

LBE Line Run

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Preliminary Status of Linac4

- The runs this year brought us **much closer to the goal of reaching the PSB beam specifications** (EDMS 1898179)
- **Very constructive collaboration** between main actors, regular meetings, concentrated effort this autumn run
- **Several issues already solved that lead to higher availability:** HW and RF controls modifications implemented during summer TS, improved cavity restart procedure, beam stoppers grounded, remove sensitivity (filter) and reactivity (watchdog) to single cavity spikes, RF controls adjustments and cooling modifications
- **Preliminary results from autumn run:** flat pulse due to removal of 200 us of beam head; extended flat top for power converters to allow for a 600 us long pulse, ppm copy and (yet reduced...) ppm operation, improved settings management in LSA, optics refinement for transfer line (extracted from layout DB), (partial) commissioning of debuncher and Kalman filter, new operational applications and procedures – AND – **clear identification of still outstanding issues** to be solved before LBE line run

Motivation for LBE Line Run

- Crucial to assure that various beams for Run 3 can be provided within required specifications from Day 1
- Long transfer line >150 m mostly composed of new equipment, matching of horizontal and vertical dispersion, line verified for 160 MeV beam energy, prove reaching range of required energy spread (first test of debuncher with beam measurements!)
- Reach good beam quality before 2020 commissioning – assure that there are no show-stoppers and solve remaining issues
 - For many parameter tests the LBE line is essential (debuncher commissioning, longitudinal painting, transverse performance at PSB entrance) and could not be evaluated before
 - If issues would be discovered by then, needs time (e.g. a couple of months for LLRF firmware upgrades)
 - Cannot delay beam commissioning of downstream machines

Expected Changes for the LBE Line Run

- **HW changes:**
 - Completion end of line L4T and connection with LT line
 - Modifications LT/LTB lines in Linac2/PS tunnel
 - Renewal LBE line
- Magnets, power supplies, BI, vacuum, dump, WIC, BIS to commission
- **Important decabling/cabling campaign mainly in PS → associated risks**
- **Controls changes:**
 - Various controls upgrades and changes, new FESA classes for certain equipment
 - New timing infrastructure for Linac4! (PSB timing master)
- **New operational applications**
 - E.g. automatise phasing in of cavities, emittance measurement with Semgrids etc.
- **Linac4 changes:** still to be finalised with new Linac4 LS2 facility coordinator
 - RF (see next slide)
 - BI: exchange Semgrids (issue with wires molten together!), laser emittance meter, repair of BSM1, new motor controllers for WS
 - Source: new source? 'Autopilot'? Modifications of source RF power supply
- **Commissioning of debuncher and longitudinal painting**

LBE Line Run and RF

- **LBE Line Run essential for RF team** for implementing, testing and confirming necessary components for Run3 as:
 - **Correction of klystron filament supply** (klystron lifespan)
 - **Set up cavities for 600 μ s long beam pulse**
 - Implementation of **Kalman filters** on all 17 RF lines to reduce transient effects (during this reliability run considerable trajectory changes during $\sim 30 \mu$ s long transients seen, filters should be tested on all 3 cavity types before end of this year; might need to implement additional filters like for PIMS in case a cavity resonance gets excited)
 - Firmware modifications to 'dampen' cavity spikes (currently done with SW filter)
 - **Debuncher commissioning with beam loading and full power**
 - LLRF development for **energy ramping & longitudinal painting**
 - Improved **source RF amplifier**
- In case issues would be found that require for example firmware modifications, could mean substantial time (of the order of 2 months) for a new tested version

