

# The SERMS laboratory: a research and test facility for space payloads and instrumentation



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**University & INFN , Perugia**

# SERMS Overview

Joint laboratory of Perugia University (Faculty of Engineering, Terni) and INFN :

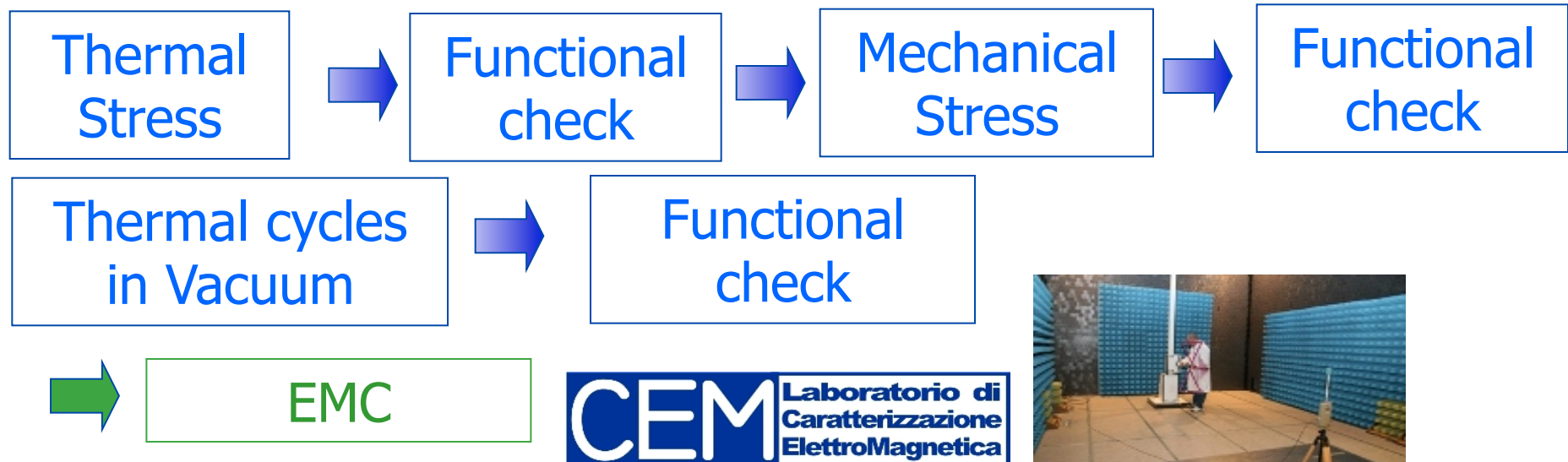
- Test facility for scientific instrumentation : mechanical, environmental stresses in air and vacuum;
- Mechanical , Thermal CAD ;
- Assembly and testing of semiconductor detectors & electronics.
- Compliant with UNI-EN-ISO 9001-2000



# Qualification sequence

Full space qualification sequence at SERMS:

- Operational tests after stress
- Verification of dynamical behaviour
- Verification of thermal model

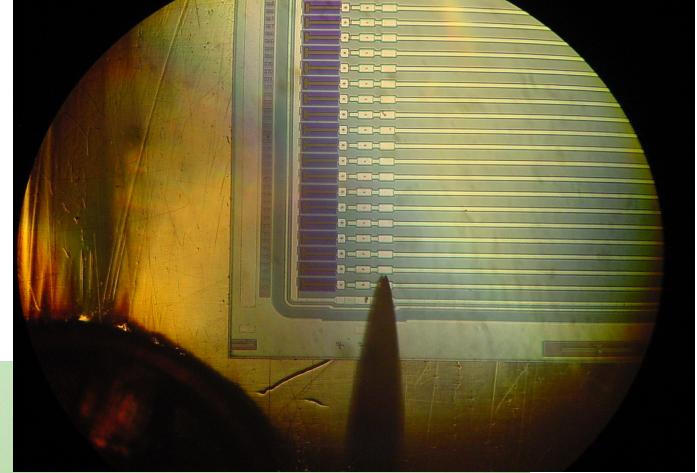


# SERMS historical Overview :

## Clean Room #1

Faculty main building:

- Clean Room (9x4x4 m<sup>3</sup>) M5.5
- Probe Station, Bonding machine



# SERMS Historical Overview :

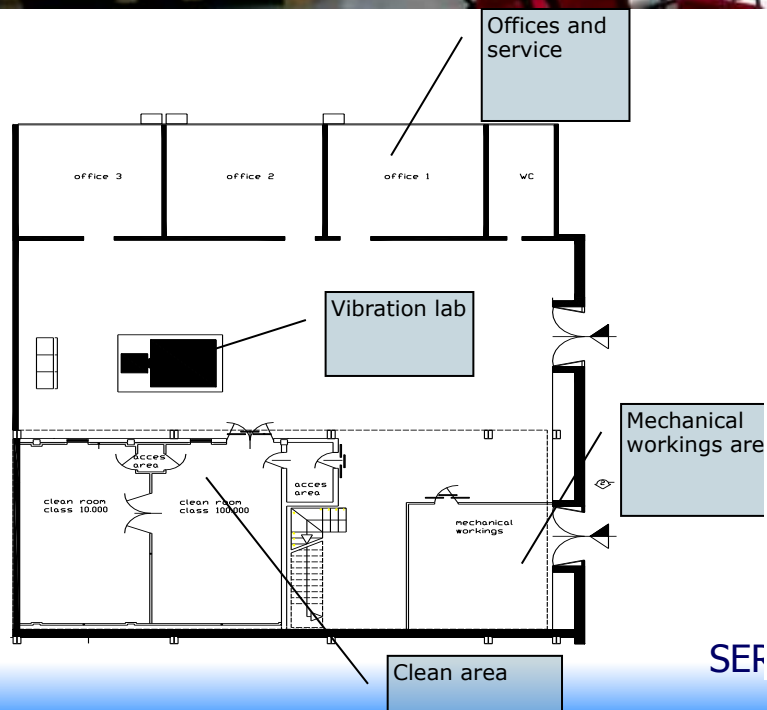
## Clean Room #1



- Electrical tests of GLAST silicon sensors (2002-2003)
- Electrical and Cosmic Rays tests of GLAST trays (2004-05)



# SERMS Overview : the “hangar”

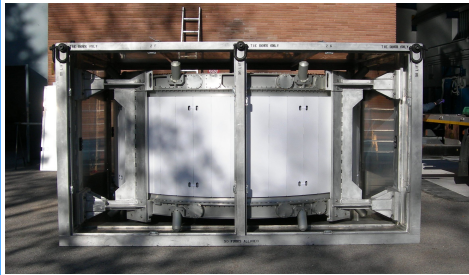


On a surface of  $\approx 500 \text{ m}^2$ :

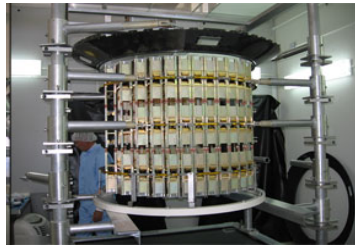
- 2 Shakers + slipping table
- Clean Rooms:
  - M5.5 ( $9 \times 4 \times 3.5 \text{ m}^3$ )
  - M6.5 ( $9 \times 5 \times 3.5 \text{ m}^3$ )
- Thermal/Climatic chambers
- Space simulator (TV chamber)

# Qualification of AMS sub-systems

MAGNET VC



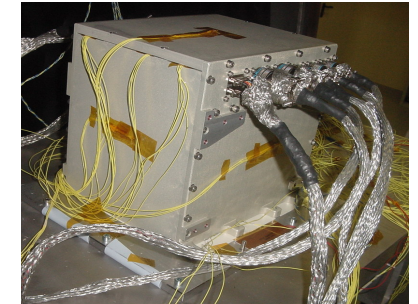
TRACKER



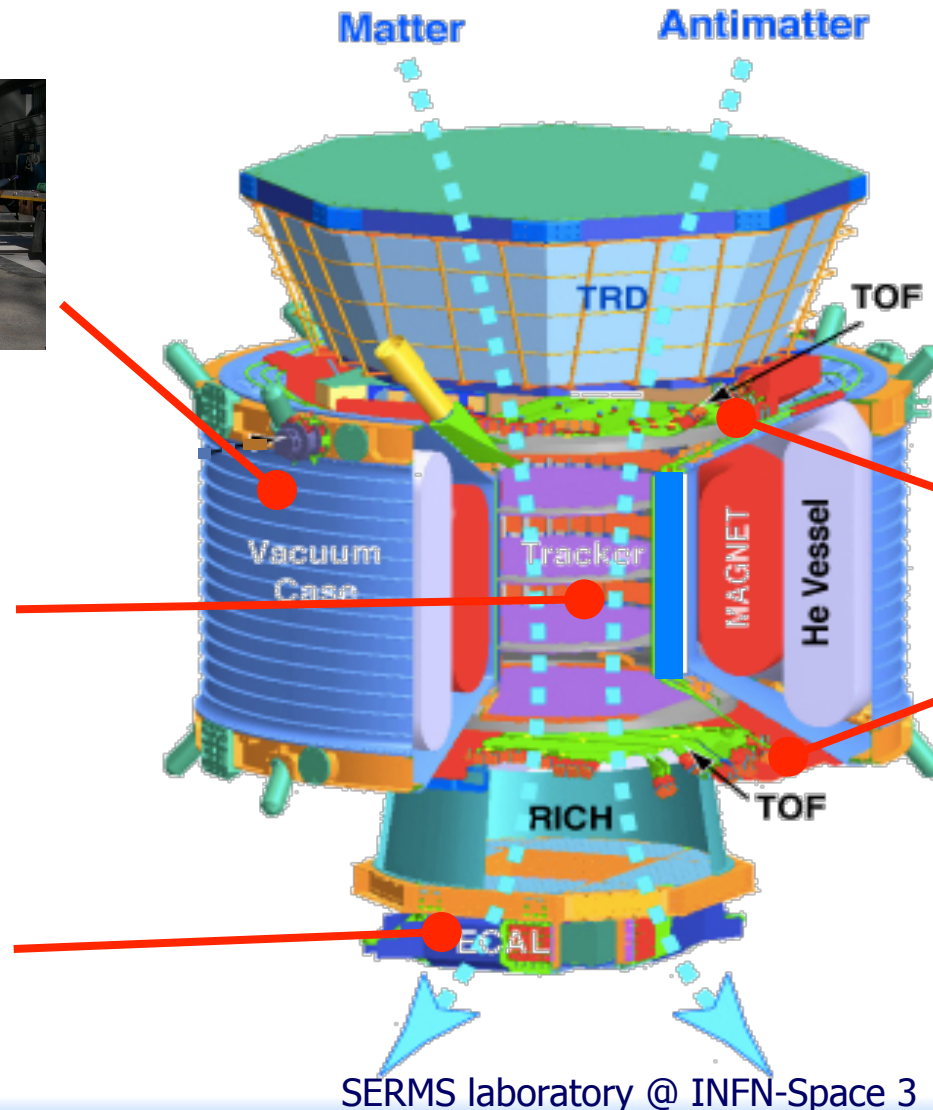
ECAL



Electronics



TOF



SERMS laboratory @ INFN-Space 3

# Thermal Stress

Large volumes (1-2 m<sup>3</sup>)  
Temperature ranges: -70°C +180°C  
Thermal gradients: 1.5/2 °C /min  
15 °C/min  
Humidity control: 10-90°C

