CERN

4th FCC Physics and Experiments Workshop

R&D on light-weight cryostats and on high-density signal feedthroughs

Maria Barba, Michel Chalifour, Johan Bremer – TE/CRG
Maria Soledad Molina, Corrado Gargiulo, Massimo Angeletti – EP/DT
Martin Aleksa – EP/ADO

Outline

- **Project 1: R&D on light-weight cryostats**

Maria Soledad Molina, Corrado Gargiulo, Massimo Angeletti – EP/DT

1. Goal
2. Preliminary studies
3. Feasibility tests

- **Project 2 : R&D on high-density signal feedthroughs**

Maria Barba, Michel Chalifour, Johan Bremer – TE/CRG

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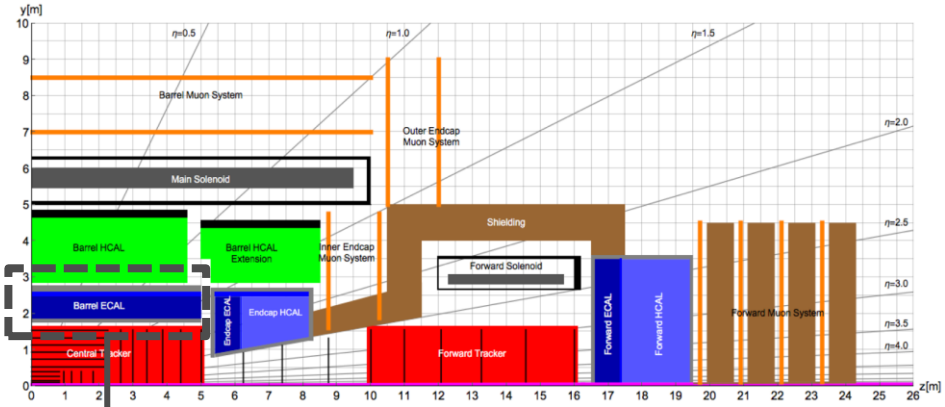
1. Goal
2. Development of high-density flanges
3. Glue tests
4. Feedthrough samples to test
5. Experimental setup
6. Simulation work
7. Next steps

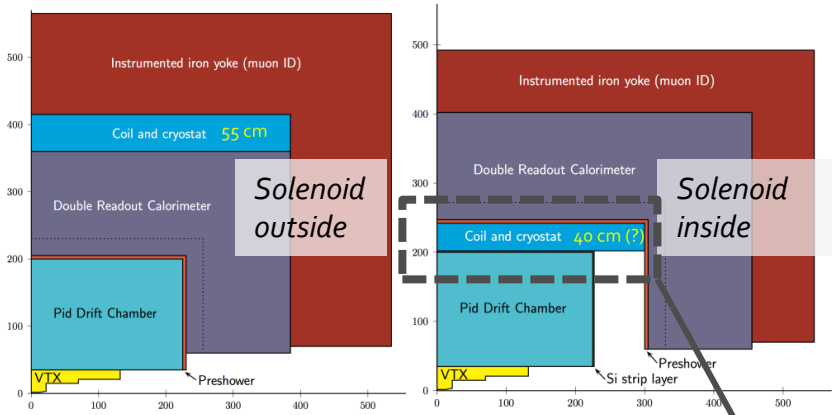
R&D on light-weight cryostats

1. Goal: decrease thickness and material budget of the next generation of cryostats for HEP → using Carbon Fibre Reinforced Plastic

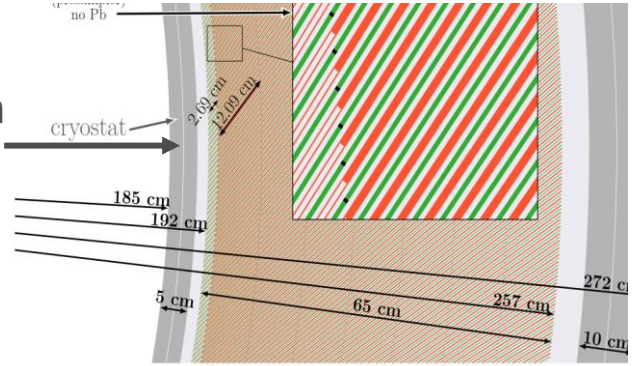
Baseline geometry, **FCC-hh** LAr barrel ECAL : Cryostat calorimeter (double vessel)

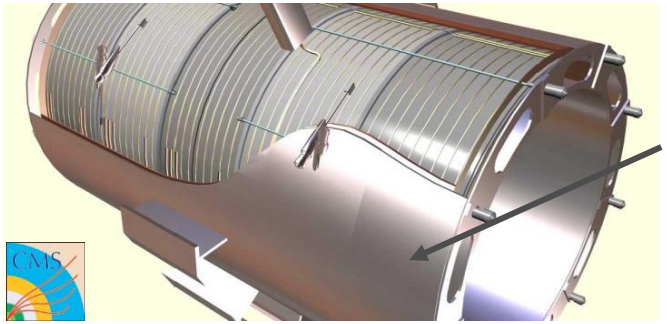


Baseline geometry, **FCC-ee** : Cryostat magnet



minimum material



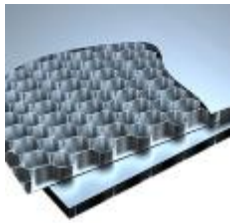


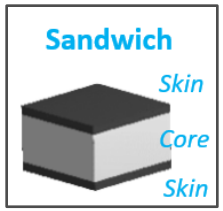
minimum material / buckling resistance

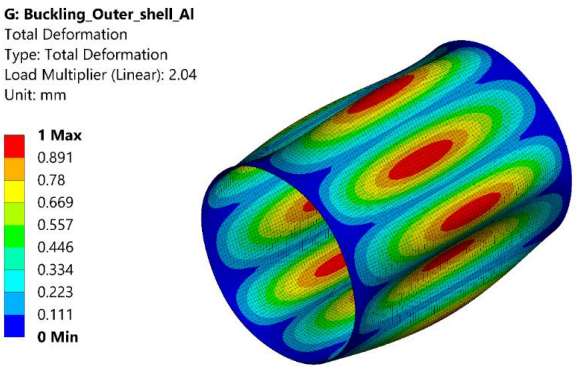
R&D on light-weight cryostats

2. Preliminary studies:

- Numerical simulations







	Sandwich					Solid plate				
	UHM CFRP	HM CFRP	IM CFRP	Al	Ti	UHM CFRP	HM CFRP	IM CFRP	Al	Ti
Avg. Th. [mm]				4.0	1.5	13.6	16.8	20.8	20.9	17.2
Material budget X/X_0	0.0134	0.0147	0.0189	0.045	0.034	0.052	0.065	0.08	0.24	0.49
X_0 + %	-70%	-67%	-58%	X_0	-24%	+16%	+44%	+78%	+433%	+989%
Thickness + %	-37%	-18%	0%	T	+133%	-69%	-61%	-52%	-52%	-60%

