The PAMELA Space Mission

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

M. Ricci (INFN Frascati National Laboratories, Italy)

on behalf of the PAMELA Collaboration

Space Part 06 - Beijing 19-21 April 2006

PAMELA International Collaboration

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

Russia:
Moscow
St. Petersburg

USA:
GSFC
NMSU

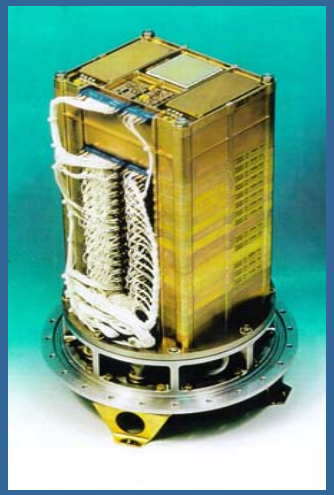
India:
Mumbai

Germany:
Siegen

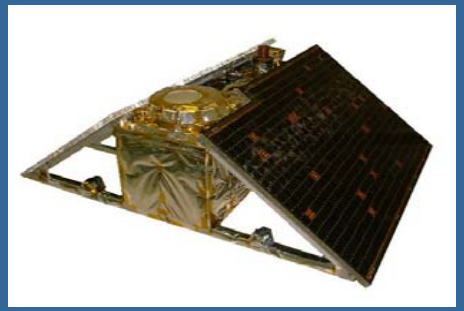
Sweden:
KTH, Stockholm

Past, Present and Future Projects

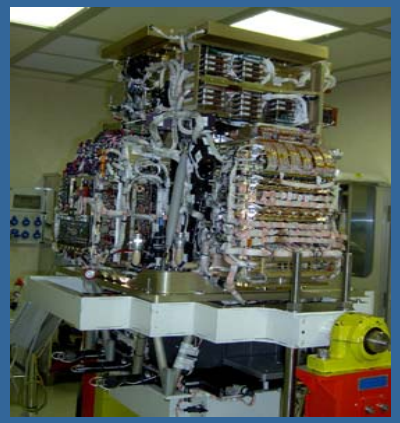
MASS-89, 91, TS-93, CAPRICE 94-97-98



NINA-1



NINA-2



PAMELA

GLAST

AGILE

M 89 M 91 TS 93 C 94 C 97 C 98 **PAMELA**

1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 ...

NINA-1 **NINA-2** **LAZIO-SIRAD**

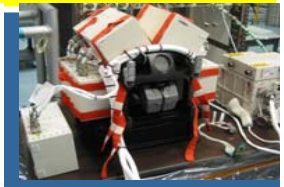
SILEYE-1 **SILEYE-2** **SILEYE-3** **ALTEA**

SILEYE-1

SILEYE-2

SILEYE-3/ ALTEINO:

LAZIO-SIRAD



SILEYE-4/ALTEA

PAMELA detectors

Tot. Weight 450 Kg, Power 360 W; h=120 cm

ToF

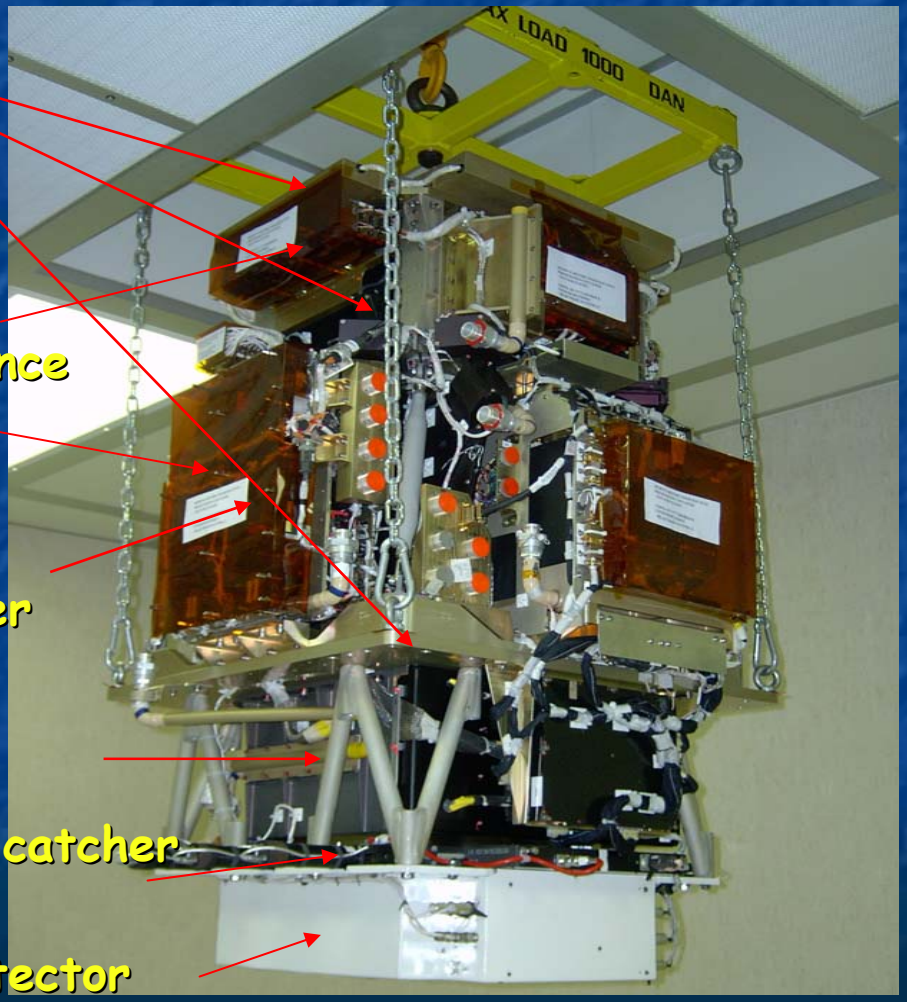
Anticoincidence shield

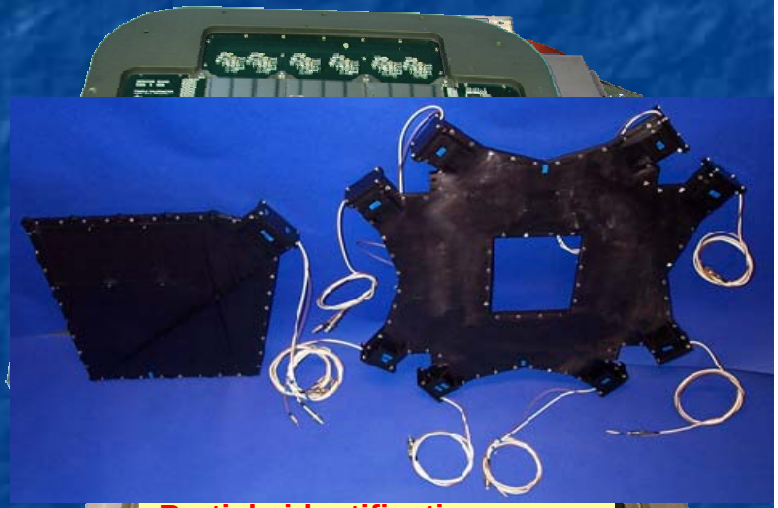
Magnetic spectrometer

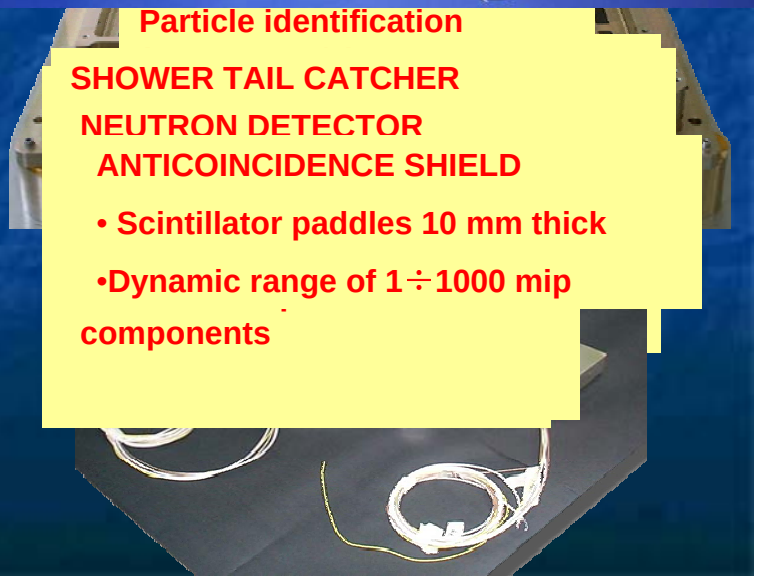
Calorimeter

Shower tail catcher Scintillator

Neutron Detector







Particle identification

SHOWER TAIL CATCHER

NEUTRON DETECTOR

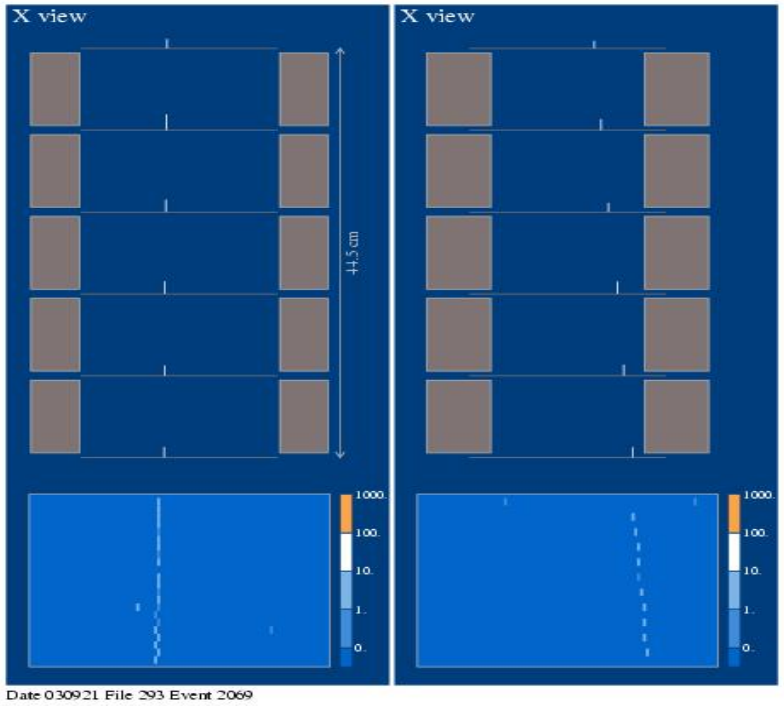
ANTICOINCIDENCE SHIELD

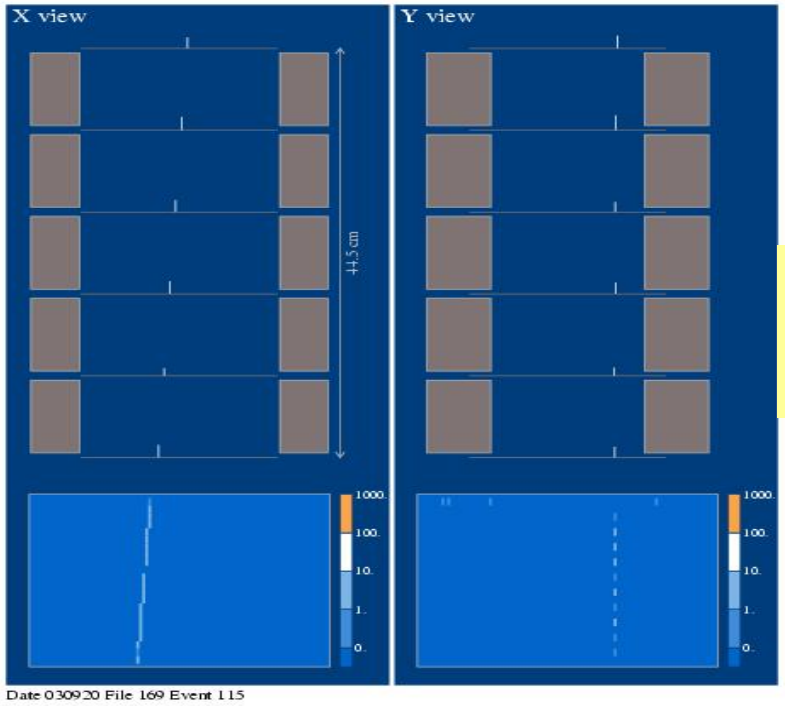
- **Scintillator paddles 10 mm thick**
- **Dynamic range of 1÷1000 mip components**

