



Science & Technology Facilities Council
UK Astronomy Technology Centre

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Dr Julian Dines

www.atcinnovations.com

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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

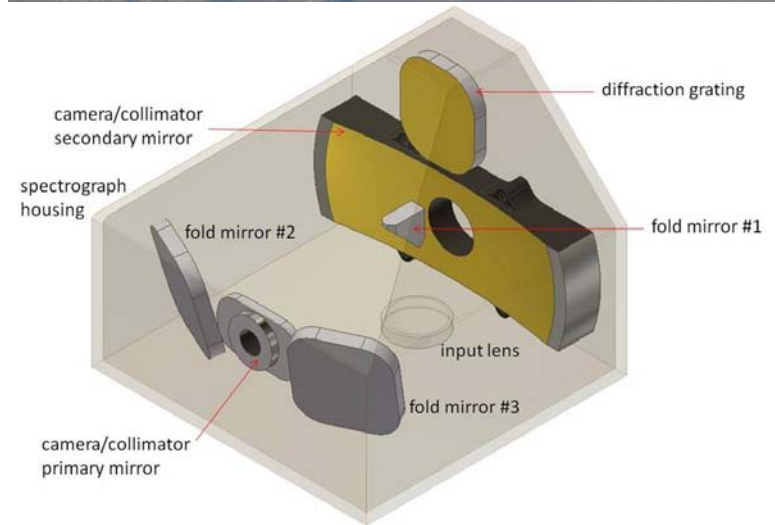


- Specialist skills / capabilities :
 - Instruments: Imagers, Spectrometers, Hyperspectral-imagers, Polarimeters
 - Wavelength range: UV - Visible - IR - THz
 - Temperature range: mK - room-temp - elevated temp
 - Vertically-integrated project-based engineering teams:
 - Optics / Opto-mechanics / Mechanics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



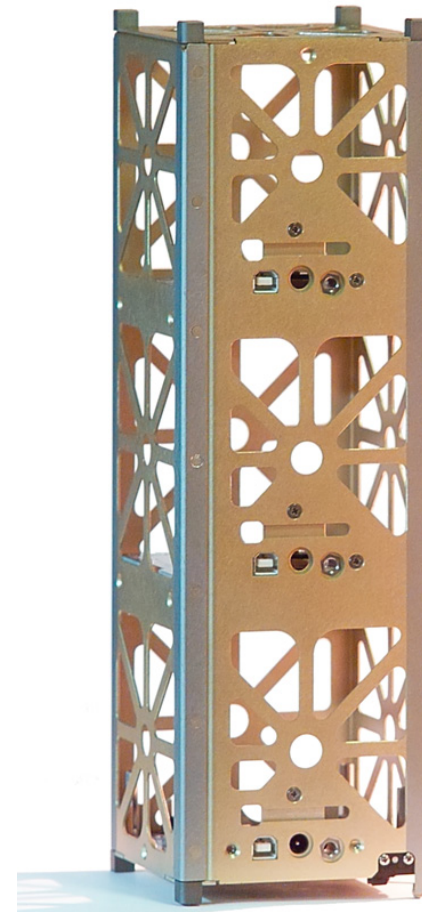
Environmental Monitoring

- **GHOST**
(*Green-House Observations of the Stratosphere & Troposphere*)
 - CO₂ monitoring from the NASA GlobalHawk UAV
 - Multiple-order spectrograph
 - ~£1M instrument design & build, followed by flight campaign
 - Enables determination of total CO₂ 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



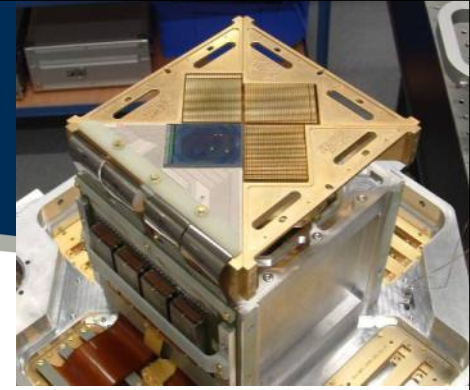


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Technologies



- 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

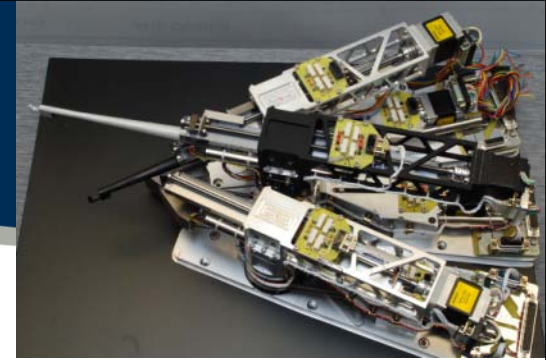
- CGS4: (commissioned '92) the *world's first* astronomical instrument to use diamond-turned optics (aspherics)

- 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



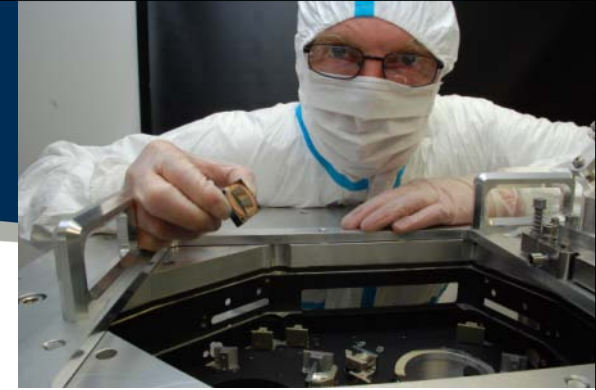
Technologies



- 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



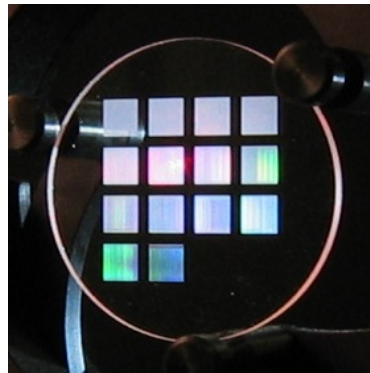
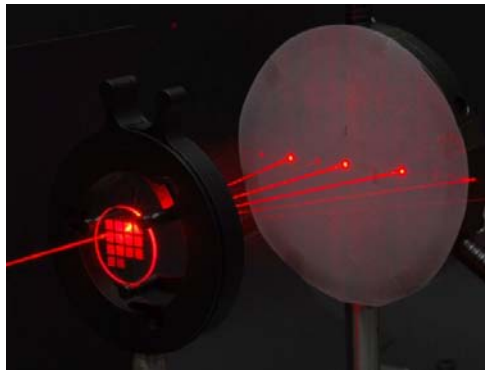
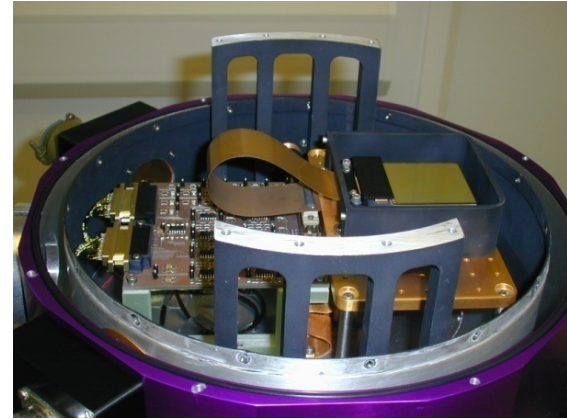
- Key infrastructure :
 - 13 lab areas:
 - Max lab height 6.5m; 10T overhead crane
 - 3 mechanical flexure rigs (test capacity: 10T / 27m³)
 - Lab facilities (compressed air, water cooling, 110V/60Hz)
 - Many optics labs & benches
 - Numerous test cryostats:
 - Standard setup to 4K, specialist <300mK
 - 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



