Simulations of deuteron and antideuteron production in cosmic ray interactions

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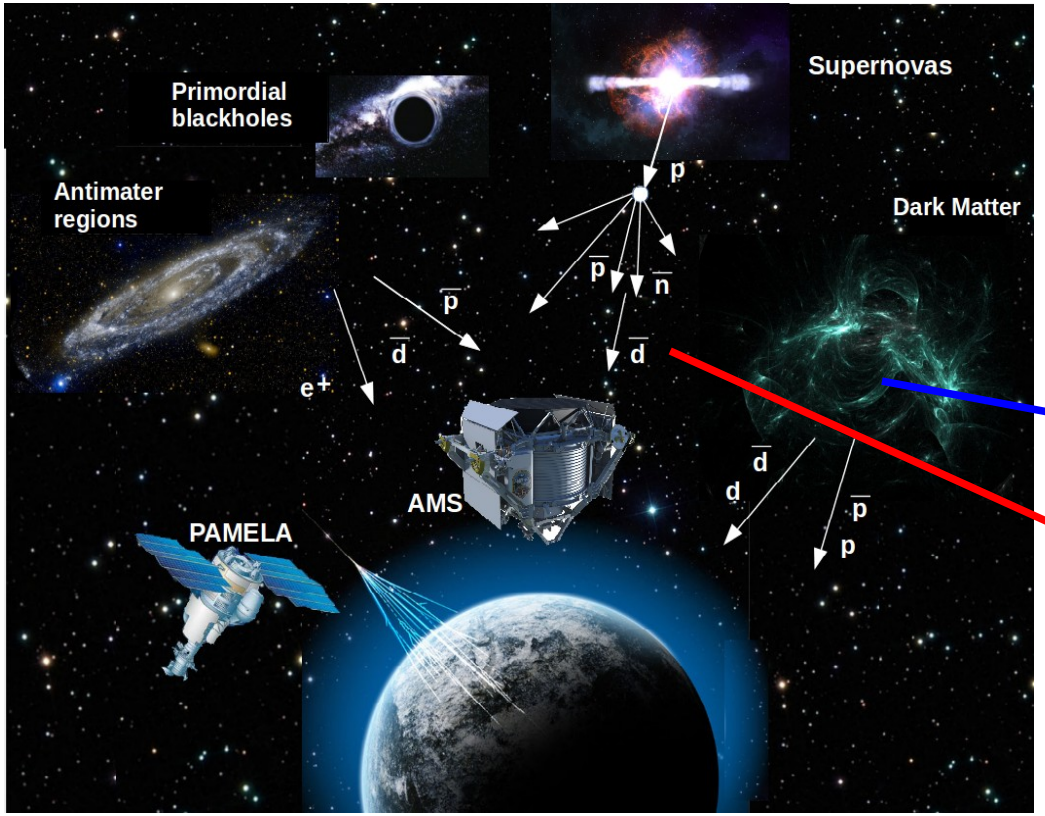
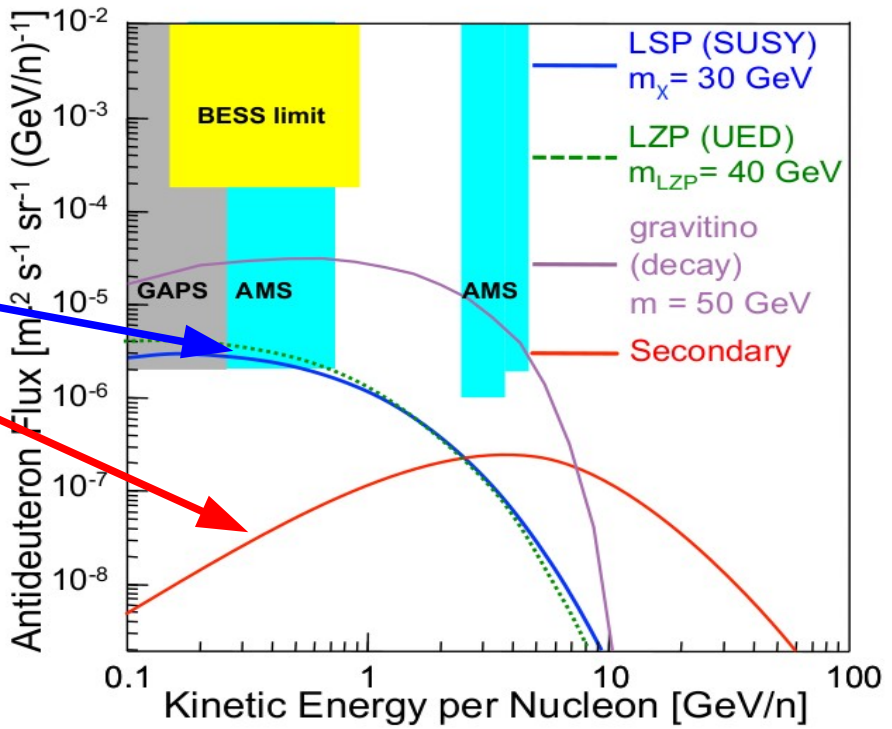
Motivation

