

Electrical Power Converters Group and forthcoming Tendering opportunities

related to built-to-print manufacturing of Electrical Cabinets and Modules

Konstantinos Papastergiou, Valerie Montabonnet and Yves Thurel

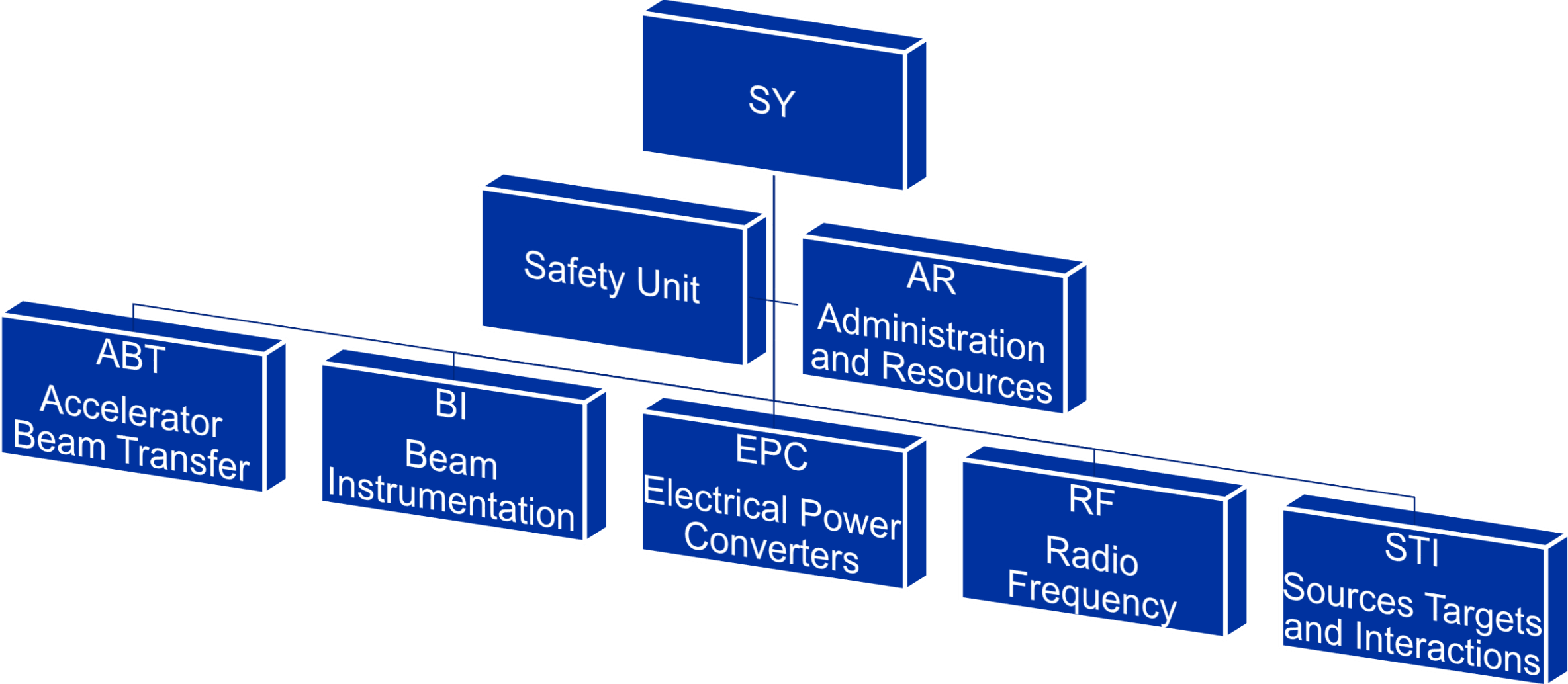
Summary

- ➔ Electrical Power Converters Group at CERN
 - Mandate – Mission – Challenges
 - Purchasing Strategy of the Group

- ➔ Forthcoming Tendering opportunities for Supply Contracts (▪→2028)
 - North Area Consolidation Project
 - High Luminosity LHC Project

Electrical Power Converter Group

Structure



Electrical Power Converters

Mandate

The EPC Group is in charge of the electrical power converters for all accelerators, transfer lines, experimental areas and tests facilities at CERN:

- Solid-state modulators for RF klystrons;
- High-voltage power converters for RF amplifiers and particle sources;
- Power converters from 100W to 100MW for DC, cycling or pulsed magnets;
- Static VAR compensators and harmonic filters.



Electrical Power Converters

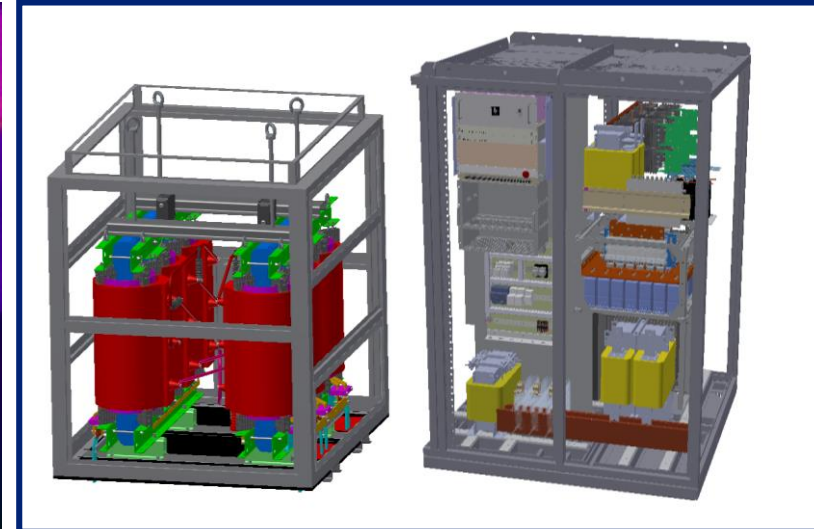
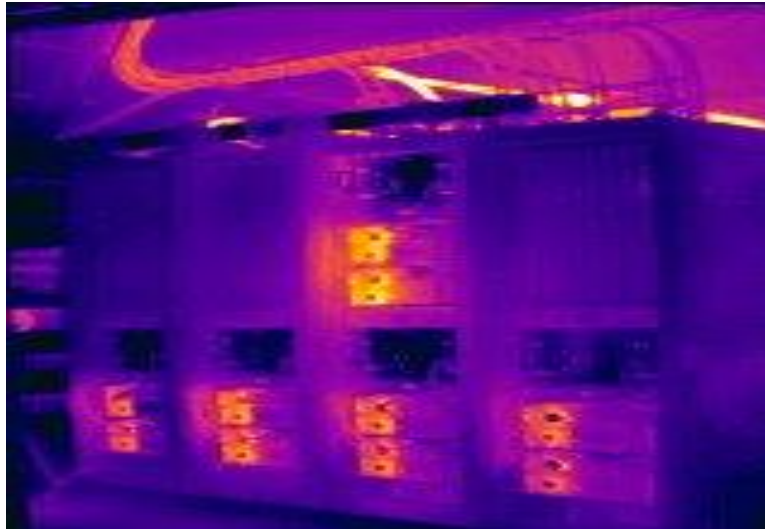
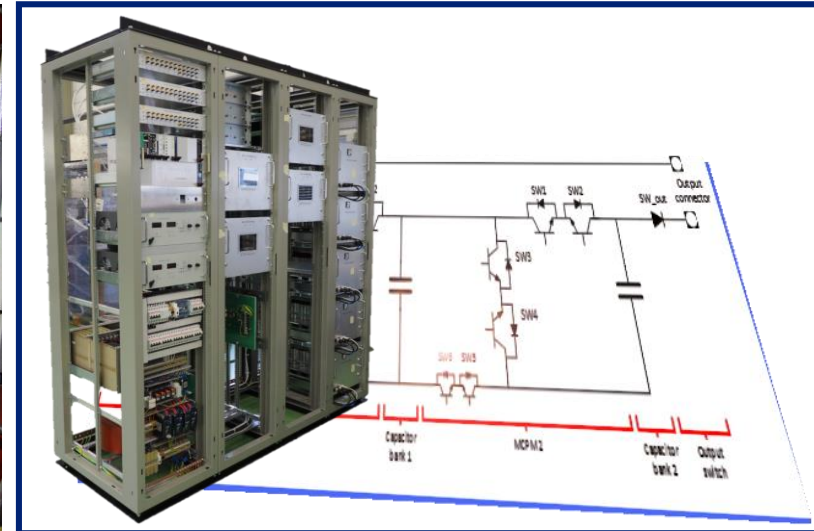
Mission

Design and Prototype converters for CERN specific accelerator needs including consolidation projects

Procure power converters based on functional specification or build-to-print files through CERN member states companies

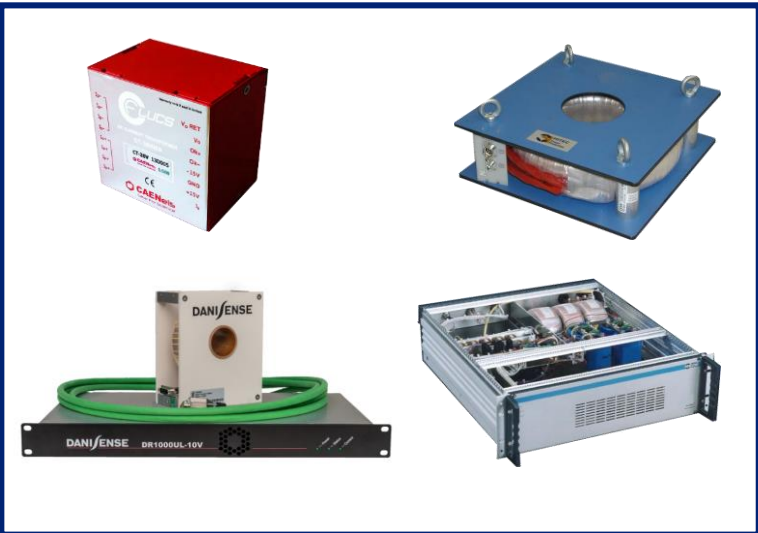
Test, install, operate and maintain CERN power converters with the highest availability

