The BESS Results and Prospects

M.Nozaki (Kobe U.)
for the BESS Collaboration

14th Rencontre de Blois

Why do we search for anti-matter ?

- Matter-Antimatter symmetry ?
  - Subatomic exp.: Not exactly but almost symmetric.
  - Astronomical obs.: Totally asymmetric.
- No established model to reconcile these two observations.
  - No antimatter at all ?
  - Antimatter domain is too faraway ?
  - Hidden in our neighbor ?
- Experimentally, anti-helium sugnal is clear.
  - Doubly charged negative particle.
  - Background is negligible (anti-He/He<10^{-12})

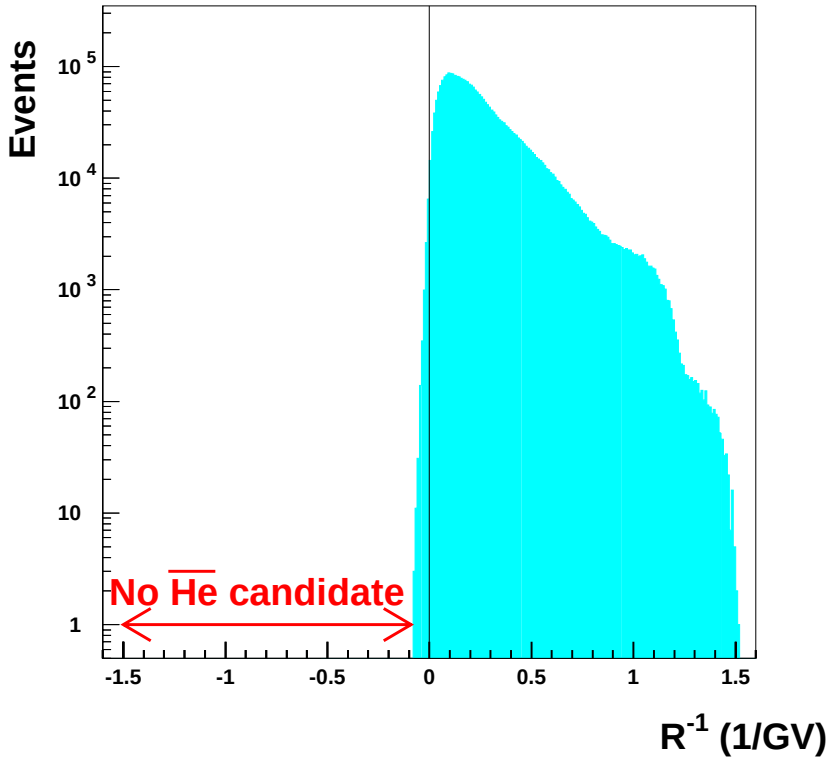
Cosmic Antiproton ?

Antiproton bomb of
"Milky Way Alliance"

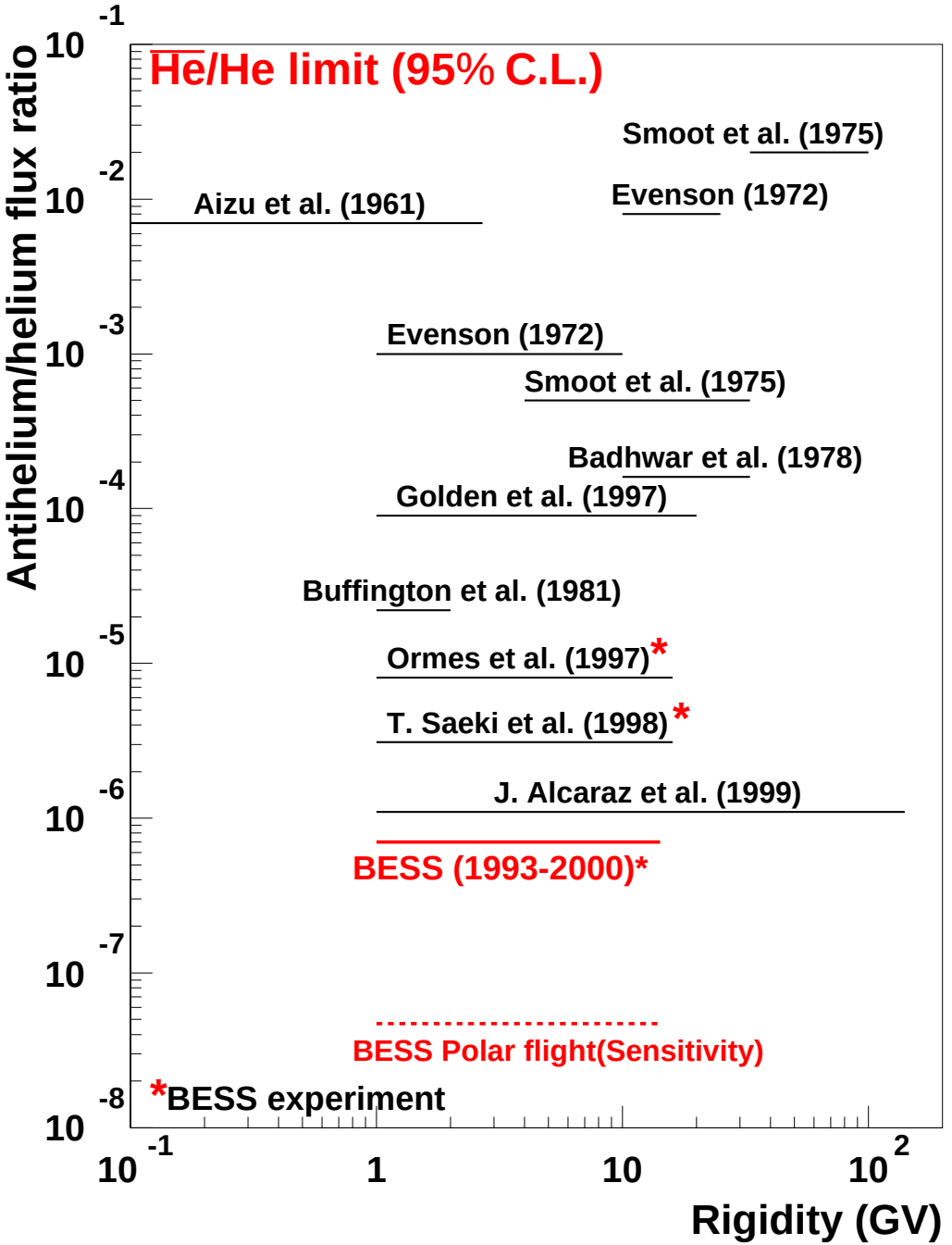
Osamu Tezuka: "Amazing Three", (1965)

Quest for Anti-helium

since 1957



$$\overline{He}/He < 6.8 \times 10^{-7}$$



The 1st Limit on Cosmic-ray Antiparticles

PHYSICAL REVIEW VOLUME 121, NUMBER 4 FEBRUARY 15, 1961

Heavy Nuclei in the Primary Cosmic Radiation at Prince Albert, Canada. II*

H. AIZU,† Y. FUJIMOTO, S. HASEGAWA, M. KOSHIBA,‡ I. MITO,§ J. NISHIMURA, AND K. YOKOI§
Institute for Nuclear Study, University of Tokyo, Tanashi, Tokyo, Japan

