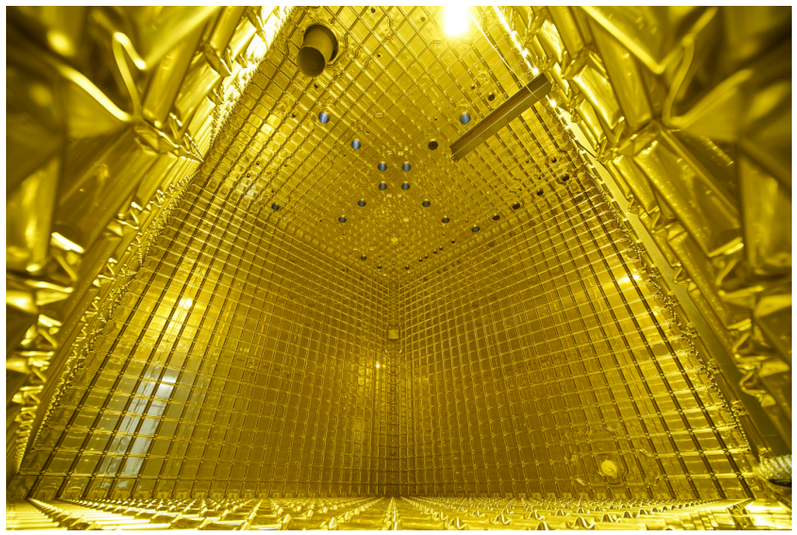
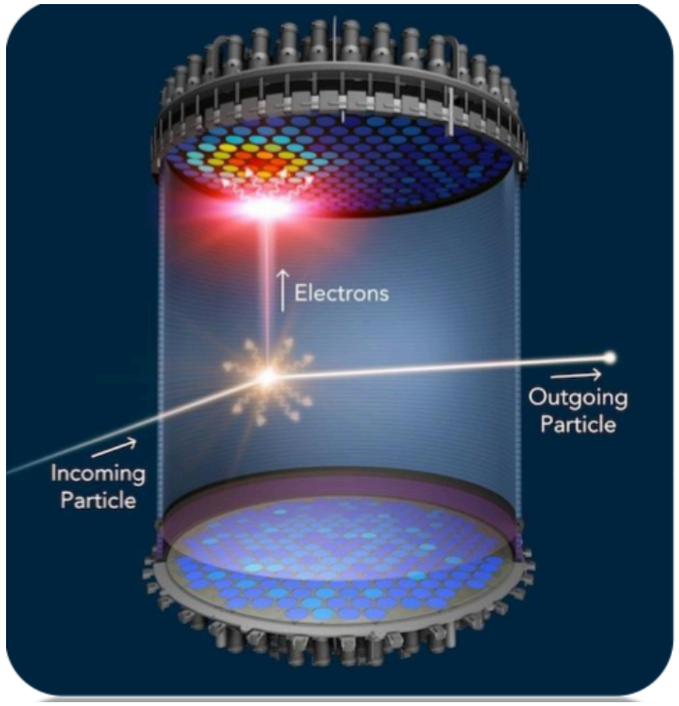
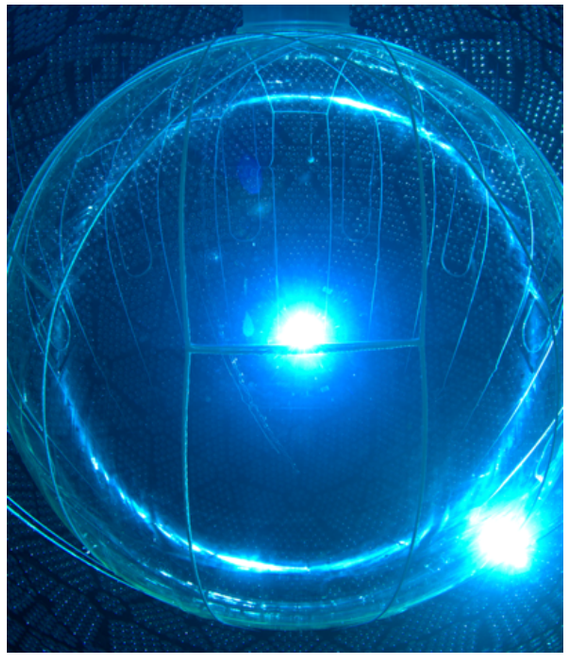






DRD2: Liquid Detectors

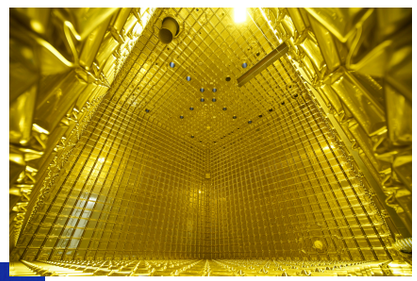
Jocelyn Monroe
Roxanne Guenette
(ECFA TF2 Conveners)

