



a **P**ayload for **A**ntimatter **M**atter **E**xploration
and **L**ight-nuclei **A**strophysics



Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics

PAMELA MissioN

17 December 2010

Prepared by FatiH KAYA

Quarks And The
Cosmos

Research & EDUCATION

Science
&
SOCIETY

matter
Space & TIME

the KNOWN and
the UNKNOWN

Astropartical Physics Issue

To inform.

Scientists Around The World

THEORY

matter & ANTI matter

PARTICLES &
FORCES

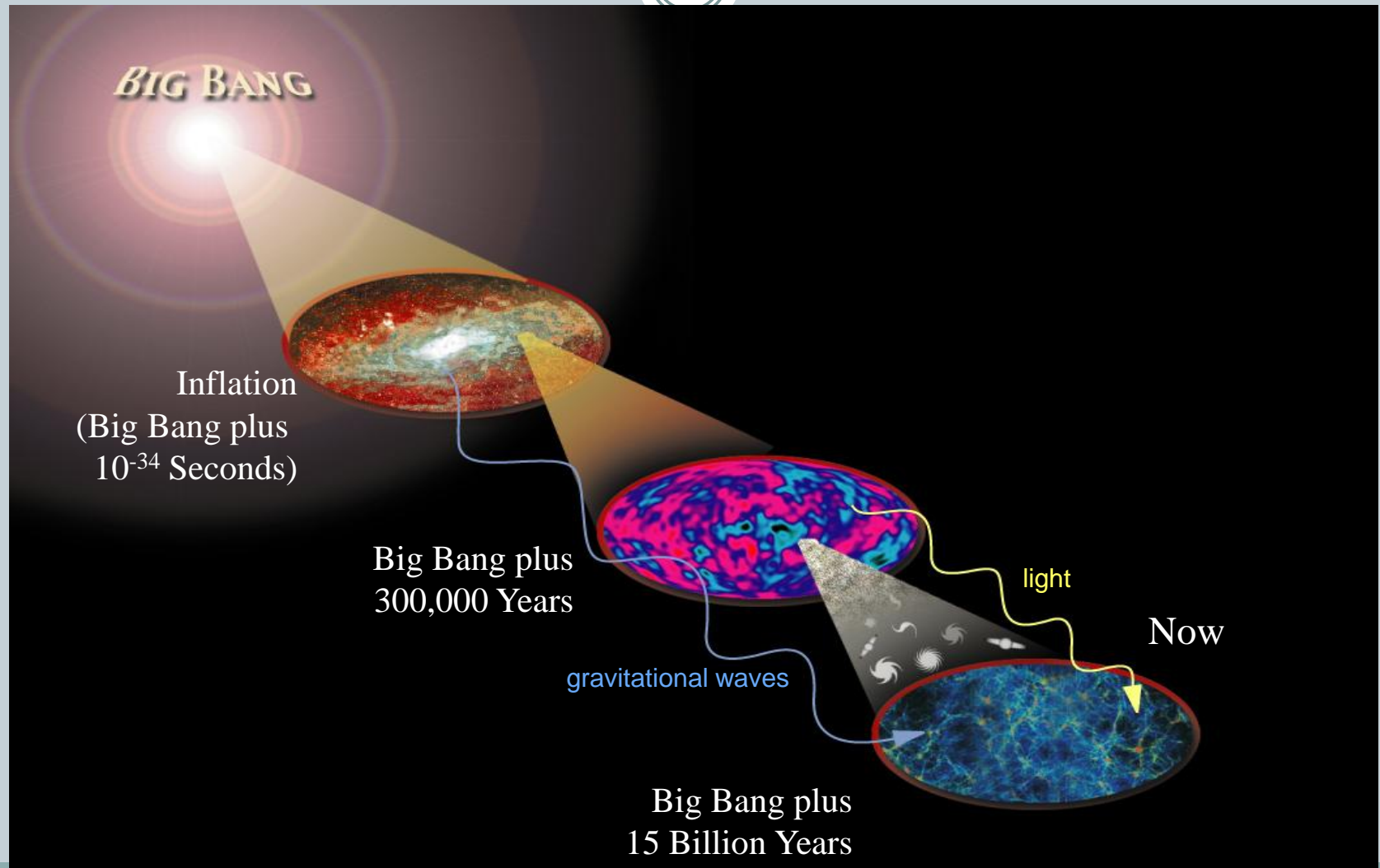
technology
&

discovery

DOE and NSF

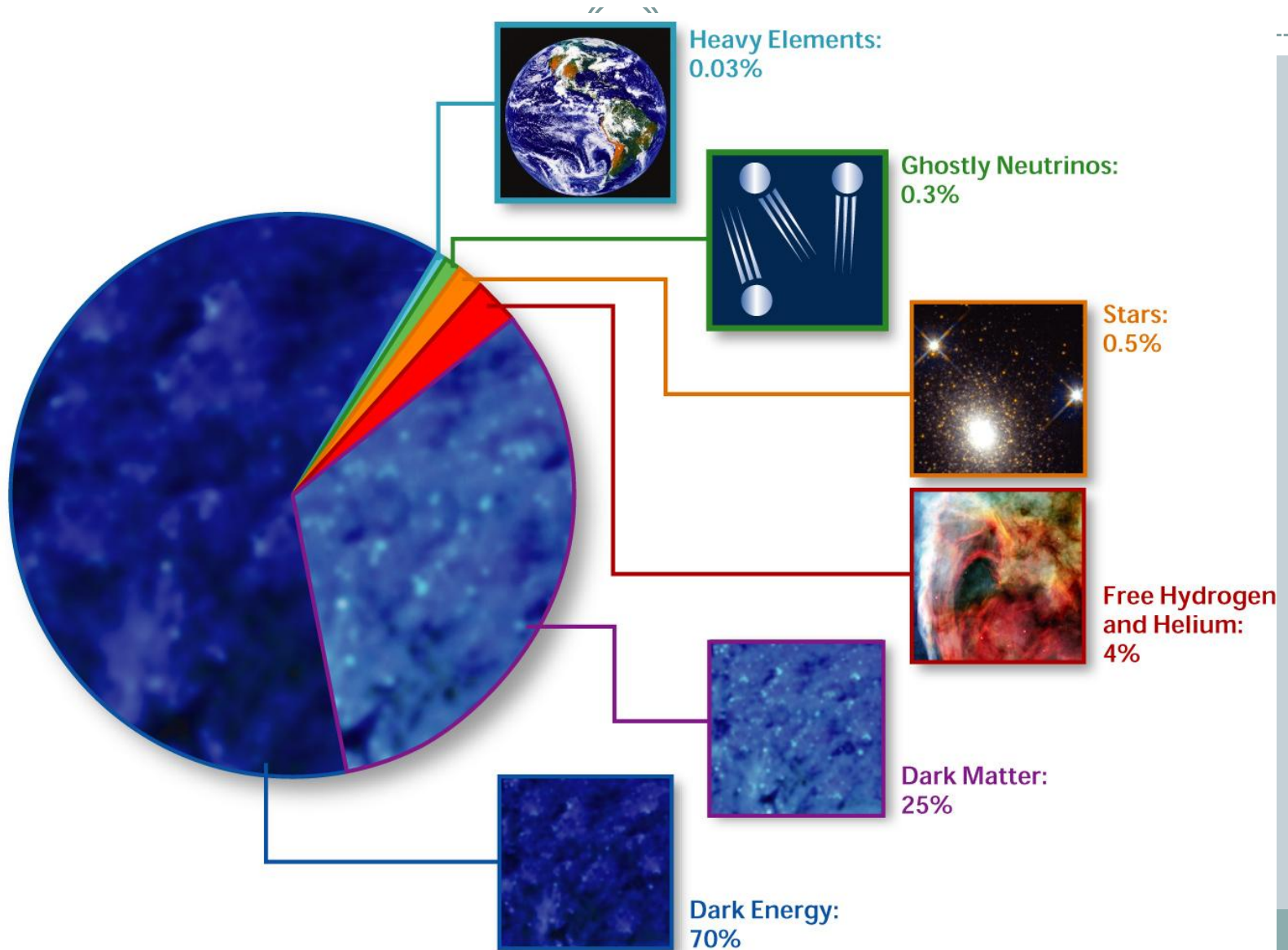
Scientists &
the Public

What Powered the Big Bang?

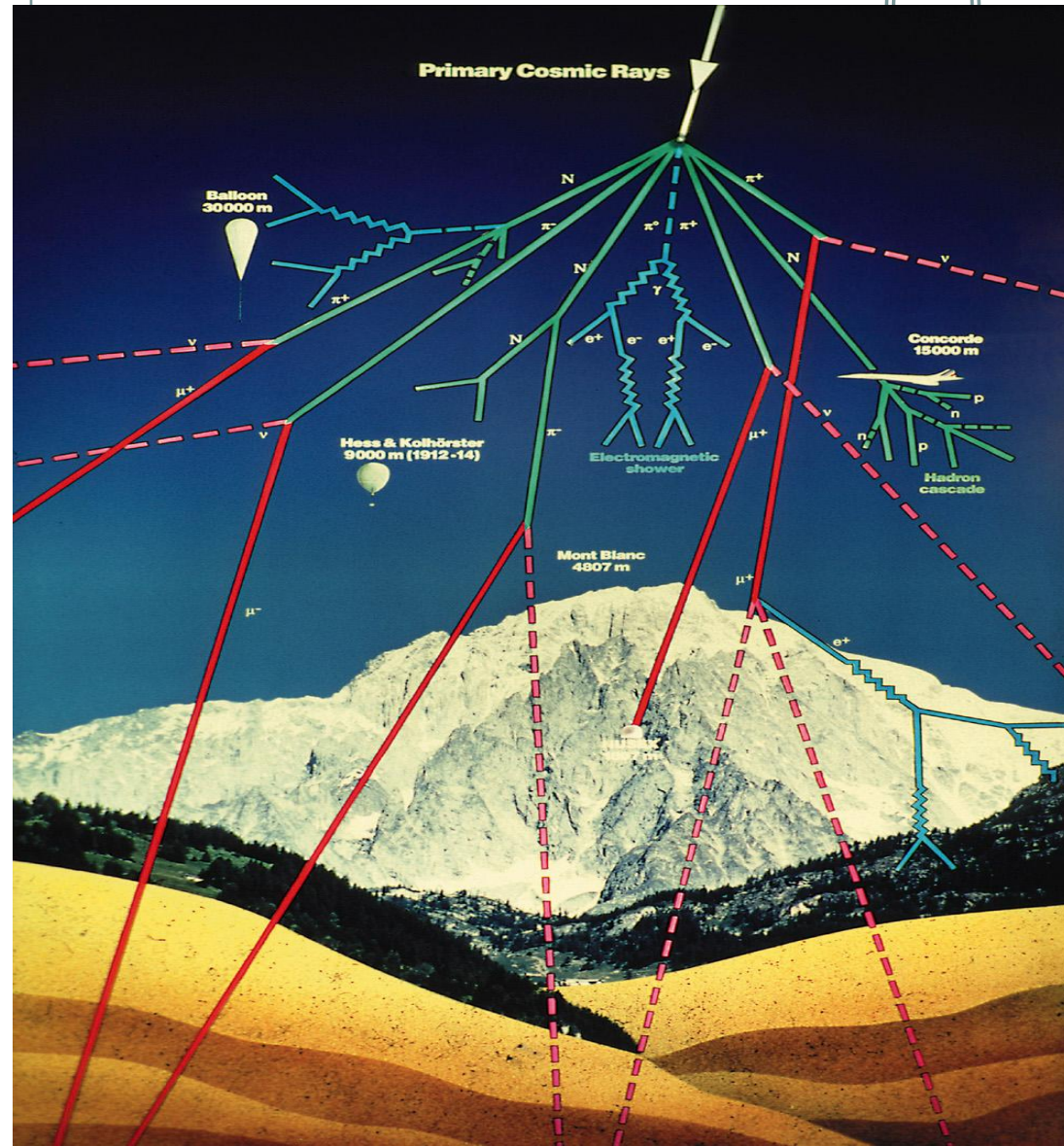


What is the Dark Energy?

We do not know what 95% of the universe is made of!



