Linea Scientifica 4: Raggi cosmici nello spazio

RASSEGNA ATTIVITA' IN CORSO E PROSPETTIVE

Esperimenti nello Spazio

(2007)

- **Studi di Astronomia γ**

  (**Agile** in orbita fine aprile, **Glast** in orbita inizio 2008)
- **Ricerca di Antimateria, Dark Matter**

  (**Pamela-Wizard** in orbita, **Ams2**)
- **Composizione chimica dei r.c. primari (E<500 TeV)** (**Cream**)

Risorse di CSN2 assegnate/FTE alla linea IV

- **2007: assegnati 2128,5/14056,5= 15,1% (db16.5%)**
- **FTE:**
  - **AGILE 13.4 ric + 1.5 tecn +tecn. = 15.6**
  - **AMS2 38.2+5.7+7.1 = 51**
  - **CREAM 8.3+0.4 = 8.7**
  - **GLAST 41.6+1+4.25 = 46.85**
  - **WIZARD 27.9+2.2+2 = 32.1**

tot = 154.25

Totale gruppo2: 603.7+91.1= 694.8 (22.2%)

Stato dell'arte

- **Primi dati dalle osservazioni di PAMELA**
- **Momento di attesa: nuove osservazioni γ dallo spazio (sino a 500 GeV circa) AGILE-GLAST**

PAMELA SPACE MISSION

Comm IGS


In orbita ed in presa dati

Piergiorgio Picozza

lancio giugno 2006

PAMELA DETECTOR

Anticoncidence system

Multiple particles rejection

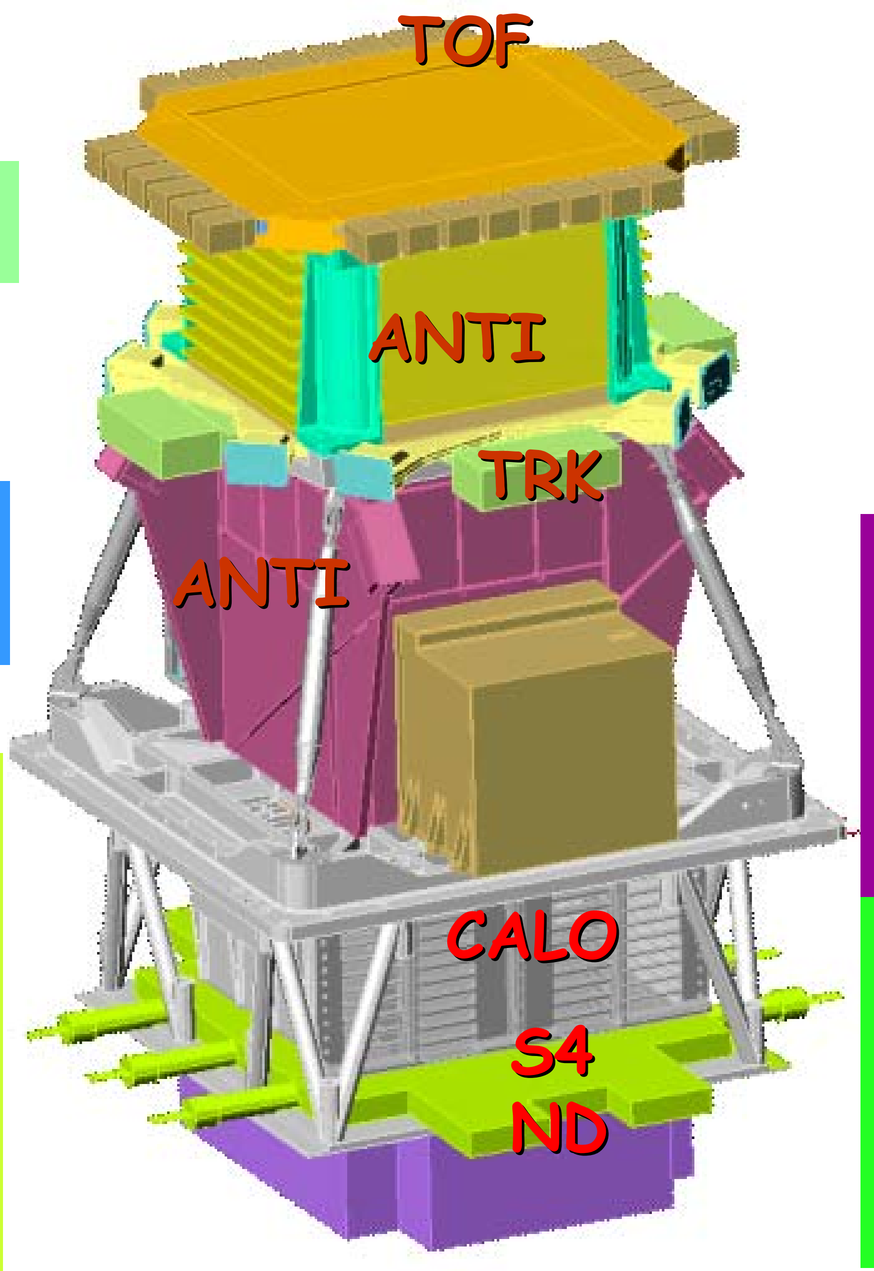
Anticoincidence system

- Defines tracker acceptance
- Plastic scintillator + PMT

Si-W Calorimeter

- Imaging Calorimeter : reconstructs shower profile discriminating e^+/p and p/e^- at level of $10^{-4} \sim 10^{-5}$
- Energy Resolution for $e^\pm$ $\Delta E/E = 15\% / E^{1/2}$.
- Si-X / W / Si-Y structure

  22 W planes
- $16.3\ X_0 / 0.6\ l_0$



Time-of-flight

- Level 1 trigger
- particle identification (up to 1GeV/c)
- dE/dx
- Plastic scintillator + PMT
- Time Resolution ~ 70 ps

Si Tracker + magnet

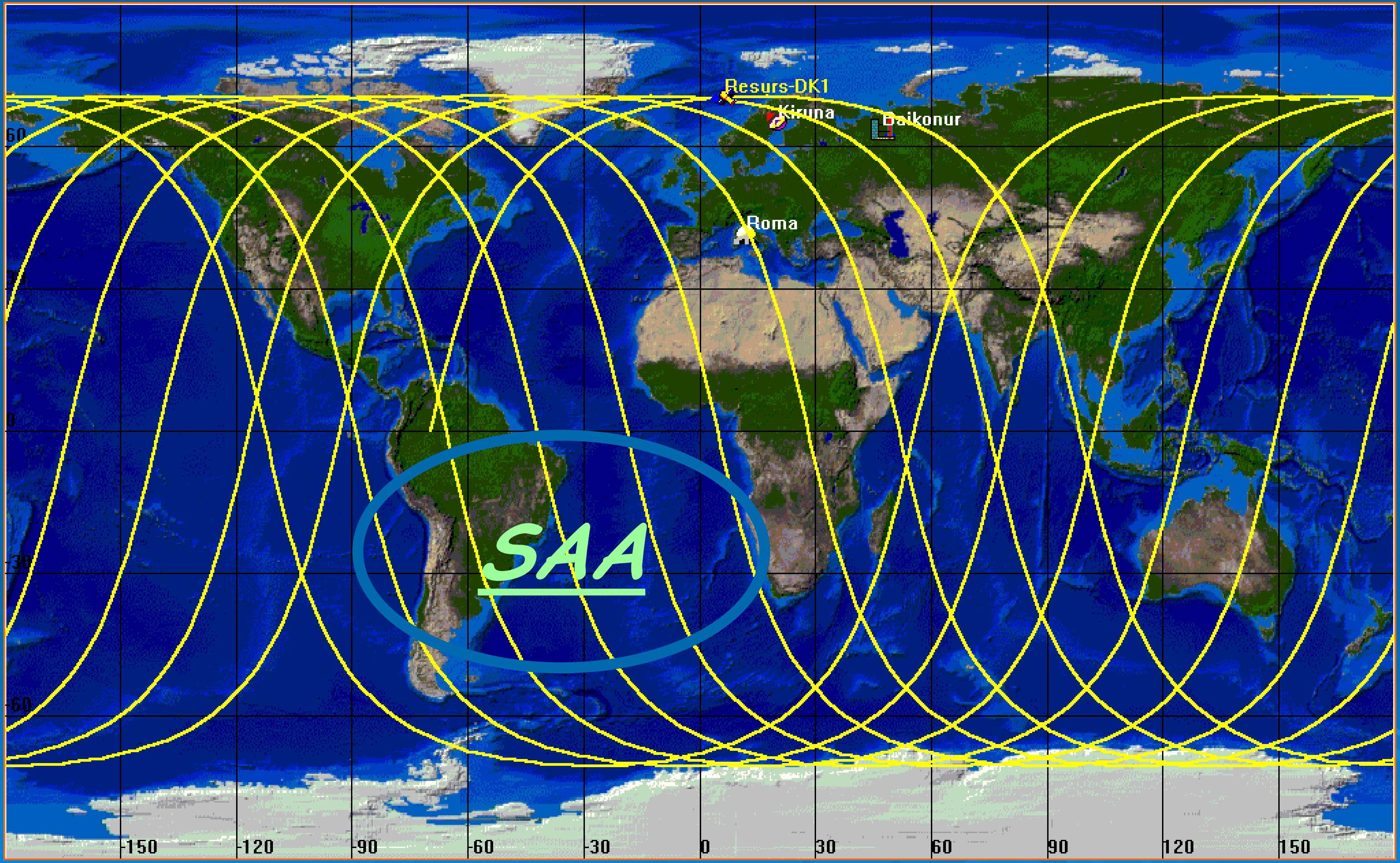
- Permanent magnet B=0.4T
- 6 planes double sided Si strips 300 μm thick
- Spatial risolution ~3μm
- Maximum Detectable Rigidity = 740 GV/c

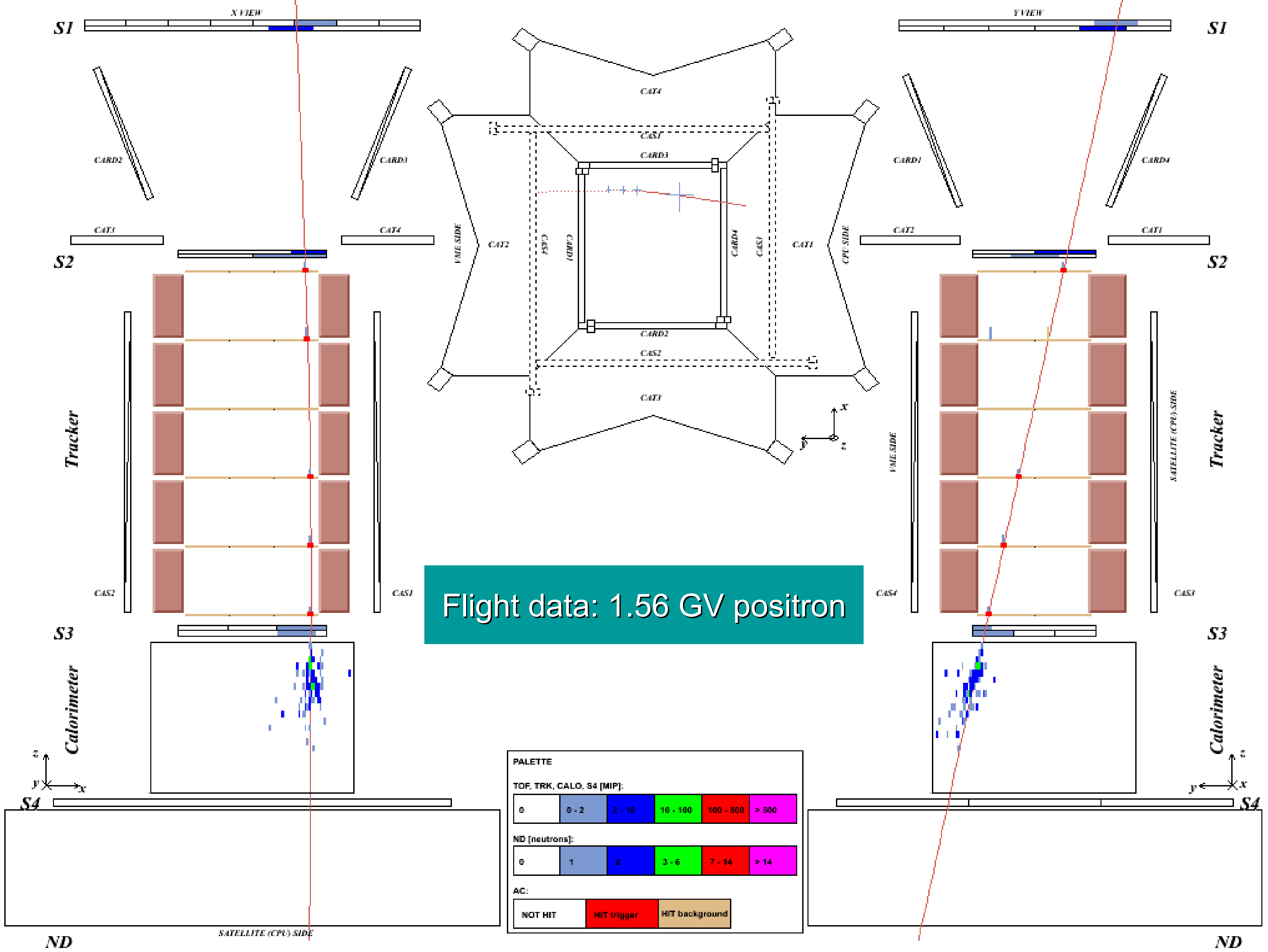
S4 and Neutron detectors

- Extend the energy range for primary protons and electrons up to 10 TeV
- Plastic Scintillator
- 36 ^{3}He counters in a polyetilen moderator

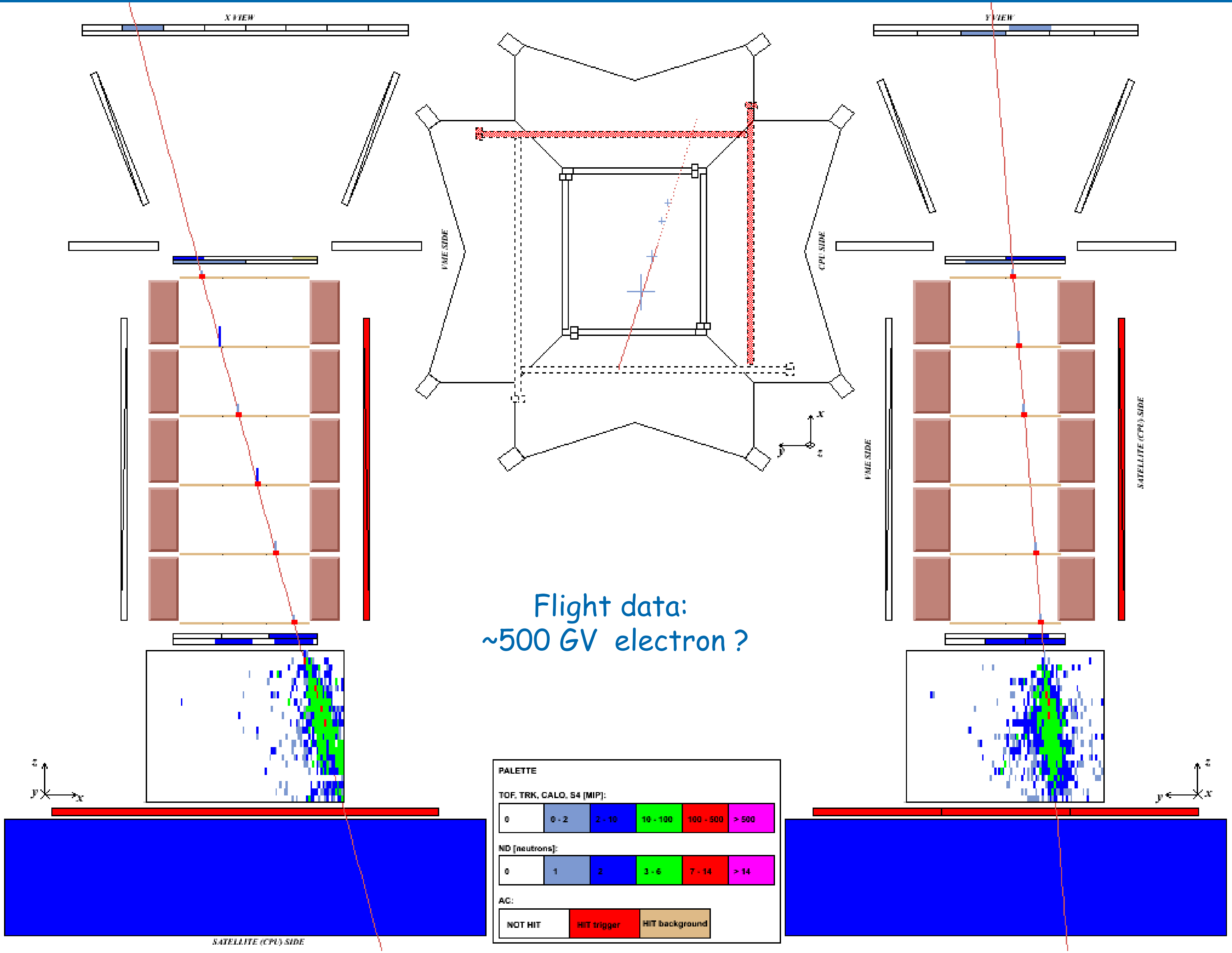
quasi-polar (70°)
elliptical (350÷600 km)
3-years-long mission

Orbit characteristics





Flight data: 1.56 GV positron



Flight data:
~500 GV electron ?

Collected Data

In the period 07/10-26/11 PAMELA has collected data for ~ 1475h, i.e. ~61 days for a total of ~9x10^7 events

Assuming a fractional live time for PAMELA of 0.7 and using the published fractional live times and acceptances of CAPRICE98 and HEAT-PBAR we can Compare the 3 experiments

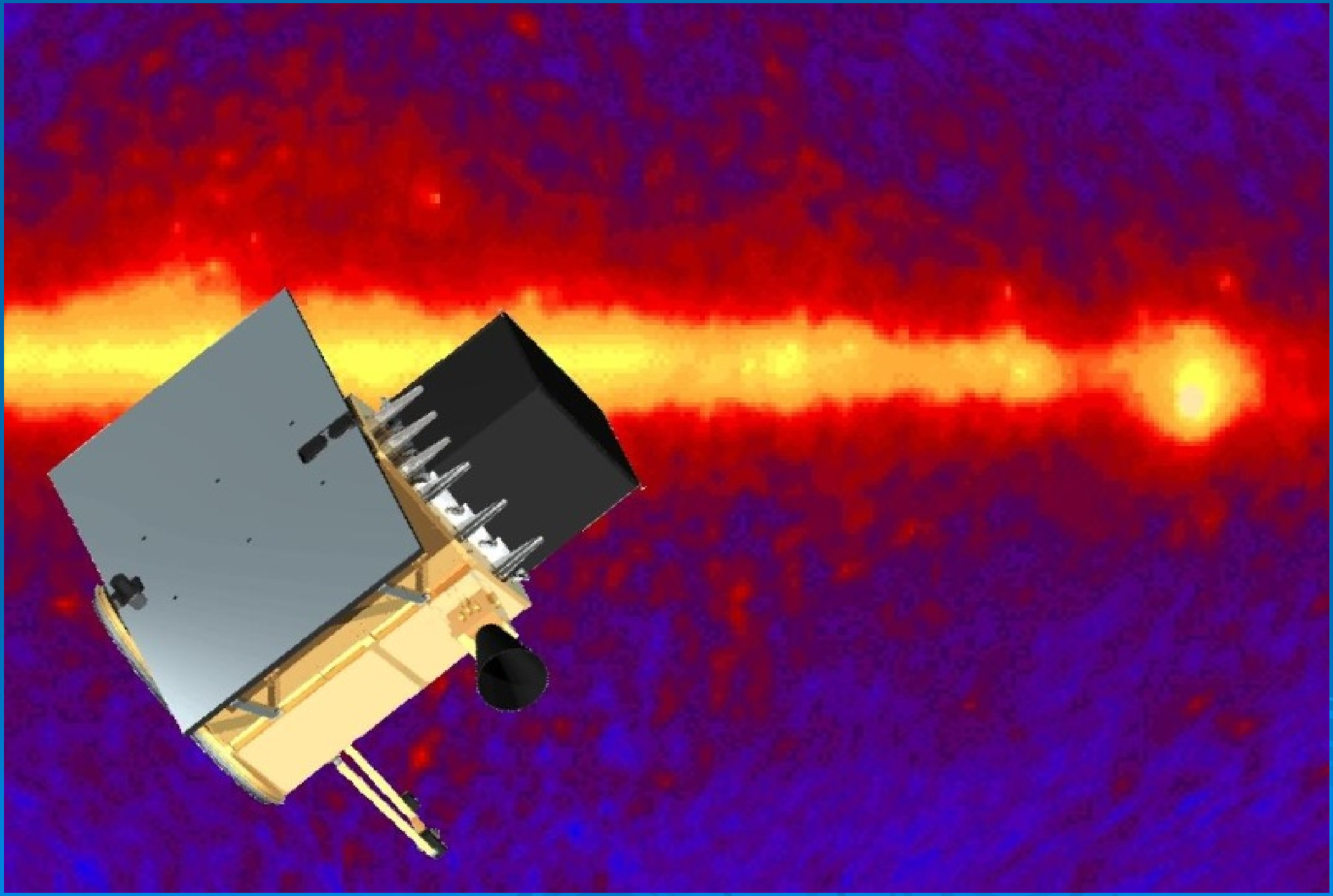
PAMELA	**CAPRICE98**	**HEAT-PBAR**
1475h	**94h**	**540h (?)**

Antiprotons & Positrons

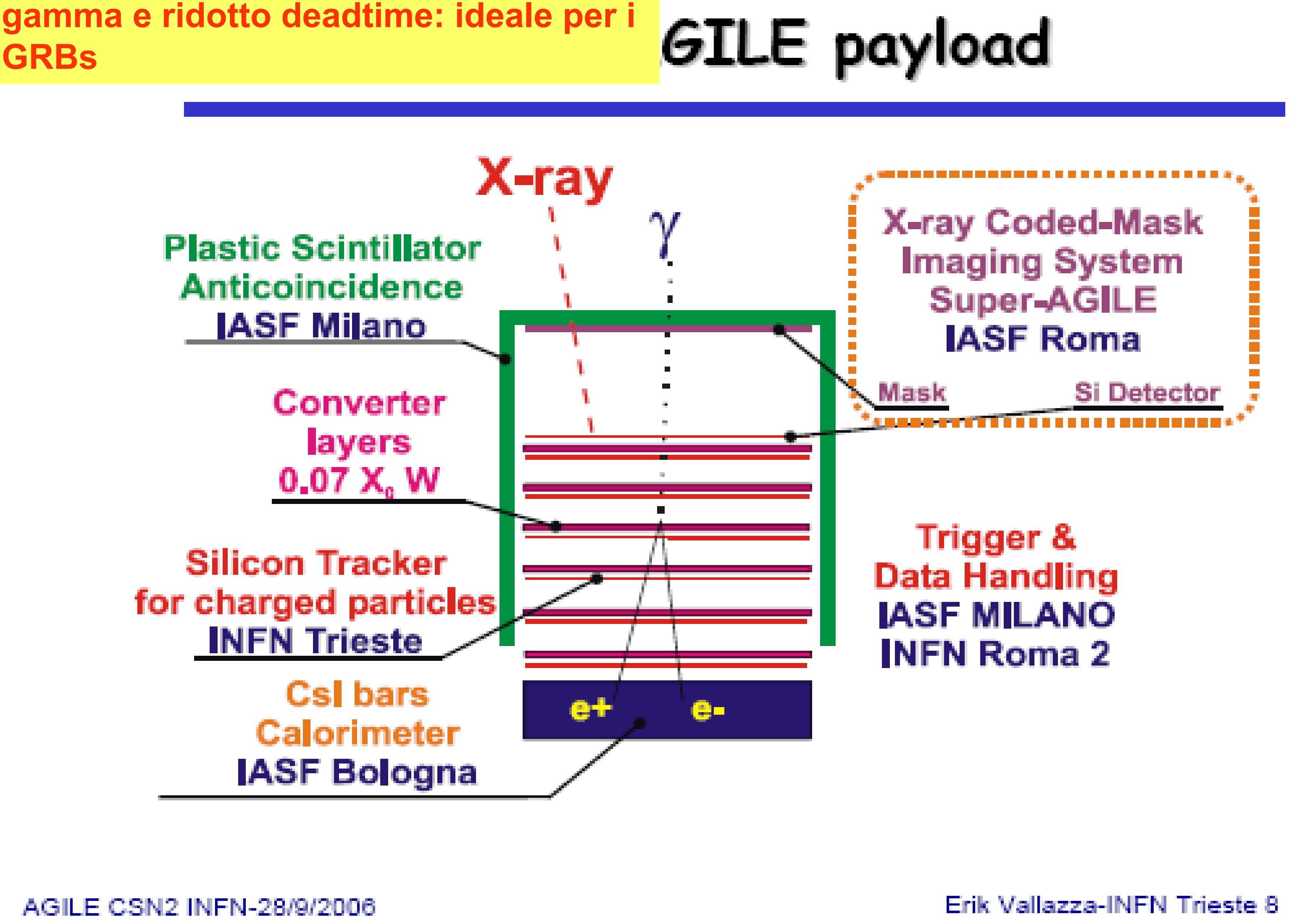
	PAMELA	**CAPRICE98**	**HEAT** **(all 3 flights)**
$\bar{p}$ Secondary flux by L. Bergström using C94 p flux	~300 0.1-190 GeV ~78 10-190 GeV	31 3-49 GeV 1.8 cont. & 7 atmo.	78 3-49 GeV 2.4 cont. & 13 atmo.
e^+ Secondary flux by Moskalenko & Strong	~3230 0.05-270 GeV ~580 4.5-270 GeV		334 4.5-50 GeV 103 5-16.4 GeV

Waiting First Results at ICRC

AGILE



Punti di forza: rivelazione **abbinata X e gamma e ridotto deadtime: ideale per i GRBs**



GILE payload

X-ray

γ

Plastic Scintillator Anticoincidence
IASF Milano

Converter layers
0.07 X_0 W

Silicon Tracker for charged particles
INFN Trieste

CsI bars Calorimeter
IASF Bologna

e+

e-

X-ray Coded-Mask Imaging System Super-AGILE
IASF Roma

Mask

Si Detector

Trigger & Data Handling
IASF MILANO
INFN Roma 2

AGILE CSN2 INFN-28/9/2006

Erik Vallazza-INFN Trieste 8

3 innovative features of AGILE

(1) Optimal imaging capabilities and large FOV in the energy bands:

* 15 keV - 45 keV (Super-Agile)

* 30 MeV - 50 GeV (GRID: Tracker+MCAL)

(2) Excellent X-ray/γ-ray timing (GPS)

(3) Burst search with large dynamic range (sub-milliseconds-60 seconds) and independent triggering of the Mini-Calorimeter (300 keV-100 MeV).

