# Cosmic ray models compared to Fermi-LAT electron and positron spectra


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**Abstract: In this symposium the Fermi-LAT collaboration released the preliminary results of the measurement of e⁻ and e⁺ absolute spectra between 20 and 120 GeV. We show as the double component models which we proposed to provide a consistent interpretation of the e⁻ + e⁺ spectrum measured by Fermi-LAT and of the positron fraction by PAMELA correctly reproduce the new data.**


## INTRODUCTION

In the standard scenario, most of cosmic ray electrons (CRE) in the GeV - TeV energy range are accelerated by Galactic Supernova Remnants (SNRs) while positrons are the secondary product of the collision of CR nuclei with the interstellar medium. Under this hypothesis the positron fraction ($e^+/(e^+ + e^-)$) is expected to be a monotonically decreasing function of energy and the $e^-$ spectrum almost coincides with that of $e^+ + e^-$.

In this symposium the Fermi-LAT released the preliminary results of the measurement of the absolute $e^-$ and $e^+$ spectra between 20 and ~120 GeV using the Earth's magnetic field (**see W. Mitthumsiri et al. plenary talk** ). Those results confirm PAMELA **[1]** finding of an increasing positron fraction above 10 GeV and allow, for the first time, to independently compare the $e^-$ and $e^+$ observed spectra with theoretical models.

In **[2]** the Fermi-LAT collaboration proposed two models to interpret the $e^+ + e^-$ spectrum measured between 7 GeV and 1 TeV. The first is a standard CRE single component model; the second model assumes the presence of a charge symmetric $e^+$ and $e^-$ extra component with a spectral slope ~ -1.5 and a cutoff at around 1 TeV. As extensively discussed in **[3,4]** this new component could be originated either by nearby pulsars or by dark matter annihilation/decay.

In this poster we compare the predictions of those models with the new Fermi-LAT $e^+$ and $e^-$ measurements.

## CR PROPAGATION MODELS AGAINST THE NEW FERMI DATA

The **single component model** in **[2]** assumes an injection spectral index of primary electrons $\gamma_0$ = -1.6/-2.5 below/above 4 GeV. CRE propagation to the Earth and secondary $e^+$ production is simulated with the GALPROP numerical packages **[5]** (practically coincident results are obtained with DRAGON **[6]**) assuming Kolmogorov diffusion and strong reacceleration (Alfvén velocity $v_A$ = 30 km/s). In Fig. 1 we compare the predictions of this model with Fermi-LAT data (data sets by other experiments are not reported to not overcrowd the figure). Black, blue and red lines represent simulated $e^+ + e^-$, $e^-$, and $e^+$ respectively. The reported Fermi-LAT 2011 preliminary data are based on two different analysis: fit-based (filled points) and Montecarlo based (empty points). Their errors bars represent statistical + systematic errors summed in quadrature.

