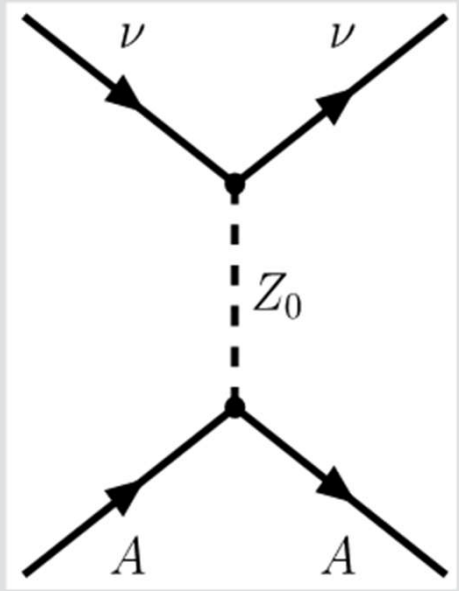
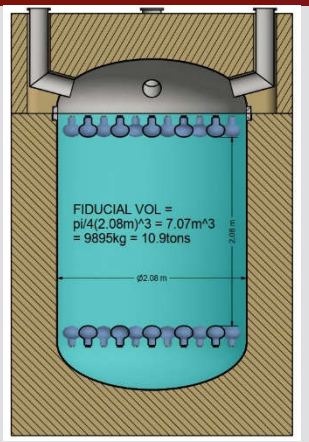
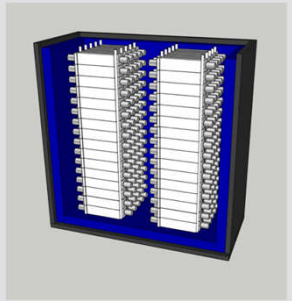
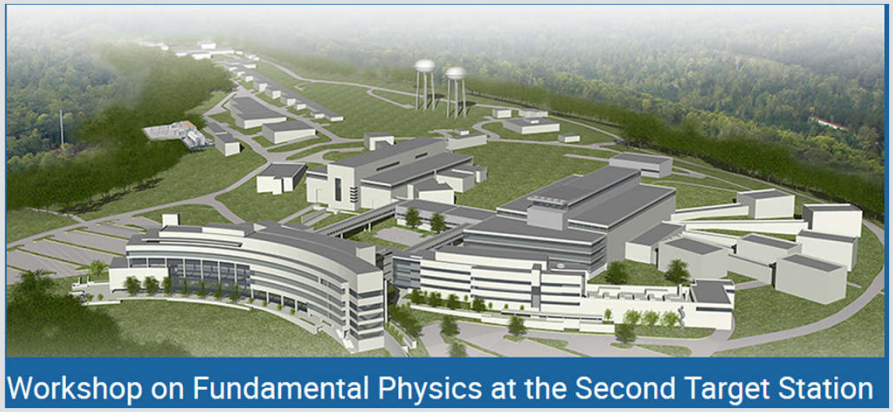
COHERENT: future plans

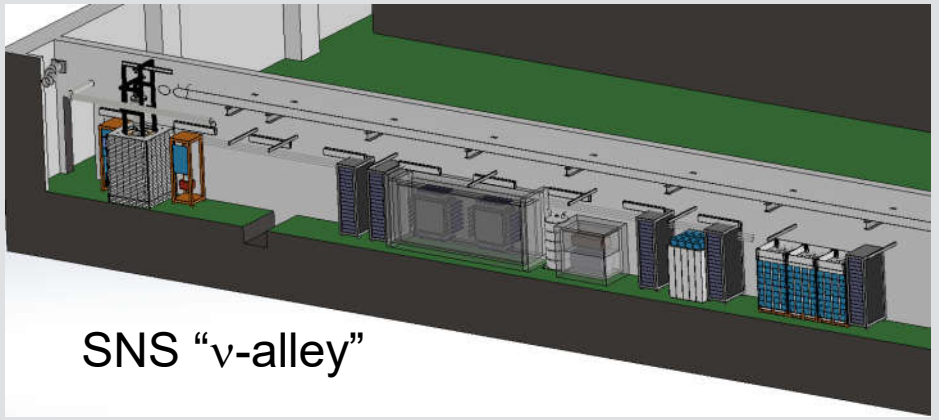
R. Tayloe, Indiana U.
for the COHERENT collaboration
SNS STS workshop, July 2019





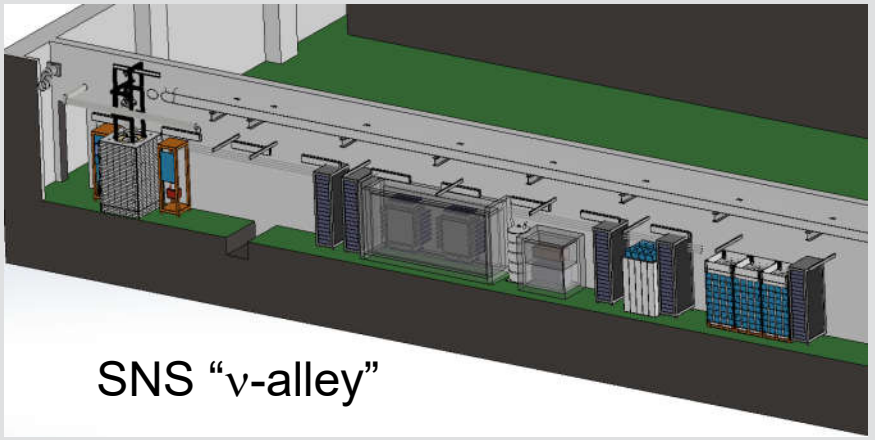



Workshop on Fundamental Physics at the Second Target Station


SNS "ν-alley"

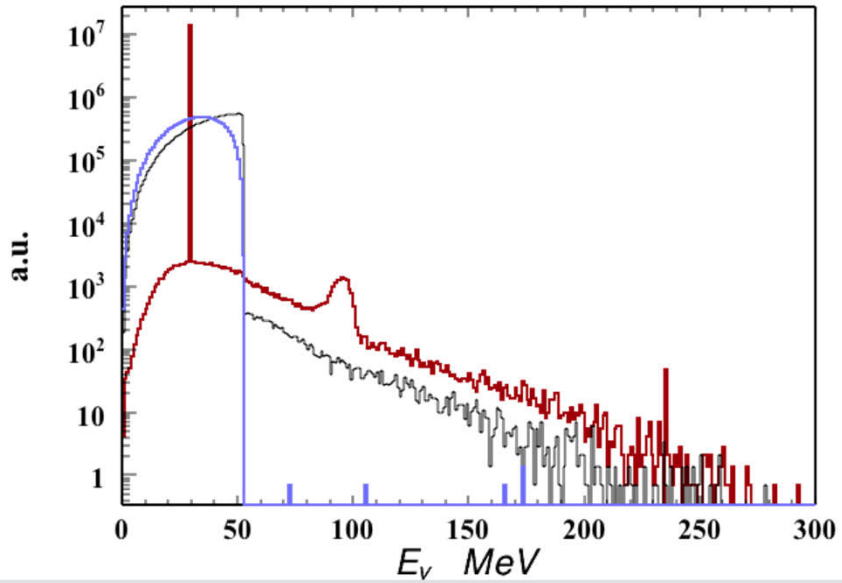
COHERENT experiment in SNS ν-alley

- Low-background area
- near (20-28 m) SNS target with
- 1.4MW, 5000MW/yr, 1.5E23POT/yr,
- pulsed beam

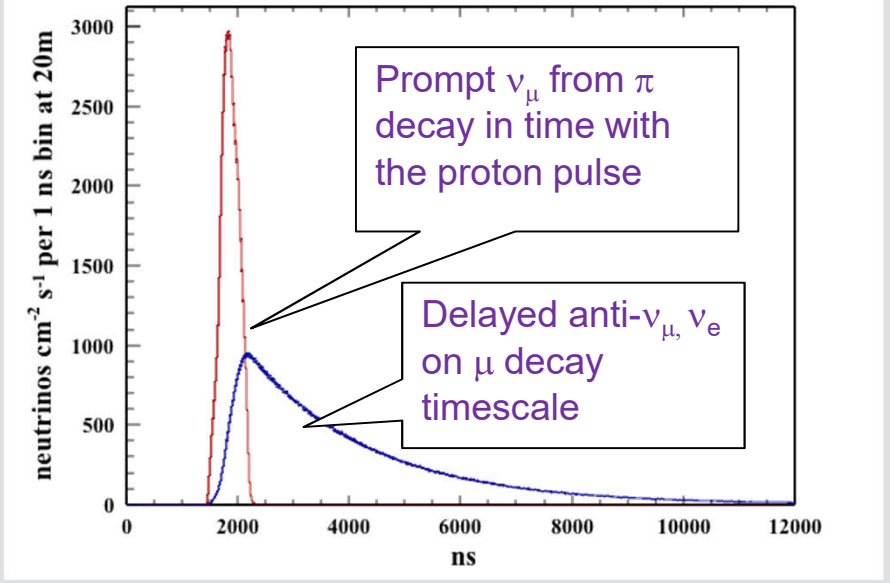


SNS "ν-alley"