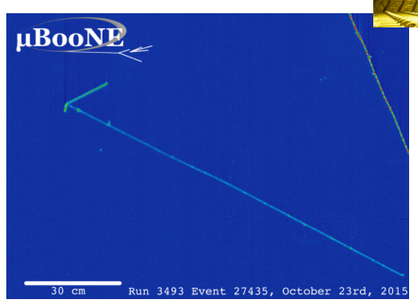
21 February 2023

The Science covered

Neutrinos

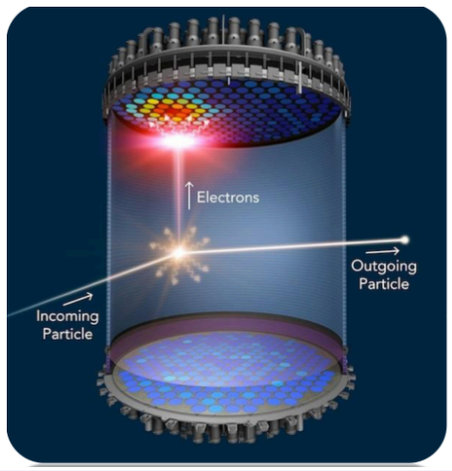
- Oscillation precision measurements (δ_{CP}, mass ordering, θ_{23} octant, sterile νs)
- Neutrino interactions (from CEvNS to DIS)
- Astro neutrinos





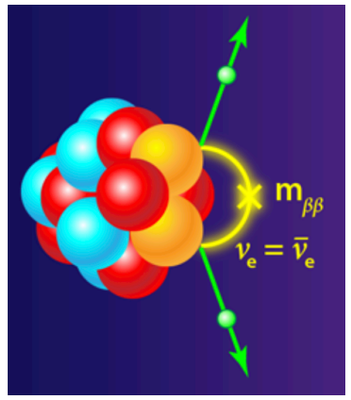
Dark Matter

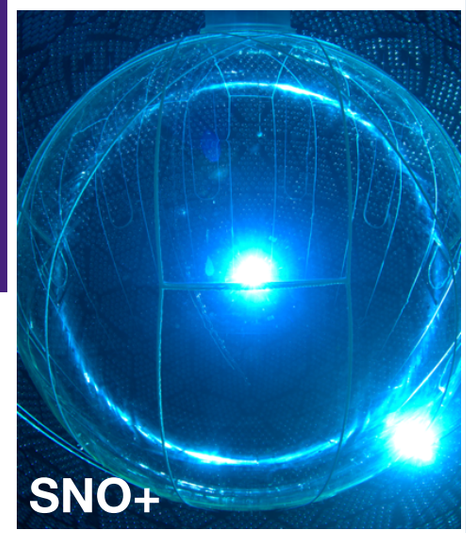
- Direct detection (WIMPs, …)

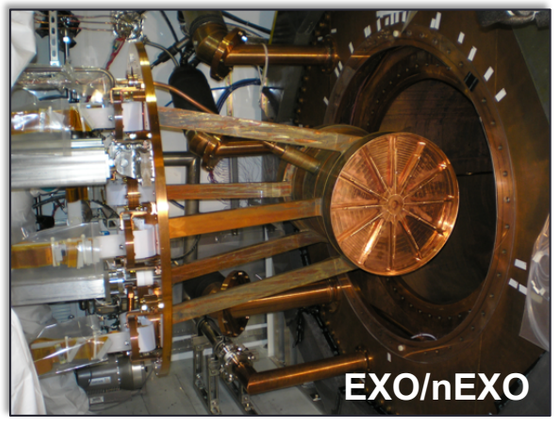


0νββ

- Search for Majorana neutrinos







The Physics Needs (high level overview)

Neutrinos

- **Push Energy thresholds down** to ~1MeV to enhance oscillation physics, supernovae νs study, to enable solar νs …
- **Unambiguous readout**
- **Scalability**

