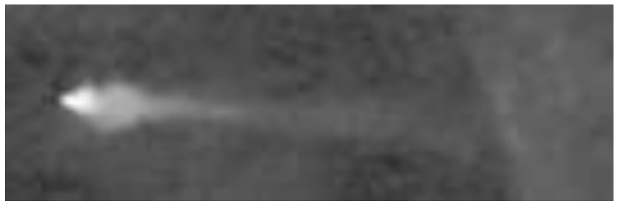
✓ Wind $e^{\pm}$ produced at inner magnetosphere (d< 40 km), via $L_{spin\text{-}down} \approx 1\% L_{SNR}$
Region responsible for the pulsed radio emission (but negligible in E-budget!)

✓ Outer magnetosphere (d~ 1000 km) implied in pulsed X and γ emission, O(0.1-1% $L_{spin\text{-}down}$) Dependence on B,Ω,geometry… *[Fermi diagnostics region]*

✓ Radio and X-ray observations at the termination shock suggest that most of the spin-down energy, formerly in the field (Poynting flux) has been converted into non-thermal particles!

✓ Adiabatic losses in the expanding bubble? Further shock reacceleration? Escape in the ISM, when? After the PWN breaks-up @~10^5 years?

Perhaps the latter problem is softened or eliminated when considering pulsars which have left their remnant, with termination shock directly in ISM.



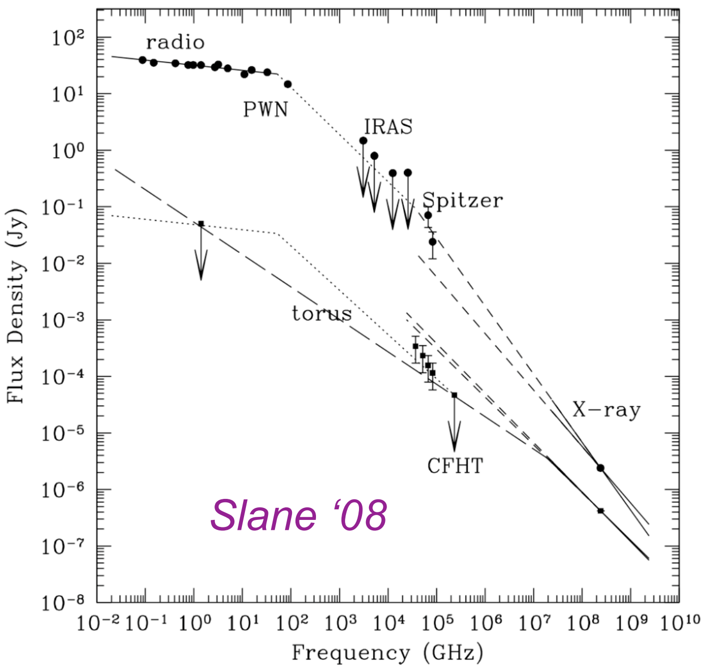
Proposal by Amato & Blasi, 2010

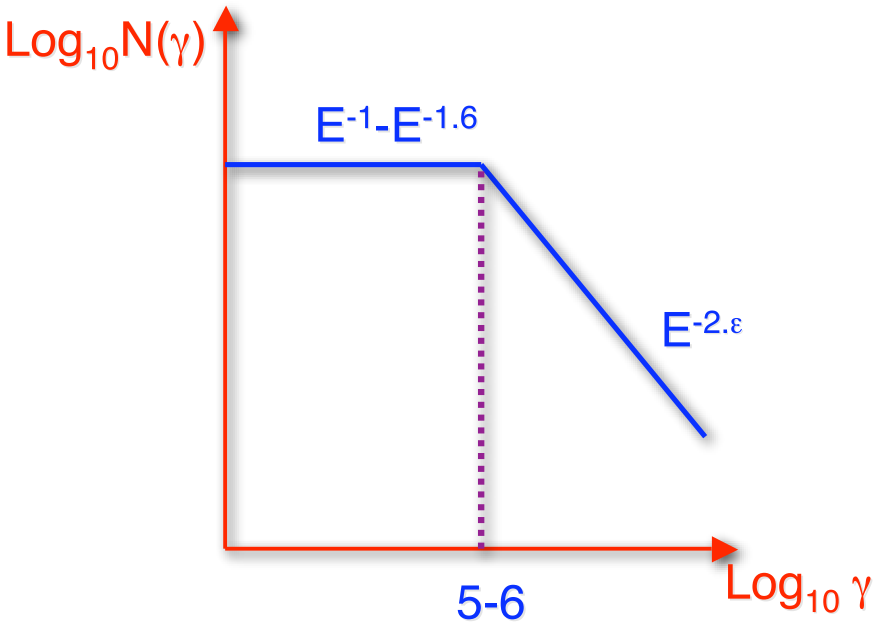
"The Mouse": inferred electron slope ~1.6

For our purposes, what do we really know?

- That the rotational energy released by pulsars is ~2 orders of magnitude larger than what needed to account for the PAMELA/Fermi "excess" energetics

- That X-ray and radio data show evidence for acceleration at the "termination shock" where the relativistic wind of pairs reaches the "slow" matter ejecta. Hard spectra are present up to 0.1-1 TeV, storing a large fraction of SD energy.





Theoretical problem:

Required E ~ large fraction of what injected by spin-down, but unclear how most of the energy initially in Poynting Flux is converted in relativistic particles (by the way, without evidence for the thermal component)

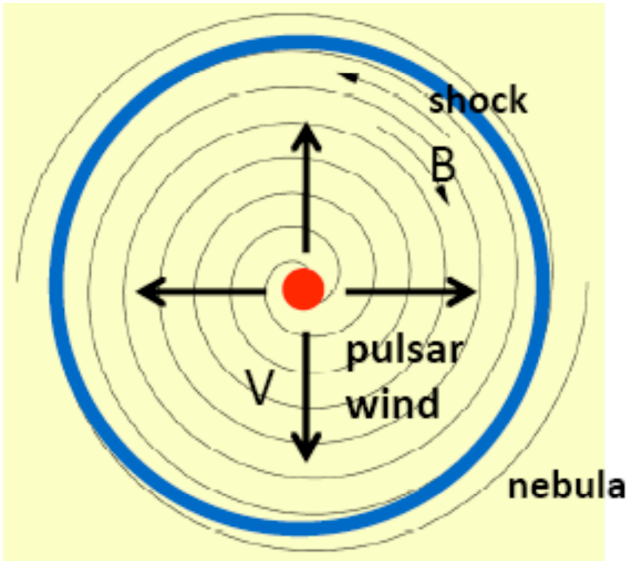
Some misconception on PWN “hard spectra”

DSA paradigm: non-relativistic, strong, parallel shocks in ordinary, ion-e^- medium predicts $E^{-2.\varepsilon}$ spectrum, but has a problem to reach E_{max}~PeV, solvable via

- B field amplification *(X-ray confirmed!)*
- non-linear shock modification (backreaction)

But PWN have a relativistic, oblique (⊥?) shock in a medium filled with pairs!
Diffusion across B line difficult ⇒ no DSA, i.e. no “standard” or generic model

~Large efficiencies & hard spectra are hard to predict robustly, not necessarily “unreasonable” :
Hard to predict ≠ Hard to obtain in Nature!
(e.g. many AGN show harder than DSA-theory spectra…)



Possible ideas put forward:

- Magnetic field reconnection

Converting B-field energy into particles.