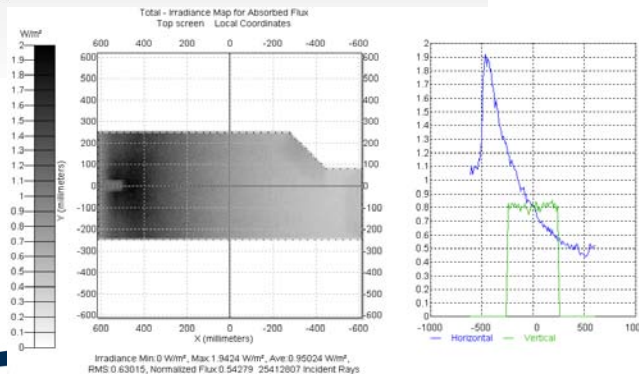
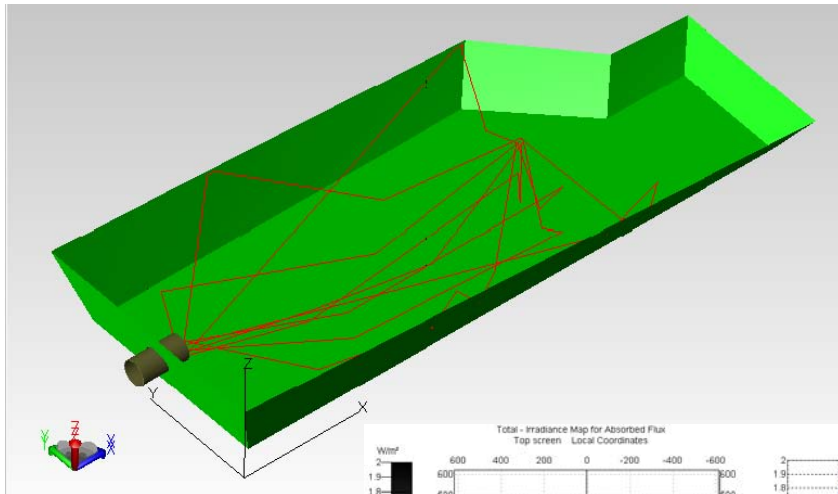
- *Ultrafast Laser Inscription of Gratings*

- Replacement technology for (delicate) Volume Phase Hologram gratings
- Working with HWU & spinout
- Potential in IR spectrographs



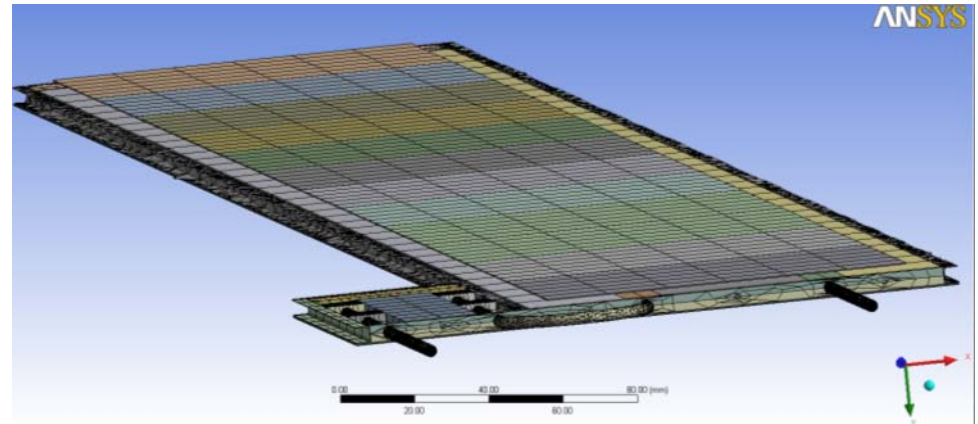
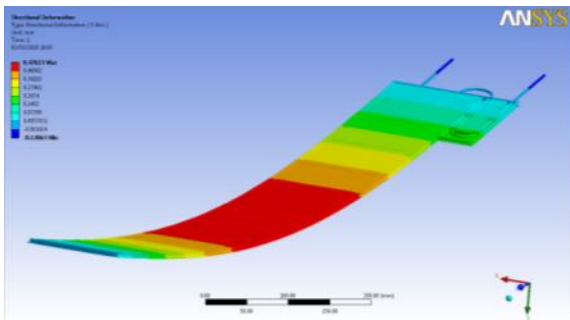
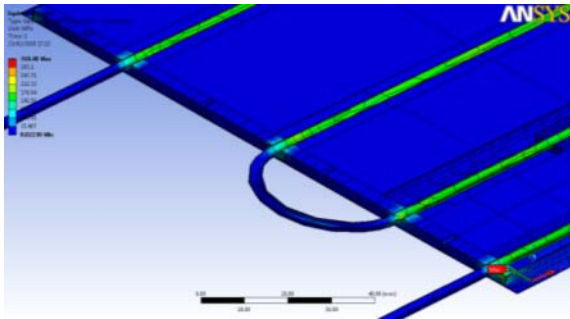
Exploitation: Optical Modelling

