

Joint program RIM opens
window into
the world of dark matter

Prof. A.M. Galper

Ambasciata d'Italia a Mosca, 2011, June, 20



MEMORANDUM

The Italy - Russia - USA meeting of scientists and technical specialists in particle astrophysics and cosmic techniques held in Florence 29/11 - 03/12 1993 was devoted to the following items:

- discussion of the results of feasibility study,
- discussion about the physical scheme of the PAMELA telescope,
- discussion concerning the characteristics of the GILDA telescope,
- distribution of responsibilities for NINA(PICCOLO) instrument,
- schedule of activity for the near future.

1. Participants of the meeting believe that the "Resourse" satellite after modifications appropriate for our instruments will satisfy all of requirements of RIM experiment.

2. Participants of the meeting consider the realising in 1995 of the technological experiment "NINA" onboard the "Resourse" #4 to be necessary and in this light to do in January-February 1994 the following:

- to make an agreement on the responsibility distribution for the design and building of "Nina" instrument,
- to estimate the cost of the project,
- to adopt the schedule.

3. Participants of the meeting considered the preliminary study of physical scheme of PAMELA instrument. The main parts of this instrument should be TOF, Calorimeter, Tracking system and Beta-measurer. The general requirements for detectors and magnetic system were settled. Final analysis and choosing of detectors to be used will be done by July 1,1994 as well as the physical scheme of the PAMELA instrument and the distribution of responsibilities

4. Participants of the meeting confirm the possibility of designing the GILDA telescope to explore the cosmic gamma radiation with energy higher than 500 MeV and believe the continuation of performance simulations and optimization to be necessary.

5. The main results of joint activity in 1994 should be:
- completed proposal for RIM project,
 - designing and building much of the NINA instrument,
 - making of general agreement to realize RIM project.

6. The financing of project in 1994 will be requested mainly from INFN.

7. The collaboration is opened for participation of scientists from other countries.

8. Participants of the meeting appreciate very much the hospitality of Prof. P.Spillantini and his colleagues and the good organization of the meeting.

On behalf of:

Italy

Prof. P.G. Picozza

Prof. P. Spillantini

Prof. C. De Marzo

Russia

Prof. A. Galper

Dr. L. Churkin

Dr. A. Moiseev

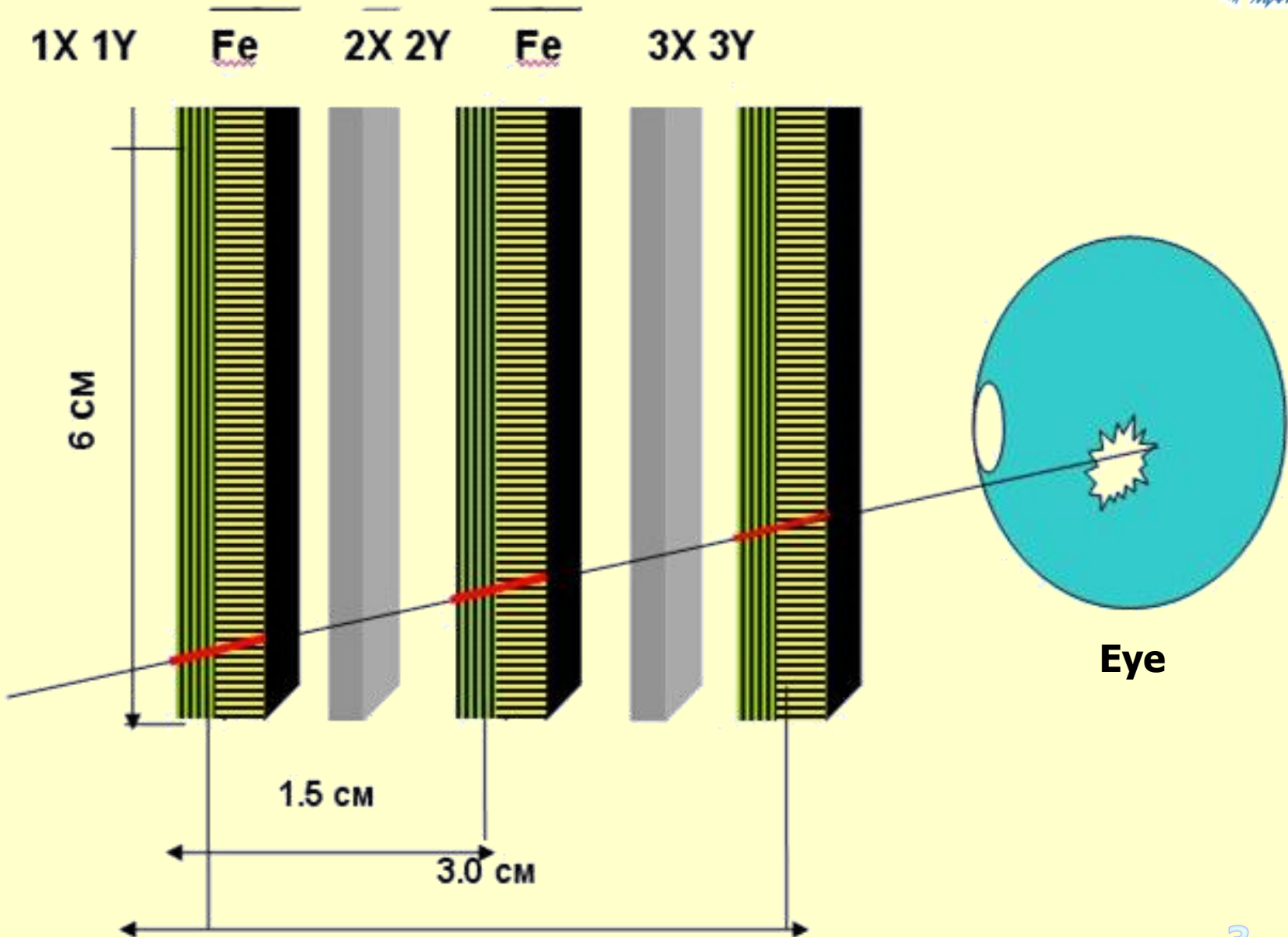
Dr. Yu. Ozerov

Mr. O. Tichonov

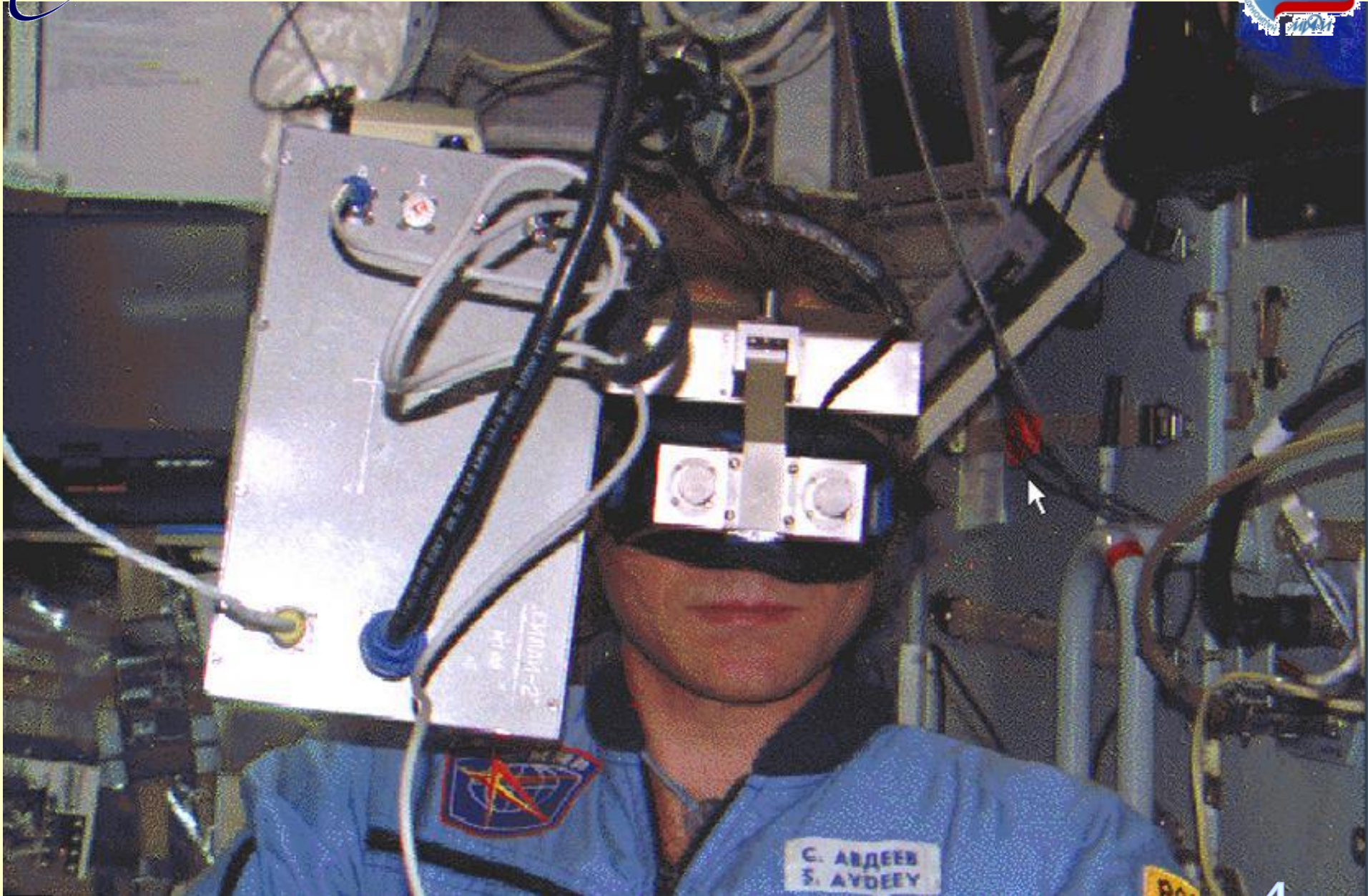
USA

Dr. R. Streitmatter

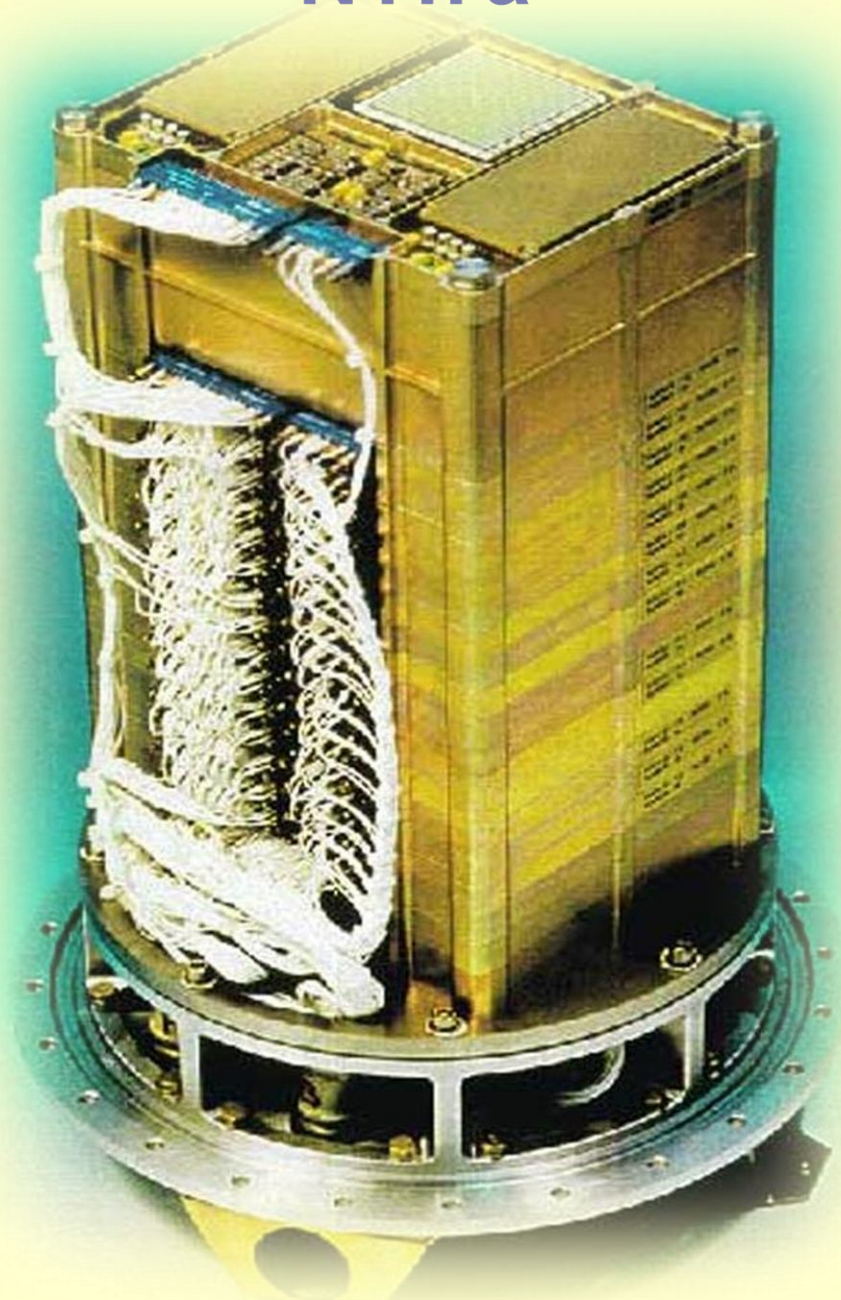
Sil Eye



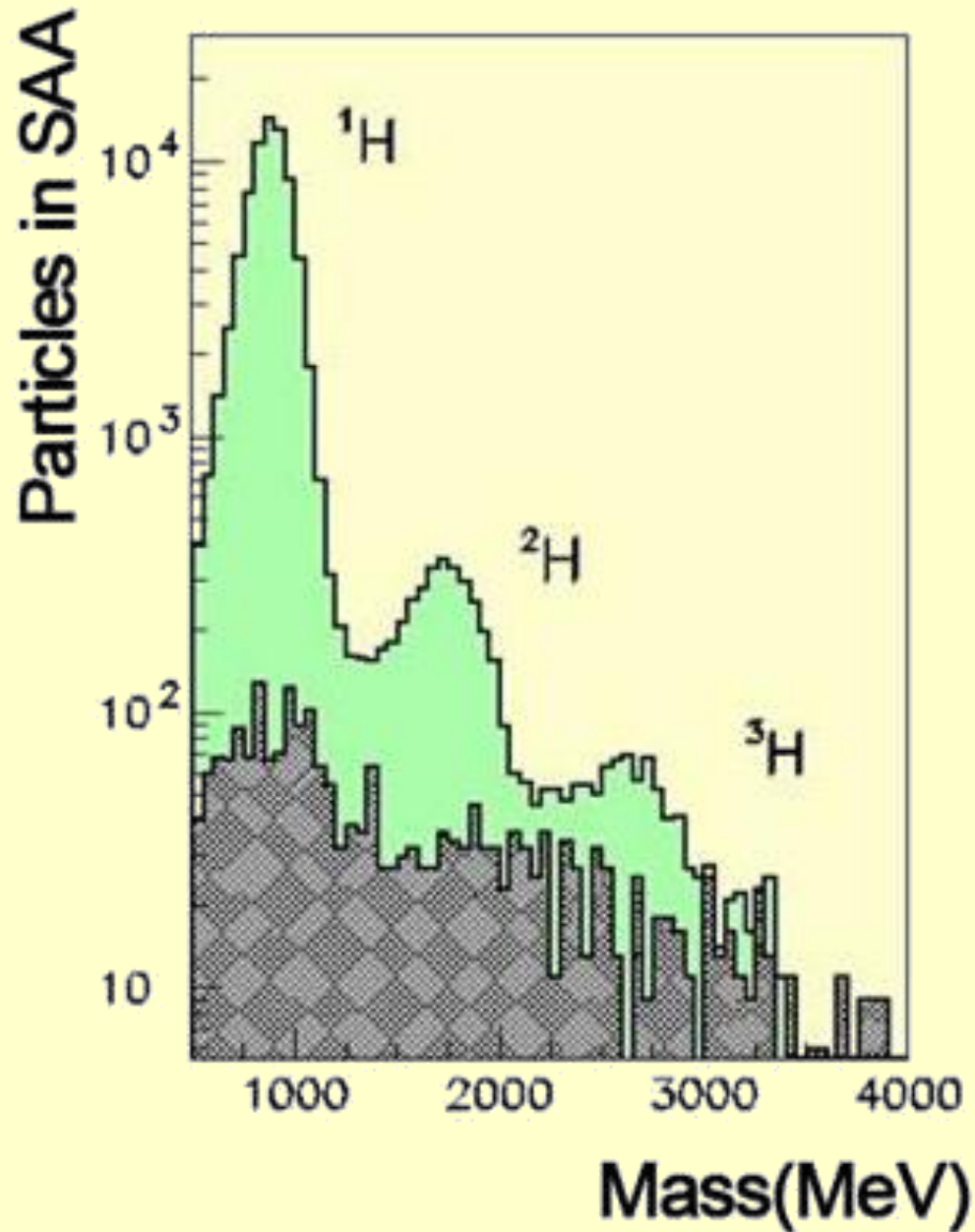
Sil Eye



Nina



Nina



PAMELA collaboration

Italy:



Bari



Florence



Frascati



Naples



Tor Vergata

Rome



Trieste



CNR, Florence

Russia:



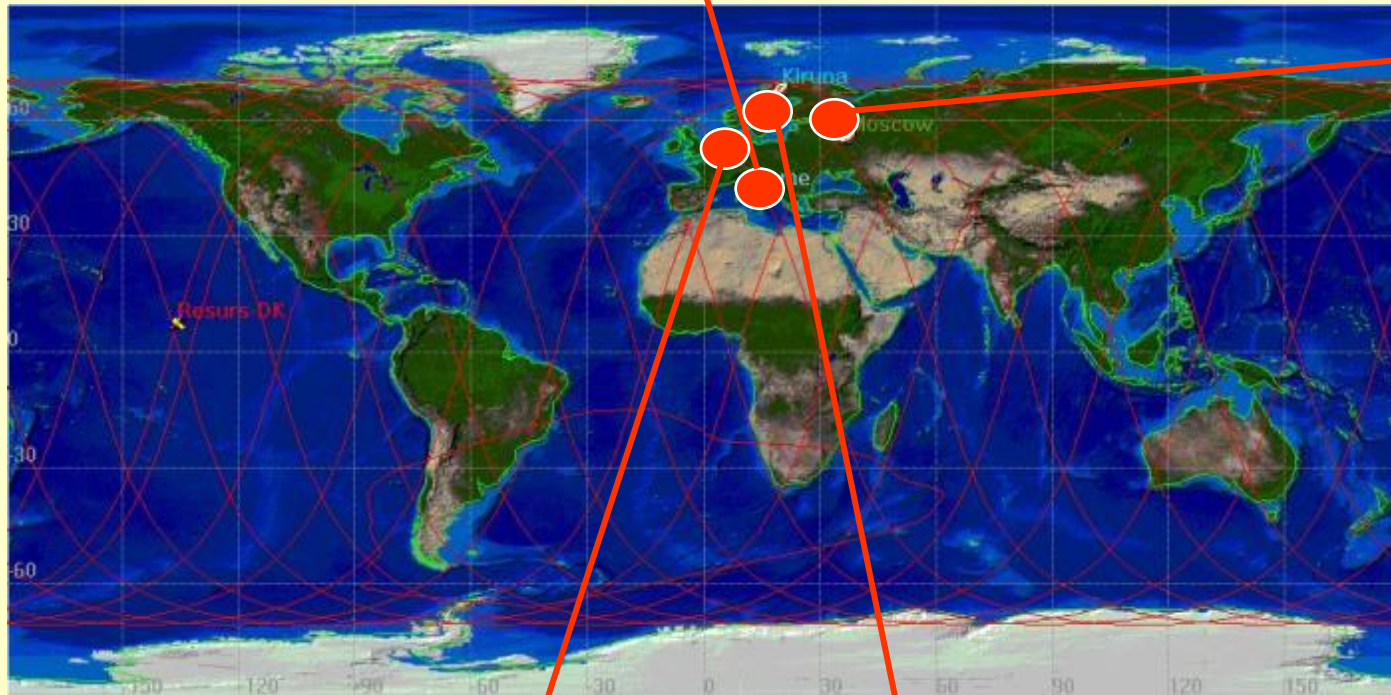
Moscow



Moscow



St. Petersburg



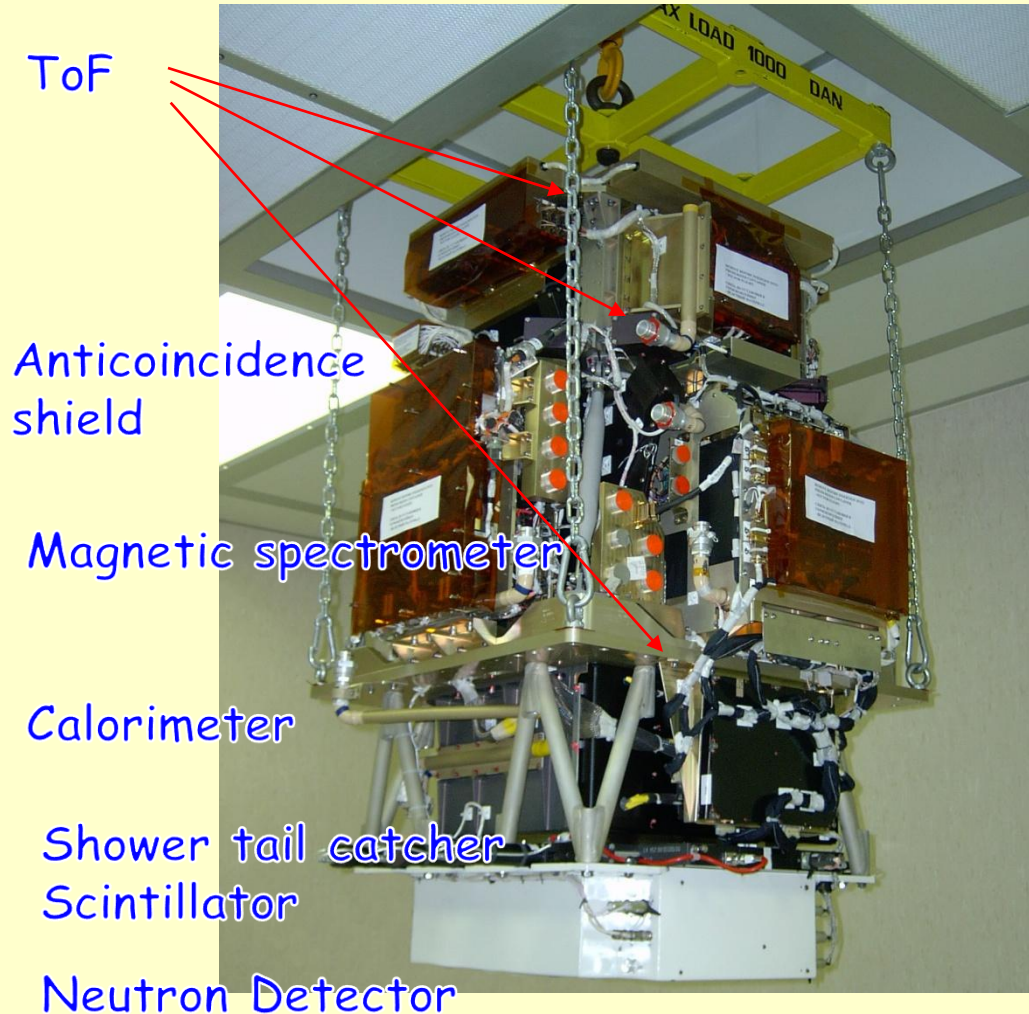
Germany:  Universität Gesamthochschule Siegen
Siegen

Sweden:  KUNGL. TEKNISKA HOGSKOLAN
KTH, Stockholm

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?)

Magnetic spectrometer “PAMELA”



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

P.Picozza, A.Galper, G. Castellini et al. // astroparticle physics 2007, V.102, P.051101

