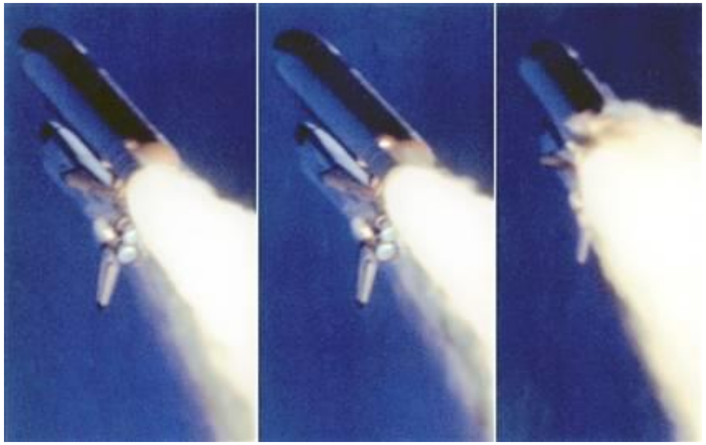


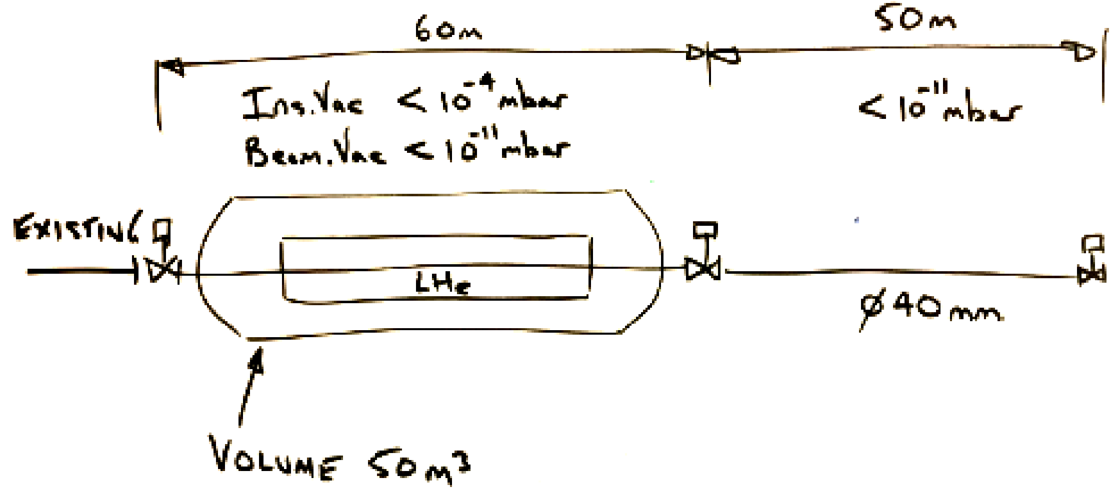
Leak Detection Tutorial Work

Group 5

Luca Dassa, A. Galimov, L. M. Grec, F. Salveter, A. Lundmark, J. Perez Espinos, S. Pirani, N. Plambeck, L. Roslund, A. Sapountzis , A. R. M. Sublet, Q. Tang,, V. Vardanyan, G. Vorobyev, N. Warner, B. Zhang

CAS, Vacuum for Particle Accelerators, 6-16 June 2017

Task



- The vacuum system shown is in design phase.
  - Propose the pumping system and instrumentation based on the required target pressures.
- With and without beam induced desorption effects
  - Define the admissible gas loads and/or leak rates for:
  - RT beam vacuum, cold beam vacuum and cryostat.
- Propose the leak testing strategy/methodology during;
  - Construction, installation and operation.
- Propose a leak test setup for:
  - the cryostat vessel and liquid helium enclosure before assembly of the cryostat
  - the 60 m RT zone during its installation.

