



Cryogenics for Cold Powering system Budget consideration

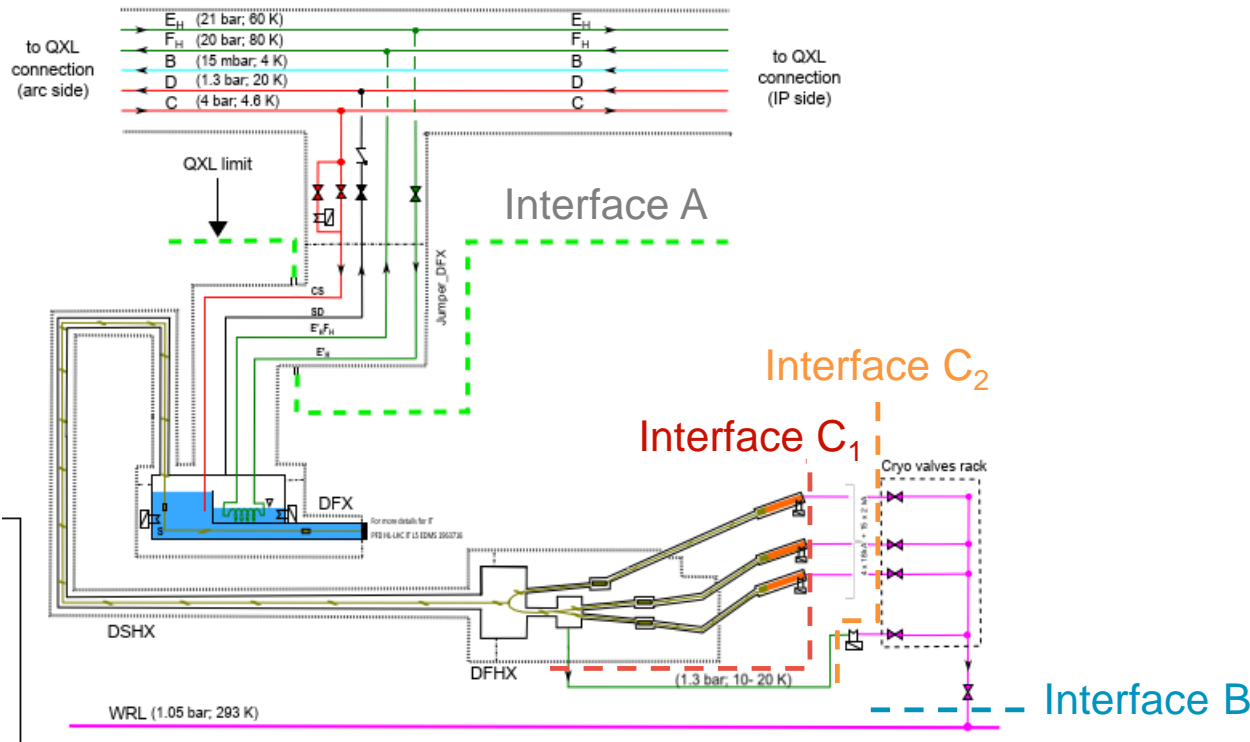
V. Gahier, TE-CRG

CERN, 20 October 2022

Outline

1. Tunnel system
 1. Interfaces definition
 2. Scope for Cryo
 3. Budget proposition /distribution
 4. Bypass cryoline and alupex optionnal scope
2. String system
3. Conclusion / Way forward

Mechanical Interfaces



Three mechanical interfaces to WP9 for the Cold Powering System :

- Interface A to the QXL
- Interface B between the GMS and WRL,
- Interface C between the DFHX and GMS.
 - Interface C₁ : at DFHX level
 - Interface C₂ : at GMS level : **current interface considered for budget/scope evaluation.**

Zone C₁-C₂ comprises :

- the Alupex line from the current leads to the GMS control valves
- The bypass cryoline from DFHX to the GMS heater
- Zone C1/C2 can be treated as a optional scope

Interface C₂

Quantity	Ref	Function	Interface & Label	Size*	Type of Connection
1	BYPASS HEATER	BYPASS HEATER	Interface C – bypass heater	DN 32	Bayonet
4	CL 18 kA	CURRENT LEAD 18 kA OUTLET	Interface C – CL 18 kA	DN 20	TBC
15	CL 2 kA	CURRENT LEAD 2 kA OUTLET	Interface C – CL 2 kA	DN 15	TBC

Interface B

Ref	Function	Interface & Label	Size	Type of Connection
WRL	WARM HELIUM RETURN	Interface B - WRL	DN 65 Min PN 6	Flange