Cosmic Rays



- What are cosmic rays?
Elementary particles, nuclei, EM radiation of extra-terrestrial origin, including μ , π , Λ
- Discovery of cosmic rays
Victor. F. Hess, Nobel Prize in 1936

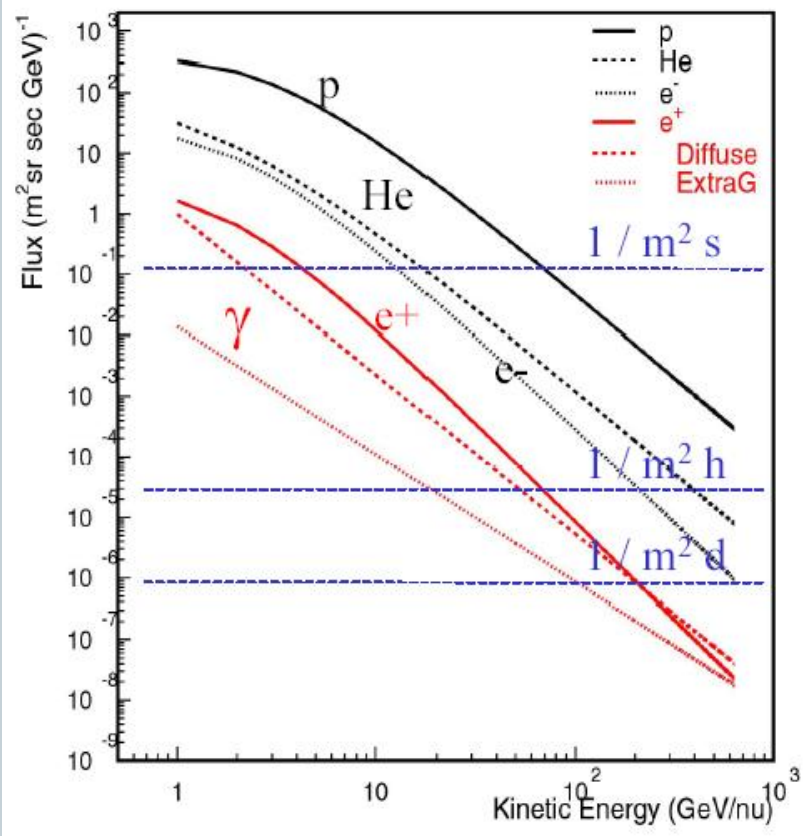
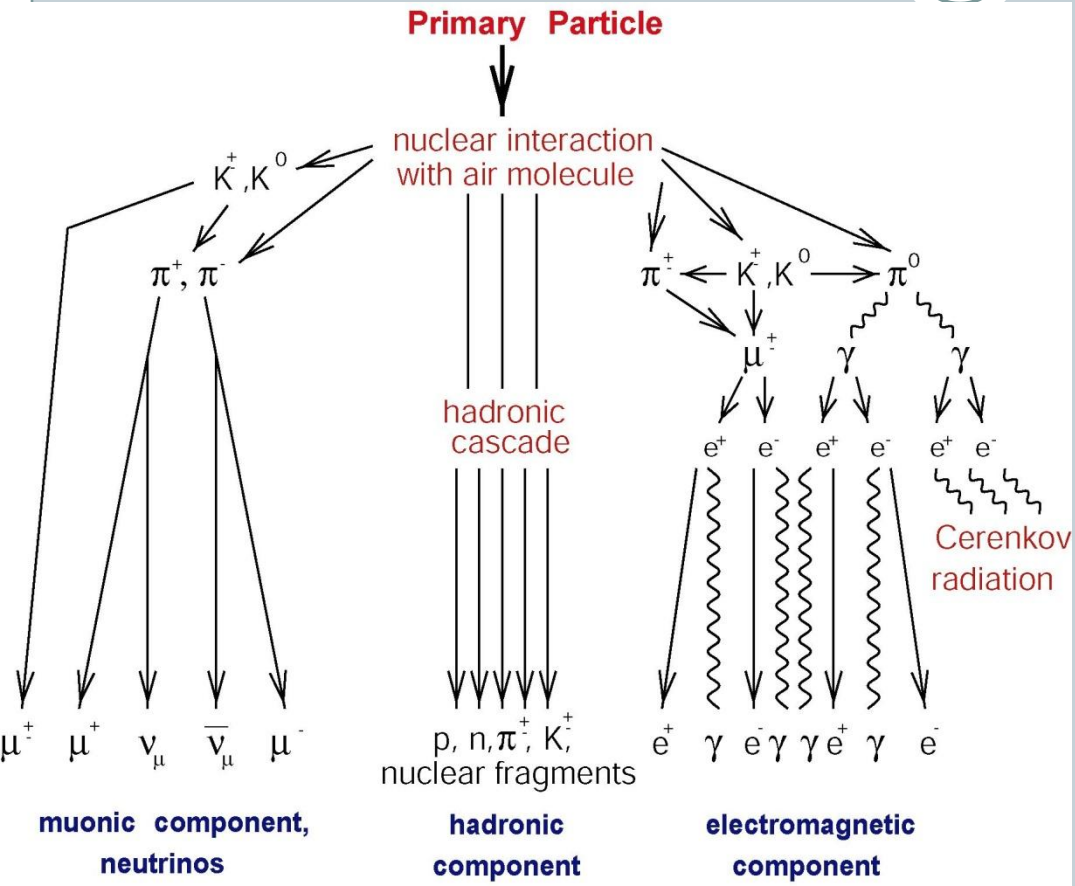
COSMIC RAYS



- Charged particles arriving in Earth from the Sun, our galaxy and other galaxies
- Mainly protons (90%) and alpha particles (9%)

Development of Cosmic-Ray Air-Shower

Cosmic Rays composition in space
 ~88% proton, ~9% He nuclei,
 ~1% $Z > 2$ nuclei, ~2% electrons, <0.1% gamma



