

SPS Upgrade: overview

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Based fully on work of SPS Upgrade Study Group and
Task Force

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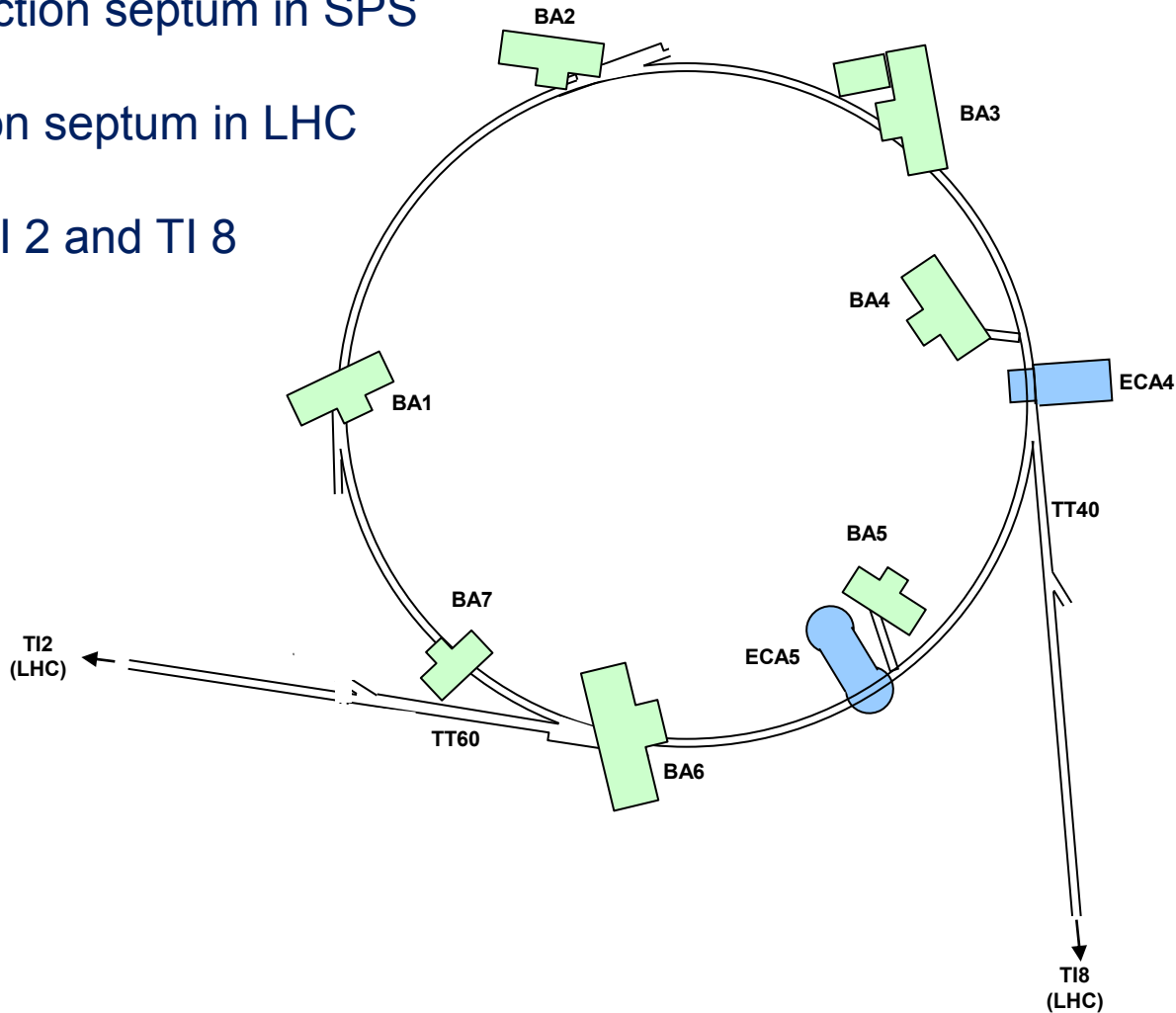
SPS-LHC Injection Upgrade: project scope

