Cosmic Antiprotons:

THE NEED FOR A MEASURE OF

THE CROSS SECTION

$p + HE \rightarrow \bar{p} + X$

IN THE AMS-02 ERA

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Secondary antiprotons in cosmic rays (CR) are produced by spallation reactions on the interstellar medium (ISM)

$$\left.\begin{array}{l} p_{CR} + H_{ISM} \\ p_{CR} + He_{ISM} \\ He_{CR} + H_{ISM} \\ He_{CR} + He_{ISM} \end{array}\right\} \quad \bar{p} + X$$

The only measured cross section is pp → $\bar{p}$ + X

ALL CROSS SECTIONS INVOLVING He (projectile or target) ARE DERIVED FROM OTHER DATA

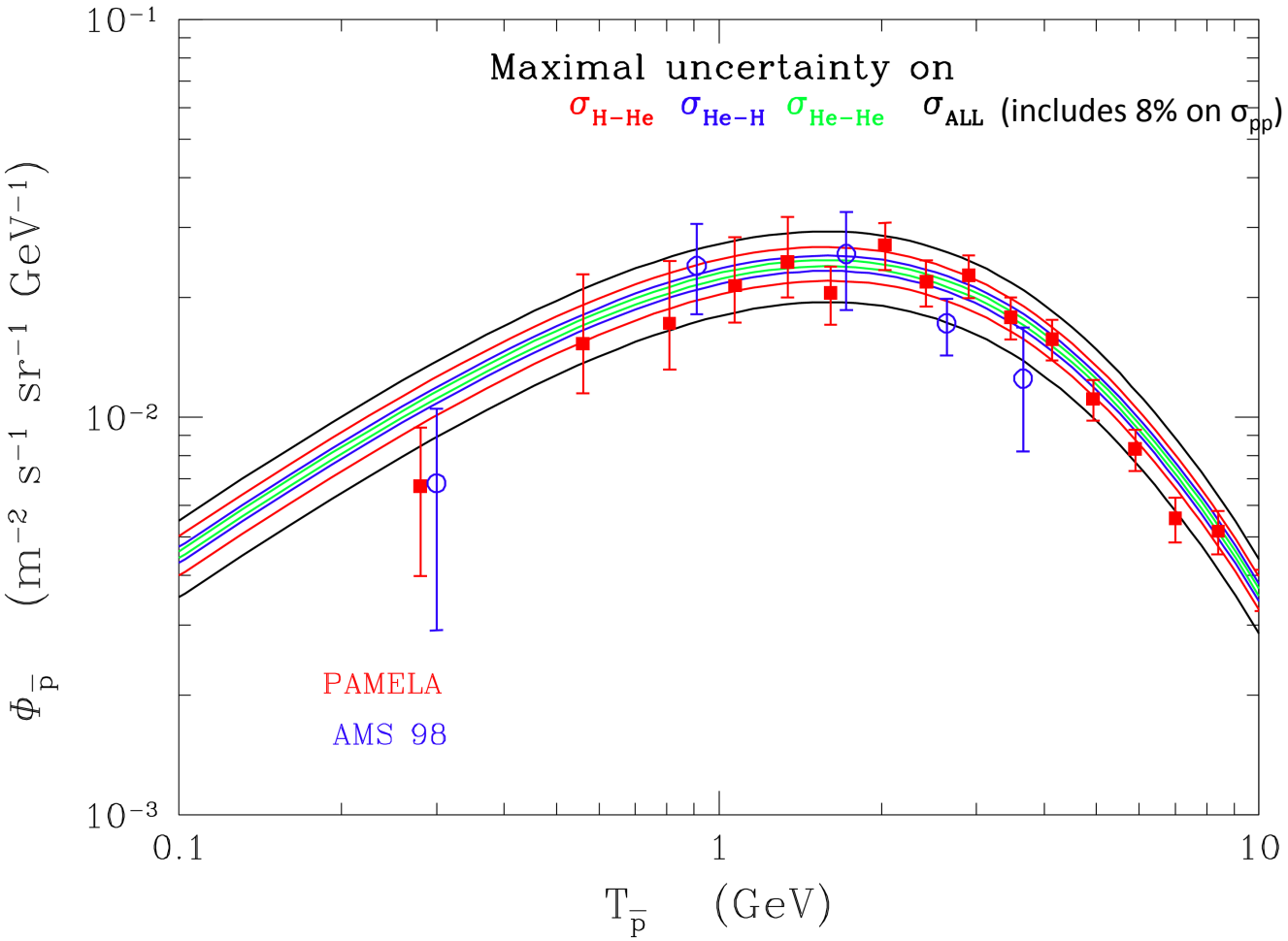
1. p+p: $\sigma_{p+p \rightarrow antiprotons}$ analytical expression
   (Tan & Ng, PRD26 (1982) 1179; J.Phys.G:NuclPhys 9 (1983) 227)
   More recent data exist

2. p+ He, He+p, He+He: $\sigma_{p(He)+(p,He) \rightarrow antiprotons}$ derived from MonteCarlo simulations, i.e. DTUNUC (Donato et al. ApJ 563 (2001) 172) verified on p+C,p+Al. and heavier nuclei (Duperray et al. 2003, 2005)

Possible improvements: MAKE THE EXPERIMENTS!!