AND

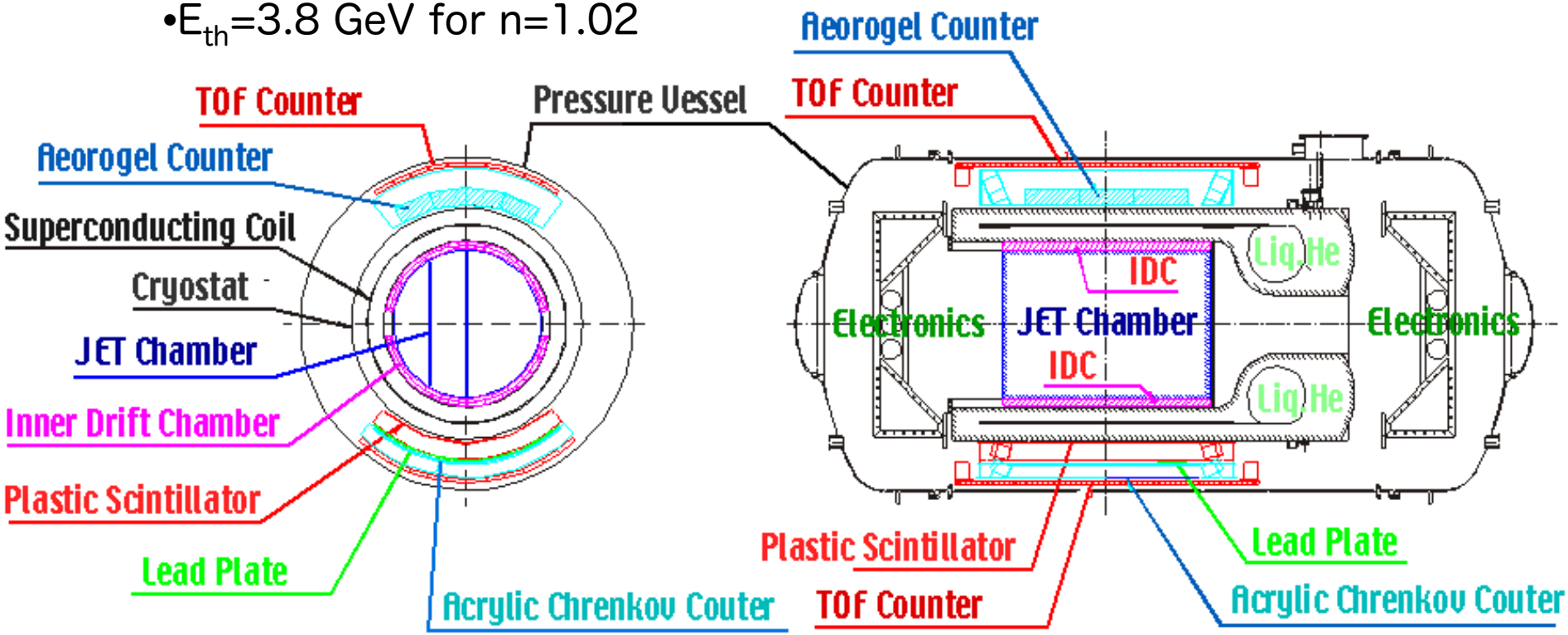
MARCEL SCHEIN‖
Department of Physics, Enrico Fermi Institute for Nuclear Studies, University of Chicago, Chicago, Illinois

(Received August 19, 1960; revised manuscript received November 4, 1960)

Finally, we would like to point out the following conclusion. Namely, there has been no single case of antiparticles among the observed stopping particles of about 500 α particles, 300 (C,N,O), and heavier elements, and more than 1000 singly charged particles. Even with a somewhat larger interaction cross section of antiparticles, this will set an upper limit for the amount of antimatter in the primary radiation at about 0.1%.

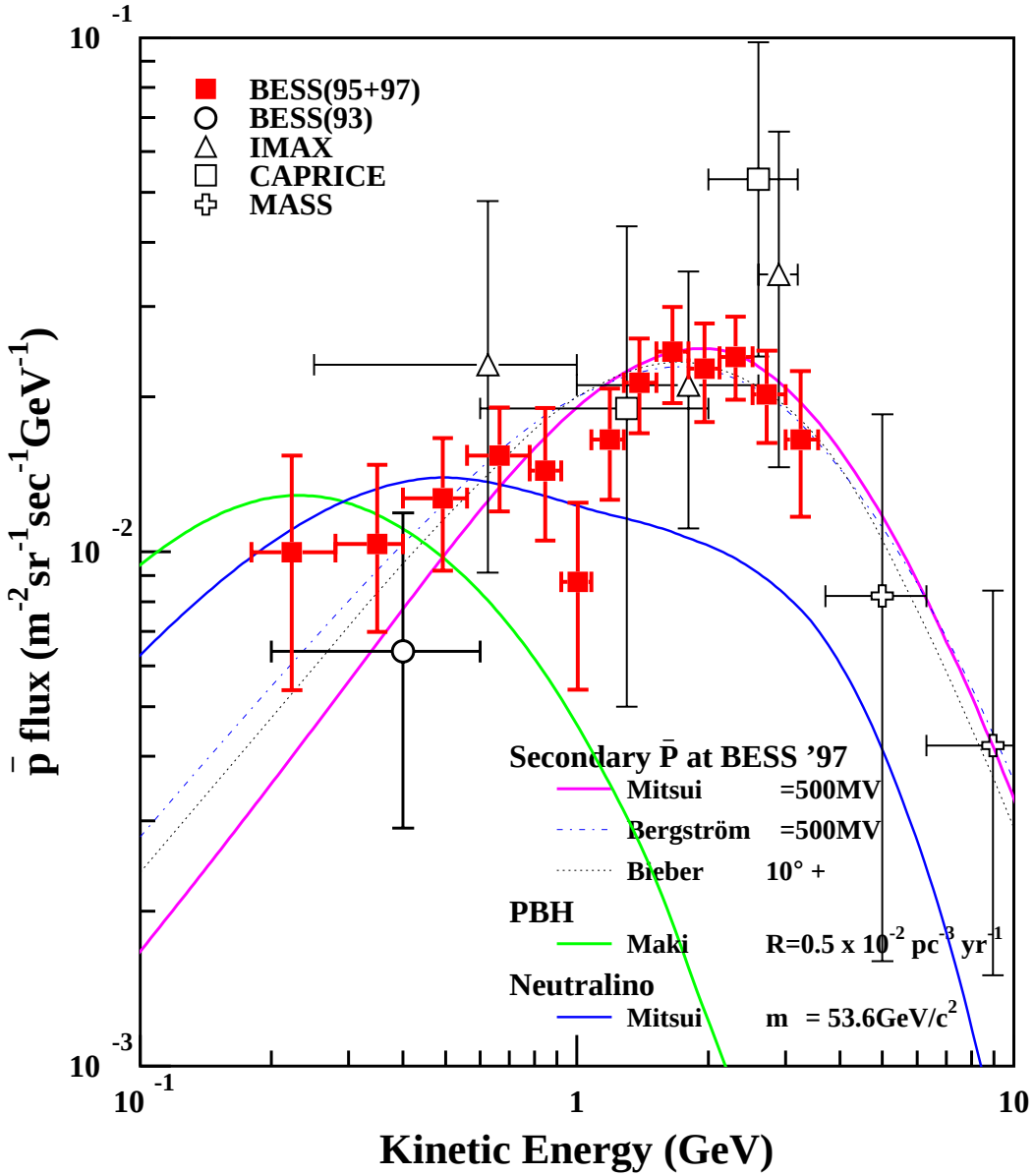
The BESS Spectrometer

- A strong (1Tesla) and uniform field (±7%) by a thin solenoid (~4g/cm^2)
- Tracking + Particle ID:
  - $m = zeR\,(\beta^{-2} - 1)^{-1/2}$
  - $dE/dx \sim z^2/\beta^2\, f(\beta)$
  - E_{th}=3.8 GeV for n=1.02