- Resonant Cyclotron Acceleration

Requires a crucial role from ions.

- …

Both hard spectra and high efficiency possible!

- 3-component plasma of e^-, e^+, p (very different in mass!)

$$\rho \equiv \frac{m_p}{m_e} = 100$$

- Rich in pairs

$$\nu \equiv \frac{n_p}{n_e} < 1$$

- Energy dominated by p-component

$$\eta \equiv \frac{E_{\mathrm{tot},p}}{E_{\mathrm{tot},e}} > 1$$

Particle-in-cell simulation find hard spectra (1<index<2), high efficiency (1-30%), preferential acceleration of e^+ (the higher ρ and η, the better). E.g., 30% efficiency for η~5.25

Amato and Arons, ApJ 653 (2006) 325

- Acceleration happens via resonant absorption of magnetosonic waves by pairs, whose frequencies are harmonics of the proton cyclotron frequency.
- Preferential e^+ acceleration due to helicity matching with dominant proton generated wave spectrum
- $E_{\mathrm{max}} \simeq \frac{m_p}{m_e} E_{\mathrm{inj}}$ *Hoshino & Arons, Physics of Fluids B, 3 (1991) 818*

Can we fit f_{e+} & e_{tot} data with "reasonable" parameters?

By taking spectral indexes and normalizations suggested by termination shock information, & # of pulsars from catalogues or theoretical estimates, the answer is Yes
(in the former case, higher η required also because not all NS are visibile as pulsars!)

$$\mathcal{L}_{\rm spindown} = I\Omega\dot{\Omega} = \frac{1}{2} I \Omega_0^2 \frac{1}{\tau_0} \frac{1}{\left(1 + \frac{t}{\tau_0}\right)^2} \qquad \tau_0 \sim 10^4\,{\rm yr}$$

$$\mathcal{L}_{e^\pm} \simeq \eta\, \mathcal{L}_{sd} \qquad \frac{{\rm d}N}{{\rm d}E} \propto E^{-\alpha} \exp(-E/E_c)$$

One may also attempt to estimate the sources contributing the most e.g. by inferring distances & energetics from gamma-ray data (e.g. Gendelev, Profumo, Dormody arXiv:1001.4540) but bear in mind the intrinsic theoretical 'prejudice': we have no way to know the escape flux & most data probe the inner region!

Electrons can reach us which are emitted by dim objects!
Theoretical (rather than empirical) arguments must be used to fit the data to catalogues or synthetic populations.

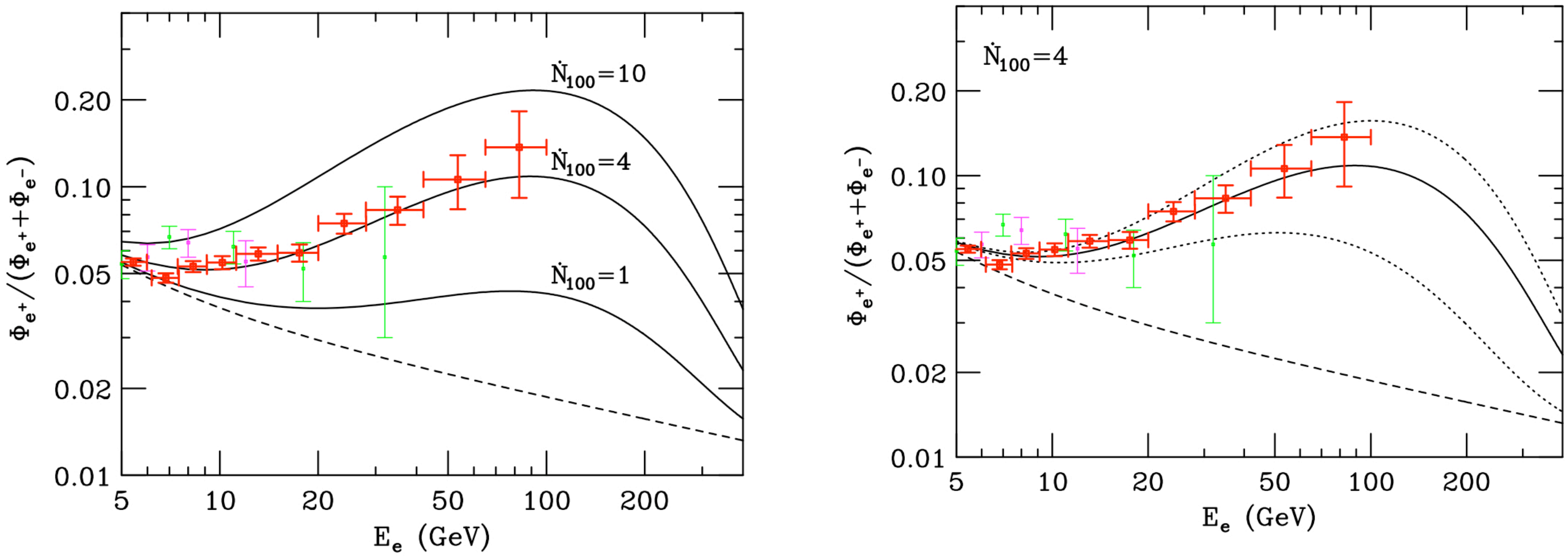
Prediction of a 'population model' of pulsars

Once fixed a model for the emission (dependence on B, age…) a population study with Galactic population of Pulsars is needed

$$Q(E,\vec{x}) \approx 8.6\times 10^{38}\ p(\vec{x})\ \dot{N}_{100}\ E_{GeV}^{-1.6} Exp(-E_{GeV}/80)\ GeV^{-1}\ s^{-1}$$

For example: L. Zhang and K. S. Cheng, Astron. Astrophys. 368, 1063-1070 (2001)

