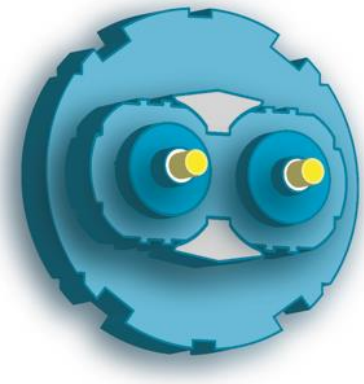

High Luminosity LHC

Power converter integration

Power converters for HL-LHC
WP 6b : Warm powering
Jean-Paul Burnet, CERN TE-EPC

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- *Introduction*
- *List of circuits*
- *Power converter types*
- *Power converter integration*
- *Infrastructure needed*

Infrastructure for Power Converters

All new power converters for HL-LHC (inner triplet and matching section) will be installed in new UR gallery.
Power converters transform electricity from AC to DC to power magnets.
Power converters are placed between the mains and the DFHM.

Power converters needs:

- *Electricity*
- *Cooling-water*
- *control*
- *Air conditioning*

Power converters shall be close to electrical switchboard and DHFM to minimized the cabling and limit the losses.

List of circuits for HL-LHC

List of circuits for one IP side for inner triplet and matching section magnets.
All IP side are identical.

Optics	Magnet	Operating current 7TeV [kA]	Lmagnet [mH]	Power converter max current [kA]	Uncertainty ppm of max current with weekly calibration
MQXF Q1-Q3	MQXFA	16.3	138	16.5	±1ppm
Q3		±1.6	69	2	±10ppm
Q2a-Q2b	MQXFB	16.3	117	16.5	±1ppm
Q2b		±0.3	58.5	0.3	±100ppm
CP	MCBXFA	±1.6	18	2	±10ppm
CP	MCBXFB	±1.6	33	2	±10ppm
CP	MCQSX	±0.182	1247	0.2	±100ppm
CP	MCTX	±0.167	229	0.2	±100ppm
CP	MCTSX	±0.157	52	0.2	±100ppm
CP	MCDX	±0.139	107	0.2	±100ppm
CP	MCDSX	±0.139	107	0.2	±100ppm
CP	MCSX	±0.132	118	0.2	±100ppm
CP	MCSSX	±0.132	118	0.2	±100ppm
CP	MCOX	±0.12	152	0.12	±100ppm
CP	MCOSX	±0.12	152	0.12	±100ppm
D1	MBXF	12	25	13	±10ppm
D2	MBRD	12	27	13	±10ppm
	MCBRD	±1.7	46	2	±10ppm
Q4	MQYY	4.8	31	6	±10ppm
	MCBYY	±1.6	46	2	±10ppm
Q5	MQY	4.5	74	6	±10ppm
	MCBY	±0.088		0.12	±100ppm
Q6	MQML	5.4	21	6	±10ppm
	MCBC	±0.1		0.12	±100ppm

List of power converters for HL-LHC

List of power converters needed for the inner triplet and matching section magnets:

Power converter	Current	Voltage	Quadrant	Quantity per IP side
Type 1	16.5kA	20V	1	2
Type 2	13kA	18V	1	2
Type 3	6kA	8V	1	6
Type 4	±2kA	±10V	4	15
Type 5	±600A	±10V	4	1
Type 6	±200A	±10V	4	7
Type 7	±120A	±10V	4	10
Total				43

Power converter types

The power converters will be of the same type as the present one.
2 new types will be developed but based on the same technology.

