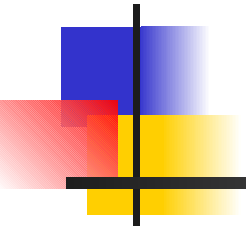
Experience with the AMS Silicon Tracker



Maurice Bourquin

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On behalf of the AMS Tracker Collaboration

Hiroshima Symposium
June 2004

AMS-02 Tracker Collaboration

- Perugia INFN and University (Italy) (INFN and ASI)
- Geneva University (Switzerland) (SNF)
- Sun Yat-Sen University, Guangzhou (China)
- National Aerospace Laboratory (NLR) (The Netherlands)
- Aachen Ist Institute (Germany) (DARA)
- Montpellier (IN2P3) (France)
- Turku University (Finland) (TEKES)
- Moscow State University (Russia)
- South East University (Nanjing) (China)
- Institute of Space Science & University of Bucharest (Rumania)
- Electronics in collaboration with CSIST (Taiwan) and MIT (USA)

The AMS-02 Detector

TRD: e/p separation

TOF: ß and |Z|, sign(Z)

Star tracker: pointing

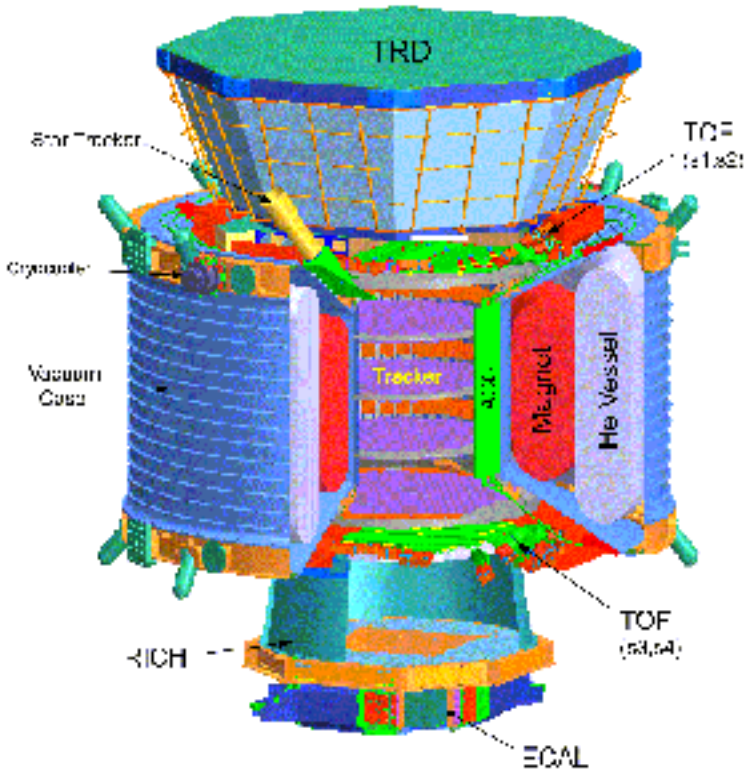
Magnet: 0.8 T, sign(Z)

Si tracker: p, |Z|, sign(Z)

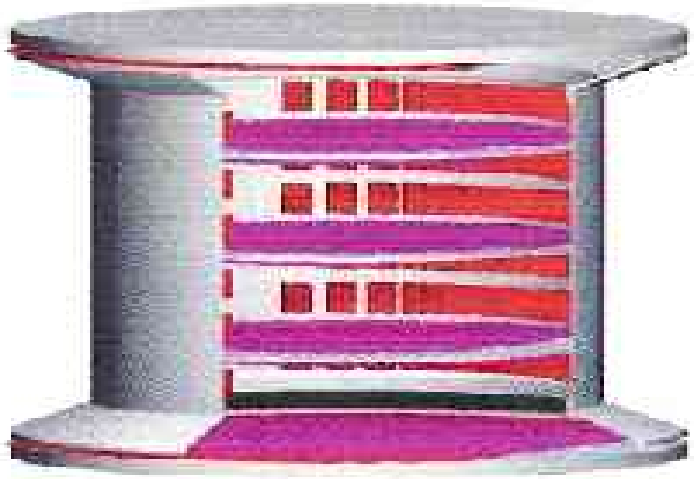
ACC: anticoincidence system

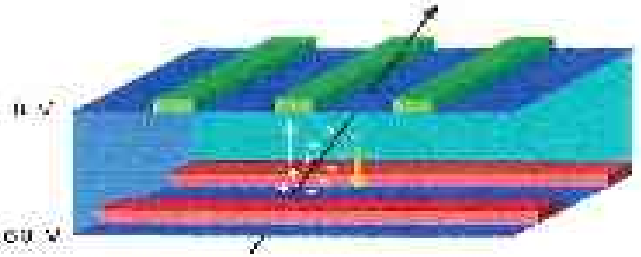
RICH: ß and |Z|, sign(Z)