Mechanical Interfaces

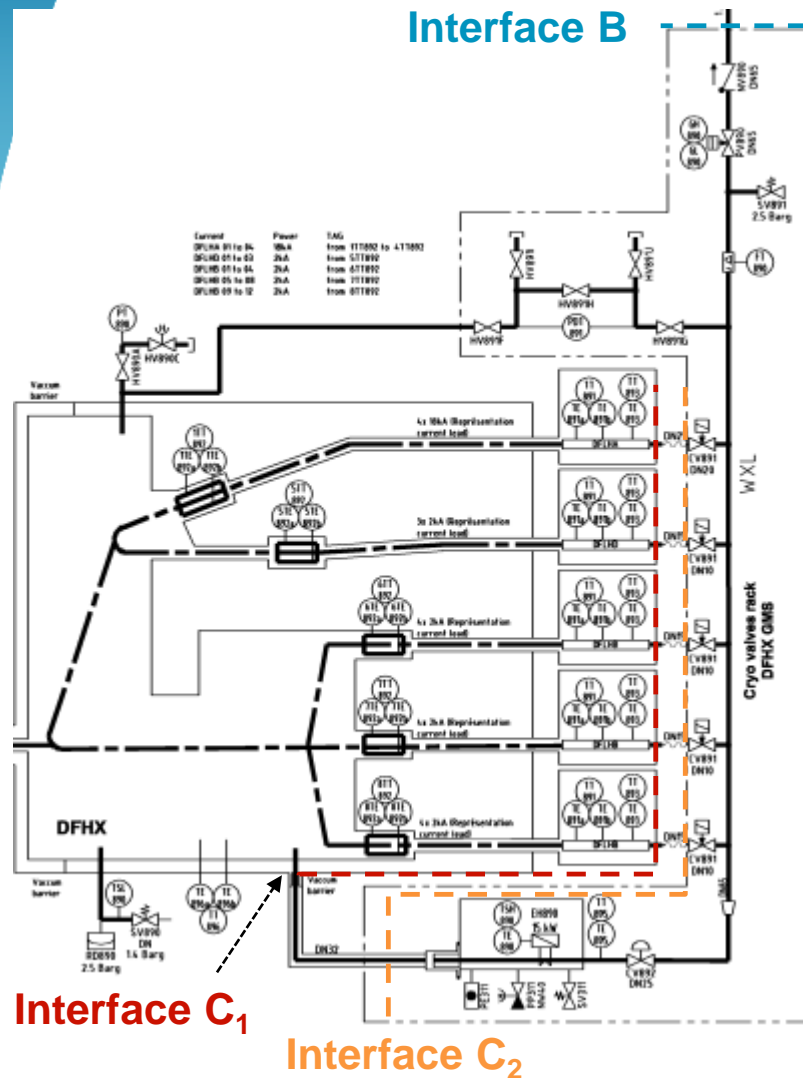
Mechanical interfaces will be geographically at the GMS level. Connection responsibilities by WP6A.

Interface B

Ref	Function	Interface & Label	Size	Type of Connection
WRL	WARM HELIUM RETURN	Interface B - WRL	DN 65 Min PN 6	Flange

