ICRC2003

Rapporteur talk

OG 1.1 - OG 1.2 - OG 1.5

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OG 1
Direct Measurements and Origin of Cosmic Rays

OG 1.1 Cosmic rays observed with balloons, satellites (23 + 10)

OG 1.2 Cosmic ray source composition (3+2)

OG 1.5 Instrumentation and new projects (25+24)

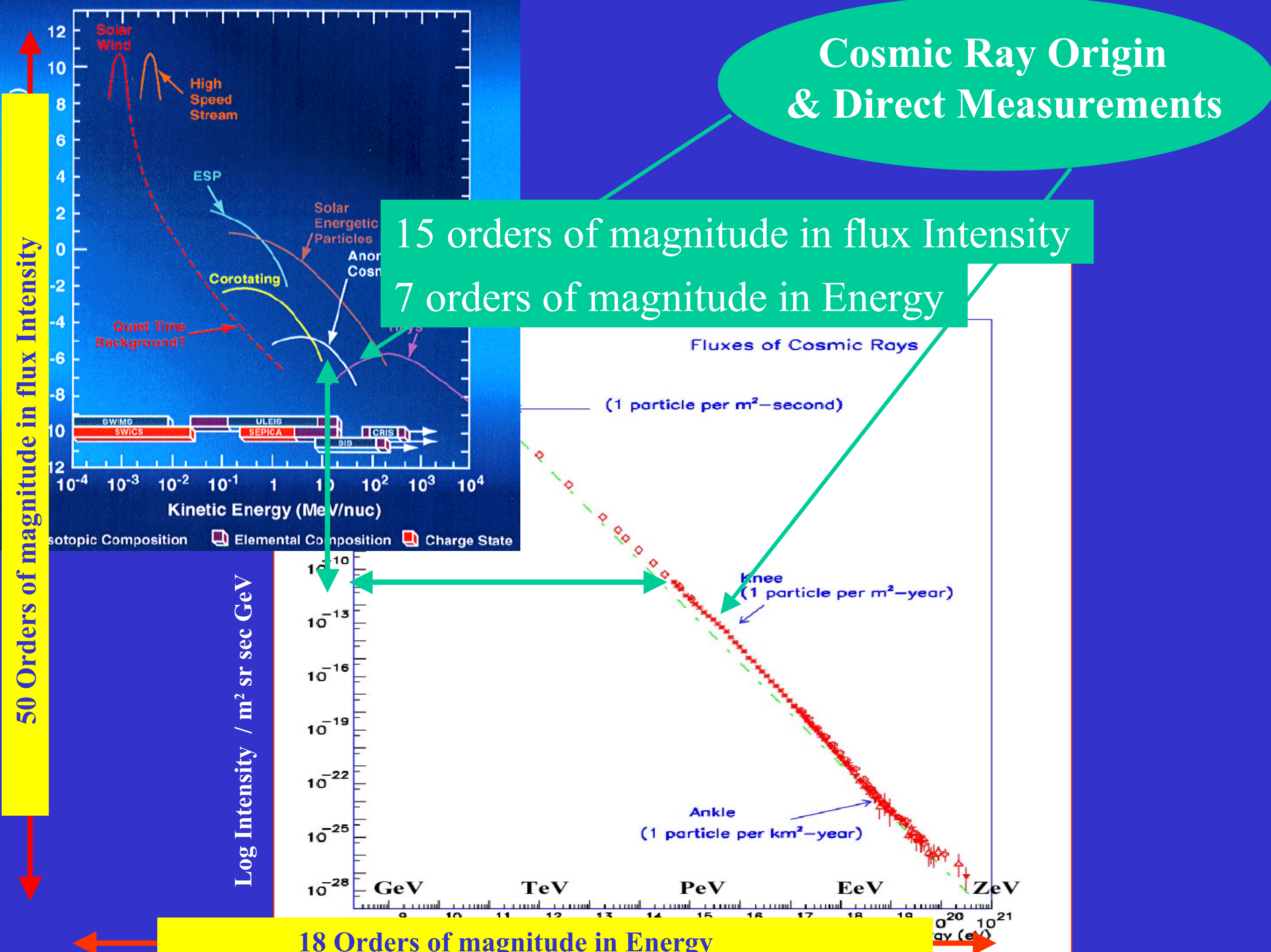
TOTAL: 97 contributions

Outline

- **Review of results presented at this conferences by Balloon and Space experiments**

- **Description of the future experimental programs and trends**

I apologize in advance for the many contributions which I could not cover in my talk !



Cosmic Ray Origin
& Direct Measurements
15 orders of magnitude in flux Intensity
7 orders of magnitude in Energy
50 Orders of magnitude in flux Intensity
18 Orders of magnitude in Energy
Log Intensity / m² sr sec GeV
Solar Wind
High Speed Stream
ESP
Solar Energetic Particles
Corotating
Quiet Time Background?
SWIMS
SWICS
ULEIS
SEPICA
CRIS
SIS
Kinetic Energy (MeV/nuc)
Elemental Composition
Charge State
Fluxes of Cosmic Rays
(1 particle per m²−second)
Knee
(1 particle per m²−year)
Ankle
(1 particle per km²−year)
GeV
TeV
PeV
EeV
ZeV

…..my particle physicist's view of CR physics

Step # 1

Understanding and calibrating nature's beam

More accurate measurements of CR composition and spectra

Better theory (CR origin and acceleration)

Better simulation tools

A text book example

Atmospheric neutrinos calculations vs neutrino oscillations

Neutrino oscillations

Anti-matter search

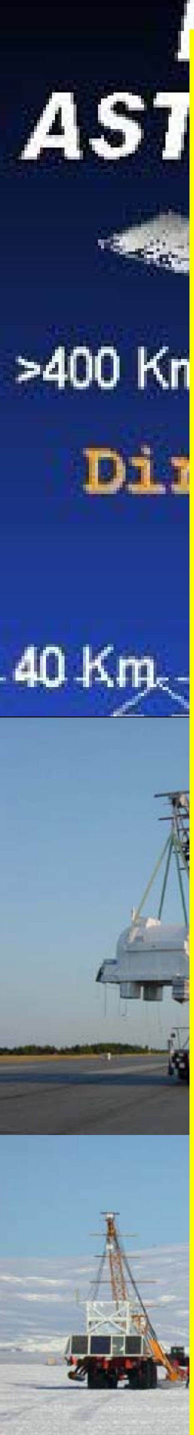
Strangelets

Indirect dark matter searches

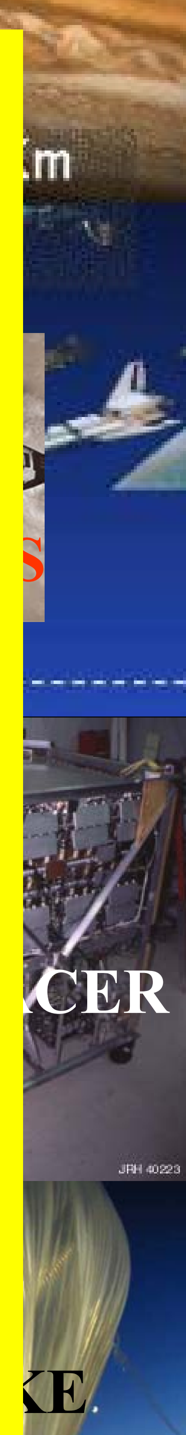
Anti-protons
Anti-deuterons
Electrons/positrons
Gamma rays

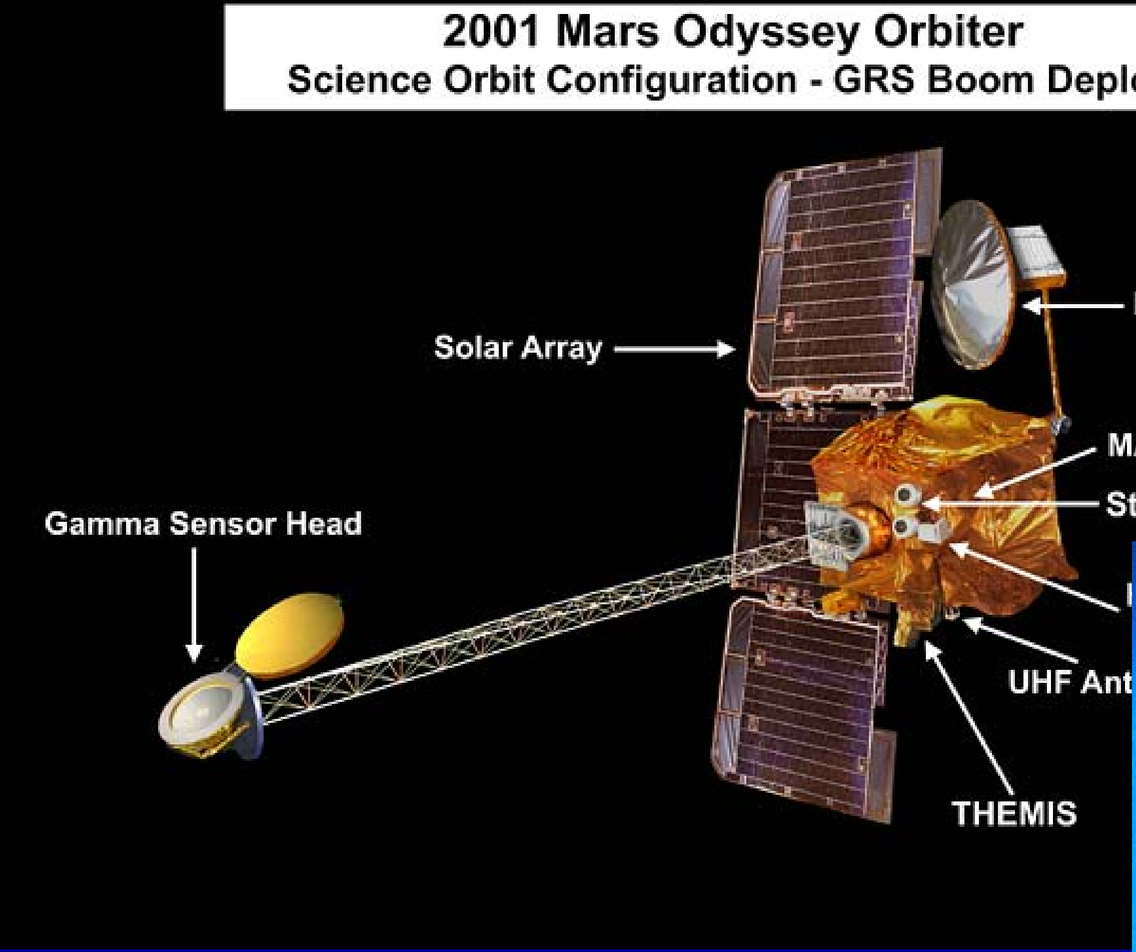
Ultraheavy particle searches

EEHCR
Neutrinos



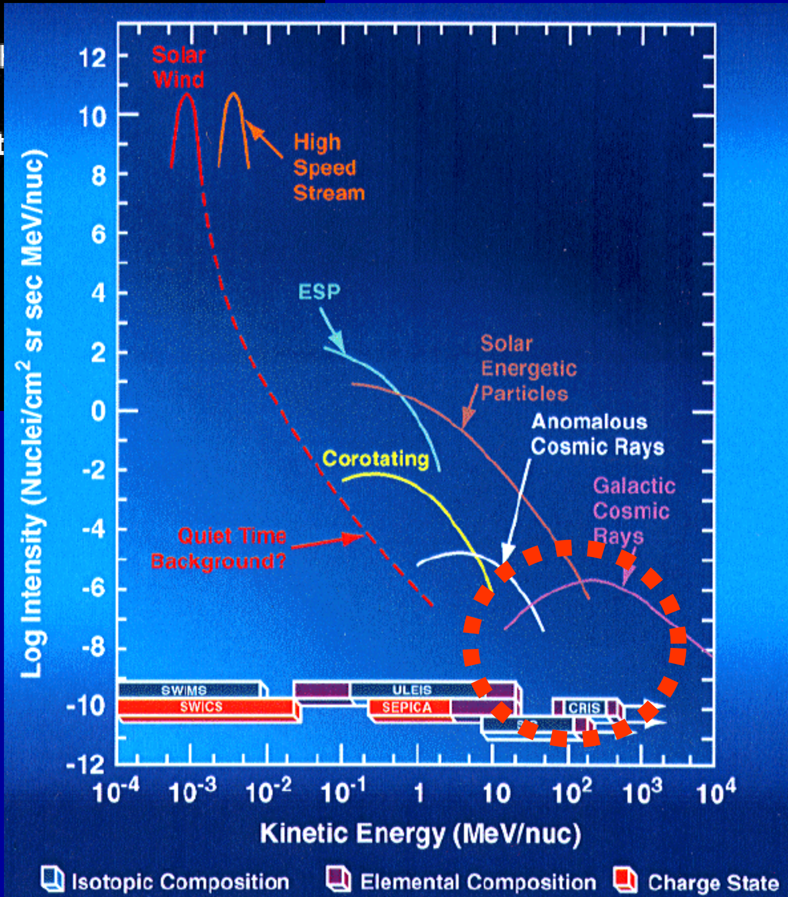
New data from Space and Balloon experiments



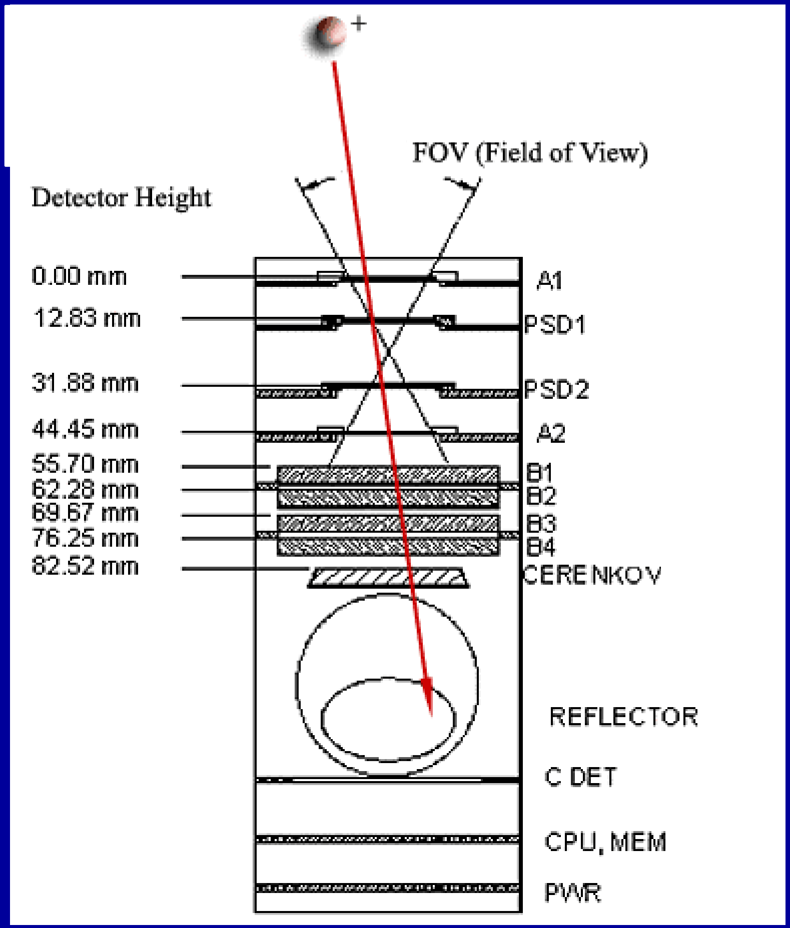


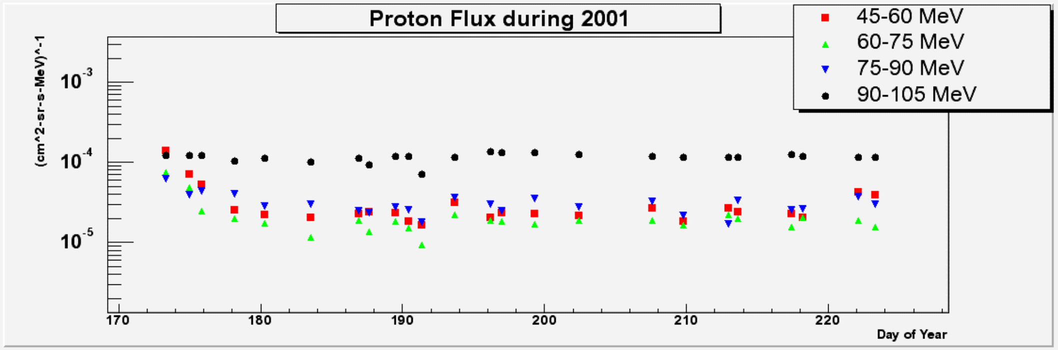
Kerry Lee
OG 1.1.4

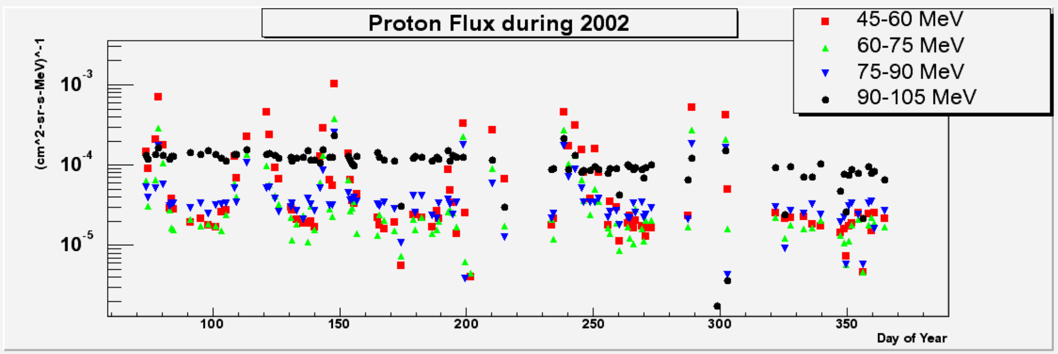
MARIE
2001 Odyssey
Spacecraft



MARIE Instrument

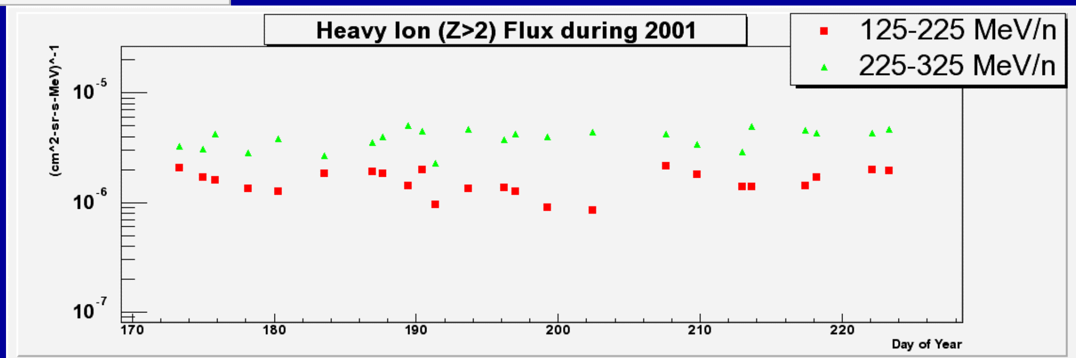


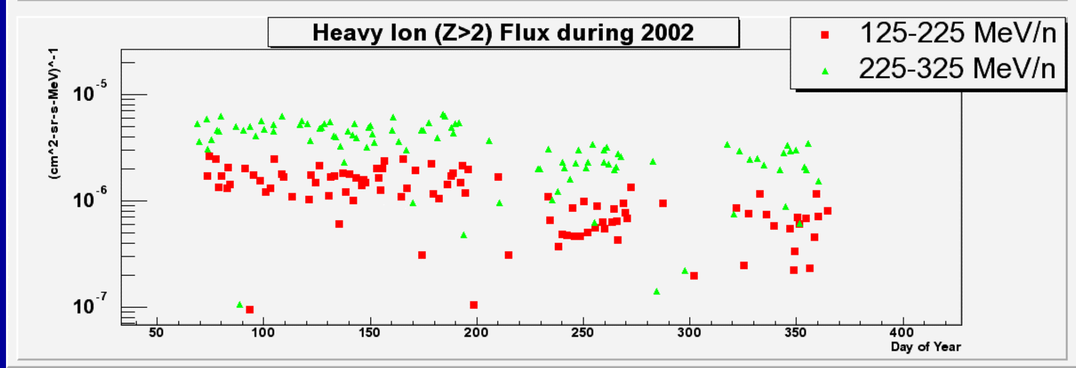




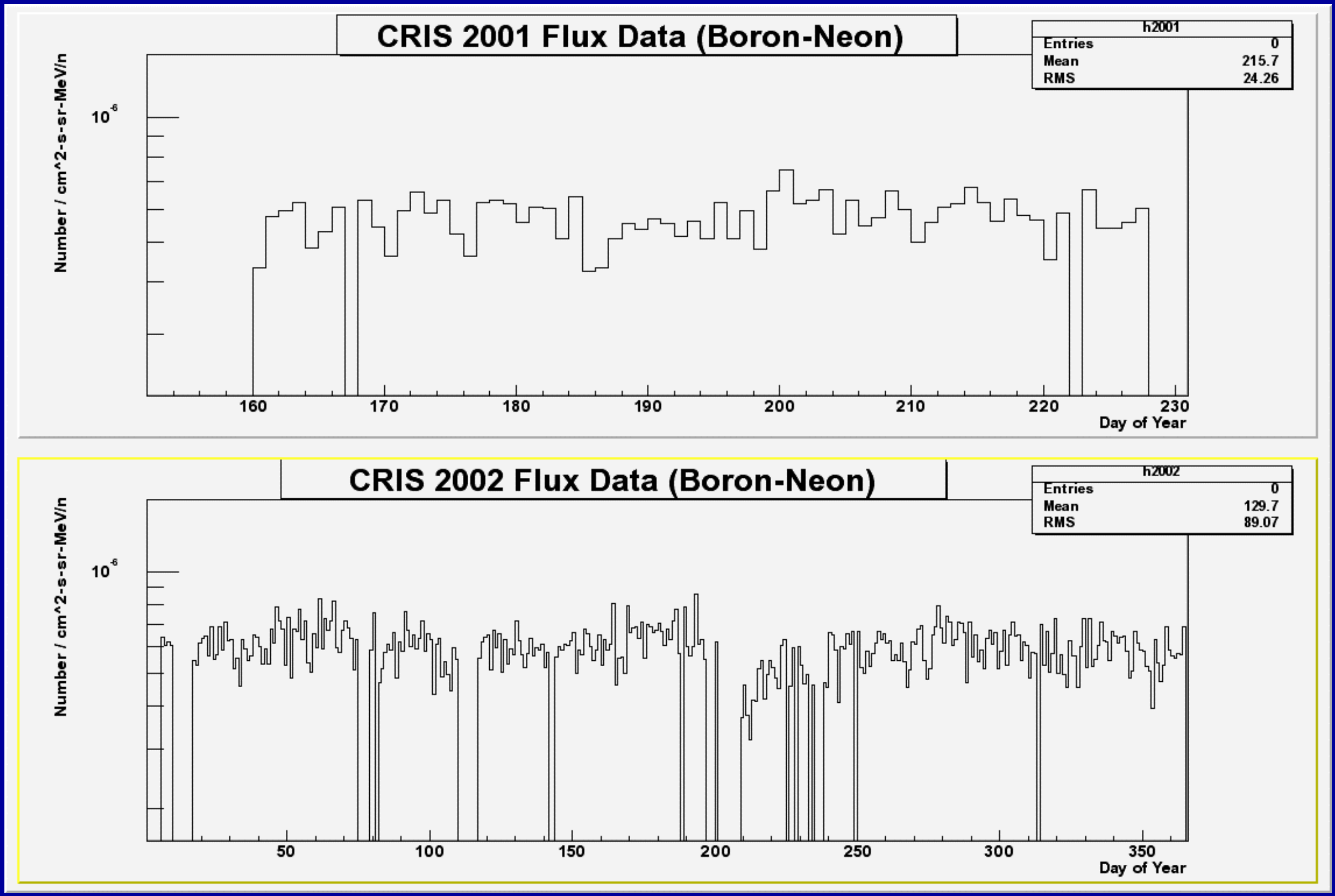
Proton FLUX

Heavy Ion Flux (Z>2)



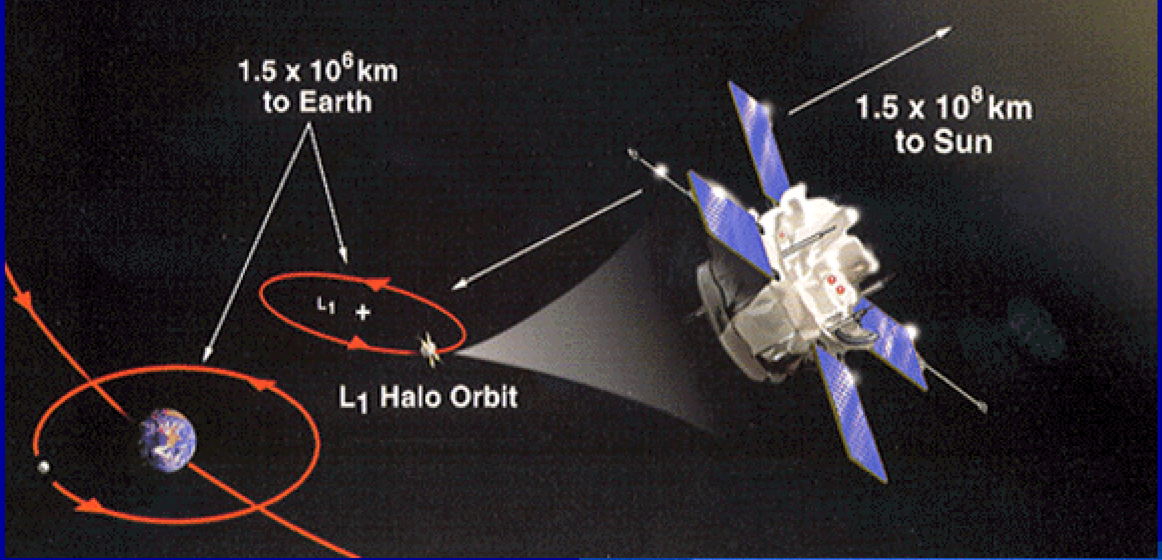


Flux Comparison with ACE/CRIS



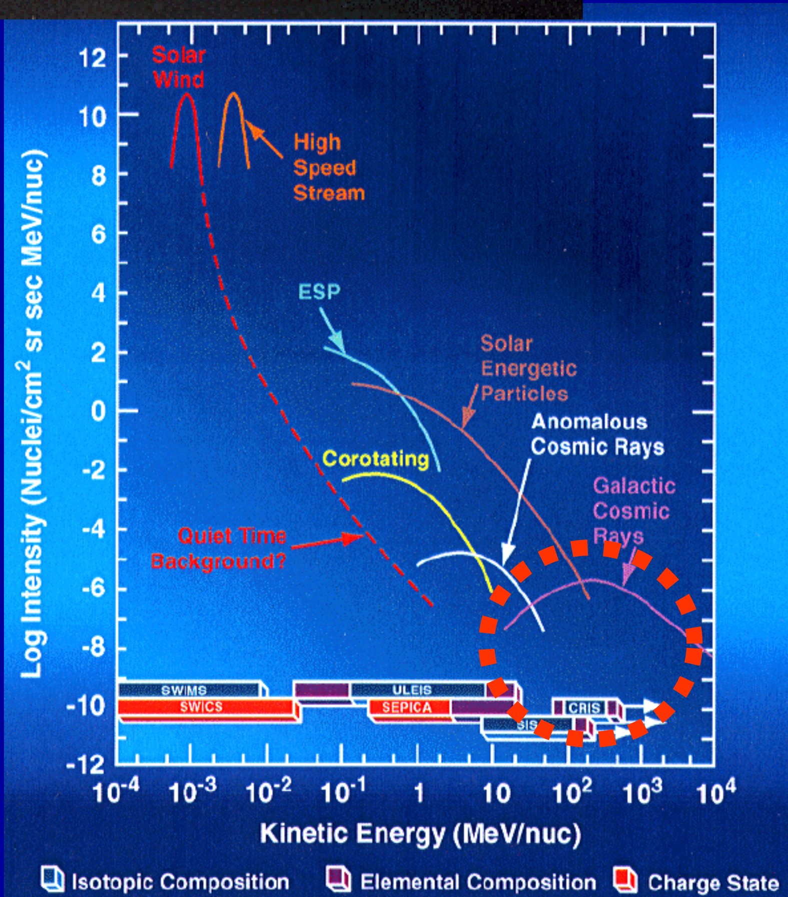
"Mars orbit flux data and near Earth flux data agree within the experimental errors"

→ input to dose calculation on Mars surface (weak B_{field})

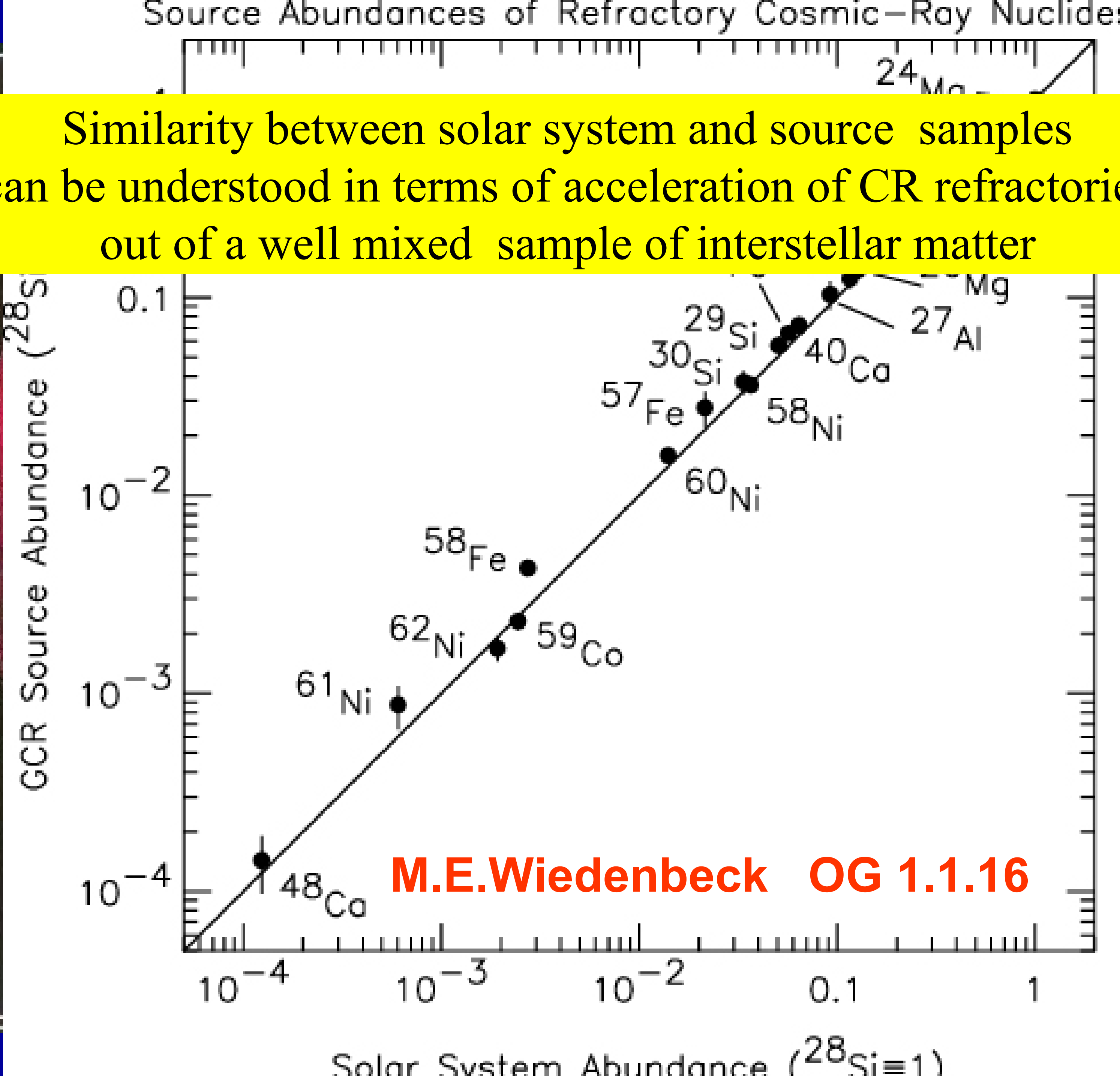


A. W. Labrador
OG 1.1.5
G. A. de Nolfo
OG 1.1.16

Cosmic Ray Isotope Spectrometer (CRIS)



- Launched August 25, 1997
- In orbit around L1 point.
- Elements, isotopes, and charge states Z = 1 – 30
- Energies from ~10 eV/n (solar wind) to ≥500 MeV/n (galactic)
- > 100 cm^2 sr



Similarity between solar system and source samples
can be understood in terms of acceleration of CR refractories
out of a well mixed sample of interstellar matter

