



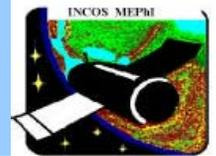
**The RIM-PAMELA
international experiment
opens the window into the
world of very-high energy
physics and dark matter**

**A.M. Galper
MEPhI, Moscow**

COPUOS Vienne, February 2010



PAMELA collaboration



Italy:



Bari



Florence



Frascati



Naples



Rome



Trieste



CNR, Florence

Russia:



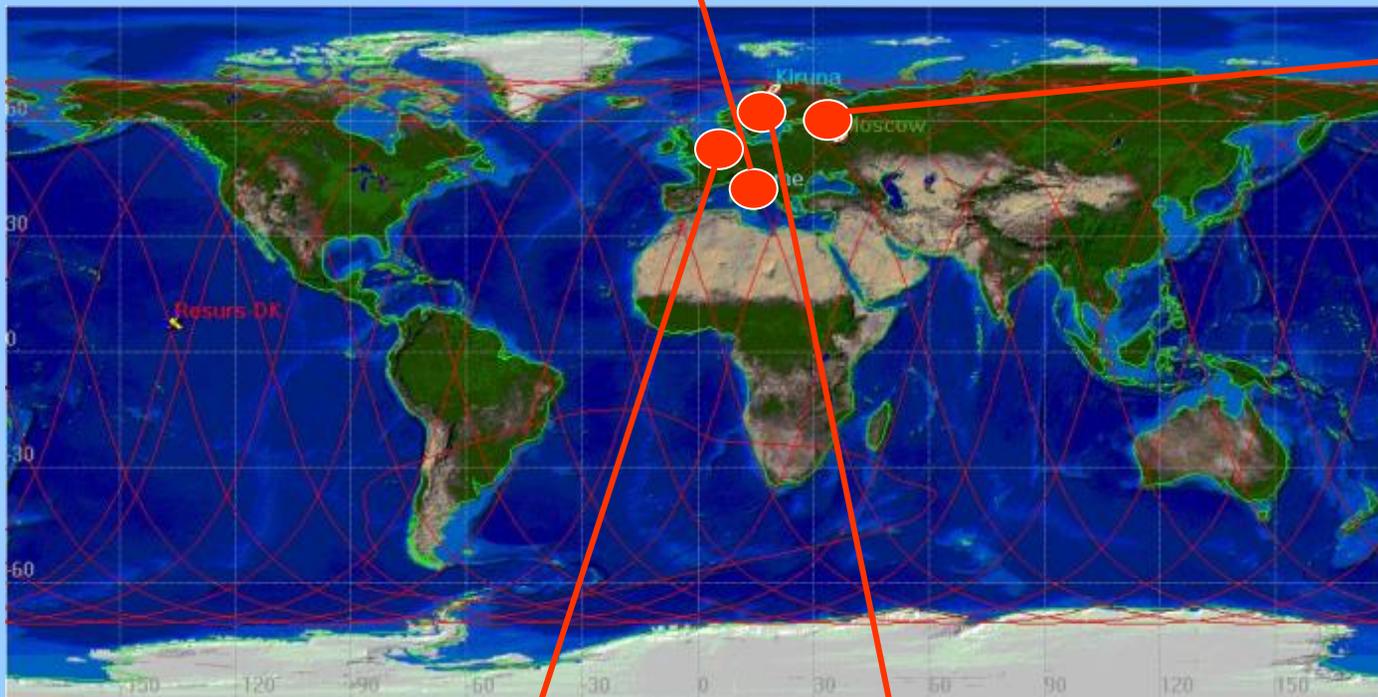
Moscow



Moscow



St. Petersburg



Germany:



Siegen

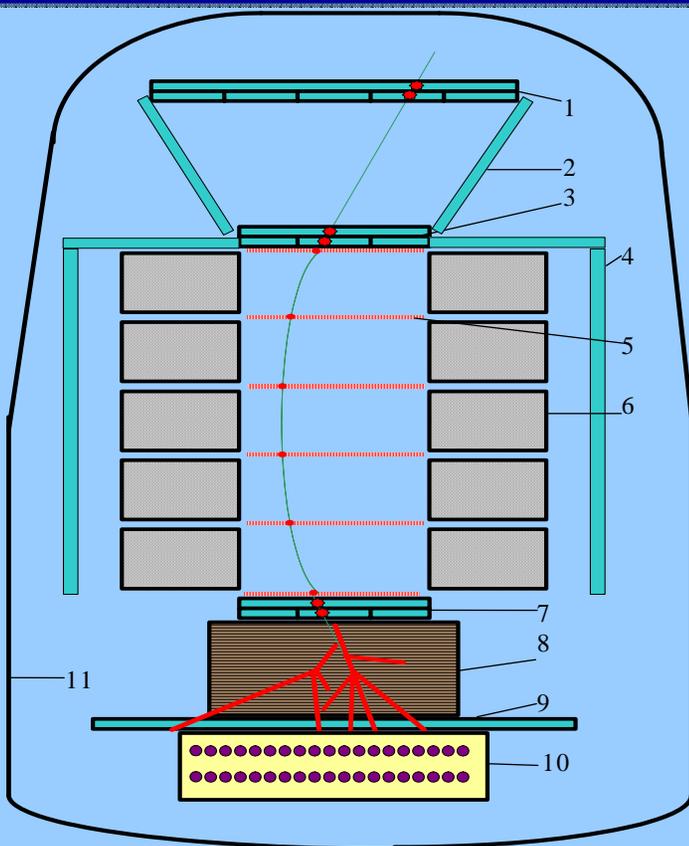
Sweden:



KTH, Stockholm

8-9 February 2010

- *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?)



- 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:

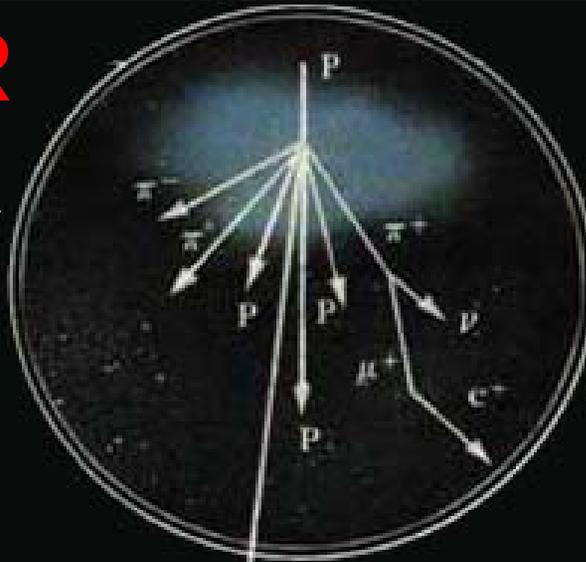
- time of flight (β);
- deflection in the magnetic field;
- energy losses in all detectors;
- number of neutrons.

Estimations:

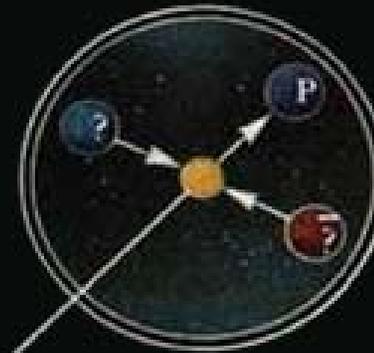
- type of particle (lepton/hadron);
- sign and value of charge ($\pm Z$);
- mass of particle (A);
- rigidity and energy (R and E);
- direction of flight;

ANTIMATTER

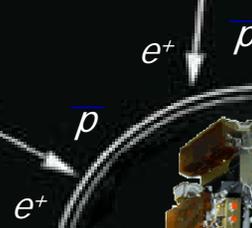
Collision of High Energy Cosmic Rays with the Interstellar Gas



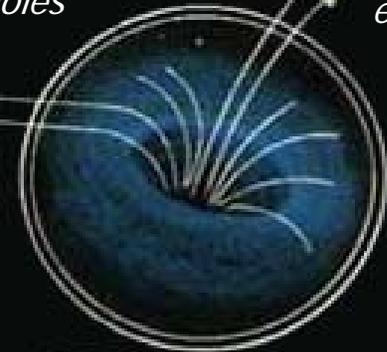
Annihilation of Exotic Particles



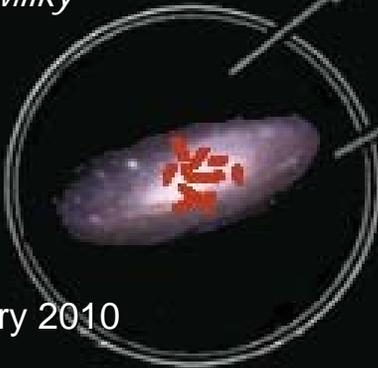
Cosmic Rays Leaking Out of Antimatter Galaxies