TESTS AT CERN SPS
AND GROUND RUNS IN ROME

Tracker + Calorimeter Performance

SPS Test Beam Data: p 50 GeV/c

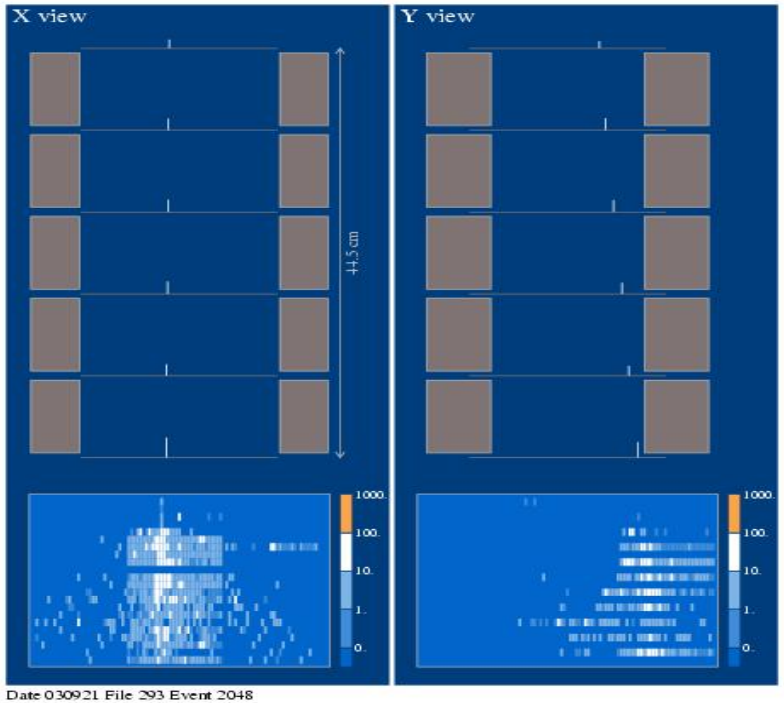


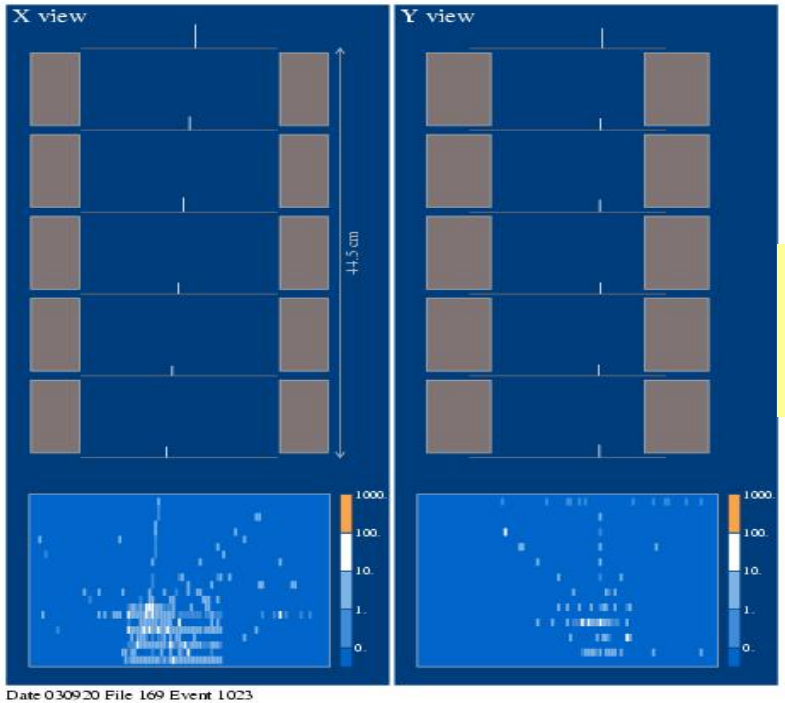


SPS Test Beam Data: p 100 GeV/c

Tracker + Calorimeter Performance

SPS Test Beam Data: p 50 GeV/c

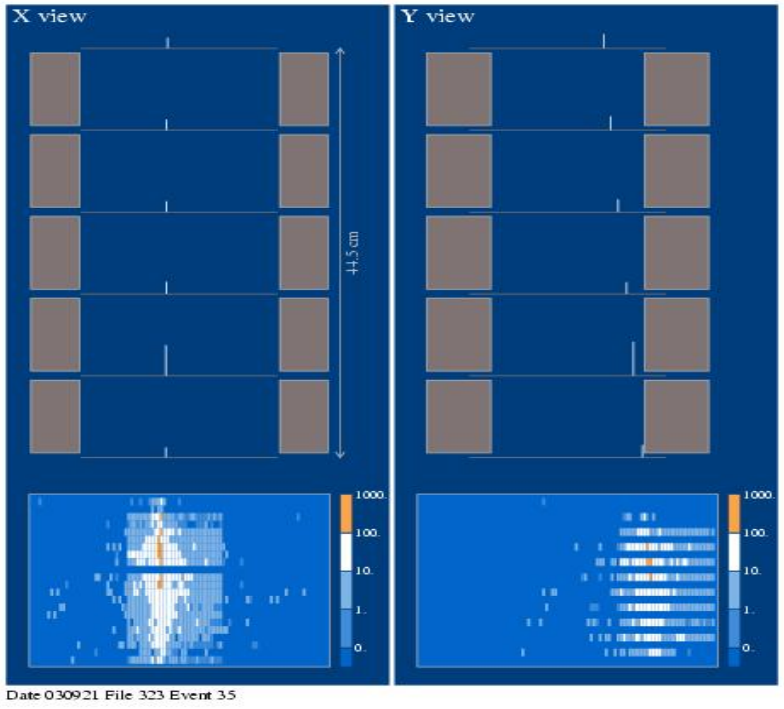


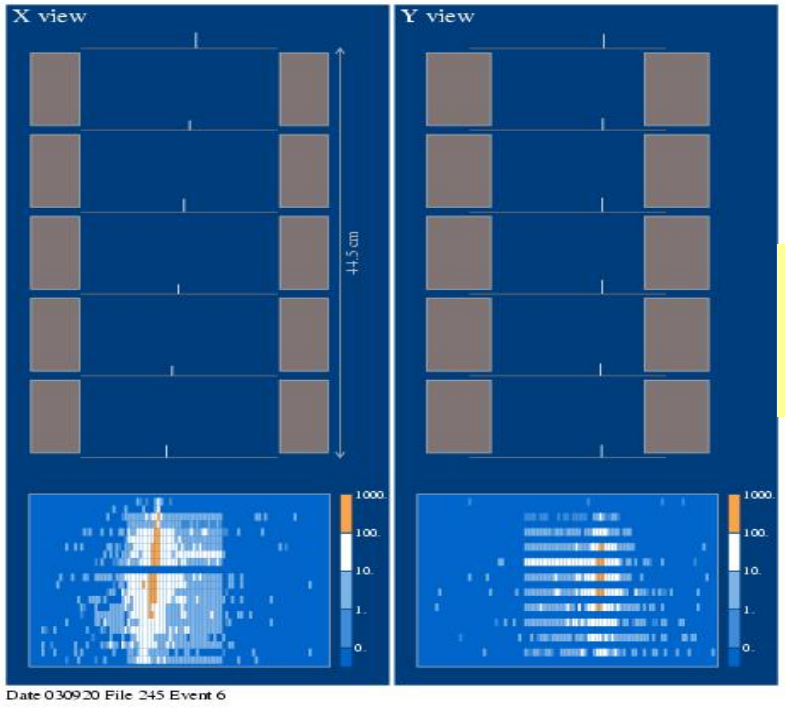