SNS ν energy spectrum

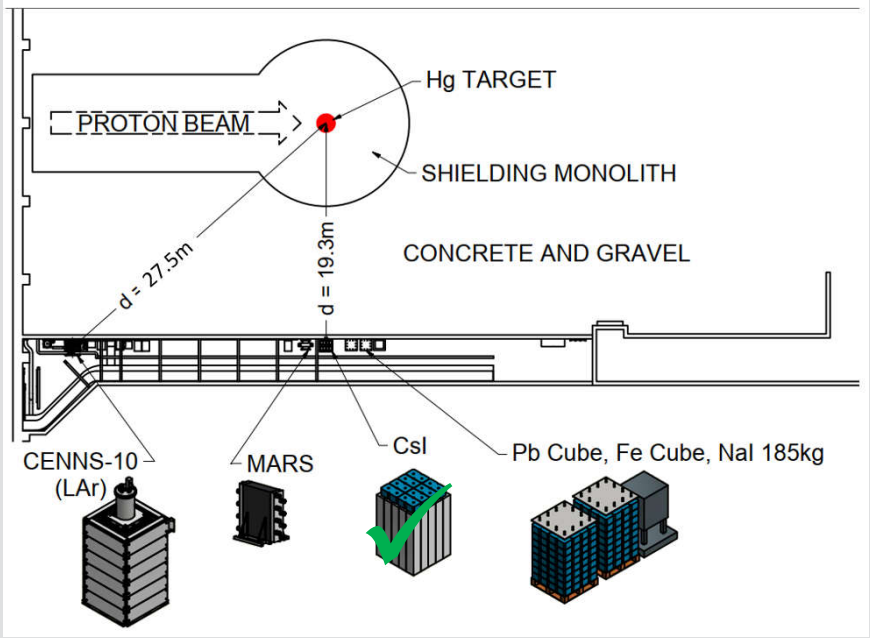


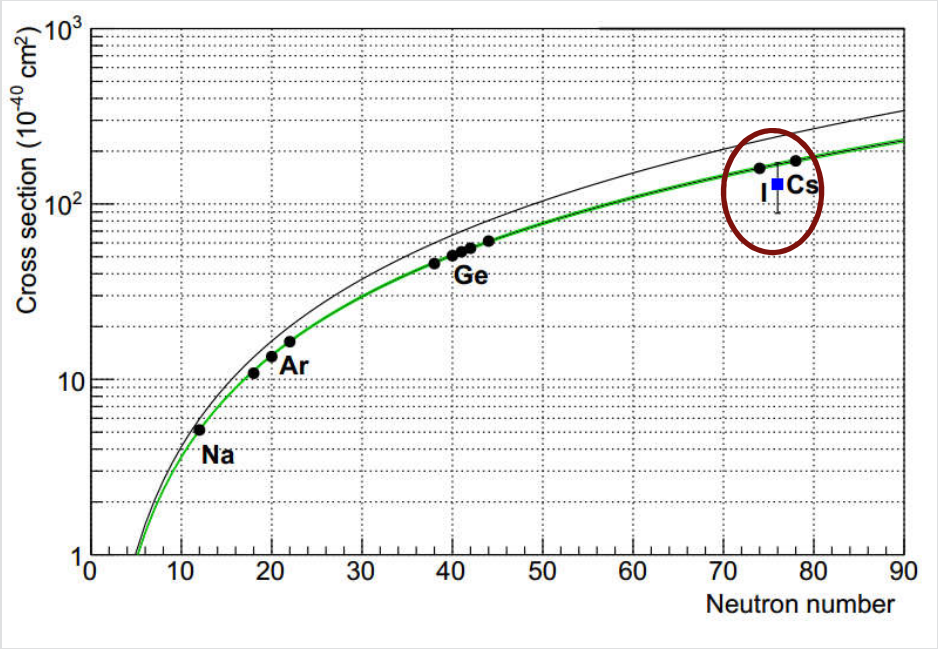
SNS ν time distribution

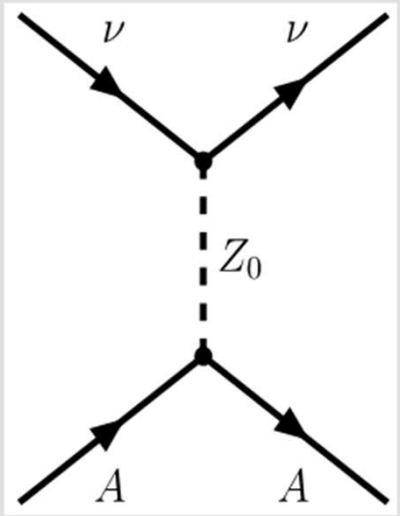


COHERENT experiment in SNS ν-alley

First detection of CEvNS with CsI

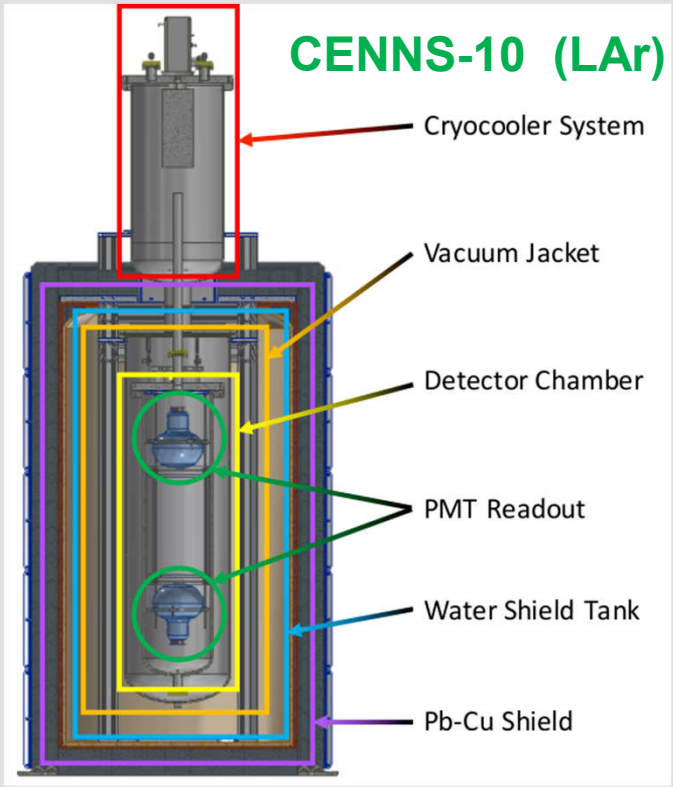


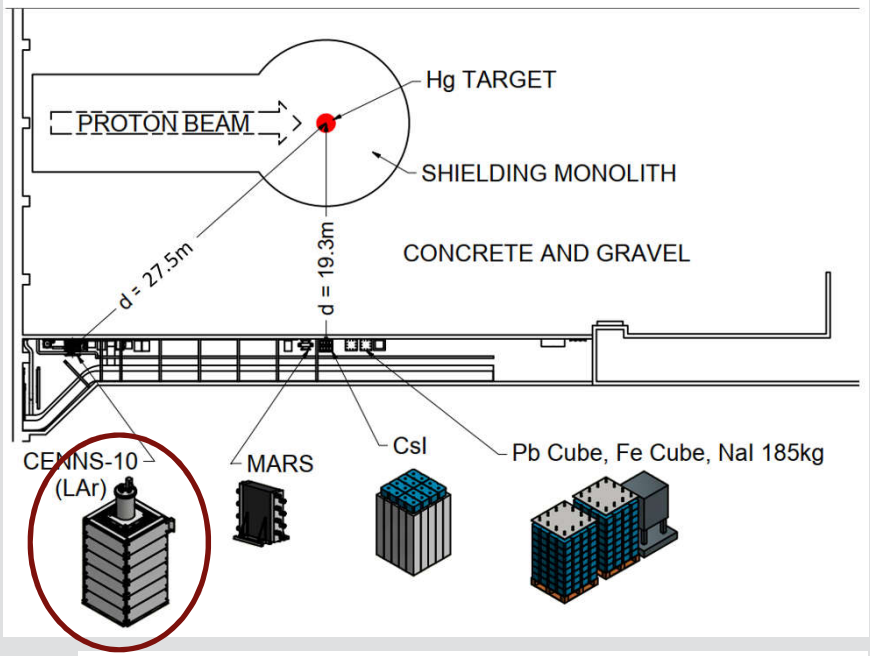


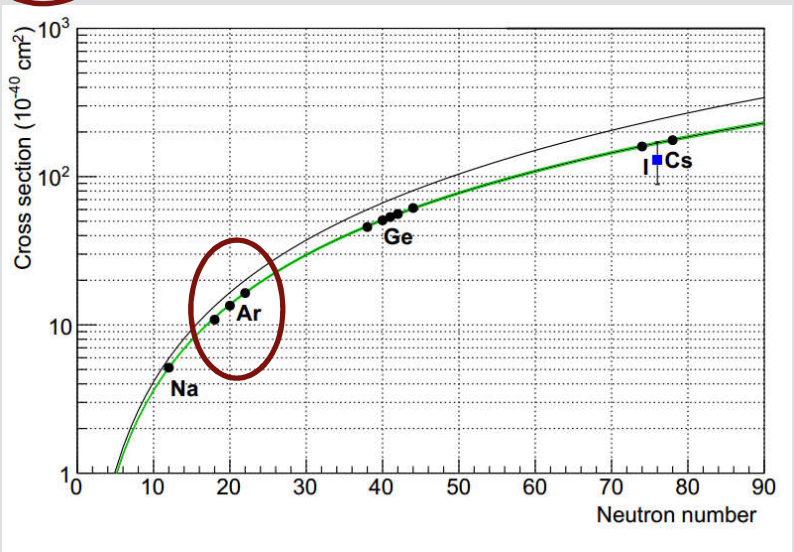


COHERENT experiment in SNS ν-alley

CENNS-10 (LAr), currently running, to demonstrate N^2 dependence of CEvNS



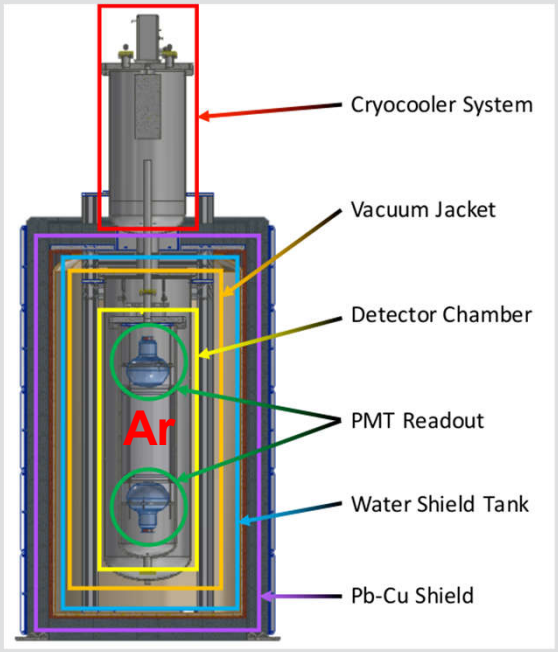




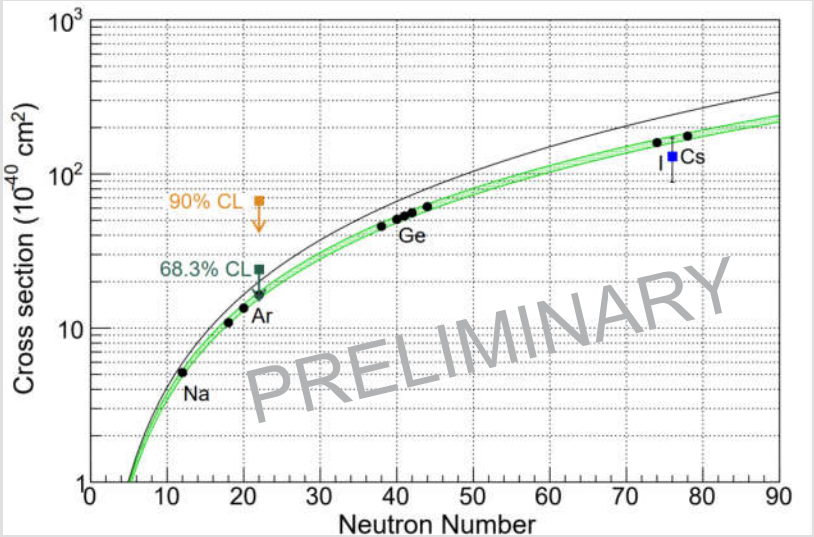
The CENNS-10 (LAr) Detector:

Specs:

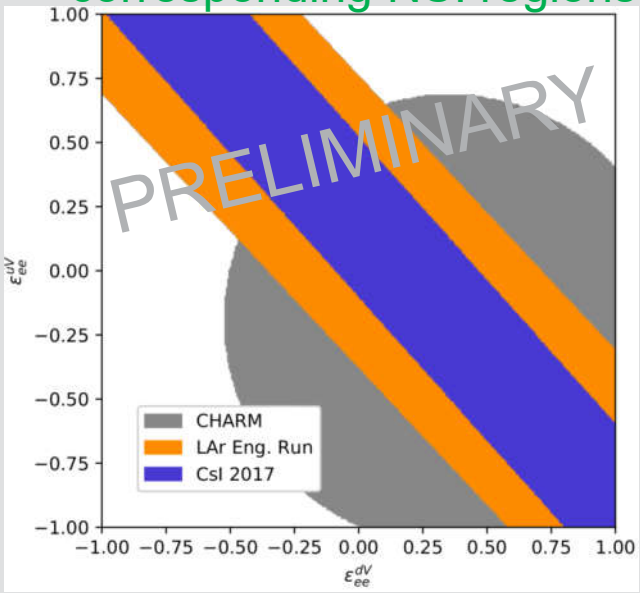
- Built at FNAL, moved to ORNL Fall 16
- 22 kg LAr fiducial volume
- 2 × Hamamatsu 8”PMTs
- TPB-coated PMTs/teflon side walls
- Energy threshold ≈ 20keVnr
- Pb/Cu/H2O shield
- Running in current configuration since 7/17