Study new technologies and topologies for CERN future machines



Electrical Power Converters

- Energy management & efficiency including magnet energy recovery
- High-precision and fast-pulsed power converters (ms range)
- Advanced regulation & real time control
- Availability
- Ionizing radiation environment
- Capital and operational cost

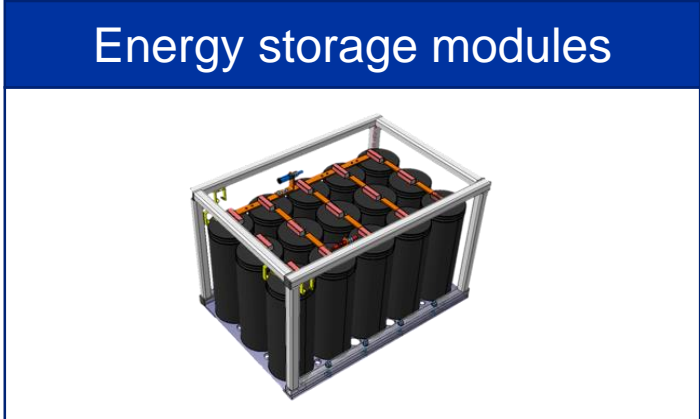
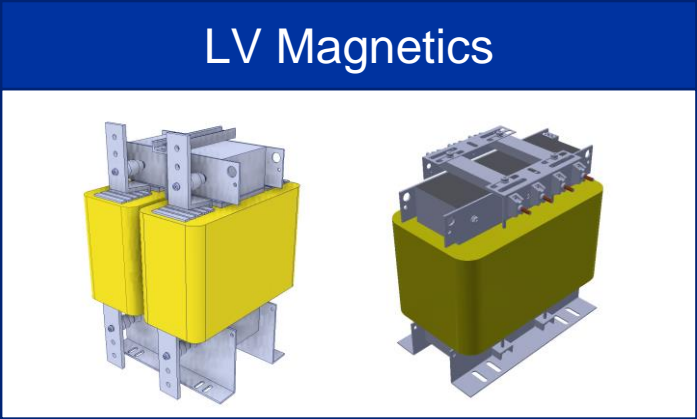
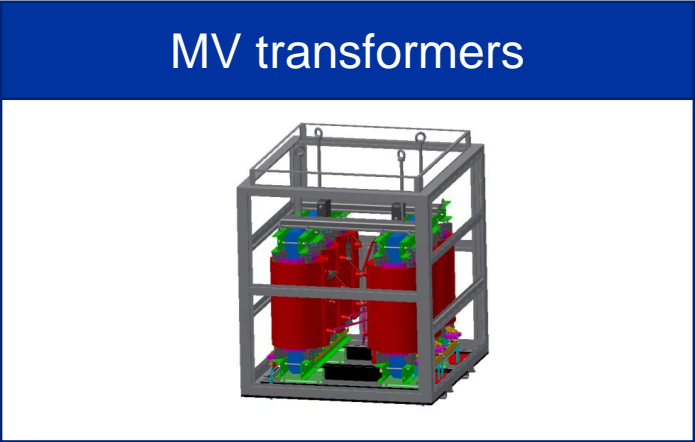
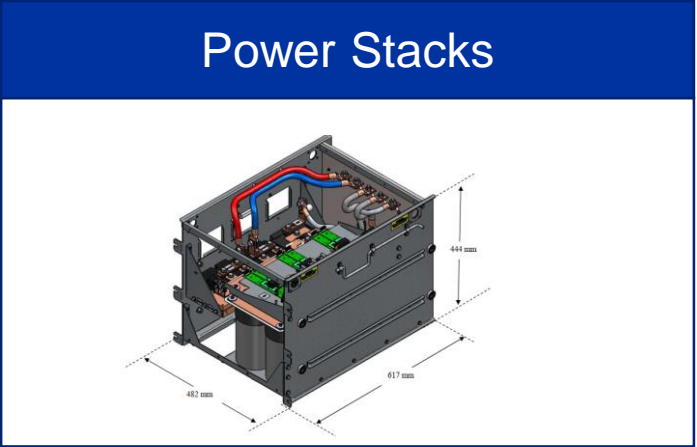


Challenges

Electrical Power Converters Industry opportunities

Be part of CERN consolidation and upgrade projects

Design, manufacture and tests of **build-to-specification** equipment

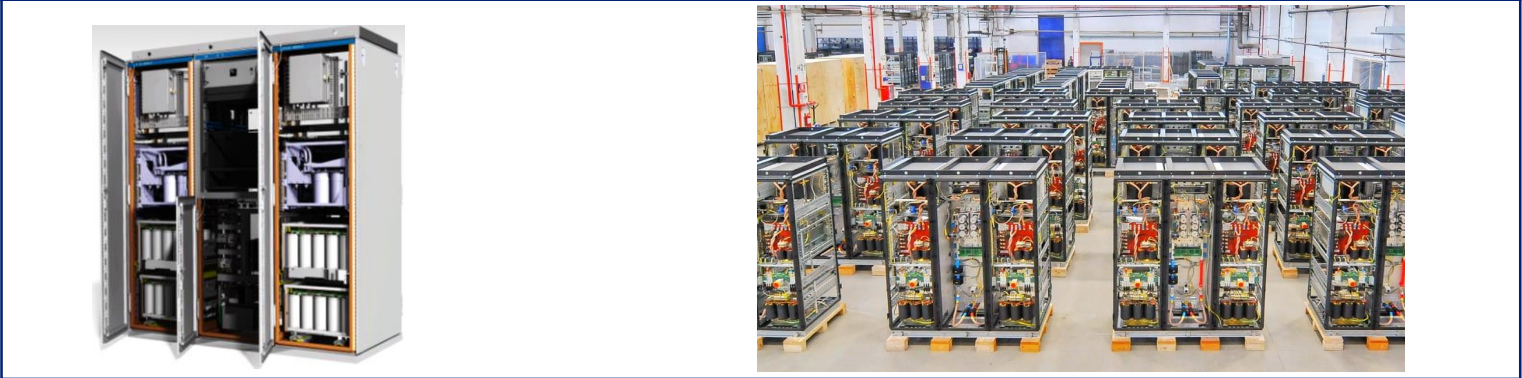


Electrical Power Converters Industry opportunities

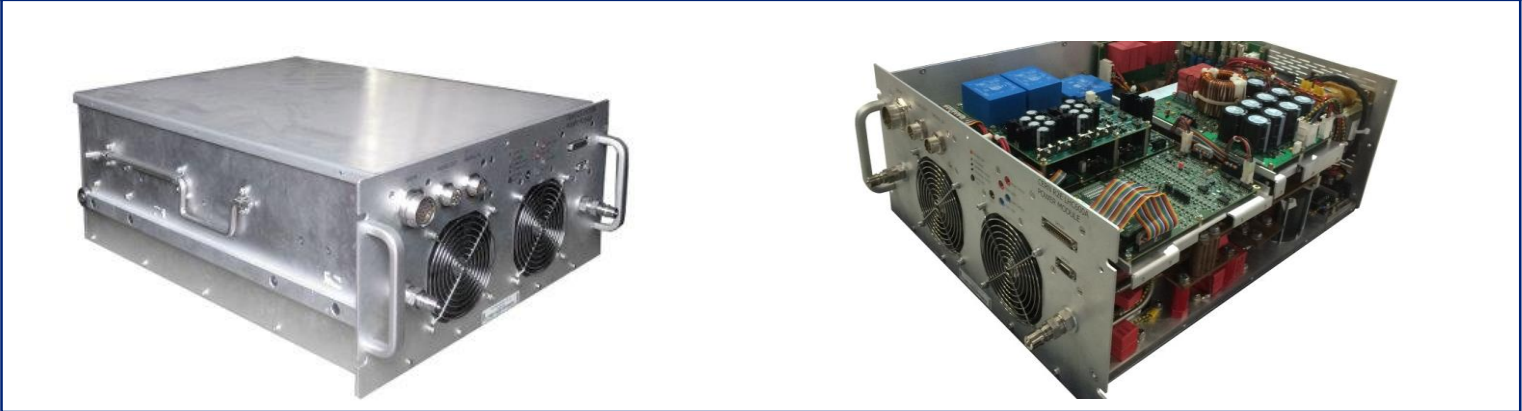
Be part of CERN consolidation and upgrade projects