ECAL: e/p separation



The AMS-02 Tracker

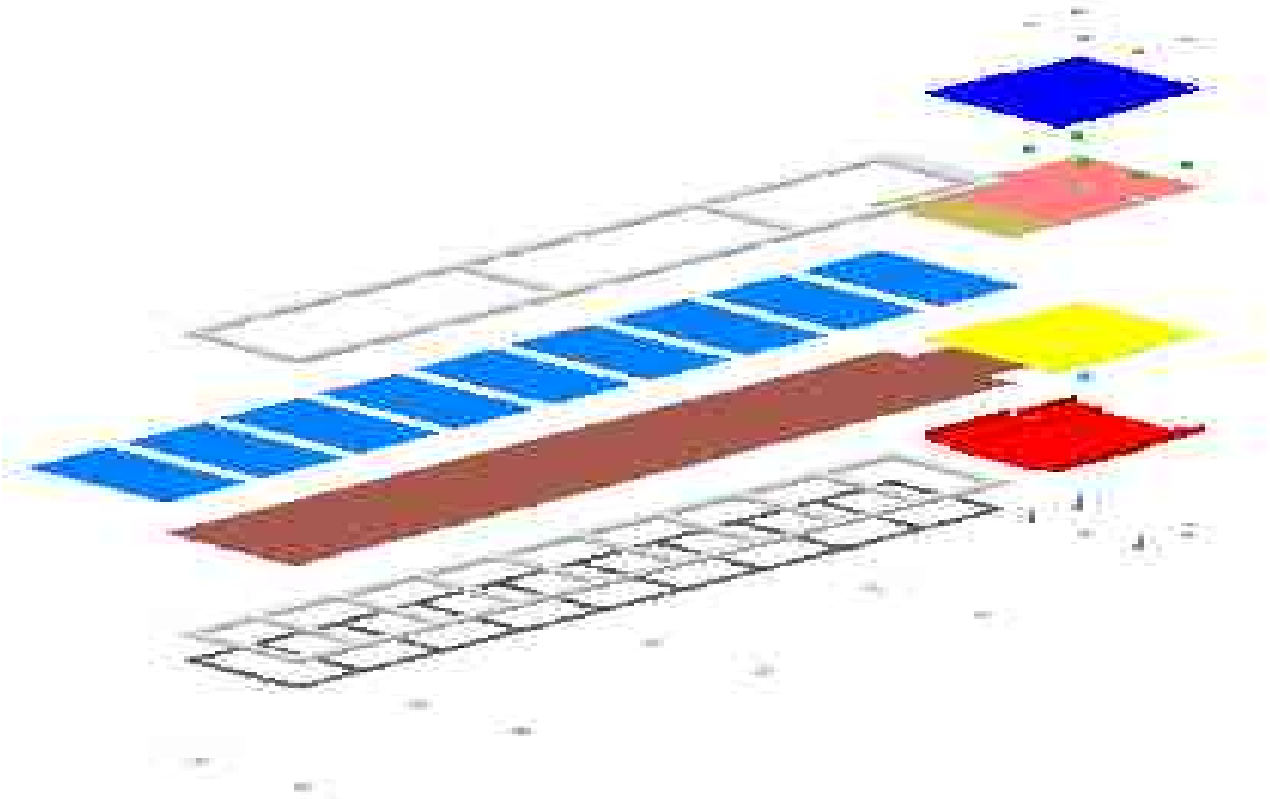




- Localization of charged particle by double sided silicon sensors
- Eight layers (L1 . . . L8) of $\sim 1\,m^2$ each on five ultra-light support planes (P1 . . . P5)
- Total of ~2500 double-sided sensors
- Resolution $\sim 10\,\mu m$ in bending direction, $\sim 20\,\mu m$ in non-bending direction

