# Pushing the limit on low-energy neutrino scattering
# Cryogenic, undoped CsI scintillators

Sponsored by FSU Council on Research and Creativity

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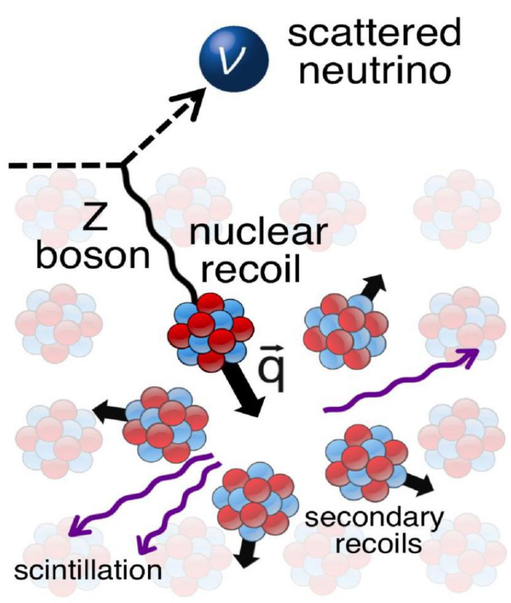
In collaboration with

## CEvNS




Coherent, elastic neutrino-nucleus scattering (CEvNS)
Low energy neutrino transfers tiny kinetic energy to nucleus
In a detector, observable as a small burst of ≈ 10 photons

$$E_\nu < \frac{\hbar c}{R_N} \sim O(\mathrm{MeV})$$

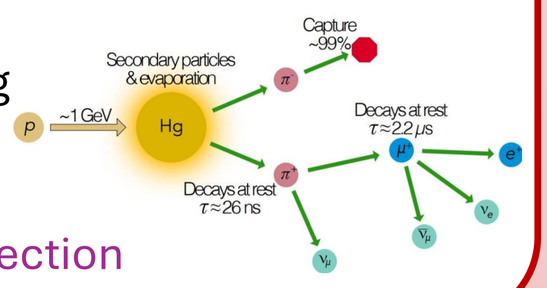
$$T < \frac{2E_\nu^2}{m_N} \sim O(\mathrm{keV})$$

## Motivation

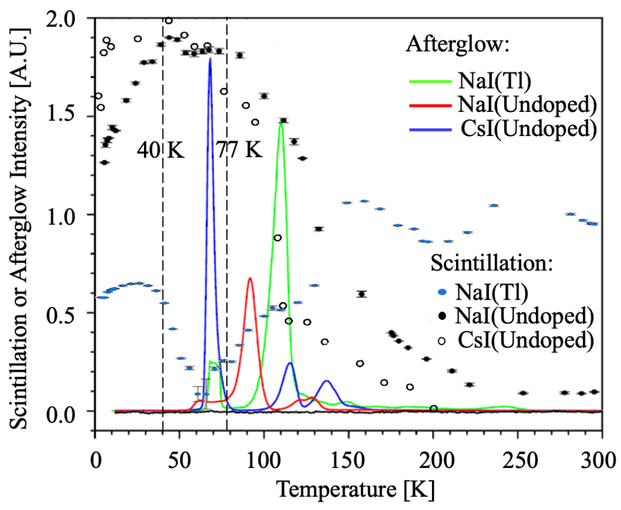
– New fundamental forces
– Discovery of dark matter
– Probes nuclear structure

## The COHERENT experiment

Spallation Neutron Source at Oak Ridge National Lab:
$10^{23}$ 1-GeV proton accelerator incident on mercury target per year → most intense low-energy neutrino source
Neutrinos from $\pi^+$ decay at rest
– Discovered CEvNS with 14.6-kg CsI[Na] detector in 2017
– Need for next-generation detector with improved light collection




COHERENT, *Science* **357** 6356 (2017)