Manufacture, test build-to-print equipment's

Integration / Cabling



Power Module Production



Useful links for Procurements

Doing business with CERN



Publication date	Type of contract	Reference	Description	Cost Range (CHF)	Status	Next step
01/09/2022	Supply	MS-4810/SY/HL-LHC	Supply of 36 collimators as part of the HL-LHC project.	750k - 5M	Announcement	Market Survey 10/2022
01/09/2022	Supply	MS-4813/SY/HL/LHC	Supply of 600 SiO2 coaxial RF cables required for the Beam Instrumentation and Collimation activities within the High Luminosity Large Hadron Collider project HL-LHC.	200k - 750k	Announcement	Market Survey 11/2022
20/07/2022	Supply	MS-4759/SY	Supply of the design, manufacture, and testing of Energy Banks for the projects NA_CONS phase 1 and phase 2 and SPS_CONS phase 1 (LS3:480 Energy Banks)	5M - 10M	Announcement	Market Survey 09/2022
20/07/2022	Supply	MS-4754/SY	Supply of design, manufacture, and testing of POLARIS power stacks for the projects NA_CONS phase 1 (LS3: 490 power stacks) and phase 2 (LS4L: 540 power stacks), and SPS_CONS phase 1 (LS3: 130 power s	5M - 10M	Market Survey	Invitation to Tender 10/2022
19/07/2022	Supply	MS-4758/SY	Supply of NEPTUNE sets of low voltage reactors and LV transformers.	750k - 5M	Announcement	Market Survey 08/2022
19/07/2022	Supply	MS-4753/SY	Supply of power cabinets manufacturing, assembly and cabling (built-to-print).	> 10M	Announcement	Market Survey 09/2022
28/06/2022	Supply	MS-4756/SY	Supply of POLARIS sets of low voltage reactors.	750k - 5M	Market Survey	Invitation to Tender 10/2022
20/06/2022	Supply	MS-4755/SY	Supply of design, manufacture, and testing of BOREAL power stacks for the projects NA_CONS phase 1 (LS3: 19 power stacks) and phase 2 (LS4L: 26 power stacks).	200k - 750k	Announcement	Market Survey 07/2022
09/06/2022	Supply	MS-4760/SY	Supply of design, manufacture and conformity tests of Power Resistor Sets for the POLARIS project	750k - 5M	Announcement	Market Survey 08/2022
30/05/2022	Supply	MS-4757/SY	Design, manufacture and testing of POLARIS power stacks (2023: 620 units, 2028: 540 units)	750k - 5M	Market Survey	Invitation to Tender 12/2022
29/06/2021	Supply	MS-4708/SY	Supply of six HV generators, with voltage multiplier stack	200k - 750k	Market Survey	Invitation to Tender 12/2021

[Click to view all forthcoming Opportunities](#)

Case 1 North Area Consolidation

Electrical Cabinets for Medium Power Converters

Project leader: *Ivan Josifovic*

Tender Technical Officer: *Konstantinos Papastergiou – K.Papastergiou@cern.ch*

Tender Procurement Officer: *Daniel Schoerling*

Project Scope

North Area

Beam from SPS

Primary beam

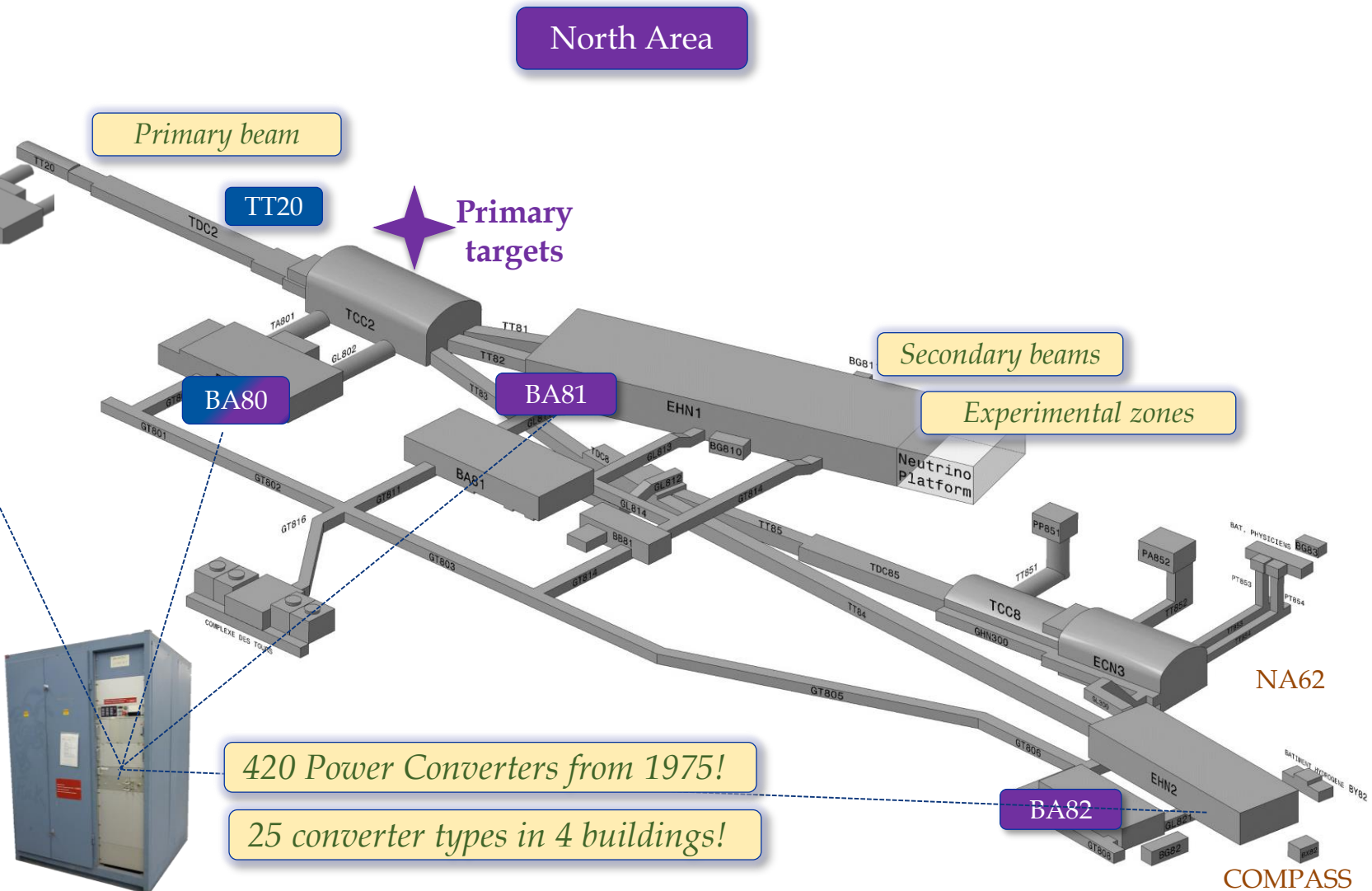
Primary targets

Secondary beams

Experimental zones

420 Power Converters from 1975!

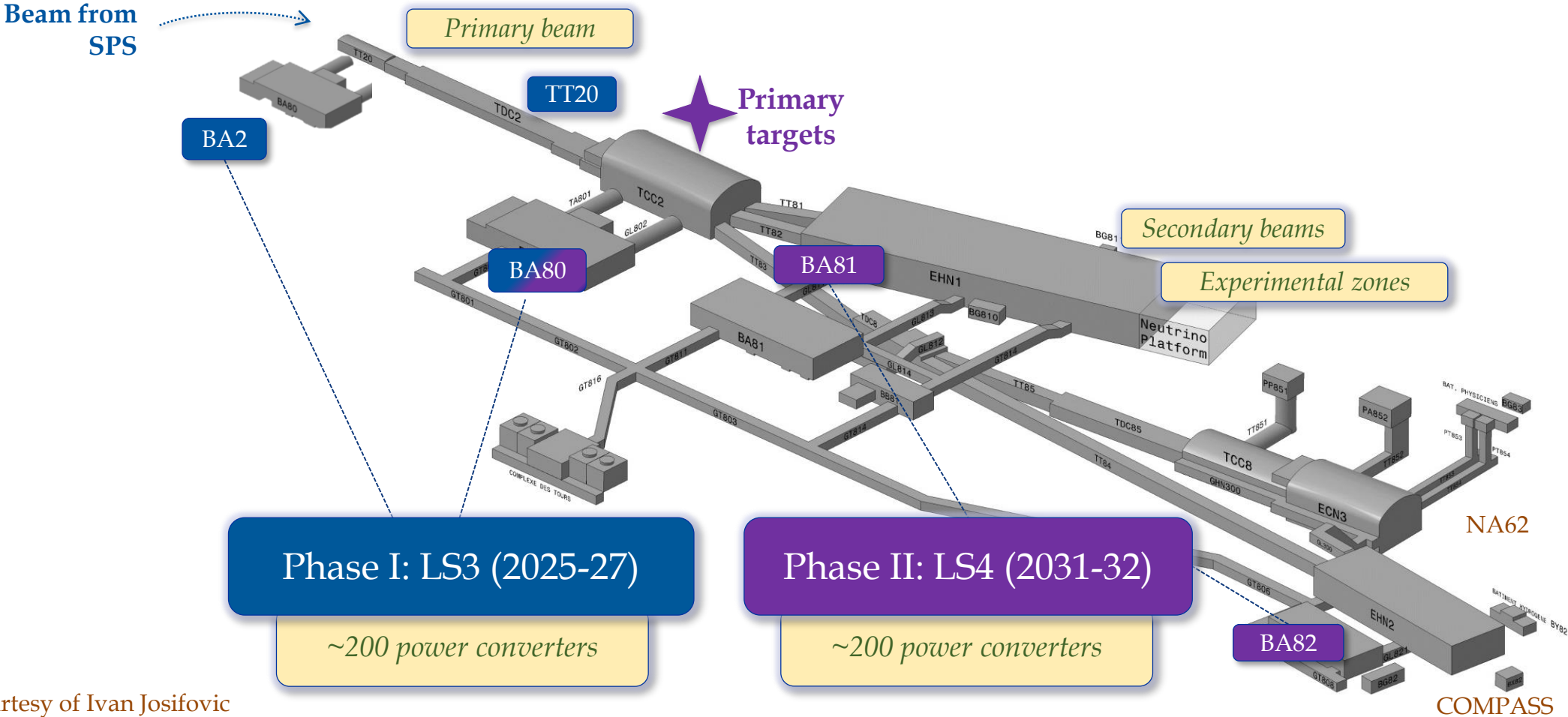
25 converter types in 4 buildings!



