iqClock: an optical lattice clock for out-of-lab operation in a telecom environment

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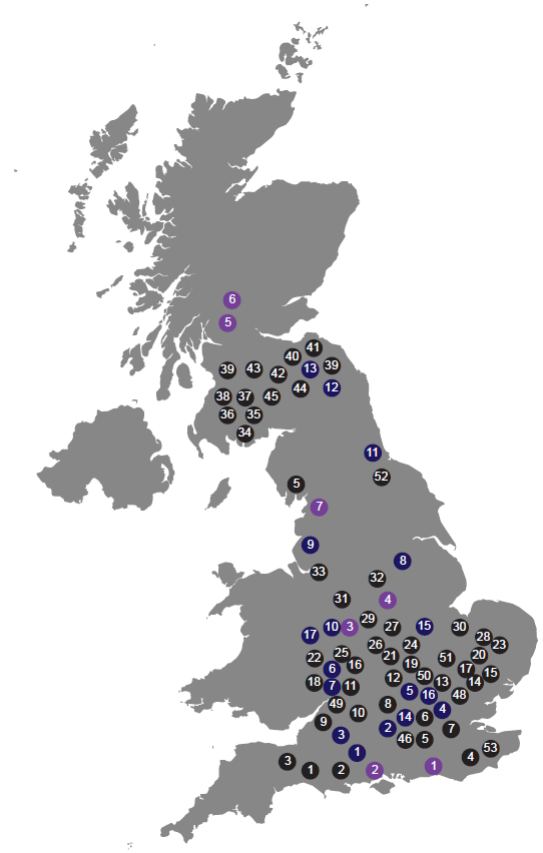
UK Quantum Sensors and Timing Hub

109 Collaborative Projects

72 Companies Invested Money

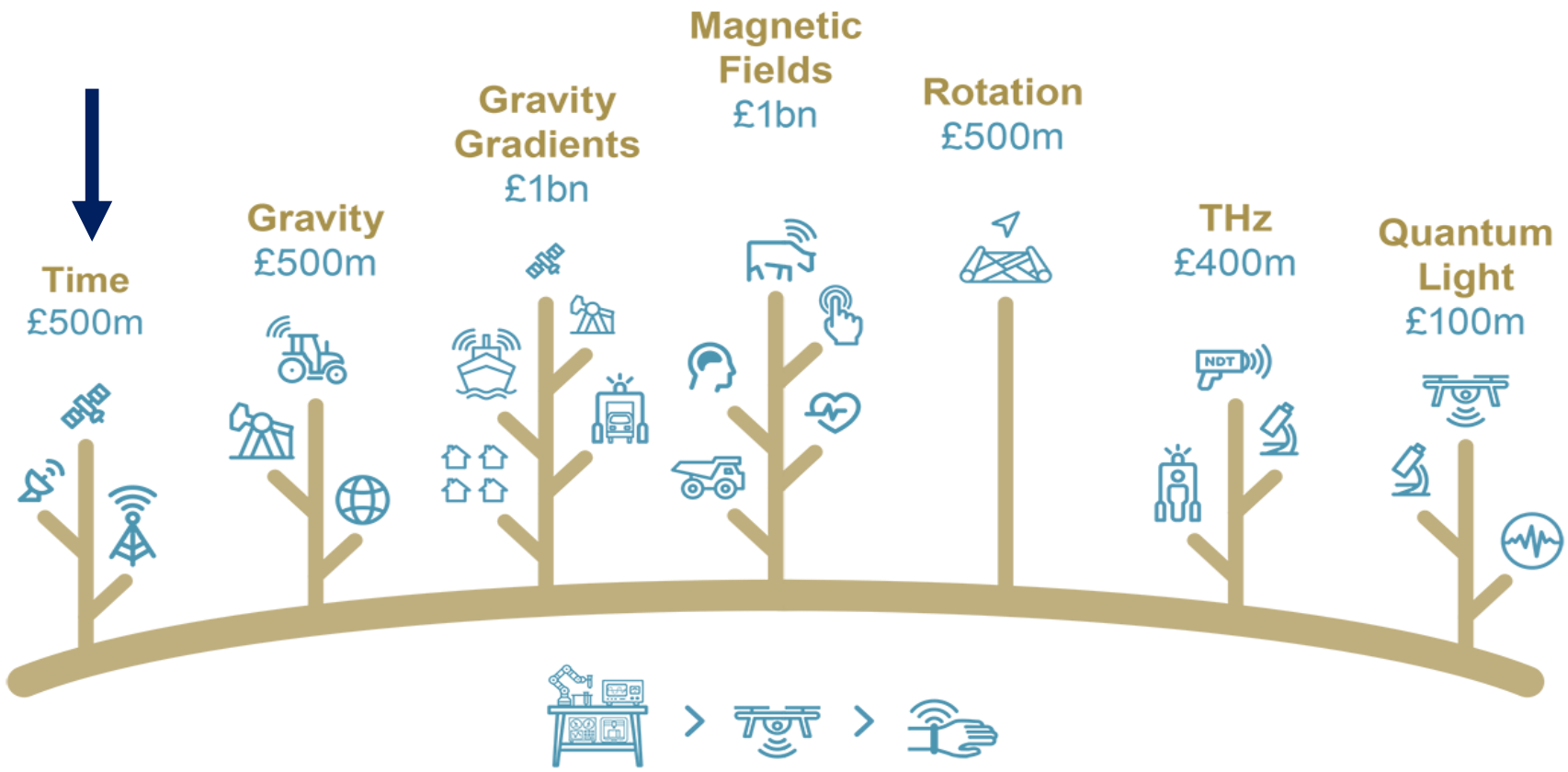
>£100M Project Value
(In Addition To Initial £35.5M)

