

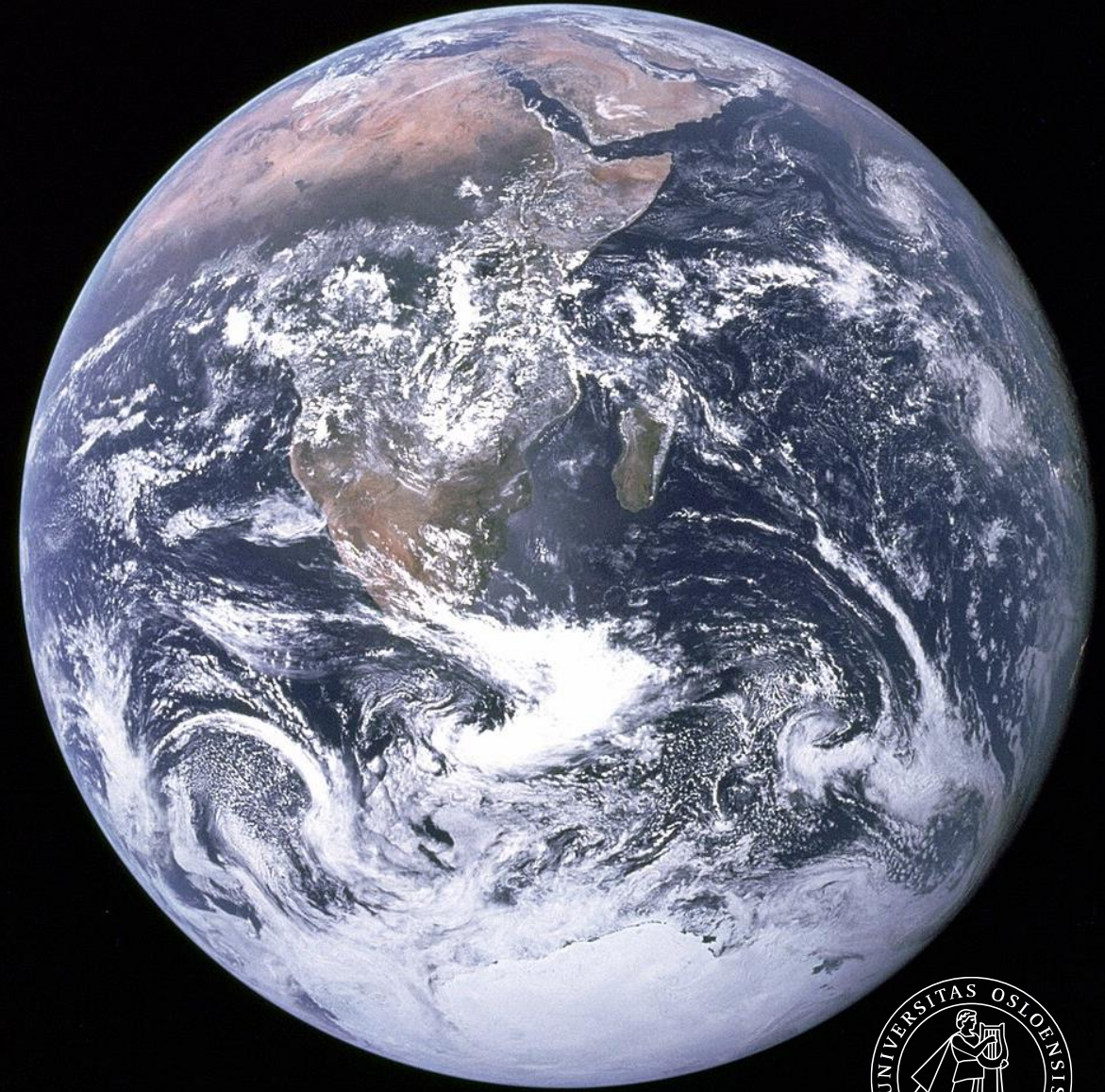
UNIVERSITY OF OSLO

Master Thesis Topics Space Systems

Status 2023

Anja Kohfeldt

Universitetet i Oslo



Master Topics

Neutron and Gamma instrument for lunar exploration

- Simulation
 - (#1 Environmental Analysis)
 - #2 Detector Design Optimisation
- Prototyping
 - #3 AIT of Neutron and Gamma instrument
 - #4 Portable Instrument implementation
- Field Demonstration
 - #5 Deployment of instrument on rover
 - #6 Field deployment & Validation



