Search for Cosmic-Ray Antideuterons with BESS-Polar II

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For BESS collaboration

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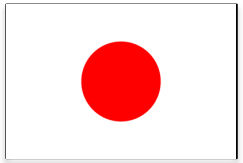
THE ASTROPARTICLE PHYSICS CONFERENCE

1 BESS collaboration

BESS is US-Japan collaborative program.



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National Aeronautical and Space Administration / Goddard Space Flight Center (NASA/GSFC)

High Energy Accelerator Research Organization (KEK)

The University of Tokyo

University of Maryland

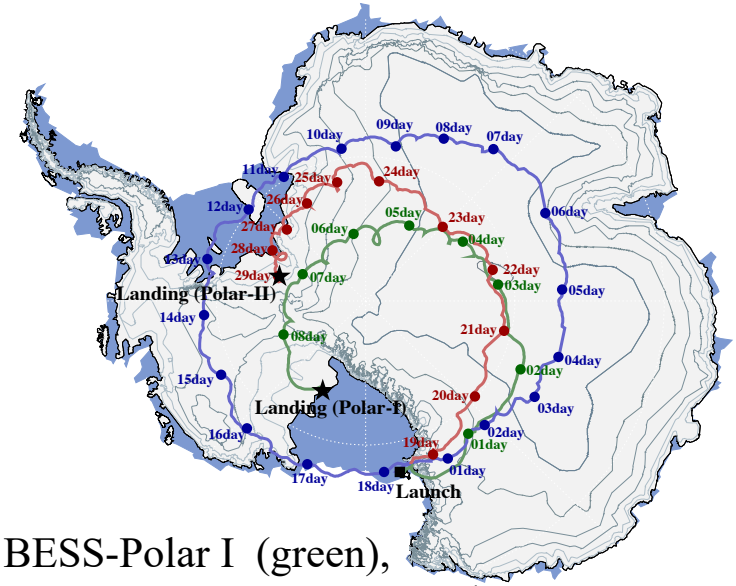
Kobe University

University of Denver (Since June 2005)

Institute of Space and Astronautical Science/JAXA

2 BESS-Polar I and II experiment

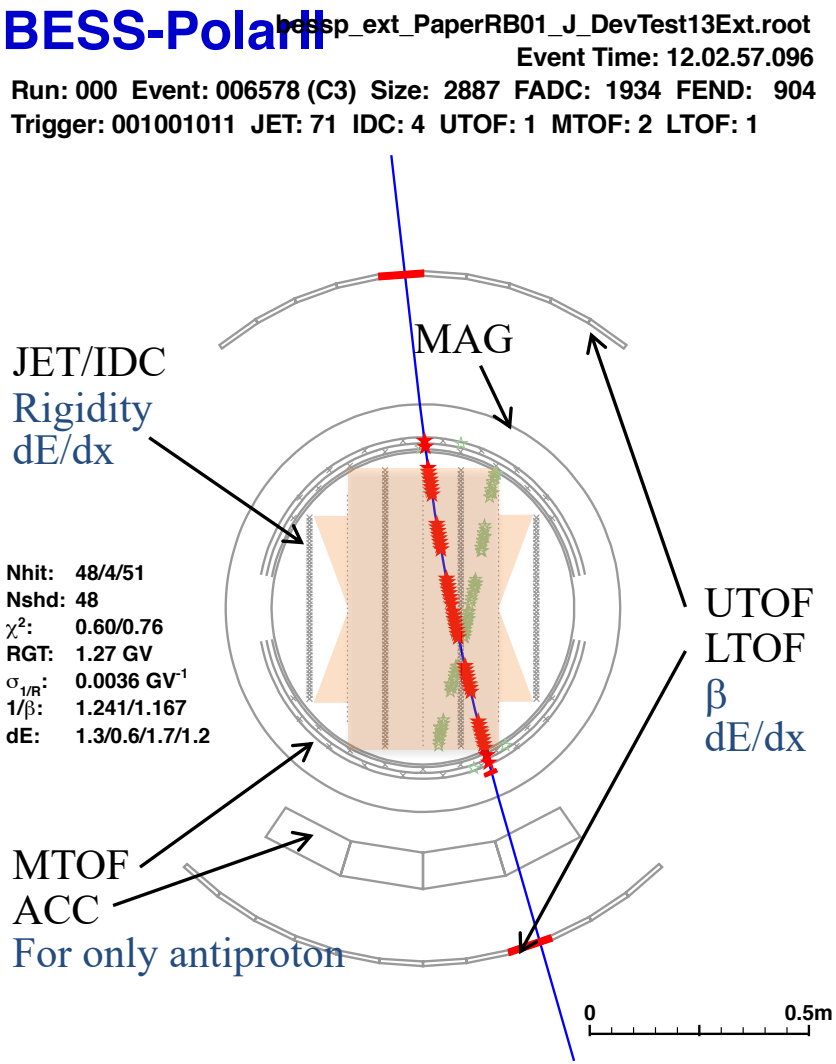
BESS-Polar I & II flights were carried out over Antarctica.



