Slide1.
Thank you for the opportunity to present the proposal on the determination of the absolute neutrino mass with quantum technologies. This proposal was put together by a very diverse community that included experts from neutrino physics, cold atoms and quantum optics and quantum sensors.

Slide2.
Determination of the absolute neutrino mass is one of the most pressing questions in modern particle physics.
The plots on the slide show the current best constraints on the neutrino mass. Cosmology provides powerful constraints on the sum of neutrino mass eigenstates while the electron neutrino mass is constrained by studying the end point b-decay, which is the only model independent method to measure the neutrino mass.
There are two clear sensitivity goals, 50 meV for the inverted ordering and 9 meV for the normal ordering. Even if nature chose the worst case scenario the electron neutrino mass cannot be smaller than 9 meV. This is a unique situation that has motivated this proposal.

Slide 3.
Studying the end-point of tritium beta-decay to measure the neutrino mass has a long history. The current state of the art is represented by the KATRIN experiment employing an electrostatic retarding potential technology. This technology cannot explore the region below 0.1 eV. An alternative approach is a Cyclotron Radiation Emission Spectroscopy (CRES) pioneered by the Project-8 experiment. Here tritium is magnetically trapped and the energy measurement is replaced with a frequency measurement of the cyclotron radiation emitted by electrons in a magnetic field. This approach has a number of key advantages that may allow the ultimate 9 meV resolution to be reached. However, significant challenges must be overcome. One needs to move from molecules to atoms and trap 10^20 of them. The magnetic field must be known with a sub-ppm precision. Quantum limited microwave detection systems and accurate modelling must be developed. All this provides a perfect match to existing UK expertise in quantum technologies and is the subject of this proposal.

Slide4.
The proposal is subdivided into five interconnected work packages with the aim to build, commission and run CRES Demonstration Apparatus (CRESDA for short) that would operate with Deuterium atoms but will be Tritium ready. The goal is to experimentally demonstrate the performance and scalability of the technique to the ultimate sensitivity of 9 meV.

Slide 5.
CRESDA will be built and commissioned at UCL and will consist of a Deuterium atom source on the left, a 36 stage Zeeman decelerator to cool D-atoms to below 1K and a magnetic trap with an antenna array that will couple the cyclotron radiation signal with a microwave detection system shown in the next slide.
The concrete goals of the 3 year proposal are to demonstrate feasibility of trapping unprecedented number of Deuterium atoms (up to 10^14) in a 1L trap, map the B-field uniformity in the trap with a sub-ppm precision, model D and T-atoms behaviour in the trap and ultimately to demonstrate the scalability to the necessary number of tritium atoms.

Slide 6.
In order to reach the challenging resolution and ultra-low noise requirements for millimetre-wave detection in the range of 25-30GHz a 3 stage quantum limited CRES detector will be developed as part of WP4 consisting of either SQUID or Josephson junction based preamplifier, a cryogenic amplifier and a room temperature readout electronics. To push the energy resolution even further a technique based on a single electron captured in a planar Penning trap, known as geonium atom will be explored. The readout and signal processing will be optimised using methods developed in WP1.

Slide 7.
Finally a brief outlook into the future. We have established closed connections with the Culham Centre for Fusion Energy, one of very few sites in the world licensed for handling tritium. They expressed strong interest in hosting a major basic science project in their recently approved H3AT facility. The proposal also received a strong endorsement from the Project-8 and KATRIN collaborations.
If the 3 year project proposed here is successful the next step we envisage is to move CRESDA to Culham and to commission the apparatus with tritium.This will also allow us to probe a neutrino mass with a competitive sensitivity and to pave the way to a full proposal by a large international collaboration for a groundbreaking experiment that could be hosted on the UK soil.