SPS for LHC beams

From: injection septum in SPS

To: injection septum in LHC

Includes TI 2 and TI 8



Main challenges

- Beam quality to LHC
 - Preservation of transverse emittance from PS into LHC
 - Limitations, instabilities
- Electron cloud induced effects
 - Mitigation measures to apply
- Beam loading and high power for RF system
- Impedance and beam induced heating of components
- Machine protection/intercepting devices
- Other “operational” limitations

Beam limitations and parameters

- LHC will request small emittance, and higher intensities.
 - Parameters to fix, at least in draft version
 - Is 25 ns still the optimum? When will we know?
- Can the SPS deliver higher than ultimate brightness?
 - What is potential bunch intensity vs emittance for different time intervals between bunches?
 - Is nominal emittance (3.5-3.75 μm) upper limit (injection, aperture, ...) for LHC?
 - What is lower limit on emittance LHC can digest??
 - Is there a limit on the intensity per bunch in LHC?
- What are potential gains/losses from lower γ_T optics?
 - Instability thresholds, impact on RF voltage...
- Impedance campaign to continue? Which elements?
- Transverse damper
 - High bandwidth needed for TMCI, ECI, general purpose?
 - Power upgrade of present (lower bandwidth) damper needed in parallel?

Electron cloud mitigation

- Could scrubbing alone be sufficient?
 - Implications for vacuum system (sectorisation, handling, venting, ...)
 - We rely on this for LHC arcs – why not for SPS?
- Electrodes – any future?
 - Maturity, impedance, aperture, production, resources, feasibility and cost, additional coatings anyway....
- Coatings
 - What information is still needed to decide on feasibility? Pressure and ageing, ions...?
 - Develop rapidly plan for 2012 (2013) – 1 sextant? More? Less?
 - Proof of reliable solution for coating inside magnets?
 - Logistics of workshop space, magnet opening, transport will be serious time/cost drivers
 - How long will “short” shutdowns be in 2013-2016? Carry on installing if no problems seen....?

200 MHz RF Upgrade

- Increase RF power by 50% (10 MV for Ultimate beam)
- Any further information needed – e.g. tests in pulsed mode?
 - If not, launch implementation now
 - Planning already tight for commissioning in 2017
- Huge project
 - New surface building near BA3
 - Four new transmitter stations and two new RF lines
 - Complete reorganisation of installations in LSS3
- Minimum 6 month SPS shutdown for tunnel installation
 - Can only be done in 2016 (2017 if long shutdown delayed)
- Is performance reach of this upgrade enough?
 - LHC ultimate for 25 ns, with present longitudinal impedance

Impedance reduction

- Beam induced heating/outgassing of components
 - Presently limitation for high duty factor MD cycles
- MKE serigraphy to complete – should help
 - 2 MKEs being installed in forthcoming TS
 - Last 3 MKE to exchange in long 2012 shutdown
 - Are all pros and cons of this solution understood? Options?
- General impedance reduction effort...
 - Simulation efforts ongoing
 - Finish studies of new MKE proposal (evaluation of impedance and requirements, technical aspects, potential gains)
 - Optimise existing systems (MKDV/H, enameled flanges, ...)
 - Continue efforts for transverse impedance identification

Machine protection upgrades

- Redesigns needed for some protection elements?
 - Limitations for LHC ultimate (at 3.5 μm) for extraction protection and TL collimators
 - Above ultimate intensity and/or below nominal emittance needs study
- FLUKA and mechanical shock (ANSYS) analyses
 - Resources and expertise needed for 2011
- Tight space constraints for LSS4
 - May not even be physically possible in today's layout
 - Sacrificial absorbers (damage + replace) – RP issues, tests (HiRadMat)