F.Longo for the AGILE Team

AGILE Instrument

AGILE: first and unique combination
of a gamma-ray imager and a X-ray imager
GeV) (15-45 keV)

Gamma-ray Imaging Detector (GRID)

- Energy Range 30MeV-50 GeV
- Field of view 2.5sr
- Flux sensitivity(E>100MeV) $3\ 10^{-7}$
- angular resolution at 400 MeV 1.2°
- Absolute time resolution 2μs
- Tempo morto: 100-200 μs

AGIL

SUPER-AGILE:

- Energy Range 15-45 keV
- Ris. Ang. 6 arcmin (0.05°)
- S/N 10
- Time accuracy 4μs

Massa 120 kg

Volume 0.25 m3

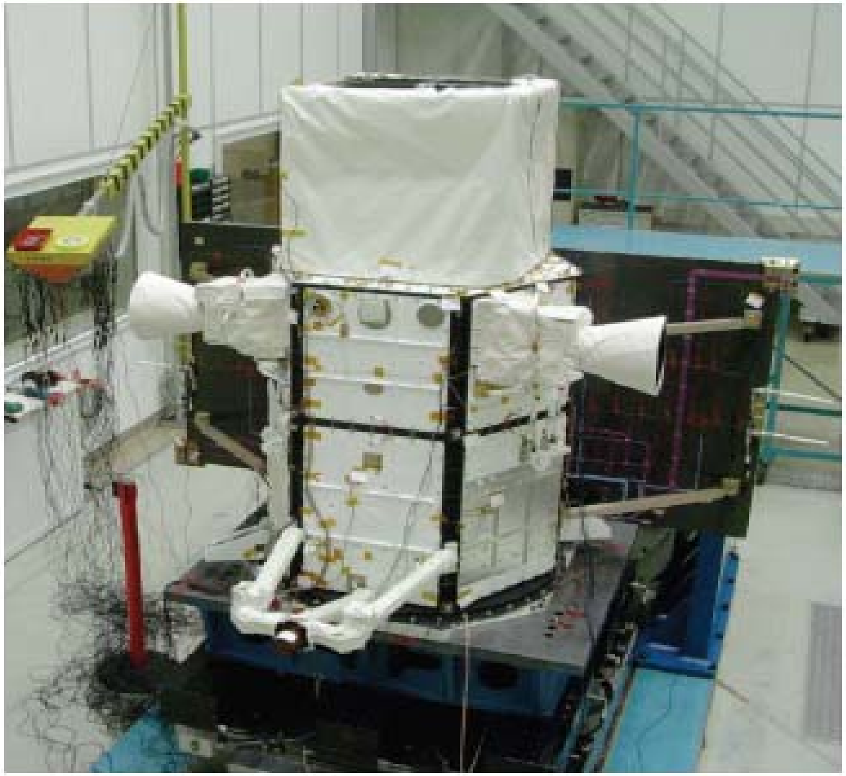
36864 sensori silicio

F.Longo for the AGILE Team

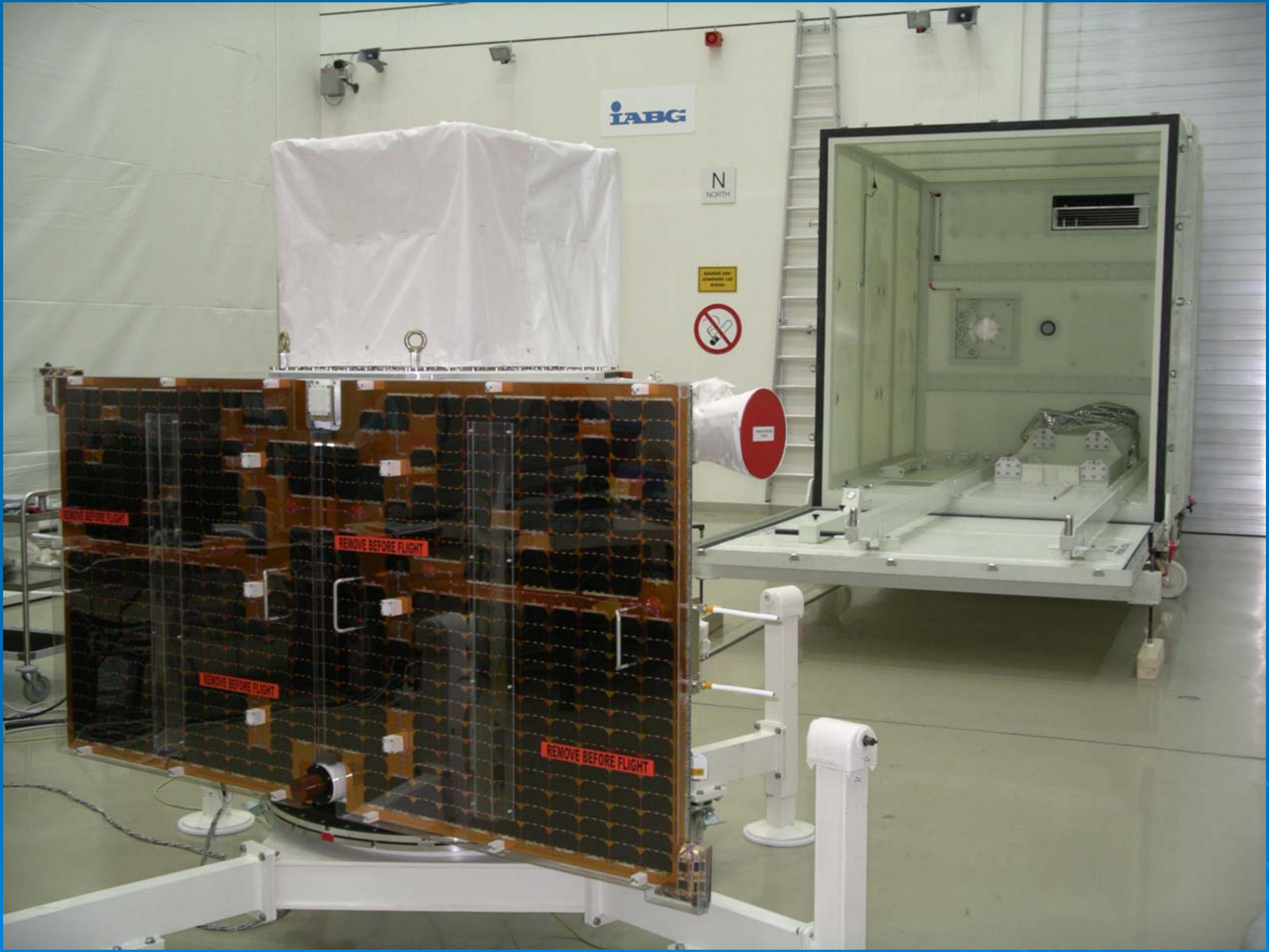
AGILE current status

AGILE Satellite (Tortona, Dec. 27, 2006)

AGILE Satellite (IABG, Munich February, 2007)



First GLAST Symposium – February 2007 2

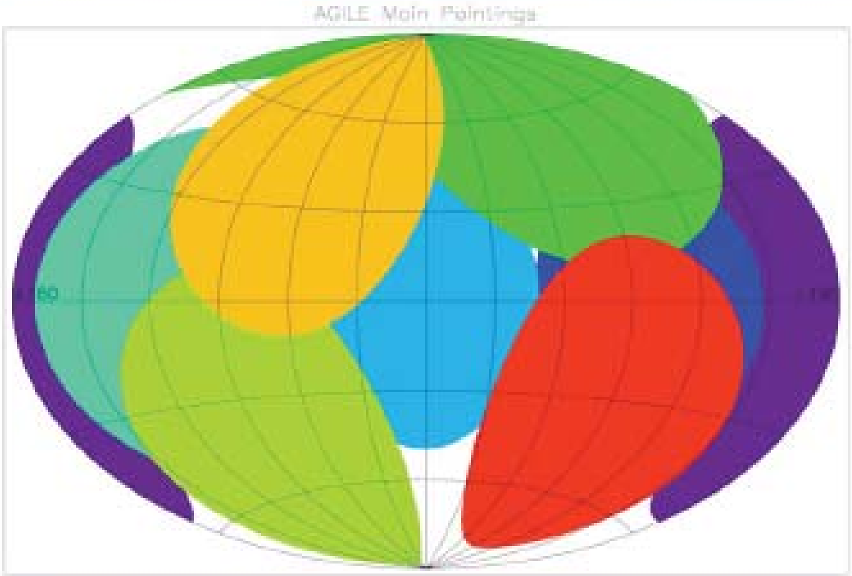


AGILE all' IABG mar 07

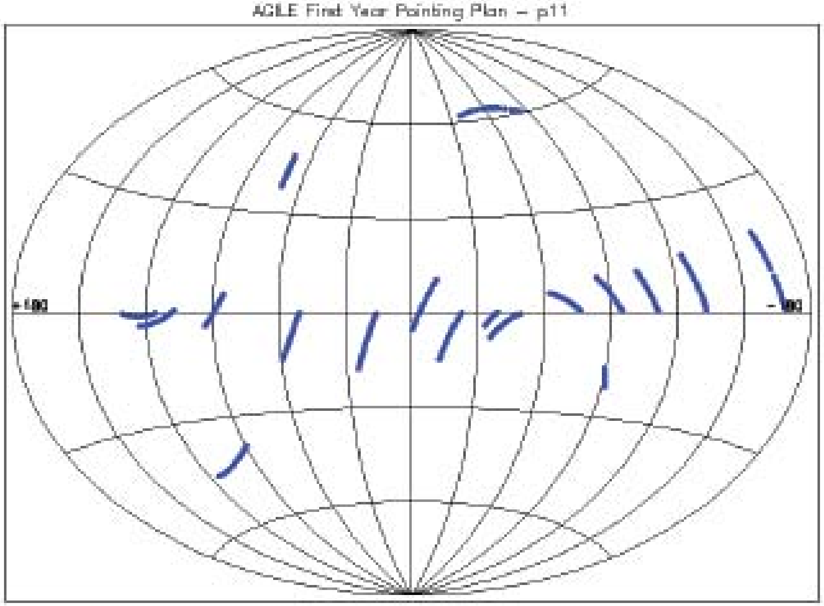
Stato di AGILE

- Satellite integrato e pronto in India dove verrà lanciato (orbita equatoriale 0-3°, low Earth orbit circa 550km) a fine aprile 2007 e circa 6 mesi prima di GLAST
- Riprogrammazione di alcuni obiettivi scientifici tenendo conto del successivo overlap con GLAST
- Puntamenti del cielo mirati (il primo anno di dati di GLAST è dedicato alla all-sky survey)
- la sensibilità di AGILE in modo pointed sarebbe simile a quella di GLAST in sky-survey mode sotto circa 200-300 MeV.

AGILE pointing program

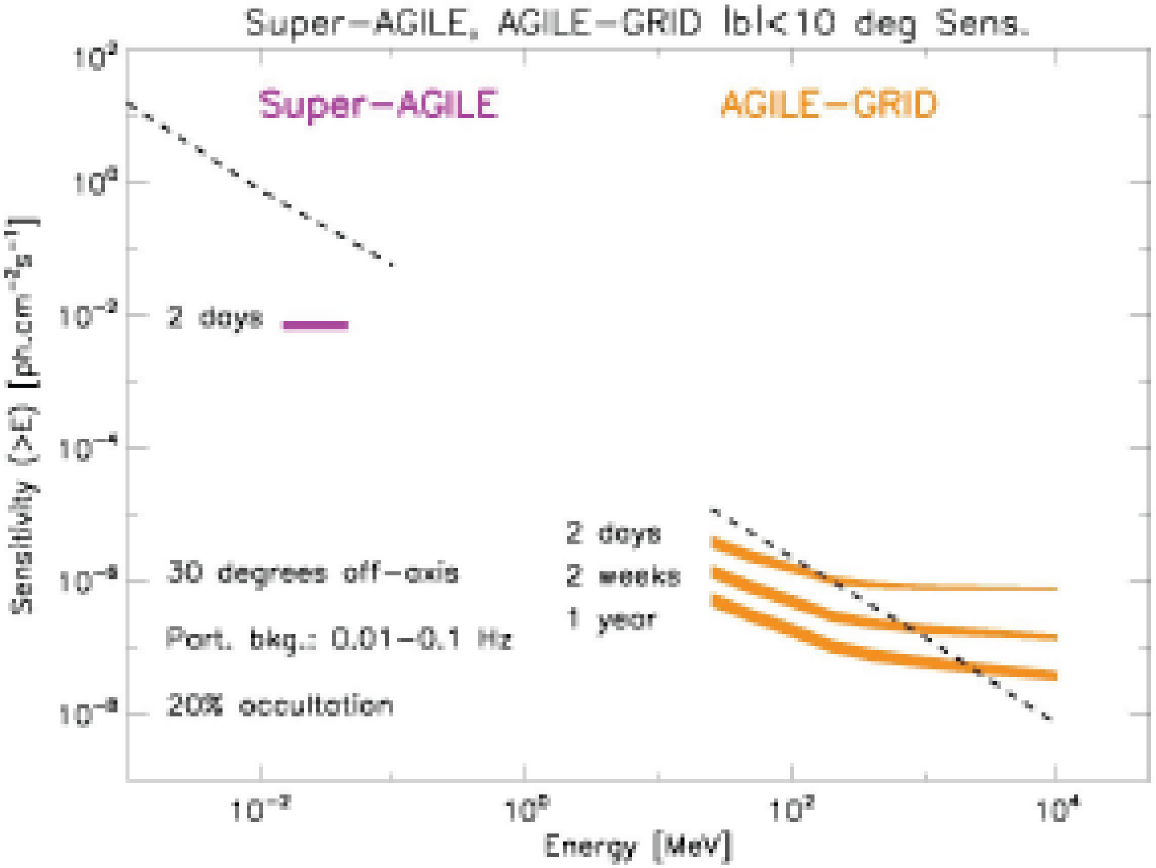


Example of sequence of pointings



Preliminary pointing program

AGILE Sensitivity



AGILE science topics

- Active Galactic Nuclei
- Gamma-Ray Bursts
- Pulsars
- TeV sources
- SNR and origin of cosmic rays
- Diffuse Galactic gamma-ray background
- Unidentified gamma-ray sources
- Microquasars
- Galactic Neutron Stars and Black Holes
- Fundamental Physics: Quantum Gravity

PLSV launcher

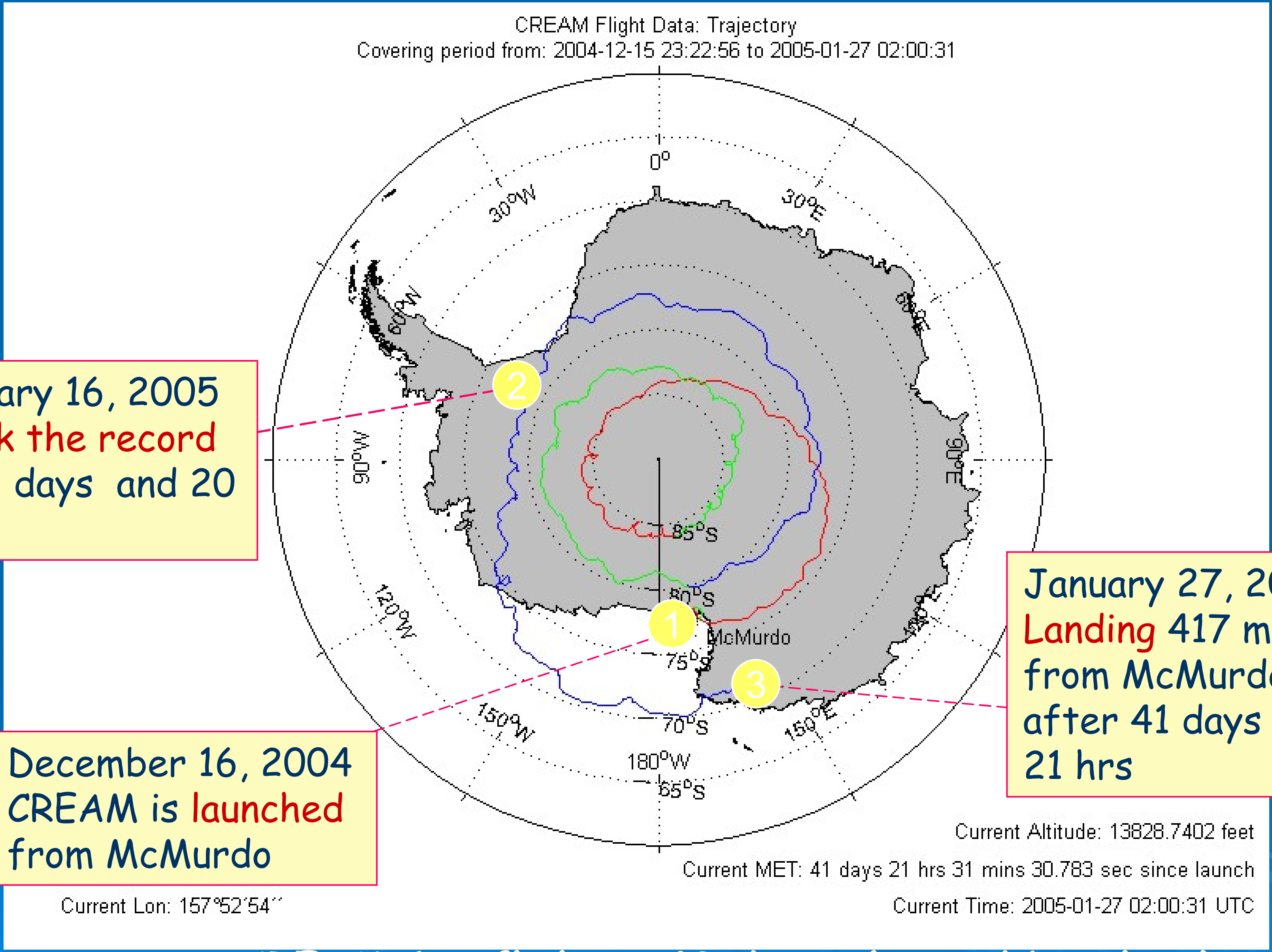
PSLV-C7 launch, 23-apr 2007

- Minimize particle background
- Use of the ASI Malindi ground station

Cosmic Ray Energetics And Mass

Launched from Antarctica on Dec 16, 2004

Approved by NASA to conduct yearly flights in 2005-2008



CREAM Flight Data: Trajectory
Covering period from: 2004-12-15 23:22:56 to 2005-01-27 02:00:31

January 16, 2005
Break the record
of 31 days and 20 hrs

January 27, 2005
Landing 417 miles from McMurdo after 41 days and 21 hrs

December 16, 2004
CREAM is launched from McMurdo

Current Altitude: 13828.7402 feet
Current MET: 41 days 21 hrs 31 mins 30.783 sec since launch
Current Time: 2005-01-27 02:00:31 UTC
Current Lon: 157°52′54′′

CREAM 1st flight ~ 42 days (record breaking)

TRD M

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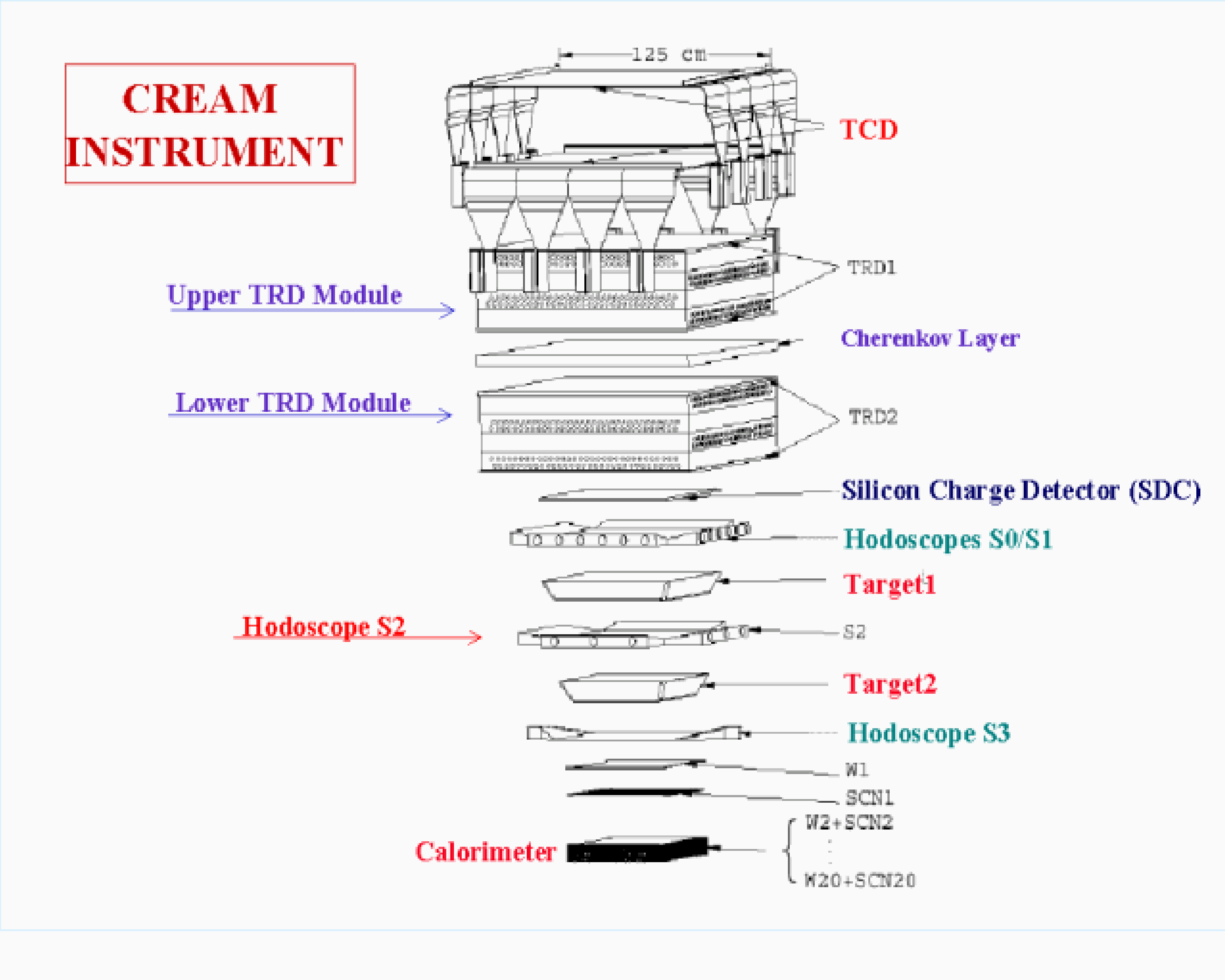
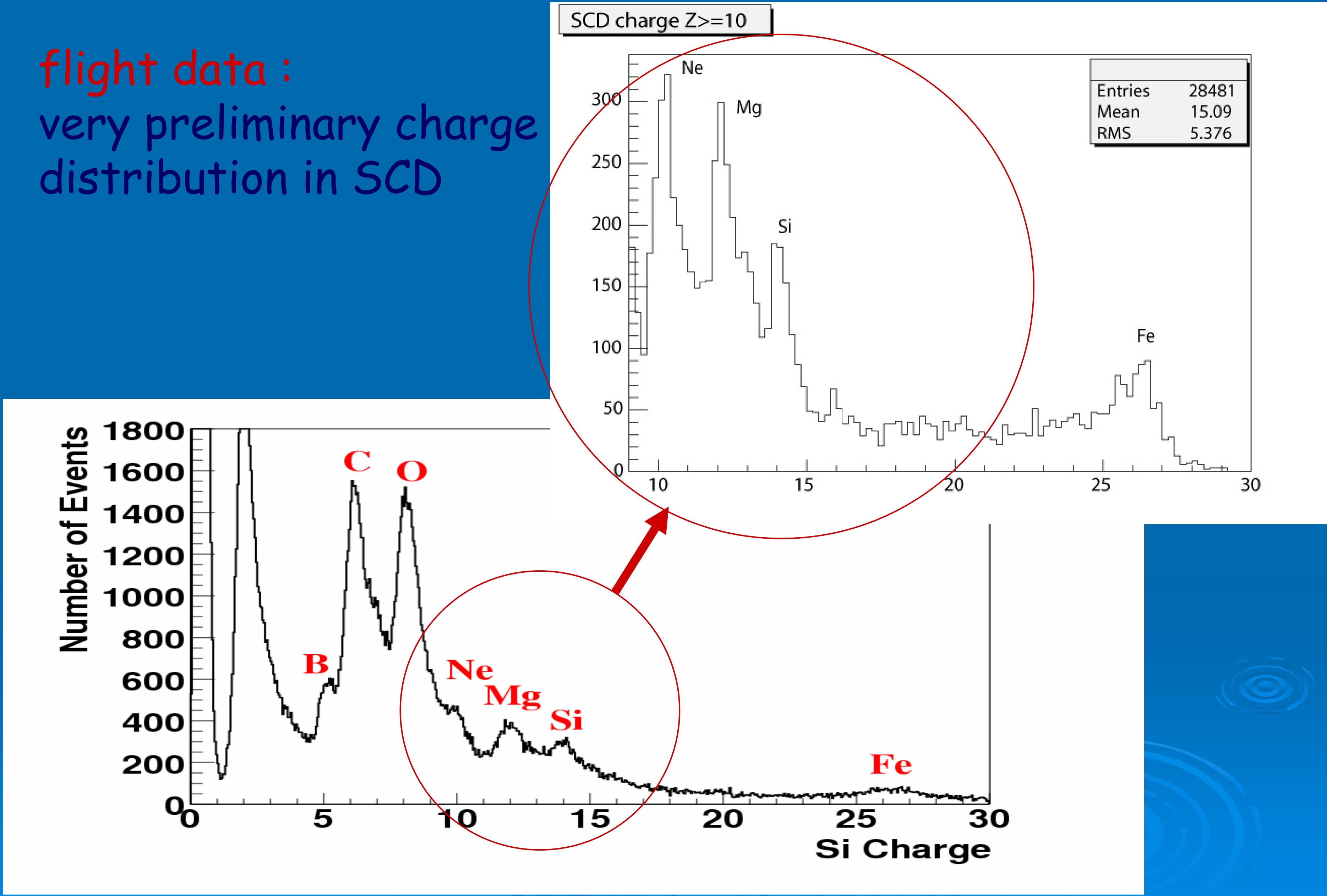
paddles ea