Supersymmetric Dark Matter

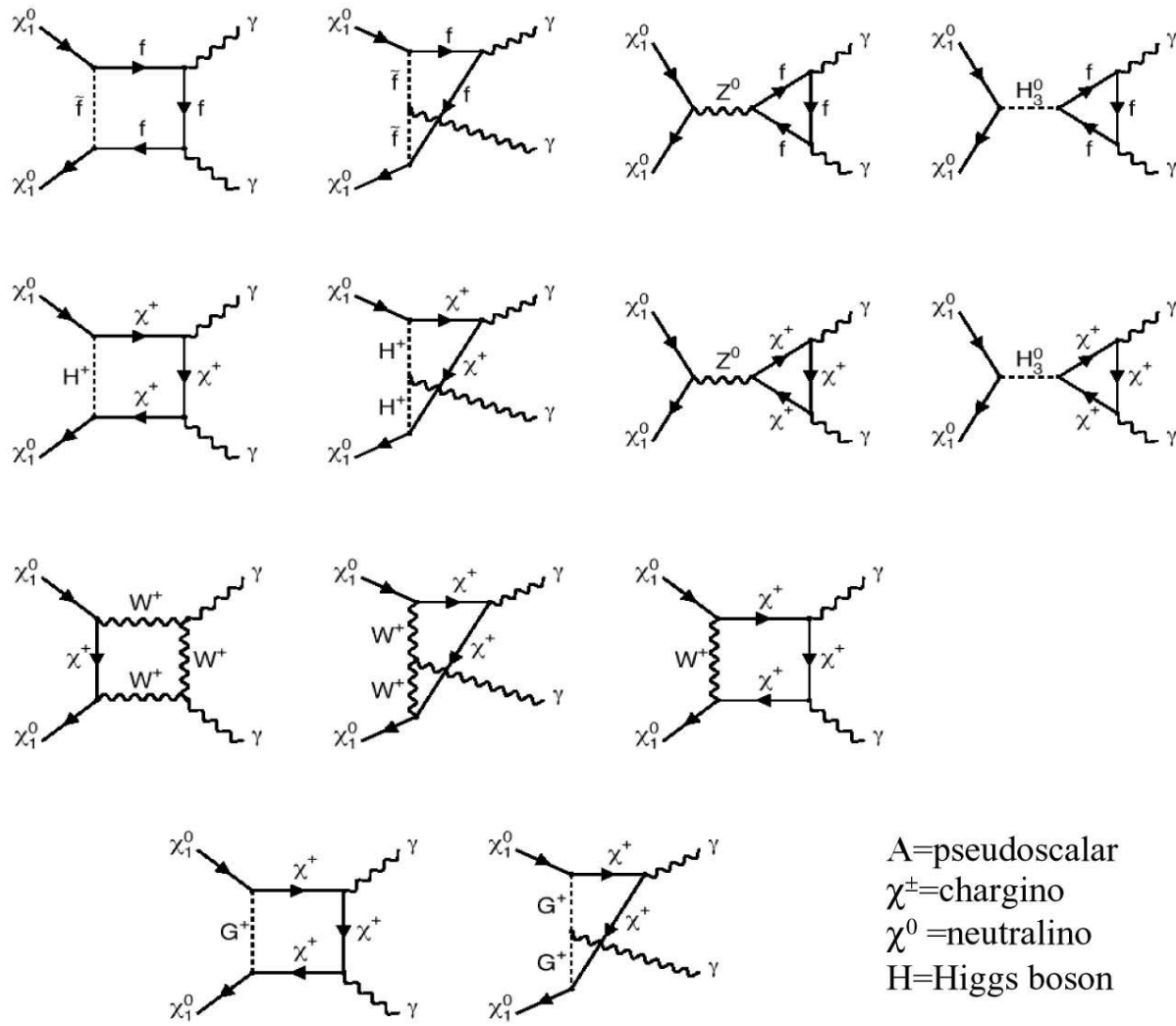
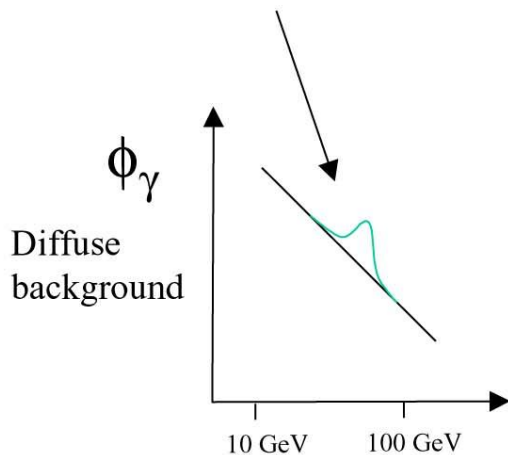
LSP is a bino-like neutralino
 neutralino is a spin $\frac{1}{2}$ Majorana particle and can annihilate

$$\chi = \begin{pmatrix} \tilde{B} \\ \tilde{W}^3 \\ \tilde{H}_1^0 \\ \tilde{H}_2^0 \end{pmatrix}$$

Neutralino is the Dark Matter candidate.

