Introduction

Project Management

Anticipated Performance Goals

Planning

Summary
Goals & Means

Mandate
“The LHC Injectors Upgrade should plan for delivering reliably to the LHC the beams required for reaching the goals of the HL-LHC. This includes LINAC4, the PS booster, the PS, the SPS, as well as the heavy ion chain…”

Implementation
The LIU Project will:
- Analyze the status of the injectors and the HL-LHC requirements,
- Propose an upgrade path for the injectors, exploiting the work done by the Task Forces on the „PSB energy upgrade“ and „SPS upgrade“ and by the Working Group on the SPS upgrade,
- Organize the upgrades (WBS with resources and planning) and take care of their implementation,
- Take care of hardware and beam commissioning.
Basic Principles

To increase performance (soon extended for heavy ions)

- Brightness $\uparrow$

- Increase injection energy in the PSB from 50 to 160 MeV, Linac4 (160 MeV $\text{H}$) to replace Linac2 (50 MeV $\text{H}^+$)

- Increase injection energy in the PS from 1.4 to 2 GeV, increasing the field in the PSB magnets, replacing power supply and changing transfer equipment

- Upgrade the PSB, PS and SPS to make them capable to accelerate and manipulate a higher brightness beam (feedbacks, cures against electron clouds, hardware modifications to reduce impedance…)

To increase reliability and lifetime (until ~2030!)
(tightly interleaved with consolidation)

- Upgrade/replace ageing equipment (power supplies, magnets, RF…)

- Procure spares

- Improve radioprotection measures (shielding, ventilation…)

Baseline Upgrade Actions

- Construction of LINAC4

- Upgrades of PSB, PS and SPS

+ Consolidation...

«Typical» list of Work Units

All equipment and service groups are involved!
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LIU Project Mandate (continued)

... The project co-ordinator will have the responsibility for the project management (WBS, technical co-ordination and integration, manpower and budget agreement with the departments as well as budget and timescale control). They will report on a regular basis to the Director of Accelerators and Technology. The executive role for manpower and budget for the projects/studies remains with the technical groups in the departments.

LIU Project Planning and Costing

1. Project / Product Breakdown Structure
2. Work Breakdown Structure
3. Organization Breakdown Structure
4. Resource Breakdown Structure
5. Resource Responsibility Matrix
6. Work Unit Dictionary
7. Project Gantt Chart :-)

Source: Project Management case study
– P. Bonnal, M. Meddahi
Project Organization Breakdown Structure

LIU Project team

Roland Garoby (Project Leader) - Malika Meddahi (Deputy) - Brennan Goddard (LIU-SPS machine coordinator) - Simone Gilardoni (LIU-PS machine coordinator) - Klaus Hanke (LIU-PSB machine coordinator) - Maurizio Vretenar (Linac4 Project Leader) - Laurette Ponce (Project Safety Officer) - Django Manglunki (LIU-Ion chain coordinator)

LIU-PSB coordination team
K. Hanke – Activity leader
B. Mikulec – Deputy
V. Raginel – Scientific secretary
https://espace.cern.ch/liu-project/liu-psb/

LIU-PS coordination team
S. Gilardoni – Activity Leader
H. Damerau – Deputy and Scientific secretary
https://espace.cern.ch/liu-project/liu-ps/

LIU-SPS coordination team
B. Goddard
E. Shaposhnikova – Deputy
G. Rumulo – Scientific secretary
https://espace.cern.ch/liu-project/liu-sps/default.aspx

LIU-Project Safety coordination
L. Ponce

Linac4 Project
M. Vretenar
http://linac4-project.web.cern.ch/linac4-project/

Templates and document handling and lifetime

![Image of EDMS portal]

**Quality Control**

[https://edms.cern.ch/](https://edms.cern.ch/) - by EDMS team and Project Support Office
# Work Breakdown Structure

| LIU Work Breakdown Structure |  |
|------------------------------|  |
| **1** | LIU project | Roland Garoby |
| LIU 1 | 62011 | Management activities (EVM, APT, MTP, EDMS...) | Roland Garoby - Malika Meddahi |
| LIU 2 | | General planning | Roland Garoby - Malika Meddahi |
| LIU 3 | | Safety | Laurette Ponce |
| LIU 4 | | Quality assurance | Roland Garoby - Malika Meddahi |
| LIU 5 | | Design office-Fabrication-Subcontracting-Materials (EN-MME) | Serge Mathot |
| LIU 6 | | Integration | Yvon Muttoni |
| LIU 7 | | Project team meetings | Cecile Noels |
| LIU 8 | 62011 | Reviews - Conferences | Cecile Noels |
| **2** | LIU-PSB | Klaus Hanke |
| LIU-PSB 1 | | Management | Klaus Hanke |
| LIU-PSB 2 | | PSB Beam dynamics | Christian Carli |
| LIU-PSB 3 | | Magnets | Antony Newborough |
| LIU-PSB 4 | | RF systems | Alan Findlay |
| LIU-PSB 5 | | Power Convertors | David Nisbet - Serge Pittet |
| LIU-PSB 6 | | Beam instrumentation | Jocelyn Tan |
| LIU-PSB 7 | | Beam Intercepting Devices | Oliver Aberle - Alternate Alessandro Masi |
| LIU-PSB 8 | | Vacuum System | Jan Hansen |
| LIU-PSB 9 | | LINAC4 to PSB transfer line and PSB injection systems | Christian Carli - Wim Waterings |
| LIU-PSB 10 | | PSB Extraction system and PSB-PS transfer line | Wolfgang Bartmann - Jan Borburgh |
| LIU-PSB 11 | | Controls | Steen Jensen |
| LIU-PSB 12 | | Electrical Systems | Davide Bozzini, Slawomir Olek |
| LIU-PSB 13 | | Cooling and Ventilation | Mauro Nonis |
| LIU-PSB 14 | | Installation, Transport and handling | Ingo Rühl |
| LIU-PSB 15 | | Civil Engineering | Luz Anastasia Lopez-Hernandez |
| LIU-PSB 16 | | Radiation Protection | Joachim Voltaire |
| LIU-PSB 17 | | Machine Interlocks | Bruno Puccio |
| LIU-PSB 18 | | Alarms | |
| LIU-PSB 19 | | Access Systems - Doors | |
| LIU-PSB 20 | | Survey | |
| LIU-PSB 21 | | Commissioning and Operation | |
| LIU-PSB 22 | | Dismantling | |

