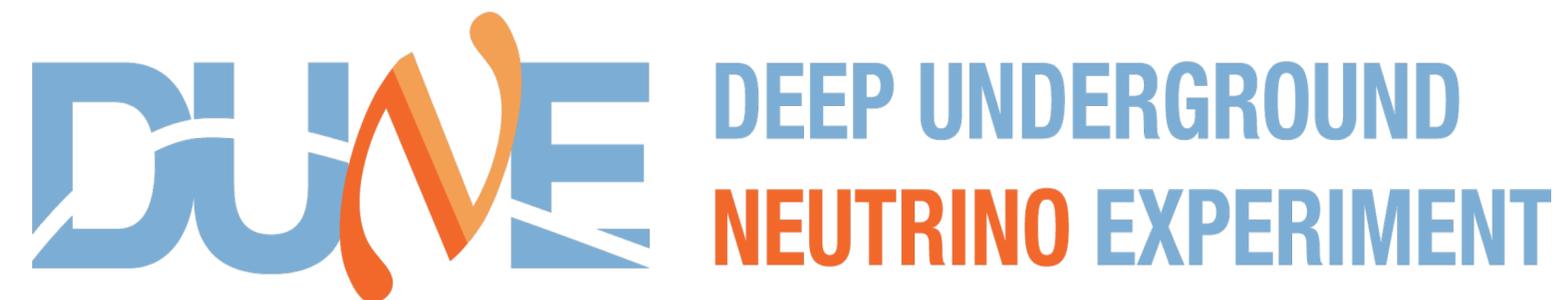




Cubism - Braque's Bottle and Fishes, Paris c.1910-12

Notes on operating pressure



ArgonCube Engineering call
November 20th 2020
James Sinclair, LHEP

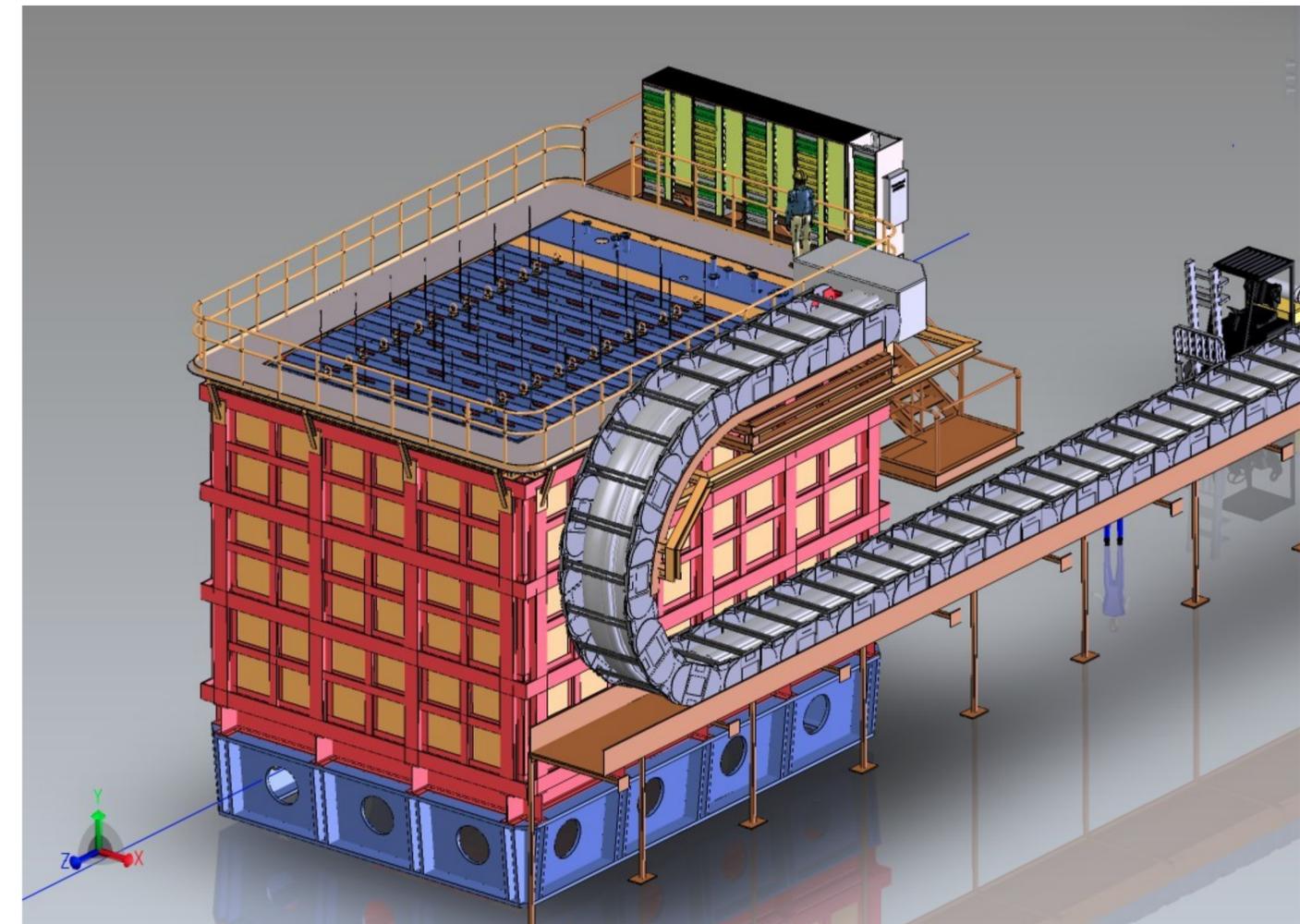
ND operating pressure

LBNF will be providing the cryogenic system, cooled LAr at desired flow rate.

Pressure		Temp.	LAr density	exp.	LAr depth	change in Ullage	Ullage	
(MPa-g)	MPa-abs	(K)	kg/m ³	(%)	(m)	%	(mm)	
-0.0064	0.0950	86.7	1399.1	-0.47%	4.180	5.1%	400	Under-Pressure
0.0000	0.1014	87.3	1395.4	-0.20%	4.191	2.2%	389	Loss of Pressure
0.0050	0.1064	87.8	1392.5	0.00%	4.200	0.0%	380	Fill / Op Pressure
0.0100	0.1114	88.2	1389.8	0.20%	4.208	-2.1%	372	
0.0150	0.1164	88.6	1387.2	0.39%	4.216	-4.2%	364	
0.0200	0.1214	89.0	1384.6	0.57%	4.224	-6.2%	356	
0.0350	0.1364	90.2	1377.3	1.10%	4.247	-12.0%	333	Max Over Pressure - all relief scenarios

Joaquim Prats has performed an analysis of safe operating pressures with ullage volume defined by EN-14620.

At 380 mm ullage, we can operate at 50 mbarg. Over-pressure relief occurring at 350 mbarg.



2x2 operating pressure.

An analysis is needed to certify the vessel and inform on safe operating pressures. Particularly for the vacuum pockets.

Min Jeong's team now have the final 2x2 geometry, analysis is pending.

Initial design was 15 mbarg operation and 50 mbarg over-pressure relief. It is desirable to increase this for purity and cooling.