Evaporation of Primordial Black Holes



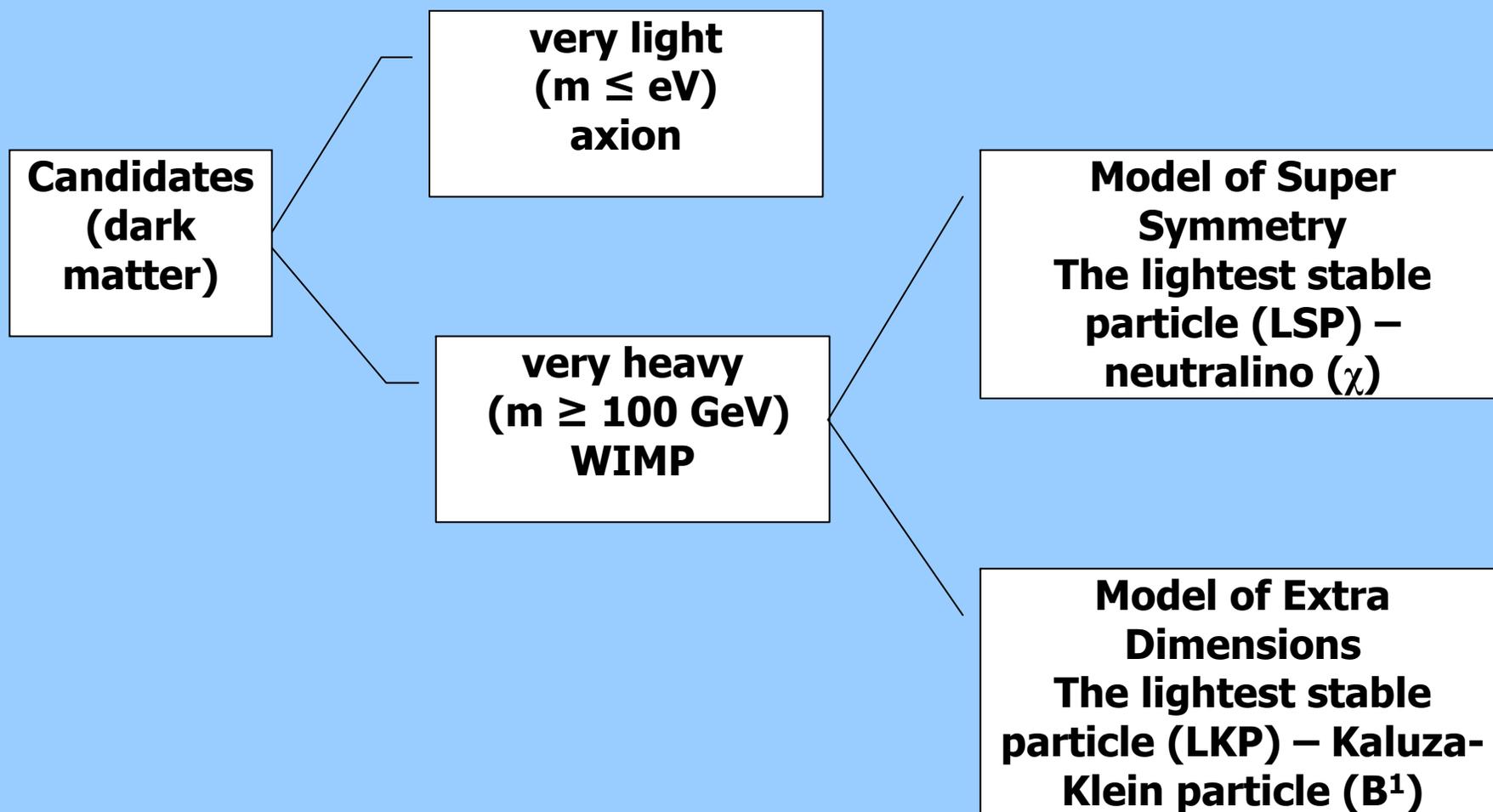
Antimatter Lumps In the Milky Way



Pulsar's magnetospheres



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Status of Direct Searches

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

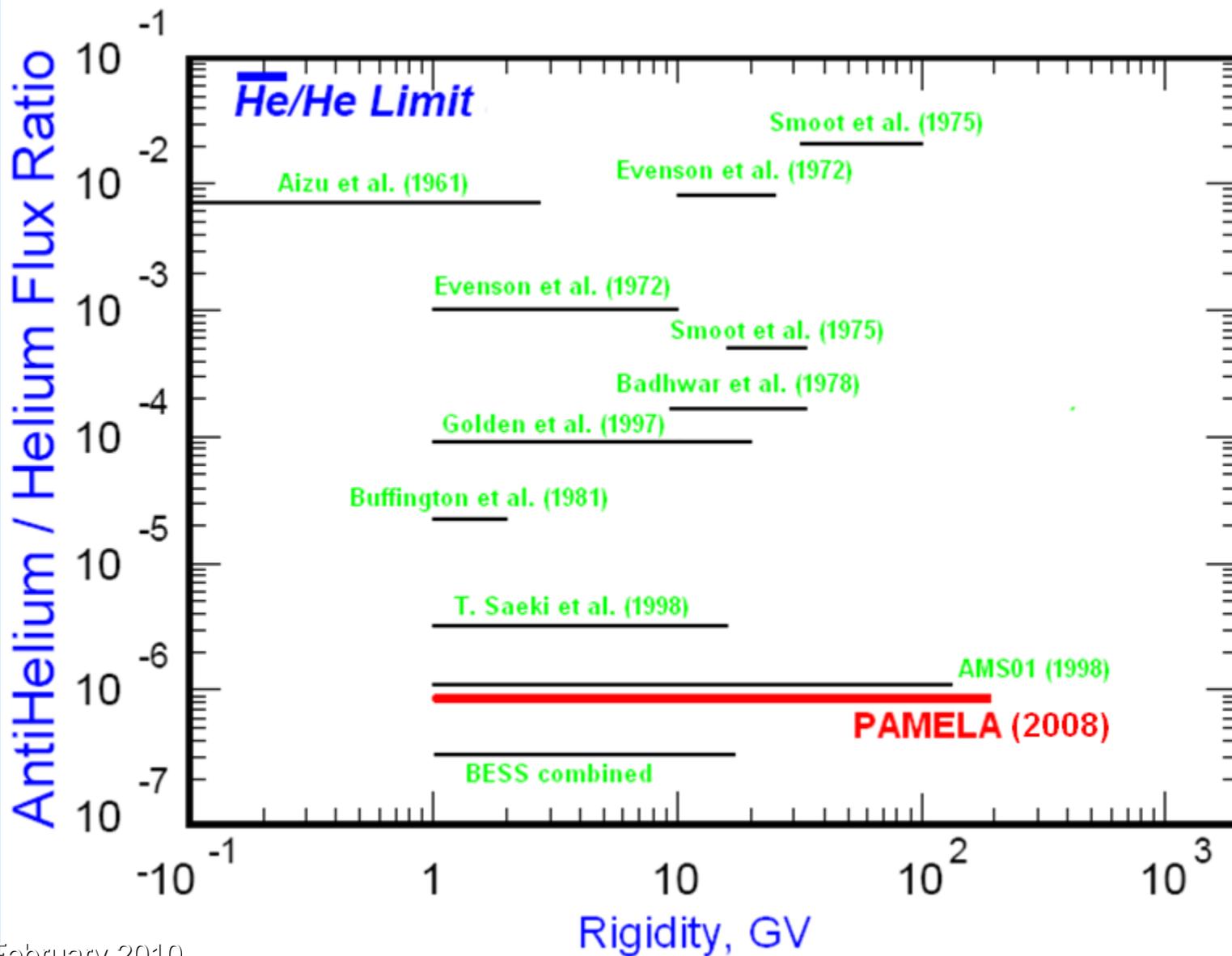
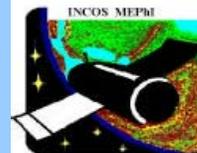
Status of Indirect Searches