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



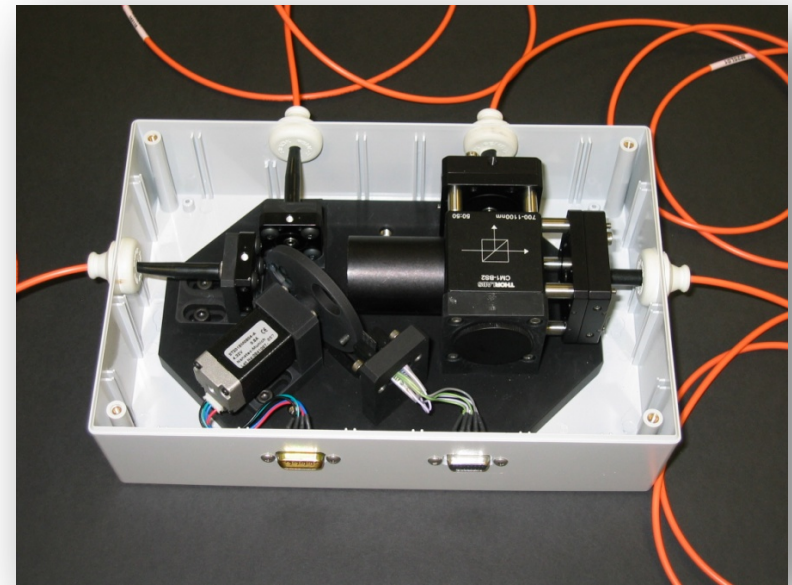
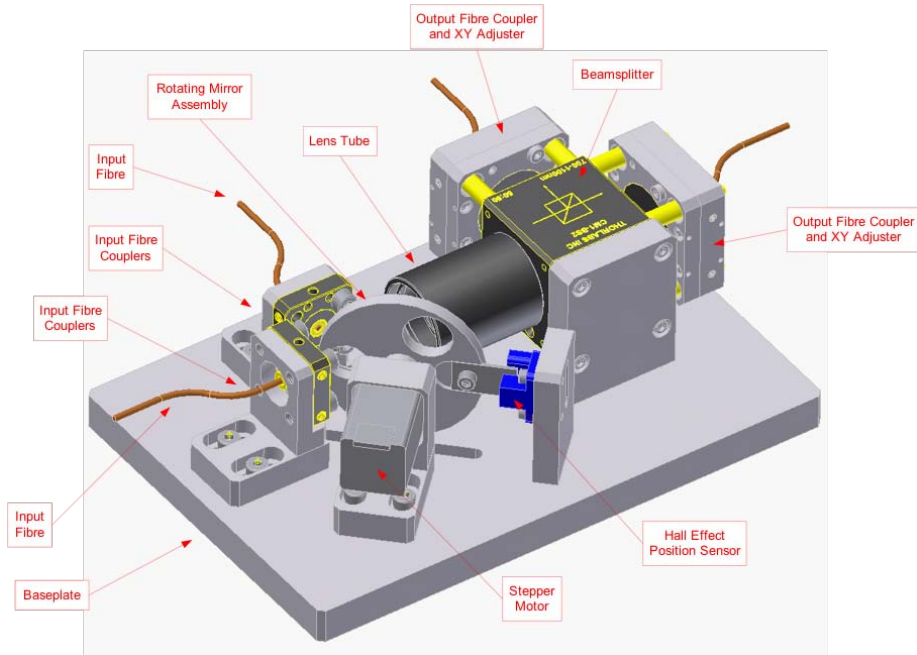
Exploitation: Mechanical Modelling

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



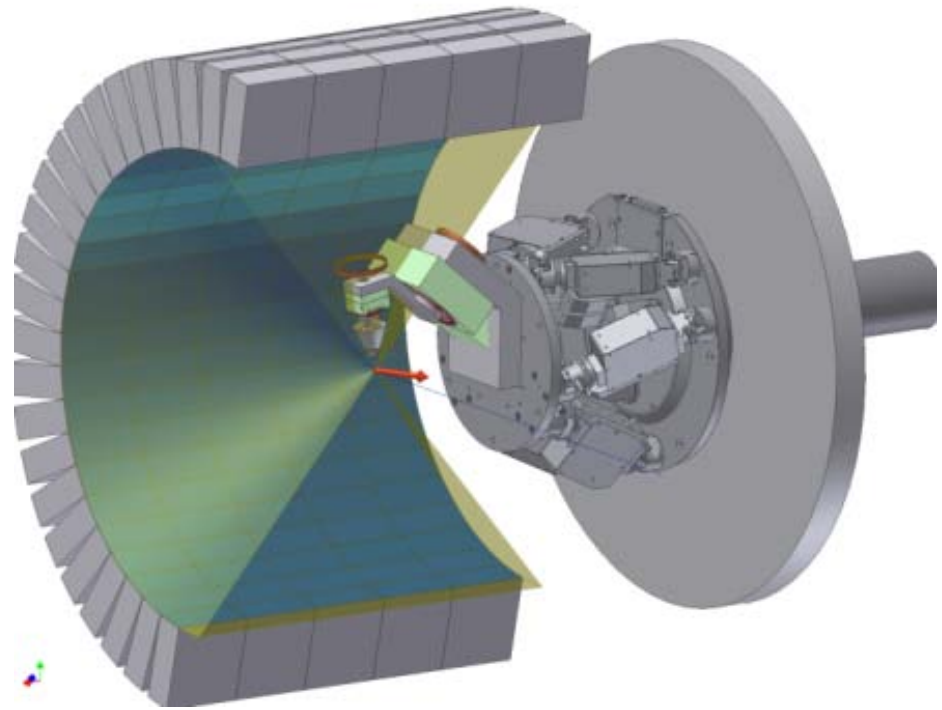
Prototyping

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



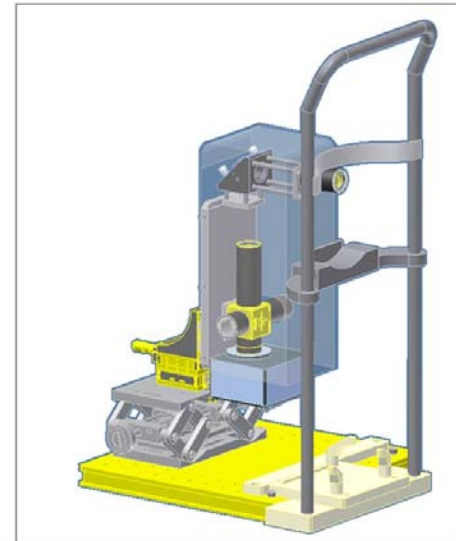
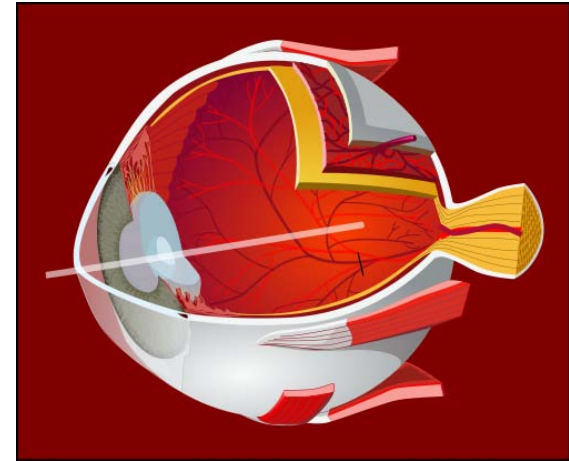
Large Science Facilities

