Scintillating Bubble Chamber (SBC) for Detecting Dark Matter

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Abstract

The search for dark matter is evolving, and the quest to reach lower cross-sections leads to new technologies. One of the newer proposals involves the use of a bubble chamber which employs noble elements (such as argon and xenon) as the active mass. The switch to these targets opens the possibility for a much lower sensitivity to backgrounds as well as an additional scintillation channel for use in discrimination which opens up the potential for lower mass dark matter to be studied with a lower energy threshold. This poster will introduce the scintillating bubble chamber as well as report on the progress and timeline.

1. Bubble Chambers [1]

Detecting particles by the energy deposited by interactions measuring the resulting bubble.

Pros:

- Good discrimination against betas, gammas, and alphas.
- Scalability: demonstrated by PICO.
- Optimal vertex reconstruction.

Cons:

- No event-by-event energy information.

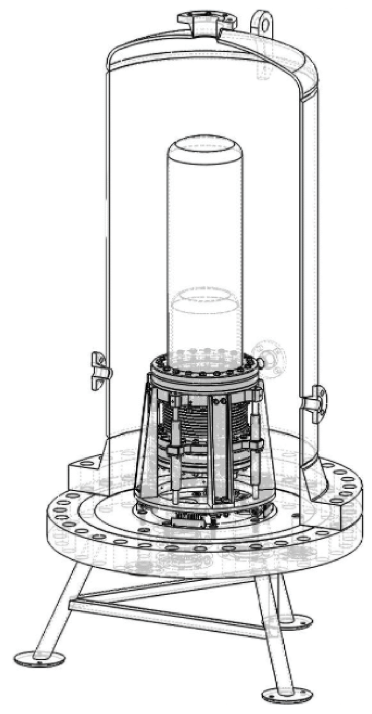

Fig. 1: PICO-40L diagram using superheated C_3F_8 is used to detect dark matter by nucleation.

2. Liquid Noble Gas as Dark Matter Detector

XENON, and DEAP3600 use the scintillation light to track for time and estimate the energy of the collision.

Pros [2, 3]:

- Good at measuring detection time.
- Good for energy resolution.
- Lower dead time.

Cons:

- Weak electron discrimination in Xenon (10^{-3}) [4].

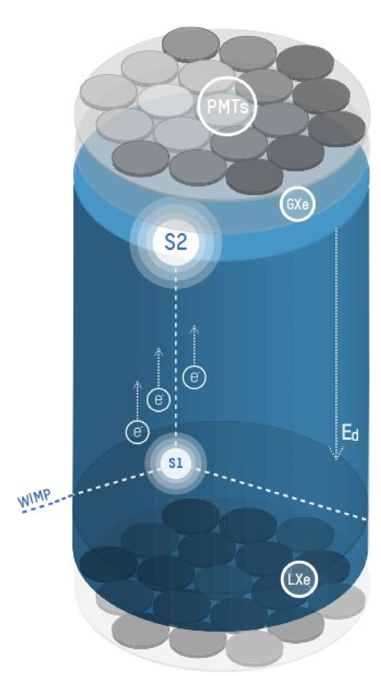

Fig. 2: XENON1T

3. Combine Both = Better! SBCs [5]

First prototype tested in Northwester University with 30-g of Xenon.

Summary:

- Possible to create bubbles in superheated xenon and measure scintillation light.
- Lower gamma discrimination supporting the hypothesis that scintillation suppresses bubble nucleation by electron recoils.

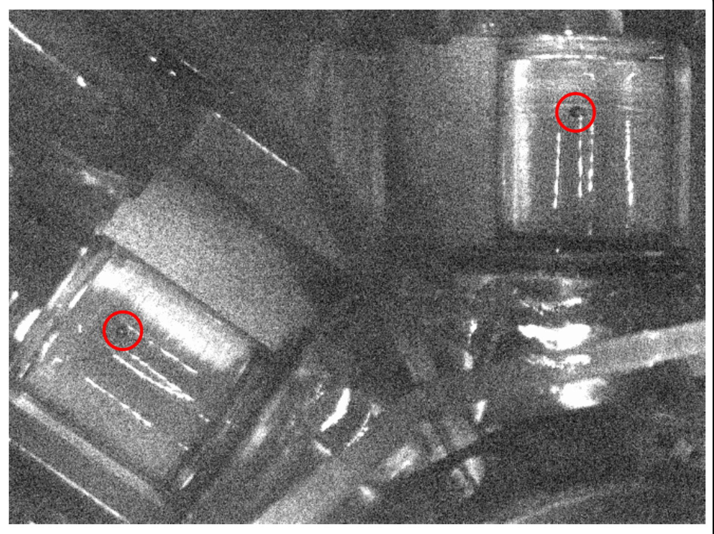

Fig. 3: Northwester xenon bubble chamber as seen by its internal camera. The bubble created by an ^{252}Cf neutron source is seen inside the red circle.

