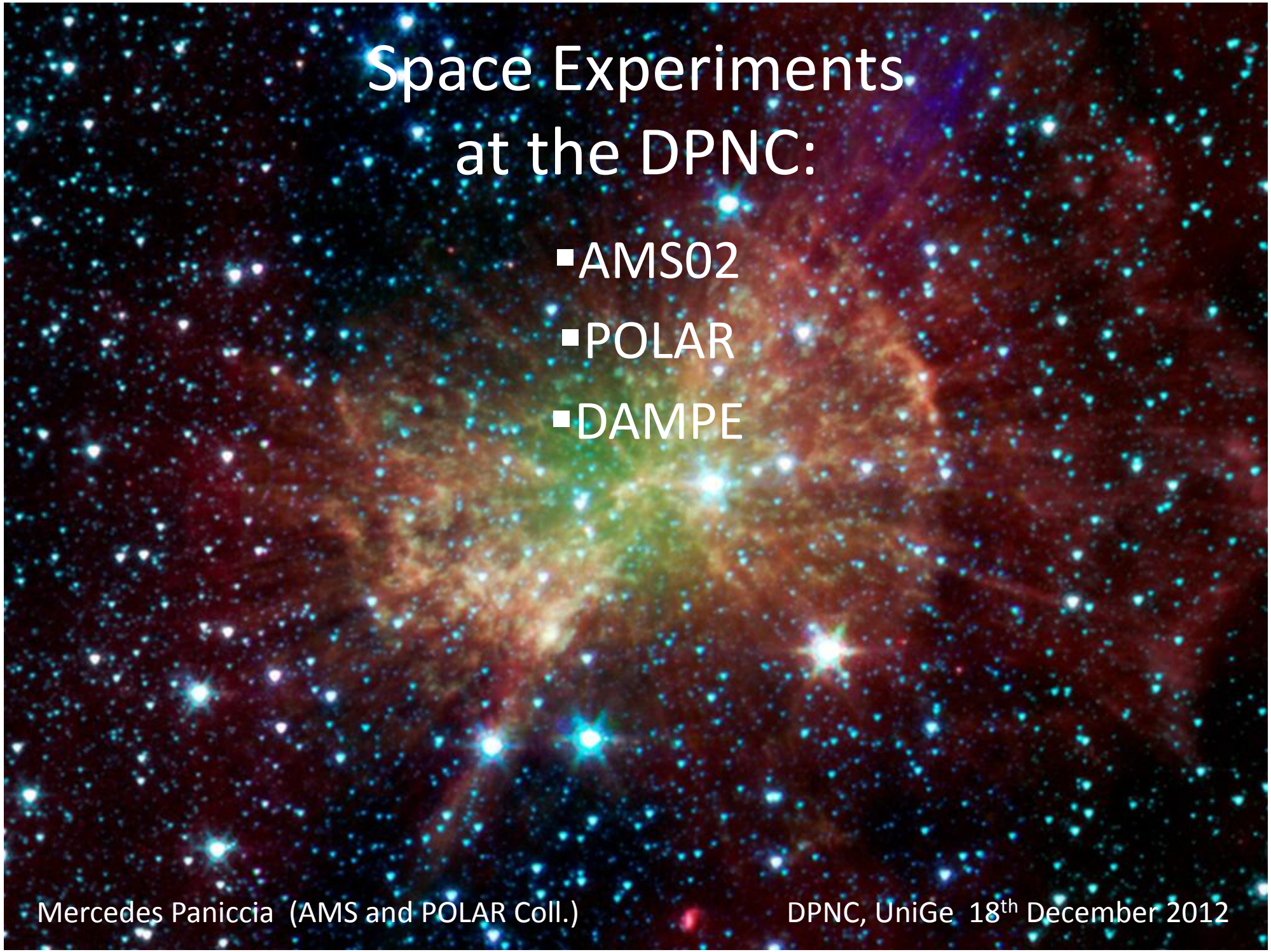
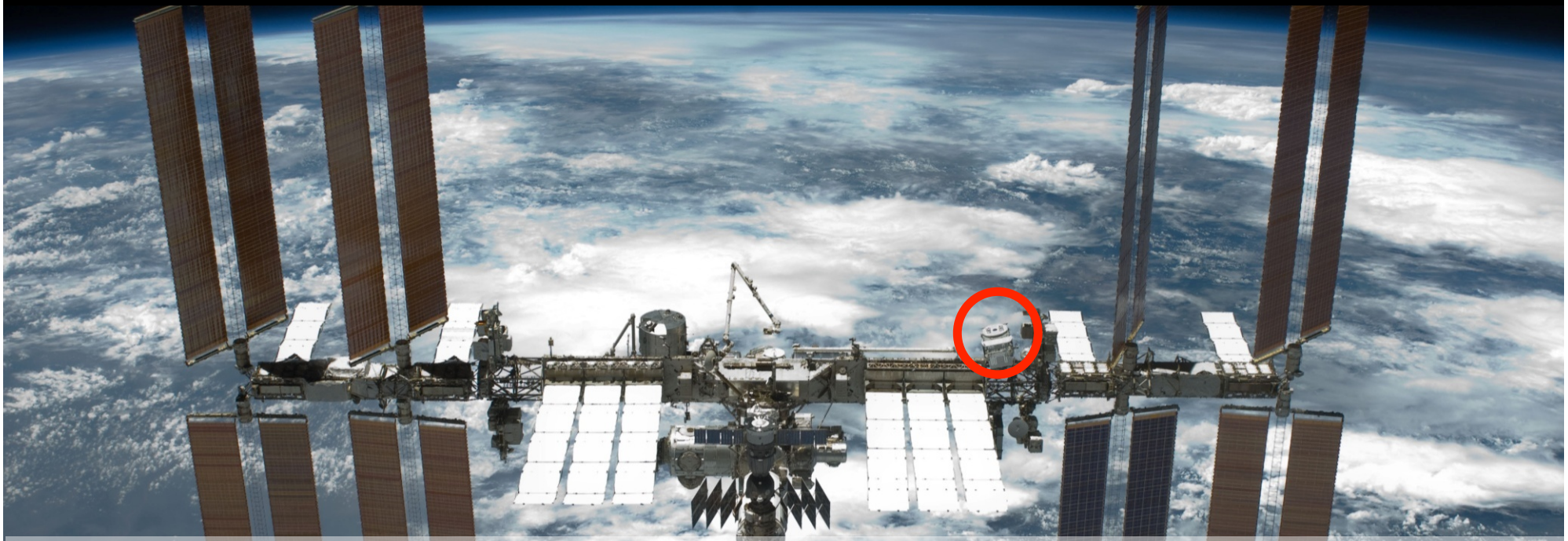


Mercedes Paniccia (AMS and POLAR Coll.)

DPNC, UniGe 18th December 2012

The AMS-02 experiment

A magnetic spectrometer conceived to study very high energy cosmic rays on the International Space Station

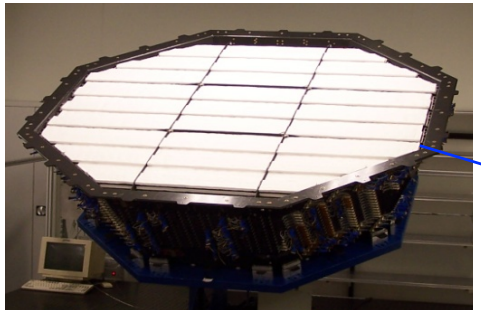


- Complete inventory of Cosmic Rays near Earth, composition and spectra, GeV to TeV
- Search for residual antimatter
- Search for non-standard sources of Cosmic Rays, like dark matter self-annihilation or decay
- Search for unusual components, new stable particles

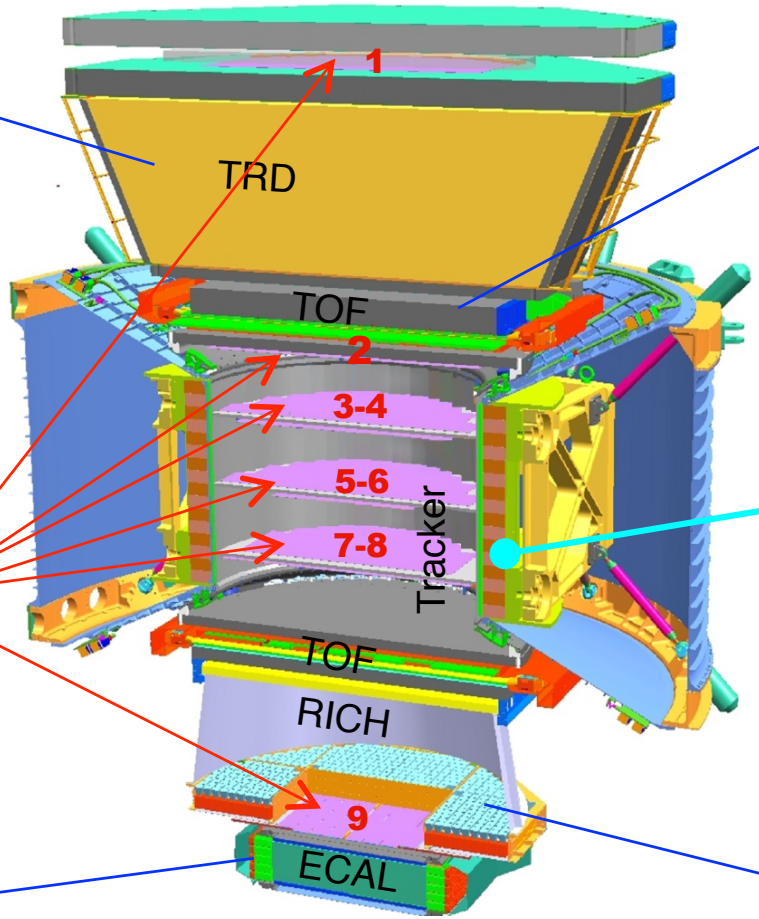
Steadily taking data on the ISS since May 19 2011

AMS: A TeV precision, multipurpose particle physics spectrometer in space.

