KU LEUVEN
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OSCAR QLITE: Quantumphysics at 30 km

A stratospheric balloon mission in the Arctic

Tom Mladenov

OSCAR QLITE

Rymdstyrelsen
Swedish National Space Agency

SSC

DLR

esa

Overview

- The experiment
- Applications
- Development
- Launch campaign
- Recovery

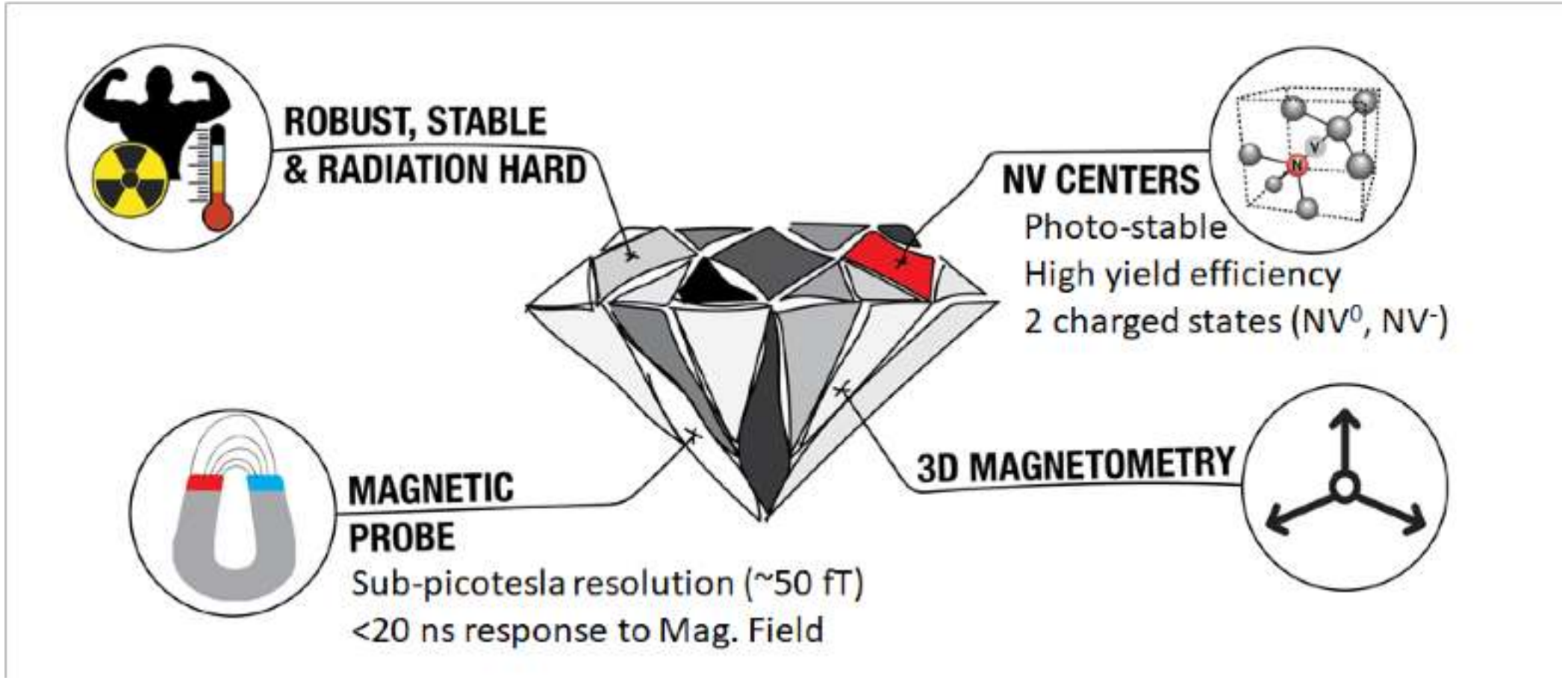
The experiment

- Ultrasensitive magnetometer based on diamond
- Sensing of magnetic field by using quantum defects in diamond

GOAL:

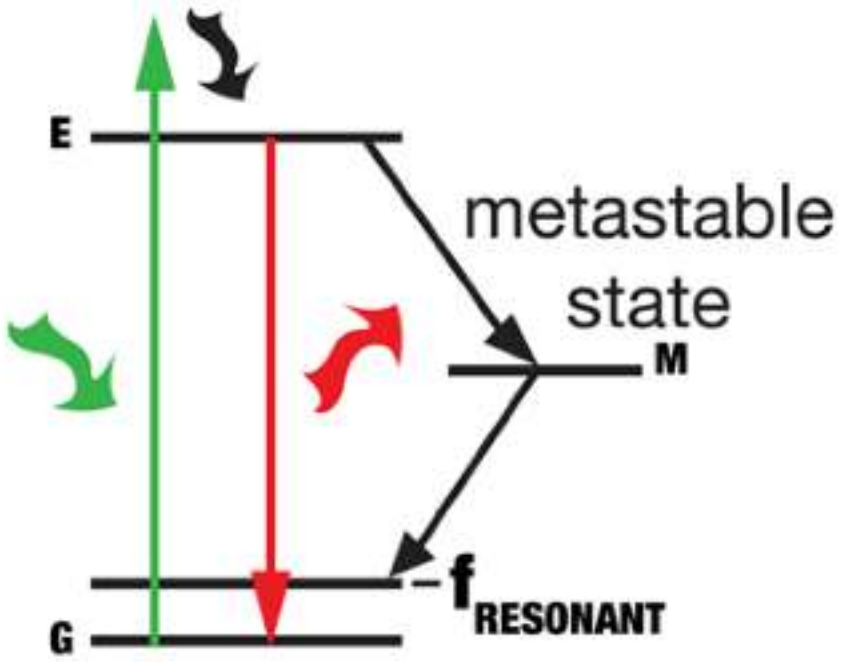
- Miniaturization of existing lab setup
- Verification of space worthiness
- Stratospheric balloon flight
- Get experienced with HW/SW for space applications

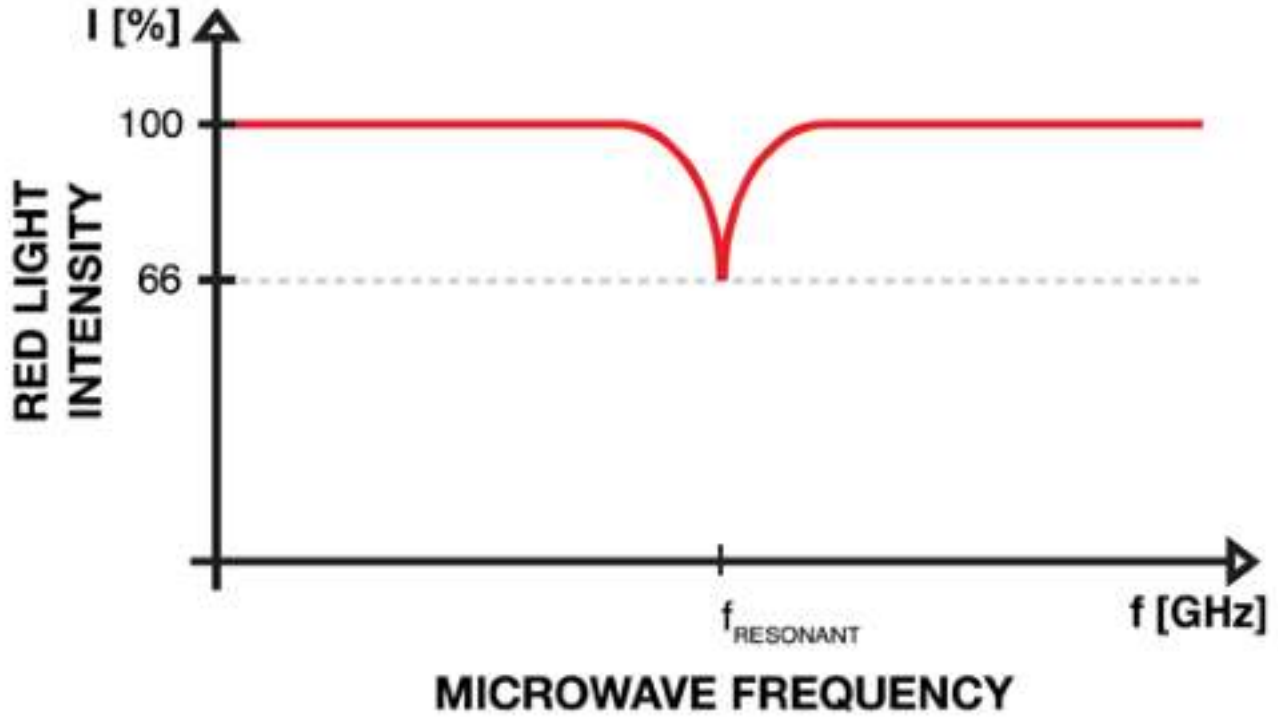
The experiment



Hruby et. al.

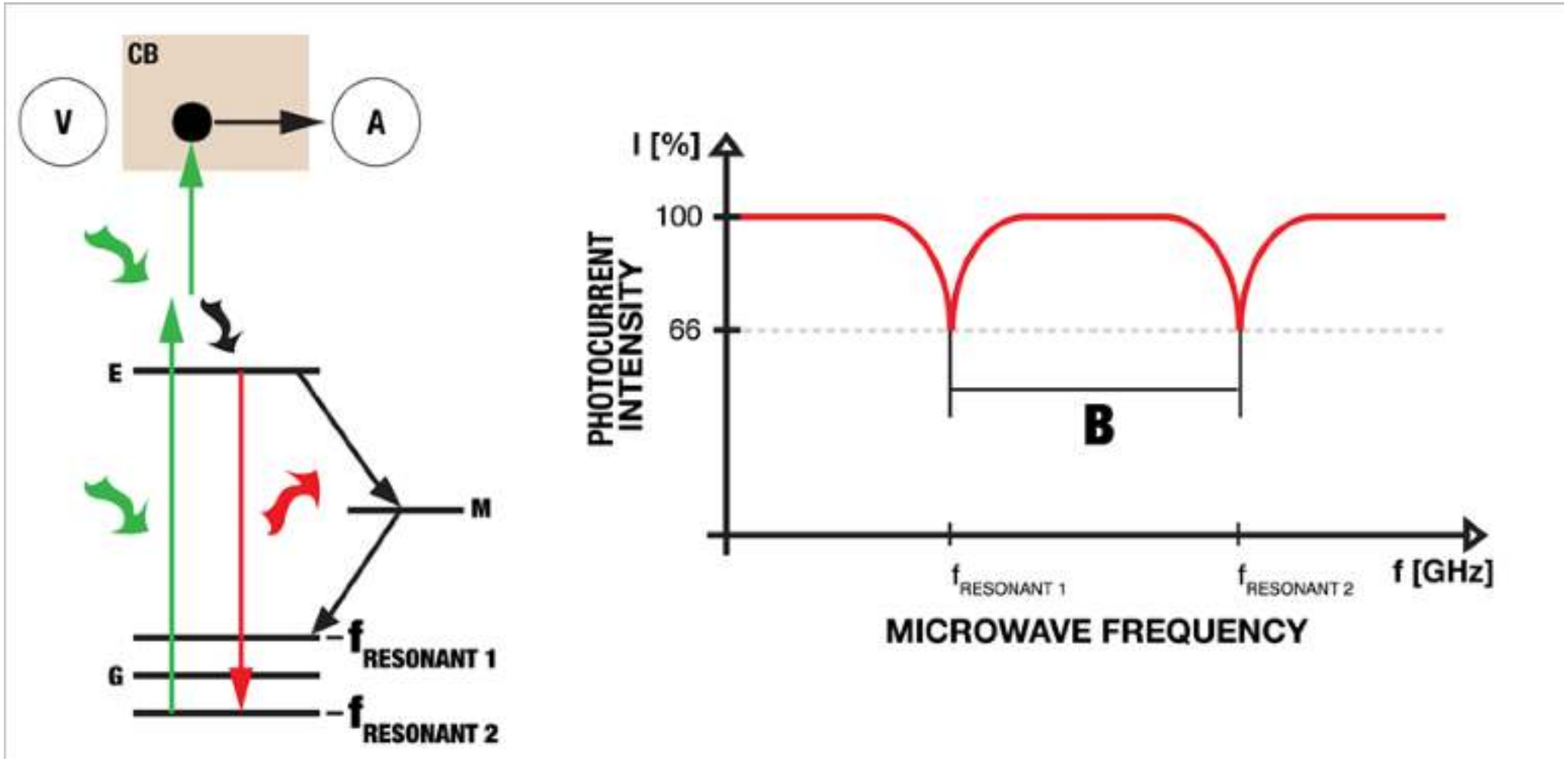
The experiment





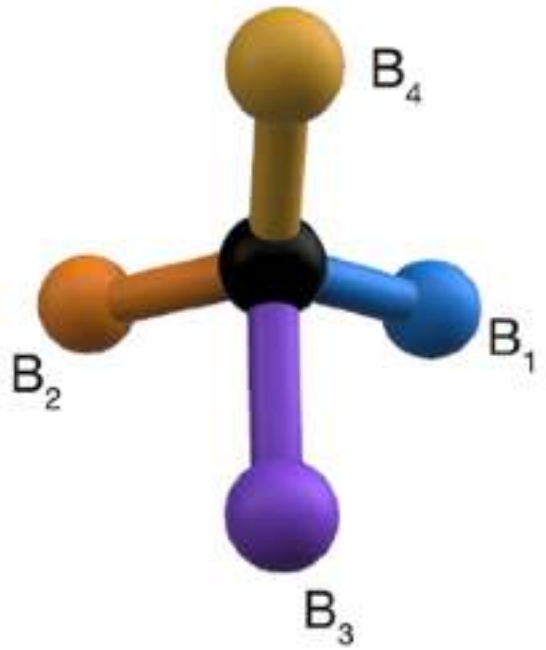
Hruby et. al.

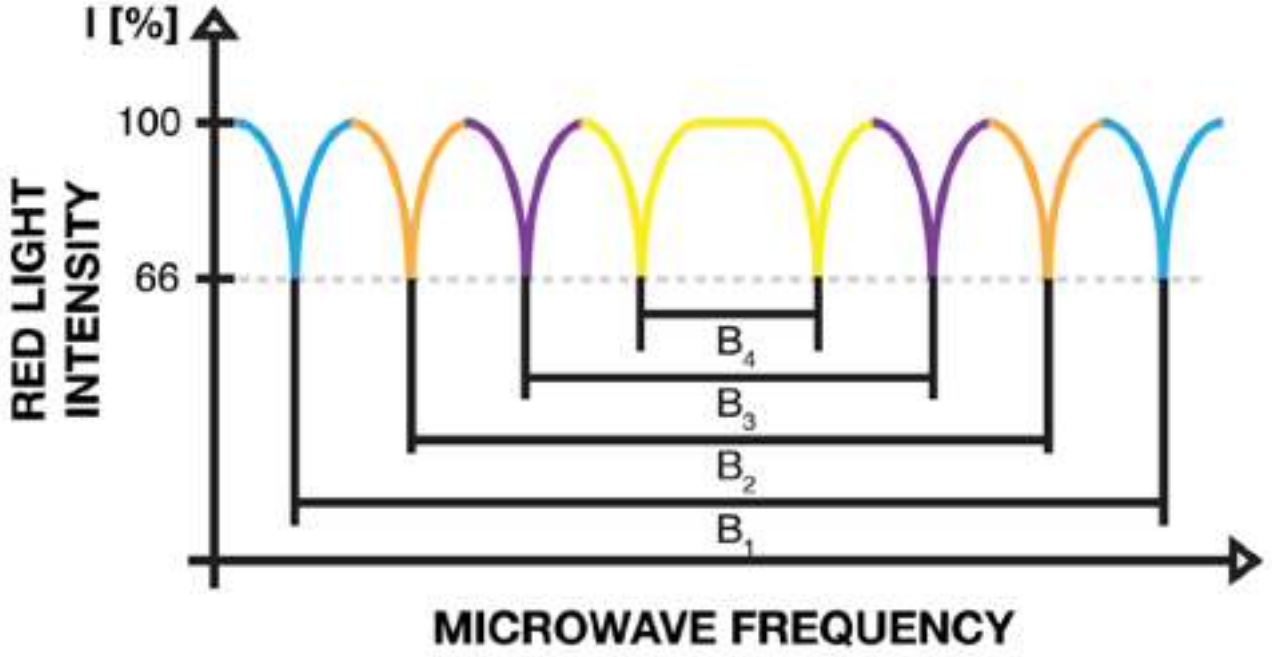
The experiment



Hruby et. al.

