The Transition Radiation Detector of the AMS-02 Experiment

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for:

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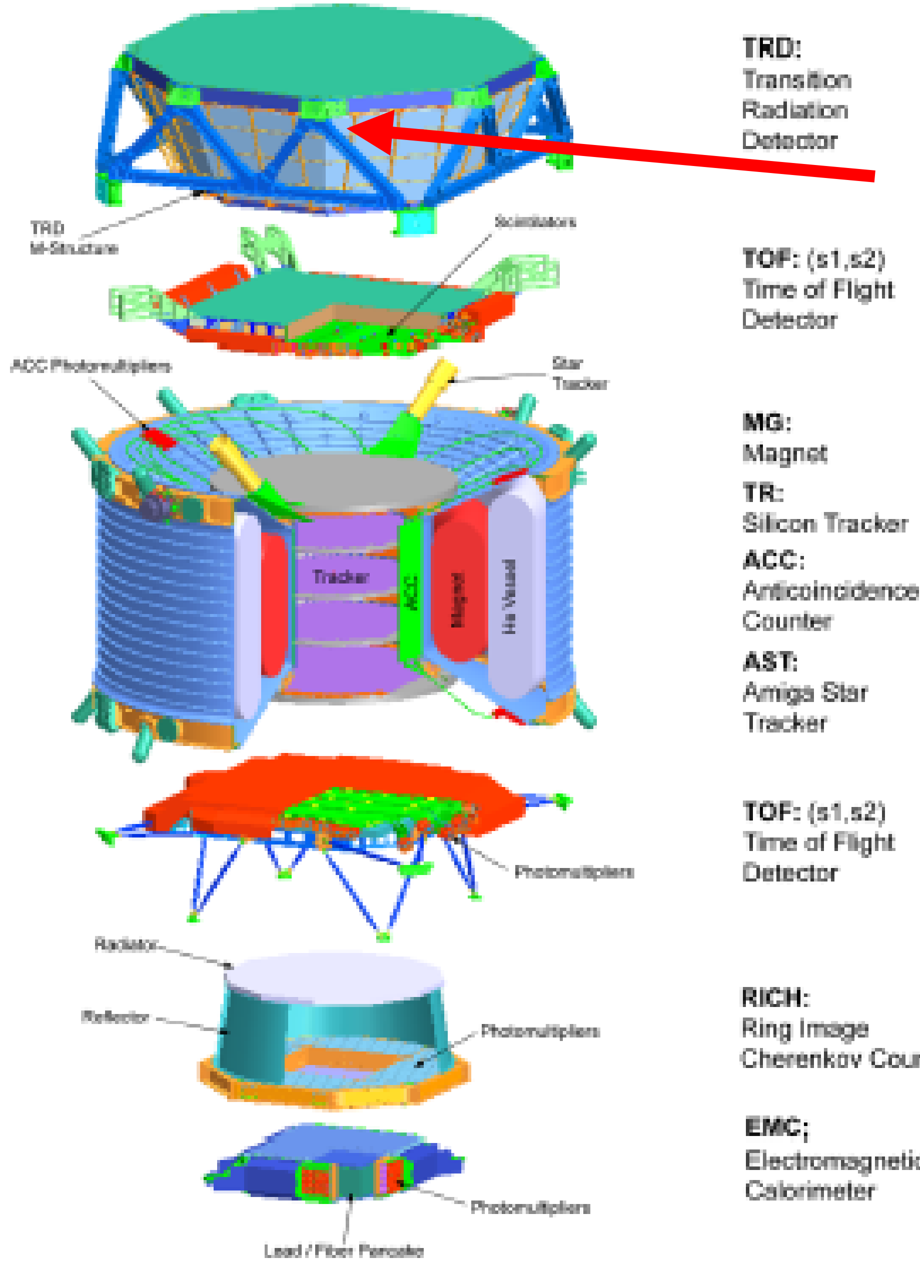
Transition Radiation Detector (TRD)

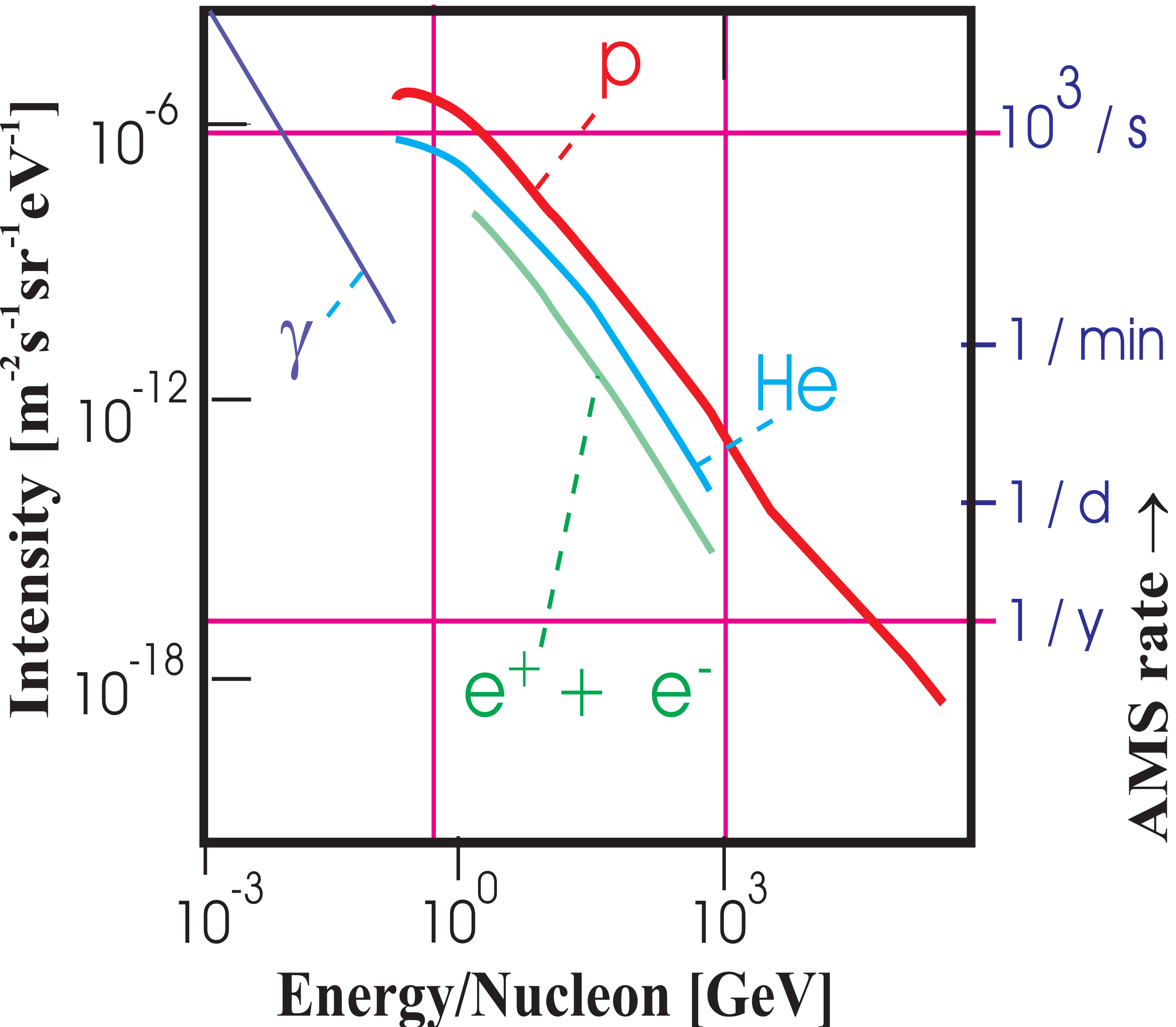


OUTLINE

- The TRD as space experiment: requirements and status
- Operating principle and construction of the TRD
- Performance
- Summary

Poster
1-P-109

Positron identification necessary to dark matter search



The primary cosmic radiation is dominated by protons

$$\frac{\#p^+}{\#p^-} = \mathcal{O}\left(10^4\right)$$

Requirements for TRD in AMS-02

AMS02 p^+ rejection 10^6 for 90% detection efficiency for e^+

Requirements for the rejection power of the subdetectors:

