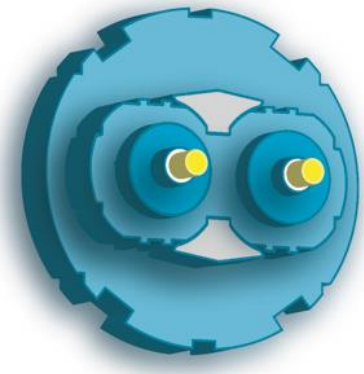

CERN

4th Joint HiLumi LHC-LARP Annual Meeting
November 17-21, 2014
KEK



High Luminosity LHC

HL-LHC SC Link Pt1-Pt5 Layout and integration

Integration studies by C. Collazos, J.P. Corso, C. Magnier.

Speaker Y. Muttoni EN-MEF-INT

The HiLumi LHC Design Study is included in the High Luminosity LHC project and is partly funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 284404.

Summary

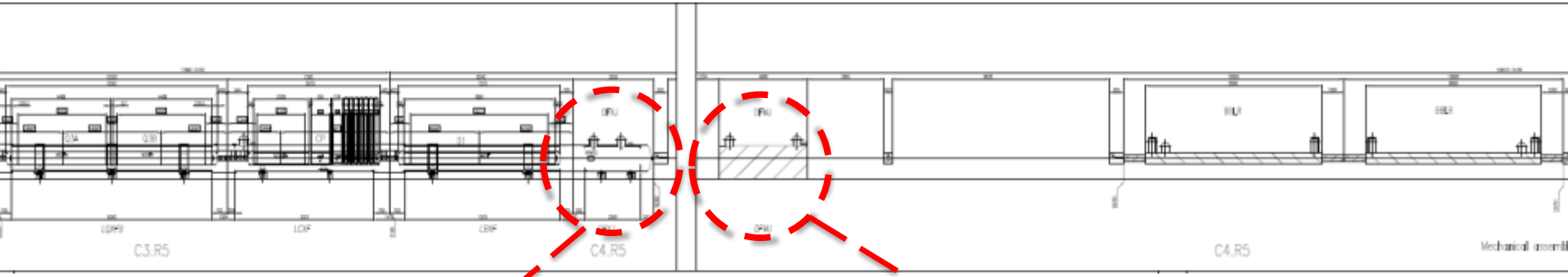
- IR 1-5 machine layout
- HL-LHC baseline
  - Point 1
  - Point 5
- HL-LHC option
  - Point 1
  - Point 5
- Conclusions

IR1 and IR5 according to approved plan LHCLSXHT0010 index A conforming to optics version HL-LHC V 1.1

New version next spring

LAYOUT STATUS IN THE IR 1,5

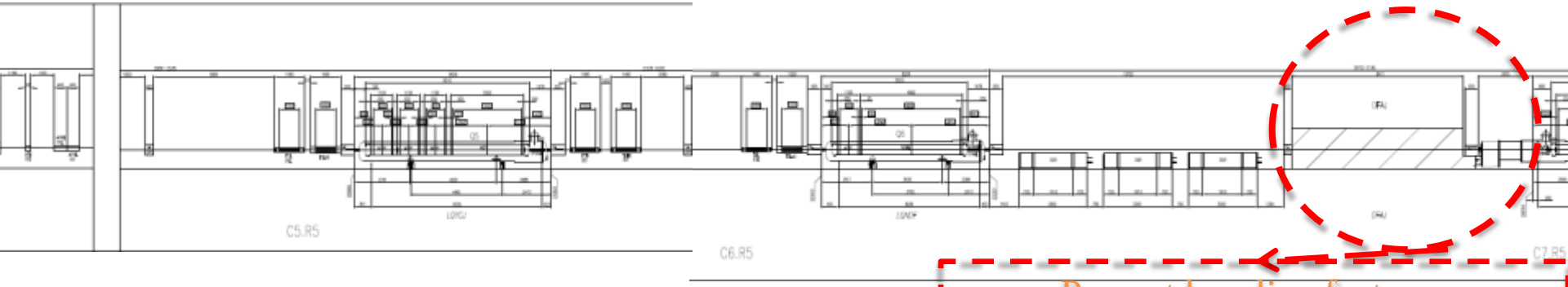
IR1-IR5 Q3→BBLR



DFX terminal of the SC link for the inner triplet

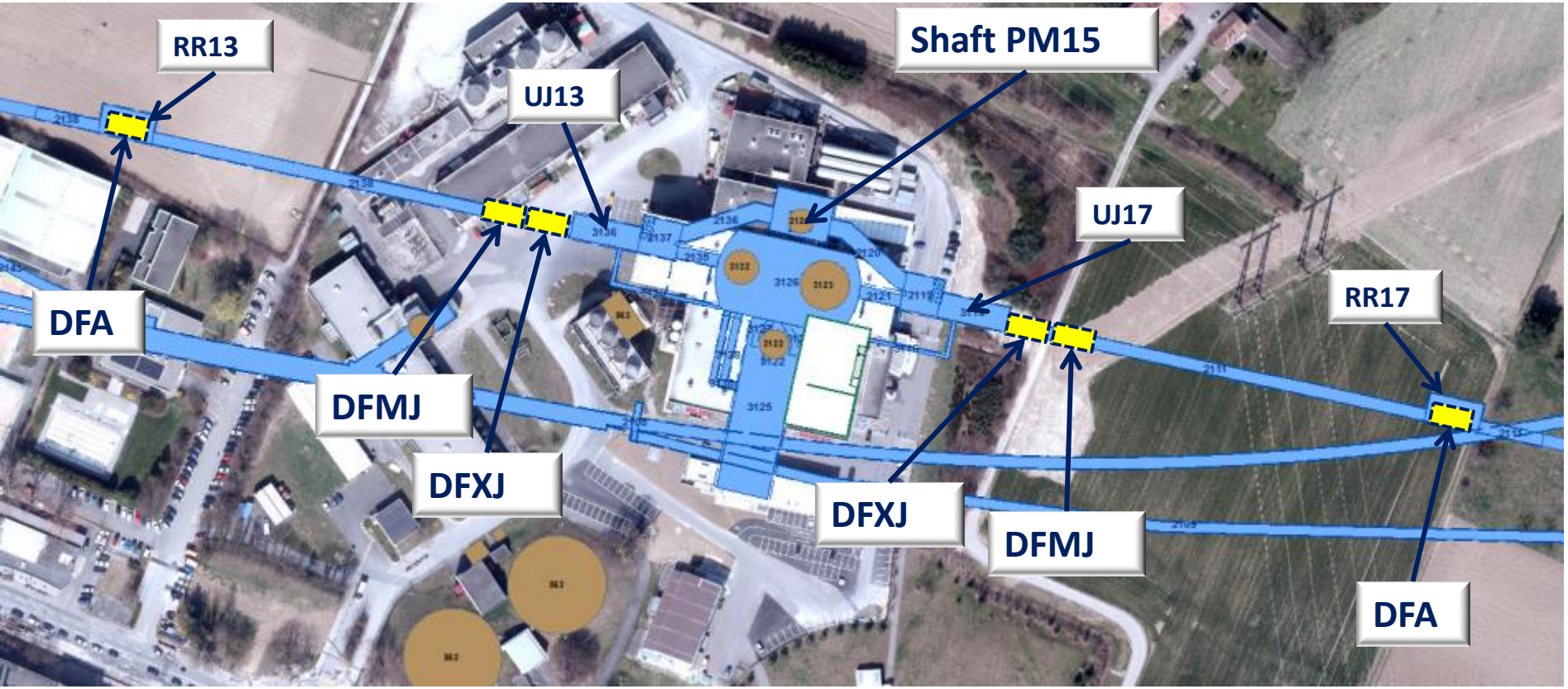
DFM: terminal of the SC link for the Matching Sections

IR1-IR5 Q5→DFBA

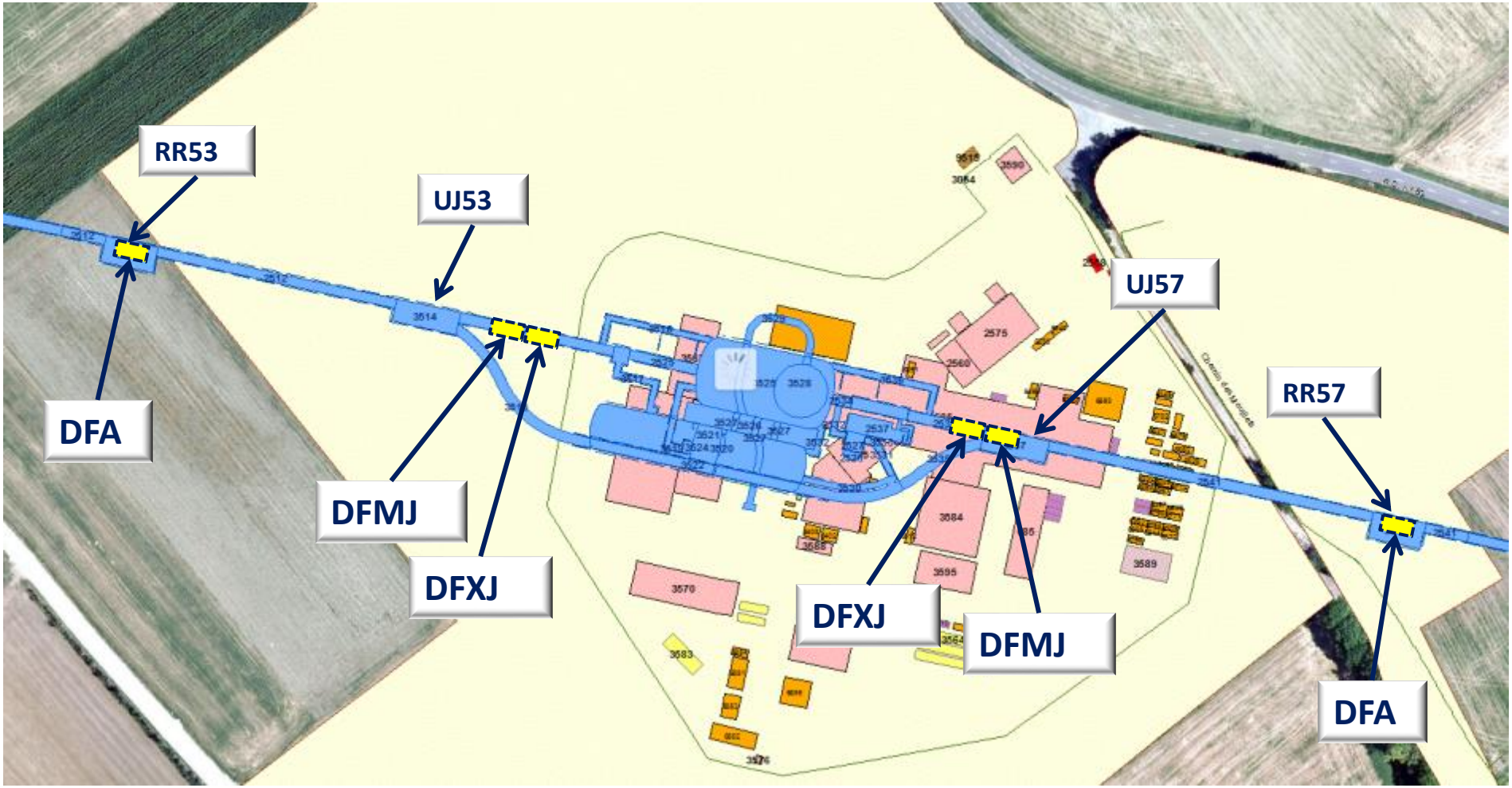


Present baseline features modification/change of the DFBA in a DFA being the terminal of a SC link feeding the 600 A and 6 kA circuits of the ARC. Possible other solution as the use of the radiation hard PC in the RR that would limit modifications and ease machine integration under evaluation