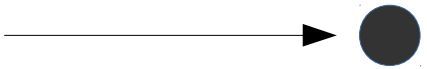




Antideuteron production is not implemented in Geant4, nor in many known Monte Carlo generators.

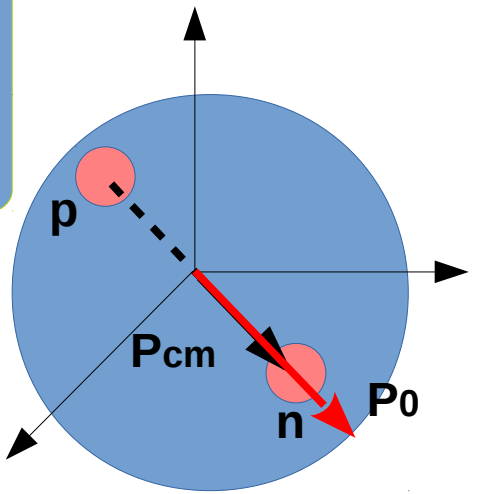
Deuteron and antideuteron formation

$$\gamma_d \frac{d^3N_d}{dp_d^3} = \frac{4\pi}{3} p_0^3 \left(\gamma_p \frac{d^3N_p}{dp_p^3}\right)\left(\gamma_n \frac{d^3N_n}{dp_n^3}\right)$$



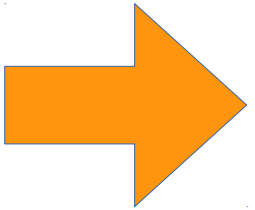
LAB Collision

CM of the pair p-n or pbar-nbar produced in collisions



Proton (Px_p, Py_p, Pz_p, E_p, m_p)

Neutron (Px_n, Py_n, Pz_n, E_n, m_n)



Center of Mass collision

If $P_{cm} < P_0$ an (anti)deuteron is created and its kinematical variables are saved:

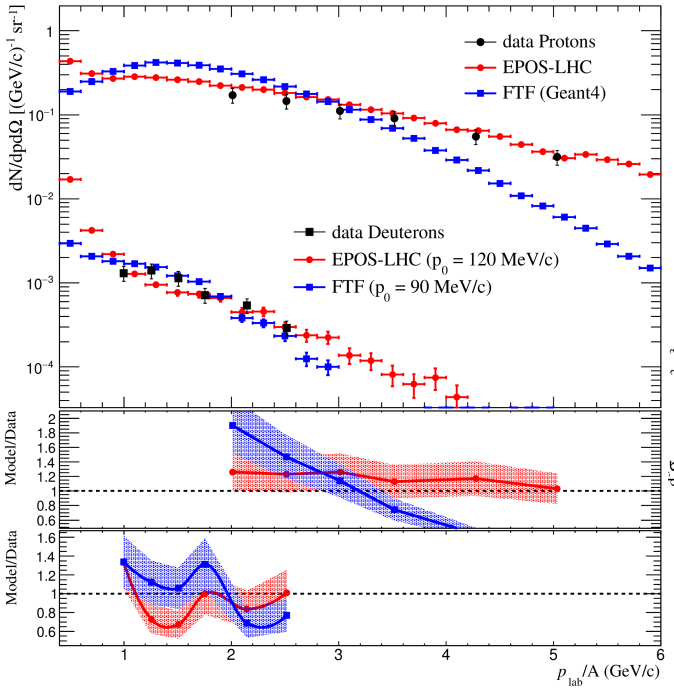
$$p_{cm} = \frac{1}{2}\frac{\sqrt{(s-(m_1-m_2)^2)(s-(m_1+m_2)^2)}}{\sqrt{s}}$$