- *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

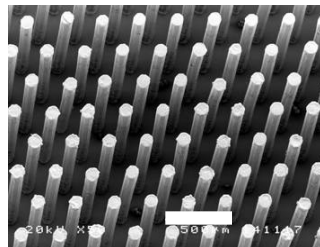
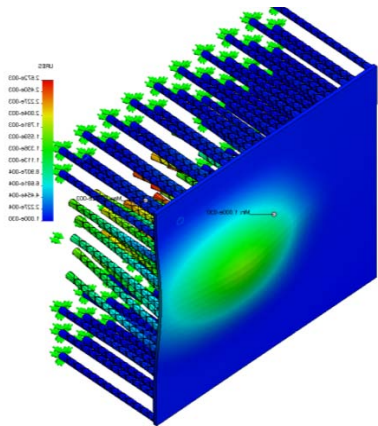
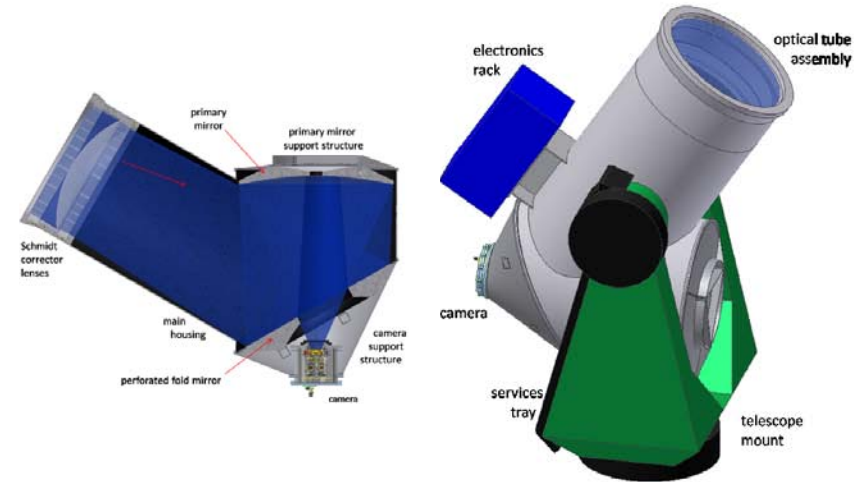


Patent filed



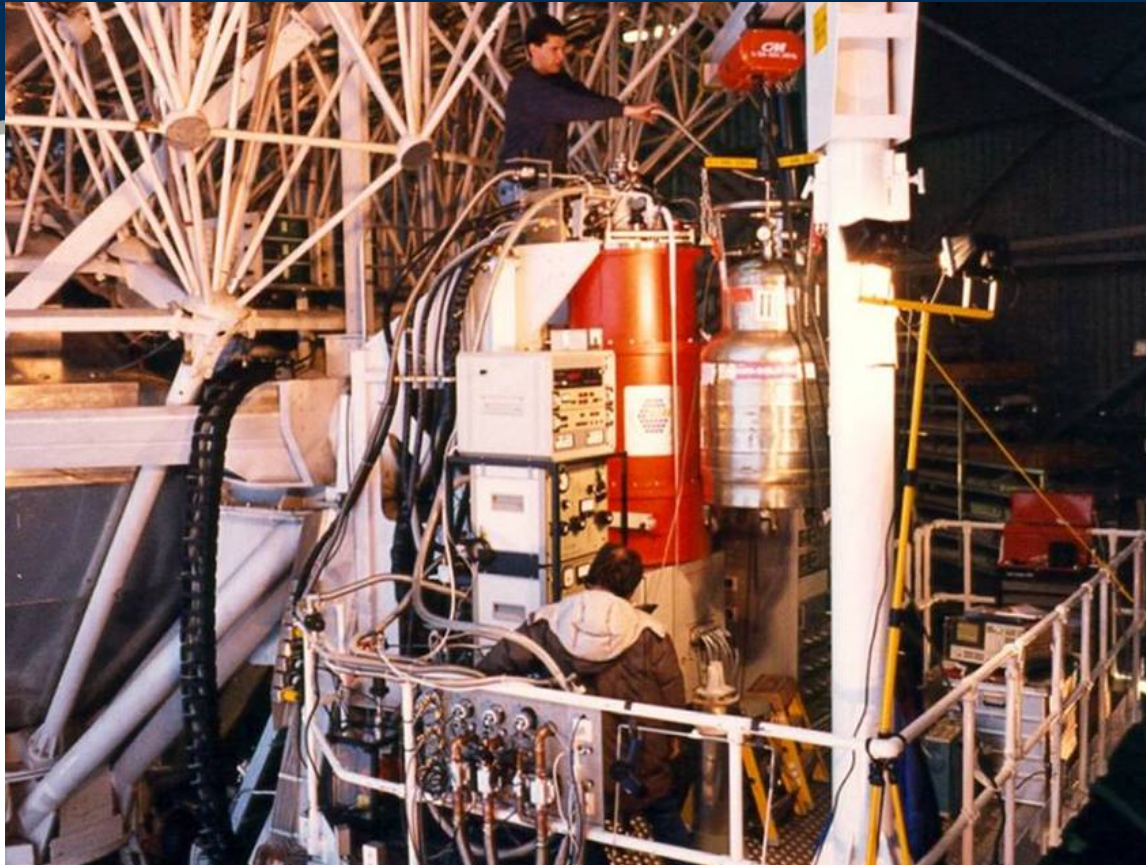
Security & Defence

- *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

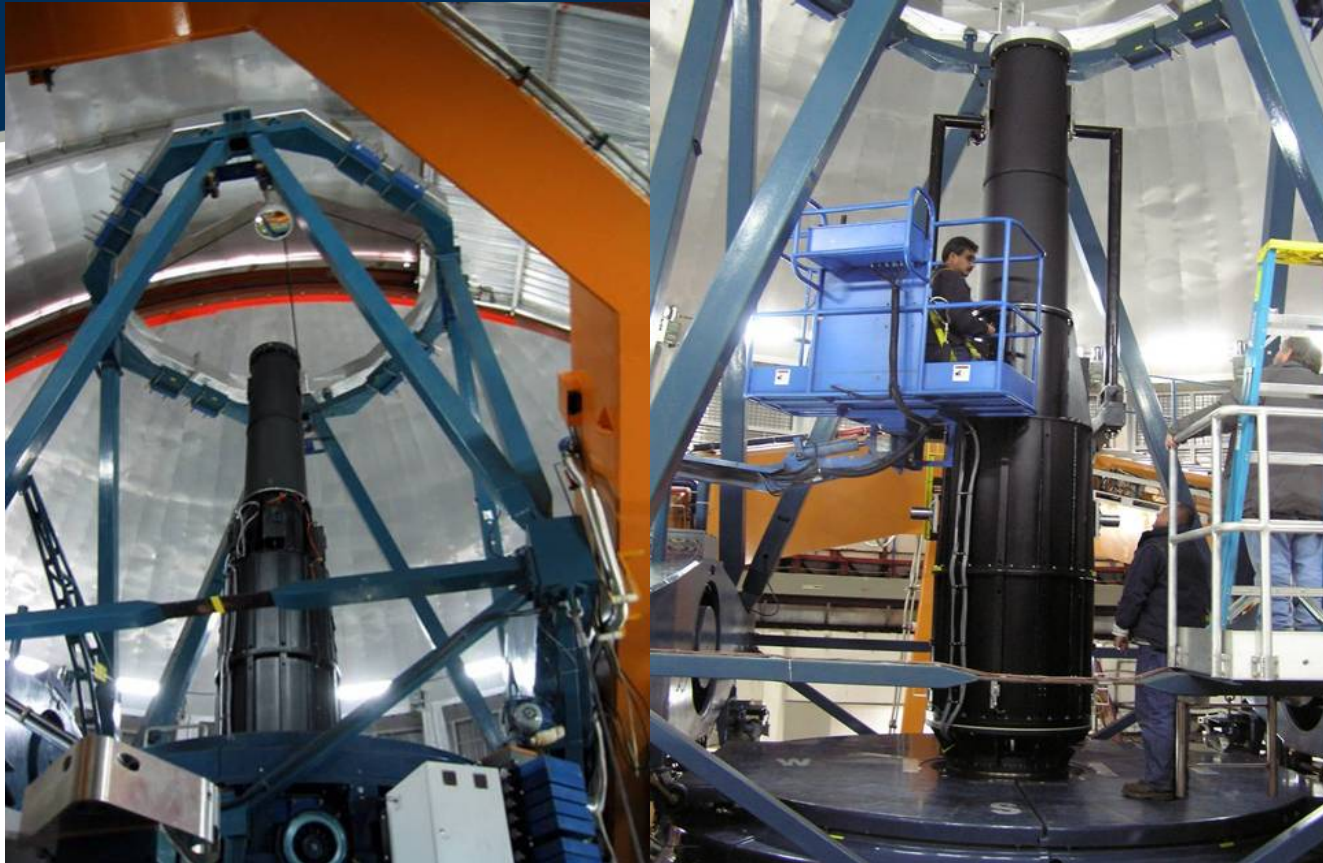
Probably the world's most successful ground-based instrument





