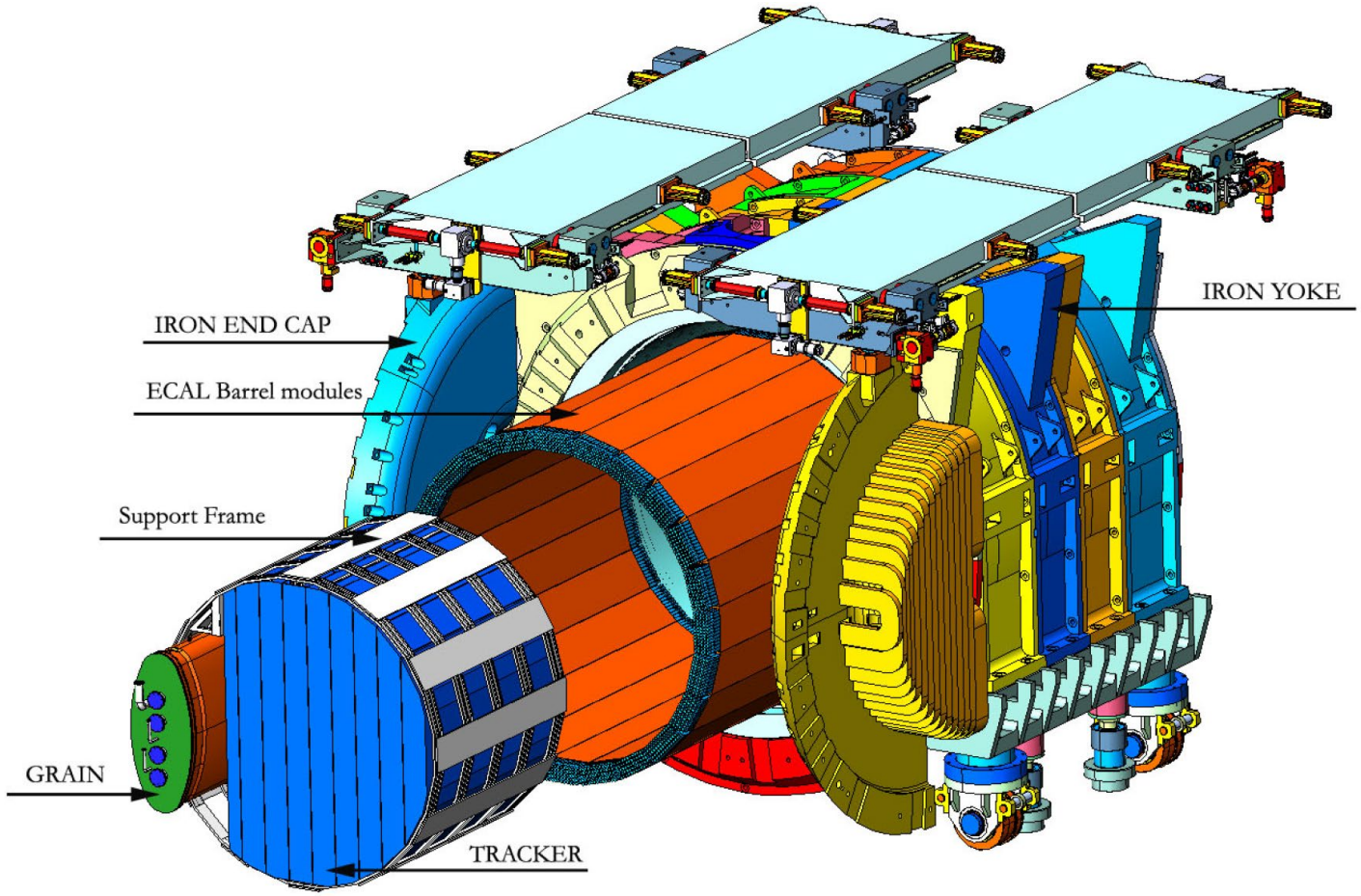
GRAIN: mechanics and proximity cryogenics

