Charge-dependent solar modulation in light of the recent PAMELA data

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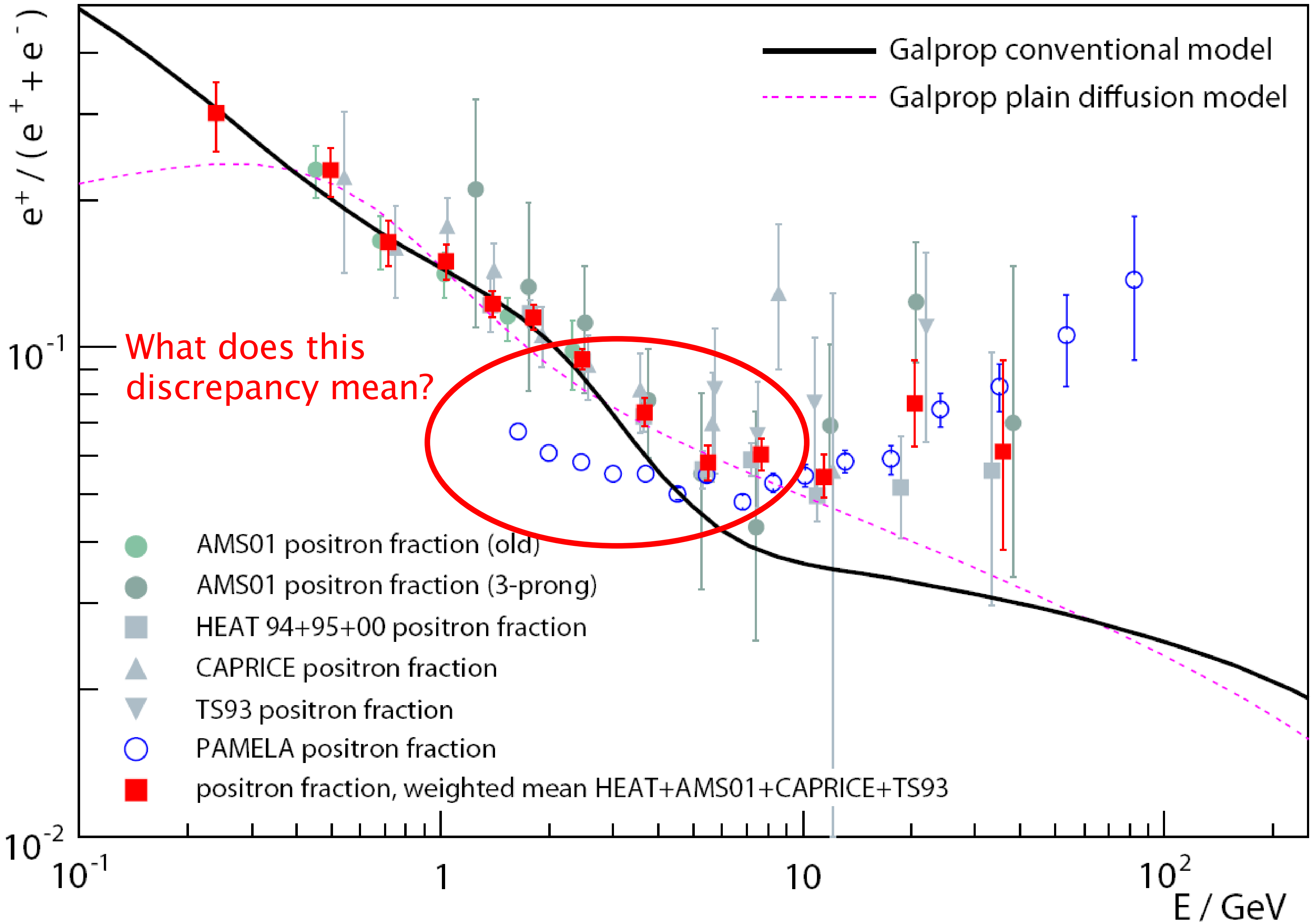
