International Russian-Italian Project "RIM-PAMELA"

A.M. Galper and P.Picozza

MEPhI, Moscow

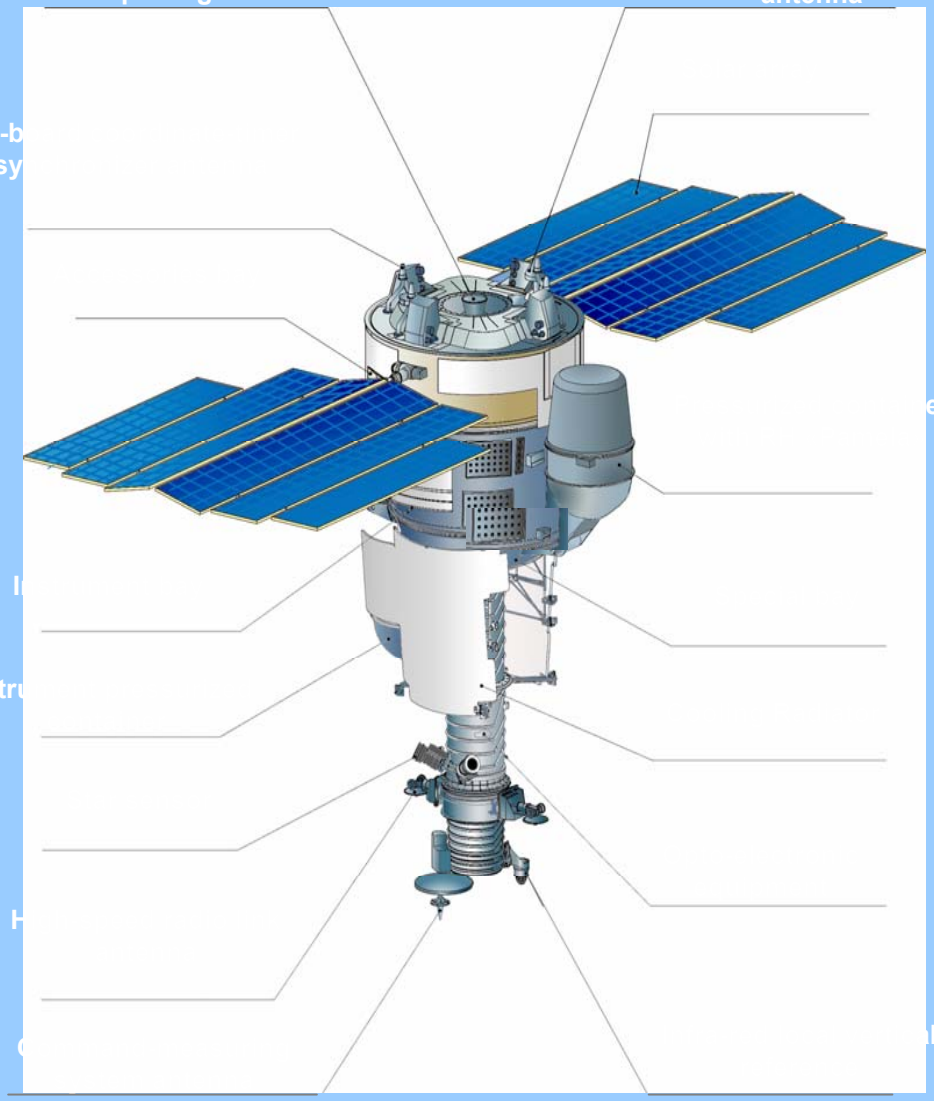
INFN, Tor Vergata, Rome

on behalf of the PAMELA collaboration

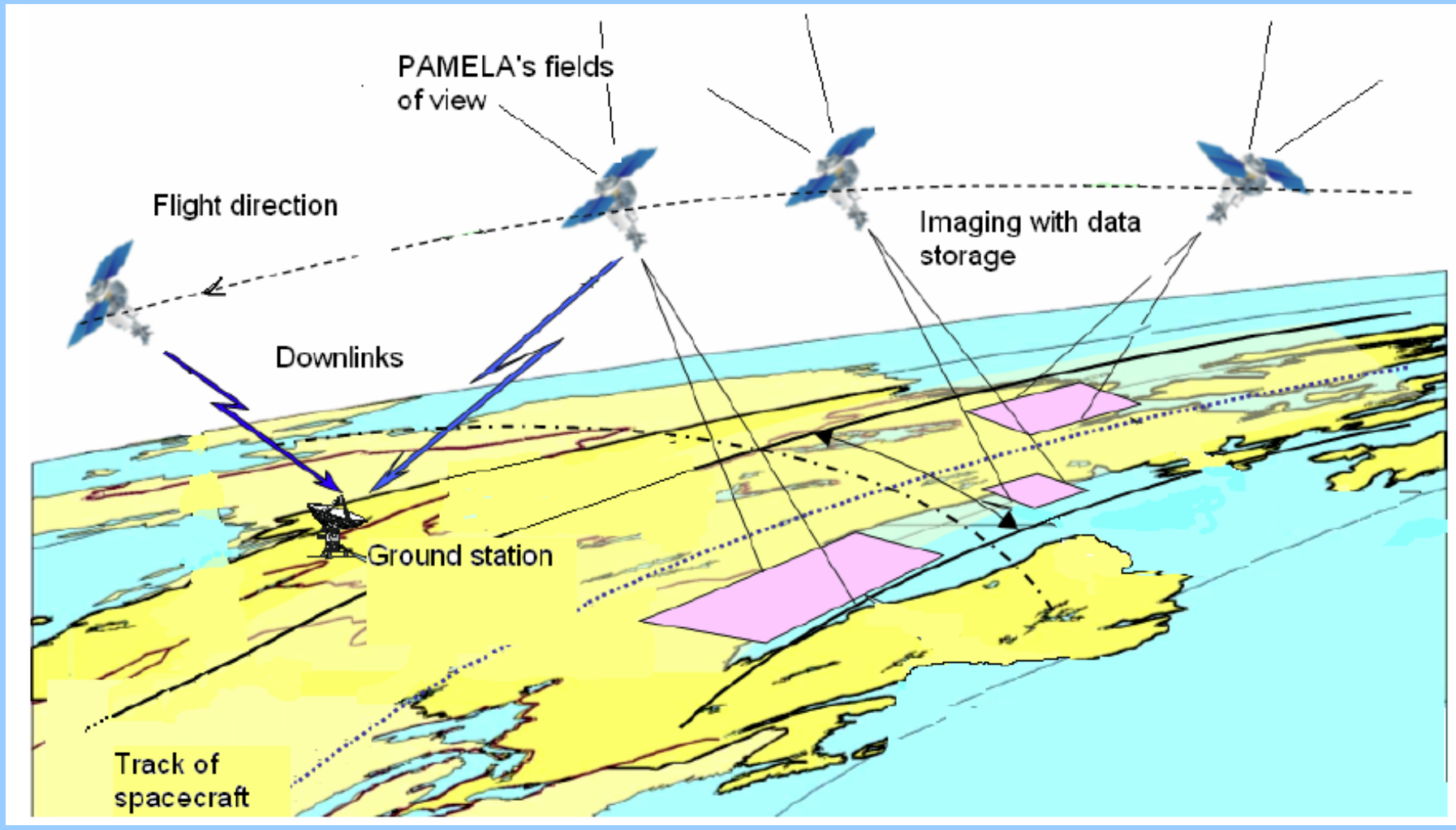
Moscow, MSU, 27-29 August 2007

PAMELA Launch 15/06/06

"Resurs-DK1" №1 spacecraft



Operational orbit parameters:	
- orbit inclination, deg	**70**
- minimal orbit altitude, km	**361**
- maximal orbit altitude, km	**604**
Active life	**3 years**
Mass of assembled and loaded SC, kg	**Maximum 6550**
Maximal length, mm	**7930**
Maximal diameter, mm	**2720**
Solar array area, m^2	**36**



Main task of SC Resurs DK1

PAMELA

Payload for **A**ntimatter **M**atter **E**xploration and **L**ight Nuclei **A**strophysics

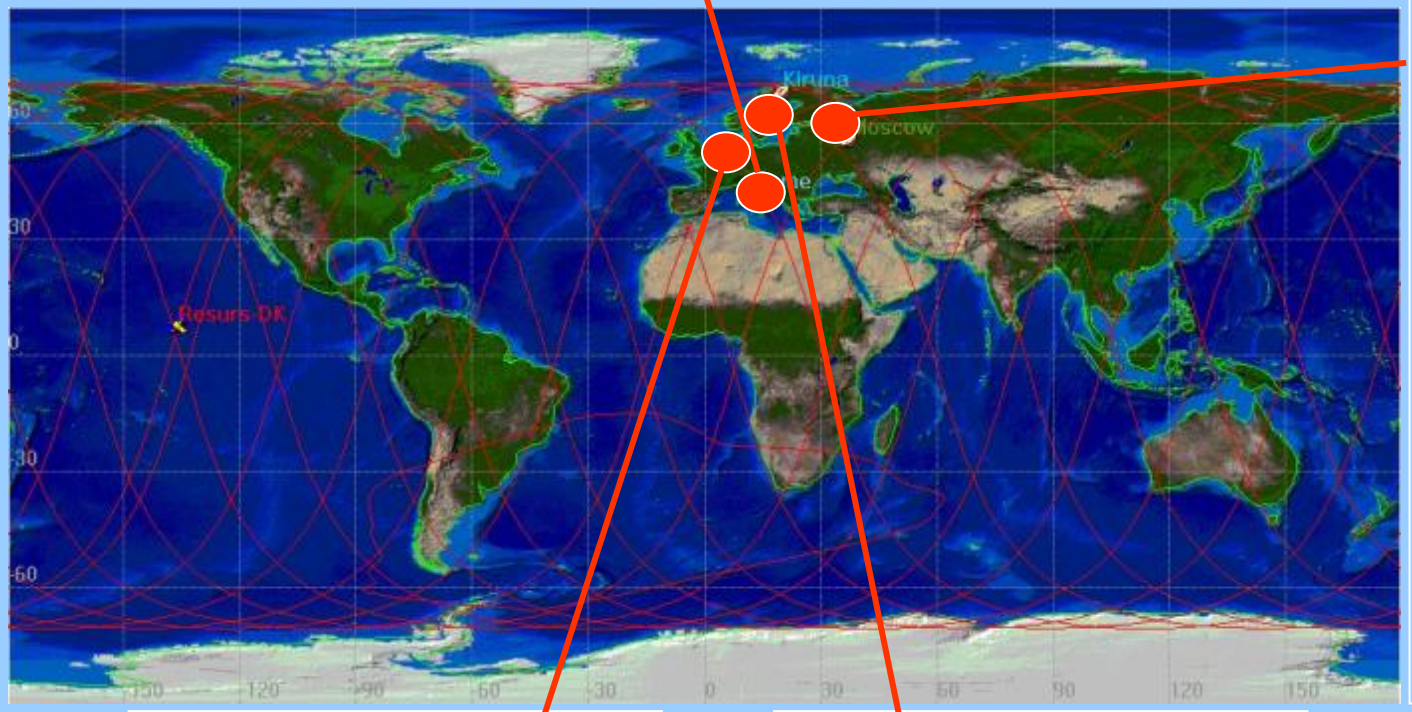
Launched in orbit on June 15, 2006, on board of the satellite **Resurs DK1** by **Soyuz** rocket from the Bajkonour launch site.

Since July 11, 2006, Pamela is in continuous data taking mode

PAMELA Collaboration

Italy:

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



Russia:

Moscow

Moscow

St. Petersburg

Germany:

Siegen

Sweden:

KTH, Stockholm

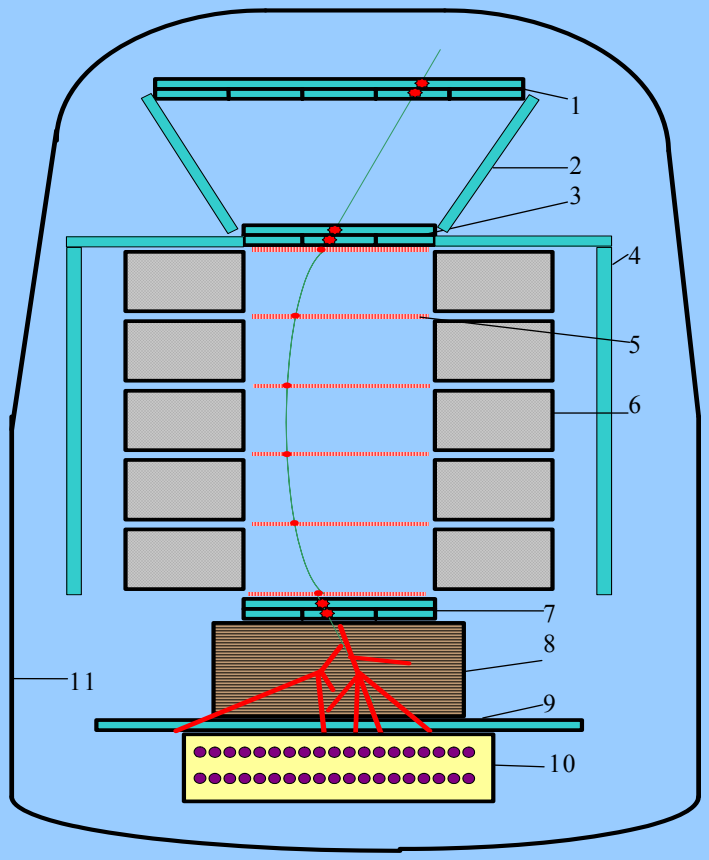
P. Picozza a, A.M. Galper b, G. Castellini d, O. Adriani c, F. Altamura a, M. Ambriola j, G.C. Barbarino g, A. Basili a, G.A. Bazilevskaja l, R. Bencardino a, M. Boezio e, E.A. Bogomolov k, L. Bonechi c, M. Bongi c, L. Bongiorno i, V. Bonvicini e, S.V. Borisov b, F. Cafagna j, D. Campanag, P. Carlson f, M. Casolino a, L.A. Grishantseva b, C. De Marzo j, M.P. De Pascale a, G. De Rosa g, D. Fedele c, P. Hofverberg f, S.V. Koldashov b, S.Yu. Krutkov k, A.N. Kvashnin l, A.A. Leonov b, J. Lund f, J. Lundquist e, O. Maksumov l, V. Malvezzi a, L. Marcelli a, W. Menn h, V.V. Mikhailov b, M. Minori a, S. Misin l, E. Mocchiutti e, A. Morselli a, N.N. Nikonov k, S. Orsi a, G. Osteria g, P. Papini c, M. Pearce f, M. Ricci i, S.B. Ricciarini c, M.F. Runtso b, S. Russo g, M. Simon h, R. Sparvoli a, P. Spillantini c, Yu.I. Stozhkov l, E. Taddei c, A. Vacchi e, E. Vannuccini c, G.I. Vasiliev k, S.A. Voronov b, Y.T. Yurkin b, G. Zampa e, N. Zampa e, V.G. Zverev b

A - *INFN, Structure of Rome "Tor Vergata" and Physics Department of University of Rome "Tor Vergata" Rome, Italy*
B - *Moscow Engineering and Physics Institute, Moscow, Russia*
C - *INFN, Structure of Florence and Physics Department of University of Florence, Florence, Italy*
D - *IFAC, Florence, Italy*
E - *INFN, Structure of Trieste and Physics Department of University of Trieste, Trieste, Italy*
F - *KTH, Department of Physics, Stockholm,Sweden*
G - *INFN, Structure of Naples and Physics Department of University of Naples, Naples, Italy*
H - *Universit¨at Siegen, Siegen, Germany*
I - *INFN, Laboratori Nazionali di Frascati, Frascati, Italy*
J - *INFN, Structure of Bari and Physics Department of University, Bari, Italy*
K - *Ioffe Physical Technical Institute, St. Petersburg, Russia*
L - Lebedev Physical Institute, Moscow, Russia

PAMELA science

- Search for antimatter
- Study of origin of dark matter
- Study of cosmic-ray generation and propagation
- Study solar physics and solar modulation
- Study terrestrial magnetosphere
- Study of electron spectrum (local sources?)

PHYSICAL SCHEME OF MAGNETIC SPECTROMETER PAMELA



1, 3, 7- TIME OF FLIGHT SYSTEM;
2, 4- ANTICOINCIDENCE SYSTEM;
5- SILICON STRIP TRACKER (SIX DOUBLE PLATES);
6- MAGNET (FIVE SECTIONS);
8- SILICON STRIP IMAGING CALORIMETER;
9- SHOWER TAIL CATCHER SCINTILLATOR;
10- NEUTRON DETECTOR;
11- HERMOCONTAINER.

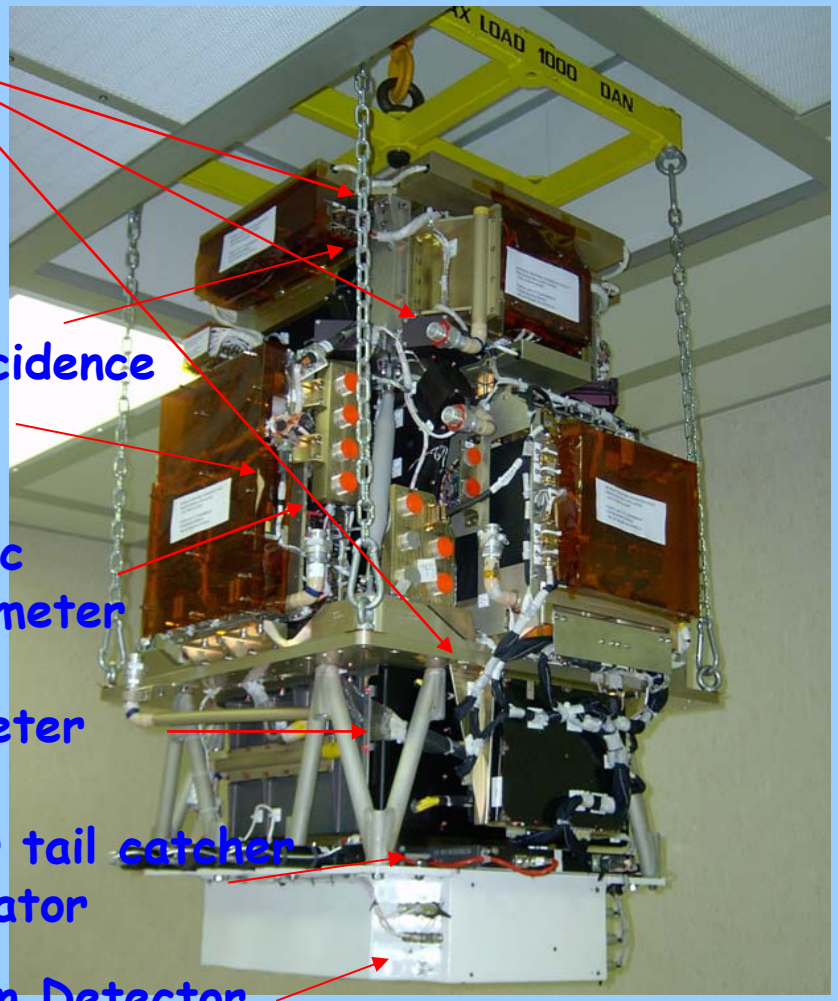
Measurements:

- time of flight (β);
- deflection in the magnetic field;
- energy losses in all detectors;
- number of neutrons.

Estimations:

- type of particle (lepton/hadron);
- sign and value of charge (±Z);
- mass of particle (A);
- rigidity and energy (R and E);
- direction of flight;

MAGNETIC SPECTROMETER PAMELA



Geometrical factor 21.5 cm^2sr;
Space resolution of bending view 3 μm;
Magnetic field 0.43 Tl;
MDR ~1 TV;
Time resolution (TOF) ~200 ps;
Thickness of calorimeter (W) 50 $g/cm^2=16X_0$;
Electrical consumption 355 W;
Size 90 x 90 x 125 cm;
Mass 470 kg;

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 anti-He/He	

→ Simultaneous measurement of many cosmic-ray species

→ New energy range

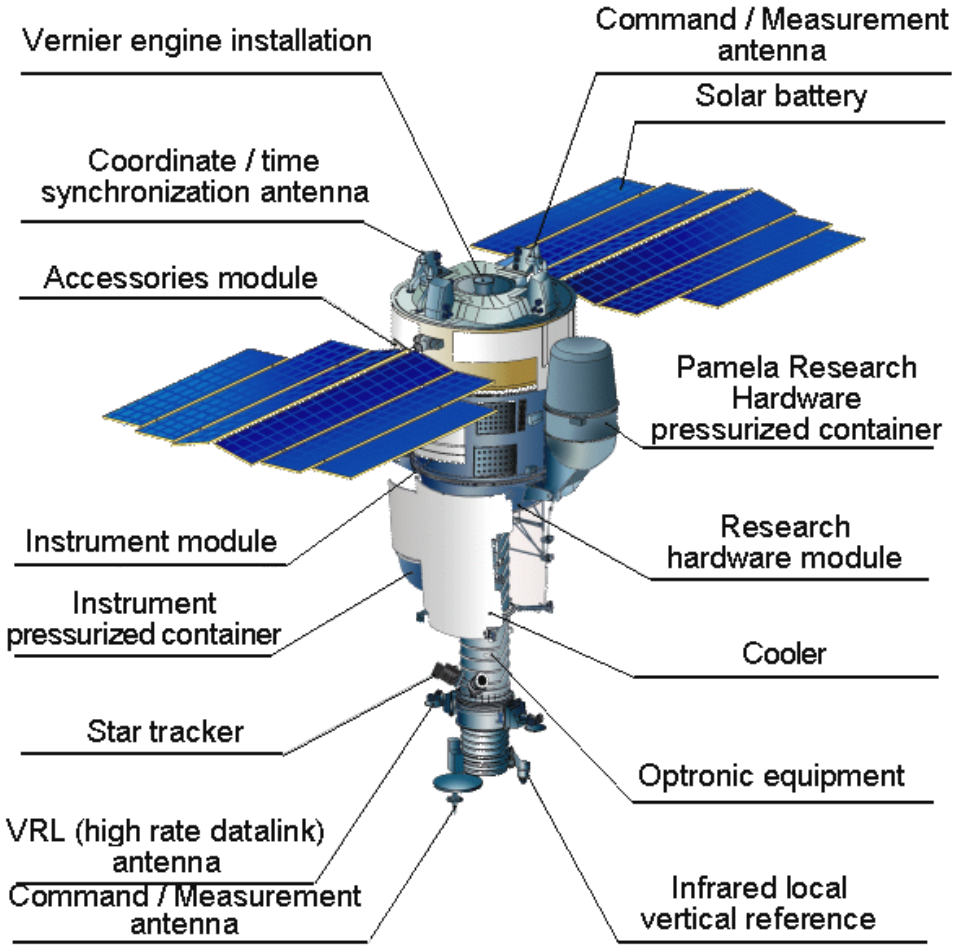
→ Unprecedented statistics

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

Resurs-DK1 Spacecraft TsSKB-Progress



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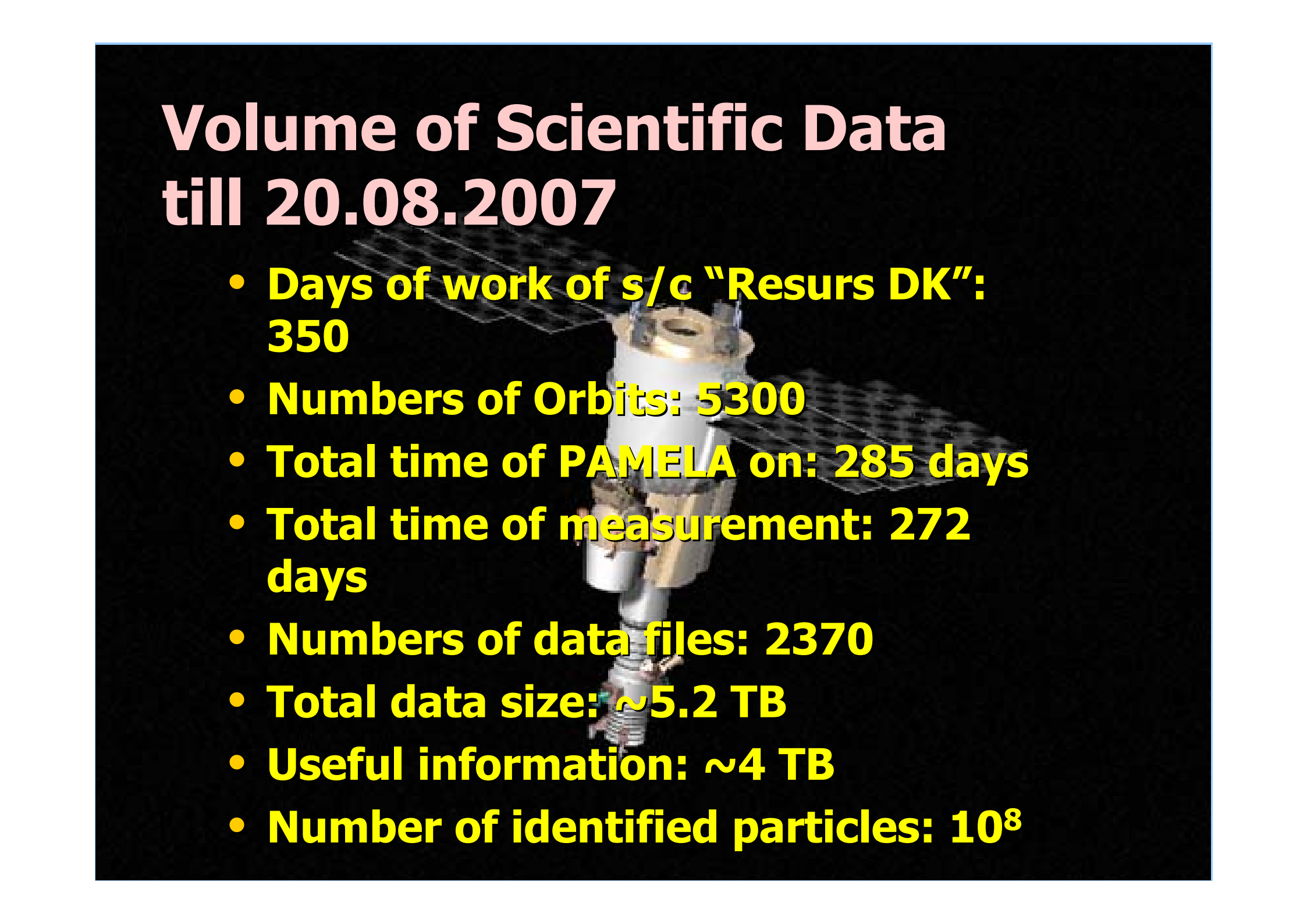
Volume of Scientific Data till 20.08.2007



- Days of work of s/c "Resurs DK": 350
- Numbers of Orbits: 5300
- Total time of PAMELA on: 285 days
- Total time of measurement: 272 days
- Numbers of data files: 2370
- Total data size: ~5.2 TB
- Useful information: ~4 TB
- Number of identified particles: 10^8

Data acquisition

- Trigger configurations

  High-radiation environment

  → (S21 AND S22) AND (S31 AND S32) OR CALORIMETER

  Low-radiation environment

  → (S11 OR S12) AND (S21 OR S22) AND (S31 OR S32) OR CALORIMETER

- Trigger rate* **~25Hz**
- Fraction of live time* ~ 75%
- Event size (compressed mode) ~ 5kB

  → 25 Hz x 5 kB/ev ~ 10 GB/day

(*outside radiation belts)

Data transmission

- Collected data stored in PAMELA mass-memory (2GB)
- Download (PAMELA → satellite)
  7-8 per day → 14-16 GB
- Downlink (satellite→ ground)
  2-3 sessions per day
- Error rate $<10^{-9}$

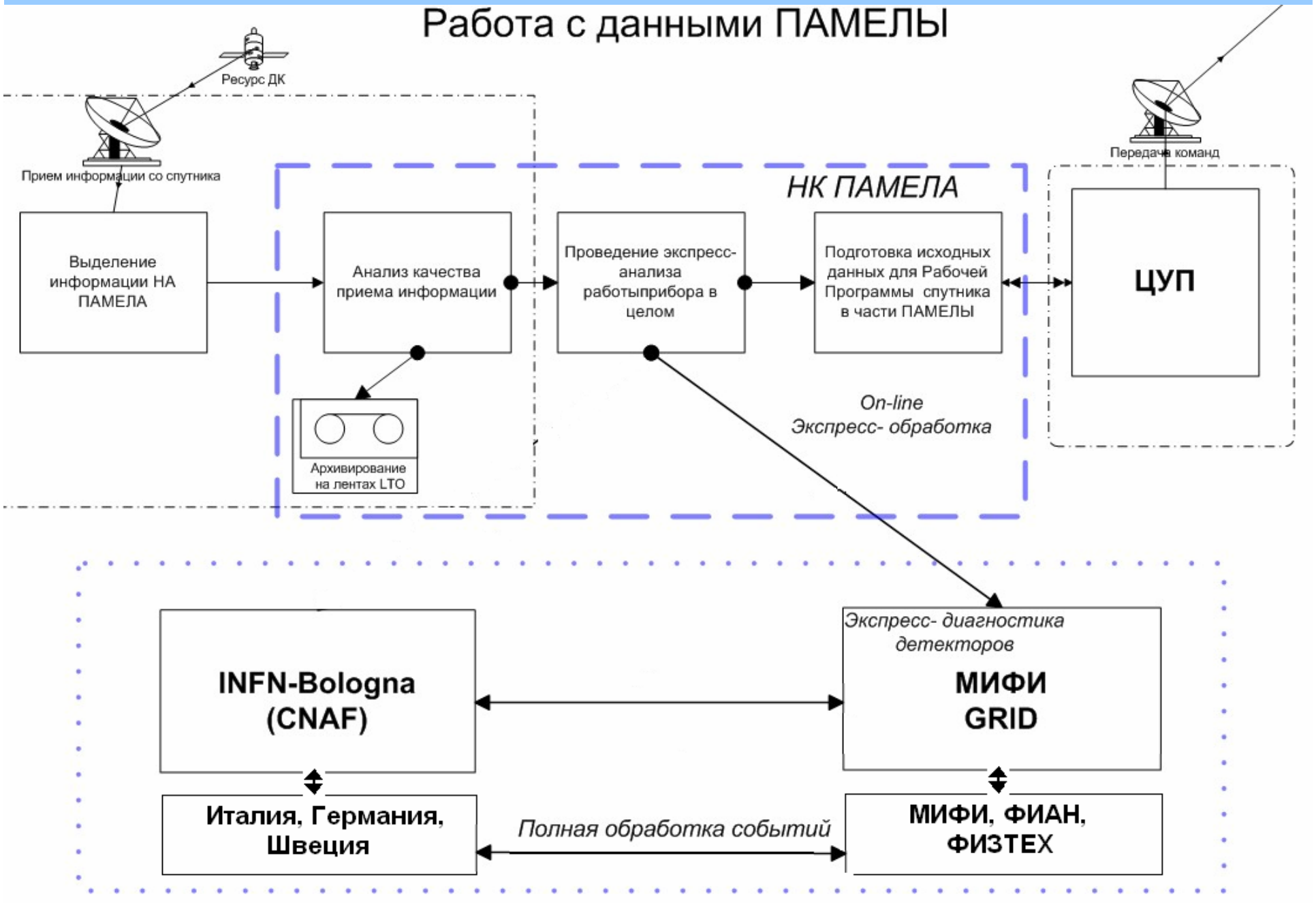
Main downlink station:

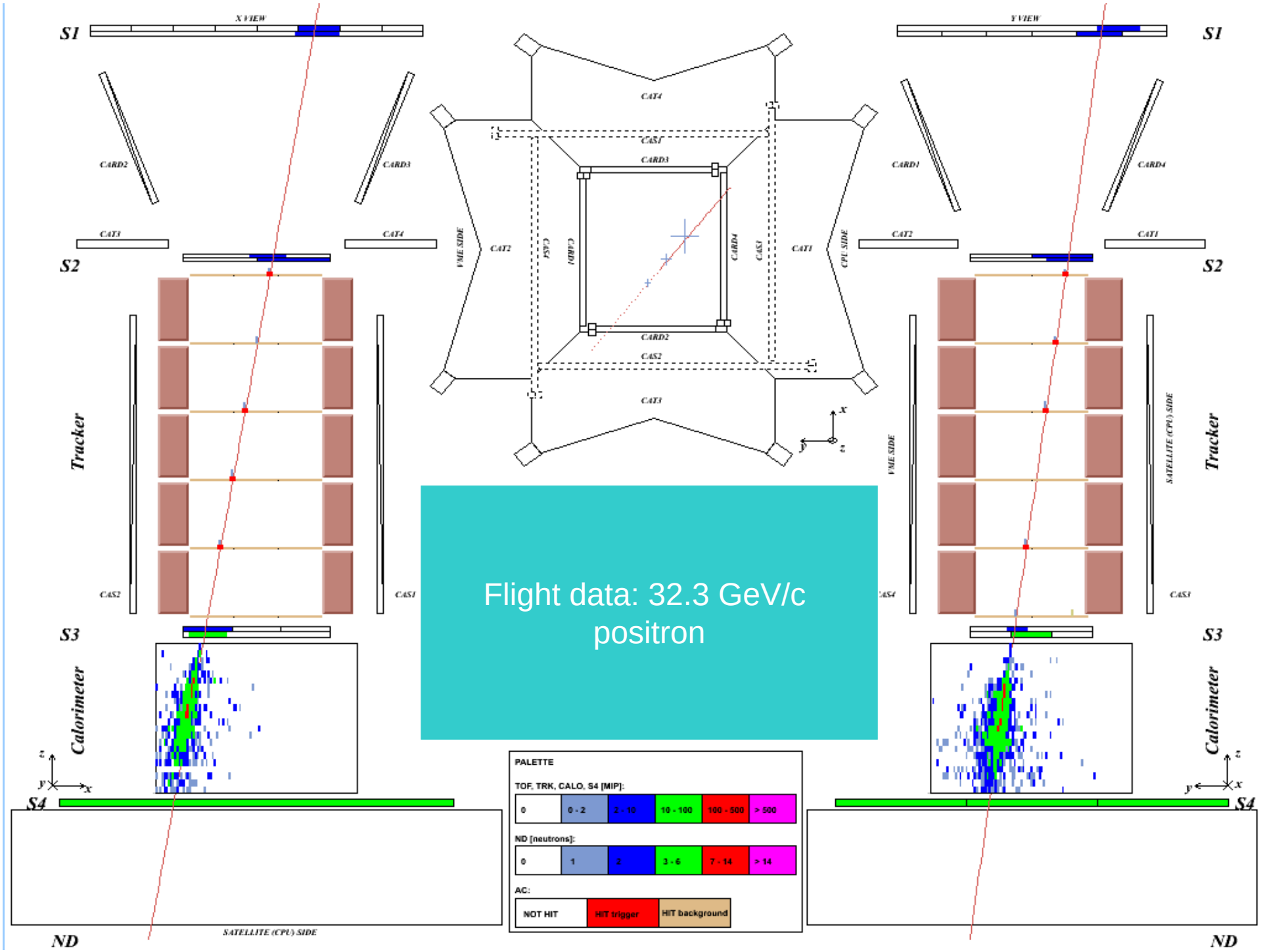
Research Centre for Earth operative monitoring“NtsOMZ” (Moscow, Russia)

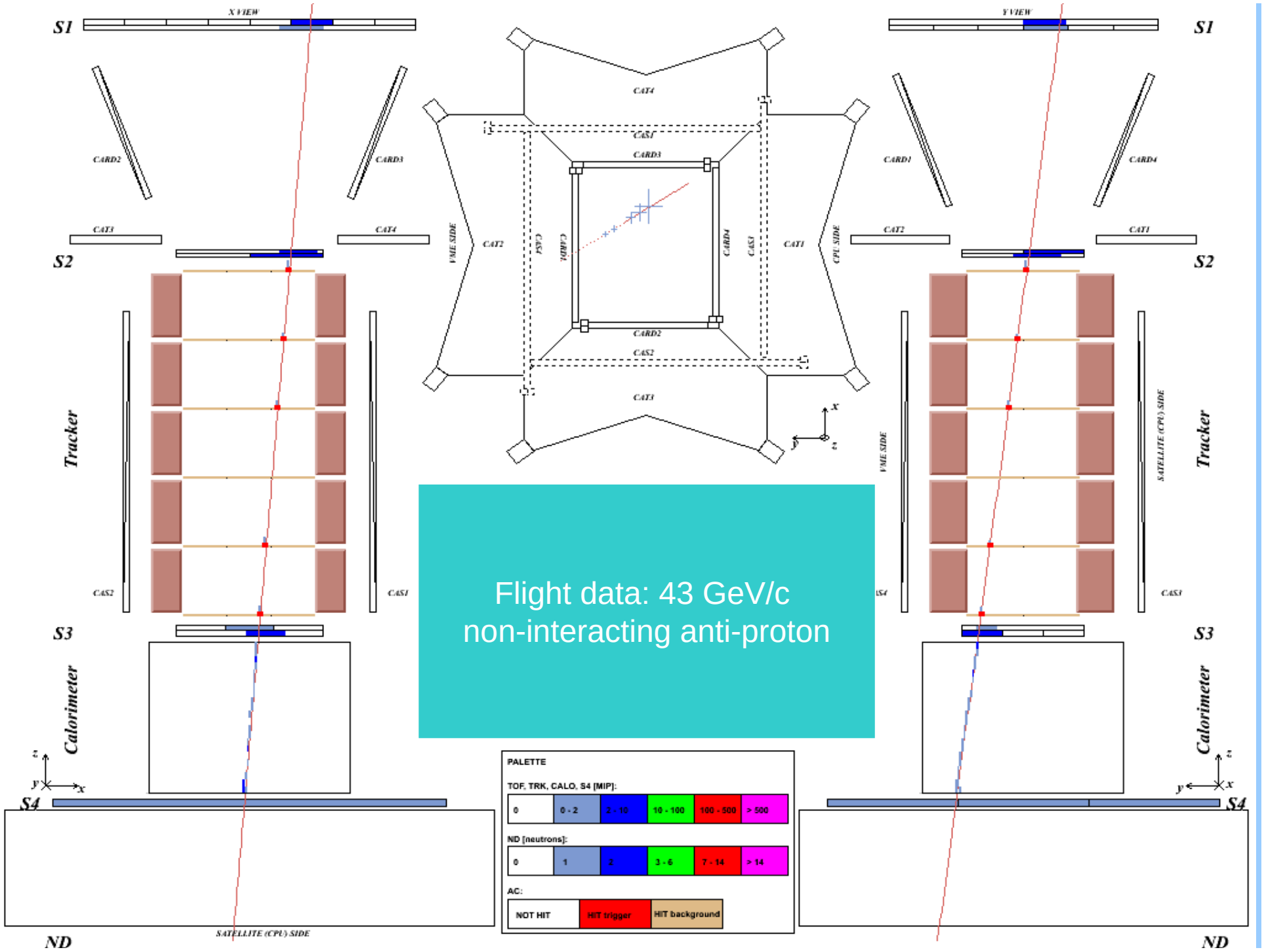
Spare downlink station:

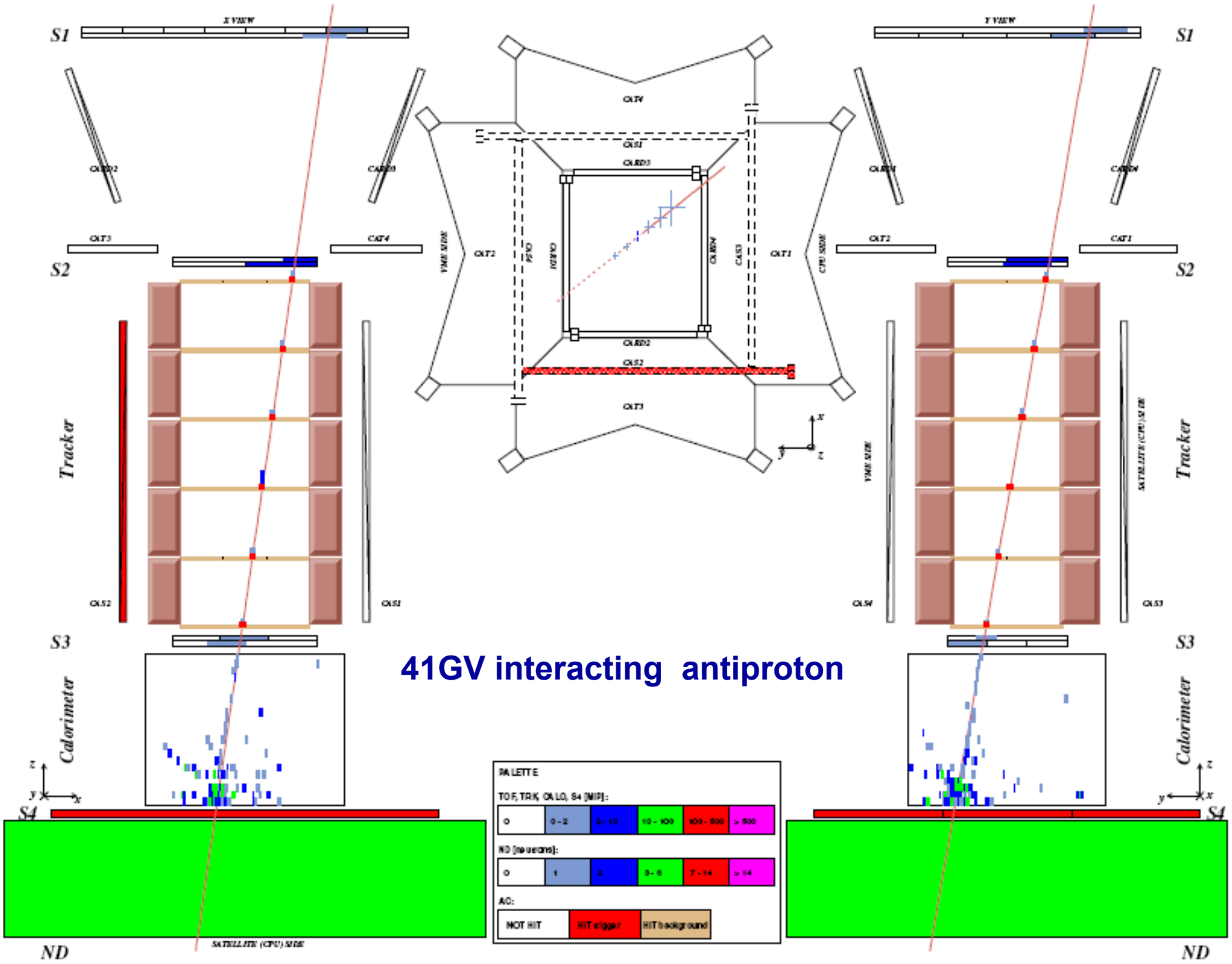
Khanty-Mansiysk West Siberia

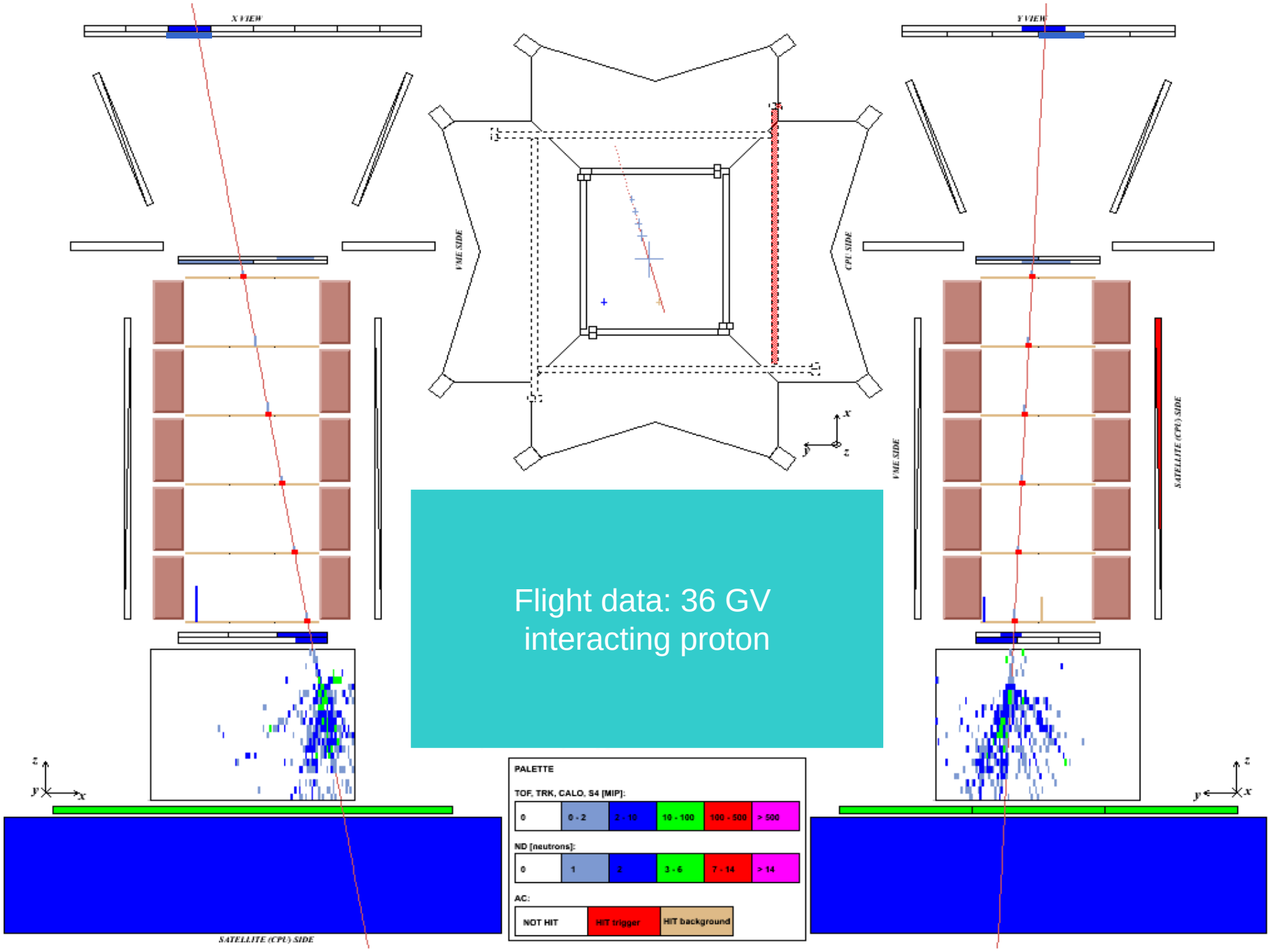
Работа с данными ПАМЕЛЫ

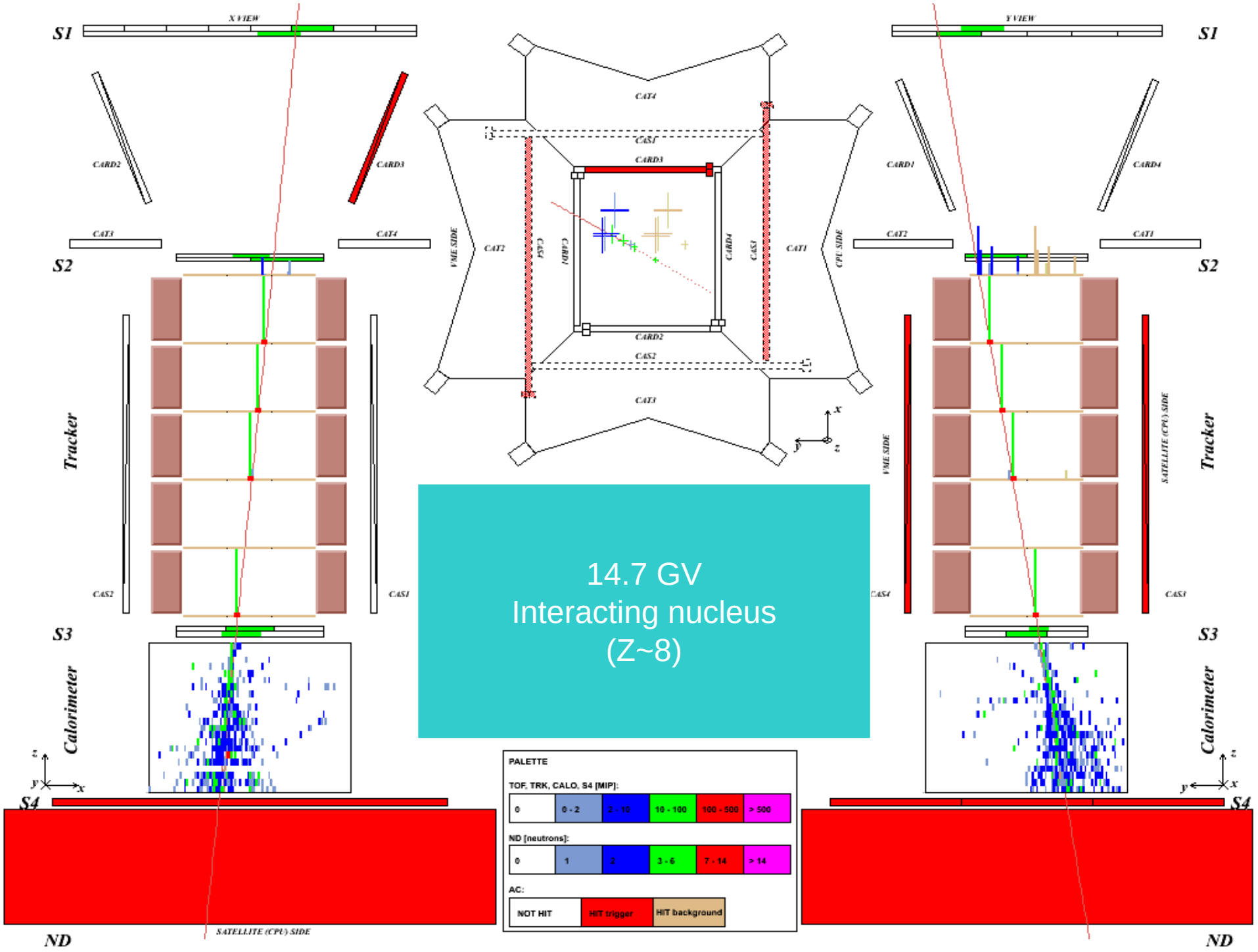


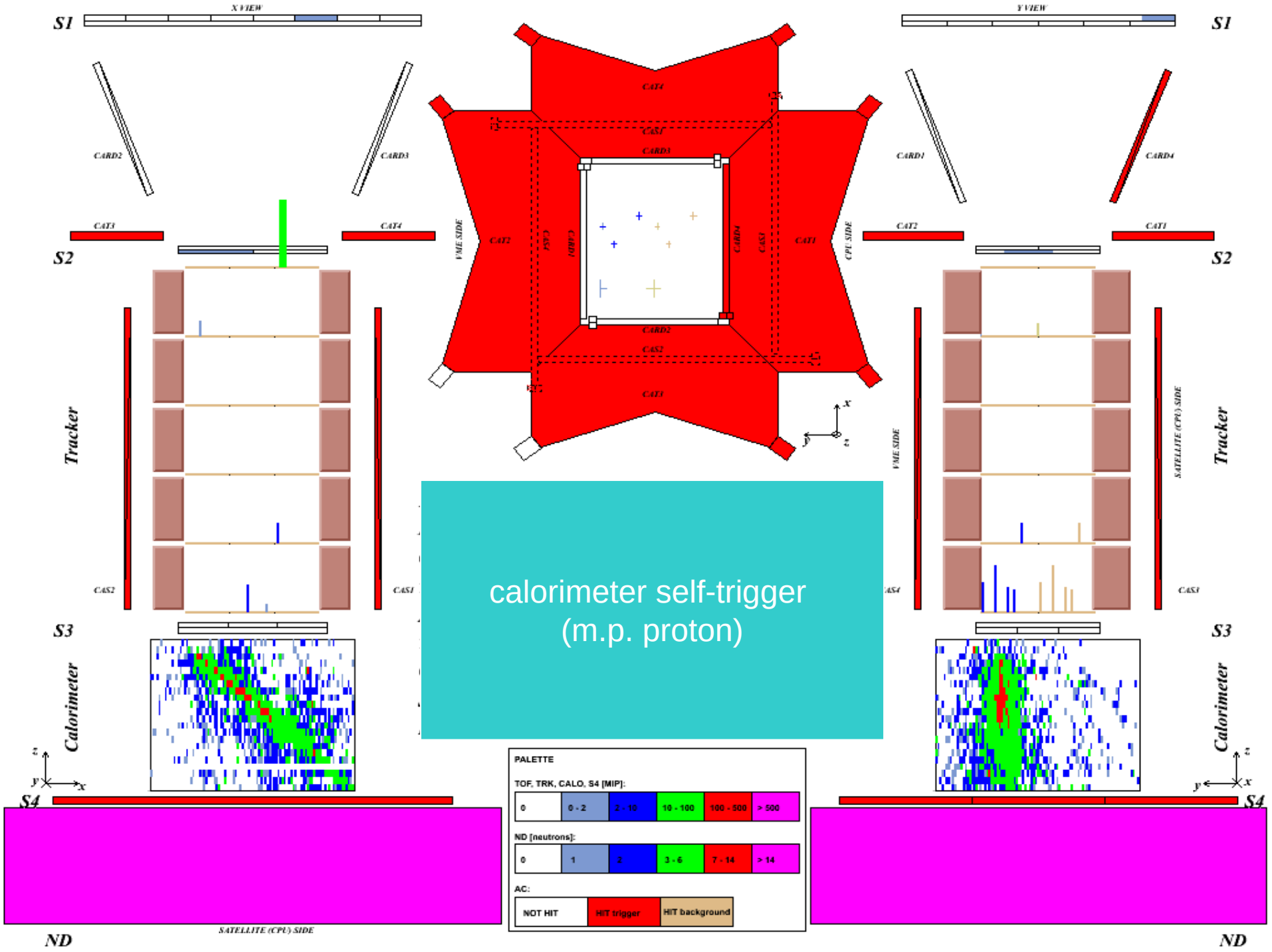

X VIEW
Y VIEW
S1
S2
S3
S4
Tracker
Calorimeter
ND
CARD1
CARD2
CARD3
CARD4
CAT1
CAT2
CAT3
CAT4
CAS1
CAS2
VME SIDE
CPU SIDE
SATELLITE (CPU) SIDE
Flight data: 32.3 GeV/c positron
PALETTE
TOF, TRK, CALO, S4 [MIP]:
0
0 - 2
2 - 10
10 - 100
100 - 500
> 500
ND [neutrons]:
0
1
2
3 - 6
7 - 14
> 14
AC:
NOT HIT
HIT trigger
HIT background


X VIEW
Y VIEW
S1
S2
S3
S4
ND
Tracker
Calorimeter
CARD1
CARD2
CARD3
CARD4
CAT1
CAT2
CAT3
CAT4
CAS1
CAS2
VME SIDE
CPU SIDE
SATELLITE (CPU) SIDE
Flight data: 43 GeV/c
non-interacting anti-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


S1
S2
S3
S4
Tracker
Calorimeter
ND
41GV interacting antiproton


X VIEW
Y VIEW
VME SIDE
CPU SIDE
SATELLITE (CPU) SIDE
Flight data: 36 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


S1
X VIEW
CARD2
CARD3
CAT3
CAT4
S2
Tracker
CAS2
CAS1
S3
Calorimeter
S4
ND
SATELLITE (CPU) SIDE
CAT4
CAS1
CARD3
VME SIDE
CAT2
CAS3
CARD1
CARD4
CAS4
CARD2
CAS2
CAT1
CPU SIDE
CAT3
Y VIEW
CARD1
CARD4
CAT2
CAT1
VME SIDE
SATELLITE (CPU) SIDE
14.7 GV
Interacting nucleus
(Z~8)
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


S1
X VIEW
Y VIEW
S1
CARD2
CARD3
CARD1
CARD4
CAT3
CAT4
CAT2
CAT1
S2
S2
VME SIDE
CPU SIDE
CAT4
CAS1
CARD3
CAT2
CAS4
CARD4
CAS3
CAT1
CARD2
CAS2
CAT1
Tracker
Tracker
CAS2
CAS1
CAS4
CAS3
SATELLITE (CPU) SIDE
S3
S3
Calorimeter
Calorimeter
S4
S4
ND
ND
SATELLITE (CPU) SIDE
calorimeter self-trigger
(m.p. 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

Search for antimatter

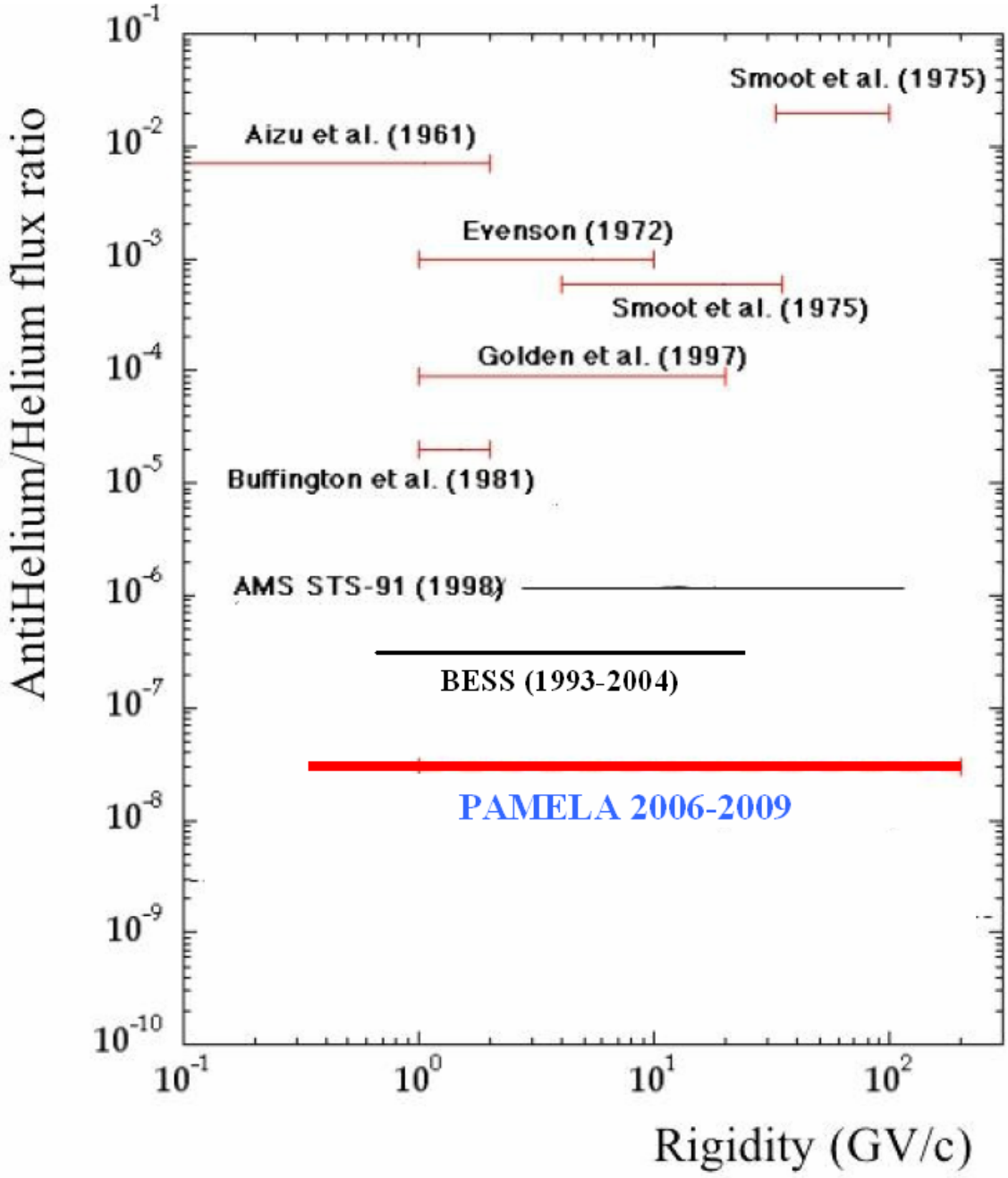
Indirect

By measuring the spectrum of the Cosmic Diffuse Gamma (CDG)

Direct

- **By measuring $\bar{p}$ and e^+ energy spectra**
- **By searching for Antinuclei**

Search for antimatter



Study of origin of dark matter

Microwave Anisotropy
WMAP - NASA - Explorer Mission

$$\Omega_{total} = \frac{\rho_{total}}{\rho_{crit.}} = 1$$

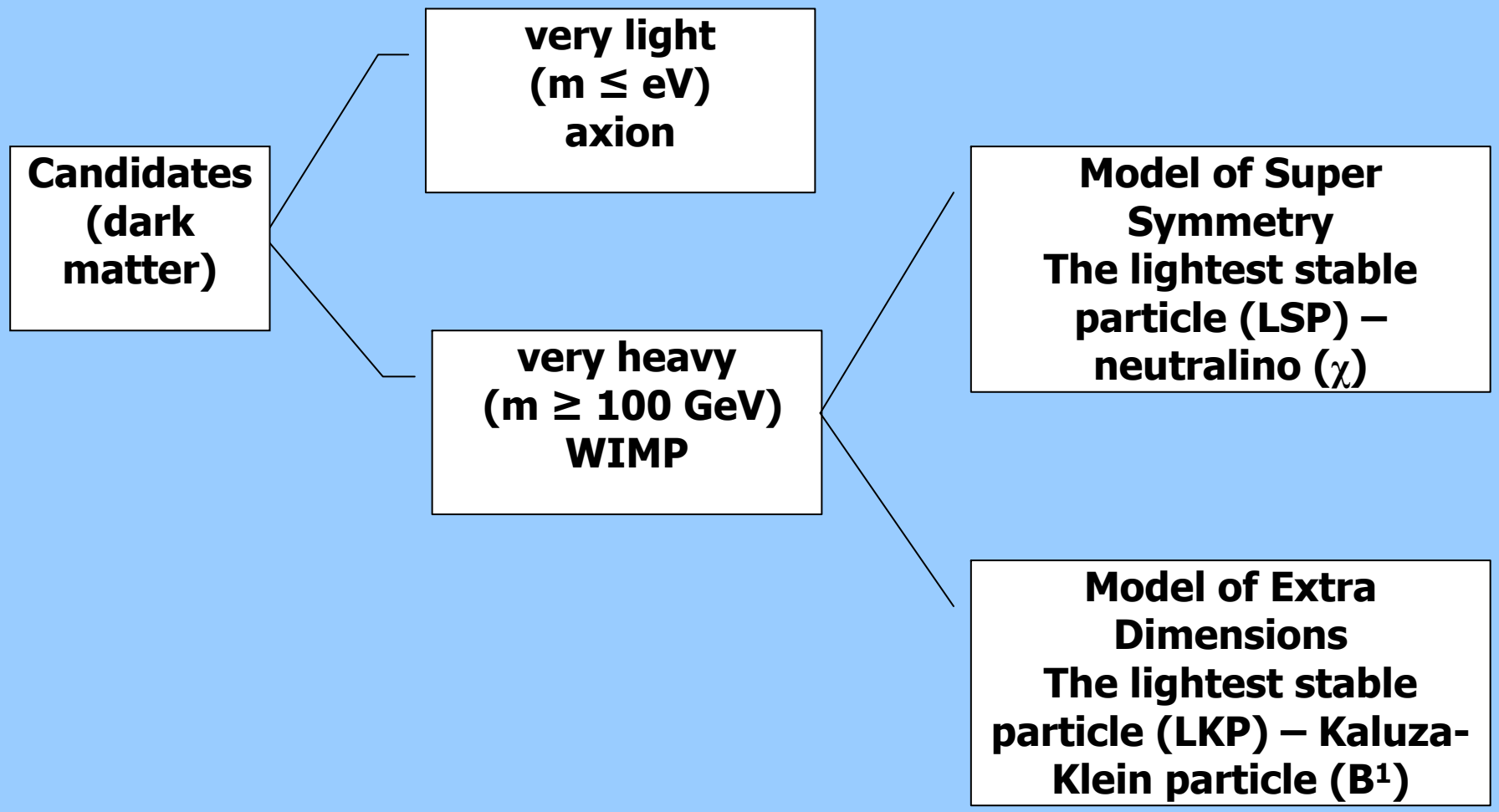
(Universe is flat)

$$\rho_{crit.} = \frac{3H^2(t)}{8\pi G}$$

$$\Omega_{total} = \underbrace{\Omega_{total,baryon.}}_{\text{baryonic matter } 5\%} + \underbrace{\Omega_{dyn.}}_{\text{dark matter } 25\%} + \underbrace{\Omega_{required}}_{\text{dark energy } 70\%}$$

baryonic matter 5%	dark matter 25%	dark energy 70%
	??	???
stars, galaxies	candidates	quintessence

Study of origin of dark matter



Study of origin of dark matter

Status of Direct Searches

Detect WIMP *interactions* with matter is via their elastic scattering off a detector nucleus.