Vacuum & Beam-Induced Effects

without beam

- Outgassing
  - Material choice and history
  - Cleaning of all components
  - Equipment installed
  - Temperature
- Number of particulates
- Pumpdown time

with beam

- increased heat load (cold system)

Quenching &
power consumption increases

- PSD
- ESD
- (H)ISD
- impedance & loss factor

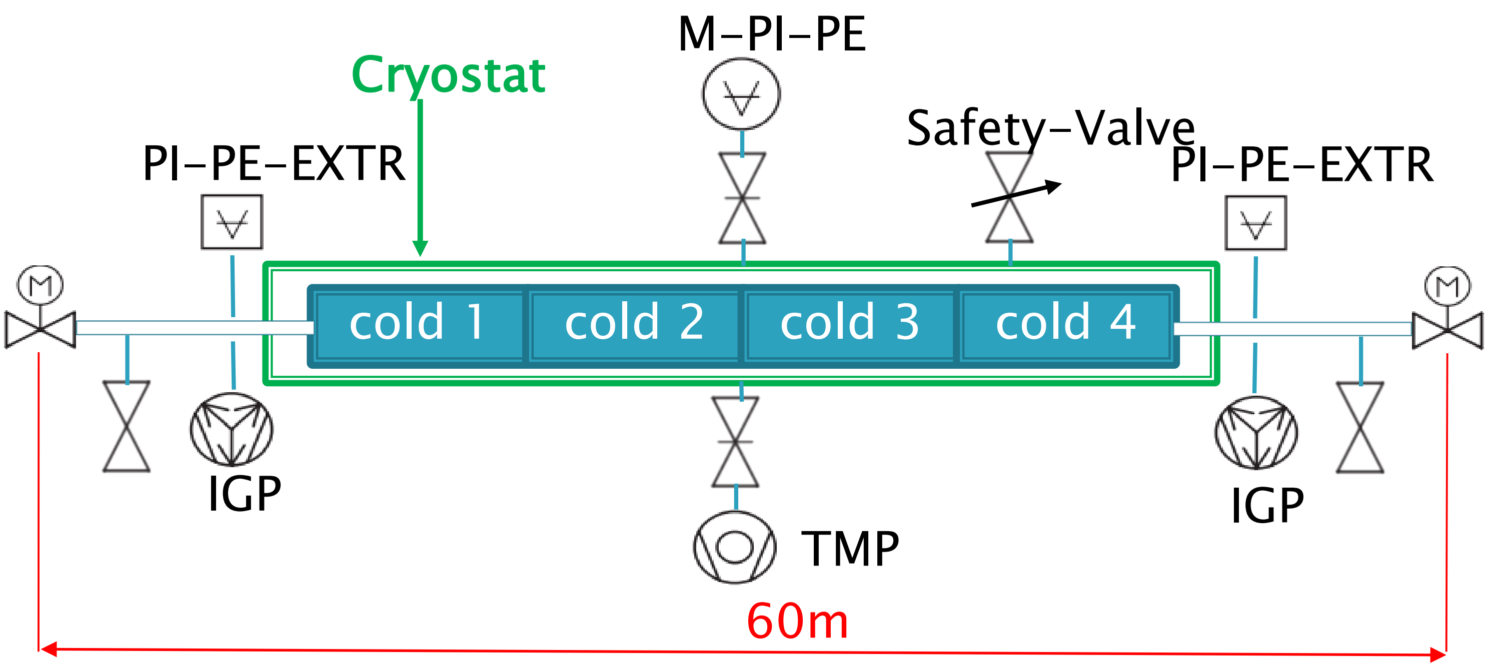
Mitigation proposal:

a-carbon thin film or LESS on beam screen surface

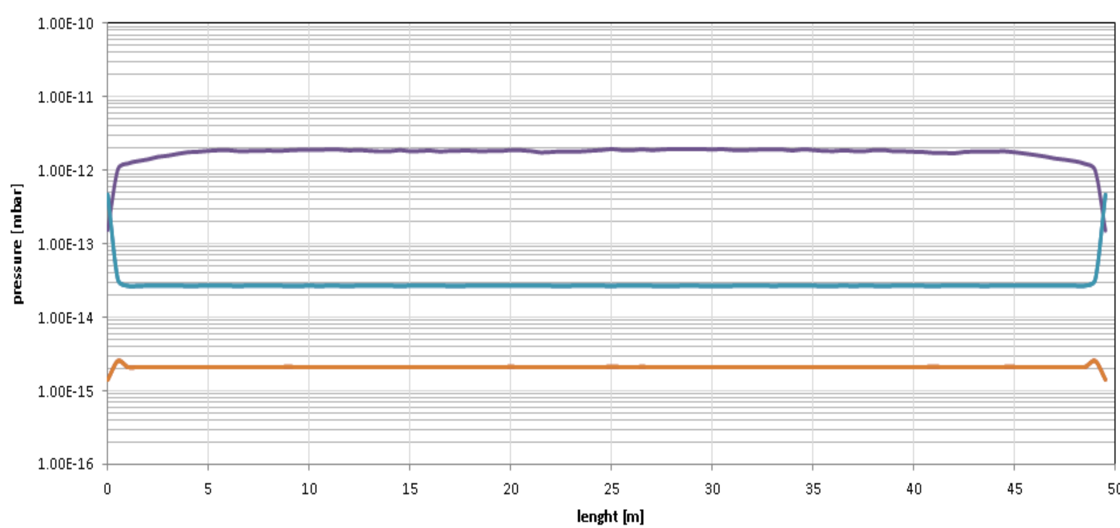
Gas loads and leak rates

	Insulation volume	Cold beam pipe	Warm beam pipe
Operating pressure, mbar	10^{-4}	10^{-11}	10^{-11}
Volume, m3	50	≈0.075	≈0.063
Operating temperature, K	1.9 to 293	1.9	293
Surface, m2	MLI ≈6000m2; Al shield ≈186m2; SS walls ≈ 190 m2	≈7.54	≈6.28
Materials	Stainless steel, vacuum rubber (VitonTM), Multi-layer insulation	Stainless steel, copper	Stainless steel, copper
Gas sources	1. Leaks in helium communications 2. Air leaks 3. Desorption	He (from Ins. volume)	1. Outgassing of H2 from bulk 2. Air leaks