- Carbon fibre cryotanks used in the aerospace industry

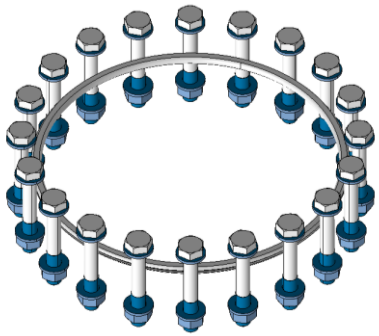
- Thermal insulation → **low-conductivity**
- Mechanical connections and differential thermoelastic expansion → **carbon and metal components**
- Manufacturing process → **OOA, Out-Of-Autoclave process**
- Liner and liner-less tanks → **Liner-less based on thin-ply composite wall**
- Materials → **Microcrack-resistant fibre/resin system for towpreg**

R&D on light-weight cryostats

3. Feasibility tests

- Design requirements → leak-tight; Pmax = 3.5 bar; T = 87 K
- First sample → composite compatibility with UHV sealing components

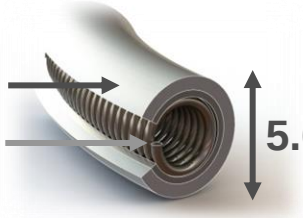
Carbon composite material:
MULTIPREG 8020*



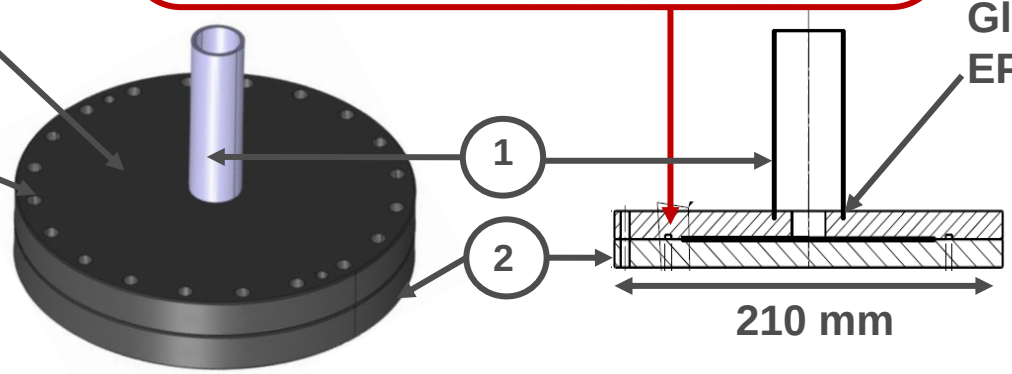
Fasteners:
20 bolts: M8 SS A4-100
20 Nuts SS A4-100
40 Washers SS A4-100

Metallic seal: HELICOFLEX H15066

Outter Jacket: Al
Spring: Nimonic



5.6 mm



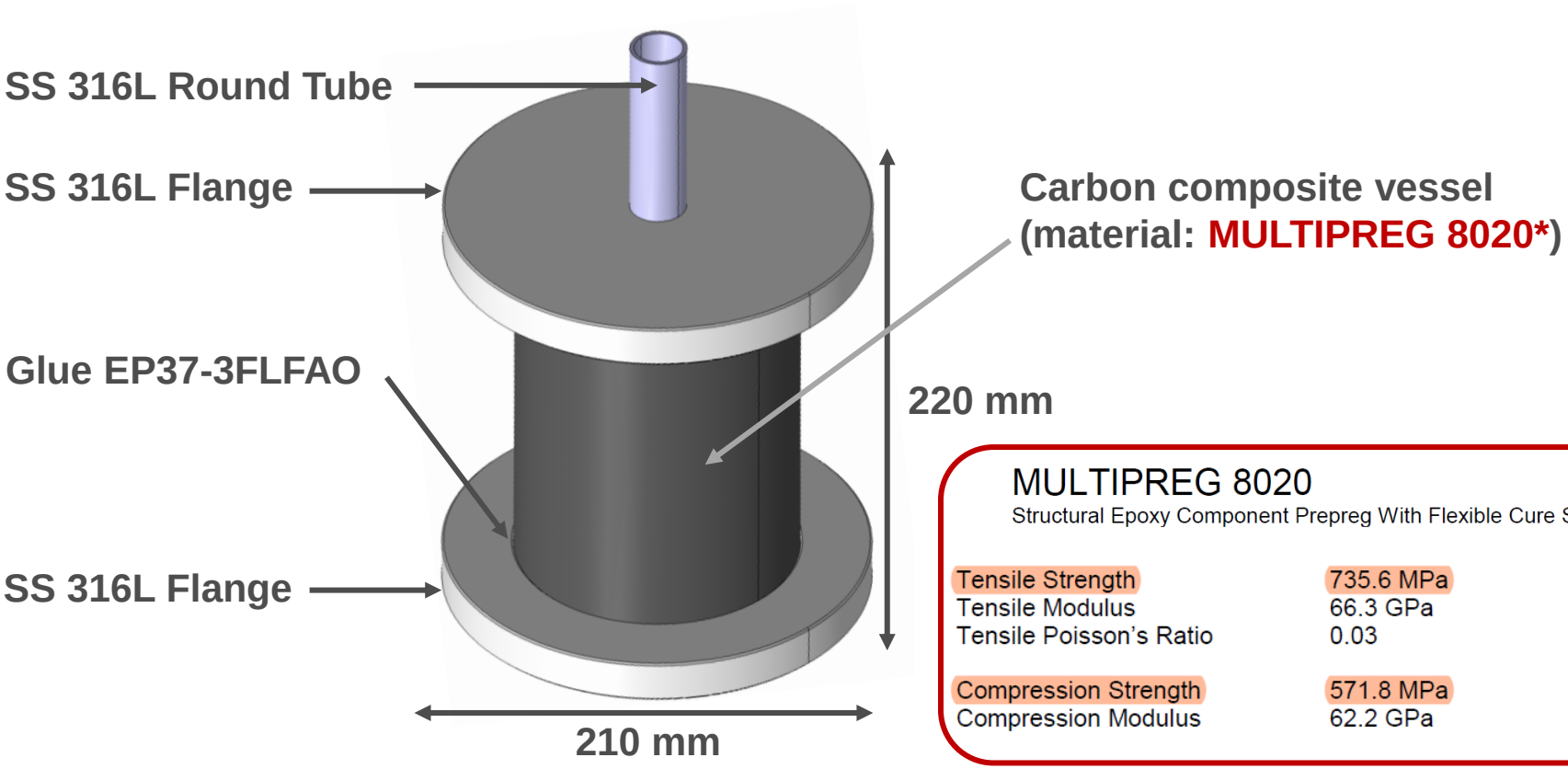
Glue
EP37-3FLFAO

1. SS 316 L Round Tube
2. Carbon Composite Flanges

R&D on light-weight cryostats

3. Feasibility tests

- Design requirements → leak-tight; Pmax = 3.5 bar; T = 87 K
- Second sample → composite thin shell permeability and microcrack resistance