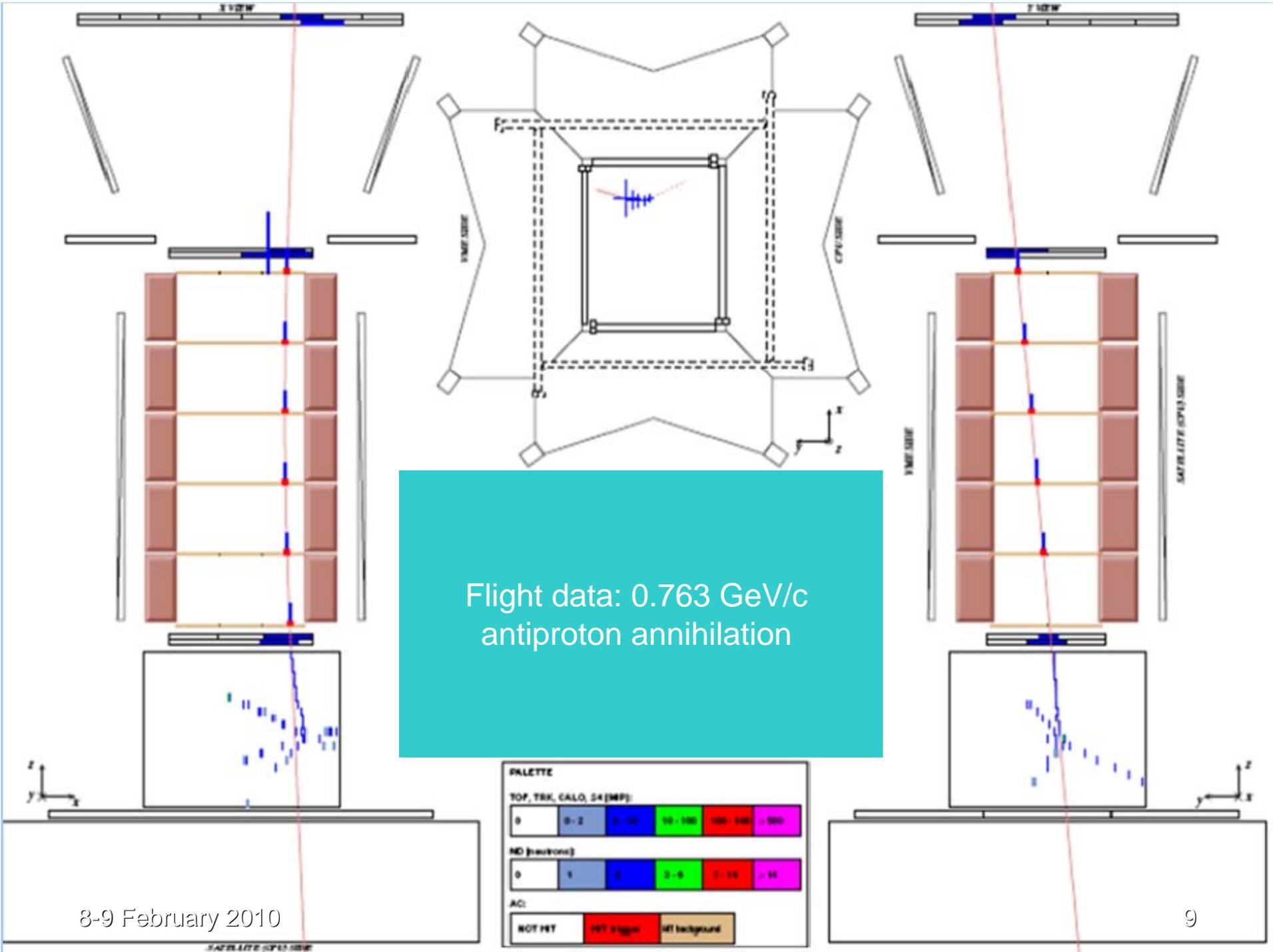
Detect WIMP annihilation process:

$$B^l + B^l \rightarrow e^+ + e^-, \gamma + \gamma, \dots$$

$$\begin{aligned} \chi + \chi &\rightarrow b\bar{b}, t\bar{t}, \tau^+ \tau^-, Z^0 Z^0, Z^0 \gamma, W^+ W^-, HH \rightarrow \\ &\rightarrow \gamma + \dots, e^\pm + \dots, p\bar{p} + \dots, d\bar{d} + \dots, \dots \end{aligned}$$