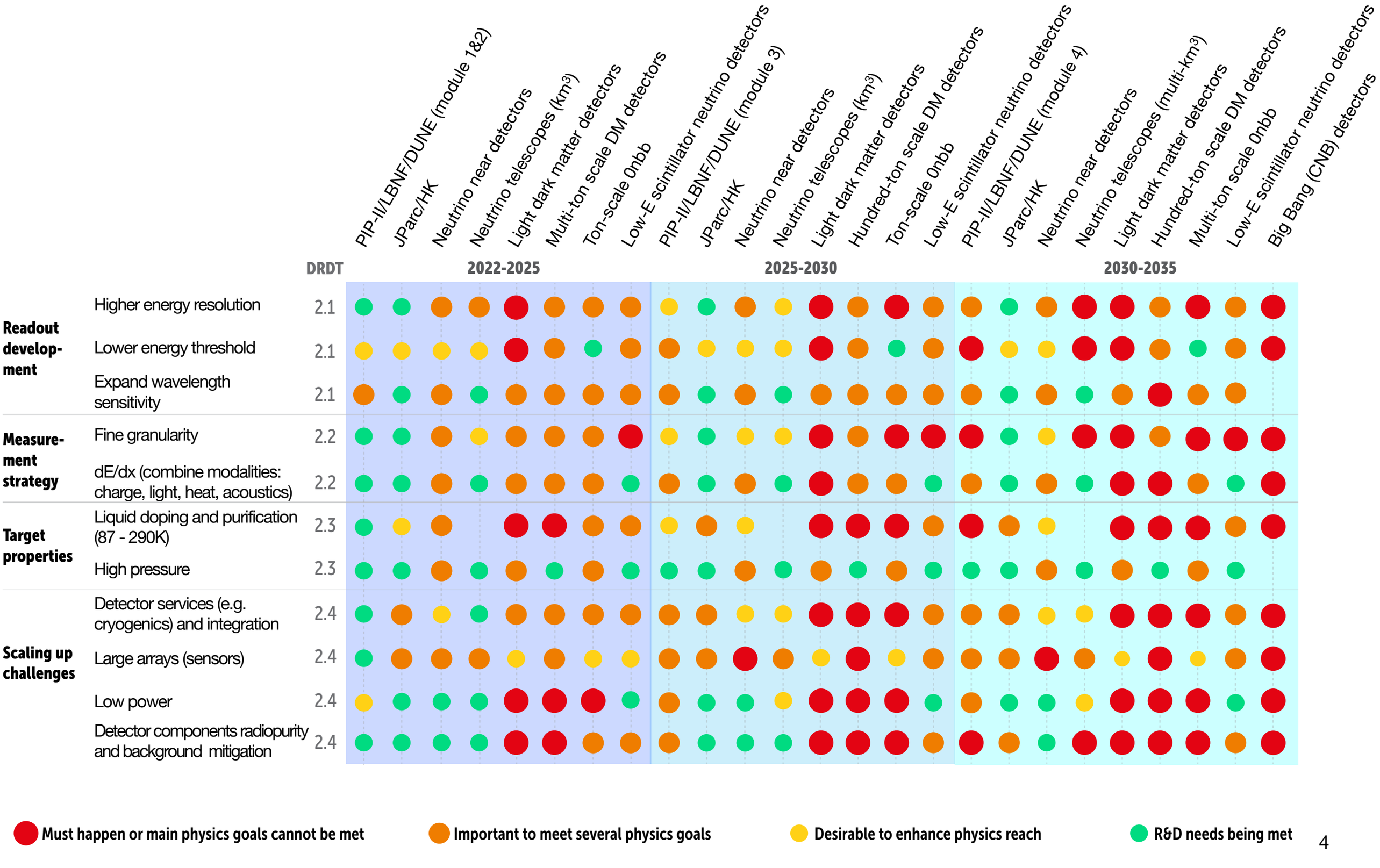
Dark Matter

- **Push Energy thresholds down** to 1 meV/10 eV/1 keV to enable low mass DM/1 GeV DM/ WIMPs.
- **Reduce background rates**
- **Scalability**

0νββ

- **Improve Energy Resolution** to sub-% FWHM
- **Reduce background rates**
- **Scalability**

R&D Roadmap for TF2



DRD2: Liquid Detectors Activities

ECFA R&D Roadmap: https://indico.cern.ch/e/ECFADetectorRDRoadmap

Apr.'21: TF2 Symposium https://indico.cern.ch/event/999815/
197+5 registered to list (used for subsequent mail distribution)

…Roadmap drafting…

Sept.-Dec.'22: Community input questionnaire, to
(i) develop the work packages of the Liquid Detectors RD Collaboration Proposal, and
(ii) invite participation in proposal-drafting team

- announced on all previous email lists, advertised at LIDINE (Sept.'22) and DUNE Module of Opportunity workshops (Nov.'22) and via ECFA: https://indico.cern.ch/event/957057/page/21912-questionnaires
- 49 responses, of whom14 willing to serve on proposal-drafting team

Dec.'22: mini-workshop of proposal-drafting team to develop collaboration proto-structure based on community inputs

Jan.'23: meeting of proposal-drafting team to define proposal structure, following ECFA Steering Group guidance

