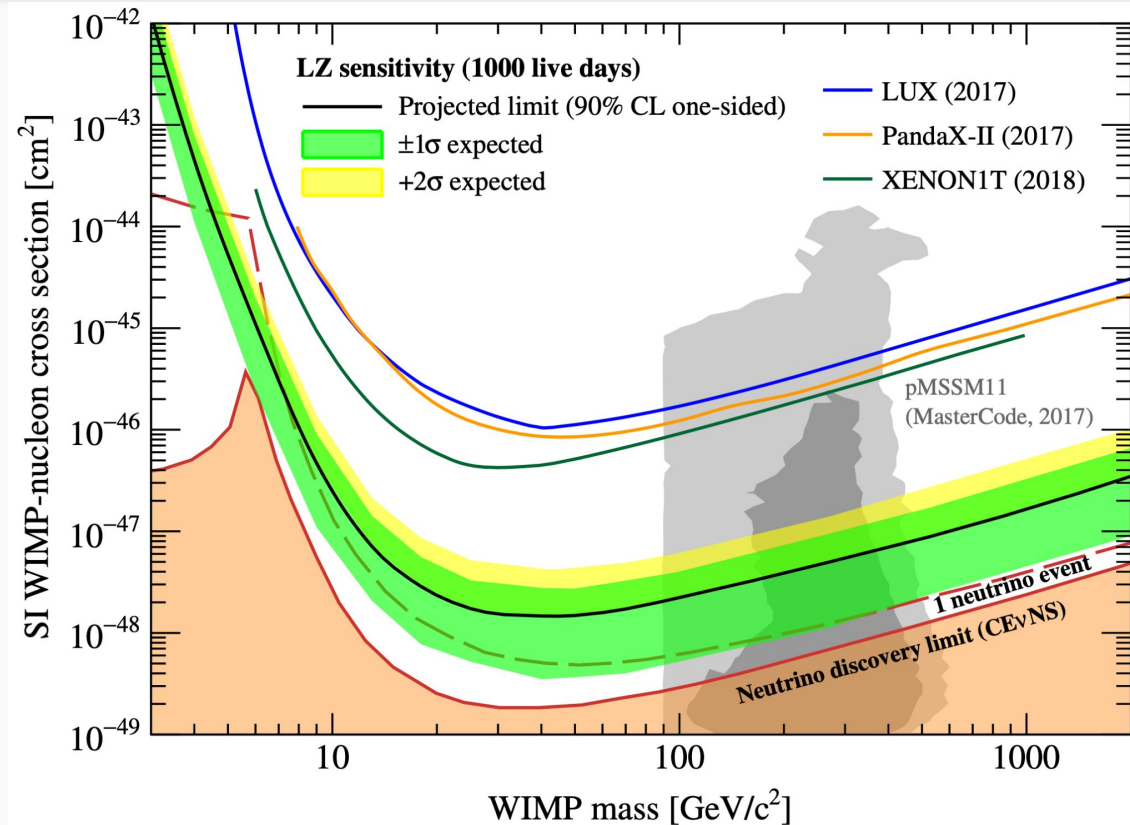


# LZ Upgrades - HydroX

Snowmass @LBNL - Aaron Manalaysay

# Normal-LZ projected sensitivity

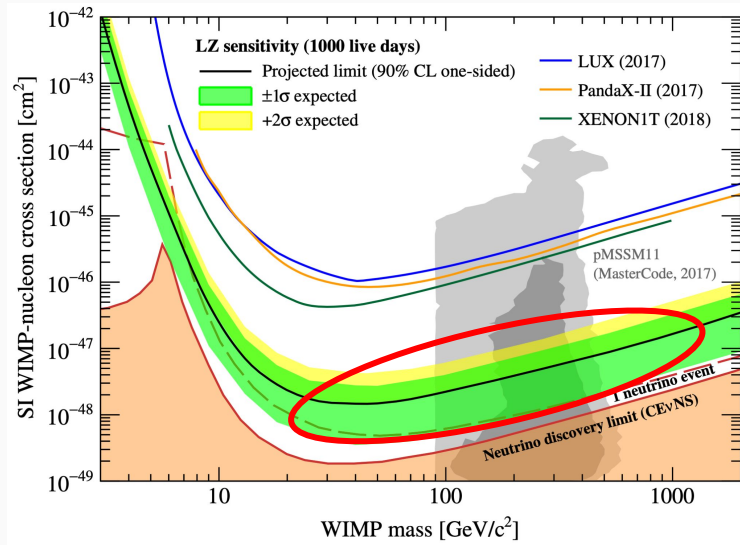


Projected sensitivity of LZ at the end of planned operations.