4. Current project: 5L of liquid Argon

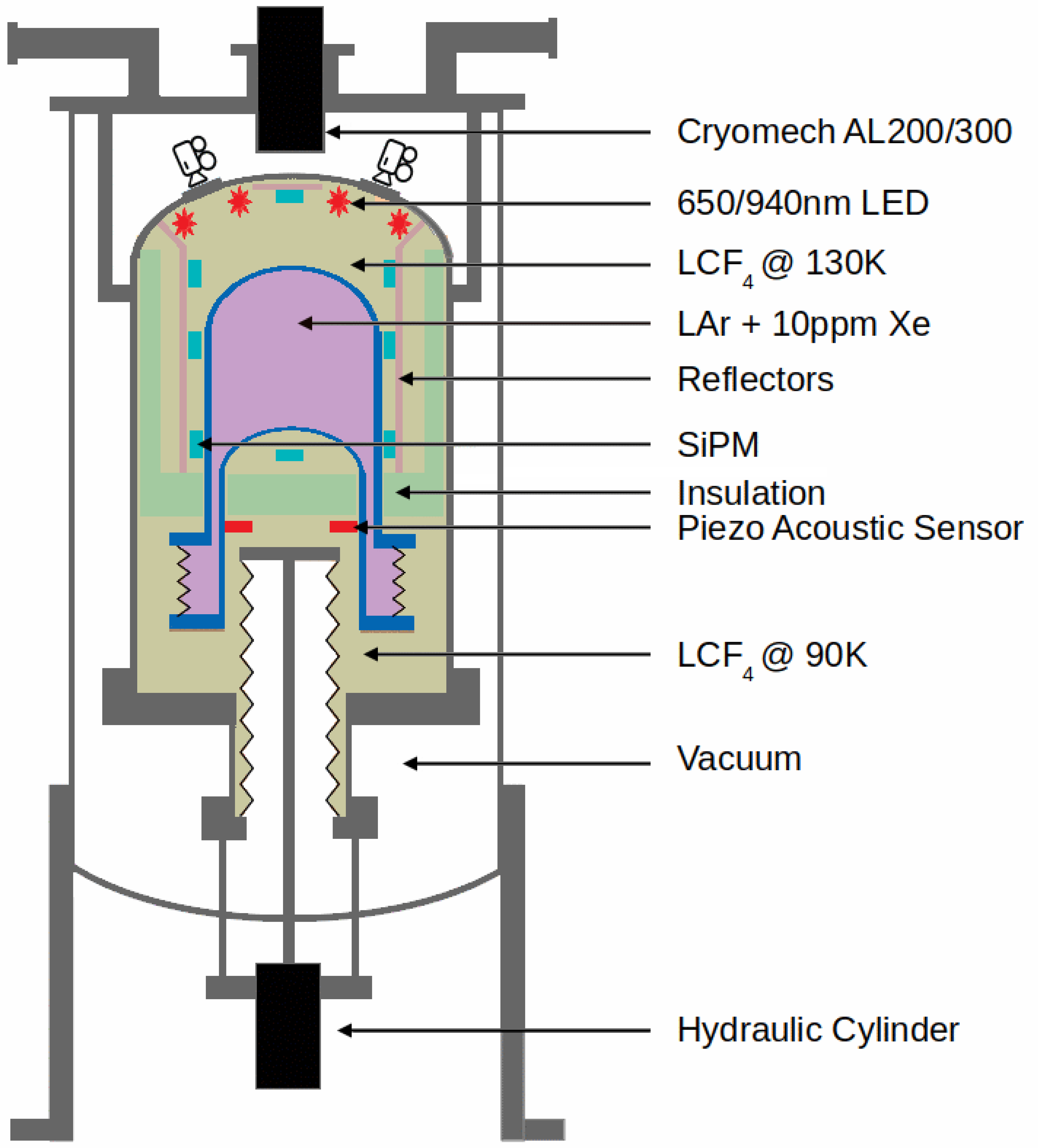

Fig. 4: Current scintillation bubble chamber schematic.

Why?

- Measure and map CEνNS (neutrino floor).
- Look for low-mass WIMP targets.

Challenges

- Design a system that can withstand cryogenic temperatures and extreme pressure cycles.
- Pack all the sensors inside to maximize light, pressure, temperature, and sound collection.
- Calibration required to reach the 100eV threshold.