LBE Line Run and BI

Equipment	Activities	Staff	Comments
BPM	<ul style="list-style-type: none"> • HW commissioning (<u>4 new monitors</u>) • Operational Support • <u>Optimize ToF</u> • Expert support during all energy/phase meas. 	<ul style="list-style-type: none"> • M.Bozzolan (BI-BP) • A.Guerrero (BI-SW) 	BI expert support critical during initial phasing of all cavities
BCT	<ul style="list-style-type: none"> • Setup (<u>Timing, gating, Watch Dog</u>) • Operational Support 	<ul style="list-style-type: none"> • J.C. Alica-S. • A. Topaloudis 	BI support critical at setup
BLM	<ul style="list-style-type: none"> • HW commissioning (<u>xxx new monitors</u>) • Setup (<u>Timing, gating beam presence</u>) • <u>Setup and commissioning of SW interlocks</u> • Operational Support, including threshold settings, managed by OP-ABP) 	<ul style="list-style-type: none"> • V.Vigano' • C.Zamantzas • S.Jackson 	Who does what for thresholds to be defined INCA must be ready to host threshold management
BSM	<ul style="list-style-type: none"> • <u>Setup and commissioning of (BSM2 to be re-located after de-buncher)</u> • Expert support during all energy/phase meas. 	<ul style="list-style-type: none"> • J.Tan • S.Bart-Pedersen 	BI expert support (maybe) critical any time BSM needed to diagnose issues with RF
BSG & BWS	<ul style="list-style-type: none"> • HW commissioning and setup (<u>8 new grids, 4 new scanners, new VME motor controllers</u>) • <u>Wire grids reliability studies</u> • Operational Support 	<ul style="list-style-type: none"> • F.Roncarolo • A.Guerrero • S.Bart-Perdersen 	New motor controllers to be validated by July 19 Final grids design to be assessed after 2018 run
Laser EM	<ul style="list-style-type: none"> • <u>From commissioning to operation</u> 	<ul style="list-style-type: none"> • F.Roncarolo • A.Goldblatt 	SW (FESA) support ensured by EN-SMM-MTA
Stripping Foil BTV	<ul style="list-style-type: none"> • Operational support 	<ul style="list-style-type: none"> • S.Burger 	

LBE Line Run Schedule



Individual System Tests Linac4 (w35/36)

- To be done before: DSO tests, lock in equipment; recabling of klystron filament supply and validation + **3 days of Controls Dry Run with RF and EPC** after lock-in and DSO tests; source ready
- <2 weeks of IST before 1.5 weeks of stop for Open Days
- 2 shifts M/A

Week 1 (w35)	<ul style="list-style-type: none">• Magnet polarity checks• BIS, WIC, power supply checks• RF restart; optimise the modulator + RF system for 600 us long pulses (up to CCDTL incl.)• Commission new motor controllers for wire scanners• OP commissioning checklist, applications etc.
Week 2 (w36) (Jeune Genevois...)	<ul style="list-style-type: none">• Optimise the modulator + RF system for 600 us long pulses (PIMS)• Start LLRF setup for RFQ• Continue commissioning of new motor controllers for wire scanners• Dry runs other beam instrumentation (without beam)• OP commissioning checklist• Lock-out Linac4 again for Open Days

Individual System Tests Switchyard + LBE (w36,39)

- Important de-cabling/cabling campaign in PS; new LBE line and many new magnets + power supplies in transfer lines
- <2.5 weeks of IST (interrupted by 1.5 weeks for Open Days + Jeune Genevois)
- 2 shifts M/A

Week 1 (w36) (Jeune Genevois...)	<ul style="list-style-type: none">• Lock in magnets and power supplies• Fence off LT/LTB/LBE Switchyard area• New LBE dump - checks (EN-STI)• Validate new controls infrastructure for TL and LBE• Start re-commissioning and commissioning of power supplies• OP checklist• Interruption for CERN Open Days (manpower availability)
Week 2 (1/2 w38, w39)	<ul style="list-style-type: none">• Re-commissioning and commissioning of power supplies• Magnet polarity checks• Dry run for beam instrumentation (without beam)• OP checklist

HW Commissioning Linac4, TLs, LBE (w38-41)

- **1.5 weeks** HW commissioning for Linac4 + L4T (1/2 w38, w39) after recovery from Open Days, equipment lock-in, patrol, DSO tests
- **2 weeks** HW commissioning for LT, LTB, LBE (w40, w41) **in parallel to Linac4 low-energy beam commissioning**
- 2 shifts M/A

<p>½ w38, w39 (HW commissioning Linac4, L4T)</p>	<ul style="list-style-type: none">• Dry run pre-chopper and chopper• Dry run stripping foil system• Detailed BIS and SIS tests with equipment experts• LLRF setup RFQ, DTL, start CCDTL (cavity loops, testing of newly implemented filters...)• Go through and finish OP HW commissioning checklist• Start with beam on the chopper dump, interlock tests with beam, LEBT/MEBT instrumentation setup with beam and optimisation
<p>w40, w41 (HW commissioning LT, LTB, LBE)</p>	<ul style="list-style-type: none">• New WIC commissioning• Detailed interlock checks (new BICs, SIS)• Go through and finish OP HW checklist

