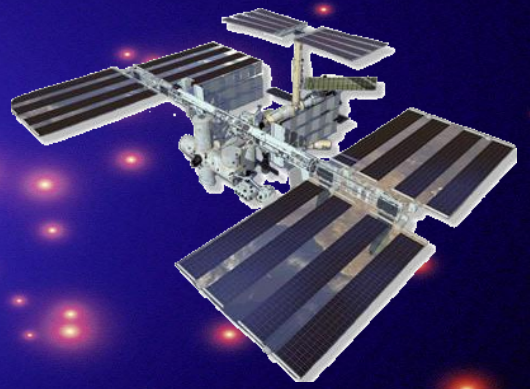
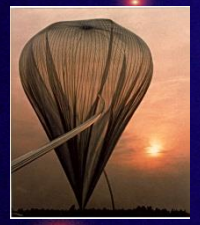
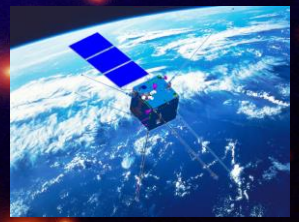
Le origini dell'esplorazione dello spazio nell'INFN
L'esperienza di Wizard







Piergiorgio Picozza

INFN e Università di Roma Tor Vergata

70 anni dell'INFN

Villa Mondragone, 11 Maggio 2022

Lo Spazio INFN a Roma Tor Vergata

MASS
1989, 1991

SILEYE-1
1995

SILEYE-2
1998

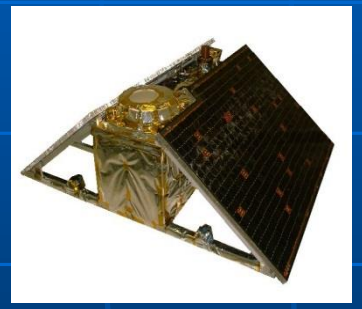
SILEYE-3
2002

LAZIO
2005

ALTEA
2006 and 2019

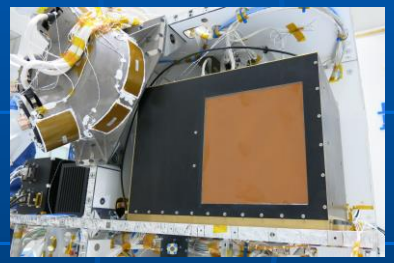
TRAM-SI
1993

NINA 1
1998



NINA 2
2000

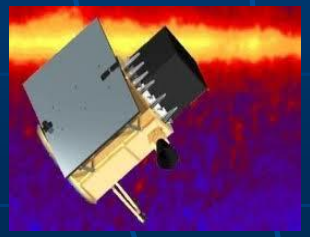
PAMELA
2006



CSES-Limadou-01
2018

Mini-EUSO
2019

CAPRICE
1994, 97, 98



AGILE
2007

FERMI
2008

CSES-Limadou-02
2023

Le Collaborazioni

Italy:

Bari Florence Frascati Naples Rome Trieste CNR, Florence

Germany:

Siegen

Sweden:

KTH, Stockholm

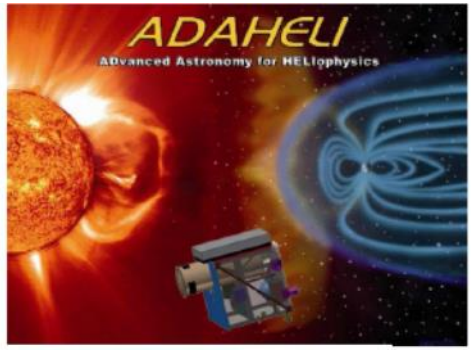
Russia:

