PLANS FOR THE SPS

B.Goddard for the LIU-SPS team

An overview is given of the plans for the SPS consolidation and SPS-LIU upgrade work. The baseline work and options still under consideration are described, and placed in the context of the present technical stop and long shutdown schedule. Preliminary resource estimates are given where possible and potential manpower concerns highlighted for the main activities, especially during LS1. The SPS-LIU MD objectives are outlined for 2011.

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Overview

- Assumed deliverables
- Baseline HW work
- Design studies and decision points
- Assumed milestones and work planning, including LS1/2
- Technical issues
- Key 2011 MD and activities

Assumed deliverables from SPS

- **For 2011/12**
  - LHC nominal beam ready for all spacings
  - Studies with nominal (3.5 μm) emittance, towards ultimate intensity
  - Studies with small emittance, nominal intensity
- **For 2014 (after LS1)**
  - Studies with lower emittances and towards ultimate intensity
- **For 2018 (baseline goals)**
  - Ultimate intensity and 2.5 um emittance for 25 ns beams
  - Super-ultimate intensity and nominal emittance for 50 ns beam
  - Studies with lower emittances/higher intensity

SPS targets

	Spacing [ns]	Intensity/b [e11 p+]	H/V emittance [um]
Baseline	**25**	**1.8**	**2.5**
Stretched	*25*	*2.1*	*2.2*
Baseline	**50**	**2.5**	**3.5**
Stretched	*50*	*2.7*	*1.6*

Values quoted at SPS extraction / LHC injection – i.e. measured in TLs

Known limitations and 2010 studies

- Single bunch
  - TMCI (transverse mode coupling instability)
  - loss of Landau damping
  - space charge
  - longitudinal instability

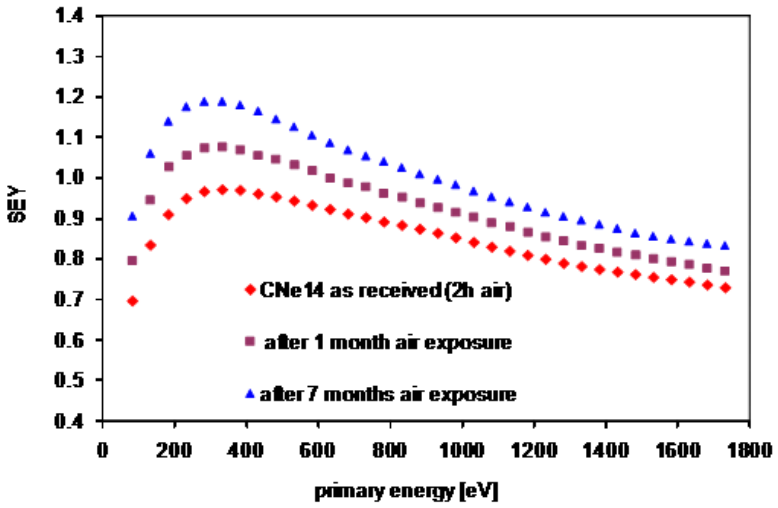
➢ High (twice ultimate) intensities, nominal and small transverse emittances, γ_t=22.8 (nominal) and γ_t=18 ("low") optics

