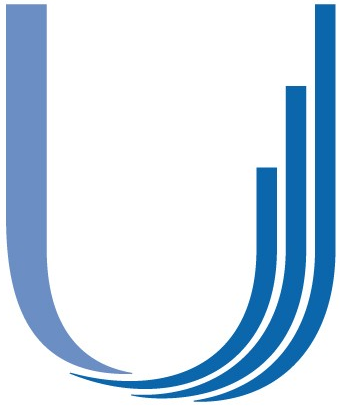
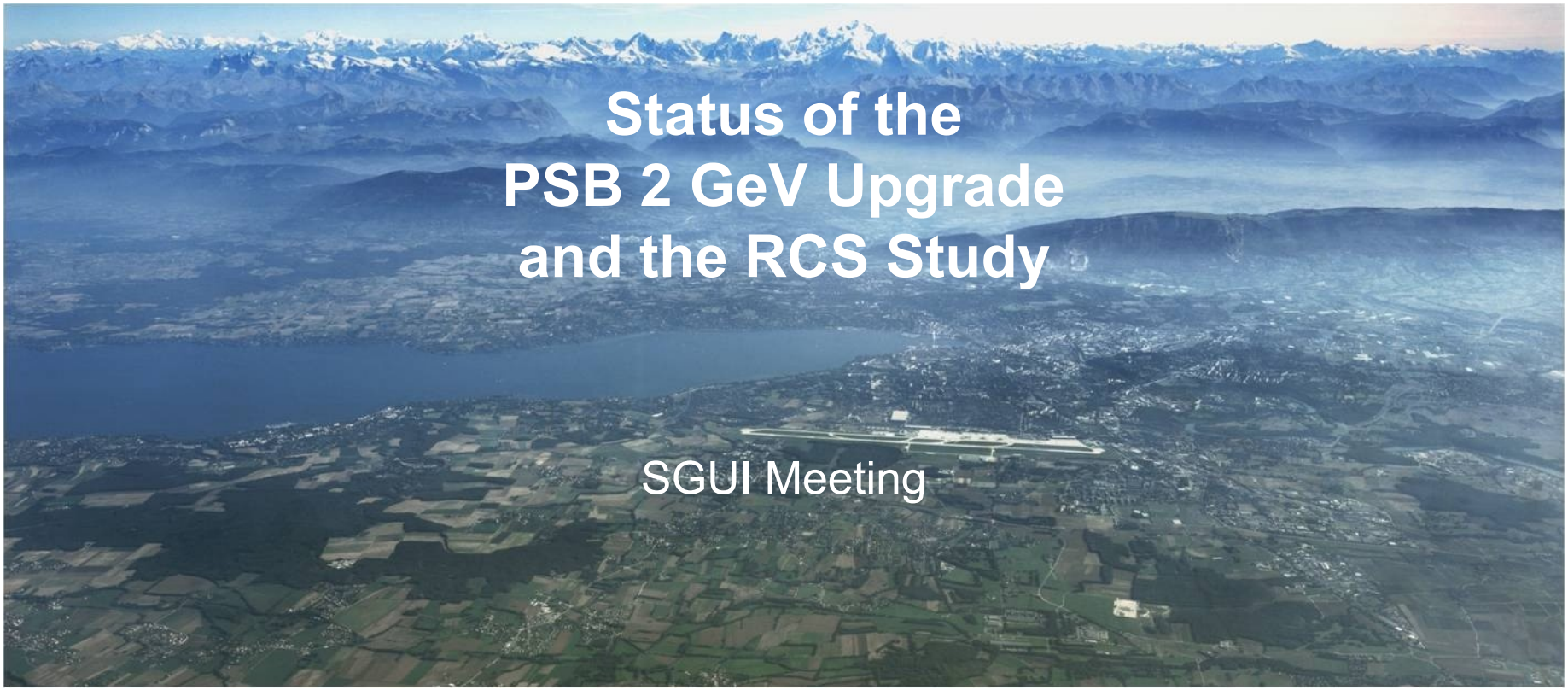


LHC Injectors Upgrade

LHC Injectors Upgrade



Status of the PSB 2 GeV Upgrade and the RCS Study

SGUI Meeting

B. Mikulec, 07 July 2011

CERN

Context

As a follow-up of the Chamonix 2010 workshop, a study of an **Energy Upgrade of the PSB** was initiated.

