3D π

Cryogenics and Cryostat

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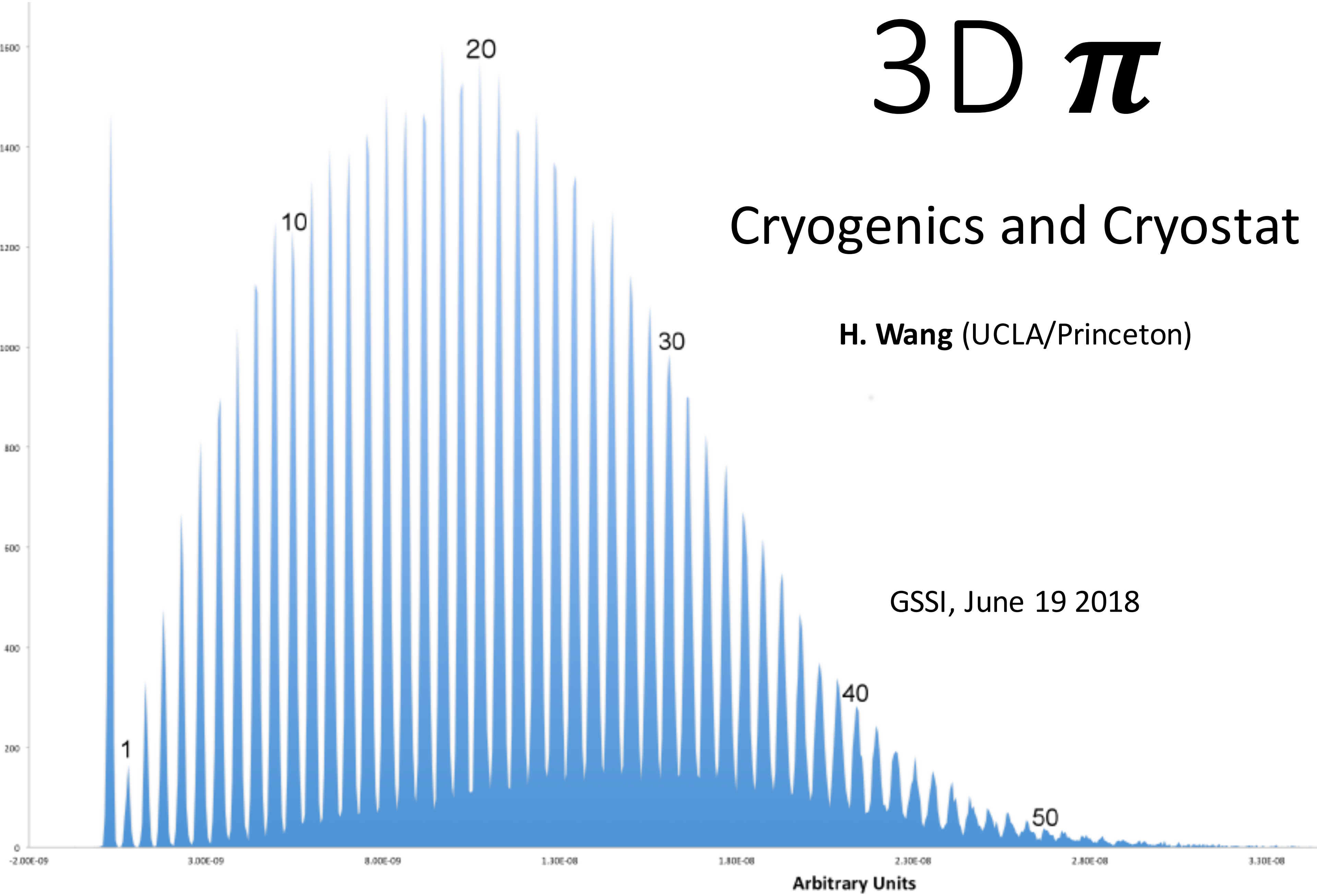
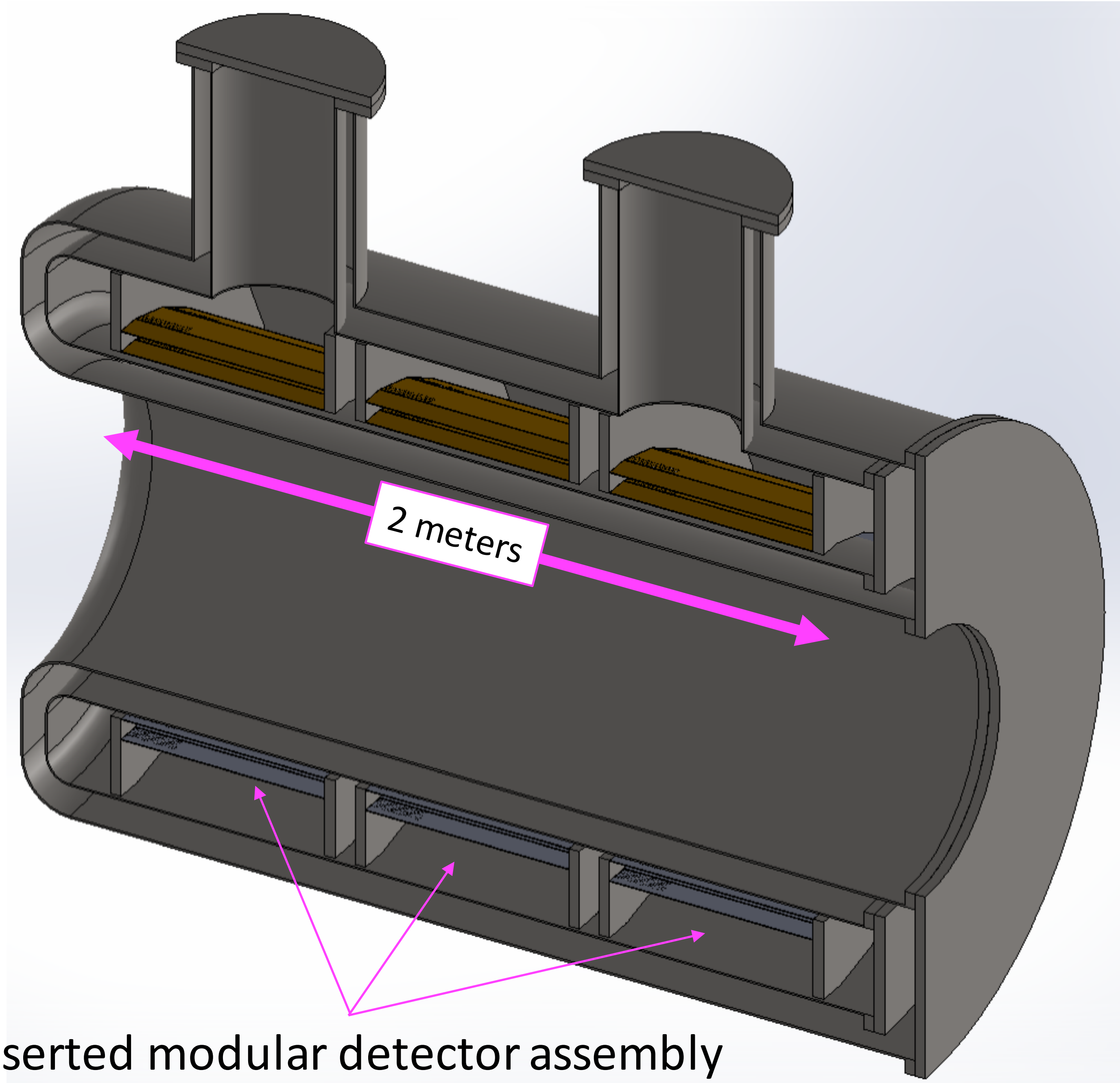
GSSI, June 19 2018





Inserted modular detector assembly

Cryogenics

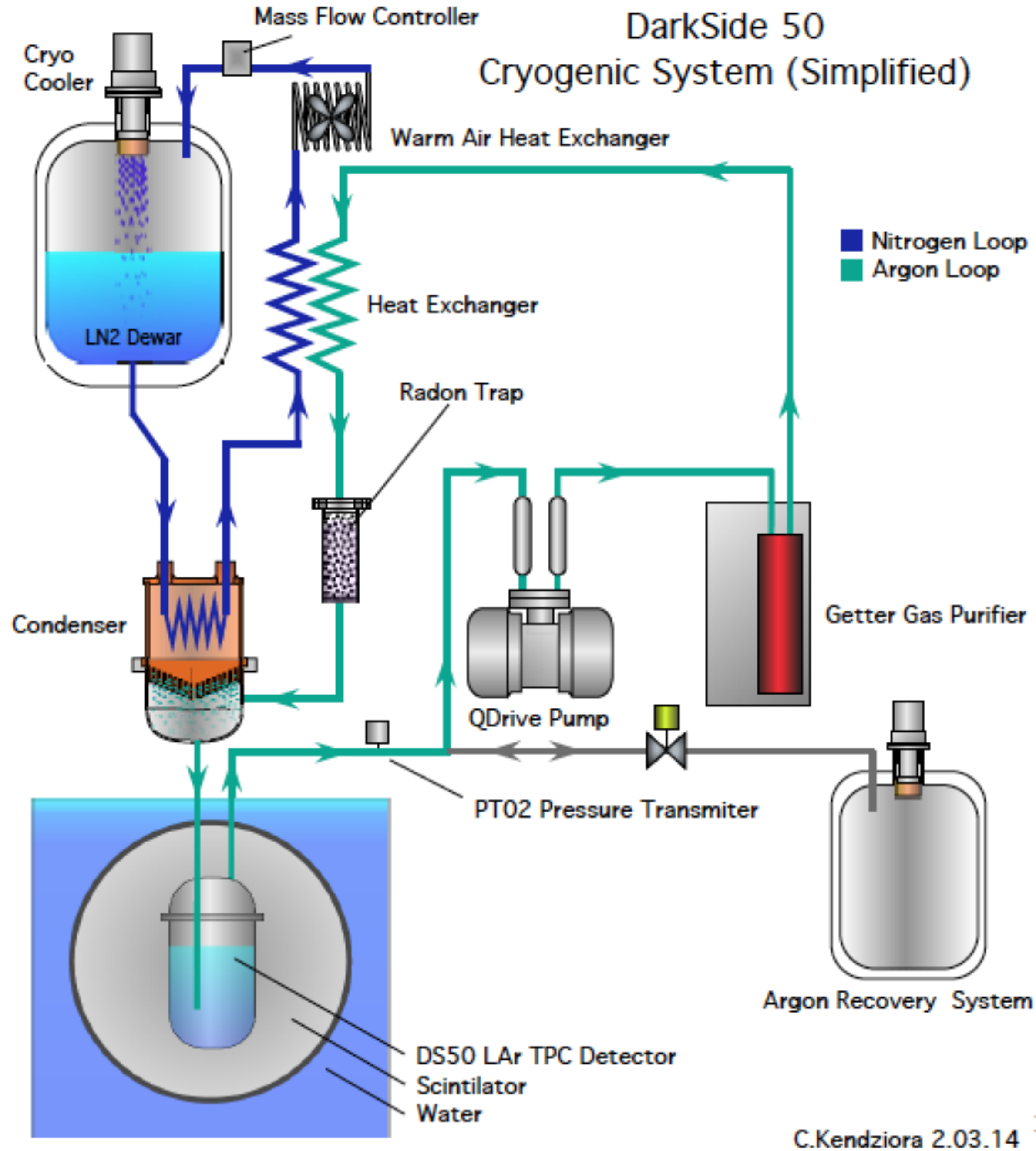
1. Power Requirement likely dominated by cold electronics load.
2. For system stability and safety, follow DarkSide-50 system using a cryocooler with LN2 buffer.
3. With relaxed purity requirement, could use passive system design, so no circulation pump required (less items to maintain). Everything is gravity driven and **no active control required**.
4. Using Large N2 reservoir on site, could avoid using cryocooler (cost saving and and less maintenance cost).
5. Xenon doping method to be optimized (condenser and system design optimization)
6. Xenon recuperations ??