Main Quadrupoles: 13kA/18V

Same family

Atlas Toroid: 20.5kA/18V

Individual Quadrupoles: 6kA/8V

4-quadrant for correctors : ±600A/±10V

4-quadrant for correctors : ±120A/±10V

4-quadrant for correctors : ±200A/±10V
±2kA/±10V

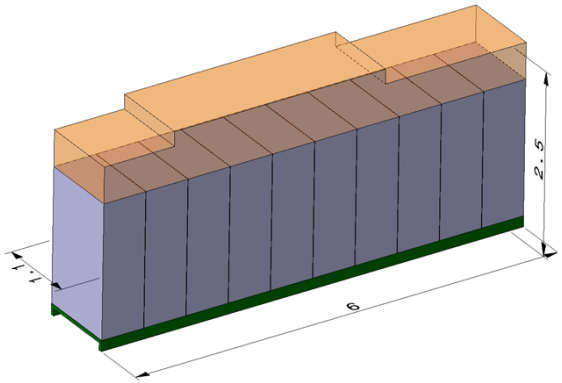
New types

Power converter underground integration

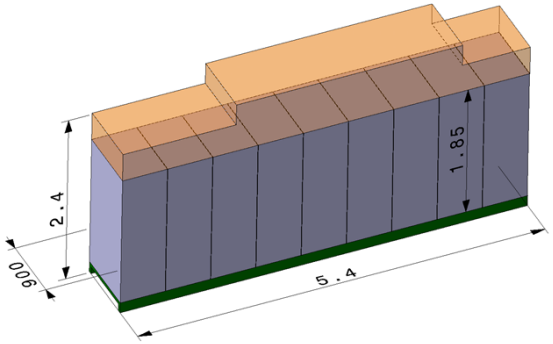
The installation should be similar to a present UA.
No mezzanine.
Space for transport and installation.
No rear access to racks.