>17 Patent Applications
>147 Records of Inventions



UK Quantum Sensors and Timing Hub

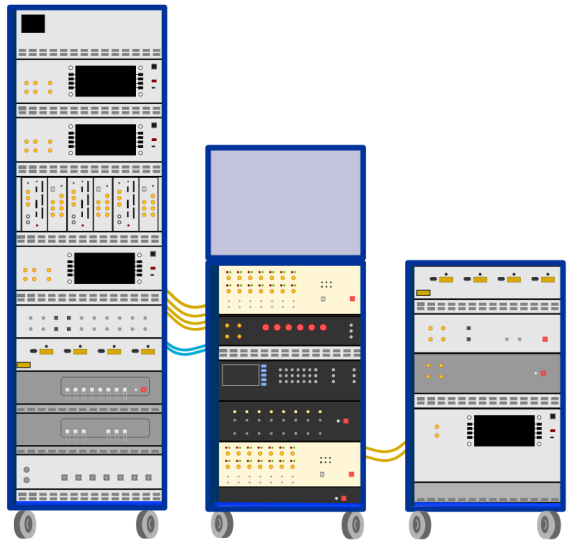
Priorities (underpinned by road map and value chain)



Where do we want to go with iqClock?

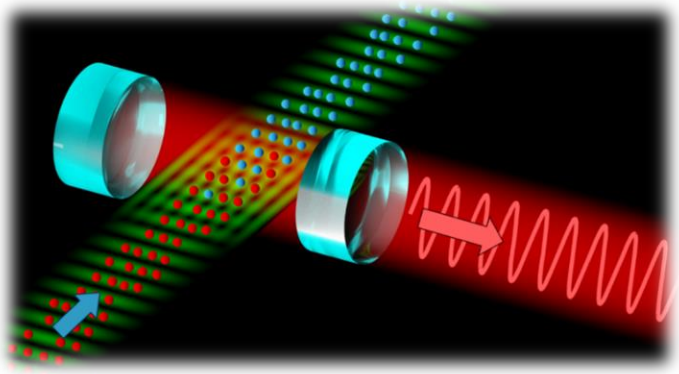
- Two intertwined streams in iqClock:

Objective 1: construction of a transportable, optical lattice clock built jointly with our industry partners



artistic illustration

Objective 2: development of continuous superradiant clocks (lab-based)



courtesy of F. Schreck, UvA

Who is iqClock?

University of Birmingham

Chronos

British Telecom

Teledyne e2v

Toptica Photonics

University of Innsbruck

Technical University of Vienna

ACKTAR

NKT Photonics

Copenhagen University

Nicolaus Copernicus University

University of Amsterdam

(*Consortium Lead*)