Michelle

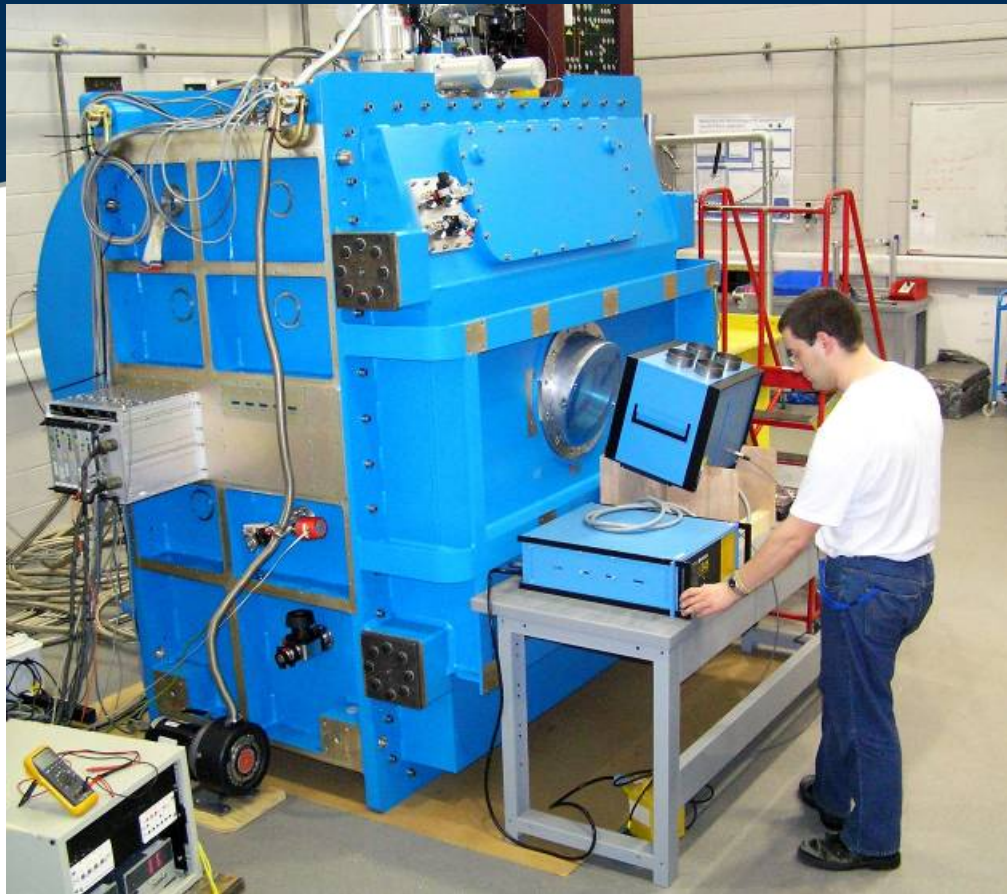




WFCAM

World's most powerful infrared camera, until VISTA





SCUBA-2

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

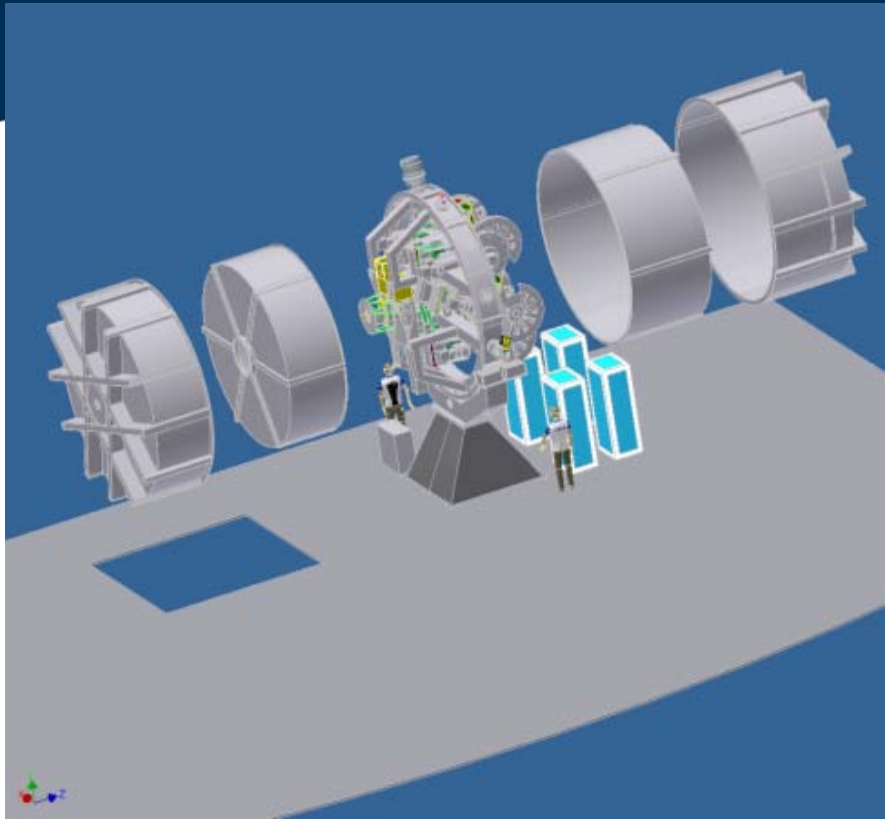




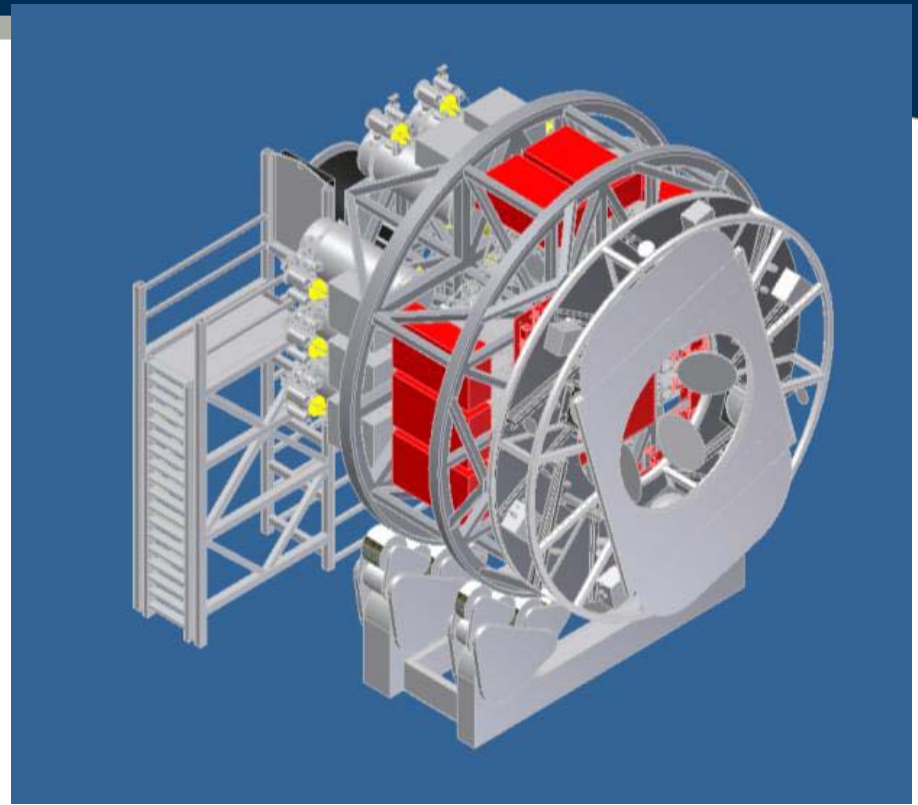
VISTA

World's most powerful infrared camera





HARMONI – 1st light instrument