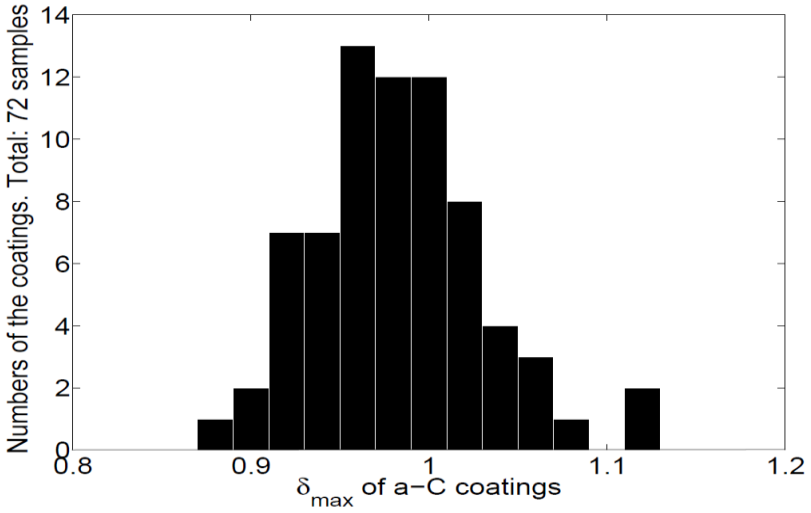
- Multi-bunch
  - e-cloud
  - beam loss (many reasons)
  - longitudinal coupled bunch instabilities
  - beam loading in the 200 MHz and 800 MHz RF systems
  - heating and outgassing of machine elements, septum (ZS) sparking

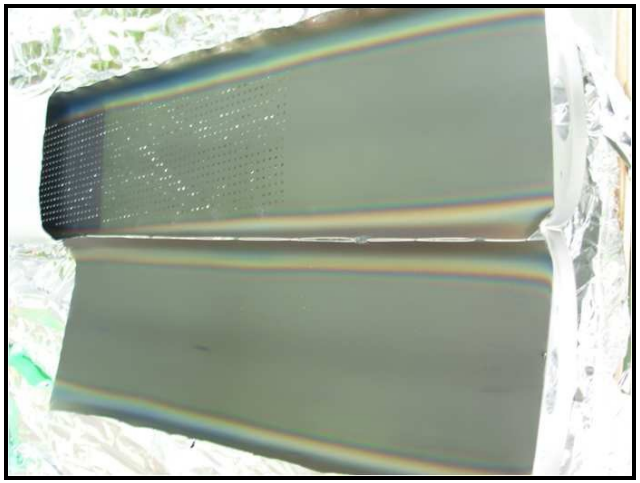
➢ Nominal 25, 50, 75, (150) ns spaced LHC beam,
Ultimate (injected) 25&50 ns spaced beam

ecloud mitigation

- Magnetron sputtering to deposit amorphous carbon (aC) layer
  - Large reduction of SEY below ecloud threshold
  - Coating in dedicated workshop (ECX5) 4-6 magnets per day

