Science & Technology Facilities Council
UK Astronomy Technology Centre

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Dr Julian Dines

www.atcinnovations.com

1 May 2013

Who are the ATC?

- The *UK Astronomy Technology Centre (UK ATC)* is part of the *Science & Technology Facilities Council (STFC)*
  - Sister sites at:
    - Rutherford Appleton Labs (near Dicot, ~1,500 people)
    - Daresbury Labs (near Warrington, ~500 people)
- Within STFC we are part of the *Technology Department*
- STFC is a *Research Council* development lab, and as such can be considered somewhere between academia and industry

What is the ATC's remit?

- We design, build, integrate, calibrate and test bespoke remote-sensing instrumentation:
  - Imagers (cameras)
  - Spectrographs
  - Imaging-spectrographs (hyper-spectral imaging)
  - Visible light to sub-mm / THz
  - Ground, Space-based and Airborne
- Key target markets are:
  - Astronomy
  - Earth Observation & Environmental Monitoring
  - Life sciences & Healthcare
  - Security & Defence
  - Space technology & Nano-Sats
  - Large (non-astronomy) science facilities

Skills & Expertise

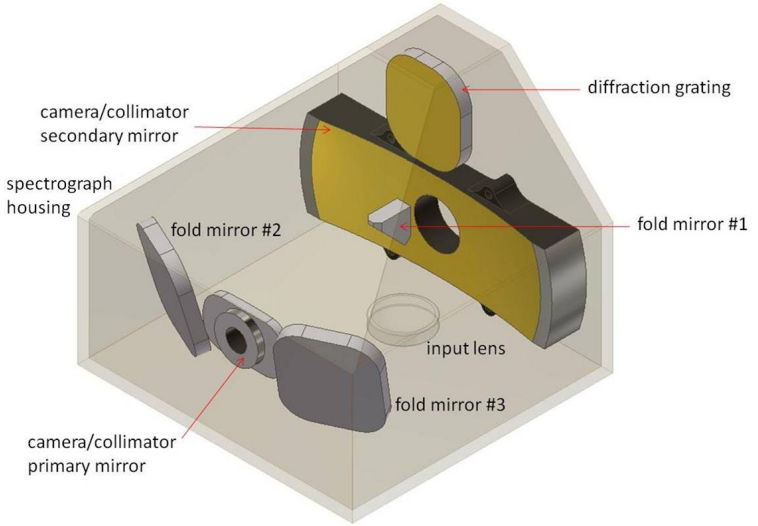
- Expertise in various engineering disciplines:
  - Instrumentation Design & Build
  - Optics & Opto-mechanics
  - Cryogenics, Thermal & Vacuum
  - Electronic Control Systems & Embedded Software
  - Detector characterisation, interfacing & control
  - Applications Software & User Interface design
  - Assembly, Integration & Test/Verification
  - Systems Engineering
  - Technical Project Management
- ~80 staff
- Work in partnership with Industry & Academia

Capabilities

- Specialist skills / capabilities :
  - Instruments: Imagers, Spectrometers, Hyperspectral-imagers, Polarimeters
  - Wavelength range: UV - Visible - IR - THz
  - Temperature range: mK - room-temp - elevated temp
  - Vertically-integrated project-based engineering teams:
    - Optics / Opto-mechanics / Mechanics / Cryo / Vacuum
    - Electronics / Detectors / Control / Software
    - Active & Adaptive Optics
    - Systems Engineering / Project Management / Mechanical Technicians
  - Operating Environments:
    - Ground, Airborne & Space-based
    - Static & Dynamic

Environmental Monitoring

- *GHOST*
  (*Green-House Observations of the Stratosphere & Troposphere)*
  - CO_2 monitoring from the NASA GlobalHawk UAV
  - Multiple-order spectrograph
  - ~£1M instrument design & build, followed by flight campaign
  - Enables determination of total CO_2 output from a single factory or power-station



High-Res CubeSat Imager

- Novel NanoSat imager payload
  - Initially targeting CubeSats
  - Interest from Defence and Environmental Monitoring
  - 10x10x30cm (3U) satellite using deployable optics
  - Can provide ~1m ground-resolution
  - Working with Clyde Space and other SMEs

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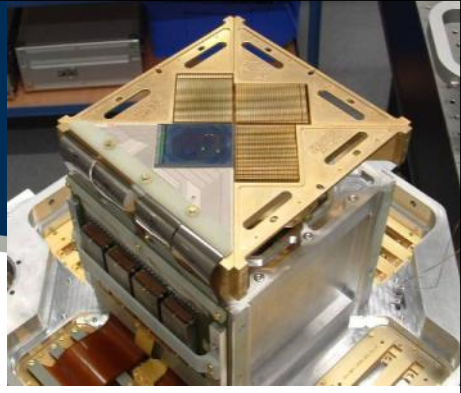
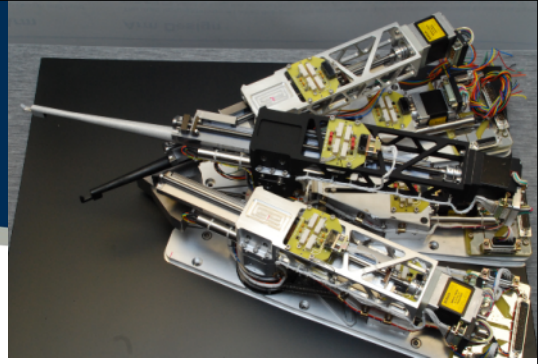
Technologies



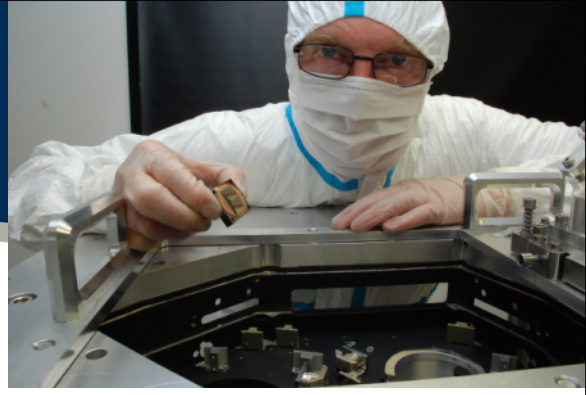
- Key Core Technologies
  - Imagers & Cameras
    - IRCAM: (commissioned ‘86) the *world’s first* facility-class IR array camera
    - SCUBA: (commissioned ’96) the *world’s first* sub-mm/THz camera and is the world’s most successful astronomical instrument
    - WFCAM: (commissioned ’02) the *world’s most powerful* IR survey camera with the largest field of view of any astronomical infrared camera
    - SCUBA-2: (commissioned ’09) the *world’s largest* field sub-mm/THz camera, with over 10,000 pixels
  - Spectrometers
    - CGS4: (commissioned ’92) the *world’s first* astronomical instrument to use diamond-turned optics (aspherics)
  - Hyperspectral-imagers
    - European lead on JWST–MIRI (Mid Infrared Instrument); working on the complex spectrometer pre-optics (>250 optical surfaces); image-slicer integral-field units

Technologies



- Key Core Technologies (cont.)
  - Software
    - Applications software: pipeline-data-processing; user-interfaces for instrument control
    - Embedded software: instrument control; real-time systems
    - Low-latency GPU implementations
  - Detector interfacing / control / characterisation
    - Integrated detector control systems (including embedded software/ firmware)
    - Full detector characterisation and optimisation suite (including cryo)
  - Cryo / space robotics
    - Cryogenic, vacuum, opto-mechanical mechanisms
    - Fully space-launcher compliant (e.g. Herschel-SPIRE)