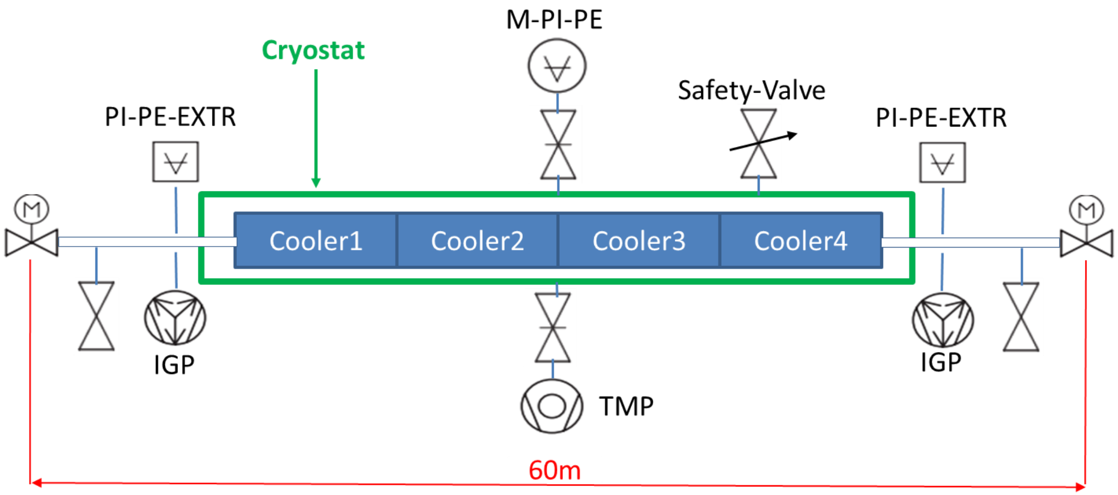
Cold Vacuum Section Design



	Cryostat	Cold b.vac.
P_max [mbar]	1E–4	1E–11



Cryostat <1E-4 mbar



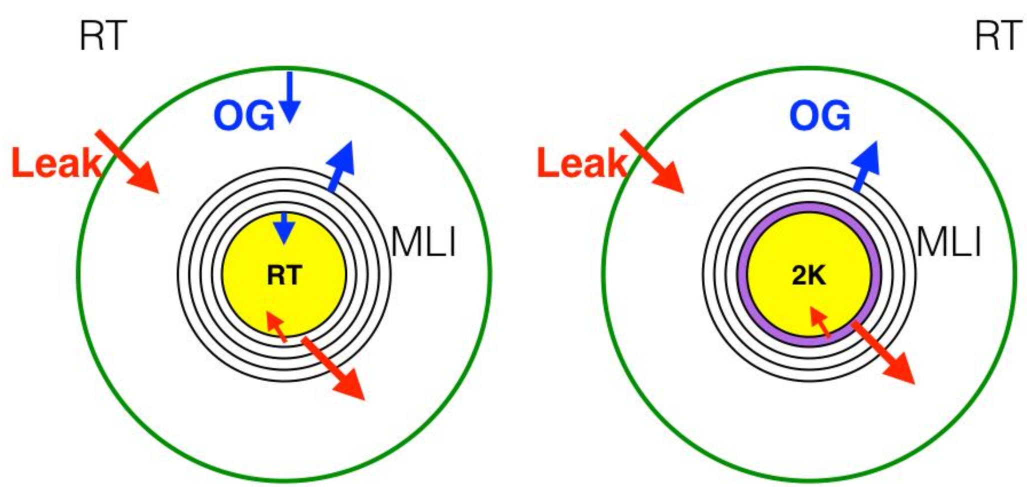
in mbar l/s

max. gas load	warm
Isovac	1

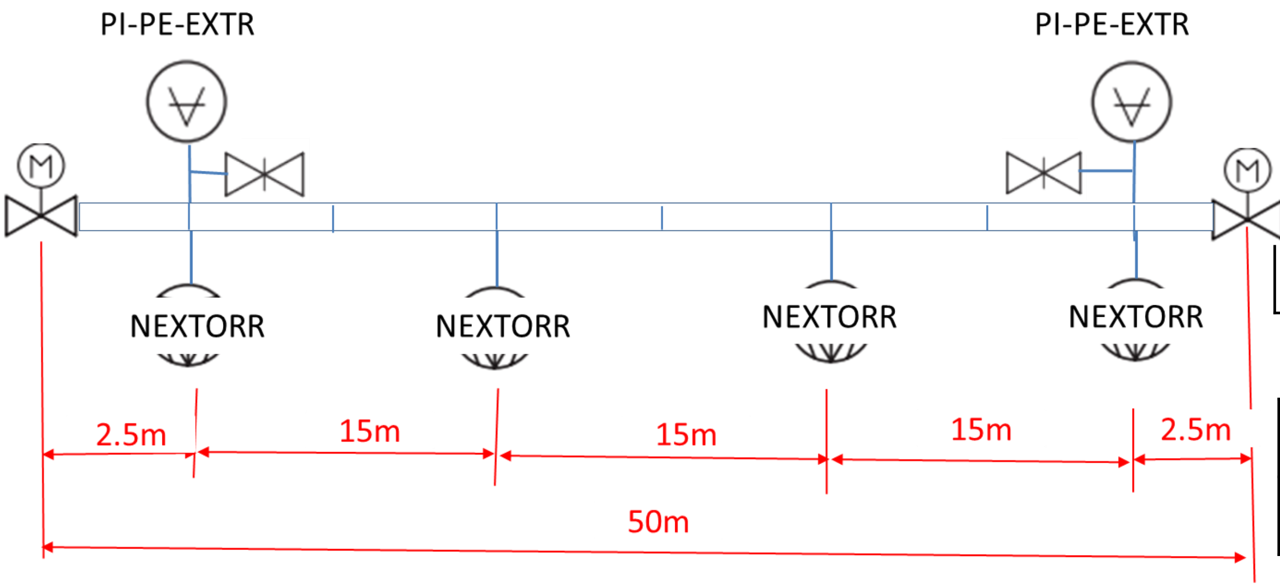
after 1000 h

max. leak rate	cold	warm
atm/Isovac	1E-6	1E-6
He/Isovac	1E-6	1E-9
Isovac/beam vac.	1E-8	1E-10