Point 1 CERN Domain Situation

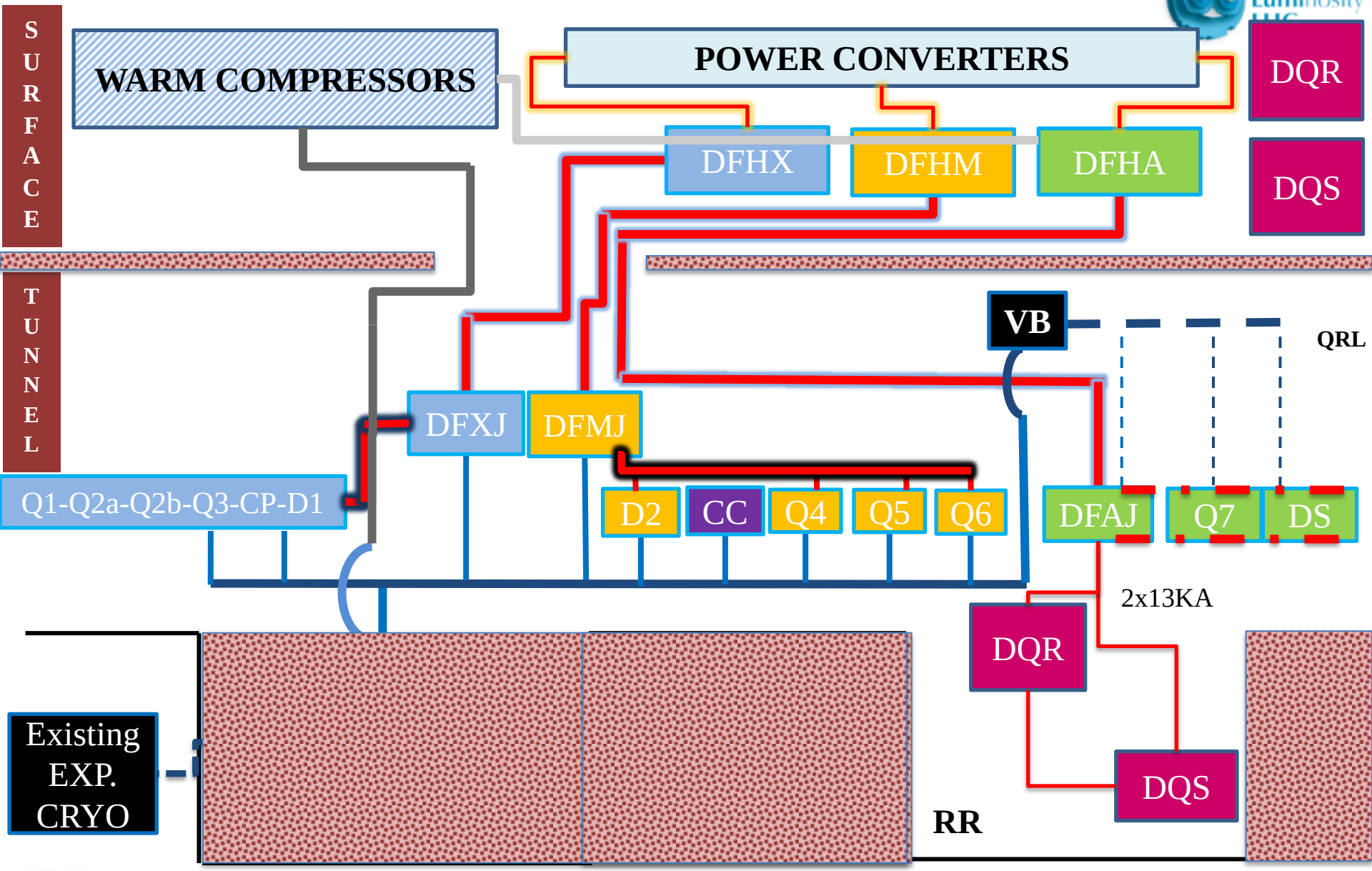


Point 5 CERN Domain Situation

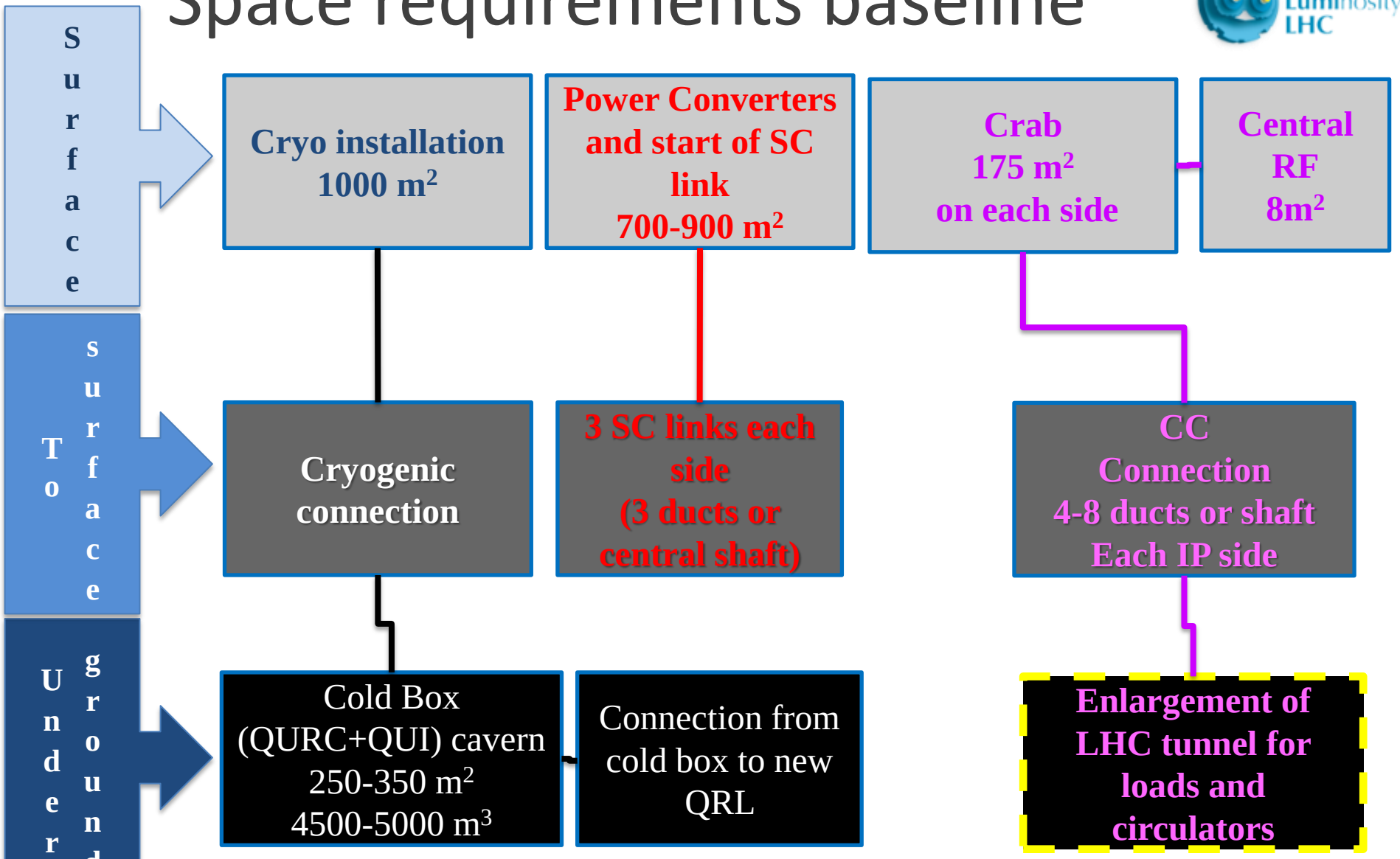


HL-LHC IR 1,5 MAIN SYSTEM DISTRIBUTION, BASELINE

Pt1 & Pt 5: cryogenic concept and magnet powering

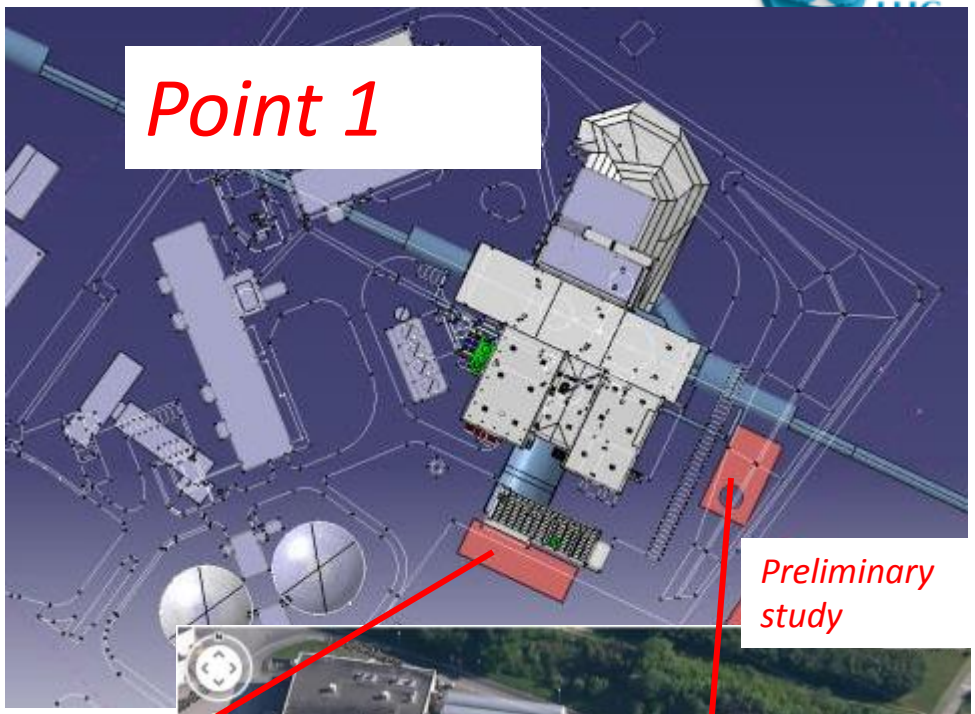


Space requirements baseline



Baseline underground I: cryogenics

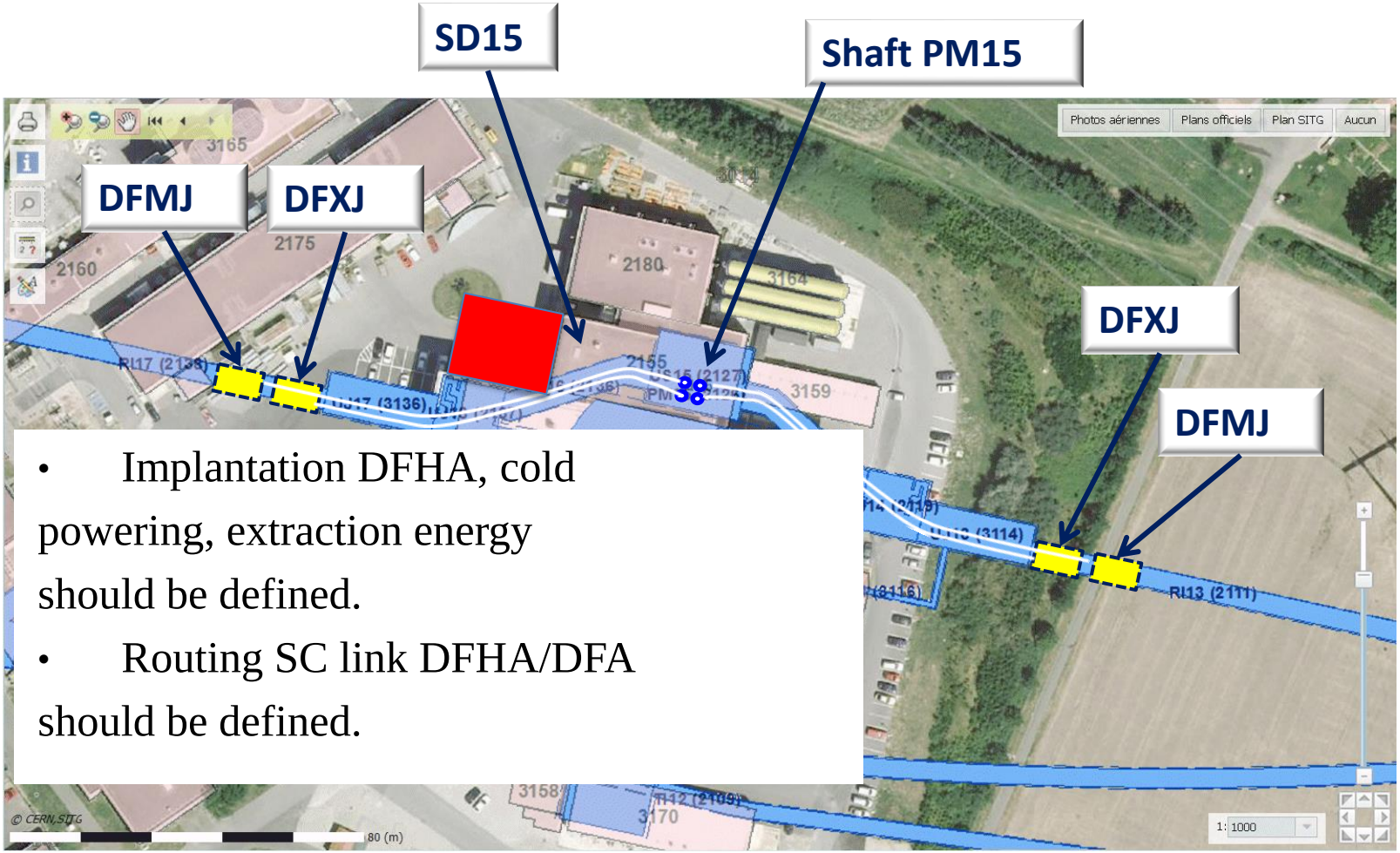