- The Tr
separated

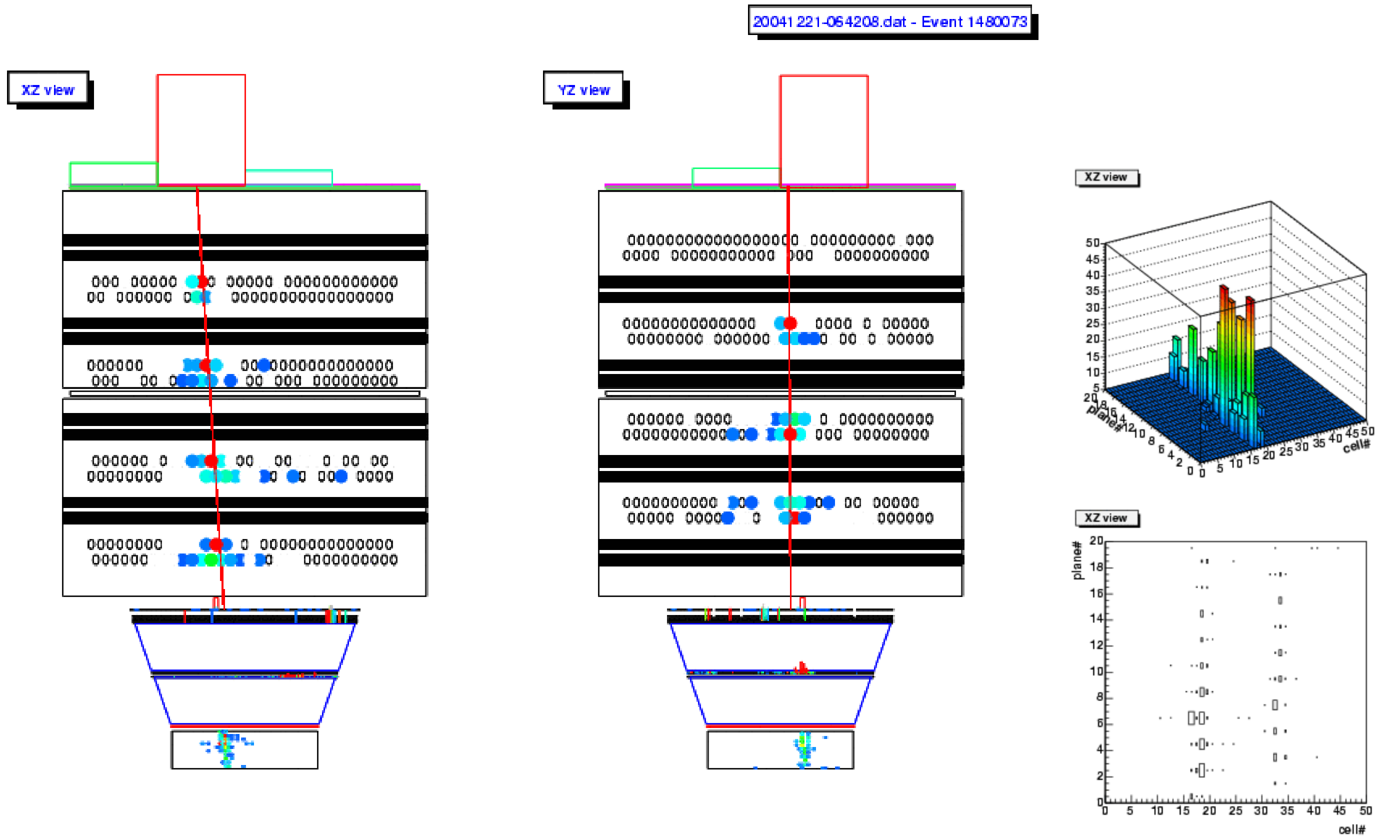


flight data :
very preliminary charge distribution in SCD



Instrument functions well

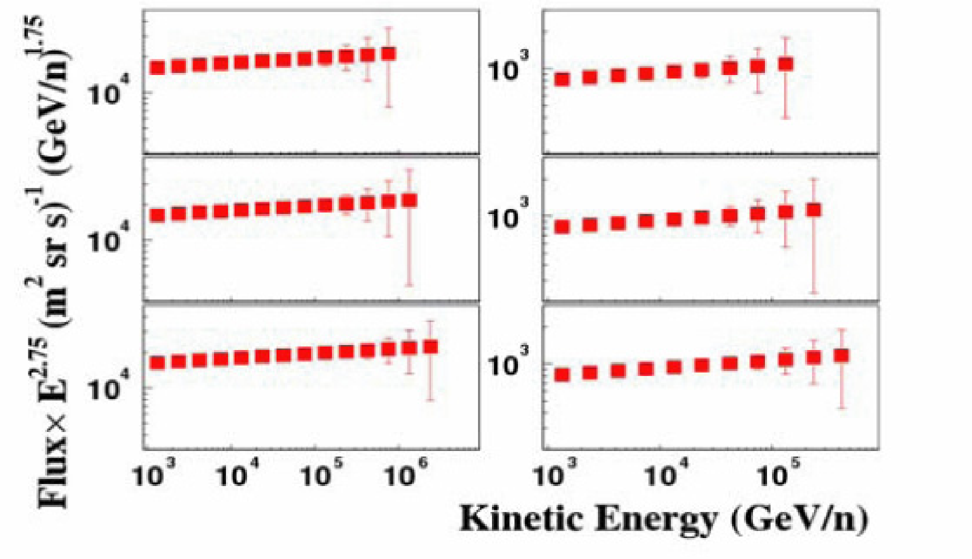
An example event: ~10 TeV Fe



Multi-flight mission : Science Objectives

- CREAM can measure individual energy spectra and elemental composition of cosmic rays (1 ≤ Z ≤ 26 and above) from **1 TeV up to 1000 TeV**

- expected to **reach 500 TeV** with 30% statistical accuracy with 3 flights



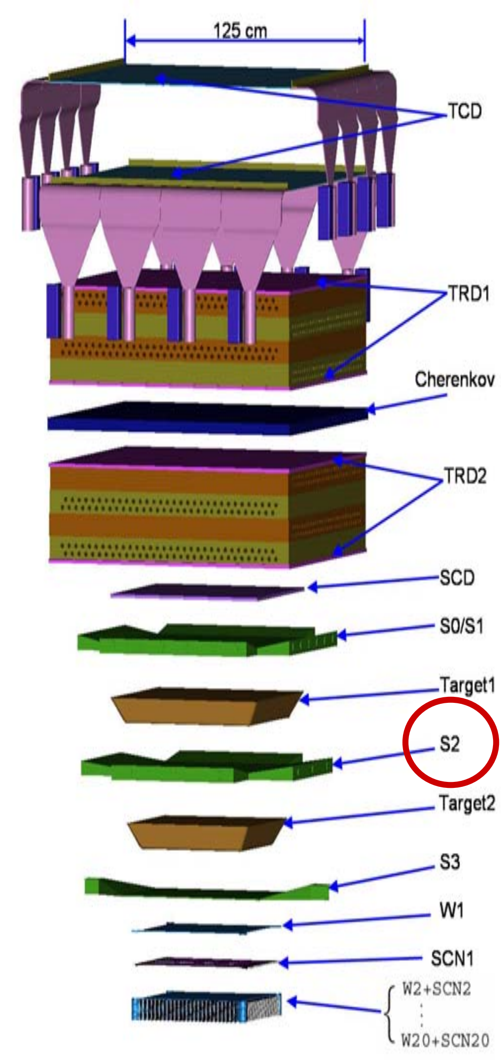
Expected spectra results for protons (left panel) and He (right panel) from CREAM after accumulating 140 days (upper), 240 days (middle), and 1000 days (lower) of flight.

- search for a **cutoff in the proton spectrum** above 100 TeV

- **measurement of B/C** ratio up to **500 GeV/n** (test of propagation models)

Two Instrument Suites : annual flights with one instrument (CREAM) being refurbished while the other one (CREAM-II) is made ready for flight

CREAM



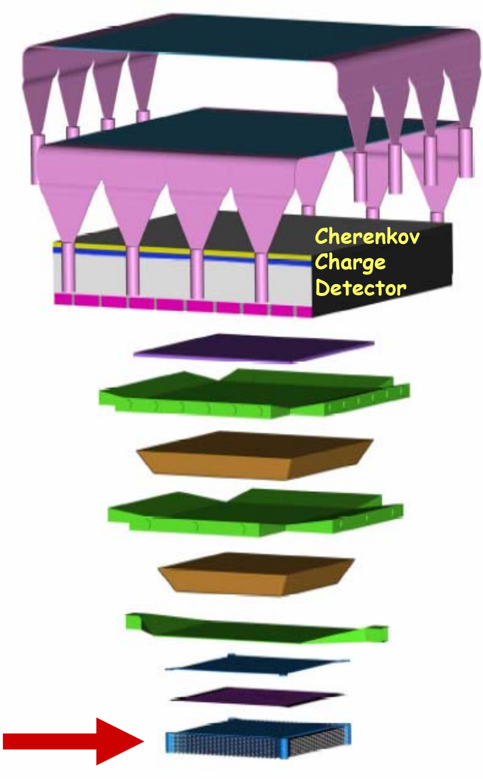
INFN subdetectors :

Hodoscope for the 1st flight

Calorimeter for the 2nd flight

CREAM-II Calorimeter Calibration at CERN, Sept. 2004

CREAM II



Activities in 2007 - 2008

INFN : - proposed **construction** of one Silicon Charge Detector for **5th flight (Dec.2008)**

- commissioning + **flight of the CREAM-4 payload (December 2007)**

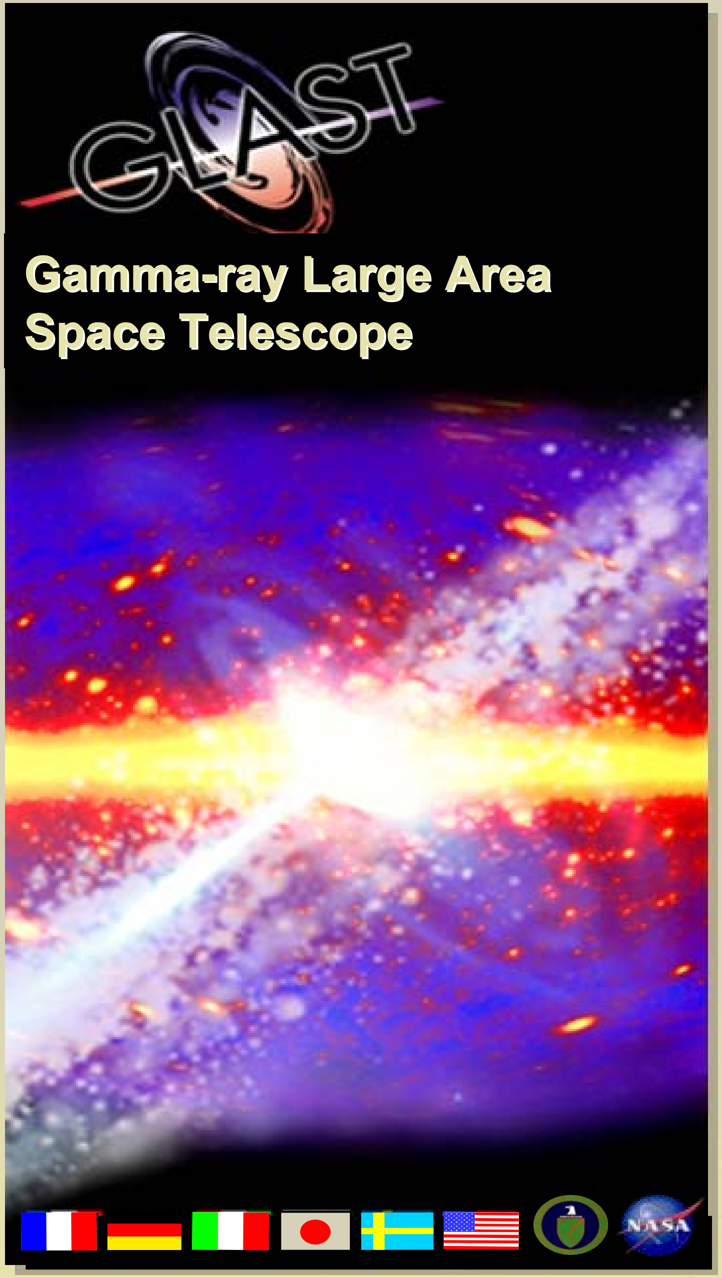
2007: PROPOSTA di costruzione di un **Silicon Charge Detector** per il
V volo (Dic. 2008) costo totale stimato circa 250 KEuro **distribuito in 2 anni :**

(1) produzione e test di circa **100 sensori** da 6" con 64 pixels da 1cm^2 gia' sviluppati in Italia (STM-Catania) dal nostro gruppo con un progetto PRIN **costo stimato 150 kEuro**

2008 : - Completamento del **Silicon Charge Detector** **costo stimato 100 kEuro**

(2) commissioning elettronica di front-end (sviluppata da INFN-CSN5 nel 2005-2006)

(3) meccanica e integrazione



GLAST Large Area Telescope

INFN Gruppo II Meeting, LNGS 27/9/2006

Stato di GLAST

- **GLAST in integrazione con lo spacecraft e GBM a Phoenix**
- **Lancio fine 2007-inizio 2008**
- **Continua messa a punto del Science Software e simulazioni**
- **ISOC and Service Challenges**

Overview of the GLAST- LAT detector

Precision Si-strip Tracker (TKR)

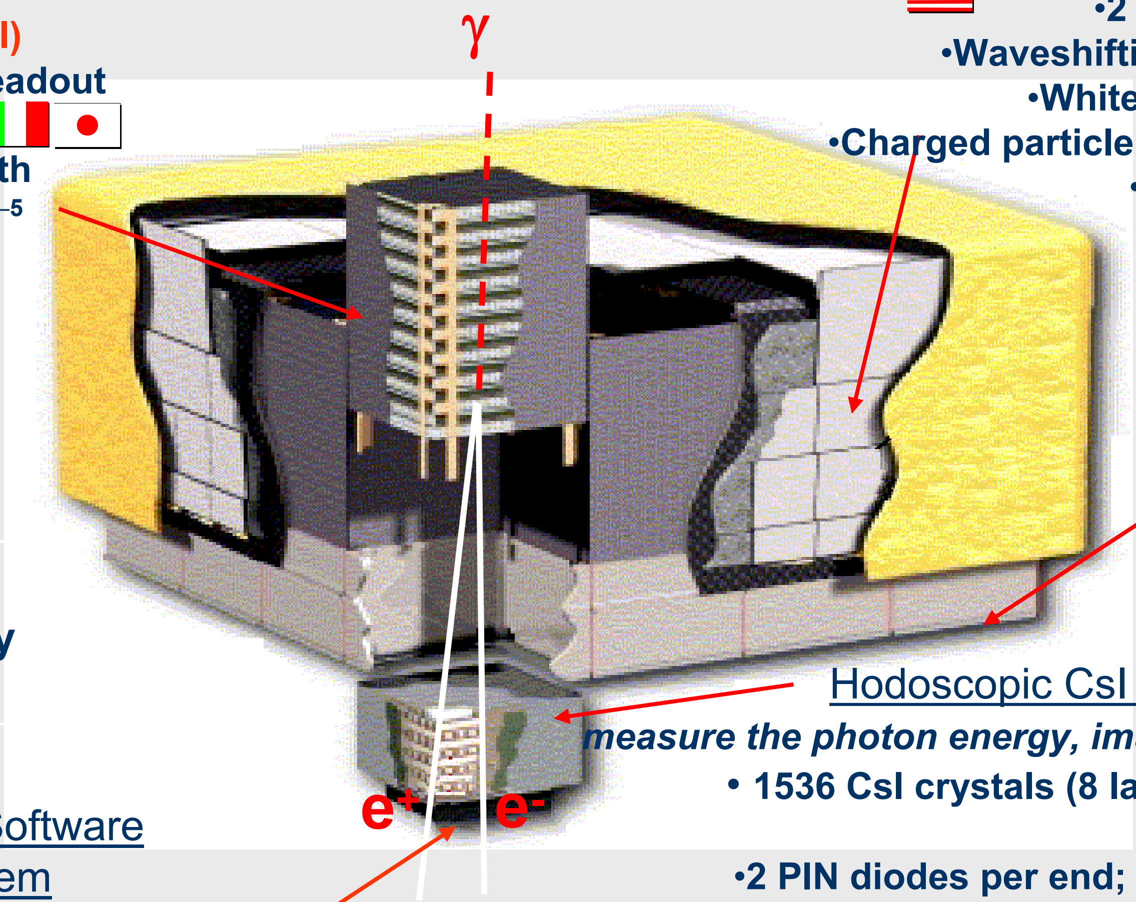
measure photon direction

- ~10K (18XY tracking planes) 6” single-sided SSD
- 880,000 channels (total)
- 228 μm pitch, digital readout
- self-triggering
- hit efficiency > 99% with noise occupancy $<\sim 10^{-5}$
- 1.5 X0 total
- power <210 μW/ch

Segmented Anticoincidence Detector (ACD)

reject background of charged cosmic rays

- 89 tiles – 1 cm thick
- 2 phototubes per tile
- Waveshifting fiber embedded
- White Tetratec wrapping
- Charged particle efficiency > 0.9997
- Power < 31 W total



GRID

Mechanical backbone

LAT:
4 x 4 modular array
3000 kg, 650 W

Hodoscopic CsI Calorimeter(CAL)

measure the photon energy, image the shower

- 1536 CsI crystals (8 layers) $2x2.7x33 \text{ cm}^3$
- 6.1 104 channels
- 2 PIN diodes per end; 2 gain ranges each
- ~ 1500 kg
- self-triggering
- 8.5 X0 total
- power (total) < 91 W

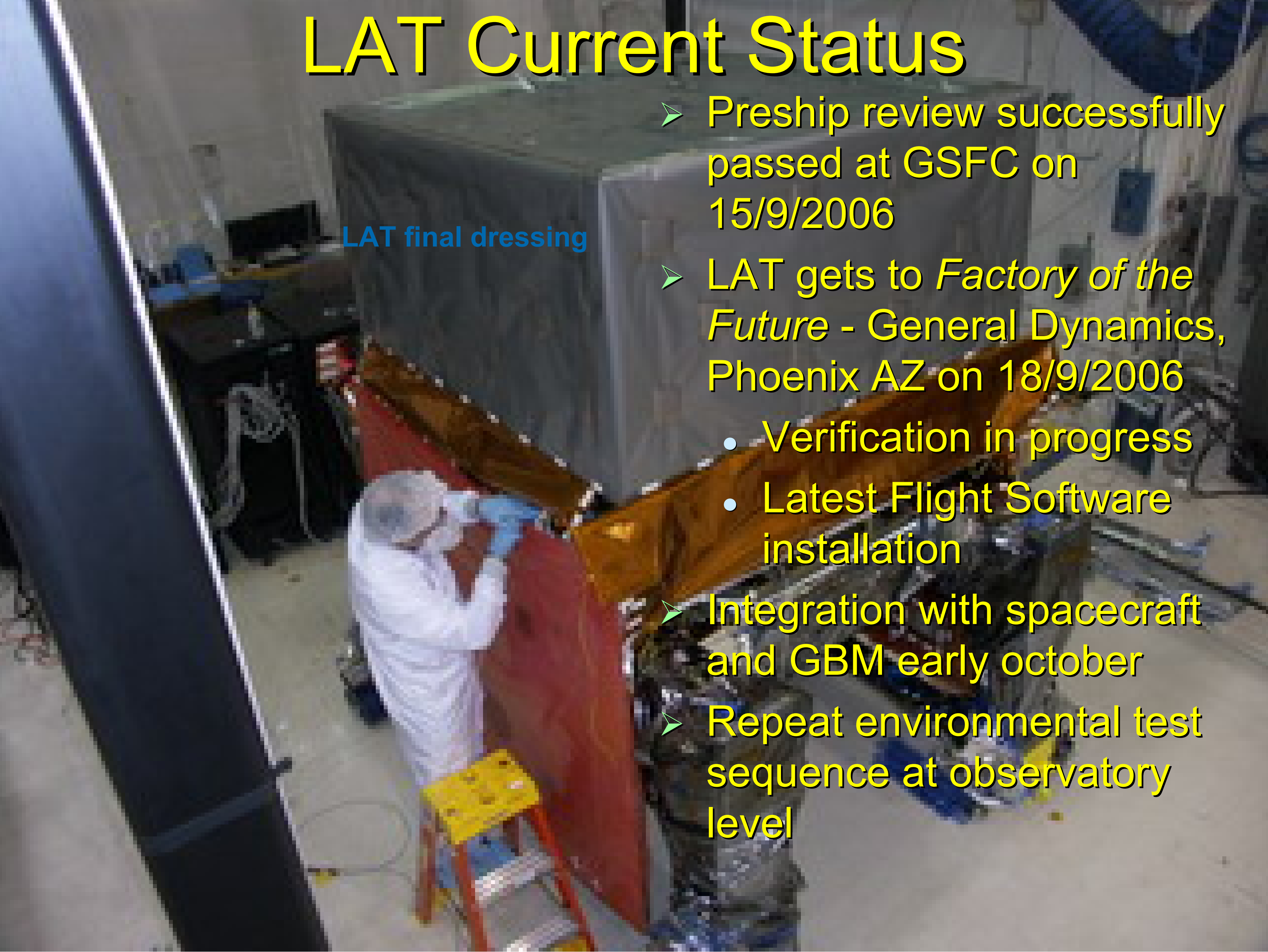
Electronics & Flying Software
Data Acquisition System

process events from 16 towers, apply trigger selection to reduce L1T rate from ~4KHz to ~30Hz

LAT Towers Assembly completion

- 16 towers in the LAT on 19/10/2005
  - TKR tower 16 shipped mid-october
  - TKR calibration tower shipped beginning november

LAT Current Status



LAT final dressing

- Preship review successfully passed at GSFC on 15/9/2006
- LAT gets to *Factory of the Future* - General Dynamics, Phoenix AZ on 18/9/2006
    - Verification in progress
    - Latest Flight Software installation
- Integration with spacecraft and GBM early october
- Repeat environmental test sequence at observatory level

Glast on 27 Mar 07 at Phoenix after the integration of the burst monitor

Launch now scheduled on feb 2008

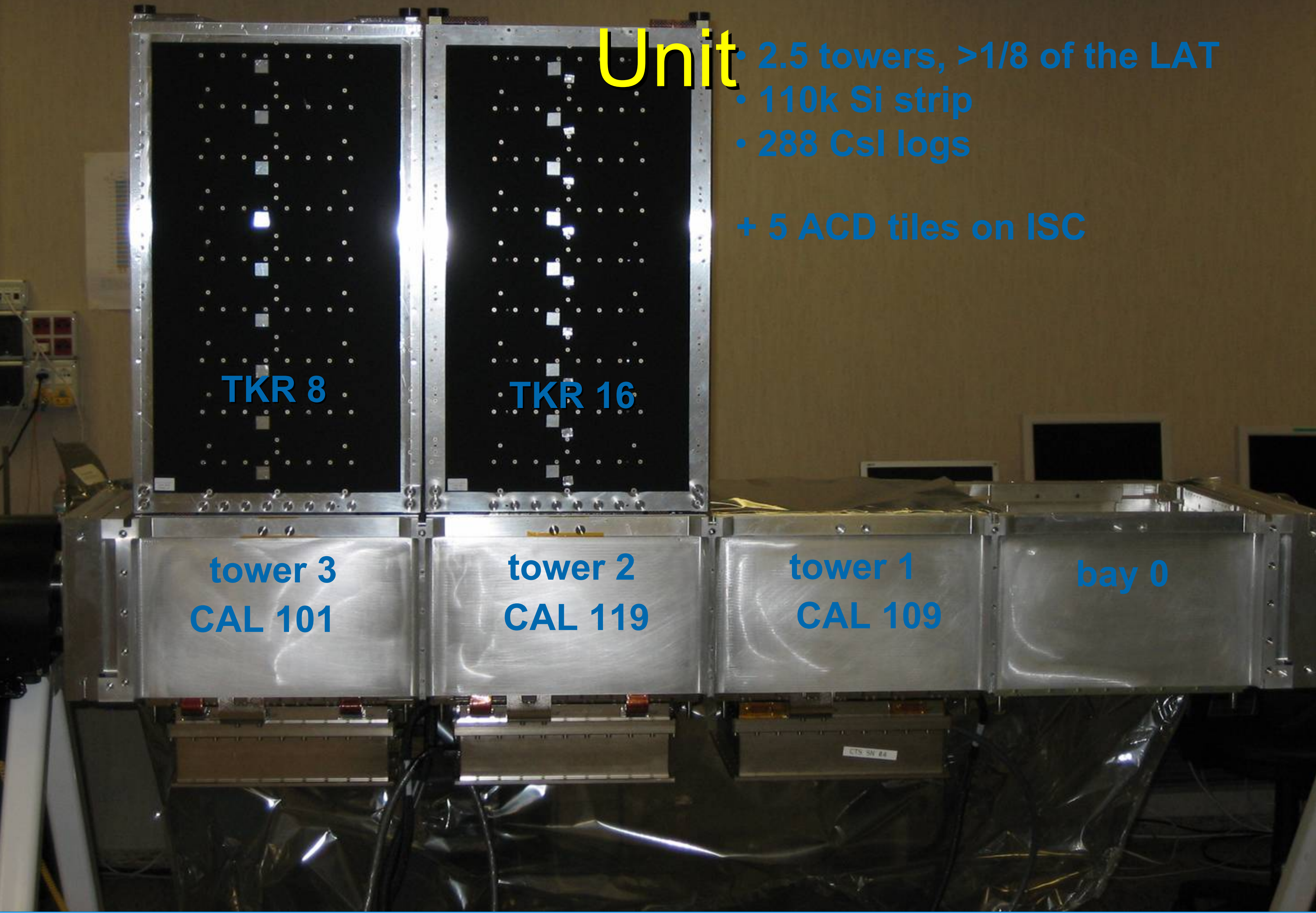
Attività 2006-07

- BeamTest estate 2006 sulla calibration unit
- Validazione MC dai dati BeamTest
- Support all'Operation Center della missione (ISOC) (monitoraggio apparato e performance)
- Supporto gruppi di scienza (Service Challenge)

The GLAST-LAT Calibration Unit

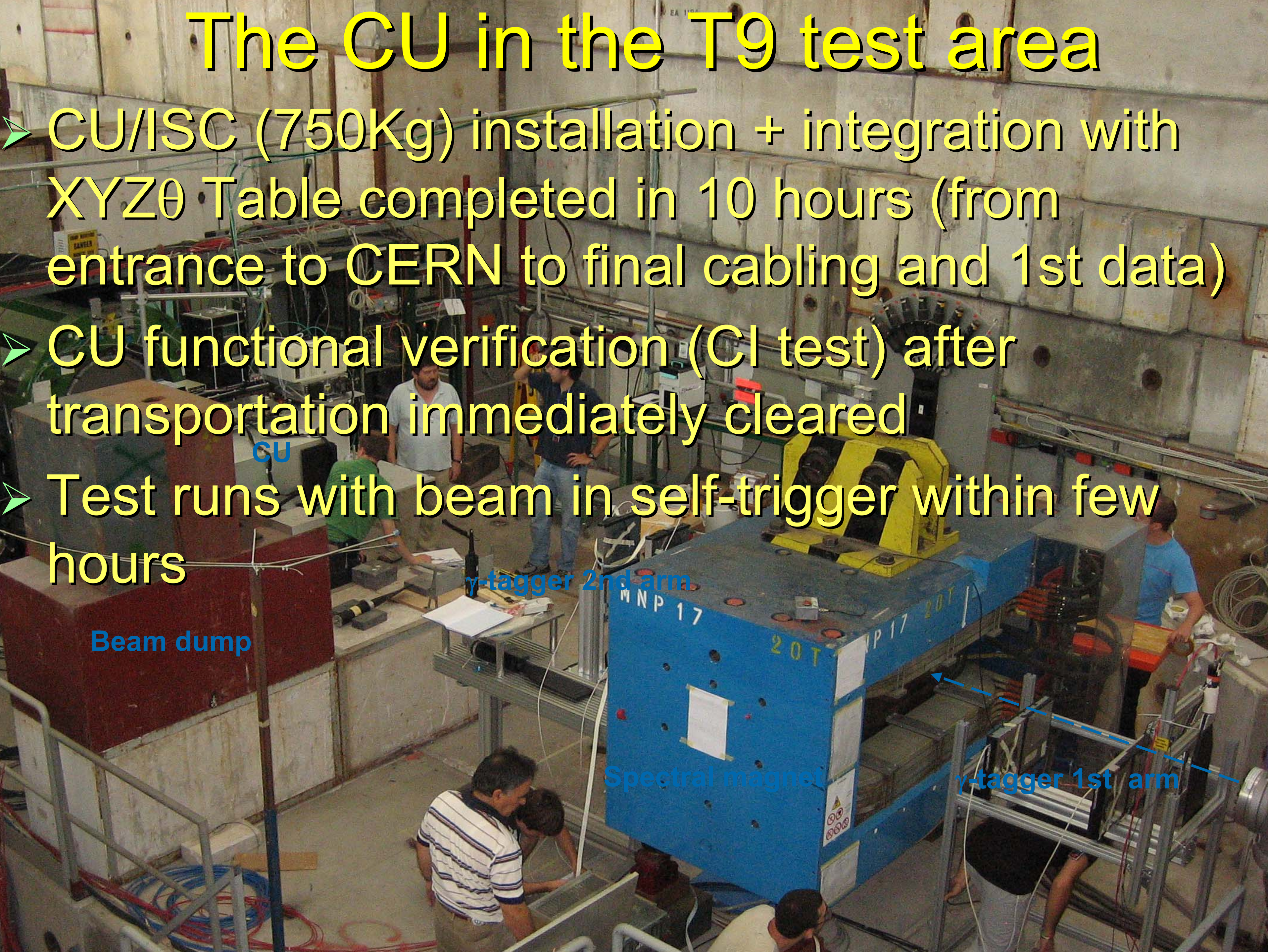
- 2.5 towers, >1/8 of the LAT
- 110k Si strip
- 288 CsI logs

