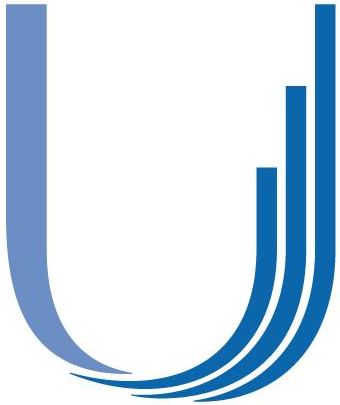


Introduction

R. Garoby

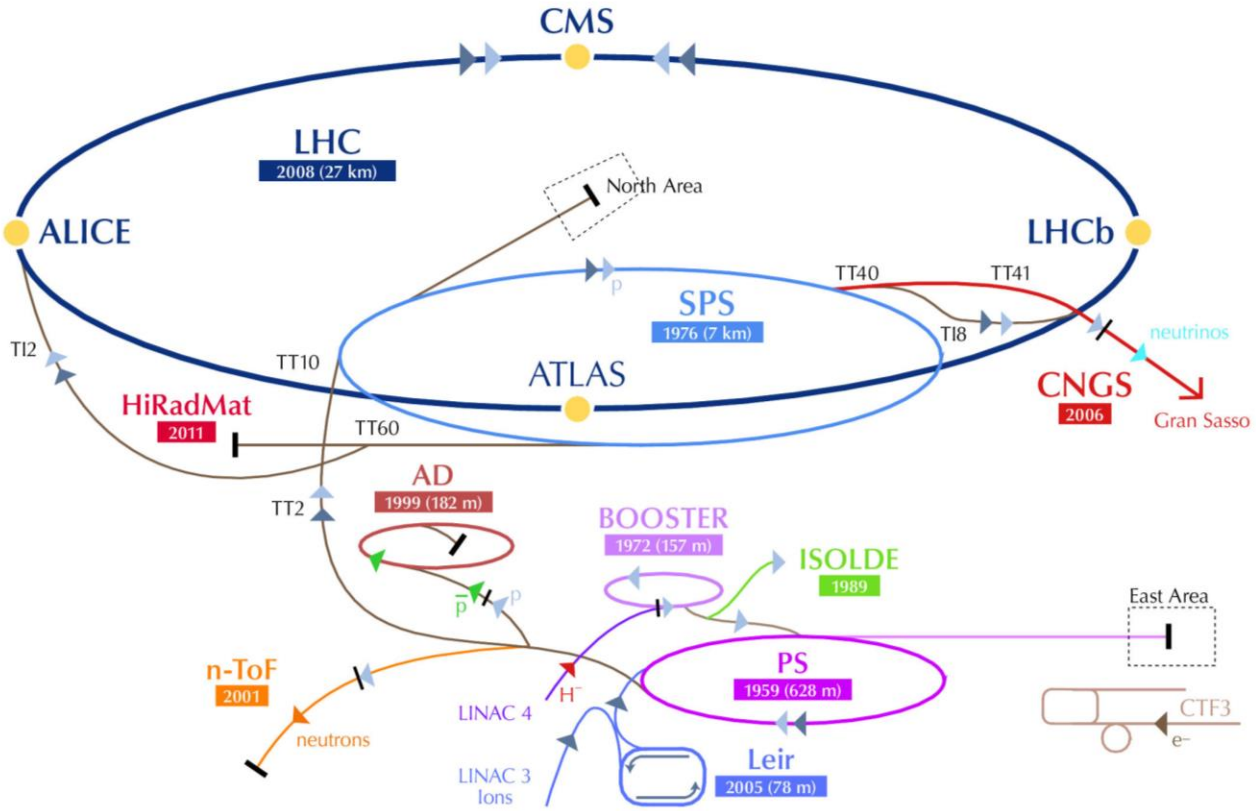
LIU summary

- LIU Highlights in 2013
- Outcome of the «Review of LHC and Injectors Upgrade Plans» (Oct.2013)
- «New» schedule for LHC and injectors
- The Challenges of 2014…

LIU Project Definition

Mandate (December 2010)

"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."



Basic Principles

To increase performance

Brightness ↗

⇒ **Increase injection energy in the PSB from 50 to 160 MeV, Linac4 (160 MeV H^-) to replace Linac2 (50 MeV 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…)**