Courtesy of Ivan Josifovic

Consolidation Strategy: Phase I and Phase II

North Area



Courtesy of Ivan Josifovic

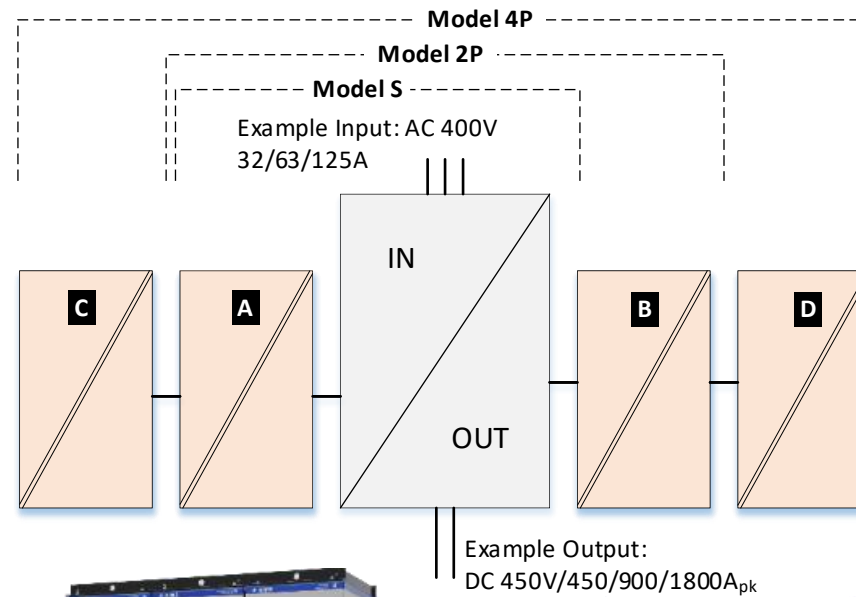
What and how

Typical requirements

- ➔ Power converters cabinets manufacturing (built-to-print)
- ➔ Typical contract duration is 5 years (+2 option)
- ➔ Approximate quantities are 200 to 500 systems/7years
- ➔ The cabinet voltage level is 1000Vdc and supply voltage is 400Vac
- ➔ Typically integrated in 19inch racks (<5 racks per system)
- ➔ The scope of the supply includes:
 - Procurement of off-the-shelf parts and raw material (copper, aluminium...)
 - Manufacturing or purchasing of enclosures (cabinets)
 - Sheet metal works (cutting, drilling, bending, welding, surface treatment) for aluminium, steel.
 - Manufacturing of copper busbar (cutting, drilling, bending, surface treatment/insulation)
 - Assembly of cooling water distribution circuit (<1inch pipework, inox + flexible hoses)
 - Assembly and cabling of subassemblies and cabinets
 - Quality control and tests of subassemblies and complete cabinets
 - Storage and delivery
- ➔ Outsourcing shall be permitted for some of the activities



Typical converter size



POLARIS type	$U_{o, pk}$ (output voltage)	$I_{o, peak}$ (output peak current)	Approximate QTY
S	400 V	500 Apk	150
2P	400 V	1000 Apk	170
4P	400 V	2000 Apk	150



