A Scintillating Bubble Chamber for Reactor CEνNS

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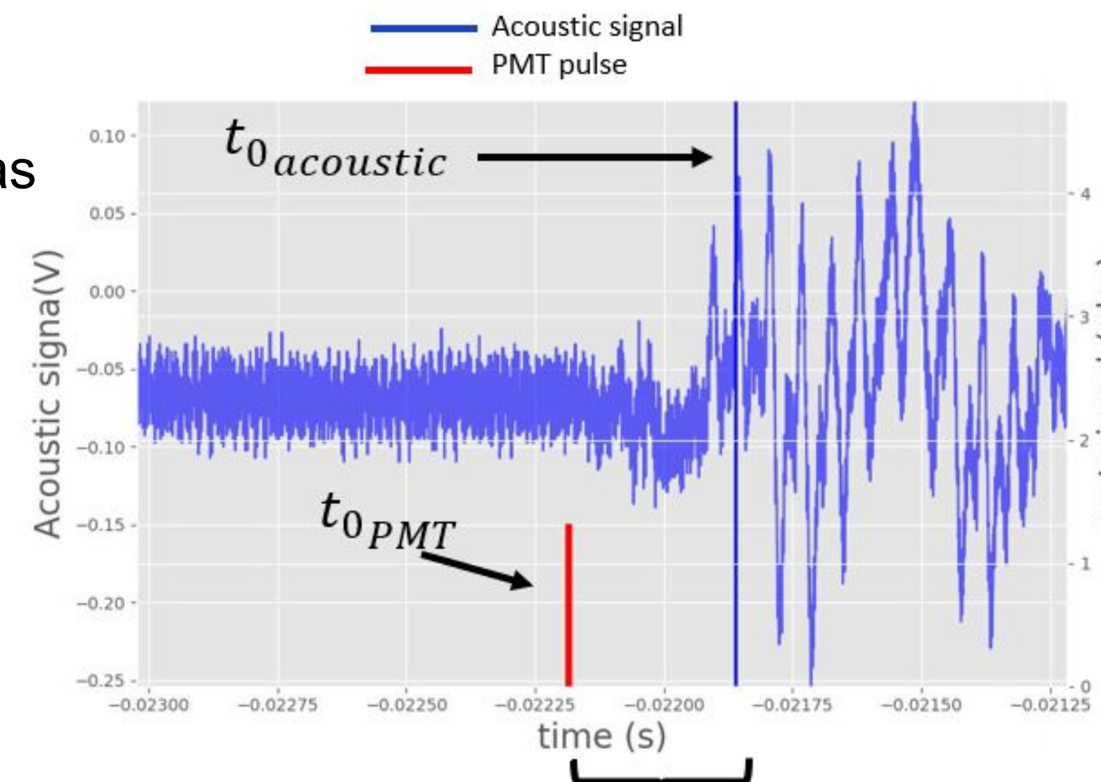
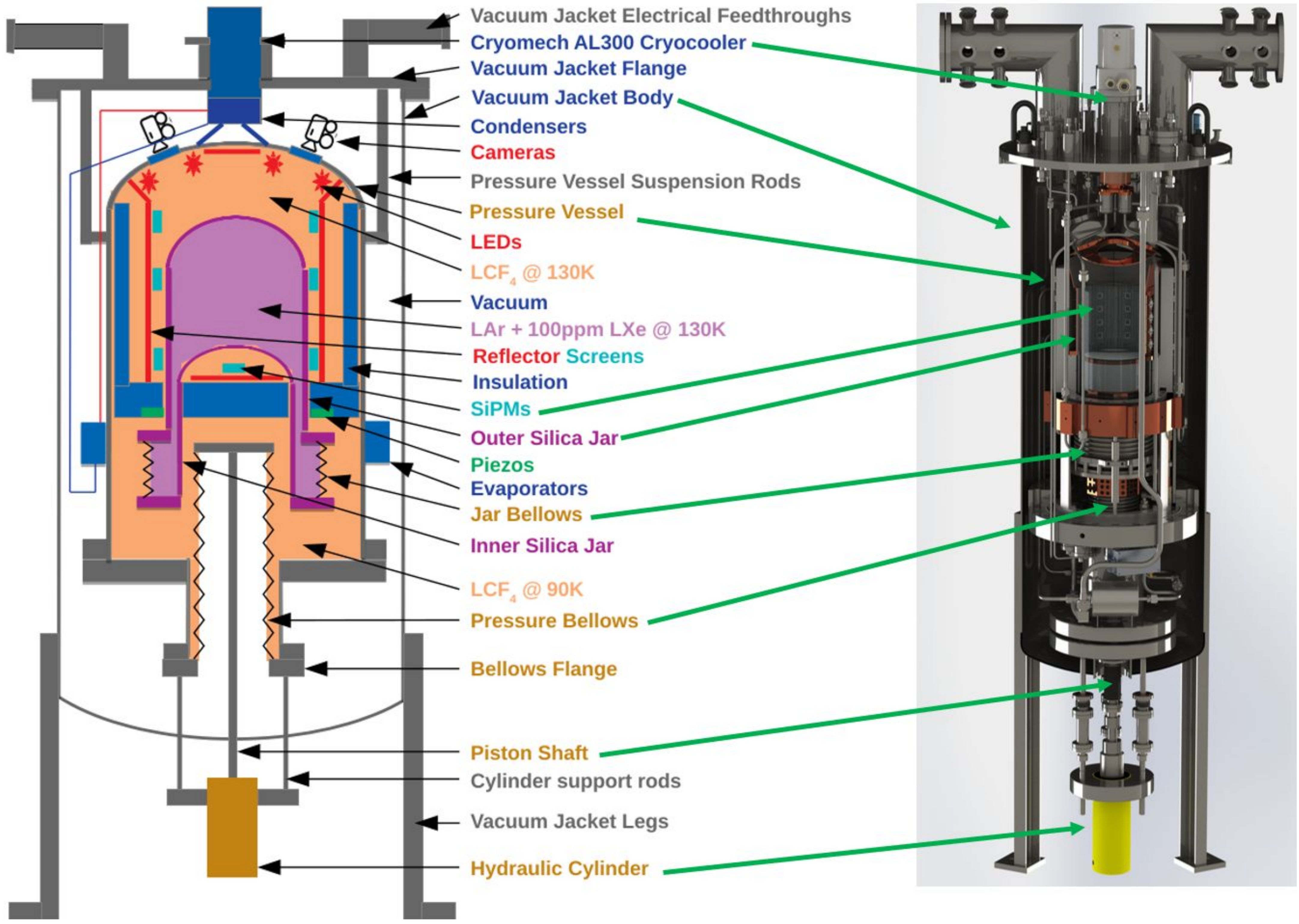
The SBC collaboration is developing liquid argon scintillating bubble chambers with projected sensitivity to coherent elastic neutrino nucleus scattering (CEνNS) from reactor neutrinos. An initial 10 kg device is under construction at Fermilab to demonstrate effectively complete insensitivity to electron recoil backgrounds with 100 eV nuclear recoil threshold. Follow-on devices will search for GeV-scale WIMPs down to the solar neutrino limit (SBC-SNOLAB), and attempt a first observation of CEνNS for reactor neutrinos (SBC-CEνNS).