Account for Propagation/Energy losses…

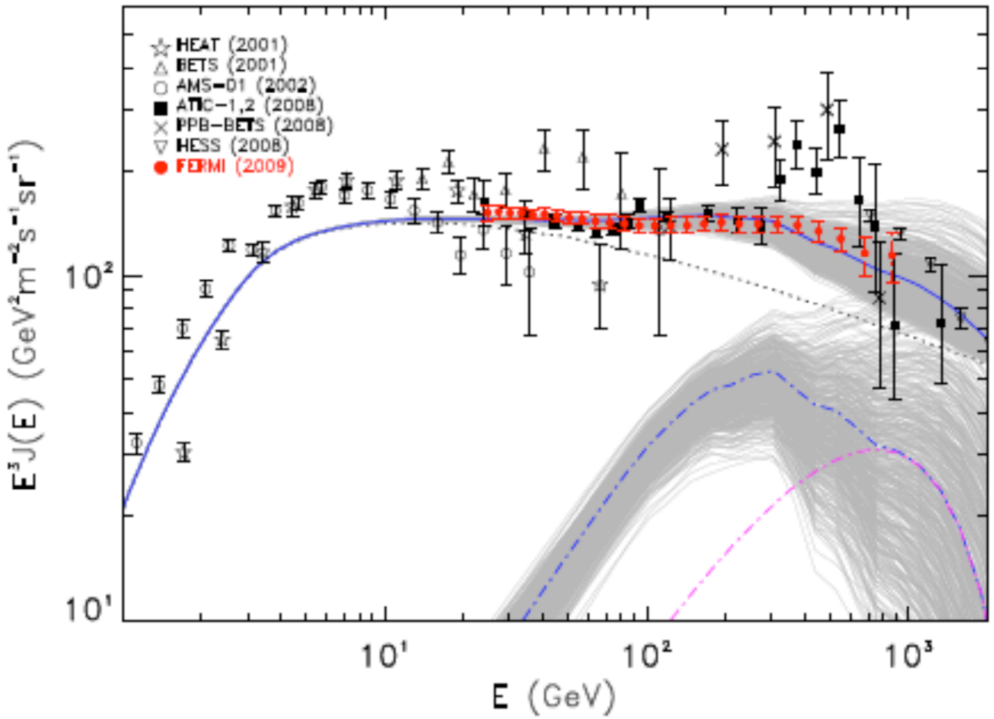


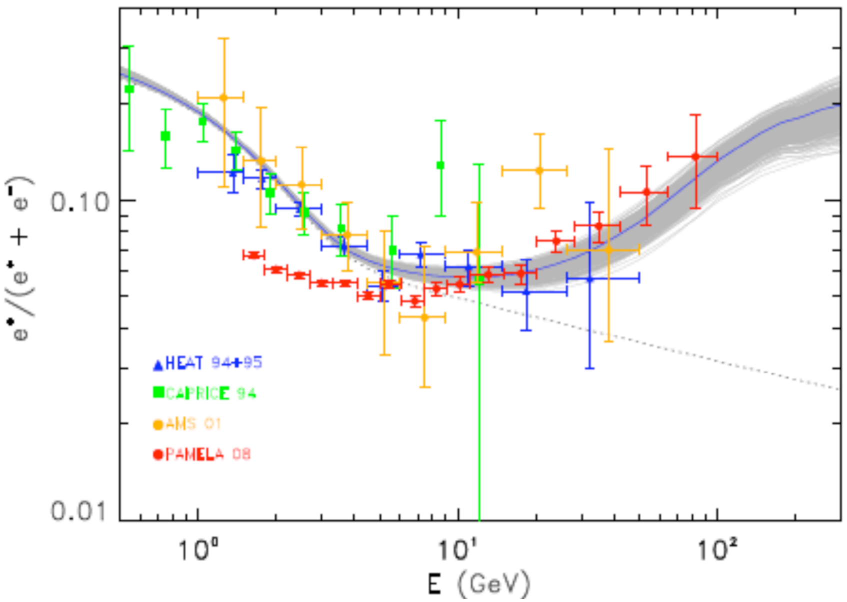
For details: D. Hooper, P. Blasi, PS, arXiv:0810.1527
(old idea, see e.g. F. A. Aharonian, A. M. Atoyan and H. J. Volk A& 95…
revisited on the light of qualitative & quantitative new data)

Contribution of local, “discrete” sources

Especially at High Energy (E>50-100 GeV) few prominent nearby sources should give dominant contributions (Monogem,Geminga,…)

Local contribution is crucial for Fermi E-range, rather than (most) PAMELA





D. Hooper, P. Blasi, PS, arXiv:0810.1527
Yuksel, Kistler, Stanev, arXiv:0810.2784;
Profumo, arXiv:0812.4457;
D. Grasso et al. arXiv:0905.0636;
Malyshev, Cholis, Gelfand, arXiv:0903.1310.
Kawanaka, Ioka, Nojiri, arXiv:0903.3782
…

"Falsifiability of the model"

Challenging to have stringent tests of a model lacking a detailed quantitative understanding of the lepton release process (probably to remain so for a while…)

All we can say is that the only "robust anchors", normalization & spectral slope, are consistent with empirically observed properties & weak theoretical constraints.

The right way to look at the issue is rather:
These objects are there and are "naturally" expected to contribute.
Are alternative/exotic theories making any clear distinctive prediction?
Otherwise Ockham's razor should apply.

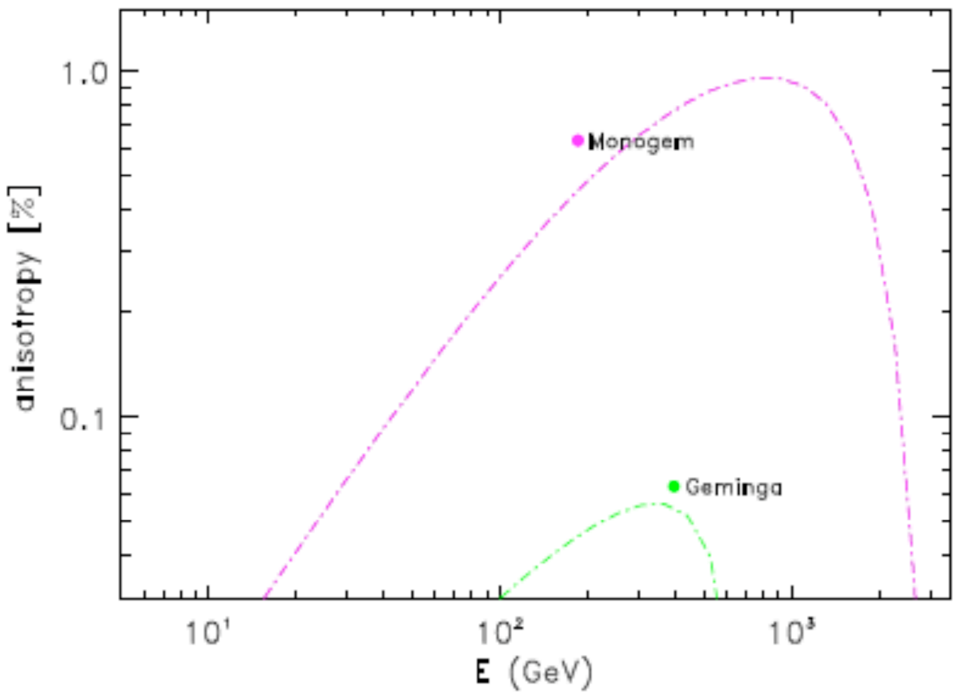
Still, note that:

- It would be very difficult to accommodate a very abrupt spectral edge
- virtually no antiprotons are expected (it's a pair wind!)
- possibly anisotropy at high energy (shared with any other 'astro' explanation)

A measurable anisotropy as diagnostics?

- Anisotropy dipole in the total e-flux>~0.1% level towards Galactic plane for promising nearby astrophysical sources
- DM could mimic if from “clump”, but unlikely oriented towards GP

...
I. Buesching et al. arXiv:0804.0220,
D. Hooper, P. Blasi, PS, arXiv:0810.1527,
D. Grasso et al. arXiv:0905.0636
...



