New result of Antideuteron search in BESS-Polar II

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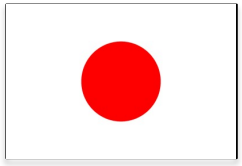
For BESS collaboration

1 BESS collaboration

BESS is US-Japan collaborative program.

J. W. Mitchell (PI, US, NASA/GSFC)



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

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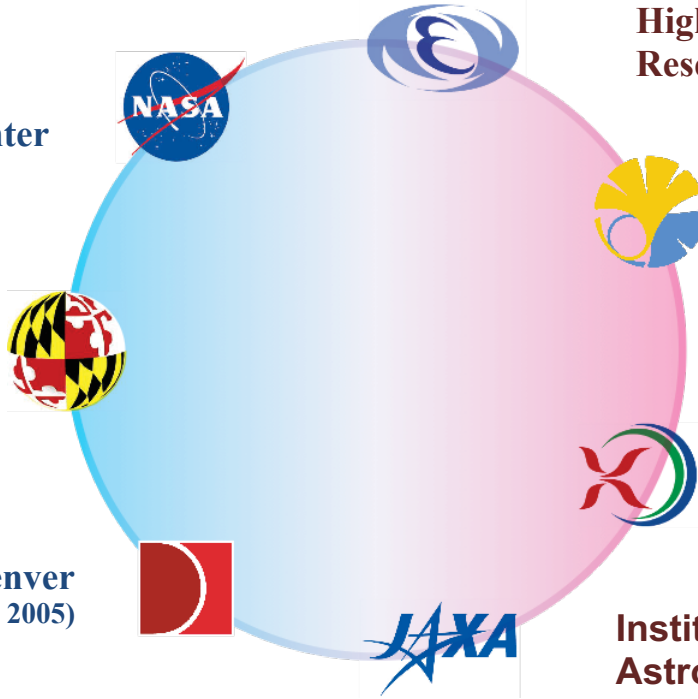


High Energy Accelerator Research Organization (KEK)

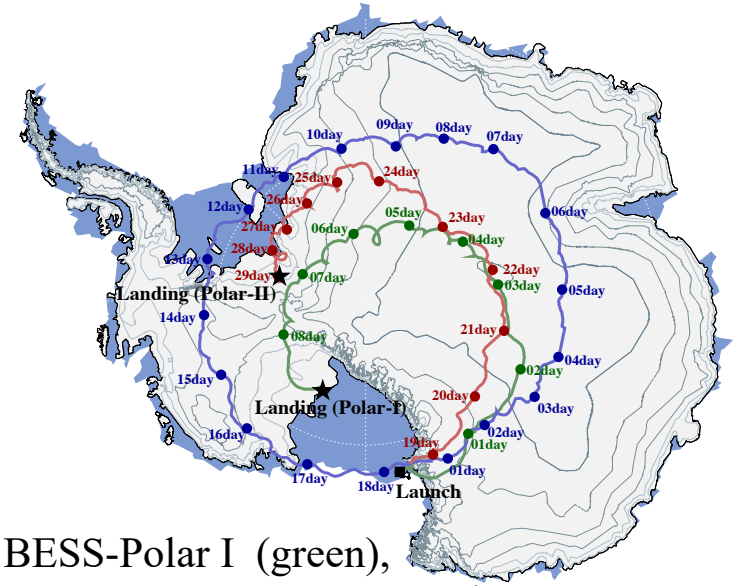
The University of Tokyo

Kobe University

Institute of Space and Astronautical Science/JAXA

2 BESS-Polar I and II experiment

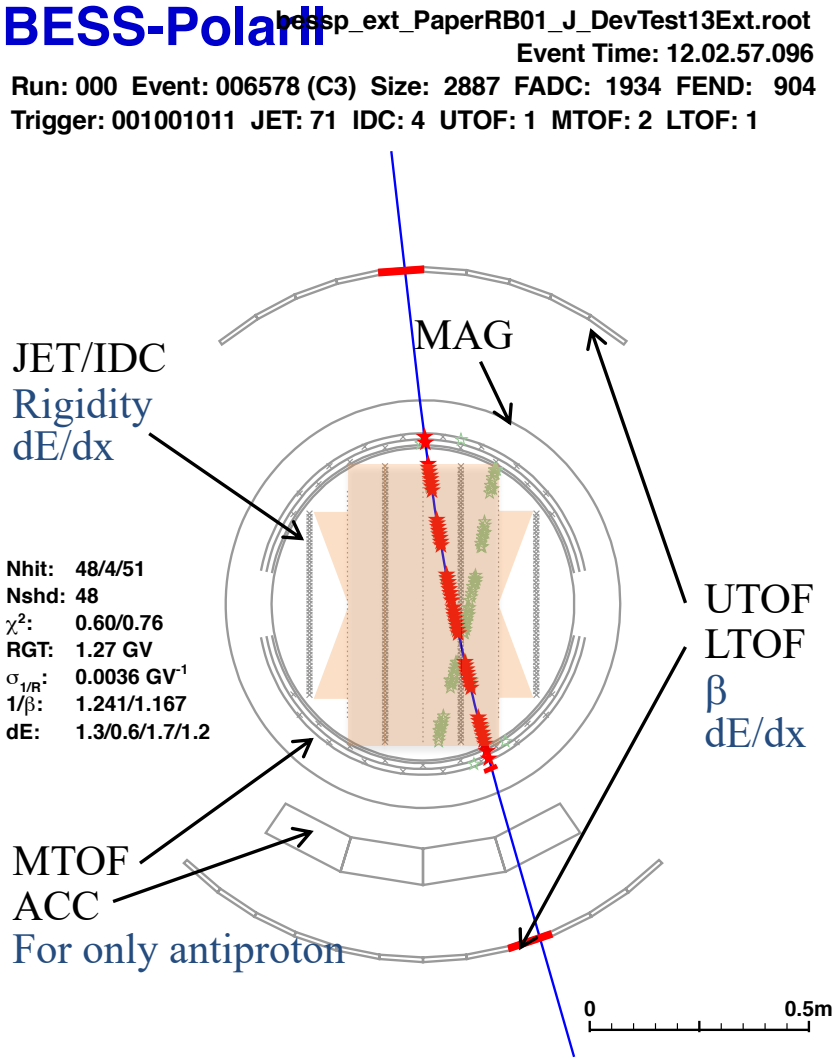
BESS-Polar I & II flights were carried out over Antarctica.



