The AMS-02 silicon tracker
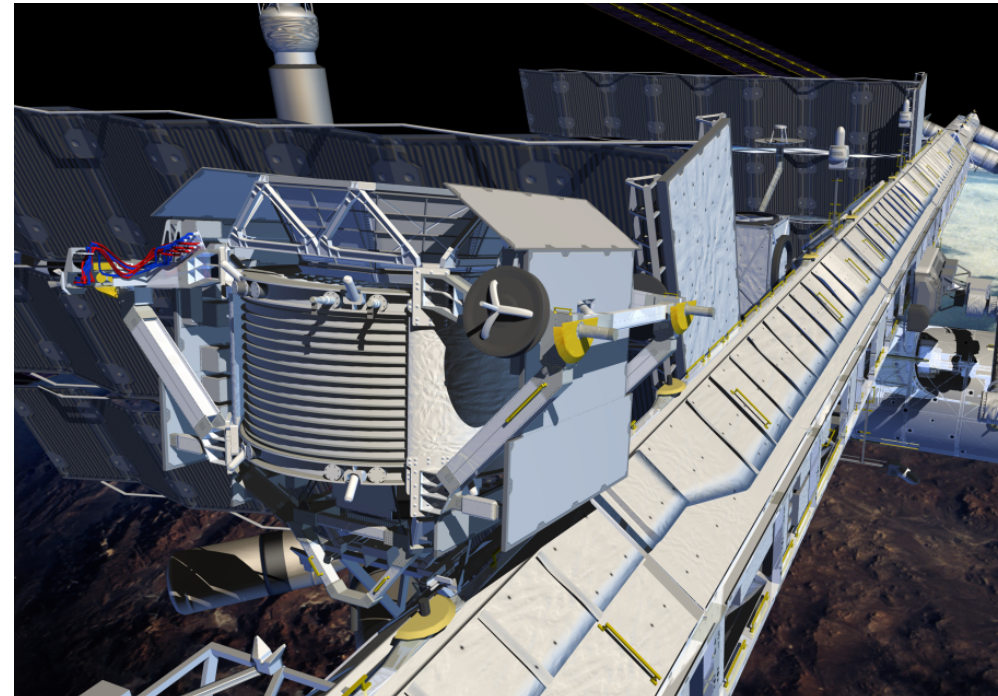
Philipp Azzarello

6.10.2005

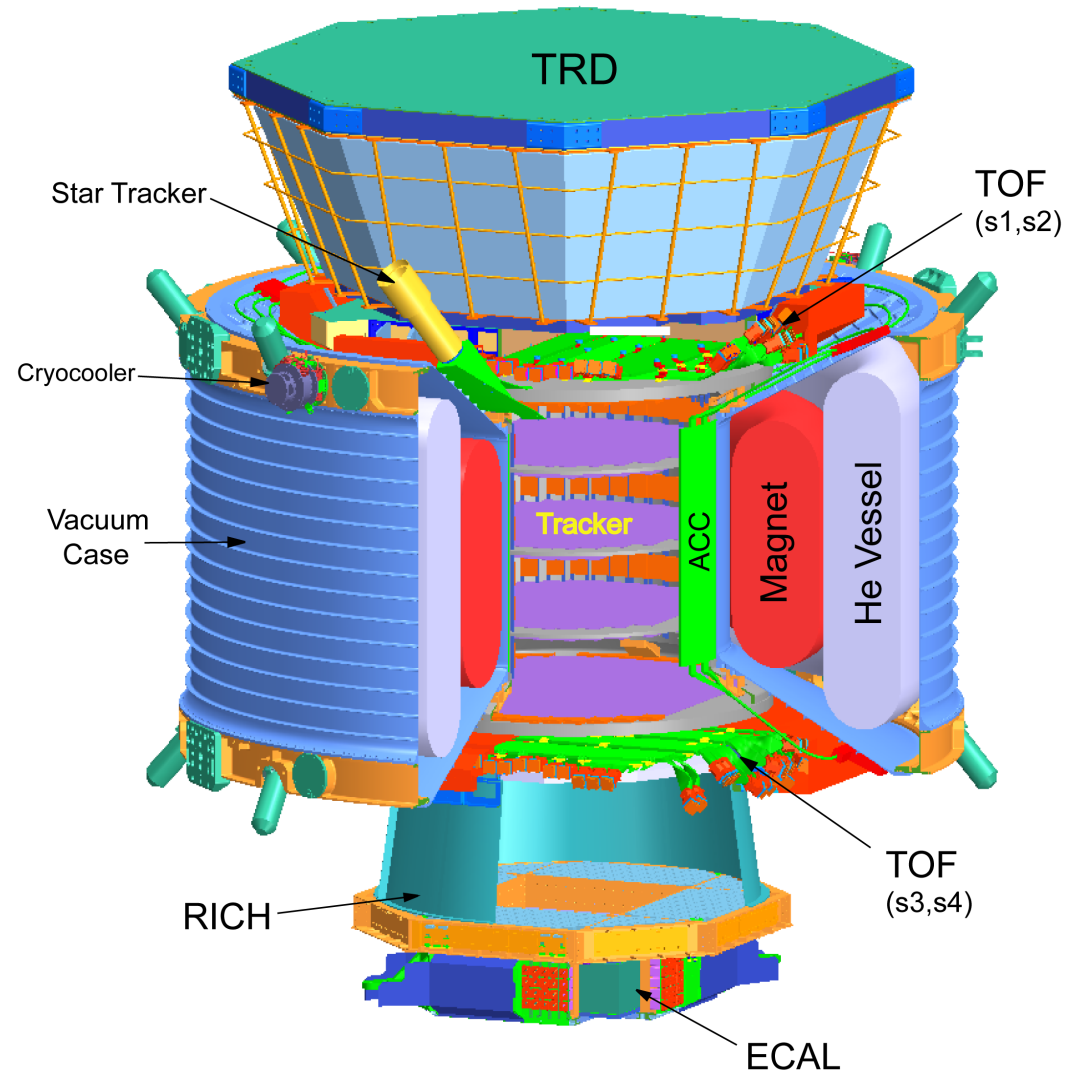# The AMS experiment

❖ Aim: Install a detector of large acceptance (0.5 sr·m^2) in space, on the International Space Station) to do a long term acquisition (3 years). Advantages compared to balloon experiments: large statistics, no atmosphere.

