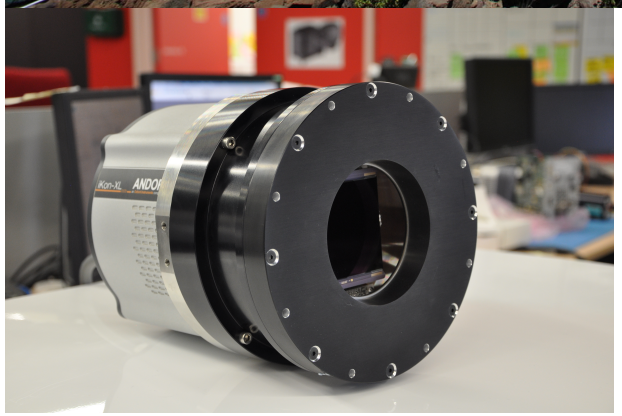
UK participation in DKIST



- Armagh Observatory
- Mullard Space Science Lab/UCL
- Northumbria University
- Queen's University Belfast
- University of Glasgow
- University of Sheffield
- University of St Andrews
- University of Warwick

- Andor Technology

Science & Technology Facilities Council

NSO

A 4m class telescope for the visible and near-IR

Top science specifications

- Aperture – 4m
- Location – Haleakala Hawaii
- First light – Late 2019
- Spectral range 380 nm – 5,000 nm
- Spatial resolution – 20 km
- Imaging spectroscopy – 200,000
- Temporal resolution < 1 sec

High resolution imagining, imaging spectroscopy, spectropolarimetry and coronal magnetometry

First light – Late 2019

DKIST Instruments

- **Visible Broadband Imager (VBI)**

  Blue channel: 390-550 nm

  Ca II K (393.3nm), Gband (430.5nm), 450.6 nm, Hβ (486.4nm)

  Red channel: 550-850 nm

  Hα (656.3nm), 668.4 nm, TiO (705.8nm), Fe XI (789.0nm)

  Spatial resolution: 0.022 arcsec @ 430.5nm

- **Visible Tunable Filter (VTF)**

  Spectral Range: 520 nm to 870 nm

  Fe I (525nm, 630.2nm), Hα (656.3nm), Ca II IR (854.2nm)

- **Visible Spectropolarimeter (ViSP)**

  Spectral Range: 380–900 nm

  Spatial Resolution: 0.07 arcsec @ 630 nm (2x Diffraction limited)

DKIST Instruments

- **Diffraction Limited Near Infrared Spectropolarimeter (DL-NIRSP)**

  500 – 900 nm: planned: 789.0 nm, 854.2 nm

  900 – 1350 nm: planned: 1074.7 nm, 1083.0 nm

  1350 – 1800 nm: planned: 1430 nm, 1565 nm

  Spatial Resolution

  high-res: ~0.06 arcsec (fov: 2.4 x 1.8 arcsec^2**)**

  mid-res: ~0.15 arcsec (fov: 6.16 x 4.62 arcsec^2)

  wide-field: ~0.93 arcsec (fov: 27.84 x 18.56 arcsec^2)