ECAL: $10^3 \ldots 10^4$

TRD: $10^2 \ldots 10^3$

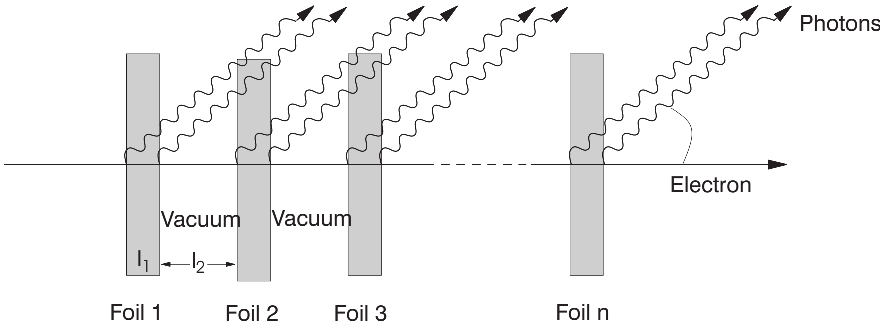
Tracker+ECAL

0.38 m^2sr

Tracker +ECAL + TRD

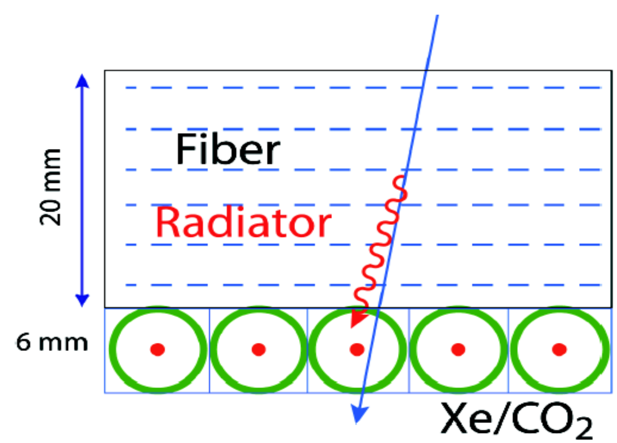
0.06 m^2sr

Principle of operation of the TRD

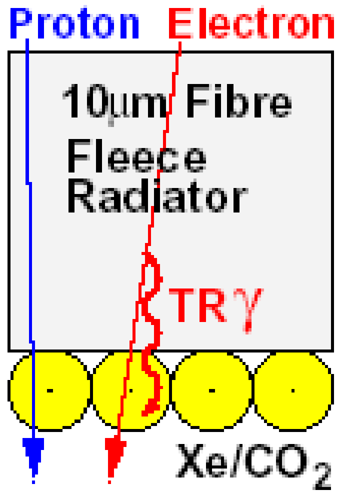


$$\gamma \;\geq\; 1000$$
$$N_{Ph} \;\; \mathcal{O} \;\; \alpha_{em} \times N_{tr}$$
$$E_{Ph} \sim \gamma(\; \mathcal{O} \; (keV))$$
$$\theta_{Ph} \sim 1/\gamma$$

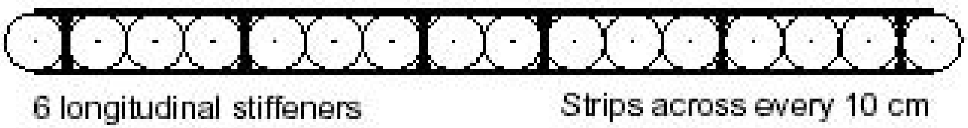
- **highly relativistic charged particle generates photons at the boundary between media ($\varepsilon_{r1} \neq \varepsilon_{r2}$)**
- **Radiator: fleece**
- **Good photon (5 –30KeV) detection: gas with high atomic number Z**



Proton-Positron separation

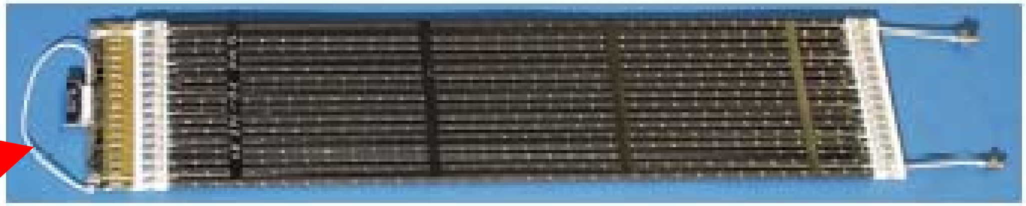


-20 layers 22 mm fleece-radiator
6mm straw-tubes Xe/CO2(80/20)
-Tubewall 72μm Kapton-Al sandwich
-Wire 30μm W/au tensioned with 100g



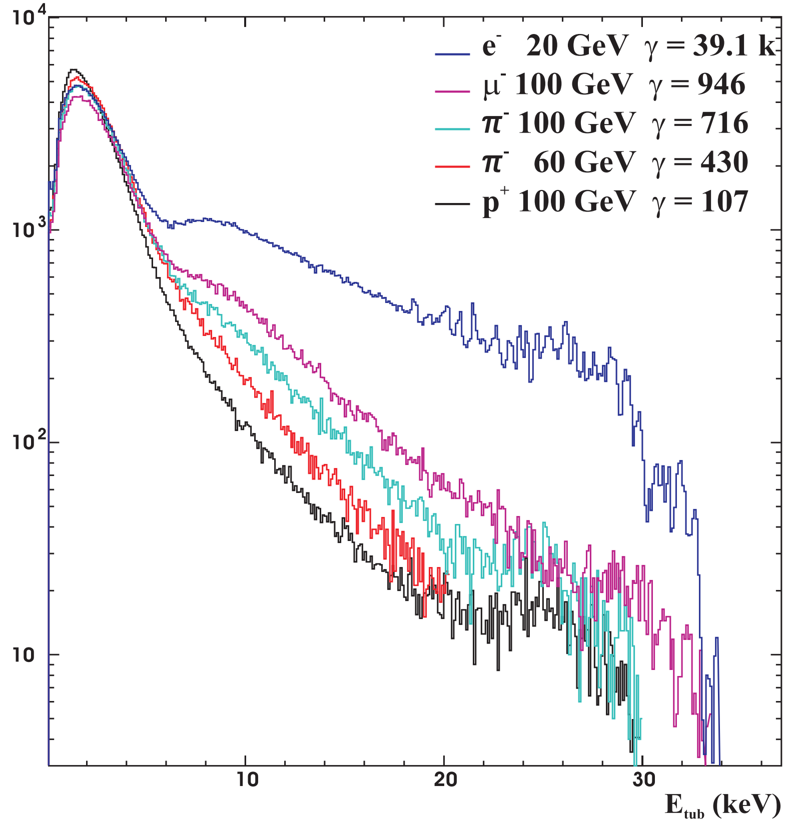
-Pressure 1250 mbar
-Gas flow 1liter/h
-Gain 3000

- Modules 16 tubes
-8 modules per gas-circuit



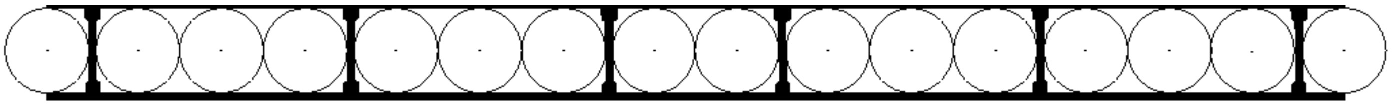
Energy deposit

Test beam results

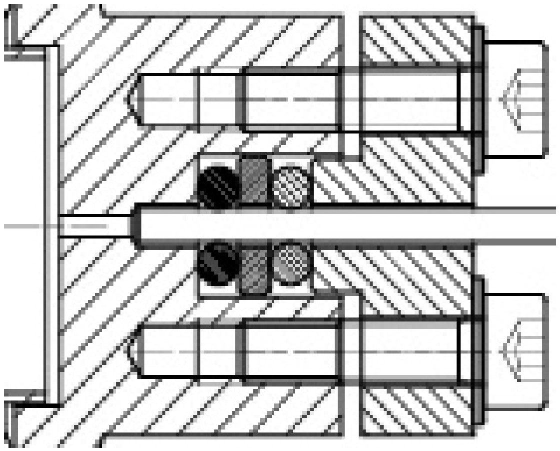


Gas tight Module

Chamber Body



16 straws with lengthwise and crosswise stiffeners

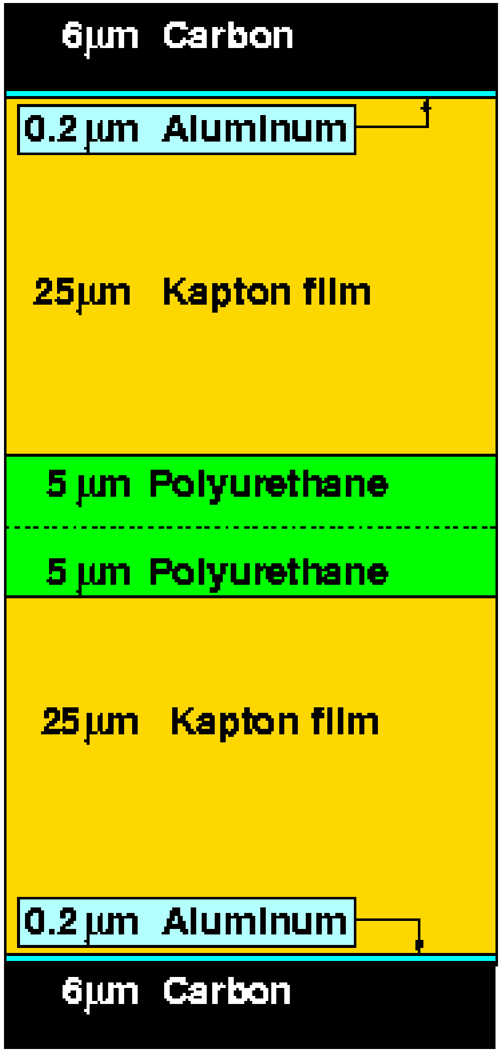


Polycarbonate endpieces
Plasma treated (O_2, 0.5 mbar, 20 min)
Glue AW 134 for potting
Copper-Tellurium Crimp Inserts

