Design of a Gas Handling System for a Liquid Noble Cryostat

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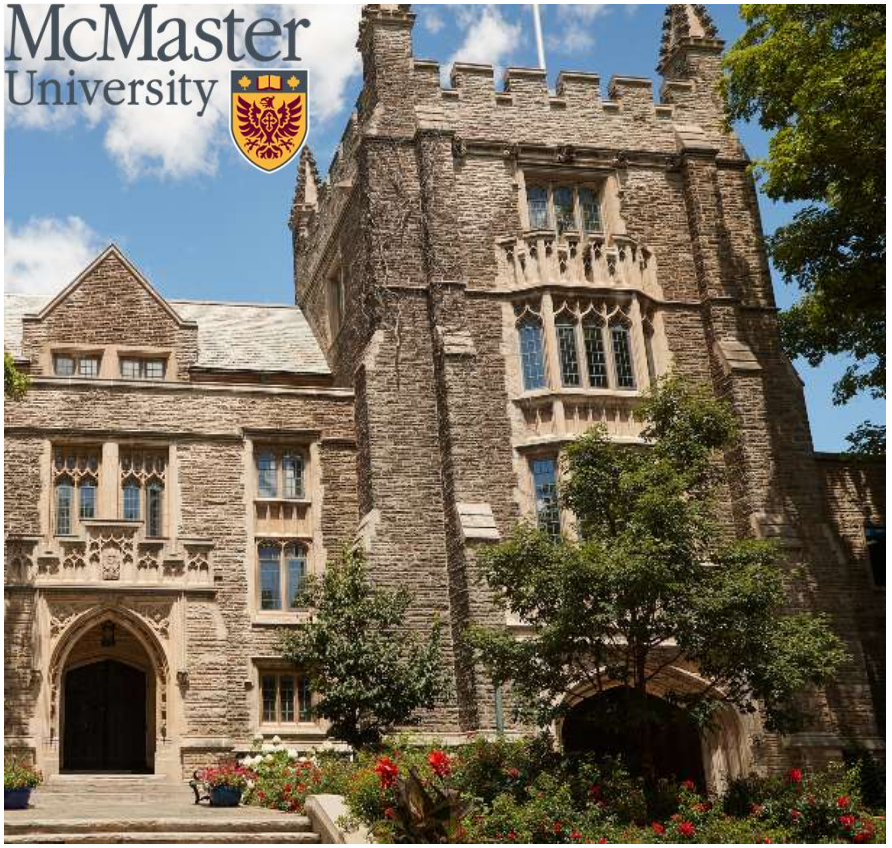
P2020-11: Liquid Noble Gas Cryogenic Facility (LNGCF)

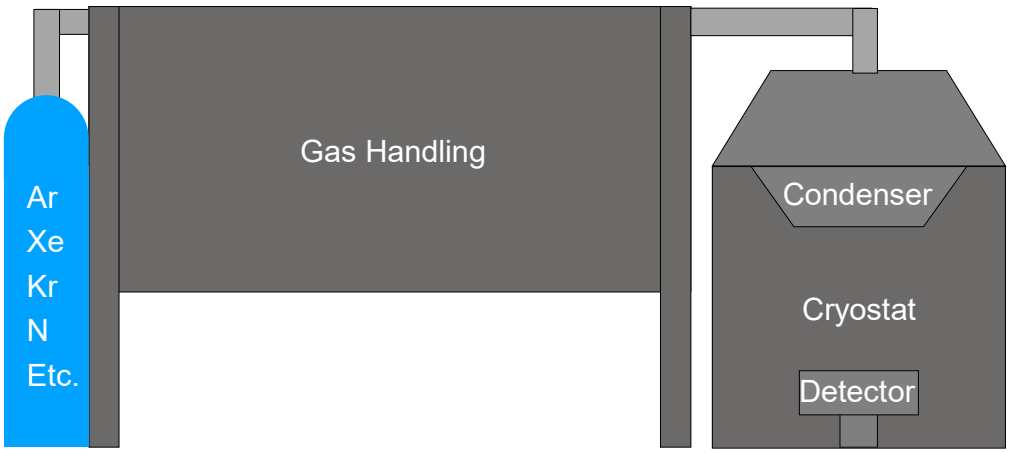
Who am I?