Moscow
St. Petersburg

Bologna Trento Turin LNF Naples Rome UTIU INAF IAPS INGV CNR, Florence

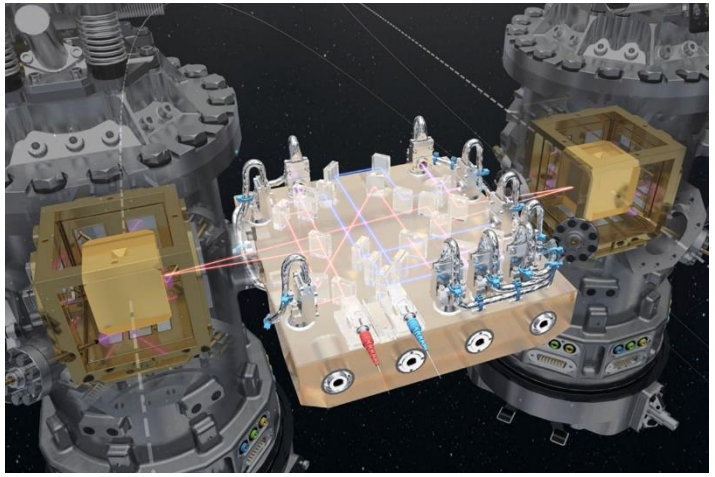
Lo Spazio a Roma Tor Vergata

Solar Physics



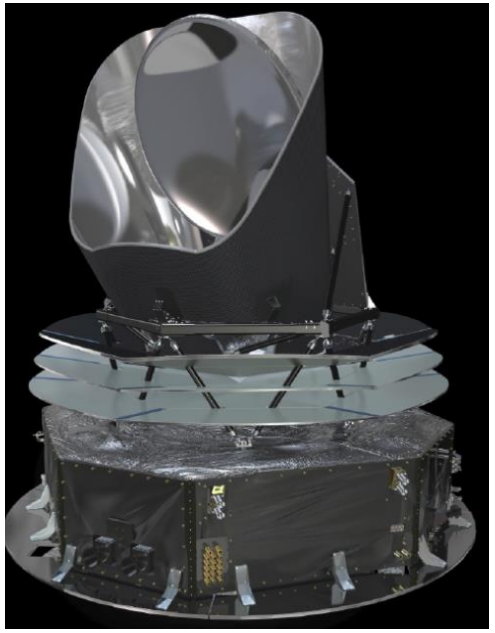
SWERTO

Gravitational waves



LISA Pathfinder

Cosmology



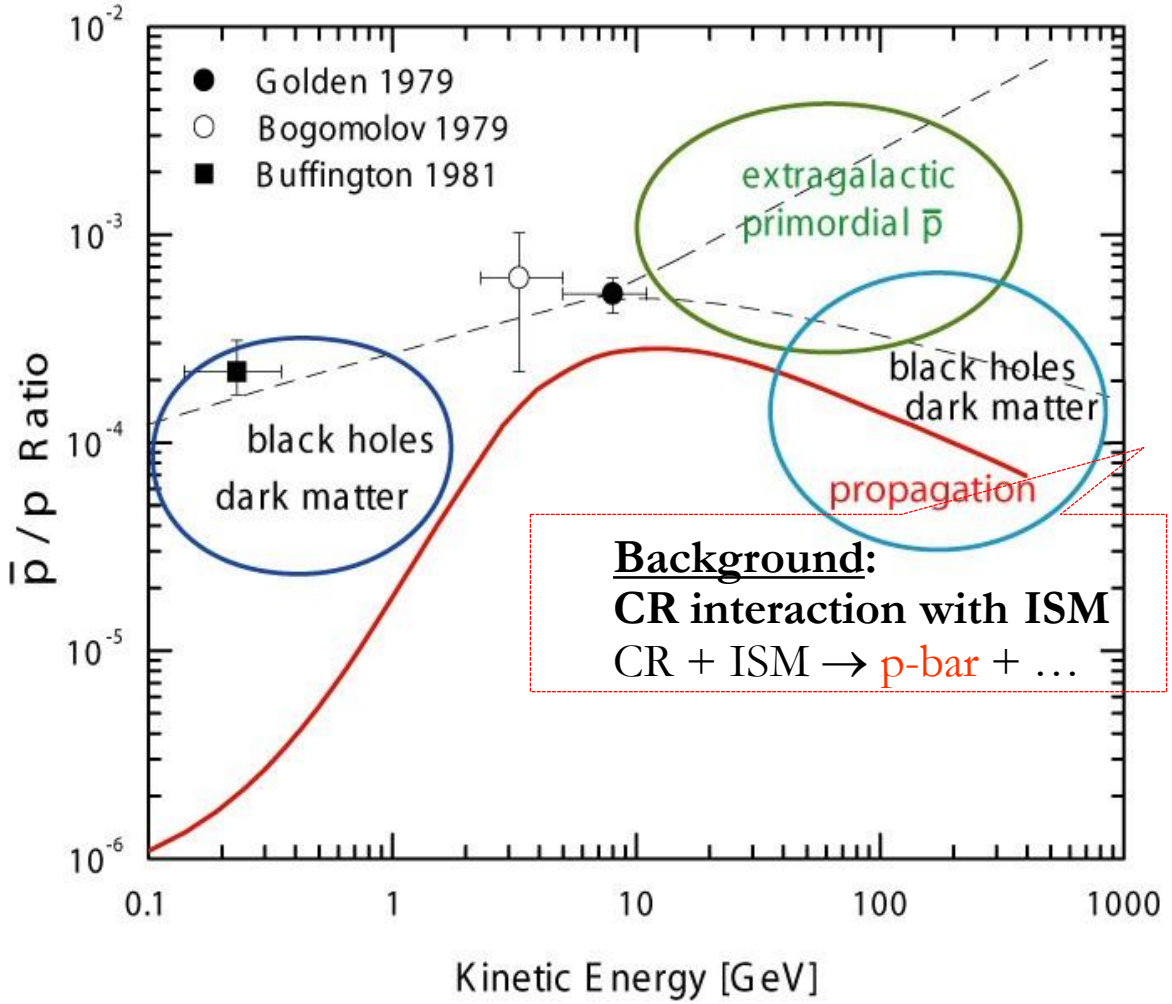
Planck
LiteBird

Life Science

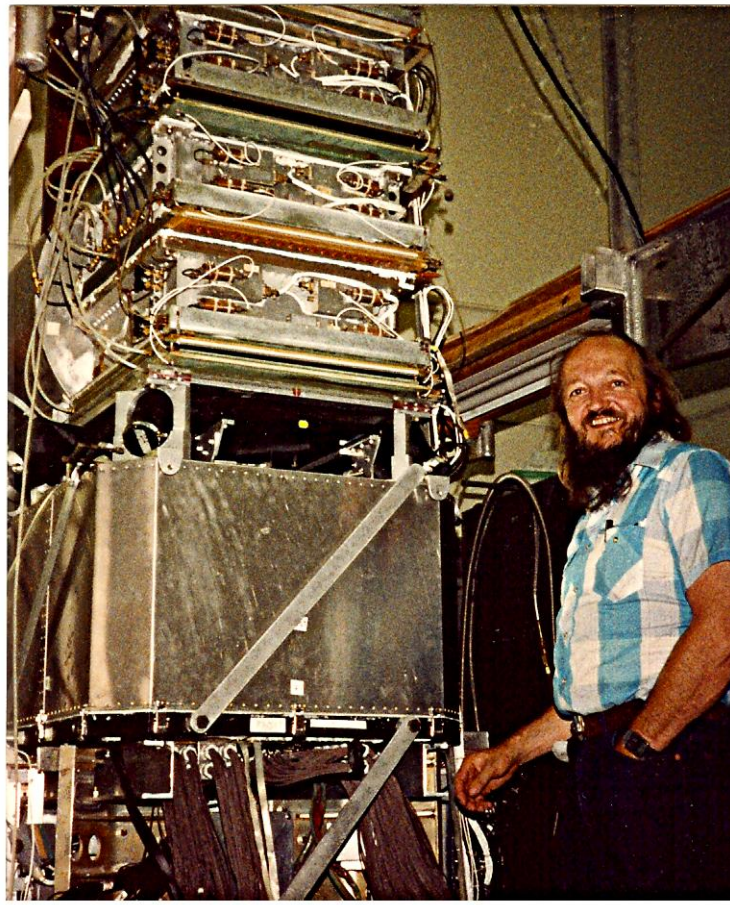
Acustic_Diagnostic

LIDAL

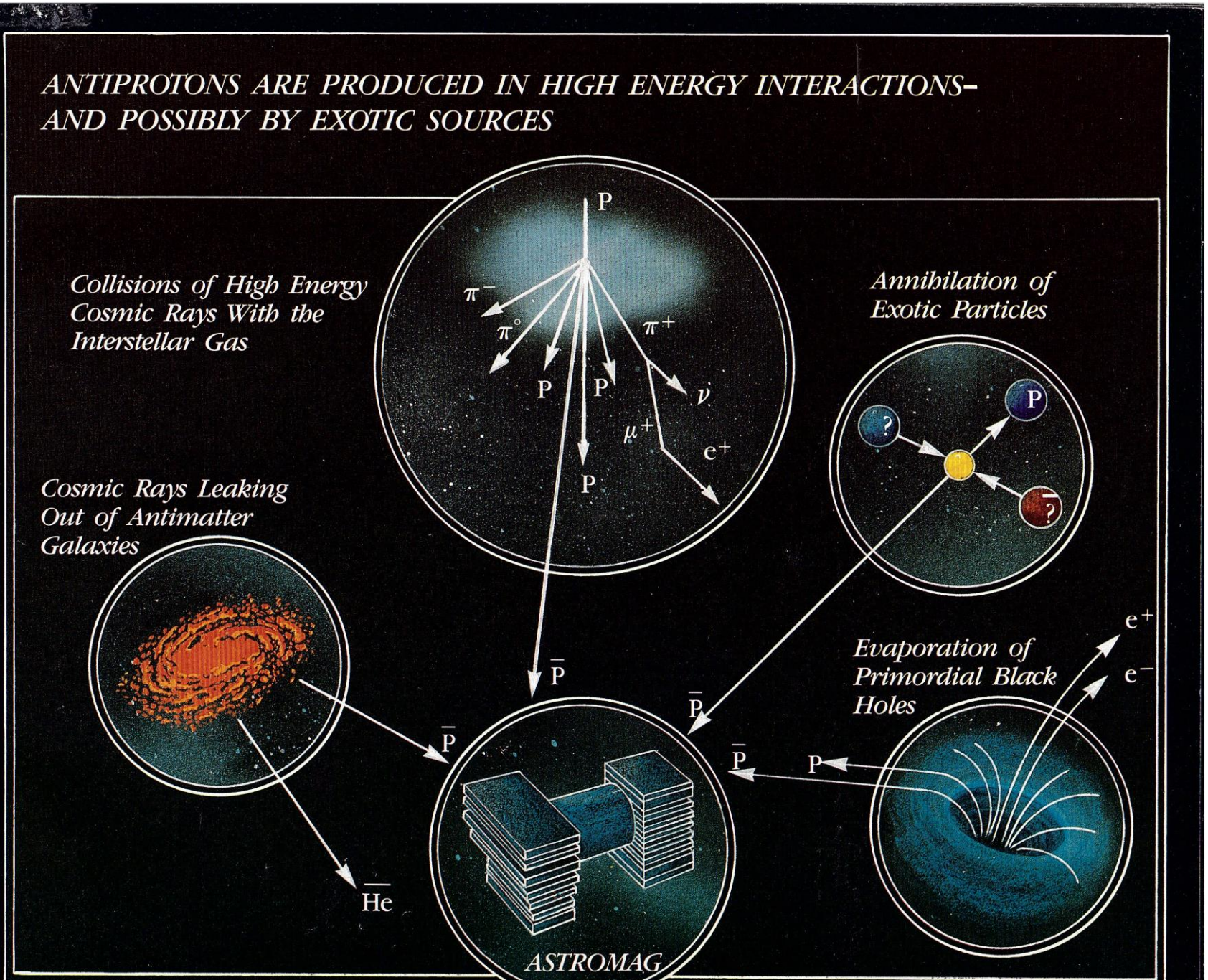
The first historical measurements of the $\bar{p}/p$ - ratio and various Ideas of theoretical Interpretations



Background:
CR interaction with ISM
CR + ISM → p-bar + …

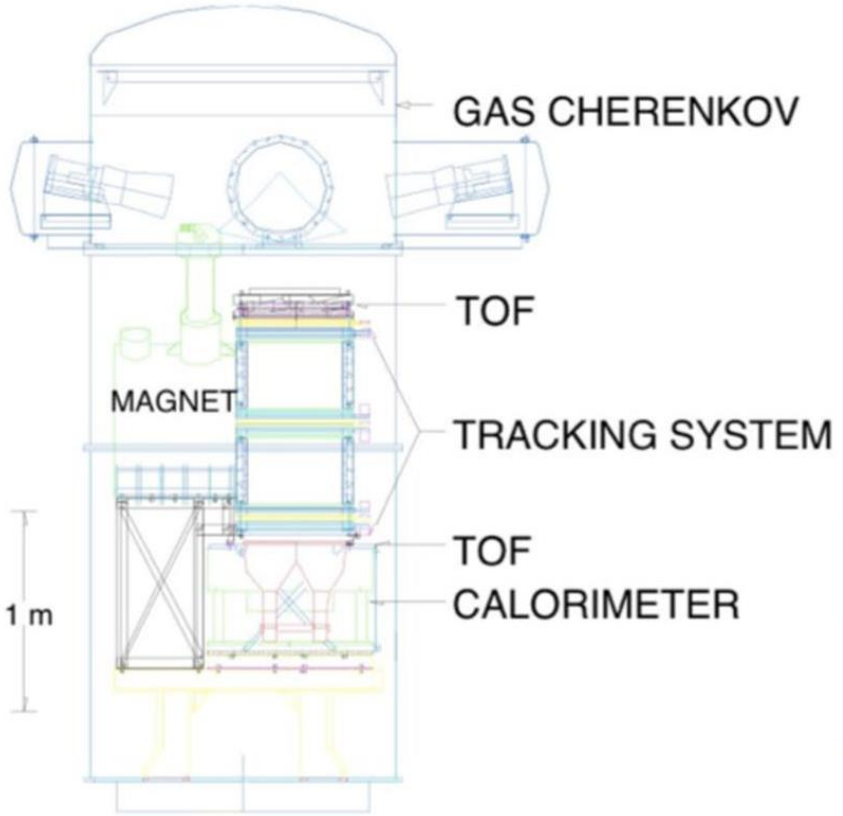


ANTIPROTONS ARE PRODUCED IN HIGH ENERGY INTERACTIONS– AND POSSIBLY BY EXOTIC SOURCES

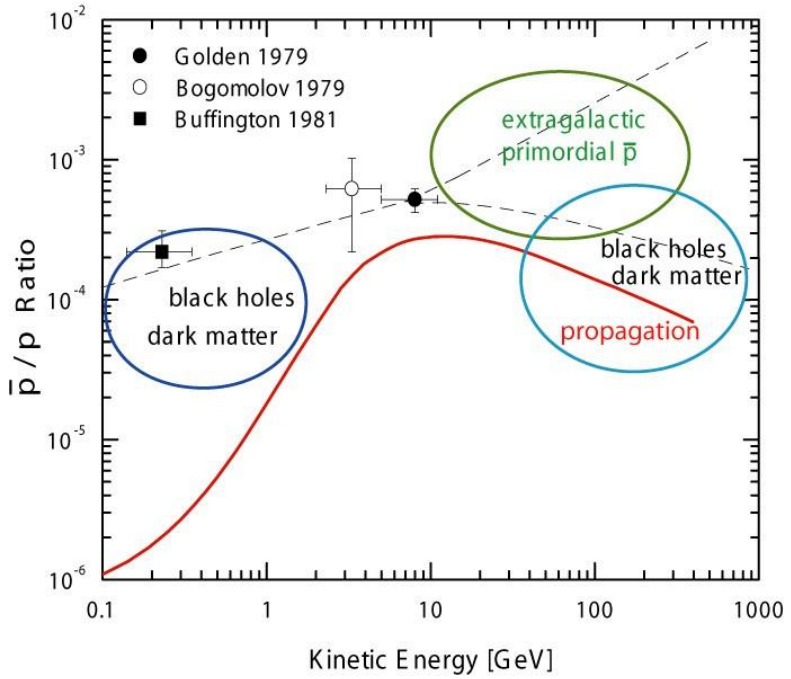


La Fisica delle Particelle Elementari si affacciava nuovamente nello Spazio dopo i grandi successi dei decenni prima dell’avvento degli acceleratori (1954-1956)

MASS *MatterAntimatter Space Spectrometer*

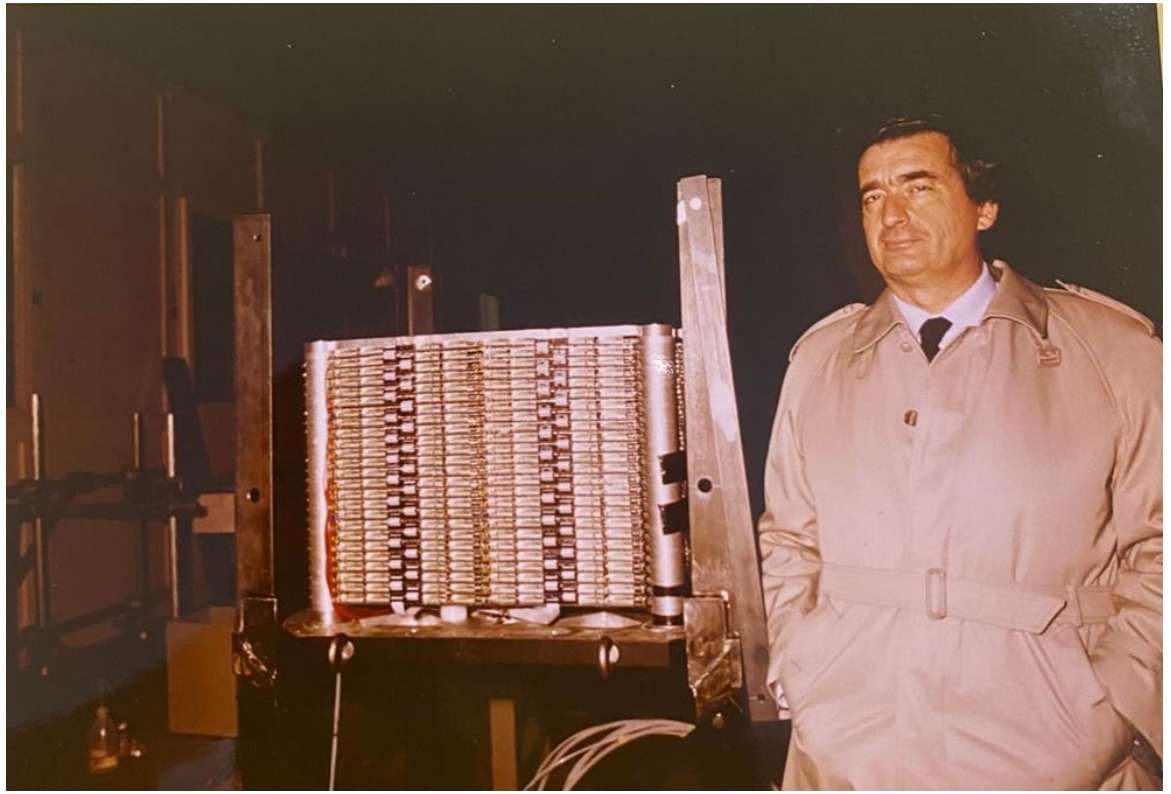


The first historical measurements of the $\bar{p}/p$ - ratio and various Ideas of theoretical Interpretations