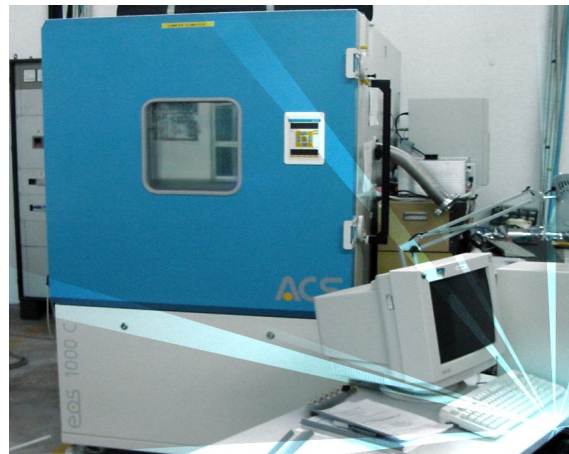


AMS-TRACKER SILICON LADDER

EOS 1000 C



TY 2000 WC



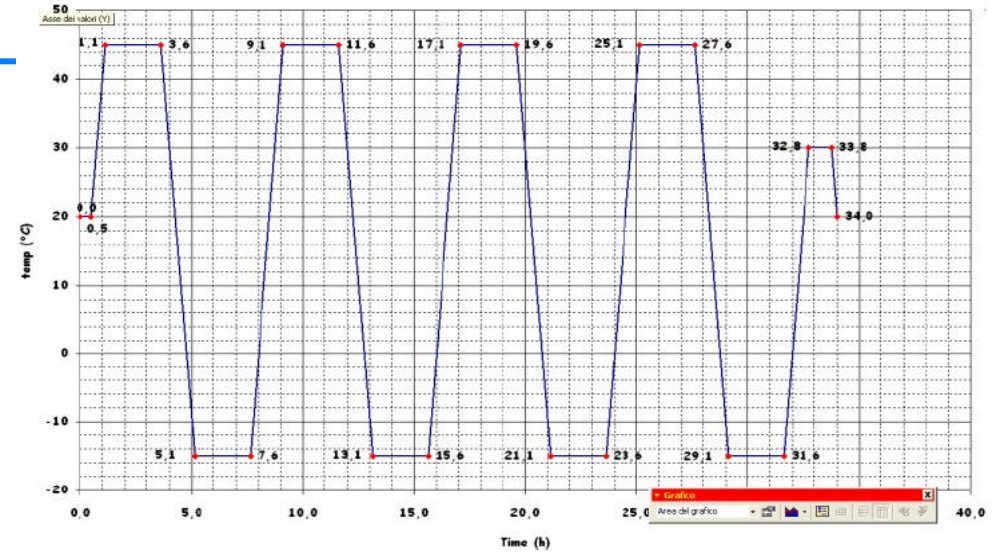


# Thermal Stress

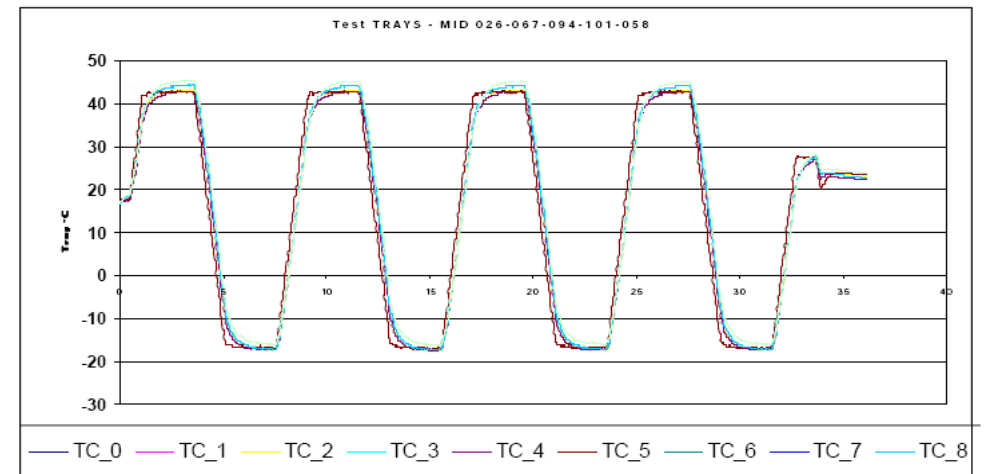
## GLAST TRAYS



Thermal profile



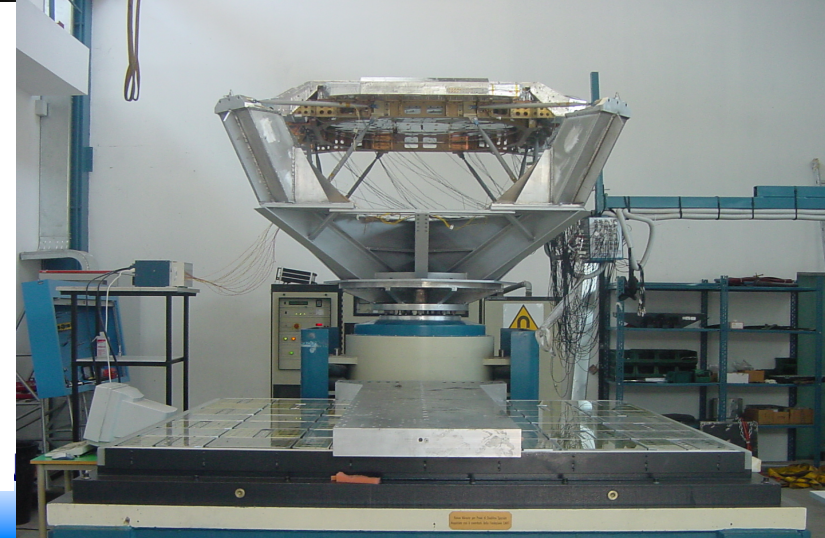
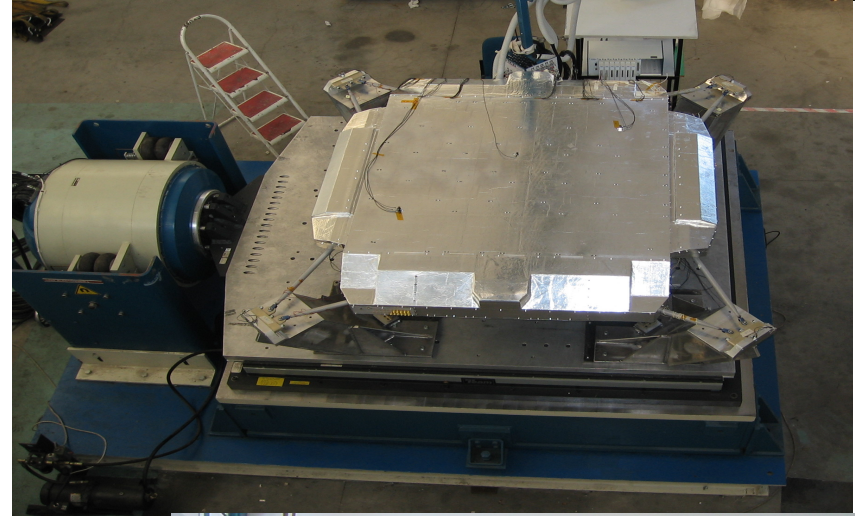
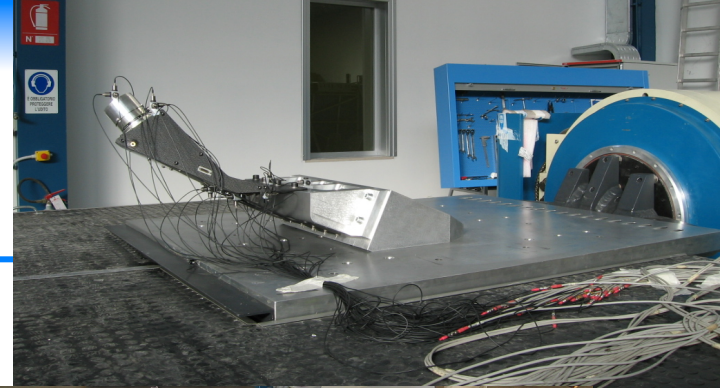
Thermocouple DAQ



# Mechanical tests

- Resistance to stress  
(manufacturing, design check)
- Verify dynamical behaviour
- Electrodynamic Shaker
  - Frequency: 5 - 3000 Hz
  - Max Force : 140 KN
  - Slipping table: max. 2x2 m
- Measurement channels:
  - accelerometers: 100
  - Strain gauges : 64

AMS : LTOF, UTOF, ECAL, STAR  
TRACKER, ELECTRONICS, MAGNET  
VC



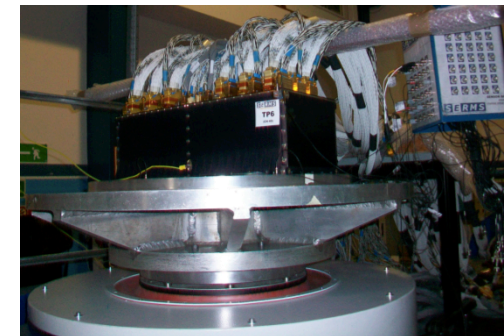
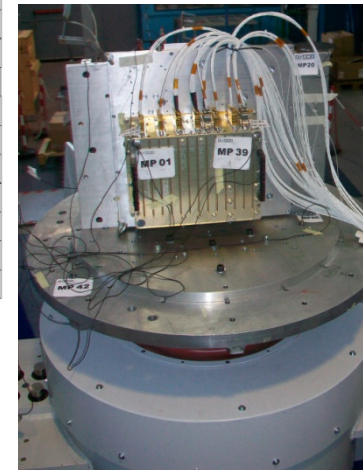
# Mechanical tests

- Resistance to stress (manufacturing, design check)
- Verify dynamical behaviour



TECHNICAL SPECIFICATION VIBRATION GENERATOR S 59349/\*-440

Rated peak force (N   lbf)	Sine/Random/Shock	49500/49500/99000	11128/11128/22256
Frequency range (Hz)		5-3000	5-3000
Max. rated travel (mm   inch)	Pk-Pk	50.8**	2.0**
Max. velocity (m/sec   inch/sec)	Sine/Random/Shock	1.8/1.8/2.5	71/71/98
Max. acceleration (g)	Sine/Random/Shock	100/100/224	100/100/224
Max. power consumption at 400 V (kVA)		40	40
Nominal impedance (Ohm)		0.3	0.3
Suspension stiffness (N/mm   lbf/inch)		200	1142
Max. weight tested (kg   lb)		910	2006
Effective moving mass (kg   lb)		43.0	94.8
Main resonance frequency (Hz)		>2100	>2100
Weight with trunnion (kg   lb)	AIT/LB	4350/3350	9590/7385
Stray magnetic field (mT)	without/with degauss kit	<20/<1	<20/<1
Armature (ø/mm   ø/inch)		440	17.3
Cooling (m³/h   ft³/min)		4200	2472
Interlocks		Temperature, overtravel, airflow, overcurrent, compressed air	



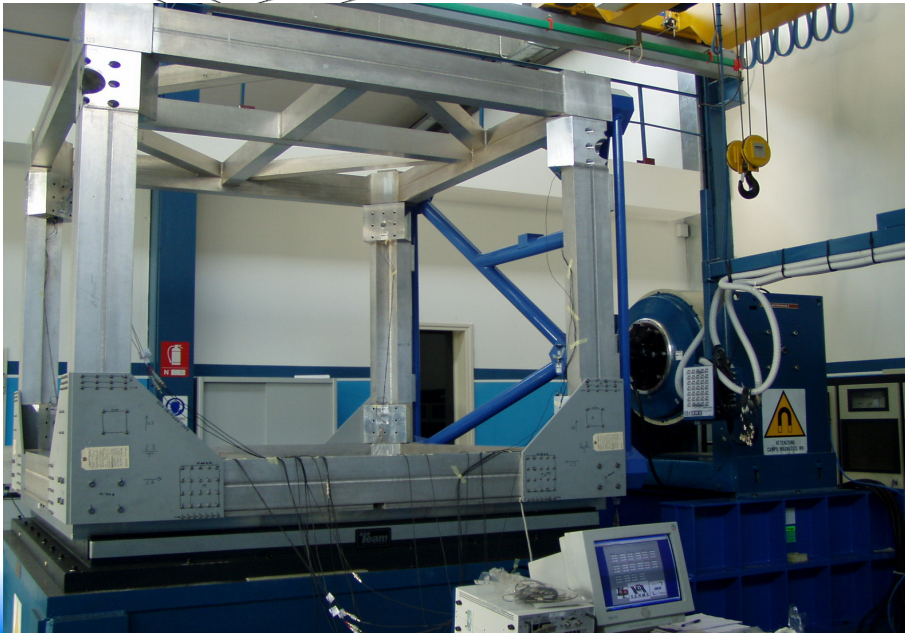
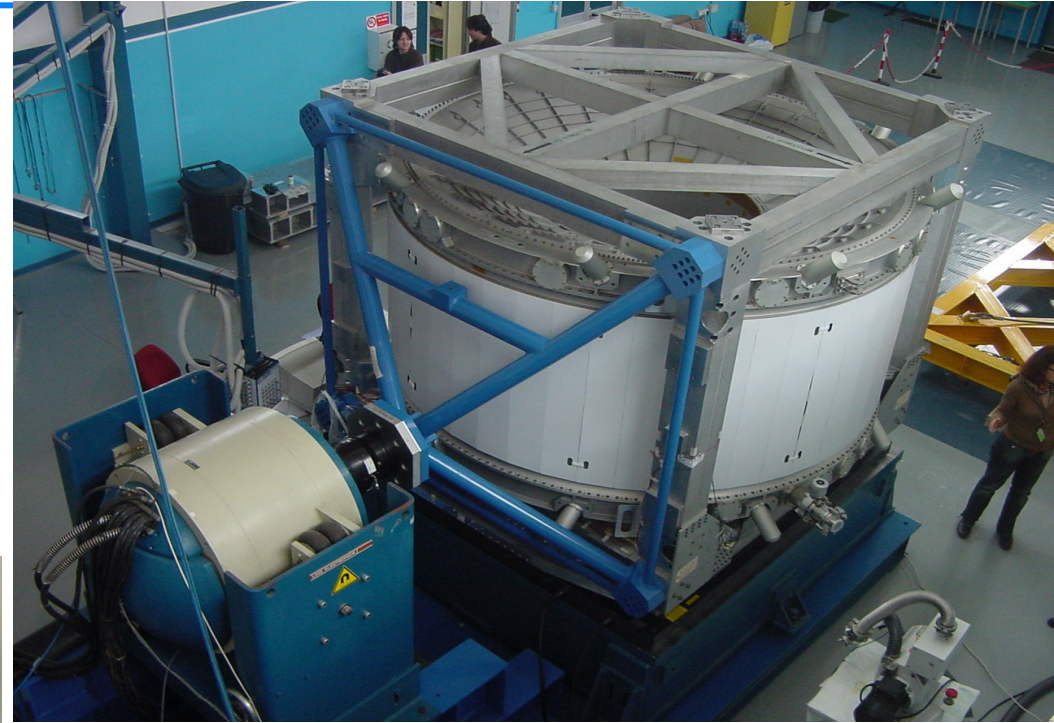
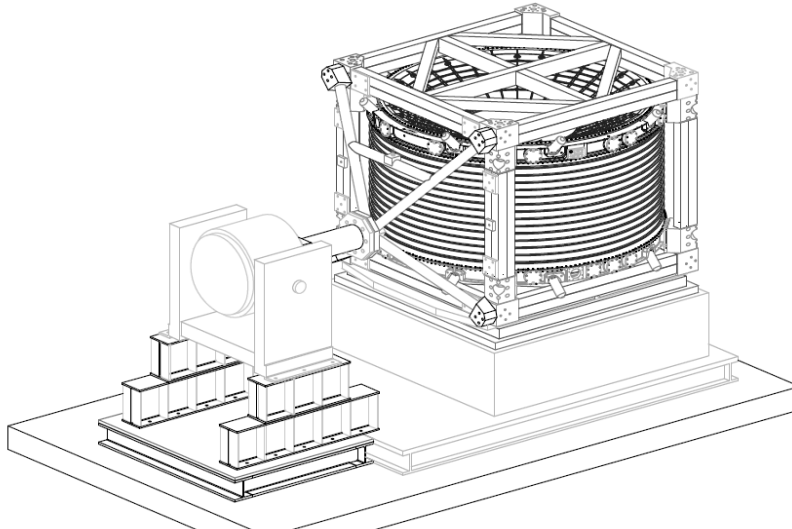
# AMS 02 Vibration Tests for sub-D & electronics