- Cavern for Cryogenics only
- Creating a new shaft
- Connection to machine tunnel: LHC machine side (not showed)
- Floor of the cryo cavern same level of machine tunnel



Preliminary study

Routing SC link

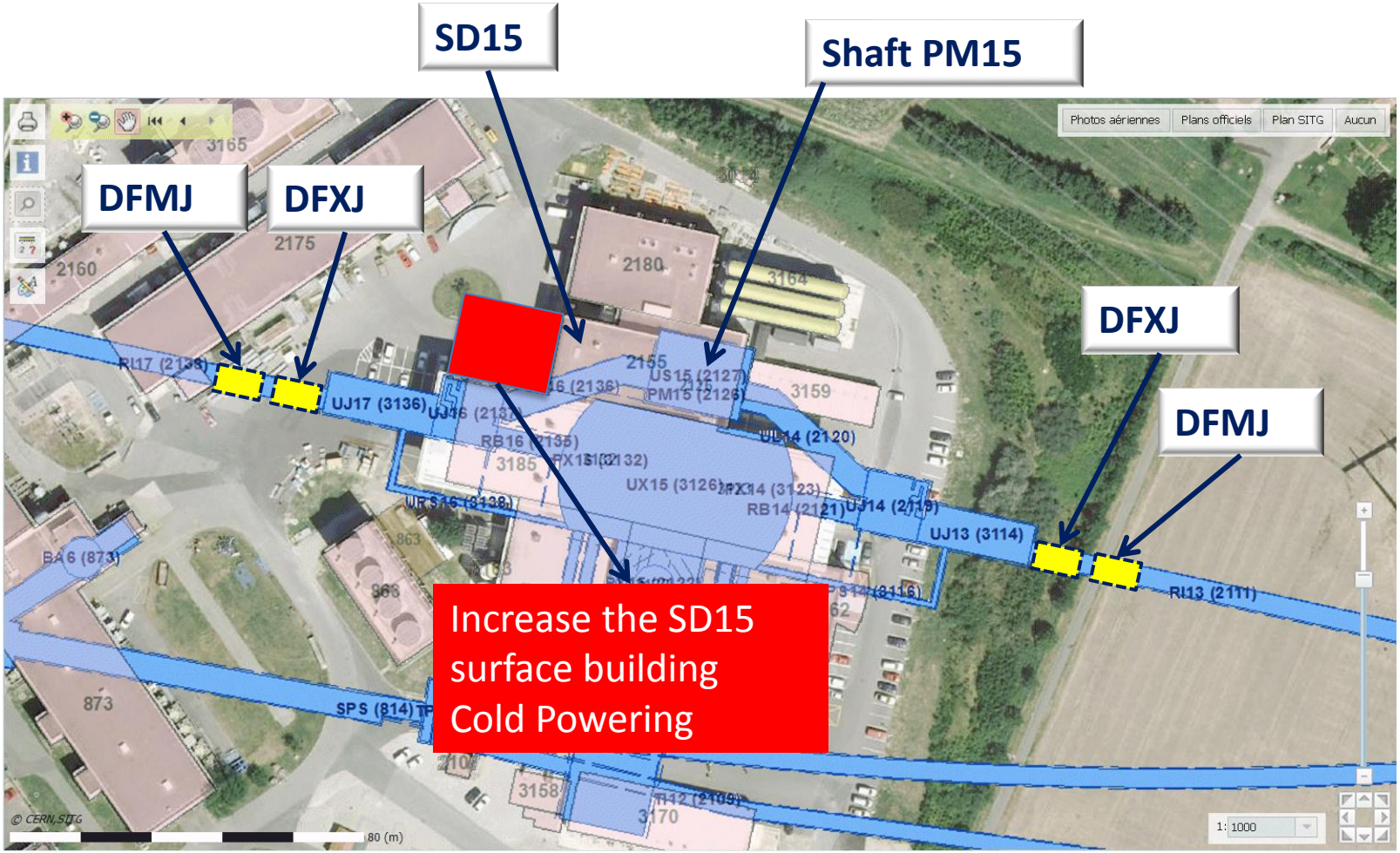
Point 1



- Implantation DFHA, cold powering, extraction energy should be defined.
- Routing SC link DFHA/DFA should be defined.