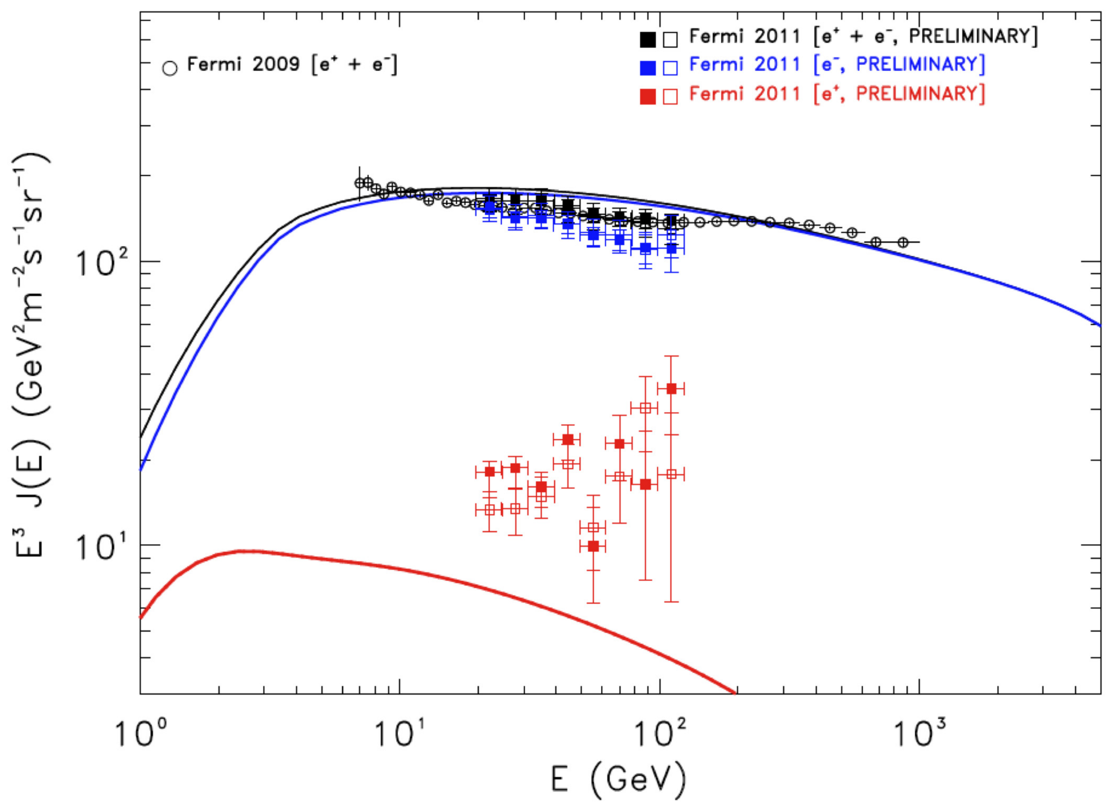


Fig. 1

For all plots in this poster solar modulation is accounted in the force-field approximation with a potential $\Phi$ = 550 MV which allows to reproduce the proton spectrum measured by PAMELA as well as complementary CRE data below 10 GeV.

We see from Fig. 1 that the single component model, which was already in tension with the $e^+ + e^-$ spectrum measured by Fermi-LAT, is clearly excluded by both the new $e^-$ and $e^+$ data.

The **extra-component model** in **[2]** adopts an injection spectral $\gamma_0$ = -1.6/-2.7 for the standard $e^-$ component, and the same propagation conditions as for the single component model. The $e^\pm$ charge symmetric extra-component was assumed to have the spectral shape $E^{-1.5}\exp\{-E/1.4\ \mathrm{TeV}\}$.

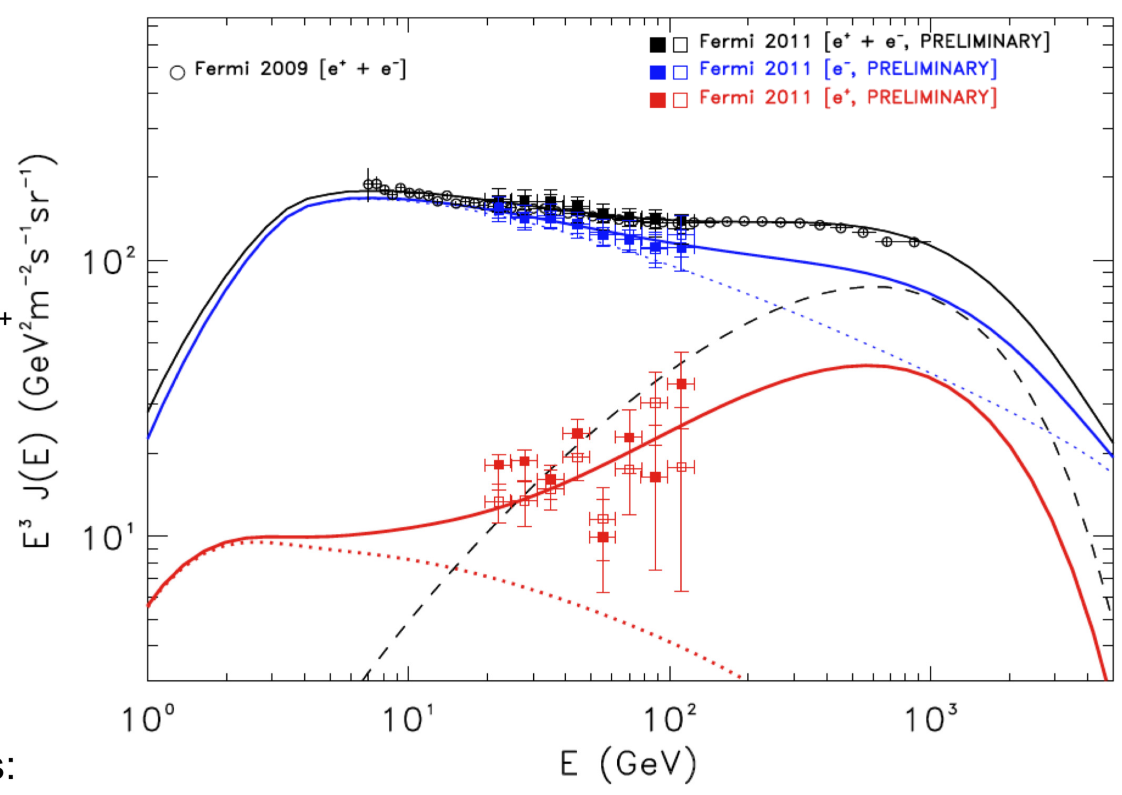


Fig. 2

In Fig. 2 the color notation is the same of Fig. 1. Blue/red dotted lines represent the electron/positron spectra in the absence of the extra-component. The black dashed line is the $e^+ + e^-$ spectrum of the extra-component.

