

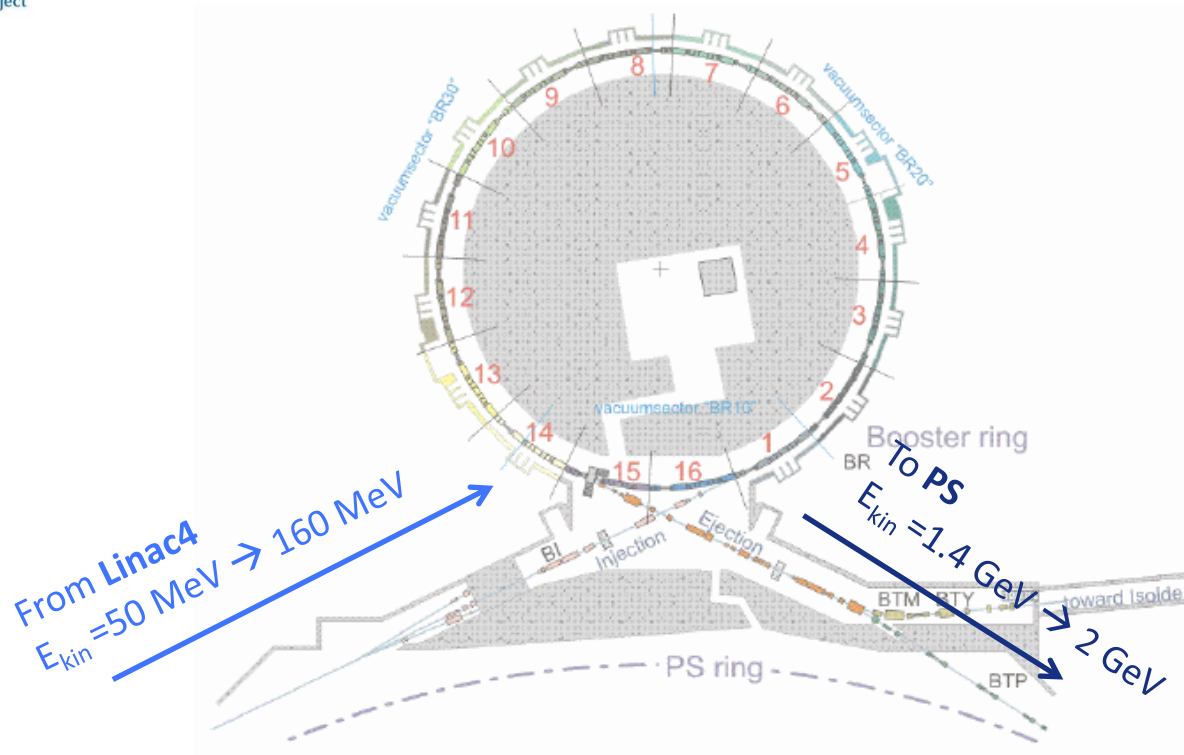


PSB Upgrade Plans
K. Hanke
for the LIU-PSB Team
IEFC Workshop
March 7–9 2012



Scope of LIU-PSB

PSB Upgrade
LIU Project

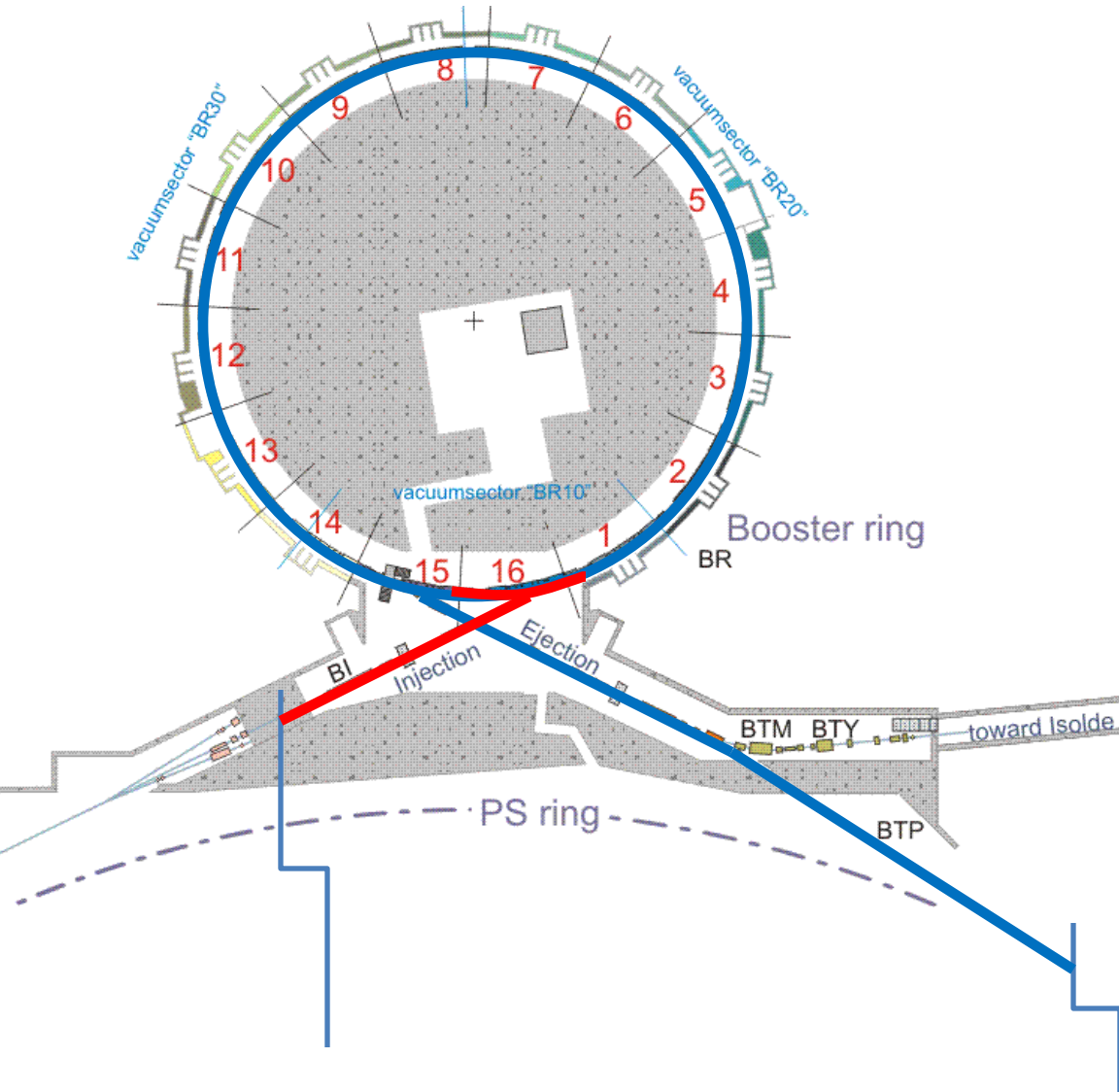


1. Linac4 will allow for production of higher brightness beams in the PSB
→ higher injection energy (160 MeV)
→ H^- injection, essentially loss free and allows to tailor emittances
2. higher extraction energy into the PS (2 GeV)
→ reduces space charge effects at PS injection



Scope of LIU-PSB

PSB Upgrade
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upgrade of the injection from 50 MeV protons to 160 MeV H- and increased intensity

- re-build injection line for 160 MeV
- replace injection septum by stripping foil
- injection bumps
- diagnostics
- ...

upgrade of rings and extraction / transfer from 1.4 GeV to 2.0 GeV and increased intensity

- replace main power supply, number of smaller power supplies, magnets, extraction elements & line, etc.