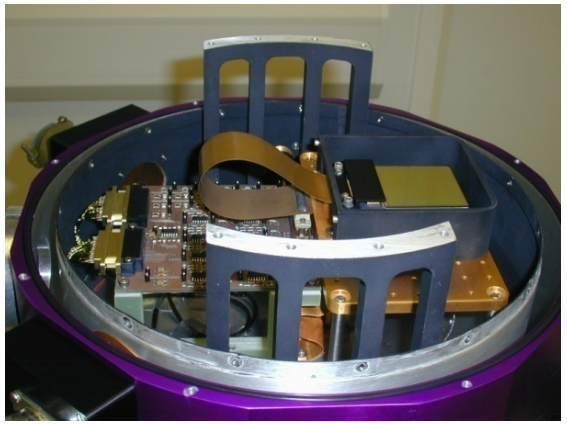
Capabilities

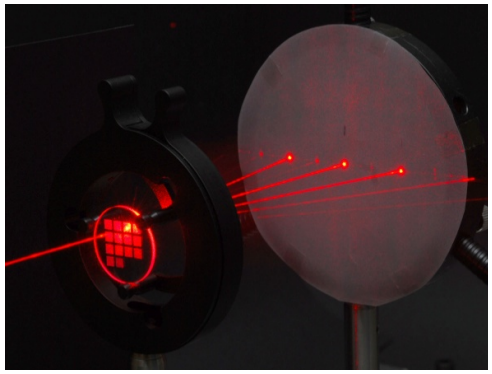


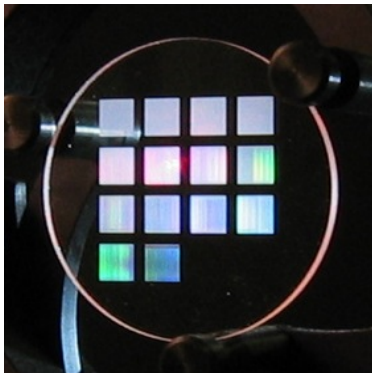
- Key infrastructure :
  - 13 lab areas:
    - Max lab height 6.5m; 10T overhead crane
    - 3 mechanical flexure rigs (test capacity: 10T / 27m^3)
    - Lab facilities (compressed air, water cooling, 110V/60Hz)
  - Many optics labs & benches
  - Numerous test cryostats:
    - Standard setup to 4K, specialist <300mK
    - Capacities up to 1m diameter
    - Full cryo support infrastructure (liquid nitrogen & helium, leak detectors etc.)
  - Various clean-rooms:
    - From Class 10,000 to Class 100
    - Additional portable clean-tents
  - Mechanical workshop
    - Including 5-axis CNC , rapid-prototyper/3D-printer, precision CMM/ metrology etc

Industrial/Commercial

- *NIR & SWIR Detectors*
  - European, space-qualified detector development
  - Working together with Selex
  - ATC performing test & characterisation



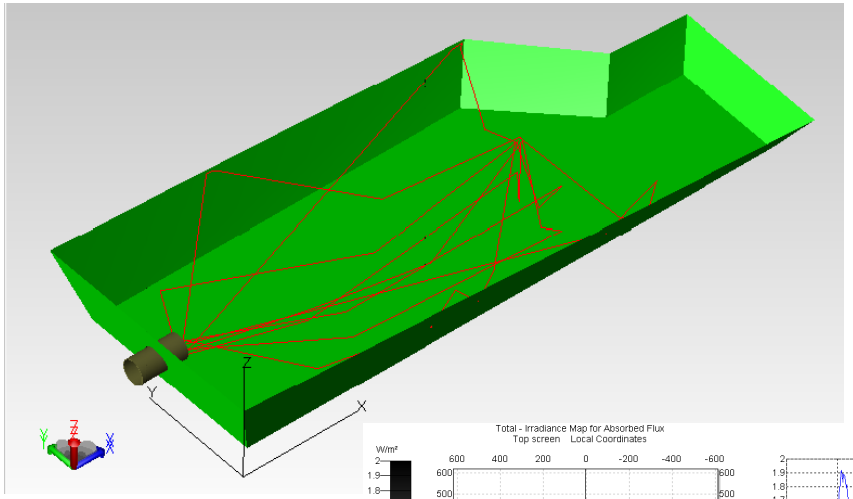


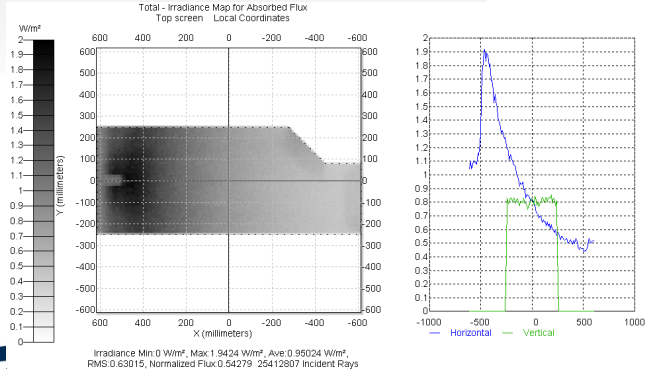


- *Ultrafast Laser Inscription of Gratings*
  - Replacement technology for (delicate) Volume Phase Hologram gratings
  - Working with HWU & spinout
  - Potential in IR spectrographs

Exploitation: Optical Modelling

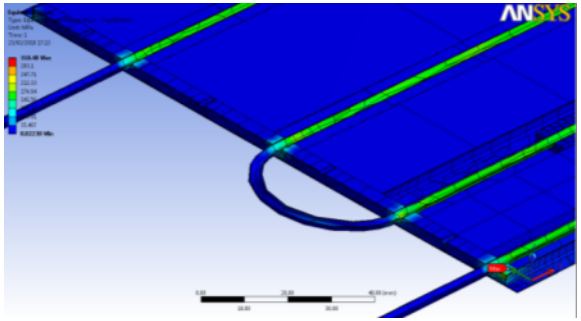
- Key expertise exploited in fields as diverse as:
  - LED backlighting for TVs
  - X-ray baggage-scanner detector-box
  - 4D Sperm motility microscope

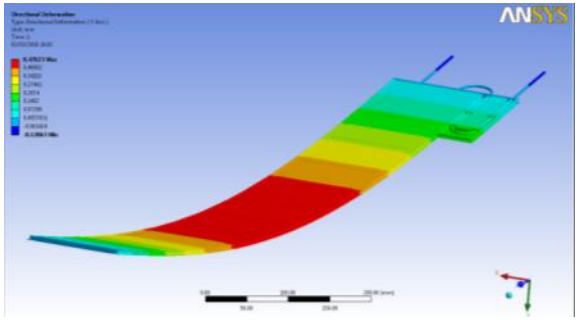


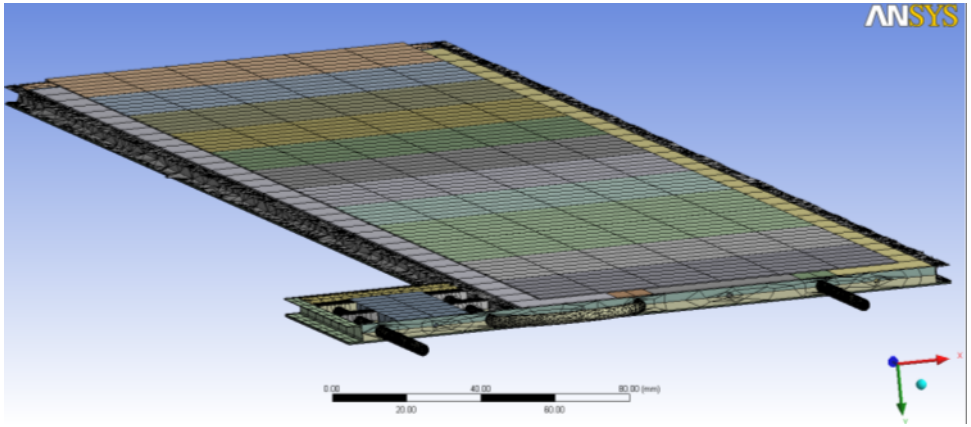


Exploitation: Mechanical Modelling

- Another key capability, being exploited across a wide range of application areas, including:
  - Unmanned Arial Vehicles (UAVs)
  - ATLAS detectors for CERN