Baseline surface II: all other equipment

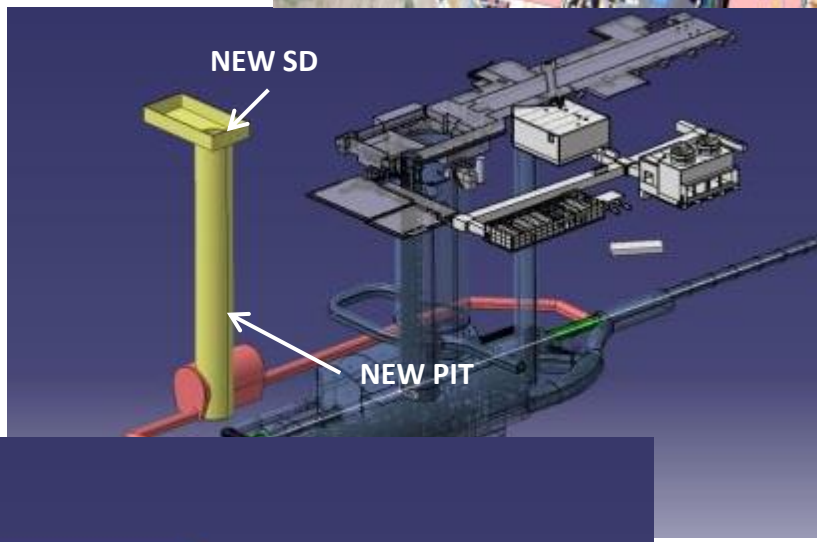
Point 1

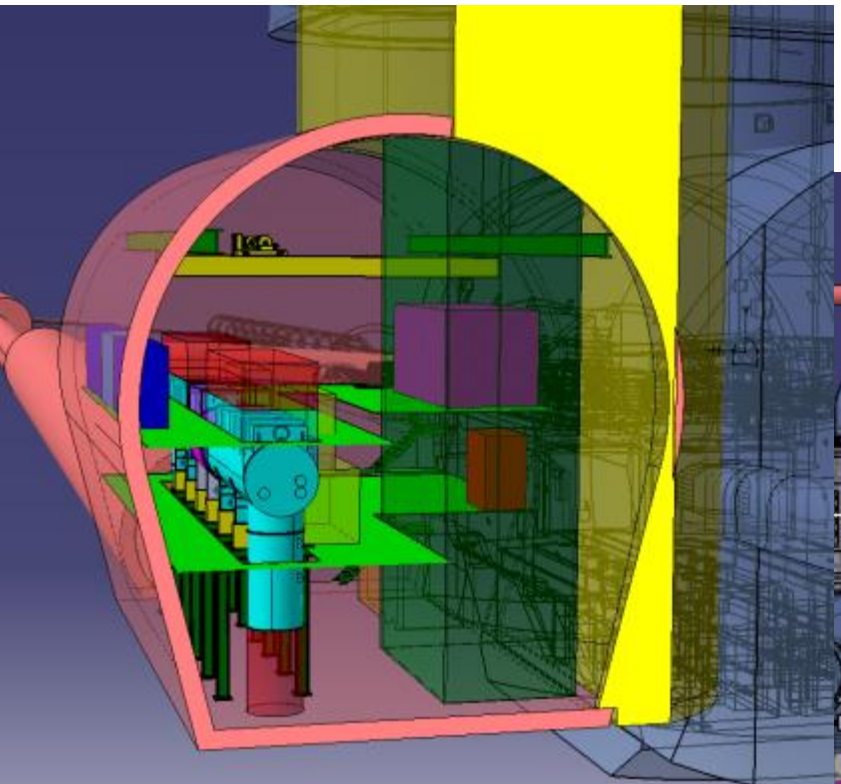


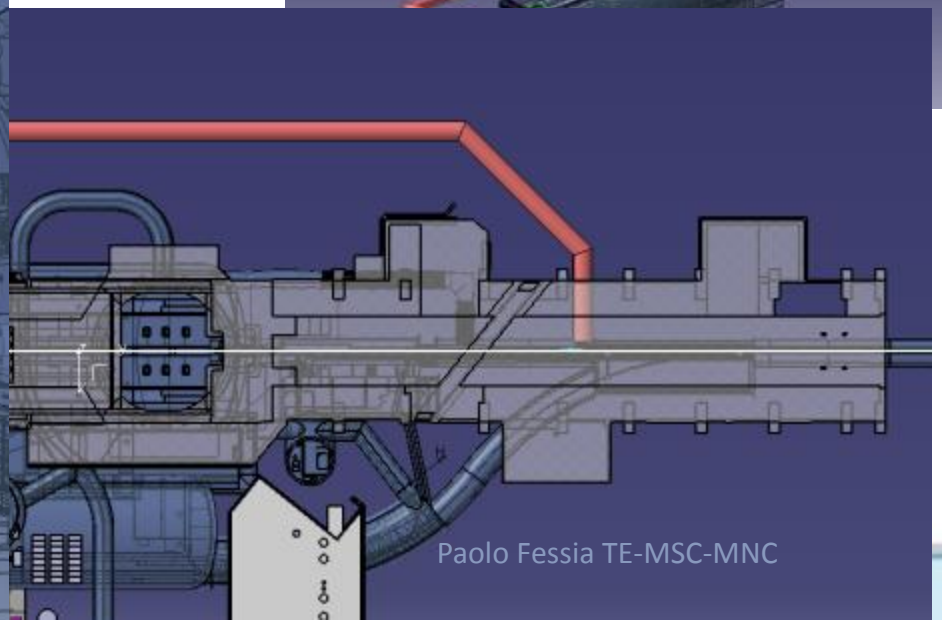
Baseline underground I: cryogenics

Point 5

- Cavern for Cryogenics only
- Creating a new shaft
- Connection to machine tunnel: LHC machine side
- Floor of the cryo cavern same level of machine tunnel

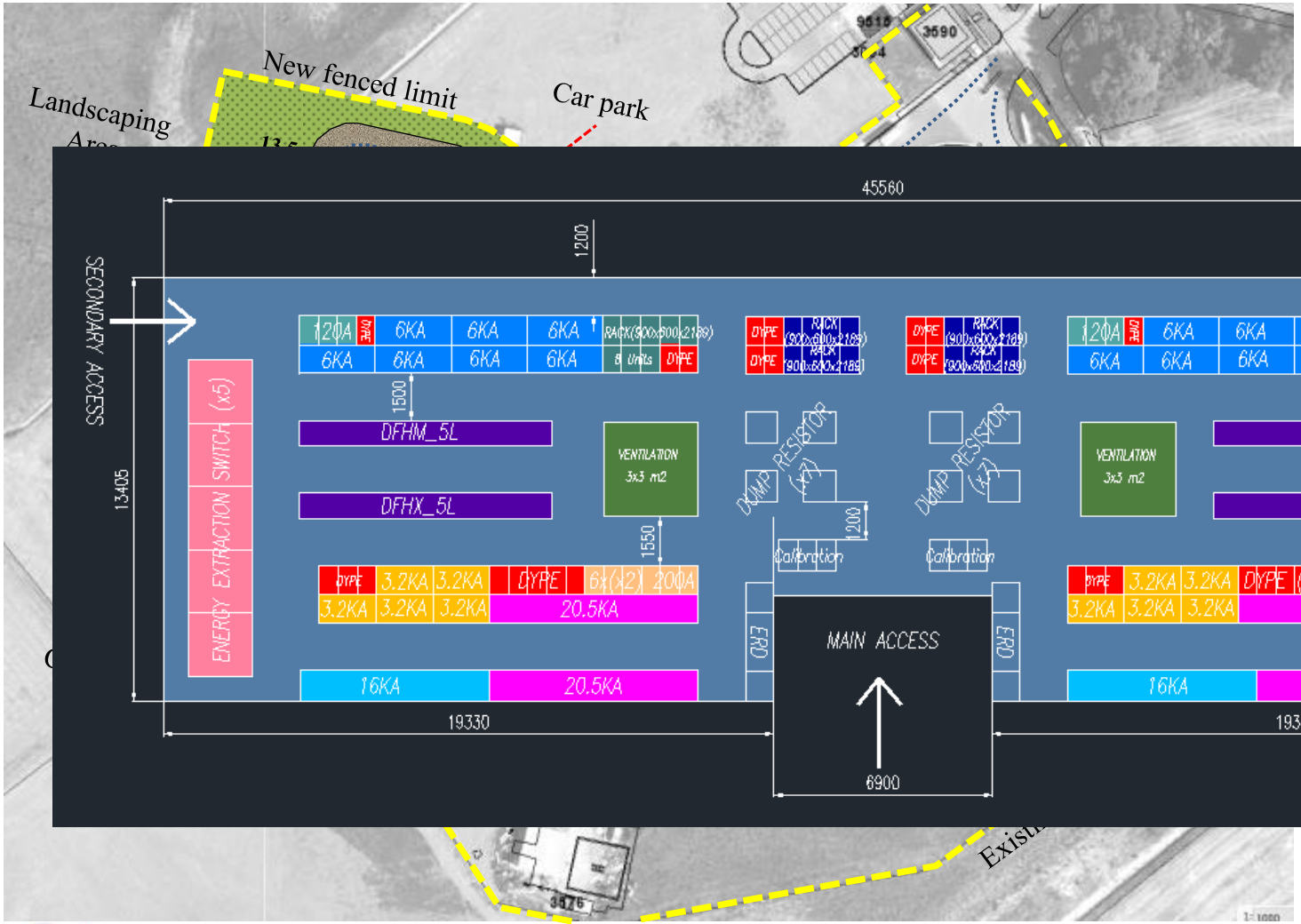






Baseline surface II: all other equipment

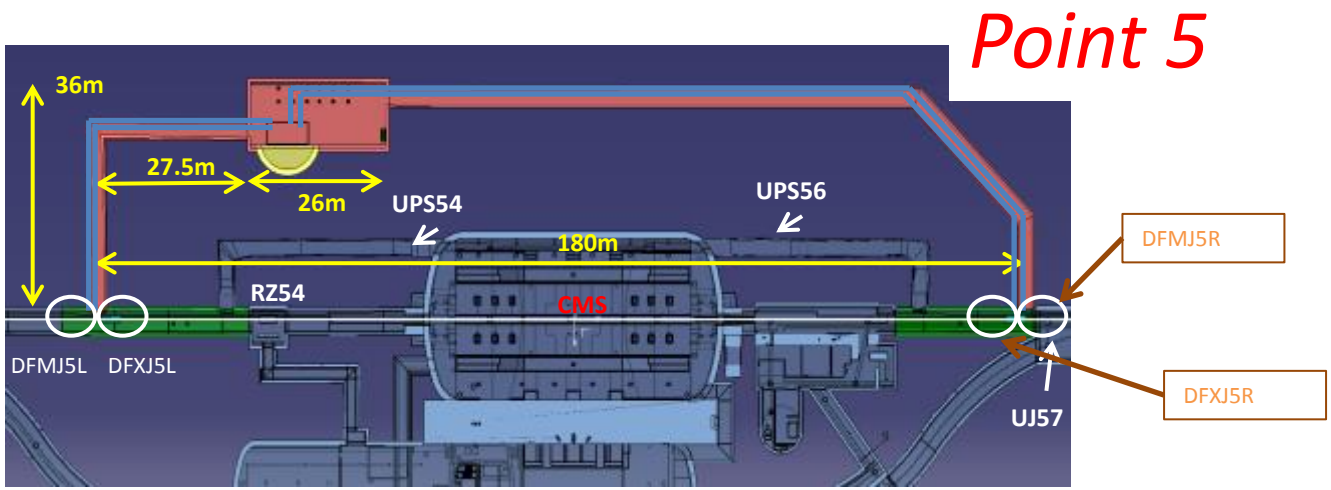
Point 5



MACHINE SIDE, WITH NEW SHAFT

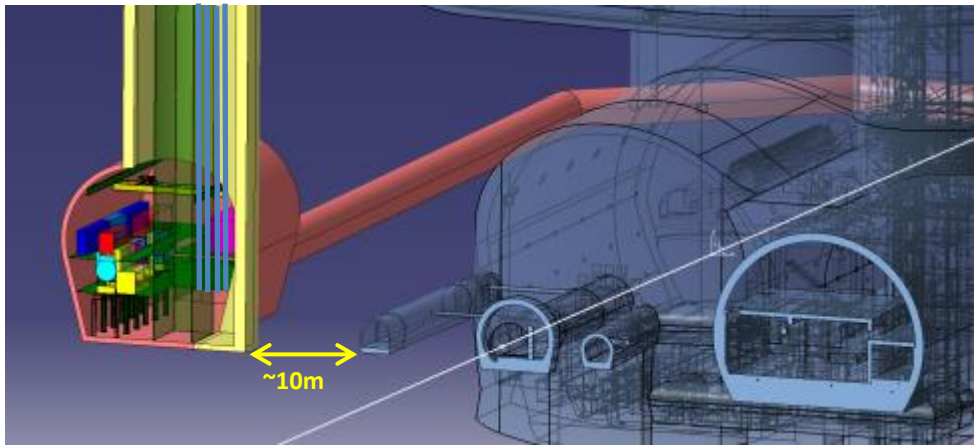
- New Road: 130m(L), 8m(W)
- New Access road: 85m(L), 6.5m(W)
- Galleries for services: 130m(L), Cross section: 2.0m(W) by 2.5m(H)
- Landscaping: 7'200m2