- **Cryogenic Near Infrared Spectropolarimeter (Cryo-NIRSP)**

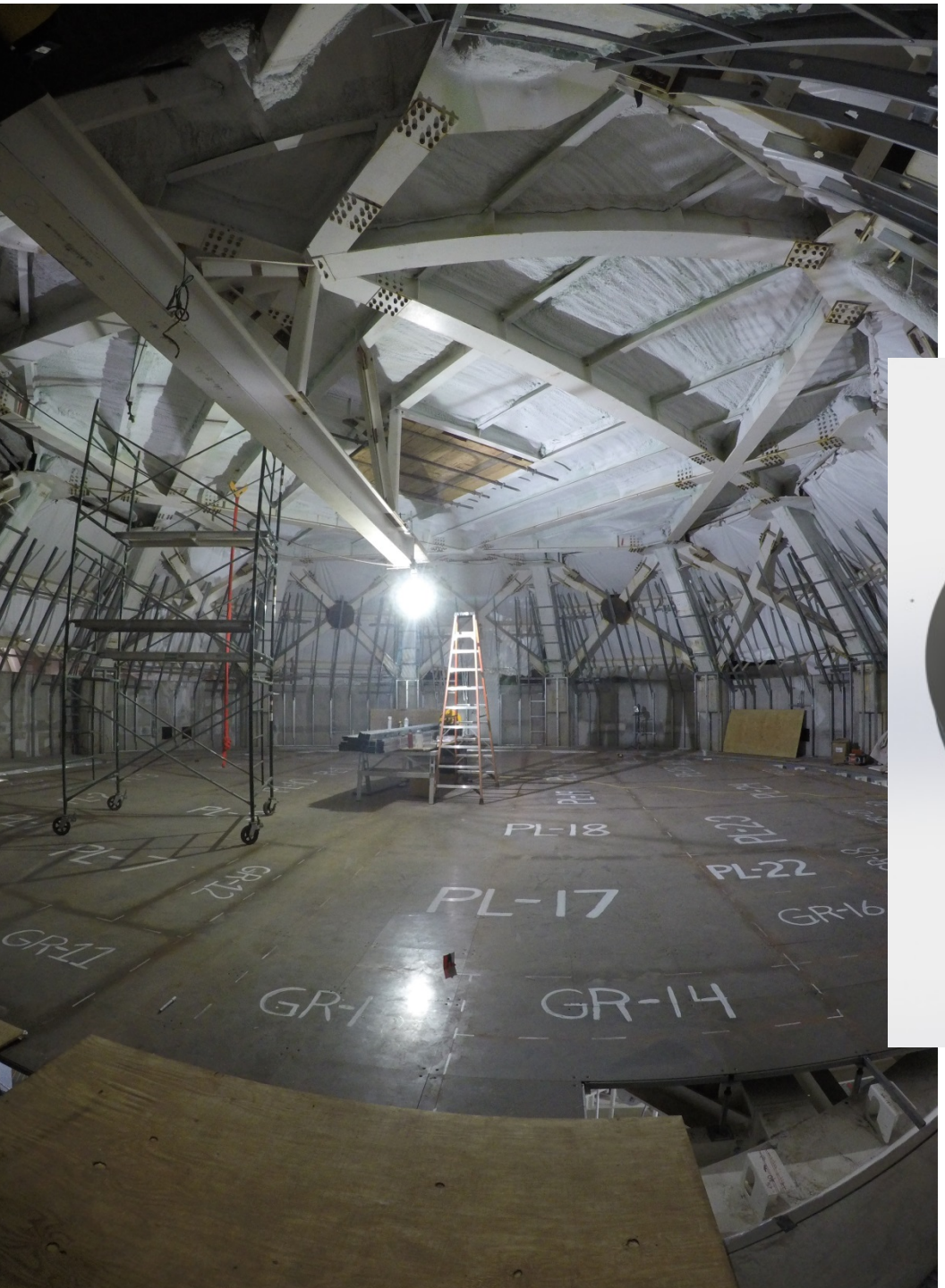
  1000 nm to 5000 nm

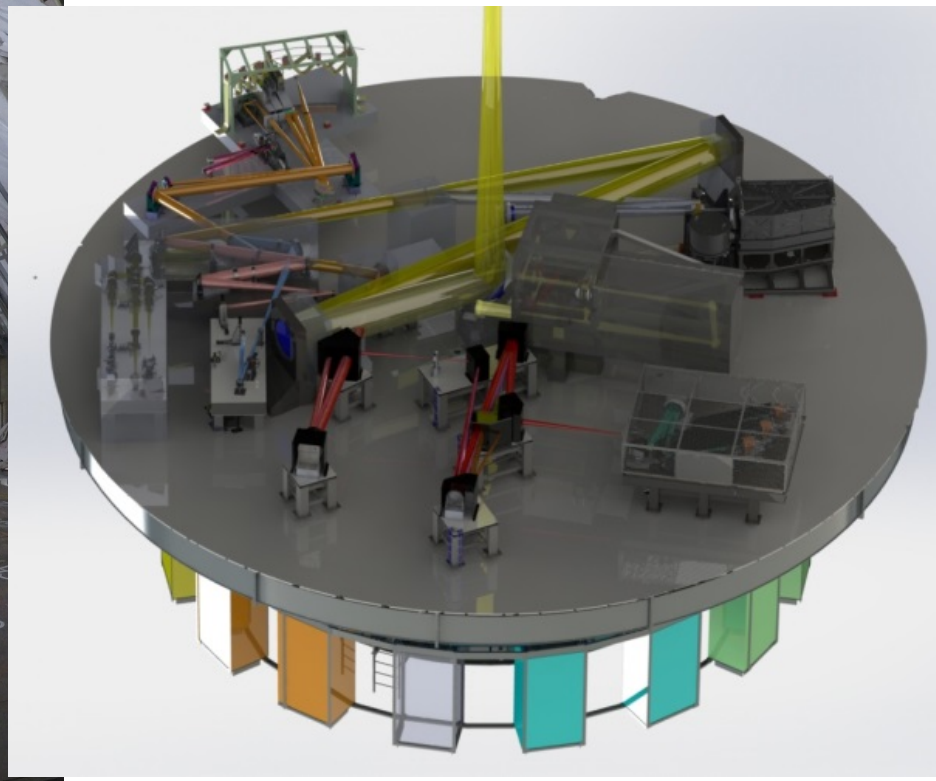
  planned: He I / Fe XIII (1080 nm), S IX (1252 nm), Si X (1430 nm),
