



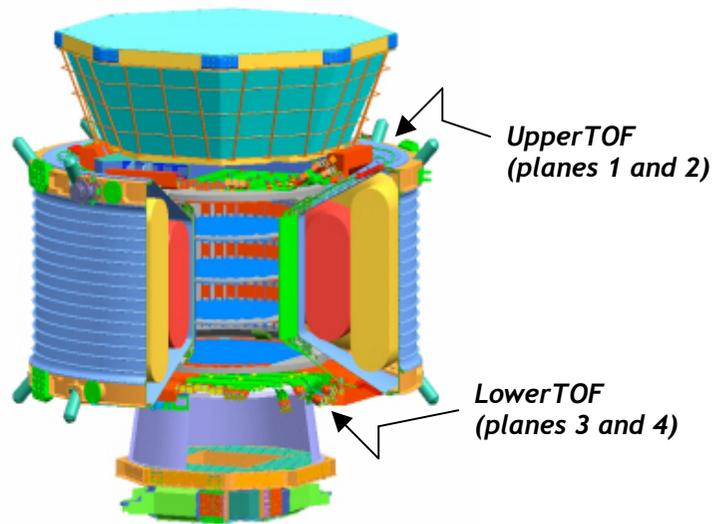
# *The AMS-02 Time Of Flight (TOF) system*

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# Introduction



## Purpose

- To start the data acquisition to the experiment.
- To measure the time of flight of the particles traversing the detector with a resolution of 150 ps, corresponding to a  $\beta=v/c$  resolution of 3%.
- To measure the absolute charge of the particle in addition to the measurement done by the silicon tracker and by the RICH.
- To distinguish at the trigger level protons from higher charge nuclei.

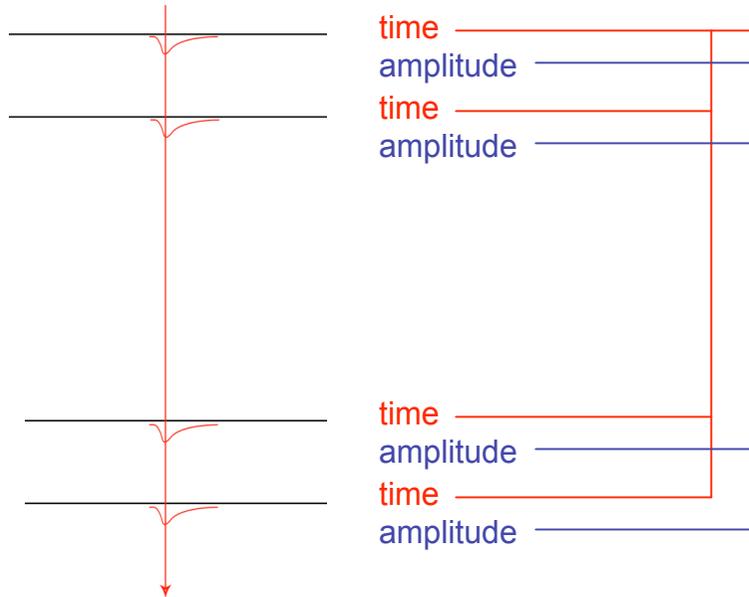
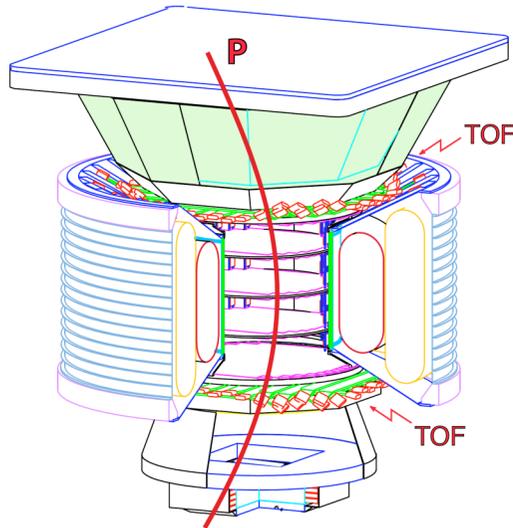
*The TOF system of AMS-02 is based on the previous experience and well-established techniques developed by the Bologna group and safely and successfully operated in the AMS-01 experiment.*

*It has been completely designed and is being built at the INFN Laboratories in Bologna, Italy.*

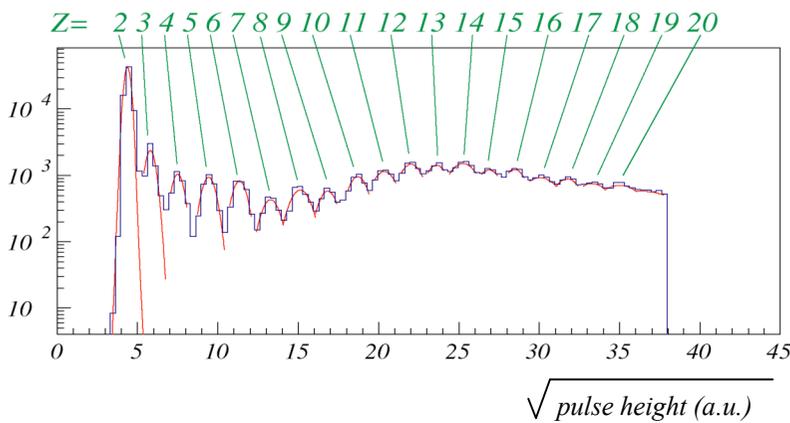
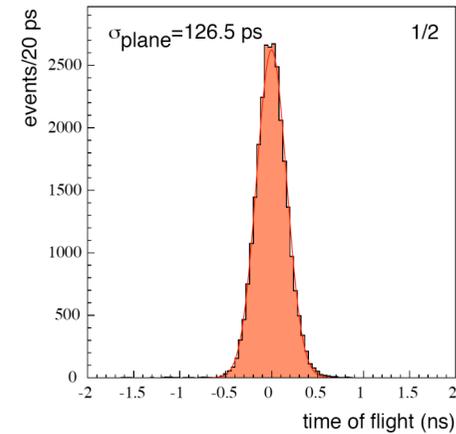