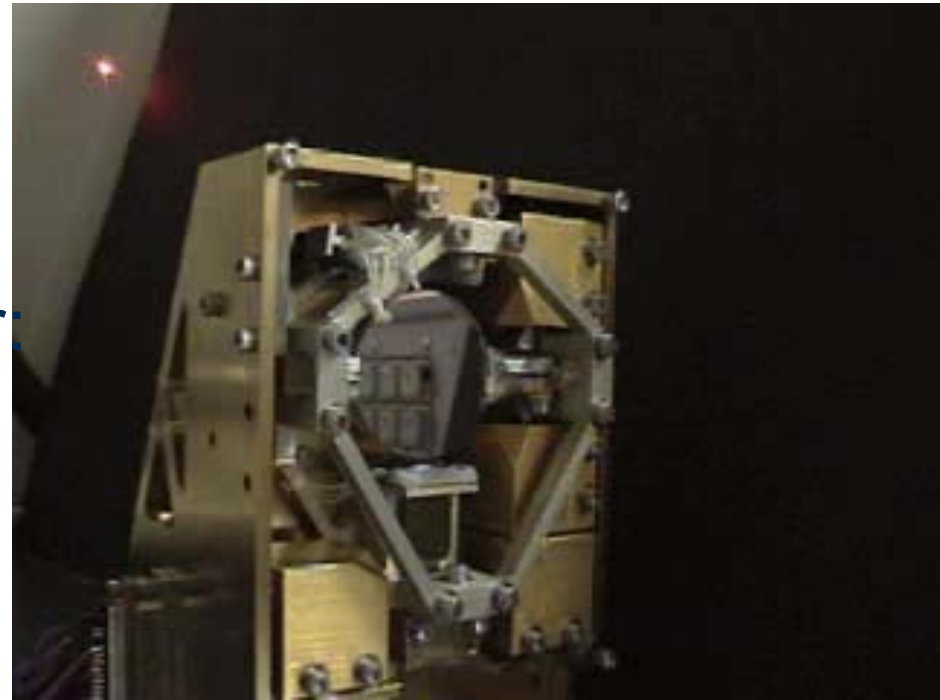


EAGLE – Multi Object Instrument

E-ELT INSTRUMENT STUDIES

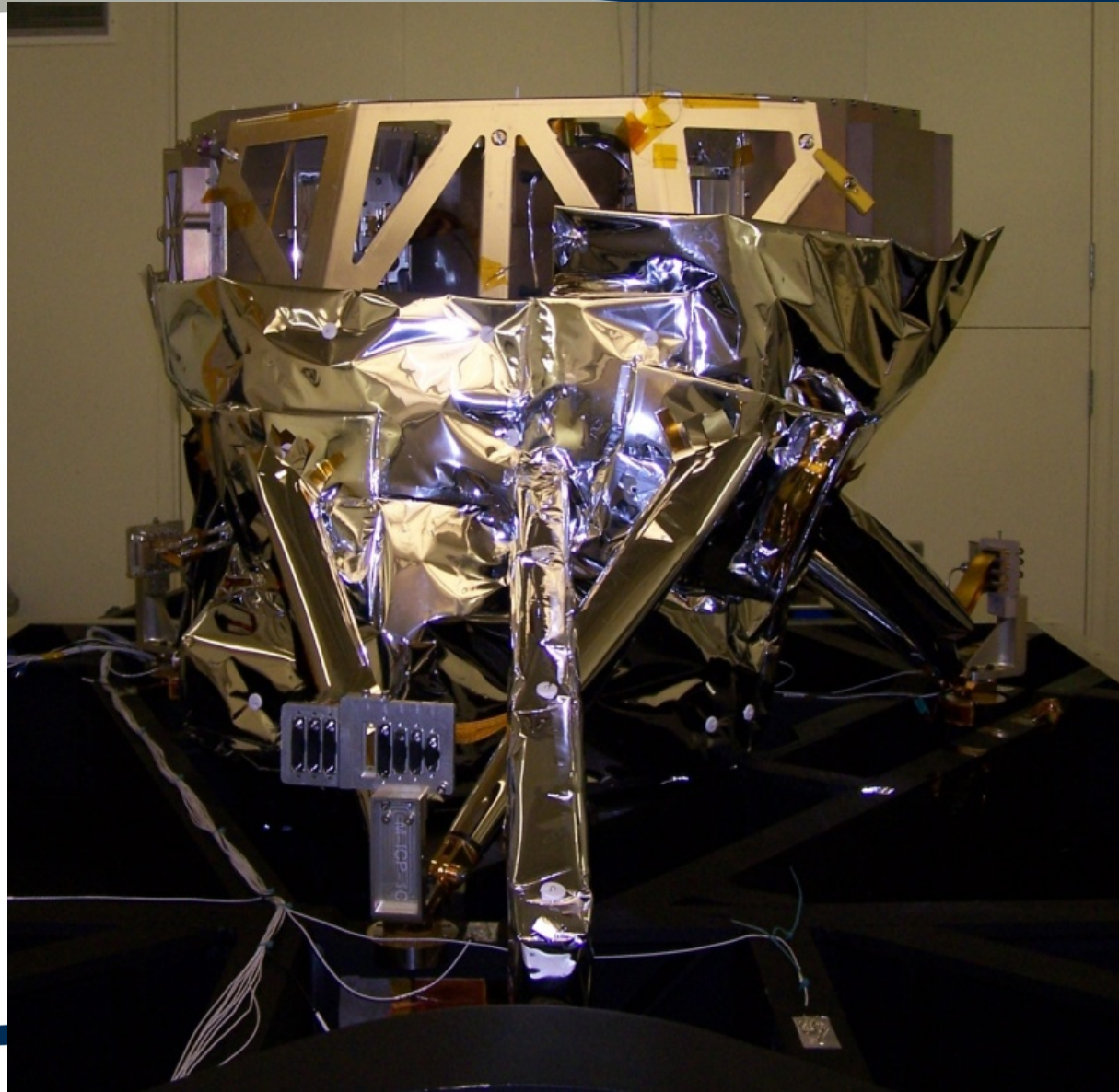
SPIRE Beam Steering Mirror

- 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

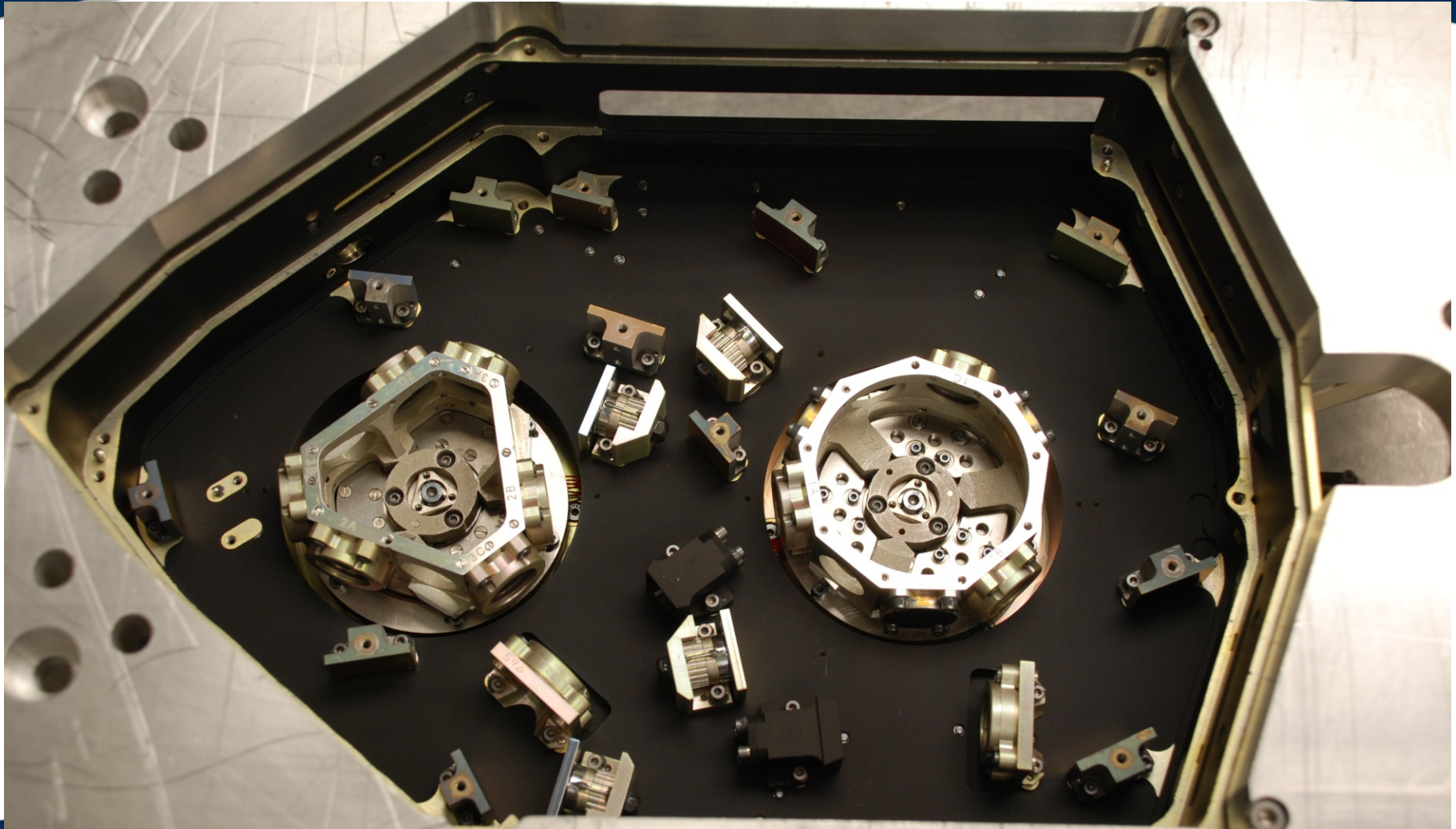


MIRI – Gillian Wright is PI

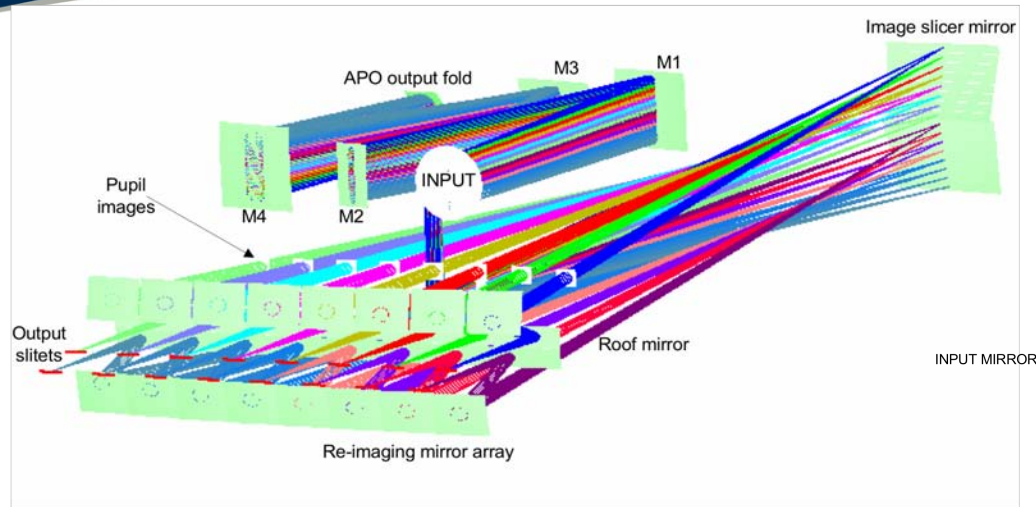
- A 5 to 28 μm imager and spectrometer
- Flight model systems were delivered to RAL for integration and testing (2010/11)
- Delivery to NASA/GSFC in 2012
- JWST Launch in 2018
- Mission Lifetime
 - 5 years minimum
 - 10 years goal
- Built by a consortium of European Institutes
 - Plus JPL for the three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