Power converter size

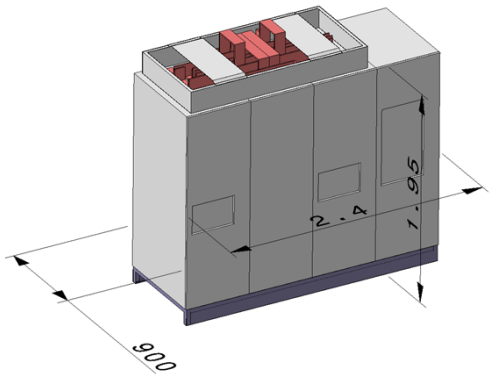
Type 1



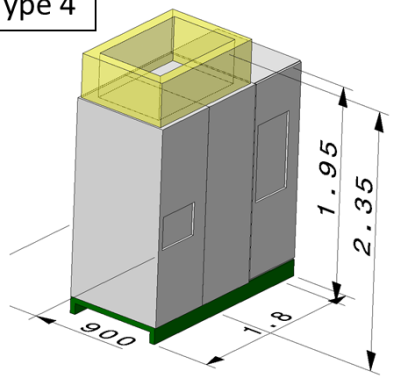
Type 2



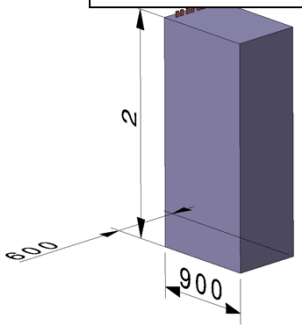
Type 3



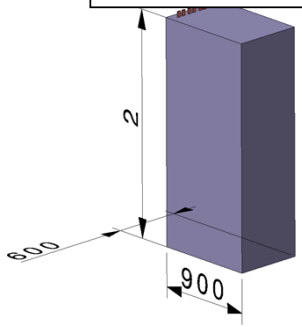
Type 4



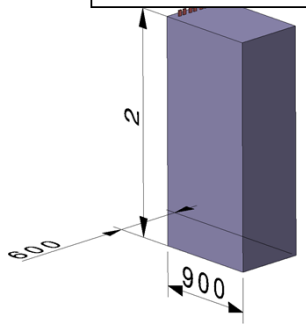
2 * Type 5 = 1 racks



2 * Type 6 = 1 racks



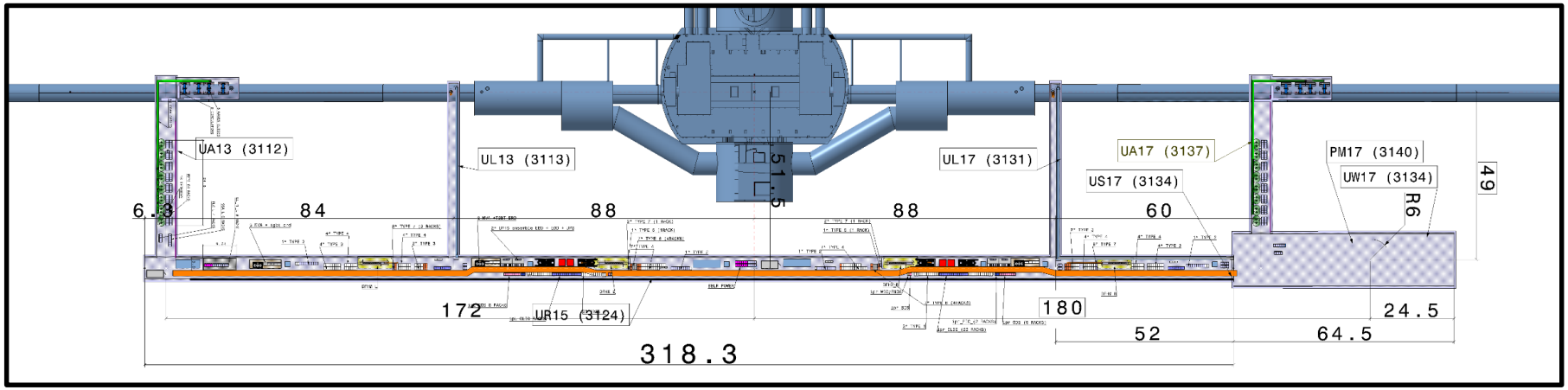
4 * Type 7= 1 racks



Power converter integration

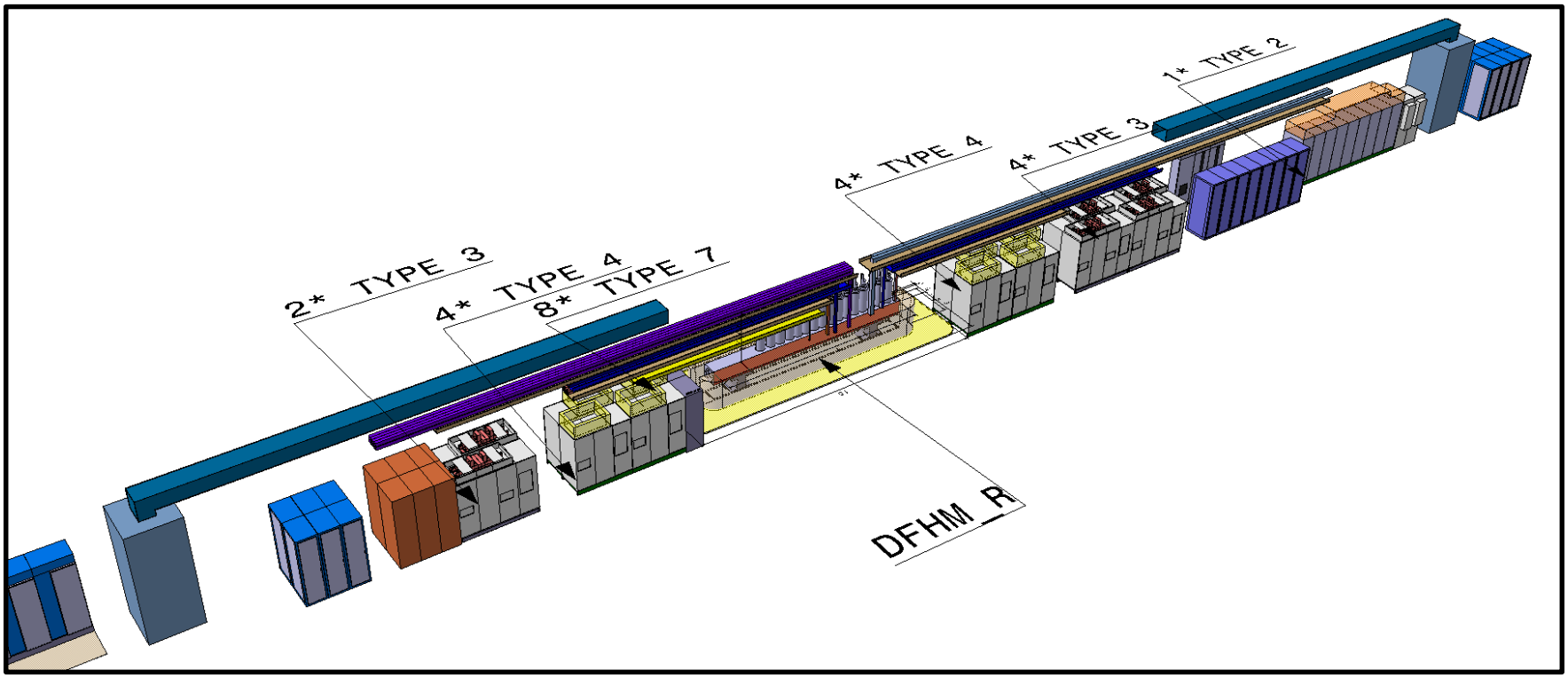
All power converters will be installed in underground galleries, UR.

