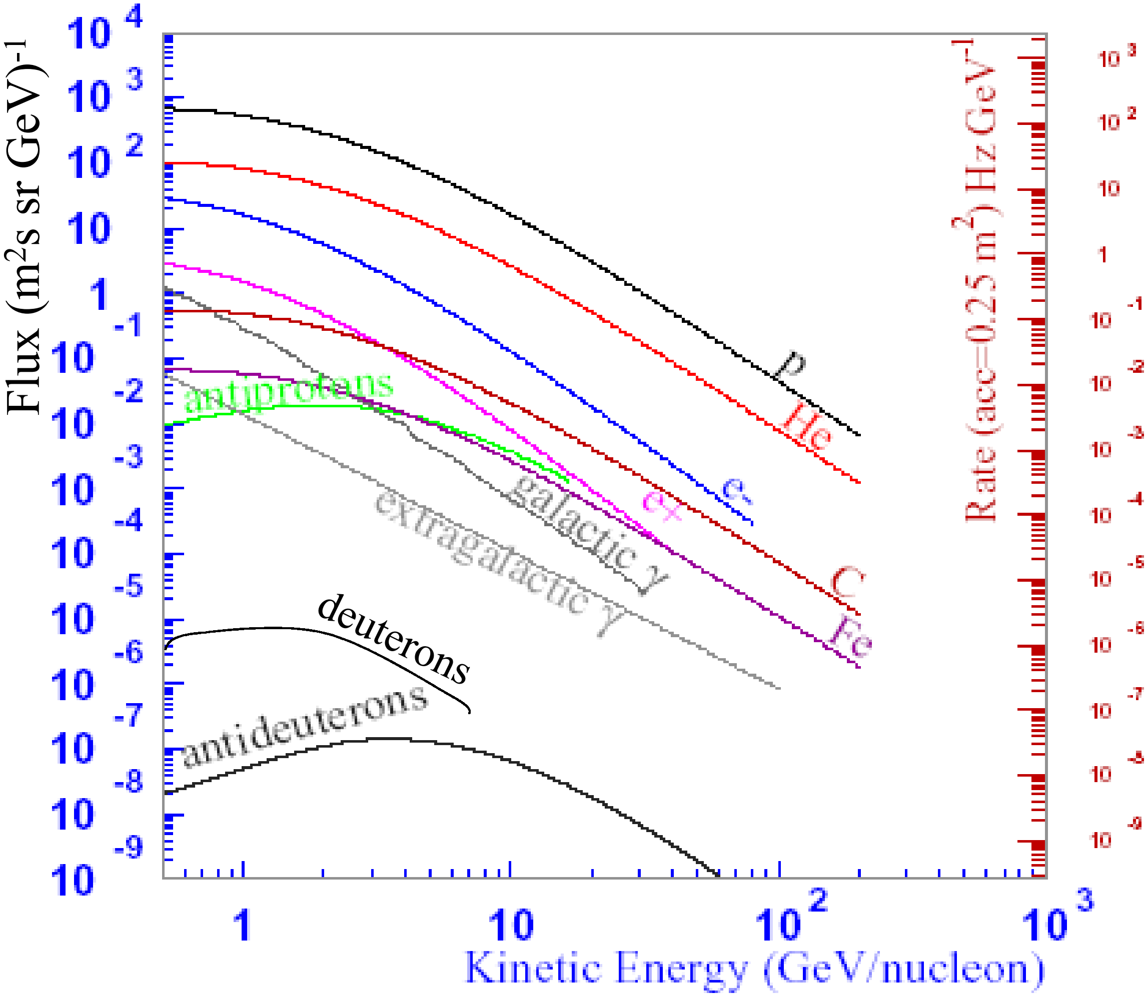
Preliminary results on antideuterons

Mariusz Sapinski, Simonetta Gentile
I.N.F.N. Roma1

Outlook:

- Goals
- Event generation
- Preselection
- Acceptance
- Selection
- Results

Goals



backgrounds:

ap – O(10^6)

e - O(10^8)

He- O(10^{11})

p - O(10^{12})

d – O(10^2)

Goals

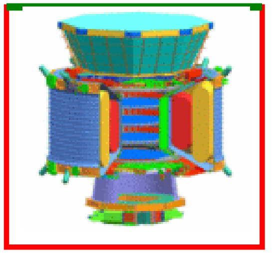
1. find acceptance
2. find rejection factors for backgrounds
3. estimate number of registered antideuterons in 3 years: from DM signal and spallation background
4. estimate the background contamination

Event generation

- generation for acceptance study:

deuterons, protons and antiprotons

(in energy points, from the box around detector)



- generation for study of cuts:

deuterons, protons, antiprotons, electrons, helium

(energy spectrum flat in log(mom),0.5-10 GeV, particles generated on the plane above AMS)

Preselection

One AMSParticle with:

- track in TRK
- track in TRD
- measurement of velocity in ToF
- absolute charge = 1