# Principle of the measurement



$$\beta = \frac{\Delta s}{c \Delta t}$$



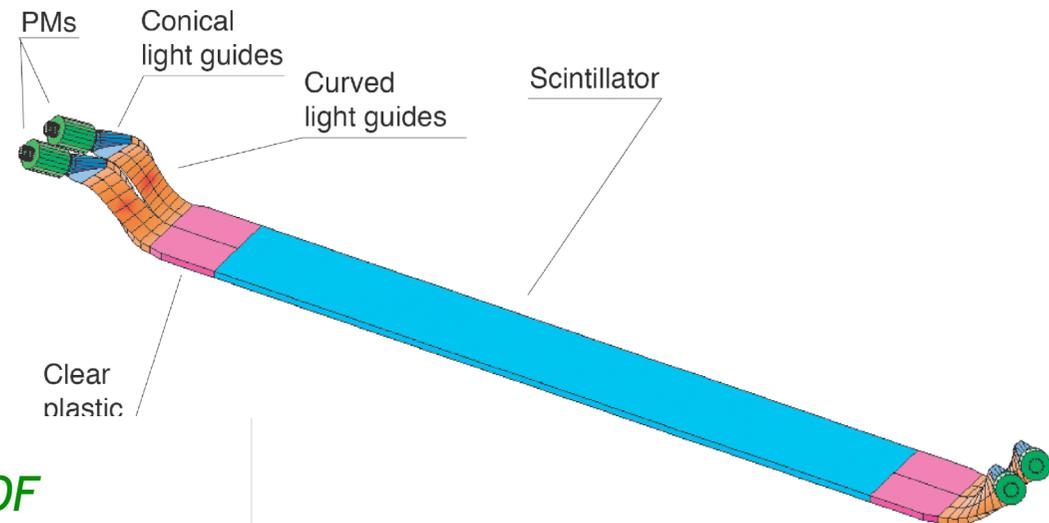
$$Z = \sqrt{\text{ampl}}$$

# The TOF Apparatus

To cover the full solid angle of AMS-02, each TOF plane has a surface of about 1.4 m<sup>2</sup>.

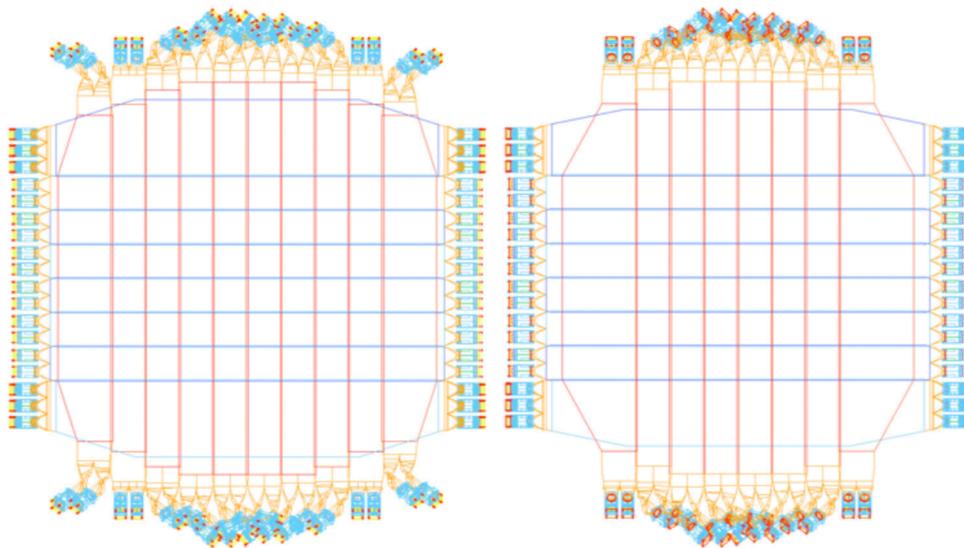
Each counter is 12 cm wide and overlaps by 0.5 cm with adjacent counters.

Light produced by particles is detected by PhotoMultiplier tubes (PMTs) on both ends of the counter.