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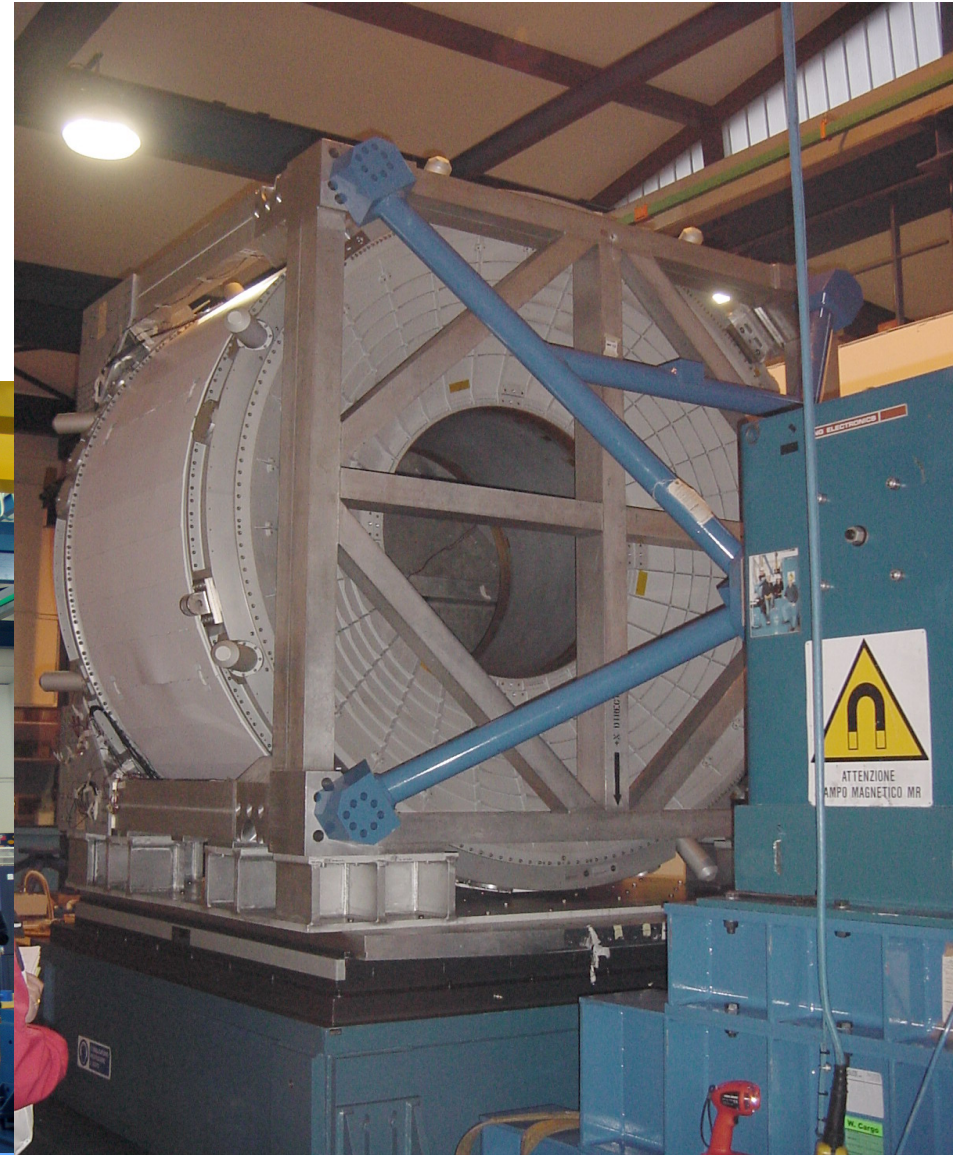
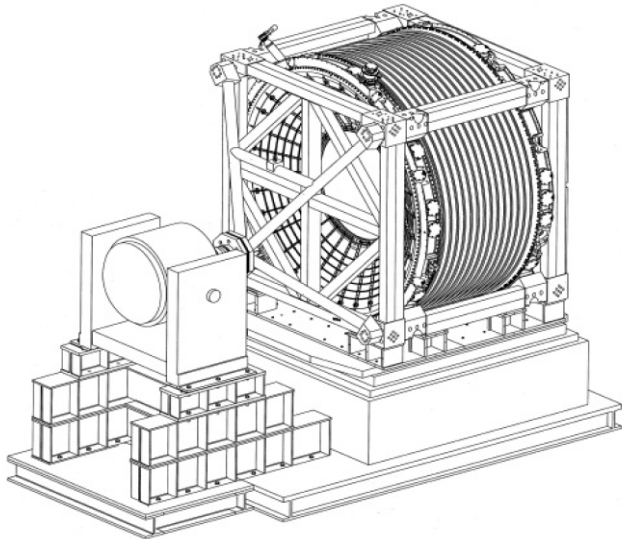
- **Sine sweep** : dynamical response and resonance searches.
  - no resonance allowed  $f < 50$  Hz
  - a “fingerprint” of the DUT
- **Random vibration**: stress the system according the MEFL/MWL as for STS91-flight
- **Post-random sine sweep**: verify that no structural change occurred after random vibration
- **Functional checks** and visual inspections to verify the status of the HW

+ experimental tests of Magnet Support Straps  
with VC Stress Test Article (STA)

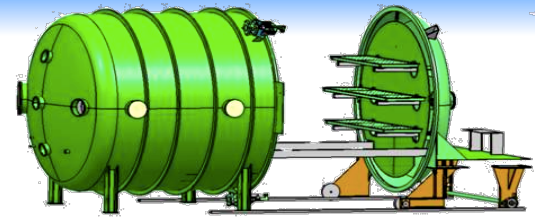
# AMS Magnet VC : x-axis



# AMS Magnet VC : z-axis



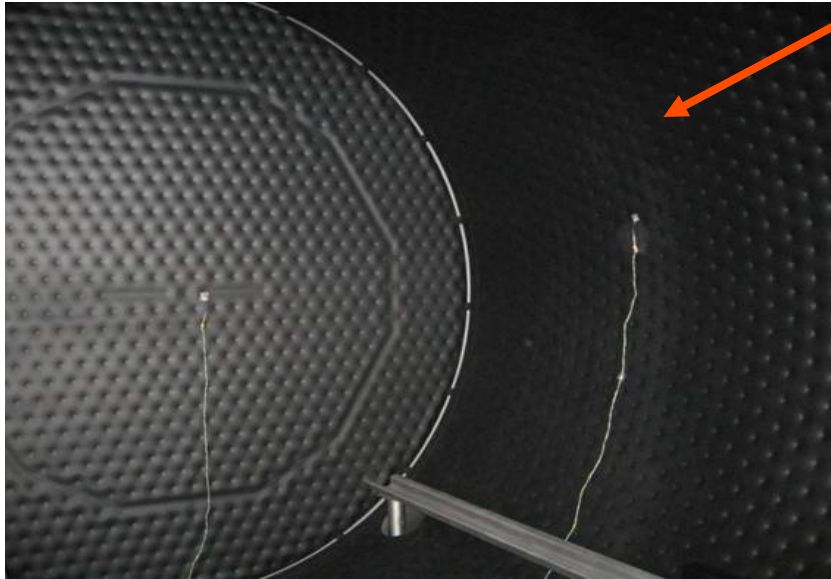
# TVT facility



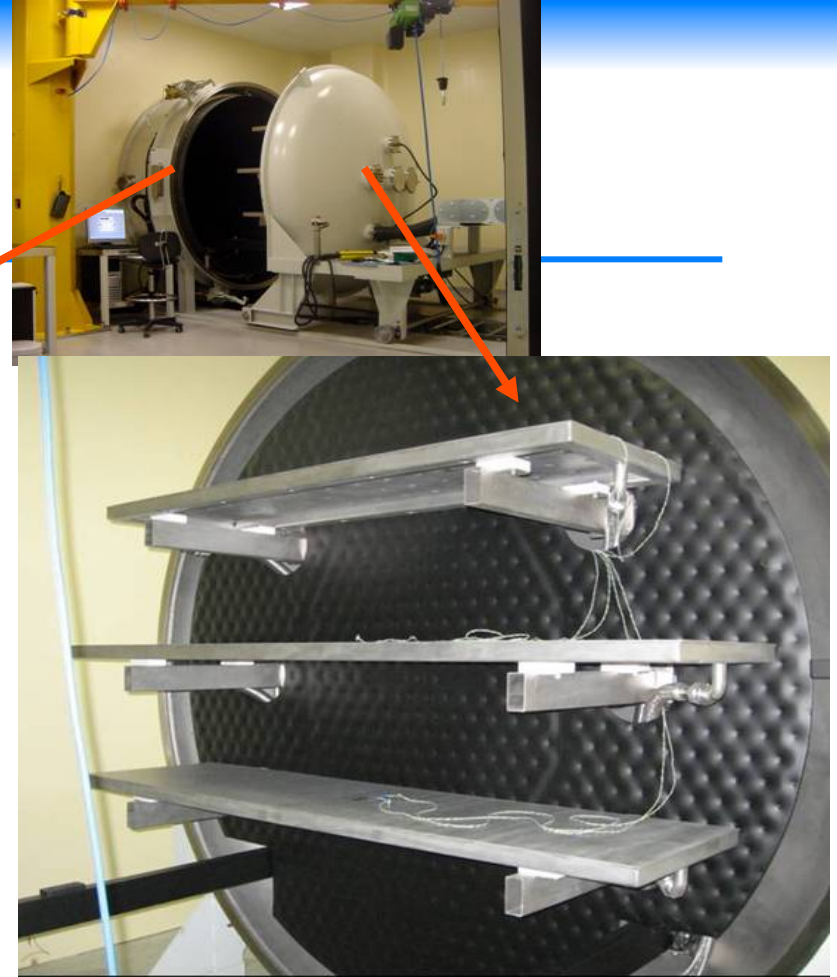
- Operational check in vacuum, at extreme T conditions
- Verify thermal model of the device under test
- Thermo-vacuum chamber:
  - Dimensions: 2100 x 2100 mm<sup>2</sup>
  - Temperature Range: -70°C/+125°C
  - Temperature Gradient: 1°C/min
  - Vacuum Level: nominal 10<sup>-5</sup> mbar (10<sup>-7</sup> reached)
  - Radiative (shroud) and conductive (cold plates) interfaces to DUT
- Measurement channels:
  - 64 pt100 sensors, NI readout
  - 12 pt100 chamber sensors, Winkratos readout



# TVT facility



Shroud → the internal walls of the chamber coated with a black paint to reproduce the black body optical properties



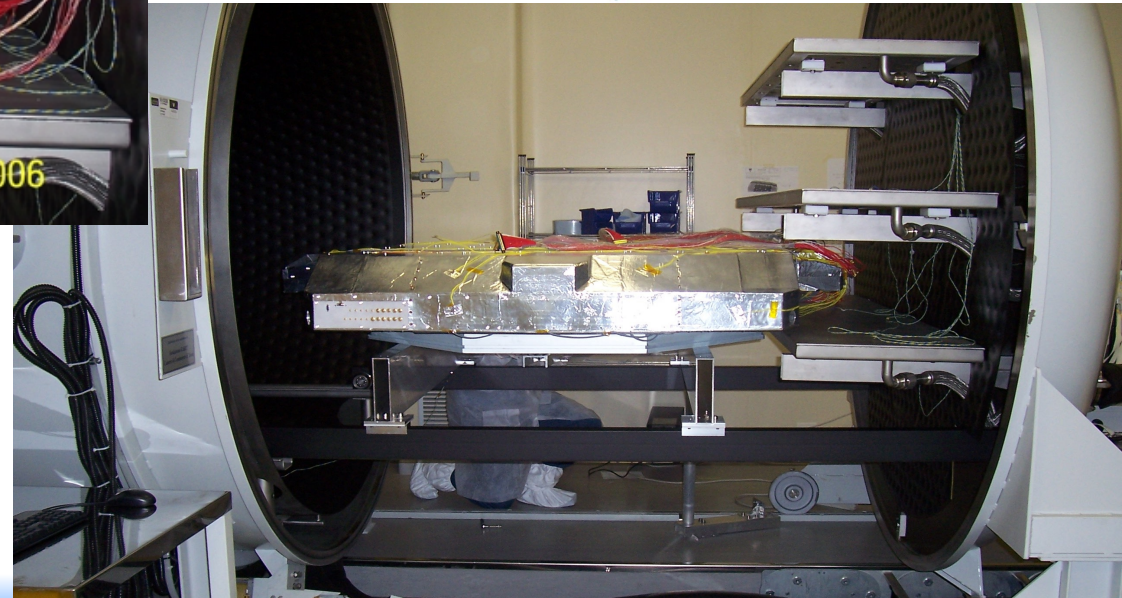
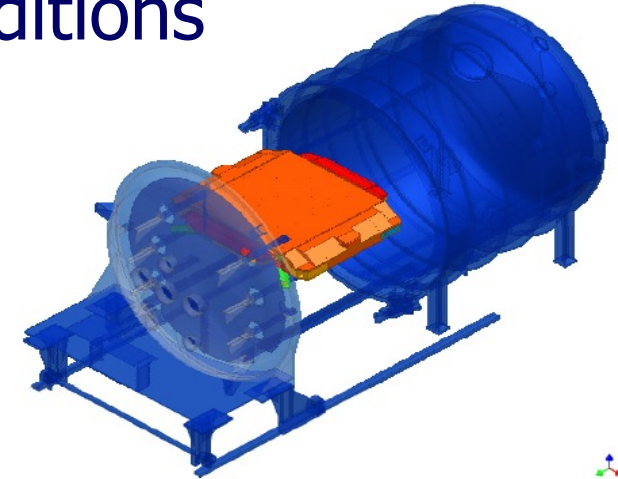
Cold Plates → Plates made of aluminum alloy used for conductive coupling of the test item to the chamber