Uncertainties on the antiproton flux from **nuclear cross sections**

(Model from Donato et al. ApJ 2001, PRL 2009)



- pp: Tan& Ng
- H-He, He-H, He-He: DTUNUC MC

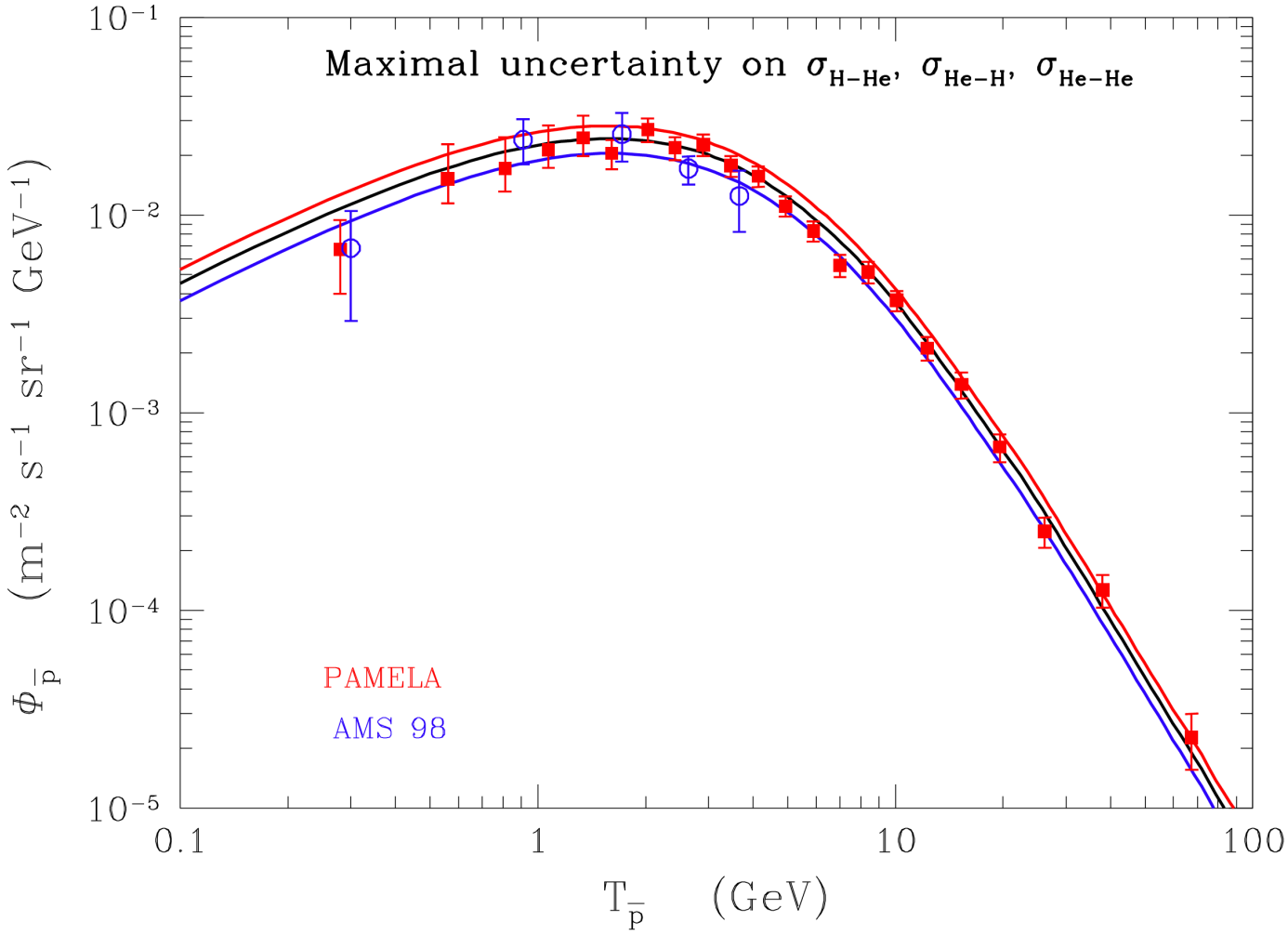
Maximal uncertainty from H-He: 20-25%

Functional form for the cross section derived from other reactions

Reactions involving helium (& high energies)

Uncertainties due to helium reactions range 40%-50%: precise data from p-He (He-p) would reduce them significantly

AMS-02 will provide data with much higher precision!



In the literature:
- DTUNUC
- Modifications of pp cross section
- Other MC are viable but data on He do not exist!

A direct measurement of ANTIPROTON production from **He** (target and/or projectile?) seems mandatory in order to interpret unambiguously the future AMS-02 data.

We need to:

- Fix the shape of the antiproton production cross section
- Reduce the relevant uncertainties

N.B. Propagation uncertainties are now confined to ~20%, and will be significantly reduced with AMS-02 data on B/C and other species.

As a nice by-product, we could in principle have some data on cross sections for the production of ANTIDEUTERONS