

Progress on Overpressure Relief including triplets, feedboxes and special magnets

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LHC risk review, 5 March 2009

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- Protection of standalone (SAM), Semi-SAM and their current feed boxes (DFBM, DFBL)
- Protection of Arc current feed boxes (DFBA)
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- Summary

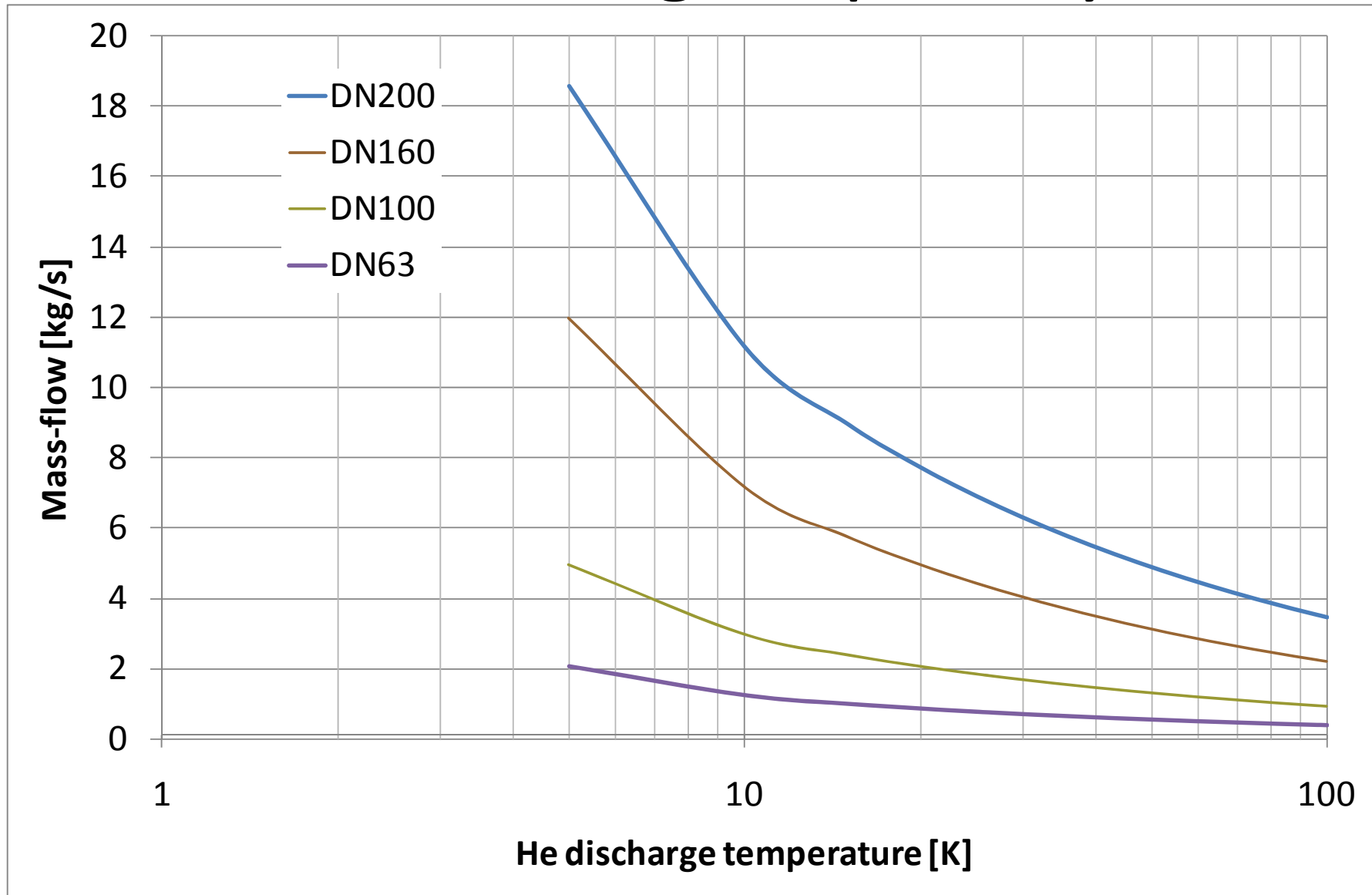
Basic assumption: He inventory

Equipment	He inventory [kg]	Remark
Standard subsector	820	
Mid arc subsector	1230	
DS subsector	680	
Standalone magnet	~30	Directly connected to Line D (+ 180 kg)
Semi-standalone magnet	~60	Directly connected to Line D (+ 180 kg)
Inner triplet	150 - 180	Depending on SC D1
Current feed box X	30	
Current feed box M & L	4 - 7	
Current feed box A	13 - 23	Directly connected to DS subsector
Superconducting link (P3)	260	Directly connected to Line C (+3400 kg)
Superconducting link (P1, P5)	25	Directly connected to Line C (+3400 kg)

Basic assumption: He discharge T

- Stored energy in main buses: 1200 MJ
→ He discharge temperature: ~ 80 K
- Stored energy in IT: 8.8 MJ
Stored energy in SAM: 1-7 MJ
→ a factor ~ 140 w/r to main buses
→ lower He discharge temperature: ~ 10 -20 K

