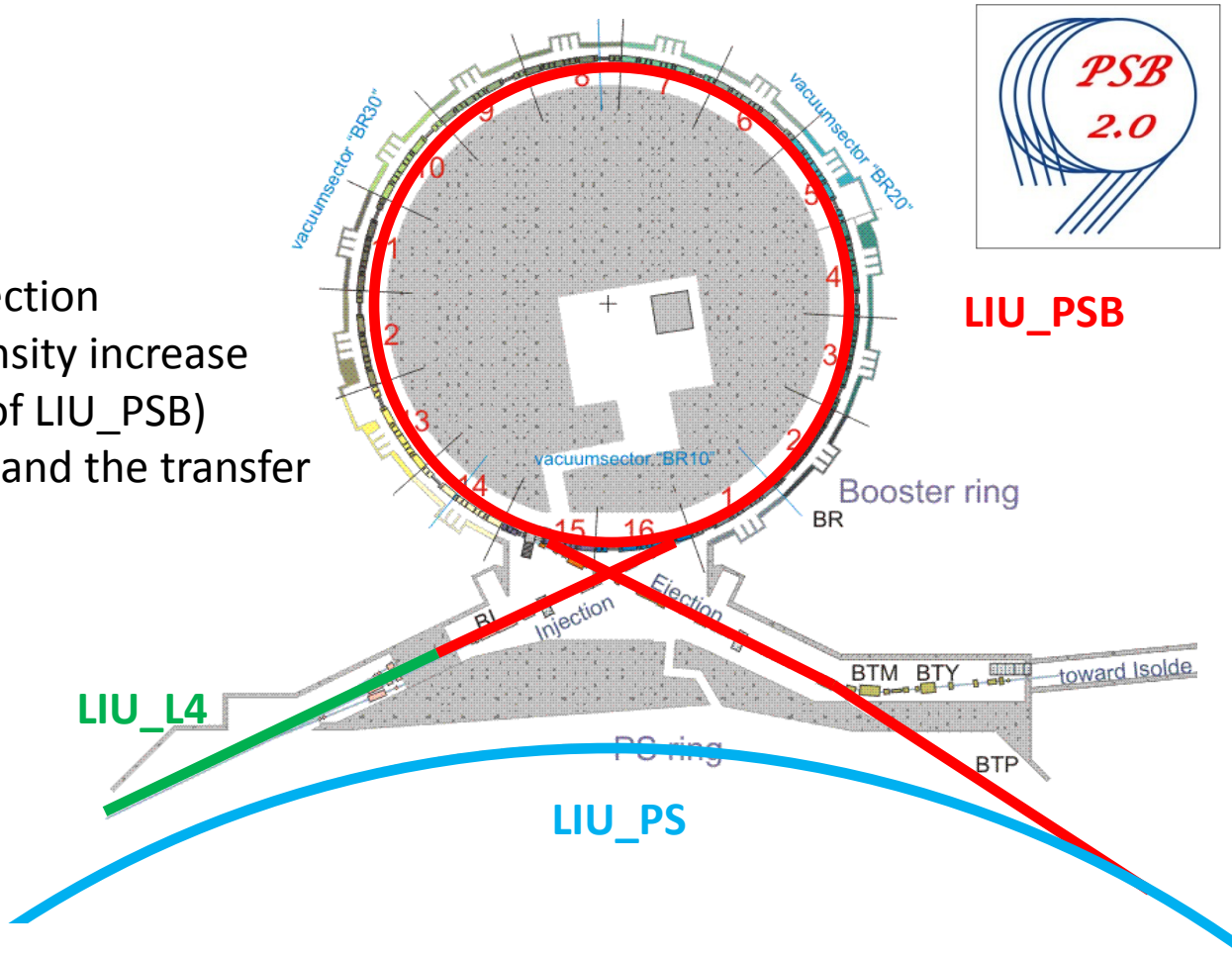
PS Booster Energy Upgrade

K. Hanke
for the PSB Upgrade WG

LIU Event 01/12/10

PS Booster

- upgrade of the BI line and injection region for 160 MeV H- & intensity increase (so far L4 project – now part of LIU_PSB)
- upgrade of the machine itself and the transfer line to the PS for 2 GeV