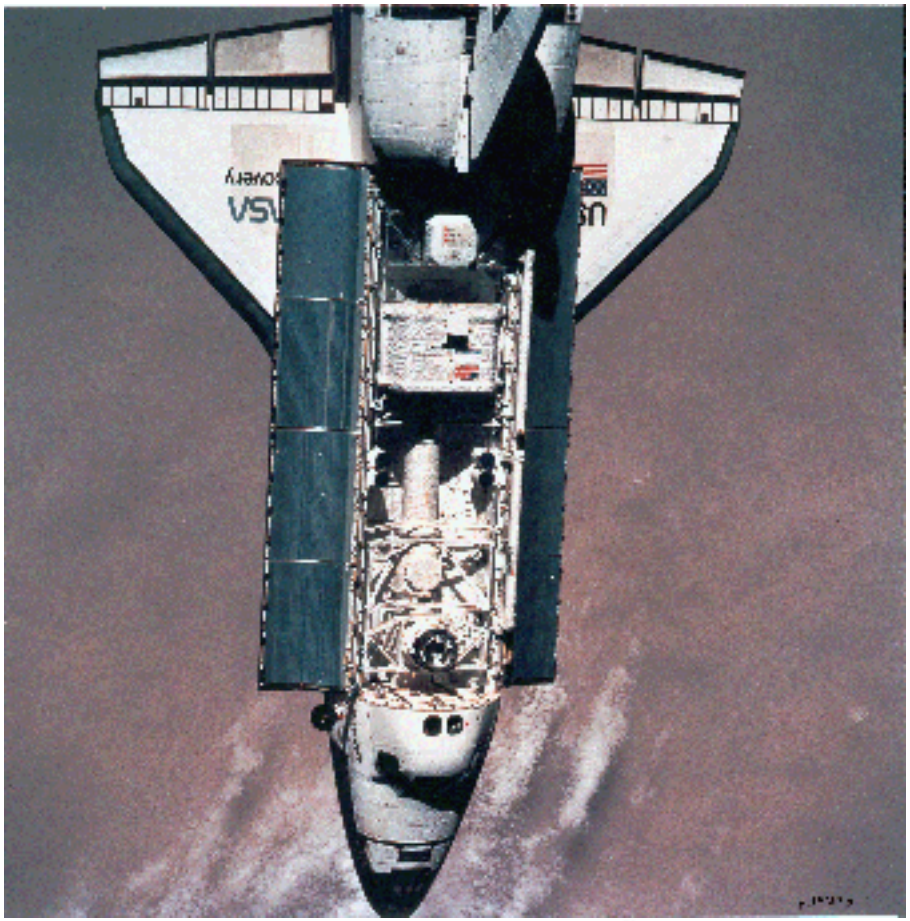
- Measures rigidity p/Z up to a few tens of TeV
- Measures specific energy loss $dE/dx \sim |Z^2|$ for identification of elements
- Measures direction and energy of converted photons

Structure of an AMS Ladder



STS-91 shuttle experimental flight

- 2-11 June, 1998
  10 days flight on Shuttle Discovery
- about 100 hours of data taking
  100 million events
- very interesting physics results
  - measurement of primary fluxes
    p, He, $e^{\perp}$ ...
  - detection of secondary fluxes
    geomagnetic field effect
  - antimatter sensitivity extended
    $\overline{He}/He \sim 10^{-6}$



Space environnement constraint

IMPACT ON SILICON TRACKER

Limited weight	Sensors on thin and rigid Al+C honeycomb support planes Planes supported by C-fiber shells and conical flanges Cables: small dimensions and weight
Limited power (200 W)	Limit number of readout channels: Daisy chain signals in bending plane and multiplexing in non-bending one
Vibrations and accelerations	All eigenfrequencies required to be above 50 HZ - Perform simulations - Tests modules under vibrations

Impact on Silicon Tracker (cont.)

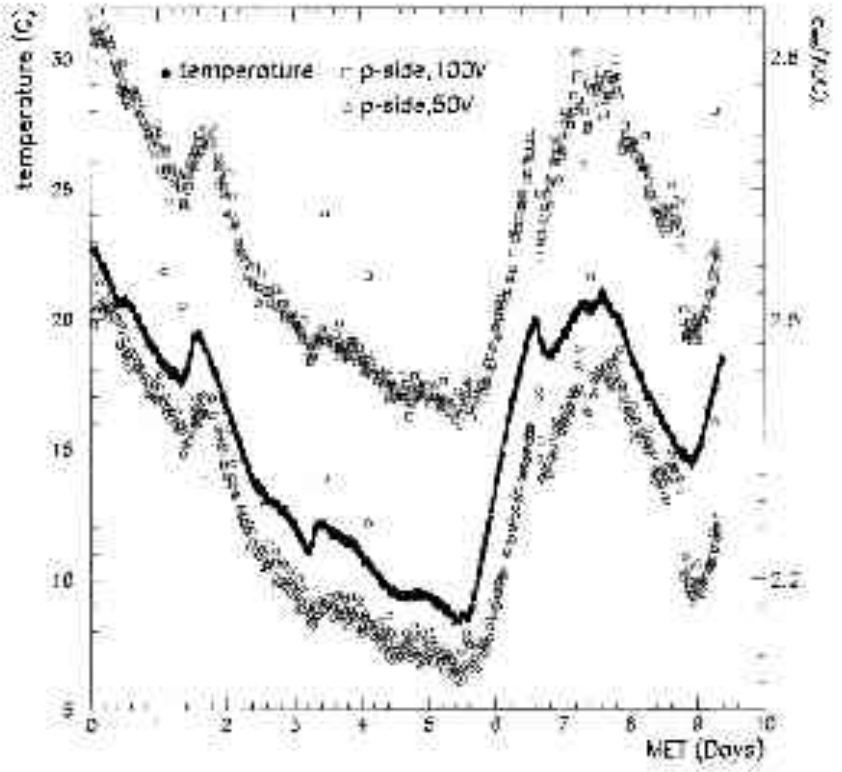
Pressure changes	Atmospheric pressure to vacuum in 10 seconds Long term outgasing: all materials checked with NASA
Limited data transfer	In situ calibration and compression of data Local buffering for extensive periods
Temperature changes	Heat removal by conduction to radiating surfaces (the permanent magnet in AMS-01) by active cooling system (two-phase pumped cooling loops to external radiators in AMS-02)
	Simulations
	Vacuum-thermal tests
	Permanent control by thermal sensors in orbit
Operation	Without human intervention (3 years for AMS)