5. Current work in progress: SiPMs testing

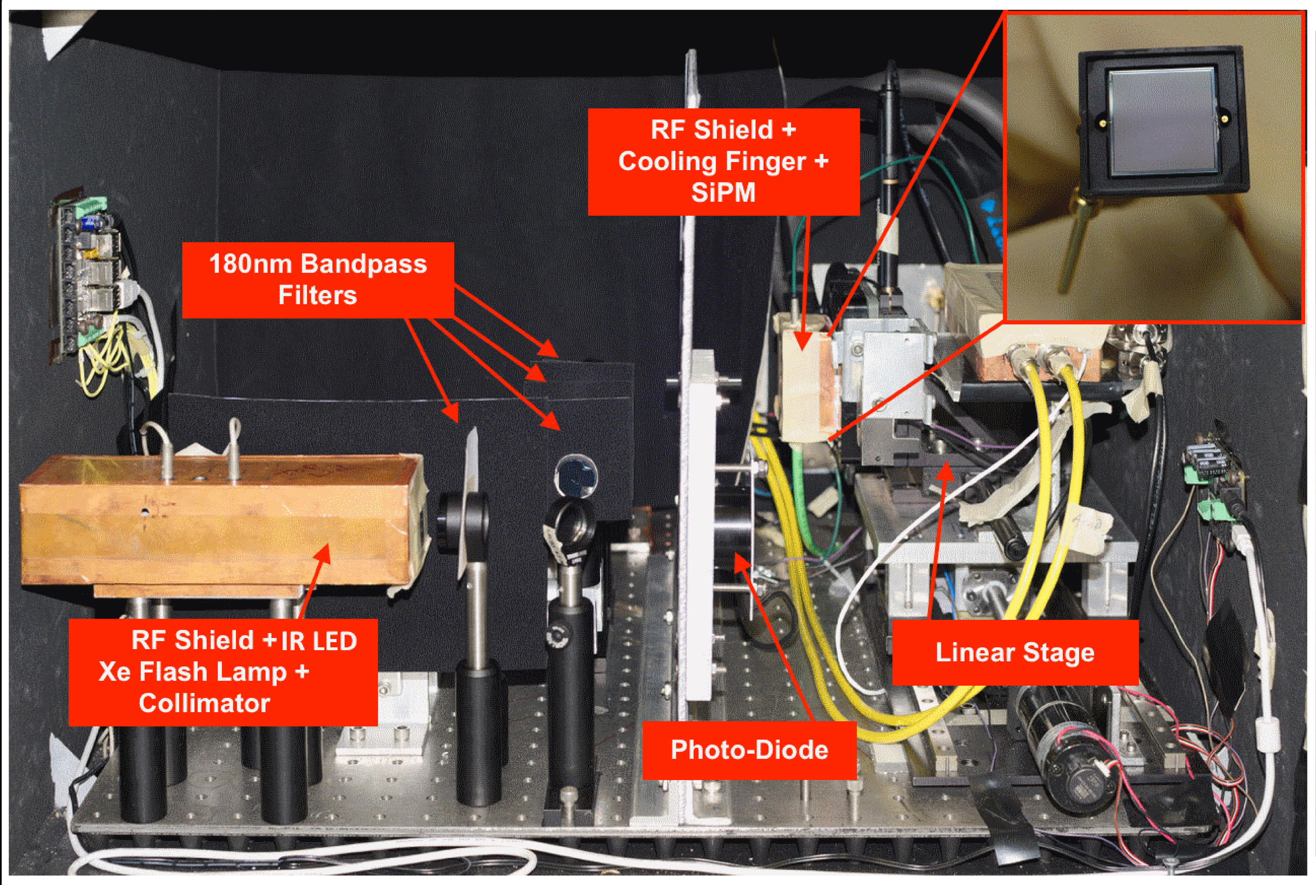

Fig. 5: Current SiPM testing setup at TRIUMF [6].

Fig. 6: SiPMs proposed to be used at SBC.

Currently investigating different SiPMs options at **TRIUMF** for survival of IR illumination, sensitivity to UV light, and radio purity. Additional pressure cycle testing at Northwestern University. Electronics development at TRIUMF.

6. Timeline for SBC

Construction	Engineering run	Calibration	WIMP Run
2019 – 2020	2020 – 2021		2022

We are expecting to finish construction by the end of the year, and test the prototype in Fermilab, and finally install it at SNOLAB for the physics run.

References

[1] C. Amole et al. (PICO Collaboration) (2017) Phys. Rev. Lett. **118** 251301
[2] E. Aprile et al. (XENON Collaboration) (2017) Phys. Rev. Lett **119** 181301
[3] R. Ajaj et al. (DEAP Collaboration) (2019) arXiv:1902.04048 [astro-ph.CO]
[4] D. S. Akerib et al. (2016) Phys. Rev. D **93**, 072009
[5] D. Baxter et al. (2017) Pys. Rev. Lett. **118** 231301
[6] G. Gallina, P. Giampa, et al (2019) arXiv:1903.03663 [astro-ph.IM]