- Expect ≈140 CEvNS events/SNS-year



Eng. run CEvNS cross section limits



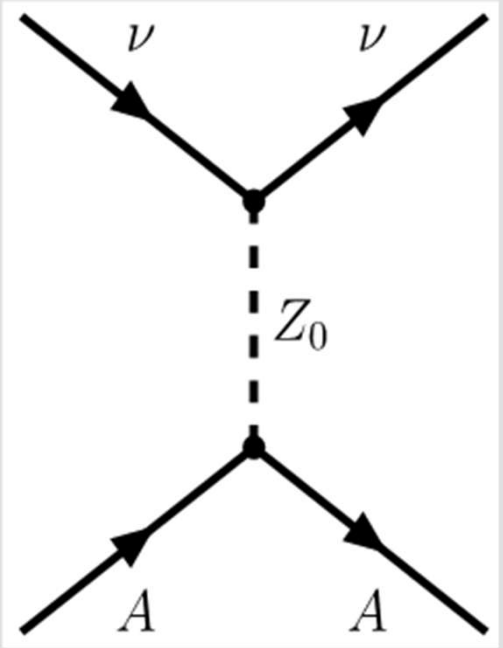
corresponding NSI regions



COHERENT future, next steps

Physics reach of CEvNS:

- Understanding supernovae (SN):
  - Expected to be important in core-collapse SN and
  - possible SN detection channel.
- Nuclear Physics: nuclear form factors
- Standard Model tests, eg: NSI, $\sin^2\theta_w$, neutrino magnetic moments
- ν oscillations: Investigation of $\nu_{sterile}$ oscillations
- reactor monitoring (non-proliferation)
- Dark Matter:
  - Important background for O(10-ton) direct searches
  - detectors sensitive for accelerator produced DM.



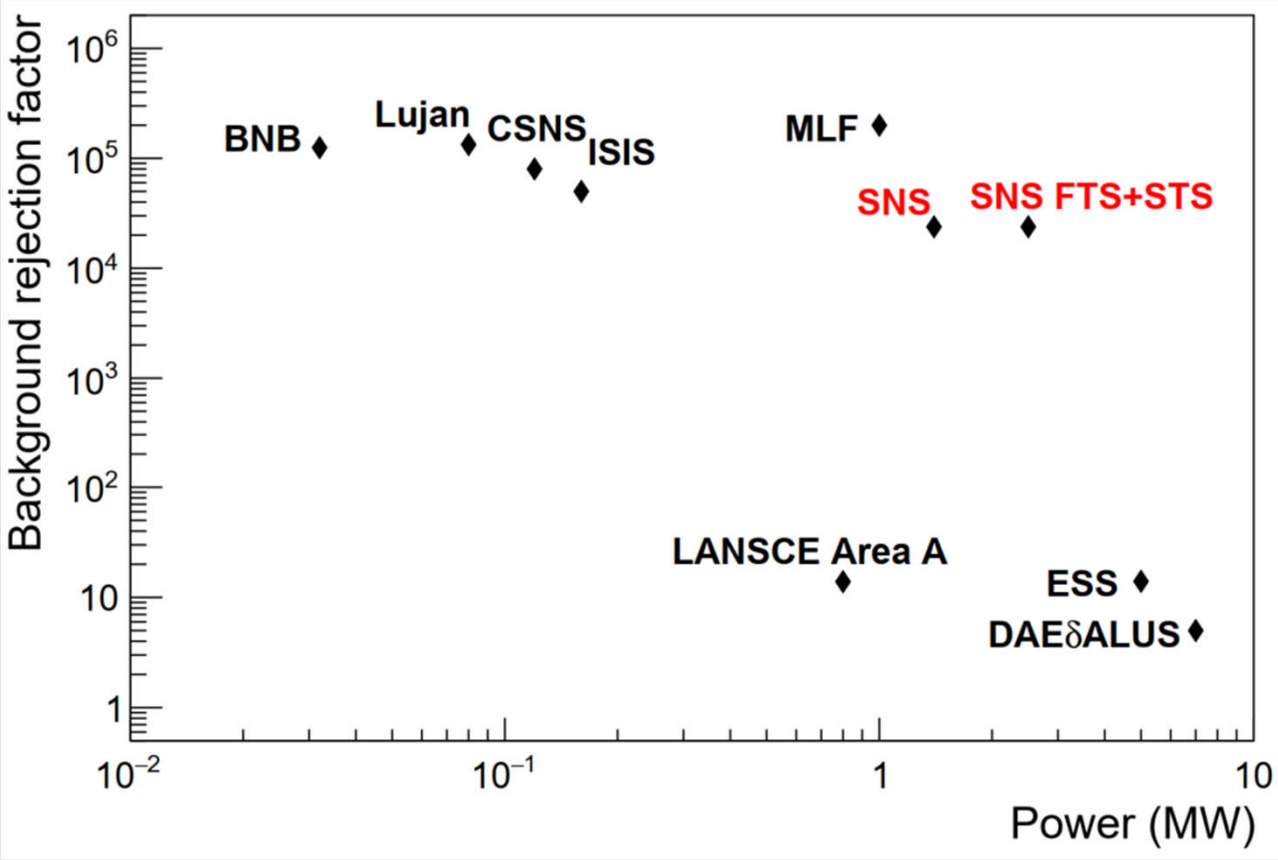
This requires:

- higher event rates via larger detetectors, lower thresholds
- reduced systematics via low backgrounds, measured flux

for a complete CEvNS physics program.