Routing SC link



- 2 SC link for each side
- 4 vertical SC link in the shaft

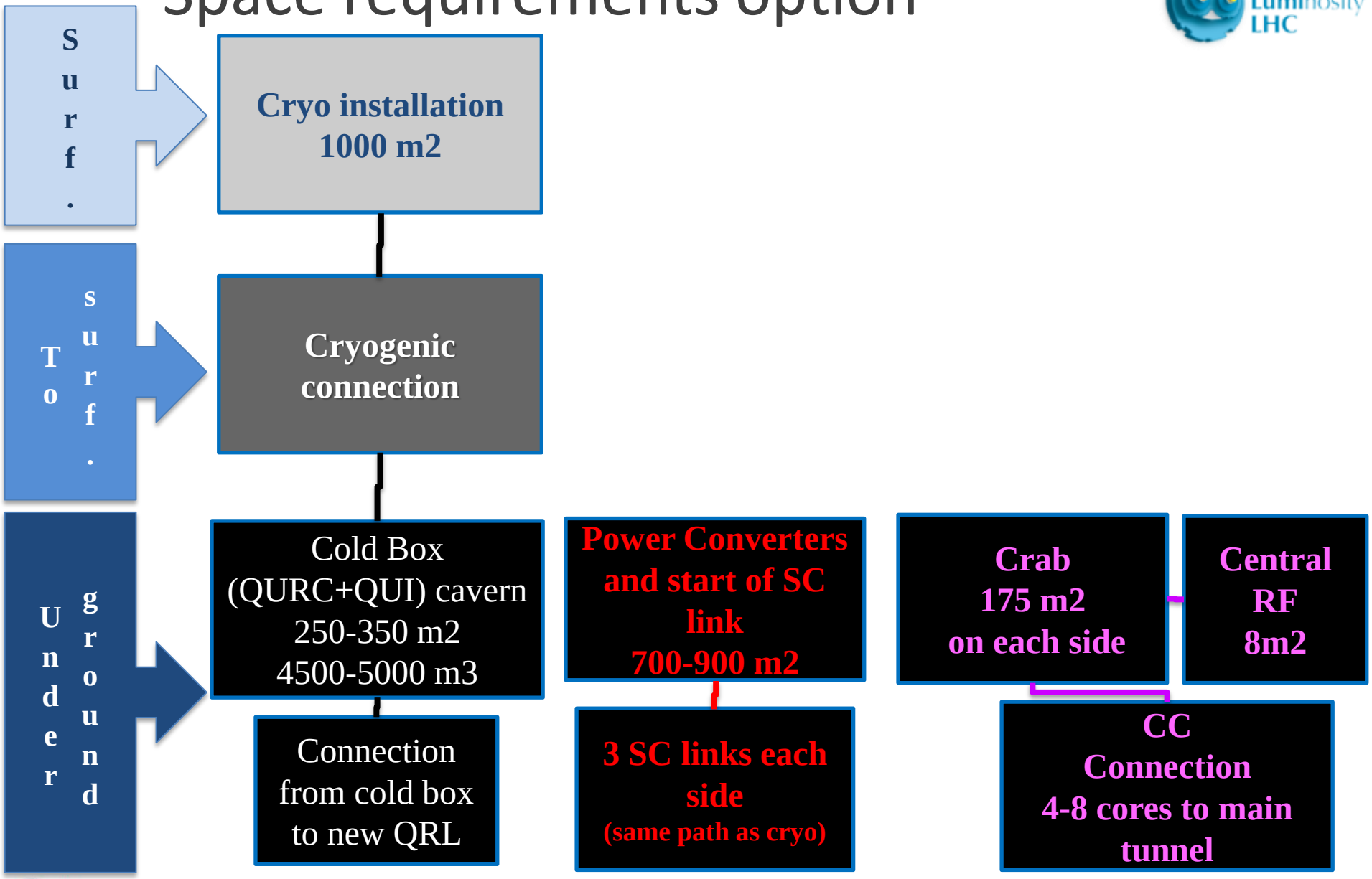
- Implantation DFHA, cold powering, extraction energy should be defined.
- Routing sc link DFHA/DFA should be defined.



HL-LHC IR 1,5 MAIN SYSTEM DISTRIBUTION

OPTION

Space requirements option



Option: underground

Point 1

Study not yet started

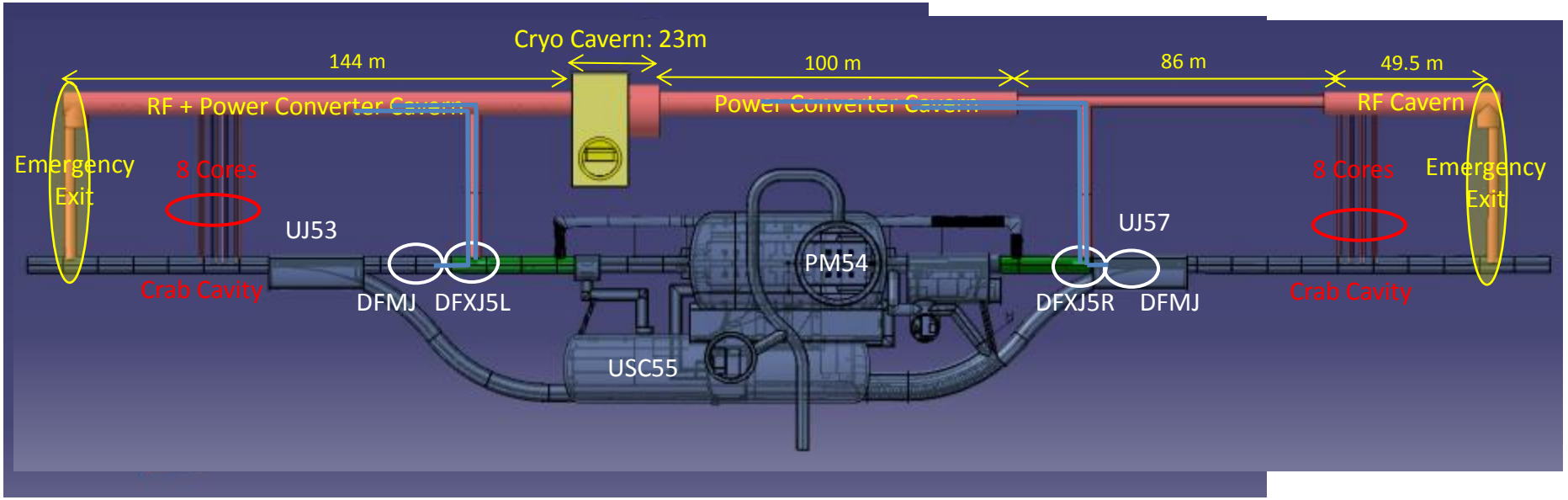
Option surface:
all other equipment

Point 1

Study not yet started

Option: underground

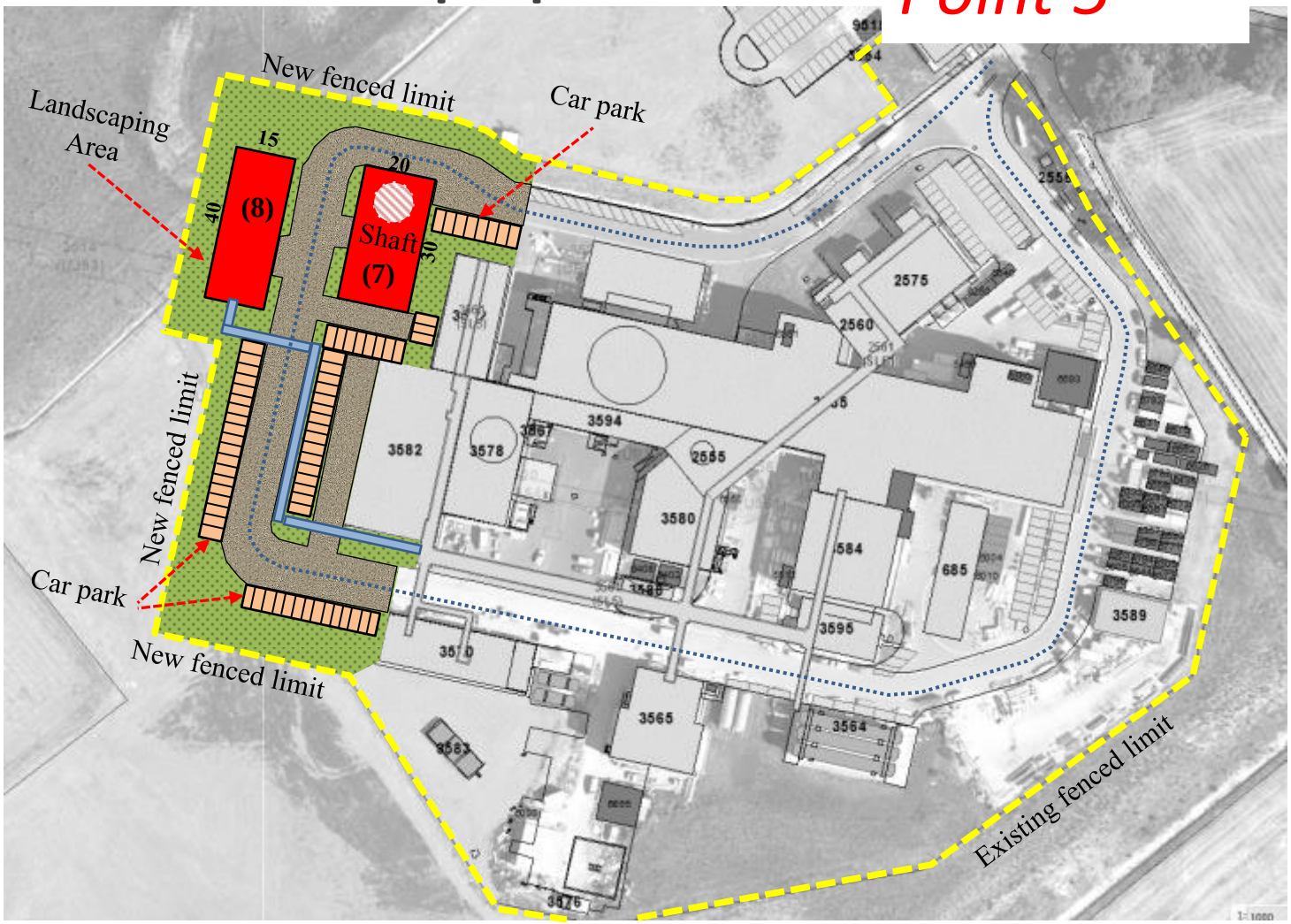
Point 5



- 2 SC link for each side
-
pc
sh
-
should be defined.

Option surface: all other equipment

Point 5



MACHINE SIDE, WITH NEW SHAFT + PC

7) SD (Steel)

- Dimension: 20 x 30 = 600m2
- Hmax = 12.0m
- Services (in;out): HV, water, SC Links ; ?
- Crane not costed (20t ?)