Simplified Sketch of DarkSide-50 Cryogenics system

Flow rate similar to ICARUS 3t (over kill)

Replace condenser with all SS condenser

Stability achieved:
0.0023 psi (rms)

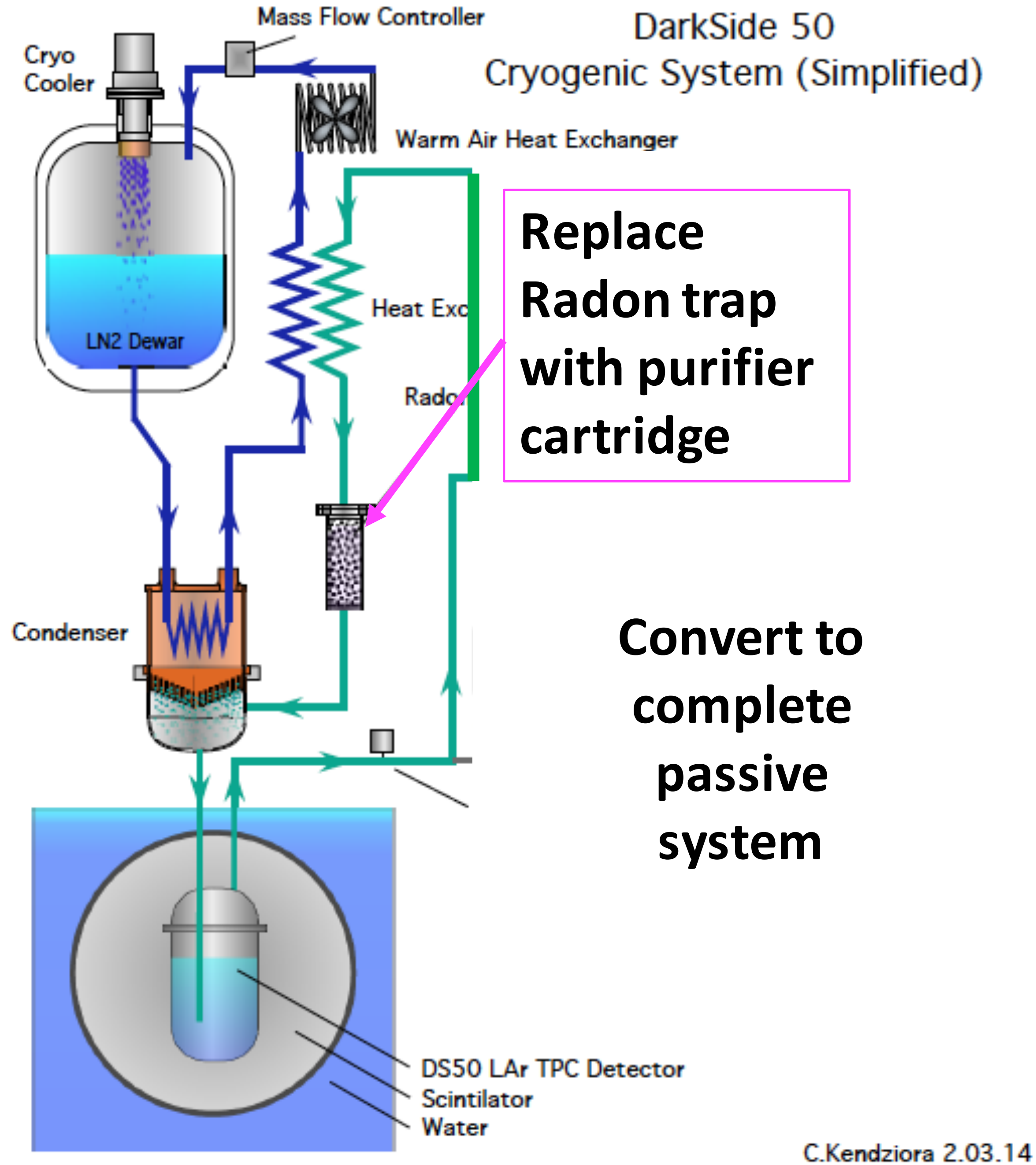


Simplified Sketch of DarkSide-50 Cryogenics system

Flow rate similar to ICARUS 3t (over kill)

Replace condenser with all SS condenser

If cold electronics power is low, go completely passive



Replace Radon trap with purifier cartridge

Convert to complete passive system

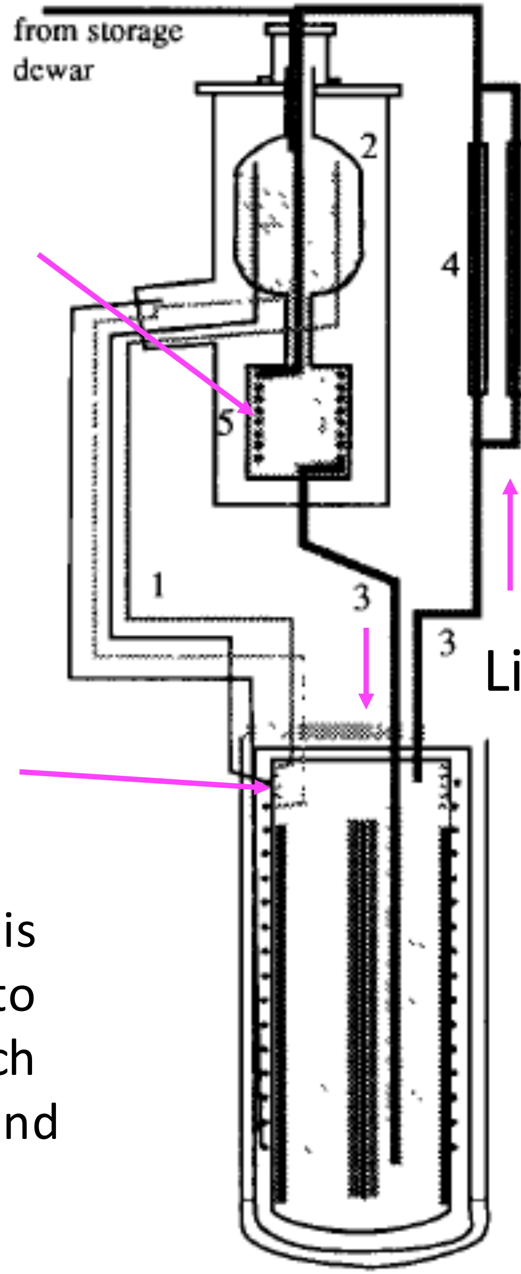
ICARUS 3t Cryogenics

Passive cooling system
ICARUS 3t
(3 ton liquid argon)

Ar-Ar heat Exchange
Gravity driven flow

Dewar Cooling
loop never used

Dewar Cooling loop



Purifier (Oxysorb)