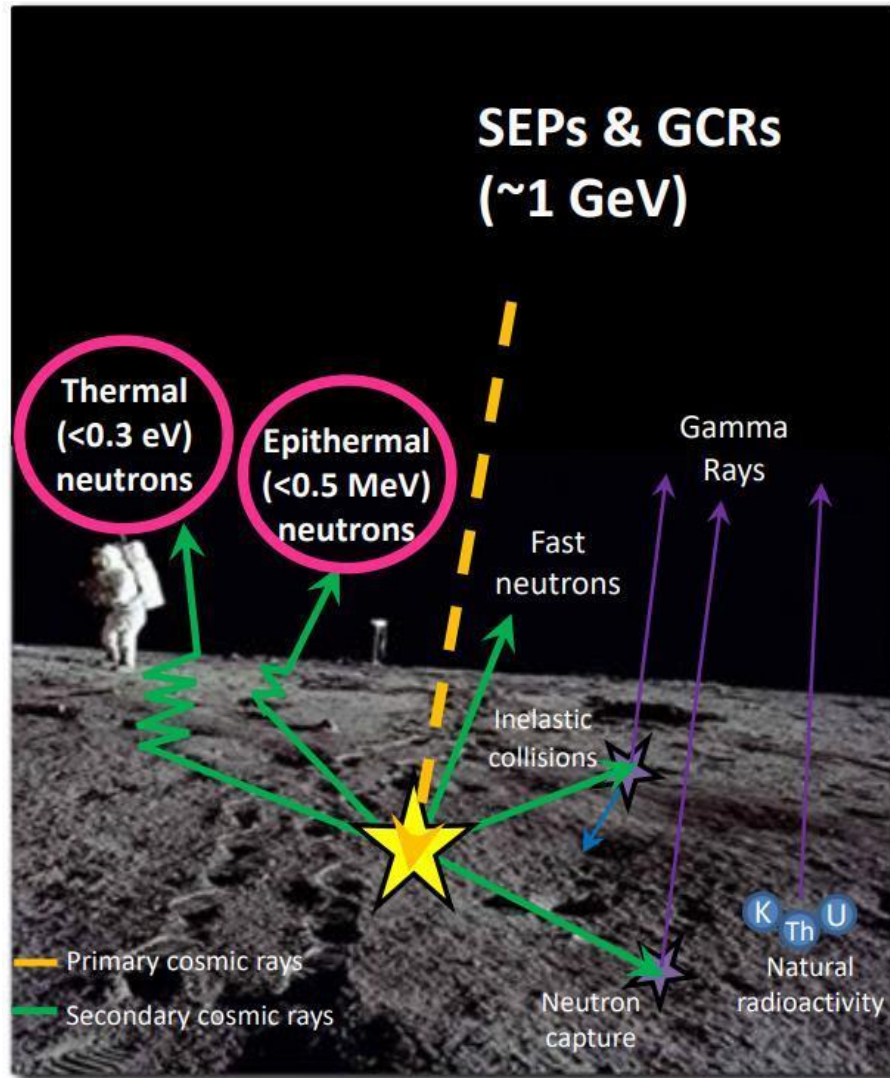
Master Topics

Neutron and Gamma instrument for lunar exploration

- Terrestrial Application
 - #7 Instrument Adaptation for Nuclear Decommissioning
- Exploration
 - #8 Space qualified instrument design
 - #9 Space qualification of components
 - #10 Lunar Mission planning



Neutron Spectrometer for ISRU



Gamma-Ray and Neutron Spectroscopy (GRNS)

- High energy cosmic rays interacting with celestial bodies
- detecting secondary decay products from GCR impact
- Also: naturally radioactive materials
- determining elemental composition of materials, → lithology, mineralogy and chemistry.

Gamma spectroscopy:

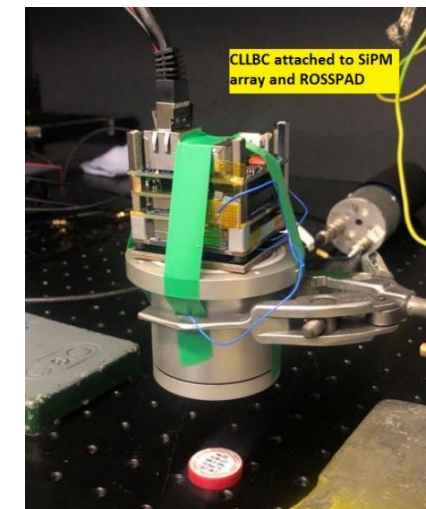
- major and minor rock-forming elements and volatiles, such as H, C, O, Na, Mg, Al, Si, S, Cl, Ca, Ti, Fe
- naturally radioactive elements like K, Th, and U spontaneously emit measurable gamma rays as they decay.