UpperTOF

LowerTOF

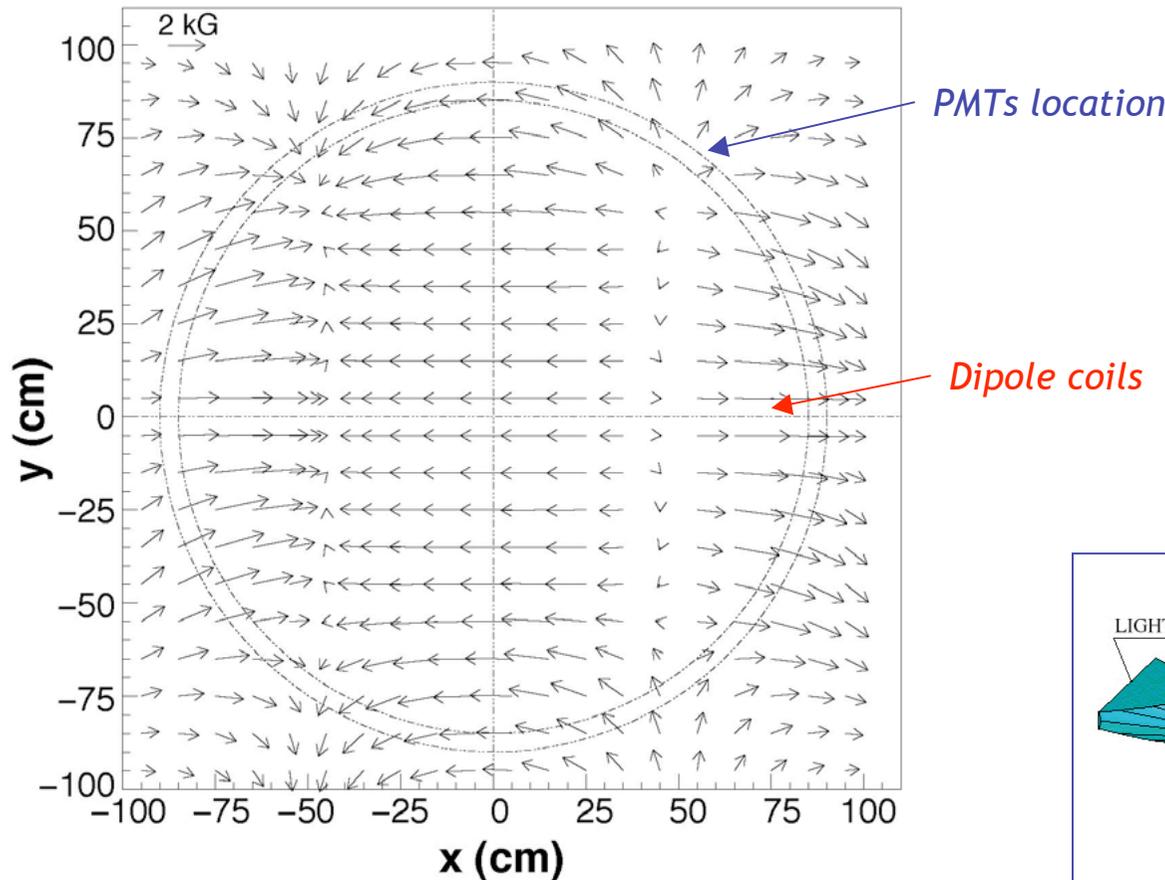


Four scintillator planes:

- 1) 8 counters, 36 PMTs
- 2) 8 counters, 32 PMTs
- 3) 10 counters, 40 PMTs
- 4) 8 counters, 36 PMTs

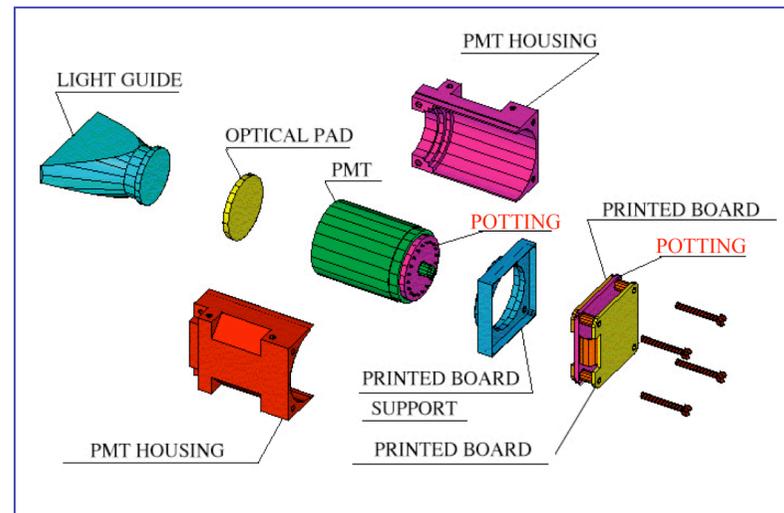
# Magnetic field and PM choice

The TOF planes are placed just above and below the magnet (60 cm from the magnet center) therefore the magnetic field on the PMs is of the order of 1÷2kG.



Fine-mesh HAMAMATSU PM R5946

HV=2000 V  
Gain=10<sup>6</sup> (4.3 x 10<sup>5</sup> at 0° and 5kG)  
Insensitive up to 45° w.r.t.magnetic field



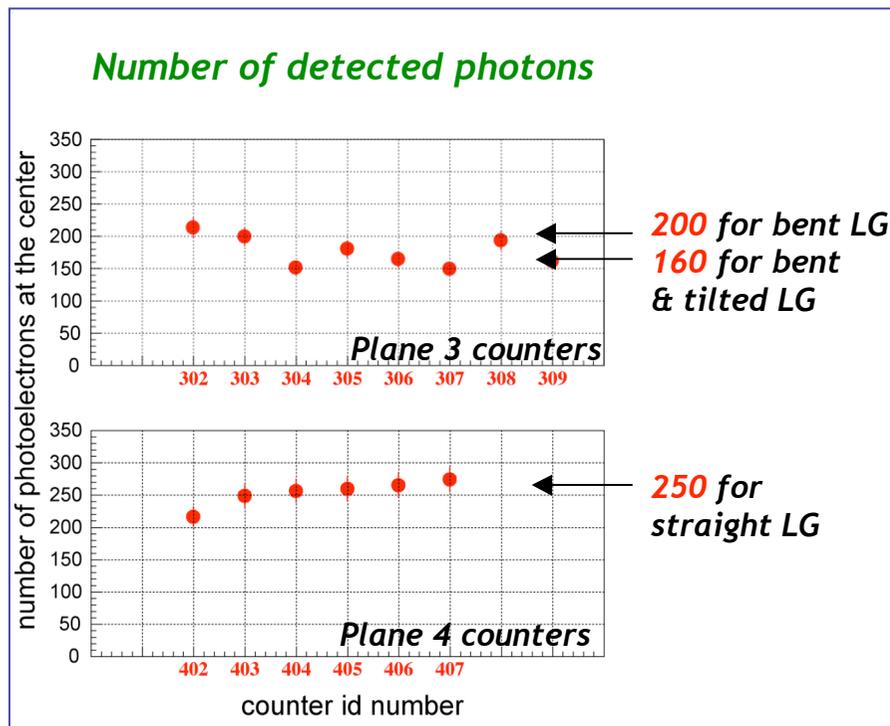
**Note:**  
The same PMs are used for the AntiCoincidence Counters (ACC)