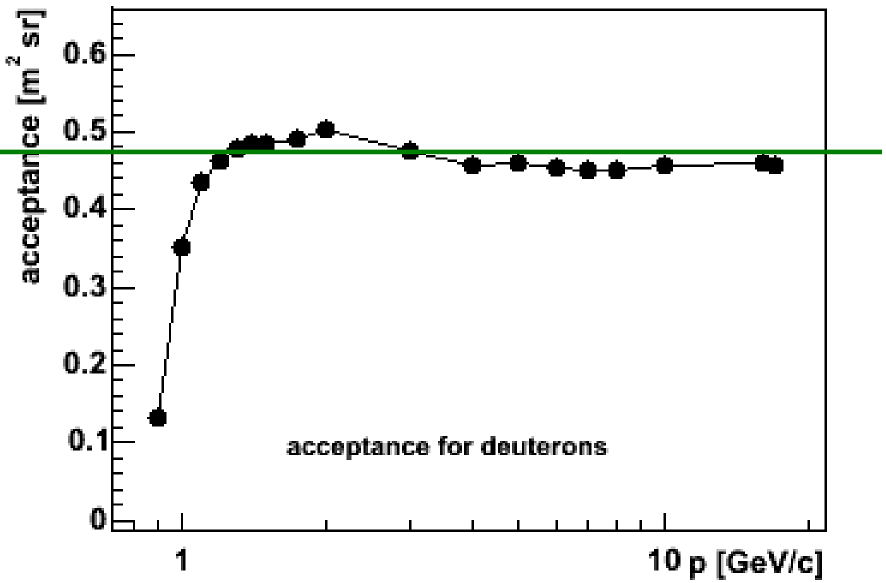
d	p	e	antip
33%	29%	23%	20%

99.7% of deuteron events in our sample has only one AMSParticle

Acceptance

geometrical, ie. after preselection cuts

$\sim 0.48 m^2 sr$



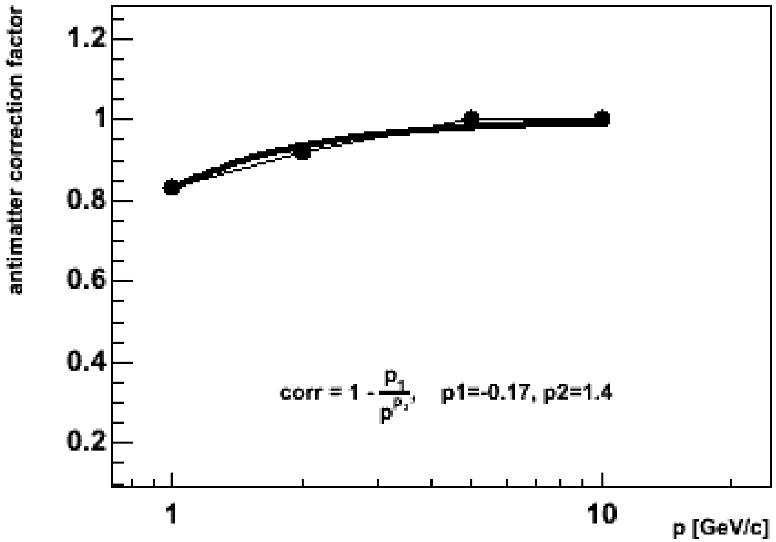
there are no antideuterons in GEANT, so:

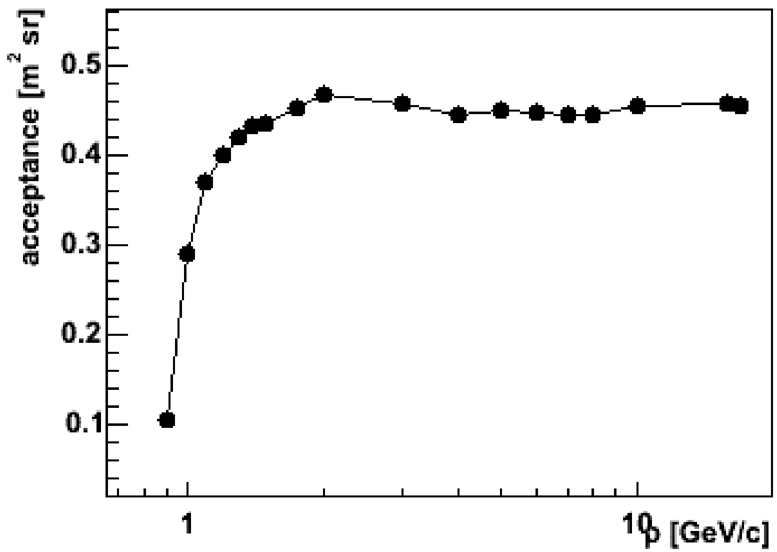
We use deuterons. We assume that antimatter effects scale for antideuterons in the same way as for antiprotons, ie.

A(antid)=A(d)•A(antip)/A(p)

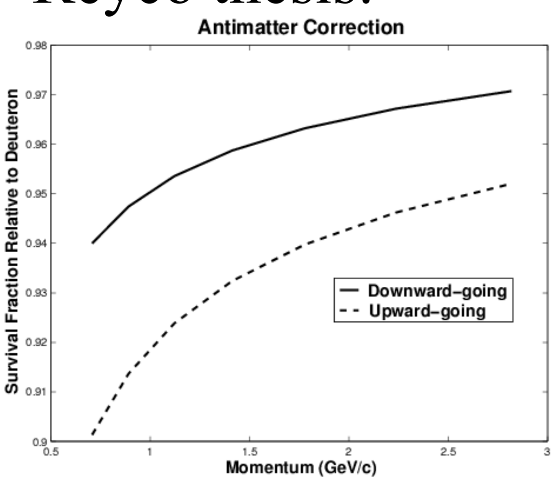
(but we do not correct cuts efficiencies)

Antimatter Correction





Reyco thesis:



$$a(p) = \frac{\exp(-\Sigma_i 1.8\,\sigma_{pA_i} \frac{\rho_i X_i}{M_i})}{\exp(-\Sigma_i 1.8\,\sigma_{pA_i} \frac{\rho_i X_i}{M_i})} = \exp(-\Sigma_i 1.8\,(\sigma_{pA_i} - \sigma_{pA_i}) \frac{\rho_i X_i}{M_i})$$

(AMS-01 – less material)

Selection

- quality cuts for β measurement
- quality cuts for track in TRK
- quality cuts for track in TRD
- other particle-id and final selection cuts

follow AMS-01 analyses

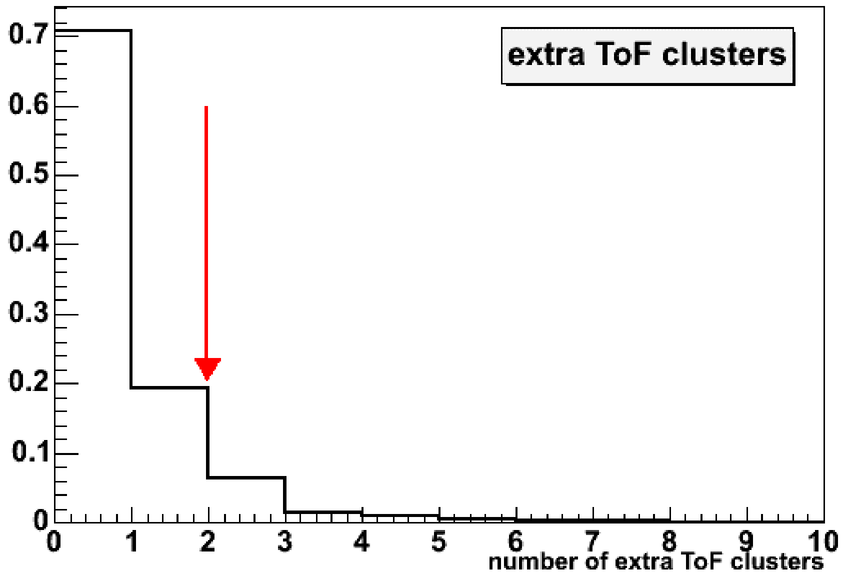
efficiencies with respect to preselected events

