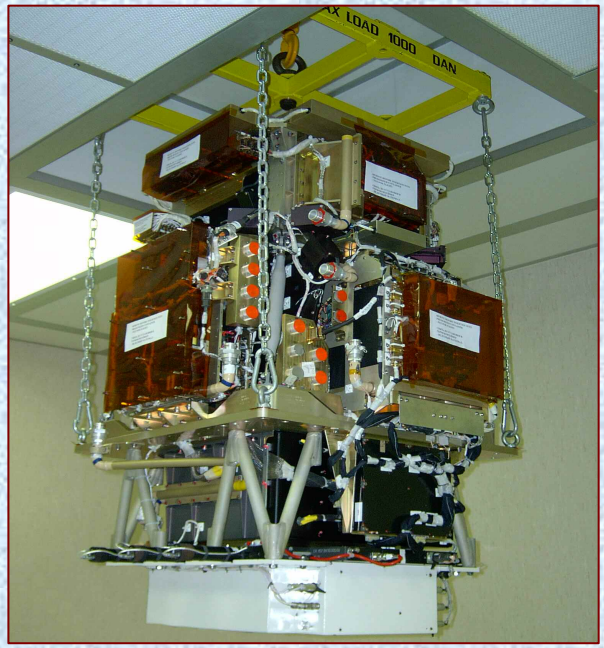
Cosmic ray measurements with the space telescope PAMELA: a status report



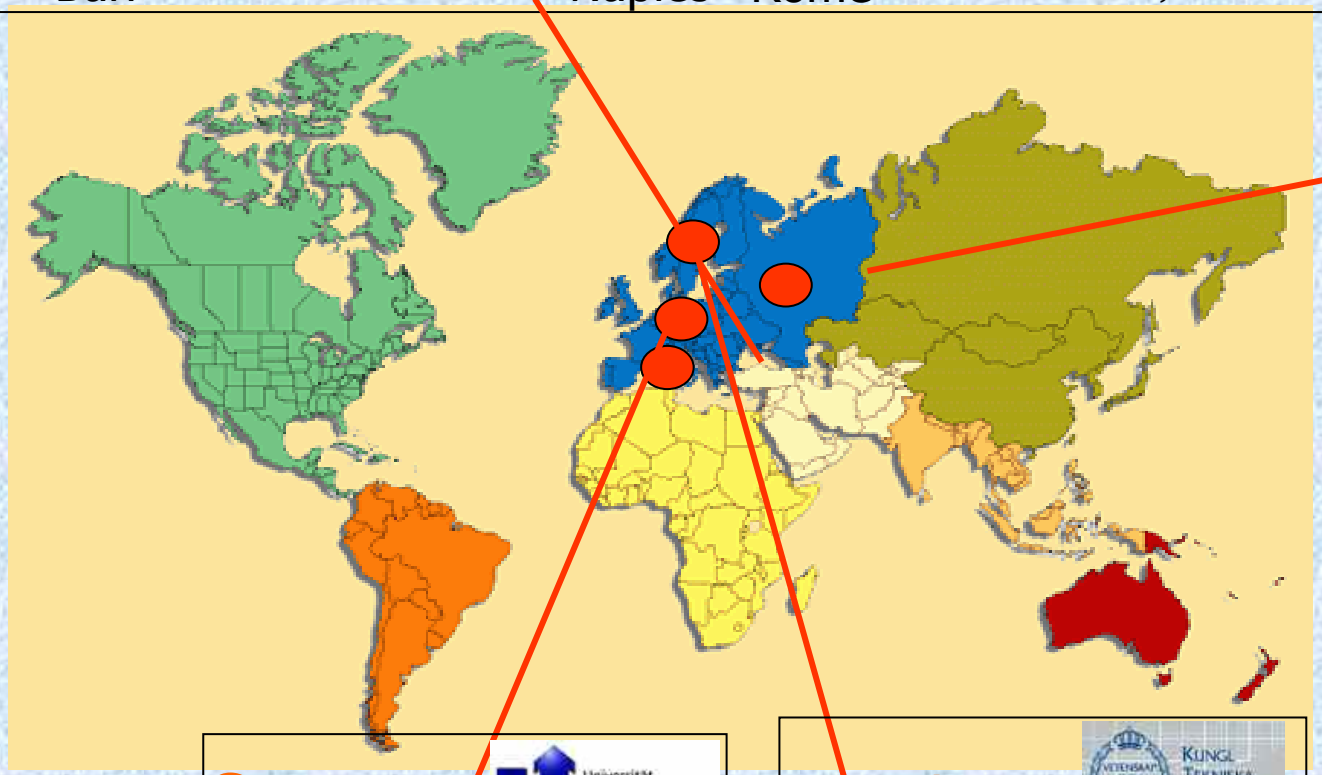
Roberta Sparvoli

(University of Rome Tor Vergata and INFN)

on behalf of the PAMELA collaboration

PAMELA collaboration

Italy: Bari, Florence, Frascati, Naples, Rome, Trieste, CNR, Florence



Russia:
Moscow
St. Petersburg

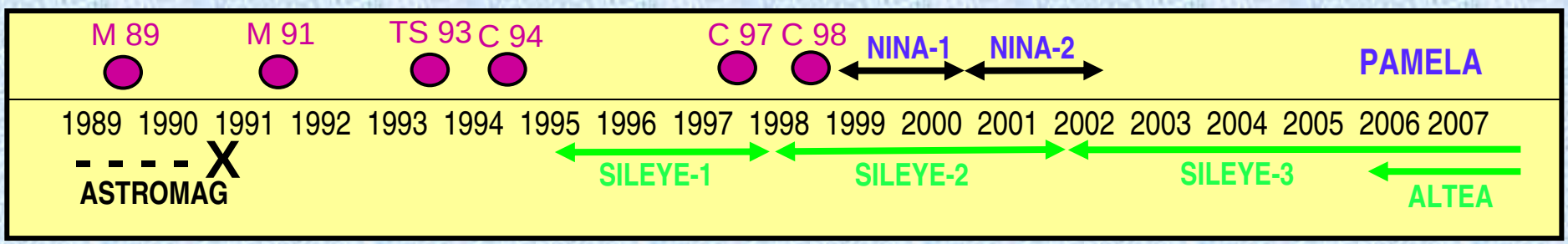
Germany: Siegen

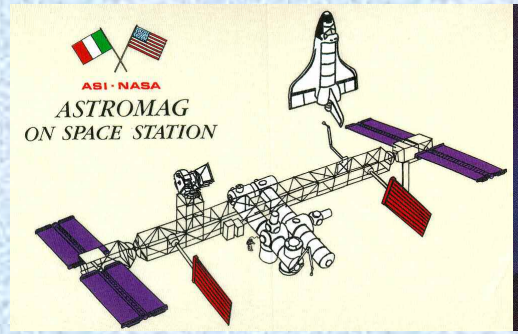
Sweden: KTH, Stockholm

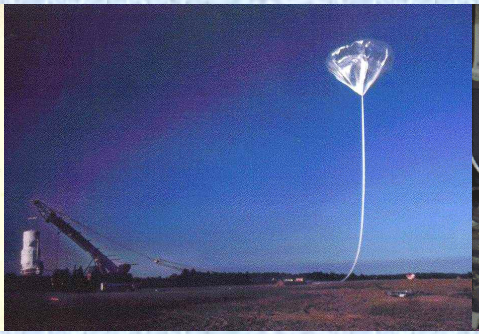
Previous space missions

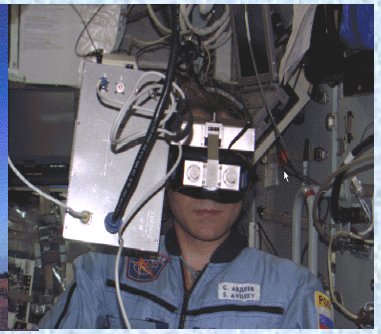
- Astromag/WiZard project (PAMELA precursor) on board of the Space Station Freedom →CANCELED
- Balloon-borne experiments: MASS-89,91 TS-93 CAPRICE-94,97,98
- Space experiments*: NINA-1,2 SILEYE-1,2,3 ALTEA

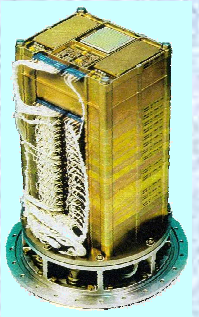
(*study of low energy nuclei and space radiation environment)