  Fe IX (2218 nm), CO (2326 nm), Si X (2580 nm),
  Mg VIII (3028 nm), Si IX (3935 nm), CO (4651 nm)

  Spatial resolution

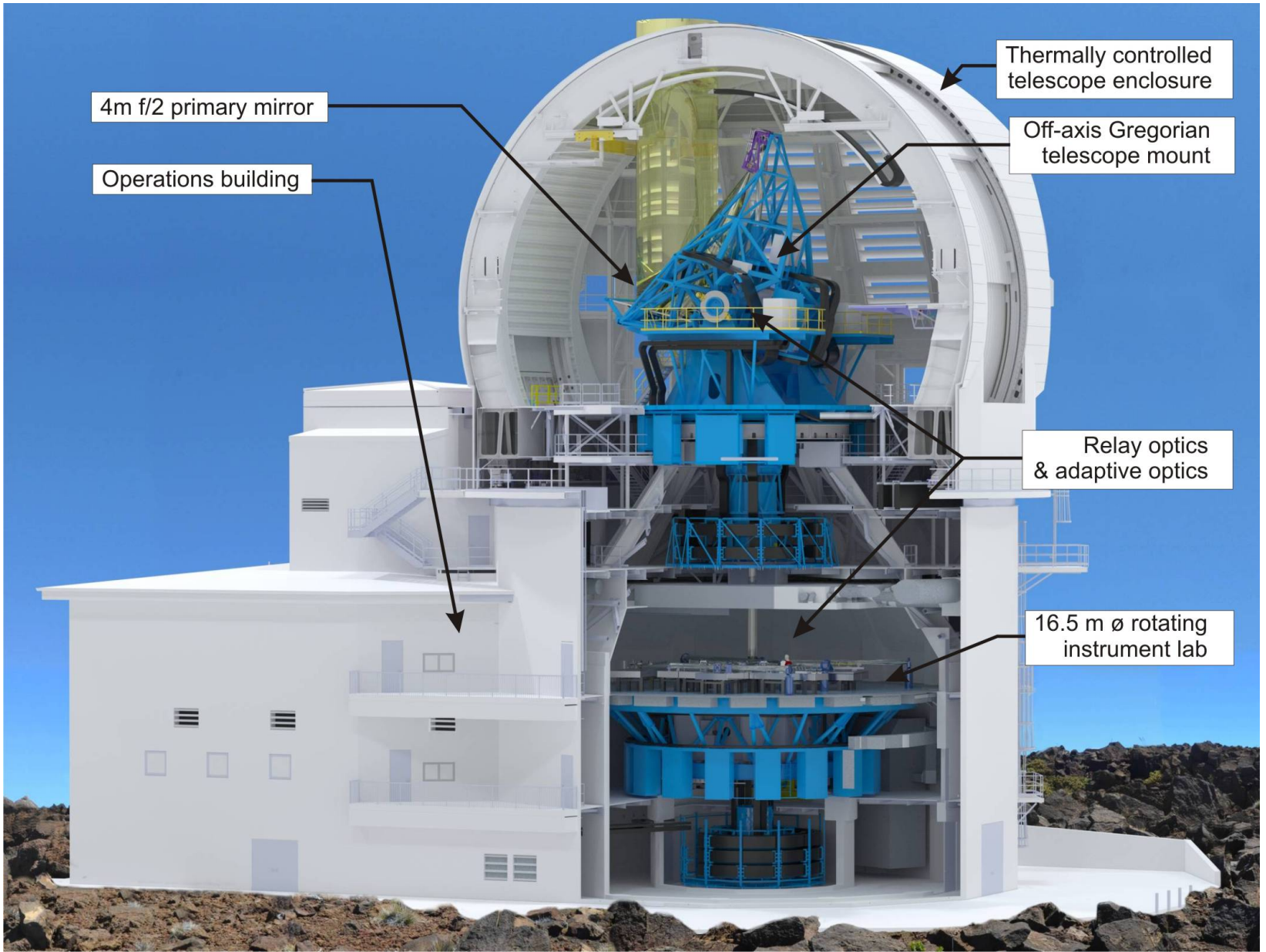
  Coronal Mode: 1 arcsec, (fov: 4 arcmin x 3 arcmin)

