Flange preparation and leak testing on top of the cryostat

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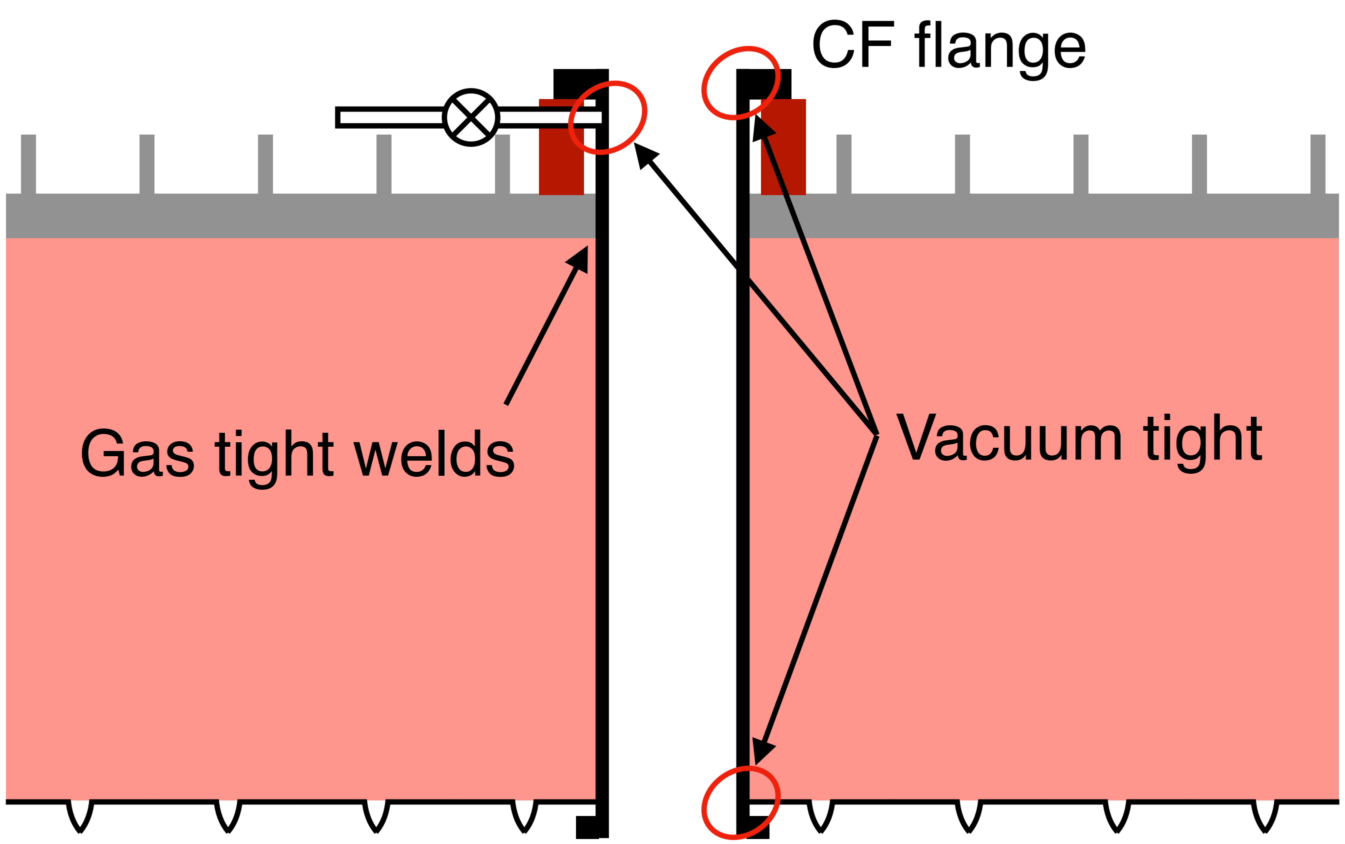
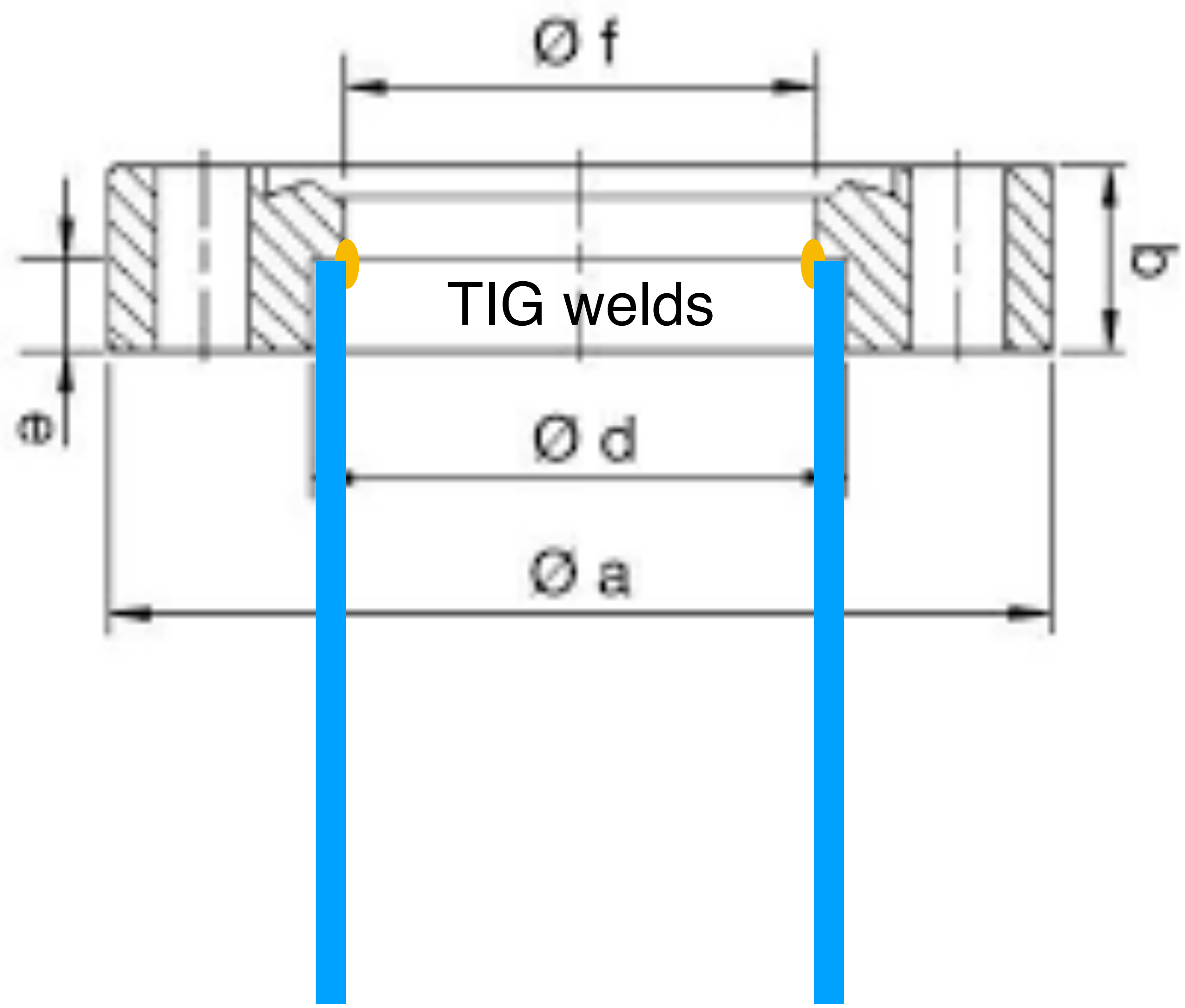
Critical welds for tightness

