





LHC Injectors Upgrade

LHC Injectors Upgrade Workshop

Montreux, 13-15 February 2019





LHC Injectors Upgrade

Timeline and requirements for beam commissioning across the ion chain

Reyes Alemany

U Beam commissioning: beam parameters pre-LS2 performance

- **Table**

Performance reminder

- **Those parameters will have to be achieved up to the exit of PS with “almost” untouched machines**
- **Those parameters will have to be achieved up to the exit of SPS with a new (LL)RF system**
- **The SPS will try to deliver a completely new beam “SLIP STACKING BEAM” with LIU performance**



New systems to commission with beam

Draft

Need to prepare a detailed plan, discussions with RF team on going

• LINAC3:

- RF amplifiers (5kW) & LLRF systems for the buncher, the debuncher and the ramping cavities
 - 3 months of HWC: new devices, new controls, logging, high level software
 - 3 months of “intermitent” BC in 2020 (when beam available from source)

• TRANSFER LINE LINAC3 to LEIR:

- New acquisition electronics for BPMs:
- One vertical slice tested and debugged in 2018 → very good results and under specifications

Reliability/stability items to keep performance!!

• LEIR:

- Upgraded PC controls to FGCs

Need to prepare a detailed commissioning plan, discussions with RF team on going

• SPS new RF:

1. Fixed frequency acceleration for EARLY (NA) and multi-bunch 100 ns & 75 ns:
 - 3 months → challenge: many RF system have to work DECOUPLED → prerequisite for slip stacking to work
2. Slip stacking:
 - Approx. 3 months

Beam performance improvement!!