Scintillating Bubble Chambers

- Combine the electron recoil insensitivity of bubble chambers with the event-by-event energy resolution of scintillation detectors
  - Nuclear recoils create scintillation proportional to energy, and produce bubbles; electron recoils do not deposit enough energy as heat in the liquid to create bubbles.
  - Cameras and LEDs to capture bubble images, SiPMs for scintillation readout, piezoelectric sensors for acoustic bubble detection.
- A 30g xenon bubble chamber was operated at Northwestern.
- Our first argon detector (below) is under construction at Fermilab.
  - 10 kg of liquid argon in the 'warm' active region at 130K. The cold region at 90K is inactive.
  - Nuclear recoil threshold is adjustable down to 40 eV by modifying the degree of superheat, via the pressure.
  - 1000 ppm xenon wavelength-shifts the scintillation light to 175nm, where the fused silica jar is transparent and SiPMs sensitive.



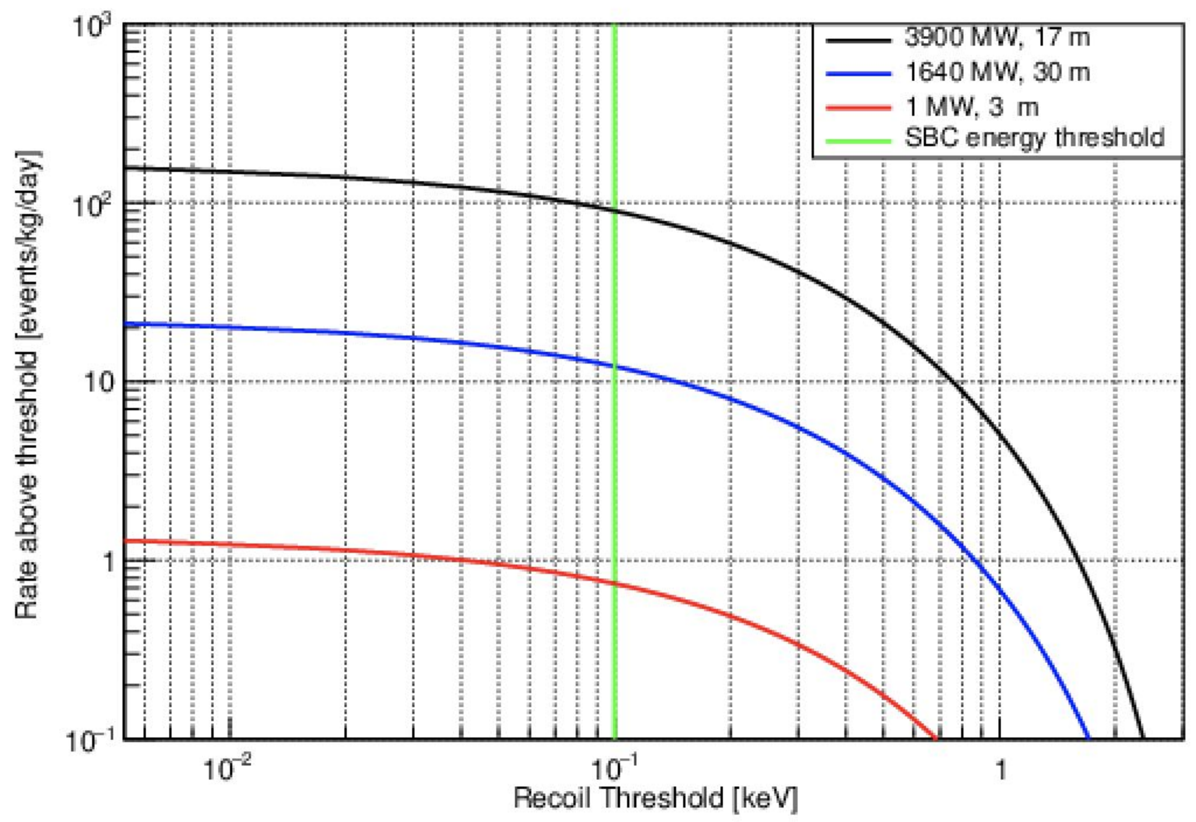
Sample acoustic and PMT data from the 30 g xenon chamber



Physics Goals

The extremely high neutrino flux at reactors allows for multiple physics searches.

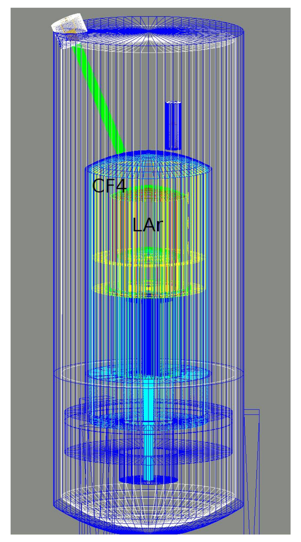
- Detection of CEνNS from reactor neutrinos.
- Search for neutrino non-standard-interactions via CEνNS.
  - Broader sensitivity than collider experiments.
  - Better reach than traditional LAr experiments at stopped pion.
- Search for sterile neutrino oscillations.
- Measure Weinberg angle at low energy.



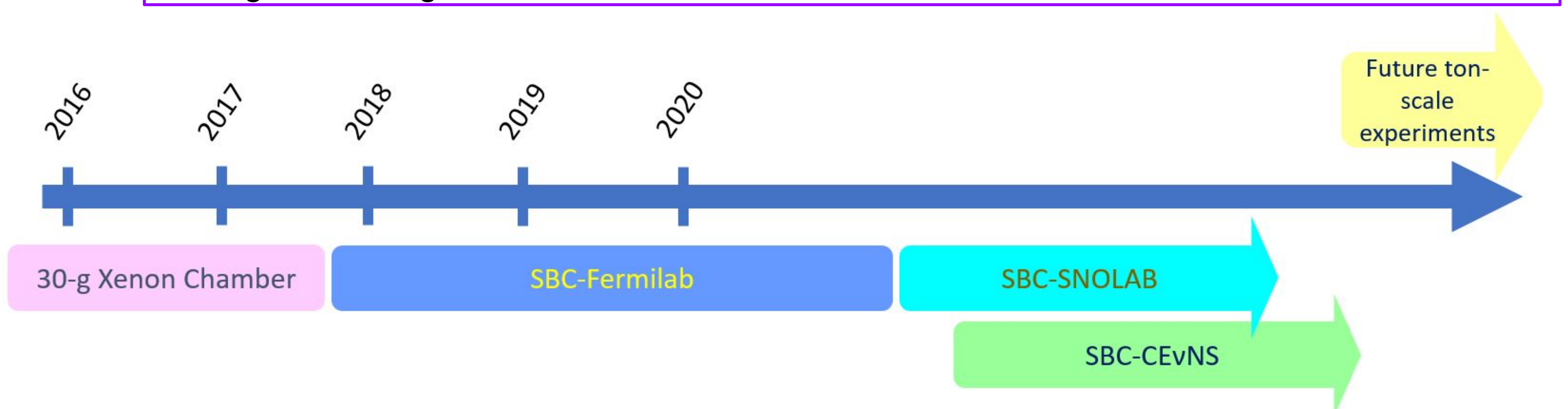
Calculated CEνNS rates at various reactor sites

