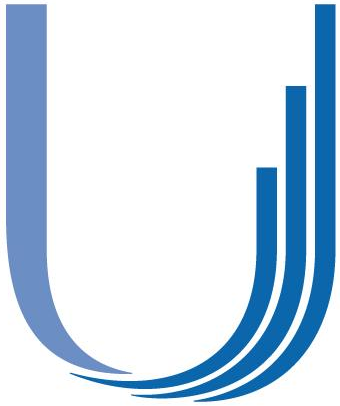


LHC Injectors Upgrade

LHC Injectors Upgrade

PICs in the injectors – what are we talking about?

K. Hanke

thanks to S. Gilardoni, B. Goddard, B. Mikulec

and the LIU working group members

CERN

Scope and Assumptions

- PIC definition
- PIC items per project
- risk *of not* doing the consolidation
- consequences *of* doing the consolidation
- cost
- time lines

assumptions for this talk:

- Linac4 and the modifications to the PSB injection region are not covered in this presentation
- ions are not considered (dedicated session)

PICs Definition

CONSOLIDATION:
Partial or complete replacement of a system to be performed in order to maintain the present level of performance/availability (from RLIUP glossary)

example: PSB multipole power converters

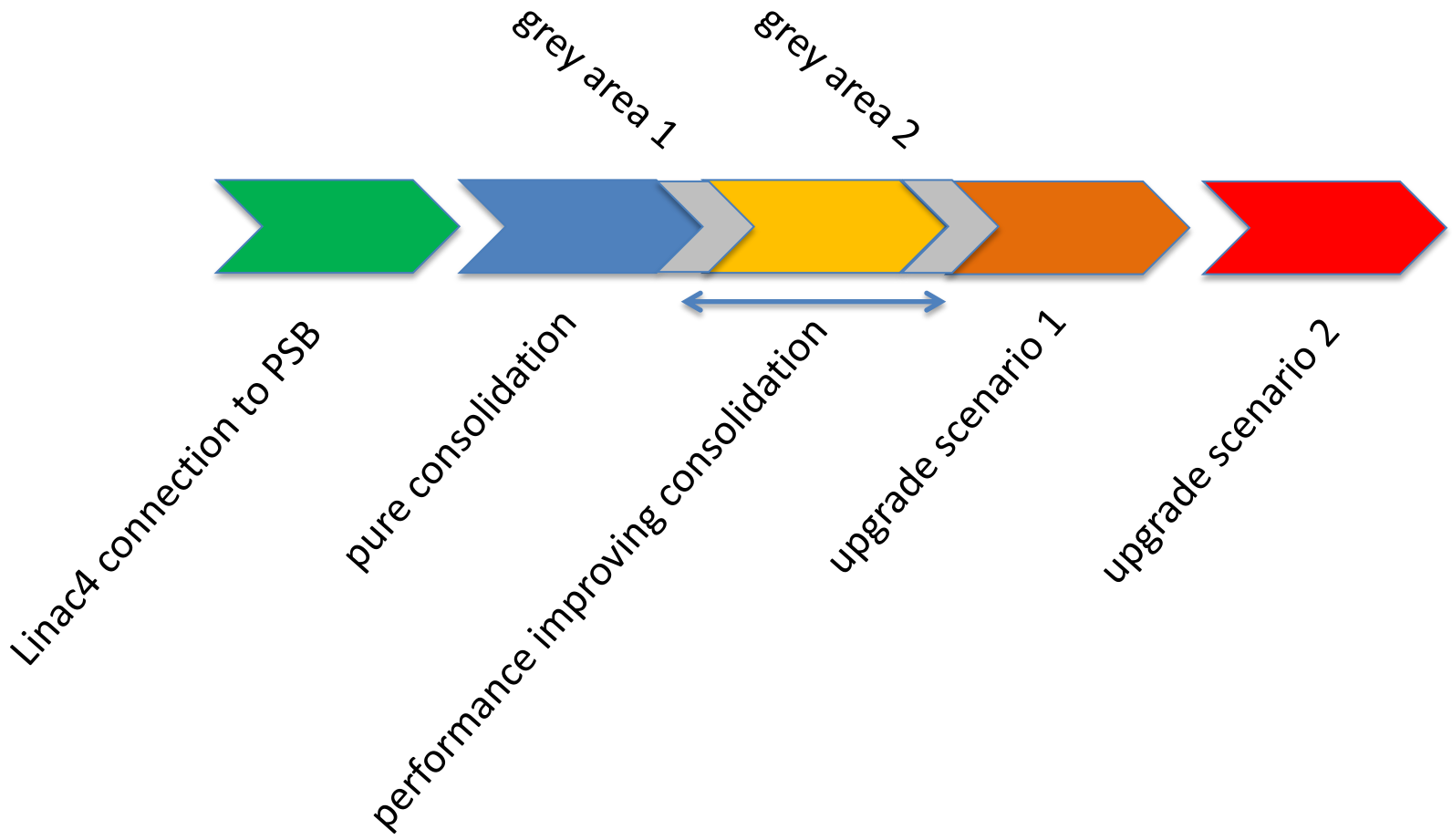
UPGRADE:
Replacement or addition of a system to improve the performance, which would otherwise not be necessary