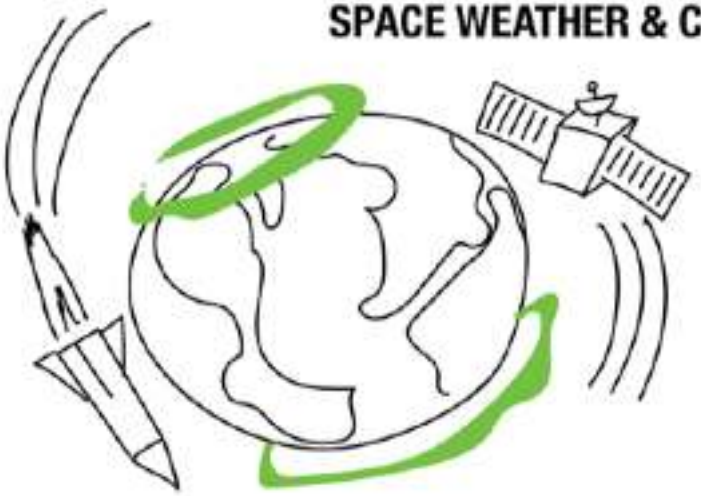
The experiment





Hruby et. al.

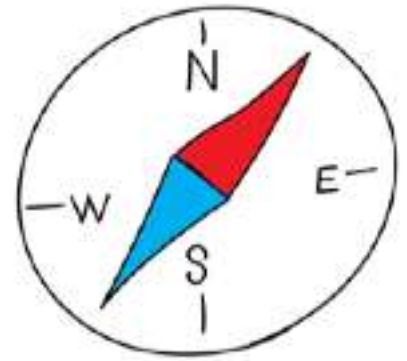
Applications



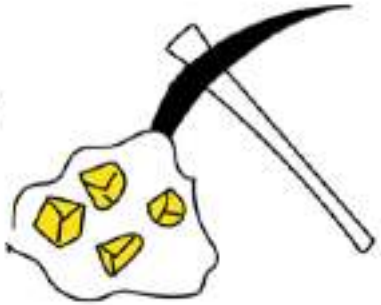
SPACE EXPLORATION

BIOMEDICAL TECHNOLOGIES

QUANTUM TECHNOLOGIES



NAVIGATION



MINERAL & OIL EXPLORATION

Hruby et. al.

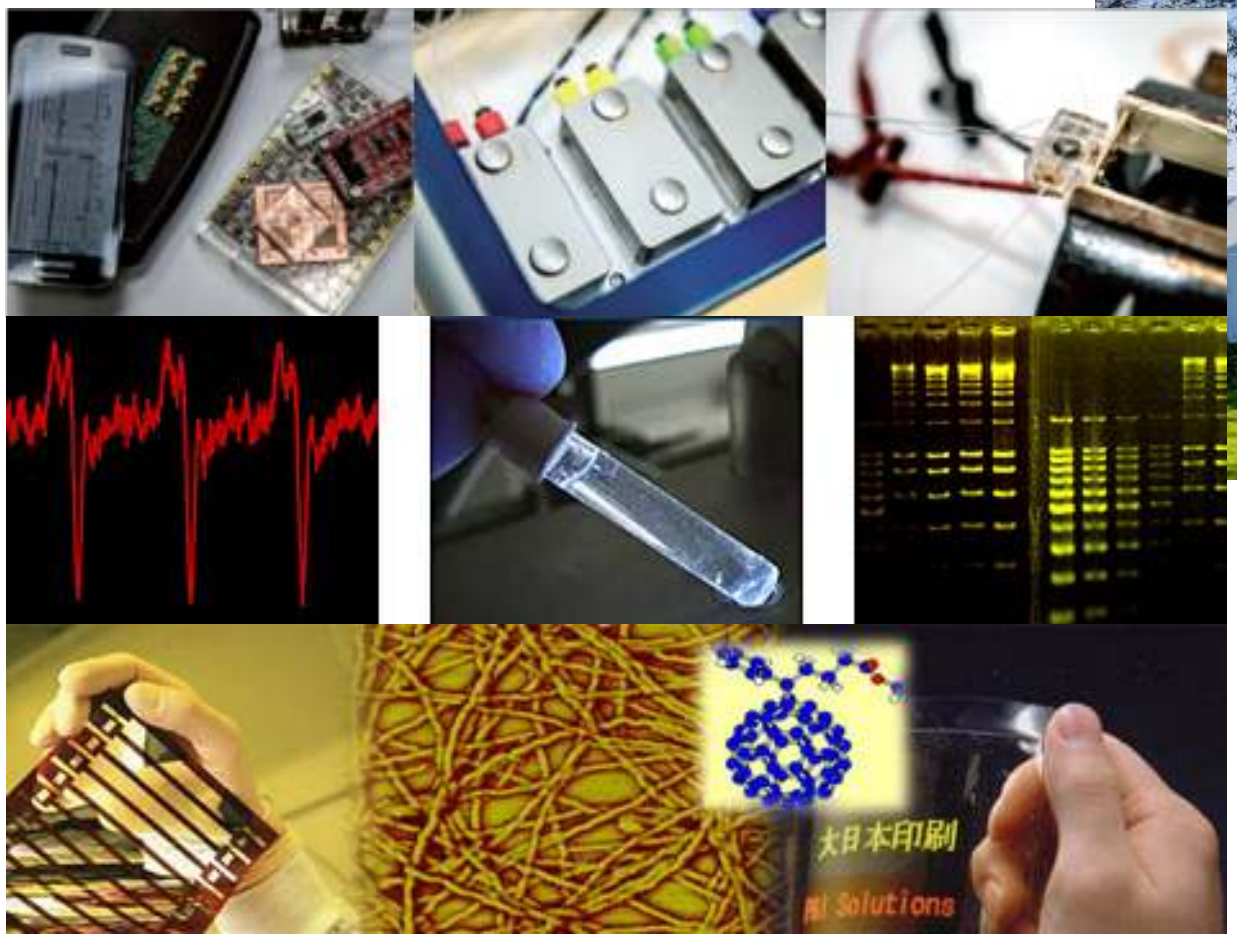
The experiment

- Thorough selection process at ESA ESTEC, NL
- Supervised by ESA, DLR, SNSA and SSC
- Expert panel

What is OSCAR-QLITE?

- OSCAR = Optical Sensors based on CARbon materials
- QLITE = Quantum Lightweight ITEration