COHERENT future, next steps

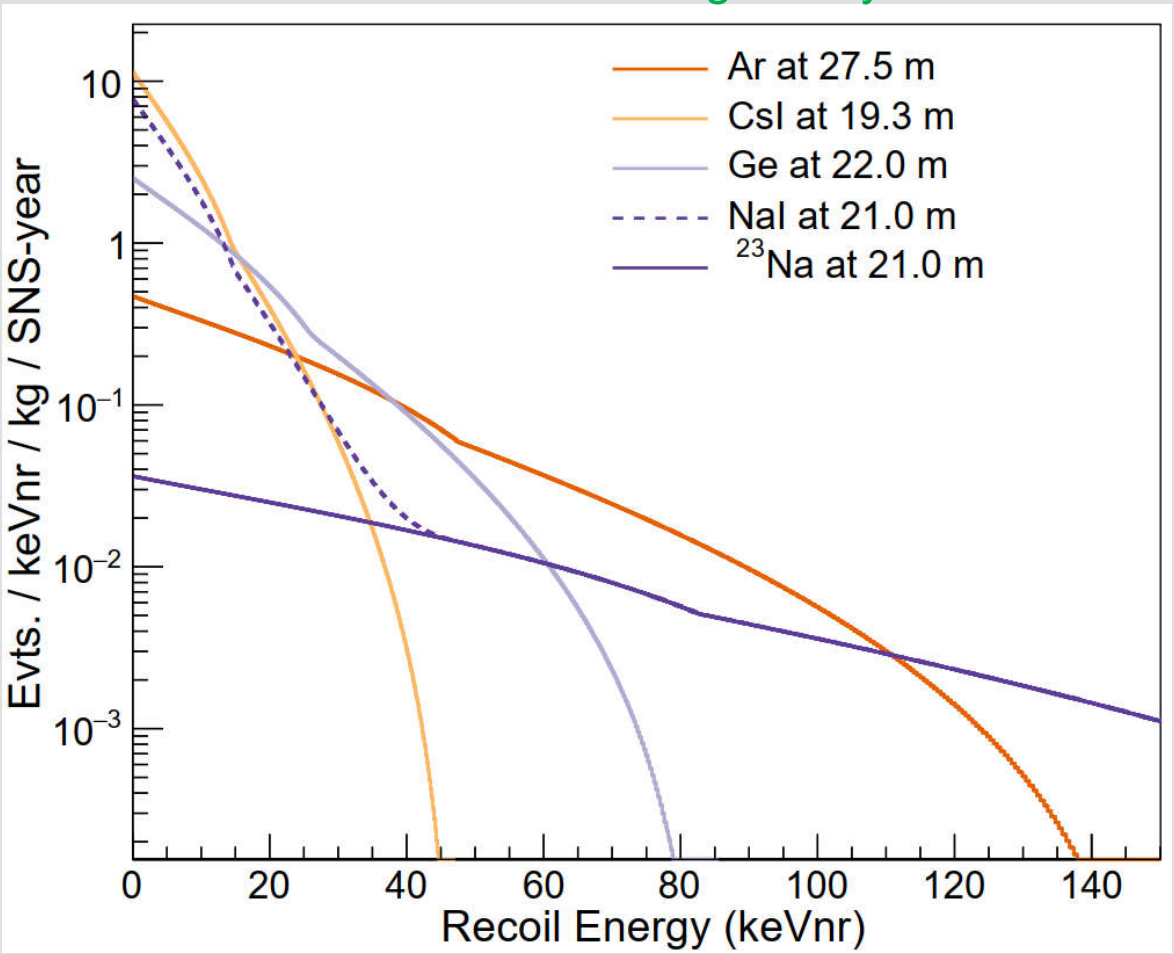
SNS is excellent source for this.
Need well-shielded space close to target



COHERENT future, next steps

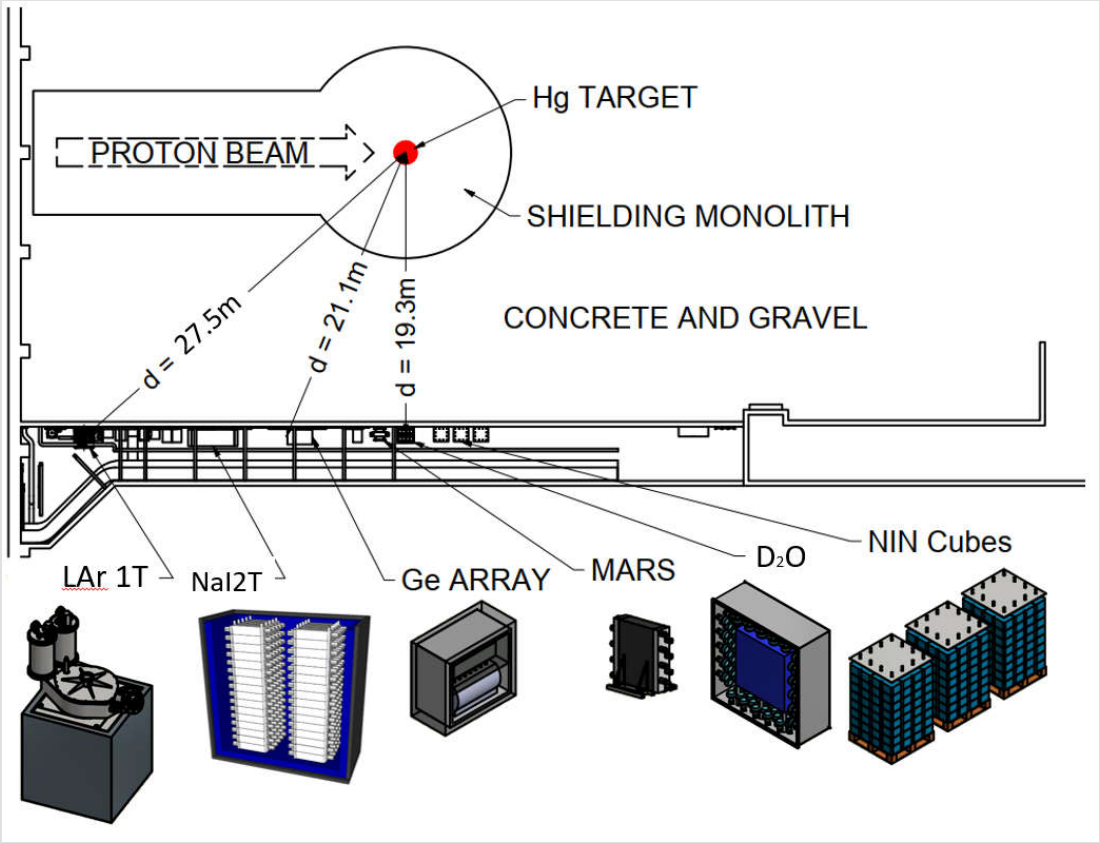
A variety of nuclei are being considered as larger detectors.

event rates/kg/SNS-yr for LAr NaI



COHERENT future, in ν-alley

- 16kg Ge array, coming soon
- multi-ton NaI, shielding/veto configuration to be finalized
- ton-scale LAr (CENNS-750), funding pending
- D_2O for flux normalization
- also NIN cubes
- neutron background measurements



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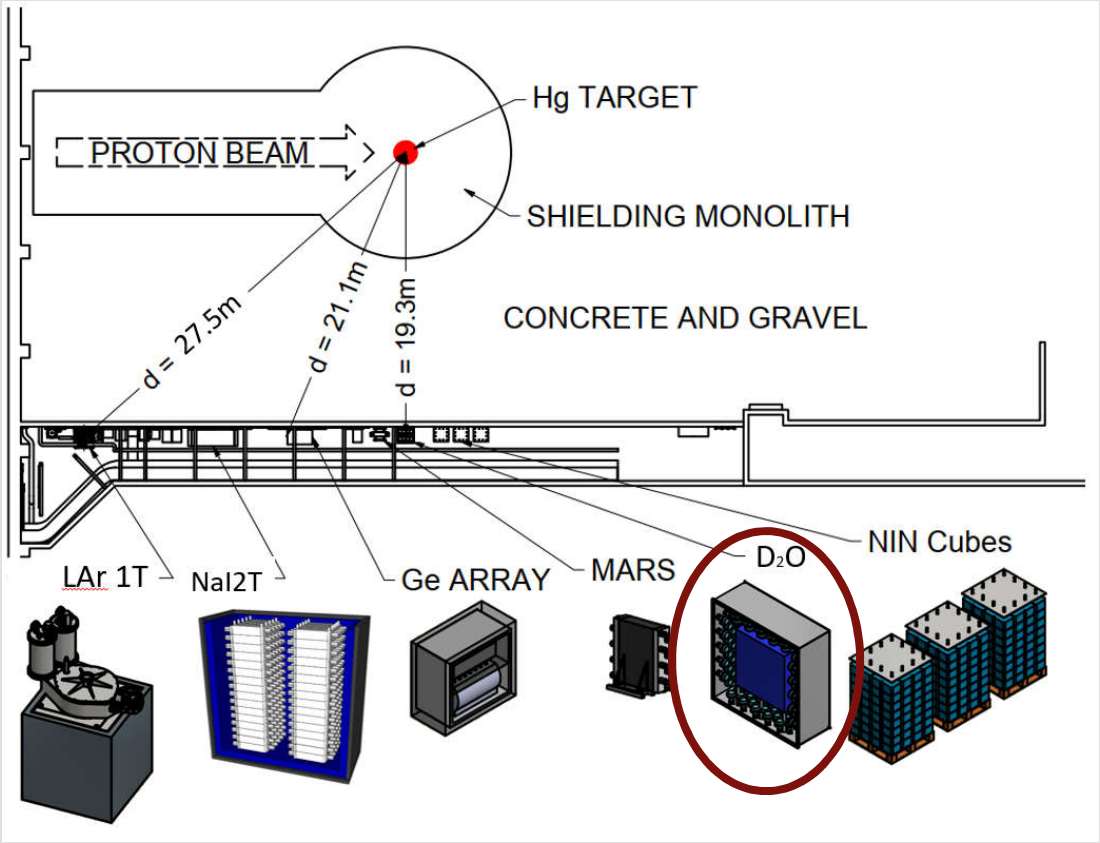
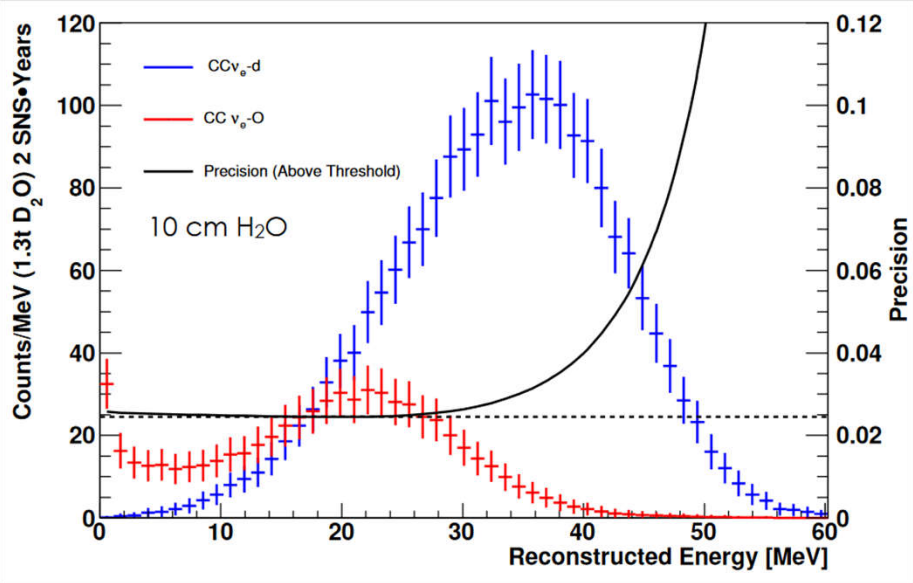
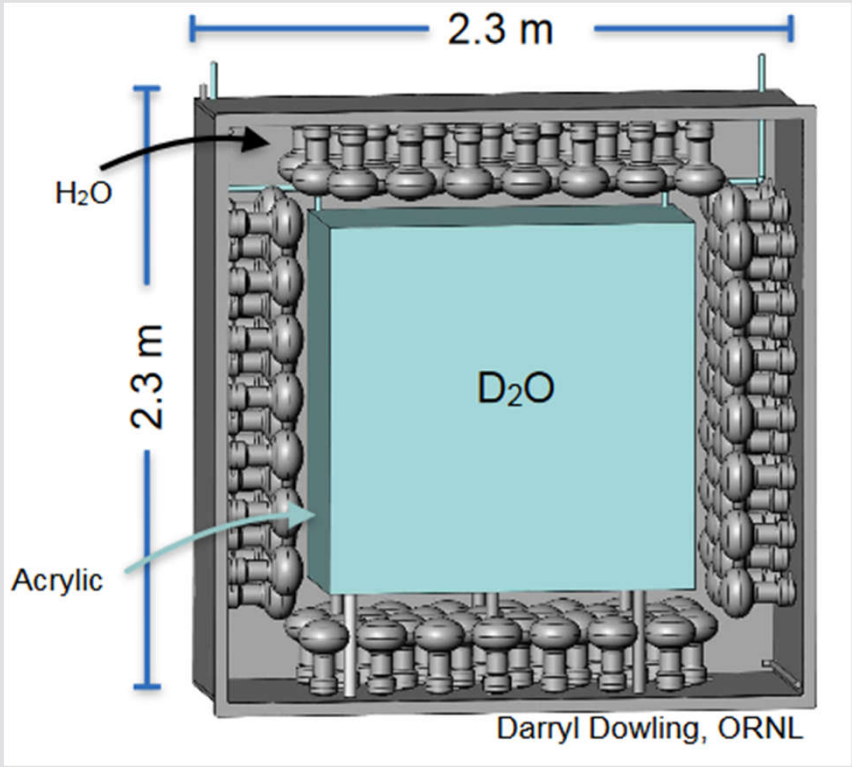


