The Current Status of the TUCAN Ultracold Neutron Source

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TUCAN

TRIUMF Ultra Cold Advanced Neutron source

Summary

UCN Production

The TUCAN source

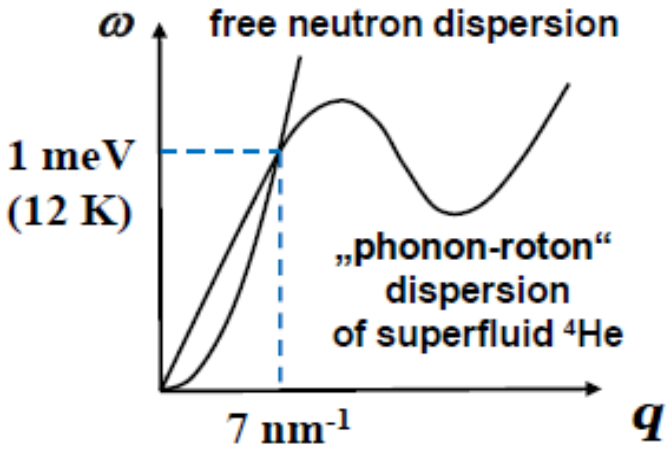
Progress of Cryogenic Subsystems

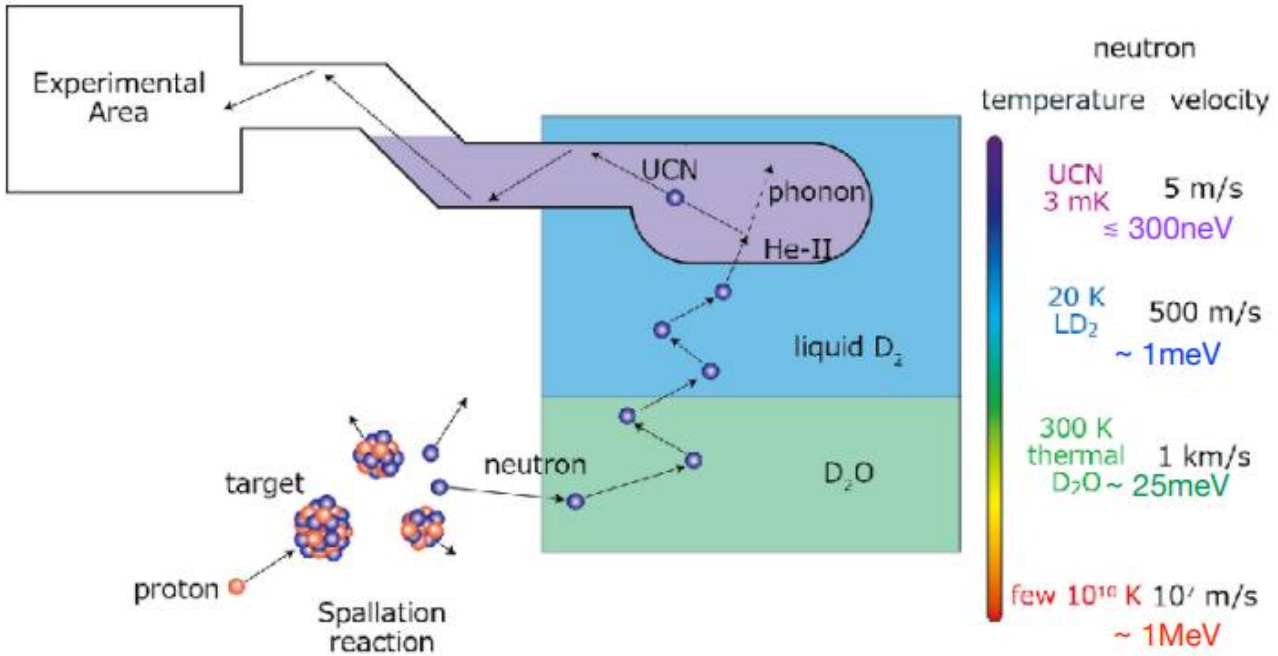
- He Cryostat
- 3He Heat Exchanger
- 3He Supply
- LD2 Cryostat
- He Pumps