Problems:
- Experimentally challenging (easily affected by unaccounted to systematics)
- Do we know enough about intrinsic CR anisotropy? (TeV results by Tibet, MILAGRO, SK)
- Possible degeneracy with magnetic-induced effects: E-dependence should be used!

Supernova remnants

The Supernova Remnant Paradigm for CRs

SNR known leptonic CR accelerators (radio, X-ray, γ-rays…). Also Hadronic?

- Galactic CRs via 1st order Fermi accel. at SNR shocks ($L_{CR} \approx 0.1 E_{kin,SNR} R_{SN}$)
- Power laws $\sim E^{-\gamma}$ generated naturally with $\gamma = 2 + \varepsilon$

(strong/supersonic non-relativistic shock, no-backreaction, perfect gas EOS)

- Spectra observed at the Earth modified by diffusive propagation in the Galaxy (which also isotropizes the flux)+spallation

At steady state source term = loss term

$$Q(E) = \frac{N(E)}{\tau_{escape}(E)} + \frac{N(E)}{\tau_{spall}(E)}$$

$$\tau_{escape}(E) \propto E^{-\delta}$$

δ~0.5 e.g. from B/C

When spallation losses are negligible…

$$N(E) = Q(E)\tau_{escape}(E) \propto E^{-\gamma-\delta}$$

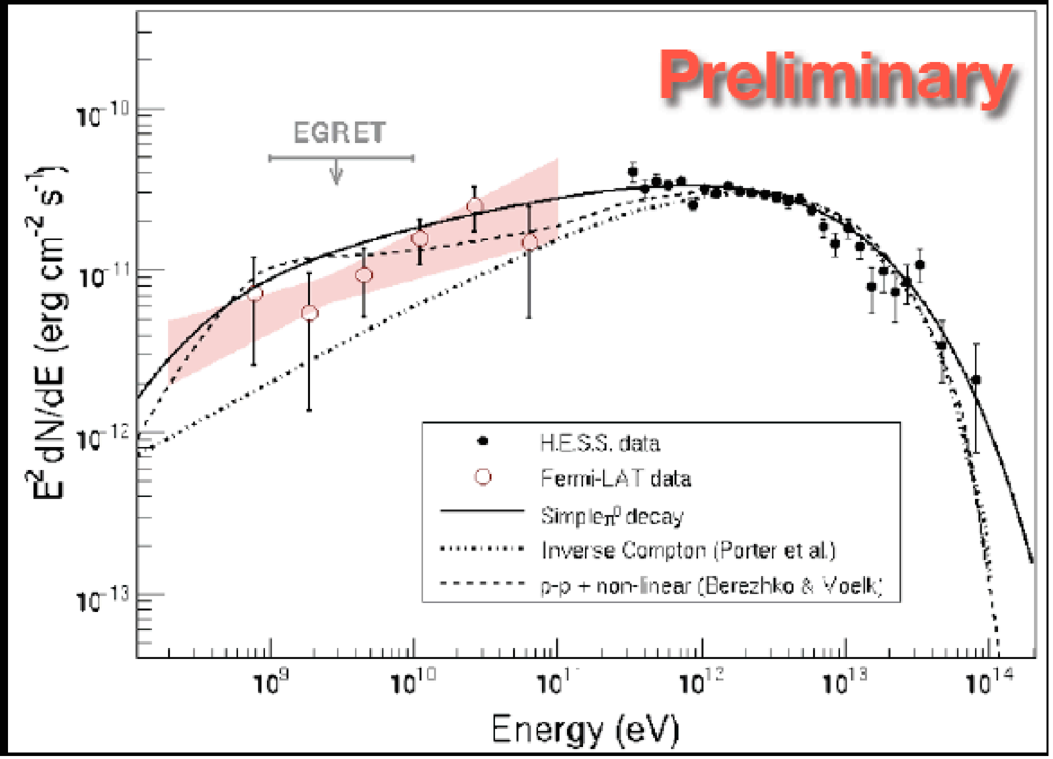
γ+δ~ 2.7→ γ~2.2, OK with simple theory!

(too simple, actually…)

Early results from Fermi (I)