  Disk Mode: 0.3 arcsec, (fov: 1.5 arcmin square)


PL-18
PL-22
PL-17
GR-16
GR-14



Detailed Design



DKIST is a Coronagraph
Located at an excellent seeing & coronal site!

DKIST - Telescope update

- Telescope Mount Assembly site installation complete
- Primary mirror and mirror cell transported to site
- Mirror coating in progress
- Project progressing on schedule and on budget (science operations in early 2020)

UK-DKIST Schedule Summary

- We will deliver 9 cameras (paid by the UK partners)
- STFC pays a significant part of the R&D costs
- The original delivery date for the cameras was January 2018
- DKIST brought the delivery date forward to August 2017
- The new delivery date was very challenging
- To mitigate against delays, we provided a number of early prototypes to assist DKIST with the camera software development

Milestones & Deliverables for UK-DKIST (to date)

- STEP file delivered to DKIST in March 2016

- Camera Alpha 1 prototype in May 2016
  no sensor – no proper casing/housing - **software compatible**

- Camera Alpha 2 prototype in May 2017
  with sensor – proper casing/housing – suitable for mechanical testing
  very limited sensor functionality

- Camera Beta prototype in December 2017
  more sensor functionality – additional features – Global Shutter mode
  sensor not science grade (too much deferred charge)