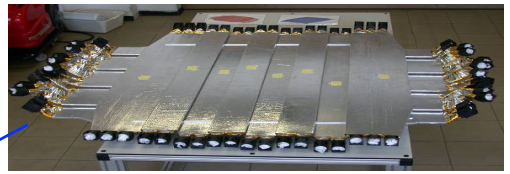
TRD
Identify e+, e-



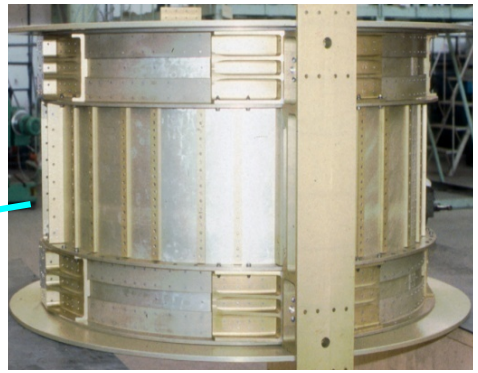
Particles and nuclei are defined by their charge (Z) and energy (E ~ P)



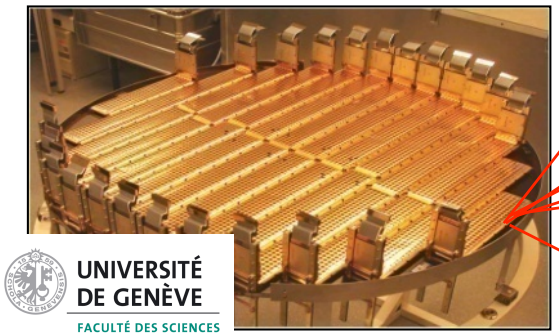
TOF
Z, E



Magnet
±Z

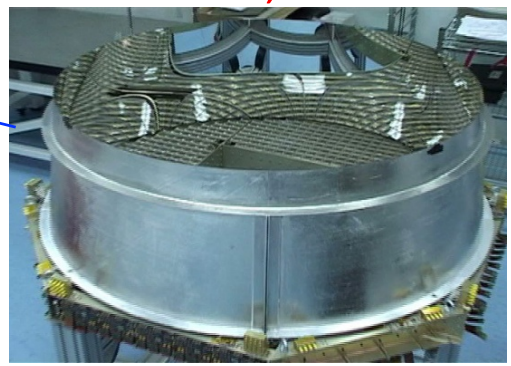


Silicon Tracker
Z, P



UNIVERSITÉ DE GENÈVE
FACULTÉ DES SCIENCES
DEPARTEMENT DE PHYSIQUE NUCLEAIRE ET CORPUSCULAIRE

RICH
Z, E



ECAL
E of e+, e-, γ

Z, P are measured independently by the Tracker, RICH, TOF and ECAL

AMS Physics highlights:
High-precision and simultaneous measurement of cosmic-ray fluxes in the GV to TV rigidity region

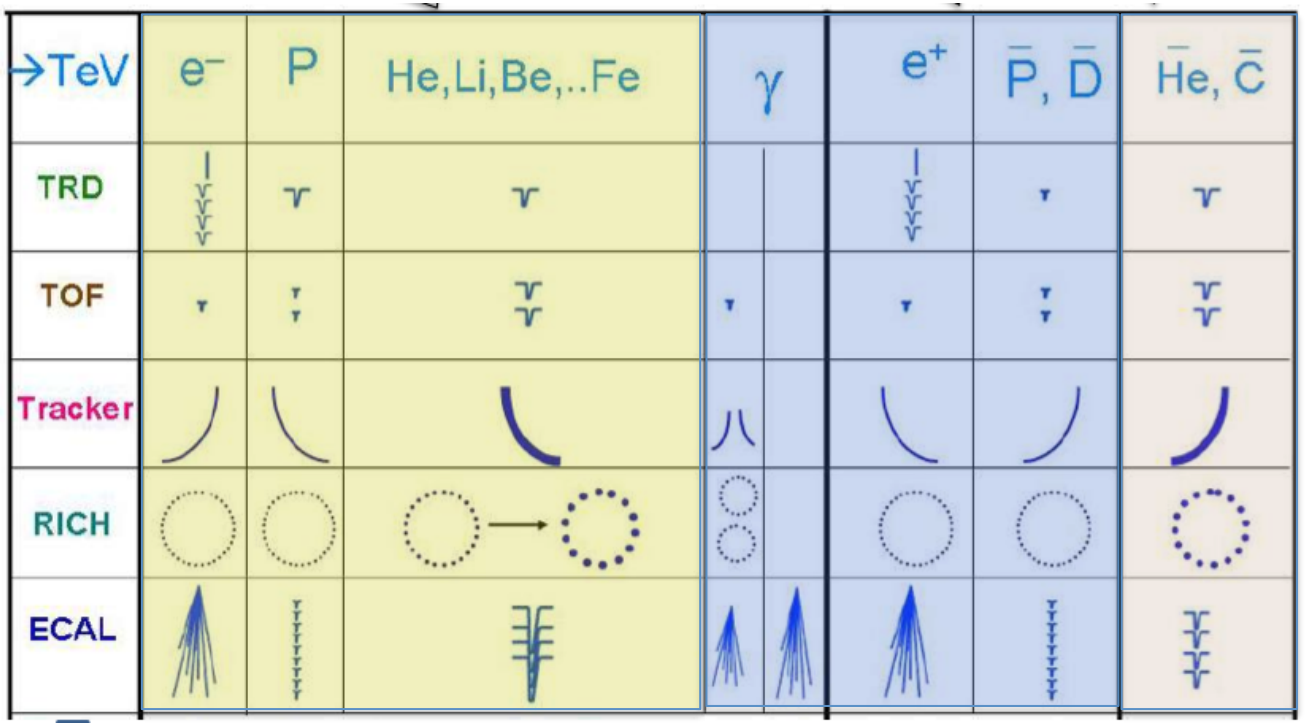
e/hadrons rejection

Trigger,
Particle direction, β, Z^2

Charge sign, P, Z^2, E

β, Z^2

Trigger,
E, e/hadrons rejection,
photon detection



Chemical composition and energy spectra of cosmic rays

Indirect search for Dark Matter

Primordial antimatter

AMS-02 Launch

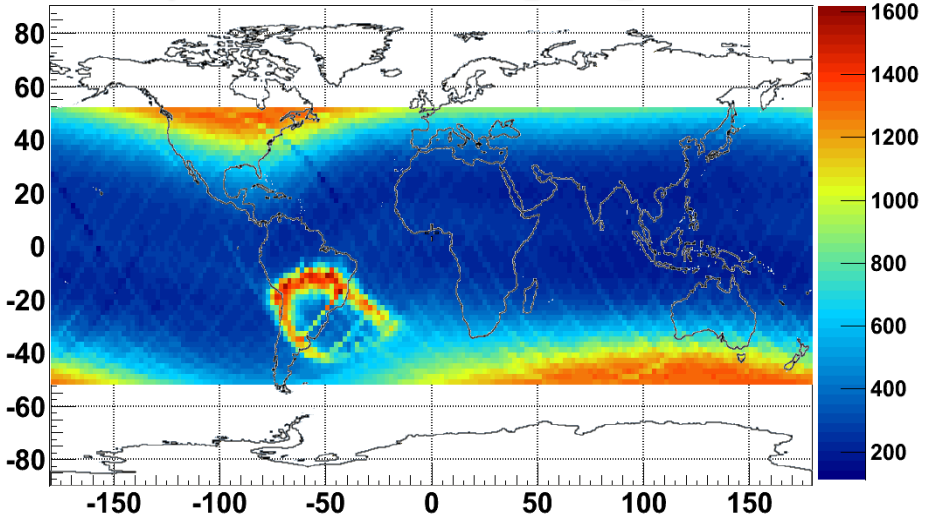
After 12 years of construction, integration, test…

STS-134 Endeavour:

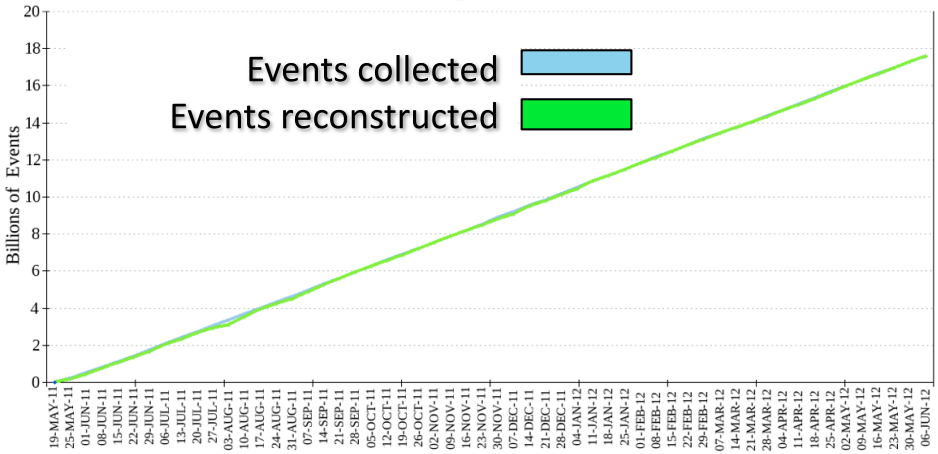
- Successful launch: May 16, 14:56
- Docking with ISS: May17, 17:59
- AMS installation complete: May 19, 11:46
- AMS up and running: May 19, 16:38
- First He nucleus: May 19, 16:42