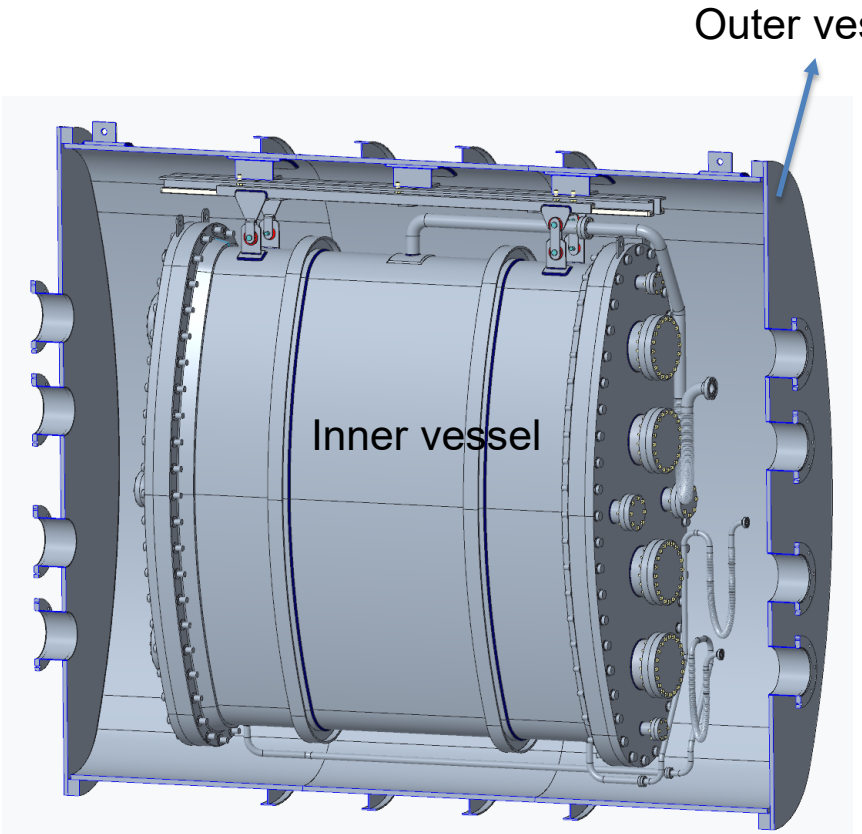
INFN BOLOGNA

DUNE Italia meeting – Nov 11, 2025

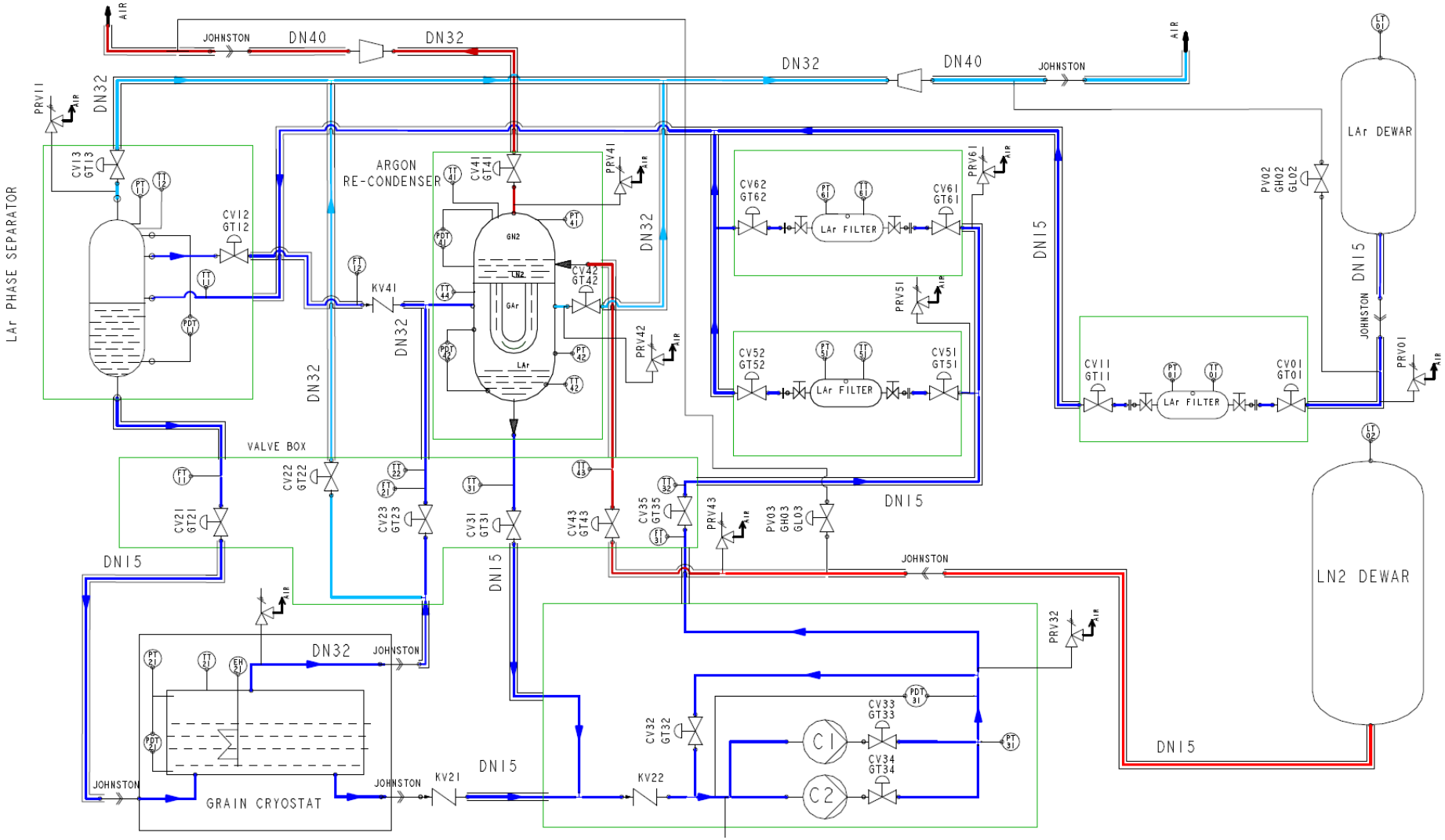
Gianluigi Piazza

GRAIN in SAND



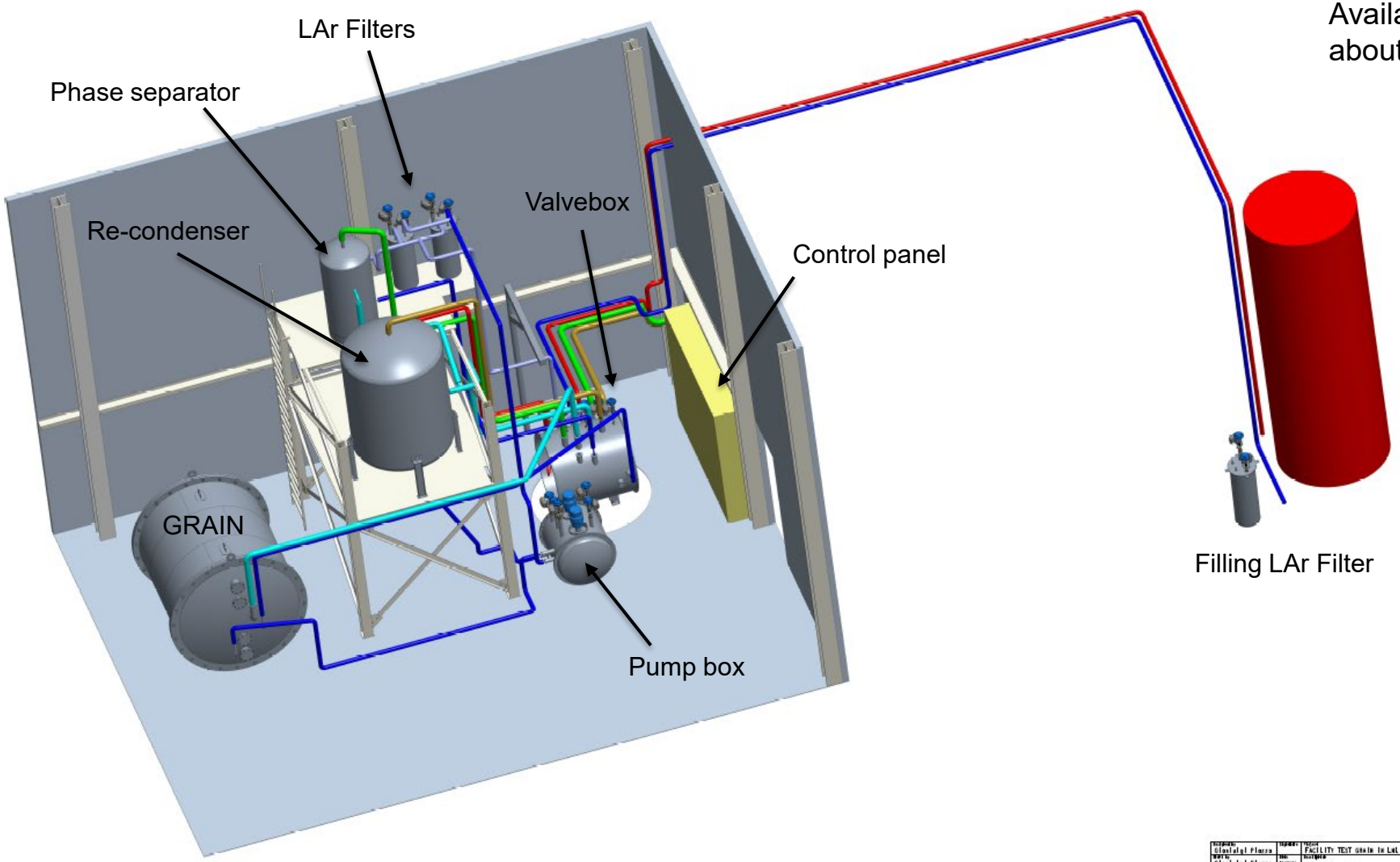


Outdated P&ID



The previous version of the P&ID has been revised

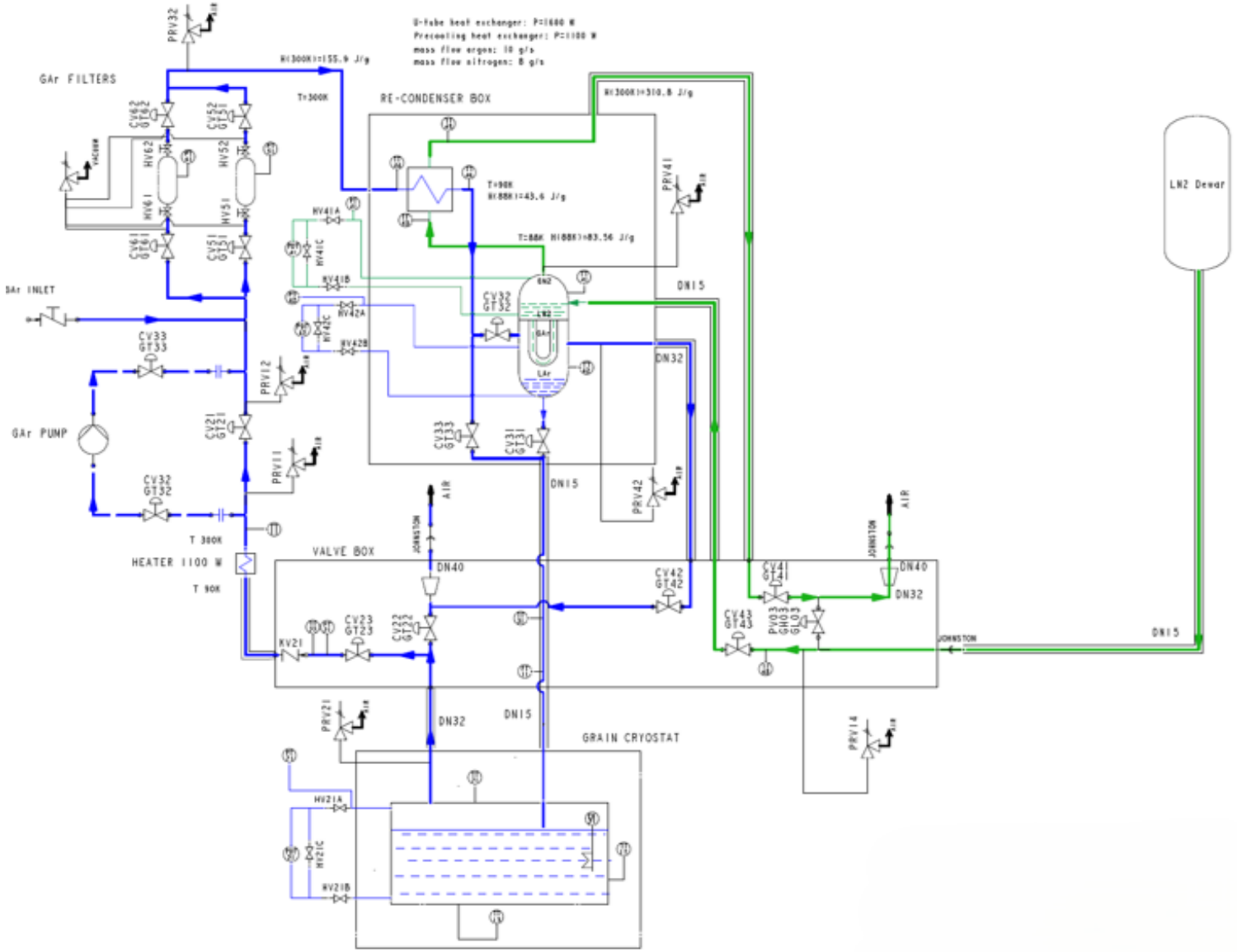
Facility test LNL



Available height inside the lab is about 5,5 meters.

Filling LAr Filter

Proximity cryogenics: new P&ID



No phase separator and no cryogenic pump

Recirculation given just by the boil off and force by a warm pump