Integrated Strontium Optical Lattice Clock

University of Birmingham

Chronos

British Telecom

Teledyne e2v

Toptica Photonics

University of Innsbruck

Technical University of Vienna

ACKTAR

NKT Photonics

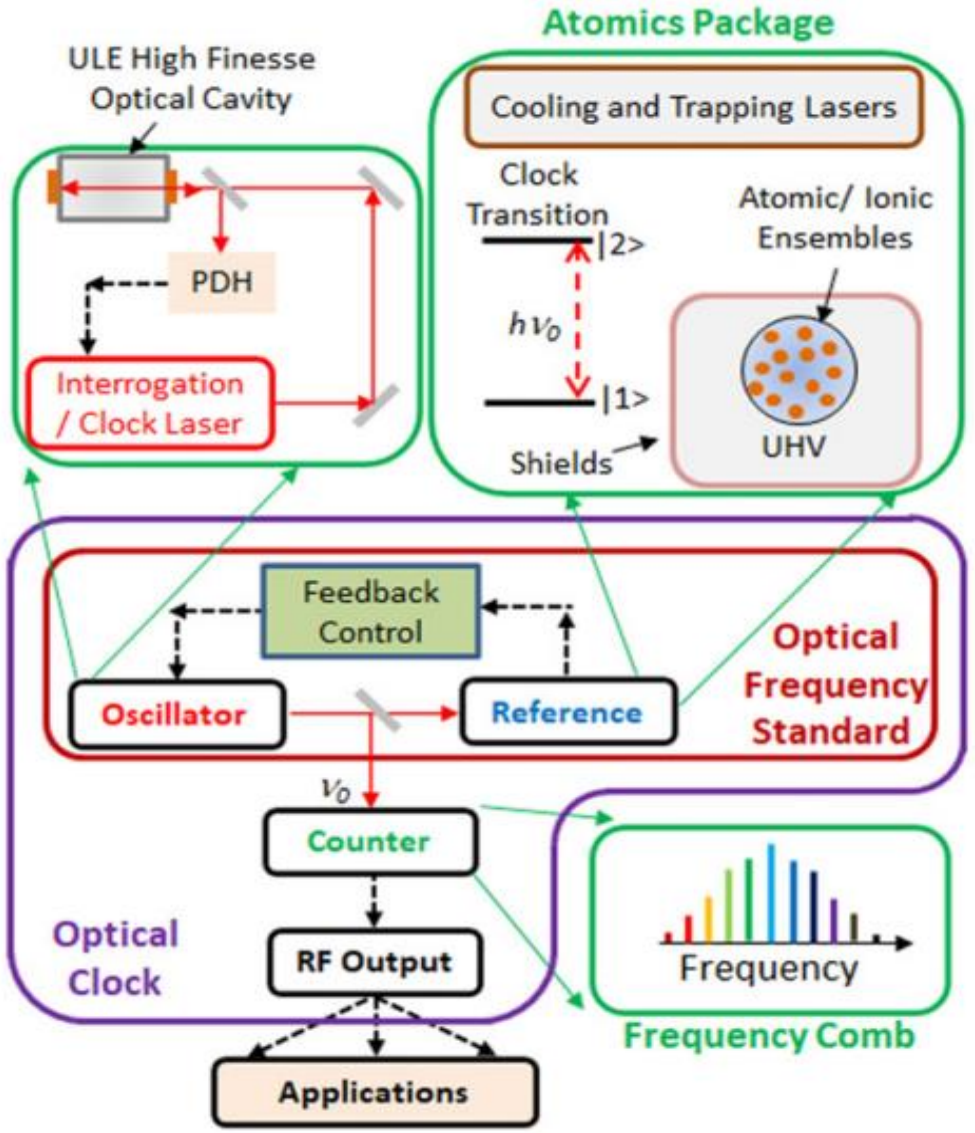
Copenhagen University

Nicolaus Copernicus University

University of Amsterdam

(*Consortium Lead*)

Ingredients of Clock

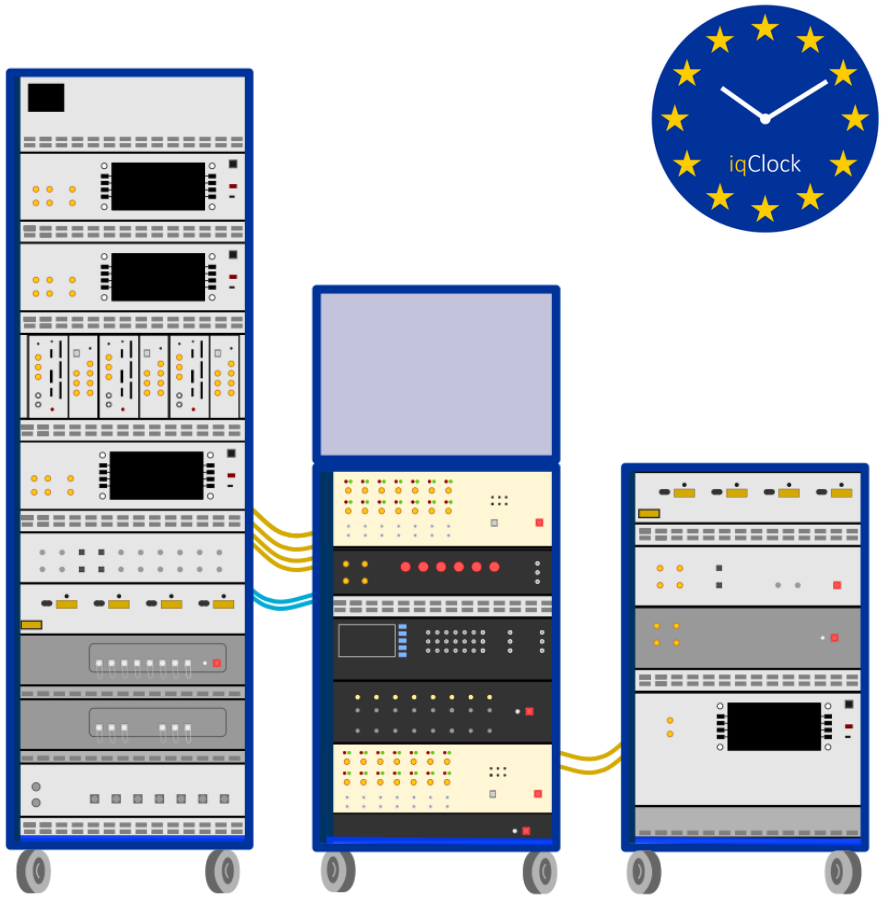


Yogeshwar B Kale *et al* 2022 *Quantum Sci. Technol.* **7** 045004

What the Industry Clock will look like:

Rack-based System: an artistic Illustration of the System Layout

Laser systems including clock laser provided by Toptica Photonics



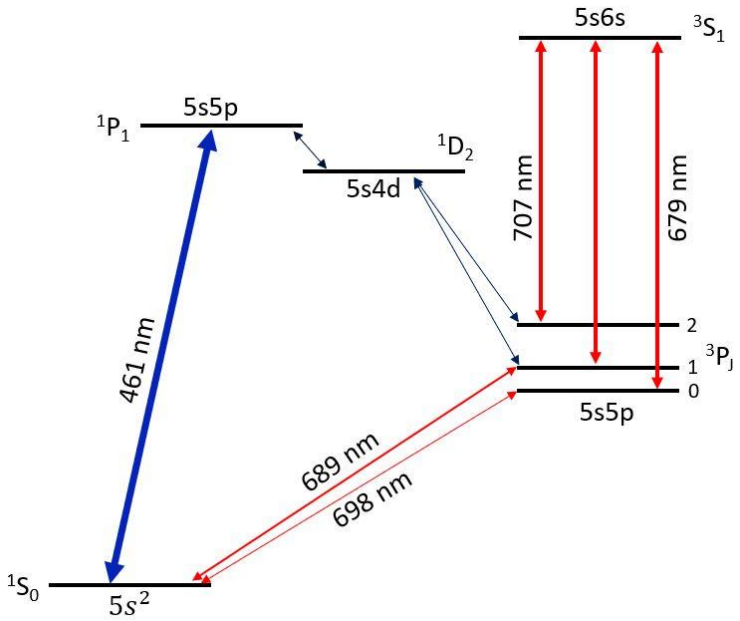
Science package, Control systems provided by Te2v

Light distribution provided by UoB

Fibre links provided by NKT Photonics

Frequency Converter provided by Chronos

Laser systems



Cavity locked clock laser

Clock laser locked DFC *or* RF synthesizer locked DFC

DFC locked 461 nm (M)

DFC locked 689 nm (M)

DFC locked 813 nm

461 nm (M) locked 461 nm (S)

689 nm (M) locked 689 nm (S)

Repump laser 707 nm

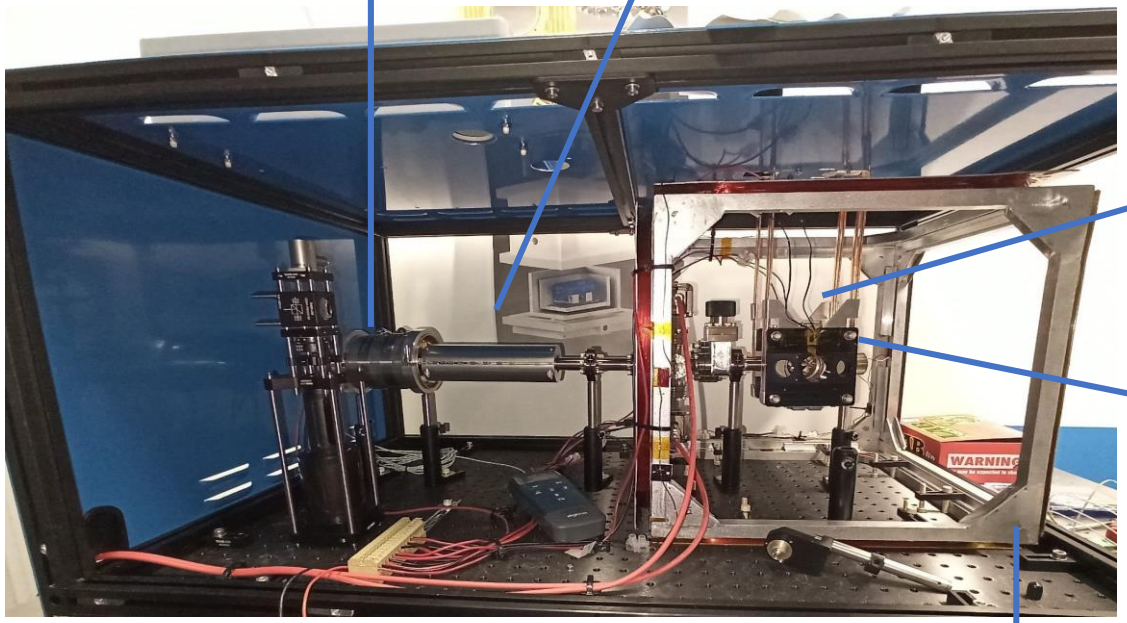
Repump laser 679 nm

All the laser frequencies can be monitored at on wavemeter and/or Toptica DFC.