SPS Test Beam Data: p 100 GeV/c

Tracker + Calorimeter Performance

SPS Test Beam Data: e^- 50 GeV/c

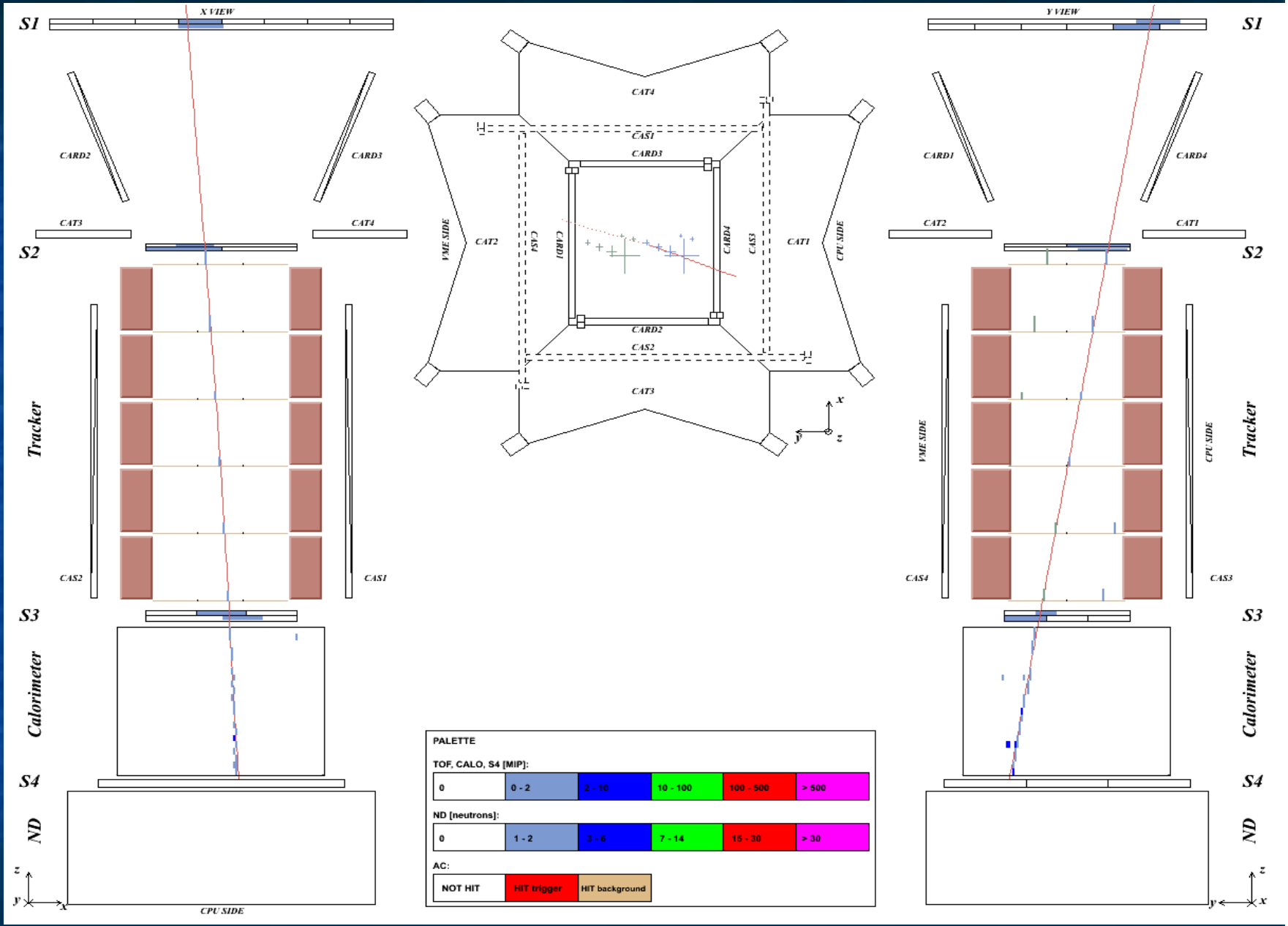




SPS Test Beam Data: e^- 100 GeV/c

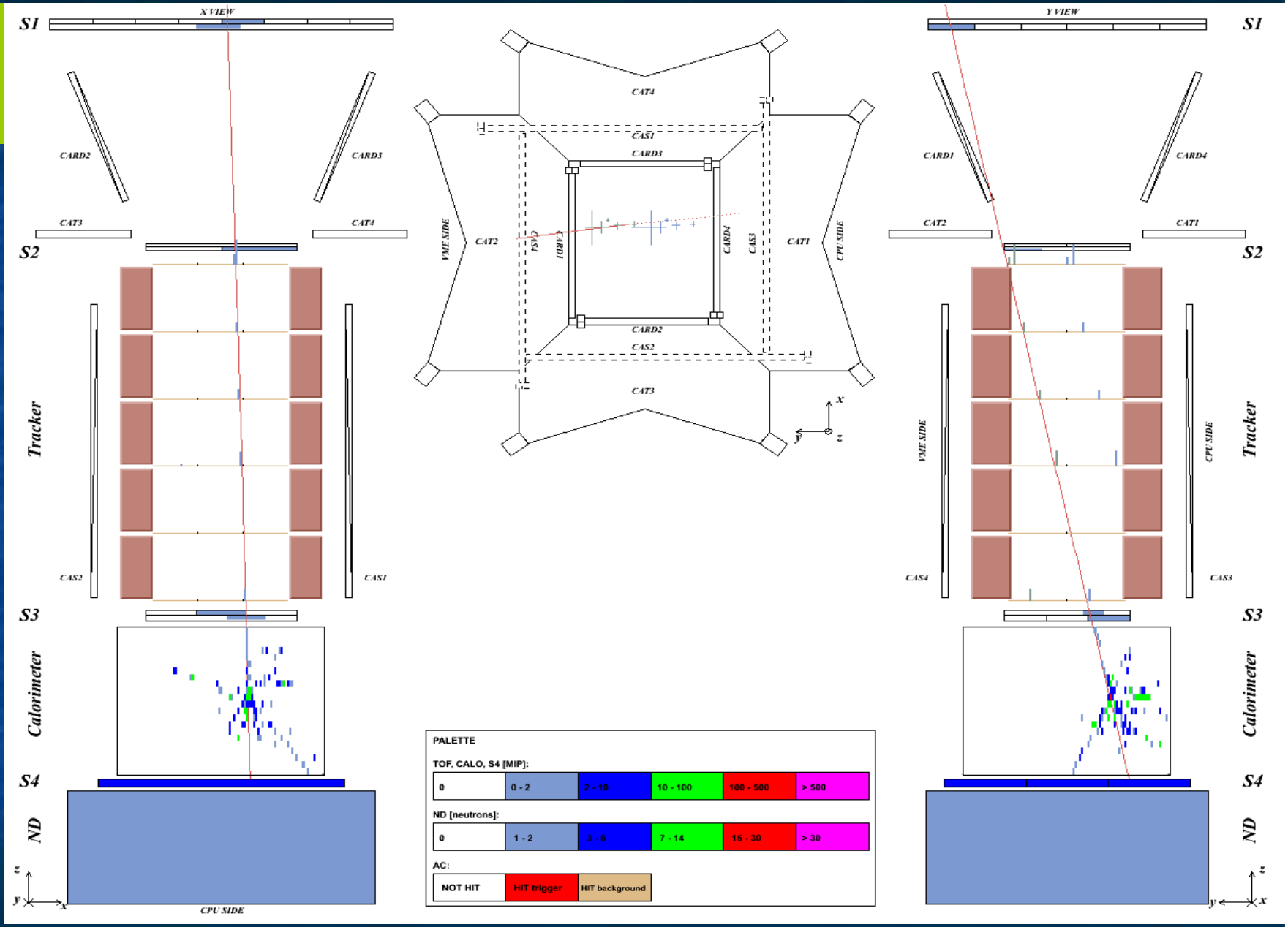
PAMELA
Event
Rome

Ground
Data muon:
2.8 GV



PAMELA Event Rome

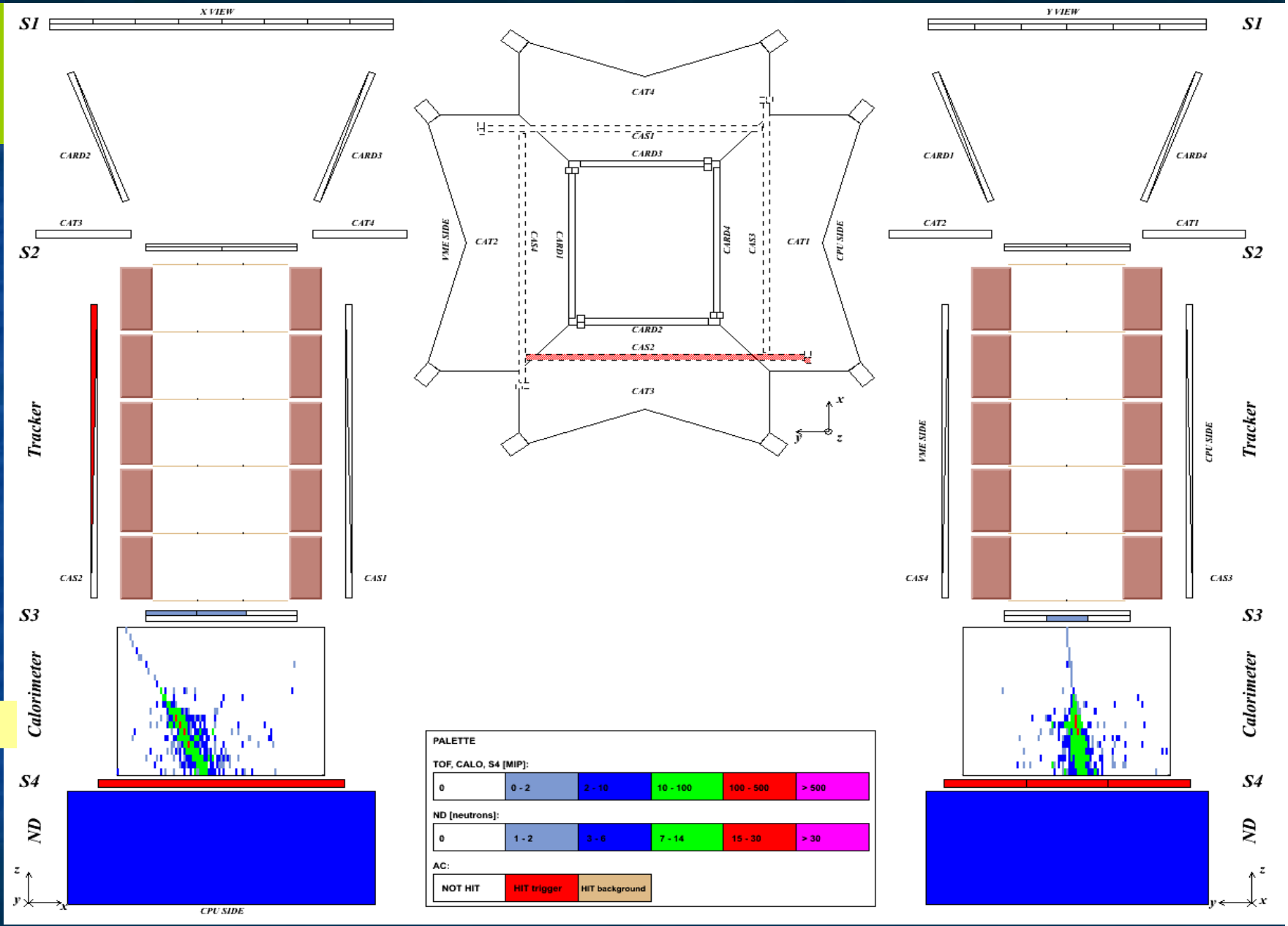
Ground Data
Hadron:
6.6 GV



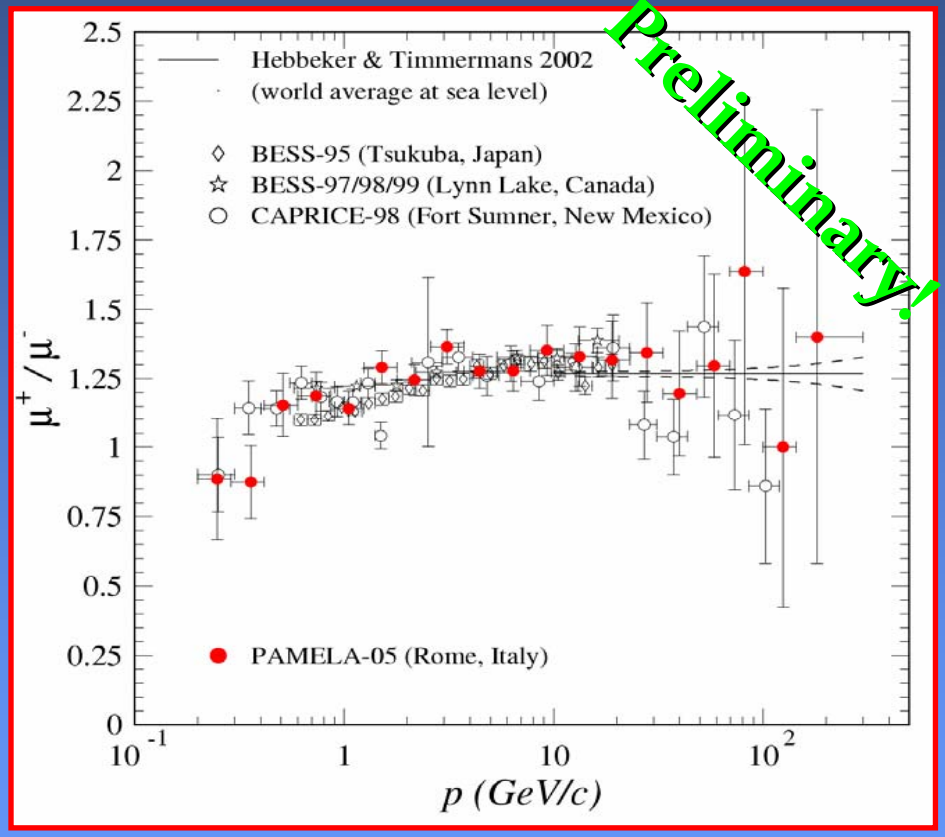
PAMELA Event Rome

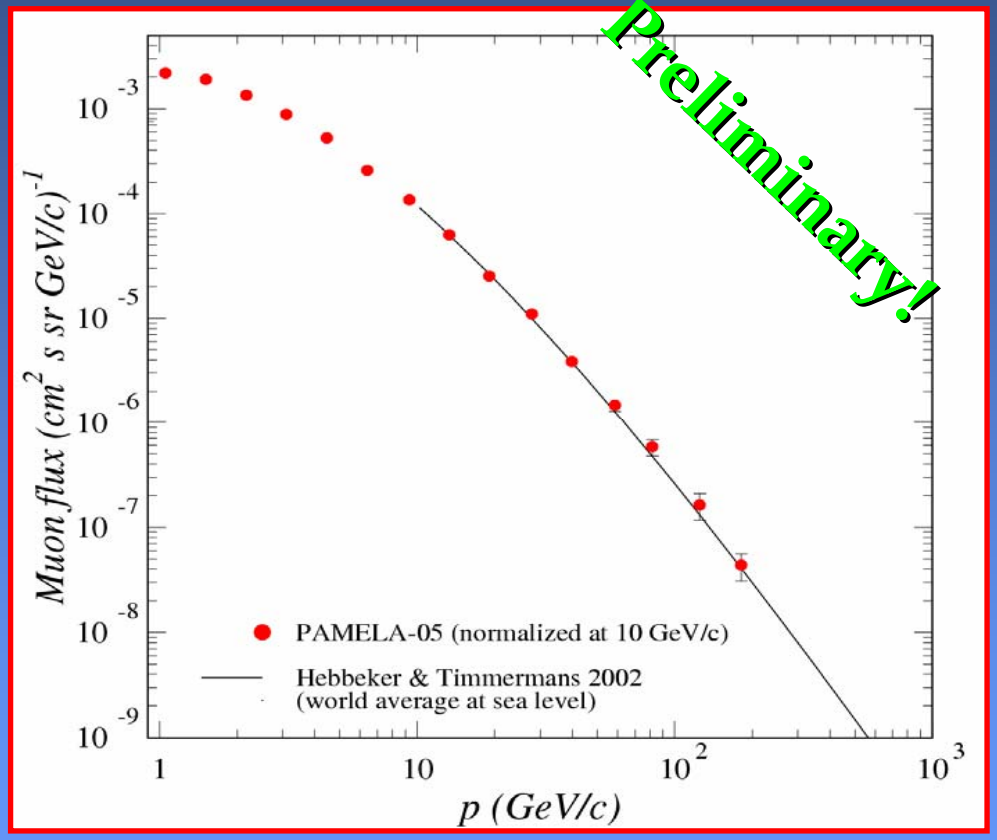
Calorimeter Self Trigger

GF: ~400 cm² sr

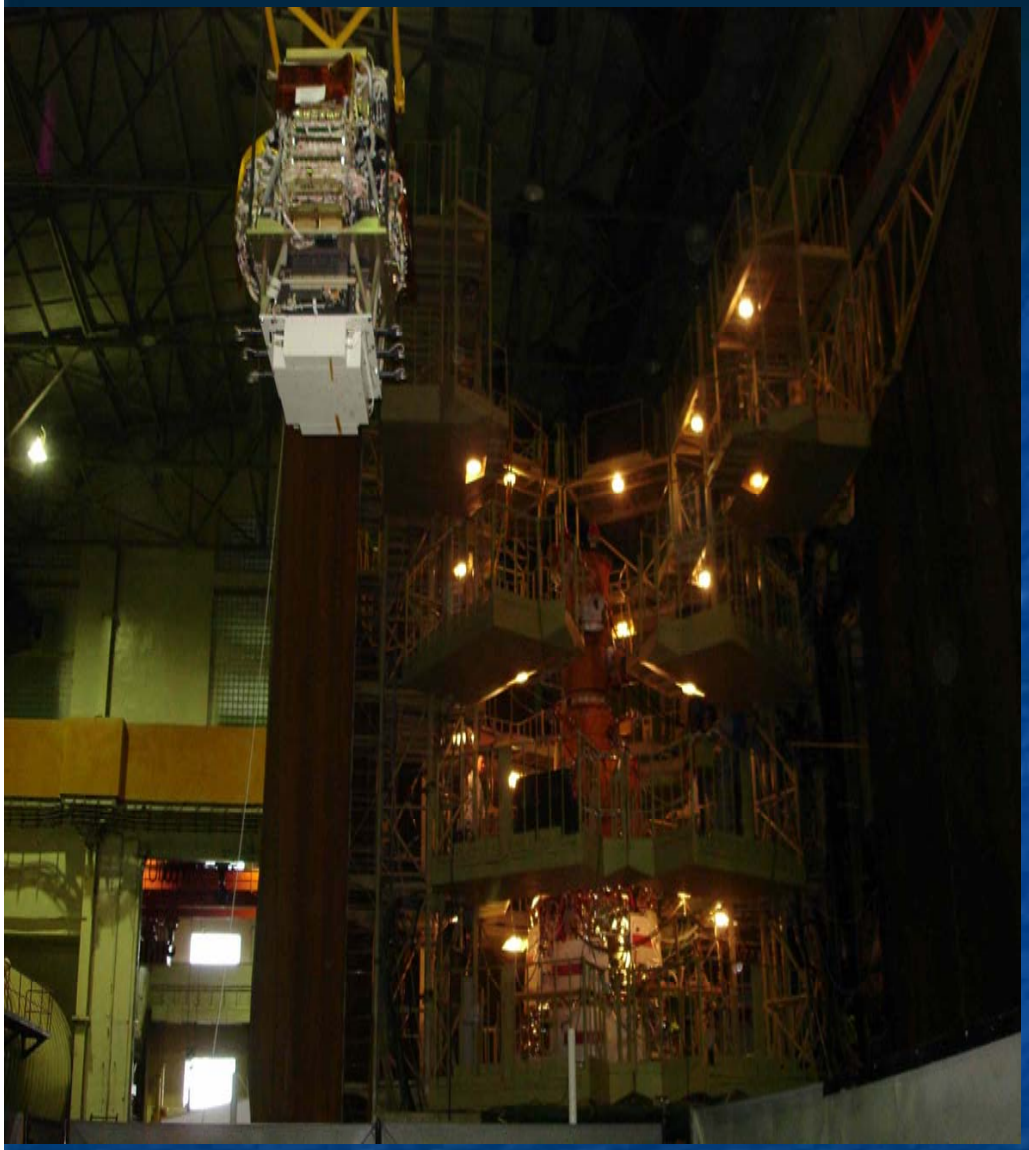


Ground muon results

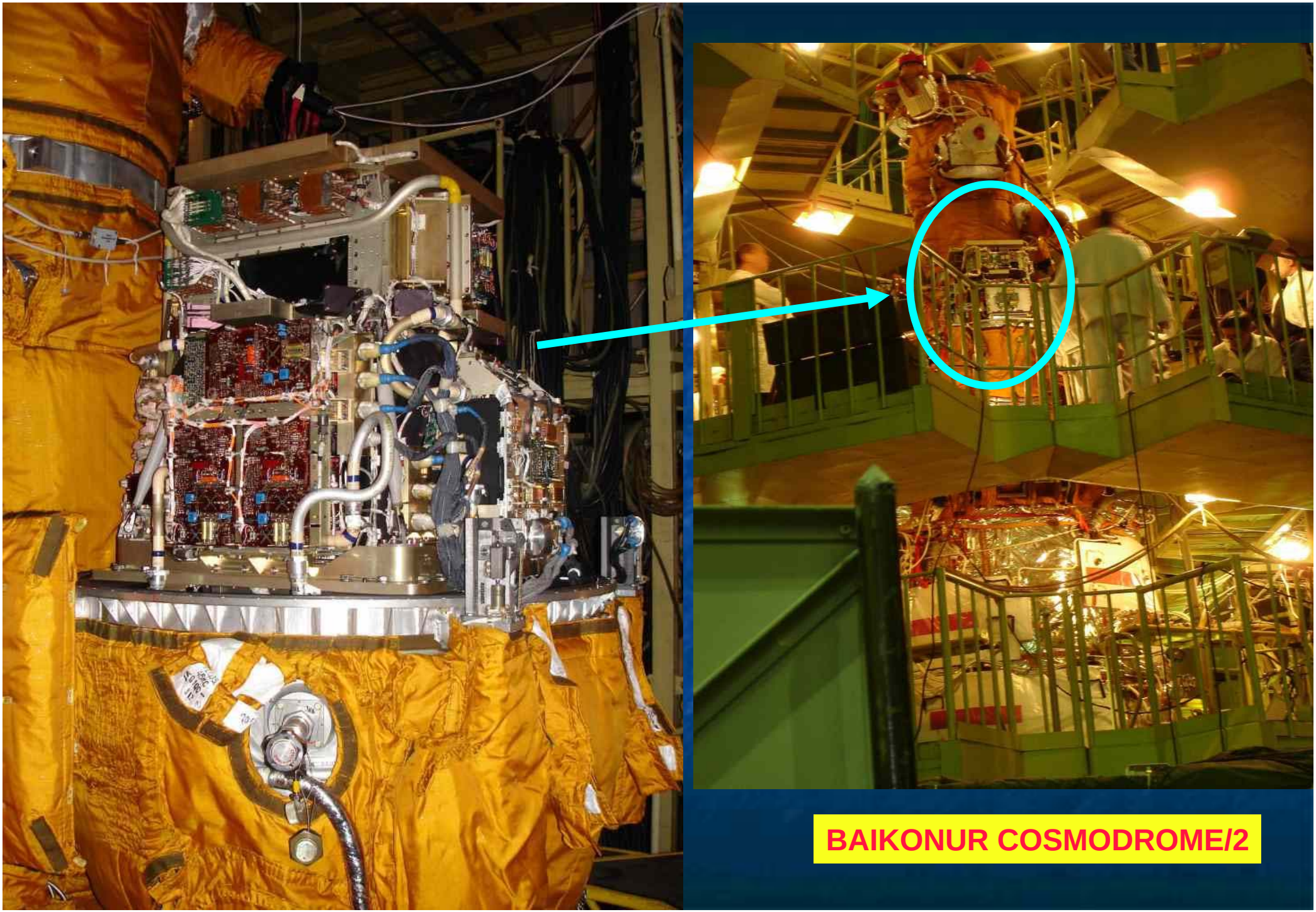




+ February 2006: tests in GSI with heavy nuclei to calibrate nuclear & isotopic identification capabilities

