LHC Injectors Upgrade

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Functional specifications review for the stripping foil BSW magnets power converters

- Introduction (specs, topology)
- Integration
- Connections with power converter
- Development strategy
- Activities & Priorities
- Milestones schedule
- Next actions

Davide Aguglia (TE-EPC), Nov. 13th 2014

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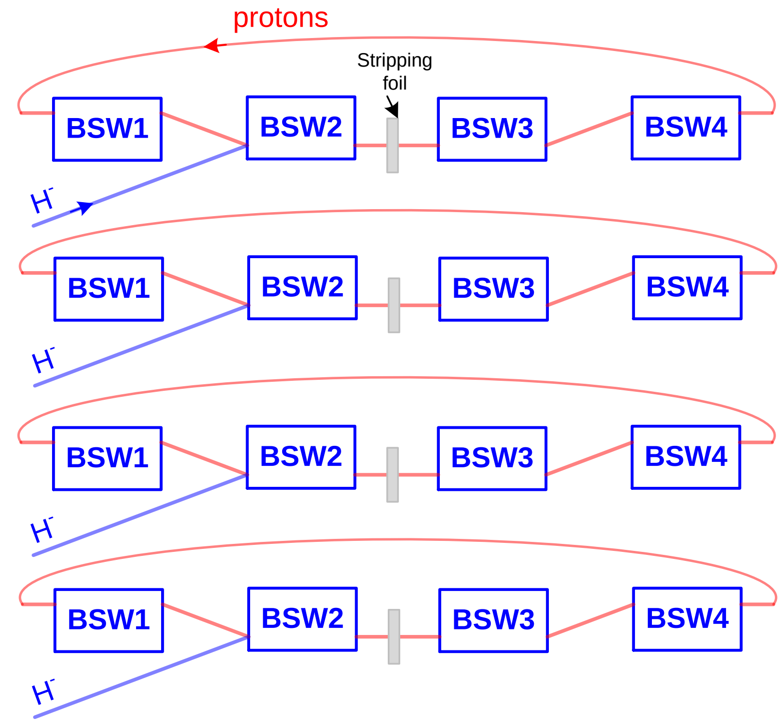
Introduction

- 16 power converters required for individually feeding 16 magnets
- 2 types of converters (BSW1 different from BSW2, 3, & 4)
- 2 spares power converters – total of <u>18 converters</u>

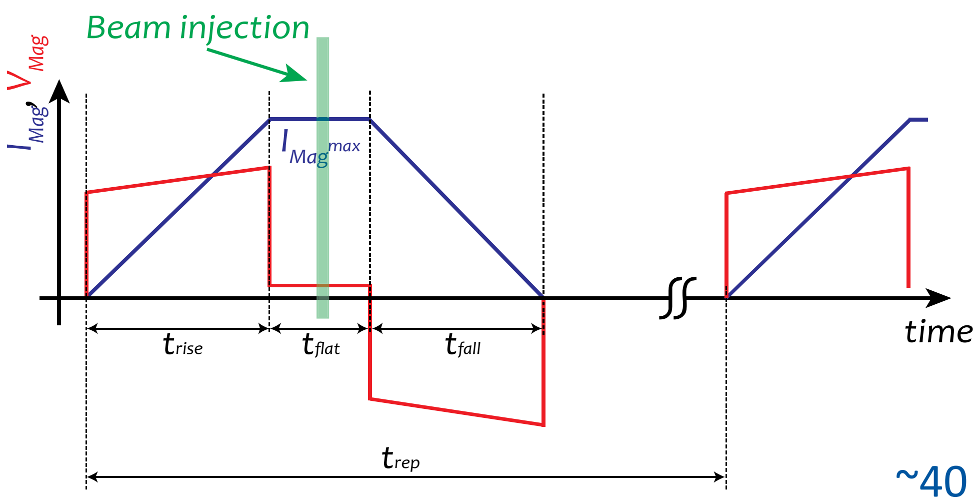
	BSW1	BSW2&3	BSW4
L (µH)	13	70	77
R (mΩ)	3.5	7	7
I_{peak} (A)	6700	3400	3400
I_{rms} (A)	463	231	231
V_{max} (V)	450	450	450