M.E.Wiedenbeck OG 1.1.16

Alpha Magnetic Spectrometer STS-91

Bruna Bertucci

OG 1.1.1

Energetic

p and e±

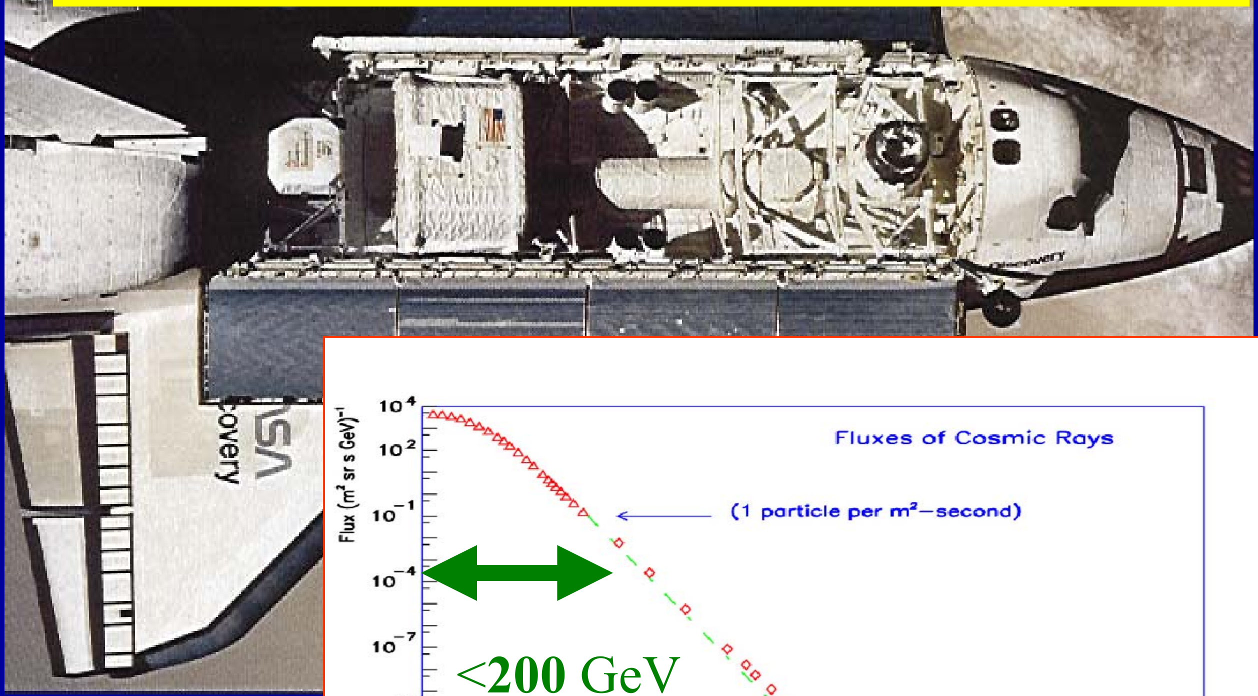
trapped

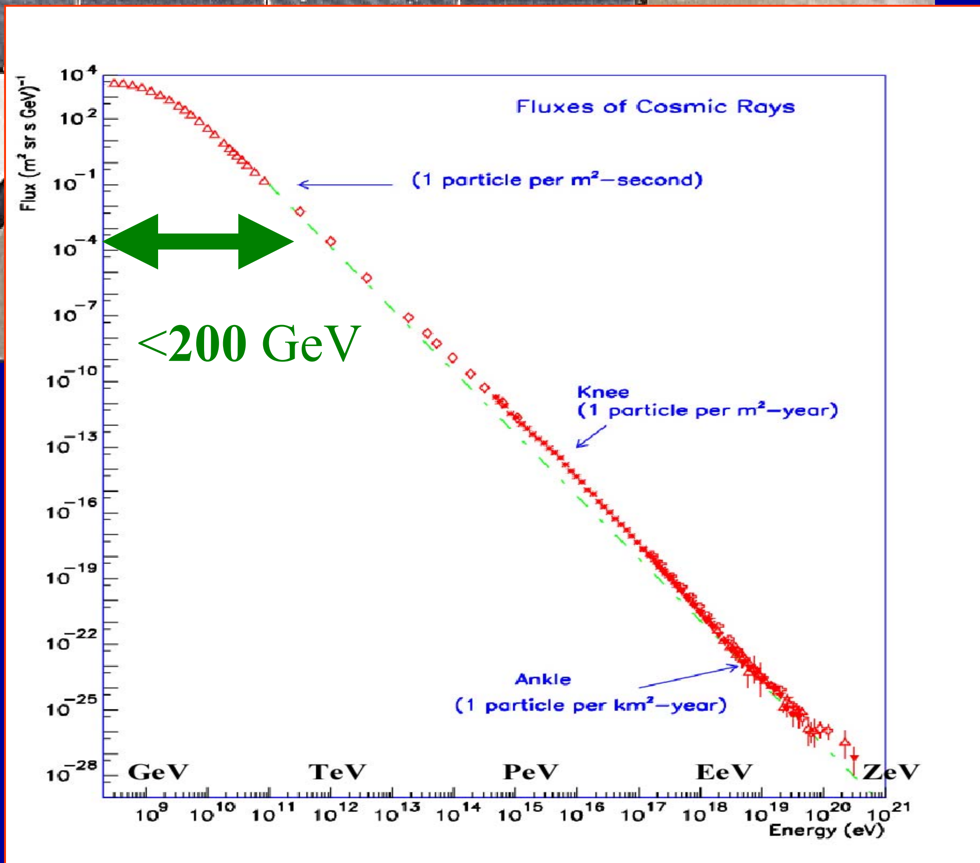
in the Earth

Magnetic

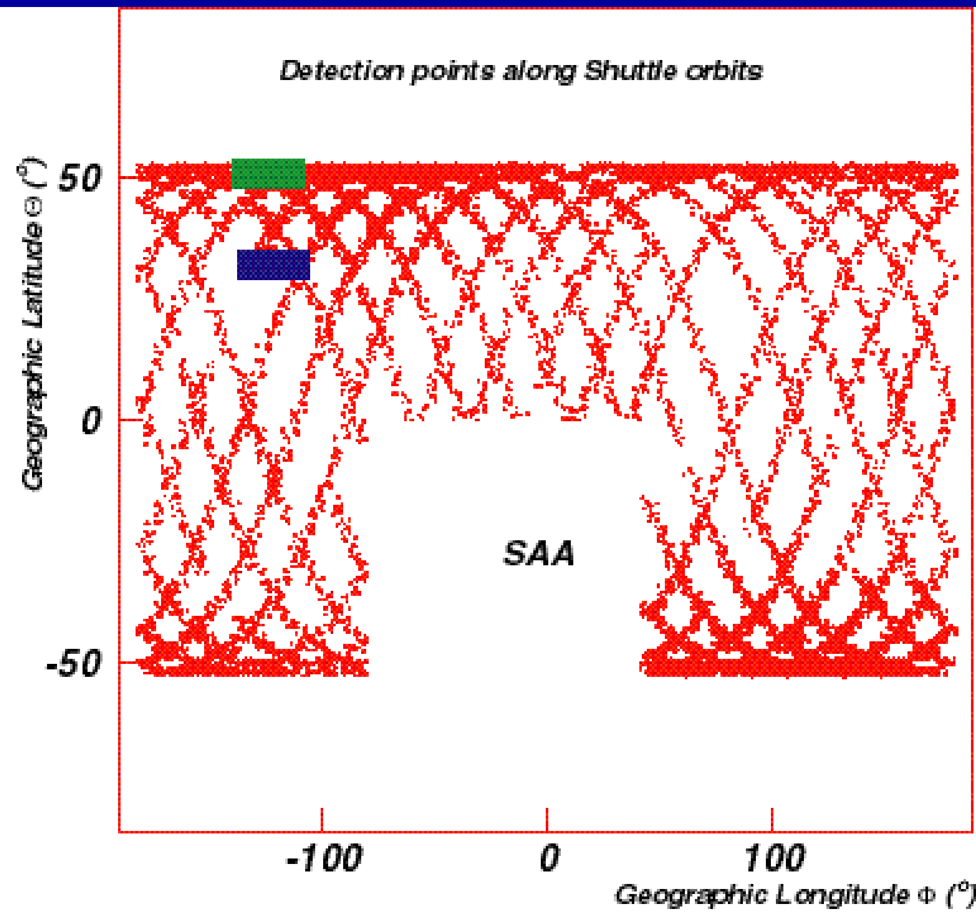
Field observed

by AMS-01



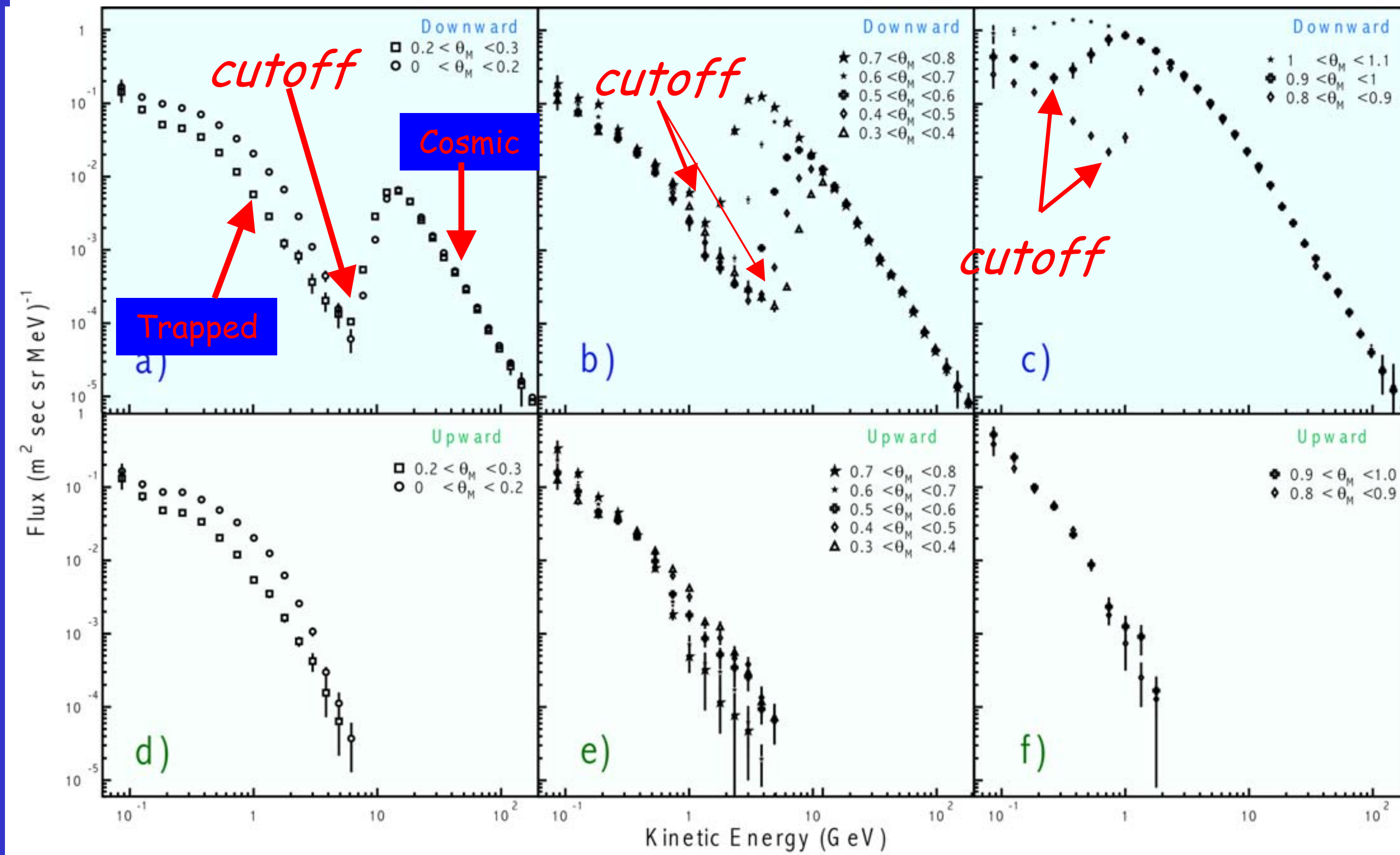


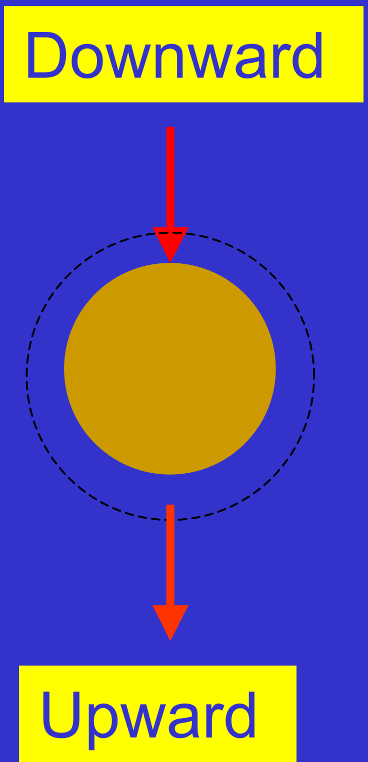
Geographical coverage much better for Satellites than for Balloons



	Cutoffs(GV)	Latitudes	Longitudes
AMS		+/- 51.7	all (SAA excluded)
BESS98	<0.5		(Lynn Lake - Canada)
CAPRICE94		+56.5 N	101-117 W (Lynn Lake - Canada
MASS91	4.3	+34 N	104 W (Forth Sumner)
IMAX92	0.37-0.63	+56.5 N	101-118 W (Lynn Lake - Canad
LEAP87	0.6-1.1	n.a.	n.a. (Prince Albert - Canad

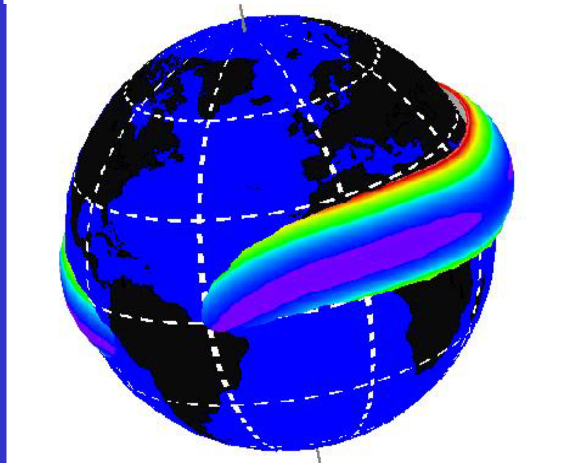
AMS-01 Published Proton spectra



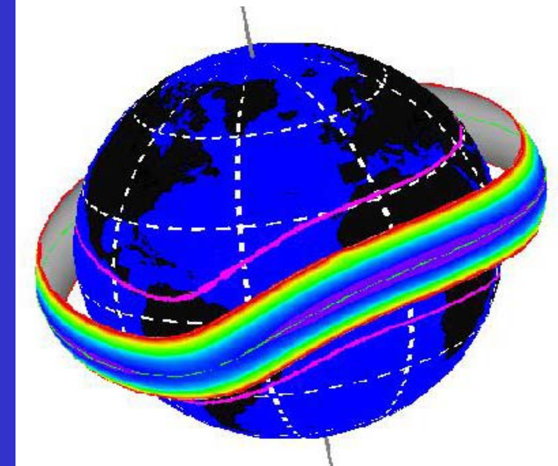


Similar energy spectra found for e^- measured up to ~ 30 GeV
e^+ measured up to ~ 3 GeV

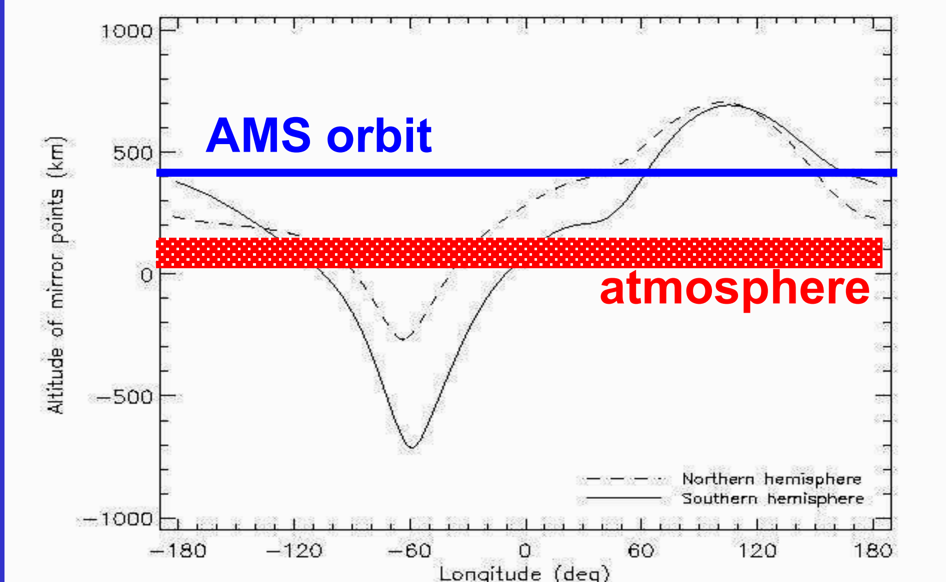
Drift shell for QT

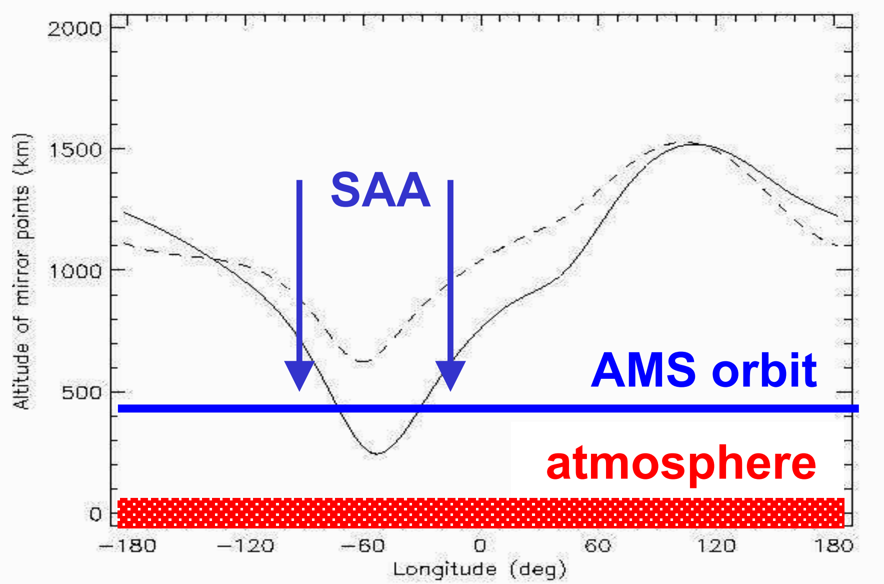


Drift shell for ST



SPENVIS map of the belts measured by AMS-01



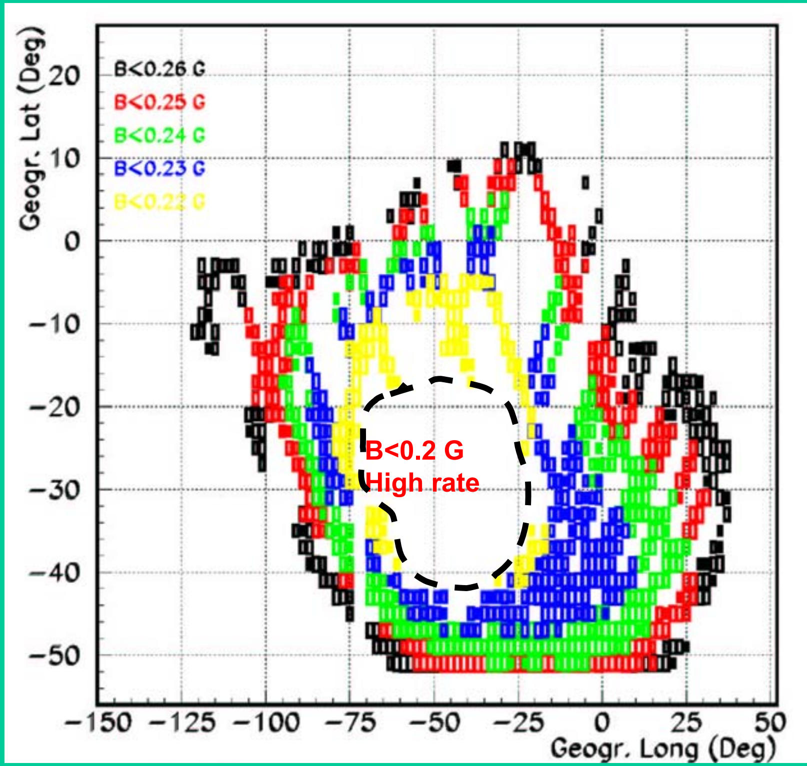


AMS coverage of particle belts:

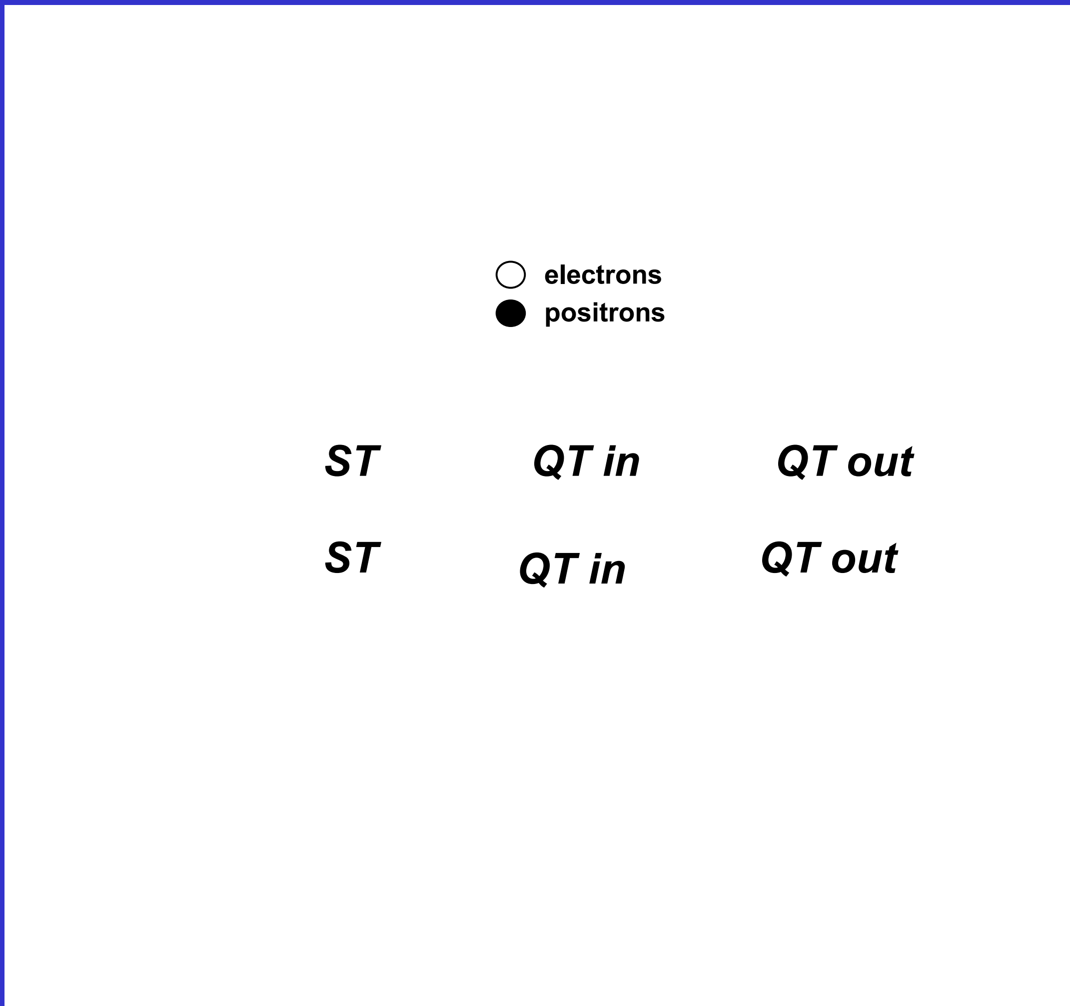
→**Outside the SAA** : open shells, i.e. intersecting the atmosphere over wide or restricted longitude intervals.

→**Inside the SAA** : open & closed shells, in particular we access closed shells below the stable Van Allen belts.

$$\sin\alpha_o \leq \sqrt{B_o/B_m} = \sqrt{0.311 \cdot /B_m L^3}$$



Radial profiles : $e^{+/-}$ with E<2.7 GeV



QT fluxes :

→similar in & out SAA

→monotonically descreasing with L

→ large excess of e^+ at very low L

ST fluxes :

→depletion region ~1.4 R_E between peaks ~ 1.25 R_E and ~ 2.1 R_E

→large excess of e^+ in the slot region

Low L radiation belts dominated by e+ over e-

First accurate measurements of a radiation belt characterized by short residence times (up to tens of seconds) and energetic particles (O (GV)), continuously filled by atmospheric interactions of primary energetic CR

Interesting for the study of belt dynamics

This explains why belts observed by AMS are characterized by an high positron content, in addition to proton, electrons, He^3 ....

±

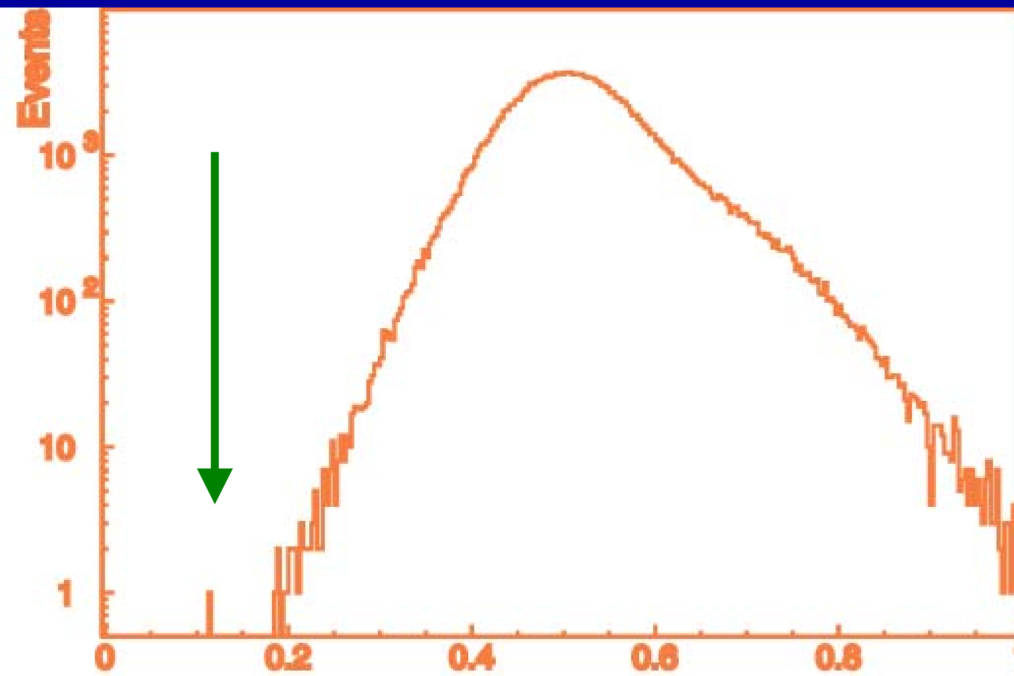


Fig. 1. The measured Z/A distribution for the survived events.

V. Choutko
O.G.1.1.3

AMS anomalous event

Anomalous event (Z/A = 0.114) reported, background probabilty $<10^{-3}$
Compatible with a strangelet predicted from a “colour locked” model.
$\Phi \sim 10^{-5}$ $(m^2\ sr\ sec)^{-1}$

Table 1. Properties of the candidate event.

Lat	Long	Rigidity (GV)	TOF	dE	Z/A	Cuto (GV)
-44.38	23.70	4.34 ± 0.38	0.462 ± 0.005	0.44 ± 0.04	0.114	1.95 ± 0.1

Light isotopes

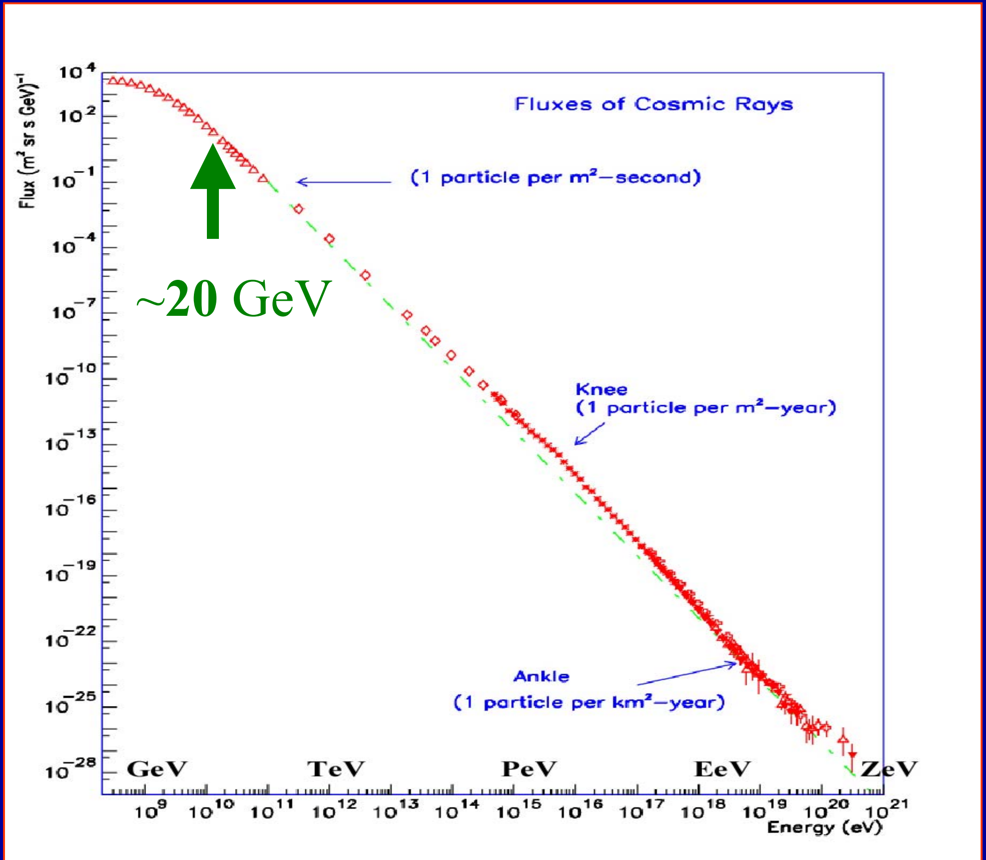
Antimatter search

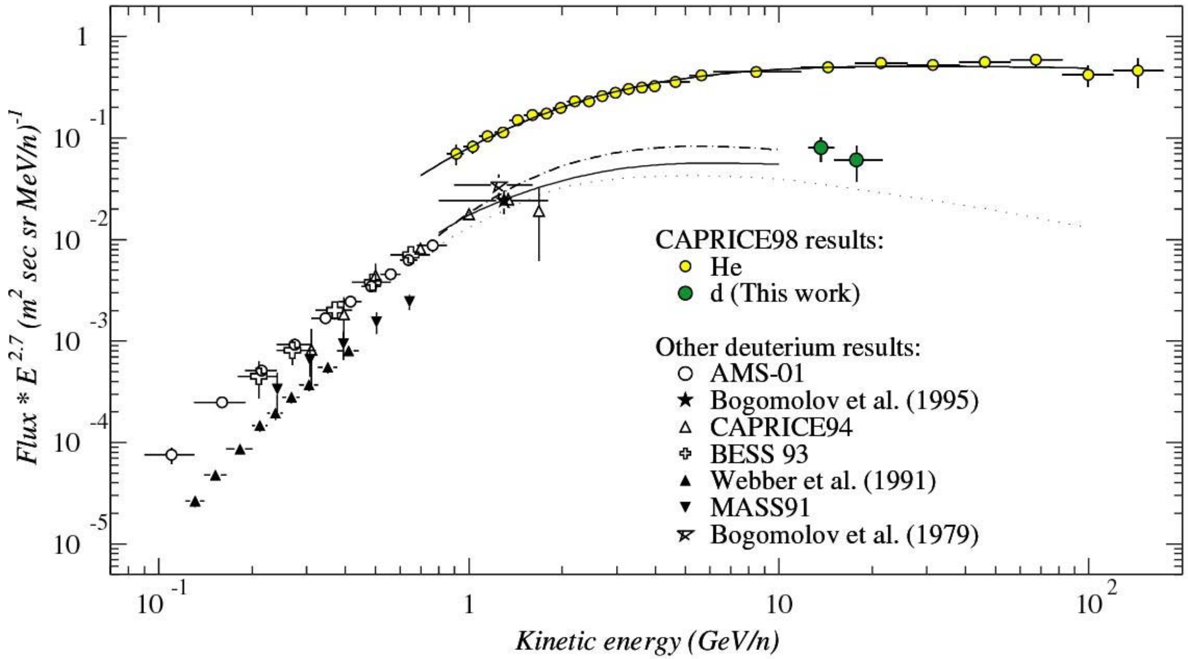
E. Vannuccini OG 1.1.9

D (12-22 GeV/n)

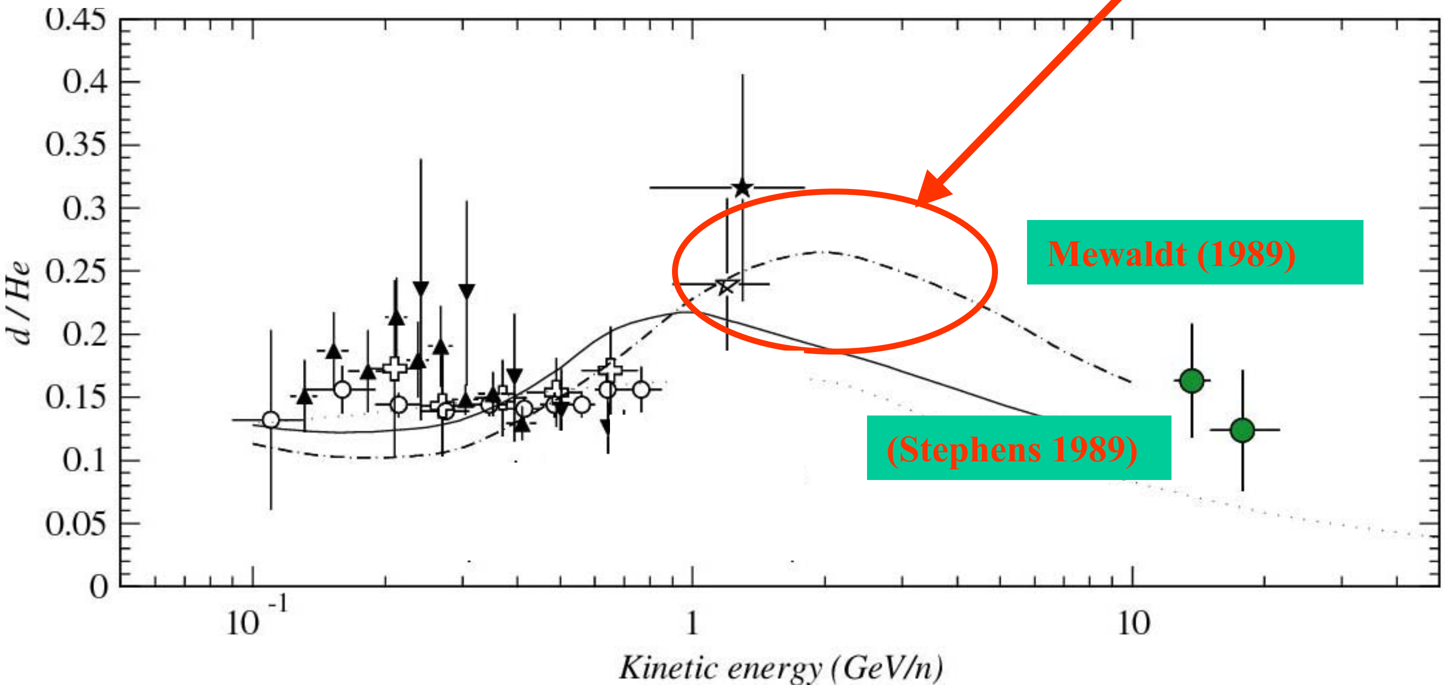
E. Mocchiutti OG 1.1.11

He3 (16.4-19 GeV/n)