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

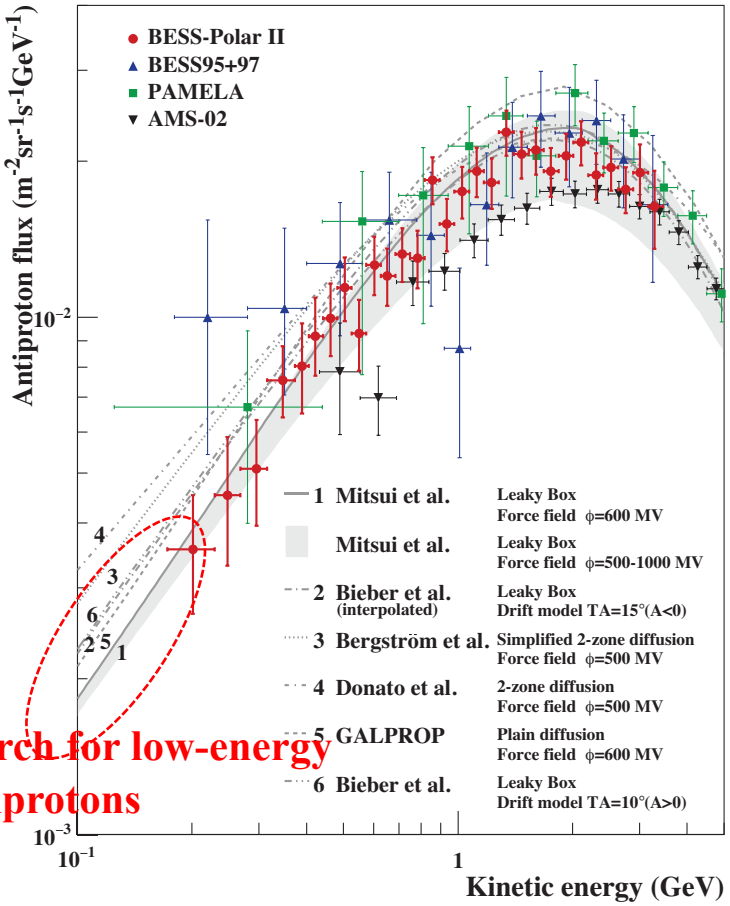
TOF, Chamber: dE/dx measurement
(Z = 1, 2, ...)

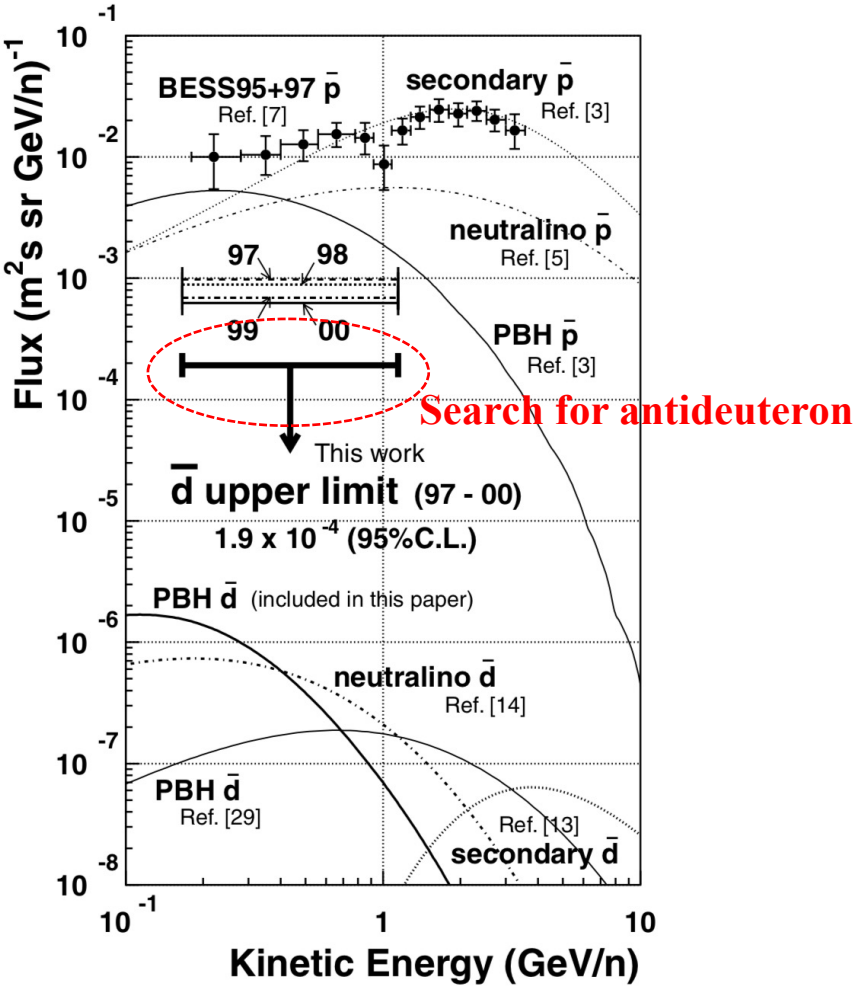
TOF: 1/β measurement (σ~1,2%)