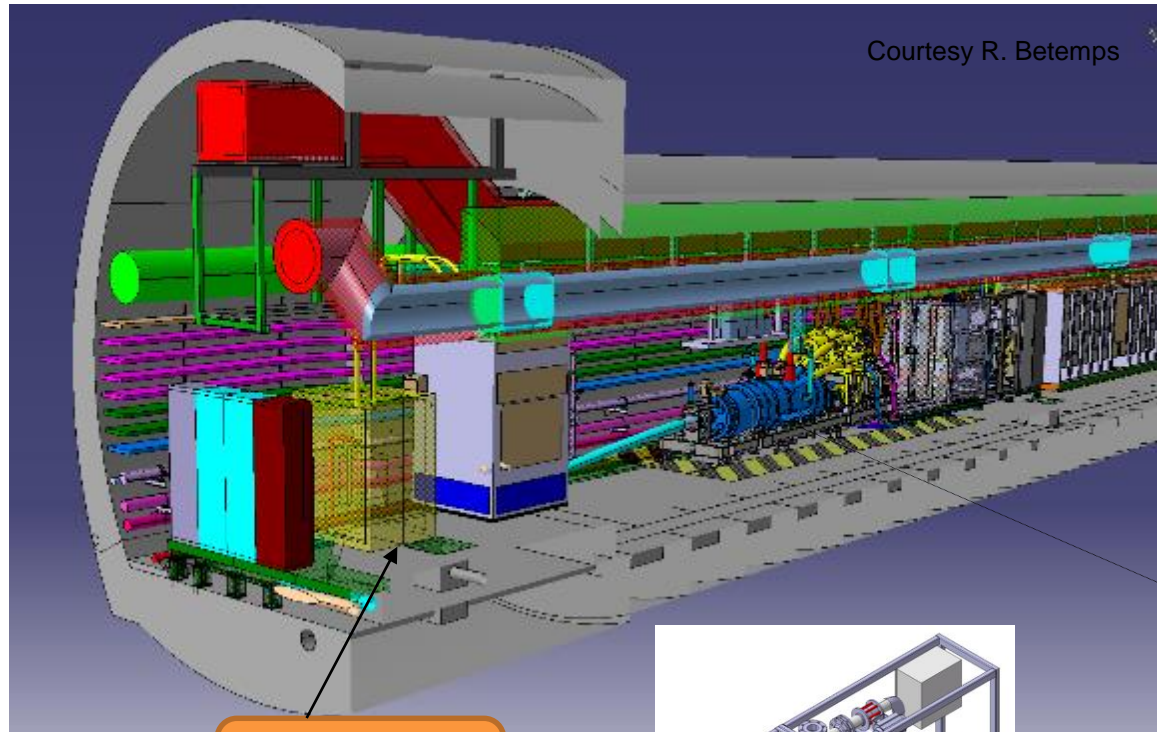
Interface C₂

Quantity	Ref	Function	Interface & Label	Size*	Type of Connection
1	BYPASS HEATER	BYPASS HEATER	Interface C – bypass heater	DN 32	Bayonet
4	CL 18 kA	CURRENT LEAD 18 kA OUTLET	Interface C – CL 18 kA	DN 20	TBC
15	CL 2 kA	CURRENT LEAD 2 kA OUTLET	Interface C – CL 2 kA	DN 15	TBC
1	PDT	Connection of GMS PDT	Interface C – PDT	3/8	TBC

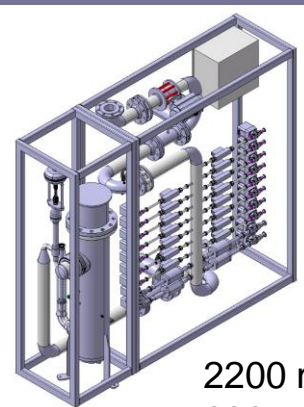


Extract of LHCLSQLJ0031

Mechanical Interfaces



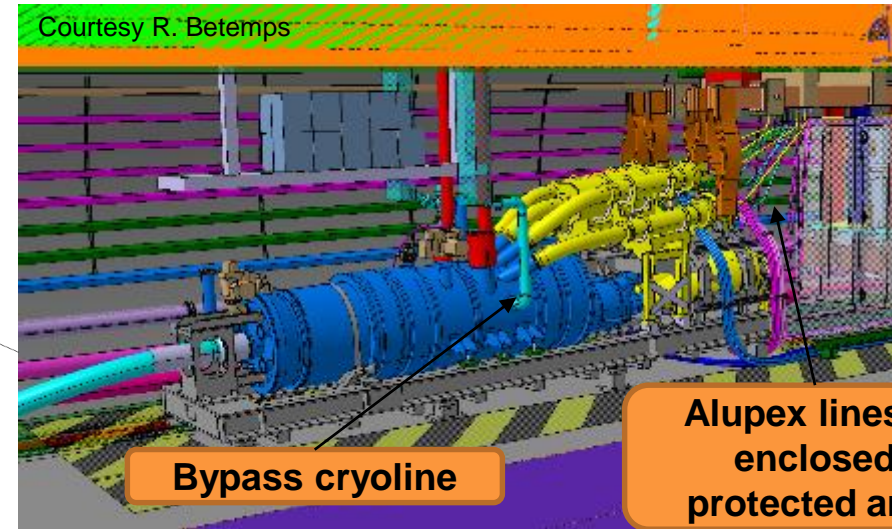
**GMS
Interface C₂**



2200 mm x
600mm x 2000mm

Alupex and bypass cryoline are routed by the top.
For the moment, only a space reservation in the 3D model.

