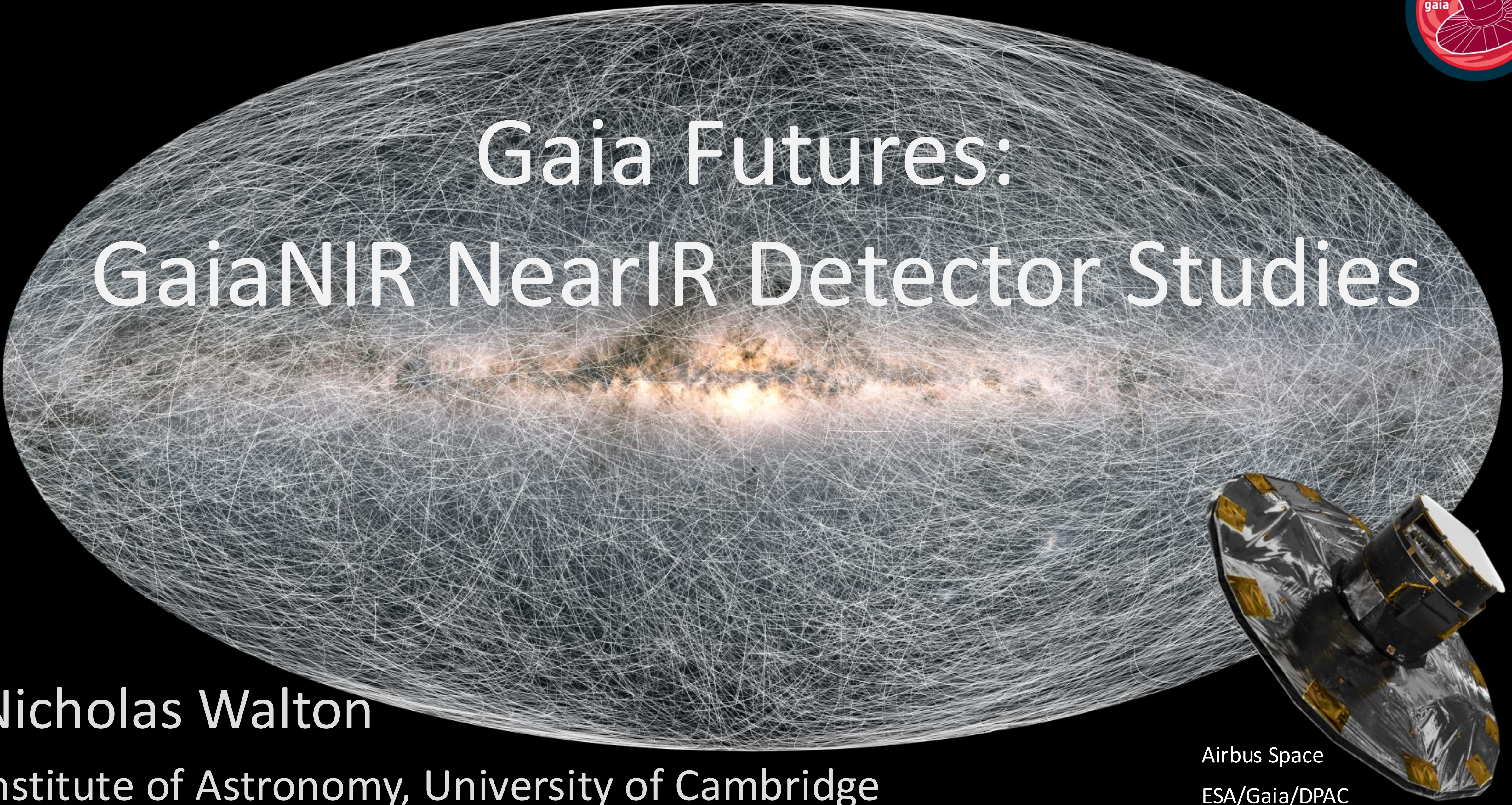
Gaia Futures:
GaiaNIR NearIR Detector Studies