Neutron detection

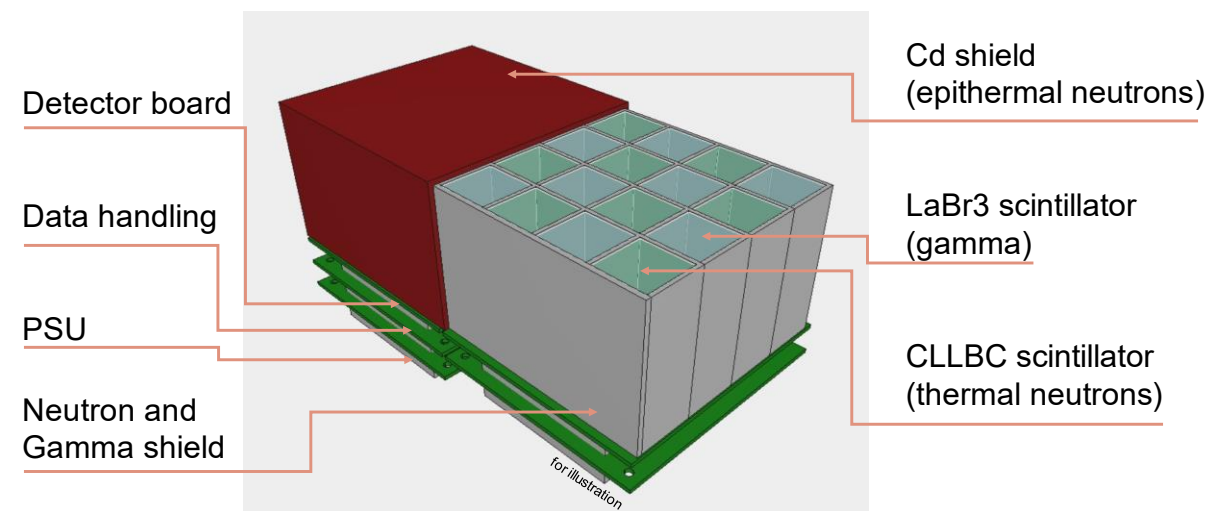
- Mainly water/hydrogen
- Also some geochemistry, such as Fe, Ti, Gd and Sm

CLUNGAS: Compact Lunar Neutron and Gamma Ray Spectrometer

- Instrument based on IDEAS ROSSPAD module for detector readout
 - Detection technology: Scintillator + SiPM (compact, robust)
 - **Detector concepts:** variations in scintillators
 - a) CLLBC, combined Neutron and Gamma detection
 - b) Li6 (or CLLBC) for Neutron and LaBr3 for Gamma rays
- Both: partly Cd shielding for epithermal neutrons