- no beam induced desorption
- pumping from atm to 1E-2 before beginning with cooldown
- outgassing from shielding (MLI) ~1E-2 mbar l/s m2 → ~ 1 mbar l/s



Warm Vacuum Section Design



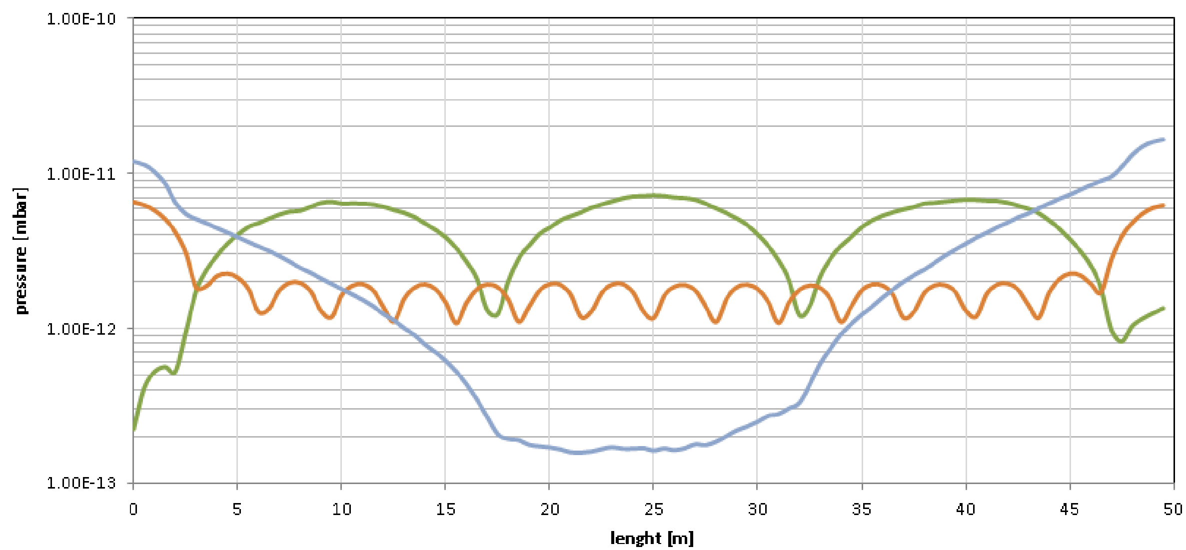
in mbar l/s

max. gas load	warm
warm pipe	1

after 1000 h

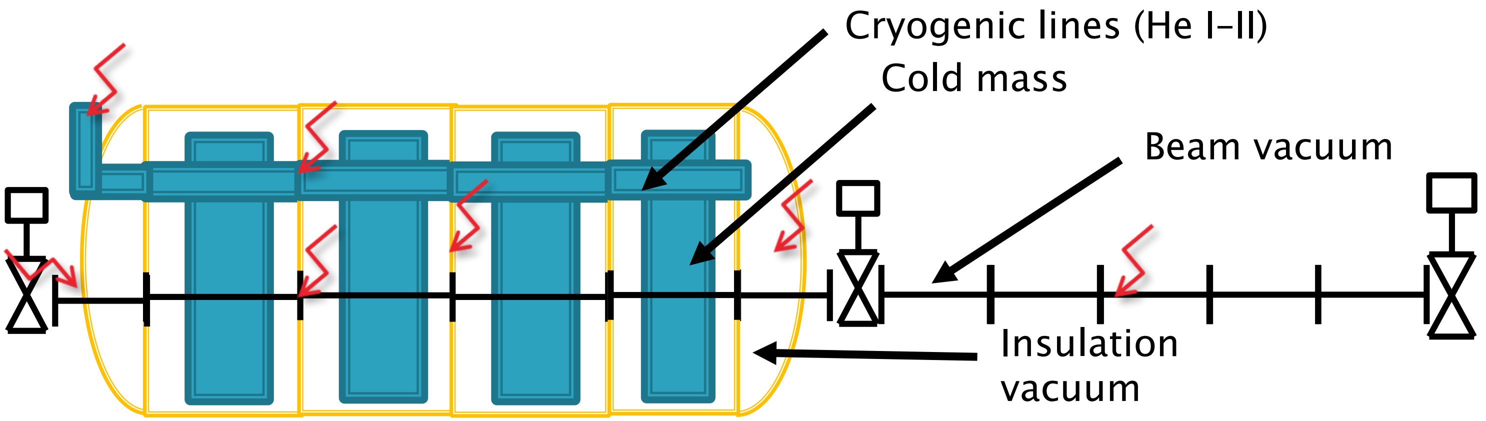
max. leak rate	warm
atm/beam vac.	1E-10

$\Rightarrow$ NEG coating mandatory



leak testing → Methodology: top-down approach

Start from operation constraints to define installation and then construction maximum leaks rates.



→ Most critical leak types for cryogenic section during operation:

1. He to beam vacuum
2. He to insulation vacuum
3. (Also to be considered: insulation vacuum to beam vacuum, atmosphere to insulation vacuum, He to atmosphere, atmosphere to beam vacuum…)

→ And atmosphere to beam vacuum for the RT section + etc.

leak testing

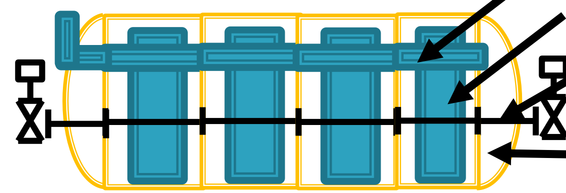