❖ Search for antimatter in large energy and sensitivity ranges;

❖ Search for dark matter;

❖ Study of the origin and transport of the cosmic rays (from 1 Gev to 1 TeV);

❖ Study of γ-rays from galactic and extragalactic sources;

❖ AMS-01: 10-days qualification flight, June 1998;

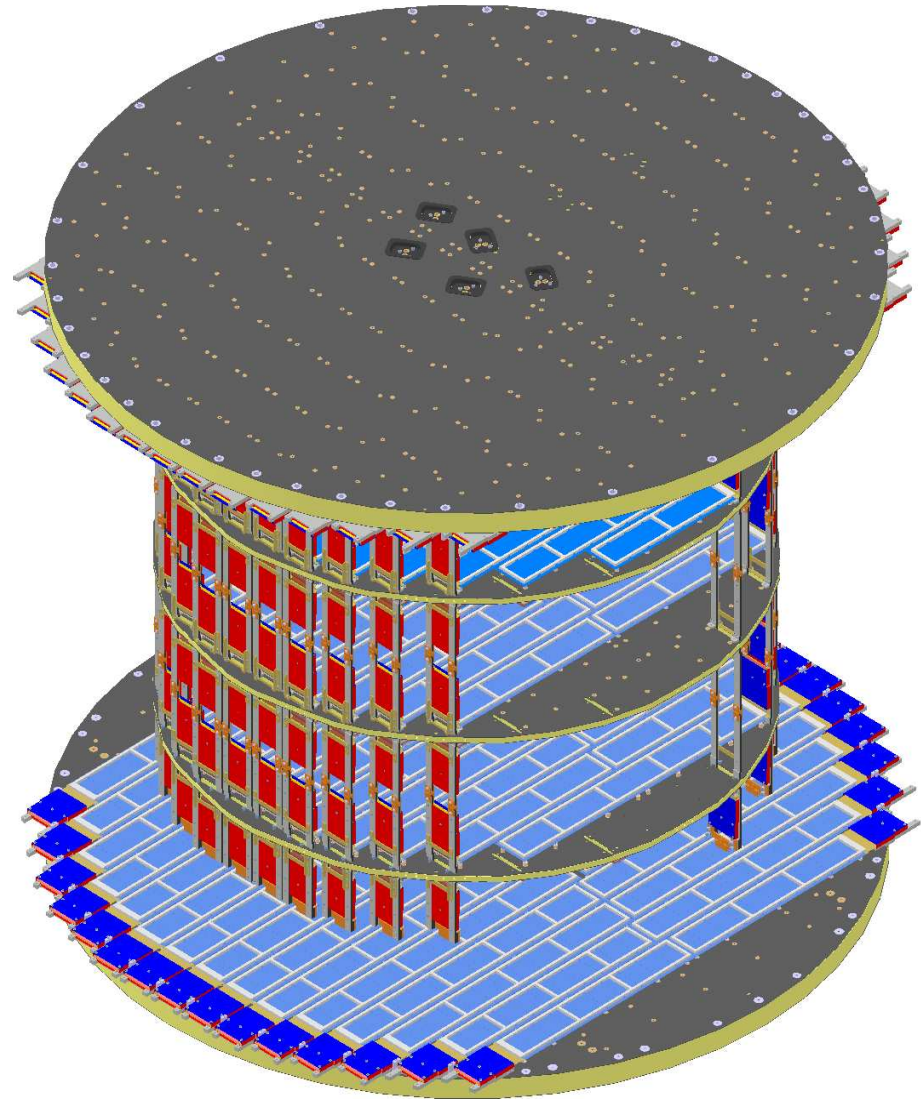❖ AMS should be ready to be installed on ISS by the end of 2007.

The AMS-02 detector

- ❖ TRD: disentangles hadrons from electrons up to 300 GeV.

- ❖ Scintillator planes (4): time of flight, β, direction.

- ❖ Superconducting magnet: 0.87 T. Capacity of the liquid helium tank chosen for three years of functioning.

- ❖ Silicon tracker.

- ❖ RICH: β, mass measurement.

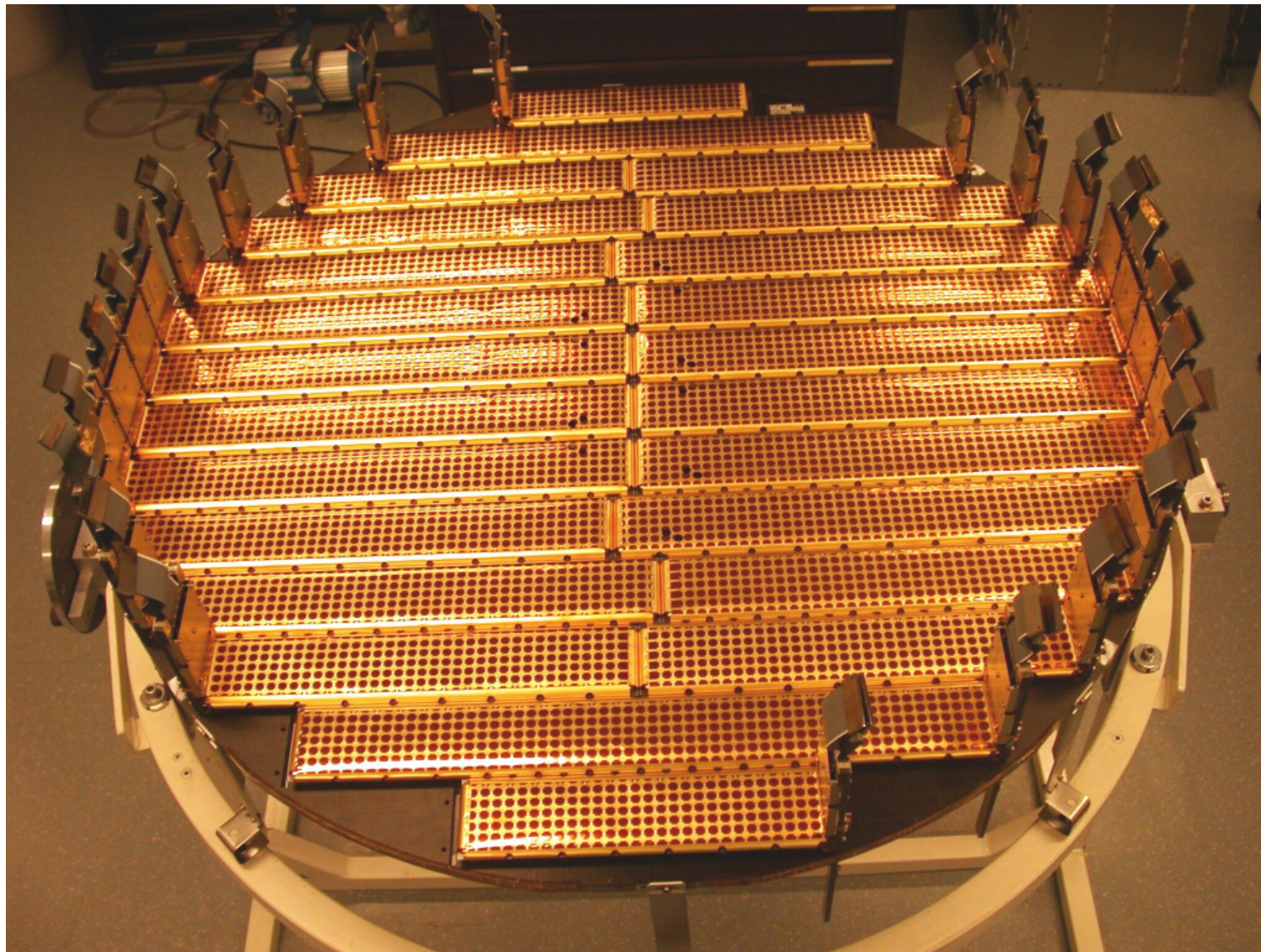- ❖ ECAL: separation between hadrons and e/γ, total energy.

