COSMIC SUM RULES

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Based on
M.T.Frandsen, I.M., F.Sannino, arXiv:1011.0013 [hep-ph]

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INTRODUCTION

We point out

new sum rules allowing to determine **universal properties** of the **unknown component of the cosmic rays** (CR) needed to explain PAMELA and FERMI-LAT data

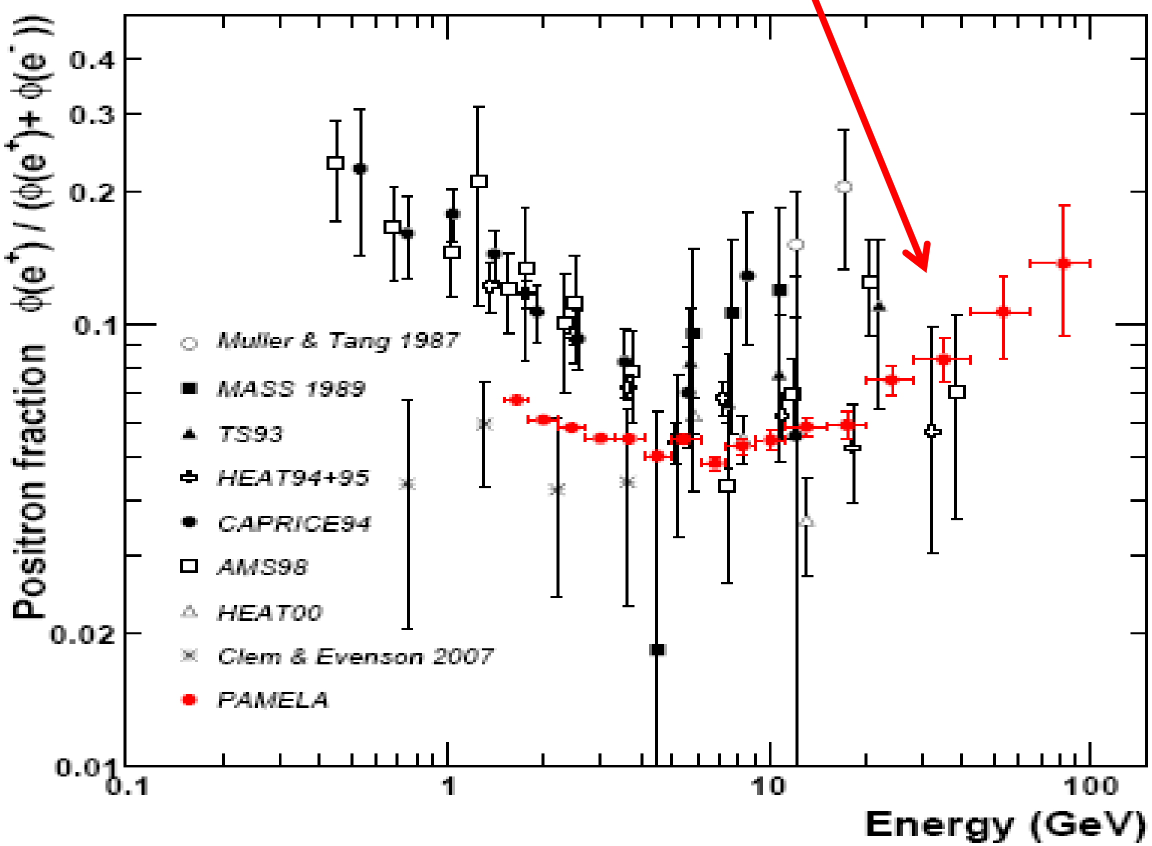
They can be used to:

1) **predict the positron fraction** at energies not yet explored by current experiments