No other way to leak check these welds other then in situ tests

At ProtoDUNE, tested with helium sniffing during the leak checks of the feedthroughs



Tested with helium sniffing during the tests of the corrugated membrane welds



Test procedure (I)

The aim of the test is to certify the tightness of all penetrations on the cryostats to avoid the pollution of the liquid argon due to the atmosphere. At the same time, the certification reduces the risk of having leaks that would result in a spill of argon gas in the atmosphere when the detector is full of liquid argon.

At ProtoDUNEs, the welds of the flanges on the roof penetrations were tested in situ during the leak checks of the various feedthroughs. For DUNE, possibly, the welds must be tested independently. This would imply to seal the penetrations with a blind flanges tight (locally) better than ~$5x10^{-7}$ mbar.l/s, which is the typical background level for the helium sniffing techniques.

This test is carried out by two trained people at a rate as high as 20 non-leaking penetration tested per shift including the preparation work. The testing rate may be reduced if (1) the He background increases (common issue, when not all the flanges are sealed), (2) several flanges are found to be leaking, and (3) the flanges must be closed with final or temporary counter-flange during the test.

Test procedure (II)

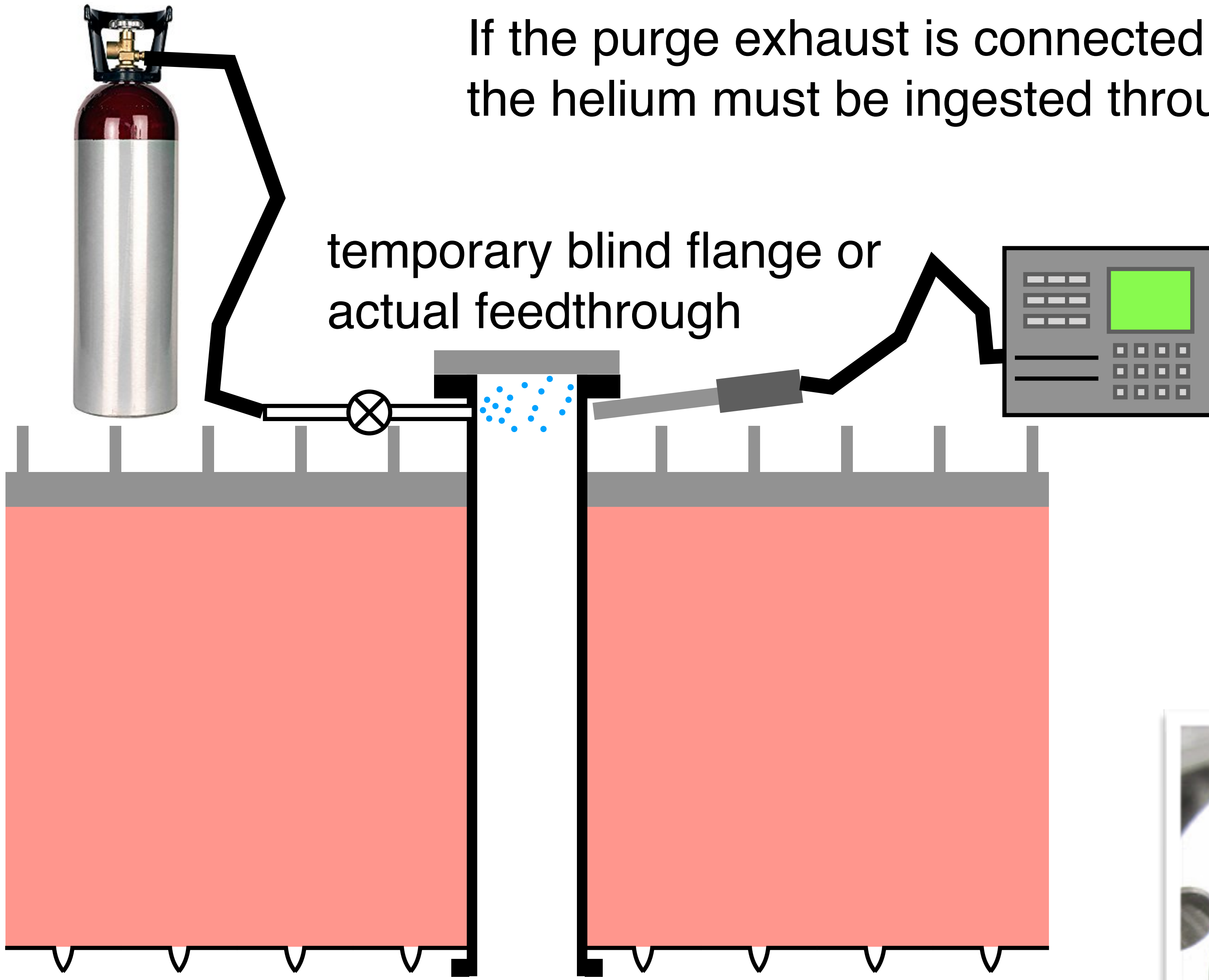
At ProtoDUNEs the tests were performed in two different ways, according to the advancement in detector preparation:

1) In a first phase, when the cryostat inner volume is accessible, the tests are performed with a helium leak detector, in sniffing mode. Helium is sprayed in large quantity inside a penetration, from inside the cryostat. On the outside of the cryostat, a special probe connected to the helium leak detector is used to search for He which, if present, would indicate a leak.