Quality cuts for β measurement (1)

number of ToF clusters

not used to β measurement < 2

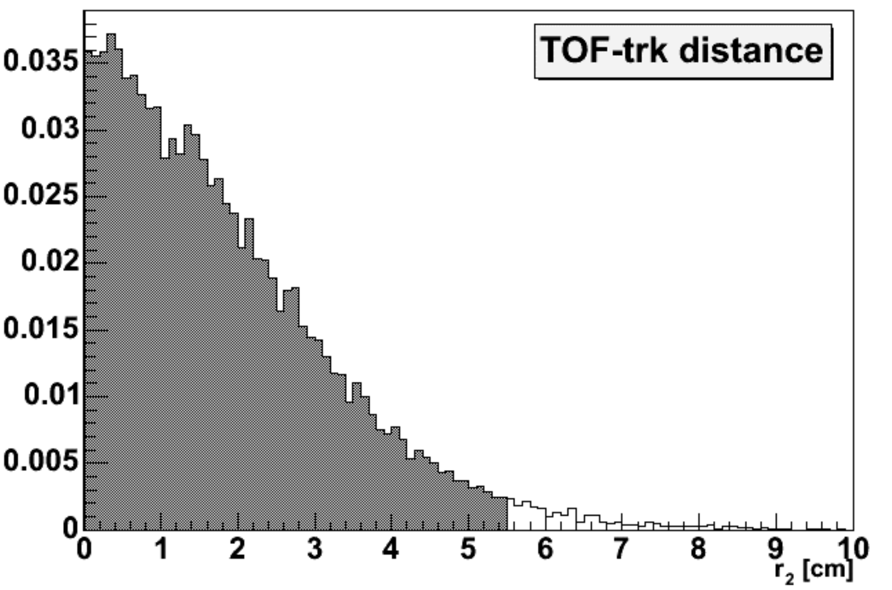
n Reyco thesis (AMS-01) the cut was < 1



$\varepsilon_d = 91.6\%$

distance between TRK track extrapolation and measurement of the position from ToF paddle < 5.5cm

in Reyco thesis the cut was 5cm, in Giovanni's 5.5cm

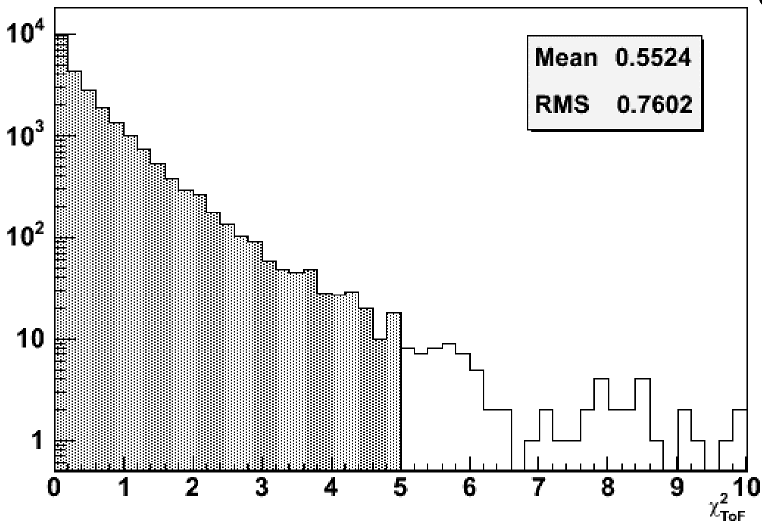


$\varepsilon_d = 87.8\%$

Quality cuts for β measurement (2)

Velocity reconstruction based on at least 3 ToF layers: $\varepsilon_d = 95.0\%$

χ^2 of the time fit < 5



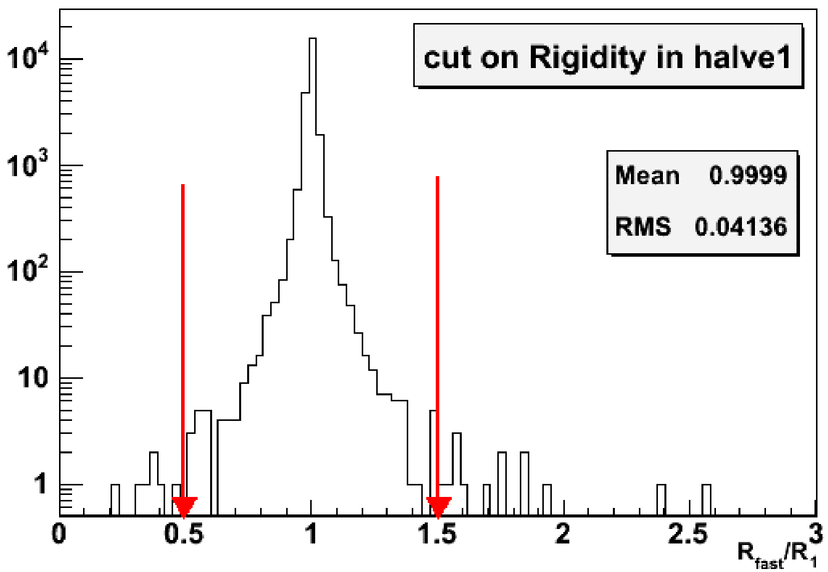
$\varepsilon_d = 99.5\%$

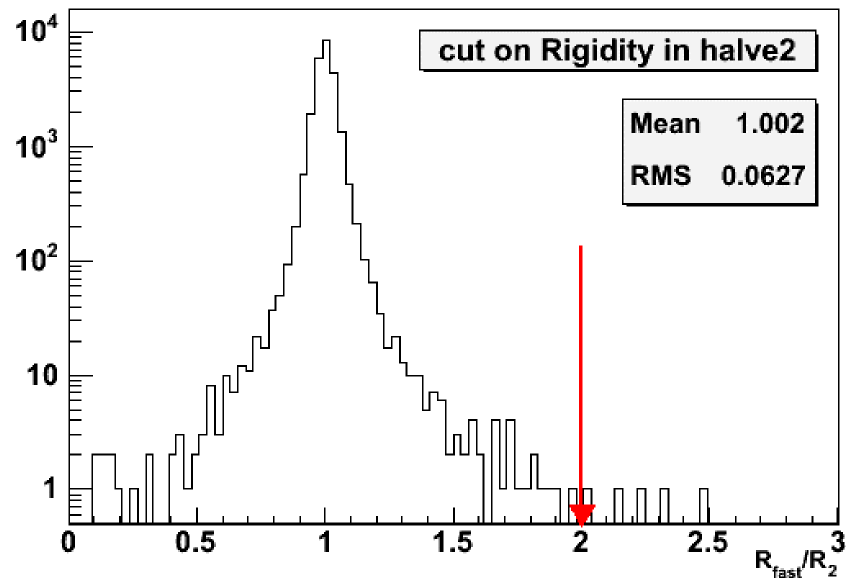
all cuts on β measurement:

79.3%

Quality cuts for TRK measurement (1)