CERN Ottobre-Novembre 1987

35 Anni di Spazio a Tor Vergata



LAS CRUCES, New Mexico

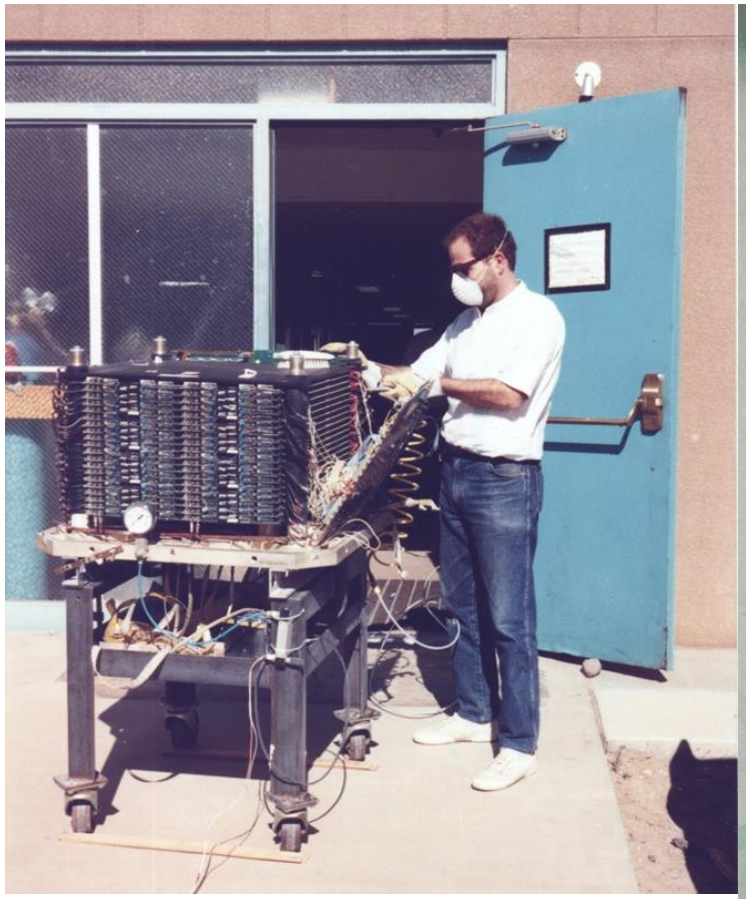
Organ Mountains

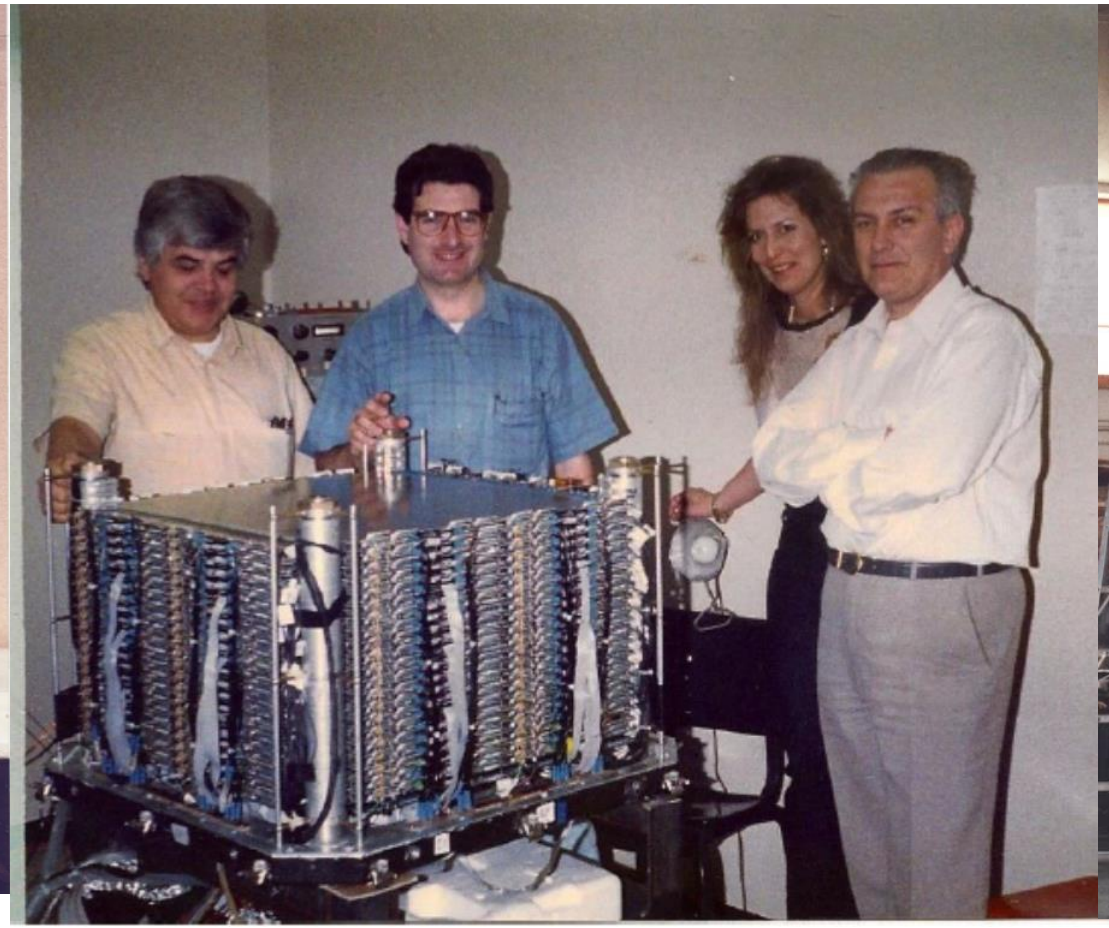
White Sands

Rio Bravo

Rio Grande

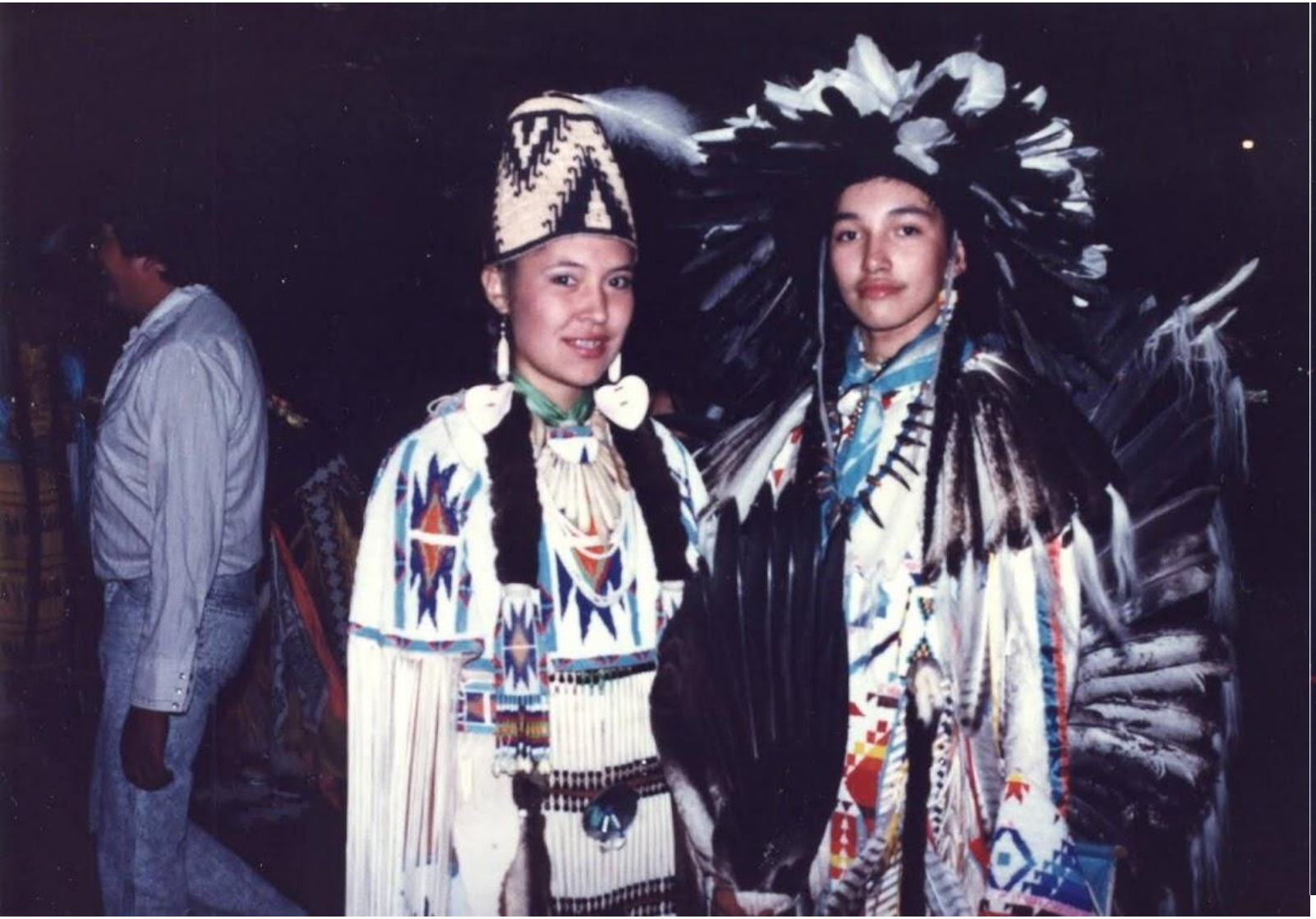
Las Cruces 1988



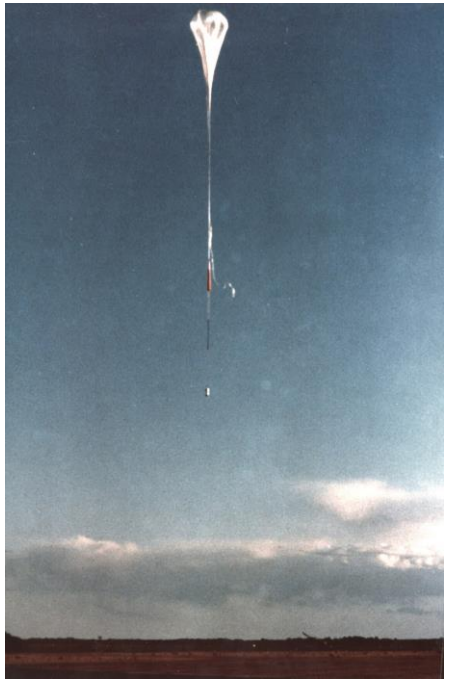


Prinz Albert, Canada
Agosto 1989

Prinz Albert



Prinz Albert 5 Settembre 1989 L'INFN torna al Top dell'Atmosfera



MASS Matter Antimatter Space Spectrometer 1989 1991

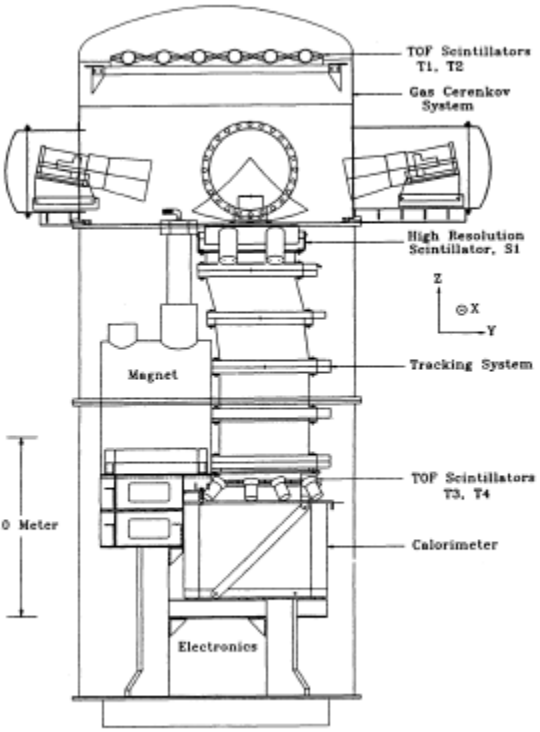


FIG. 1.—A schematic diagram of the MASS Instrument

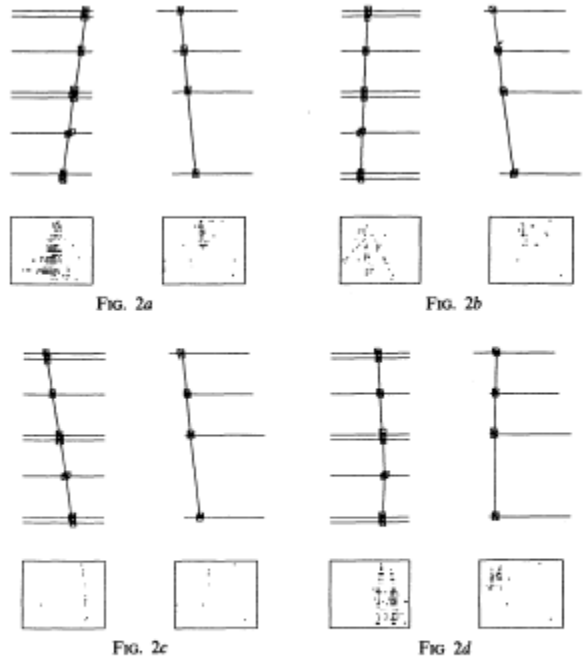
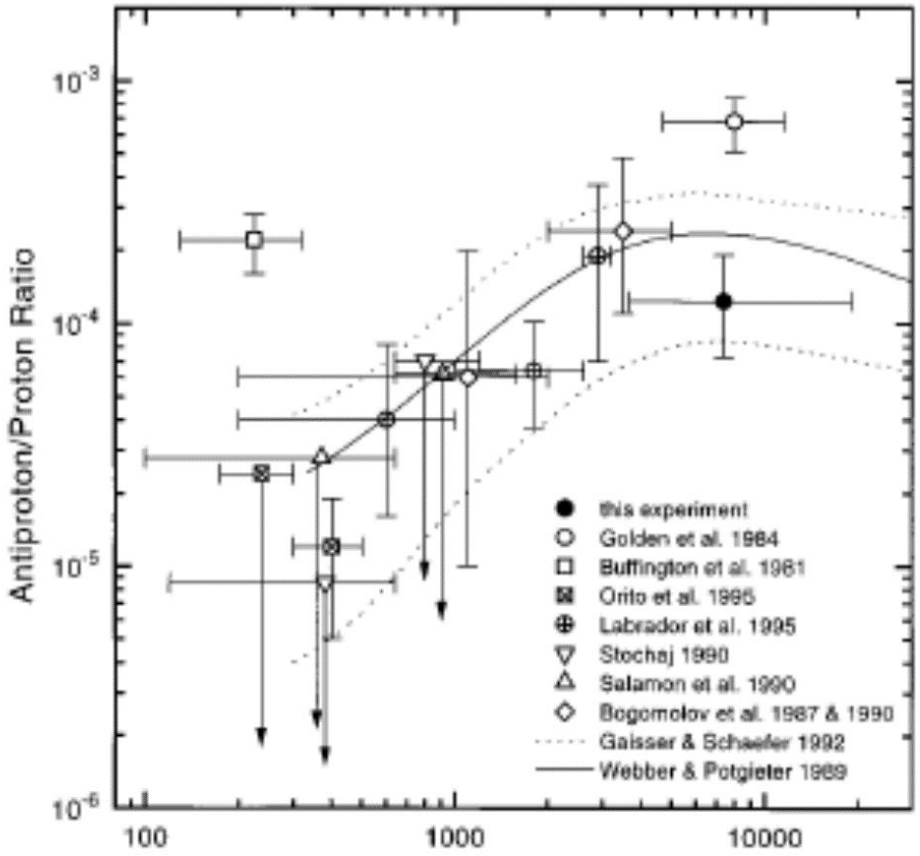


FIG. 2a FIG. 2b

FIG. 2c FIG 2d

FIG. 2.—Images for four different types of events. (*a*) 7 GeV electron. (*b*) 7 GeV proton. (*c*) 7 GeV muon. (*d*) 1.7 GeV double cascade. Each figure shows the MWPC data and the calorimeter image. The left side of each view is the *x*-view where most of the bending takes place. The right half is the *y*-view. Note that the lower half of the *y*-view of the calorimeter was not operating during the flight.



WIZARD sulla Freedom

IL NUOVO CIMENTO VOL. 105 B, N. 2

WiZard: a Program to Measure Cosmic-Ray Antiprotons and Positrons, and Search for Primordial Antimatter.

R. L. GOLDEN
Particle Astrophysics Laboratory, New Mexico State University - Las Cruces, NM

S. P. AHLEN and J. J. BEATTY
Department of Physics, Boston University - Boston, MA

H. J. CRAWFORD and P. J. LINDSTROM
Space Sciences Laboratory, University of California - Berkeley, CA

J. F. ORMES and R. E. STREITMATTER
NASA Goddard Space Flight Center - Greenbelt, MD

C. R. BOWER, R. M. HEINZ and S. MUFSON
Department of Physics, Indiana University - Bloomington, IN

T. G. GUZIK and J. P. WEFEL
Department of Physics and Astronomy, Louisiana State University - Baton Rouge, LA

S. A. STEPHENS
Tata Institute for Fundamental Research - Bombay, India

J. H. ADAMS, K. E. KROMBEL and A. J. TYLKA
Naval Research Laboratory - Washington, DC

M. SIMON and K. D. MATHIS
University of Siegen - Siegen, B.R.D.

P. PICOZZA
Dipartimento di Fisica, Università di Roma II «Tor Vergata» - Roma, Italia

G. BARBIELLINI
CERN - Geneve, Switzerland
Dipartimento di Fisica dell'Università - Trieste, Italia

G. BASINI, F. BONGIORNO and M. RICCI
Laboratori Nazionali INFN - Frascati (Roma), Italia

A. CODINO
Dipartimento di Fisica dell'Università - Perugia, Italia
INFN - Sezione di Perugia

C. DE MARZO and B. MANAGELLI
Dipartimento di Fisica dell'Università - Bari, Italia
INFN - Sezione di Bari

P. GALEOTTI
Laboratori di Cosmogeofisica del CNR - Torino, Italia

P. SPILLANTINI and M. BOCCIOLINI