+ 5 ACD tiles on ISC



The CU in the T9 test area

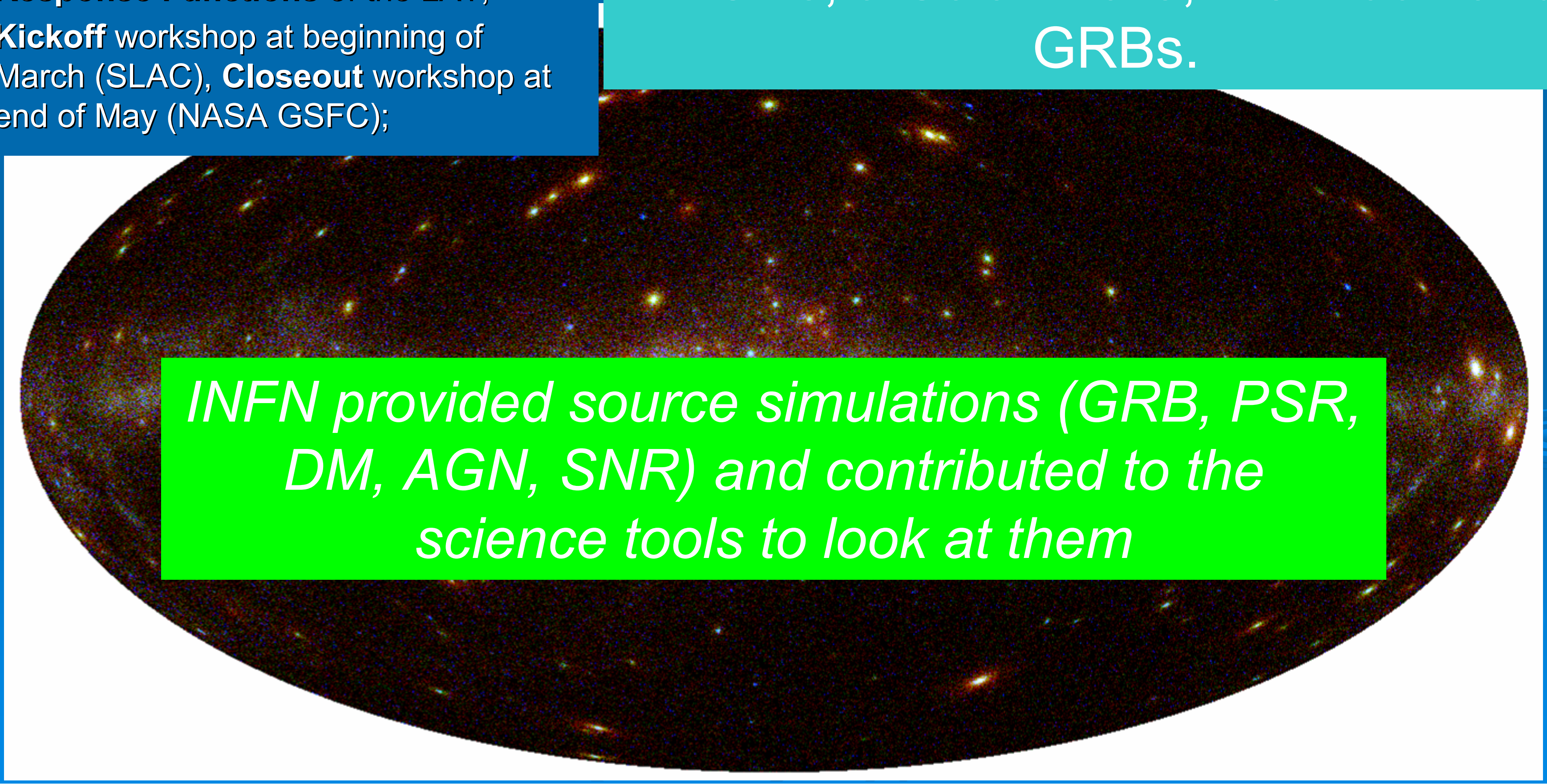
- CU/ISC (750Kg) installation + integration with XYZθ Table completed in 10 hours (from entrance to CERN to final cabling and 1st data)
- CU functional verification (CI test) after transportation immediately cleared
- Test runs with beam in self-trigger within few hours



- High-detailed simulation of a **55-days** LAT observation in scanning mode;
- **Updated MonteCarlo** simulation of the instrument and upgraded algorithms for reconstruction of photon energy and direction;
- **Detailed sky model** including currently known classes of galactic and extragalactic sources and possible new classes of gamma-ray sources;
- Analysis of the upgraded **Instrument Response Functions** of the LAT;
- **Kickoff** workshop at beginning of March (SLAC), **Closeout** workshop at end of May (NASA GSFC);

The DC2 Gamma-ray Sky Map

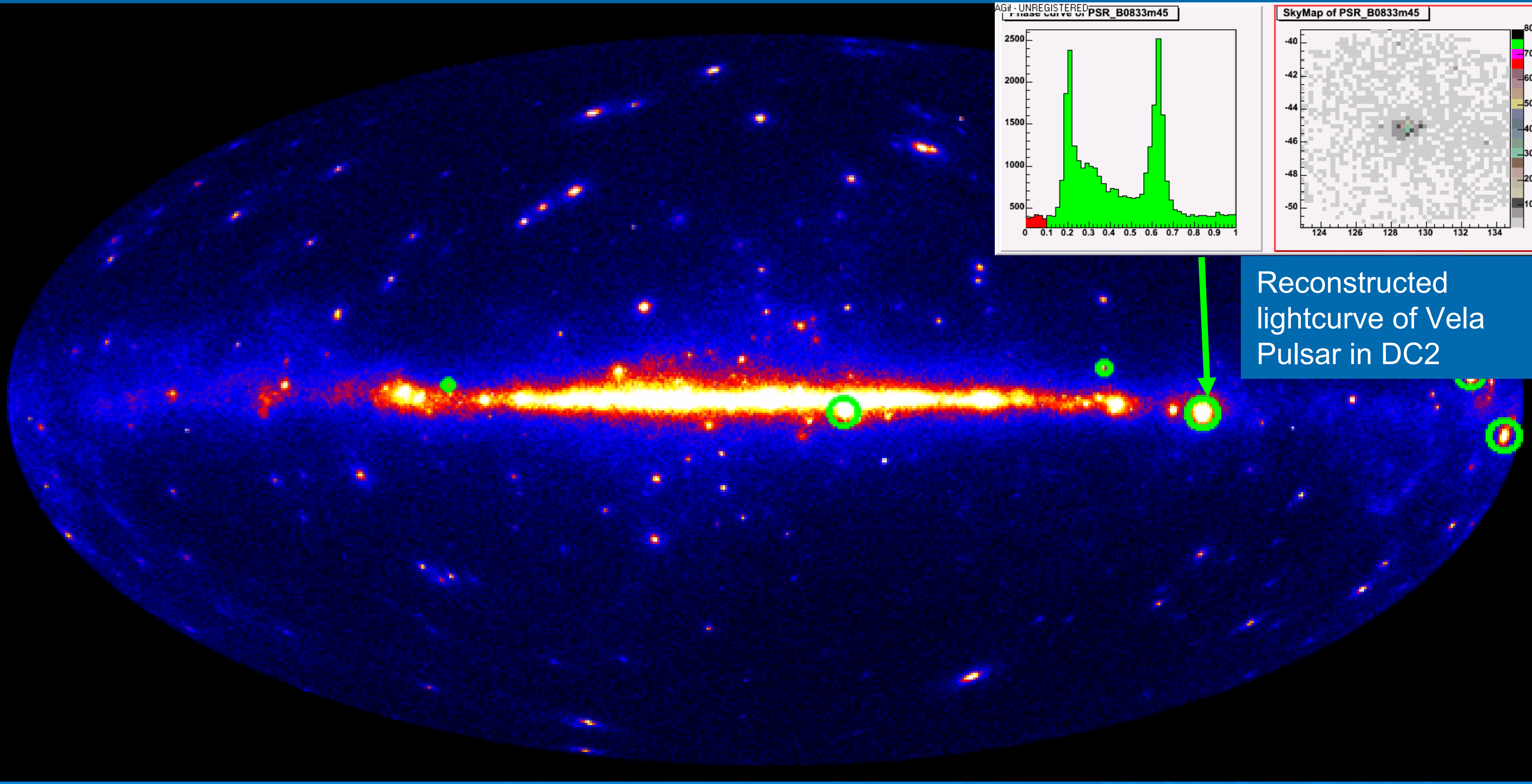
Other galactic and extragalactic components are present in DC2, e.g. AGNs, a Solar Flare, the Moon and GRBs.



INFN provided source simulations (GRB, PSR, DM, AGN, SNR) and contributed to the science tools to look at them

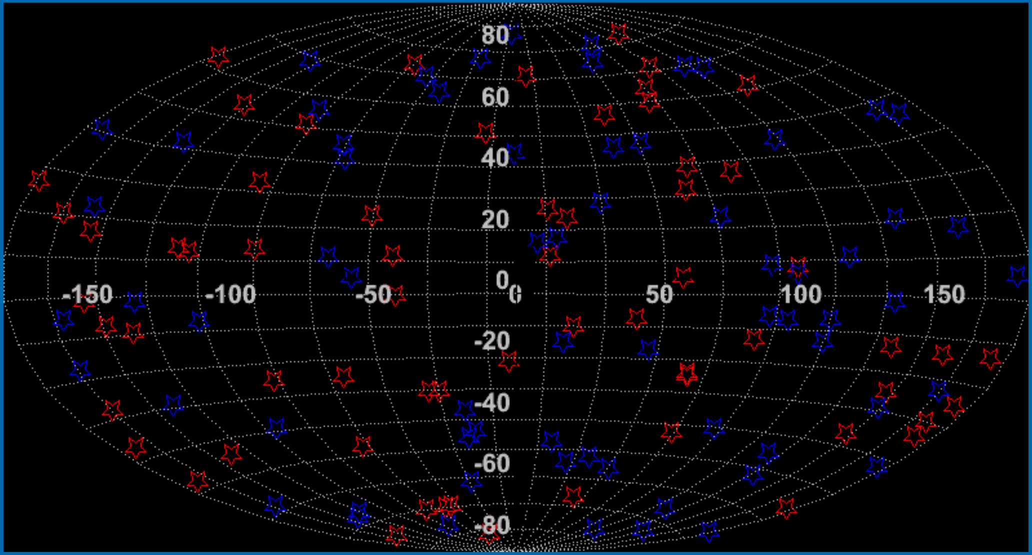
GLAST Pulsar

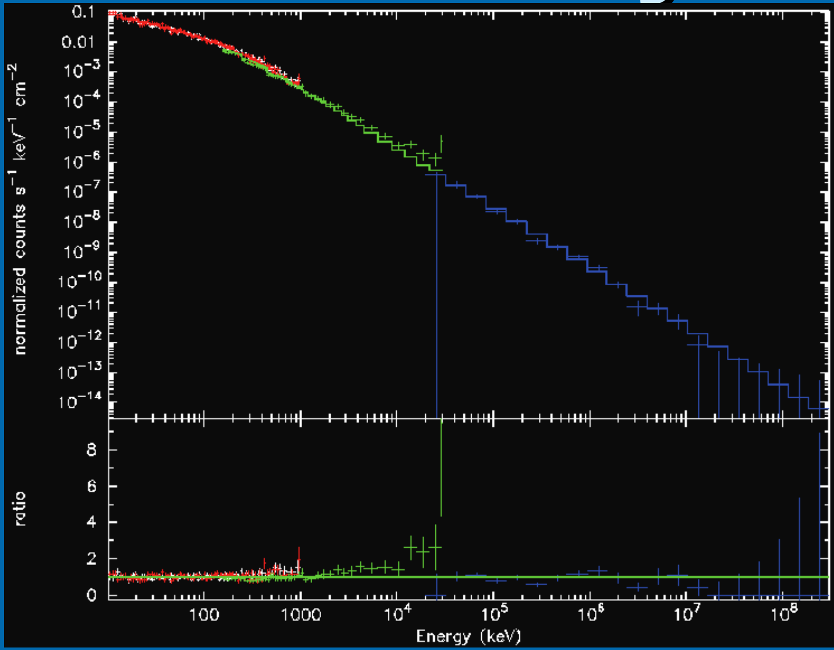
Pulsar Analysis and Science



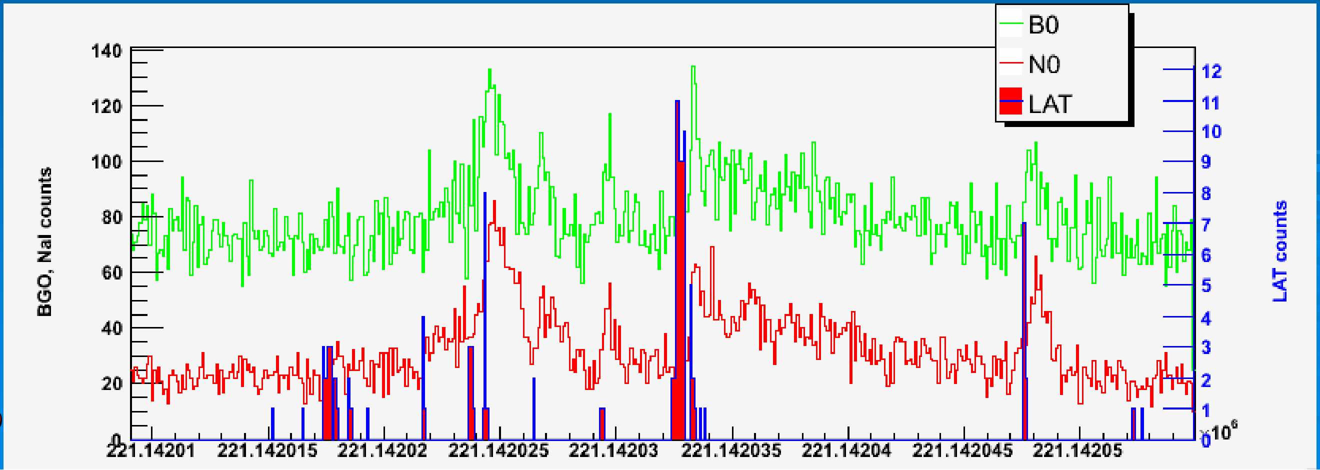
Reconstructed lightcurve of Vela Pulsar in DC2

GRB simulation and study





Combined signal from GBM (BGO NaI) and LAT detectors



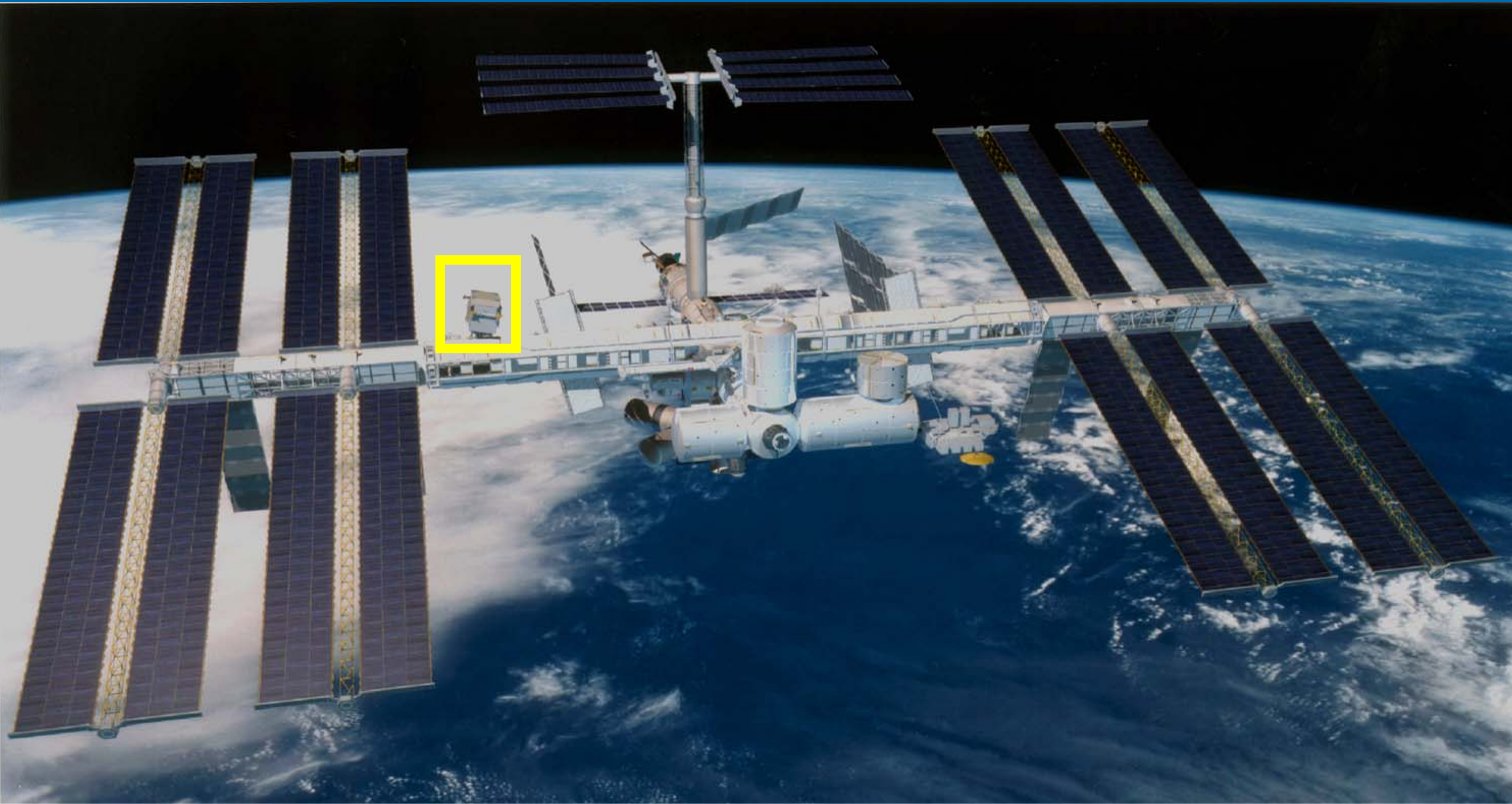
N. Giglietto

Science Groups SW activities

- Activities
  - C&A activities

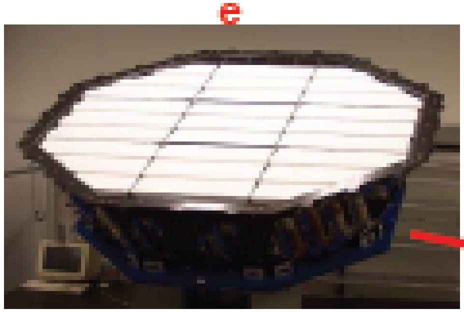
    TKR testing, MC validation, BkgRejection, IRF studies, CR testing, LAT properties, EvtDisplay, etc..
    - Paper development
    - Instrument Science activities
  - Science Groups (4 infn coordinators)
    - GRB, PSR/SNR, AGN, DM
    - Unid, Diffuse, Catalog, Solar
    - Multi WV, GeVTeV

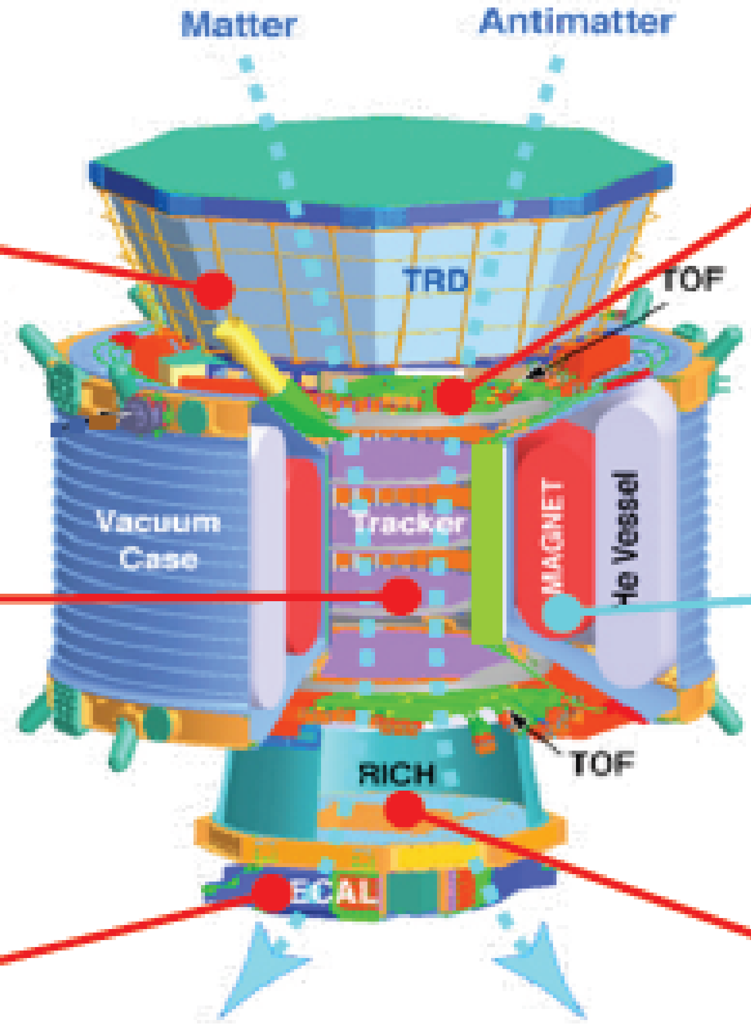
AMS:
la misura della radiazione cosmica dal GeV al TeV



Construction of the detectors nearly completed.