- Feasibility report released in September 2010.

Also at Chamonix 2010, the idea of a **Rapid Cycling Synchrotron (RCS)** was already presented by C. Carli, but it was only after the 2011 Chamonix workshop that a feasibility study was requested by the management.

- A first draft of this study was circulated internally 1 week ago for first comments.
- An RCS would replace the PSB.

PSB Energy Upgrade

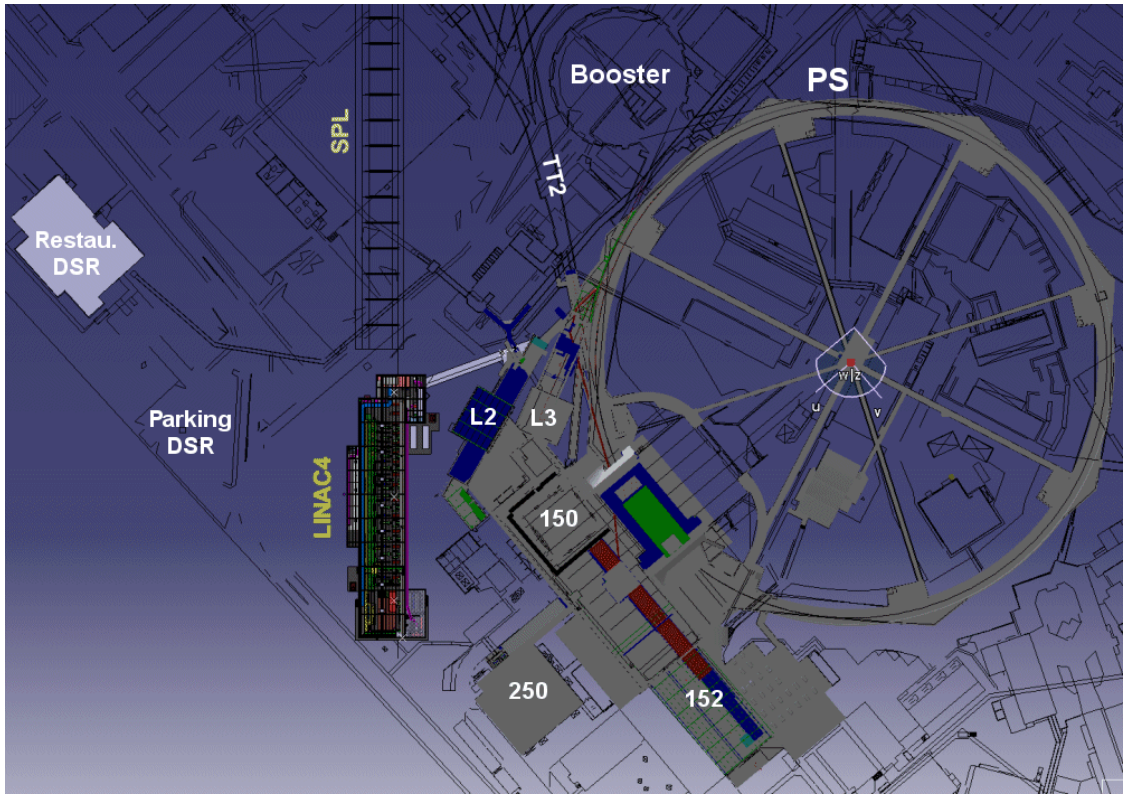
https://twiki.cern.ch/twiki/bin/view/PSBUpgrade/PSBUpgradeMainWebEnergyUpgrade

towards ISOLDE…

Goals of the 2 GeV Upgrade:

- Reduce space charge effects at PS injection (bottleneck for ultimate LHC beams)
- Use consolidation effort for performance increase