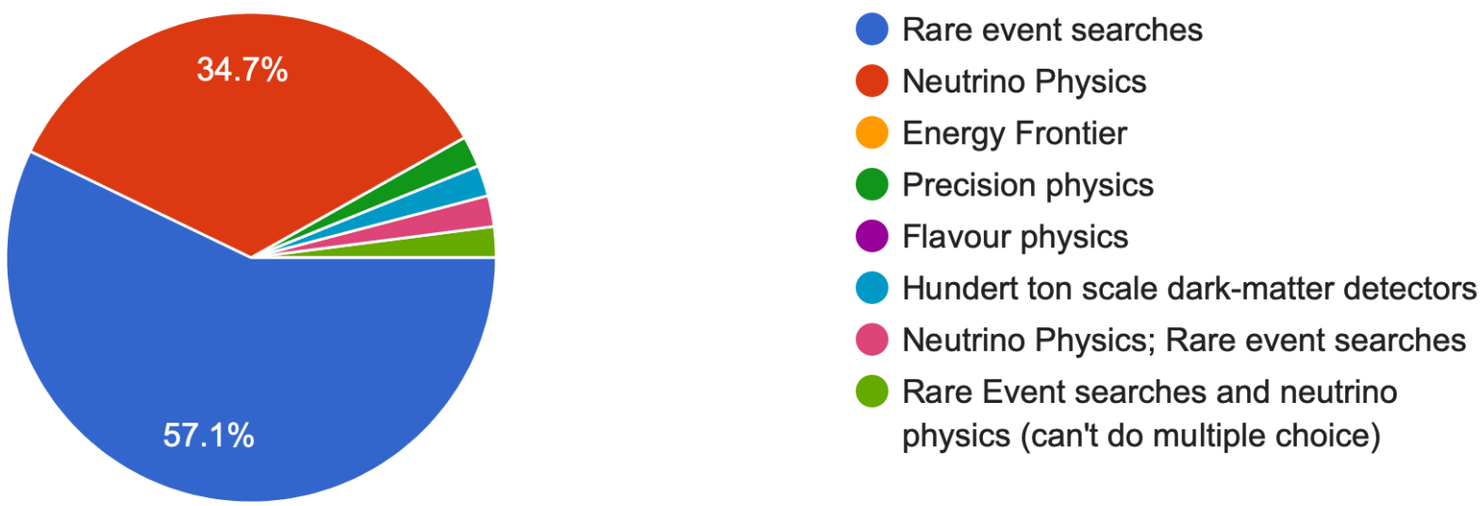
Feb-Mar.'23: …proposal drafting…

Apr.'23: plan 2nd community workshop

Community Survey Outcomes

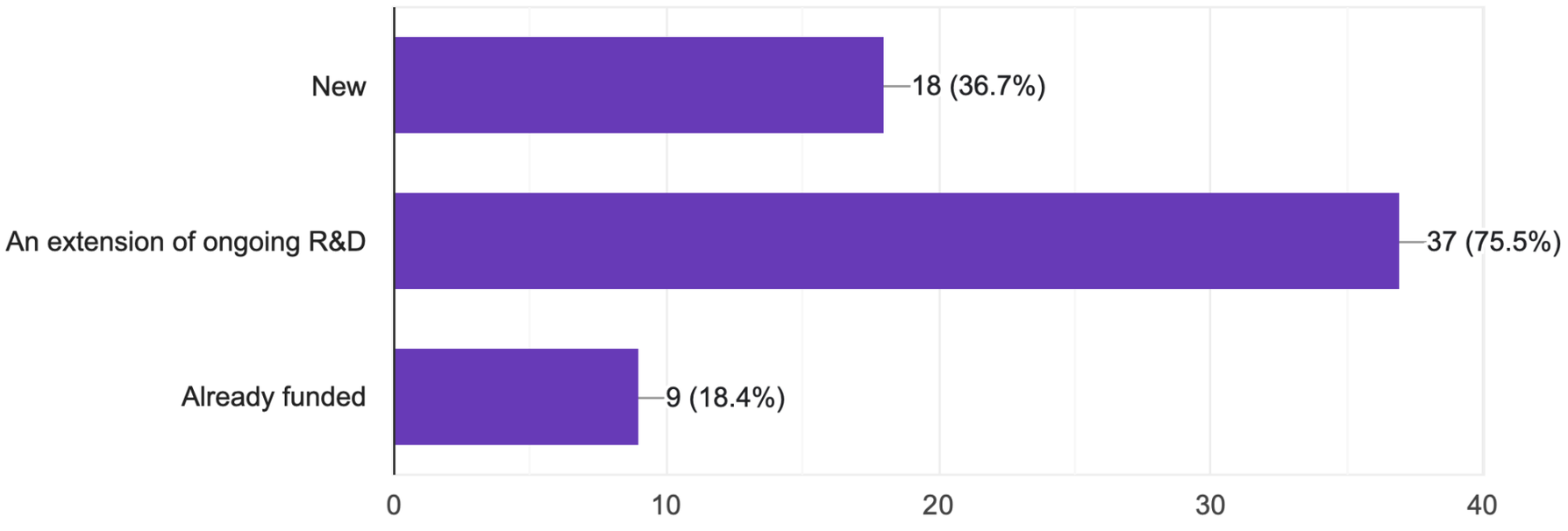
What physics areas does your R&D address?