Development

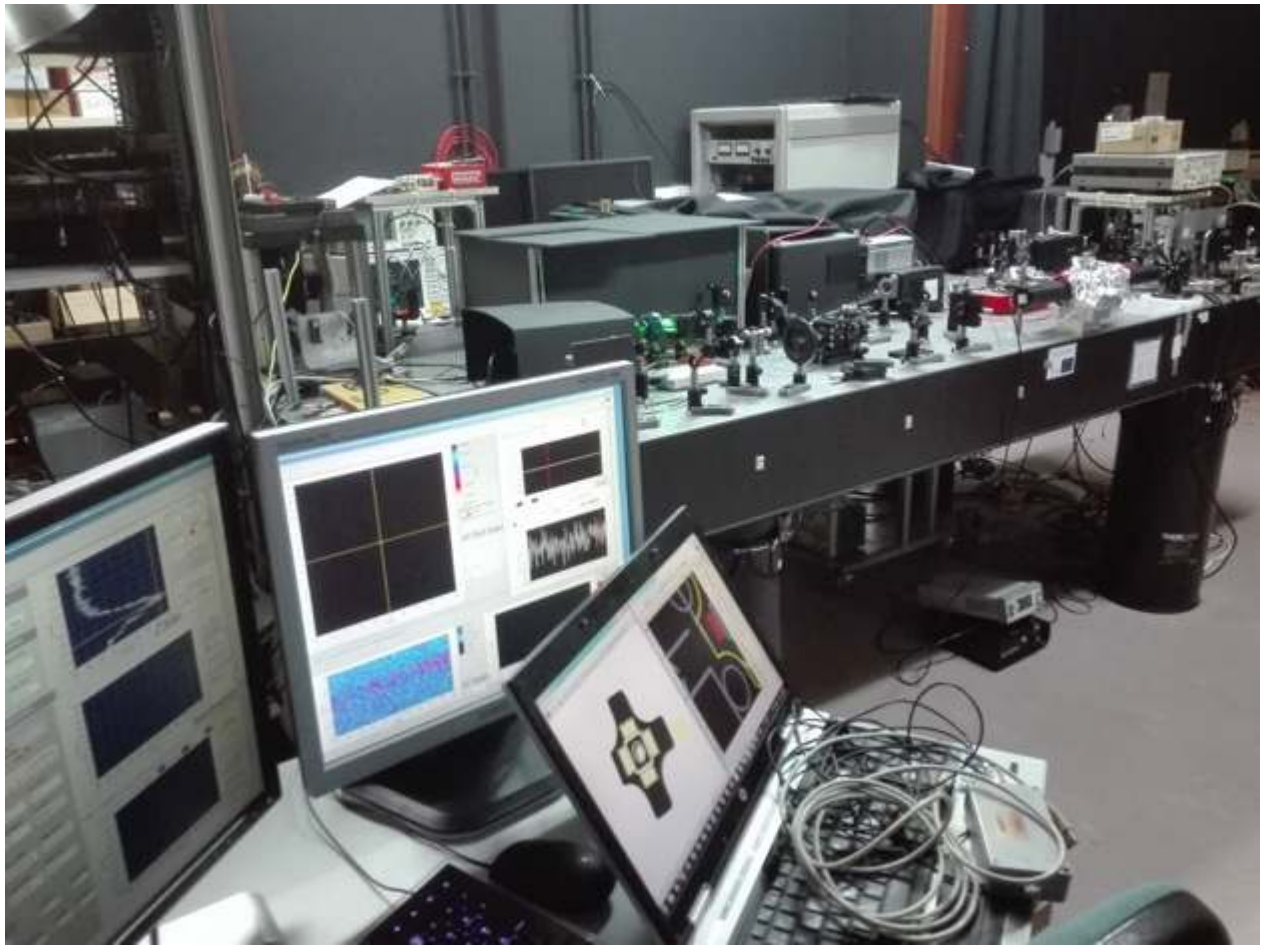


IMO-IMOMEC

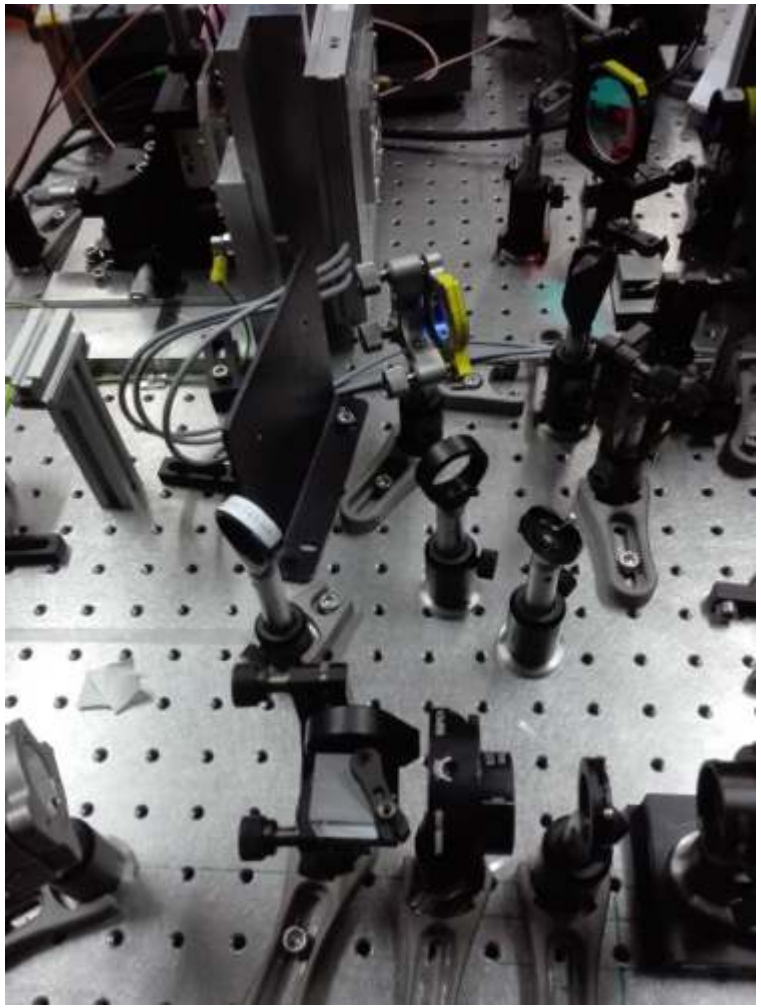
UHASSELT imec

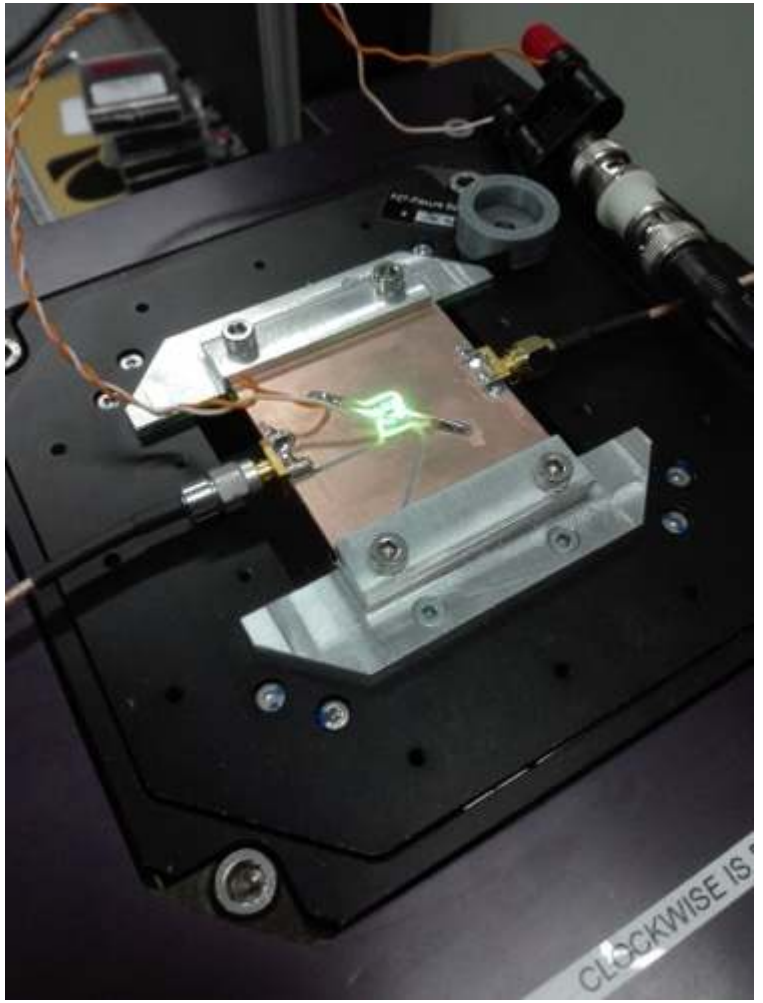
https://www.uhasselt.be/IMO

Development



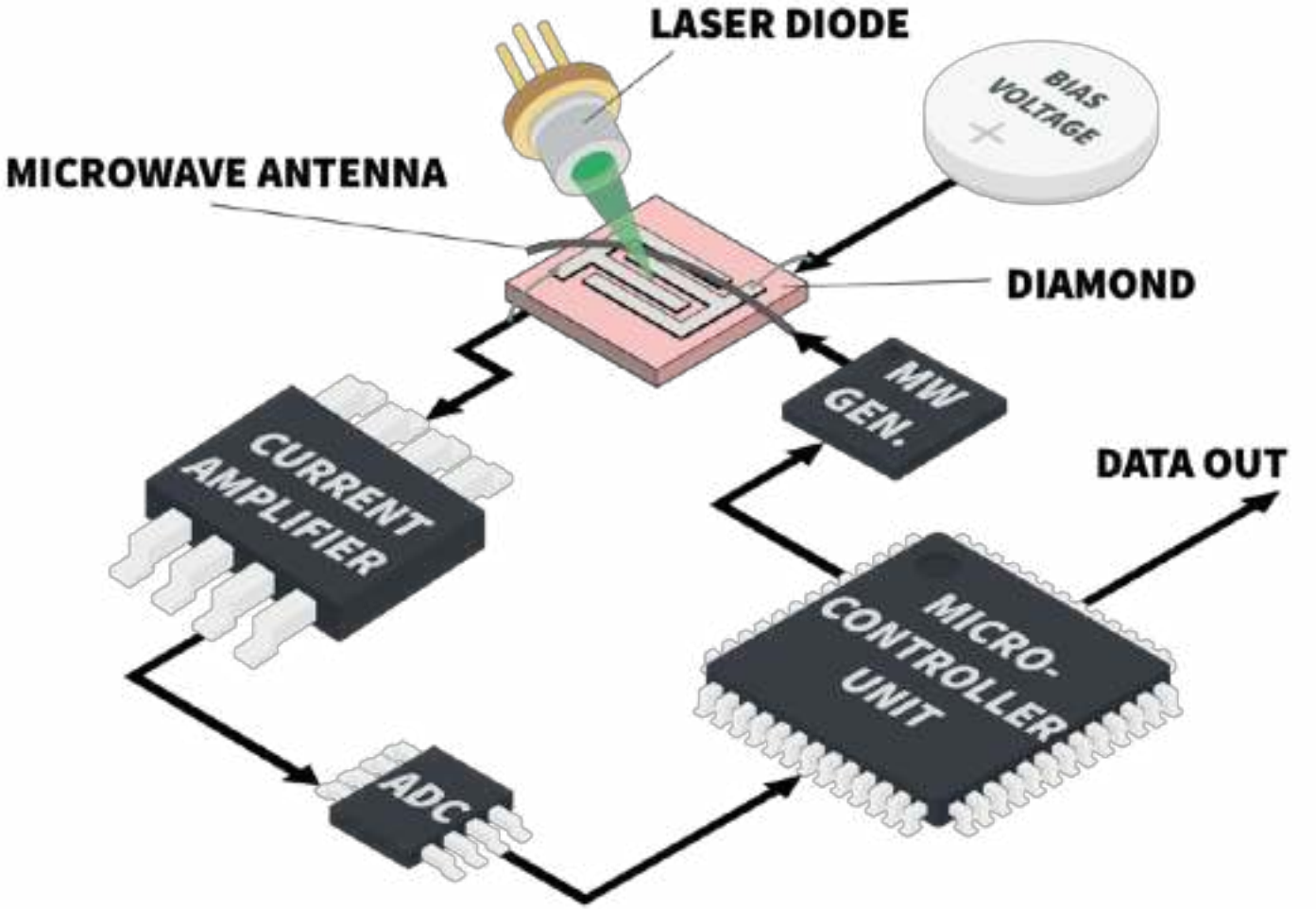
Development





The challenge

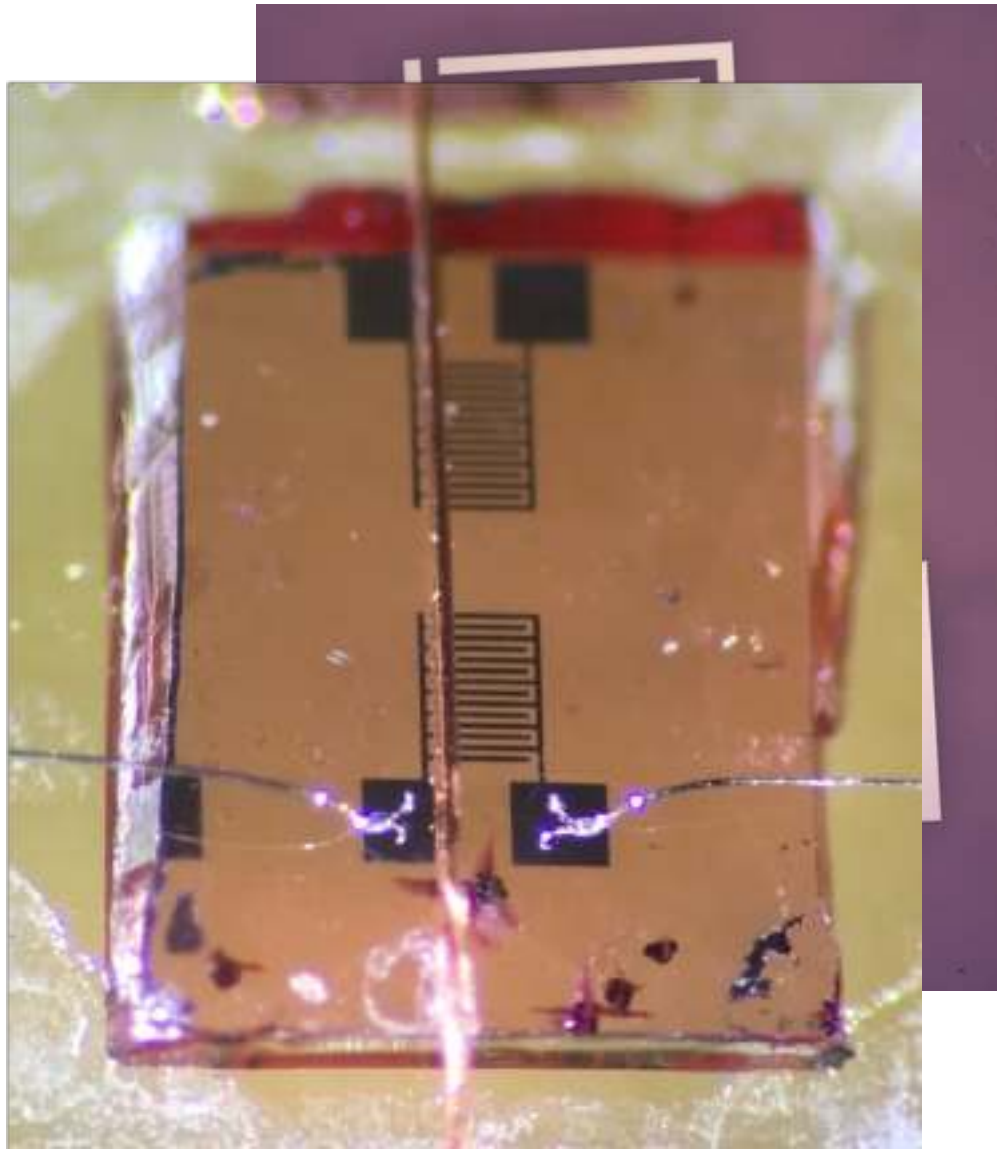
Development



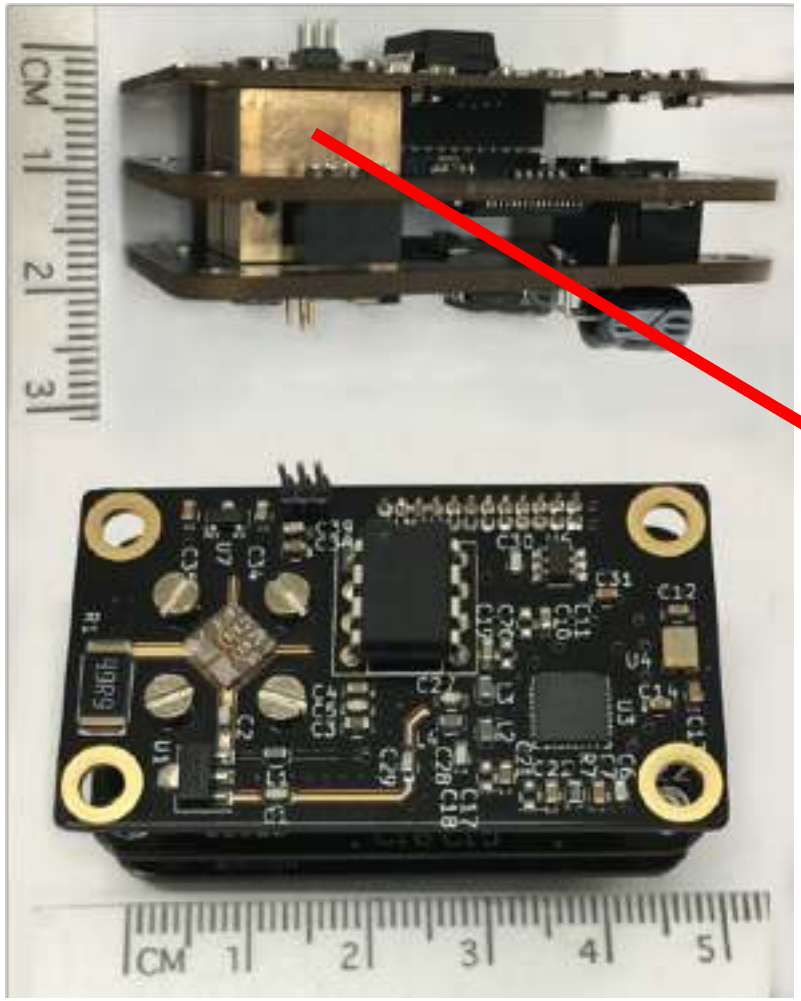
Hruby et. al.

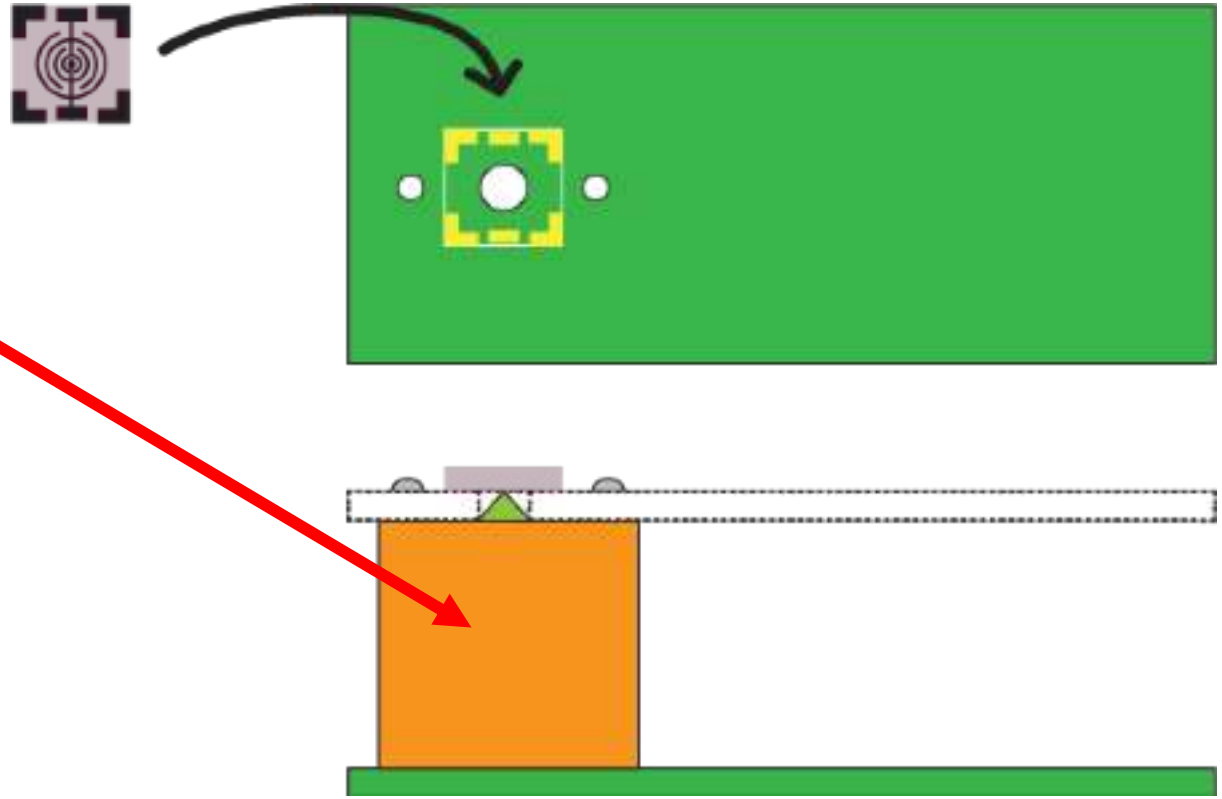
Development - diamond

- Nitrogen doped (pink color)
- Lithography facilities at IMEC
- Interdigitated aluminium electrodes
- 5 micron gap