The AMS-01 flight was a success

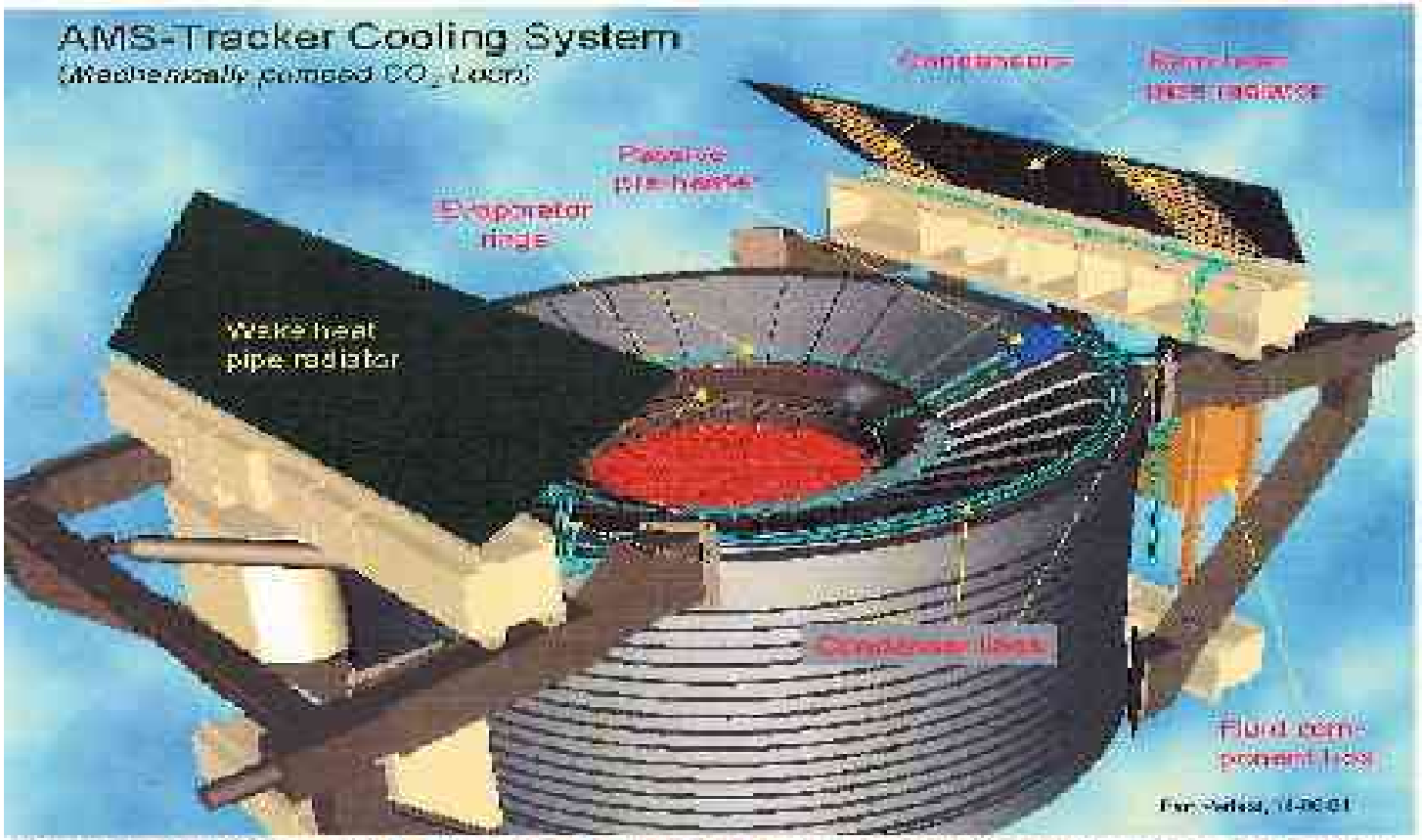
The tracker behaved perfectly well

AMS temperature and tracker noise during STS-91

Operating temperature 20 C+-5 C, surviving temperature 20 C+-20 C

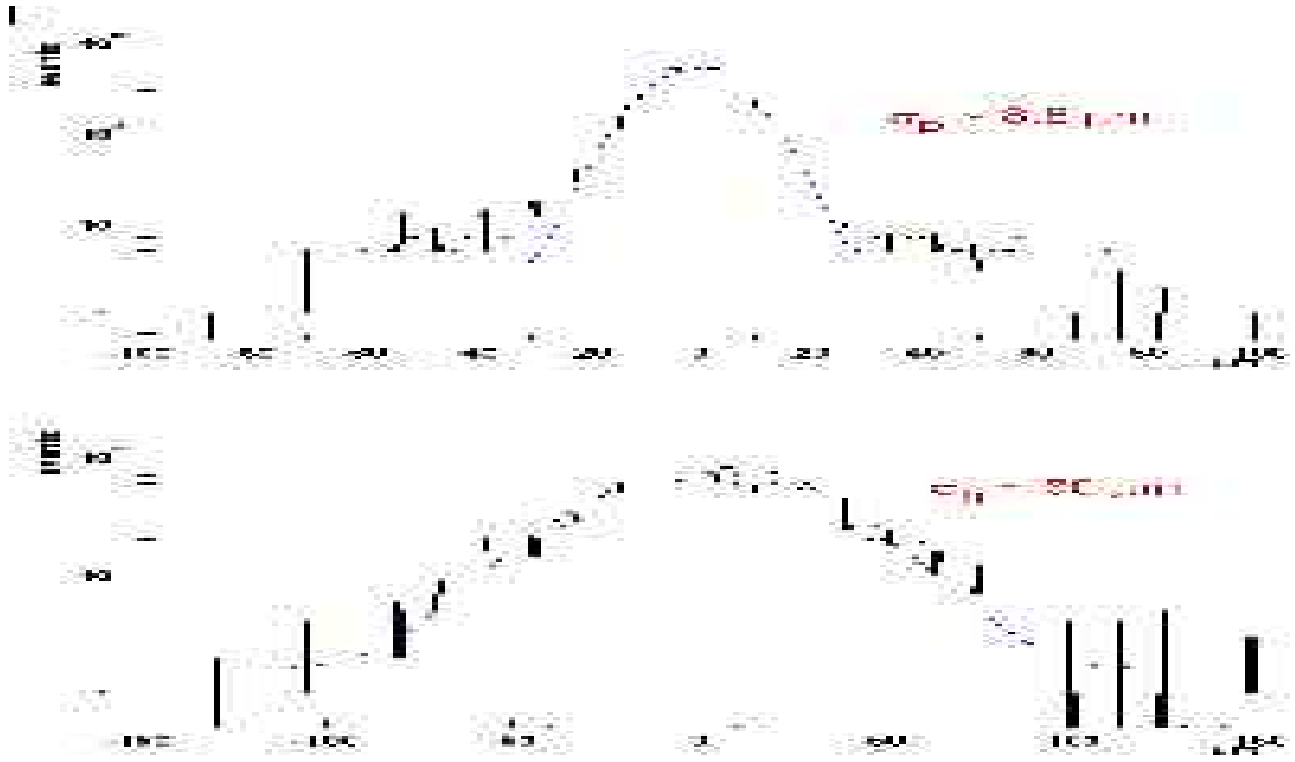


Tracker Thermal Control System