# AMS L-TOF

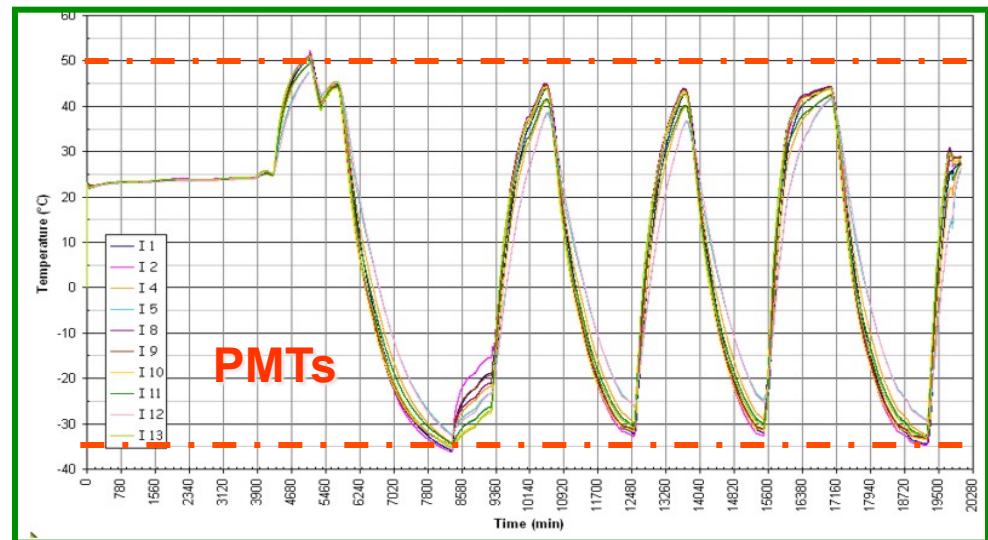
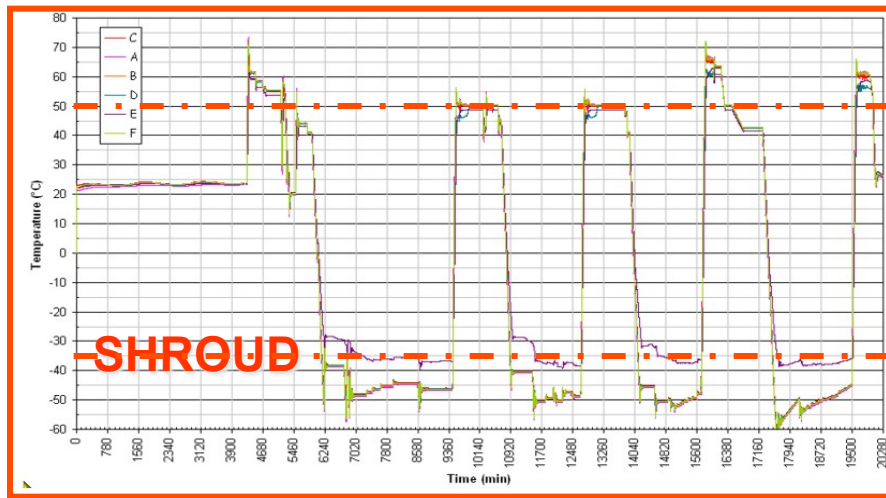
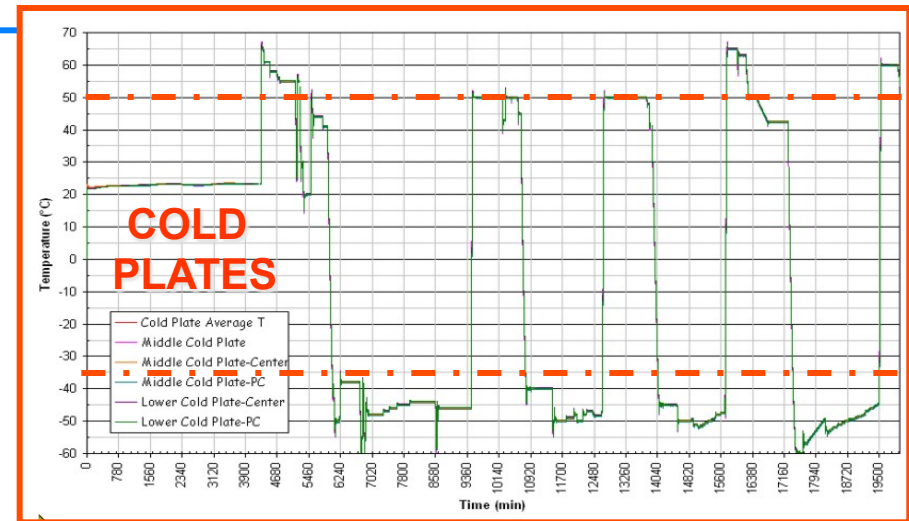
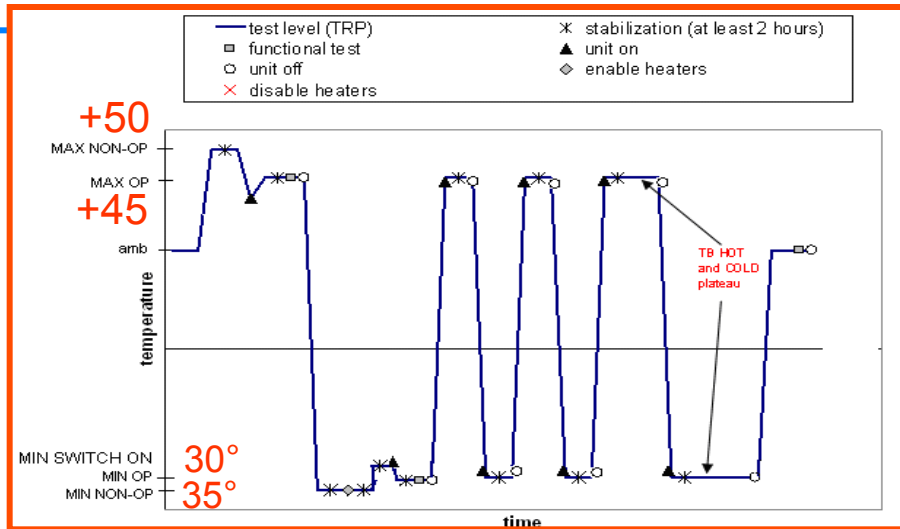


Only radiative coupling as in flight conditions



SERMS

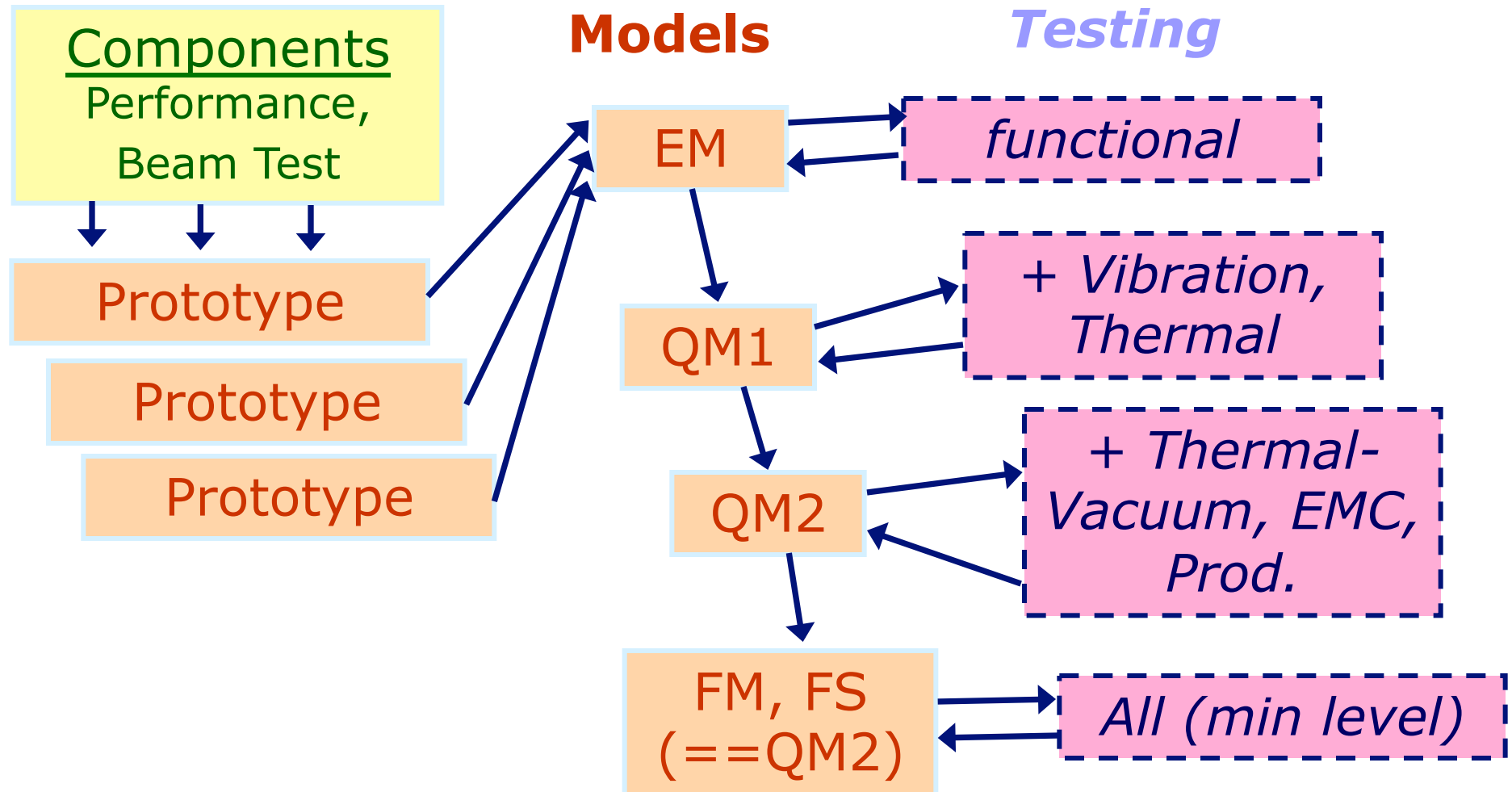
# AMS L-TOF : thermal cycles



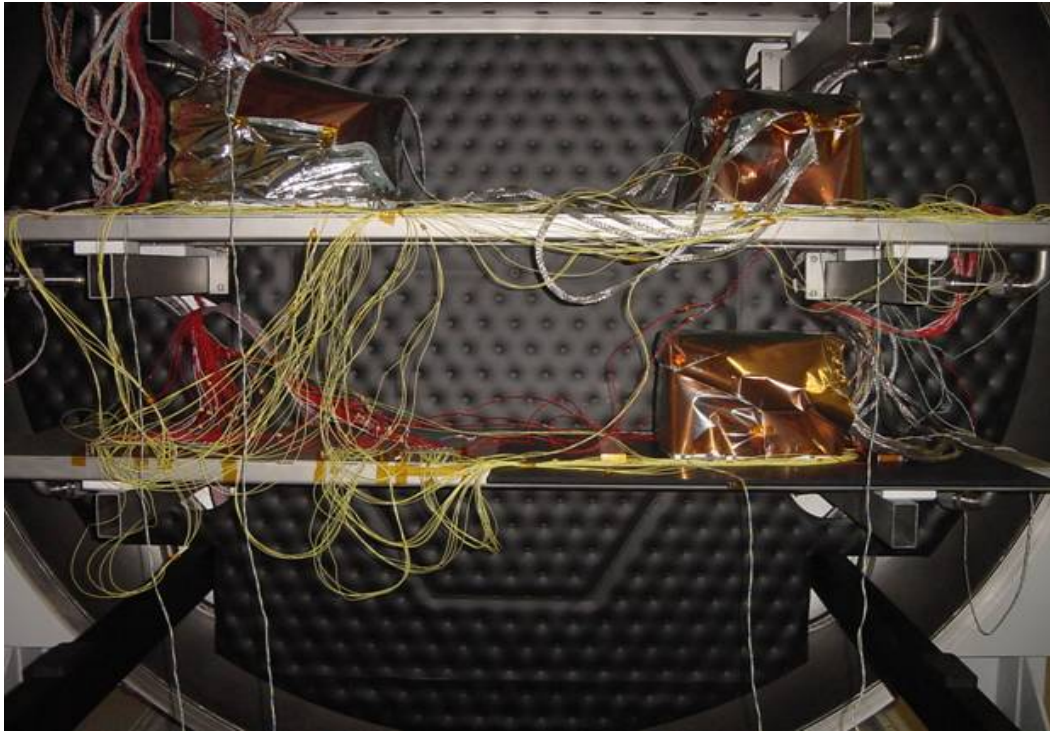
# AMS ECAL



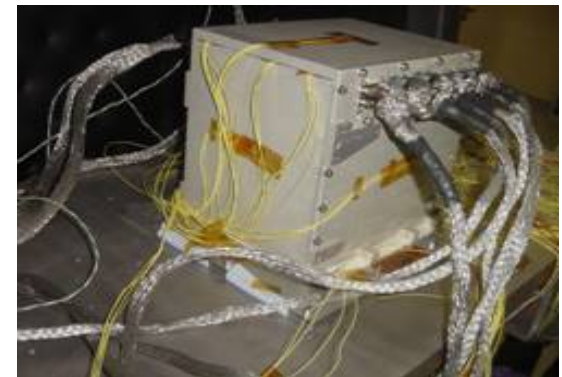
# AMS ELECTRONICS : production flow



# AMS ELECTRONICS



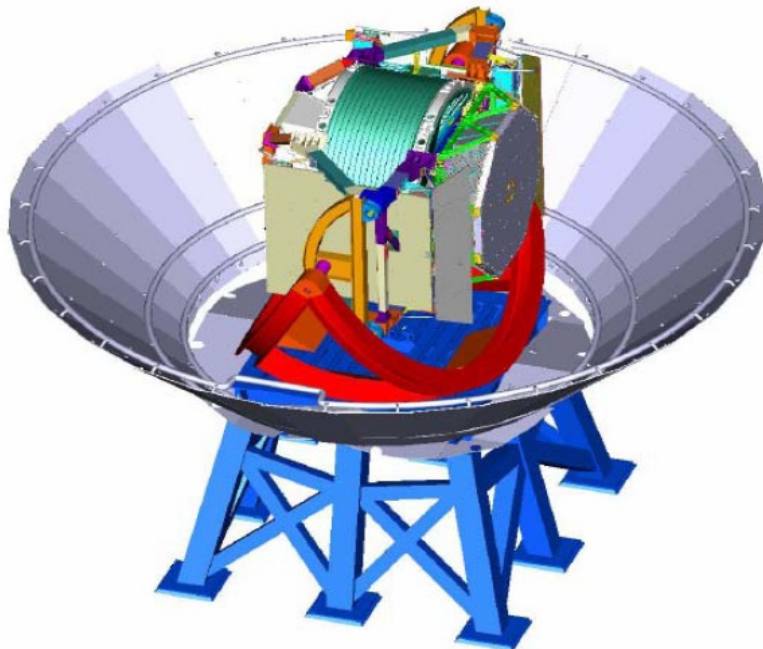
Conductive coupling as in flight conditions