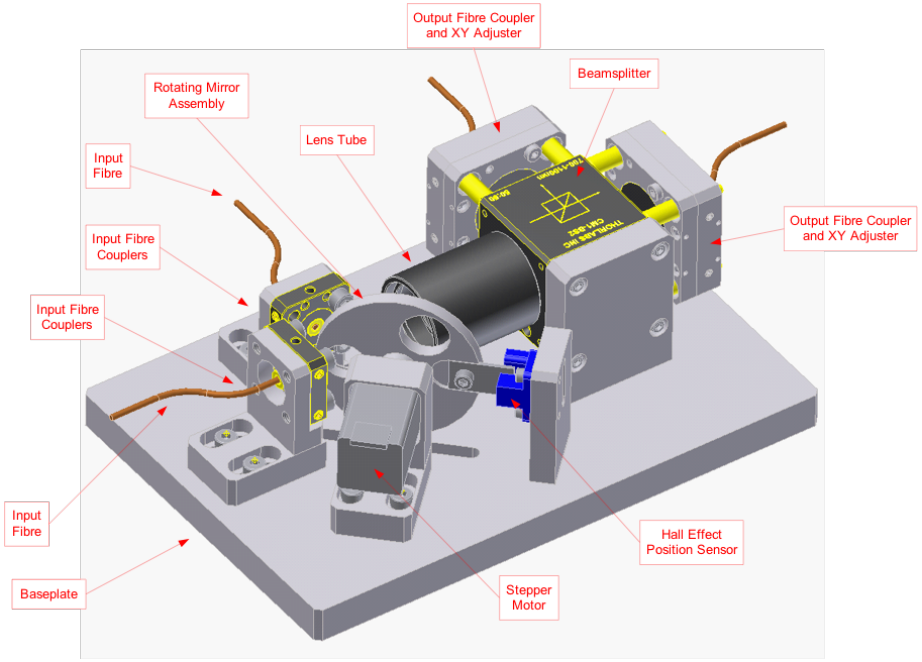


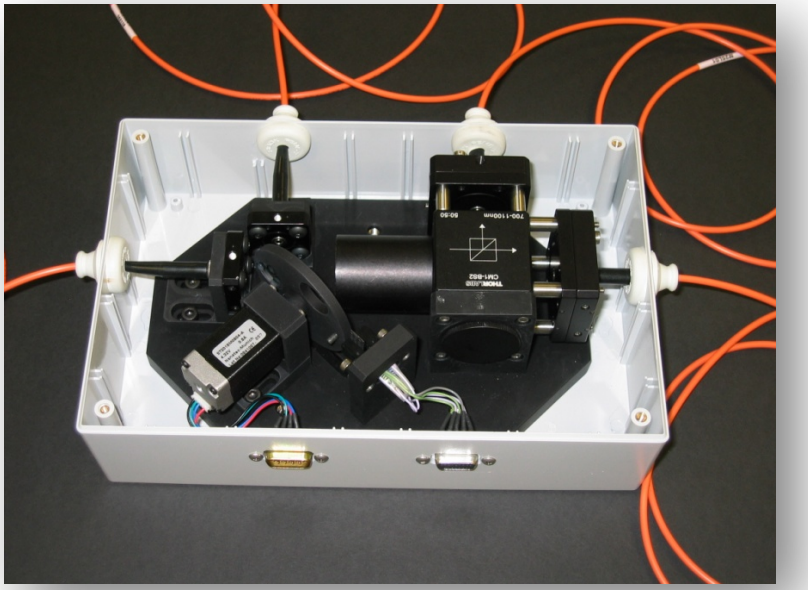




Prototyping

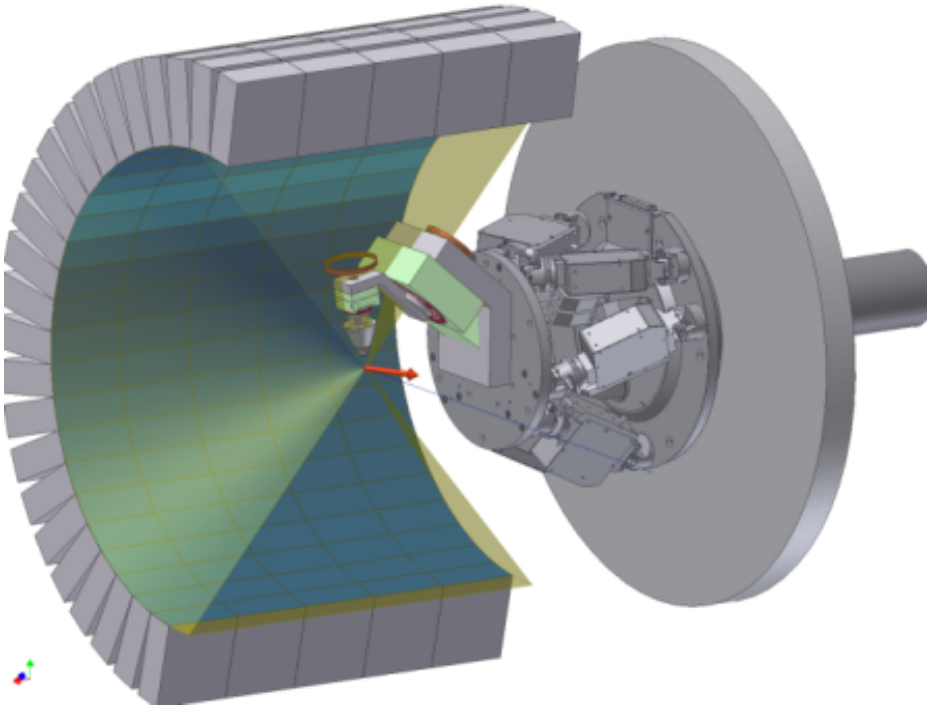
- Development of pre-production prototypes:
  - Modelling & simulation
  - Use of rapid-prototyping / 3D-printers
  - Use of 5-axis milling machine