The Project

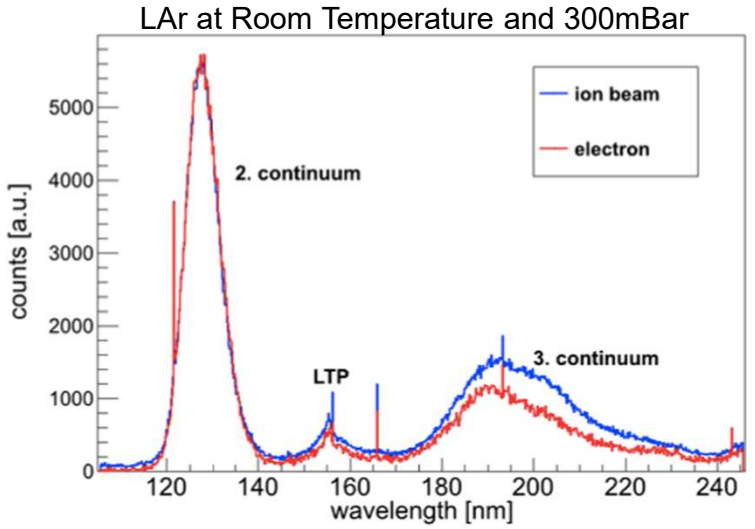
WHAT

Facility open to the full community for testing, learning, or training on liquid noble gas techniques. Features a gas handling system (GHS) and a cryostat that can hold up to 12-15kg of LAr.



WHY

Noble gases are excellent for particle ID due to high yields of scintillation light. Different light and timed detections from different incident particles allow for the a more accurate particle ID.



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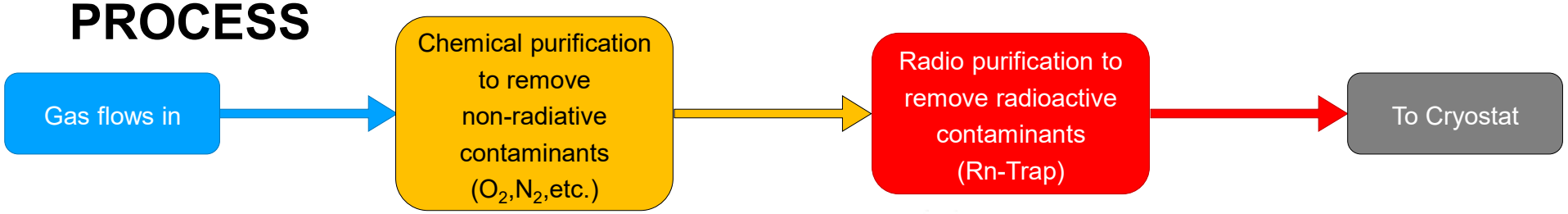
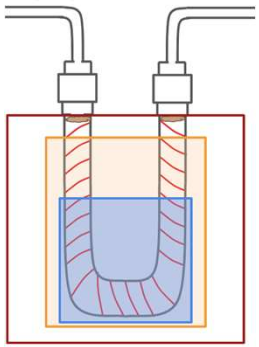
Gas Handling System

GOAL

Ensure the delivery of pure noble gas to the cryostat by eliminating any atmospheric or radioactive impurities (oxygen, nitrogen, radon, etc.). We are aiming for <1ppb of atmospheric contaminants (10ppm for oxygen) and <1mBq/kg of radioactive contaminants (Rn-222).

PROCESS





Design Requirements and Problems

- Set upper pressure limit to 15psig to simplify design (Dictated by TSSA).
- Vacuum pressure (10E-7mBar) must be achieved before filling to ensure system is clear.
- Restrict back streaming of gas through the system.
- Ensure each component has a bypass.
- Ensure each component has access to a vacuum line.
- Ensure each component has access to a relief line.
- Some components can reach high temperatures (50-100^{o}C).
- Other components require low temperatures for efficiency (-40,-196^{o}C).