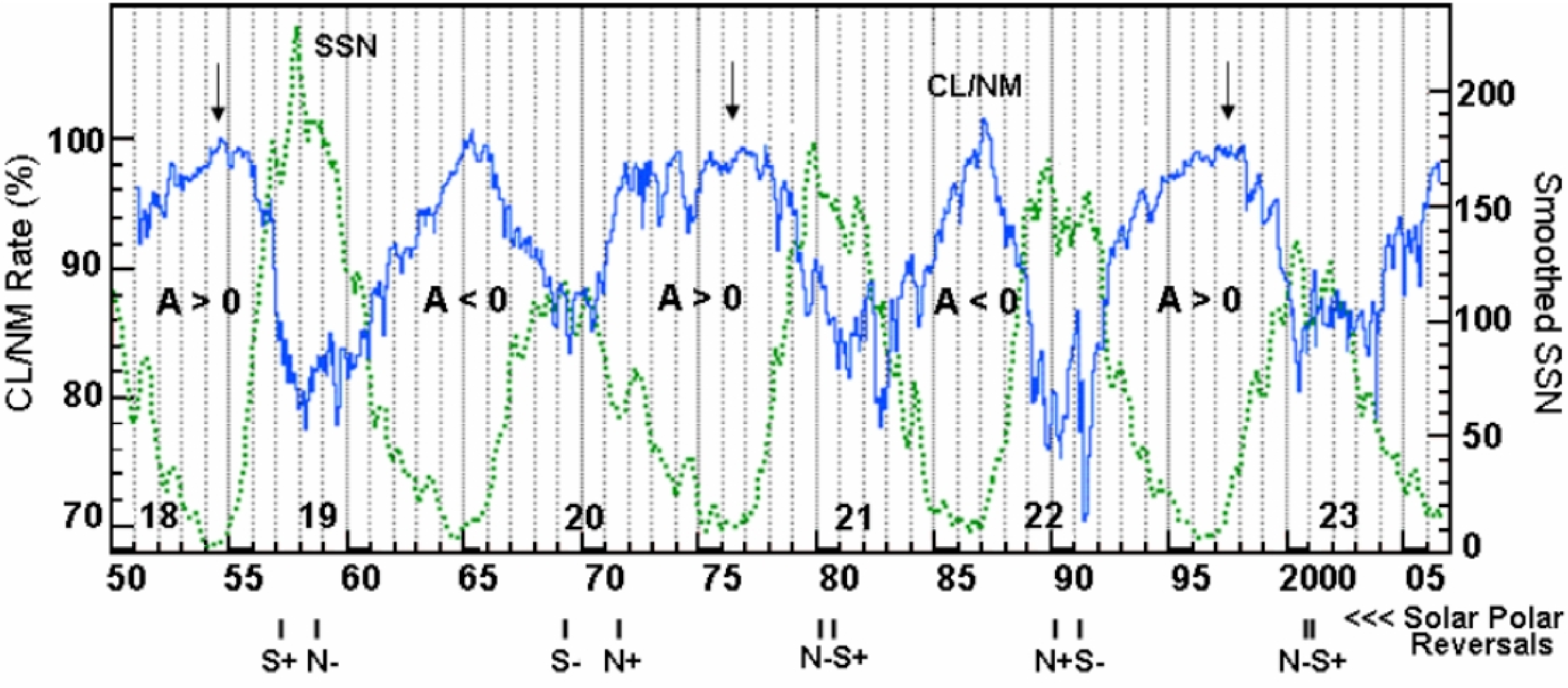
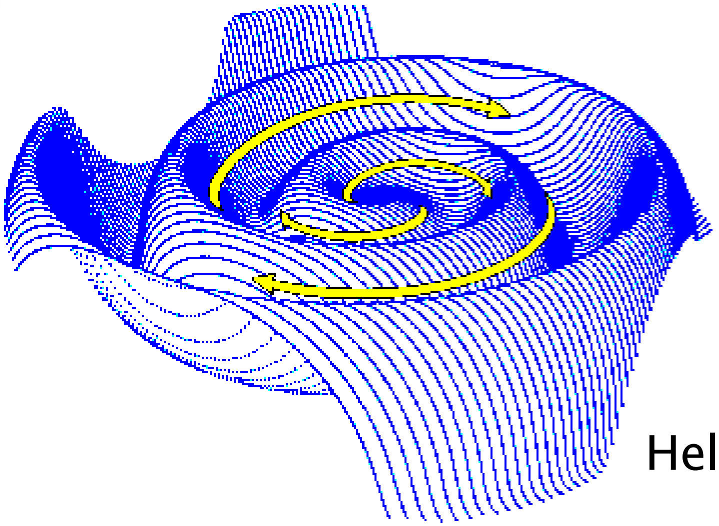
The anomaly in the cosmic-ray positron fraction