Distance DFHX-GMS ~ 14 m
Distance DFHM-GMS ~ 17 m



Bypass cryoline

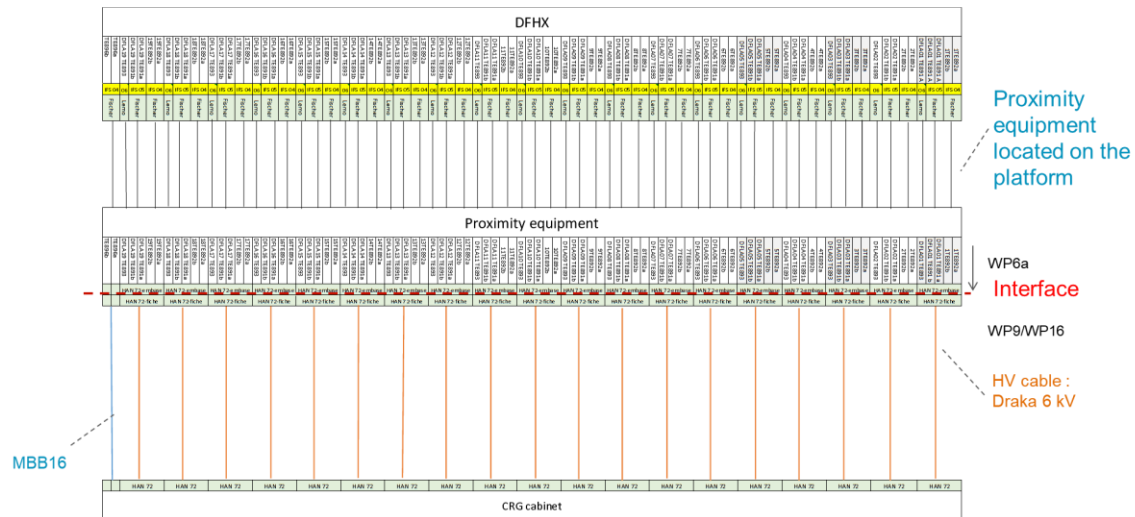
**Alupex lines in
enclosed
protected area**

**DFHX
Interface C₁**

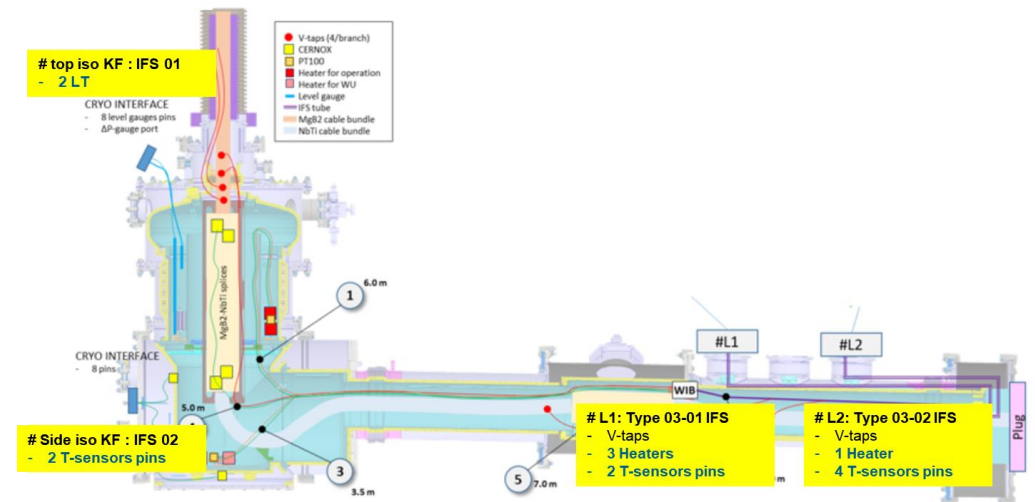
Electrical Interface

- For DFX signals, Electrical interface will be at connector level
- For DFHM signals, Interface will be at the proximity equipment level.

DFHM electrical interface



DFX electrical interface



Proposed Responsibility Matrix for work execution

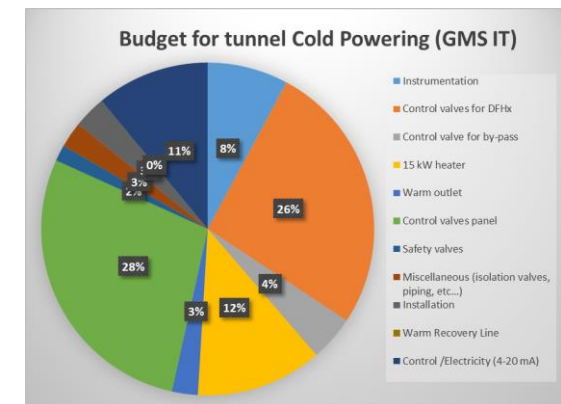
	Material	Design / specification	Procurement	Installation	Remark
DFX	TEMPERATURE PROBES	CRG	CRG	MSC	
	HEATERS	CRG	CRG	MSC	
	LEVEL GAUGES	CRG	CRG	MSC	
	PRESSURE TRANSDUCERS	CRG	CRG	MSC	
DFHX	TEMPERATURE PROBES	CRG	CRG	MSC	Value engineering in progress regarding splices temperature probes
	PRESSURE TRANSDUCERS	CRG	CRG	MSC	
Current Leads DFLH	TEMPERATURE SENSORS (TT 891 / TT 893)	MSC	MSC	MSC	Data acquisition required
Gas Management System (DFHX GMS)	BYPASS HEATER	CRG	CRG	CRG	
	CONTROL VALVES	CRG	CRG	CRG	
	RACK	CRG	CRG	CRG	
	OTHER INSTRUMENTATION	CRG	CRG	CRG	
	LOCAL FIELD BOX	CRG	CRG	CRG	
	PIPING BETWEEN GMS AND WRL	CRG	CRG	CRG	Refer to proposed mechanical interface
Zone C1-C2	VACUUM INSULATED LINE BETWEEN DFHX AND HEATER	MSC	MSC	MSC	Design /specification / Fabrication/ Installation could taken by CRG – refer to next slide for option pricing Alupex connection currently in the protected DFHX zone
	ALUPEX LINES	MSC	MSC	MSC	