TRD
e





Time of Flight
v, Z

Magnet
P

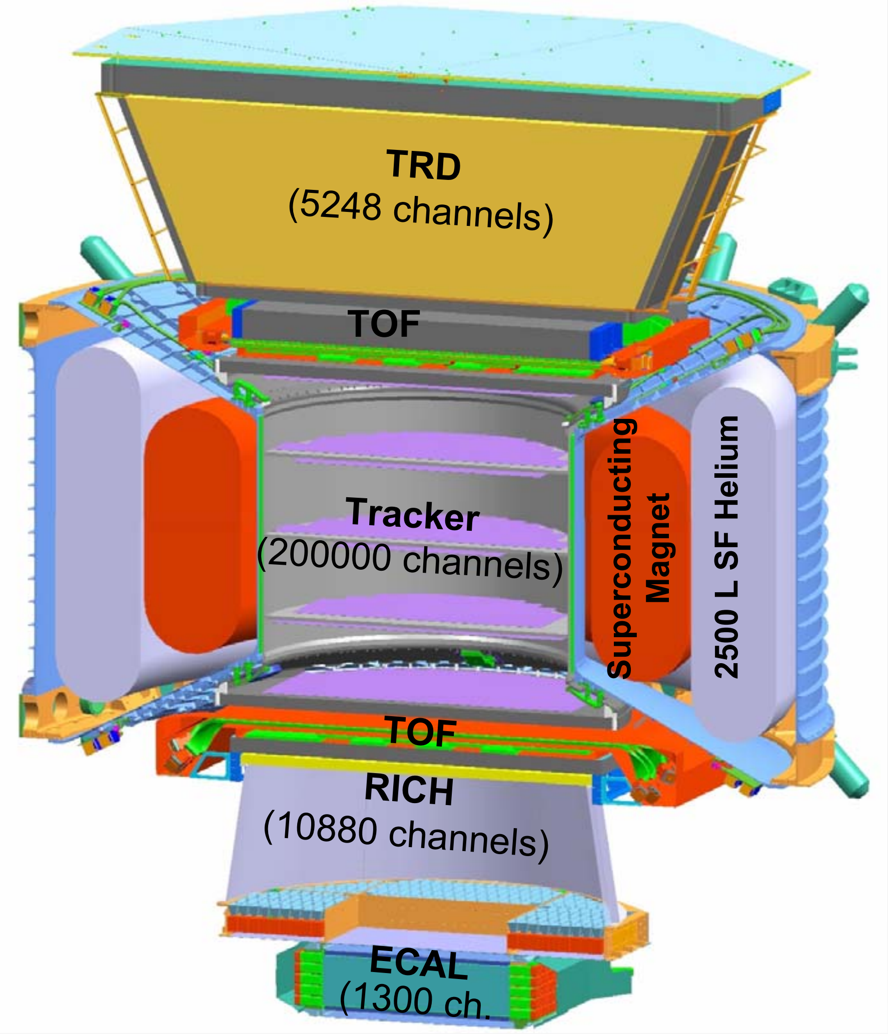
Silicon Tracker
Z, P

Calorimeter
e, γ

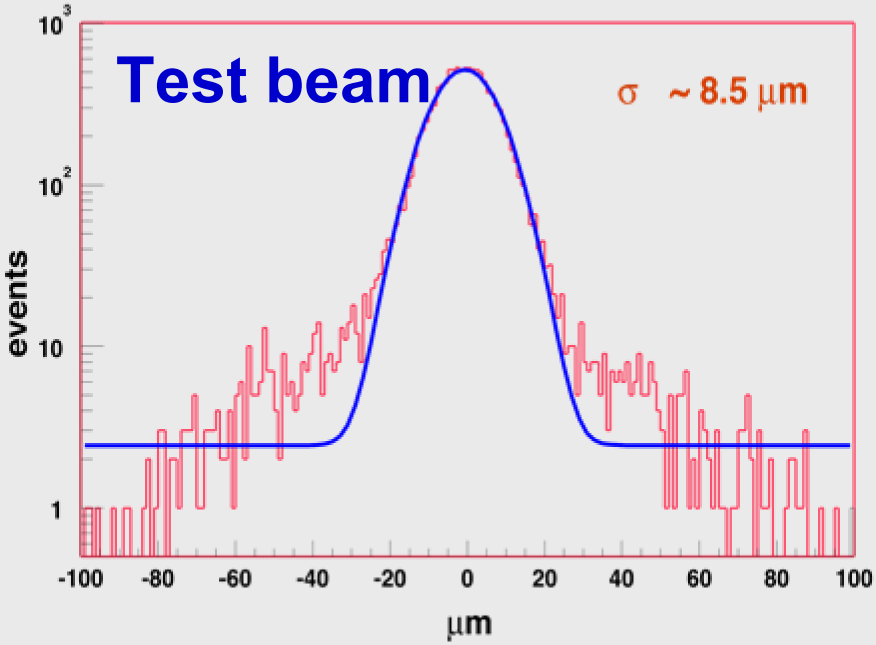
RICH
v, Z

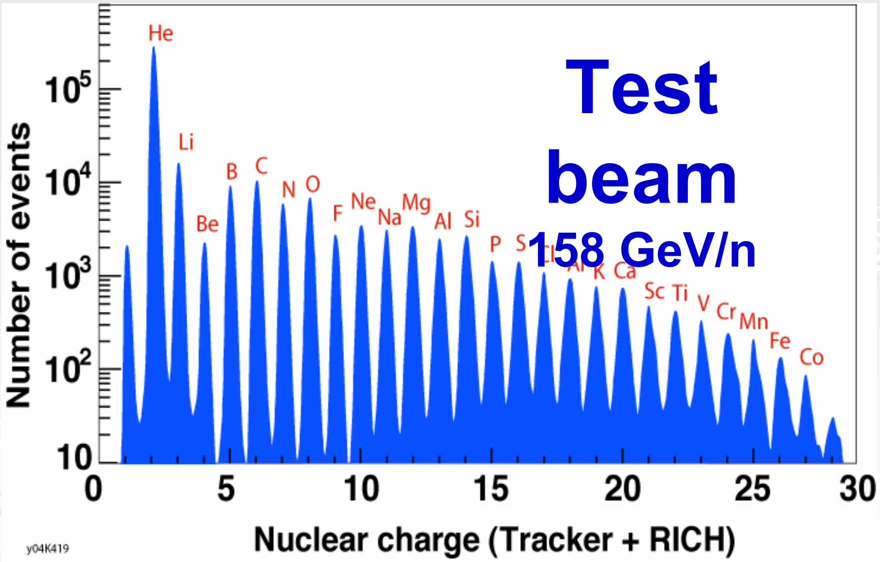
Size: 3m x 3m x 3m
Weight: 7 tons

Silicon Tracker

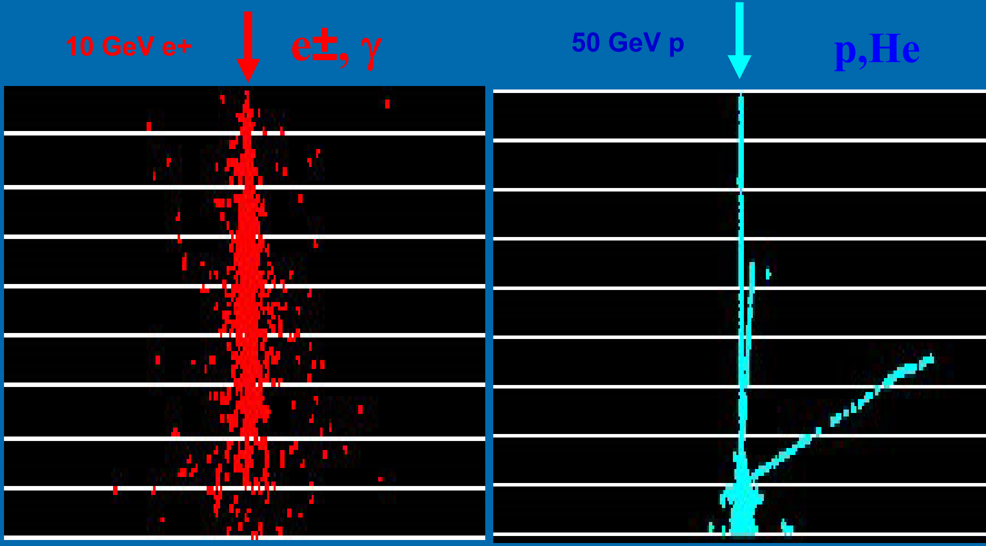


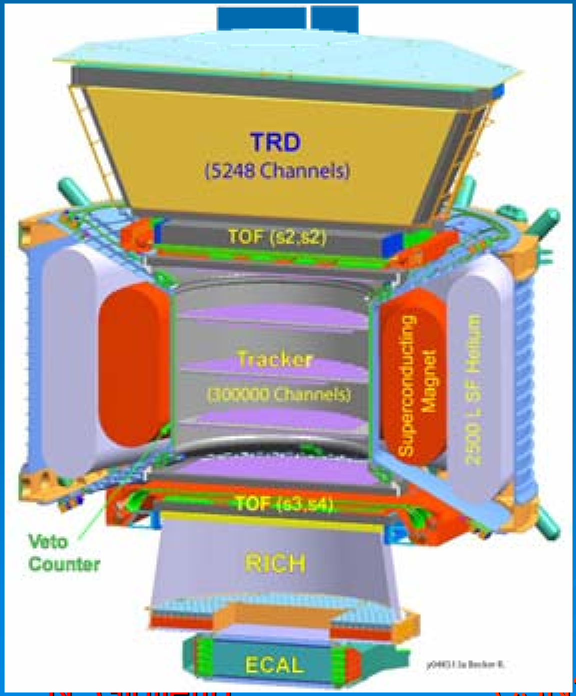
8 planes, 6.6 m^2



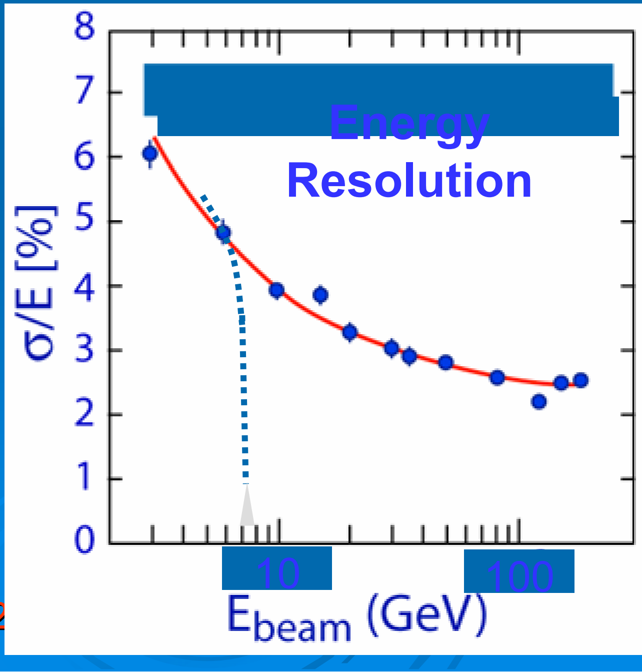


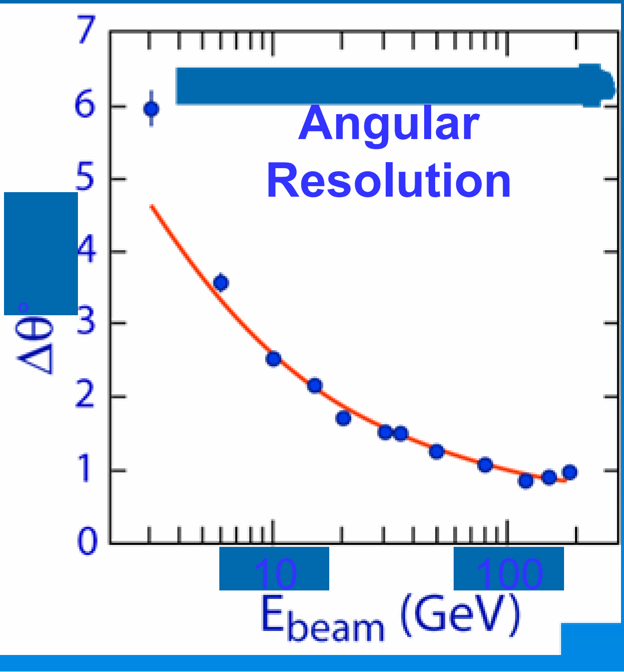
ECAL: A 3 dimensional, 16 X_0 measurement of the direction & energy of gamma and electrons





Verified by accelerator calibration





AMS2: Milestones Attuali

Test Beam ECAL	Ottobre 06
Integrazione Ecal-Rich	Maggio 07
Test Beam AMS	Luglio 07
KSC	Marzo 08
Lancio	**April 2009**

?? Incentezze lanci shuttle - Nuovo lanciatore?

Sviluppi futuri

- Iniziative connesse a road map APPEC e ASPERA
- Polarimetria X (R. Bellazzini)
- JEM-EUSO (A. Petrolini)
- MONICA (monitoraggio CR <1GeV, P.Picozza)
- Iniziative ESA per la Luna (R.Battiston)

Studio della Radiazione Cosmica di altissima energia dallo spazio post EUSO (A.Petrolini)

- It is a rather common opinion that a large and challenging space-based experiment will be required as a next-generation experiment after the Pierre Auger Observatory (both south and north).
- ESA has included such a kind of mission in its roadmap for the decade 2015-2025.
- ESA has just emitted its *Call for proposals for the first planning cycle of the new Cosmic Vision 2015-2025 plan (proposal due by June 29).*
- The Call also invites proposals for concepts of more ambitious missions of the flagship category (Class L mission concepts) that will require an extended preparation phase and specific technology developments leading to a first launch opportunity in late 2018.
- An International Collaboration is building up, as an enlargement of the Collaboration which carried on the EUO phase A.

The Italian environment

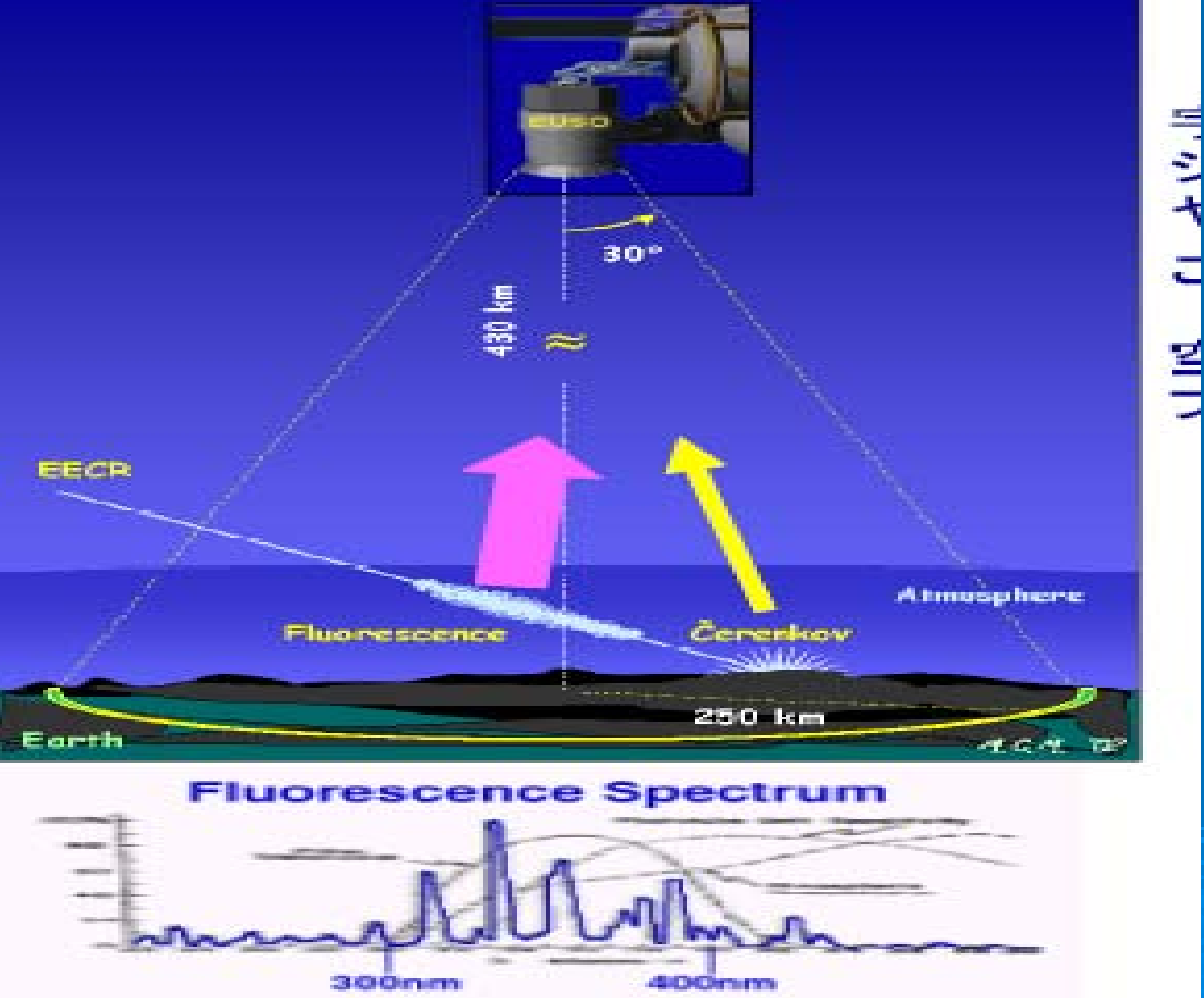
- New INFN groups have expressed interest - in the long-term - for this kind of mission/physics.
- A total of about one hundred Italian scientists are either participating or externally supporting this initiative (LoI sent to ASI in 2005).
- ASI has just started its contract for funding the proposal study.
- CROS (Cosmic Radiation Observatory from Space) is the name of the initiative within the ASI contract (about 120 kEuro received for one year).

Some relevant points

- There is no clash with the Pierre Auger Observatory as the time-scale for a space-based experiment, realistically, goes not before 2018.
- However, should the proposal pass, the development and construction has to start long before (some 8 years appear reasonable for development and construction).
- Should the proposal pass the ESA selection (this will be known not before the end of this year) a phase A (concept) study might last one year (2009?).
- The initiative is challenging and it can be successful only if it is taken as a shared effort of all the community.
- A part of the Italian community is also willing to participate in the Japan JEM-EUSO initiative, for a pathfinder to be installed on the ISS in 2012.

JEM-EUSO

- **JEM/EUSO has been planed as a space mission for the investigation of Ultra-High-Energy Cosmic- Rays(UHECRs), with the wide-angle telescope mounted at ISS to detect photon component accompanying air shower in the earth’s atmosphere.**
- **determination of UHECR spectrum above the GZK energy and the reconstruction of atmospheric shower development with an improvement of event statistics compared to the current ground-based UHECR experiments.**
- **JEM/EUSO will be launched by Japanese H-II Transfer Vehicle(HTV) and mounted at the Exposed Facility of Japanese Experiment Module(JEM/EF) in the second phase of utilization plan.**
- **The telescope which consists of the high transmittance optical lens with a diameter of 3.5m and the advanced photo-sensitive device at the focal surface, will allow us to detect of cosmic rays with energy of >1019eV**


EUSO
30°
430 km
≈
EECR
Fluorescence
Čerenkov
Atmosphere
250 km
Earth
Fluorescence Spectrum
300nm
400nm

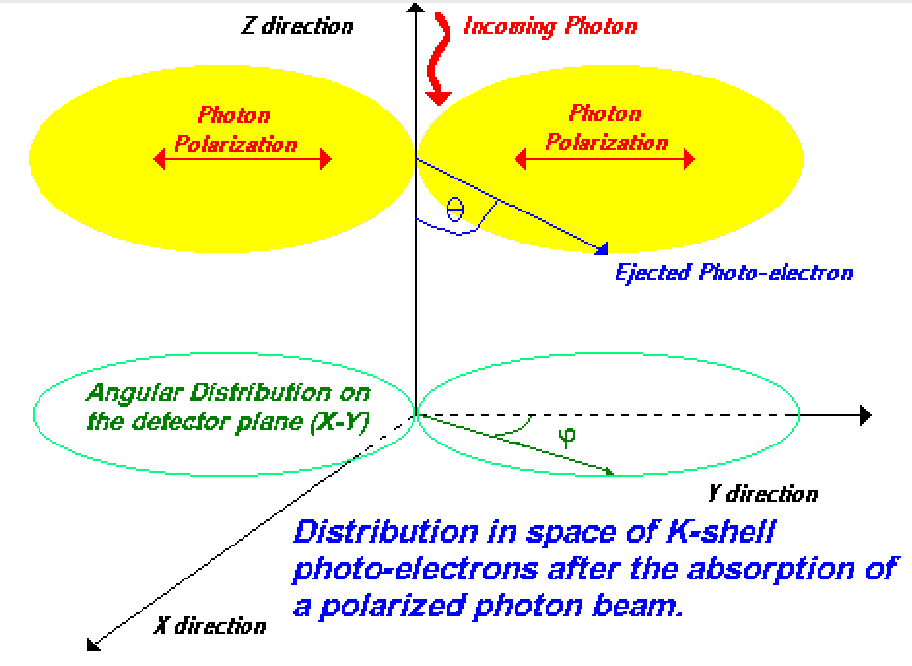
Polarimetria X

L’emissione di raggi X polarizzati è attesa nei processi di produzione non termici in particolare:

- Negli oggetti compatti (BH,stelle di neutroni)
- In presenza di intensi campi magnetici
- Inoltre potrebbe essere un canale di probe per la verifica della Lorentz invariance

Photoelectric cross section

The photoelectric effect is very sensitive to photon polarization!



Distribution in space of K-shell photo-electrons after the absorption of a polarized photon beam.

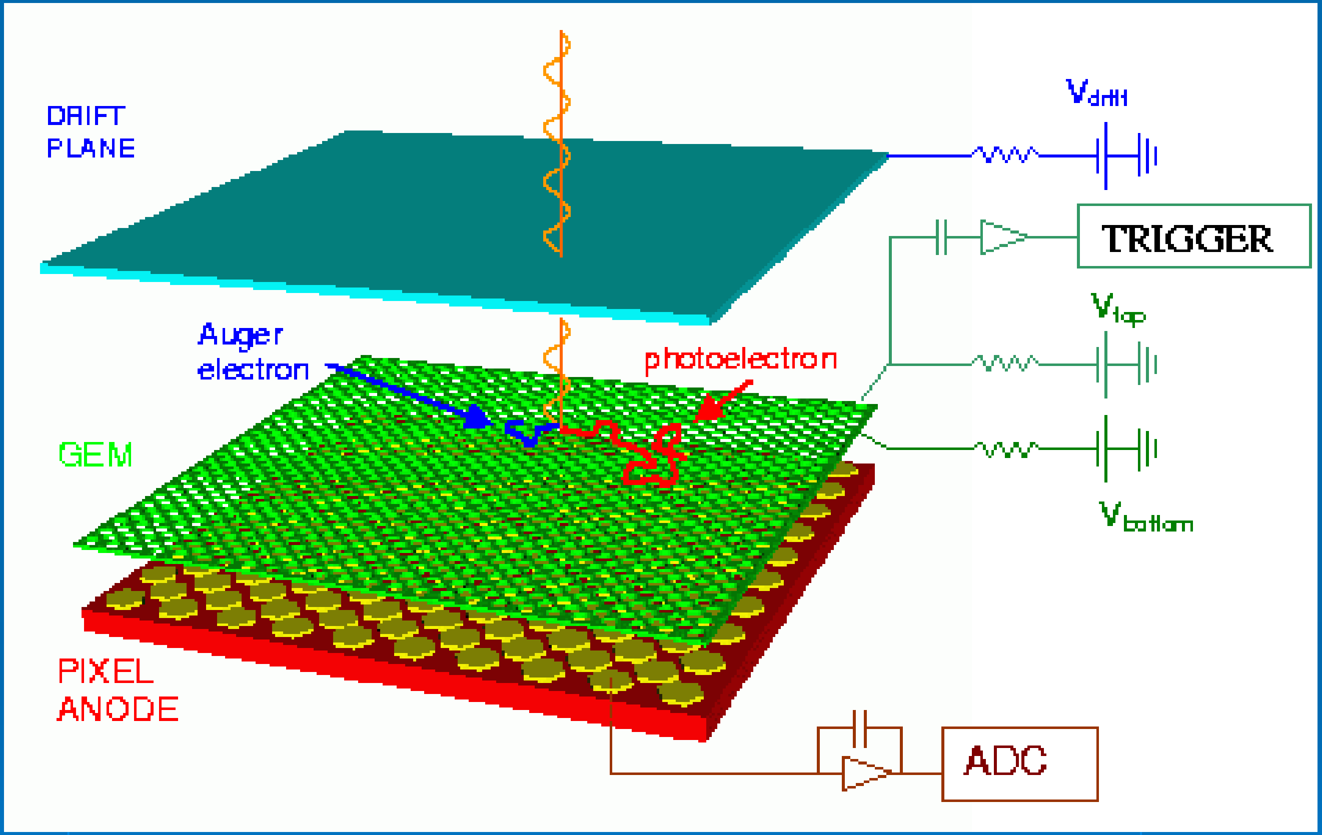
Simple analytical expression for photoemission differential cross section (k-shell photoelectron in non-relativistic limit):

$$\frac{\partial\sigma}{\partial\Omega} = r_o^2 \frac{Z^5}{137^4}\left(\frac{mc^2}{h\nu}\right)^{7/2} \frac{4\sqrt{2}\sin^2(\theta)\cos^2(\varphi)}{(1-\beta\cos(\theta))^4}$$

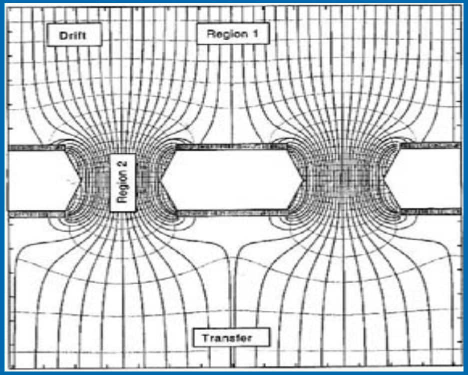
If we project on the plane orthogonal to the propagation direction…

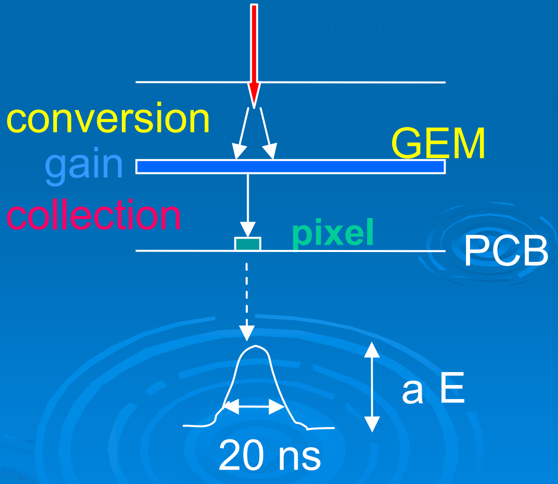
$$\frac{\partial\sigma}{\partial\Omega} \propto \cos^2\phi$$

XPOL: The principle of detection
R. Bellazzini



GEM electric field





Polarization information is derived from the tracks of the photoelectron, imaged by a finely subdivided gas detector.

Tracks reconstruction

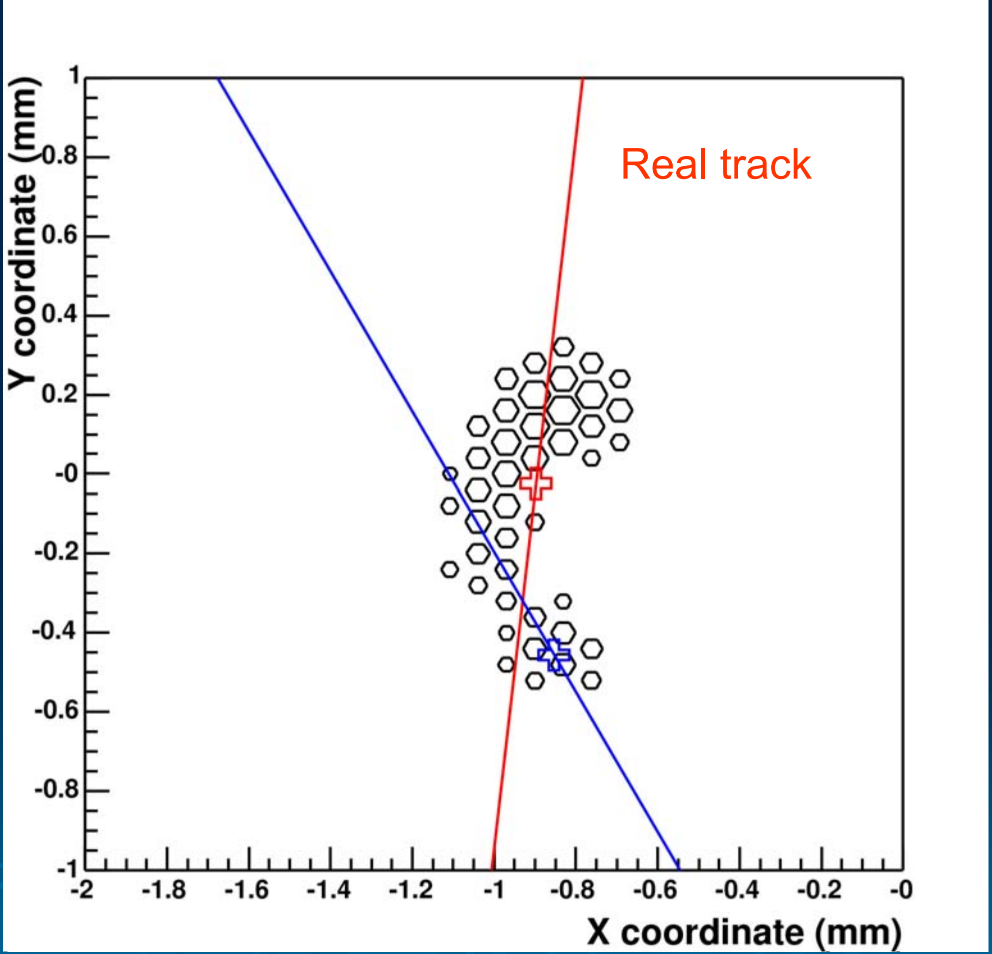
1) The track is recorded by the PIXel Imager

2) Baricenter evaluation

3) Reconstruction of the principal axis of the track: maximization of the second moment of charge distribution

4) Reconstruction of the conversion point: major second moment (track length) + third moment along the principal axis (asymmetry of charge release)

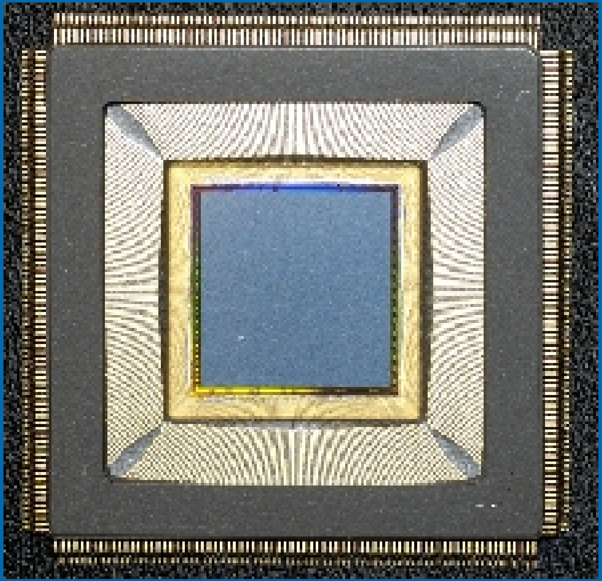
5) Reconstruction of emission direction: pixels are weighted according to the distance from conversion point.



