Suspension of a Cryogenic Detector at 50 mK

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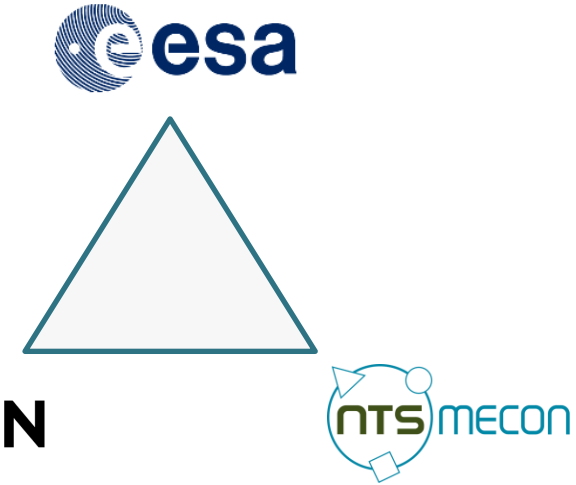
Introduction – Participants

1. European Space Agency (ESA)
   Programme lead and funding

2. Netherlands Institute for Space Research (SRON)
   Scientific research and instrumentation for space

3. NTS Mecon
   Co-development, engineering and prototyping



Note: this presentation doesn't reflect the official opinion of the European Space Agency and the Netherlands Institute for Space Research

Introduction – Suspension concept

Key requirements:

1. Detector shall be kept extremely cold (50 mK) with limited cooling capacity

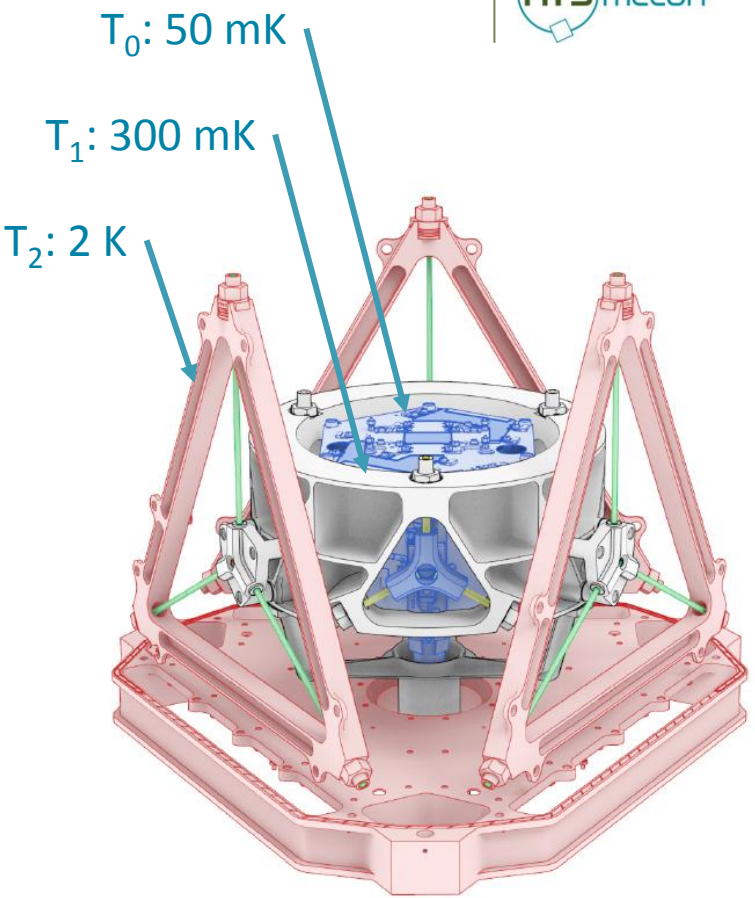
   → Need for thermal insulation

2. Fixation shall survive launch into space and shall keep detector in well-defined position

   → Need for high strength and stiffness

SRON concept:

Detector suspension using kevlar cords under pretension.



SRON X-IFU DM FPA design

Introduction – Cord material

Kevlar has most suitable combination of strength, stiffness and low thermal conductivity.