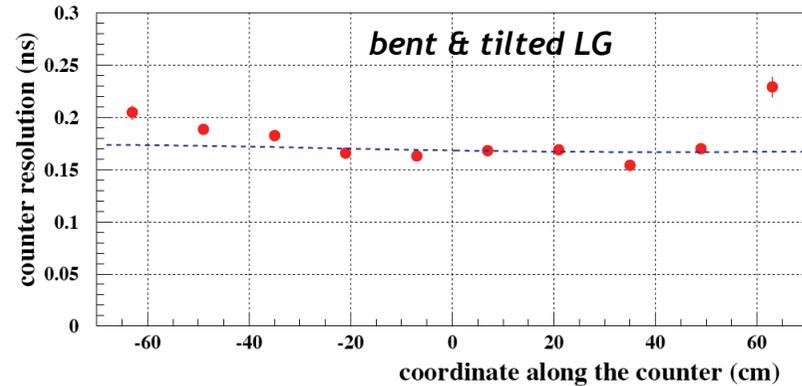
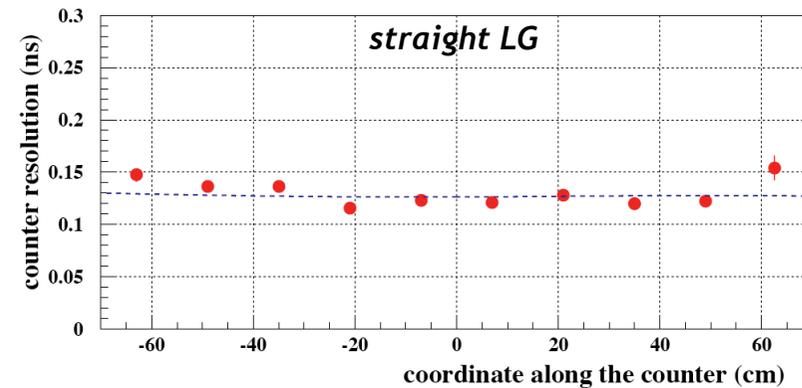
# Time resolution



The time resolution depends on the number of photons detected by the PMs.



**Time resolution measured with cosmic rays**



The overall time resolution corresponds to a  $\beta$  resolution of 3%, i.e. identification of positrons vs. protons up to about 1.4 GeV.

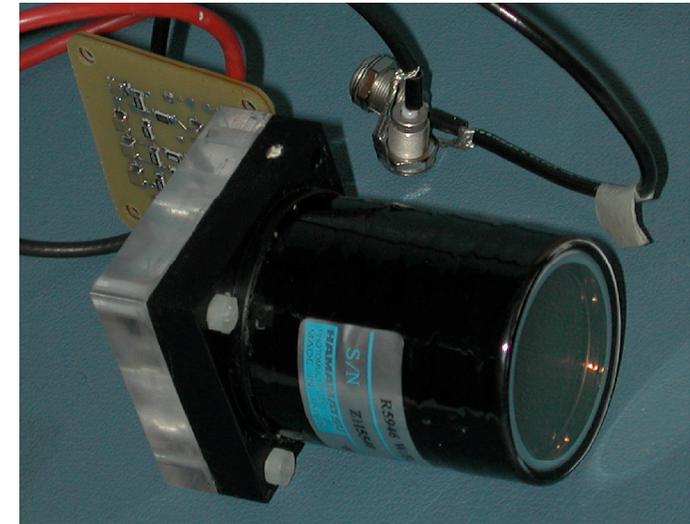


# Operation in space

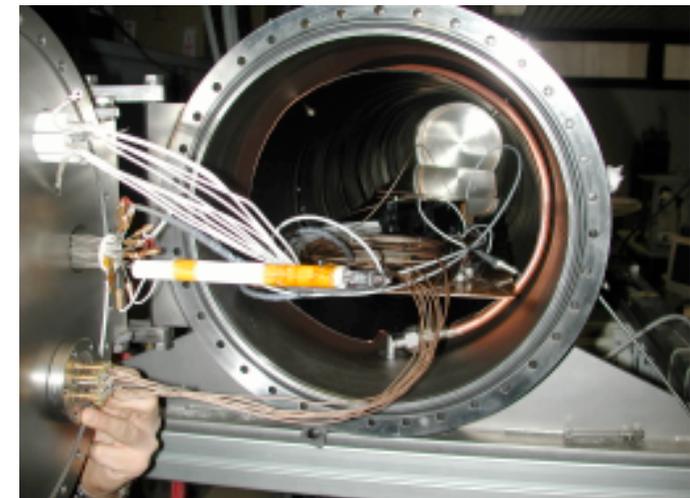


Requirements on the design and on the servicing electronics for the TOF system:

- Each plane is housed into a mechanically robust and light-tight cover with a system for fast depressurization
- The support structure conforms to the NASA specifications concerning resistance to load and vibrations
- The electronics is protected from the highly ionized low-orbit environment
- The system have been designed for maximum redundancy to ensure the fast trigger to AMS even in presence of HV, PM or front-end electronics faults:
  - Each counter is 4-times redundant in PMs
  - Each HV power supply is doubly redundant
  - Each coincidence signal for the fast trigger is doubly redundant



PM potting



PM test for discharge in thermal vacuum



# Counter calibration with cosmic rays



Each counter has been characterized for:

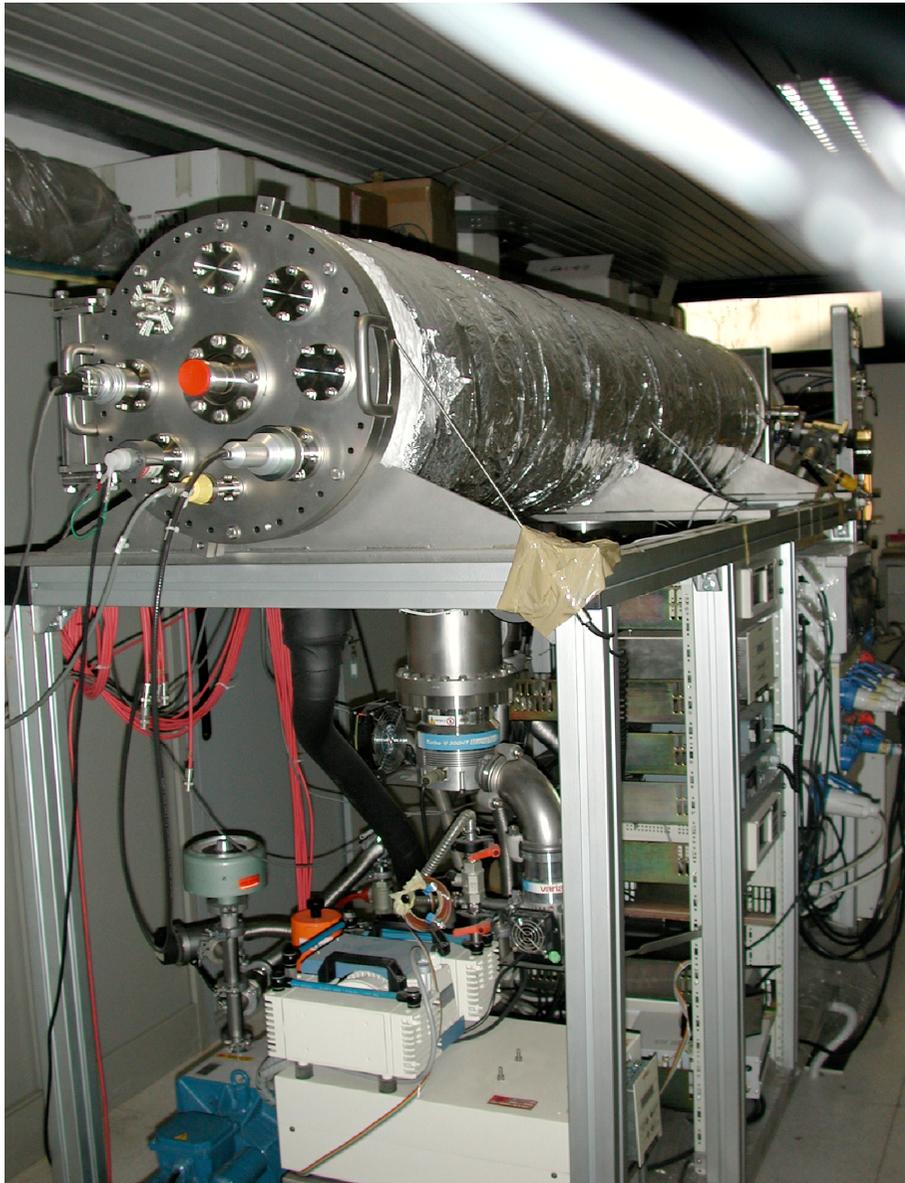
- attenuation length
- time resolution
- anode/dynode ratio

using cosmic rays





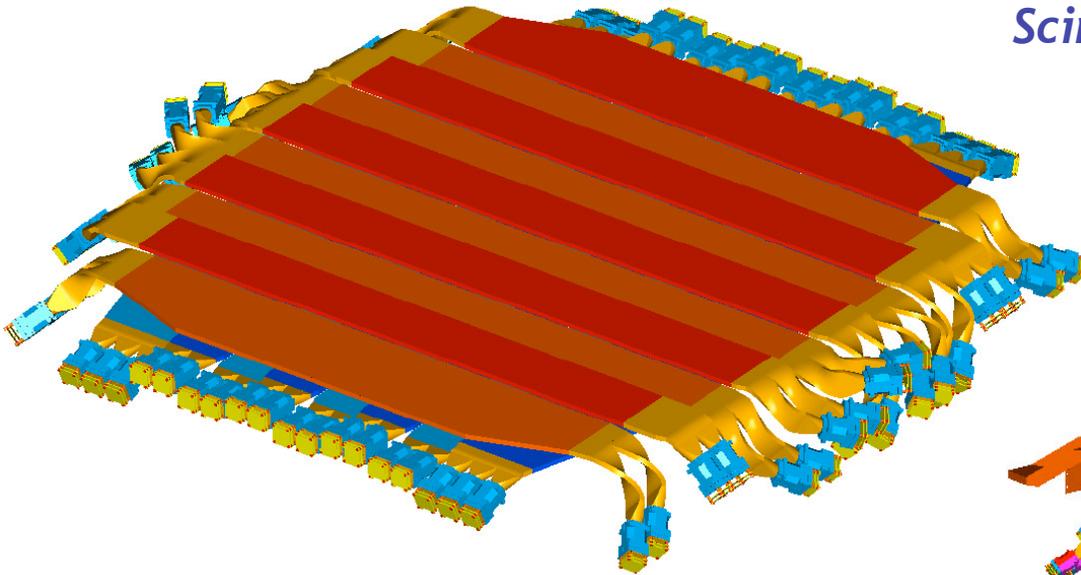
# *Thermal-Vacuum chamber*



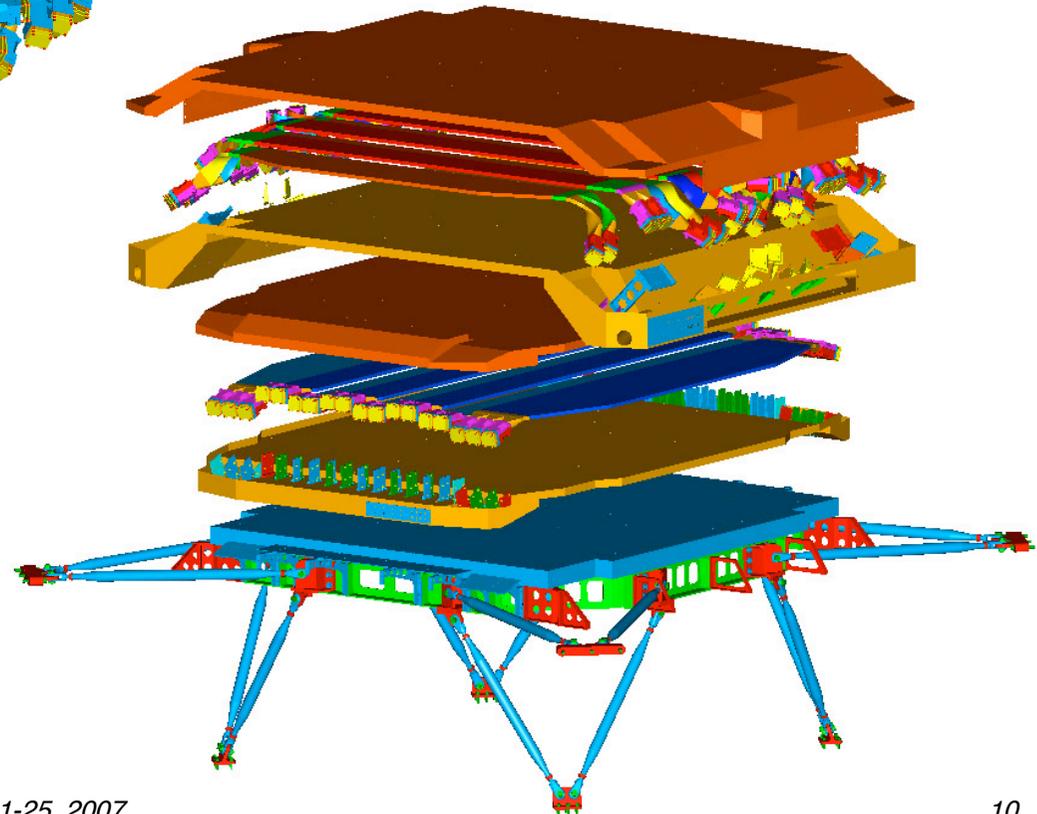
*Each counter has been tested in thermal-vacuum chamber*