NB : the proposed responsibility matrix is only for Work execution – budget funding are not covered.

GMS Tunnel Budget

		GMS For IT 2022		GMS For MS 2022		
1	Cryogenic Distribution System	CHF	159,000	CHF	137,500	comments
1.1	Gas Management System	CHF	141,500	CHF	120,000	
1.1.1	Instrumentation	CHF	12,500	CHF	12,500	
1.1.2	Control valves for DFHx	CHF	42,000	CHF	22,000	considering cryogenic valve "Weka or Velan"
1.1.3	Control valve for by-pass	CHF	7,000	CHF	7,000	
1.1.4	15 kW heater	CHF	19,500	CHF	19,500	
1.1.5	Warm outlet	CHF	4,000	CHF	4,000	
1.1.6	Control valves panel (design, manufacture, documentation)	CHF	45,000	CHF	45,000	considering REX of Test bench F2
1.1.7	Safety valves	CHF	2,500	CHF	2,500	
1.1.8	Miscellaneous (isolation valves, piping, etc...)	CHF	4,000	CHF	4,000	
1.1.9	Installation	CHF	5,000	CHF	3,500	
1.2	Warm Recovery Line	CHF	-	CHF	-	
2	Control /Electricity (4-20 mA)	CHF	17,500	CHF	17,500	Local field box, PLC card
	Grand total	CHF	159,000	CHF	137,500	

- GMS is estimated to :
 - **159 kCHF** for the one item of the IT version (GMSX)
 - **137.5 kCHF** for one item of the MS version (GMSM)
- In total, there are :
 - 4 GMS for IT
 - 4 GMS for MS
- NB :
 - Cryo signals data acquisition (PLC, crate...) is in WP9 budget
 - Cabling from interface to electrical WP9 budget.
 - Cryo- instrumentation in WP9 budget



Budget distribution for GMS Tunnel configuration

- The proposed distribution is as follows :
 - WP9 : control valves; instrumentation, heater , warm outlet....
 - WP6A : control valve panel, safety valve, installation..
 - **WP9 budget** is overall estimated to **740 kCHF.**
 - **WP6A budget** is overall estimated to **446 kCHF.**
- } **Total overall 8 GMS cost : 1186 kCHF**

		GMS For IT 2022		GMS For MS 2022		
1	Cryogenic Distribution System	CHF	159,000	CHF	137,500	comments
1.1	Gas Management System	CHF	141,500	CHF	120,000	
1.1.1	Instrumentation	CHF	12,500	CHF	12,500	
1.1.2	Control valves for DFHx	CHF	42,000	CHF	22,000	considering cryogenic valve "Weka or Velan"
1.1.3	Control valve for by-pass	CHF	7,000	CHF	7,000	
1.1.4	15 kW heater	CHF	19,500	CHF	19,500	
1.1.5	Warm outlet	CHF	4,000	CHF	4,000	
1.1.6	Control valves panel (design, manufacture, documentation)	CHF	45,000	CHF	45,000	considering REX of Test bench F2
1.1.7	Safety valves	CHF	2,500	CHF	2,500	
1.1.8	Miscellaneous (isolation valves, piping, etc...)	CHF	4,000	CHF	4,000	
1.1.9	Installation	CHF	5,000	CHF	3,500	
1.2	Warm Recovery Line	CHF	-	CHF	-	
2	Control /Electricity (4-20 mA)	CHF	17,500	CHF	17,500	Local field box, PLC card
	Grand total	CHF	159,000	CHF	137,500	
		WP9	CHF 102,500	CHF	82,500	
		WP6a	CHF 56,500	CHF	55,000	

for split FSU/Installation refer slide 14.

