LHC Injectors Upgrade

CERN

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PSB
Main Power Supply

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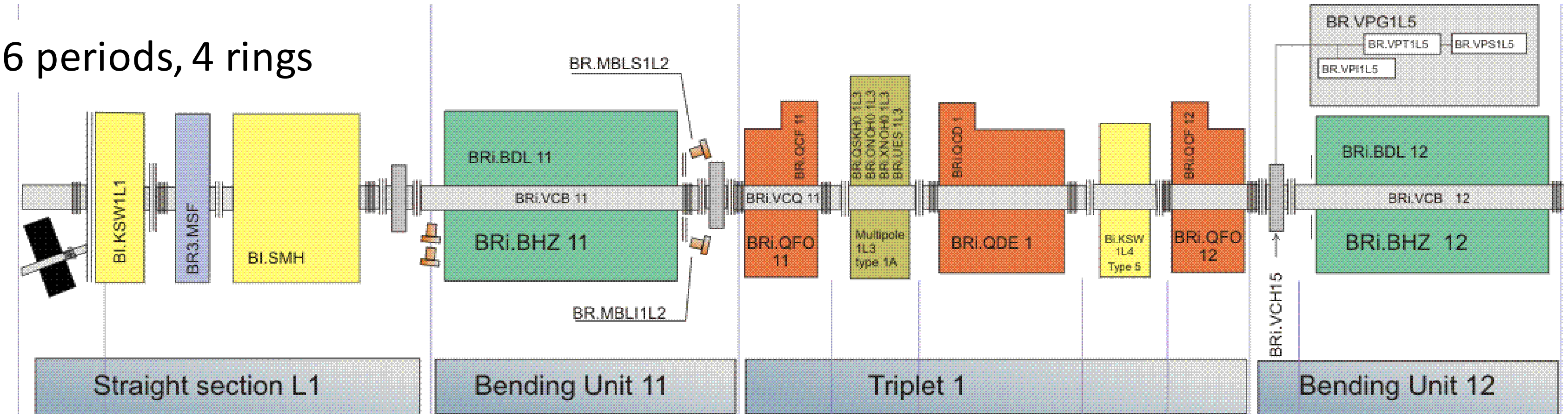
- Overview of the existing Booster MPS system.
- The 2GeV requirements.
- LIU baseline: The “POPS” style alternative.
- Technical alternatives.

Booster MPS load characteristic

16 periods, 4 rings



	Magnets quantity	Total resistance [mOhms]	Total inductance [mH]
Dipoles outer ring	64	172	64
Focusing quadrupoles	128	74	8
Reference magnet	4	10	4
Defocusing quadrupoles	64	51	6
Dipoles inner ring	64	172	64
Total	**324**	**479**	**146**

Booster MPS circuit

1.4GeV margins:

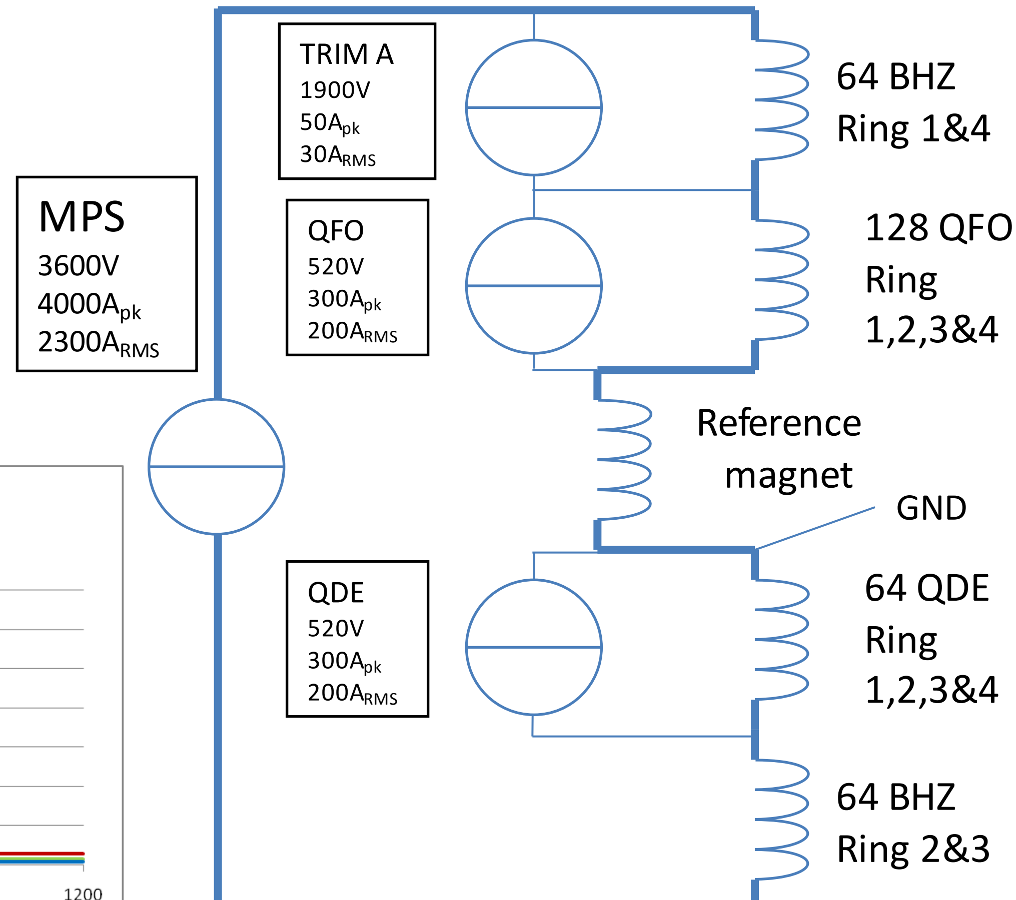
MPS voltage: -2%

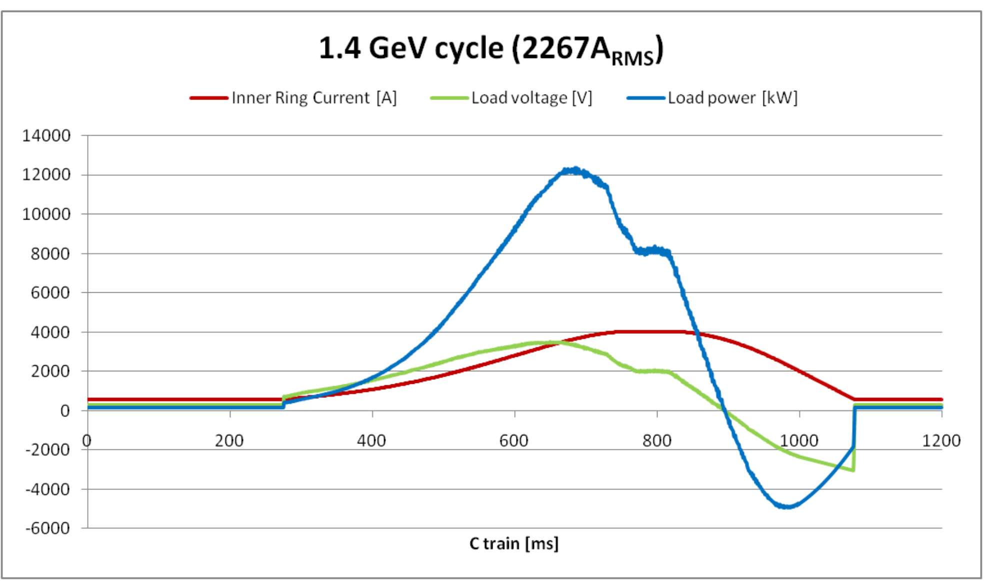
MPS peak current: -2%

MPS rms current: 3%

TRIM A peak current: 40%

TRIM Q peak current: 0%

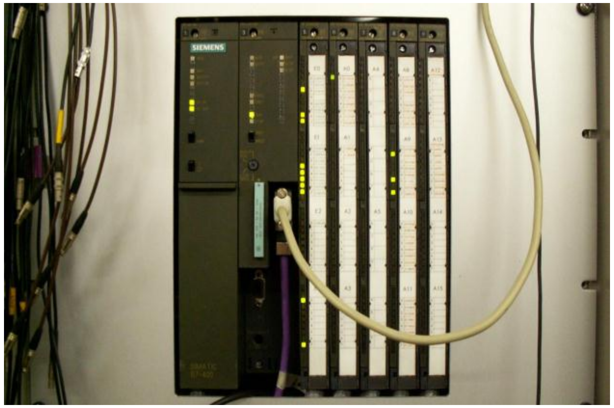




Booster MPS: the eighties

Booster MPS: 1998 consolidation

Automation & firing



Trims

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LIU project scaling factors

TE EPC

- From 1.4Gev to 2 GeV. — B-field: x1.3
- Considering some saturation effect, margin for B-field regulation and operation. — Peak Current: x1.4
- Power dissipation in the magnets with today's ramp rate — Power: x2
  Far from design margins (20-30%)…
- Power dissipation in the magnets with existing MPS at maximal ramp rate. — Power: x1.8
  Better but not enough…