Performance Gain with Linac4 and 1.4 GeV

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- double intensity in the PSB
- loss-free injection
- ability to tailor emittances (e.g. reduce losses in the PS)

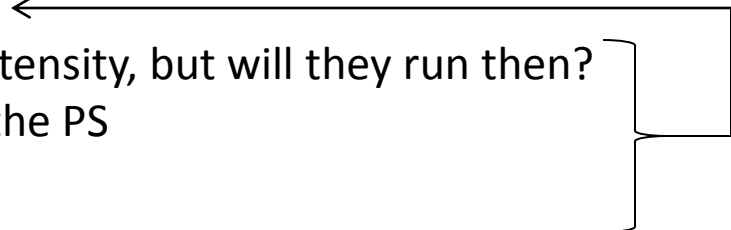
LHC users:

- double batch: gain depends on tolerable space charge tune shift in the PS
- single batch: becomes possible, presently not known how large the tune spread in the PS can be, gain in brilliance accordingly

ISOLDE:

double today's intensity (target and target area to be addressed by the HIE ISOLDE project!)

non-LHC PS/SPS users:



- "remain as they are today" (LIU policy) ←
 - CNGS target could accept ~45% more intensity, but will they run then?
 - SFTPRO is with $3E13$ at the loss limit in the PS
 - AD: is already at limit in PS
 - TOF: is already at limit in PS
- 



Booster Injection Modifications: When?

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2013												2014												2015											
1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
LHC injectors stop																																			

 L4 ready for PSB injection
 Booster injection equipment ready for installation

2016												2017												2018											
1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
																								LHC injectors stop											

potential slot

present official slot for connection

1. connection of Linac4 to the PSB during LS1 ruled out
2. connect to the PSB during a possible intermediate length shut-down (e.g. 2016/17)
3. connect to the PSB during LS2 (assumed 2018)

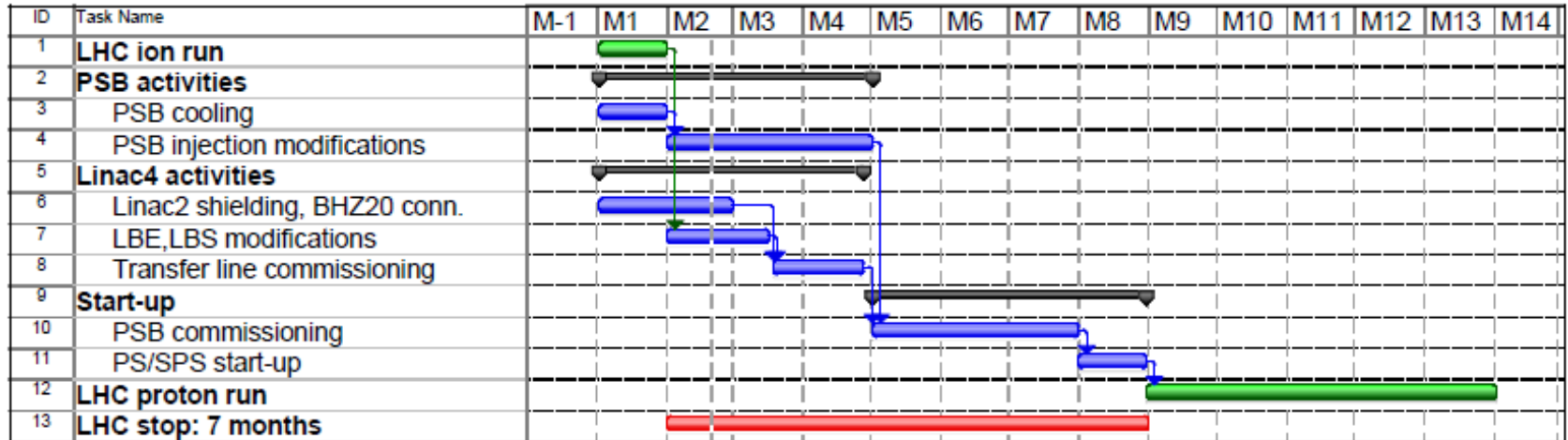
We had been hoping for a clearer picture after Chamonix...

it is very important for us to have a clearer idea about the constraints and milestones



Booster Injection Modifications: How Long?