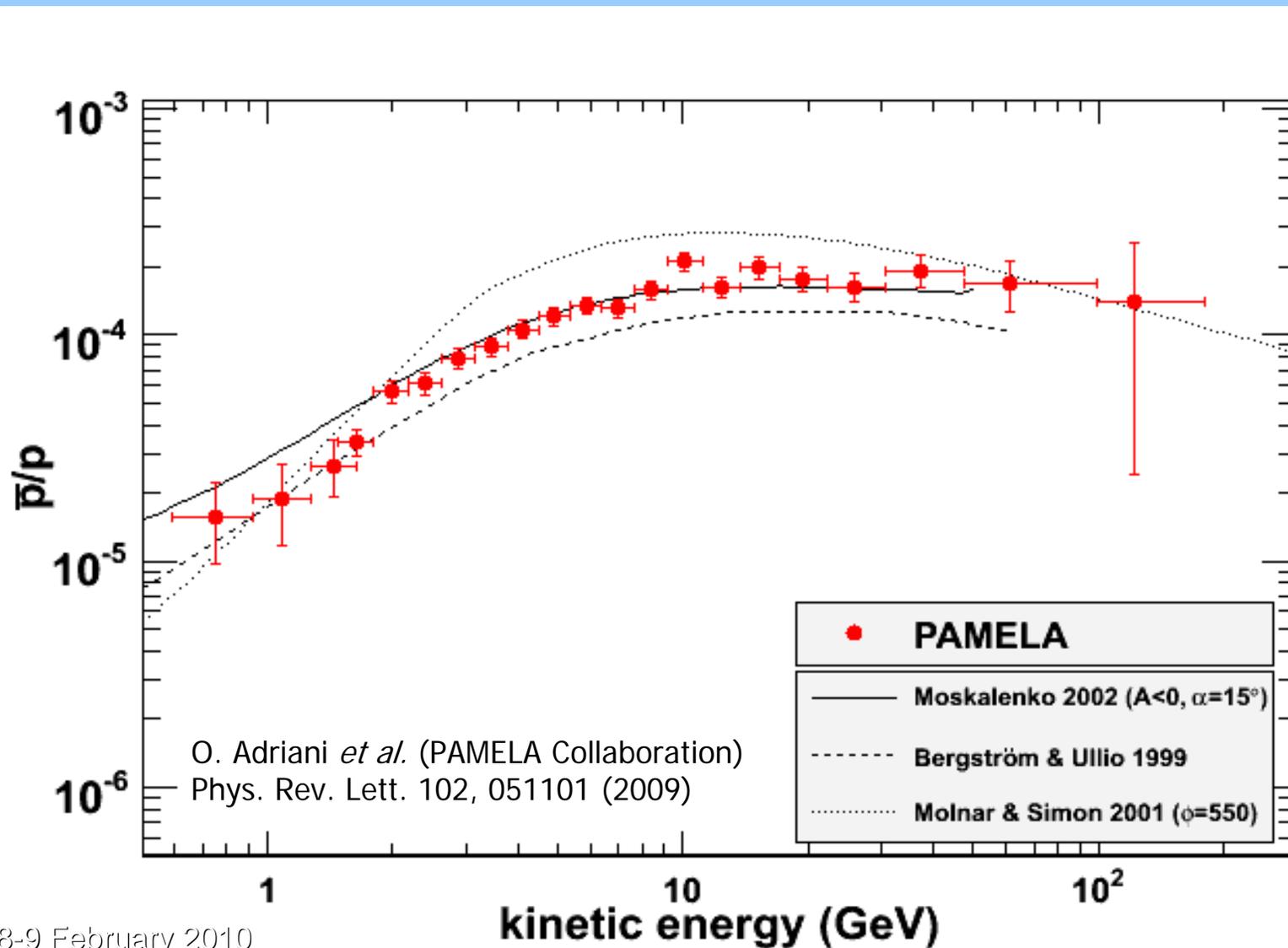
Antihelium/helium ratio

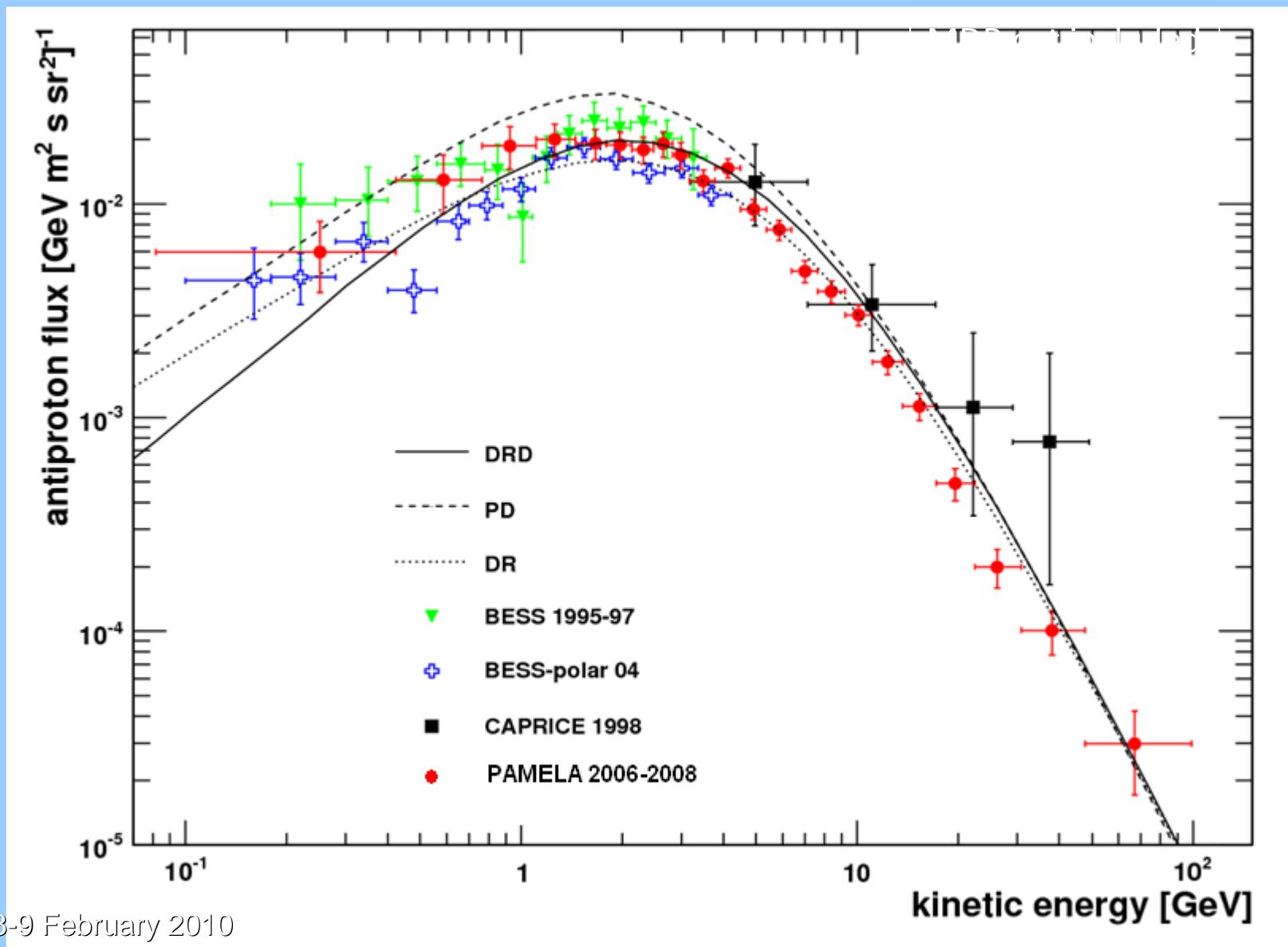




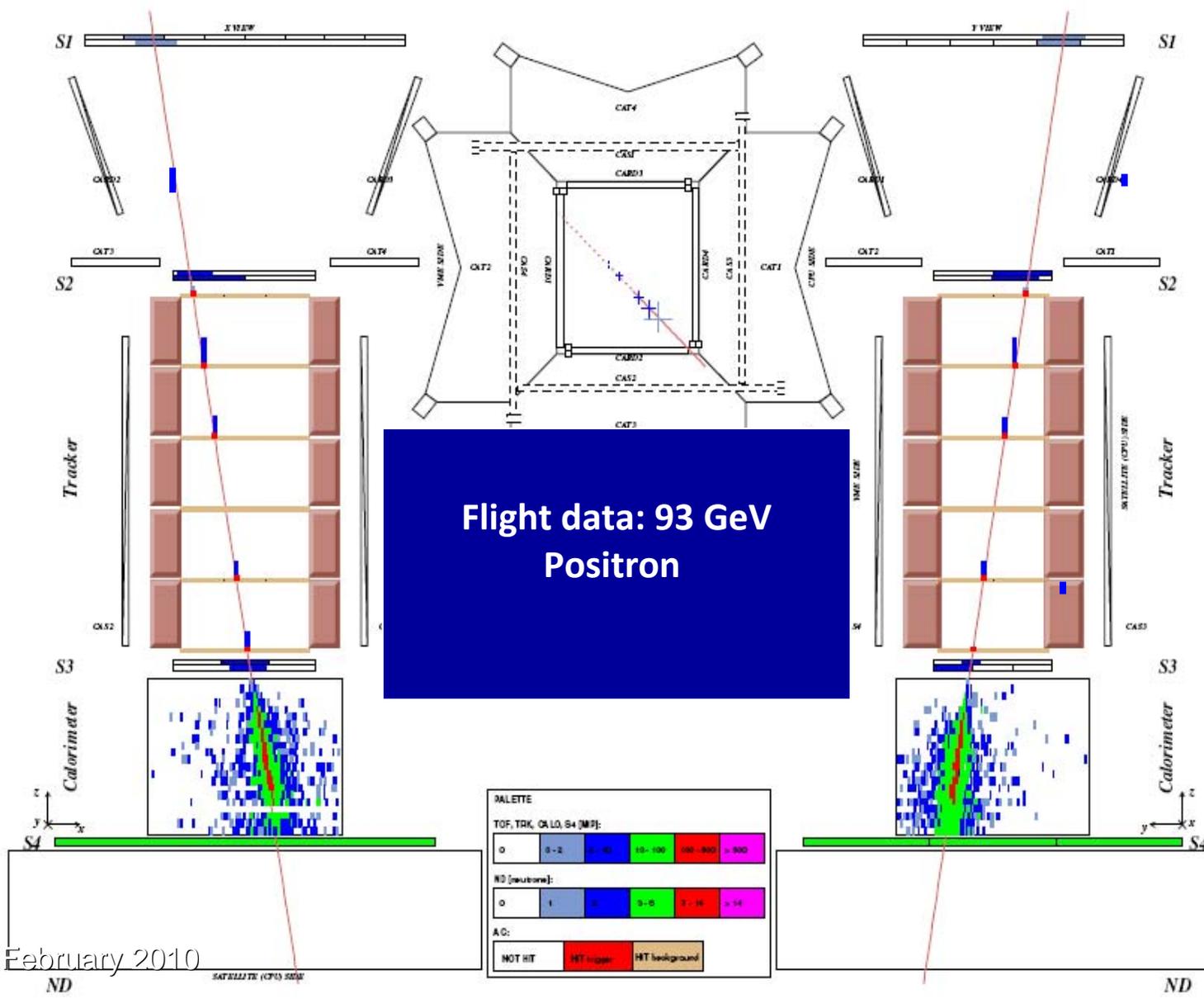
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Antiproton to proton ratio





The sample of event



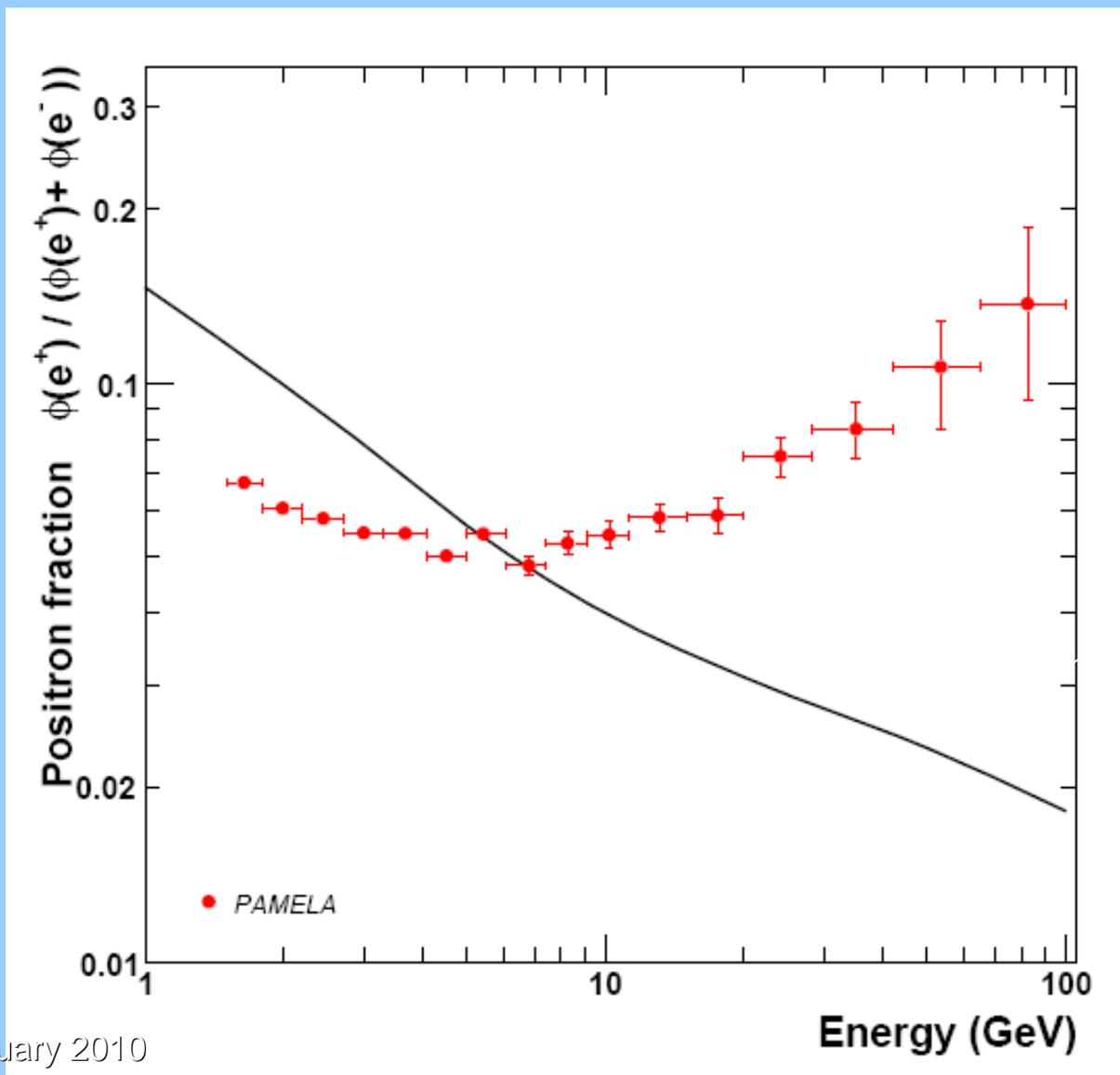
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ND