Large Temperature Drops

PROBLEM

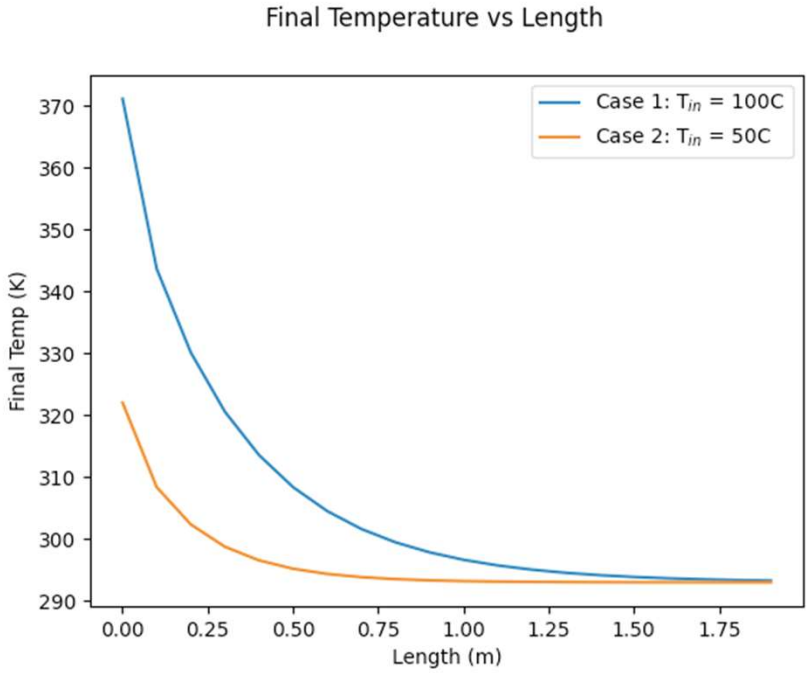
The gas purifier can reach high temperatures from long operation times while the radon trap requires low temperatures. **These two components are in connection with each other.**

DEFINITION

What length of piping will be most efficient to cool off gas before entering the radon trap assuming no external cooling mechanisms are present?

CONCLUSIONS

Argon gas: low thermal conductivity => fast heat dissipation. 30cm-1m would be appropriate for this application.



$$T_{\mathrm{o}} = T_{\mathrm{s}} - (T_{\mathrm{s}} - T_{\mathrm{i}})e^{\frac{-hA_{\mathrm{s}}}{\dot{m}c_{\mathrm{p}}}}$$

Pressure Relief Under High Vacuum

PROBLEM

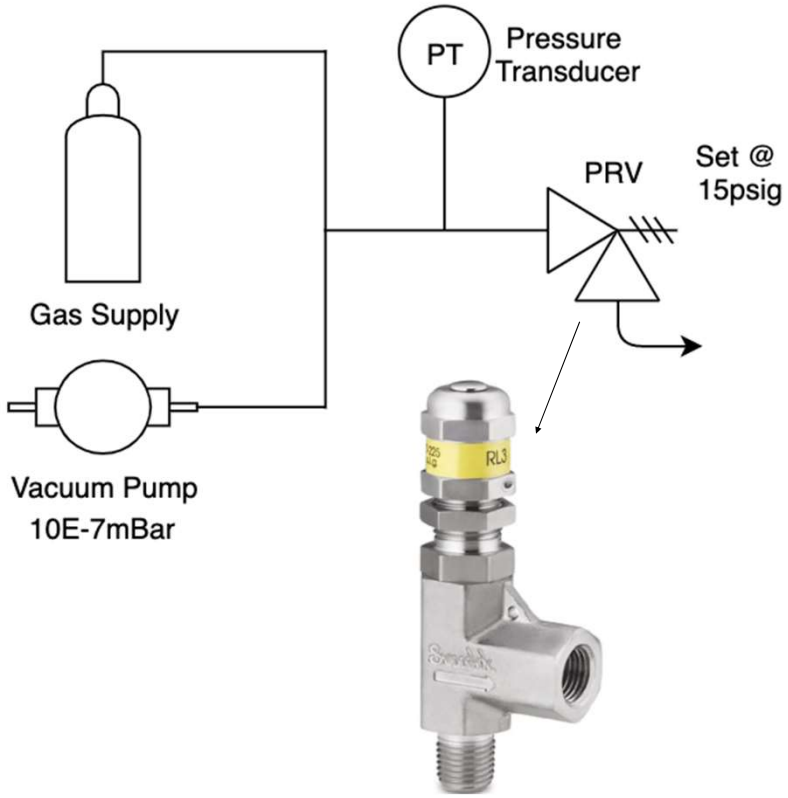
High vacuum pressures(10E-7mBar) will be applied when cleaning out the system. No relief valves have been rated to this low pressure and we want to refrain from using check valves for safety reasons.

DEFINITION

We need to ensure relief valves can still function under high vacuum pressures to ensure the safety of the system.