Conclusions

UCN Production

- UCN's produced by downscattering cold neutrons in superfluid helium
- Maximizing UCN output depends on minimizing UCN guide temperature (losses $\sim T^7$)





TRIUMF Ultracold Neutron Source

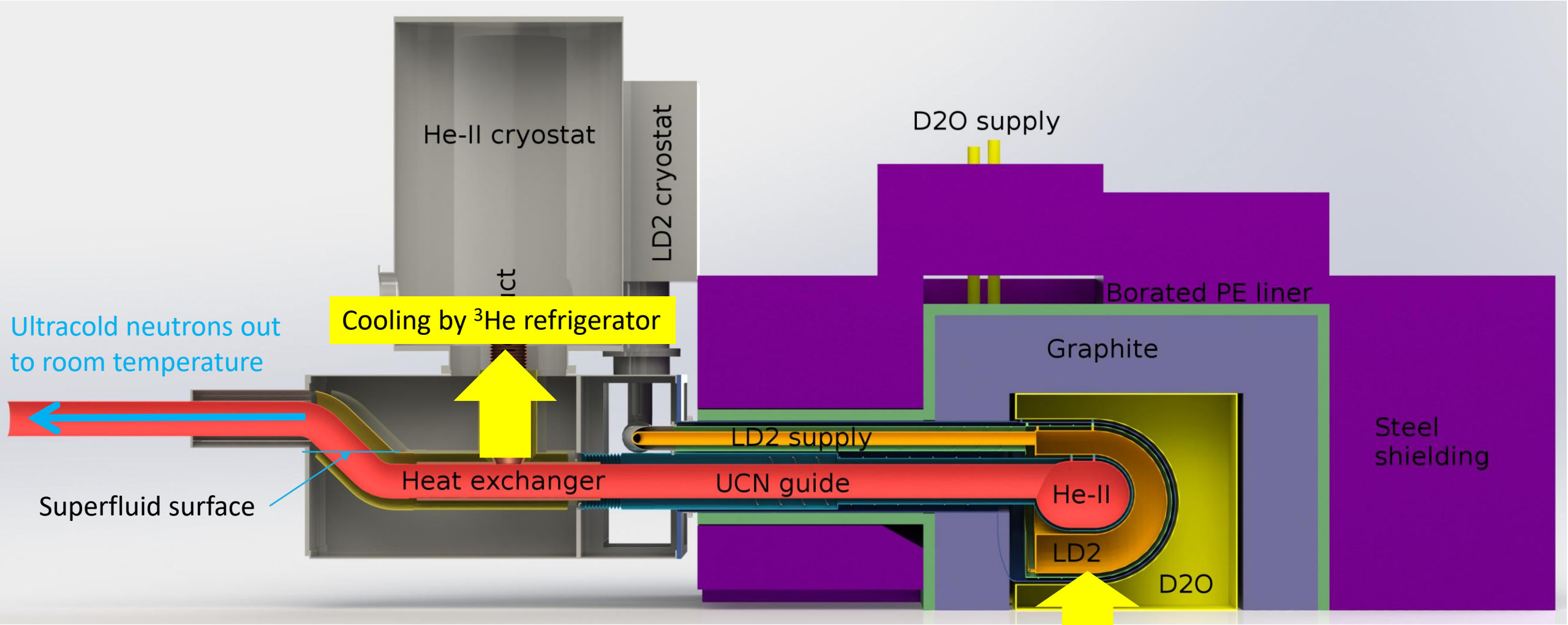
Designed to improve UCN production rate compared to the prototype:

- Beam power: $1\mu A \rightarrow 40\mu A$ beam power
- UCN production rate: $3.2 \times 10^4 \rightarrow 1.5 \times 10^7 \, {}^{\mathrm{UCN}}/_{\mathrm{s}}$
- UCN density: $9 \rightarrow 4.7 \times 10^3 \, {}^{\mathrm{UCN}}/_{\mathrm{cm}^3}$