Zone C1/C2 option – cryogenic lines budget estimation

- Estimation revised for the cryogenic lines - valid for 8 units produced together and taking into account the simplified configuration : **276 kCHF as a budget estimation for the Zone C1/C2 bypass cryoline.**
- Two options considered - overall cost identical at 276 kCHF for both options.
 - Production of the line segments by industry – In this case, components produced by industry, specification and installation by CERN/FSU.
 - Production of the cryolines by CERN.
- NB : The Alupex lines from DFHX (Interface C1) is currently in the DFHX protected area : it is proposed that this scope is kept by WP6A.
- Leak tests of the Alupex lines will require discussion between WP9 and WP6A.

	OPTION 1 Production of the line segments by industry		OPTION 2 internal CERN production	
FSU costs	CHF	124,000	CHF	196,000
Industrial supply	CHF	152,000	CHF	80,000
TOTAL	CHF	276,000	CHF	276,000

Detailed cost estimate – FSU cost detailed for the different phases

		FSU cost	
		OPTION 1 Production of the line segments by industry	OPTION 2 internal CERN production
	For one cryoline		
Design phase			
study and drawings	CHF 5,000	CHF 3,000	CHF 5,000
Manufacture phase			
Manufacture	CHF 6,000		CHF 6,000
Material	CHF 6,000		
leak test	CHF 1,000		CHF 1,000
X ray control	CHF 1,000		
supports	CHF 1,500	CHF 1,500	CHF 1,500
Installation phase			
Scaffolding	CHF 3,000		
Installation	CHF 10,000	CHF 10,000	CHF 10,000
Inspection (leak test, Xray,...)	CHF 1,000	CHF 1,000	CHF 1,000
Grand TOTAL for one cryoline	CHF 34,500	CHF 15,500	CHF 24,500
Total for the 8 cryolines	CHF 276,000	CHF 124,000	CHF 196,000

String

- It was agreed to **use the GMSX #1 for the String**. Schedule of installation/de-installation to be defined.
- The supplementary cost (**13-43 kCHF**) related to the following items is imputed to the String – provisionnal cost is shown in yellow.
- Additional costs due to lack of scale savings
- Installation and de-installation
- Material re-qualification before tunnel re-installation
- Potential reconfiguration to match tunnel final GMS design.

1	Cryogenic Distribution System		
1.1	Gas Management System		
1.1.1	Instrumentation	CHF 10,200	PT/PDT not compatible with the Tunnel
1.1.2	Control valves for DFHx	CHF 8,000	Counts for supplementary cost for Weka Valve (4 valves)
1.1.3	Control valve for by-pass	CHF 2,000	Counts for supplementary cost for Weka Valve (1 valves)
1.1.4	15 kW heater	CHF 1,071	electrical Connection of the heater
1.1.5	Warm outlet	CHF -	
1.1.6	Control valves panel	CHF 1,750	Pressure and leak test
1.1.7	Safety valves	-	requalification of safety valve
1.1.8	Miscellaneous (isolation valves, piping, etc...)	CHF -	
1.1.9	Installation	CHF 5,000	FSU cost
	Control valve for by-pass	CHF 10,000	reconfiguration (potential) for reinstallation
	qualification for tunnel re-installation	CHF 5,250	electronic + mechanical
	Grand total	CHF 43,271	

Conclusion and way forward

- Thorough exercise for the cost estimate of the GMS.
- Total Cost estimate for the **8 GMS is 1186 kCHF**. Interface is defined at the GMS level (interface C₂ and Interface B) for the fore-mentioned cost.
- The proposed budget distribution between WP6A and WP9 is as follows :
 - Budget to be taken by **WP9** is estimated to **740 kCHF (62% of total GMS cost)**
 - Budget to be taken by **WP6A** is estimated to **446 kCHF (38% of total GMS cost)**
- **Vacuum insulated cryogenic line** between DFHX and heater can be optionally designed/ manufactured/ installed by CRG. The total cost for the 8 units has been estimated to **276 kCHF**.
- It is proposed that the **Alupex lines** remains **out of CRG scope** due to their connection in the restricted enclosure area of the DFHX.
- **GMS serie X1** can be used for the **String**. Supplementary **costs** related to the early installation and material requalification (**13-43kCHF**) shall be imputed to the WP16.

