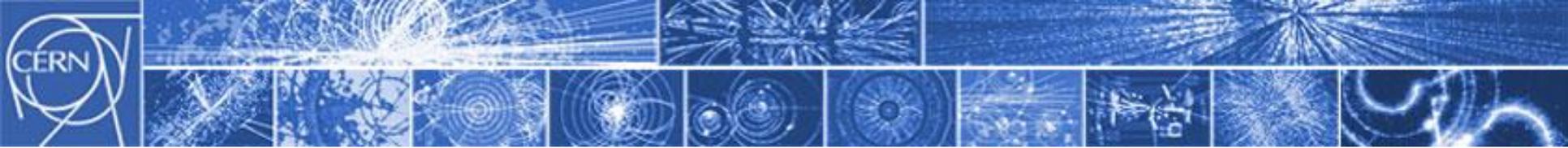


*POPS-B: The new MPS for the PS  
Booster 2GeV LIU project*

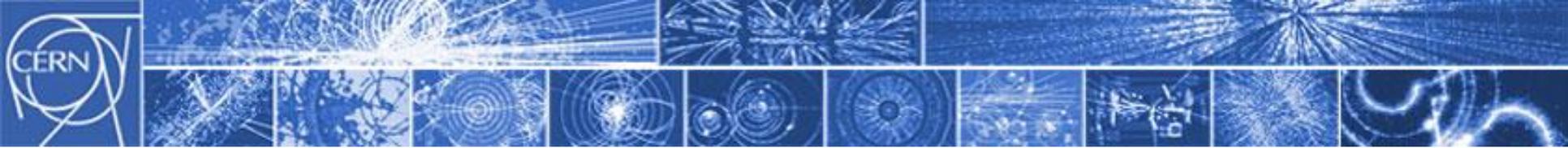
LIU-PSB-WG

Fulvio Boattini TE/EPC/HPC



## Summary

- POPS-B: the Booster 2GeV MPS
- Magnets Upgrade
- POPS-B design
- Project Management
- Project Planning



## POPS-B: the Booster 2GeV MPS



## Booster 2GeV MPS: budget

The project includes the following working units:

- Construction of a new building to host the new MPS
- Realization of the MPS high power converters (MPC)
- Realization of the quadrupole trims (+ injector and extraction trims)

The total budget is 16MCHF

- Building: 3.4MCHF
- MPS high power converters: 12 MCHF
- Trims: 0.6MCHF

Commissioning 2019 (end LS2)



# Booster 2GeV MPS: budget

The dream team:

Fulvio Boattini, Yves Gaillard, Xavier Genillon: project coordinators and power converters

Natacha Lopez: b245 construction

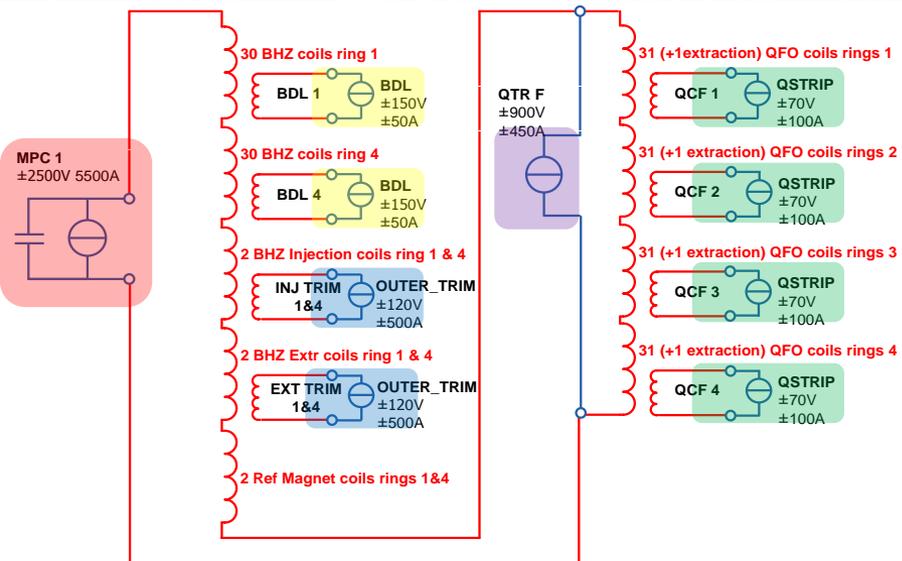
Clement Bovet: electrical network

Stefano Mocci & Michel Obrecht: Cooling and ventilation

Caterina Bertone: Handling tools and transportation



# Booster 2GeV MPS: power converters overview



Existing: BDL. No modifications foreseen

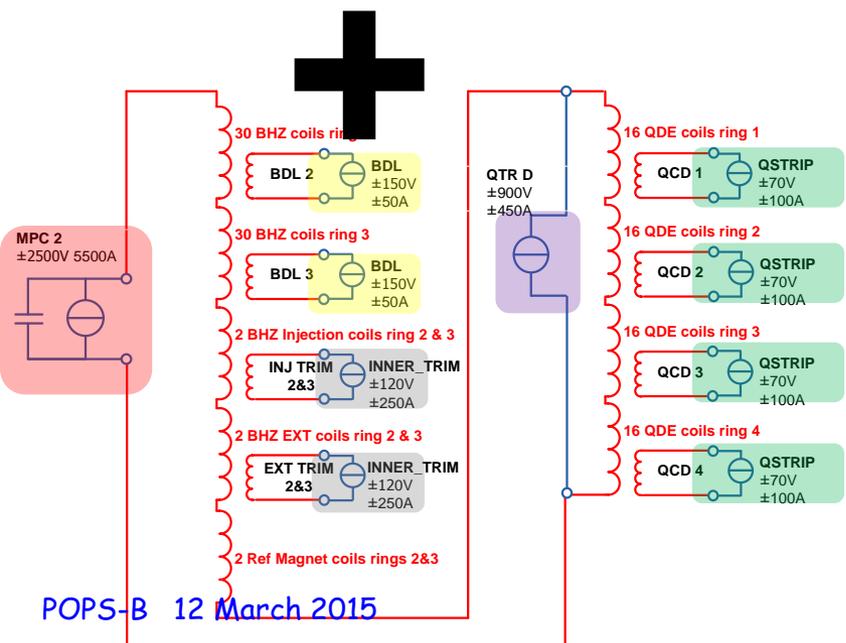
Existing: QSTRIP. Covered by LIU PSB INJECTION

To be designed: POPS-B MPC

To be adapted: QTR. Isolated APOLO\_2S.

To be constructed: OUTER TRIM. COMET\_2P/APOLO

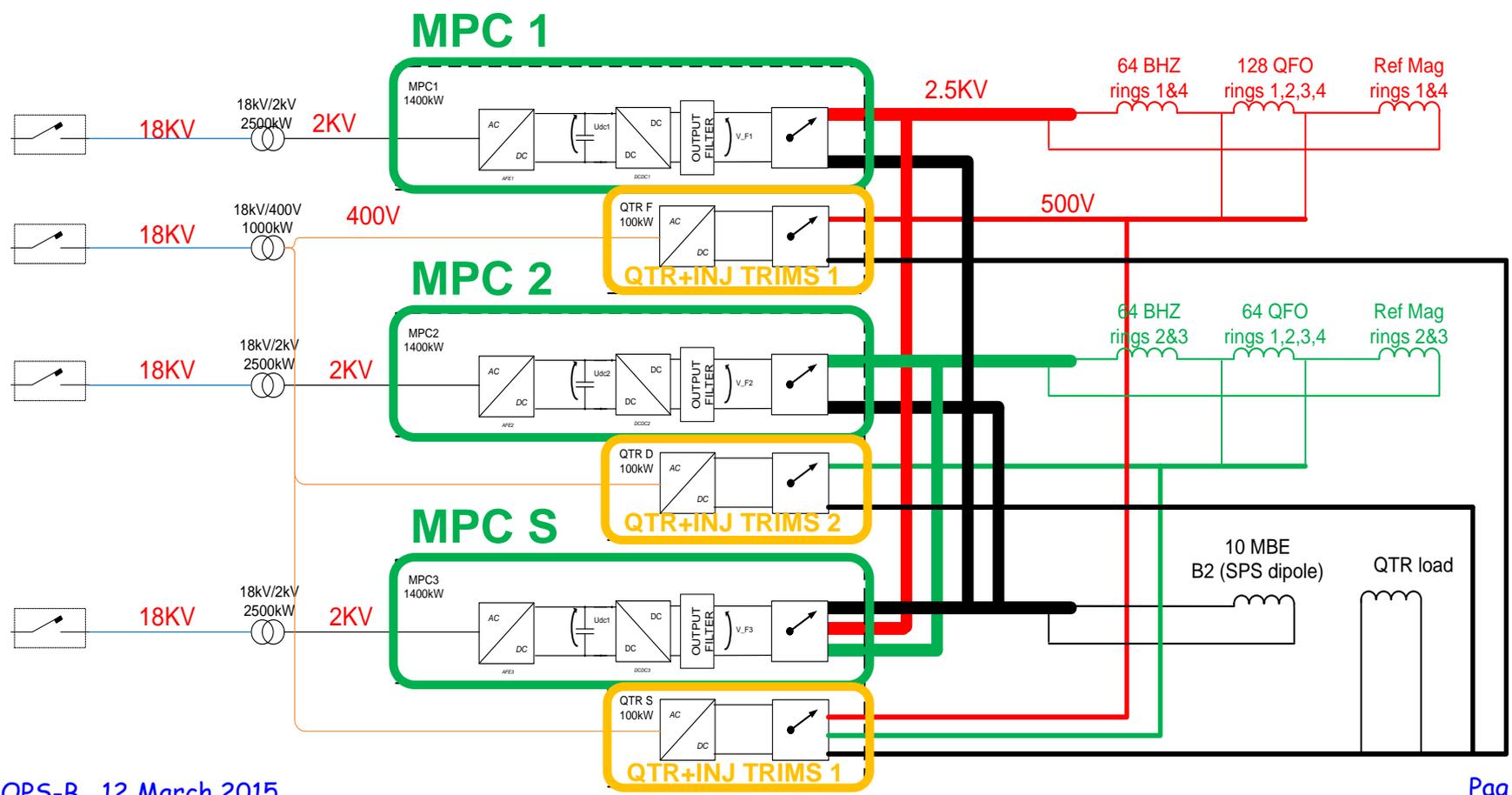
To be constructed: INNER TRIM. COMET.