New magnets and/or new MPS needed in any case

The existing Booster MPS at 2 GeV

Upgrade scaling on one cycle

MPS peak current: +30%

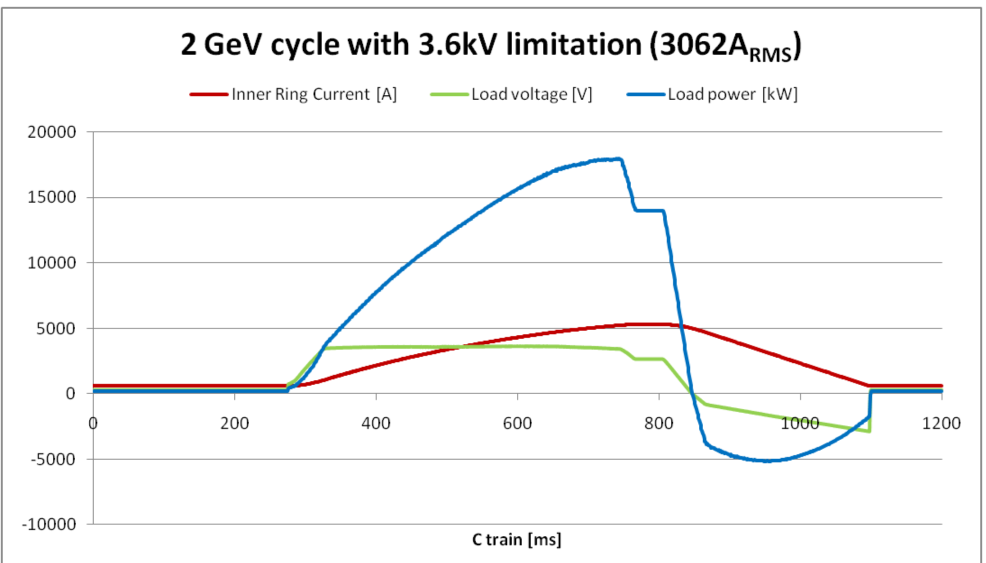
MPS rms current: +35%

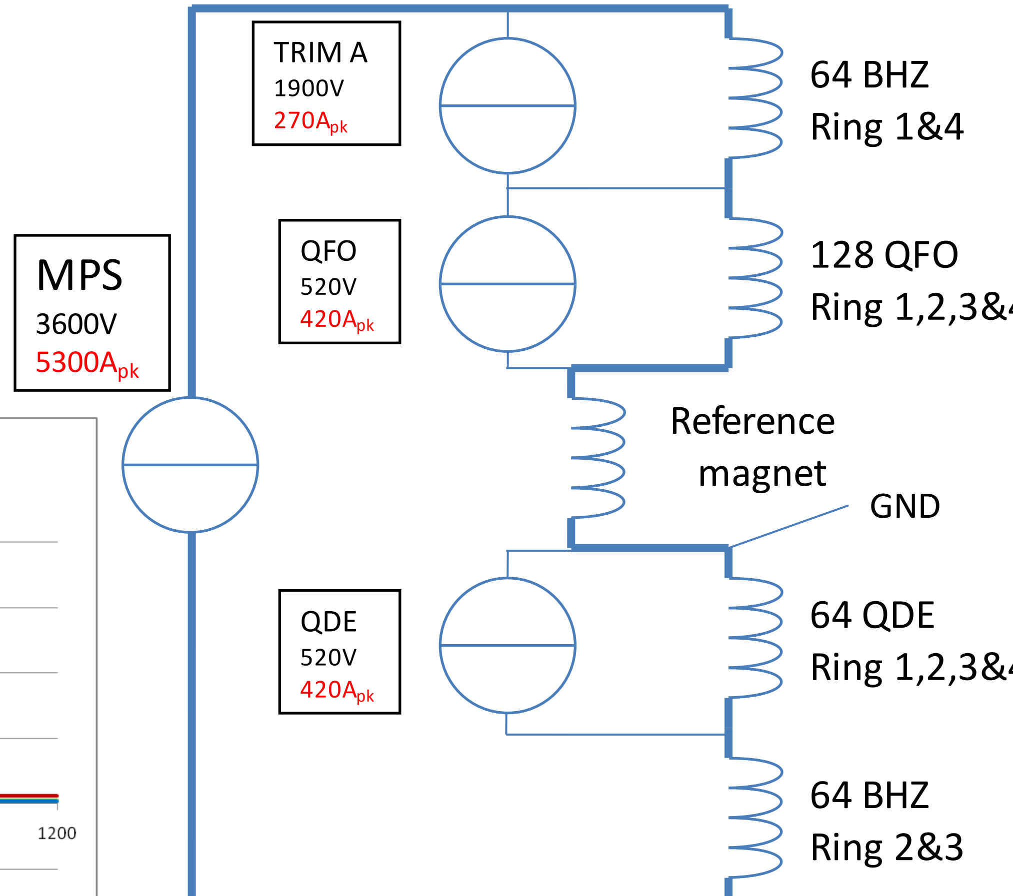
18kV apparent power: +77%

18kV peak power: +45%

TRIM A peak current: +540%

TRIM Q peak current: +40%

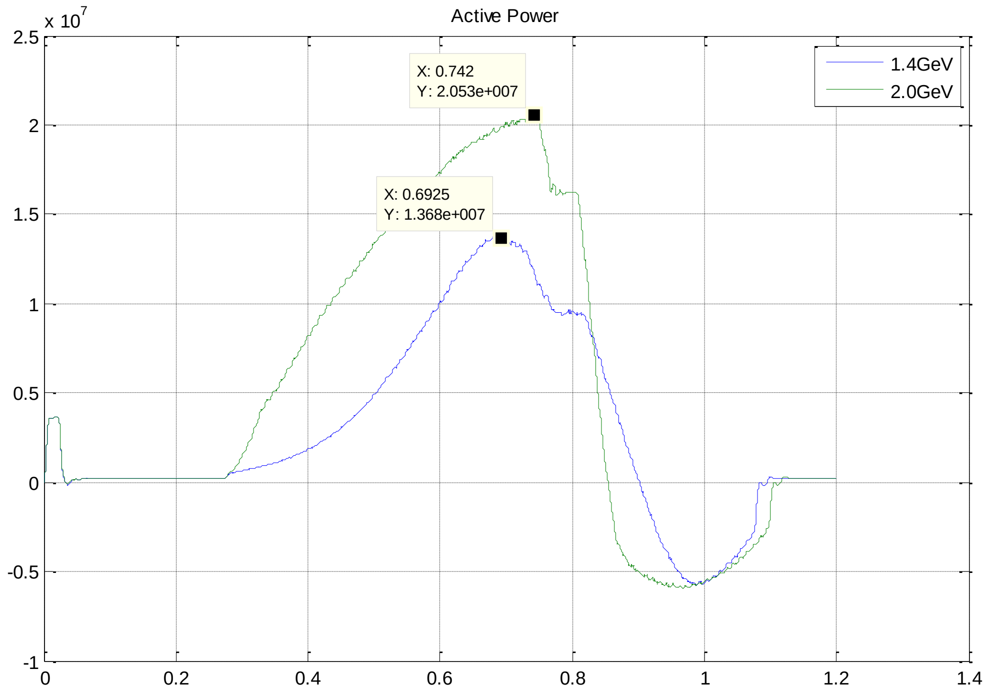


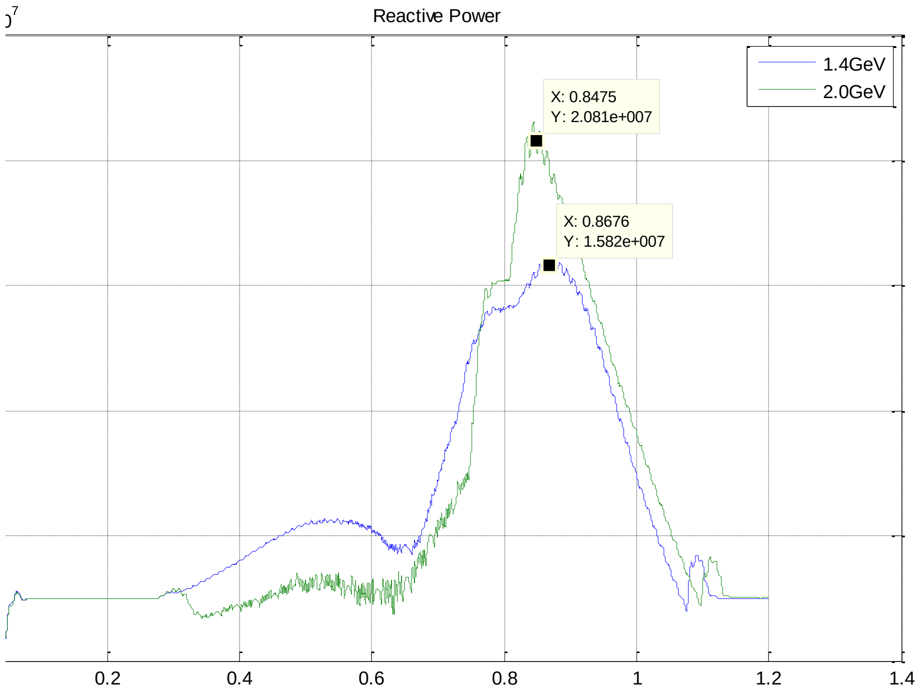


Impact on the 18kV Meyrin network

Fast transients with 2GeV cycle which can not be compensated by Meyrin SVC.