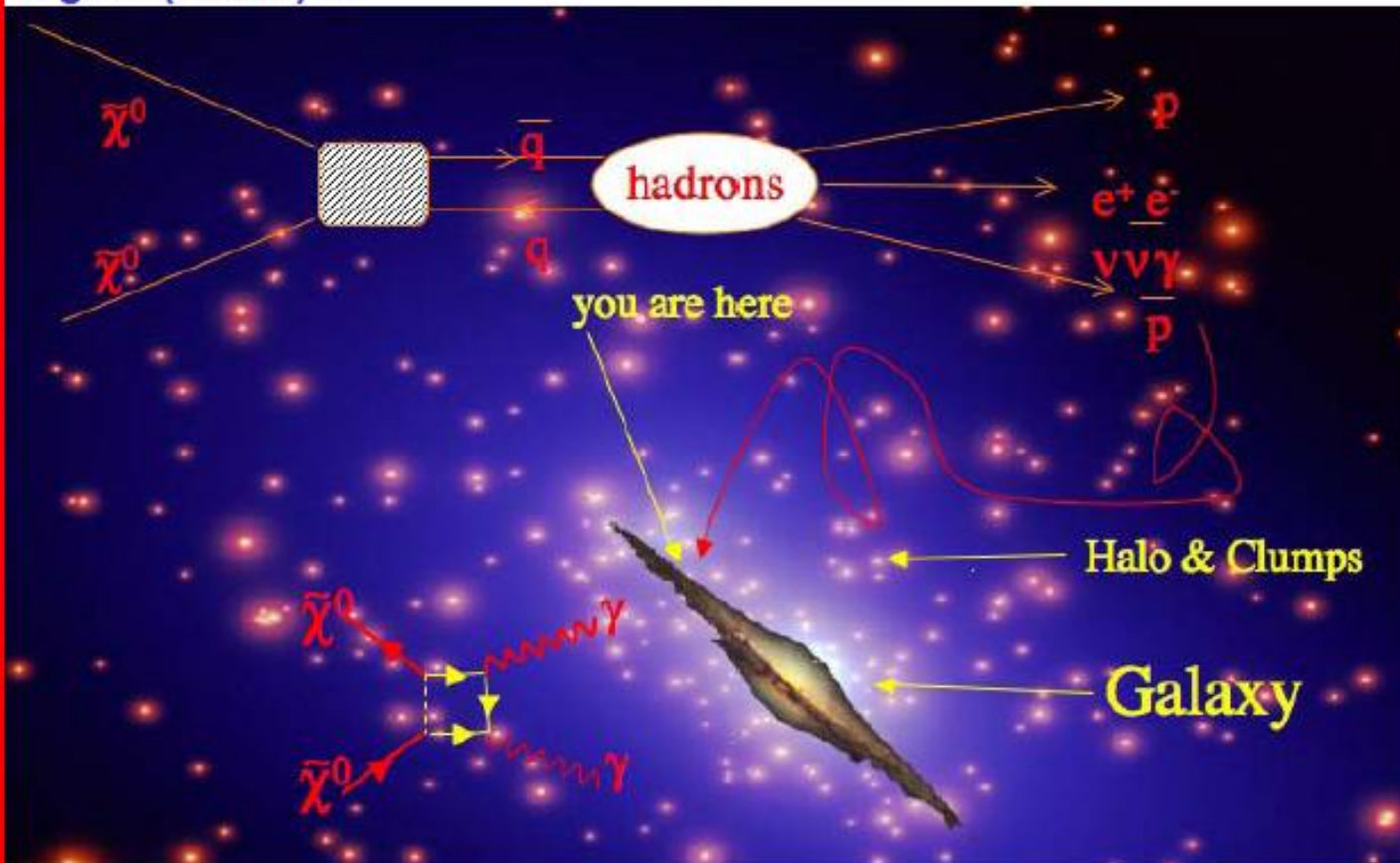
Possible signature:
 Gamma Ray
 from Neutralino Annihilation

Annihilation at rest:
 bump around Neutralino mass



A=pseudoscalar
 χ^\pm =chargino
 χ^0 =neutralino
 H=Higgs boson

Signal (SUSY)...



... background

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

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

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

PHYSICS GOALS



- Search for cosmic antimatter
 - Search for dark matter
 - Deep study of cosmic ray composition and energy spectrum
 - Gamma ray astrophysics
-
- **Need of high precision and high statistics data collection** (up to 20GB of data are transferred every day to the ground station in Moscow)
 - Detector design
 - Negligible background environment (Mission duration 3 years)
 - Long exposure time (4 years, 5 months, and 29 days)

DESIGN

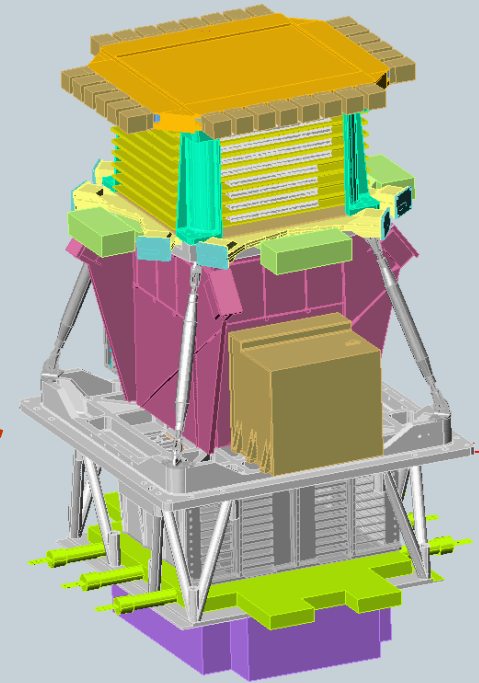
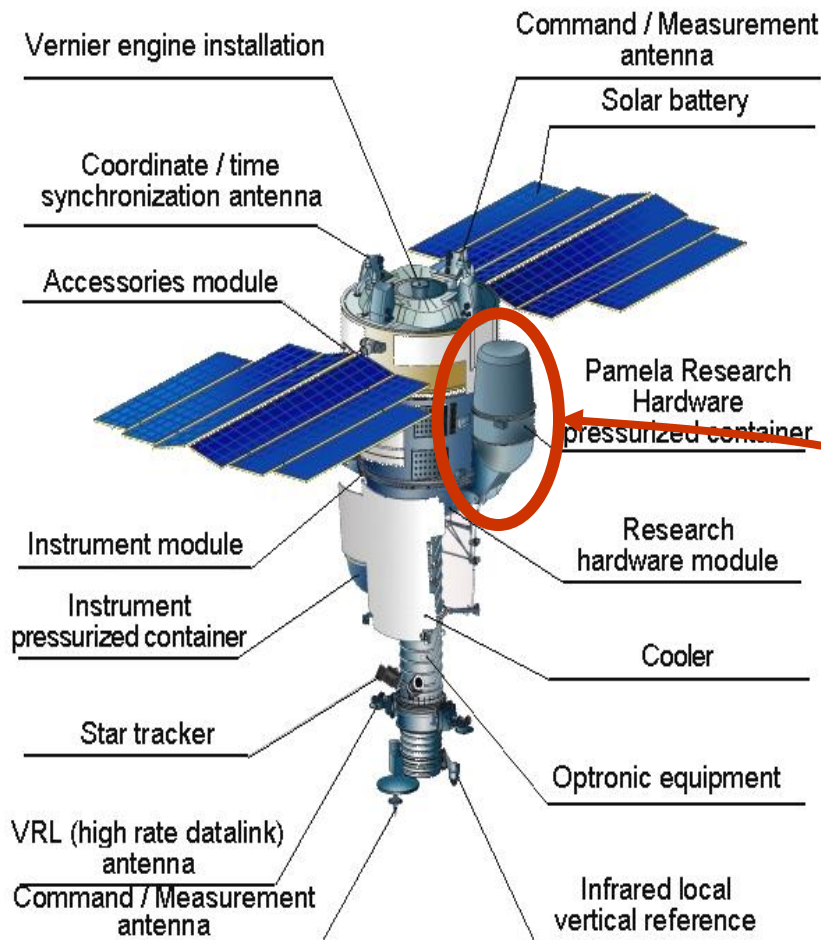