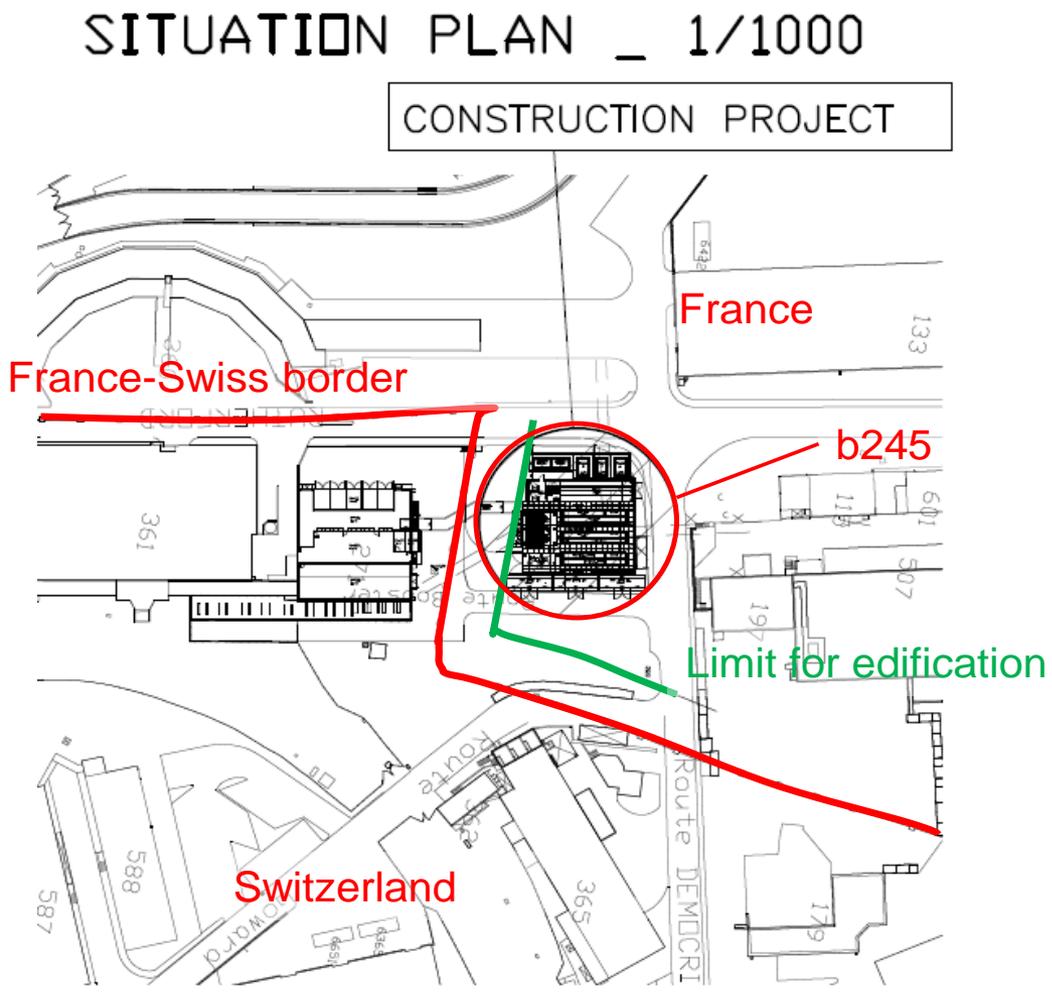
# Booster 2GeV MPS: power converters overview

1 MPC based on IGBT/IGCT technology and energy storage principle.  
 1 QTR + Inj Trims for trimming the current in quadrupole and bending  
 Identical structure repeated three times: two for the magnet strings  
 and one for spare

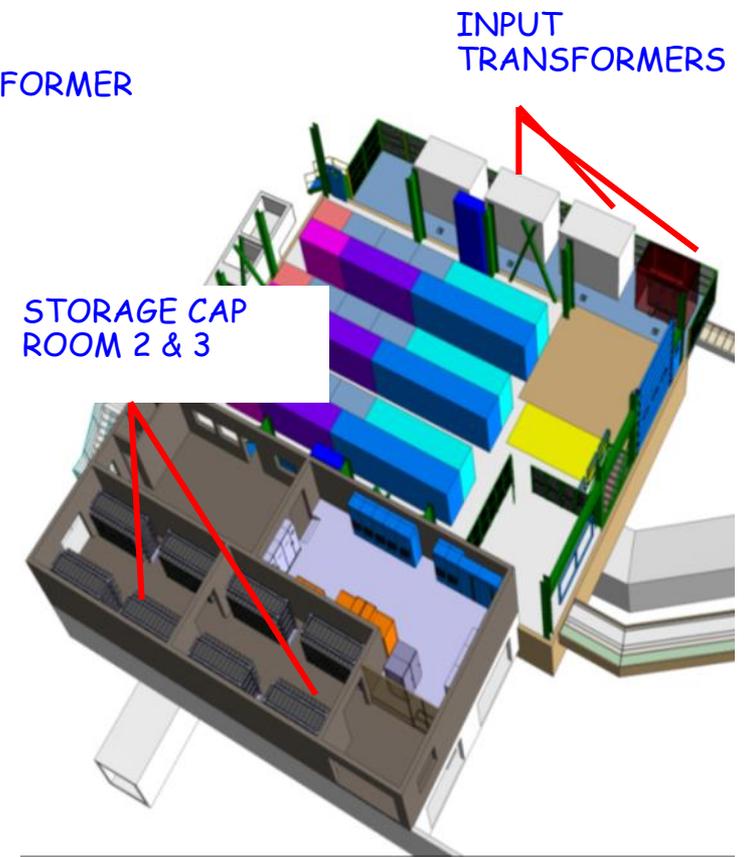
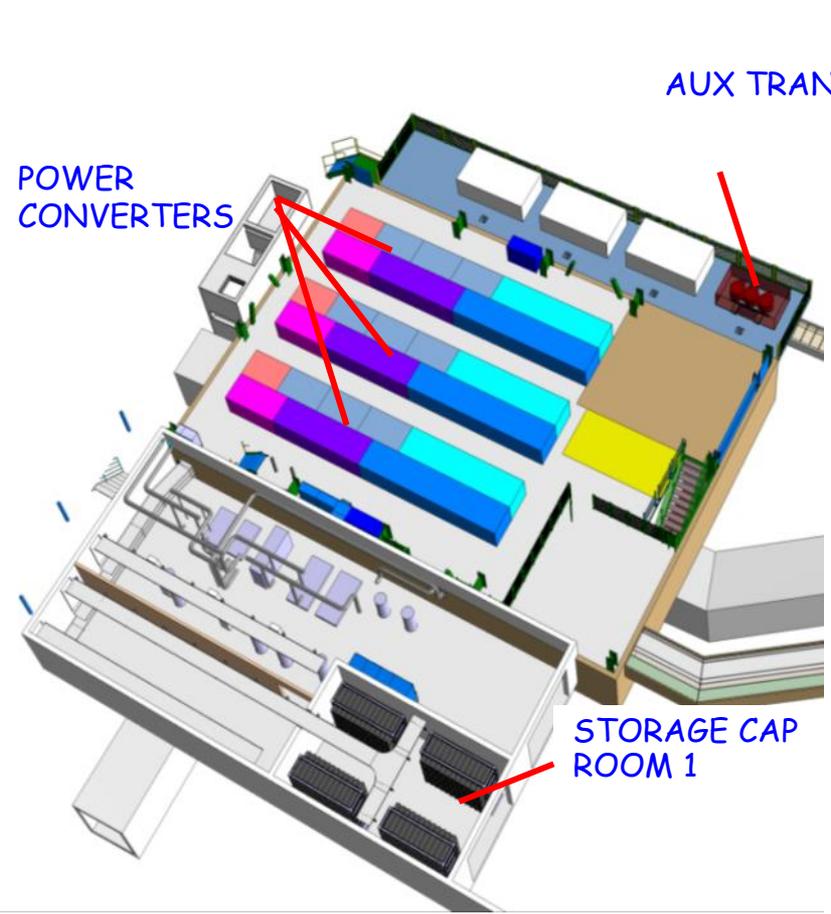