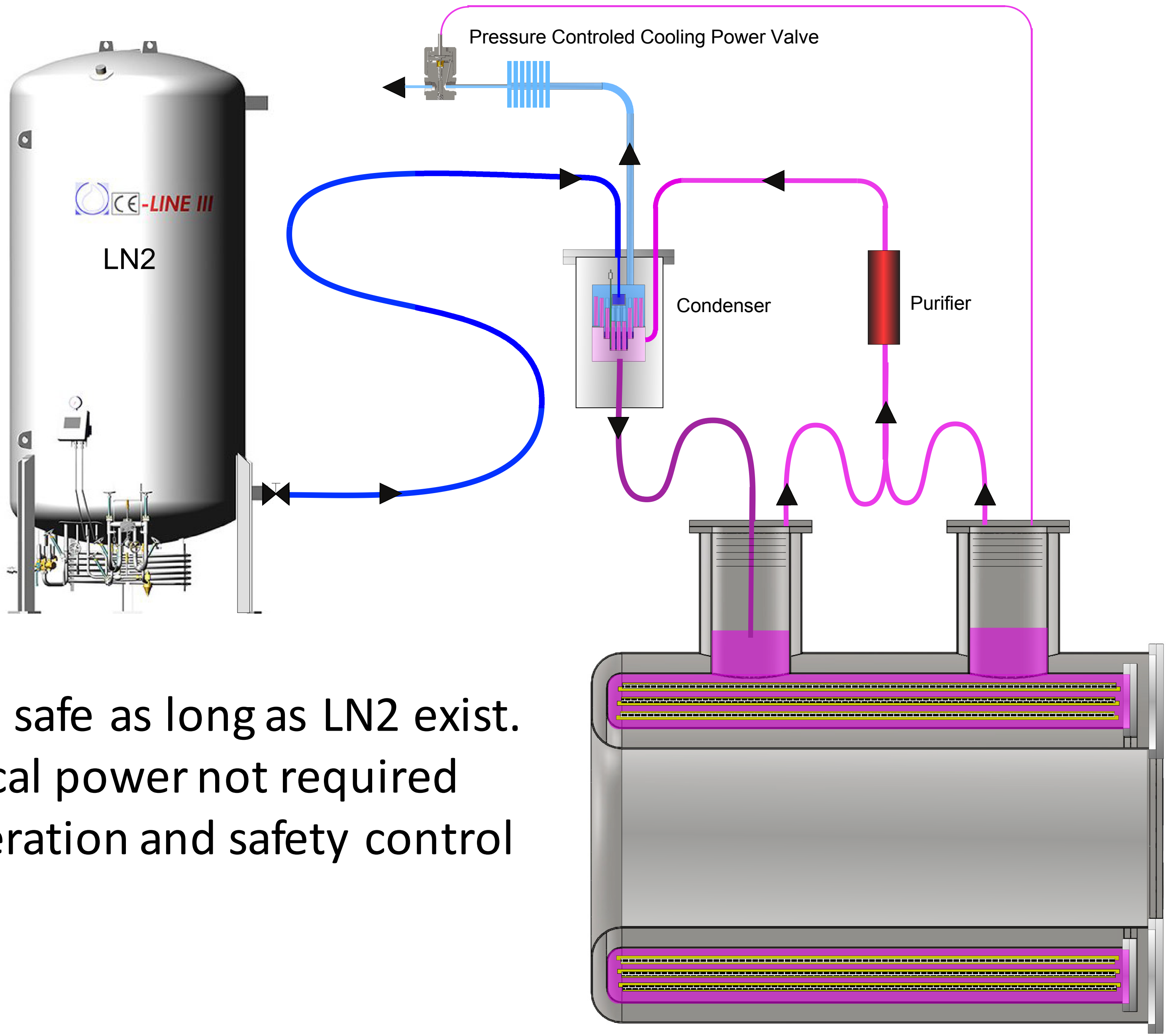
Gas argon up

Liquid argon down

Detector Dewar 3 ton

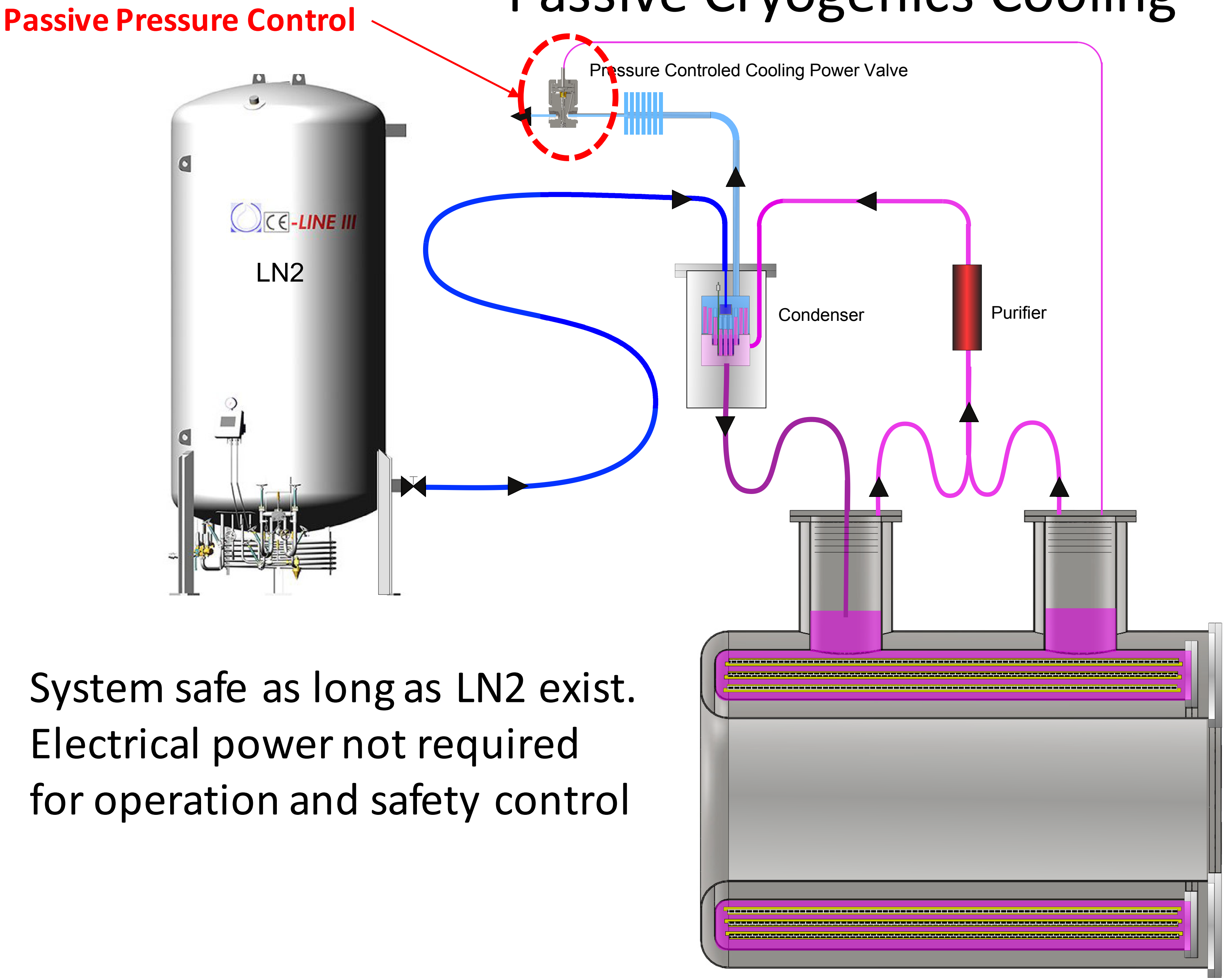
3D π purity requirement is much relaxed compared to the liquid argon TPC. Much easier to achieve cooling and purification objectives

Passive Cryogenics Cooling



System safe as long as LN2 exist.
Electrical power not required for operation and safety control

Passive Cryogenics Cooling



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Electrical power not required
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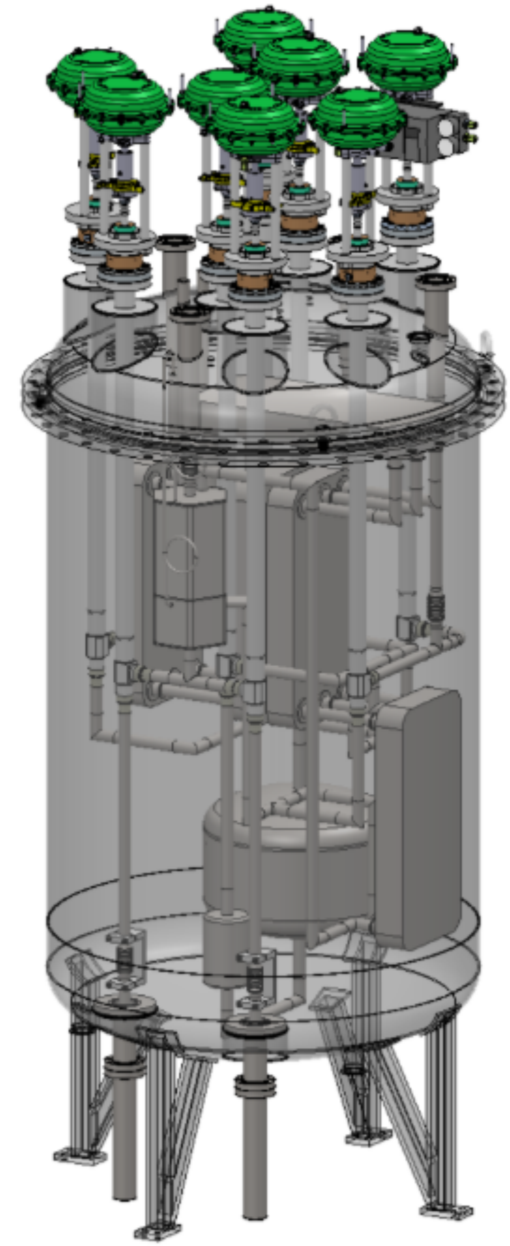
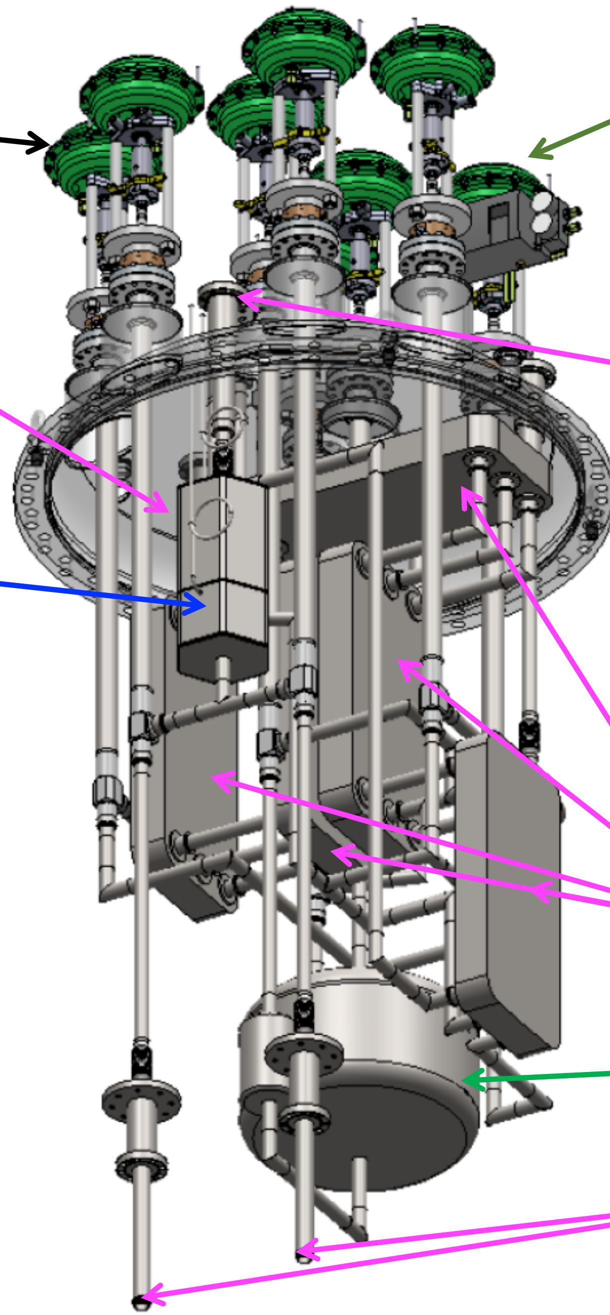
DarkSide-20k Condenser Unit

- A modular unit integrates a condenser, a heat exchanger set and a radon trap.
- The total cooling power is 4.7 kW and the radon trap is passively cooled at ~110 K.
- The cooling power is adjustable from 0 W to full scale capability (4.7 kW) by controlling the LN2 vapor gas vent flow using a MFC operating at room temperature (after the heat-exchanger).
- The cold box engineering details is finalized and PO placed.
- The first test is planned at CERN late summer in 2018.