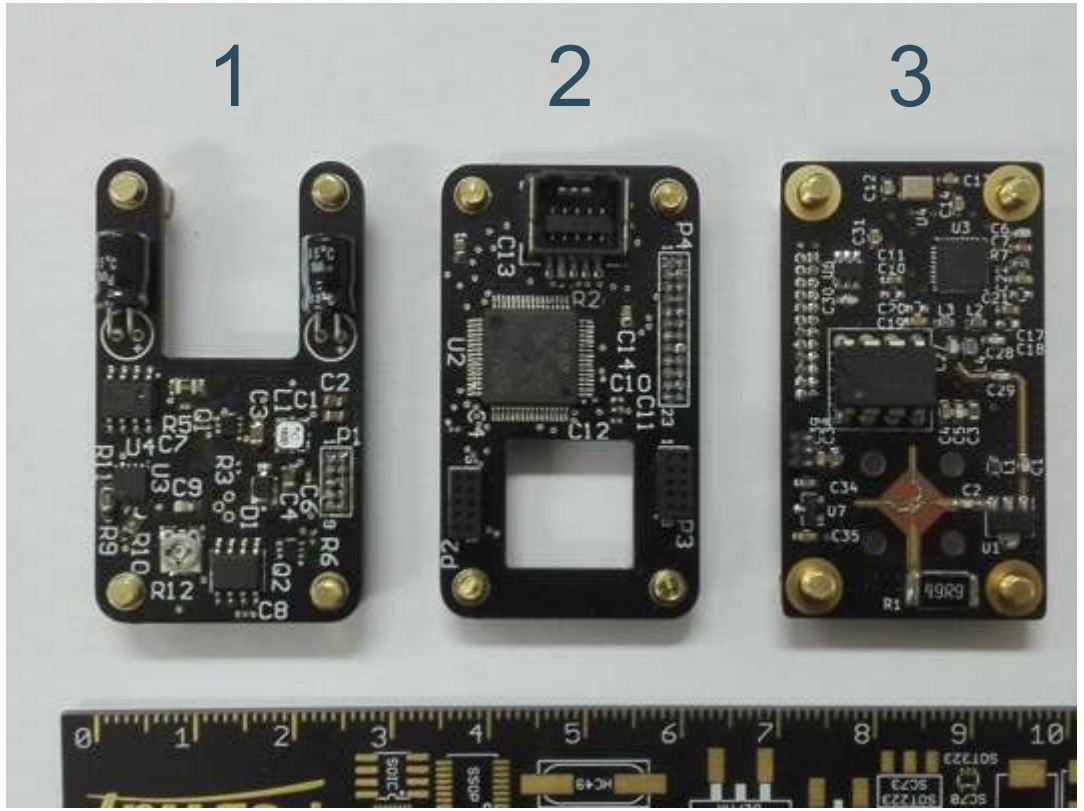
Development - optics





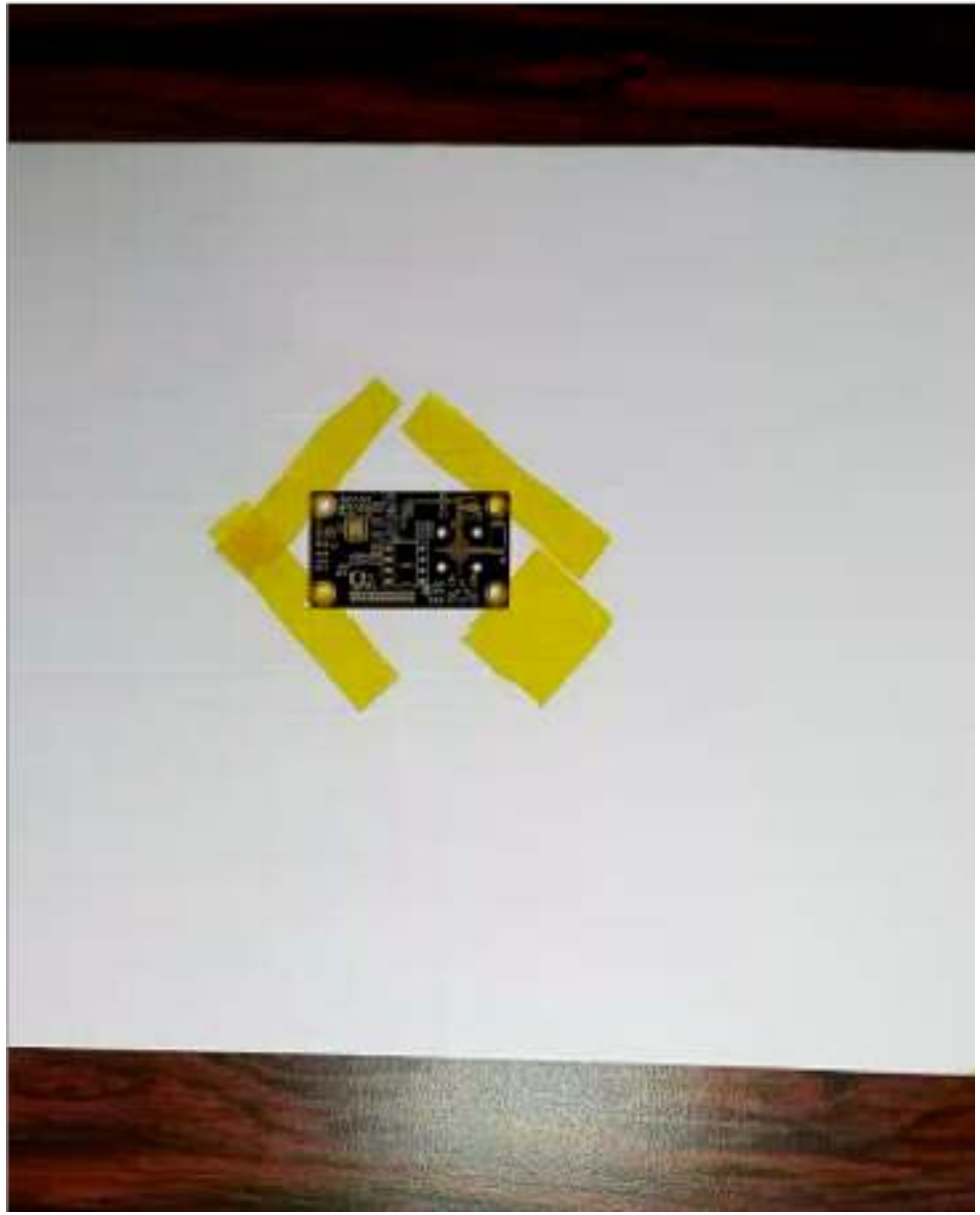
Development

- Separate PCBs for the subsystems
  1. Laser driver
  2. MCU and power regulation
  3. Photocurrent readout and microwave generator