# Booster 2GeV MPS: building 245

New building to be realized for the Booster2GeV MPS (b245)



# Booster 2GeV MPS: building 245

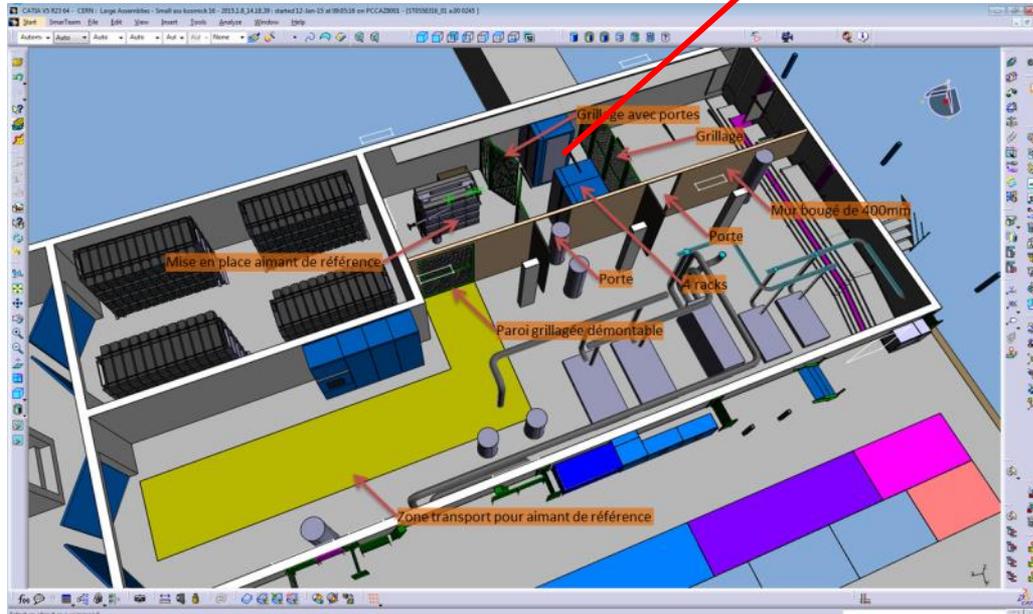




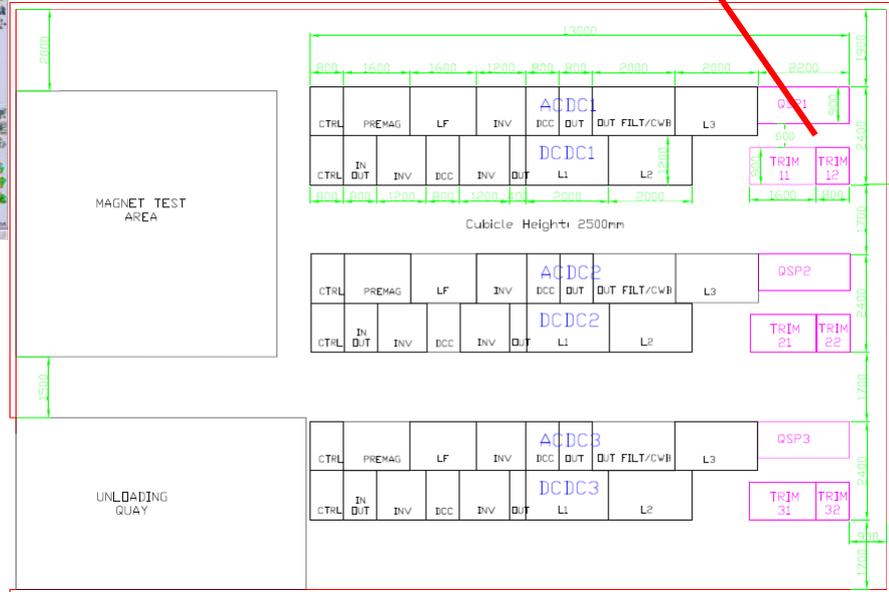
# Booster 2GeV MPS: building 245

## Latest Modifications

Additional Bref magnet + Bmeas electronics to be hosted in b245



Revised layout with Injector and Extraction trims





# Booster 2GeV MPS: building 245

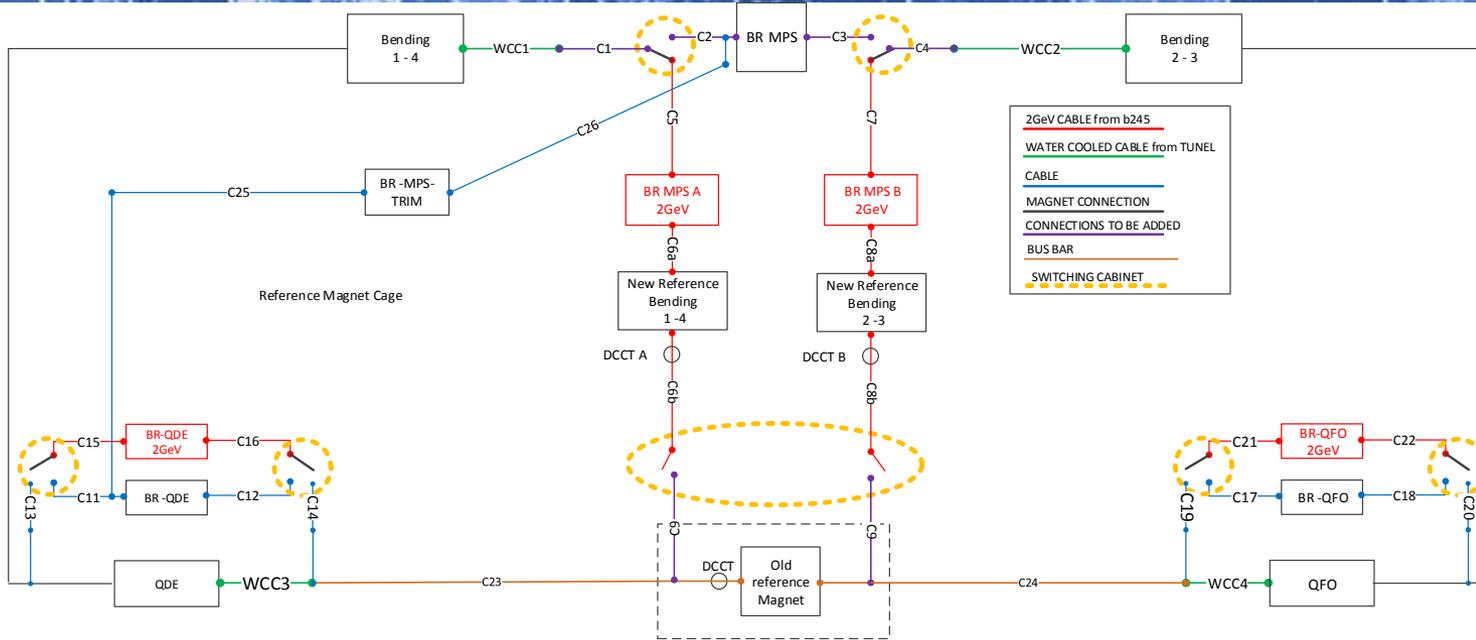
Status:

FC: 17 March 2015

Start of Works: April 2015

Still waiting for the construction permit from the mayor of Preveessin Moens

# Booster 2GeV MPS: new VS present MPS switchover system

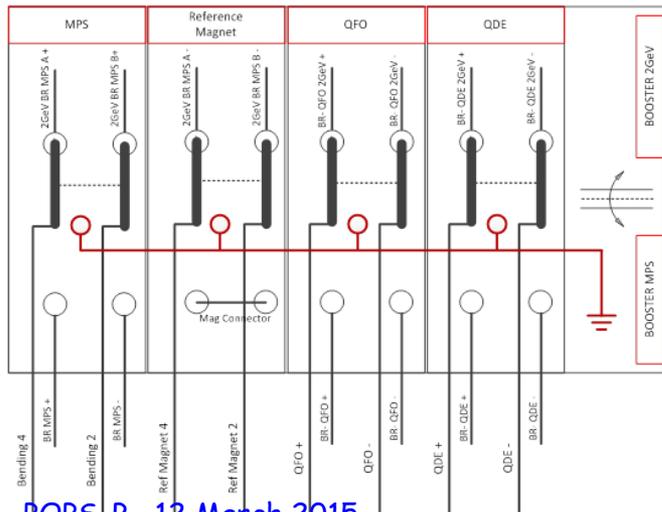


$I = 2500A$  RMS  
 $I = 5500A$  Peak  
 $V = \pm 5000V$

$I = 2500A$  RMS  
 $I = 5500A$  Peak  
 $V = \pm 5000V$

$I = 500A$   
 $V = \pm 5000V$

$I = 500A$   
 $V = \pm 5000V$

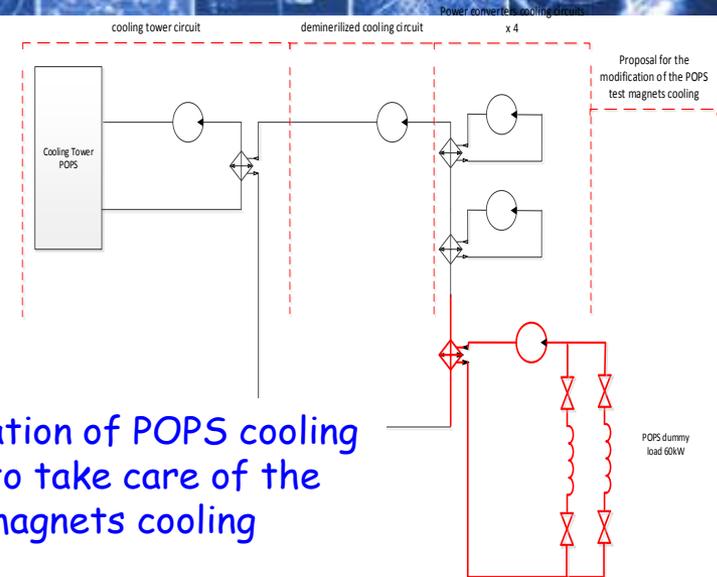


A switchover system is required to commute from present to new MPS and back.