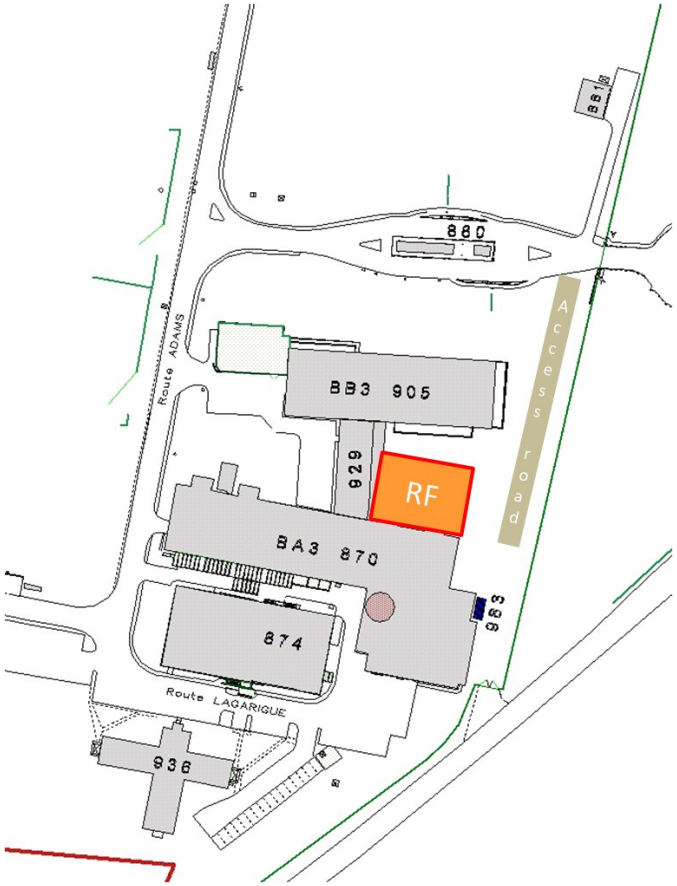






RF 200 MHz reorganisation

- Increase power to 6 MW into 6 shorter cavities (from present 4) to give 10 MV required at ultimate intensity
  - Needed for longitudinal stability (increase emittance to 0.6 eVs)
  - Reduces impedance by 20%
  - Big job: new building, new LSS3 layout, 26.5 MCHF over 7 years



Baseline HW upgrades – LIU-SPS

- ZS test stand: for 2011
- MKE impedance reduction: for 2012

[---------- Long Shutdown 1 ----------]

- MKDV/H impedance reduction (transitions): for 2014
- Beam instrumentation upgrades: for 2014
- Existing damper upgrade: for 2014
- Extraction protection device upgrade: for 2015
- New high bandwidth damper: for 2016

[---------- Long Shutdown 2 ----------]

- RF 200 MHz upgrade: for 2018
- ecloud mitigation: aC coating, for 2018

Design studies and decision points

- Collimation/scraper design study: end 2012
  - Localise losses and improve reliability
- Transfer line protection design study: end 2012
  - Protect against loss of higher intensity beams
- New MKE/extraction study/prototyping: end 2013
  - Further reduce kicker impedance.
- Beam dump design study/prototyping: end 2013
  - Remove operational limitations.

Main LIU-related consolidation activities

25Y	Comment	kCHF	
TWC800 consolidation	Couplers, antenae, cables...	675	
TWC200 Simatic	Replacement of obsolete PLCs	180	
SPS scrapers	Replacement of cables and controls, plus upgrade	300	CONS -> LIU
Approved CONS			
SPS kicker impedance reduction	MKE serigraphy to be completed in LSS4	90	
SPS MKDV power supplies	MKDV only	125	
SPS MKDV kicker HV generator (controls)	MKDV only	315	
SPS MKDV kicker HV generator	MKDV only	825	
SPS MOPOS	Consolidate for PRESENT requirements	1,630	
SPS MTV electronics	Consolidate for PRESENT requirements	55	
SPS RF driver amplifier	200 MHz upgrade of Siemens part	525	
SPS RF beam controllers and feedback	200 MHz renovation Faraday cage + controls (delayed)	955	
SPS TIDVG	New baked TIDVG plus studies for improvement	65	
Non-approved CONS			
Move damper to LSS3	Removal of damper kickers, LL and pickups to LSS3/BA3	500	CONS -> LIU
(Renovation of damper pickups)	New or refurbished couplers needed - 12 units + cables	240	New for LIU
Damper PA consolidation	Replacement of existing damper power amplifiers	350	CONS -> LIU
LLRF transverse damper	Refurbishment of existing damper LL	175	CONS -> LIU
(Damper LL upgrade)	Complete upgrade of damper system for LIU requirements	375	New for LIU
TWC200 amplifiers ECA renovation	Replacement of existing electronics	100	CONS -> LIU
SPS Wirescanner consolidation	Upgrade of existing scanners to single bunch	600	CONS -> LIU
SPS BLM consolidation	Upgrade of existing system with LHC type approach	580	CONS -> LIU
White paper			
PS and SPS feedback, and SPS LL	1 turn feedback for SPS 800 MHz cavities, SPS LL, PS long. Kicker	1,400	

- LIU-SPS depends DIRECTLY on 7 MCHF of Consolidation work (indirectly much more)
- Some double accounting sorted out:
  - Can reduce SPS consolidation requests by 2.6 MCHF (of which 0.3 MCHF already allocated)
  - Then need to increase LIU-SPS budget by 1 MCHF

Consolidation and LIU-SPS coexistence

- MOPOS and wirescanner consolidation
  - Take into account LIU-SPS requirements
- MKDV switch and generator consolidation
  - Coordinate with beam dump upgrade
- 200 MHz driver/controls & Faraday cage consolidation
  - Coordinate with 200 MHz upgrade, LL upgrades
- Possible main dipole coil consolidation
  - Coordinate with aC vacuum chamber coating

- Major LIU-SPS works need to be closely coordinated with high impact consolidation activities
  - LV/control recabling campaigns
  - Infrastructure work
  - LSS3 200 MHz RF rearrangement
  - aC magnet coating for ecloud
  - Damper relocation
  - ...