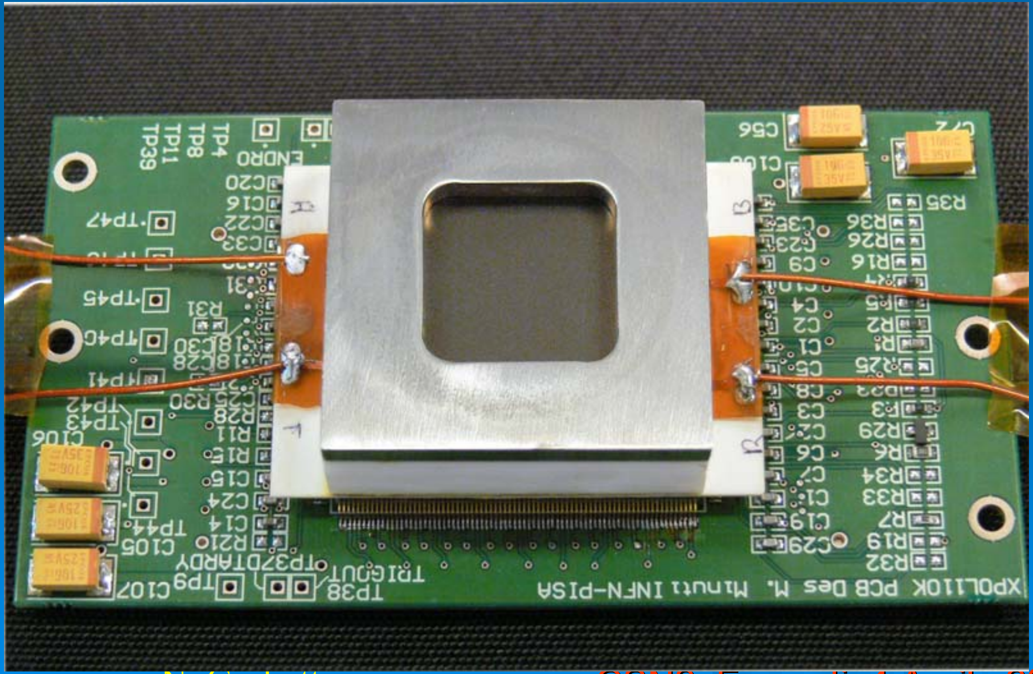
The sealed X-ray polarimeter

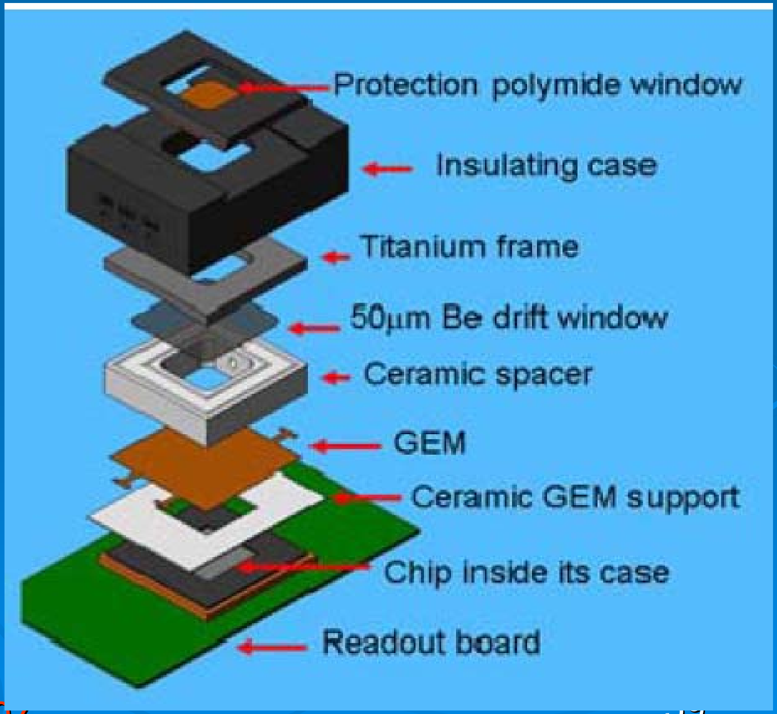
A sealed version of the MicroPattern gas detector is running in the lab since 5 months.

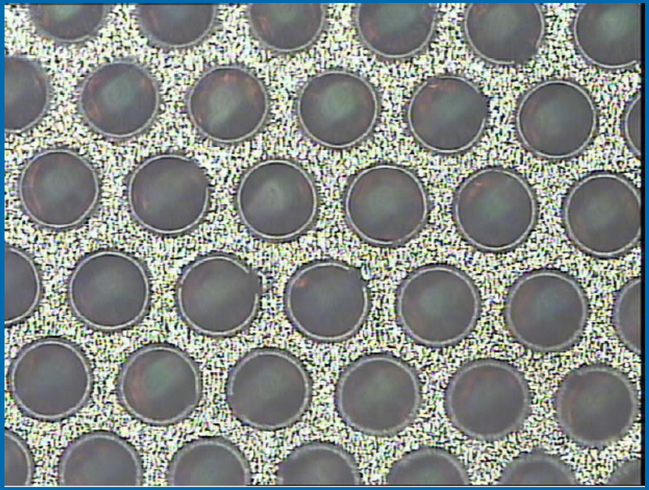
It is manufactured by Oxford International Oy with techniques, glues and material compatible with use in space (eg. low out-gassing, minimum thermal stress).



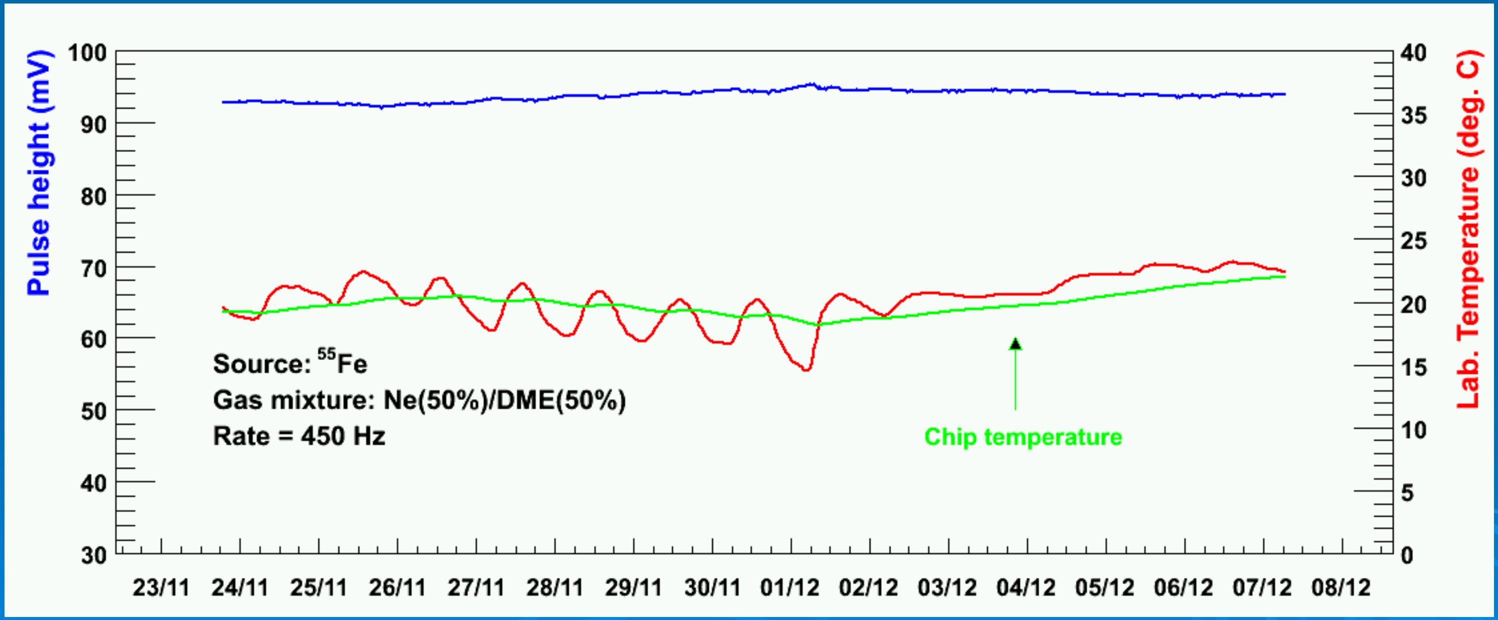
The 105600 pixel ASIC chip



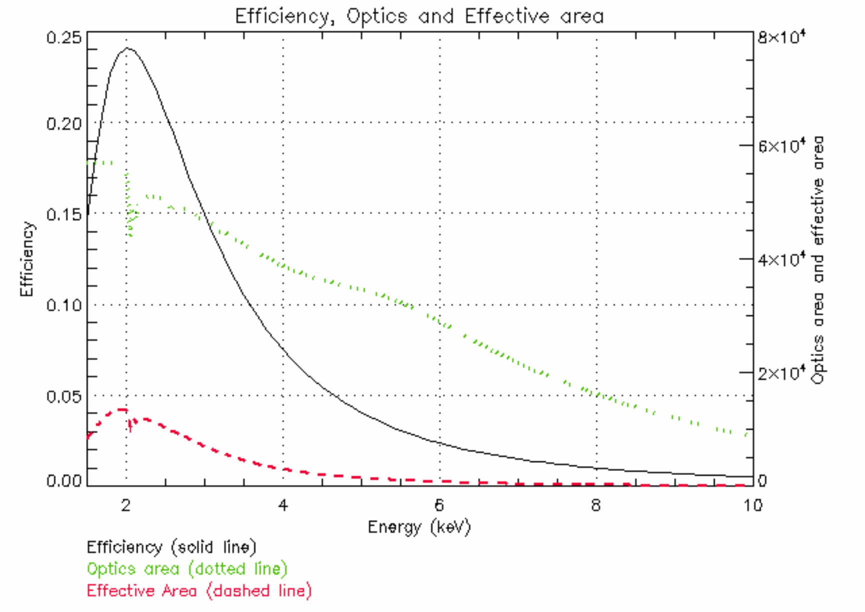


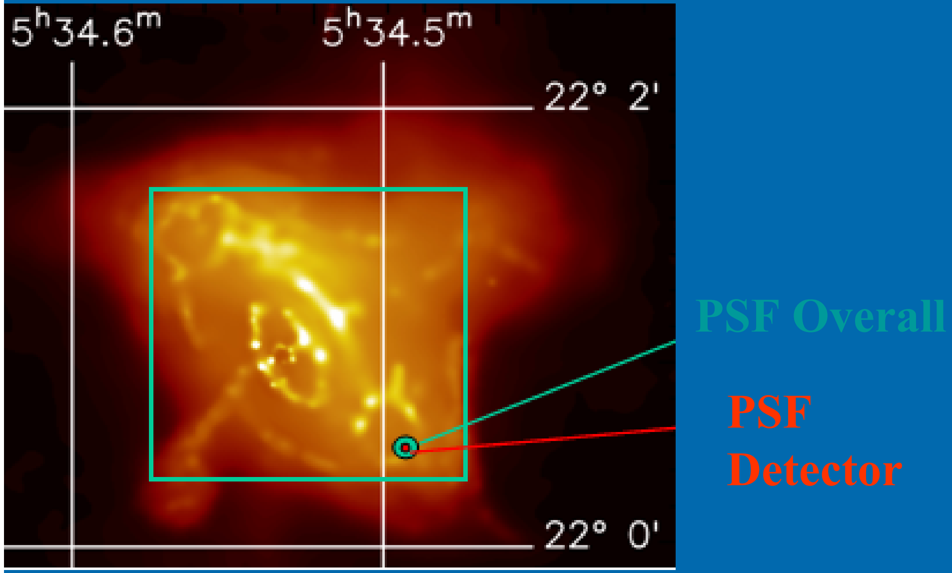


The 50 μm pitch GEM with 33 μm diameter holes. The high level of granularity permits to exploit the fine ptch of the detection plane and reach a high level of modulation expecially at low energies.



Stability of the GEM pulse height after a continous irradiation of Fe^{55} source (Blu line) of the sealed detector





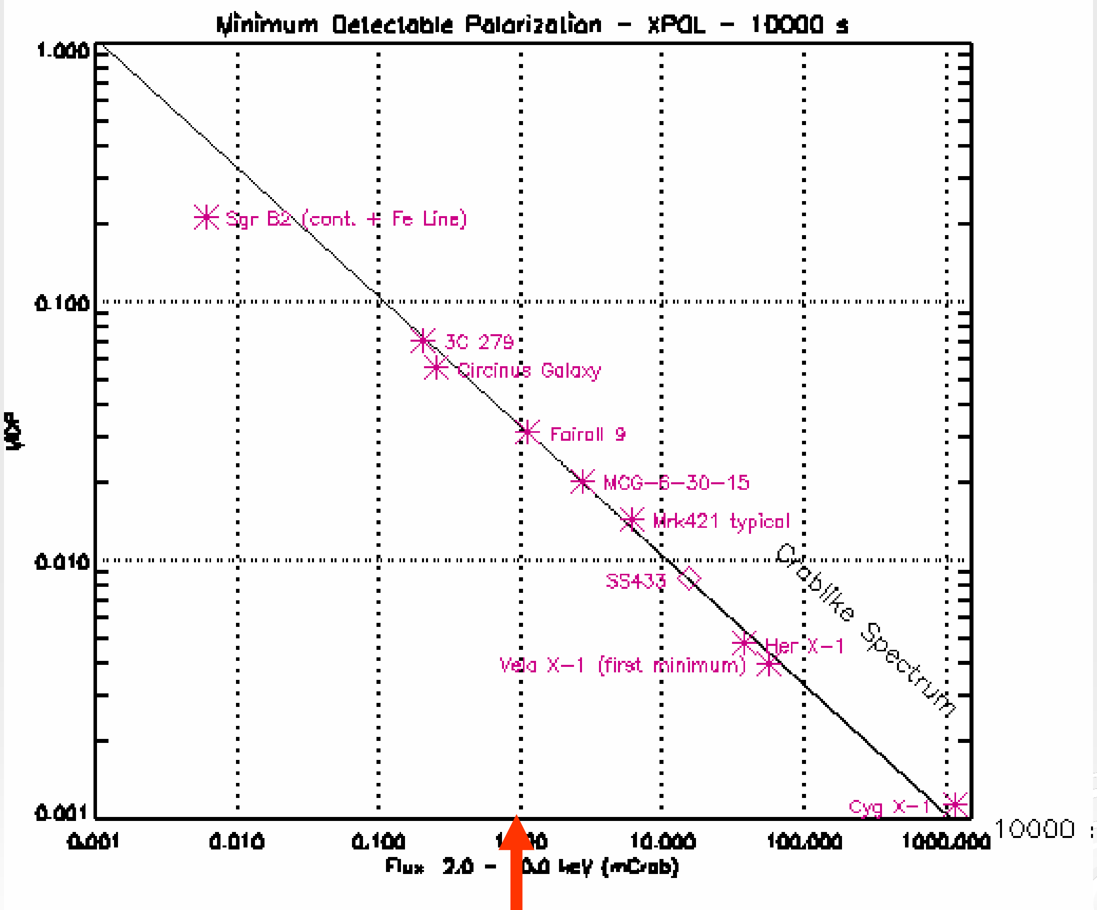
Instrumental Characteristics

FOV = 1.5’ x 1.5’ (30 m Focal length)
PSF (overall) = 5’’ (730 µm, limited by the optics)
PSF detector = 1’’ (150 µm)
Crab counting rate = 20.000 counts/s (2-10 keV)

Background (internal) ~ 2.0 x 10 ^-5 c/s
(Extrapolated by LEO data with Methan filling detector to be increased no more than 1 order of magnitude for XEUS orbit)

Expected polarization sensitivity

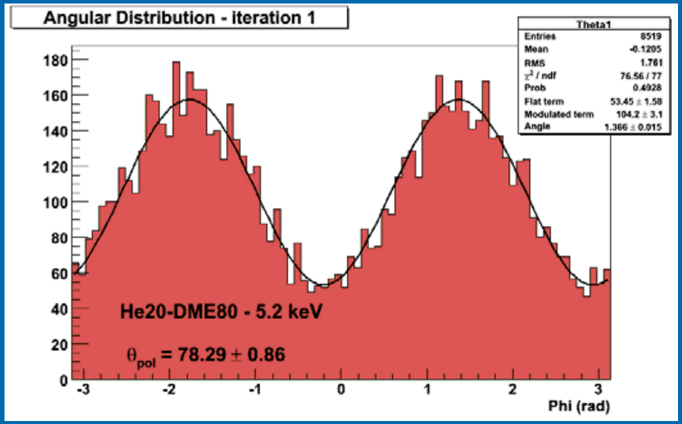
3%

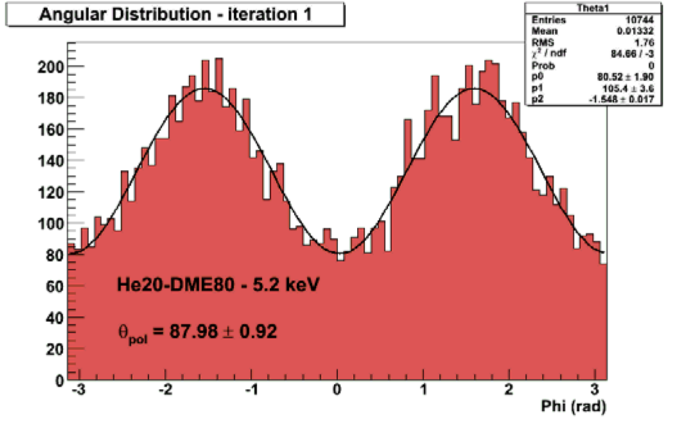


1mCrab flux

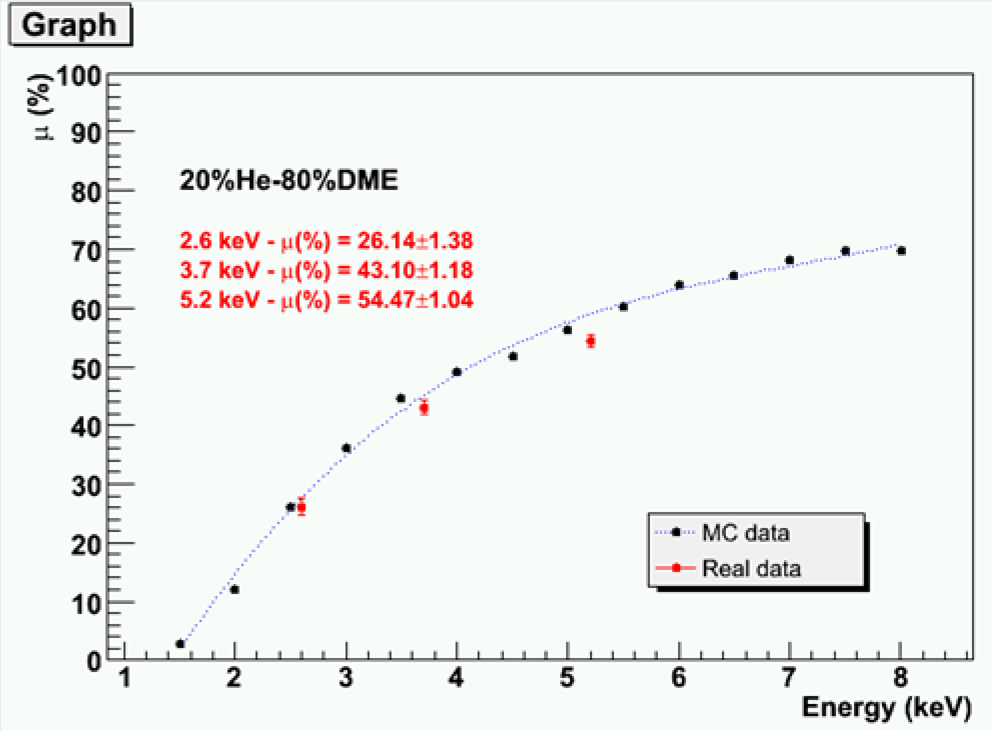
Expected sensitivity for selected sources and 10.000 s observing time.

Results of the last measurement campaign (march 2007)





5.2 keV polarized photons for two angular rotatio of the polarizer showing the good angular sensitivity.



The modulation factor measured at 2.6 keV, 3.7 keV and 5.2 keV with XPOL has been compared with the Monte Carlo previsions. The agreement is very satisfying.

Conclusioni e problemi aperti

- Verifica dei meccanismi di accelerazione CR (nuovi tipi di rivelatore: polarimetri X-γ?)
- Spettro degli UHECR (post EUSO)
- Integrazioni osservazioni sorgenti a diverse bande
- DM

Conclusions from Blasi presentation 7/4/2005 CSN2

1. The mystery of the bulk of Cosmic Rays can be unveiled only by
   a) Observing the putative sources at many frequencies
   b) Making an effort to really go deeper in the understanding of acceleration and propagation
2. There is no doubt that current TeV observations (HESS) are providing invaluable information on SNR's.
   LOWER THRESHOLDS! GLAST is coming up too…
   GO HIGHER IN ENERGY! (cutoff?)
3. UHECR's most likely point to their sources. The AUGER project is collecting data.
4. The future of UHECR's should be an EUSO-like mission.
5. BUT DO NOT FORGET: sources of UHECRs are no exception to astronomical sources. We should look at them at other frequencies!

BEYOND EINSTEIN

FROM THE BIG BANG TO BLACK HOLES

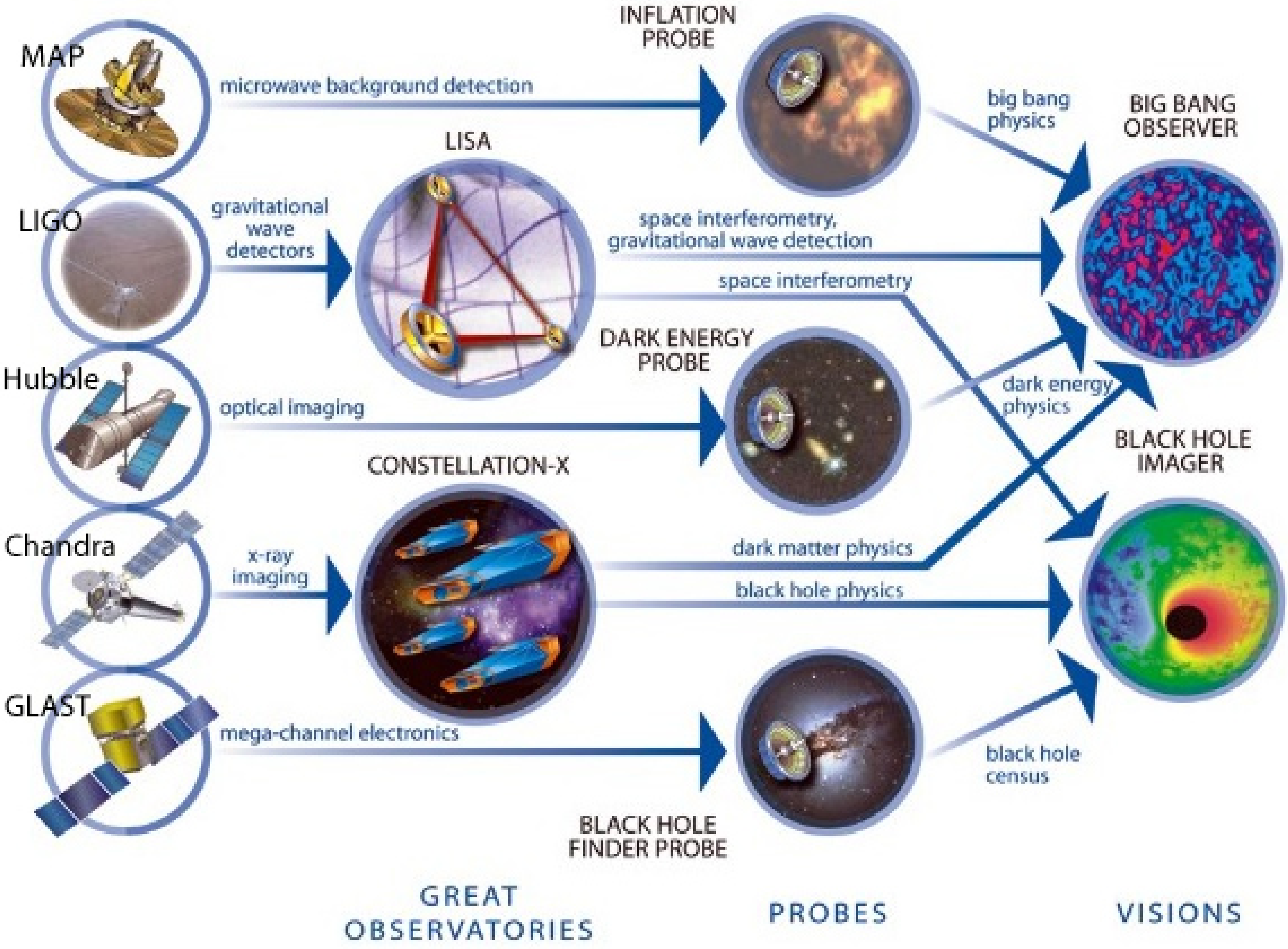
What powered the Big Bang ?

What happens at the edge of a Black Hole ?

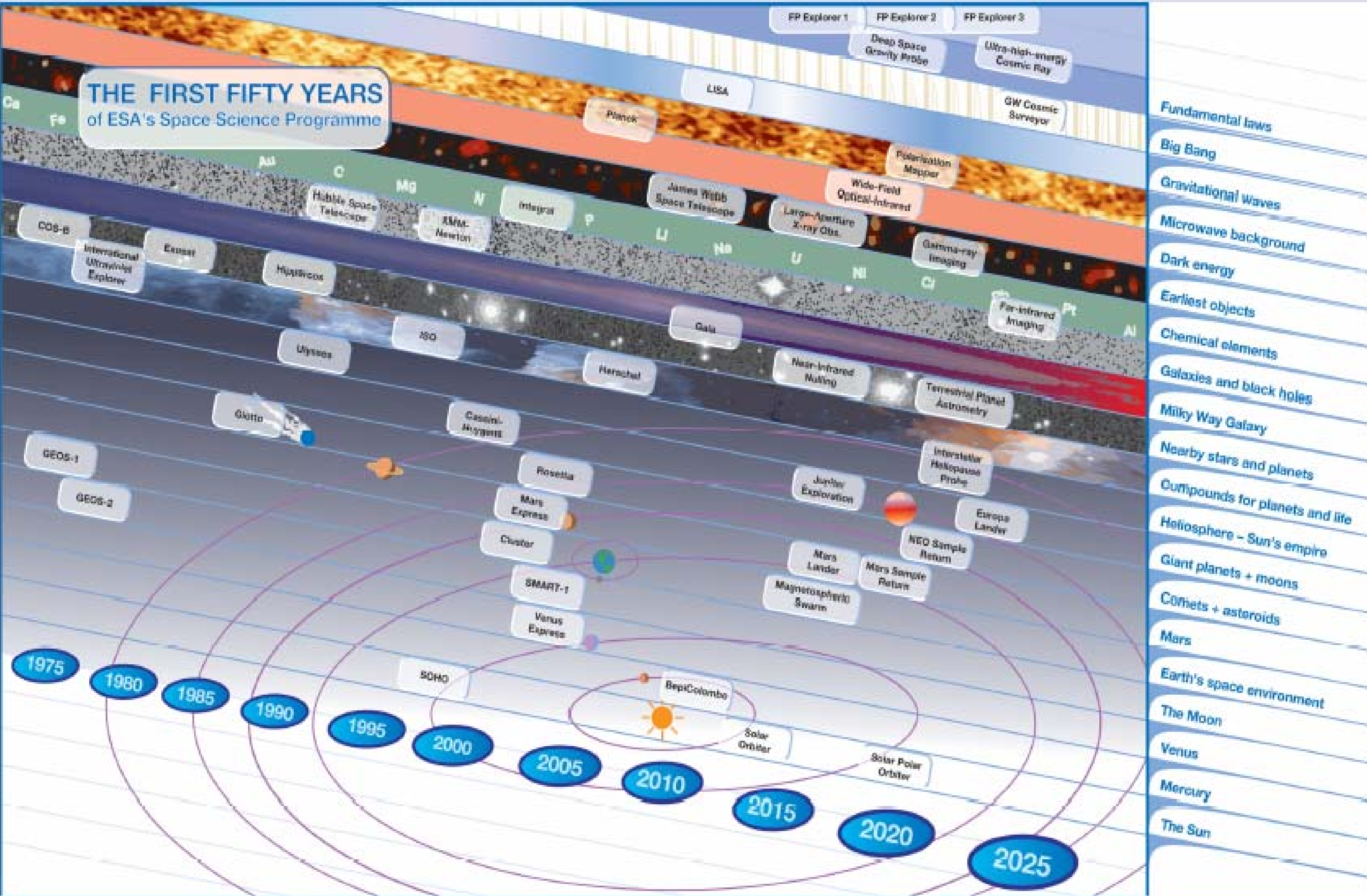
What is Dark Energy ?