Solar modulation

30th ICRC, 1, 493





Heliospheric current sheet

A simple model for charge-dependent solar modulation

general case: Parker equation (1965)

$$\frac{\partial f}{\partial t} = -(\boldsymbol{V} + \langle \boldsymbol{v}_D \rangle) \nabla f + \nabla (\boldsymbol{K}^{(S)} \nabla f) + \frac{1}{3} (\nabla \boldsymbol{V}) \frac{\partial f}{\partial \ln p}$$

- V solar wind velocity
- K diffusion tensor
- v_D related to antisymmetric part of diffusion tensor

force–field approximation (Gleeson and Axford, 1968):

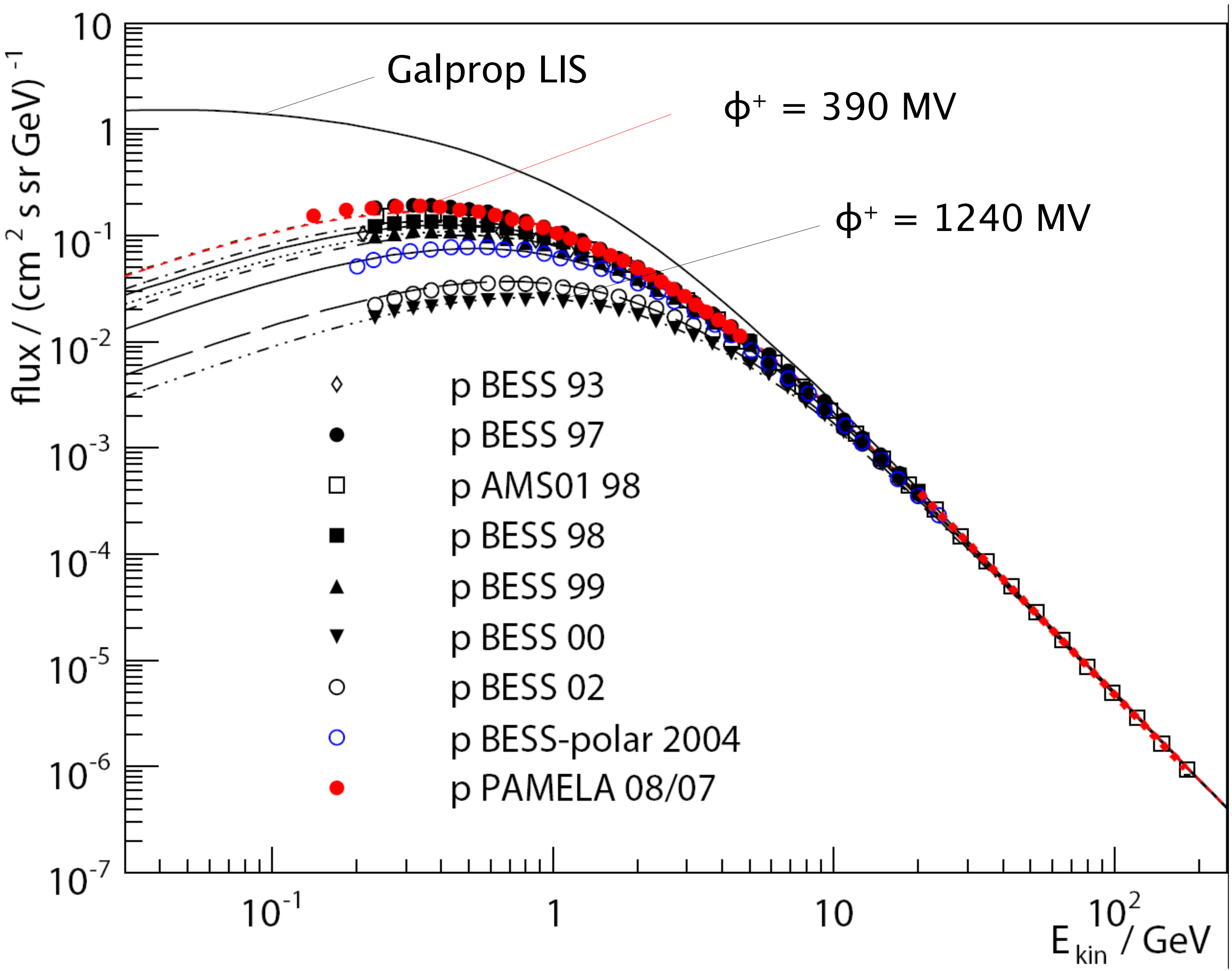
$$J(E) = \frac{E^2 - m^2}{(E + |z|\phi)^2 - m^2} \cdot J_{IS}(E + |z|\phi)$$