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

4 Which particles are good probes for searching exotic sources?

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



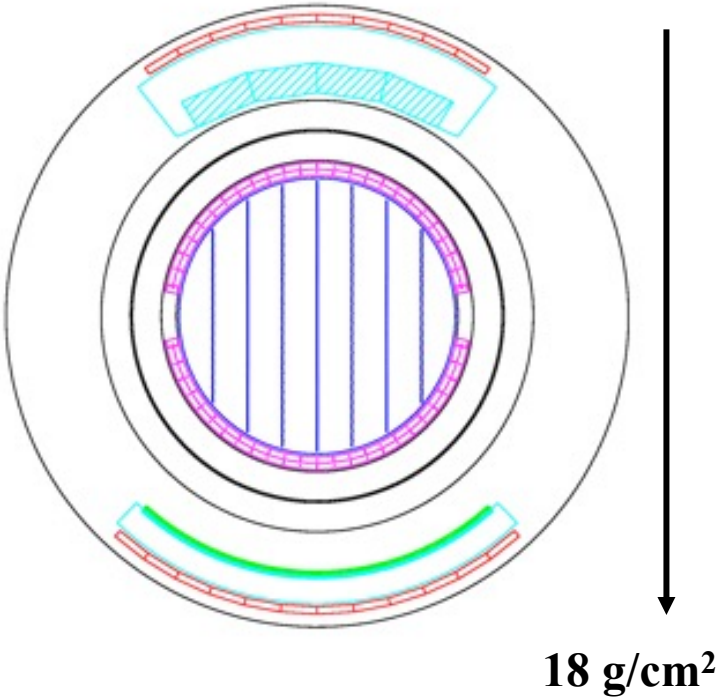


Very-low energy antiproton spectrum

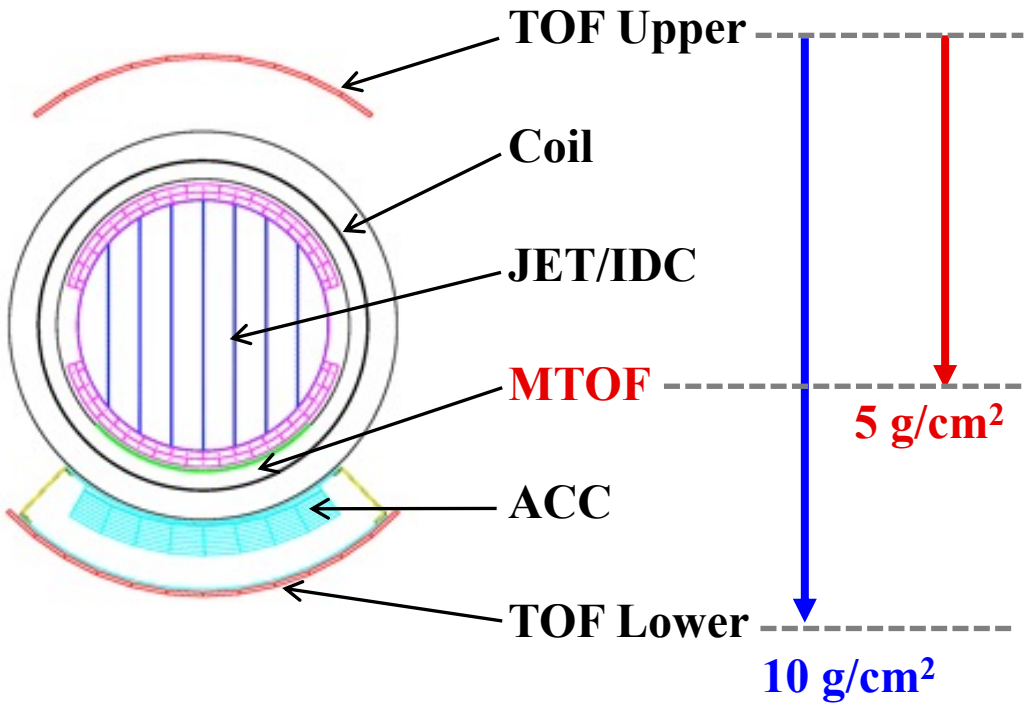
5 Minimizing Material in particle path

To minimize material in spectrometer: New detector (Middle TOF)