BESS-Polar I (green),
BESS-Polar II (1st :blue, 2nd :red)

	BESS-Polar I	BESS-Polar II
Launch date	Dec. 13th ,2004	Dec. 23rd , 2007
Observation time	8.5 days	24.5 days
Cosmic-ray observed	9 x 10^8 events	4.7 x 10^9 events
Flight altitude	37~39km (5~4g/cm^2)	~36km (6~5g/cm^2)

3 BESS spectrometer



Event display with reconstructed proton track is shown.

Rigidity (MDR:200GV)

Solenoid: Uniform field (ϕ=0.9m, B=0.8T)
Thin material (2.4 g/cm^2/wall)

Drift chamber: Redundant hits
(σ~150μm, 32~48+4hits)

Charge, Velocity

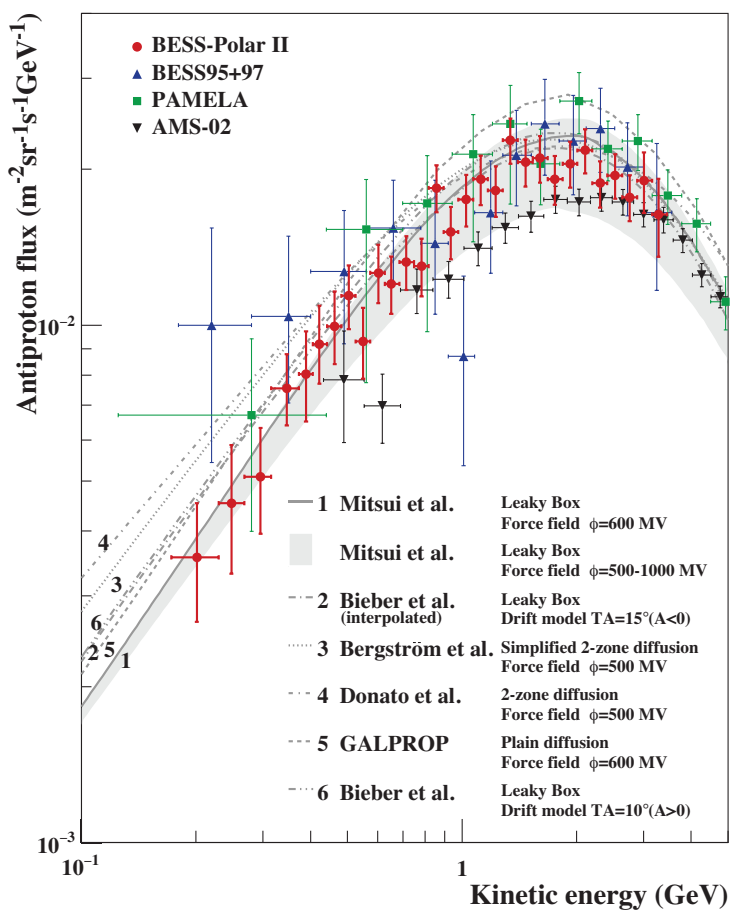
TOF, Chamber: dE/dx measurement
(Z = 1, 2, ...)

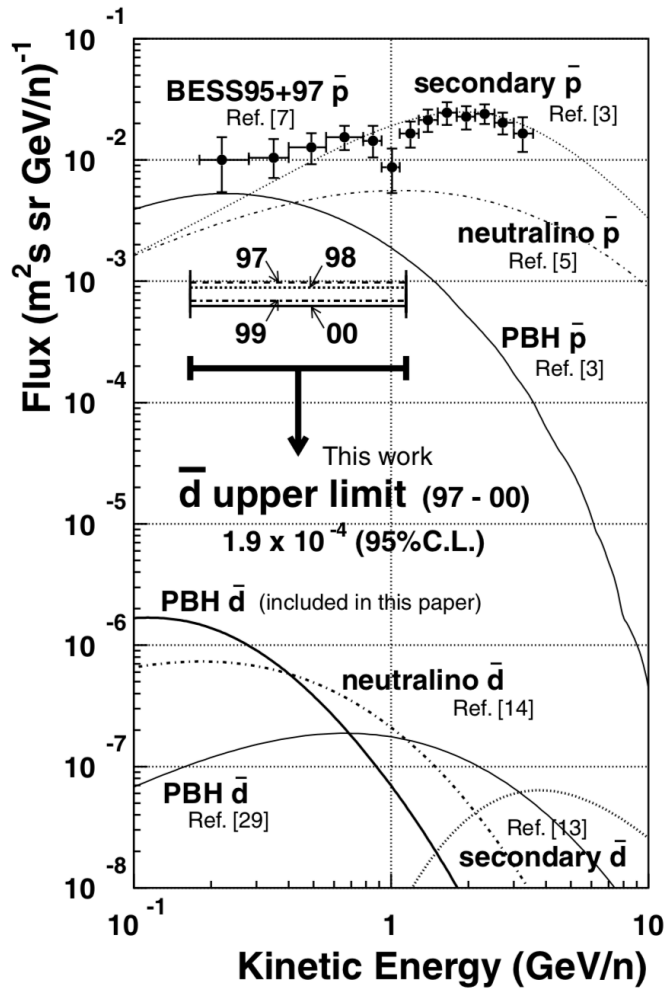
TOF: 1/β measurement (σ~1,2%)