The schema needs to be revised in view of the additional INJ and EXT trims and the Bref magnet positioning in b245

Do we need to keep the INJ&EXTR trims in the present configuration?

# Booster 2GeV MPS: commissioning/testing load



Modification of POPS cooling system to take care of the dummy magnets cooling

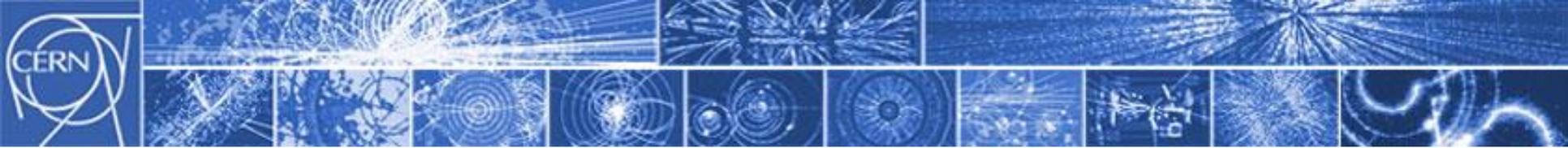


Path E

300mt power cables

The POPS dummy load has about the same inductance as one of the PSB magnet strings. It will be used for commissioning and testing of the POPS-B as well.

The modification of POPS cooling will allow testing during LS2.



# Magnets Upgrade

# Magnets Upgrade: Main Dipoles (courtesy A. Newborough)

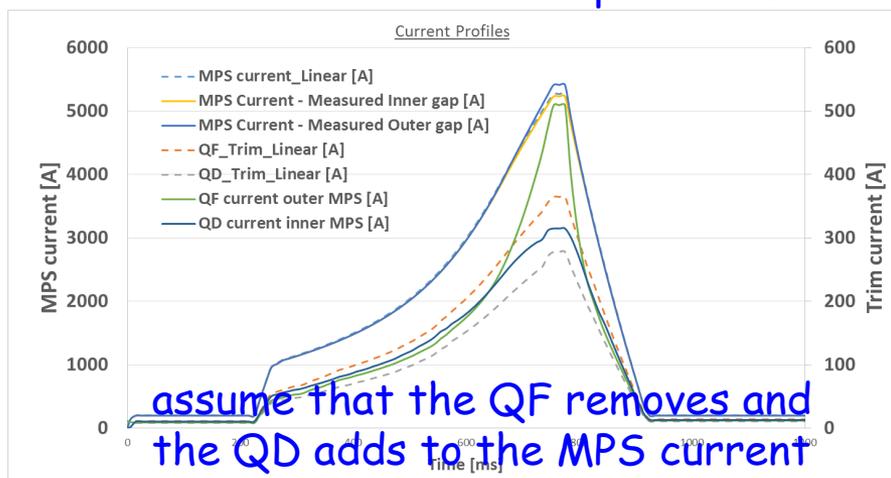
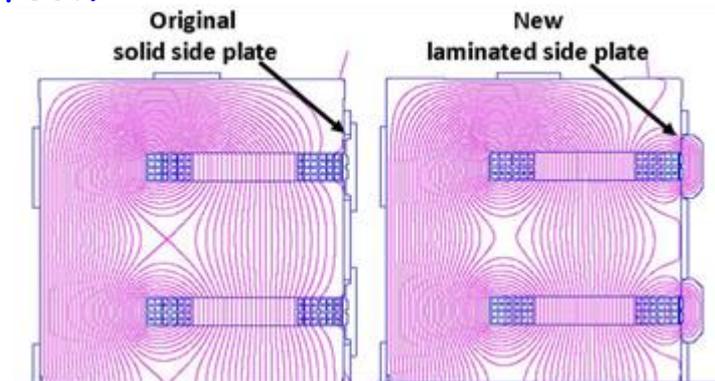
SIMULATED INTEGRAL FIELD BEFORE MODIFICATIONS

Parameter	Units	1.4 GeV	2.0 GeV
Flat-top current	(A)	4032	5200
Inner apertures	(Tm)	1.416	1.815
Outer apertures	(Tm)	1.401	1.729
Difference	(%)	1.07	4.97

Operation at 2GeV increases the saturation of outer magnetic circuits, thus enhancing the difference between inner and outer coils. To correct this a substantial current trim must be allowed in outer ring with respect to inner.

QFO trims must be severely over-dimensioned to compensate this effect.

"The addition of the laminated side plates on the four aperture PSB dipole magnet allow the increase of extraction energy from 1.4 to 2.0 GeV energy without further increasing the difference between the inner and outer apertures."



SIMULATED INTEGRAL FIELD STRENGTH AFTER MODIFICATION

PARAMETER	Units	1.4 GeV	2.0 GeV
Flat-top current	(A)	4032	5200
Inner apertures	(Tm)	1.418	1.823
Outer apertures	(Tm)	1.416	1.800
Difference	(%)	0.14	1.3

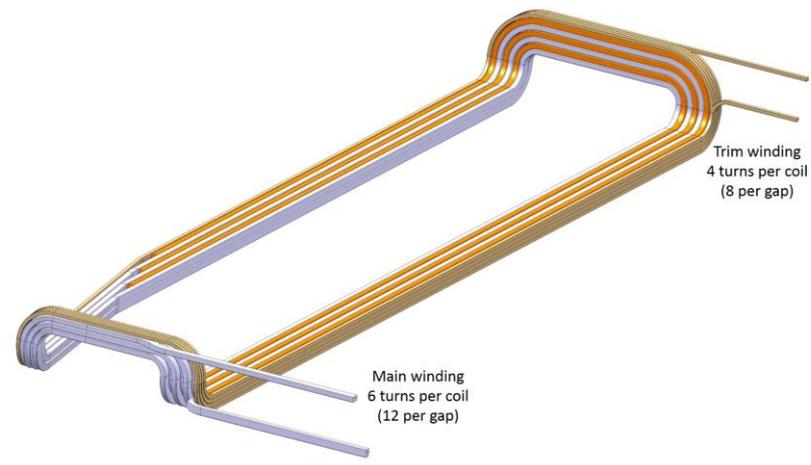
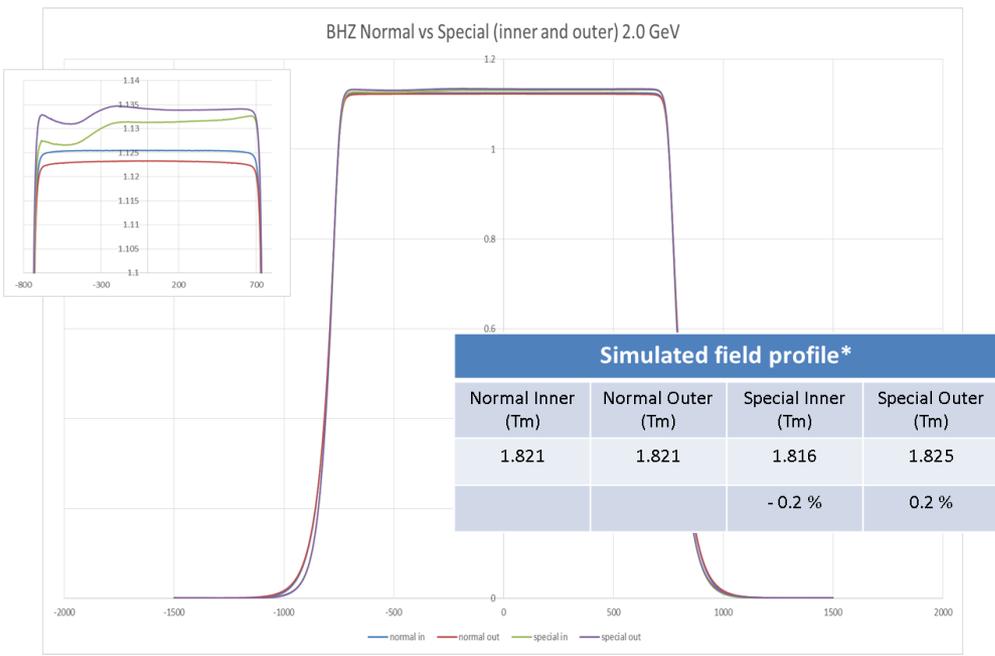


# Magnets Upgrade: Inj-Ext Dipoles (courtesy A. Newborough)

Why do we need additional trim converters for special Injection and Extraction dipoles ?