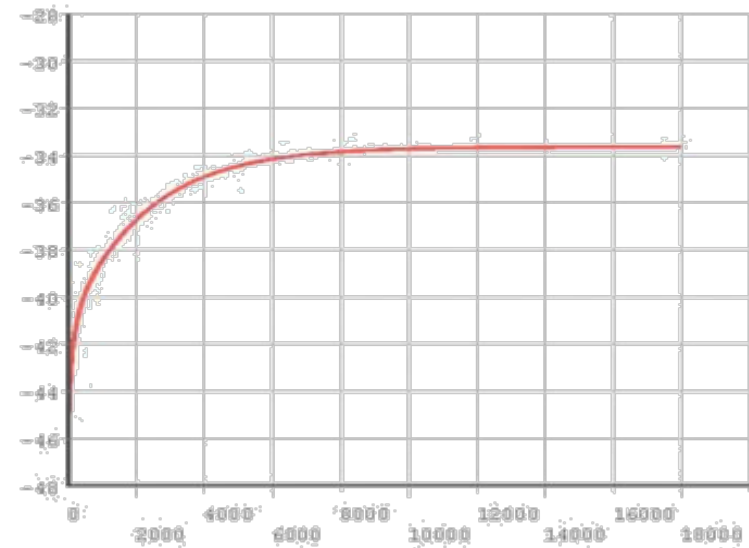
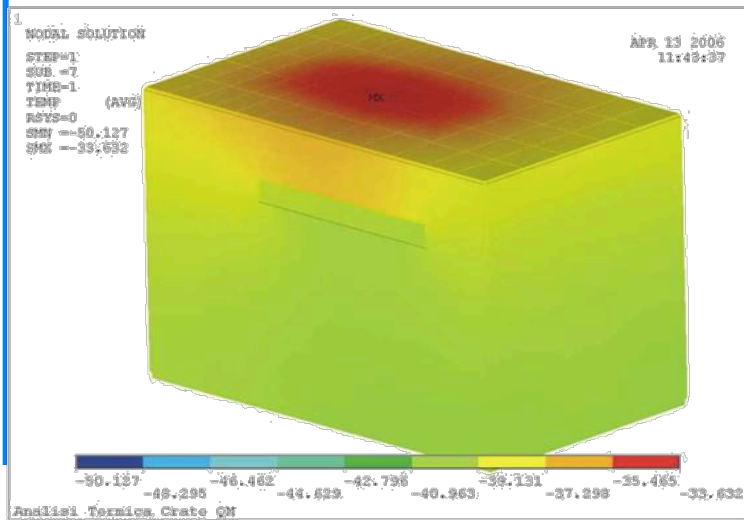
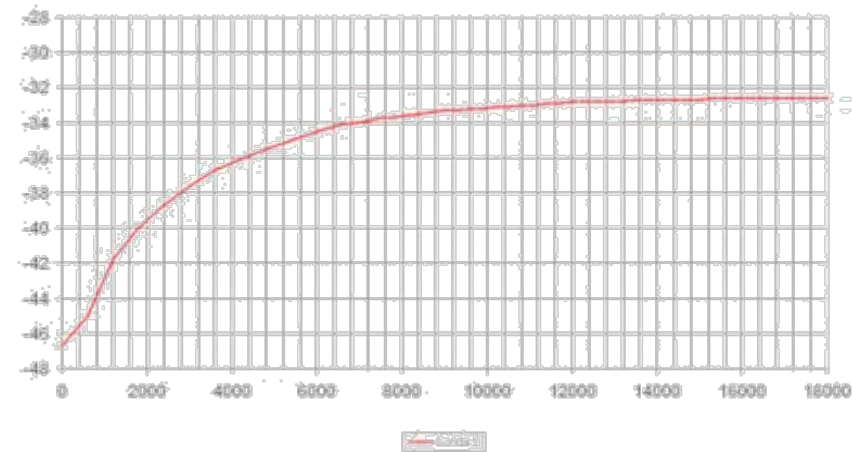
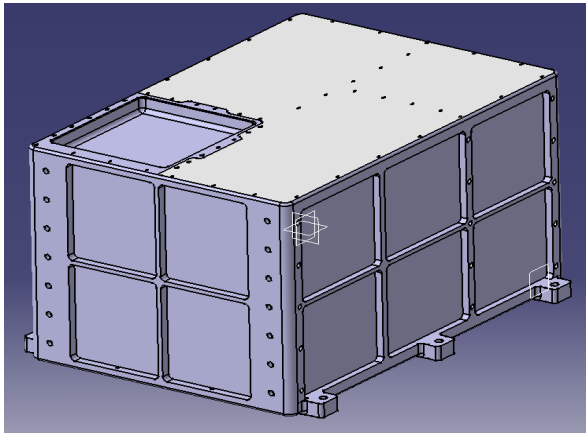
# Tests...but not only! Design / Modelling @ SERMS

## AMS-02 TVT @ ESTEC

- Thermal model test predictions
- Test procedure
- Thermal model correlation with data
- Thermal model update and flight prediction



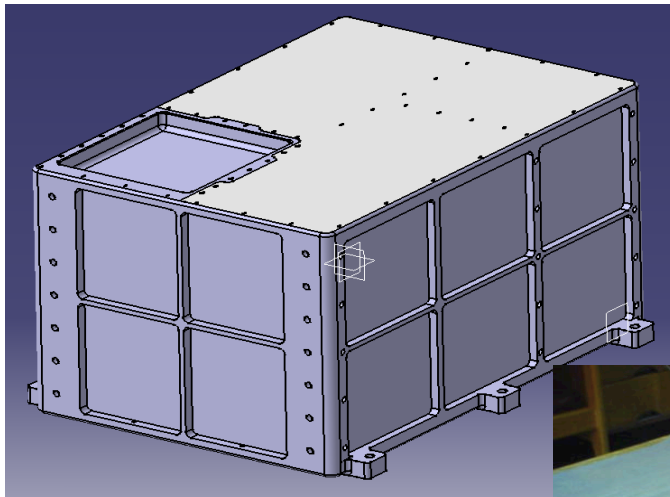
# Tests...but not only! Design / Modelling @ SERMS



# Design / Modelling @ SERMS



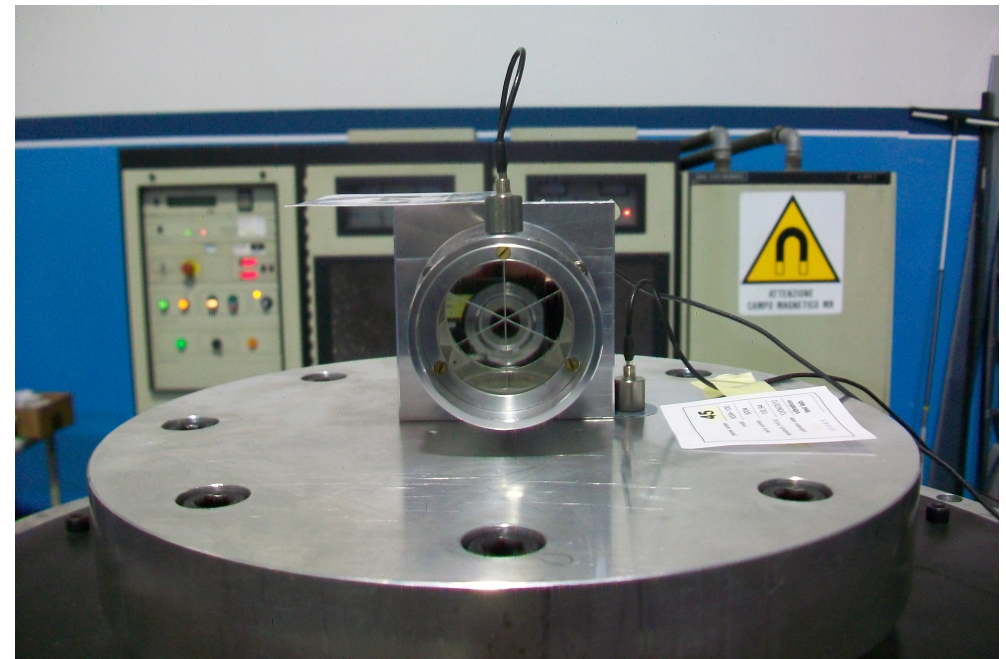
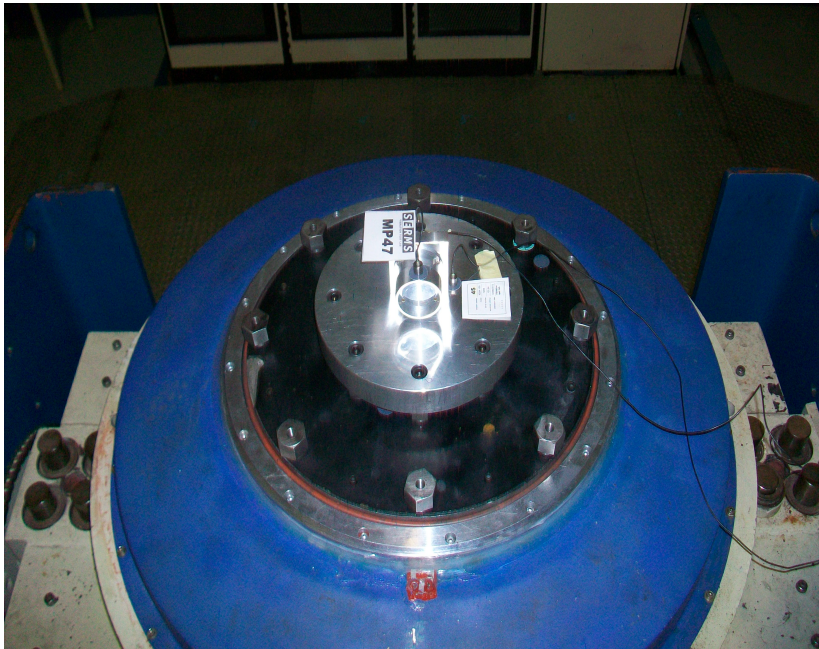
## LAZIO experiment on ENEIDE Mission





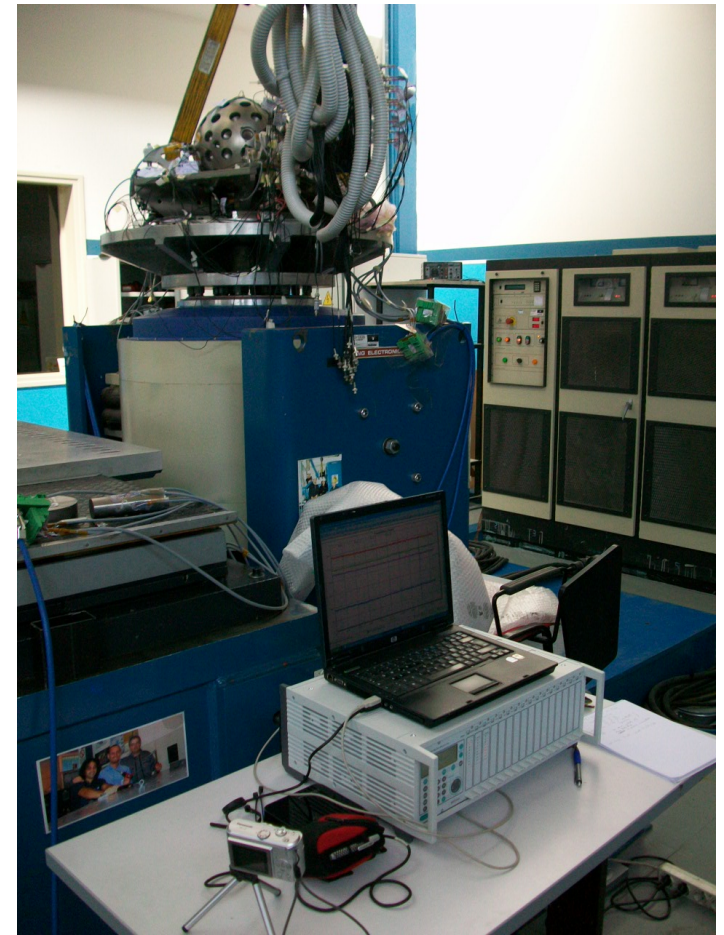
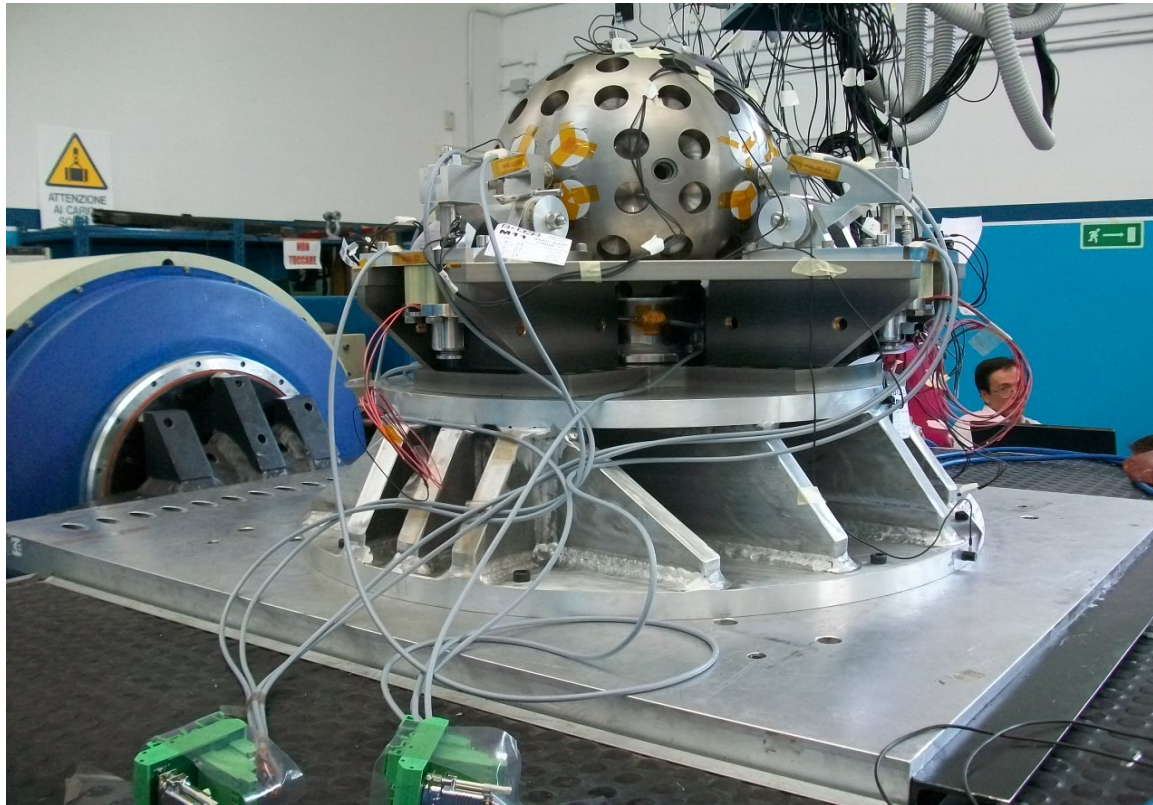
# ..not only AMS !