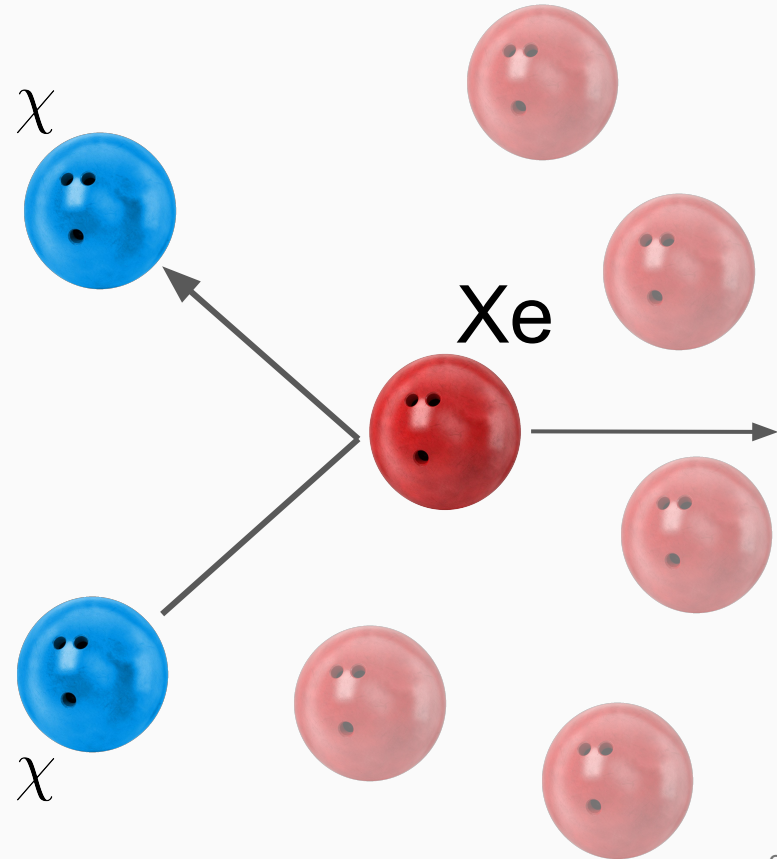
Key LZ details:

- 10-tonne tank of liquid xenon (LXe)
- Particle interactions spit out pulses of photons and electrons
- photon/electron amplitude ratio gives particle ID -> helps reduce backgrounds.