Dipartimento di Fisica dell'Università - Firenze, Italia
INFN - Sezione di Firenze

IL NUOVO CIMENTO Vol. 102 B, N. 6 Dicembre 1988

Application of Silicon-Detector Technology to Experiments in Space. An Option for the Astromag Facility.

G. Barbiellini and A. Vacchi

INFN - Trieste
CERN - Geneva, Switzerland

G. Basini, A. Morselli, M. Occhigrossi and M. Ricci

INFN Laboratori Nazionali di Frascati (Roma)

F. Bongiorno

INFN Laboratori Nazionali di Frascati (Roma)
Dipartimento di Metodi e Modelli Matematici dell'Università «La Sapienza» - Roma

P. Spillantini and Yi-F. Wang

INFN - Firenze

R. Bernabei, M. P. De Pascale and P. Picozza

Dipartimento di Fisica dell'Università «Tor Vergata» - Roma
INFN Laboratori Nazionali di Frascati (Roma)

A. Codino and M. Menichelli

Dipartimento di Fisica dell'Università di Perugia
INFN - Perugia

WIZARD si rafforza

ELSEVIER

INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A

WiZard Si–W imaging calorimeter: a preliminary study on its particle identification capability during a balloon flight in 1993

F. Aversa [a], G. Barbiellini [a,*], M. Boezio [a], U. Bravar [a], A. Colavita [a], F. Fratnik [a], P. Schiavon [a], A. Vacchi [a], N. Zampa [a], V. Bidoli [b], M. Candusso [b], M. Casolino [b], M.P. De Pascale [b], A. Morselli [b], P. Picozza [b], R. Sparvoli [b], M. Bocciolini [c], F. Celletti [c], N. Finetti [c], M. Grandi [c], P. Papini [c], A. Perego [c], S. Piccardi [c], P. Spillantini [c], G. Basini [d], F.M. Brancaccio [d], G. Mazzenga [d], M. Ricci [d], R. Bellotti [e], F. Cafagna [e], M. Castellano [e], M. Circella [e], C. De Marzo [e], G. De Cataldo [e], N. Giglietto [e], B. Marangelli [e], A. Raino [e], P. Spinelli [e], M.T. Brunetti [f], A. Codino [f], C. Grimani [f], M. Menichelli [f], M. Miozza [f], F. Bronzini [g], R.L. Golden [h], S.J. Stochaj [h], S.A. Stephens [i], J.W. Mitchell [j], J.F. Ormes [j], R.E. Streitmatter [j], M. Hof [k], W. Menn [k], M. Simon [k]

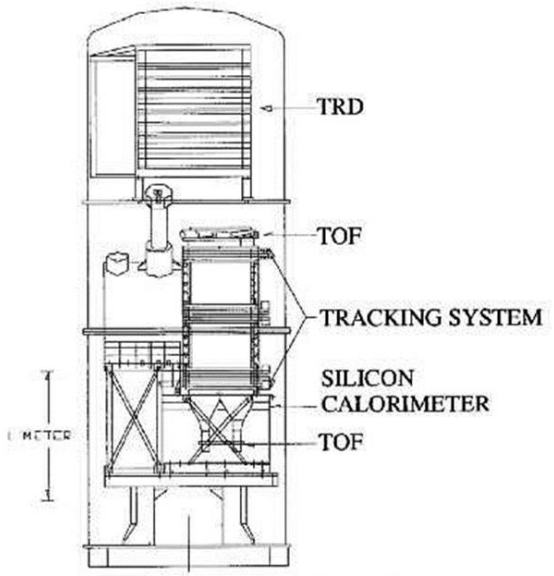
[a] *Dipartimento di Fisica and Sezione I.N.F.N. dell'Università di Trieste, Italy*
[b] *Dipartimento di Fisica and Sezione I.N.F.N. dell'Università di "Tor Vergata", Roma, Italy*
[c] *Dipartimento di Fisica and Sezione I.N.F.N. dell'Università di Firenze, Italy*
[d] *I.N.F.N. Laboratori Nazionali, Frascati, Italy*
[e] *Dipartimento di Fisica and Sezione I.N.F.N. dell'Università di Bari, Italy*
[f] *Dipartimento di Fisica and Sezione I.N.F.N. dell'Università di Perugia, Italy*
[g] *Dipartimento di Fisica and Sezione I.N.F.N. dell'Università "La Sapienza", Roma, Italy*
[h] *New Mexico State University, Las Cruces, USA*
[i] *Tata Institute of Fundamental Research, Bombay, India*