Spectrometer Pre-optics



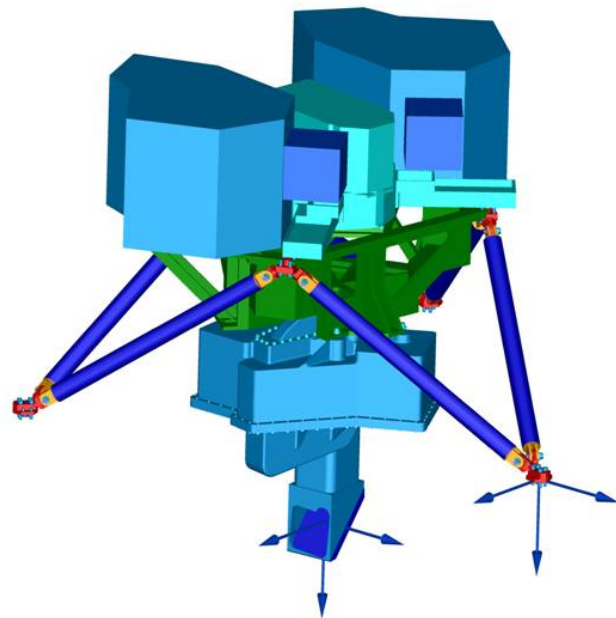
JWST: Hyperspectral Imager



CHANNEL 1 APO

Spectrometer Pre-Optics

Blocking filter



Light trap

WHEEL A

Adjustable fold mirror

D1

D2

CHANNEL 2 APO

D3

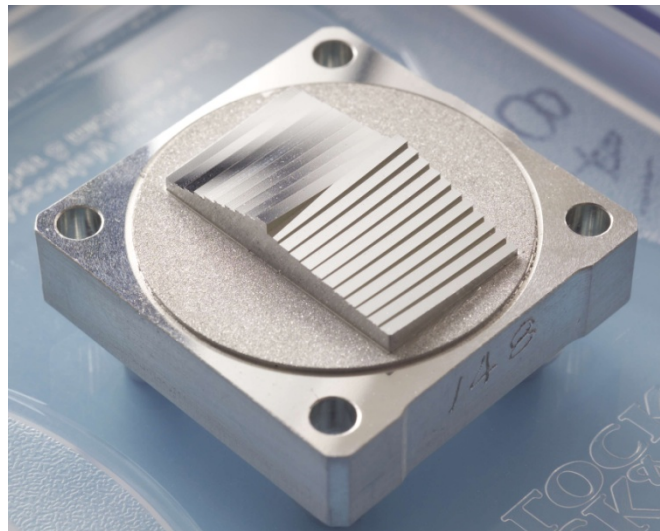
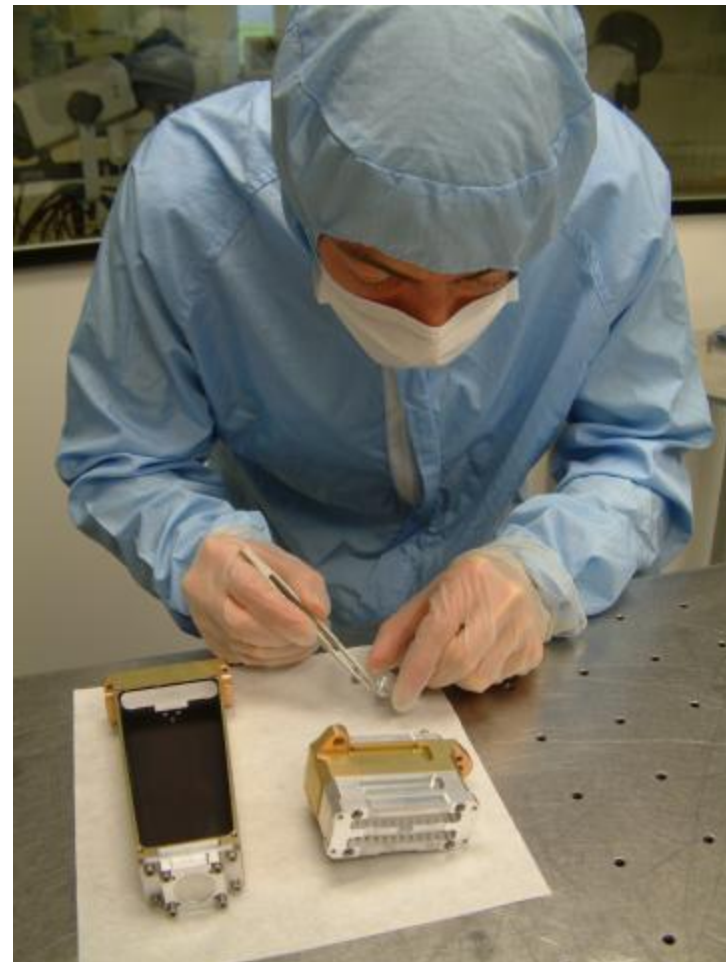
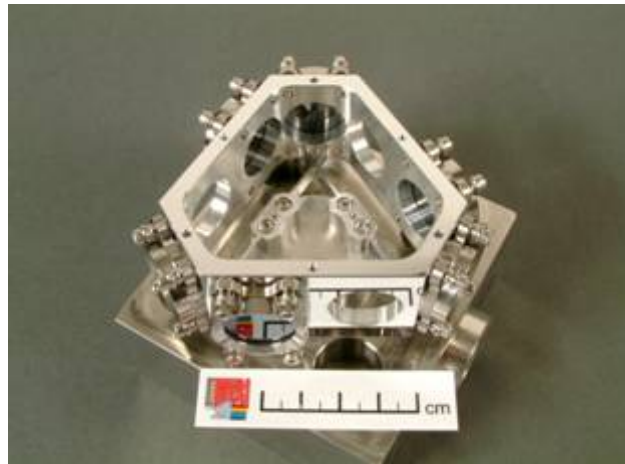
Light trap

Fold mirror

WHEEL B

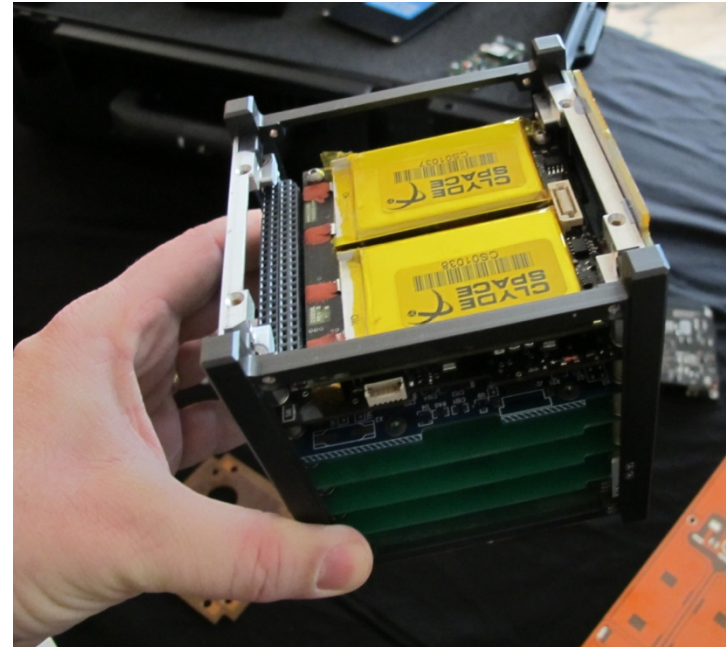
CHANNEL 3 exit port

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