BESS-2000



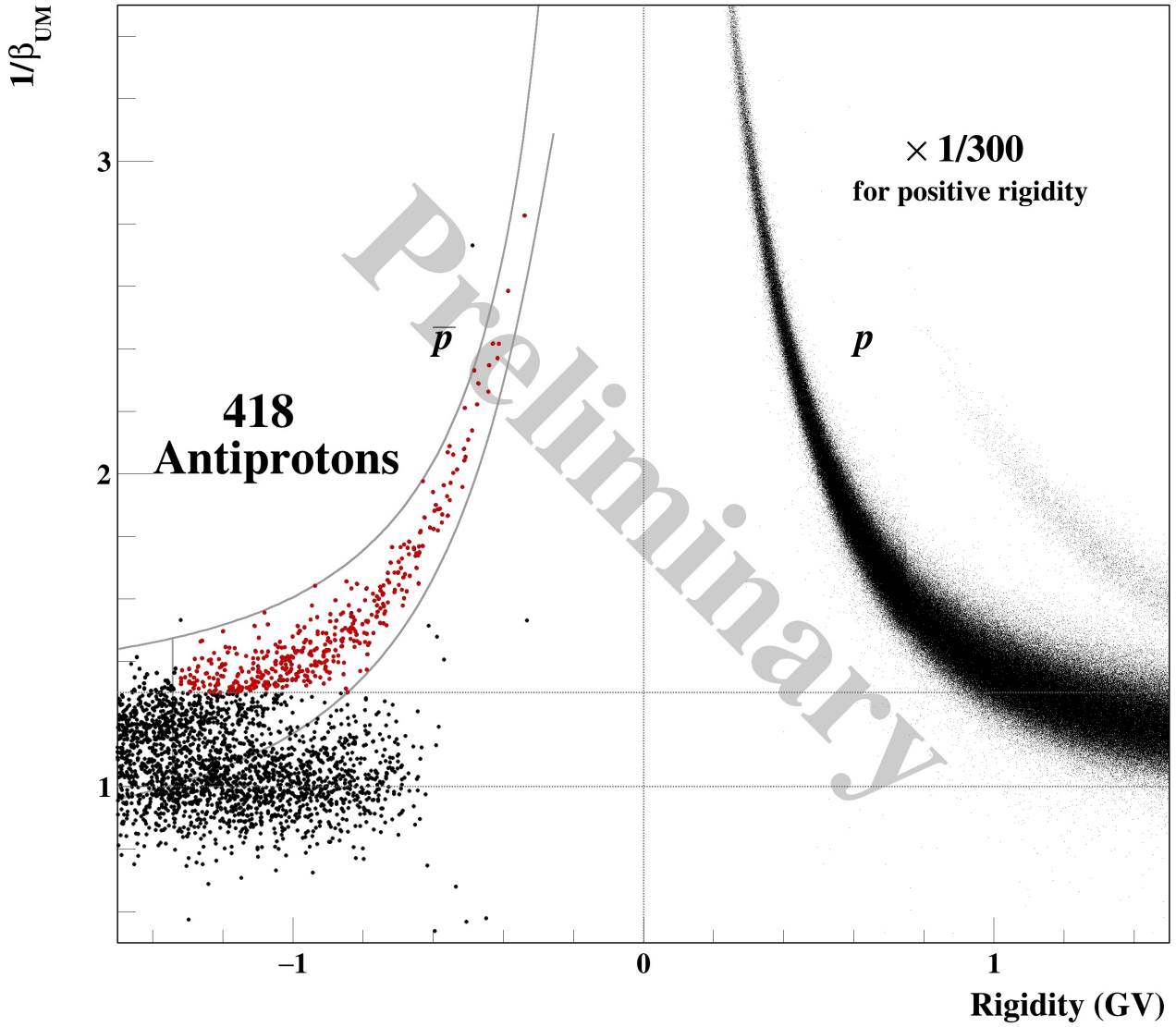
BESS-Polar



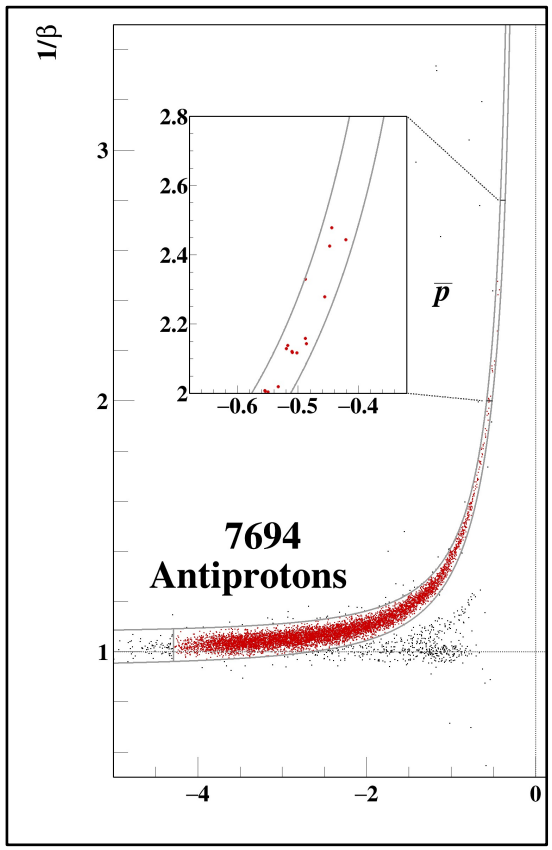
MTOF extends the energy range down to about 0.1 GeV.