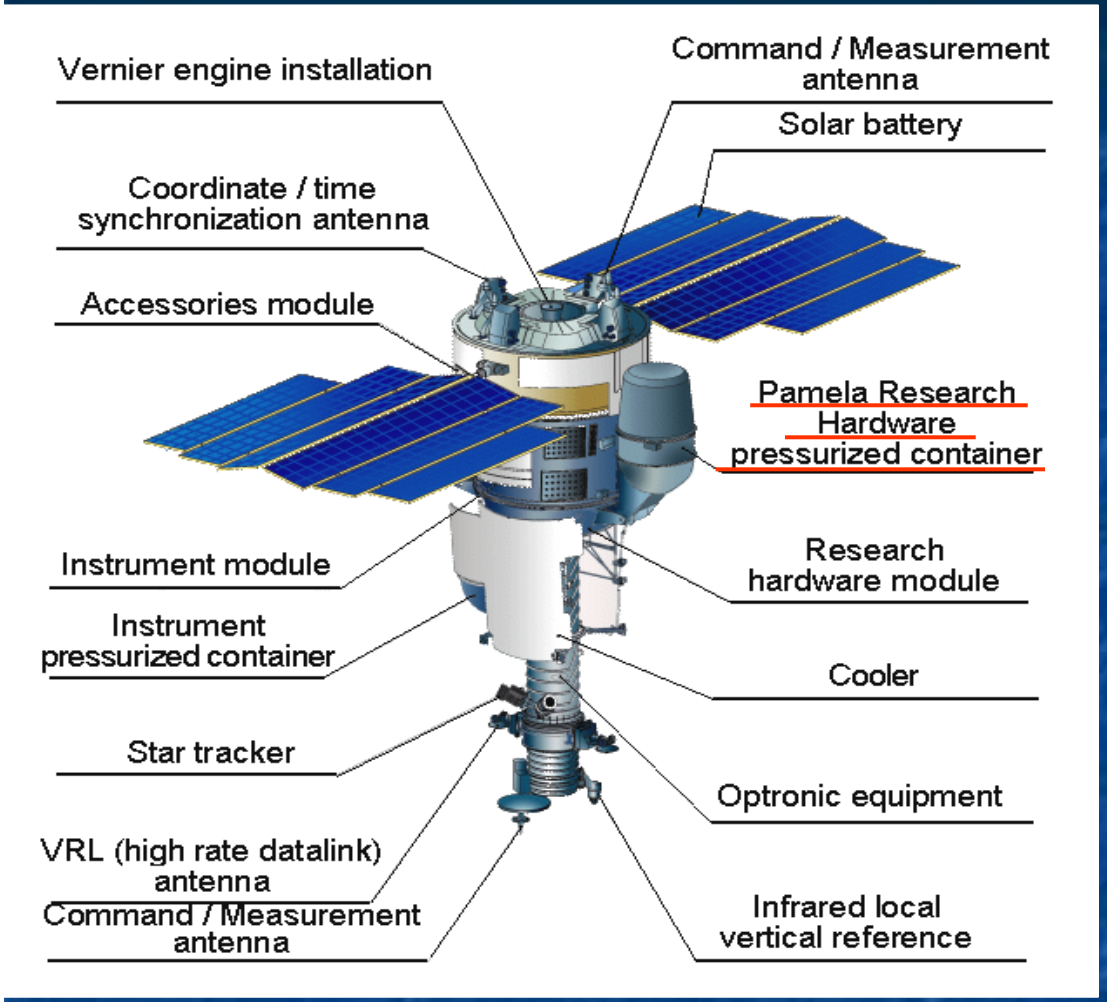


PAMELA IN BAIKONUR COSMODROME/1



BAIKONUR COSMODROME/2

Resurs-DK1 Satellite:

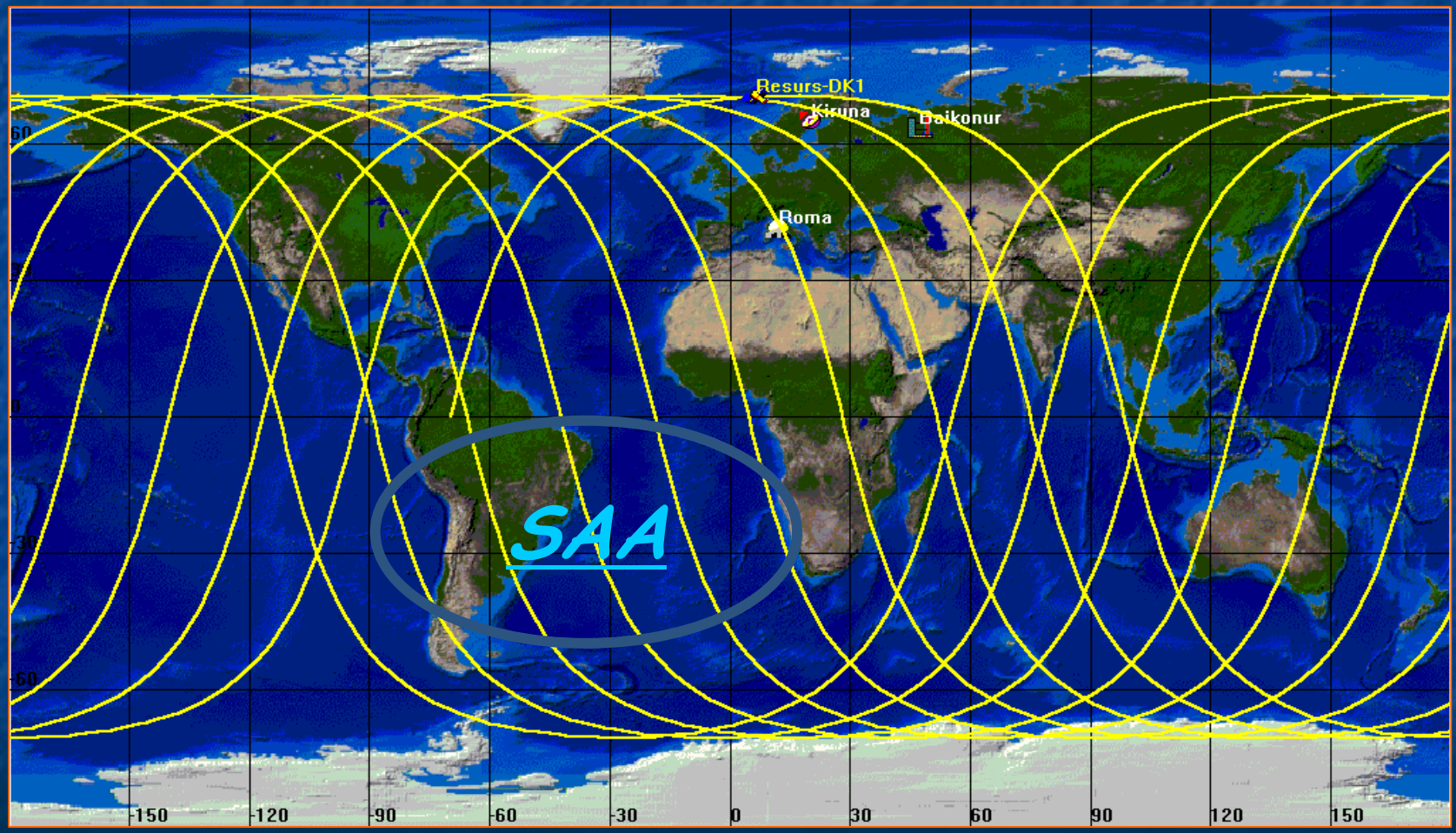


Built by the Space factory TsSKB-Progress in Samara (Russia)

- Mass: 6.7 tons
- Orbit: Elliptic
- Altitude: 300 - 600 Km
- Inclination: 70.0°
- Life Time: > 3 years
- 2 downlink stations: Moscow and Khanty-Mansiysk West Siberia

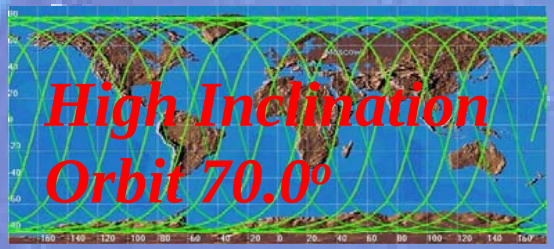
quasi-polar (70.0°)
elliptical (300÷600 km)
3-years-long mission

Orbit characteristics



THE SCIENCE OF PAMELA

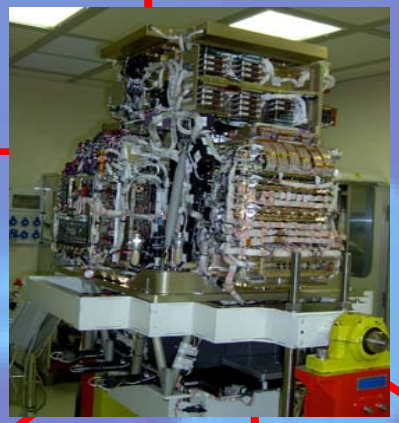
PAMELA as a Space observatory at 1AU



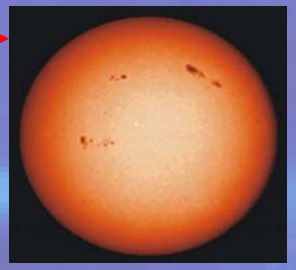
Galactic cosmic ray
Matter / Antimatter
/ Dark Matter

Solar Energetic particles

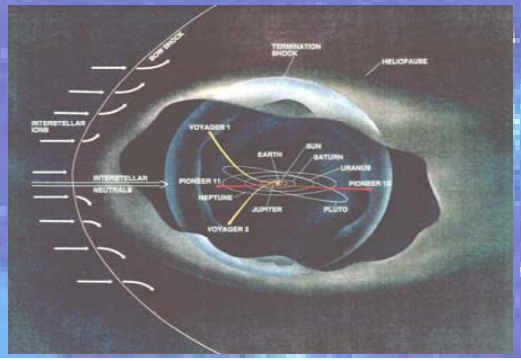
Jovian electrons



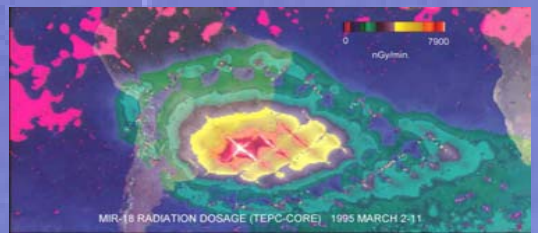
Solar Modulation



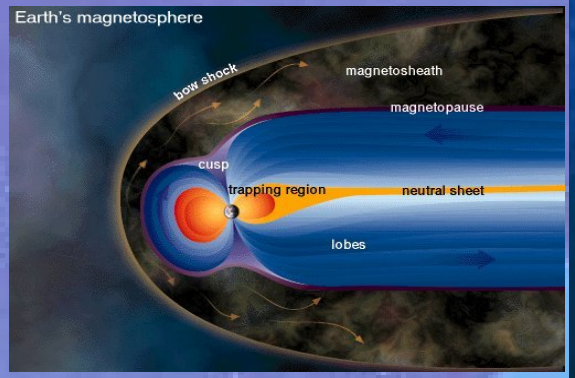
Interplanetary Physics,
Solar Wind Termination Shock