$0.5 < R_{fast}/R_1 < 1.5$ and $0.0 < R_{fast}/R_2 < 2.0$



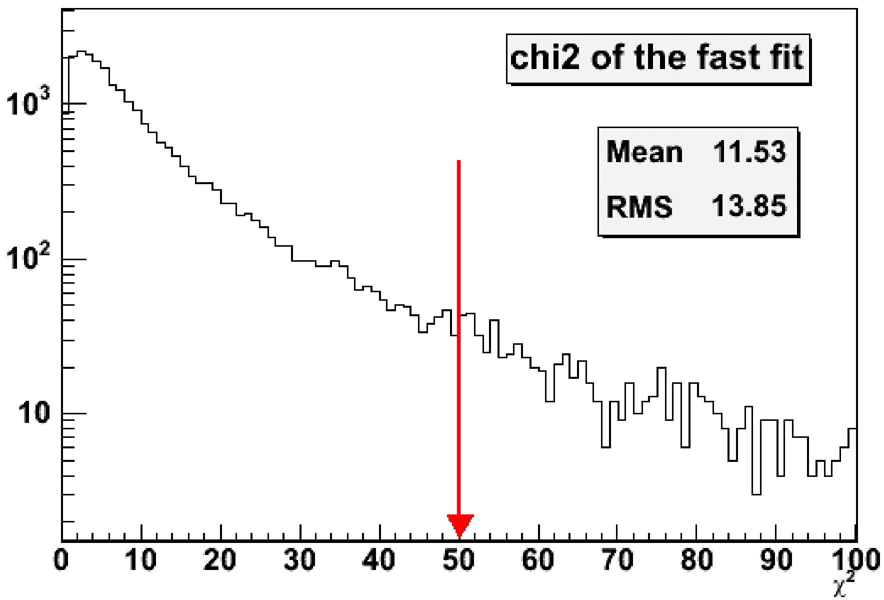


$\varepsilon_d = 99.8\%$

R_1, R_2 - rigidities measured in two TRK halves

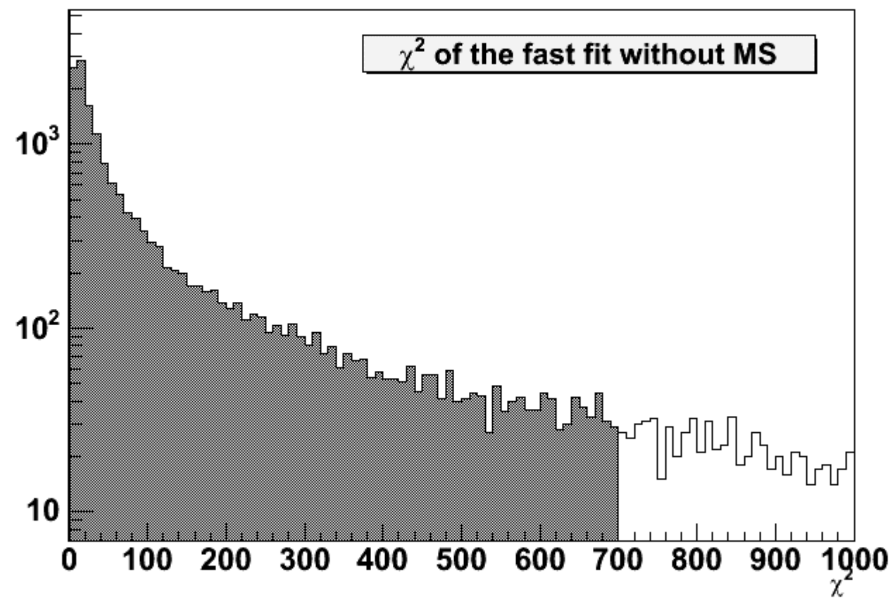
Quality cuts for TRK measurement (2)

χ^2 of Fast Fit < 50



$\varepsilon_d = 94.5\%$

$\chi^2_{no\ MS}$ of Fast Fit < 700



$\varepsilon_d = 84.2\%$

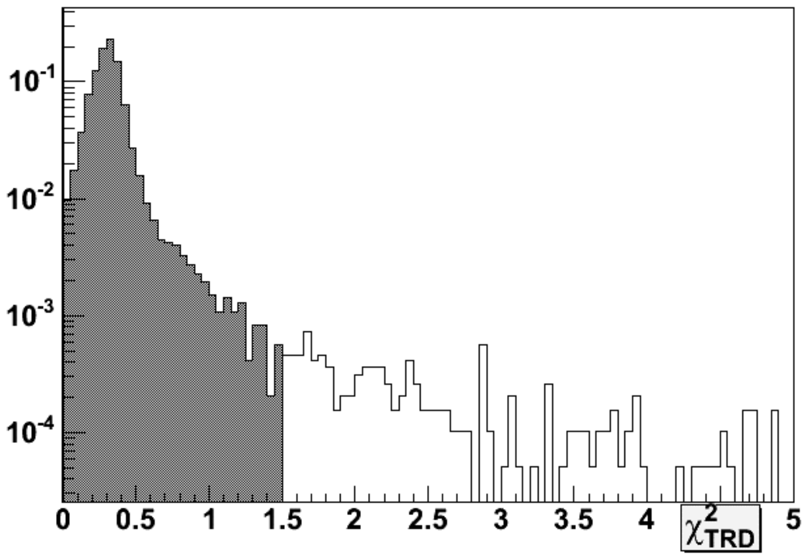
in Reyco thesis cut was on 500

$$\chi^2 = \sum_i \left(\frac{x_i^m - x_i}{\sigma_{x_i}}\right)^2 + \left(\frac{y_i^m - y_i}{\sigma_{y_i}}\right)^2 + \left(\frac{s_i^m - x_i cos\theta_i - y_i sin\theta_i}{\sigma_{s_i}}\right)^2$$