simple idea: allow different value of ϕ for positively and negatively charged particles

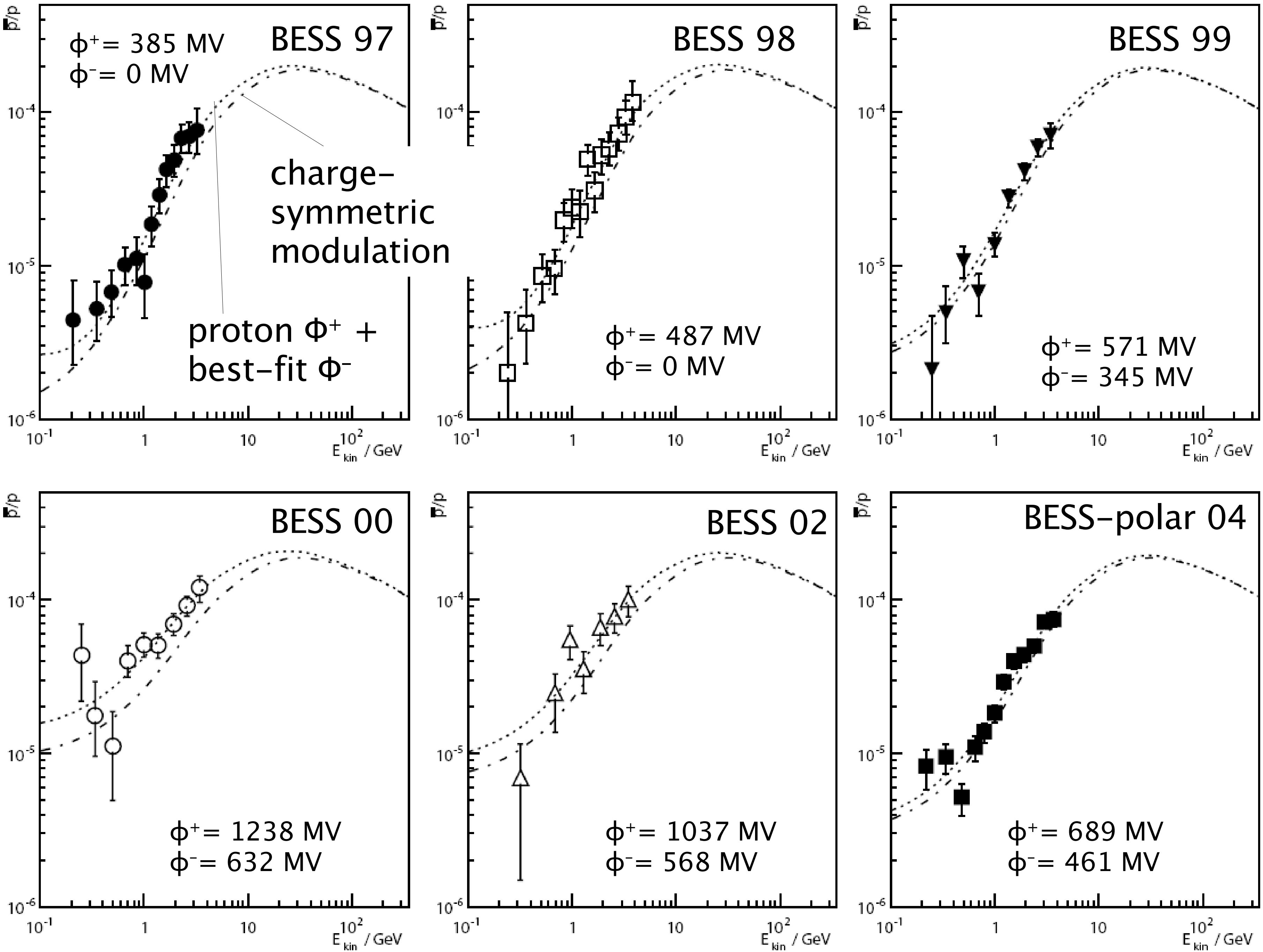
Galprop conventional model is used for the calculation of interstellar flux J_{IS} for all particle species