SV discharge capability



IT MCI mass flow

Inner Triplet - MCIs

J. Strait

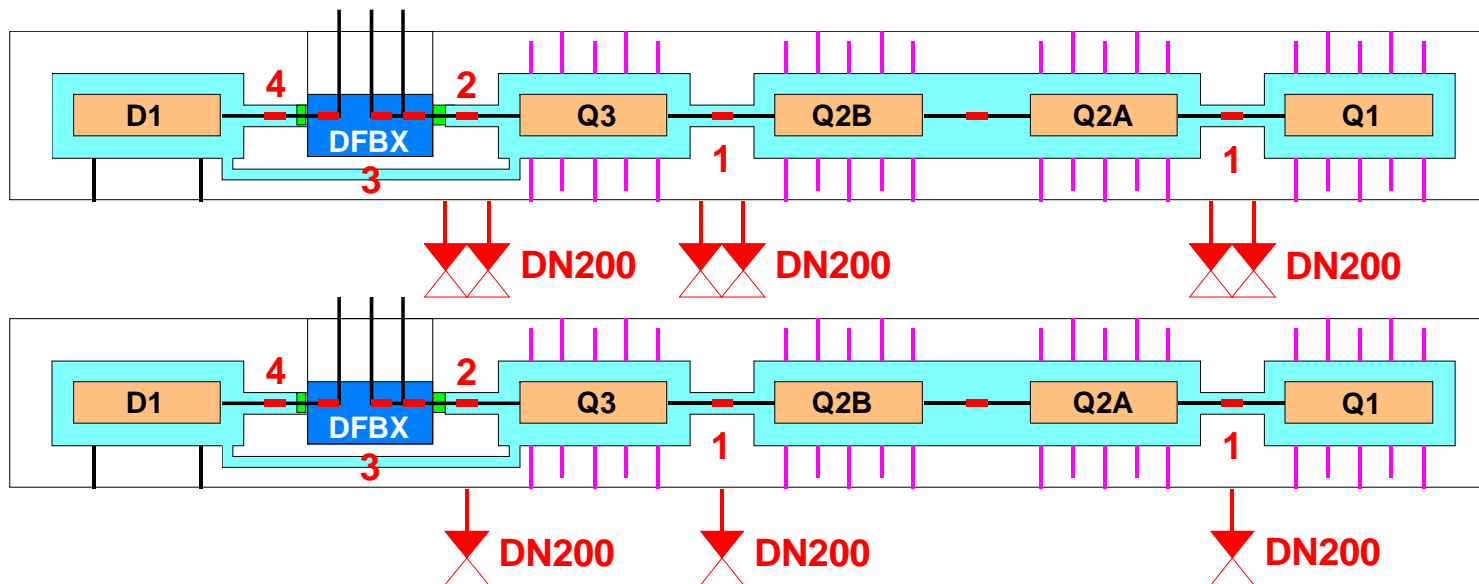
- ~~Bus fault rupturing interconnect bellows:~~
 - Up to 20 kg/s helium flow into cryostat.
 - Cryostat pressurized to many bar, similar to 19 Sep event.
 - Anchors to floor will break for $P > 1.5 \sim 2$ bar.
 - Superconducting D1 could also be pushed off its stands.
 - DFBX (square cryostat) could be severely damaged by internal pressure.
No spare DFBX* \Rightarrow 1-2 years to build new from scratch.
- Inter-turn short puncturing/rupturing cold bore tube.
 - Scaling from a similar incident with an SSC R&D magnet, such an event could create a 20-30 mm diameter hole in the beam tube.
 - Up to 10 kg/s high pressure helium released into vacuum tube, adjacent to experiments, in presence of electrical arc.



* There are 8 DFBX of 6 variants

Protection of Inner Triplet

Slice type		S He	m MCI	T He Vacuum	He inventory	Stored energy	Vacuum volume	Vac buffering	
		[cm ²]	[kg/s]	[K]	[kg]	[MJ]	[m ³]	[Inv. %]	[s]
Q-Q	1	60	20	10-20	180	8.8	15	20	1.8
Q-DFBX	2	30	10	10-20	180	8.8	15	20	3.6
DFBX	3	30	10	10	30	8.8	15	100	3.0
D1-DFBX	4	30	10	10-20	180	1	15	20	3.6