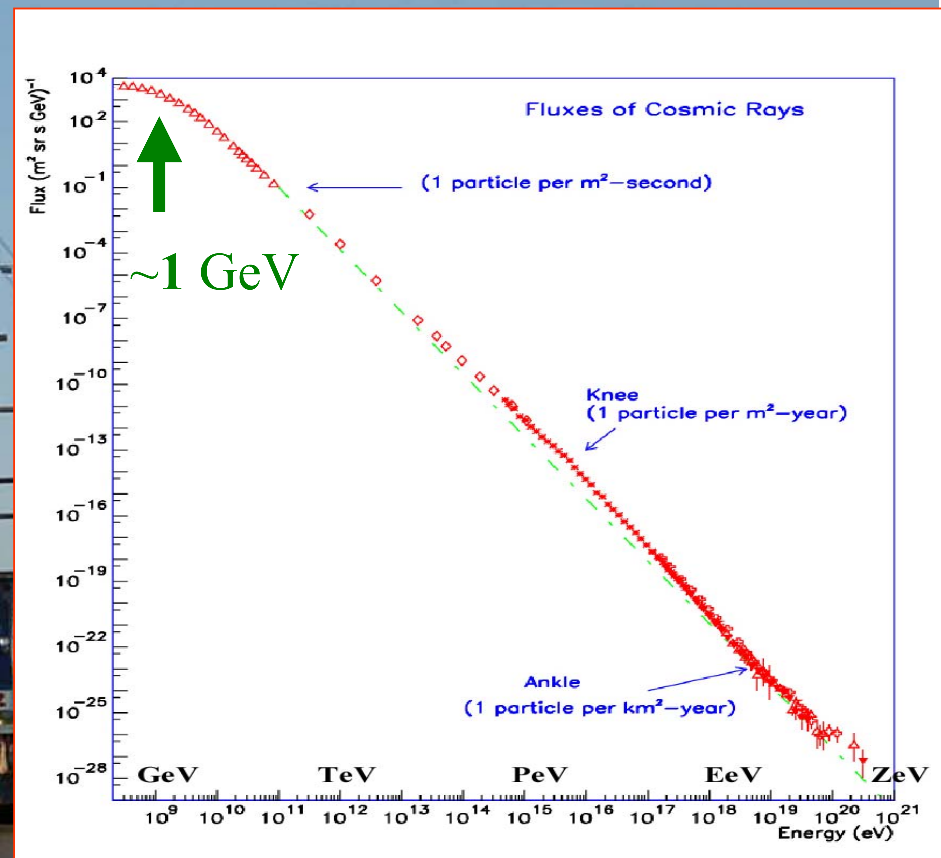
More data needed around Ekin ~ 2 GeV to allow discrimination among propagation models → BESS



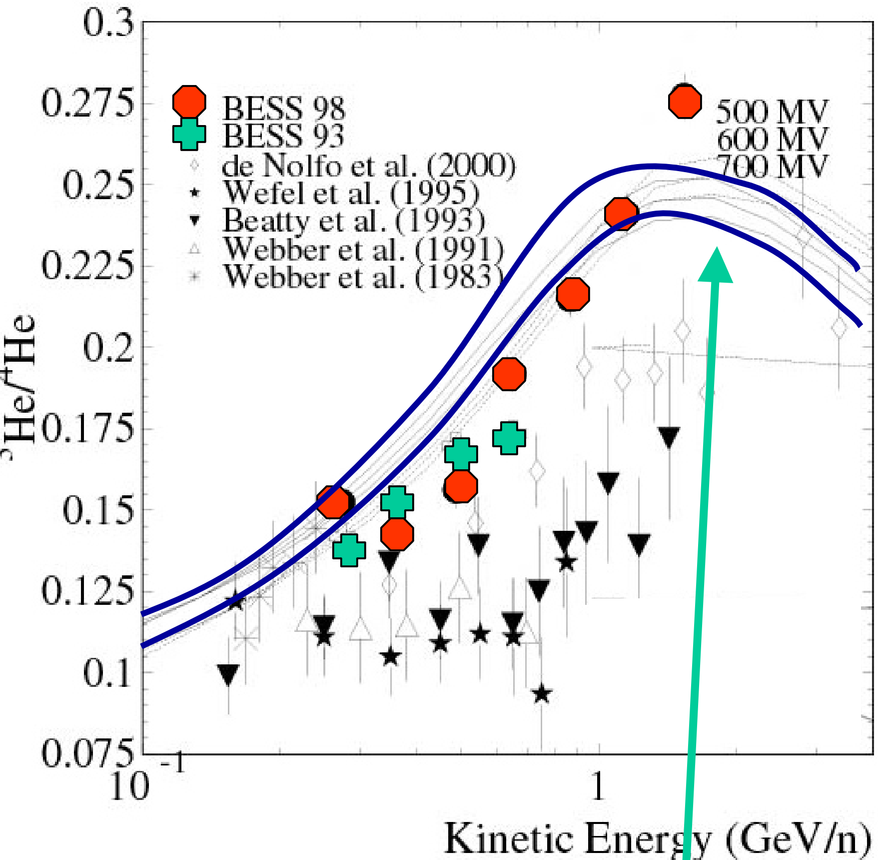
Z. D. Myers OG 1.1.10

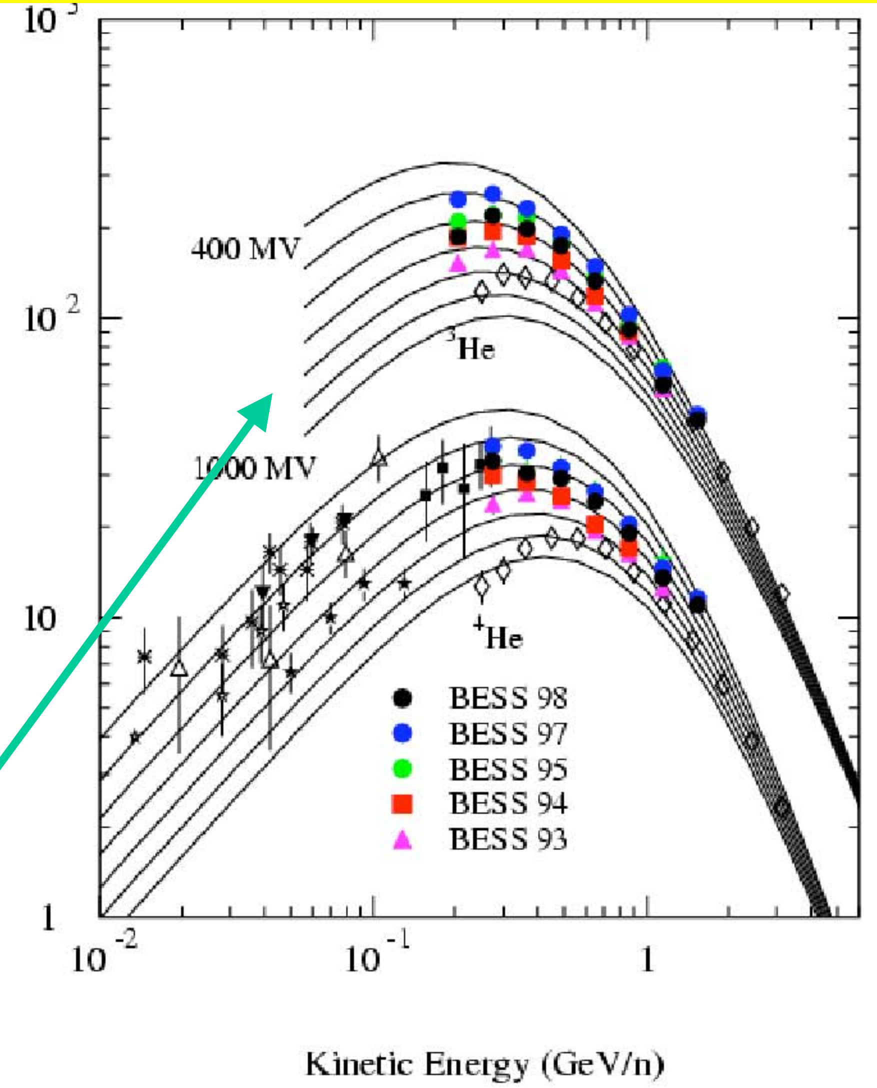
He3 He4 (0.2-1.5 GeV/n)

BESS



3He/4He increase by a factor of 2 in the 0.2 –1.5 GeV/n range



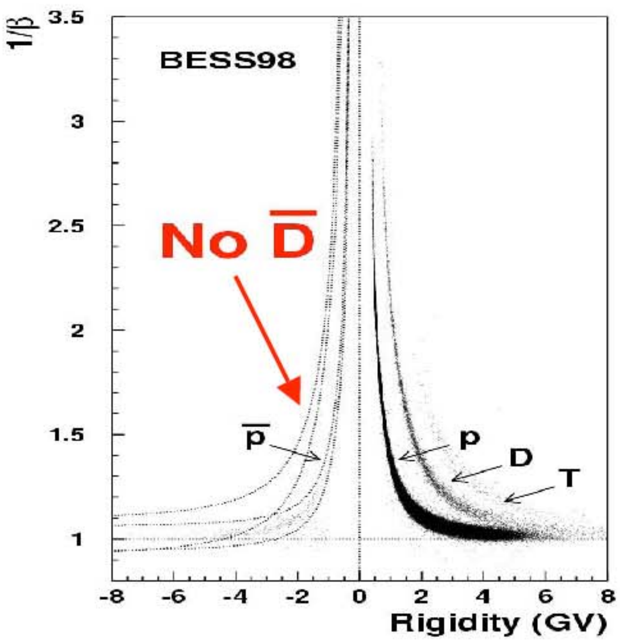


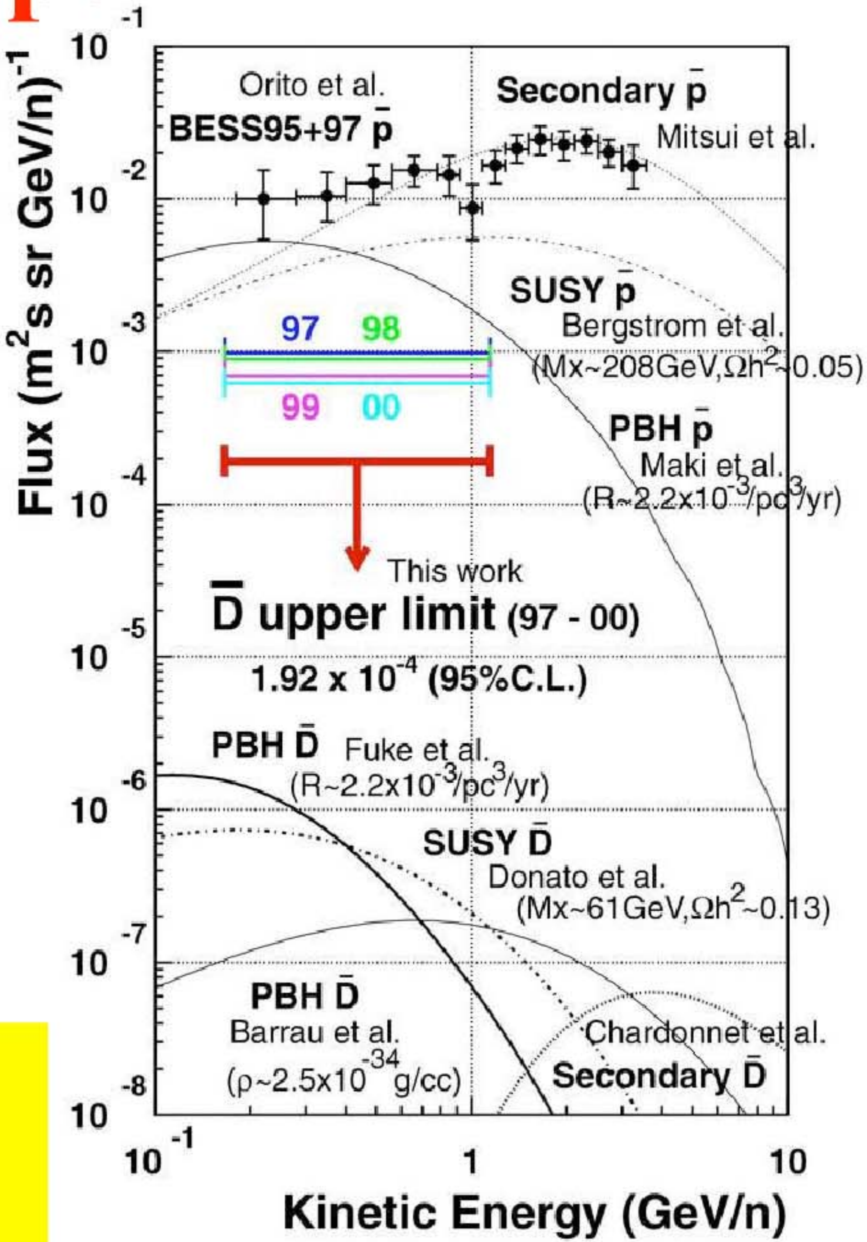
Solar modulation

Antideuteron Upper Limit

(Fuke et al., OG1,1,-P)

$\overline{D}$ searched in BESS-97, 98, 99, 00

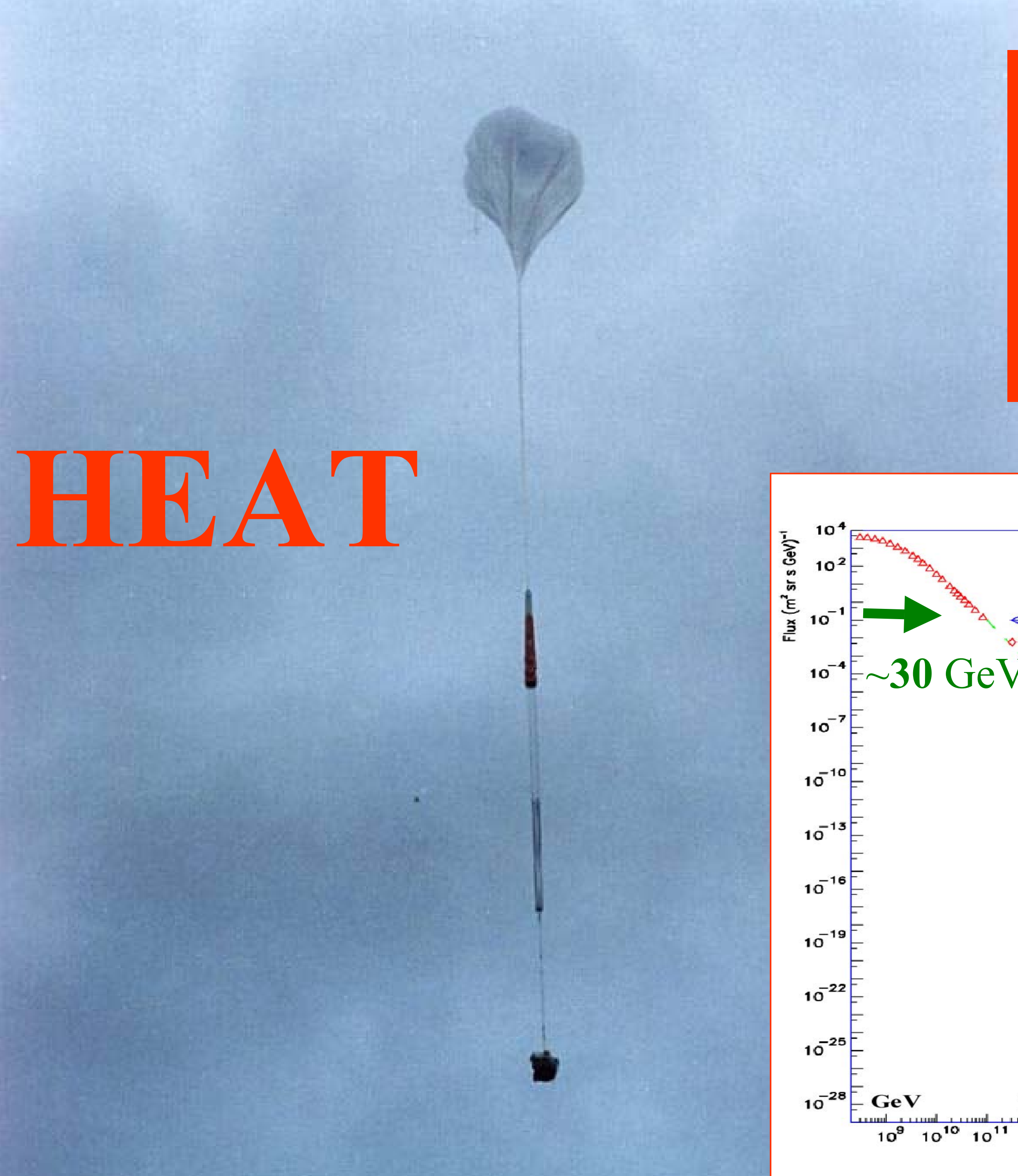




$\overline{D}$ upper limit, for the first time,

1.92×10^{-4} (m^{2}s.sr.GeV/n)$^{-1}$

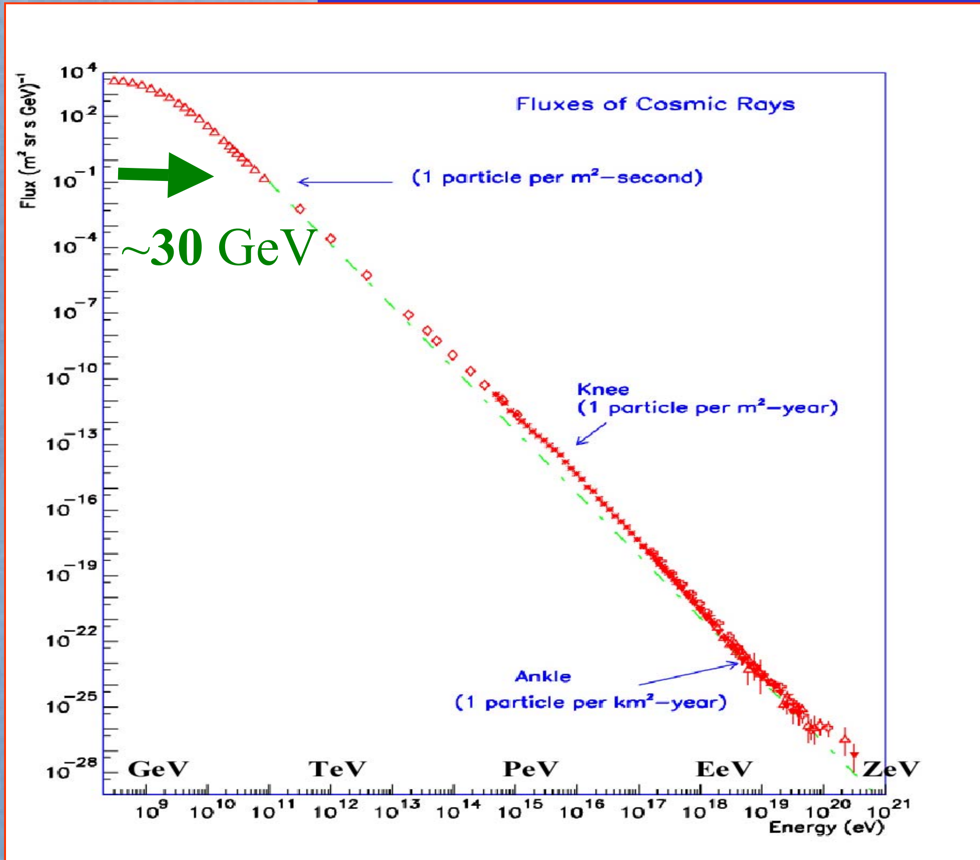
HEAT



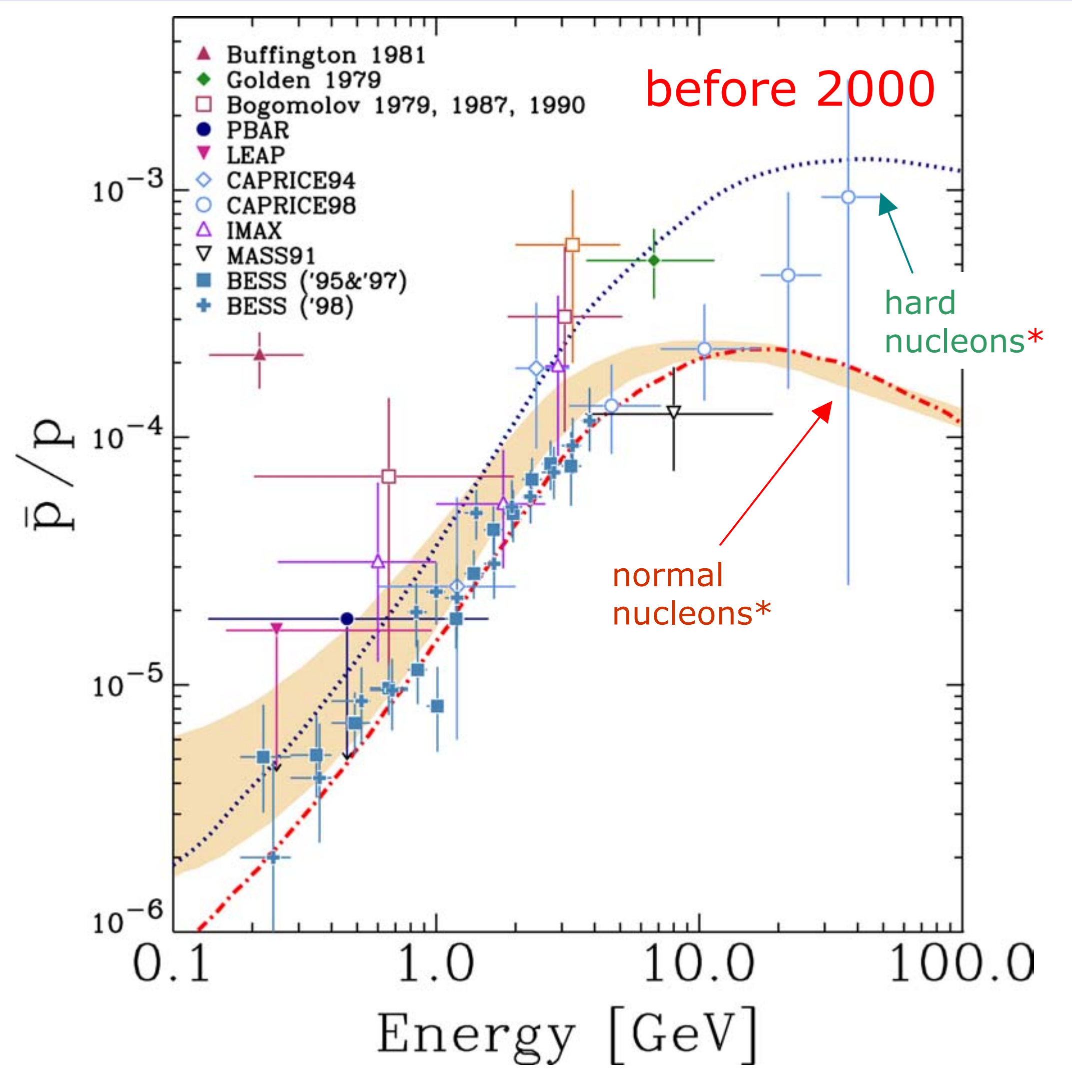
S. Swordy

OG 1.1.8

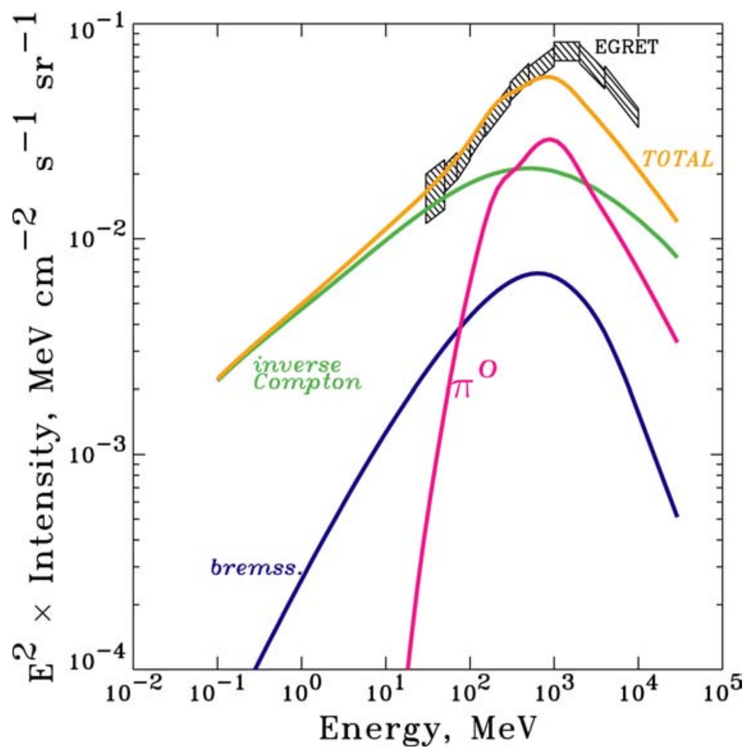
$\bar{p}$ (4 – 30 GeV)



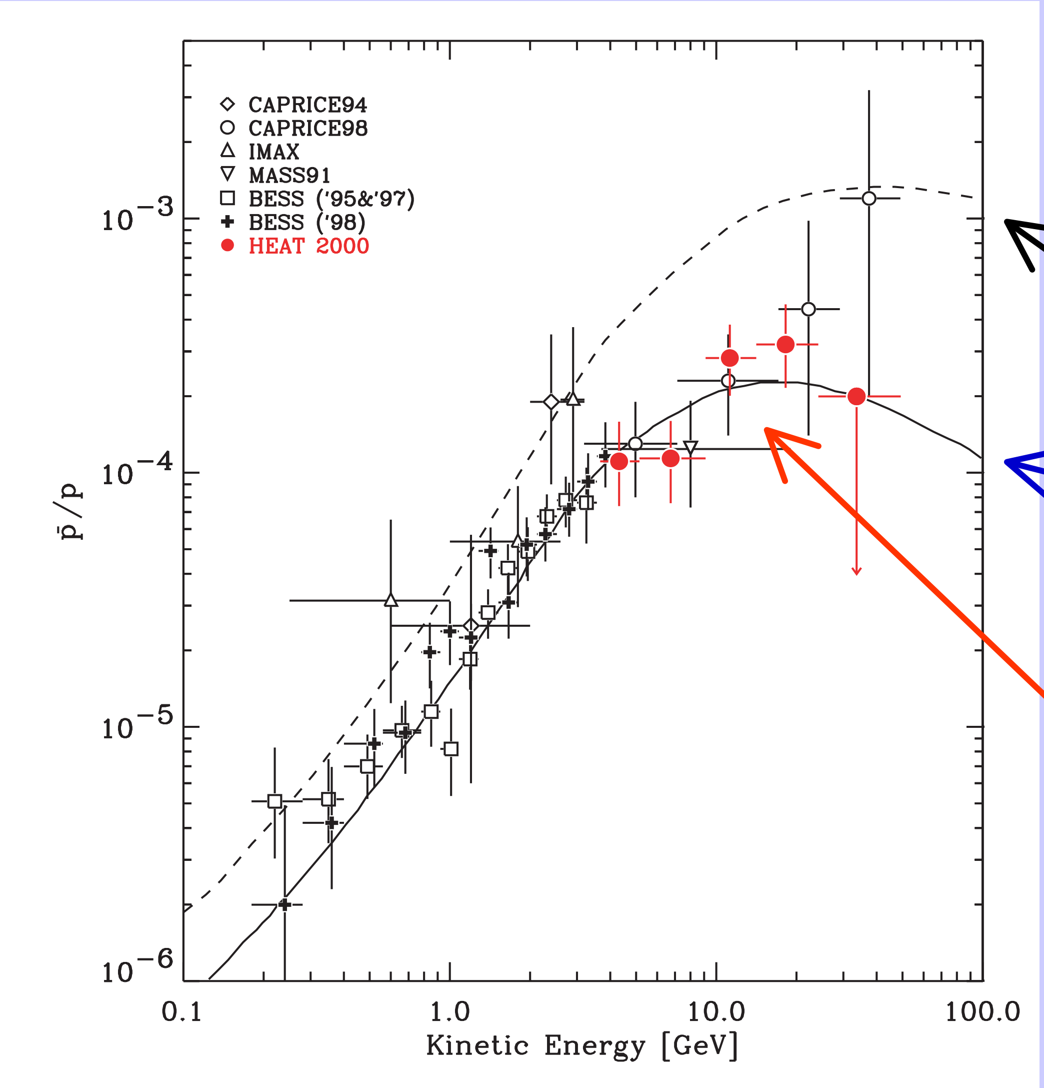
Positrons and antiprotons probe the structure of the ISM and the primary nucleon component.



High observed diffuse GeV γ-ray flux (EGRET)



(*) Moskalenko, Strong, Reimer

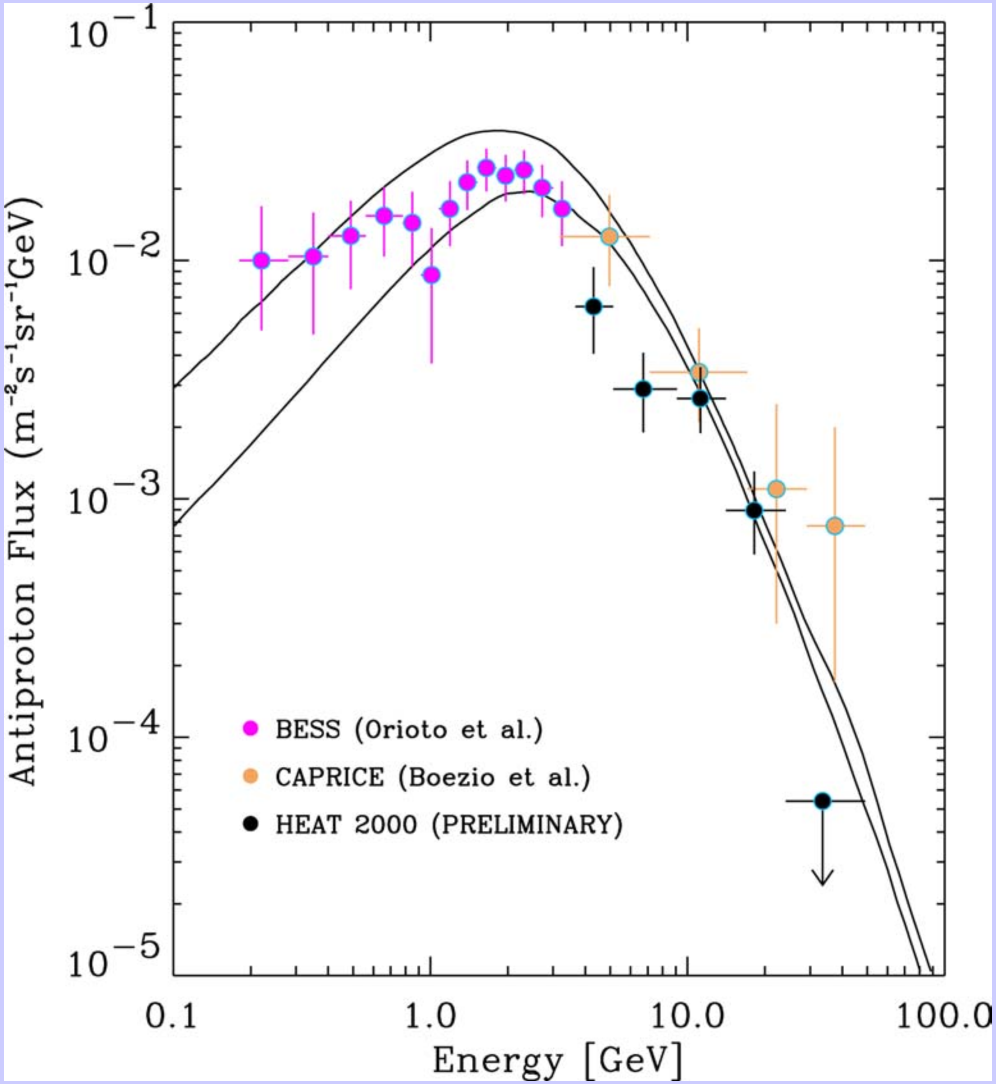


Results from HEAT-pbar 2000 flight: Beach et. al. Phys. Rev. Lett. 87, 271101 (2001). Flight of 22 hours, June 2000.

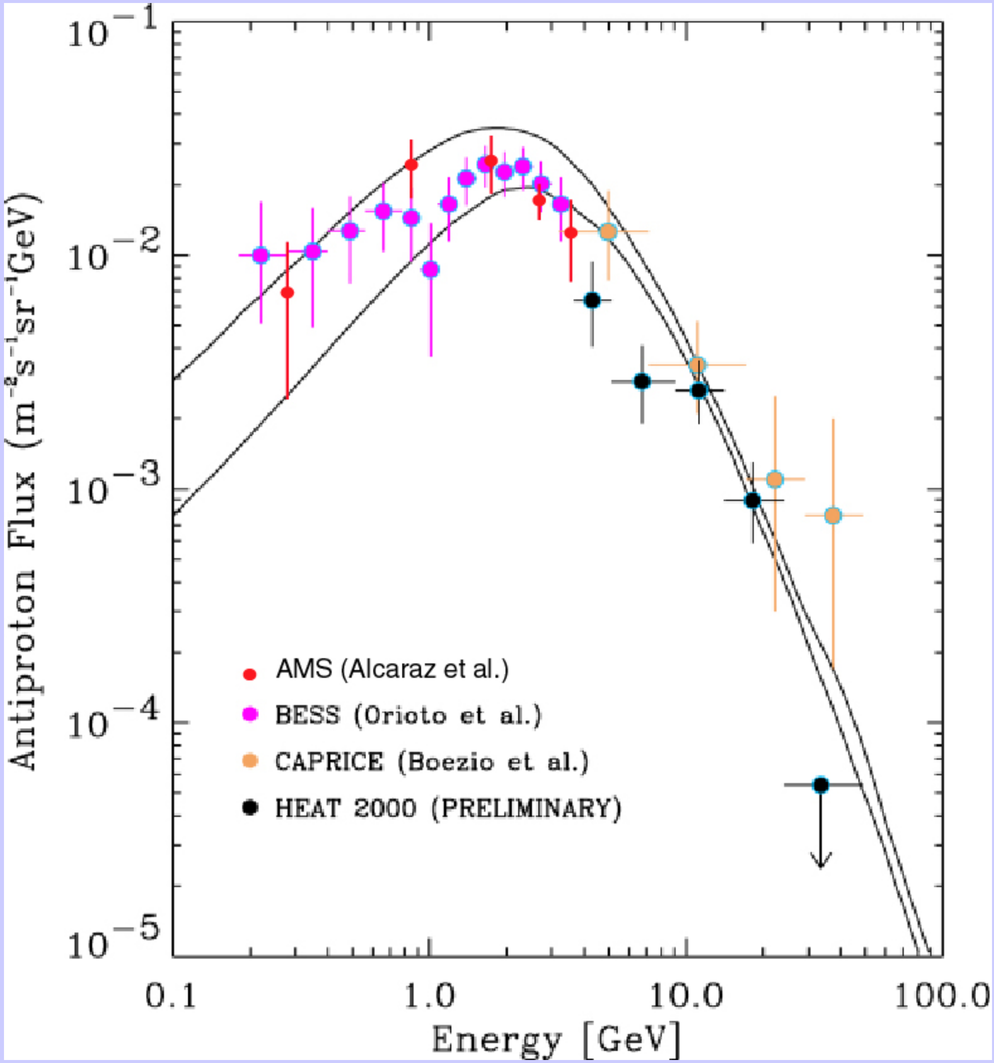
No support for 'hard nucleon injection spectrum' models

Measurements are consistent with purely secondary production of antiprotons.