1.6mm SS Tubing

Double O-Ring
Gas Connector

Gastight Modules Require Gastight Straws



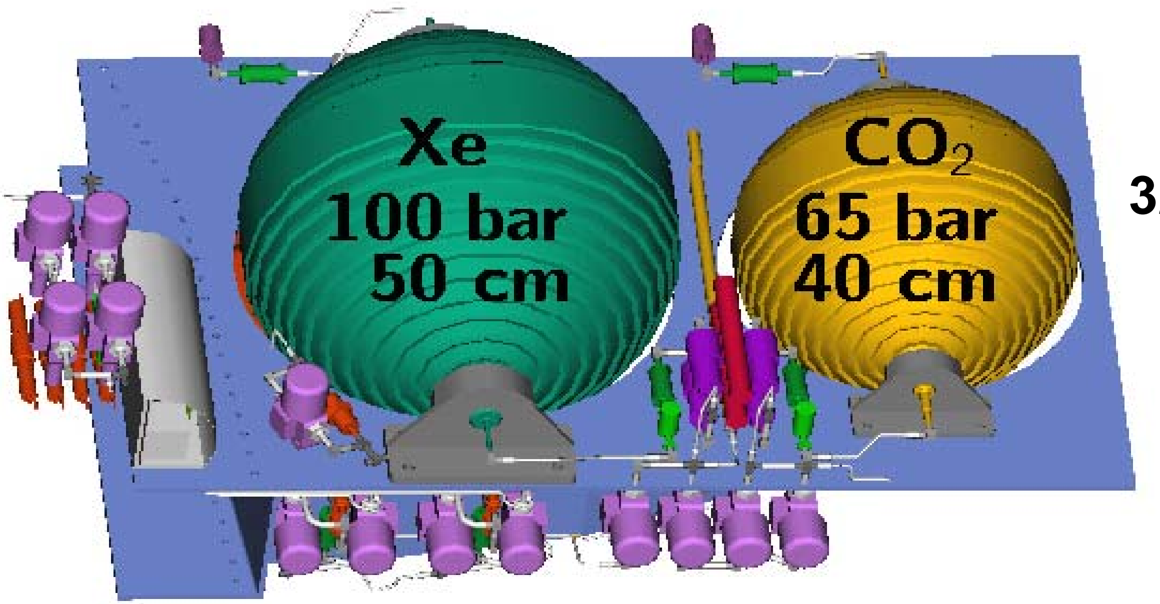
Laboratory Tests:

-12h Gastightness
2.8 bar He in Atmosphere
- 60h Gastightness
1.8 bar CO_2 in Vacuum

Max leakage for 3 years (10^8s)
5×10^{-4} mbar/s(safety factor 5)

-pA Leakage Current
-Ar/CO_2 ^{55}Fe Gas Gain Measurement

TRD Gas System

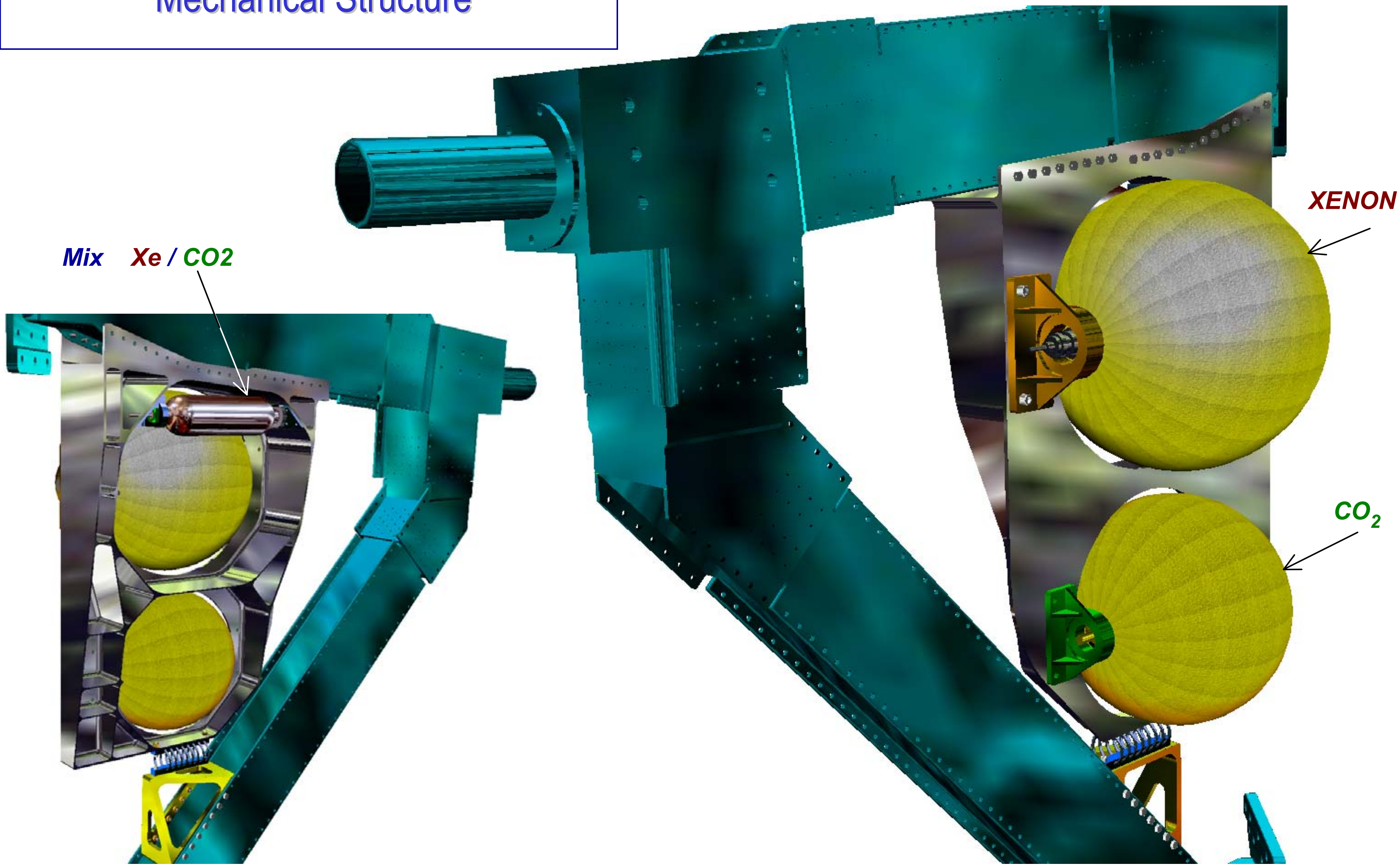


320 l @ 1 bar in 41 loops

46kg Xe (8100 l @ 1bar)
4 kg CO_2 (2000 l @1bar)

AMS

AMS TRD GAS SUPPLY SYSTEM
BOX_S
Mechanical Structure



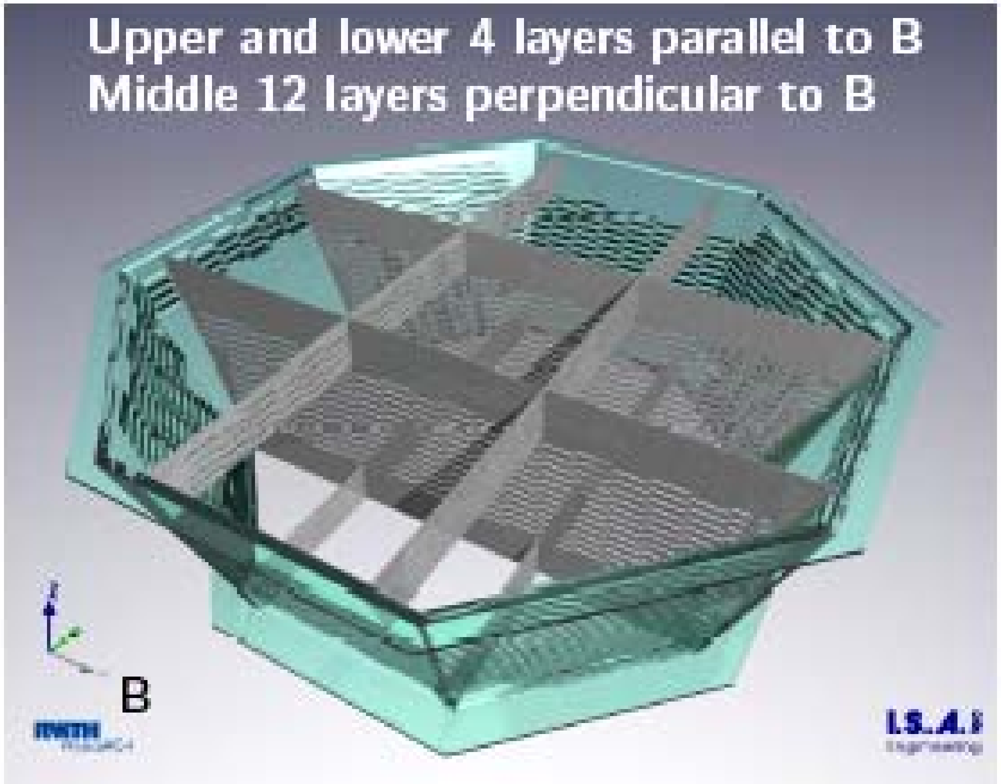
To reach the request positrons/proton rejection factor :

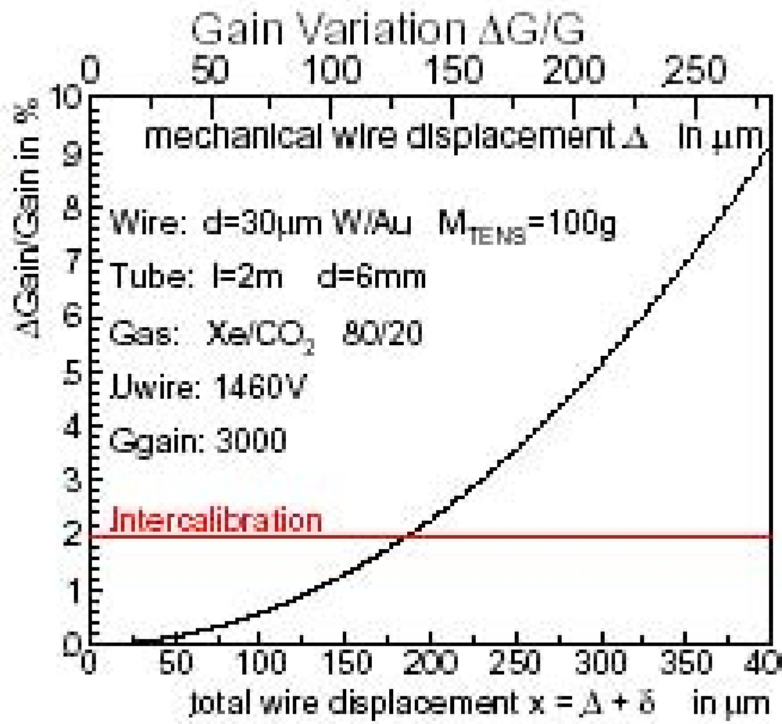
Gas gain controlled better than 5%.