Overall hardware and beam commissioning planning

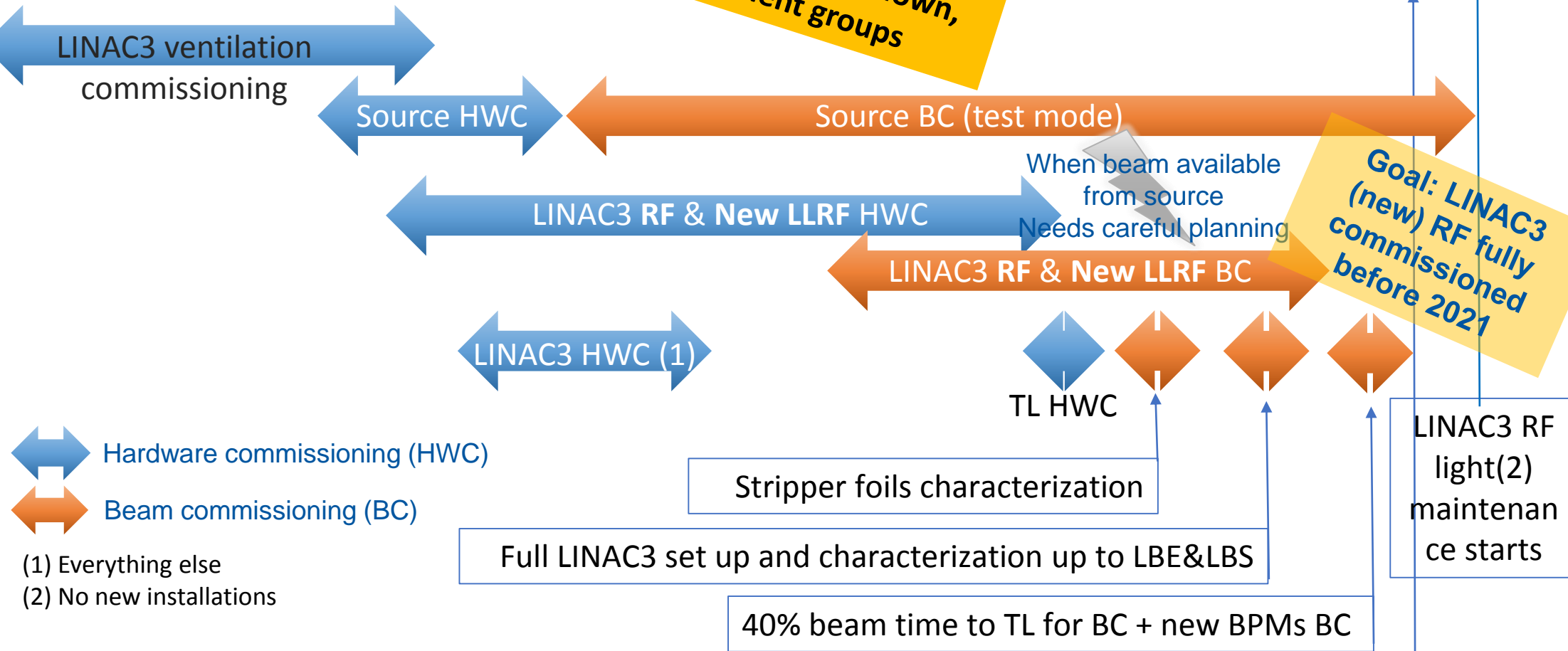
Draft
2020



Planning is consistent with finishing of shutdown, and will be circulated to equipment groups

ITH/LBS etc HWC
TL Polarity checks
(Technical services needed in the TL)

PS Switch
Yard
closes



Goal: LINAC3 (new) RF fully commissioned before 2021

Hardware commissioning (HWC)
Beam commissioning (BC)
(1) Everything else
(2) No new installations

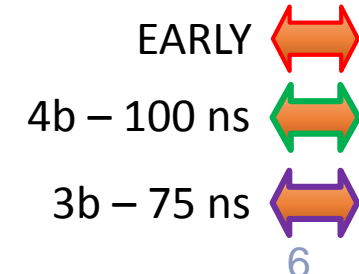
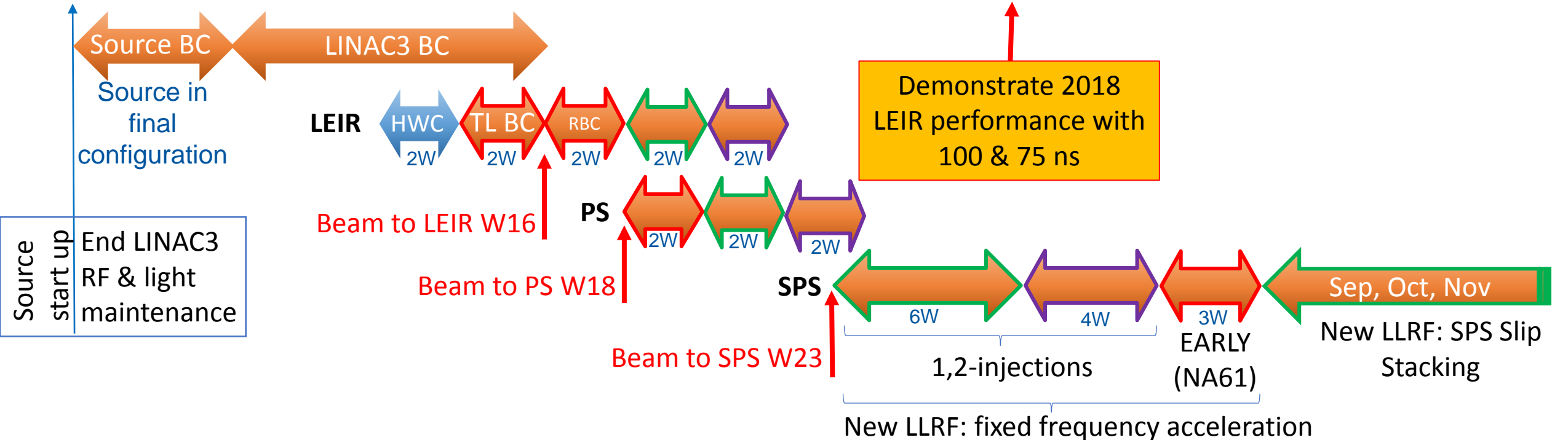
LBE/LBS tests with ions, including controls aspects, foreseen in 2019 LBE run and end 2020





Overall hardware and beam commissioning planning across the ion injector chain

Draft
2021



U Caveats/requirements

- **SPS ion beam commissioning is scheduled “in general” two days per week**
- **As done in 2018, the long SPS cycle for multi-bunch injection, which fills the whole supercycle, will be commissioned during the ion run**
- **As done in 2018, the SPS EARLY cycle to NA will be commissioned up to transition energy. The rest of the cycle during the ion run.**