In fact, data are in good agreement with 'standard spectrum' calculated by Moskalenko et al. [A&A 338, L75 (1998)]



- Atmospheric corrections same as PRL 2000 (e.g. ~10% at 10GeV)
- Preliminary estimates
- High statistical sample at high enery
- Consistent with secondary production models up to ~50GeV



- Atmospheric corrections same as PRL 2000 (e.g. ~10% at 10GeV)

- Preliminary estimates

- High statistical sample at high enery

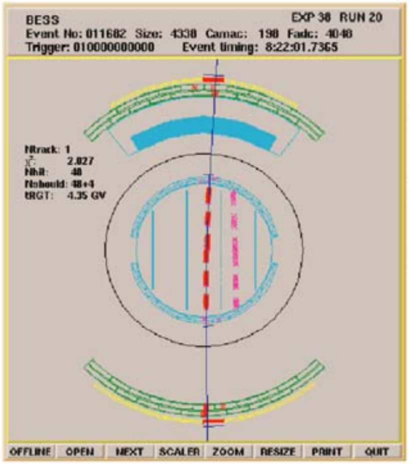
- Consistent with secondary production models up to ~50GeV

S. Haino OG 1.1.14

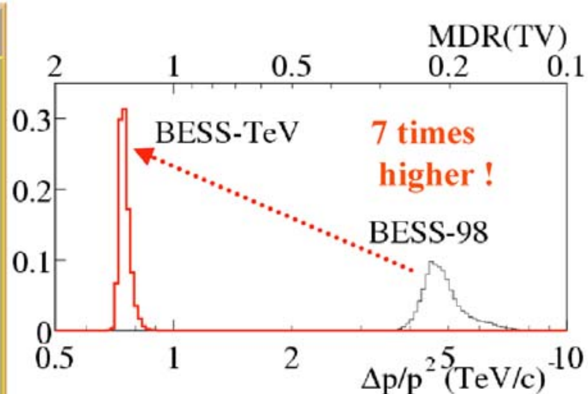
p, He with R <500 GV

BESS-TeV

MDR achieved in BESS-TeV (-02)



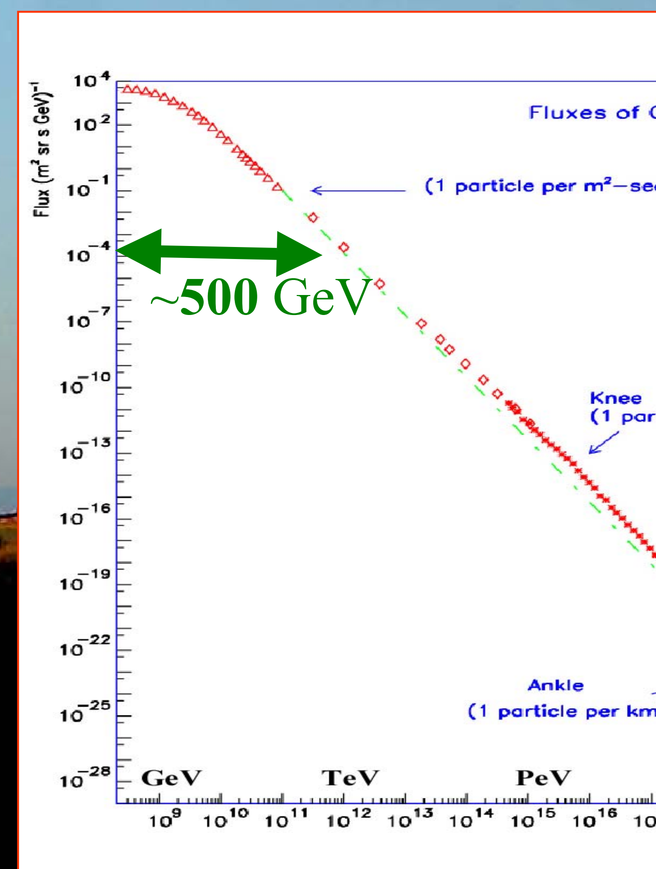
Event Display in Flight



Momentum resolution achieved

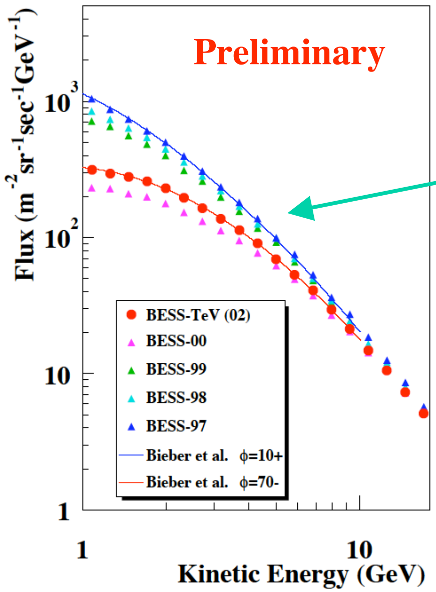
$\Delta p/p^2 = \mathbf{0.7}\ (\mathrm{TeV/c})^{-1}$

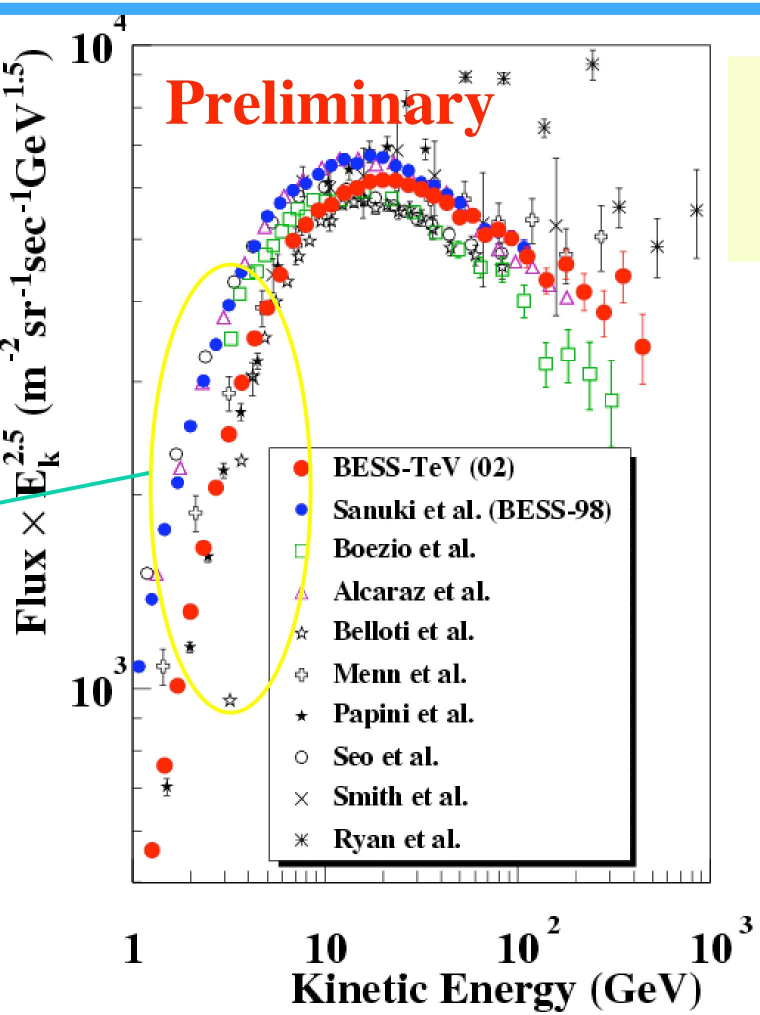
MDR = 1.4 TV



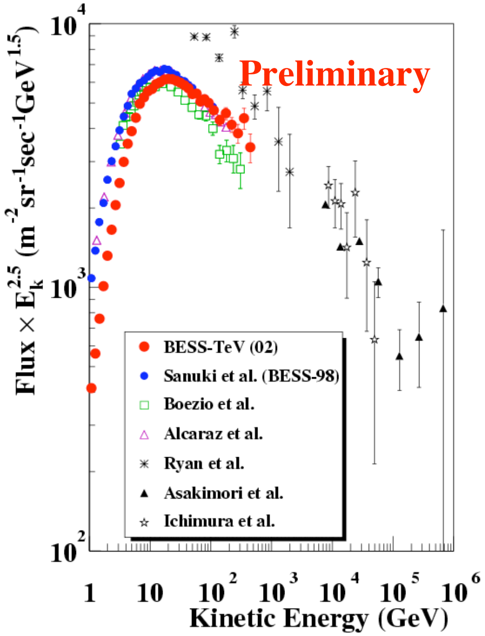
Proton Spectrum Extended to 500 GeV

(S. Haino et al.; OG1.1.14)





BESS-TeV Preliminary Result, Systematic Error not included



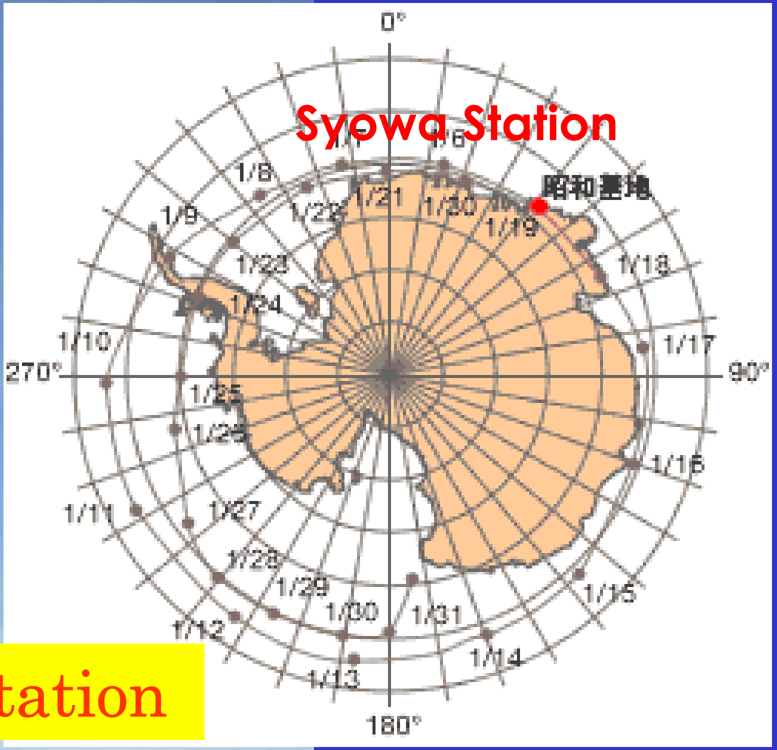
- BESS-TeV result consistent with BESS-98, and AMS-I, at ~ 100 GeV,
- Lower energy fluxes may be explained with “Solar Modulation”

BETS Polar Patrol test flight

S. Torii O.G.1.1.4

Polar Patrol Balloon (PPB)

Japanese Antarctic base at Showa Station



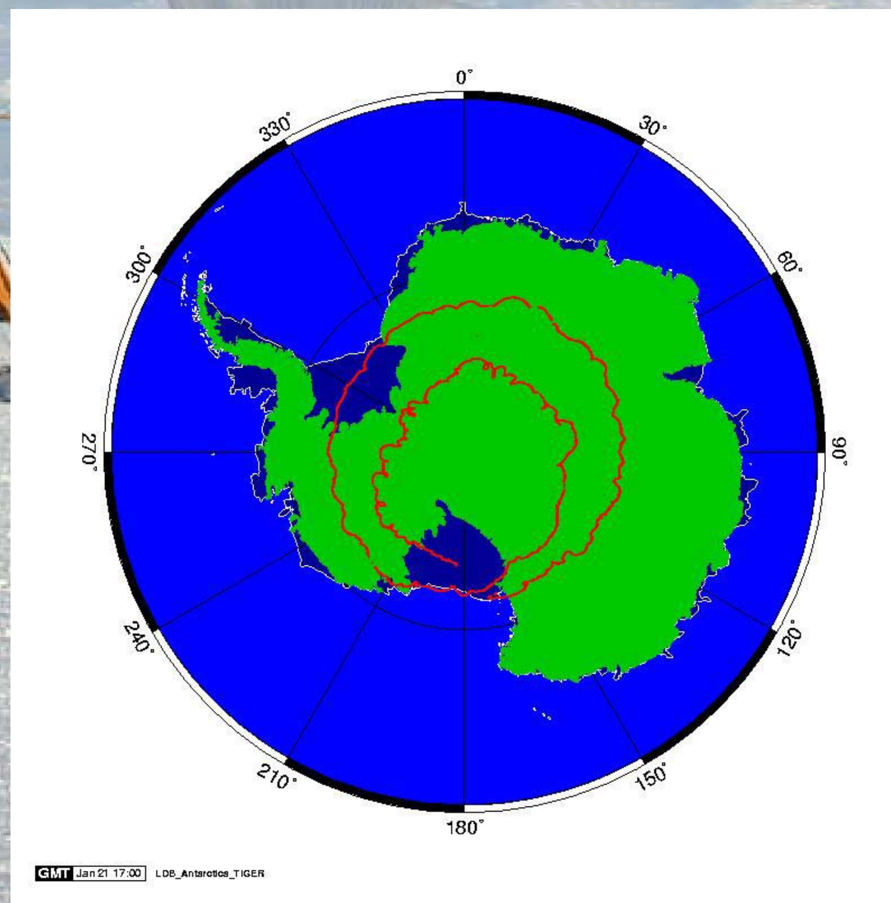
Example of PPB Trajectory for 30 days

Jason T. Link OG 1.1.7

TIGER

Trans iron CR (30 < Z < 40)

Record long duration antartica flight 31.8 days



.........towards the knee

3 new balloons measurements

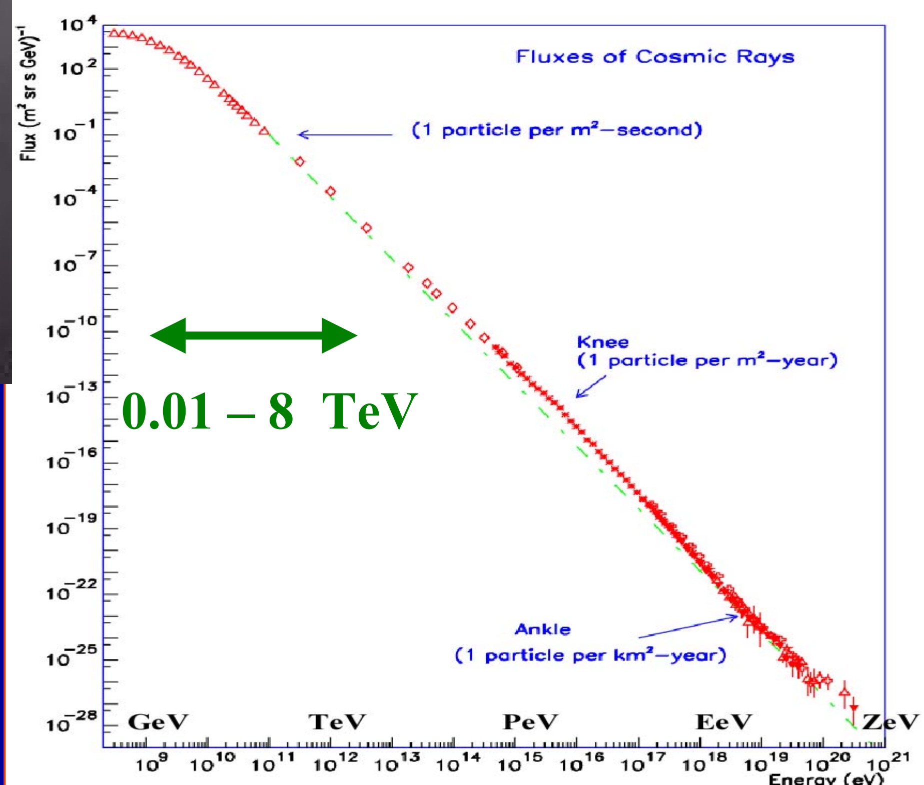
TRACER

ATIC

RUNJOB

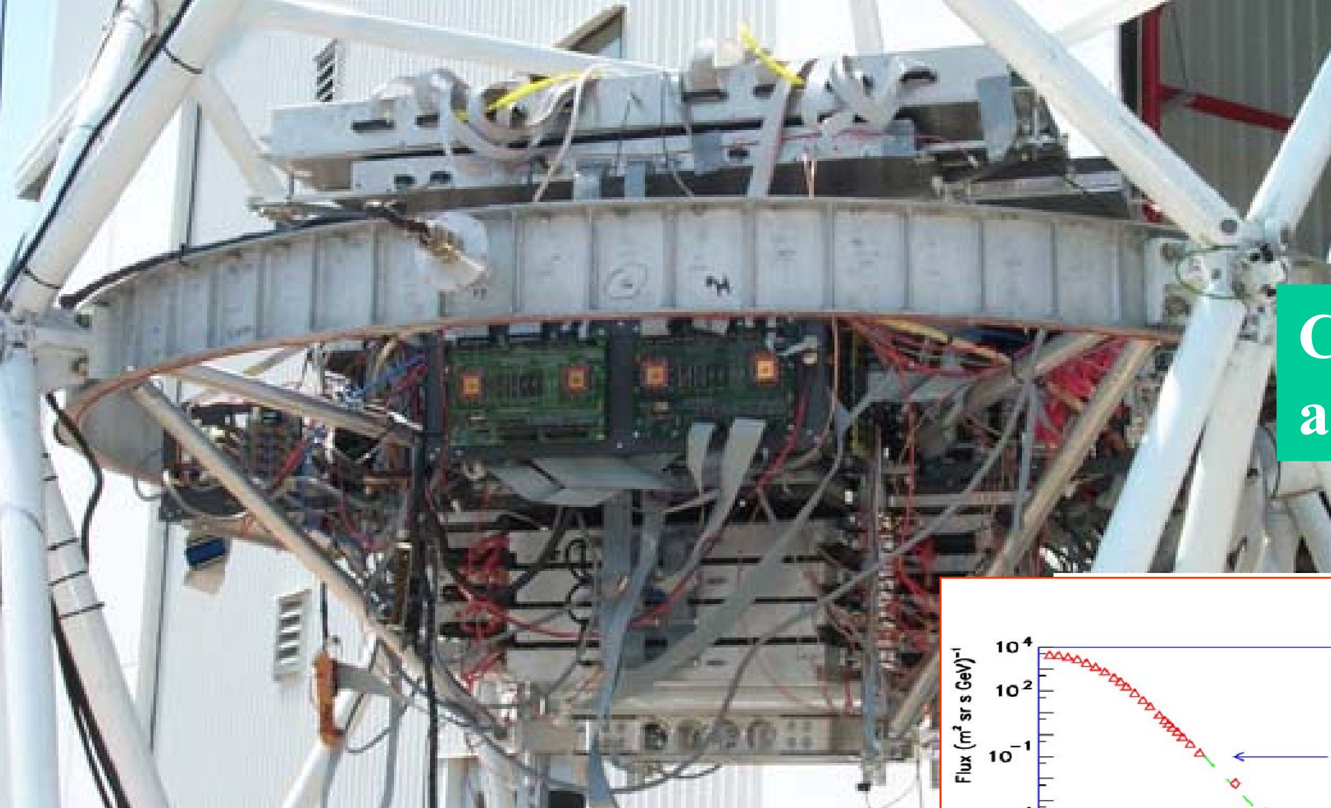
TRACER

~1 day long test flight



D.Muller OG 1.1.20

O, Ne, Mg, Si, Fe spectra
Ekin ~ 0.010- 8 TeV

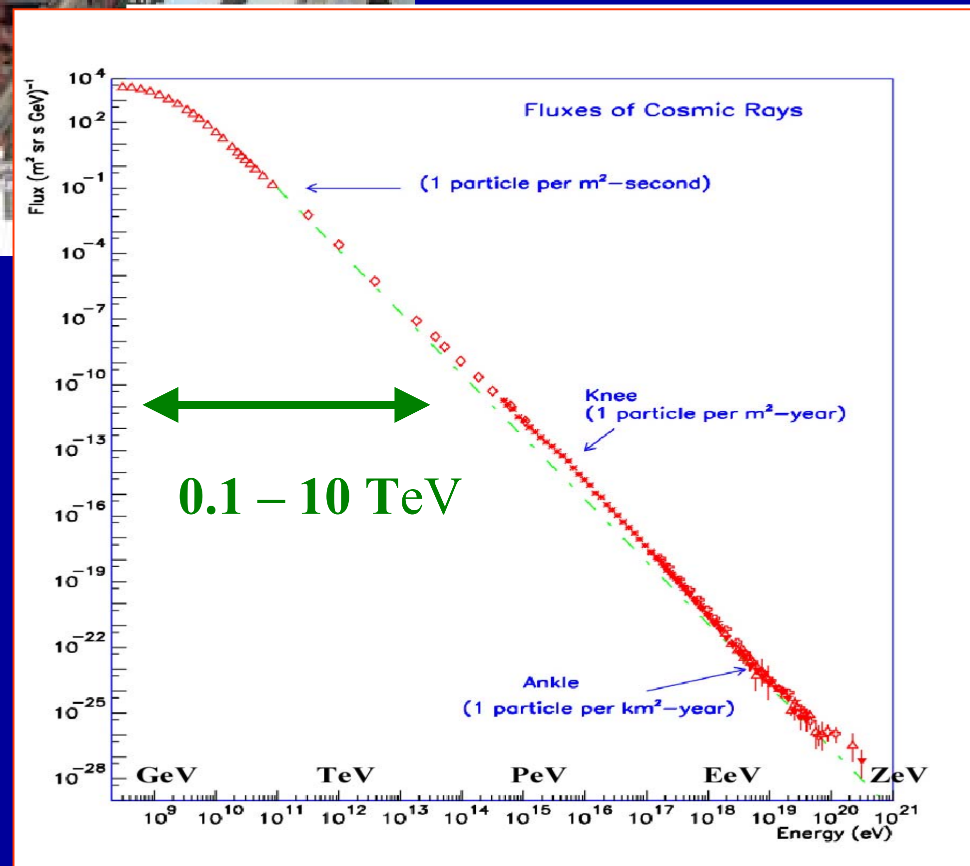


ATIC

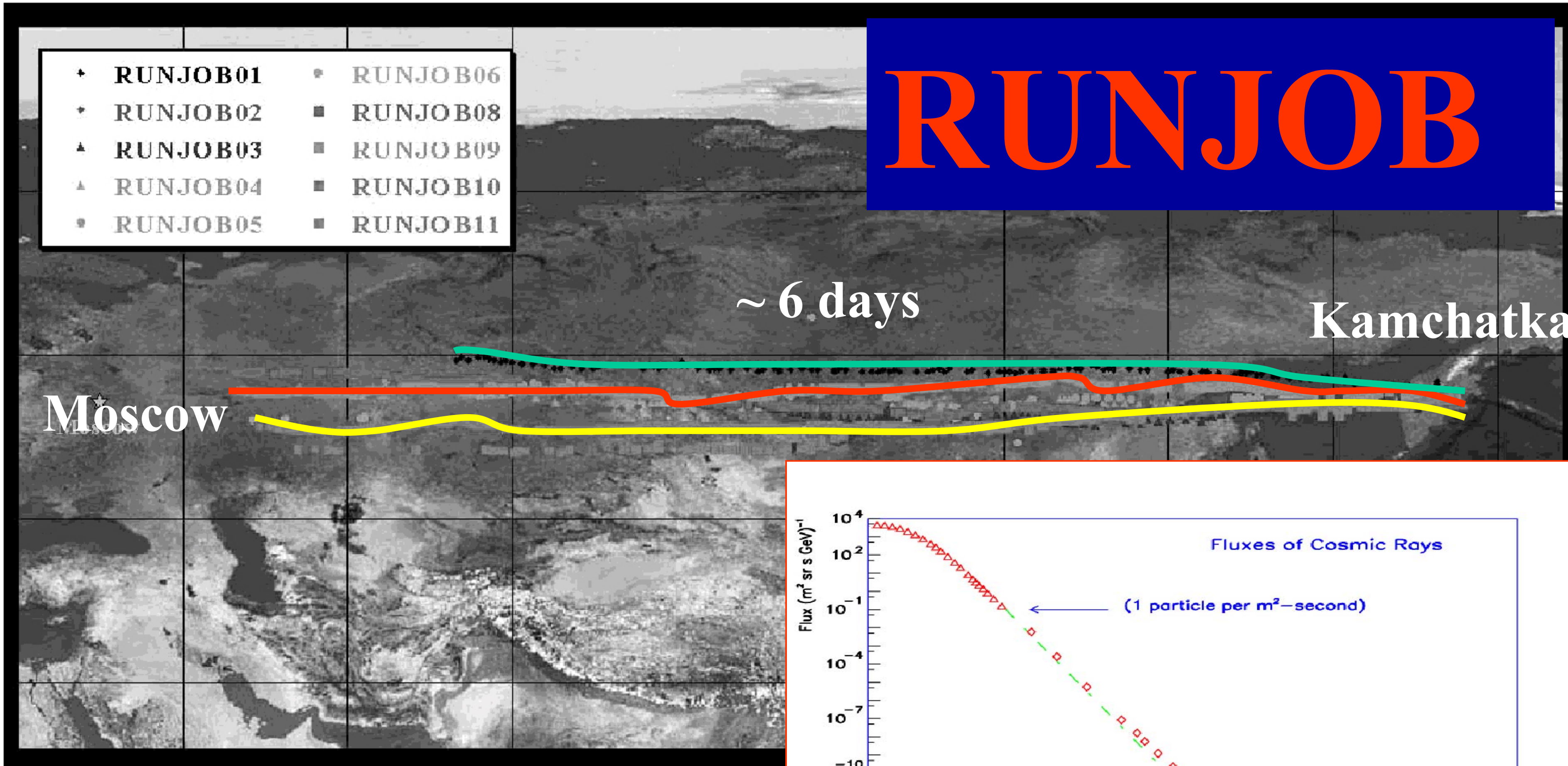
CR Composition and Spectra < 10TeV

19.7 days Long Duration Flight

J. Chang OG 1.13
V. Zatsepin OG 1.1.15
H. Ahn OG 1.1.16
J. P. Wefel OG 1.1.18
A. R. Fazely OG..1.1.19

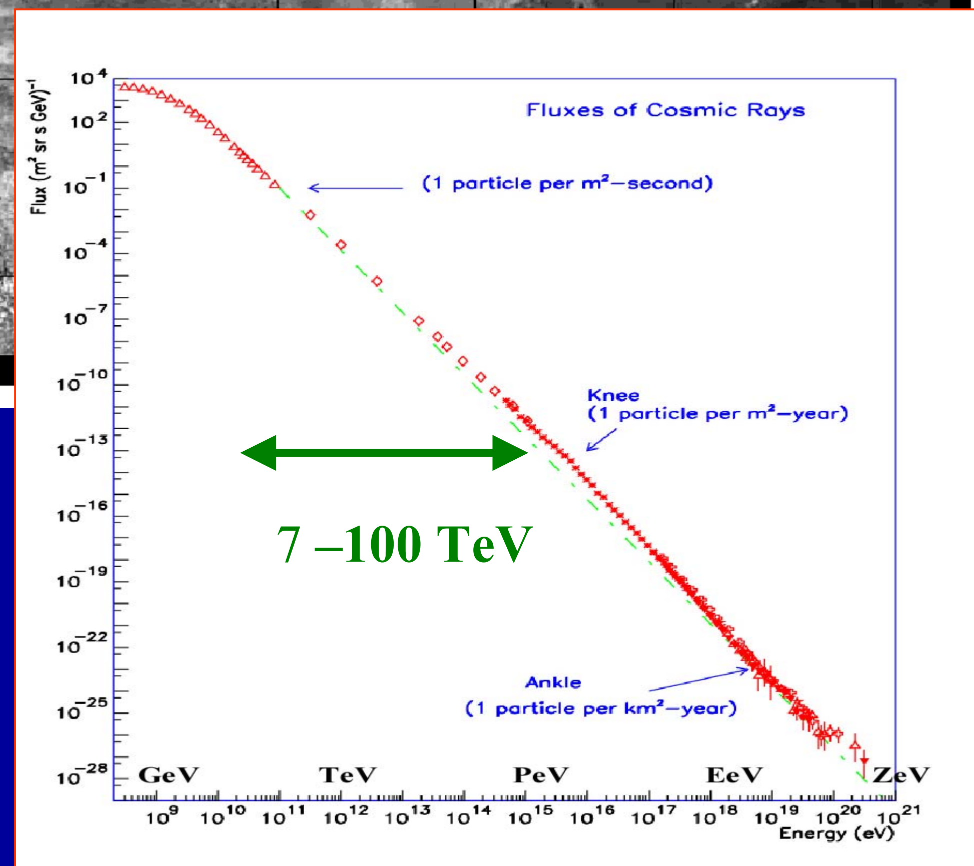


RUNJOB



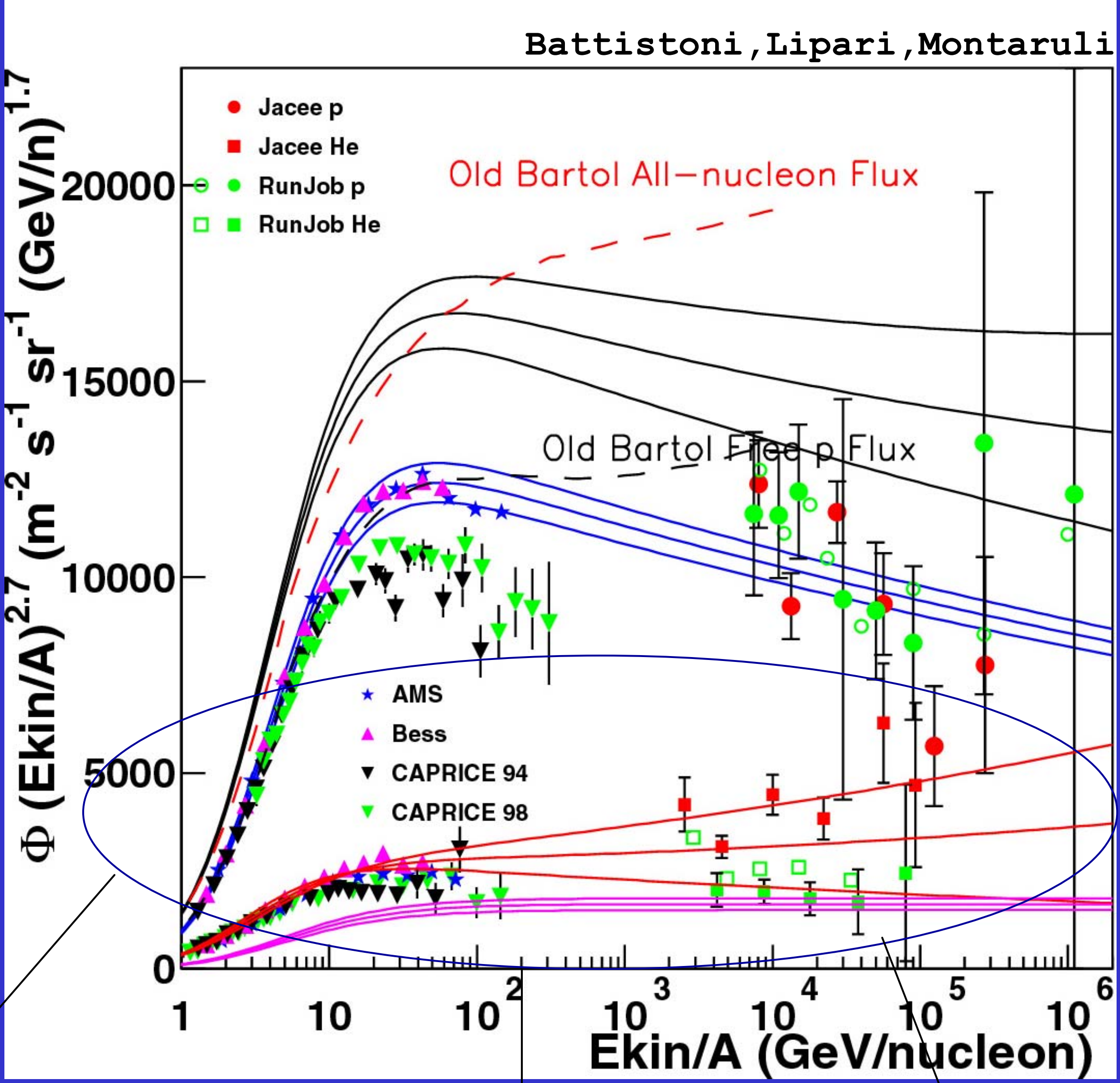
M. Hareyama OG 1.17
S. Kuramata OG 1.1.21
L.G. Sveshnikova OG 1.1.23

CR Composition
and Spectra 7- 100 TeV



Compostion and fluxes of High Energy CR before ICRC 2003.....