The silicon tracker
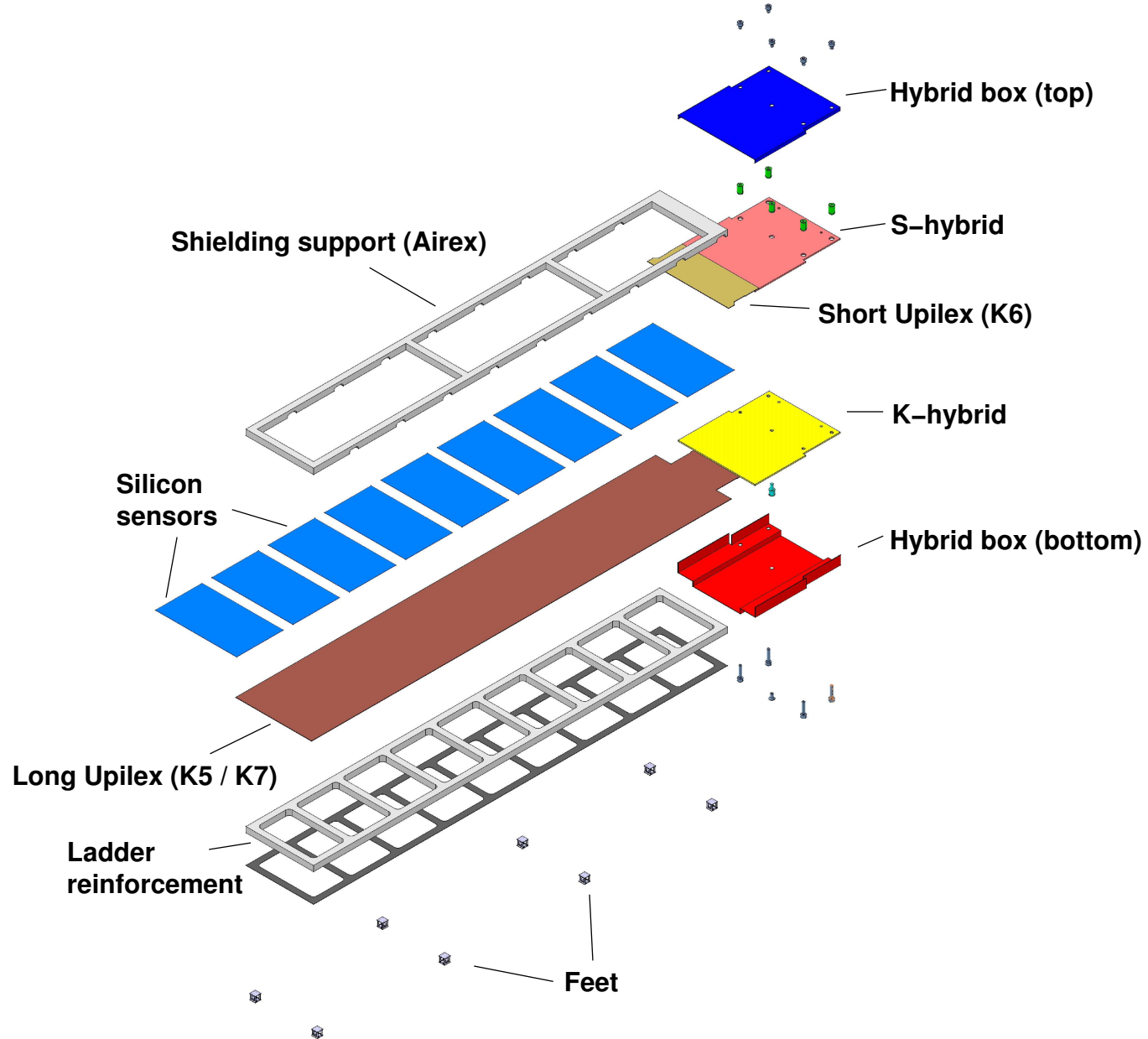
- 192 modules ("ladders"), for a total surface of ~ 6 m^2.
- Double-sided microstrip detectors.
- 5 support structures ("planes"), 8 silicon layers.
- Ladder length varies from 29 cm to 62 cm, i.e. from 7 to 15 detectors.
- One ladder has 1024 readout channels (p-side: 640, n-side: 384).

- Charged particle track measurement.
- Particle rigidity ($\frac{p}{Z}$) measurement up to ~ 3 TV.
- Charge identification via the energy loss measurement ($dE/dx \propto Z^2$).
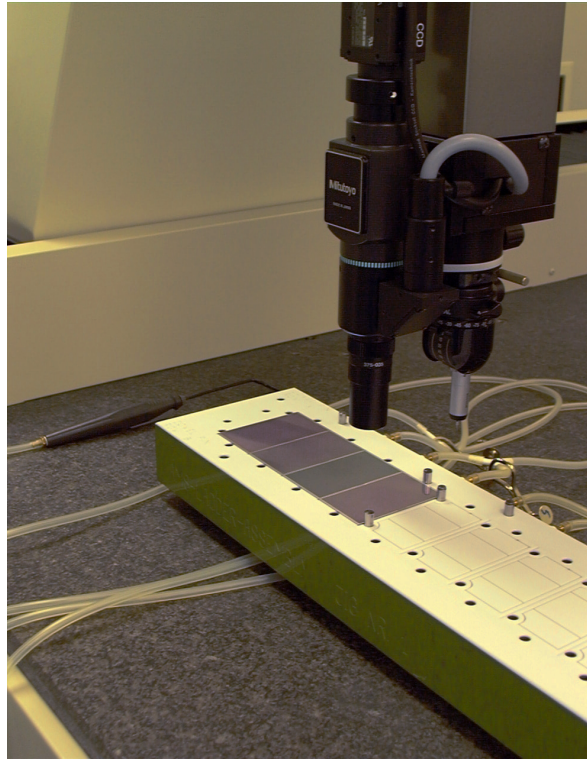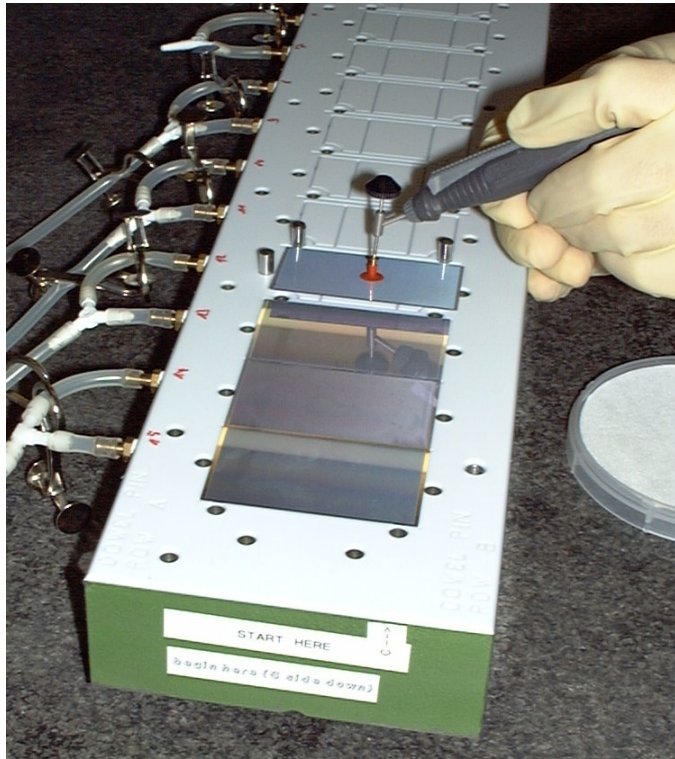
A layer