MS:additional position uncertainity ~ $(\eta/\beta)^2$

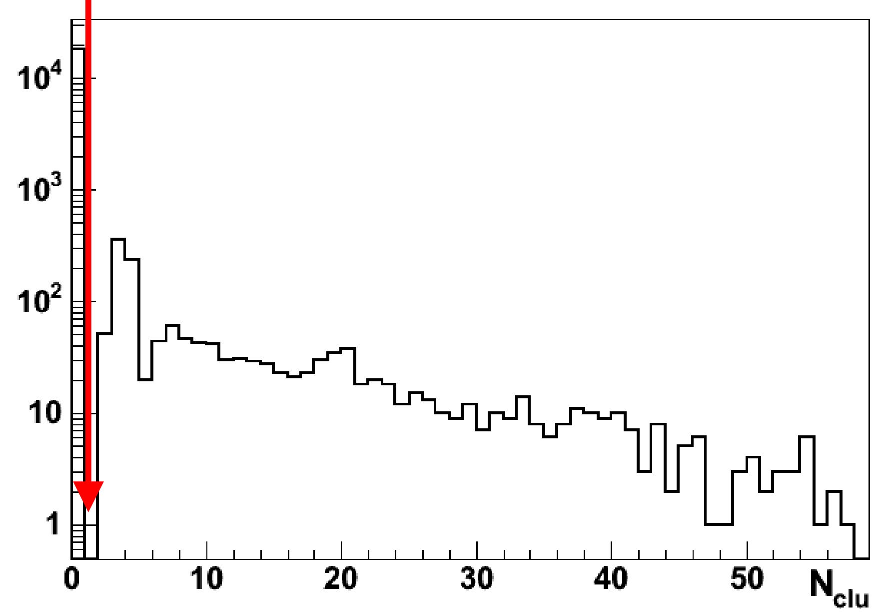
Quality cuts for TRD measurement

TRD track $\chi^2 < 1.5$



$\varepsilon_d = 98.8\%$

no TRD clusters not used in TRD track reconstruction

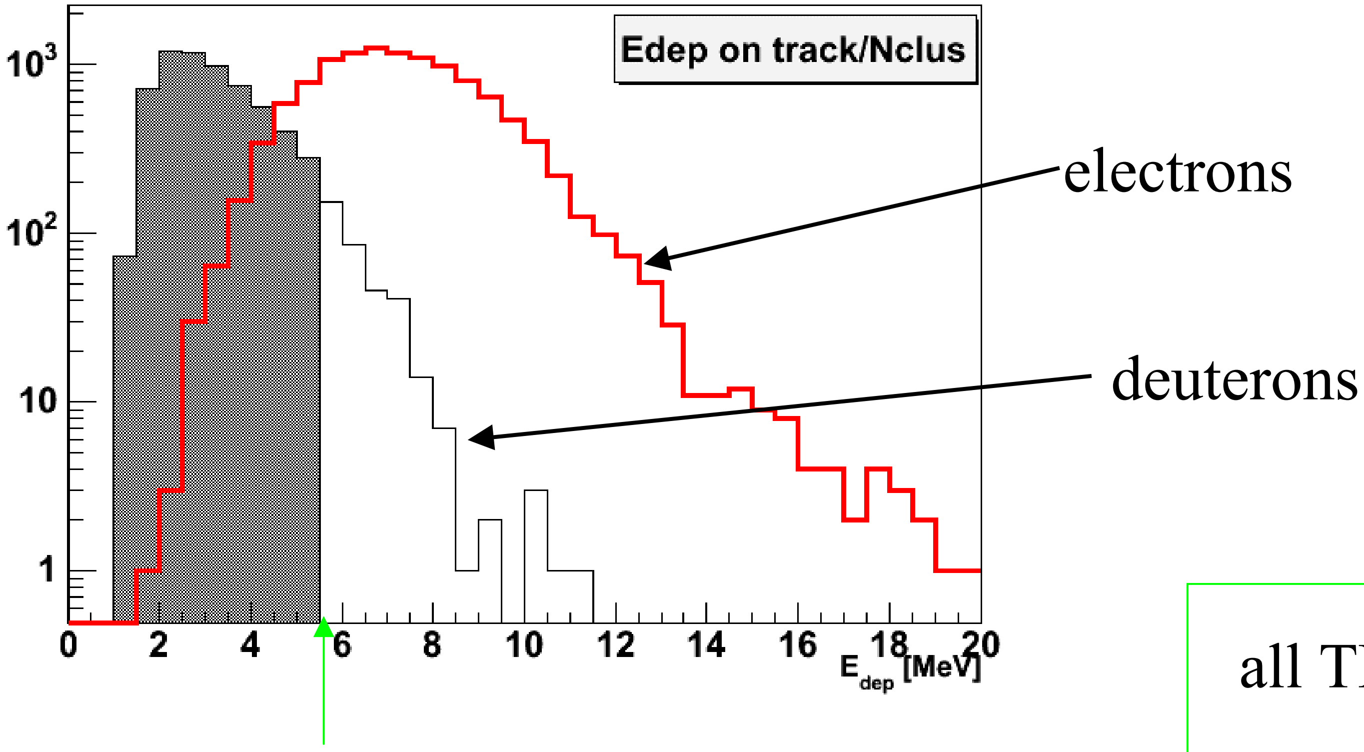


$\varepsilon_d = 92.3\%$

TRD electron ID

energy dposited along the track (TR and dE/dx)

$\varepsilon_d = 92.3\%$



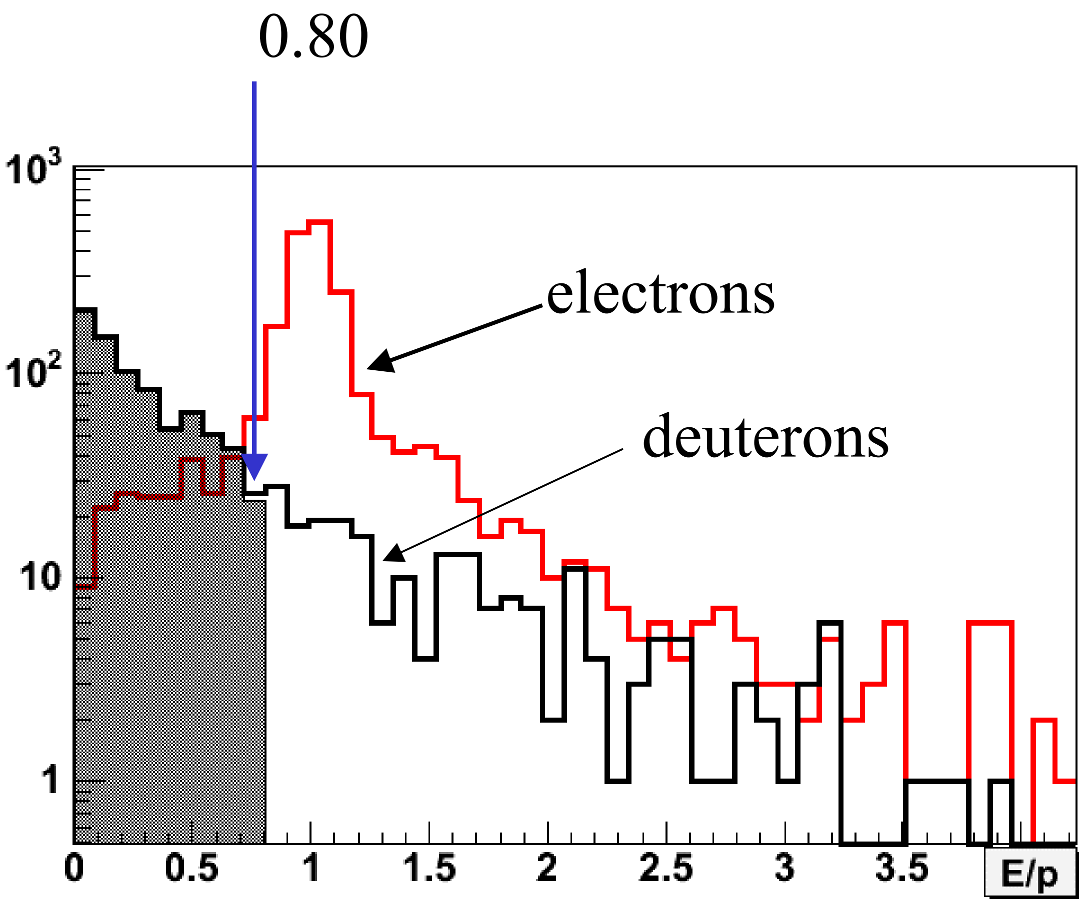
5.5 MeV

all TRD cuts:

87.4%

E_{ECAL}/p_{TRK}

compare energy from ECAL with momentum from TRK



$\varepsilon_d = 96.3\%$

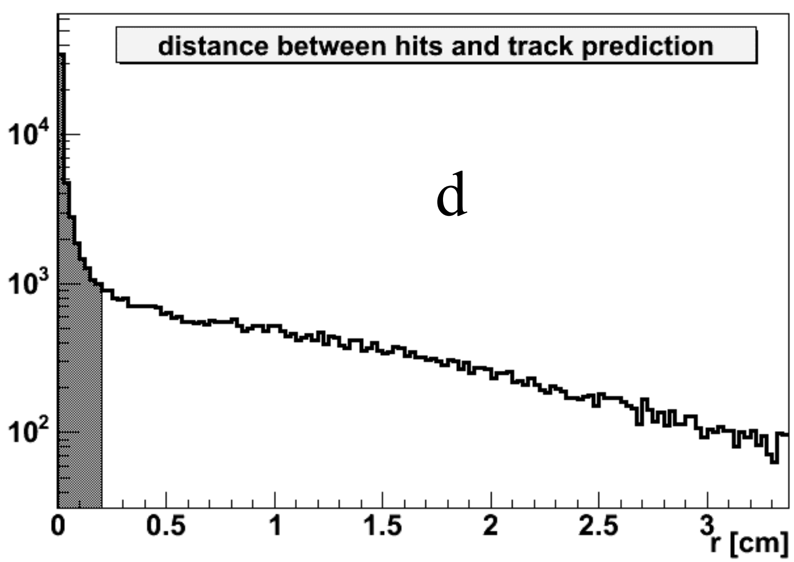
This cut is used only if ECAL shower exists, ie. 16% of deuteron events (for these events efficiency is 77%)

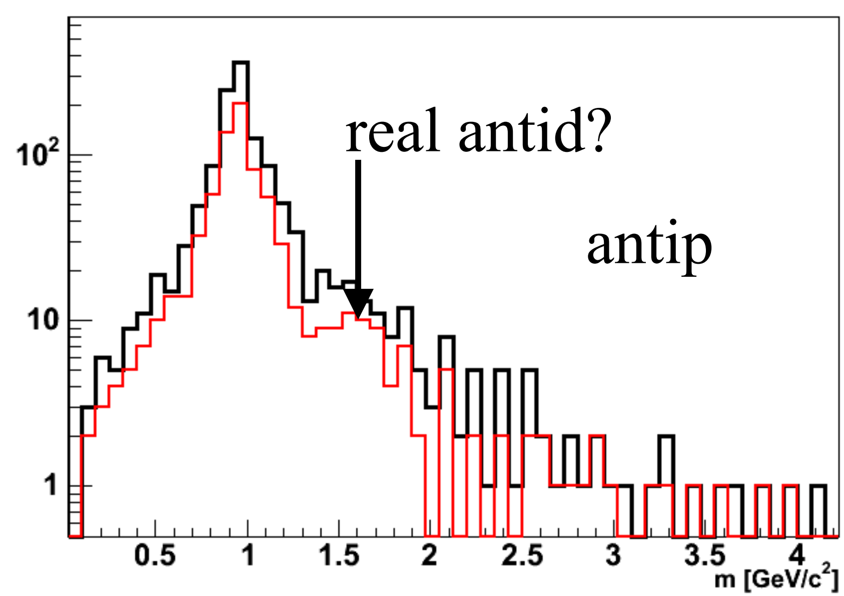
Collinear delta rays

All these cuts are not enought to reject antip background

- we try to remove events with collinear delta rays by asking about maximally one reconstructed hit in r=2 mm around predicted track position in TRK layer.

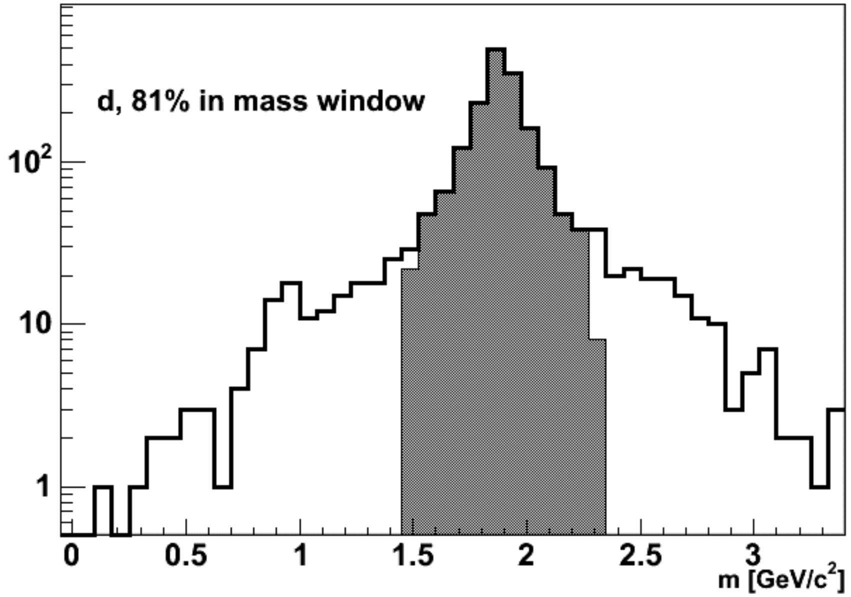
(similar cut was used in AMS-01 antihelium search)