102-cm(D) x 248-cm(H)

DarkSide-20k Condenser Unit



UAr ColdBox Final Design Pending Collaboration Review Before Fabrication

Tests planned as soon as build

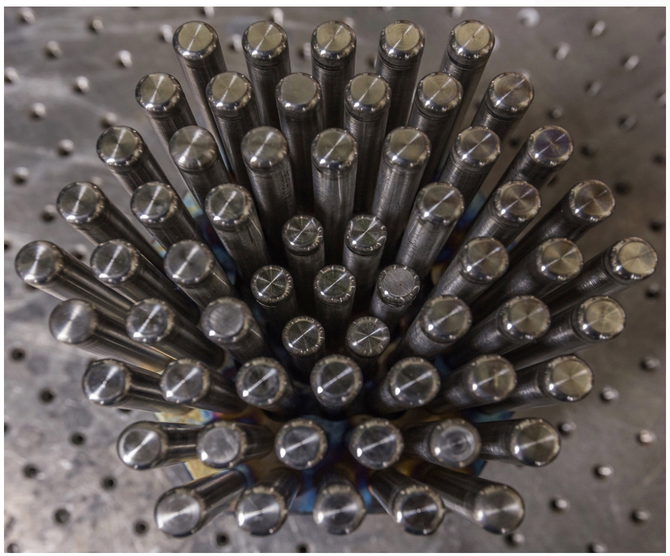
Parts Ordered

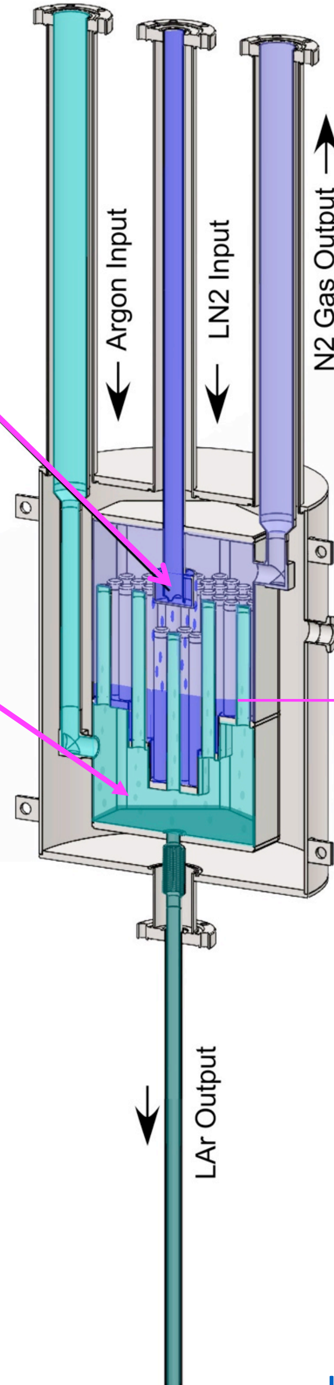
Xiang@UCLA

DarkSide-20k Argon Condenser Design and Test

Chicken Feeder Auto LN2 Delivery

Liquid argon fast drop no freezing above triple point pressure





GN2 vent flow control determines cooling power

Integrated N2 and Ar pressure sensor ports

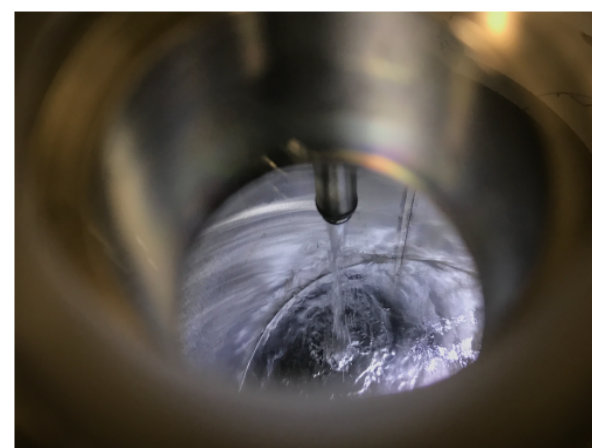
No LN2/LAr T balancing w/P

LN2 level auto balance

Cooling Test Results:

2.2 kW latent heat only

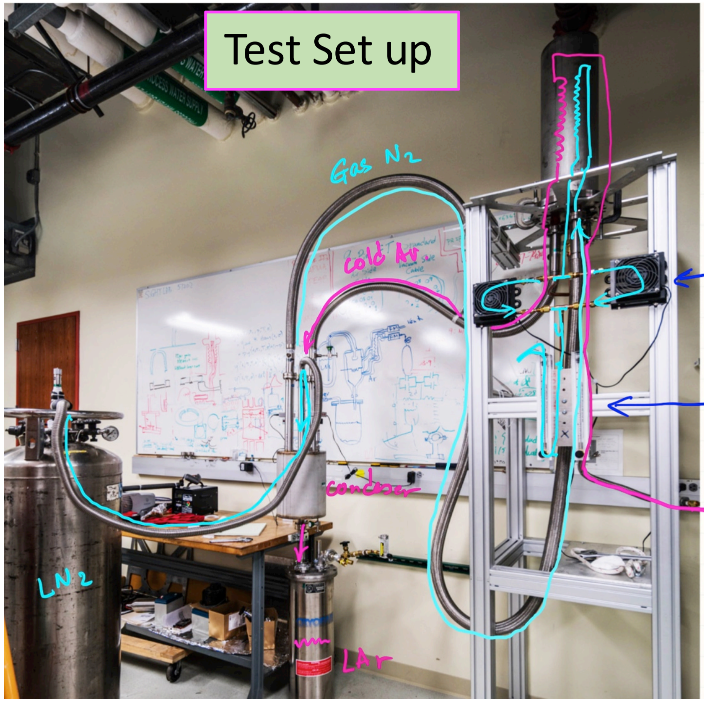
4.7 kW with heat exchanger



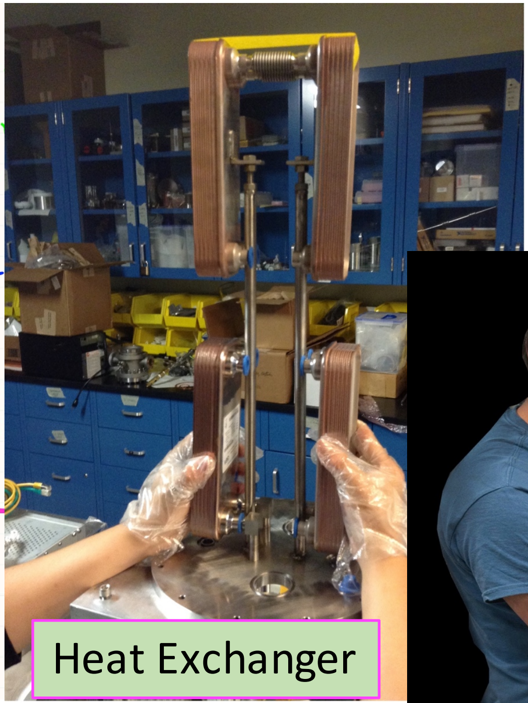
https://youtu.be/Be9Uy3UDfsI

Proof of Concept Condenser Fabricated and Tested

Click here for Links to photos and videos taken during the tests



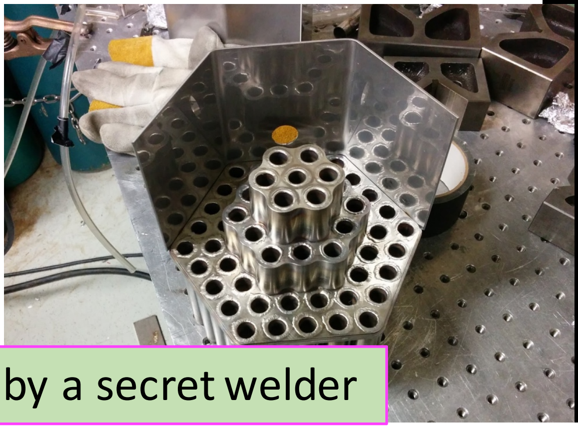
Test Set up



Heat Exchanger

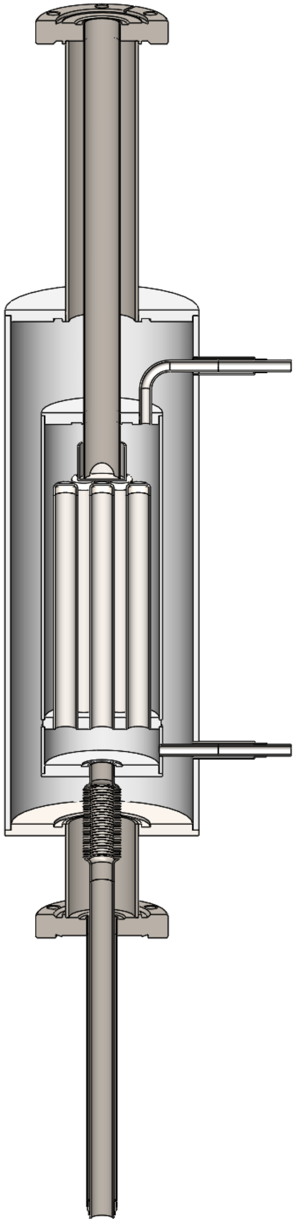
Condenser final Check

Leak test



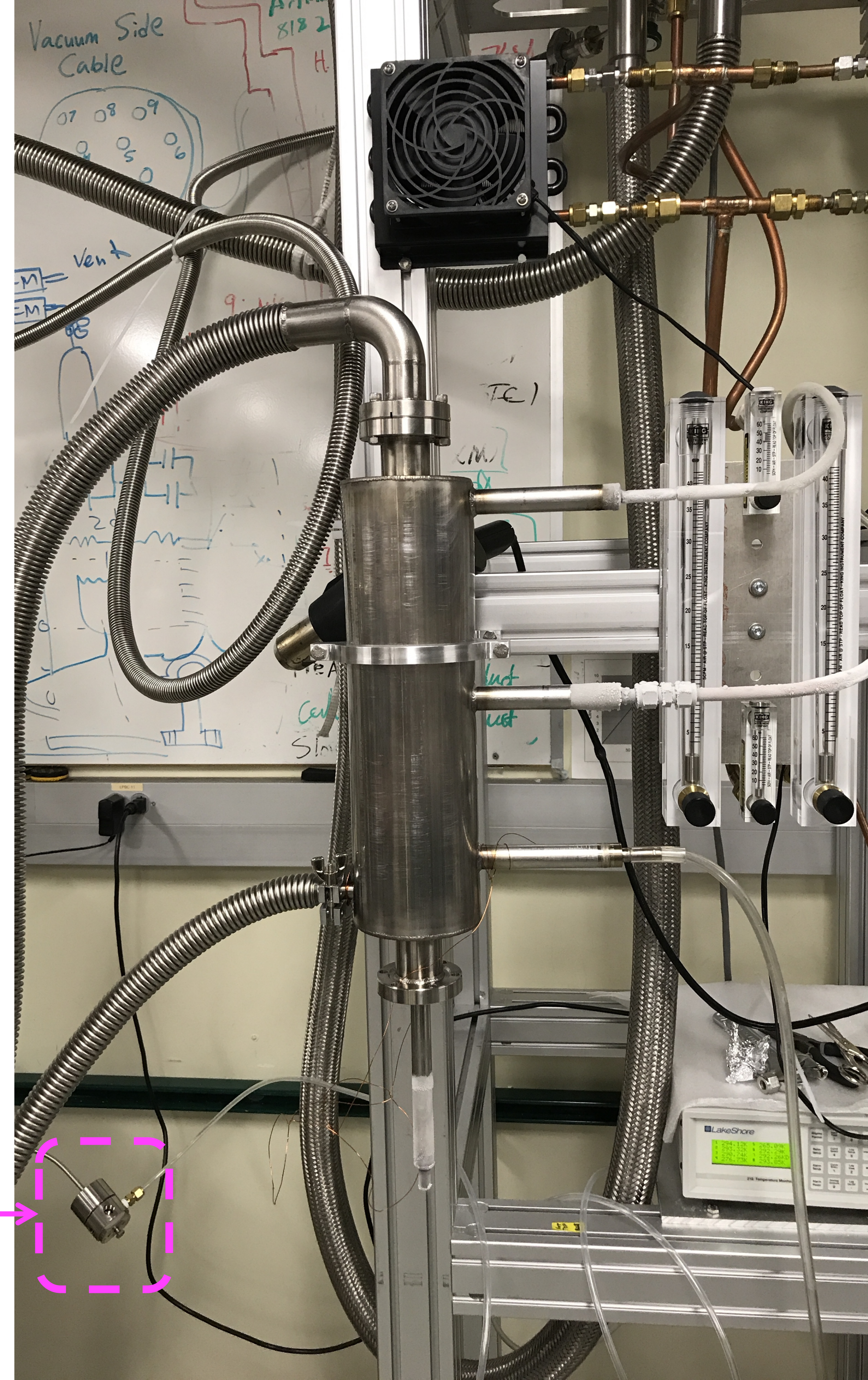
Plasma Welding by a secret welder

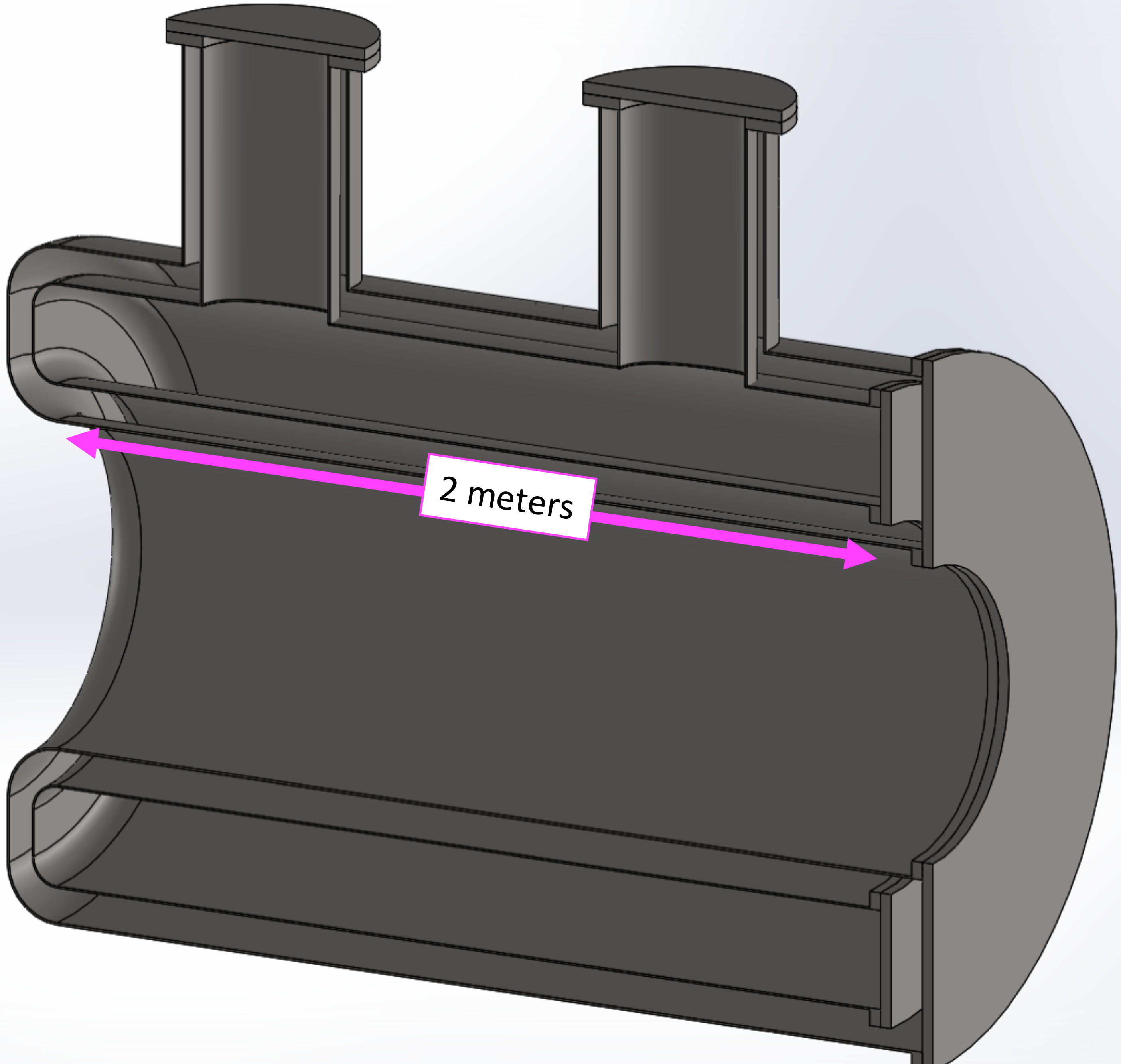
Mini Version of the Condenser for Small Scale Testing