2) **constrain** specific **models**

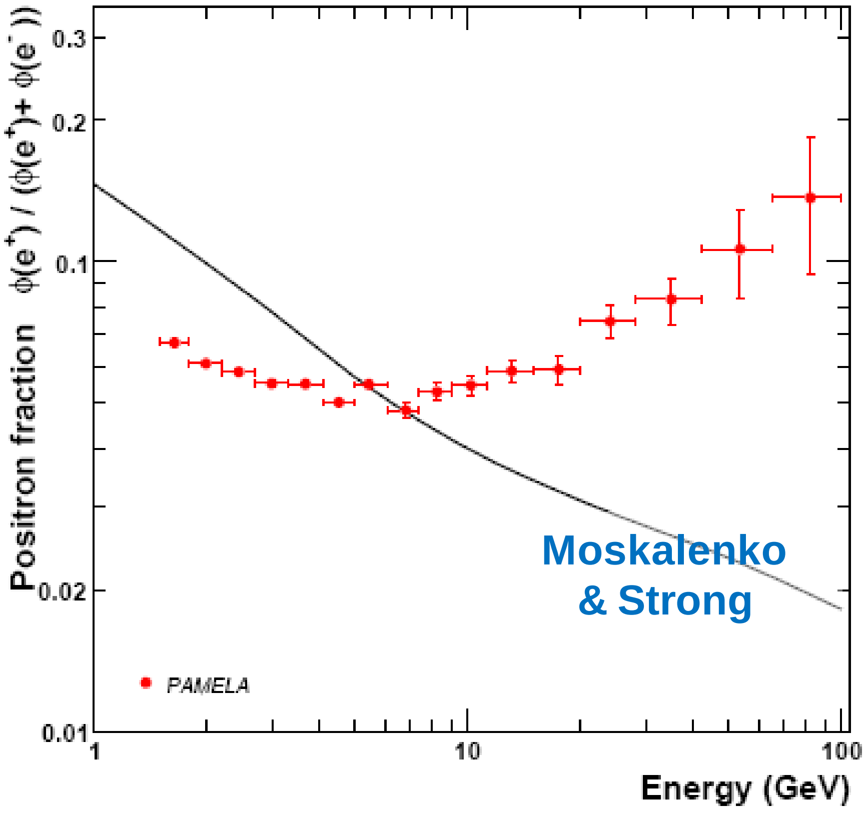
PAMELA DATA

Indicate e^+ excess in CR above 10 GeV



From arXiv:0810.4995

which **does not fit previous estimates** of CR formation and propagation



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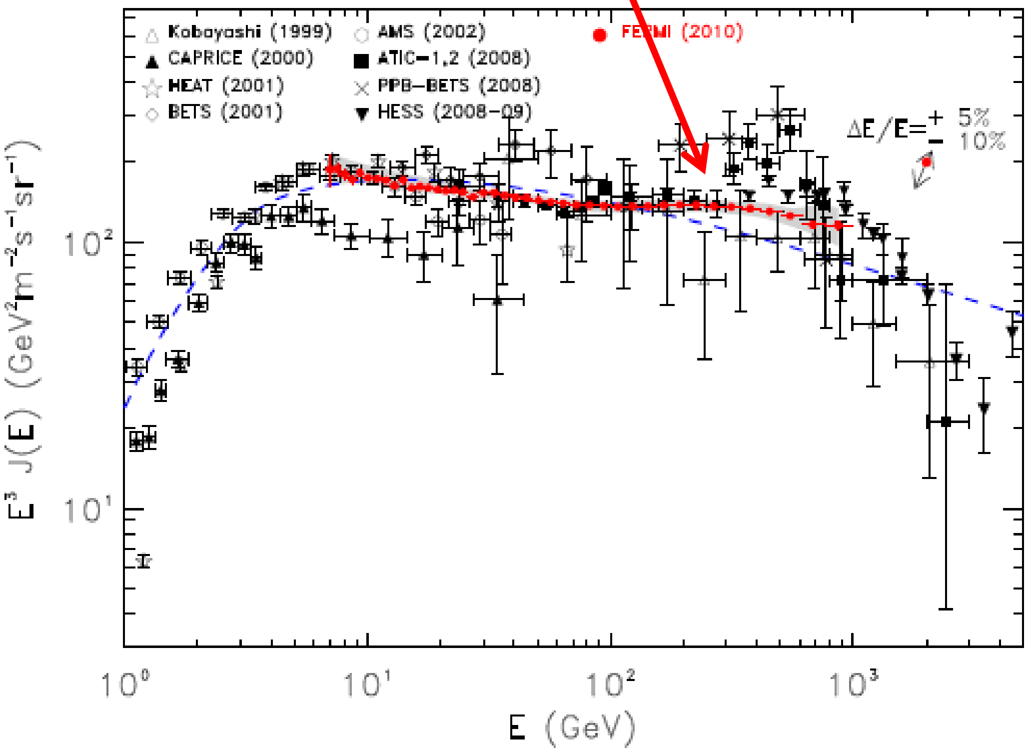
possible existence of

positrons of unknown origins

while no excess in anti-protons [arXiv:1007.0821]