SAA, Albedo,
secondary particle



Magnetospheric physics



PAMELA Capabilities

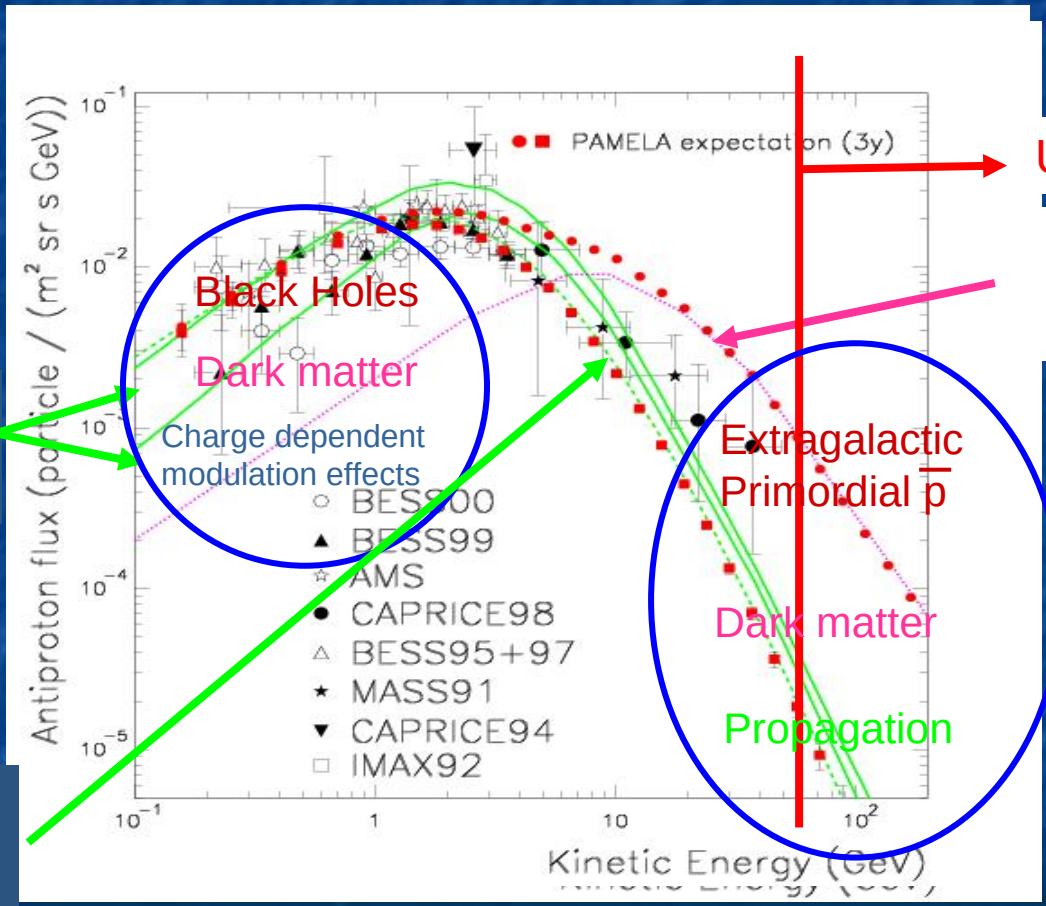
PAMELA will explore:

❑ Antiproton flux	80 MeV - 190 GeV
❑ Positron flux	50 MeV – 270 GeV
❑ Electron flux	up to 400 GeV
❑ Proton flux	up to 700 GeV
❑ Electron + positron flux	up to 2 TeV
❑ Light nuclei (up to Z=6)	up to 200 GeV/n
❑ Antinuclei search	(sensitivity ~ 10^{-8} in antiHe/He)

+

- ❑ Long-term monitoring of the solar modulation of cosmic rays
- ❑ Energetic particles from the Sun (e^+)
- ❑ High-energy particles in the Earth magnetosphere

Cosmic-ray antiparticle measurements: antiprotons



Unexplored Region

Primary production from $\chi\chi$ annihilation ($m(\chi)$ = 964 GeV)

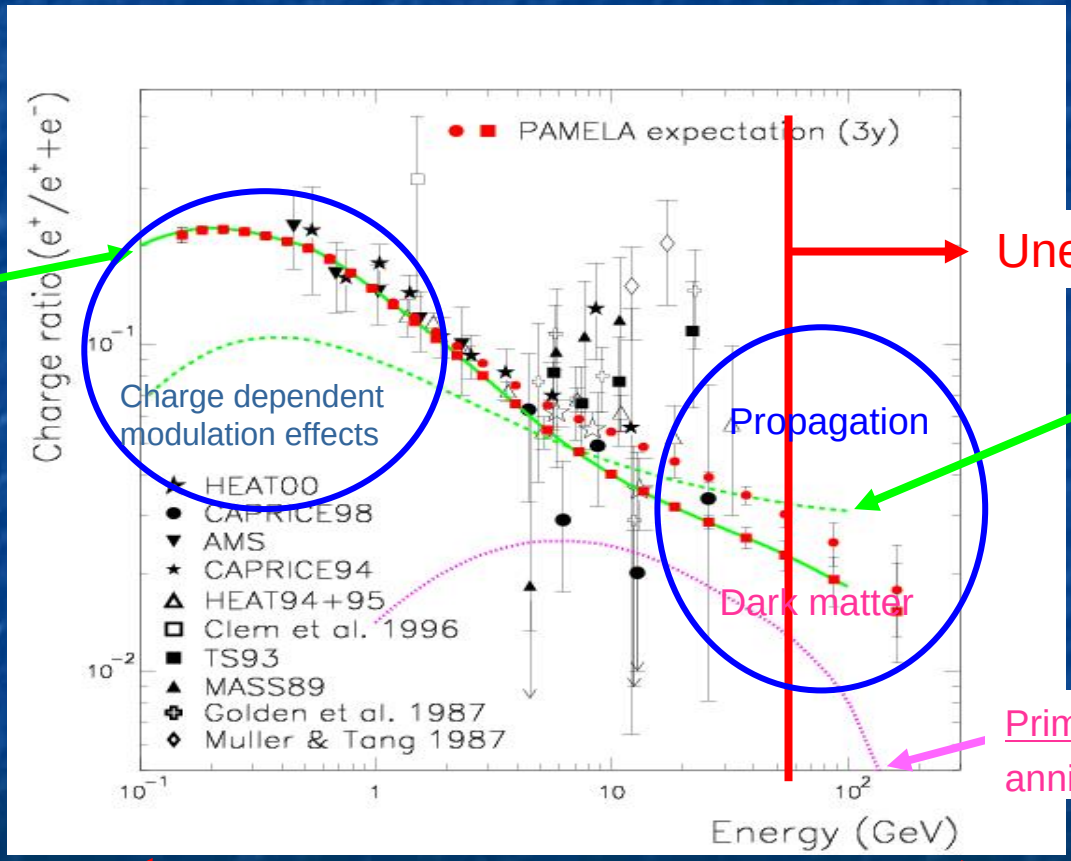
Secondary production (upper and lower limits) Simon et al.

Secondary production (CAPRICE94-based) Bergström et al.

PAMELA energy range

Cosmic-ray antiparticle measurements: positrons

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



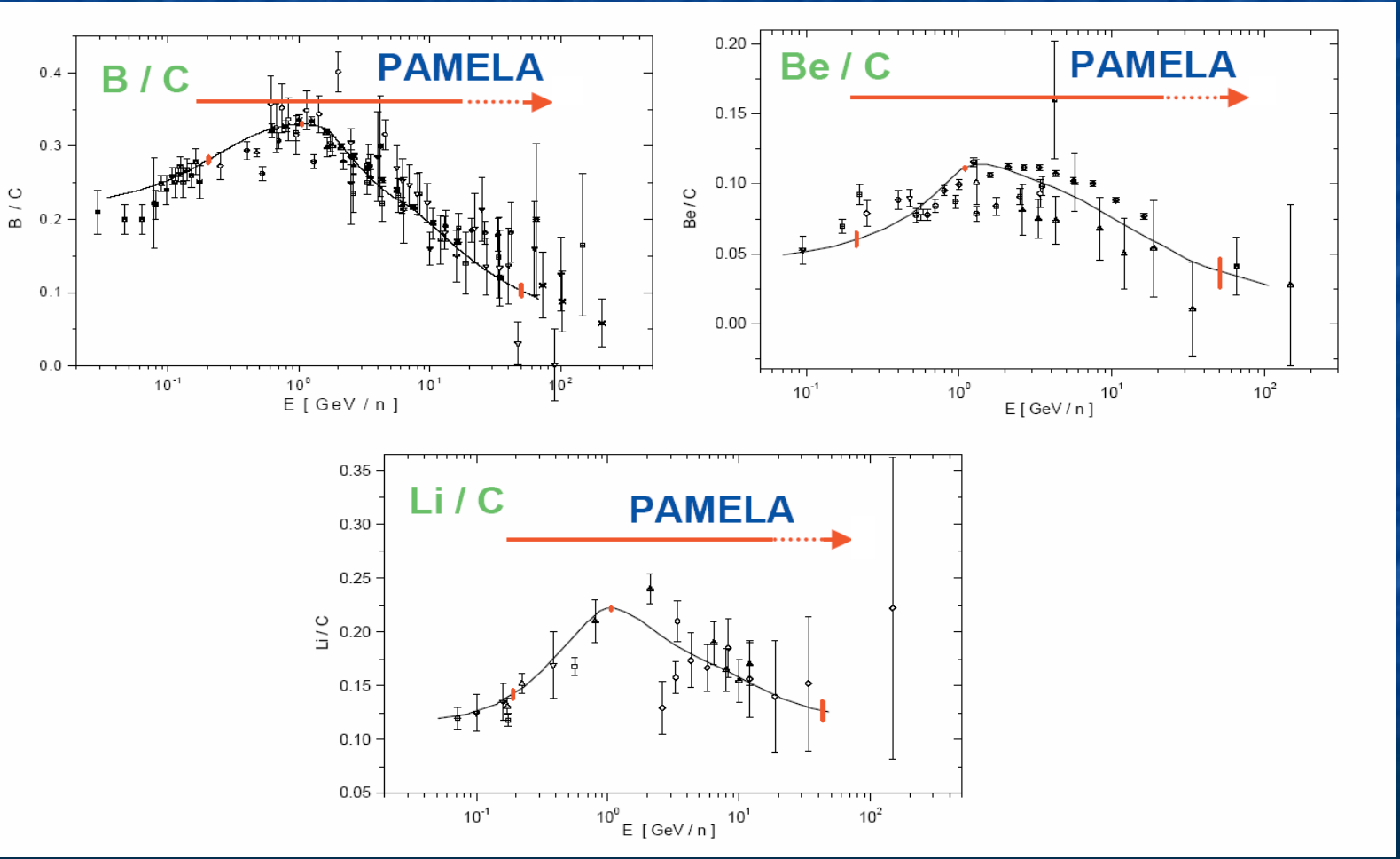
Unexplored Region

Secondary production 'Leaky box model' (Protheroe 1982)