SATALLITE (CPU) SIDE

ND

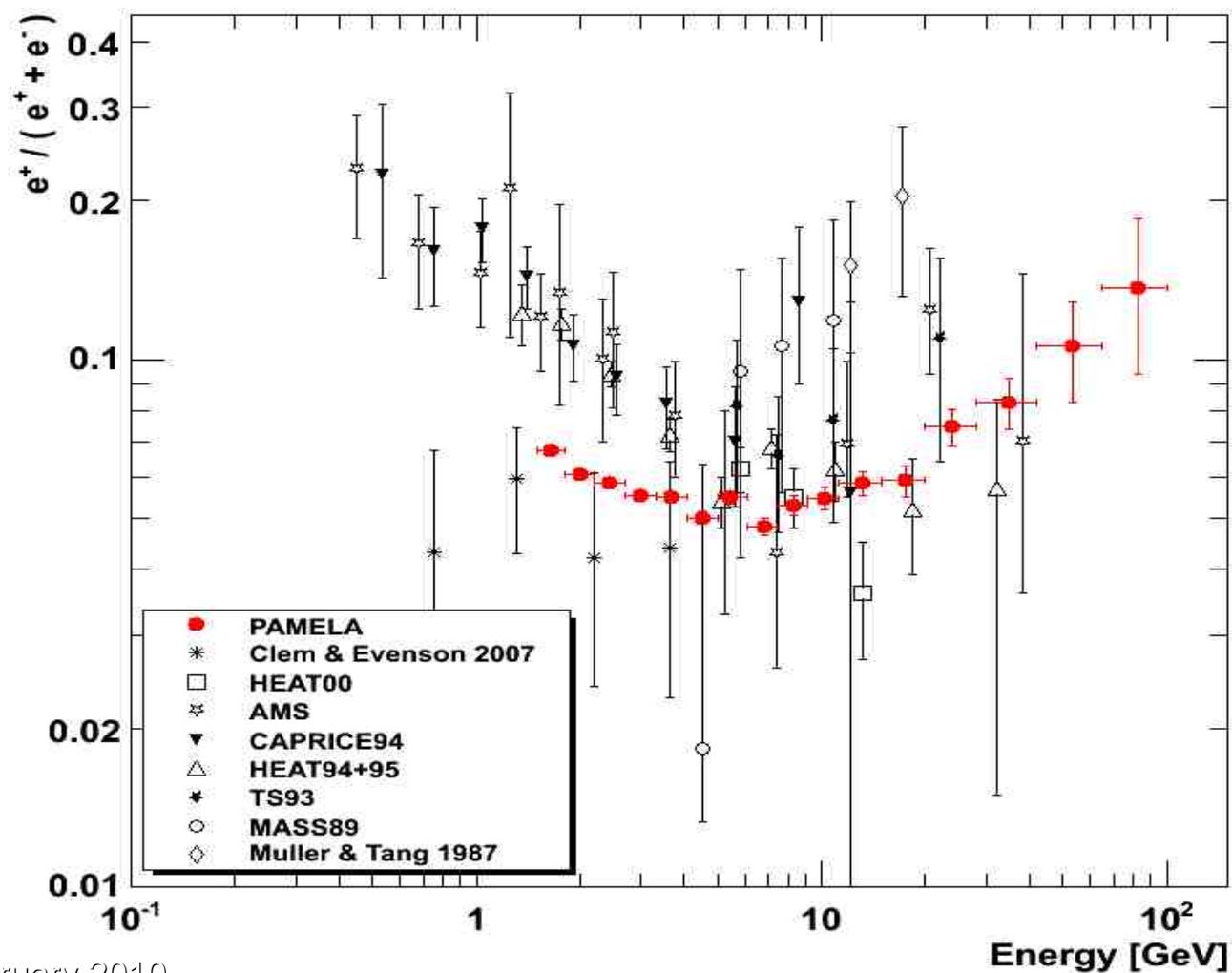
positron to electron ratio

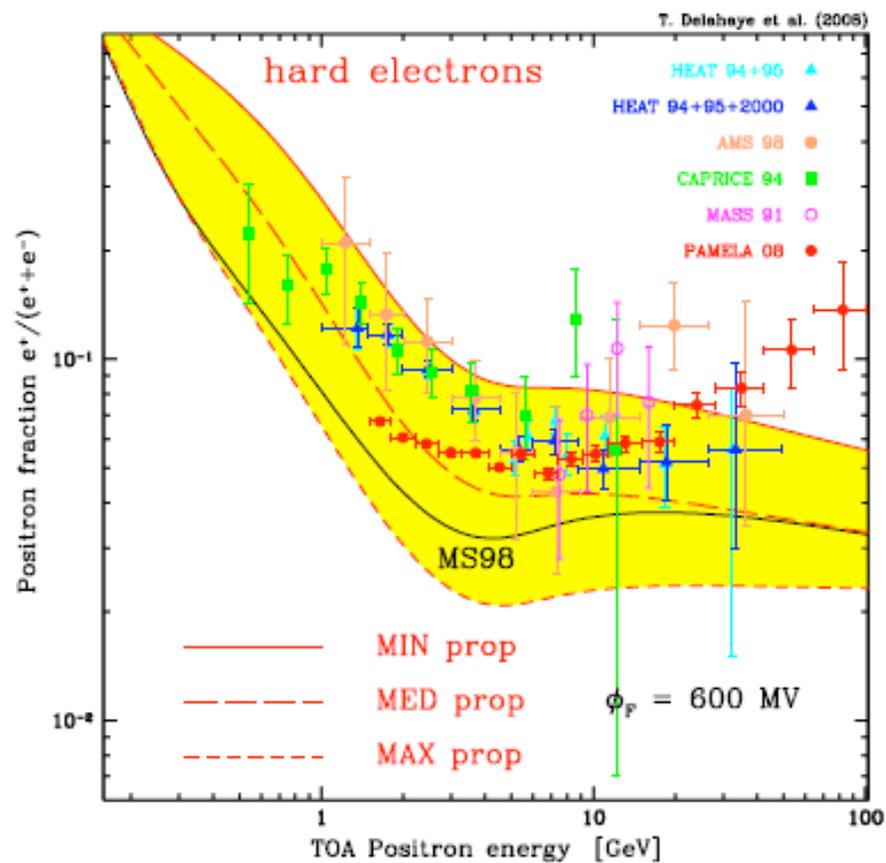
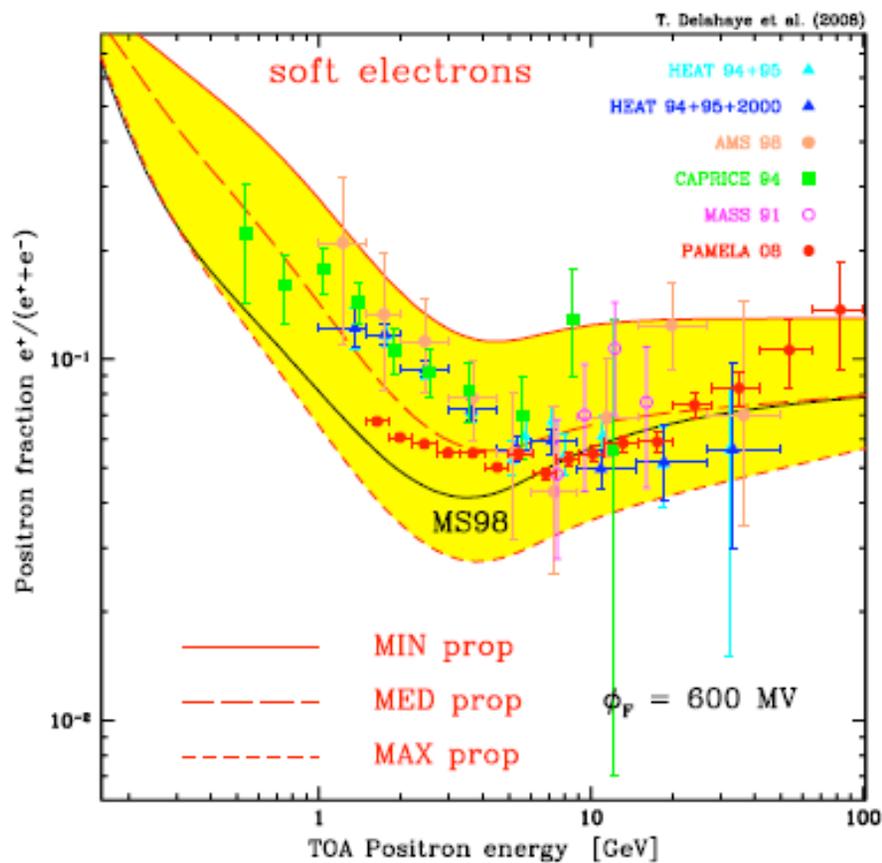


Secondary production
Moskaleiko-Strong
(1998)