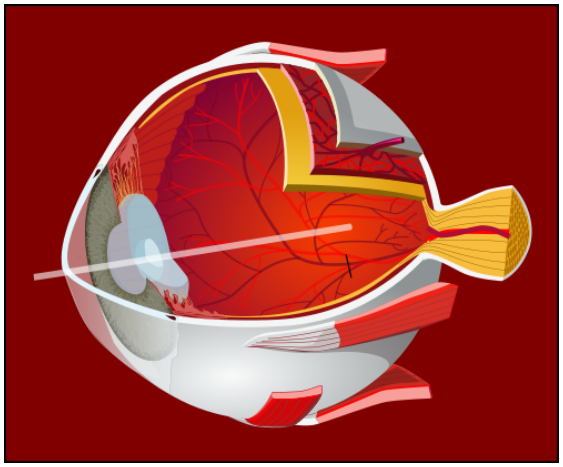
Large Science Facilities

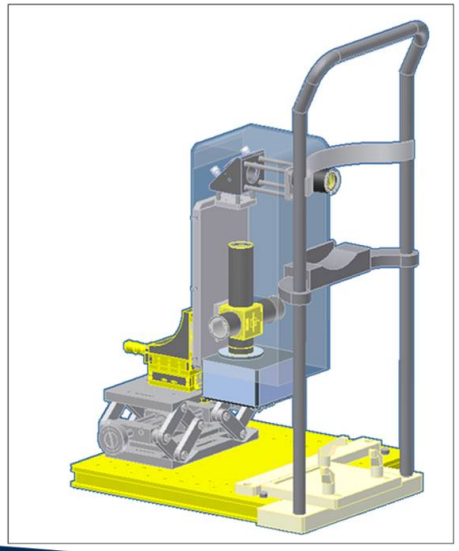
- *Cryogenic Goniometer*
  - Long-wavelength macromolecular crystallography beamline
  - Unique vacuum, cryogenic, 6-axis, high-precision positioning robot
  - Design, simulate, build, test
  - ~£1.5M project
  - For Diamond Light Source



Life Sciences & Healthcare

- *Retinal Imaging*
  - Use of optical measurement for disease diagnosis: Age-related Macular Degeneration (AMD)
    - Leading cause of blindness in the Western world
  - Design & build instrument to take quantitative measurements, especially at early stages
  - Significant improvement in early diagnosis and development of better treatments
  - Impact in improving quality of life for the aging population

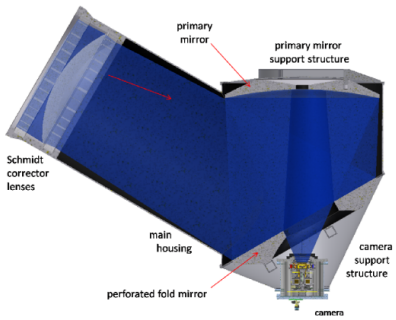


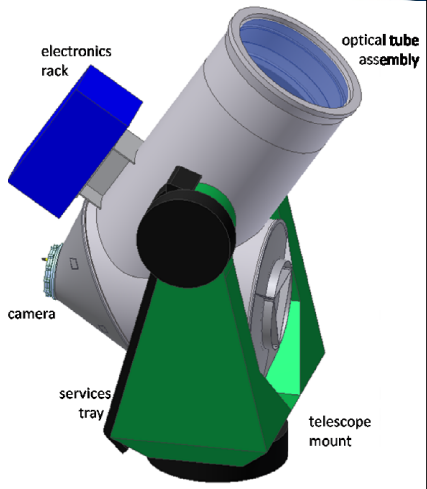


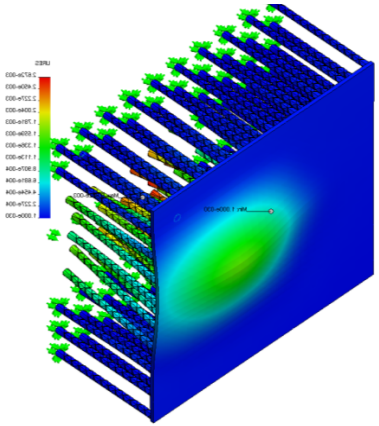
Patent filed

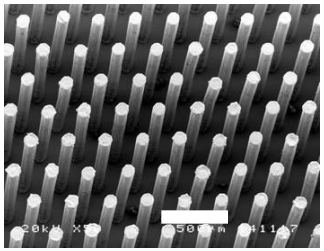
Security & Defence

- *ESA Space Debris Monitoring Telescope Network*
  - European desire to have independent space monitoring
  - Full design study for network of ground-based optical telescopes

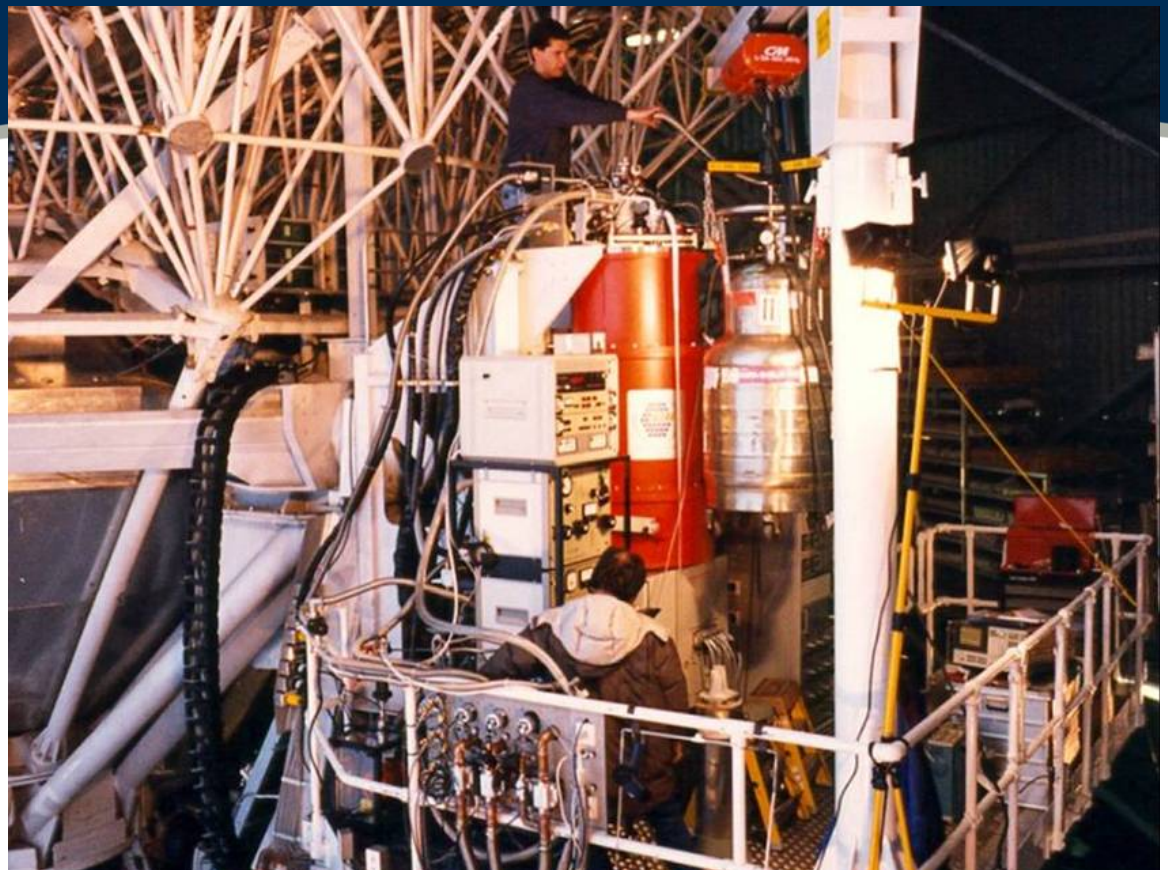








- *MOD: Fast AO for Lasers*
  - Working with Selex on deformable mirrors for lasers
  - Airborne system requirements