First experiment: Measurement of the neutron EDM to a precision of 10^{-27} e cm

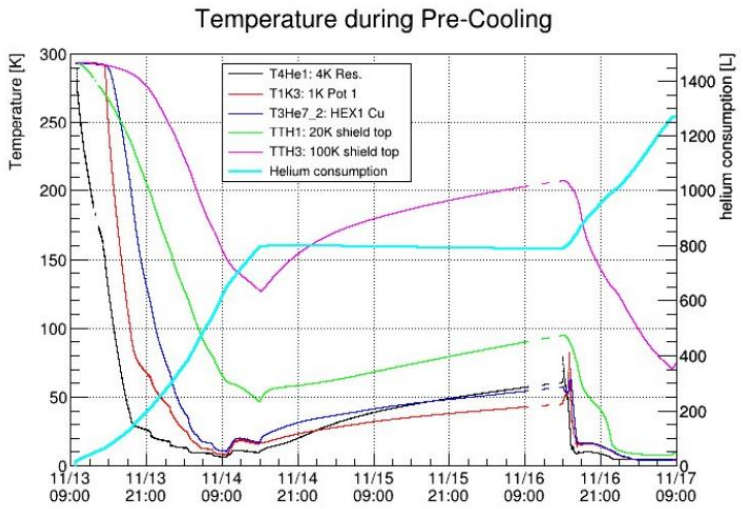
First UCN production target: 2023

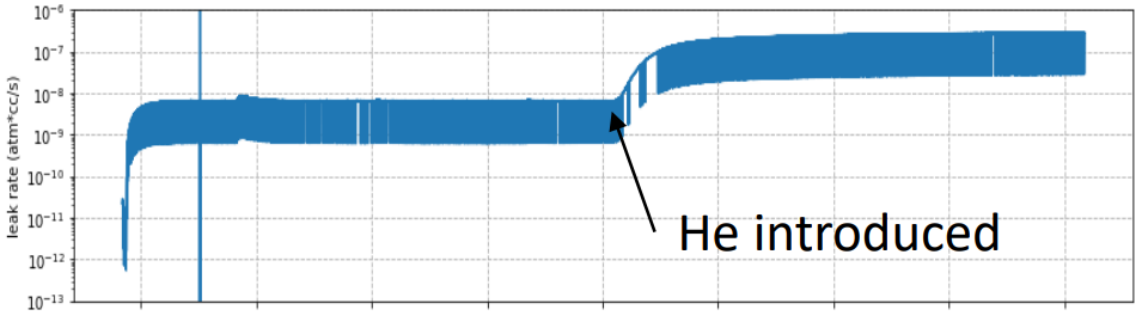
The TUCAN (TRIUMF Ultracold Advanced Neutron) Source