Purification in gas at ambient temperature, therefore precooling stage needed in the re-condenser box

The LAr inlet is now from the top of the cryostat instead of from the bottom as previously foreseen.

Proximity cryogenics: new P&ID

Extimated time for **cooling down GRAIN** with a maximum temperature difference across the vessel of 40 K:

$$H_{300K} - H_{90K} = 80\ MJ$$

$$Q = c_p\ \dot{m}\ \Delta T = 224\ \mathrm{W}$$

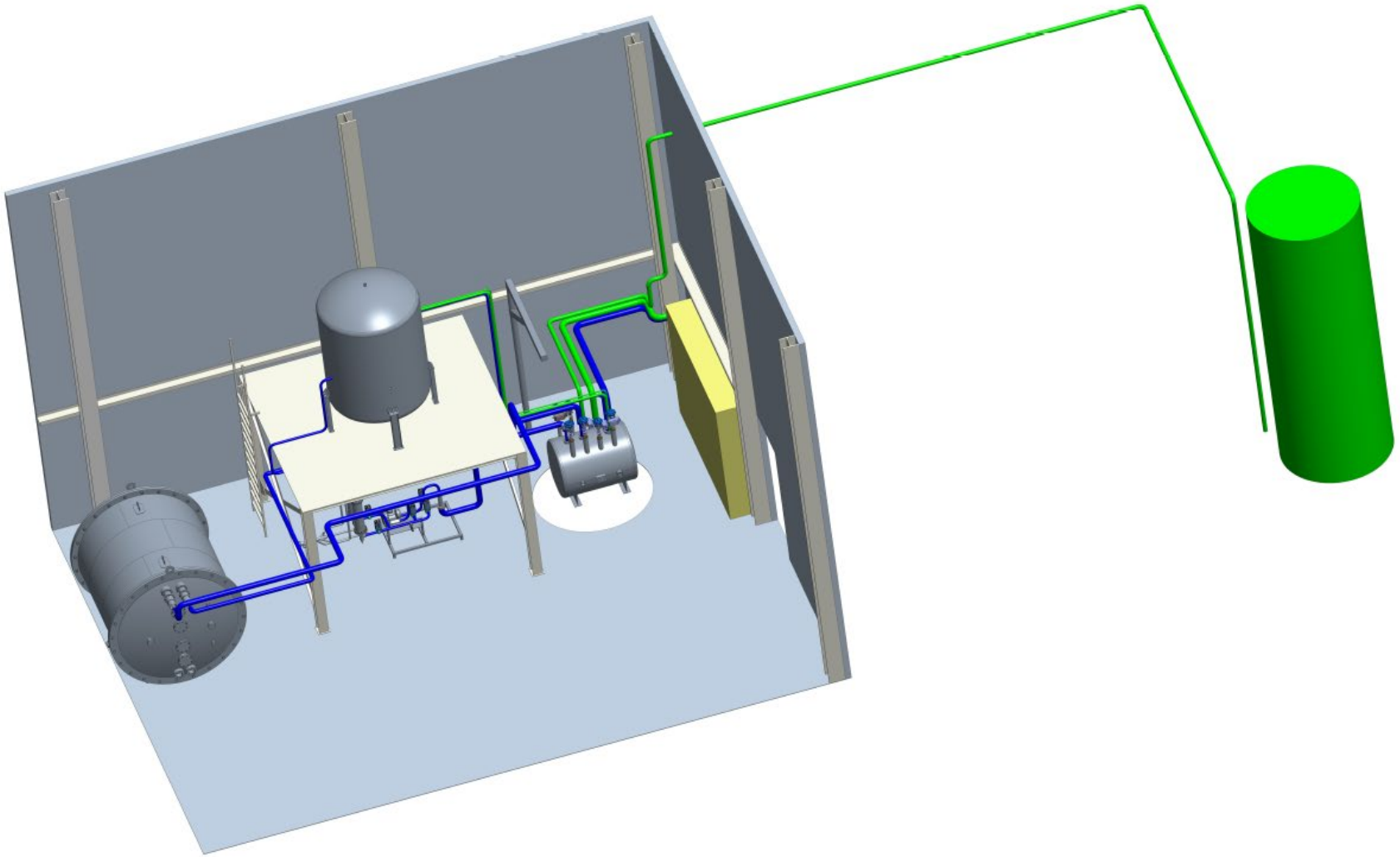
$$t = \frac{\Delta H * Q}{3600} = 99\ hours = 4\ days$$

