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# **CNES: Laser and fibre components qualification results**

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# Pharao

(Projet d'Horloge Atomique par Refroidissement d'Atomes en Orbite)

## Fibre optical components

- Polarisation maintaining fibre (PM fibre 850 Bow-Tie) tested :
  - Traction PASS
  - Thermal vacuum PASS
  - Humidity PASS
- Connections:
  - NASA FC/PC (PM fibre 850 Bow-Tie) 4 tested
    - Vibration (losses < 3dB) PASS
  - Geltec Aspheric lens 7 tested
    - Coupling (<70%) FAIL
  - Selfocs Index gradient lens 7 tested
    - Radiation (1.6krad) PASS
    - Coupling (70%) PASS

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# Pharao

## Non fibre optical components of interest

- Laser diodes not pigtailed (JDSU 5420) 18 tested:

- Lifetime (accelerated under vacuum) FAIL
- Thermal vacuum FAIL
- Thermal cycling/Storage (hot) PASS
- Chip connection pull PASS
- Mechanical vibration and choc PASS

Note Beryllium present in the laser chip, not JDSU packaging

- AOM (A&A ST-88/75/90/163) 8 tested:

- Storage FAIL 1 transducer size
- Thermal vacuum FAIL (T>40-70°C)
- Mechanical vibration and choc PASS

# IASI

(Infrared Atmospheric Sounding Interferometer)

## Fibre optical components 1

- Laser diodes pigtailed (**Alcatel** ILM 246) 9 tested:
  - Fibre pull PASS
  - Mechanical vibration and shocks PASS
  - Thermal vacuum/Storage/Life Test PASS
  - Radiation PASS
- Coupler 2x1 monomode (**Gould** WFC 80/20 1x2 S) 5 tested:
  - Mechanical vibration and shocks PASS
  - Thermal vacuum PASS
- Faraday isolator (**ISOWAVE** 1-15-PIPT-X-A) 6 tested:
  - Mechanical vibration and shocks PASS
  - Thermal vacuum PASS

## IASI Fibre optical components 2

- Fibre welding (**CSO** fibres 8.5/125) 31 tested:
  - Pull/Shear/Mechanical PASS
  - Thermal/Storage (cold and hot) PASS
- Detection module (**Thales** FMR-21000) 10 tested:
  - Thermal vacuum/Thermal/Storage PASS
  - Mechanical vibration and shocks PASS
  - Fibre pull PASS
  - Life test PASS
  - Radiation PASS
- Monomode fibre (**Corning** SMF28) 1 tested (system test):
  - Mechanical vibration and shocks PASS
  - Thermal vacuum/Storage PASS

# SWARM

## ESA Earth Observation mission

CNES is responsible for Absolute Scalar Magnetometer

### **Fibre optical components to be tested**

- Fibre Laser Assembly (Koheras/LETI custom made) PQ
- Laser diodes pigtailed (JDSU 2700 or LUMICS LU0980S450)
- WDM (980-1083nm) (OZ Optics custom made)
- Electro-Optic Modulator (Photline custom made)
- Multimode fibre (@1064nm currently used)
- Photodiodes pigtailed (@1064nm currently used)
- Coupler 2x1 (@1064nm currently used)
- Faraday isolator (@1064nm currently used)

## T2L2 / Optical Interconnections

### Laser Time Transfer and R&T CNES-Alcatel Alenia Space

#### **Fibre optical components to be tested**

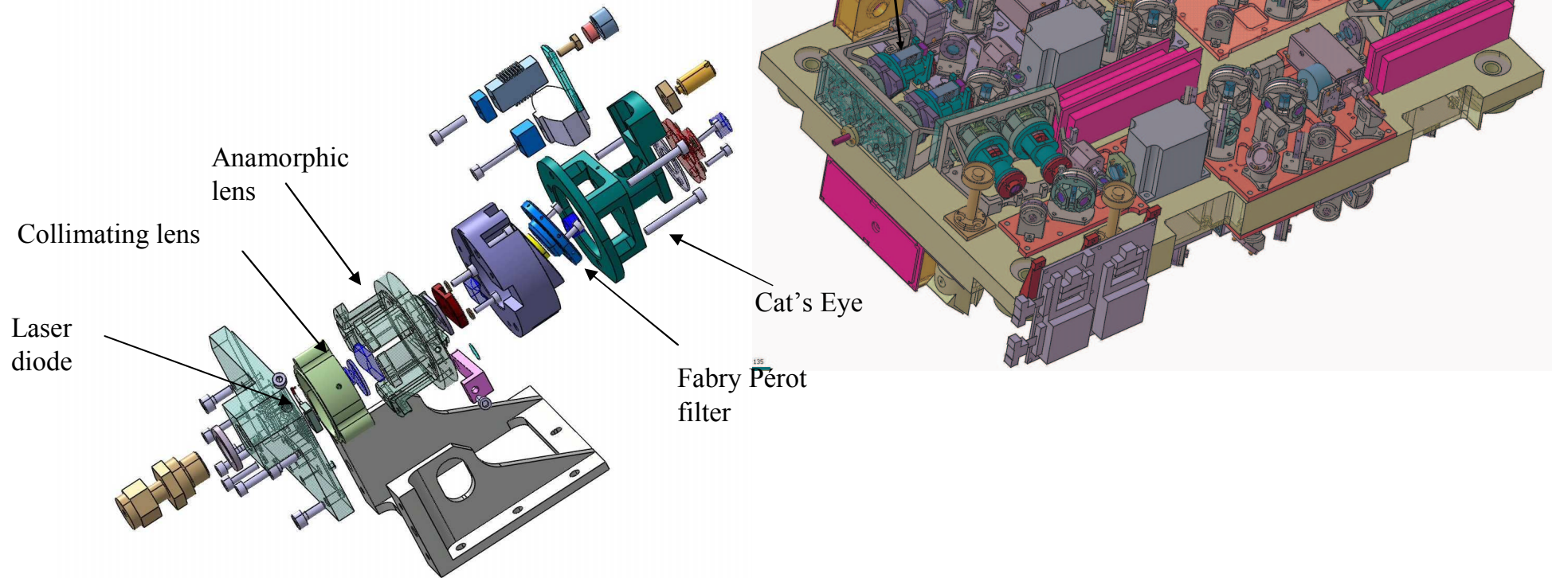
- Polarisation maintaining Fibre @ 532nm, radiation resistant:
  - Thermal cycling
  - Radiation
- Multi channel transmitter and receiver optoelectronic modules:
  - Loss below 0.25dB (already tested)
  - Thermal -40/80°C (already tested)



## Conclusions

- CNES has several upcoming / on going fibre qualifications :**
  - SWARM**
  - FOG Pleiades**
  - Interconnections (Alcatel Alenia Space)**
  - T2L2**
- Also R&T environmental studies on**
  - Erbium doped fibre amplifier (Alcatel Alenia Space and Montpellier University)**
  - Photonic crystal fibres**

# PHARAO Space Atomic Clock



**Exploded view of an extended cavity laser and view of the PHARAO Laser Source developed under funding CNES by EADS-SODERN (France)**