MULTIPREG 8020

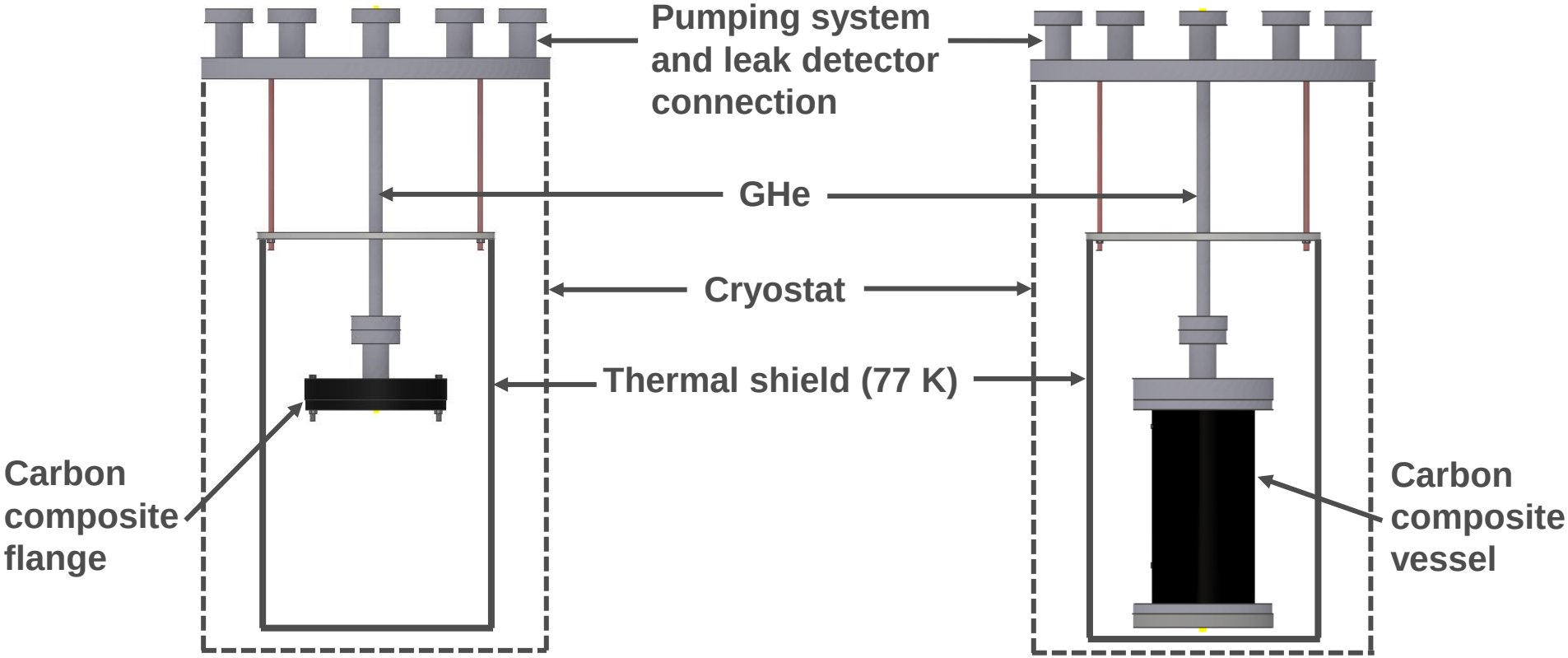
Structural Epoxy Component Prepreg With Flexible Cure Schedules

Tensile Strength	735.6 MPa	EN 2597
Tensile Modulus	66.3 GPa	EN 2597
Tensile Poisson's Ratio	0.03	EN 2597
Compression Strength	571.8 MPa	EN 2850
Compression Modulus	62.2 GPa	EN 2850

R&D on light-weight cryostats

3. Feasibility tests

- Design requirements → leak-tight; Pmax = 3.5 bar; T = 87 K
- Type of tests : leak and pressure test at room and low temperature



Outline

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- **Project 2: R&D on high-density signal feedthroughs**

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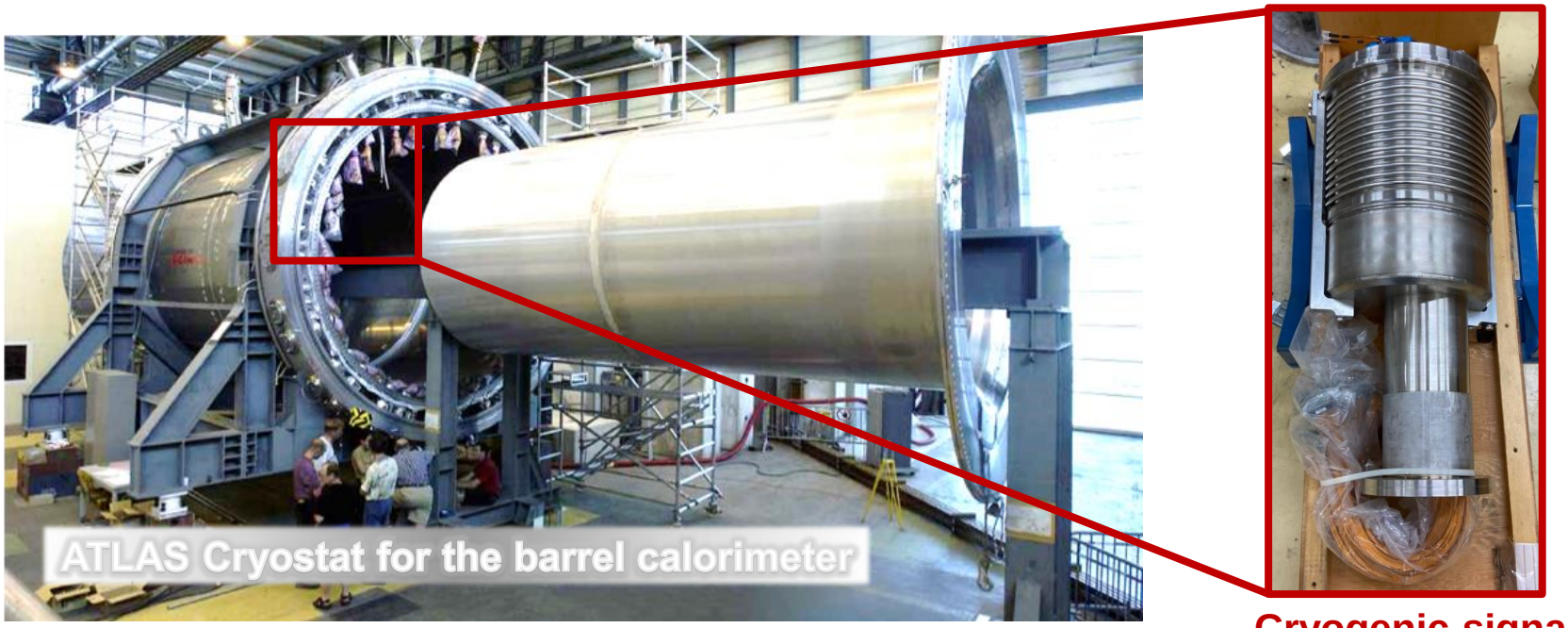
R&D on high-density signal feedthroughs