BSW magnet's electrical specifications

Introduction

Overall current/voltage specification

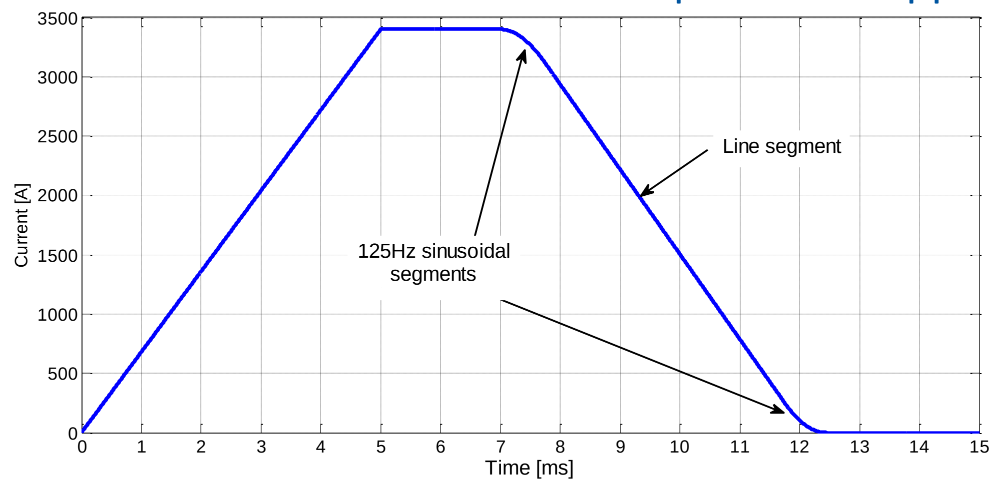


t_{rise} (ms)	**5**
t_{flat} (ms)	1 to 2
t_{fall} (ms)	5
t_{rep} (ms)	900

Because infinite *dv/dt* not possible, current smoothing agreed with beam optics

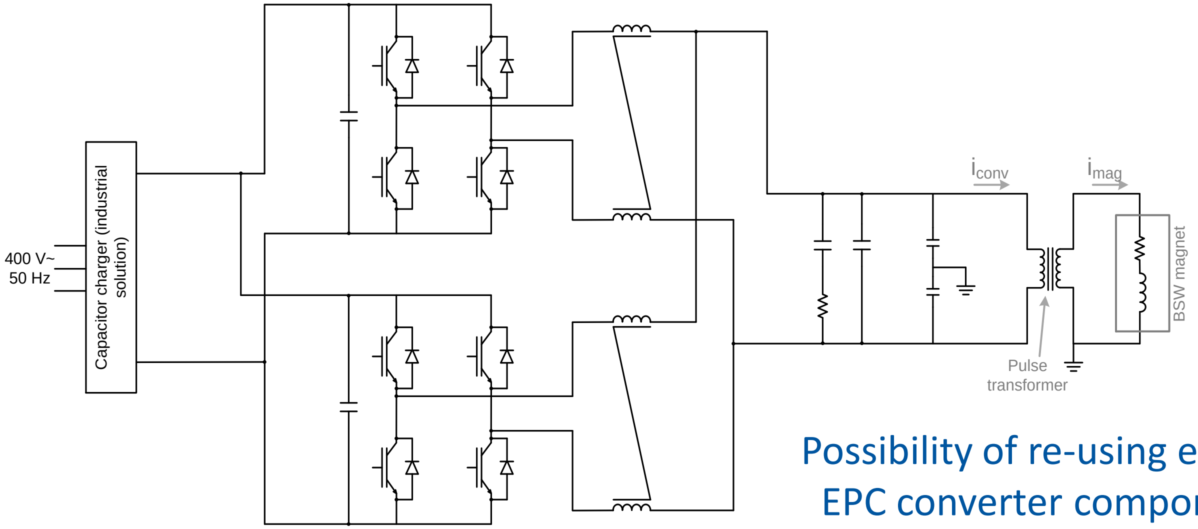
Absolute precision:
100 ppm (±50 ppm) during flat-top (starting from when beam is injected)
1000 ppm (±500 ppm) during ramp-down

~40 kHz harmonic content – amplitude ~50 ppm

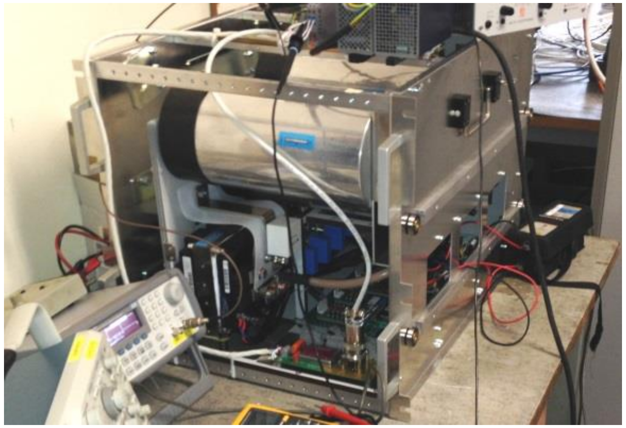


Evaluated topology

Power converter topology and features



Possibility of re-using existing EPC converter components

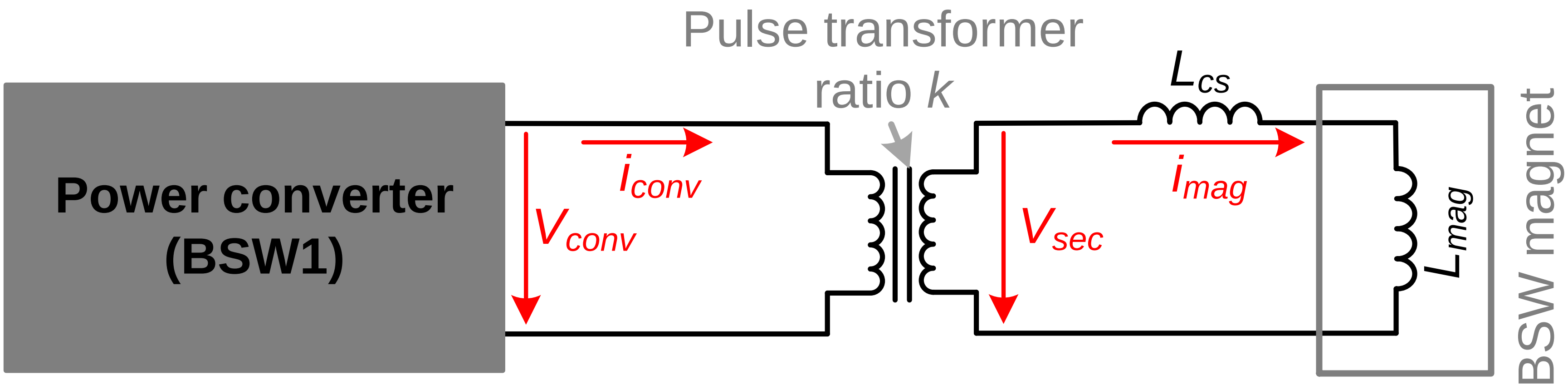


EPC-MPC new APOLO power stack under evaluation:

- H-Bridge equipped with 1.7kV-1.6kA IGBTs
- Tests undergoing to check if they can be used for this project – 95% probability!
- If yes, two APOLO modules in parallel enough

Integration

Simplified analysis – cable length issue



- If cable length increases, L_{cs} increases
- *di/dt* imposed by specs
- V_{conv} and V_{sec} increase as well!
- Power converter maximum power, volume, losses, and cost increase with cable length!!!
- Overall design parameters are:
  - transformer ratio *k* and
  - cable length!