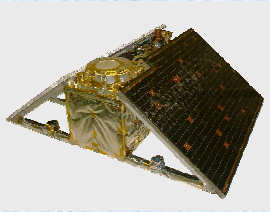




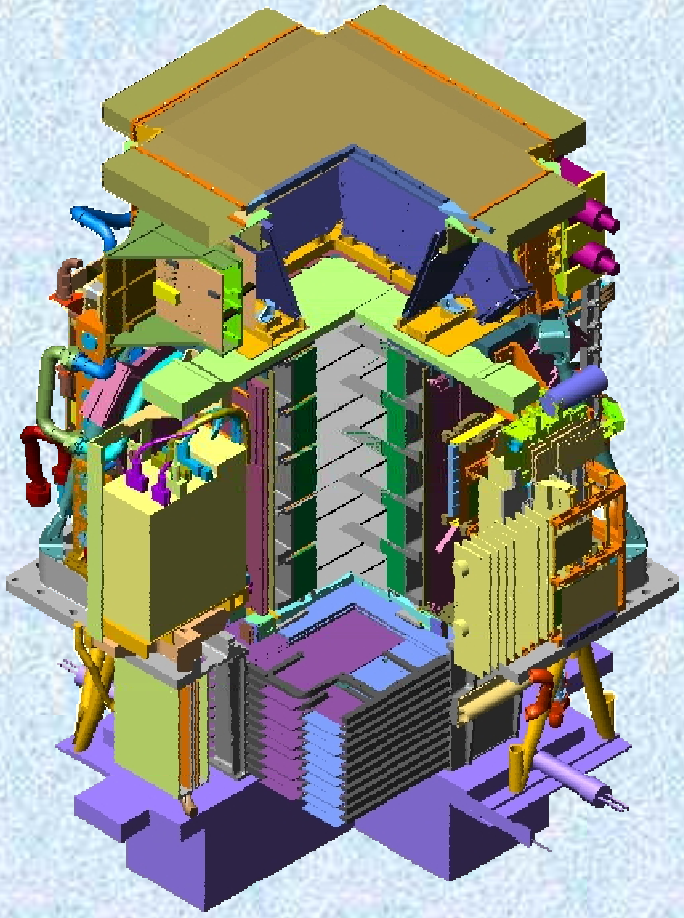


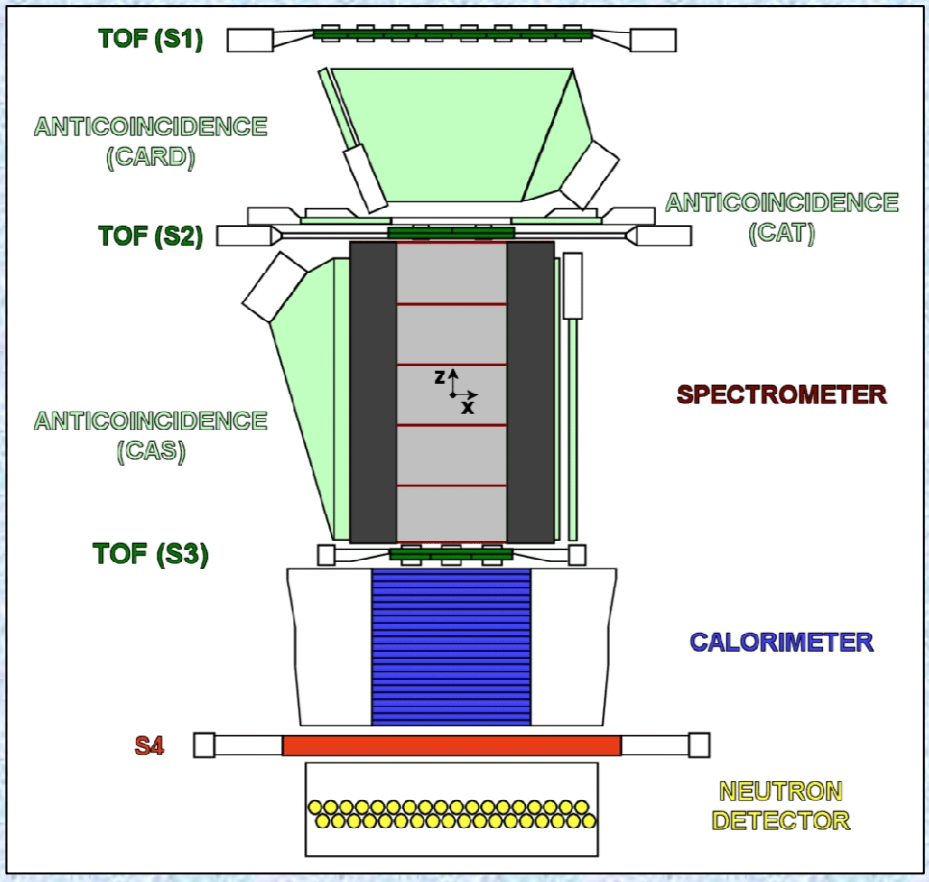






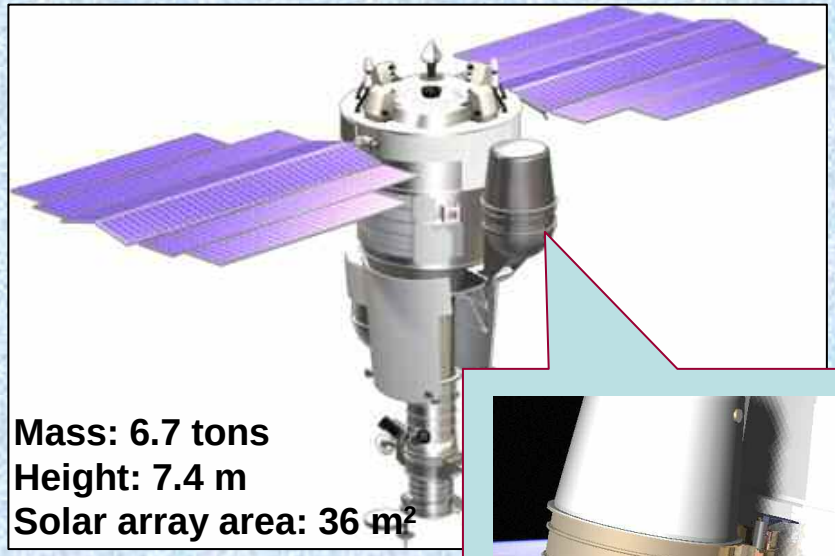
PAMELA apparatus



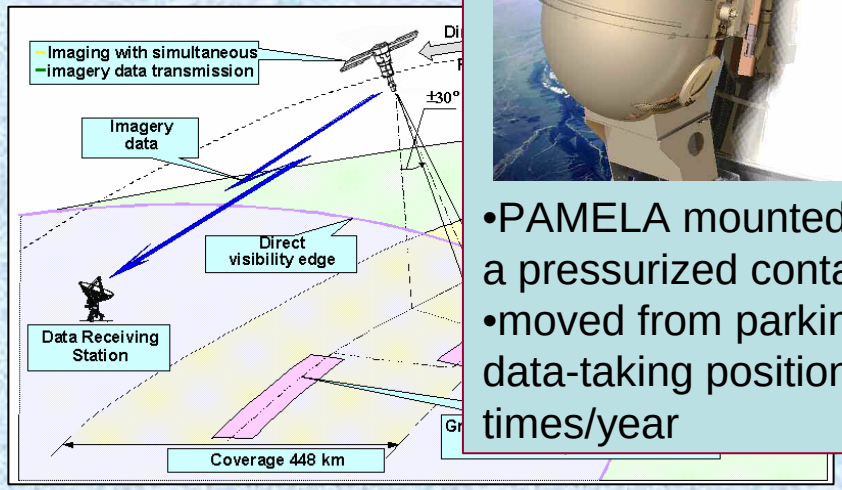


GF: 21.5 cm^2 sr
Mass: 470 kg
Size: 130x70x70 cm^3
Power Budget: 360 W

The Resurs DK-1 spacecraft



Mass: 6.7 tons
Height: 7.4 m
Solar array area: 36 m²



•PAMELA mounted inside a pressurized container
•moved from parking to data-taking position few times/year

- Multi-spectral remote sensing of earth's surface
  → near-real-time high-quality images
- Built by the Space factory TsSKB Progress in Samara (Russia)
- **Operational orbit parameters:**
  - **inclination ~70°**
  - **altitude ~ 360-600 km (elliptical)**

Active life >3 years

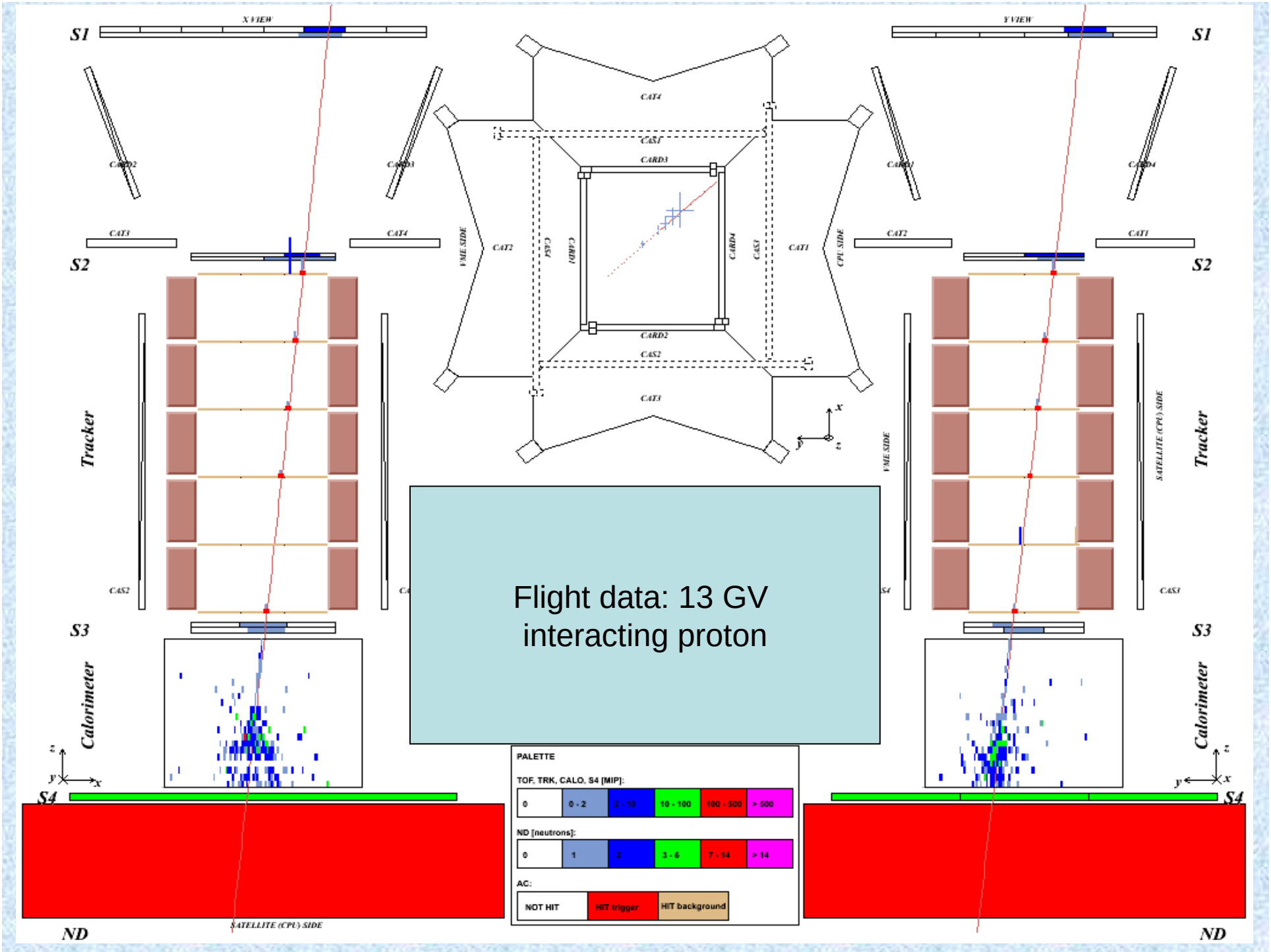
Data transmitted via Very high-speed Radio Link (VRL)

PAMELA in Space

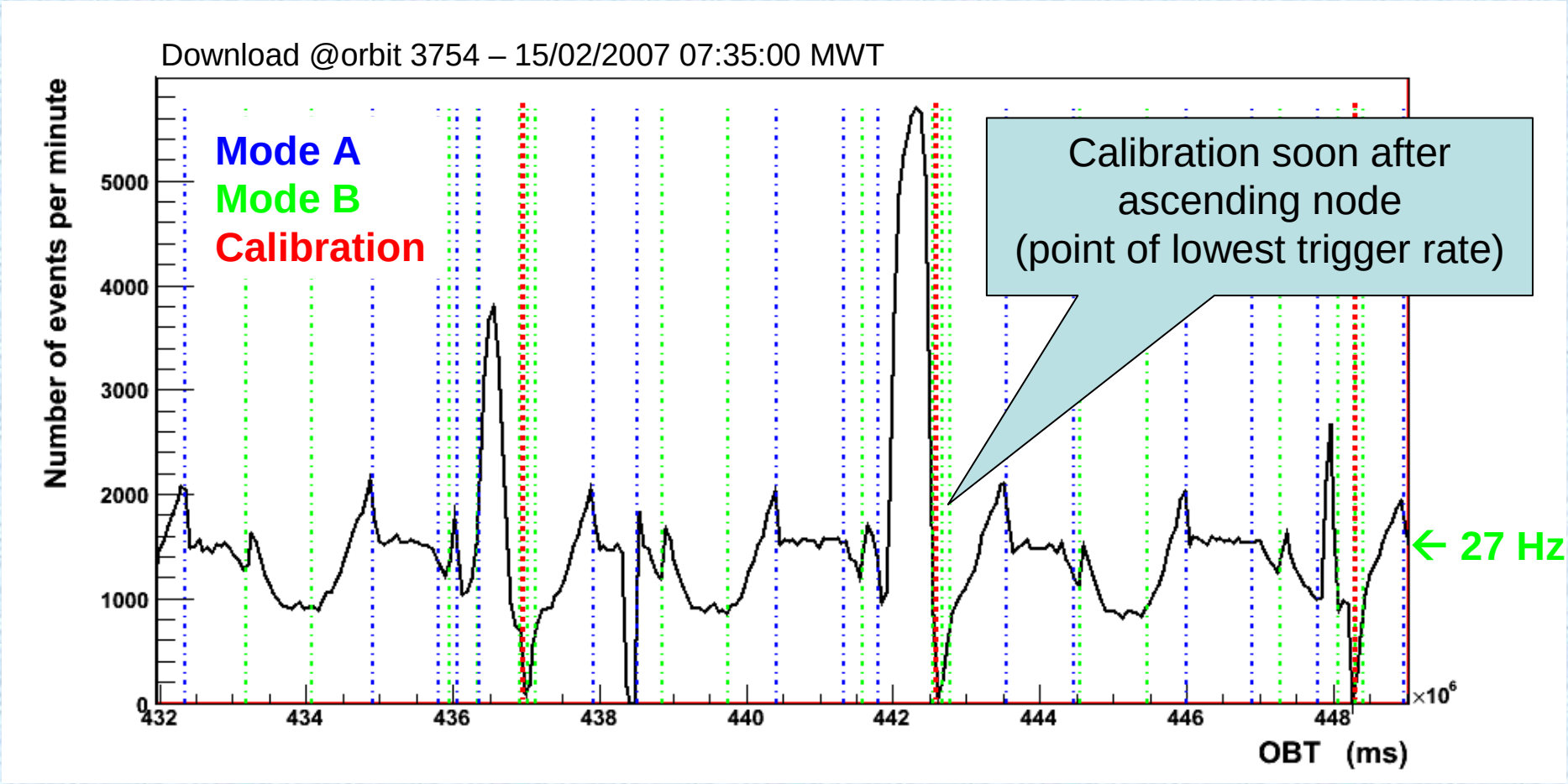
- On June 15th 2006 at 08:00 UTC the RESURS DK-1 satellite housing the PAMELA apparatus was successfully launched in space for the Russian cosmodrome of Baikonur.
- PAMELA was switched on for the first time on June 21st.
- In the following days PAMELA was on for several hours and continuously since the 11th of July.
- On September the 15th the commissioning phase of the RESURS was completed.

PAMELA flight

- Detectors operated **as expected** after launch
- Tested **different trigger and hardware configurations**
- As of ~July 07 PAMELA has collected data for about 26 million seconds corresponding to more than **300 days** (7200 hours) of continuous data taking (life time ~70%)
- The amount of data collected is ~5.4 TB, corresponding to more than **610 million events**


S1
X VIEW
Y VIEW
S2
S3
S4
Tracker
Calorimeter
ND
CAT1
CAT2
CAT3
CAT4
CARD1
CARD2
CARD3
CARD4
CAS1
CAS2
CAS3
CAS4
VME SIDE
CPE SIDE
SATELLITE (CPU) SIDE
Flight data: 13 GV
interacting proton
PALETTE
TOF, TRK, CALO, S4 [MIP]:
0
0 - 2
2 - 10
10 - 100
100 - 500
> 500
ND [neutrons]:
0
1
2
3 - 6
7 - 14
> 14
AC:
NOT HIT
HIT trigger
HIT background

Trigger rate



- Mode A → (**S21** AND **S22**) AND (**S31** AND S**32**) + CALORIMETER
- Mode B → (**S11** OR **S12**) AND (**S21** OR **S22**) AND (**S31** OR S**32**) + CALORIMETER

PAMELA nominal capabilities

	energy range	particles in 3 years
• Antiproton flux	80 MeV - 190 GeV	~ 10^4
• Positron flux	50 MeV – 270 GeV	~ 10^5
• Electron flux	up to 400 GeV	~ 10^6
• Proton flux	up to 700 GeV	~ 10^8
• Electron/positron flux	up to 2 TeV (from calorimeter)	
• Light Nuclei	up to 200 GeV/n He/Be/C:	~$10^{7/4/5}$
• AntiNuclei search	sensitivity of 3×10^{-8} in He/He	

→ **Simultaneous measurements of many cosmic-ray species**

→ **New energy range**

→ **Unprecedented statistics**

Taking into account live time and geometrical factor:

1 HEAT-PBAR flight ~ 22.4 days PAMELA data

1 CAPRICE98 flight ~ 3.9 days PAMELA data

PAMELA Science

PAMELA is:

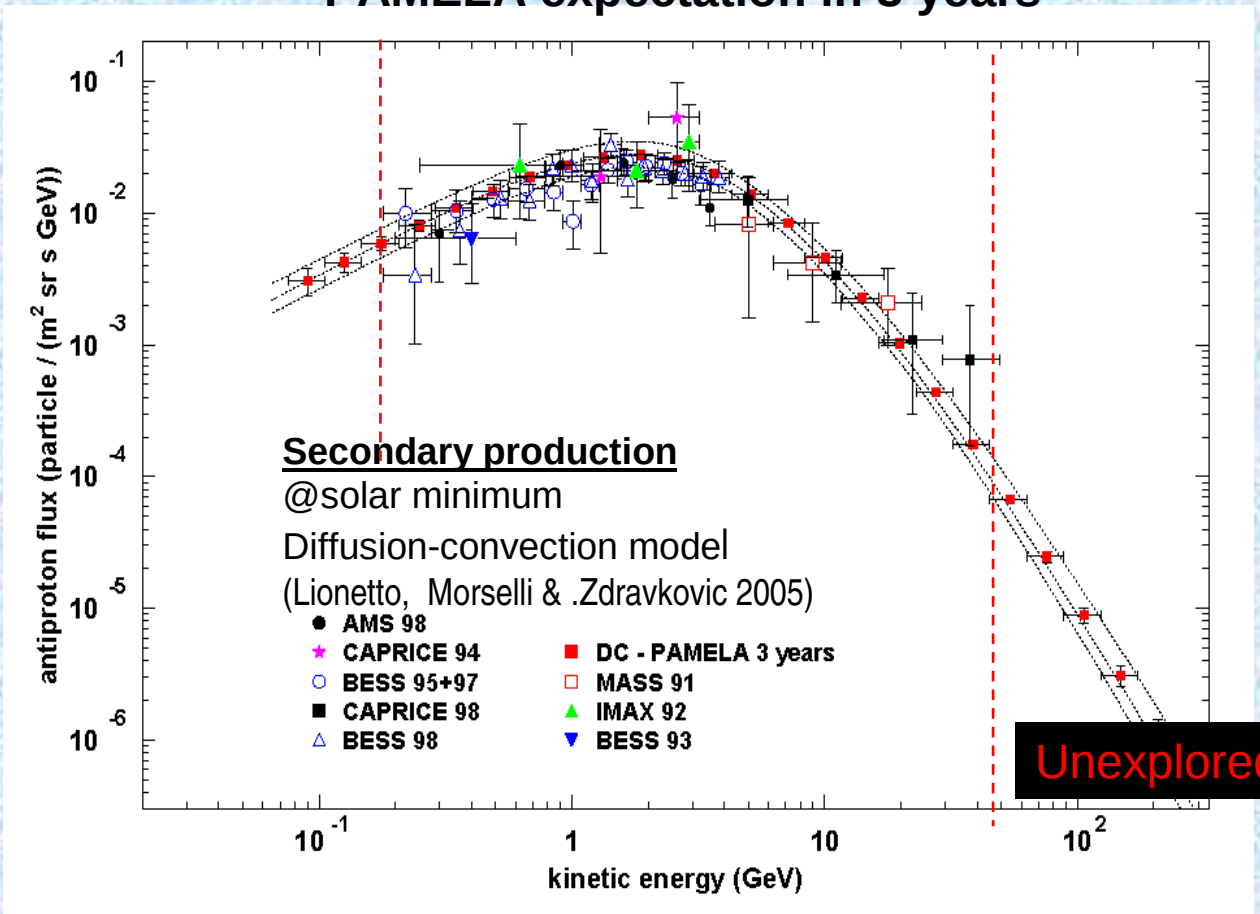
- Searching for antimatter

Antimatter in the Universe?

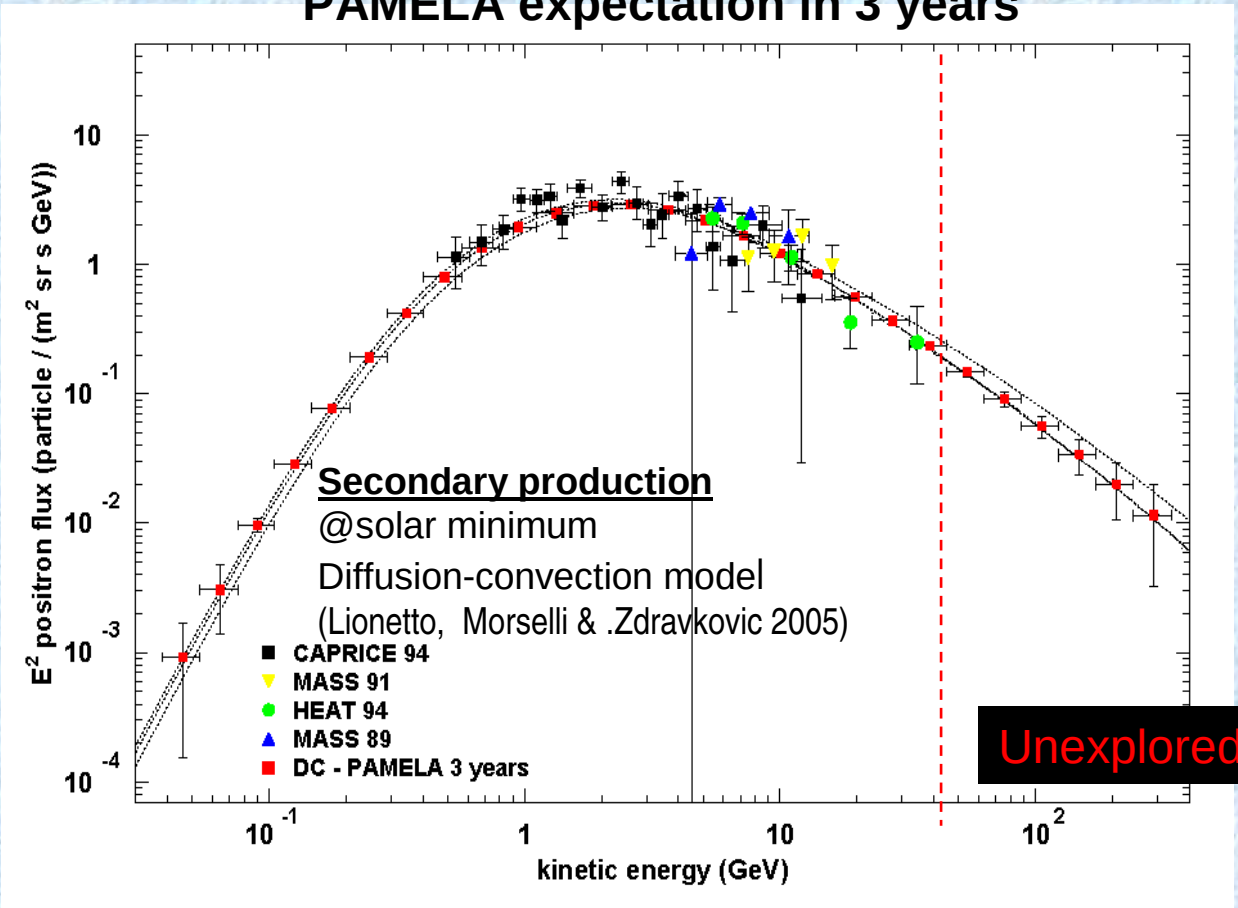
- The Universe is 100% matter dominated ?
- Globally B-symmetric Universe ?
- Domains of Antimatter in Matter Dominated Universe ?

Antiproton absolute flux

PAMELA expectation in 3 years

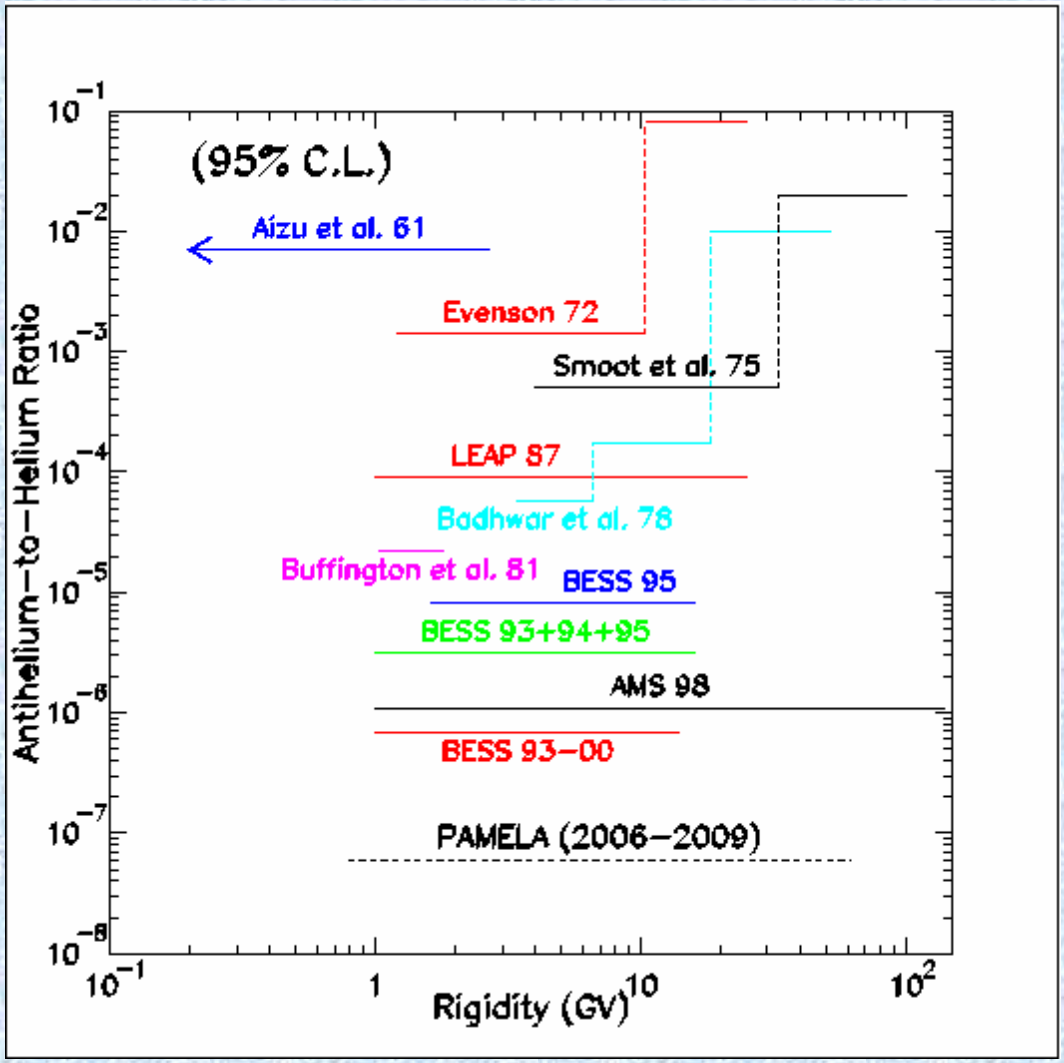


Positron absolute flux



Extragalactic Antimatter Search

Unequivocal signature of large-scale antimatter structures

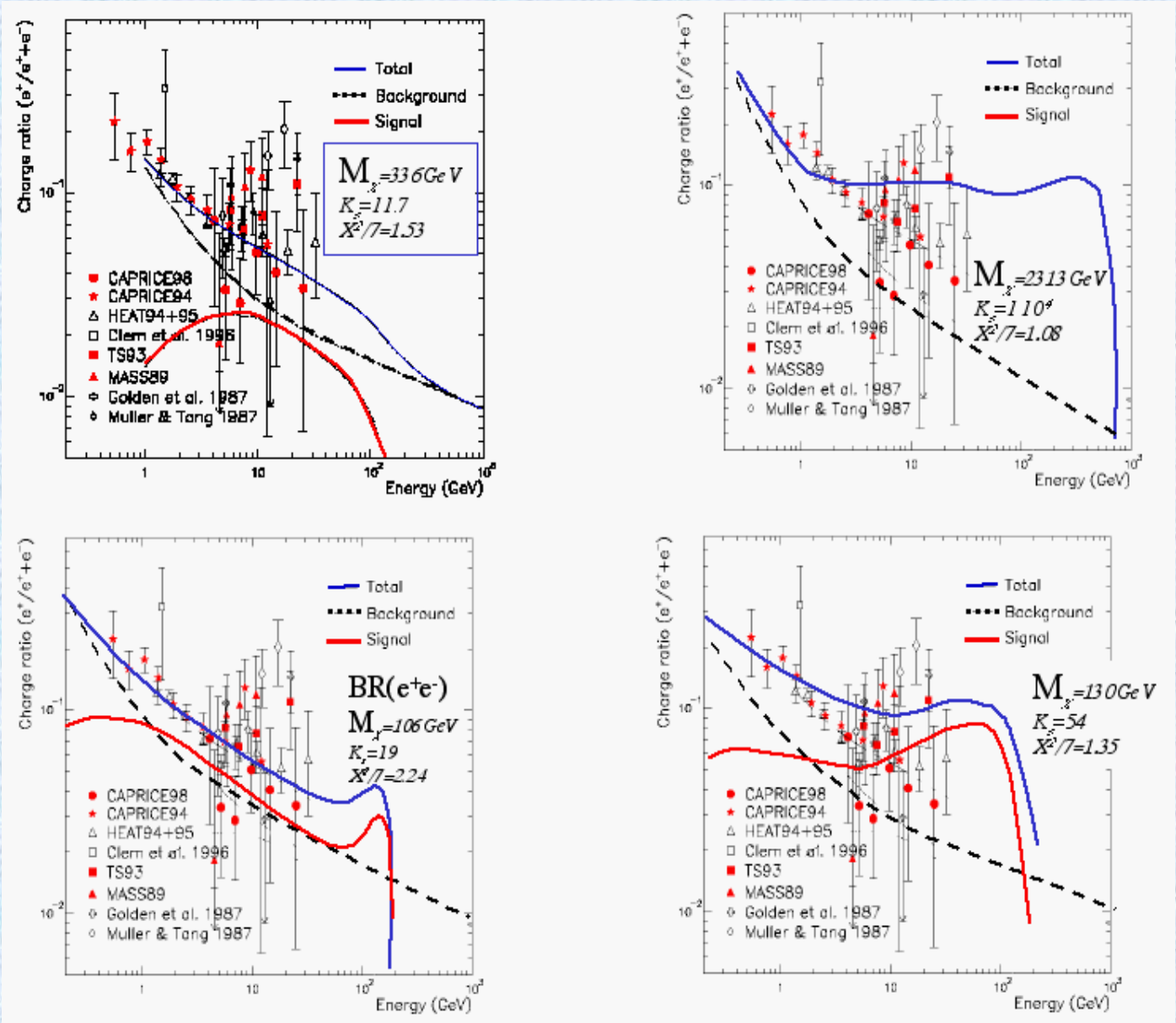


PAMELA Science

PAMELA is:

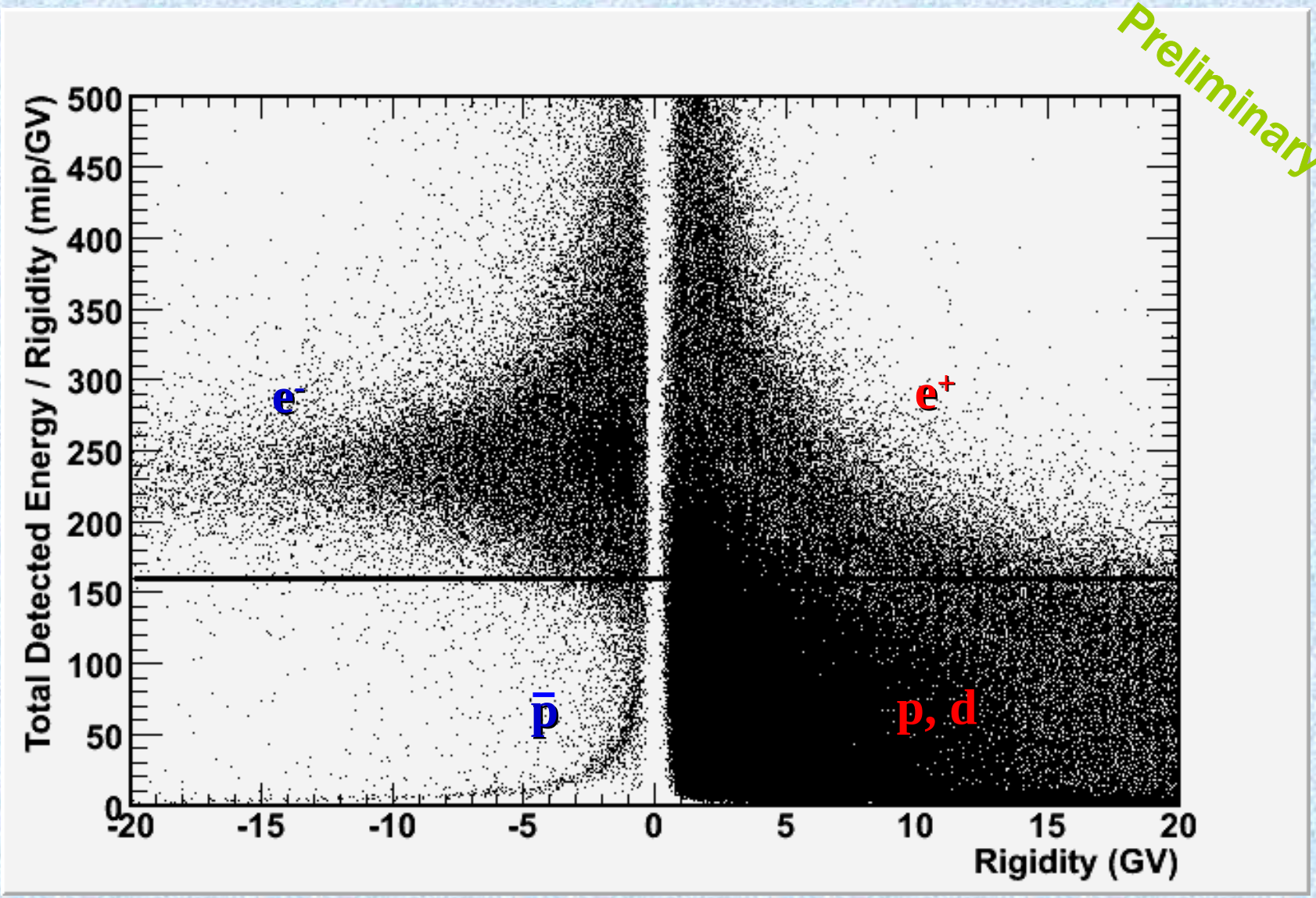
- Searching for antimatter
- Searching for dark matter

Distortion of the secondary positron fraction induced by a signal from a heavy neutralino.

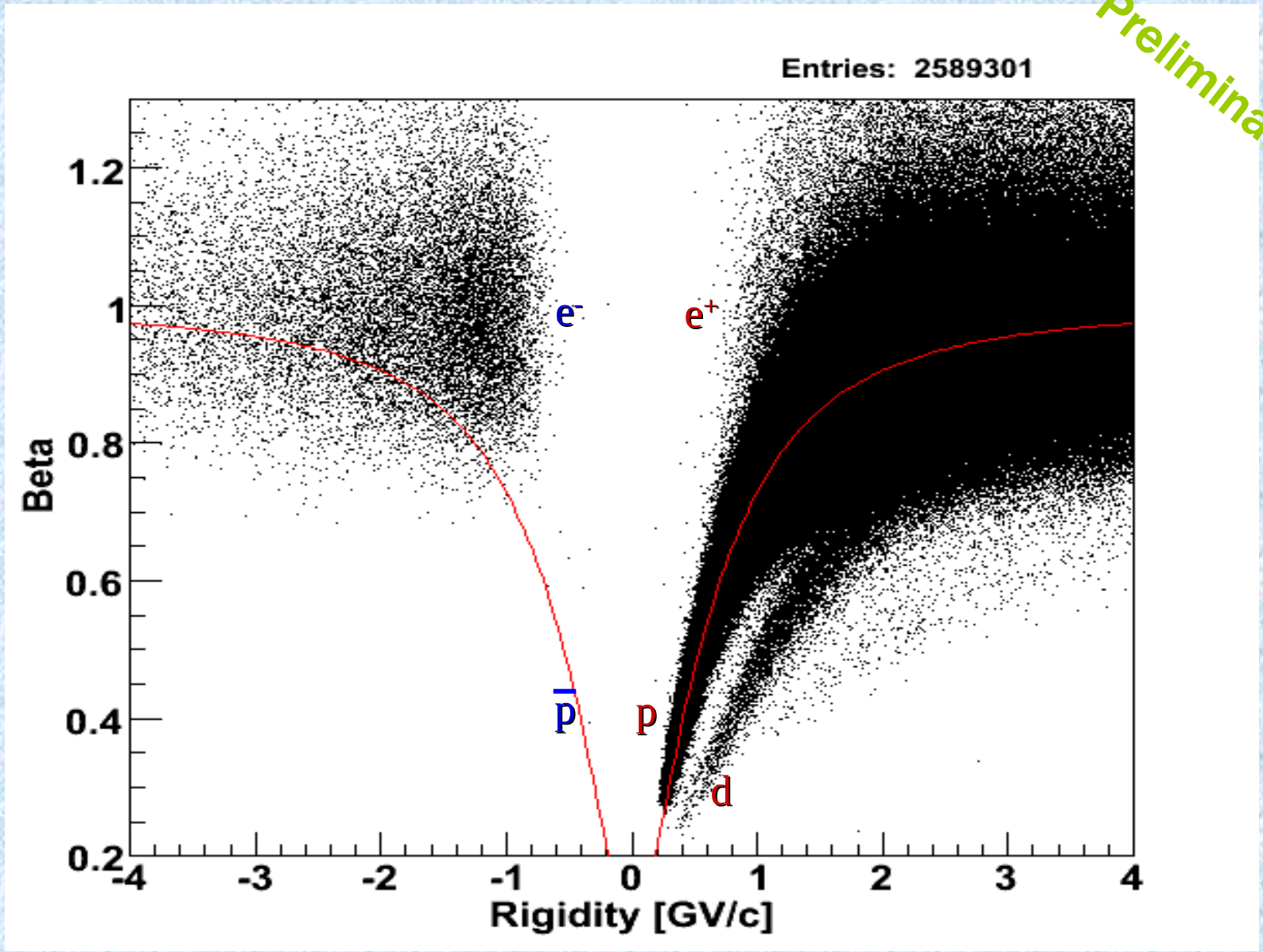


Baltz & Edsjö
Phys.Rev. D59 (1999)
astro-ph 9808243

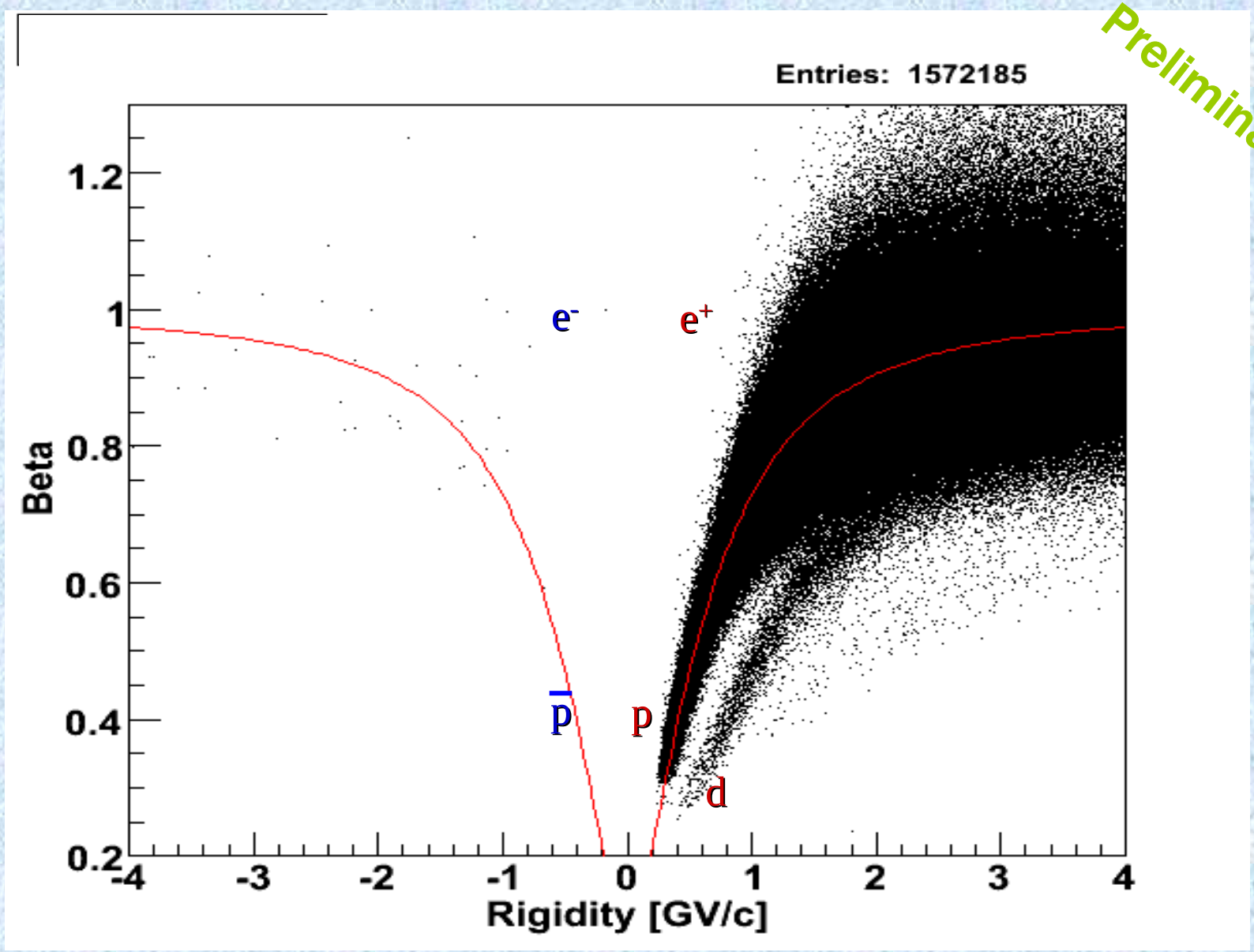
Antiparticle Selection



ToF β for p-like events



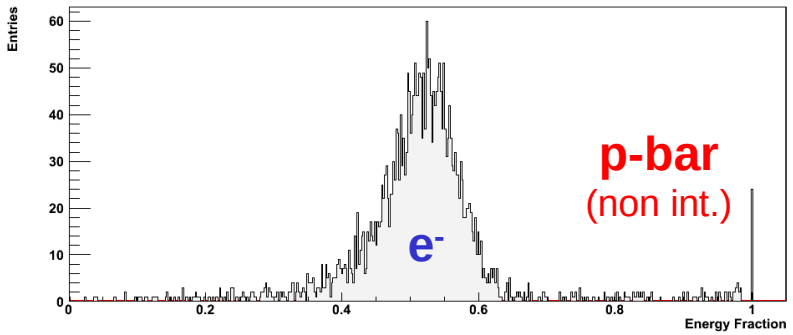
ToF β for p-like events

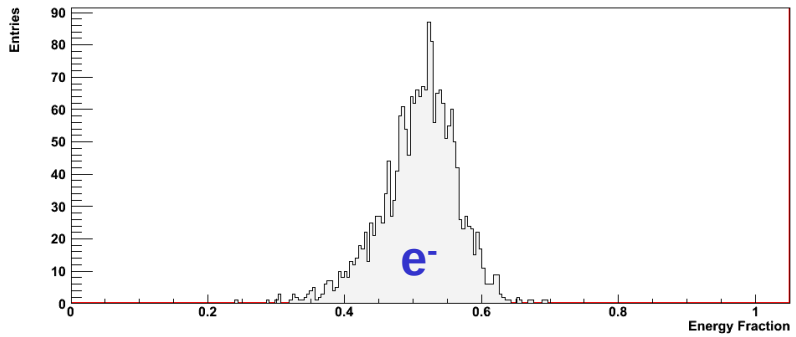


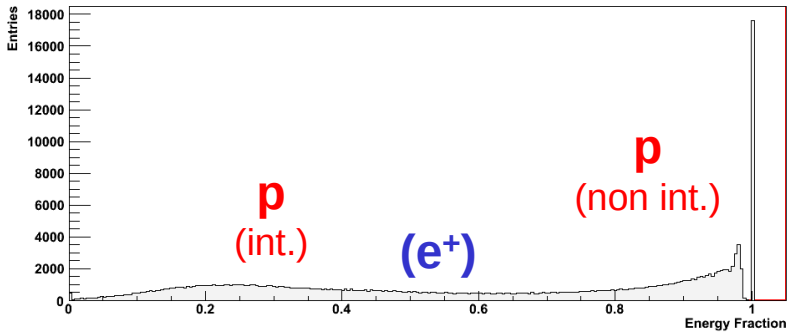
Positron selection

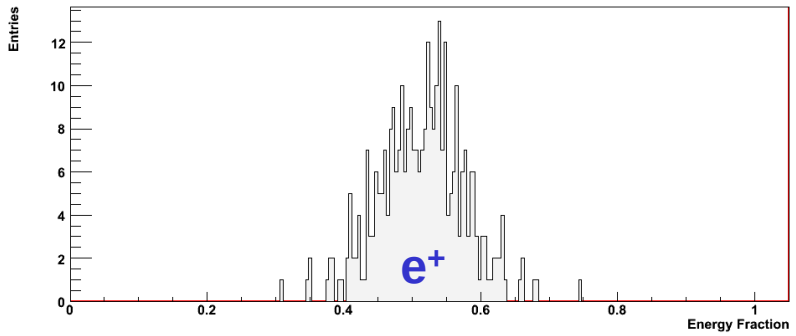
Preliminary !!!