The actual build included a phase separator to further improve the stability

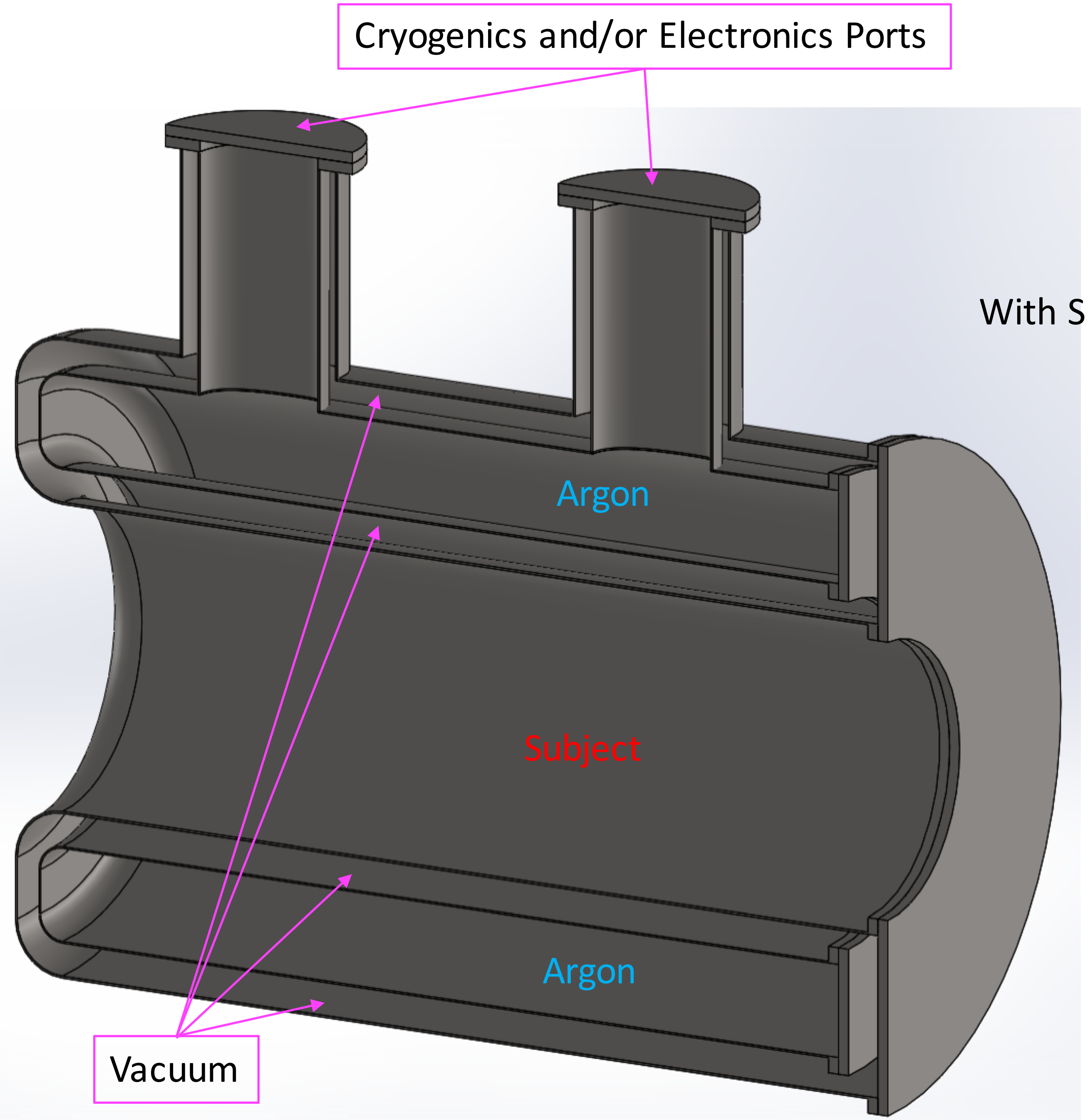
Tested Passive Control Valve



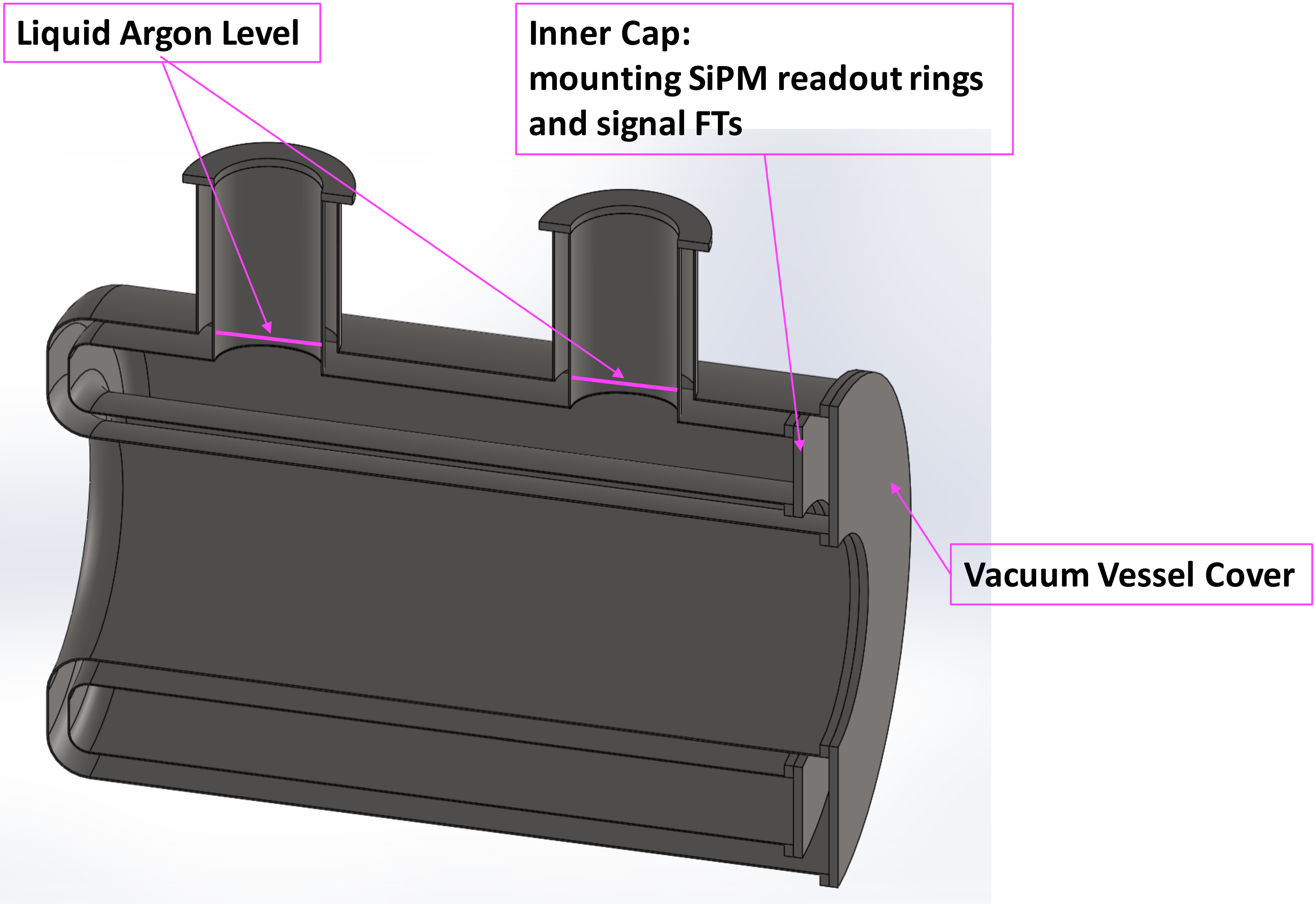

2 meters

3D π Cryostat

With Super-Insulation in Vacuum

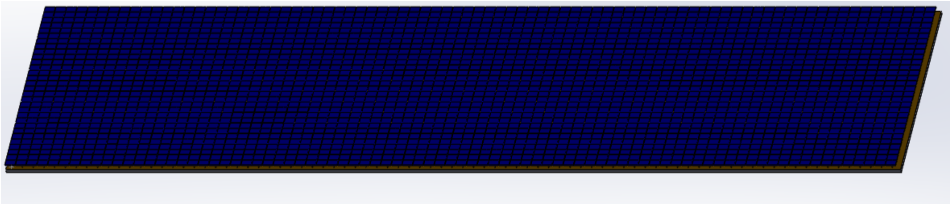


3D π Cryostat

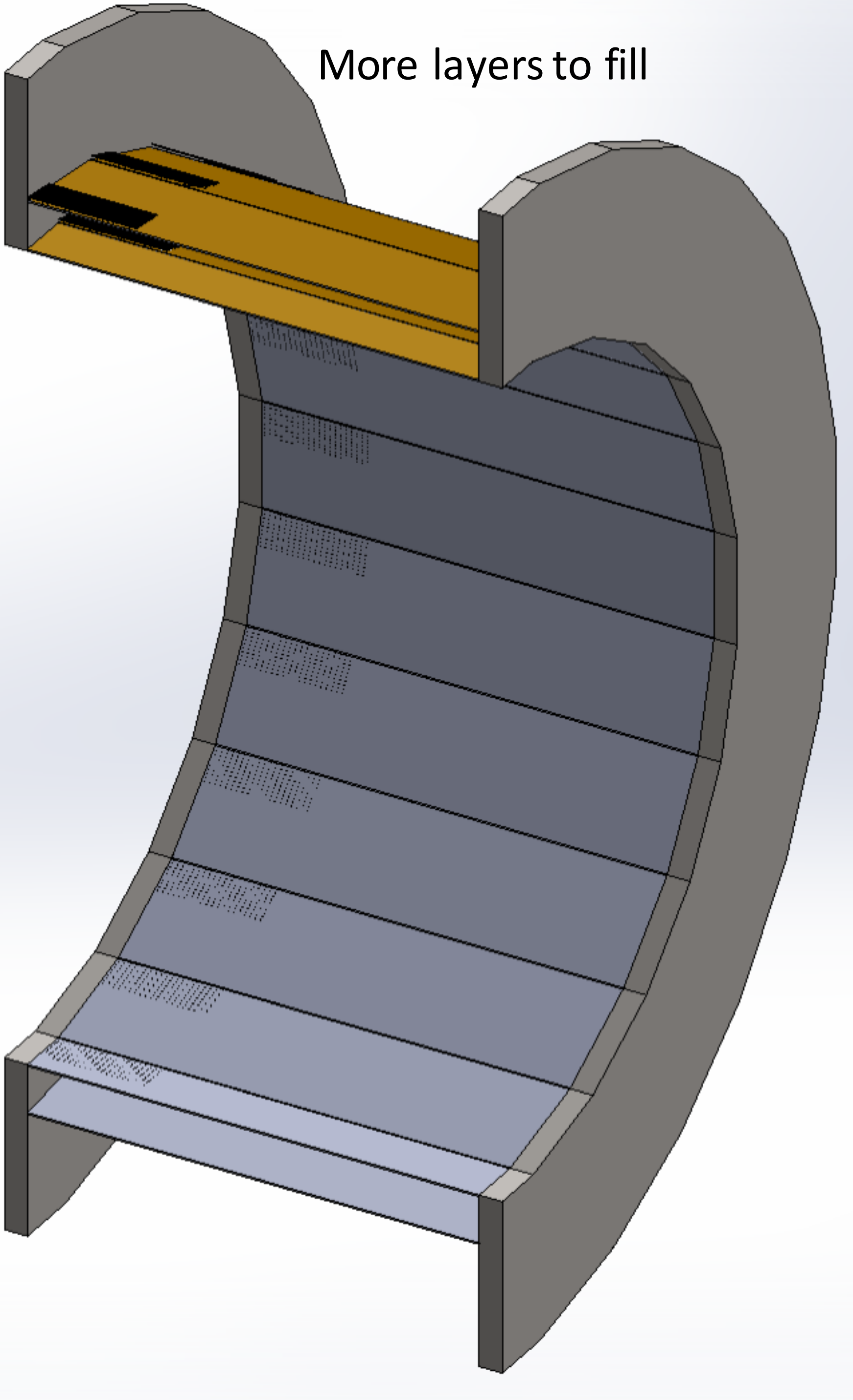


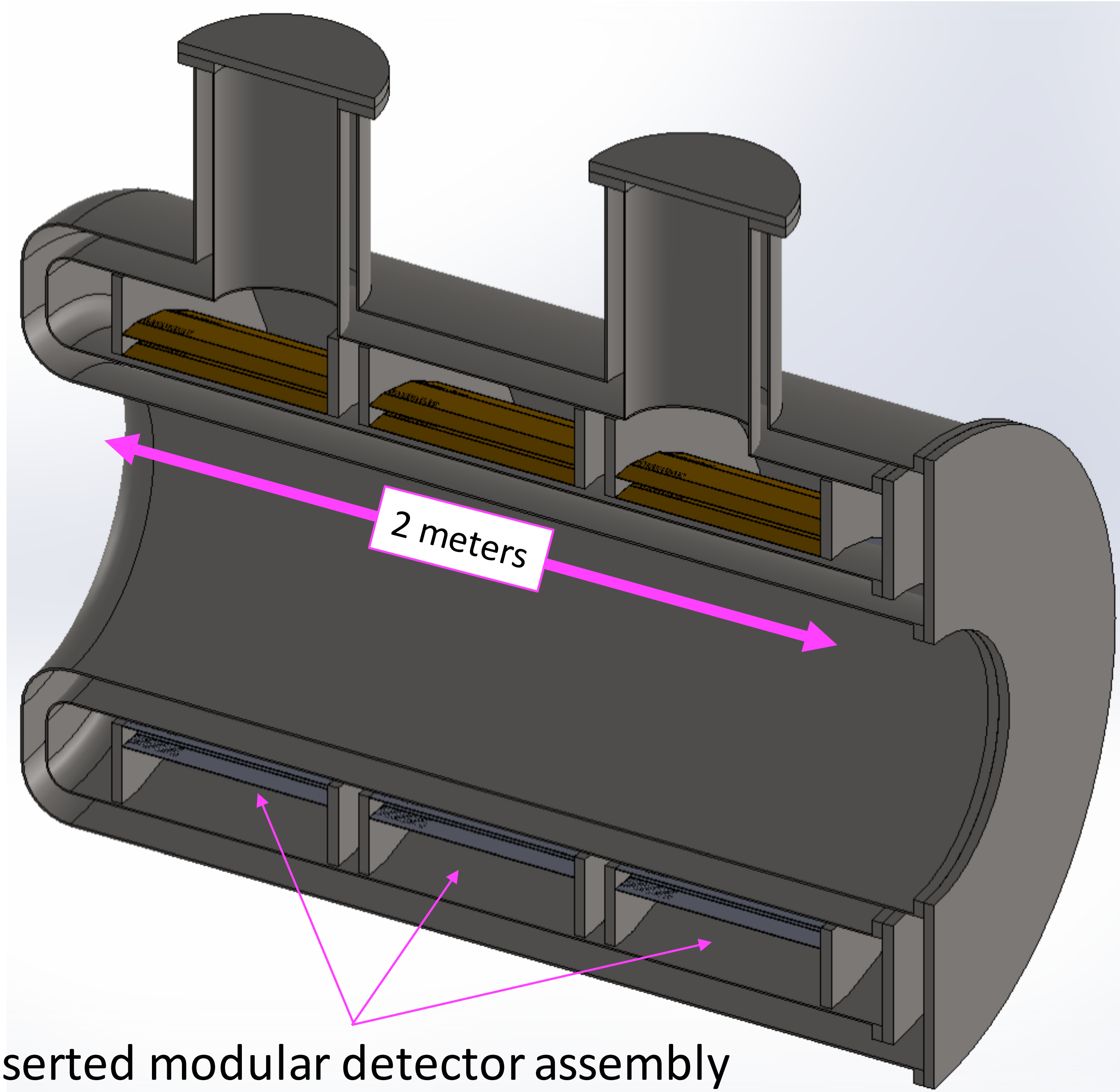
Pre-assembled tested modules

Integrated SiPM panels with readout



Assemble to modular detector





Inserted modular detector assembly

In fig. 1 we show μ as a function of E for nominal molar Xe concentrations $x = (0.98 \pm 0.001)\%$, $(10 \pm 2)\%$, and $(20 \pm 5)\%$, and also that in pure Ar. In the mixture with $x \approx 20\%$ μ was measured only for one field strength. The different mixtures were prepared as follows:

(i) For the lowest x we liquefied directly a 0.98% gaseous mixture of gas chromatographic grade.