50% increase of active power, 30% increase of reactive power





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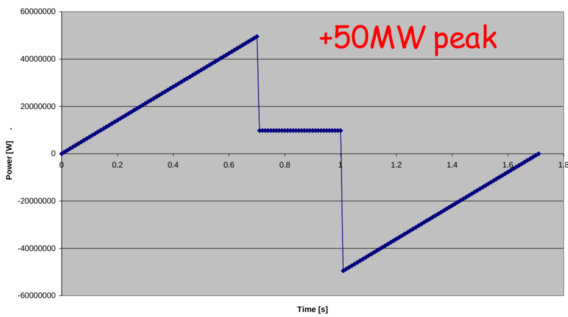
“POPS” basic principles

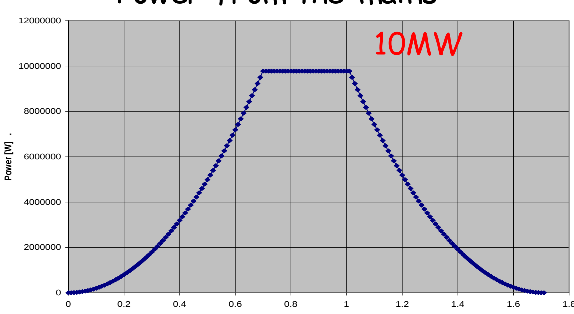
The energy to be transferred to the magnets is stored in capacitors.

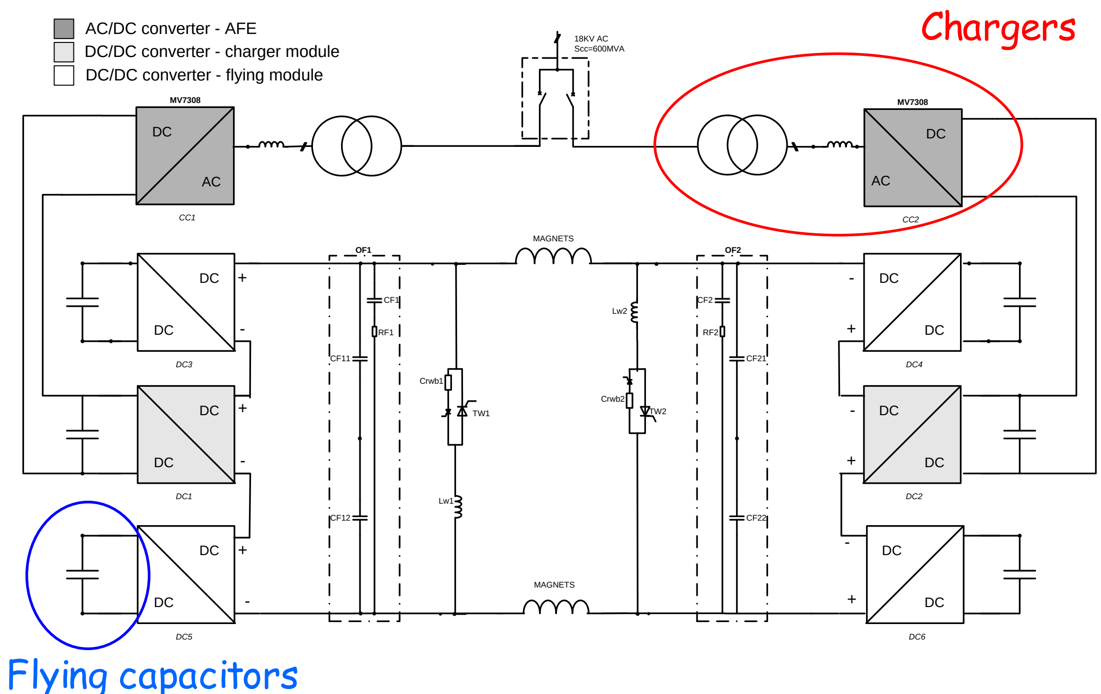
- DC/DC converters transfer the power from the storage capacitors to the magnets.
- Four flying capacitors banks are not connected directly to the mains. They are charged via the magnets.
- Only two AC/DC converters (called chargers) are connected to the mains and supply the losses of the system.

Power to the magnets:

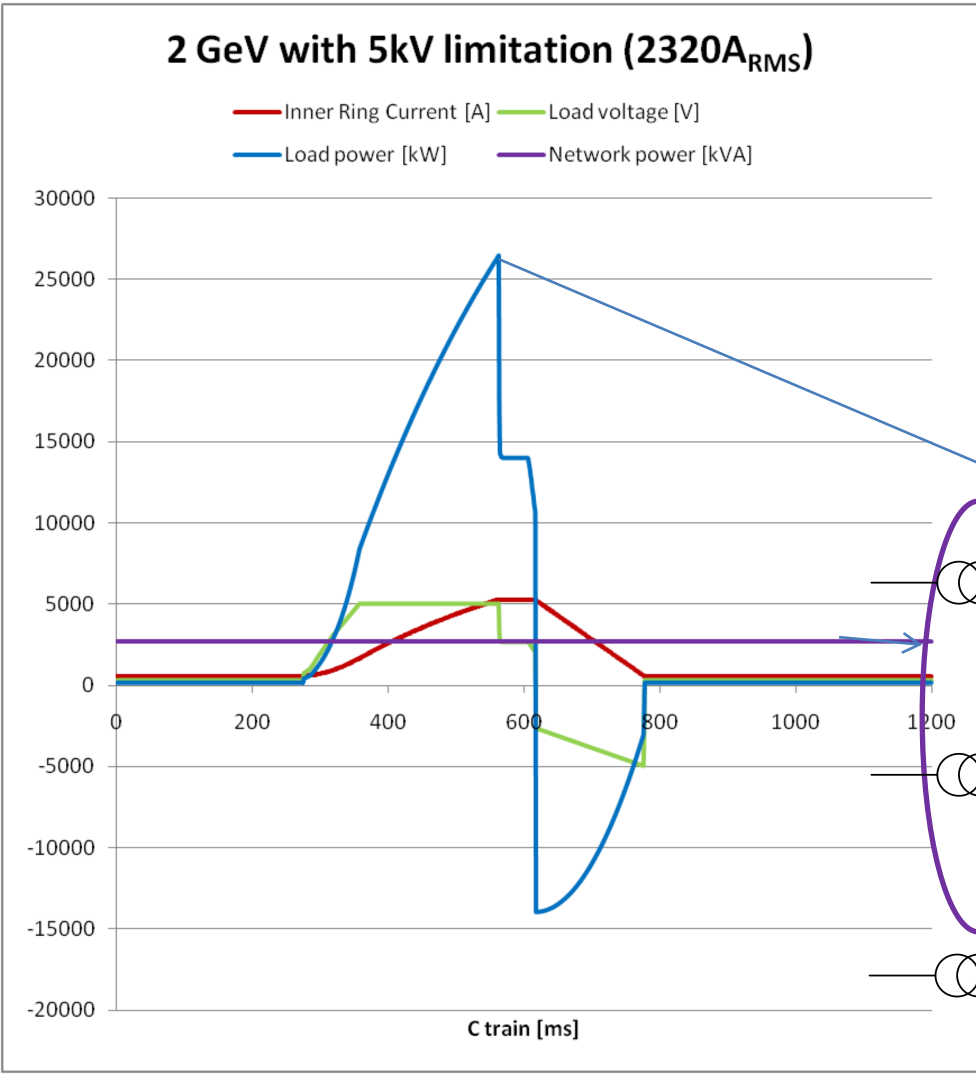


Power from the mains





LIU Baseline: Fast cycle



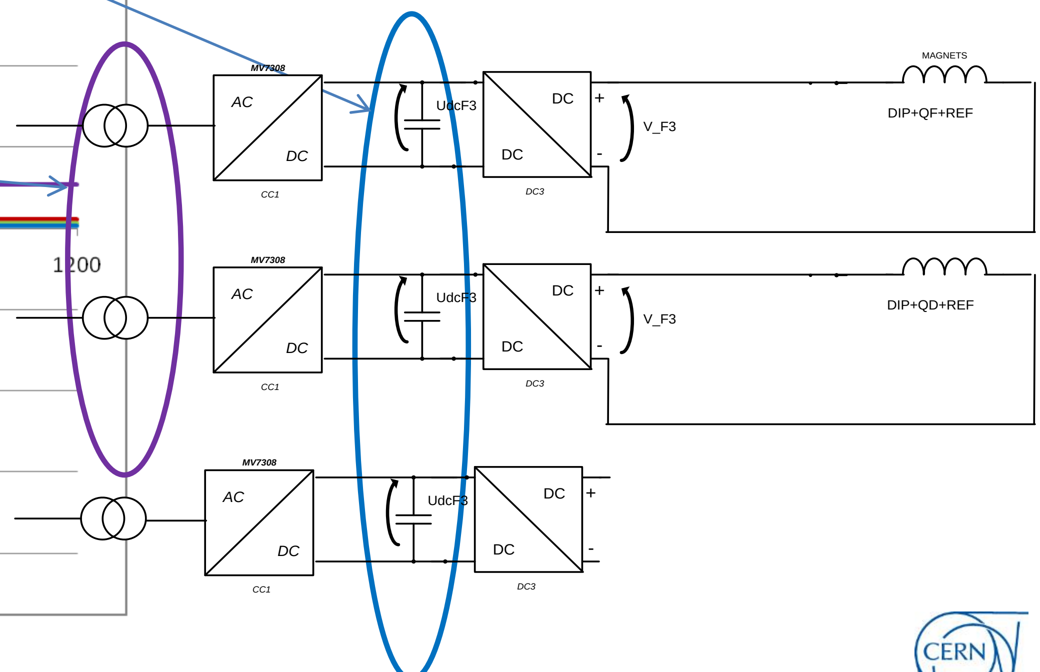
Upgrade scaling on one cycle

MPS peak current: +30%

MPS rms current: +3%

18kV apparent power: -26%

18kV peak power: -78%



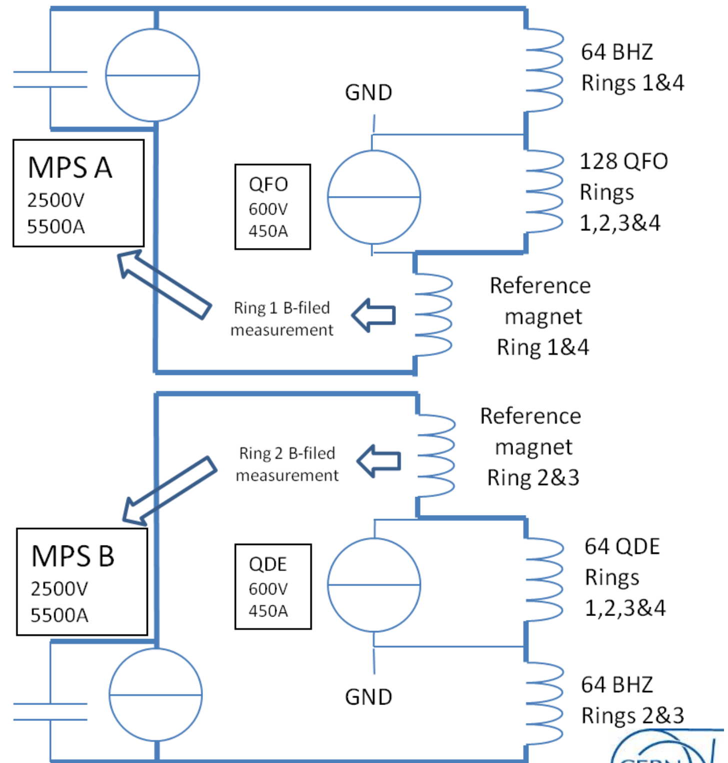
LIU-PSB 5.2 WU– MPS power converter

physics		LS1	physics				LS2	physics
2011	2012	2013	2014	2015	2016	2017	2018	2019

- Alternative with new magnet studied
- Design baseline confirmed and refined
- Specification ready for submission
- Market survey and call for tender completed
- Converter manufactured and installed
- Converter system commissioned
- Converter commissioned and ready for operation