Material	$\frac{E}{\lambda}$ [10^3 s/m^2]		$\frac{\sigma_{max}}{\lambda}$ [10^3 s/m^2]	
	E/λ		σ_{max}/λ	
	50mK - 0.3K	0.3K - 2K	50mK - 0.3K	0.3K - 2K
SS 304	10	0.23	13.4	0.30
Kevlar 49	75.8	0.78	835	8.61
NbTi	26.8	0.12	111	0.51
Carbon fibre	55.9	0.78	319	4.46
Ti 15333	42.8	0.24	360	1.99

But other Kevlar properties introduce challenges:

- Expansion upon cooling → loss of pretension in construction.
- Low ductility → ESA requires FoS = 2 → required strength ≈ 5 kN.
- Poor adhesion → fixation difficulties.

Project objectives

A. Optimization of high-strength end fittings for Kevlar cord fixation

- Selection end fitting concepts
- Verification by sample testing

B. Characterization of suspension built with optimized end fittings

- Thermal / mechanical modelling
- Suspension testing

C. Development of reliable and reproducible manufacturing process

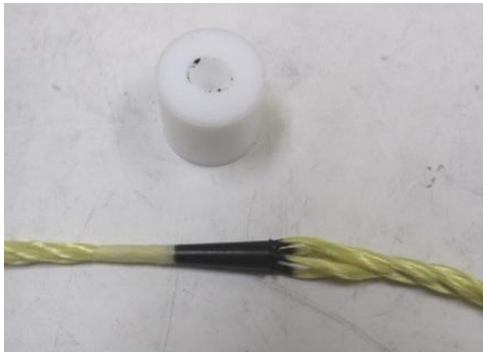
- Production tooling
- Manufacturing procedures

A. Optimization of high-strength end fittings for Kevlar cord fixation

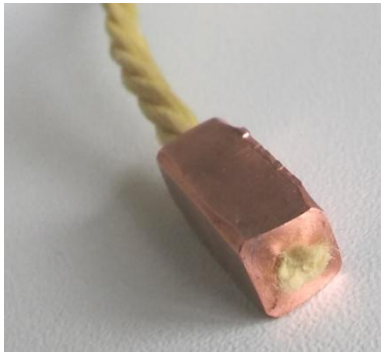
A. Optimization of high-strength end fittings

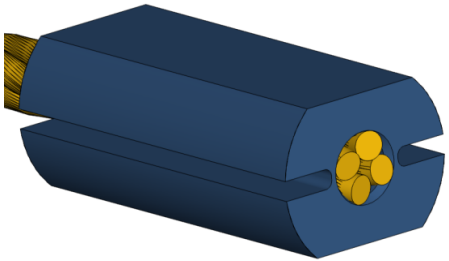
Two concepts selected for sample testing.

Concept 1 – Tapered potting



Concept 2 – Swaging





Photo's: SRON

A. Optimization of high-strength end fittings

Sample test iteration 1: tensile testing.

Variable
Reference
Twisting
Cord diameter
Cleaning
Catalyst

Variable
Reference
Cord diameter
Dam width
Swaging distance
Roughness

Photo: SRON

Result:
Optimized design for preferred concept (tapered potting)

A. Optimization of high-strength end fittings

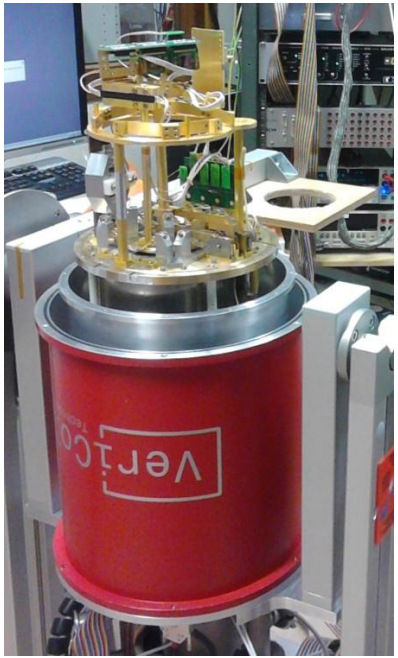
Sample test iteration 2: full testing of optimized design.