COHERENT future in nu-alley, D_2O detector

- D_2O reduces flux normalization systematic,from ~10% to ~3%
  - 1.3 tons D2O within acrylic inner vessel
  - H2O “tail catcher” for high energy e-
  - Outer light water vessel contains PMTs, PMT support structure, and optical reflector. Outer steel vessel to support shielding and veto



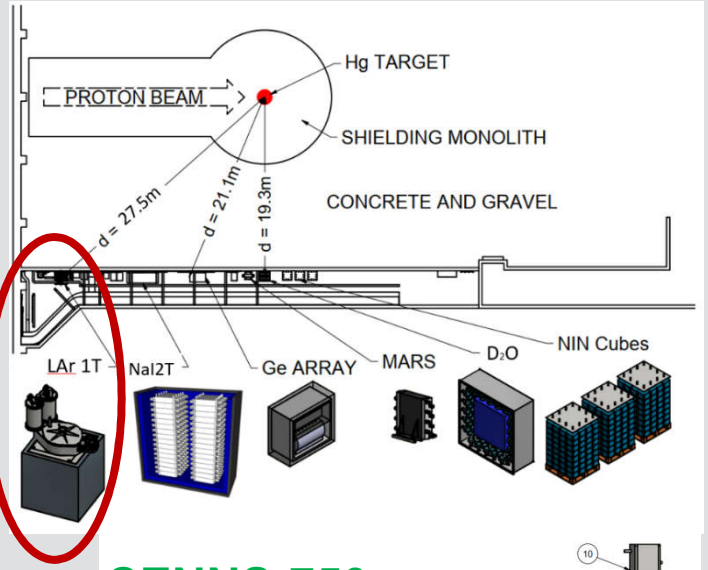


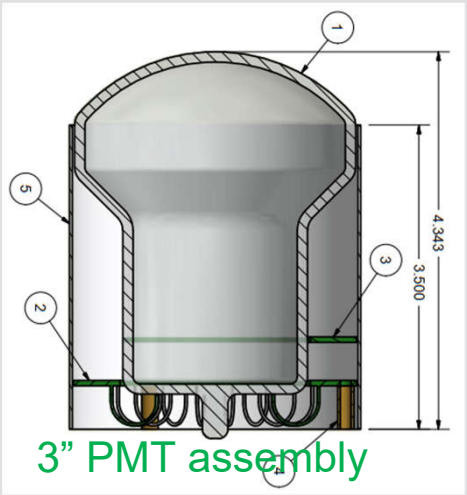
COHERENT future, large LAr detector

CENNS-750:

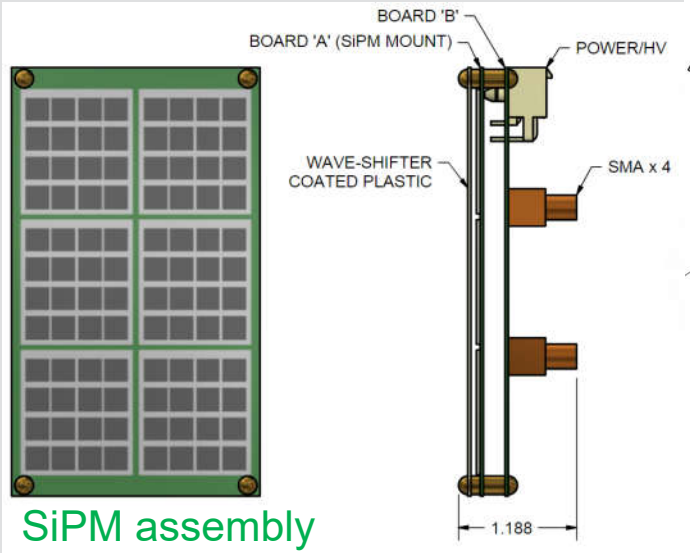
- Based on our experience with CENNS-10 detector, running since 2017.
- Single-phase LAr (scintillation-only) calorimeter, 750/**610kg** total/**fiducial**
- Purpose-designed cryostat w/LN2 precool, and dual cryocooler for liquification/gas purification.
- Light collection: TPB coated reflectors combined with 3”PMTs/SiPMs
- Eventual use of underground (low ^{39}Ar) argon.

- $\Rightarrow$ 3000 CEvNS, 440 inelastic CC/NC events/yr !