Time for filling GRAIN (800 L) with mass flow of 10 g/s: **31 h**

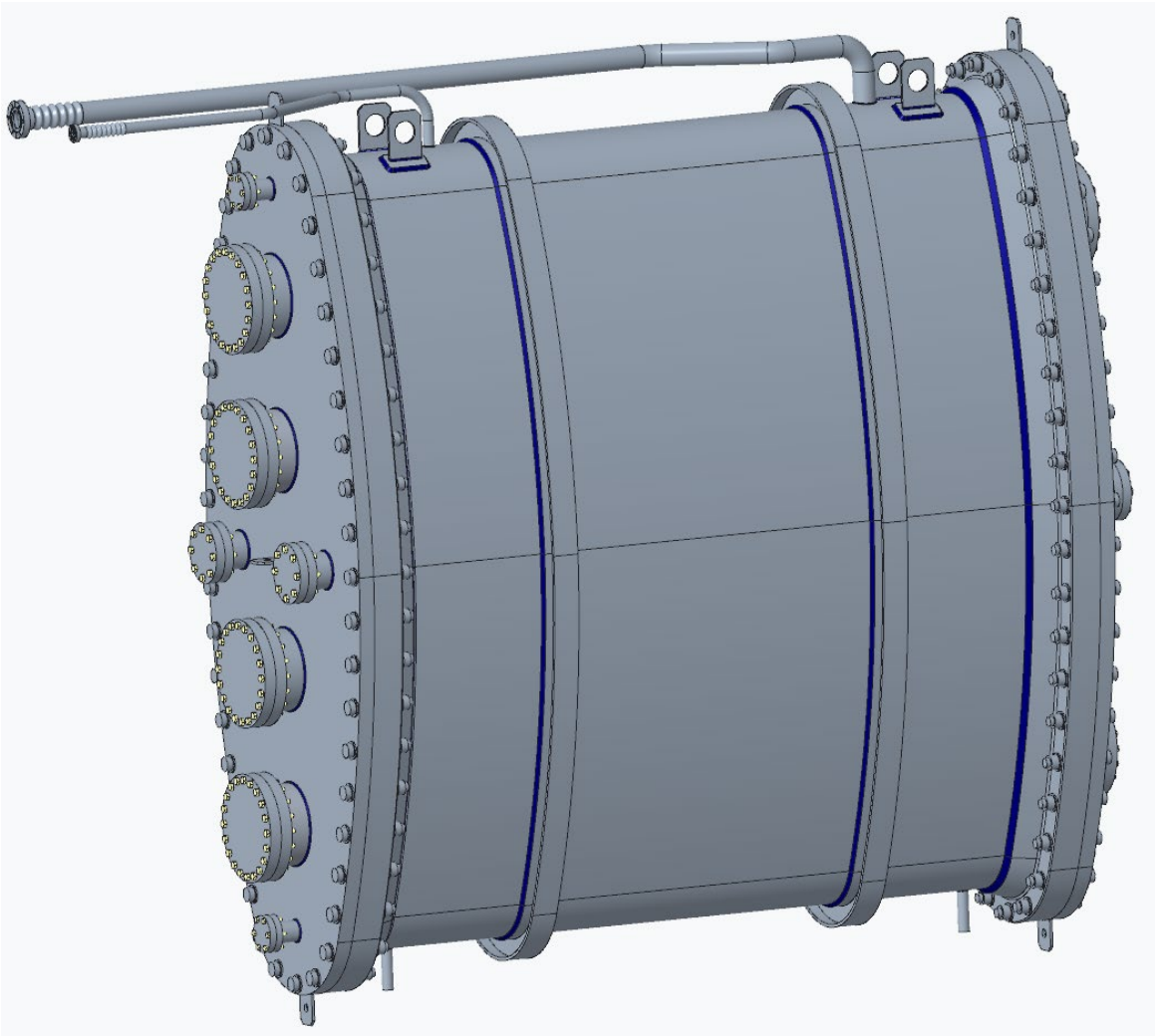
Liquid nitrogen consumption for cooling down: 1100 L

Extimated **Liquid nitrogen consumption** at steady state regime : **9 g/s → 40 L/h**

Proximity cryogenics: new P&ID

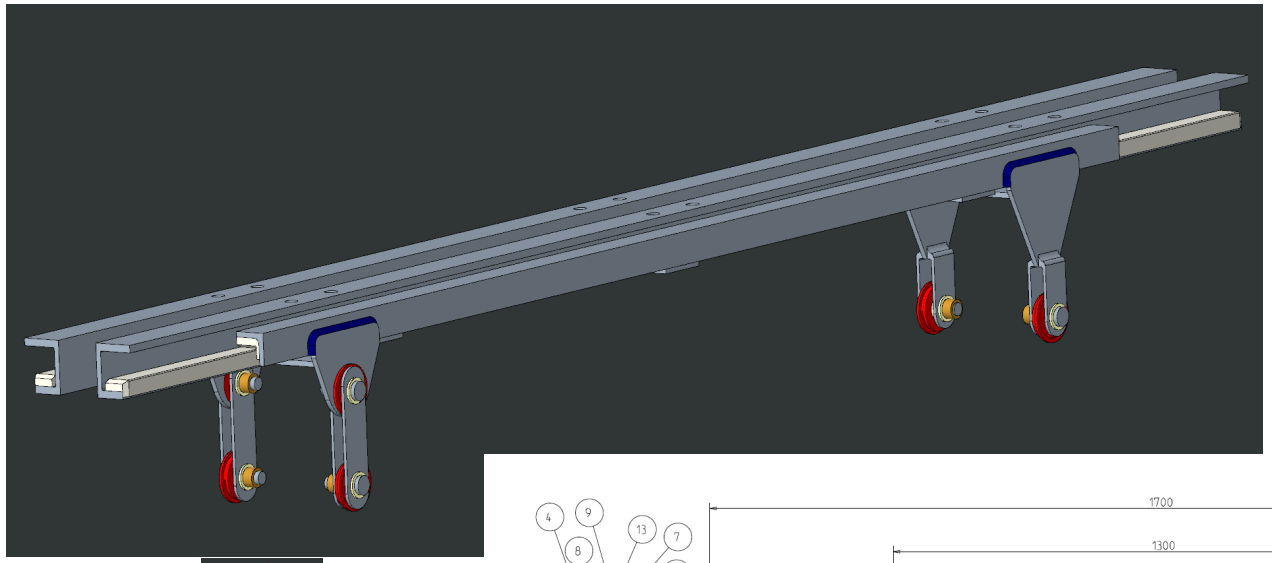


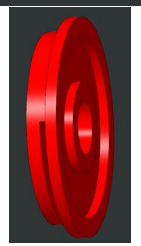
Inner vessel

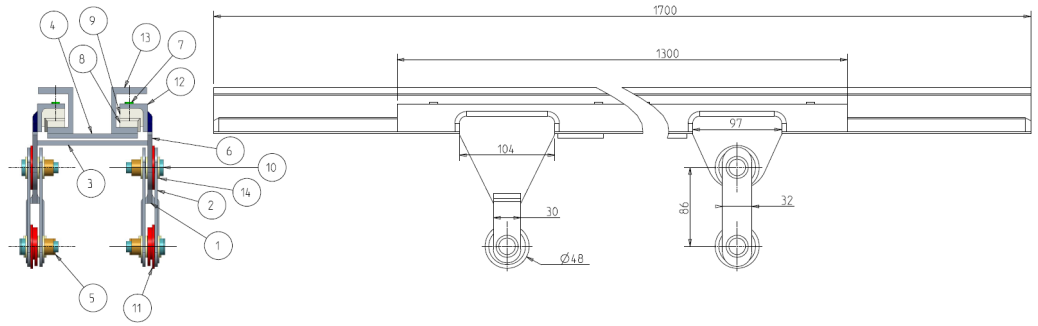


- Inner vessel modified following proximity cryogenic redesign
  New top nozzle for LAr inlet, boil-off nozzle relocated
- Modification required additional review by Enginesoft for EN 13445 certification update.
- Fermilab will accept the equipment based on CE marking under PED