$$m = ZeR\sqrt{1/\beta^2 - 1}$$

4 Why does antideuteron search probe possible exotic sources?

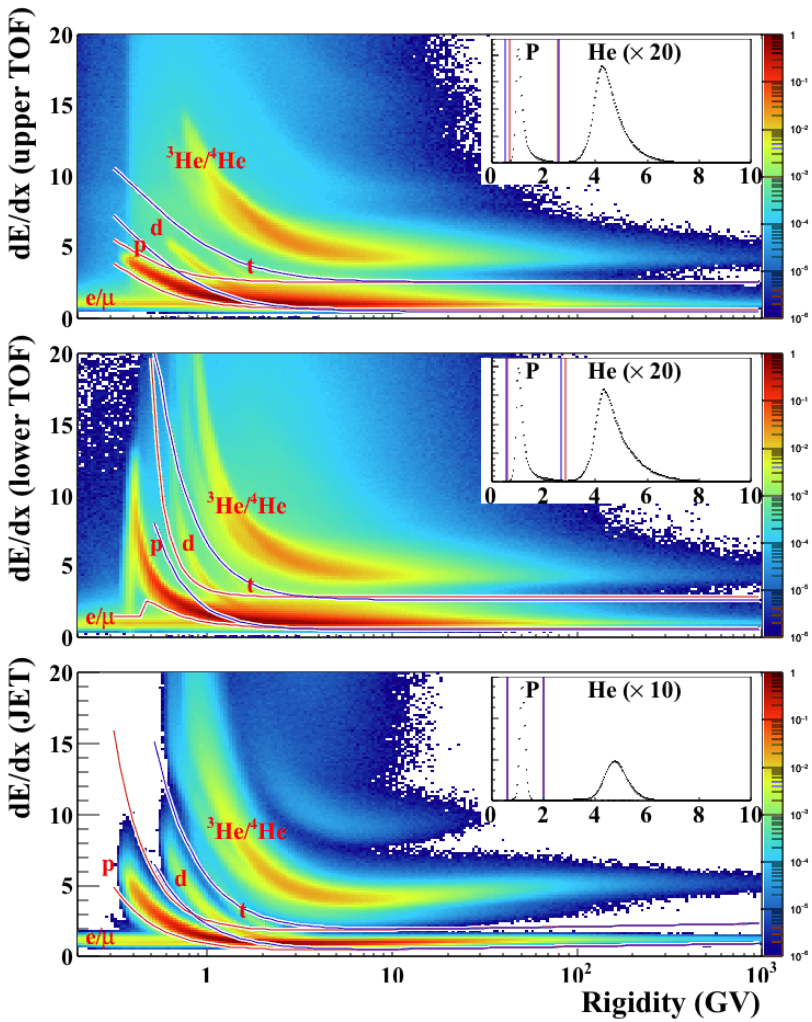
Antiproton	Antideuteron
BESS-Polar II PRL 108, 051102 (2012)	BESS 97-00 PRL 95, 081101 (2005)