6 Antiproton identification

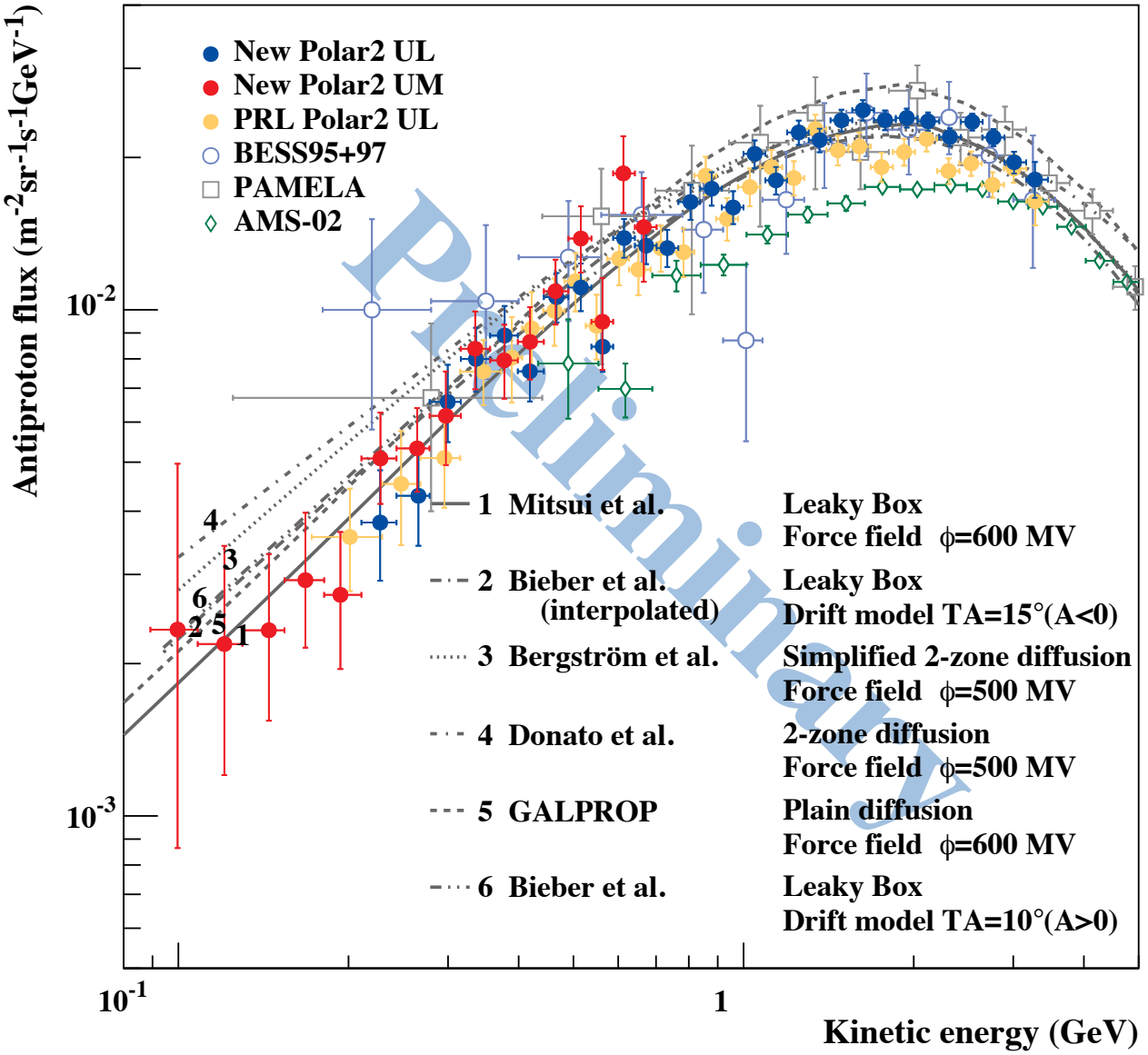
The $1/\beta_{UM}$ VS rigidity plot



Ref: $1/\beta_{UL}$ VS rigidity



7 Antiproton flux with UTOF-MTOF trigger events



New UM and UL absolute differential energy spectra of antiprotons measured by BESS-Polar II together with earlier published BESS-Polar II UL antiproton spectrum

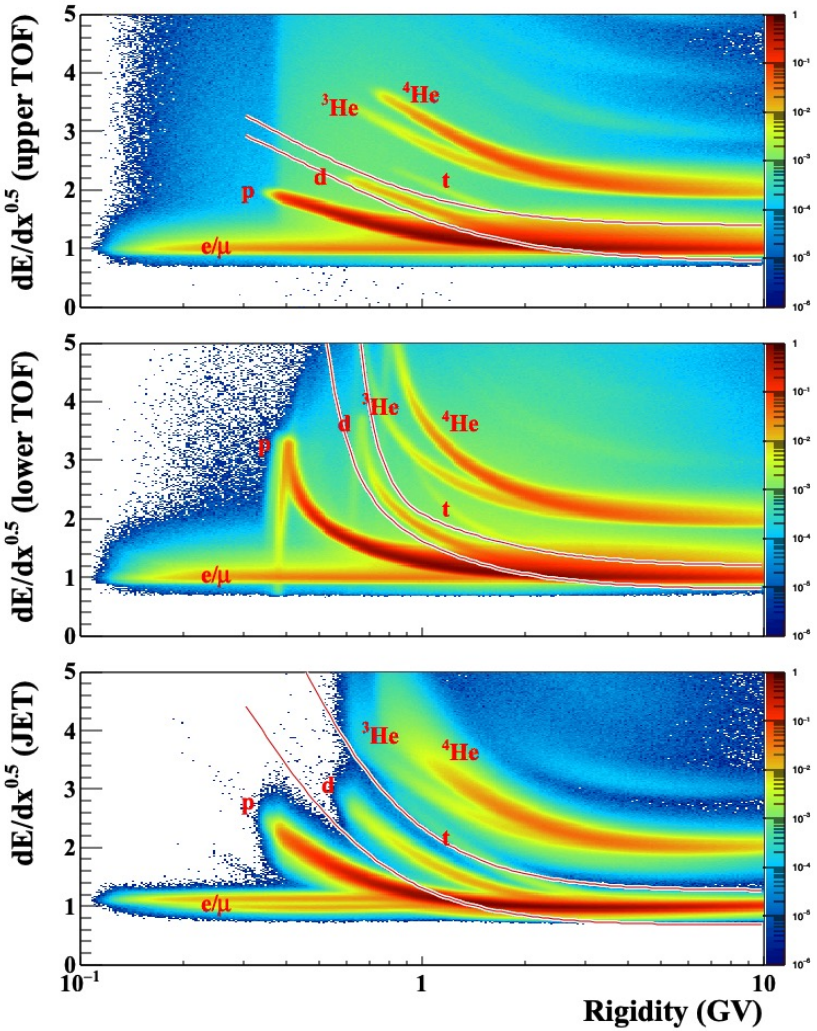
- UL antiproton flux: 0.2-3.5 GeV
- UM antiproton flux: 0.1-0.7 GeV

A systematic shift in antiproton flux was introduced by modified acceptance of Geant3 to Geant4.