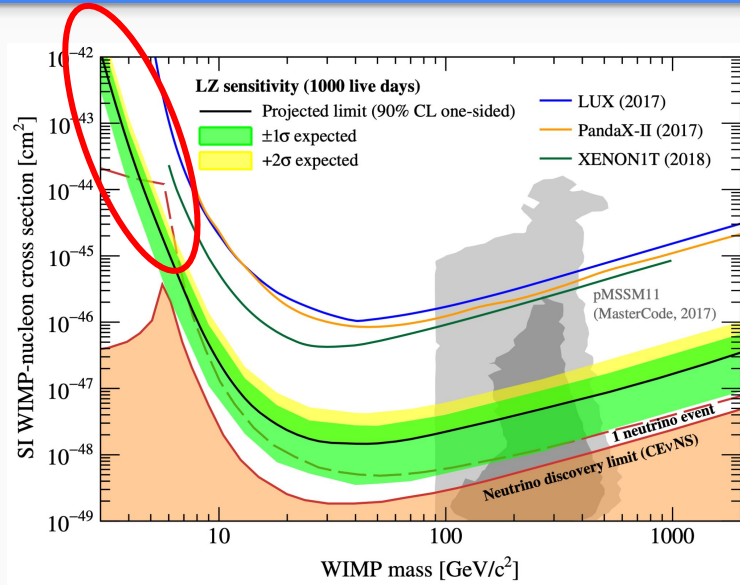
# WIMP sensitivity -- heavy masses



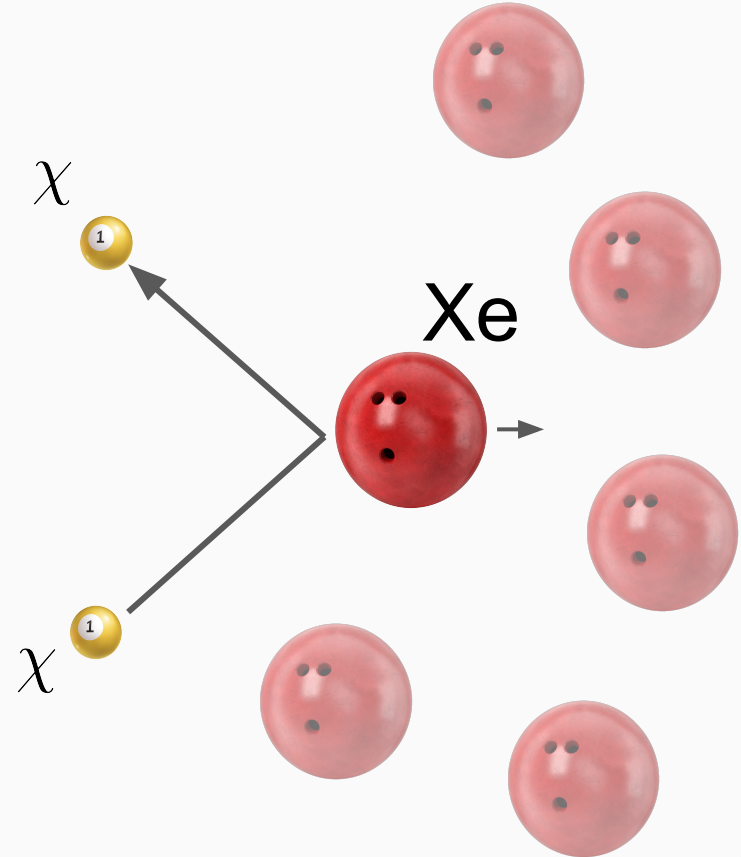
Xe ( $A=131$ ) is a good kinematic match for mid-high mass WIMPs



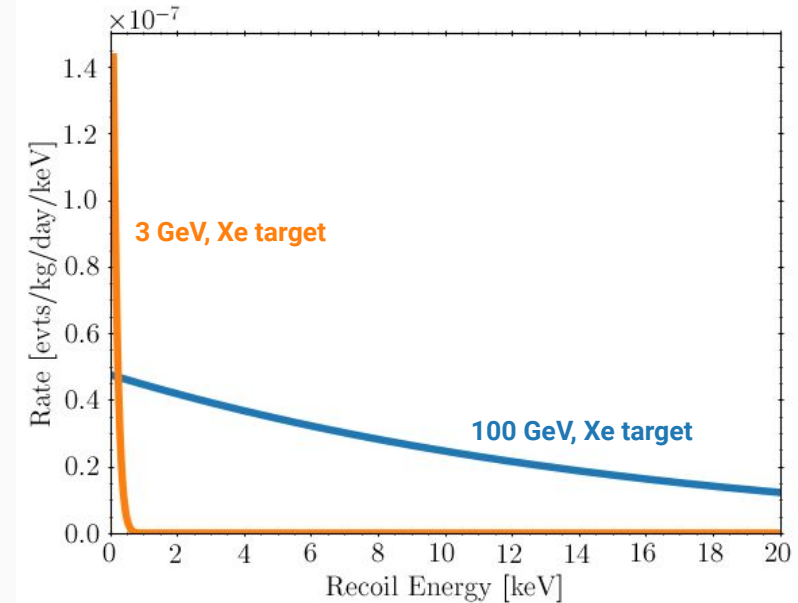
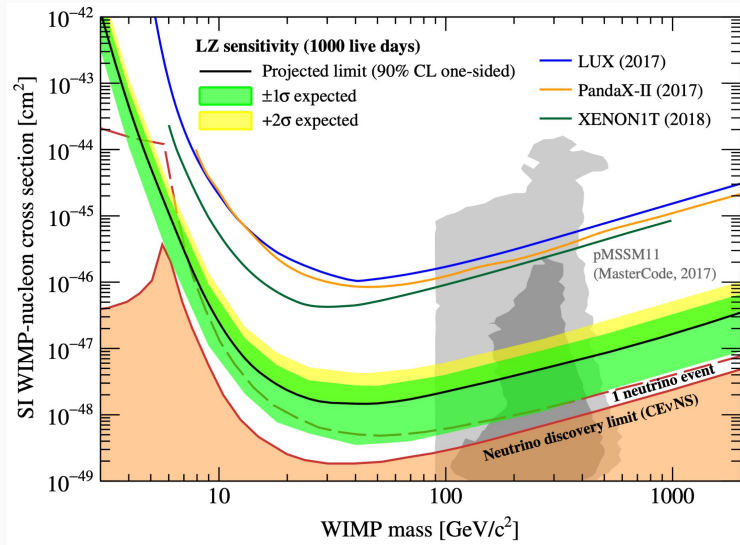
# WIMP sensitivity -- light masses