Suspension system





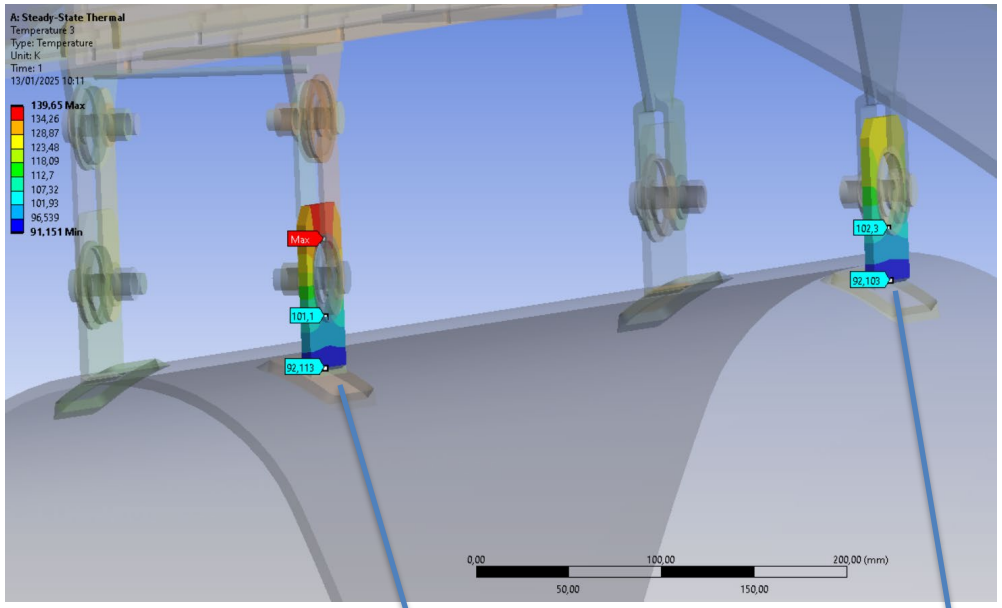


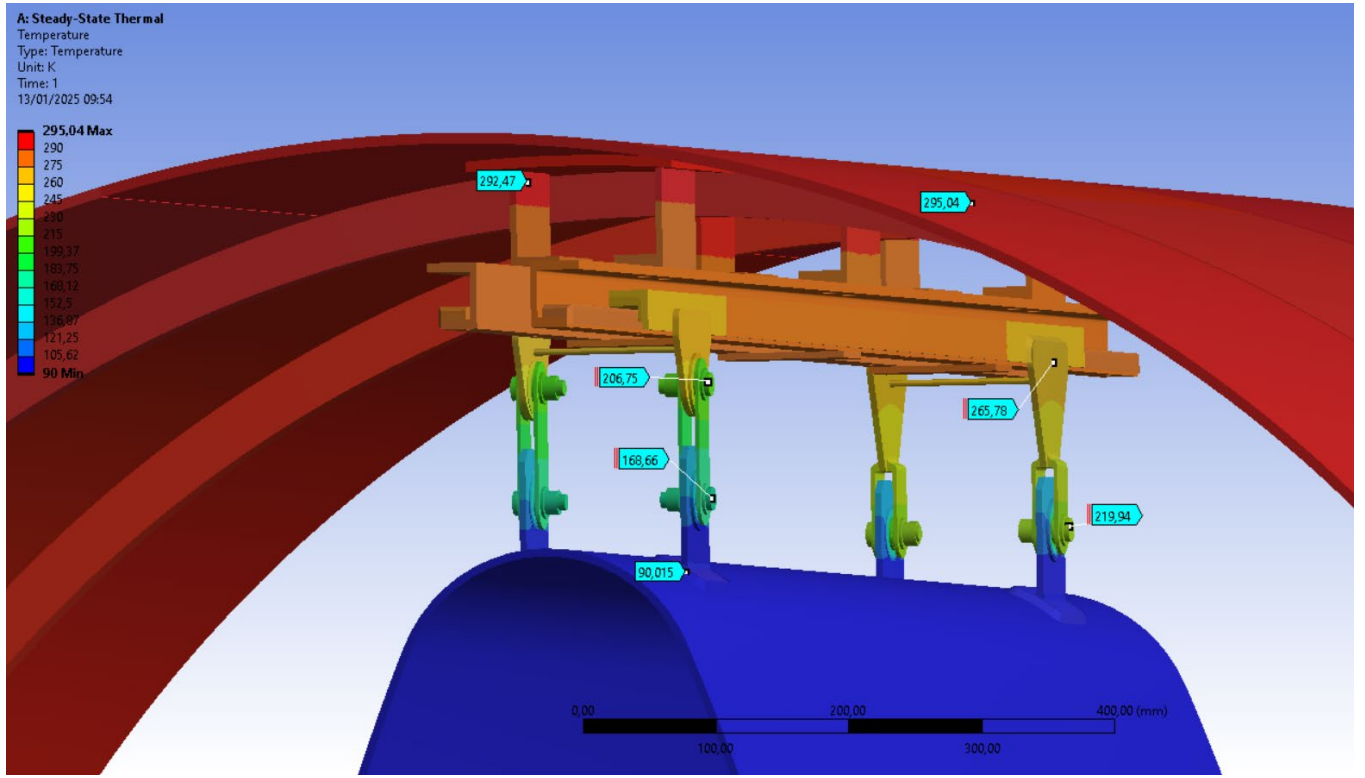
14	PLASTIC_WASHER		22	PTFE
13	UPN_50_LASER		2	AISI 316L
12	GFXFR_ANGLE_BEAM_4		2	AISI 316L
11	THERMAL_INSULATION_BUSH	boccola taglio termico	6	G10
10	PIN	Ø 12	6	AISI316L
9	PATTINO_PTFE_CARRELLO		6	PTFE + GLASS FIBER 20%
8	PATTINO_PTFE		10	PTFE + GLASS FIBER 20%
7	RIVETTO_INOX_A2		40	AISI316L
6	PIASTRA_COLLEGAMENTO_CARRELLO		2	AISI316L
5	NUT_12		6	AISI316L
4	CROSSPLATES		3	AISI316L
3	CROSSBAR		2	AISI316L
2	CONNECTING_ROD		4	AISI316L
1	BRACKET_FORK		2	AISI316L
Pos.	Drawing N.°	Description	Q.ty	Material

Designed by: Gianluigi Piazza	Signature	Project: GRAIN	
Drawn by: Gianluigi Piazza	Date: 05/03/25	Description: sistema di supporto	Quantity: 1
INFN Istituto Nazionale di Fisica Nucleare, Sezione di Bologna		Material	Gen. surf. finish
		Treatment	Scale: 1:4 / Mass [kg]: 28.7 / Frm.: A3
		Technical Drawings ISO 8015, Gen. Tol. UNI-EN 22768/2-mK	Drawing N°: 01_01_03 GRAIN / Rev.: 2

- Engineering note finalized following Eurocodes
- updates to be implemented following Fermilab engineer's recommendations

Suspension system





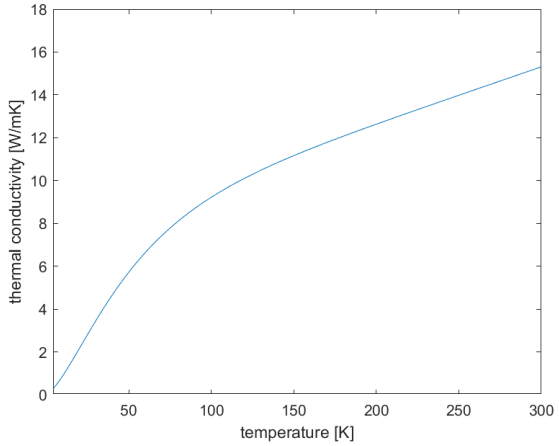
Q=kmxAxDT/L
k(92)=8,8138 W/mK
k(101)=9,2721 W/mK
km=9,0429 W/mk
A=0,005x0,066 m^2
L=0,029 m