FERMI-LAT DATA

Indicate positrons+electrons excess in CR above 100 GeV [arXiv:0905.0025]



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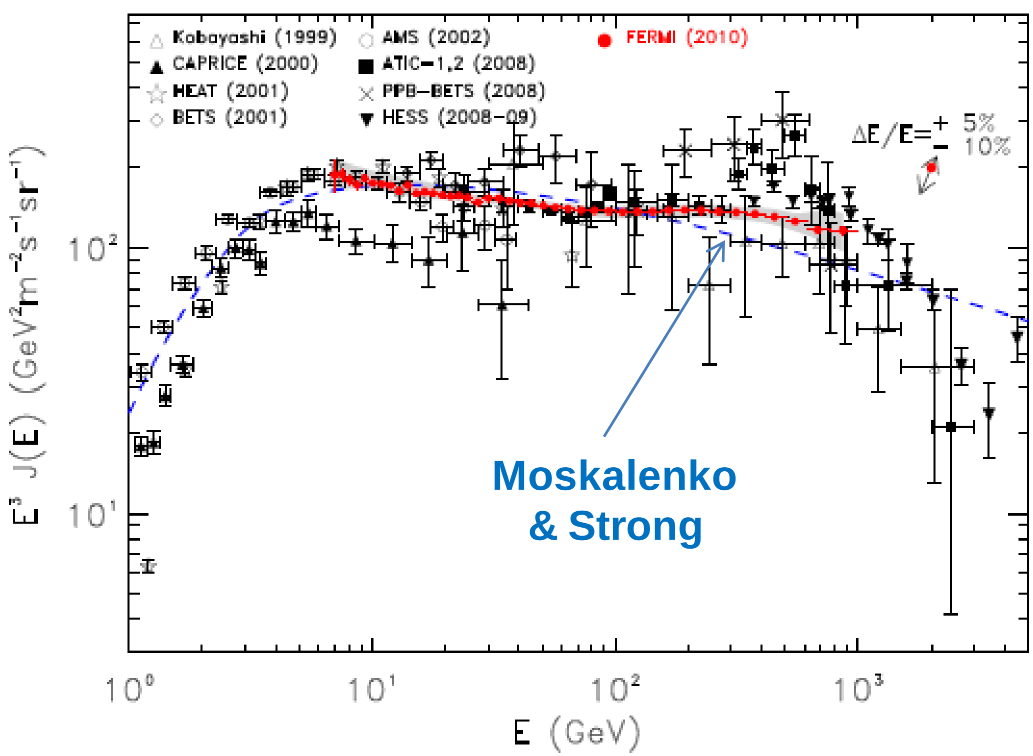

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also implying the possible existence

of positrons and/or electrons of unknown origins

Some **EXPLANATIONS** have been proposed for unknown excesses:

[see e.g. Fan Zhang Chang, arXiv:1008.4646 for review]

- ✓ inadequate account of the CR background in previous modeling;
- ✓ new astrophysical sources;
- ✓ annihilations and/or decays of dark matter.

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Which are of the **IGNOTUM PER ÆQUE IGNOTUM** kind
(G.Galilei, *Dialogue Concerning the Two Chief World Systems, Day 2)*

i.e. **THE UNKNOWN BY THE EQUALLY UNKNOWN**

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Whatever the origin of these excesses,
we derive **simple relations (sum rule)**
able to shed light on the **PHYSICAL NATURE**
of their source and/or propagation

SUM RULE

Start writing the observed flux of e^- and e^+ as the sum of two components

Unknown ***Background*** due to known astrophysical sources (at least for e^-)

$$\phi_{\pm} = \phi_{\pm}^{U} + \phi_{\pm}^{B}$$

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PAMELA measures

$$P(E) = \frac{\phi_+(E)}{\phi_+(E) + \phi_-(E)}$$

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The **unknown component's e^-/e^+ ratio** is then

$$r_U(E) \equiv \frac{\phi_-^U(E)}{\phi_+^U(E)} = \frac{F(E)\,(1 - P(E)) - \phi_-^B(E)}{P(E)\,F(E) - \phi_+^B(E)}$$