example: H- injection, PS injection for 2 GeV

PERFORMANCE IMPROVING CONSOLIDATION:
Replacement or upgrade of a system justified by consolidation but with the goal of improving performance

example: change an ageing PSB power supply by a new one which is more reliable and which can also go up to 2 GeV

PICs in the Upgrade Scheme



LIU-PSB: List of PICs and Borderline Cases

PIC	comments
Magnets	○ a number of BI quadrupoles pure consolidation items ○ partial replacement of transfer line magnets → consolidation + upgrade ○ modifications of main magnets: upgrade
LL RF	○ new digital LL RF, new TFB
HL RF	○ replacement of present C02 and C04 by Finemet
Power Converters (rings, extraction, transfer)	○ replace MPS (borderline case) ○ replace power converters in extraction and transfer which cannot operate at 2 GeV
Beam Instrumentation	○ new wire scanners ○ new orbit ○ new BLM system (partly consolidation, but additional BLMs for upgrade)
Main Dump	○ new PSB dump (completed LS1)
Extraction & Transfer	○ new extraction elements ○ new recombination and transfer line elements (borderline cases)
Cooling & Ventilation	○ complete renovation of the system, cooling for new MPS, dump, etc.
Transport & Handling	○ renovate handling equipment to be operational for upgrade work ○ studies and work for removal of old dump and other equipment

LIU-PSB: Risks

PIC	if not done	if done
Magnets	○ some magnets are urgent consolidation items, risk of failure, unsatisfactory spare situation (BT.BHZ10)	○ delicate transport & handling
LL RF	○ old system obsolete and inappropriate for Linac4 and new HL RF	○ re-commissioning needed
HL RF	○ old system obsolete and will not work with Linac4 intensities and 2 GeV	○ system cannot be fully tested before decision (space) ○ technical issues, impedance
Power Converters (rings, extraction, transfer)	○ ageing equipment ○ MPS would need consolidation if it were to continue (MPS and SCV) ○ transfer line power converters consolidation items	○ commissioning of new MPS required ○ LS2 duration
Beam Instrumentation	○ insufficient machine protection ○ insufficient emittance diagnostics	○ new systems need to be commissioned
Main Dump	○ old dump inappropriate	○ none identified
Extraction & Transfer	○ reliability and spare situation issue with some equipment	○ issue with rise time of recombination kickers
Cooling & Ventilation	○ present system obsolete (was CONS item); to be renovated taking into account new requirements; closely related to RP issues	○ potential time driver for LS2
Transport & Handling	○ equipment not ready, delays	○ some critical issues under study