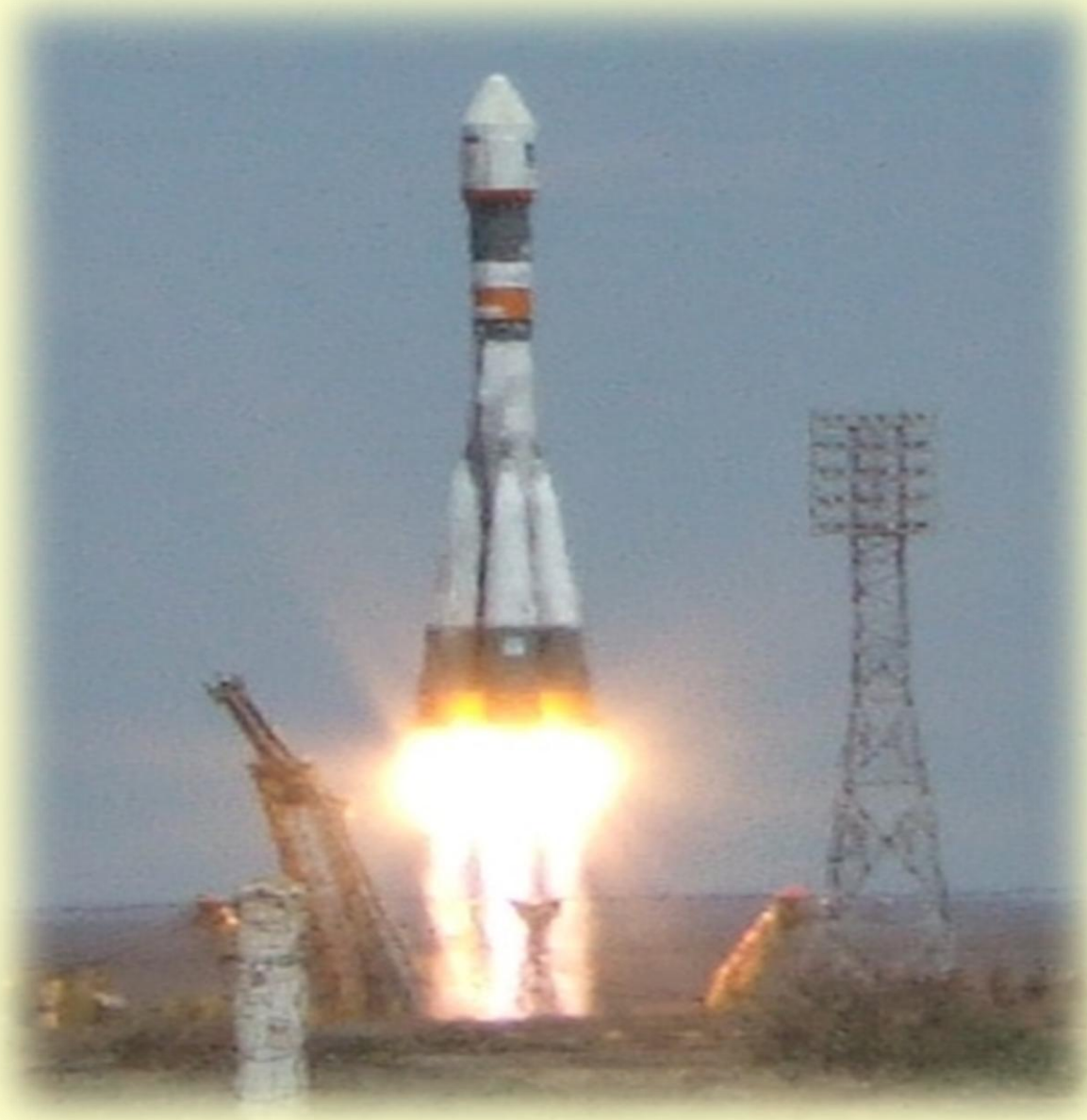


Before PAMELA Launch



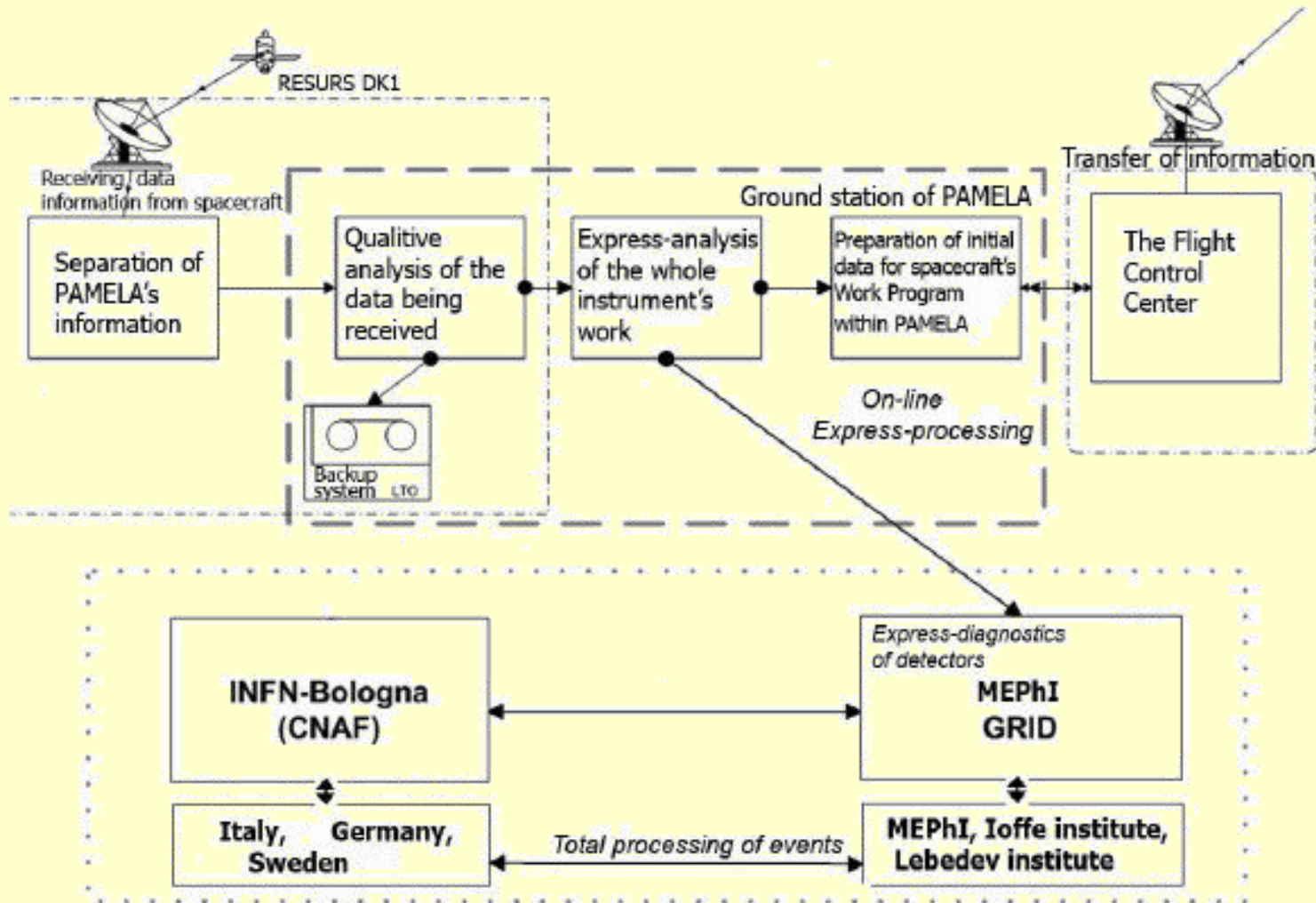


PAMELA Launch 15/06/06

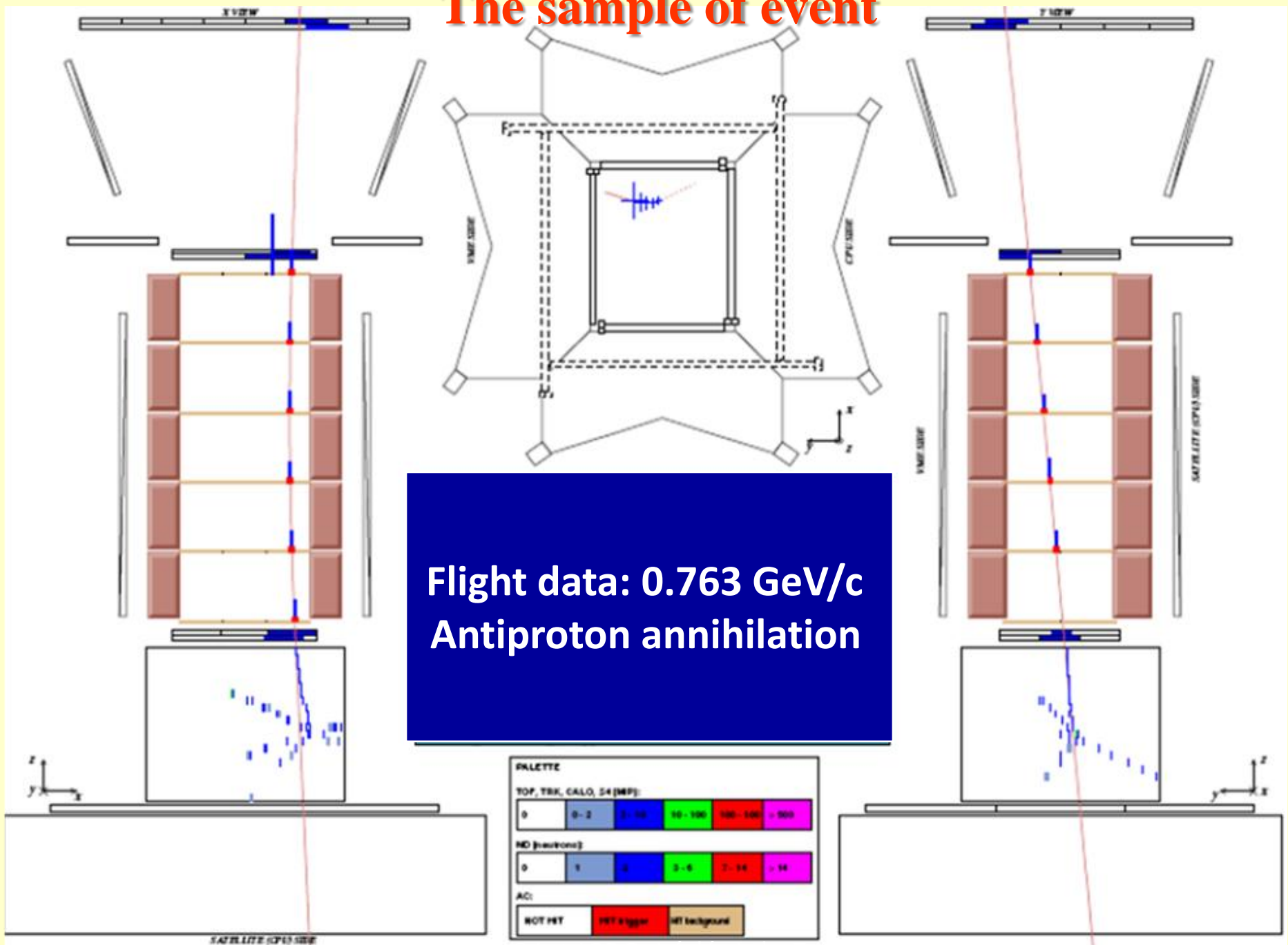


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Scheme of PAMELA data receiving and processing