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$$\phi^B_\pm(E) = N_B B^\pm(E)$$

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SUM RULE

$$R(E) \equiv \frac{F(E)}{B^-(E)} \, \frac{1-(1+r_U(E))P(E)}{1-r_U(E)\frac{\phi^B_+(E)}{\phi^B_-(E)}} = N_B$$

Although R(E) seems to depend on the energy it should actually be a constant!
→ a nontrivial constraint linking together:

experimental data, **unknown comp. charge asymmetry r_U** , **background model**

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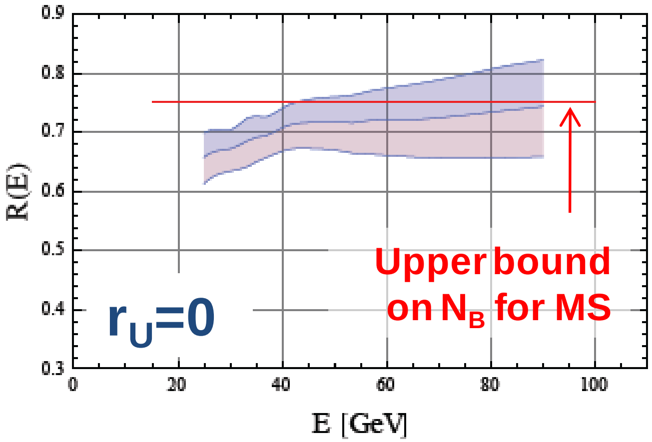
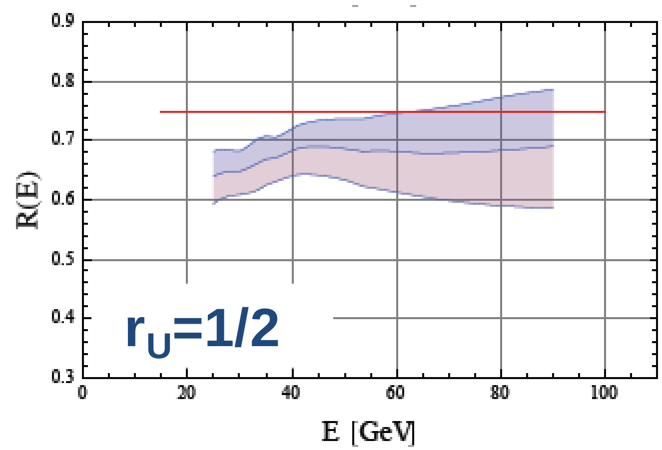
can consider just the common energy range, i.e. 25-90 GeV

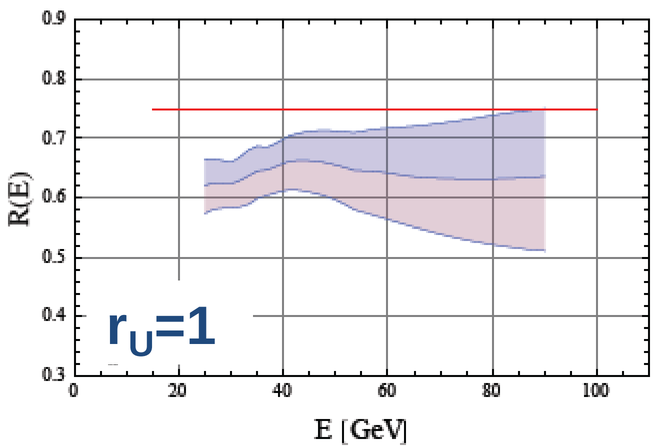
within this energy range it is therefore sensible to assume r_U to be nearly constant

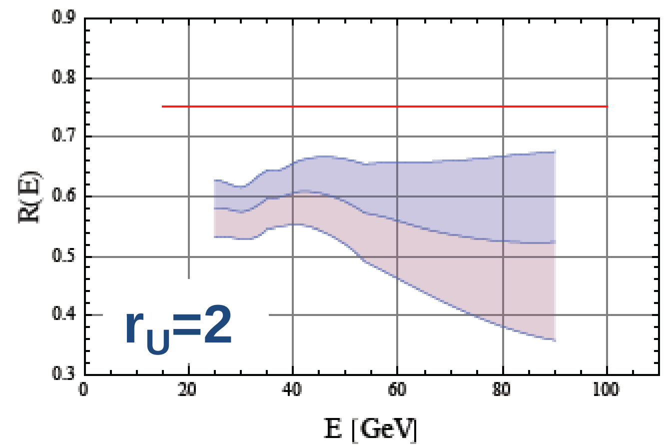
adopt for definiteness the Moskalenko and Strong one