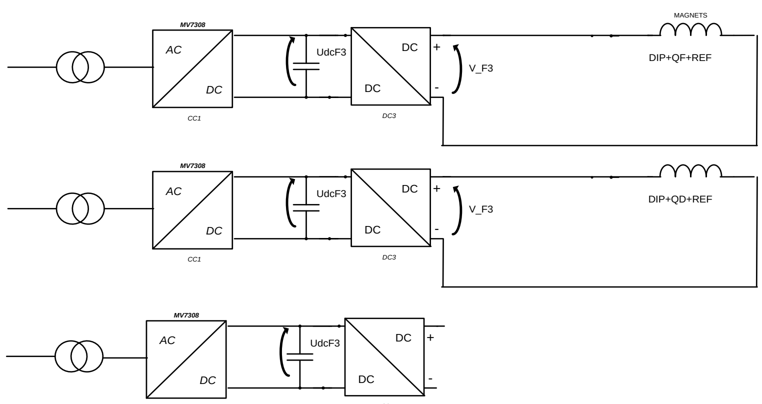
Benefits

- Overall voltage available increases and would allow a reduction of the RMS current using a faster ramping.
- The capacitor bank totally absorbs the peak power on the 18kV network. Meyrin SVC would then become optional.
- Spare sharing between MPS A and B and eventually with POPS.
- Only a few new cables needed between the reference magnet (BCER) and the MPS.
- New B-field regulation to minimize eddy currents and saturation effects impact at higher current and acceleration rate.



Drawbacks

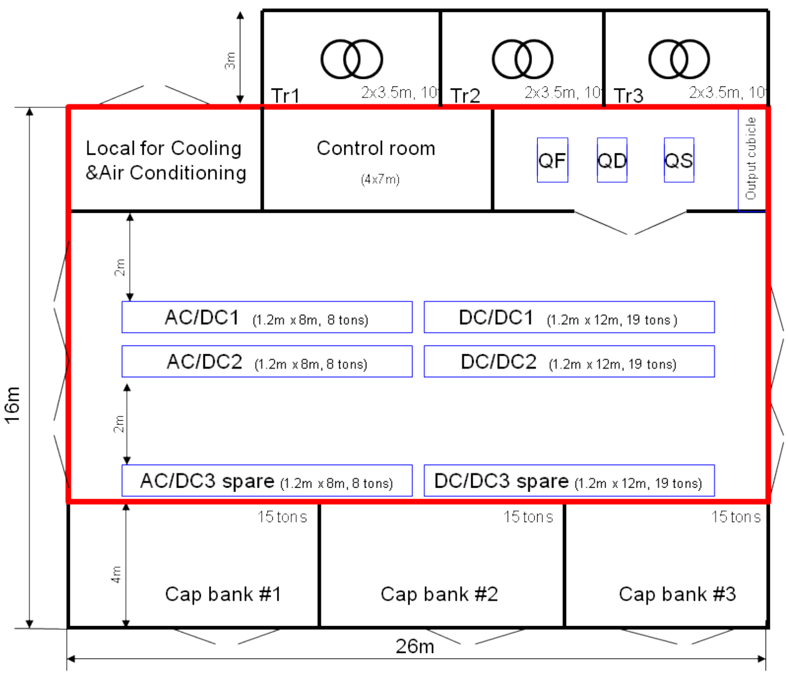
- Cost.



LIU-PSB 5.2 WU– MPS civil engineering

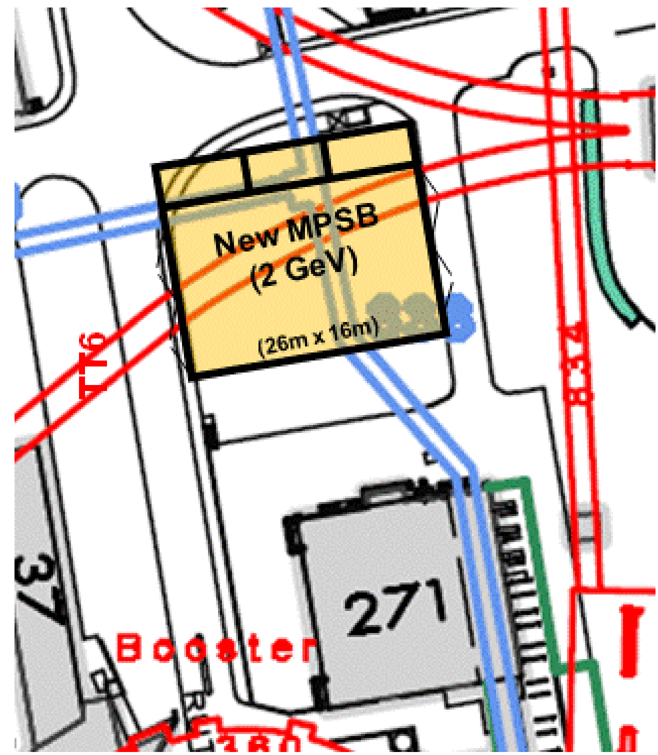
physics		LS1	physics				LS2	physics
2011	2012	2013	2014	2015	2016	2017	2018	2019

- Civil engineering pre-study completed
- Civil engineering designed
- Civil engineering heavy workload done
- Building infrastructure & services ready