at low energies: geomagnetic cutoff effects complicate the picture

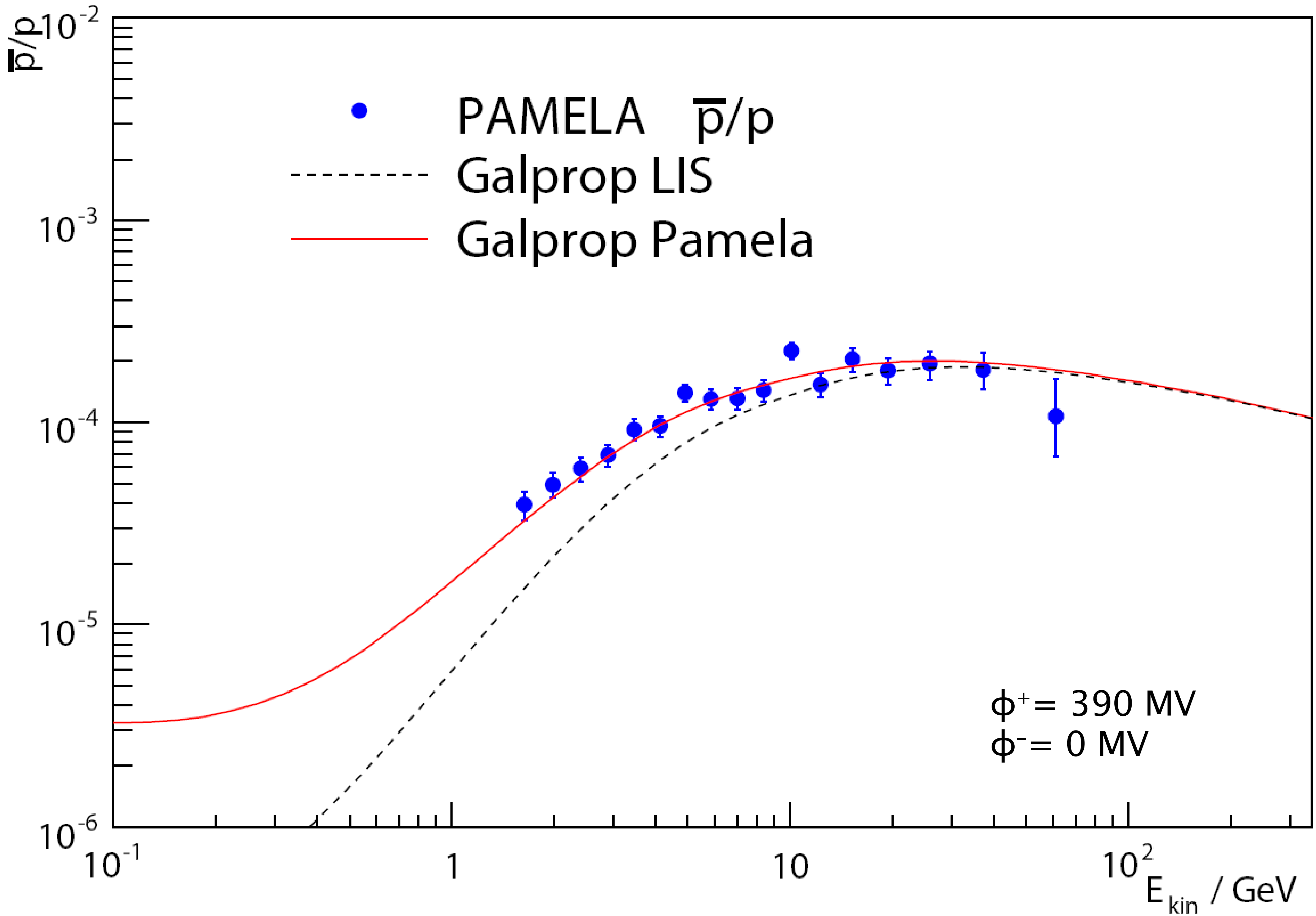
Modulated proton spectra