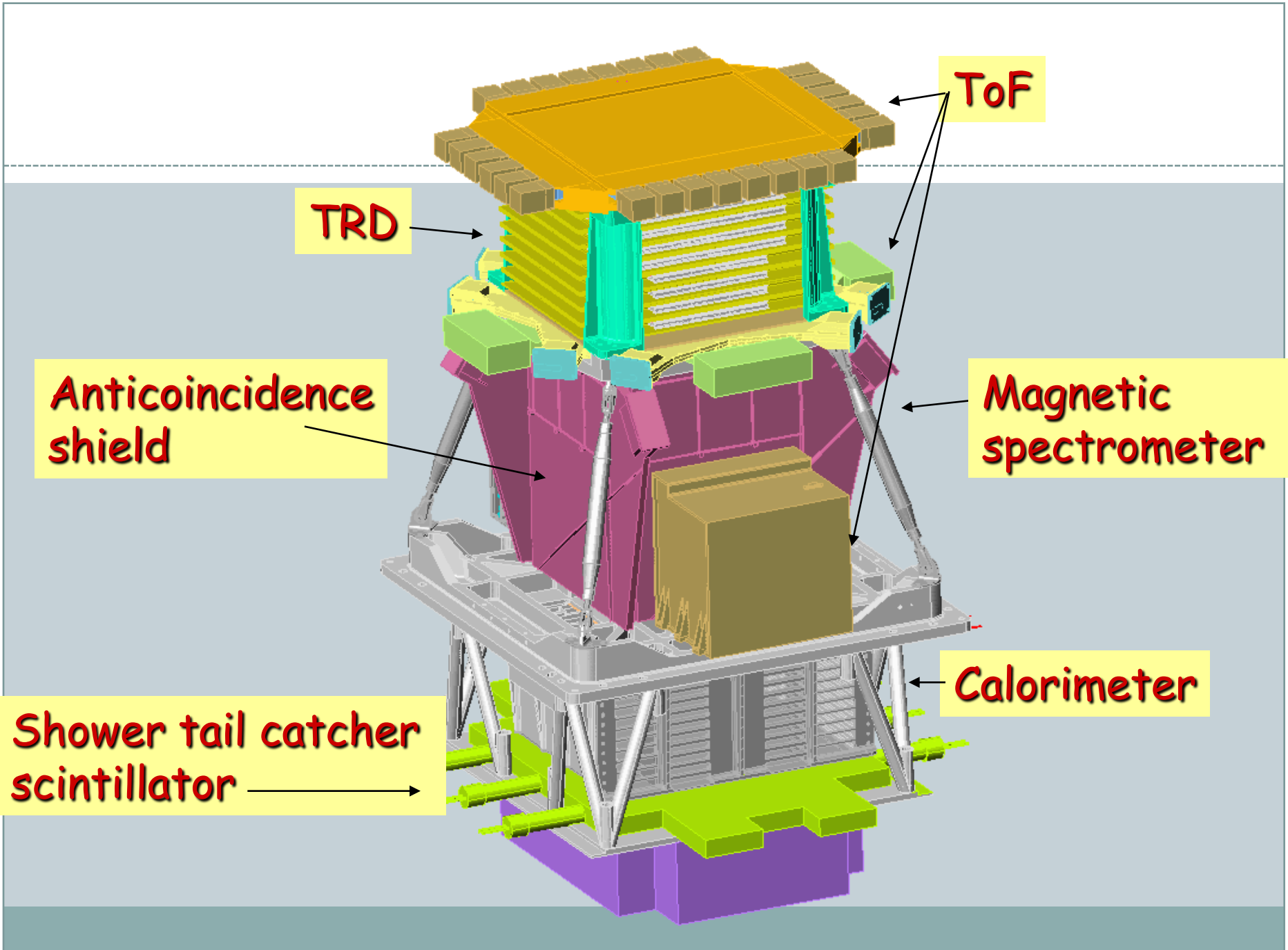
- Study signals among intense backgrounds
 - Minimum amount of material traversed
 - Repeated measurements of momentum and velocity_{7.2km/s}
- Technical
 - High vacuum conditions and radiation levels
 - Strong temperature $\sim (-60^{\circ}\text{C to } +40^{\circ}\text{C})$
 - The apparatus is 1.3 m high
 - Total weight 470 kg
 - Total power consumption 335 W
 - *PAMELA* has been put in a polar elliptical orbit at an altitude between 350 and 610 km, with an inclination of 70° .

The Space Experiment PAMELA Satellite

The Satellite: Resurs DK1

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





ToF

TRD

Anticoincidence shield

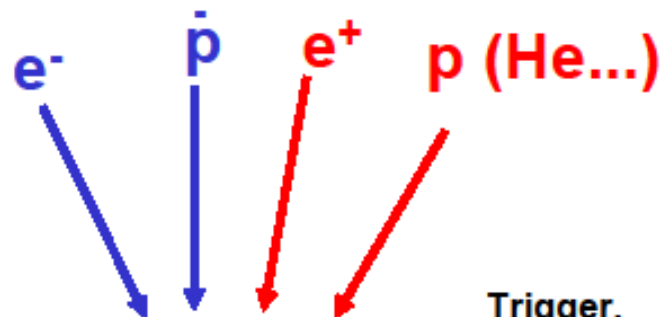
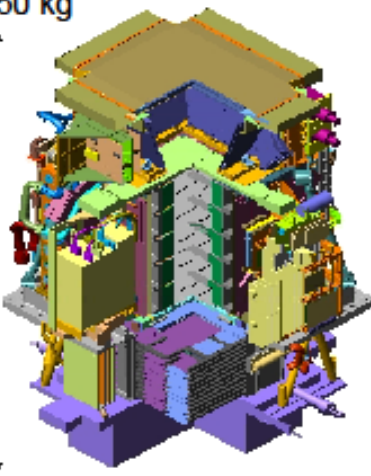
Magnetic spectrometer

Calorimeter

Shower tail catcher scintillator

~450 kg

~1.2 m



Trigger,
ToF, dE/dx

TOF (S1)

ANTICOINCIDENCE
(CARD)

ANTICOINCIDENCE
(GAT)

TOF (S2)

SPECTROMETER

Anticoincidence
system reduces
background.