Simplified analysis

$$800\,V \geq \left(L'_{mag} + L'_{cs}\right)\frac{di_{conv}}{dt}$$

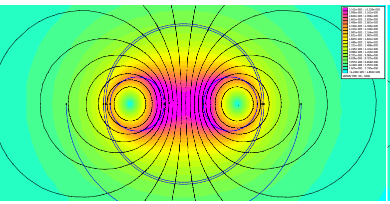
$$k = \frac{i_{mag}}{i_{conv}}$$

$$800\,V \geq \left(L_{mag} + L_{cs}\right)\frac{di_{mag}}{dt}k$$

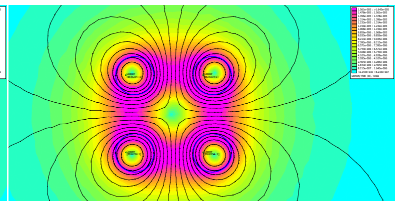
Integration

Analysis – limitations vs cable length & type

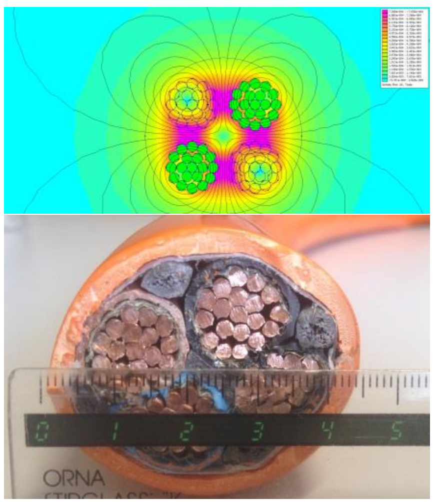
2 conductors of 150mm², L=0. 6µH/m:



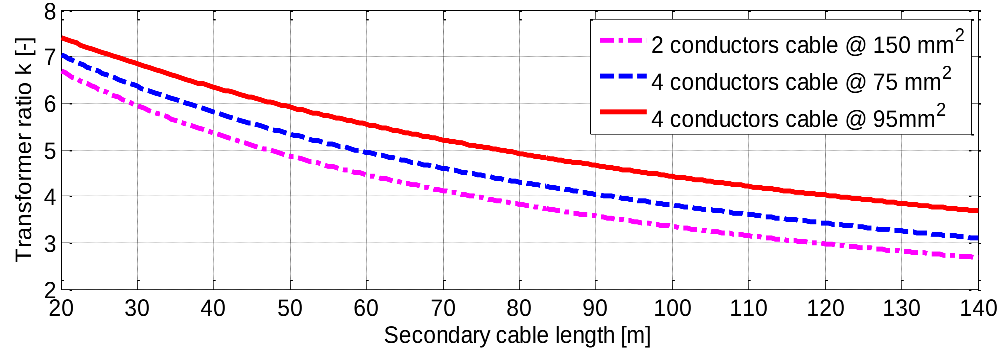
4 conductors of 75mm², L=0.26µH/m:

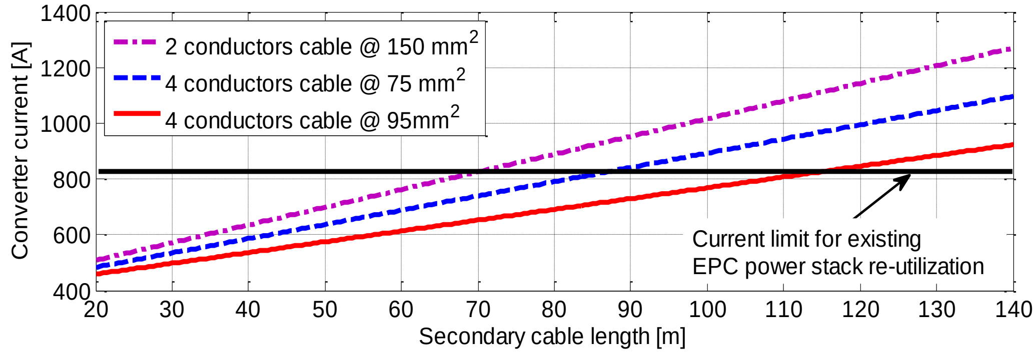


4 conductors of 95mm², L=0. 16µH/m



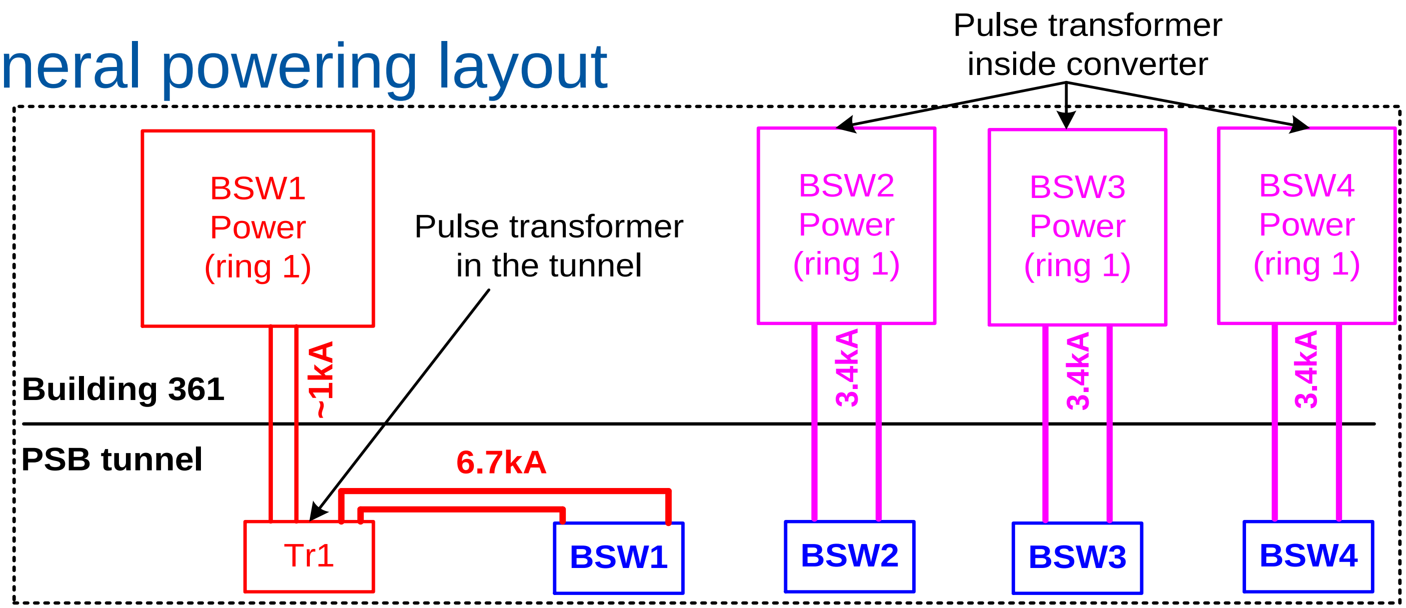
Converters power, volume and cost increase with cable length (analysis considering resistive effects):