2200 kg & 1200 W

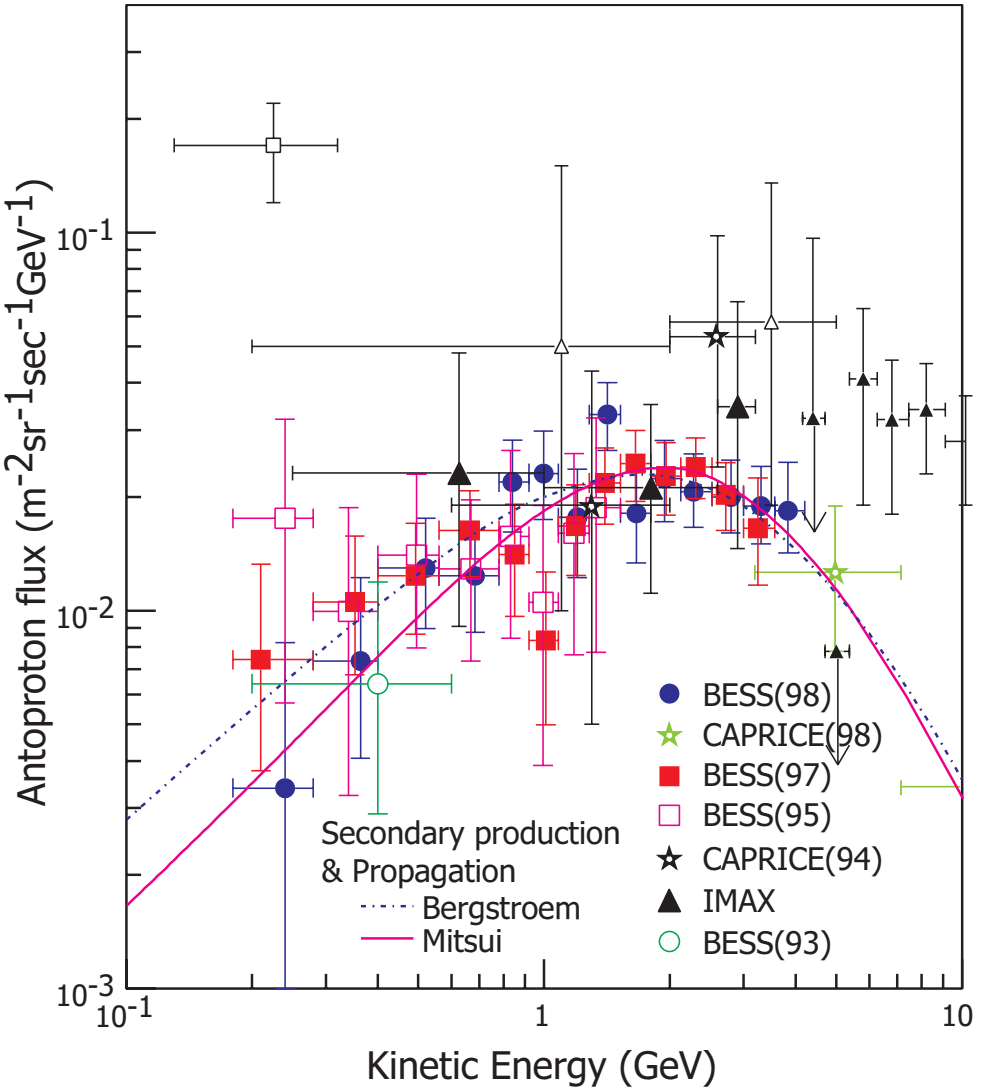
Antiproton Spectrum



- "Primordial" pbar
  - No anti-BBN
- "Secondary" pbar
  - Collision
- "Primary" pbar
  - PBH
  - Neutralino

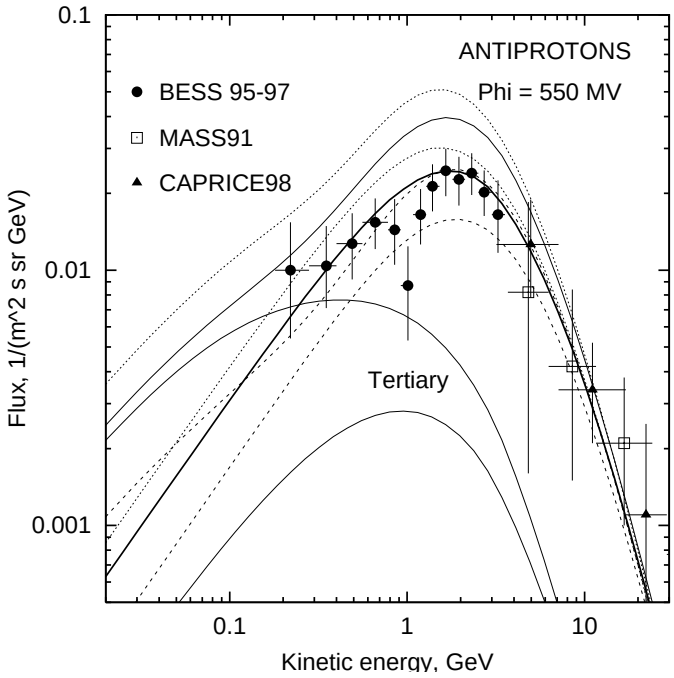
Antiproton Warriors

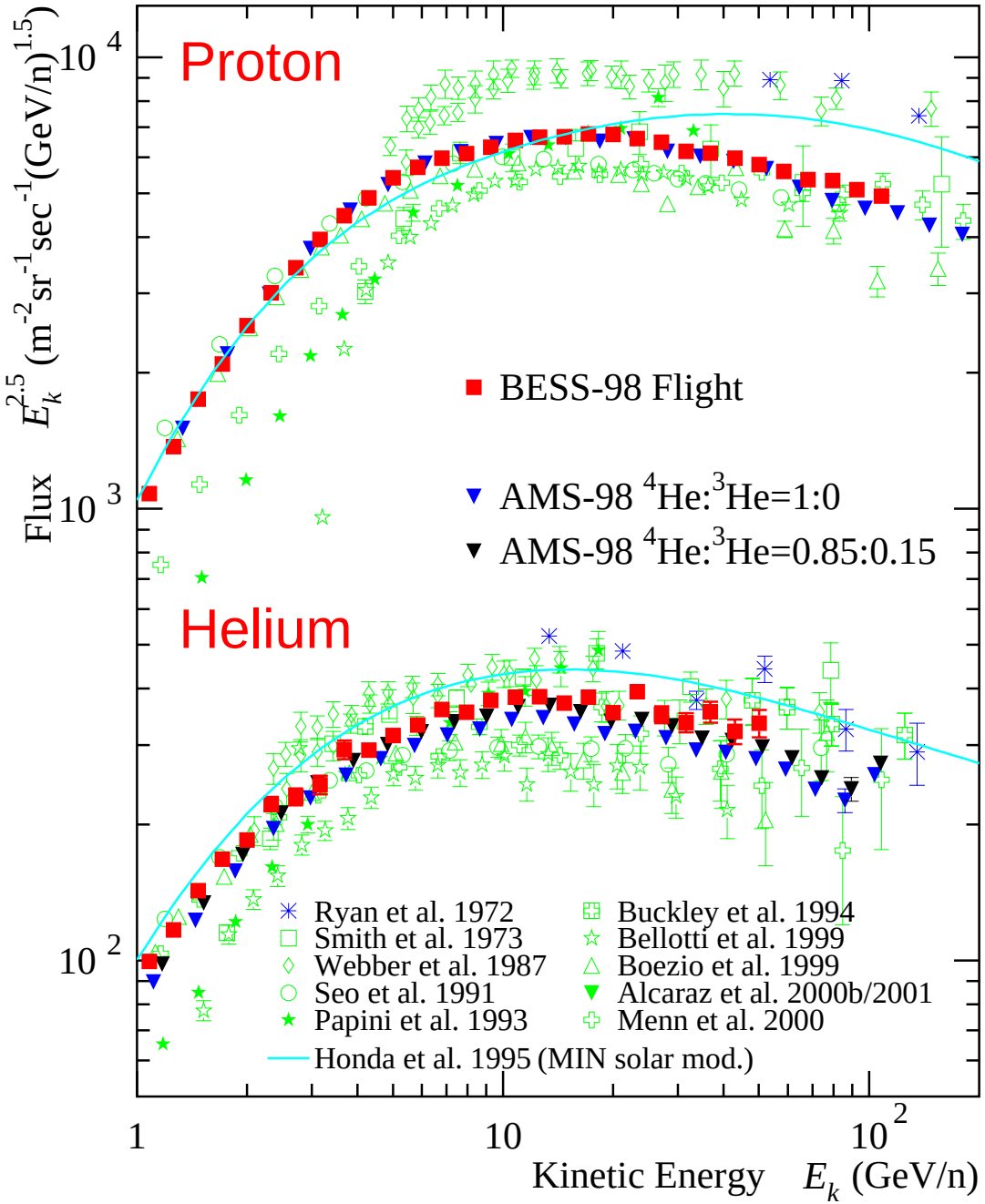
1979: Golden et al., Bogomolov et al.
1980: Buffington et al.
1985: Bogomolov et al.
1987: LEAP, PBAR
1991: MASS2
1992: IMAX
1993: BESS
1994: BESS, CAPRICE
1995: BESS
1997: BESS
1998: BESS,CAPRICE
1999: BESS
2000: BESS, HEAT-pbar
2001: BESS (high cut-off)
2002: PAMELA (Polar-orbit)
2003: BESS-Polar
2004: AMS (Space Station)