Ladder structure

Hybrid box (top)

S–hybrid

Shielding support (Airex)

Short Upilex (K6)

K–hybrid

Silicon sensors

Hybrid box (bottom)

Long Upilex (K5 / K7)

Ladder reinforcement

Feet

AMS-02 detector characteristics

Dimensions	72.045×41.360 mm^2
Thickness	$\sim 300 \pm 10$ μm
Active width, p side	70.565 mm
Strip pitch, p side	27.5 μm
no. of p-strips	2568
Readout pitch, p side	110 μm
no. of p-side readout strips	640
Active width, n side	39.832 mm
Strip pitch, n side	104 μm
no. of n-strips	384
Readout pitch, n side	208 μm
no. of n-side readout strips	192

❖ High resistivity ($>$6 kΩcm) wafers: $V_{depl} < 54$ V ➜ $V_{op} < 80$V

Assembly

The sensors are aligned with a manual procedure: a precise cut and precise alignment jigs are mandatory. Sensor positions are measured by metrology (optical measurement).
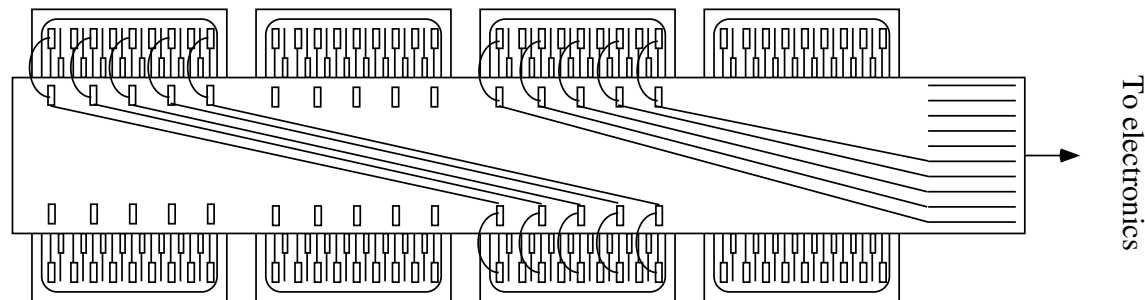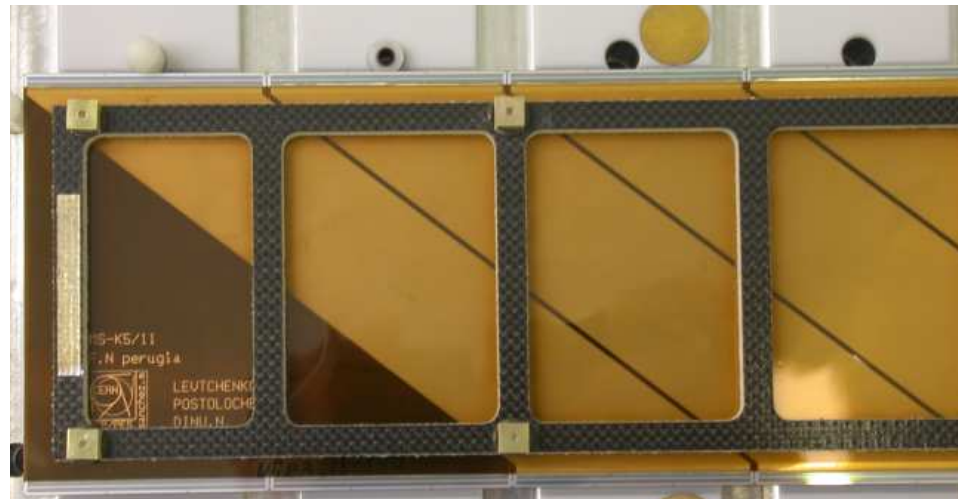
Hybrid gluing, bonding

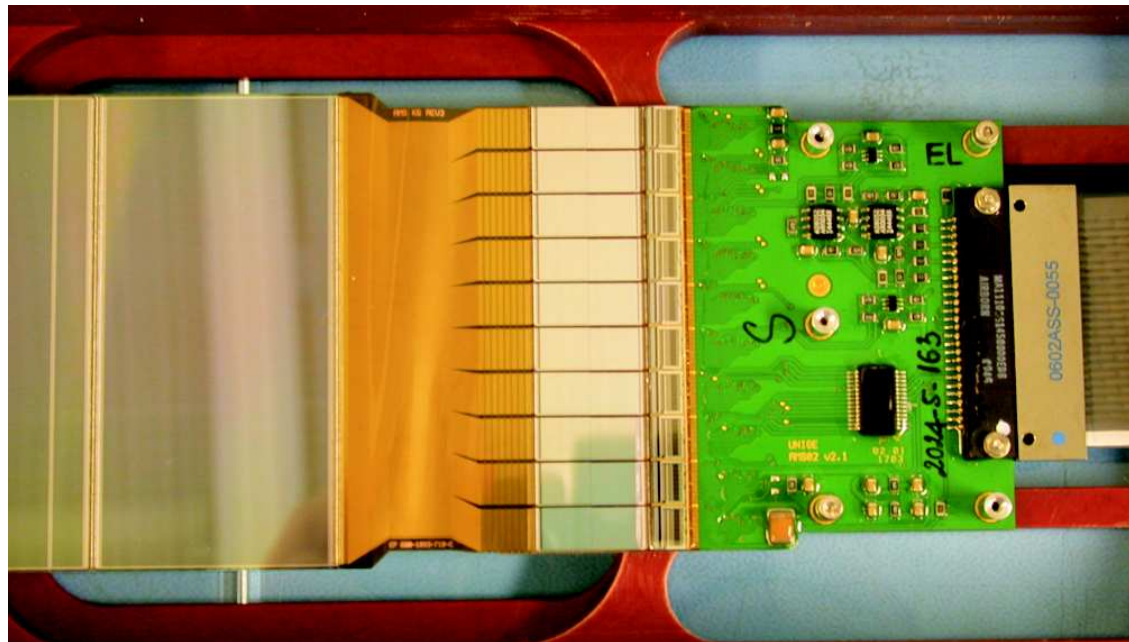For a 12-sensors ladder, $\sim 13'000$ bonds are performed.