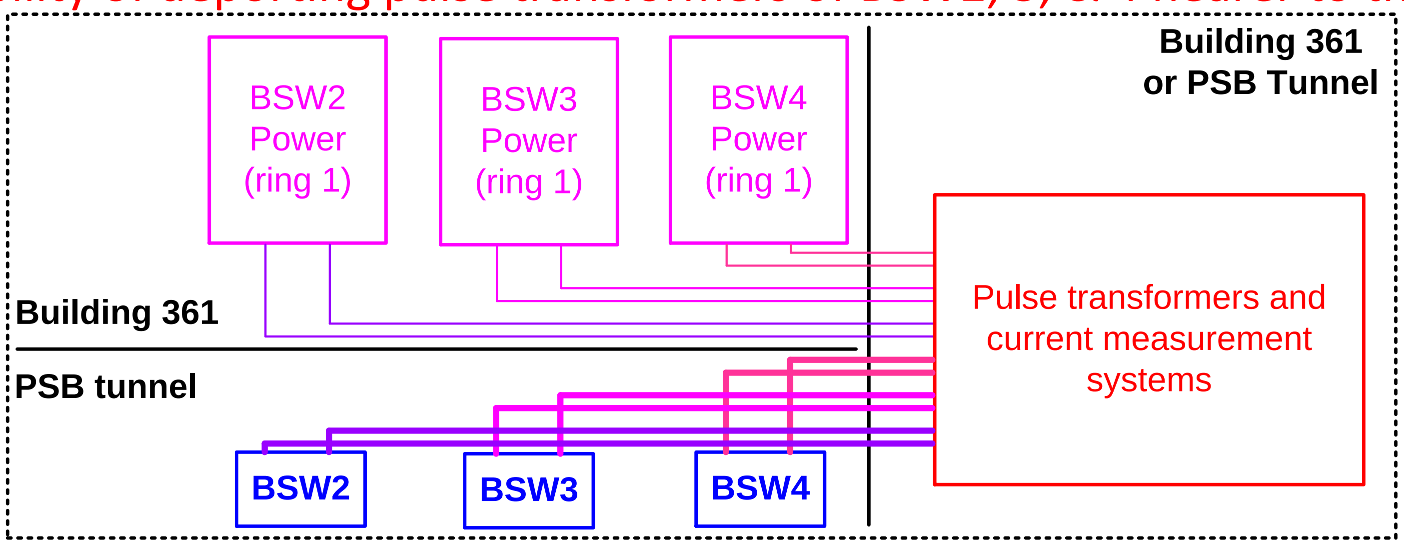


Integration

General powering layout

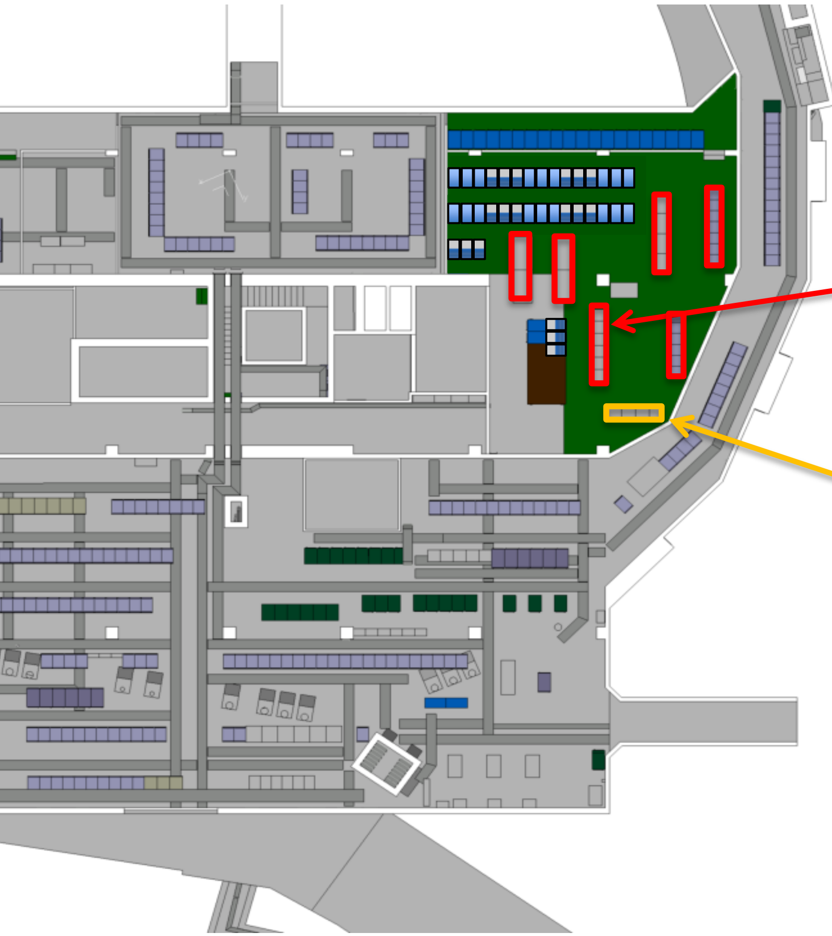


Possibility of deporting pulse transformers of BSW2, 3, & 4 nearer to the magnet:



Integration

Reserved space in **BRF2** (bld. 361) for power conv. racks

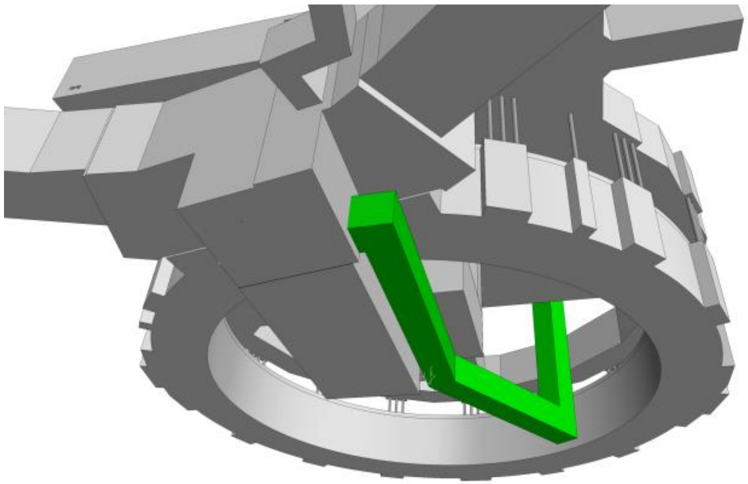


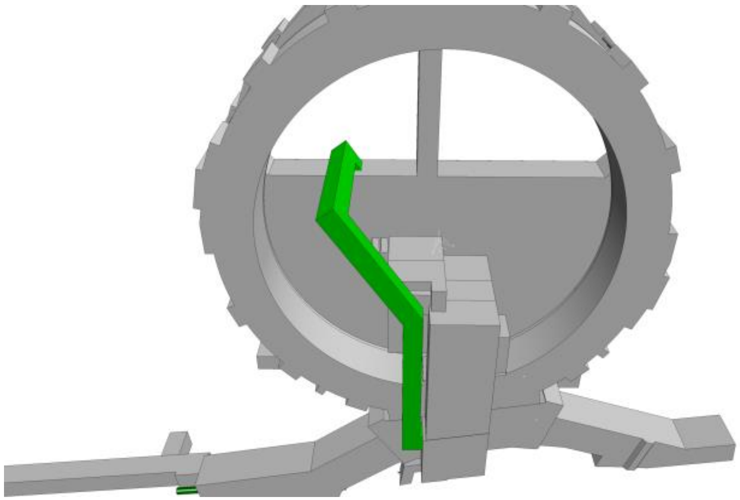
- Each converter 3 racks (fighting for 2…)
- Access from front and rear of each rack!
  56 racks total
- Existing RF equipment to be moved; renovation/re-installation of RF equipment coordinated with TE-EPC to optimally re-configure the space
- Power distribution/switchgears to be renovated (RF) and extended (strip foil)
- Water cooling probably needed (taps available – should not be an issue)
- False floor to be modified/reinforced

Integration

Evaluated solution for cable length minimization from BRF2 down to magnets

- Cable path studies showed an issue in finding a suitable cable gallery with appropriate length
- The option of a new cable trench/passage from BRF2 down to the injection area (1L1) into the tunnel has been preliminarily investigated
- Very rough cost estimation was made, and a total of ~2 MCHF would be necessary to construct a new cable trench illustrated in green
- Too expensive, other solutions can be found