1. He–II to beam vacuum in cryogenic section / beam pipe

- Beam vacuum <10–11 mbar (design constraints)
- maximum leak → "defined above"
- Cold bore at 1.9K → only He remains, all the rest is assumed to be cryopumped
- Design = no weld on beam vacuum side.
- Construction: vacuum and pressure leak tests in RT and cold conditions prior to installation

leak testing

2. Insulation vacuum and cold mass / operation

He-II from the cold mass to insulation vacuum



A. Operation (cryogenic condition):

- insulation vacuum <10-4 mbar (design constraints)
- Cold mass at 1.9K → only He remains, all the rest is assumed to be cryopumped
- Estimation for 50 m3 vessel at 10-4 mbar over 1 year

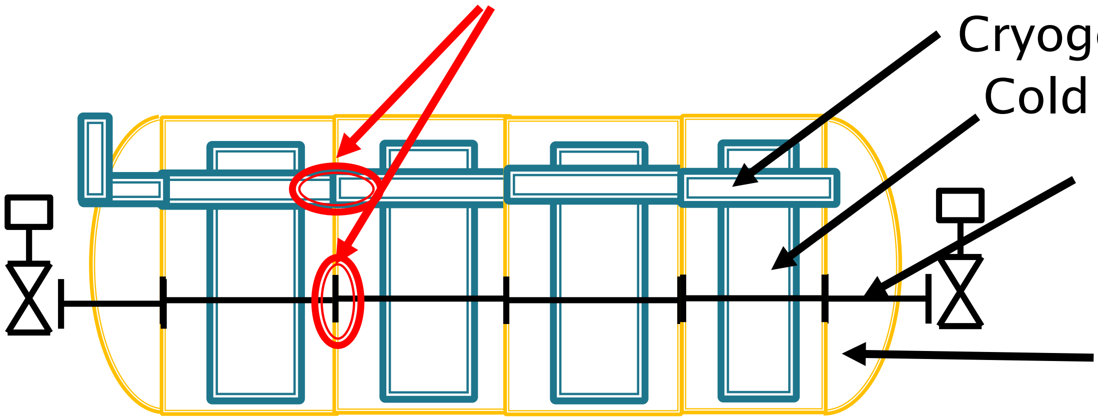
⇒ **1.5e-7 mbar.l.s-1 maximum leak rate** in static vacuum in operation.

leak testing

2. Insulation vacuum and cold mass / installation

He-II from the cold mass to insulation vacuum

- Example: interconnections during installation (no He)