Status of Indirect Searches

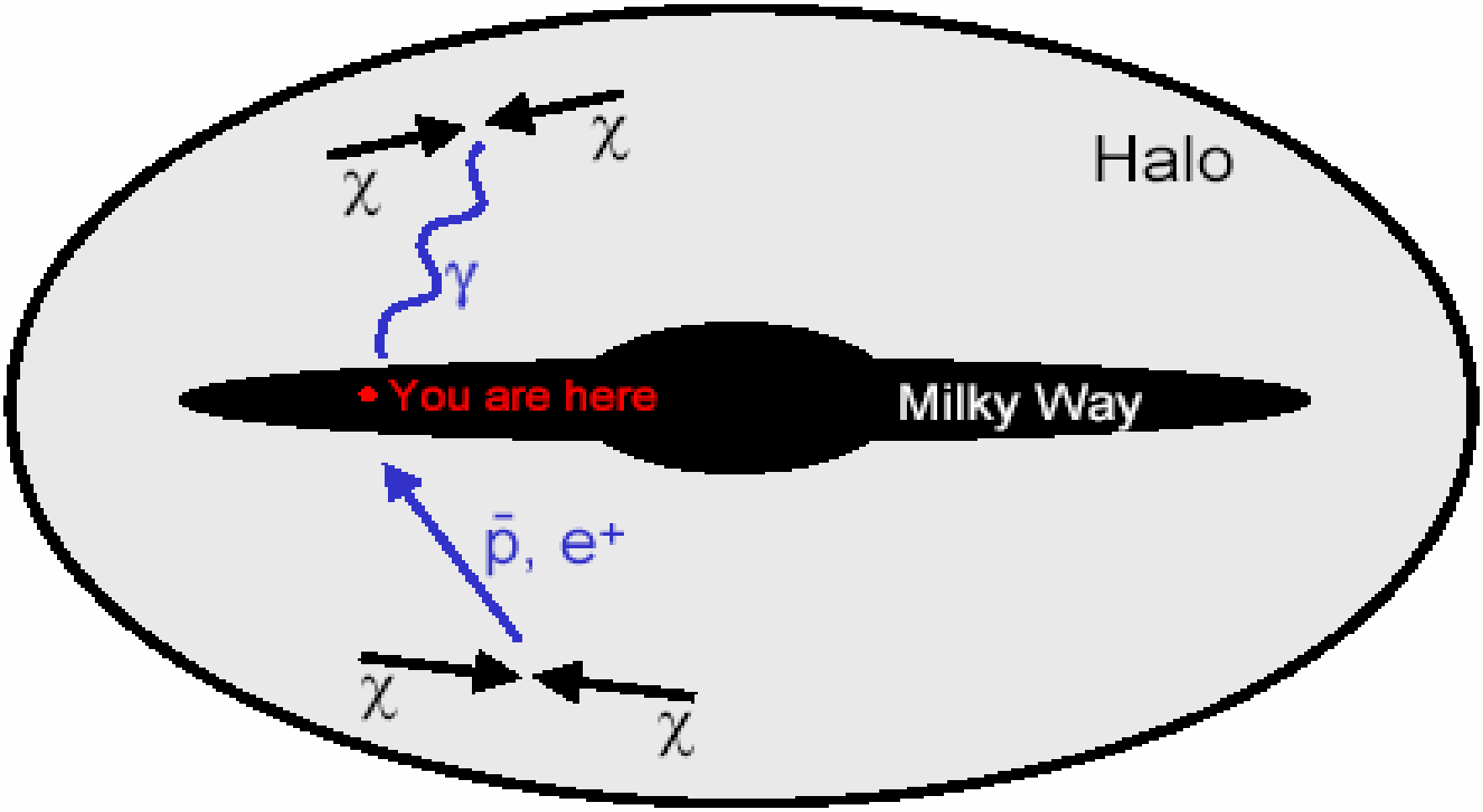
Detect WIMP *annihilation* process:

$$B^1 + B^1 \rightarrow e^+ + e^-, \ldots.$$

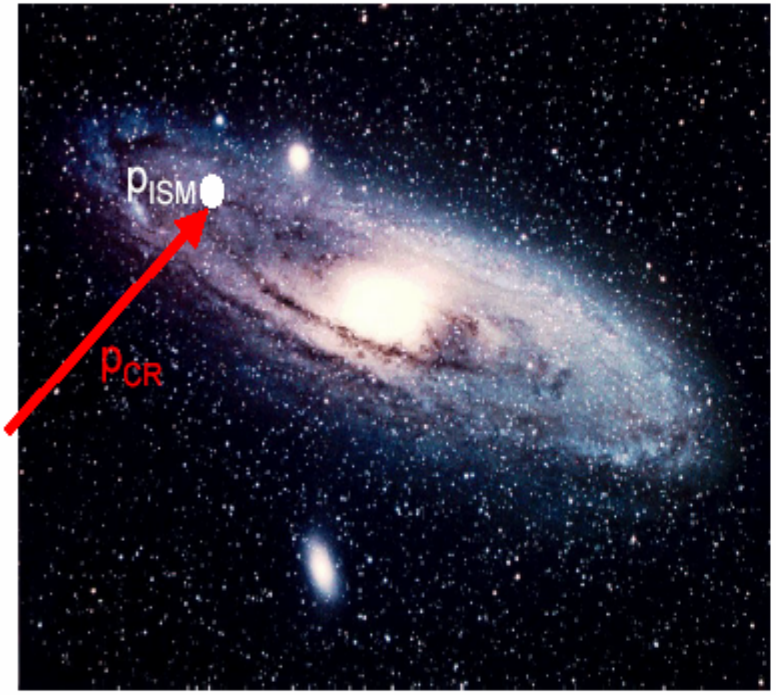
$$\chi + \chi \rightarrow b\bar{b}, t\bar{t}, \tau^+\tau^-, Z^0Z^0, Z^0\gamma, W^+W^-, HH \rightarrow$$

$$\rightarrow \gamma + \ldots, e^{\pm} + \ldots, p\bar{p} + \ldots, d\bar{d} + \ldots, \ldots$$

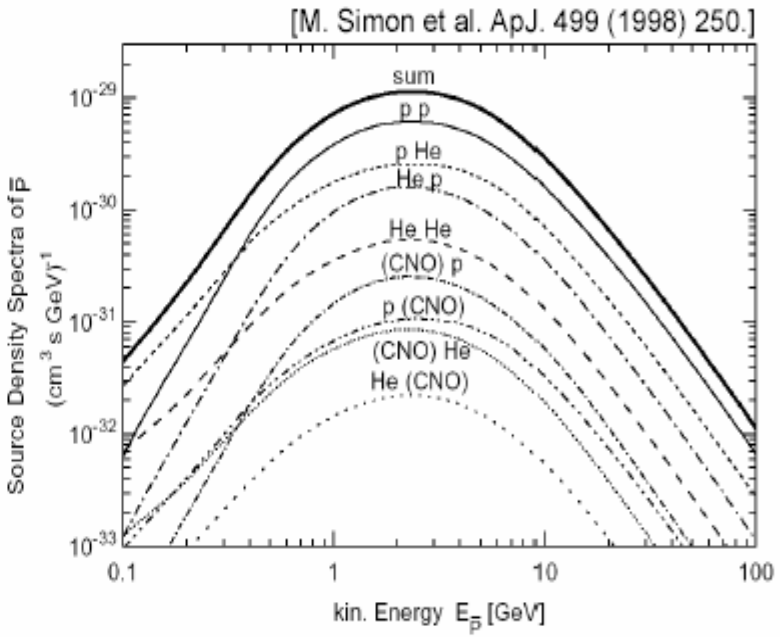
Study of origin of dark matter



Study of origin of dark matter
Secondary antiprotons



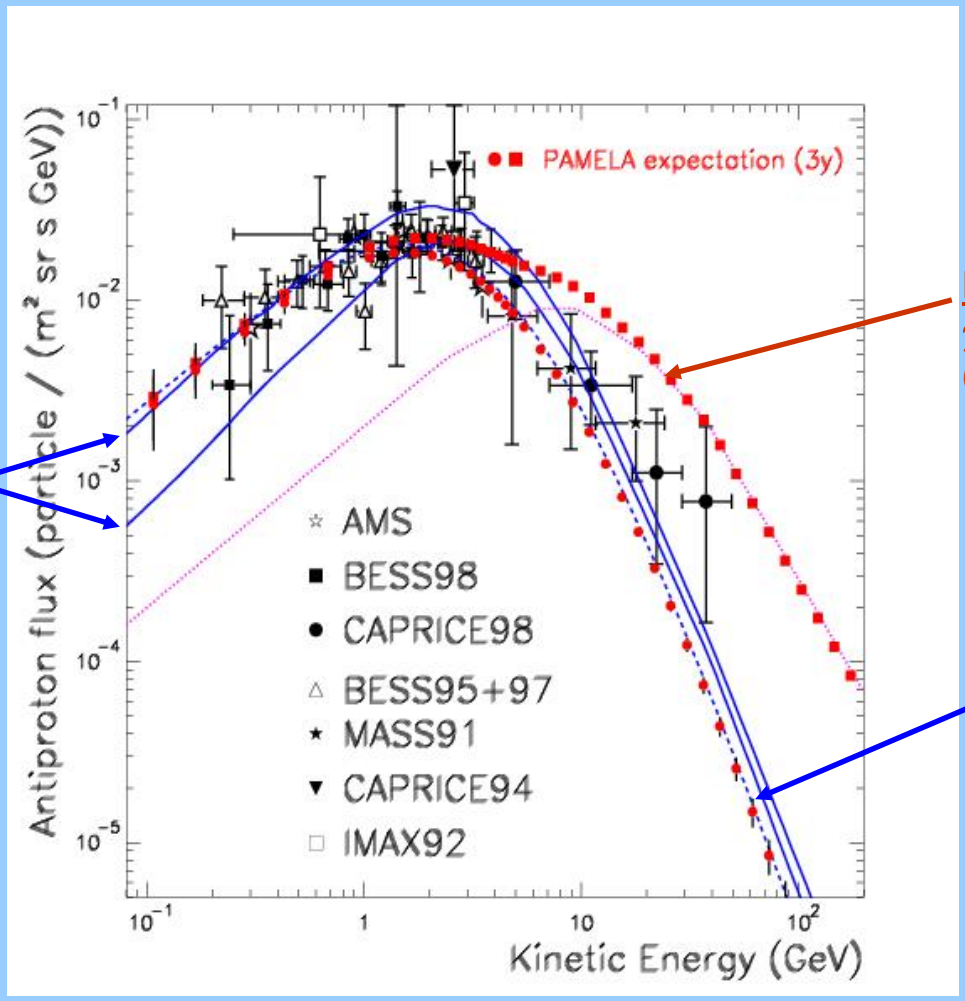
$$p_{CR} + p_{ISM} \rightarrow \bar{p} + p + p + p$$



$$p_{CR} + p_{ISM} \rightarrow \pi^+ + X; \pi^+ \rightarrow \mu^+ + \nu_\mu; \mu^+ \rightarrow e^+ + \nu_e + \bar{\nu}_\mu$$

$$p_{CR} + p_{ISM} \rightarrow \pi^0 + X; \pi^0 \rightarrow \gamma + \gamma; \gamma \rightarrow e^+ + e^-$$

Study of origin of dark matter

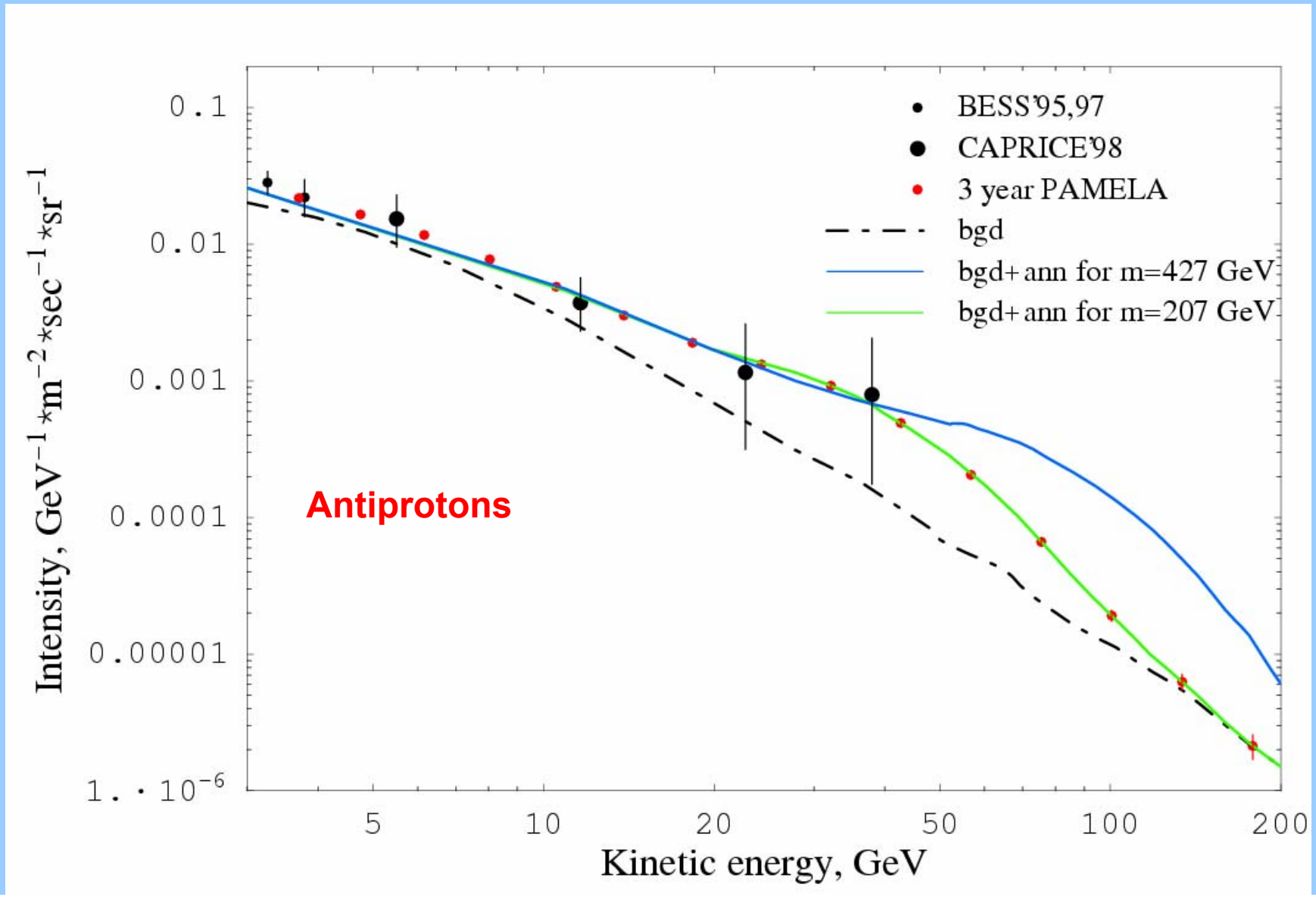


Secondary production
(upper and lower limits)
Simon et al.

Primary production from
$\chi\chi$ annihilation
($m(\chi)$ = ~ 1 TeV)
(astro-ph 9904086)

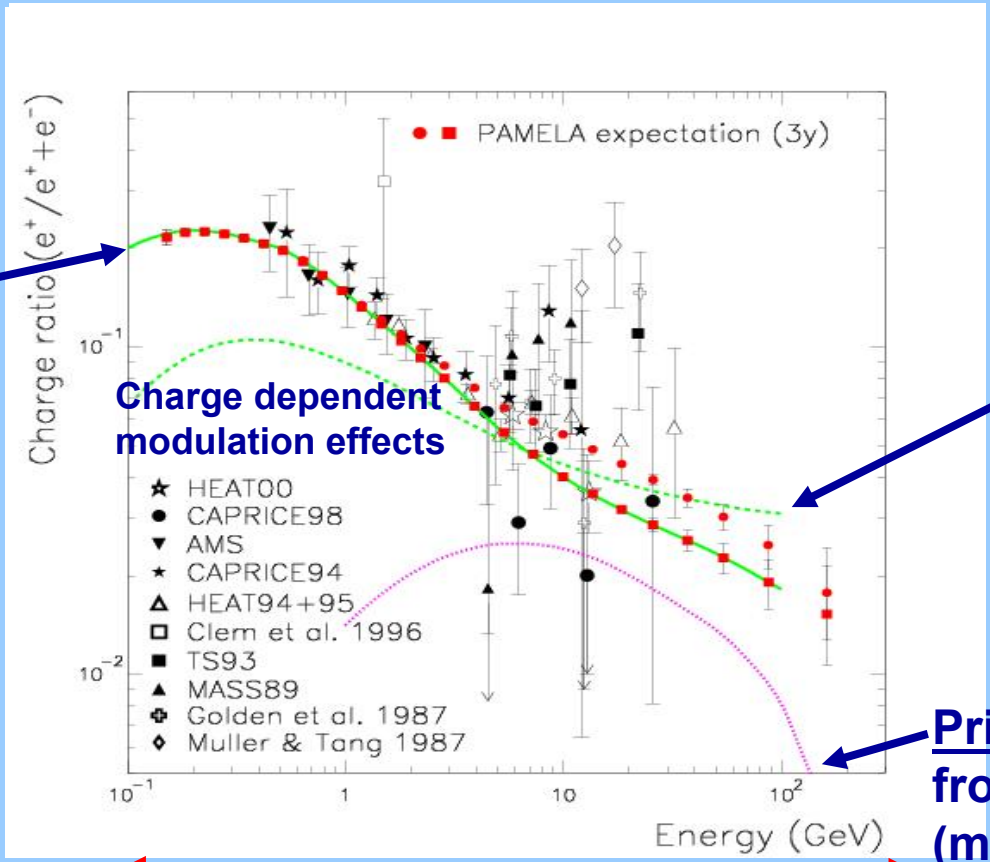
Secondary production
(CAPRICE94-based)
Bergström et al.

Study of origin of dark matter



Study of origin of dark matter

Secondary production
'Moskalenko + Strong model' (1998) without reacceleration



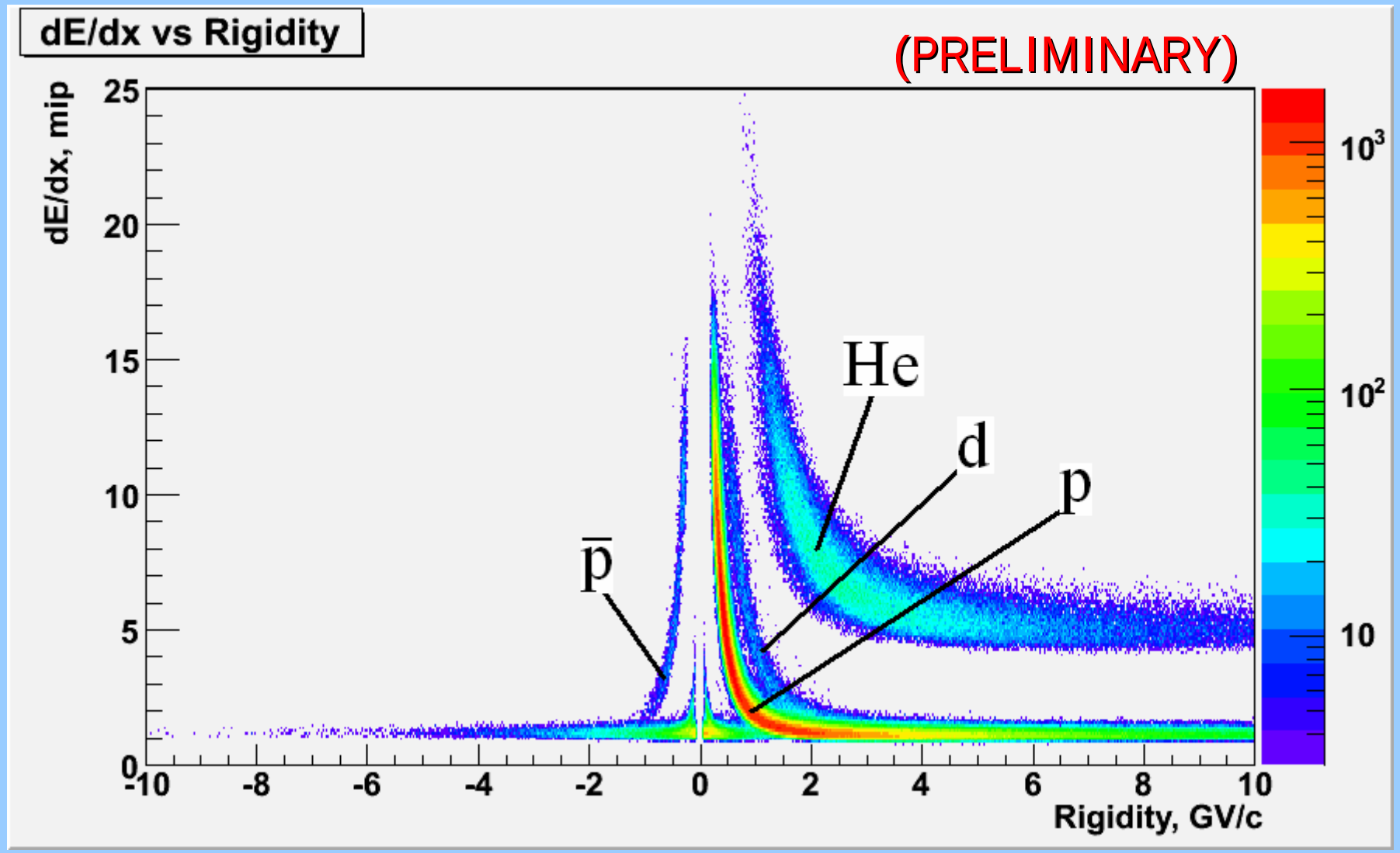
Secondary production
'Leaky box model' (Protheroe 1982)

Primary production from $\chi\chi$ annihilation ($m(\chi)$ = 336 GeV)

PAMELA energy range

Study of origin of dark matter

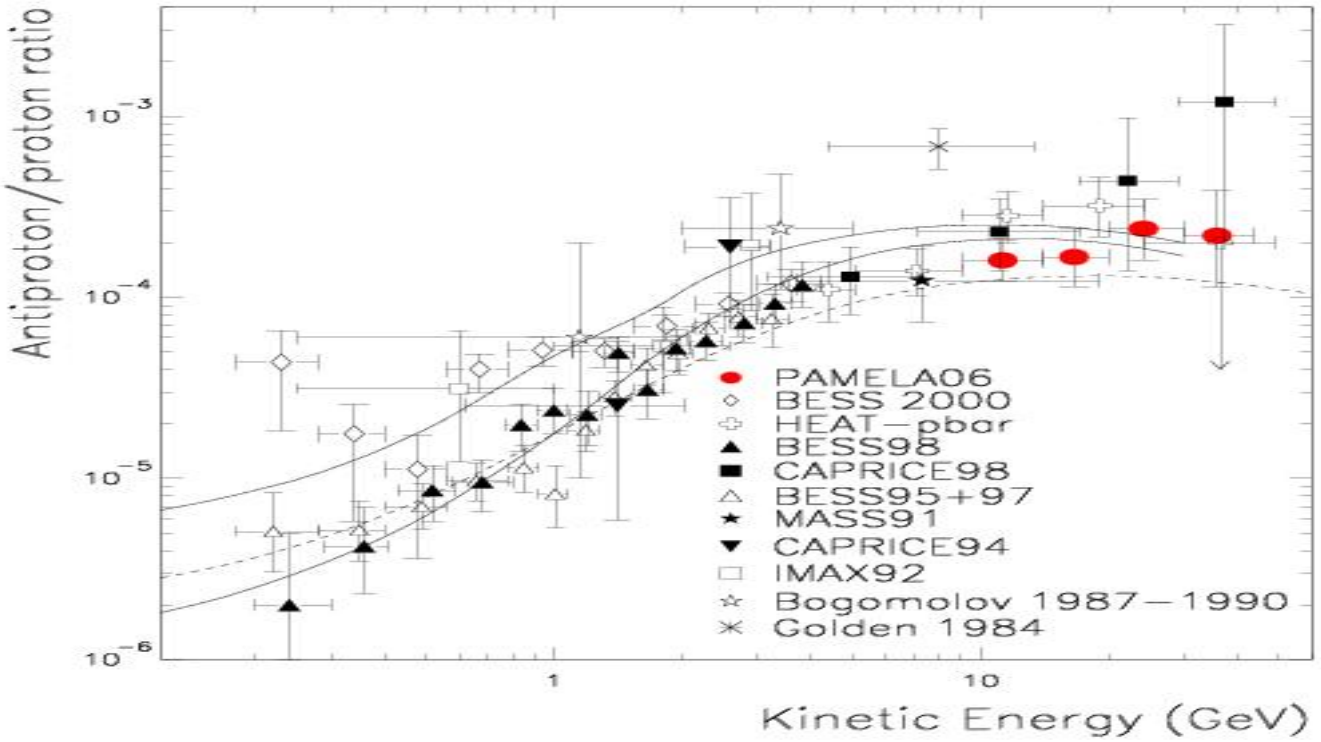
Data from PAMELA flight



Study of origin of dark matter

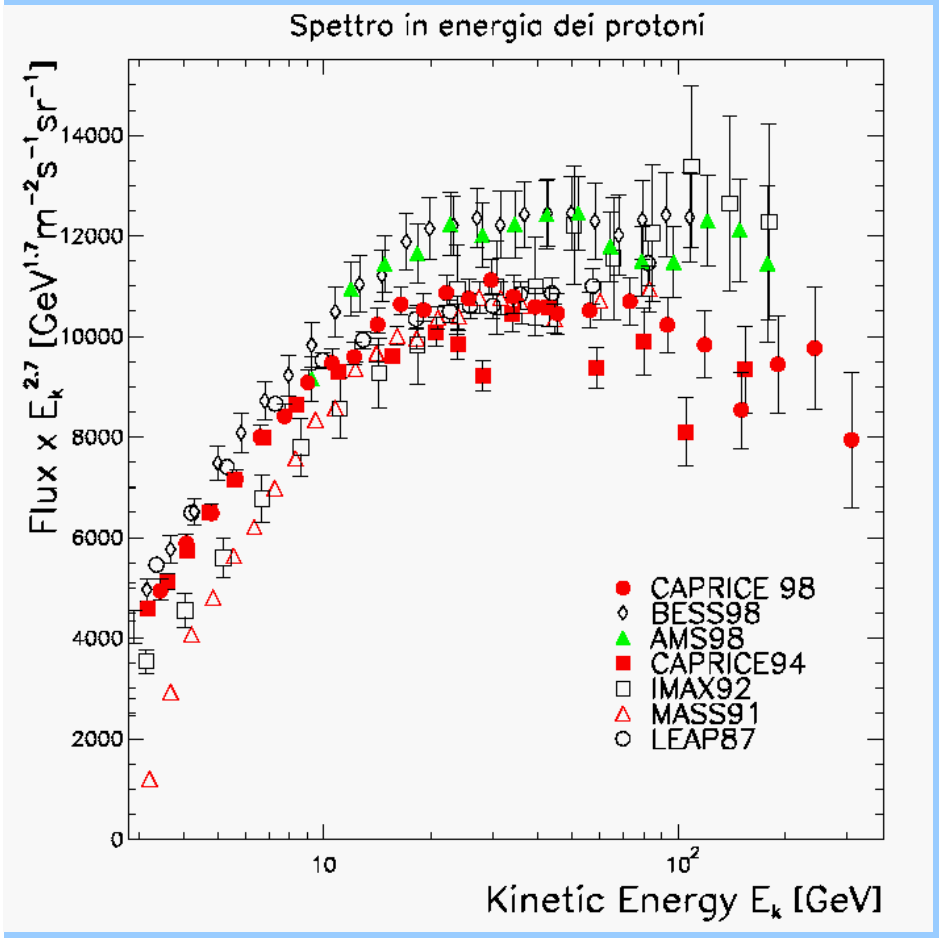
Data from PAMELA flight

(PRELIMINARY)