8) WARM COMPRESSOR (Conc)

- Dimension: 15 x 40 = 600m2
- Hmax = 9m
- Services (in;out): HV, water, Cryo pipes ; ?
- 20t crane not costed

10) PARKING, ROADS, GALLERIES

- Car Park: 20 places added
- New Road: 180m(L), 8m(W)
- New Access road: 70m(L), 6.5m(W)
- Galleries for services: 110m(L), Cross section2.0m(W) by 2.5m(H)
- Landscaping: 6,600m2

Conclusion

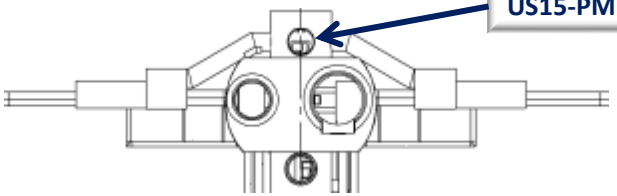
- The integration studies are not finished.
- Continue the work in WP15 integration and using the possibilities to install the power converter in underground….

Thanks for your Attention !

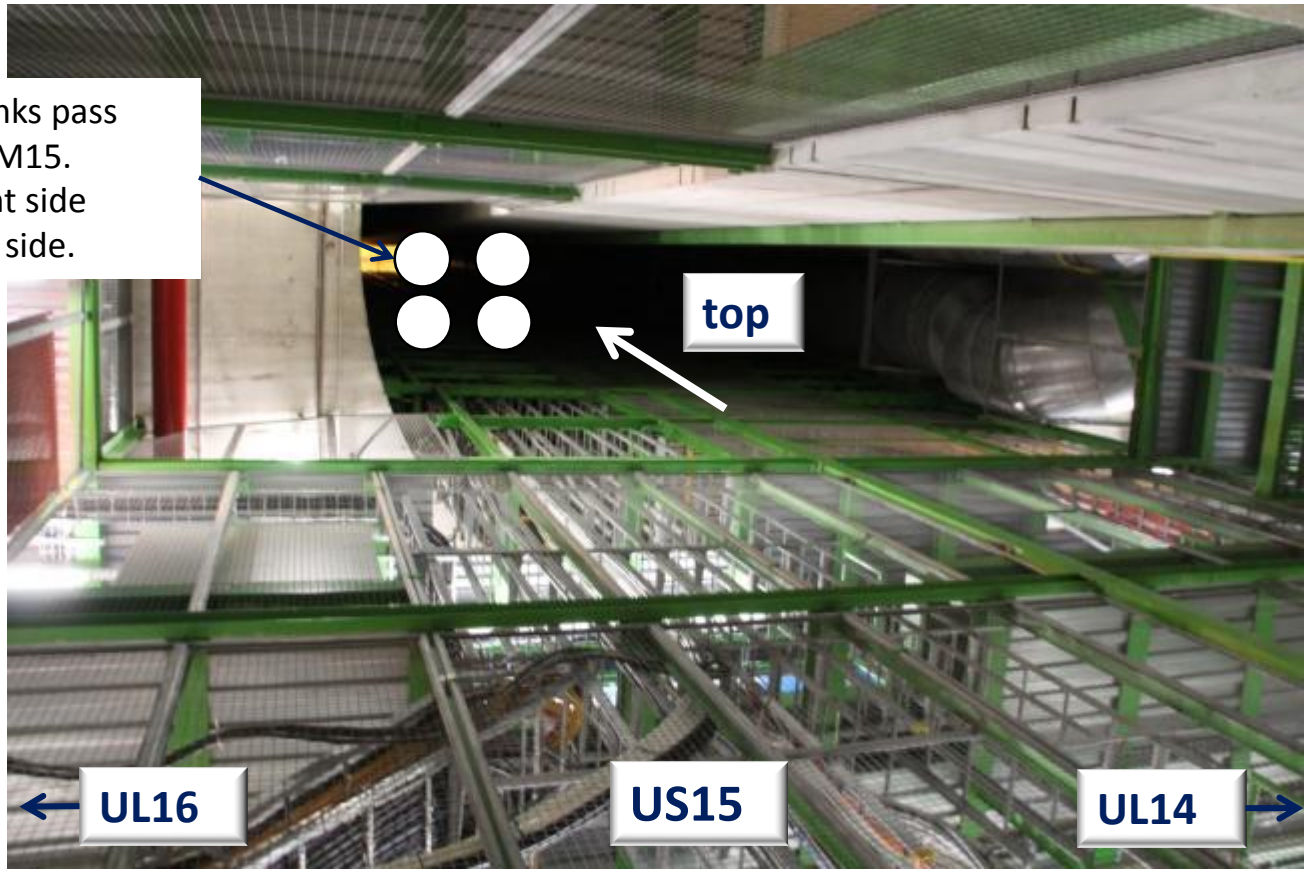
ANNEX

SC LINK POINT 1

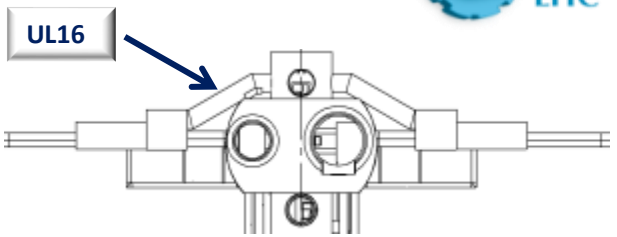
Routing link into US15/PM15

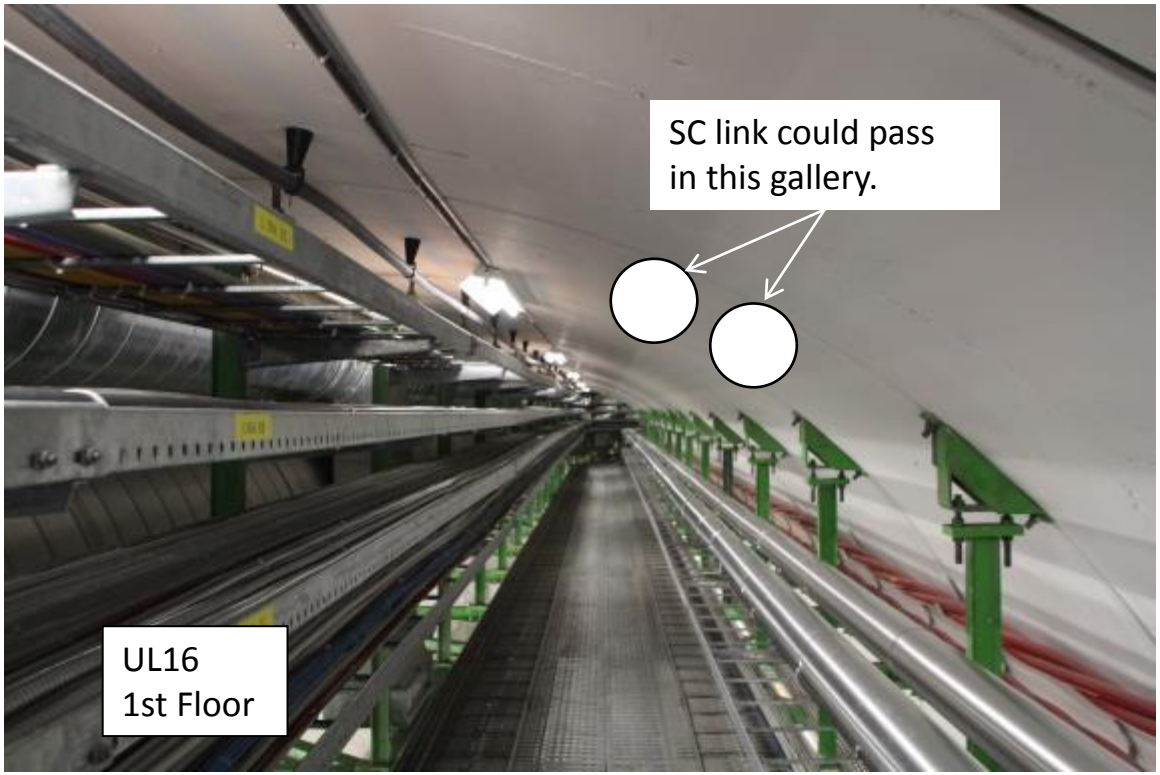


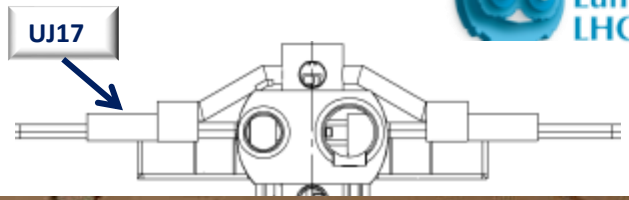
The four SC links pass
in the shaft PM15.
One from right side
One from left side.