## INRRI retroreflector prototype

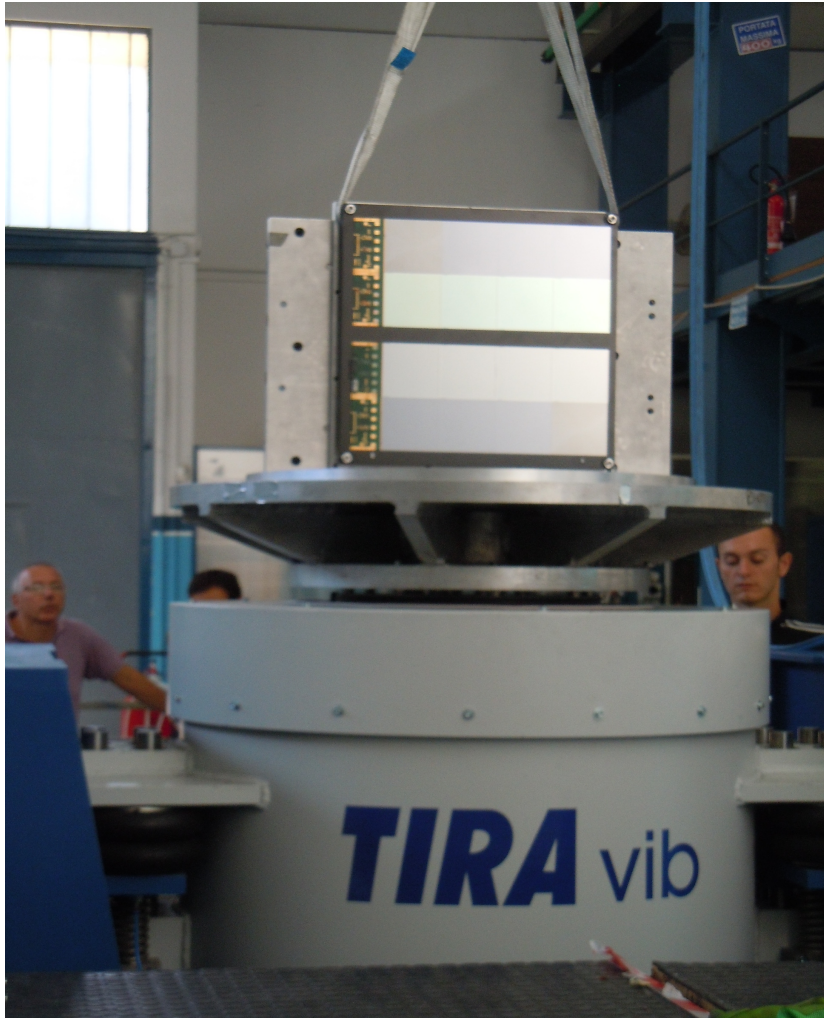


# ..not only AMS !

## LARES, ASTRO-H , POLAR , DAMPE...



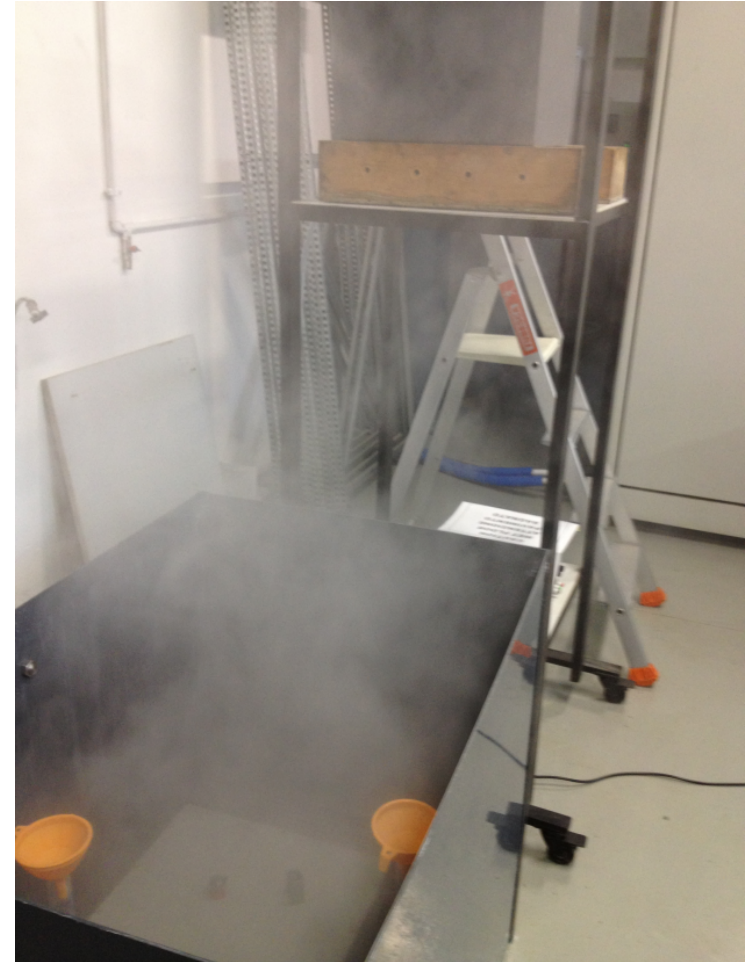
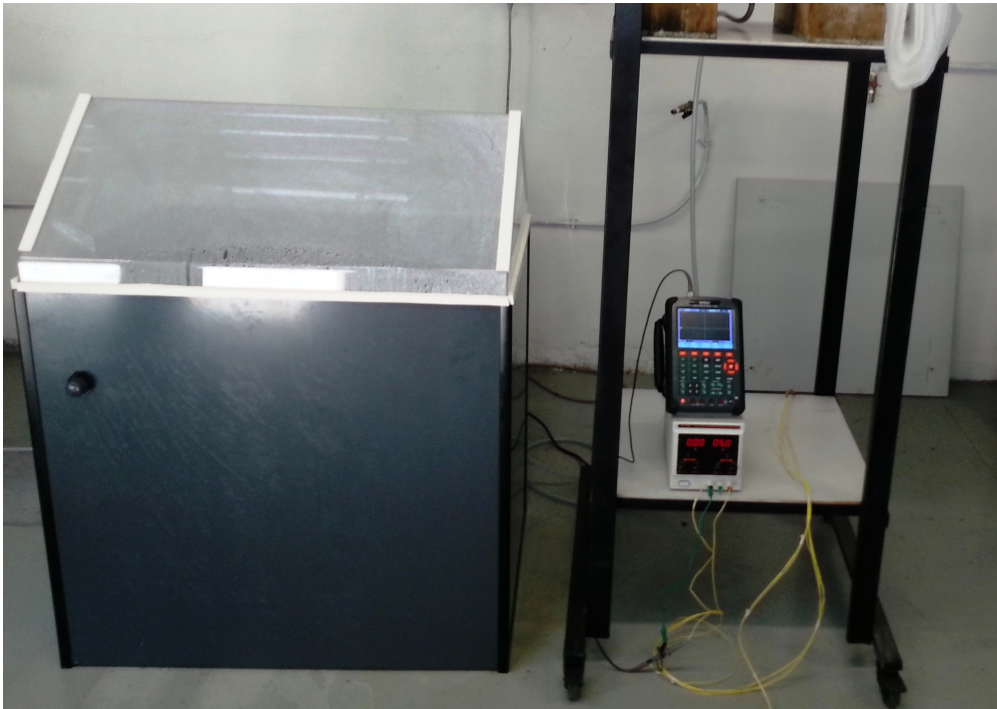
# DAMPE STK: quarter plane test



- 3 mechanical and one electrical ladder prototypes mounted on the plane
- vibration and shock test
- thermal cycling
- Preliminary results:
  - electrical behaviour is unaffected by stress
  - Silicon detector 'move' by few microns

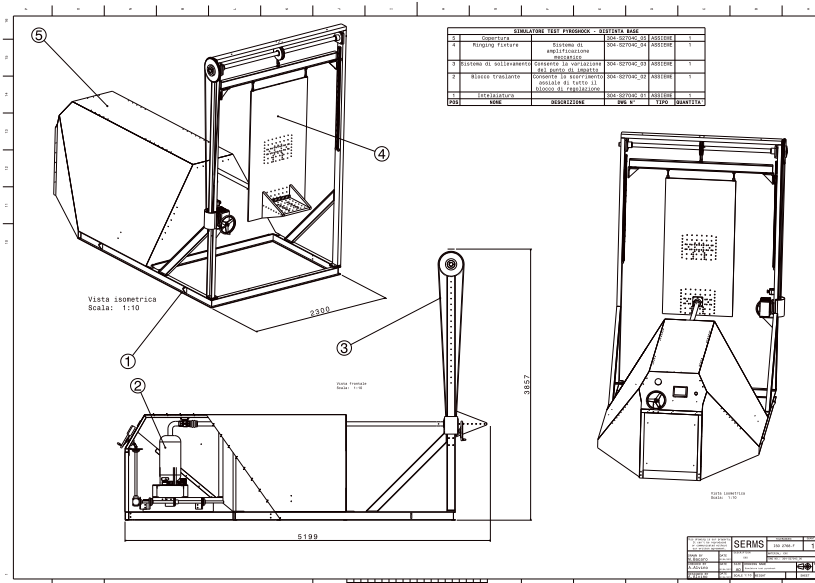
# Research & Development in testing...

## Salt fog chamber



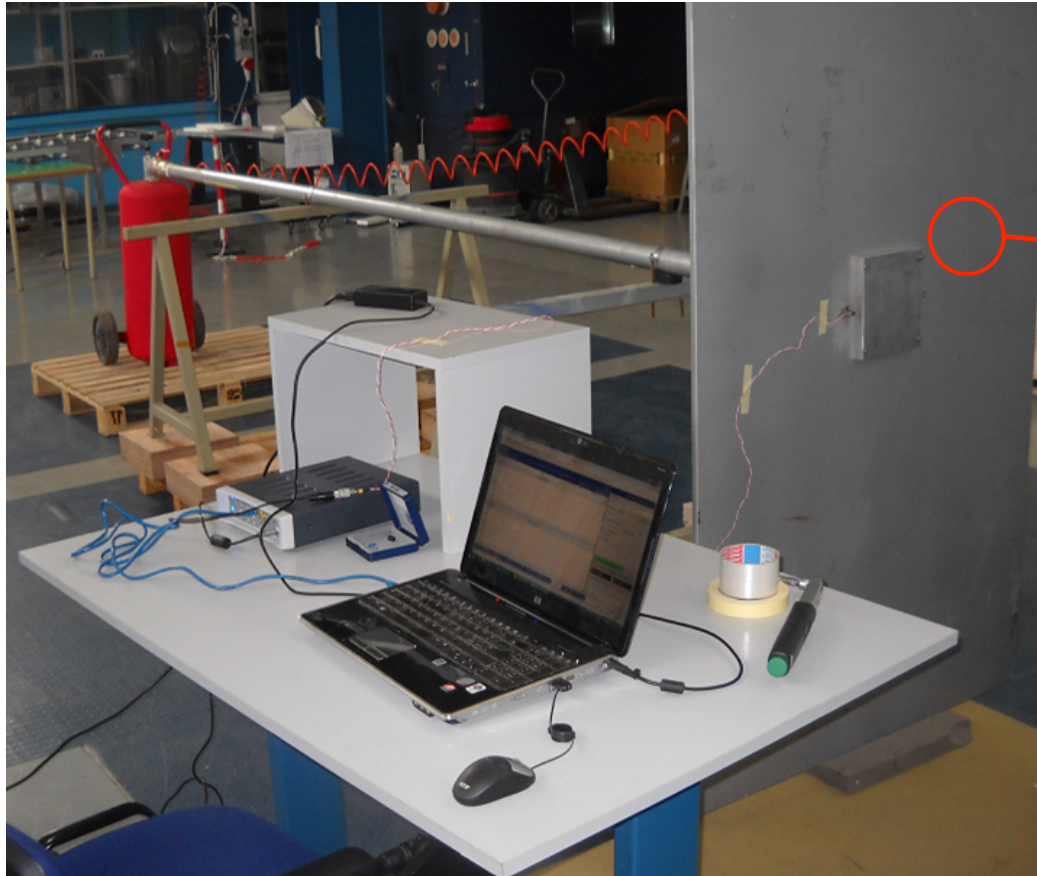
# Research & Development in testing...