→ ΔT controlled at 1°

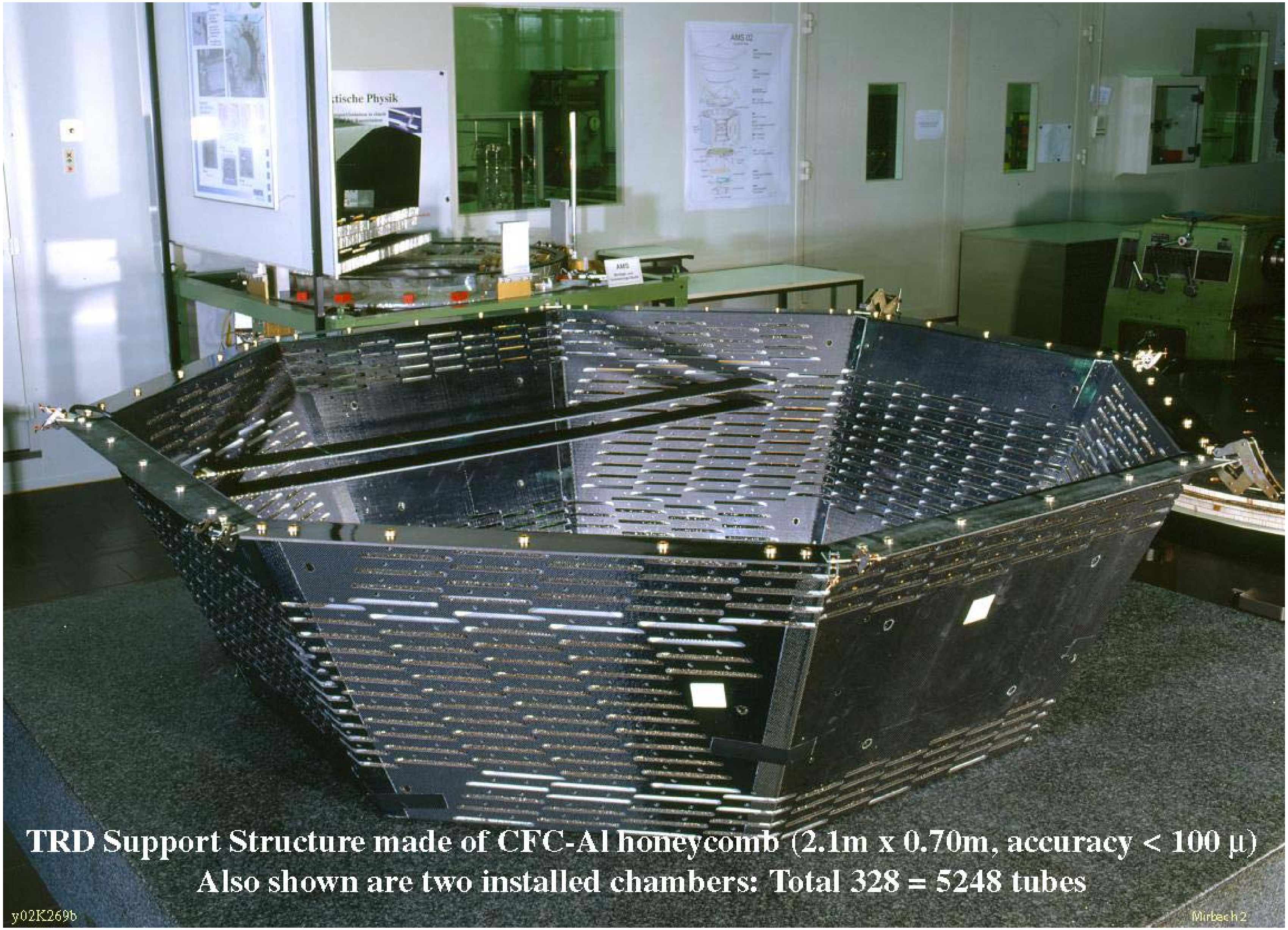
Chamber Support in Carbon-Fibre / Honeycomb Octagon