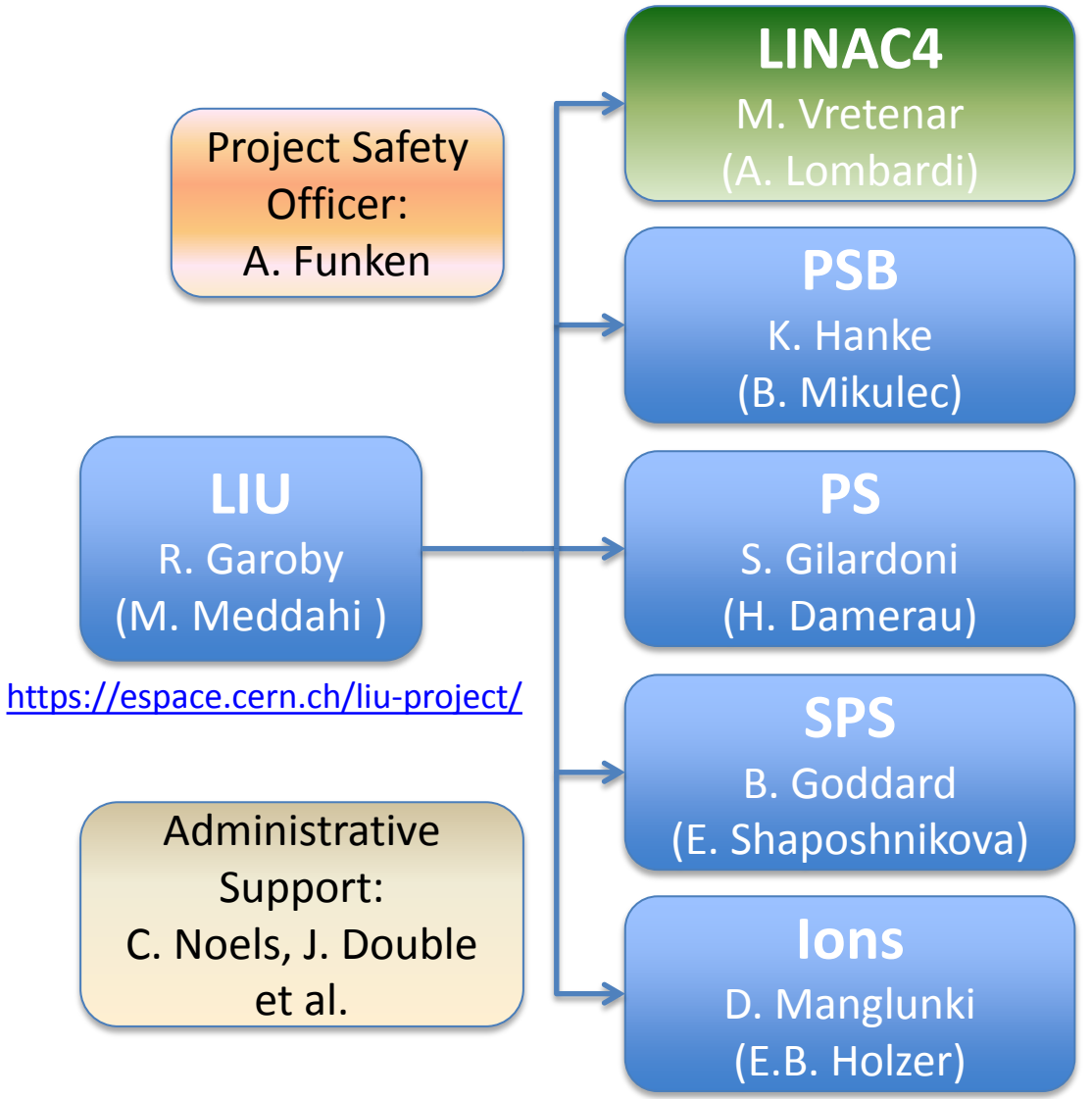
To increase reliability and lifetime (until ~2030!)
(tightly interleaved with consolidation)

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

⇒ **Procure spares**

⇒ **Improve radioprotection measures (shielding, ventilation…)**

Project Organization Chart



Linac4 Project
[http://linac4-project.web.cern.ch/linac4-project/]

LIU-PSB coordination
[https://espace.cern.ch/liu-project/liu-psb/]

LIU- PS coordination
[https://espace.cern.ch/liu-project/liu-ps/]

LIU –SPS coordination
[https://espace.cern.ch/liu-project/liu-sps/]

LIU –Ions coordination
[https://espace.cern.ch/liu-project/liu-ions/]

Overall baseline (as of April 2014) planning

	Deliverables	Proton beam characteristics at LHC injection
2013 – *mid* 2014 (Long Shutdown 1 for injectors)	• TDR, CtC and planning • Start of commissioning of Linac4 • Exploitation of MDs and simulations • Modifications and installation of prototypes in PSB, PS and SPS • Design § construction of equipment	
***Mid* 2014 – mid 2018** (Run 2)	• Regular operation with BCMS • Test/validation of installed prototypes • Full commissioning & reliability run of Linac4 • Equipment design § construction for PSB, PS and SPS • Beam studies § simulation	Potential for exceeding LHC nominal luminosity (~2x) with 25 ns bunch spacing…
Mid 2018 – 2020 (Long Shutdown 2)	• Connection of Linac4 to the PSB • Extensive installations in PSB, PS and SPS • Hardware commissioning • Beam commissioning: recovery of previous beam characteristics for LHC restart	
***2020* – 2022**	• Beam commissioning : MDs and studies for improving beam characteristics • Installation of last upgrades for protons and ions during the first winter shutdown.	Before LS3: LIU «baseline» beam characteristics attained