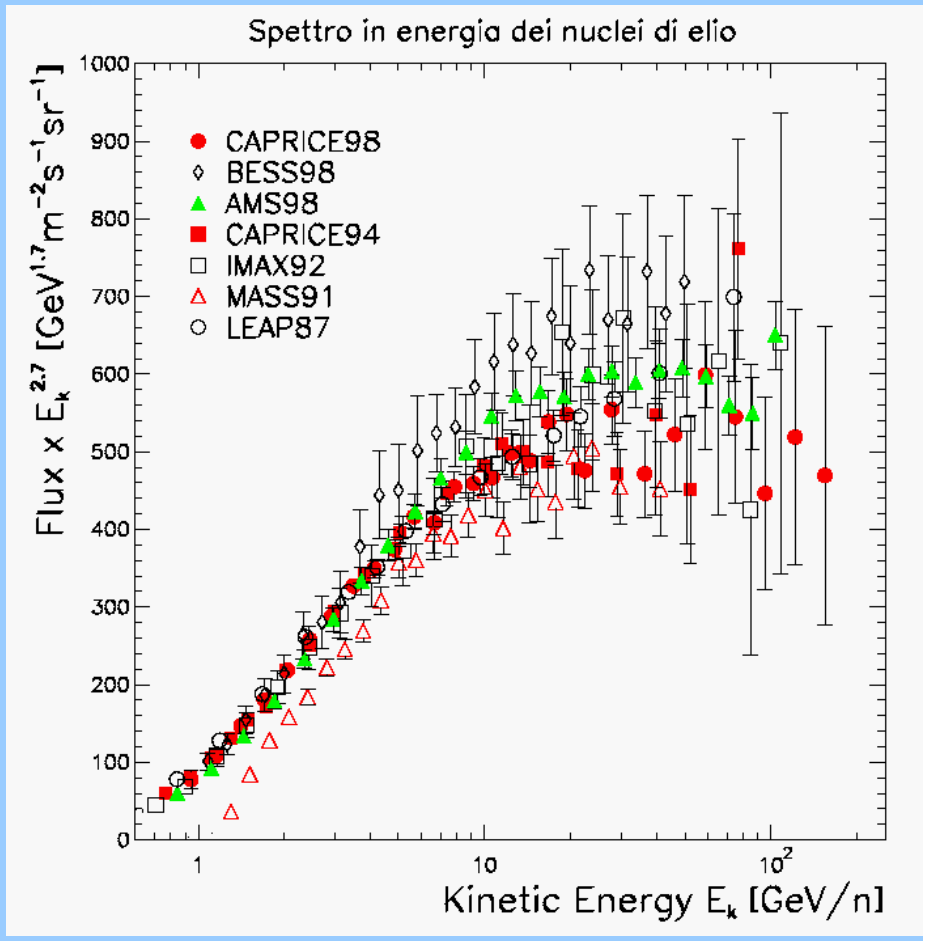


Study of cosmic-ray generation and propagation

Protons

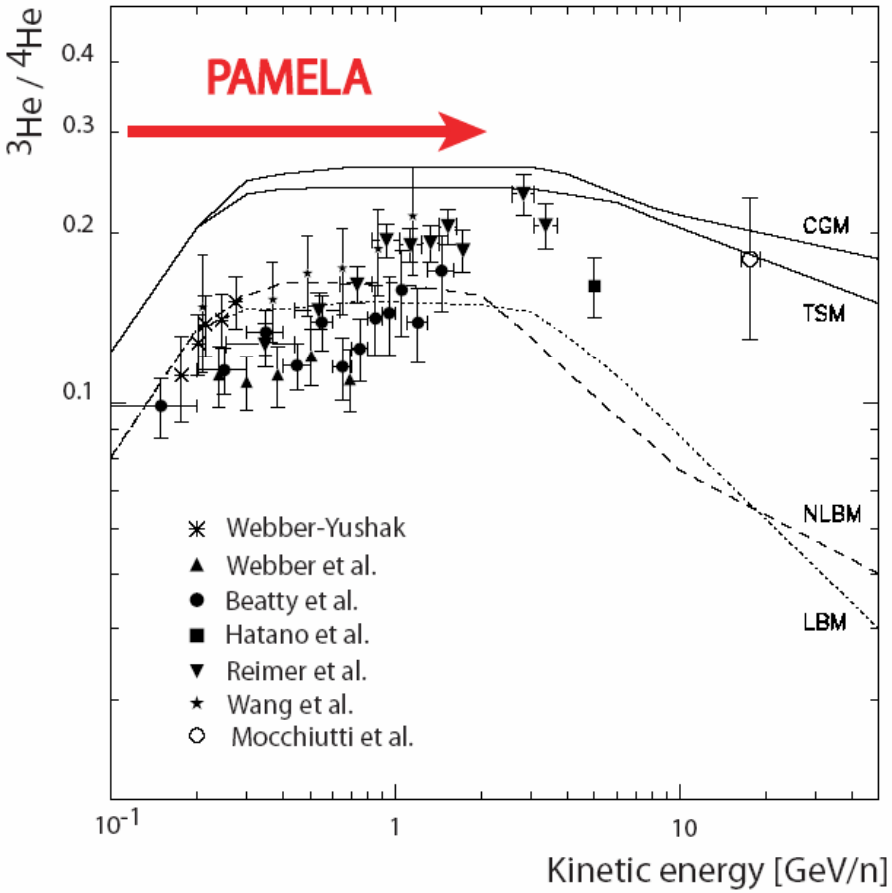


Helium

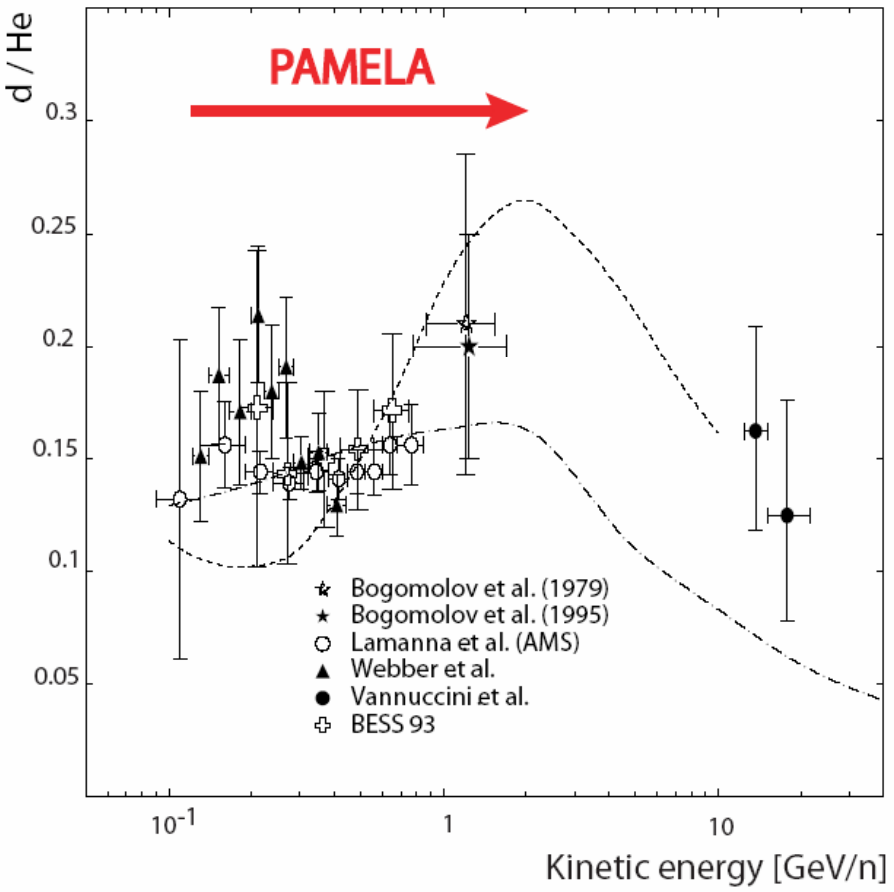


Study of cosmic-ray generation and propagation

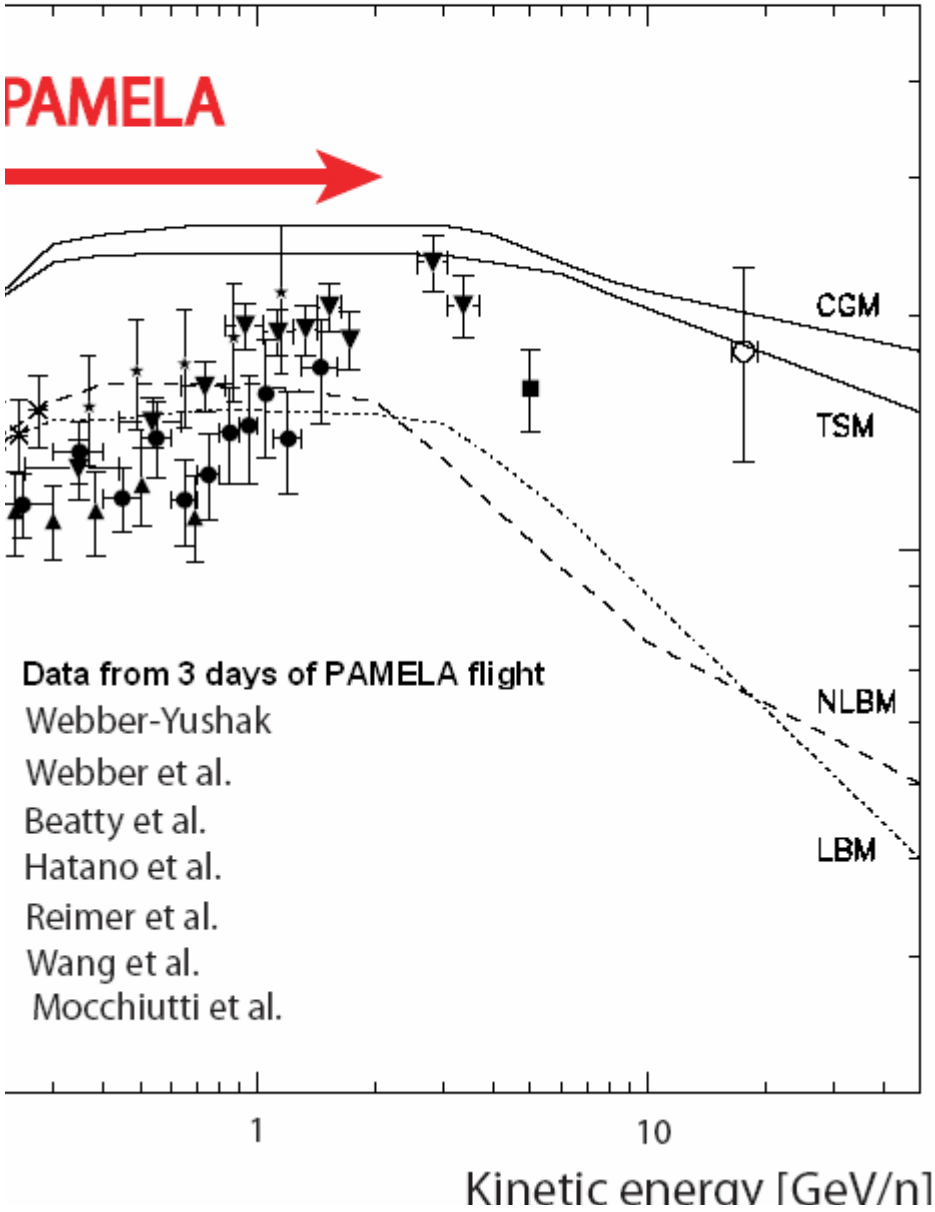
The current situation of the $^3He / ^4He$ ratio



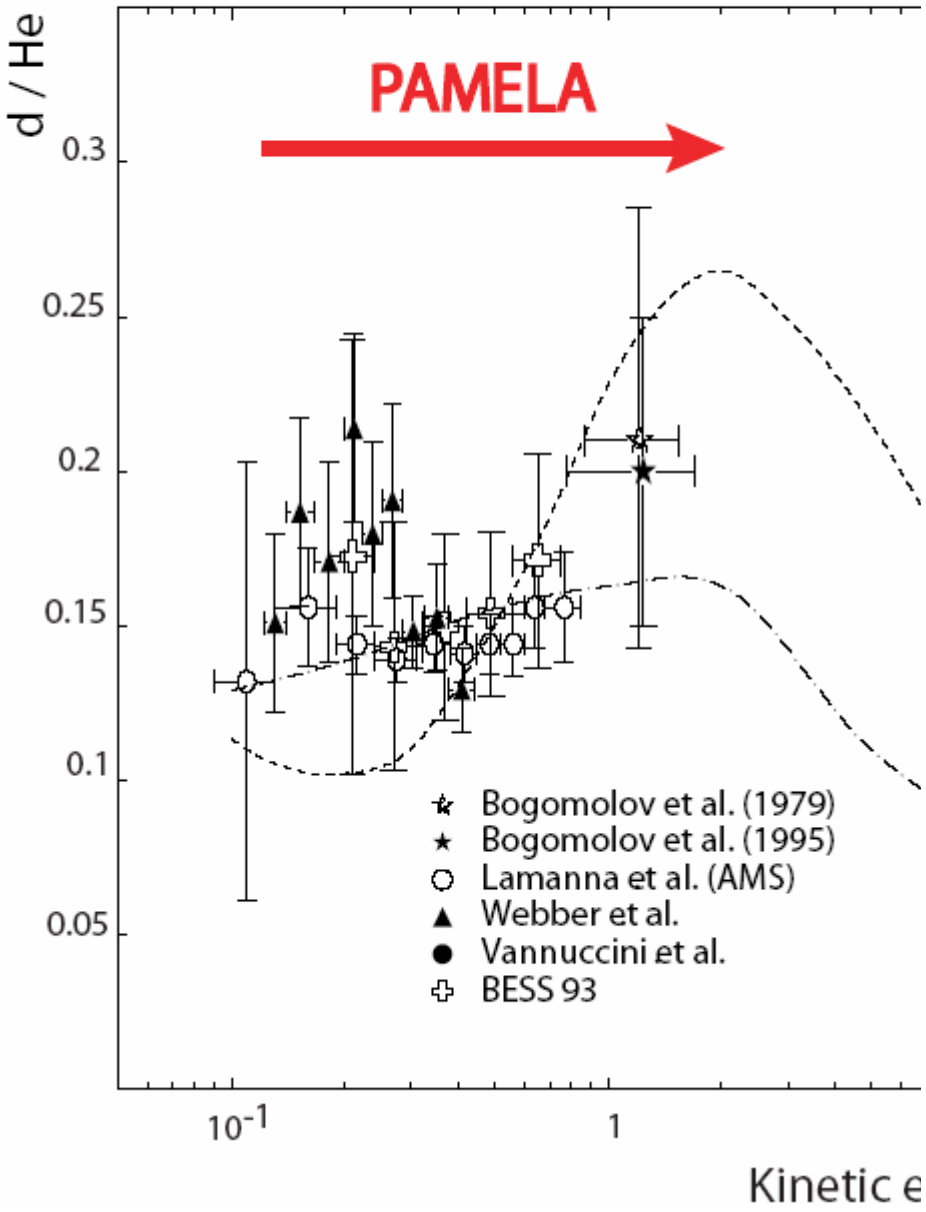
The current situation of the d / He ratio



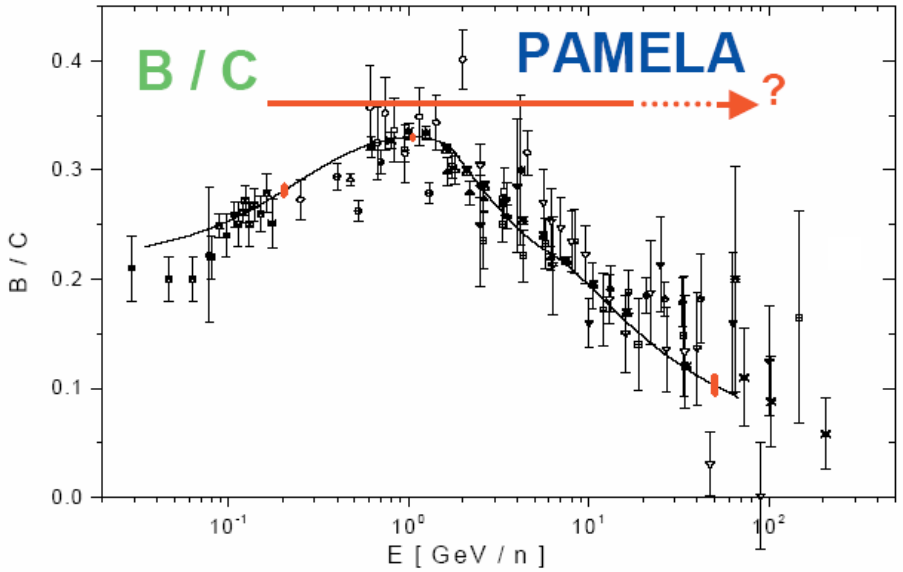
$^3He / ^4He$ ratio

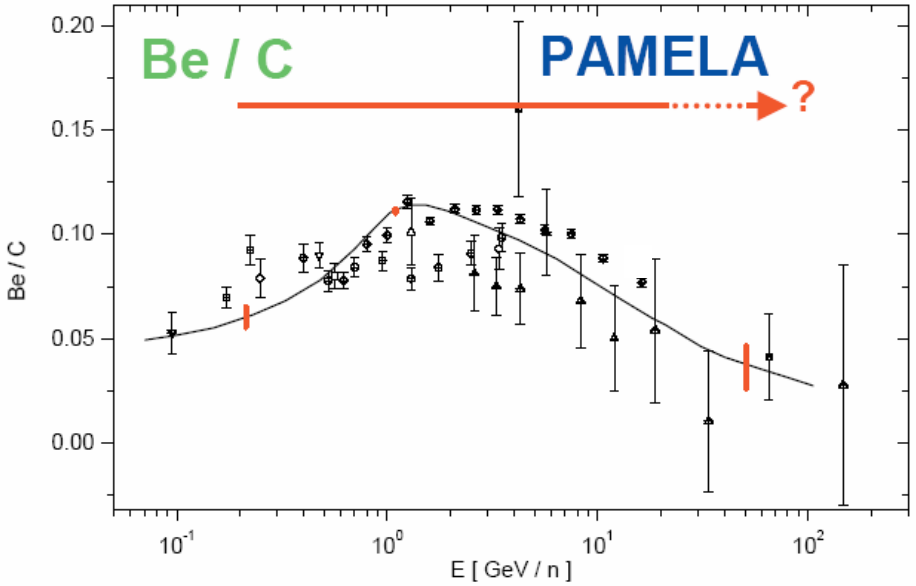


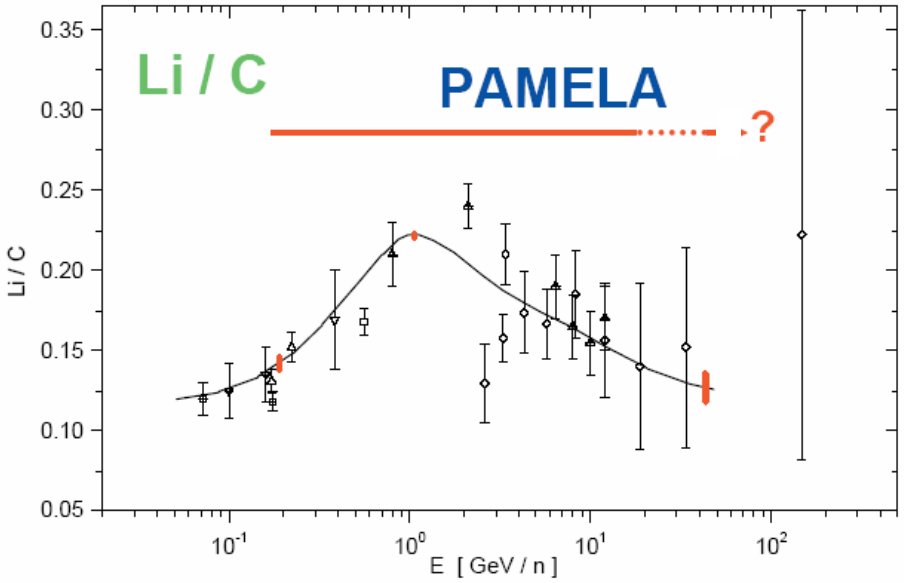
the d / He ra



Study of cosmic-ray generation and propagation

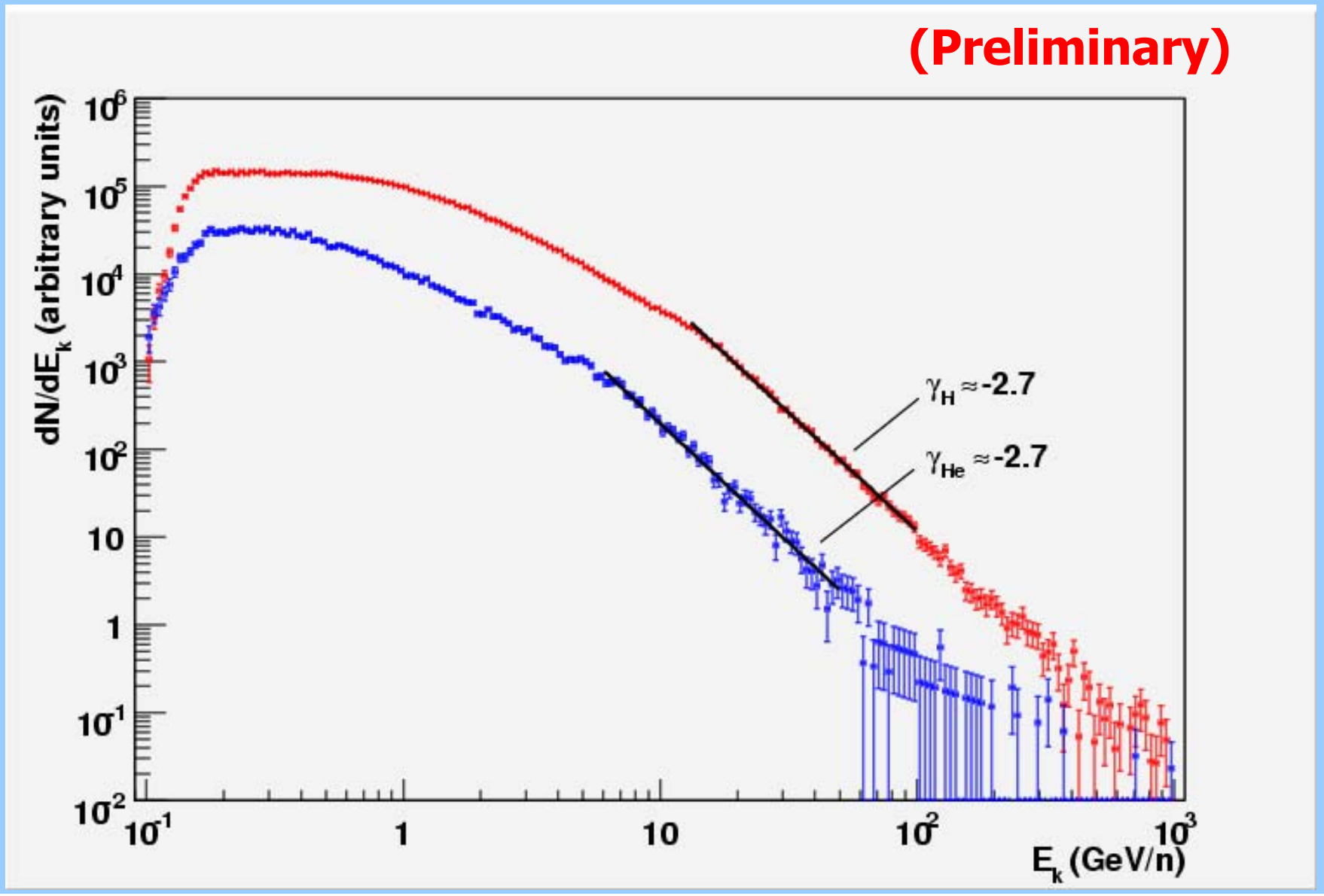






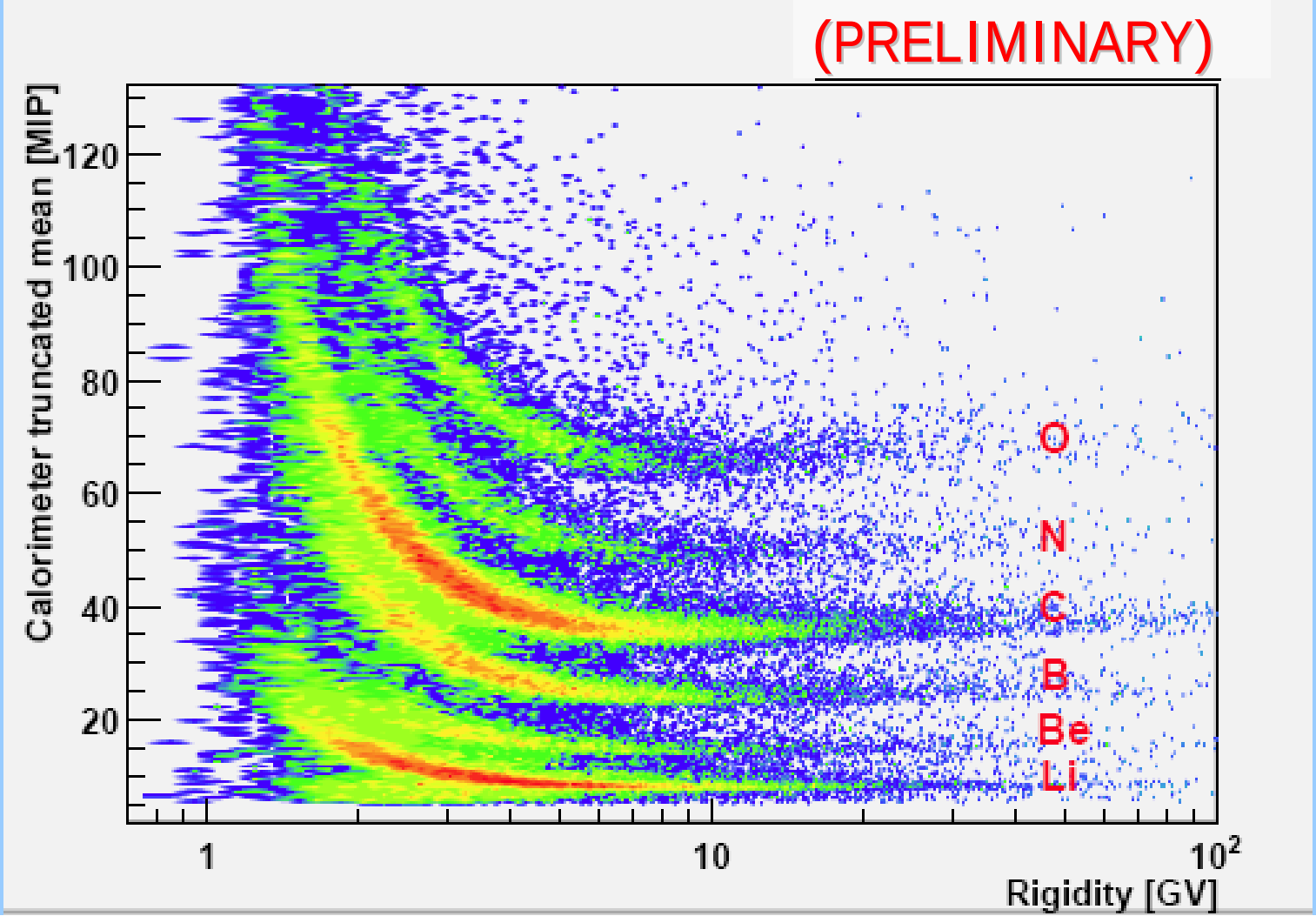
Study of cosmic-ray generation and propagation

Data from PAMELA flight



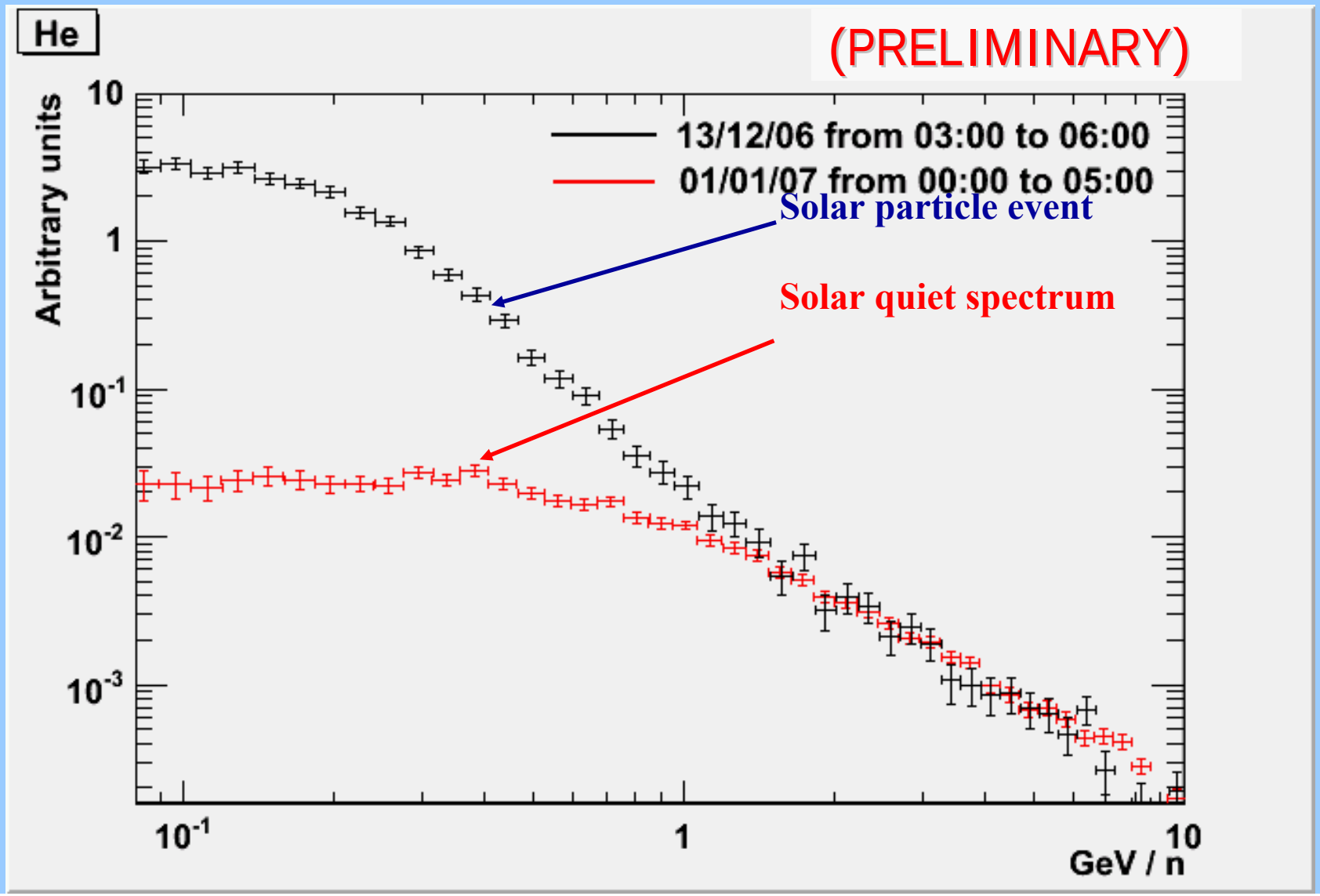
Study of cosmic-ray generation and propagation

Data from PAMELA flight



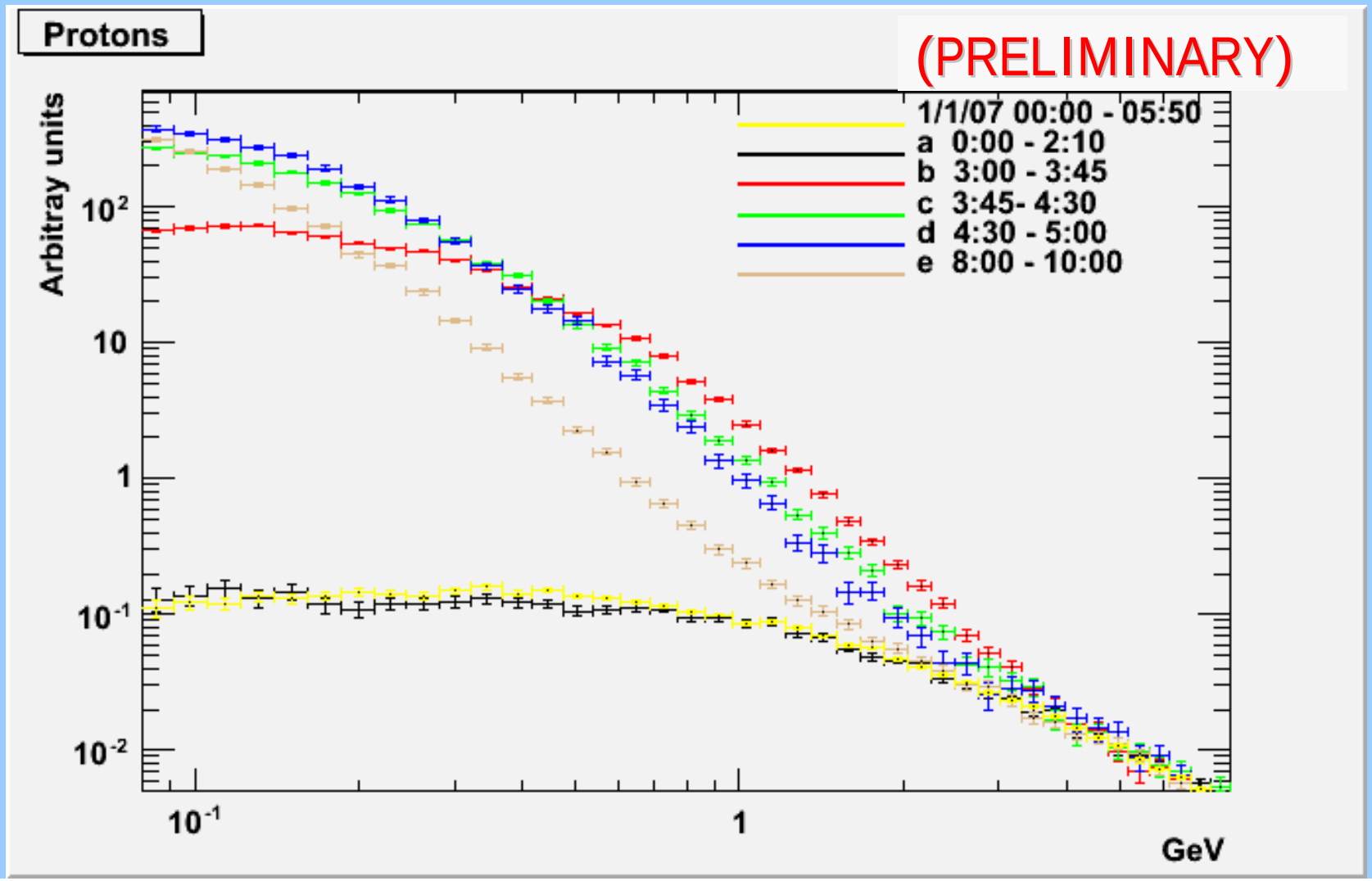
Study solar cosmic rays and solar modulation

