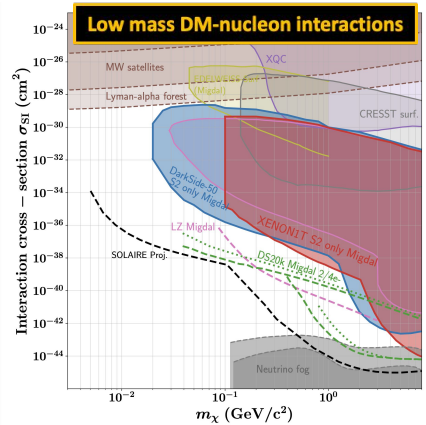
SOLAIRE

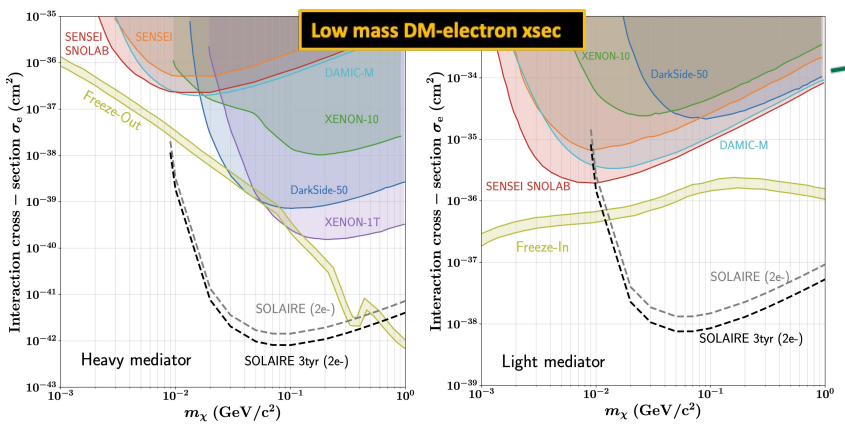
UK ESPPU Input to Nov. 4 Drafting Session
Oct. 21, 2024

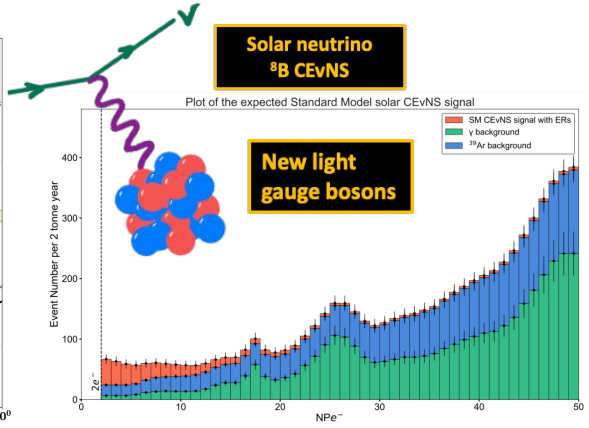
SOLAIRE: Key Physics Deliverables

Summary of key physics deliverables and comparison to current state-of-the-art (1 yr of running):

- SOLAIRE will enable dark matter discovery in the challenging MeV–GeV mass scale (nucleon-DM scattering) and keV–MeV mass scale (electron-DM scattering) well beyond any other running or currently-funded project.
- Pathfinder for novel neutrino instrumentation - combined charge and light measurement – and in-situ background measurements relevant for future experiments using membrane cryostat technology (i.e. expanding DUNE science reach)
- New physics searches with precision measurement of low-energy solar neutrinos (non-standard neutrino–nucleon interactions++)







List the project's main advantages compared to competitor projects:

- Purpose-designed detector to reach down to 2-electron threshold, reaching 0.025 keV recoil energy threshold for detected scatters.
- Small detector, pivoting on existing technology: construction to operation *in the UK* on short timescales.
- World-leading physics reach achieved with 1 year of data-taking.
- Opportunities for upgrade to experimental platform for enhanced sensitivities following initial run (targets, sensors).

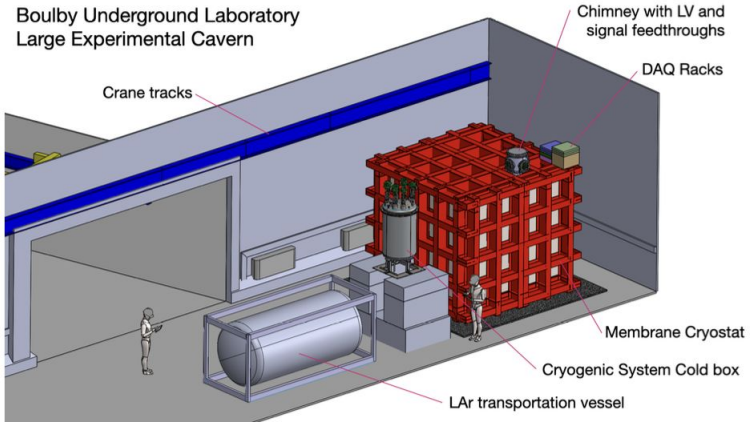
Main risks/obstacles for realisation of physics goals: control / modelling of low-energy spurious electrons, and material background targets.