328 Modules in 20 layers



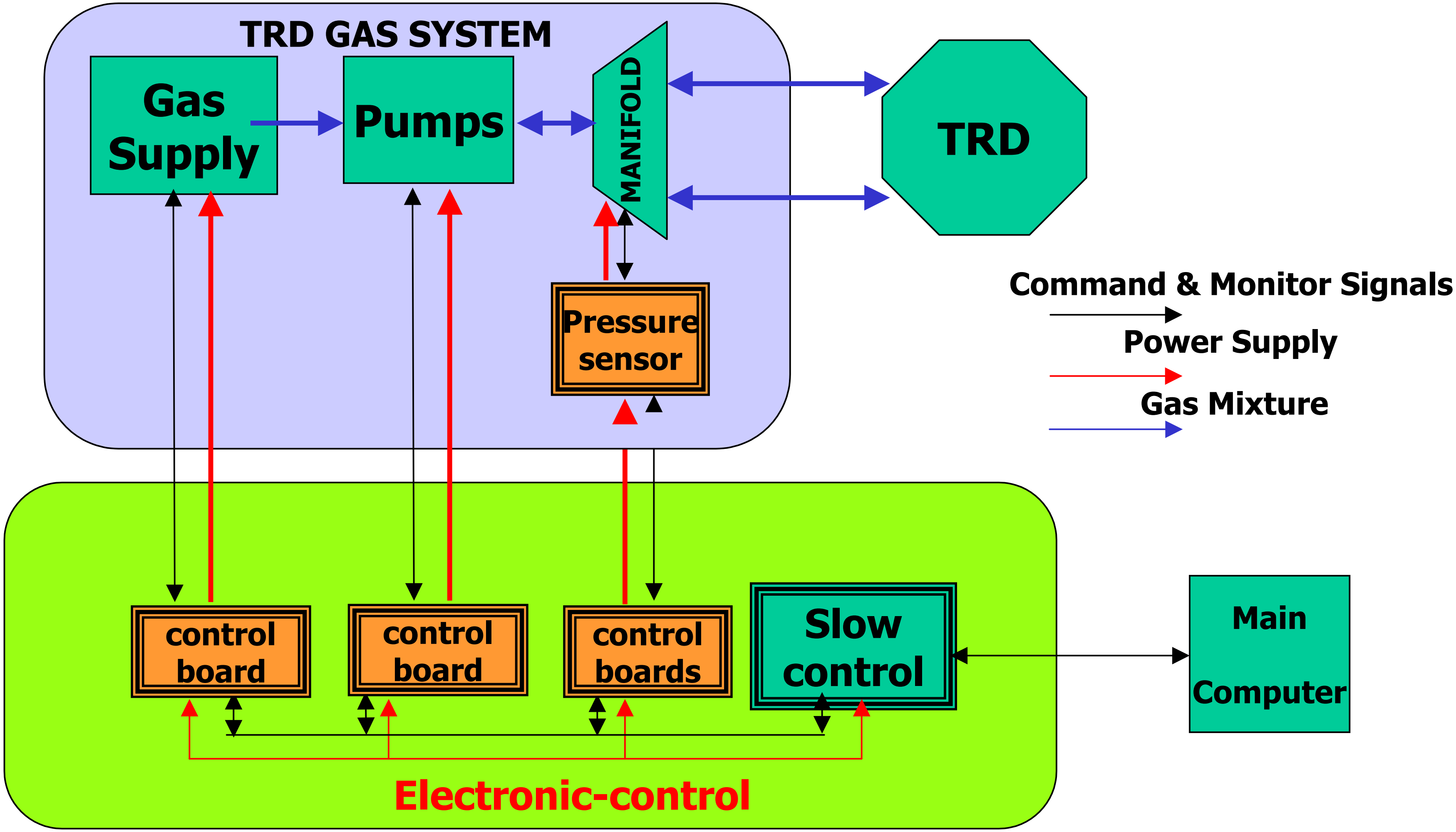


Mechanical precision < 100μm
Module lengths up to 2m

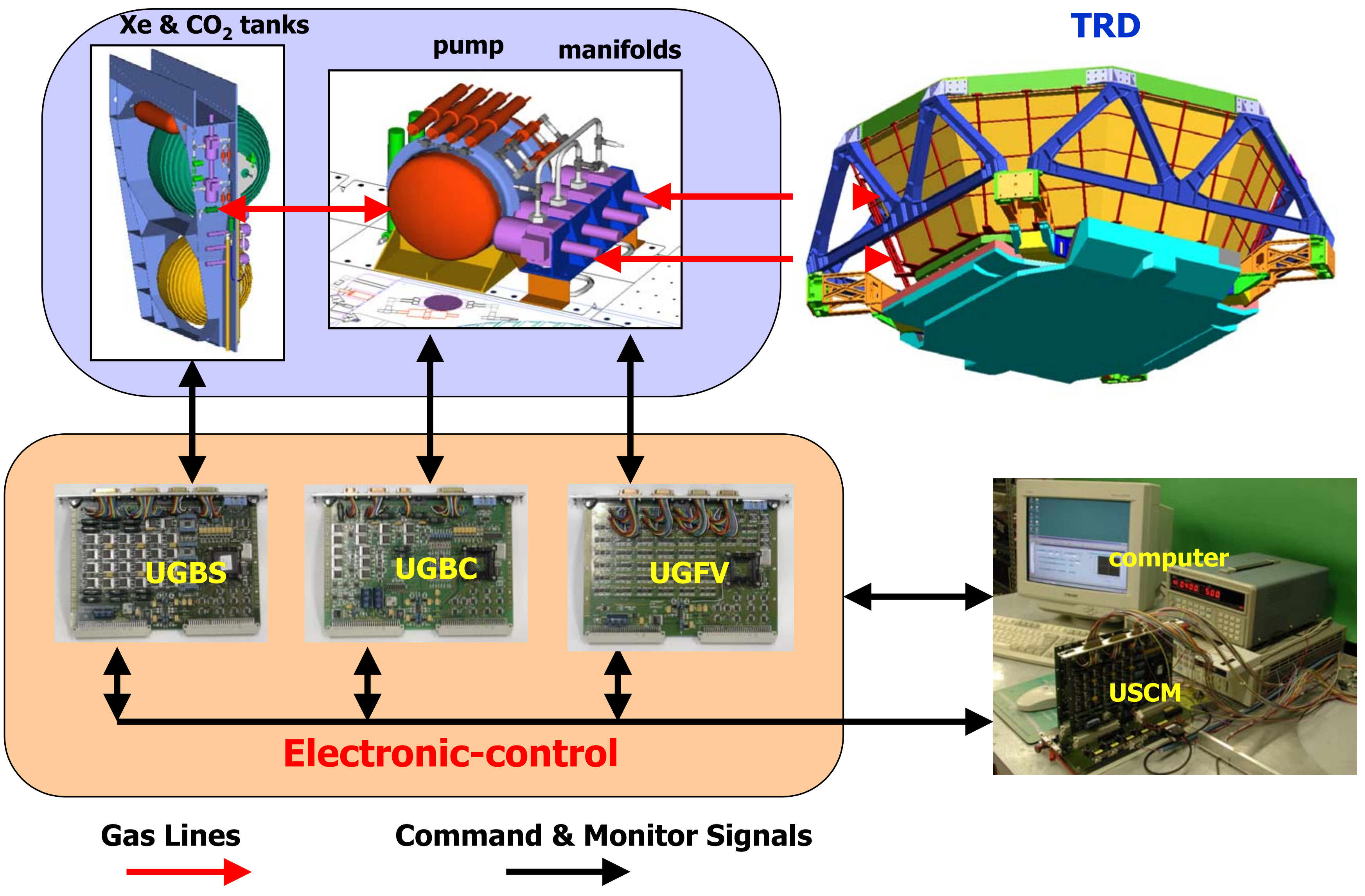


TRD Support Structure made of CFC-Al honeycomb (2.1m x 0.70m, accuracy < 100 μ)
Also shown are two installed chambers: Total 328 = 5248 tubes
y02K269b
Mirbach 2

AMS TRD GAS SYSTEM ELECTRONIC CONTROL

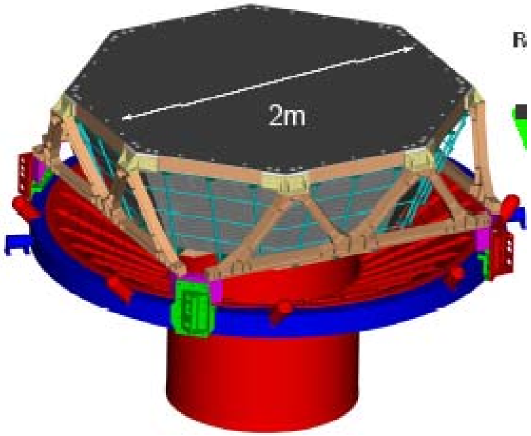


AMS TRD GAS SYSTEM ELECTRONIC CONTROL

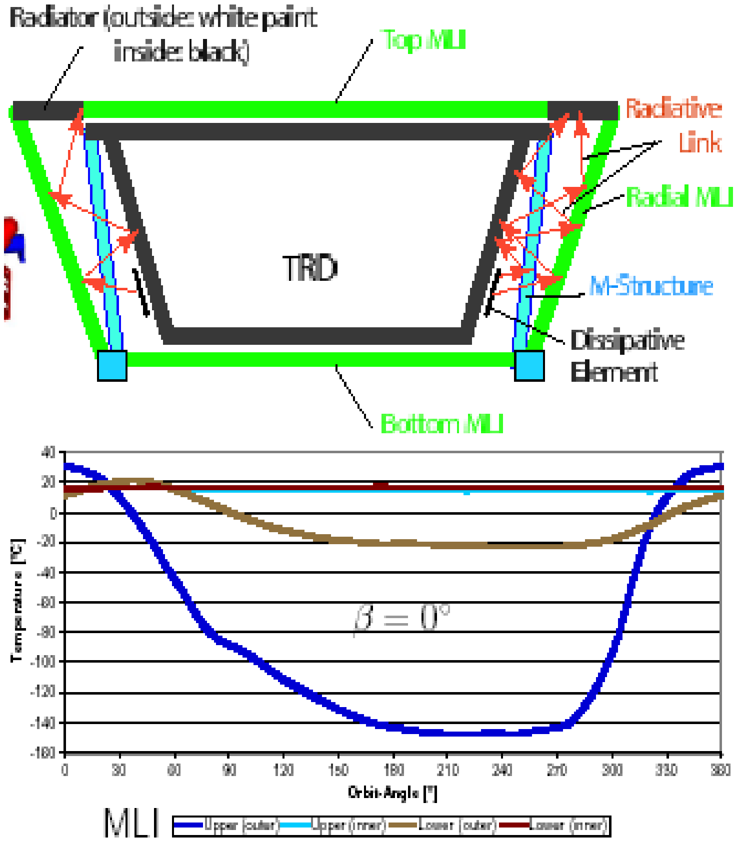


Mechanical Structure

TRD Octagon Support



Thermal Model



Other β: $+10C° < T_{inner} < +25C°$

Octagon of aluminum honeycomb with carbon fiber walls

-Stable and light

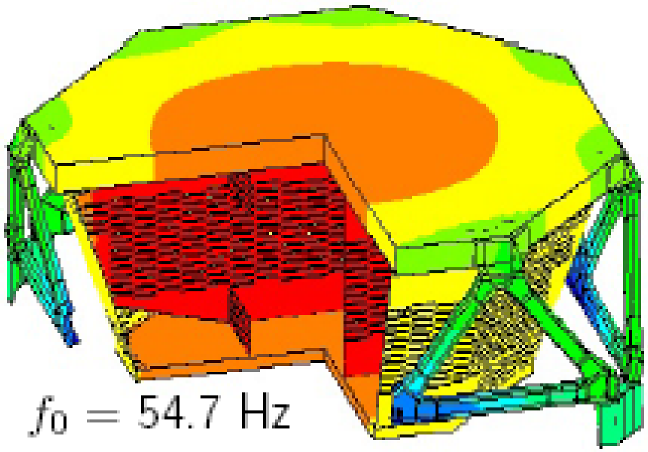
-Dimensions: height 62.3 cm, ∅ 201.8 cm (above)

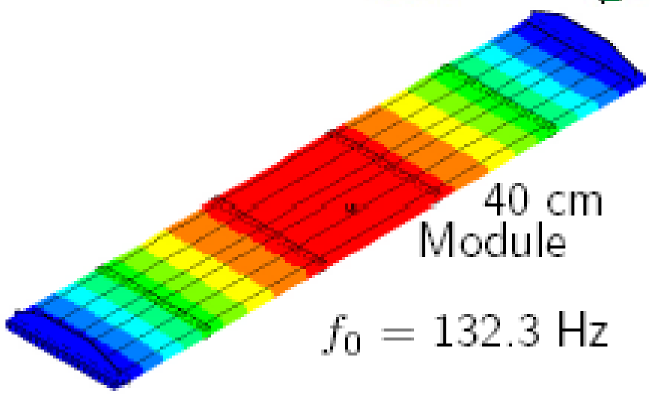
-Weight: 207 kg (including external support)

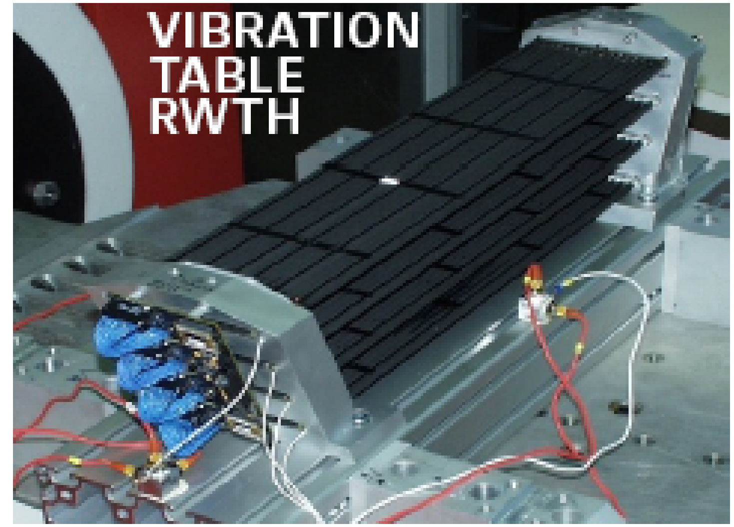
-Thermal stability through multi-layer insulation (MLI)