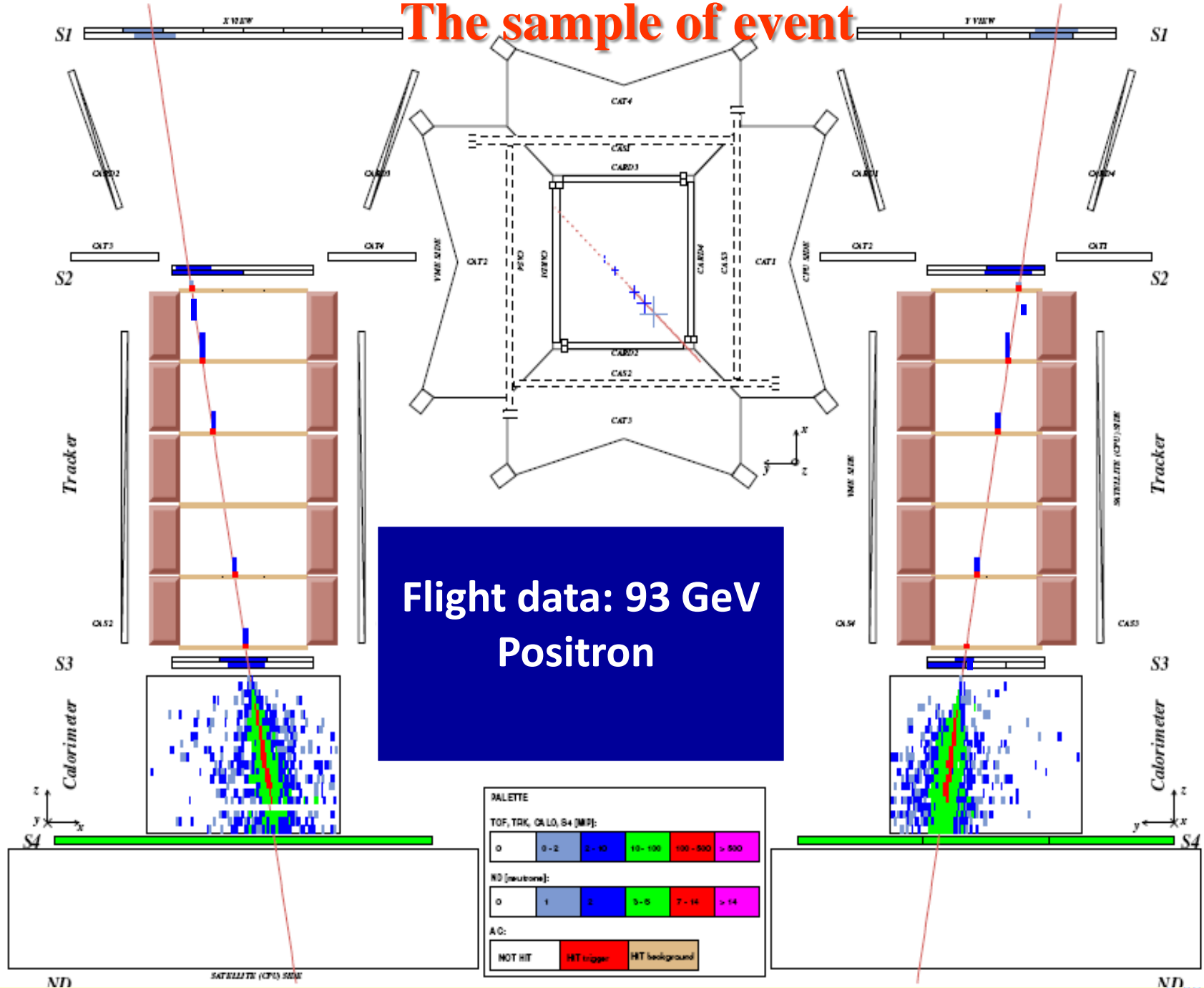
The sample of event



**Flight data: 0.763 GeV/c
Antiproton annihilation**

PALETTE					
TOP, TRK, CALO, S4(MFP)					
0	0-2	3-10	10-100	100-1000	>500
ND (neutrons)					
0	1	2	3-6	7-14	>14
AC:					
NOT HIT	HIT trigger	HIT background			

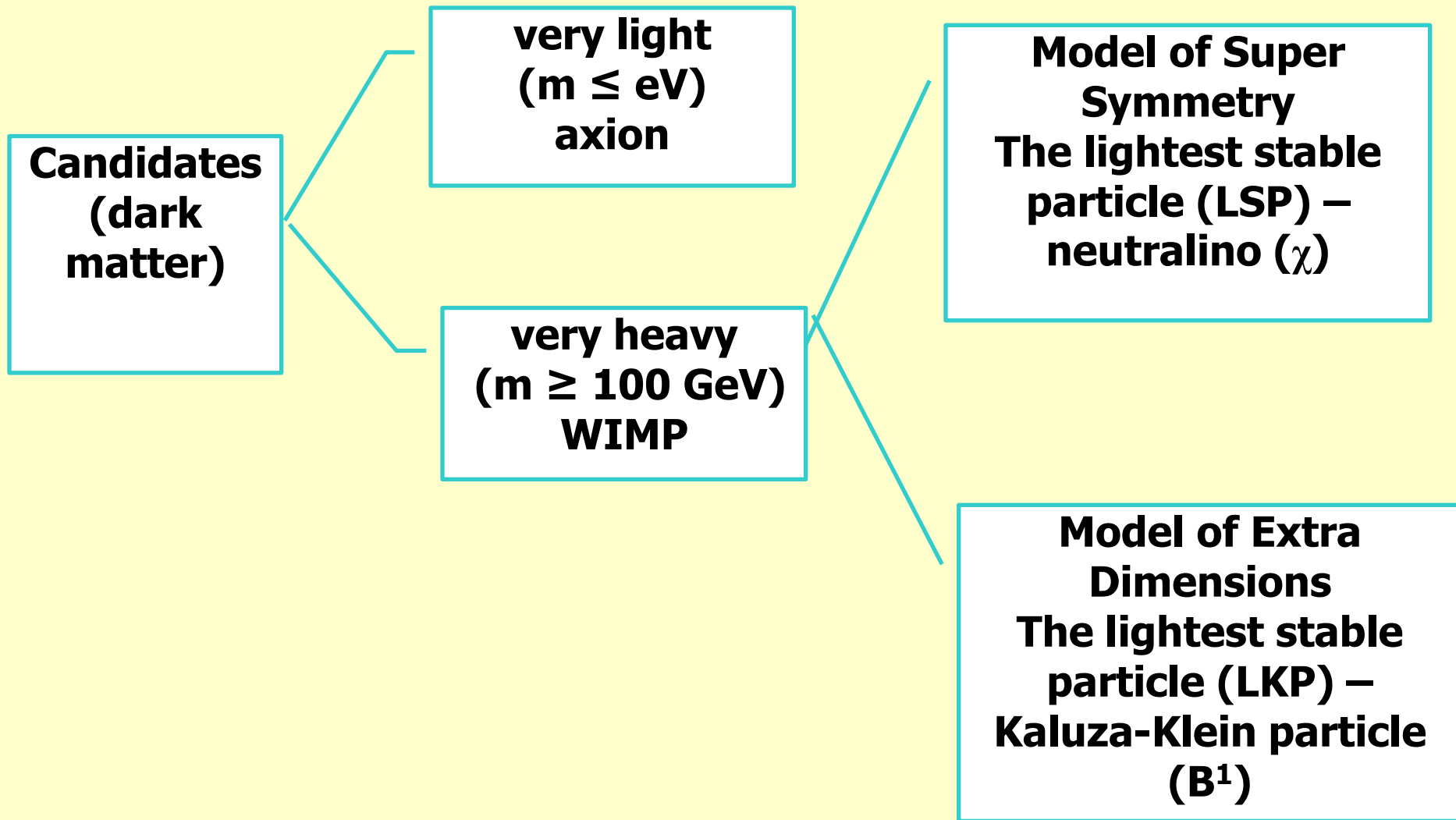
The sample of event



PAMELA science

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Study of origin of dark matter



Status of Direct Searches

Detect WIMP interactions with matter is via their elastic scattering of the detector nucleus.