Orbital DAQ Parameters

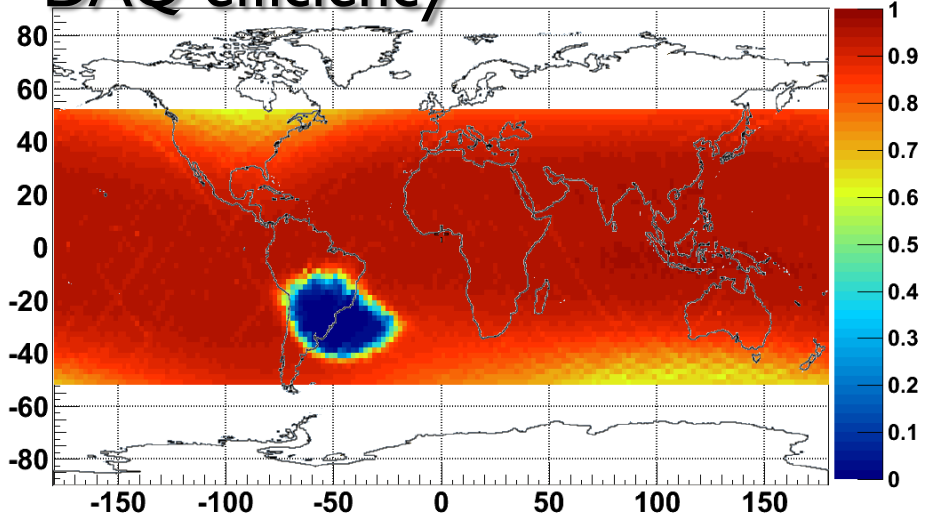
Acquisition rate [Hz]



18×10^9 events/year



DAQ efficiency

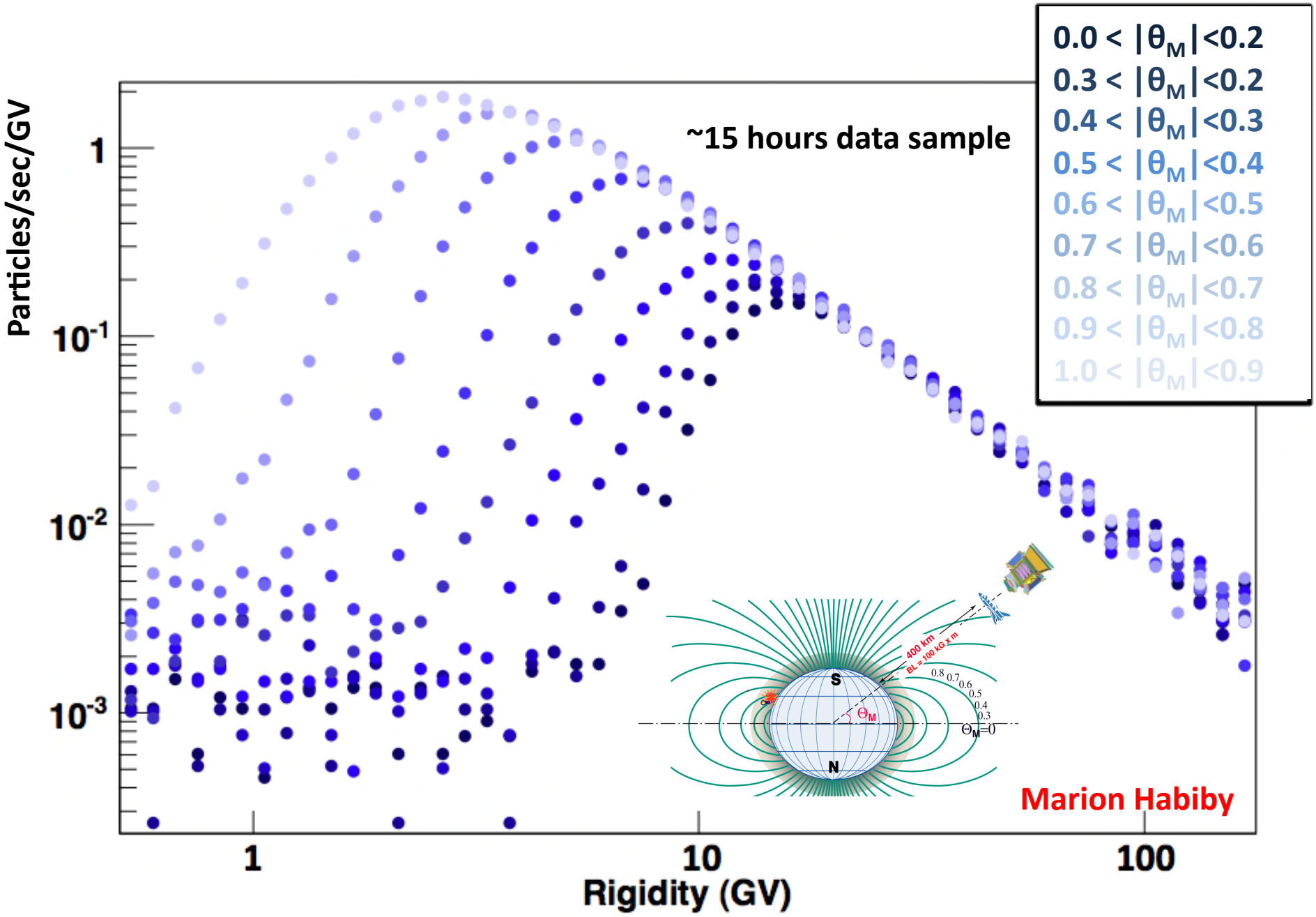


Particle rates vary from 200 to 2000 Hz per orbit

On average:
DAQ efficiency 85%
<DAQ rate> ~ 700Hz

Helium spectrum measurement

(Ph.D. Thesis Marion Habiby)



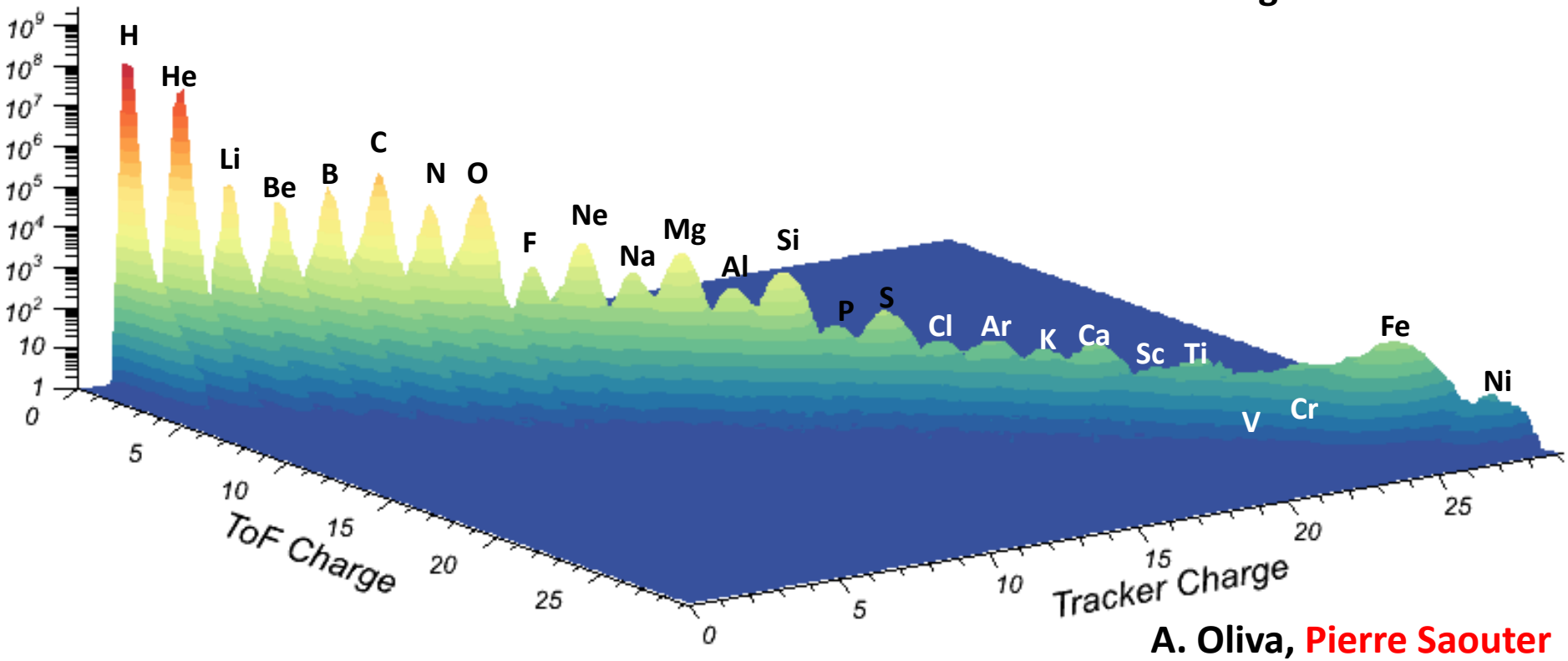
Nuclear Abundance Measurements

(Ph.D. Thesis Pierre Saouter)

For energies from 100 MeV to 1 TeV
with 1% accuracy over the 11-year solar cycle.

- Input to galactic propagation models
- Radiation hazard and space weather
- Background to search for non-standard sources