49 responses



Is your R&D activity

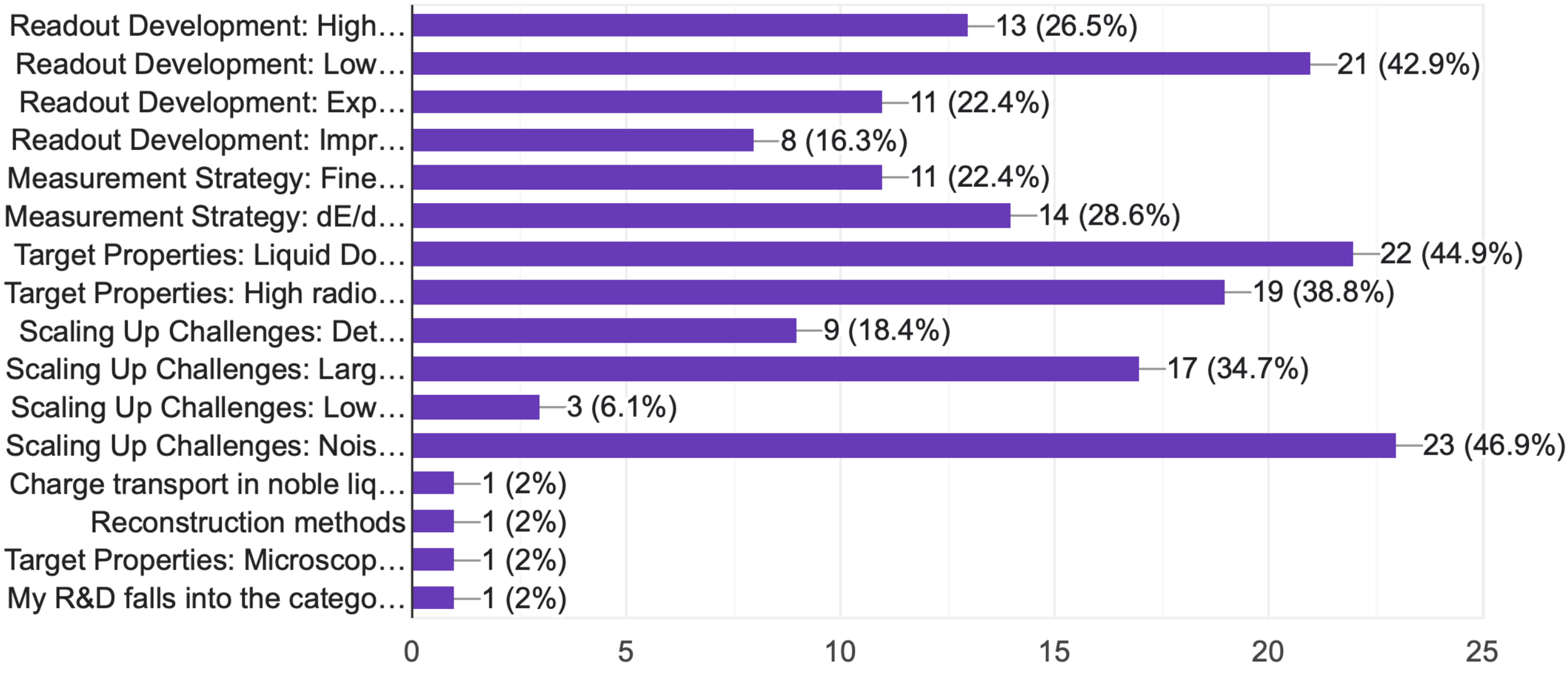
49 responses



Community Survey Outcomes: DRDTs

Under which Detector R&D Theme(s) would your R&D activities fall? Please refer to the Roadma
document for more details on the definition of DRTDs (link).

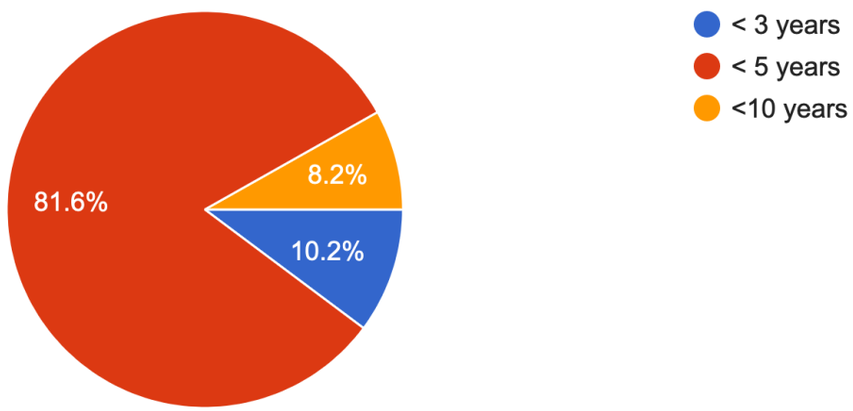
49 responses



Community Survey Outcomes: Type of activity

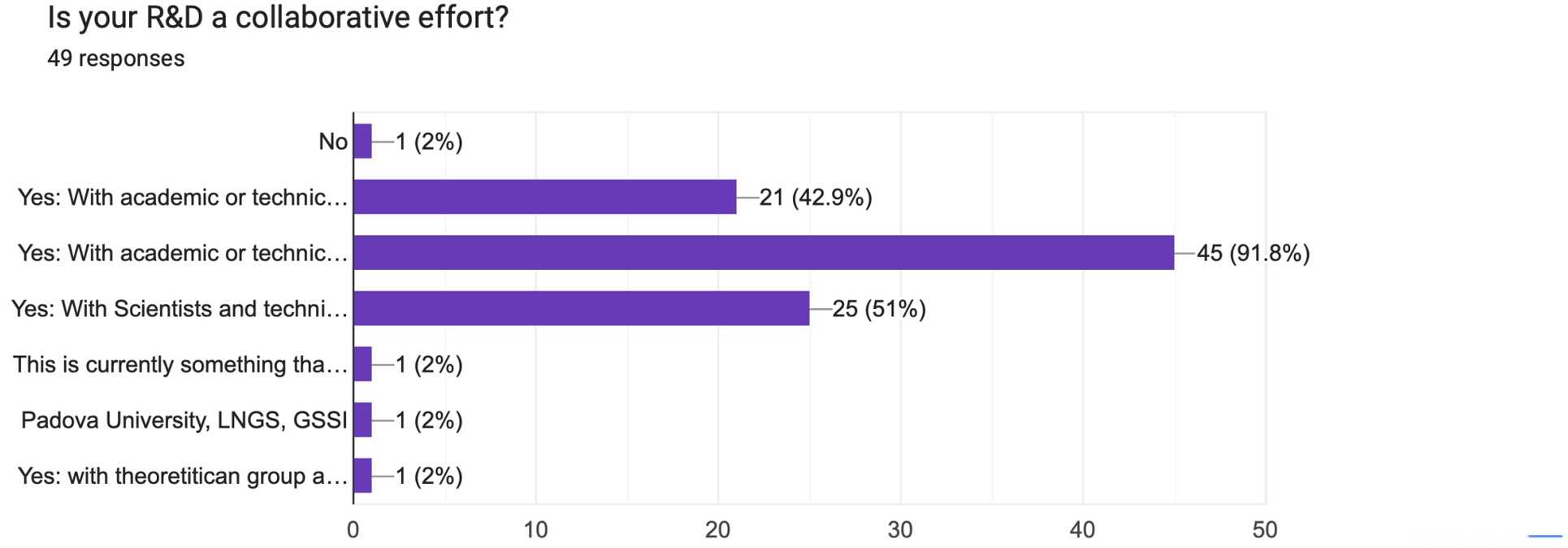
How long do you expect this particular R&D activity to last for?