The UR contains the power converters for both IP side. In total 86 power converters will be installed in this gallery.



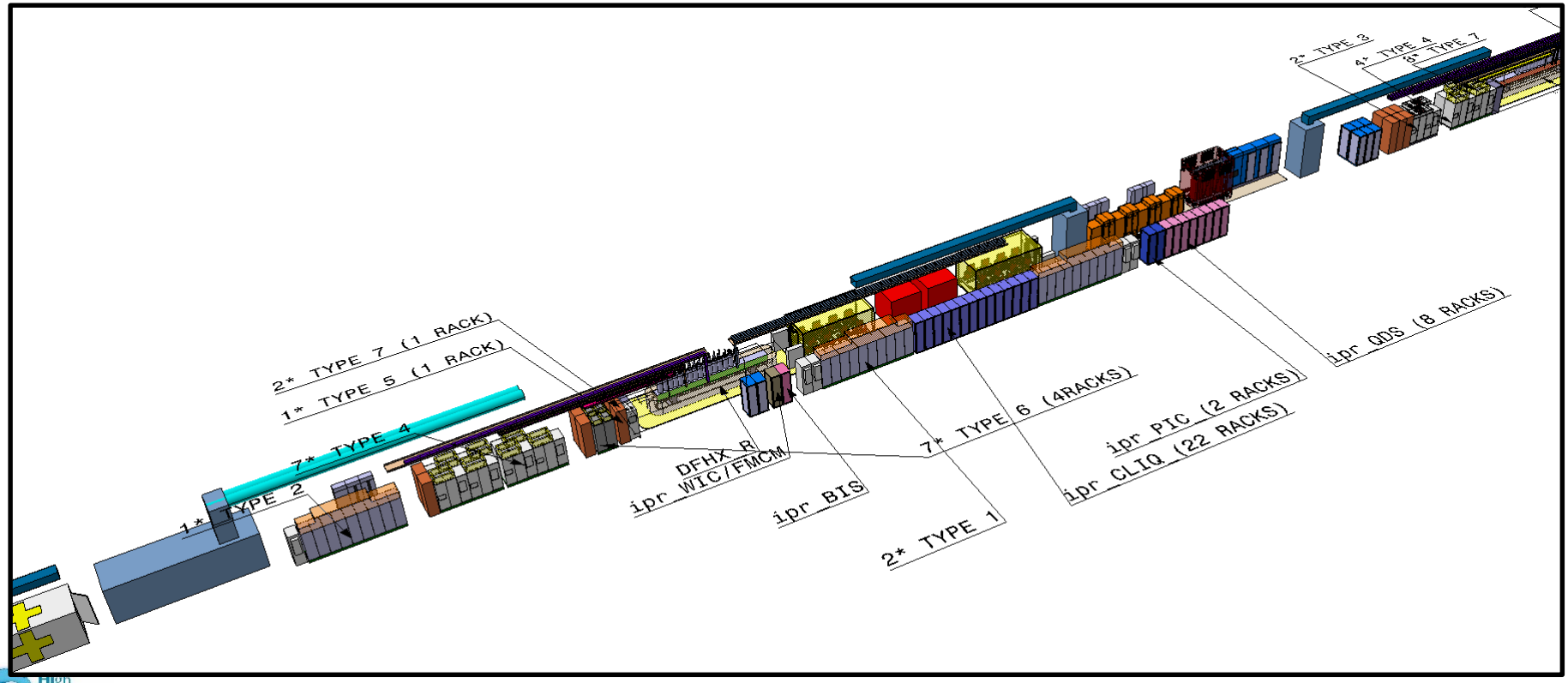
Power converter underground integration

Layout of the UR15, arrangement around the DFHM



Power converter underground integration

Layout of the UR gallery.