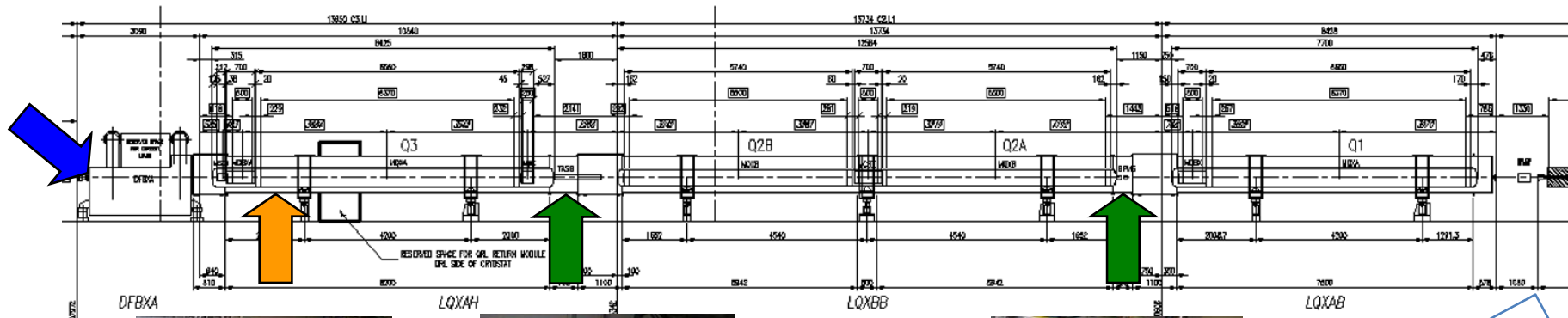


Too high cryostat hydraulic impedance

With acceptable cryostat hydraulic impedance

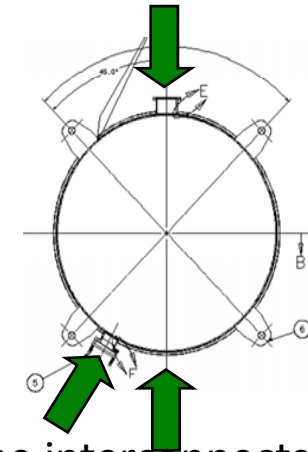
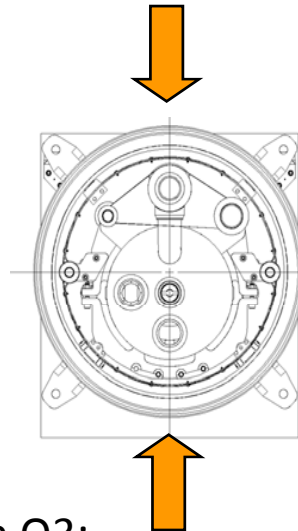
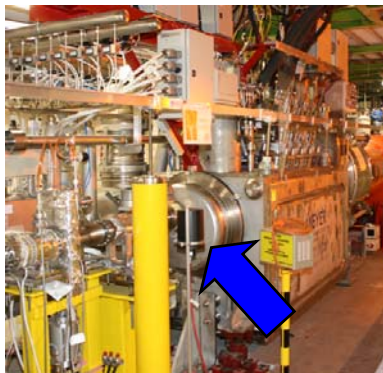
Positions of the safety valves (1/2)

Longitudinally:



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Radial:



On DFBX:

- DN 160 on the dished cover

On Q3:

- DN 200 on top or bottom

In the interconnects:

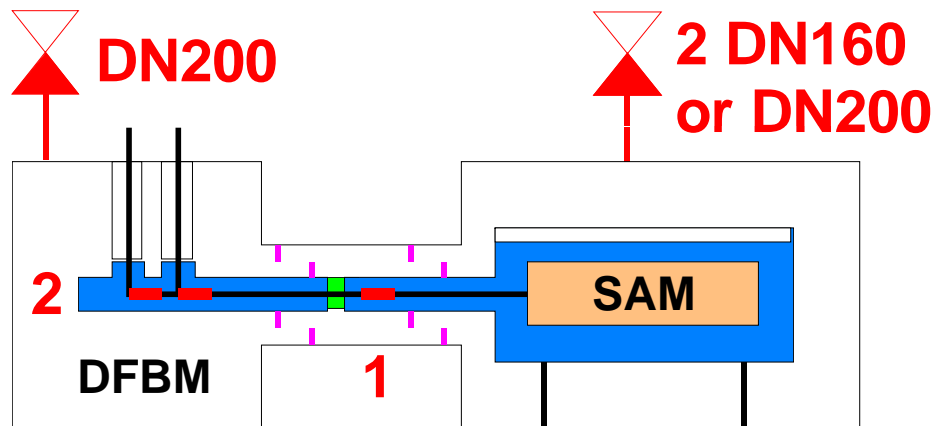
- DN 200 on top, bottom or enlarging the existing safety valve

IT Protection recommendation

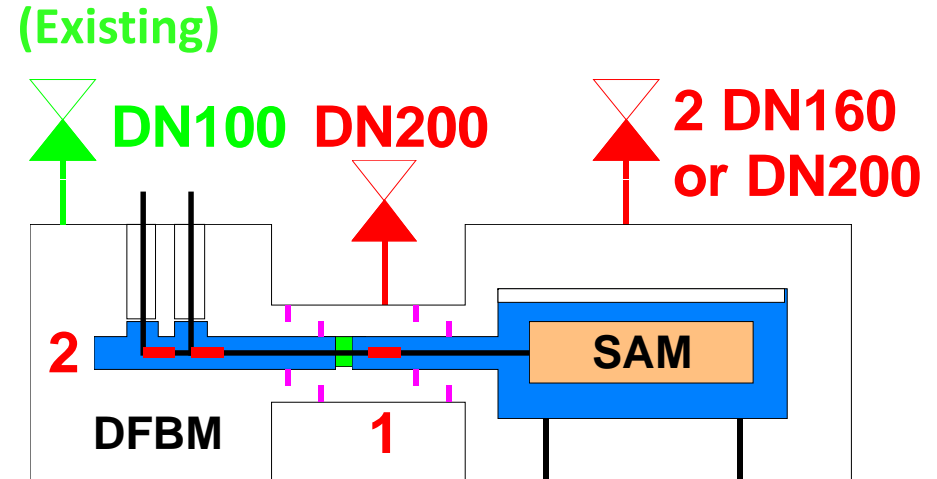
- Installation of the SV at the bottom of the cryostat.
 - minimize the work load (5 to 3 days per IT)
 - but require specific flow deflector to protect personnel and the QRL equipment in carbon steel
- The cryostat hydraulic impedance and the MLI blanket resistance still to be confirmed.
 - doubling of the SV can solve the problem

SAM protection

Slice type		S He	m MCI	T He Vacuum	He inventory	Stored energy	Vacuum volume	Vac buffering	
		[cm ²]	[kg/s]	[K]	[kg]	[MJ]	[m ³]	[Inv. %]	[s]
SAM-DFBM	1	23	8	10-20	30	2	4	32	1.3
DFBM	2	8	3	10	4	2	4	100	1.5