It is evident from this figures as this model (which was proposed well before the Fermi-LAT $e^+$ and $e^-$ data were available) provides a reasonably good description of all Fermi-LAT data sets.

We also consider here a similar extra-component model (see **[4]**) which, differently from the models in **[2]**, assumes Kraichnan diffusion rather then Kolmogorov, weaker raccelerations ($v_A$ = 15 km/s) and a less pronounced spectral break in the electron spectrum. This model describes Fermi-LAT data (besides other complementary CR data sets) equally well and it allows to match PAMELA positron fraction data even below 10 GeV **[1]** (see Fig. 3).

In Fig. 3 we compare the prediction of all those models with the available positron fraction data. The dashed region represent the region allowed by Fermi data centered on the average between the fit-based and MC analysis.

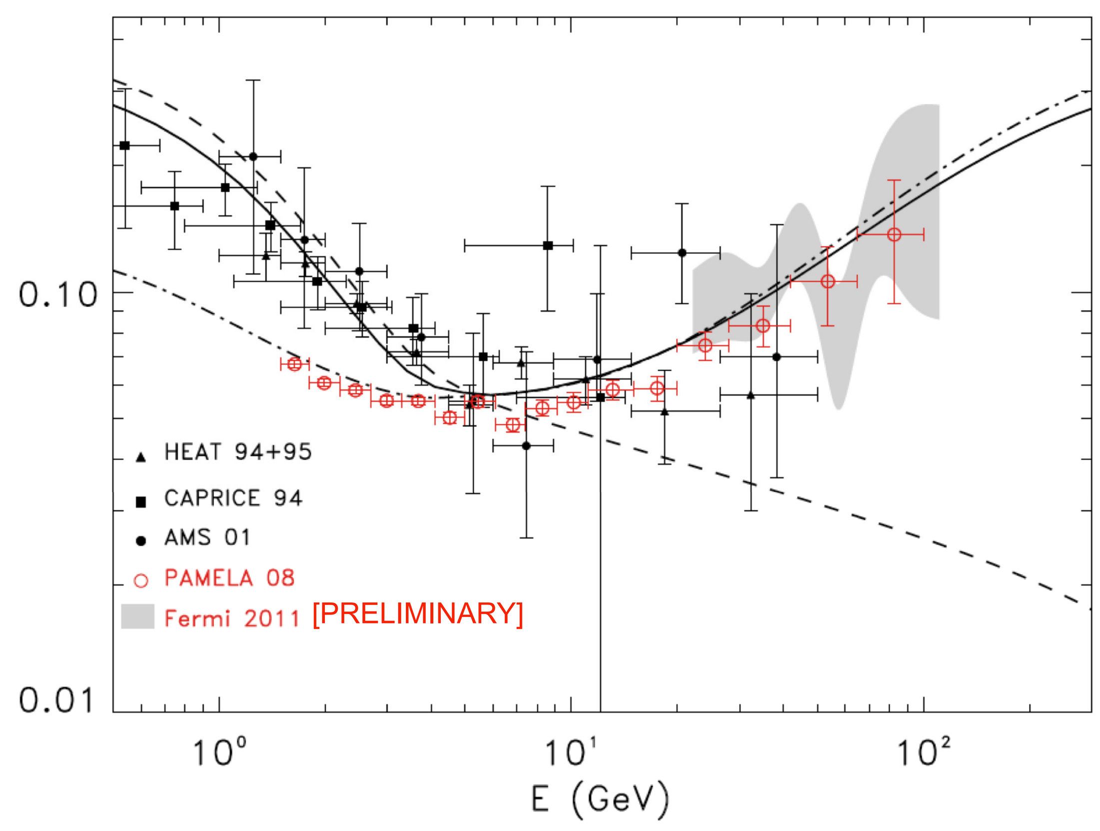


Fig. 3

In this figure the dashed, solid and dot-dashed line represent the prediction of the single component model **[2]**, extra-component model in **[2]** and extra-component model in **[4]** respectively.

We conclude this presentation noticing that the electron absolute spectrum recently measured by PAMELA **[7]** between 1 and 625 GeV agrees with Fermi-LAT data if the normalization of one of those data sets is slighlty rescaled. We found that if the PAMELA $e^-$ normalization is chosen to agree with the $e^+ + e^-$ Fermi-LAT spectrum and the PAMELA positron fraction at 10 GeV, the double-component models discussed in this poster nicely fit the whole PAMELA $e^-$ spectrum as well.

## REFERENCES:


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**[4]** G. Di Bernardo et al., [cat III Fermi-LAT paper] Astropart. Phys. 34 (2011) 528.

**[5]** A.W. Strong, I.V. Moskalenko, T.A. Porter, G. Johannesson, E. Orlando, S. Digel. Available from: <arXiv:0907.0559 >.

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