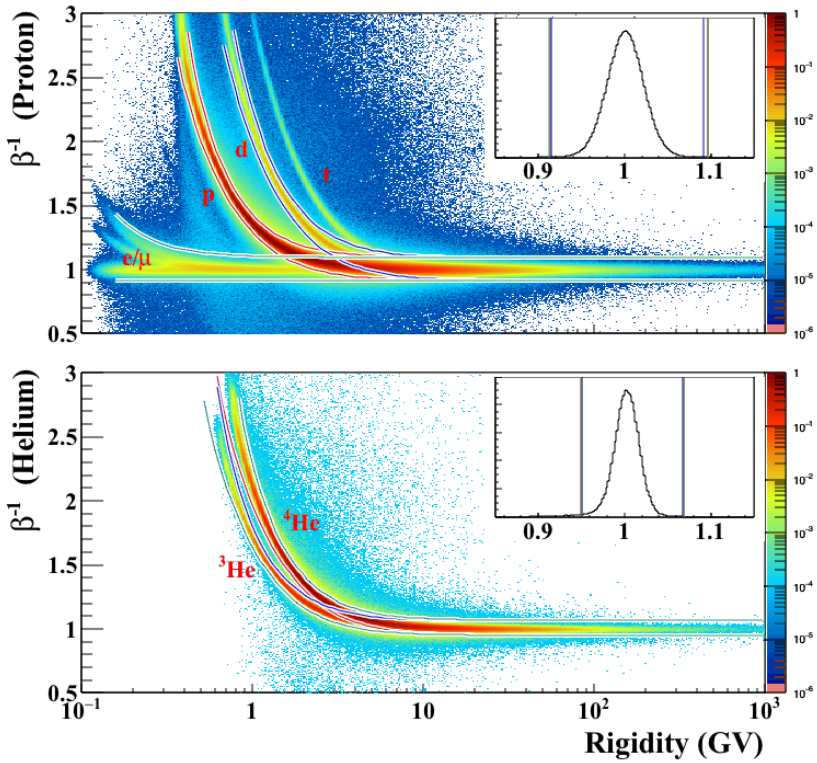


5 Particle identification

dE/dx

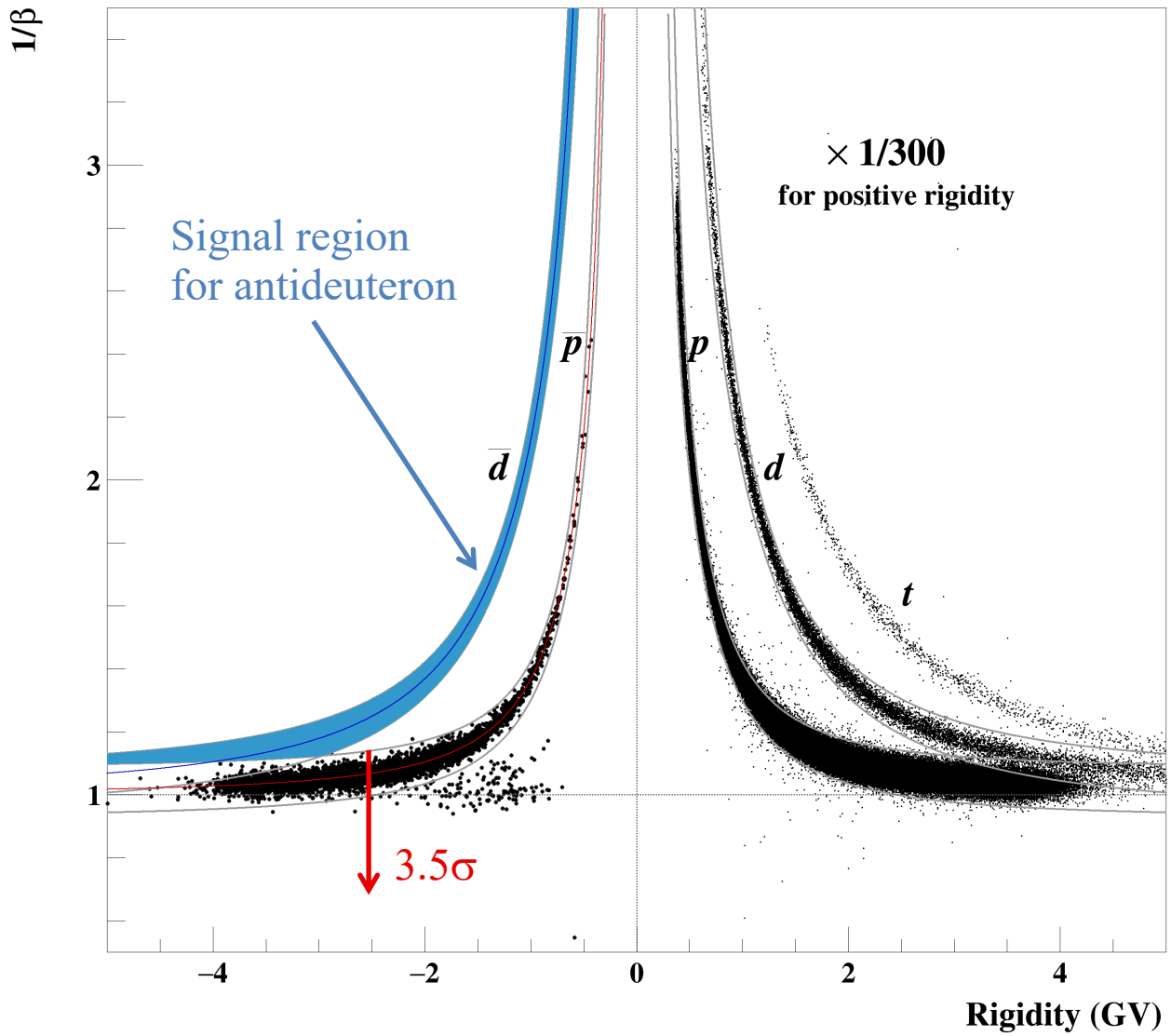


1/β



6 Antideuteron search

The $1/\beta_{UL}$ VS rigidity plot



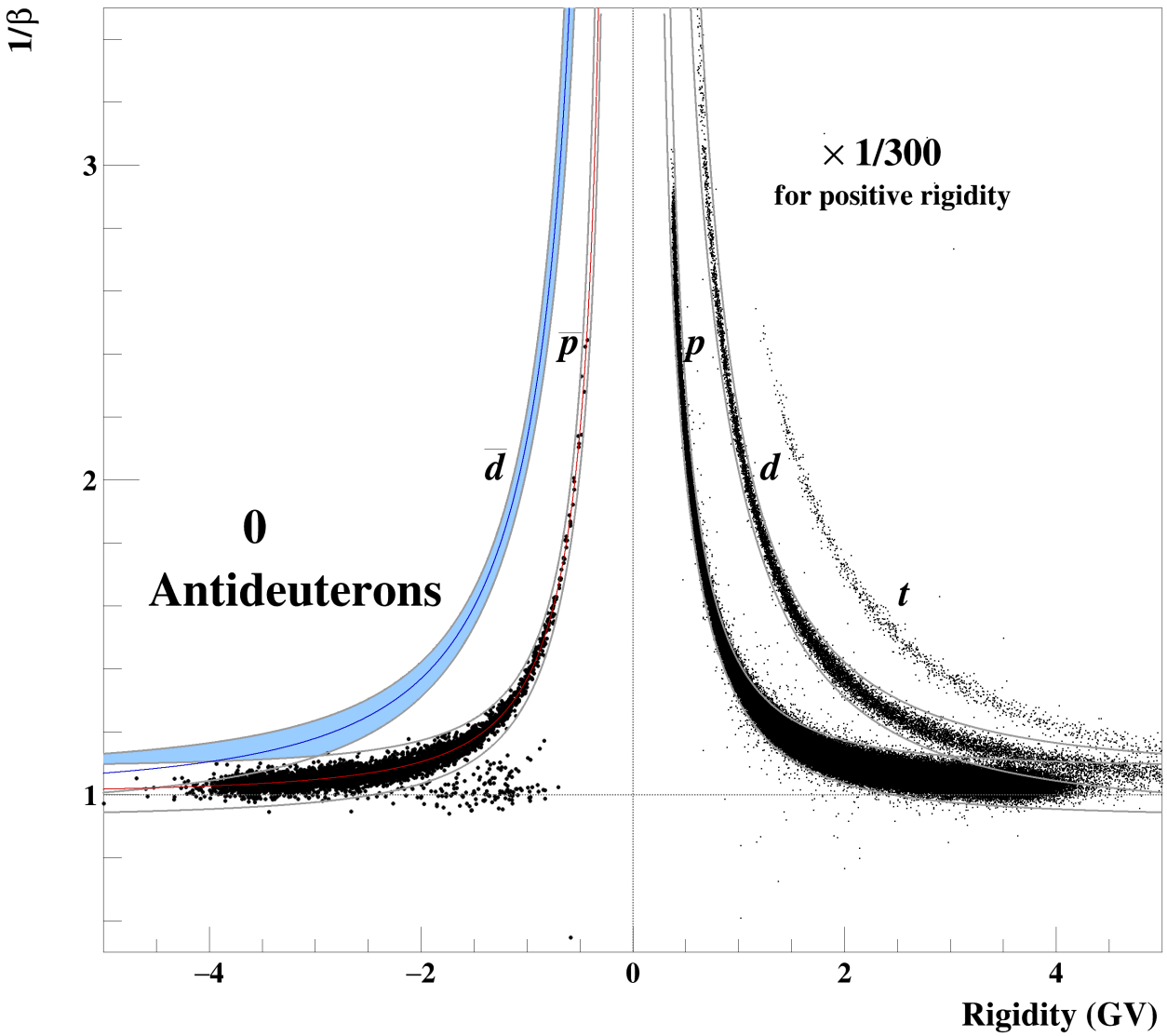
The $1/\beta_{UL}$ VS rigidity plot and antideuteron's selection band.

- Signal region for antideuteron

Excluding 3.5σ region from antiproton center to prevent antiproton contamination

7 Antideuteron search

The $1/\beta_{UL}$ VS rigidity plot



The $1/\beta_{UL}$ VS rigidity plot and antideuteron's selection band.

- Signal region for antideuteron

  Excluding 3.5σ region from antiproton center to prevent antiproton contamination

- No antideuteron candidate in BESS-Polar II data

8 Upper limit calculation

$$\Phi_{\bar{d}}\, dE = \frac{N_{obs}}{S\Omega \cdot T_{live}} \frac{1}{\varepsilon_{single} \cdot \varepsilon_{Q-ID}} \frac{1}{\eta} \frac{1}{(1-\delta_{sys})}$$