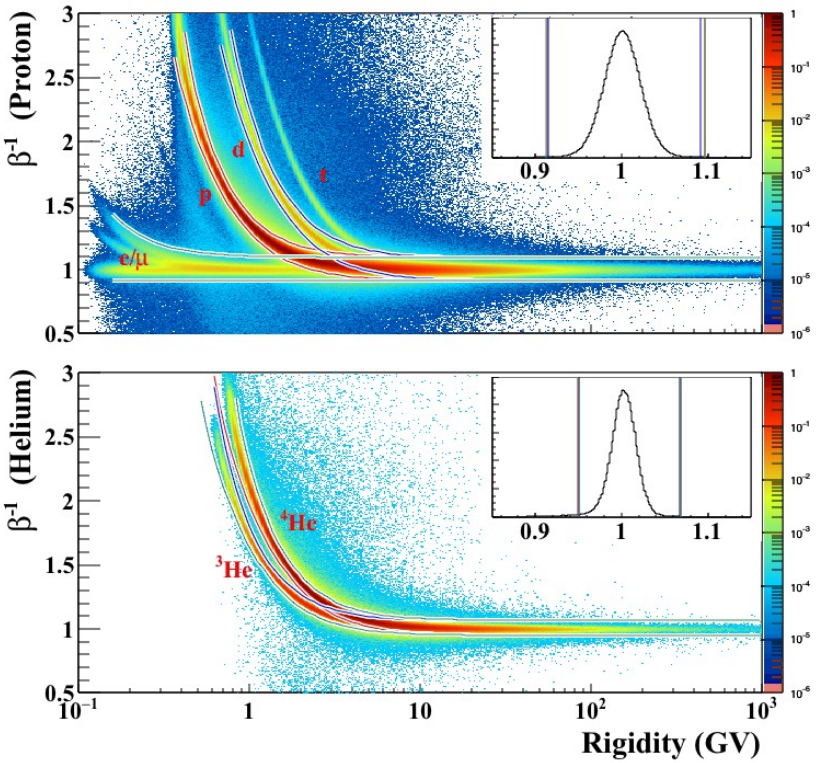
Antideuteron search

8 Particle identification

dE/dx

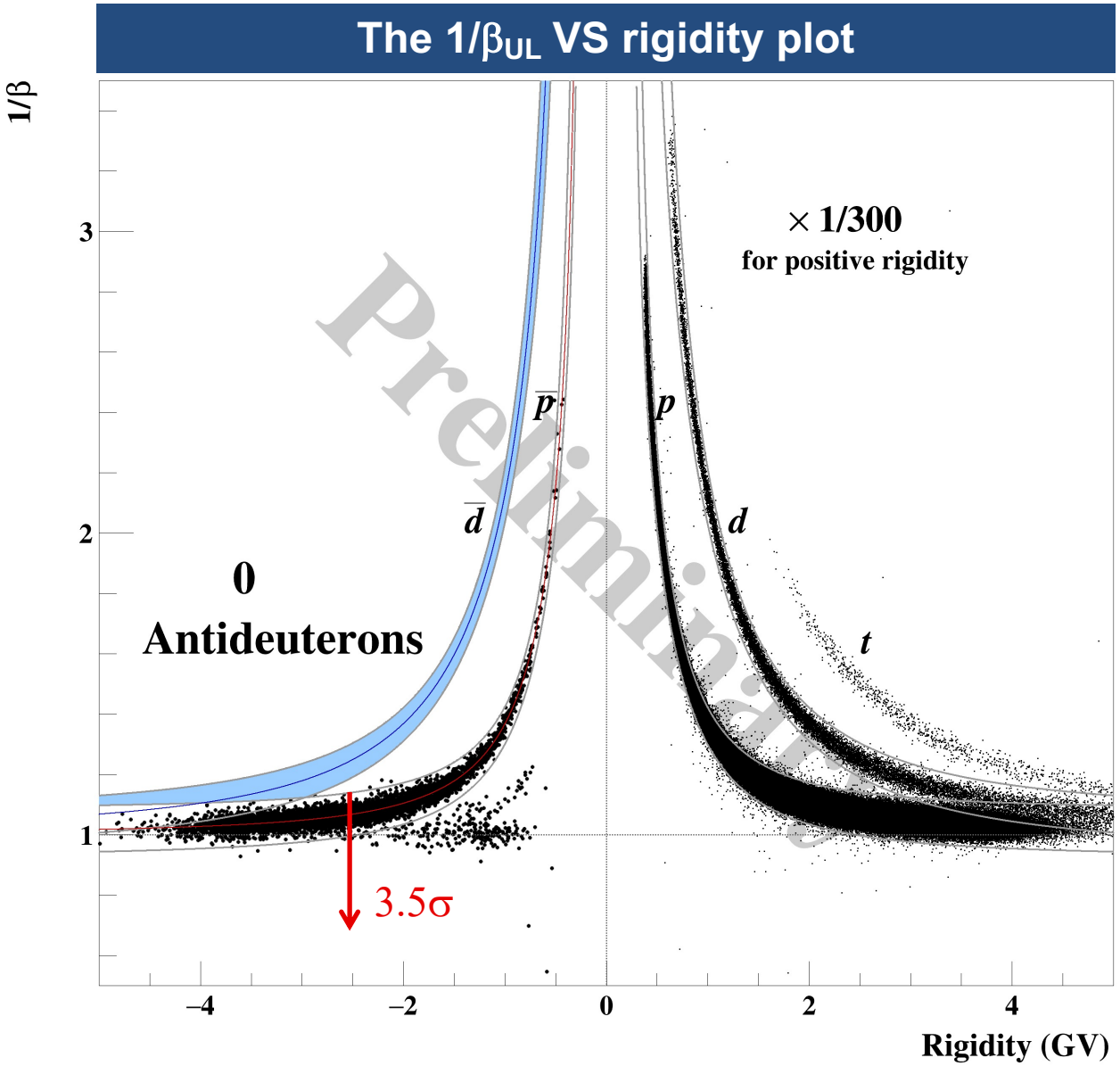


1/β



In general, selection criteria of Dbar analysis are identical to that of Pbar analysis except for slightly strict cut of JET/IDC chamber, and ACC.