Xe (A=131) is a bad kinematic match for light WIMPs

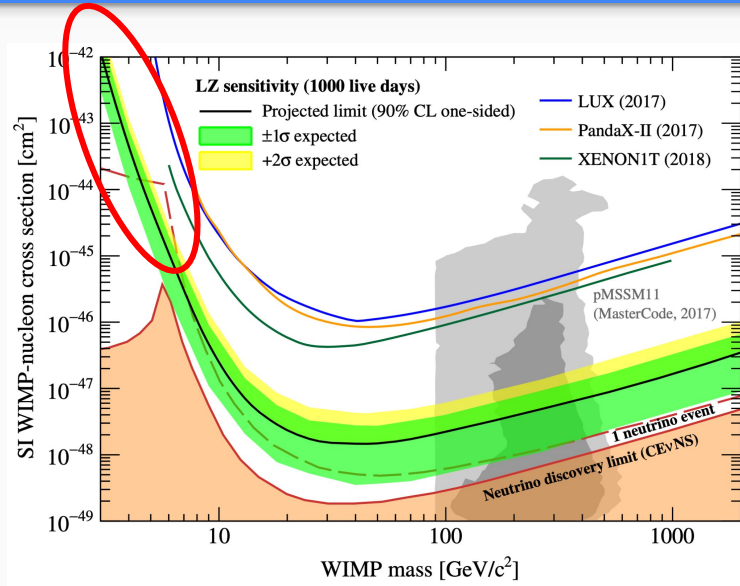


# WIMP sensitivity -- light masses

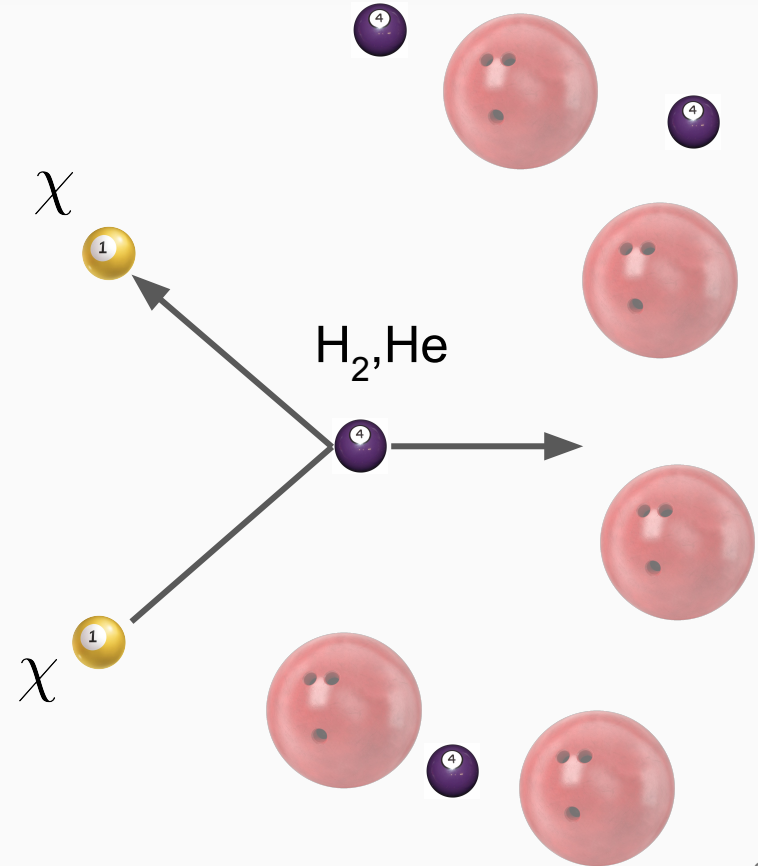


The recoil energies of light WIMPs on xenon are mostly below threshold