Physics Package

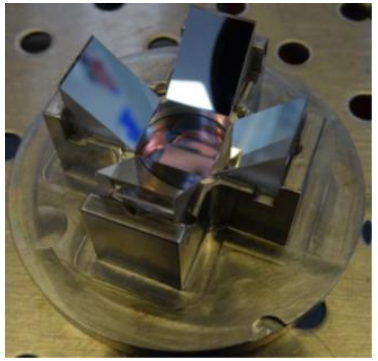
Sr Dispensor

Permanent magnet based Zeeman slower

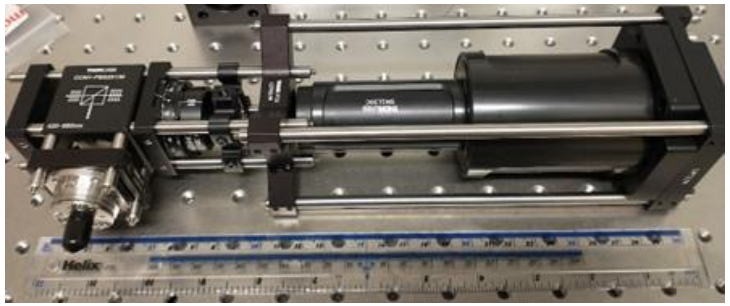


Physics Package

Compensation Coils



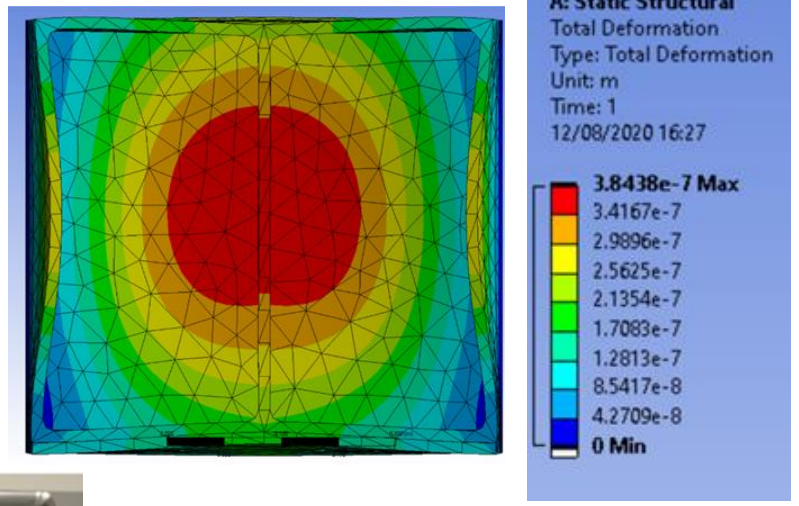
Pyradimidal MOT setup inside science chamber

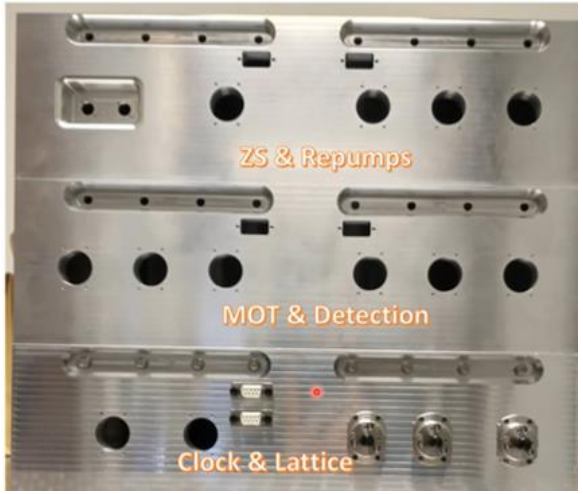


Cage-mounted telescope

Compact vacuum system with pyramid MOT setup including a permanent-magnet Zeeman slower, oven with beam collimator, and heat pipe assisted thermal management; light delivery via cage-mounted telescopes.

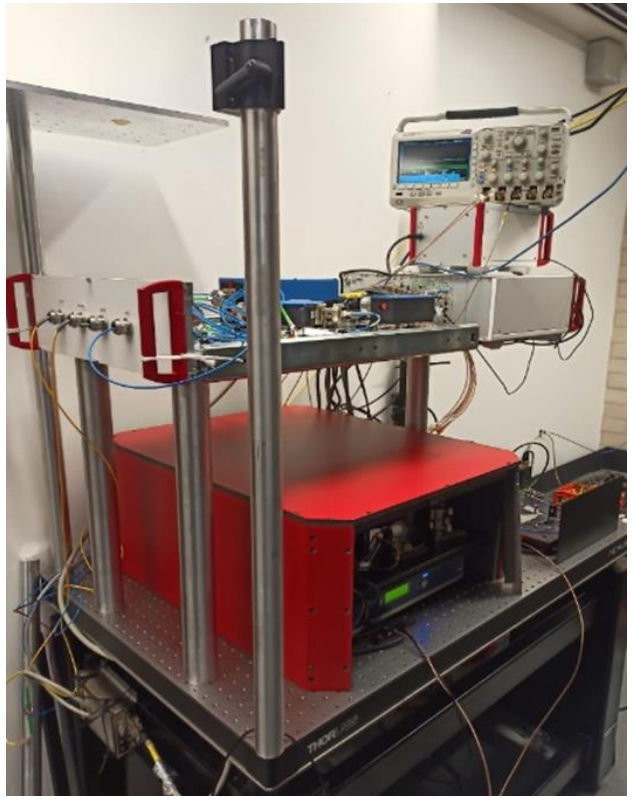
Light Distribution Unit (LDU)





Optimised rack-drawer based design (<0.4um/g peak deformation) interfacing with the Laser System (optical input), Computer Control (control input), and Physics Package (optical output) as part of the system integration approach

Clock Laser



A rack-drawer based laser system and an ultra-stable cavity with a stability of 3×10^{-15} over 1 s averaging time