## Drop test facility



# Research & Development in testing...

Pyroshock Simulator : air gun + resonating fixture

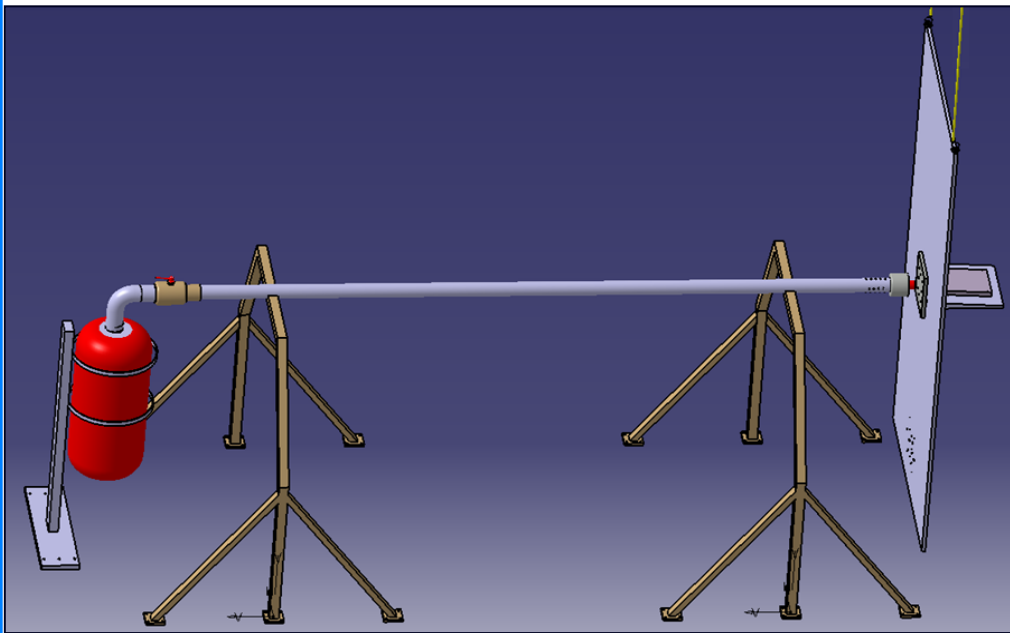


Accelerometer



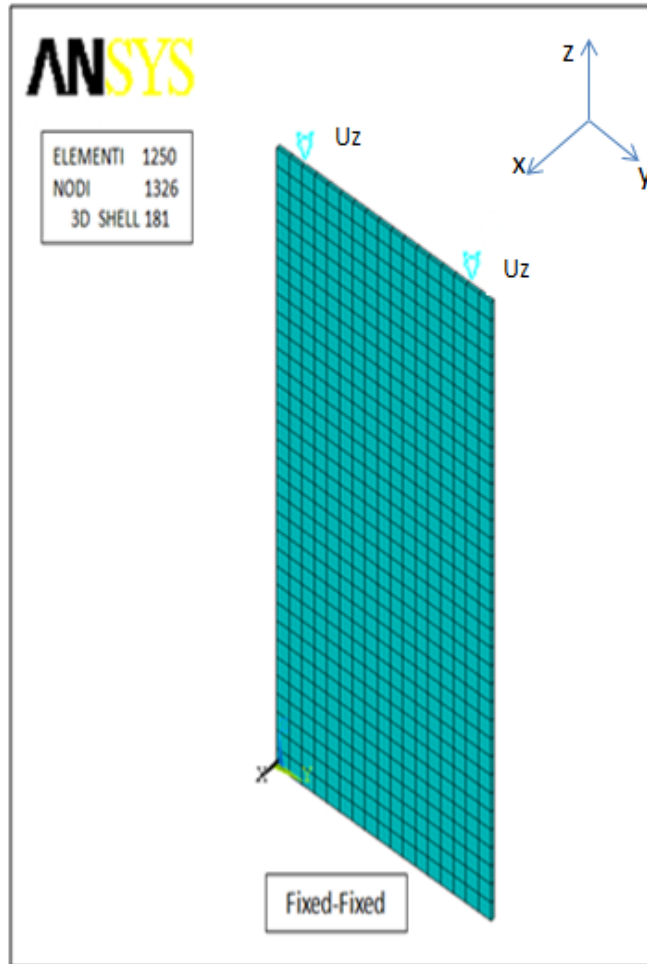
# Pyroshock Simulator

The principle : air gun + resonating fixture



From CAD MODEL to reality....

# FEM MODAL CHARACTERIZATION OF THE RINGING PLATE



Fixed (UZ)	fn [Hz]
$\omega_1$	0,000
$\omega_2$	6,80E-05
$\omega_3$	8,85E-05
$\omega_4$	6,98E-04
$\omega_5$	20,057
$\omega_6$	24,780
$\omega_7$	54,548
$\omega_8$	55,762
$\omega_9$	82,343
$\omega_{10}$	94,742
$\omega_{11}$	97,190
$\omega_{12}$	111,27
$\omega_{13}$	134,59
$\omega_{14}$	149,76
$\omega_{15}$	181,43
$\omega_{16}$	189,55
$\omega_{17}$	189,69
$\omega_{18}$	220,18
$\omega_{19}$	230,45
$\omega_{20}$	244,94



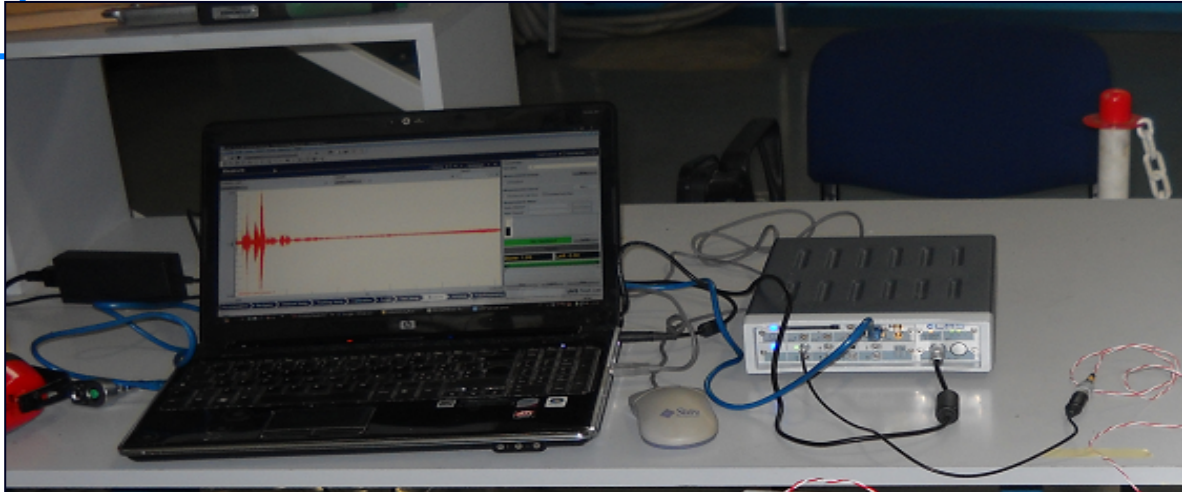
# TWO IMPACT POINTS



Second configuration  
"lower impact"



# DATA ACQUISITION SYSTEM



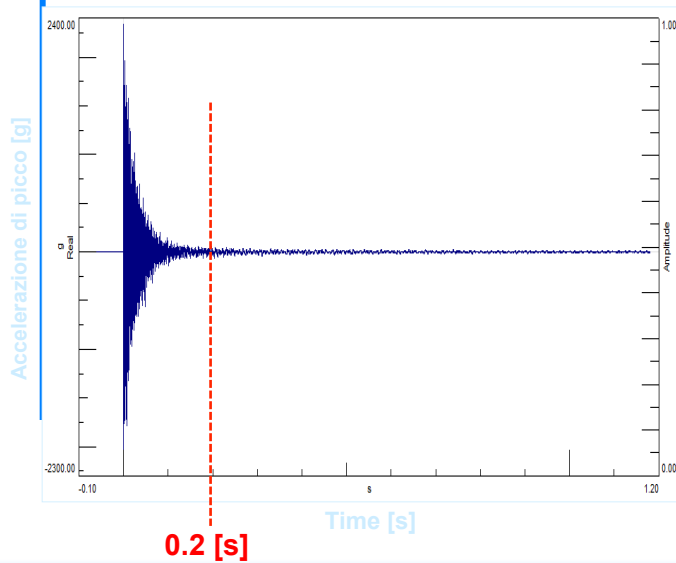
Pyroshock accelerometer



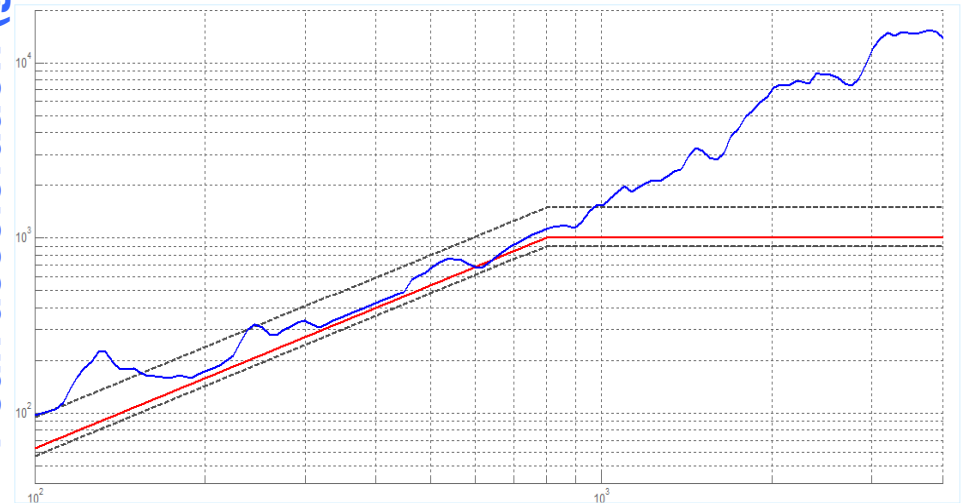
**Shock Response Spectrum (SRS)**

Specification "ASTRO-H"

**Time History**

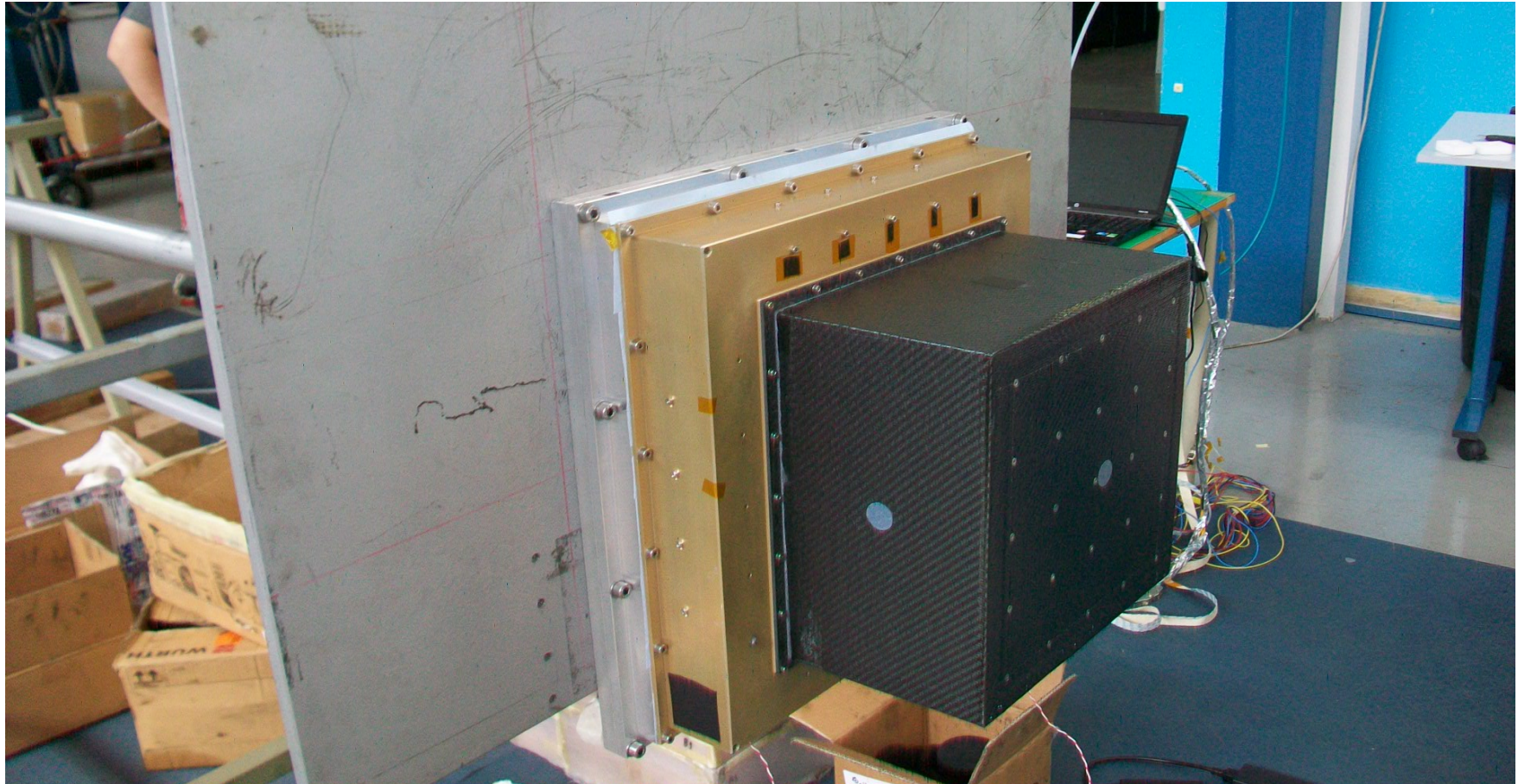


**Peak acceleration (g)**



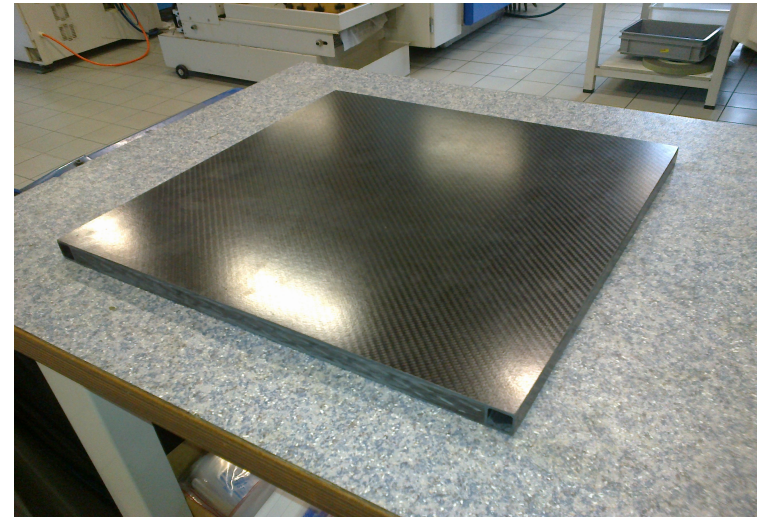
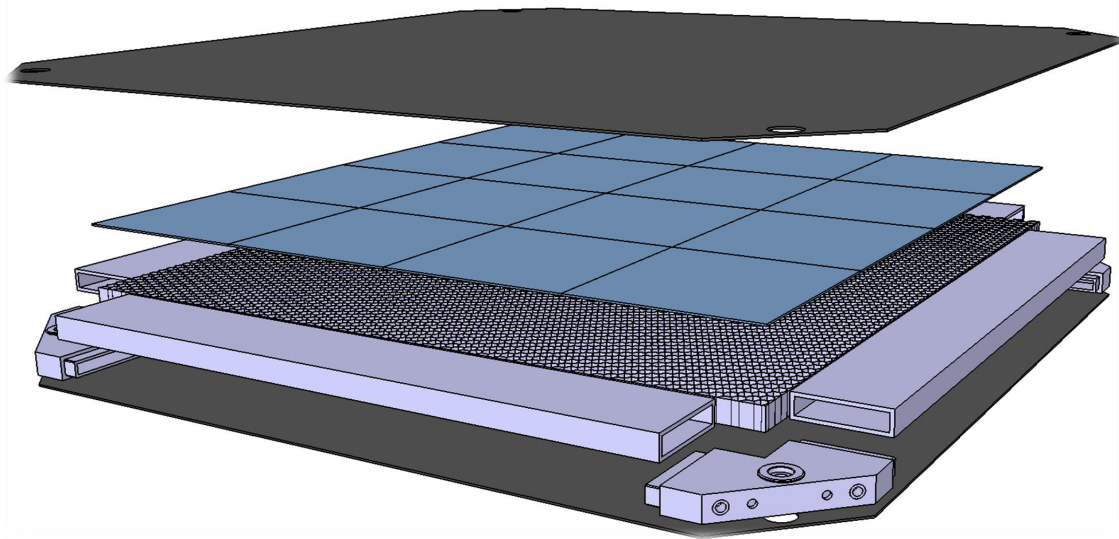
**Natural frequency [Hz]**