Battiston 2005

NASA Beyond Einstein Program



ESA Cosmic Vision



The Moon Our Laboratory

Draft of the Letter of Intent for the ESA call “Cosmic Vision 2015-2025”

Sir,

with this Letter we respond to the “Call for themes for 2015-2025” opened by the Science Programme of the European Space Agency in view of its future long term Scientific Programme.

The theme we propose is ***“Our Laboratory Moon”*** which is based on the exploitation of the unique features of our satellite to study fundamental physics phenomena.

Space means exploration. Exploration in turn means searching for things never reached before. After the landing on the Moon with the Apollo missions, human space exploration is aiming towards the challenges of travelling to Mars. Robotic exploration is aiming to even more distant planets or comets. But there is also another kind of space exploration which is related to new perspectives opened by a change of system of reference. In the present proposal it means establishing a continued presence on a planet or satellite to exploit its resources and to explore the possibilities opened by the fact of being there. The advent of always more advanced telepresence techniques, give to the Moon a unique role in this regards. Establishing our telepresence on the Moon today would be much simpler than it was sending there the Apollo astronauts 40 years ago, but would give a tremendous return in term of science and perspectives. In addition to the more general interest of developing enabling technologies for a future human moon-base, this theme will allow us to exploit the extraordinary resources offered by our satellite to perform a set of fundamental physics and astrophysics experiments.

The proposed theme appears to be related to at least four of the grand themes outlined by the Cross Disciplinary Perspective Group (XPG) for 2015 and beyond, namely

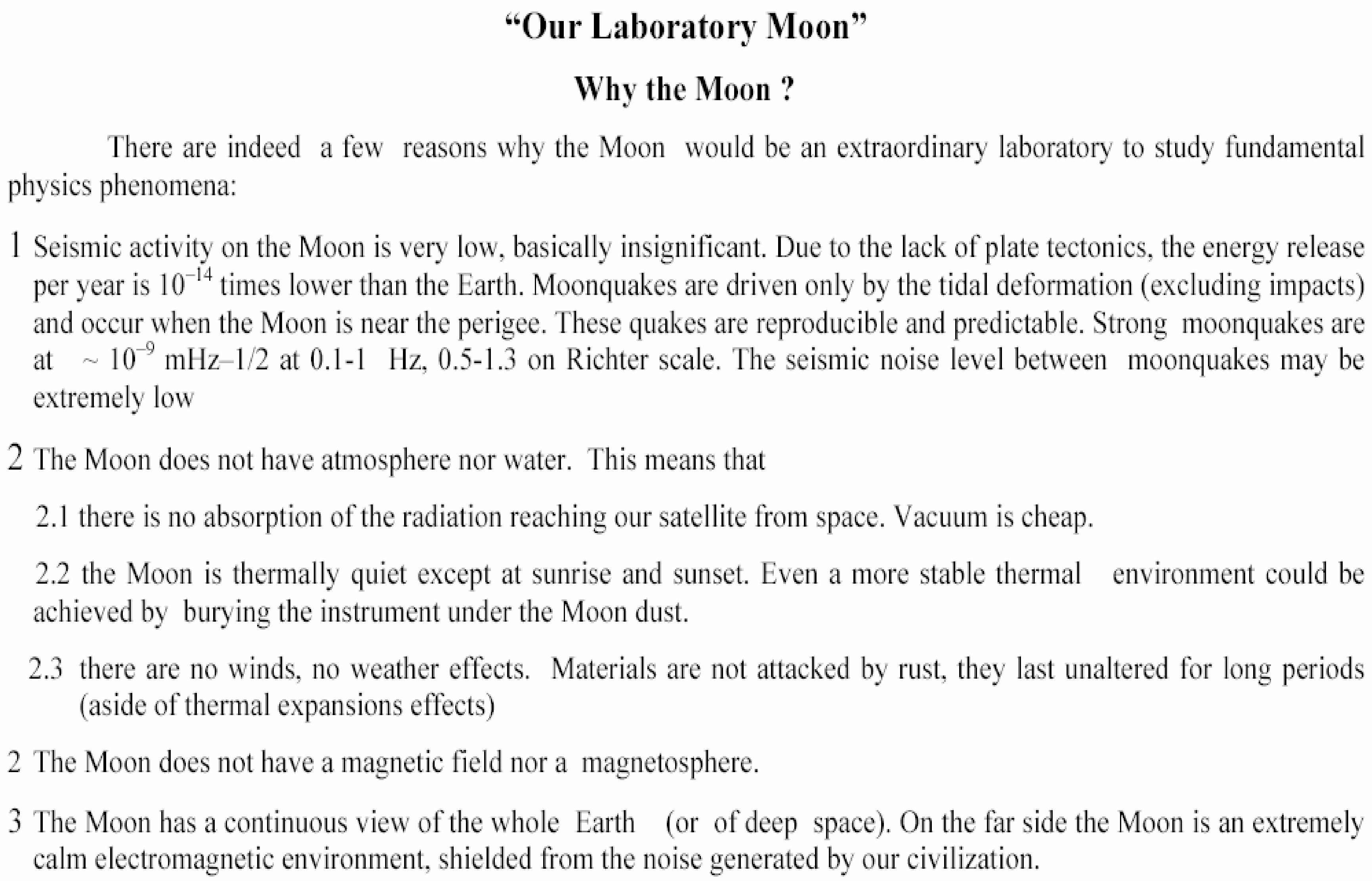
- Nature of physical laws including their immutability in time.
- High energy physics beyond the accelerator.
- Quantum world, edges of space, cosmic microwave background and black holes.
- Universe: origin and evolution and changing nature of the universe

We are looking towards interacting with the members of the ESA review process committees for a introduction of such a theme within the next ESA long term science plan,

Best Regards

Signatures follow

R. Battiston University and INFN of Perugia (Italy)
L. Gammaitoni University and INFN of Perugia (Italy)
P. Trampus CARSO, Trieste (Italy)
S. Natale Universite' de Geneve (Switzerland)
G. Barbarino University and INFN of Napoli (Italy)
R. Ambrosi University of Leicester, Space Research Cent
A. Paolozzi Universita' "La Sapienza", Roma, (Italy)
A. Petrolini University and INFN of Genova (Italy)
P.Spinelli University and INFN of Bari (Italy)
N.Giglietto University and INFN of Bari (Italy)
C.Favuzzi University and INFN of Bari (Italy)
M.N.Mazziotta University and INFN of Bari (It
P.Fusco University and INFN of Bari (Italy)
M.A. Franceschi INFN-LNF (Italy)
S. Dell' Agnello INFN-LNF (Italy)
P. G. Rancoita University and INFN of Milano
M. Gervasi University and INFN of Milano (Ita
E. Fiandrini University and INFN of Perugia (It
B. Alpat University and INFN of Perugia (Italy)
M. Menichelli University and INFN of Perugia
P. Lubrano University and INFN of Perugia (Ita
F. Cervelli INFN of Pisa (Italy)
P. Galeotti University and INFN of Torino (Italy
A. Gregorio University and INFN of Trieste (Ita



"Our Laboratory Moon"

Why the Moon ?

There are indeed a few reasons why the Moon would be an extraordinary laboratory to study fundamental physics phenomena:

1 Seismic activity on the Moon is very low, basically insignificant. Due to the lack of plate tectonics, the energy release per year is 10^{-14} times lower than the Earth. Moonquakes are driven only by the tidal deformation (excluding impacts) and occur when the Moon is near the perigee. These quakes are reproducible and predictable. Strong moonquakes are at ~ 10^{-9} mHz–1/2 at 0.1-1 Hz, 0.5-1.3 on Richter scale. The seismic noise level between moonquakes may be extremely low

2 The Moon does not have atmosphere nor water. This means that

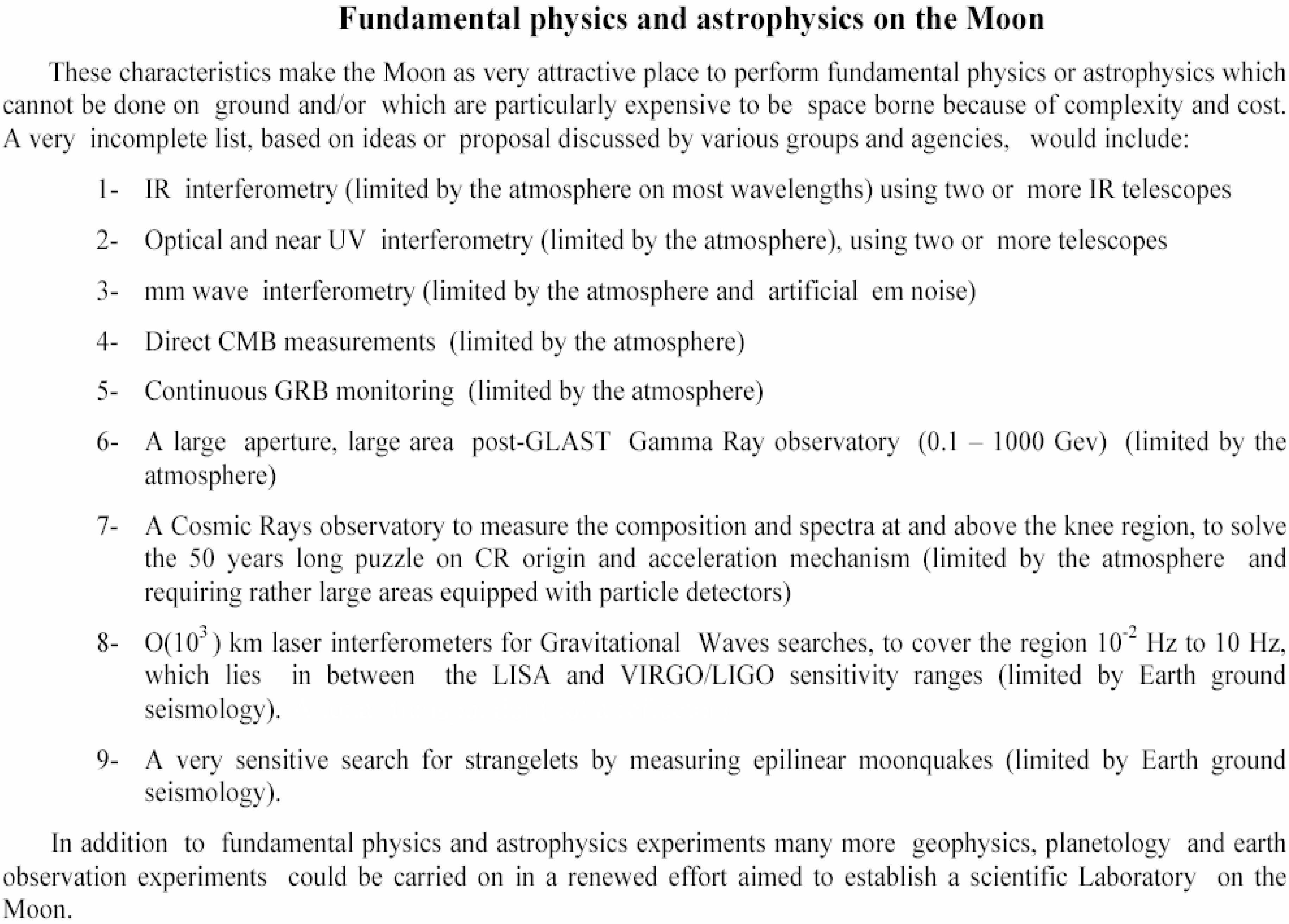
2.1 there is no absorption of the radiation reaching our satellite from space. Vacuum is cheap.

2.2 the Moon is thermally quiet except at sunrise and sunset. Even a more stable thermal environment could be achieved by burying the instrument under the Moon dust.

2.3 there are no winds, no weather effects. Materials are not attacked by rust, they last unaltered for long periods (aside of thermal expansions effects)

2 The Moon does not have a magnetic field nor a magnetosphere.

3 The Moon has a continuous view of the whole Earth (or of deep space). On the far side the Moon is an extremely calm electromagnetic environment, shielded from the noise generated by our civilization.



Fundamental physics and astrophysics on the Moon

These characteristics make the Moon as very attractive place to perform fundamental physics or astrophysics which cannot be done on ground and/or which are particularly expensive to be space borne because of complexity and cost. A very incomplete list, based on ideas or proposal discussed by various groups and agencies, would include:

1- IR interferometry (limited by the atmosphere on most wavelengths) using two or more IR telescopes

2- Optical and near UV interferometry (limited by the atmosphere), using two or more telescopes

3- mm wave interferometry (limited by the atmosphere and artificial em noise)

4- Direct CMB measurements (limited by the atmosphere)

5- Continuous GRB monitoring (limited by the atmosphere)

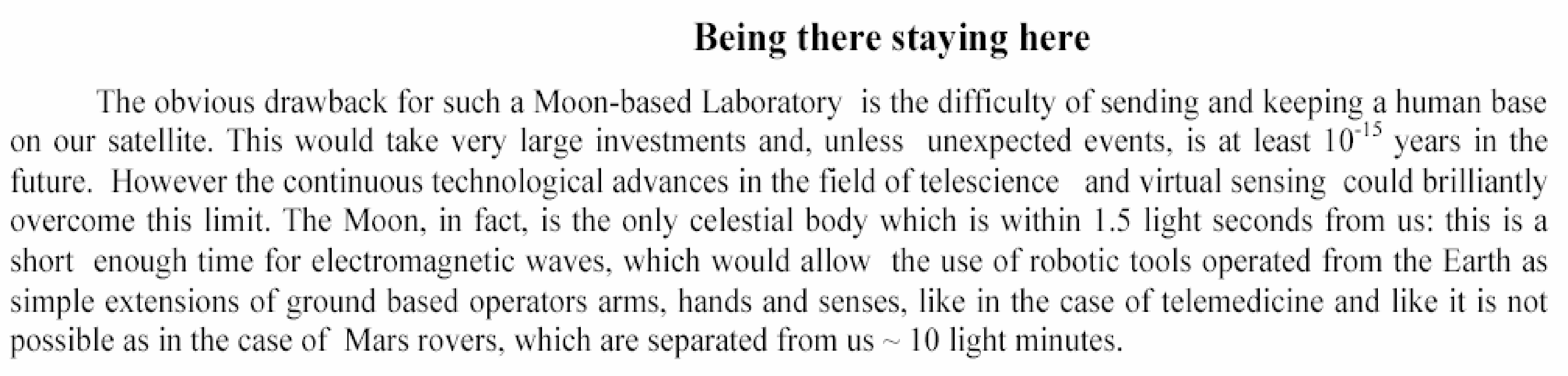
6- A large aperture, large area post-GLAST Gamma Ray observatory (0.1 – 1000 Gev) (limited by the atmosphere)

7- A Cosmic Rays observatory to measure the composition and spectra at and above the knee region, to solve the 50 years long puzzle on CR origin and acceleration mechanism (limited by the atmosphere and requiring rather large areas equipped with particle detectors)

8- O(10^3) km laser interferometers for Gravitational Waves searches, to cover the region 10^{-2} Hz to 10 Hz, which lies in between the LISA and VIRGO/LIGO sensitivity ranges (limited by Earth ground seismology).

9- A very sensitive search for strangelets by measuring epilinear moonquakes (limited by Earth ground seismology).

In addition to fundamental physics and astrophysics experiments many more geophysics, planetology and earth observation experiments could be carried on in a renewed effort aimed to establish a scientific Laboratory on the Moon.



Being there staying here

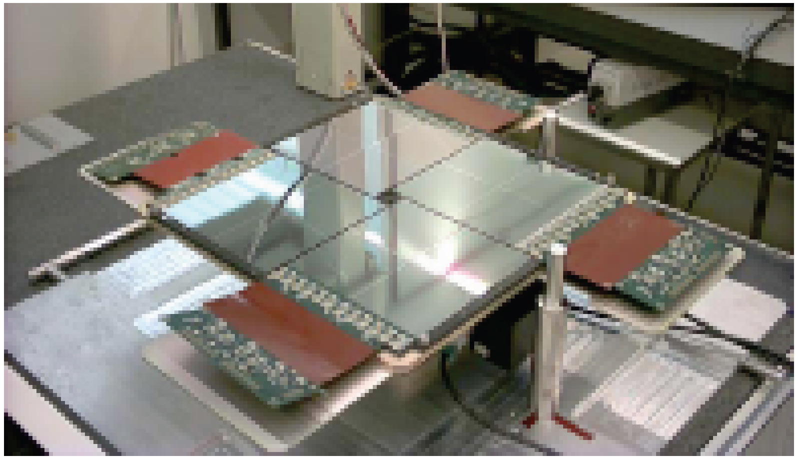
The obvious drawback for such a Moon-based Laboratory is the difficulty of sending and keeping a human base on our satellite. This would take very large investments and, unless unexpected events, is at least 10^{-15} years in the future. However the continuous technological advances in the field of telescience and virtual sensing could brilliantly overcome this limit. The Moon, in fact, is the only celestial body which is within 1.5 light seconds from us: this is a short enough time for electromagnetic waves, which would allow the use of robotic tools operated from the Earth as simple extensions of ground based operators arms, hands and senses, like in the case of telemedicine and like it is not possible as in the case of Mars rovers, which are separated from us ~ 10 light minutes.

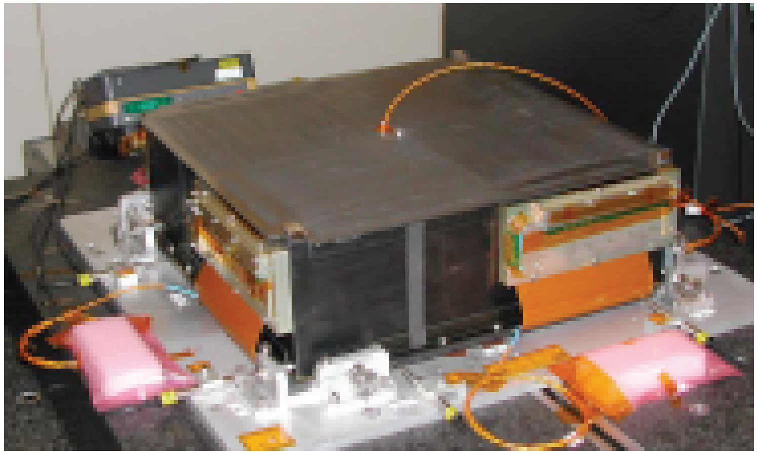
- A dream ? Likely not
- ESA Lunar orbiter is a reality
- China will have a lunar orbiter in 2007
- India will have in 2008
- China will land sample and return in 2012
- US will go back (manned) to moon in 2018

……ASI can join existing programs or develop a new one…….

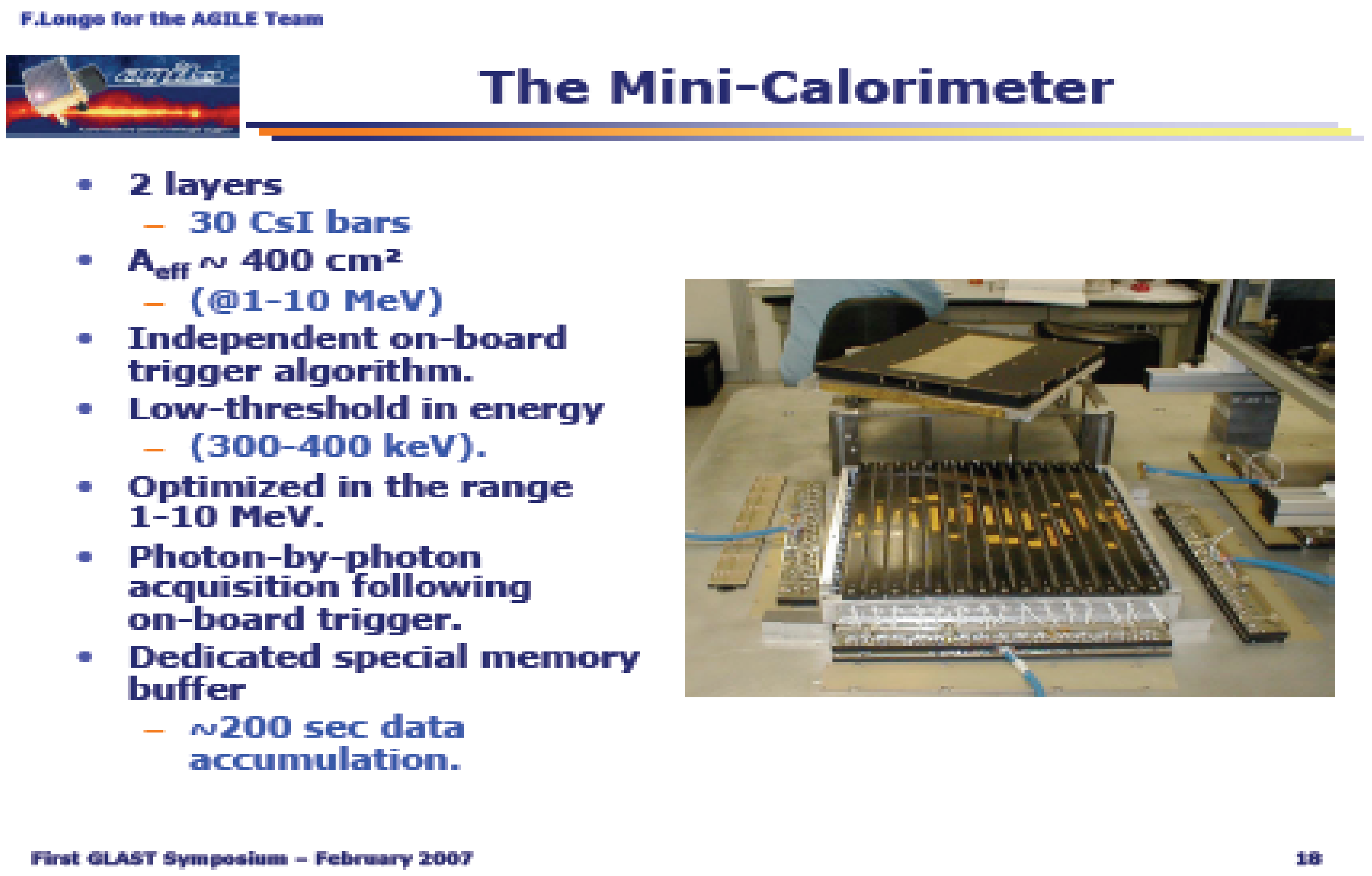
Materiale di riserva

Super-Agile



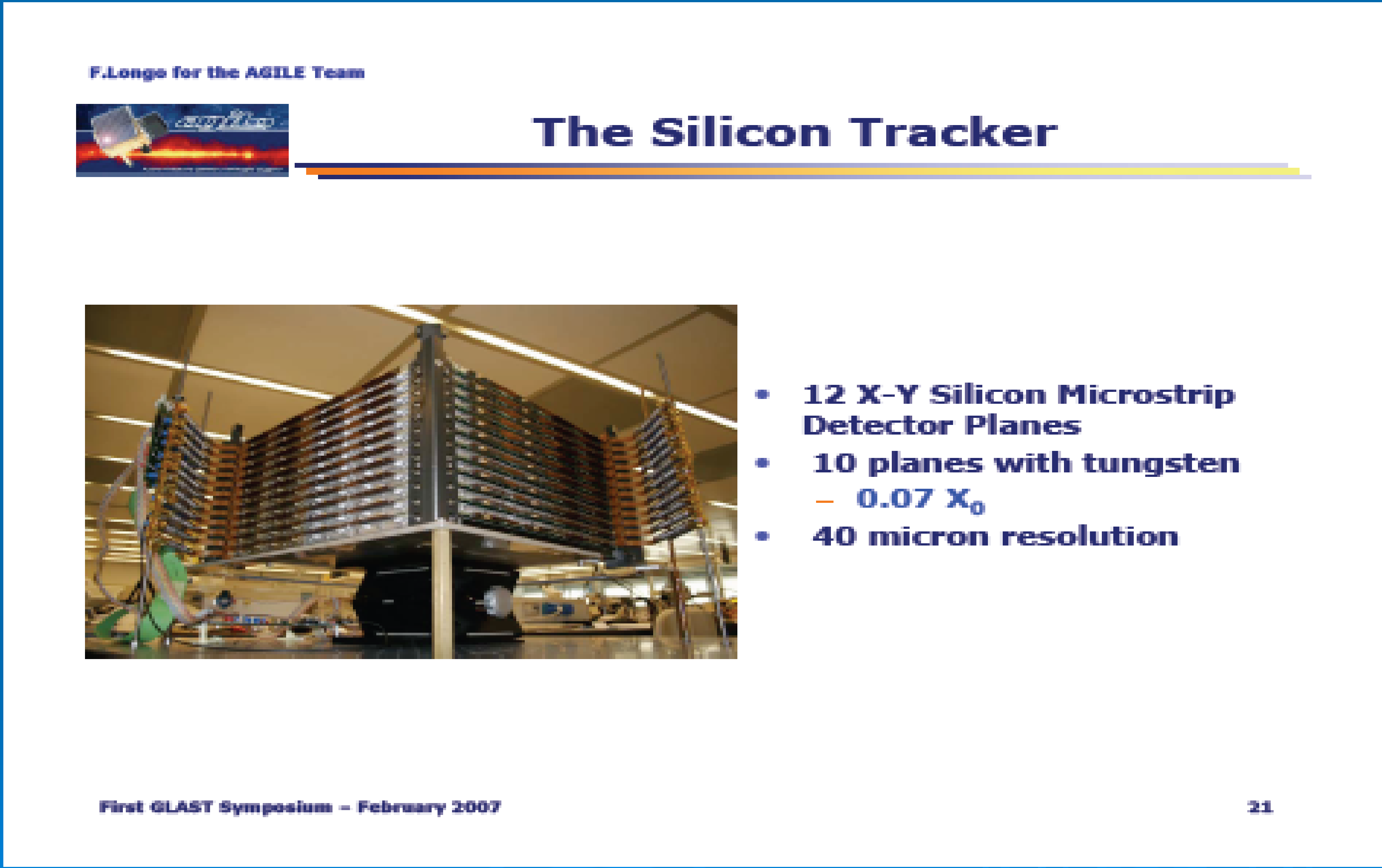


- Arcmin imager
- 15- 45 keV
- 2 x 1-D coded masks
  - 6′ pixel size
- Eff Area 300 cm² on axis (@15 keV)
- Large Field of View
  - ~ 1 sr
- ~6 keV FWHM
- Timing
  - < 5 μs accuracy
- Source localization
  - 1.5 arcmin for bright sources