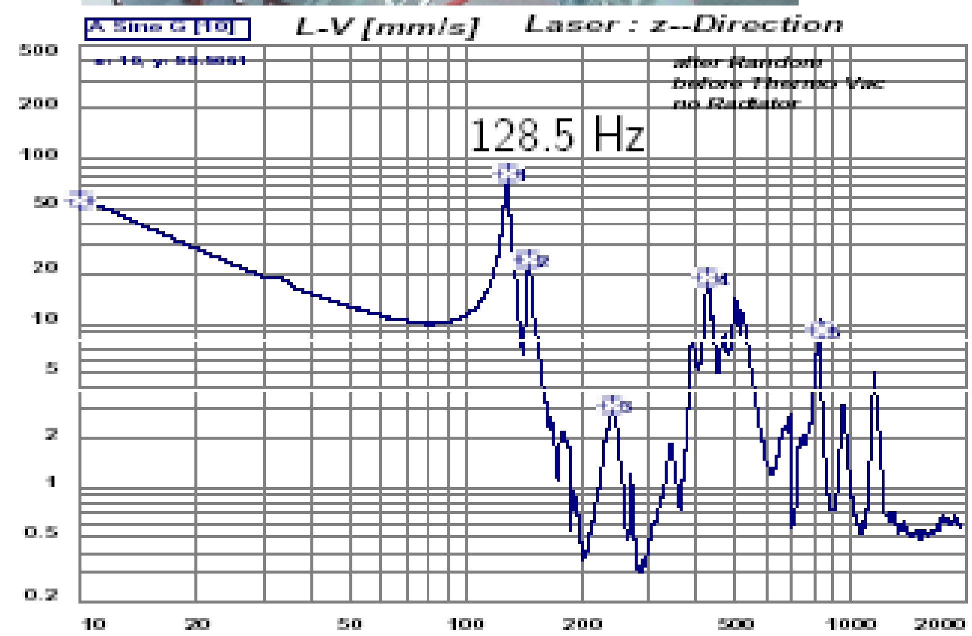
Structural Verification

FEC sufficient for $f_0 > 50$ Hz



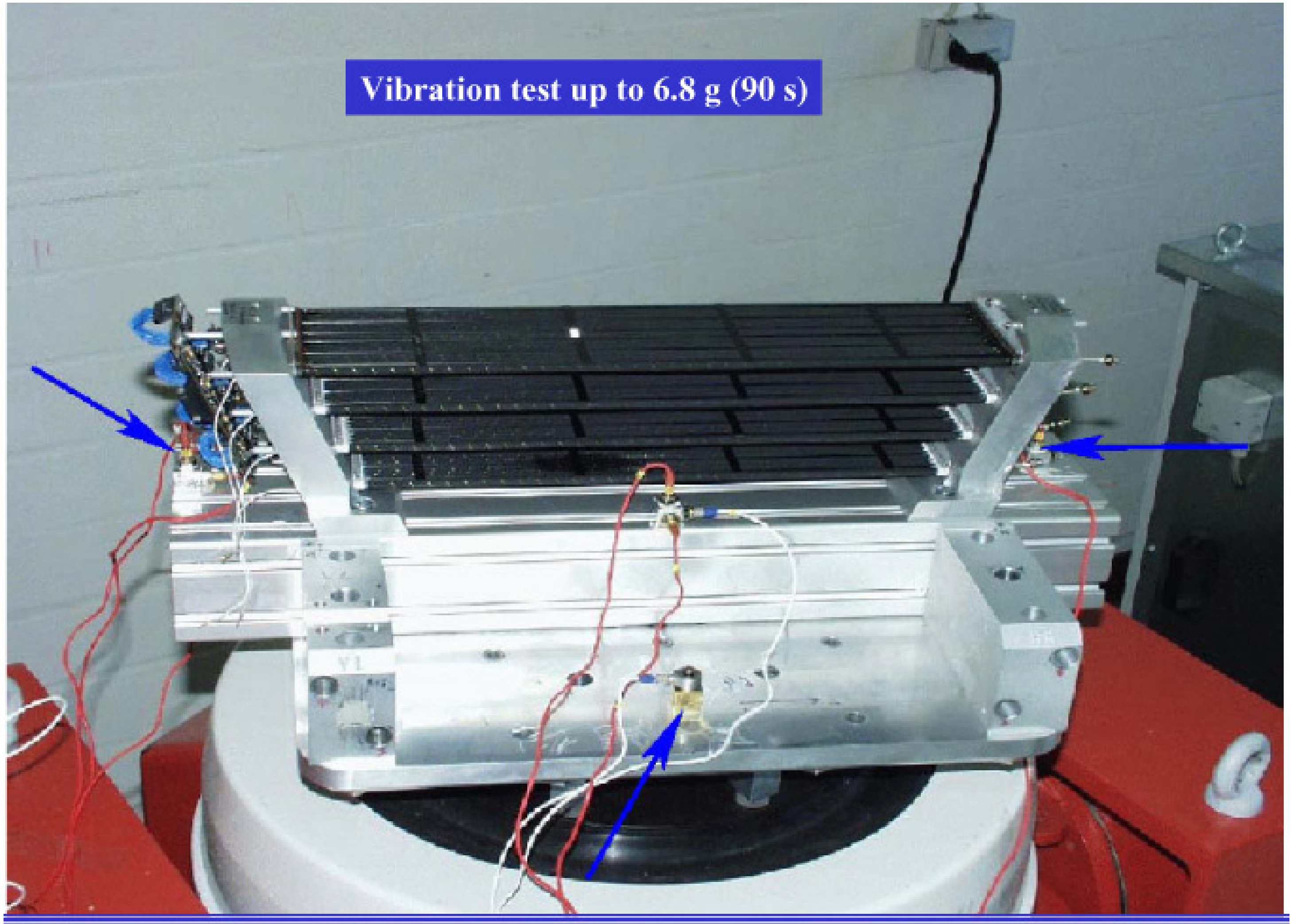






FEC coupled load modal analysis

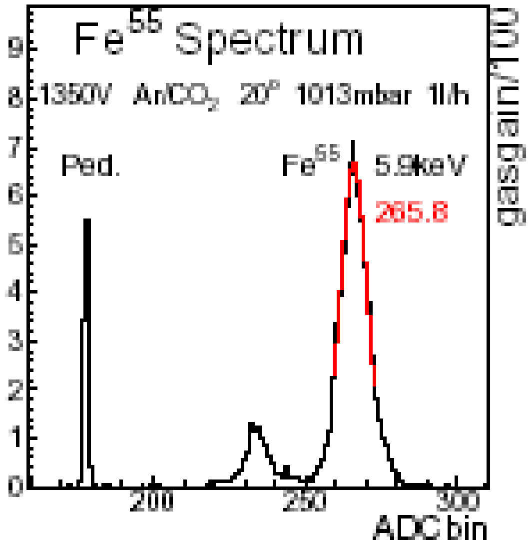
Parameters from static measurements
Verify with component vibration tests