Fraction of charge released along the track



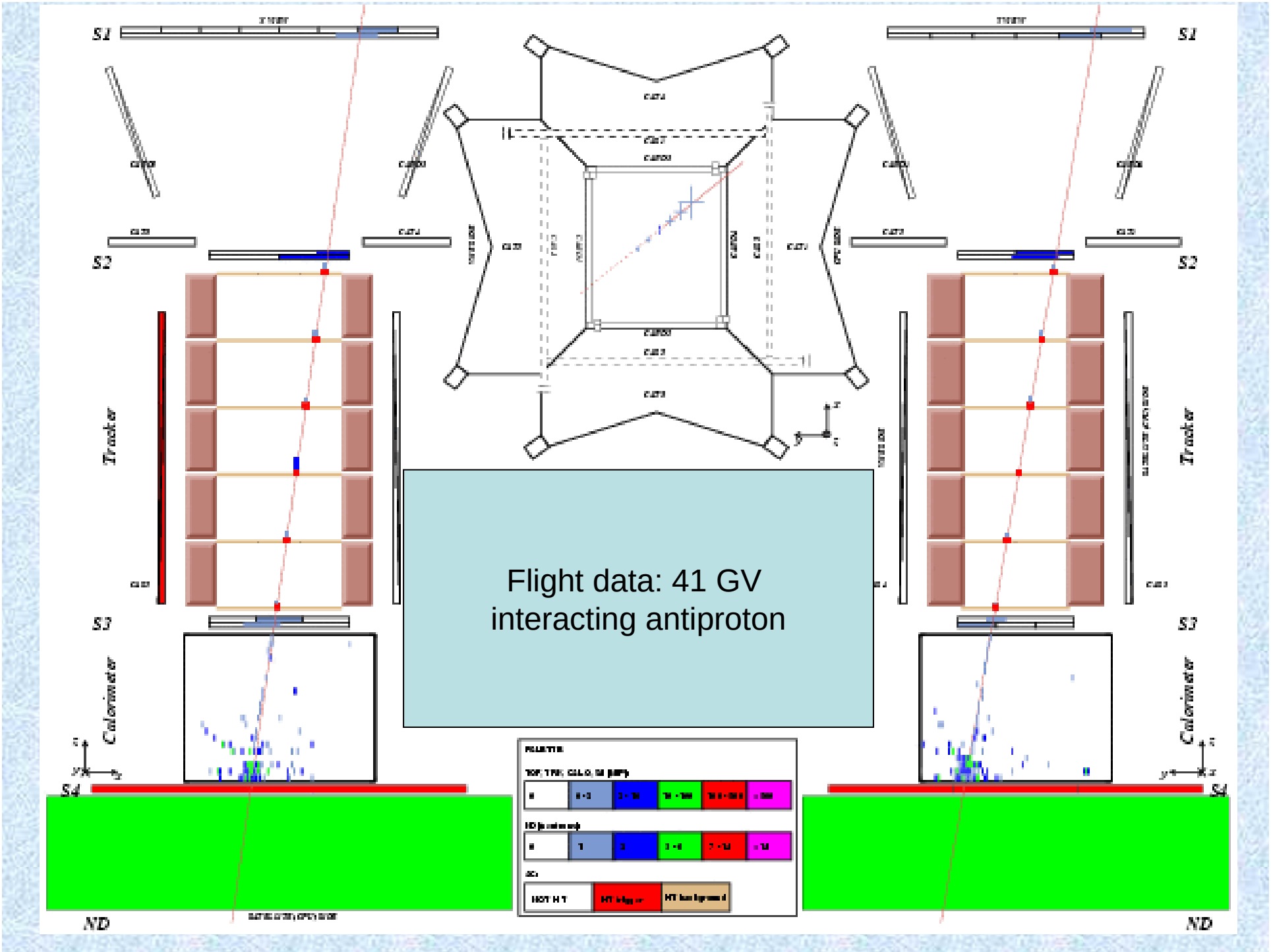


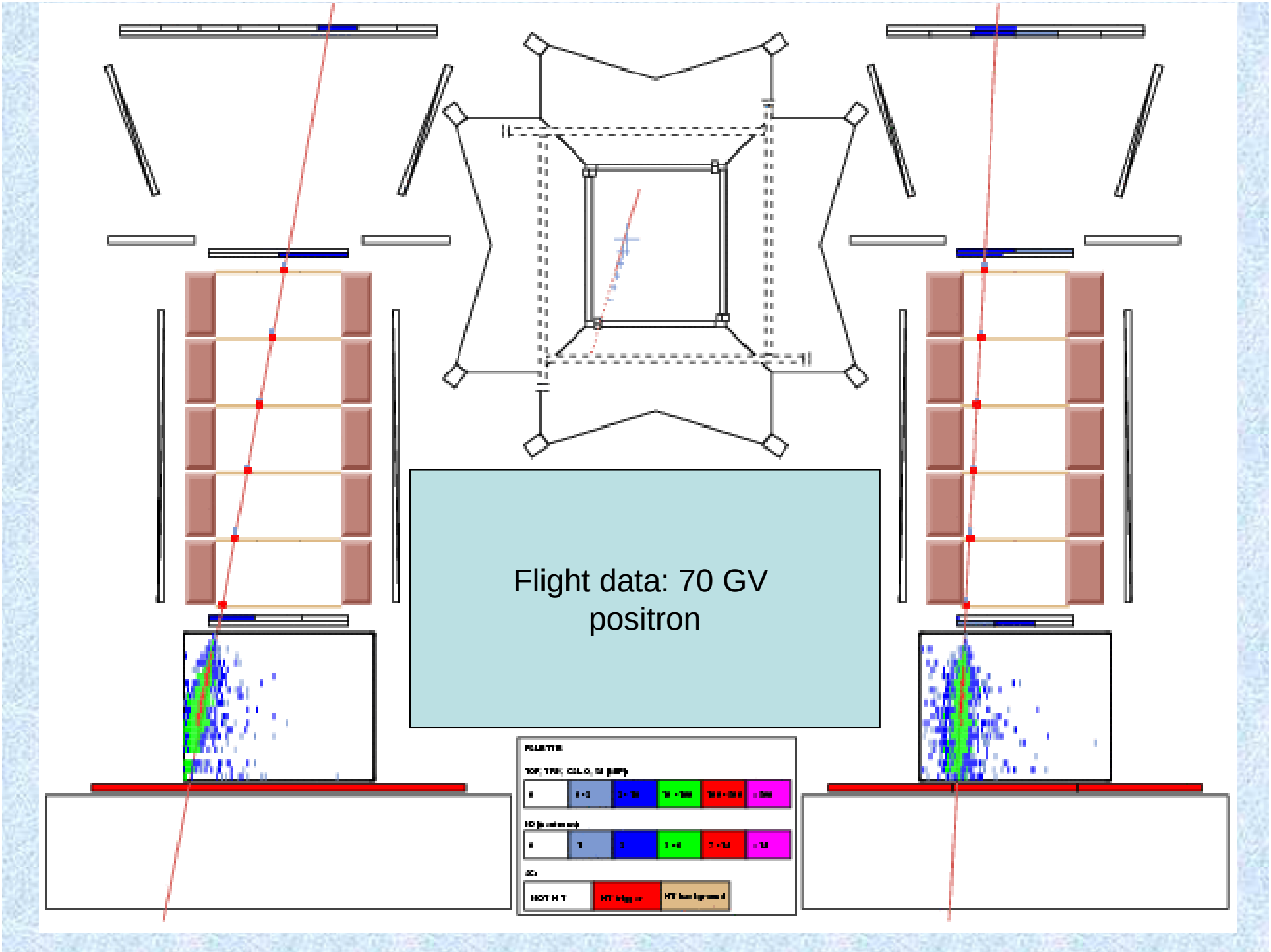




Many selection criteria provided by the calorimeter:

- total energy release
- longitudinal and later shower development
- shower topology
- …