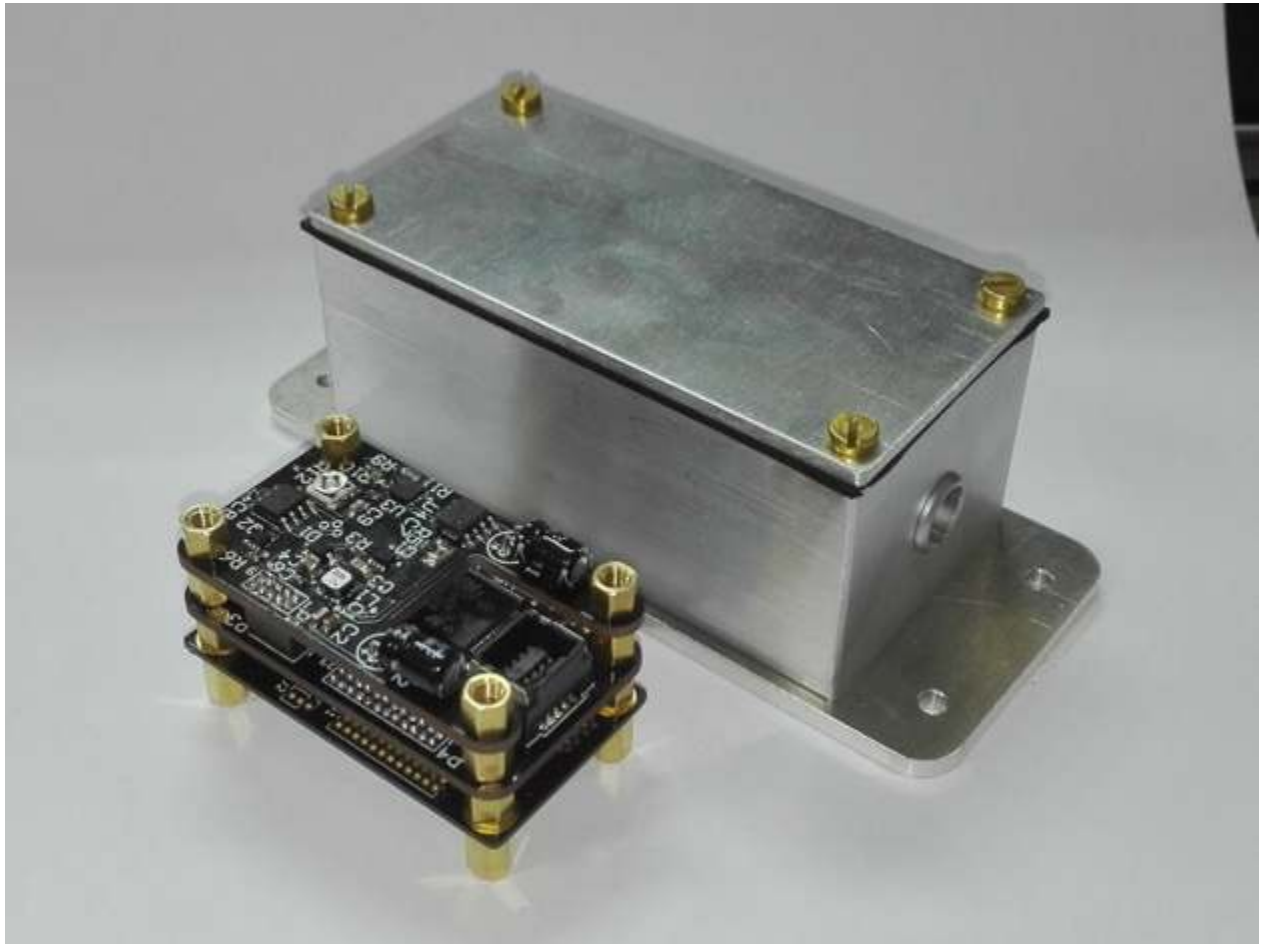
Development

- Clean PCB
- Apply solder paste
- Place components
- Bake PCB
- Test



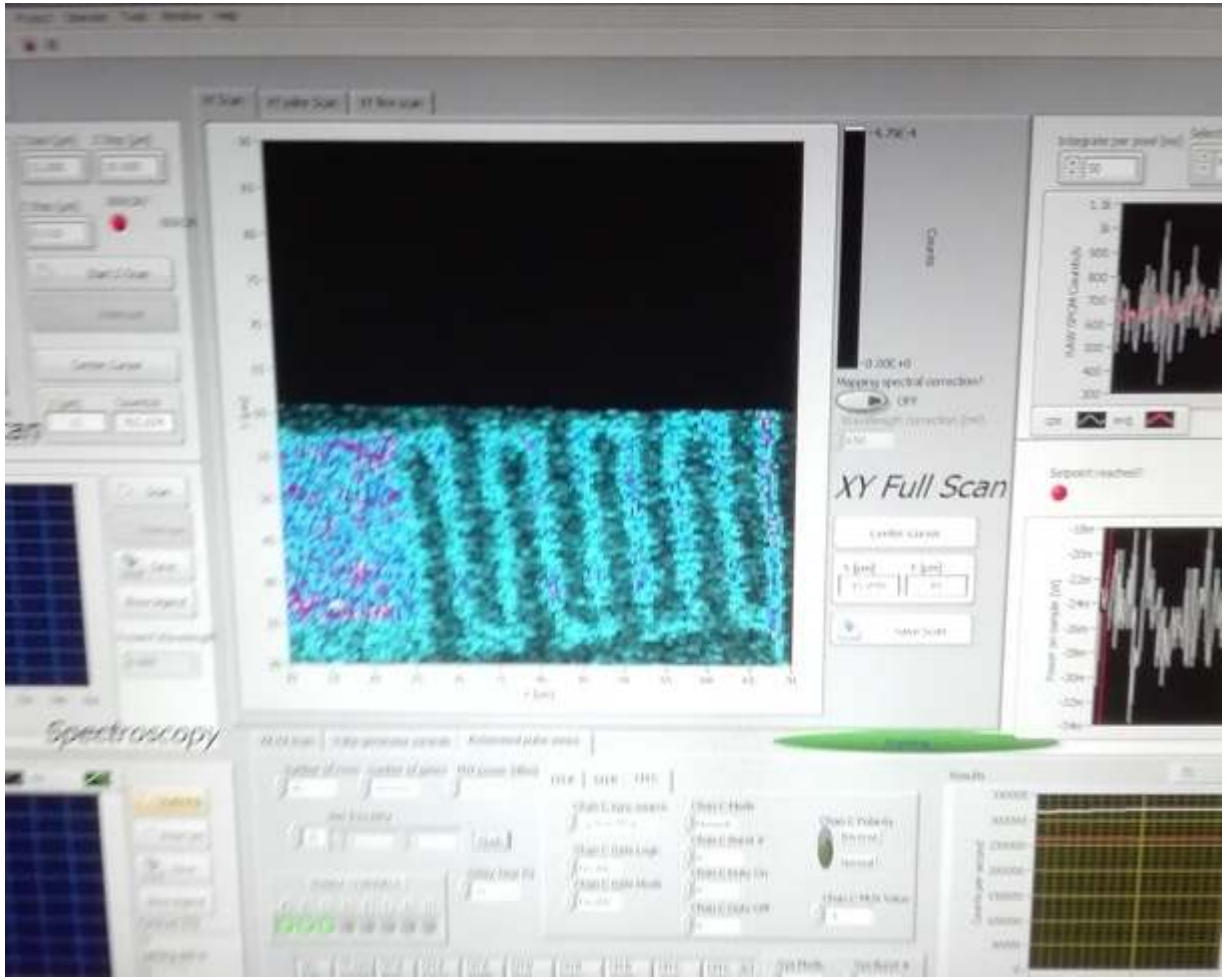
Development

- Finished PCB stack and machined housing

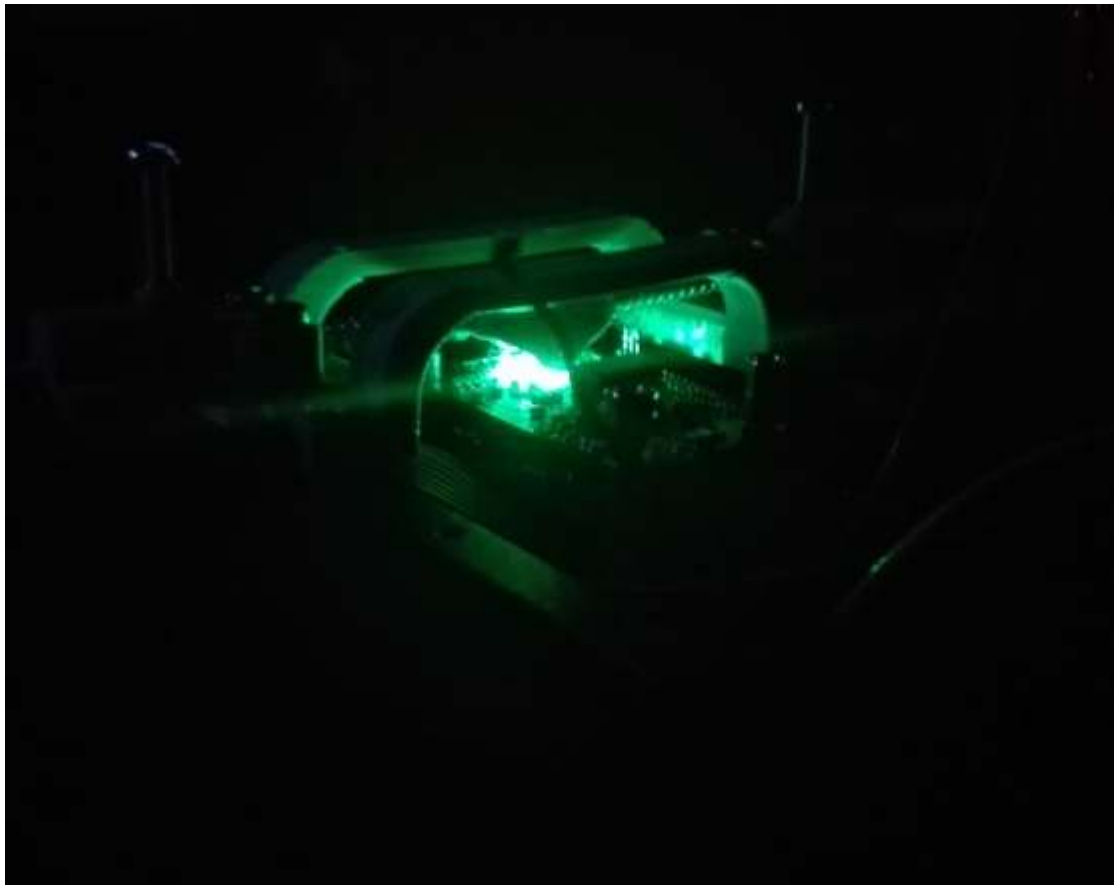


Development

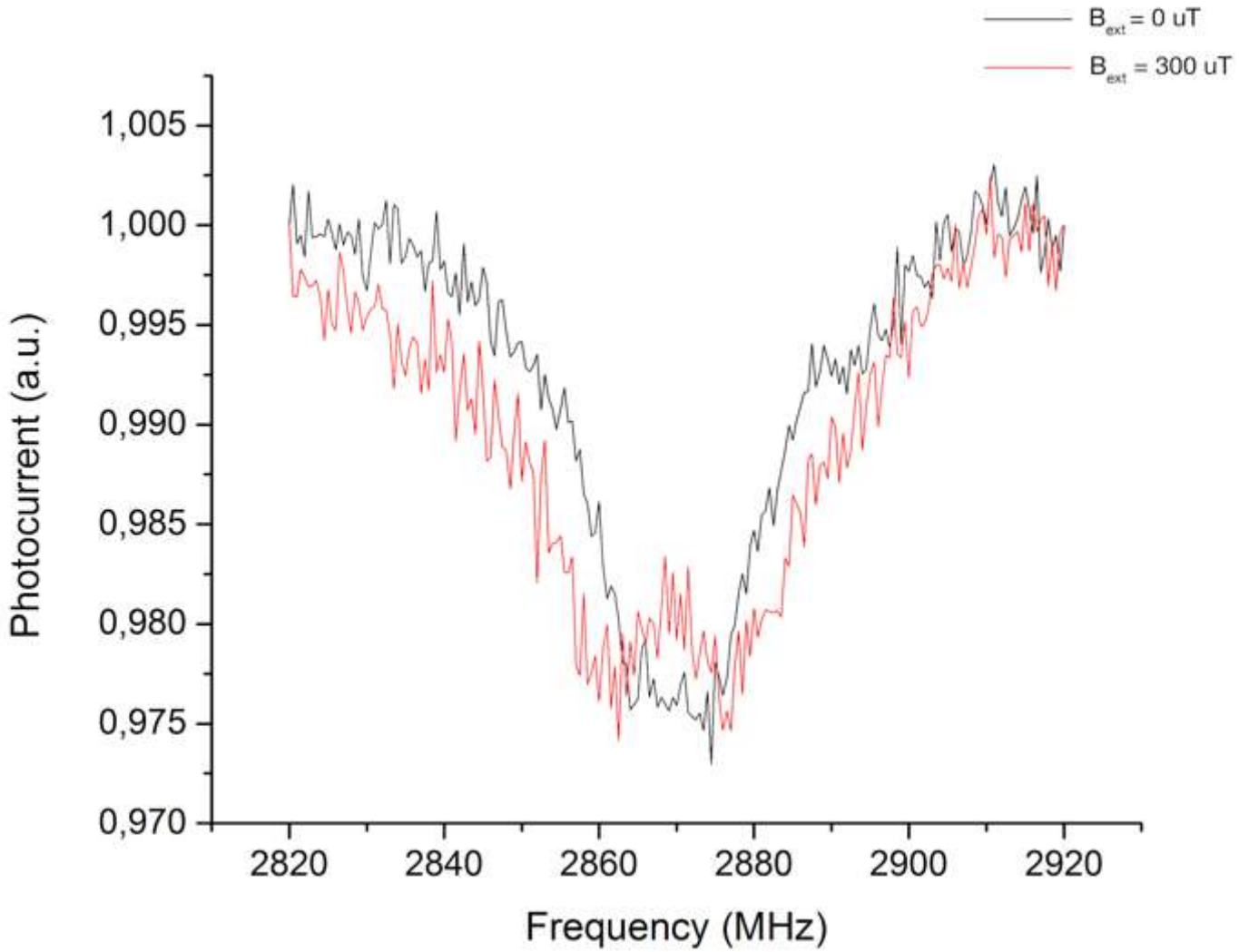
- Laser spot moves over electrodes
- Photocurrent plot vs XY position
- Electrical ‘image’ of the diamond



Development



Development



Meanwhile across the pond…

LOCKHEED MARTIN

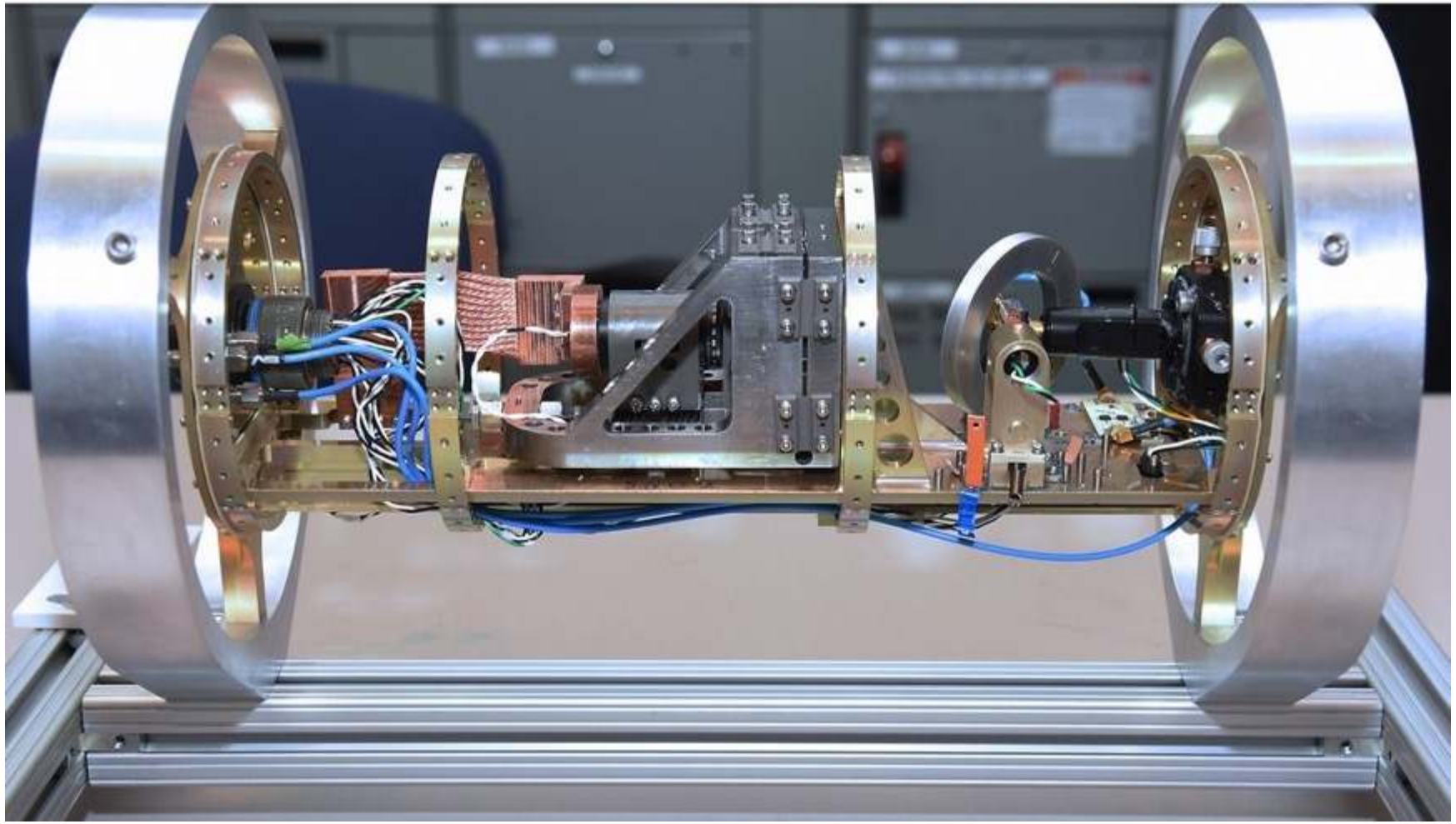


Image: Lockheed Martin

SCAR OLITE

Rymdstyrelsen
Swedish National Space Agency

SSC

DLR

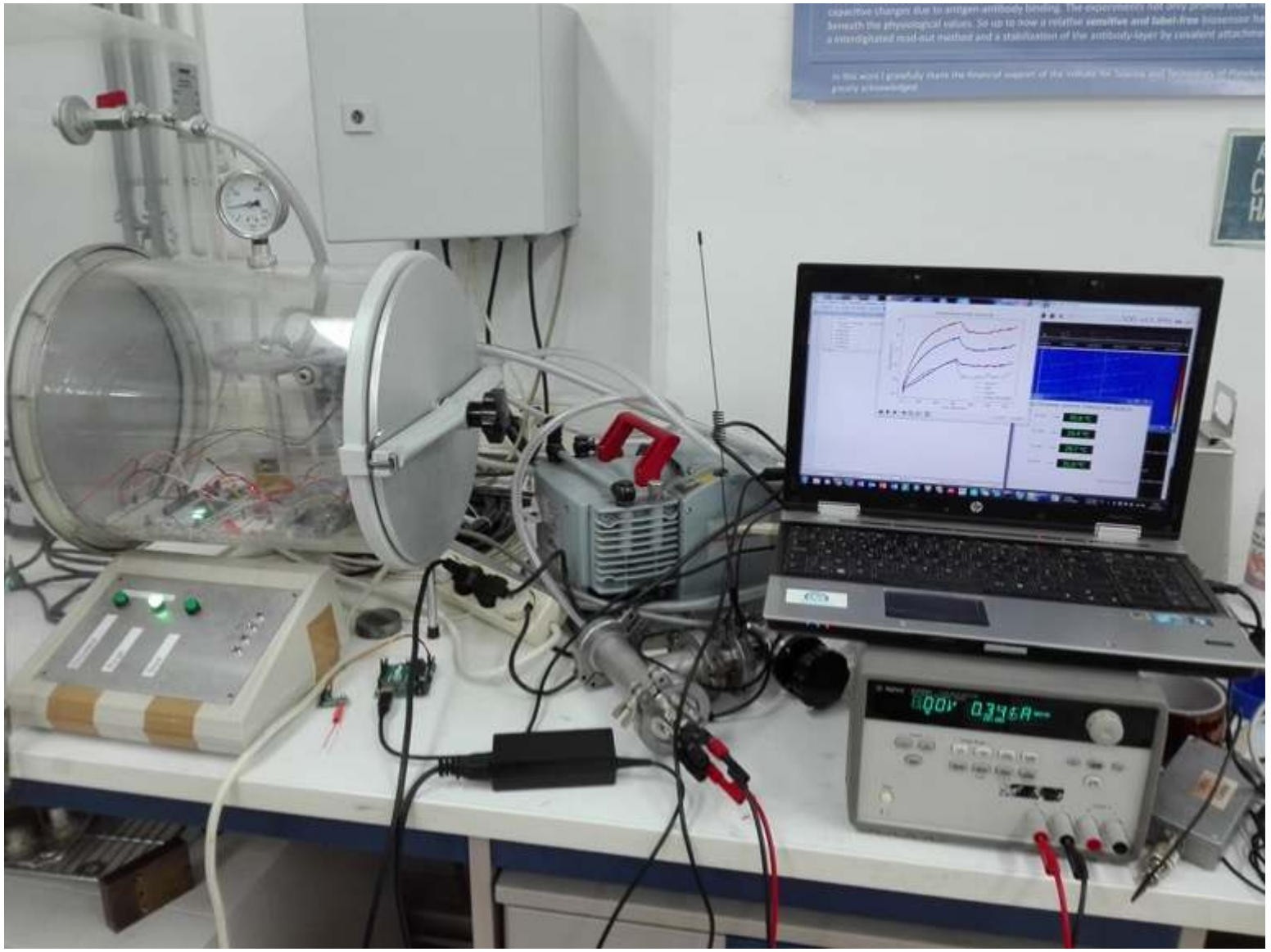
esa

UHASSELT

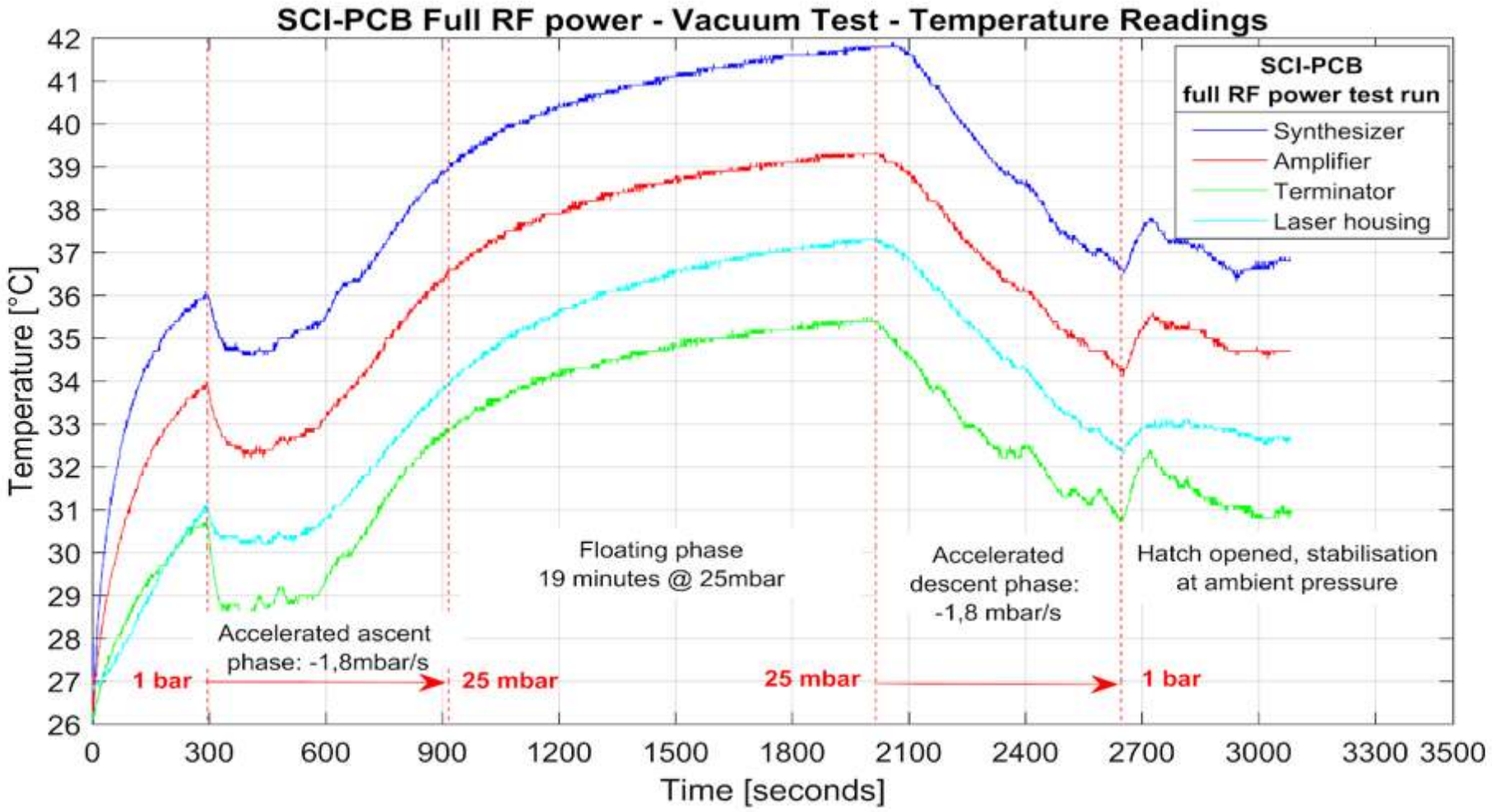
KU LEUVEN

Development

- Vacuum testing of subsystems
- Multiple temperature channels
- Testing at stratospheric pressures