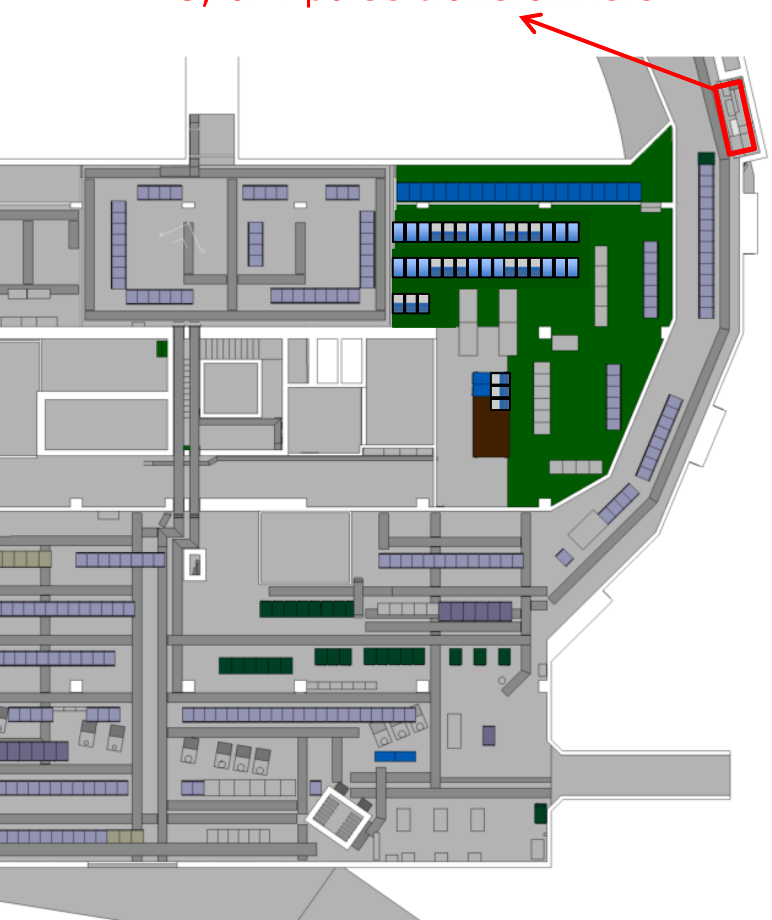




Integration

Most likely solution – deporting BSW2, 3, & 4 pulse transformers

Identified possible zone for BSW2, 3, & 4 pulse transformers



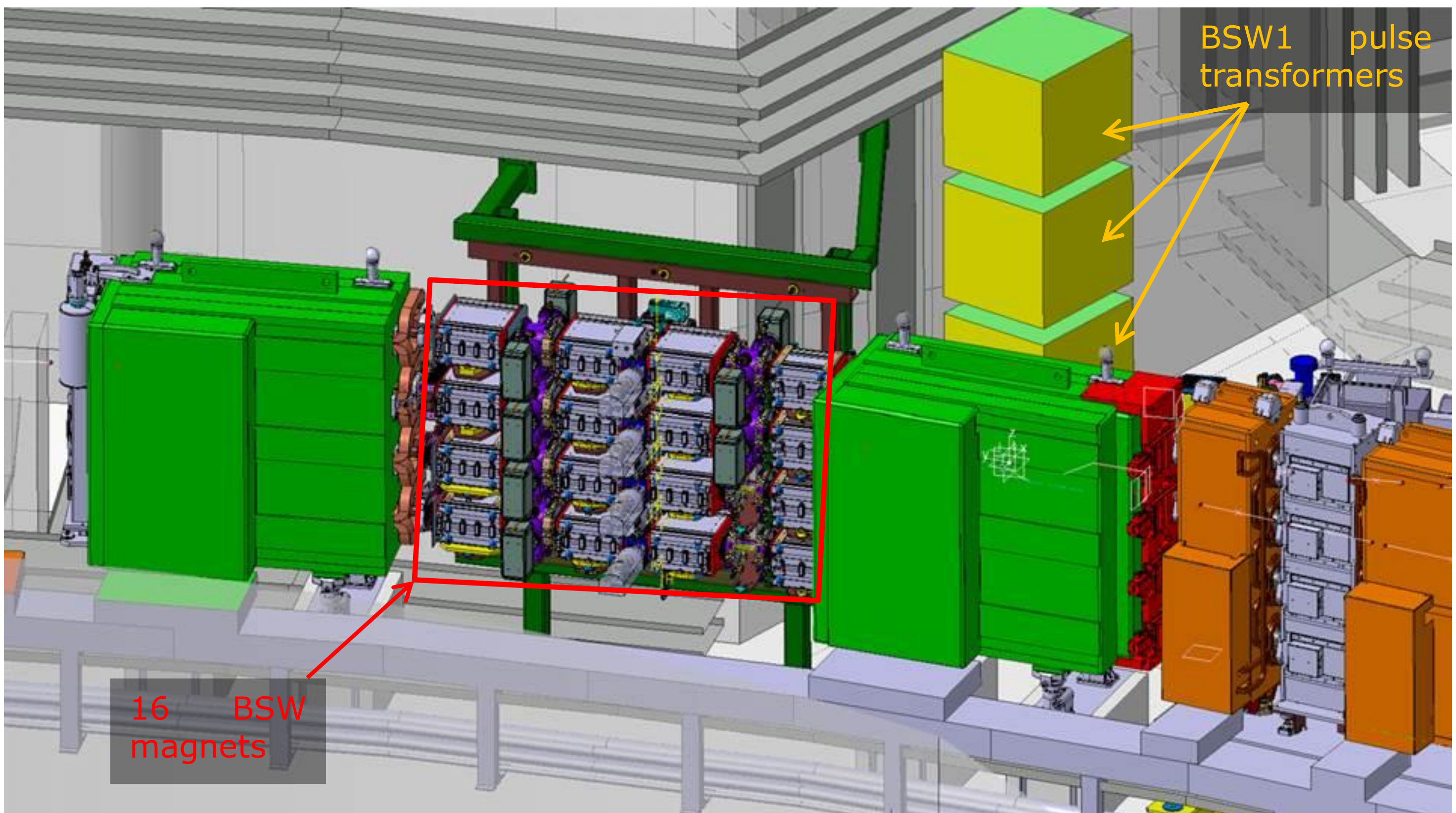
- Identified old access shaft to the PSB tunnel
- Verifications undergoing DGS/RP for the utilisation of this zone.
- Advantages with this solution:
  - Shortening the secondary cables lengths
  - Equalize the secondary cable length such that the converters current controls algorithms are exactly the same (simplified operation and spares organization).
  - Have a unique pulse transformer spare in the same zone and reduce PSB
  - downtime in case of a pulse transformer or DCCT failure.

Integration

BSW1 pulse transformers

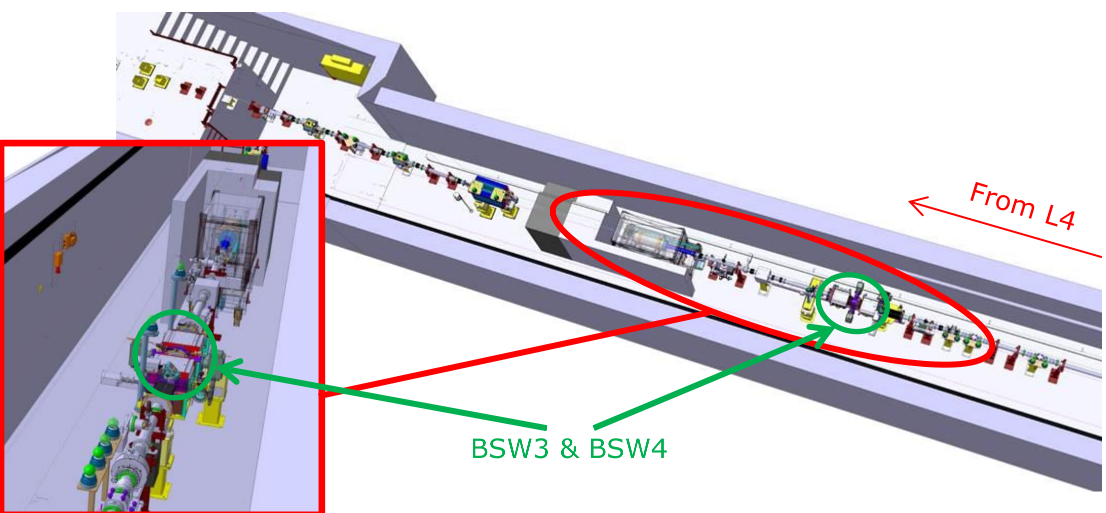
- Shall be placed next to injection region
- Either on concrete slab or false floor reinforcement
- Secondary cables or bus-bars to be selected