S1
S2
S3
S4
Tracker
Calorimeter
ND
Flight data: 41 GV
interacting antiproton

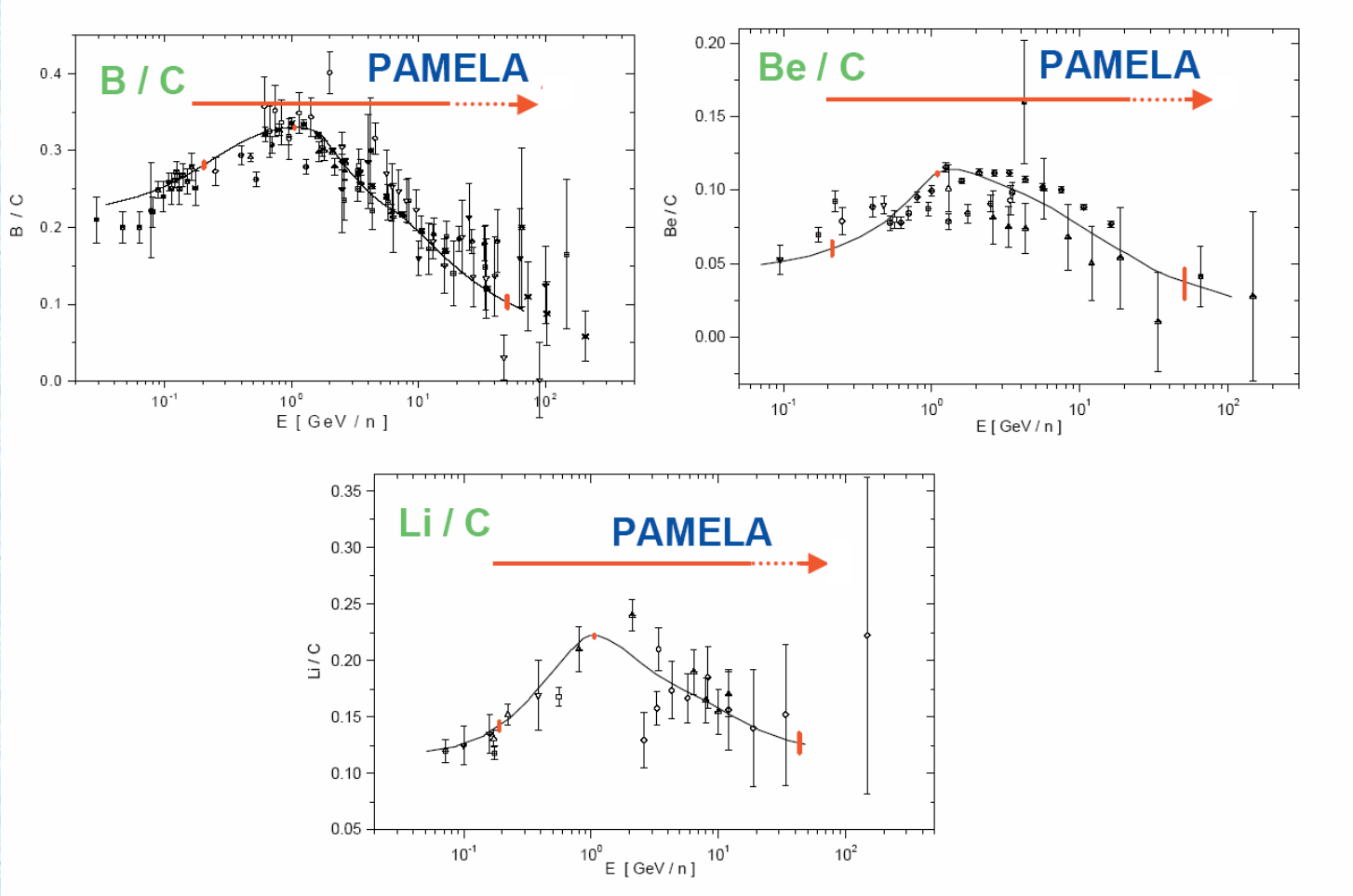

Flight data: 70 GV
positron

PAMELA Science

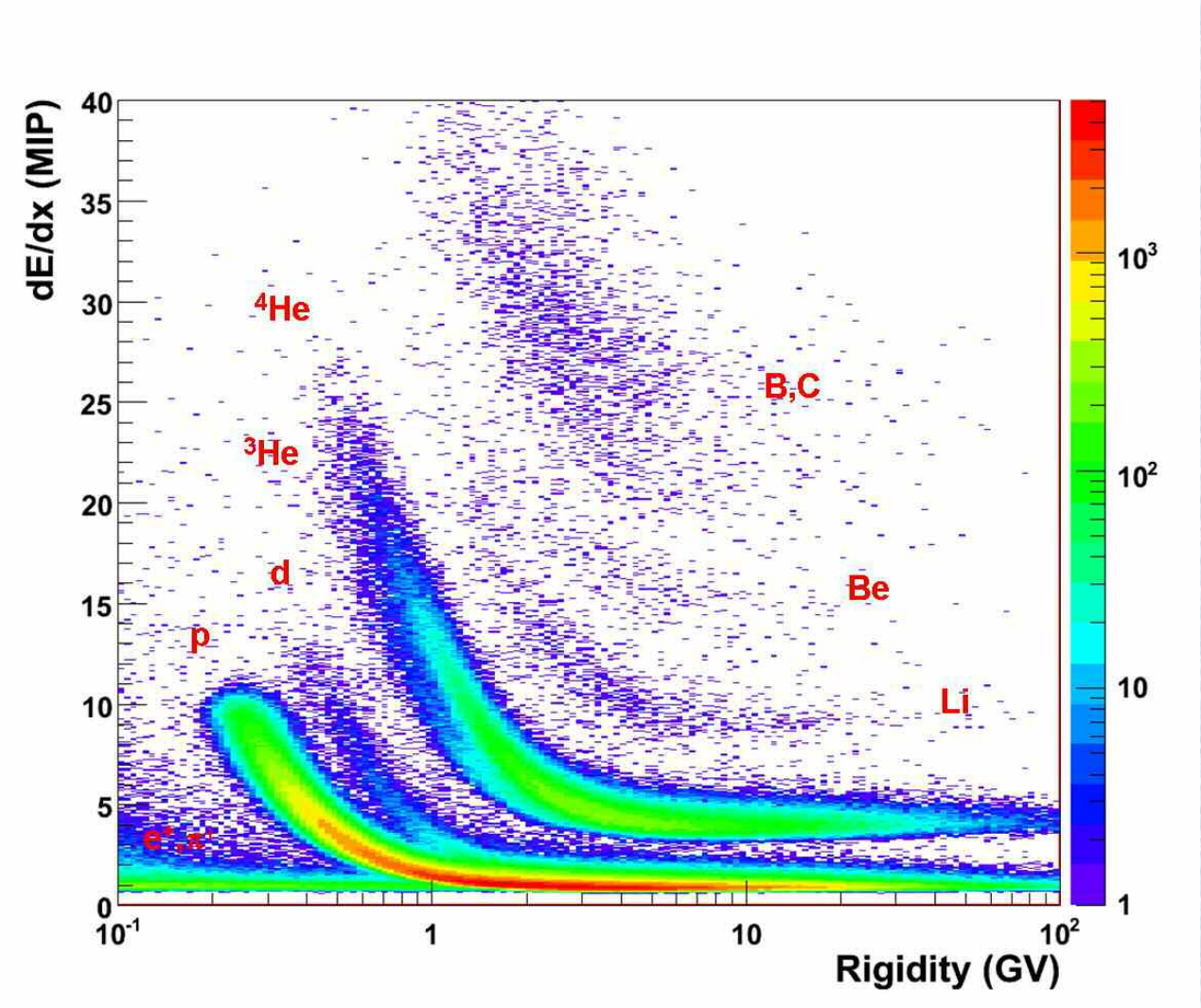
PAMELA is:

- Searching for antimatter
- Searching for dark matter
- Studing cosmic-ray propagation

Secondary to Primary ratios

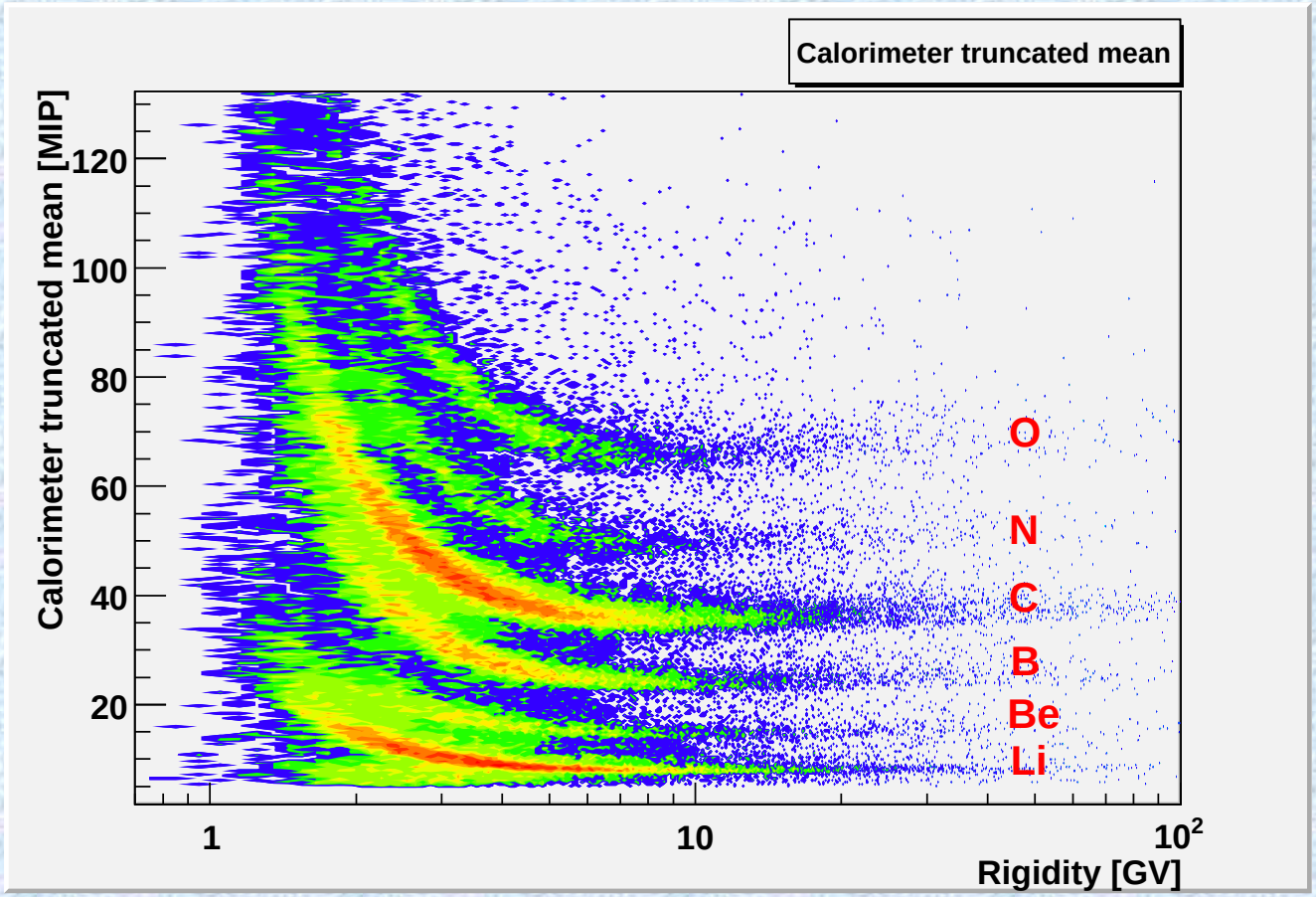


Charge measurement with Tracker



Mean of six ionization losses vs rigidity

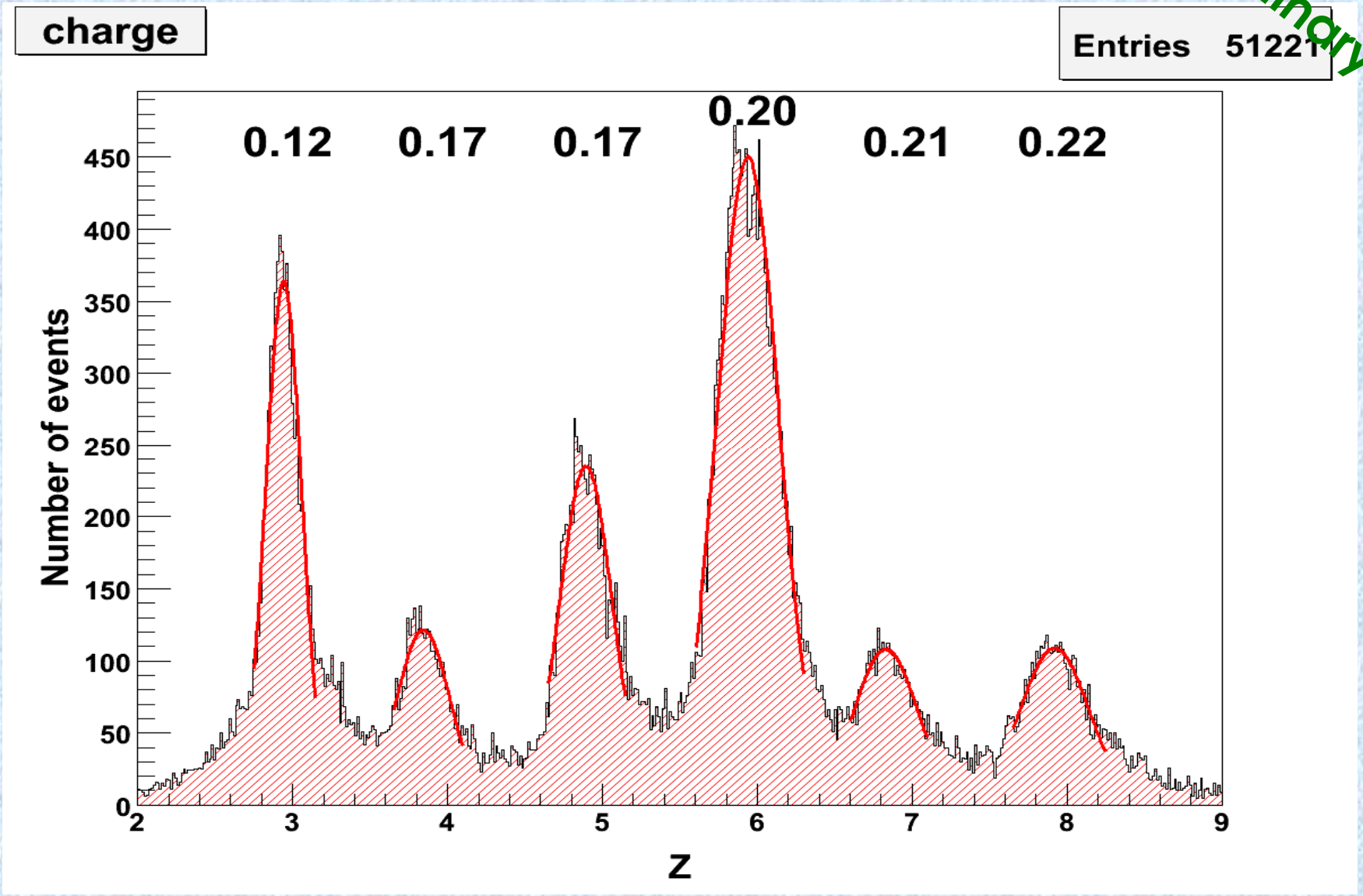
Charge measurement with Calorimeter



Truncated mean of multiple dE/dx measurements in different silicon planes

Charge resolution

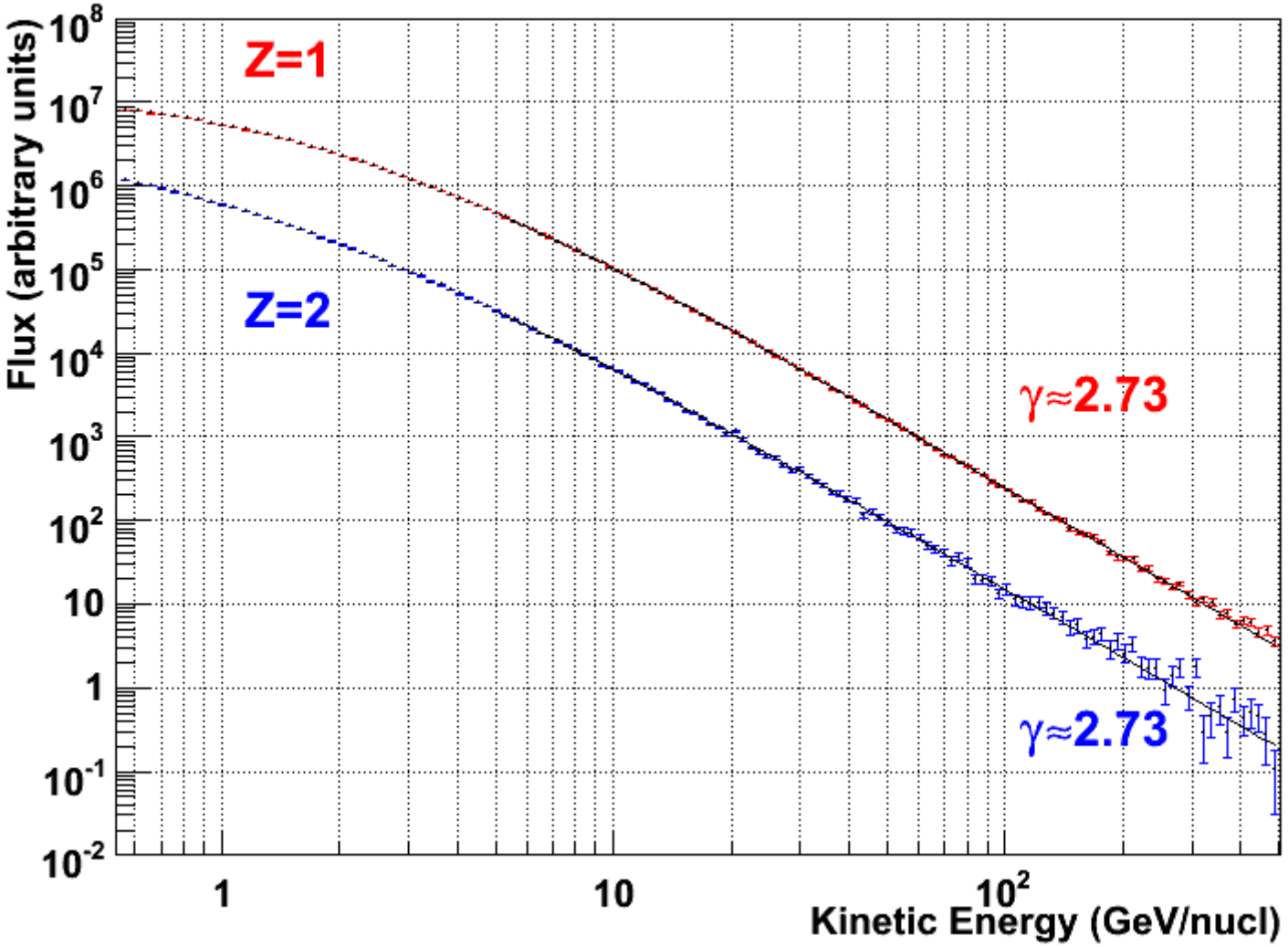
Preliminary !!!