Equipments in place







Equipments in place

UJ17

RI171

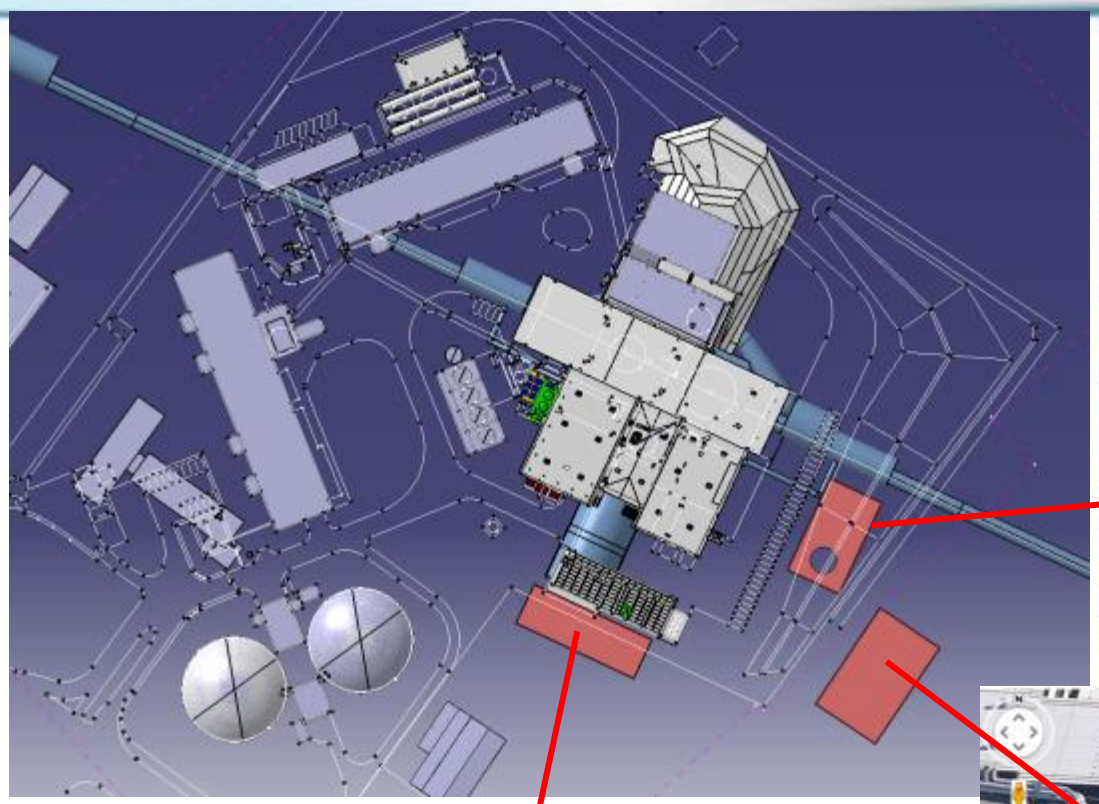
A REPRENDRE

Baseline underground I: cryogenics

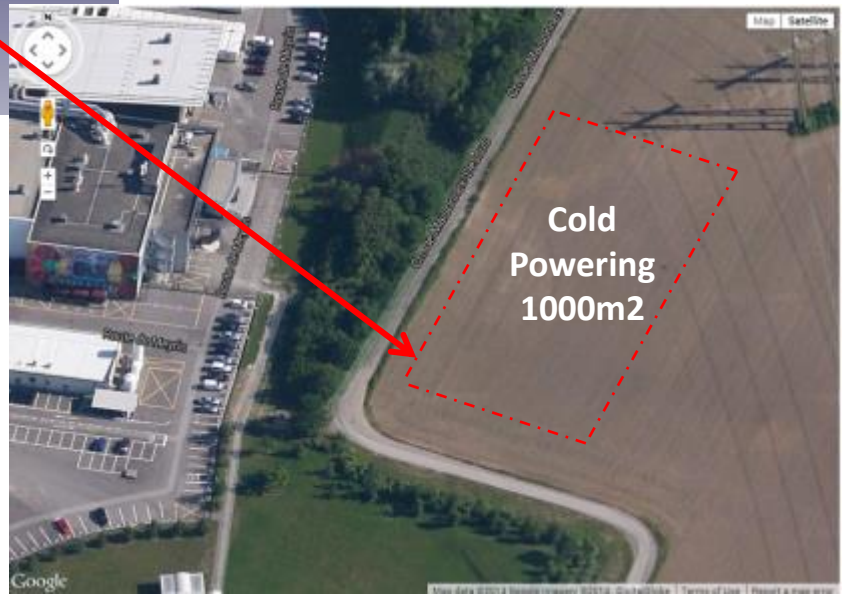
Point 1

- Cavern for Cryogenics only
- Creating a new shaft
- Connection to machine tunnel: LHC machine side
- Floor of the cryo cavern same level of machine tunnel

Preliminary study




SD “cryo” + pit
400m2


Cold
Powering
1000m2


Wam compressor
cyo 600m2

SPACE REQUIREMENT SYSTEM BY SYSTEM

CRYOGENICS

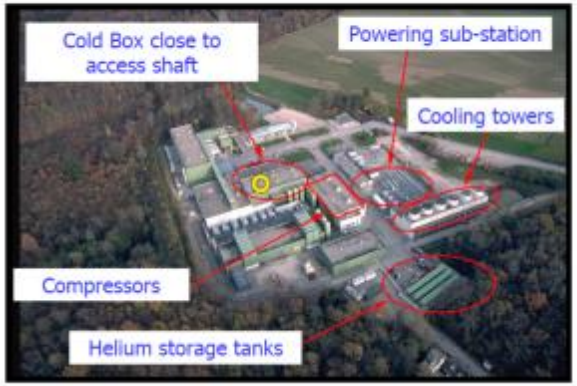
STOCKAGE
HELIUM (warm & cold)

WARM COMPRESSOR BUILDING
600m2

High Lumi LHC

Surface building (SD) (30mx10m)

Infrastructure at LHC technical area



Illustrations : Serge Claudet (CRG)

PIT

QPLB

UNDERGROUND CAVERN

cluded in the High Luminosity ... ded by the European ork Programme 7 Capacities Specific Programme, Grant Agreement 284404.

Cryogenics

Cryogenic system	Where		
Warm compressor	Surface	Area	700 m^2
		Crane	20 t
		Type	Noise insulated
Surface SD building	Surface	Area	30×10=300 m^2
		Crane	5 t
Cold Compressor	Underground	Volume	200 m^3
		Surface	0 m^2
		Crane	2 t

Remark

The electronics for the magnetic bearings of the cold compressor is radiation sensitive and maximum distance from its control electronics to the compressor is

50 m

COLD POWERING

Cold powering Circuits Q1 to D1

Q1 to D1 (for each IP side)						
circuits connected to the DFHX						
C.M.	Circuit / magnet	Op. current [kA]	PC current rating [kA]	N of circuits	N. of 19" racks /PC	Total racks/ Circuit type
Q1-Q3	MQXF	17.5	20	1	10	10
	trim MQXF Q3	±2	±3.2	1	3	3
Q2A-Q2B	MQXF	17.5	20	1	10	10
	trim MQXF Q2	±0.3	±0.8	1	0.5	0.5
	MCBXB	±2.5	±3.2	4	3	12
CP	MCBXA	±2.5	±3.2	2	3	6
	MQSXF	0.182	0.2	1	0.5	0.5
	MCTXF	0.17-0.2	0.2	1	0.5	0.5
	MCTSXF	0.17-0.2	0.2	1	0.5	0.5
	MCDXF	0.193	0.2	1	0.5	0.5
	MCDSXF	0.193	0.2	1	0.5	0.5
	MCOXF	0.17-0.2	0.2	1	0.5	0.5
	MCOSXF	0.17-0.2	0.2	1	0.5	0.5
	MCSXF	0.17-0.2	0.2	1	0.5	0.5
	MCSSXF	0.17-0.2	0.2	1	0.5	0.5
D1	MBXF	11.8	16	1	9	9

Space needed	
circuits connected to the DFHX	
Total racks	55
Installation surface [m^2]	40
Access/manipulation surface [m^2]	43
Linear installation extension [m]	35
Height [m]	2.6
Installation volume [m^3]	100
Cooling water flow rate [l/min]	305

Cold powering Circuits D2 to Q6

D2 to Q6 (for each IP side)

Circuits connected to the DFHM

C.M.	Circuit / magnet	Op. current [kA]	PC current rating [kA]	N. of circuits	N. of 19" racks /PC	Total/ circuit type
D2	MBRD	12.4	16	1	9	9
	MCBRD	±3	±4	4	4	16
Q4	MQYY	16.1	20	2	10	20
	MCBYY	±3	±4	4	4	16
Q5	MCBY	0.088	±0.12	6	0.25	1.5
	MQY	4.2	8	2	4	8
Q6	MCBC	0.1	±0.12	2	0.25	0.5
	MQML	5.39	8	2	4	8

Space needed

Circuits connected to the DFHM

Total racks	79
Installation surface [m^2]	56
Access/manipulation surface [m^2]	60
Linear installation extension [m]	50
Height [m]	2.6
Installation volume [m^3]	145
Cooling water flow rate [l/min]	400

Cold powering arc

Continuous cryostat presently fed from DFBA (for each IP side)				
Circuits connected to the DFHA				
Magnet	**PC current rating [kA]**	**N. of circuits**	**N. of 19" racks /PC**	**Total/ circuit type**
MQT	±0.6	2	0.5	1
MQS	±0.6	2	0.5	1
MQTL	±0.6	2	0.5	1
MQT	±0.6	2	0.5	1
MSS	±0.6	2	0.5	1
MO	±0.6	4	0.5	2
MQM	6	4	4	16
MQML	6	4	4	16
D11 T trim	±0.6	2	0.5	1

Space needed	
Circuits connected to the DFHA	
Total racks	38
Installation surface [m^2]	27
Access/manipulation surface [m^2]	29
Linear installation extension [m]	25
Height [m]	2.6
Installation volume [m^3]	68
Cooling water flow rate [l/min]	NA

Space becoming free in RR by DFHM related PC	
Racks removed	34
Installation surface made available	24
Linear installation extension [m]	22

Spare Power Converters

Q1 to D1 (for each IP side)

"DFHX"

N. spare	PC current rating [kA]	N. Circuit served	N. of 19" racks
1	20	2	10
1	16	1	9
1	±3.2	7	3
1	±0.8	1	0.5
1	0.4	10	0.5

D2 to Q6 (for each IP side)

"DFHM"

N. spare	PC current rating [kA]	N. Circuit served	N. of 19" racks
1	20	2	10
1	8	4	3
1	±4	4	0.5
1	±0.12	8	0.5

Cont. cryostat (for each IP side)

"DFHA"

N. spare	PC current rating [kA]	N. Circuit served	N. of 19" racks
Total 5 racks			

Q1 to Q6 (for each IP side)

DFHX+ DFHM spares

N. spare	PC current rating [kA]	N. Circuit served	N. of 19" racks
1	20	5	10
1	8	4	3
1	±4	12	0.5
1	0.4	10	0.5
1	±0.12	8	0.25

Q1 to Q6 (for each IP side)

DFHX+ DFHM spares

Installation surface [m^2]	10
Access/manipulation surface [m^2]	12
Linear installation extension [m]	9
Height [m]	2.6
Installation volume [m^3]	18
Cooling water flow rate [l/min]	100

Quench detection, Q.H. powering

Q1 to D1 (for each IP side)

circuits connected to the DFHX

C.M.	Circuit	DQS	Q.H.	Total racks
Q1-Q3	MQXF	1	2	1.5
	trim MQXF Q3	1	NA	0.5
Q2A-Q2B	MQXF	1	2	1.5
	trim MQXF Q2	1	NA	0.5
	MCBXB	4	Not def	2
CP	MCBXA	2	1	1.5
	MQSXF	1	0	0.5
	MCTXF	1	0	0.5
	MCTSXF	1	0	0.5
	MCDXF	1	0	0.5
	MCDSXF	1	0	0.5
	MCOXF	1	0	0.5
	MCOSXF	1	0	0.5
	MCSXF	1	0	0.5
	MCSSXF	1	0	0.5
D1	MBXF	1	1	0.5

D2 to Q6 (for each IP side)

Circuits connected to the DFHM

C.M.	Magnet	DQS	Q.H.	Total racks
D2	MBRD	1	1	1
	MCBRD	4	Not def	2
Q4	MQYY	2	1	1.5
	MCBYY	4	Not def	2
Q5	MCBY	6	0	3
	MQY	2	1	1
Q6	MCBC	2	0	1
	MQML	2	1	1

Plus 0.5 rack for each SC link itself

Space needed SC link included

	DFHX related	DFHM related
Total racks	14	14
Installation surface [m^2]	9	9
Access/manipulation surface [m^2]	11	11
Linear installation extension [m]	9	9
Height [m]	1.8	1.8
Installation volume [m^3]	25	25

Document re

Quench extraction

Quench extraction system main equipment modules		
Equipment	Dimensions [m]	remark
Energy extraction switch	2×2×2 [L×W×H]	Solid state based switches best guess for dimension 20 kA
Dump resistor	1×1×1 [L×W×H]	Cooled dump resistor with water to coolant heat exchanger. Best guess dimension for 10 MJ