T. Montaruli
Rapporteur talk



Hydrogen

- 0.1 GeV $\lesssim E \lesssim 100$ GeV
  Spectrometers: within 5%
- 100 GeV $\lesssim E \lesssim 1$ TeV
  Calorimeters: within $\approx 25\%$
- 1 TeV $\lesssim E \lesssim 1000$ TeV
  Emulsion Chambers: within $\approx 25\%$

Helium

- 0.1 GeV $\lesssim E \lesssim 100$ GeV
  Spectrometers: within 10%
- $E \gtrsim 100$ GeV
  Emulsion Chambers: Poor statistics

Z>2

- Absolute fluxes from 0.6 to 35 GeV/n
- Systematic Errors $\sim 5\%$

ATIC preliminary data

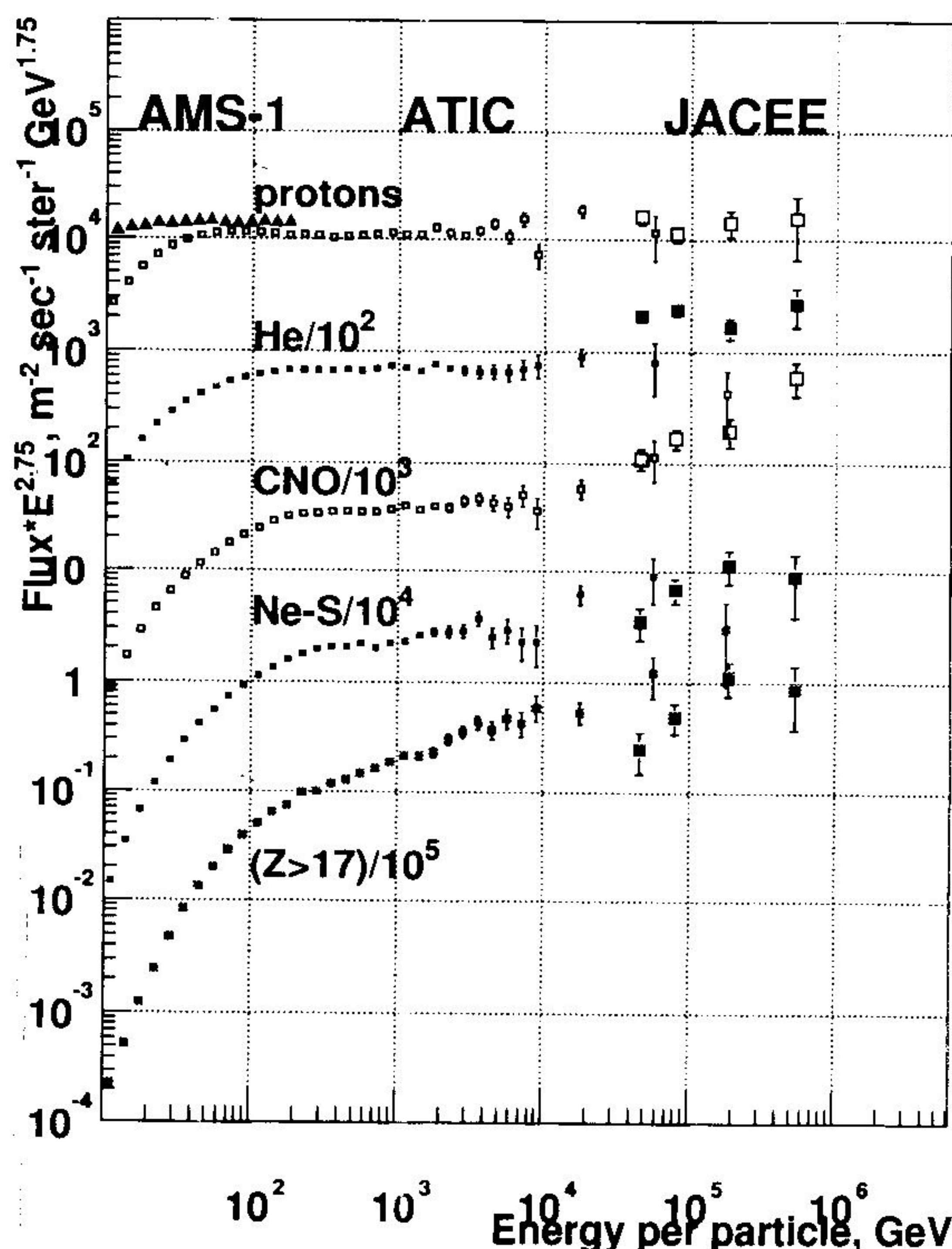
Filling the gap between

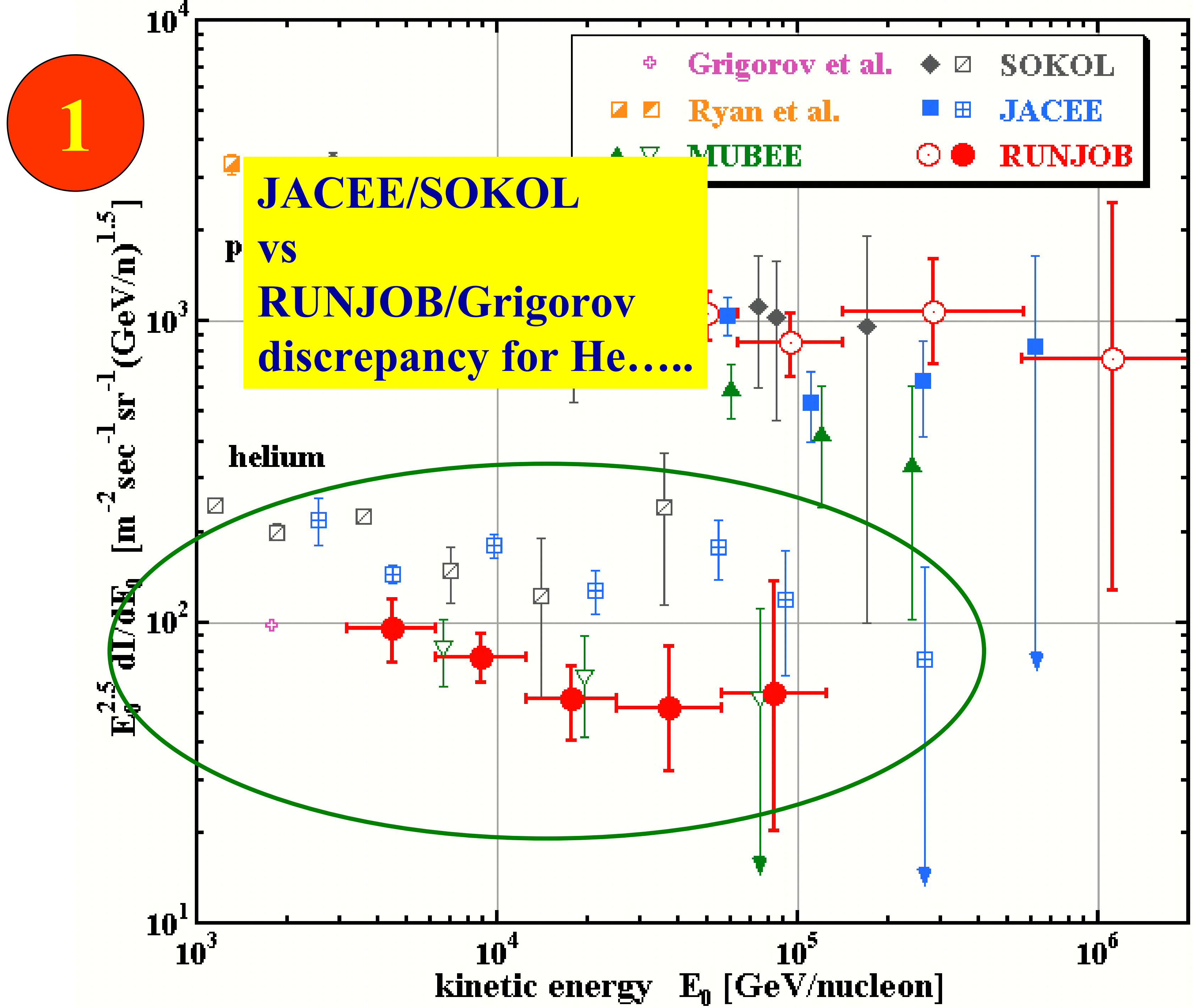
AMS-01/Bess/Caprice

RUNJOB/JACEE

Slope ~ 2.70-2.75

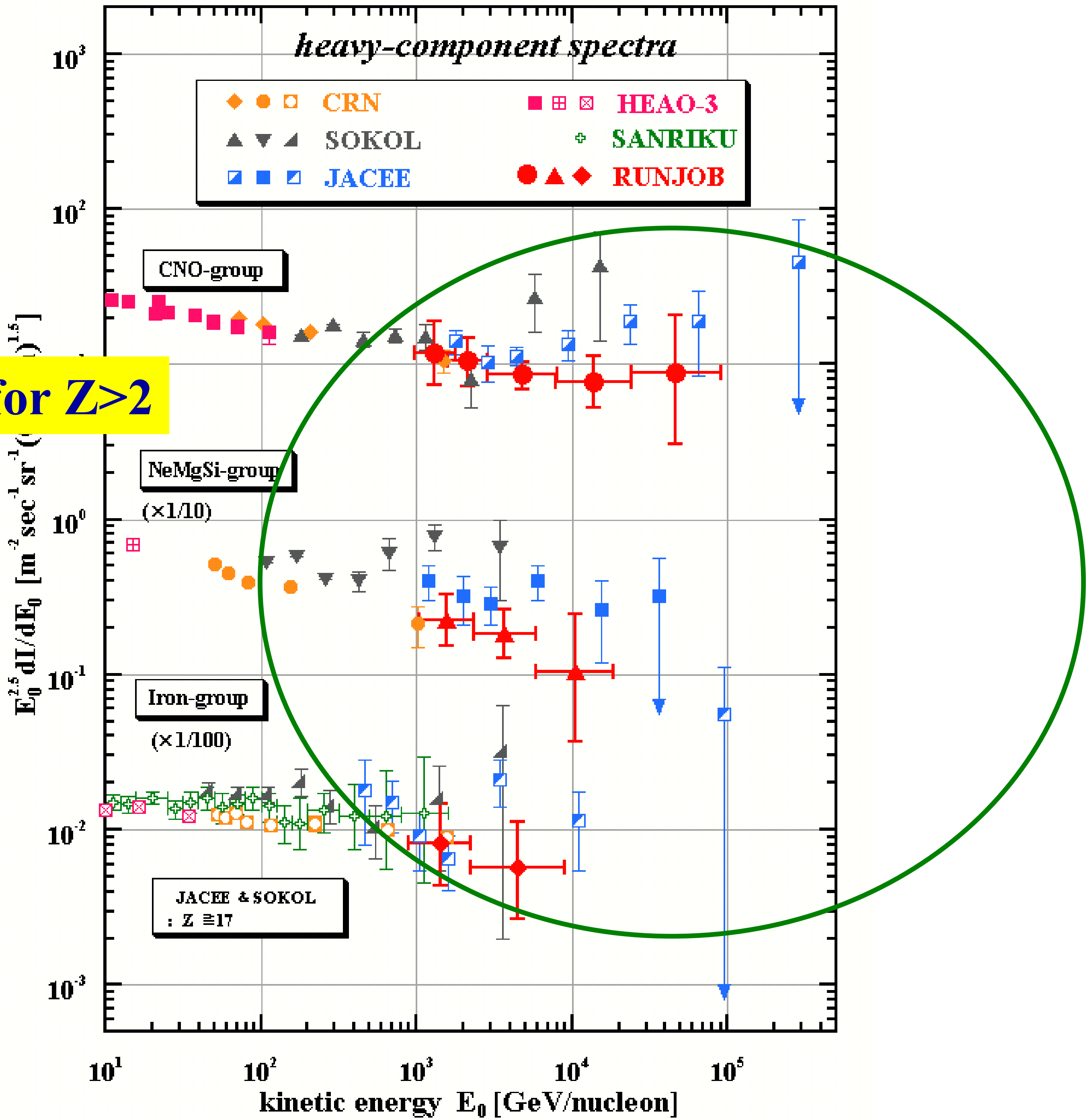
? Iron ?




1
JACEE/SOKOL
vs
RUNJOB/Grigorov
discrepancy for He…..
Grigorov et al.
SOKOL
Ryan et al.
JACEE
MUBEE
RUNJOB
p
helium
$E_0^{2.5}\,dI/dE_0$ [m^{-2}sec^{-1}sr^{-1}(GeV/n)$^{1.5}$]
kinetic energy E_0 [GeV/nucleon]
10^1
10^2
10^3
10^4
10^5
10^6

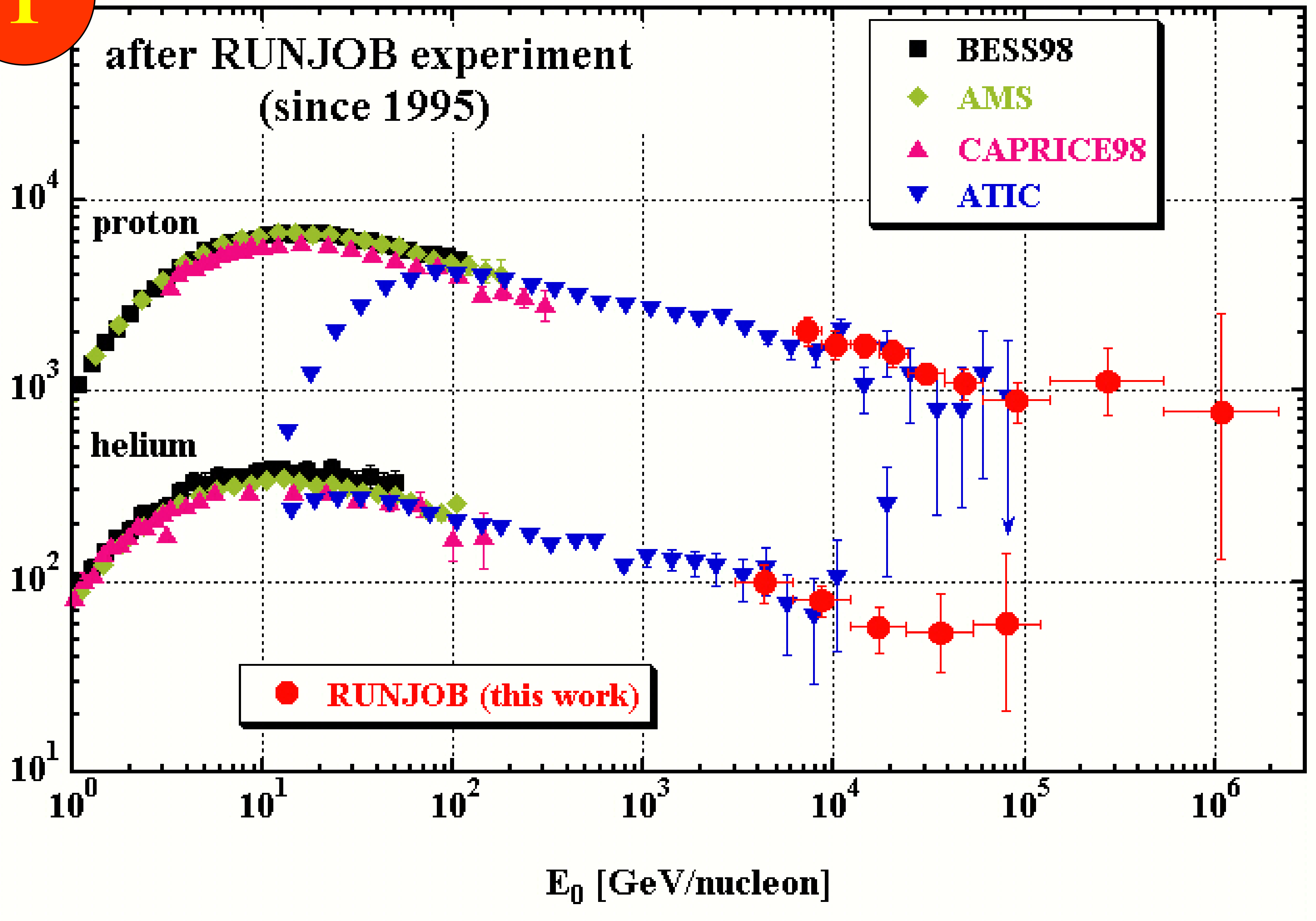
1

…..and for Z>2


heavy-component spectra
CRN
HEAO-3
SOKOL
SANRIKU
JACEE
RUNJOB
CNO-group
NeMgSi-group
(×1/10)
Iron-group
(×1/100)
JACEE & SOKOL
: Z ≧17
$E_0^{2.5}\, dI/dE_0$ [m^{-2} sec^{-1} sr^{-1} (GeV)$^{1.5}$]
10^3
10^2
10^0
10^{-1}
10^{-2}
10^{-3}
10^1
10^2
10^3
10^4
10^5
kinetic energy E_0 [GeV/nucleon]

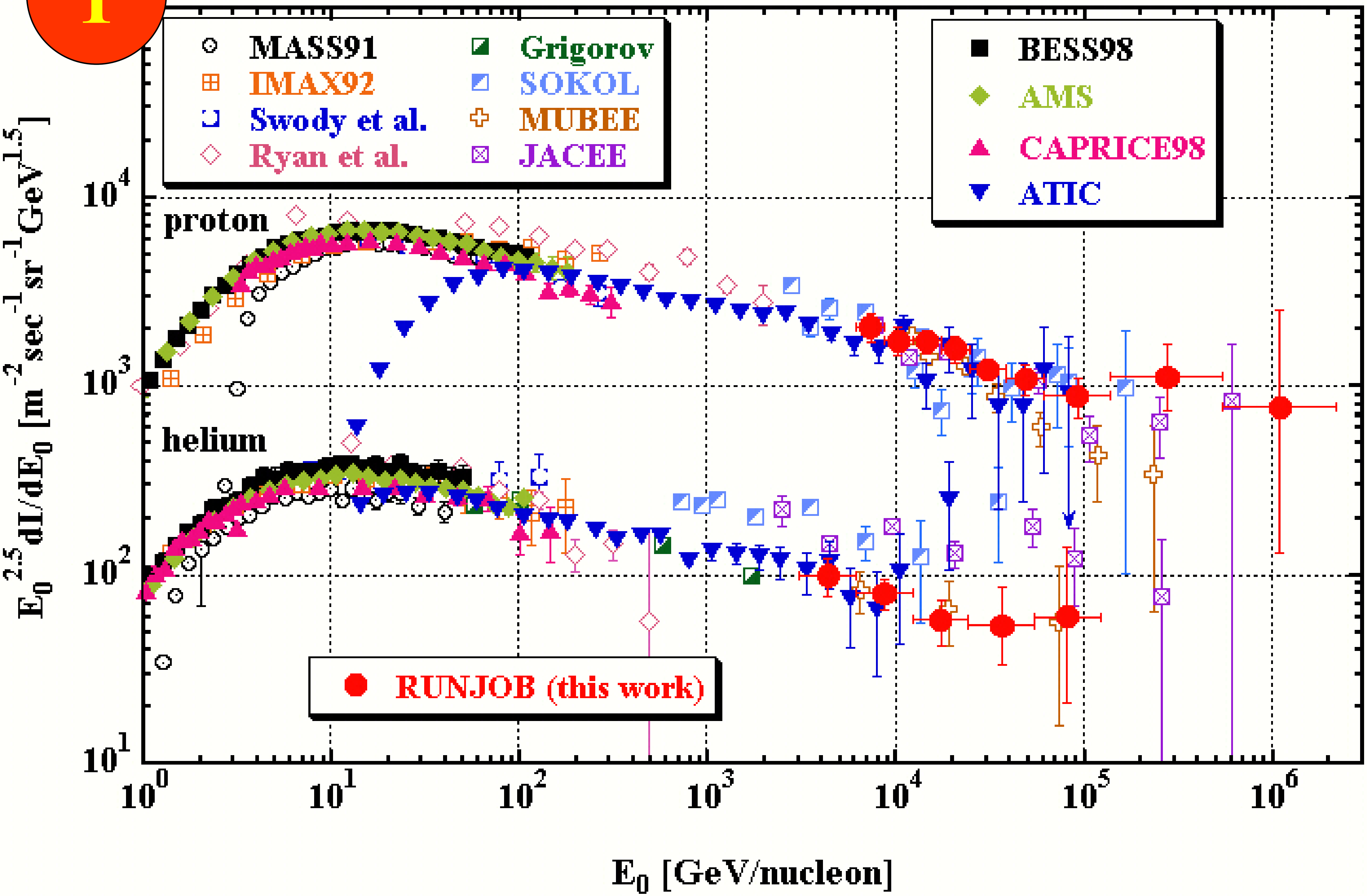
1

…..is solved in favour of RUNJOB if ATIC is normalized to low energy (AMS-01/BESS/Caprice) data



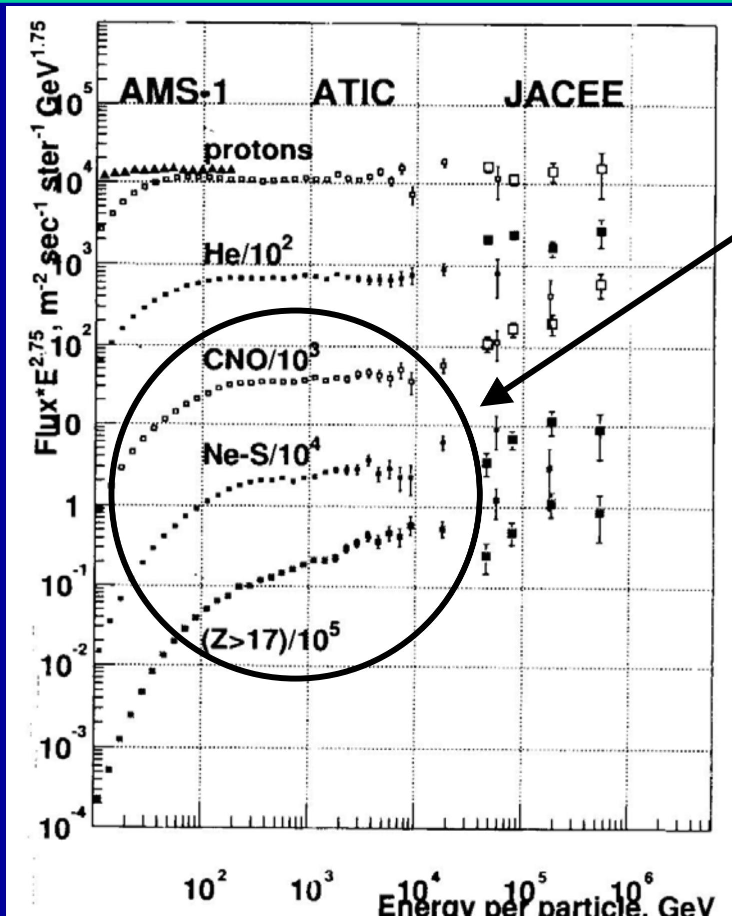
1

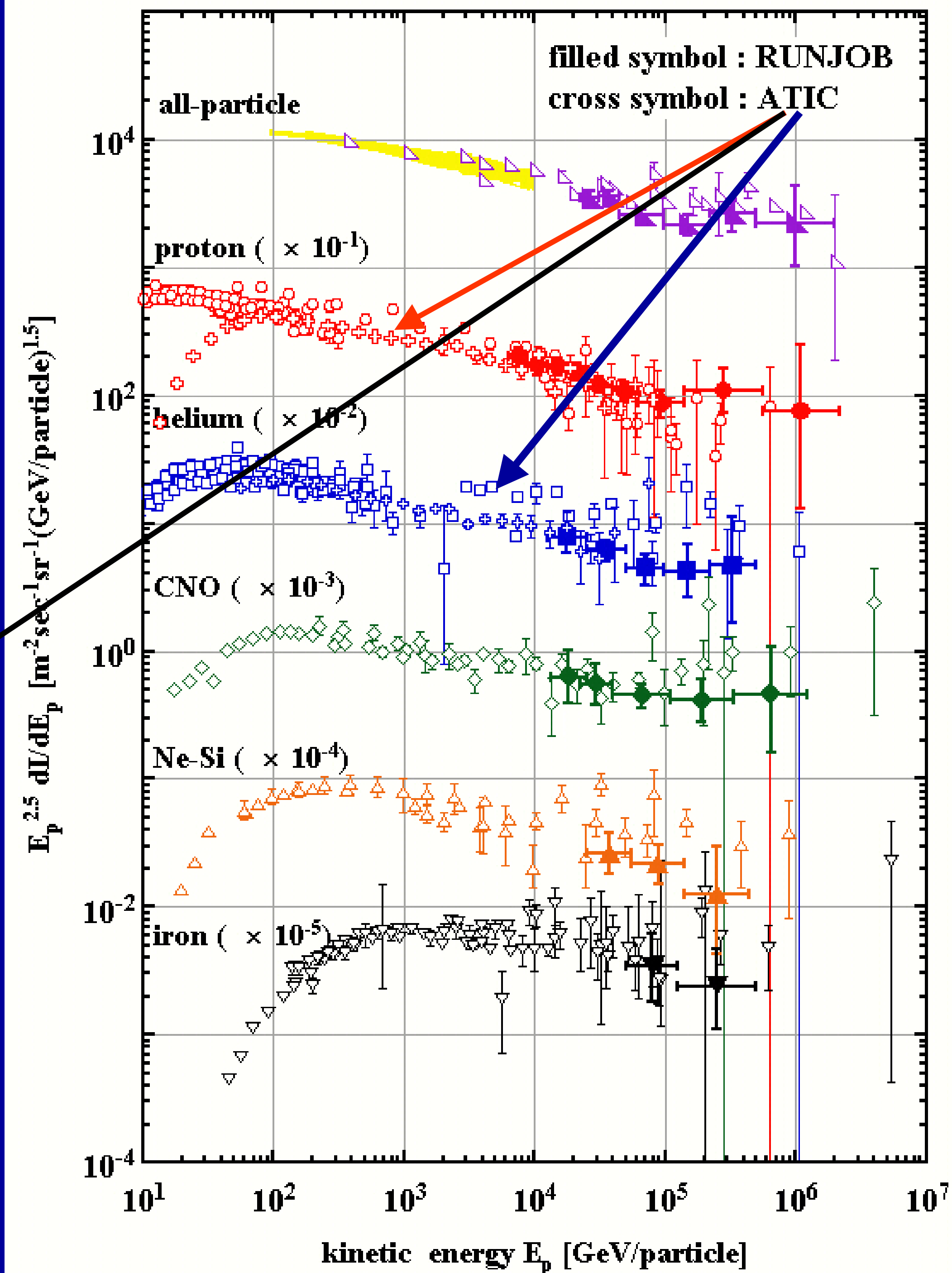
…..is solved in favour of RUNJOB if ATIC is normalized to low energy (AMS-01/BESS/Caprice) data



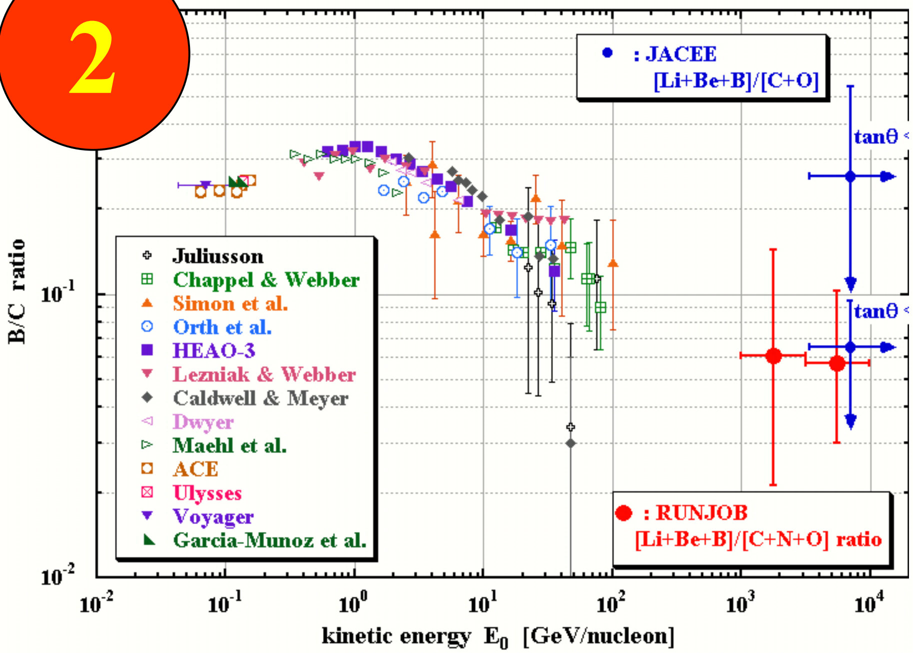
2

Better understanding of the CR composition approaching the knee region

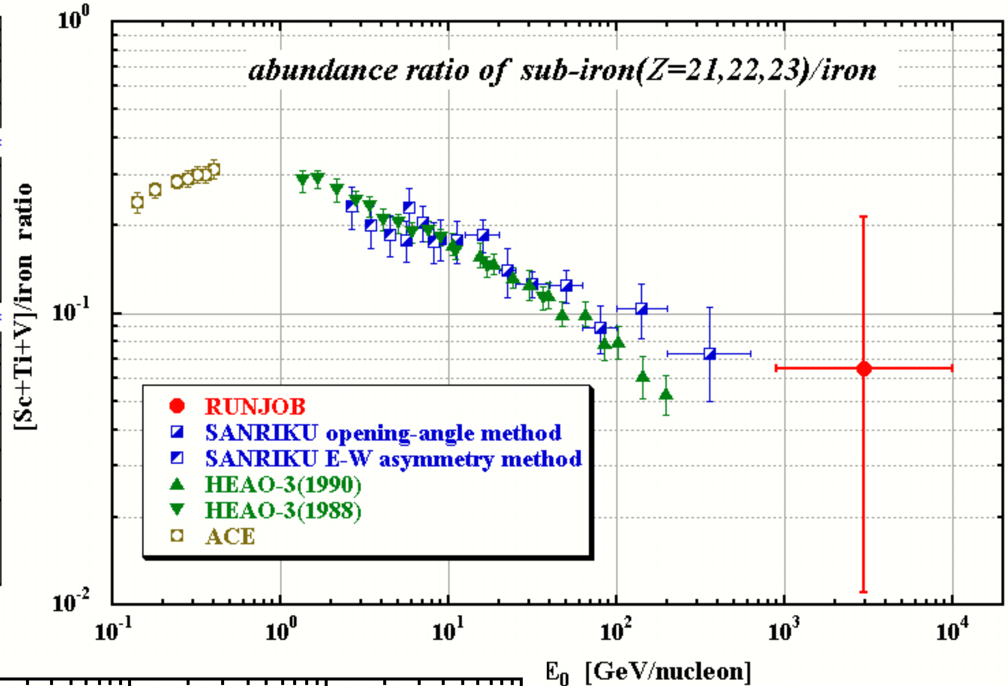




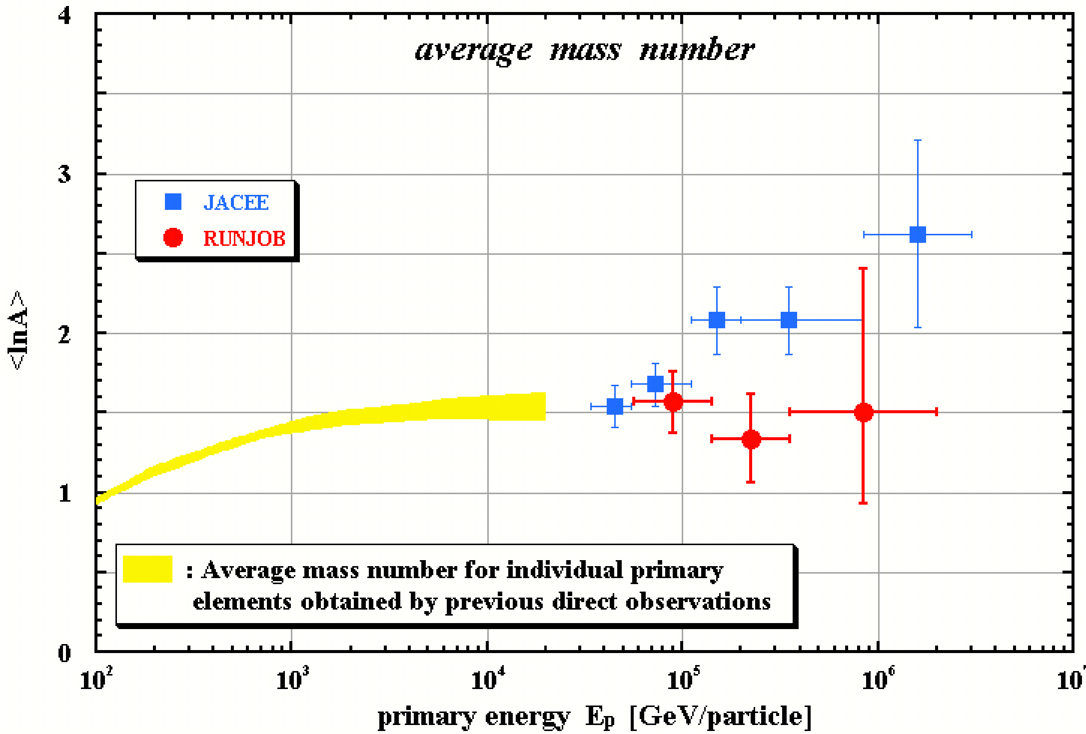
2



: JACEE
[Li+Be+B]/[C+O]
tanθ <
tanθ <
B/C ratio
Juliusson
Chappel & Webber
Simon et al.
Orth et al.
HEAO-3
Lezniak & Webber
Caldwell & Meyer
Dwyer
Maehl et al.
ACE
Ulysses
Voyager
Garcia-Munoz et al.
: RUNJOB
[Li+Be+B]/[C+N+O] ratio
kinetic energy E_0 [GeV/nucleon]