O.Adriani et al. //
Nature 2009, V.458, P.607

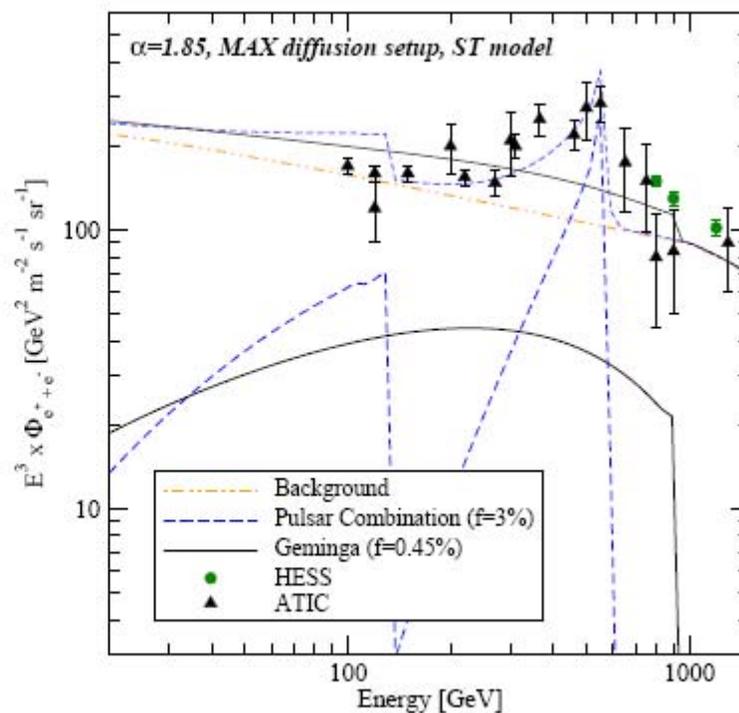
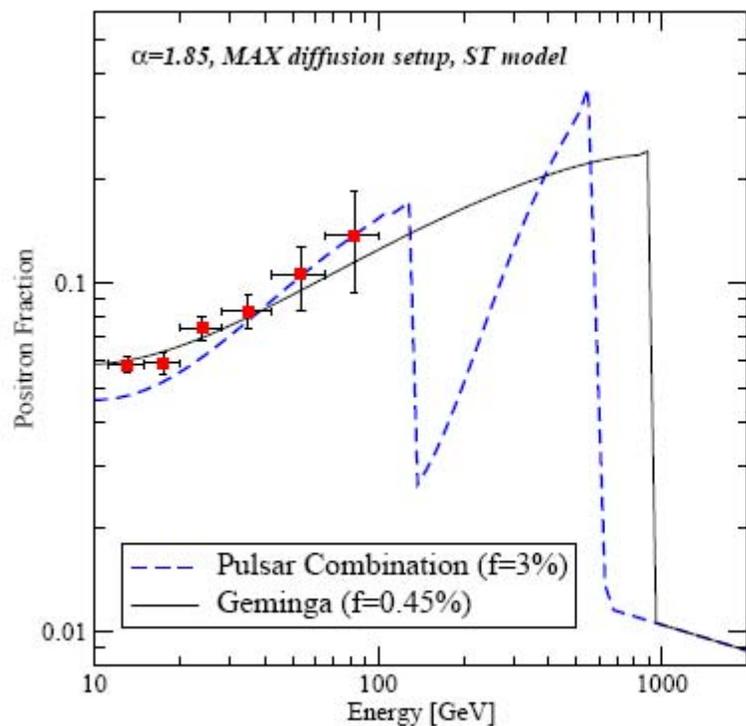
Positron to all electron ratio

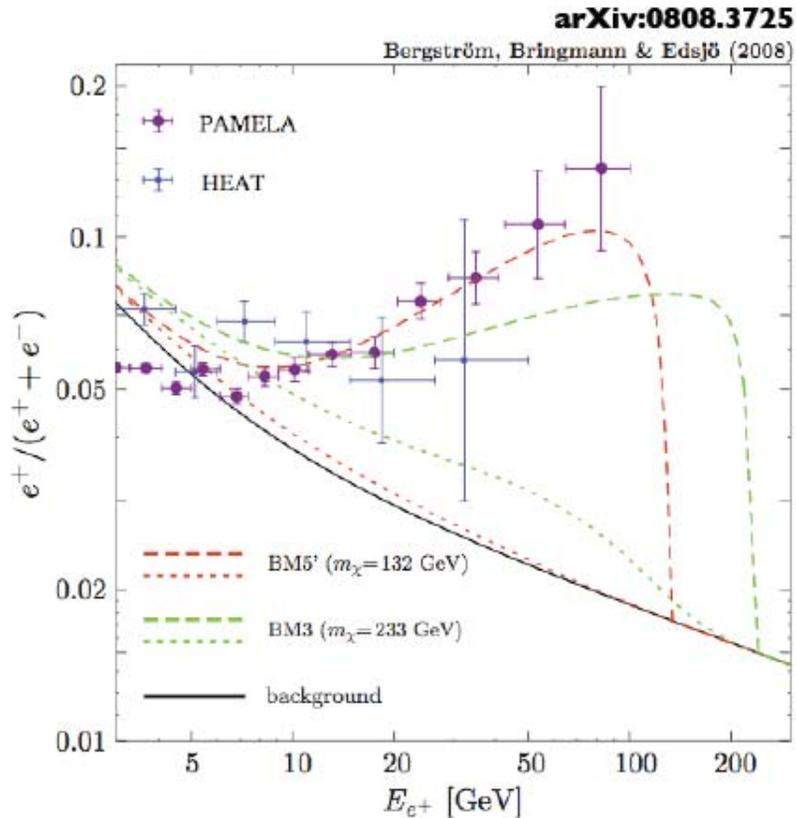




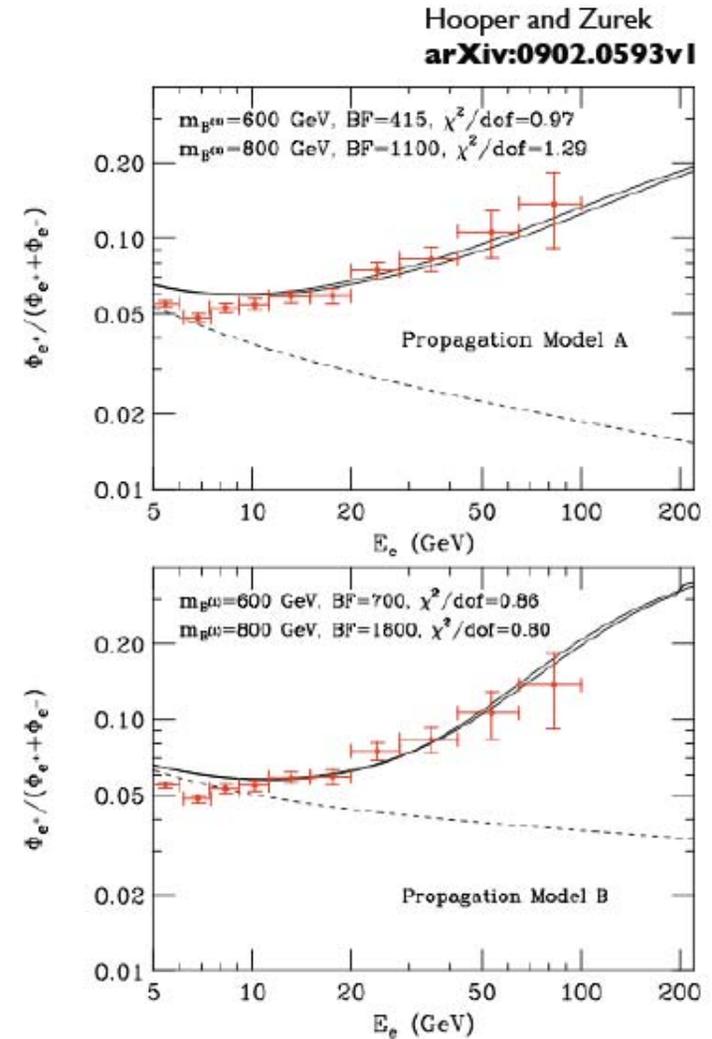
Galactic secondary positron flux at the Earth

T. Delahaye, F. Donato, N. Fornengo, J. Lavallo, R. Lineros, P. Salati, R. Taillet.





Majorana DM with **new** internal bremsstrahlung correction. NB: requires annihilation cross-section to be 'boosted' by > 1000 .