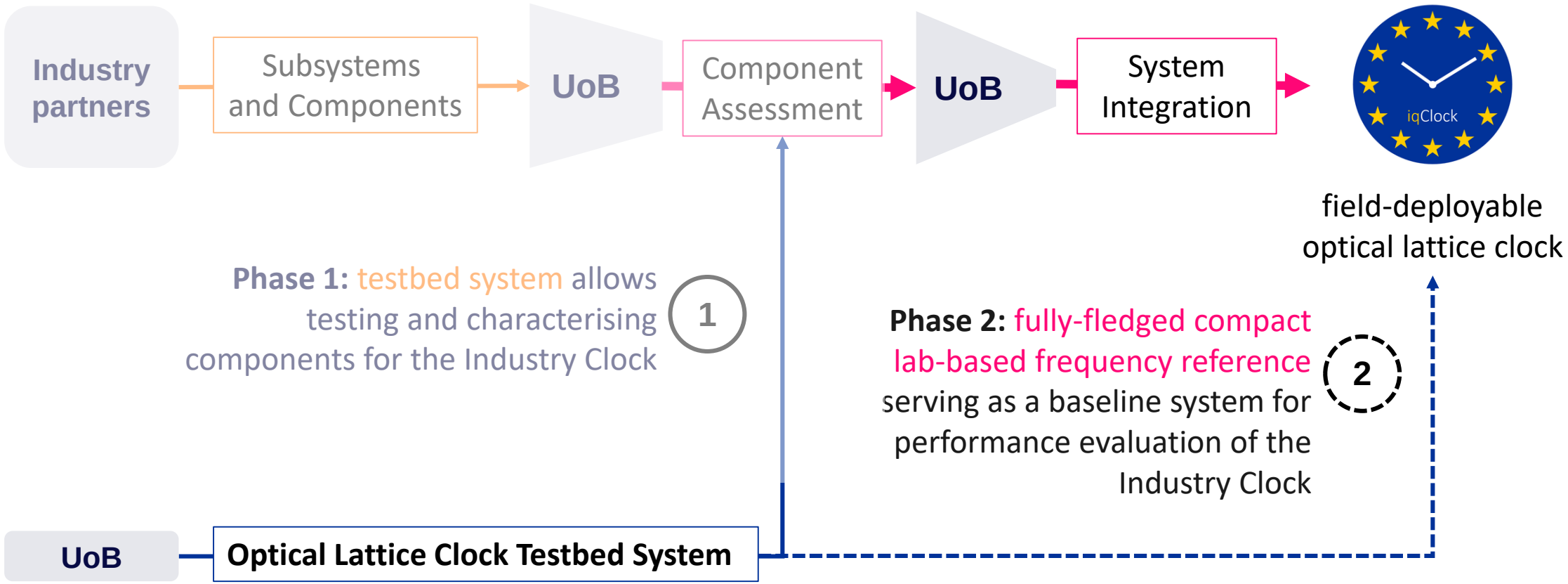
Computer Control

Provides control input to the LDU and the Physics Package and comprises TTL, RF, and analogue signals as well as power management and interfaces for signal outputs from the Physics Package

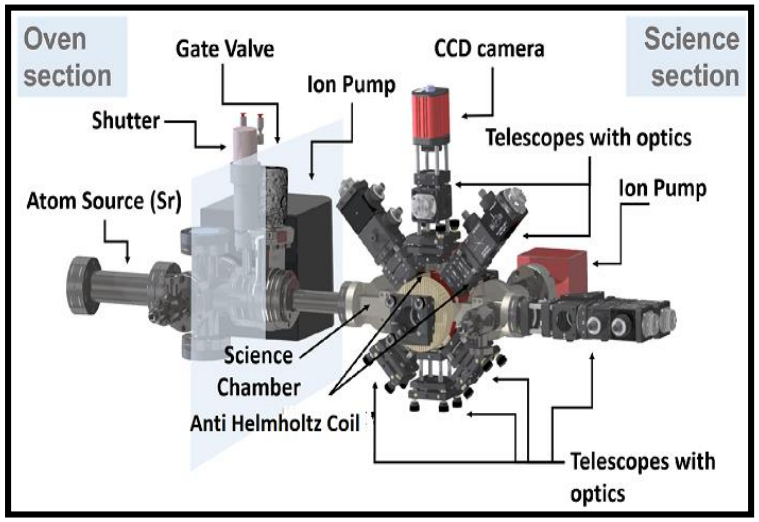
UTC Source and frequency down convertor

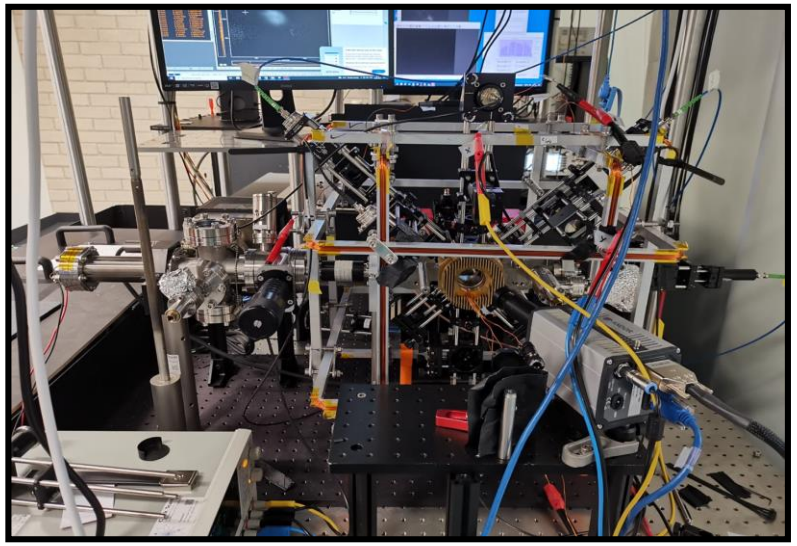
Frequency converter module developed by Chronos

What about the Testbed System?