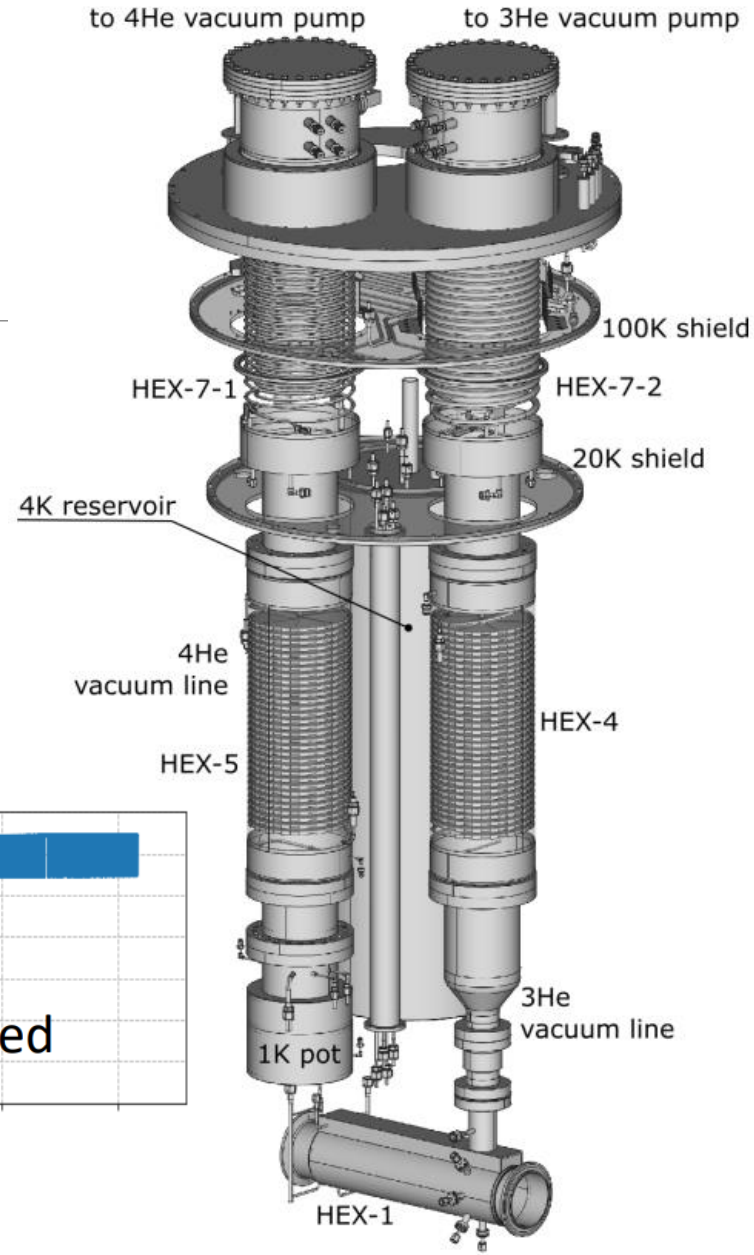


He Cryostat

- He cryostat arrived from Japan in August, 2021
- 10W of cooling at $\approx 0.9\mathrm{K}$ via evaporative cooling of ^{3}He
- Successfully cooled to 1.4K during cooldown in Japan in 2020
- **Currently undergoing leak testing, LHe cooldown in April**







^{3}He Heat Exchanger (HEX1)

HEX1 is responsible for cooling the He-II in the UCN guide.

Two models under consideration:

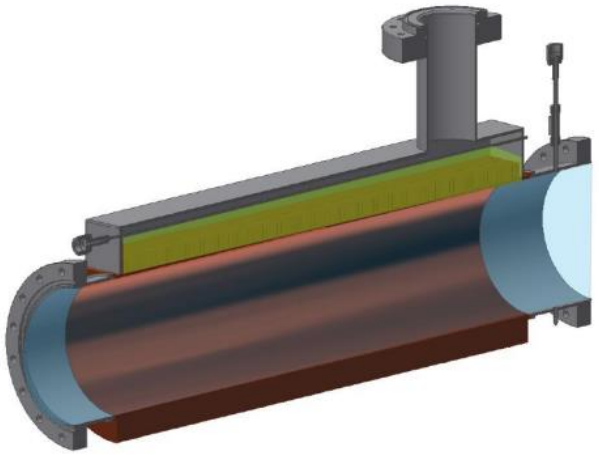
- Vertical fin (shown in figure)
- Cylindrical fin

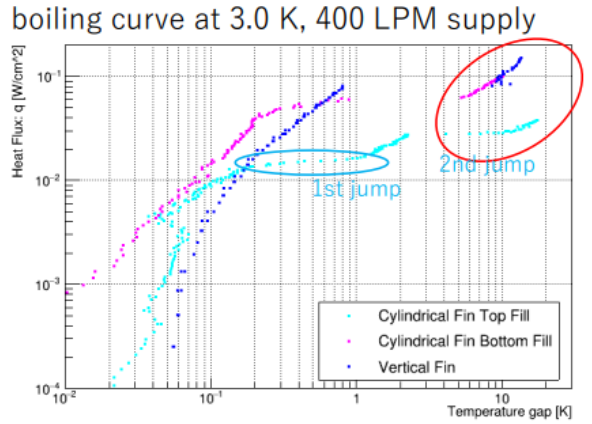
Vertical fin has advantages, including

- Improved critical flux
- Reduced ^{3}He volume required to operate

Currently undergoing detailed design in Japan

Scheduled for delivery in October 2022





S. Kawasaki. Helium Cryostat Report, Jan. 2022

^{3}He Supply

Large volume of ^{3}He required: up to 550 standard litres.

^{3}He price between $2000 - $3000 per standard litre!