Data from PAMELA flight



Study solar cosmic rays and solar modulation

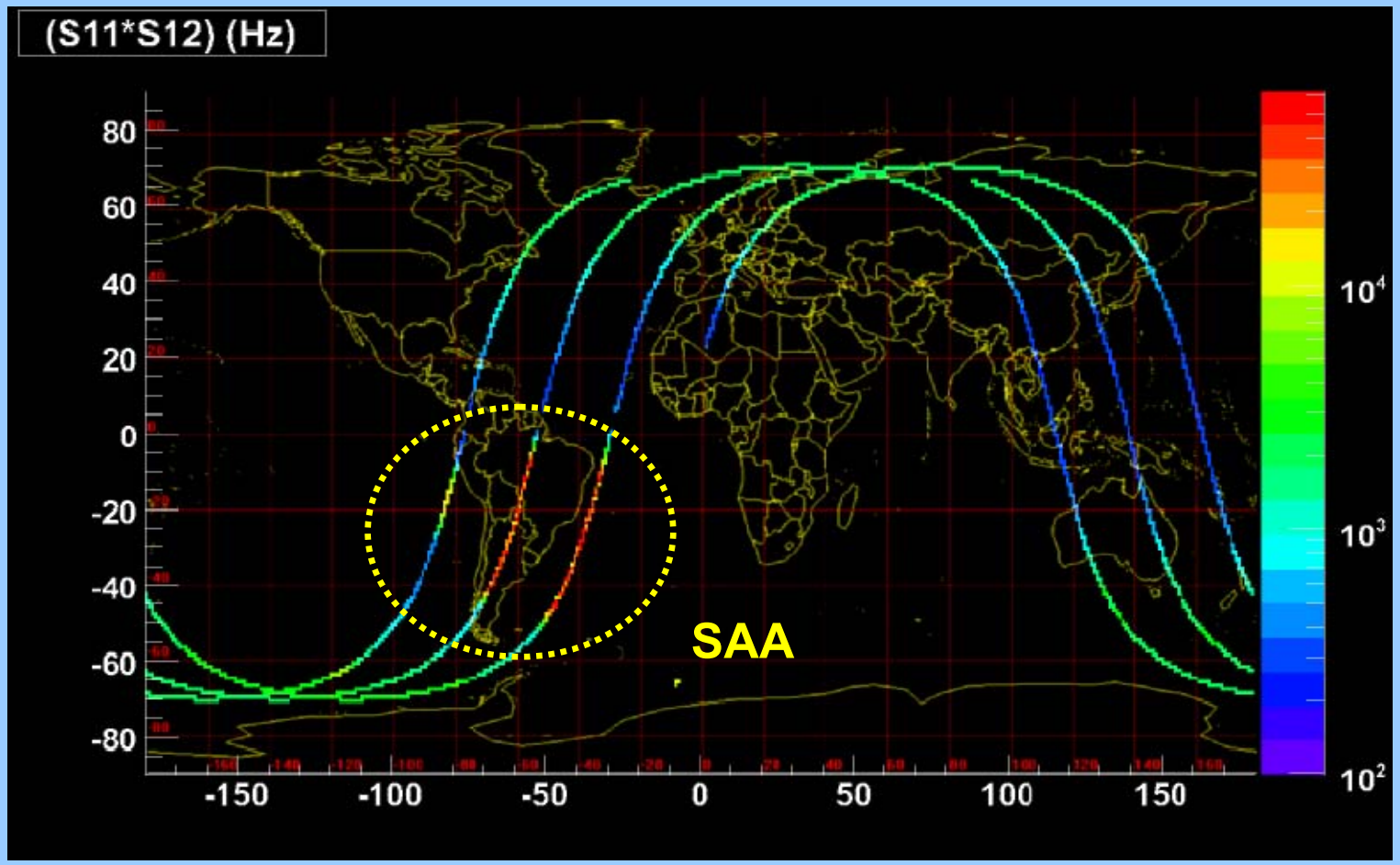
Data from PAMELA flight



Study terrestrial magnetosphere

Data from PAMELA flight

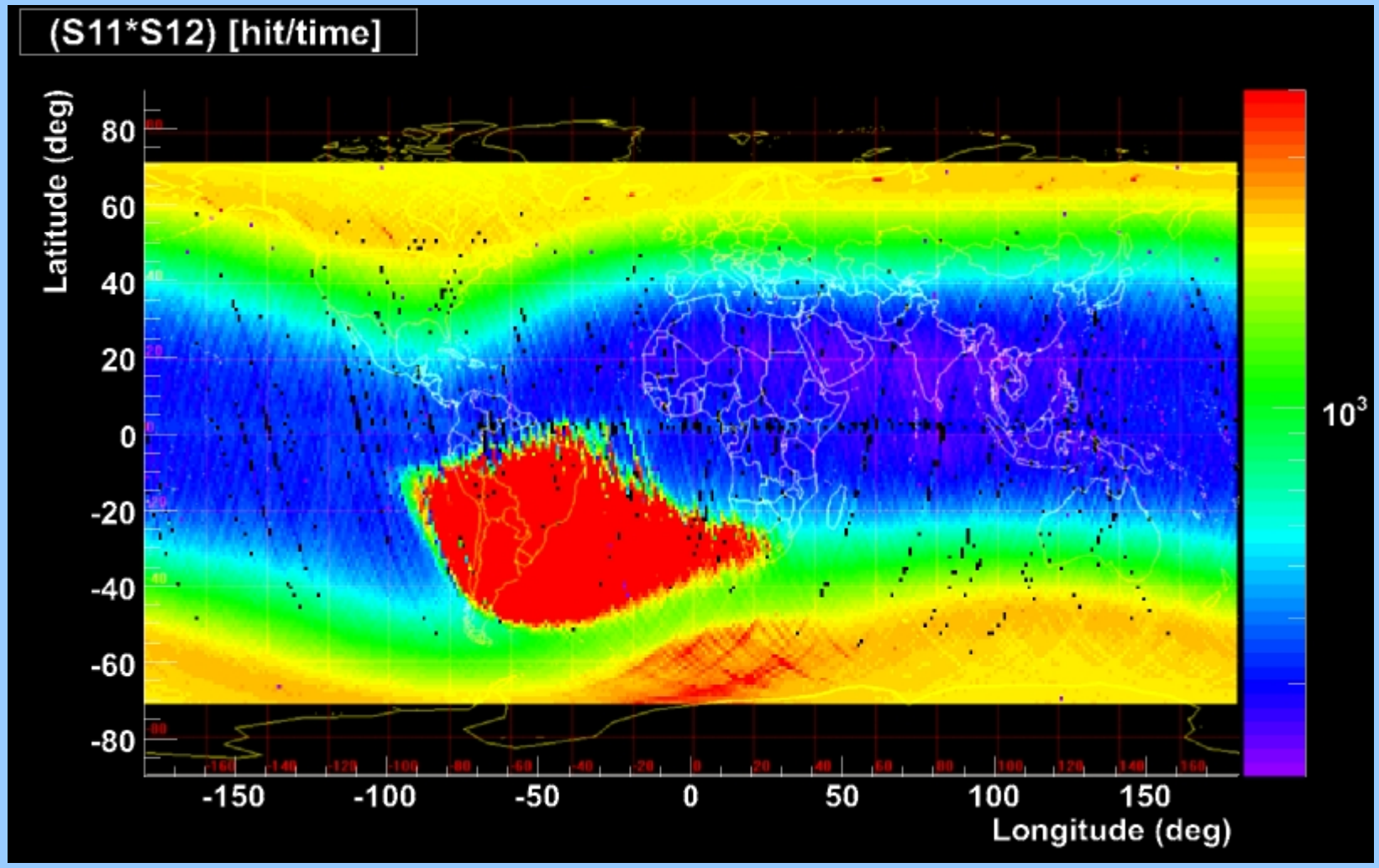
Download @orbit 3754 – 15/02/2007 07:35:00 MWT



Study terrestrial magnetosphere

Data from PAMELA flight

Pamela World Maps: 350 – 650 km alt

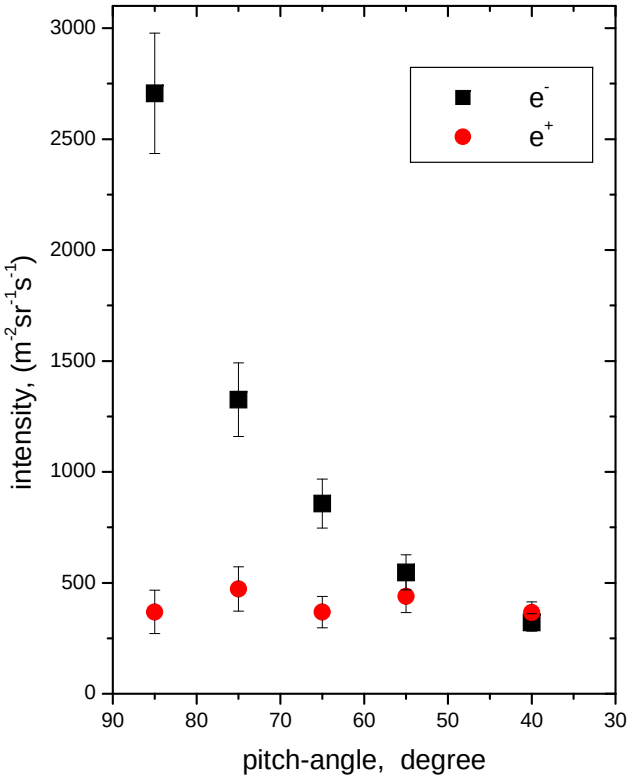


36 MeV p, 3.5 MeV e-

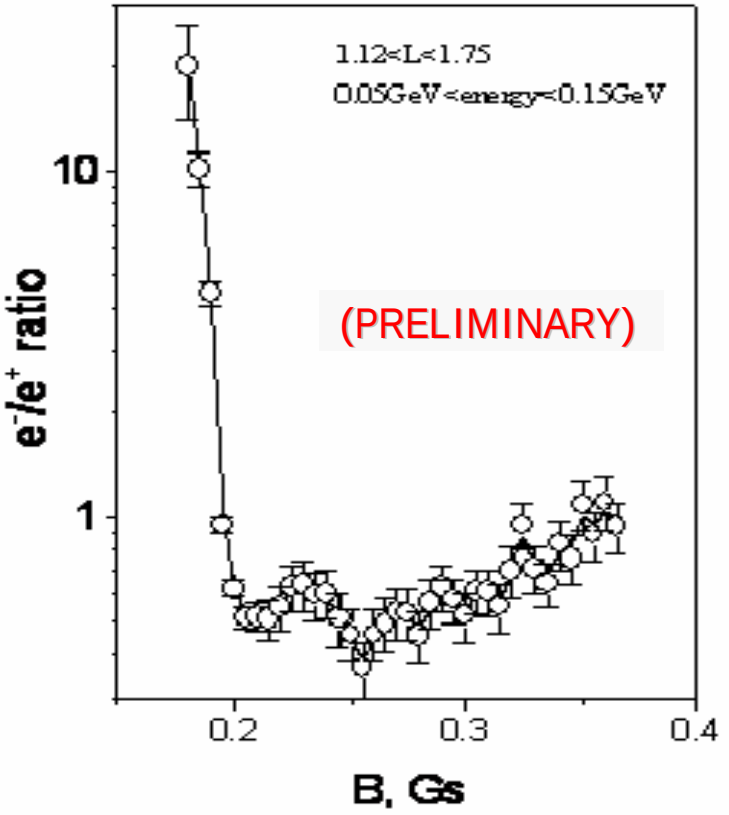
Study terrestrial magnetosphere

Electron and positron fluxes in the SAA region (data of the MARIA-2 and PAMELA)

Data from PAMELA flight



MARIA-2
Integral fluxes of electrons and positrons (30-150 MeV) vs pitch-angle (SAA, L=1.12-1.8, B<0.22).

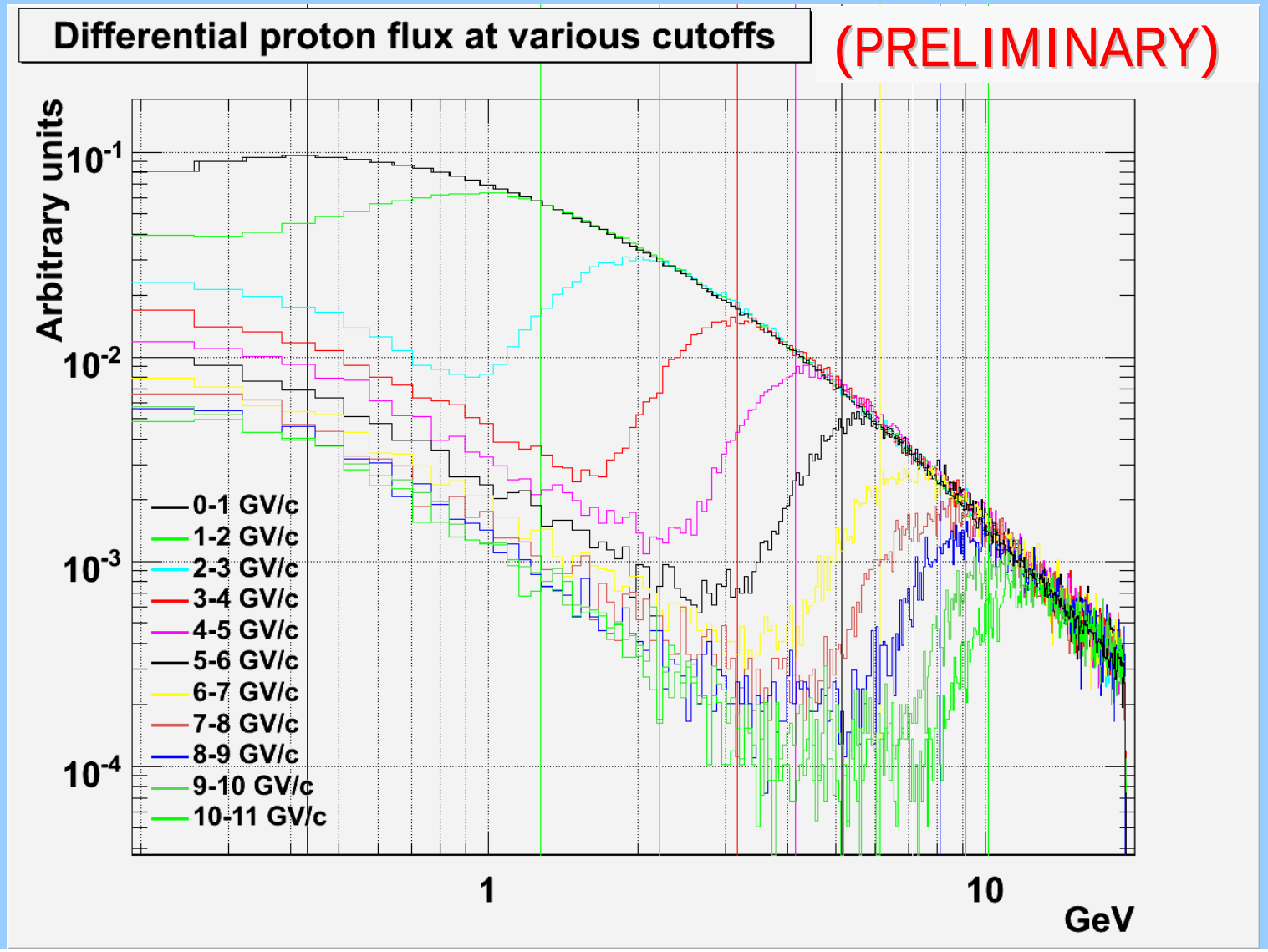


PAMELA
Electron-positron ratio (100-150 MeV) vs B geomagnetic field (SAA, L=1.12-1.75, pitch-angle>60°).

Study terrestrial magnetosphere

Data from PAMELA flight

Primary and Albedo (sub-cutoff measurements)



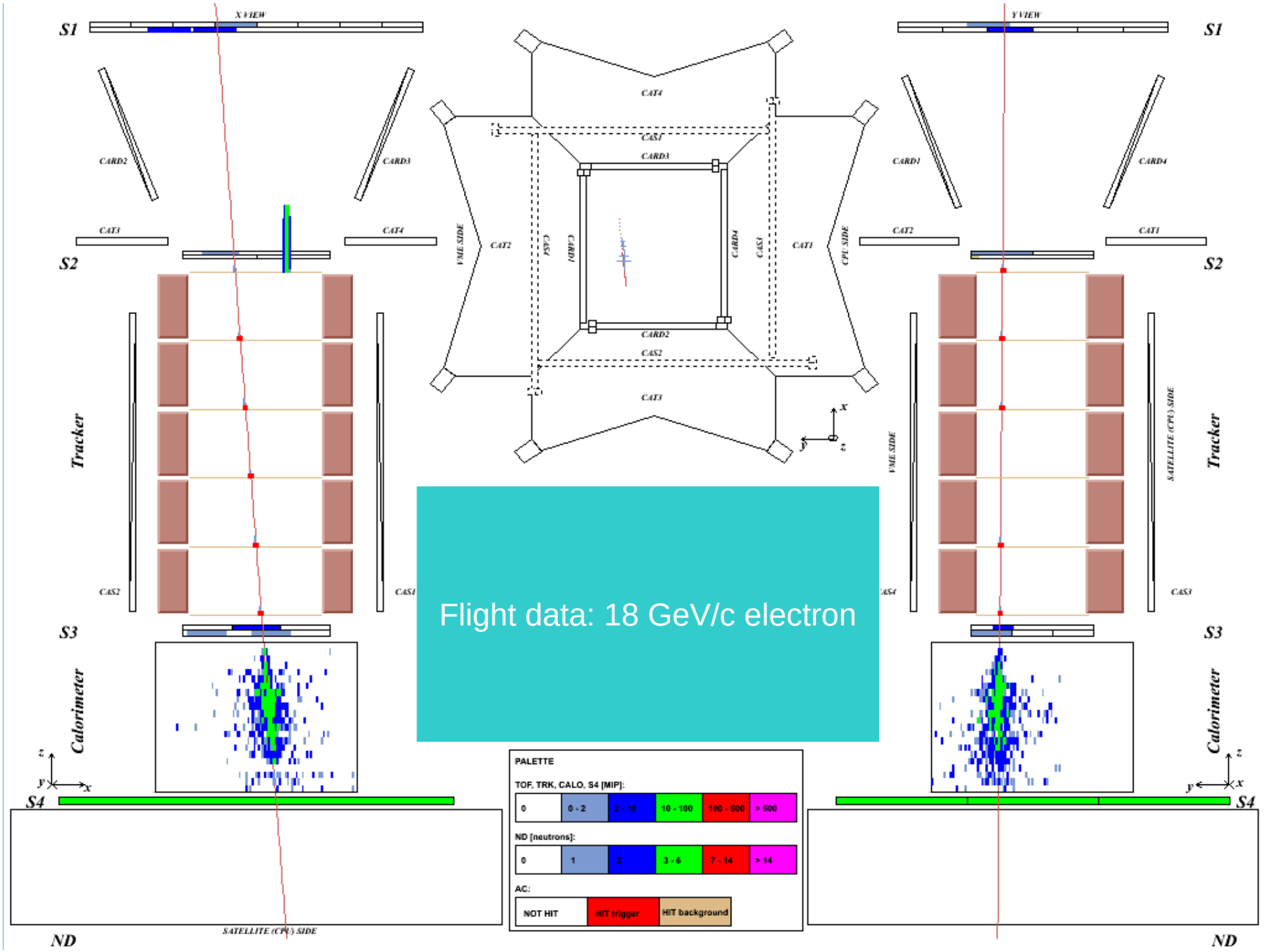
Conclusion

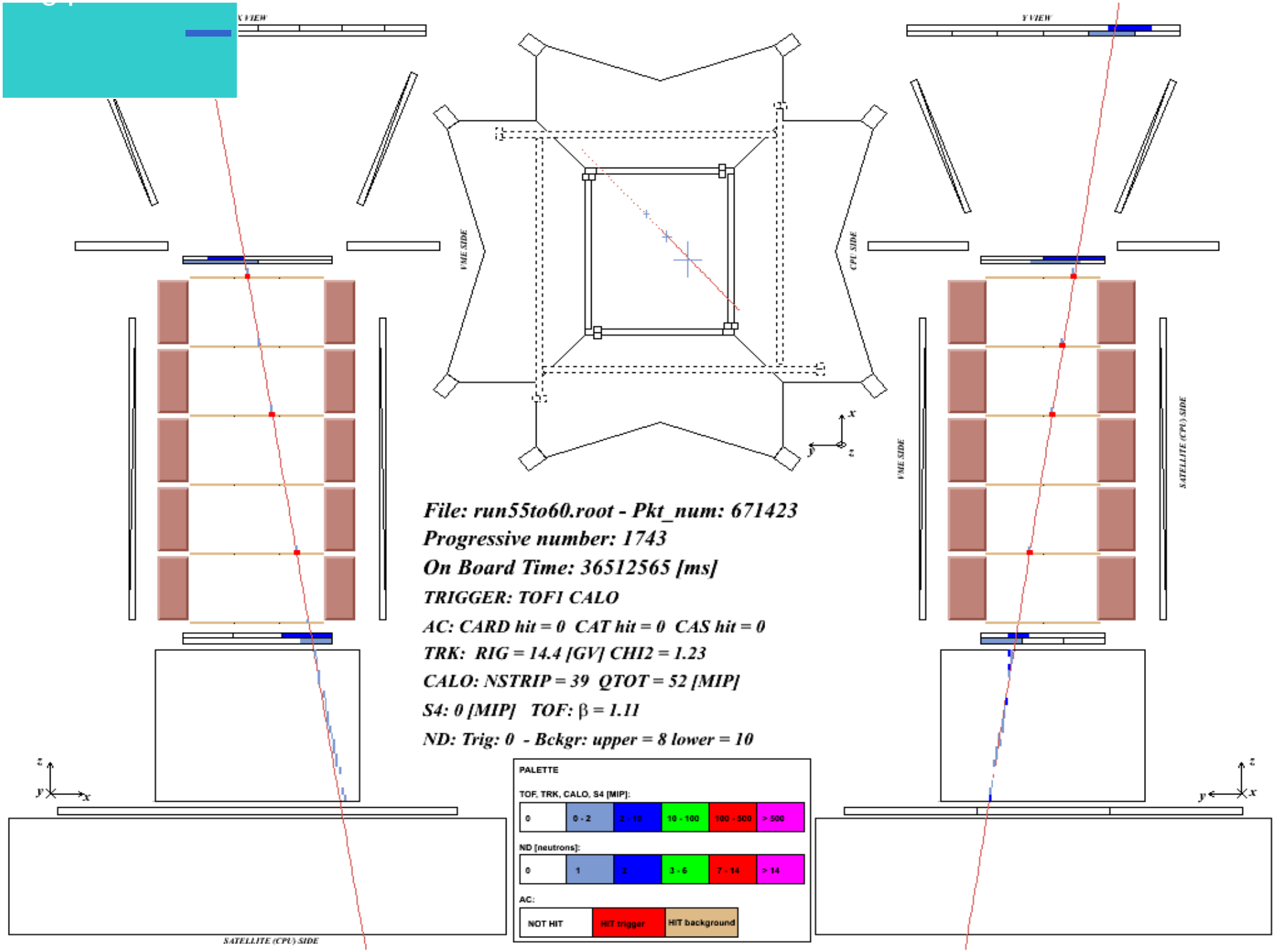
29 august 2007

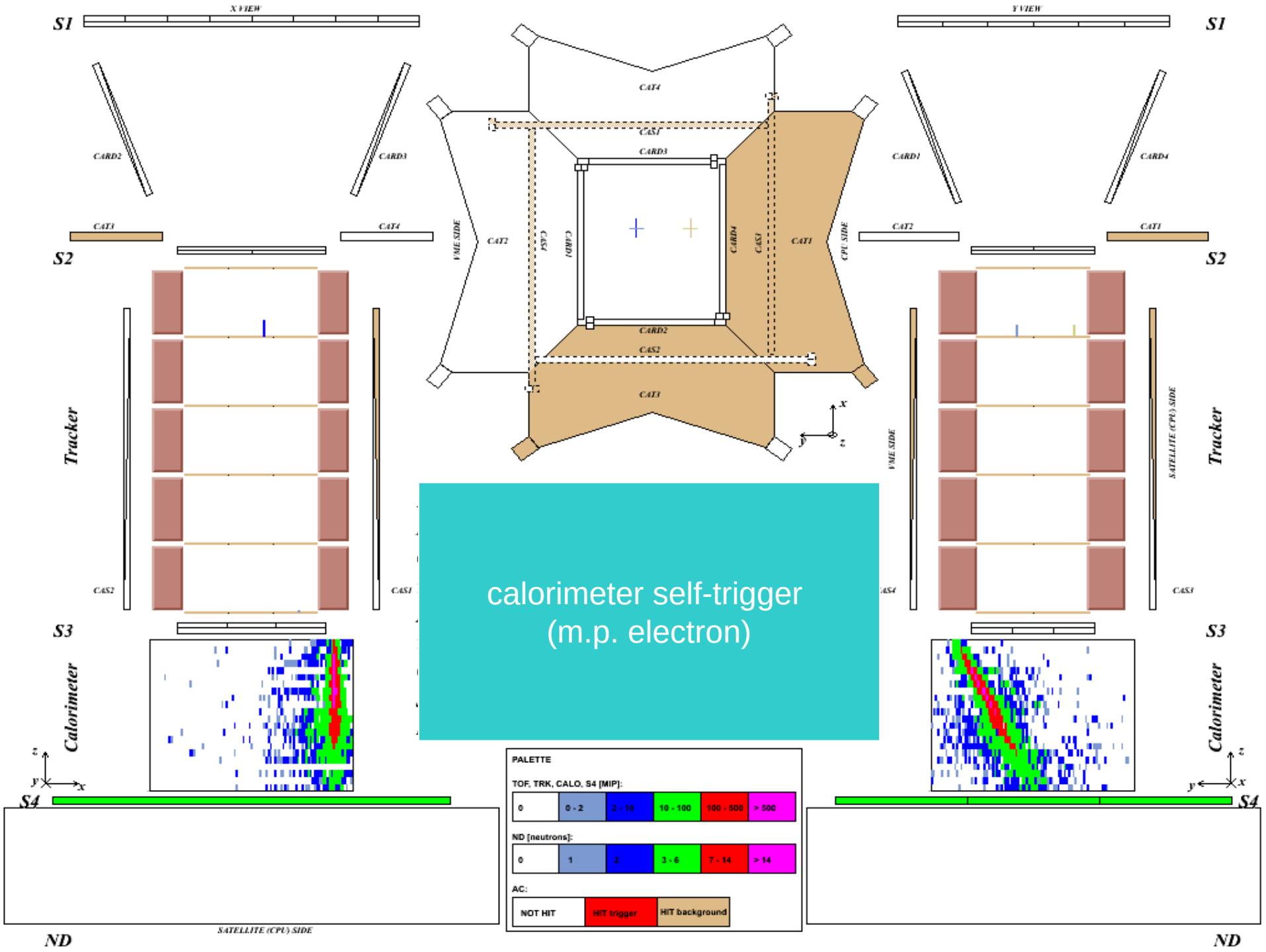
PAMELA is functioning normally

In the last 24 hours 4 downlinks were done

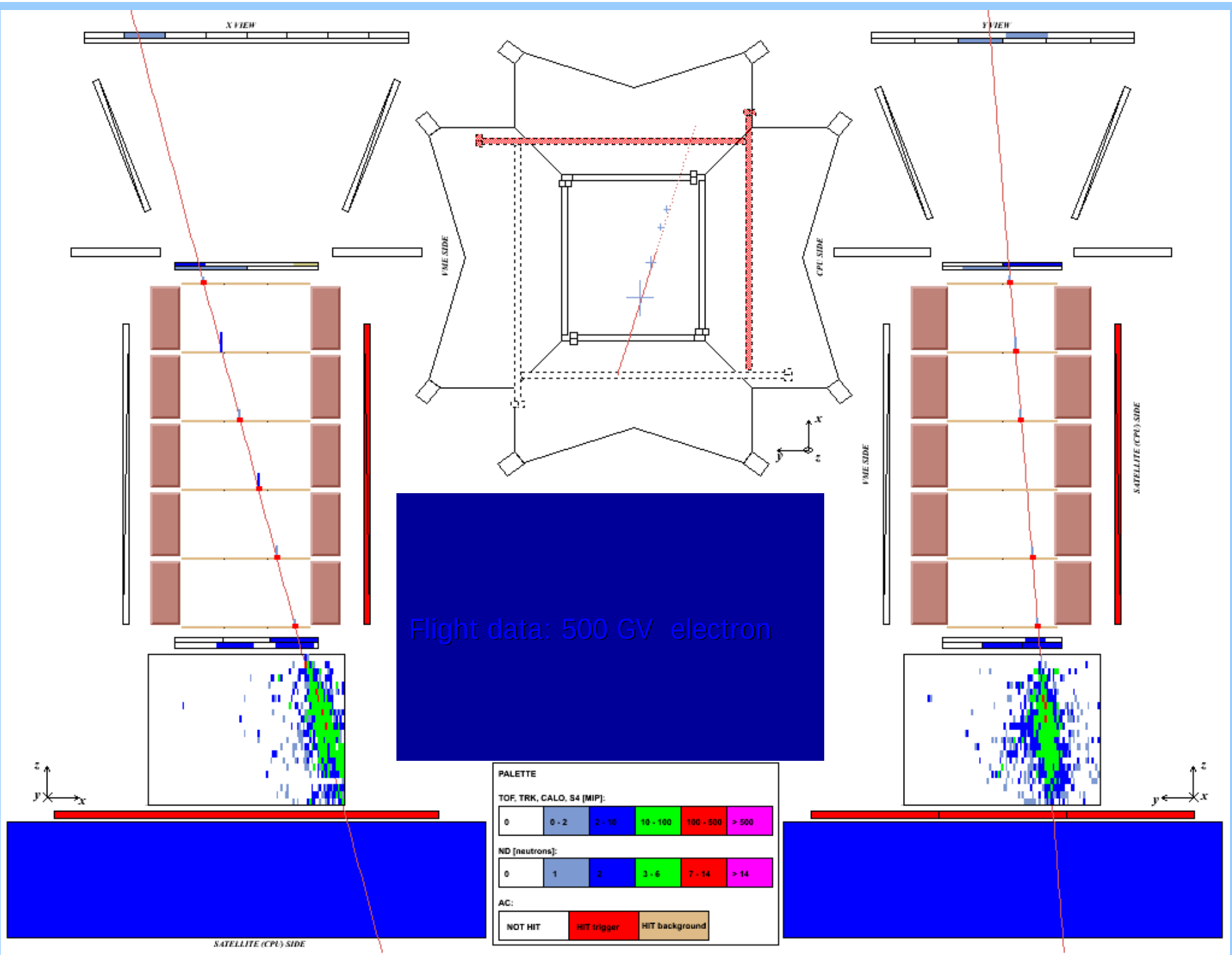
14.6 Gb of information was transmitted


X VIEW
Y VIEW
S1
S2
S3
S4
CARD1
CARD2
CARD3
CARD4
CAT1
CAT2
CAT3
CAT4
CAS1
CAS2
CAS3
CAS4
VME SIDE
CPU SIDE
SATELLITE (CPU) SIDE
Tracker
Calorimeter
ND
Flight data: 18 GeV/c electron
PALETTE
TOF, TRK, CALO, S4 [MIP]:
0
0 - 2
2 - 10
10 - 100
100 - 500
> 500
NID [neutrons]:
0
1
2
3 - 6
7 - 14
> 14
AC:
NOT HIT
HIT trigger
HIT background