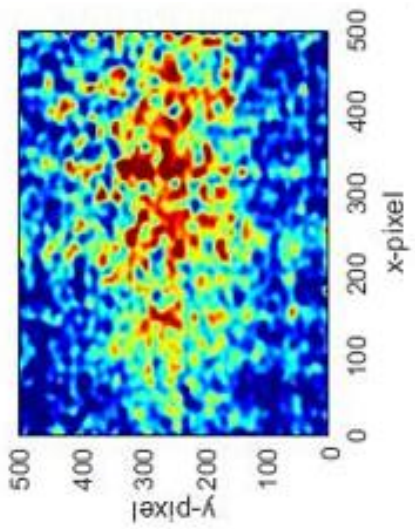
A quick look at test-bed system





- Two-section UHV System with MOT chamber.
- Magneto-optical trapping system.
- Beam delivery optics.
- Computer control (Labview Based).

Atoms in optical lattice for ^{88}Sr



Lattice Hold Time = 50 ms

Beam Waist = 30 µm,

Beam Power =750 mW

Grating-MOT

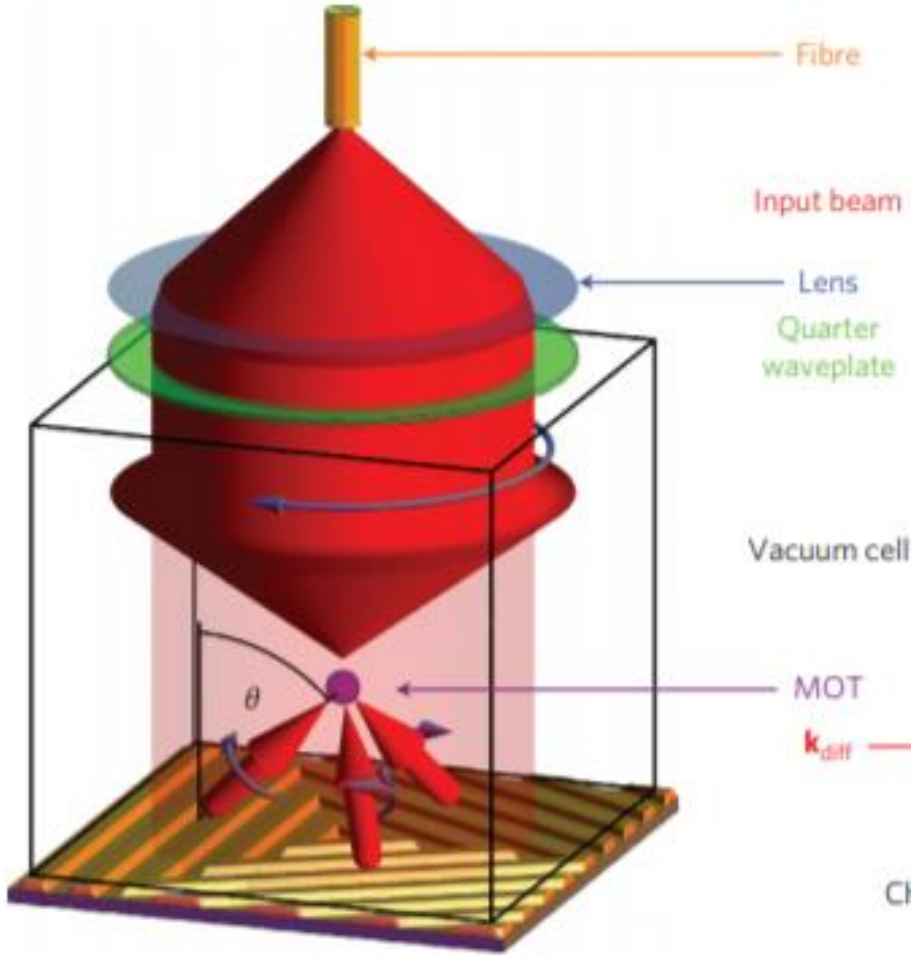
UK Research and Innovation

UNIVERSITY OF BIRMINGHAM

KELVIN NANOTECHNOLOGY

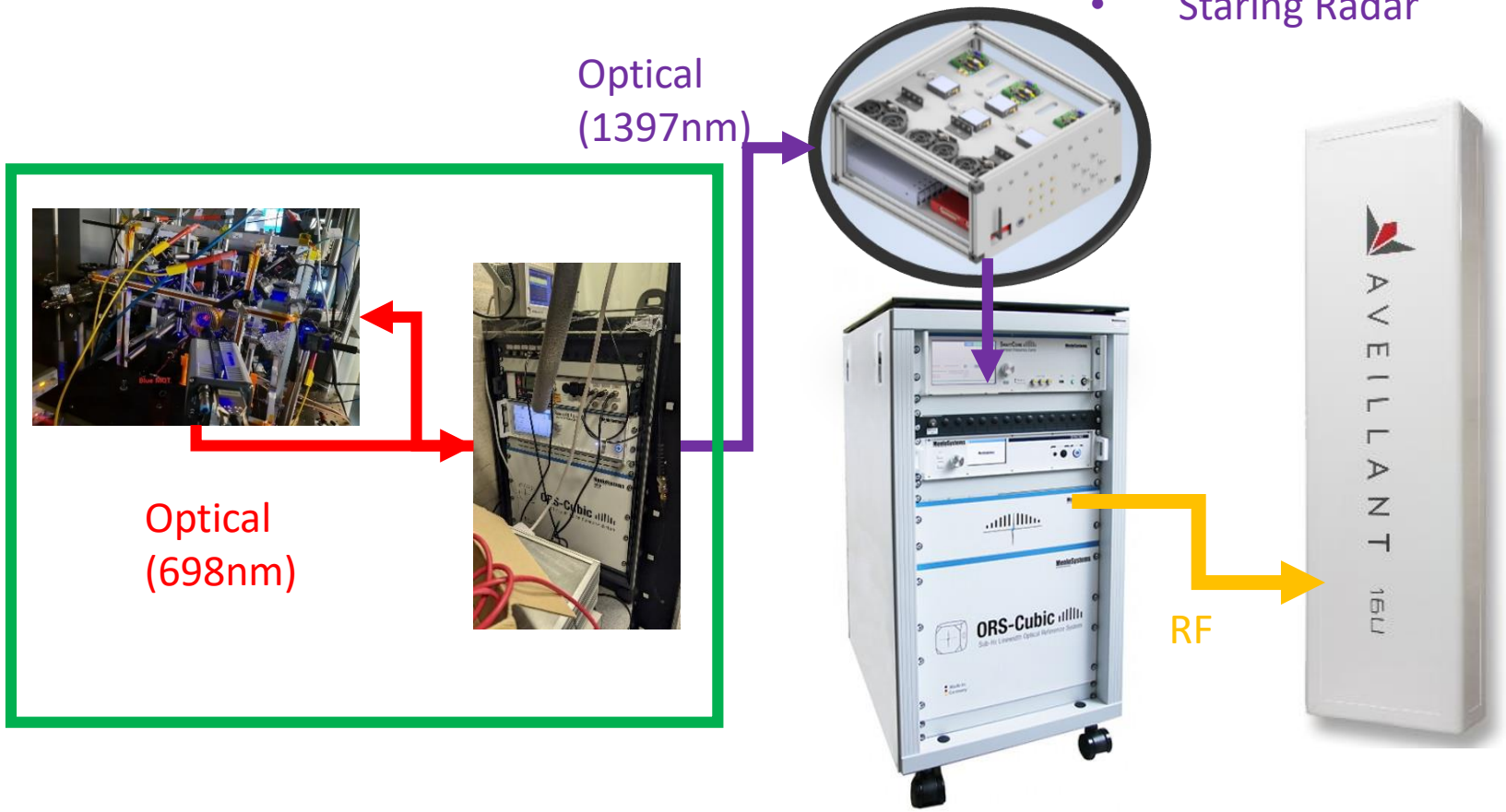