Vacuum pocket

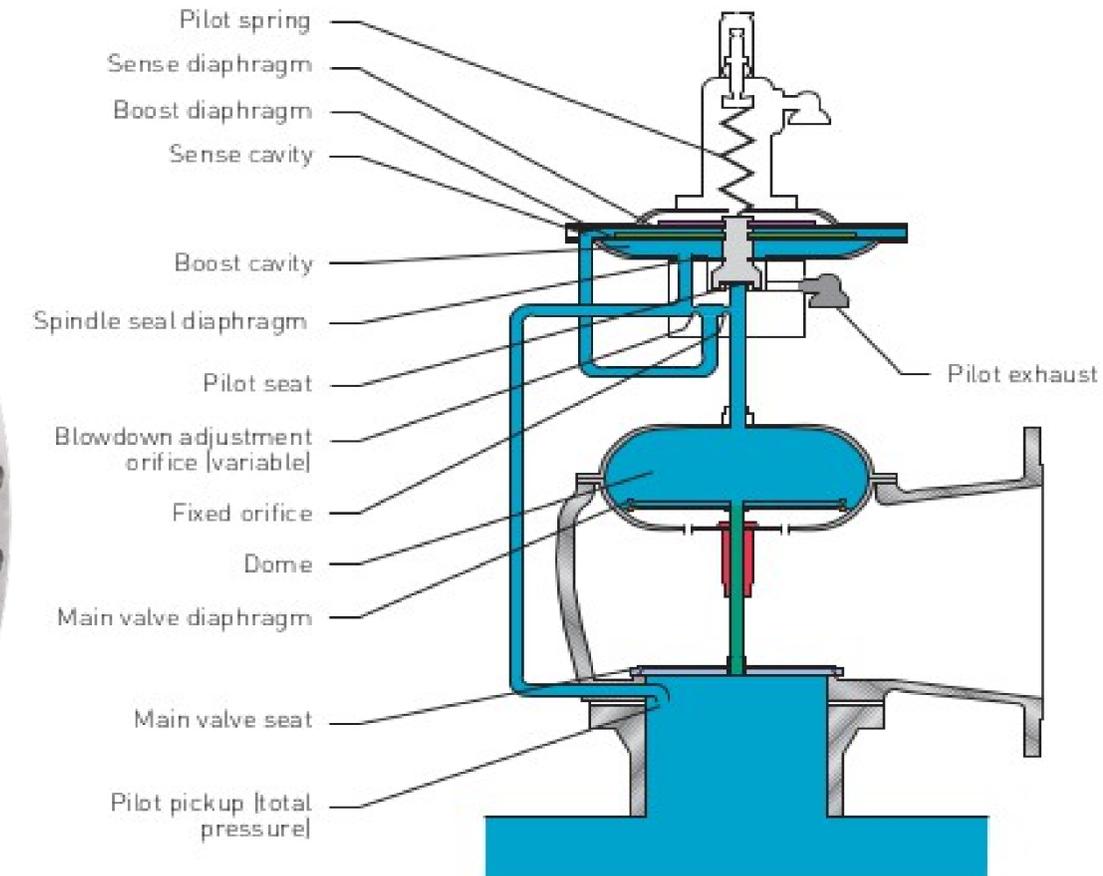


2x2 operating pressure.

Operation at FNAL requires certified exhaust valves. Kathrine Laureto has advised:



Bern 15 mbarg exhaust valve



Anderson Greenwood 9300 series pilot operated pressure relief valve, via Emerson.
Full seat tightness up to 95% of set pressure – no back flow issues.