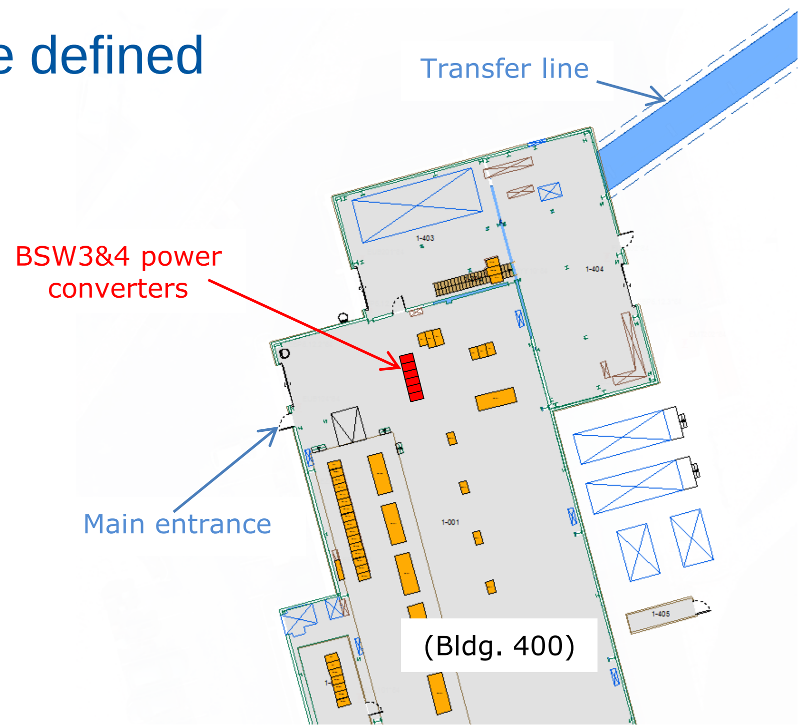
Concrete slab ends here



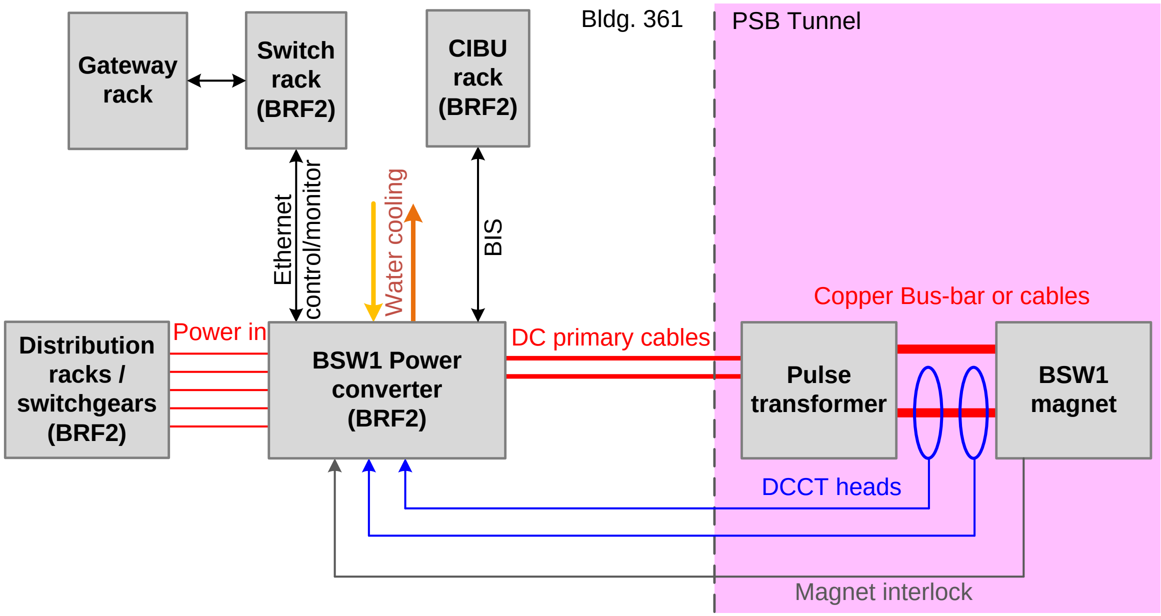
Half Sector Test in a nutshell

- Same power converters to be re-used in PSB (BSW2&4)
- Power converters ready in early 2016!
- 2 x power converters installed in Bldg. 400
- BSW3 & 4 magnets installed in L4-PSB transfer line
- Cable length: 70m. If shorter in PSB, pulse transformers are different
- Pulse transformers installed inside PC racks
- Water cooling and power distribution to be defined



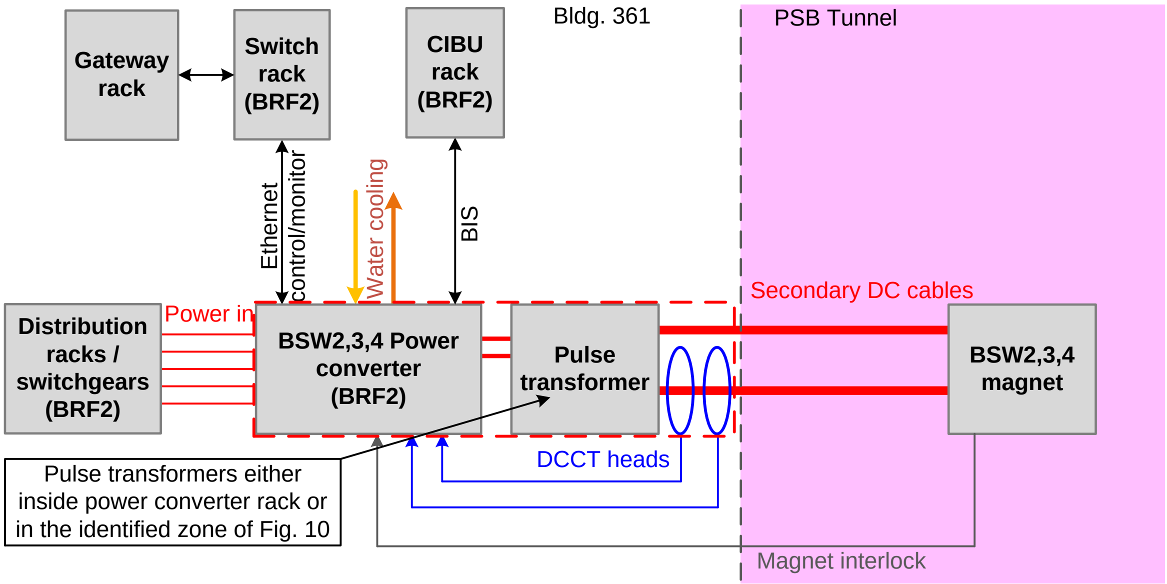


Connections with power converters / summary



BSW1 converters (PSB only)

- AC distribution cables (with neutral)
- Water cooling
- BIS
- Primary DC cables
- Secondary cables/busbars
- DCCTs cabling
- Magnet interlock cable/interface