2) In a second phase, when the penetrations are not accessible from inside the cryostat, the argon purge pipes are used. Each penetration is equipped with a purge line collecting the argon boil-off during normal detector operation. Each line is equipped with a valve, closed by default, which can be opened with a compressed air line. In this test phase, helium is injected into the purge line system, with overpressure of the order of 100 mbar with respect to the atmospheric pressure. Rough vacuum is pumped in the manifold prior the helium injection to eliminate the air and increase the fraction of helium. One valve at a time (sometimes at most two) is opened, feeding helium into the penetration selected for the test. Leaks are then searched again like in the previous case. The presence of helium inside the penetration is controlled wherever possible, for instance for penetrations that are either not yet completely sealed, or have an additional valve for purge purposes.

Test for tightness

If the purge exhaust is connected to the manifold,
the helium must be ingested through the manifold



For temporary sealing with
blind flanges Viton (instead of
copper) gaskets may be used

Test procedure (III)

The actual helium sniffing test is done moving slowly the probe as close as possible to the region of interest. For a CF connection, for instance, the test takes at least 30 s per turn for a medium-sized flange. The check is performed at least twice for each region.

More tests are performed if a positive reading comes from the leak detector. A positive reading is defined as any positive deviation from the background. The maximum background level accepted is $5x10^{-6}$ mbar.l/s.
Positive readings may be due to temporary increase of the background, in fact, helium may escape from the cryostat through the still open flanges, helped by the forced air ventilation.

If there is the suspect that the positive signal is not due to an actual leak in the tested region, the test is interrupted, until the He level read by the detector goes back to acceptable background levels. To speedup this process, compressed air or nitrogen may be sprayed all around the test-area. False readings are actually characterised by random positive signals that cannot be reproduced, therefore they are quite easily identified from real leaks.

The feedthroughs and the bolted flange connections installed on the penetrations are tested with this method as well. They are expected to be already tested or certified in other ways according to the UHV CF standards. Custom made flanges should therefore be tested elsewhere prior to the installation on the cryostat.

Example of NP04

A summary of the leak check can be found at https://edms.cern.ch/document/1975301/1

Not the complete list of all the penetration tested

Penetration	Function	Size	Date of test	Result	Background (mbar l/s)
2.1	Spare	DN250	30/06 – 01/07 2018	✓	2-4 $\times 10^{-6}$
18.1	Beam Plug line	DN160	30/06 – 01/07 2018	✓	2-4 $\times 10^{-6}$
18.2	Camera/Acrylic tube	DN160	30/06 – 01/07 2018	✓	2-4 $\times 10^{-6}$
2.6, 2.7, 2.8	APA Beam Right (Main flanges already tested, purge line connection tested)	DN250	30/06 – 01/07 2018	✓	2-4 $\times 10^{-6}$
4.2	Manhole BR	ø 700 mm	05/07/2018	✓	2-4 $\times 10^{-6}$
14.4	Valencia profiler	DN160 (flange adapter)	05/07/2018	×	> 10^{-4}
11.1	Spare	DN160	30/06 – 01/07 2018	✓	2-4 $\times 10^{-6}$
14.3	Ground Plane RTDs	DN160	03/07/2018	✓	2-4 $\times 10^{-6}$
3.1	HV FT	DN250	30/06 – 01/07 2018	✓	2-4 $\times 10^{-6}$
15.1	Diffusers	DN250	30/06 – 01/07 2018	✓	2-4 $\times 10^{-6}$
14.2	Camera/Acrylic tube	DN160	30/06 – 01/07 2018	✓	2-4 $\times 10^{-6}$