Quench extraction number and volume approximation		
Equipment	No of units	Volume best guess on the base of energies and current
Energy extraction switch	5	2×[2×2×2]+3×[2×2×1]
Dump resistor	7	4×[1×1×1]+3×[0.5×0.5×0.5]

Quench extraction 1st guess installation surface and volume		
Equipment	Surface including access [m^2]	Volume [m^3]
Energy extraction switch	42	30
Dump resistor	20	5

Cold Powering volume and surface total needs

Q1 to D1 (for each IP side) including DFHX and DFHM						
	Q1 to D1	D2 to Q6	Spare PC Q1 to Q6	QDS	QEE	total
Installation surface [m^2]	52	68	10	18	25	173
Access/manipulation surface [m^2]	56	73	12	22	37	200
Linear installation extension [m]	46	61	9	18	14	148
Installation volume [m^3]	120	164	18	50	35	387
Cooling water flow rate [l/min]	305	400	100	NA	NA	810

DFH (X M A)	
Length [m]	11
Width [m]	0.95
Height [m]	1800
Installation surface [m^2]	11
Access surface [m^2]	13
Installation volume [m^3]	19

Arc including DFHA	
Installation surface [m^2]	37
Access/manipulation surface [m^2]	41
Linear installation extension [m]	35
Installation volume [m^3]	86

Summary per IP

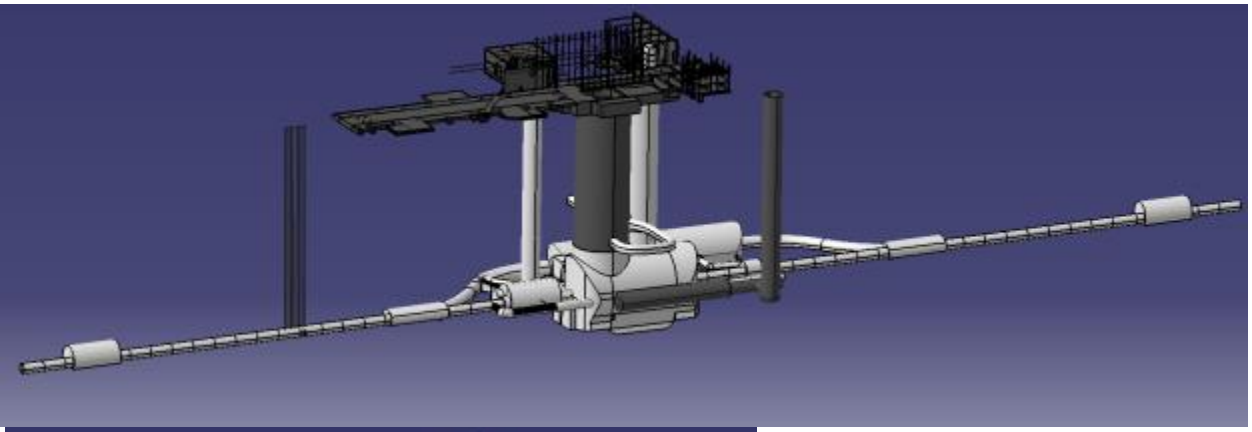
Maximum in surface				
	Crab cavities	Cryogenics	Cold Powering	Total
Installation area on surface	2×172 m^2 + 8 m^2	1000 m^2	2×450 m^2	2244 m^2
Installation area underground		150 m^2		150 m^2

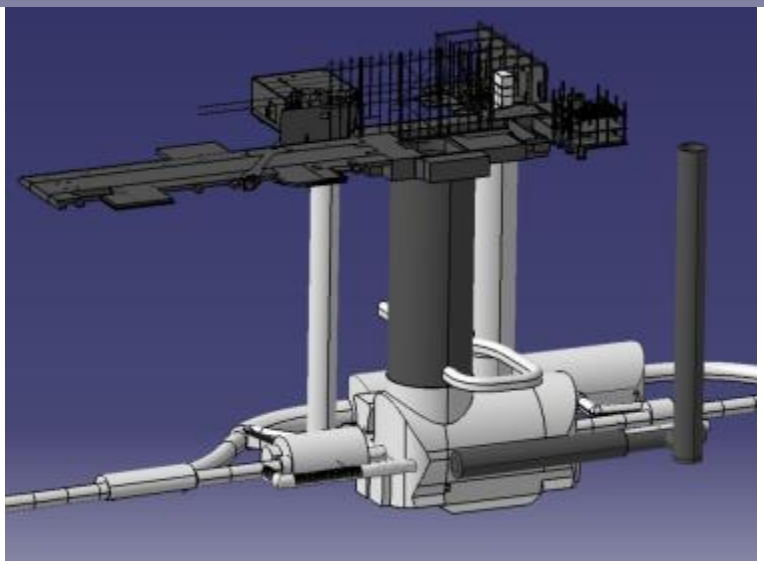
Maximum in tunnel				
	Crab cavities	Cryogenics	Cold Powering	Total
Installation area on surface	2×65 m^2	1000 m^2		1130 m^2
Installation area underground	2×107 m^2 + 8 m^2	150 m^2	2×450 m^2	1280 m^2

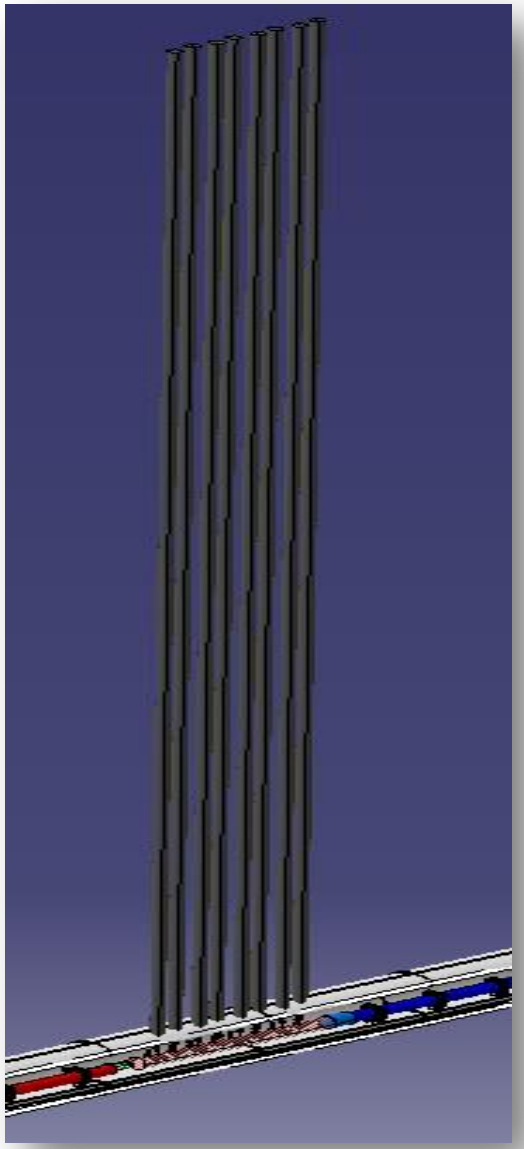
DFHA in RR				
	Crab cavities	Cryogenics	Cold Powering	Total
Installation area on surface	2×172 m^2 + 8 m^2	1000 m^2	2×372 m^2	2096 m^2
Installation area underground		150 m^2	2×88 m^2 (RR)	150+176 m^2

DFHA + QDS in RR				
	Crab cavities	Cryogenics	Cold Powering	Total
Installation area on surface	2×172 m^2 + 8 m^2	1000 m^2	2×332 m^2	2016 m^2
Installation area underground		150 m^2	2×128 m^2 (RR)	150+256 m^2

Option B2: short service tunnel







Option comparisons

		Option A1 CP: service tunnel RF: service tunnel New pit	Option A2 CP: surface RF: service tunnel New pit	Option B1 CP: surface RF: surface New pit	Option B2 CP: surface RF: surface Extension	Option B1 CP: surface RF: surface New pit	Option B2 CP: surface RF: surface Extension
		SC link to the DFHA				No SC link to the DFHA	
S	**Central building CRY**	1000 m^2	1000+900 m^2 ***1900 m^2***	1000+900+8 m^2 ***1908 m^2***	1000+900+8 m^2 ***1908 m^2***	1000+644+8 m^2 ***1652 m^2***	1000+280+8 m^2 ***1288 m^2***
		Cryo	Cryo + CP (X+M+A)	Cryo + CP (X+M+A) + LLRF	Cryo + CP (X+M+A) + LLRF	Cryo + CP (X+M) + LLRF	Cryo + CP (X+M) + LLRF
S	**Crab buildings CL and CR**			***175 m^2 +175 m^2***	***175 m^2 +175 m^2***	***175 m^2 +175 m^2***	***175 m^2 +175 m^2***
U	**Underground Extension**				***150 m^2***		***150 m^2***
					plus connection to LHC machine		plus connection to LHC machine
U	**RR**					2×128 m^2	2×128 m^2
U	**Service Tunnel**	2×(175+450) + 8 + 150 m^2 **2×*625+150 m^2***	2×(175) + 8 + 150 m^2 **2×*175+150 m^2***	***150 m^2***		***150 m^2***	
		RF+CP+LLRF+ Cbox	RF + LLRF + Cbox	Cbox		Cbox	
U	**Vertical**	New PIT	New PIT	New PIT	PM54	New PIT	PM54

Option comparisons I

	Option A1 CP: service tunnel RF: service tunnel New pit	Option A2 CP: surface RF: service tunnel New pit	Option B1 CP: surface RF: surface New pit	Option B2 CP: surface RF: surface Extension	Option B1 CP: surface RF: surface New pit	Option B2 CP: surface RF: surface Extension
	SC link to the DFHA				No SC link to the DFHA	
Access Crab	-	-	+	+	+	+
Access PC	-	+	+	+	+	+
Access QDS	-	+	+	+	+	+
Access QEE	-	+	+	+	+	+
Radio shielding PC	+	+	++	++	+	+
Radio shielding	+	+	+	+	+	+
Civil work impact on planning	Limited Connection to machine tunnel	Limited Connection to machine tunnel	Limited Crab connection	Important Common pit use	Limited Crab connection	Important Common pit use
Tunnel installation complexity	Very high	High	Mild	Mild	Easiest	Easy
Integration complexity	Difficult Cryo to SC link	Difficult Cryo to SC link	Mild	Mild	Easiest No SC link to DFBA	Easy No SC link to DFBA
Equipment simplification	Very high (only hor. SC link)	None	None	None	4 SC link less probably the most complex to install and integrate no modif. of	4 SC link less probably the most complex to install and integrate no modif. of DFBA

Option comparisons II

	Option A1 CP: service tunnel RF: service tunnel New pit	Option A2 CP: surface RF: service tunnel New pit	Option B1 CP: surface RF: surface New pit	Option B2 CP: surface RF: surface Extension	Option B1 CP: surface RF: surface New pit	Option B2 CP: surface RF: surface Extension
	SC link to the DFHA				No SC link to the DFHA	
Extension of underground civil work	+++	+++	++	+	++	+
Service underground installation	++++	+++	++	++	+	+