PLOT OF $$R(E) \equiv \frac{F(E)}{B^{-}(E)}\;\frac{1-(1+r_U(E))P(E)}{1-r_U(E)\frac{\phi_{+}^{B}(E)}{\phi_{-}^{B}(E)}} = N_B$$

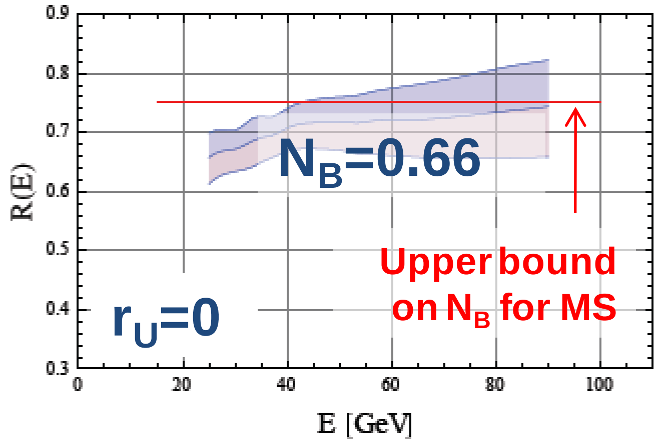


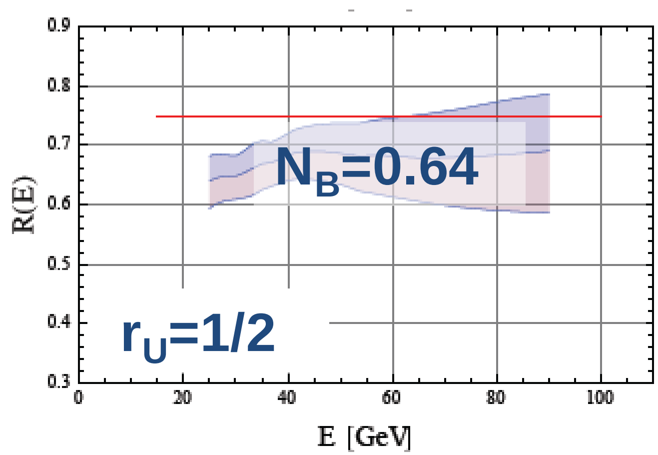


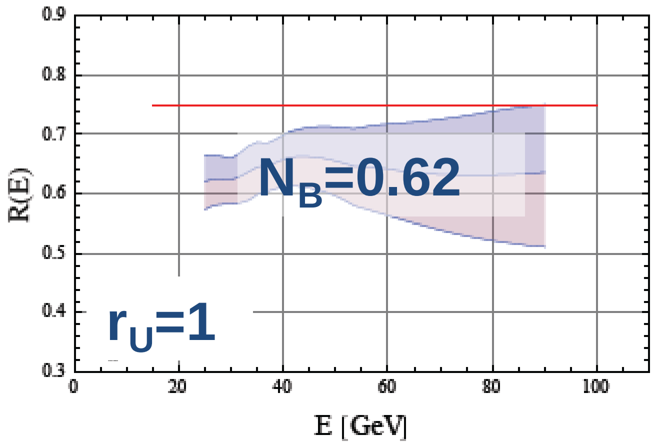


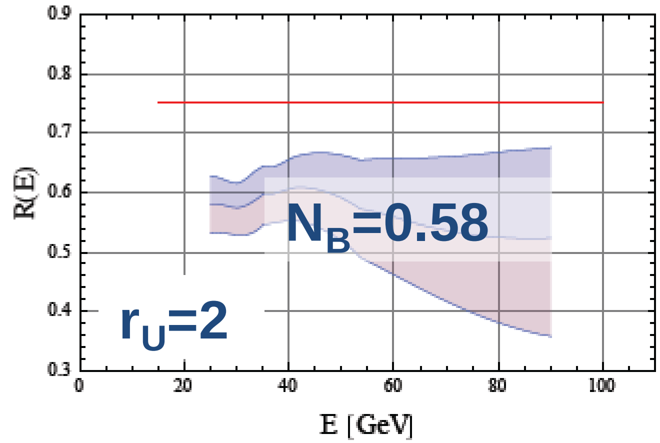


PLOT OF $$R(E) \equiv \frac{F(E)}{B^-(E)} \, \frac{1-(1+r_U(E))P(E)}{1-r_U(E)\frac{\phi_+^B(E)}{\phi_-^B(E)}} = N_B$$