Primary & Propagation

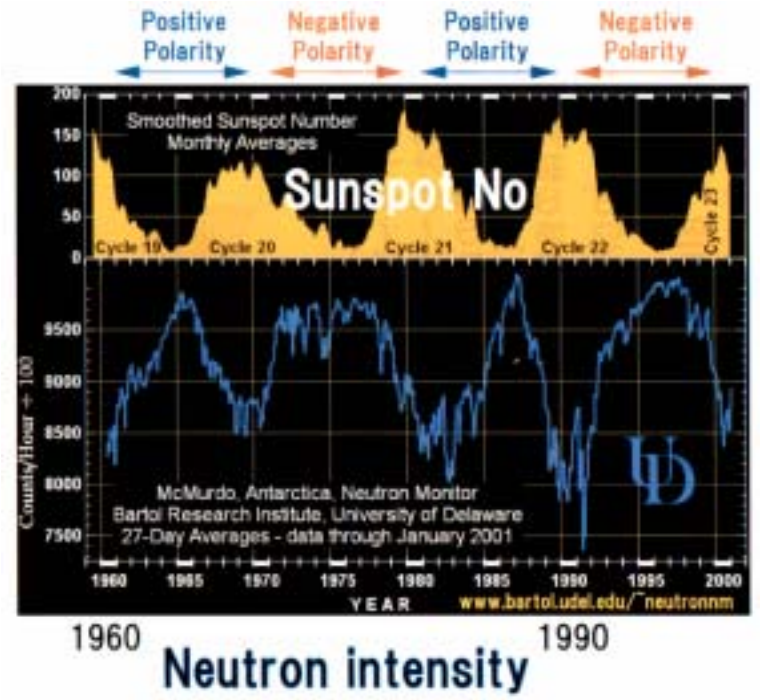
Moskalenko et al.:
Ap.J. 565 (2002) 280-296

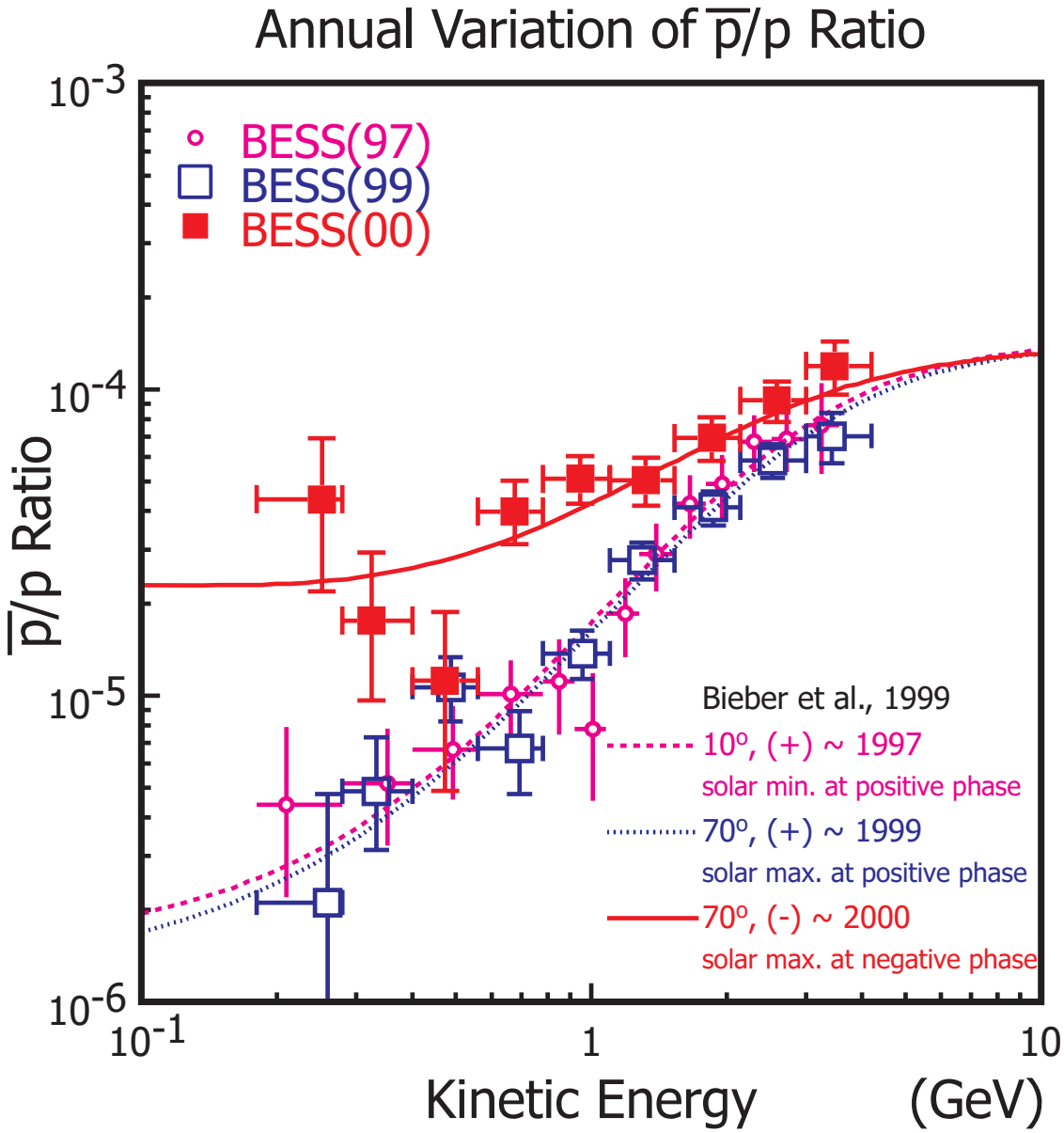




Solar Modulation

Charge sign dependence





Atmospheric p/pbar @Mountain Altitude

~2800m

Preliminary

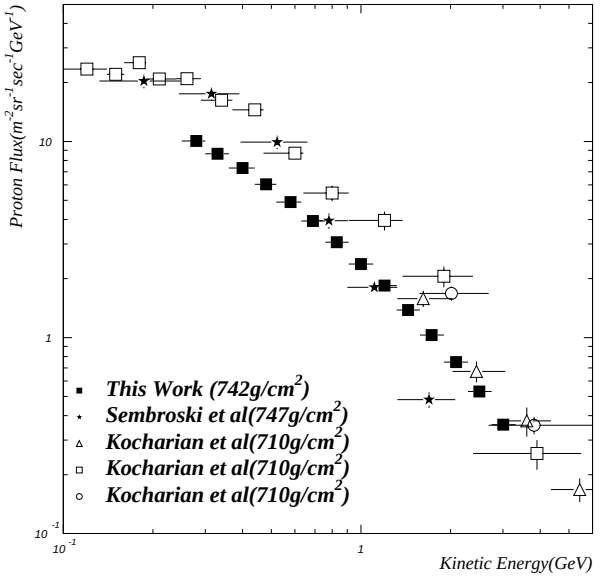


FIG. 2: Proton vertical flux ($\cos\theta_z \geq 0.95$) vs kinetic energy.