- 1. Vacuum  $10^{-7}$  mbar*
- 2. Thermal cycles from  $-60^{\circ}$  to  $80^{\circ}$  C*
- 3. Glass window*
- 4. Feed through for High Voltage and counter signals*

## Scintillator planes 3 and 4

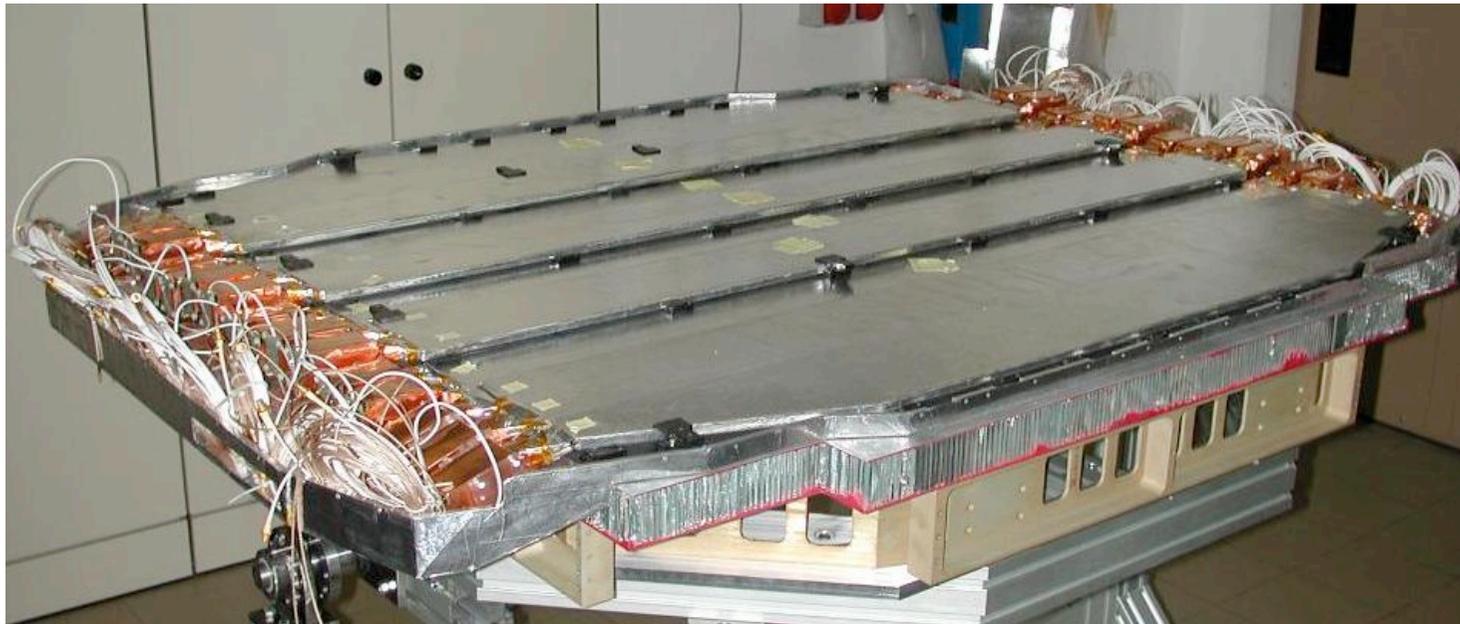


*Complete structure of the Lower TOF: exploded view*



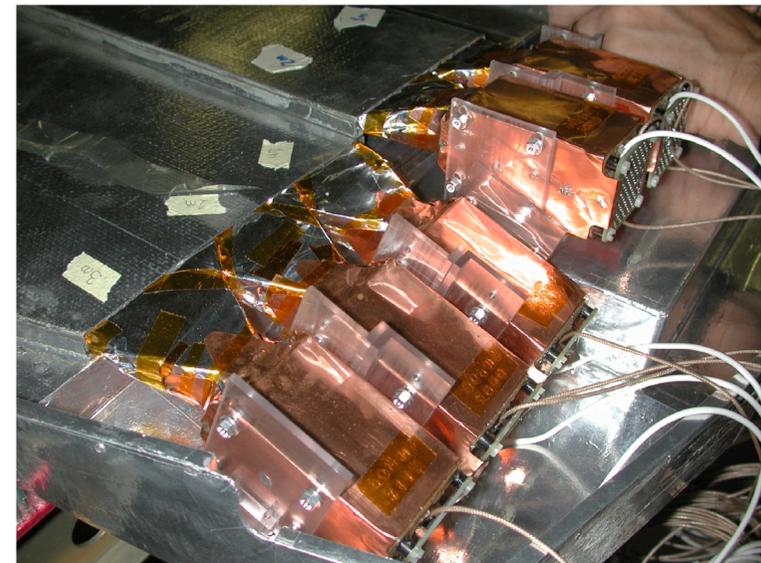


# Plane 4 counters (Lower TOF)



Plane 4 counters

*The PMs are fixed to the lower cover in order to withstand vibration stresses*