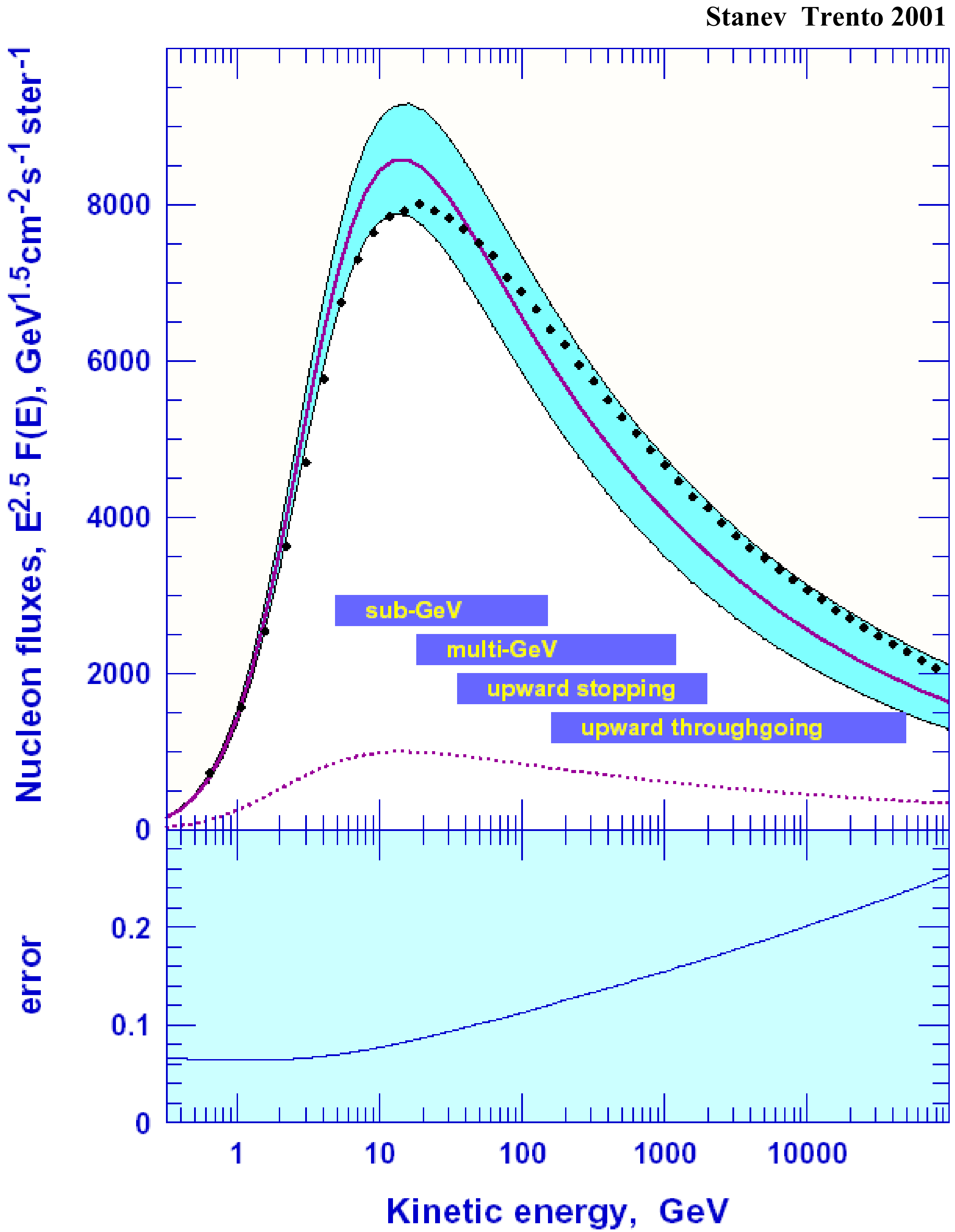


abundance ratio of sub-iron(Z=21,22,23)/iron
[Sc+Ti+V]/iron ratio
RUNJOB
SANRIKU opening-angle method
SANRIKU E-W asymmetry method
HEAO-3(1990)
HEAO-3(1988)
ACE
E_0 [GeV/nucleon]



average mass number
JACEE
RUNJOB
<lnA>
: Average mass number for individual primary
elements obtained by previous direct observations
primary energy E_p [GeV/particle]

3



Knowledge of the proton/helium slopes relevant for Atmospheric Neutrino flux calculations

(→ T. Montaruli)

3

Slopes of p and H approaching the knee

Because of the large lever arm and the good statistics ATIC data dominate the accuracy on slope determination

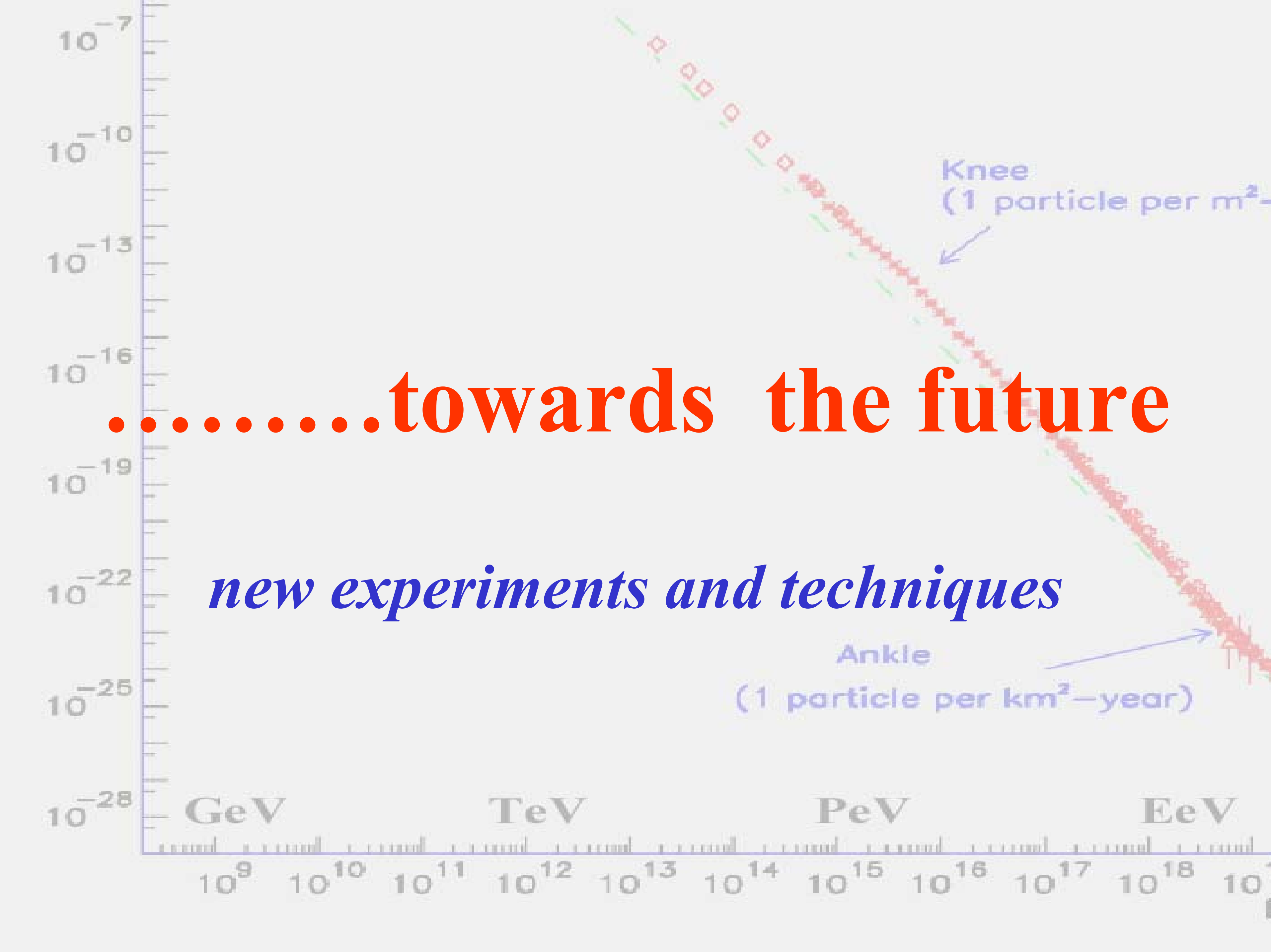
P			Ekin	Fit	Stat	Sys	Total
	1	AMS+BESS+IMAX	30-200	-2.71			0.07
	2	ATIC	100-100000	-2.71	0.01	??	??
	3	1+2+JACEE+RUNJOB	100-1000000	-2.71	0.01	??	??
He			Ekin	Fit	Stat	Sys	Total
	1	AMS	120-400	-2.72			0.12
	2	ATIC	100-10000	-2.71	0.02	??	??
	3	1+2+RUNJOB	120-100000	-2.71	0.02	??	??

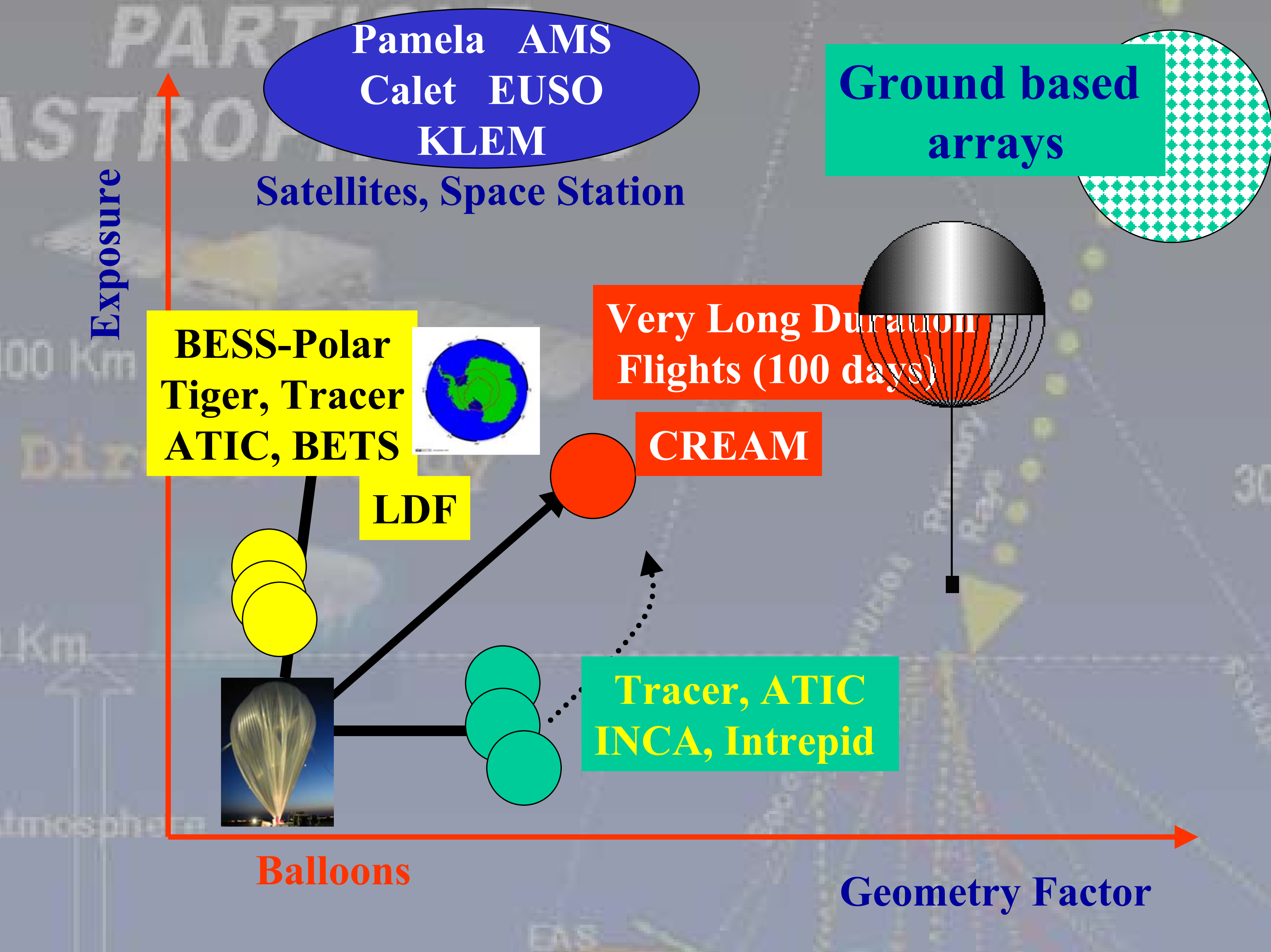
Once ATIC data will be "final" the p and He slopes up to below the knee should be known with and accuracy of 0.02 - 0.03
Preliminary ATIC data favours identical slopes ~ 2.71

New BESS TeV data will also be important to improve the accuracy

………towards the future

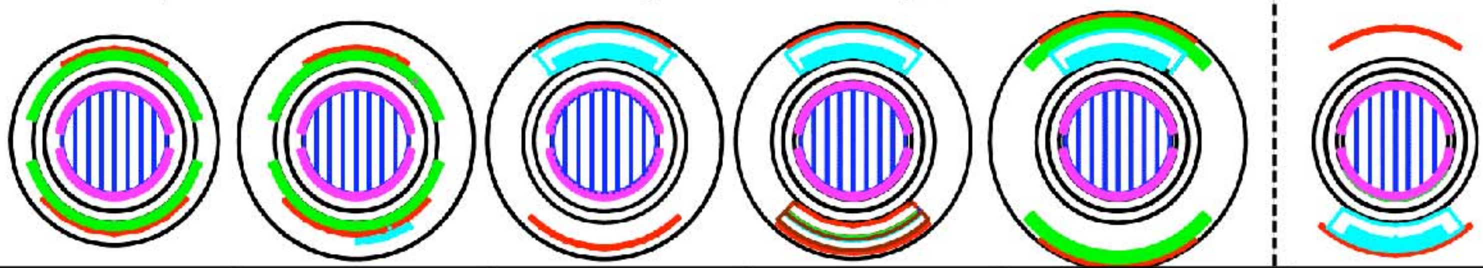
new experiments and techniques




Pamela AMS
Calet EUSO
KLEM
Satellites, Space Station
Ground based arrays
Exposure
BESS-Polar
Tiger, Tracer
ATIC, BETS
LDF
Very Long Duration Flights (100 days)
CREAM
Tracer, ATIC
INCA, Intrepid
Balloons
Geometry Factor

BESS Spectrometer Progress

⇒Future

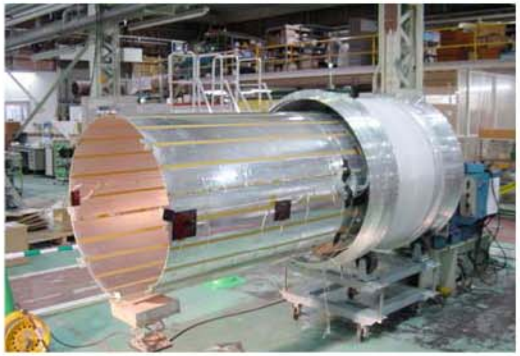


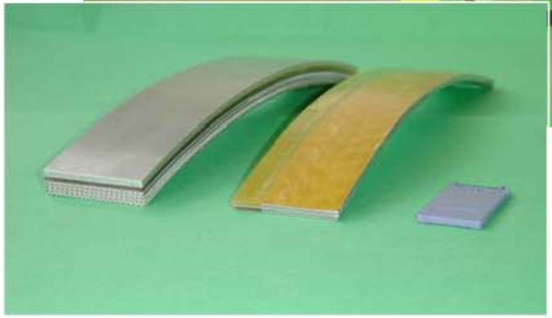
BESS-93,94	BESS-95	BESS-97,98	BESS-99,00	BESS01,02 BESS-TeV	BESS-Polar
	Larger Vessel			Larger Vessel	No Vessel
σ_{TOF} =300 ps	σ_{TOF} =110 ps	σ_{TOF} =70 ps Aerogel C 97 n=1.03 $\bar{p}$ 0.2-3.5 GeV 98 n=1.02	Shower Counter $2X_0$ Lead e/μ sep.	New ODC's New JET/IDC's p/He up to 1 TeV	New Mag (ultra thin)
$\bar{p}$ 0.2-0.6 GeV	$\bar{p}$ 0.2-1.4 GeV	$\bar{p}$ 0.2-4.2 GeV	$\bar{p}$ 0.2-4.2 GeV	$\bar{p}$ 0.2-4.2 GeV	$\bar{p}$ 0.1-4.2 GeV

BESS improved in every 9 successful flights

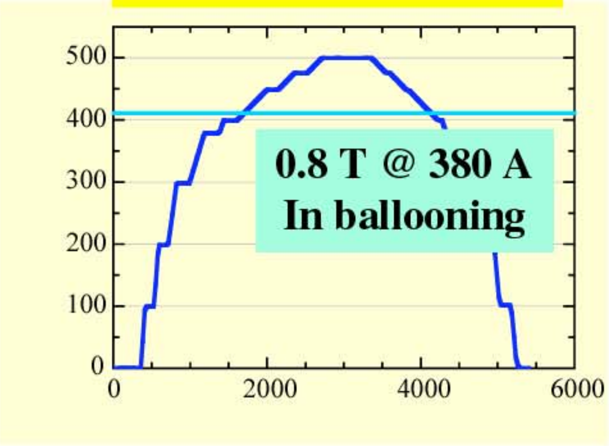
Maximizing advantages in Balloon Experiments

BESS-Polar Thin Solenoid Coil
completed and tested up to 1.05 T





1.05 T @ 500 A Tested



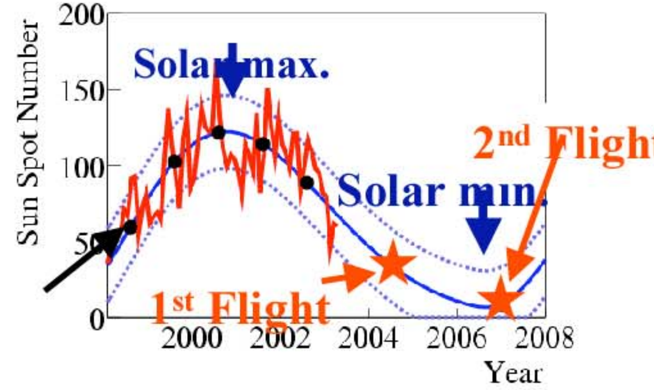
BESS-Polar

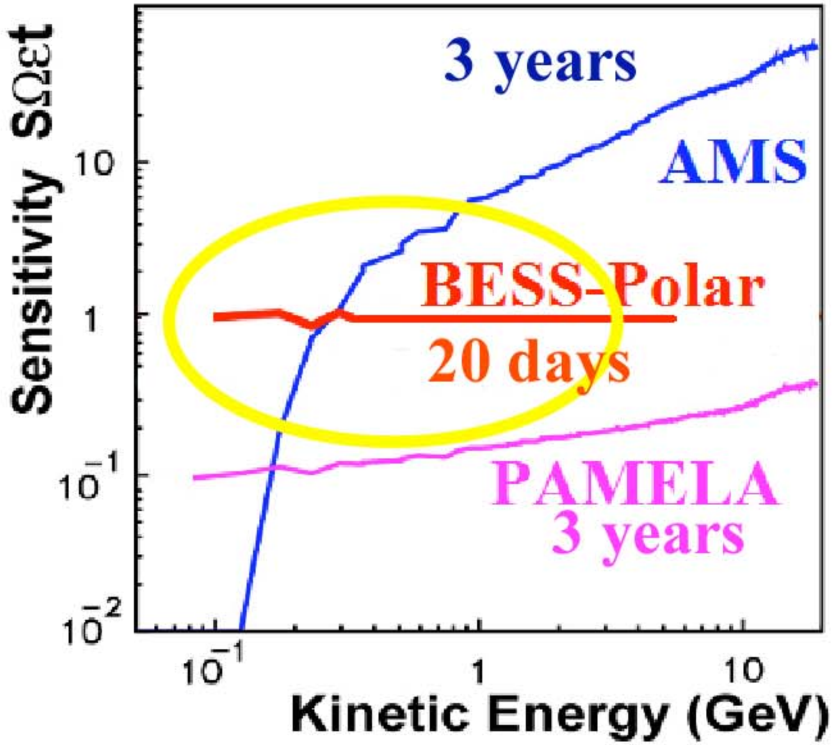
Unique and ideal for low energy particles

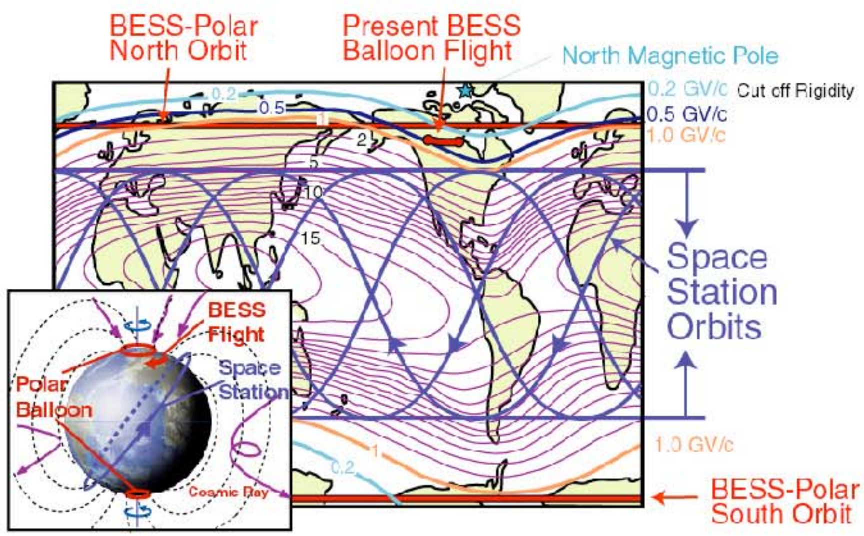
Stay in **low magnetic cut-off** regions

Complementary with PAMELA and AMS,

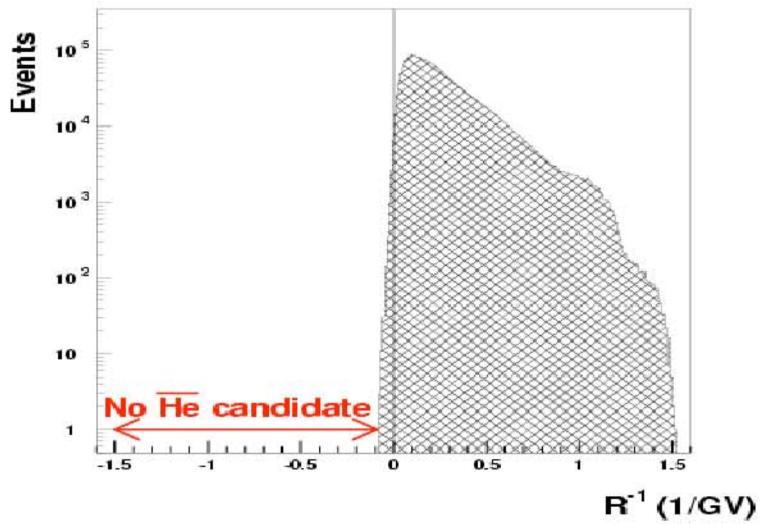
And be maximized at Solar Minimum







Search for Antihelium



Progress in BESS93~00

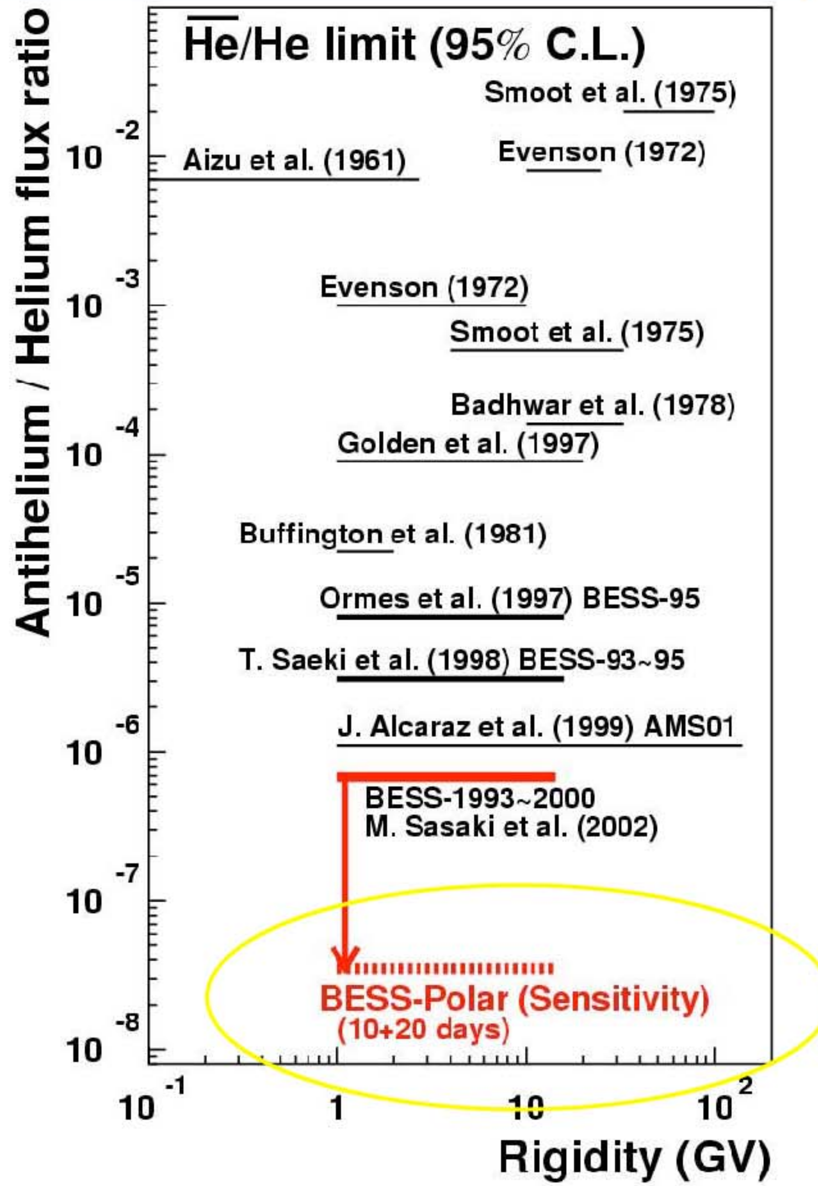
Upper Limit:

$\overline{He}$/He: 7×10^{-7}

BESS-Polar:

Sensitivity:

$\overline{He}$/He: 3×10^{-8} (30 days)

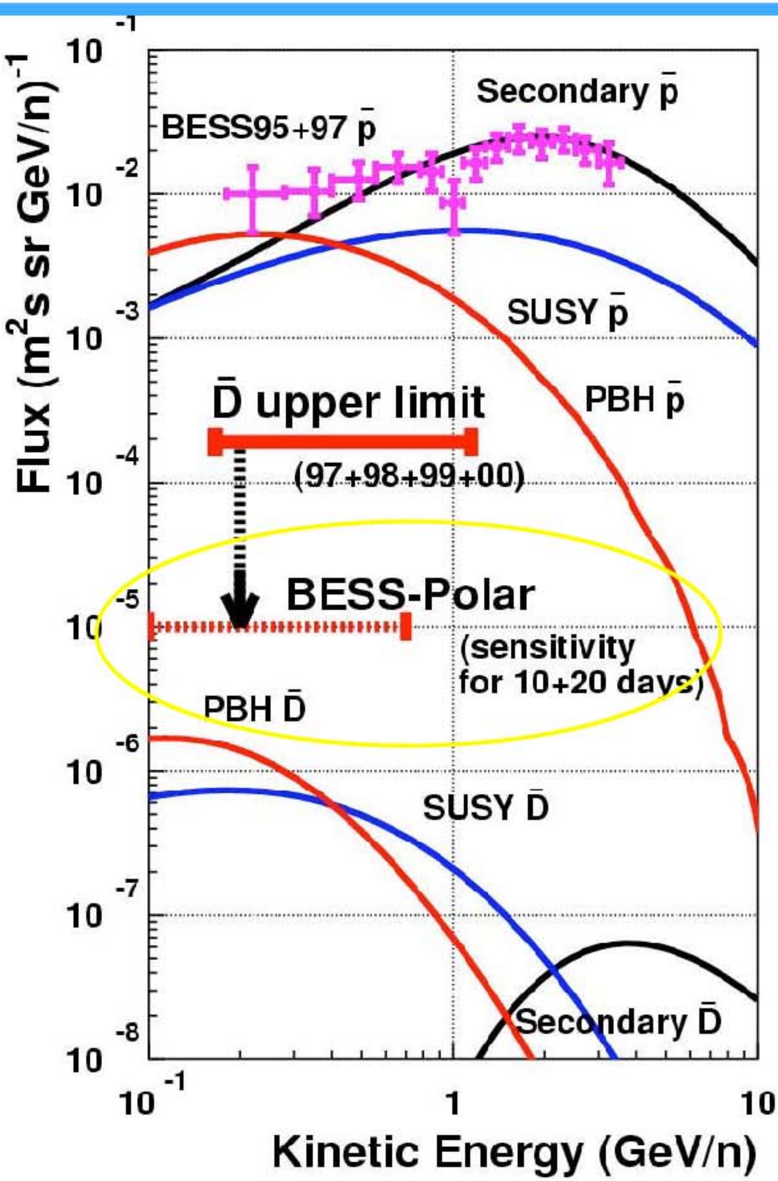


Search for Antideuteron

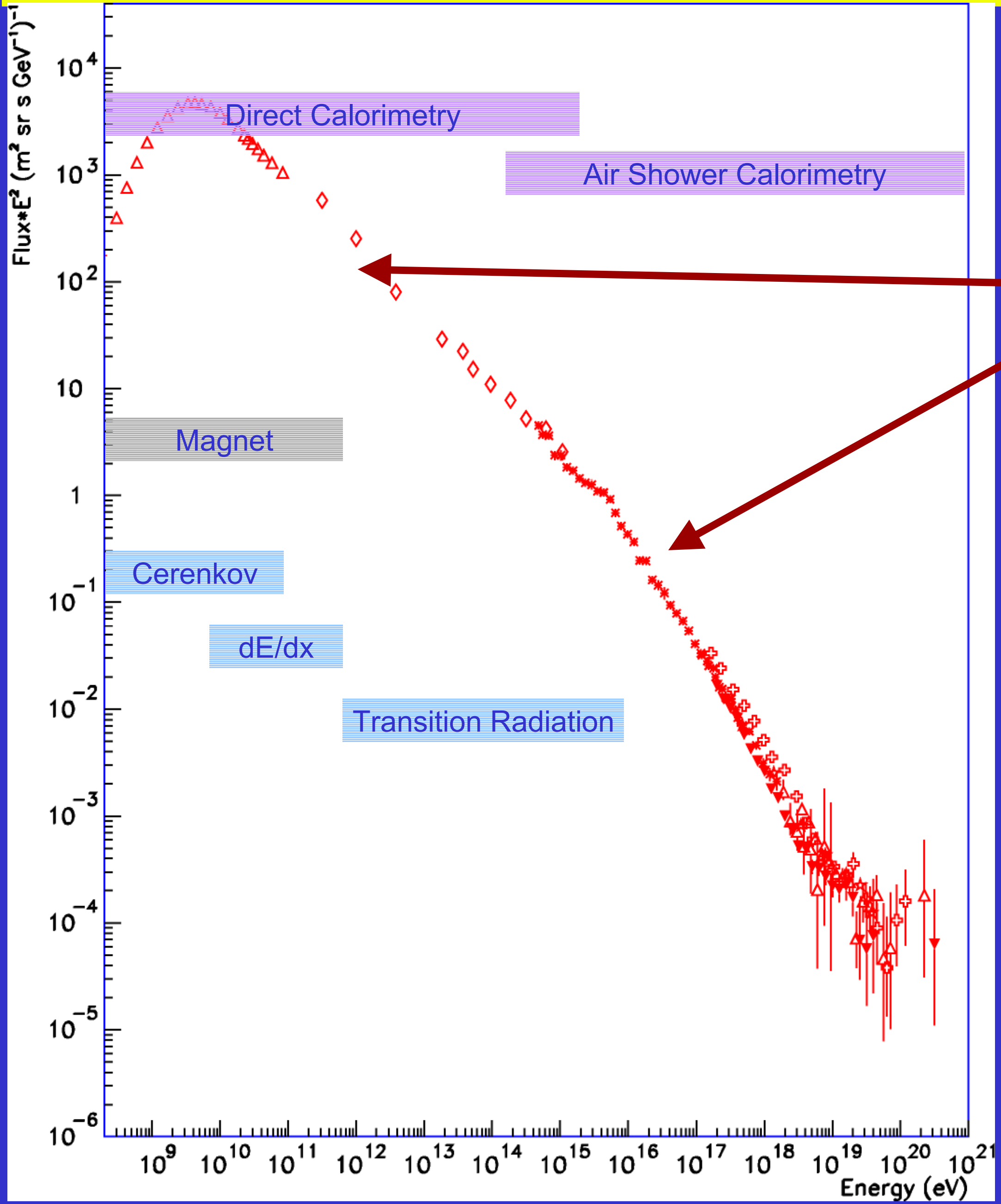
Sensitivity

1 x 10^{-5} $(m^2 s.sr.GeV/n)^{-1}$

with assuming two flights for 10 + 20 days



Energy Measurement Techniques



S. P. Swordy

OG.1.5.23

Transition Radiation Calorimetry

to study CR composition at TeV-PeV Energies

CERN Test Beam results (95% xenon, 5%CH4)

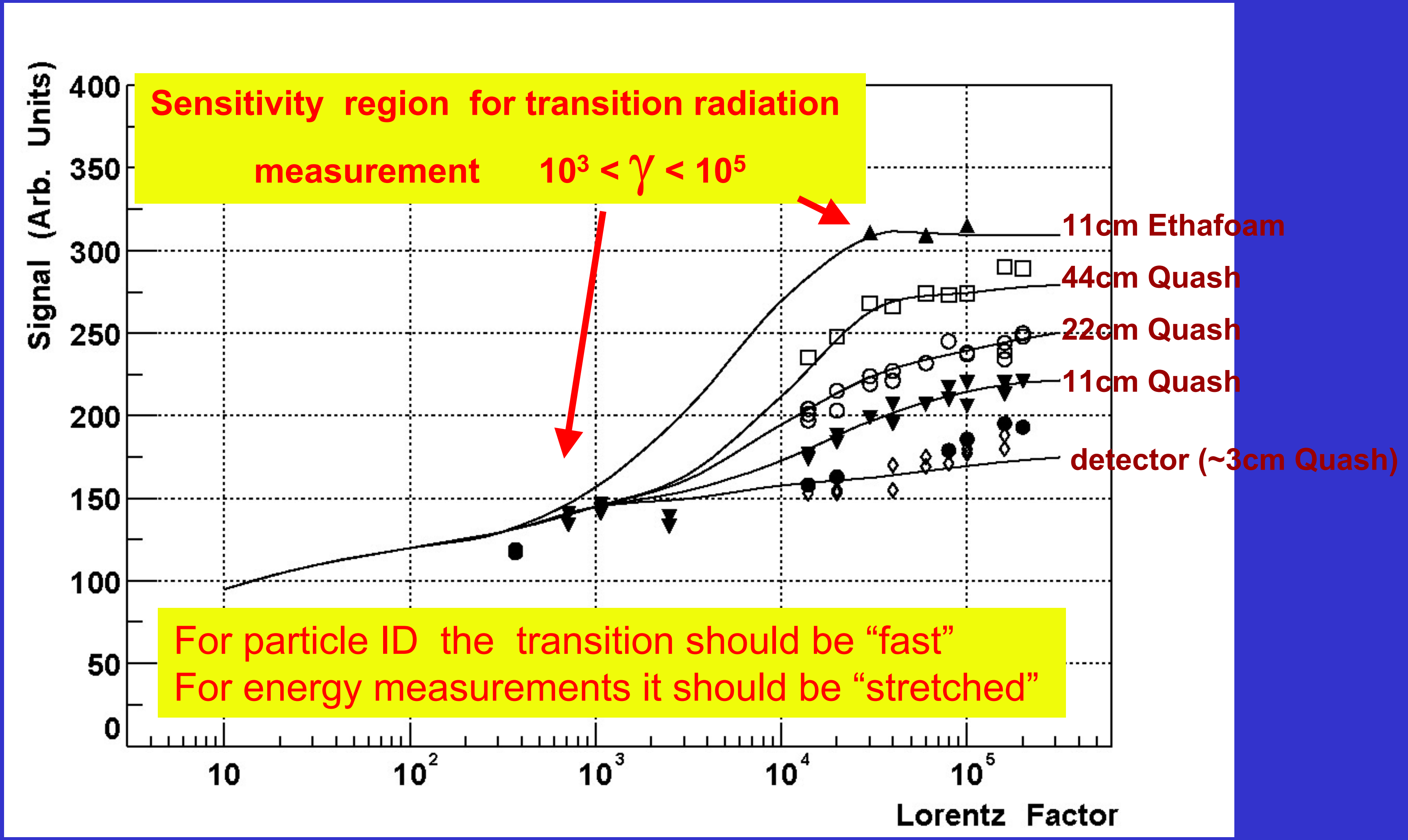
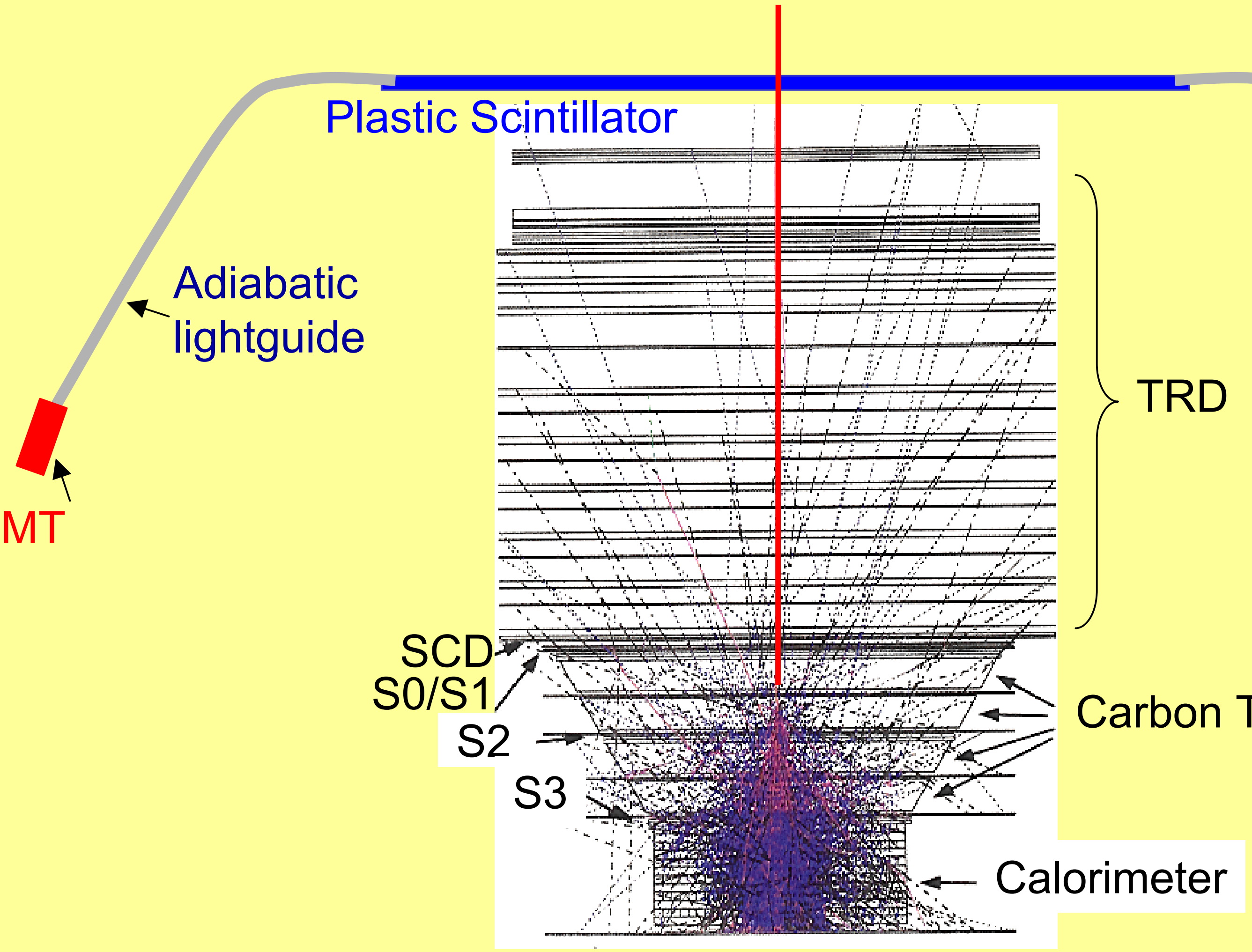


Figure 6. Response of radiator configurations versus Lorentz Factors. The symbols are as follows : background (filled circles), bremsstrahlung (open diamonds), Quash 11cm (downward triangles), Quash 22cm (open circles), Quash 44cm (open squares), Ethafoam 11cm (upward triangles). The solid lines are from Monte Carlo simulations of the respective set ups. The Monte Carlo data has been normalized using a single normalization factor to the low energy data.