~48L of ^{3}He at 90% purity has been recovered using a dilution refrigerator

- Also have 110L from the prototype source

Negotiations to purchase the remaining required ^{3}He are ongoing

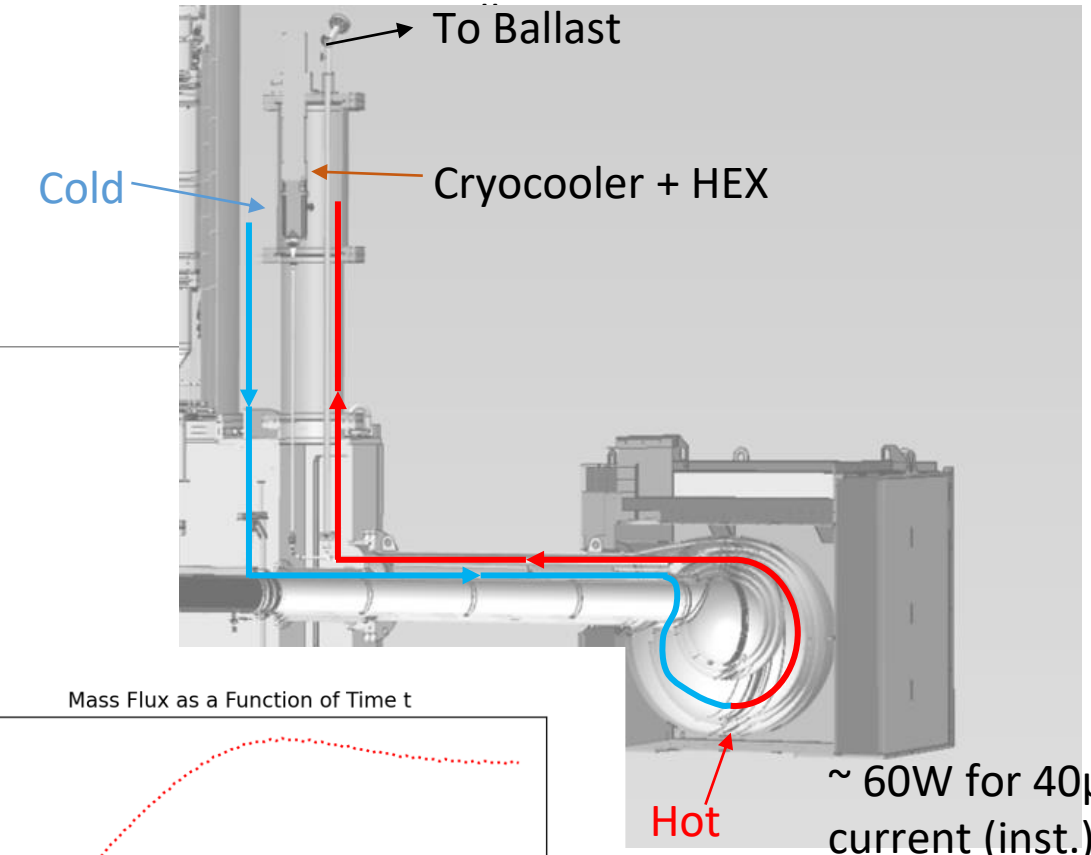
LD_2 cryostat

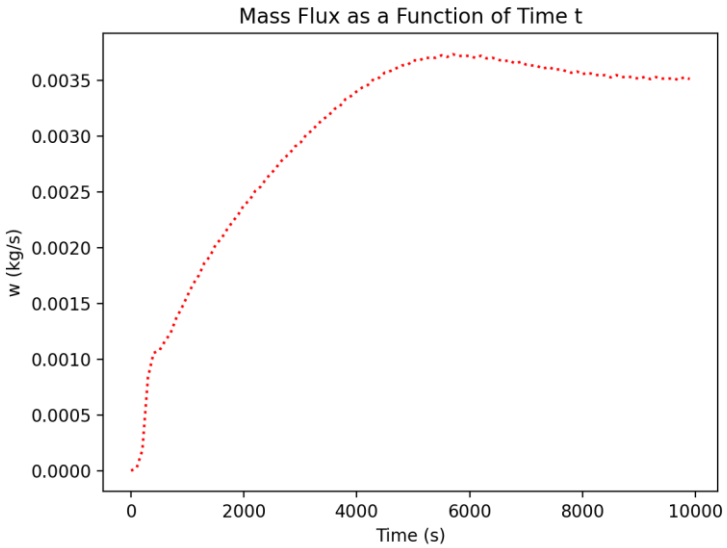
LD2 cryostat is a single phase thermosyphon loop cooled by a GM cryocooler.