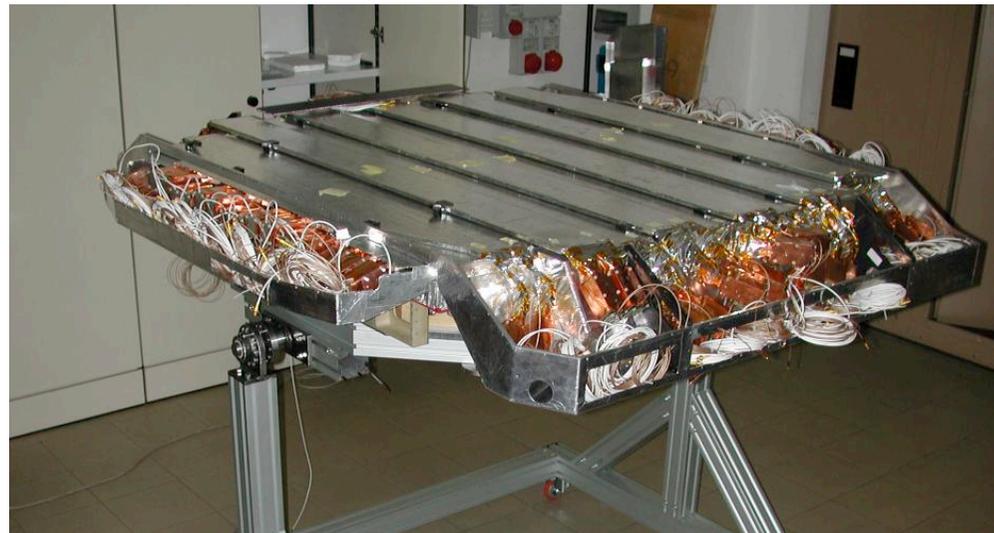
# Planes 3 counters (Lower TOF)



*Plane 3 carbon fiber down cover*



*Plane 3 counters*

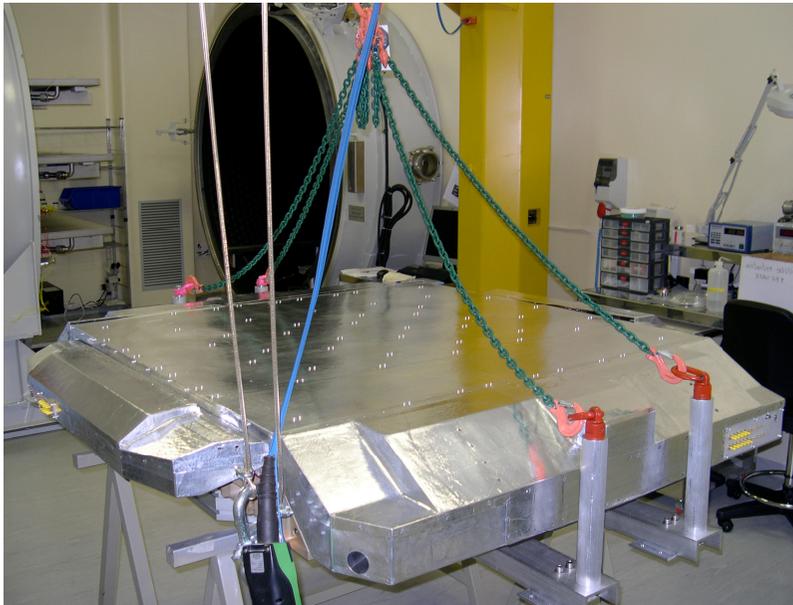




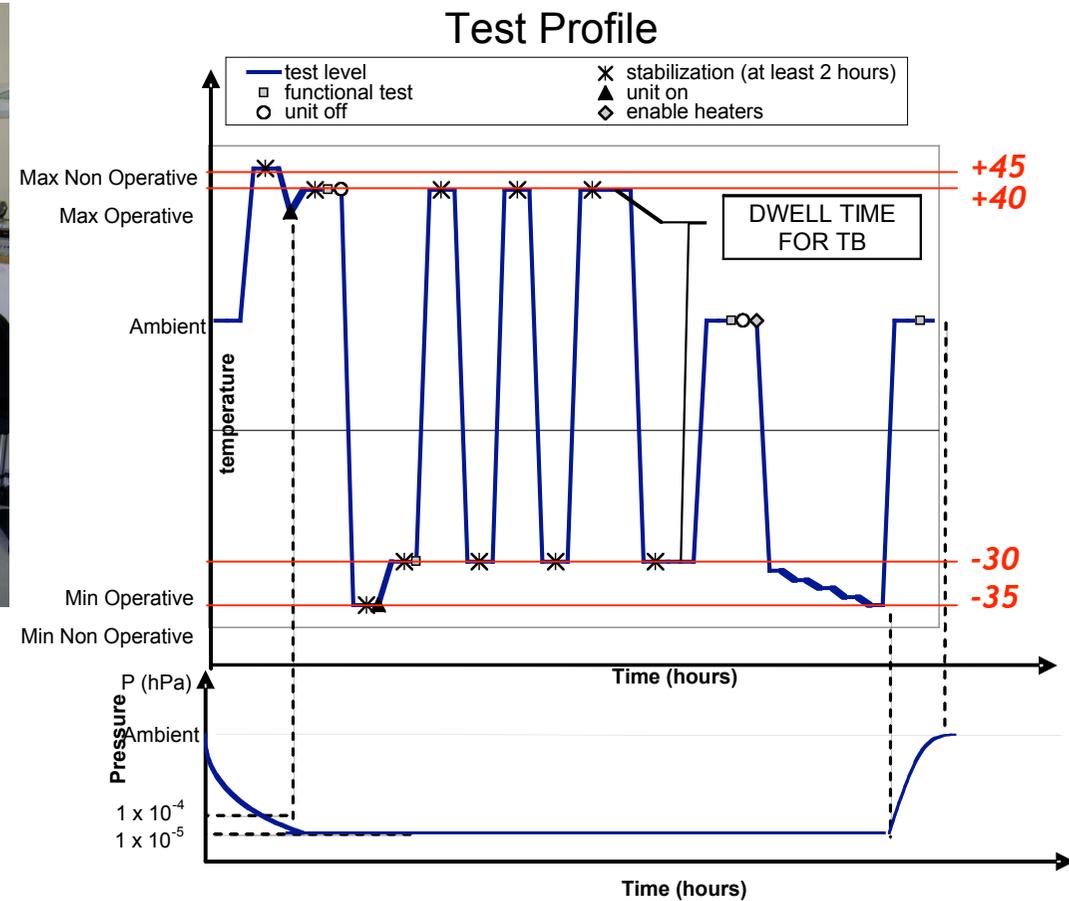
# Lower TOF Thermal Vacuum Test



The Lower TOF, being inserted into the Thermal Vacuum Chamber at SERMS in Terni (Italy)



The thermal cycling test in vacuum was successfully completed.