n-side signal readout

To connect the n-side strips, a Upilex foil with copper strips is used to transmit the signal to the front-end electronics.
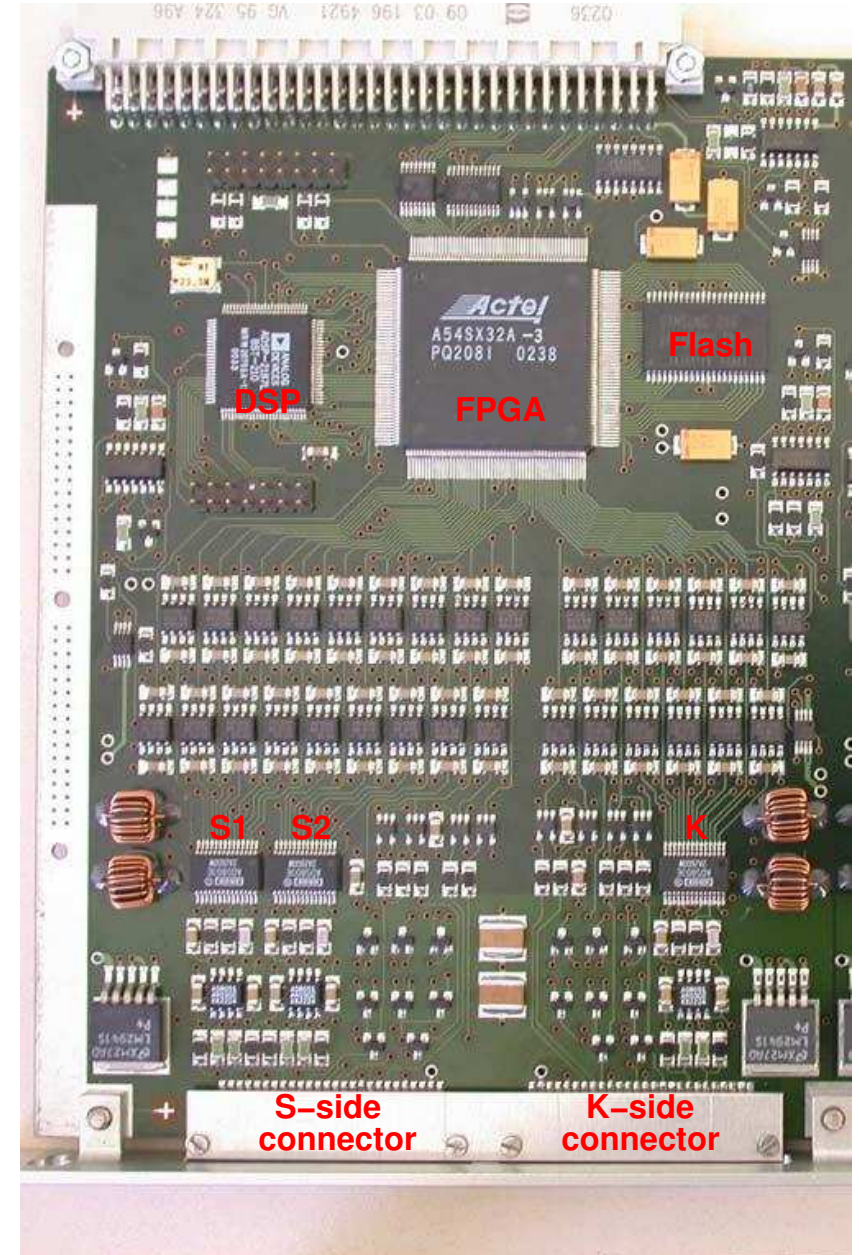
Acquisition electronics: front-end

❖ AC coupling with the preamplifiers, using capacitor chips (C=725 pF).

❖ Preamp: VA hdr9a (IDEas, Norway).

❖ 64 channel preamplifier-shaper.

❖ Multiplexed analog readout.

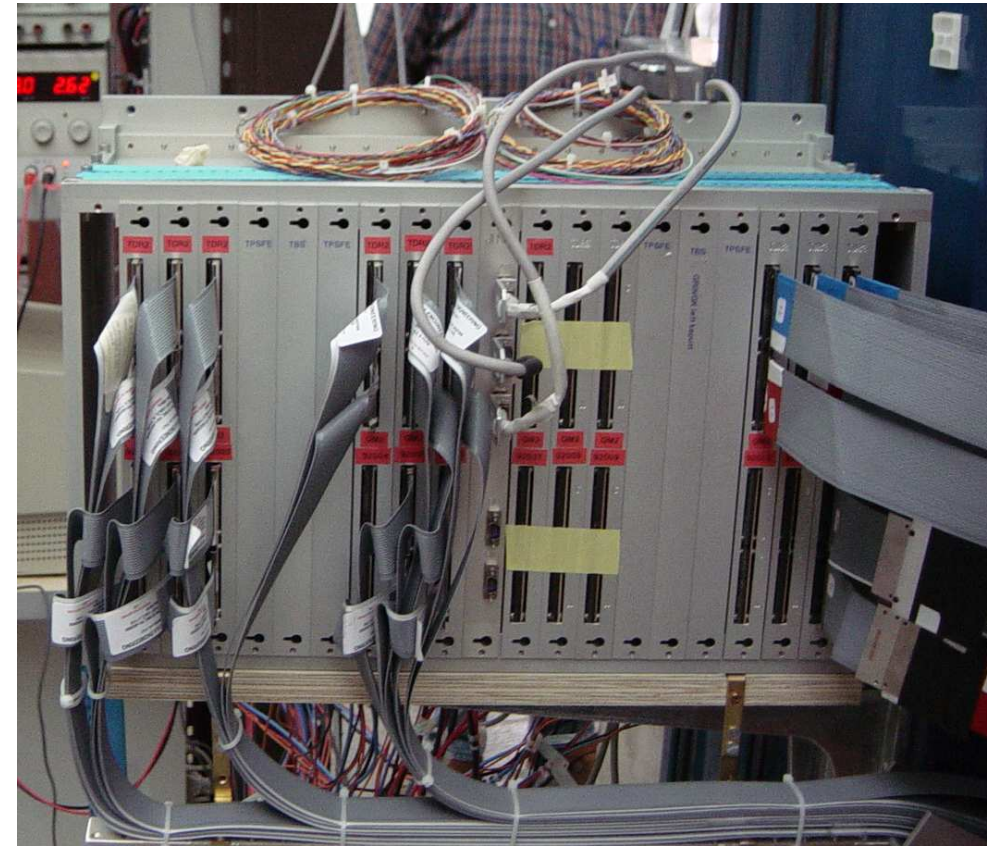# Acquisition electronics: TDR

The Tracker Data Reduction (TDR) circuit:

❖ Acquires data from the front-end electronics (1024 channels);

❖ Computes and subtracts pedestals and common noise;

❖ Identifies and isolates the signal regions (data reduction).