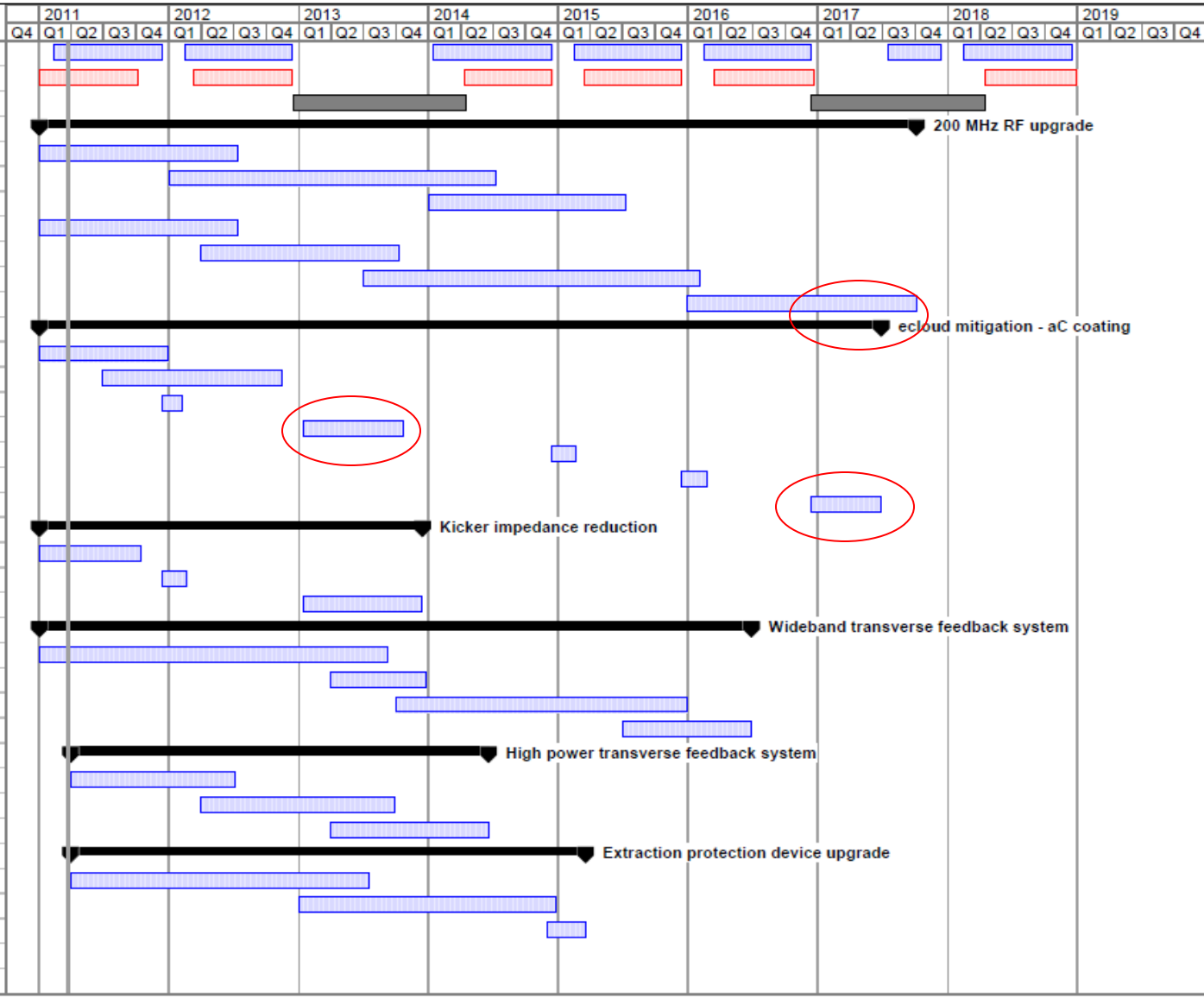
Assumed constraints and planning

- Constraints (working assumptions)
  - LHC LS1 in 2013, for 15 months
  - LHC LS2 in 2017, for 15 months