Development

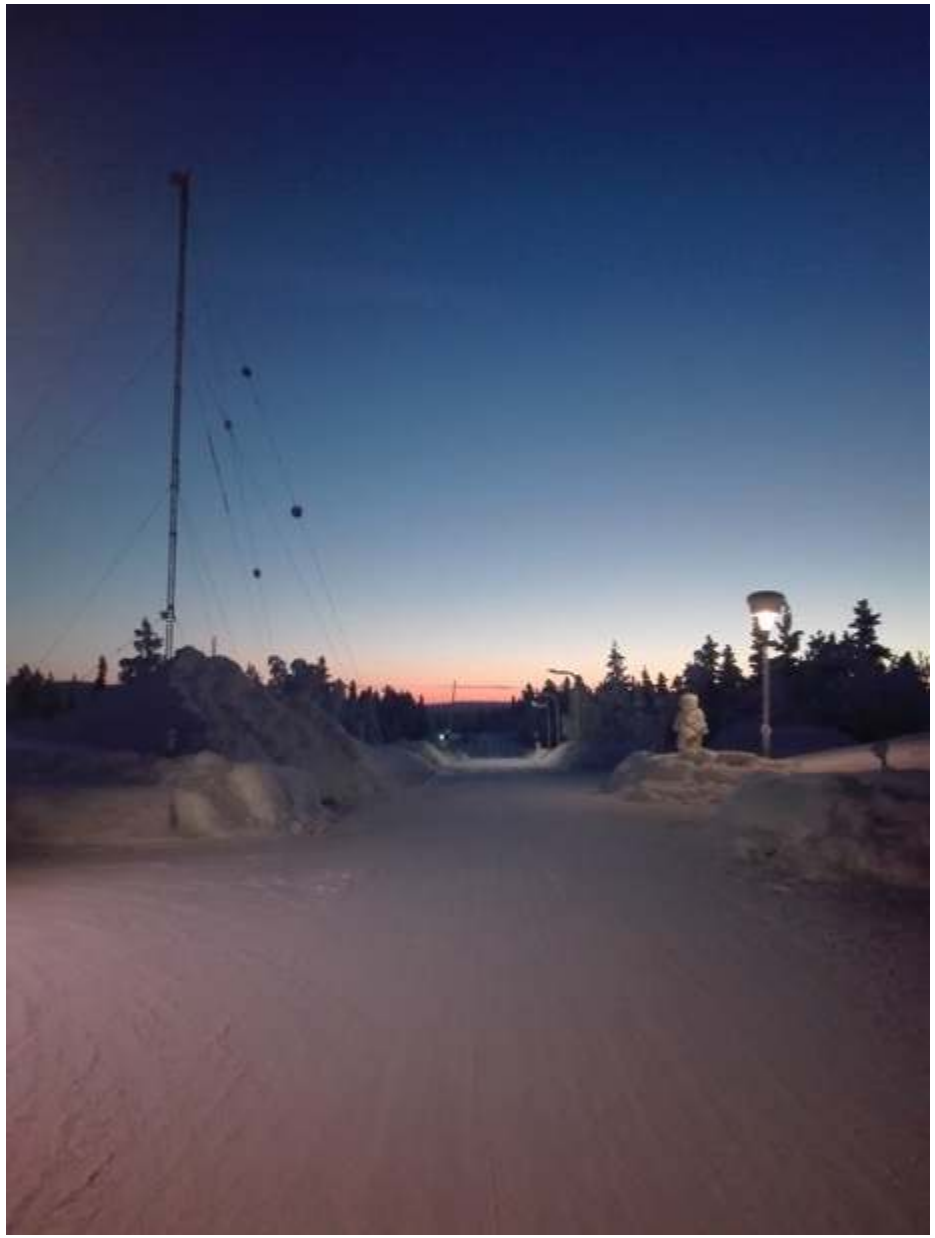


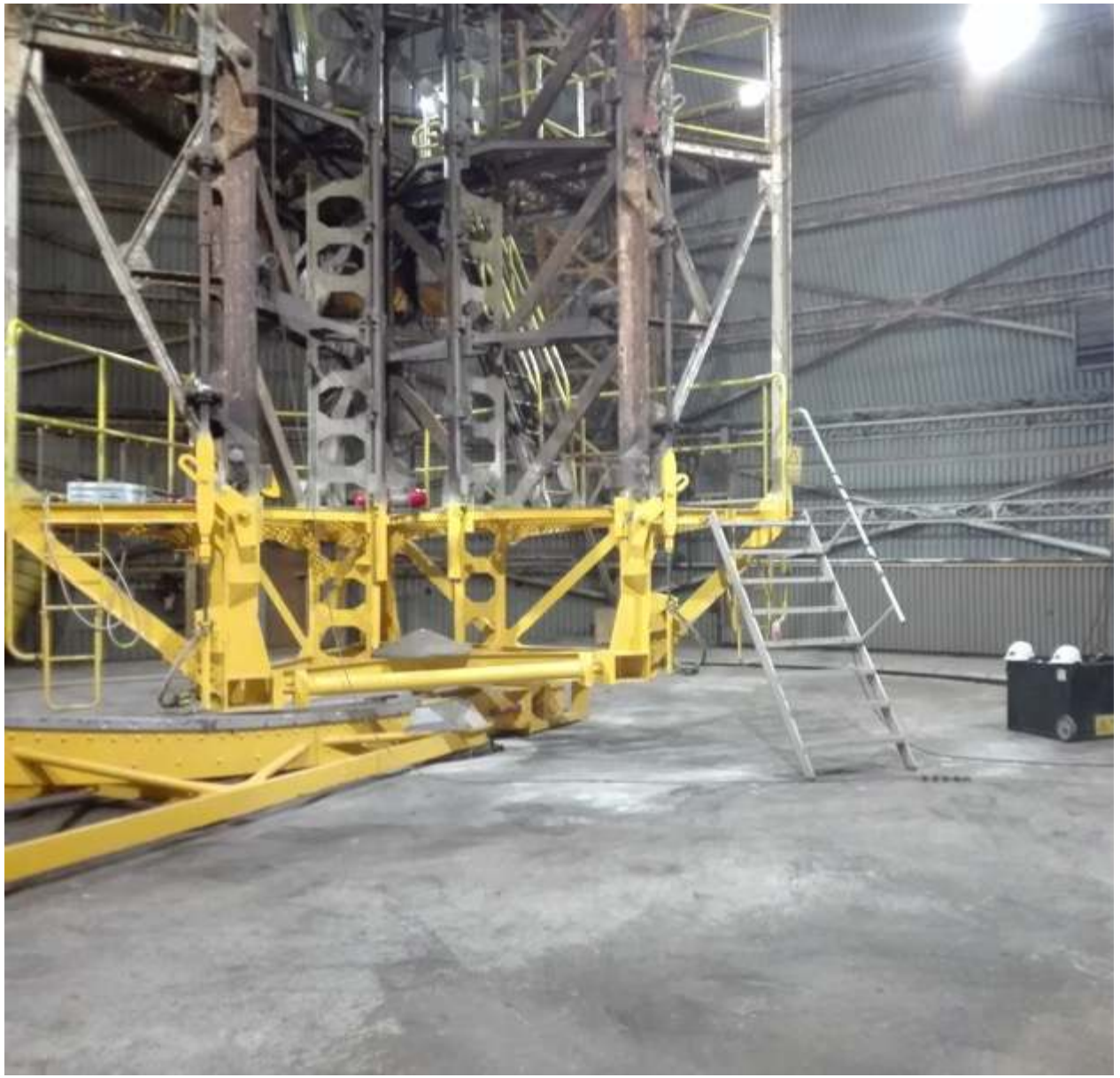
Training week

- Kiruna, Sweden

Training week

- Kiruna, Sweden





Training week

- Esrange, Sweden
- Lectures, workshops and exercises on space compatible hardware, software, electronics, ECSS standards,…
- Preliminary design review (PDR)

Reviews


SCAR
QLITE
Optical Sensors based on CARbon materials:
Quantum Lightweight ITEration
Critical Design Review

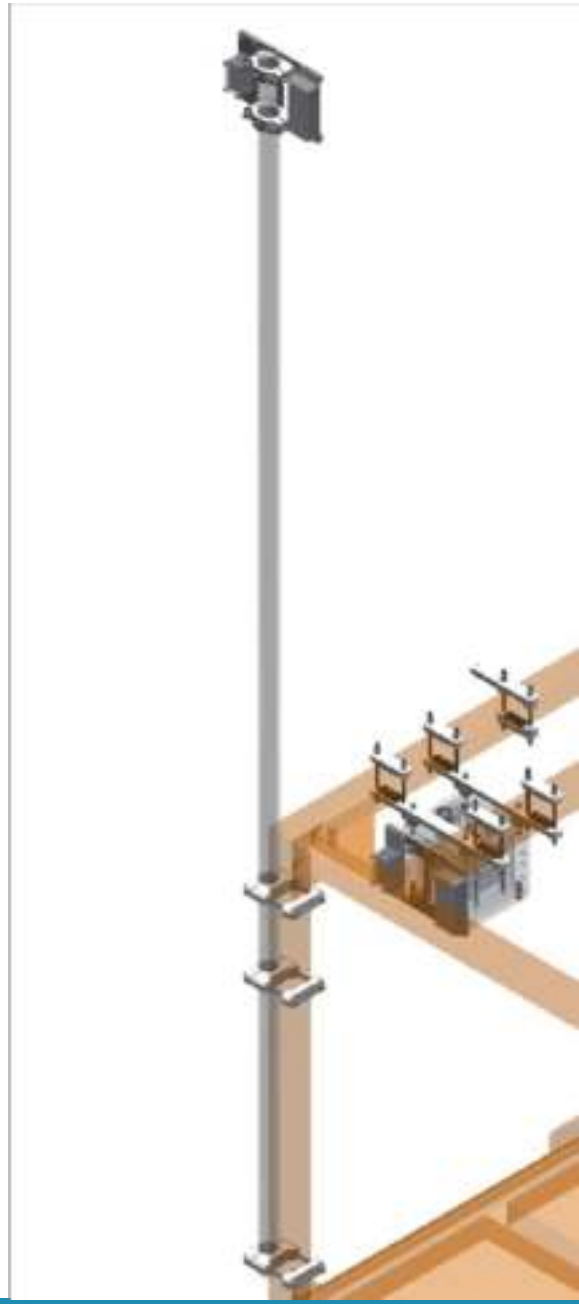
Reviews

- 1 Document: SED (Student Experiment Documentation)
- PDR – Preliminary Design Review (Esrange, Sweden)
- CDR – Critical Design Review (ESA ESTEC, the Netherlands)
- IPR – Integration Progress Review (Hasselt)
- EAR – Experiment Acceptance Review (Hasselt)
- FRR – Flight Readiness Review (Esrange, Sweden)