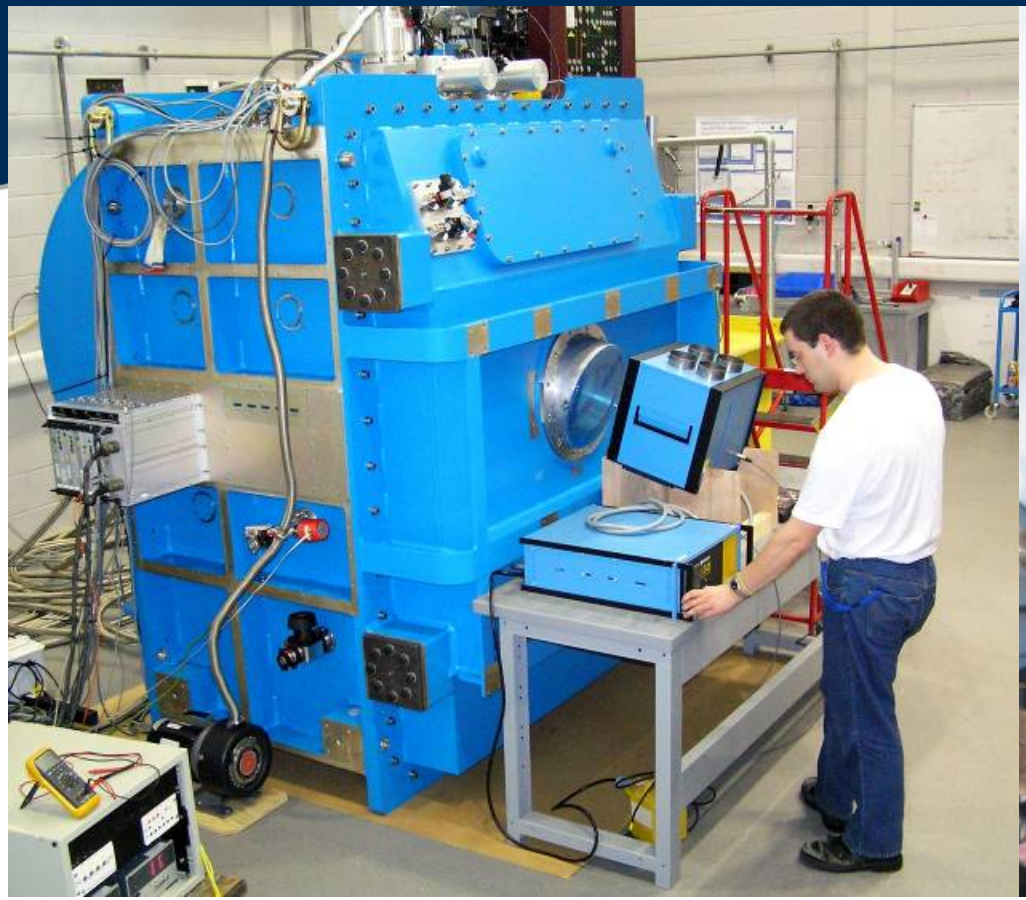
SCUBA

Probably the world's most successful ground-based instrument


Michelle

WFCAM

World’s most powerful infrared camera, until VISTA

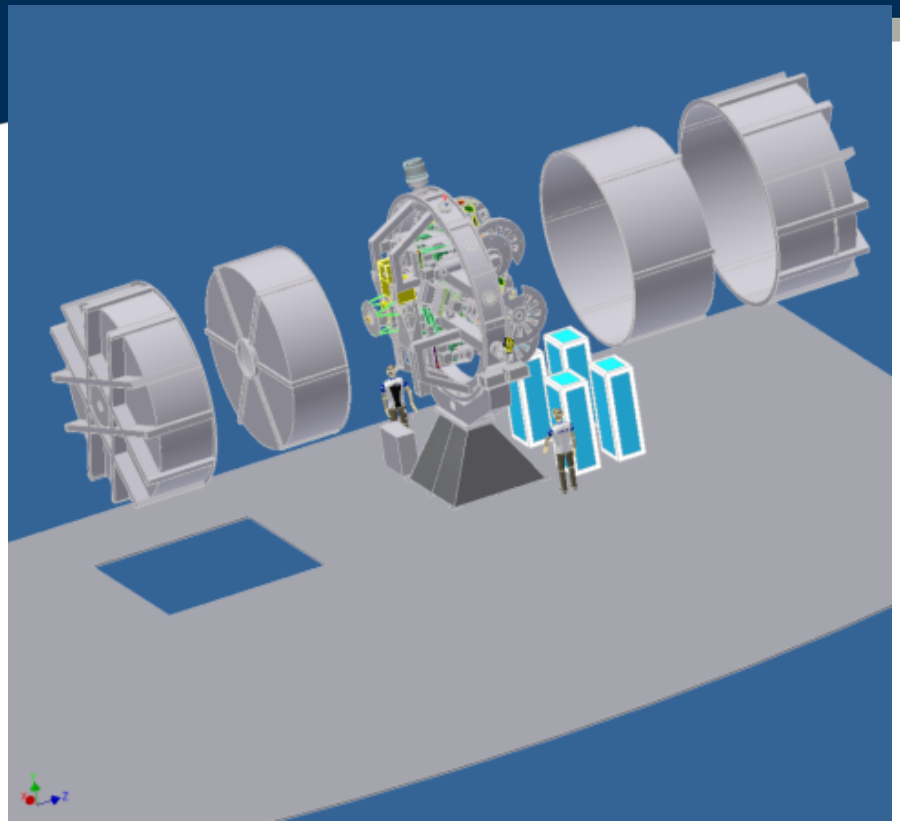


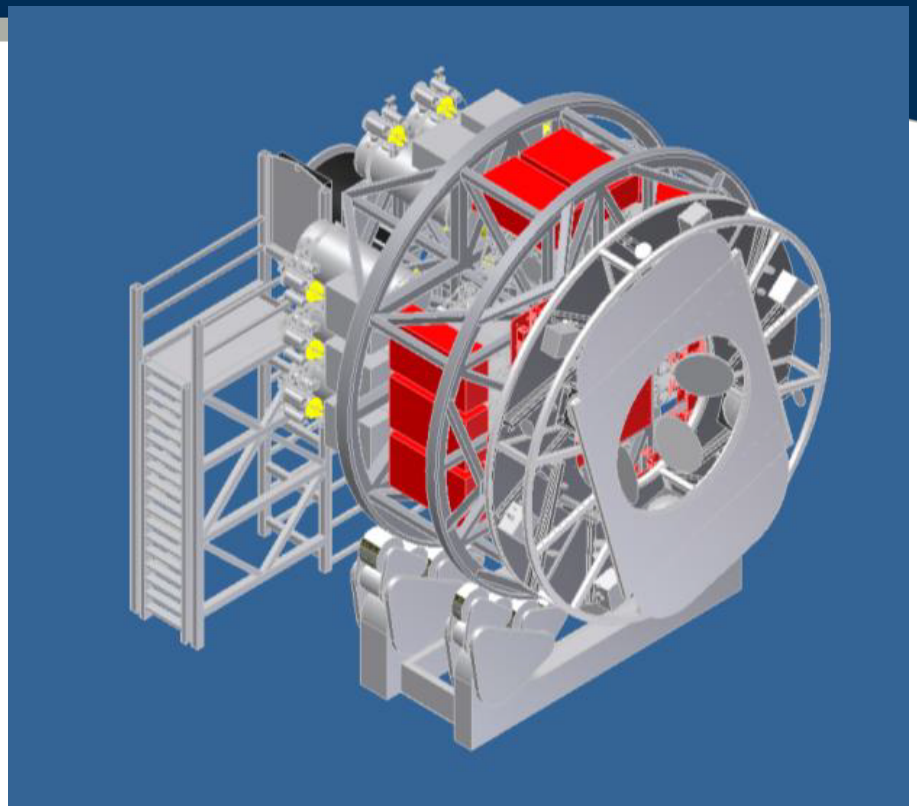
SCUBA-2

World's most powerful sub-mm/THz camera, by far

VISTA

World's most powerful infrared camera





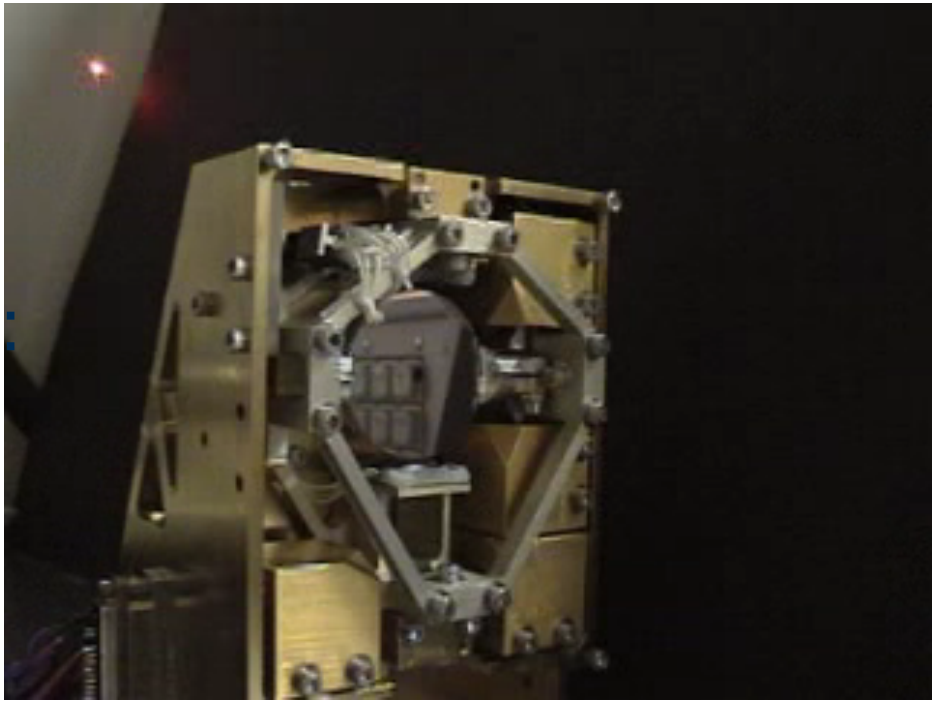
