Antiproton modulation in the Heliosphere and AMS-02 antiproton over proton ratio prediction

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# Modulation of Cosmic Rays







22° ECRS, 3-6 July 2010 Turku

Charge sign dependence





### • Propagation of Cosmic Rays in the Heliosphere

Antiproton/proton ratio

Our results

Prediction for AMS-02





#### We improved our model with a dynamic and more realistic description of Heliosphere



For the neutral sheet drift we use the description Potgieter-Moraal 1985 with a Parker Magnetic Field modified as Jokipii-Kota 1989 and constant Solar Wind

![](_page_8_Figure_1.jpeg)

Ordinary Drift  $\mathbf{v}_d = f(\theta) \nabla \times \left( K_A \frac{\mathbf{B}_m}{B} \right) + \frac{\partial f(\theta)}{\partial \theta} \frac{K_A}{r} \mathbf{e}_{\theta} \times$ NS drift Transition Function that emulate the effect of a wavy neutral sheet  $K_{\parallel} = K_0 \beta P \frac{B_{\oplus}}{3B} \sum K_{\perp} = (K_{\perp})_0 K_{\parallel}$ We used a quasi-linear Theory for the diffusion coefficient

K0 From neutron monitor Counting rate

Estimation of modulation potential

Usoskin et al. JGR 2005

![](_page_9_Figure_3.jpeg)

Oulu Neutron Monitor Data, plotted by David Archibald with prediction point added. Data source: University of Oulu, Finland

Force Field approach

$$K_0 = \frac{V_{SW}(R_{TS} - R_{1AU})}{3\phi}$$

**Modulation Potential published until 2004** 

We find a linear relation between K0 (previous slide) and Smoothed Sunspot Numbers

Dispersion of data ~19%

In our model K0 is Gaussian

9% RMS) distributed around the analytical value

![](_page_11_Figure_0.jpeg)

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![](_page_12_Figure_0.jpeg)

![](_page_13_Figure_0.jpeg)

![](_page_14_Figure_0.jpeg)

![](_page_15_Figure_0.jpeg)

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![](_page_16_Figure_0.jpeg)

![](_page_17_Figure_0.jpeg)

### Conclusions

- We developed a 2D MonteCarlo Stochastic model for Cosmic Rays propagation in the Heliosphere
- Solar modulation is charge and polarity dependent and we improved our model for antiparticles
- Starting from Galprop LIS we reproduced antiproton/proton measured ratio (Pamela, BESS).
- We compared our results with FF modulated ratio (only proton modulated!!)
- We use the predictive features of our model to provide modulated fluxes for AMS-02

![](_page_19_Picture_0.jpeg)

## **BACKUP** slides

![](_page_21_Figure_0.jpeg)

![](_page_22_Figure_0.jpeg)