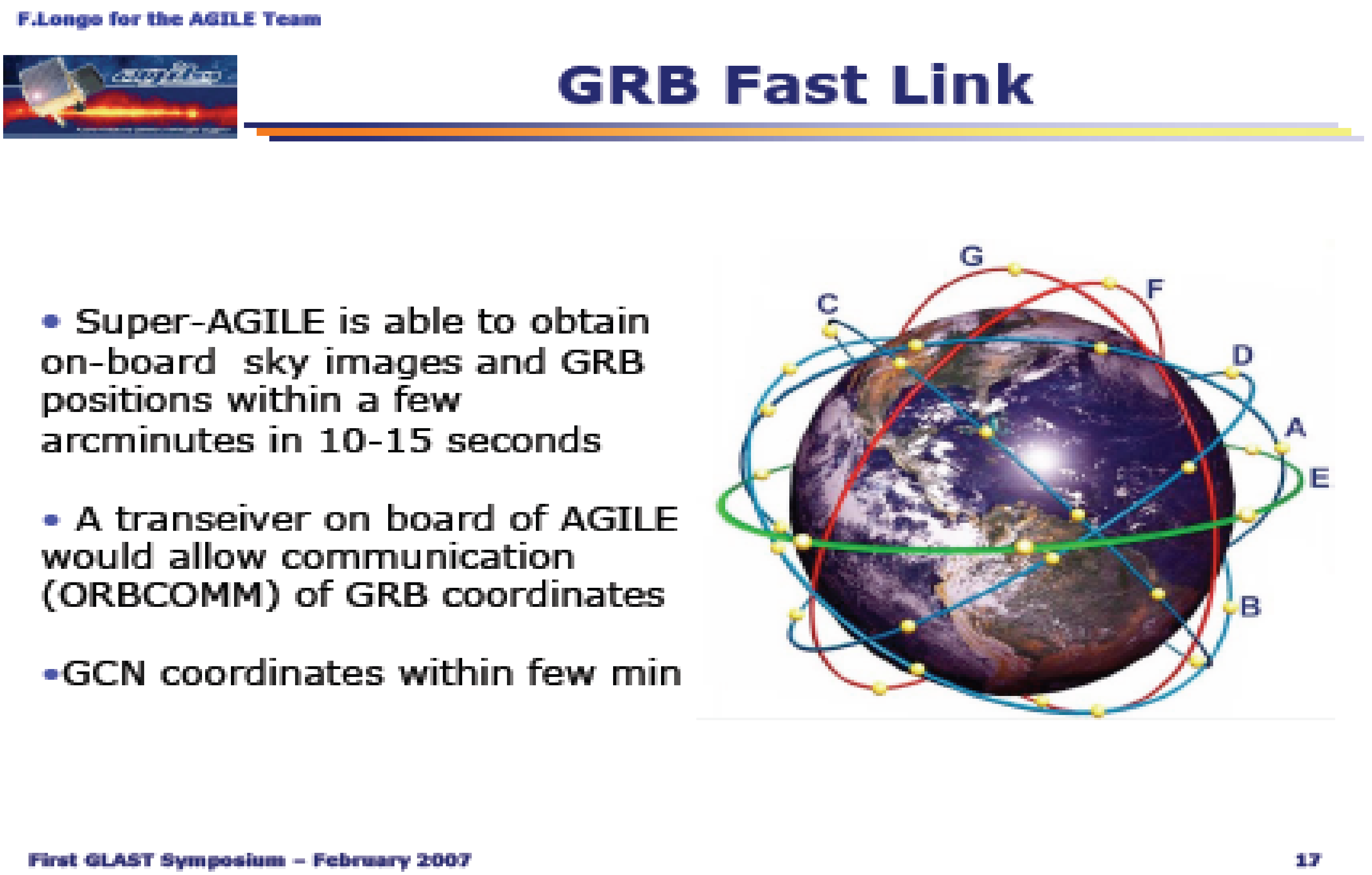
The Mini-Calorimeter

- 2 layers
  - 30 CsI bars
- A_{eff} ~ 400 cm²
  - (@1-10 MeV)
- Independent on-board trigger algorithm.
- Low-threshold in energy
  - (300-400 keV).
- Optimized in the range 1-10 MeV.
- Photon-by-photon acquisition following on-board trigger.
- Dedicated special memory buffer
  - ~200 sec data accumulation.



The Silicon Tracker

- 12 X-Y Silicon Microstrip Detector Planes
- 10 planes with tungsten
  - $0.07\ X_0$
- 40 micron resolution



F.Longo for the AGILE Team

GRB Fast Link

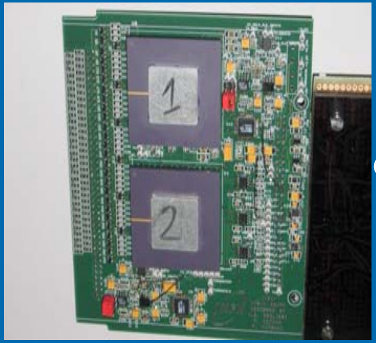
- Super-AGILE is able to obtain on-board sky images and GRB positions within a few arcminutes in 10-15 seconds
- A transeiver on board of AGILE would allow communication (ORBCOMM) of GRB coordinates
- GCN coordinates within few min

First GLAST Symposium – February 2007

17

CREAM - **Activities in 2005**

INFN :
- **upgrade** of calorimeter **front-end electronics** for **3rd flight (2006)**
- commissioning of the CREAM-2 payload : delivery to NASA (July 2005)
- CREAM-2 balloon integration until September 2005 (shipment to Antarctica)
- **2nd flight from McMurdo (December 2005)**
- Cosmic Ray DATA ANALYSIS from the 1st flight



FE board developed by INFN

Activities in 2006

INFN :
- **refurbishment** of INFN calorimeter for 4th flight (2007)
- commissioning of the CREAM-3 payload : delivery to NASA (July 06)
- CREAM-3 balloon integration until September 2006 (shipment to Antarctica)
- beam calibration at CERN of INFN calorimeter in preparation for **4th flight**
- **3rd flight (December 2006 – ULDB flight)**
- CR DATA ANALYSIS

Activities in 2007 - 2008

INFN :
- proposed **construction** of one Silicon Charge Detector for **5th flight (Dec.2008)**
- commissioning + **flight of the CREAM-4 payload (December 2007)**

CREAM - INFN **2005 - 2008**

- Previsioni di spesa sulle costruzioni :

2005 : - **upgrade dell'elettronica di front-end del calorimetro** per il **III volo** (Dic. 2006)

(richiesta integrativa in corso d'anno 2005 : 35 KEuro)

2006 : - **ricostituzione** del calorimetro INFN per il **IV volo** (Dic. 2007)

costo stimato (dipende dalle condizioni di recupero del calorimetro dopo il volo in Antartide) : **da un minimo di 40 kEuro** per il prevedibile danneggiamento delle fibre e scintillatori e parte dell'elettronica, fino al **costo totale del calorimetro** nel caso in cui il payload non venga recuperato.

2007 : - PROPOSTA di costruzione di un **Silicon Charge Detector** per il **V volo** (Dic. 2008)

costo totale stimato circa 250 KEuro **distribuito in 2 anni :**

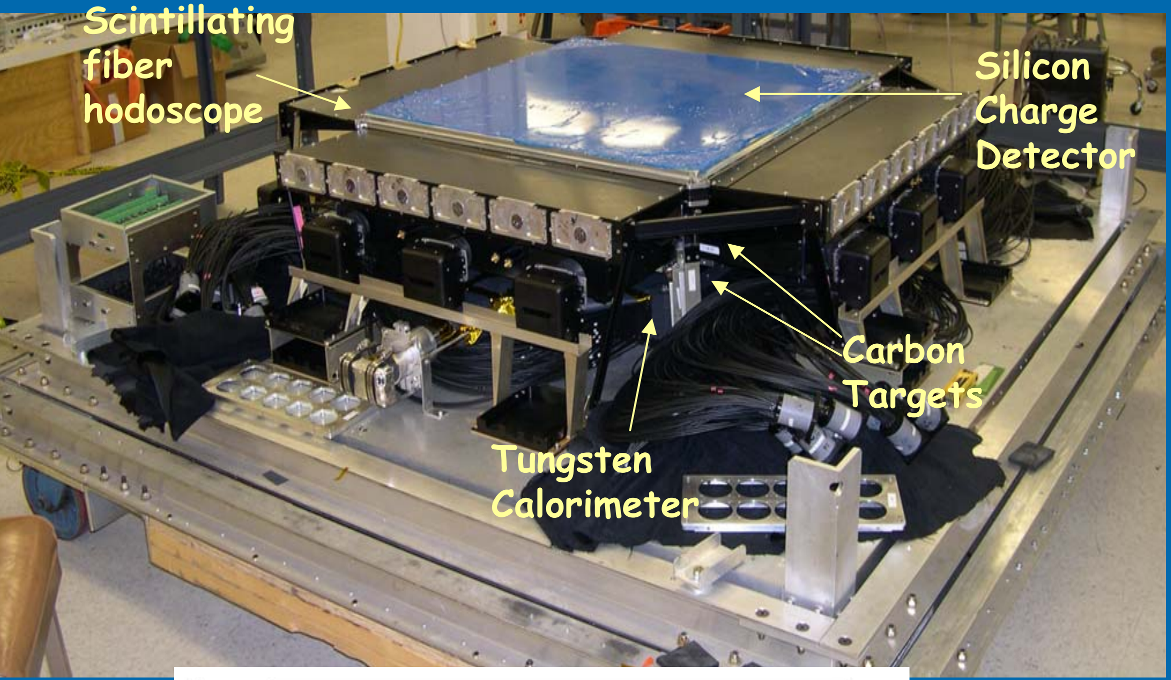
(1) produzione e test di circa **100 sensori** da 6" con 64 pixels da 1cm^2 gia' sviluppati in Italia (STM-Catania) dal nostro gruppo con un progetto PRIN **costo stimato 150 kEuro**

2008 : - Completamento del **Silicon Charge Detector** → **costo stimato 100 kEuro**

(2) commissioning elettronica di front-end (sviluppata da INFN-CSN5 nel 2005-2006)

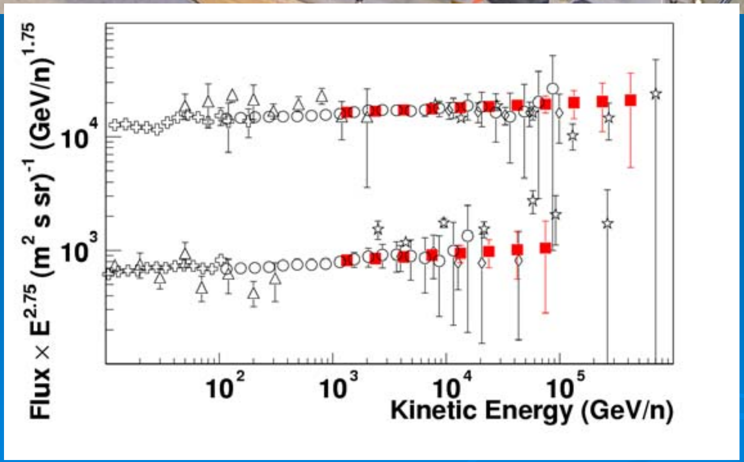
(3) meccanica e integrazione

Exploring Supernova Acceleration Limit



Calorimeter Module

- The **Silicon Charge Detector (SCD)** provides particle charge identification
- The 20-layer **tungsten-scintillating fiber calorimeter** provides its own event trigger, shower energy and direction
- The **scintillating fiber hodoscope** provides x,y tracking coordinates at fixed z above the calorimeter



Comparison of Calorimeter data (red squares) for protons (upper) and Helium (lower) with prior data

Calorimeter Science Objectives

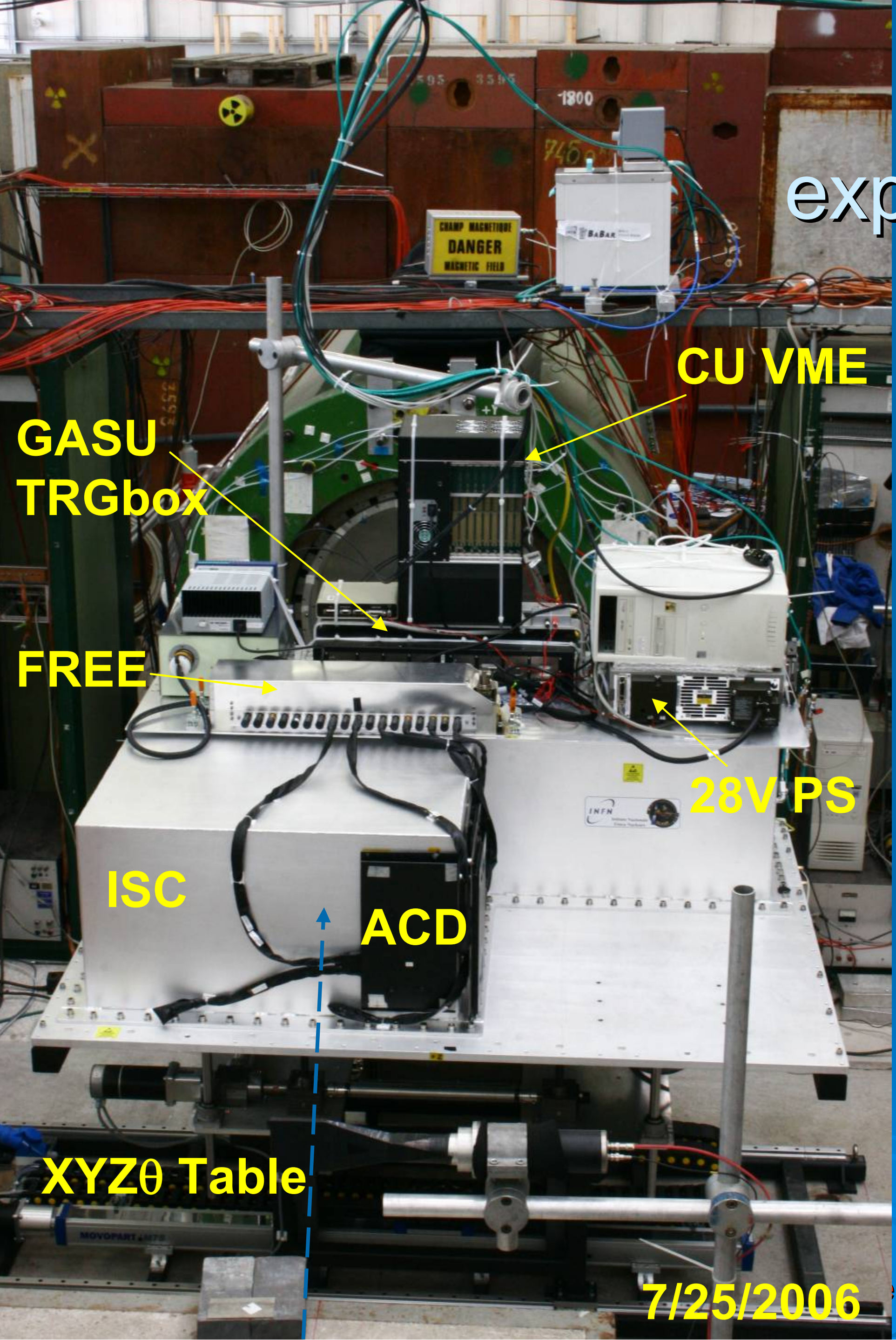
- The Figure (left) shows **p** and **H**e spectra measurements with the Calorimeter as **expected from a 40-day flight**
- Simultaneous measurements of Z > 3 particles provides inflight cross calibration of Calorimeter and TRD

LAT goes to NRL

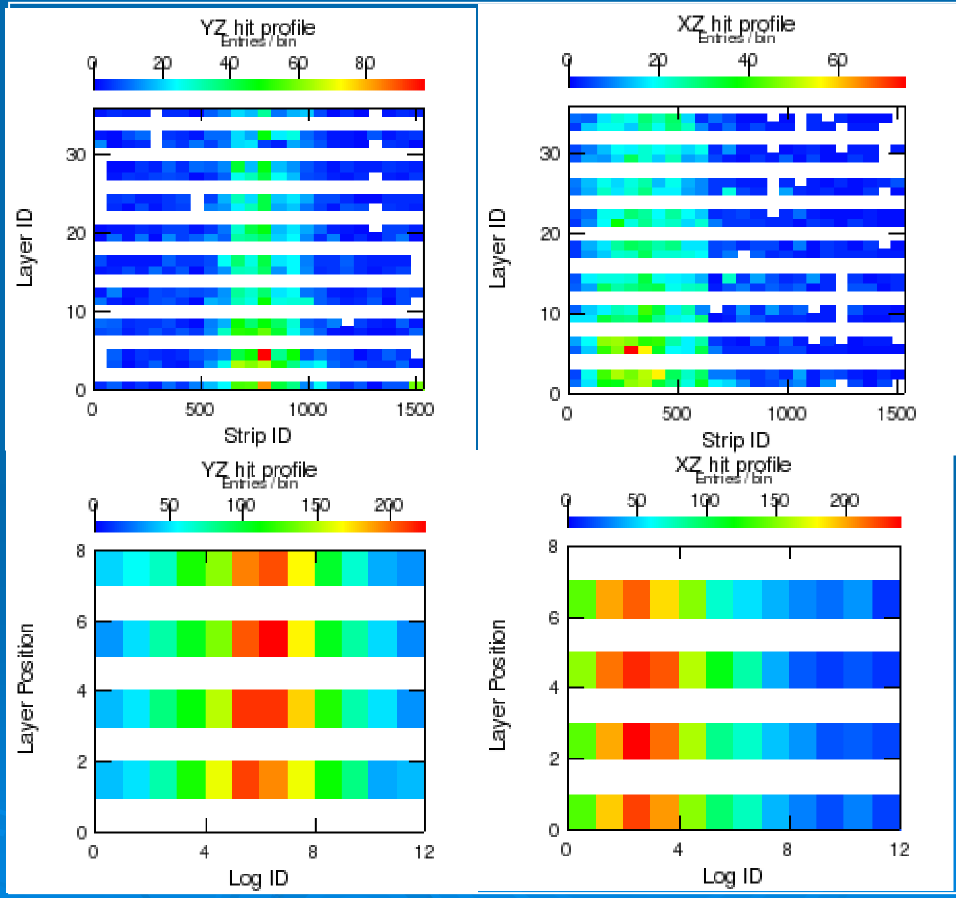
- LAT commissioning completed at SLAC 10/5/2006
- Ship to NRL for Environme 11/5/2006
  - Post-shipment test OK

Arrival of hardware to CERN

The CU in the experimental area and first online events

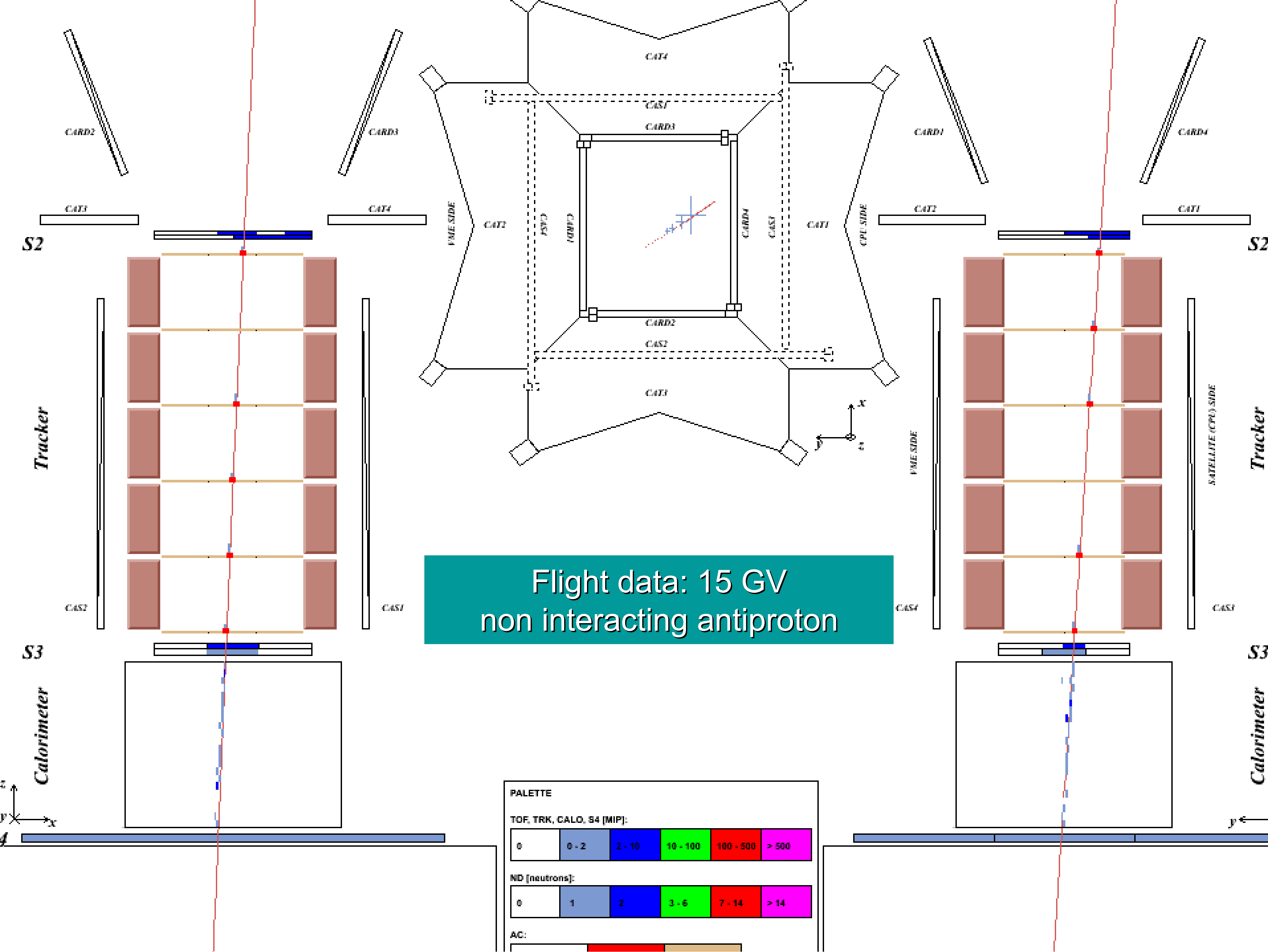


7/25/2006

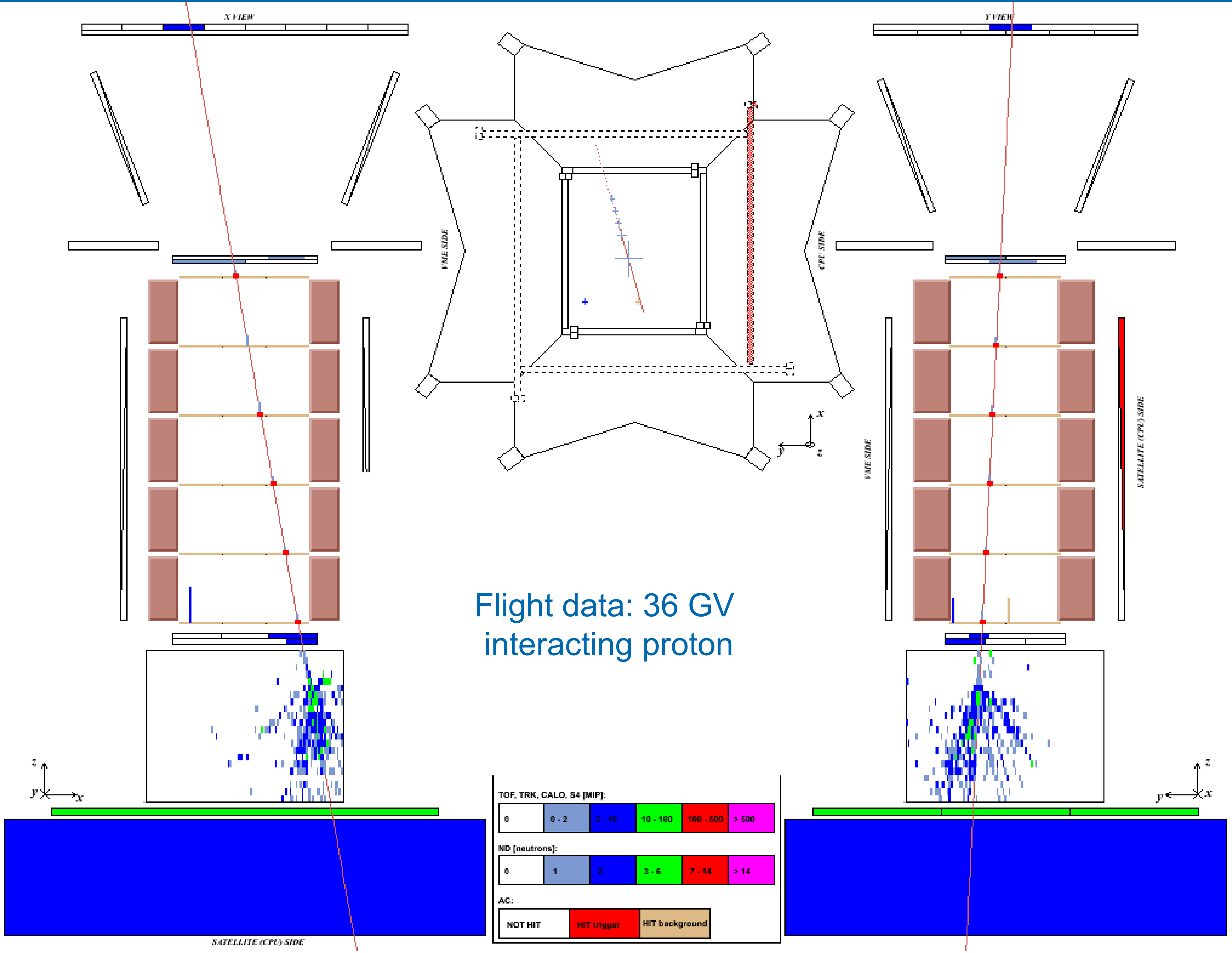


Expected INFN support to ISOC

- Instrument Science Operations Center (at SLAC)
  - Instrument monitoring
    - Sanity checks and calibration
  - Science data processing and monitoring
    - Performance monitor and parameterization on known sources
    - Pipeline maintainance
      - Provide L1 data to scientific community
    - Transients alert distribution
- ISOC ramp-up (starting now)
  - Software flow from I&T experience but new development required
  - Train data from Service Challenges and CU data
  - Many elements for operations from beam test experience
- ISOC Duty Scientist Program
  - Request for operations coordinators, shift leaders and scientist with presence at SLAC



Flight data: 15 GV
non interacting antiproton



Flight data: 36 GV interacting proton