Fermi-LAT view of RX J1713.7-3946

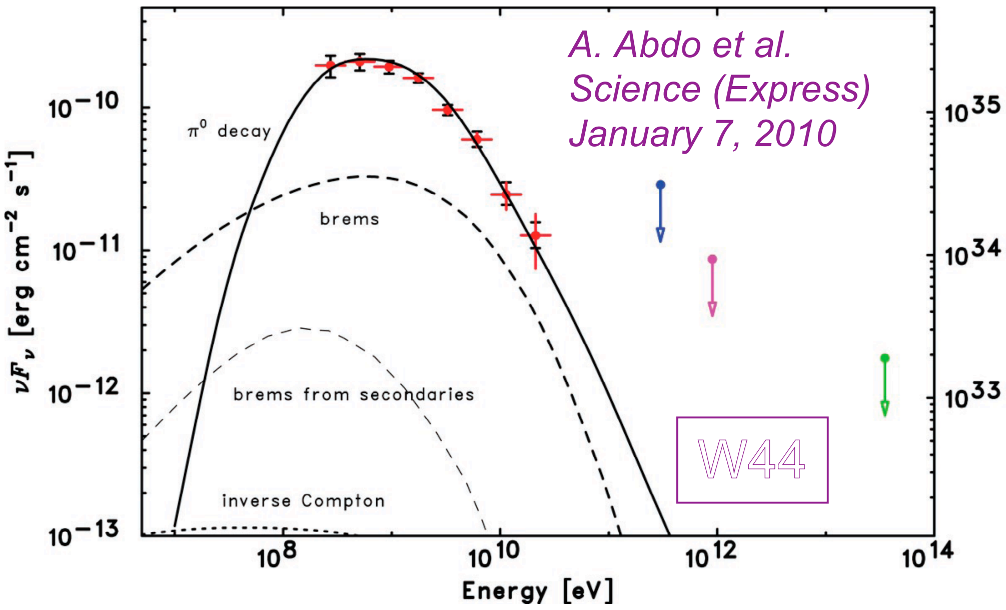
S. Funk @ Fermi Symposium

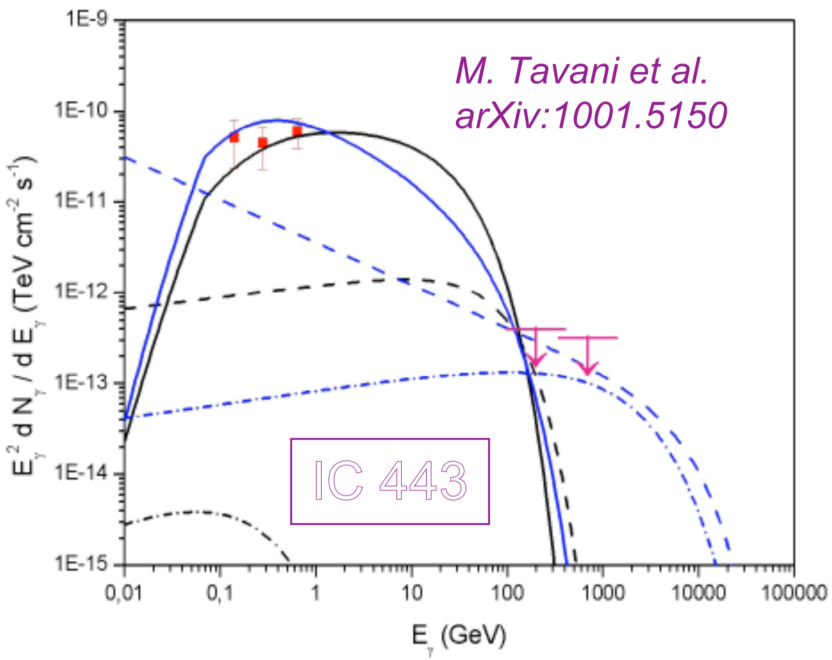


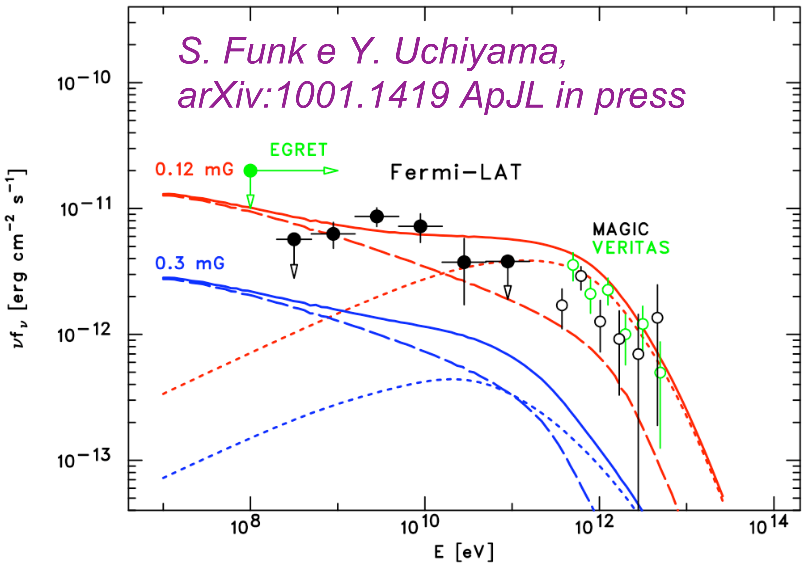
Very preliminary, but

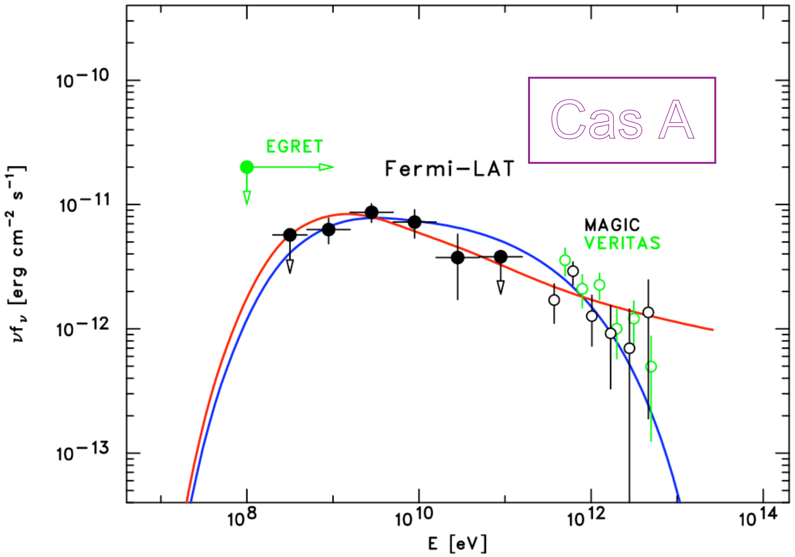
- all points are above leptonic acceleration models
- a couple of them by “>3 σ”
- points fluctuate (within 1-2 σ) around the non-linear hadr. model prediction…

Early results from Fermi and Agile (II)