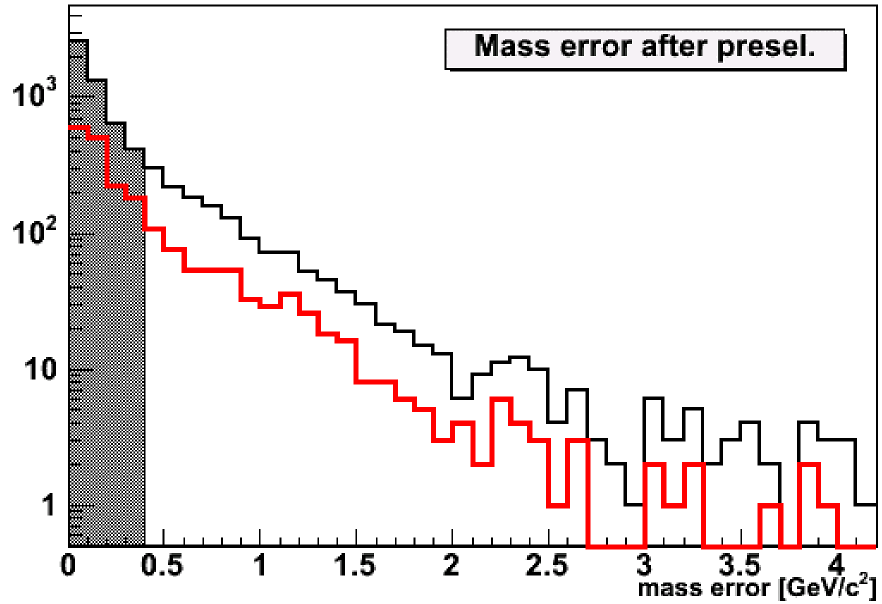




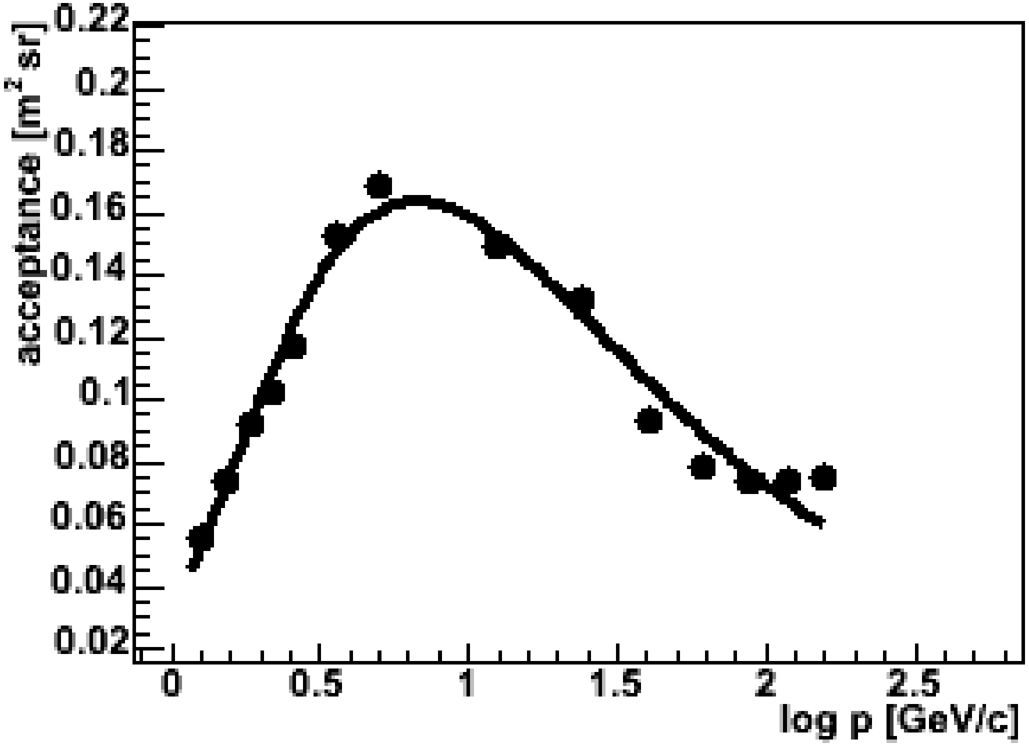
Final cuts

- No of ACC clusters < 2 ε_d = 87.8%
- negative charge ε_d = 100%
- mass window ε_d = 44% (81% of the dist.)
- mass error ε_d = 37% (85% of the dist.)





Final Acceptance



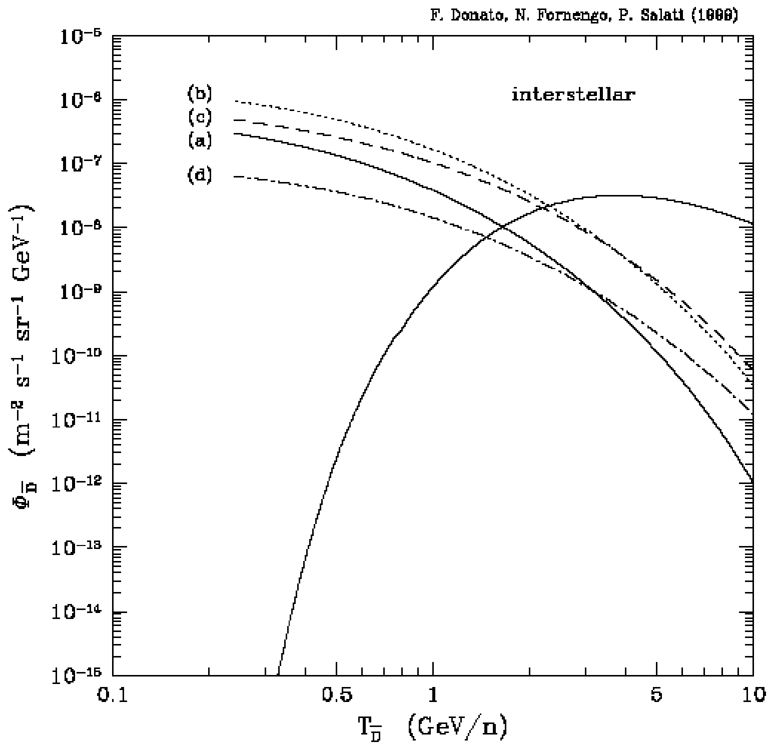
fit $A = p0 \cdot exp\left(-\frac{z + exp(-z)}{2}\right)$ z=(log(mom)-p1)/p2