Model S

 800



Model 2P

 1300

W1800mm x D900mm x H2200mm

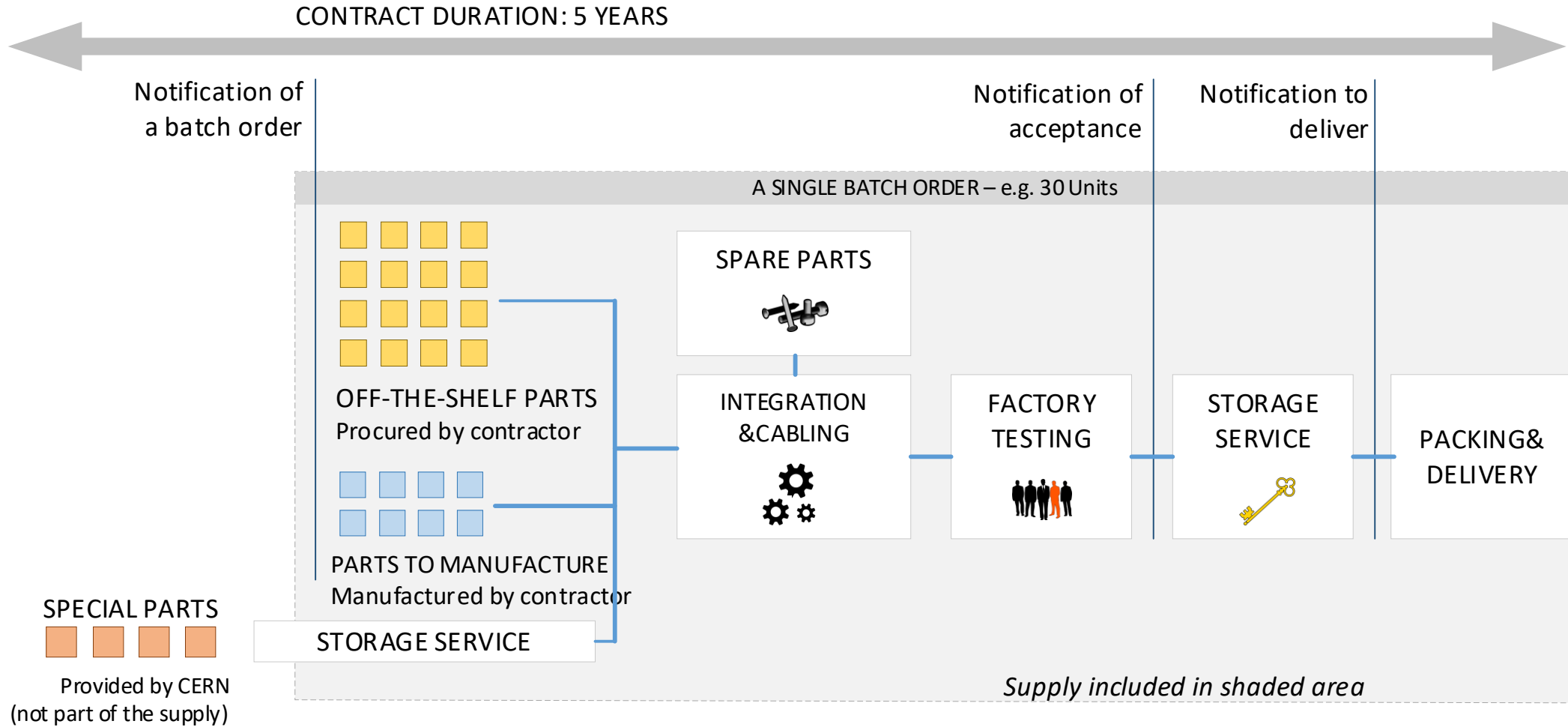


Model 4P

 2200

W3000mm x D900mm x H2200mm

Typical order roll-out

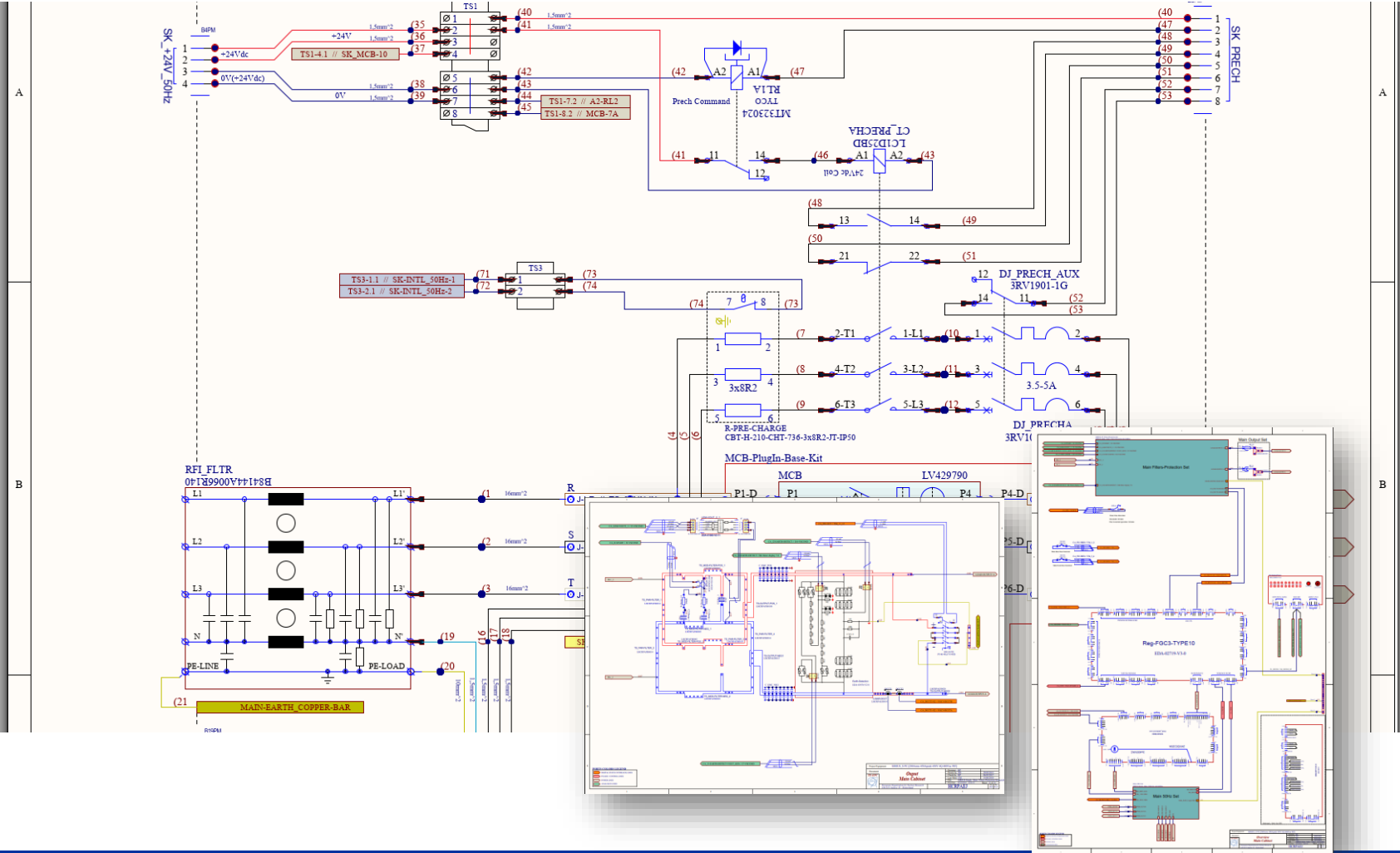


Built-to-print

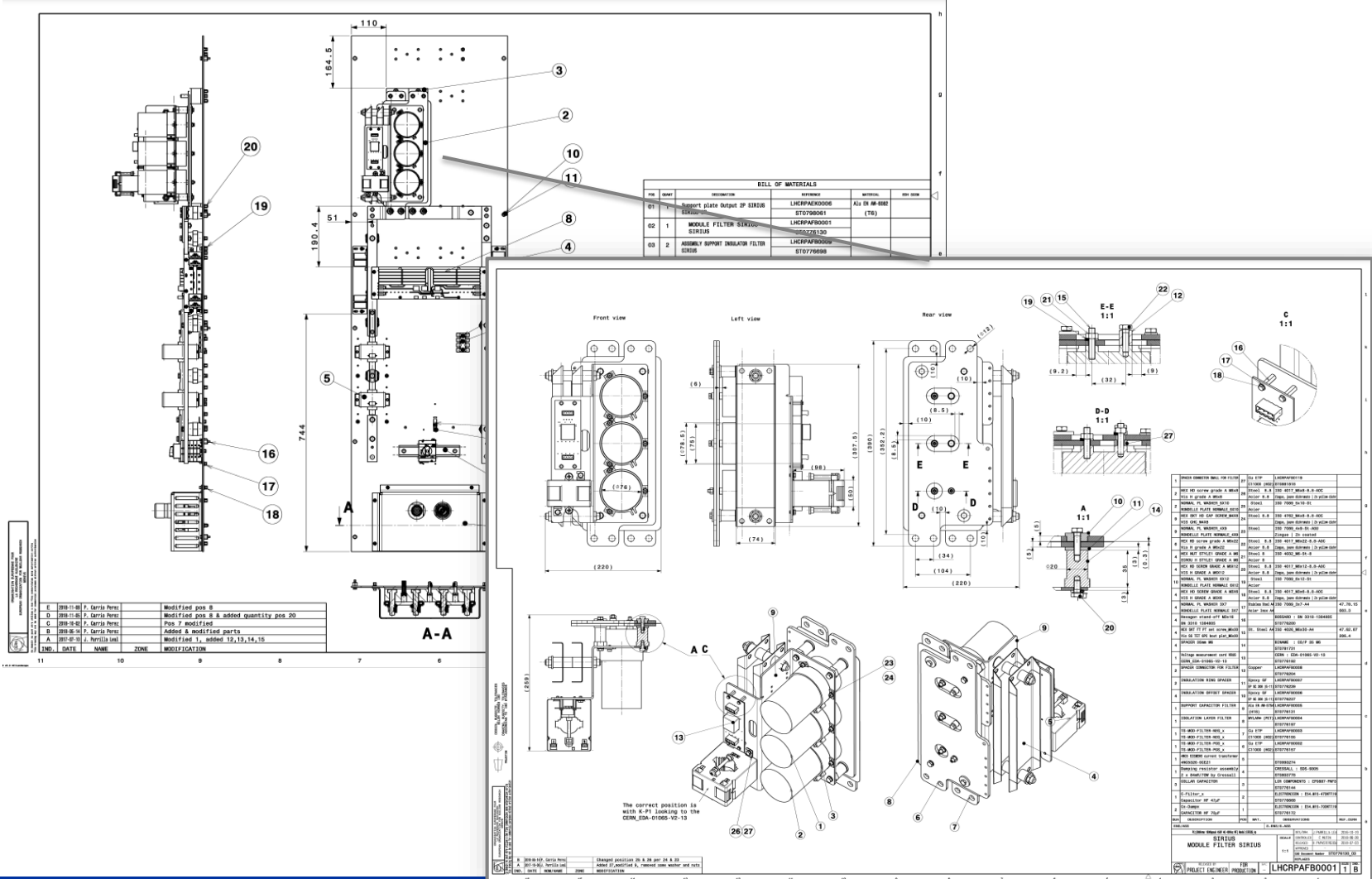
CERN manufacturing folder includes:

- Electrical diagrams
~10 A3 pages organised per sub-assembly
- Bill of materials
~ 300 part numbers per model
- Drawings of parts & assemblies
~ 120 2d and assembly drawings/converter model
- 3d step files
- Cabling lists
~ 160 cables per converter model
- Auxiliaries (stickers, labels)

Electrical drawings



Mechanical drawings



Bill of materials

Bill of materials

Bill Of Material Report												
ITEM Number	ST0797439 Rev a.00											
Definition	SIRIUS S CONVERTER											
Nomenclature	LHCRPAE/0033											
Date	1 - 9 - 2017											
Extracted by	Parrilla Leal Javier											

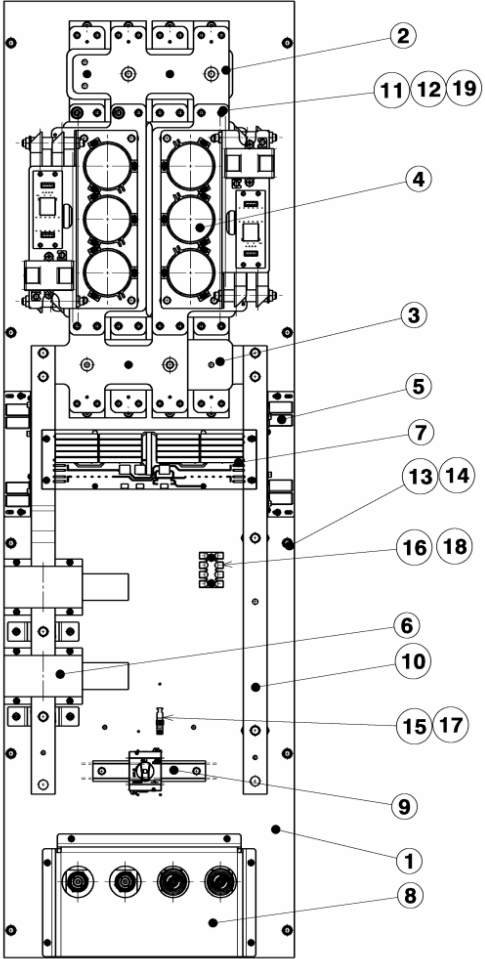
Item present in various sub assemblies

ITEMS and documents												
Type	ST number	Revision	Definition	Nomenclature	Index	total qty	Make or Buy	Mass	Supplier	Supplier Ref	Document type	Material
ITEM	ISO 4762_M4x8-8.8-A0C		HEX SKT HD CAP SCREW_M4X8			20	Normalized					Steel 8.8
ITEM	ISO 7089_3x7-A4		NORMAL PL WASHER 3X7			4	Normalized					Stainless Steel A4 Acier Inox.
ITEM	ISO 7089_4x9-St-A0U		NORMAL PL WASHER_4X9			13	Normalized					Steel
ITEM	ISO 7089_5x10-St		NORMAL PL WASHER_5X10			20	Normalized					Steel Acier
ITEM	ST0776131		SUPPORT CAPACITOR FILTER	LHCRPAF0005		1	CERN Design					Alu EN AW-6060 (T6)
ITEM	ST0776144		COLLAR CAPACITOR			3	Commercial Item			LCR COMPO/EP0887-PNF3		
ITEM	ST0776155		TS-MOD-FILTER-NEG_x	LHCRPAF0003		1	CERN Design					Cu ETP C11000 (H02)
ITEM	ST0776157		TS-MOD-FILTER-POS_x	LHCRPAF0002		1	CERN Design					Cu ETP C11000 (H02)
ITEM	ST0776172		Cx-Dampx			2	Commercial Item			ELECTRONICO E54-M15-703NT/79		
ITEM	ST0776192		Voltage measurement card VBUS			2	Commercial Item			CERN EDA-01065-V2-10		
ITEM	ST0776195		TI TRANSFO 500/1A 4N53			1	Commercial Item			SIEMENS 4NC5326-OCE20		
ITEM	ST0776197		ISOLATION LAYER FILTER	LHCRPAF0004		1	CERN Design					Polyethylene (PE)
ITEM	ST0776200		Hexagon stand-off M3x16			4	Commercial Item			BOSSARD BN 3318-1384805		
ITEM	ST0776204		SPACER CONNECTOR FOR FILTER	LHCRPAF0008		2	CERN Design					Copper
ITEM	ST0776237		INSULATION OFFSET SPACER	LHCRPAF0006		4	CERN Design					Epoxy GF EP GC 308 (G-11)
ITEM	ST0776239		INSULATION RING SPACER	LHCRPAF0007		2	CERN Design					Epoxy GF EP GC 308 (G-11)
ITEM	ST077666R		C-Filter			1	Commercial Item			ELECTRONICO E54-M15-471NT/79		