Pre-requisite: Linac4 injection



PSB Energy Upgrade – Main Parameters

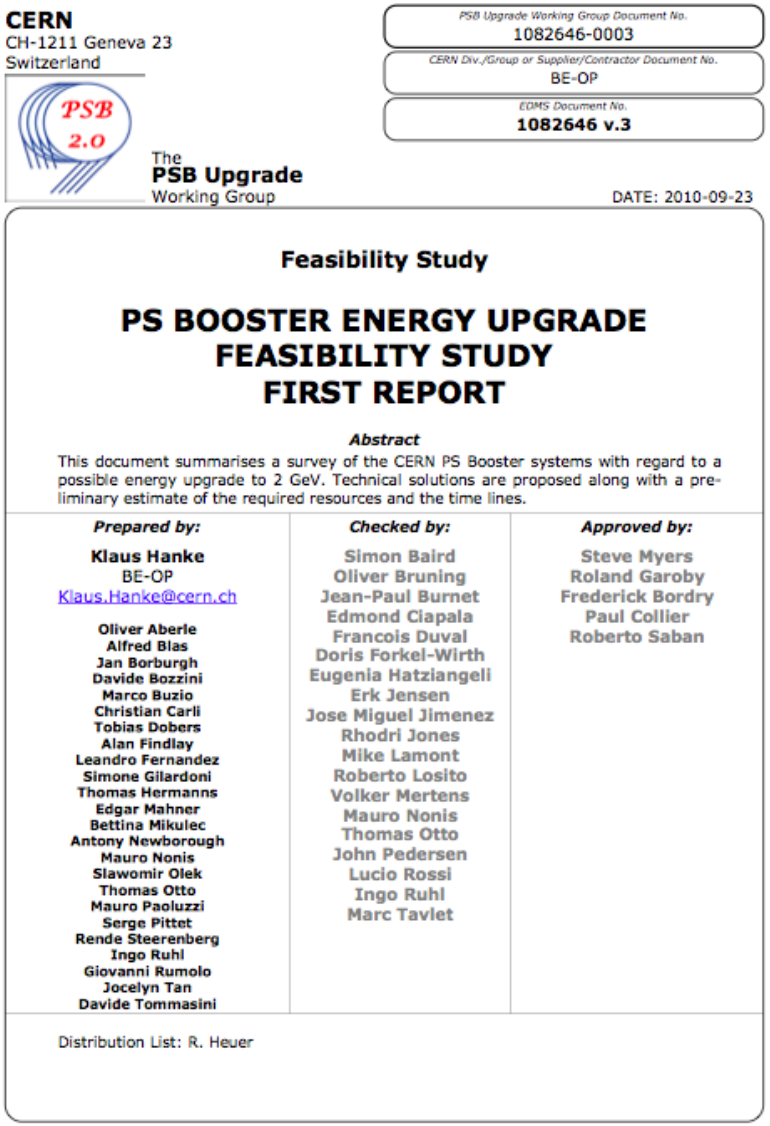
PSB Energy Upgrade – main characteristics	
Injection Energy	160 MeV
Extraction Energy	1/1.4 GeV (ISOLDE) / 2 GeV (other beams)
Revolution Frequency	~1 – 1.81 MHz
Basic Cycle Length	1.2s
Harmonics	1, 2, 1+2
Max. intensity / ring	1.4E13 p (or maybe more)

PSB @ 2 GeV: Main Modifications

In order of cost (for LIU or consolidation)…

- New MPS (POPS-type like in PS): cost driver, ~15 MCHF
  - Includes civil engineering (new building to house the MPS)
- RF consolidation is mandatory (main limit: C04 system)
  - Idea: replacement of C02/C04 cavities with Finemet wide-band cavities
- Exchange of certain power converters
  - Mainly in transfer line and for PS injection
- Beam transfer
  - Kickers/septa at extraction/recombination PS injection
- Cooling and ventilation
  - Replacement of cooling station and piping, upgrade ventilation
- Magnets
  - Upgrade cooling system+shimming of main magnets, replacement of transfer line magnets and PS injection+low-energy correction magnets
- Electrical systems
- Intercepting devices, transport, beam instrumentation, vacuum etc.

PSB Energy Upgrade Study – Status



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The **PSB Upgrade** Working Group

PSB Upgrade Working Group Document No.
1082646-0003
CERN Div./Group or Supplier/Contractor Document No.
BE-OP
EDMS Document No.
1082646 v.3

DATE: 2010-09-23

Feasibility Study

PS BOOSTER ENERGY UPGRADE FEASIBILITY STUDY FIRST REPORT

Abstract

This document summarises a survey of the CERN PS Booster systems with regard to a possible energy upgrade to 2 GeV. Technical solutions are proposed along with a preliminary estimate of the required resources and the time lines.