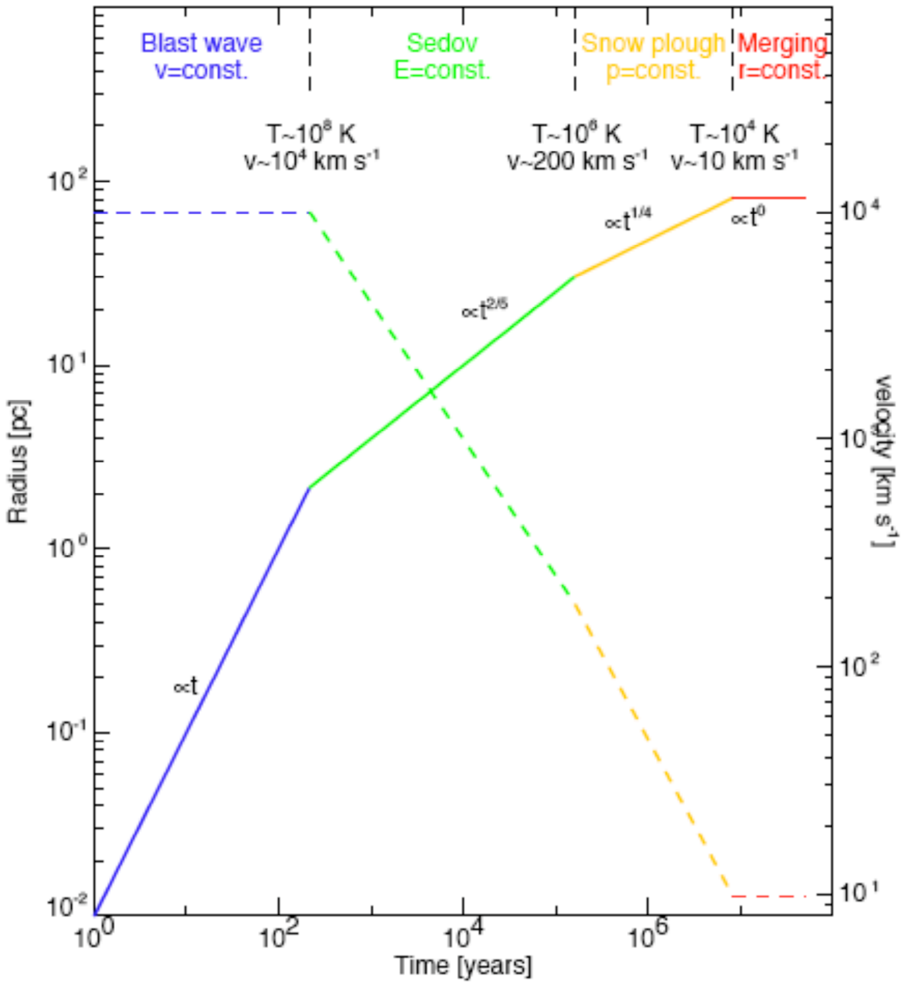




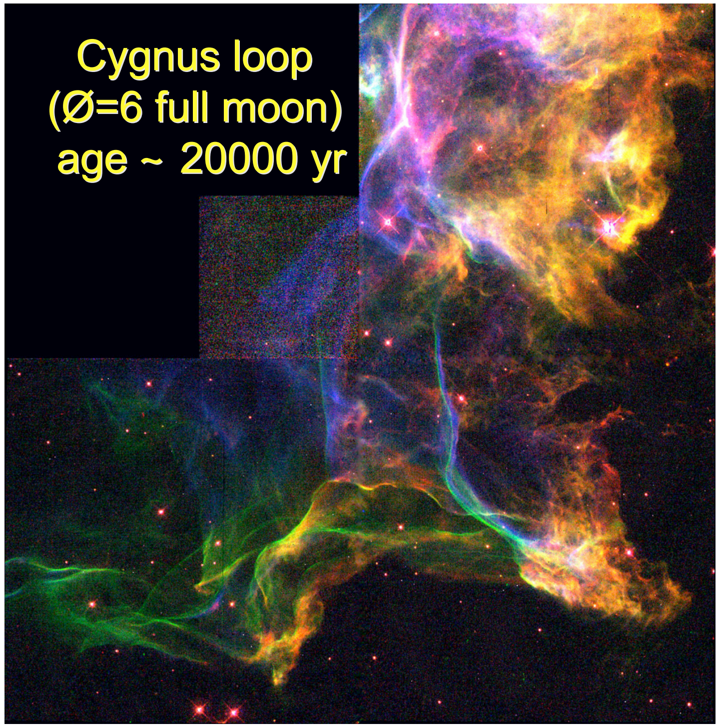
Old Supernova Remnants?

Young SNRs ($\tau_{SN} \sim 10^3$ yr) can accelerate Galactic CRs up to the "knee" (few PeV)
But "low energy" (E< TeV) CRs can be accelerated for much longer ($\tau_{SNR} > 10^5$ yr)

the bulk of GeV-TeV CRs should come from old (almost invisible?) SNRs!



Collisions in the accelerating environment are not crucial for predicting the bulk of CR injection, but are not irrelevant when considering secondaries!



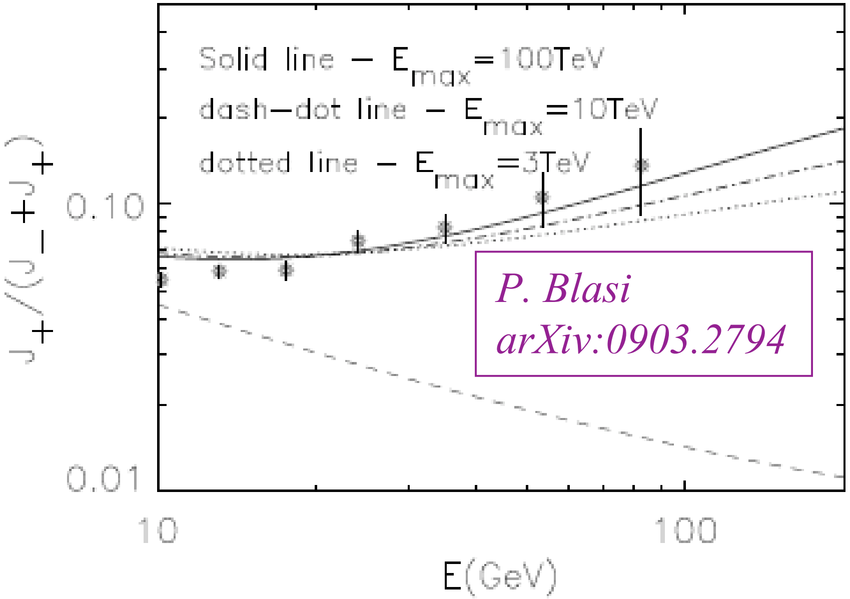
Reacceleration of Source $e^{\pm}$

- Primary e^- $\sim E^{-\alpha}$, after propagation $\sim E^{-\alpha-\delta}$
- Secondary e^+ and e^- at Earth, produced during CR propagation: $\sim E^{-\alpha-2\delta}$
- Secondary e^+ & e^- in source $\sim E^{-\alpha} + E^{-\alpha+d}$ after propagation $\sim E^{-\alpha-\delta} + E^{-\alpha-\delta+d}$

Positron fraction
$\sim a_0\, E^{-\delta} + a_1 + a_2\, E^d$

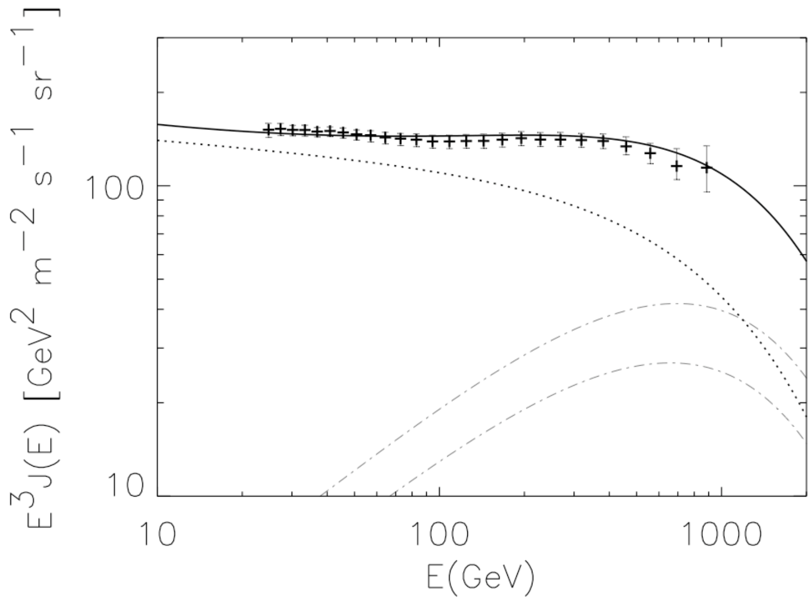
→ $\sim n\, r^2 \gamma\, D/\, u^2$ (2 effective par.)

↓ $\sim n\, r\, \tau_{SN}$ (1 effective parameter)



Crucial physics ingredient production in the same region where CRs are accelerated. These e^+e^- have a very flat spectrum!

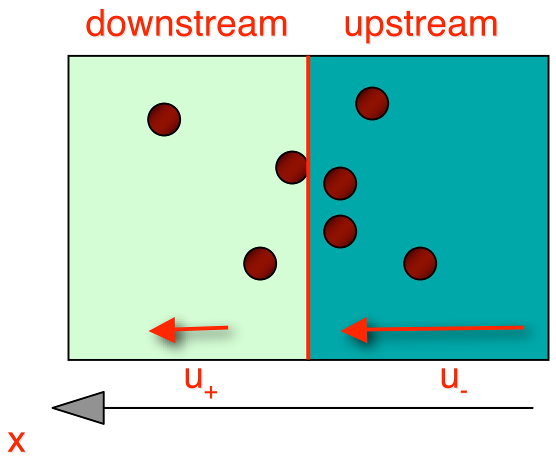
Universal (unavoidable) effect: strength depends on environment parameters in mature SNRs