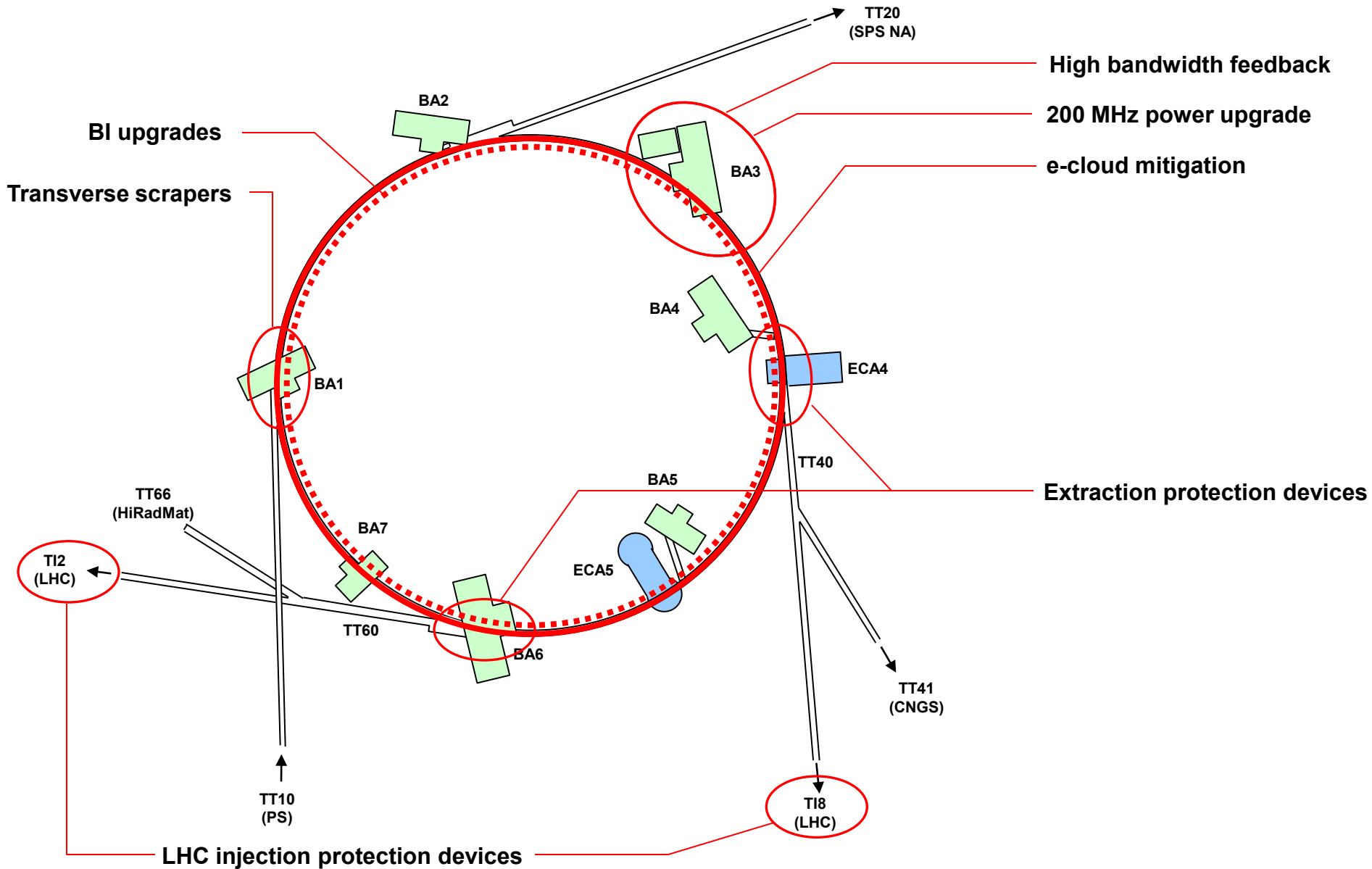
Beam quality

- Longitudinal
 - Bunch length, satellites, uncaptured beam (BQM exists)
- Transverse
 - Scraping tails will continue to be critical
 - New scraper design for long-term? Bumpers & fixed block?
 - Localization of losses from scraper?
- Bunch to bunch variations
 - Where do they come from?
 - Need realistic and enforceable specifications on limits
 - Adequate diagnostics in injector chain and SPS?
 - Ghost bunches and how to fight them
- Injection kicker risetime
 - Issue for smallest emittances?