$$P_d = P_p + P_n$$

$$m_d$$

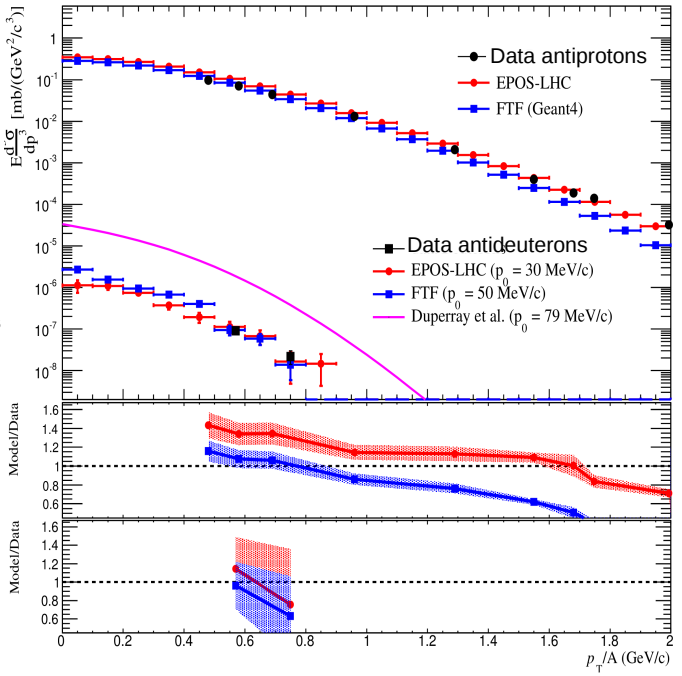
$$E_d = (P_d^2 + m_d^2)^{1/2}$$

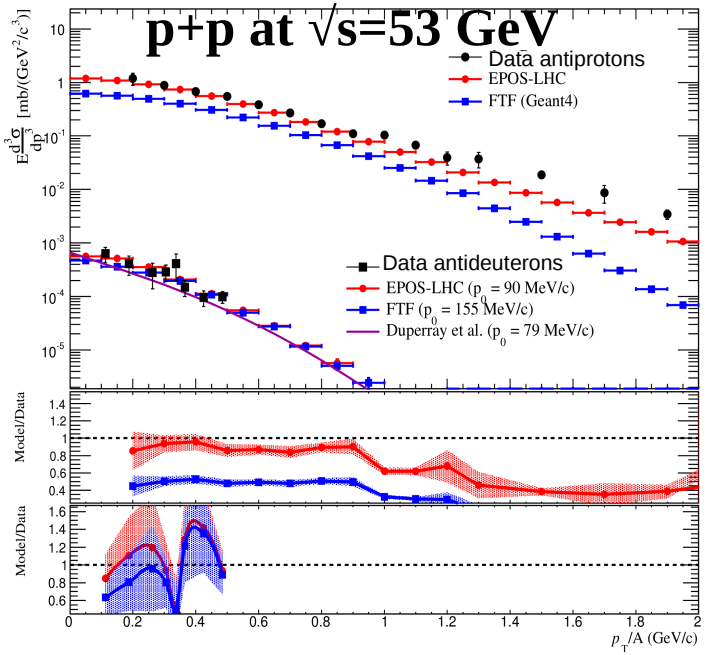
Comparisons with accelerator data



p+Be at 33 GeV/c

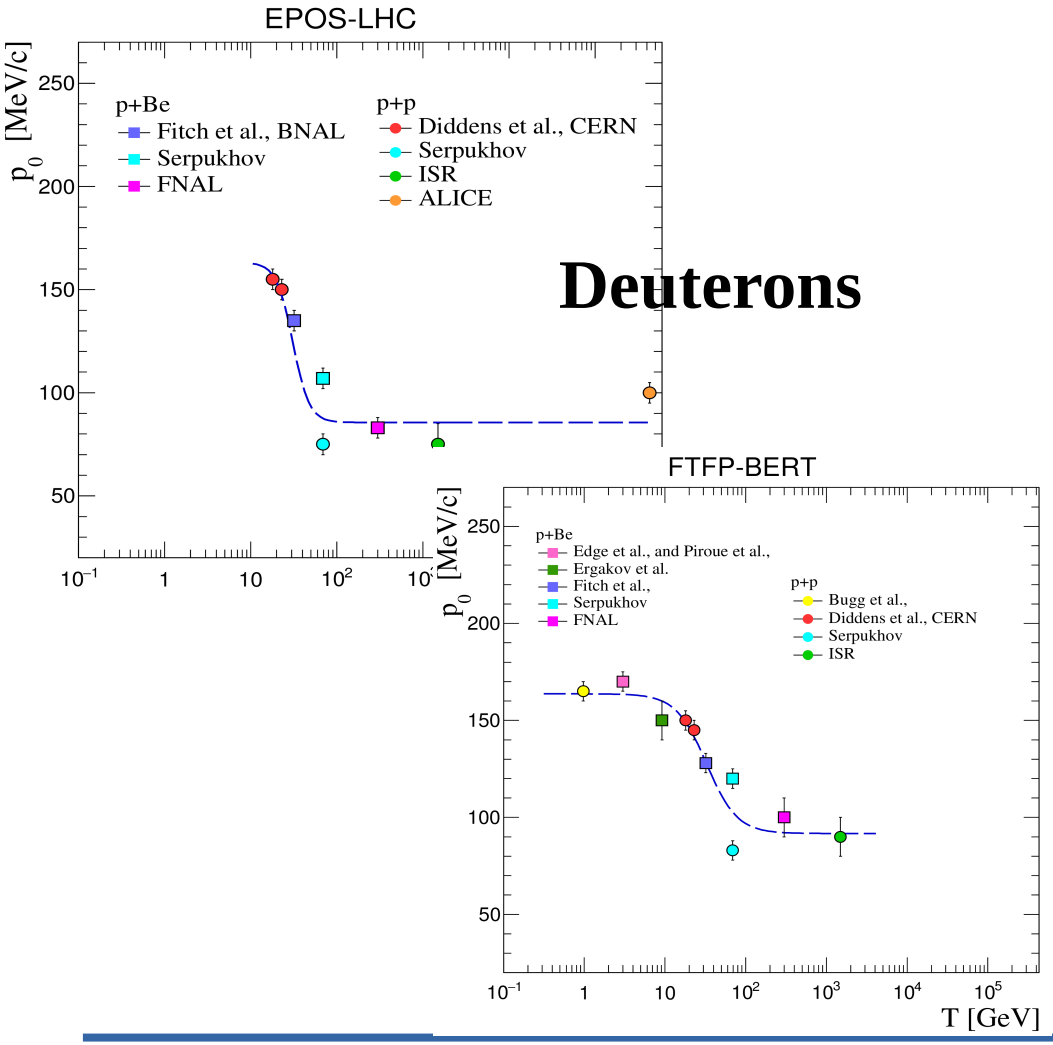
p+p at 70 GeV/c