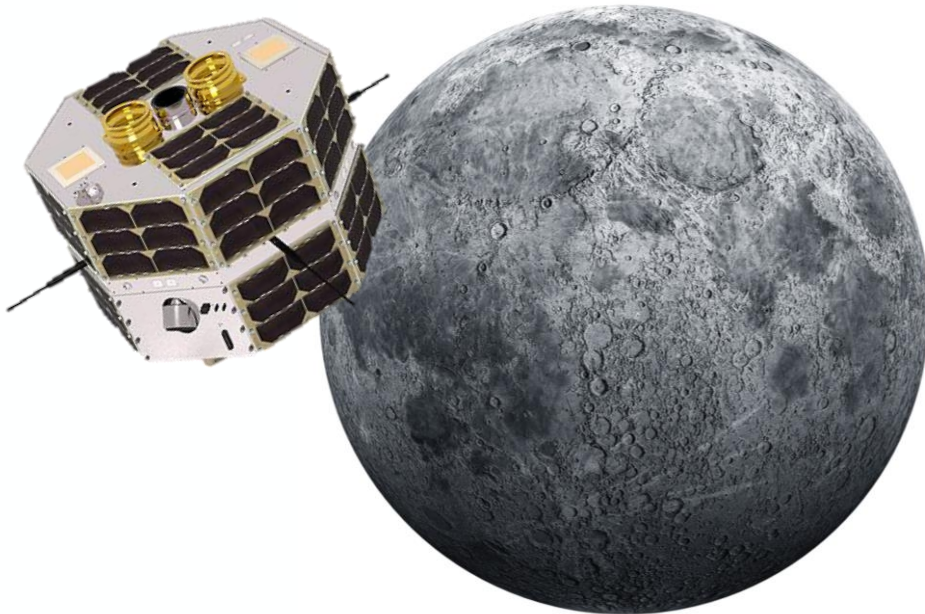


Detection of	Gamma-Ray: 30keV - 4MeV Neutrons: thermal and epithermal
Energy resolution	<4% @662keV (Cs) (Gamma-ray)
Power consumption	< 5 W (peak) per module
Mass	< 3 kg driven by the scintillator size and optional collimator/anticoincidence shield
Size	10x10x20 cm ³ or less
Temperature range	-40 °C to +70 °C
Technology	Scintillator + SiPM array + readout-IC + backend electronics Optional: collimator, anticoincidence shield
Payload items	2 detector modules, dedicated to gamma-ray and neutron spectroscopy separately



Mission in lunar orbit

- High resolution maps of water reservoirs and abundance maps
- Neutron lifetime



Low Earth Orbit

- Technology demonstration
- Neutron lifetime



Master Topics: Simulation

#1 Environmental Simulation

Key Tasks:

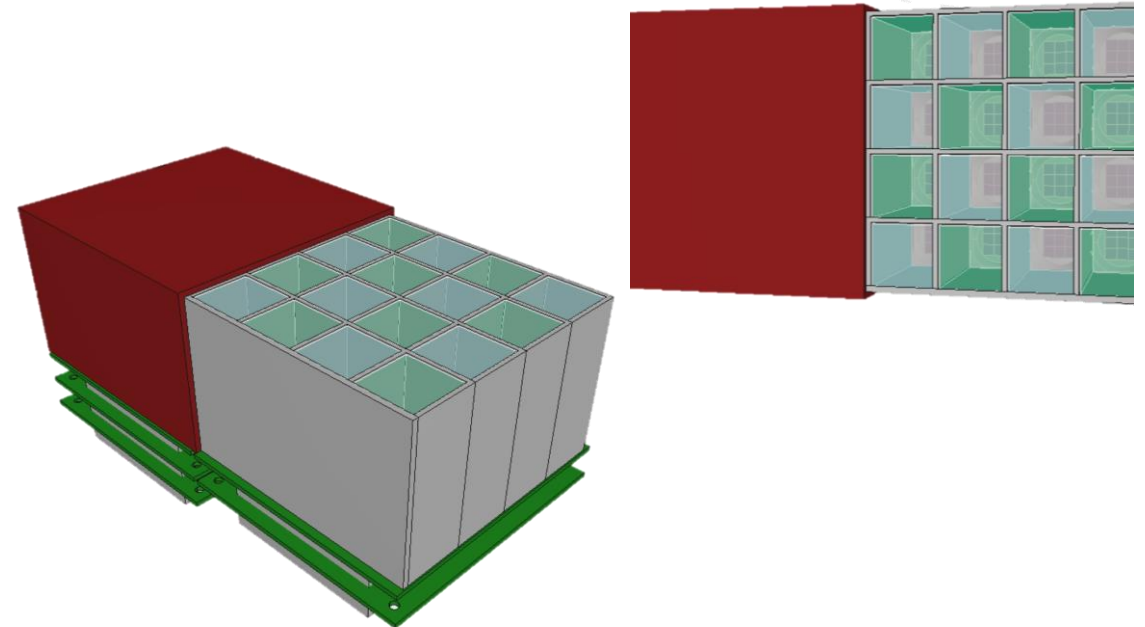
- Enhanced Elemental Analysis through Gamma-Ray Spectroscopy: Develop a robust gamma-ray spectroscopy model to enable precise elemental analysis in the target environment.
- Quantification of Soil Moisture Levels: Utilise simulated environmental and neutron data to quantify moisture levels in the soil, contributing to a deeper understanding of the correlation between neutron data and soil moisture content

allocated

#2 Detector optimization:

Key Tasks:

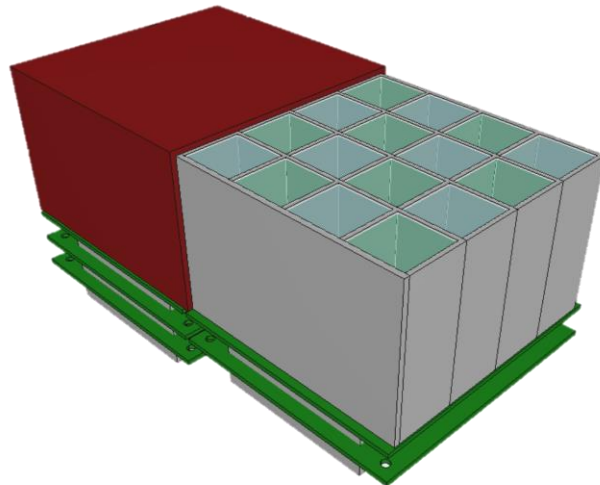
- Perform modelling and geometry optimisation using Geant4 to assess:
 - Light collection efficiency
 - Neutron detection efficiency
 - Gamma-ray detection efficiency



Master Topics: Prototyping

#3 AIT of Neutron and Gamma instrument

- Building the instrument
- Key Tasks:
 - Integration and Testing: Assemble the C-GRNC prototype with the chosen scintillator and geometry.
 - Calibration and Commissioning
 - Integration with Rovers



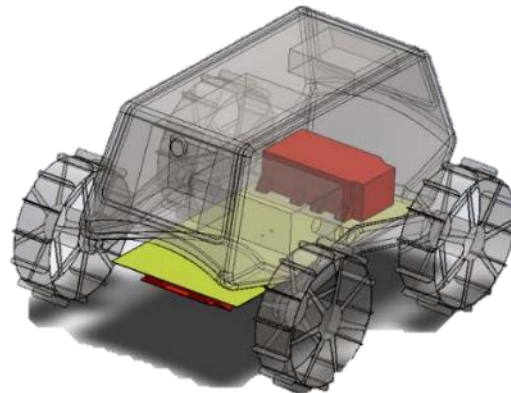
#4 Portable Instrument implementation

- Building GSE for portable instrument
- Key Tasks:
 - Develop robust and weather-resistant enclosure Standalone Control System
 - Onboard Data Acquisition
 - Implement Data Transmission
 - Integrate environmental/ housekeeping sensors
 - Wiring and Routing concept

Master Topics: Applications

#5 Deployment of instrument on rover

- Integrate and demonstrate instrument on a rover
- Key Tasks:
 - Rover Integration
 - Subsystem Synchronisation
 - Thermal Control
 - Power Management
 - Wiring and Routing Optimization
 - Remote Control Interface
 - Field Testing