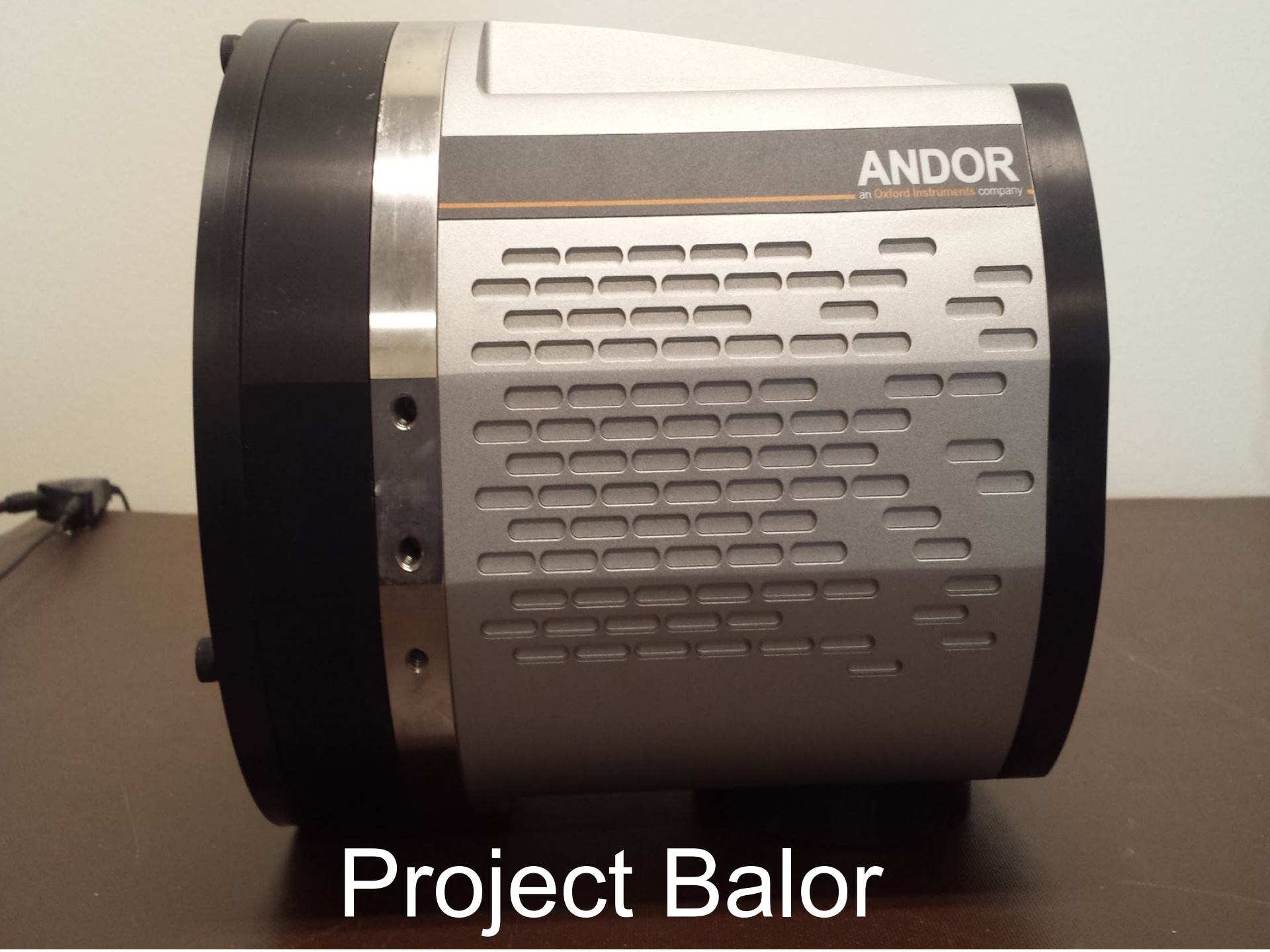
UK-DKIST: Upcoming Milestones & Deliverables

- Characterisation of the new cameras is under way
  Due to be completed in **mid February 2018**