Infrastructure needed

- *Electricity (400V)*
- *UPS (400V) for control electronics*
- *Classical DC cables (<1kA)*
- *Water cooled cables (>1kA)*
- *Water cooling for power converters and DC cables*
- *Air conditioning*
- *Ethernet (technical network)*
- *Gateway for control FGC2 or FGC3 (worldfip or Ethernet)*
- *PIC*
- *BIC*
- *WIFI*

Power converter size

The size of the power converter is based on the present one.

Power converter	DC Current	DC Voltage	Quantity per building	Number of racks 19'' / converter
Type 1	16500	20	4	9
Type 2	13000	18	4	7
Type 3	6000	8	12	4
Type 4	2000	10	30	3
Type 5	600	10	2	0.5
Type 6	200	10	14	0.5
Type 7	120	10	20	0.25
Total			86	

Corresponding to 215 equivalent rack 19’’ inside the UR.

Electricity

The list of AC sockets is presented below for one UR.

Power converter	DC Current	DC Voltage	Quantity per building	AC type	AC current	AC socket	Total AC current	Total AC socket
Type 1	16500	20	4	400V tri-phase	595	630	2382	2520
Type 2	13000	18	4	400V tri-phase	422	630	1689	2520
Type 3	6000	8	12	400V tri-phase	87	100	1039	1200
Type 4	2000	10	30	400V tri-phase	36	63	1083	1890
Type 5	600	10	2	400V tri-phase	11	16	22	32
Type 6	200	10	14	400V tri-phase	4	10	51	140
Type 7	120	10	20	400V tri-phase	2	10	43	200
Total			86				6308	8502

Water cooling for power converters

The water flow needed for the power converter for one UR.

Power converter	DC Current	DC Voltage	Quantity per building	water flow l/min	Connection in / out	Differential Pressure drop B	Total water l/min
Type 1	16500	20	4	60	DN32	3.0	240
Type 2	13000	18	4	45	DN32	3.0	180
Type 3	6000	8	12	15	DN25	2.5	180
Type 4	2000	10	30	10		3.0	300
Type 5	600	10	2	5	¼''	3.0	10
Type 6	200	10	14				0
Type 7	120	10	20				0
Total			86				910

without the water-cooled cables.

Losses in Air for power converters

The air losses are presented below for one IP side.

Power converter	DC Current	DC Voltage	Quantity per building	Air losses W	Total Air losses W
Type 1	16500	20	4	4000	16000
Type 2	13000	18	4	3100	12400
Type 3	6000	8	12	1100	13200
Type 4	2000	10	30	800	24000
Type 5	600	10	2	234	468
Type 6	200	10	14	600	8400
Type 7	120	10	20	470	9400
Total			86		83868

Control infrastructure

Additional racks are needed for the control infrastructure.

- *Gateway racks, 2 racks 19''*
- *Calibration rack for high-precision measurement, 4 racks 19''*

High voltage power supplies for crab cavities

To power the crab-cavities, two options are possible depending of the power needed.

Option 1: tetrode

Option 2: IOT

High voltage power supplies for crab cavities

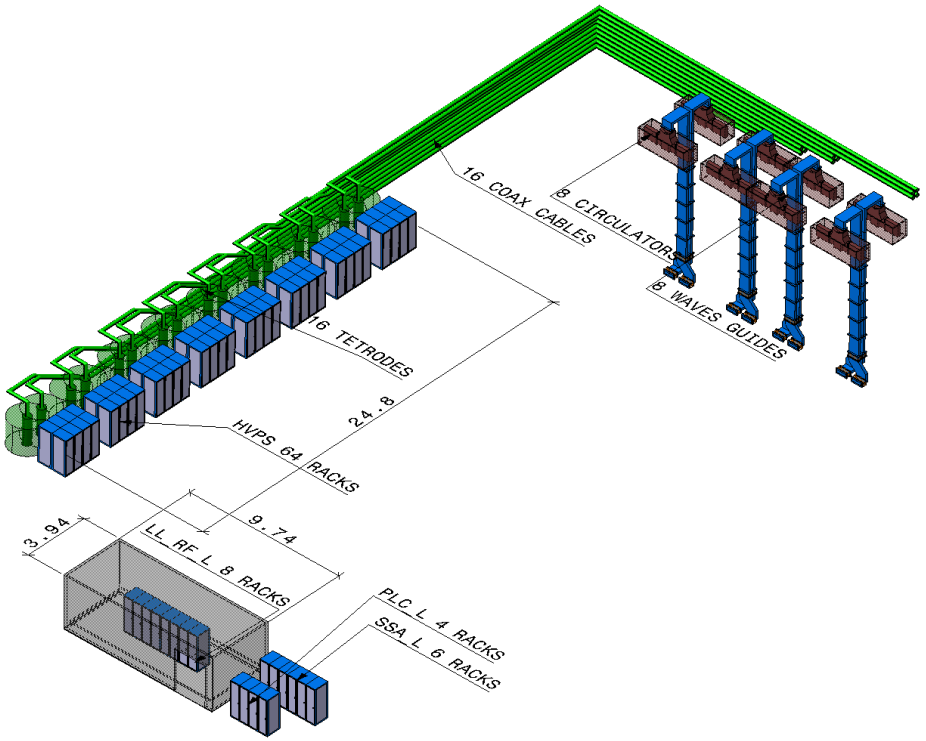
Option tetrode:

Each tetrode needs an HVPS. 8 tetrodes are placed in UA with its associated HVPS.

HVPS rating:

200kVA, 10kV DC
4 racks 19''
Water cooled

Total power is 3.2 MW per IP.



High voltage power supplies for crab cavities

Option tetrode: SR17

18 HVPS placed in SR17. 16 + 2 spare converters.
4 racks 19'' / HVPS
Water cooled

*AC socket : 400A * 18*
*DC cable: 10kV / 10A * 18*
*UPS: 1kVA * 18*

*Air losses : 16 * 20kW + 40kW for test*

*Water losses: 16 * 10kW + 40kW for test*

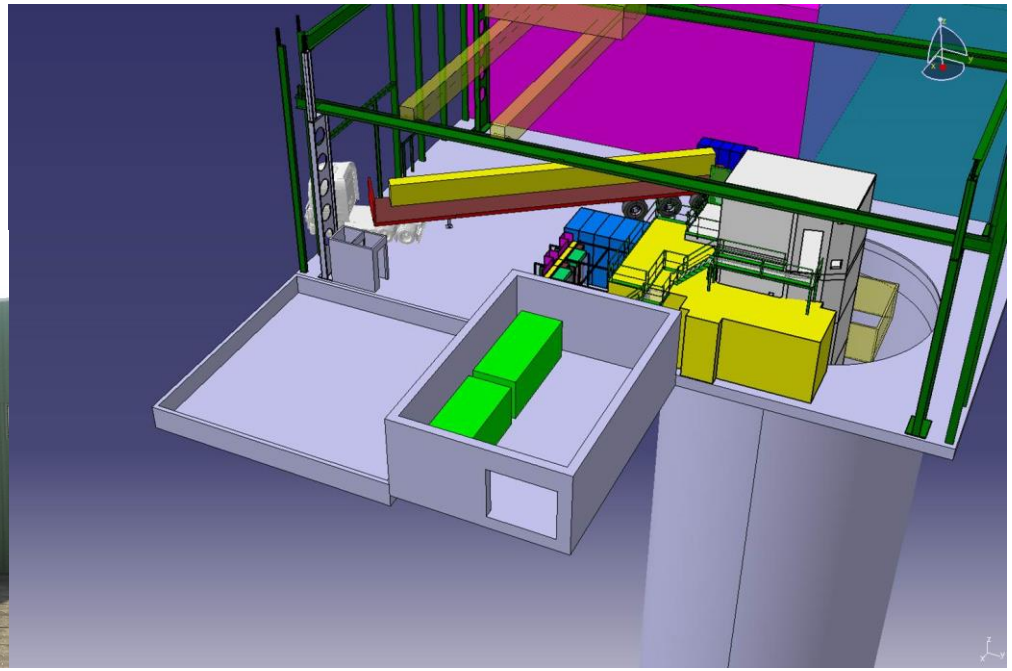
High voltage power supplies for crab cavities

Option IOT:

IOT need 50kV DC power. The power converter technology is completely different and oil is need for insulation. In this case, the solution is to place the HVPS in surface. One HVPS for one IP side.

HVPS rating:
2MVW, 50kV DC

Total power is 4 MW per IP.



Summary

- All needs were communicated for the integration works and service groups.

- All is inside the model.