1. Goal: 10 times more signal wires than ATLAS feedthroughs (density x5 area x2) → 20 to 50 wires/cm^2



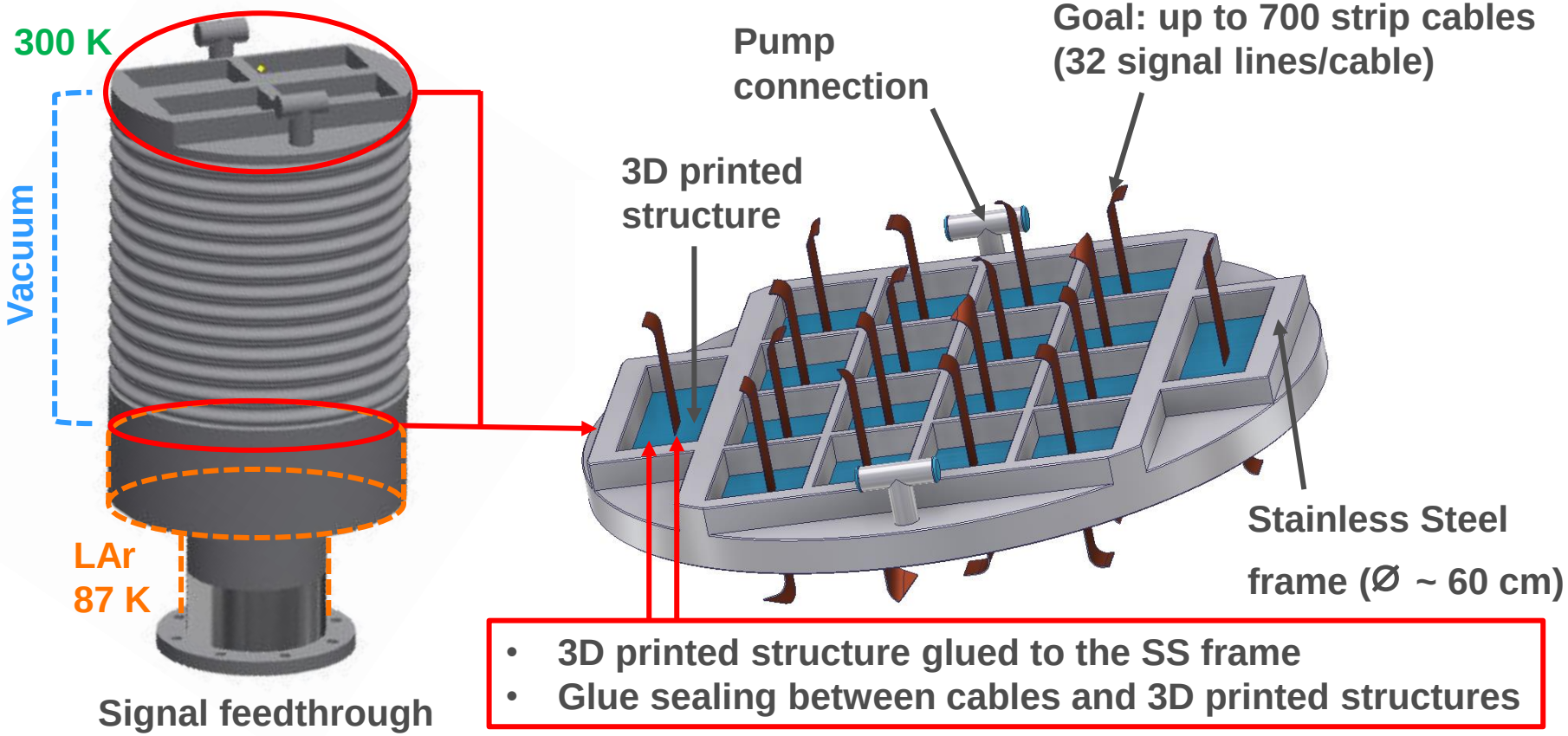
Cryogenic signal feedthrough

- Future calorimeter: higher granularity → higher number of read-out channels → high-density signal feedthroughs

R&D on high-density signal feedthroughs

2. Development of high-density flanges:

- 3D printed epoxy pieces / fiberglass pieces (G10) and epoxy glues → avoiding connectors