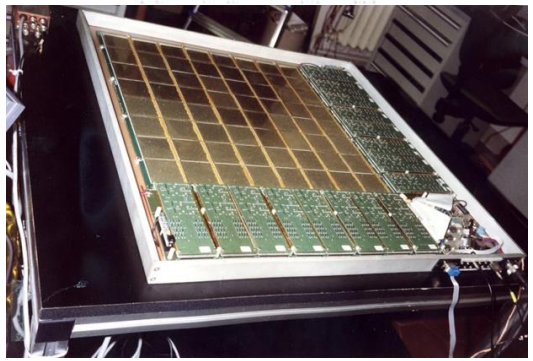
CAPRICE FLIGHTS

CANADA & NEW MEXICO

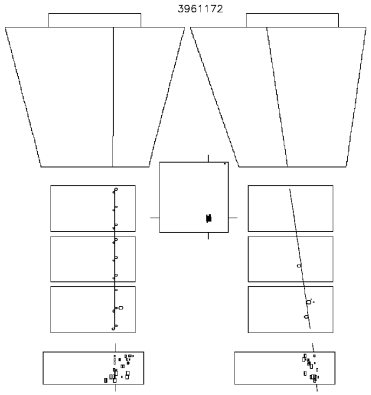
1994 - 1998

TramSi - 1993

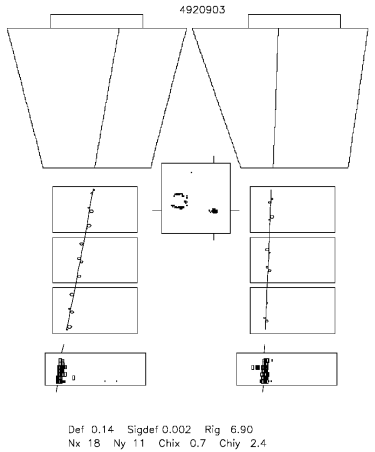


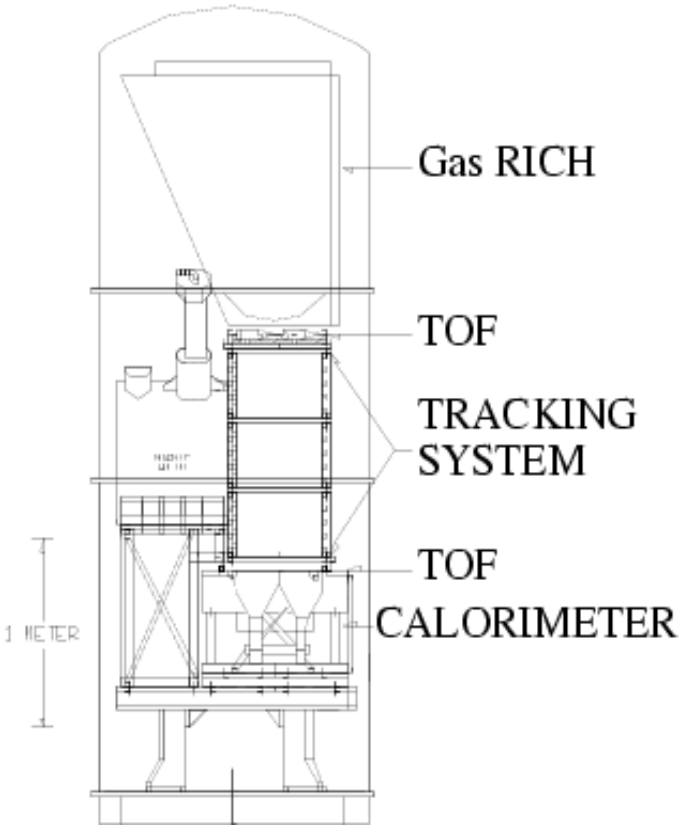


Antiproton



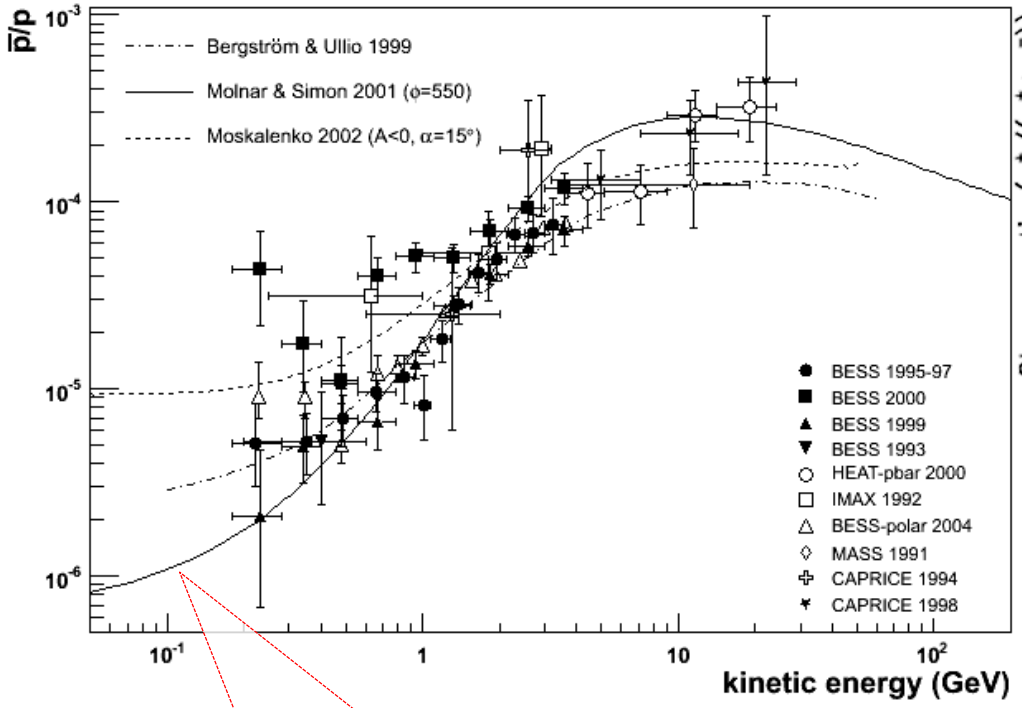
Positron



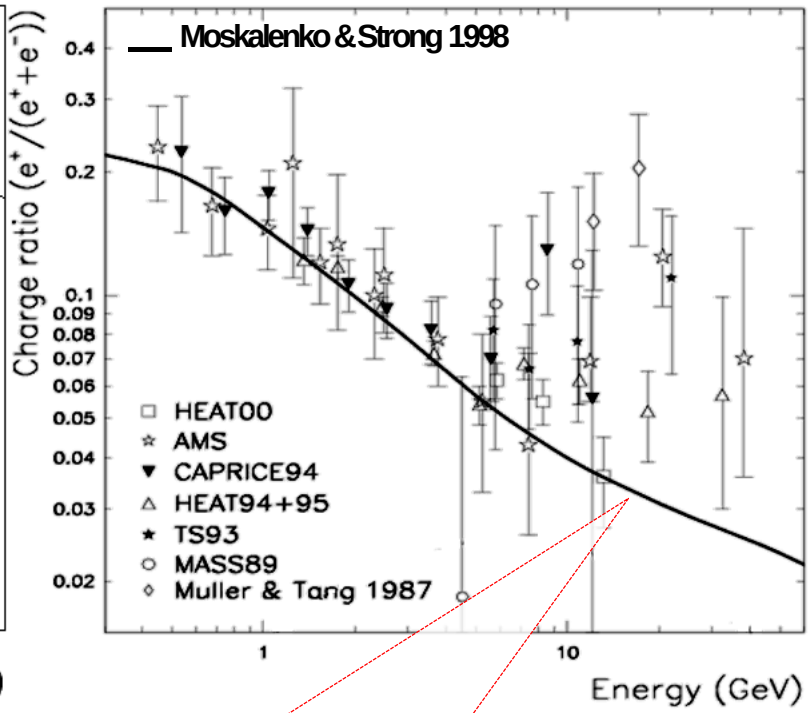


CR antimatter

Antiprotons



Positrons



CR + ISM → **p-bar** + …
kinematic treshold:
5.6 GeV for the reaction

$pp \rightarrow \bar{p}ppp$

CR + ISM → $\pi^{\pm}$ + x → $\mu^{\pm}$ + x → **$e^{\pm}$** + x
CR + ISM → π^0 + x → $\gamma\gamma$ → **$e^{\pm}$**

RIM (Russian Italian Missions)

Il primo accord 22 Maggio 1993

Tre missioni

PROTOCOL
of the discussions held in Moscow on May 24-26, 1993, between INFN and Moscow Engineering Physics Institute (MEPhI) on collaboration in Astroparticle Physics

Following the letter of the INFN President of May 19, 1993, (see Annex 1 to the present Protocol), an INFN Delegation visited from 24 to 26 May 1993 MEPhI in order to discuss a possible collaboration in the field of Astroparticle Physics.

The INFN Delegation, composed by Prof. P.G.Picozza, Vice-President of INFN, by Prof. P.Spillantini, Director of the INFN Section of Florence, and by Dr. M.Gigliarelli-Fiumi, Director for INFN International Affairs, met Prof. A.V. Shalnov, Rector of MEPhI and Prof. A.Galper, Head of C.Ph. Laboratory of MEPhI.

During these discussions the main lines of a joint research work on a large γ-ray telescope have been agreed and presented in Annex 2 to the present Protocol. Results of discussion have been included in Annex 3.

The two parties also took note of the offer made by the All-Russian Research Institute of Electromechanics (VNIIEM) of Moscow declaring their readiness to grant the installation of a silicon telescope to search for γ-ray sources in the energy range between 100 MeV and 100 GeV in their satellite which, according to their programs, is scheduled to be launched in 1996-97.

INFN an MEPhI agreed that a detailed feasibility study of all the scientific and technical aspects, in particular related to the installation of the silicon detector in the satellite, is needed.

Such a study, to be completed by 30 October, 1993, should be contracted by INFN to VNIIEM.

INFN and MEPhI, however, will follow in close co-operation with VNIIEM, the development of the above study.