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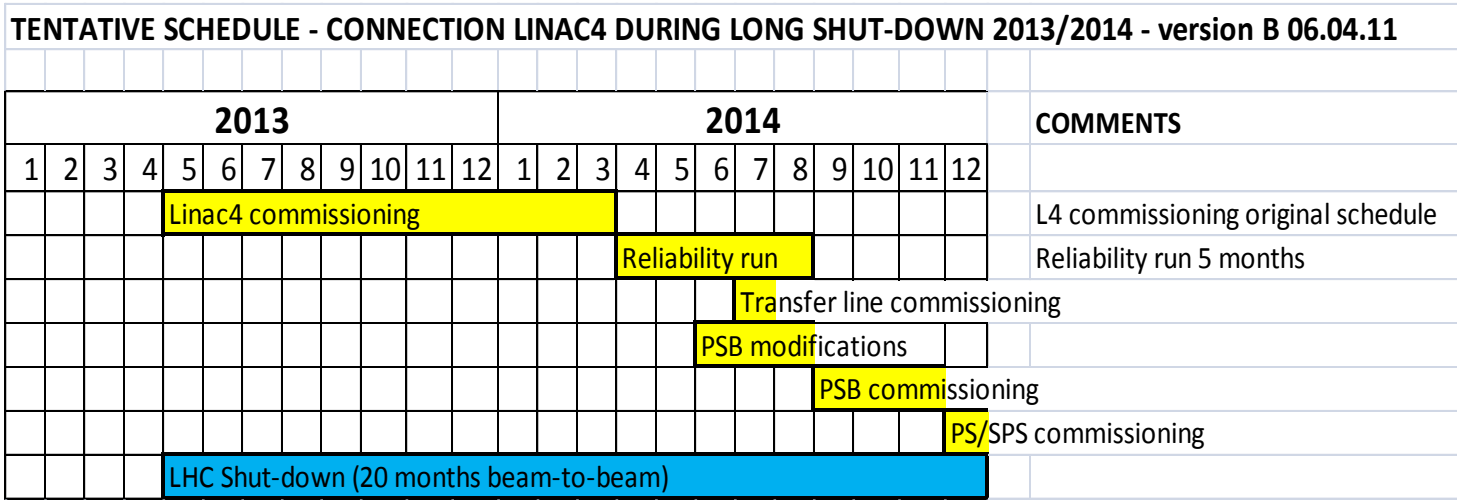
Distribution List: R. Heuer

- Feasibility report published
  - Detailed study of required modifications
  - Timelines and budget estimate
- Study currently frozen
- Waiting for management/council decision for PSB Upgrade or RCS, something else or no upgrade
- If accepted end of this year, could be done in LS2

Potential Linac4 Connection to PSB in LS1

- Recommended by the LIU Project Management only in case LS1 starts in May 2013 (not December 2012); LS1 duration: 20 months.



RCS

https://twiki.cern.ch/twiki/bin/view/PSBUpgrade/PSBUpgradeMainWebEnergyUpgrade

RCS underlying design constraints:

- Match the performance of one PSB ring at 2 GeV for LHC with Linac4 as injector
- Keep the cost within limits…