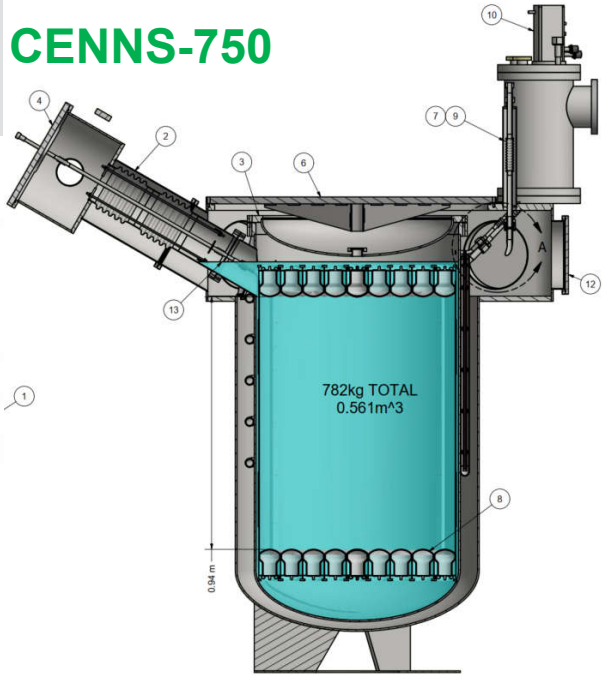




3” PMT assembly

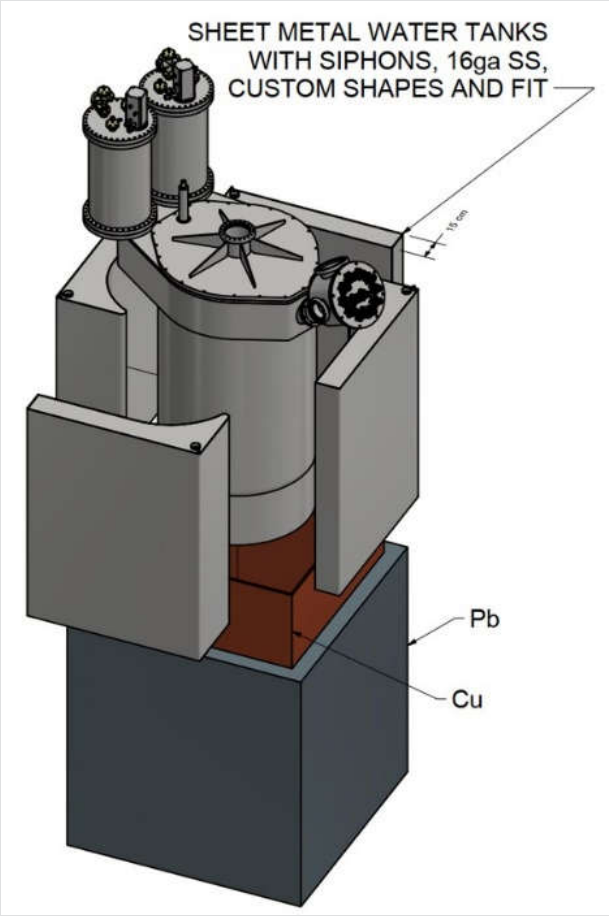


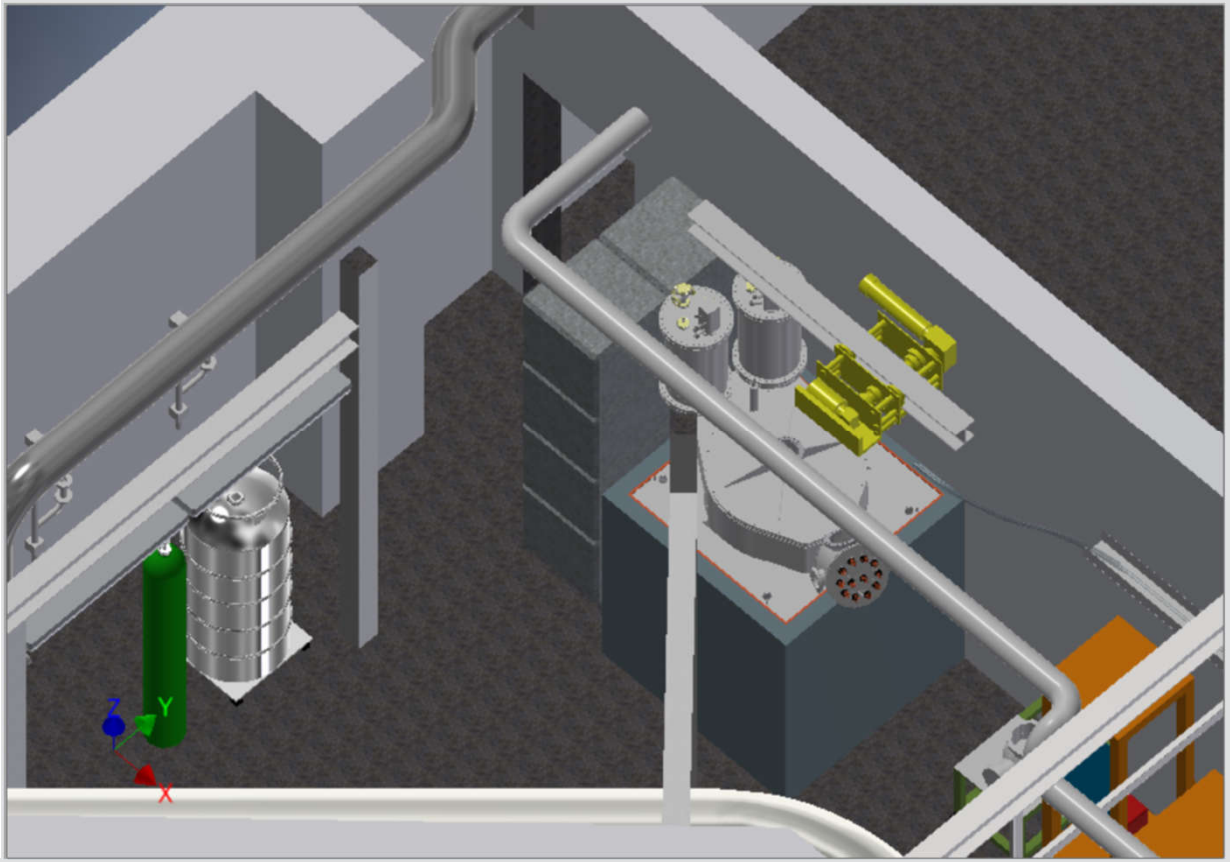
SiPM assembly



COHERENT future, large LAr detector

CENNS-750:



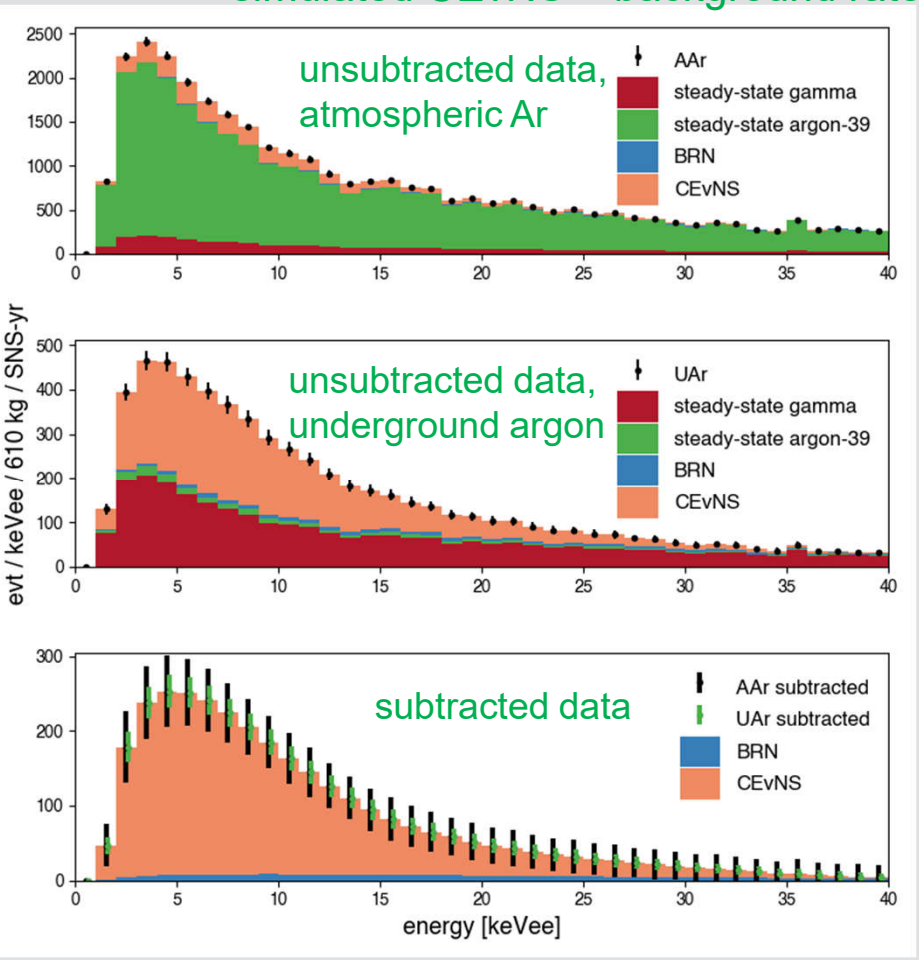


CENNS-750 LAr detector

event rates in 610kg fiducial LAr detector:

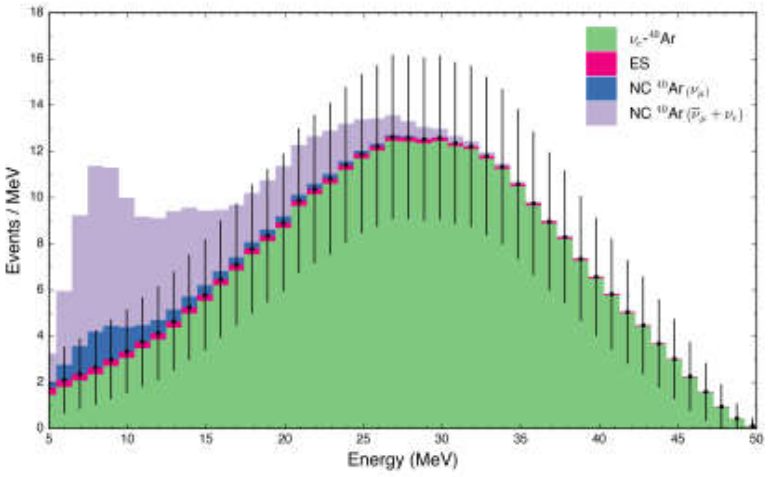
~3000 CEvNS events/year

simulated CEvNS + background rates



~440 inelastic CC/NC events/yr

estimated inelastic CC/NC CEvNS rates



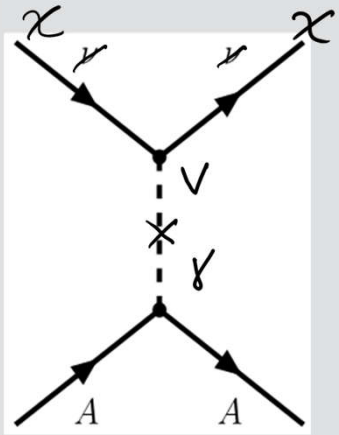
COHERENT future, beyond ν-alley

Search for accelerator-produced, low-mass, dark matter

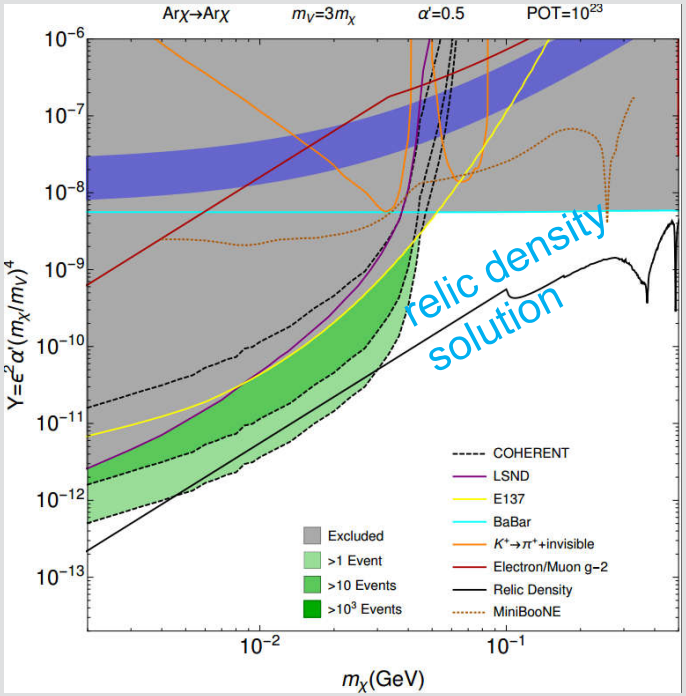
Via:

$$p \rightarrow \mathrm{Hg} \rightarrow \pi^{0,\pm}$$

$$\pi^0 \longrightarrow \gamma + V^{(*)} \longrightarrow \gamma + \chi^\dagger + \chi$$