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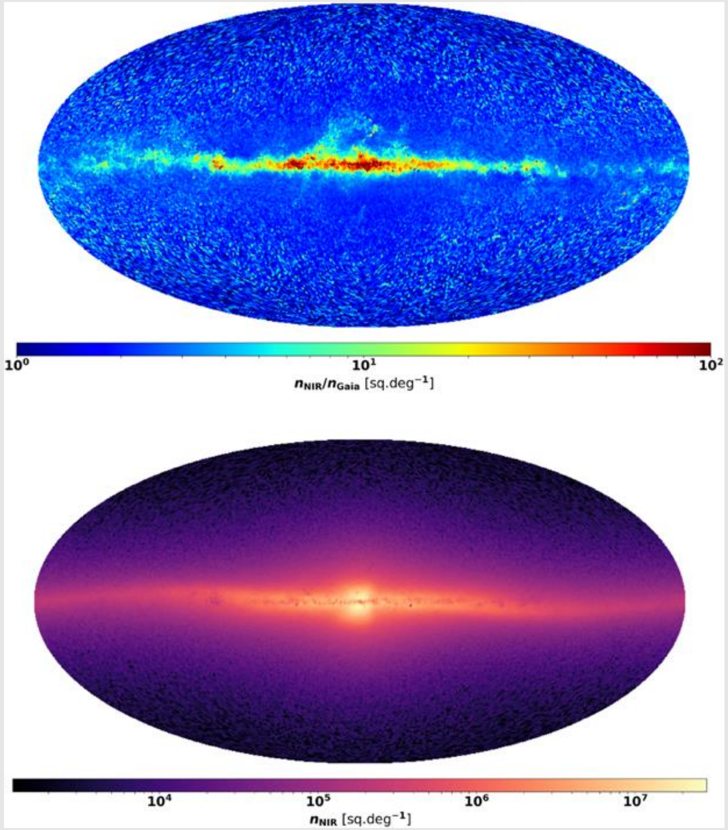
ESA/Gaia/DPAC

What follows? Into the centre of the Milky WayGaiaNIR & ESA Voyage 2050

See David Hobb's talk earlier in this meeting

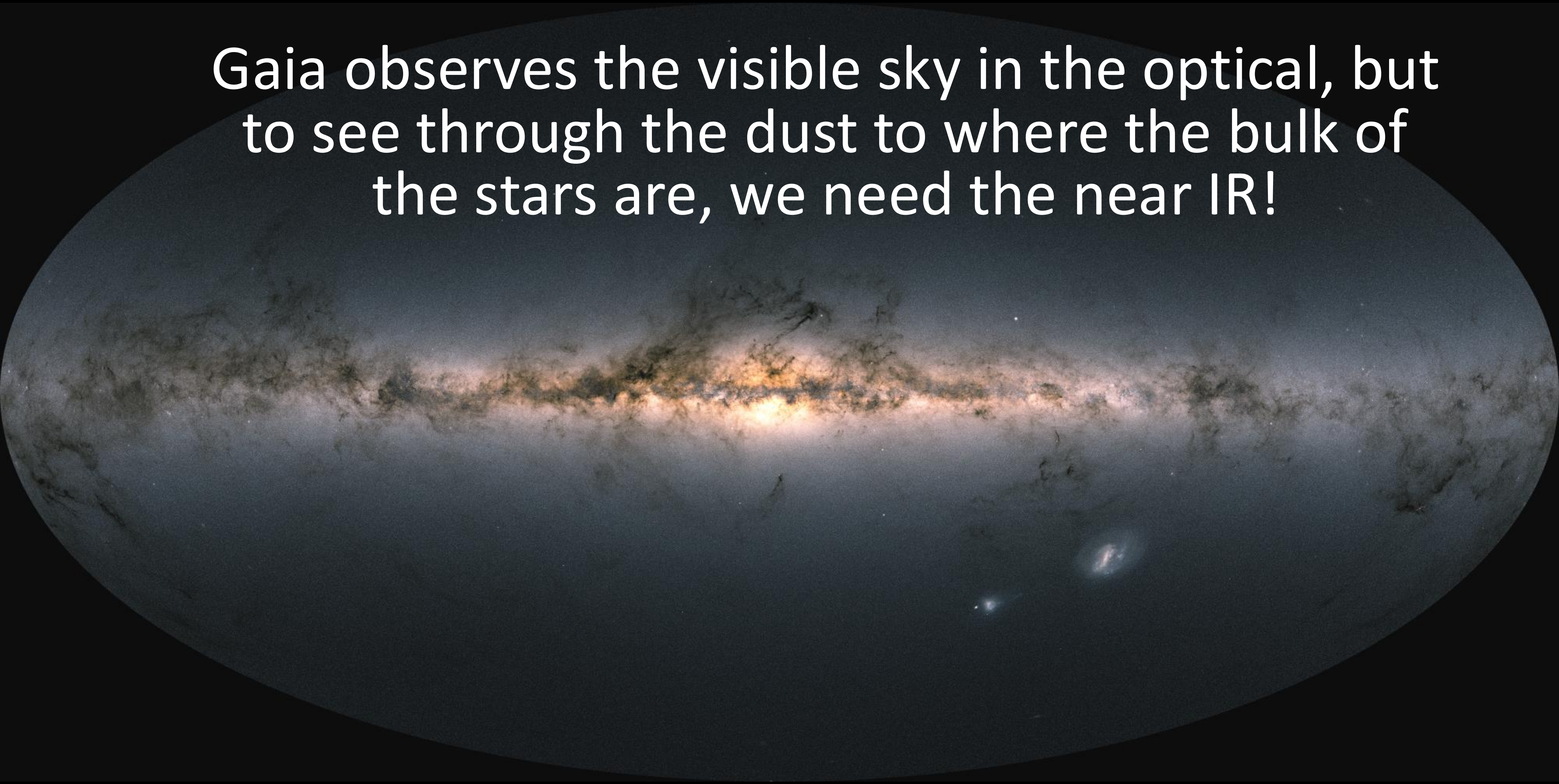
- Gaia like mission extending to the near infrared – probes x5 Gaia sources – implies > 50 Billion sources
- Three key science goals:
  - Penetrate dust obscured of the Milky Way to reveal the Bulge and Disk to disentangle the formation history of our Galaxy
  - Combine with Gaia data to increase the proper motion baseline to probe the outer regions of our galaxy
  - Maintain the Celestial Reference Frame and explore the fundamental physics of gravitational waves
- Key technical challenges include the development of InfraRed detectors