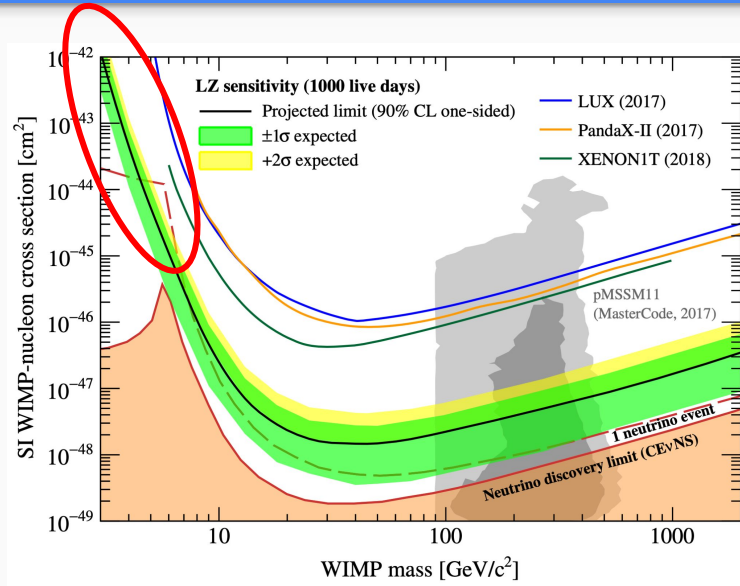
# Adding a light dopant



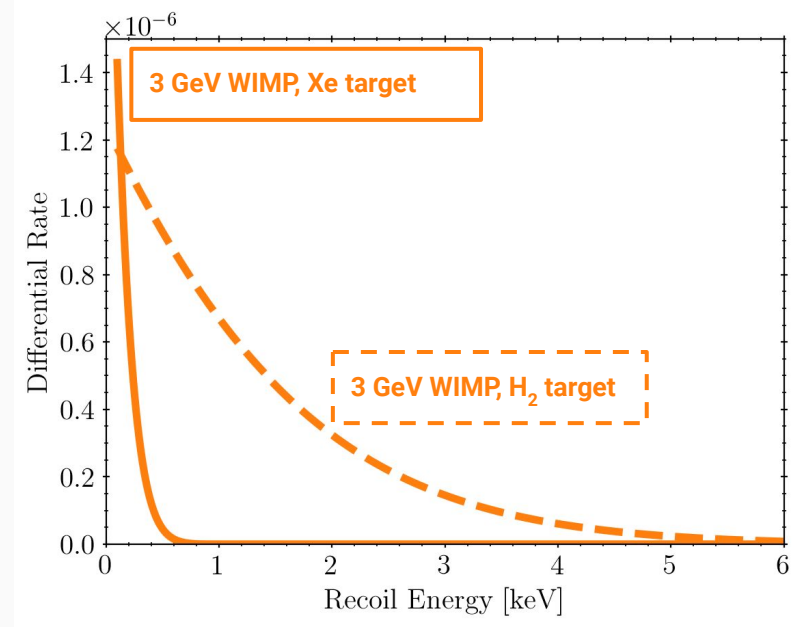
Strategy: choose a target that is a good kinematic match for light WIMPs, dissolve it into the xenon.