Status of Indirect Searches

Detect WIMP annihilation process:

$$B^l + B^l \rightarrow e^+ + e^-, \mu^+ + \mu^-, \tau^+ + \tau^- \dots$$

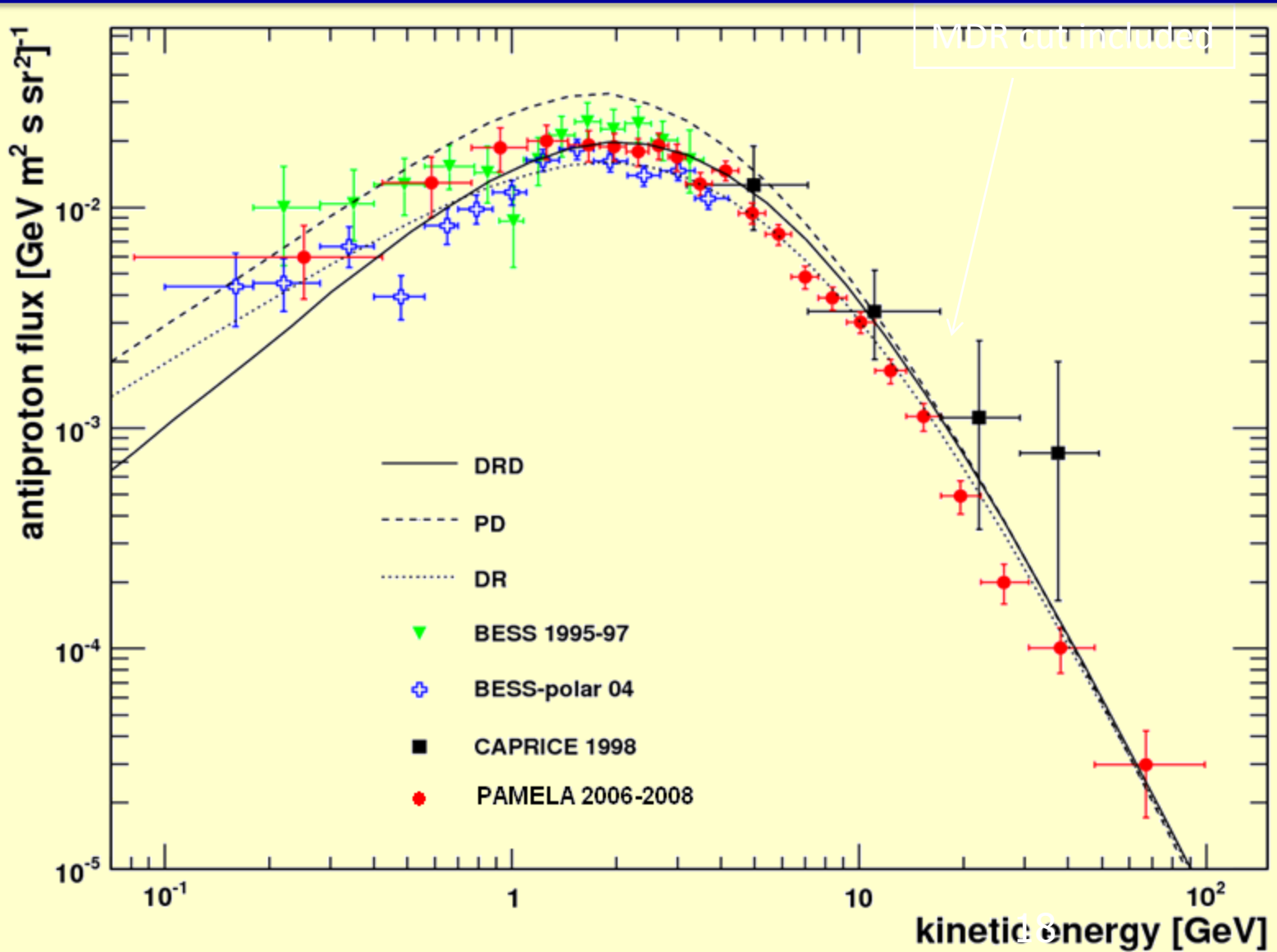
$$\chi + \chi \rightarrow b\bar{b}, t\bar{t}, \tau^+ \tau^-, Z^0 \bar{Z}^0, Z^0 \gamma, W^+ W^-, H\bar{H} \rightarrow \\ \rightarrow \gamma + \dots, e^\pm + \dots, p\bar{p} + \dots, d\bar{d} + \dots$$

Detect WIMP decays

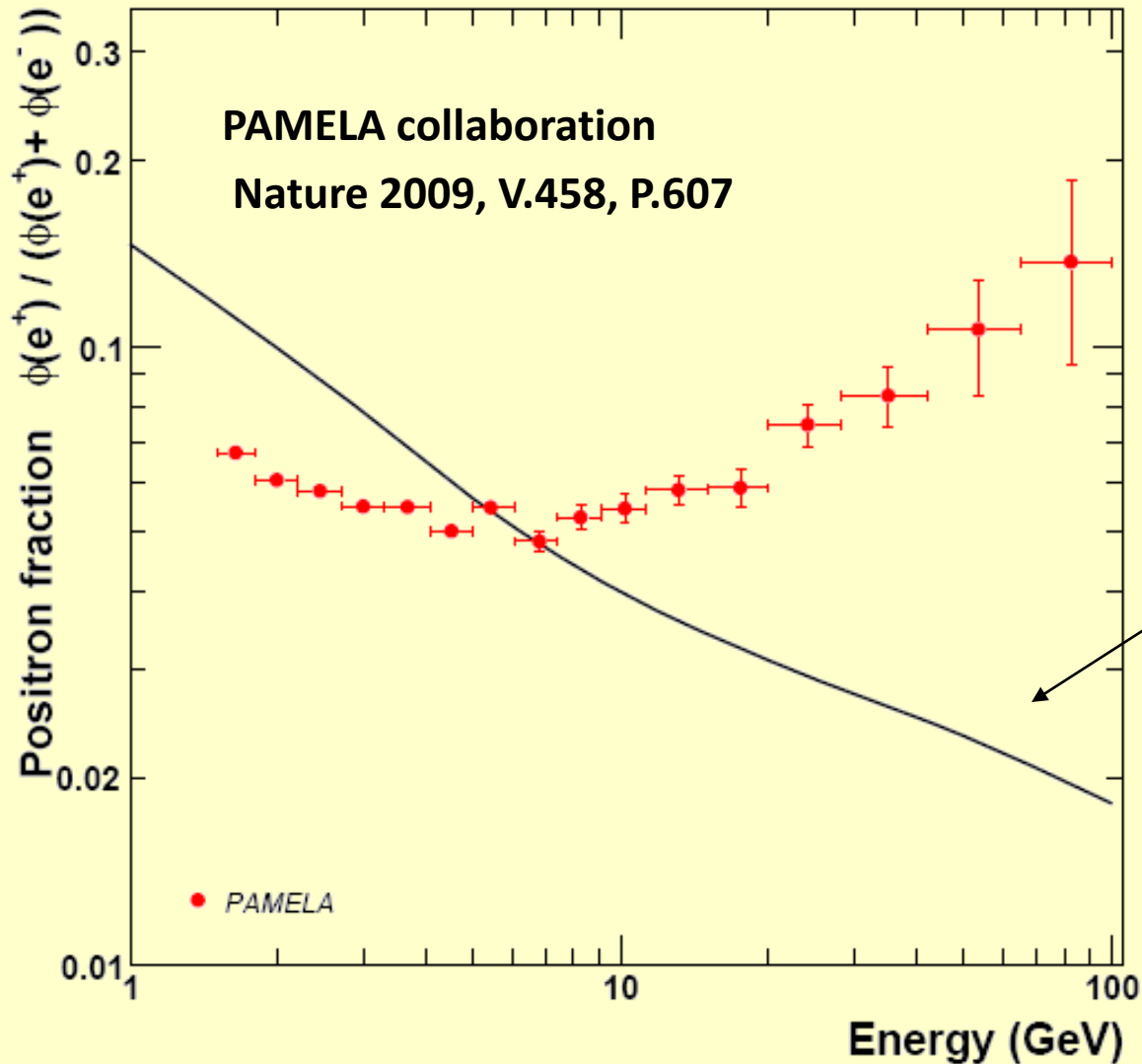
$$B_{kk} \rightarrow l^+ l^-; Z^0 Z^0; W^+ W^-$$