X VIEW
Y VIEW
VME SIDE
CPU SIDE
VME SIDE
SATELLITE (CPU) SIDE
SATELLITE (CPU) SIDE
File: run55to60.root - Pkt_num: 671423
Progressive number: 1743
On Board Time: 36512565 [ms]
TRIGGER: TOF1 CALO
AC: CARD hit = 0 CAT hit = 0 CAS hit = 0
TRK: RIG = 14.4 [GV] CHI2 = 1.23
CALO: NSTRIP = 39 QTOT = 52 [MIP]
S4: 0 [MIP] TOF: β = 1.11
ND: Trig: 0 - Bckgr: upper = 8 lower = 10
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



calorimeter self-trigger
(m.p. electron)


X VIEW
Y VIEW
VME SIDE
CPE SIDE
VME SIDE
SATELLITE (CPE) SIDE
Flight data: 500 GV electron
PALETTE
TOF, TRK, CALO, S4 [MIP]:
0
0 - 2
2 - 10
10 - 100
100 - 500
> 500
NID [neutrons]:
0
1
2
3 - 6
7 - 14
> 14
A/C:
NOT HIT
HIT trigger
HIT background
SATELLITE (CPE) SIDE

The SUSY Particle Spectrum

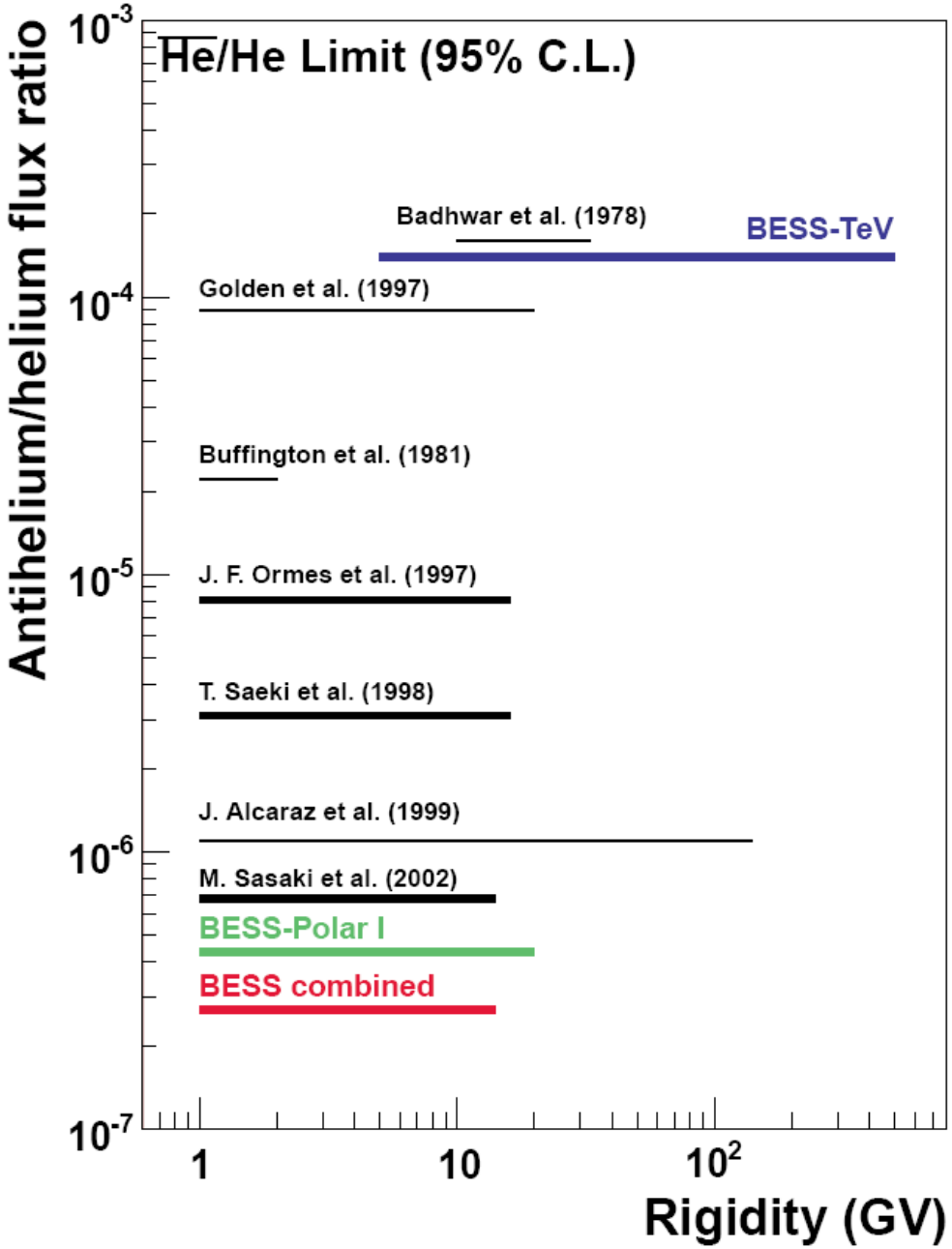
Standard Model

Particles			Sparticles		
Name	Symbol	Spin	Name	Symbol	Spin
leptons	l, ν	1/2	sleptons	$\tilde{l}_R, \tilde{l}_L, \tilde{\nu}_L$	0
quarks	q_L, q_R	1/2	squarks	$\tilde{q}_L, \tilde{q}_R (\tilde{b}_{1,2}, \tilde{t}_{1,2})$	0
photon Z boson light Higgs heavy Higgs pseudoscalar Higgs	γ Z h H A	1 1 0 0 0	neutralinos	$\tilde{\chi}_1^0, \tilde{\chi}_2^0, \tilde{\chi}_3^0, \tilde{\chi}_4^0$	1/2
W boson charged Higgs	$W\pm$ $H\pm$	1 1	charginos	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^\pm$	1/2
gluon	g	1	gluino	$\tilde{g}$	1/2
graviton	G	2	gravitino	$\tilde{G}$	3/2

'LSP'
(usually)

$$\chi = N_1\tilde{\gamma} + N_2\tilde{Z}^0 + N_3\tilde{H}_1^0 + N_4\tilde{H}_2^0; \sum_{i=1}^{4} |N_i|^2 = 1$$

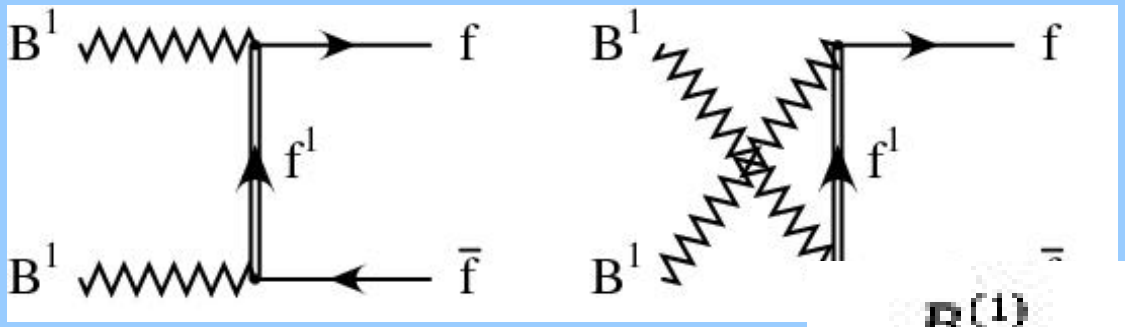
Mark Pearce [pearce@particle.kth.se]


$\overline{He}$/He Limit (95% C.L.)
Antihelium/helium flux ratio
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
Badhwar et al. (1978)
BESS-TeV
Golden et al. (1997)
Buffington et al. (1981)
J. F. Ormes et al. (1997)
T. Saeki et al. (1998)
J. Alcaraz et al. (1999)
M. Sasaki et al. (2002)
BESS-Polar I
BESS combined
1
10
10^2
Rigidity (GV)

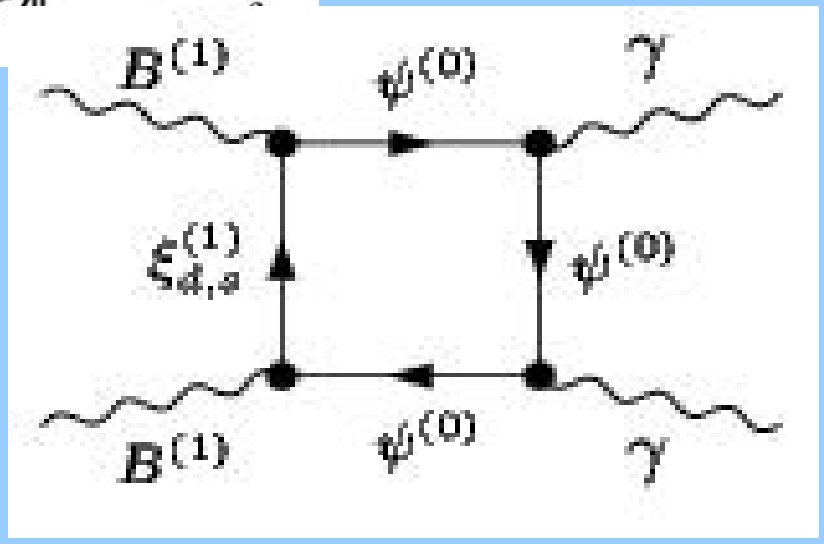
Another possible scenario:
KK Dark Matter

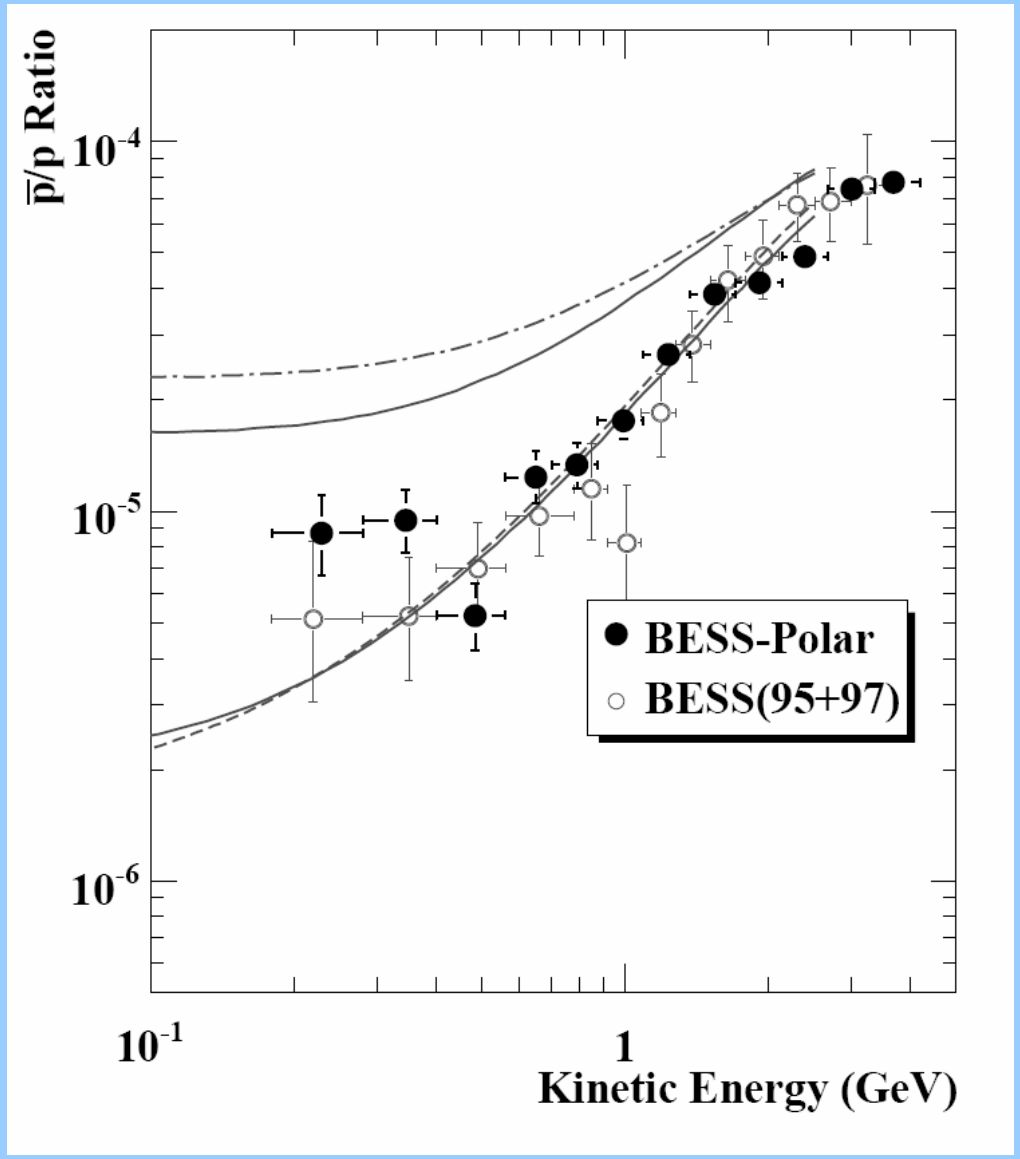
Lightest Kaluza-Klein Particle (LKP): $B^{(1)}$

Bosonic Dark Matter:
fermionic final states
no longer helicity suppressed.
e+e- final states
directly produced.



As in the neutralino case there are 1-loop processes that produces monoenergetic
γ γ in the final state.




$\bar{p}/p$ Ratio
10^{-4}
10^{-5}
10^{-6}
10^{-1}
1
Kinetic Energy (GeV)
BESS-Polar
BESS(95+97)

Cosmic-ray Antimatter from Dark Matter annihilation

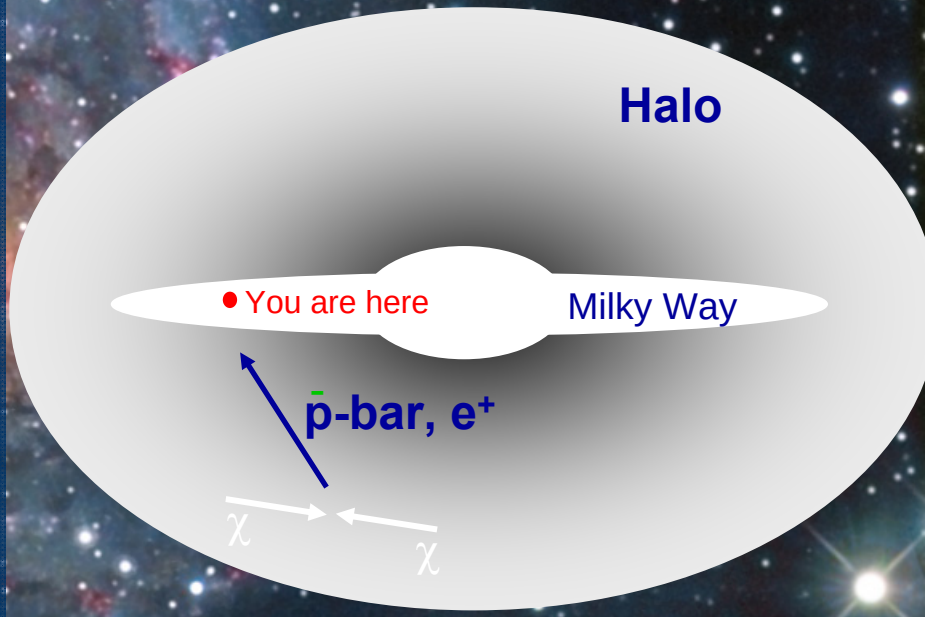
A plausible dark matter candidate is neutralino (χ), the lightest SUSY particle.

Annihilation of relic χ gravitationally confined in the galactic halo

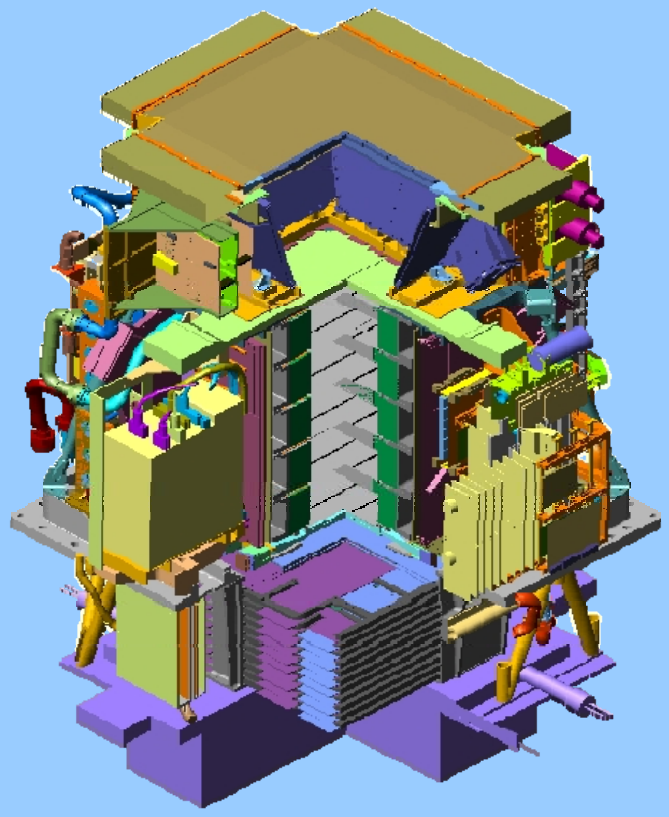
→ Distortion of antiproton and positron spectra from purely secondary production

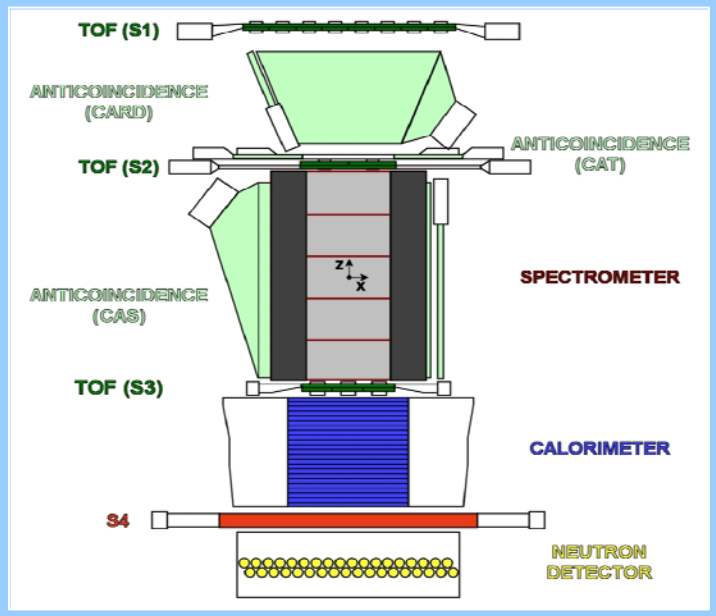
Most likely processes:

- $\chi\chi$ → qq → hadrons→ anti-p, e^+,...
- $\chi\chi$ → W^+W^-,Z^0Z^0,... → e^+,...
  direct dicay ⇒ positron peak $Ee+ \sim M\chi/2$
  other processed ⇒ positron continuum



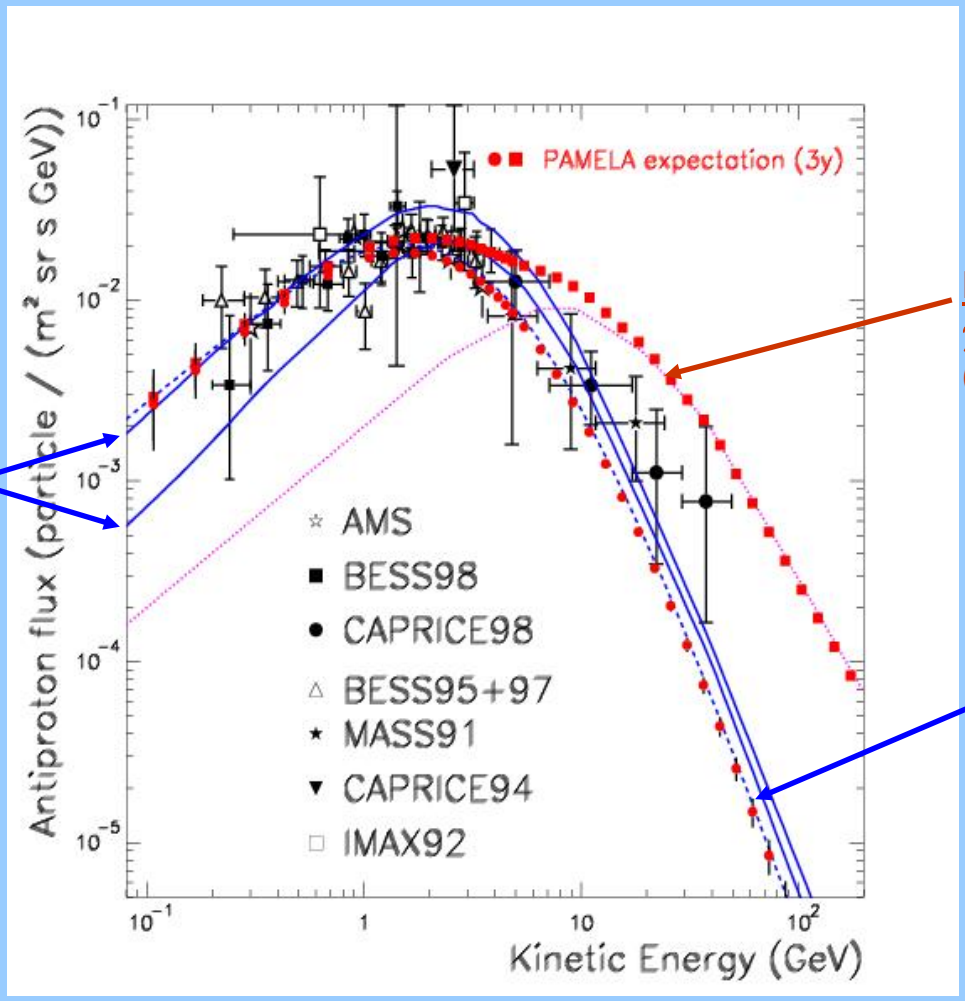
PAMELA apparatus





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

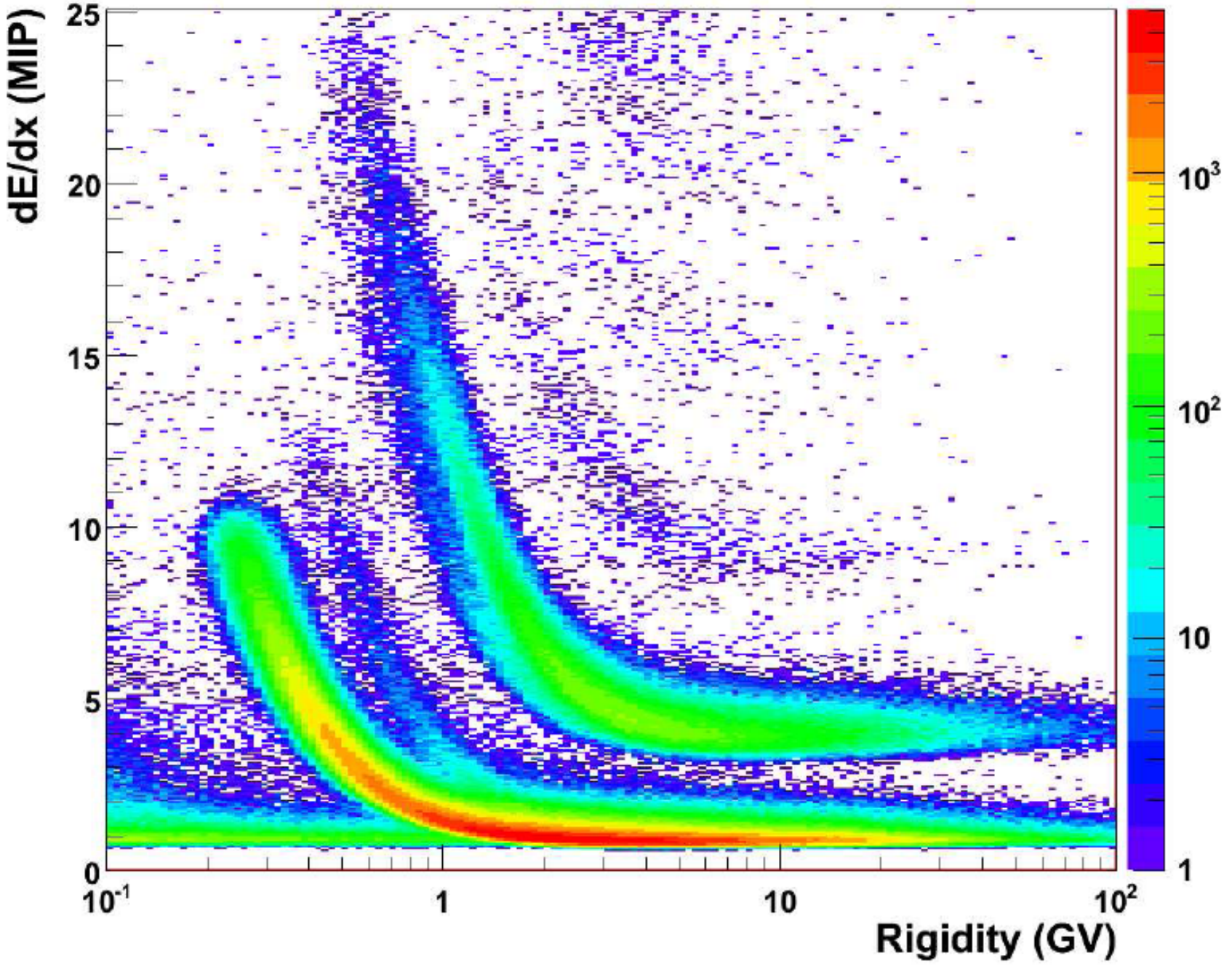
Search of structures in antiproton spectrum

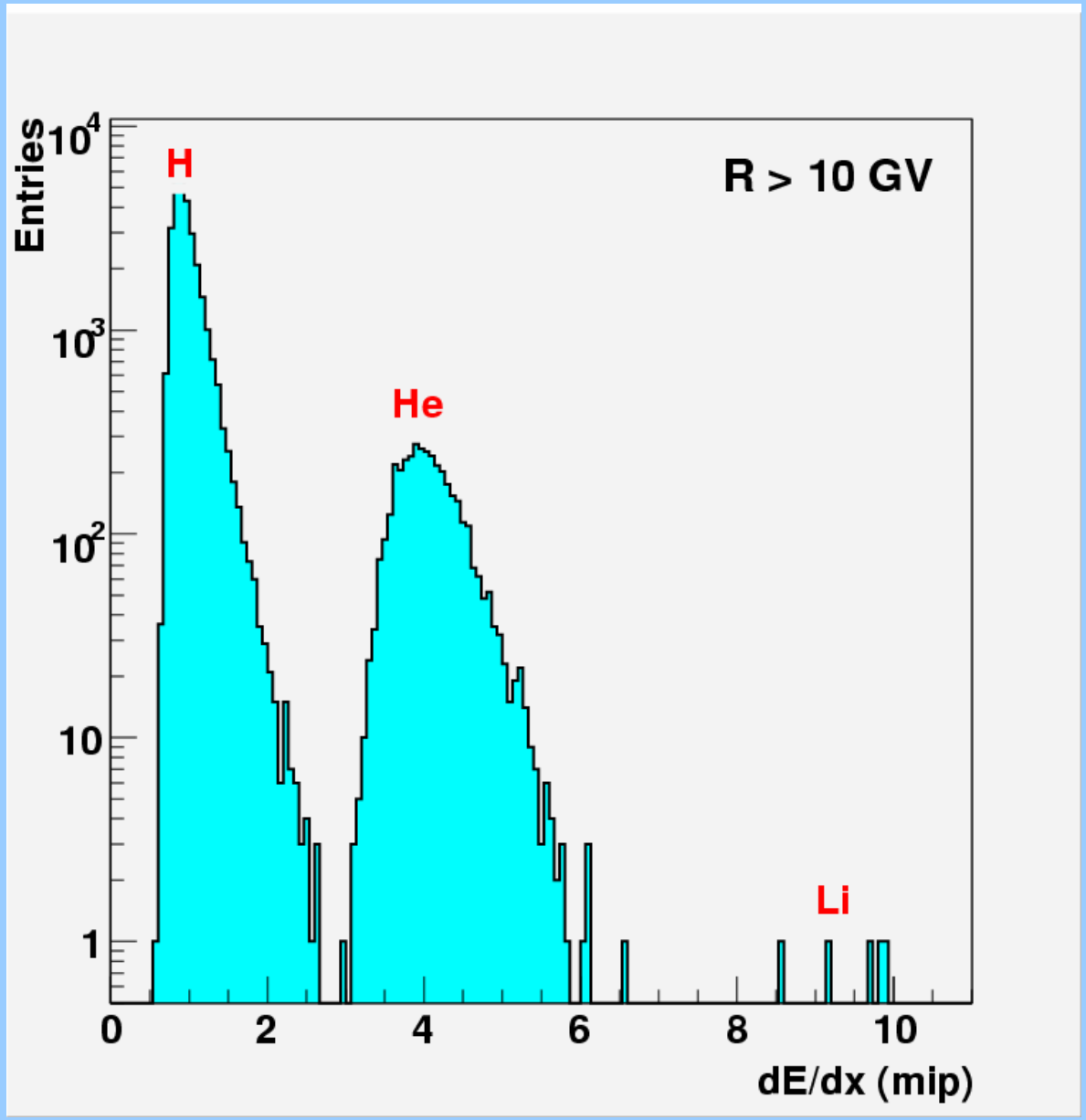


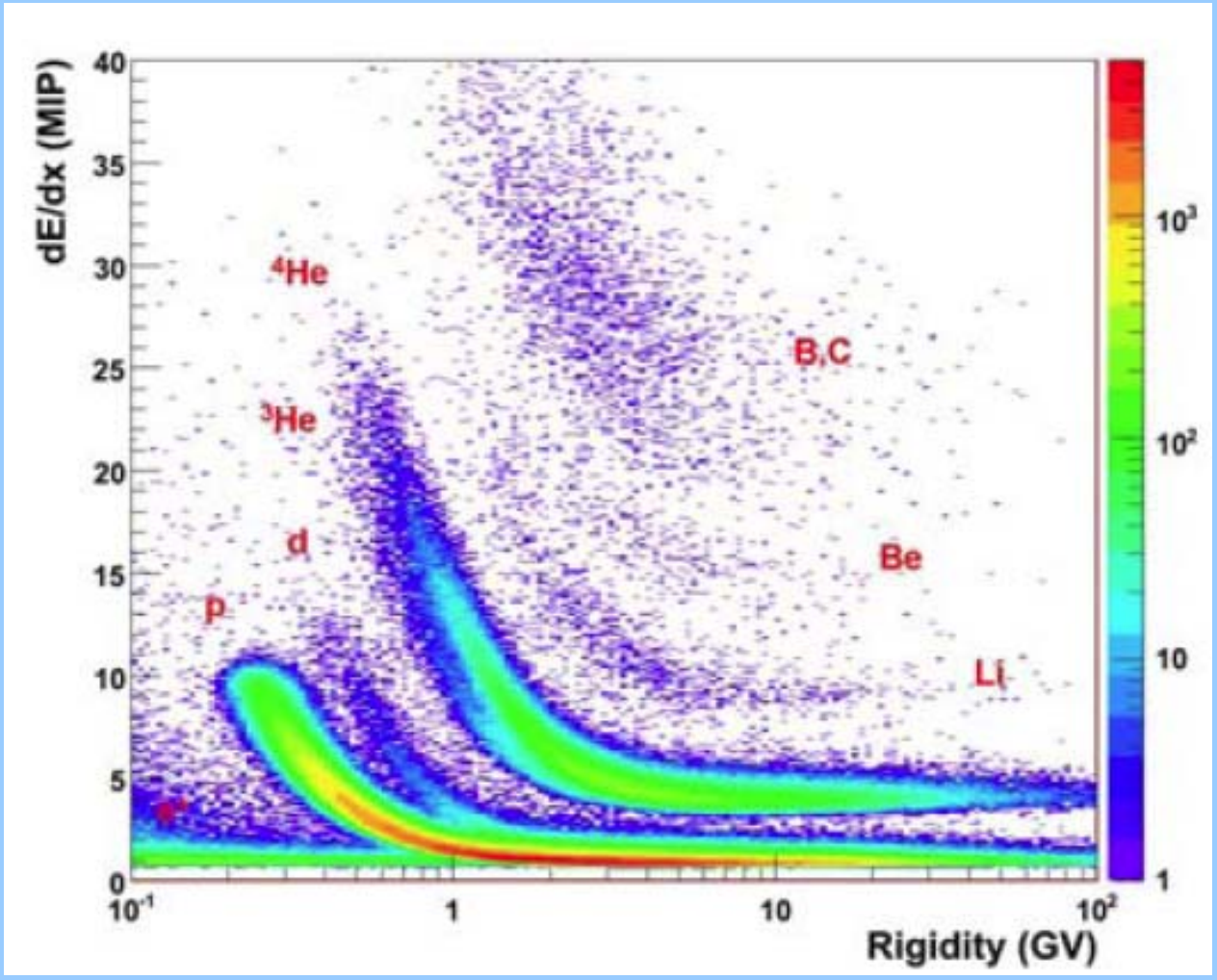
Secondary production
(upper and lower limits)
Simon et al.