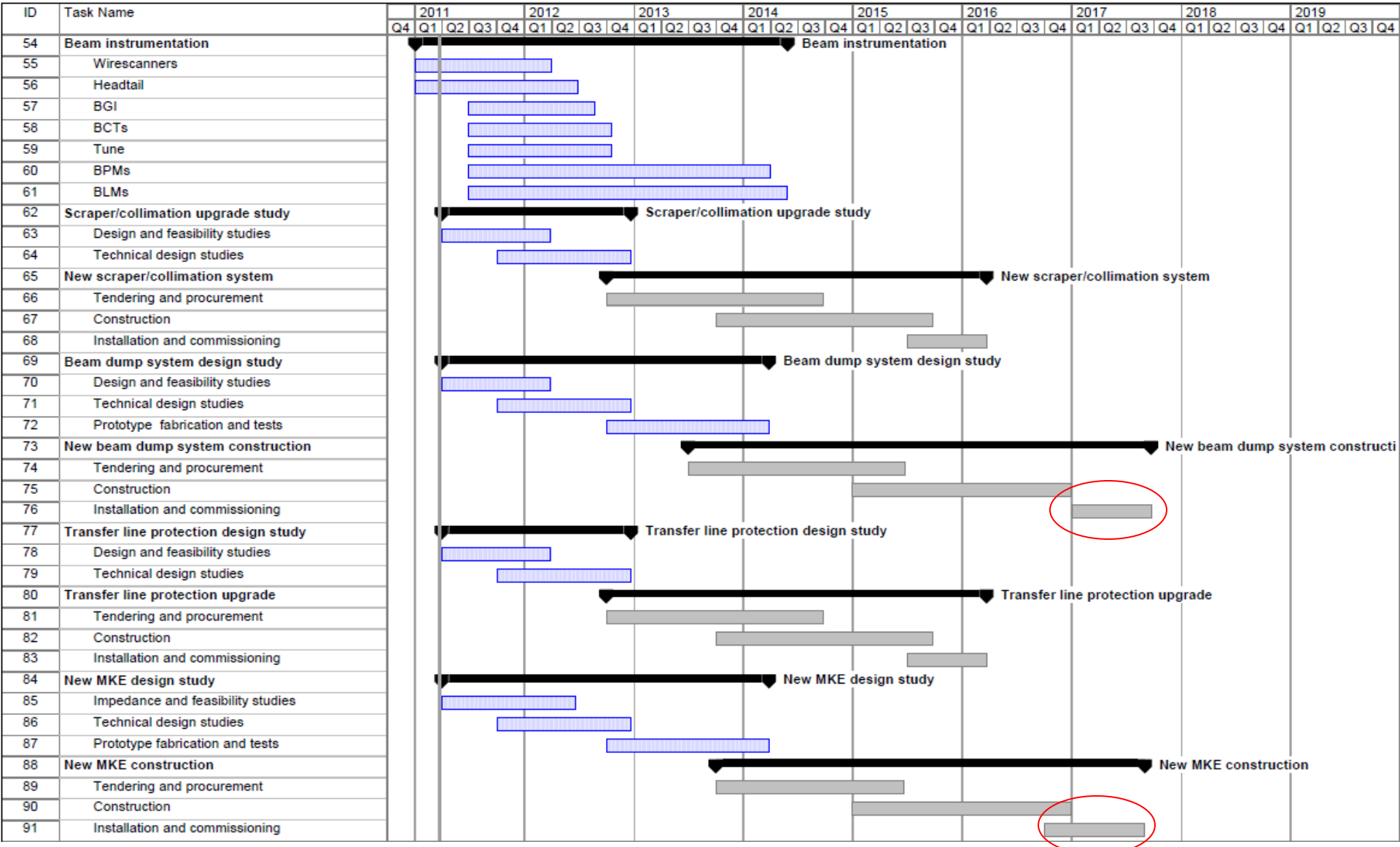
  - LHC injectors OFF in 2013, for 12 months
  - LHC injectors OFF in 2017, for 6 months (min. for SPS 200 MHz)