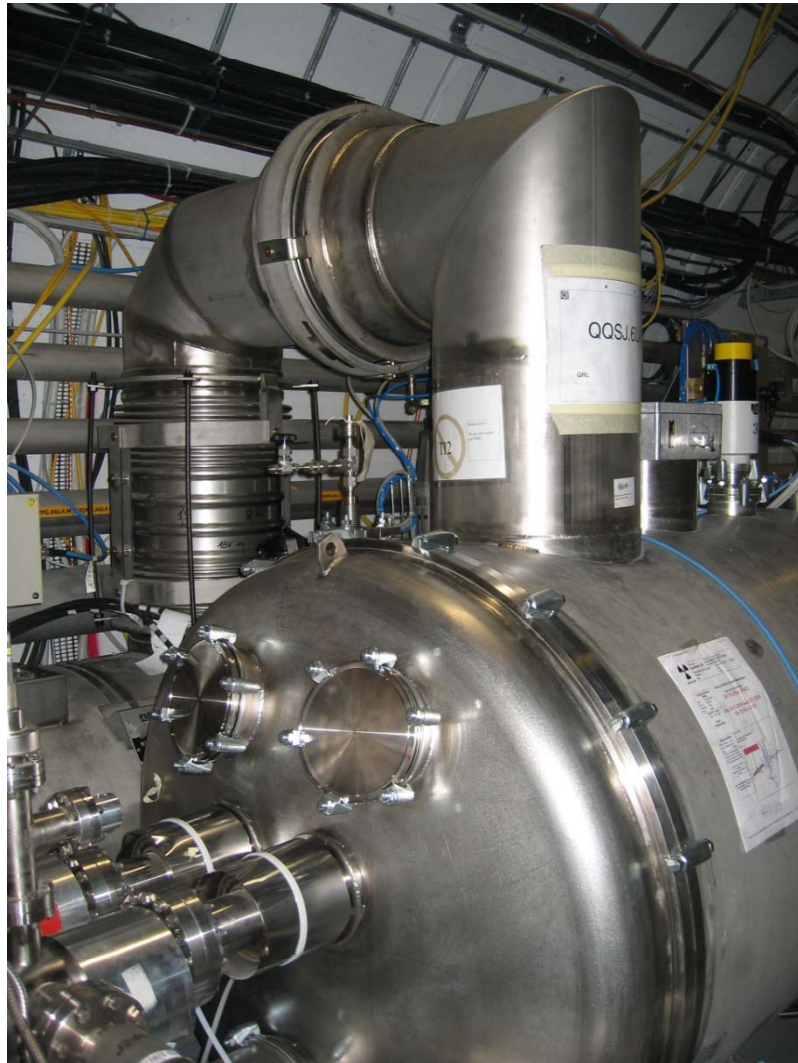


Variant A: 1 DN200 on DFBM service chimney



Variant B: 1 DN200 on Interconnect sleeve

SAM protection



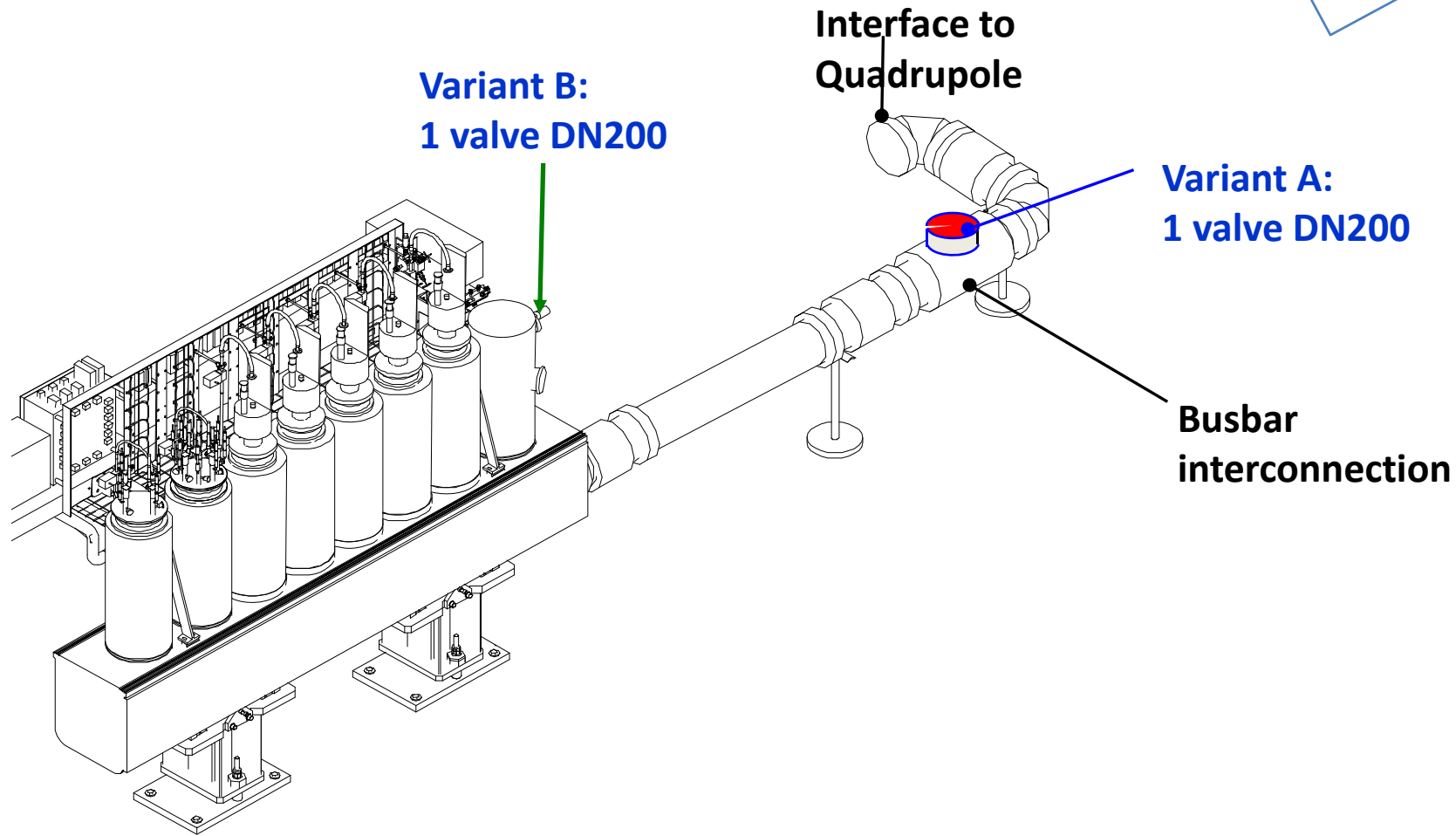
27 cryo-magnets already need to be equipped with DN160 ports (He level capillary consolidation)