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M.Vretenar, Linac4 Project Meeting 23 Feb 2012

present assumption:

- 1 month cool-down
- 3 months installation
- 3 months PSB commissioning
- 1 month PS/SPS commissioning
- 8 months, one of which possibly in shadow of ion run

detailed planning in progress



Upgrade of the Booster to 2.0 GeV

PSB Upgrade
LIU Project

CERN
CH-1211 Geneva 23
Switzerland



The
PSB Upgrade
Working Group

DATE: 2010-09-23

PSB Upgrade Working Group Document No.
1082646-0003

CERN Div./Group or Supplier/Contractor Document No.
BE-OP

EDMS Document No.
1082646 v.3

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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study launched following Chamonix 2010
→ feasibility, cost & time lines confirmed
RCS alternative studied following Chx. 2011
→ Booster option retained

3rd energy upgrade:

- from 800 MeV to 1 GeV (1988)
- from 1 GeV to 1.4 GeV (1999)
- from 1.4 GeV to 2.0 GeV (LS2)

- no technical showstoppers identified
- however a number of equipment and systems need to be changed or upgraded
- high-impact items: MPS, RF, kickers, septa, ...



Expected Performance Gain with 2.0 GeV

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LASLETT TUNE SHIFT

$$\Delta Q_{x,y} = \frac{r_p N_b}{(2\pi)^{\frac{3}{2}} \gamma^2 \beta \sigma_z} \oint \frac{\beta_{x,y}(s) ds}{\sqrt{\epsilon_{x,y} \beta_{x,y}(s)} (\sqrt{\epsilon_x \beta_x(s)} + \sqrt{\epsilon_y \beta_y(s)})}$$

if we assume that:

- ⇒ the optics at the PS injection remains the same
- ⇒ the bunch length does not change

$$\frac{(\gamma^2 \beta)_{2 \text{ GeV}}}{(\gamma^2 \beta)_{1.4 \text{ GeV}}} = 1.63$$



$$\frac{N_b}{\epsilon_x \epsilon_y} \text{ up to 63\% larger}$$



Performance Gain with Linac4 and 2.0 GeV

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LIU Project

LHC users:

25 ns	PSB inj	PSB extr	PS inj	PS extr	SPS inj	SPS extr	LHC inj	LHC coll
Energy GeV	0.16	2	2	26	26	450	450	7000
Nb	1	1	6	72	72	288	288	2808
Ib [e11 p+]	32.0	30.5	30.5	2.4	2.4	2.2	2.2	2.0
Ib in LHC [e11 p+]	2.7	2.5	2.5	2.4	2.4	2.2	2.2	2.0
Exyn [m m .m rad]	1.9	2.0	2.0	2.1	2.1	2.3	2.3	2.5

50 ns	PSB inj	PSB extr	PS inj	PS extr	SPS inj	SPS extr	LHC inj	LHC coll
Energy GeV	0.16	2	2	26	26	450	450	7000
Nb	1	1	6	36	36	144	144	1404
Ib [e11 p+]	26.4	25.2	25.2	4.0	4.0	3.6	3.6	3.3
Ib in LHC [e11 p+]	4.4	4.2	4.2	4.0	4.0	3.6	3.6	3.3
Exyn [m m .m rad]	2.2	2.4	2.4	2.5	2.5	2.7	2.7	3.0

B.Goddard,
Chamonix 2012

PSB not expected to be a limit for 50 ns beam, and prospect to run with ΔQ above -0.3 for 25 ns

ISOLDE:

double today's intensity *plus*

optional 1.4 or 2.0 GeV (1.0 GeV option abandoned)

2 GeV upgrade of the BTY line not part of LIU, would need its own small project

non-LHC PS/SPS users:

- would however be able to deliver ~60% more intensity in a given emittance w.r.t. today or decrease emittance if beneficial

- optional 1.4 or 2.0 GeV to the PS (BT-BTP line ppm)



List of Actions and Planning of Implementation

PSB Upgrade
LIU Project

work Package	activity	status & target dates
beam dynamics	MD studies collimation studies beam loss studies resonance compensation studies impedance studies short magnet scheme etc.	need to start need to start need to start need to start started
magnets	main magnets cooling modifications main magnets saturation reduction injection region magnets reference magnet refurbishment transfer line magnet changes/upgrades	LS1 by LS2 by LS2 by LS2 by LS2