$$\chi \rightarrow l^+ l^- \nu; Z^0 \nu; W^\pm l^\pm$$

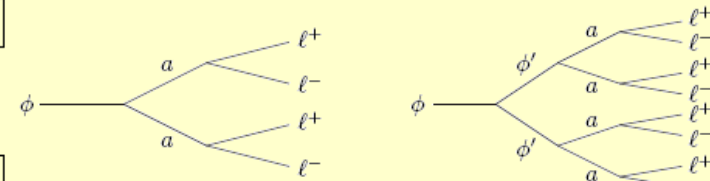
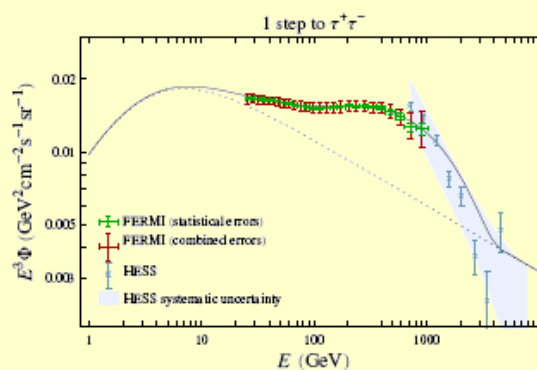
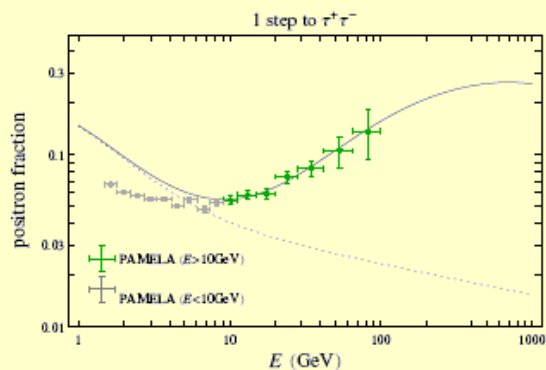
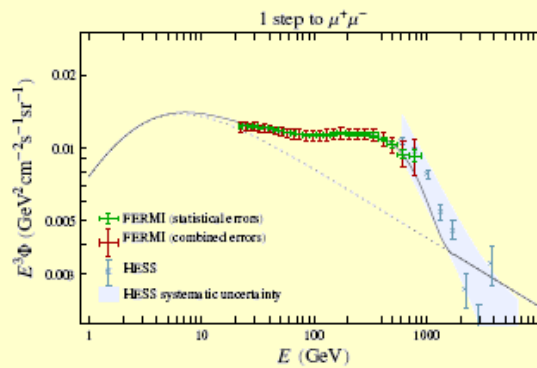
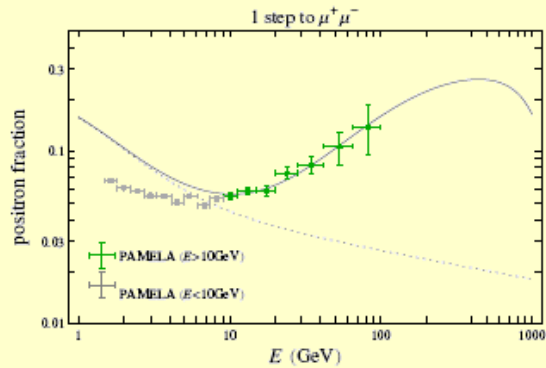
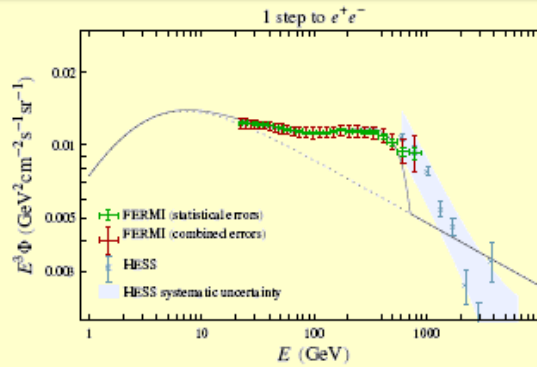
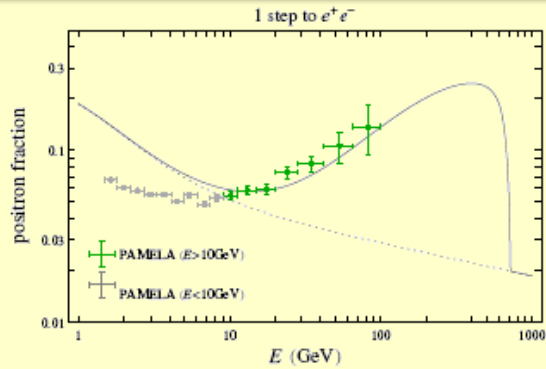
Study of origin of dark matter



Study of origin of dark matter



Study of origin of dark matter



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

Jeremy Mardon
arXiv:0905.3749v2

Main results

1. PAMELA obtained an increase of galactic positron/electron flux ratio for energy range from 10 GeV up to 150 GeV. This contradicts to mechanisms of secondary electron and positron production.
2. In the same time measured values of antiproton/proton flux ratio is in agreement with model of secondary production.
3. These experimental facts can be explained by:
 - generation of electron-positron pairs in the supernovas and pulsars;
 - **annihilation and/or decay** of hypothetic **dark matter** particles (WIMPs, Kaluza-Klein bosons).

In the last case it is the most important because it would be the first positive indirect observation of dark matter particles.



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>)