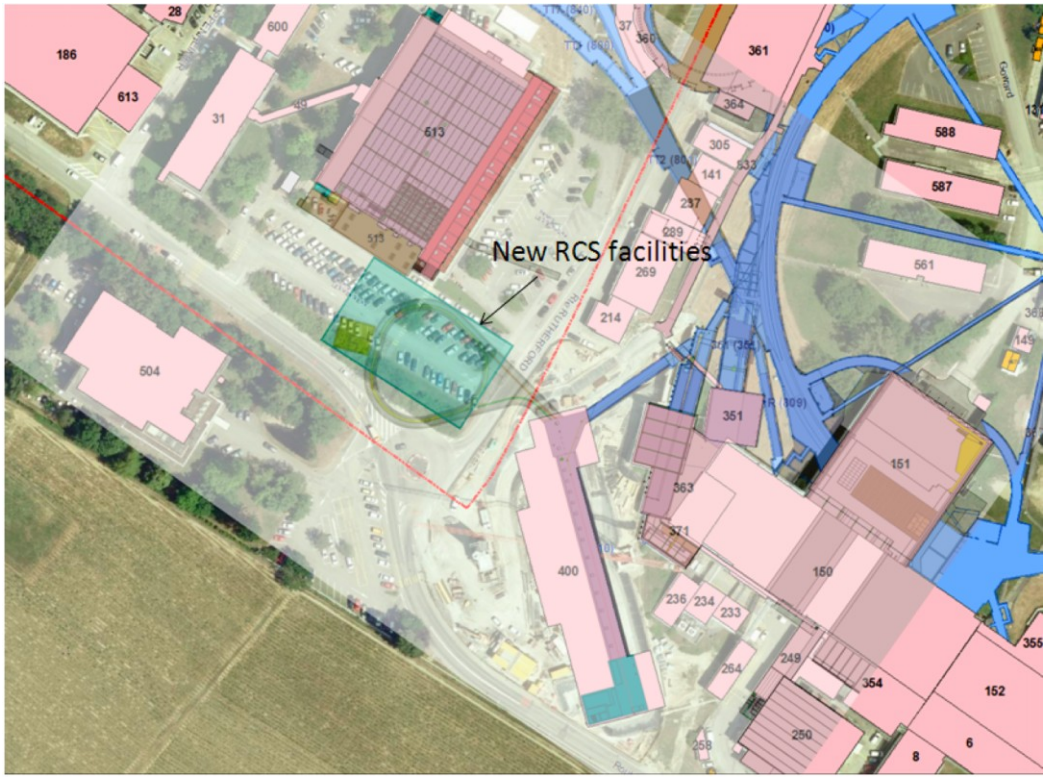
Advantages on first sight:

- New machine
- Faster cycling, therefore potential gain for certain beams/users

But: there are also certain disadvantages

- Initial cost estimate suggests at least twice that of the PSB 2 GeV Upgrade + consolidation
- Operational and beam dynamics issues in PSB and PS
- Scheduling

RCS – Civil Engineering Proposal



- Original proposal for location inside PS ring not practicable
- Implantation planned under the car park beside the computer center ~13 m below ground plus surface building with access shaft

RCS – Main Parameters

RCS – main characteristics	
Circumference	119.68 m (4/21 of PS circumference)
Injection Energy	160 MeV
Extraction Energy	2 GeV (all beams); ISOLDE?
Revolution Frequency	1.3 – 2.4 MHz
Cycling Rate	10 Hz
Harmonics	1, 2, 2+1, 2+4, 4(?)
Max. intensity / pulse	1E13 p

RCS – Preliminary Design

- 3-fold structure: 1 straight section for injection, 1 for RF and 1 for extraction
- Linac4 H^- charge-exchange injection, transverse and longitudinal painting
- Whole acceleration cycle within 50 ms
- Leaves very little time for beam manipulation (transverse and in particular longitudinal blow-up)
- Magnet aperture is a problem with required high magnetic fields; magnet design is challenging
- Lattice design proposed, but far from being frozen
- Extraction to measurement/dump line or to long transfer line towards PS and ISOLDE (using already existing tunnels and passing through PSB zone)

RCS – Remarks and Challenges

① Upgrade of Linac4 for faster cycling (10 Hz instead of 1.11 Hz)

② Injection and Extraction: very tight space

- Chicane bump, H^- stripping and painting bump (3x4 magnets)
- For extraction need kicker rise-time of 40 ns (for potential h=4 operation)

③ Lattice: current baseline 21 cells (5 per arc and 2 per straight section)

- FODO with space for additional equipment (steerers, beam instrumentation etc.) only between QFs and bends (~55 cm)
- γ- transition: 3.6, max. β_x: 8.73 m, max. β_y: 12.06 m, max. dispersion 3.73 m
- ISOLDE beams most challenging for aperture considerations

④ RF: Wide-band Finemet cavities at 60 kV total rf voltage

⑤ Magnets: field of up to 1.3 T (bends) to be achieved with thin lamination of grain orientated high silicon content steel

⑥ MPS: POPS-type for max. flexibility and ppm operation (including 'off' cycles)

⑦ Transfer lines to PS and ISOLDE: full upgrade needed for 2 GeV@10 Hz plus additional shielding at certain locations