Beam commissioning time line: LINAC 3



Activity	Related tasks	Tool requirements	Risks	Remarks	Estimated duration
RFQ and buncher phase amplitude to ITFS	First beam transfer to ITFS line	All magnets. Scanning scripts SEMGrids			2d
MEBT Emittance		Emittance measurement tool SEMGrids			3d
CAV1/2/3 phase amplitude to ITFS		All magnets. Scanning scripts SEMGrids			2d
Stripper Measurements		Stripper controls, slits, BCTs			2d



Beam commissioning time line: LINAC 3

Milestone 2
 Milestone 1
 2020



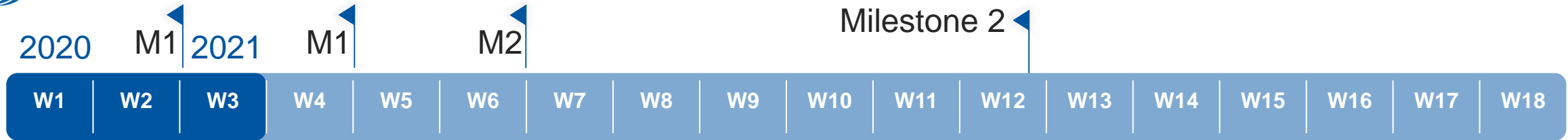
Activity	Related tasks	Tool requirements	Risks	Remarks	Estimated duration
Ramping cavity phase scan		SEMGrids			1d
LBS Test		Master Slave Line controls working. LBS working.			2d
Debucher phase scan		LBS			1d
ITH Emittance Scan		Quad Scan application			1d





Beam commissioning time line: TRANSFER LINE & LEIR

Draft



Activity	Related tasks	Tool requirements	Remarks	Time	Groups
TL BC	Beam steering	BTVs, Sem GRIDs, new BPMs		2W	OP, BI, ABP
	New BPM commis.	new BPMs			
	Beam instrumentation commis.	BTVs, Sem GRIDs, new BPMs, BCTs			
Finalise TL BC					





Beam commissioning time line: LEIR - EARLY

2021

← Milestone 1: EARLY beam (1 injection) ready for PS



Activity	Related tasks	Tool requirements	Groups	Time
Transfer line steering and injection, TL BI beam commissioning	Beam steering and kick response First injection optimization BI beam commissioning	BTV, Sem Grids, BPM, BCT, YASP	OP, BI, ABP	2 d
Establish circulating beam, RING BI beam commissioning	E-cooler optimization, orbit correction, Q&Q' correction, kick response, injection optimization, BI commissioning	e-cooler, Schottky monitor, BPM, BCT, YASP, Q&Q' app, automatic injection optimization app	OP, BI, ABP	2 d
Set up RF capture and acceleration	Commissioning of isoadiabatic capture h=1, loops commissioning, extraction synchro loop	Longitudinal Schottky, tomoscope	OP, RF	3 d
Orbit, Q&Q' correction through the cycle	Orbit, Q&Q' correction through the cycle Kick response	YASP, Q&Q' app	OP, ABP	1 d
Setting up extraction	Extraction bump optimization, TL steering to PS, LEIR to PS synchron	BPM, YASP	OP, ABP	2 d





Beam commissioning time line: LEIR - NOMINAL 4b – 100 ns

Draft

2021

Milestone 2: 4b – 100 ns beam (7 injection) ready for PS



Single injection

Activity	Related tasks	Tool requirements	Groups	Time
Orbit correction at injection	Orbit correction at injection (exclude injection bump, 1 injection)	BTV, BPM, BCT, YASP	OP, ABP	3 d
Maximize momentum acceptance	<ul style="list-style-type: none"> Match capture fRF with frev Set injected beam +1‰ off frev Set stack beam -1‰ off frev Optimize capture Flat orbit at radial pickups 	e-cooler, Schottky monitor, BPM, BCT	OP, ABP	
Optimize injection efficiency	Run injection optimization: injection bumps, e-cooler bumps, etc	Automatic injection optimization app	OP, ABP	
RF capture with frequency modulation	First RF capture with frequency modulation	Schottky monitor, tomoscope, BCT	OP, RF, ABP	
Orbit, Q&Q' correction at through cycle	Orbit, Q&Q' correction through the cycle Kick response	YASP, Q&Q' app	OP, ABP	2 d