Collaboration with Dutch Aerospace Laboratory NLR and ZSU.

Tracker Performance: 1) spatial resolution



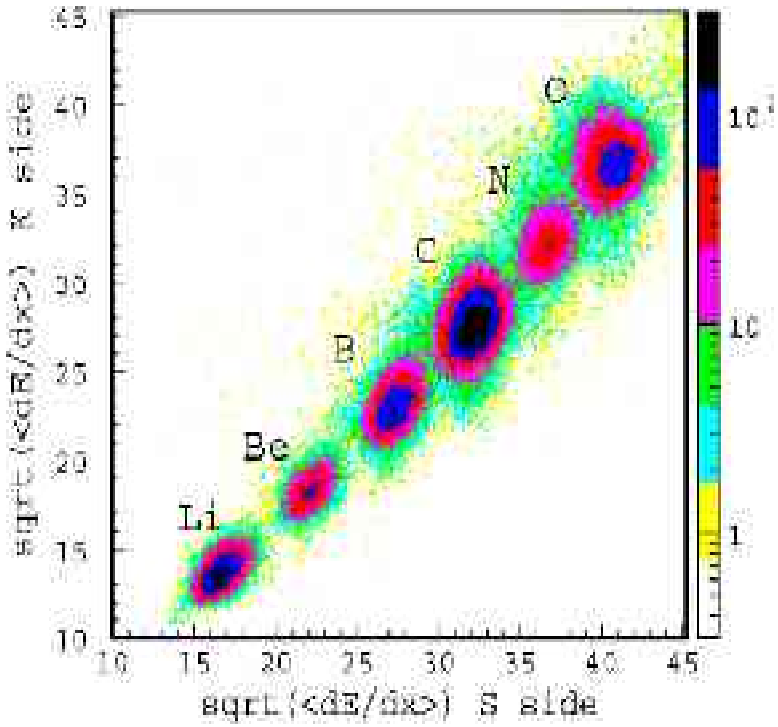
2) Charge determination

In AMS-01

high noise level of n-side strips

inefficient charge collection across the 208-micrometer readout gap

--> identification of nuclei up to Z=6 only (up to Z=26 for AMS-02)