<https://www.emerson.com/documents/automation/flier-9300h-series-en-5302740.pdf>

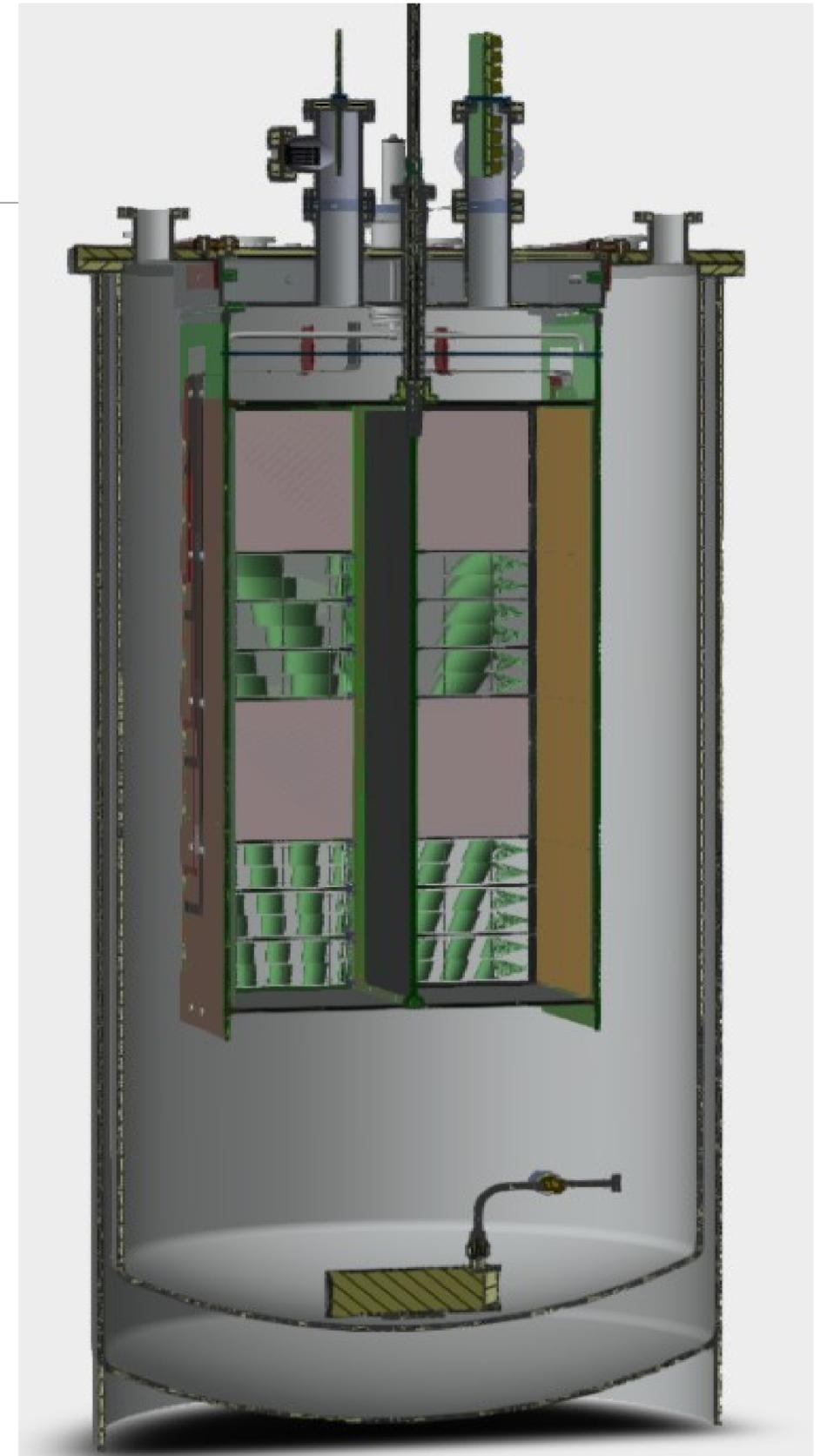
5 month lead time on valves, so decision needs to be made ASAP.

Single Module

The cryostat operated a 380 mbarg, with overpressure relief at 500 mbarg, and 1.2 barg burst disc.