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

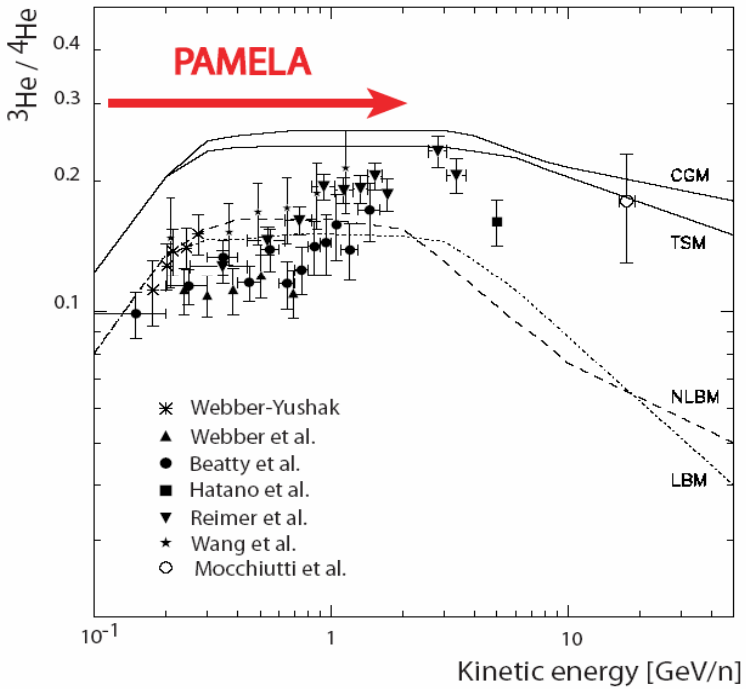
PAMELA energy range

Secondary to Primay ratios

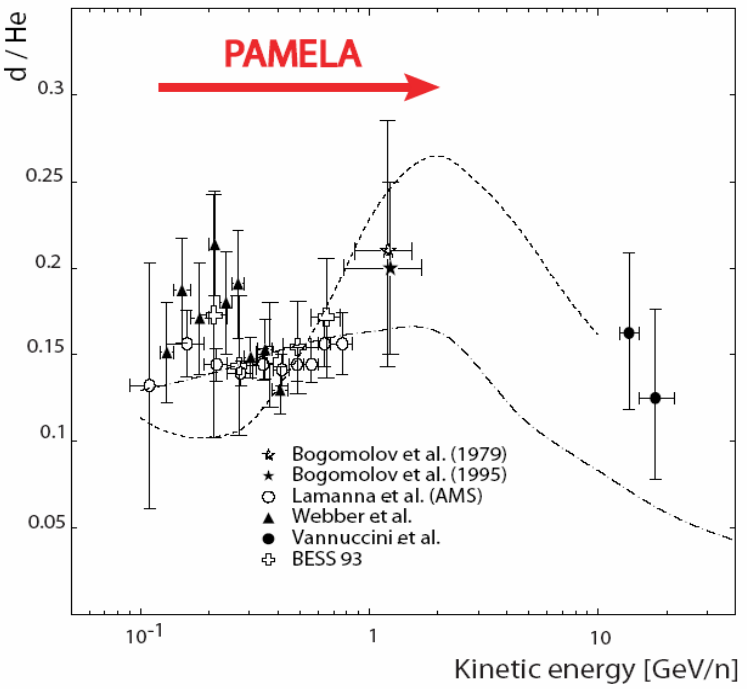


Helium and Hydrogen Isotopes

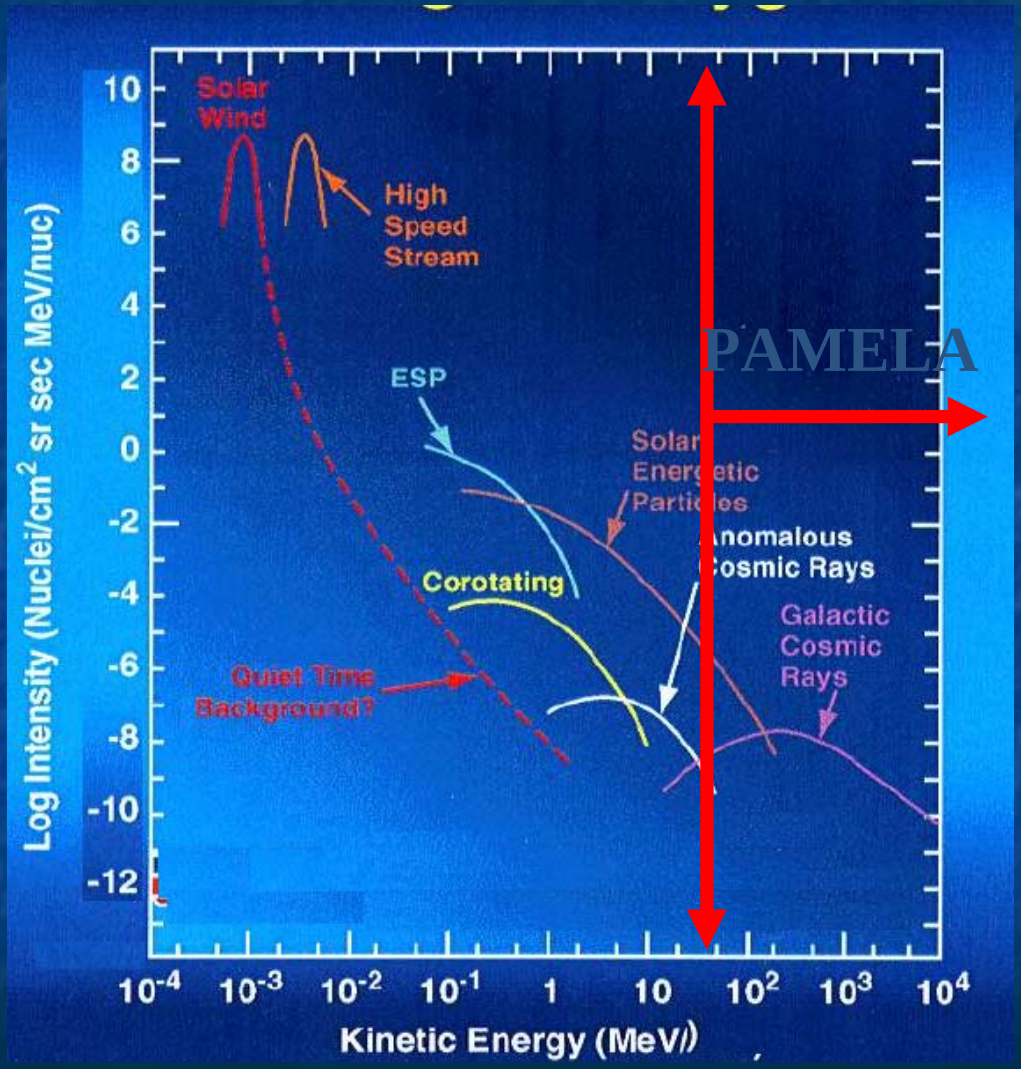
The current situation of the $^3He / ^4He$ ratio



The current situation of the d / He ratio



Solar Physics with PAMELA



- Solar Modulation effects
- High energy component of Solar Proton Events (from 80 MeV to 10 GeV)
- High energy component of electrons and positrons in Solar Proton Events (from 50 MeV)
- Nuclear composition of Gradual and Impulsive events
- ^{3}He and ^{4}He isotopic composition
- Electrons of jovian origin
- Anomalous Cosmic Rays

PAMELA models

Mass&Thermal Model
Full cycle of vibration/shock/ tranport tests

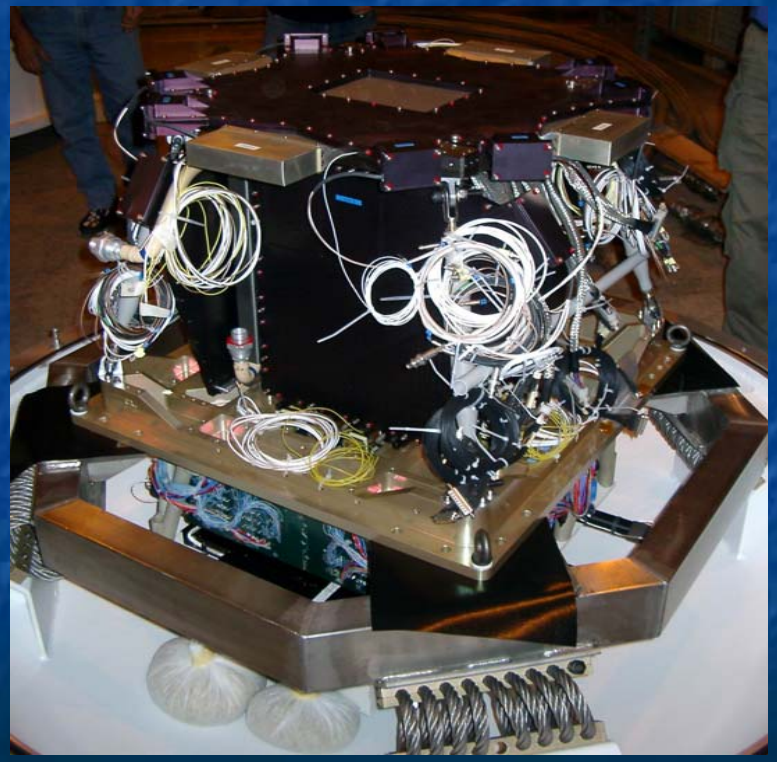
Technological Model
Preliminary Acceptance Tests with EGSE: power ON/OFF, telecommands, data transmission through adapter; magnetic compatibility tests

Flight Model
Integration, beam tests; pre-flight operations

PAMELA Milestones/1

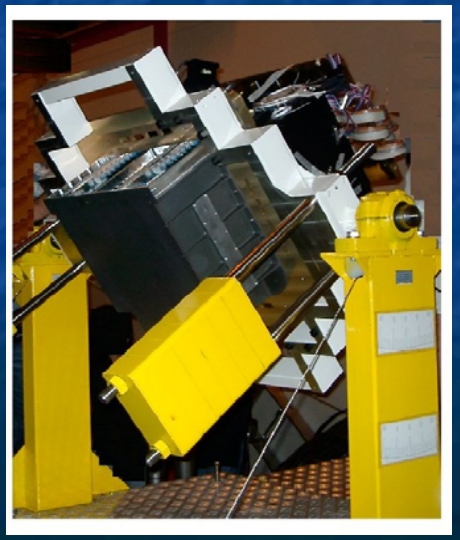
Detectors tested at CERN PS / SPS
Prototypes and in FM configuration

First prototypes SPS, July 2000



FM
SPS, September 2003

Magnet/Tracker,
Calorimeter
SPS, July 2002



PAMELA Milestones/2

Detectors tested at PS / SPS
Test facilities as Prototypes
and in FM configuration

Mass/Termal Models
Qualified, March-May 2003

PAMELA Thermal Model passed thermal tests at TsSKB Thermal/Vacuum Chamber

PAMELA Milestones/3

Detectors tested at PS / SPS Test facilities as Prototypes and in FM configuration