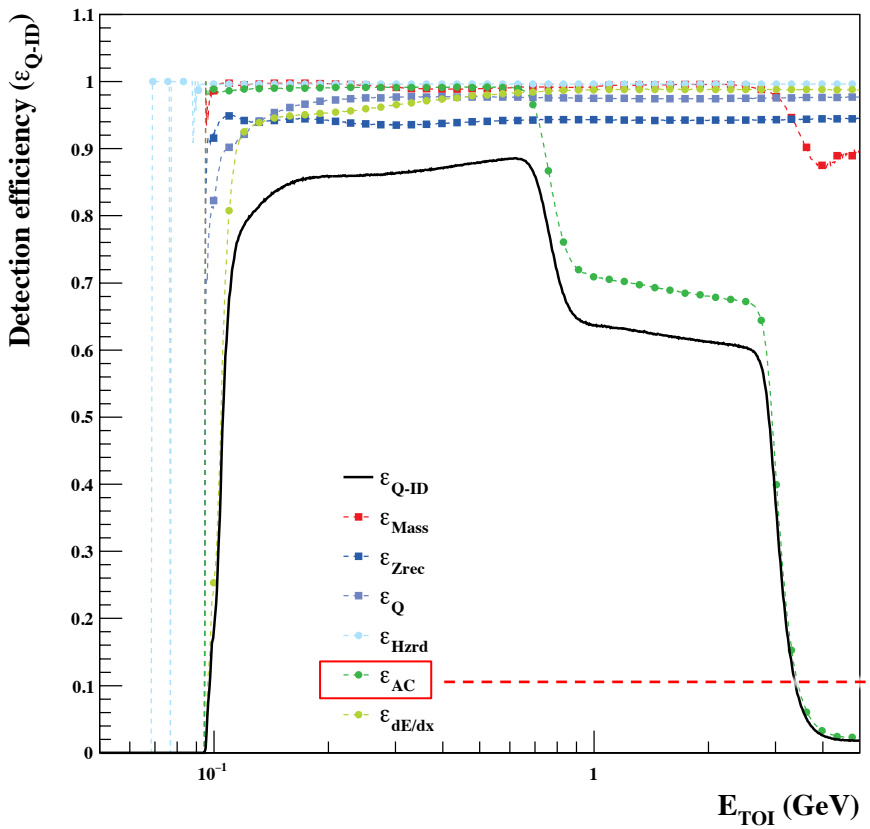
N_{obs} : Number of Observed candidate = 3.1
$S\Omega$: Geometrical acceptance
T_{live} : Live time
ε_{single} : Single track efficiency
ε_{Q-ID} : Detector selection efficiencies
η : Survival fraction through atmosphere
δ_{sys} : Systematic error

- Since no antideuteron was found, 3.1 was taken as the number of the observed antideuteron events for the calculation of 95% C.L. upper limit.
- In order to obtain the most conservative limit, the minimum value of the effective exposure factors ($S\Omega \cdot T_{live} \cdot \varepsilon_{single} \cdot \varepsilon_{Q-ID} \cdot \eta$) was used.

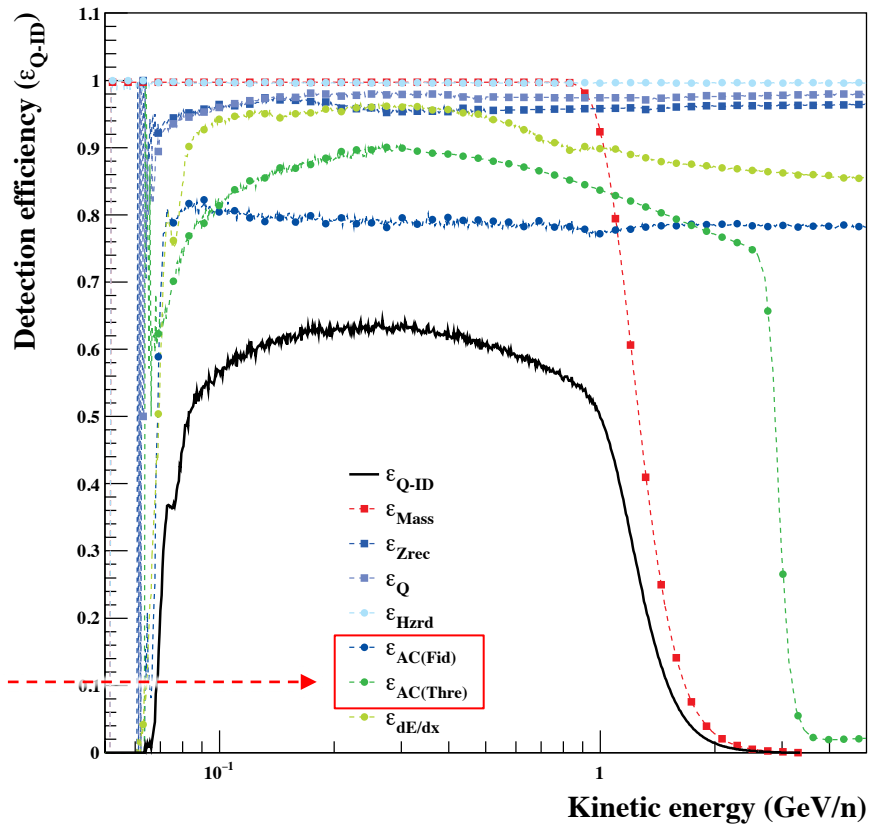
9 Detector efficiencies

$$\Phi_{\bar{d}}\, dE = \frac{N_{obs}}{S\Omega \cdot T_{live}} \frac{1}{\varepsilon_{single} \cdot \varepsilon_{Q-ID}} \frac{1}{\eta} \frac{1}{(1-\delta_{sys})}$$