List of Actions and Planning of Implementation

PSB Upgrade
LIU Project

work Package	activity	status & target dates
RF system transferred from CONS	new RF system installation & tests LL RF consolidation (TFB, digital beam control)	has started compl. by LS2 LS1
power converters partial transfer from CONS	specify and procure new MPS injection converters transfer line converters other converters	started / LS2 before LS2 LS2 LS2



New RF System: Planning

PSB Upgrade
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Finemet®

- 2011 Design, produce and install in 6L1 a test cavity (5 cells, 3 kV).
- 2012 Beam test on dedicated users and MDs.
- 2013 - 2014 13 cells, 8 kV installed in 6L1.
- 2015 Beam test on dedicated users and MDs.

Parallel activities

C02 and C04 standard

- 2011 Design an upgraded C04 final amplifier and renovate test place.
- 2012 – 2014 C04 tests in the test place. C02 and C04 tuning and filament supplies studies.
- 2015 Specification of items for C02 and C04 consolidation.

Parallel activities

C16

- 2012 - 2014 C16 Tuning and filament supplies studies.
- 2015 Specification of items for consolidation.

Depending on test results

- 2016 - ? Production of cells to fully equip the PSB with wideband cavities instead of C02 and C04! Procurement of power supplies, ITL, new cables installation, etc.

- 2016 - ? Production of C04 upgraded amplifiers. Procurement of power supplies, ITL, new cables installation, etc. for C02 and C04 consolidation

- 2016 - ? Procurement of power supplies, ITL, new cables installation, etc. for C16 consolidation

- LS 2 Wideband cavities installation or C02 and C04 consolidation + C16 consolidation



M.Paoluzzi

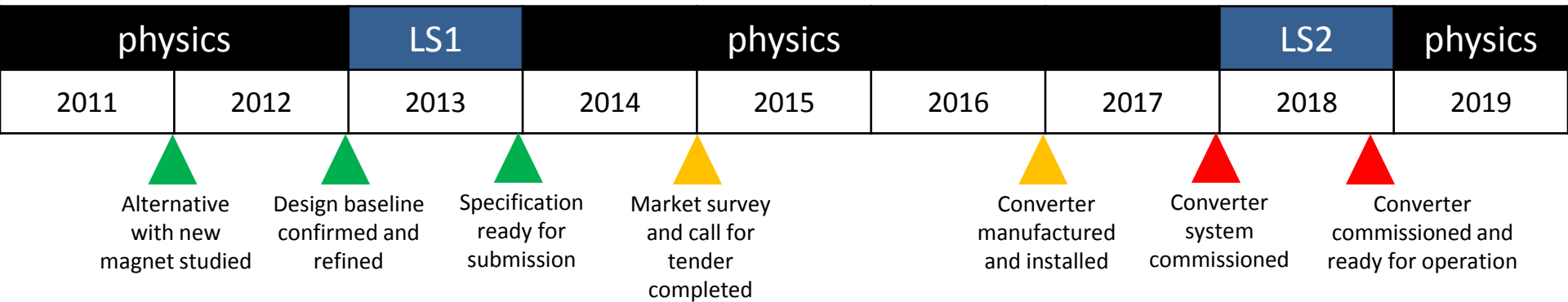
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BRXSK 4E1
BRONG 4E1
BRXSK 4E1