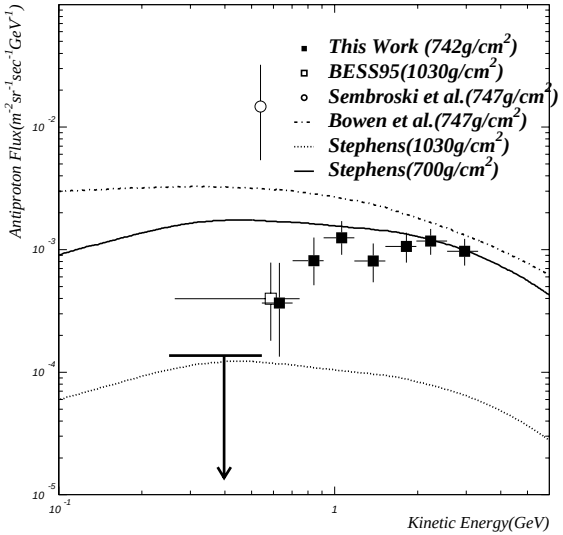
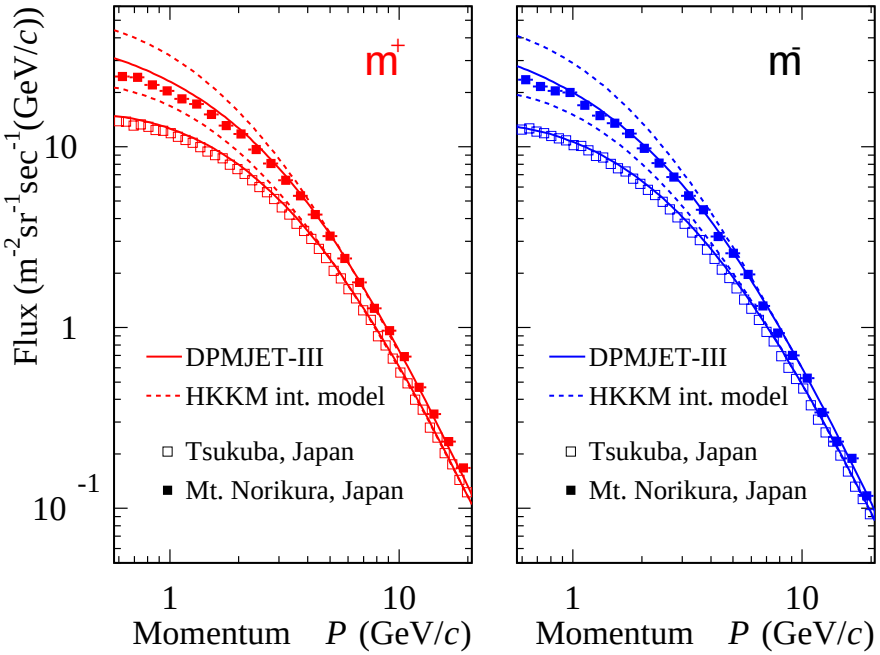
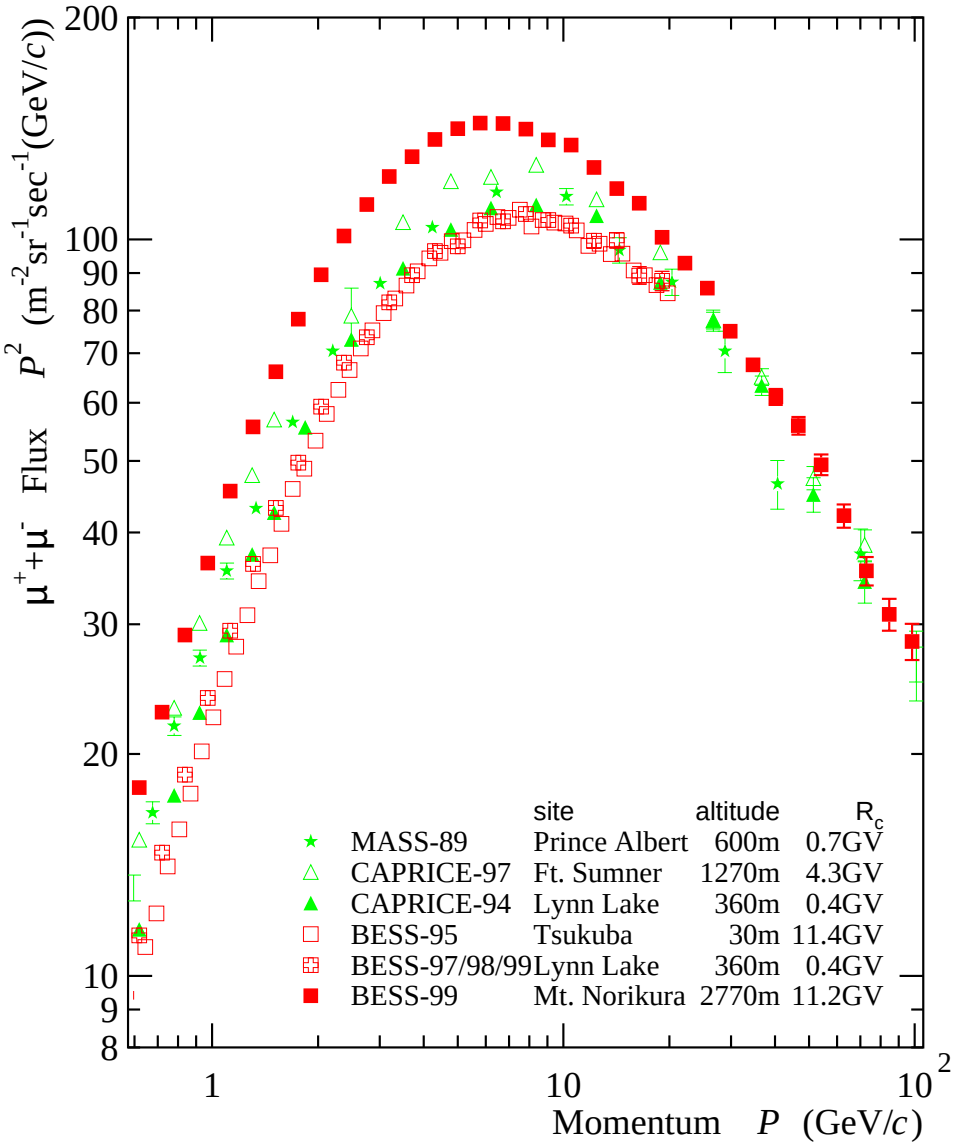


FIG. 3: Antiproton vertical flux ($\cos\theta_z \geq 0.84$) vs kinetic energy.

