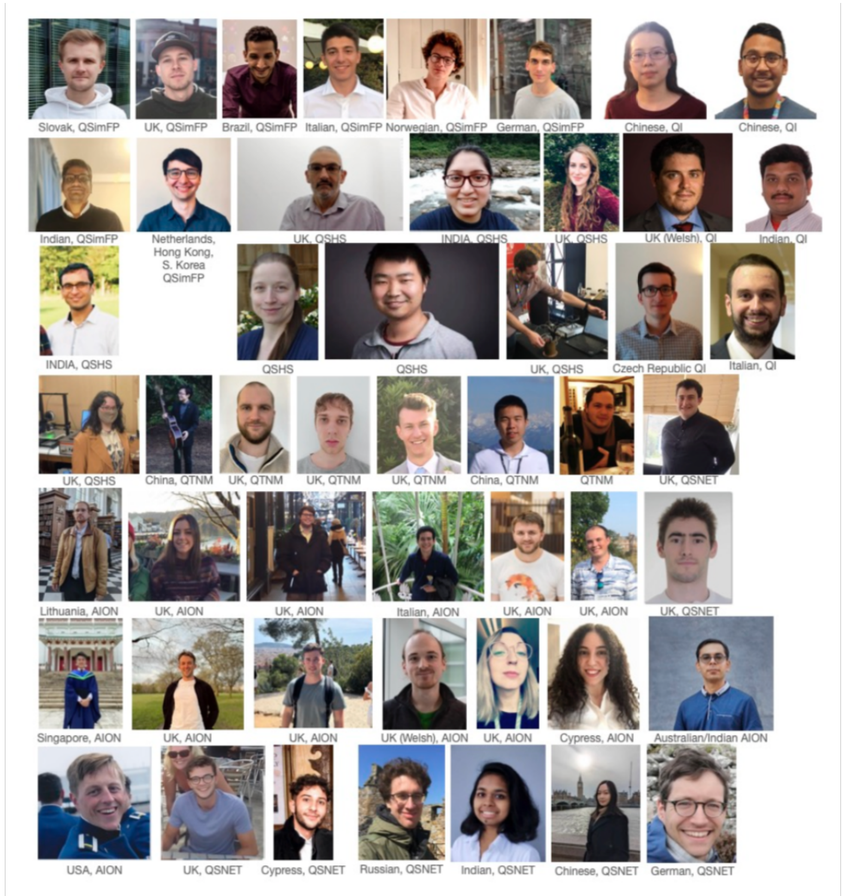
Quantum Technologies for Fundamental Physics

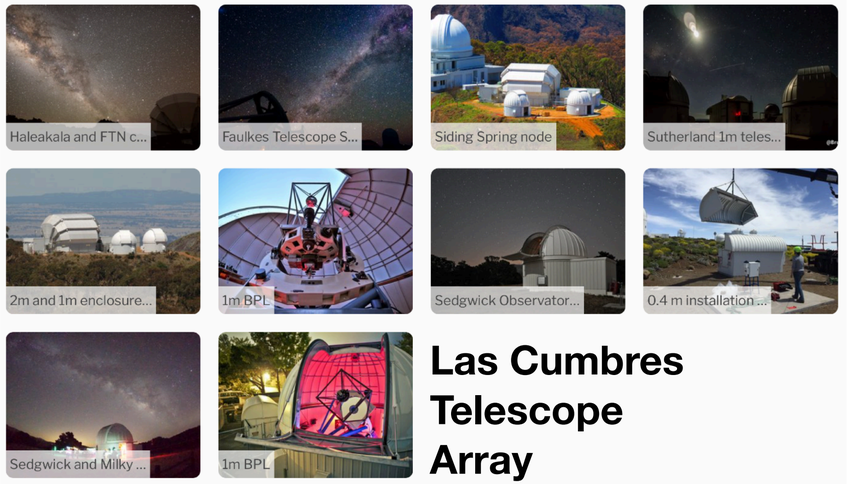
Ed Daw, The University of Sheffield
Principal Investigator-Quantum Sensors for the Hidden Sector