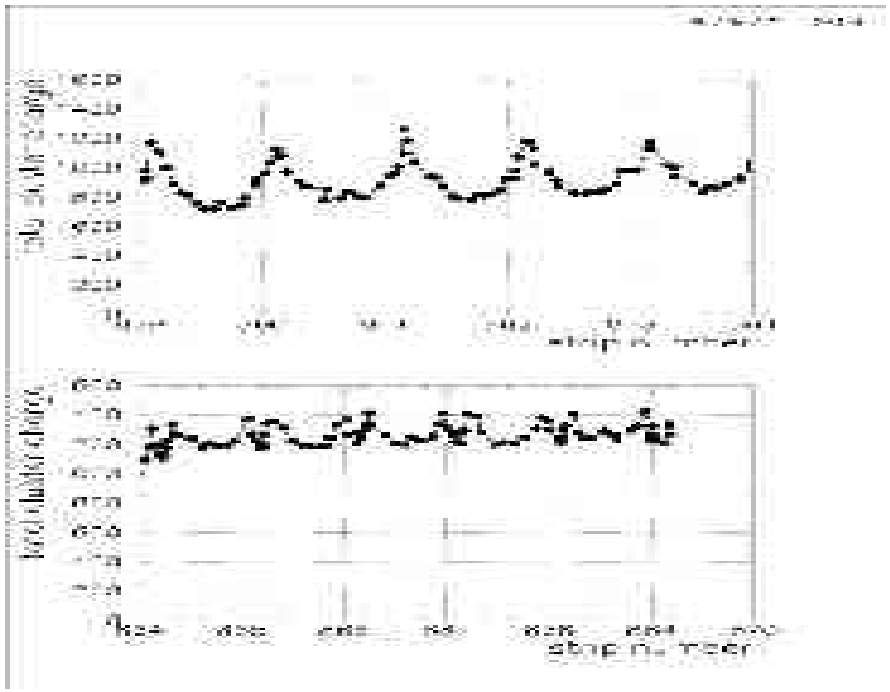


Improvements

- 1. Passivation of the silicon sensors to protects the sensors from surface damage during contacts with assembly tools.

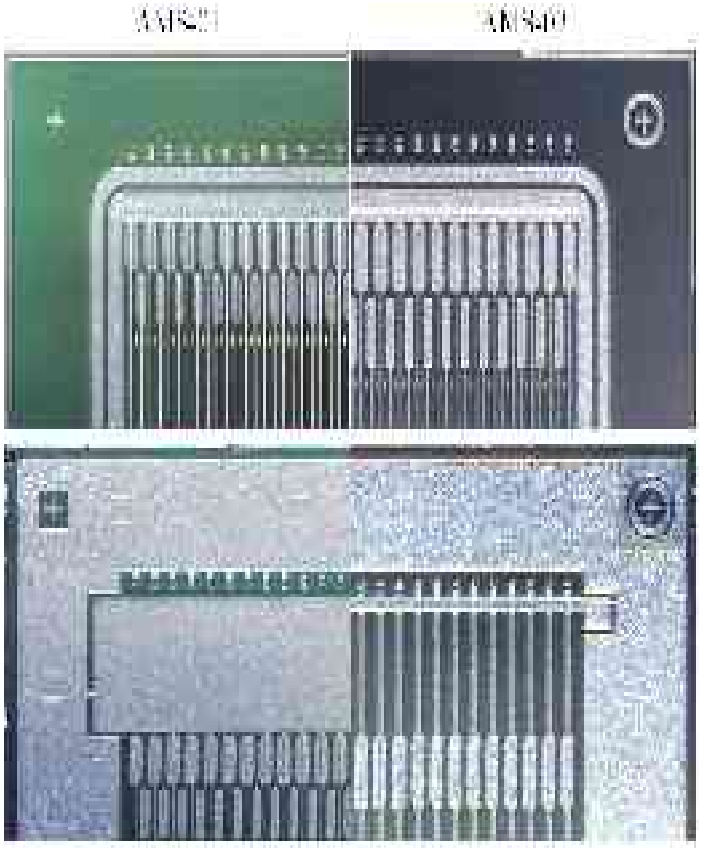
- 2. Redesign of sensors to increase ohmic side signals

➡ more uniform charge collection



Reduction of number of n-side strips to increase charge collection

	AMS 01	AMS 02
Dimensions	72.045 × 41.360 mm²	
Thickness	~300 μm	
Active width, p-side	70.595 mm	
Strip pitch, p-side	27.5 μm	
no. of p-strips	2566	
no. of metal strips, p-side	1281	
no. of p-side readout strips	640	
Readout pitch, p-side	110 μm	
Active width, n-side	39.852 mm	
Strip pitch, n-side	52 μm	104 μm
no. of n-strips	767	384
no. of metal strips, n-side	767	384
no. of n-side readout strips	192	
Readout pitch, n-side	208 μm	



Improvements

- 3. New fabrication technology (by CSEM, now Colibrys) to diminish noise.