Material budget

LIU total: Status in April 2014 (as included in MTP2014)

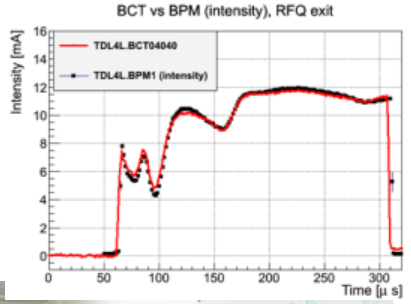
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Grand Total
LIU-MNG	62011 (M)				95	482	616	764	500	500	500	500	500	500		**4,957**
LIU-MNG	62011 (M to P)				324	1,365	1,945	1,236	1,500	1,500	1,500	1,000	500	500		**11,370**
PBU-PRJ	total	138	313	340	955	1,711	3,821	5,816	13,757	21,694	11,863	4,165	396	0		**64,969**
PBU-PRJ	Add'l Half sector test						374	535	70	0						**979**
PSU-PRJ	total				245	461	3,429	3,246	4,814	4,936	3,297	1,795	240	75	44	**22,582**
SPU-PRJ	total				504	2,126	3,450	5,856	8,712	13,583	18,308	15,085	9,168	1,075		**77,867**
LIU-ION	total							50	400	500	2,100	2,300	2,000	0		**7,350**
LIU Project Grand Total		138	313	340	2,123	6,145	13,635	17,503	29,753	42,713	37,568	24,845	12,804	2,150	44	**190,074** kCHF

- LIU summary

LIU Highlights in 2013

- Outcome of the «Review of LHC and Injectors Upgrade Plans» (Oct.2013)
- «New» schedule for LHC and injectors
- The Challenges of 2014…

Linac4: a memorable year 2013!

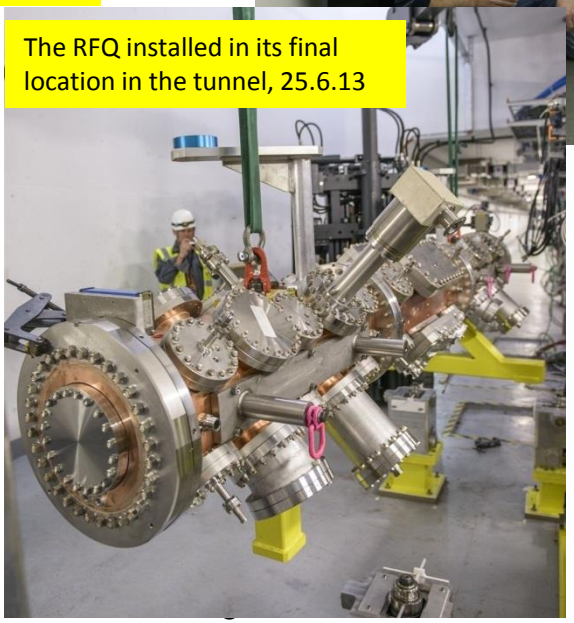


Klystrons and modulators installed in the Linac4 Hall

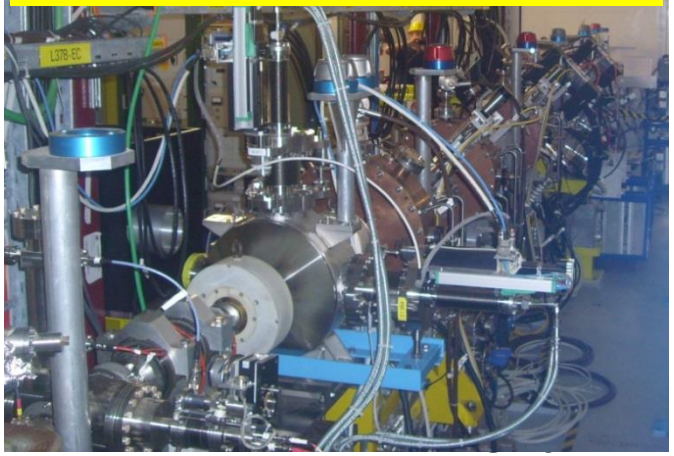
A cheering crowd celebrating the first beam accelerated by the RFQ on the Test Stand (13.3.13)

Open Days 2013: 2'500 visitors!

The RFQ installed in its final location in the tunnel, 25.6.13



7.11.2013: ready for 3 MeV beam tests in the tunnel!