21 cryo-magnets needs port manufacturing :

- 2 DN160 ports per magnet
- or 1 DN200 port per magnet

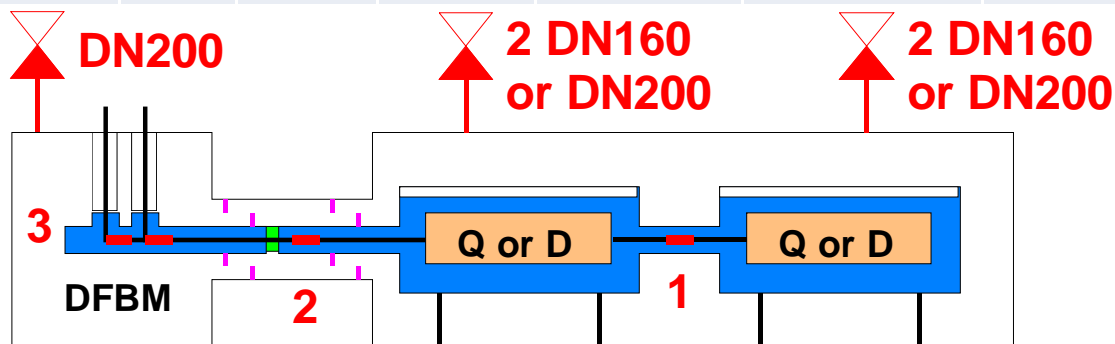
Pressure relief for the DFBM

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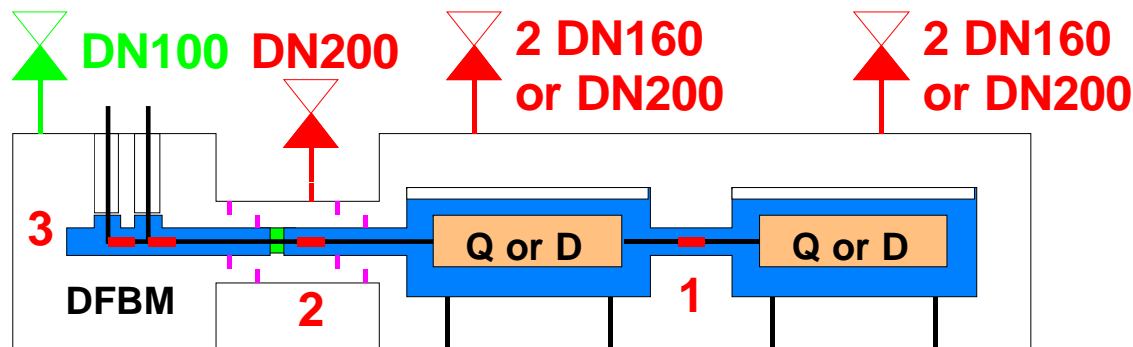


Semi-SAM protection

Slice type		S He	m MCl	T He Vacuum	He inventory	Stored energy	Vacuum volume	Vac buffering	
		[cm ²]	[kg/s]	[K]	[kg]	[MJ]	[m ³]	[Inv. %]	[s]
M-M	1	46	15	10-20	60	3	4	16	0.6
M-DFBM	2	23	8	10-20	60	3	4	16	1.3
DFBM	3	8	3	10	4	2	4	100	1.5



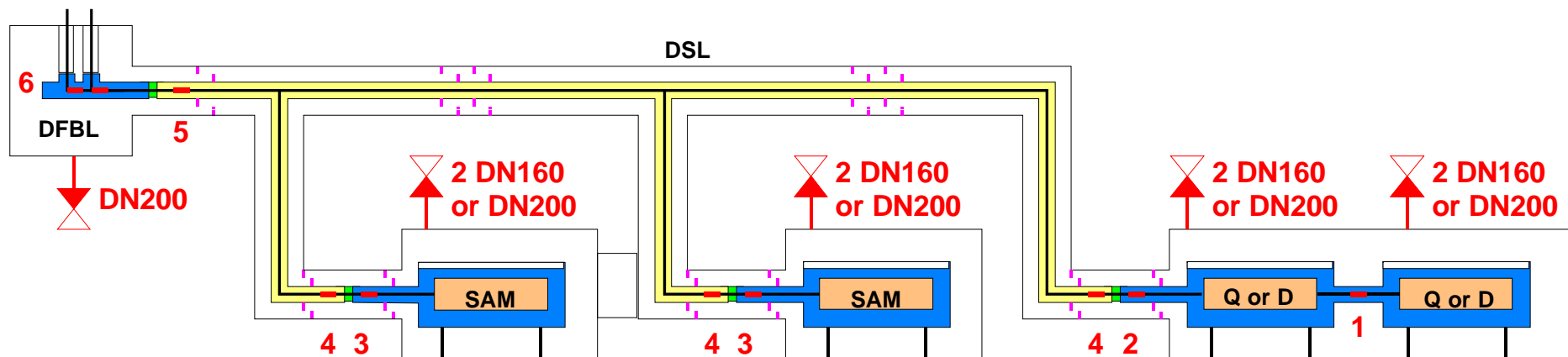
Variant A: 1 DN200 on DFBM service chimney