Outline LIU-SPS planning - provisional

ID	Task Name
1	**SPS operation**
9	**LHC operation**
16	**LHC LS**
19	**200 MHz RF upgrade**
20	Building studies and authorisation
21	Main building construction
22	Services
23	Aplifier studies, prototypes, specs
24	Purchase
25	Construction
26	Installation, commissioning
27	**ecloud mitigation - aC coating**
28	studies and specifications
29	Facility preparation
30	Coating 2 half-cells
31	Coating 1 sextant
32	Coating 0.5 sextant
33	Coating 0.5 sextant
34	Coating 4 sextants
35	**Kicker impedance reduction**
36	Kicker preparation (3xMKE)
37	Kicker installation, bakeout & tests
38	MKDV/H transitions
39	**Wideband transverse feedback system**
40	Prototype
41	Specifications
42	Detailed design and fabrication
43	Installation and commissioning
44	**High power transverse feedback system**
45	Specifications
46	Detailed design and fabrication
47	Installation and commissioning
48	**Extraction protection device upgrade**
49	Design, feasibility studies and HiRadMat tests
50	Detailed design and fabrication
51	Installation and commissioning
52	
53	



Outline LIU-SPS planning - provisional



MTP input – v1.0

Baseline kCHF	2011	2012	2013	2014	2015	2016	2017	2018	Total kCHF
Beam dynamics studies and simulations	10	10	10	10	10	10	10	10	**80**
MKDV/H impedance reduction		50	100						**150**
Beam instrumentation upgrades	200	600	500	500	300				**2,100**
Extraction protection upgrade		100	200	350	300	150			**1,100**
New high bandwidth damper	150	150	600	600	300				**1,800**
Existing damper power upgrade (power + LL)		100	450	300	150				**1,000**
Existing damper removal to LSS3		200	300						**500**
RF 200 MHz upgrade	850	1,400	2,400	9,850	7,450	3,650	600	300	**26,500**
ecloud mitigation: aC coating (in magnets)	145	350	550	505	620	1,050	1,800	600	**5,620**
MKE impedance reduction									***0***
Scraper upgrade									***0***
RF 800 Mhz 1 turn feedback									***0***
RF 200 Mhz LL control upgrade									***0***

Subject to detailed design studies kCHF									Total kCHF
New collimation system		100	200	800	2,700	2,700	1,500	1,200	**9,200**
New MKE and extraction channel upgrade		200	300	600	1,800	1,700	1,200	600	**6,400**
Beam dump upgrade		150	250	800	2,500	2,100	1,300	1,000	**8,100**
TL protection upgrade		100	200	1,500	1,500	1,500	1,000	200	**6,000**

Variants kCHF									Total kCHF
ecloud mitigation: aC coating (remove chambers)	500	1,200	1,700	1,900	2,200	3,500	5,500	2,100	**18,600**

Totals									Total kCHF
Yearly total (baseline without "studied options")	1,355	3,510	5,110	12,115	9,130	4,860	2,410	910	**39,400**
Yearly total (baseline + "studied" options)	1,355	3,510	6,060	15,815	17,630	12,860	7,410	3,910	**68,550**
Yearly total (baseline + remove chambers + "studied" options)	1,710	4,360	7,210	17,210	19,210	15,310	11,110	5,410	**81,530**