Kaluza-Klein dark matter

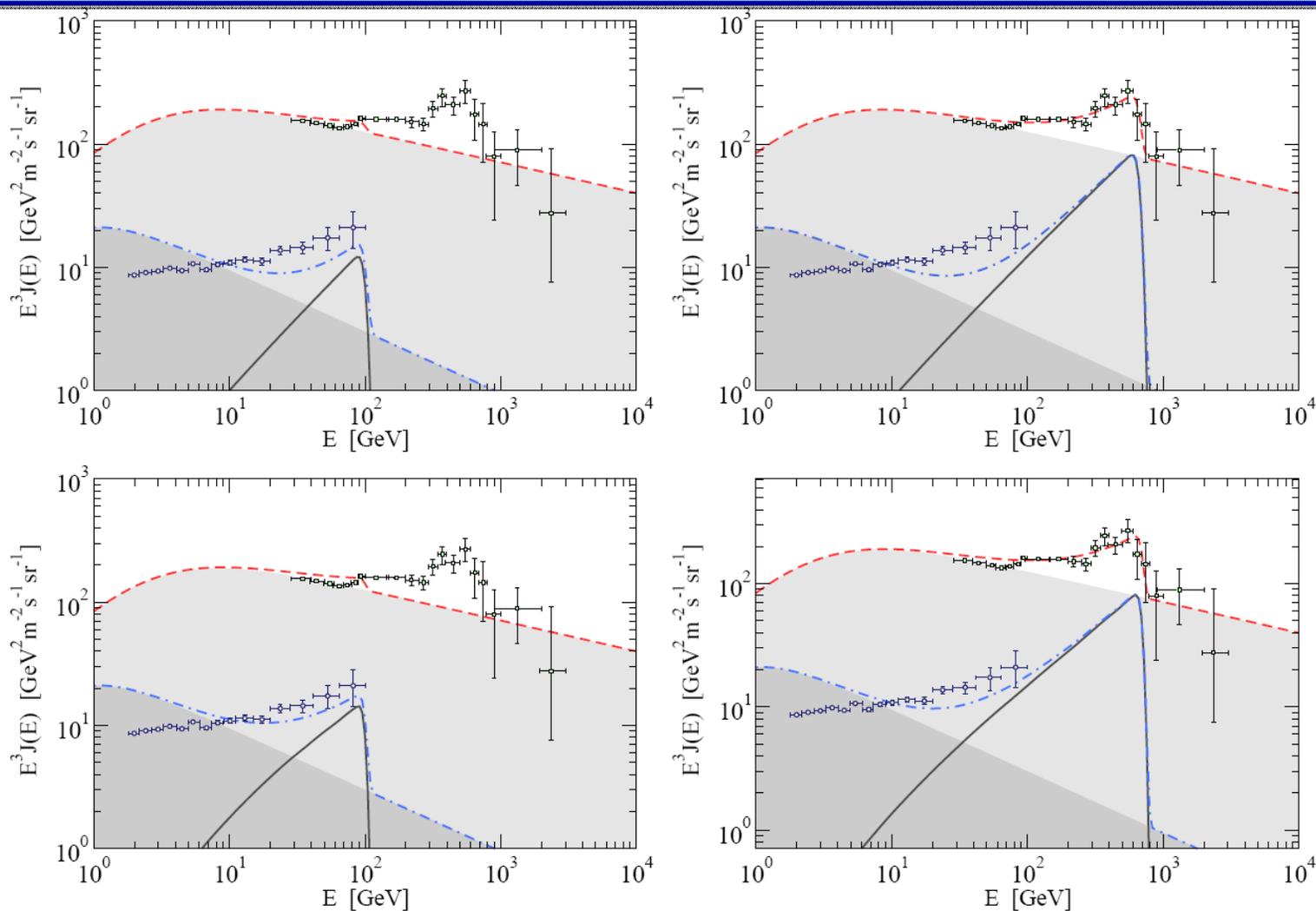
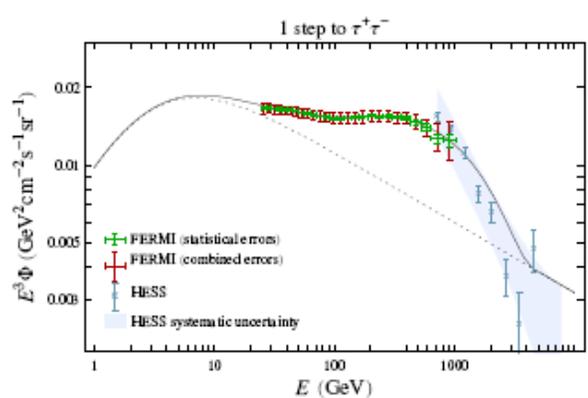
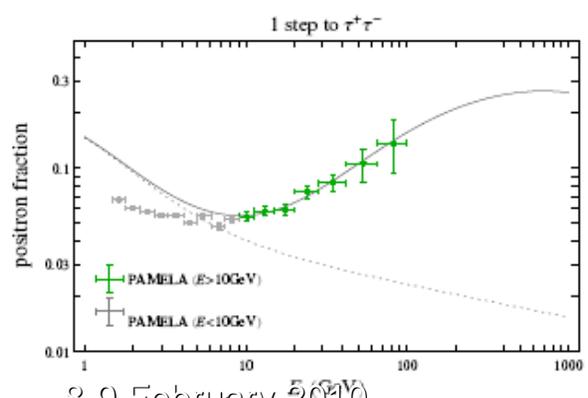
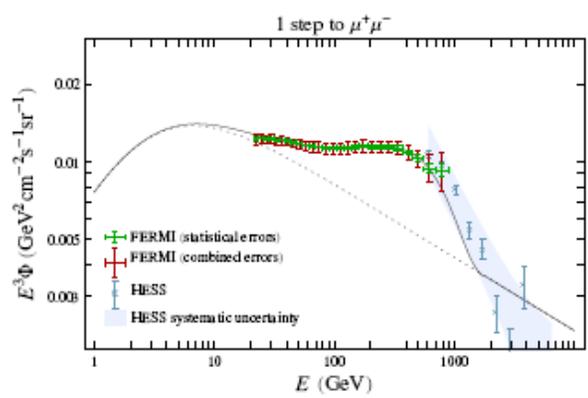
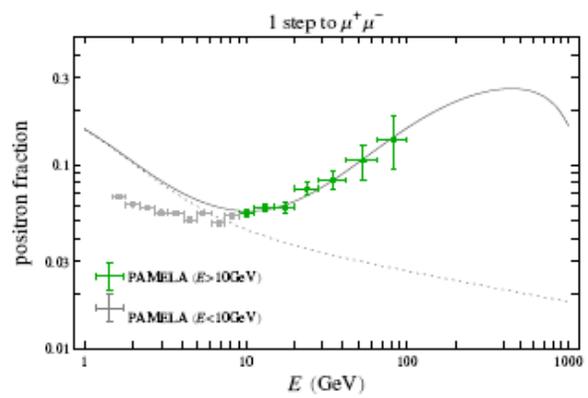
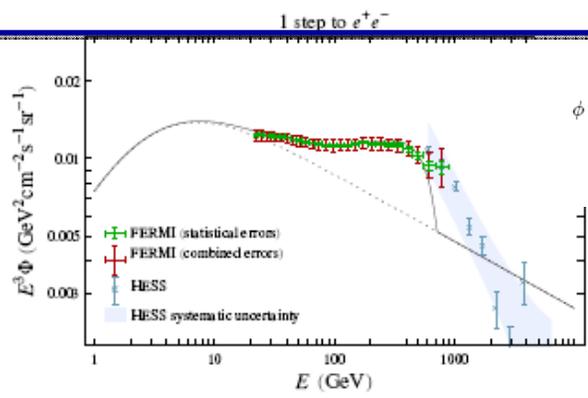
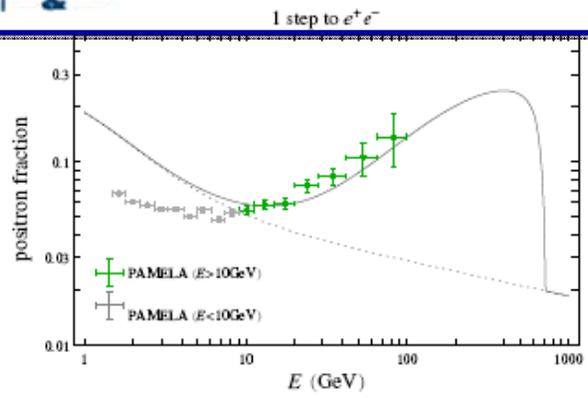
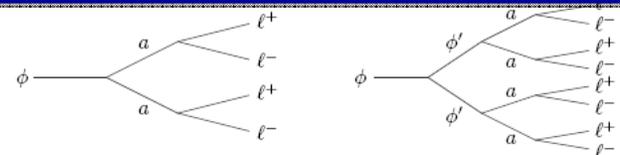
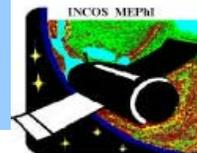


FIG. 2: Models of cosmic ray electron/positron background spectra and observations as in Fig. 1. Here the additional e^\pm contribution (solid line) is assumed to be originated from dark matter decay (top panels) or annihilation (bottom panels) and aimed at explaining either only PAMELA (left panels; as a lower bound on dark matter mass) or also ATIC (right panels; as an upper bound on dark matter mass). See text



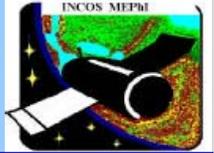
Study of origin of dark matter



Mass ~ 1 TeV
 Lifetime $\sim 10^{26}$

8-9 February 2010

The main results:



1. PAMELA has found an increase of galactic positron/electron flux ratio for energies from 10 GeV up to 100 GeV that contradicts models of secondary electron and positron generation. Meanwhile measured antiproton/proton ratio is in agreement with these models.

This fact can be explain by:

- correction of the generation and diffusion model of particle propagation in the interstellar space;
- generation of electron-positron pairs in the supernova and pulsars;
- **annihilation and/or decay** of hypothetic particles, which can consist dark matter, on the electron-positron pairs.