- construction 1972
- present energy range 50 MeV to 1.4 GeV
- **energy upgrades from 800 MeV to 1 GeV (1988), and from 1 GeV to 1.4 GeV (1999)**
- 7 flavors of LHC beams, 10 types of fixed target beams, intensity and emittances cover several orders of magnitude
- ppm operation (1.2 s cycle length)

PS Booster Energy Upgrade

Follow-up of the 2010 LHC performance workshop at Chamonix
http://indico.cern.ch/conferenceOtherViews.py?view=standard&confId=67839

- remove bottlenecks in the LHC injector chain
- consolidation of the injectors is necessary anyway
- put in place ***Task Force*** for a feasibility study and first resource & time estimate

Working group web page:
https://twiki.cern.ch/twiki/bin/view/PSBUpgrade/WebHome

Mandate

The aim of the study is to evaluate the technical feasibility of an increase in beam energy of the CERN PS Booster from presently 1.4 GeV to about 2 GeV as proposed at the Chamonix 2010 workshop.

<u>The study comprises:</u>

• Confirm the potential gain in terms of intensity and brilliance for LHC-type beams as presented at the Chamonix 2010 workshop.

• Confirm the technical feasibility. Identify accelerator components and equipment that need to be upgraded or exchanged. Identify potential showstoppers and point out solutions. Assign the responsible groups/units. Provide first rough time estimates for the various interventions needed.

• Provide a first estimate of material and personnel resources needed to complete the upgrade. Draft a project break-down into work packages, in preparation for a project to be launched by the director of accelerators.

Working Group Organisation

coordinator K. Hanke / sc. secretary T. Hermanns

1.	Beam Dynamics	G. Rumolo	BE/ABP
2.	Magnets	D. Tommasini, A. Newborough	TE/MCS
3.	Magnetic Measurements	M. Buzio	TE/MCS
4.	RF System	A. Findlay, M. Paoluzzi	BE/RF
5.	Beam Intercepting Devices	O. Aberle	EN/STI
6.	Power Converters	S. Pittet	TE/EPC
7.	Vacuum Systems	E. Mahner	TE/VSC
8.	Instrumentation	J. Tan	BE/BI
9.	Commissioning & OP Issues	B. Mikulec (deputy coordinator)	BE/OP
10.	Extraction and Transfer	J. Borburgh	TE/ABT
11.	Controls	L. Fernandez	BE/CO
12.	Electrical Systems	D. Bozzini, S. Olek	EN/EL
13.	Cooling and Ventilation	M. Nonis	EN/CV
14.	RP and Safety	M. Widorski	DGS/RP
15.	Transport and Handling	I. Ruehl	EN/HE
16.	Survey	T. Dobers	BE/ABP

Linkperson Consolidation	N. Gilbert	EN/MEF
Linkperson Design Office	R. Folch	EN/MME
Linkperson PS	R. Steerenberg	BE/OP
US LARP	E. Prebys	FNAL

…plus other experts from various fields

Feasibility Study

			feasible	impact
1.	Beam Dynamics	BE/ABP	YES	
2.	Magnets	TE/MCS	YES	+++
3.	Magnetic Measurements	TE/MCS	YES	
4.	RF System	BE/RF	YES	(+++)
5.	Beam Intercepting Devices	EN/STI	YES	(+)
6.	Power Converters	TE/EPC	YES	+++
7.	Vacuum System	TE/VSC	YES	+
8.	Instrumentation	BE/BI	YES	
9.	Commissioning	BE/OP	YES	
10.	Extraction, Transfer, PS Injection	TE/ABT	YES	+++
11.	Controls	BE/CO	YES	
12.	Electrical Systems	EN/EL	YES	++
13.	Cooling and Ventilation	EN/CV	YES	++
14.	RP and Safety	DGS/RP	YES	
15.	Transport and Handling	EN/HE	YES	
16.	Survey	BE/ABP	YES	