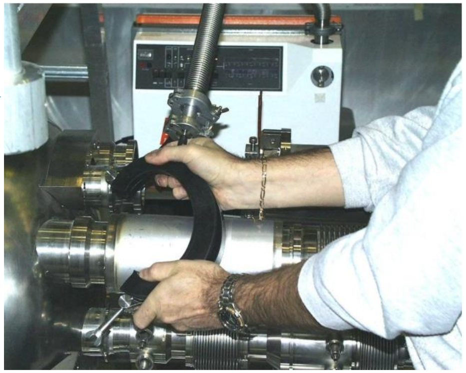


1.5e-7 mbar.l.s-1 at 1.9K ⇔ 1.5e-10 mbar.l.s-1 at RT

→ Sum of all interconnects + components leak < **1.5e-10 mbar.l.s-1**

→ leak detection with clam shell

→ + pressure test of fluid pipes

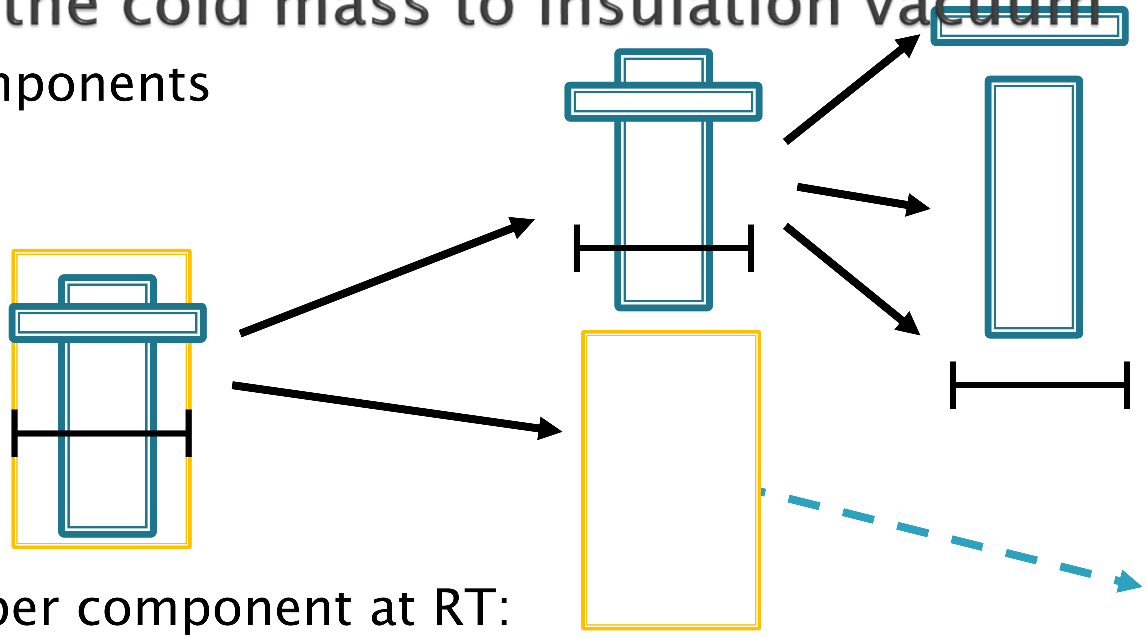


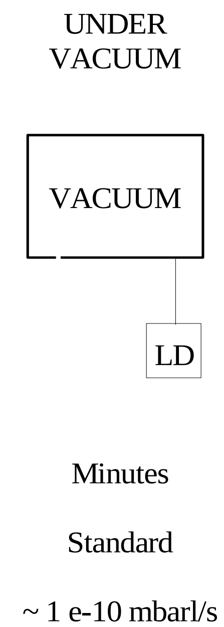
leak testing

2. Insulation vacuum and cold mass / construction

He-II from the cold mass to insulation vacuum

N sub-components





Leak rate per component at RT:

1.5e-10 mbar.l.s-1 /N + safety margin

→ leak detection with He spray

→ confinement of He around the critical area

→ + test at cold and under pressure

→ Same strategy for RT vacuum components + RGA

Thanks for your attention