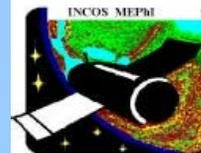
The last case can be the most important because it would be the first positive indirect observation of the DM particles existing.

2. Detailed measurements of electron, positron, proton and light nuclei spectra permit to plot the high-energy model of radiation in the near-Earth space including the radiation belts (PAMELA- model).

This results has large practical application.



TOP TEN PHYSICS STORIES OF THE YEAR 2008



INSIDE SCIENCE RESEARCH --- **PHYSICS NEWS UPDATE** The American Institute of Physics
Bulleting of Research News Number 879 #1, December 22, 2008 www.aip.org/pnu by Phil Schewe

- *SUPERCONDUCTORS*
- *LARGE HADRON COLLIDER*
- *PLANETS*
- *QUARKS*
- *FARTHEST SEEABLE THING*
- *ULTRACOLD MOLECULES*
- *DIAMOND DETECTORS*

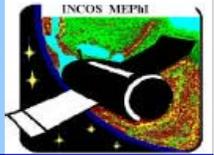
- **COSMIC RAYS**

Another mystery pertains to the findings of two detectors held aloft—one by a balloon and one on a satellite—looking for oddities in the number of antiparticles arriving with regular particles among cosmic rays reaching Earth. They see an excess of such particles which some interpret as evidence for “dark matter,” a class of very-weakly-interacting particles not seen before. Scientists associated with the balloon-borne ATIC detector (*Nature*, 20 Nov) and the satellite **PAMELA** (<http://arxiv.org/abs/0810.4995>)

- *LIGHT PASSES THROUGH OPAQUE MATTER*
- *MACROSCOPIC FEEDBACK COOLING*

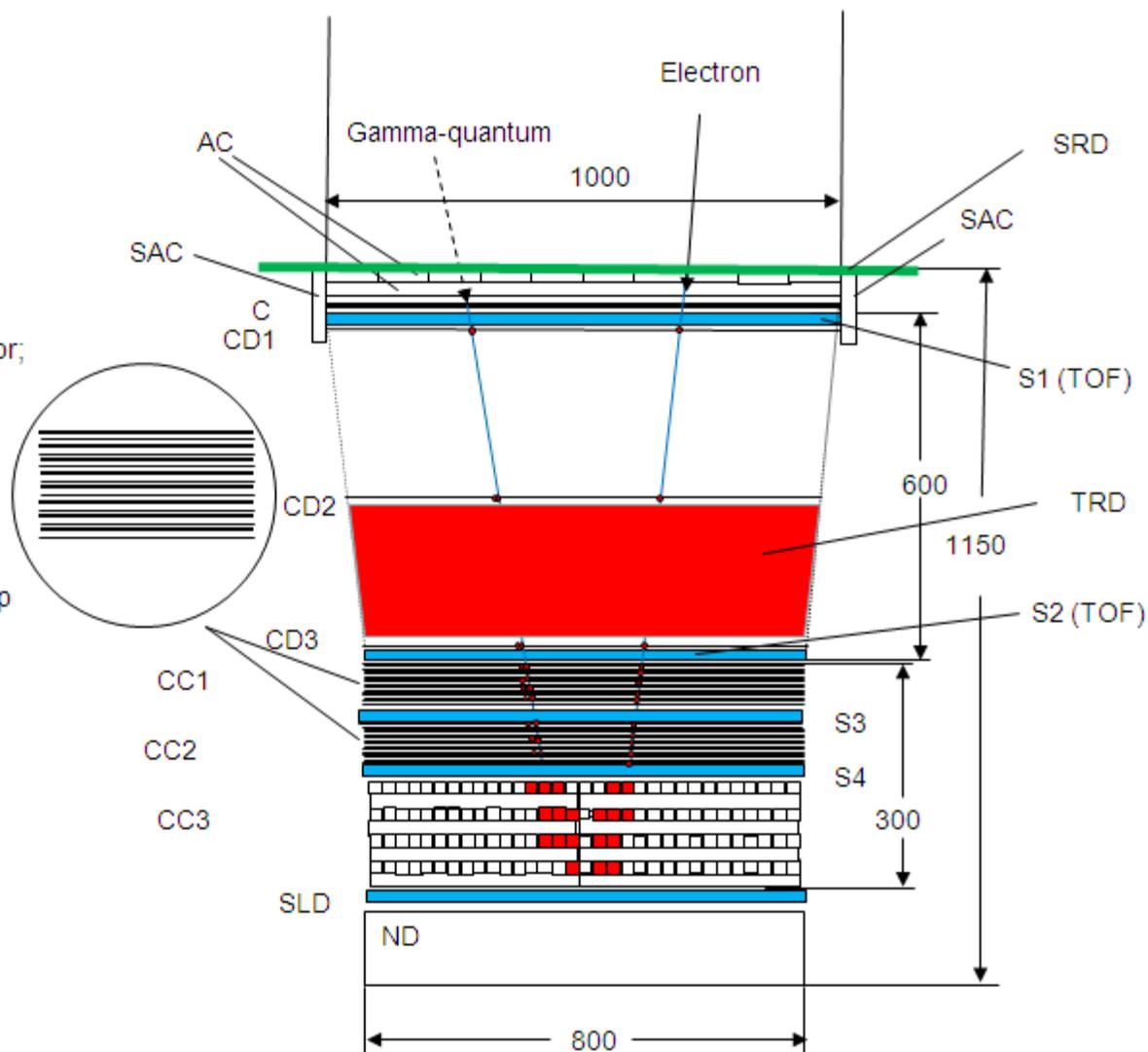


Conclusion

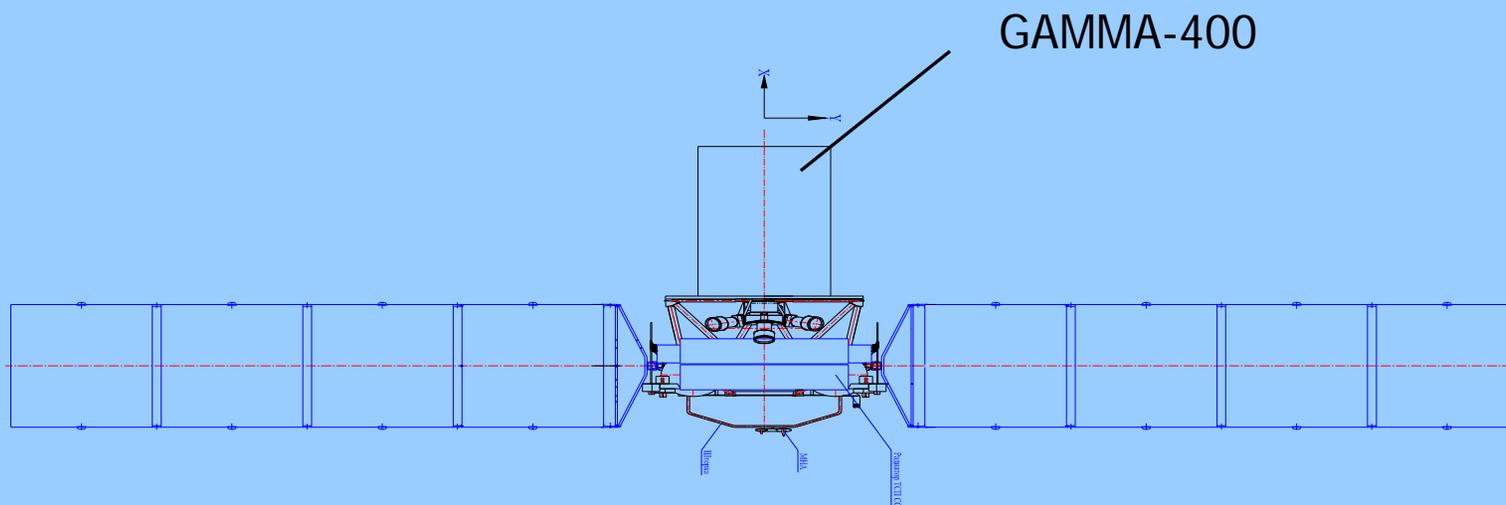


- Till 1st February 2010 PAMELA is functioning ~1200 days, 19.7 Tb of information was received, $\sim 10^9$ of events were registered
- In the last 24 hours 5 downlinks were done, 16.0 Gb of information was transmitted
- PAMELA is functioning normally and the fly is continuing.

- SRD – synchrotron radiation detector;
- AC – anticoincidence detector;
- SAC – side anticoincidence detector;
- C – convertor;
- S1, S2 – TOF scintillators;
- TRD – transition radiation detector;
- CD1 – CD3 – coordinate strip detectors;
- CC1, CC2 – coordinate calorimeters (8 layers: W convertor+strip detector);
- CC3 – PbWO₄ coordinate calorimeter ;
- S3, S4 – trigger scintillators;
- SLD – scintillator Shower Leakage Detector;
- ND – neutron detector.



NAVIGATOR SATELLITE



Apogee height 300 000 km;
Perigee height 500 km;
Inclination $51,8^\circ$;
Orbit duration 7 days.