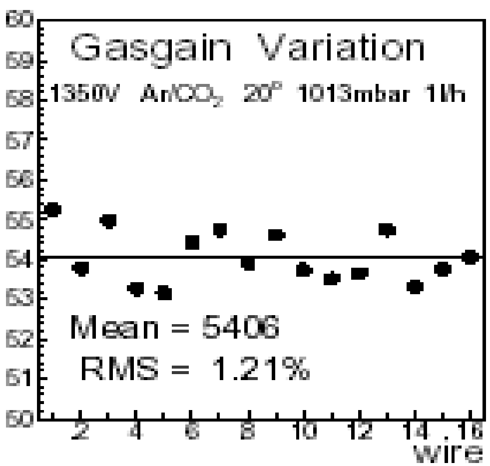


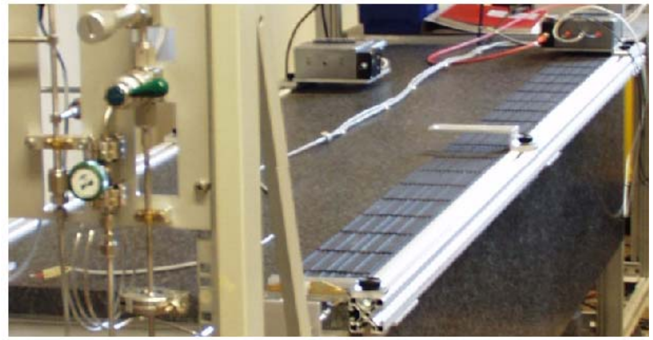
y02K248

Gain Gas Measurement

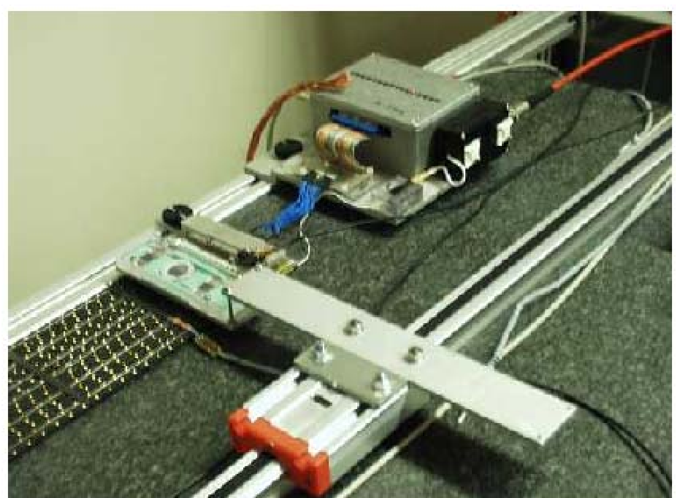
Laboratory



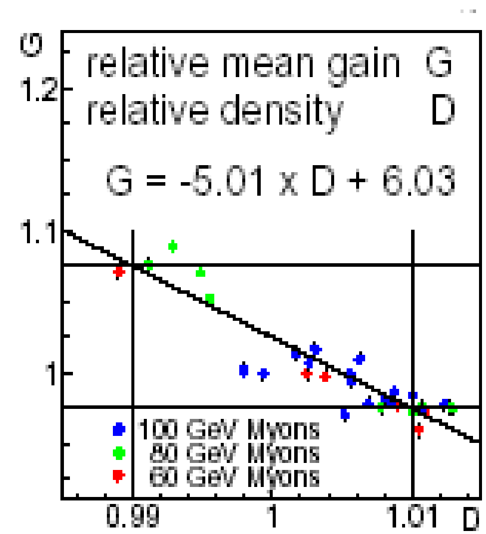




Gas gain precalibration
With **Ar/CO2**

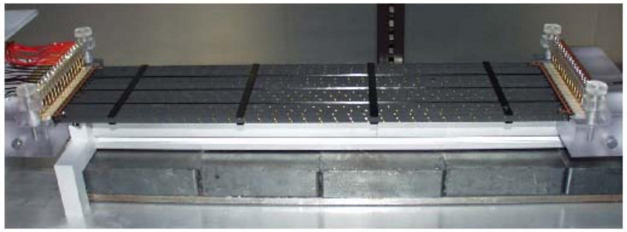


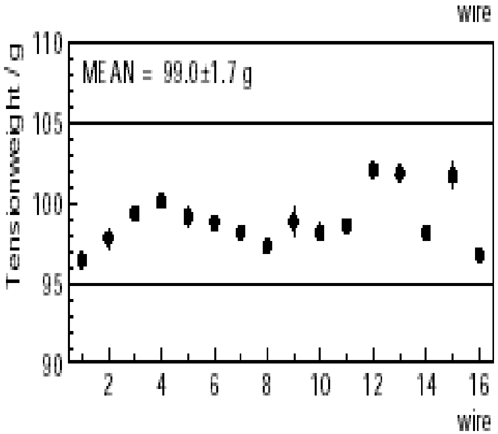
Test beam

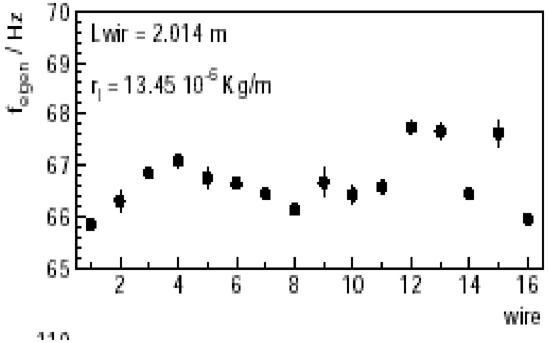


Wire Tensioning and Tension Measurement

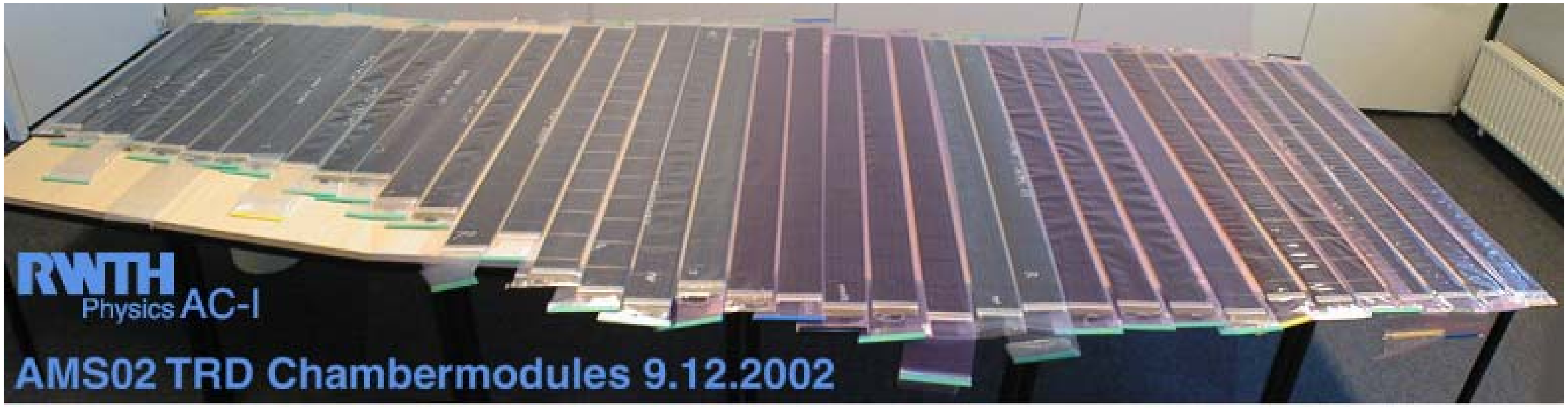
Requested wire tensioning measurents   100+/-5 gr