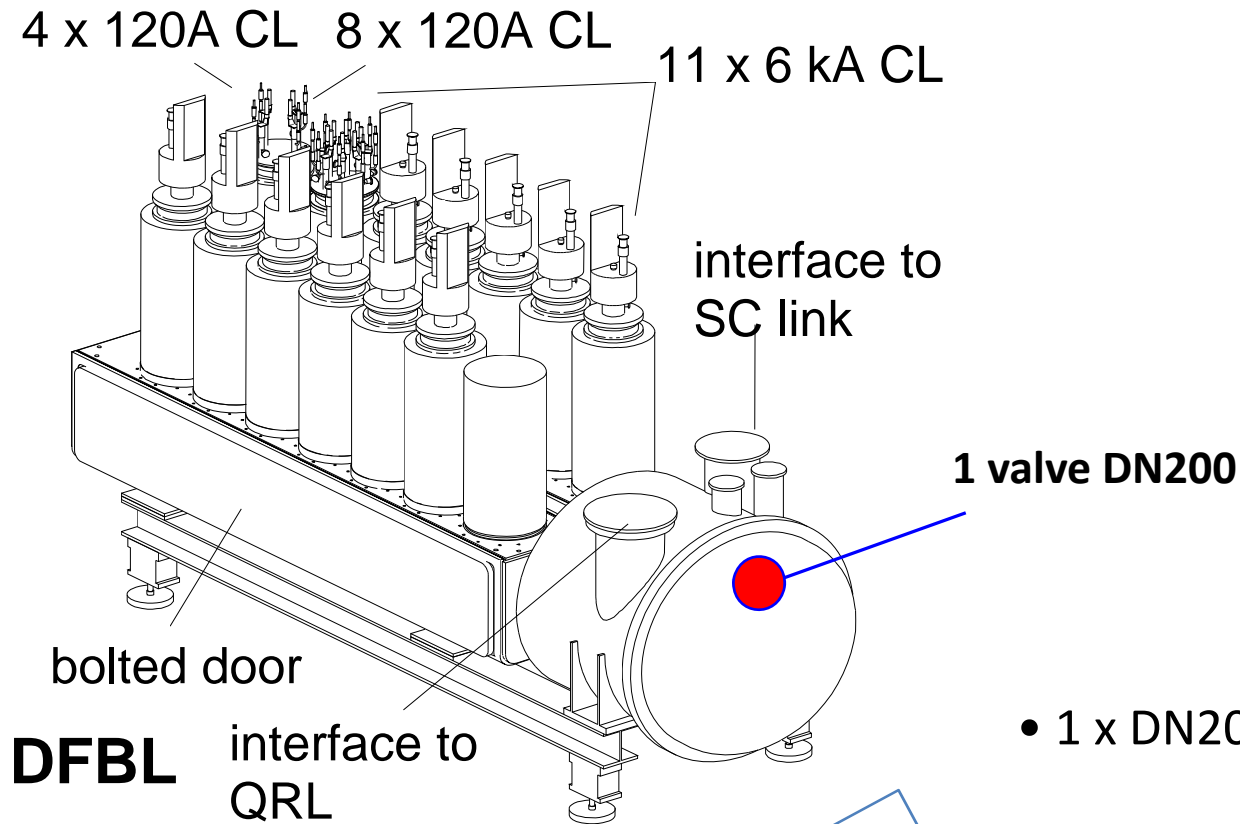
Variant B: 1 DN200 on Interconnect sleeve

SAM / Semi-SAM / DSL protection

Slice type		S He	m MCI	T He Vacuum	He inventory	Stored energy	Vacuum volume	Vac buffering	
		[cm ²]	[kg/s]	[K]	[kg]	[MJ]	[m ³]	[Inv. %]	[s]
M-M	1	46	15	10-20	60	3	17	68	2.7
SSAM-DSL (He)	2	23	8	10-20	60	3	17	68	5.3
SAM-DSL (He)	3	23	8	10-20	30	2	17	100	3.9
SAM-DSL (SHe)	4	24	8	10-20	25	2	17	100	3.1
DSL-DFBL (SHe)	5	24	8	10-20	25	7	17	100	3.1
DFBL	6	8	3	10-20	7	7	17	100	2.6