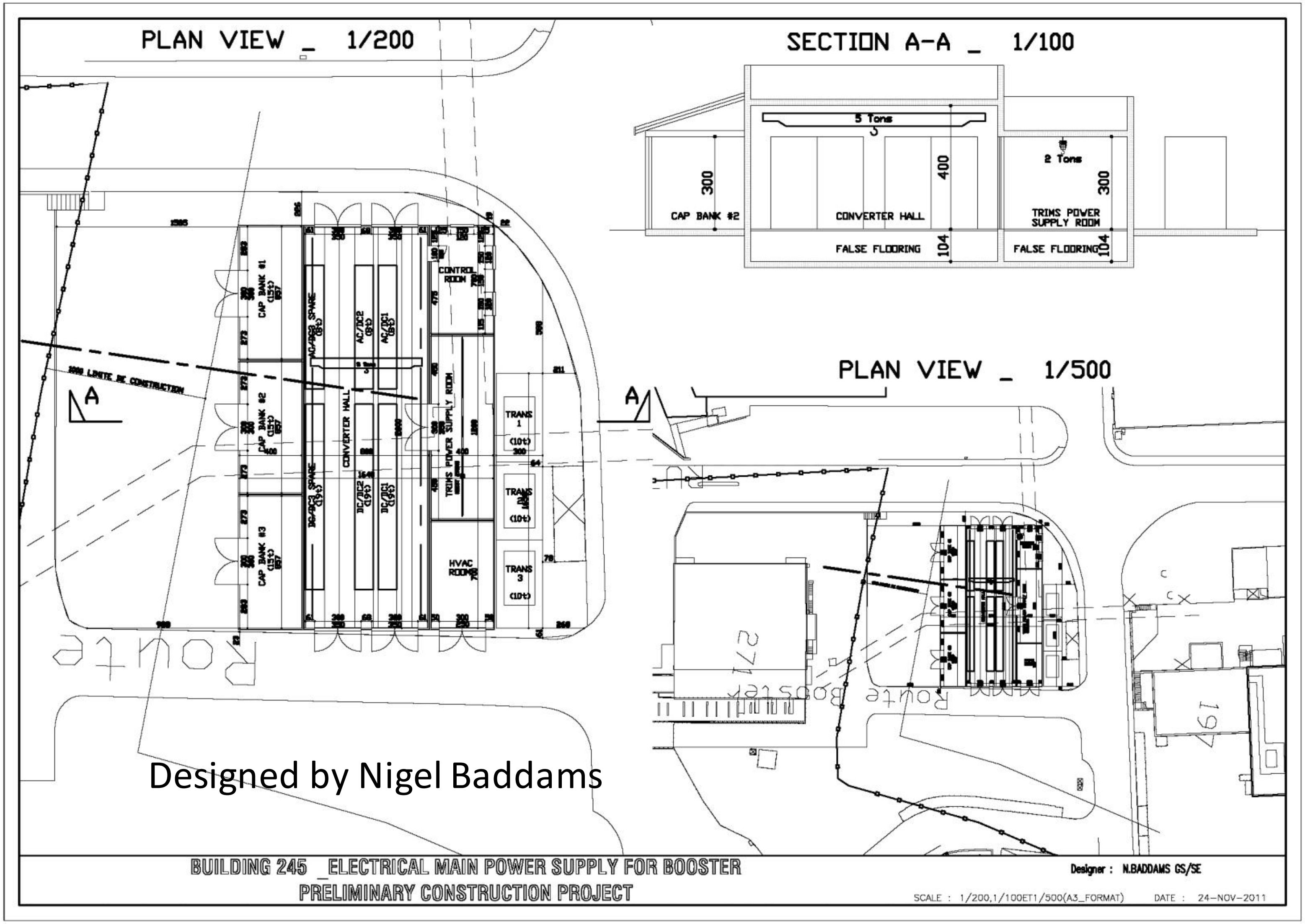


With this new building:

- We can install and commission during Booster operation.
- We have a backup power supply during the first years.
- Easy connection to existing cables and cooling services.



Building 245 - Preliminary Drawing



Designed by Nigel Baddams

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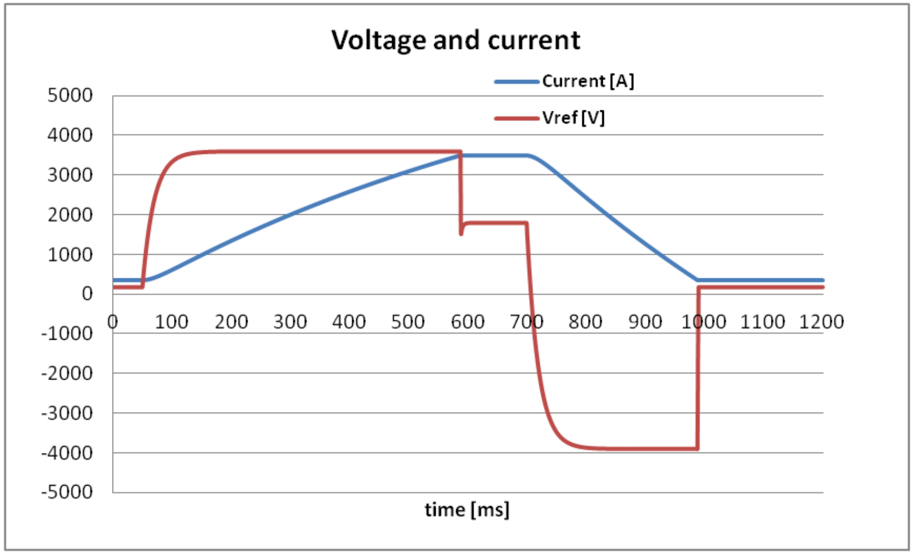
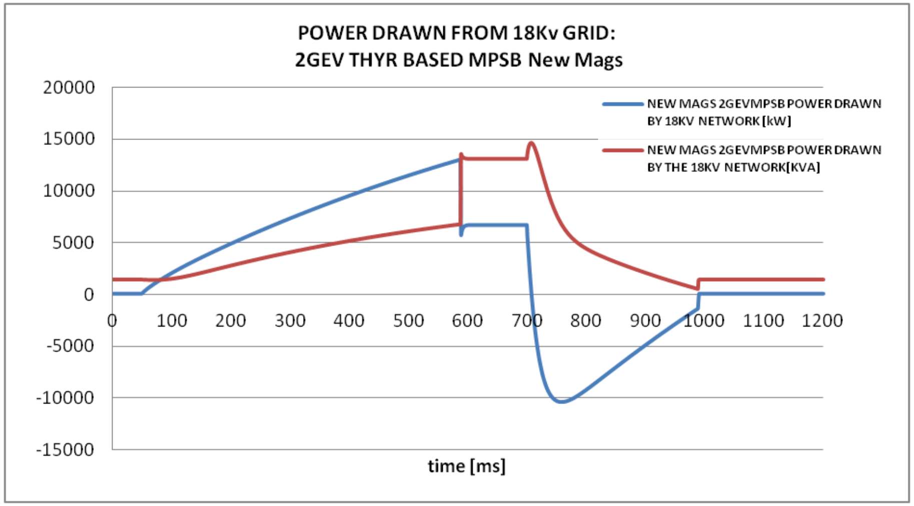
Existing MPS with new magnets

- Preliminary design of the magnets by TE-MSC: R=0.52Ohm, L=0.42H, Inom@2GeV=3500A.
- Simulation shows that the existing MPS could be reused (consolidation sill needed!).
- Stress on the meyrin 18kV network similar to what is measured today at 1.4GeV.