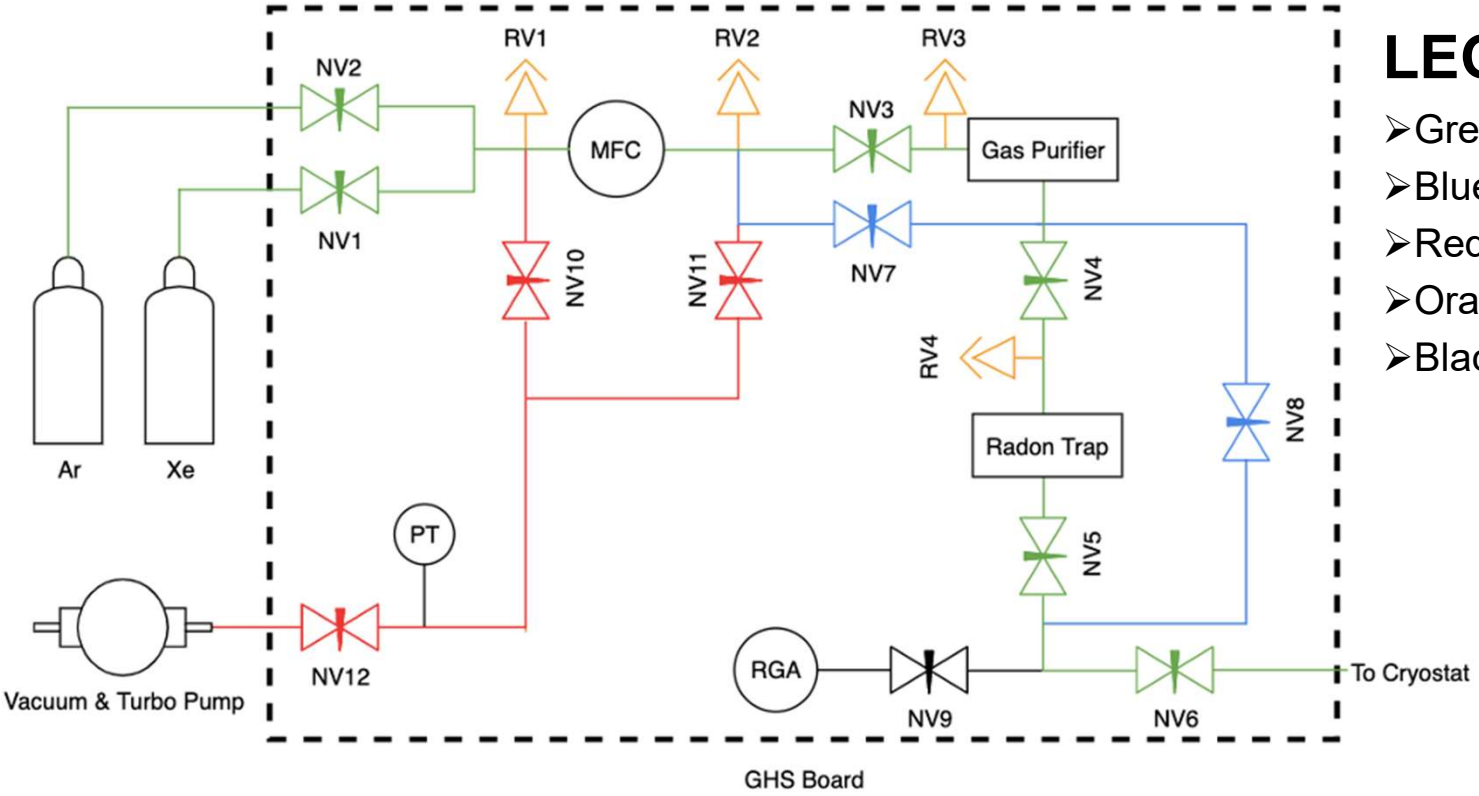
CONCLUSIONS

Experimentally validate the pressure relief valves under high vacuum pressure to see if they are still functional.



SS-RL3M4-F4

Finalized Design



LEGEND

- Green = Operational Flow
- Blue = Bypass Line
- Red = Vacuum Line
- Orange = Relief Line
- Black = Gas Analysis Line

Outcomes

ENGINEERING EXPERTISE

- Lots of engineering went into the GHS design to solve complex temperature and pressure problems scattered throughout the system.
- Input from several other experiments with similar design problems allowed for new compromises and solutions to be developed enhancing the problems faced.
- New input is very welcome as this can further solve similar problems for future experiments.