DSA with Secondaries

Acceleration determined by compression ratio

$$r = \frac{u_-}{u_+} = \frac{n_+}{n_-}$$



The transport equation

$$u\frac{\partial f_{e^\pm}}{\partial x} = D\frac{\partial^2 f_{e^\pm}}{\partial x^2} + \frac{1}{3}\frac{\mathrm{d}u}{\mathrm{d}x}p\frac{\partial f_{e^\pm}}{\partial p} + q_{e^\pm}$$

subject to the boundary conditions

$$\lim_{x\to-\infty} f_{e^\pm} = 0, \quad \lim_{x\to+\infty} |f_{e^\pm}| \neq \infty$$

has the solution

$$f^0_{e^\pm}(x,p) = \begin{cases} f^0_{e^\pm}(p)\exp(u_- x/D) & \text{for } x < 0 \\ f^0_{e^\pm}(p) + \frac{q_{e^\pm}(x=0)}{u_+}x & \text{for } x > 0 \end{cases}$$

where

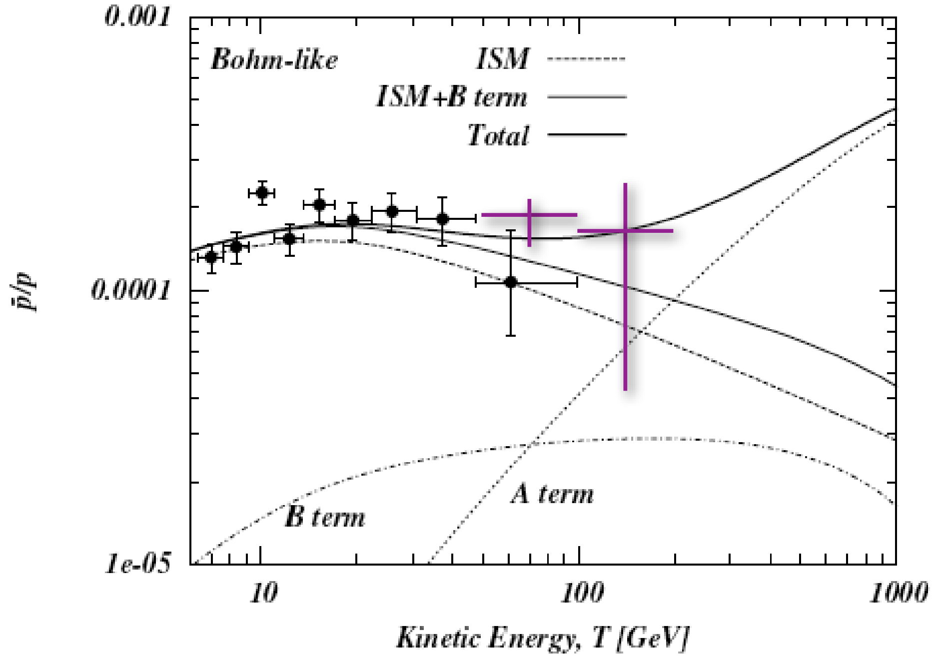
$$f^0_{e^\pm}(p) = \gamma(1+r^2)\int_0^p \frac{\mathrm{d}p'}{p'}\left(\frac{p'}{p}\right)^\gamma \frac{q_{e^\pm}(x=0)D(p')}{u_-^2} \qquad D(p) \propto p^d$$

"Primary" antiproton

The same ("hadronic") mechanism produces anti-p!

- The scenario is consistent with current antiproton data
- Sharp difference with respect to standard predictions for AMS-02 range

P. Blasi & PS arXiv:0904.0871



➢ Implications for astrophysics: info on sources present, but degeneracy propagation/source properties possible!
➢ Correlated "rises" in e^+ and anti-p. Troubles for DM searches?

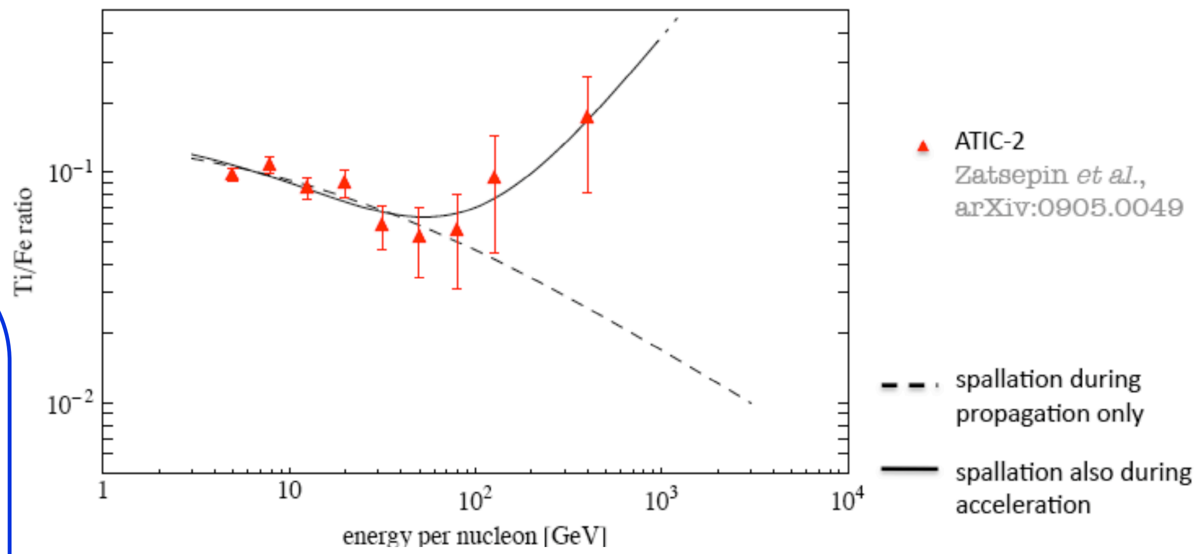
Lesson: astrophysical "backgrounds" to CR antimatter might be not so trivial…
The viability of antimatter for DM searches should rely on robust signatures only!

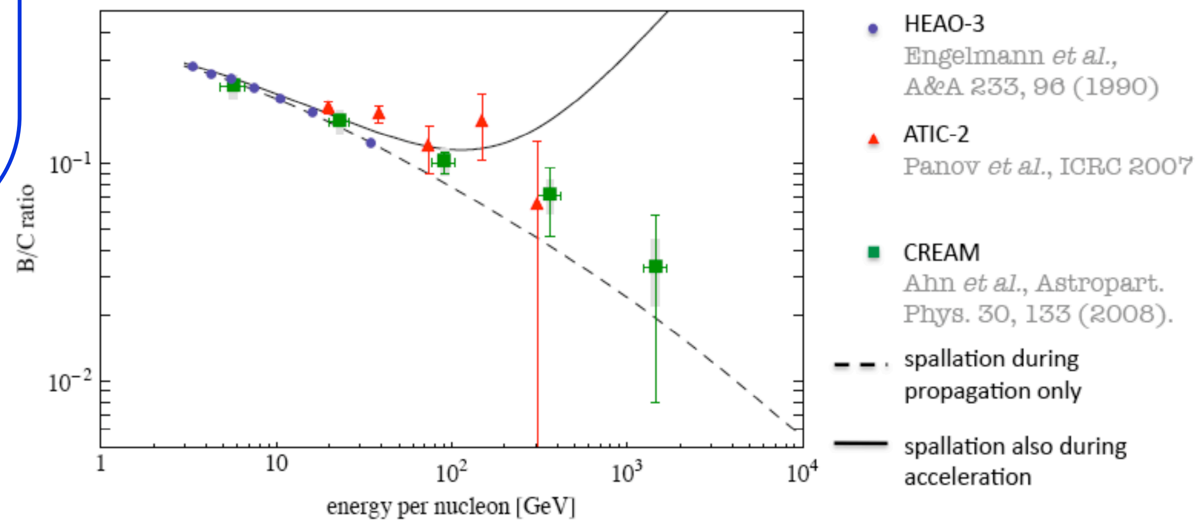
Similar effect for secondary/primary nuclei

