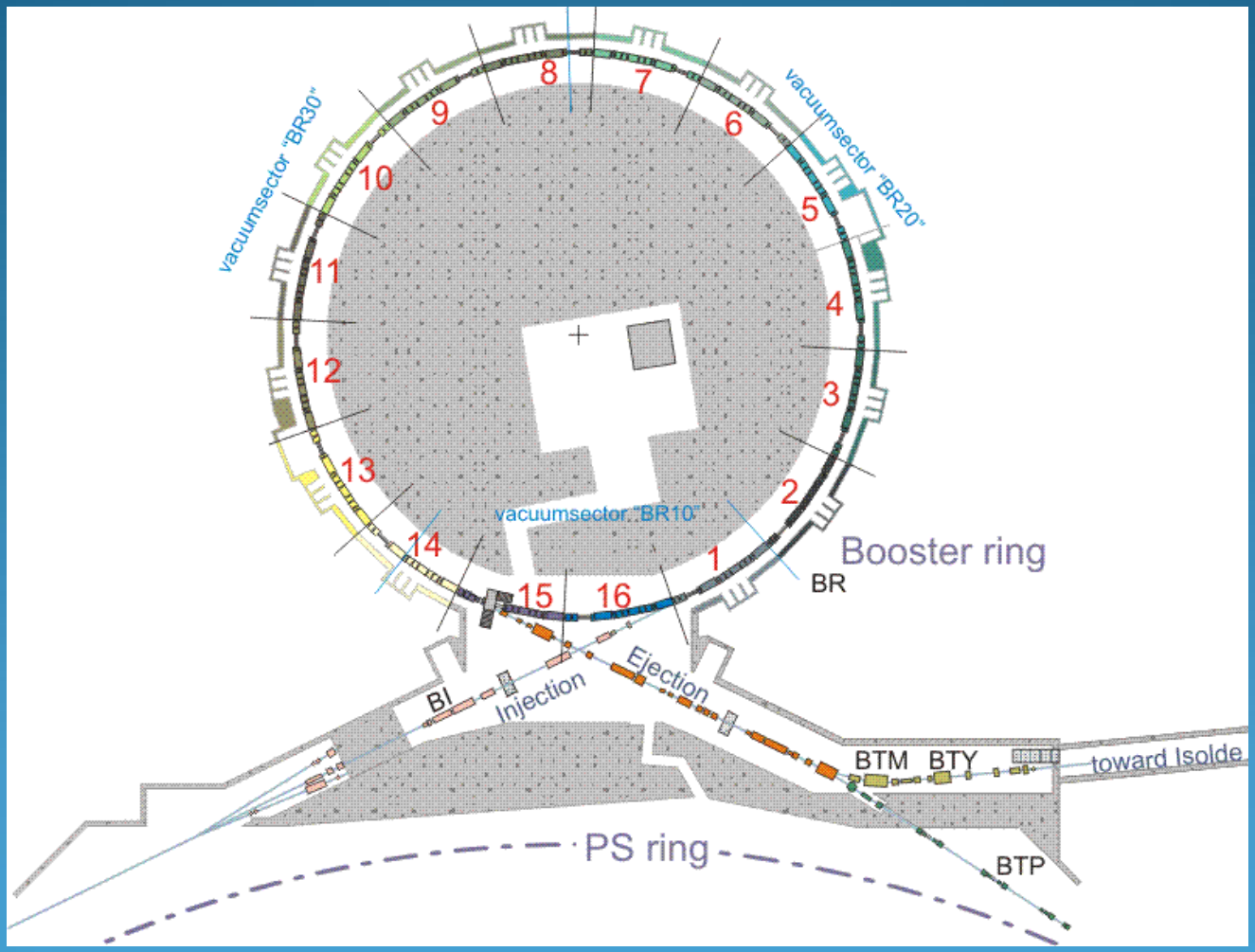
How to ensure reliable PSB operation for the next 25 years



History of Booster

- The accelerator was built in 1972.
- The **Proton Synchrotron Booster** is the first, in the accelerator chain, and smallest proton circular accelerator in the LHC injection complex.
- It has four superimposed rings with a radius of 25 meters.
- It takes 50 MeV protons from the Linac2 and accelerates them up to 1.4 GeV, ready to be injected into the PS.