UK Particle Physics Community Meeting, Birmingham University, 6th July 2023



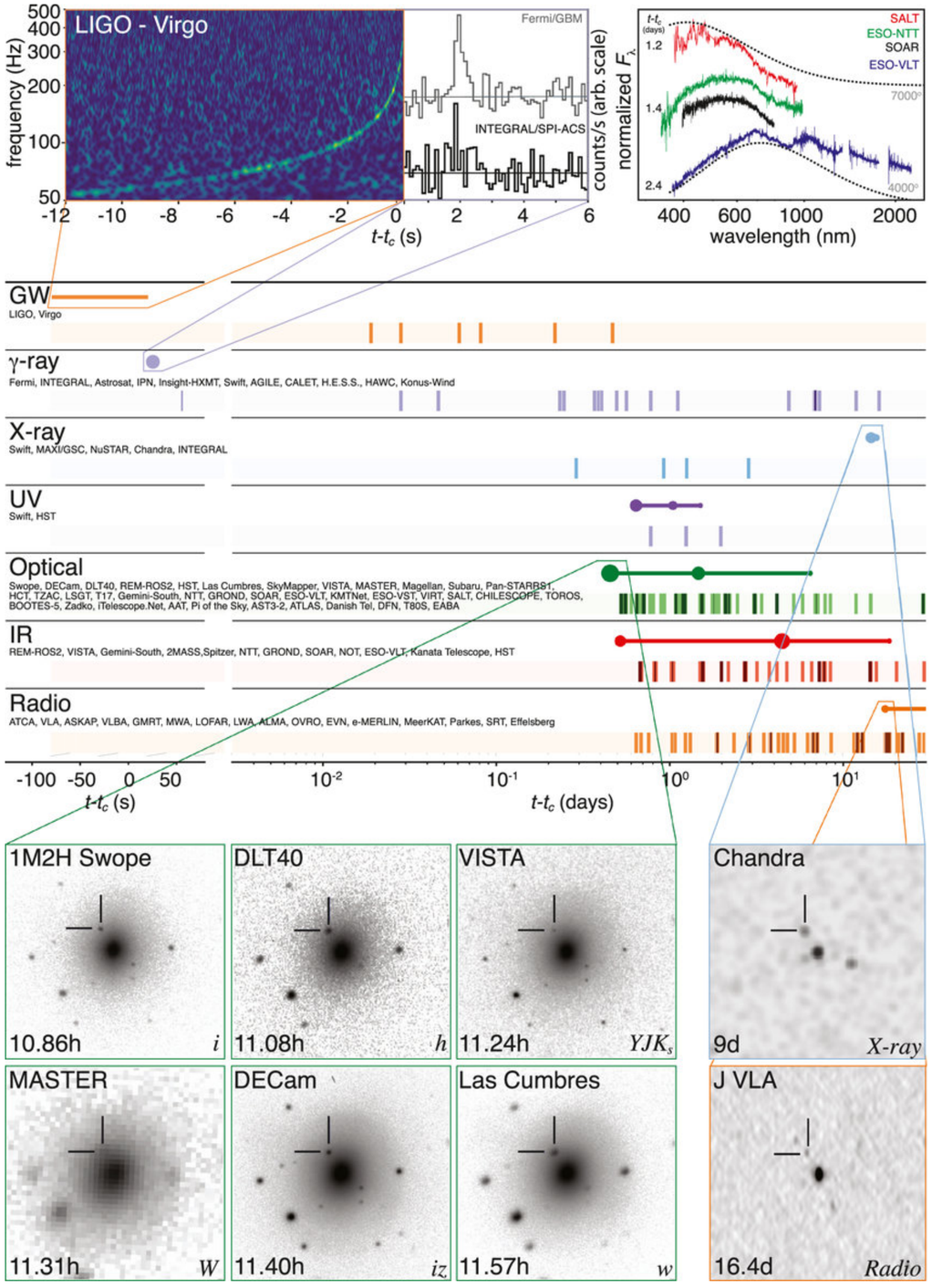
Multi-messenger astronomy

GW170817



Las Cumbres Telescope Array

- **Short Hard GRB**
- **Kilonova**
- **Origins of Elements heavier than iron**



Quantum Technologies for Fundamental Physics

Multi-Messenger Particle Physics!

QSimFP - PI Silke Weinfurtner - analog **Lab simulation of complex systems** with vortices in liquid helium.
QI - PI Hartmut Grote - Laser interferometry for **ALP dark matter, GW, spacetime quantisation** research.
QSHS - PI Ed Daw - Axion, **Hidden sector dark matter** search with quantum electronics. **(ADMX)**
QTNM - PI Ruben Saakyan - **Neutrino mass** measurement with cyclotron radiation **(Project 8)**
AION - PI Oliver Buchmueller - Ultra-sensitive interferometry with atomic beams for **GW, ALPS (MAGIS)**
QSNET - PI Giovanni Barontini - Network of ultra-precise clocks **probing fundamental constants**.
QUEST-DMC - PI Richard Haley - **Particle dark matter search with liquid helium 3**

PLUS, 17 other smaller scale funded research projects

Vortices in Superfluid Helium 4

Precision tabletop optical interferometry

Ultra-low-noise microwave sensing of microwaves

Qubit detectors

Photon counting, sub-standard-quantum-limit detection

Atom interferometry

Neutrino mass direct measurements using Cerenkov radiation

Neutrino mass direct measurements using Cerenkov radiation

Precision atomic clocks, new clock technology

Liquid Helium 3 'Universe in a lab'

Theory of low-energy states adjacent to the vacuum

Discussion points

- We are in an era of uncertainty in particle physics. Nobody knows where the next new physics will manifest itself.
- In this context, it makes sense to try many new things.
- Particle physics will benefit from closer association with other research areas.
- Quantum sensing is a neighbouring field with many commonalities with high energy physics and particle physics.
- Government has just committed £2.5B over 10 years to quantum. However, this money has to fund the whole national quantum technology programme.
- There is currently no guaranteed funding for QTFP projects beyond March 2025.
- Young scientists thinking about entering the field can be hesitant because there are no assurances of future viability of the field. This is a problem.
- In the background, the whole of the PAAP portfolio (within STFC core) currently receives 3-4% of the STFC budget - funds at least 5 whole research fields.
- Finding a more assured funding route for QTFP, and improved support for particle astrophysics in general, will nurture a growing and exciting field, and greatly increased discovery potential for new physics.