Simulations demonstrate:

- Flow equilibrium $\sim 10000\ \mathrm{s}\ (3\ \mathrm{hrs})$
- Mass flow rate $\approx 30\ {}^{g}/_{s}$
- Insensitivity to beam duty cycle (25%)
- High sensitivity to system pressure losses

Cryocooler has arrived, currently undergoing detailed mechanical design





K. Augusto, UW

He Pumps

- ^{3}He and ^{4}He pumped in two stages:
  - WZ2001A Busch vacuum Panada booster
  - NS0600C Busch Cobra screw compressor

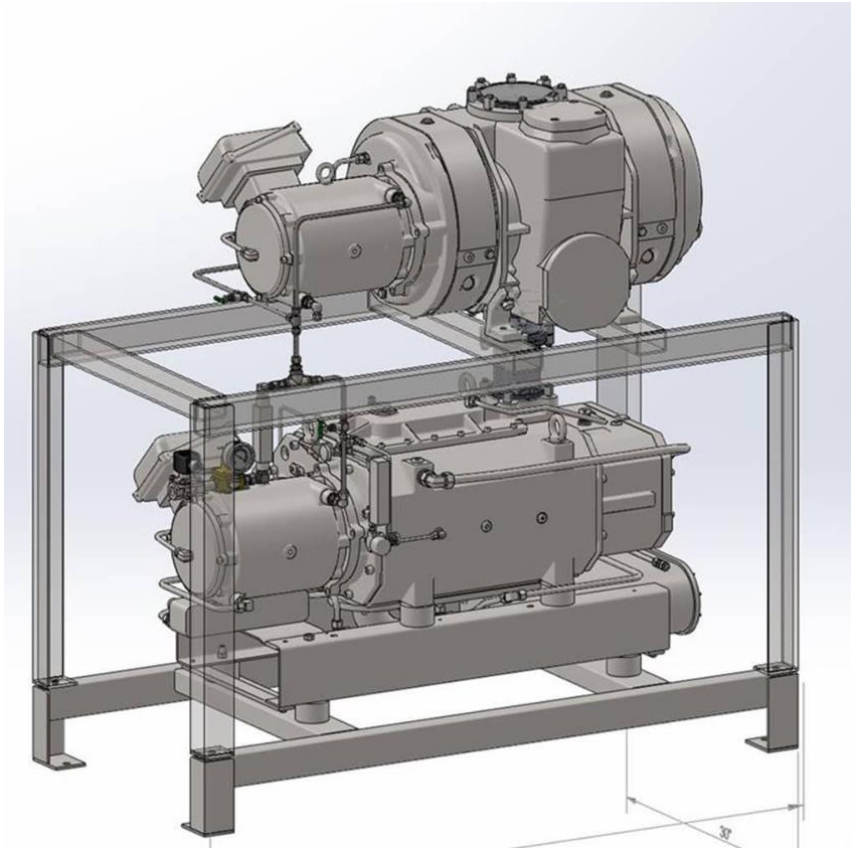
Pumps configured to deliver:

$0.57\ {}^{g}/_{s}\ \left(4650\ {}^{m^3}/_{hr}\right)\ ^3$He

$0.607\ {}^{g}/_{s}\ \left(1900\ {}^{m^3}/_{hr}\right)\ ^4$He

- Mechanical, electrical and controls installation in progress.

Pump commissioning tests to begin in March or April



Conclusions

- TUCAN Collaboration aims to create a UCN source productive enough to enable the measurement of the nEDM to a precision of 10^{-27} e cm
- He cryostat currently undergoing leak checks, will be cooled with LHe in April
- ^{3}He heat exchanger undergoing detailed mechanical design, scheduled to arrive in October 2022
- ~ 150L ^{3}He has been recovered, purchase of remainder in progress
- Mechanical design of LD_2 cryostat in progress, simulations are encouraging
- ^{3}He and ^{4}He pump installation in progress. Commissioning tests to begin in March or April
- First UCN production anticipated in 2023

Questions?

Thank You!