1 ton-year LAr
SNS DM sensitivity



Light new physics in coherent neutrino-nucleus scattering experiments

Patrick deNiverville,[1] Maxim Pospelov,[1,2] and Adam Ritz[1]

[1] *Department of Physics and Astronomy, University of Victoria, Victoria, BC V8P 5C2, Canada*
[2] *Perimeter Institute for Theoretical Physics, Waterloo, ON N2J 2W9, Canada*

(Dated: May 2015)

arXiv:1505.07805

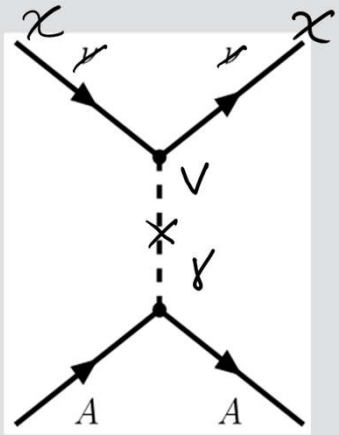
COHERENT future, beyond ν-alley

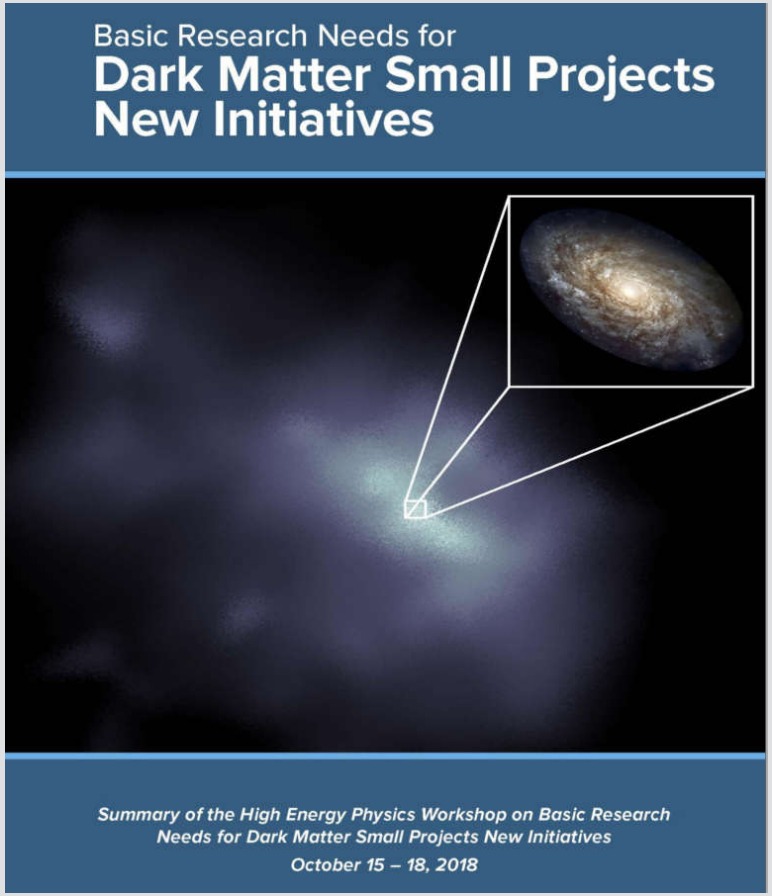
Search for accelerator-produced, low-mass, dark matter

Via:

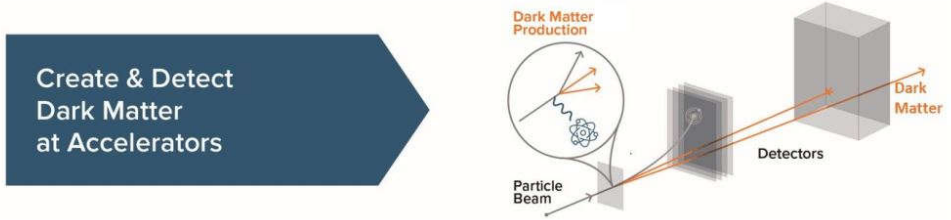
$$p \rightarrow \mathrm{Hg} \rightarrow \pi^{0,\pm}$$

$$\pi^0 \longrightarrow \gamma + V^{(*)} \longrightarrow \gamma + \chi^\dagger + \chi$$





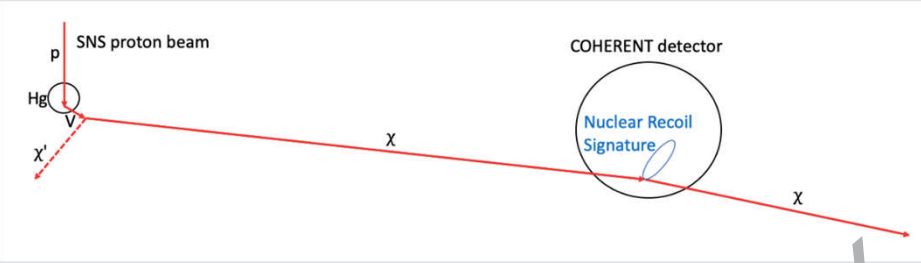
PRD 1: Create and detect dark matter particles below the proton mass and associated forces, leveraging DOE accelerators that produce beams of energetic particles.

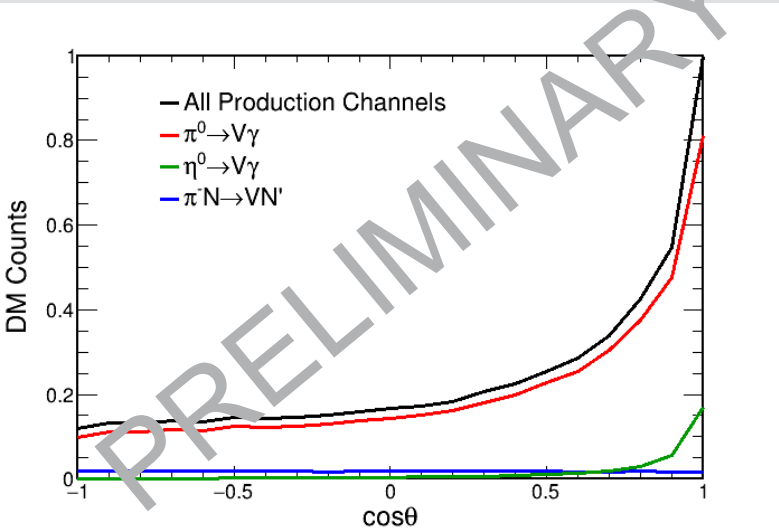


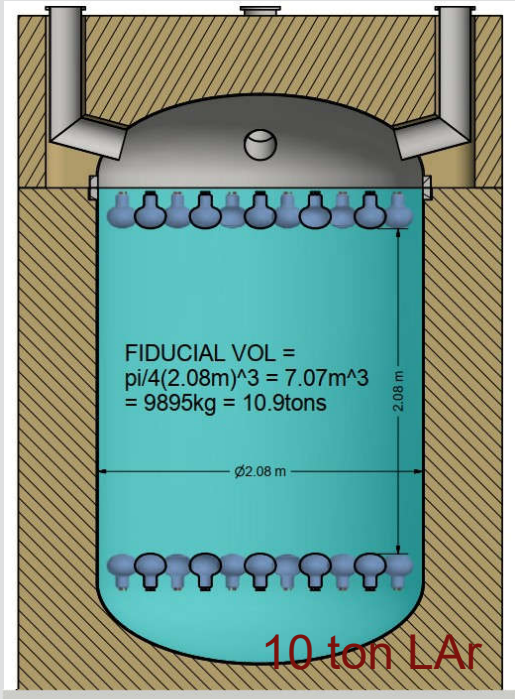
COHERENT future, beyond ν-alley

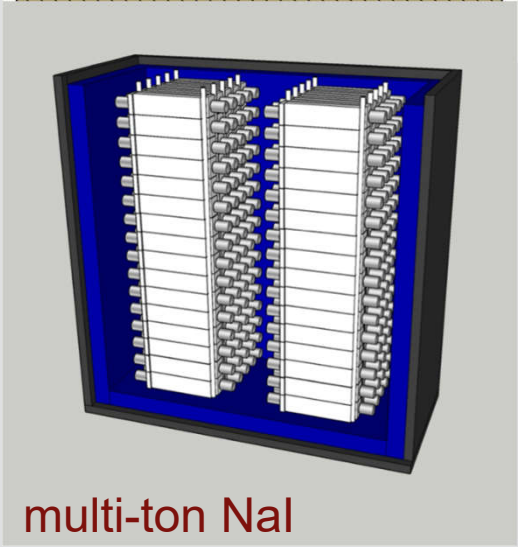
Search for accelerator-produced, low-mass, dark matter

10-ton LAr or ~20ton cryogenic NaI detector downstream (ideally) from high power neutron target, eg SNS STS