Mass/Termal Models Qualified, March-May 2003

PAMELA Technological Model completed and delivered to Russia December 2003

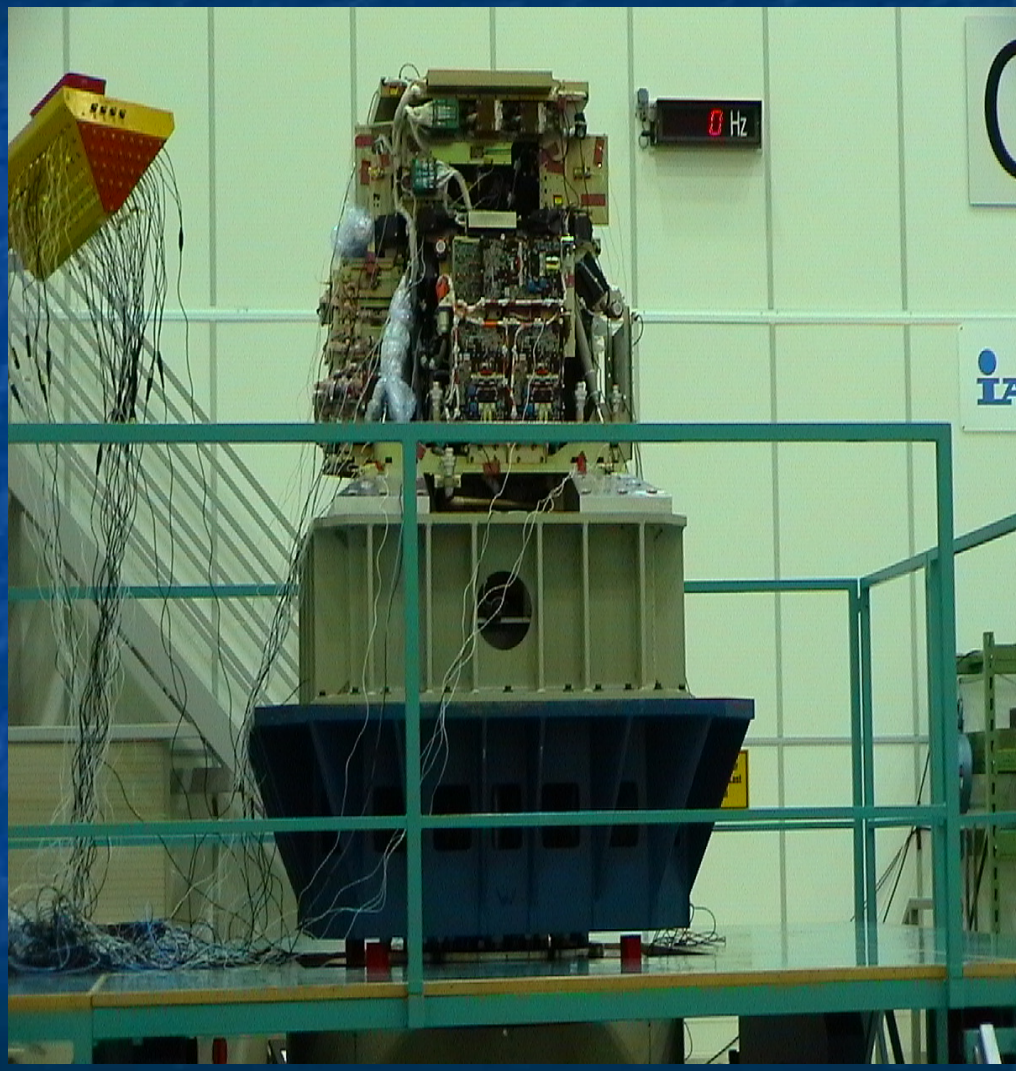
PAMELA Milestones/4

Detectors tested at PS / SPS Test facilities as Prototypes and in FM configuration

Mass/Termal Models Qualified, March-May 2003

PAMELA Technological Model completed and delivered to Russia December 2003

Full Cycle of Vibration /Shock of the Flight Model passed at IABG/ Munich, January 2005



PAMELA Milestones/5

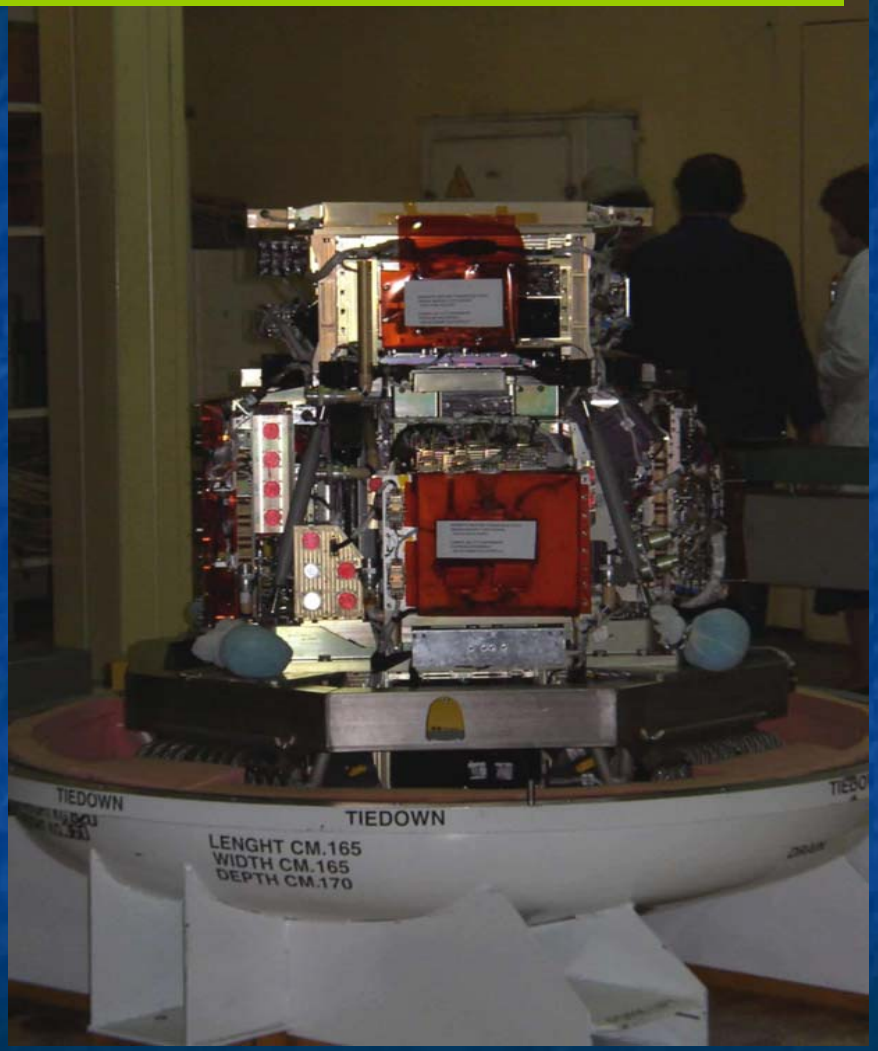
Detectors tested at PS / SPS Test facilities as Prototypes and in FM configuration

Mass/Termal Models Qualified, March-May 2003

PAMELA Technological Model completed and delivered to Russia December 2003

Full Cycle of Vibration /Shock of the Flight Model passed at IBAG/ Munich, January 2005

PAMELA Flight Model delivered to TSSKB_Progress Factory in Samara Russia, April 2005

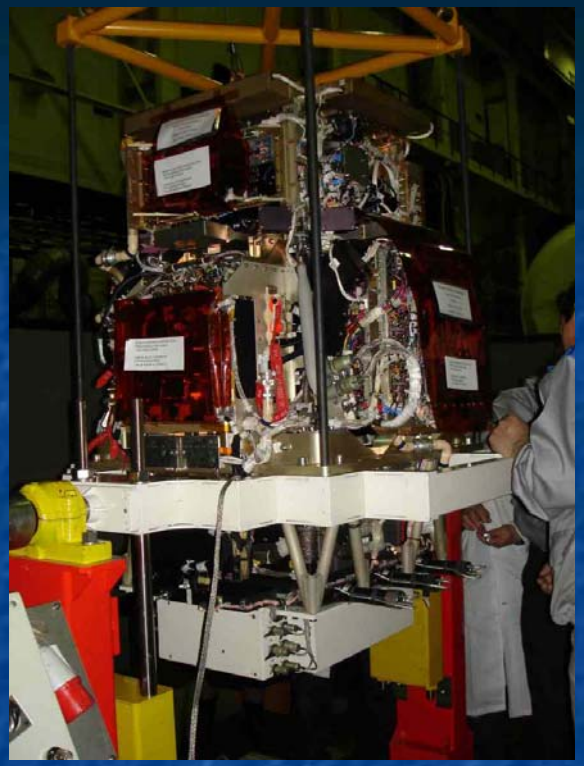


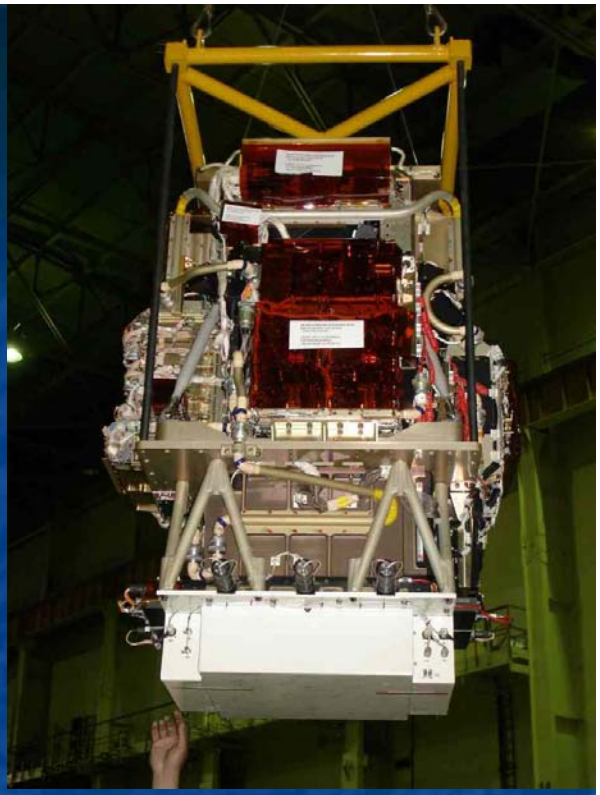
PAMELA Milestones/6

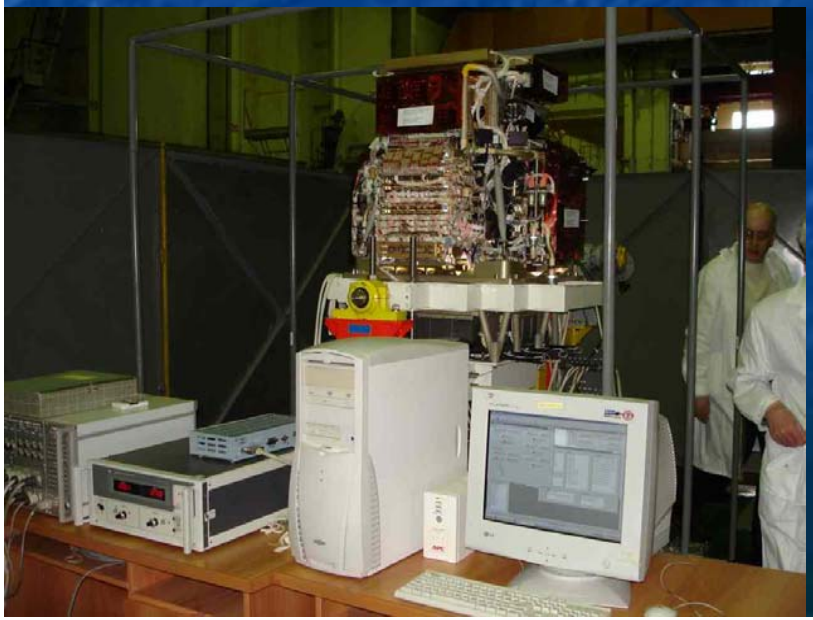
Loading Operations in Samara (Russia)

March 28th, 2006

Unloading in Baikonur --> transport by rail to test area







Baikonur March 30, 2006

Initial operations, Stand-alone tests

LAUNCH SCHEDULED JUNE 14, 2006 !