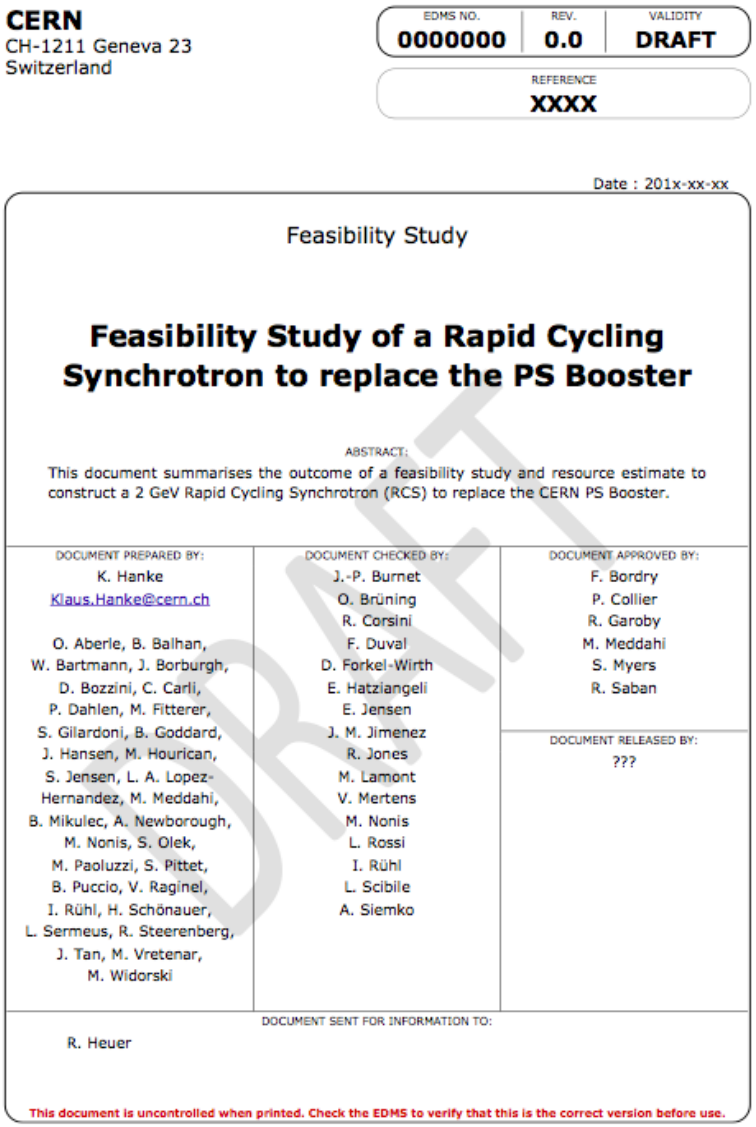
ISOLDE Beam Production with the RCS

- Injection at h=1+2 on a ramp with transverse and longitudinal painting to minimize space charge effects at injection
- Extract 1 bunch at max. 1E13 p
- Can receive several subsequent shots every 100 ms (depending on need and supercycle)
  - Better beam power distribution over time
  - In average increased proton delivery for HIE-ISOLDE

Potential issue for HIE-ISOLDE:

- In case HIE-ISOLDE would request also 1.4 GeV extraction energy, increase of transfer line cost by several MCHF for ppm operation – who would cover the cost?

RCS Study – Status



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REFERENCE
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Date : 201x-xx-xx

Feasibility Study

Feasibility Study of a Rapid Cycling Synchrotron to replace the PS Booster

ABSTRACT:
This document summarises the outcome of a feasibility study and resource estimate to construct a 2 GeV Rapid Cycling Synchrotron (RCS) to replace the CERN PS Booster.