ANTICOINCIDENCE
(CAS)

Sign of
charge,
rigidity,
dE/dx

TOF (S3)

CALORIMETER

Electron energy,
dE/dx, lepton-hadron
separation

S4

NEUTRON
DETECTOR

NB:

e^+/p : 10^3 (1 GeV) \rightarrow $5 \cdot 10^3$ (10 GeV)

p/e : $5 \cdot 10^3$ (1 GeV) \rightarrow $<10^2$ (10 GeV)

PAMELA Status

Integration of PAMELA Technological Model completed and delivery to Russia underway and Launch from Baikonur: June 15th 2006, 0800 UTC.

Integration of PAMELA FM underway at INFN - Roma2

'First light': June 21st 2006, 0300 UTC.

PAMELA in continuous data-taking mode since commissioning phase ended on July 11th 2006

As of ~This period:

- > 300 days of data taking (70% live-time)
- ~5.5 TByte of raw data downlinked
- ~610 million triggers recorded and under an alysis



PAMELA Capabilities

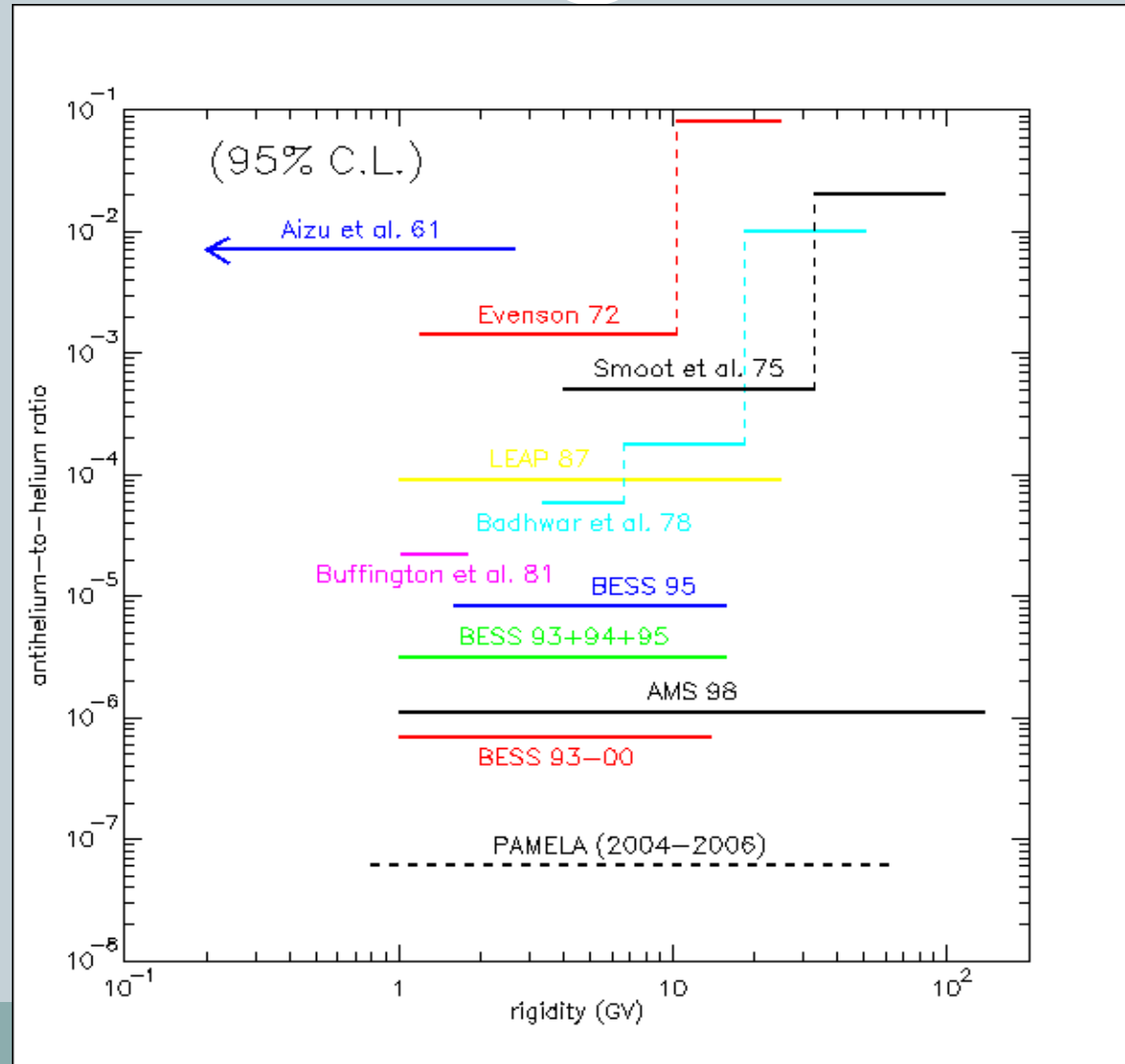
PAMELA will explore:

- 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 of 10^{-7} in He/He)