9 Antideuteron search



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

10 Upper limit calculation

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

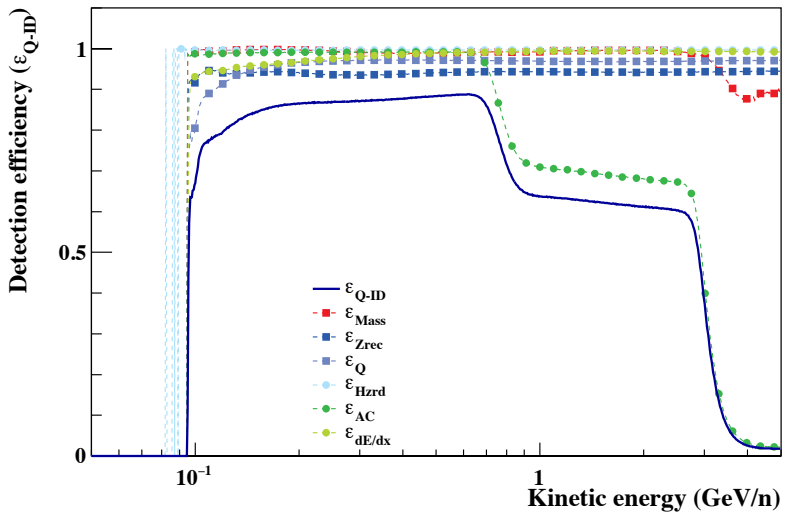
N_{obs} : Number of Observed candidate = 3.1
$S\Omega$: Geometrical acceptance
T_{live} : Live time
ε_{single} : Single track efficiency
ε_{Q-ID} : Detector selection efficiencies
η : Survival fraction through atmosphere
δ_{sys} : Systematic error

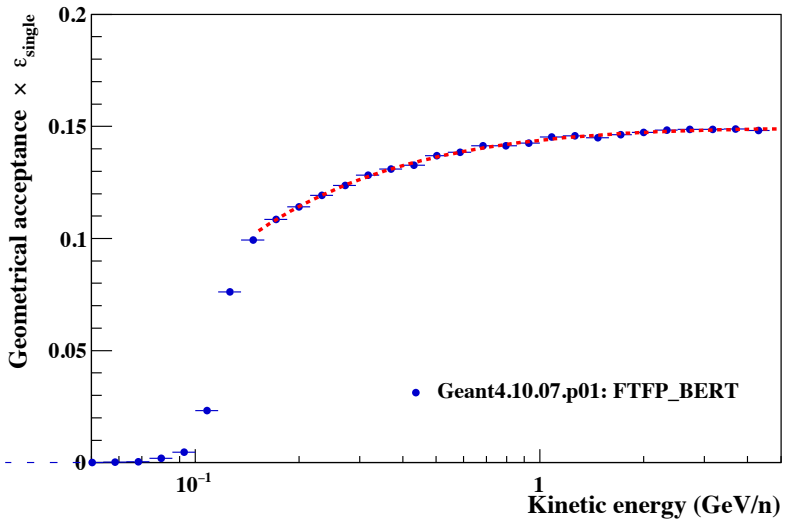
- Since no antideuteron was found, 3.1 was taken as the number of the observed antideuteron events for the calculation of 95% C.L. upper limit.
- In order to obtain the most conservative limit, the minimum value of the effective exposure factors ($S\Omega \cdot T_{live} \cdot \varepsilon_{single} \cdot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

11 Detector efficiencies/Acceptance

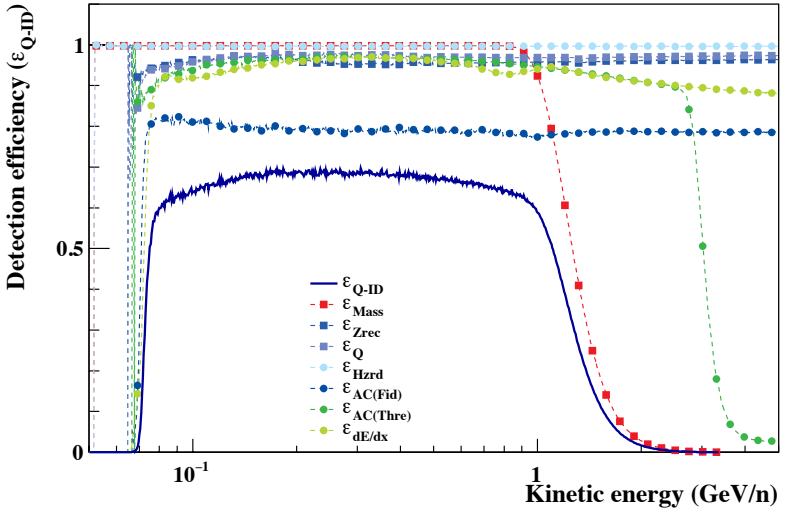
$$\Phi_{\bar{d}}\, dE = \frac{N_{obs}}{S\Omega \cdot T_{live}} \frac{1}{\varepsilon_{single} \cdot \varepsilon_{Q-ID}} \frac{1}{\eta} \frac{1}{(1-\delta_{sys})}$$