Areas covered

- Electrical power converters
- Septum / kickers
- Magnets
- Interlocks
- RF (Low level / High level)
- Cabling
- Cooling and ventilation
- Instrumentation
- Vacuum
- Source targets and interactions
- General Infrastructure
- Final thoughts

Electrical Power Converters (TE/EPC)

Model	Quantity	Designation	Last upgrade	Unit Cost (kCHF) 2009 ESTIMATION	Next upgrade	Consolidation Cost (kCHF) 2009 ESTIMATION
A1/IP	16	InverPower 15kW	1998	80	2018	1280
A2/IP	10	InverPower 31.5kW	1998	80	2018	800
A3/IP	4	InverPower 35kW	1998	80	2018	320
B1/IEP-REC	3	IEP avec récupération 100kW	1998	150	2018	450
BEN-250KW	2	IEP 250kW	1998	250	2018	500
BI_QNO	3	Power Converter : BI.QNO [±40A, ±35V]	1995	10	2015	30
BIX_QNO	8	Power Converter : BIX.QNO [±100A, ±30V]	1995	10	2015	80
BR_MPS	1	Power Converter : PS01 [±4100A, ±3900V] - POWER	1982	900	2015	900
SVC MEYRIN FILTER	1	SVC : MEYRIN FILTER [-22.7Mvar]	1976	700	2014	700
SVC TCR BOOSTER	1	SVC : TCR BOOSTER [+17Mvar]	1997	2000	2020	2000
Total						**7060**

- 50% of all existing power converters will need to be replaced by 2020 = 7 MCHf

Septum / Kickers (TE/ABT)

System	Type	Subsystem	Action	Comment
BE.BSW	Kicker	Magnets	Build spare magnets	
		Transmission lines	Change HV cables	
		Electronics & Controls	Renew controls & electronics equipment	
BT.KFA10	Kicker	Magnets	Build spare magnet modules	
		Transmission lines		HV gas cables not manufactured anymore
		PFLs & HV switches		HV gas PFL not manufactured anymore
		Electronics & Controls	Renew controls & electronics equipment	
BT.KFA20	Kicker	Magnets	Refurbish spare vacuum tank (radioactive)	1 full spare exists but vacuum tank has leaks
		Transmission lines		HV gas cables not manufactured anymore
		PFLs & HV switches		HV gas PFL not manufactured anymore
		Electronics & Controls	Renew controls & electronics equipment	
BE.KFA 14L1	Kicker	Magnets	Refurbish spare magnet modules	
		Transmission lines		HV gas cables not manufactured anymore
		PFLs & HV switches		HV gas PFL not manufactured anymore
		Electronics & Controls	Renew controls & electronics equipment	
oil/gas	Kicker	Hydraulic	Renew equipment and change insulation fluid	
		Electronics & Controls	Renew controls & electronics equipment	Partially part of approved consolidation program
Thyratron	Kicker	Thyratron	Buy and store thyratrons for 20-25 years	Single source supplier - could disappear

Magnets
(TE/MSC)

- It is believed that the PSB magnets can operate during the next 25 years with very high levels of reliability provided that:
  - the present maintenance plan is pursued;
  - Procure one spare multiple corrector per type (about 300 kCHF in total)

- All magnets of the PSB transfer lines are covered by spares with the exception of -TBH (PXMBHFBWWP) -BHZ20 (PXMBHEACWP) The manufacture of a spare unit of each has been recently approved in a frame of the consolidation budget.
  - The new spare units shall be available by mid-2011.

- Note that we cannot increase energy, some magnets are already in saturation. If there is an energy upgrade of the PSB, it will not be possible with the present setup.

Magnet Interlock (TE/MPE)

- Protection of magnets covered by new interlock system (i.e. **WIC**):
  - Based on Safety PLC (*F series from Siemens*)
  - Solution used in LHC, SPS transfer lines , LEIR and LINAC3.
  - Will protect <u>all</u> Booster circuits.

- Note: deployment initially foreseen during shutdown 2010-2011. Due to new LHC schedule, the installation should be postponed to next shutdown.

RF (Low level)

(BE/RF)

* The figures below are in addition to the usual annual budget for maintenance activities.

Requirements to keep the PSB RF System running for 25 years

- Renewal of the pick-up head amplifiers for the phase loop, 1 plus 1 spare per ring or 8 amplifiers in total including power supply, estimated delivery 2013, cost approximately ***25kCHF***.
- The cabling may need to be renewed due to the increased radiation with the higher beam intensities from LINAC 4, i.e. probably 16 coax cables or 8 twisted pairs and 8 power cables from the head amplifiers to the BOR.
- The renewal of PSB beam control (including spares), is a project that is underway and estimated to be delivered in 2013 for ***450kCHF*** from the currently agreed consolidation budget. This will not include control of the cavity tuning or voltage loops, so if this is required due to cavity changes, additional money and manpower would need to be added.
- It would be estimated that a further consolidation of the PSB beam control would be required after 12-15 years of operation, with a cost estimation of ***500kCHF***.