Tracker calibration for the measurement of the charge



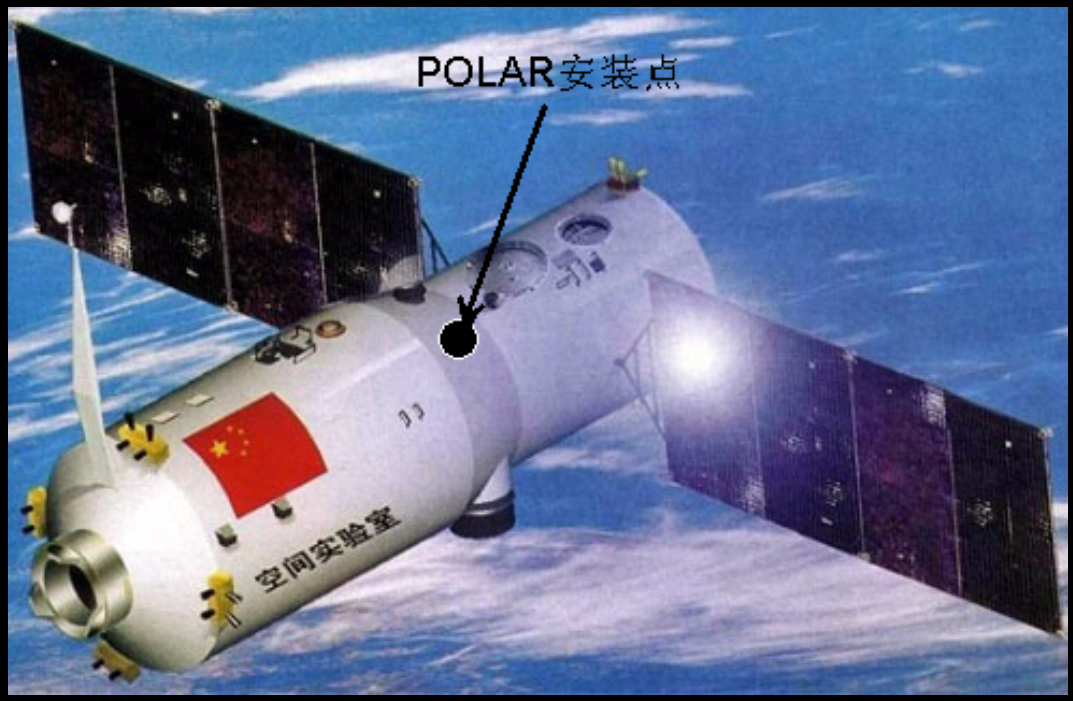
A. Oliva, Pierre Saouter

AMS-02: Conclusions

- AMS has been successfully launched and installed on the ISS.
- All detector subsystems are alive and well, no damage has been incurred during launch.
- All control systems, including thermal control function perfectly.
- Science and meta-data are timely transmitted with the necessary bandwidth.
- Detector performance is the same as the one assessed on ground.
- Commissioning phase is finished.
- Calibration and alignment are progressing well.
- DPNC involvement in data analysis:
  - Calibration of the Silicon Tracker (P. Saouter)
  - Measurement of nuclei spectra (P. Saouter and M. Habiby)
  - Study of the effect of solar activity on Cosmic Ray spectra (M. Paniccia)
- Expect first public science results by 2013

POLAR: a Gamma Ray Bursts Polarimeter in space

- novel and compact Compton polarimeter devoted to study the prompt emission of GRBs
- Measure X-rays in the energy range 50–500 keV
- Launch on the Chinese Spacelab Tian Gong-2 in 2014
- Lifetime: 3 years



Univ. Geneva

ISDC Geneva

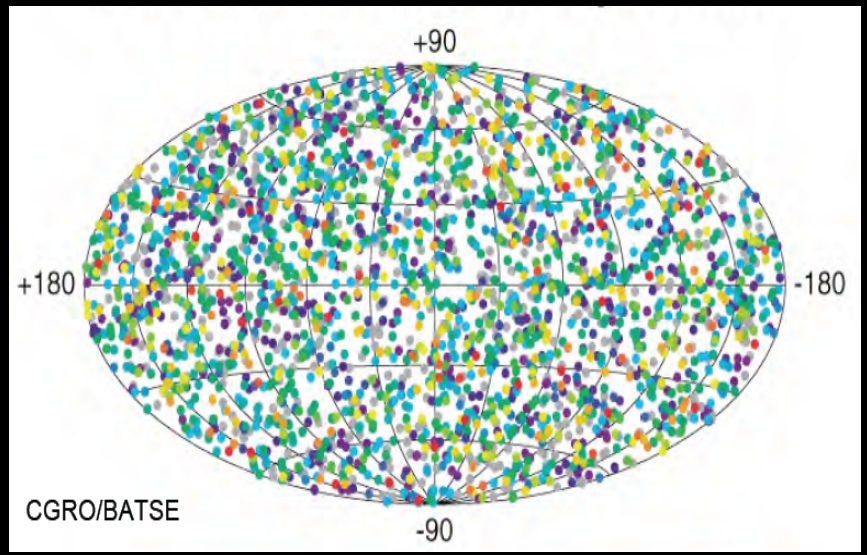
PSI Zurich

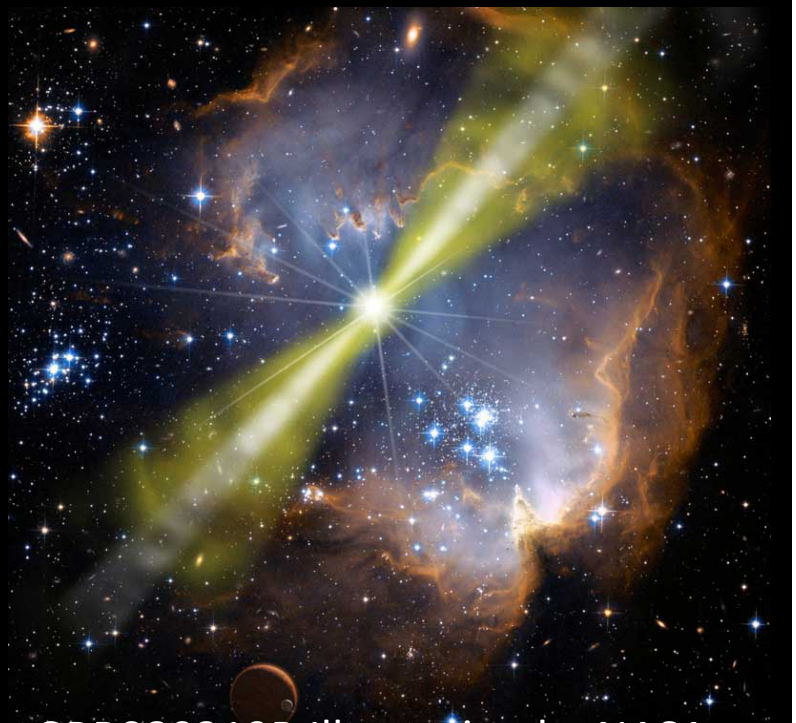
IHEP Beijing

NCBJ Warsaw

What are Gamma Ray Bursts ?

- Gamma Ray bursts (GRB) are flashes of gamma rays randomly distributed in the sky and in time.
- Brightest events in the universe since Big Bang; some release more energy in 10 seconds than what the Sun will emit in its entire 10 billion year lifetime!
- Traditionally divided in two categories:
  - long: associated to the collapse of massive stars
  - short: originate from NeutronStar- NeutronStar or BlackHole-NeutronStar mergers
- 491 GRBs in *2-year Fermi GRB catalog*



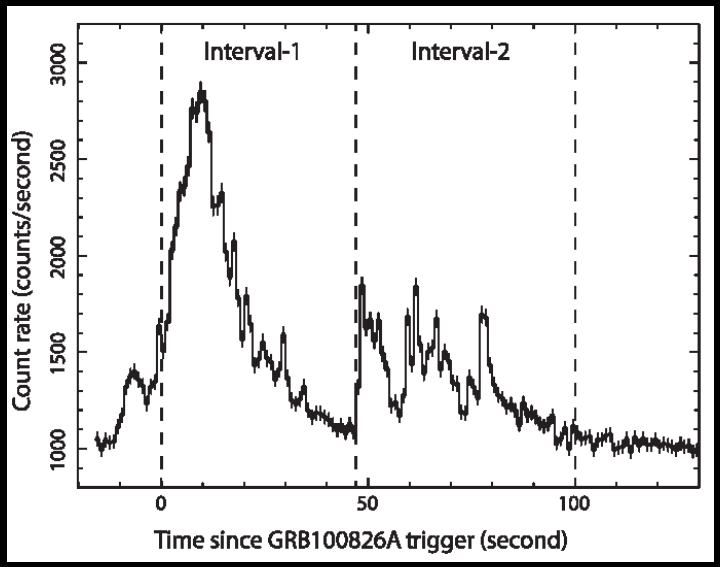


GRB080319B Illustration by NASA

GRB Characteristics

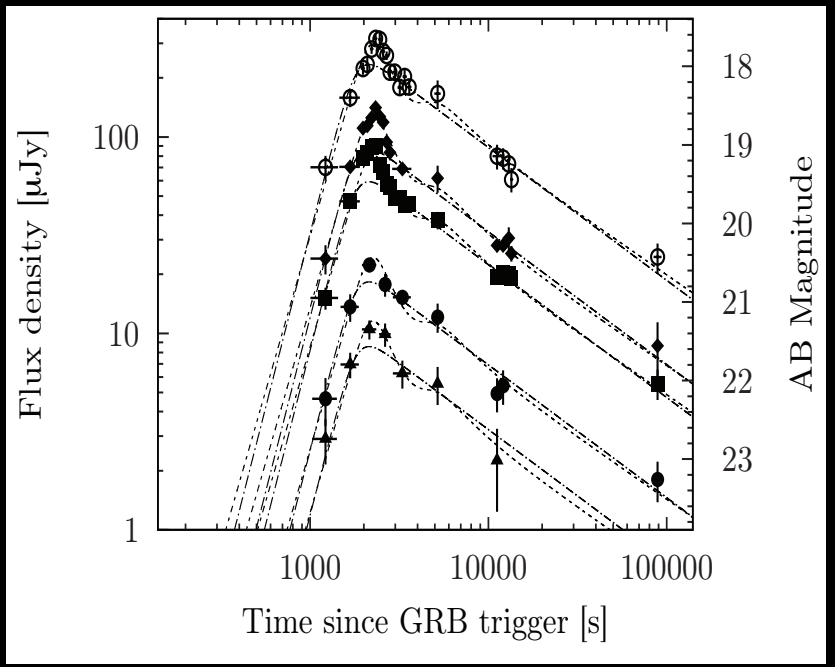
Presence of jets

Prompt emission:



- duration of seconds/minutes
- Energy spectrum broken power law from keV to O(100) MeV, evolving in time, asymmetric
- High Efficiency in converting energy to radiation
- Polarization?