HARMONI – 1st light instrument

EAGLE – Multi Object Instrument

E-ELT INSTRUMENT STUDIES

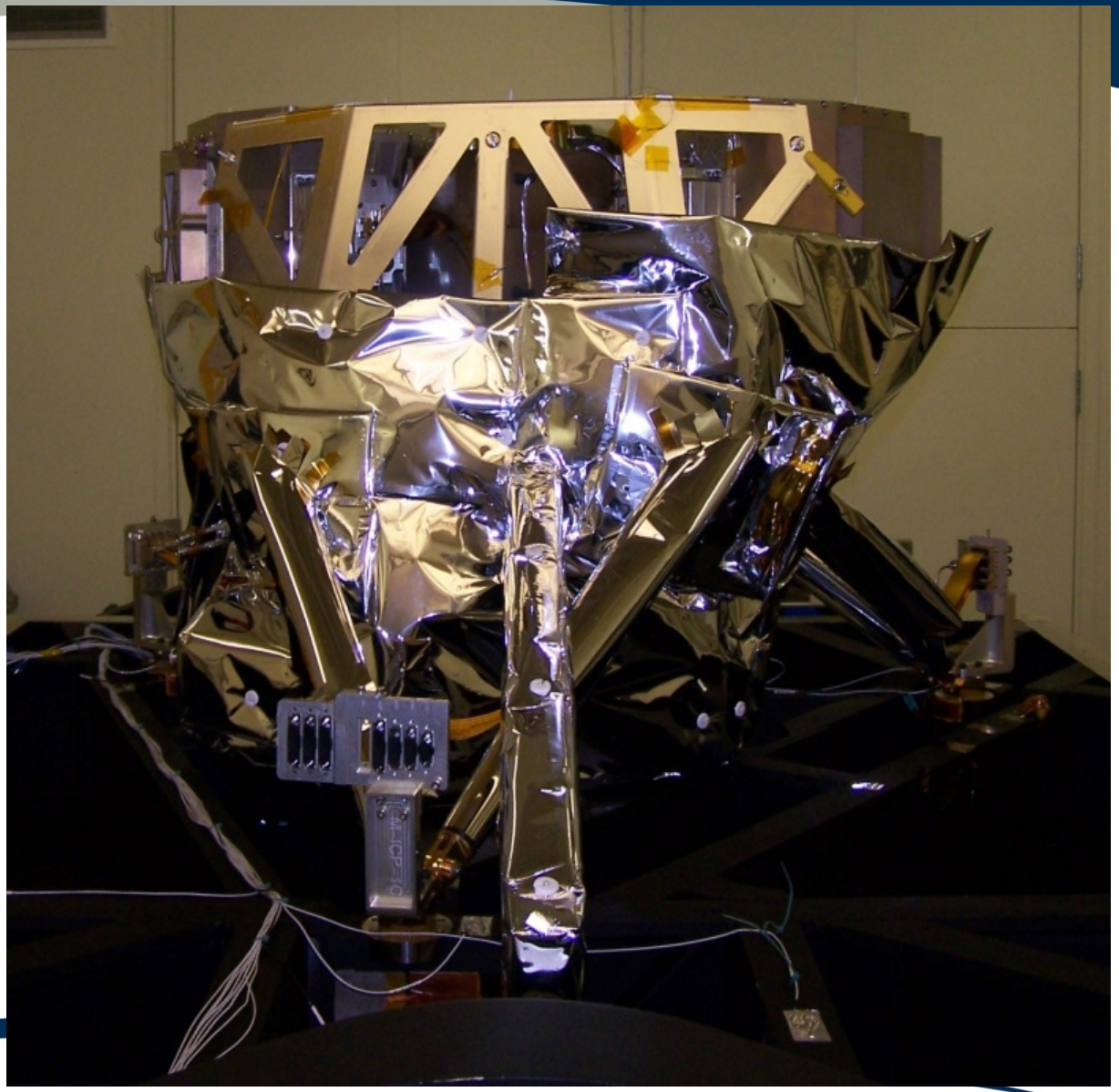
SPIRE Beam Steering Mirror

- For the Herschel Space Observatory
- Operates at 4K and sustains 50G loads
- High precision-low power:
  - Flex pivots
  - Superconducting voice coil actuators
  - Permanent magnets
  - Magneto-resistive sensors