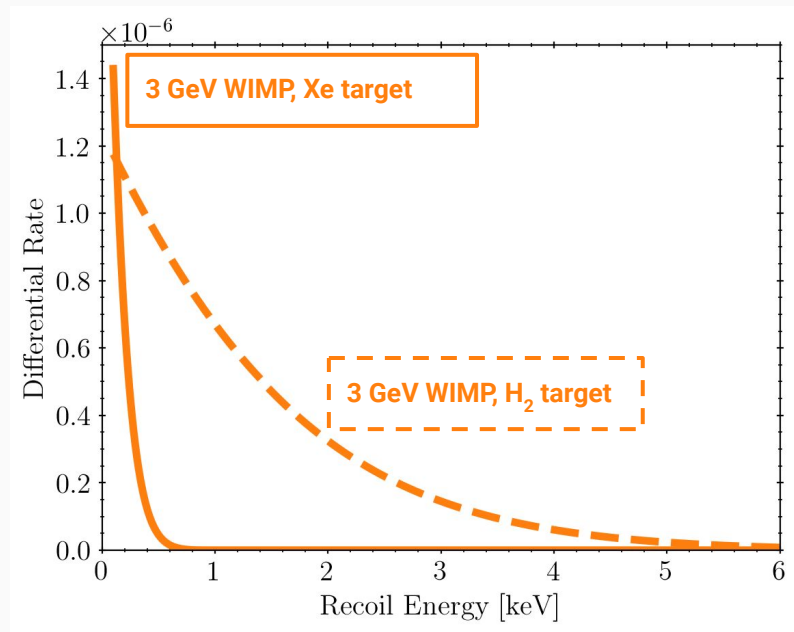
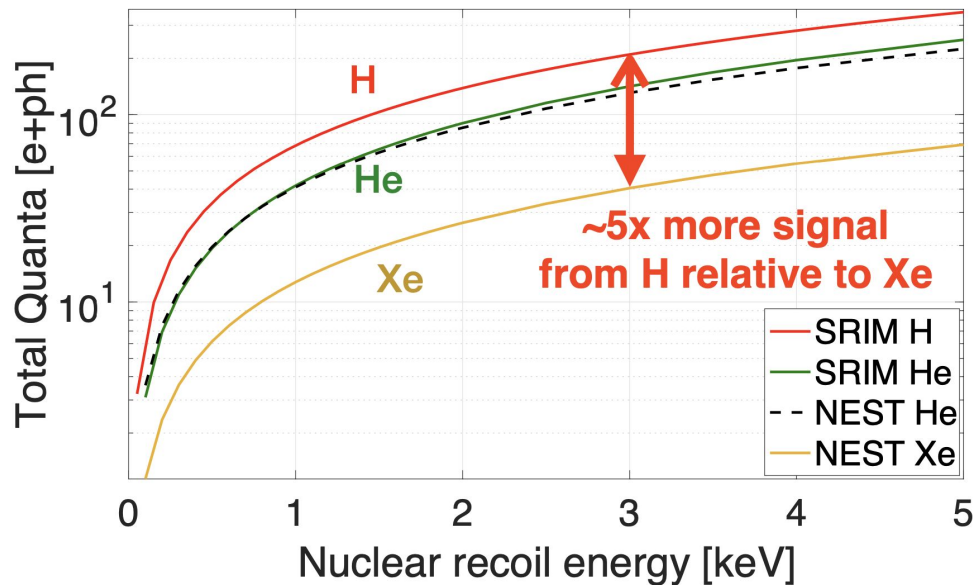
# Adding a light dopant



The light dopant energetically boosts the recoil energies from a light WIMP.



# Adding a light dopant



Equally important: the signal yields of H-recoils in Xe is expected to be  $\sim 5\times$  higher than Xe-recoils.