Mertsch & Sarkar
arXiv:0905.3152

- some CR nucleosynthesis data (Ne) might suggest that the bulk of nuclei and of p are not necessarily accelerated in the same medium.
- Clearly we need better measurements and over a larger dynamical range
- Endpoint issue?

task for AMS-02



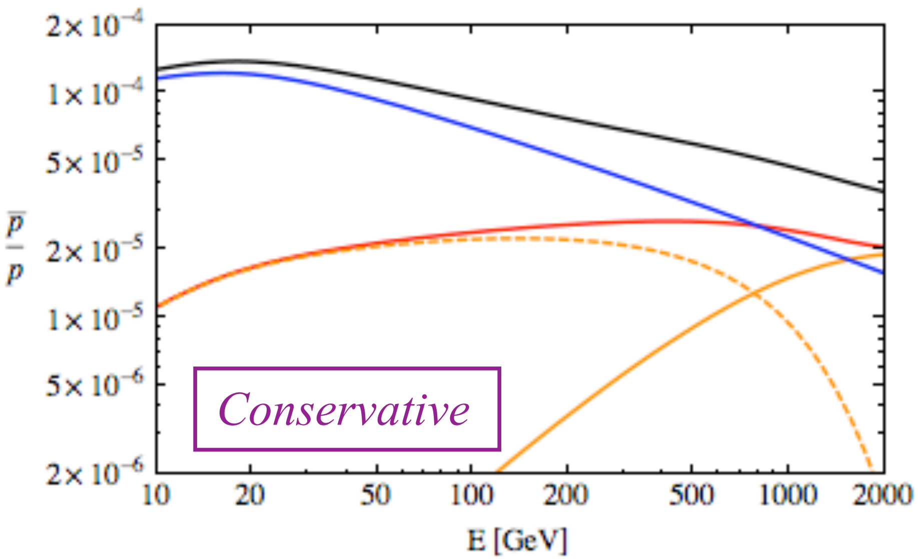


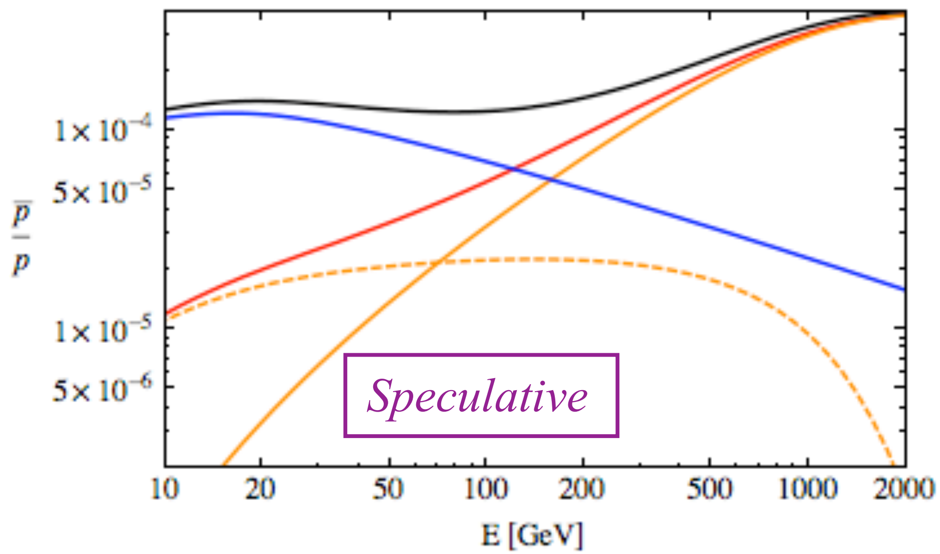
Important Caveat!

- The previous analytical solution does not include a lot of effects! In particular, D is a function of t,x,E… and is subject to non-linear coupling with f.

- The advected production yield is quite robust, and would lead to a flat (not rising) secondary/primary ratio. Alone, this is significant enough to alter standard ISM secondary production and background for DM searches.

- The "reaccelerated part" which might produce the rise depends on poorly understood details. This was parameterized in terms of a diffusion coefficient D which is not necessarily linked to primary particles E_{max} . Mechanisms to decouple E_{max} from background D are known (e.g. nonlinear amplification), but it remains to be checked, likely observationally, if this is a significant effect in the case at hand.



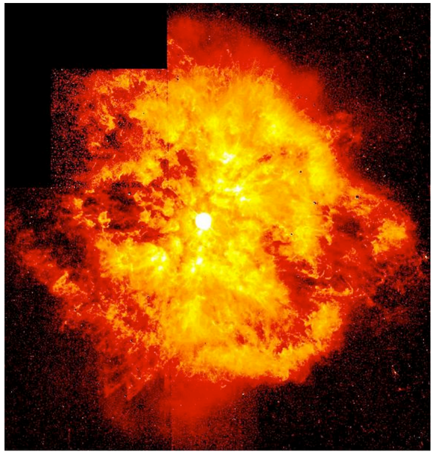


Enriching the scenario: e^+ blowing in the wind?

It is possible that SNRs from different classes of progenitors dominate CRs of different type/energy

- Red-Blue SG are very massive stars (M> 15-25 M_{sun}) which typically experience significant mass losses; their SN explosion happens in a (relatively) dense, magnetized and Z-enriched medium (Wolf Rayet stars)

- Theories invoking those objects as responsible for HE tail of Galactic CRs exist since longtime, recently reassessed in relation to positron/electron data



WR 124 (HST)

P.L. Biermann, T. K. Gaisser, T. Stanev astro-ph/9501001;
P. L. Biermann et al., arXiv:0903.4048

Peculiarities:

- detectable HE ν and γ sources? (less sources contribute, more localized…)
- contributions from β^+ nuclei (less anti-p than in baseline "SNR" scenario?)

Conclusions

- Astrophysical models can fully account for the lepton observations in FERMI/PAMELA. Contrarily to the common lore, some qualitative features revealed were predicted. The fact that many particle physicists (I include myself) ignored some or all of those facts does not make alternative solutions more likely (although certainly worth exploring…)

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- While clean DM discovery via these channels is challenging, CR antimatter is still useful to provide bounds within a given self-cosnsitent model for the Galaxy (where DM signals are subleading wrt astrophysics) or to look for cross-checks in case of DM discovery at some other experiment (collider, direct, neutrino…)