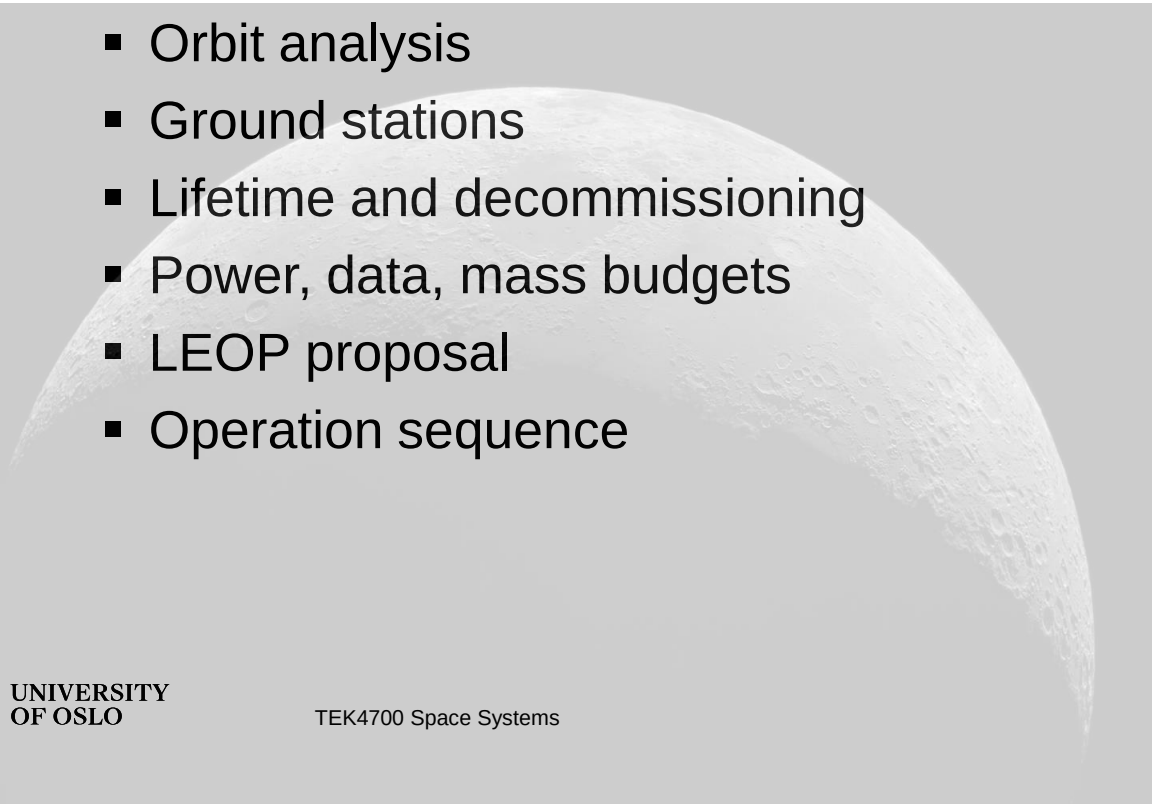
#6 Field deployment & Validation

- Planning field test and data analysis
- Key Tasks:
 - Operational Deployment
 - Calibration Procedures
 - Planning of Field Measurement Campaign
 - Data Collection and Real-time Analysis
 - Comparison with Models and Simulations
 - Scientific Analysis
 - Validation and Validation Report
 - Recommendations

Master Topics: Field Testing

#10 Lunar Mission planning

- Plan the mission to the moon
- Key Tasks:
 - Requirement definition
 - Orbit analysis
 - Ground stations
 - Lifetime and decommissioning
 - Power, data, mass budgets
 - LEOP proposal
 - Operation sequence



#7 Instrument Adaptation for Nuclear Decommissioning

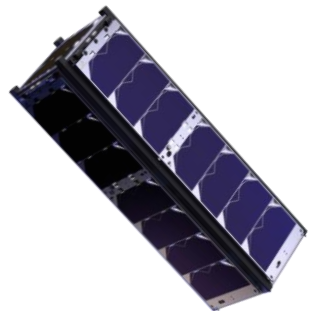
- Adapt CLUNGAS instrument
- Key Tasks:
 - Kit Design and Assembly
 - Sensor Integration
 - Gamma-ray Detector
 - Muon Detector
 - Neutron Survey
 - Environmental Modelling Software
 - Field Deployments
 - Data Integration and Analysis
 - Reporting and Recommendations



Master Topics: Space-qualified Design

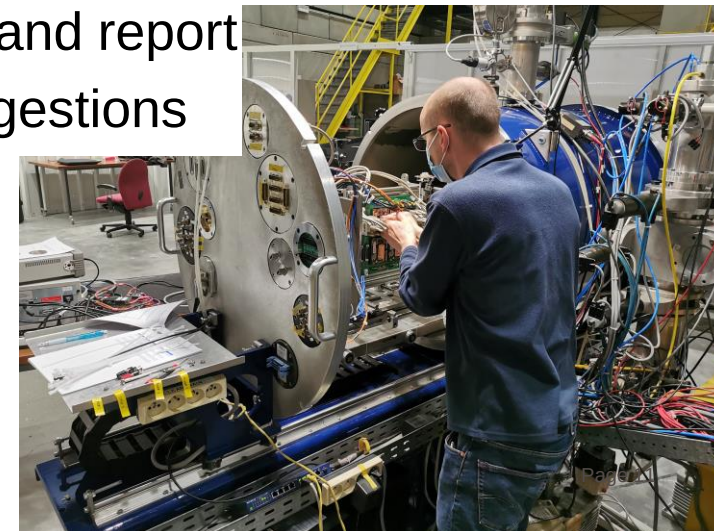
#8 Space qualified instrument design

- Current instrument design is non-compliant to CubeSat format PC-104
- Key tasks:
 - Identify component replacements (available in space-grade, industry or MIL)
 - Identify other weak points in current design (such as connectors, thermal..)
 - Re-design PCBs
 - Assembly, integration and test (AIT)



#9 Space qualification of components

- Critical components in current system are known to be not space-qualified
- Key tasks:
 - Plan SEE test campaign
 - Develop test setup
 - Data gathering
 - Data analysis and report
 - Mitigation suggestions





anja.kohfeldt@its.uio.no

rom 406

Space system master topics

Lets go to the moon!