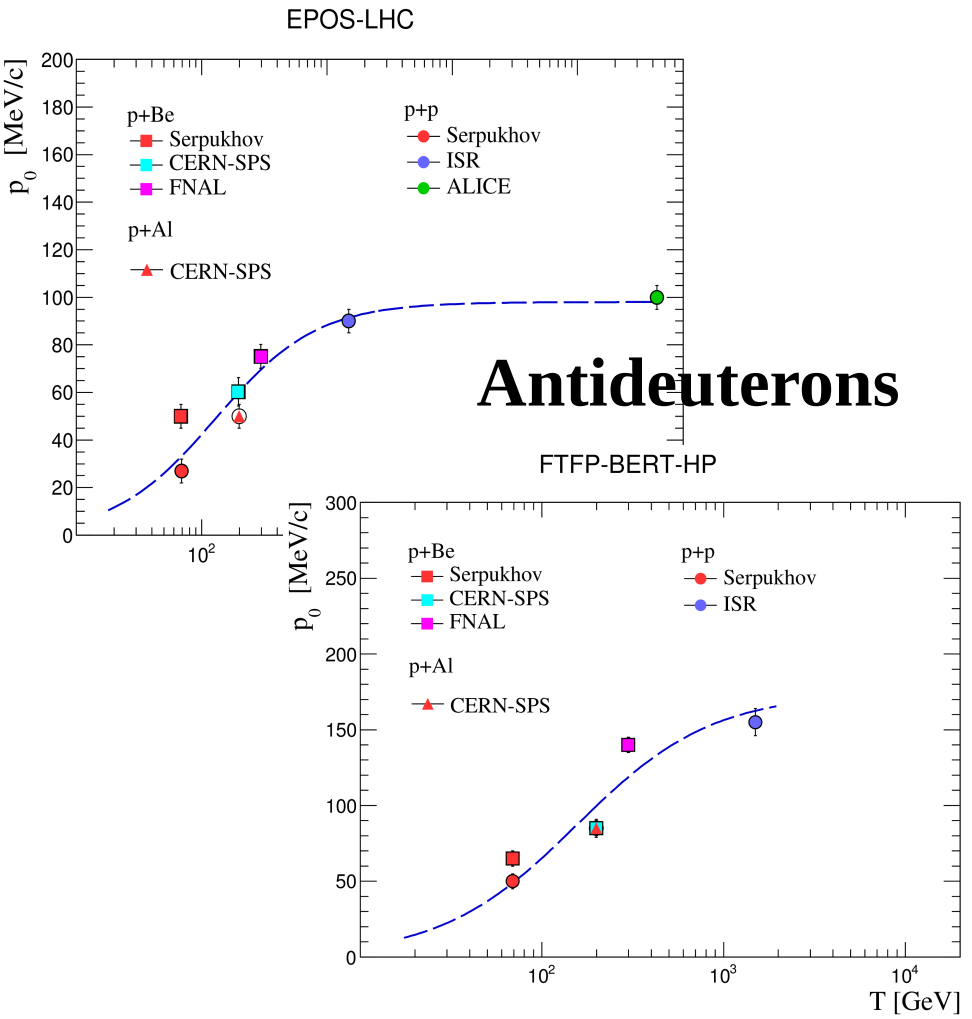




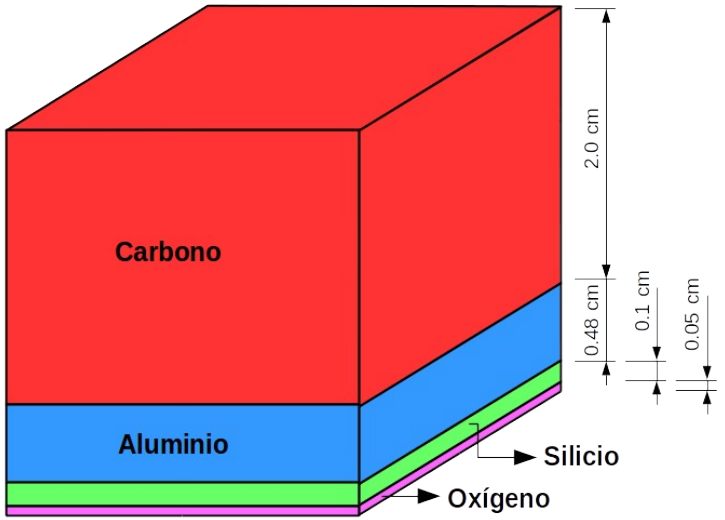
Experiment or Laboratory	Publication	Collision	$p_{inc}(GeV/c)$	$\sqrt{s}(GeV)$
CERN	26	p-p	19.2	6.15
	26	p-Be		
	26	p-Al		
	27	$\bar{p}$-p	32	7.9
Serpukhov	28, 29	p-p	70	11.5
	30	p-Be		
	31	p-Al		
	31	p-Pb		
Fermilab	32	$\bar{p}$-p	100	13.8
CERN-NA49	25	p-p	158	17.5
	33	p-C		
CERN-SPS	34	p-Be	200	19.4
	34	p-Al		
Fermilab	35	p-Be	300	23.8
	35	p-W		
CERN-ISR	36	p-p	1497.8	53.0
CERN-ALICE	37	p-p	431769	900