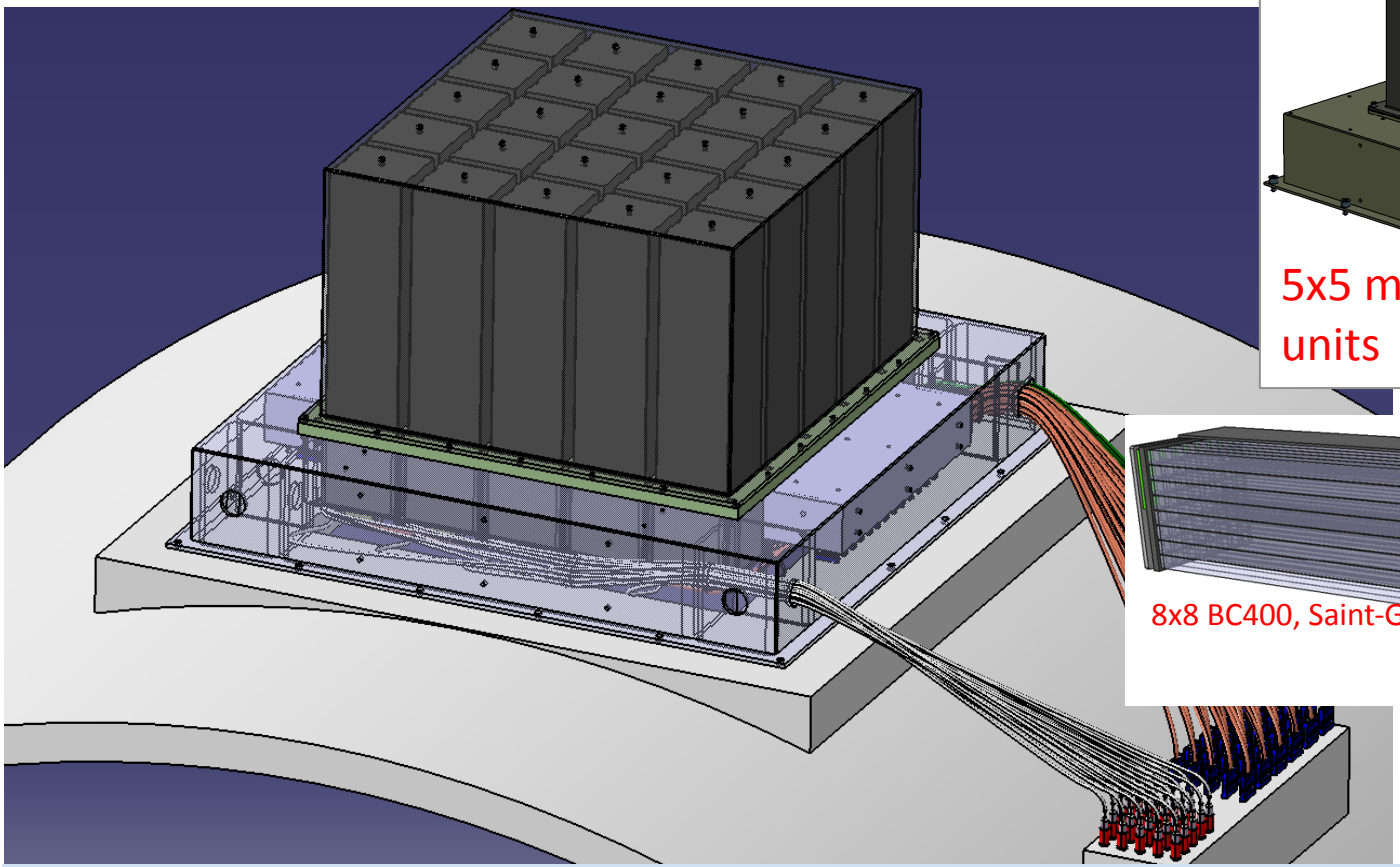
Afterglow:

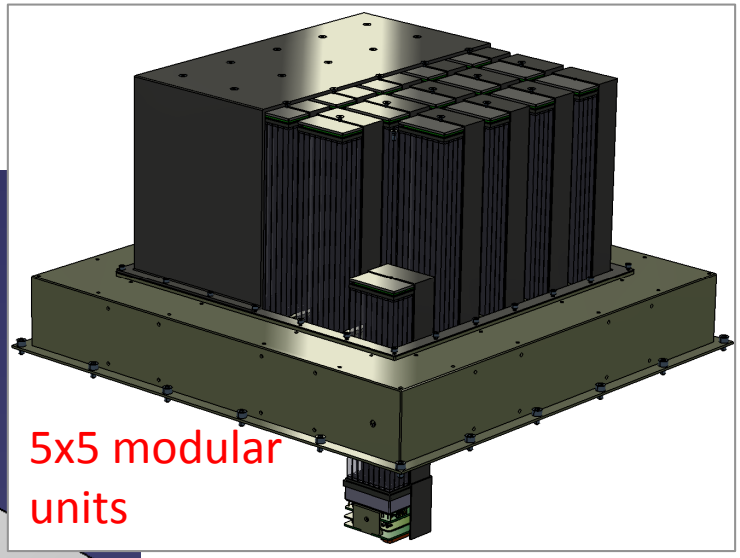


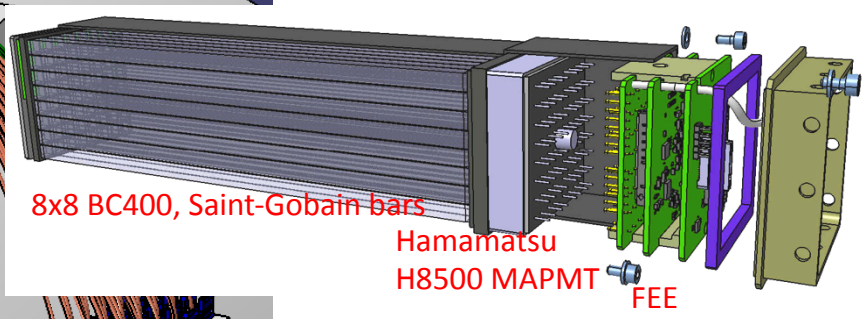
- Optical / NIR
- highly variable

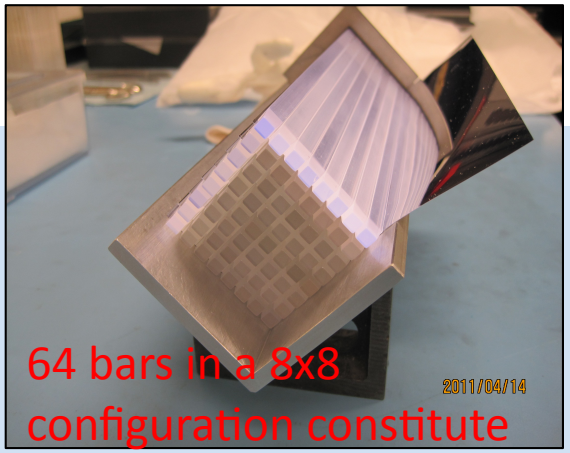
To discriminate among models describing GRB prompt emission need to measure the polarization better than 10%

The POLAR detector







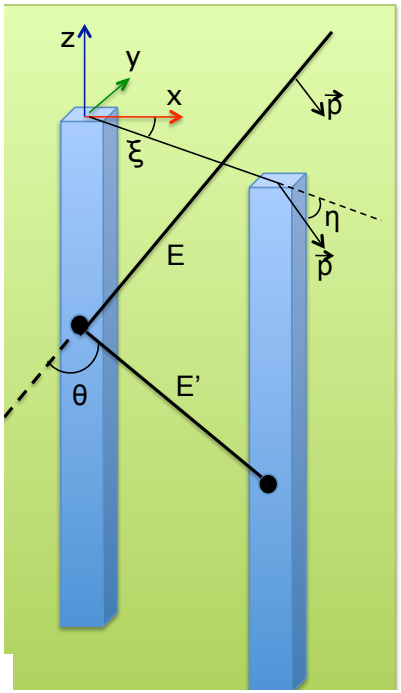


- Compton polarimeter
- Measure X-rays in the energy range 50–500 keV
- Space-based (atmosphere opaque for X-rays)
- Compact: 30kg
- Wide field of view: ~1/3 full sky
- During transients, flux is up to tens of photons cm^{-2} s^{-1}: rate >10kHz

Photon polarization measurement in POLAR

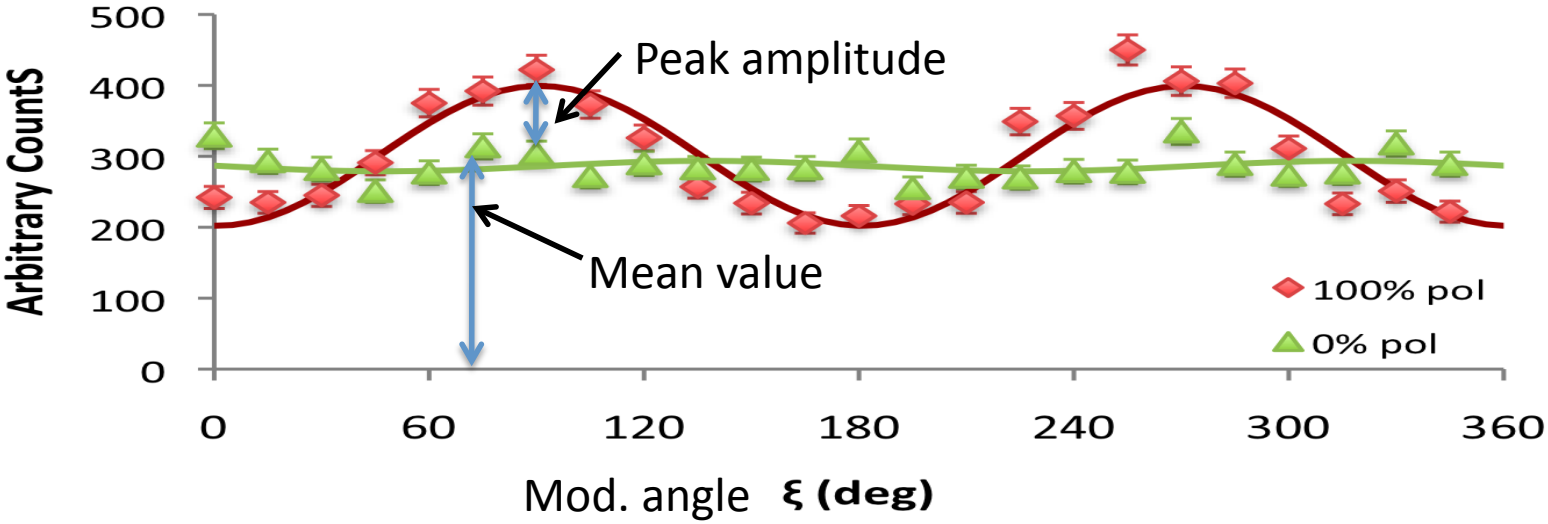
Photons tend to Compton scatter at right angles to the incident polarization direction