(ii) The 10% mixture was prepared by first condensing a known amount of Xe gas and then liquefying pure Ar.

(iii) The 20% mixture was prepared by loading the Oxisorb cartridge with a known amount of Xe and then letting pure Ar flow through.

Physics Letters A 178 (1993) 407—412

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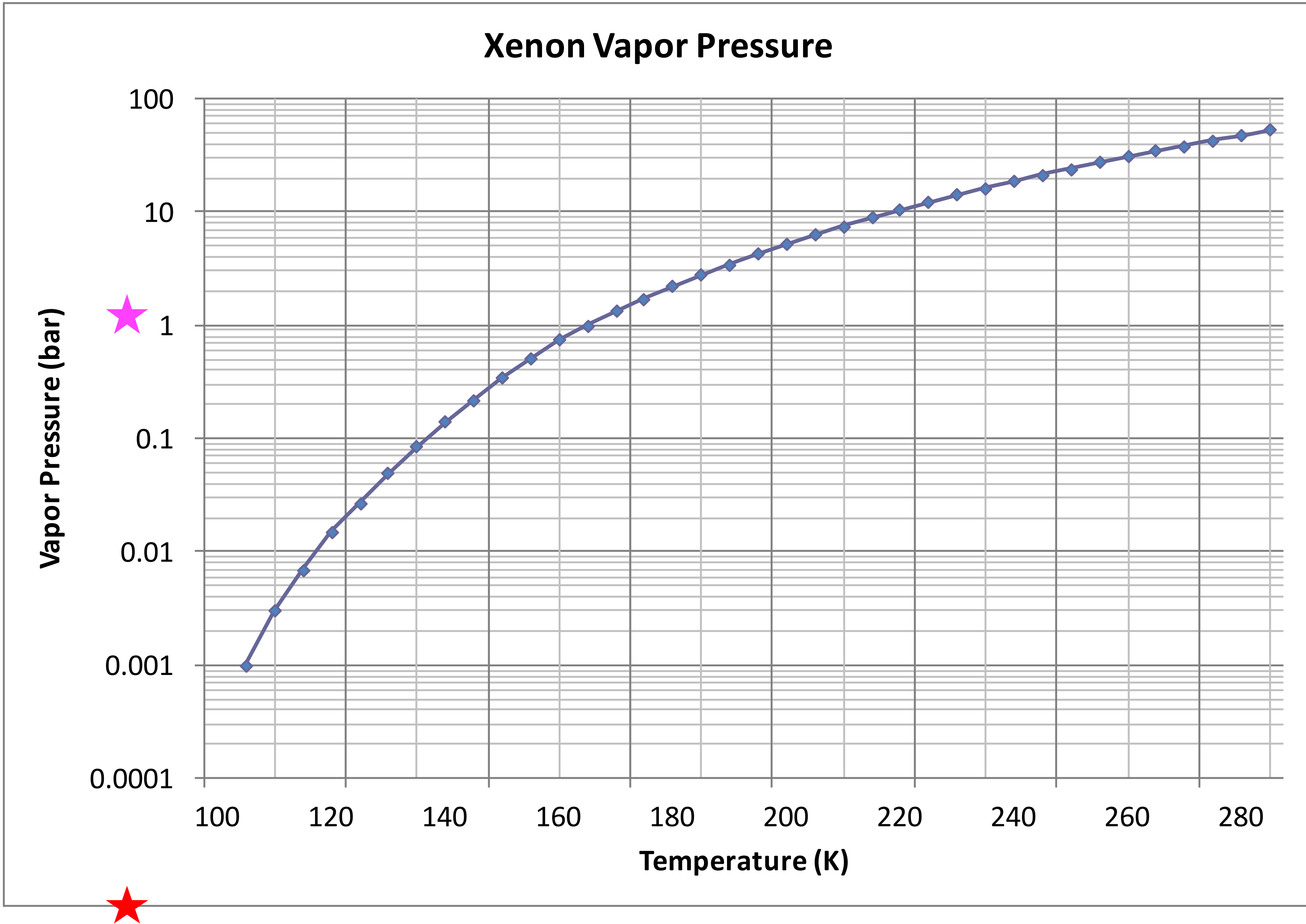
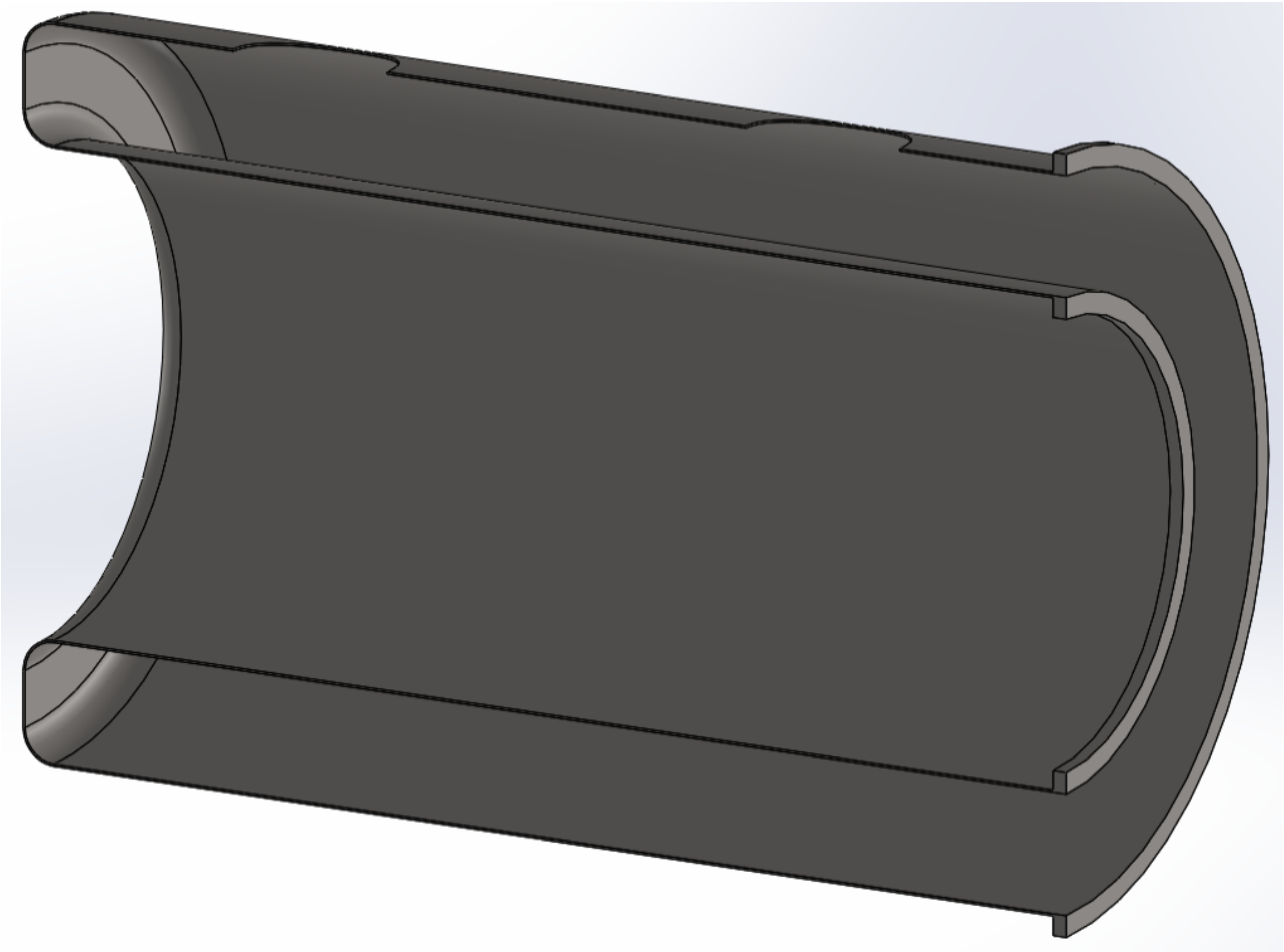
Information only