49 responses



Is your R&D a collaborative effort?

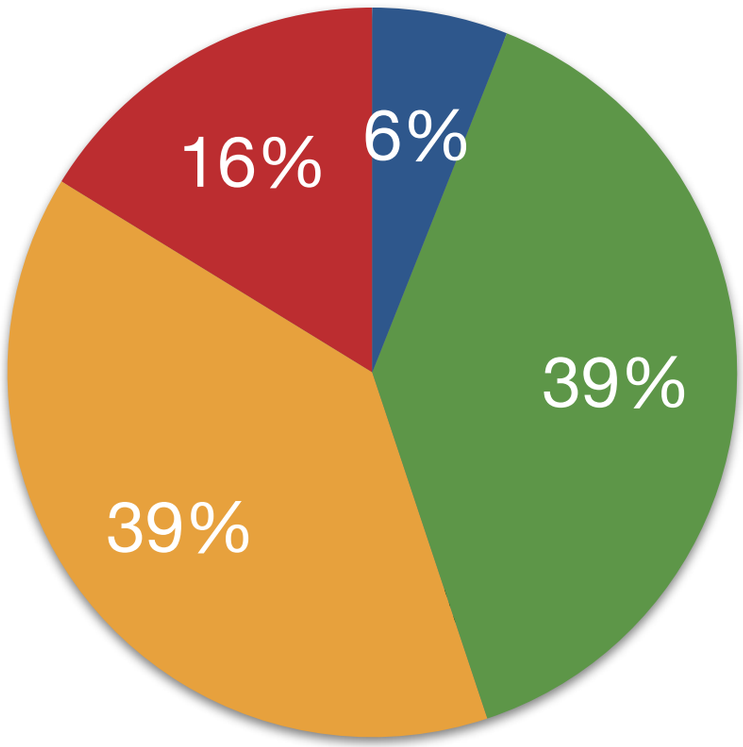
49 responses



Industrial partners?