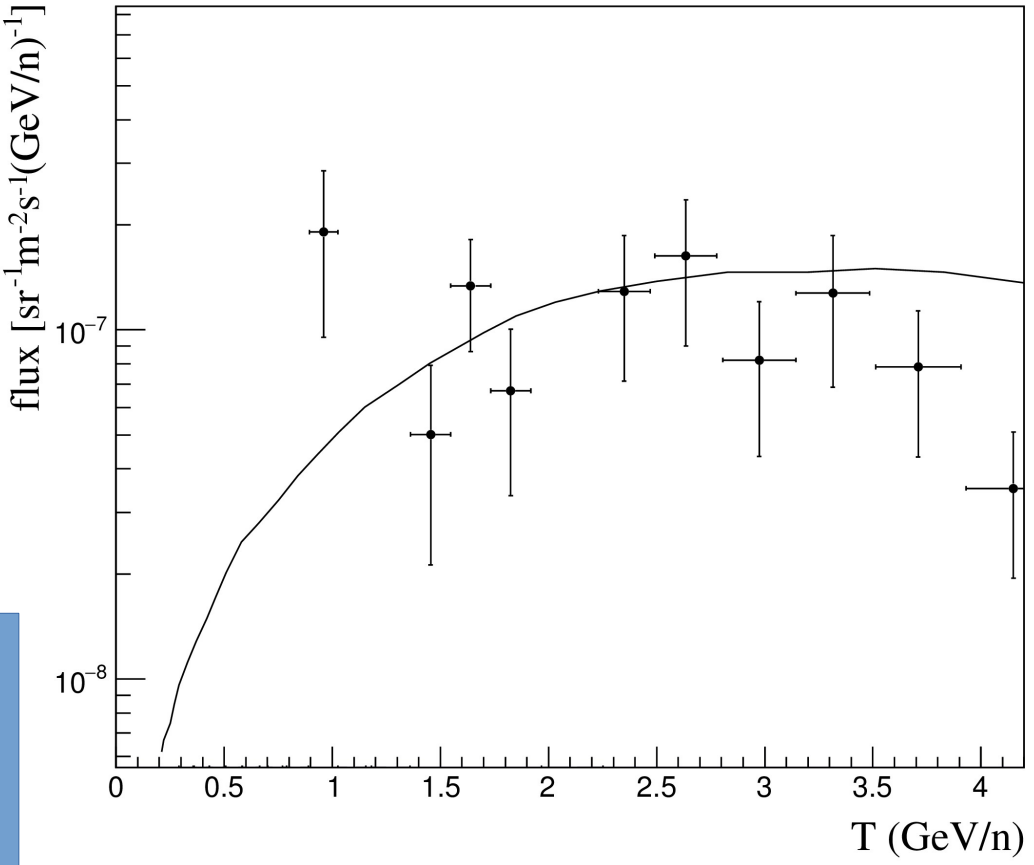
Coalescence parameter (p_0) as energy function





Estimation of antideuteron production in common detector materials





- Total production: 2.5 x 10^{-7} antideuterons per event.
- Considering for example AMS-02 accepatance for antideuterons during 10 years we get ~ 1.5 antideuterons.