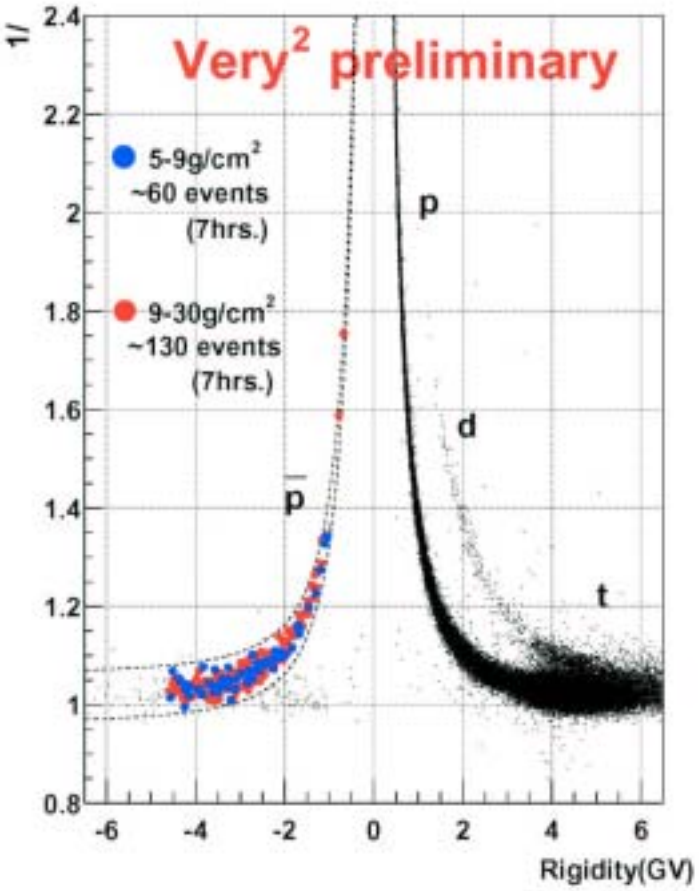
Atmospheric Muon @ Mountain Altitude

Preliminary

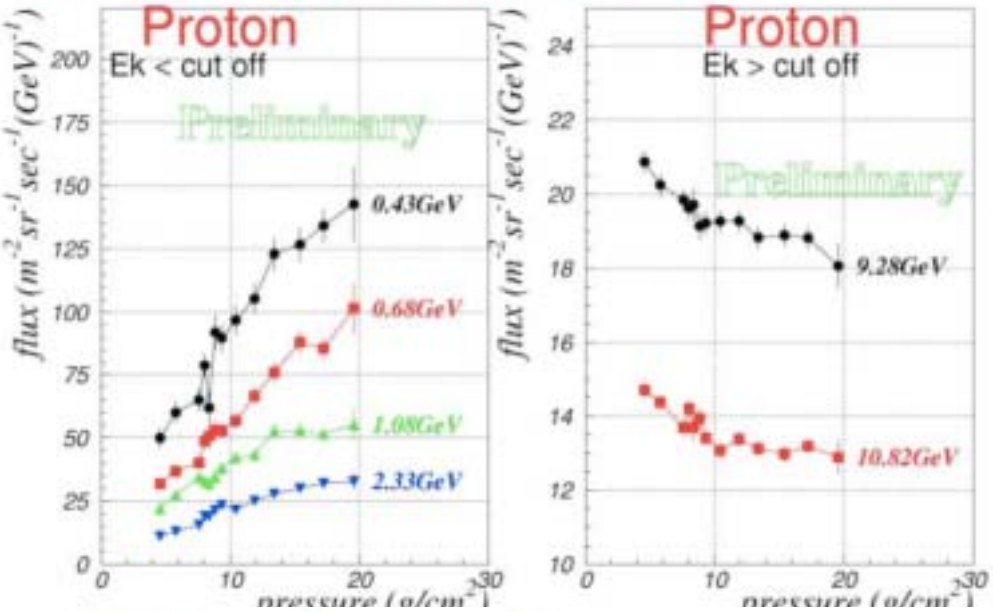




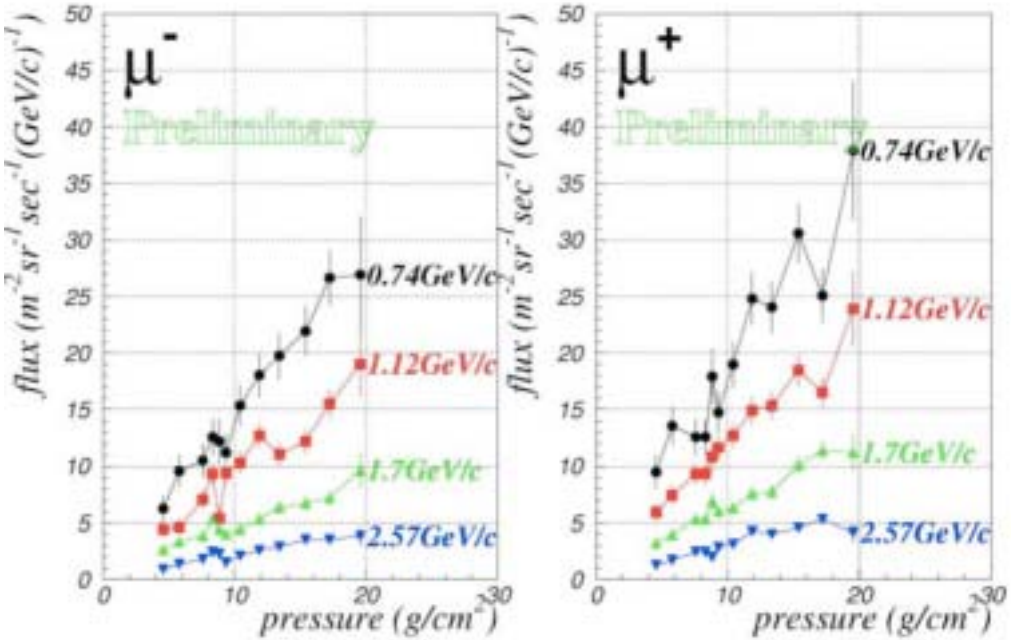
BESS 2001 @ Ft.Sumner



Proton growth curve

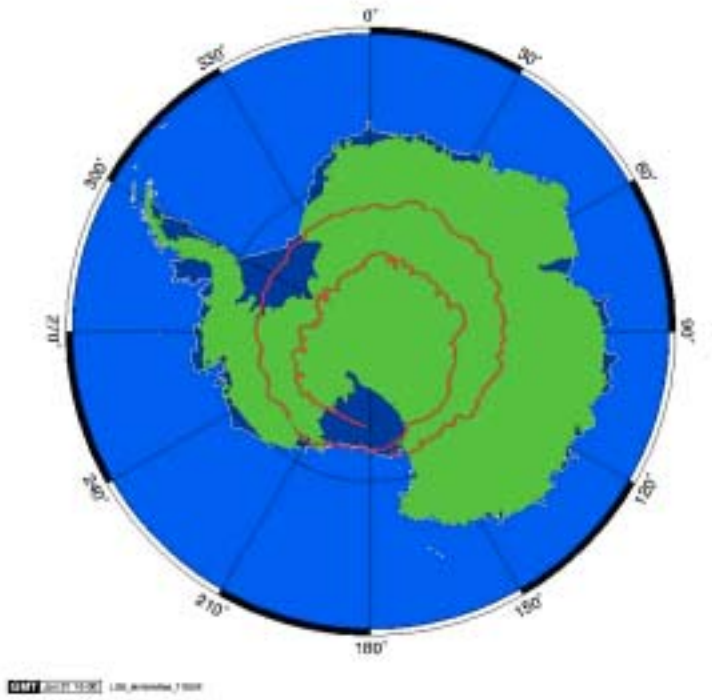


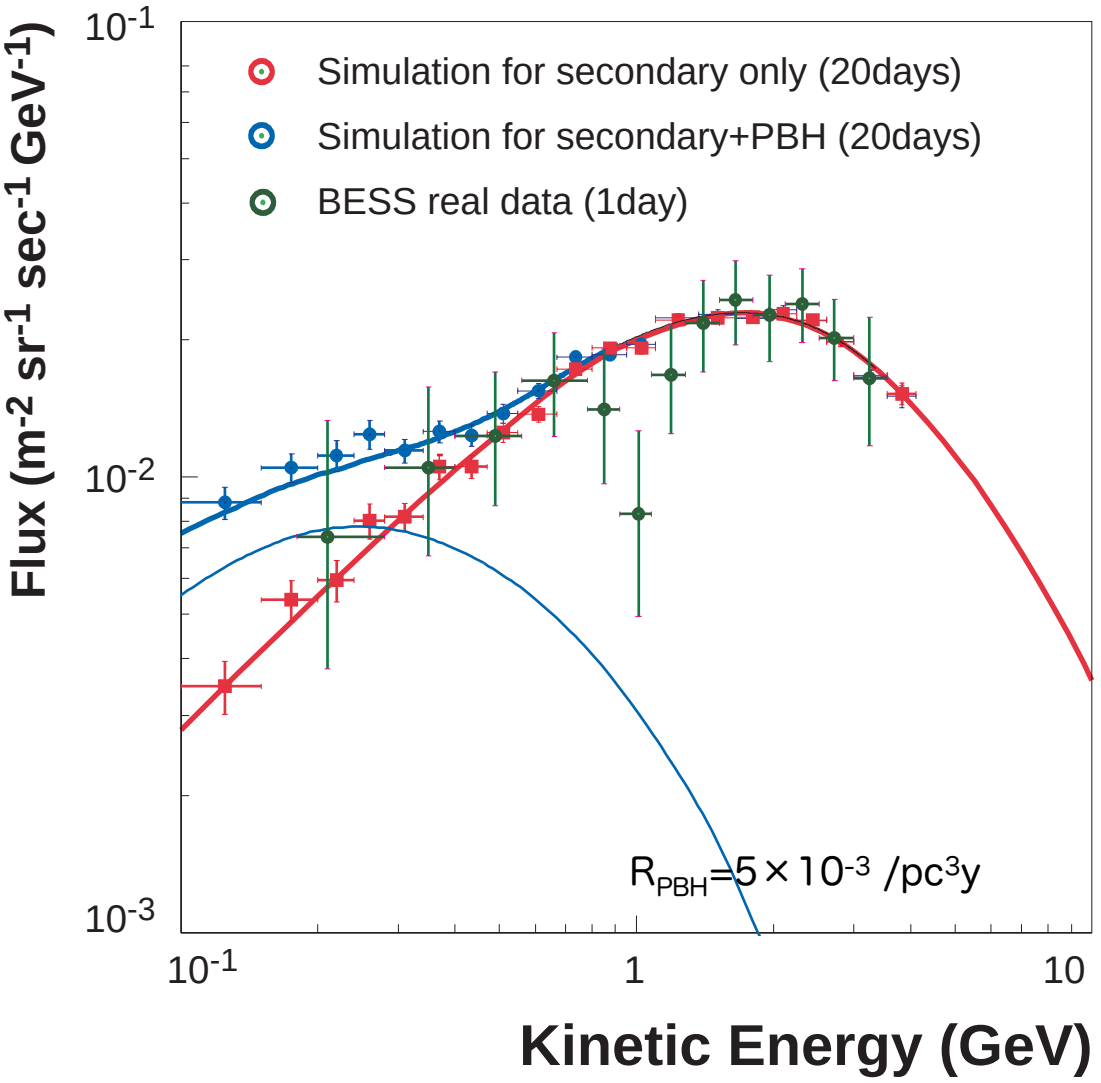
Growth curve of muon



Final Fantasy @Antarctica

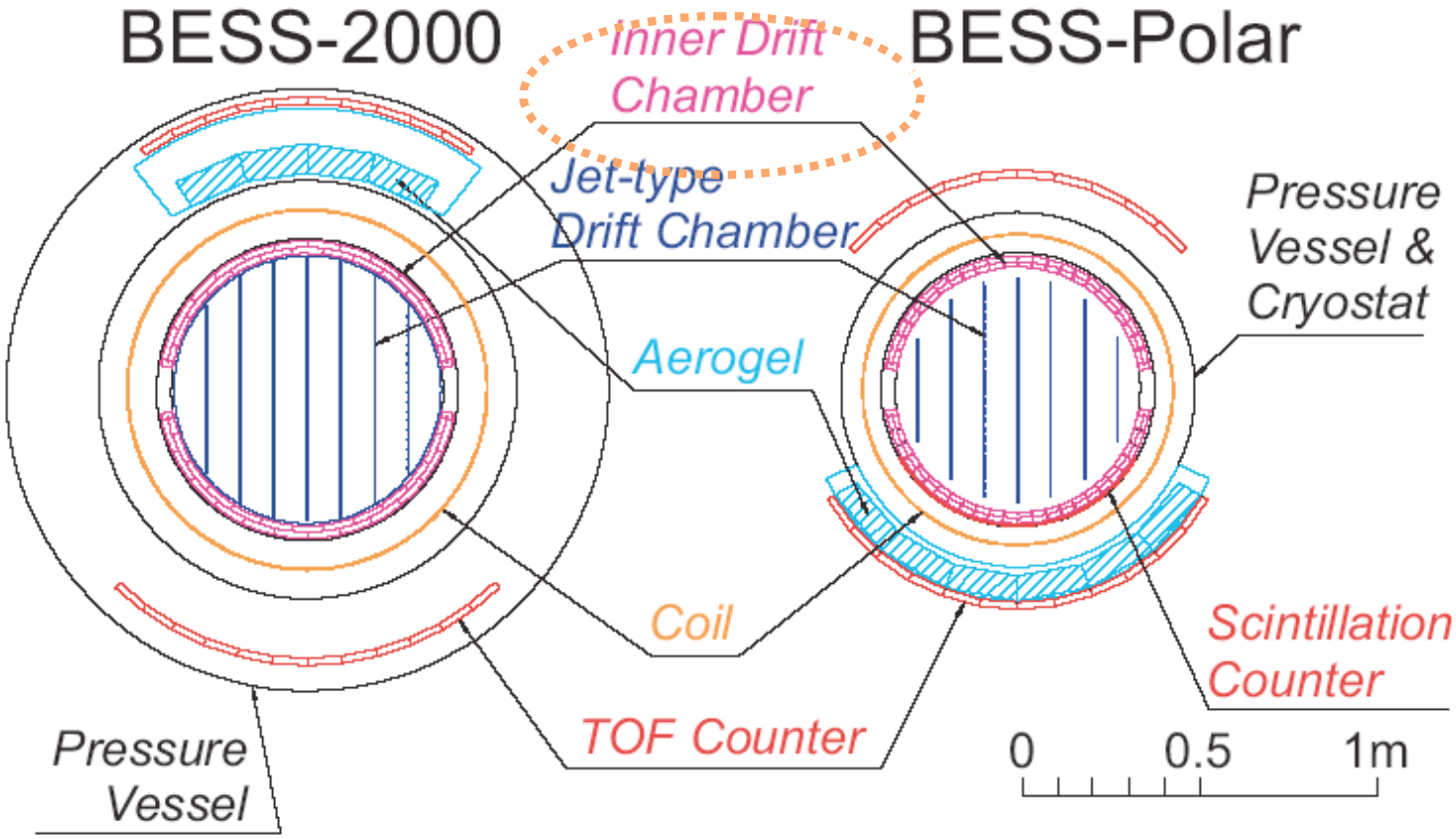
Long duration flight