wideblue
making technology happen

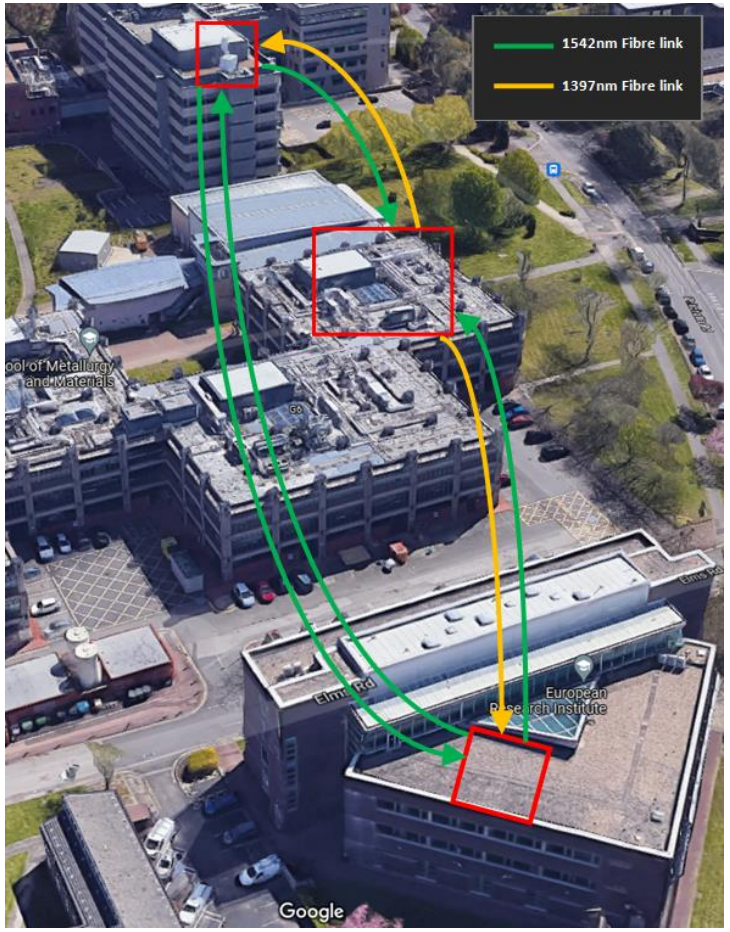
University of Strathclyde Glasgow



Quantum Enabled Staring Radar

- Quantum Oscillator & Transfer Laser - Optical
- Phase-noise stabilised Fibre
- Interface Node to Slave MGU to QT Oscillator
- Menlo MGU Frequency Comb: RF external reference
- Radar interface for External RF reference
- Staring Radar





High stable Quantum oscillator => Ultra low phase noise Staring Radar

Thanks!