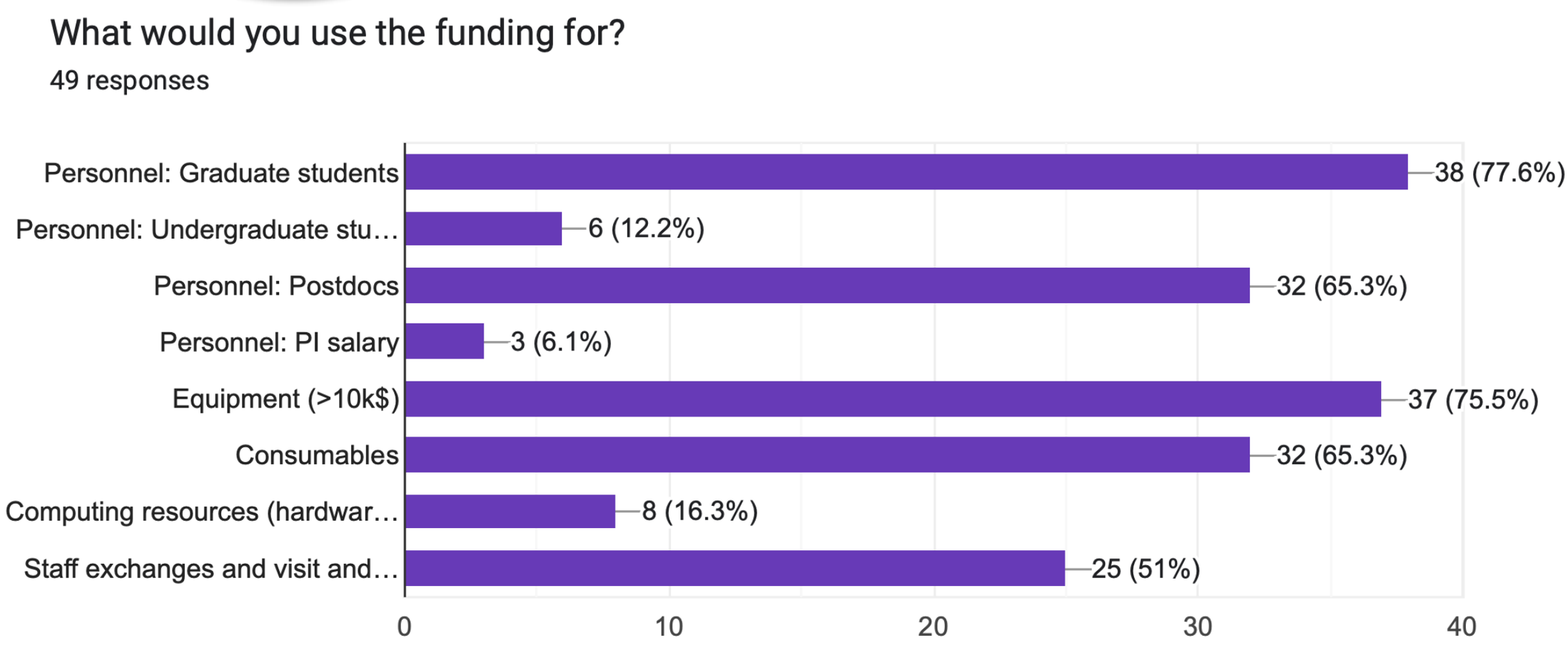
49 responses

Community Survey Outcomes: Budgets



- <50k total:~0.1M
- 50-100k total:~1.4M
- 100-200k total:~2.8M
- > 200k total:~2.0M

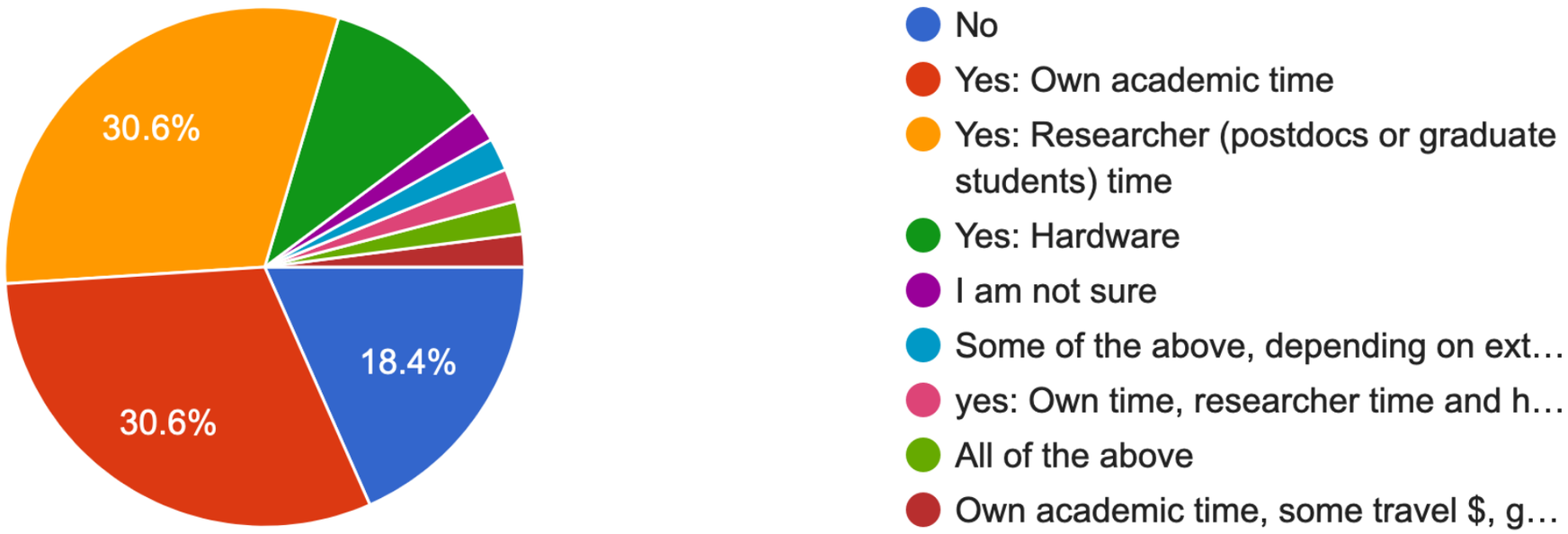
Current total:~5M



Community Survey Outcomes: Matching?

Similarly to the AIDAinnova programme, could there be matching resources from your institute? If yes, what would this be?