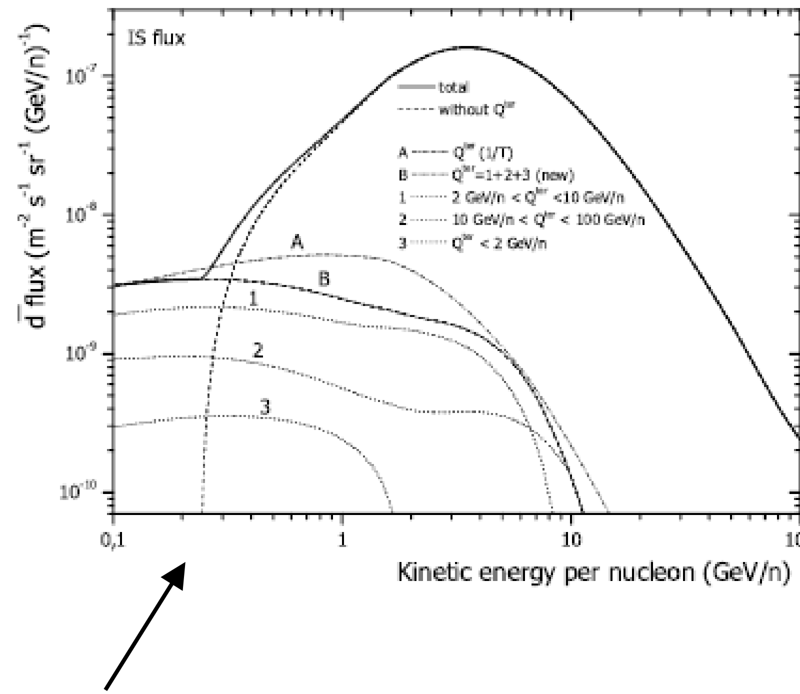
p0 = 0.27, p1 = 0.82, p2 = 0.46

Background rejection

%	d (as bck)	p	e	antip
cuts on β	79	82	75	78
cuts on TRK	82	82	82	86
cuts on TRD	87	80	15	56
cut E/p	96	97	83	87
collinear δ-rays	61	60	57	62
ACC< 2	88	91	78	83
All	32	35	4	19
+neg. charge	$<2*10^{-3}$	$<2*10^{-5}$	4	19
+mass window	$<2*10^{-3}$	$<2*10^{-5}$	0.05	1
+mass error	$<2*10^{-3}$	$<2*10^{-5}$	0.008	0.3

Antideuteron background





PHYSICAL REVIEW D 71, 083013 (2005)

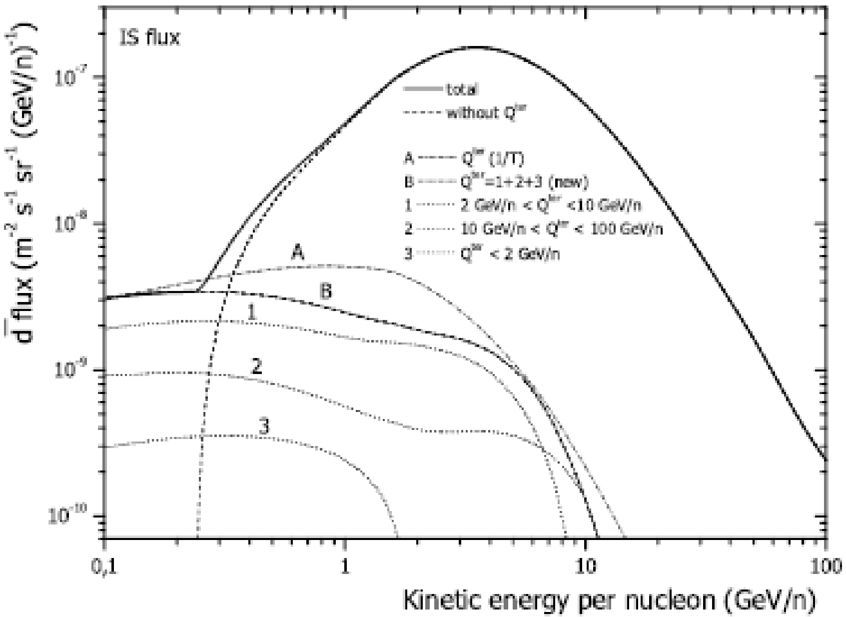
Flux of light antimatter nuclei near Earth, induced by cosmic rays in the Galaxy and in the atmosphere

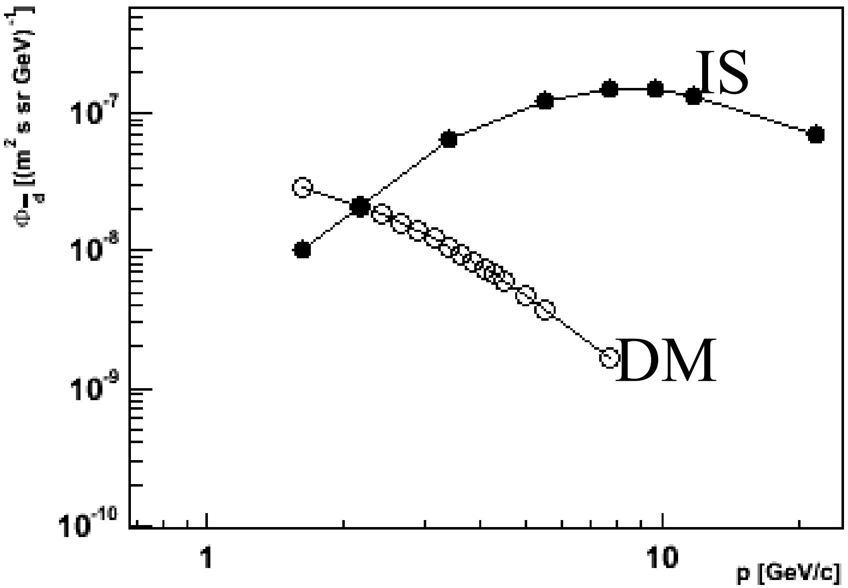
R. Duperray,[1] B. Baret,[1] D. Maurin,[2] G. Boudoul,[1,*] A. Barrau,[1] L. Derome,[1] K. Protasov,[1] and M. Buénerd[1,†]
[1]Laboratoire de Physique Subatomique et de Cosmologie, CNRS/IN2P3, 53 avenue des Martyrs, 38026 Grenoble-cedex, France
[2]Service d'Astrophysique, SAp CEA-Saclay, F-91191 Gif-sur-Yvette CEDEX, France
(Received 18 November 2004; published 26 April 2005)

The fluxes of light antinuclei $A \leq 4$ induced near Earth by cosmic ray interactions with the interstellar matter in the Galaxy and with the Earth's atmosphere are calculated in a phenomenological framework. The hadronic production cross section for antinucleons is based on a recent parametrization of a wide set of accelerator data. The production of light nuclei is calculated using coalescence models. For the standard

Example of Dark Matter signal

$m_{1/2}$=450 GeV,m_0=300 GeV, tgβ=50





$\int A(p)\Phi(p)dp \bullet \Delta T =$ **8 (IS)**

$= 0.3$ (DM)

(ΔT = 3 years)

Contamination of backgrounds

Estimation: after 3 years the amount of backgrounds which pass the cuts is at the level of $3 \bullet 10^3$ for antip and 10^2 for electrons. From MC statistics we can say that contamination of deuterons is less than 10 and protons less than 10^3.

Better cuts are needed, ideas?

more severe cuts on β quality

more severe cuts on momentum reconstruction?

better mass estimation?

another?

Summary

- acceptance calculated, max around 2 GeV
- cuts developed, but low rejection for backgrounds
- estimation for deuterons: about 10 from spallation processes will be registered
- Dark Matter signal – rather weak
- background contamination is very high

  - better rejection cuts are needed