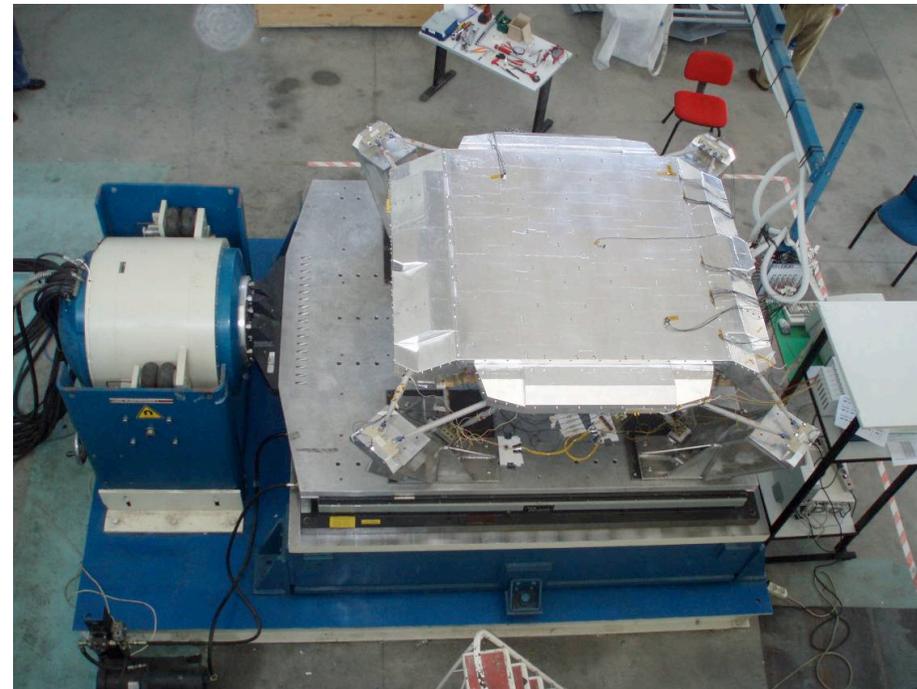


*Z vibration stand*



*The vibration tests were successfully completed.*

*X-Y vibration stand*



*The Lower TOF will be delivered to CERN for integration into the AMS-02 detector in June 2007.*

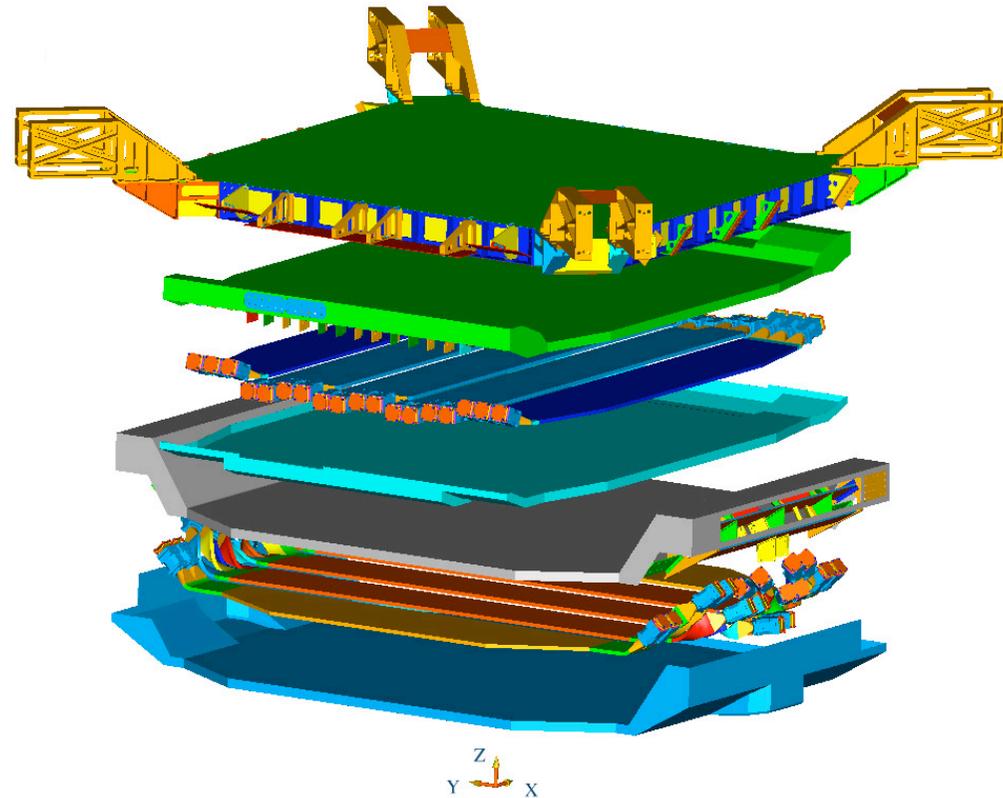


# Upper TOF



*TOF planes 1 and 2*

*Complete structure of the  
Upper TOF: exploded view*





# Planes 1 and 2 counters (Upper TOF)



*The Upper TOF is being assembled.  
It will undergo TVT and vibration tests in June-July and delivered  
to CERN for integration in October 2007.*

*Plane 1 counters*



*Plane 2 counters*