BSW2,3,4 converters (PSB & HST)

As above with transformer outside tunnel

General development strategy

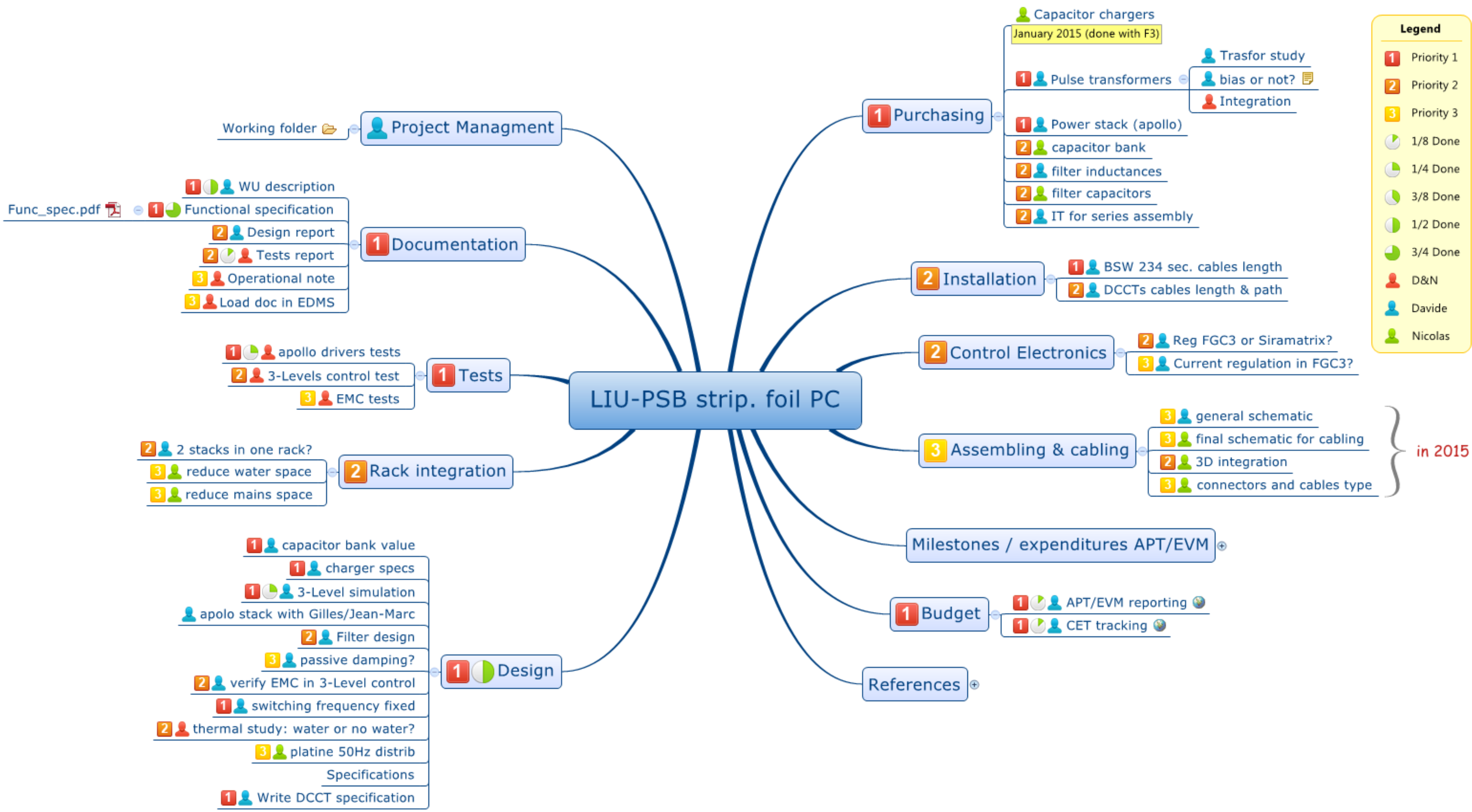
Reminder:

- HST power converters (PC) ready (before commissioning) by early 2016
- PSB PC ready (before commissioning) by end 2017

Strategy:

- Same PC for BSW1 and BSW2,3, & 4 – only pulse transformer and current measuring system differ
- Re-utilization of existing power stack design-probably no MS-IT procedure!
- 3 PCs ready by early 2016 – 2 x BSW3 & 4, and 1 x BSW1. Power stacks for prototypes via recent contract options
- Reception at CERN of main series components (chargers, capacitors, power stacks, DCCTs) by end 2016
- MS-IT procedures for chargers (~200kCHF), DCCTs (~200kCHF), pulse transformers, and power converters assembly

Activities and priorities



Milestones Schedule

Major milestones and activities

Description	2014	2015			2016			2017		
	Sept-Dec	Jan–Apr	May-Aug	Sept-Dec	Jan–Apr	May-Aug	Sept-Dec	Jan–Apr	May-Aug	Sept-Dec
Eng. design										
Parts for HST + BSW1										
HST PC construction										
Series prod MS-IT										
Parts 4 series (MS-IT)										
Transfo MS-IT										
Series assembling										

Installation and commissioning in 2018

Actions for finalizing functional spec.

Major actions to finalize functional spec. and finalize design / start purchasing

Item #	Objective	who	By date
1	Confirm that 50 *ppm* 40 *kHz* current ripple acceptable	TE/ABT	Now
2	Cable length between pulse transformers and magnet	EN/EL	21st Nov.
3	Cable distance and path for BSW1 DCCTs (current measurement)	EN/EL	21st Nov.
4	Dimensions of identified zone for pulse transformers	EN/EL – EN/MEF	28th Nov.
5	Define the interfaces, type and number of cables, for magnet interlock. Actions with	TE/EPC - TE/ABT	5th Dec.
6	Define timing management solutions.	TE/EPC – BE/OP	12th Dec.
7	Define BIS current tolerance for safe operation in the PSB and HST.	BE/ABP - BE/OP	12th Dec.
8	BRF2 global integration studies considering RF renovation + HST global integration study	TE/EPC - BE/RF EN/MEF – EN/EL	Early 2015
9	Water distribution needs and work	TE/EPC – EN/CV	Early 2015

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