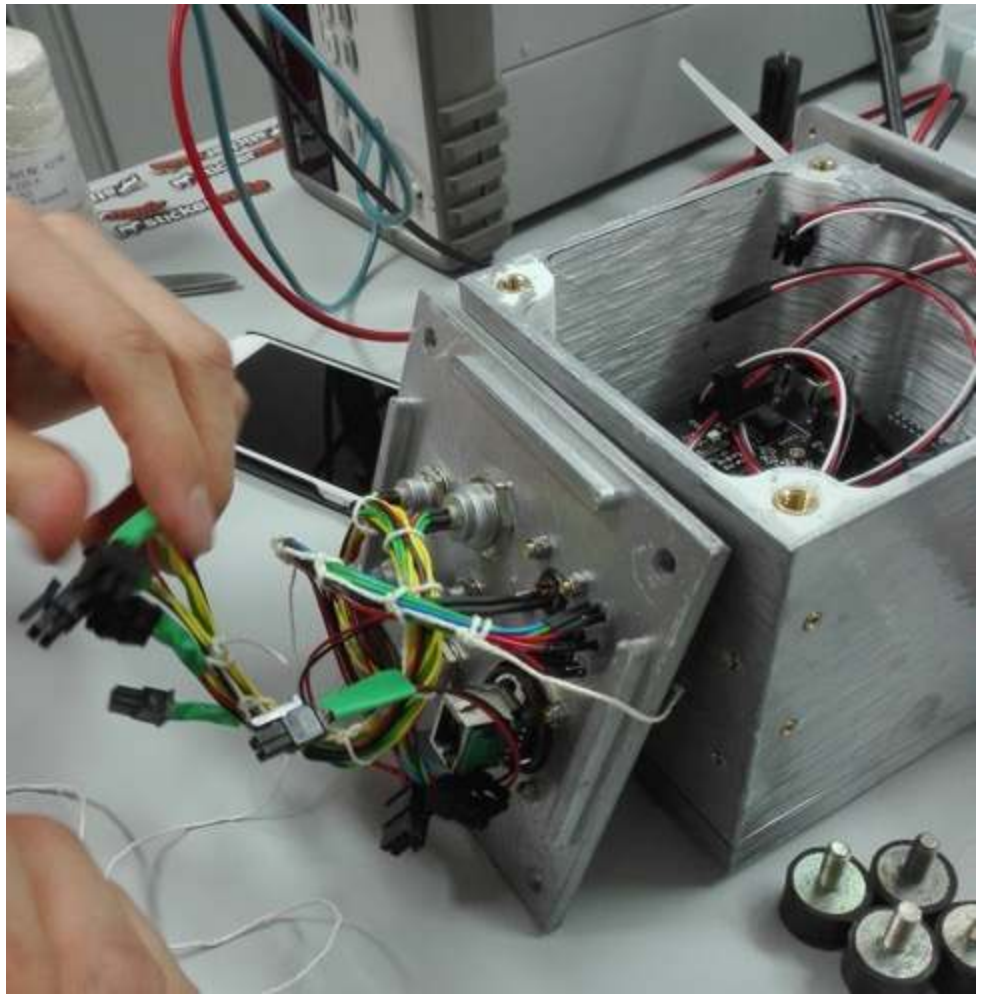
System overview

Masterbox

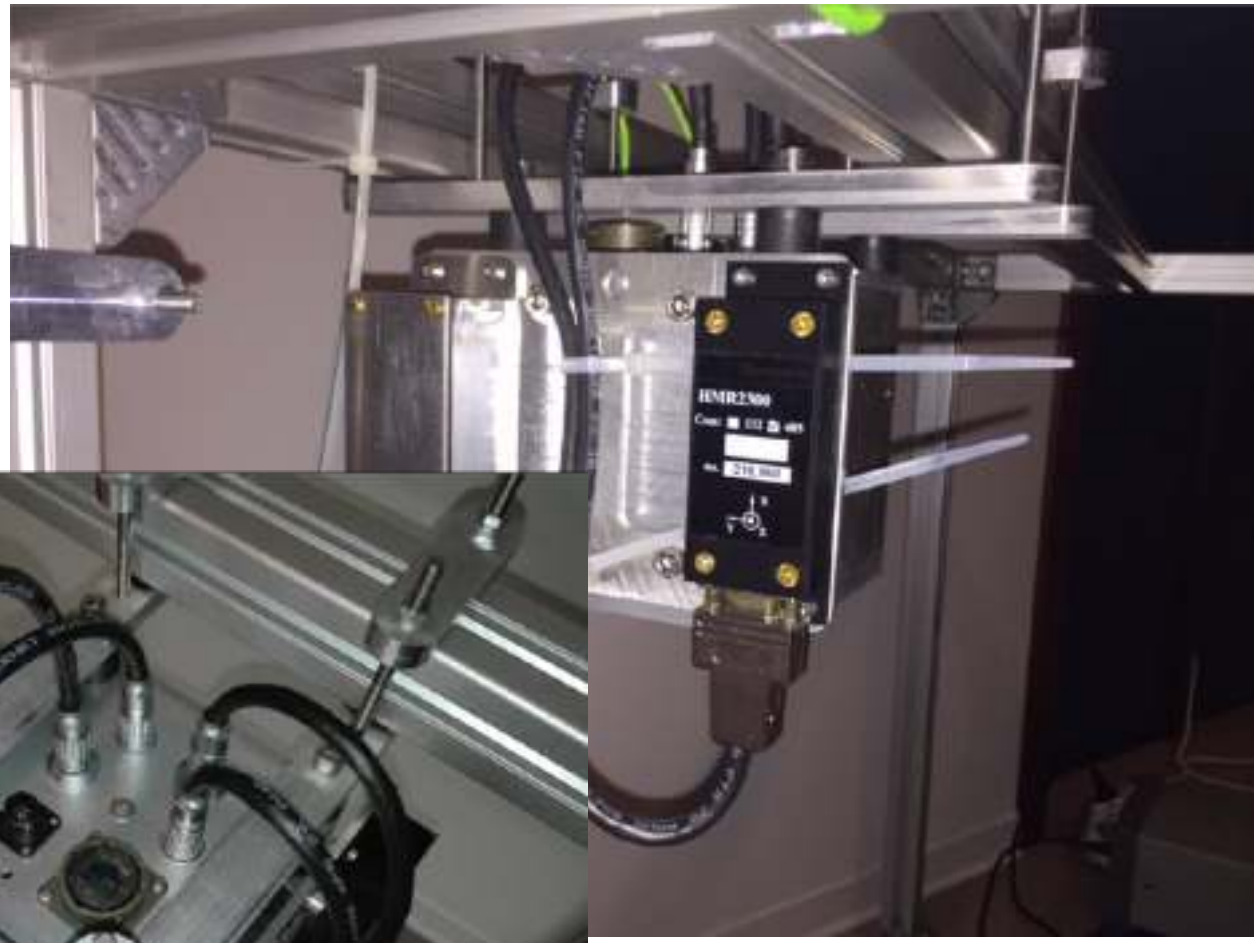
Sensors



System overview



System overview



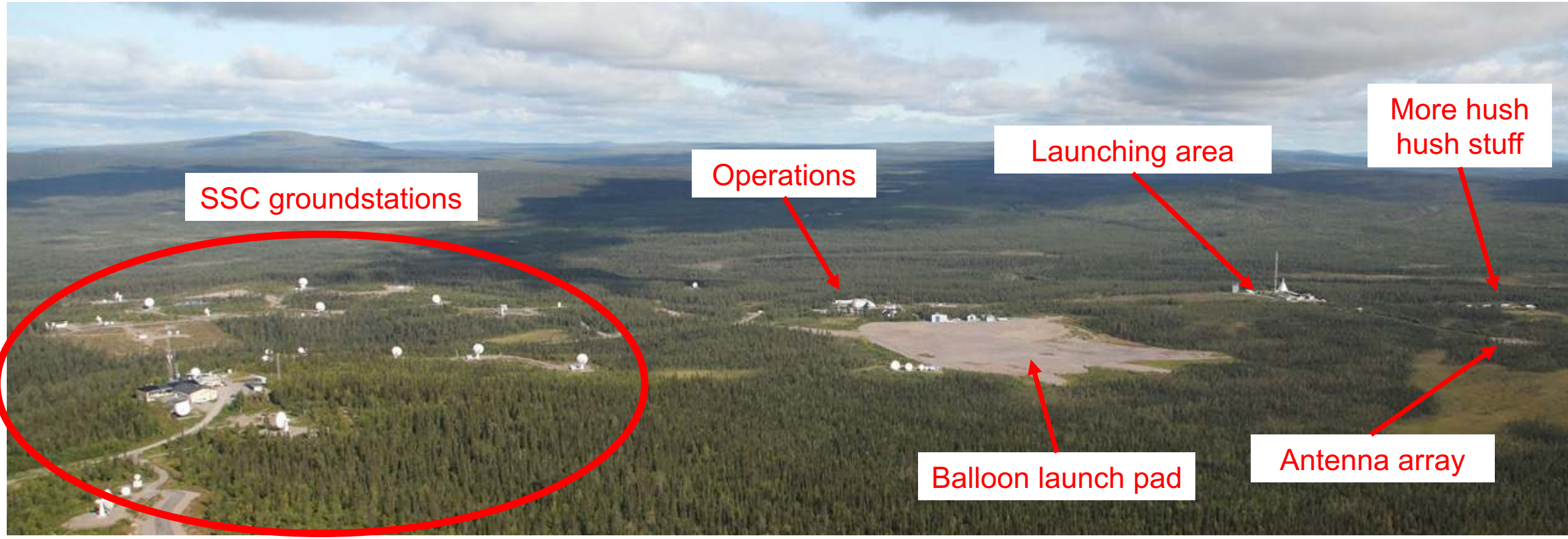
Launch campaign

- Esrange Space Center
- 200km north of Arctic circle

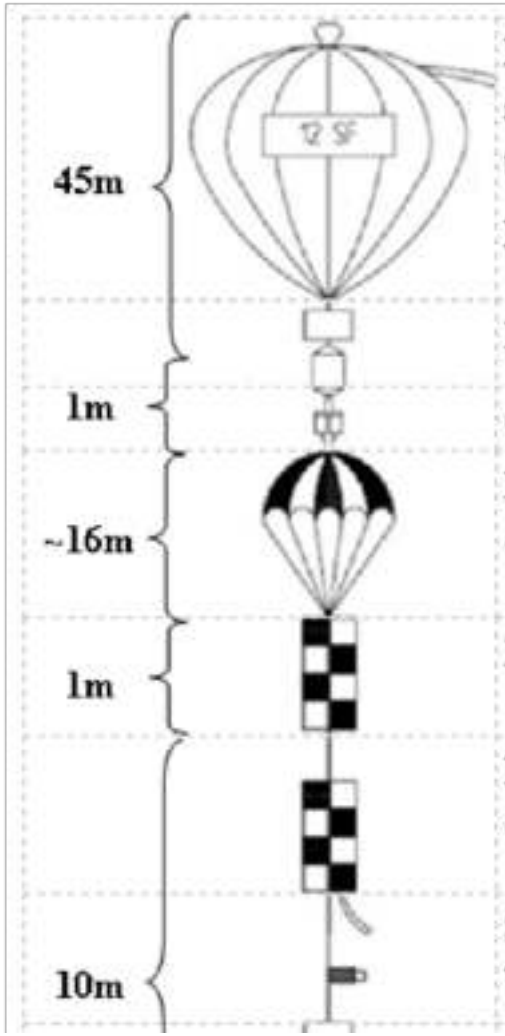
Launch campaign

- Esrange Space Center
- 200km north of Arctic circle
- Restricted airspace
- 5600 km^2 uninhabited test range

Launch campaign



Flight train



Balloon: Typically a Zodiac 12 SF (12,000 m^3), mass 100.6kg. Typical lift 120kg to 30km to 340kg to 25km with Helium. Lift = total mass + 12%

For lighter payloads a 10 SF may be used

Balloon Air Traffic Transponder (ATC)

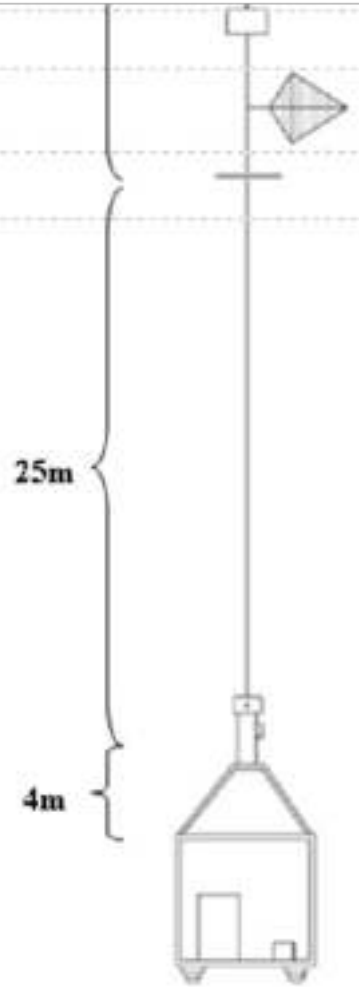
Cutter

Parachute : Typically 80m^2, 100m^2 or 120m^2 dependant on flight train mass.

EBASS System: See section 5.2

Ballast and Ballast container: Not normally used on BEXUS

Strobe light: SEE-BLITZ strobe light [10]
Wide spectrum bright light at 0.3Hz for entire flight