Budget

MTP input – v1.0

Baseline FTE	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Total FTE**
Beam dynamics studies and simulations	2.0	2.0	1.5	2.0	2.0	2.0	1.5	2.0	**15.0**
MKDV/H impedance reduction		0.2	0.3						**0.5**
Beam instrumentation upgrades	0.5	1.0	3.0	3.0	3.0	3.0			**13.5**
Extraction and TL protection upgrade		0.5	1.0	1.0	0.5	0.5			**3.5**
New high bandwidth damper	0.5	0.5	1.5	1.5	1.0				**5.0**
Existing damper power upgrade (power + LL)		0.5	1.0	1.0	0.5				**3.0**
Existing damper removal to LSS3		1.0	1.0						**2.0**
RF 200 MHz upgrade	2.0	3.0	4.0	5.0	5.0	5.0	3.0	1.0	**28.0**
ecloud mitigation: aC coating (in magnets)	1.0	1.5	3.0	1.5	1.5	2.5	3.5		**14.5**
MKE impedance reduction									***0.0***
Scraper upgrade									***0.0***
RF 800 Mhz 1 turn feedback									***0.0***
RF 200 Mhz LL control upgrade									***0.0***

Subject to detailed design studies FTE									**Total FTE**
New collimation system	1.0	2.0	2.0	3.0	10.0	11.0	4.0	3.0	**36.0**
New MKE and extraction channel upgrade	0.5	1.5	2.0	4.0	5.0	4.5	3.0	1.5	**22.0**
Beam dump upgrade	0.5	1.5	3.0	5.0	6.0	6.0	4.0	2.0	**28.0**
TL protection upgrade		1.0	1.0	2.0	2.5	2.5	2.0	1.0	**12.0**

Variants FTE									**Total FTE**
ecloud mitigation: aC coating (remove chambers)	1.5	3.0	5.5	3.0	3.5	4.5	7.0		**28.0**

Totals									**Total FTE**
Yearly total (baseline without "studied options")	8.0	16.2	16.3	15.0	13.5	13.0	8.0	3.0	**93.0**
Yearly total (baseline + "studied" options)	8.0	16.2	24.3	29.0	37.0	37.0	21.0	10.5	**183.0**
Yearly total (baseline + remove chambers + "studied" options)	8.5	17.7	26.8	30.5	39.0	39.0	24.5	10.5	**196.5**

Manpower

Key activities in Long Shutdown 1 (2013)

- aC coating of 1 full SPS sextant: Sextant_n
  - 3.0 FTE (1 TE/VSC, 2 TE/MSC) plus transport, FSU
- Modification of MKDVs (impedance): LSS1
  - 1.0 FTE (TE/ABT) plus punctual transport, VSC, plus FSU,
- Relocate/upgrade of transverse damper and PUs: LSS2 & LSS3
  - 1.0 FTE (BE/RF) plus transport, VSC, plus FSU
- Preparation for RF 200 MHz upgrade: LSS3
  - 4.0 FTE (2.5 BE/RF, 1.5 GS & EN) plus FSU
- BLM and MOPOS upgrades (electronics): full ring
  - 2.0 FTE (BI) plus FSU

Preliminary numbers!

Key activities in Long Shutdown 2 (2017)

- aC coating of 4 full SPS sextants: ???
- RF 200 MHz upgrade: LSS3

- Potential activities
  - New beam dump system: LSS1
  - New fast extraction channels: LSS4/LSS6

- All very “heavy” activities and resource intensive

- Min. 6 month shutdown imposed by LSS3 200 MHz work alone

(mostly) Technical issues to address

- ecloud - aC feasibility questions to be answered in 2011
  - Explanation for dynamic pressure rise, if ecloud is being suppressed
  - Confidence in lifetime, handling etc.
  - Need for coating quadrupoles, LSS, SSS, ...?
  - Definition of other precautions (extra sectorisation, ...)
- ecloud - clearing electrodes development
  - No resources to develop a prototype before end 2011
  - Check impedance and aperture implications of possible options
- Beam induced heating/outgassing of components
  - Limitation for high duty factor MD/LHC filling cycles
  - Complete MKE serigraphy should help (but new MKE4 limited 25 ns...)
  - Review general impedance reduction effort (kickers, other elements, ...)
- Existing 200 MHz LL/PA/ECA upgrades/consolidation
  - Careful coordination with 200 MHz rearrangement
- Transverse damper upgrade/relocation
  - Careful coordination with 200 MHz rearrangement