“Due to the different coil configuration to allow space for the INJ and EXT vacuum chambers, there is a slight difference in field to that of the normal magnets”

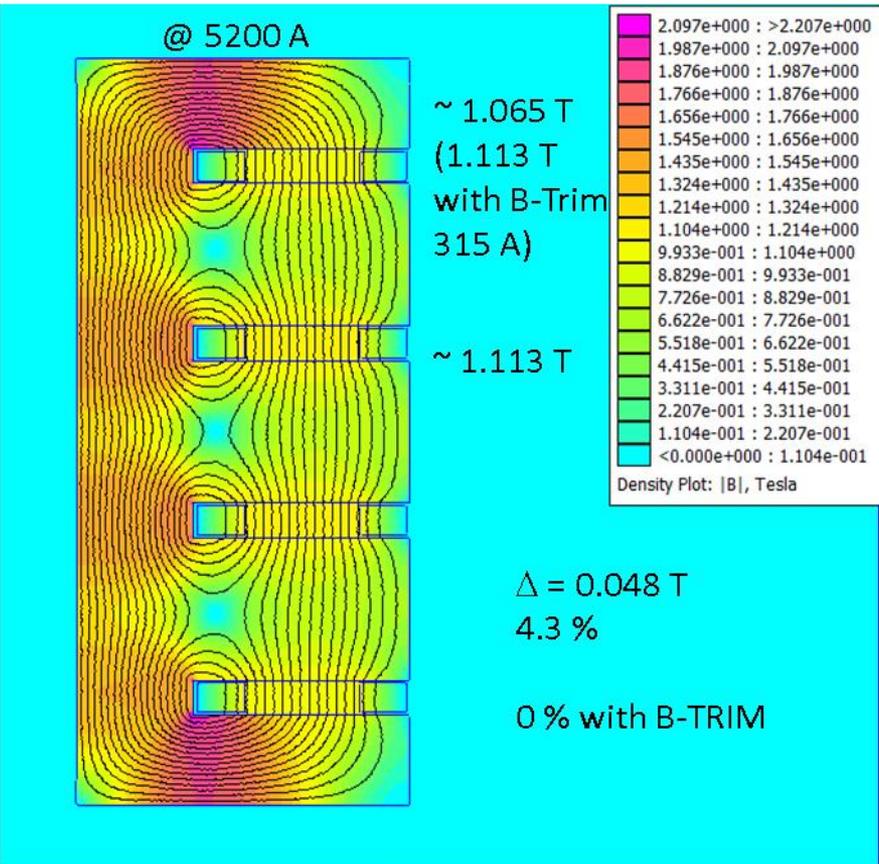
“As we will install the laminated side plates on the normal magnets but not the special magnets, we must compensate for this with the new PC”



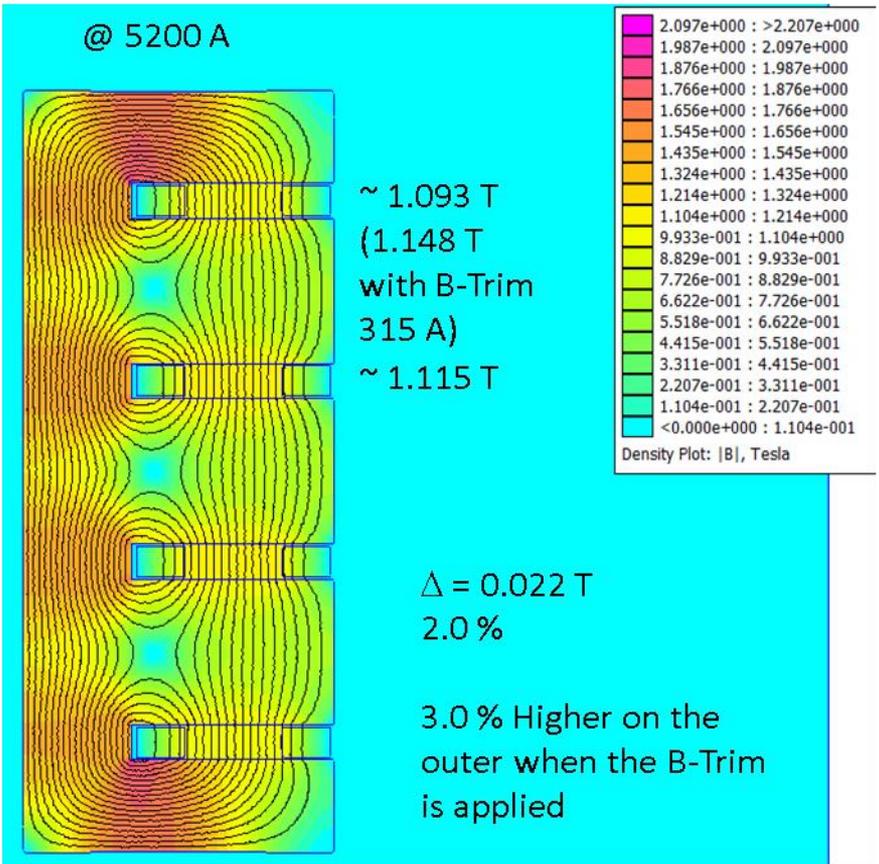
# Magnets Upgrade: Ref Magnet (courtesy A. Newborough)

Why do we need a new Ref magnet to operate at 2GeV ?

BHZ 'Normal' magnet



BHZ 'REF' magnet

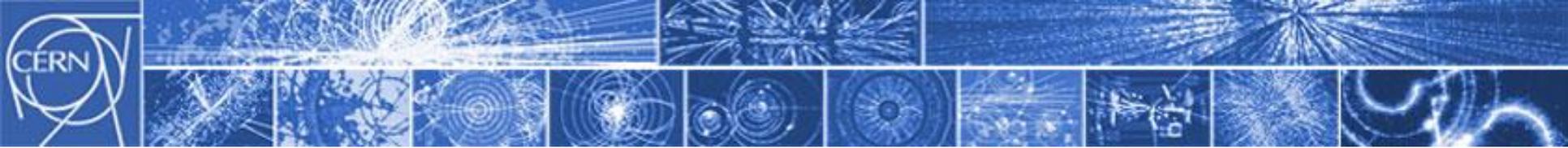




# Magnets upgrade open points

Go-no-go decision on laminates steel plates has direct impact on type of QTR converter for QFO

Confirm number of INJ & EXTR trims required

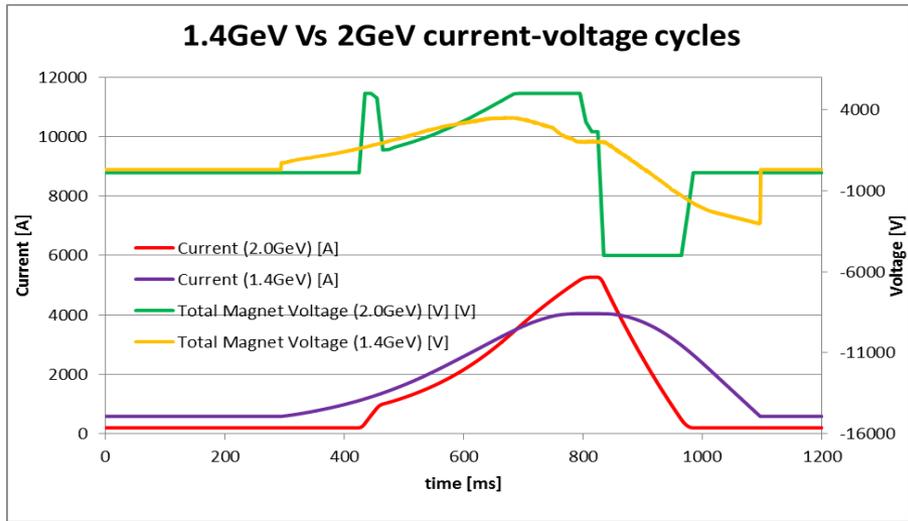


## POPS-B design: MPC

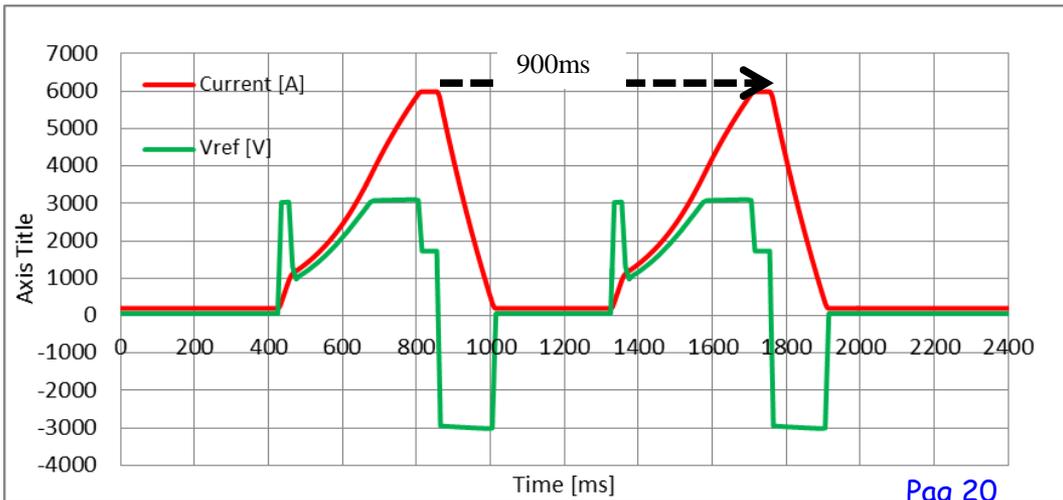


# POPS-B MPC design: Performance requirements

New 2GeV cycle requires 47% higher (total) voltage, 25% higher peak current and 10% higher rms current.