Beam commissioning time line: LEIR - NOMINAL 4b – 100 ns

Draft

2021

← Milestone 2: 4b – 100 ns beam (7 injection) ready for PS



Multiple injection

Activity	Related tasks	Tool requirements	Groups	Time
Orbit bump in SS4	Orbit bump in SS4 at injection to minimize vacuum pressure	YASP, vacuum profiles, BCT	OP, ABP	1 d
Three injections	Optimize e-cooler	Schottky monitor, IPM, BPM, BCT, YASP	OP, ABP	
Seven injections	<ul style="list-style-type: none"> Optimize e-cooler Transverse damper commissioning 	e-cooler, Schottky monitor, IPM, BPM, BCT, YASP, TFB	OP, ABP	
Orbit, Q&Q' correction through the cycle	Orbit, Q&Q' correction through the cycle Kick response	YASP, Q&Q' app	OP, ABP	





Beam commissioning time line: LEIR - NOMINAL 4b – 100 ns

Draft

2021

← Milestone 2: 4b – 100 ns beam (7 injection) ready for PS



Multiple injection

Activity	Related tasks	Tool requirements	Groups	Time
RF capture with frequency modulation	Optimize RF capture with frequency modulation	Schottky monitor, tomoscope, BCT	OP, RF, ABP	2 d
E-cooler current optimization	<ul style="list-style-type: none"> Optimize e-cooler gun current Optimize e-cooler bump 	e-cooler, Schottky monitor, BPM, BCT YASP	OP, ABP	1 d
B field decay measurement and correction	<ul style="list-style-type: none"> B field decay measurement Optimize accumulation 	New implementation of the decay in LSA, Longitudinal Schottky, YASP, BCT	OP, ABP	
Q 2.75 during capture	Bring Q towards 2.75 during capture	YASP, Q&Q' app	OP, ABP	
Extraction setting up	Match extraction settings to EARLY		OP, ABP	1 d





Beam commissioning time line: LEIR - NOMINAL 3b – 75 ns

Draft

2021

← Milestone 3: 3b – 75 ns beam (7 injection)



W6: Contingency week: need to accommodate oven refills

Single injection

Activity	Related tasks	Tool requirements	Groups	Time
Clone 4b – 100 ns cycle to 3b – 75 ns cycle	<ul style="list-style-type: none"> Clone cycle Commission new cycle with beam at injection 	All	OP, ABP	2 d
RF capture with frequency modulation	Optimize RF capture with frequency modulation	Schottky monitor, tomoscope, BCT	OP, RF, ABP	2 d
Extraction setting up	Match extraction settings to EARLY	BCT properly gated	OP, BI, ABP	1 d





SPS SLIP STACKING COMMISSIONING

Draft

- the functionality for slip-stacking should be ready after the hardware tests.
- Slip-stacking with beam will then have two major milestones:
 - Ensure ion beam stability throughout transition crossing and arriving stably at the plateau using the CEBU and 800 MHz where possible. This will anyway be investigated for the ions and could be done maybe towards the second half of commissioning for ions.
 - Start the independent beam control by sending the two different frequency programs. I would assume this would then come together with the actual start of slip stacking setup by mid September, if I remember correctly. There will be lots of studies with simulations before this and one would then have to look at how the beam responds with the actual system.

NEEDS CAREFULL PLANING WEEKLY BASIS



Risks and mitigations

- **Risk: Source tests destabilize performance.**
- **Mitigation: Early restart for these tests, and time to rollback to 2018 set-up ready for LEIR restart.**

- **Risk: RF modifications.**
- **Mitigation: Early test of performance in 2020, well in advance of LEIR restart.**

- **Risk: LEIR in shut down for 2 years, but this applies to all the accelerators**
 - Risk: LEIR vacuum
 - Mitigation: Surveillance of the LEIR vacuum “critical item for ions” during LS2 by VSC (Alexander Sinturel)

U Summary

- Linac3: Will have a significant 2020 test period and RF commissioning. 2021 restart is then fast.
- LEIR: Planning for beam commissioning is optimized, clear and tight.
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