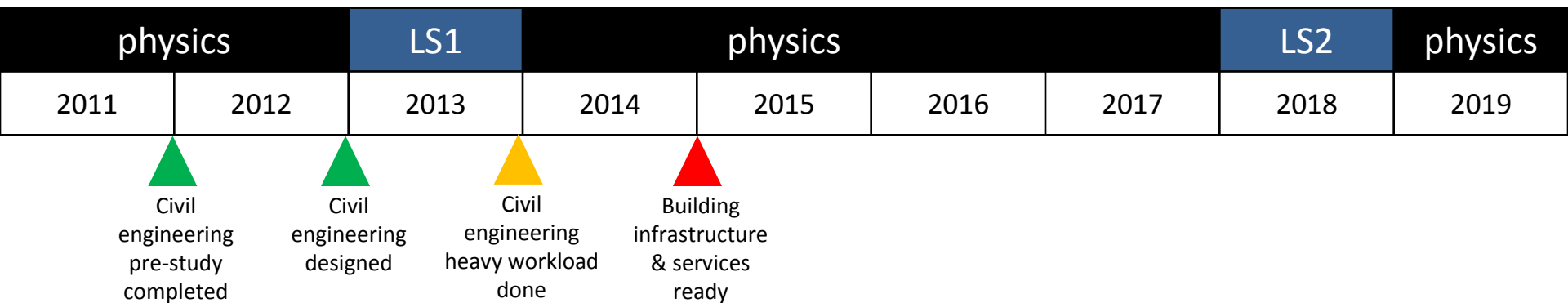
New MPS: Planning

PSB Upgrade
LIU Project

MPS



new building





List of Actions and Planning of Implementation

PSB Upgrade
LIU Project

work Package	activity	status & target dates
beam instrumentation	injection diagnostics (special BLMs, screens, etc.) orbit renovation H0/H- dump diagnostics pick up renovation BLM renovation turn-by-turn profile	need to start started need to start advanced in progress need to start all for LS1
beam intercepting devices	new dump removal old dump new beam stopper	design started tests done, plan being worked out in progress LS1



List of Actions and Planning of Implementation

PSB Upgrade
LIU Project

work Package	activity	status & target dates
vacuum system	determined by other WPs	ongoing
injection systems	injection equipment design and construction	ongoing target date any moment as from end 2015 confirm time lines
extraction and BTP	beam optics studies extraction hardware design magnets and power supplies	ongoing ongoing depend on optics all for LS2
controls	interact with all WPs	ongoing



List of Actions and Planning of Implementation

PSB Upgrade
LIU Project

work Package	activity	status & target dates
electrical systems	cabling clean-up	study ongoing LS1
	new installations	LS1/LS2
cooling & ventilation	consolidate Booster cooling	LS2
	consolidate Booster ventilation	LS2
	C&V for new MPS building	must start LS1
transport & handling	consolidate lifting equipment	LS1
civil engineering	new MPS building	study ongoing LS1
radiological protection	following other WPs (activation estimates, dump cooling circuit, ...)	ongoing
interlocks	specify & implement	specs. being iterated



List of Actions and Planning of Implementation

PSB Upgrade
LIU Project

work Package	activity	status & target dates
survey	following other WPs	
commissioning	scheduling	ongoing



List of Actions and Planning of Implementation

PSB Upgrade
LIU Project

Other contributors who did not appear in the tables

- coordination
- safety
- LARP
- design office
- integration
- data bases
- consolidation and shutdown work
- technical coordinator