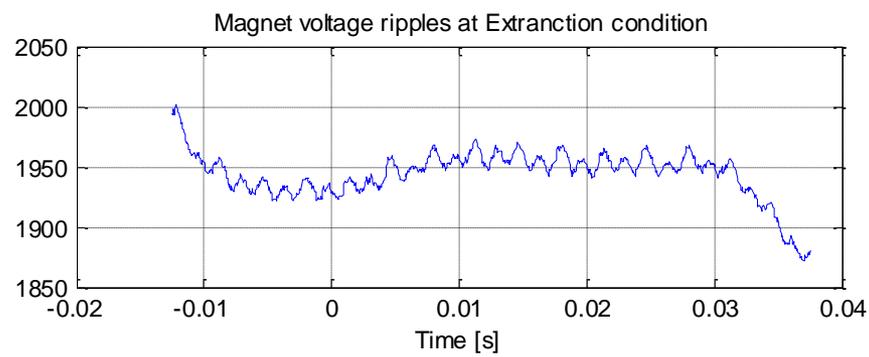
Current and voltage profiles for dimensioning of the single POPS-B power converter



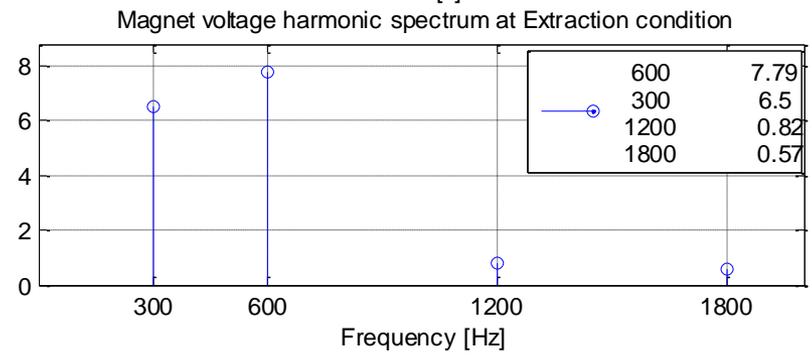


# POPS-B MPC design : Performance requirements

Voltage measurements on present cycle flat-top gives 10Vpk ripple mainly at 300Hz and 600Hz..



For each string this translates into a requirement of  $DV < 3.5V_{rms}$ .  
2.5V<sub>rms</sub> would give additional improvement





# POPS-B MPC design : power topology

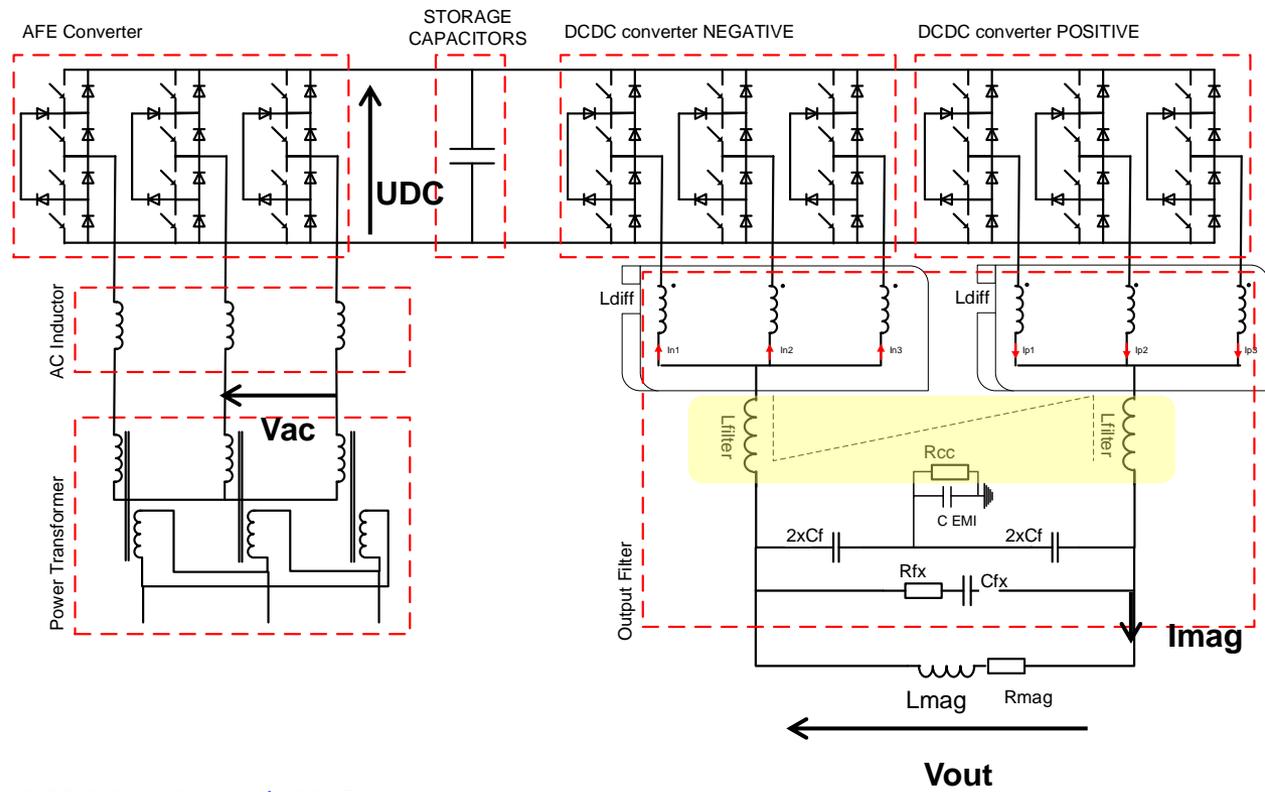
A storage capacitor bank connected on the DC side provide power decoupling from the network.  
The storage capacitance is around 0.3F (@5kV Udc nominal)

Power transformer:  
Power=2.5MW  
Vac=2000Vrms

Storage Capacitors:  
Cap=0.3F  
Vmax=5000V  
Vmin=3000V

Output:  
Imag\_pk=6000A  
Imag\_rms=3000A  
Vout\_pk=3000V

Load (Mag):  
Lmag=100mH  
Rmag=250mOhm



Additional common mode filter inductance required for DVripple



# POPS-B MPC design: status

Status:

MS for MPC: sent out

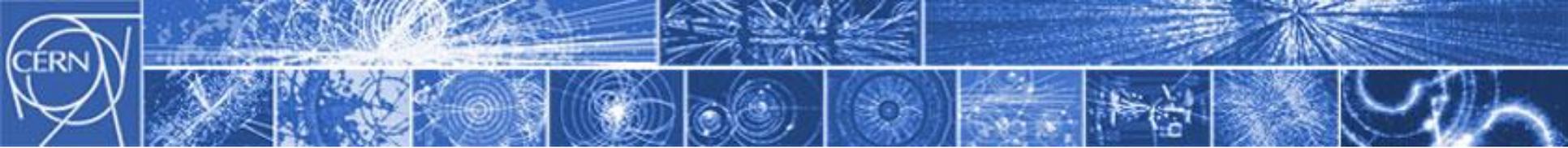
IT for MPC: April-May 2015

FC for MPC: December 2015

MS for storage capacitors: sent out

IT for storage capacitors : April-May 2015

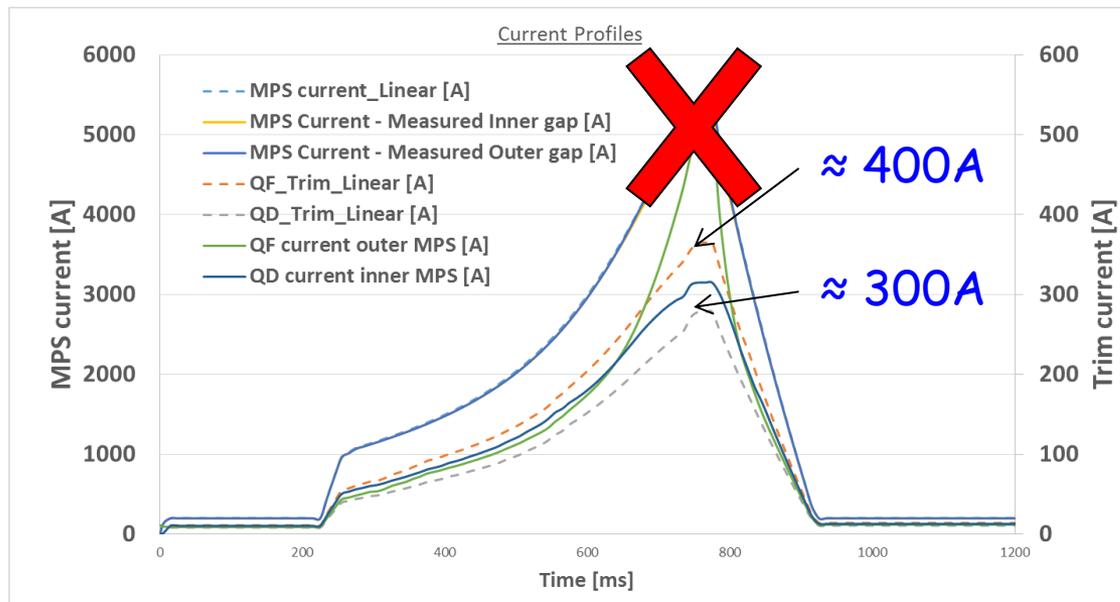
FC for storage capacitors : December 2015