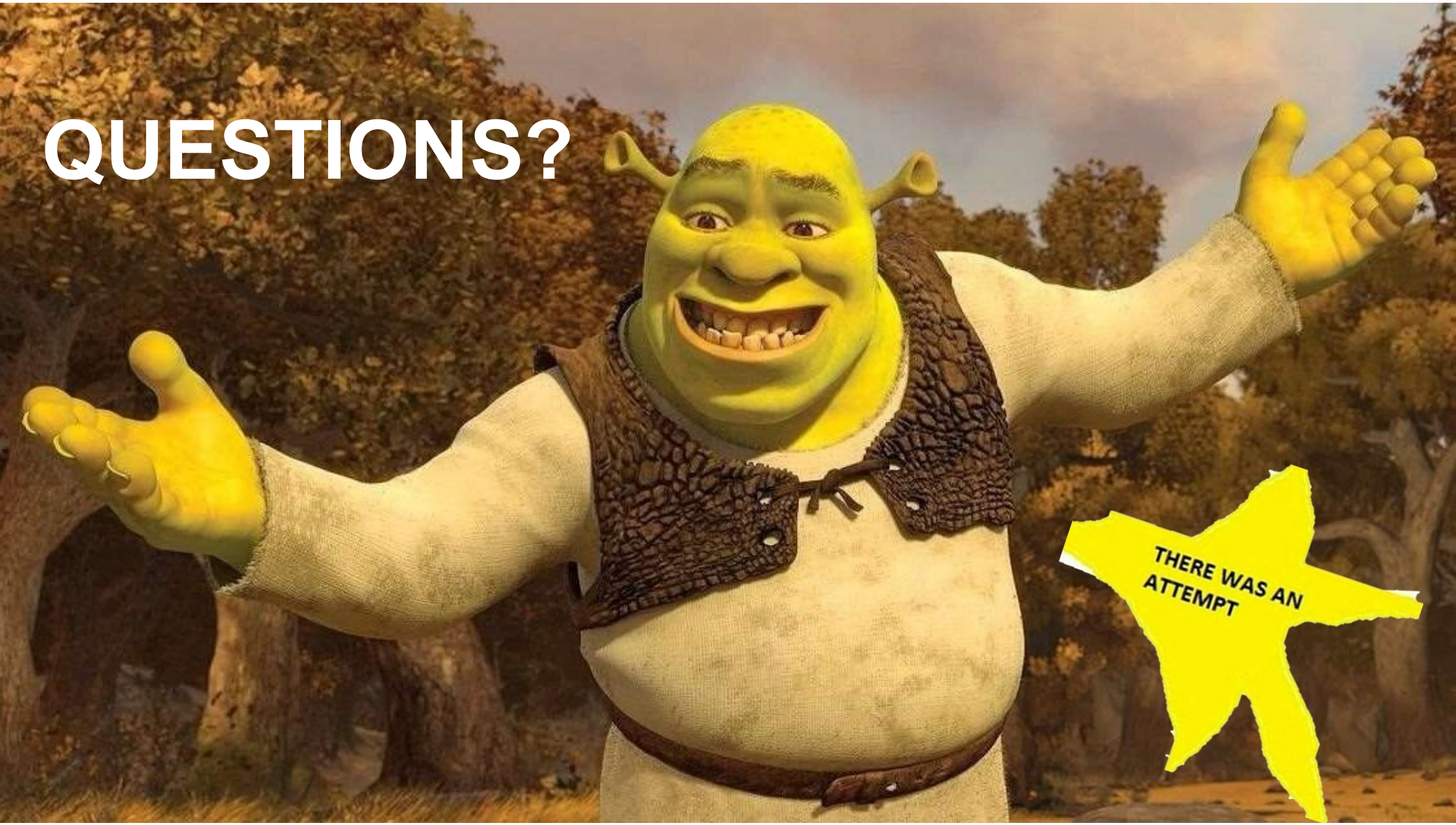
Future Impacts

NEXT STEPS

- Finalize the design of the cryostat/condenser and begin construction.
- Grant access to the facility for the full community through a sing-up portal similar to the SNOLAB Material Access.

ACKNOWLEDGEMENTS

- I would like to thank each member of the team for their insights and support throughout the design process: Paul Larochelle, Pietro Giampa, Ryan Curtis & Ryan Hupping


QUESTIONS?
THERE WAS AN ATTEMPT

Backup Slides

Process Diagram