Finally, INFN and MEPhI agreed that a specific "Memorandum of Understanding" between the two Institutions should be concluded in view of better implementing their scientific collaboration. It was also agreed the joint work program to be carried out before 30 October 1993 (Annex 4)

Prof. P.G.Picozza - INFN

Prof. A.Galper - MEPhI

26.05.93

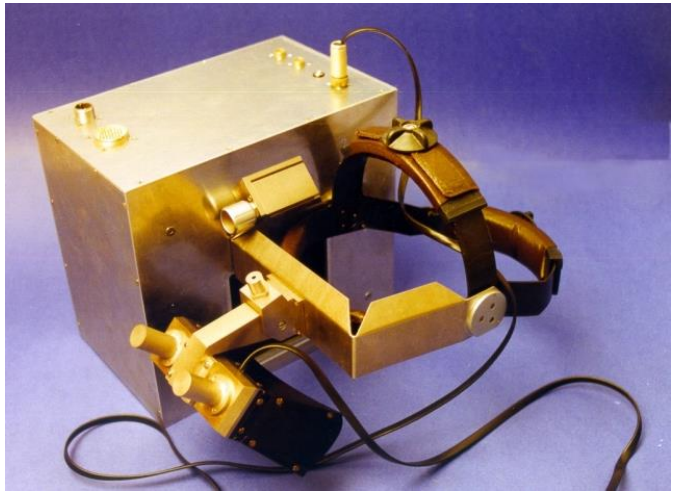
I Referee Commissione II

- Ettore Fiorini, Marcello Coradini, Paolo Giubellino, Emanuela Meroni, Ludovico Riccati, G. Barbarino (fino al 2000)

- Il loro completo appoggio è stato fondamentale per non sparire

- La prima richiesta: mostrate di essere capaci di mandare un pezzo di ferro in orbita con i russi

Sil-EYE Missions



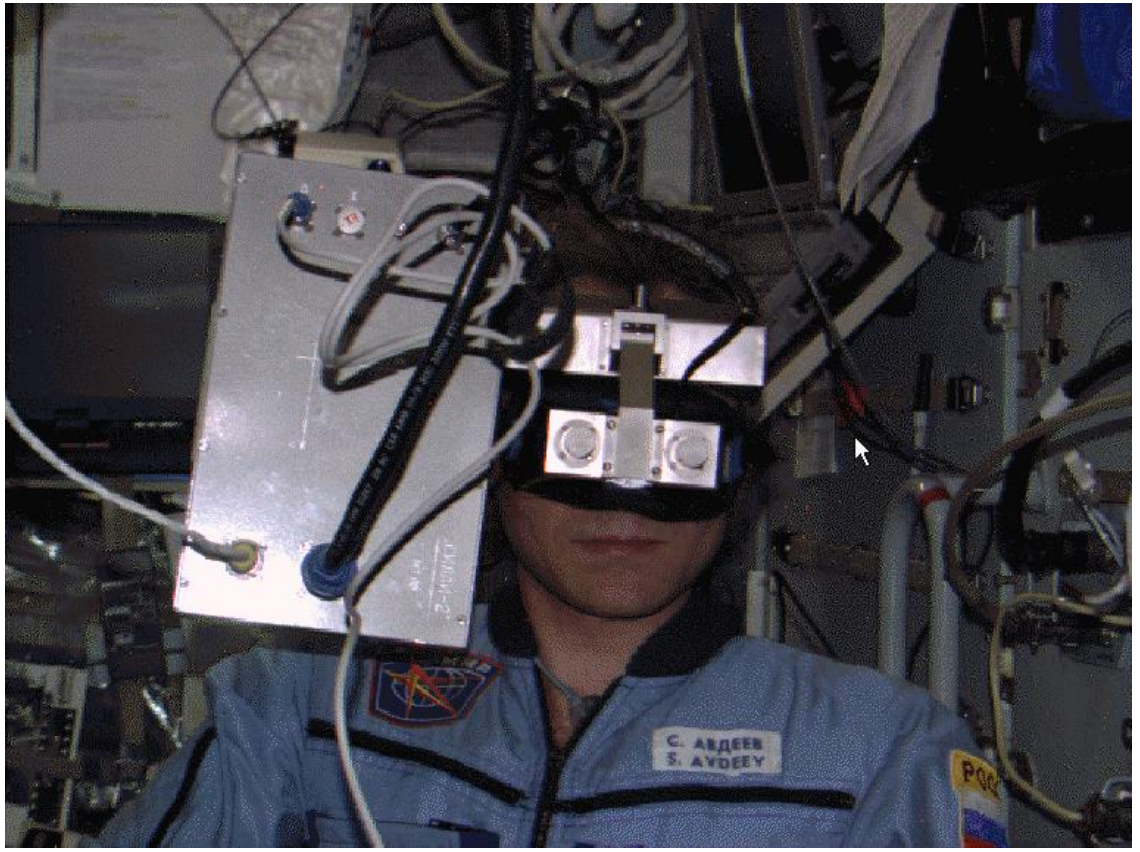
3 Settembre 1995

L'INFN nello Spazio

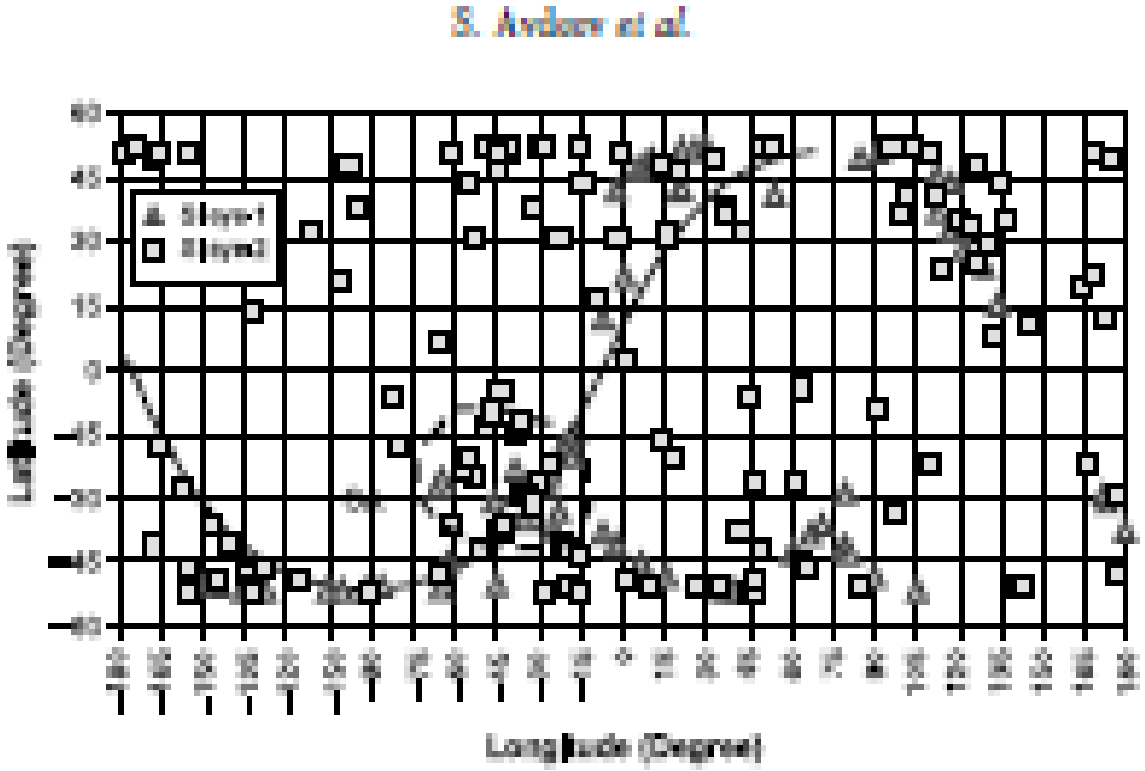
MIR

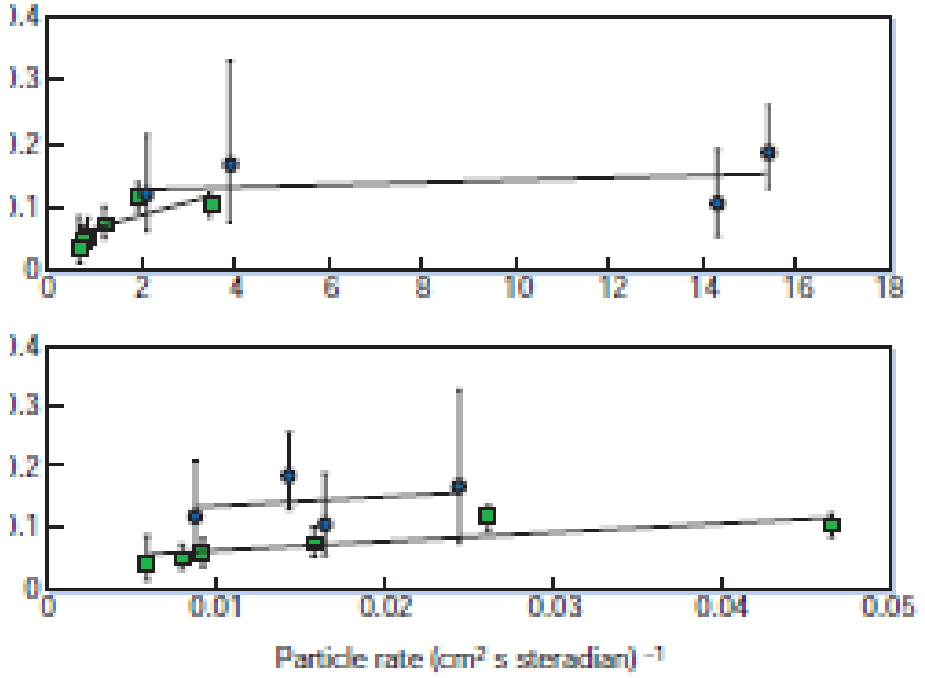
Sil-Eye 1
1995

Sil-Eye 2
1998



Lampi di Luce nella MIR

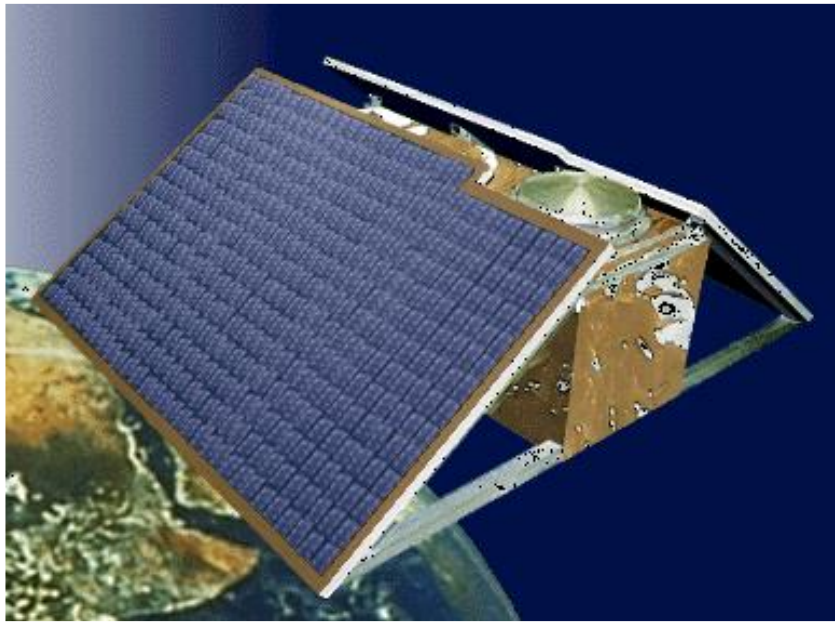


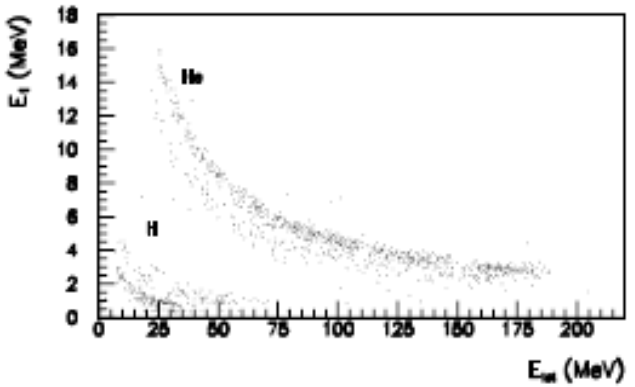


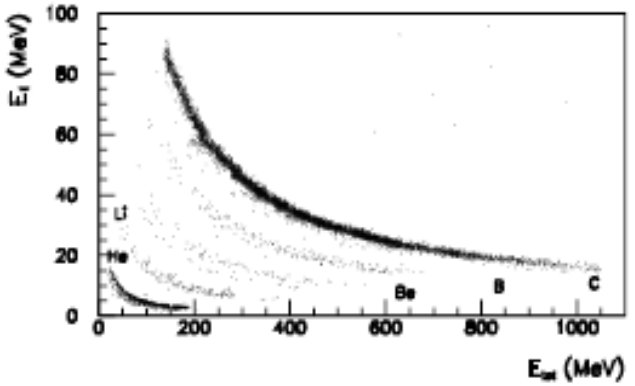
Nature, Vol. 422, 680 (2003).