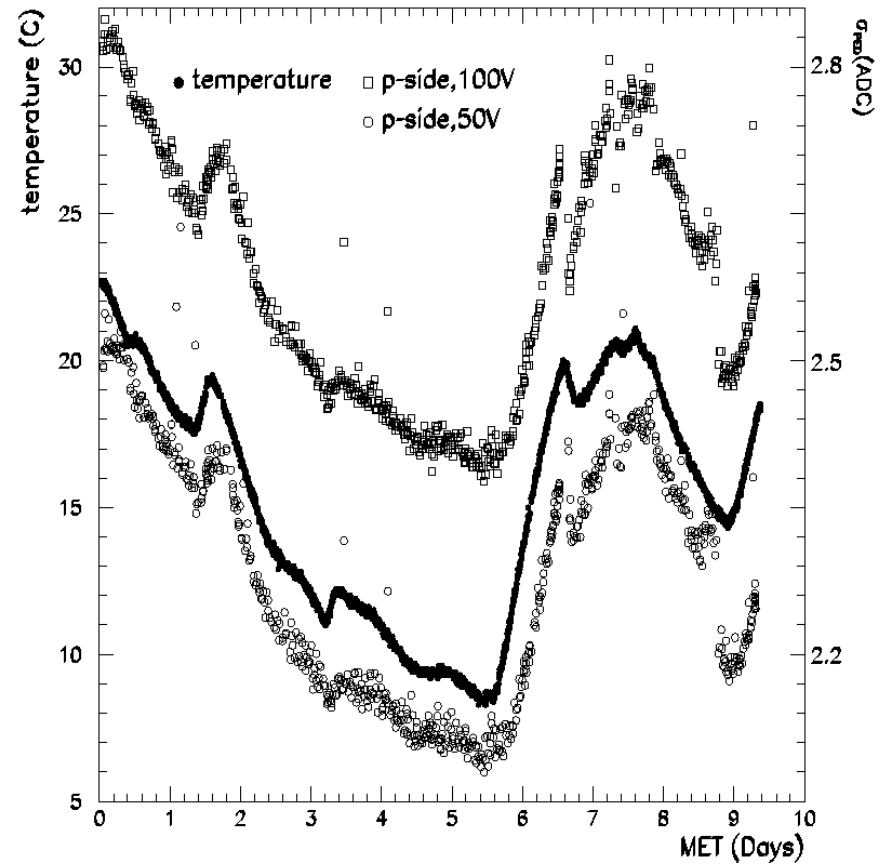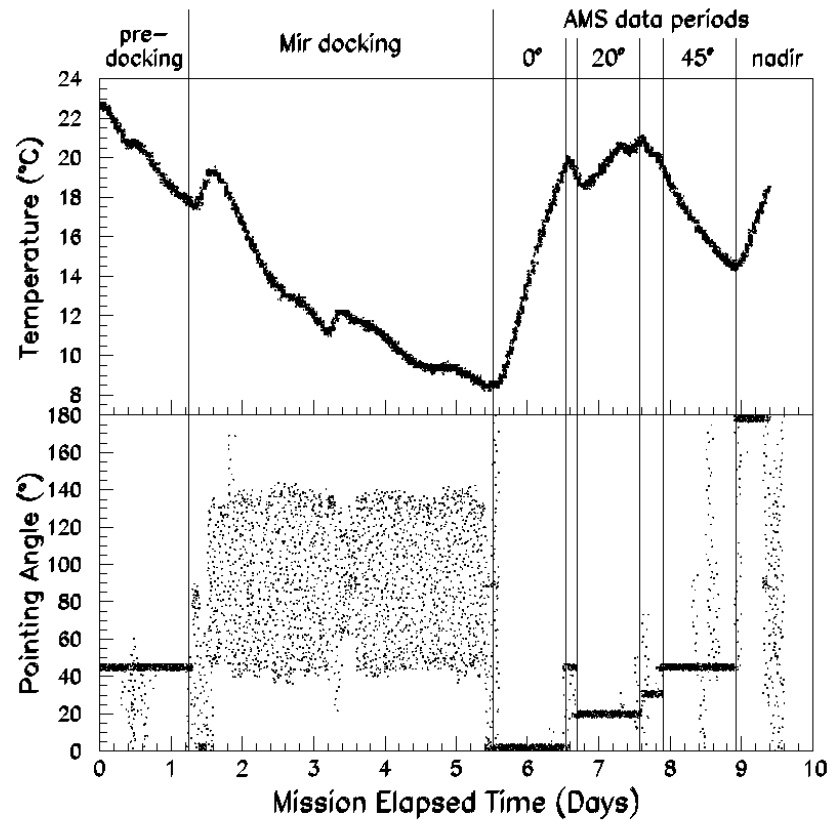❖ Data are then sent to another board ("Jinf") which centralizes the information from 24 TDRs.

Tracker crate

The tracker crate is composed of following boards:

❖ 12 TDR2 boards (2 TDR circuits, readout for 2 ladders);

❖ 4 TPSFE: front-end power distributors for 6 ladders each;

❖ 2 TBS: silicon bias distributors for 12 ladders each;

❖ 1 JINF: distributes commands to TDRs and concentrates the TDR outputs. Also communicates with power distribution boards.
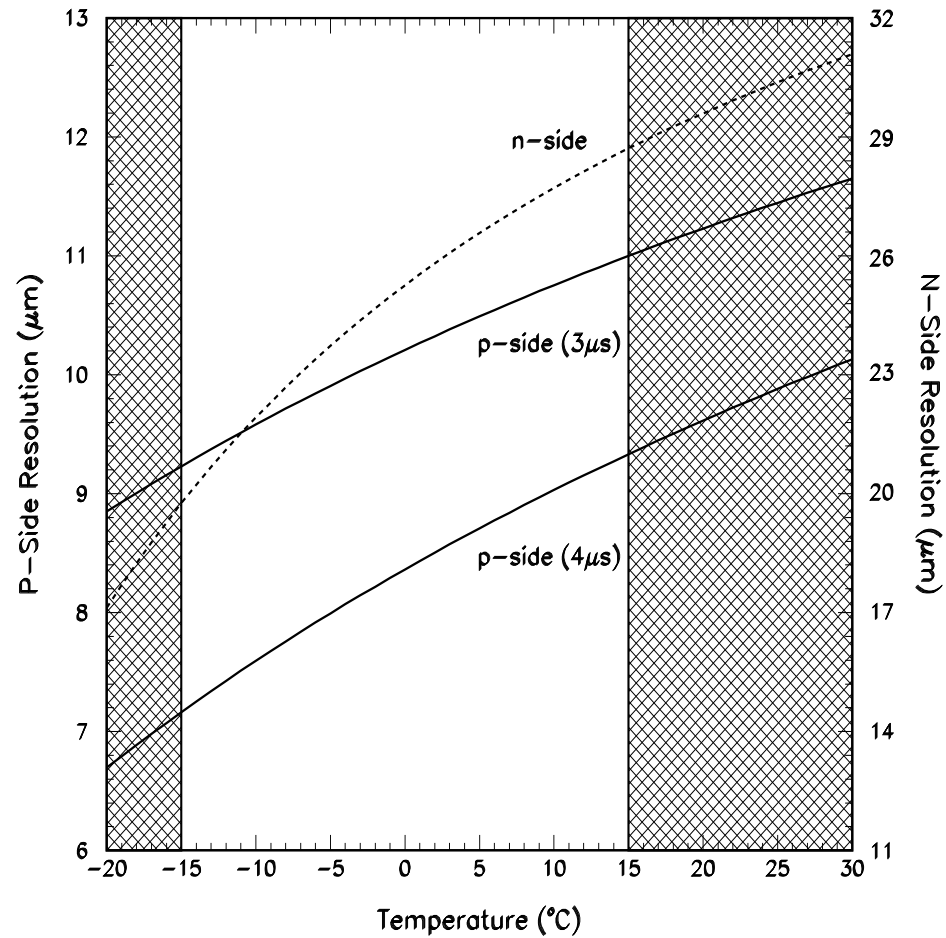
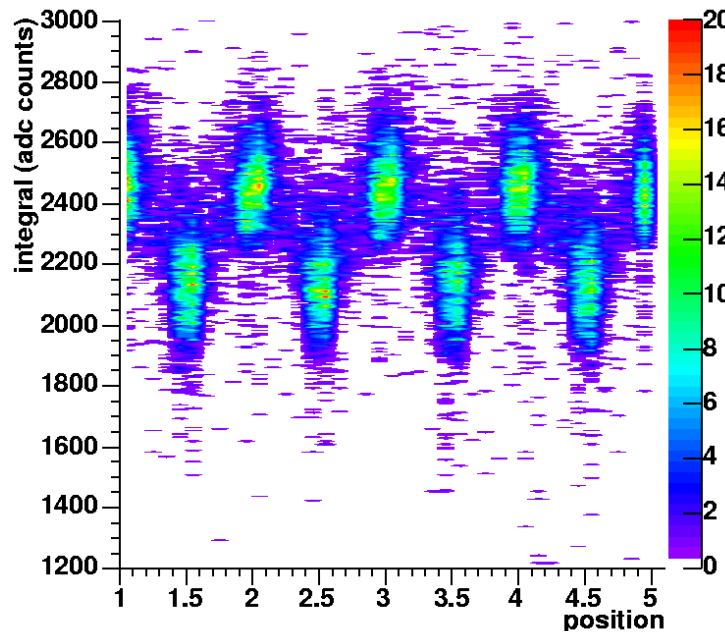# AMS-01: noise and temperature