## POPS-B design: QTR



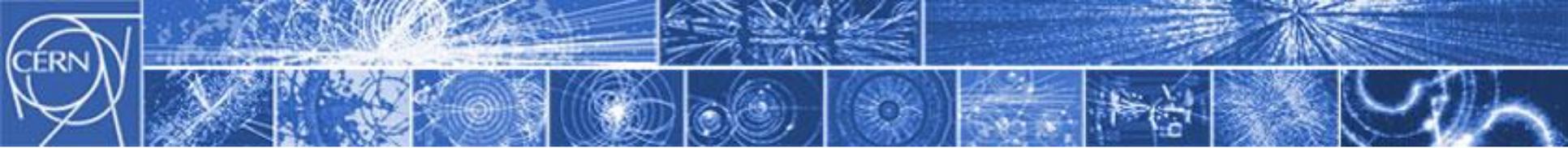
# POPS-B QTR design: Performance requirements



Laminated steel plates on bending magnets applied

Please confirm !





## POPS-B design: INJ & EXT trims



## *E-mail from A. Newborough*

### Power Converter Options

(2 times 4 gaps)

1 PC Outer INJ & EXT in series (412.5 A, 44 V)

1 PC Inner INJ & EXT in series (165 A, 18 V)

(4 times 2 gaps)

1 PC Outer INJ in series (412.5 A, 22 V)

1 PC Outer EXT in series (412.5 A, 22 V)

1 PC Inner INJ in series (165 A, 9 V)

1 PC Inner EXT in series (165 A, 9 V)

(8 times 1 gap)

4 PC Outer 412.5A, 11 V

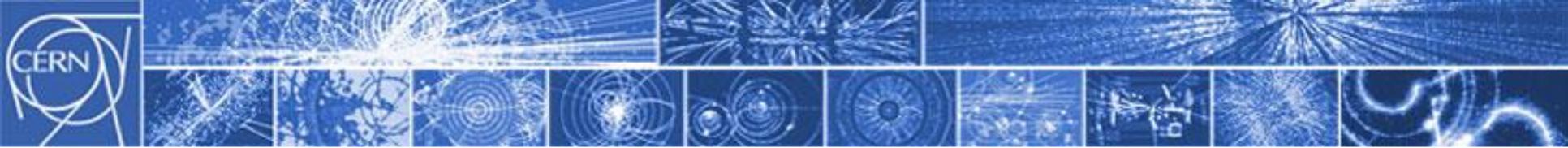
4 PC Inner 165 A, 4.5 V

COMET2P/APOLO

COMET



# Please confirm !



# Project Management

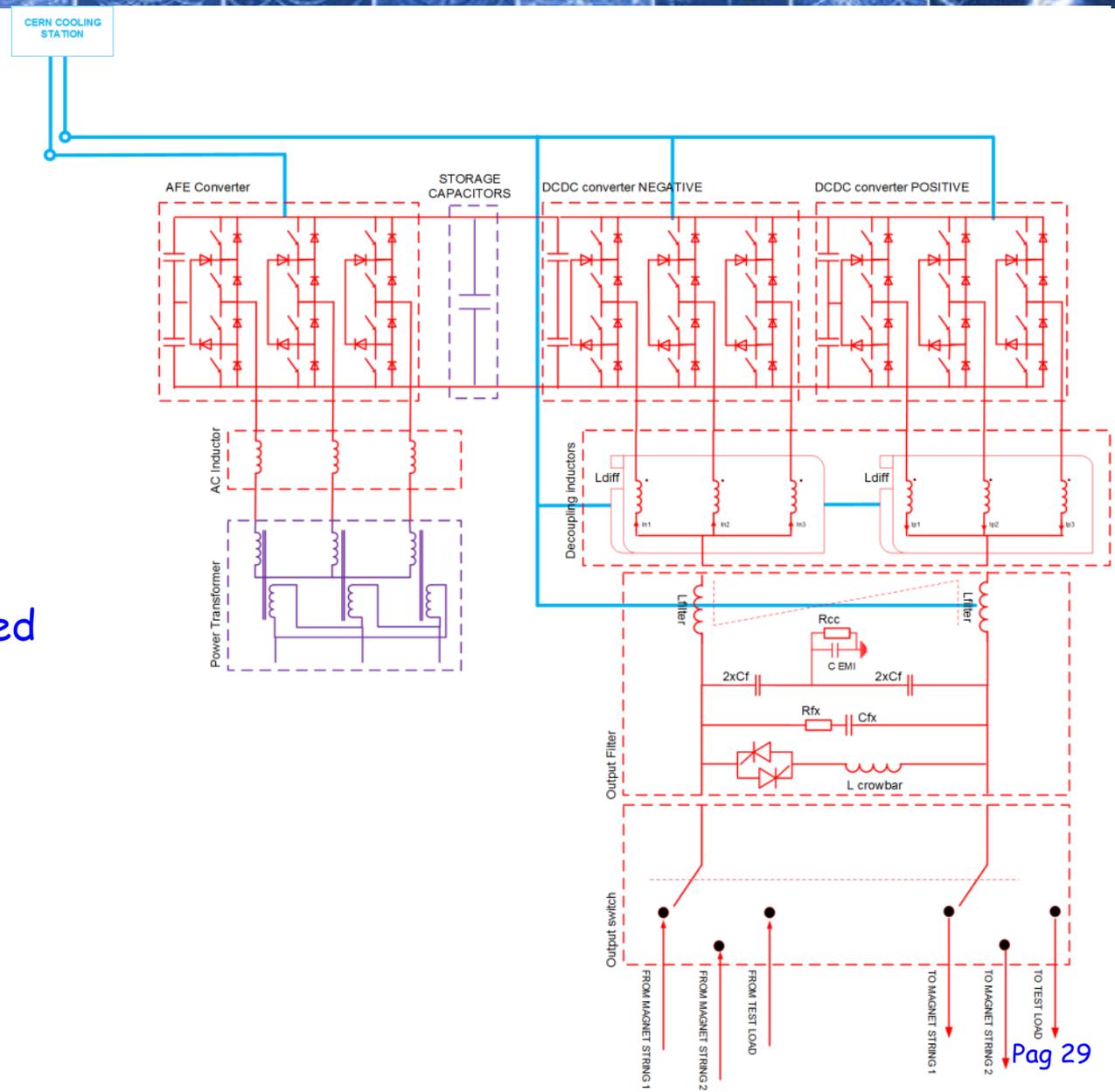


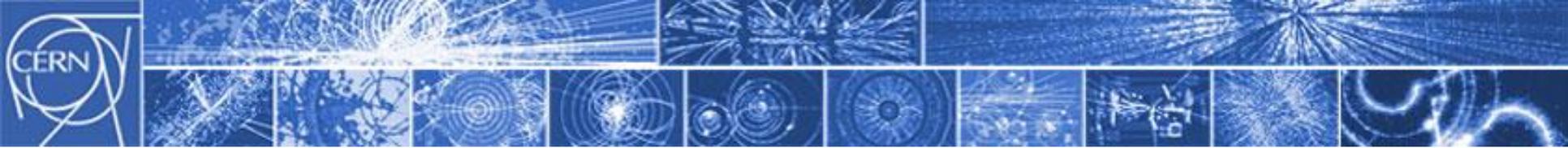
# Project Management: POPS-B realization (Power)

CERN takes the responsibility for final performance.