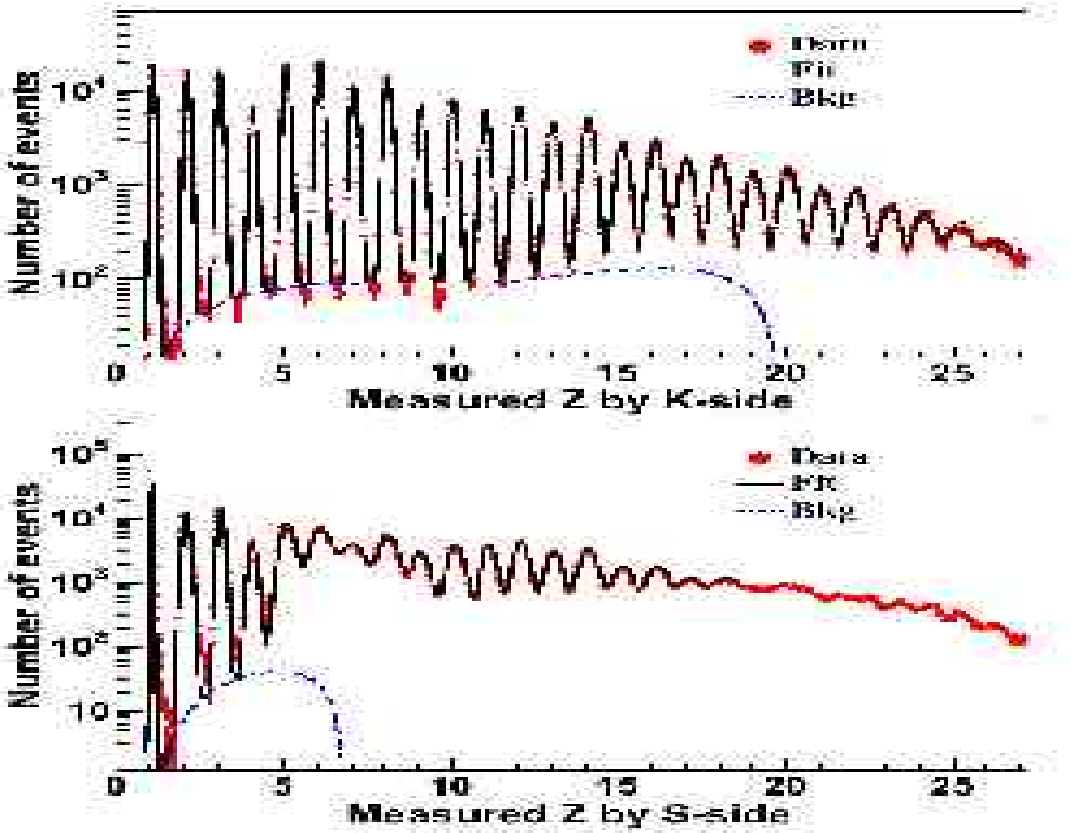
- 4. More careful assembly procedures to minimize mechanical, chemical and electrical impacts

Improved Assembly Procedures (Ph. Azzarello thesis)