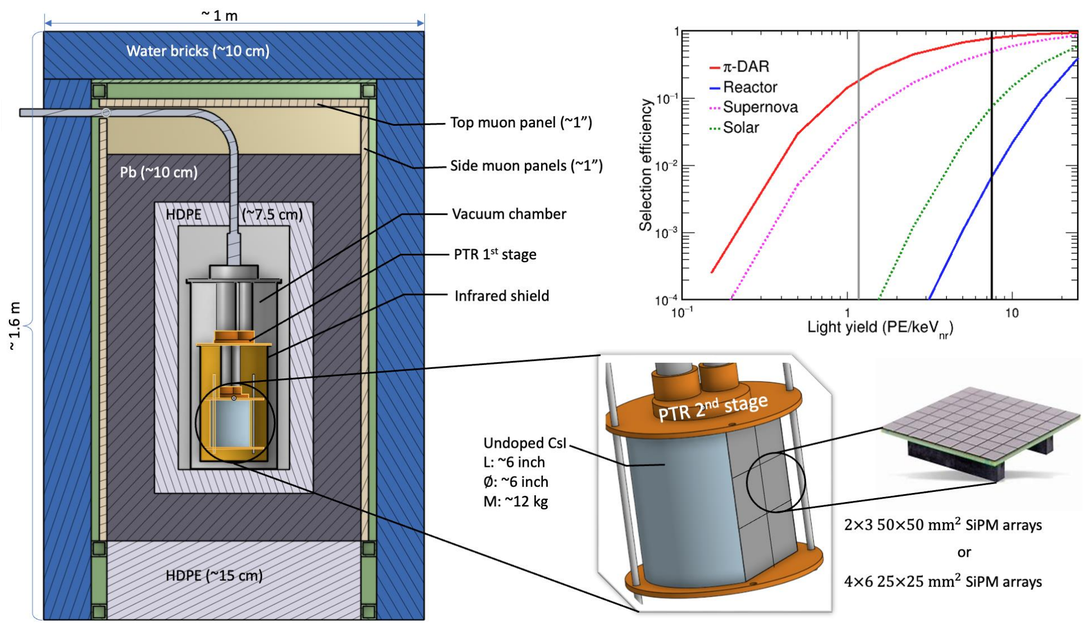



At 40K, scintillation output of CsI 20x higher than room temp with reduced backgrounds
→ Cryogenic CsI ideal next generation experiment

## @ FSU – cryogenic CsI scintillators

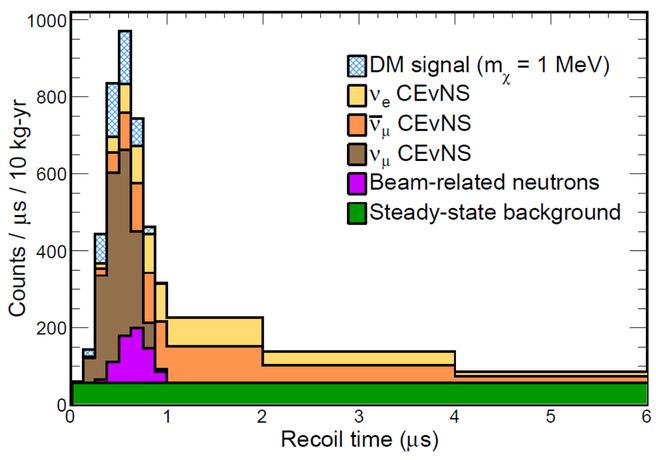
Funding from NSF to team from FSU, USD, and NCCU to build and operate detector for COHERENT

FSU effort
– Vacuum and cryogenic systems
– Background characterizations
– Physics searches interrelated with neutrino mass, oscillations, and dark matter discovery