PAMELA PREDICTION

Let extract N_B for fixed values of r_U as disussed above,

the sum rule can be rewritten under the form of a

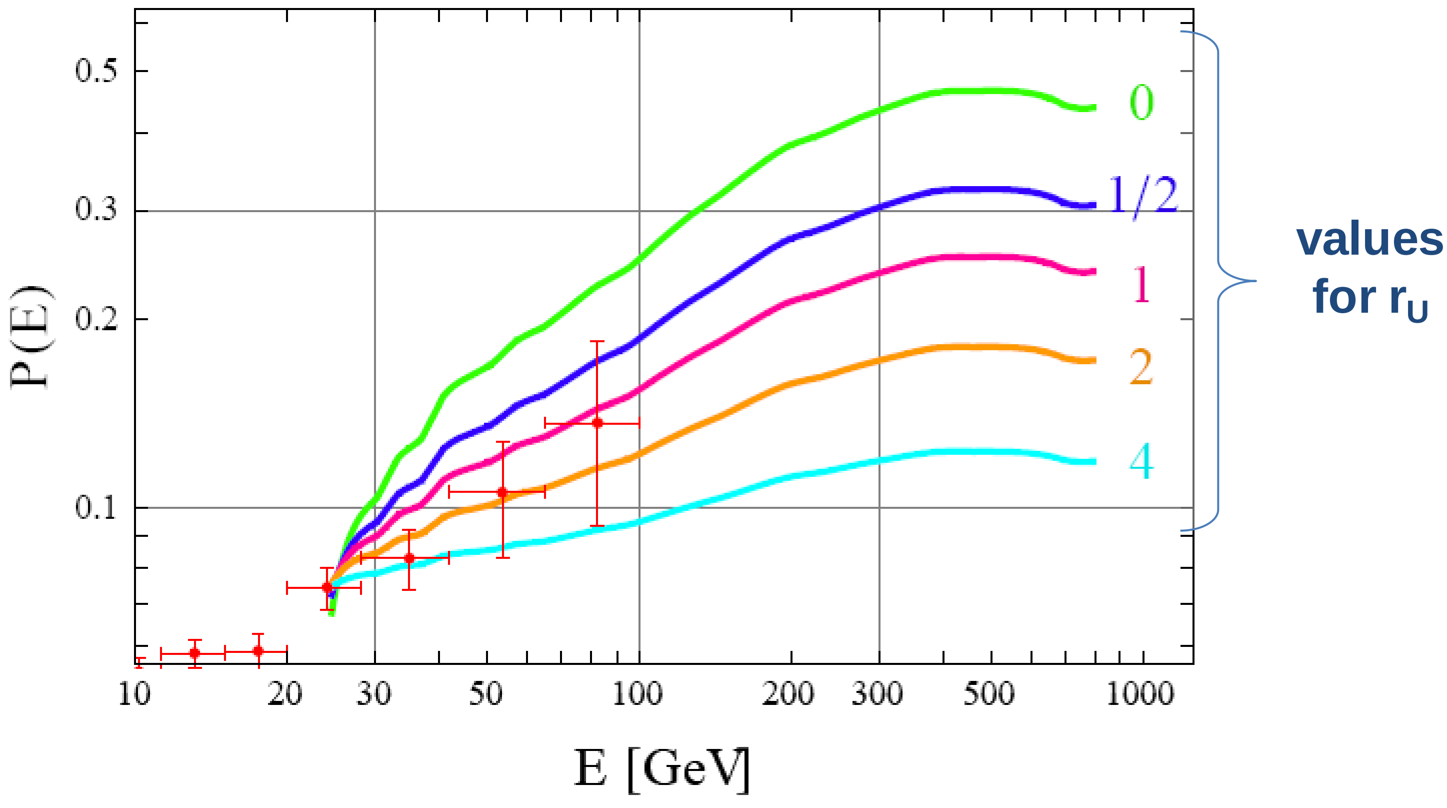
PREDICTION for PAMELA

$$P(E) = \frac{1}{1+r_U}\left(1 - \frac{\phi_-^B(E)}{F(E)}(1 - r_U\frac{\phi_+^B(E)}{\phi_-^B(E)})\right)$$