Cables list

Cable name	Cable	Sub-assem	END 1			Cable	Length	Cable	Sub-assem	END 2		
			Terminal 1	termination reference 1	con					terminal 2	termination reference 2	connector pin 2
CA_+24V-50Hz	Main	24VAuxPow	SK_+24V_OUT1	PLUG-ROUND-CABLE-4C-TY-UT		2x1.5mm2-CERN	200	Main	50HzSwBrd-;SK_+24V_50Hz	SOCKET-ROUND-CABLE-4C-TY-UT		
				PIN-BURNDY-MAL-1.5mm2	1					PIN-BURNDY-FEM-1.5mm2	1	
				PIN-BURNDY-MAL-1.5mm2	5					PIN-BURNDY-FEM-1.5mm2	5	
CA_POWER-24V	Main	24VAuxPow	SK_POWER-24V	PLUG-ROUND-CABLE-12C-TY-UT		12x0.5mm2-SHIELDED-CABLE	200	Main	CtrlCrate	SK_POWER	SOCKET-ROUND-CABLE-12C-TY-UT	
CA_M+24VOUT2 // J21-VSCOND	Main	24VAuxPow	SK_+24V_OUT2	PLUG-ROUND-CABLE-4C-TY-UT		2x1.5mm2-CERN	150	Pow-A	VSCond	J21-VSCOND	SOCKET-WEID-2WAY	
CA_M+24VOUT3 // J24V-INTF	Main	24VAuxPow	SK_+24V_OUT3	PLUG-ROUND-CABLE-4C-TY-UT		2x1.5mm2-CERN	150	Pow-A	PStack	J24V-INTF		
CA_INTF // FGC3-PULSES_A	Main	CtrlCrate	SK_PULSES_A	PLUG-ROUND-CABLE-19C-TY-UT		24x0.22mm2-SHIELDED-CABLE	150	Pow-A	PStack	SK_PULSE	SOCKET-ROUND-CABLE-19C-TY-UT	

Example: SIRIUS converter



Example: SIRIUS converter



[Video: Converters example](#)

Case 2 High Luminosity LHC

Power modules and Integration in Racks for Low Voltage Converters

Work Package leader: *M. Martino*

Tender Technical Officers: *Y. Thurel*, *S. Pittet*, *N. Kuczerowski*, *V. R. Herrero Gonzalez*

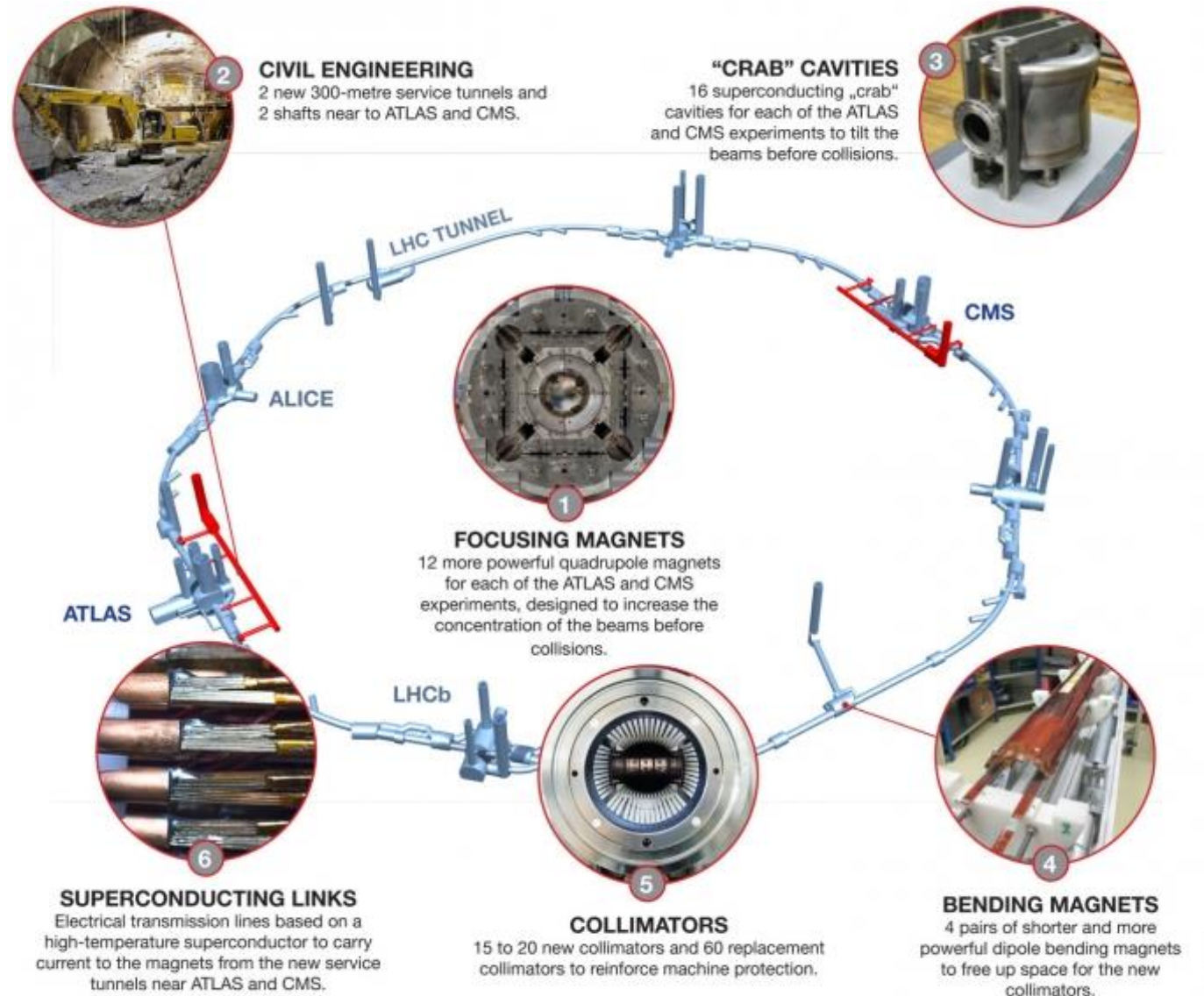
Tender Procurement Officer: *D. Schoerling*

HL-LHC in a nutshell

The High-Luminosity LHC (HL-LHC) is a major upgrade of the Large Hadron Collider (LHC).

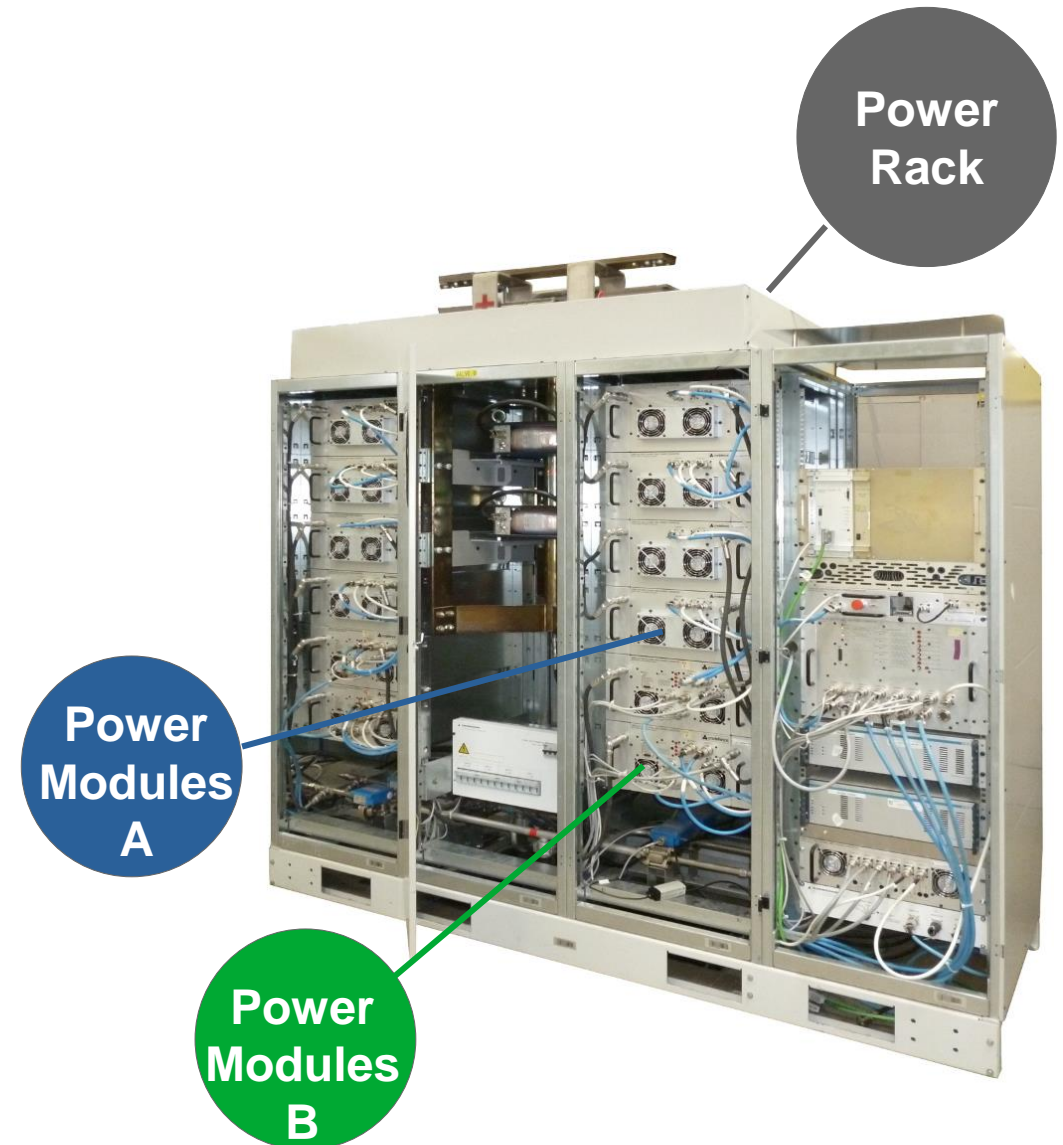
The High-Luminosity LHC will make it possible to observe rare processes by increasing the instantaneous number of collisions by a factor of between five and seven.