CREAM Detector Concept

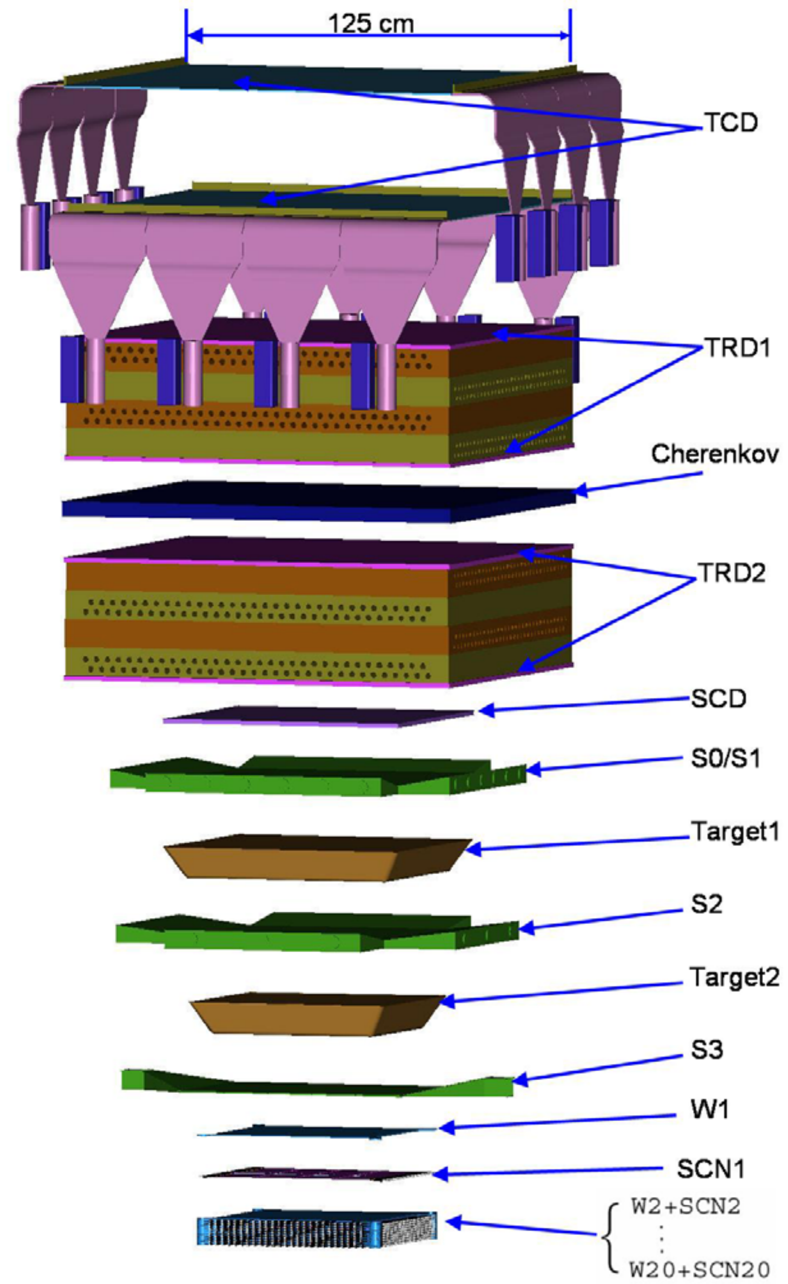
In-flight Cross Calibration of TRD and Calorimeter



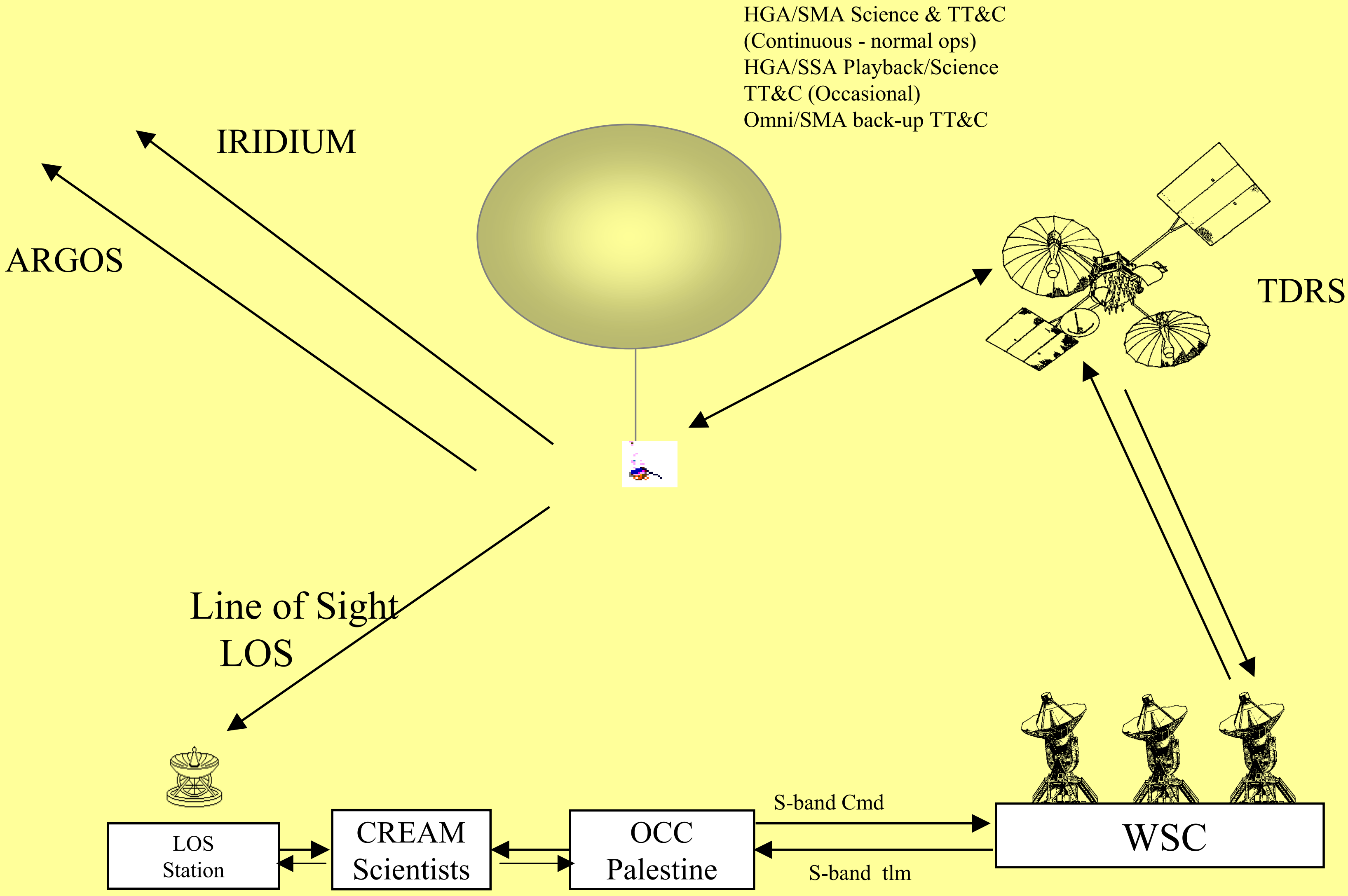
E. Seo OG.1.5.5 H. Park OG.1.5.6

Measurement Capabilities

- Element Coverage:
  H to Ni (Z = 1 through Z = 28)
- Charge Resolution:
  Individual elements for all Z (SCD)
  Individual elements Z < 15 &
  at least element groups Z ≥ 15 (TCD)
- Energy Calibration: Better than 10%
- Energy Resolution: Better than 50%
- Collecting Power:
  0.3 m^2sr for Z = 1 & 2
  (considering interaction fractions in CAL)
  1.3 m^2sr for Z ≥ 3 (Z ≥8 for TRD-lite)
  (TRD efficiency not included)



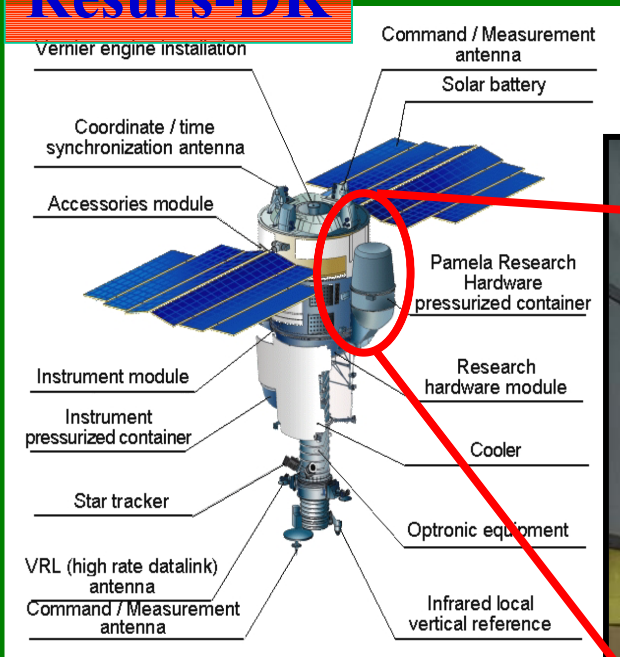
CREAM Operations Diagram



The PAMELA Spectrometer

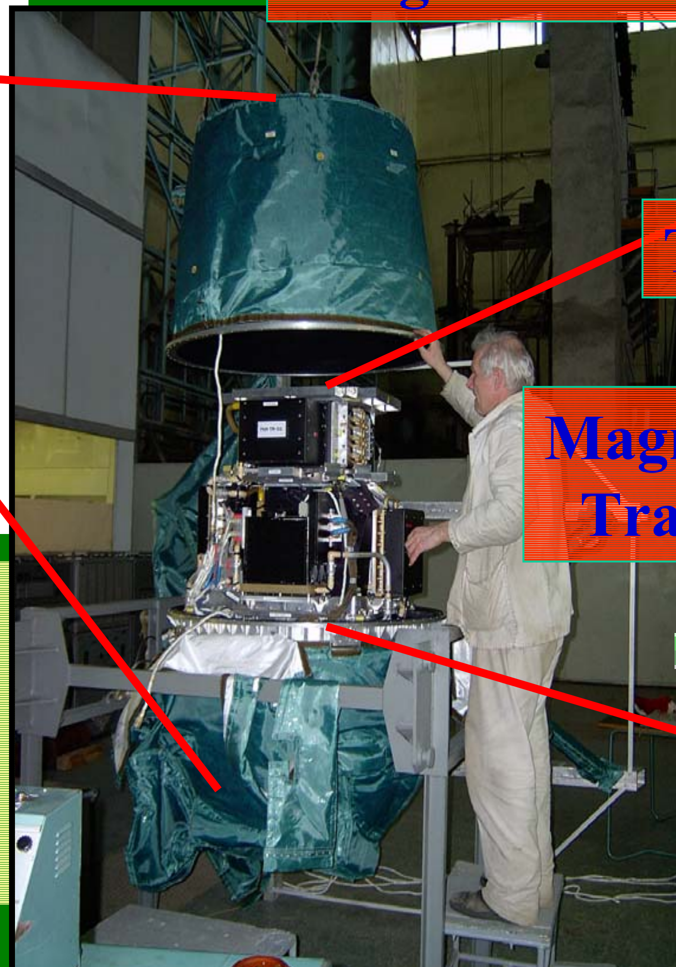
M. Simon O.G.1.5.7
M.Pearce O.G.1.5.9
F.S.Cafagna O.G.1.5.8

Resurs-DK

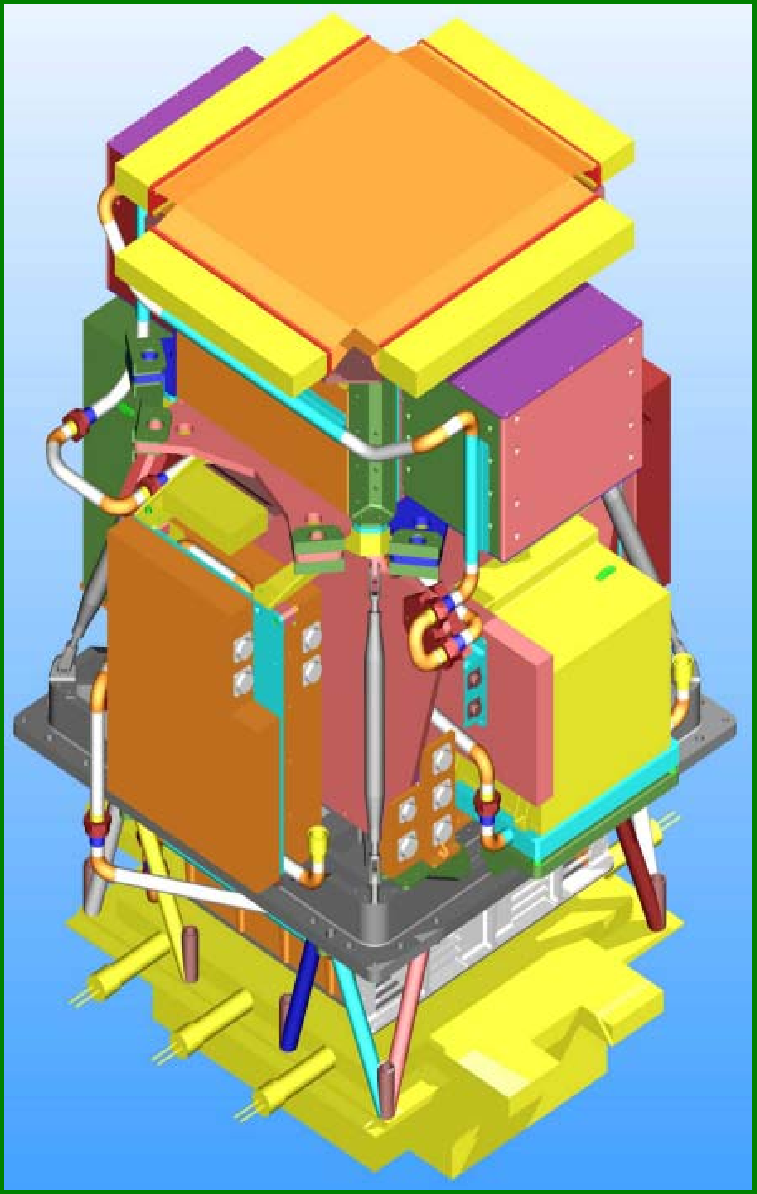


- $\bar{p}$: 80 MeV ÷ 190 GeV
- e^{+}: 50 MeV ÷ 270 GeV
- $\overline{He}$/He: some unity 10^{-7}
- nuclei spectra (H to O) 100 MeV/n ÷ 200 GeV/n

Integration test



PAMELA Spectrometer

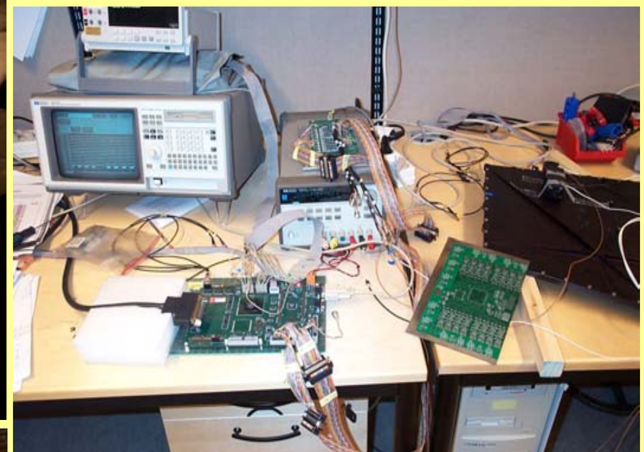


- GF 20.5 $cm^2 sr$ for HE particles
- Angular aperture of 19°x16°
- Spatial res.:
  4 μm (B. V.), 15 μm (N. B. V.)
- Maximum Detectable Rigidity (MDR): 740 GV
- TOF accuracy <100 ps
- e/p discrim. better than 2×10^5

Launch date 2004

Space Qualification Test

[Thermal]



[Vibrations]

[Irradiation]

[Efficiency]

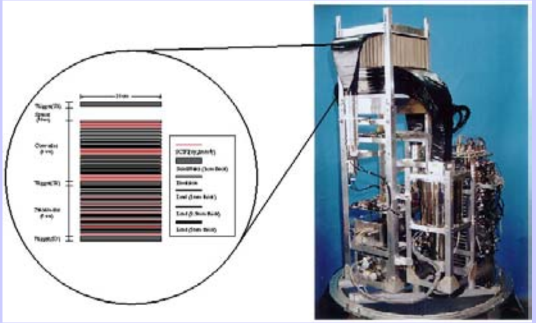

CALET on Exposed Facility of JEM (JEM-EF)
S. Torii O.G.1.5.16
M. Takyanagi P.G.1.5.17
Attach Point for Heavy Payload
CALET

Heritage

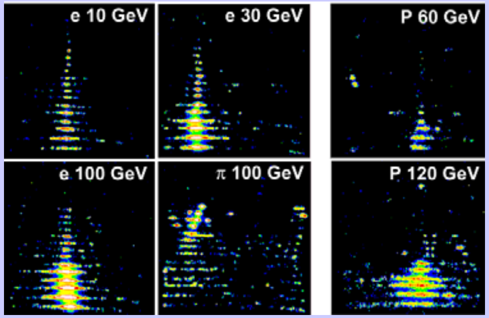
1993-1998：

- Development of SciFi/Lead Calorimeter for Electron Observation (BETS) NIM 457, 499-508 (2001)
- Successful observation of electrons in 10-100 GeV ApJ 559, 973-984 (2001)
- Observation of atmospheric gamma-ray flux with improved BETS Phys Rev D.66 052004(1-9) (2002)

Balloon Flight



BET Instrument

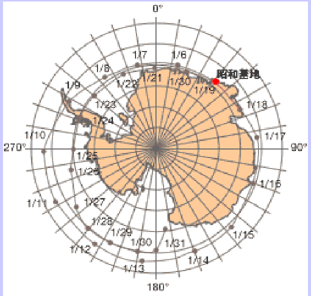


Shower Image at CERN

1999-2003:

- Development of new detector of Antarctic Flight (PPB-BETS) for observation in 100-1000 GeV
- Observation expected in 2003 at Showa Station

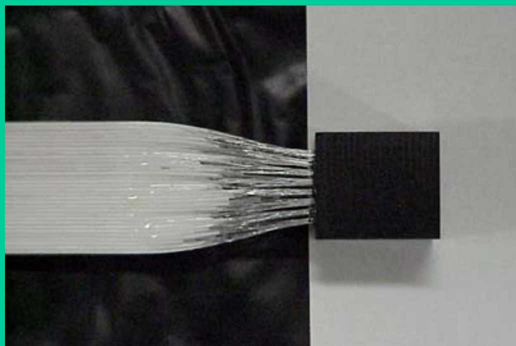
Balloon Flight at Antarctica



Expected Trajectory

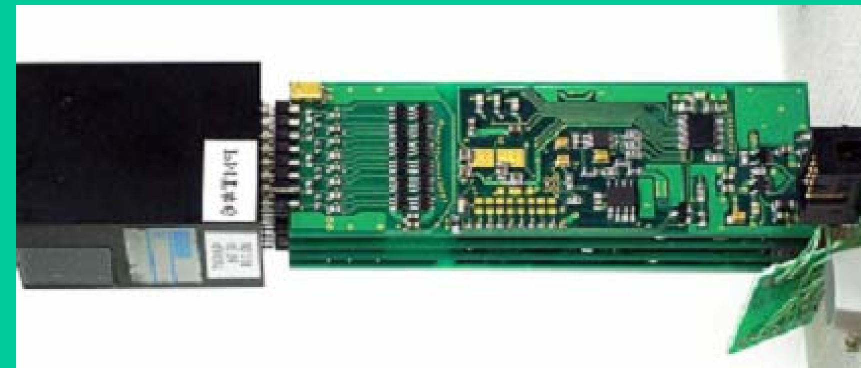
PPB-BETS with solar panels

SciFi Belt (32 x 2 layers)

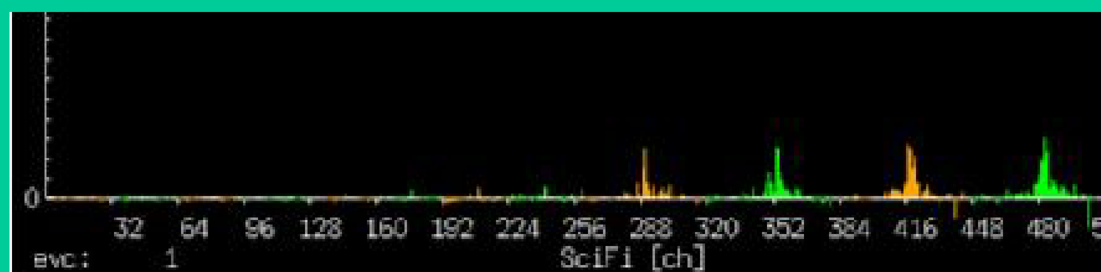


64-anode PMT

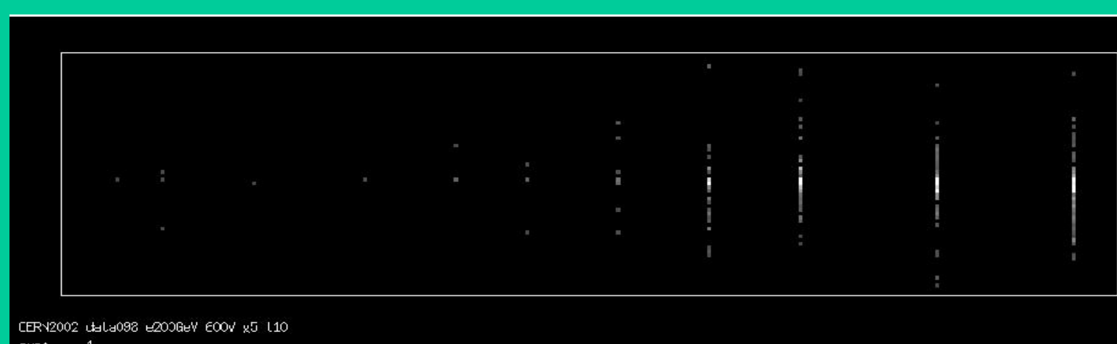
FEP (New VA32, TA, 16bits ADC, FPGA)