49 responses



Current state of the collaboration structure

- Proposal structure with technical area writing leads

WP 1: Charge Readout	WP 2: Light Readout	WP 3: Target Properties	WP4: Scaling-up challenges
1.1: Pixels J.Asaadi (US) R. Guenette (UK)	2.1: Increased sensor QE J. Monroe (UK)	3.2: Doping & isotope loading A. Zeni (Italy) H. Steiger (Germany)	4.2: Radiopurity & bkg mitigation Roberto Santoreli (Spain) Potential UK leader
1.2: Amplification A. Diesting (Germany)	2.2: Higher efficiency WLS/collection M. Kuzniak (Po) J. Martin-Albo (Spain) C. Cuesta (Spain)	3.1: Purification W. Bonivento (Italy) A. Goretti (Italy)	4.1: Material properties No representation Potential UK leader
1.3: Ion detection No representation	2.3: Electronics, readout, integration for cryogenics No representation -> in WP 4.4	3.3: Optimization of light emission & transport *M.Wurm (Germany)* *S. Schoppman (Germany)* *Potentially UK leader*	4.3: Detector & target procurement/production W. Bonivento (Italy) M. Yeh(US)
1.4: Dual (charge + light) E. Gramellini (UK) J. Asaadi (US)	2.4: Improved sensors for LS/Water M. Bongrand (France) T. Lachenmaier(Germany)	3.4: Microphysics & characterization *M.C. Piro (Canada)*	4.4 Large-area (light) readout I. Gil-Botella (spain) J. Crespo (Spain) G. Fiorillo (Italy)
1.5: Charge to light K. Mavrokoridis (UK)			

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Lots of UK involvement. More welcome!

UK Potential TF2 R&D Infrastructure: SOLAIRE

- Preliminary Infrastructure bid, selected by PPAP/PAAP in 2022 process, to build globally-unique underground liquid detectors R&D cryostat - a la 1/4 ProtoDUNE, in Boulby
  (leads: Price (DarkSide-LowMass), Soldner-Rembold (SoLAR), Monroe (DarkSide-20k))
- Presented at Feb,'22 Boulby Development workshop (slides from D. Price)

The SOLAIRE international project @ Boulby

SOLAIRE: proposed UK-led LAr TPC experimental facility leveraging future instrumentation R&D to probe dark matter & neutrino interactions with world-leading prospects for discovery in late 2020's

☆1 t (fiducial) dual-phase Ar inner TPC (SiPM instrumented) with 15 t outer TPC (charge-pixel readout)

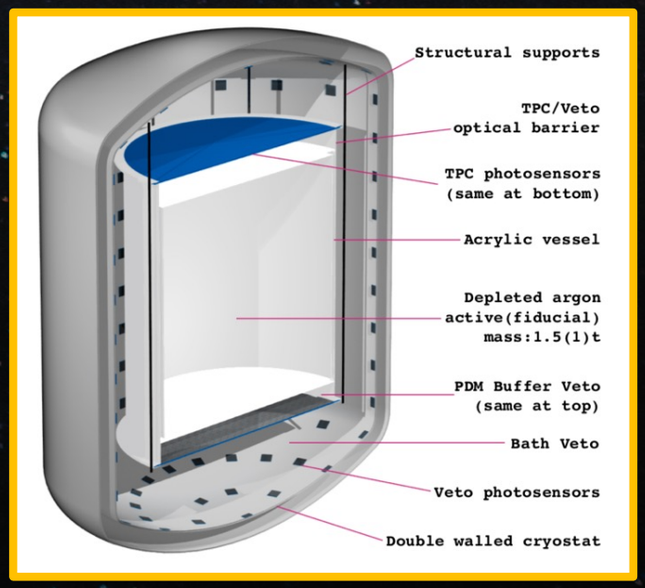
Based on DarkSide-LowMass [arXiv:2209.01177] and SoLAr [arXiv:2203.07501] design proposals.

☆**First phase** (AAr): domestic platform for novel instrumentation development and testing

Leverage world-leading UK silicon detector integration capability for lower-background readout, skills and capability in SiPM readout (DarkSide-20k) and pixelated charge-and-photon sensors (DUNE).

→ **Enable UK leadership in low-background readout for the DUNE low background module.**
→ **Serves as a pathfinder for ARGO technologies with UK spearheading development.**
→ **Demonstrate capability for Boulby to host a next-generation global experiments at multi-ton scale.**

☆**Second phase** (UAr): operation of optimised detector for main science runs, studies with doped LAr



- *16+ UK institutions already on board (Birmingham, Boulby, Daresbury, Edinburgh, Imperial, Lancaster, Liverpool, Manchester, Open University, Oxford, QMUL, RAL, RHUL, Sussex, UCL, Warwick…), with international collaborators in USA, Italy, Poland...*
- *Supported by PPAP and PAAP.*

SOLAIRE Infrastructure

- Underpins UK as an R&D centre at-scale for low-radioactivity, low noise, high quantum efficiency cryogenic sensors for the future of science and industry

Ambitions and milestones: funding needs

☆SOLAIRE Year 1—2 **Need some near-immediate PDRA/Engineering time to begin**

☆Site study; background assessment; preliminary engineering designs; preliminary simulations.

☆Development of international partnerships + UK industrial partners.

☆SOLAIRE Year 2—5 **Estimate total cost £9M (incl. key personnel)**

☆Design, production and assembly of a LAr cryostat with inner/outer volume.

☆Development and demonstration of prototype readouts (SiPM and pixelated charge readout).

☆Installation of a small-scale ultra-low background TPC prototype to study backgrounds.

☆**First physics runs.**

☆Delivery of engineering design for final SOLAIRE experiment.

☆Late 2020's: position to bid host the next scale argon dark matter detector?

☆SOLAIRE Year 6—10 **Estimate total cost (re-using infrastructure) £21M**

☆Delivery of optimised SOLAIRE experiment with readout / doping strategy informed by previous phase.

☆**Main science runs.**