New focusing Magnets requires new powering scheme, involving new power converters, planned for installation in LS3 (2025-2027).



Project Scope

- Four main types of Power Converters entirely designed by CERN (**built-to-print**) for HL-LHC.
 - HL-LHC18kA-10V **05** converters
 - HL-LHC14kA-08V **09** converters
 - HL-LHC600A-10V ~ **20** converters
 - R2E-HL-LHC120A-10V ~**120** converters
 - R2E-HL-LHC60A-10V ~**150** converters
- For each type, and **even if level of power is largely different**, Power Converter is
 - **A housing rack**
 - **Several Power Modules** (quantity & types depending on output power level)

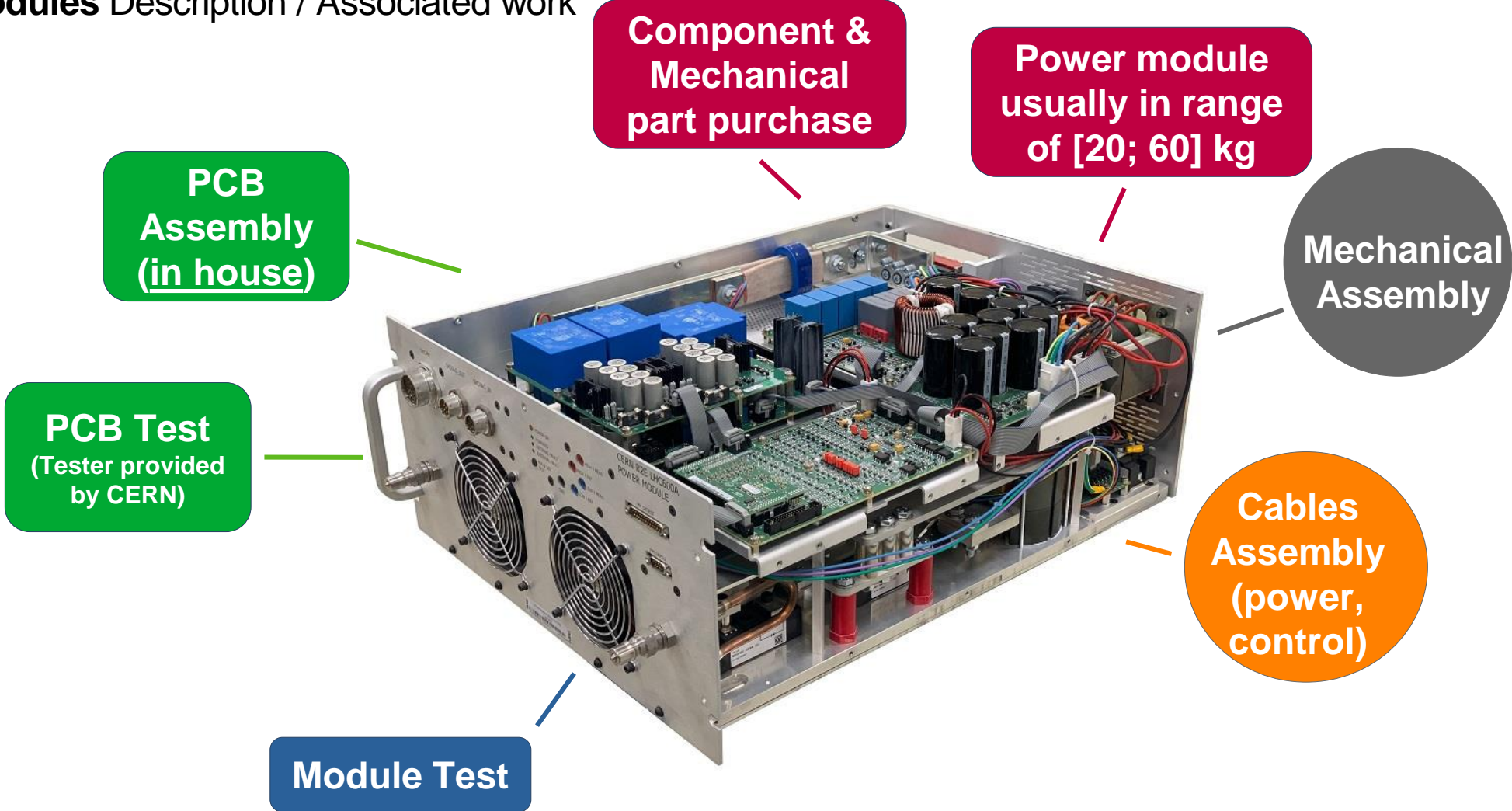


Organisation of sub-packages

- Three **production types** – depends on project
 - Production of **complete power converters** (power modules + its rack)
 - Production of **power racks only**
 - Production of **power modules only**
 - Project **timeline**
 - Power Modules **Market survey**
 - Power Modules **Invitation to Tender will come per project**
 - Power Racks depends on projects (MS & IT)
 - Project **Power Modules** Quantity – per project
 - HL-LHC18kA-10V
 - HL-LHC14kA-08V
 - HL-LHC600A-10V
 - R2E-HL-LHC60& 120A-10V
- MS Q4-**2022**
IT Q2-**2023**..Q1-**2024**
2023-2024
- 220** power modules (**3**-types)
250 power modules (**2**-types)
70 power modules (**3**-types)
1 200 power modules (on **2**-types)