Summary (before going into the details)

- we have double checked the arguments presented at the 2010 Chamonix workshop and we confirm that an increase in beam energy will facilitate injection of high-brilliance and intensity beams into the PS

- we have done a complete survey of all PSB equipment and systems with regard to an energy increase and did not find any showstopper

- we have identified PSB equipment and systems that need to be modified or exchanged in order to operate at 2 GeV beam energy

- we propose technical solutions for these items, along with a cost estimate and schedule

- we have identified items, which were already accounted for in the consolidation program; we have disentangled these items from our budget request

- we propose a project schedule, which is in line with the long-term LHC planning

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The
PSB Upgrade
Working Group

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Feasibility Study

PS BOOSTER ENERGY UPGRADE FEASIBILITY STUDY FIRST REPORT

Abstract

This document summarises a survey of the CERN PS Booster systems with regard to a possible energy upgrade to 2 GeV. Technical solutions are proposed along with a preliminary estimate of the required resources and the time lines.

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Distribution List: R. Heuer

document released

Findings and Recommendations

- we were asked to put in place the upgrade rapidly, even before Linac4; this turned out to be technically challenging and schedule wise unrealistic

→ energy upgrade and commissioning with L4 will coincide (in 2015/16)

- the aim is energy increase and not intensity increase; however we will operate at 2 GeV with Linac4 (increased intensity)

→ compatibility with L4 intensities

- the study aims at LHC beams only; however we found that no savings are expected by upgrading only LHC beams (presently under discussion whether kickers can be re-used)

→ consider all beams to the PS at 2 GeV (ISOLDE remains at the present 1.0/1.4 GeV) confirmed as baseline by scenario by the LIU project

- we have studied variants of the "LHC-only" scenario, where we suppress fixed-target physics cycles whenever we have LHC cycles in the injectors (LHC filling and setting up)

→ some savings (but not the cost drivers), while the loss of non-LHC physics is substantial; separate note published (https://edms.cern.ch/document/1079117/1)

- we have addressed the question of intermediate energies between 1.4 and 2.0 GeV

→ we found that the present MPS is not able to run at any higher energy than 1.4 GeV and needs to be replaced anyway; not considered an option

- we have designed a magnetic cycle where the rms current remains within 10% of the present one

→ only minor modifications to the main magnet cooling circuits required

WU 2 Magnets [A. Newborough, D. Tommasini]

issues:

- concern over life span due to mechanical stress during permanent pulsing at 2 GeV
- saturation of outer rings will increase even more
- main unit cooling, present system insufficient
- auxiliary magnets: majority not affected, but study to be completed
- 15-18/59 transfer line magnets presumably require exchange; need optics studies for final confirmation
- PS injection bumpers, correctors and quads being studied; preliminary results suggest that the majority of PS low-energy magnets will need to be replaced

proposed technical solutions:

- main magnets: new field levels are achievable
- stress test completed in SM18; no degradation found
- change solid retaining plates by laminated ones to reduce/eliminate saturation
- cycle with rms current within 10% of the present one makes only minor modifications on the cooling circuits necessary (in situ)
- auxiliary ring magnets mainly used at low energy, no worry
- modification/replacement of ~30% of the transfer line magnets
- replacement of many PS low-energy magnets; study ongoing

see A. Newborough

budget: 3445 kCHF – 210 (cons.) = 3235 kCHF

WU 4 RF System [A. Findlay, M. Paoluzzi]

issues:

- if consolidation is budgeted and completed in time for the 2 GeV upgrade: everything covered by consolidation, no issues left for the upgrade project.

proposed technical solution:

- high-level rf: consolidation of C02, C04 and C15
- consolidation of ll rf, transverse damper, rf cables

important notice: it is a necessary condition for the energy upgrade that the RF consolidation is completed; in case this is not (or not completely) covered, or if consolidation is not completed within the time frame of the upgrade, then the upgrade will not work

budget: 14320 kCHF – 14320 kCHF (cons.) = 0 kCHF

WU 5 Beam Intercepting Devices [O. Aberle]

issues:

- present dump and BTP beam stopper not appropriate
- study of the PSB dump has been triggered by the question whether it can accept L4 intensities – the energy upgrade comes now as additional constraint into this ongoing study
- beam stopper BTP.STP10 has to be checked with regard to 2 GeV operation; new design might be needed, still to be confirmed.

proposed technical solution:

- dump: new design (in progress), production of a new dump plus spare to be launched.
- BTP stopper: if insufficient, launch new design and construction (2 units)

budget: 700 kCHF – 700 kCHF (cons.) = 0 kCHF

WU 6 Power Converters [S. Pittet]

issues:

- present MPS is not able to deliver a 2 GeV cycle; in addition it cannot deliver required RMS current; increasing peak power using traditional thyristor technology would have an unacceptable effect on the whole Meyrin network; the present 1.4 GeV is the limit, any higher energy than this will require a new MPS
- number of smaller power converters needs to be changed
- number of power converters in the PS to be upgraded
- ppm operation between 1.0/1.4 GeV (ISOLDE) and 2 GeV (PS) is feasible

proposed technical solution:

- new POPS-type MPS using capacitor bank
- some civil engineering needed
- divide machine in 2 circuits (inner and outer rings); will make 1+4 Trim power supply obsolete
- replacement of a number of smaller power supplies

budget: 20850 kCHF (cost driver) – 6630 kCHF (cons.) = 14220 kCHF

see S. Pittet

WU 10 Extraction, Transfer & PS Injection [J. Borburgh]

issues:

- number of septa/kickers to be re-built , notably PSB extraction kicker, recombination septa and PS injection septum
- re-design PS injection; under study; presently not yet completed to the last detail
- PS injection kicker rise time and ripple increase if used in short-circuit mode to obtain required deflection (emittance growth)

proposed technical solution:

- PSB extraction kicker and septa need modification
- PSB recombination kickers and septa need modification
- longer PS injection septum under study
- PS injection kickers either in short-circuit mode or supplementary PS injection kicker to be built

For injection into the PS two options being considered:

a) injection as now in ss42: requires new septum, new bumpers, possibly supplementary new kicker in PS (53?)

b) injection in ss41: requires enlarged vacuum chamber in main dipole, new BTP line, new septum, new bumpers and possibly supplementary new kicker in PS (53?)

Should have a conclusion beginning 2011

budget: 5763 kCHF – 550 kCHF (cons.) = 5213 kCHF

WU 12 Electrical Systems [D. Bozzini, S. Olek]

issues:

- present power consumption around 10 MVA
- future electrical distribution will depend on the requests (power, magnets and CV)
- TE/EPC estimates a 10% increase in their request for the MPS, and 40% for the transfer line.
- CV estimate a 15-20% increase of the power demand
- no more power available from transformer for general services; 18 kV cubicles cannot be extended; system needs consolidation

proposed technical solution:

- After topical meetings with EN/CV and TE/EPC the needs have been clarified and the re-design of the system has started; to be seen within the context of a global re-design of the electrical network on the Meyrin site

budget: 1700 kCHF

WU 13 Cooling and Ventilation [M. Nonis]

issues:

- cooling: future design of cooling and ventilation will depend on the cooling needs, mainly magnets, power and rf; survey of the cooling needs of the different work units has shown so far no increase in the cooling needs
- ventilation: no specific need communicated to CV, work will consist in the complete refurbishment of existing plant keeping the same existing working functionalities

proposed technical solution:

- refurbishment of cooling station and some distribution piping
- the work schedule has to take into account the commissioning of cooling plant and the commissioning of new equipment, delays are therefore more important; length of the shutdowns is a concern (might need ~6 months in a row)

recently RP has expressed concerns whether a general revision of the Booster ventilation might be required; discussions ongoing