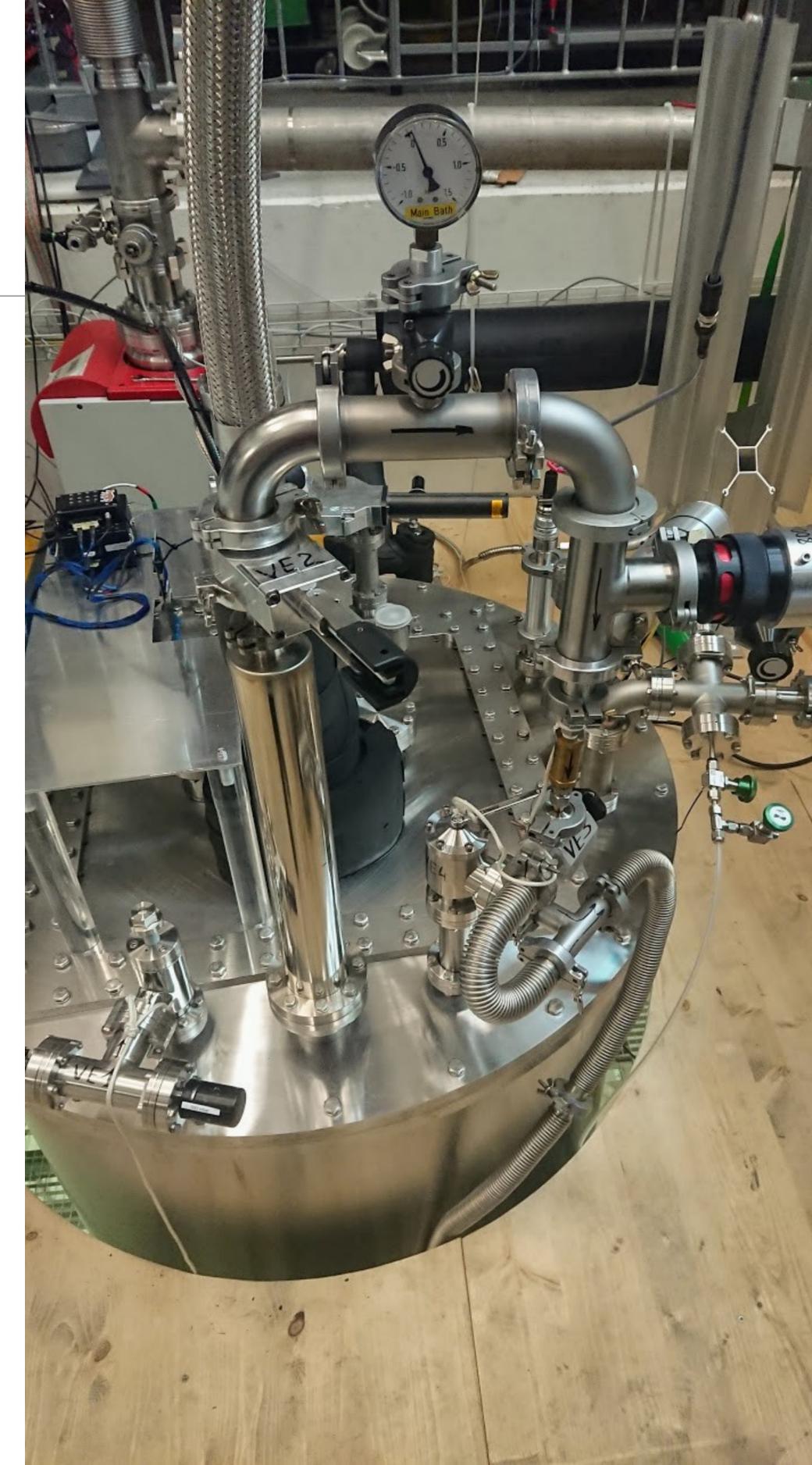
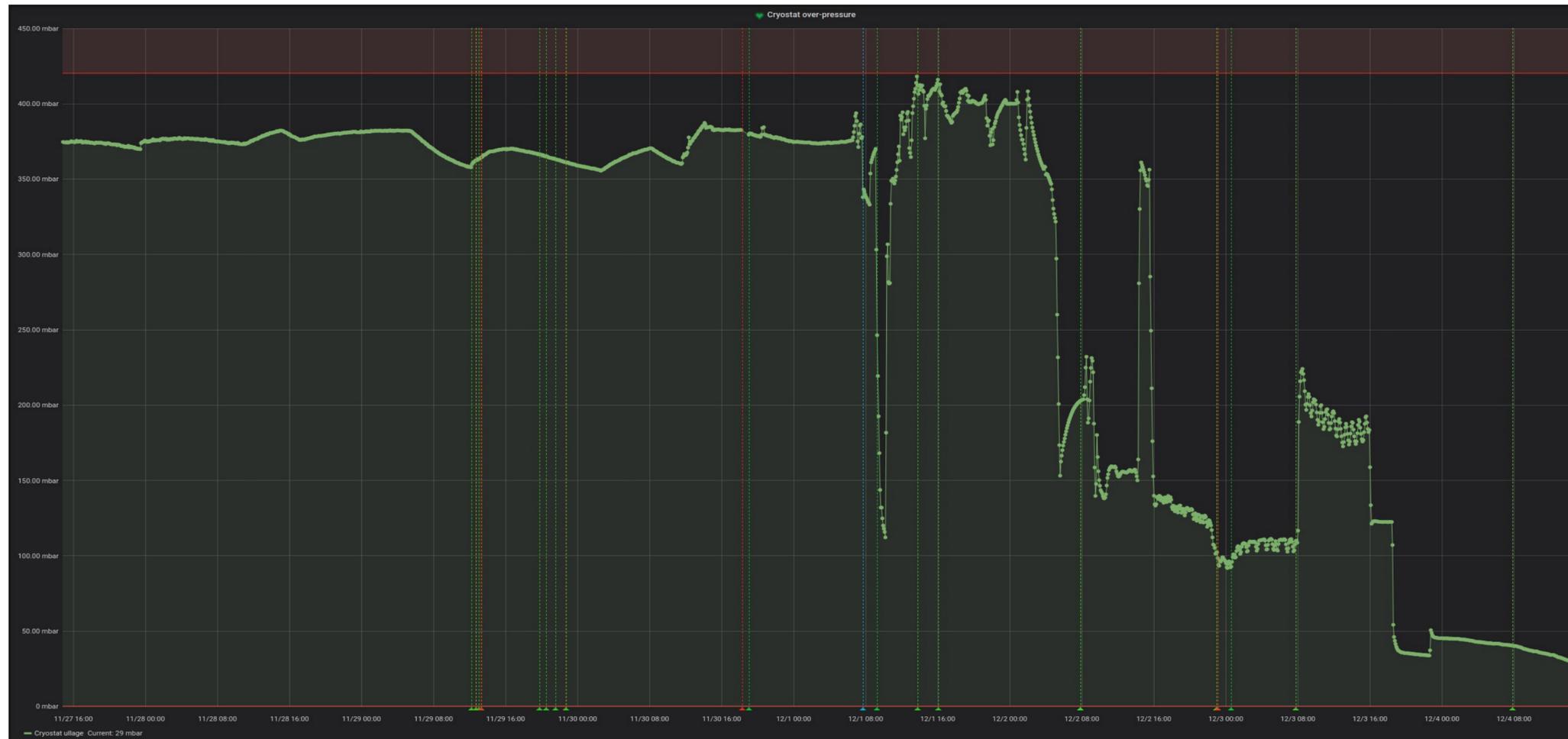
380 mbarg was required given the cooling power available from the filter.

The new pump will help this (100 l/h \rightarrow 2k l/h), but a more powerful cooling system is needed for 2x2 and the ND demonstrators.



Single Module

The exhaust valve used was manually actuated, requiring shifter input. An automated system is desirable, given commercial lead time production in-house is only option.



In short

The ND will operate at 50 mbarg, with relief at 350 mbarg. But LBNF are providing significant cooling power.

Analysis needed to inform safe operating pressures for 2x2.

Valves must be ordered as soon as pressures are known.

Analysis will also inform safe pressure for Single Module as vacuum pocket is common.

Single module currently at 380 mbarg. Needed due to limited cooling power. Updates to the system will help this, but heat load will also increase at next run.

Desirable to swap out manually controlled exhaust valve for automatic version.