Storage Capacitors and Input transformers purchased by CERN

Converters cooling realized by CERN

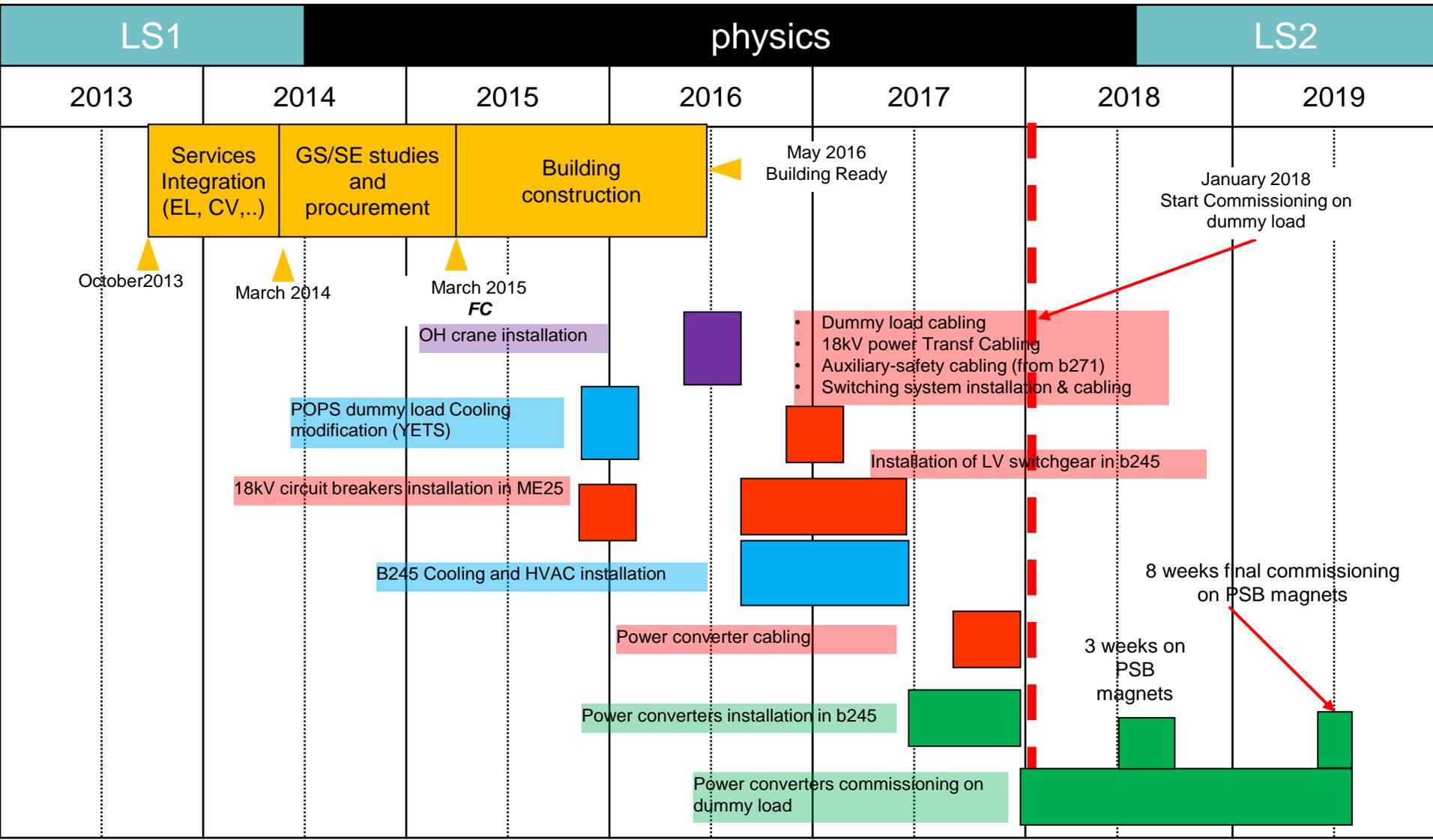


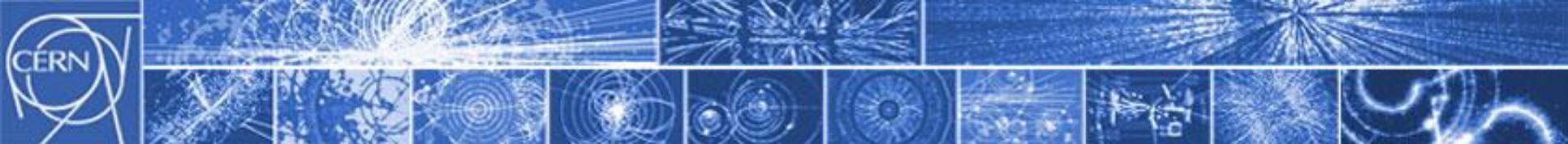


# Project Planning



# Project Planning: total





# POPS-B: budget codes

# POPS-B: budget codes

76805(GS/SE)



99238(TE/EPC)



Inj+extr Trims  
not included  
≈300kCHF

54360(EN/HE)



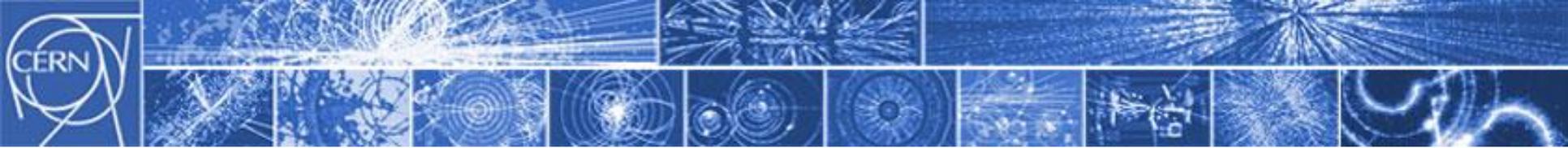
54247(EN/EL)



53661(EN/CV)



Modification of  
POPS dummy  
load cooling  
not included



# POPS-B documentation



# POPS-B: documentation



  
**LHC Injectors Upgrade**

**Technical Design Report**  
**PSB NEW MPS POWER CONVERTER DESIGN**

F.Boattini and G. Szwedzki  
CERN, Geneva, Switzerland

Abstract  
This document describes the technical design of the new Booster MPS.

July 2014  
EDMS no. 121473

CERN CH-1211 Geneva 23 Switzerland

EDMS NO. <b>XXXXXXXX</b>	REV. <b>XX</b>	VALIDITY <b>DRAFT</b>
REFERENCE <b>PSB-R-EC-0001</b>		
Date: 2015-03-04		

**ENGINEERING CHANGE REQUEST**  
**New MPS for LIU Booster (POPS-B)**

BRIEF DESCRIPTION OF THE PROPOSED CHANGE(S):

For the LIU Booster project the replacement of the present PSB-MPS with a new one (POPS-B) is needed. It will be installed into a new building (B245) to be realized in the area in front of B271. Many contributions from EN-CV, EN-EL and OS-SE are required for the construction of the new building and for the cabling and cooling of the new MPS. This ECR lists all the activities to be foreseen and the planning required.

<small>PREPARED BY:</small> F. Boattini TE/EPC	<small>TO BE CHECKED BY:</small> D. Aguilera, J. Benl, J.-D. Bunnert, A. Frosch, C. Gagnier, G. Georgiev, D. Hay, F. Magrin, B. Müller, R. Naves, A. Newborough, M. Oberst, J. Pedersen, L. Sillke, B. Stenlund, N. Tardif, EDMS e-group, LIU-PSB-PROJECT/TEAM, B245 e-group, 'ser-pad'	<small>TO BE APPROVED BY:</small> K. Hada, M. Haddad (on behalf of LIU), G. Ruggini, R. Sakai (on behalf of EPFC)
---	--	--

DISTRIBUTION LIST  
LIU-PSB Project team members

Summary of actions to be undertaken:

- Construction of a new building named B245;
- Realization and installation of water cooling and HVAC systems for POPS-B in the B245;
- Modification of the present POPS cooling system for dummy load cooling;
- Realization and installation of the electrical network for the supply of POPS-B power converters;
- Dummy cabling of the POPS-B internal to B245;
- Power cabling of the POPS-B with the dummy load in B367;
- Installation of the POPS-B via PSB MPS switching cabinets and power cabling;
- POPS-B testing on PSB magnets.

CERN CH-1211 Geneva 23 Switzerland

CERN Project Number <b>TE/EPC</b>	EDMS Number <b>13991468</b>	Title <b>Booster 2GeV</b>
--------------------------------------	--------------------------------	------------------------------

**Electrical Power Converters GROUP (EPC)**      Date: 20/03/2014

**Technical note**  
**Booster 2GeV cabling**

This report presents the Booster magnets connections and cabling required for Booster MPS supply upgrade and to connect the new MPS to the dummy load of POPS. The report does not include the 18kV cables for bus and main power transformers and all low voltage cables required for B245 auxiliaries.

<small>Prepared by:</small> F. BOATTINI G. SZWEDZKI	<small>Checked by:</small> F. BOATTINI	<small>Approved by:</small>
---	---	-----------------------------

CERN CH-1211 Geneva 23 Switzerland

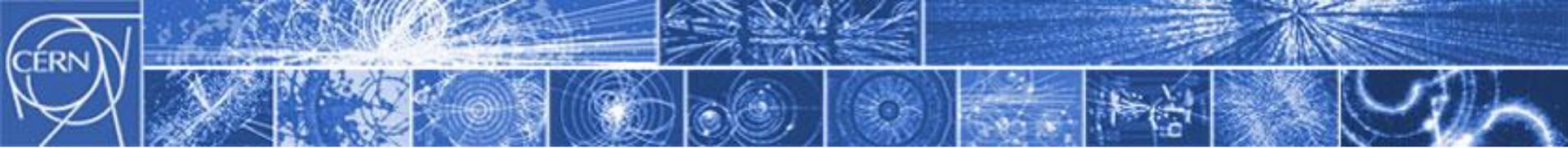
CERN Project Number <b>TE/EPC</b>	EDMS Number <b>132397148</b>	Title <b>Booster 20kV</b>
--------------------------------------	---------------------------------	------------------------------

**Electrical Power Converters GROUP (EPC)**      Date: 19/03/2014

**FUNCTIONAL SPECIFICATION**  
**Cooling System for the POPS-B Power Converters**

This report contains the water cooling and air conditioning technical specifications for POPS-B power converters and the description of the modification of POPS cooling water station for the dummy load magnets.

<small>Prepared by:</small> F. BOATTINI	<small>Checked by:</small> F. BOATTINI Y. GAILLARD	<small>Approved by:</small>
--	--	-----------------------------



Thank you for the attention

Questions ?