A transformational L-class ESA Space mission



Credit: Hobbs et al 2020

Gaia observes the visible sky in the optical, but to see through the dust to where the bulk of the stars are, we need the near IR!



Near-IR Detector Challenge

- Earlier ESA CDF study for a GaiaNIR M size mission envisaged large format HgCdTe devices operating in traditional 'stare' mode
  - This required field de-rotation optics to allow GaiaNIR to operate a Gaia-like scanning law
  - Added complexity, risk and cost to the baseline mission design
- Considered a range of detector technologies
  - A hybrid detector HgCdTe layer bump bonded to a Si CCD – technology is challenging
  - Ge is very promising - scaling to large format arrays – but λ limited to ~1400 nm
  - MKIDs - scaling to large format arrays – but active cooling needed
- Decided to study feasibility of HgCdTe Avalanche PhotoDiodes (APDs) with 'TDI like mode' signal processing technology

GaiaNIR and the UK: NSTP Study Programme: 2021/22

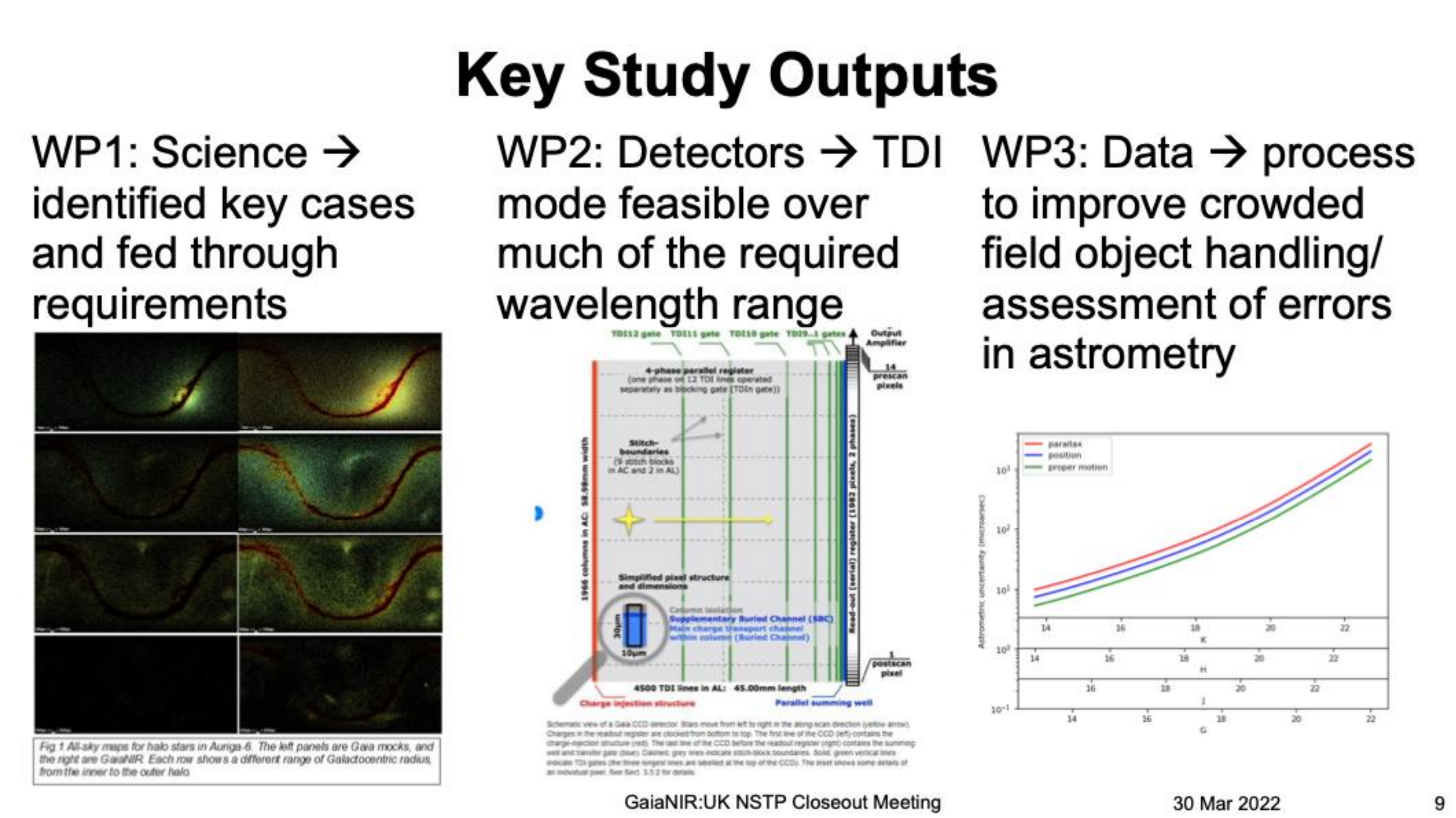
(Cambridge, Durham, Leonardo, MSSL-UCL, UKATC)

From the Initial UK Study Kick-Off meeting: Dec 2021

‘This study will develop the capability of the UK technology and academic sector in taking leadership positions in a candidate mission concept for an ESA Large (L-class) mission as part of its upcoming Voyage 2050 programme.

- Payload (nearIR detectors), Data, Science
- Plan the future development roadmap
- Timely: next down-select in ~2024/25’