which depends on r_U, the model for known background and Fermi data

→ taking r_U constant
the prediction goes up to E about 1000 GeV

Model independent prediction for P(E) as a function of the energy E of electrons and positrons.
Secondaries are estimated according to Moskalenko and Strong
(we checked that the curves are marginally affected by using other models).



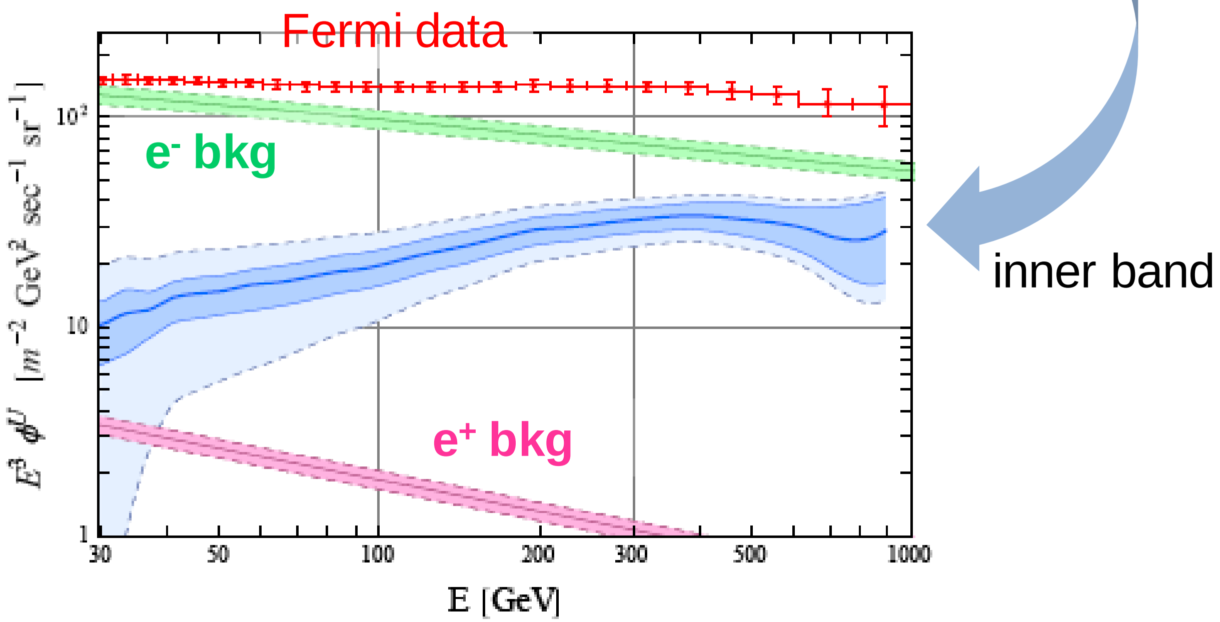
Future data by PAMELA could reveal whether unknown source and/or propagation is charge asymmetric or not

CHARGE SYMMETRIC CASE

Consider the case r_U=1 (which applies to many models), and MS model for backgrounds (with NB=0.62).

Then

$$\phi^U_\pm(E) = \frac{F(E) - (\phi^B_-(E) + \phi^B_+(E))}{2}$$



wider band obtained by allowing a 10% error in the background spectrum (in top of FERMI-LAT error)

CONCLUSIONS AND PROSPECTS

The **general sum rules** introduced here **shed light on** the **charge asymmetry** of the **unknown component of the CR** needed to explain PAMELA and FERMI-LAT data

In particular, they can be used to **predict the positron fraction** at energies not yet explored as a function of the charge asymmetry

Current data allow for approximately equal contributions of the e^- and e^+ but seem to disfavor e^-/e^+ fractions smaller than 1/2 and larger than 4

Future data will be decisive!