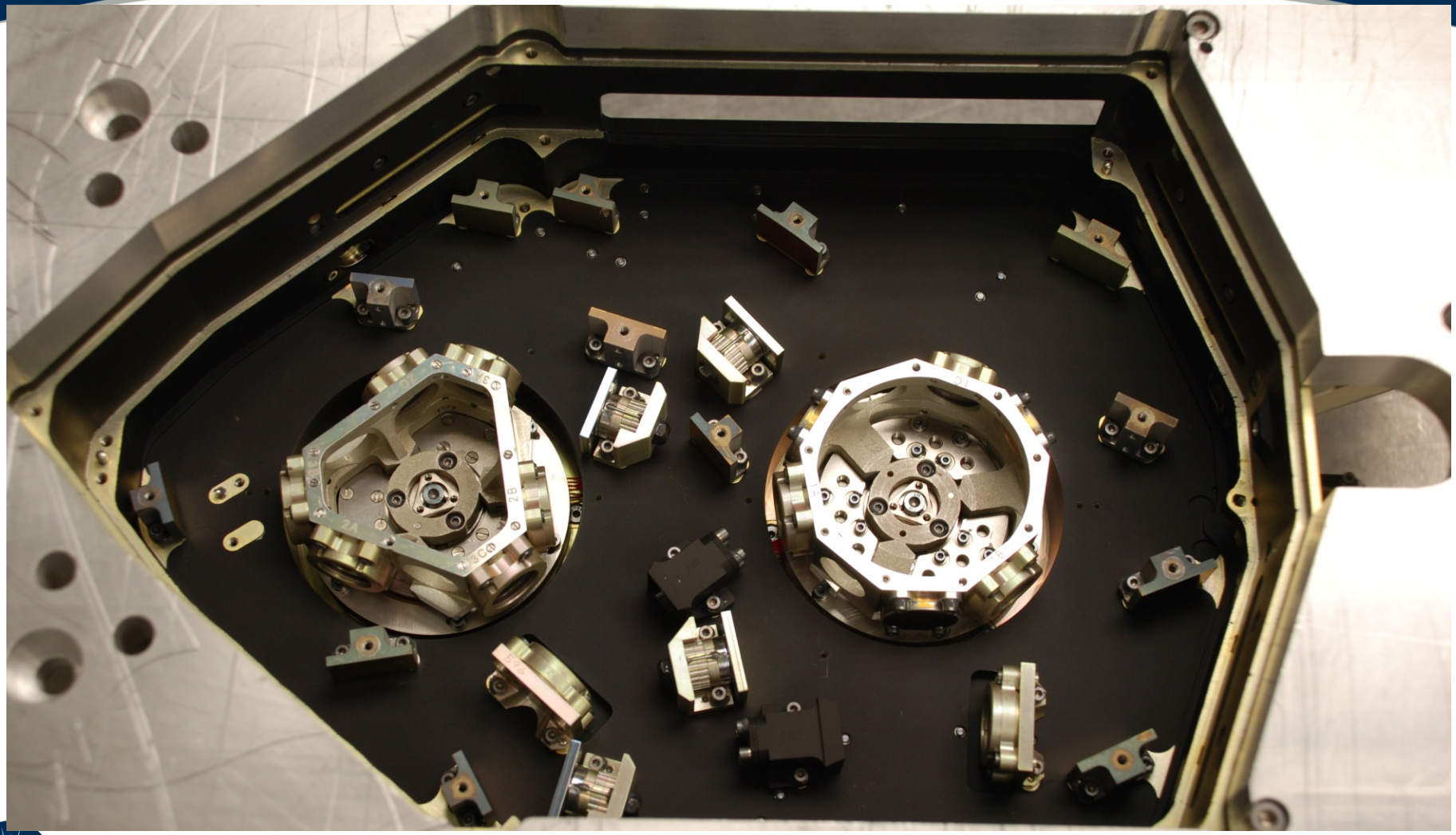


MIRI – Gillian Wright is PI

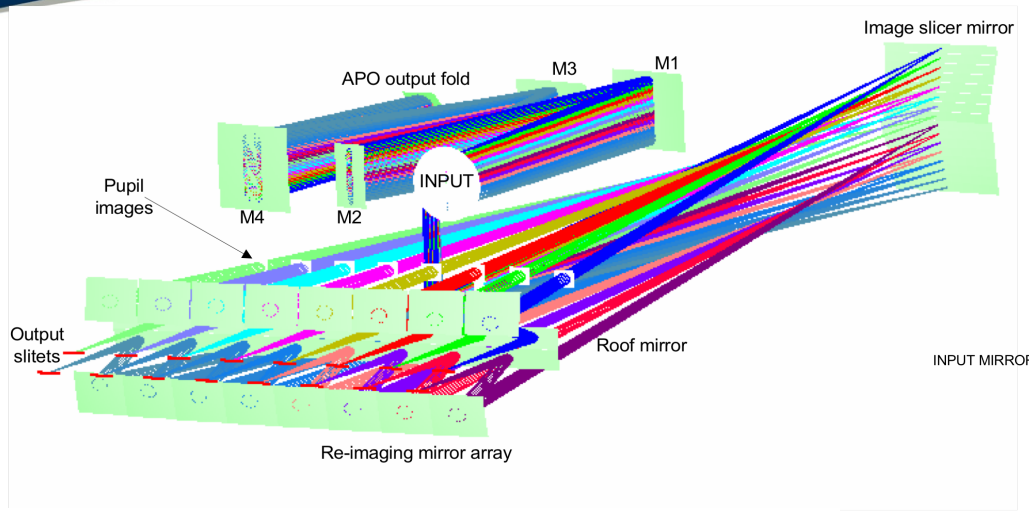
- A 5 to 28 μm imager and spectrometer
- Flight model systems were delivered to RAL for integration and testing (2010/11)
- Delivery to NASA/GSFC in 2012
- JWST Launch in 2018
- Mission Lifetime
  - 5 years minimum
  - 10 years goal
- Built by a consortium of European Institutes
  - Plus JPL for the three 1024 x 1024 pixel Si:As IBC detectors