budget: 5500 kCHF – 4500 kCHF (cons.) = 1000 kCHF

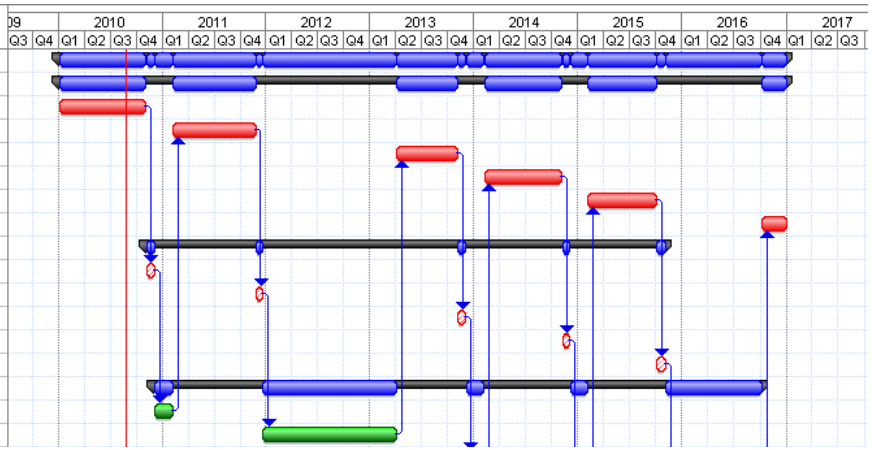
Summary Resources in kCHF

		Consolidation	
Total Beam Dynamics	50	0	50
Total Magnets	3445	-210	3235
Total Magnetic Measurements	111	0	111
Total RF	14320	-14320	0
Total Beam Intercepting Devices	700	-700	0
Total Power Converters	20850	-6630	14220
Total Vacuum System	100	0	100
Total Beam Instrumentation	67	-10	57
Total Commissioning	50	0	50
Total Extraction, Transfer, Injection	5763	-550	5213
Total Controls	116	0	116
Total Electrical Systems	1700	0	1700
Total Cooling & Ventilation	5500	-4500	1000
Total RP	0	0	0
Total Transport and Handling	680	-400	280
Total Survey	50	0	50
Total Project	**53502**	**-27320**	**26182**

Behind this overview there is a detailed budget & manpower break-down for each WP

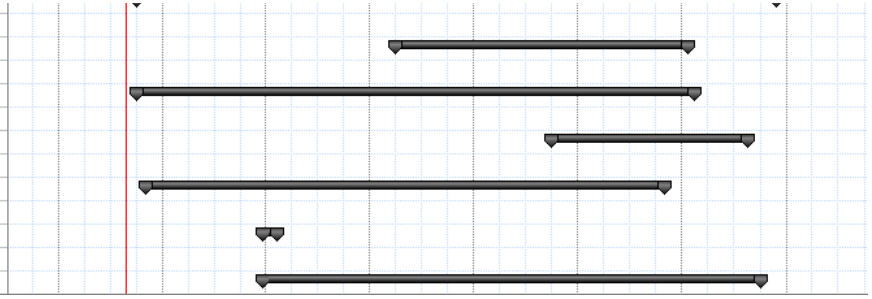
Draft Project Schedule

ID	Task Name
1	**Injector Operation**
2	**Proton Operation Periods**
3	Proton Operation 2010
4	Proton Operation 2011
5	Proton Operation 2013
6	Proton Operation 2014
7	Proton Operation 2015
8	Proton Operation 2016
9	**Ion Operation Periods**
10	Ion Run 2010
11	Ion Run 2011
12	Ion Run 2013
13	Ion Run 2014
14	Ion Run 2015
15	**Shutdown Periods**
16	Xmas Break 2010/11
17	Shutdown 2012



assumes resources (money and manpower) are made available in due time

175	
176	**WP 10 Controls**
183	
184	**WP 11 Electrical Systems**
189	
190	**WP 12 Cooling & Ventilation**
207	
208	**WP 13 Radio Protection, Safety**
215	
216	**WP 14 Transport and Handling**
221	
222	**WP 15 Survey**



Summary & Next Steps

- One year of intense work
- We know what we need to do and what resources we need
- Consolidation items have been disentangled from the budget
- The budget we have estimated has been entered in the MTP
- Next steps:

- conclusions from retreat and Chamonix
- freeze design choices
- prepare TDR