Hard X-ray photons arriving from a GRB have a 80% probability of experiencing Compton scattering in the target, generating a signal in more than one channel



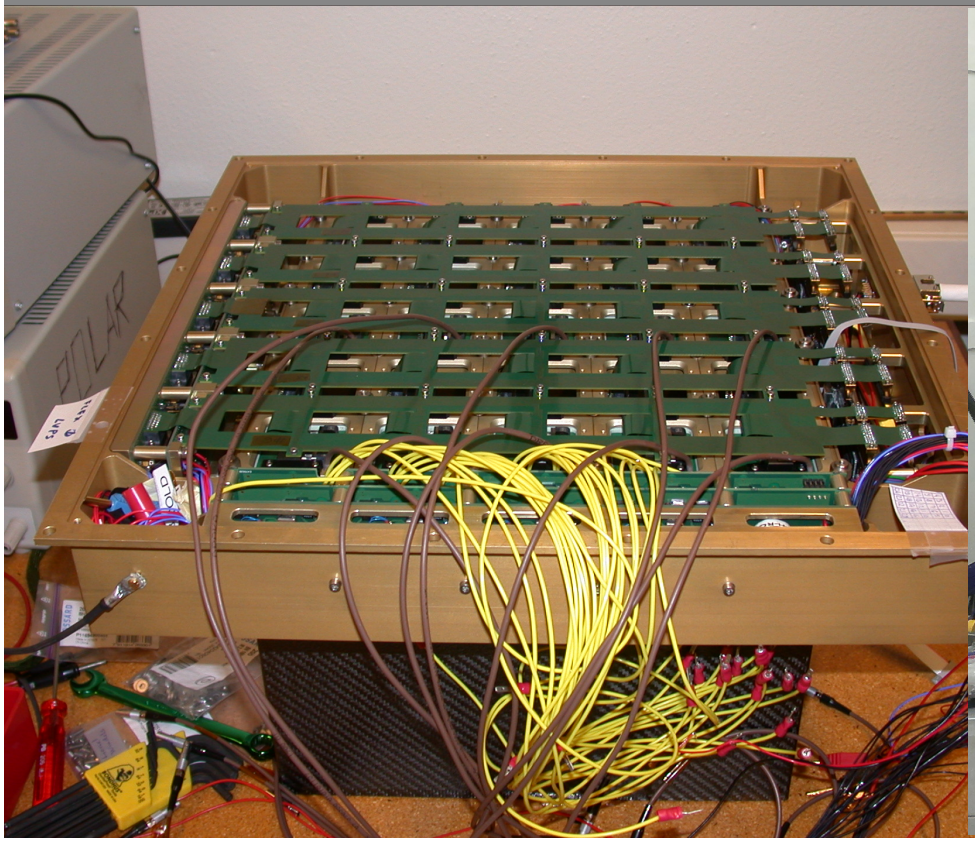
The position of the two bars with the highest energy depositions is related to the azimuthal Compton-scattering angle of the incoming photon.

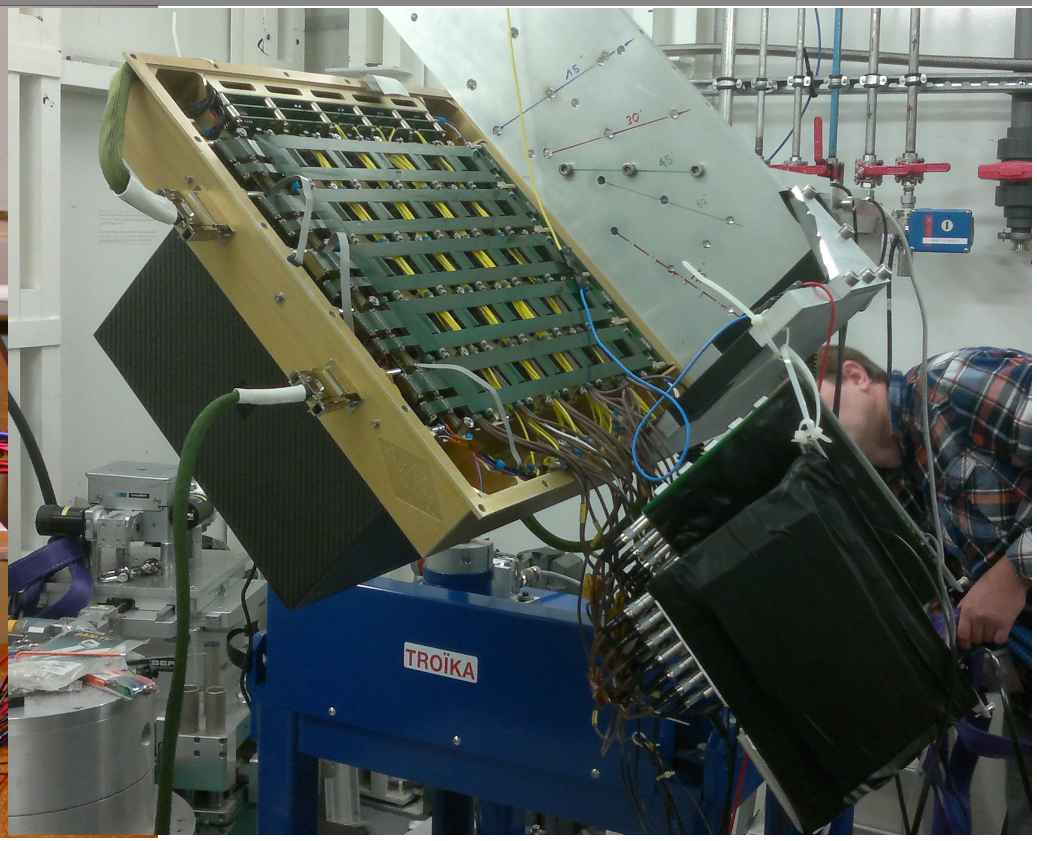
If the γ-ray emission from the GRB was not polarized, the modulation curve, i.e. the azimuthal distribution of the ensemble of events, is flat. Otherwise it follows a sinusoidal curve whose amplitude is the so-called modulation factor, and whose phase-shift indicates the angle of linear polarization of the GRB photons



Status of POLAR

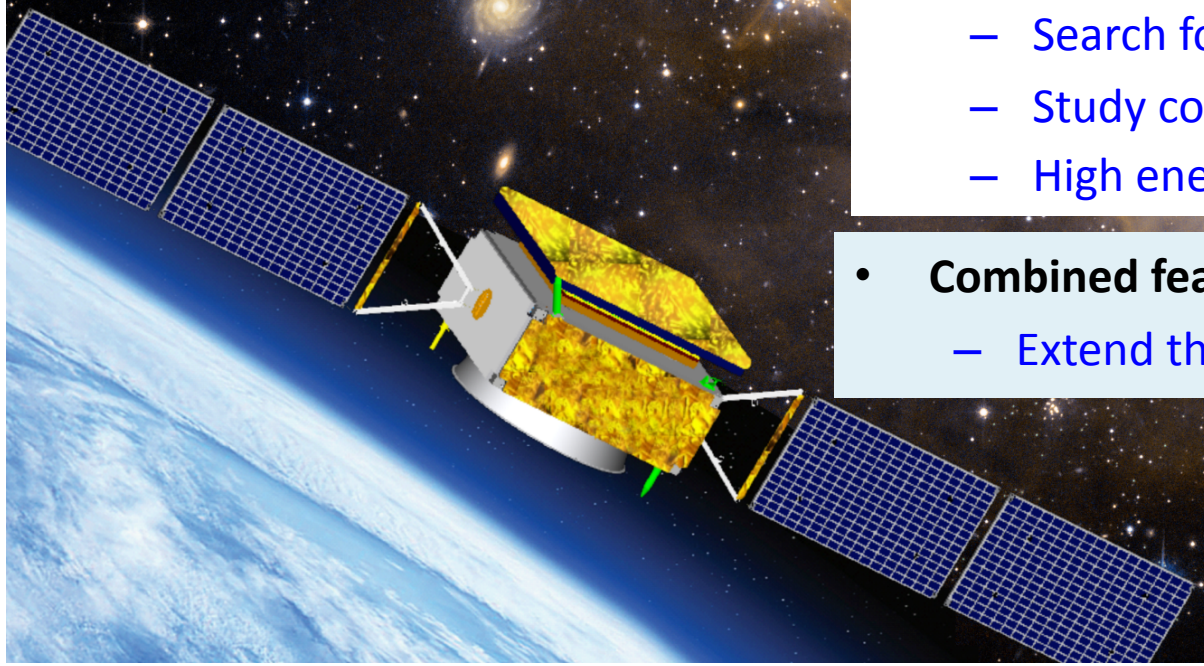
- Two copies of flight model already built:
  - QM1 fully assembled, now under test in China
  - QM2 fully assembled, tested in ESRF (France) 3-11 Dec 2012 :
    assess the polarimetric capabilities of POLAR and validate MC simulations
- Space qualification tests of QM2 in early 2013





DAMPE: DArk Matter Particle Explorer

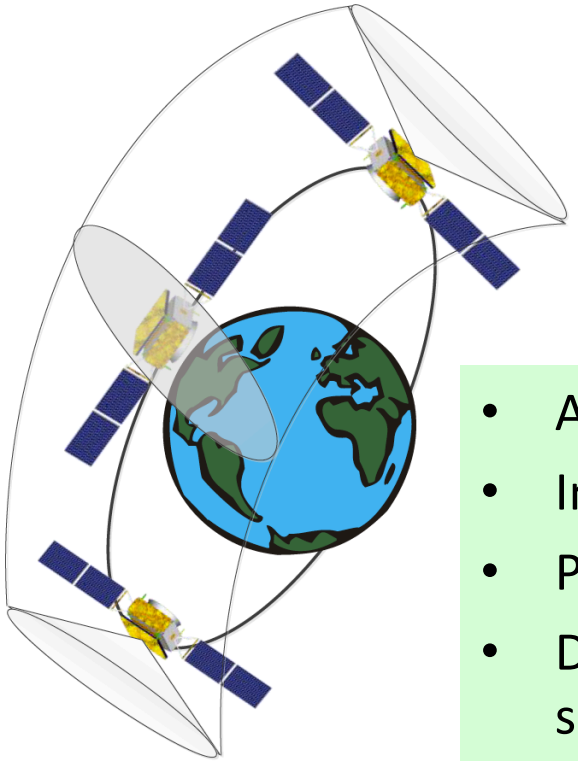
DPNC: X. Wu, M. Pohl, F. Cadoux, D. La Marra