Primary production from
$\chi\chi$ annihilation
($m(\chi)$ = ~ 1 TeV)
(astro-ph 9904086)

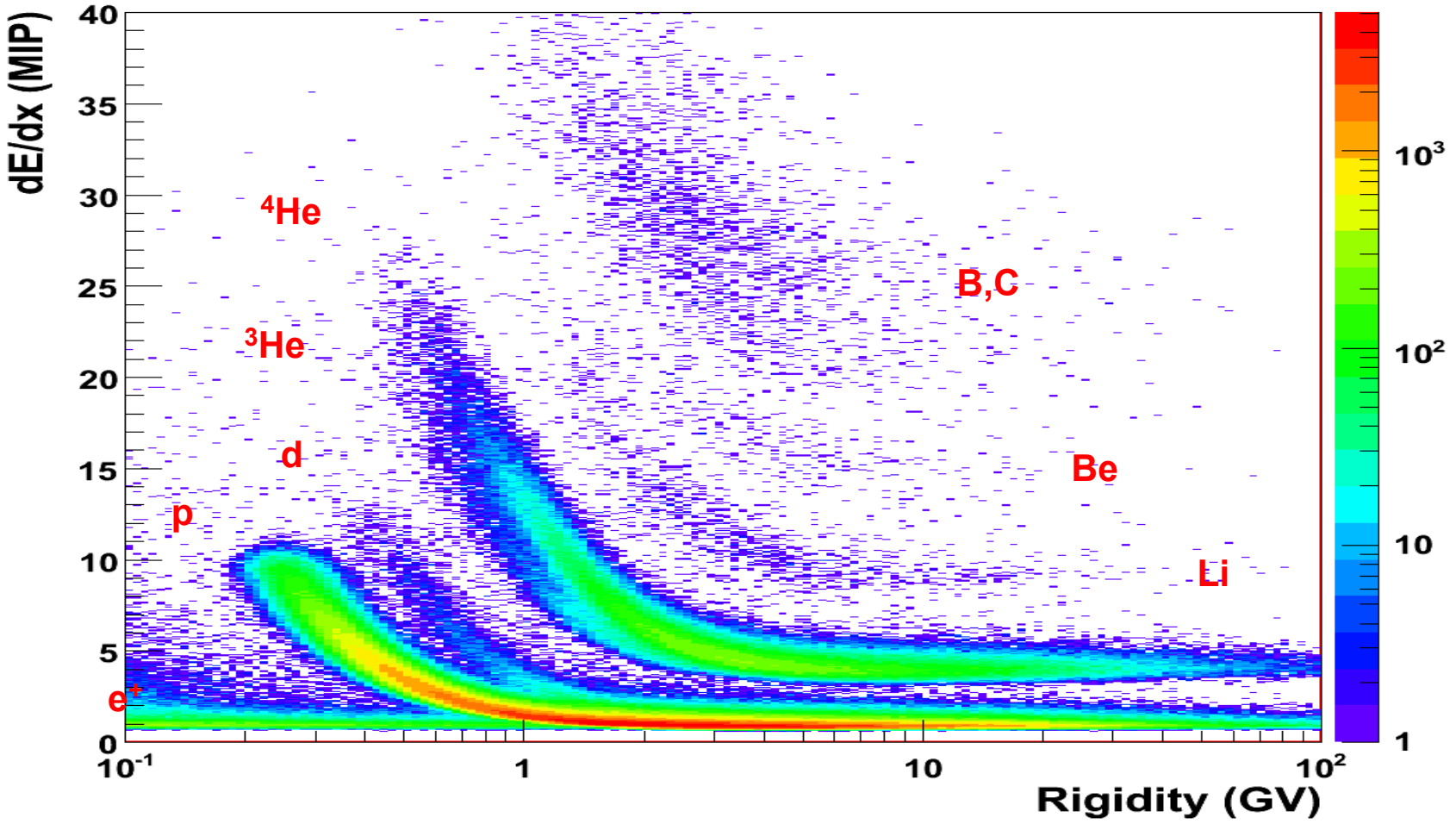
Secondary production
(CAPRICE94-based)
Bergström et al.

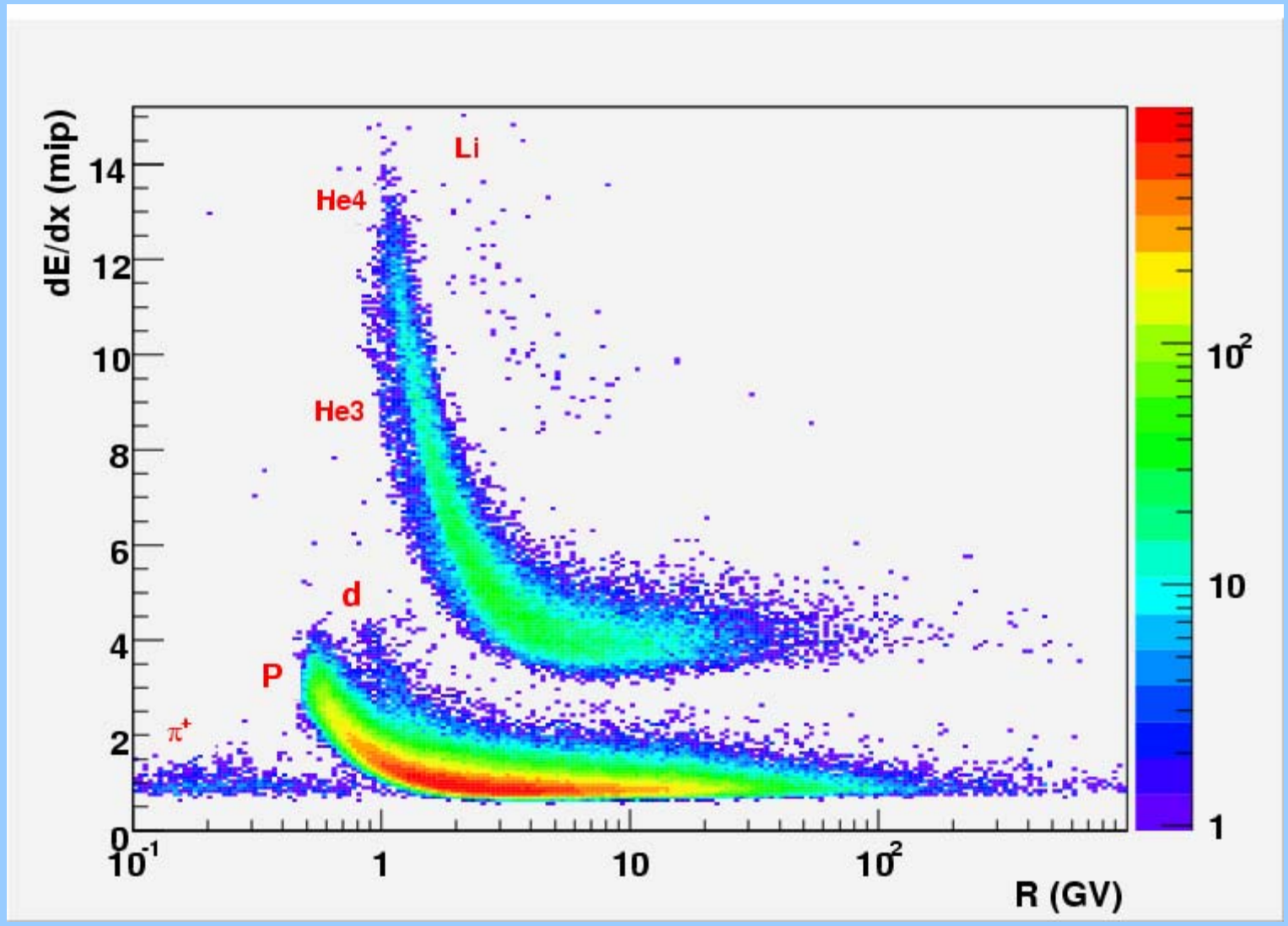

dE/dx (MIP)
25
20
15
10
5
0
10^{-1}
1
10
10^2
Rigidity (GV)
10^3
10^2
10
1


Entries
10^4
10^3
10^2
10
1
H
He
Li
R > 10 GV
0
2
4
6
8
10
dE/dx (mip)


dE/dx (MIP)
40
35
30
25
20
15
10
5
0
^{4}He
^{3}He
d
p
e$^+$
B,C
Be
Li
10^3
10^2
10
1
10^{-1}
1
10
10^2
Rigidity (GV)

Tracker dE/dx

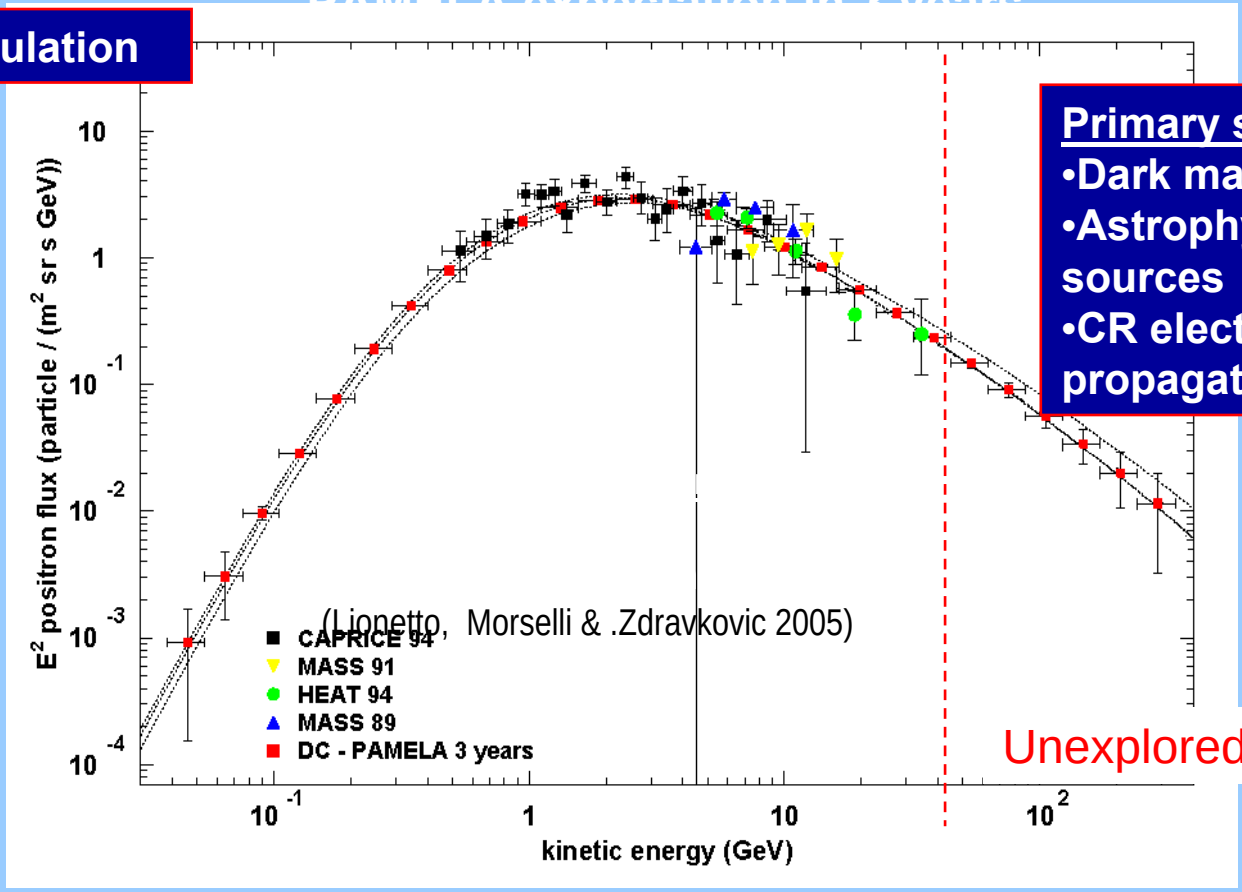



dE/dx (mip)
14
12
10
8
6
4
2
0
Li
He4
He3
d
P
π+
10-1
1
10
10²
R (GV)
10²
10
1

Orbital environment

Positrons

• Solar modulation



Primary sources ?
- Dark matter
- Astrophysical sources
- CR electron propagation

Unexplored Region

Pamela main objectives:

Study of antimatter component in cosmic rays:

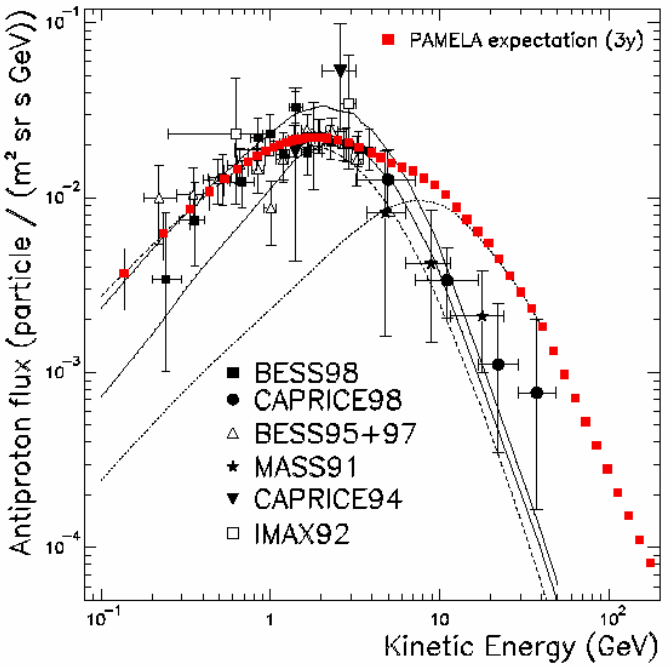
- Antiprotons (80MeV -190 GeV) ~ 10^4
- Positrons (50MeV - 270 GeV) ~ 10^5
- Search for Antihelium (some parts 10^{-8})

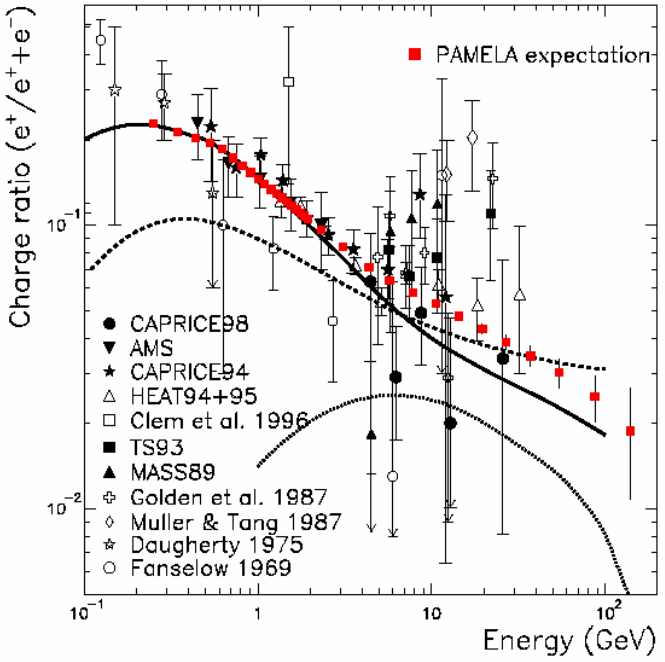
Study of galactic cosmic ray spectrum

- Protons (80MeV - 700 GeV) ~ 10^8
- Electrons (50MeV – 400 GeV) ~ 10^6
- Electron+positron (up to 2TeV)
- Nuclei (He/Be/C) ~$10^{7/4/5}$

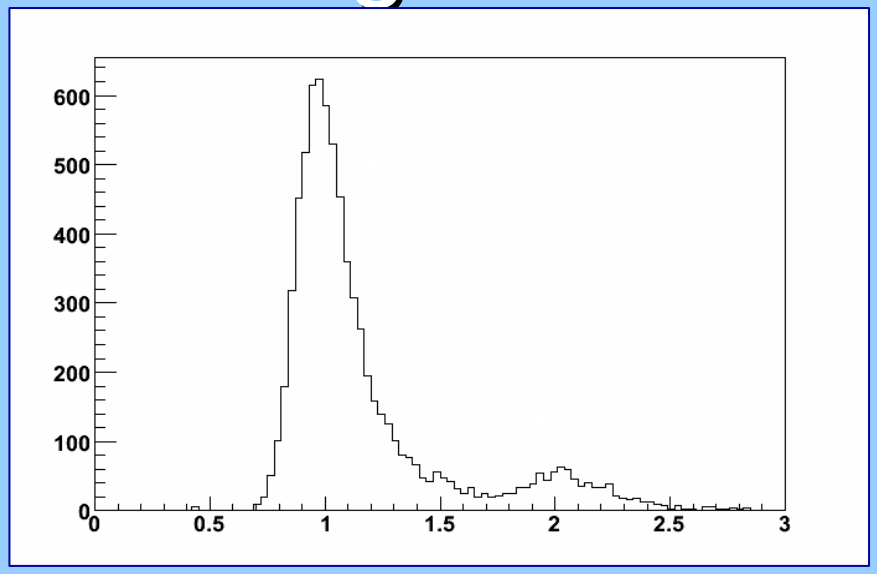
- Geom. Fact. 21.5 cm^2 sr,
400 cm^2 sr (in calo self trigger mode)

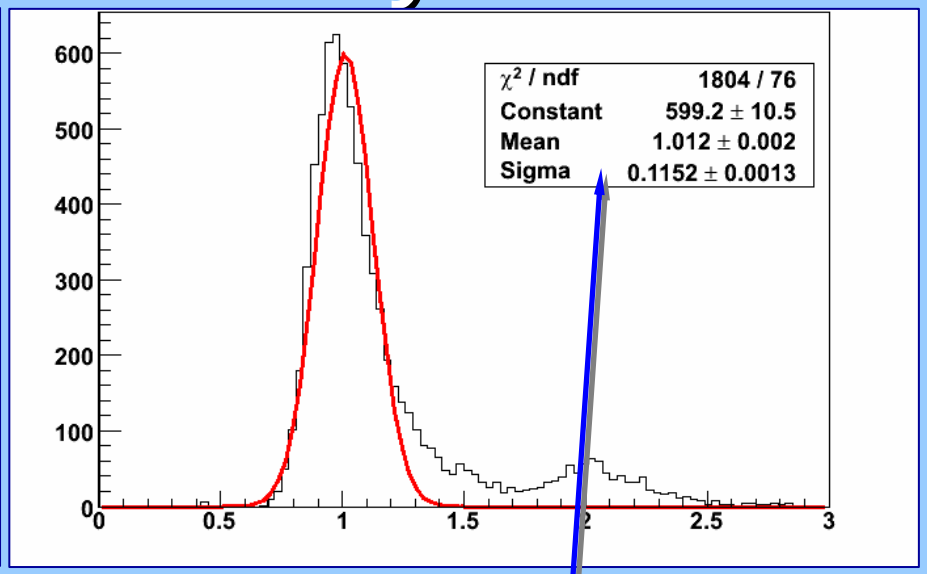
Taking into account live time and geometrical factor:
1 HEAT-PBAR flight ~ 22.4 days PAMELA data
1 CAPRICE98 flight ~ 3.9 days PAMELA data

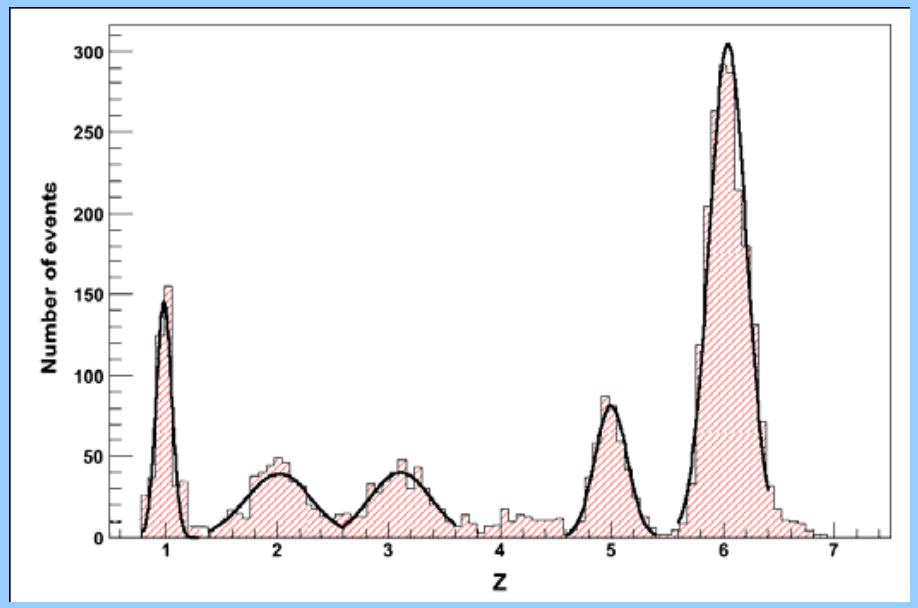




Charge reconstruction by TOF

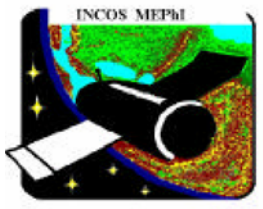






σ (Z=1)= ~ 0.12

Z	σ (GSI)
1	0.15
2	0.31



Модель суперсимметрии объединяет фермионы и бозоны. Каждой частице со спином соответствует партнер со спином $|j-1/2|$

Частица - Счастица
Кварк – скварк (*sq*)
Лепон – слептон (*sl*)

$\bar{\gamma}$ - фотино
$\overline{\mathrm{Z}}$ - зино
$\overline{\mathrm{H}}_{12}$ - хиггсино
$\overline{\mathrm{W}}^{\pm}$ - вино

нейтралино (χ)

$$\chi_i = a_1\bar{\gamma} + a_2\bar{Z}^0 + a_3\bar{H}_1^0 + a_4\bar{H}_2^0$$

чарджино (ψ)

$$\psi^{\pm} = c_1\bar{W}^{\pm} + c_2\bar{H}^{\pm}$$

PAMELA status

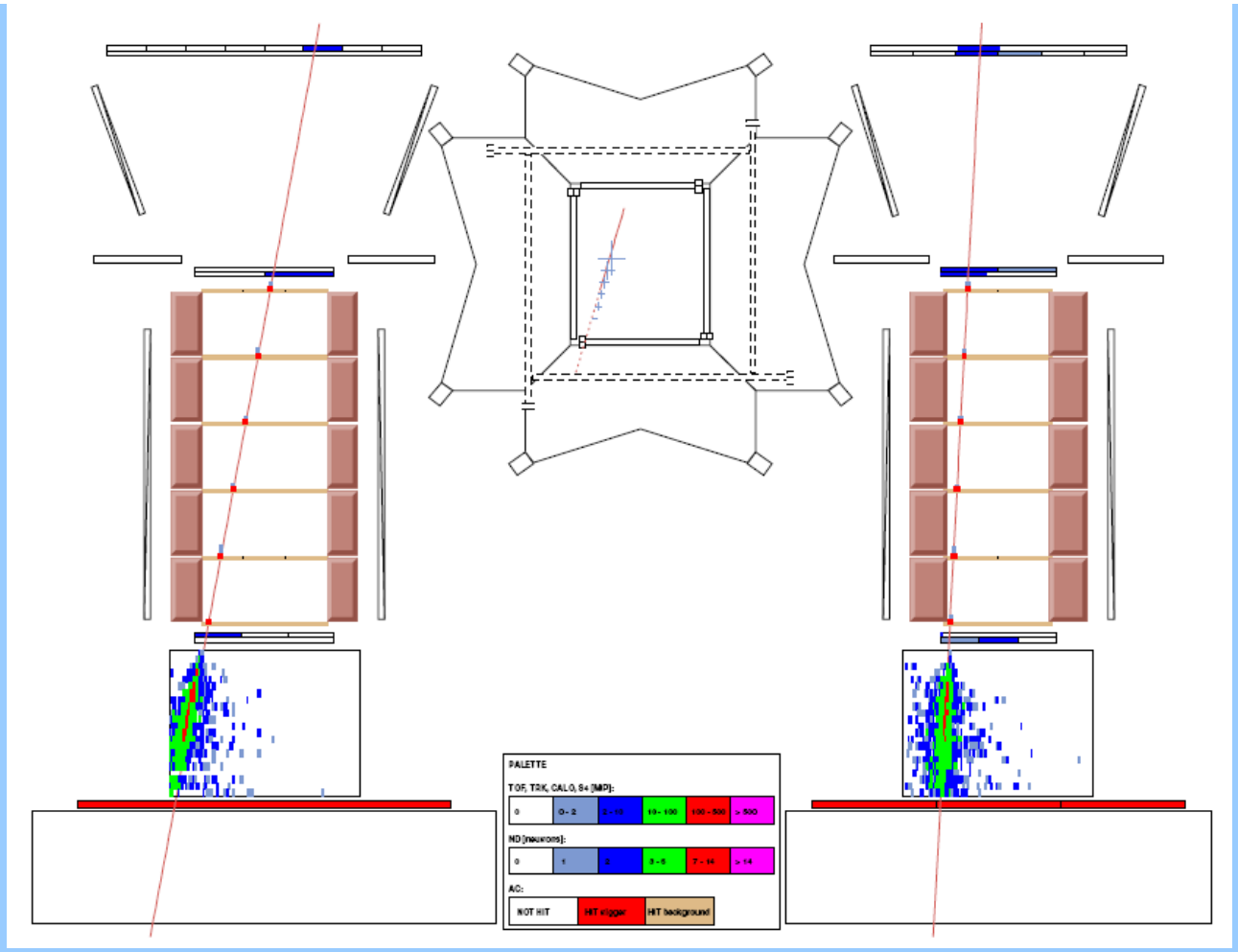
First switch-on on June 21st 2006

- Detectors in nominal conditions (no problems due to the launch)
- Tested different trigger and hardware configurations
- Commissioning phase successfully ended on September 15th 2006

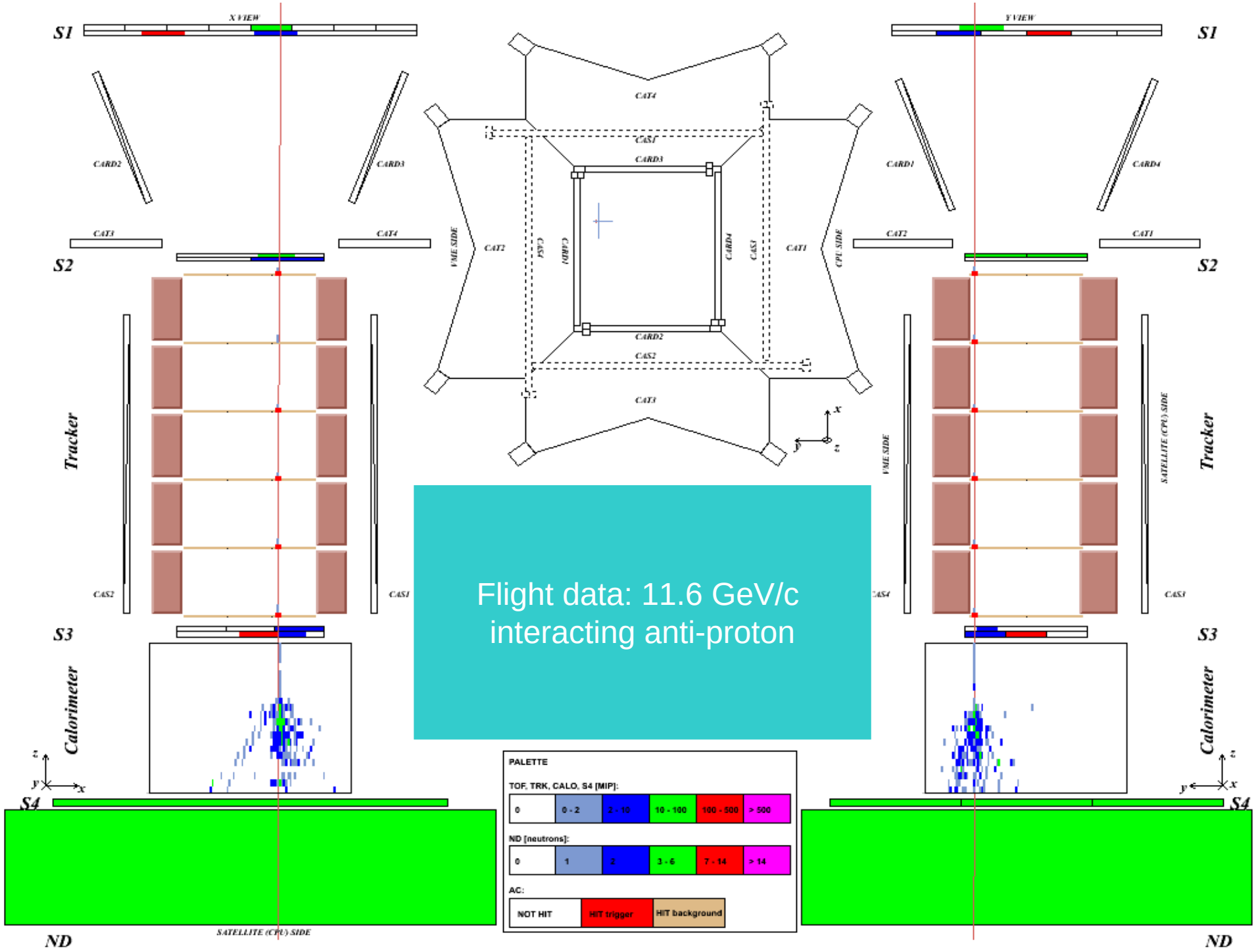
→ PAMELA in continuous data-taking mode

At January 30th 2007:

- PAMELA ON for **201 days**
- 20880 acquisition runs
- 2.8 TB of raw data
- **344961274 triggers recorded**
- 13905282 s (~ **161 days**) of total acquisition time



70 GV positron


X VIEW
Y VIEW
S1
S2
S3
S4
Tracker
Calorimeter
ND
CARD1
CARD2
CARD3
CARD4
CAT1
CAT2
CAT3
CAT4
CAS1
CAS2
CAS3
CAS4
VME SIDE
CPE SIDE
SATELLITE (CPE) SIDE
Flight data: 11.6 GeV/c
interacting anti-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

Matter in the Universe

Microwave Anisotropy
WMAP - NASA - Explorer Mission

$$\Omega_{total} = \frac{\rho_{total}}{\rho_{crit.}} = 1$$

(Universe is flat)