Q1=0,93 W

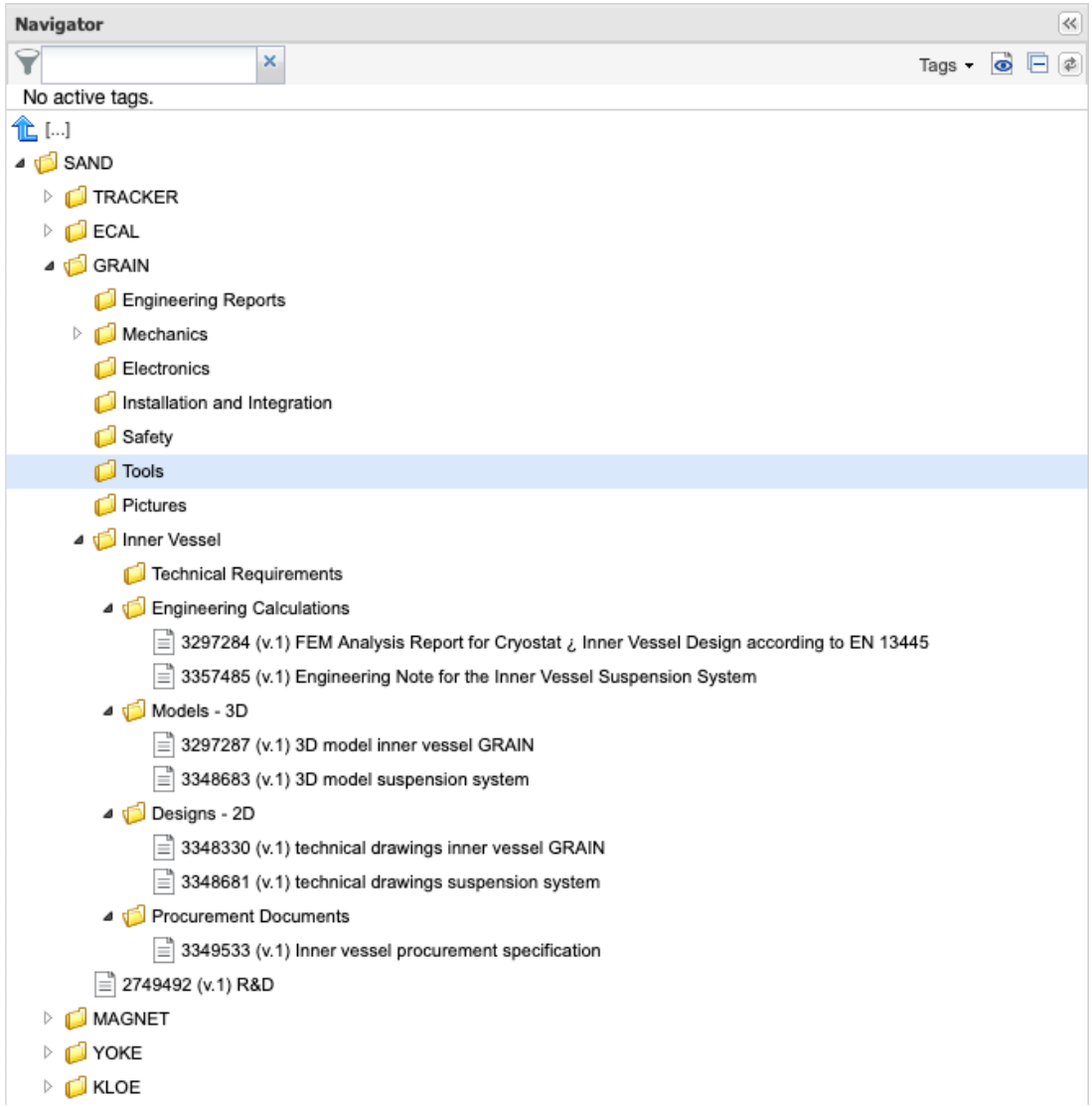
Q=kmxAxDT/L
k(92)=8,8138 W/mK
k(102)=9,3201 W/mK
km=9,0669 W/mk
A=0,005x0,066 m^2
L=0,029 m

Q1=1,03 W

Qtotal =2Q1+2Q2= 3,9 W



Documentation in EDMS

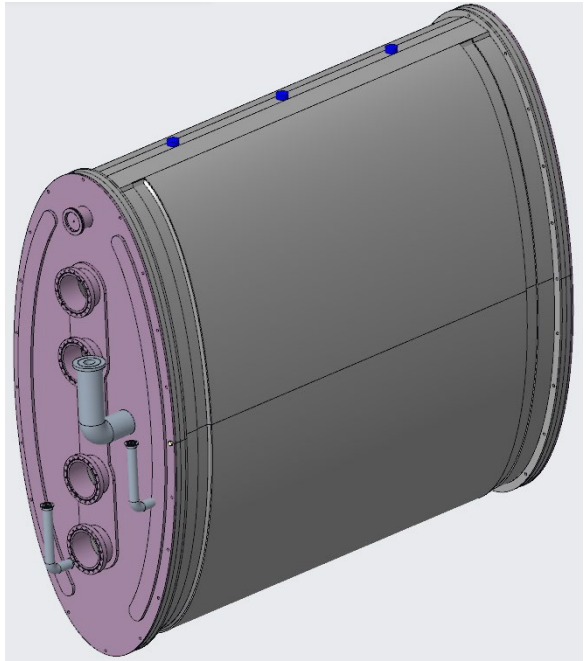


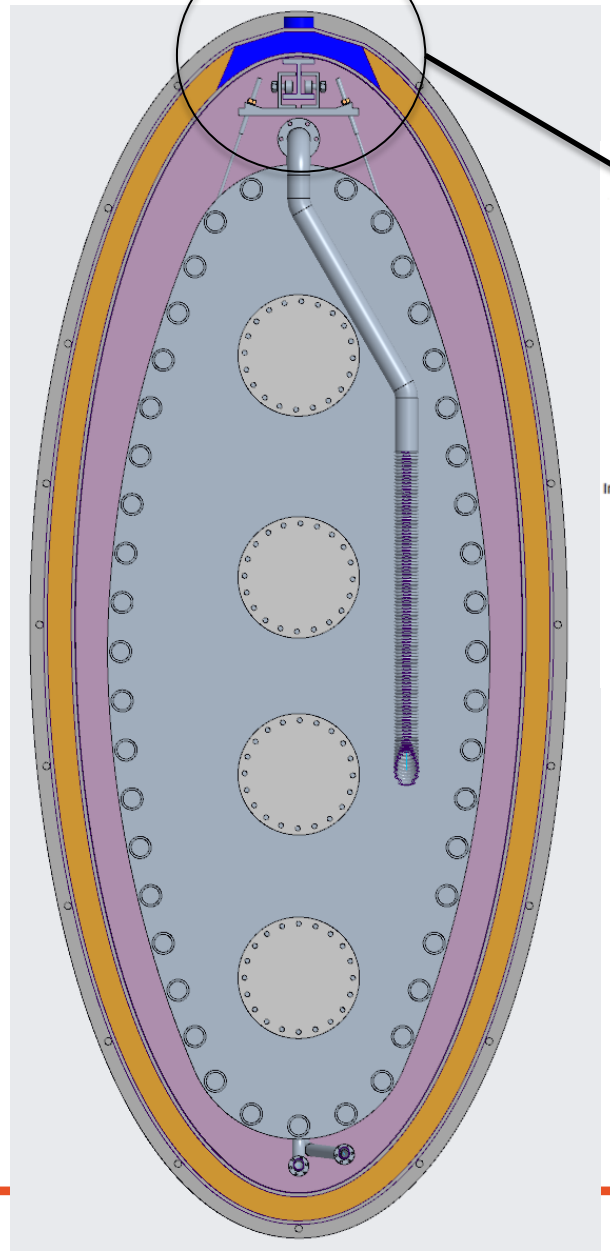
Technical documentation of Inner Vessel uploaded in EDMS