- **High energy particle detection in space**
  - Search for Dark Matter signatures
  - Study cosmic ray spectrum and composition
  - High energy gamma astronomy
- **Combined features of Fermi/LAT and AMS-02**
  - Extend the energy reach and better resolution

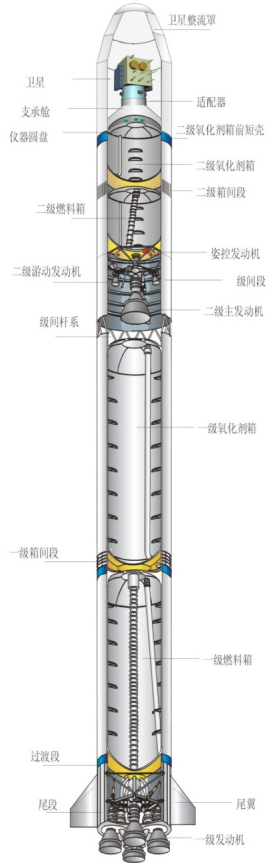
Dark Matter Particle Explorer Satellite

- One of the 5 satellite missions of the “Strategic Priority Research Program in Space Science” of Chinese Academy of Sciences
  - Approved for construction in Dec. 2011, launch date “late 2015”
  - Purple Mountain Observatory, University of Science and Technology of China, Institute of Modern Physics, Institute of High Energy Physics, Chinese National Space Science Center, **DPNC, (Perugia)**

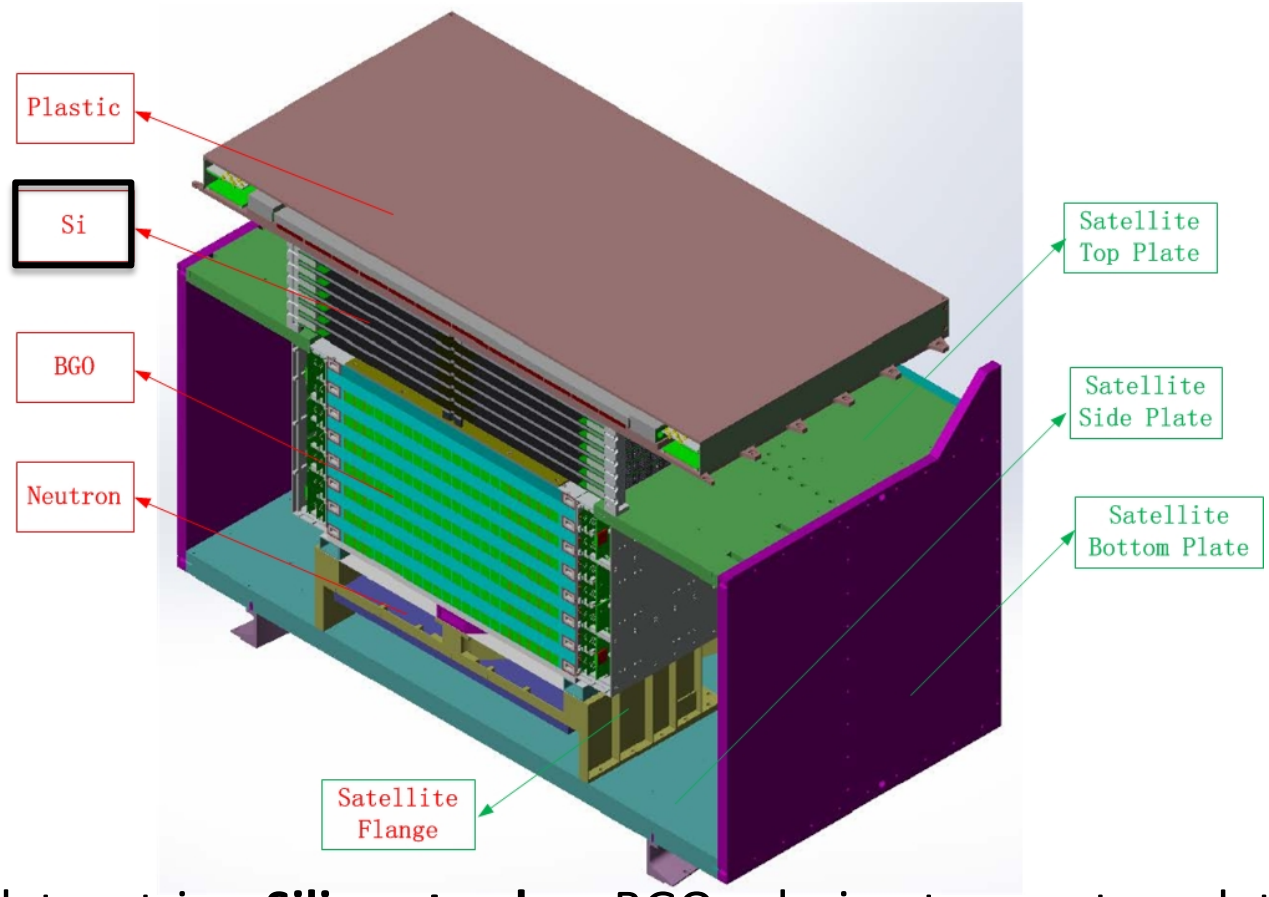


- Satellite < 1900 kg
- Power consumption 840W
- Lifetime > 3 years
- Launched by CZ-2D rockets

- Altitude 500 km
- Inclination 97.4065°
- Period 90 minutes
- Dawn/dsk (6:30 AM) sun-synchronous orbit

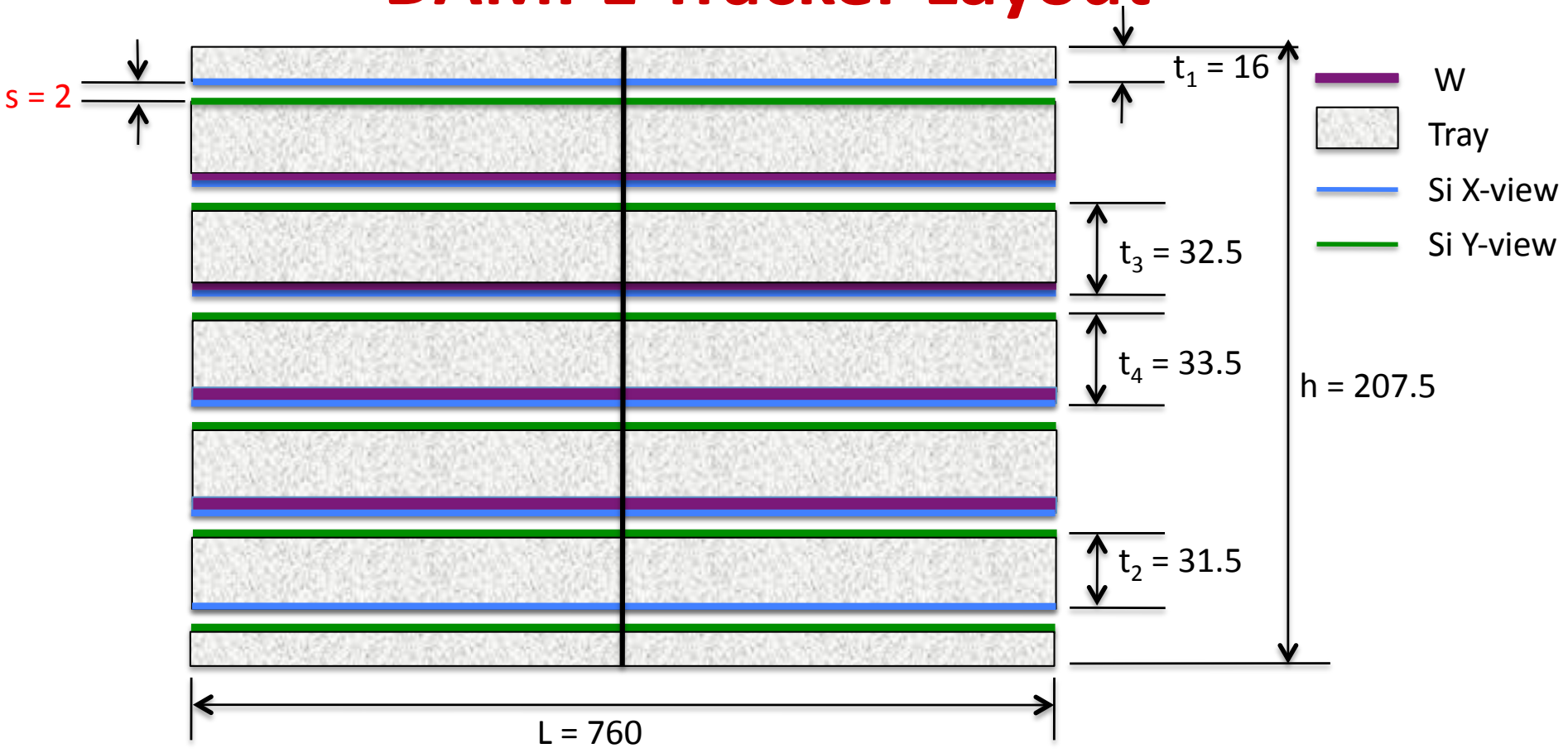


Sketch of DAMPE Payload



- Scintillator strips, **Silicon tracker**, BGO calorimeter, neutron detector
- Combine a γ-ray space telescope with a deep imaging calorimeter
  - Silicon tracker/converter + BGO imaging calorimeter
    - Total ~35 X_0 → deepest calorimeter in space
- **DPNC in charge of the Silicon Tracker and the test beam coordination**