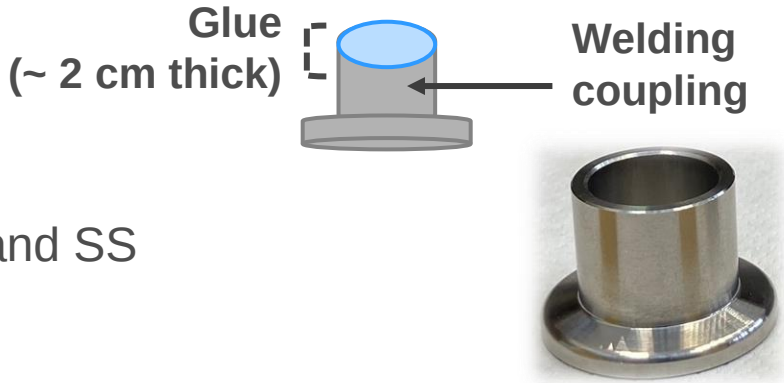


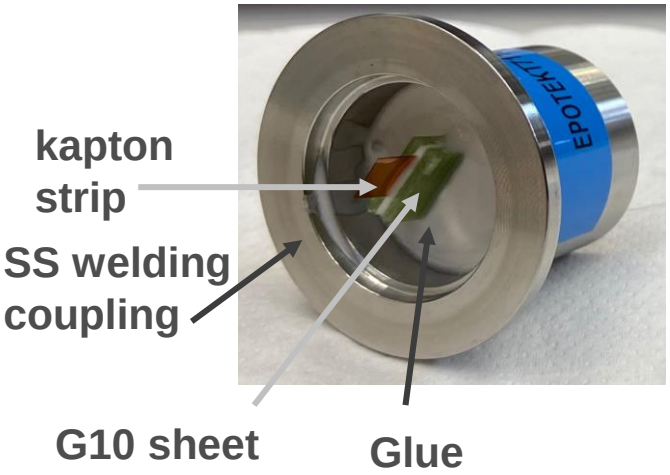
- 3D printed structure glued to the SS frame
- Glue sealing between cables and 3D printed structures

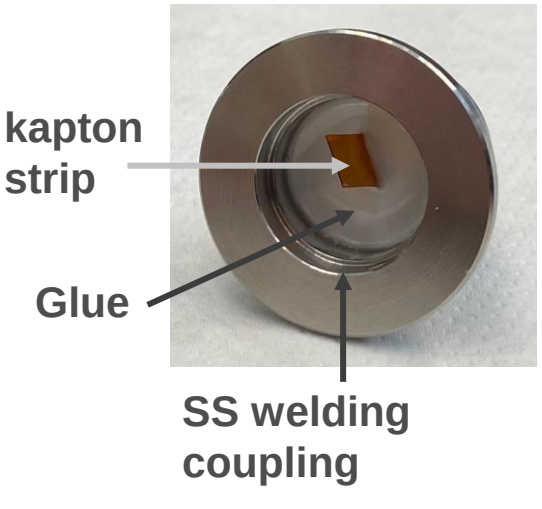
R&D on high-density signal feedthroughs

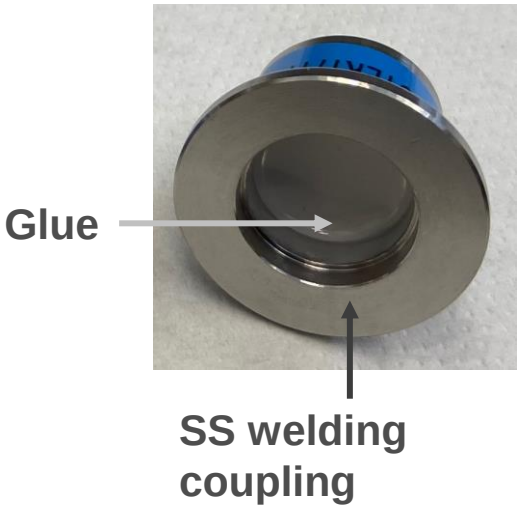
3. First step: glue tests

- Type of samples:
  - Glue and Stainless Steel (SS)
  - Glue + Kapton strip and SS
  - Glue + G10 sheet + Kapton strip and SS
  - Glue + 3D printed piece and SS





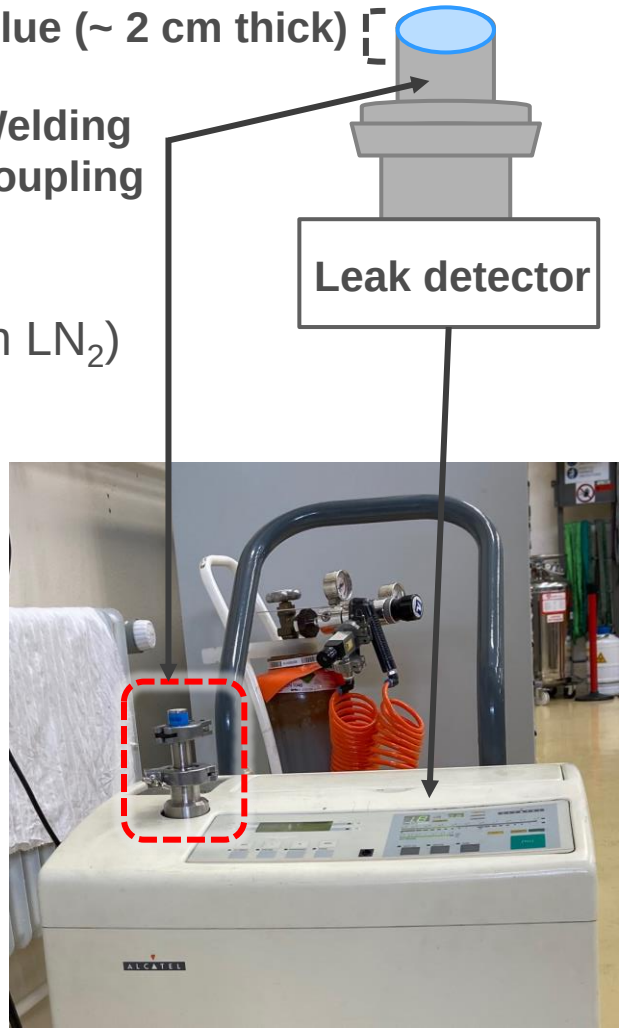




R&D on high-density signal feedthroughs

3. First step: glue tests

- Type of tests:
  1. Leak test before thermal shock
  2. Thermal shock in vapor and liquid N_2
  3. Leak test after thermal shock
  4. Extreme thermal shock at 77 K (directly in LN_2)
  5. Leak test after extreme thermal shock



R&D on high-density signal feedthroughs

3. First step: glue tests

- Summarized results:

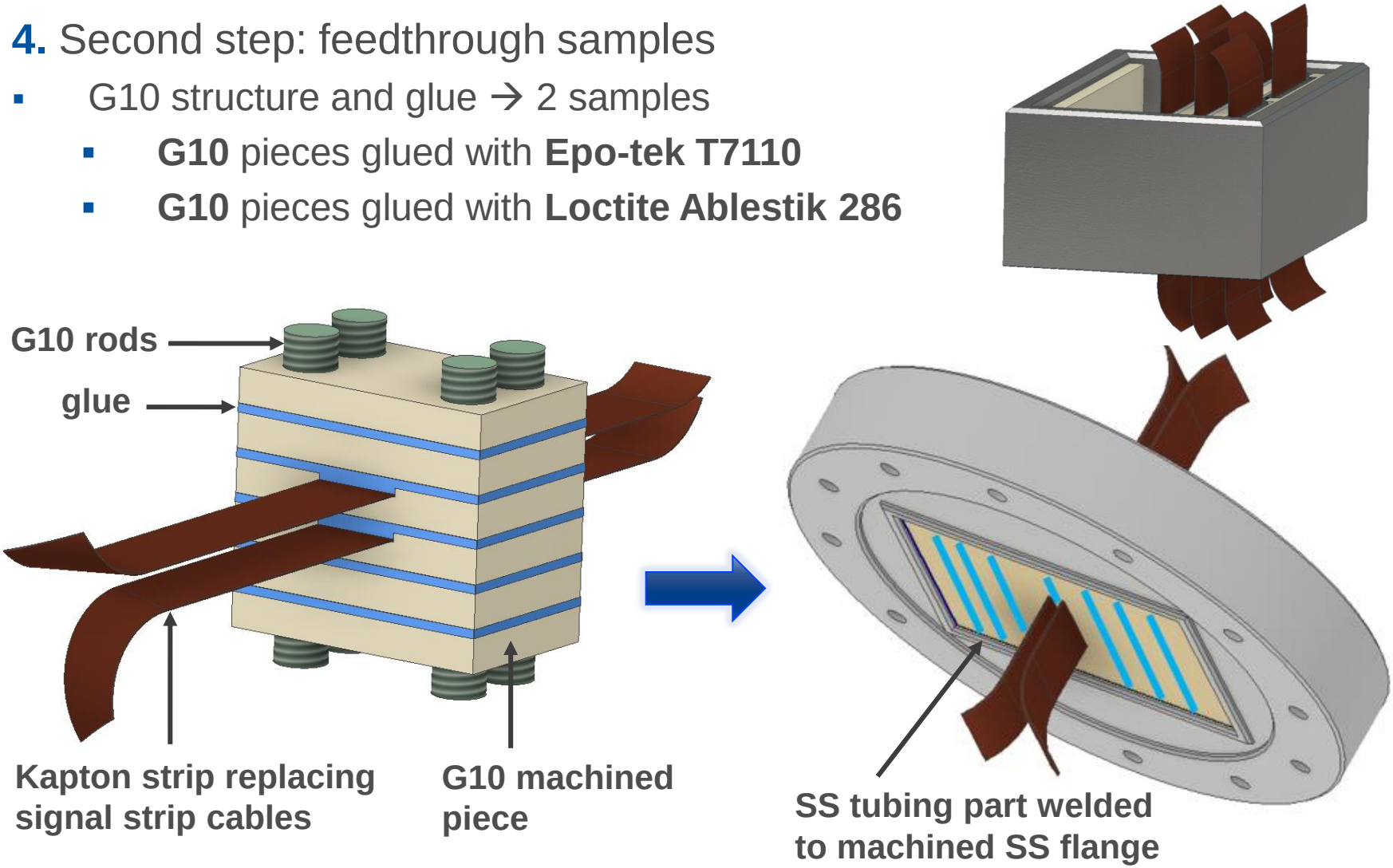
Type of glue/silicone	Leak test before thermal shock	Leak test after first thermal shock	Leak test after extreme thermal shock
Epoxy adhesive DP190	NO LEAK	LEAKS	-
Loctite Ablestik 286	**NO LEAK**	**NO LEAK**	**LEAKS**
Rhodorsil CAF-4	**NO LEAK**	**NO LEAK**	**NO LEAK**
RESINPRO	NO LEAK	LEAKS	-
Epo-tek T7110	**NO LEAK**	**NO LEAK**	**NO LEAK**
Araldite 2011	**NO LEAK**	**NO LEAK**	**NO LEAK**
Stycast 2850FT	NO LEAK	LEAKS	-

Rmk: Leak above 10^{-7} mbar.l/s

R&D on high-density signal feedthroughs

4. Second step: feedthrough samples

- G10 structure and glue → 2 samples
  - **G10** pieces glued with **Epo-tek T7110**
  - **G10** pieces glued with **Loctite Ablestik 286**