Beam Commissioning (w40/41)

- 2 weeks of beam commissioning up to 50 MeV
- LLRF setup has to always be in advance of the beam commissioning progressing along the linac
- Start full shift rota (tbc)

Week 1 (w40) BC low energy	<ul style="list-style-type: none">• LEBT/MEBT beam commissioning, chopping• Optimise LEBT for beam pulse flatness• LLRF setup of CCDTL (cavity loops, testing of newly implemented filters)• Start with DTL1 setup (new cavity phasing applications!)• OP beam commissioning checklist
Week 2 (w41) Beam up to 50 MeV	<ul style="list-style-type: none">• DTL beam commissioning and phasing• LLRF setup of PIMS (cavity loops, testing of newly implemented filters)• Beam instrumentation checks with beam following progress• OP beam commissioning checklist

Beam Commissioning up to LBE (w42-45)

- 4 weeks of beam commissioning Linac4 up to 160 MeV, transfer lines and LBE
- Full shift rota

Week 1 (w42) Beam to 160 MeV	<ul style="list-style-type: none">• PIMS beam commissioning and phasing• Beam instrumentation, interlocks, applications L4T (part 1) and L4Z (BSM, transv. emittance meas., laser wire scanner...)• Steering to LN4DMP• Optimise chopping efficiency• LLRF setup of debuncher (cavity loop, scan of cavity-to-waveguide coupling, tuner scans...)
Week 2 (w43) Transfer line	<ul style="list-style-type: none">• Transfer line commissioning with low intensity (new equipment in second part of L4T, LT, LTB, LBE)• YASP steering (validate optics); optimise transmission• Beam instrumentation, interlocks, applications• Optimise vertical dispersion• LLRF setup of debuncher with beam loading
Week 3 (w44) LBE	<ul style="list-style-type: none">• Transfer line commissioning with high intensity• Optimise transmission and minimise losses• Follow up on issues; potential source caesiation/access
Week 4 (w45) LBE	<ul style="list-style-type: none">• Twiss parameter matching and dispersion → quad settings for matched conditions• Setup of BSM2; prepare laser emittance meter for operation• Reliability run for Semgrids and wire scanners

Beam Tests (w46-49)

- 4 weeks of beam tests with beam to LBE
- Full shift rota
- W49 end of LBE line run 2 weeks before Christmas stop

Week 1 (w46) Debuncher commissioning	<ul style="list-style-type: none">• Control of debuncher• Setting different energy spreads and measurement with BSM2• Debuncher: find phase and amplitude through beam-based measurements; confirm combination for different energy spreads• Semgrid and wire scanner reliability run; accuracy studies LEM
Week 2 (w47) Energy ramping	<ul style="list-style-type: none">• Energy ramping with last PIMS cavities – debuncher OFF; TOF measurements• Semgrid and wire scanner reliability run
Week 3 (w48) Longitudinal painting	<ul style="list-style-type: none">• Energy ramping with last PIMS cavities – debuncher ON; TOF and BSM2 measurements• Semgrid and wire scanner reliability run
Week 4 (w49) Optimisation	<ul style="list-style-type: none">• Energy ramping with last PIMS cavities, debuncher ON and corresponding chopping pattern• Reference measurements• Prepare machine for end of LBE line run

To be done

- Finalise current planning depending on results from this Linac4 autumn run
- Update IST/HW commissioning checklist for Linac4 and add new equipment in L4T
- Prepare IST/HW commissioning checklist for LT, LTB, LBE
- Same for beam commissioning checklists
- Transfer current planning into ASM tool
- Meetings with equipment experts to discuss details of tests and reserve dates for Dry Runs
- Prepare during LS2 new applications, controls, settings etc.
- Very dense ‘planning for success’ – need to be very efficient! Prepare automatic tools as much as possible beforehand...

Summary

- LBE run essential to mitigate risks for required post-LS2 beam quality and delays
- IST: <2 weeks for Linac4, <2.5 weeks for Switchyard and LBE
- HW commissioning: 1.5 weeks for Linac4 + L4T, 2 weeks for LT, LTB, LBE
- Beam commissioning: 6 weeks
- Beam tests: 4 weeks
- Very dense program → need perfect planning and dedication of involved people (and hopefully no unforeseen issues...)