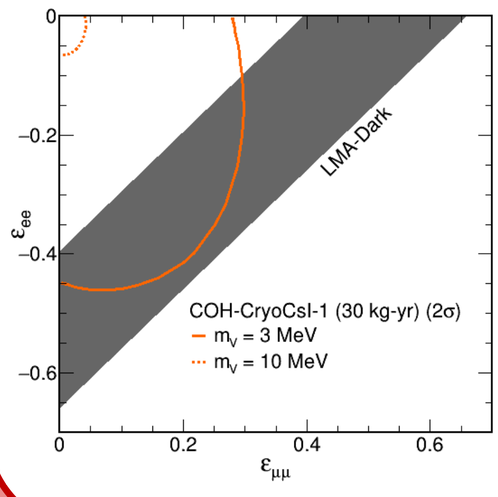



Chernyak, Pershey, Liu, Ding, Saunders, *Eur Phys C* **80** 6 (2020)

## New physics with CryoCsI



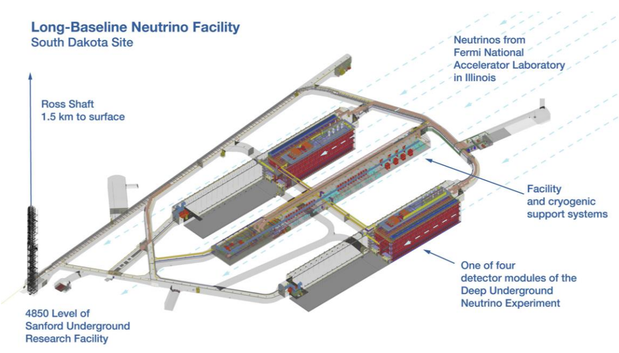

Possible production of exotic particles such as dark matter
World-leading sensitivity with handheld detectors
Likely to discover DM if mass is 1 – 100 MeV/$c^2$

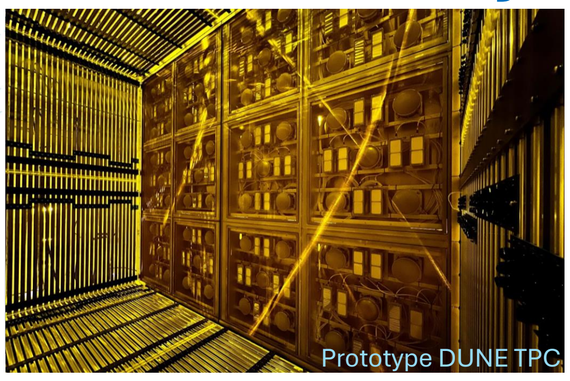


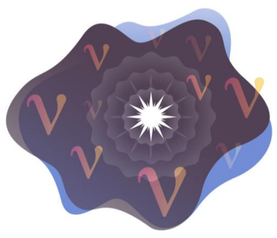

Low-threshold needed to discover new forces that gently interact with matter
Critical ambiguity between these effects and neutrino oscillations
COHERENT + similar efforts at nuclear reactors solve problem

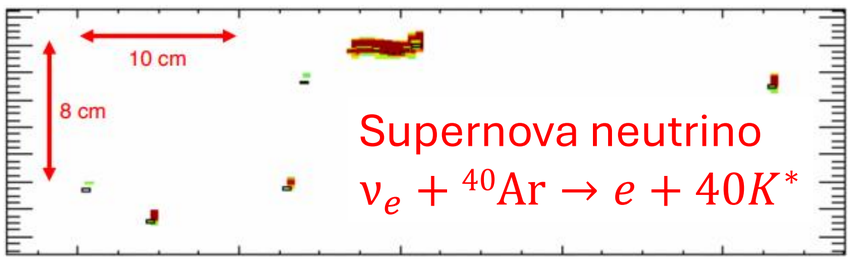
COHERENT, *PRD* **109**, 092005 (2023)

## Applications to neutrino astronomy






Supernova neutrino
$\nu_e + {}^{40}\mathrm{Ar} \rightarrow e + 40K^*$

– Neutrinos peer into dense astronomical objects
– DUNE experiment will construct four 10-kt argon time projection chambers – a "tracking neutrino telescope"
– Will observe ~ 4000 neutrinos from a galactic supernova
– Understand astrophysics of collapse and properties of neutrinos such as mass, magnetic moment, and charge

DUNE, *Eur Phys C* **81**, 5 (2021)