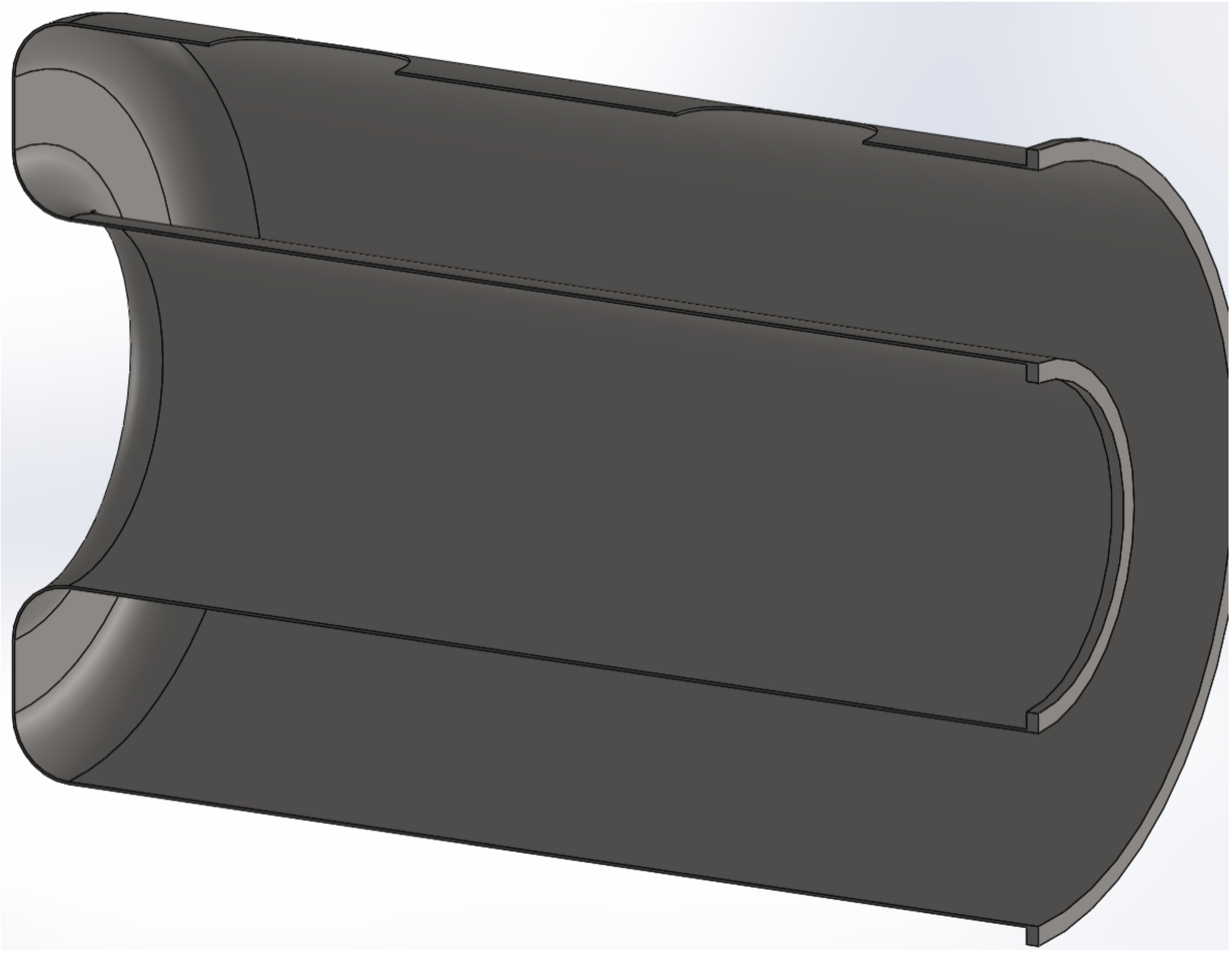
Conclussion

- Cryogenics system readily available in any scale
- Passive system with absolute minimum control requirement
- Requires LN2 present on site
- Xenon doping to be tested to optimize the fraction
- Recuperation requirement and method to be investigated.
- Cryostat safety care for the safety of subject

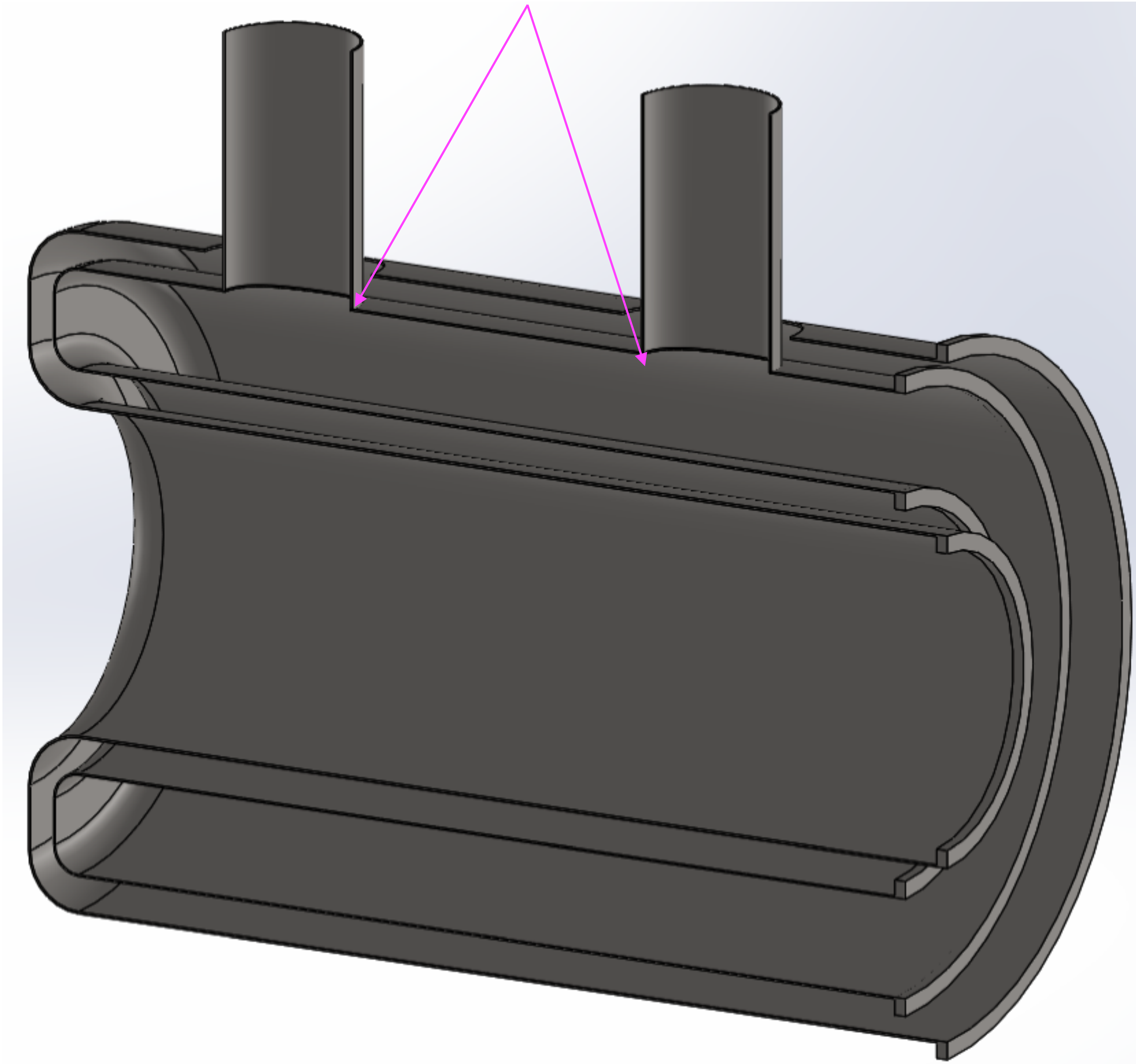
Inner vessel



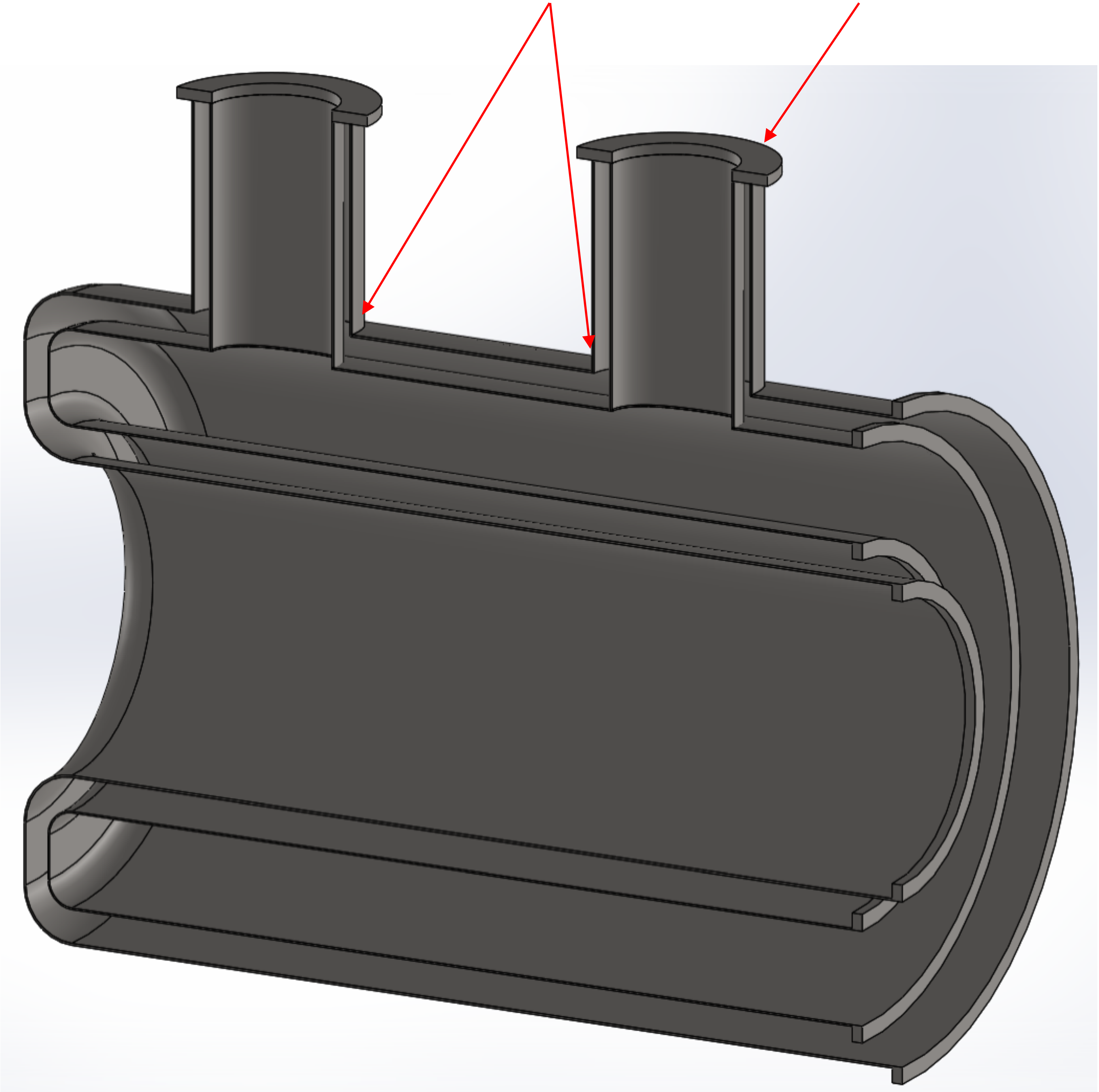
Outer vessel



Insert inner vessel and weld chimneys



Weld vessel chimneys and flanges



Inner tube serves as thermal bridge and weight load