UK NSTP Study Programme Outcomes: 2021/22



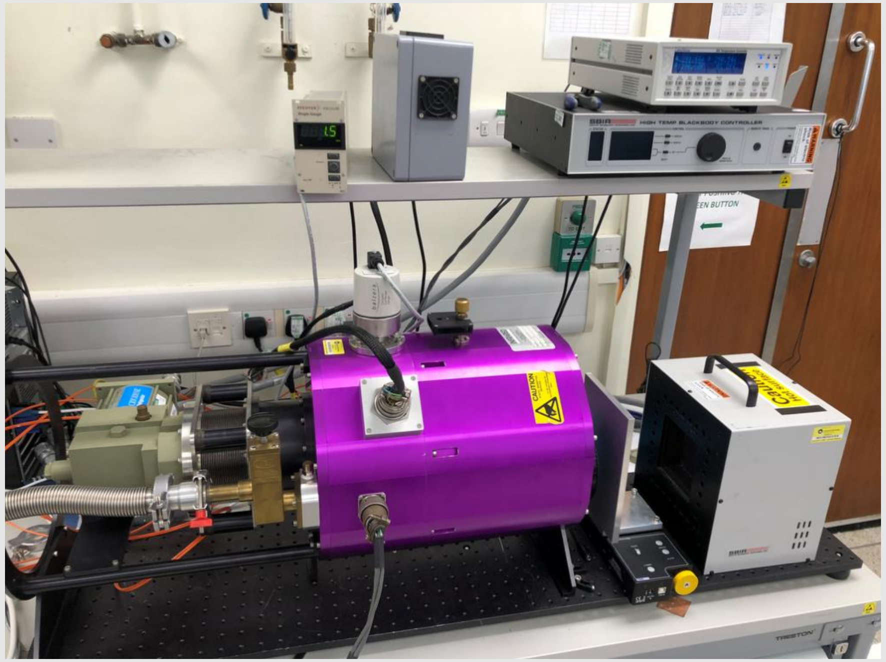
- Science assessment: no significant requirement <800nm
- Detectors: explore photon counting APDs in 'TDI-like' mode of operation
- Data: model on Gaia architecture. Assessment of crowding and on-board processing

Science cases taken from the Hobbs et al, Voyage 2050 white paper: Experimental Astronomy, 2021
https://doi.org/10.1007/s10686-021-09705-z

GaiaNIR Detector Studies in the UK

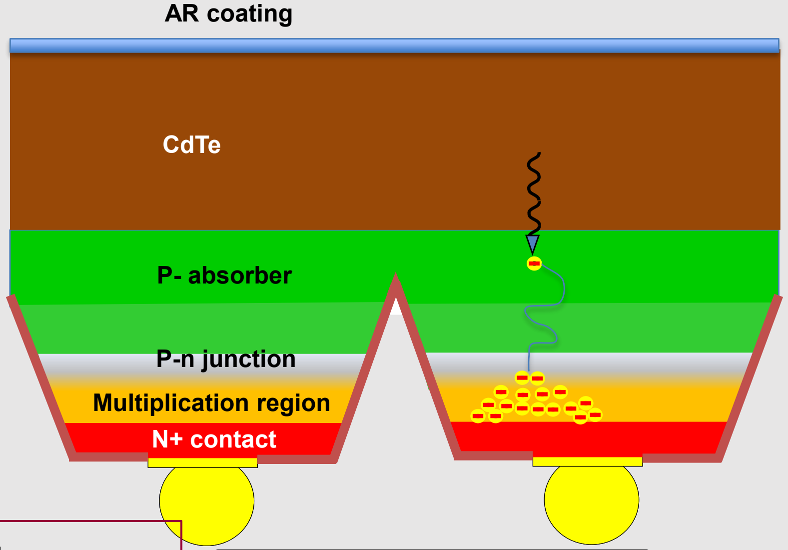
See Rob Wilson's talk earlier in this meeting

- Following on from the initial UKSA NSTP study
- Characterise Linear Mode Avalanche Photon Detectors (APD) as the IR detector operating in a 'TDI' like mode now being studied (Leonardo, Cambridge, UKATC, UCL/MSSL)
  - ESA CTP funded study (18 months: 2024-2026) now underway to carry out evaluation of physical devices
  - Requirements review: Sep 2024
  - Test Readiness review: Dec 2024
  - Mid Term review: Aug 2025
  - Final review: Jan 2026
- Initial results (e.g. 'read noise') indicate performance likely suitable for GaiaNIR



GaiaNIR Detector Studies in the UK

- Range of Saphira devices being tested at both Leonardo and UKATC
  - four MOVPE devices with range of p-n band gaps
  - Comprehensive characterisation of each device, e.g. …
  - Gain, Linearity, QE and QE stability
  - Read Noise, Dark Current
  - Persistence, Cross Talk



- Initial analysis of detector size (pixel and number of pixels), FPA packaging, optimisation of large-scale array configurations
- Generation of performance model
- Current ESA CTP study to complete Jan 2026
- Outcome: confirm feasibility of APDs for a GaiaNIR mission.

Credit: Leonardo: see Rob Wilson's presentation yesterday 15/7/25