BESS antiproton/proton ratios

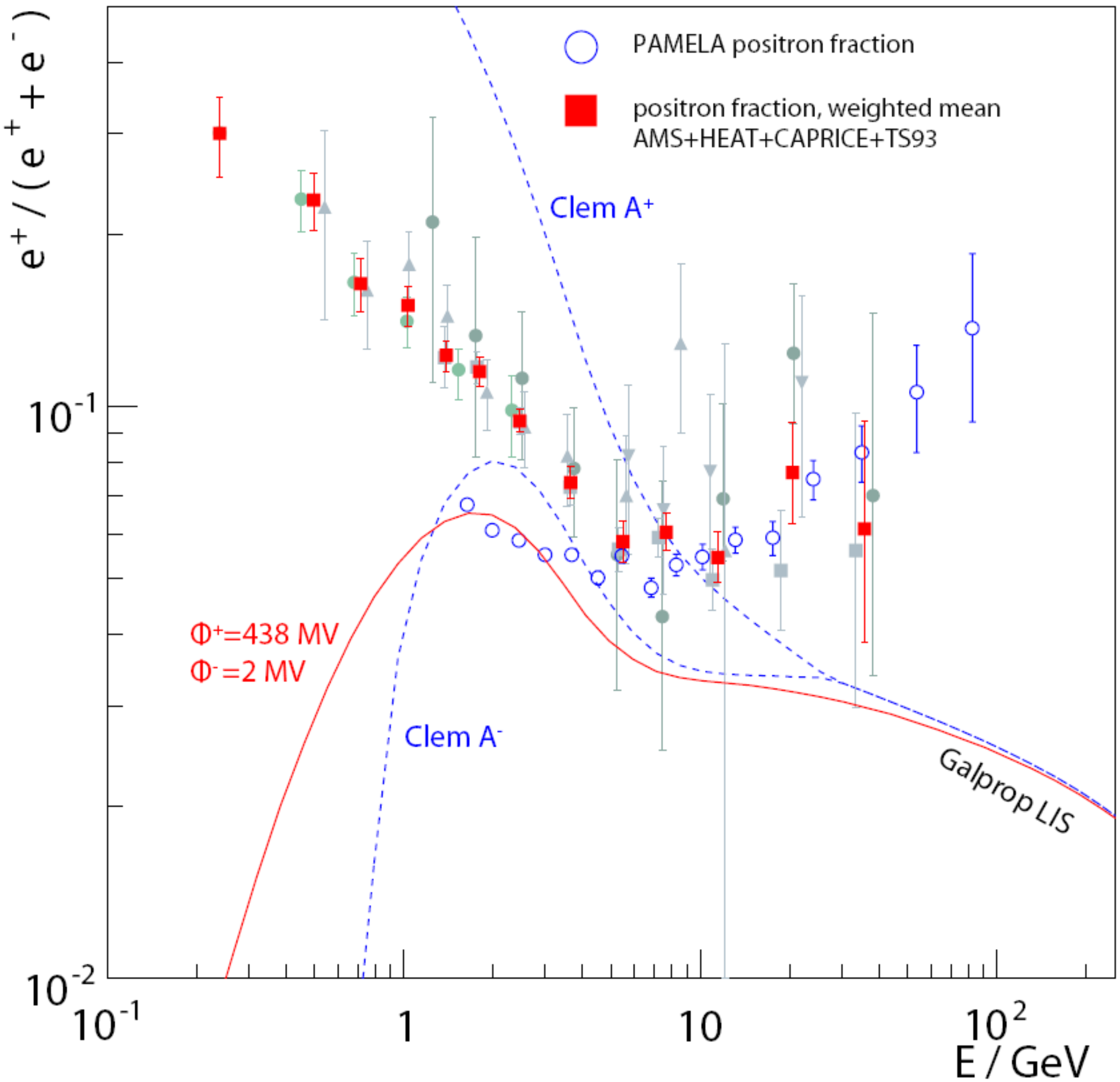


PAMELA pbar/p



Comparison to model by Clem et al.