DAMPE Tracker Layout

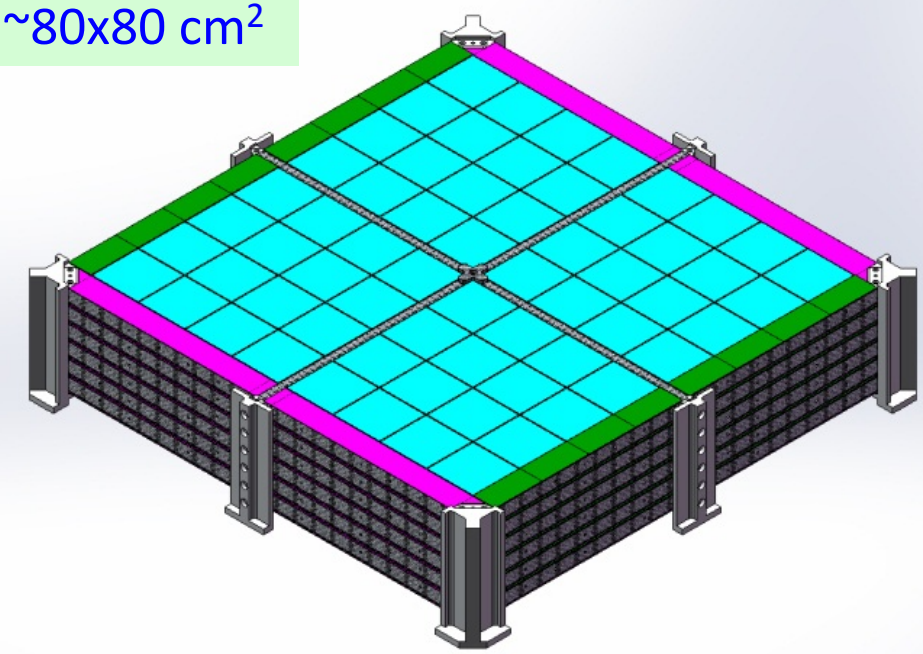


- 4 tungsten layers, total 67 kg of W, total weight ~85kg
  - thickness 2x1 mm + 2x2 mm = 1.71 X_0
- A tracking plane is made of 2x8 ladders head to head
  - 7 m^2 of total silicon surface, 74k analog readout channels
- **Achieve 40 µm position resolution**

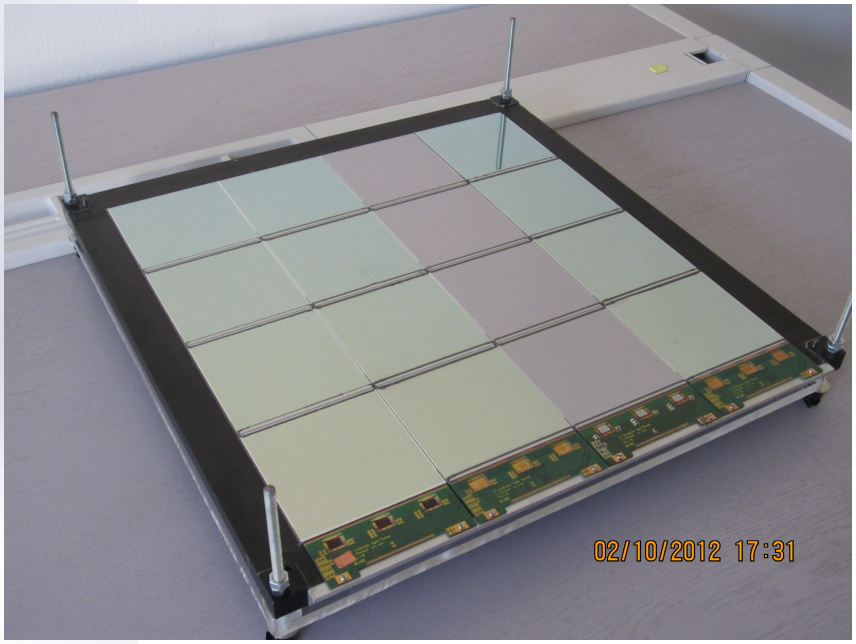
The DAMPE Si Tracker

- **Great improvement of science capability of the payload**
  - Superior γ−ray identification and efficiency, better pointing precision
  - **Excellent ion charge measurement (Analog readout)**
  - Integrate Tungsten plates into a tracker with Si strip detectors
    - Successfully used in AGILE and Fermi/LAT
- **Fits well with experience and technical expertise of DPNC**

~80x80 cm^2



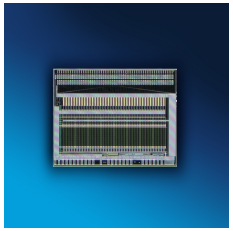
~40-100 μm position resolution

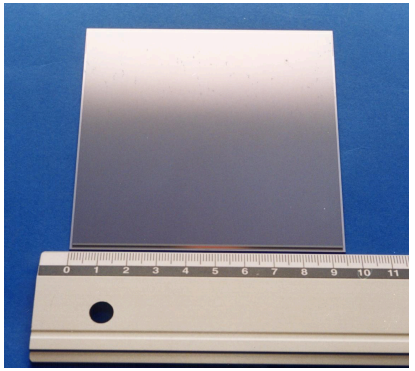


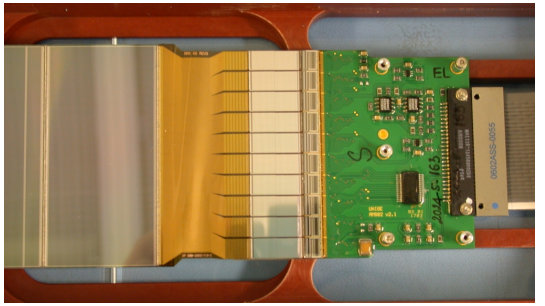
- A prototype tray (from AGILE, 4 times smaller)

DAMPE Tracker Components and Assembly

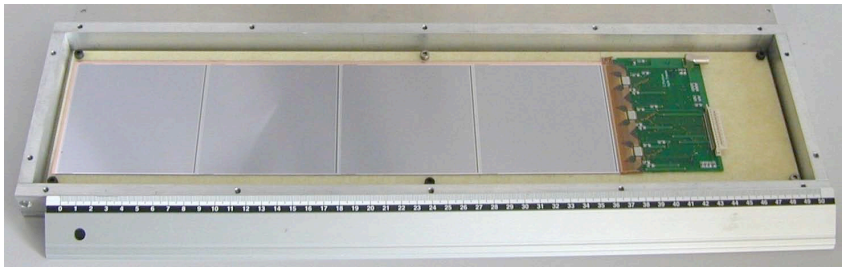
- Silicon sensor (Hamamatsu)
  - use AGILE specification, available
- FE ASIC (Gamma Medica-Ideas)
  - use updated version of the AMS ASICs, available
- Readout electronics
  - Updated of the AMS readout electronics
    - designed by DPNC

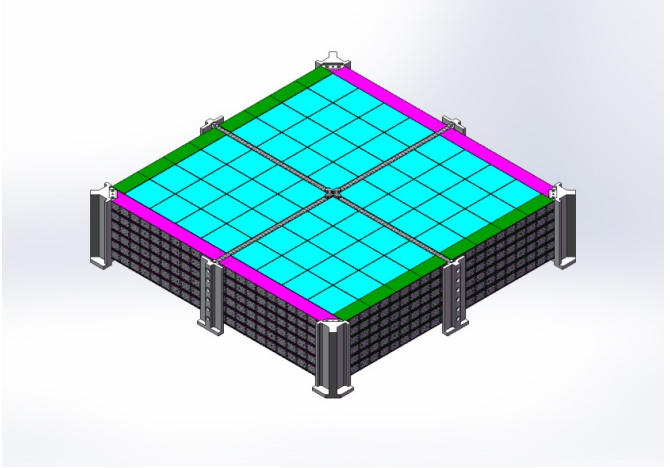






- Mechanics: silicon ladder, support tray and tracker assembly (DPNC, Perugia)

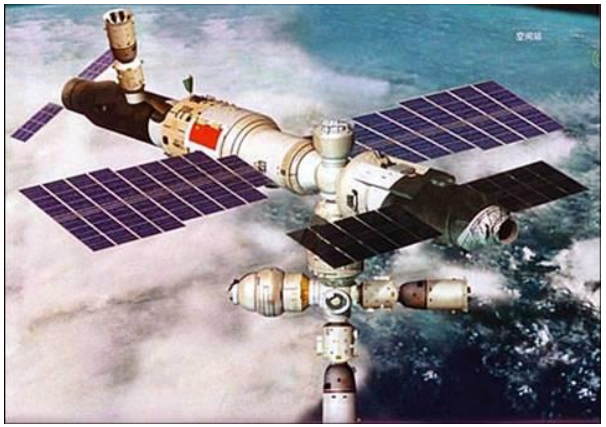




DAMPE Silicon Tracker Status

- Chinese Academy of Science has agreed to fully finance the project
  - In final stage of discussion of funding agreement
- Planning: two stages of about 1 year each
  - Calibration Module (CM) stage: 2013
  - Flight Module (FM) stage: 2014
- Development and construction will be mainly done at DPNC and Perugia with manpower financed by CAS
  - Suitable tasks will be subcontracted to industry
- Preparing for science to reflect important construction responsibilities of DPNC and close proximities with AMS-02, POLAR and ISDC
  - Simulation of the response of DAMPE to electron, photon and nuclei
  - Collaboration with the AMS-02 team at DPNC to study chemical composition of cosmic rays
  - Analysis of FERMI public data to prepare for the analysis of high energy γ

Future project: HERD



- **HERD: H**igh **E**nergy cosmic **R**adiation **D**etection facility
  - On board of the Chinese Space Station (~2020)
  - Bigger geometrical acceptance, better energy resolutions to very high energy cosmic rays ("knee region" ~1 PeV)
  - Pushing the boundary on DM search, γ-ray astronomy and cosmic rays
- **Mission concept selected as one of very few at facility scale**
- 1st International Workshop (Pohl in Program Committee) in Oct., 2012, Beijing
  - DPNC (Pohl) assigned as convener for charge measurement and tracking
- DPNC proposed a Si shower tracker
- With POLAR, DAMPE and HERD, DPNC is becoming a very active partner of the fast growing Chinese Space Science program