Upilex cable on p-side and electronics

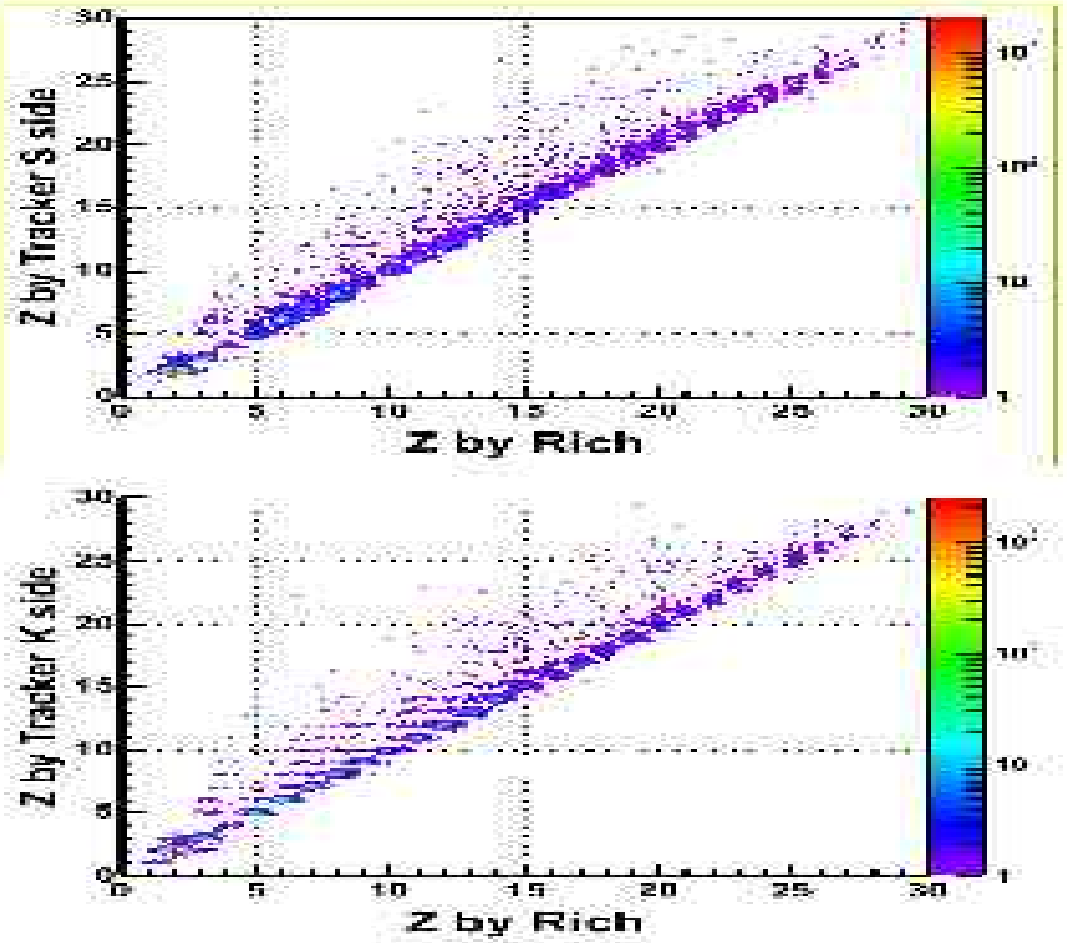
AMS-02 Ladders: charge determination

- Beam tests at CERN and GSI
- Combined results of 6 ladders

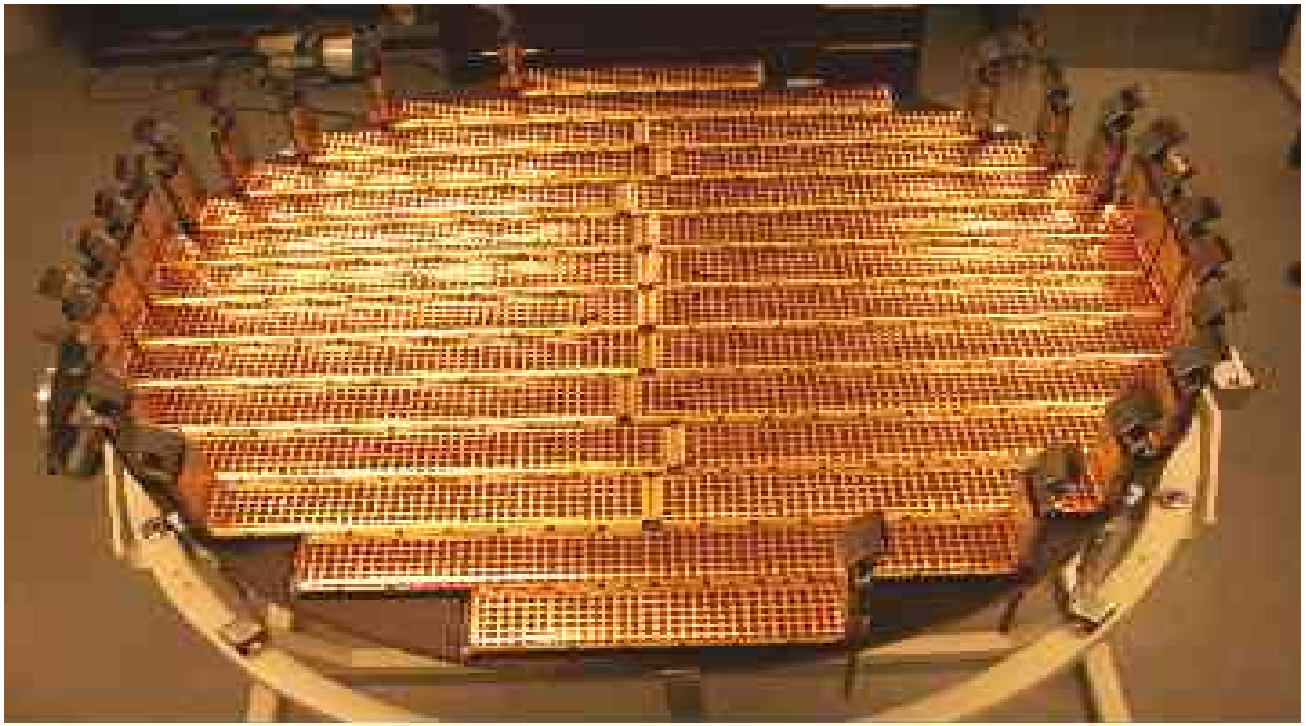


AMS-02 Ladders: charge determination

- Correlation of p-side and n-side measurements with a prototype RICH detector



AMS-02 Tracker Plane



Conclusions

- No major problems encounted with the silicon tracker during AMS-01:

  Electrically and mechanicaly the tracker was unaffected by launch, landing and in orbit operations.

- For AMS-02, the number of independant measurement points and the issue of temperature control needed to be reconsidered.

- The tracker performance on the n-side of the silicon sensors had to be improved.

- In 2005, the new tracker for AMS-02 will be ready for system tests.