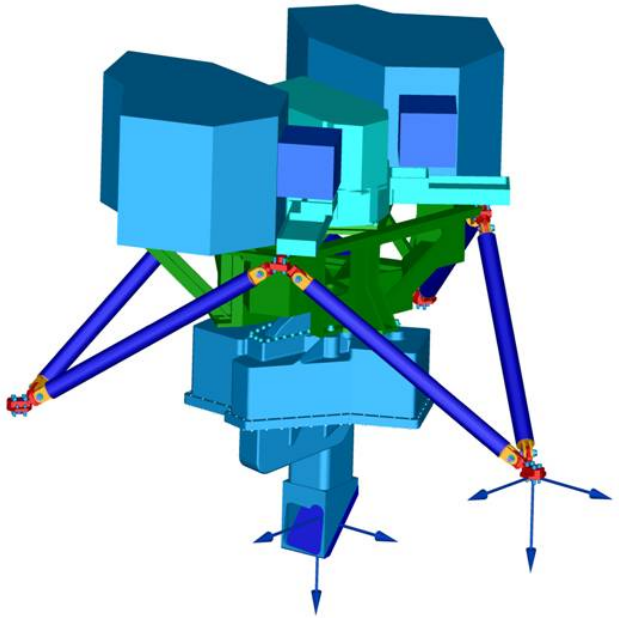


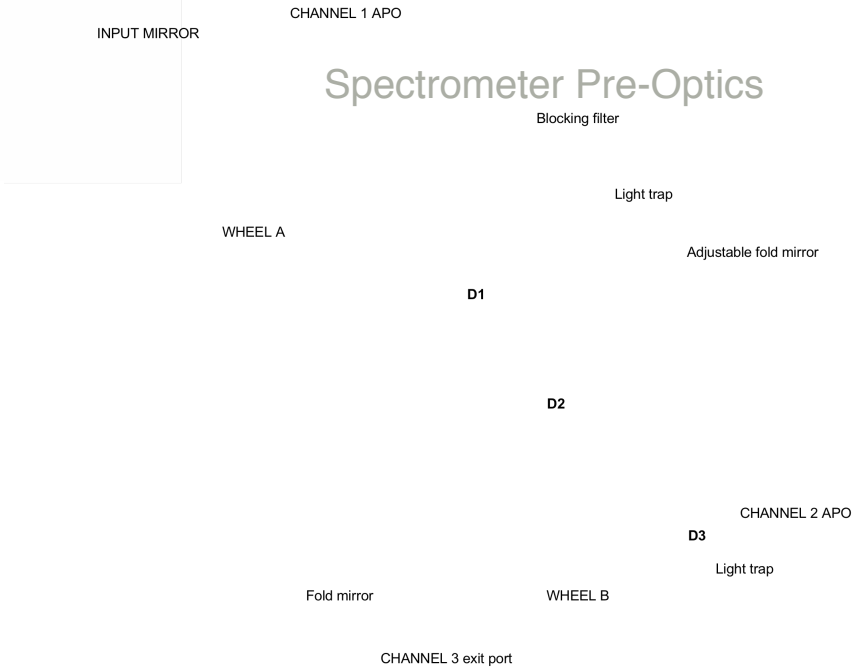
Spectrometer Pre-optics



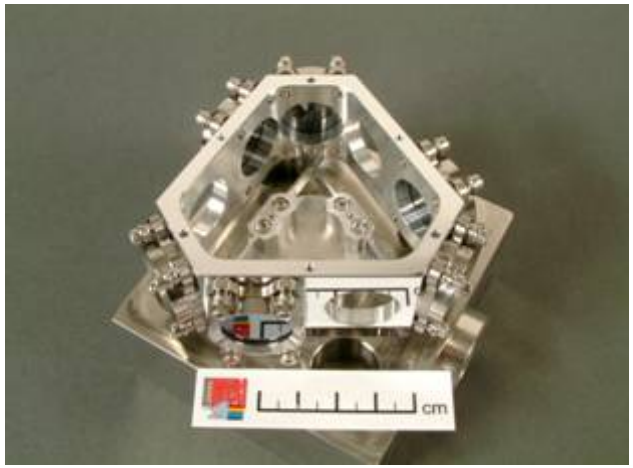
JWST: Hyperspectral Imager

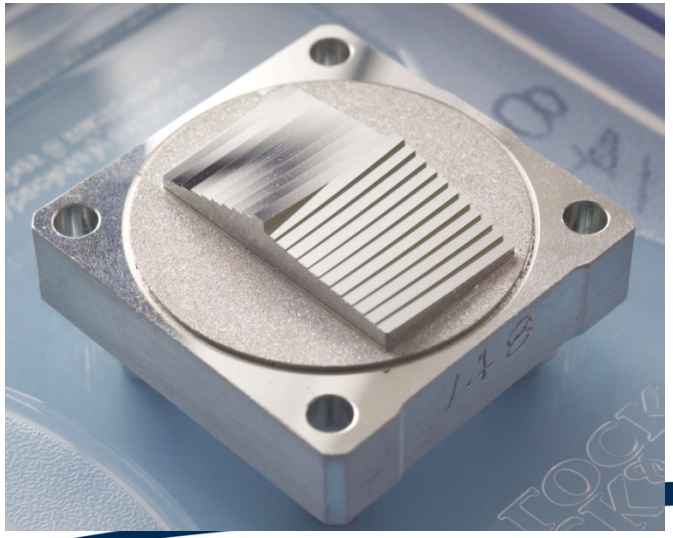


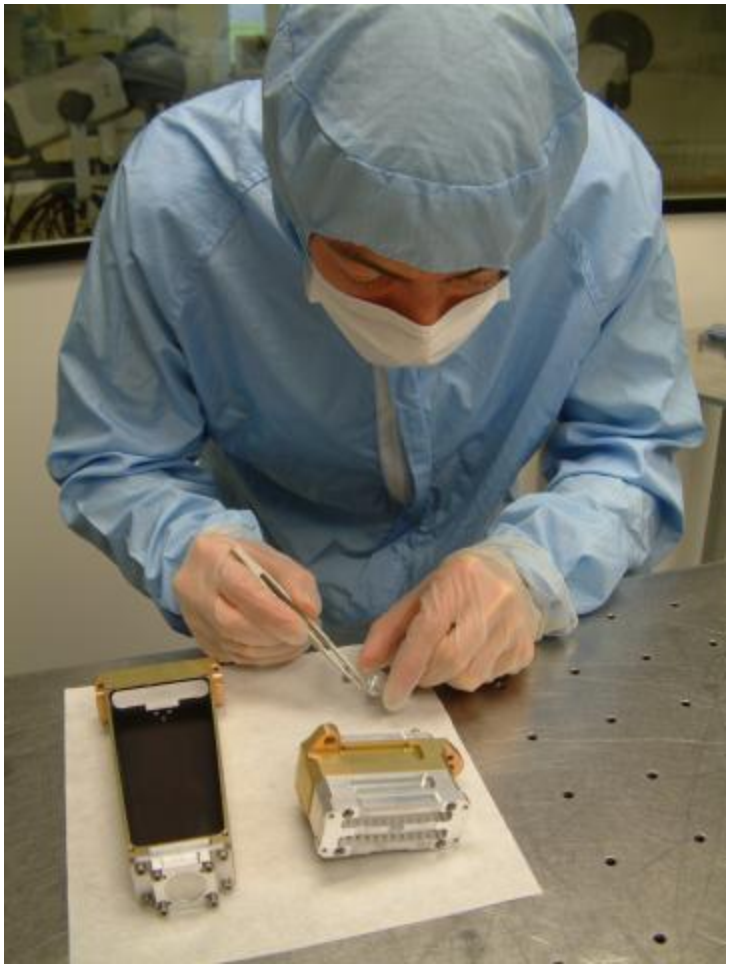




Space-qualified precision optics

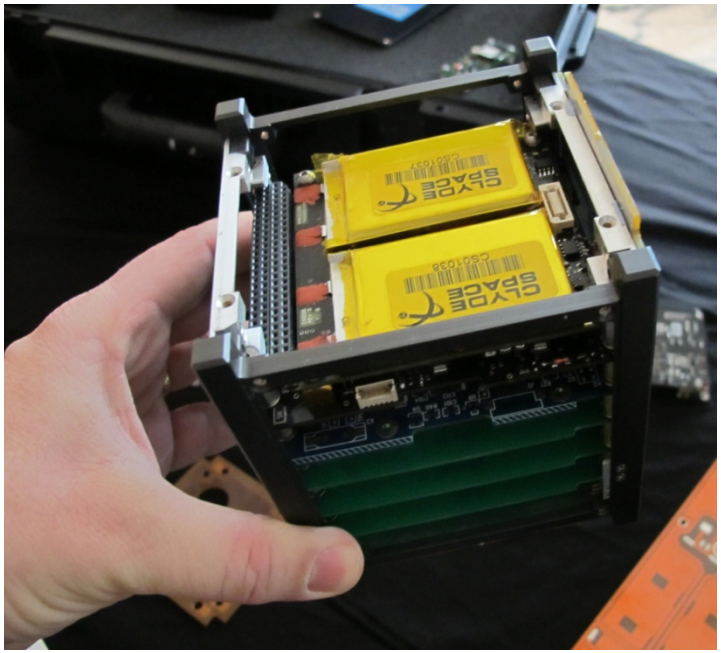






CubeSats: ClydeSpace partner

- Standard 10cm unit size
- Easy access to space;
  - Standard sub-assemblies
  - COTS components
  - Low launch cost
  - Common deployment
- ~50 launches so far
- Disruptive technology
  - Cheaper entry
  - Fast deployment
  - Better sampling (constellations)



1U (10cmx10cmx10cm) Cubesat with Clyde Space power sub-system.

A Compact Wide Field Telescope for Space Situational Awareness

European Space Agency's SSA Preparatory Programme has identified the need for a network of up to 20 such telescopes to monitor objects as small as 1 cm in low Earth orbit