R.G. – 11/04/2014

Linac4

09:50 **Linac4 commissioning overview 10'+10'** *20'*
Speaker: Alessandra Lombardi (CERN)

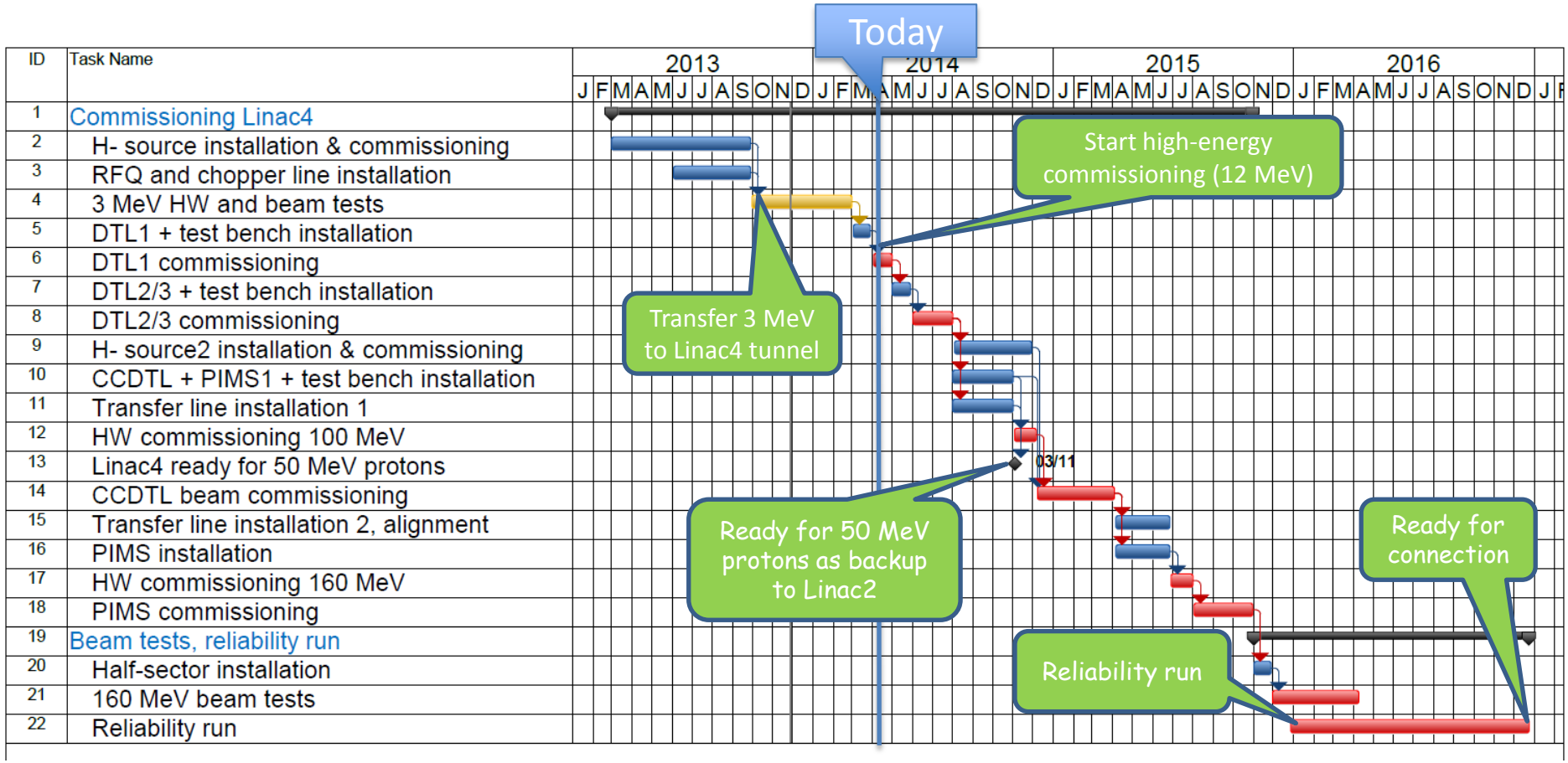
10:10 - 10:30 Coffee Break

10:30 - 12:30 Session 2

10:30 **H- ion source development programme 10'+10'** *20'*
Speaker: Jacques Lettry (CERN)

10:50 **Linac4 Drift Tube Linac 10'+10'** *20'*
Speaker: Suitbert Ramberger (CERN)