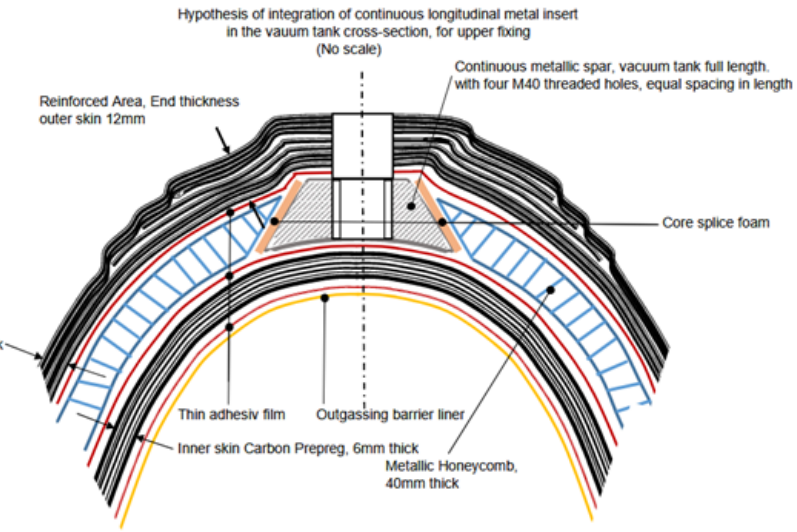
Outer vessel CFRP

Design is still conceptual
and the work is on hold

Made of composite material:
Carbon fiber
Nomex honeycomb
Aluminum alloy and/or stainless steel



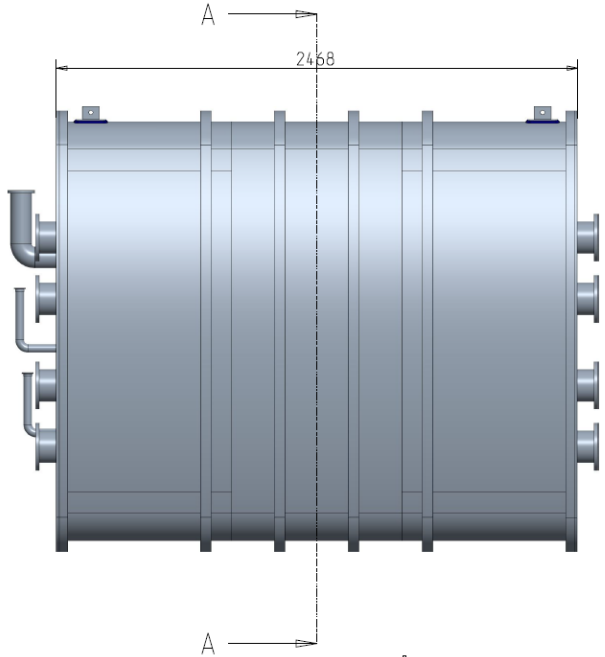


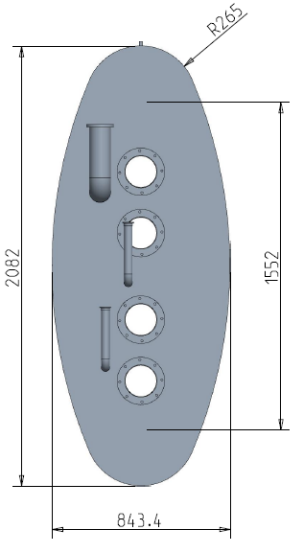


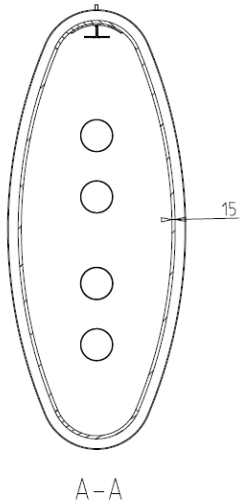
Aluminum foil first layer to prevent ougassing, but difficult to make this adhere without defects

Mass weight ca 770 kg

Outer vessel: alternative





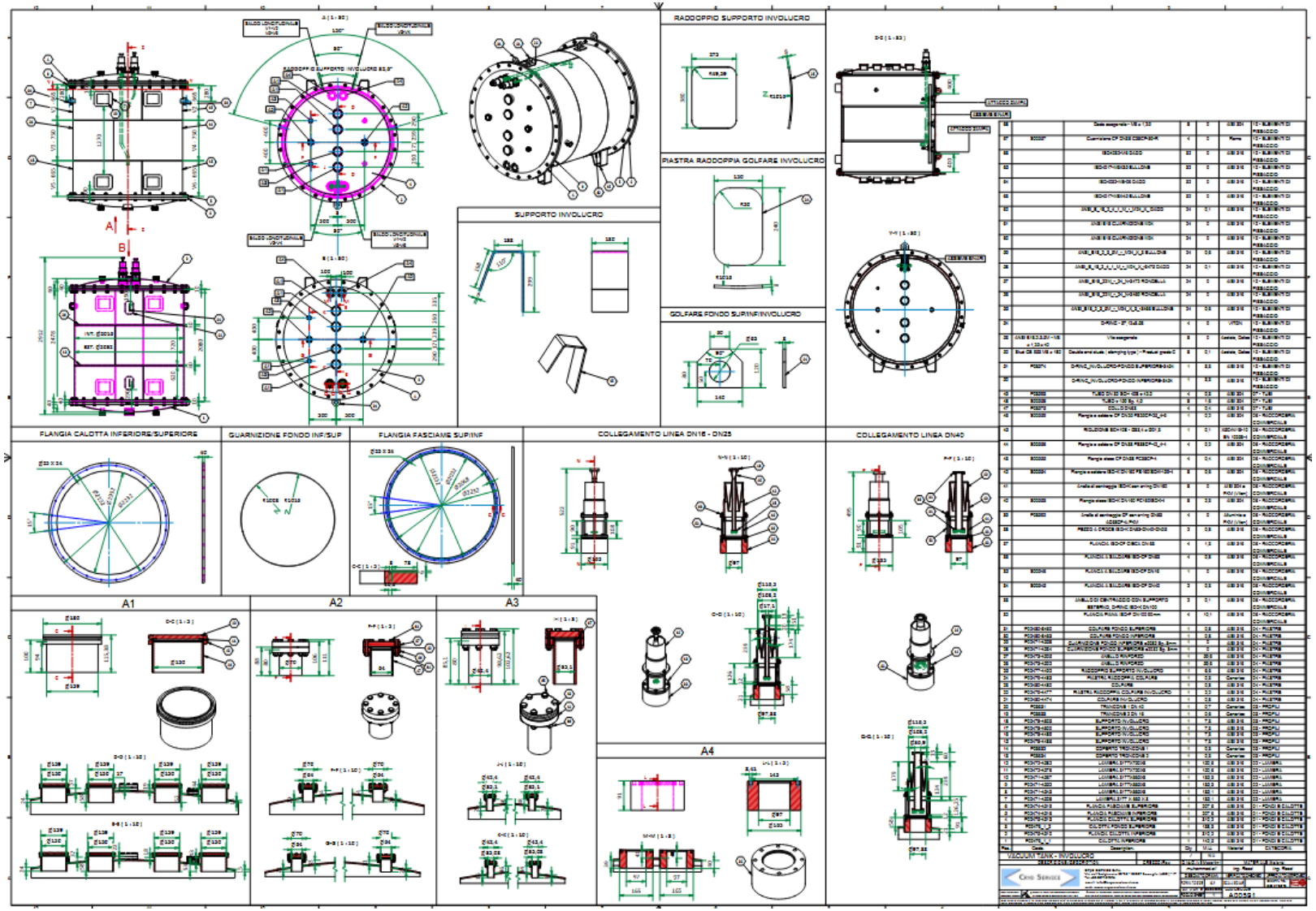


All the vessel in aluminum alloy

Mass weight ca 840 kg
(ca 70 kg more than the composite one)