Calorimeter dE/dx truncated mean (3 points over at least 4 measurements)

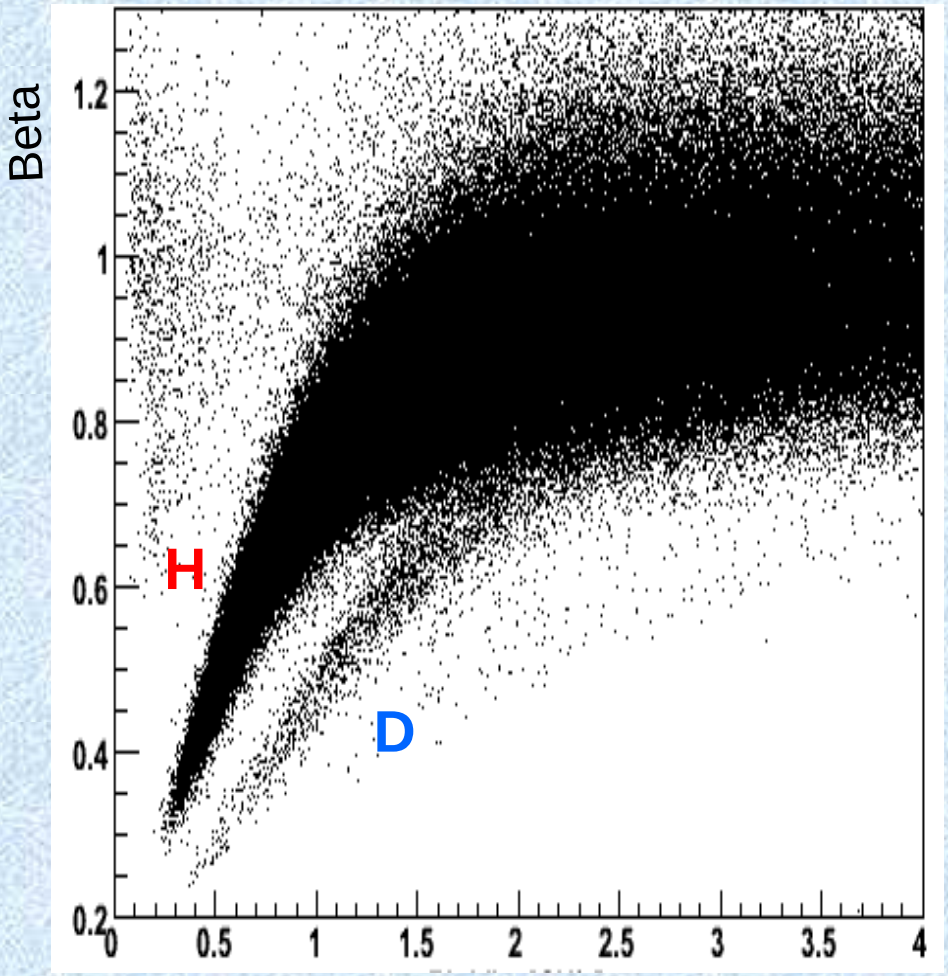
Galactic H and He spectra

Preliminary !!!

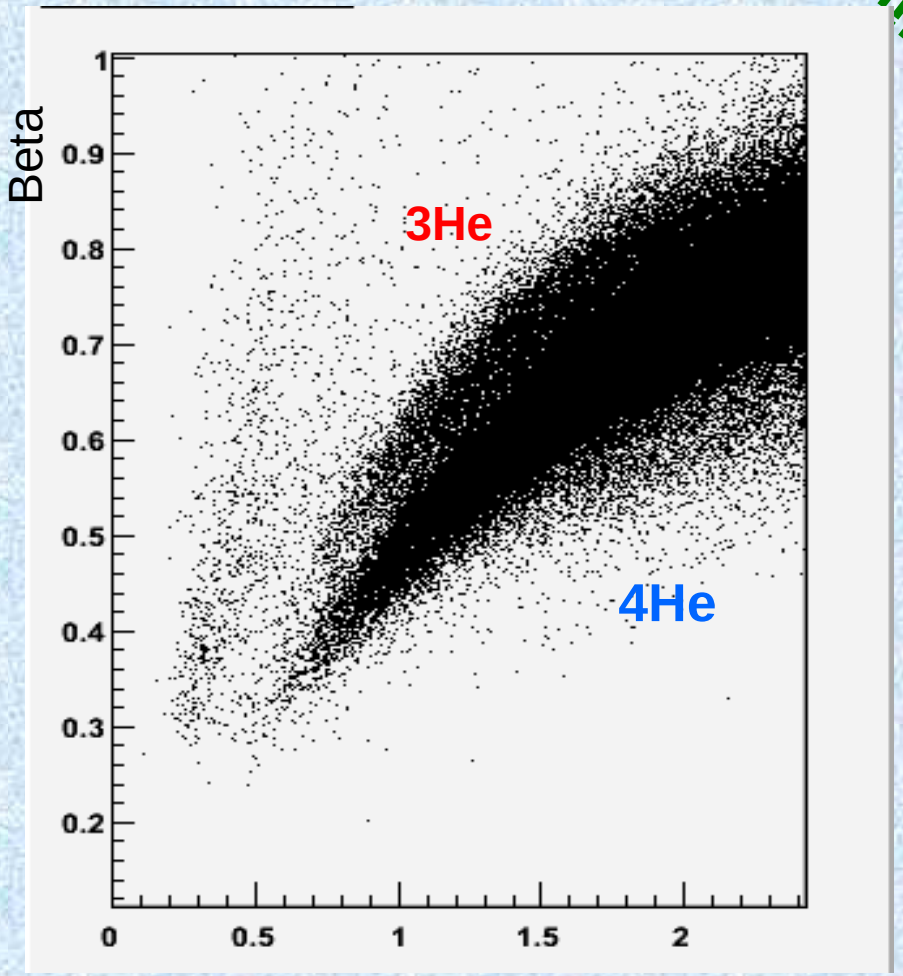


Isotopes: beta vs rigidity

Preliminary !!!



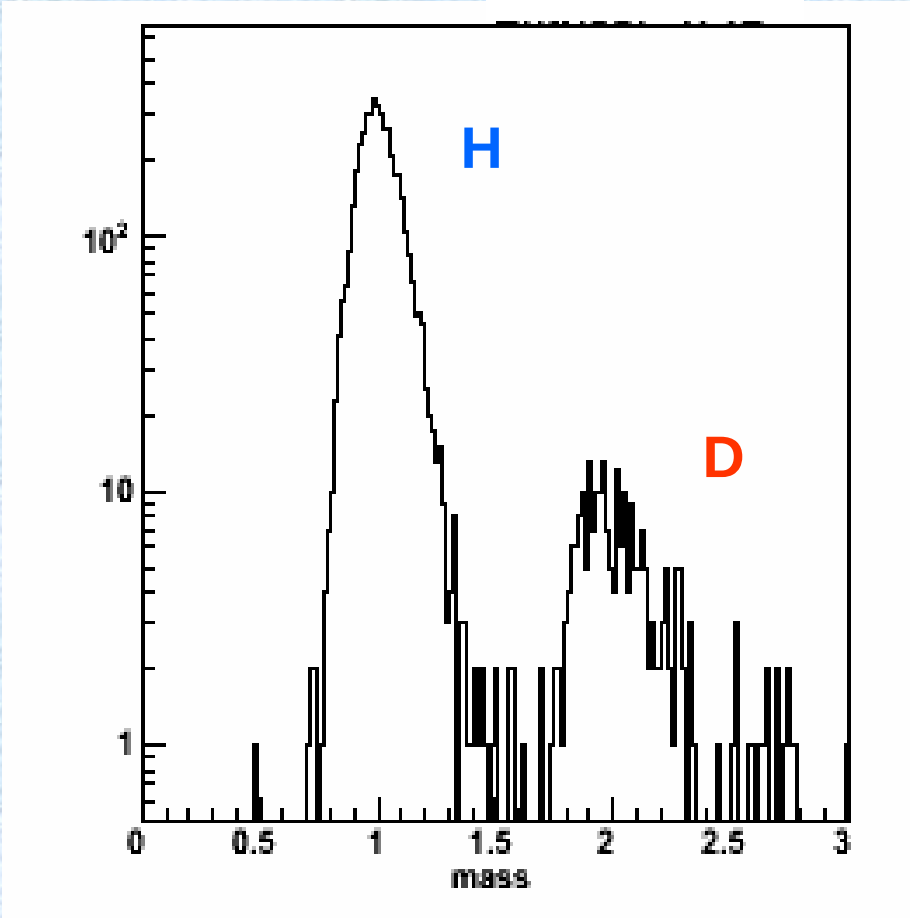
Z = 1

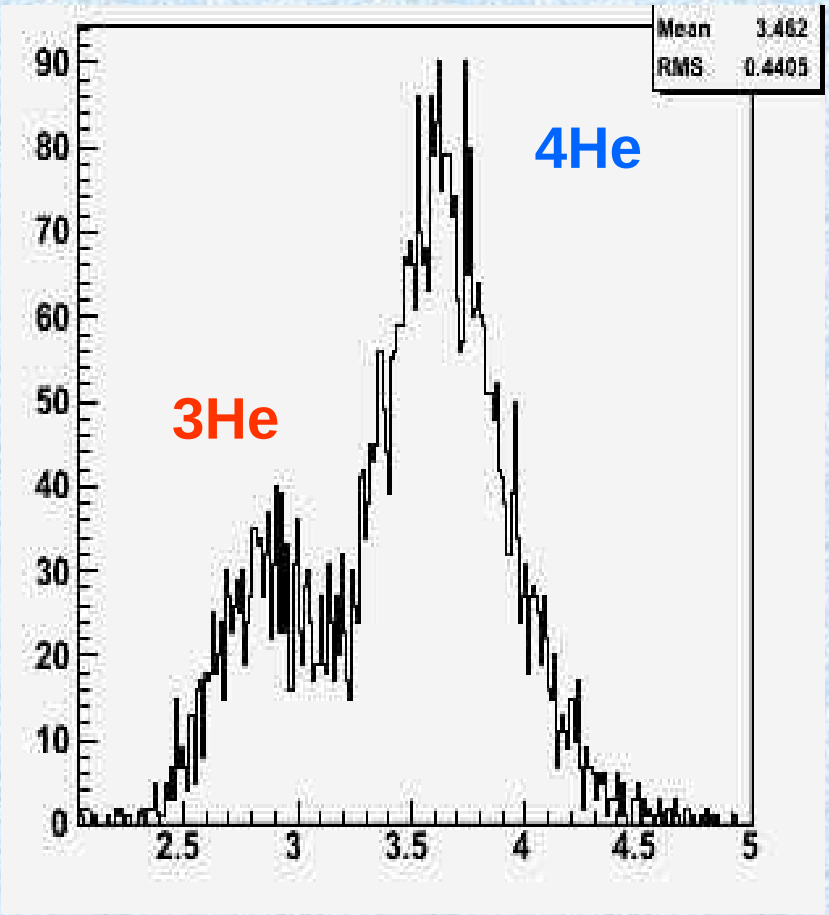


Z = 2

Mass resolution

Preliminary !!!





Z = 1

Z = 2

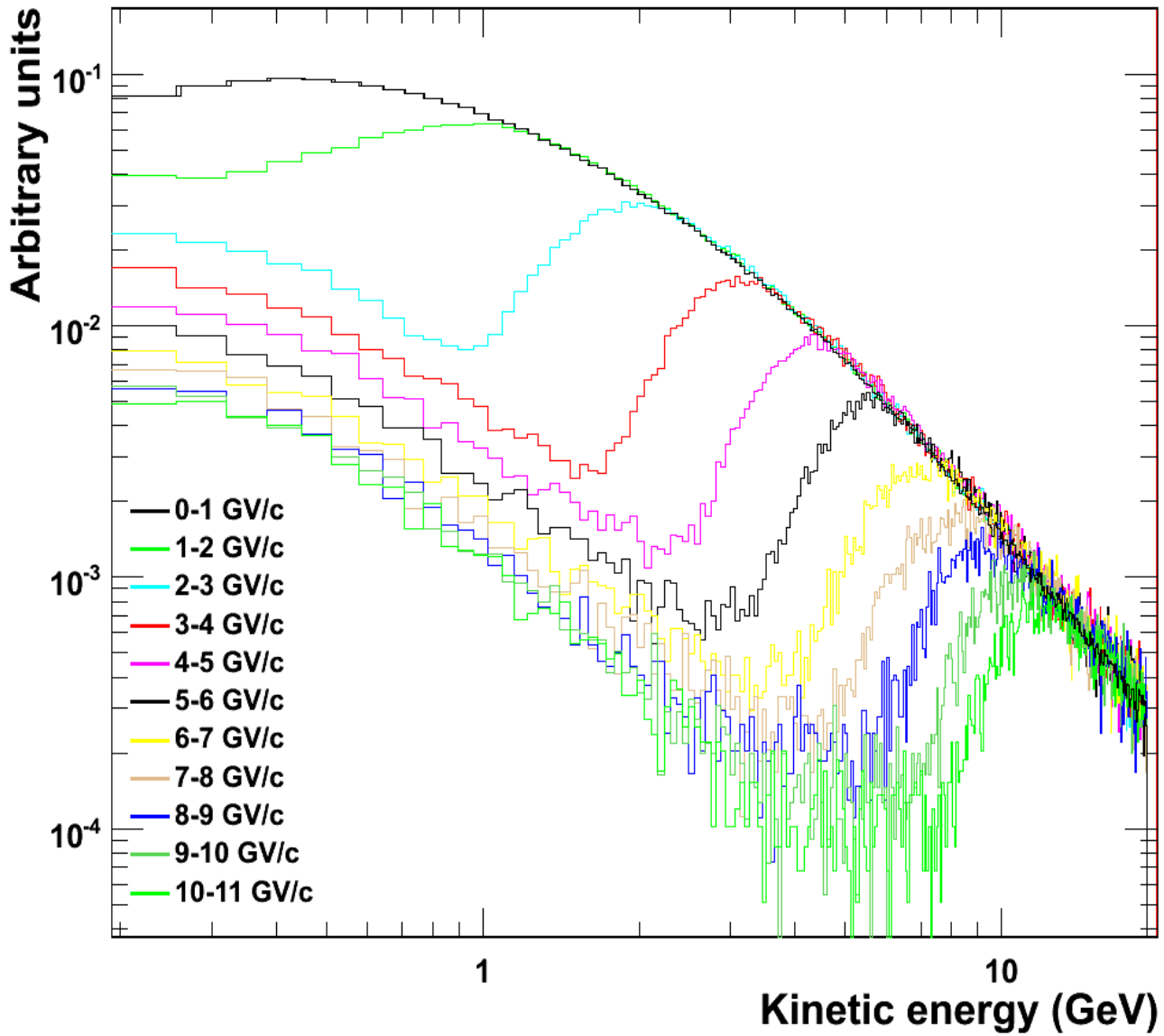
PAMELA Science

PAMELA is:

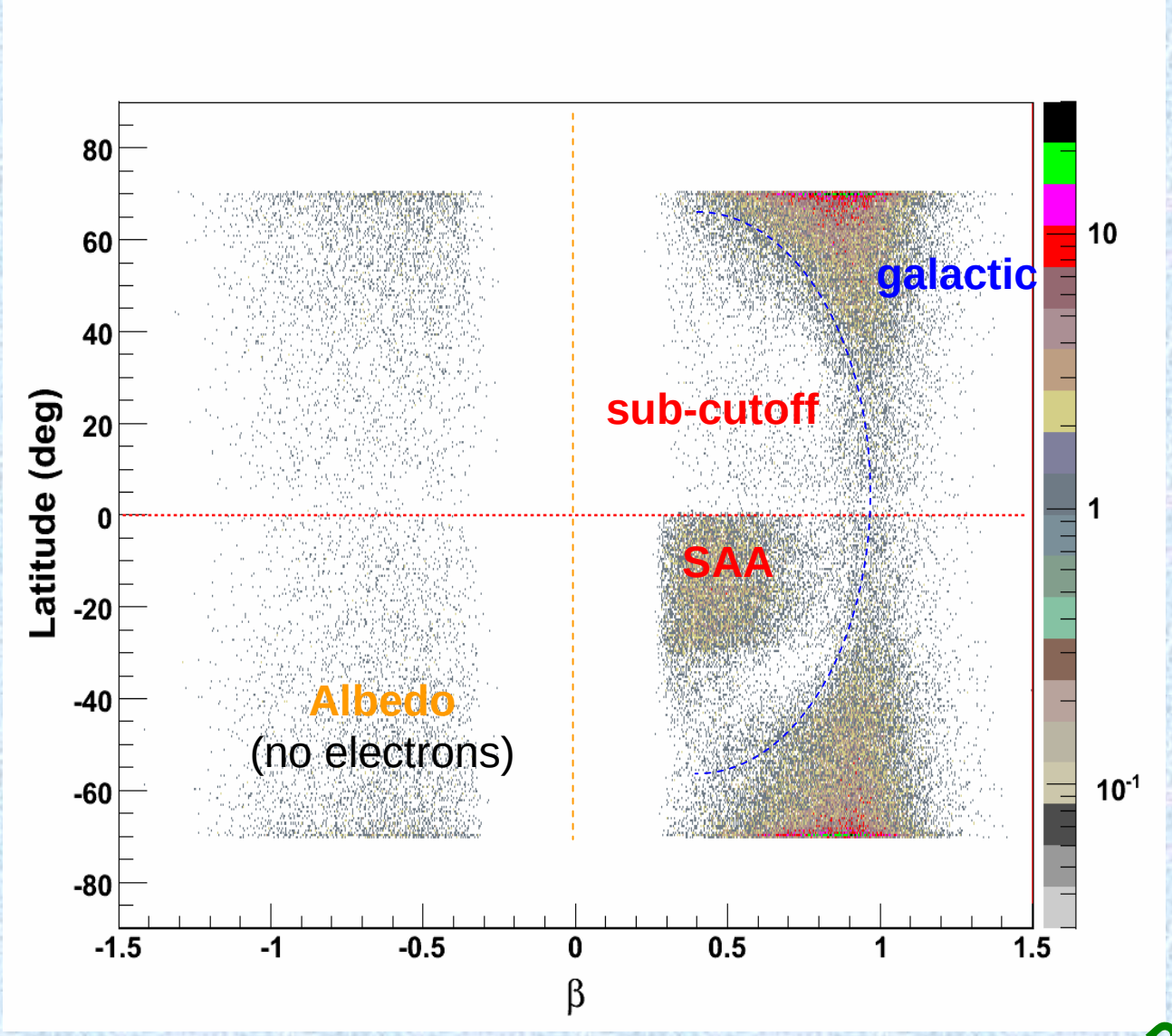
- Searching for antimatter
- Searching for dark matter
- Studing cosmic-ray propagation
- Studing magnetosphere physics

H spectra @ different cutoff rigidities

Preliminary !!!

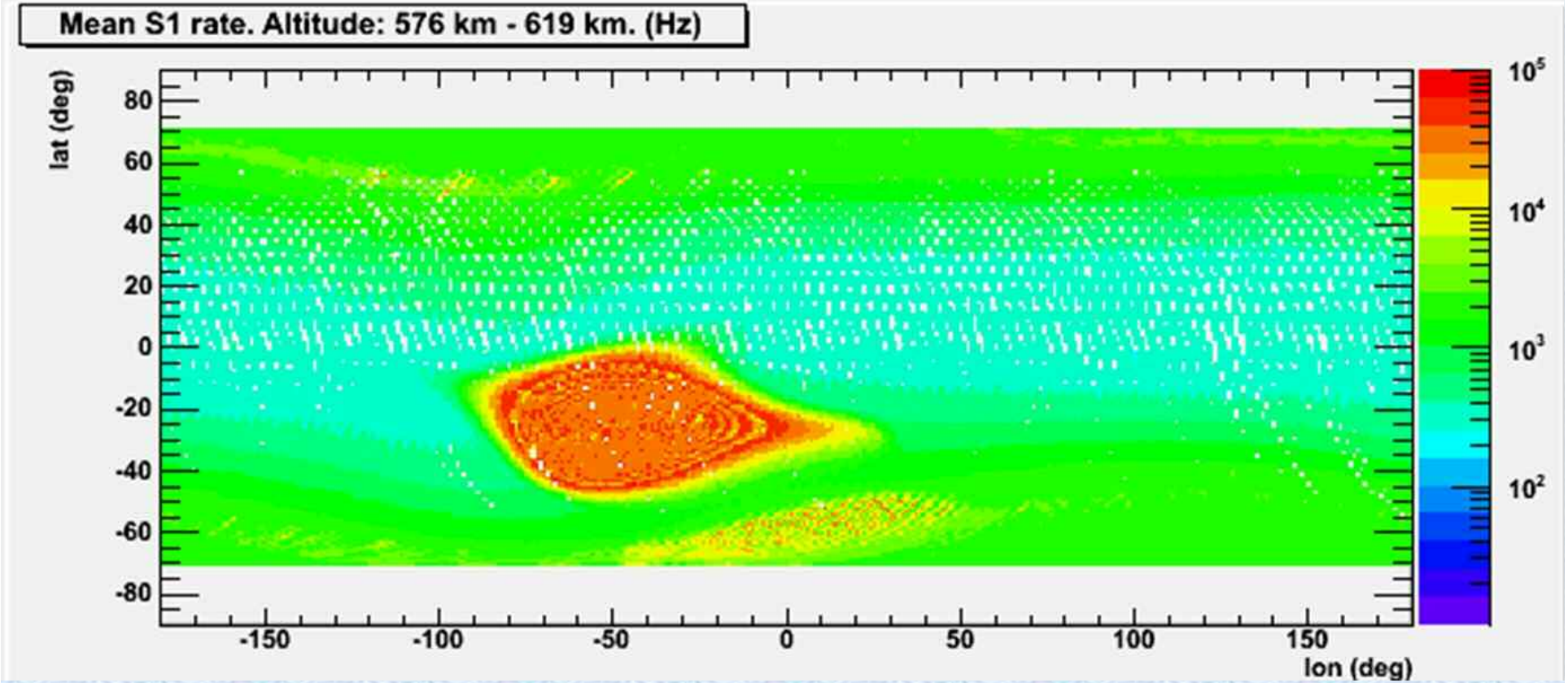


Latitude vs beta (Z=1)



Preliminary !!!

Pamela maps at various altitudes

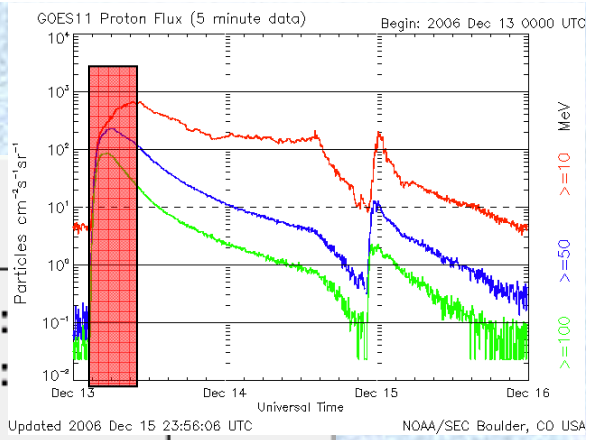


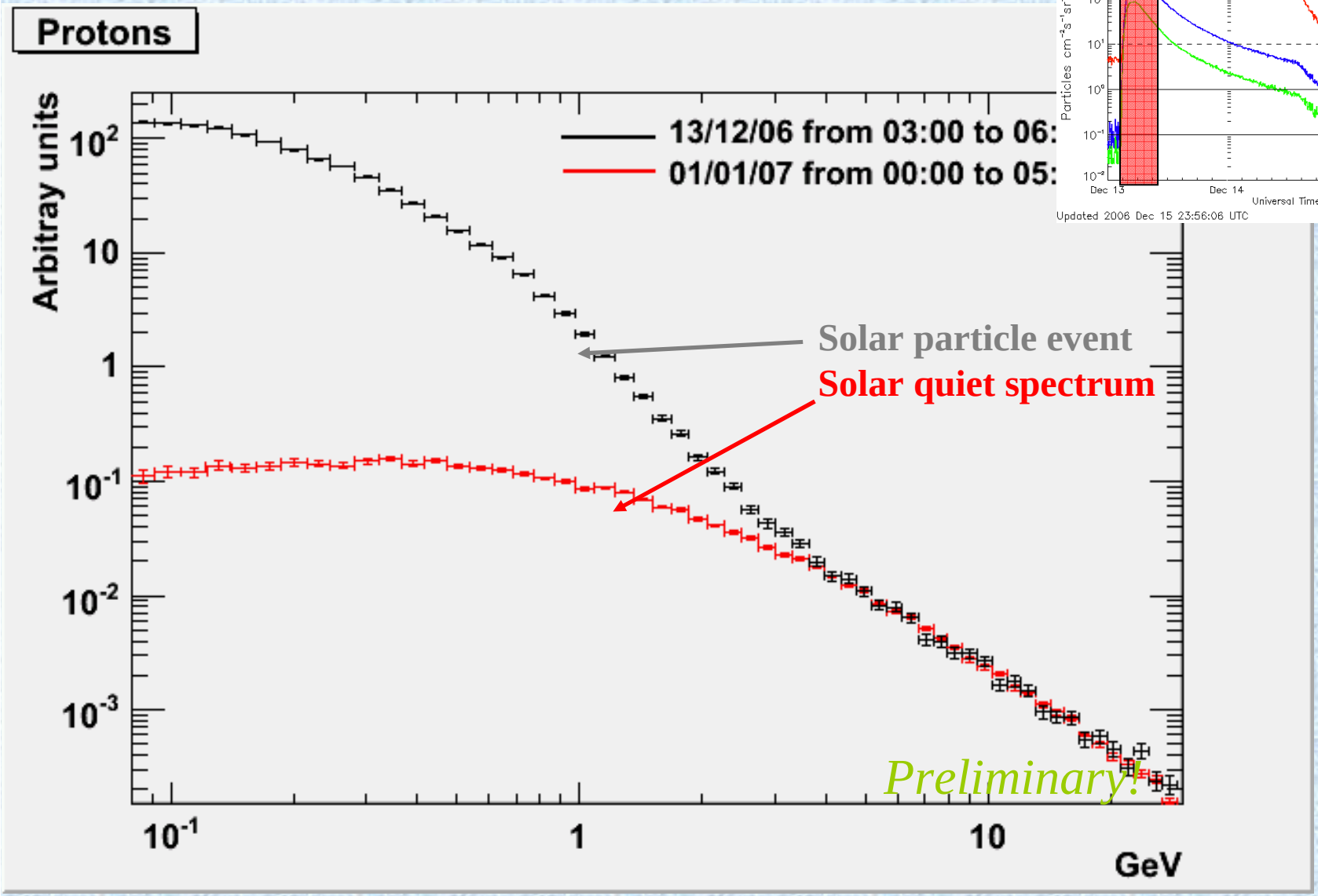
PAMELA Science

PAMELA is:

- Searching for antimatter
- Searching for dark matter
- Studing cosmic-ray propagation
- Studing magnetosphere physics
- Studing solar physics and solar modulation

13 December 2006 differential spectrum





Current statistics

- Antiproton events:
  - *hundreds of p-bar detected so far;*
- Positron events:
  - *thousands of positrons detected so far;*
- Light nuclei:
  - *more than 70000 events with Z>2 detected so far;*
- Solar and magnetospheric physics
  - *1 SEP event detected so far.*

Conclusions

- PAMELA is in continuous data taking mode since 11th July 2006
- PAMELA is measuring antiparticles with an unprecedented statistical precision, conducting an indirect search for dark matter
- PAMELA is measuring the elemental composition with an unprecedented precision, helping to improve the understanding of particle propagation in the interstellar medium
- PAMELA is able to measure the high energy tail of solar spectra and for the first time solar positrons

First scientific results by the end of 2007 !