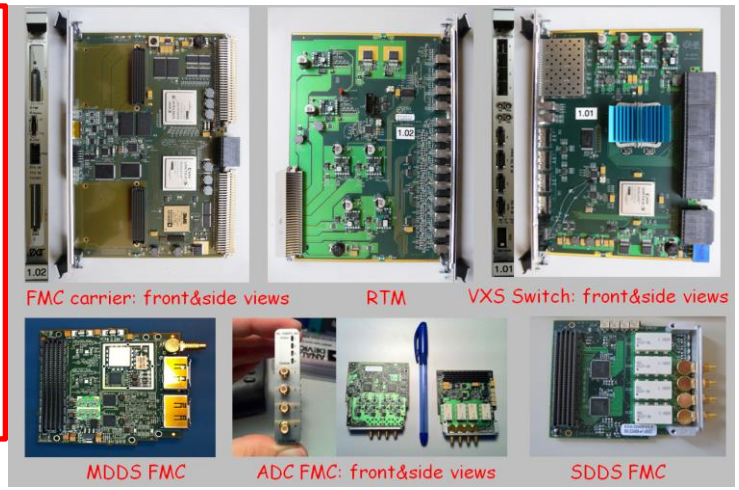
Linac4 in LIU 2014

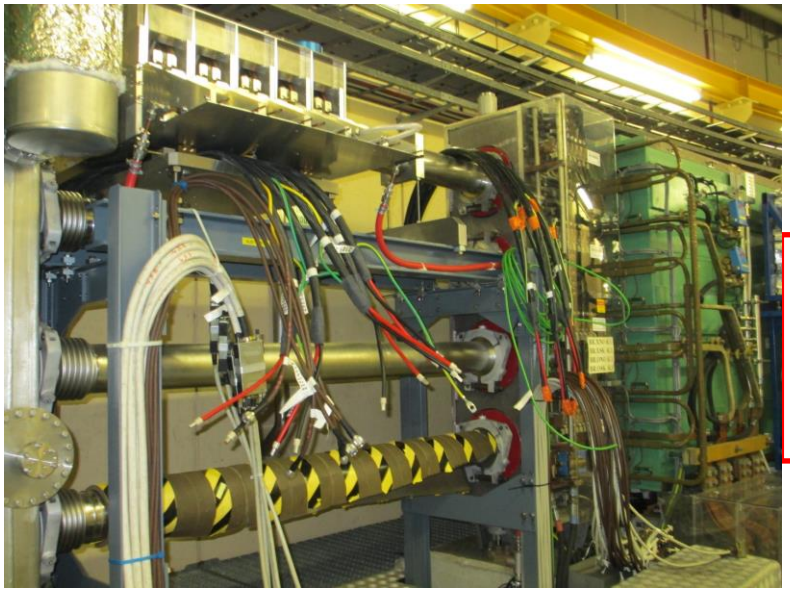


LIU-PSB: LS1 work [1/2]

Digital LLRF:

- H/w series production & validation
- Cabling done
- S/w (all levels, also application programs) to be completed by mid April 2014
- H/w installed by mid-April 2014, ready for h/w tests.
- PSB will restart with DLLRF as the operational system on 4 rings.



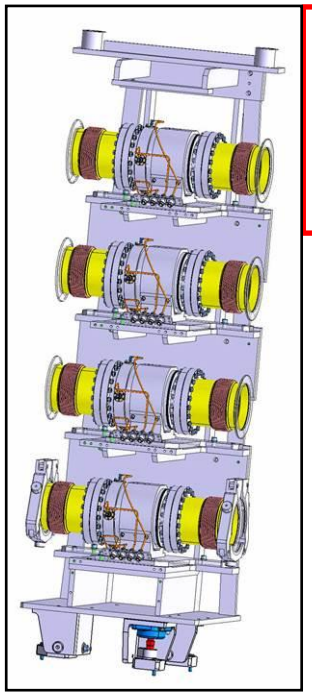


RF cavities:

- Addition of 5 Finemet cavity cells in ring 4 (cabling ready, cells to be installed before start-up)

LIU-PSB: LS1 work [2/2]

Change of PSB front-end computers

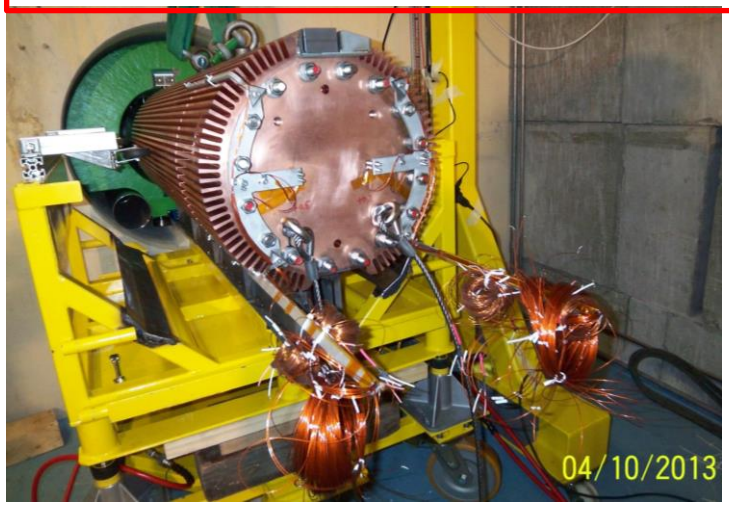


Stack of PUs in BI line

New Beam Instrumentation:

- Orbit measurement system (in // with old one)
- BLMs and cables (in // with old ones)
- BPMs in the Linac to PSB transfer line

PSB Beam dump exchange



LIU-PSB

PSB in LIU 2014

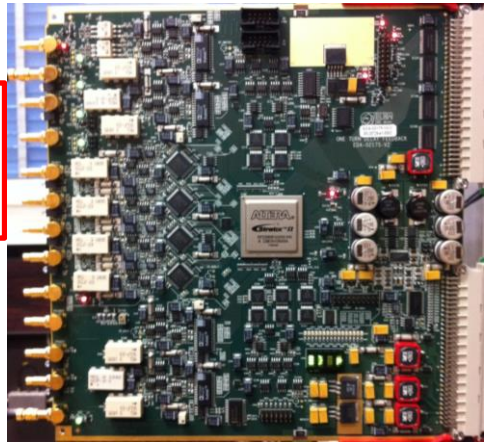
11:10	**New PSB beam dump 10'+10'** *20'* Speaker: Antonio Perillo Marcone (CERN)
11:30	**PSB injection beam dynamics 10'+10'** *20'* Speaker: Chiara Bracco (CERN)