Requirements to keep the PSB Transverse Damper System running for 25 years

- Renewal of the pick-up head amplifiers and power supplies for the H&V systems in each ring, i.e. 16 amplifiers plus 8 spares, delivery for 2013 at a cost of approximately ***25kCHF***, unless a similar amplifier to that used for the phase loop above is suitable, when this cost could be reduced.
- Renewal of the PSB Transverse Damper System:
- 4 VME crates : 32 kCHF, 4 Power PCs : 40 kCHF, 8 mother boards + 2 spares = 10 boards: 20 kCHF
- Design office: 15 kCHF (shared with all 1TFBs, and TFBs for other machines)
- 8 new power amplifier + power loads + PLC control + renewal of the water cooling system = 380 kCHF
- ***Total: 500 kCHF***

- It would be estimated that a further consolidation of PSB Transverse Damper would be required after 12-15 years of operation, with a cost estimation of ***500kCHF***.

RF (High level)
(BE/RF)

- Reconstruction of the Co4 RF system going from air cooled to water cooled system and including new HV power supplies, tuning supplies, interlocks and servos: **7 MCHF**
- Partial reconstruction of the Co2 system, including HV power supplies, tuning supplies, interlocks and servos: **2.4 MCHF**
- Partial reconstruction of the C16 system, including HV power supplies, tuning supplies, interlocks and servos: **2.4 MCHF**
- Cabling renewal due to radiation damage (?): **1 MCHF**

Cabling

- On top of existing Consolidation (44MCHf)
- PSB & PS
  - Replace all cabling (48 MCHF)
  - Replace low voltage switchboards, UPS, safety lighting etc. (14MCHf)
  - Renovate HV substations ME16, ME49 & M76 (2MChF)

Cooling & Ventilation (EN/CV)

- Replacement of the Booster ventilation systems (including the problem of the asbestos)
- For the cooling stations:
  - Replacement of the cooling towers,
  - Replacement of the valves,
  - Replacement of the control and electrical part,
  - possibly replace several heat exchanger.
- Compressed air production needs to be fully refurbished.
- Renovate production for dematerialized water

Instrumentation
(BE/BI)

System	Replacement of detector		Replacement of acquisition system		Comments
	Price [CHF]	Man power [MM]	Price [CHF]	Man power [MM]	
Booster orbit	0	0	250k	18	192 ADC ch+ new cables
Booster half turn	0	0	50k	6	
Booster BCTDC	40k	4	100k	8	Monitor modif. + new electronics
Booster BCTFR	50k	12	80k	8	Monitor ? + new electronics
Booster WCM	0	0	20k	1	Connection to OASIS?
Booster extraction PU's	0	0	150k	12	
Booster extraction BCTF's	200k	12	50k	10	Cabling BTMTRA, ISO transformers + Acq. chains
Total	**1300kCHF**	**85MM**	**1830kCHF**	**135MM**	

Vacuum
(TE/VSC)

- First “estimate”
  - Operation to 2022 replace 50-70% of system hardware
  - Operation to 2035 replace 100%
- Any major consolidation campaign (ABT, MSC, RF etc…) would involve a lot of vacuum activity

Source Targets & Interactions (EN/STI)

- No major modifications or upgrades are forseen
- Need to verify that all the objects (dumps, collimators etc..) can sustain the eventually increased intensity (from Linac 4) and build spares.

- Booster dump: the present dump has no spare, nobody knows any details about it and it is unclear how it will behave when we increase the beam intensity (with Linac 4).

General Infrastructure

- Money would need to be allocated to the maintaining of the Booster buildings. They are already quite old and various areas would need to be renovated if they are to be used for a further 25 years.

- Cranes, lifts, handling equipment are in the existing Consolidation plan.

Final Thoughts

- No upgrade in performance considered (treated elsewhere)
- Maintain current beam performance and availability for LHC lifetime
- Major modifications to the injection line and other areas will be done under the LINAC 4 project and therefore are not covered under this topic.
- Consideration has to be made to that fact that the Booster is a labour intensive machine and most works will be done in radioactive zones and will have to be scheduled during shutdowns.