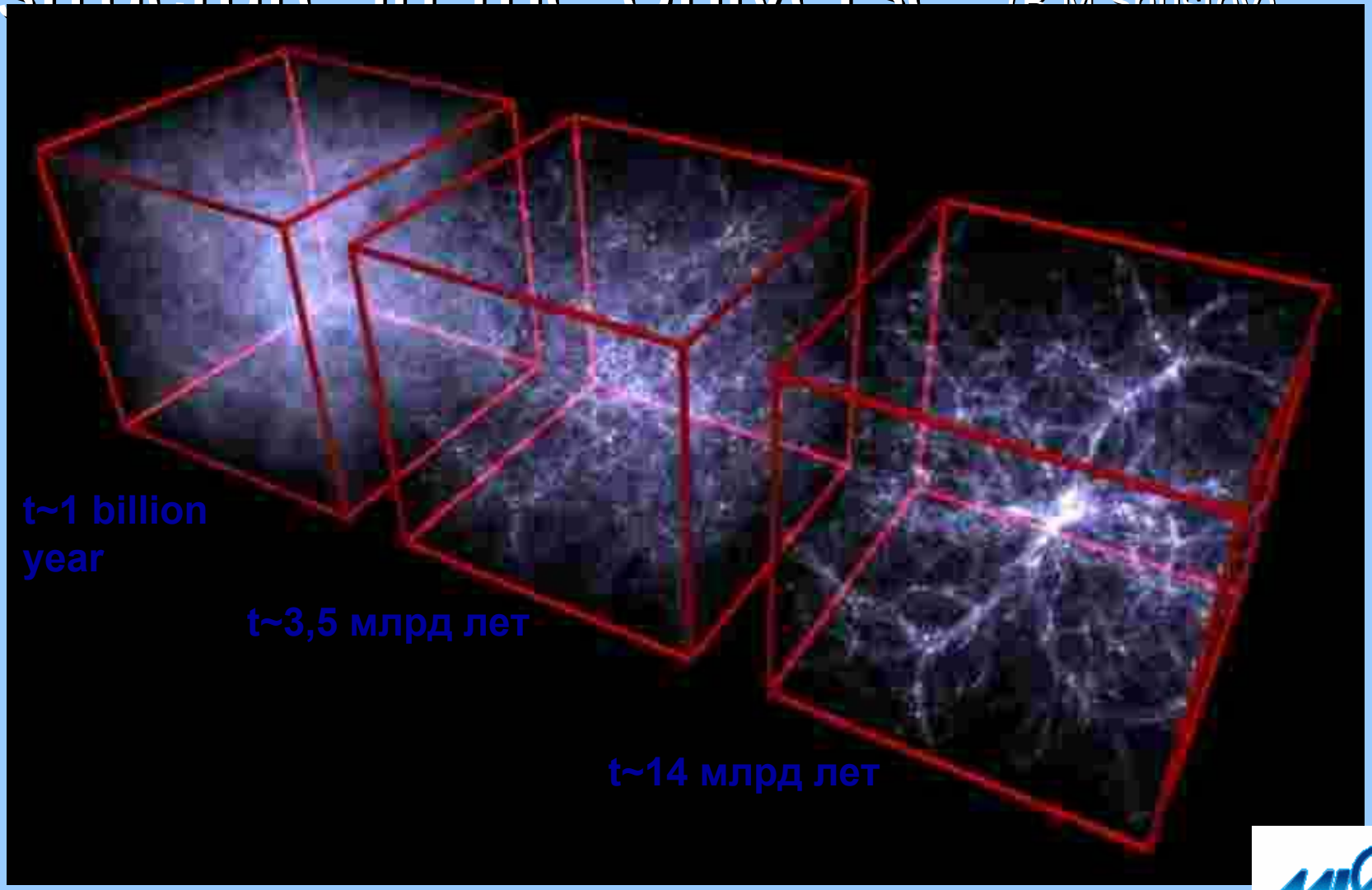
$$\rho_{crit.} = \frac{3H^2(t)}{8\pi G}$$

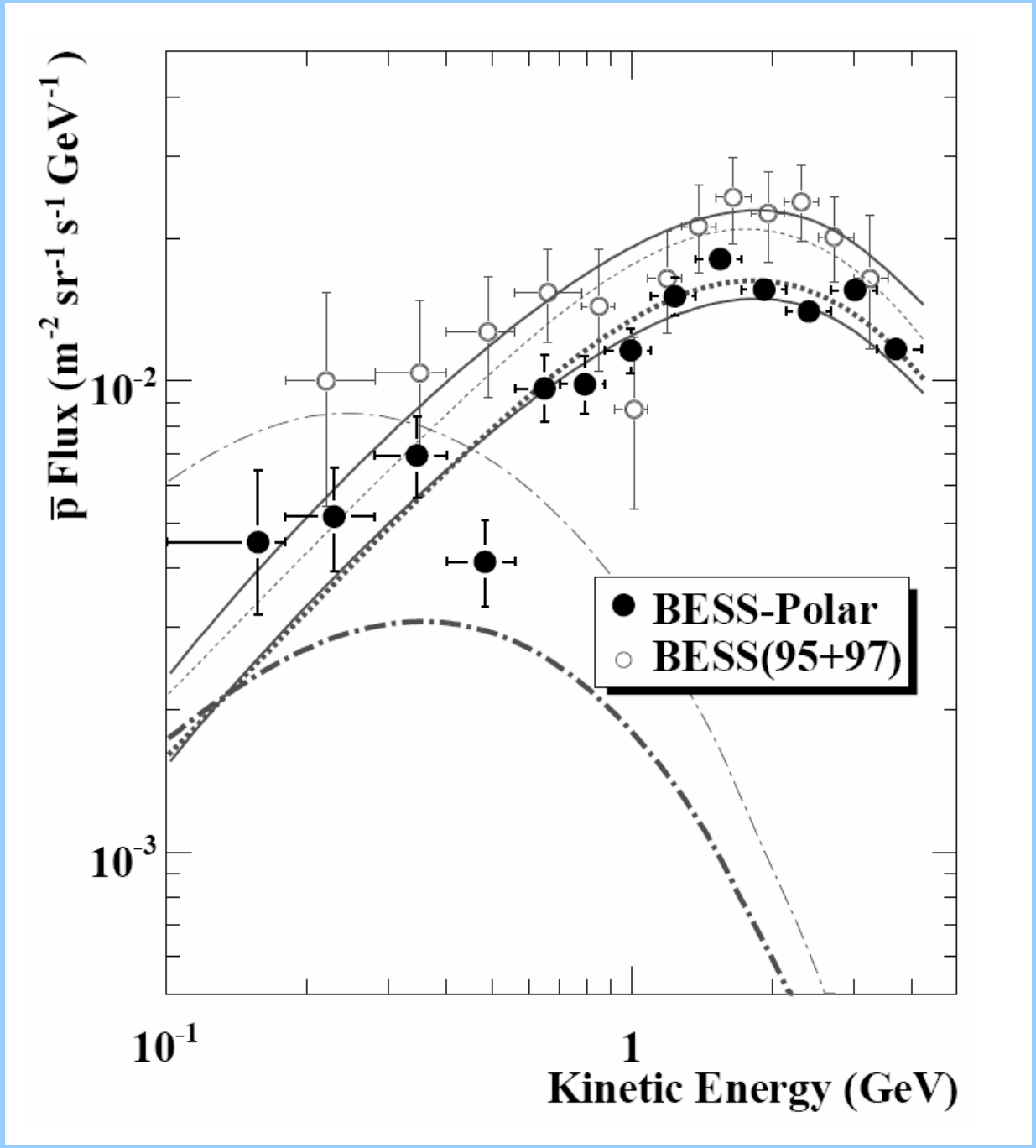
$$\Omega_{total} = \underbrace{\Omega_{total,baryon.}}_{\text{baryonic matter } 5\%} + \underbrace{\Omega_{dyn.}}_{\text{dark matter } 25\%} + \underbrace{\Omega_{required}}_{\text{dark energy } 70\%}$$

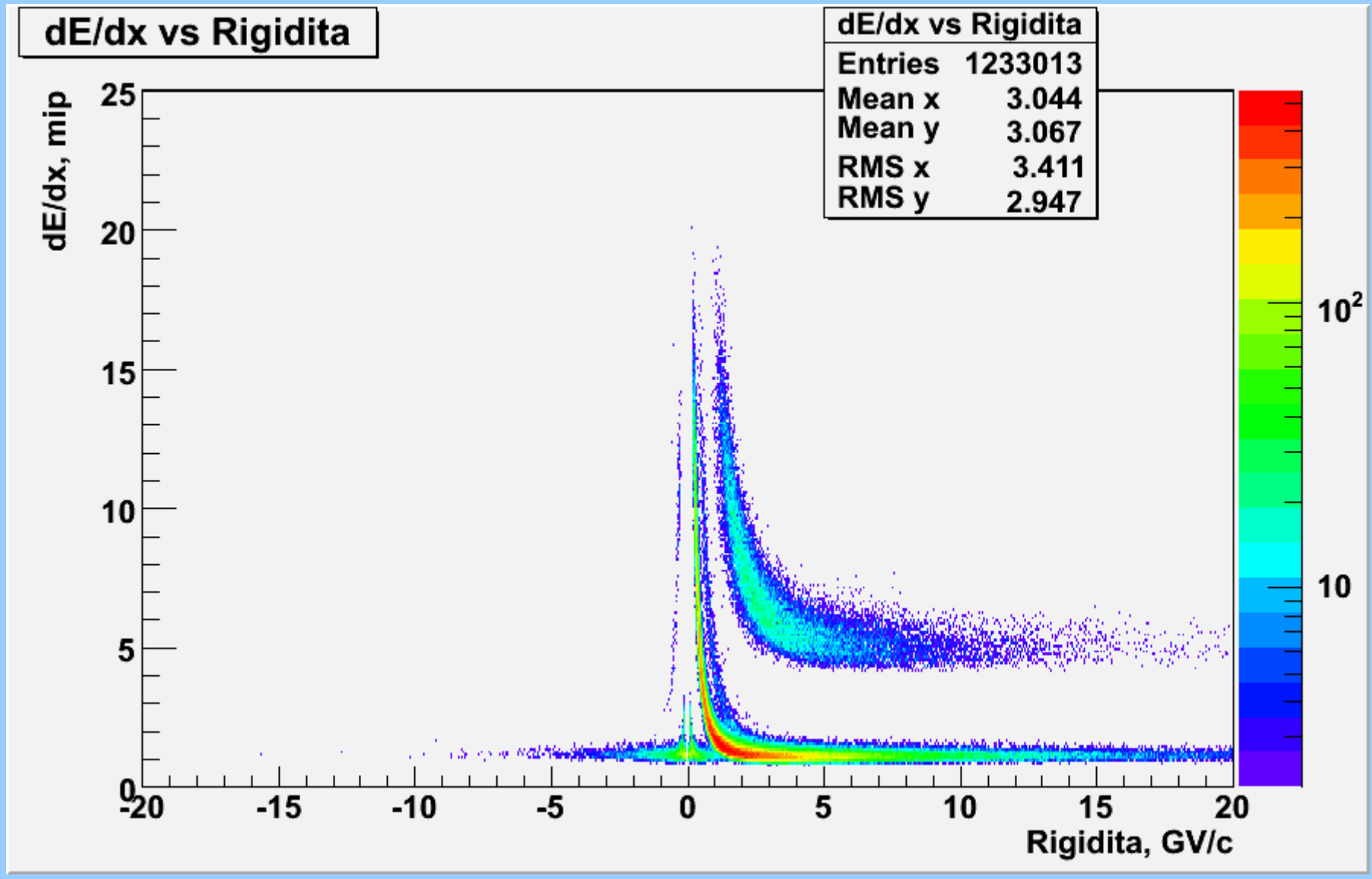
baryonic matter 5%	dark matter 25%	dark energy 70%
	??	???
stars, galaxies	candidates:	quintessence

- WIMPs
- Q-balls
- axions
- Kaluza-Klein-part.

Development of dark matter structure in the Universe (R.M.Shustov)

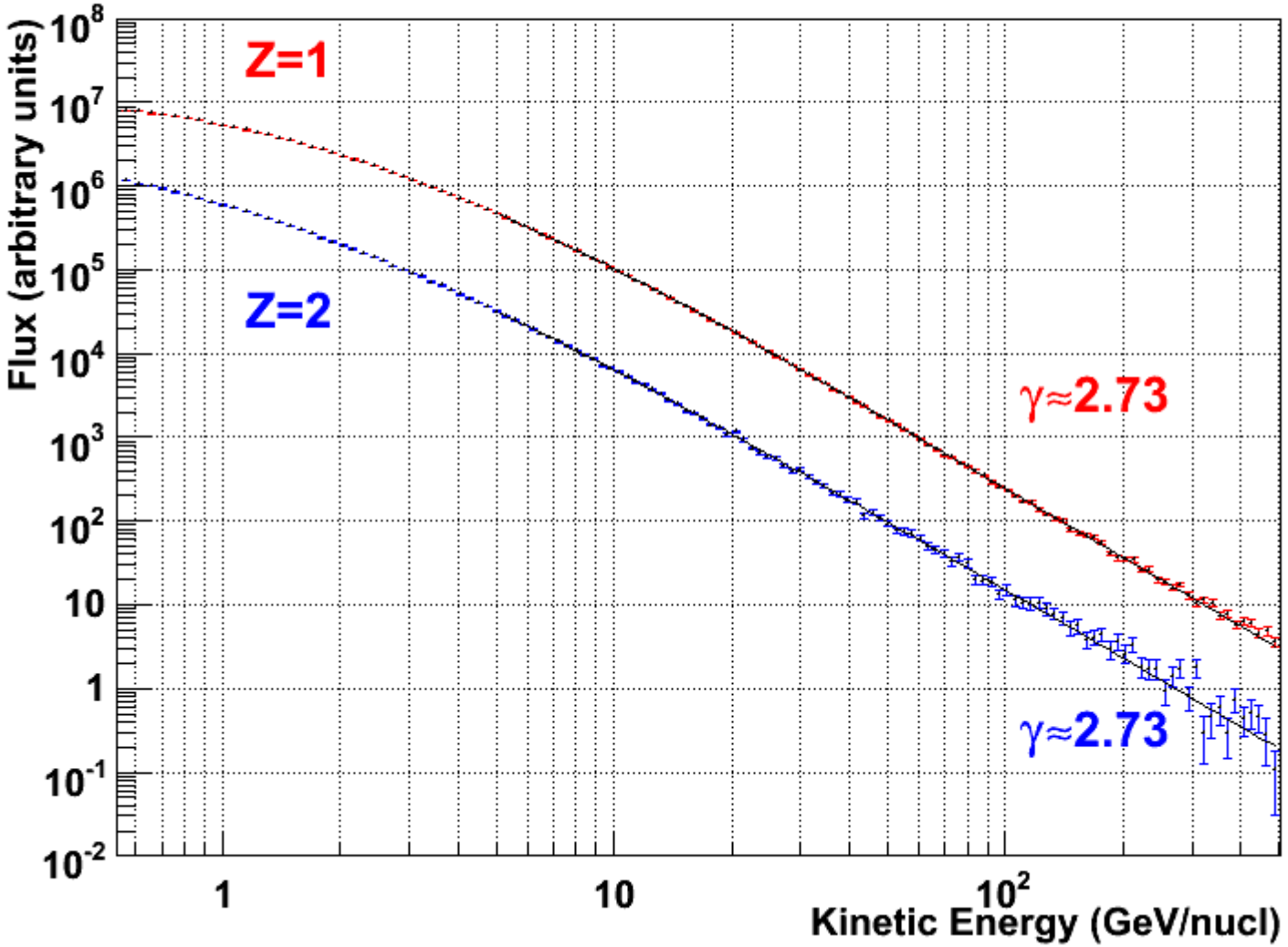


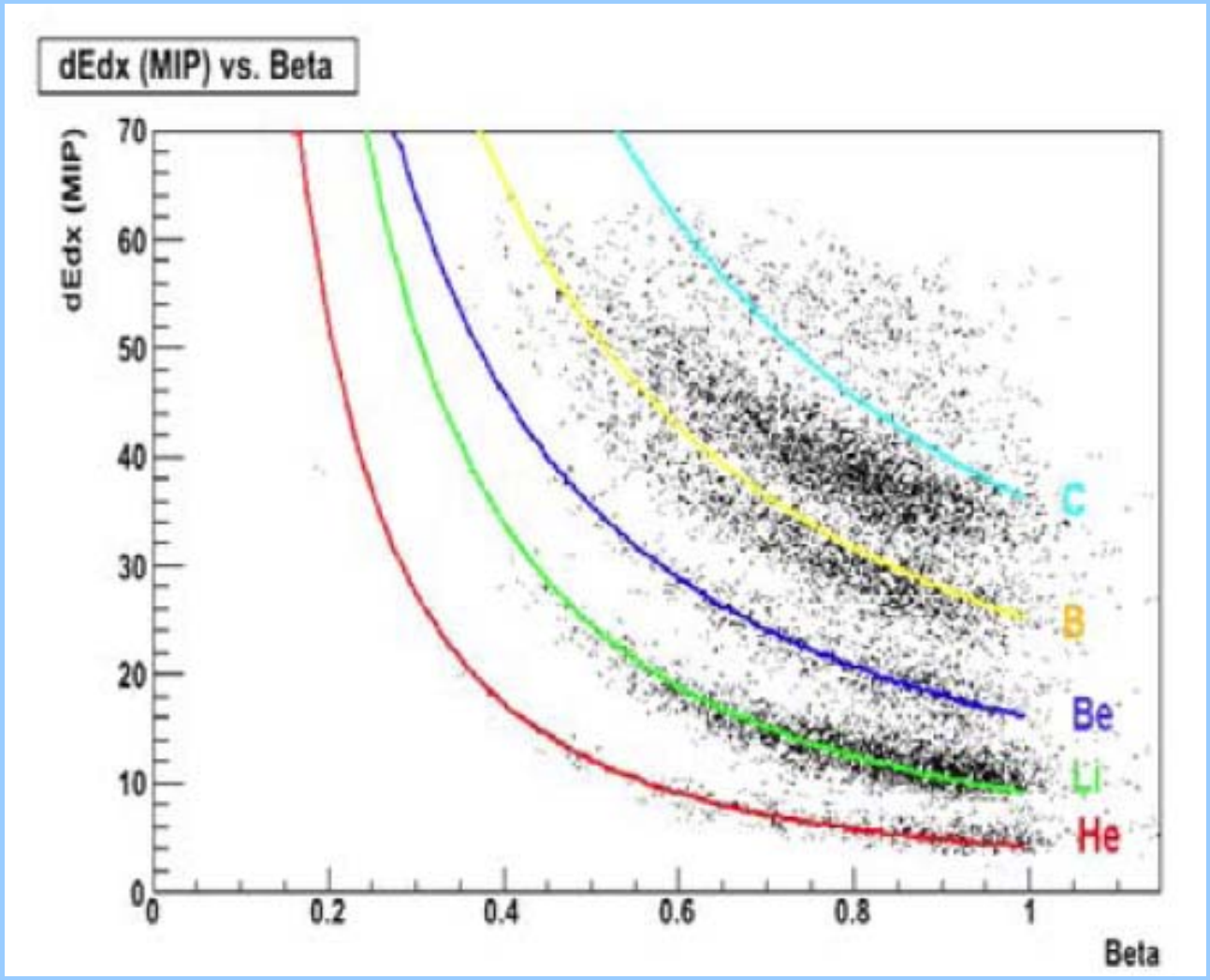

$\bar{p}$ Flux (m^{-2} sr^{-1} s^{-1} GeV^{-1})
10^{-2}
10^{-3}
10^{-1}
1
Kinetic Energy (GeV)
BESS-Polar
BESS(95+97)

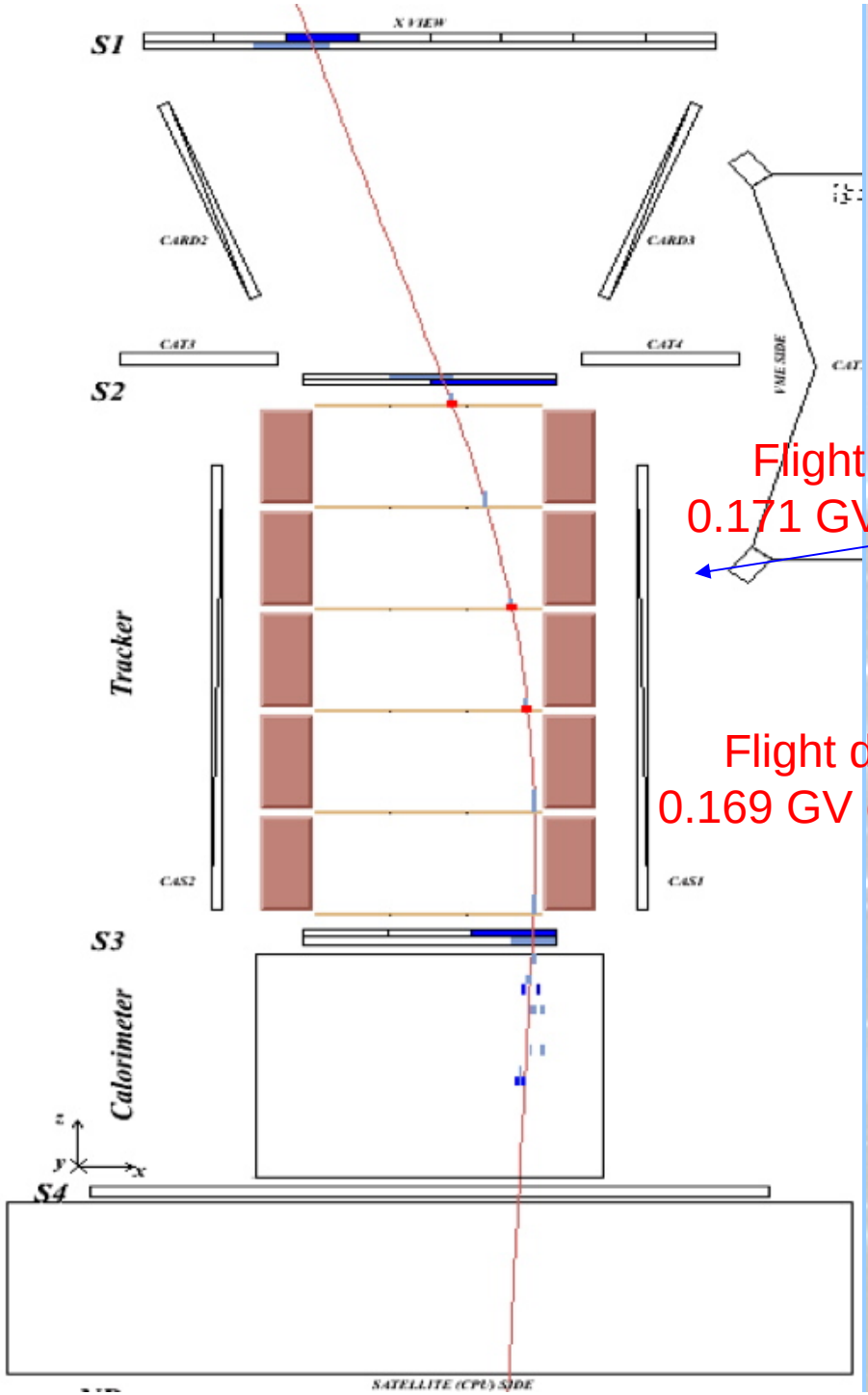

dE/dx vs Rigidita
dE/dx vs Rigidita
Entries 1233013
Mean x 3.044
Mean y 3.067
RMS x 3.411
RMS y 2.947
dE/dx, mip
25
20
15
10
5
0
-20
-15
-10
-5
0
5
10
15
20
Rigidita, GV/c
10^2
10

Galactic H and He spectra

Preliminary !!!

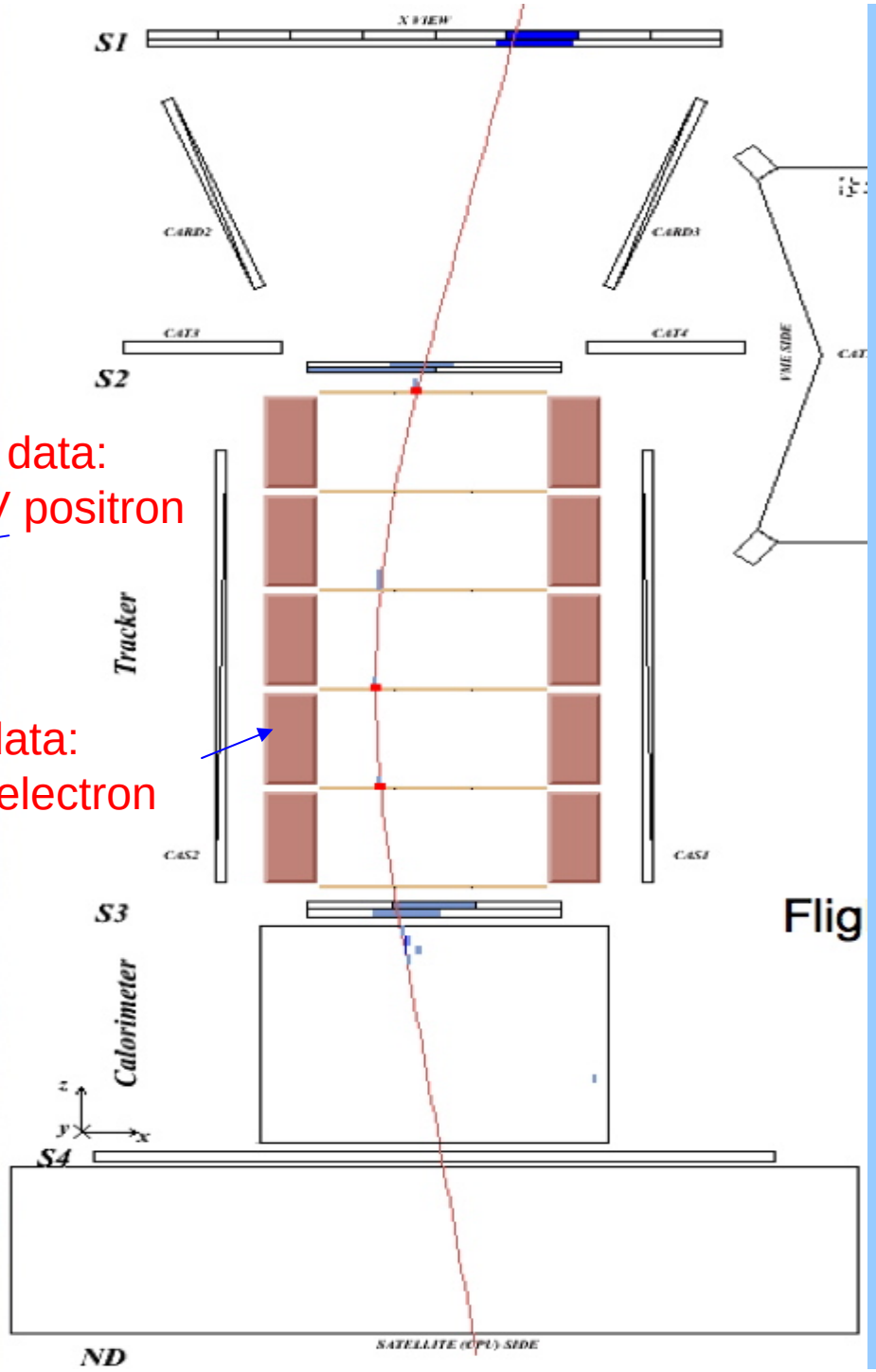



dEdx (MIP) vs. Beta
dEdx (MIP)
70
60
50
40
30
20
10
0
0
0.2
0.4
0.6
0.8
1
Beta
C
B
Be
Li
He

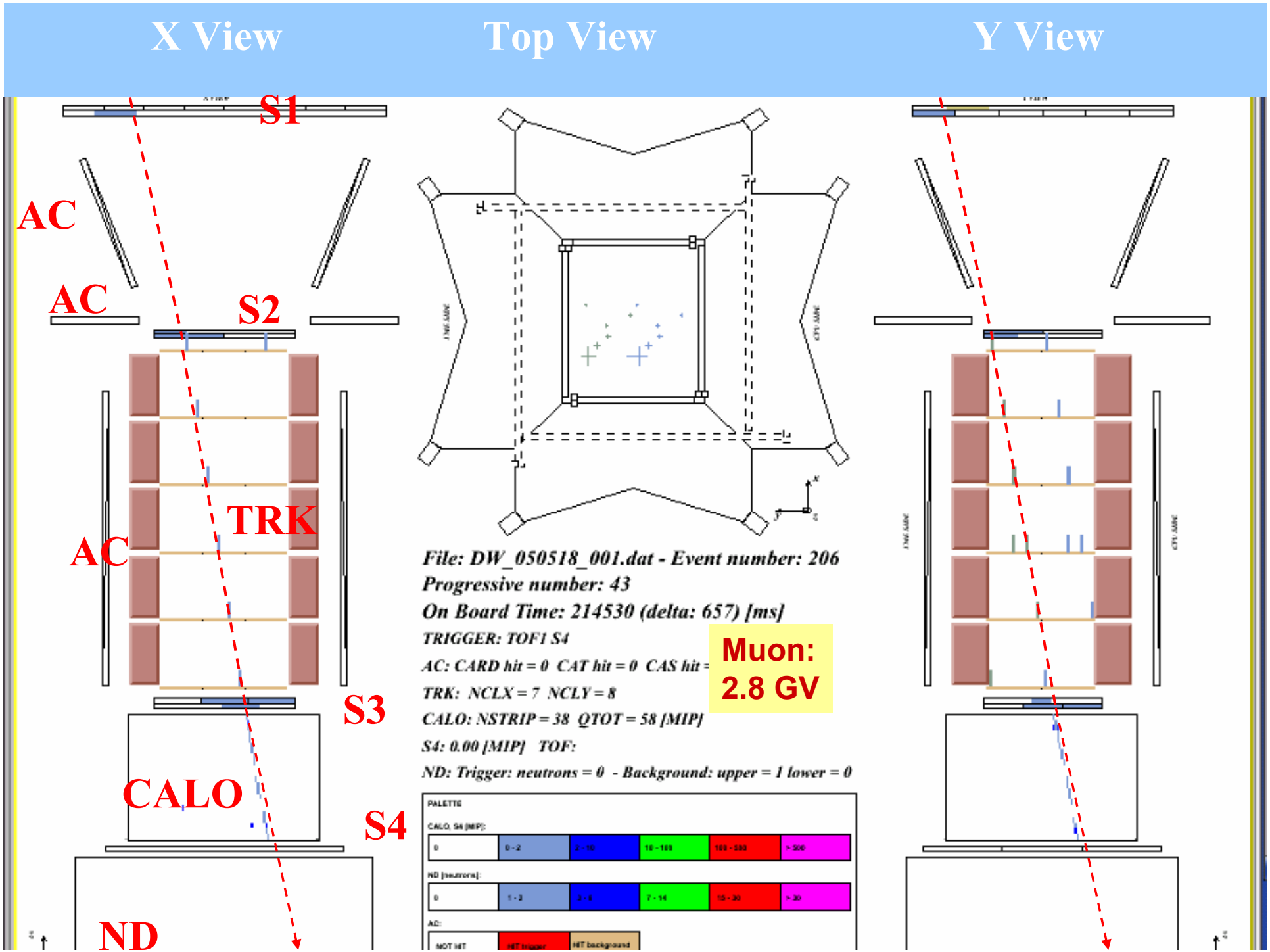


Flight data:
0.171 GV positron

Flight data:
0.169 GV electron



Flig


X View
Top View
Y View
S1
AC
AC
S2
TRK
AC
S3
CALO
S4
ND
File: DW_050518_001.dat - Event number: 206
Progressive number: 43
On Board Time: 214530 (delta: 657) [ms]
TRIGGER: TOF1 S4
AC: CARD hit = 0 CAT hit = 0 CAS hit =
TRK: NCLX = 7 NCLY = 8
CALO: NSTRIP = 38 QTOT = 58 [MIP]
S4: 0.00 [MIP] TOF:
ND: Trigger: neutrons = 0 - Background: upper = 1 lower = 0
Muon:
2.8 GV
PALETTE
CALO, S4 [MIP]:
0
0 - 2
2 - 10
10 - 100
100 - 500
> 500
ND [neutrons]:
0
1 - 3
3 - 7
7 - 14
15 - 30
> 30
AC:
NOT HIT
HIT trigger
HIT background