Operational limitations

- **Beam dumping**
 - Outgassing of TIDV affecting MKP OK? (was solved for CNGS)
 - Clean dumping of beams at 37-105 GeV required? Or OK as-is for higher intensity/lower emittance beams?
 - Adequate workarounds for all cases with present systems?
- **Beam instrumentation**
 - Dynamic ranges and bunch by bunch – which instruments to upgrade?
 - New instruments - requirements well defined yet? BSRT+wiggler??
- **Beam losses**
 - At what level does 'general' beam loss become intolerable?
 - Do we really need dedicated collimation to localize losses?
- **TEDs and exit windows**
 - Intensity/transverse emittance limits to analyse
- **Cycle cohabitation and management**
 - What limitations could LHC beams impose (e.g. ZS off = no FT beam)?

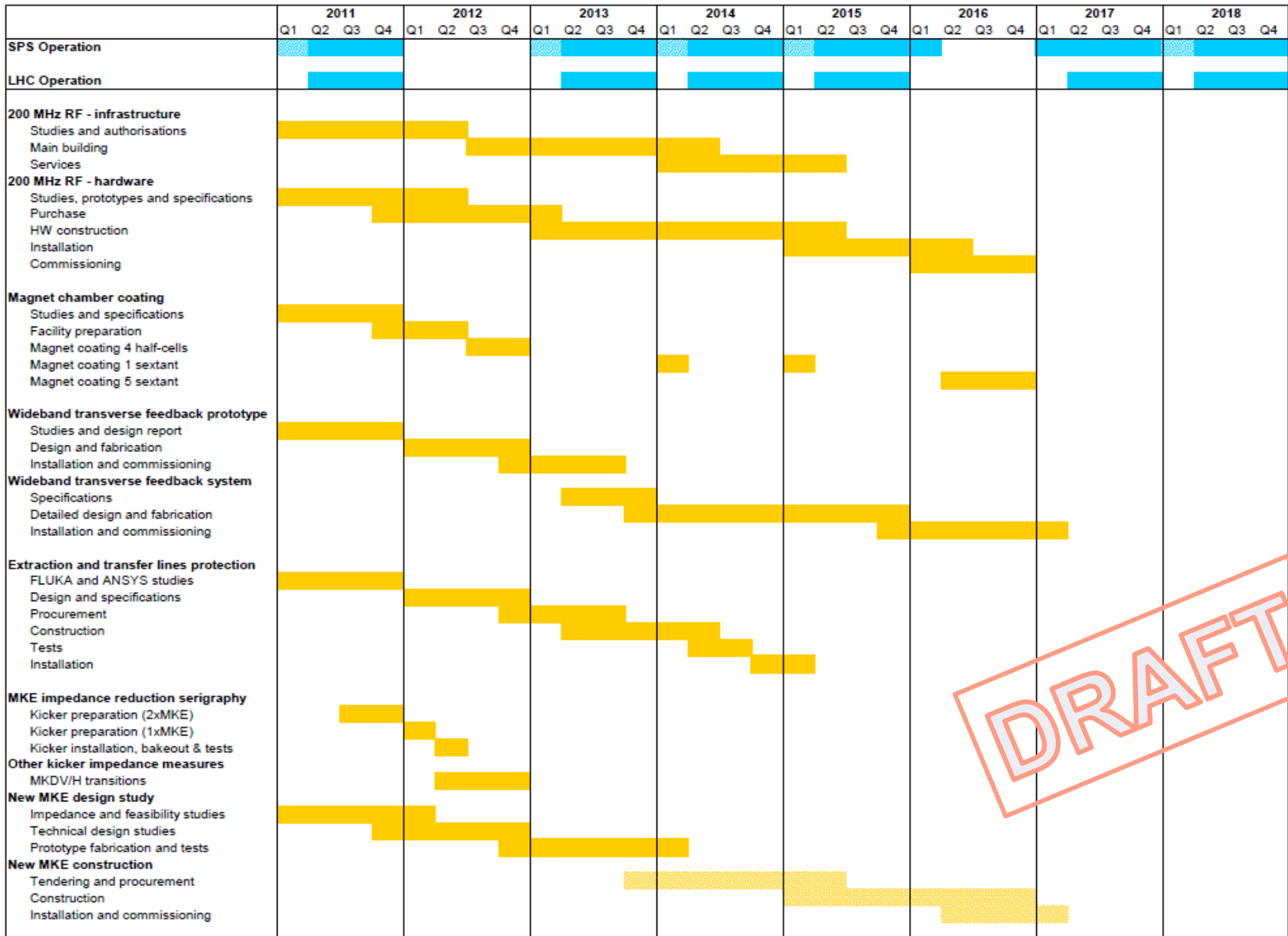
SPS upgrade by location



Timeline for project deliverables

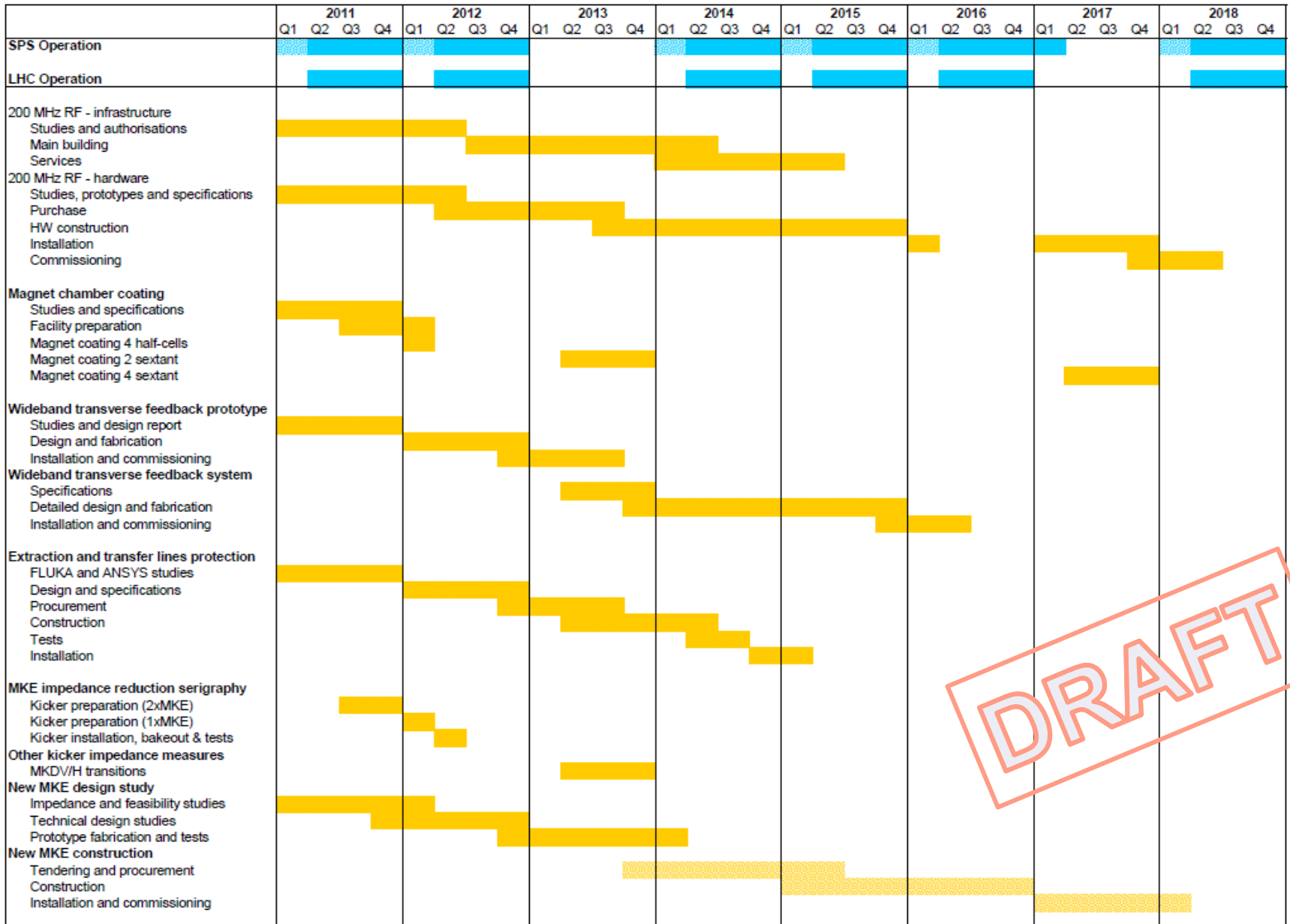
- For 2011
 - LHC nominal beam ready for all spacings
- For 2013 (2014?) startup
 - Higher intensities (towards ultimate) with 50 ns and 75 ns
 - Studies with lower emittances/high intensity at 25 ns
- For 2017 (2018?) startup
 - Ultimate intensities and nominal emittance ready for 25 ns
 - Ultimate intensities and small emittance ready for 50 and 75 ns
- Machine development and beam deployment
 - Adequate MD time allocation needed – 2010 experience?
 - People needed for MD and analysis...
 - Are requisite beams available from injectors?