Actual leak, that could not be resolved

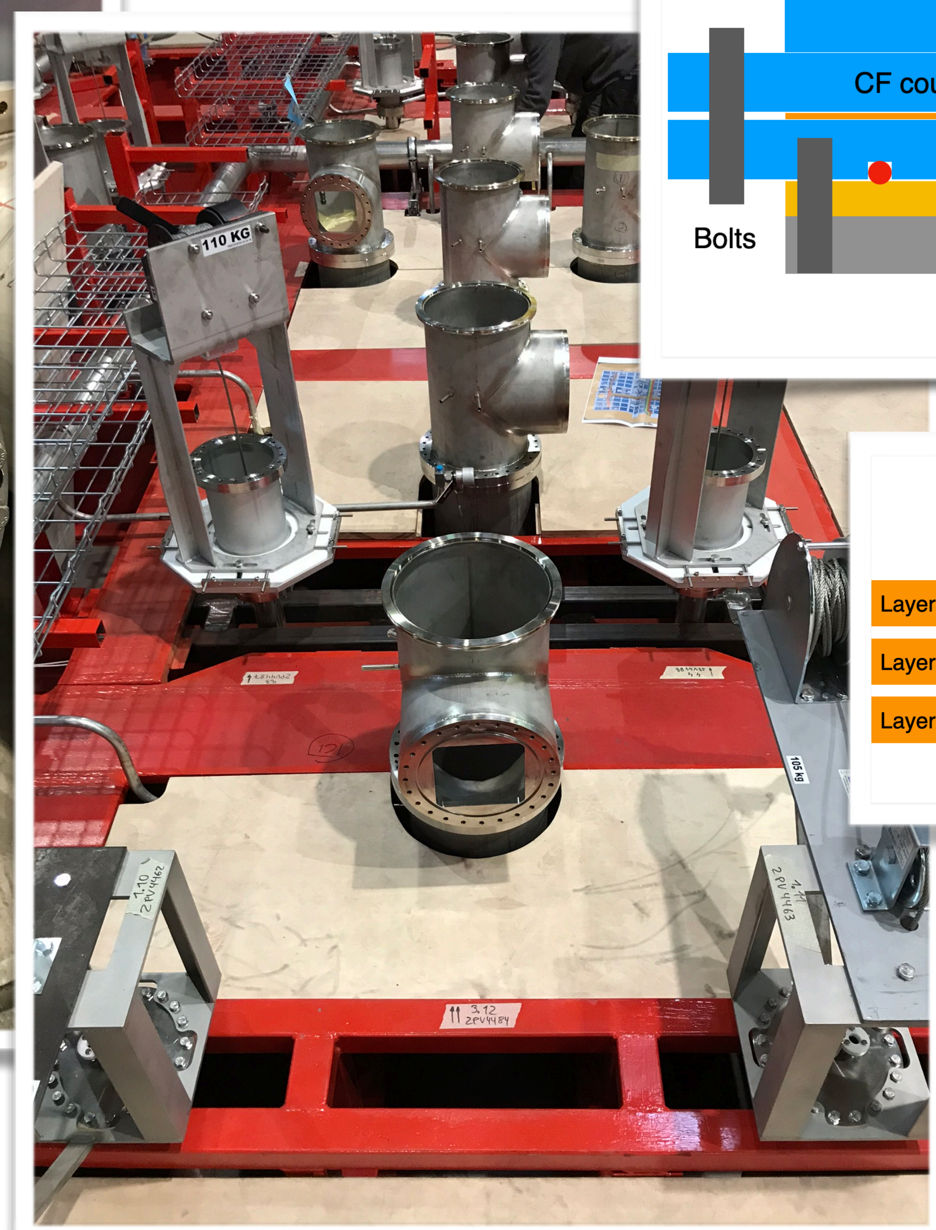
Background level increased

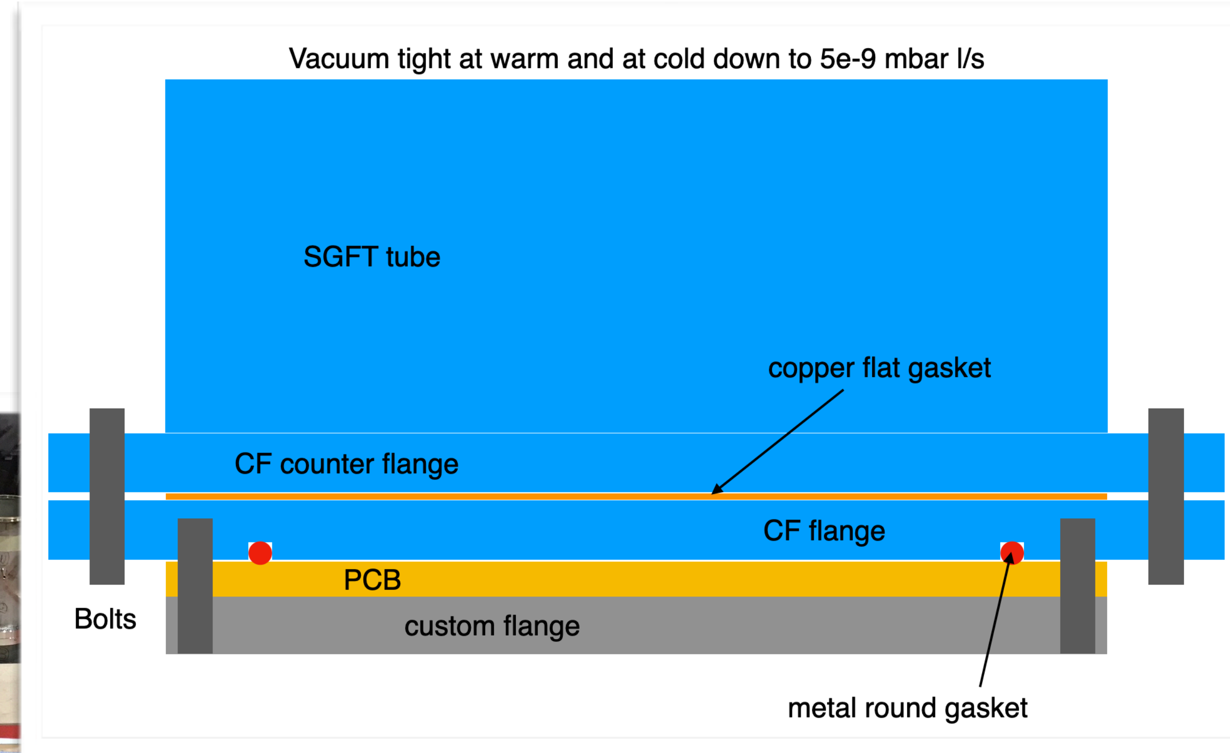
9.8	Cryo Pressure Gauges	DN250	06/07/2018	✓	2-4 $\times 10^{-6}$
14.1	Spare	DN160	30/06 – 01/07 2018	✓	2-4 $\times 10^{-6}$
2.2	APA Upstream BL	3x DN300	~~30/06 – 01/07 2018~~ 03/07/2018	× ✓	~~>1 x 10^{-5} on WIB flange*~~ 2-4 $\times 10^{-6}$
2.3	APA Midstream BL	3x DN300	30/06 – 01/07 2018	✓	2-4 $\times 10^{-6}$
2.4	APA Downstream BL	3x DN300	30/06 – 01/07 2018	✓	2-4 $\times 10^{-6}$
19.1	Spare	DN250	30/06 – 01/07 2018	✓	2-4 $\times 10^{-6}$
10.4	Cryo GAr extraction	DN250	06/07/2018	✓	2-4 $\times 10^{-6}$
4.1	Manhole BL	ø 700 mm	06/07/2018	✓	2-4 $\times 10^{-6}$
10.2	Cameras/GP monitor	DN250	06/07/2018	✓	2-4 $\times 10^{-6}$