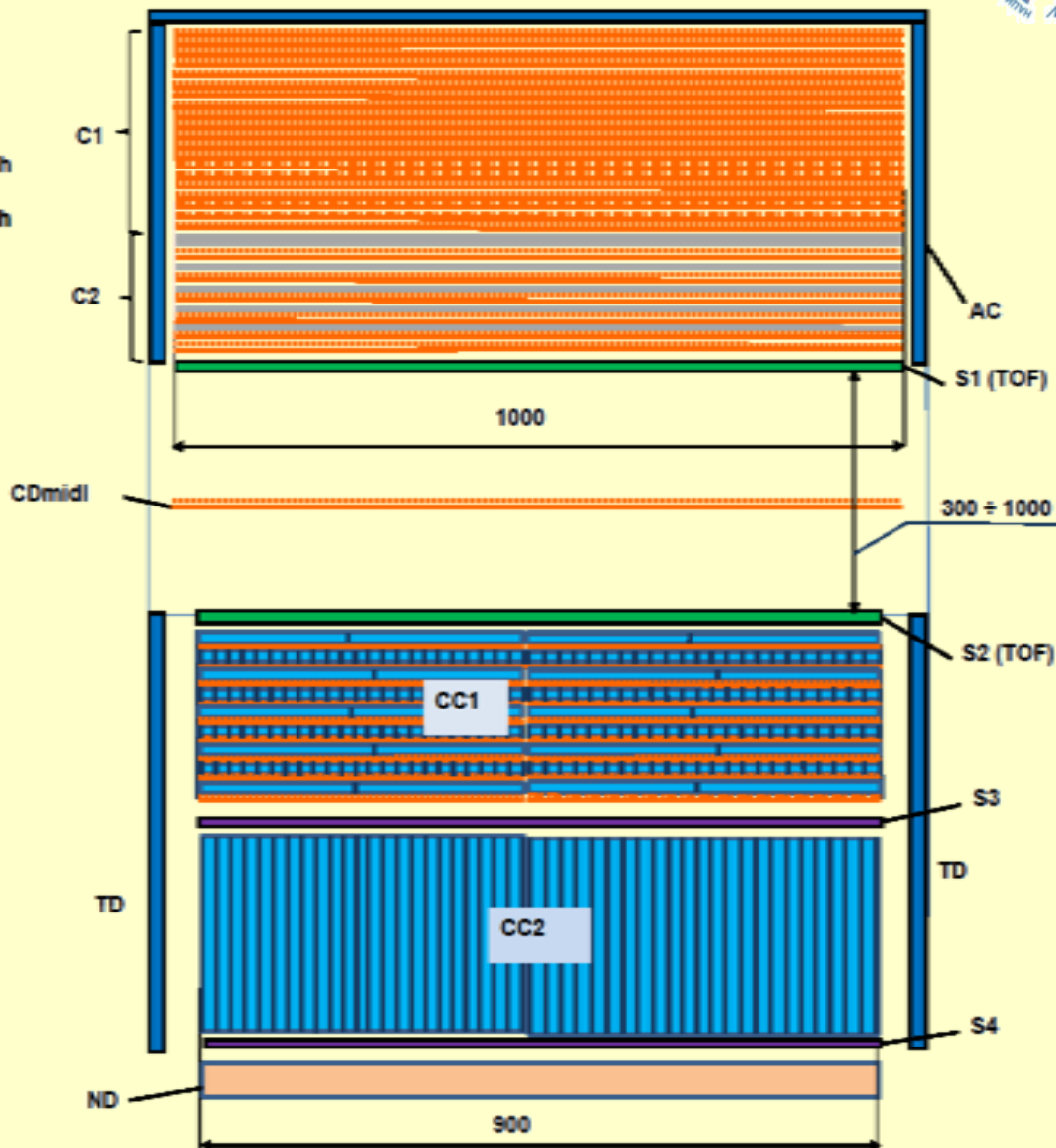
- *LIGHT PASSES THROUGH OPAQUE MATTER*
- *MACROSCOPIC FEEDBACK COOLING*

Gamma-400 scientific objectives

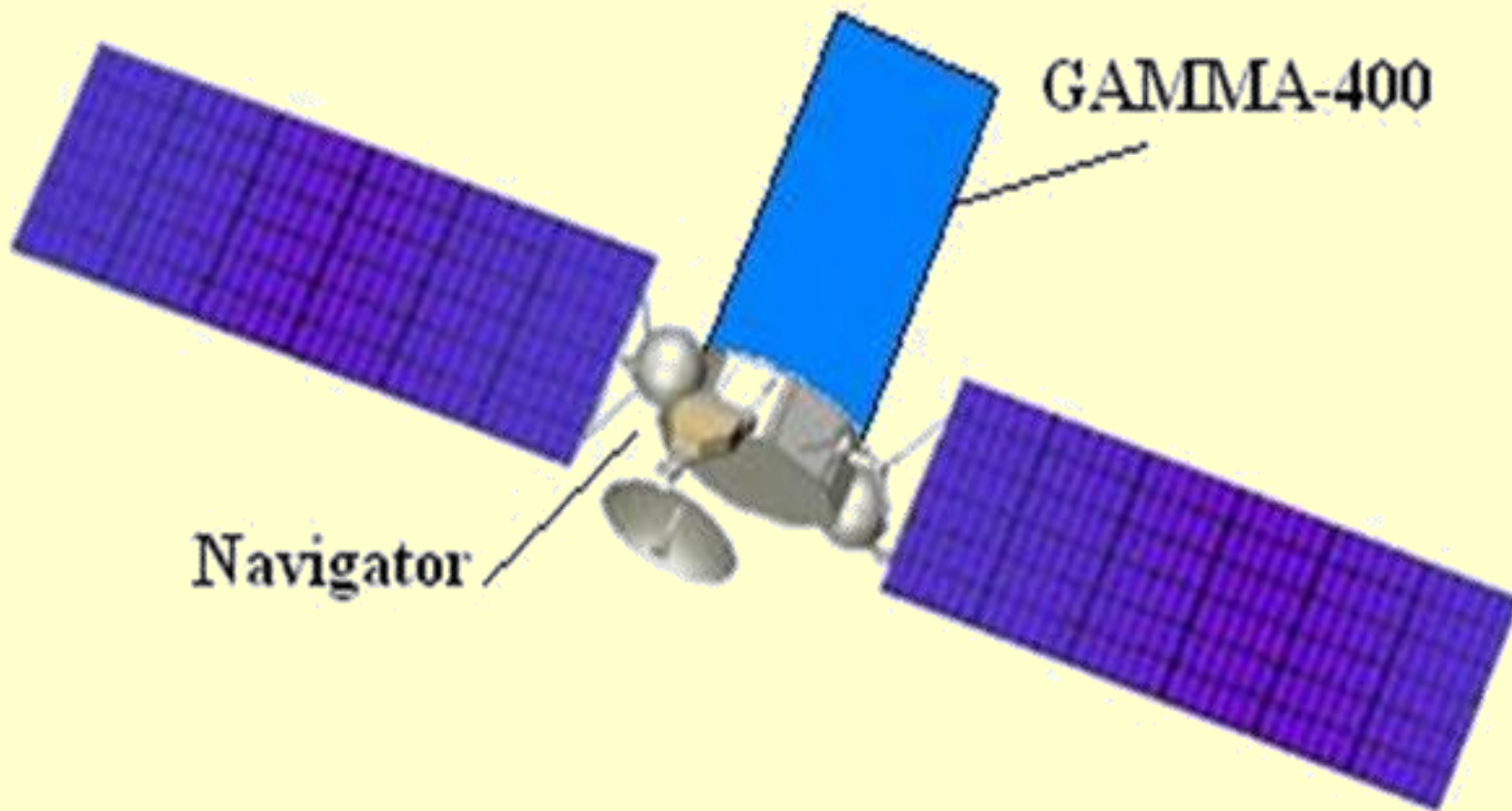
- Study of a nature of acceleration processes in active astrophysical objects responsible for origin of high-energy gamma-ray emission
(from 0.05 GeV up to 3 TeV).
- Research of a nature and properties of hypothetical dark matter particles by their annihilation and decay processes to gamma rays and electron-positron pairs.

Gamma-400 project

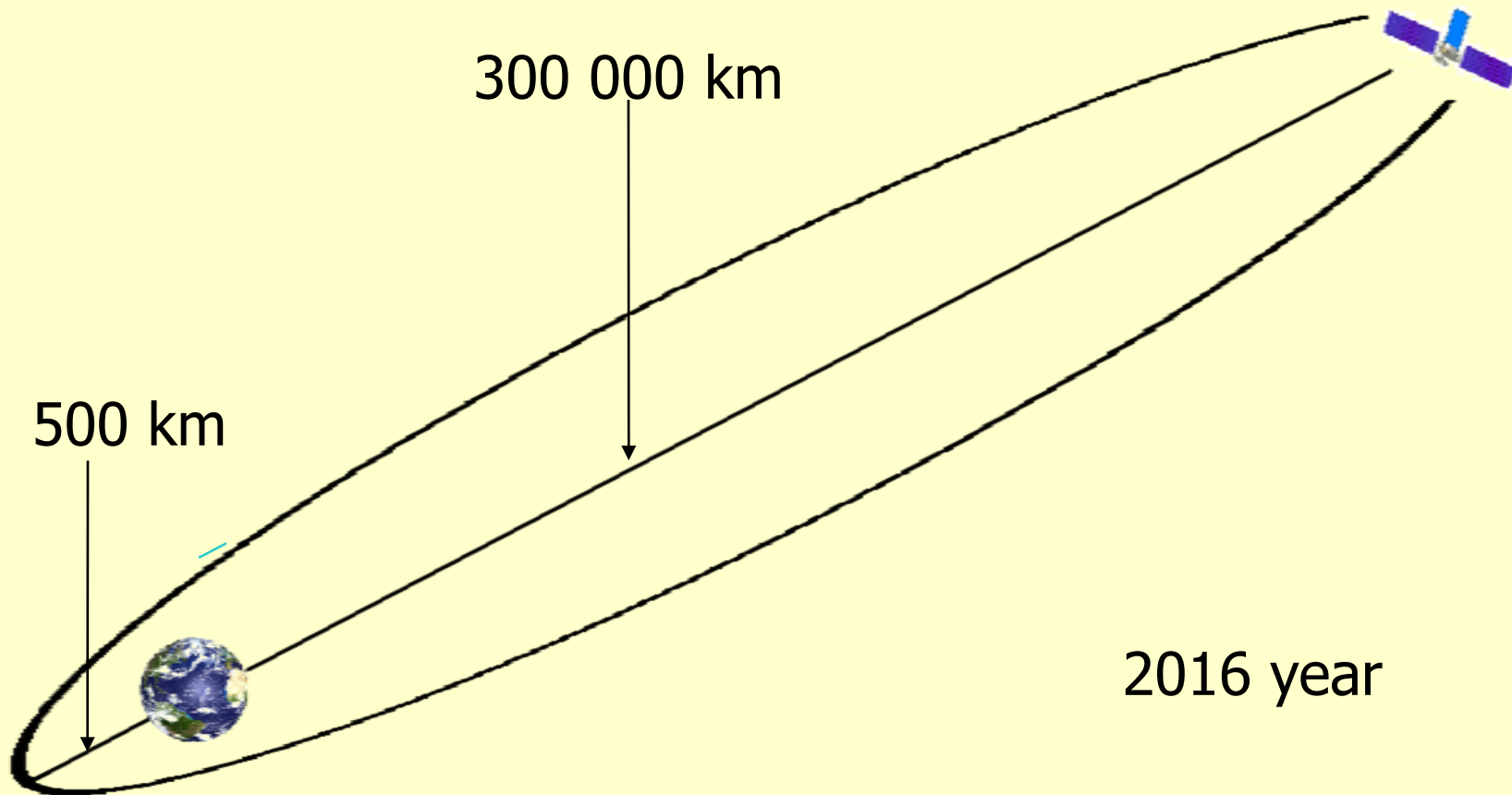
- AC - anticoincidence detectors
- C1 - 20 layers x 2 single side Si 0.3mm (pitch 0.5 mm)
- C2 - Converter - total 1 Xo
 - 1 layer W 0.7 Xo (2.45 mm) +Si (x,y) 0.5mm (pitch 0.1mm)
 - 2 layers W 0.1 Xo (0.35 mm) +Si (x,y) 0.5 mm (pitch 0.1 mm)
 - 2 layers W 0.05 Xo (0.175 mm) +Si (x,y)0.5 mm (pitch 0.1 mm)
 - 1 layer Si (x,y) 0.5 mm (pitch 0.1 mm)
- CDmidl - Si (x,y) detectors (pitch 0.1 mm)
- S1, S2 - TOF detectors
- S3, S4 trigger detectors
- CC1 - imaging calorimeter (10Xo)
 - 10 layers BGO 1.12x2.24x23 + 1.12x2.24x22 cm (20+20)x4x10 crystals
 - (WLS 1mm 2 layers x, 2layers y) Si (x,y)(pitch 1cm)
- CC2 - electromagnetic calorimeter BGO (14Xo)
 - 2.24x2.24x15.7cm - 400x4 crystals
- ND - neutron detector
- TD - 4 lateral detectors



GAMMA-400 telescope on spacecraft "Navigator"



GAMMA-400 flight on spacecraft "Navigator"



**Joint program RIM
and PAMELA flight
are going on!**