Pbar



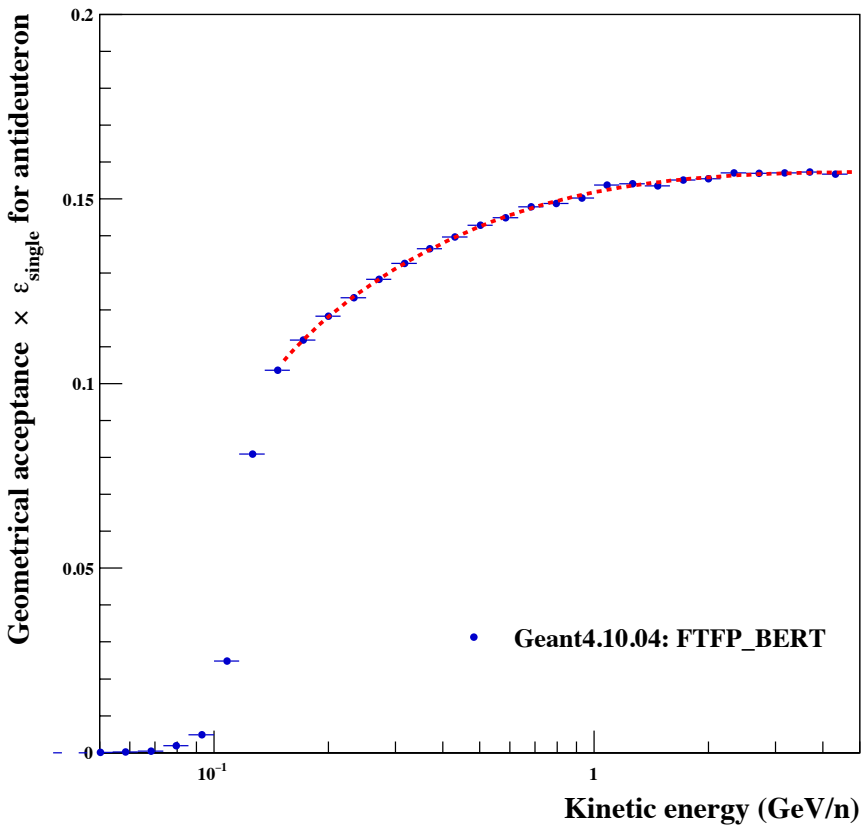
Dbar



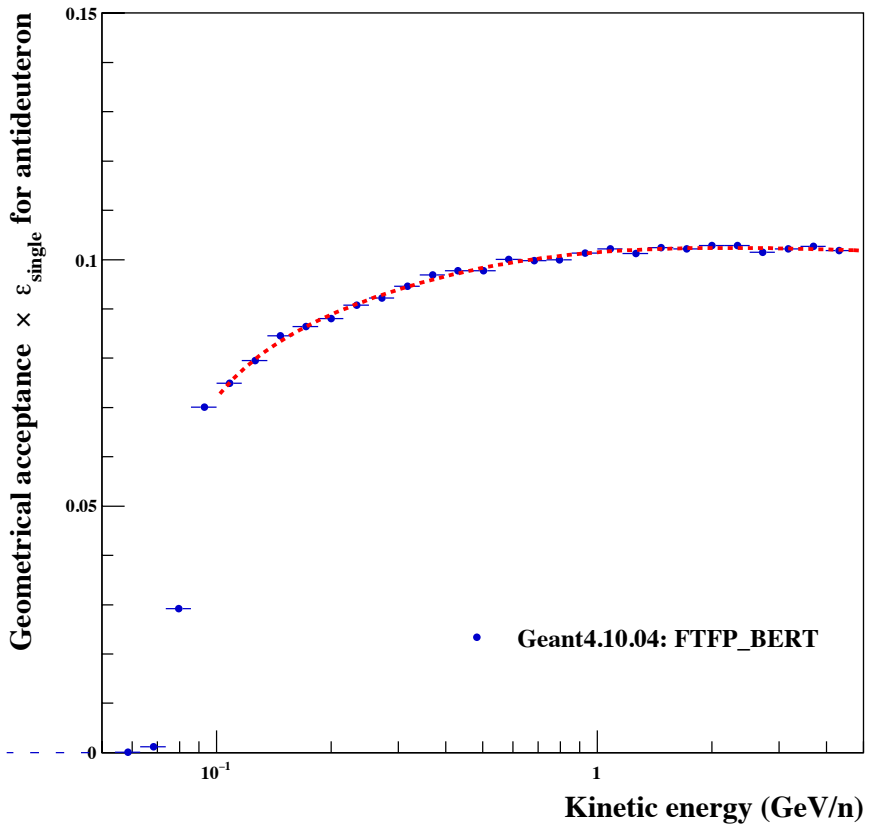
10 Geometrical acceptance x ε_{single}

$$\Phi_{\bar{d}}\, dE = \frac{N_{obs}}{S\Omega \cdot T_{live}} \frac{1}{\varepsilon_{single} \cdot \varepsilon_{Q-ID}} \frac{1}{\eta} \frac{1}{(1-\delta_{sys})}$$