Detailed list of components of GMS X

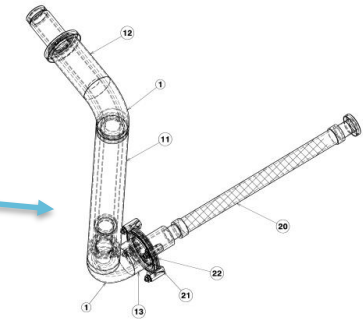
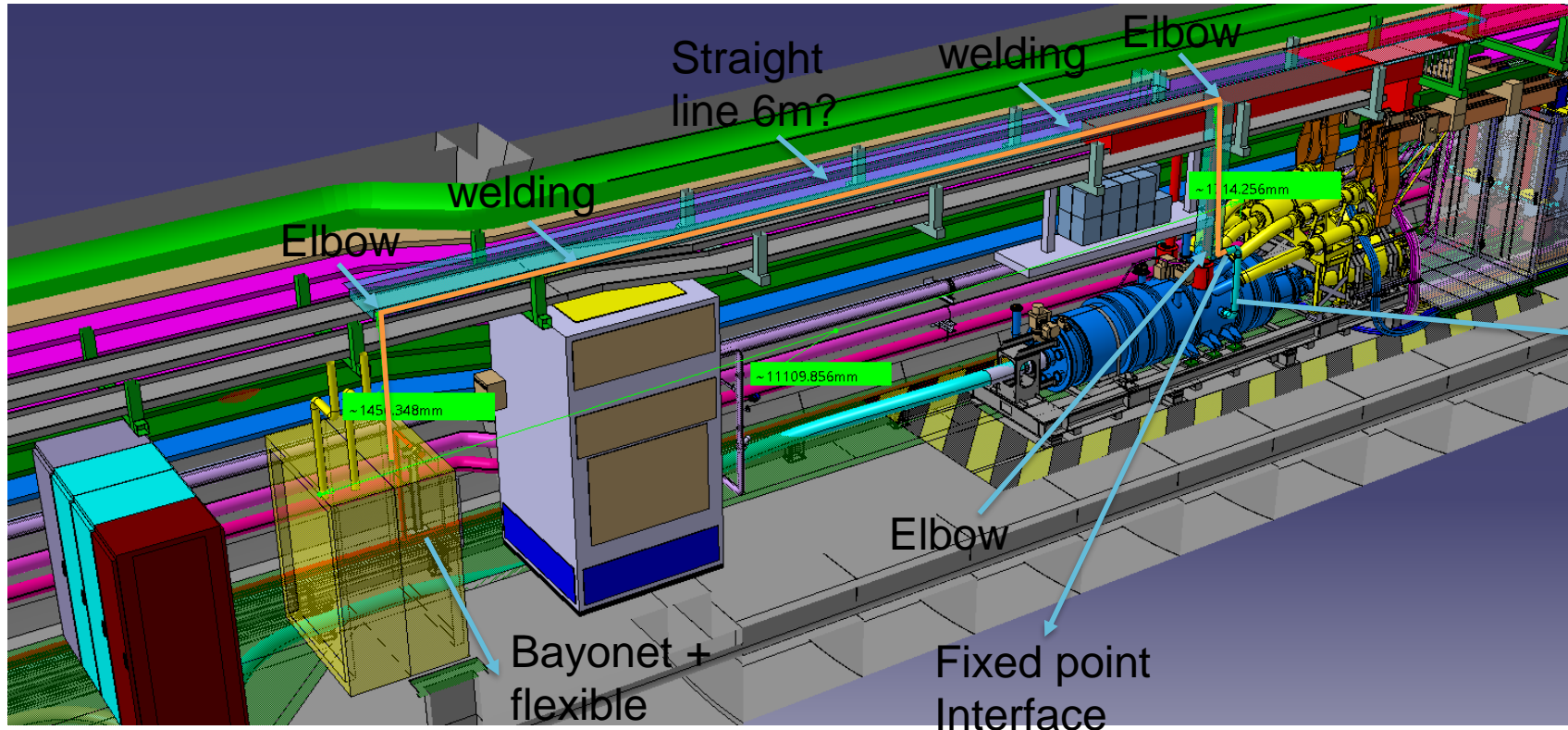
Item	Nominal mass flow [g/s]	Model considered	Connection size / Characteristics	Number
18 kA CL control valve	1	Weka / Velan	Kv = 3.2 m ³ /h	4
2 kA CL control valve	0.1	Burkert	G 1/2 Kv = m ³ /h	15
Bypass control valve	Up to 10	Weka /Velan	DN 25 Kv =14.7 m ³ /h	1
Electrical heater	Up to 10	Cetal	15 kW	1
Thermometers - heater outlet	-	PT100	-	1
Differential pressure transmitter	-	Rosemount 3051C - TBC	0-62 mbar	1
Outlet shut-off valve	5	Worcester	DN65	1
Outlet non-return valve	5	TBC	DN65	1
Outlet flowmeter	Up to 10	Bronkhorst	DN65 0-10 g/s $\Delta p_{\max} < 10$ mbar	1
Safety valve	TBD	Circle seal	TBD	1

WP6a GMS budget split

- GMS budget split as required by WP6a is shown below detailing :
 - Drawing by FSU in green
 - Installation in green
- Cost is indicated per GMS.
- No tooling cost identified.