Photo's: SRON

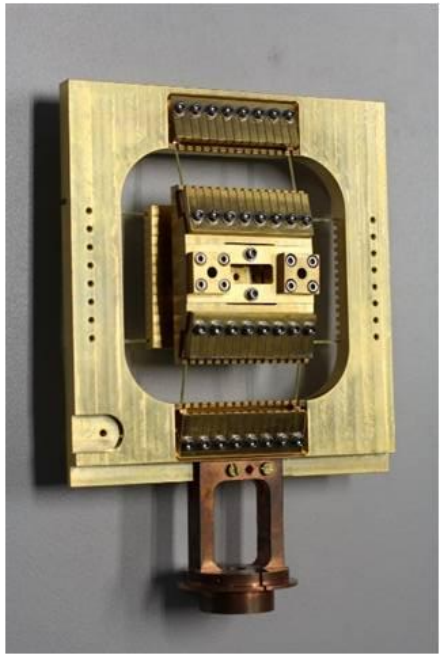
Tensile test

Bake-out test

Relaxation test



Thermal cycling



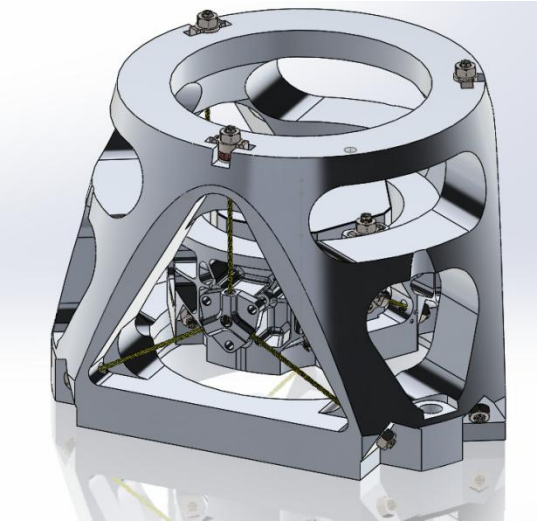
Thermal conductivity

B. Characterization of suspension built with optimized end fittings

B. Characterization of suspension

1. Thermal / Mechanical Modeling
   - Strength
   - Eigenfrequencies
   - Heat flows through suspension

2. Vibration testing
   - Strength
   - Eigenfrequencies
   - Pretension loss
   - Vibration induced heating



Test set-up for vibration testing

C. Development of reliable and reproducible manufacturing process

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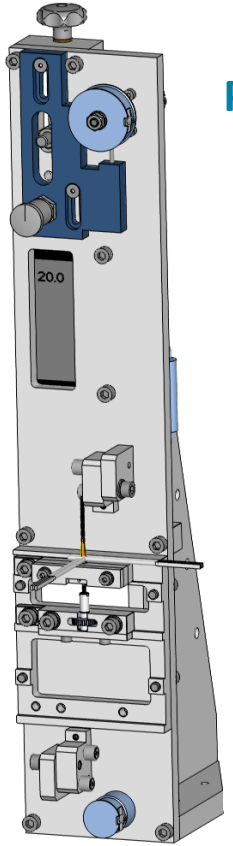
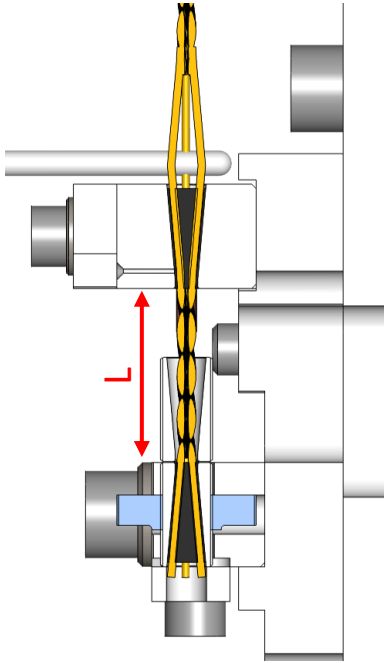


Potting tool



Air pockets deviation

Bake-out tool

Questions ?