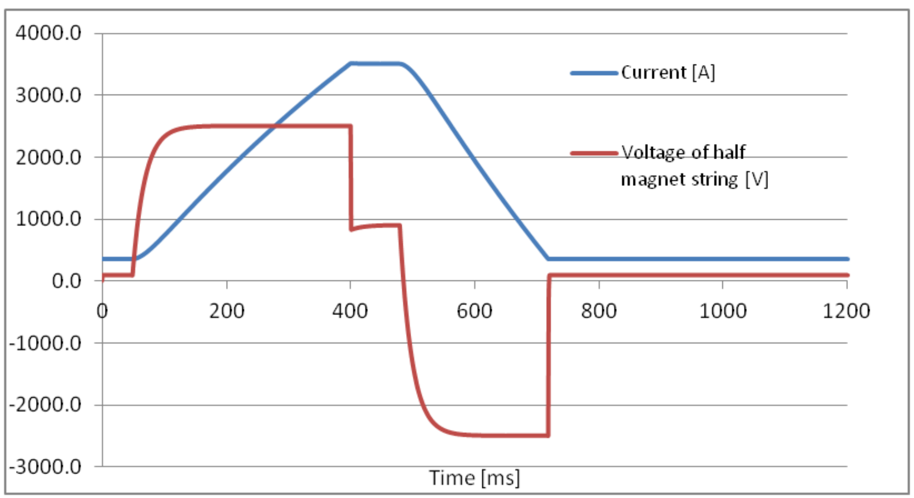


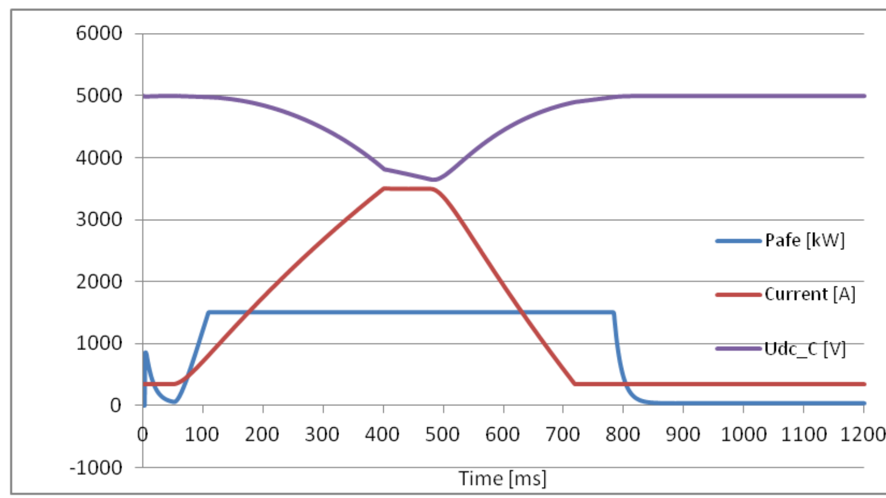


New MPS with new magnets

- Allows fast cycle and significant reduction of the RMS current in the magnets.

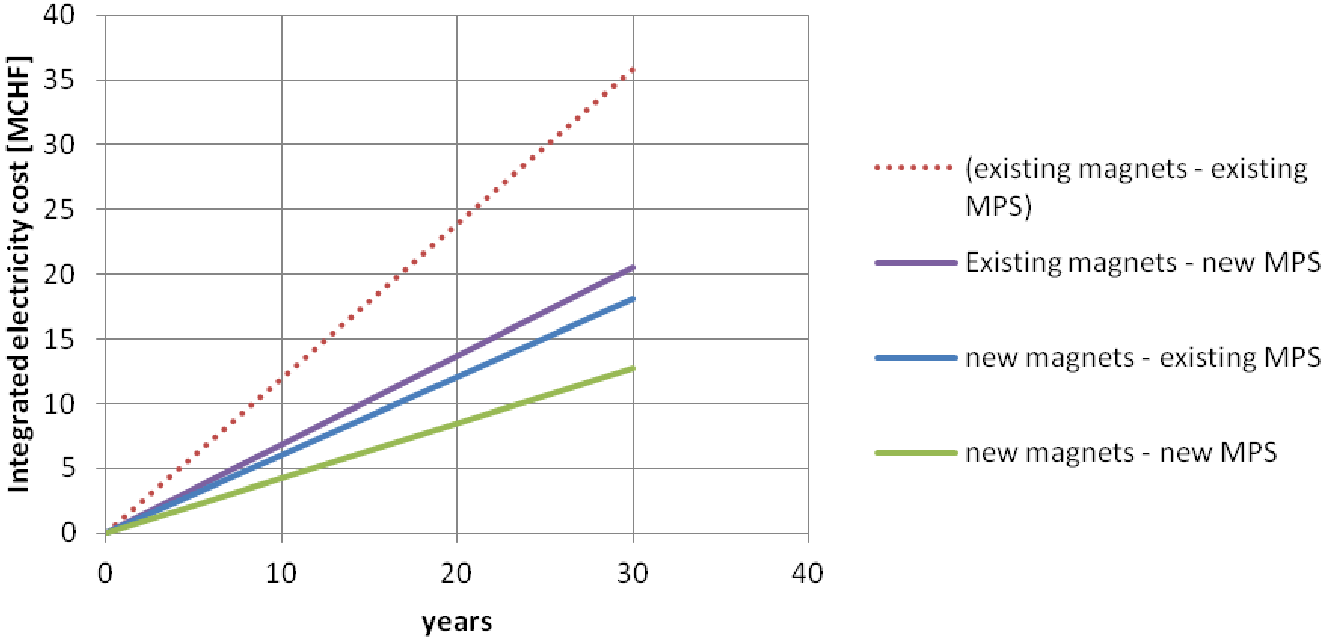
- Cost of an adapted POPS style MPS to be compared to the consolidation cost of the existing one.





Comments on Power Consumption

- Values plotted below are based on the existing magnets, 5000 hours of operation per year and 0.051CHF/kWh (average price in 2010).
- In any cases several MCHF would be saved on a new supply and/or on electricity consumption with new magnets.
- **Does not include a foreseeable increase of the price per kWh.**



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THANK YOU FOR YOUR ATTENTION!

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