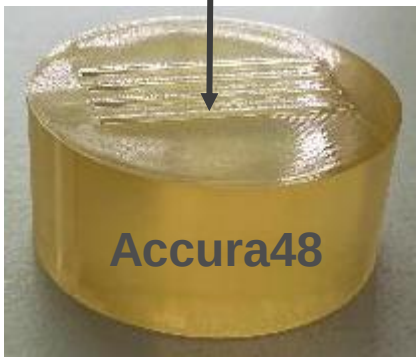


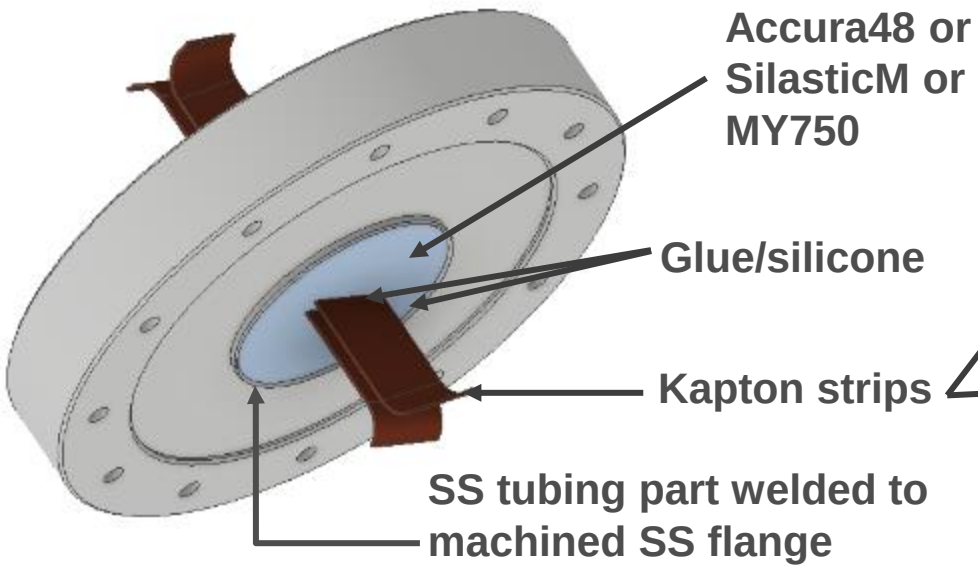
R&D on high-density signal feedthroughs

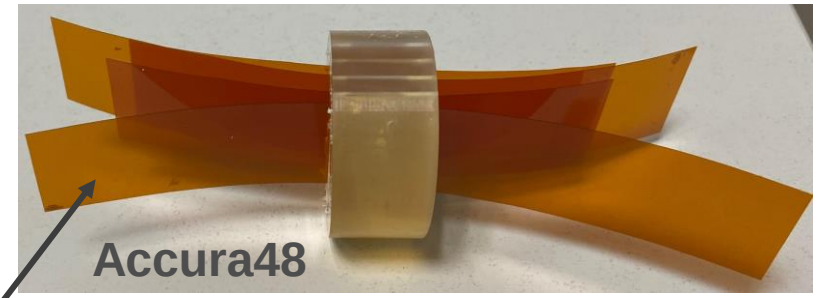
4. Second step: feedthrough samples

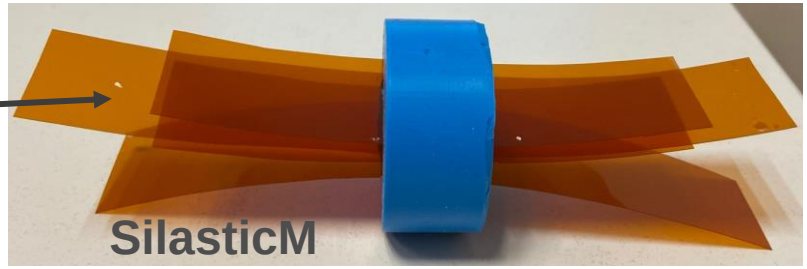
- 3D printed piece and glue/silicone → 5 samples
  - 3D printed piece in **Accura48** with **CAF-4 (silicone)**
  - 3D printed piece in **Accura48** with **Epo-tek T7110**
  - Piece in **SilasticM (silicone)** with **CAF-4**
  - Piece in **MY750 (silicone)** with **Epo-tek T7110**
  - Piece in **MY750 (silicone)** with **Loctite Ablestik 286**