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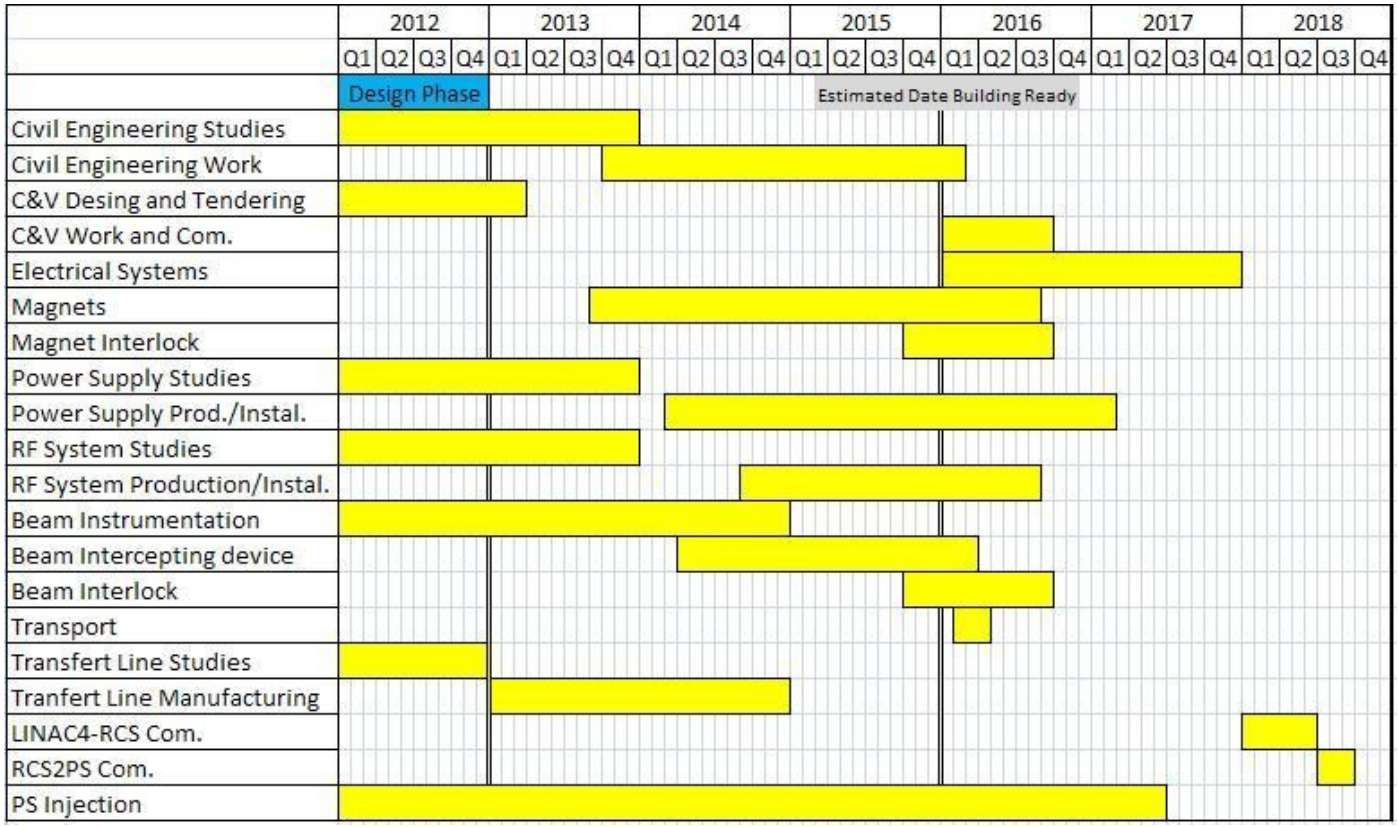
- First draft of feasibility report under discussion
  - Preliminary RCS layout
  - Feasible, but need to still work out many details (lattice, magnets, rf, operational parameters, transfer lines etc.)
  - Rough timelines and budget estimate
- Waiting for management/council decision for PSB Upgrade or RCS
- If accepted in principle, the study will have to be refined
- Not clear if the RCS connection could be done during LS2 (with current planning beam not available before end of 2018)

RCS – Draft Planning



Potentially first beam end of 2018…

Summary

- 2 GeV PS injector upgrade is required for LHC ultimate beams
- Detailed study of PSB 2 GeV Upgrade available; can be achieved during LS2
- Draft feasibility study for RCS end of July; if all goes well, might just be possible to commission end of LS2
- HIE-ISOLDE would profit both from PSB 2 GeV Upgrade + Linac4 and from an RCS (main gain of 2 GeV for unstable isotope beams after T. Stora; additional gain through increased intensity or repetition rate)
- Management decision hopefully this autumn

Further studies awaited from HIE-ISOLDE:

- Conclusion on advantages/disadvantages for targets in both scenarios
- In case of the RCS: could HIE-ISOLDE drop the 1.4 GeV beams?
- Upgrade of BTY line for 2 GeV – what needs to be changed? (including shielding)