Pulse Height Distribution of 512 ch

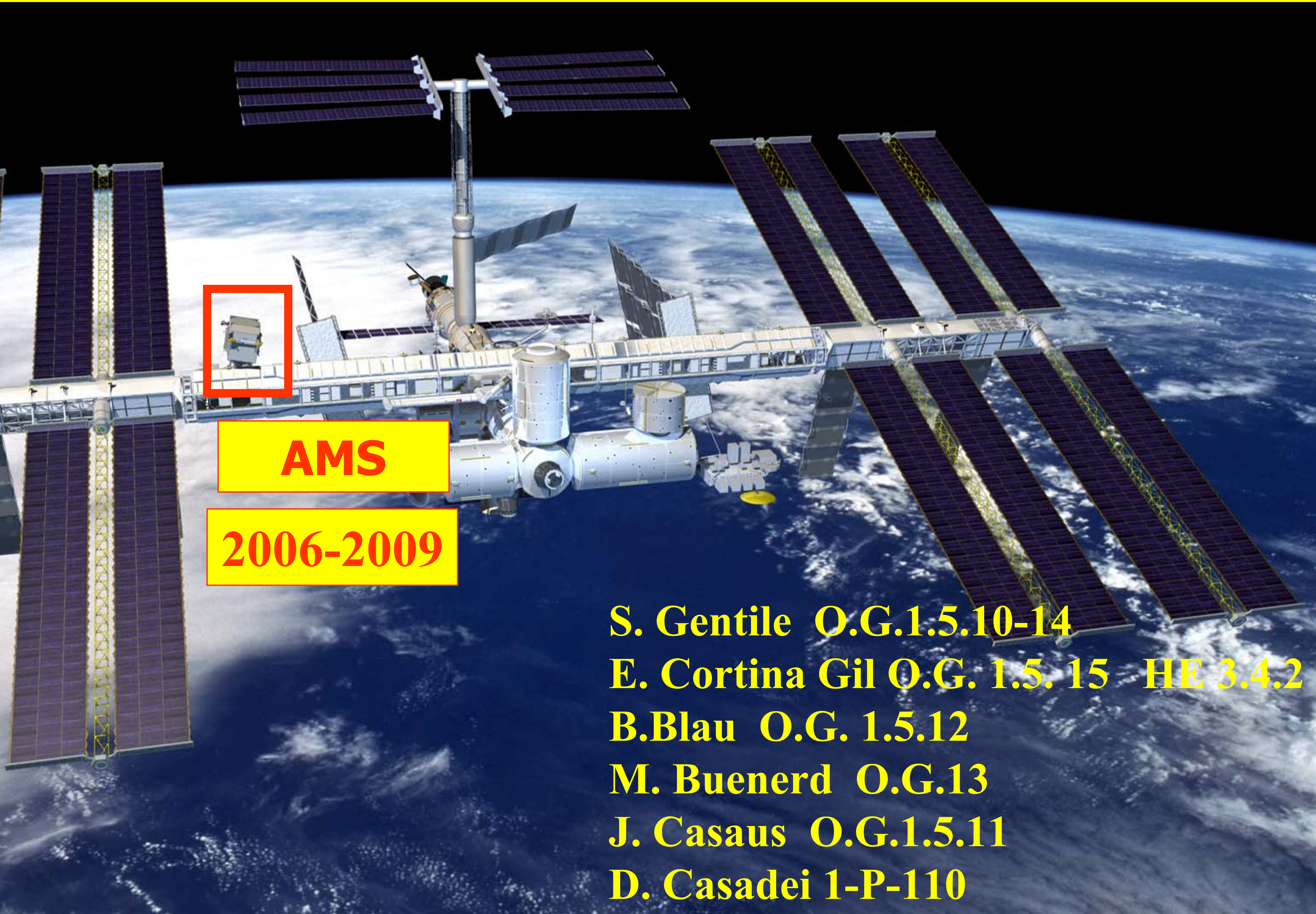


Shower Profile



200 GeV Electron Shower atCERN Observed with VA32HDR2

AMS-02 on the International Space Station



S. Gentile O.G.1.5.10-14

E. Cortina Gil O.G. 1.5. 15 HE 3.4.2

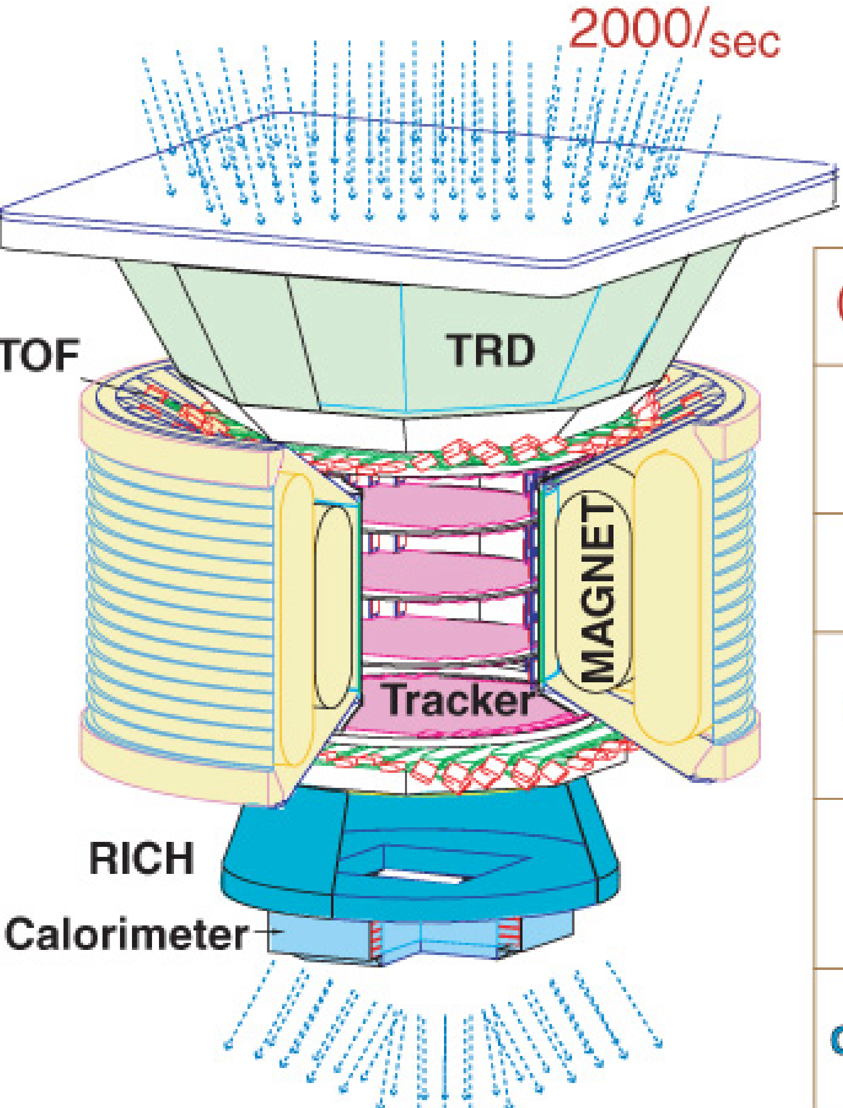
B.Blau O.G. 1.5.12

M. Buenerd O.G.13

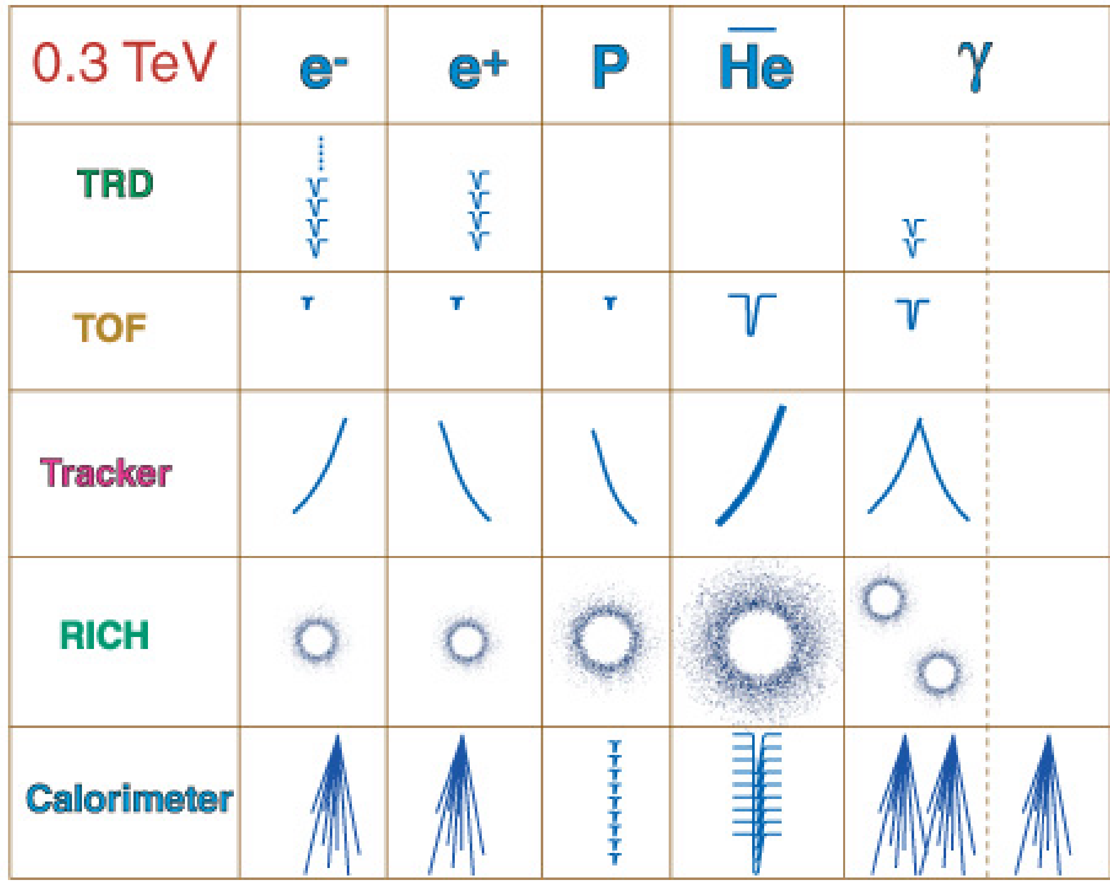
J. Casaus O.G.1.5.11

D. Casadei 1-P-110

AMS: A TeV Magnetic Spectrometer in Space



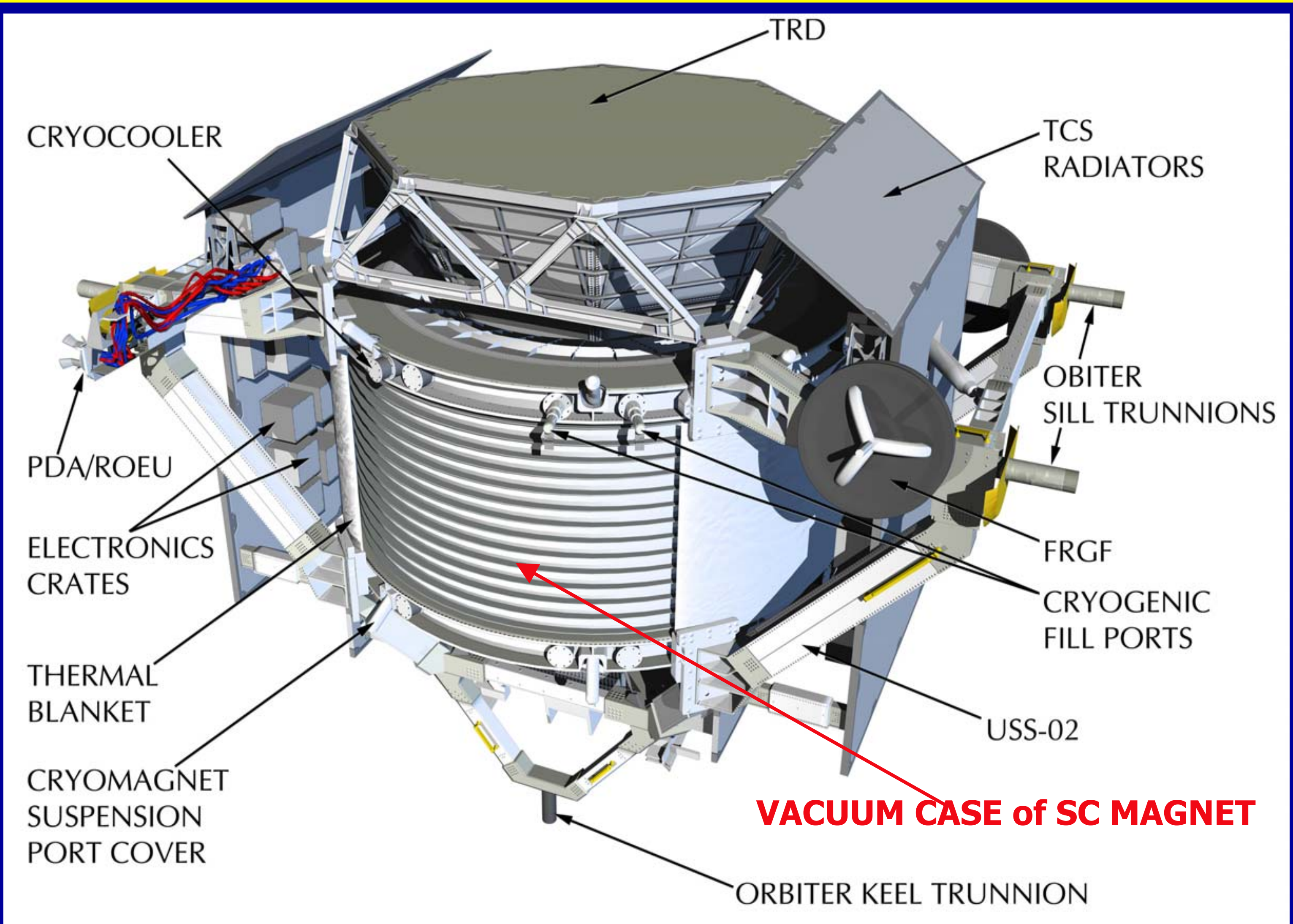
G.F. 5000 cm² sr
Exposure > 3 yrs



y2K025 _5 Gamma

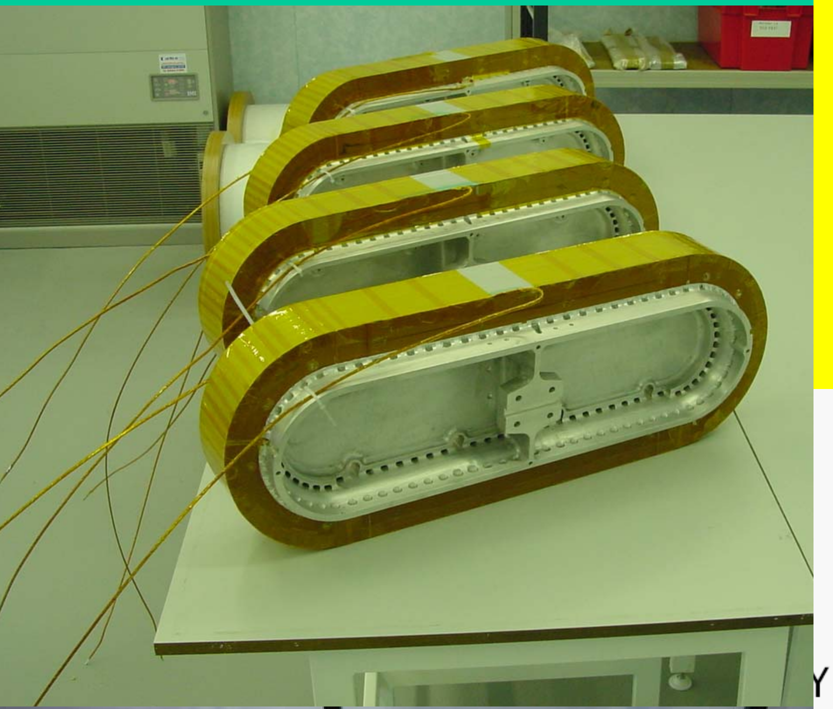
$h/e = 10^{-6}$ ECAL +TRD combined

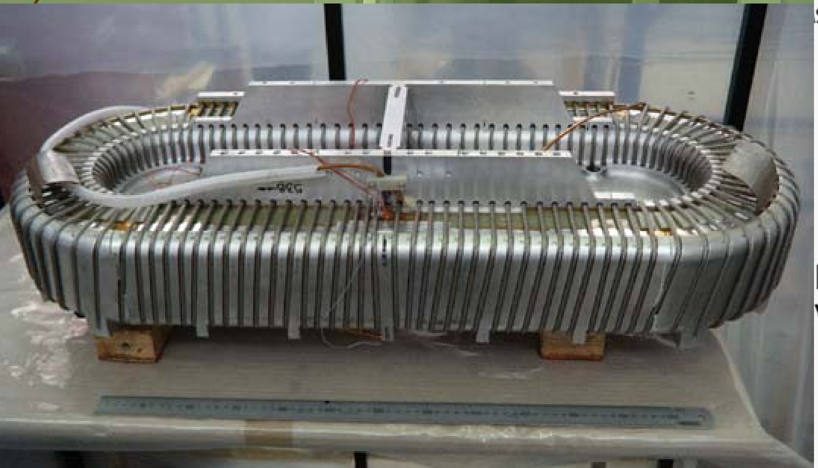
AMS-02 Detector

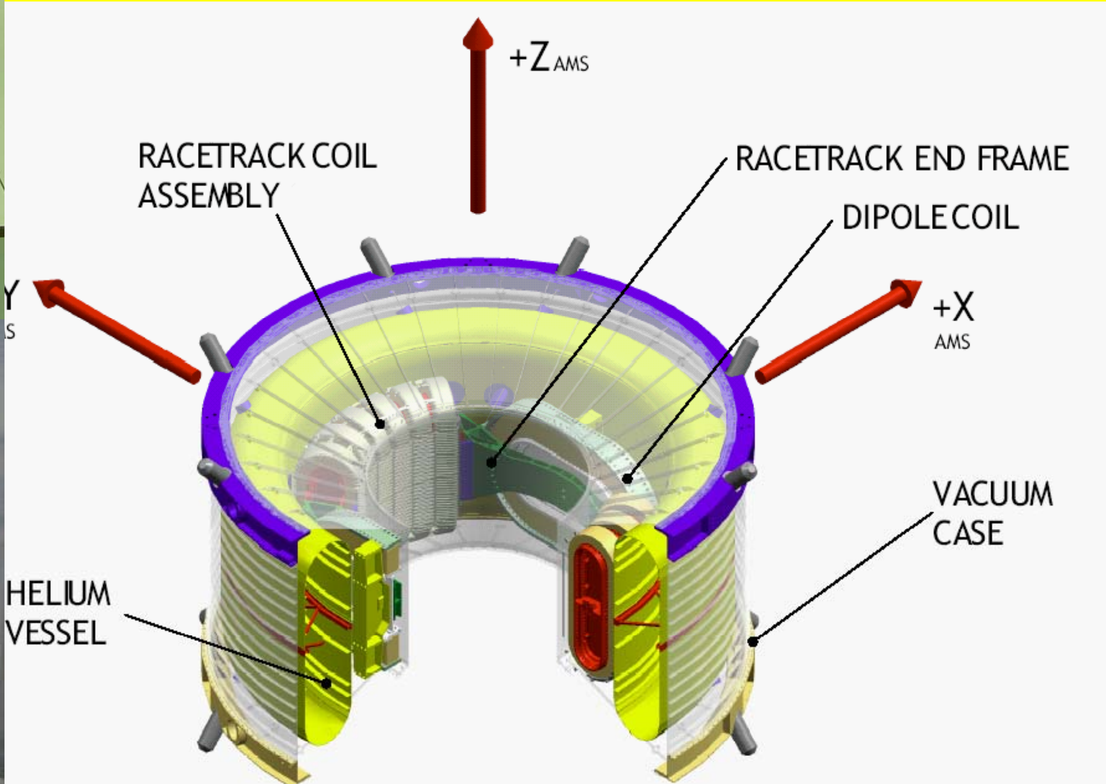


The AMS SC Magnet

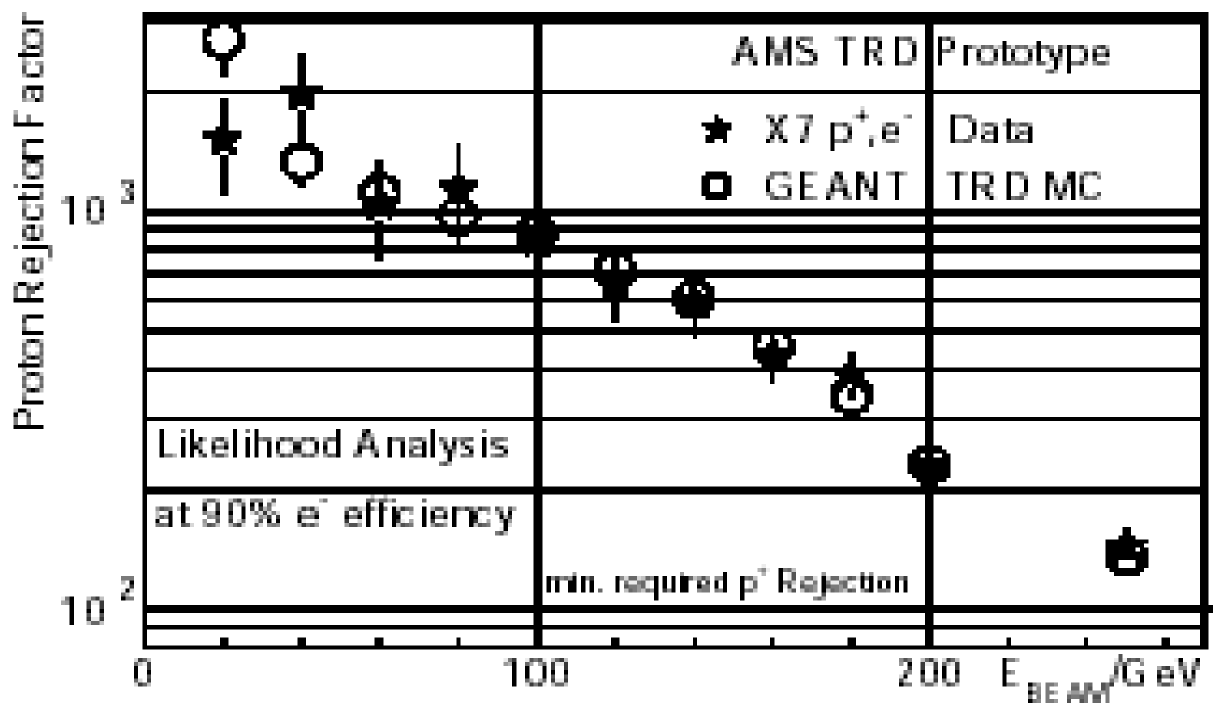
Central magnetic field B_x	0.87 T
Dipole bending power	0.78 Tm^2
Nominal operating current	459 A
Nominal inductance	48.9 H
Stored energy	5.15 MJ
Peak field on Dipole coils	6.6 T
Peak field on RT coils	5.9 T







TRD Performances



20 layer prototype tested with

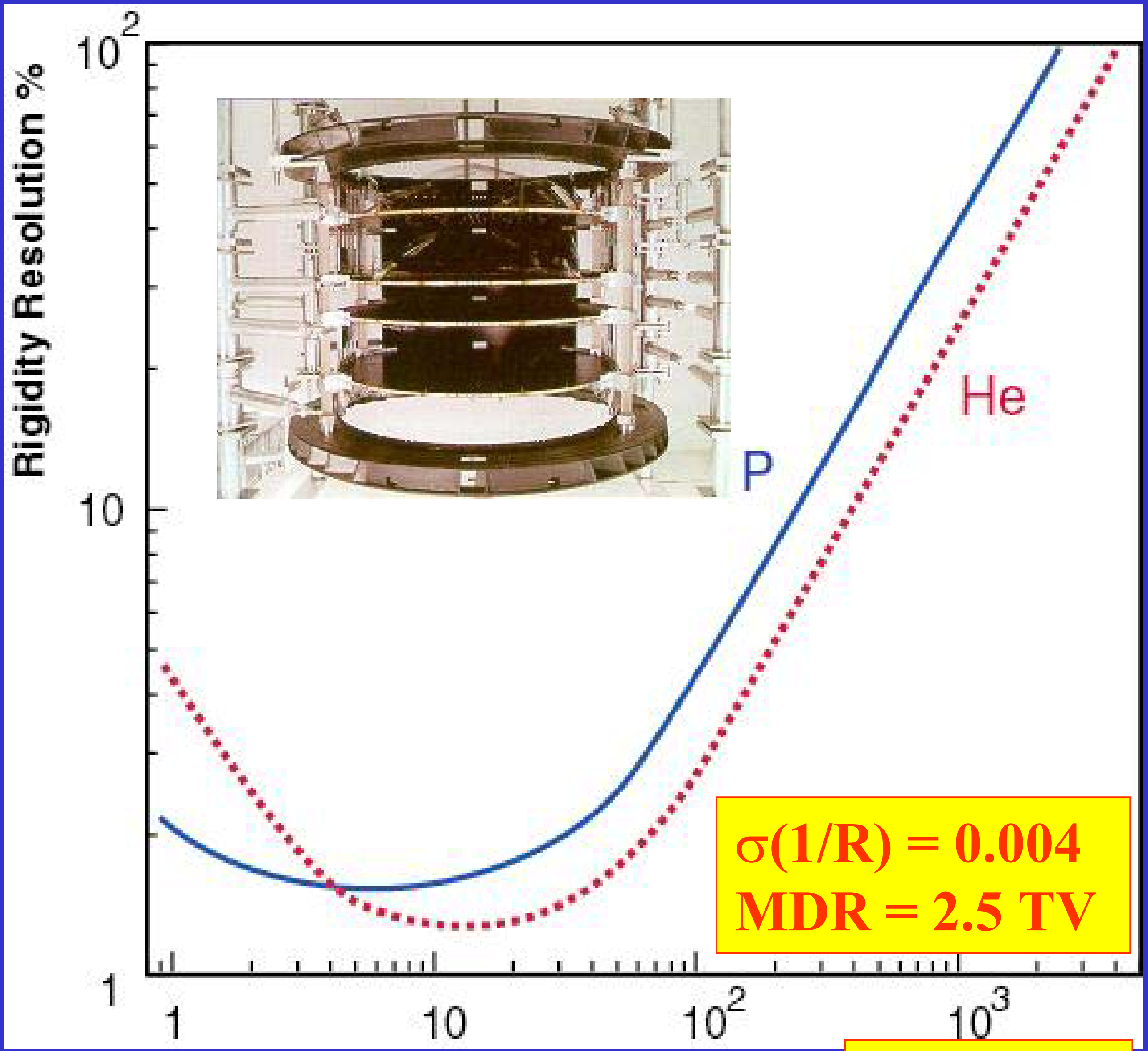
e^-, μ^-, π^+, p^+

1-P-109

Proton rejection $>10^2$

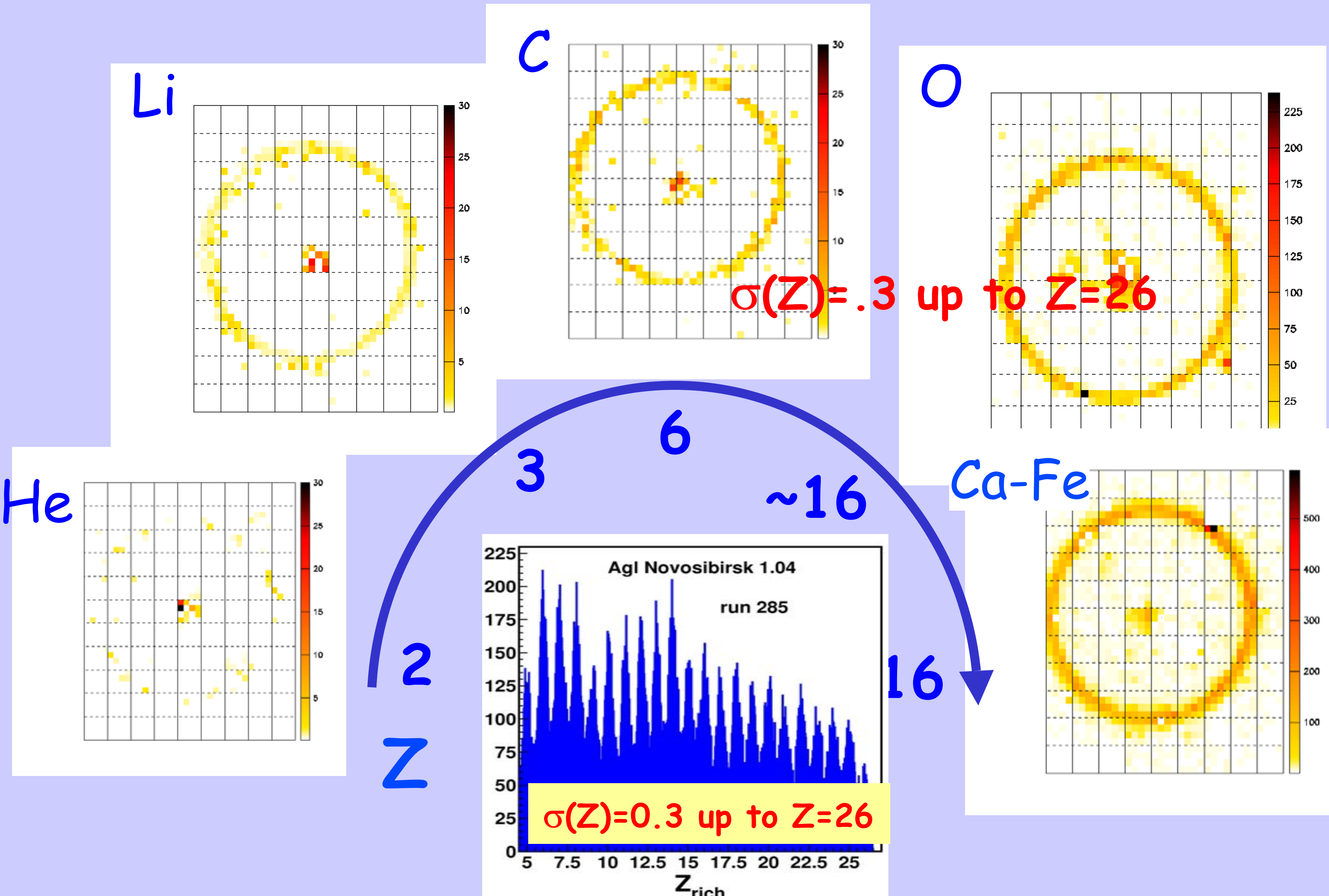
reached up to 250GeV with 90% electron efficiency

AMS-02 Silicon Spectrometer Rigidity Resolution/

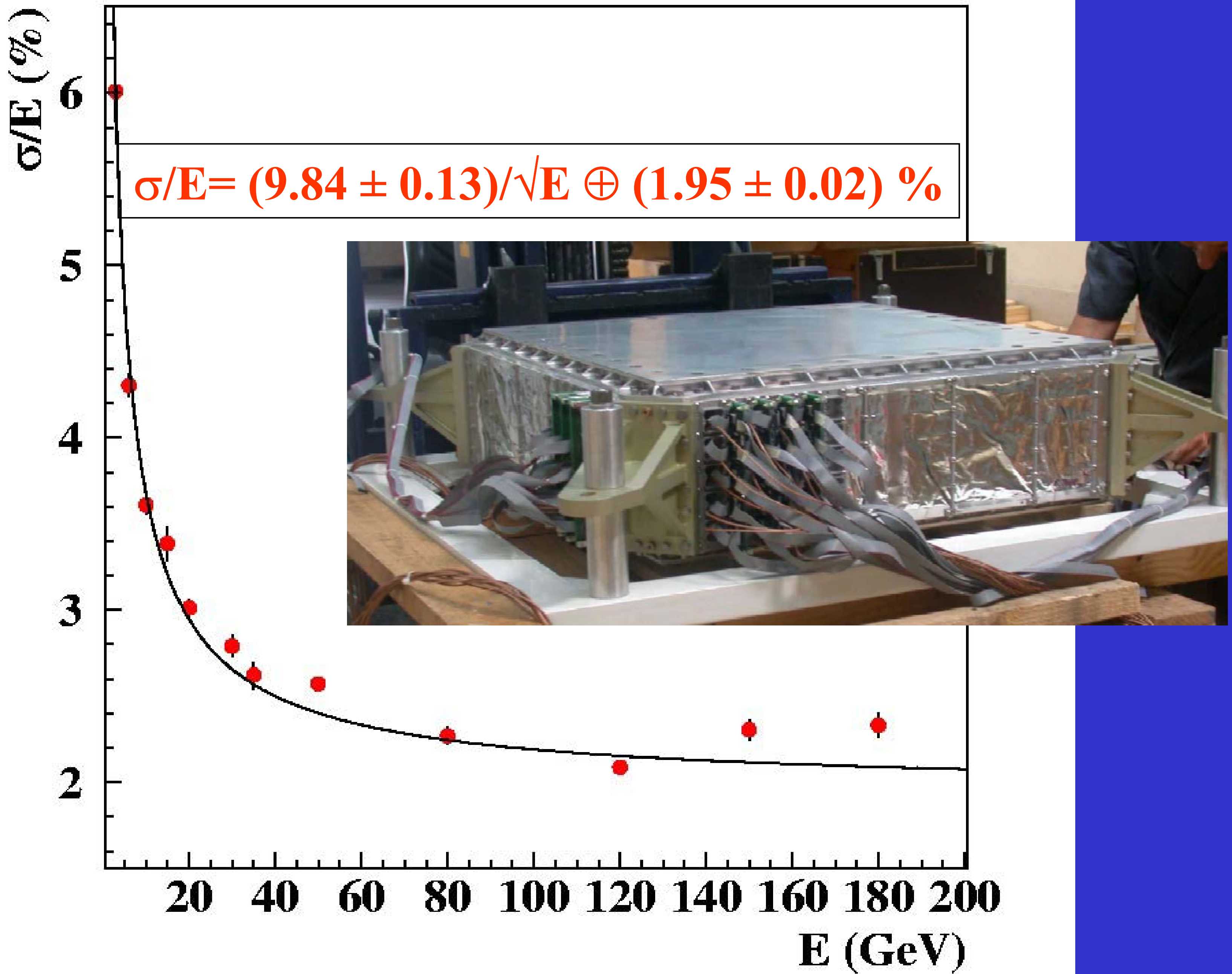


Rigidity (GV)

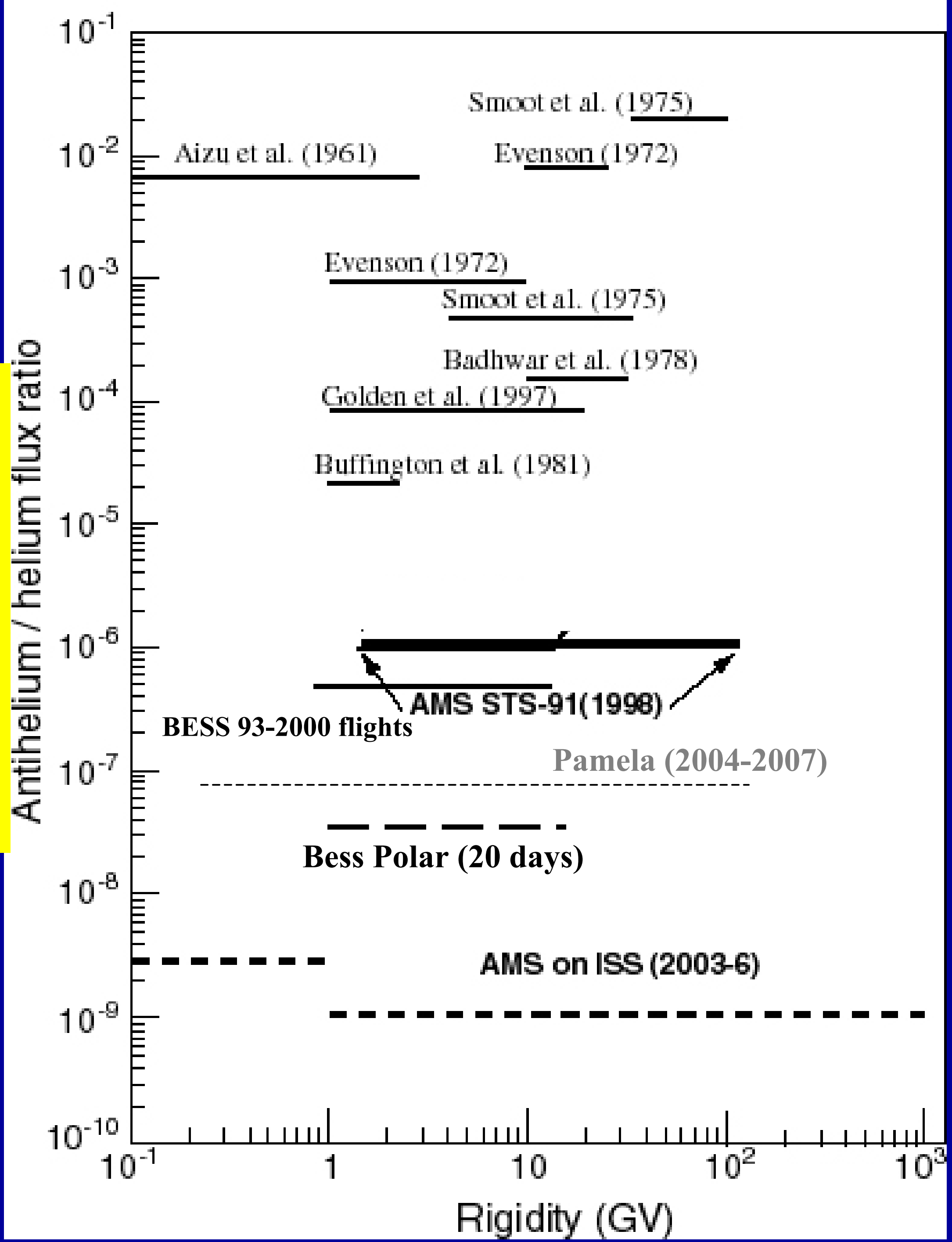
Cherenkov RINGS (single events)



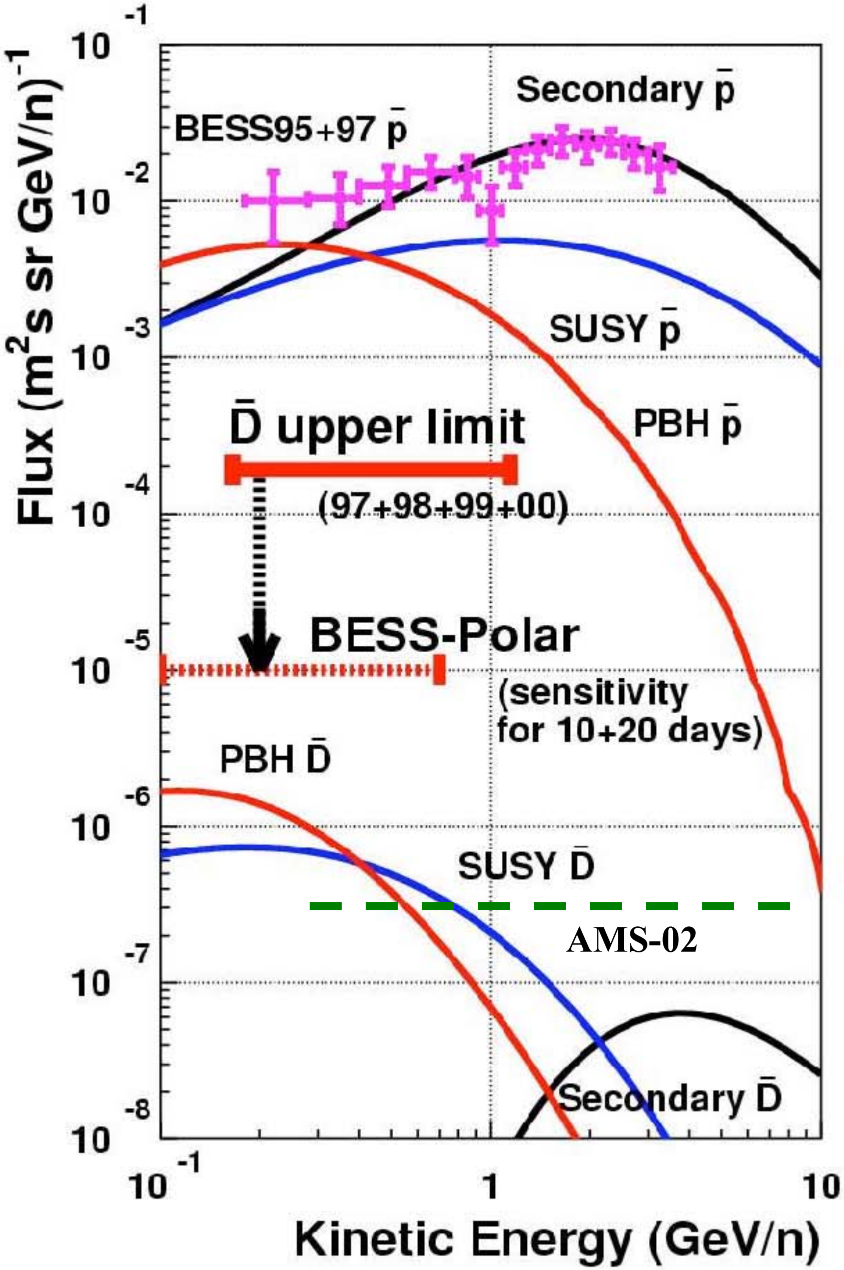
ECAL energy resolution



Search for antimatter at the 10^{-9} level of sensitivity with AMS-02 on the ISS



AMS sensitivity to anti D



OG 1.1 highlights (my view)

- Accurate measurement of the Solar to Galactic composition at high Z
- Energetic particle belts observed by AMS with a dynamics linked to CR atmospheric interaction
- 3He/4He ratio and high energy p and He from BESS and BESS-TeV
- New HEAT anti-p measurement covering high energies
- ATIC+(low energy/high energy) data gives a slope ~ 2.71 for both He and p up to energies approaching the knee
- RUNJOB data on chemical composition and spectra
- JACEE-SOKOL/RUNJOB-Grigorov discrepancy solved

- **A very exciting program in the years to come with lot of accurate new data expected from a wealth of Long Duration Balloons and Space Experiments**

Thanks for this great conference !