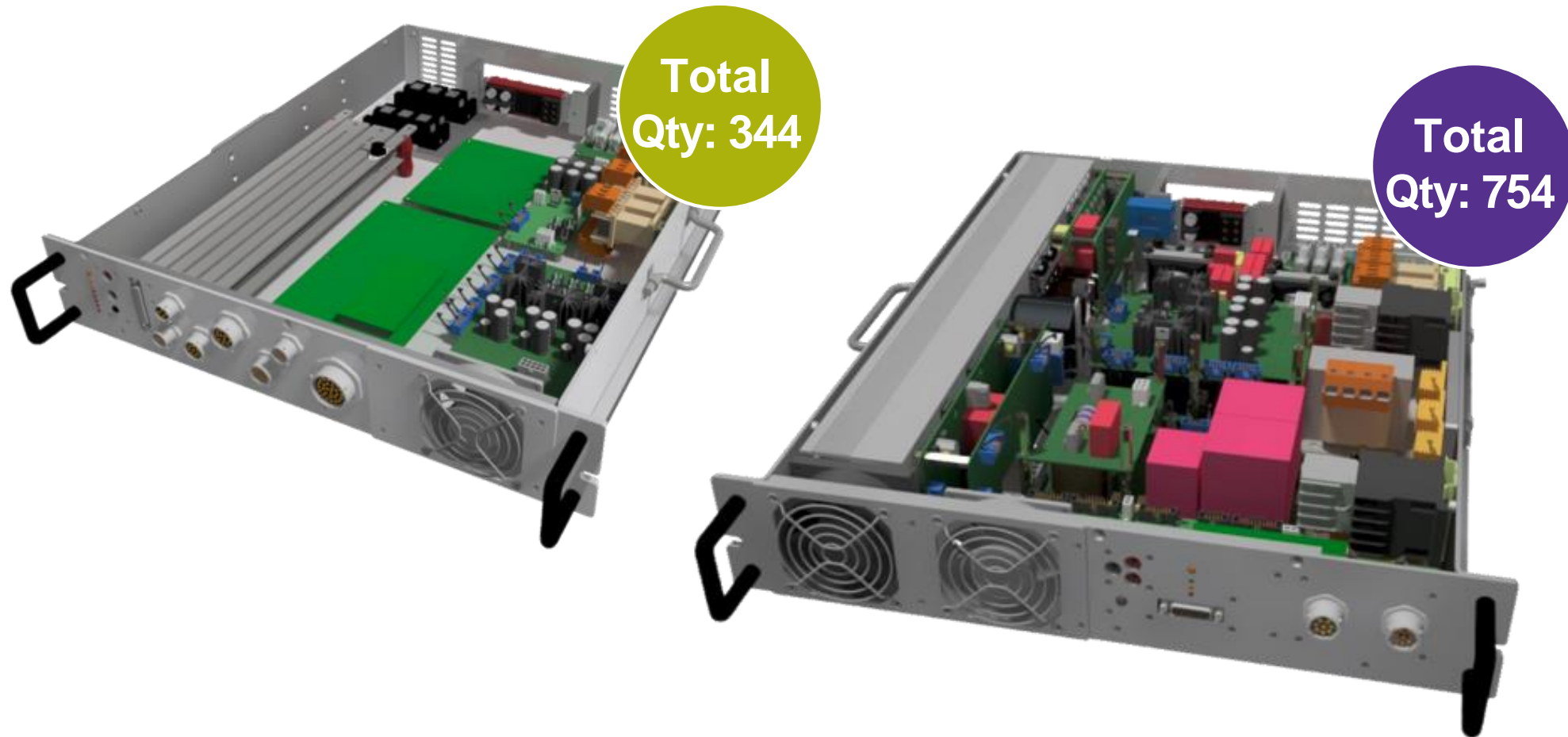
Power Modules

- **Power Modules** Description / Associated work



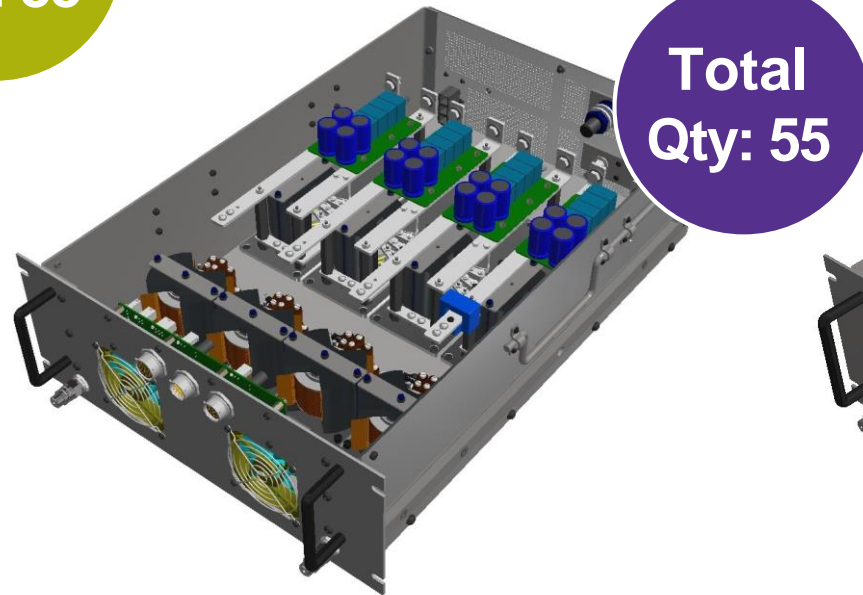
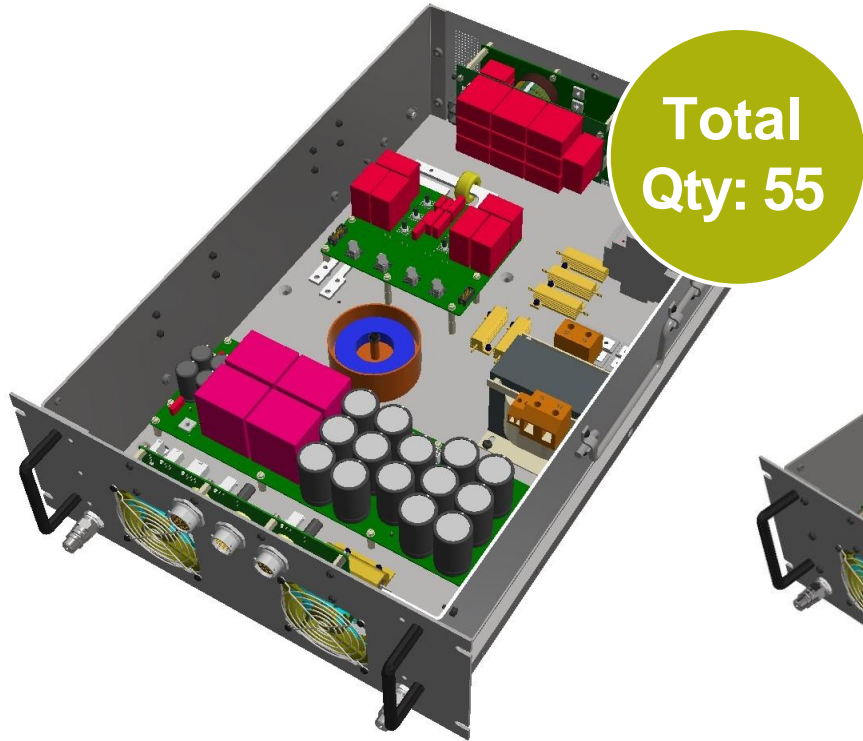
Examples of Power Modules

- Power Modules Examples-1



Examples of Power Modules

- Power Modules Examples-2



Rack Integration

- **Power Racks** Description / Associated work



**Component &
Mechanical part
purchase**

**Cables
Assembly
(power, control)**

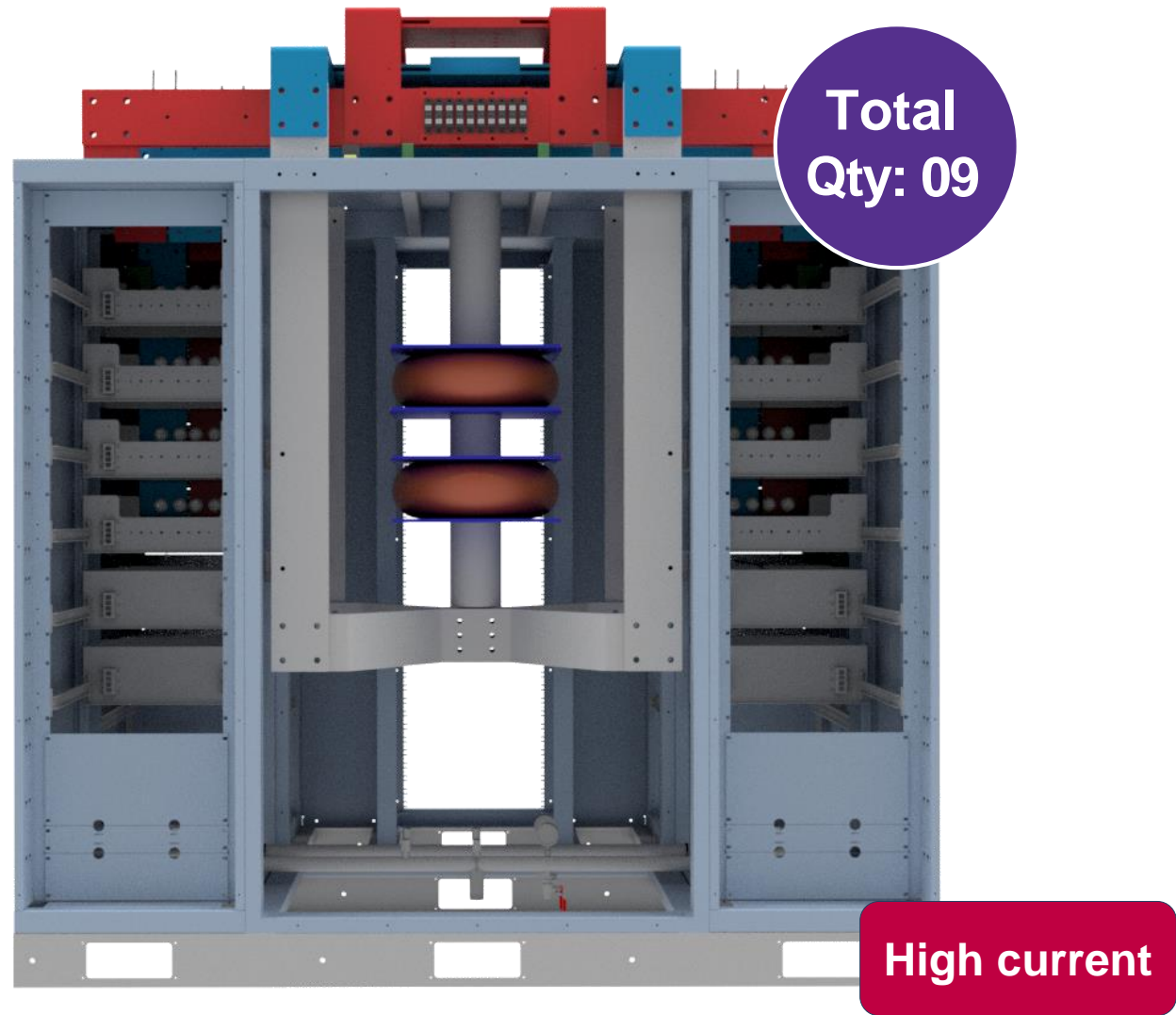
**-Power-
Mechanical
Assembly**



Typical Rack Series Production

Examples of Racks

- Power Racks Examples





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