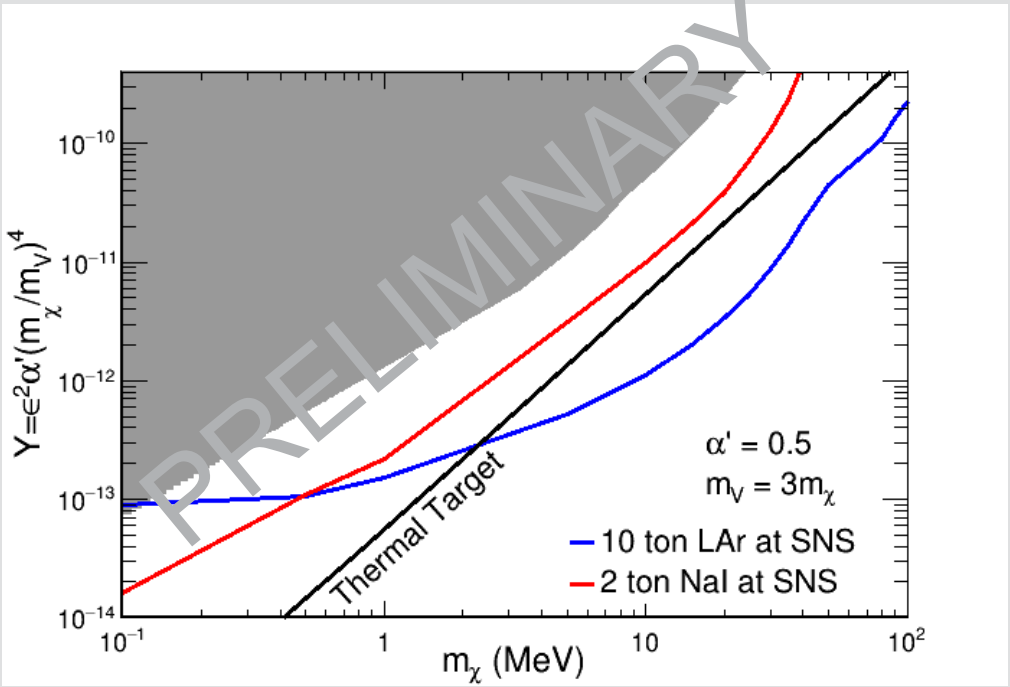


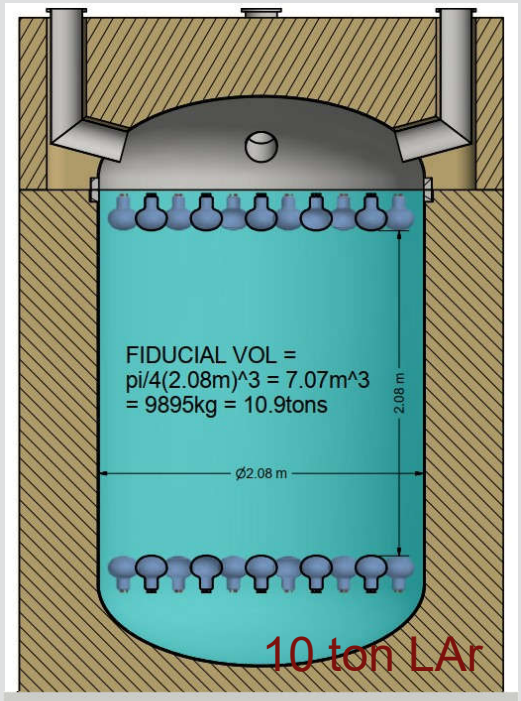


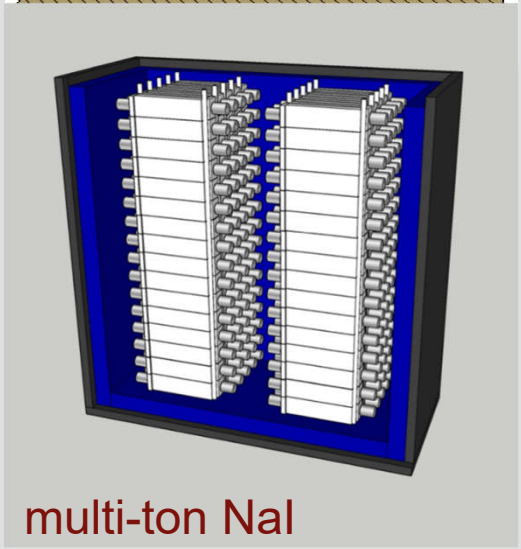
COHERENT future, beyond ν-alley

Search for accelerator-produced, low-mass, dark matter

10-ton LAr or ~2-ton cryogenic NaI detector downstream (ideally) from high power neutron target, eg SNS STS



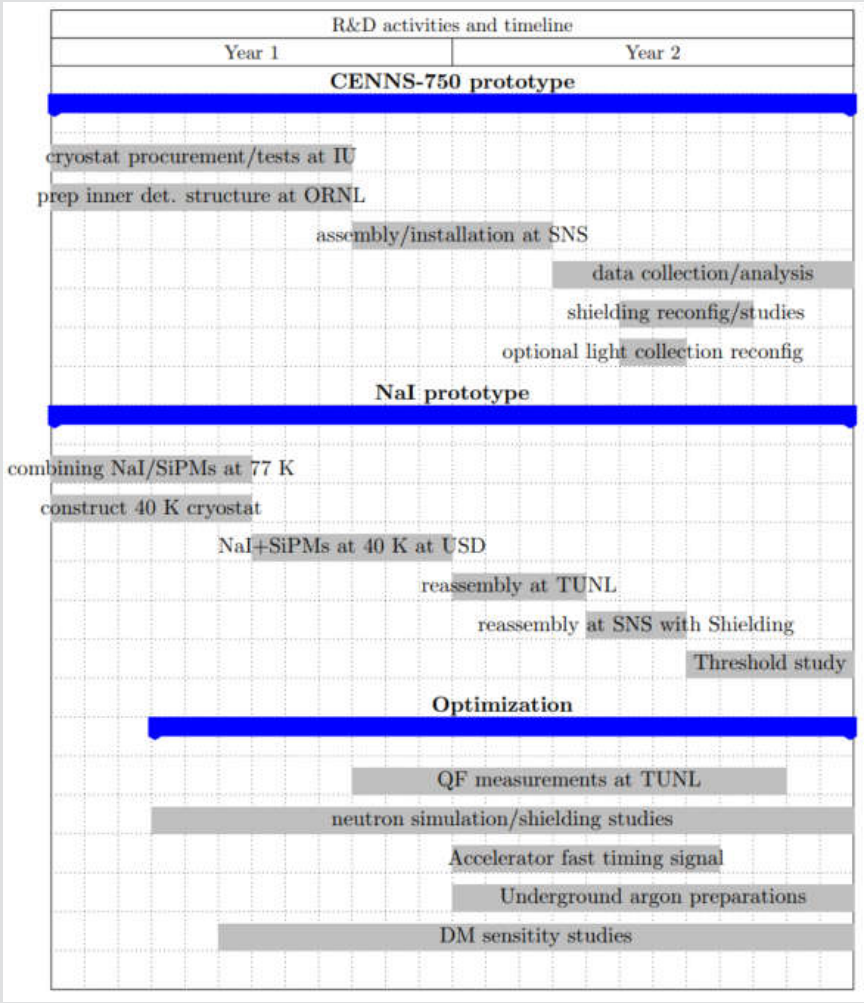


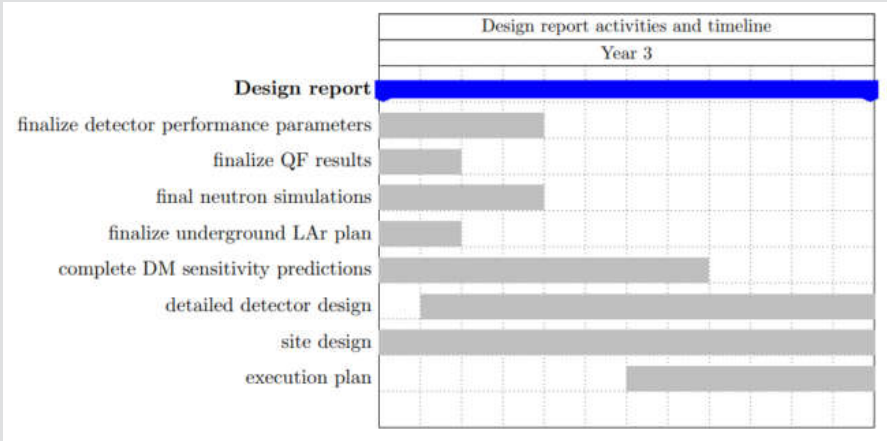


Will enable other CEvNS physics as well!

Large CEvNS detector for DM

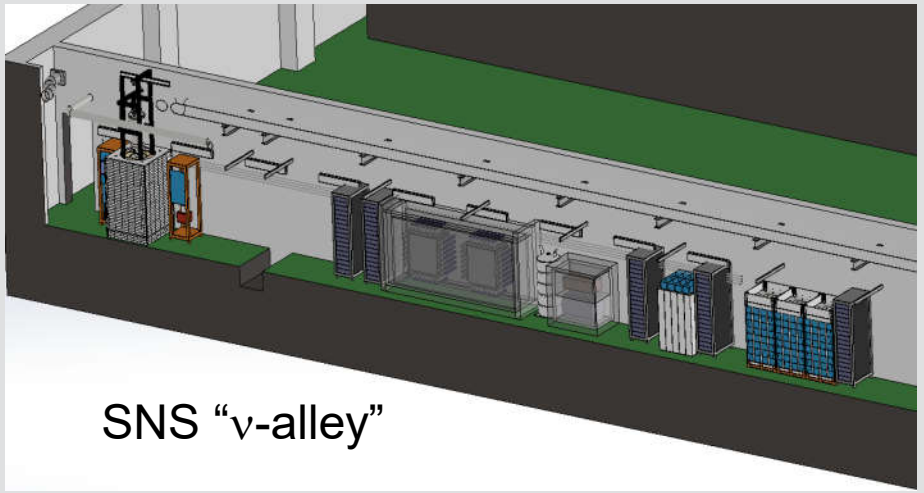
Proposal submitted to design large LAr/cooled NaI detector for accelerator-DM search at SNS, with R&D and design/planning components





COHERENT future, summary

- SNS ν-alley offers substantial CEvNS physics program in near-future
- SNS STS with dedicated detector hall with optimized location and shielding would be a world-class ν facility



SNS "ν-alley"