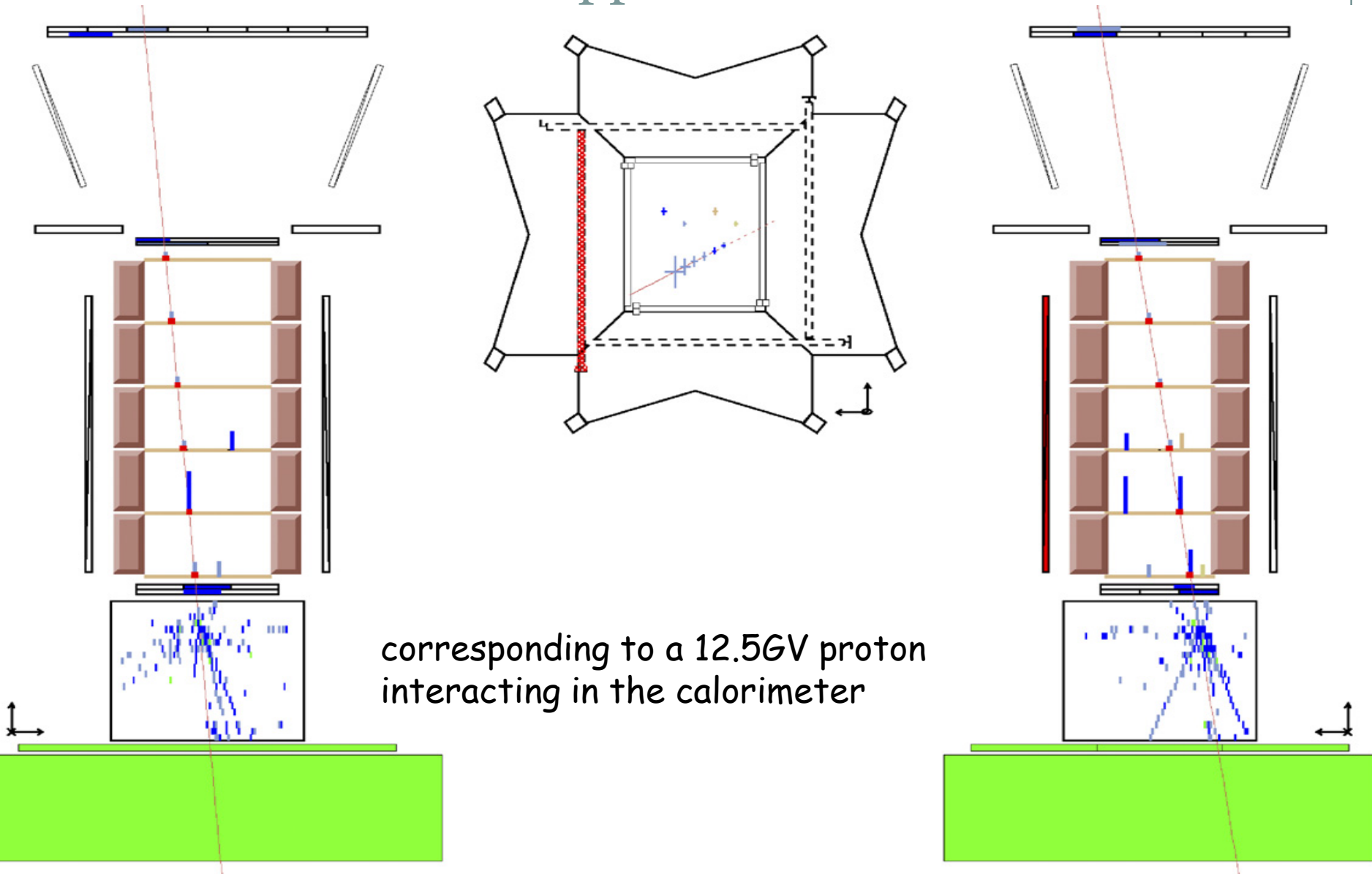
1 CAPRICE98 flight ~ 3.9 days PAMELA data



Cosmic-ray Antimatter Search



Example of a reconstructed event in the PAMELA apparatus



Summary



- Launched on June 15th 2006. **PAMELA** is conducting an indirect search for dark matter using antiparticles (e^+ , $p\text{-bar}$) in the cosmic radiation.
- Mission duration : 3 years But it elapsed time 4 years, 5 months, and 29 days and soon is Over.
- **The Alpha Magnetic Spectrometer Experiment** is a research module with similar goals scheduled to be attached to the [International Space Station](#) in 2011.

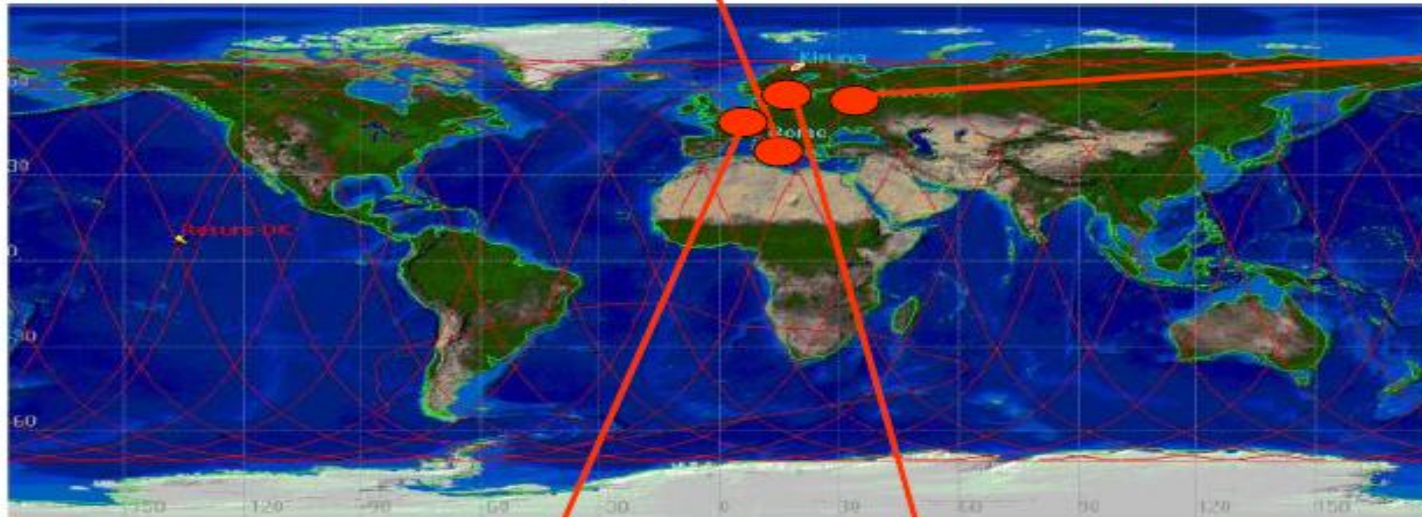
The PAMELA Collaboration

Italy:  Bari  Florence  Frascati  Naples  Rome  Trieste  CNR, Florence

Russia:



Moscow
St. Petersburg



Germany:  Universität
Gesamthochschule
Siegen
Siegen

Sweden:  KTH, Stockholm

Source

<http://cdsweb.cern.ch/record/981255> // CERN Document Server

http://en.wikipedia.org/wiki/Payload_for_Antimatter_Matter_Exploration_and_Light-nuclei_Astrophysics

<http://hyperphysics.phy-astr.gsu.edu/hbase/astro/cosmic.html>

<http://pamela.roma2.infn.it/index.php>