$$f_E(P, \phi, qA) = C(qA, P) \times M(P, \phi) \times f(P)$$

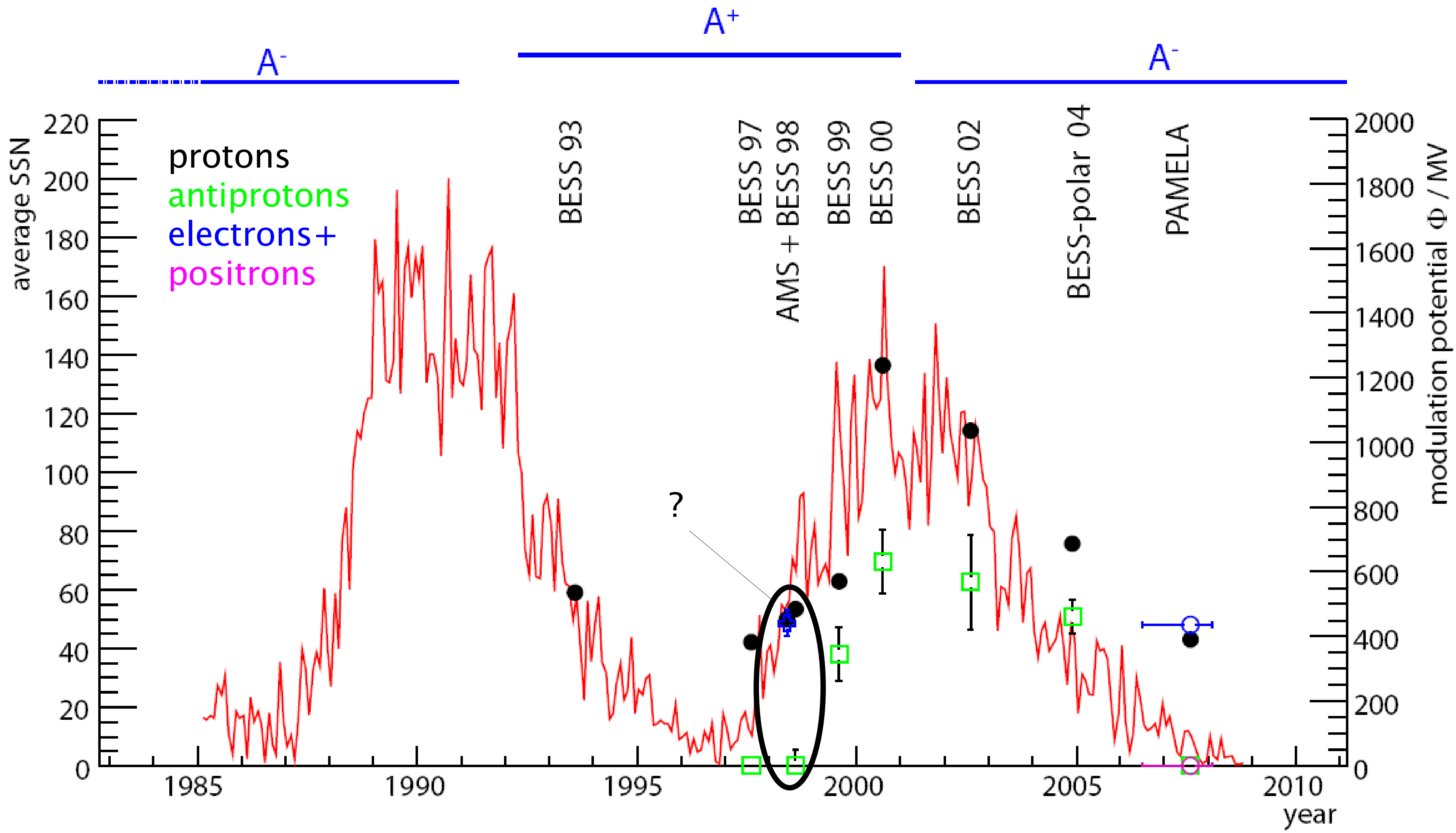


Clem et al., ApJ **464** (1996) 507

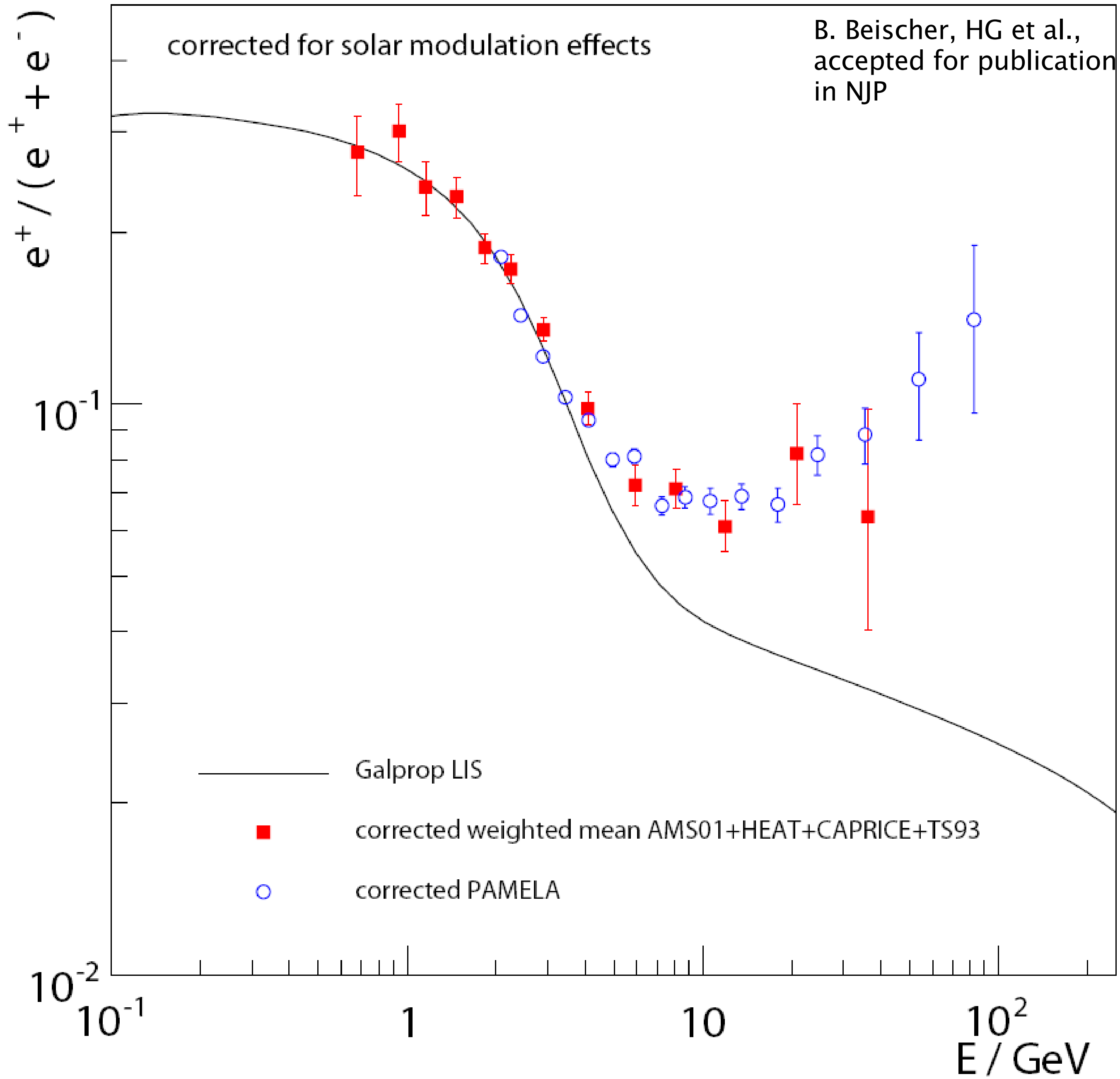
q: charge
A= ±1: orientation of solar dipole
Φ: generic phase
P: momentum

ϕ^+,ϕ^- from p/pbar data match!

Correlation with sunspot number



PAMELA positron fraction II



Conclusion

A simple phenomenological model based on the force-field approximation and the conventional Galprop model can explain the low-energy PAMELA data.

PAMELA data are then in excellent agreement with previous measurements, but the high-energy excess remains.