9.3	Camera/Acrylic tube	DN160	30/06 – 01/07 2018	✓	2-4 $\times 10^{-6}$
9.1	Cryo-side RTDs	DN160	~~30/06 – 01/07 2018~~ 05/07/2018	× ✓	~~>1 x 10^{-5}~~ 2-4 $\times 10^{-6}$
10.3	Purity monitors	DN250	30/06 – 01/07 2018	✓	2-4 $\times 10^{-6}$

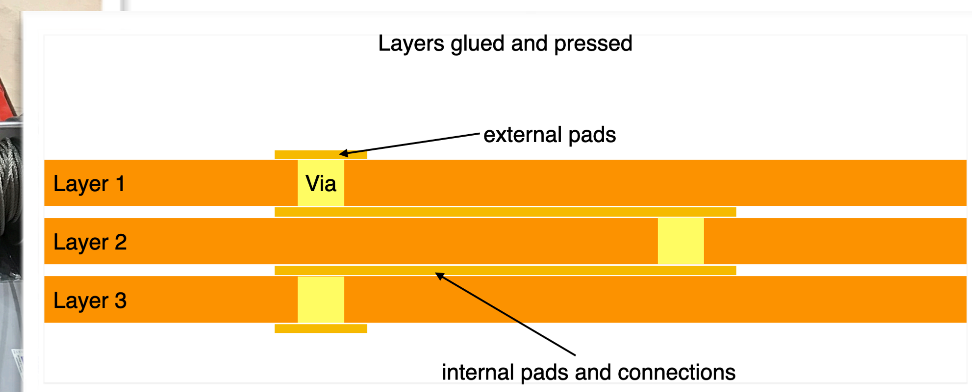
For instance, the SGFT case

Report of the leak check can be found at https://edms.cern.ch/document/2143281/1

12 chimneys (10 finally installed) that host the cold electronics







For instance, the SGFT case

Each SGFT was leak tested to level of few10^{-9} mbar.l/levels prior the installation in NP02. Three randomly selected of the 10 installed were tested also in cryogenic conditions. Report of the leak check can be found at https://edms.cern.ch/document/2143281/1