Pbar

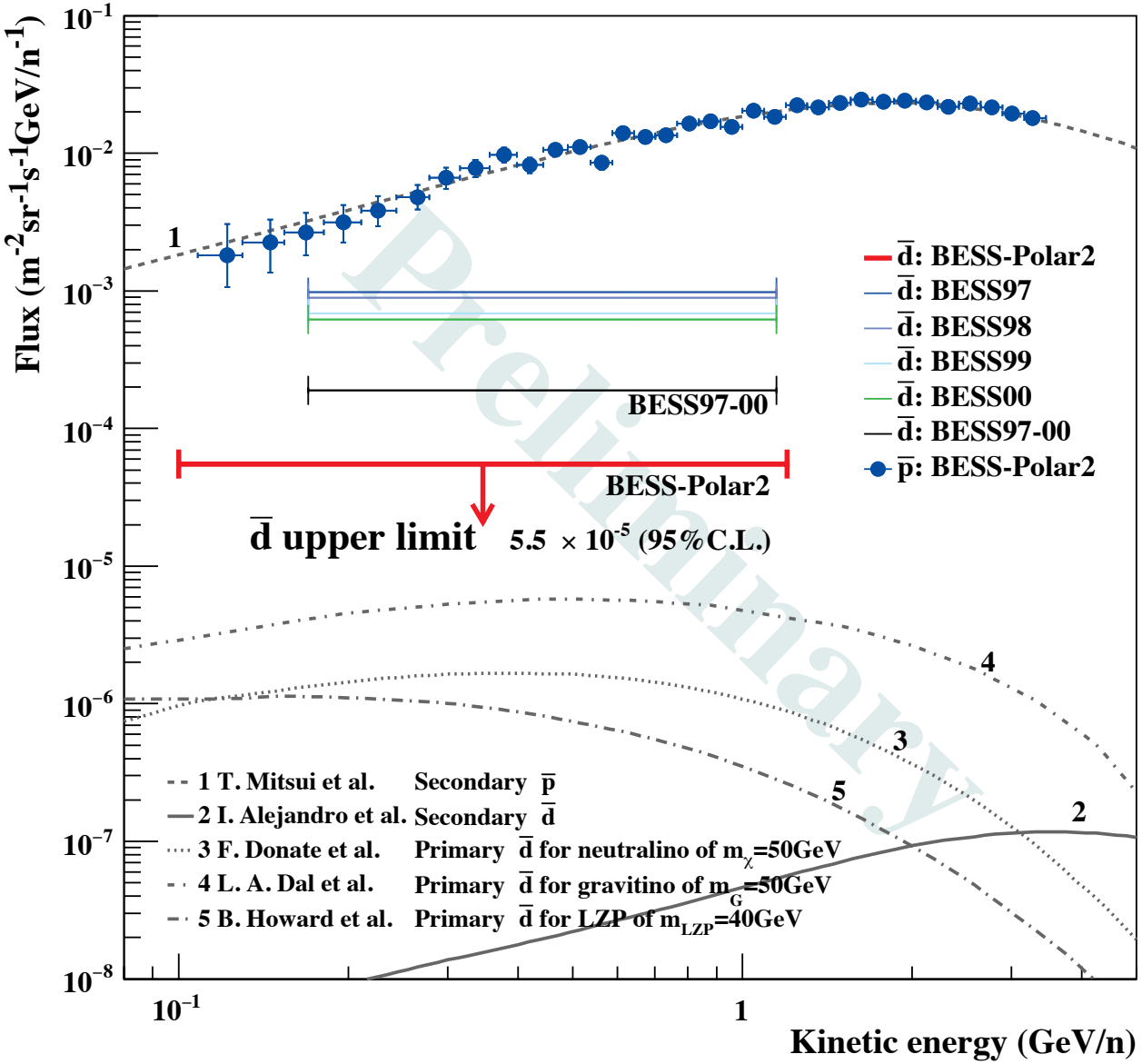


Dbar



11 Upperlimit of Antideuteron flux

$$\Phi_{\bar{d}}\, dE = \frac{N_{obs}}{S\Omega \cdot T_{live}} \frac{1}{\varepsilon_{single} \cdot \varepsilon_{Q-ID}} \frac{1}{\eta} \frac{1}{(1-\delta_{sys})}$$



Upper limit on antideuteron flux measured by BESS-Polar II together with earlier published BESS97-00 antideuteron upper limit

J(d) < 5.5 x 10^{-5} $(m^2 sr\ sec\ GeV/n)^{-1}$ (95%C.L.)

- Compared with the data taken in the solar minimum (BESS97), order of magnitude improvement has been achieved.

12 Summary

Antideuteron search

- No antideuteron candidate in BESS-Polar II.

- New upper limit $J(d) < 5.5 \times 10^{-5}$ $(m^2 sr\ sec\ GeV/n)^{-1}$ (95%C.L.)
  - 3.1 was taken as the number of the observed antideuteron events for the calculation of 95% C.L. upper limit.
  - In order to obtain the most conservative limit, the effective exposure factors was reduced by using with the systematic error (dsys = ~4%).

- Compared with the data taken in the solar minimum (BESS97), order of magnitude improvement has been achieved.