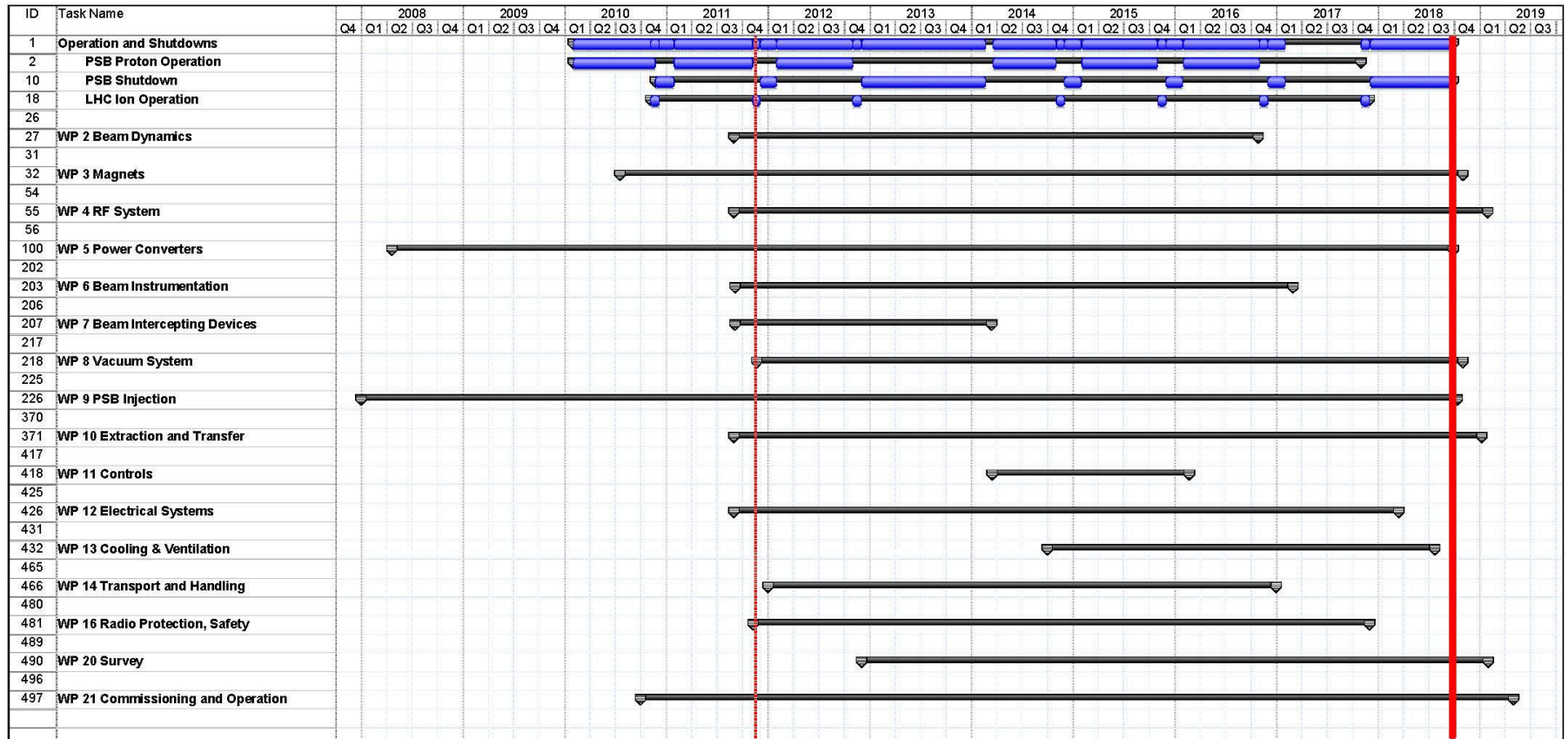
<https://espace.cern.ch/liu-project/liu-psb/default.aspx>

<https://edms.cern.ch/nav/P:LIU-000363:V0/P:LIU-000363:V0>



Time Lines

PSB Upgrade
LIU Project



- Linac4 connection possible as from end 2015, constrained by LHC stops
- full upgrade including 2 GeV to be completed during LS2



technical risks

- no experience with H- injection (activation, foil damage, painting schemes, ...)
 - commissioning time
 - need good support from beam dynamics
- technical surprises that we may find, e.g. when replacing the dump

scheduling risks

- cabling clean up: this is a MUST, otherwise we will not be able to install any new equipment; if not done during LS1, the option of Linac4 before LS2 is at risk; if done only in LS2, then significant additional time will be needed in LS2 cabling inventory is available (P. Bonnal)
- Linac4 connection scheduling: if we do L4 and 2 GeV together in LS2, this becomes a huge installation and commissioning task associated with risk (not to meet the schedule); the injection modifications are considered the more challenging part
- an injection test stand has been proposed and is strongly encourage in order to mitigate risks
- commissioning: need realistic planning



Summary

- transformed the 2 GeV task force into a project with WBS, budgets, etc
first baseline 1st March 2012
- the task force report should now be replaced by a TDR, in progress
- work is ongoing in many fields, mainly in the hardware groups
- we have identified a number of items that **MUST** be done during LS1
(cable campaign, dump replacement, ...)
- schedules are by their nature moving targets, but it would help us to have a
clearer picture about Linac4 connection
- in most areas there is good progress, but some other items become now critical
(collimation studies, instrumentation for the injection region, ...)