- Cameras will be shipped to MSSL for acceptance tests **in February 2018**

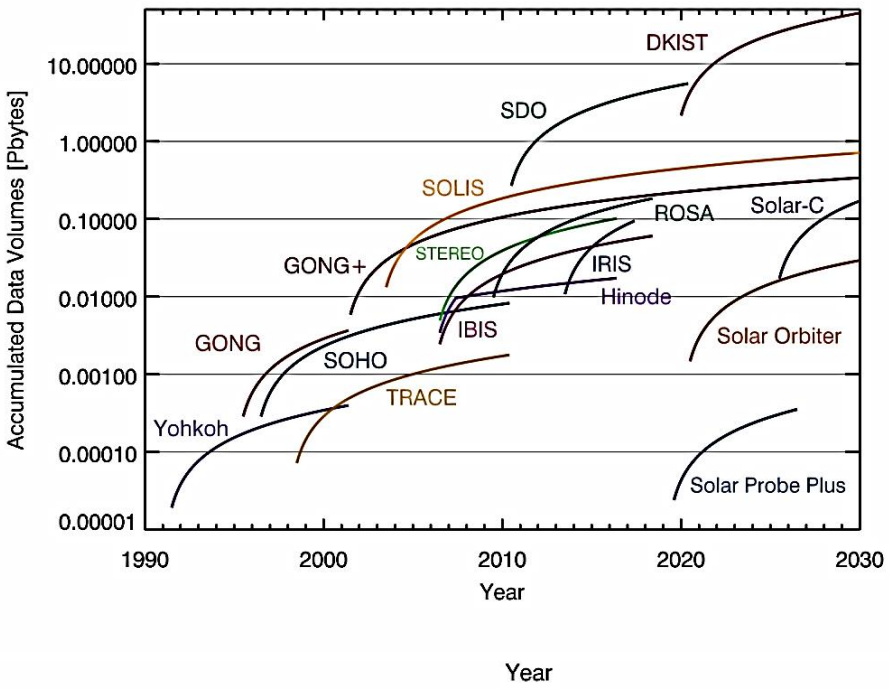
- The first 3 cameras to be formally handed over in **March/April 2018**
  (VBI & DL-NIRSP)

- The remaining 6 camera to be handed over in the **summer of 2018**



Project Balor

Challenges: DKIST Big Data



Instrument	Data Volume	
	Daily (TB)	Annually (PB)
VBI (reconstructed)	0.3	0.6
VTF	12	4.4
ViSP	7.4	2.6
DL-NIRSP	3	1.1
Cryo-NIRSP	0.6	0.2
Lossless Compression	*x 0.5*	*x 0.5*
Estimated Totals	**12 TB**	**4.5 PB**

Aaron Reid: A tool for analysing data from multiple instruments

UK-DKIST: Diagnostic Toolchain Development

- **Forward modelling of observations**

Improvement to the Lare3d code *(Warwick & St Andrews)*

GPU code for MHD simulations in gravitationally stratified plasma *(Sheffield)*

Mapping of non-potential fields *(Sheffield)*

- **Automated feature identification**

Instrumental Cookbook *(Armagh)*

Wavelet and Fourier (spatial & temporal) filtering packages *(Warwick & QUB)*

Nonlinear and anisotropic diffusion tool *(Warwick)*

Automated analysis of transverse motions in magnetic structures *(Northumbria)*

Tools for the detection and analysis of spicule oscillations *(Sheffield)*

Automated identification of vortex flows *(Sheffield & Northumbria)*

Feature detection with machine learning & velocity maps of MFTs *(Sheffield)*

MGN enhancement of fainter & small-scale spatial structures *(Aberystwyth)*

Alignment & Visual Optimisation Code for Analysing DKIST Observations *(QUB)*

UK to be key partner in the world's most advanced solar telescope

The UK is investing in the world's biggest and most advanced solar telescope, currently under construction in Hawaii. This 'super-telescope' will have UK-built cameras and detectors that will be able to record even the tiniest amounts of solar activity, and so help to predict when solar magnetic energy could disrupt our climate and our technological systems on Earth.