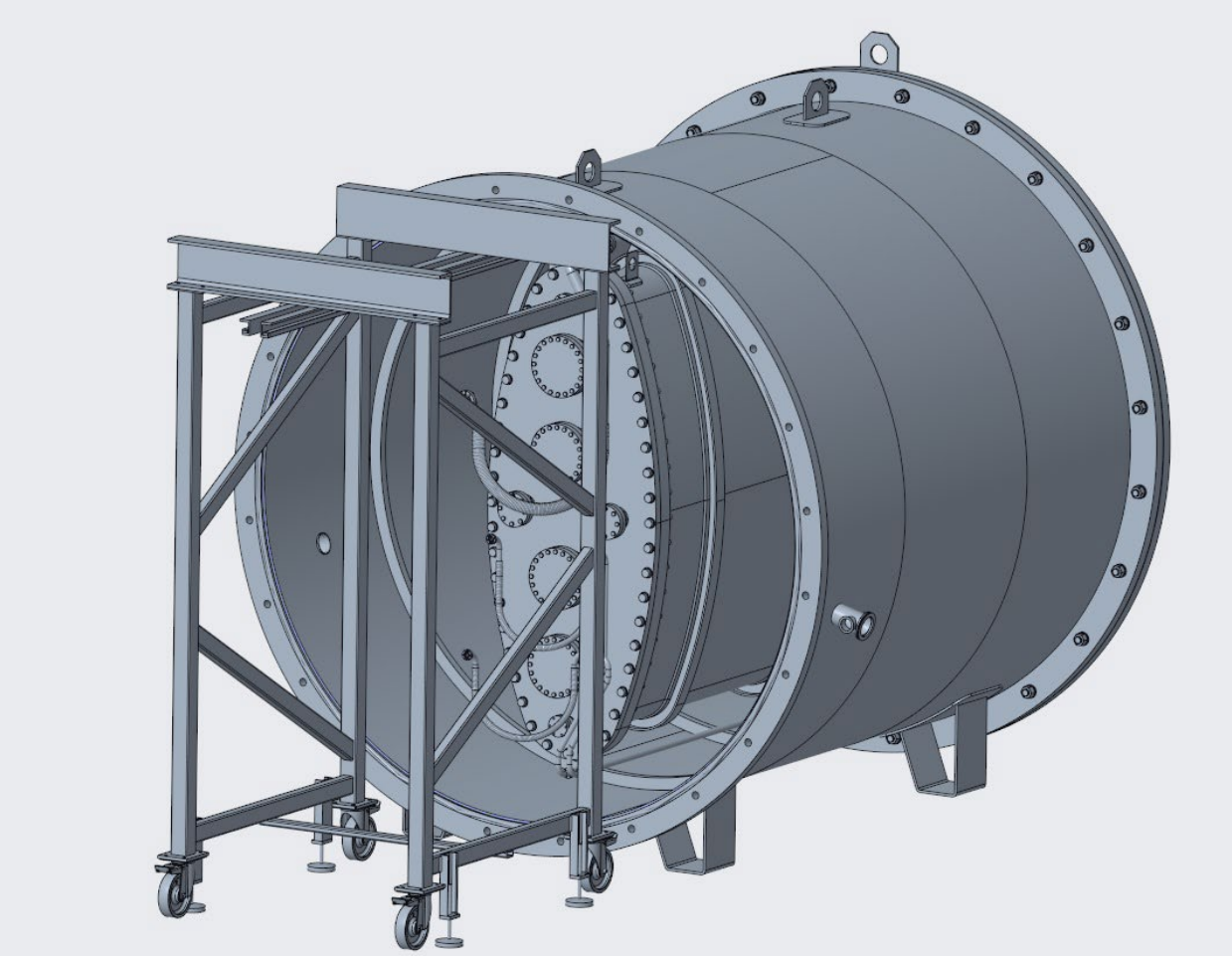
Cheapear
More reliable and safe
Easier to be approved by Fermilab

Vacuum tank for LNL facility test

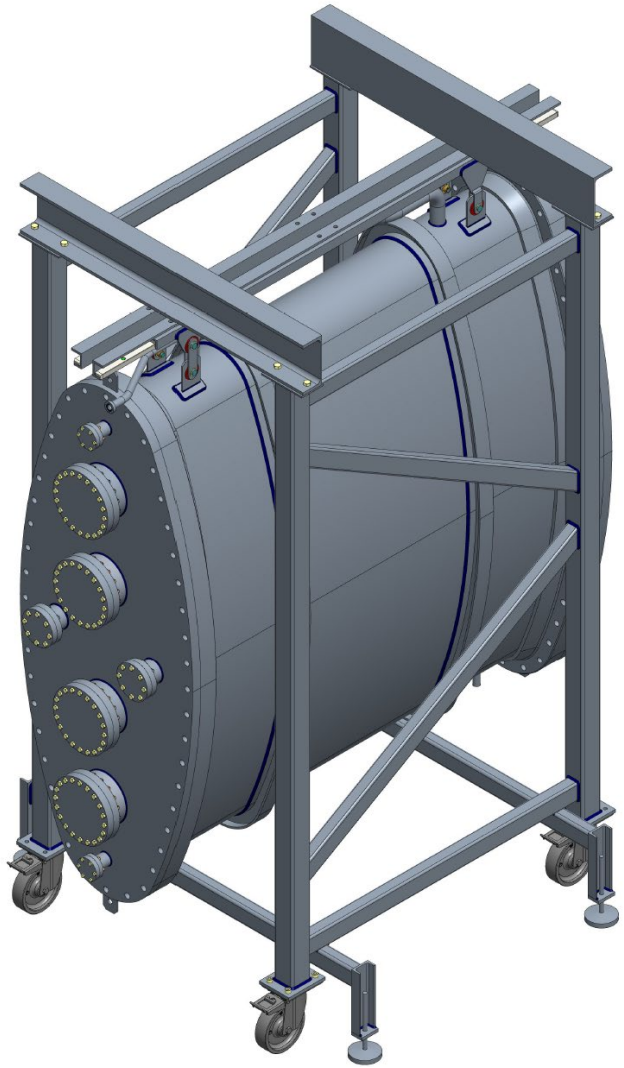


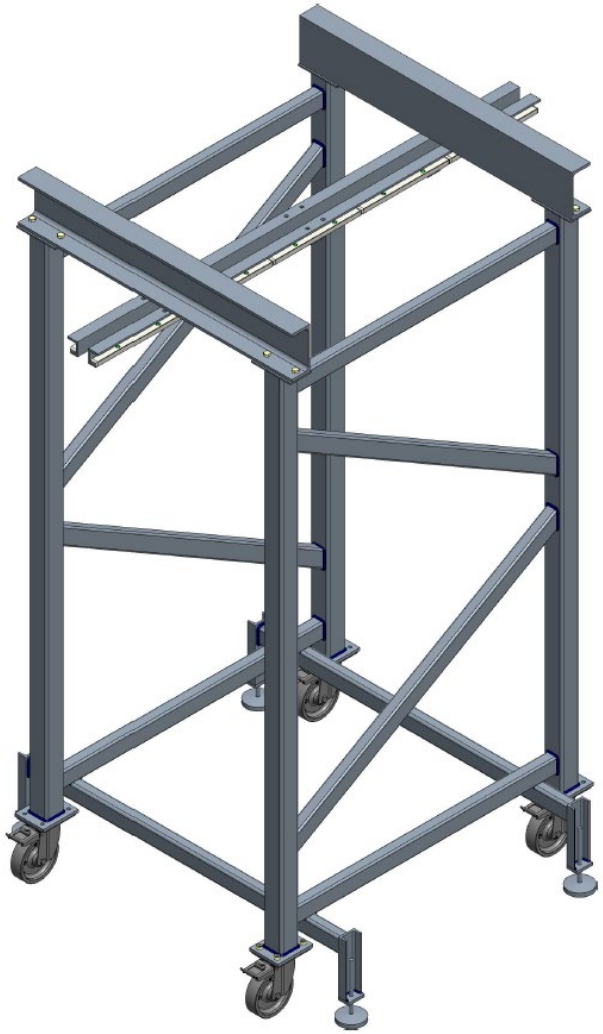
- Vacuum tank for Legnaro tests – order already placed
- Final details and modifications defined, following proximity cryogenics changes
- Telescopic sleeves for argon transfer line connections
- Construction is starting

Vacuum tank for LNL facility test



Inner vessel mechanical cradle





Mechanical cradle to support inner vessel
Enables insertion and extraction from vacuum tank

Thank you