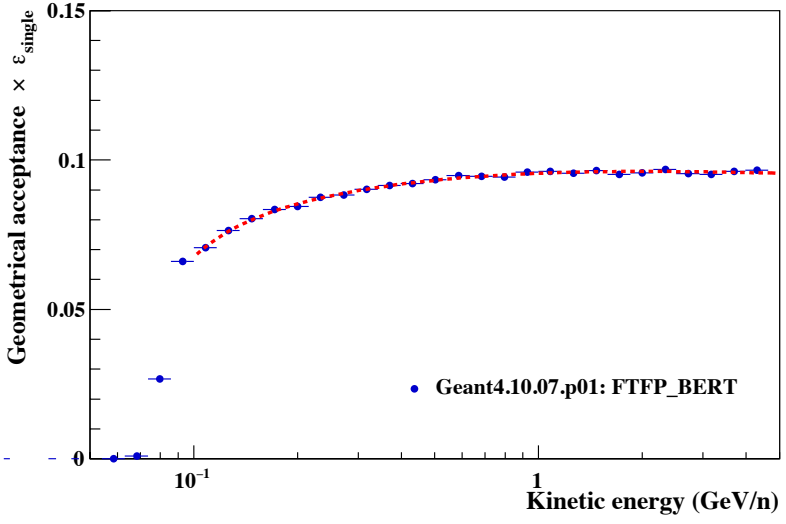
Pbar





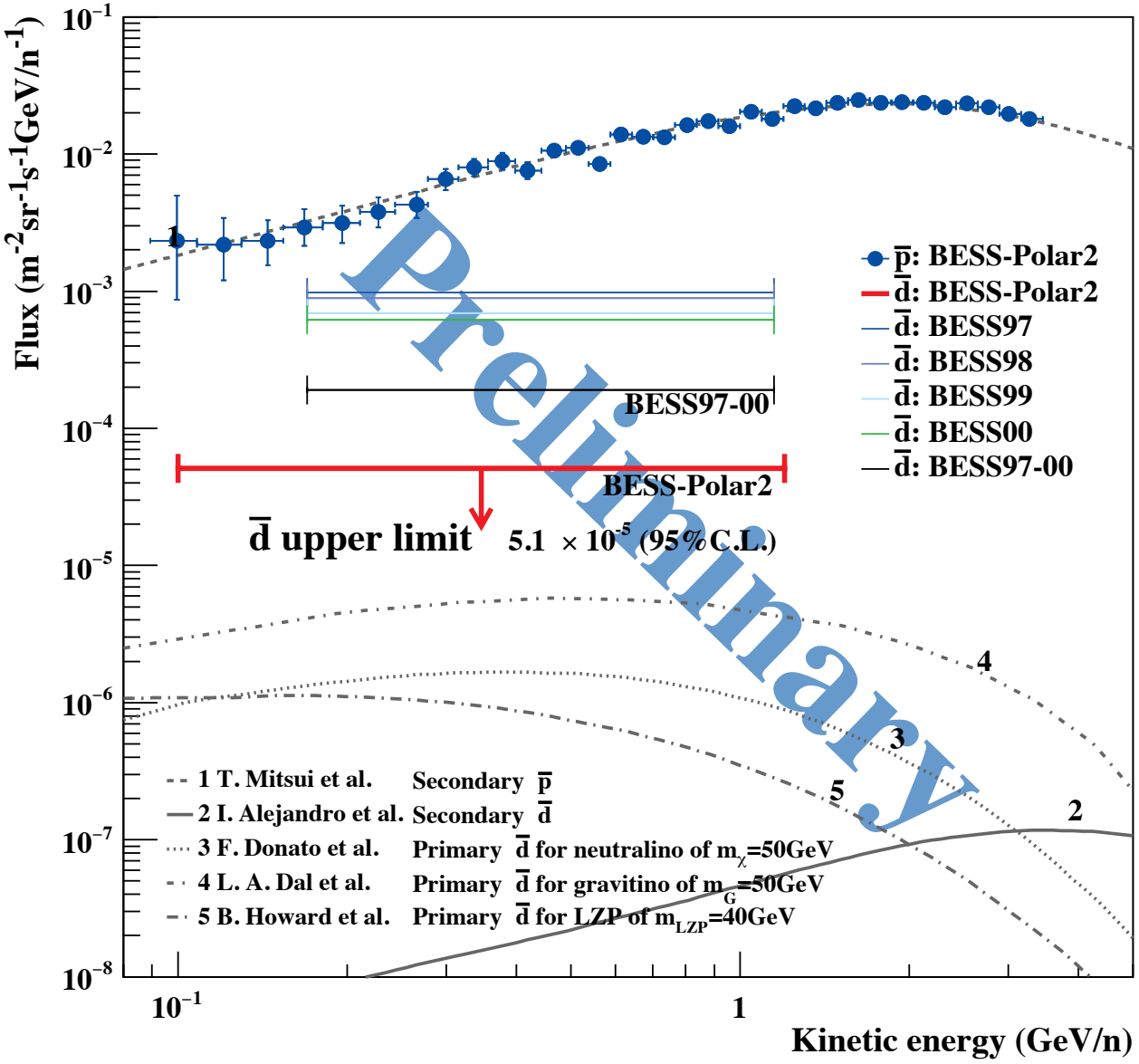
Dbar





12 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

$J(d) < 5.1 \times 10^{-5}$ $(m^2 sr\ sec\ GeV/n)^{-1}$ (95%C.L.)

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

13 Summary

Very-low energy antiproton spectrum

- MTOF extends the energy range down to about 0.1 GeV.
- 418 antiprotons within UTOF-MTOF triggered events in BESS-Polar II.
- New UM antiproton flux in the range 0.1 to 0.7 GeV shows good consistency with secondary calculations.

Antideuteron search

- No antideuteron candidate in BESS-Polar II.
- New preliminary upper limit $J(d) < 5.1 \times 10^{-5}$ $(m^2 sr\ sec\ GeV/n)^{-1}$ (95%C.L.)
  - 3.1 was taken as the number of the observed antideuteron events for the calculation of 95% C.L. upper limit.
- Compared with the data taken in the solar minimum (BESS97), order of magnitude improvement has been achieved.