Flight Train ATC: See section 4.3

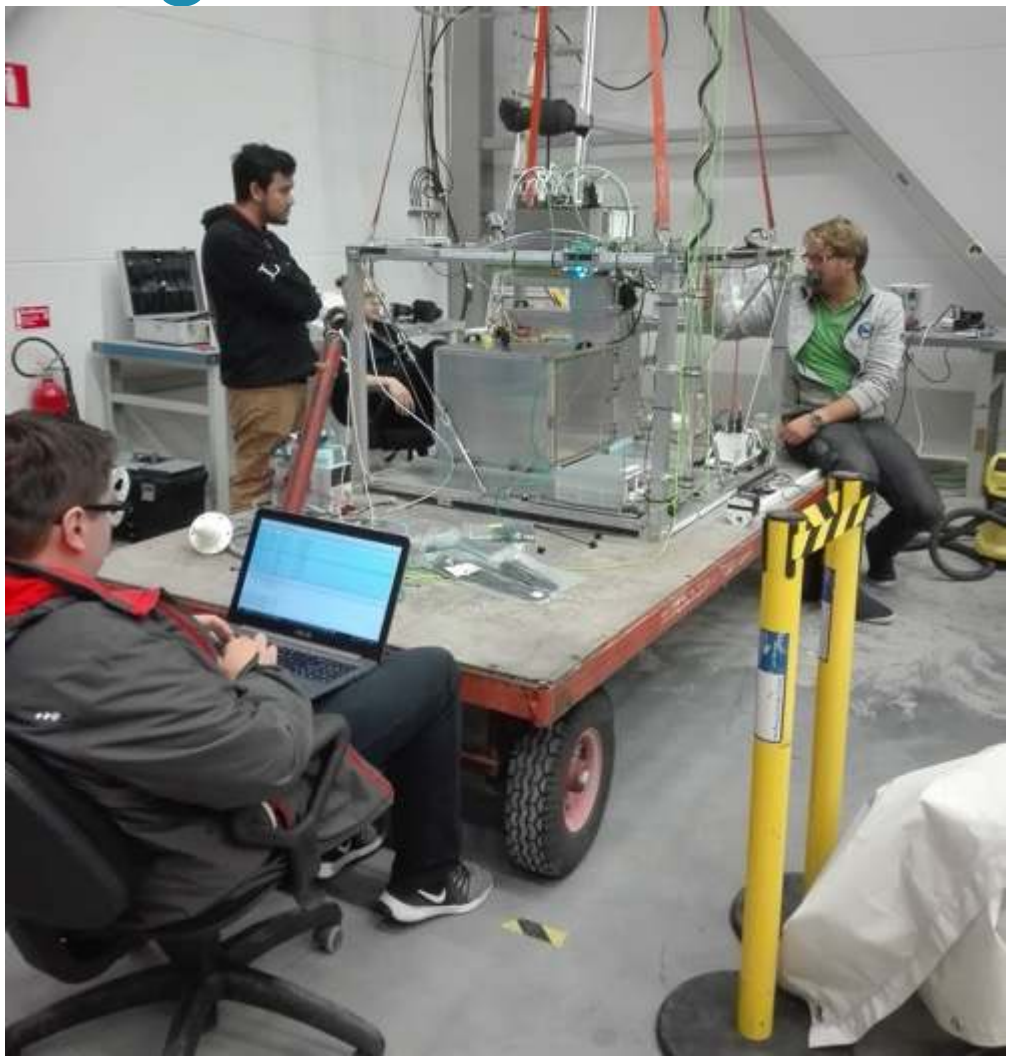
Radar Reflector: Passive

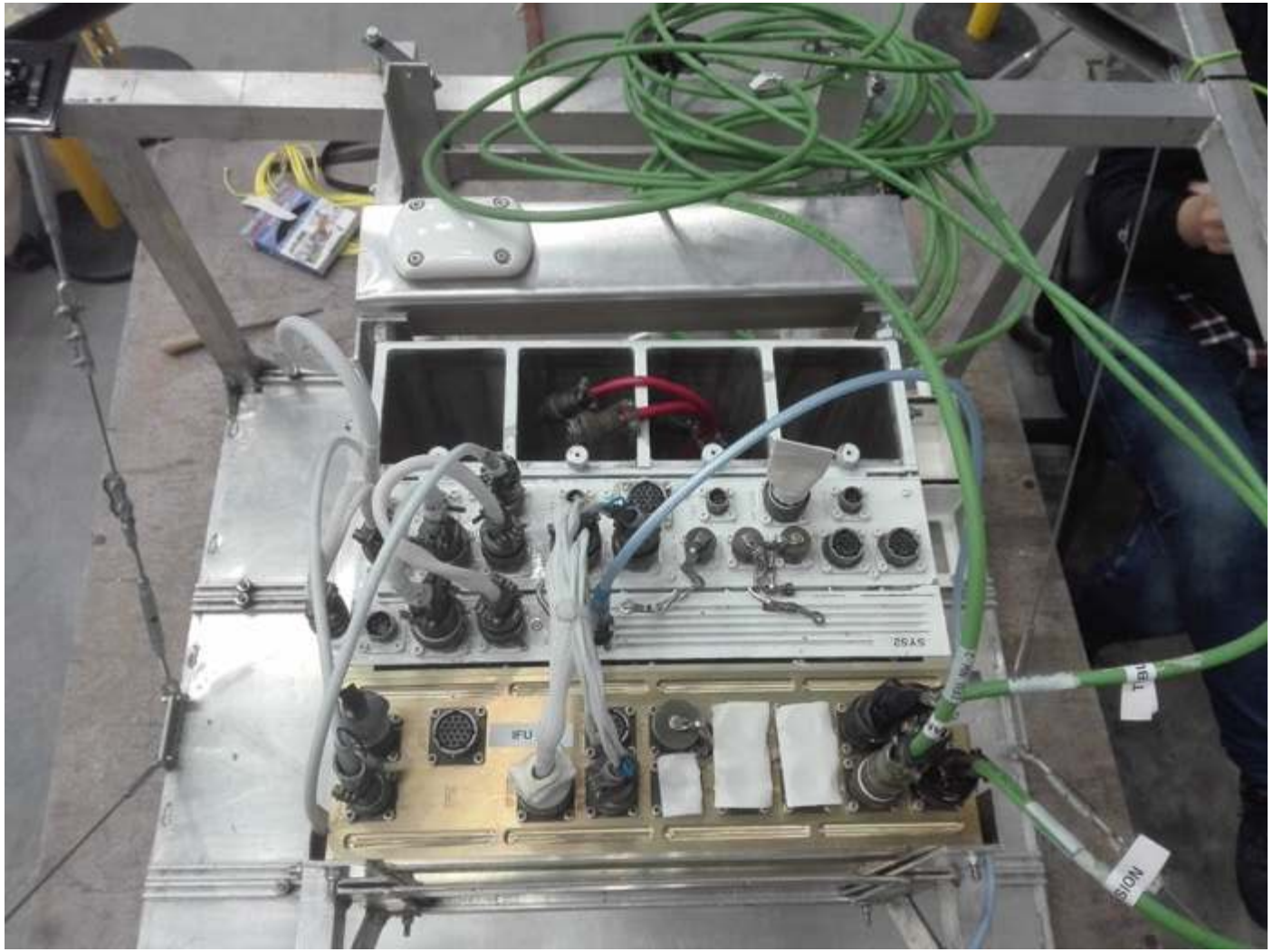
Truck Plate

Gondola and E-Link System:

See sections 4.2 and 4.3

Flight train - instrumentation





Launch operations

- Launch scheduled for 0700 LT
- 5hrs (+30m) of countdown
- Groundstation manned 0130LT

Launch operations

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- Gondola pickup by Hercules

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- Flight train rollout

Launch operations

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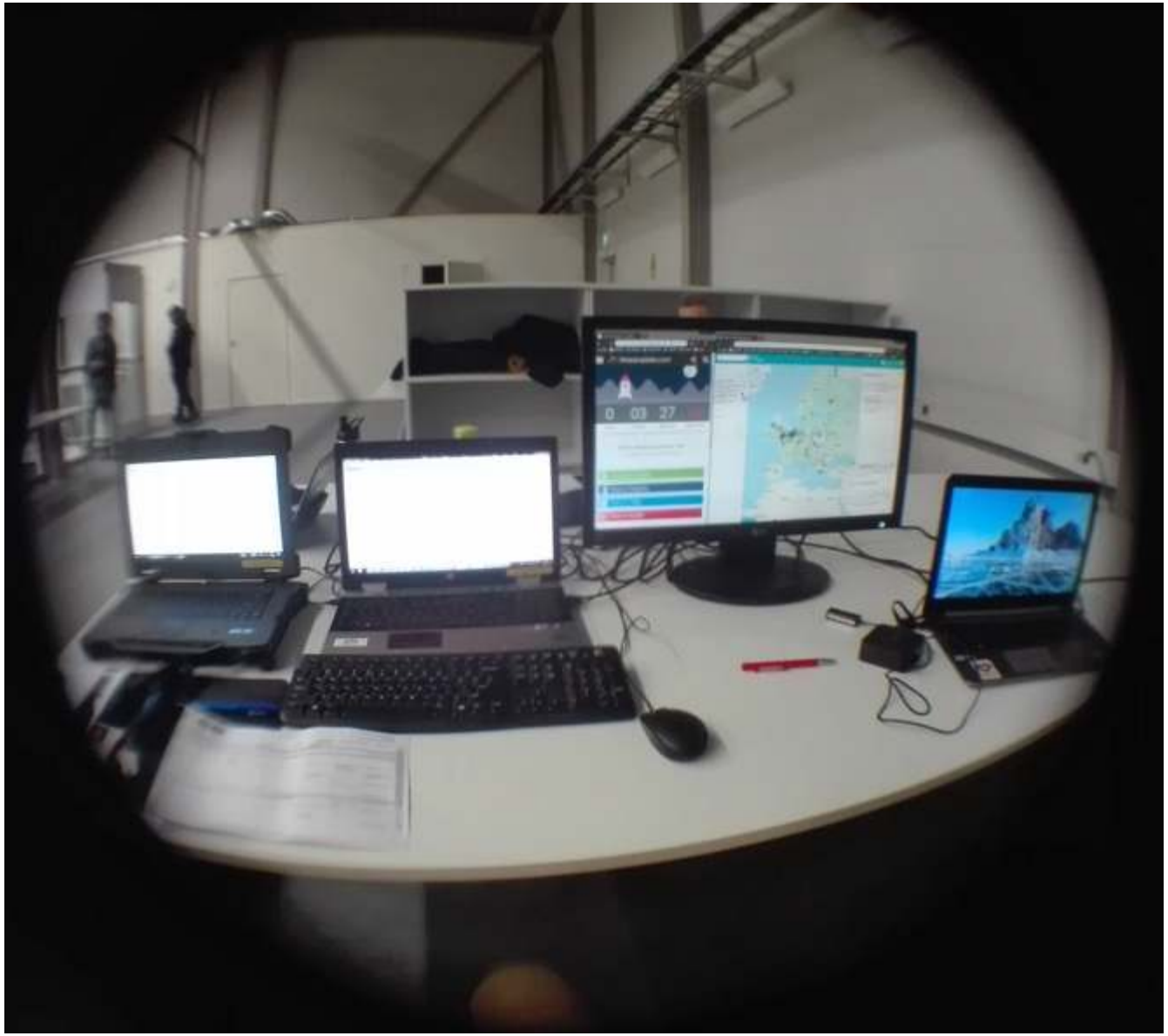
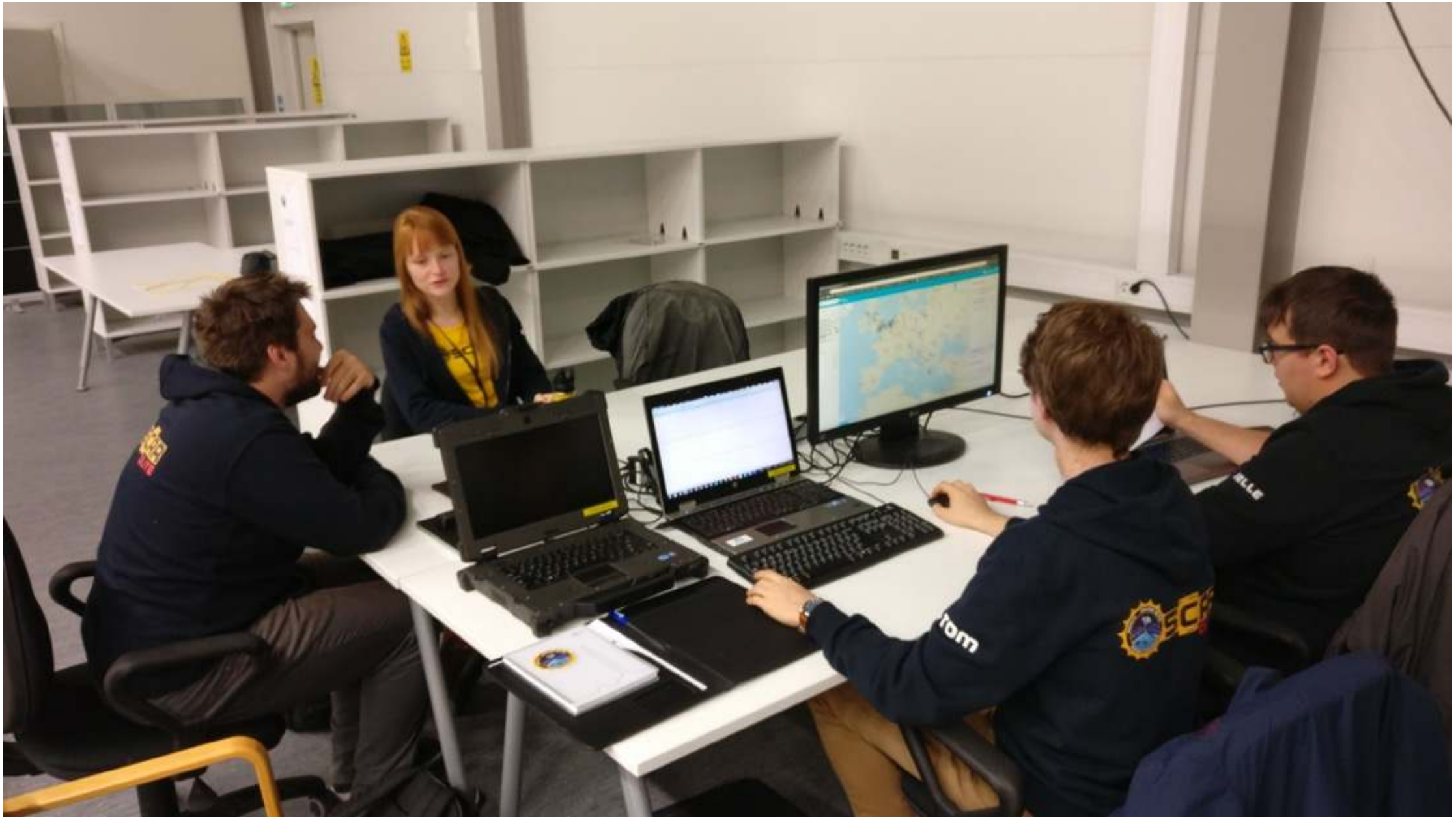
- Flight train rollout
- Communications checks





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- Balloon inflation

Launch operations

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- Balloon inflation
- Balloon release

Launch operations

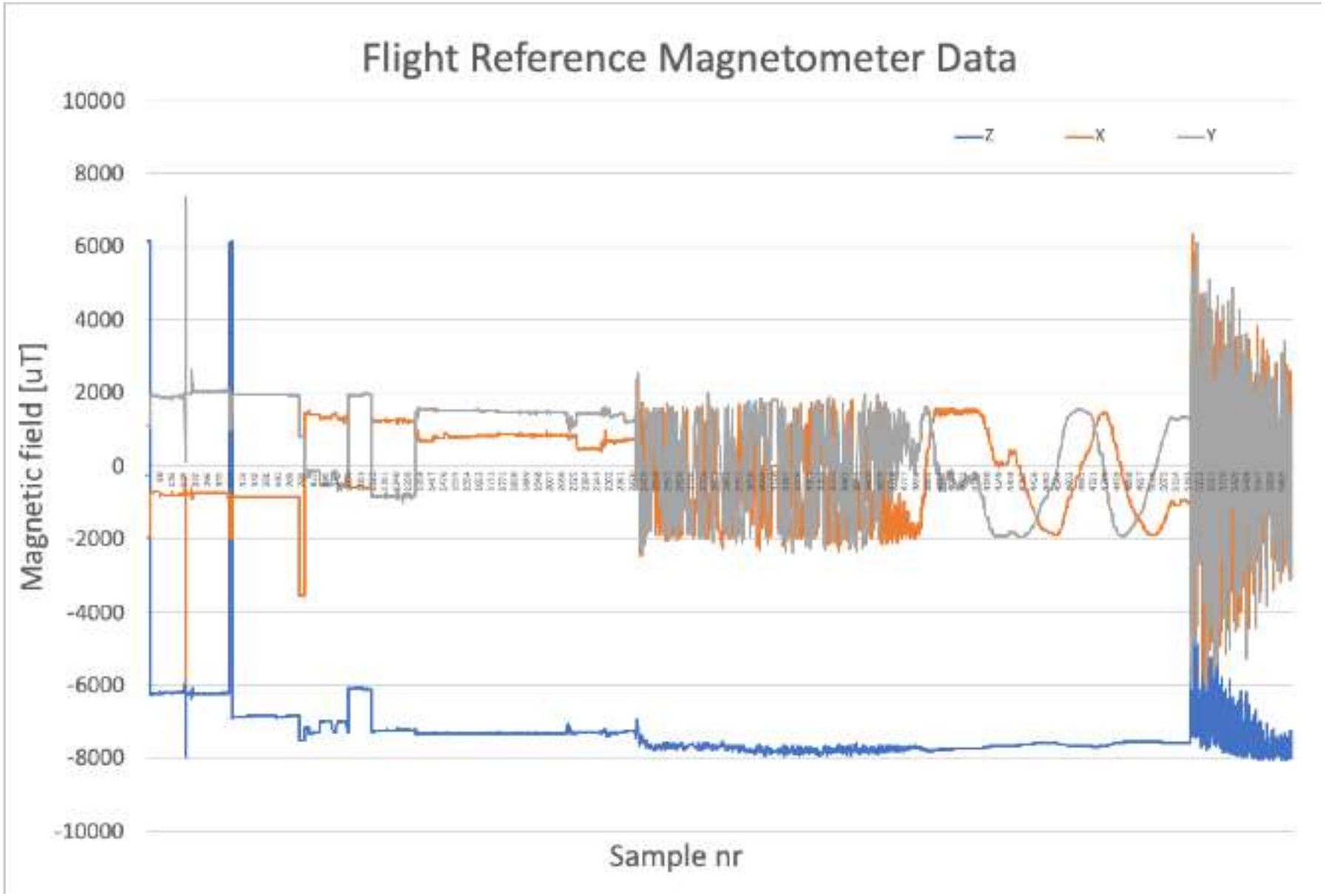
- Launch scheduled for 0700 LT
- 5hrs (+30m) of countdown
- Groundstation manned 0130LT
- Gondola pickup by Hercules
- Flight train rollout
- Communications checks
- Balloon inflation
- Balloon release
- Flight train release (T+ clock running)

Recovery

- Landing coordinates forwarded to recovery pilot

Recovery

- Landing coordinates forwarded to recovery pilot
- Gondola is air lifted on truck
- Payloads brought back to ESS


Flight Reference Magnetometer Data
10000
8000
6000
4000
2000
0
-2000
-4000
-6000
-8000
-10000
Magnetic field [uT]
Z
X
Y
Sample nr

Lessons learned

- Miniaturization is extremely difficult
- Current configuration for diamond mounting and alignment wasn't ideal (mechanical drift –> unstable photocurrent)
- Prototyping is a very time-consuming process
- Many other valuable lessons that will contribute to further sensor development

THE END!