NINA1 NINA2

1998 2000







GILDA

ELSEVIER

Nuclear Instruments and Methods in Physics Research A 354 (1995) 547–552

NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A

The GILDA mission: a new technique for a gamma-ray telescope in the energy range 20 MeV–100 GeV

G. Barbiellini [a], M. Boezio [a], M. Casolino [b], M. Candusso [b], M.P. De Pascale [b], A. Morselli [b,*], P. Picozza [b], M. Ricci [d], R. Sparvoli [b], P. Spillantini [c], A. Vacchi [a]

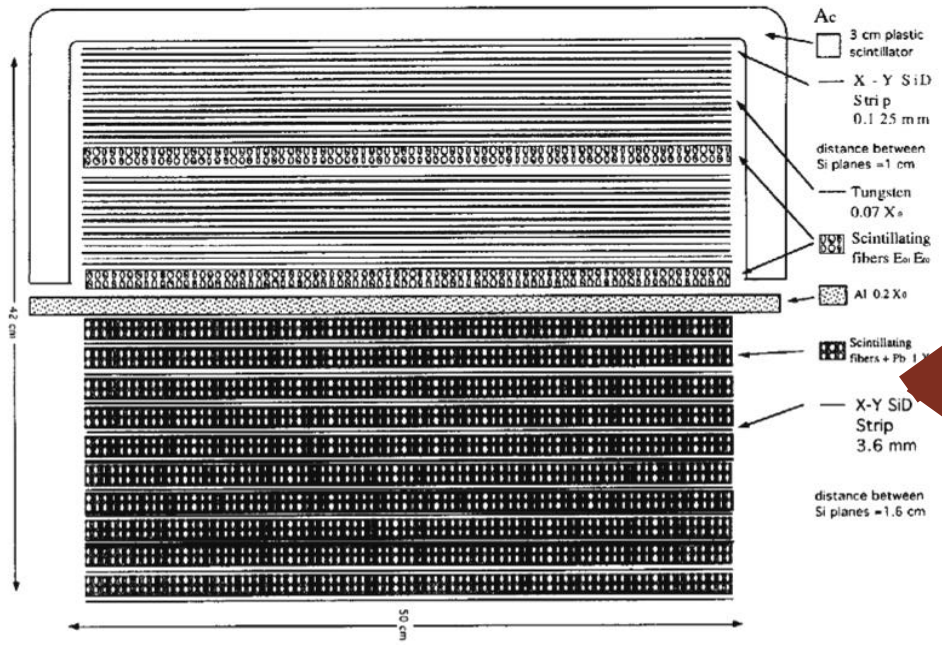
[a] *Dept. of Physics, Univ. of Trieste and INFN, Italy*
[b] *Dept. of Physics, II Univ. of Rome "Tor Vergata" and INFN, Italy*
[c] *Dept. of Physics, Univ. of Firenze and INFN, Italy*
[d] *INFN Laboratori Nazionali di Frascati, Italy*

Received 5 August 1994

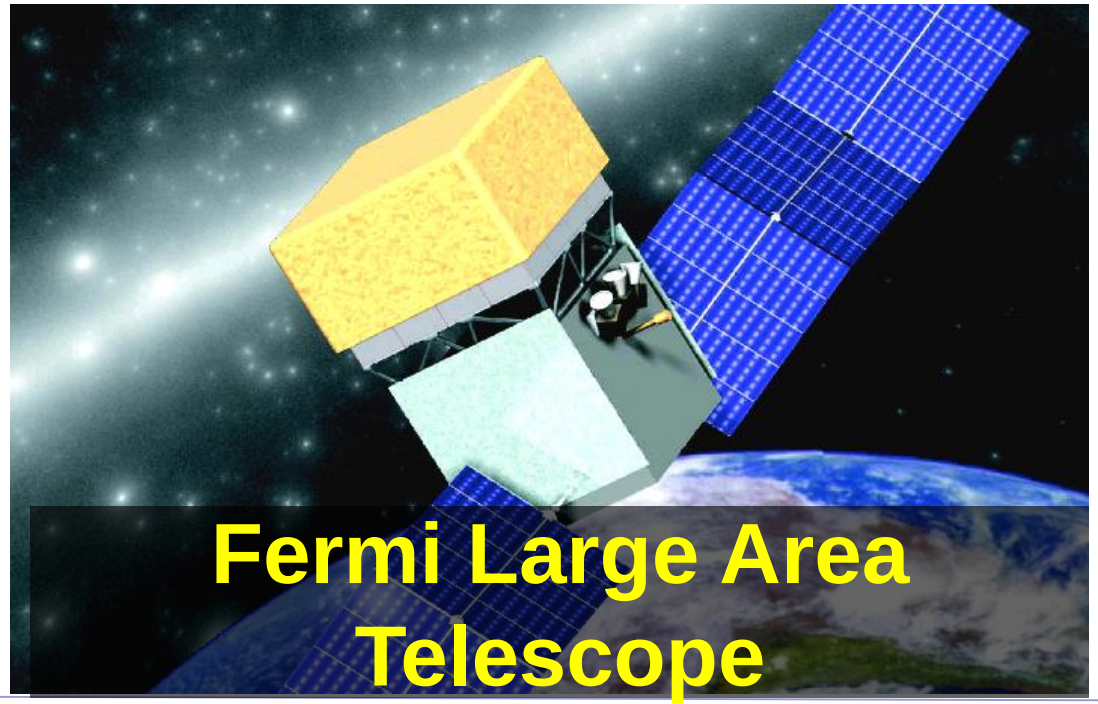
Abstract

In this article a new technique for the realization of a high energy gamma-ray telescope is presented, based on the adoption of silicon strip detectors and lead scintillating fibers. The simulated performances of such an instrument (GILDA) are significatively better than those of EGRET, the last successful experiment of a high energy gamma-ray telescope, launched on the CGRO satellite, though having less volume and weight.

GILDA


Ac
3 cm plastic scintillator
X - Y SiD Strip 0.1 25 mm
distance between Si planes =1 cm
Tungsten 0.07 X₀
Scintillating fibers
Al 0.2 X₀
Scintillating fibers + Pb
X-Y SiD Strip 3.6 mm
distance between Si planes =1.6 cm
42 cm
56 cm


agile
Astro-rivelatore Gamma a Immagini Leggero
INAF
INFN
Aleniа
telespazio


Fermi Large Area Telescope

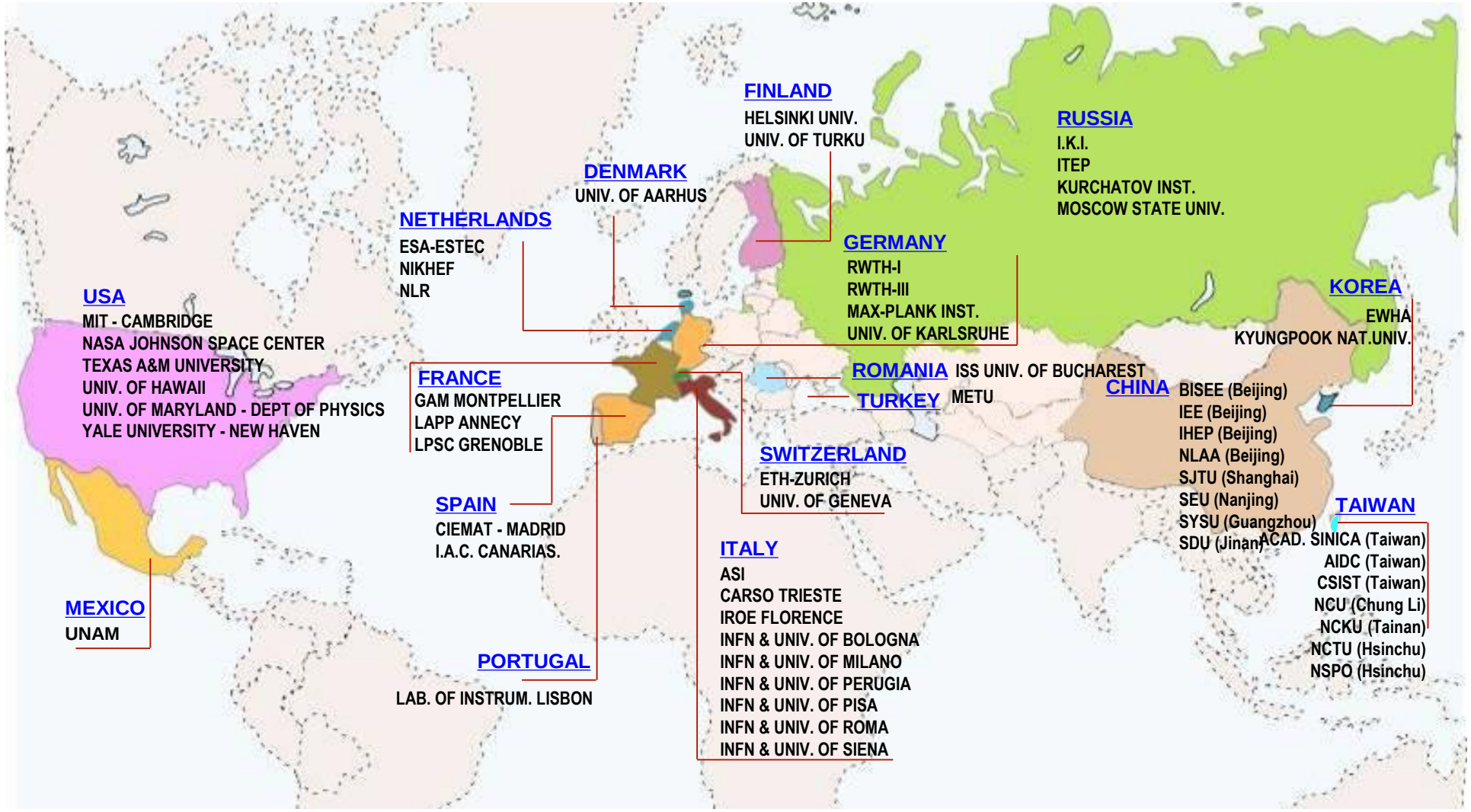
PAMELA

The Magnetic Spectrometer PAMELA for the Study of Cosmic Antimatter in Space

O. Adriani[1], B. Alpat[2], G. Barbiellini[3], L.M. Barbier[4], S. Bartalucci[5], R. Bellotti[6], G. Basini[5], M. Bocciolini[1], M. Boezio[3], F M. Brancaccio[1], U. Bravar[3], F. Cafagna[6], M. Candusso[7], R. Cardarelli[7], P. Carlson[8], M. Casolino[7], M. Castellano[6], G. Castellini[1], M. Circella[6], E.R. Christian[4], A.J. Davis[9], G. De Cataldo[6], C.N. De Marzo[6], M.P. De Pascale[7], E. Fiandrini[2], N. Finetti[2], T. Francke[8], C. Fuglesang[8], A.M. Galper[10], F. Giannini[7], N. Giglietto[6], R.L. Golden[11], M. Hof[12], S.V. Koldashov[10], M.G. Korotkov[10], J. Krizmanic[4], M.L. Lamorte[5], M. Lanfranchi[2], P. La Riccia[2], B. Marangelli[6], L. Marino[5], R.A. Mewaldt[9], V.V. Mikhailov[10], J.W. Mitchell[4], A A. Moiseev[10], A. Morselli[7], J.F. Ormes[4], J.V. Ozerov[10], P. Papini[1], A. Perego[1], S. Piccardi[1], P. Picozza[7], M. Ricci[5], P. Schiavon[3], S.M. Schindler[9], M. Simon[12], R. Sparvoli[7], P. Spillantini[1], P. Spinelli[6], S.J. Stochaj[11], R.E. Streitmatter[4], O. Toker[2], A. Vacchi[3], V. Vignoli[1], S.A. Voronov[10], N. Weber[8], N. Zampa[3]

[1] *Università and INFN, Firenze, Italy.* [2] *Università and INFN, Perugia, Italy.* [3] *Università and INFN, Trieste, Italy.* [4] *NASA Goddard Space Flight Center, Greenbelt, USA.* [5] *Laboratori Nazionali INFN, Frascati, Italy.* [6] *Università and INFN, Bari, Italy.* [7] *II Università and INFN, Roma, Italy.* [8] *Royal Institute of Technology, Stockholm, Sweden.* [10] *Moscow Engineering and Physics Institute, Moscow, Russia.* [11] *Particle Astrophysics Lab, New Mexico State University, Las Cruces, USA.* [12] *Universität Siegen, Fachbereich Physik, Siegen, Germany.*

AMS: U.S. DOE sponsored international collaboration



An antimatter spectrometer in space. S. Ting et al.