# POLAR PYROSHOCK TEST



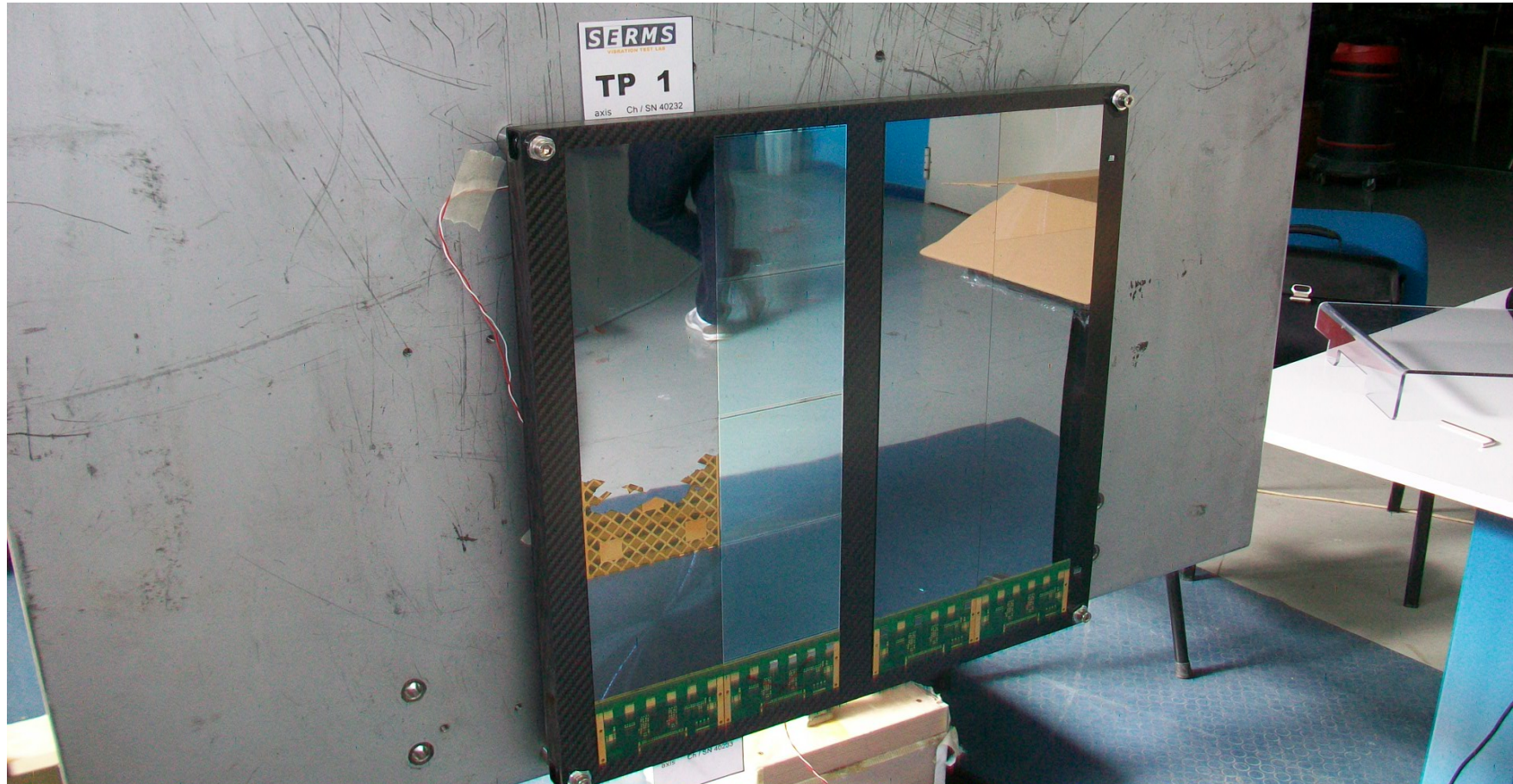
# DAMPE STK: Support Plane

- 7 planes, 3 with tungsten plates
  - 22 kg of tungsten for planes with 2mm plates
  - CFRP side beams and corners to reduce total weight (~140 kg)



- A quarter size plane with 2mm tungsten plates have been produced by Composite Design (a Swiss company)

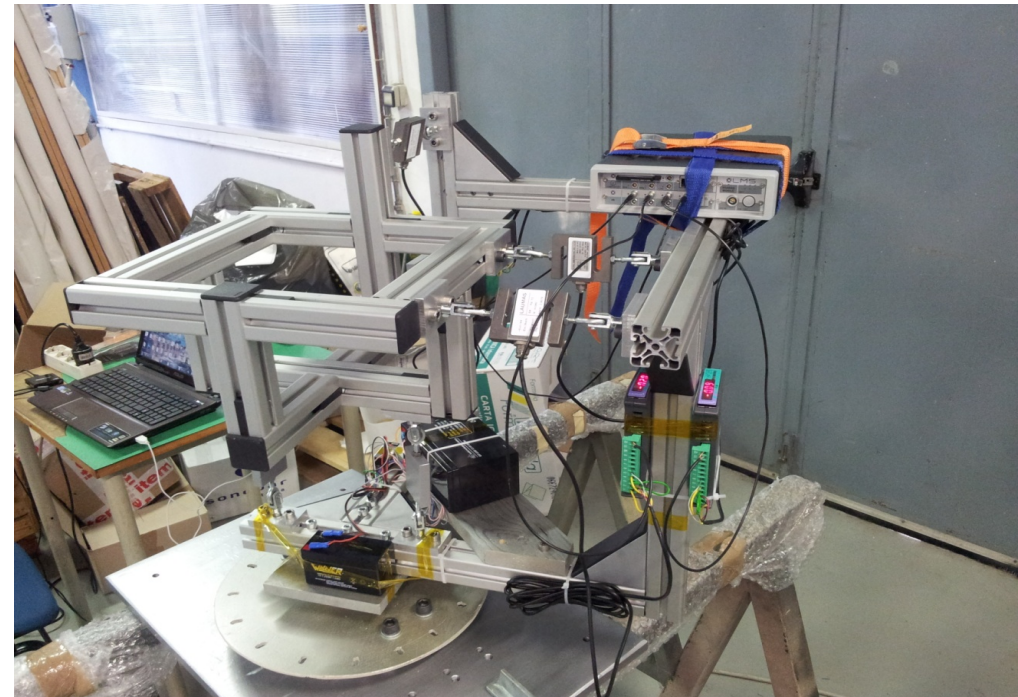
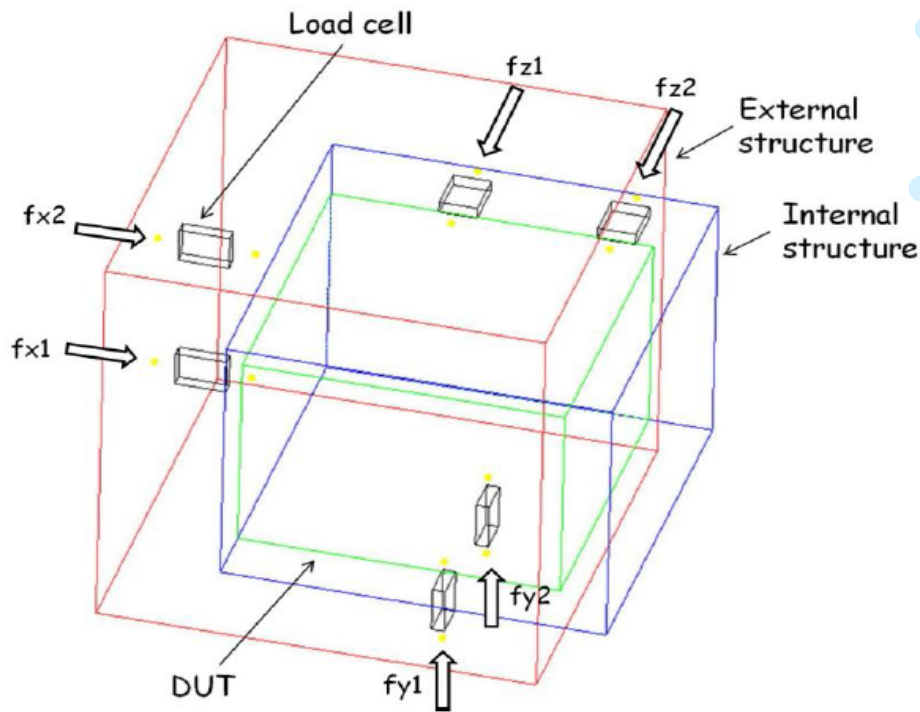
# DAMPE PYROSHOCK TEST



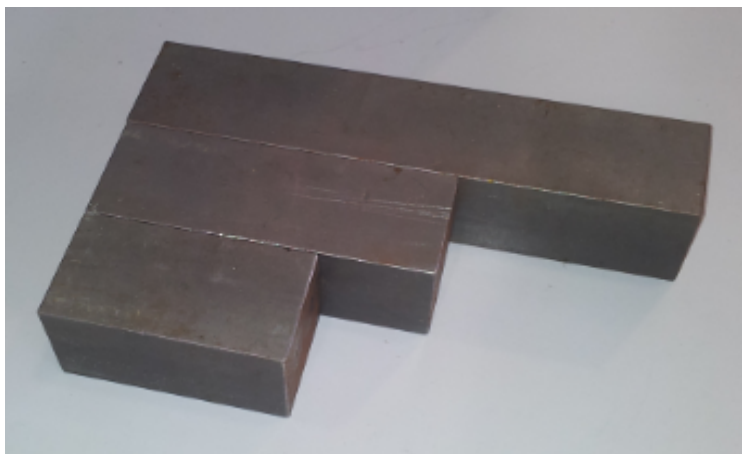
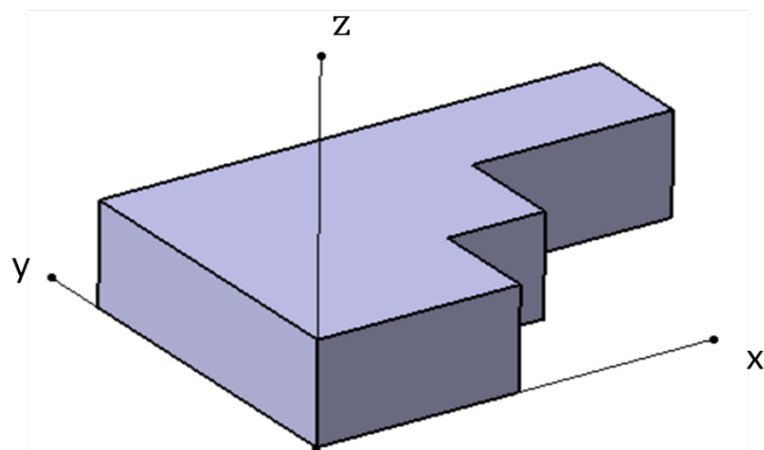
# Barycenter & mass distribution measurement

Basic principle : rotate the DUT s under controlled conditions ( $\omega$ ) and measure the resulting forces along different axes.

From the rigid body dynamics retrieve the Center of mass and inertia tensor.



# First tests are encouraging !



	<i>Valori teorici</i>	<i>Valori misurati</i>	<i>Errore assoluto</i>
<i>Massa [kg]</i>	12,0	11,9	0,1
<i>X del baricentro [mm]</i>	95,8	94,3	1,5
<i>Y del baricentro [mm]</i>	98,8	98,0	0,8
<i>Z del baricentro [mm]</i>	27,5	29,1	1,6
<i>A [kg · m<sup>2</sup>]</i>	0,028	0,025	0,003
<i>B [kg · m<sup>2</sup>]</i>	0,055	0,060	0,005
<i>C [kg · m<sup>2</sup>]</i>	0,078	0,074	0,004
<i>D [kg · m<sup>2</sup>]</i>	-0,016	-0,013	0,003
<i>E [kg · m<sup>2</sup>]</i>	0,000	0,003	0,003
<i>F [kg · m<sup>2</sup>]</i>	0,000	-0,005	0,005

# Conclusions

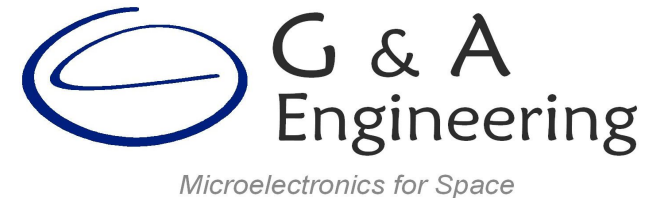
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The SERMS lab. is one of a kind facility for development of space instrumentation:

- Design & Test
- University & Research : flexibility !
- Collaboration with companies : professional approach !



# Collaborating with...



Carlo Gavazzi Space SpA





# Pressure tests

From 10 mbar to 0.7 bar

Diameter : 1.5 m

Base plate: 1.5x1 m



Compliant with standard RTCA-DO-160ERTCA