Reactor Sites

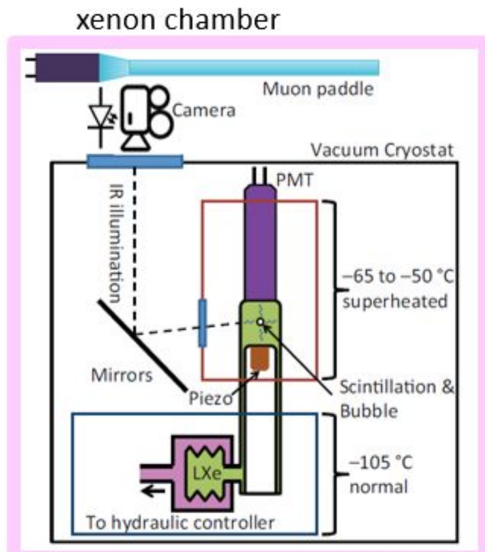
Three reactor sites are being considered for preliminary studies to assess the physics potential of this detector. First, a 3.9 GW reactor, with the chamber located at 17 m, in a similar configuration as the CONNUS experiment at Brokdorf. Second, a 1.64 GW reactor at 30 m, as this is an explored possibility at the Laguna Verde reactor in Mexico. And third, a 1 MW reactor at 3 m, which is another possibility at ININ in Mexico. Simulations for cosmogenic backgrounds are currently underway to evaluate the contribution from neutron induced nuclear recoils to the background budget.



Geant4 model for background estimates

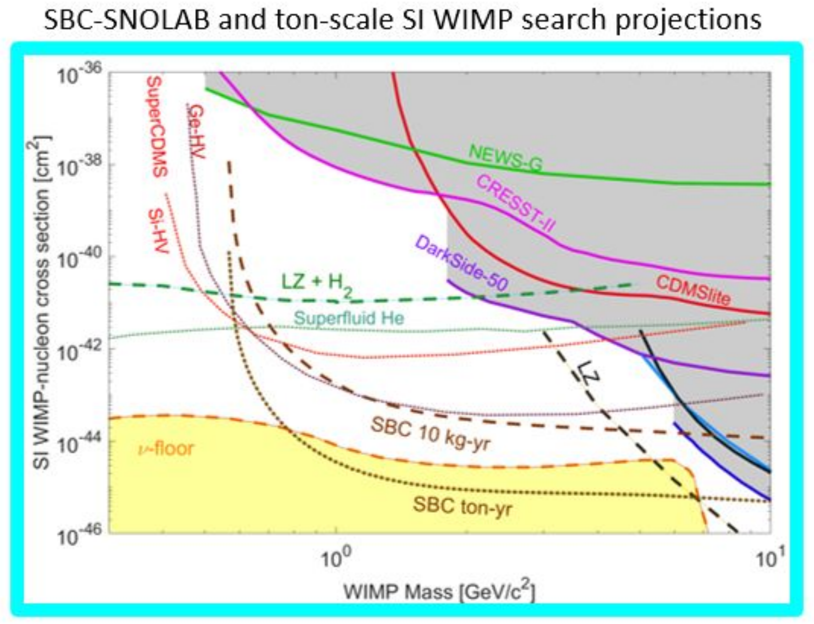


Schematic of the 30-g xenon chamber



The SBC-Fermilab pressure vessel next to the 15' bubble chamber

SBC-SNOLAB and ton-scale SI WIMP search projections



Candidate reactor sites for SBC-CEvNS

Left: ININ

Below: Laguna Verde