- ✓ Progress in the definition of the H^- injection systems (optics, apertures, vacuum sectorisation, magnets…):
  - Review of H^-/H0 dump on 18 April, 2013 (http://indico.cern.ch/conferenceDisplay.py?confId=244116)
- ✓ Progress in the definition of the beam transfer equipment at 2 GeV:
  - Review of PSB ejection lines at 2 GeV on 10 October, 2013 (http://indico.cern.ch/conferenceDisplay.py?confId=274495)
- ✓ Active involvement in the coordination of the PSB dump replacement:
  - ALARA procedure meetings (http://indico.cern.ch/categoryDisplay.py?categId=4284)
- ✓ Space management/cables identification in preparation for installation of future equipment
- ✓ Specifications for new MPS and its building (to be shared with CV)

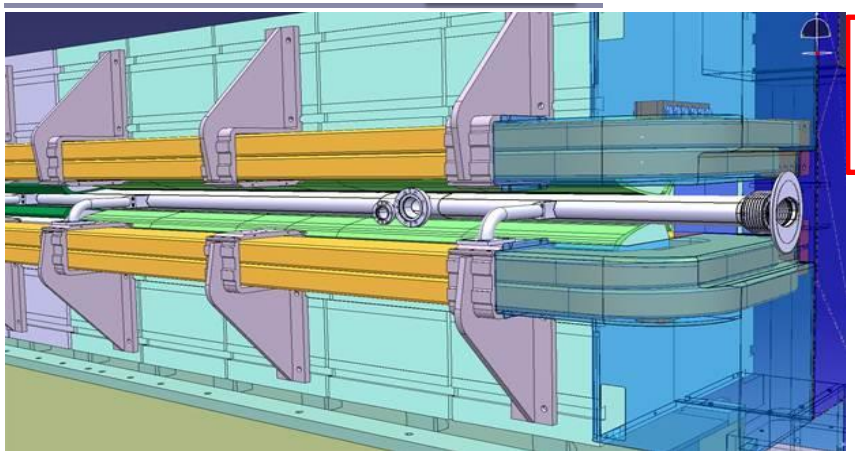
LIU-PS: LS1 work [1/2]

Resonances compensation:
Installation of 4 skew quads for 3rd order resonance compensation and 2 more octupoles to investigate $4q_V=1$ resonance compensation.

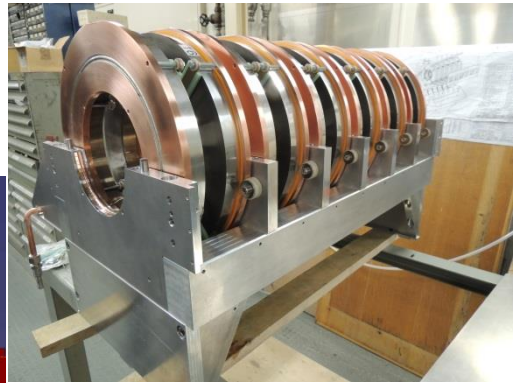
Transverse damper: new power amplifiers and cables.



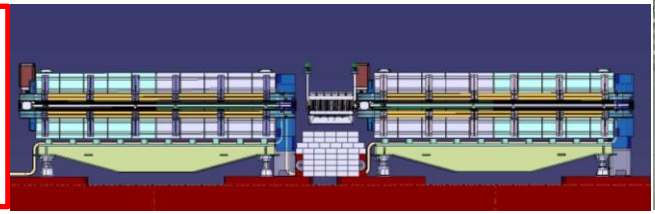
One-turn delay feedback on ferrite cavities:
- New digital electronics card being installed (derived from LHC) and cables.
- Operational immediately after LS1.



New e-cloud detectors in modified MU98 vacuum chamber



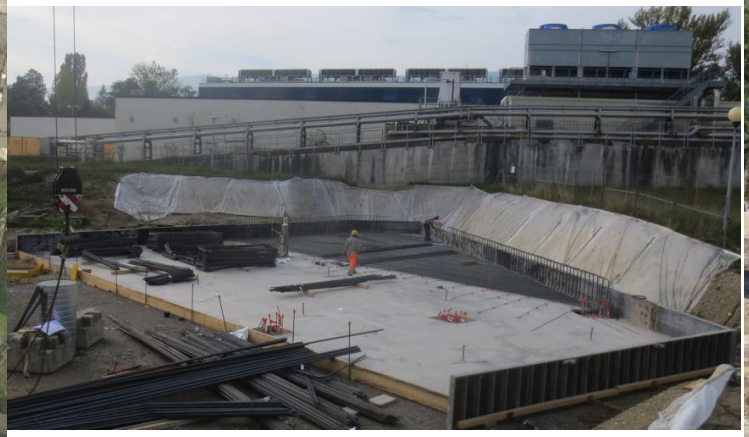
Longitudinal coupled-bunch feedback:
- 6 cells cavity assembled. Installation before start-up.
- Operational immediately after LS1.