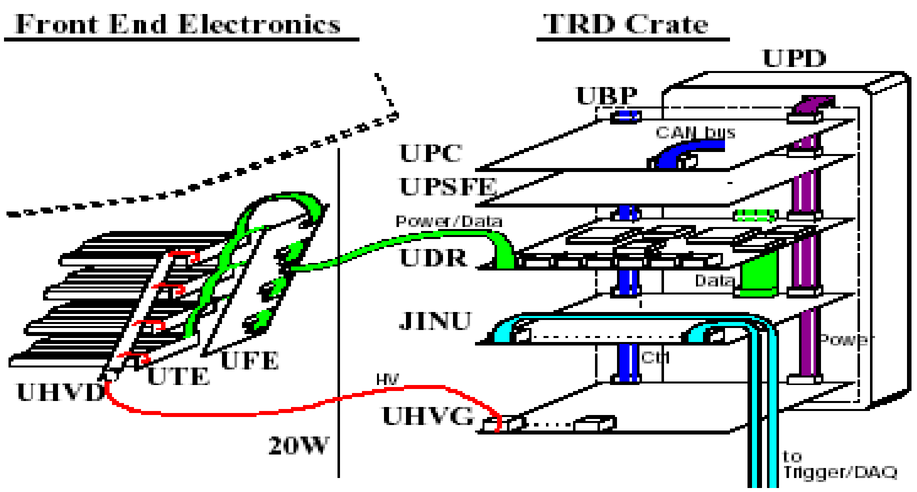
First natural frequency f_0


RWTH
Physics AC-I
AMS02 TRD Chambermodules 9.12.2002


1.5m Chamber on assembly Gigg

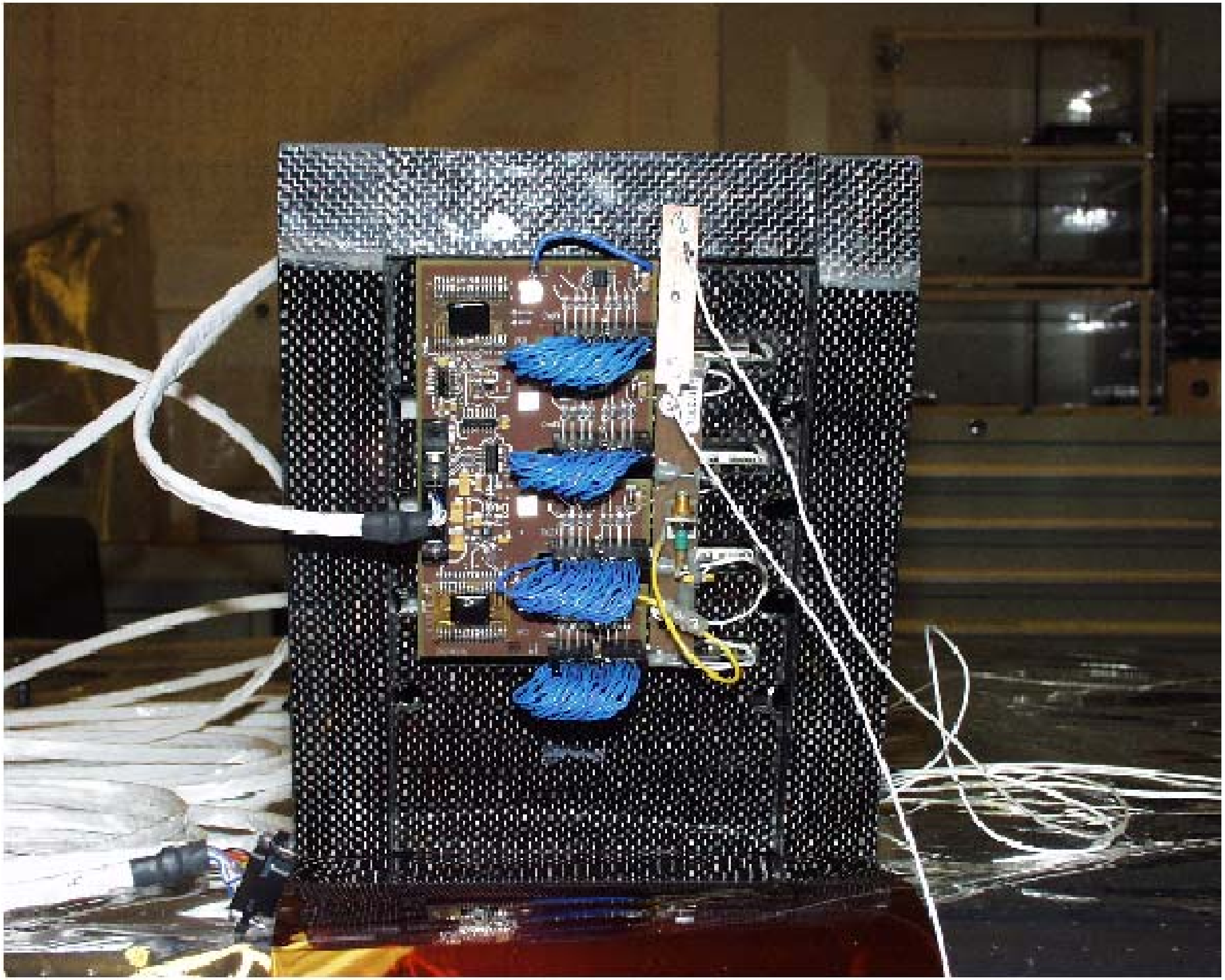
y02K266c

TRD Electronics

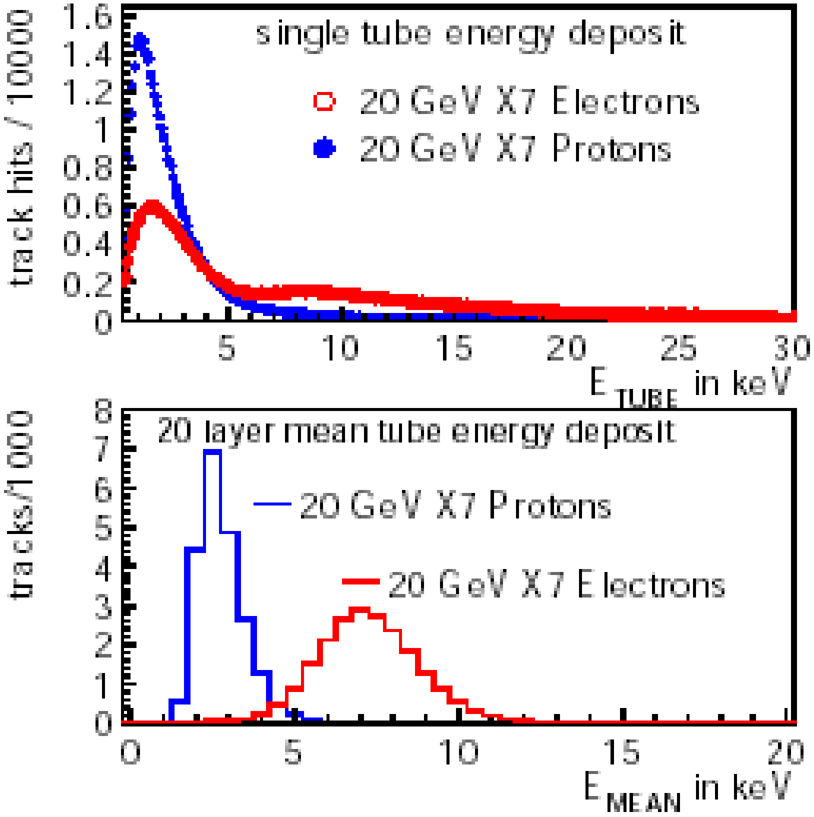


- 82 front-end units (FE), 2 crates (+ power supply)
- 5248 channels, double redundant throughout up to the front-end
- a 28V DC connection for each crate

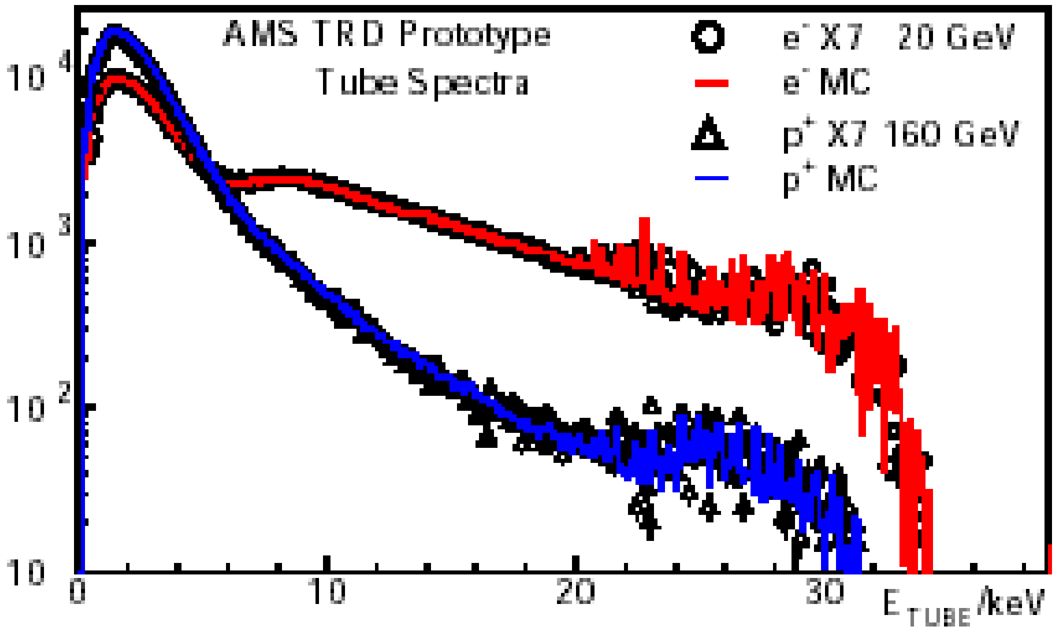
Test Assembly of a Front Electronic



TRD Beamtest beam



TRD Beamtest Proton Rejection for 90% Electron efficiency

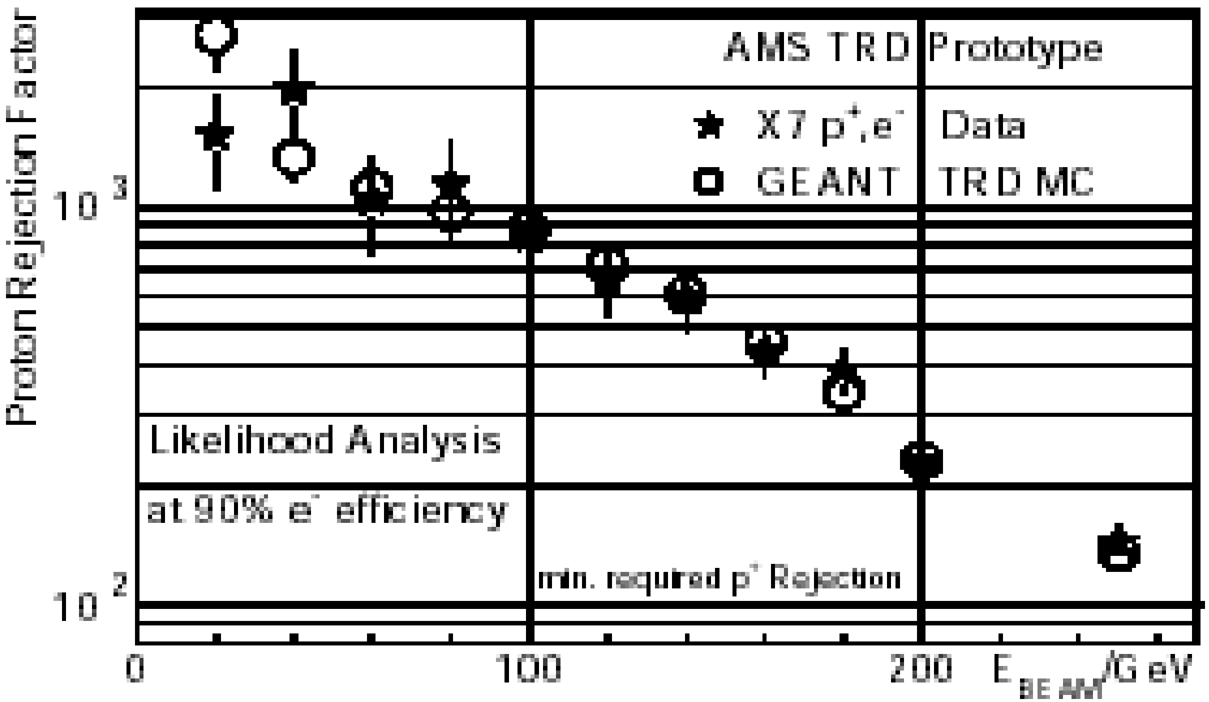


Single track preselection with MC 90% efficiency p^+/e^- likelihood separation with

$\mathcal{L} = \Pi\, p_e / (\Pi p_e + \Pi p_p)$

p_e, p_p from single tube spectra

TRD Testbeam



20 layer prototype tested with

e^-, μ^-, π^+, p^+

1-P-109

Proton rejection >10^2

reached up to 250GeV with 90% electron efficiency

Conclusion

- Required proton rejection of > 10^2 for 250 GeV has been reached

-Quality of the design (mechanical, electronic) demonstrated through calculations and tests.

-Limits kept for

- weight , power
- outgassing, leak tightness