2~3 weeks





~1000 pbars at E<1 GeV
He-bar/He < 10^{-7}

The BESS-Polar Spectrometer



Compact, Transparent, Solar Panel, Cryogen life

Basic Parameters of BESS-Polar

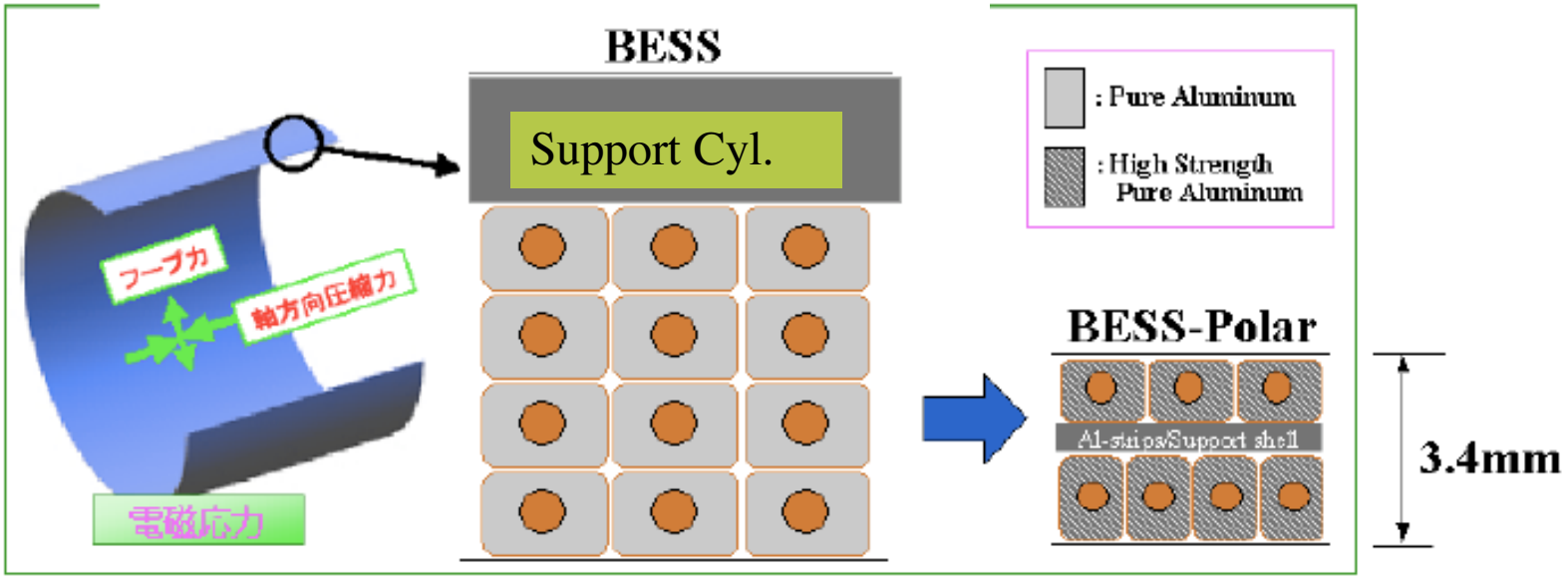
	BESS-2000	BESS-Polar
Acceptance	0.3	0.3 m^2•sr
Material	18	4.5 g/cm^2
Emin@TOA	200	100 MeV
Magnetic field	1.0	0.8 tesla
Weight	2.2	1.4 tons
Power	Li-battery	Solar-panel
Comsumption	1200	600 W
Cryogen life	5.5	20 days