LIU-PSB: Cost

PIC	total cost [kCHF]	consolidation /performance [%]
Magnets	2696	10 / 90
LL RF	1566	100
HL RF	11732	100
Power Converters (rings, extraction, transfer) [1]	18451	35 / 65
Beam Instrumentation[2]	2954	100
Main Dump (compl. LS1)	460	74 / 26
Extraction & Transfer	3515	15 / 85
Cooling & Ventilation	6994	65 / 35
Transport & Handling	644 t.b.c.	60 / 40
	49012	**51 / 49**

1)

- MPS consolidation foreseen before LIU: **3 MCHF**
- total cost for the 2 GeV MPS including building: **15 MCHF** → large part “performance”
- power converters transfer line: total **4 MCHF**, of which **3.3 MCHF** pure consolidation

2) budgeted in LIU, but is a MUST in all possible scenarios

From the Feasibility Study (EDMS 1082646)

20.2.17 BUDGET ESTIMATE SUMMARY

	all units kCHF		
	all beams at 2 GeV (baseline)	only LHC beams at 2 GeV	from con-solidation budget
Beam Dynamics	50	50	0
Magnets	3445	3595	-210
Magnetic Measurements	111	111	0
RF	14320	14320	-14320
Beam Intercepting Devices	700	700	-700
Power Converters	20850	21100	-6630
Vacuum system	100	100	0
Beam Instrumentation	67	67	-10
Commissioning and Operation	50	50	0
Extraction, Transfer, PS Injection	5763	5763	-550
Controls	116	116	0
Electrical Systems	1700	1700	0
Cooling and Ventilation	5500	5500	-4500
Radiological Protection	0	0	0
Transport and Handling	680	680	-400
Survey	50	50	0
Total	**53502**	**53902**	**27320**
covered by consolidation	27320		
after correction for consolidation	**26182**	**26582**	

total

upgrade part

consolidation part

LIU-PSB: Time Lines

PIC	total time [m]	split (y/n)	minimum single block [m]	earliest start date
Magnets	4-5	y	3	partly before LS2
LL RF	7	n	7	LS2 dig .compl. LS1
HL RF	10.5	n	10.5	LS2
Power Converters (rings, extraction, transfer)	MPS: 2×1+3 TL: 12	y n	12	LS2
Beam Instrumentation	9	y	3.5	LS1
Main Dump		n		LS1 (done)
Extraction & Transfer	7	n	7	LS2
Cooling & Ventilation	7 excluding other activities + 12	n	7 + 12	
Transport & Handling		y		after LS1

LIU-PS: List of PICs and Borderline Cases

PIC	comments
Beam Instrumentation	○ new wire scanners ○ new BLMs
Magnets	○ new vertical correctors ○ new normal & skew quadrupoles
Transverse Damper	○ new power converter ○ second kicker
Longitudinal Damper	○ Finemet cavity to damp longitudinal and coupled-bunch instablilities
Radiation Shielding	○ increase shielding on top of extr. septum and route Goward
Power Converters	○ low energy quadrupoles ○ orbit correctors ○ skew quadrupoles/sextupoles ○ 40/80 MHz cavity power amplifier
Beam dumps	○ new beam dumps
HL RF	○ renovation of 10 MHz system
LL RF	○ upgrade feedback amplifiers ○ new 1-turn delay feedbacks for 10,40 and 80 MHz systems ○ new digital beam control

LIU-PS: Risks

PIC	if not done	if done
Beam Instrumentation	○ limited emittance diagnostics ○ old BLM system obsolete	○ need to recommission
Magnets	○ skew quadrupoles: low reliability due to large thermal heating. Head-tail instability today cured by linear couling not available	○ need to recommission
Transverse Damper	○ limited DC power and bandwidth	○ need to recommission
Longitudinal Damper	○ limited bunch intensity incompatible with HL-LHC parameters	○ none identified
Radiation Shielding	○ RP issues	○ none
Power Converters	○ increased number of failures due to large RMS current and old thermal protections.	○ need to recommission
Beam Dumps	○ present mechanics prone to vacuum leaks. ○ precision on triggering.	○ need to recommission
HL RF	○ limited longitudinal beam stability, degradation of beam quality	○ need to recommission
LL RF	○ transient beam loading issues at high intensity ○ degraded beam quality & stability, bunch-to-bunch spread ○ drift, break-down, insufficient spares	○ need to recommission