NIM, Volume 15 October 1994, Pages 351-367

Afferire al nuovo progetto?

- Per anni Presidenti INFN e Commissione II hanno « consigliato» Wizard a convergere in AMS

- Per quale motivo tanta perplessità?

Perché:

Perché?

- Un gruppo giovane, affiatato, entusiasta, molto competente, che credeva in ciò che faceva e desideroso di fare qualcosa di veramente importante.

- Un gruppo che si è fidato

10 anni dopo

La Svolta: dicembre 1998

- Enzo Iarocci — Presidente INFN
- Yuri G. Milov — Deputy General Director of the Russian Federal Space Agency
- G.M.Polishchuk — Deputy General Director of the Russian Federal Space Agency

La Firma

Dec. 1998

Memorandum of Understanding

between

The European Organization for Nuclear Research ("CERN"), represented by the Director of Research and Scientific Computing,

on the one hand,

and

The Collaborating Institutions of the PAMELA Experiment (as listed in Annex 1), represented by its Spokesperson (or other appointed representative),

on the other hand,

hereafter referred to as "Parties" or individually as "Party".

Preamble

(a) The main purpose of the PAMELA Experiment (the "Experiment") is the observation and study of Cosmic Rays in Space, in particular antiparticles and possible signatures of Dark Matter.

(b) On 5th June 2013, in application of the provisions of CERN document *"Recognized Experiments at CERN"* (Annex 2), the CERN Research Board has granted to the Experiment, on the recommendation of the Recognized Experiments Committee, extension of its status of Recognized Experiment.

Chamber of Commerce (Sweden). The place of arbitration shall be Stockholm and the language of arbitration shall be English. The decision of this arbitration shall be final and binding for both Parties.

17.3. The thirty (30) day period for resolution of disputes prior to arbitration does not apply if either Party becomes insolvent or is subject to proceedings under any law relating to bankruptcy, or in the event of an appointment of a receiver or trustee or the assignment by either Party for the benefit of creditors.

ARTICLE 18: EFFECTIVENESS, TERM, CHANGES

18.1. The present Agreement shall become effective since the date of its signature by two Parties.

18.2. The present Agreement shall expire in 6 months, after the date of launch.

18.3. The Parties can extend the term of the present Agreement according to the conditions to be agreed in additional agreement.

18.4. The present Agreement can be modified or added as a result of a written agreement of the Parties.

18.5. In the case of premature termination of the Agreement, the articles 11,12,13,14,17 shall remain in effect.

The present Agreement is signed in the city of Rome in English, Italian and Russian in two originals in each language, but the English version will be the only official legal text. The English version shall be the only version which can be used for the purposes of Article 17.

On behalf of INFN

President of INFN

On behalf of RSA (Russia)

Deputy Director General of the Russian Space Agency

December 22, 1998

GO ON!

Marzo 2001

000019

Agreement №1
Addendum

to the Agreement between

RSA

and

INFN

about the joint realization of the experiment "PAMELA"

(experiment RIM-2 of the Russian Italian Mission program)

Specialists of INFN will be present during the main stages of work with "PAMELA", during the electrical tests at the factory "Progress" in Samara, during the integration works and tests in Baikonur. 000027

ROSAVIAKOSMOS will provide specialists of INFN with admittance to the electrical tests on the factory "Progress" in Samara, to the integration works and tests in Baikonur. Business trips of INFN specialists are paid by INFN.

This Addendum to Agreement N.1 is an inalienable part of "Agreement between ROSAVIAKOSMOS and INFN for the joint realization of the "PAMELA" experiment of 22 December 1998 and is effective since the date of its signing.

For INFN

INFN President

ISTITUTO NAZIONALE DI FISICA NUCLEARE
IL PRESIDENTE
(Prof. Enzo Iarocci)

E. Iarocci

"1 MAR. 2001" 2001

For ROSAVIAKOSMOS

ROSAVIAKOSMOS

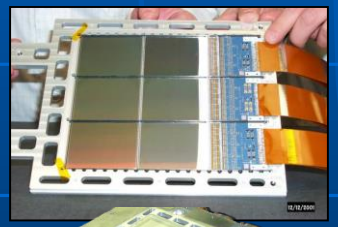
Director Deputy General

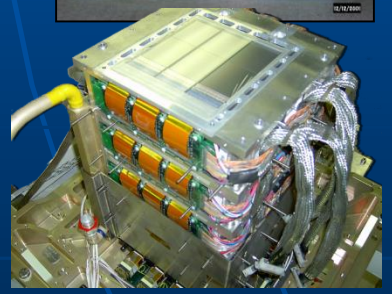
G.M. Polishyu

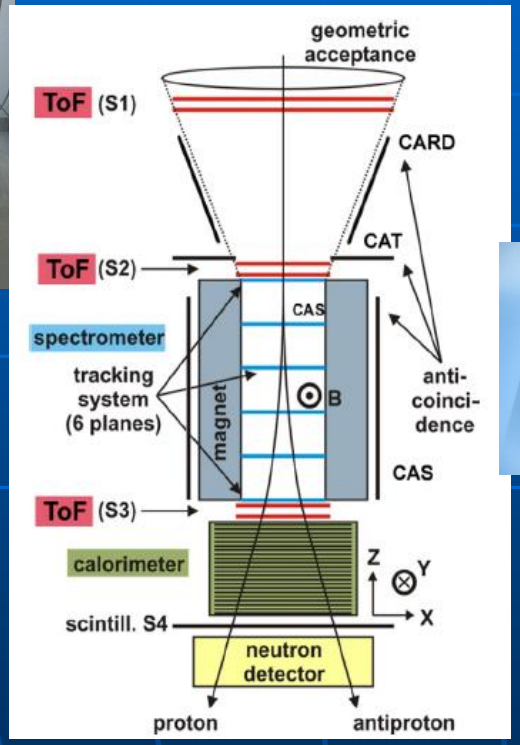
"7" 03 2001

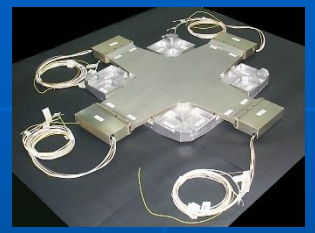
PAMELA nei vari Istituti

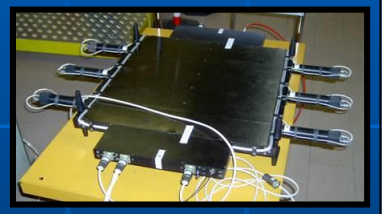
Bari · Florence · Frascati · Naples · Rome · Trieste · CNR, Florence

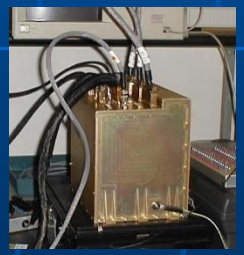












Russia:

Moscow
St. Petersburg

Germany:

Siegen

Sweden:

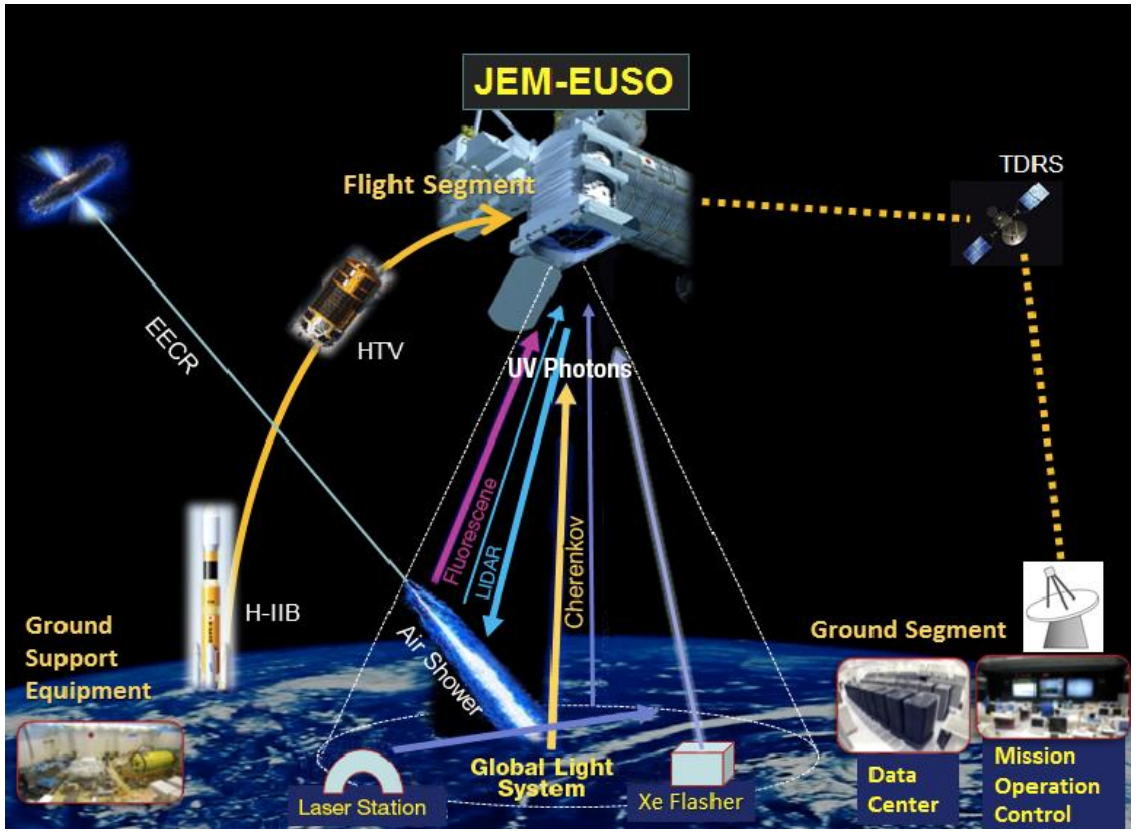
KTH, Stockholm

WIZARD

- Wizard ha seguito PAMELA in orbita per 10 anni fino alla perdita delle comunicazioni con il satellite

- Poi, in Tor Vergata il gruppo Wizard ha preso due strade:

Sol Levante



Celeste Impero

CSES-Limadou