(mostly) Technical issues to address

- Beam instrumentation
  - Specifications for upgrades (dynamic ranges, bunch by bunch, presently foreseen upgrades/new instruments, LIU requirements)
  - Half-day review of LIU requirements with BI plus experts (31/3/11)
- Dump limitations for MDs
  - Outgassing of TIDVG affecting MKP (was solved for CNGS)
  - Dumping beams at 37-105 GeV impossible – strong motivation for LIU?
  - Check workarounds for all cases: impacts dump upgrade requirements
- Beam losses
  - Quantify level where 'general' beam loss become intolerable (RP, equipment lifetime, extracted intensity, …)
  - Decide whether need dedicated collimation to localize losses, or if can combine collimation with new scraper system
- Exit windows and TEDs
  - Intensity/transverse emittance limits to be defined (I, ε)

MD for 2011

- 434 h maximum available (floating + dedicated)
  - Total SPS MD requests to date ~336 h
  - LIU-SPS MD requests ~204 h
- Beam dynamics and beam quality
  - Re-establish low loss nominal 25 ns, measurements for ecloud
  - Low γ_t studies – feasibility, multibunch, RF limits, working point,...
  - Limitations of above nominal intensity beams
  - Transverse emittance preservation
  - Electron cloud dependence on bunch current and emittances
  - Impedance identification + reference measurements
  - TMCI threshold in double RF system and multibunch behaviour
  - Double RF system (stability and emittance blowup) with nominal LHC beam
- ecloud
  - Measure / estimate accumulation of surviving electrons
  - Tests for wideband feedback against electron cloud instabilities or TMCI
- Beam instrumentation
  - Wire scanners: cross calibrations and improvements
  - Fast BCT: bandwidth and filling patterns/intensity effects
  - BGI (transverse) and BSRT (longitudinal) testing
  - LHC BPMs: improved optics measurements
  - Headtail monitor attenuator improvements

Key 2011 LIU-SPS activities

- 200 MHz upgrade: launch work
  - Internal review - finished
  - Civil engineering studies - launched
  - Amplifier studies and prototyping - started
- eClound: prepare for aC coating in TS (2 half-cells)
  - Industrialisation of aC - continuing
  - Decide on quadrupoles, pumping ports, other elements (simulation)
- Kicker impedance reduction: continue
  - Preparation (serigraphy) of 2 of final 3 MKE - in progress
  - Impedance calculations and benefit analysis
- Wideband feedback: continue
  - Studies, design report (LARP)
- Existing transverse feedback upgrade: launch work
  - Requirements to define
- BI upgrades: launch work
  - Requirements - defined
  - Specifications to finalise with BI group and experts
- Design studies: launch work
  - Start scraper/collimation, beam dump, transfer line protection, new MKE/extraction
- 2011 MD
  - Studies and priorities - defined
  - Studies to make (time allocation!)
- Other operational limitations
  - Review and make sure all are being addressed

Conclusions

- Outline planning developed for LIU-SPS project duration
  - Busy program for LIU-SPS and related consolidation activities until 2018
  - Some design studies will lead to decisions on major options
  - Other factors (low gamma_t optics, ...) may change some items
- LIU-SPS and related Consolidation activities checked for double-accounting and missing items
- Co-existence with all consolidation work to plan and manage carefully
  - Shutdown planning a key aspect
  - Possible bottlenecks like transport to investigate
- Main LS1 and LS2 activities defined
  - Some changes inevitable as progress/delays/design choices occur
  - Items with possible impact on other work identified – details to plan
- Shared planning (time, resources) needed across all machines