LIU-PS: Cost

PIC	total cost [kCHF]	consolidation /performance [%]
Beam Instrumentation[1]	1062	34 / 66
Magnets	1000	48 / 52
Transverse Damper	350	50 / 50
Longitudinal Damper[2]	1500	100
Radiation Shielding	3150	100
Power Converters	3065	42 / 58
Beam Dumps	850	30 / 70
HL RF	4200	10 / 90
LL RF	900	63 / 37
	16077	**42 / 58**

1) part of it is only required for upgrade (IPM and fast BLMs)
2) considered a MUST in all scenarios

LIU-PS: Time Lines

PIC	total time [m]	split (y/n)	minimum single block [m]	earliest start date
Beam Instrumentation	5	y	1	LS2
Magnets	12	y		LS2
Transverse Damper	not critical	n		ongoing
Longitudinal Damper				done LS1
Radiation Shielding				done LS1
Power Converters	3	n	3	end 2015
Beam Dumps	1	y	0.5	LS2
HL RF	3	n		LS2
LL RF	parallel	y		LS2

LIU-SPS: List of PICs and Borderline Cases (1)

PIC	comments
Machine Interlocks (WIC)	○ replace obsolete electromechanical relays with PLC solution compatible with other SPS TL and CERN systems ○ better reliability and maintenance, standard supervision and diagnostics
800 MHz Upgrade	○ replacement of analogue control with digital ○ new 1-turn feedback and feed-forward (essential for beam control) in low level ○ consolidation of existing power system and doubling available power (needed to match 200 MHz upgrade)
LSS1 Vacuum Sectorisation	○ addition of sector valves around TIDVG and MKP/D, to reduce personnel dose, protect sensitive equipment and reduce pump-down times
Scraper Improvement	○ construction of additional spares and improvements to local shielding
Beam Instrumentation	○ replacement of obsolete MOPOS electronics, plus new fibre backbone ○ replacement of obsolete BLM electronics, using MOPOS fibres ○ replacement of wire scanners with new devices ○ improvement of BGI, BSRT, IMM and Head-Tail monitors
Transverse Damper Improvement	○ improvement of low-level control ○ addition of dedicated pickups ○ consolidation of damper cables

LIU-SPS: List of PICs and Borderline Cases (2)

PIC	comments
Arc Vacuum Sectorisation	○ reduce length of arc sectors by factor 2, to reduce pumping times ○ improved protection against loss of ecloud scrubbing
New TIDVG Core	○ replace present TIDVG core with improved version ○ robust against present and future LHC beams
Other Kicker Impedance Reduction	○ addition of transition pieces in MKD kickers ○ serigraphy of MKQ kickers
ZS Improvements	○ improvement of pumping ○ impedance reduction ○ improvement of ion trap connections ○ short-circuiting of anodes
200 MHz RF Consolidation	○ consolidation of drivers, cavity controllers, HV power supplies, CV and power couplers ○ low-level improvement

LIU-SPS: Risks (1)

PIC	if not done	if done
Machine Interlocks (WIC)	○ possible reliability issue, extra maintenance costs, extra resources for keeping obsolete system operational	○ none identified
800 MHz Upgrade	○ beam instabilities at higher intensity ○ insufficient 800 MHz voltage ○ extra cost, resources and reliability risk to keep obsolete low-level running	○ readiness for SPS operation end 2014
LSS1 Vacuum Sectorisation	○ increased risk of venting and damage to sensitive or very radioactive equipment ○ increased radiation dose to personnel	○ none identified
Scraper Improvement	○ insufficient spares ○ reduced LHC performance (unable to clean transverse tails in SPS)	○ none identified
Beam Instrumentation	○ extra cost, resources and reliability risk to keep obsolete systems running ○ no reliable transverse beam size measurement ○ insufficient resolution and no bunch-by-bunch capability for LHC beams	○ none identified for MOPOS and BLM (deployment in parallel with existing system) ○ HOM heating for new WS
Transverse Damper Improvement	○ extra cost, resources and reliability risk to keep obsolete systems running ○ not able to properly damp Pb ion beams	○ none identified