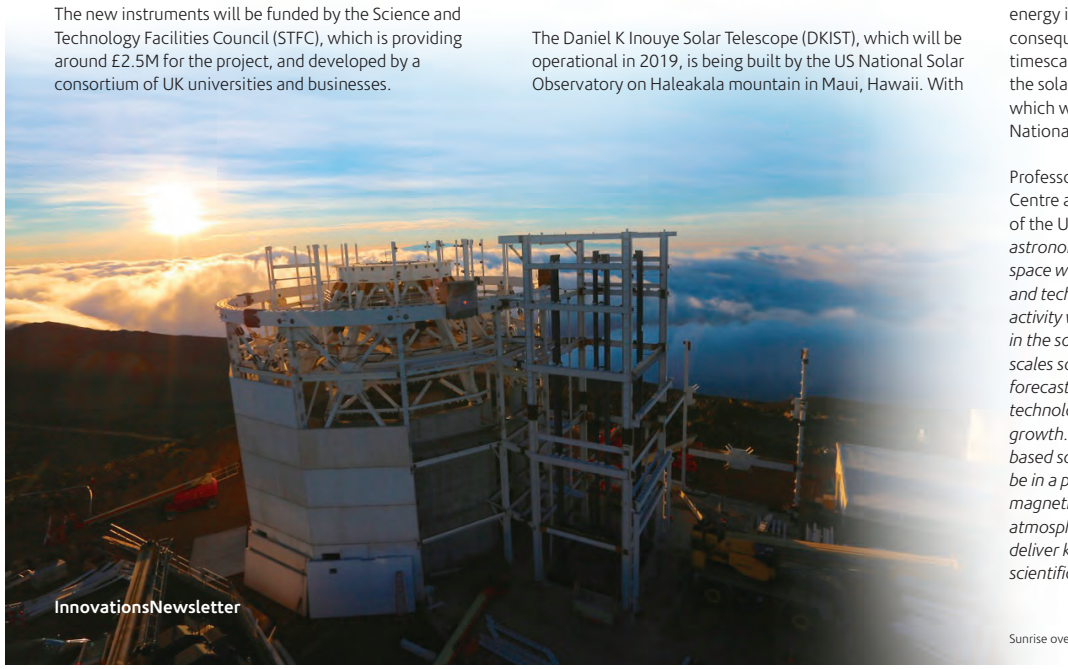
The new instruments will be funded by the Science and Technology Facilities Council (STFC), which is providing around £2.5M for the project, and developed by a consortium of UK universities and businesses.

Professor Grahame Blair, STFC's Executive Director of Programmes, said, "*Understanding and predicting space weather and its impacts is becoming much more important as we become more reliant on technology in our everyday lives. We at STFC are very pleased to be able to contribute to this project, which will help scientists and industry leaders to prepare for any future solar disruption and find ways to diminish its effects.*"

The Daniel K Inouye Solar Telescope (DKIST), which will be operational in 2019, is being built by the US National Solar Observatory on Haleakala mountain in Maui, Hawaii. With a four-metre diameter primary mirror, the telescope will be able to pick up unprecedented detail on the surface of the Sun – the equivalent of being able to examine a £1 coin from 100 km away.

It is hoped that DKIST will address fundamental questions at the core of contemporary solar physics – such as what causes solar magnetic variability or how magnetic energy is transported, stored and released, and with what consequences? It will do this via high-speed (sub-second timescales) spectroscopic and magnetic measurements of the solar photosphere, chromosphere and corona. DKIST, which will cost $344M, will be mainly funded by the US National Science Foundation.

Professor Mihalis Mathioudakis of the Astrophysics Research Centre at Queen's University Belfast, Principal Investigator of the UK consortium, said: "*The Sun is the most important astronomical object for humankind with solar activity driving space weather and having profound effects on global climate and technology-based communications. To understand solar activity we need to observe and model the physical processes in the solar atmosphere on their intrinsic spatial and temporal scales so that, among other questions, we can reliably forecast this activity in space.Scientific discoveries demand technological innovation and play a major role in economic growth. DKIST will be a revolutionary instrument for ground-based solar physics, which is a growth area in the UK. It will be in a position to explore key questions regarding solar magnetic field generation and dissipation, solar variability, atmospheric structure and dynamics. Our consortium will deliver key equipment that will allow DKIST to achieve these scientific goals.*"



Sunrise over the DKIST site Credit: National Solar Observatory/AURA/NSF

STFC Innovations Club Issue 53

Start of science operations in 2020