**3** LIU-PS

**4** LIU-SPS

- Simone Gilardoni
- Brennan Goddard
WUs dictionary defined for all LIU machines - resources, schedule and deliverables
• Introduction
• Project Management
• **Anticipated Performance Goals**
• Planning
• Summary
Basic assumptions

- Beam parameters are given at injection in LHC: beam loss and blow-up inside the LHC are not accounted for.

- All necessary improvements are implemented in the injectors (Linac4, PSB to PS transfer at 2 GeV, coupled bunch instabilities suppressed, e-cloud suppressed, hardware upgraded...)

- Estimated beam degradation in the accelerator chain (based on observations in 2010):
  - PS: 5% beam loss, 5% transverse blow-up
  - SPS: 10% beam loss, 5% transverse blow-up.

- RF gymnastics being kept, imperfections are unchanged:
  - +10% fluctuation of all bunch parameters within a given PS bunch train.
  - Traces of ghost/satellite bunches.
Beam parameters at LHC injection [50 ns]

Nominal performance

Today (2011)

HL-LHC requirement at 7 TeV

Anticipated performance after LIU

SPS single bunch limit

Constant transverse density (Space charge)

Bunch intensity within constant longitudinal emittance [$x10^{11}$ p/b]
Beam parameters at LHC injection [25 ns]

- **Nominal performance**
- **Today (2011)**
- **Anticipated performance after LIU**
- **HL-LHC requirement at 7 TeV**

*Constant transverse density (Space charge)*

**SPS single bunch limit**

Bunch intensity within constant longitudinal emittance [$10^{11}$ p/b]
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Comments

LIU performance goals in terms of beam characteristics at injection in the LHC have to meet the needs of HL-LHC and to be feasible... Subject of active interactions between HL-LHC and LIU teams (2nd joint «Brainstorming» session on January 24, 2012).

MDs until the end of 2012 will help refine the knowledge and understanding of the injectors and check the potential of upgrades.

End 2012/beginning 2013, the performance goals of the LIU project will be specified and the precise list of hardware modifications with their specifications will be issued.
<table>
<thead>
<tr>
<th>Year Range</th>
<th>Linac4</th>
<th>PS injector, PS and SPS</th>
<th>Beam characteristics at LHC injection</th>
</tr>
</thead>
</table>
| 2011 - 2012 | Continuation of construction... | • Beam studies § simulations  
• Investigation of RCS option  
• Hardware prototyping  
• Test of new beam gymnastics  
• Design § construction of equipment  
• TDR | 25 ns, $1.2 \times 10^{11}$ p/b, $\sim 3$ mm.mrad  
50 ns, $1.7 \times 10^{11}$ p/b, $\sim 2$ mm.mrad |
| 2013 – 2014 (Long Shutdown 1) | • Linac4 beam commissioning | • Modifications and installation of some prototypes in PSB, PS and SPS  
• Design § construction of equipment | |
| 2015 - 2017 | • Progressive increase of Linac4 beam current | • Implementation of new PS beam gymnastics...  
• PSB modification and connection to Linac4 during extended winter shutdown  
• If/when Linac4 connected: progressive increase of PSB brightness with benefits for PS and SPS.  
• Equipment design § construction for PSB, PS and SPS  
• Beam studies | • Possibly smaller emittance (25 ns) with new PS beam gymnastics...  
• Limited gain from Linac4 proper (pending PSB, PS and SPS hardware upgrades) |
| 2018 (Long Shutdown 2) | | • Extensive installations in PSB, PS and SPS  
• Hardware commissioning | |
| 2019 –2021 | | • Beam commissioning | After ~1 year of operation: beam characteristics for HL-LHC... |
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**Summary**

- The goal of the LIU project is to make the LHC injector complex capable to **reliably** deliver the **higher performance proton and ion beams** required for High Luminosity in LHC until later than 2030.

- Performance for other users will at least be preserved and generally benefit (e.g. high intensity).

- More MDs will take place in 2012 to finalize the hardware modifications and their precise specifications.

- The implementation of hardware modifications will finish during LS2.

All equipment and service groups are concerned!
THANK YOU 
FOR YOUR ATTENTION!
Why is today’s beam better than nominal?

*Simple*! *No more blow-up along the accelerators cascade*...

- **PSB:**
  - Improved (achromatic) optics in the Linac2 to PSB transfer line since 2005

- **PS:**
  - Injection trajectories
  - Working point along the whole cycle
  - Transition

- **PS to SPS:**
  - Transverse matching with better optics in TT2-TT10

**WARNING: NO MARGIN LEFT!**