Preliminary timeline – long 2012 shutdown



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Preliminary timeline – long 2013 shutdown



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Organisation and other issues

- Overall coordination in SPS-LIU (led by BG, deputy ES)
- SPS-LIU Working Groups for different studies
 - Instabilities, beam dynamics, longitudinal, limits (ES)
 - e-cloud and its mitigation (JMJ)
 - Beam loss control, machine protection and transfer lines (MM)
- Decide Q1 2011 on what we will implement, and when
 - Deadlines being defined from shutdown planning
 - Can adjust later if needed
- Produce specifications for HW groups
 - All HW responsibilities to define – names
- Other important aspects...?
 - Resources for studies and work a big issue – busy elsewhere.
 - Shutdown and works planning (major planning outline needed)
 - Split between LIU and consolidation, co-planning of activities
 - Design office and engineering support planning and requests
 - Drawings, layouts and databases

Work plan for 2011...

- Launch 200 MHz upgrade
 - Technical decision mid 2011, + civil engineering studies/permissions
- Preparation for coating: 3 half-cells, 1 sextant? (or for clearing electrodes, or both?)
 - Must include quadrupoles, pumping ports, other elements
 - Impact if long shutdown moved to 2013 – more logical progress
- High bandwidth feedback: studies + design report (LARP)
- Define all additional BI upgrade requirements
- Prepare 2 of final 3 MKE with serigraphy
 - Problem for #3 if long shutdown moved to 2013 - needs 10 weeks
- Launch full feasibility study for extractions with new MKE
 - Including impedance calculations and benefit analysis
- Key MDs - defined for 2011?
 - High intensity single bunch → high intensity multibunch
 - Making 'ultimate' intensity beams operational (50 and 75 ns?)
 - Parameter limits for 25 ns spacing
 - e-cloud mitigation validation
 - low gamma transition optics

Summary

- Huge body of knowledge and work existing
 - Due to SPSU Study Group, and also Task Force review
- Implementation outlines are reasonably clear
 - Some major questions still to answer to finalize implementation priorities (e.g. scrubbing alone for e-cloud mitigation?)
 - Need firm decision on major shutdowns as this affects feasibility of different options
 - Urgent to have agreed draft of parameter envelope from LHC
- Details of the major issues in following talks
 - Beam dynamics and limitations
 - e-cloud mitigation
- Resources and priorities for all this work are a concern