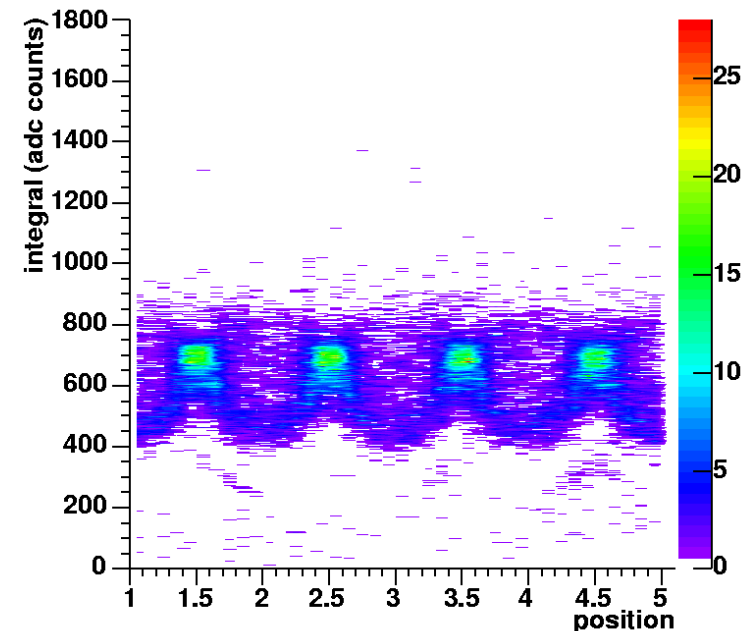# Spatial Resolution

Calculated from proton test beams. Preliminary.

(W. Burger)

Nuclei

❖ Beam test at CERN with fragmentation ion beam 2002, 2003;

❖ 6 ladders tested;

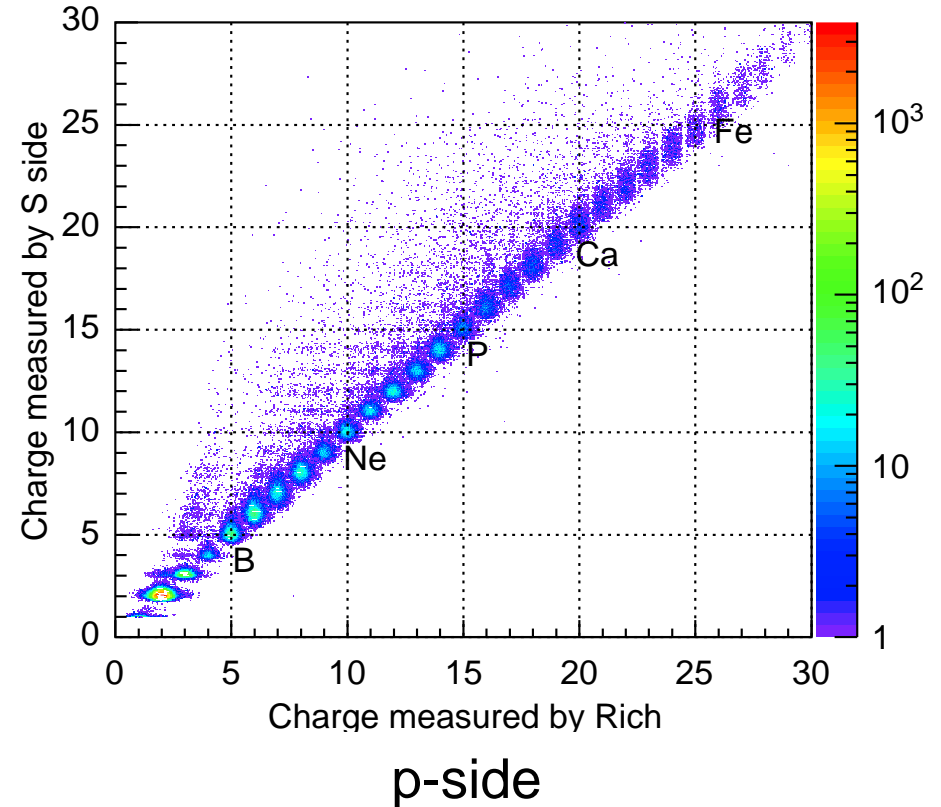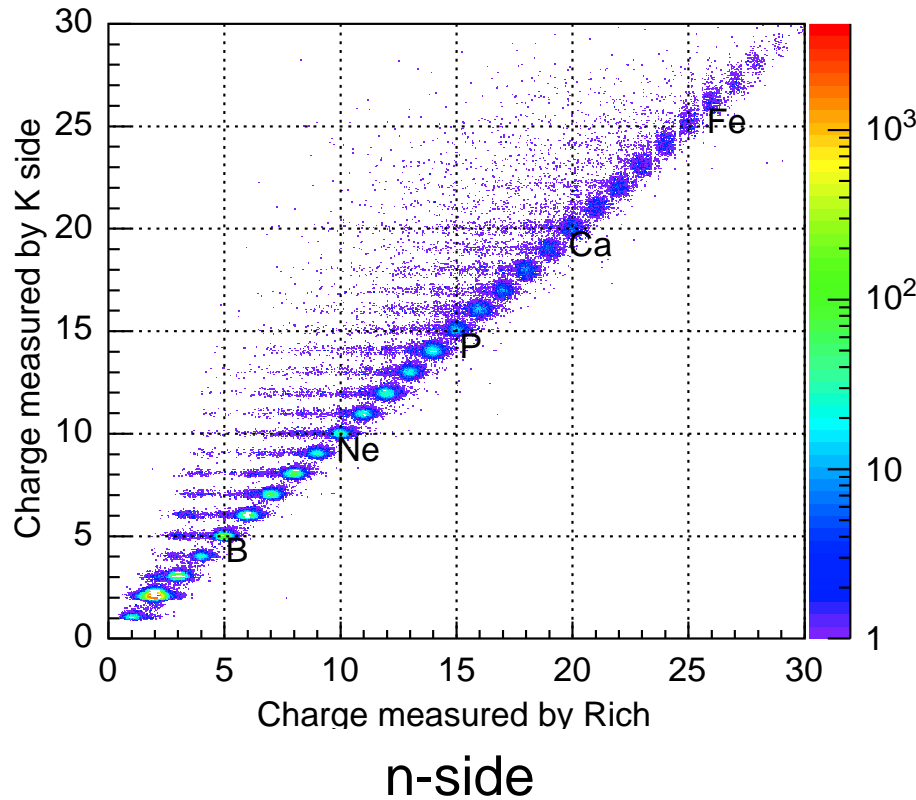❖ Cluster integrals depend on the cluster center of gravity:

n-side   p-side

❖ Corrections are needed.

Nuclei

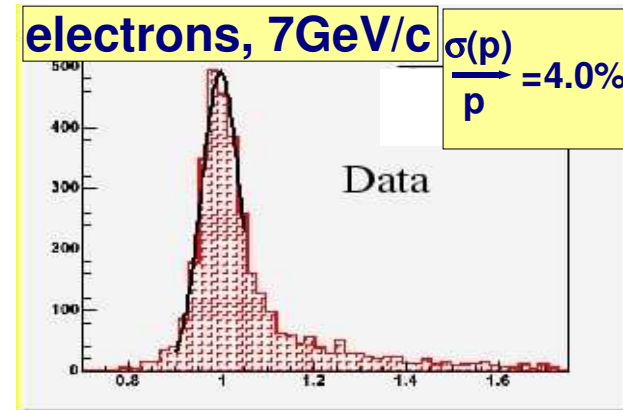❖ Comparison of the charge computed with the tracker, and the charge computed with the RICH:
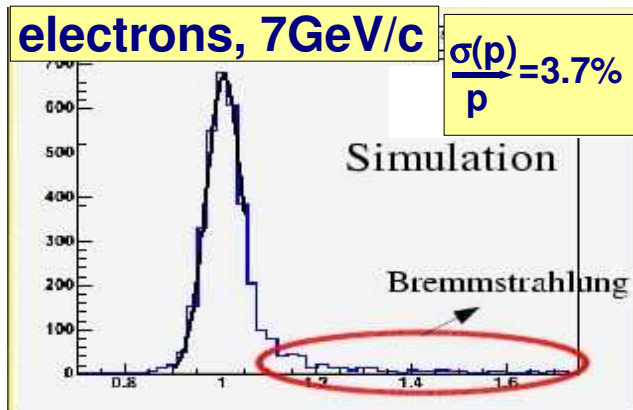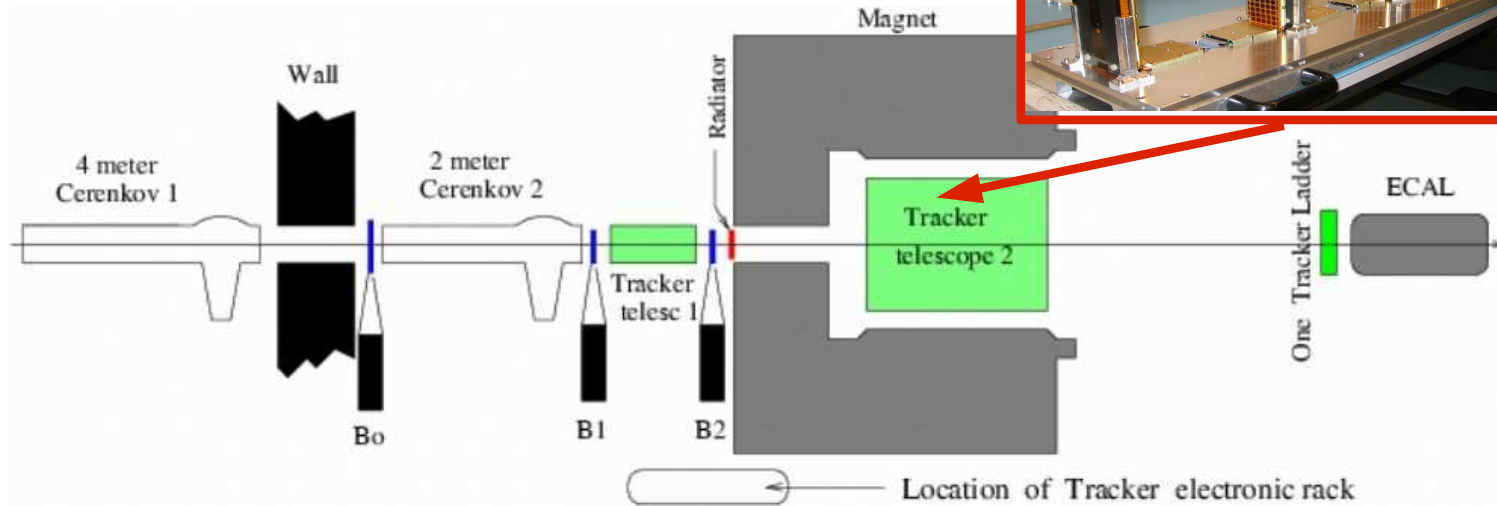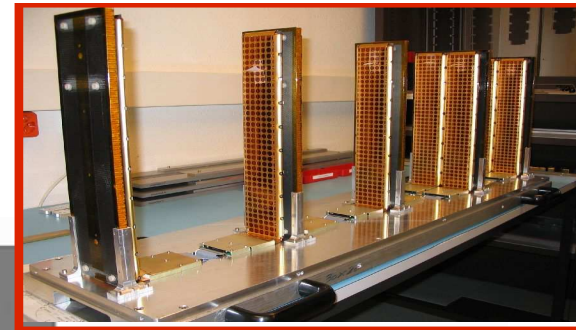

n-side

p-side

❖ RICH was behind the silicon detectors: lower measured charges correspond to fragmented nuclei.

e+/e- beam test

❖ September 2004 at CERN.

❖ Beam energy: 3 GeV, 5 GeV, 7 GeV.

❖ 16 ladders used;

❖ 4 used as a telescope, 11 in a magnet, 1 close to the ECAL prototype;

❖ A complete crate with 24 TDRs was used for the first time;

❖ First time that the acquisition was done in data reduction mode only: data acquired depend on the quality of the calibration and the reduction codes.

e+e- Test Beam @ Cern

http://ams.cern.ch/AMS/Tracker/tbeam04.html

(S. Natale, I. Sevilla).

Assembly Status

❖ The last ladders have been produced a few weeks ago.

❖ 5 layers are fully equipped, a sixth will be ready soon.

❖ The outer layers will be equipped beginning of next year.

❖ Tracker assembly is foreseen for mid-2006.