SOLAIRE: Location / Timeline / Prioritisation

Location for the project:

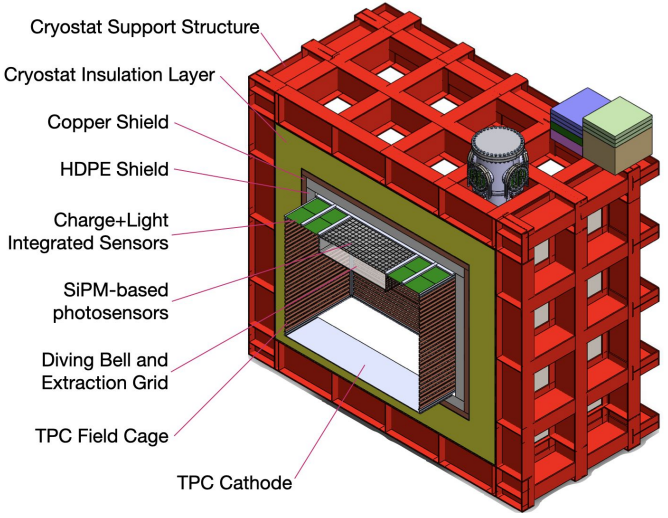
SOLAIRE is proposed for the Boulby Underground Laboratory, UK.

- A number of countries/sites (Canada, Italy, China) have expressed a desire to host such a low-mass dark matter LAr observatory.
- The UK will be the host of this internationally competitive experiment, uniquely bringing together the liquid argon dark matter and neutrino communities, if UK funding is secured.
- Following SOLAIRE's science run, this will be a unique infrastructure to host the international community's underground liquid noble detector R&D, strongly connected with the Liquid Detectors DRD Collaboration



Timeline:

2025–2027	Construction
2027	Outer Detector commissioning
2028	Inner Detector installation/commissioning
2029–2030	Calibrations and physics runs
2030+	Potential upgrades + additional physics runs



Prioritisation:

- SOLAIRE is supported as the next LAr DM detector focused on low-mass dark matter searches by the Global Argon Dark Matter Collaboration.
- SOLAIRE is supported by the SoLAr Collaboration.
- SOLAIRE has received funding via the Boulby Development Study, and positive endorsements from STFC PPAP, PAAP, and the STFC Dark Matter Oversight Committee.

SOLAIRE: UK Involvement

Area(s) of UK involvement

UK leads the project with the support of the Global Argon Dark Matter Collaboration and the SoLAr neutrino/sensor collaboration.

- UK would act as **host site**, with **top-level WBS responsibilities** in the international project, which has attracted proposal signatories from 29 institutions in 10 countries. UK **deliverables**: infrastructure, TPC, readout components, DAQ.

Total number of FTE /year required for construction/operation. What is the expected UK FTE?

25 UK PIs and 19 international PIs (+ more anticipated if positive funding decision) + anticipate PDRA/Engineer/Tech averaging 13 FTE/yr for construction/operation from the UK + similar investment from international partners.

Estimate of financial costs (provide separate numbers for R+D phase, construction phase and operations phase)

Current estimated costs are a total £11M (£10M UKRI-STFC contribution) for capital and personnel, including construction (£9.5M) and operations (£1.5M), inclusive of

- procurement of underground argon from GADMC at cost of extraction,
- cryostat/cryogenics design/construction from CERN Neutrino Platform/GTT,
- with in-kind contributions from international partners.

Does your project plan dedicated submission(s) for the ESPPU?

SOLAIRE will submit input to ESPPU as the UK realisation of a global desire for construction of a dedicated liquid-argon-based low-mass dark matter observatory.

Main message for UK input *to ESPPU*: contributions of the CERN Neutrino Platform to cryostats, detectors and prototyping is important!

SOLAIRE: Environmental Cost Estimates

Environmental cost of operation per year (in units of tonnes of CO_2 equivalent):

- Primary impacts due to cryogenics system (1.2 kW) and electronics/DAQ/online computing systems (0.8 kW) for a 2 kW total draw. With the conservative assumption of 100% up-time, using the conversion of 0.2071 kg CO_2e per kWh, this results in an estimate of 4 t/y CO_2e.

Environmental cost of construction (in units of tonnes of CO_2 equivalent):

- Not yet quantified at this time. The project construction requires no new excavation, no new buildings, and transportation of detector components is by ship (underground argon target) and truck (within the UK).