Pressure relief for the DFBLs

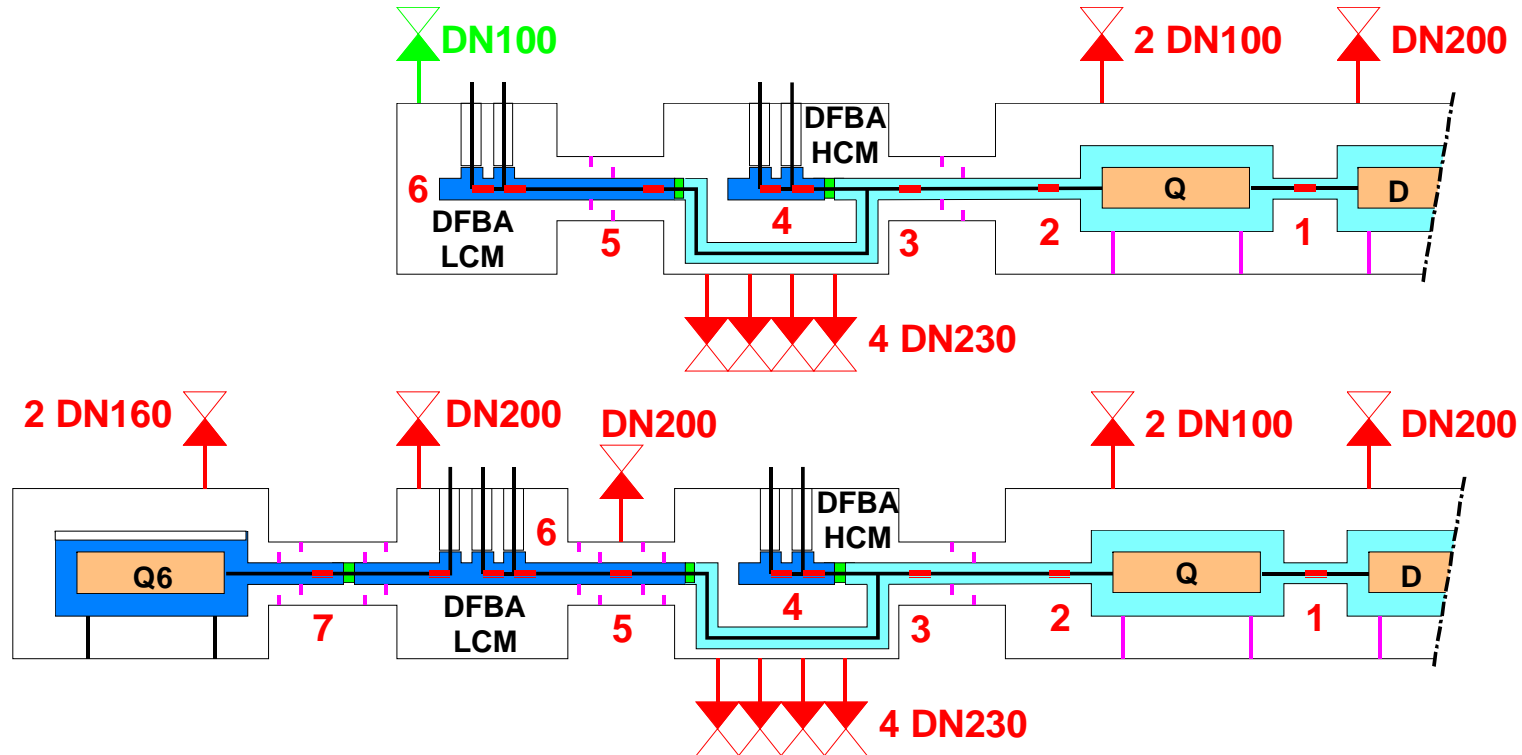


- 1 x DN200 valve
- installed on interface box cover
- work in tunnel: remove cover, reinstall cover

A. Perin

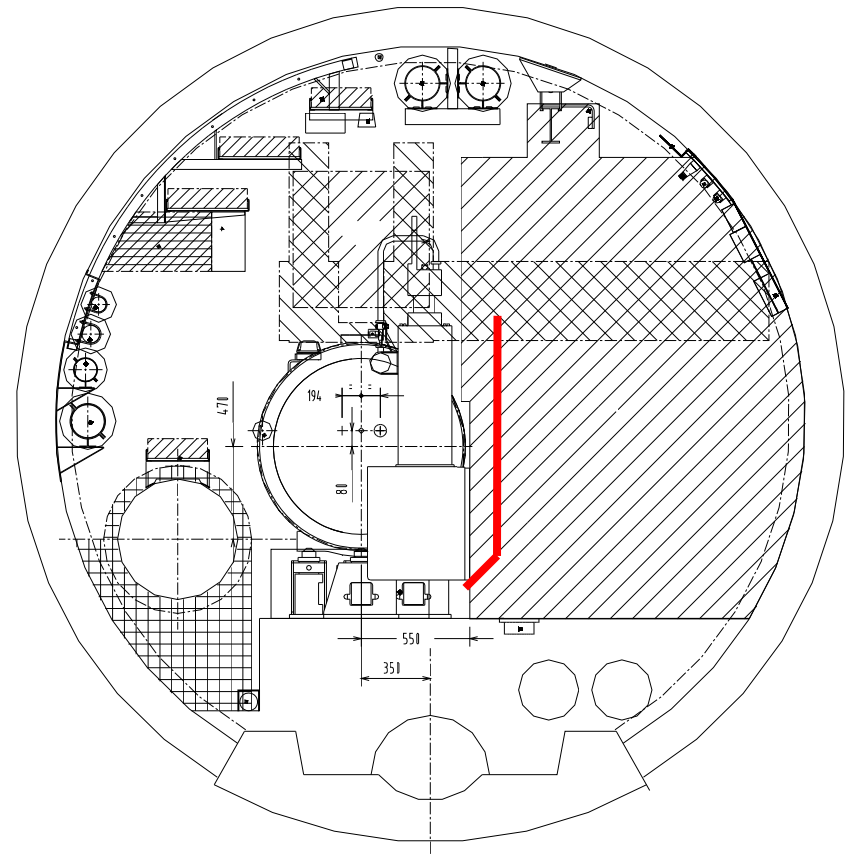
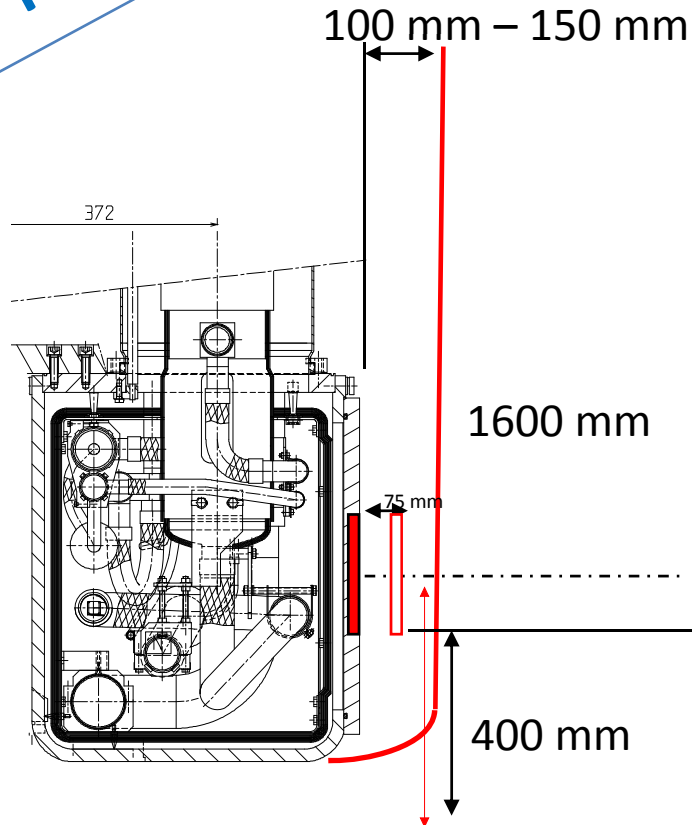
DFBA protection