Groove for Kapton strip glue/silicone





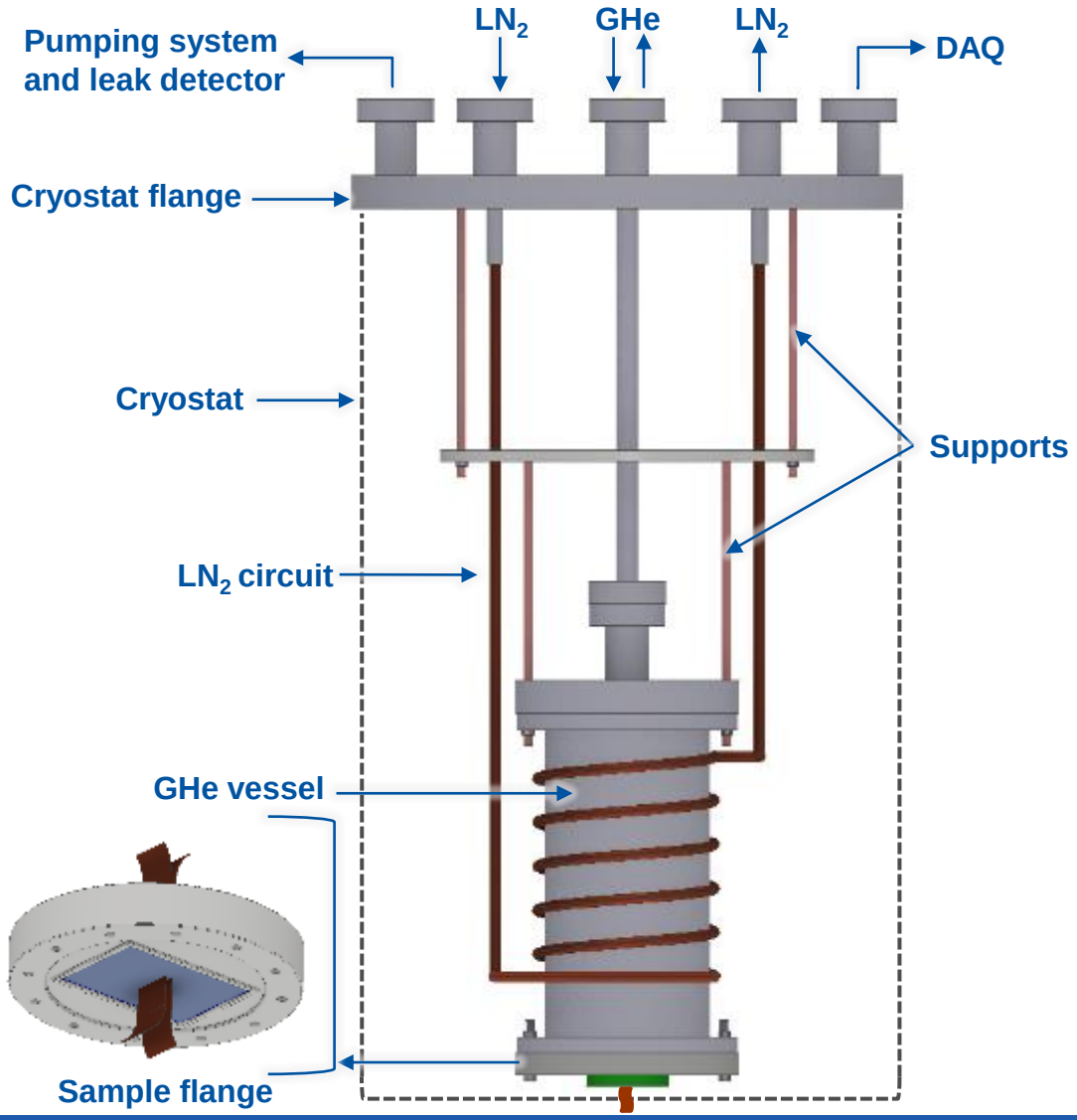




High-density signal feedthroughs

5. Experimental setup

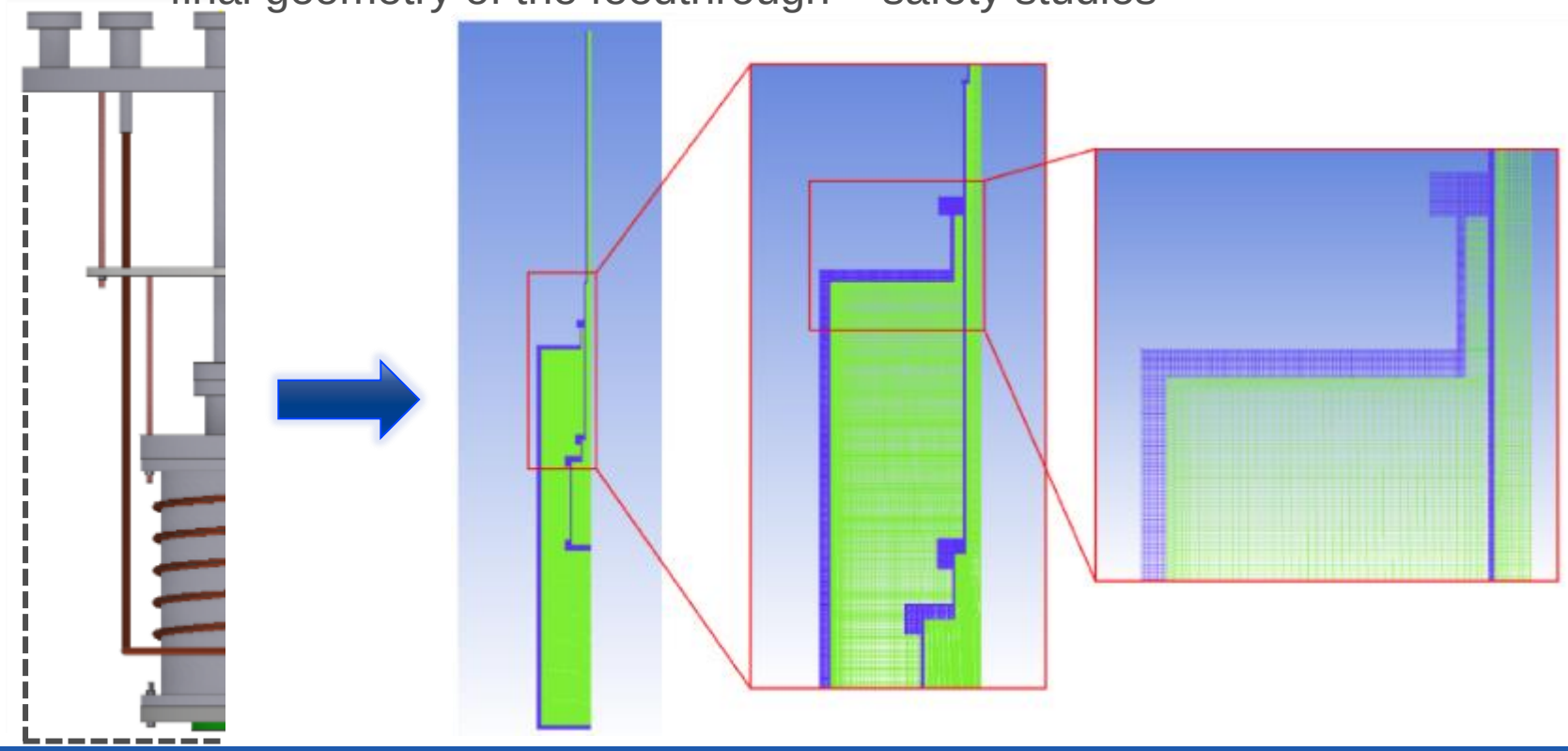
- Leak and pressure tests at room (300 K) and low temperature (77 K)



High density signal feedthroughs

6. Simulation work

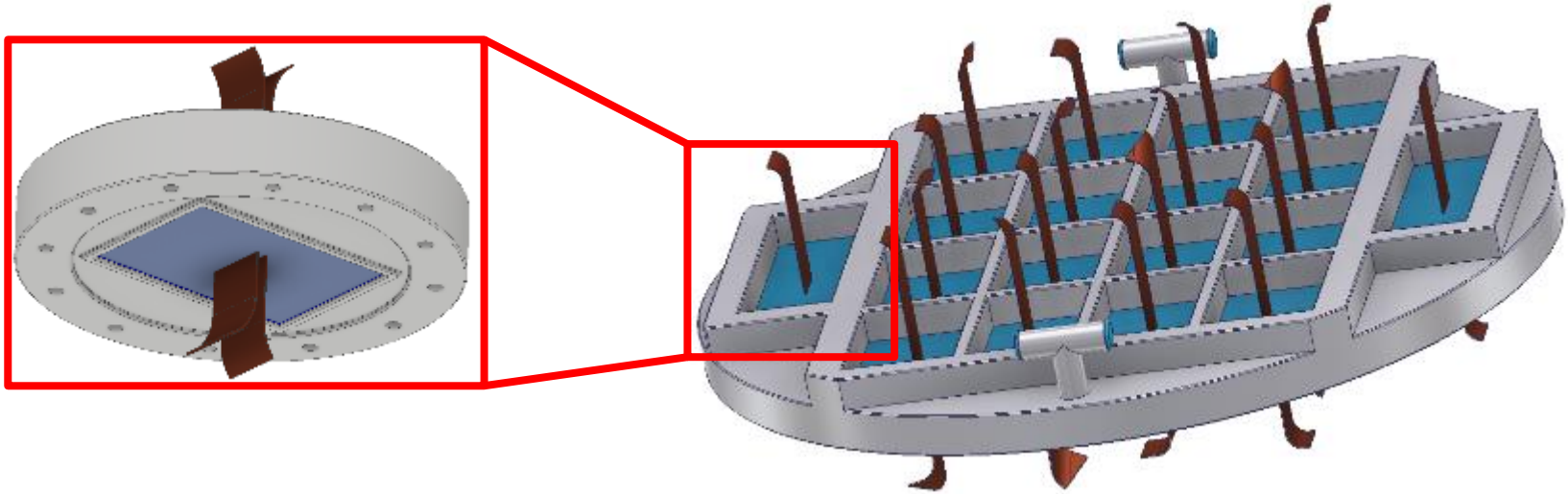
- Vacuum breaking study → CFD simulation
  - Geometry: 2D axisymmetric with refinement at the BD layer
  - Goal: validation of the turbulence model for future simulations with the final geometry of the feedthrough + safety studies



High density signal feedthroughs

7. Next steps

1. Leak and pressure tests of the first group of samples
2. Leak and pressure tests of the best samples (according to previous experimental results) with strip cables (available from the ATLAS experiment)
3. Mechanical simulations of the deformation of an entire flange at high pressure
4. **Production in house of an entire feedthrough flange**



Thank you for your attention!

Questions?

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