LIU-SPS: Risks (2)

PIC	if not done	if done
Arc Vacuum Sectorisation	○ longer scrubbing times for ecloud	○ none identified
New TIDVG Core	○ damage to TIDVG for repeated dumping of intense/bright LHC beams ○ long (months) recovery to condition with beam	○ long beam conditioning time of newly installed dump
Other Kicker Impedance Reduction	○ intensity limitation with high duty cycle beams due to other kickers ○ limitation of scrubbing beam time	○ none identified
ZS Improvements	○ ZS sparking ○ limitations on other beams ○ longer switch to LHC cycle	○ none identified
200 MHz RF Consolidation	○ extra cost, resources and reliability risk to keep obsolete systems running ○ insufficiently performing beam control	○ none identified

LIU-SPS: Cost

PIC	total cost [kCHF]	consolidation /performance
Machine Interlocks (WIC)	600	100
800 MHz Upgrade		50 / 50
LSS1 Vacuum Sectorisation	800	25 / 75
Scraper Improvement	200	100
Beam Instrumentation	5600	25 / 75
Transverse Damper Improvement	1300	50 / 50
Arc Vacuum Sectorisation	2500	25 / 75
New TIDVG Core	2900	50 / 50
Other Kicker Impedance Reduction	4100	25 / 75
ZS Improvements	1000	50 / 50
200 MHz RF Consolidation	3700	25 / 75
	22700	**48 / 52**

LIU-SPS: Time Lines

PIC	total time [m]	split (y/n)	minimum single block [m]	earliest start date
Machine Interlocks (WIC)	6	n/a	n/a	done LS1
800 MHz Upgrade	12	n/a	n/a	done LS1
LSS1 Vacuum Sectorisation	6	n/a	n/a	done LS1
Scraper Improvement	0			
Beam Instrumentation	24	y	3	LS1
Transverse Damper Improvement	9	y	6	LS1
Arc Vacuum Sectorisation	6	y	3	2015/16
New TIDVG Core	3	n	3	LS2
Other Kicker Impedance Reduction	3	y	2	2015/16
ZS Improvements	3	y	2	2015/16
200 MHz RF Consolidation	6	y	3	2016/17

Summary & Conclusions (1)

time drivers and smallest increment

LIU-PSB: smallest increment **12 m**

→ LIU time drivers CV, RF, cabling (combined)

LIU-PS: smallest increment **3 m**

can be done during intermediate shutdowns

not all details known, but not considered critical

LIU-SPS: smallest increment **6 m**

can be done during intermediate shutdowns

all time estimates depend strongly on available resources (manpower)

cost of PICs [kCHF]

LIU-PSB: 50’000 (essentially LIU-PSB budget[1] without the Linac4 part)

LIU-PS: 16’000 (80% of total budget 20’000[2])

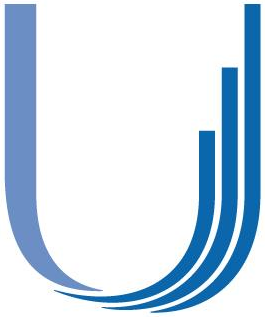
LIU-SPS: 23’000 (30% of total budget 77’000)

1: total budget 60.8 MCHF

2: baseline 20 MCHF, with all options 32 MCHF

Summary & Conclusions (2)

- classification of what is a PIC is often ambiguous (many borderline cases)
- accounting of what is the “PI” and what is the “C” in a PIC is often ambiguous - however it is interesting to notice that a 50/50 split seems to be the average across all machines
- for LIU-PSB PICs cover almost the entire budget, for the PS 80% and for the SPS 30%
- several items (e.g. beam instrumentation) need to be done in all possible scenarios in order not compromise performance over the coming years
- PICs are important and must be fully implemented in the injectors regardless of which upgrade scenario is chosen



LHC Injectors Upgrade

THANK YOU FOR YOUR ATTENTION!