	GMS IT		GMS MS	
structure + mounting	CHF	40,000	CHF	40,000
radiography	CHF	1,000	CHF	1,000
pressure / leak test test	CHF	1,750	CHF	1,750
by FSU comprise dwg	CHF	2,188	CHF	2,188
Safety valves	CHF	2,500	CHF	2,500
Miscellaneous (isolation valves, piping, etc...)	CHF	4,000	CHF	4,000
Installation	CHF	5,000	CHF	3,500

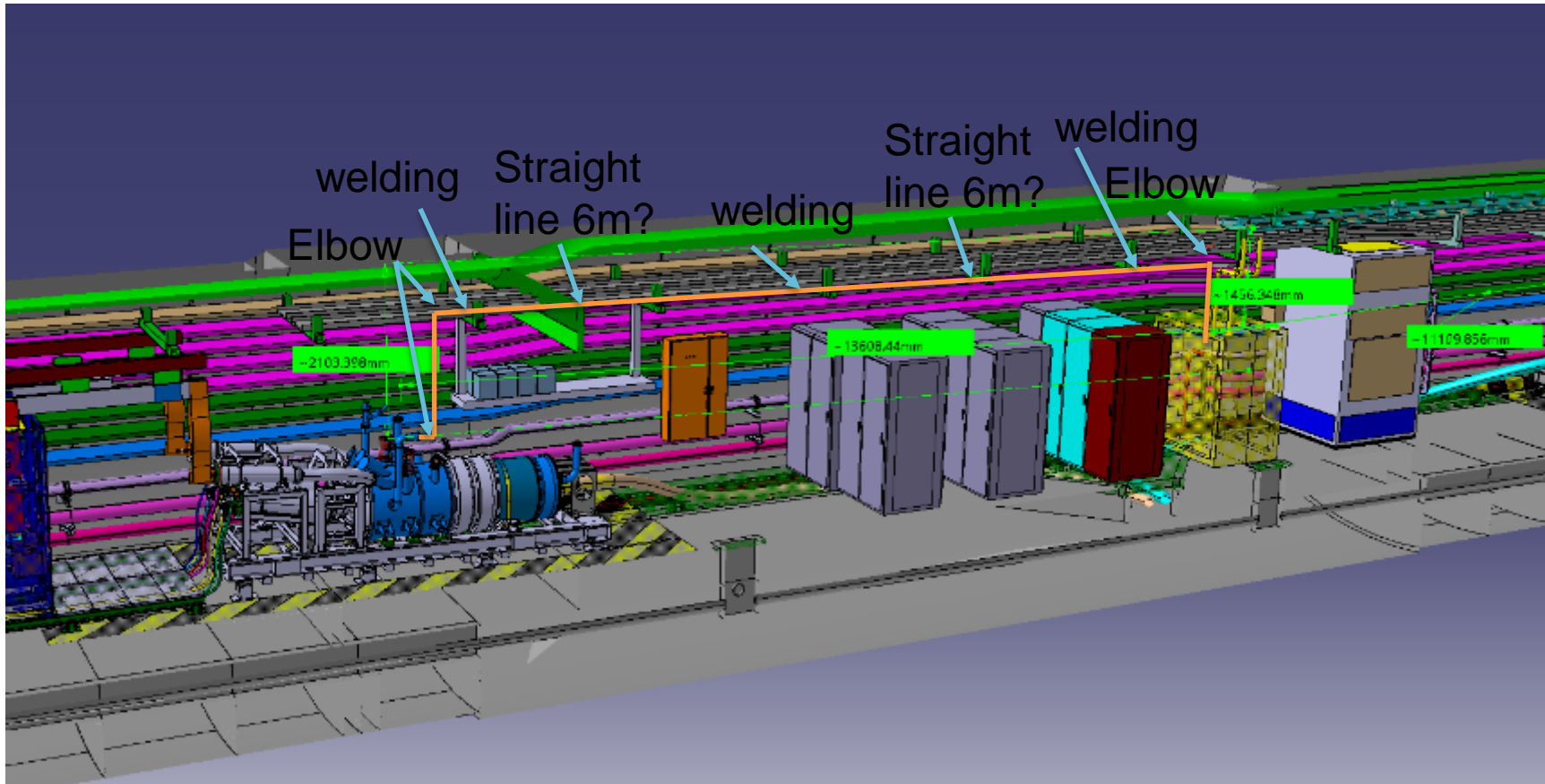
Bypass line Simple routing DHFX



Drawing
LHCDFX_0026

Bypass in DN32
Length ~14.26 m

Bypass line simple routing DFHM



Bypass in DN32
Length ~17.15 m