Superconducting Coil : Key Technology

Challenge for coil thickness to be thinnest

1/3 in coil and totally ~1/2 including cryostat

Coil cross section

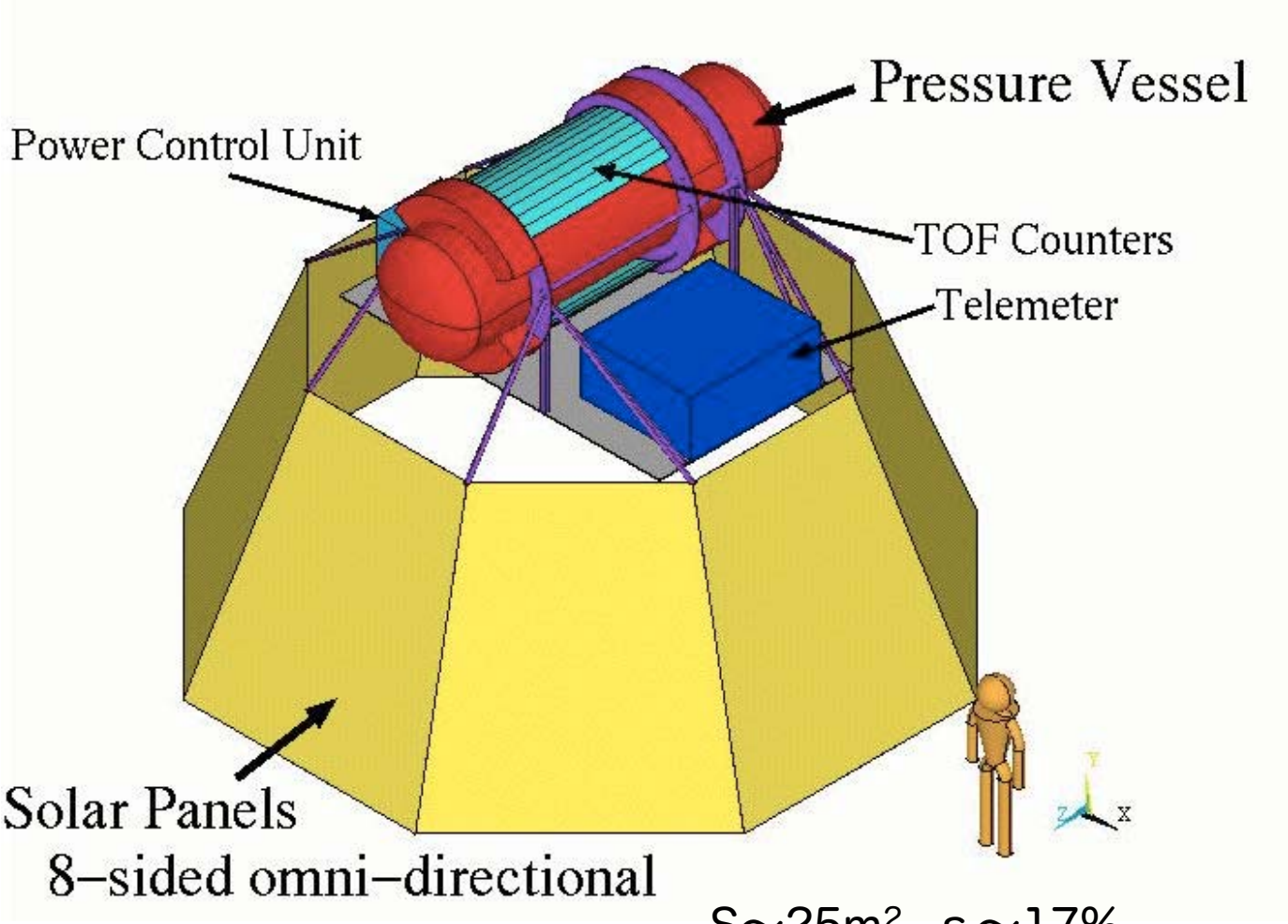


Full Dia. Model-1 (in 1/7 length)

Thickness: 3.3 mm

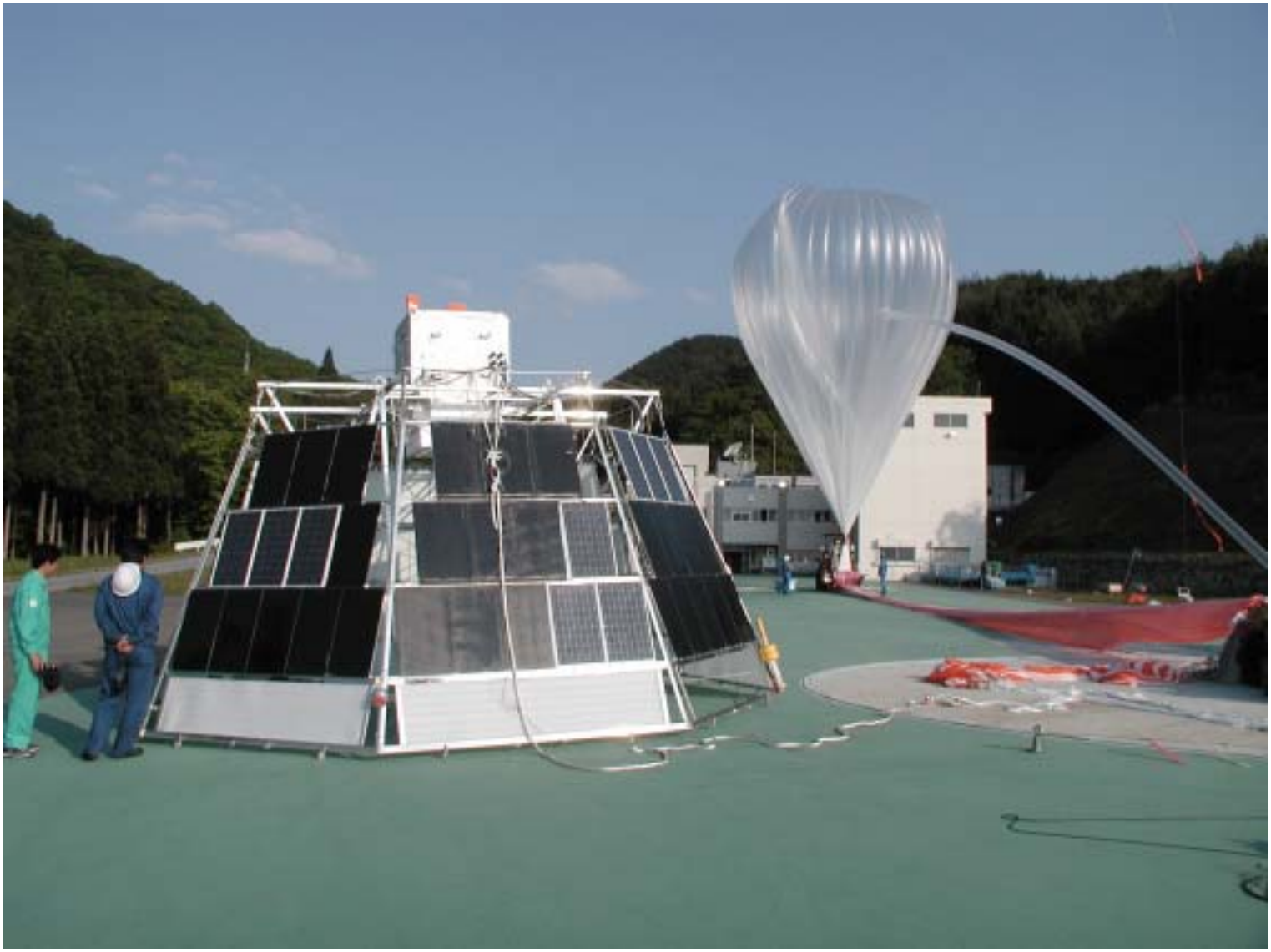
Material: ~1 g/cm^2

A General Layout



S～25m^2, ε～17%

Technical flight at Sanriku in May 2002



BESS-Polar General Plan

2000/7	BESS-Polar Development Start
2002/5	Technical Flight for Solar Panel (in Japan)
2002/8	BESS-TeV in Lynn Lake
2003/3	BESS-Polar Spectrometer complete
2003/6	General Technical Flight (in Palestine, US)
2003/12	Flight Ready in Antarctica
2004/1	BESS-Polar; 1st flight
2006~7/1	BESS-Polar 2nd flight in Solar minimum

Summary

- Antihelium search: Upper limit has been improved by a factor10^4 in 40 years
  - BESS is in the lead for the time being
- Antiprotons: > 2000 have been collected in 20 years and we now know that secondary production is the dominant source of cosmic ray antiprotons
  - The world wide "collaboraton" has clarified the general view
  - BESS has played the leading role
- Ultimate measurement at Antarctica is planned
  - A new spectrometer is being developed