Slice type		S He	m MCI	T He Vacuum	He inventory	Stored energy	Vacuum volume	Vac buffering	
		[cm ²]	[kg/s]	[K]	[kg]	[MJ]	[m ³]	[Inv. %]	[s]
M-M	1	120	40	80	680	1200	67	6	1.0
M-DFBA	2	60	20	80	680	1200	67	6	2.0
DFBA (HelI)	3	60	20	80	680	1200	67	6	2.0
DFBA (Hel)	4	24	8	80	13	1200	67	100	1.6
HCM-LCM (Hel)	5	20	7	10-20	10	1	68	100	1.5
LCM (Hel)	6	8	3	10	10	1	68	100	3.8
LCM-Q6	7	23	8	10-20	10	1.5	72	100	1.3



DFBA-HCM protection

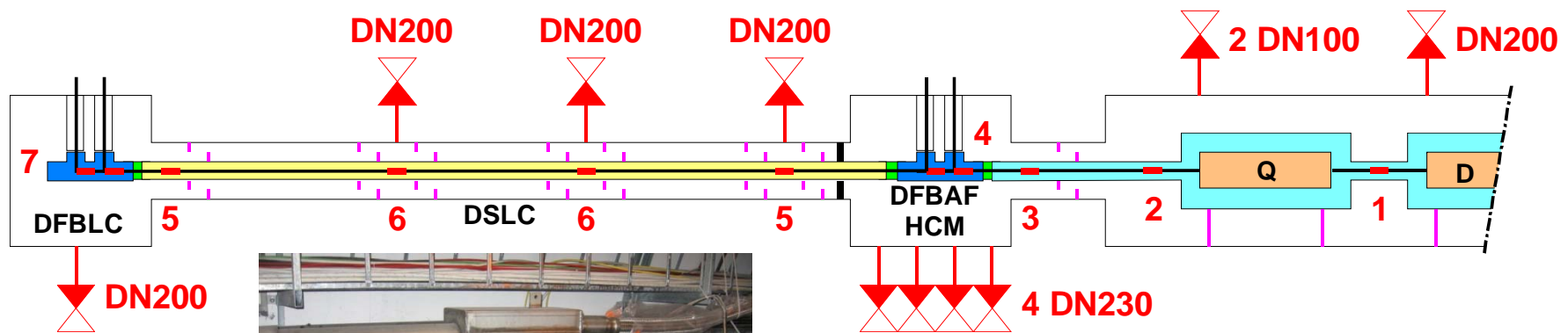
A. Perin



Ø3800 tunnel: interference between deflector and transport passage

DFBLC-DSLCL protection

Slice type		S He	m MCI	T He Vacuum	He inventory	Stored energy	Vacuum volume	Vac buffering	
		[cm ²]	[kg/s]	[K]	[kg]	[MJ]	[m ³]	[Inv. %]	[s]
DSLCL-DFB	5	20	7	10-20	260	1	15	29	11.1
DSLCL	6	40	13	10-20	260	1	15	29	5.6
DFBLC	7	8	3	10-20	7	1	15	100	2.6



Summary

- IT (8 units) → 24 to 48 DN200 (depending on cryostat hydraulic impedance)
- SAM & semi-SAM → 48 magnets
 - 27 to be equipped with 2 x DN160 on existing holes
 - 21 to be equipped with 2 x DN160 or 1 x DN200
 - Remark: **consolidation of two Q6 not possible during this SD**
- DFBM → 23 DN200 on service chimney or link
- DFBL → 5 DN200 on the end cover
- DFBA → HCM: 64 DN230 on access doors
LCM: 3 DN200 on service chimney
 - Remark: **Consolidation of 8 DFBA not possible during this SD**
- DSLC → 3 DN200 on interconnect sleeves
- Total for LSS → ~200 to 250 relief valves (depending on open choices)
 - Remark: 38 SV installation not possible with the present SD scenario: Mitigation measures under study for the protection of equipment (8 DFBA + 2 SAM) during the next run.