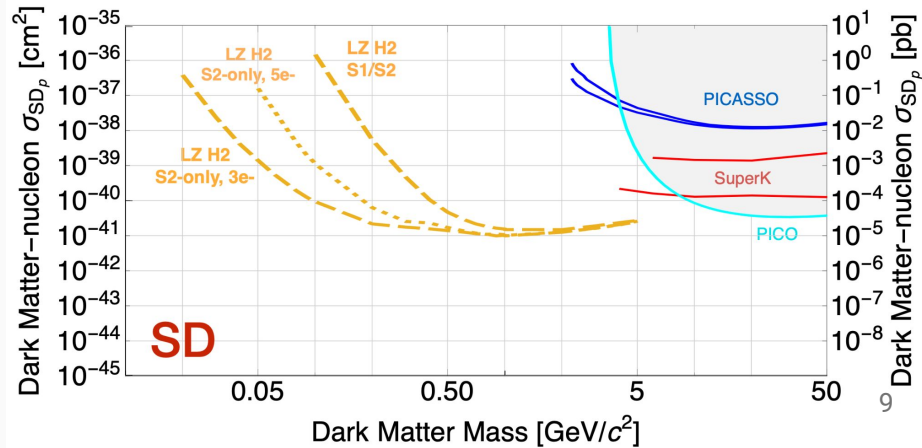
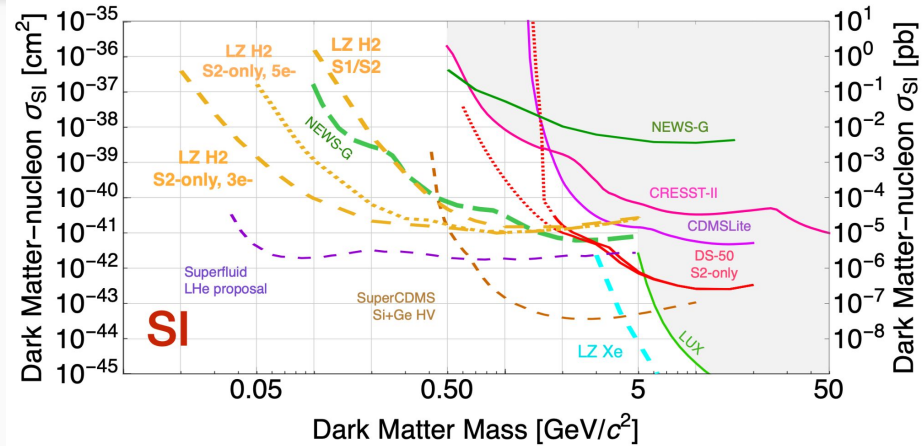


# Projected sensitivity of LZ doped with H<sub>2</sub>

Modest assumptions:

- LZ doped with 2.6% mol fraction H<sub>2</sub> in Xe
- No BG discrimination
- 250 live-day exposure

Crucial point: the dopant can be changed to test different WIMP couplings



## Snowmass2021 - Letter of Interest

### *HydroX- Using hydrogen doped in liquid xenon to search for dark matter*

**Topical Group(s):** (check all that apply by copying/pasting /)

- (CF1) Dark Matter: Particle Like
- (CF2) Dark Matter: Wavelike
- (CF3) Dark Matter: Cosmic Probes
- (CF4) Dark Energy and Cosmic Acceleration: The Modern Universe
- (CF5) Dark Energy and Cosmic Acceleration: Cosmic Dawn and Before
- (CF6) Dark Energy and Cosmic Acceleration: Complementarity of Probes and New Facilities
- (CF7) Cosmic Probes of Fundamental Physics
- (Other) [*Please specify frontier/topical group*]

#### **Contact Information:**

Name (Institution) [email]: Hugh Lippincott (UCSB) [hlippincott@ucsb.edu]

HydroX: doping liquid xenon with H<sub>2</sub>.  
Letter of interest was submitted.

Idea developed by H. Lippincott at UCSB.

Proposal is to upgrade LZ with this idea after LZ ends. But can also be applied to a G3 experiment.

## Issues and open questions related to doping Xe

- What are the signal yields of light recoils in LXe?
  - How does H<sub>2</sub> in the Xe gas phase affect charge readout?
- Can background discrimination be performed?
- How much dopant can be dissolved in the LXe? (i.e. what is the Henry's coefficient)
- Cryogenics are challenging with a dopant with a very different boiling point than the solvent.
- How can continuous Xe purification be performed?
- Are PMTs the optimum photosensor in the presence of a light dopant?
- How do we separate <sup>3</sup>H from the natural H? (natural abundance at around 1 part in 10<sup>18</sup>).

(Red = questions we will try to answer at LBNL)

# HydroX work at LBNL

- Won a small LDRD to do collaborative work with UC Davis.
- The UC Davis LZ group has an existing small Xe testbed and cryostat that is collecting dust.
- We are in the process of moving this to LBNL to perform HydroX R&D.