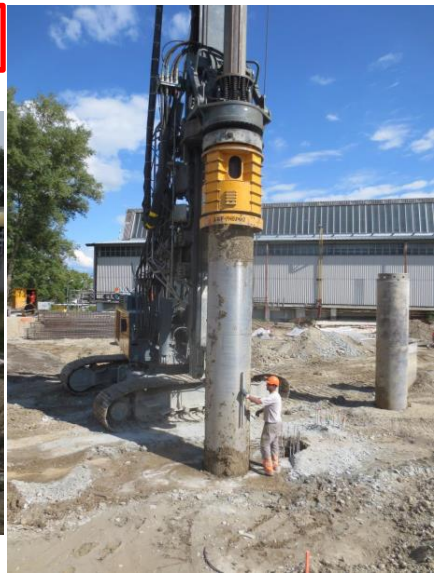


LIU-PS: LS1 work [2/2]

Injection region shielding increase (Route Goward's hill)

Extraction region shielding increase (above SS16)





LIU-PS

PS talks during LIU 2014

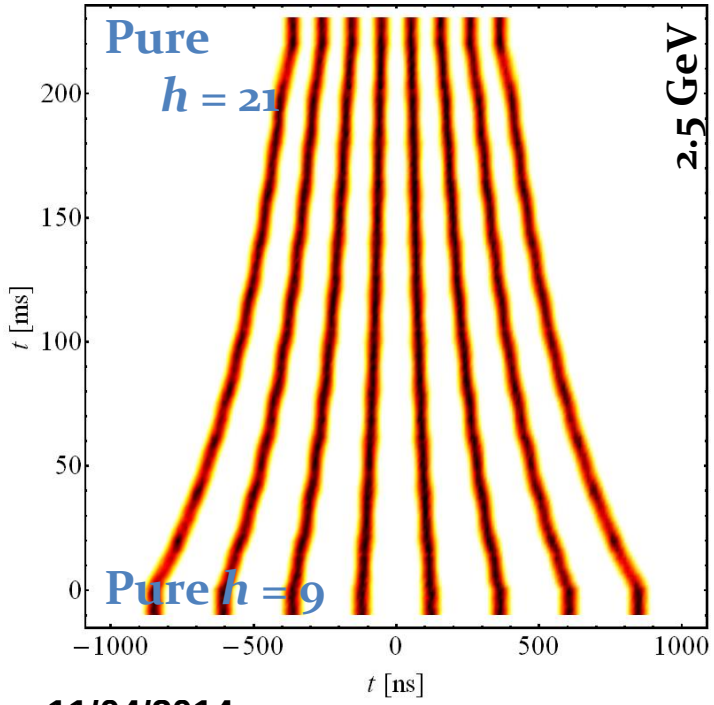
11:50	**PS: longitudinal instabilities and damper 10'+10'** *20'*	Speaker: Letizia Ventura
12:10	**PS: new "one-turn delay" feedbacks 10'+10'** *20'*	Speaker: Damien Perrelet (CERN)
14:00	**PS: transverse beam dynamics issues 15'+10'** *25'*	Speaker: Raymond Wasef (Institut National Polytechnique de Grenoble (FR))

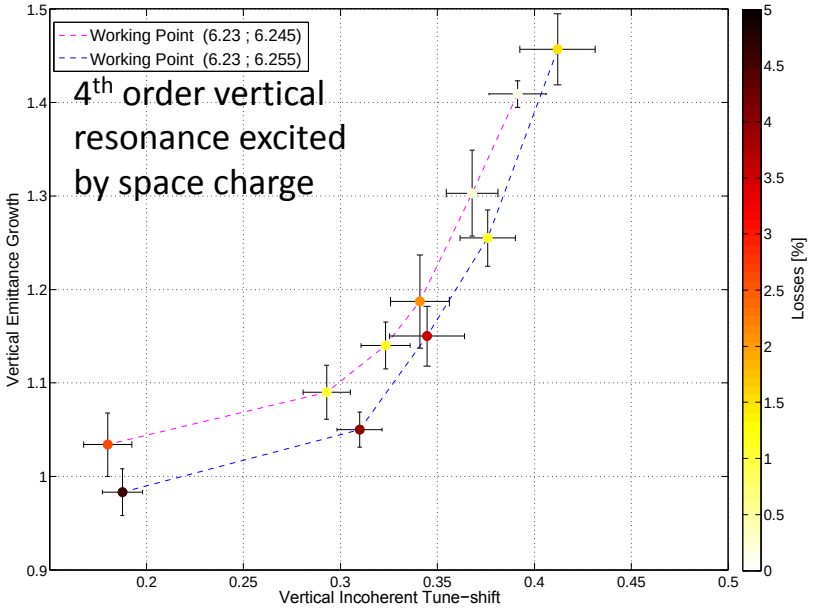
Space-charge:

- Vertical growth vs. Tune-spread and beam loss→
- Extensive simulation

Proposal for generation of very bright beam:

Pure Batch Compression (with splitting at 26 GeV) → 32 bunches per PS batch





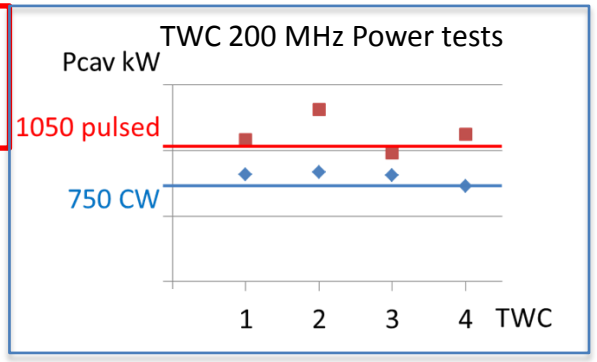
Proposal for 8b+4e bunch train (25 ns) in case of excessive e-cloud effects in LHC with full train:

- 4 bunches missing every 8 bunches → less e-cloud in LHC
- 33 % less bunches in LHC, but with significantly higher intensity
- To be tested with beam after LS1

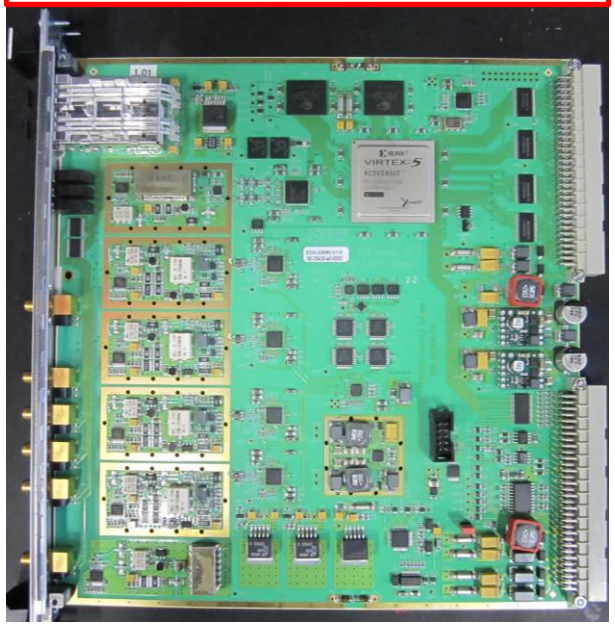
LIU-SPS: LS1 work

aC coating of dipole magnets:
- 12 additional magnets equipped with aC coated vacuum chambers (→ 16 in total after LS1)

200 MHz high power RF:
- Tests up to 750 kW CW and 1.05 MW pulsed (43 kHz & 172 kHz)
- Modification of all Siemens amplifiers DC circuitry



800 MHz Low Level RF:
- LLRF replaced with digital version



800 MHz high power RF:
- All klystron transmitters dismantled
- 4 IOT-based amplifiers installed

New 800 MHz IOT transmitters

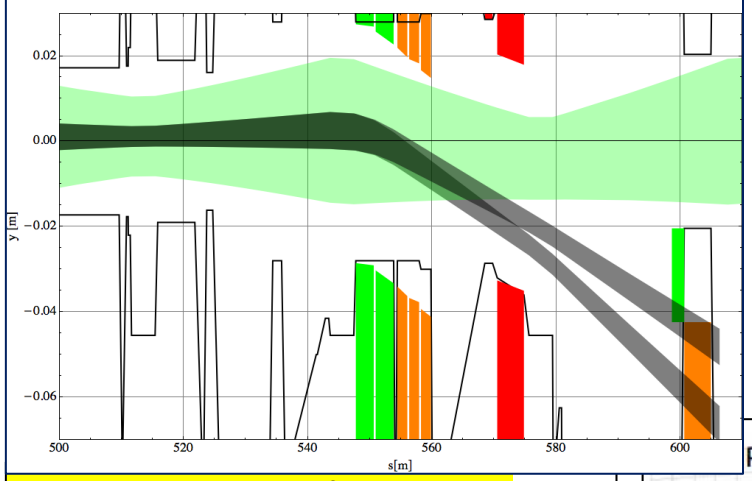
LIU-SPS

SPS in LIU 2014

14:25 **SPS: instabilities and impedance model in longitudinal and transverse planes 2x10'+15'** *35'*
Speakers: Carlo Zannini (CERN), Jose Enrique Varela Campelo (CERN)

15:00 **SPS to LHC transfer line collimation 15'+10'** *25'*
Speaker: Verena Kain (CERN)

Dumping of LHC beam with Q20 optics



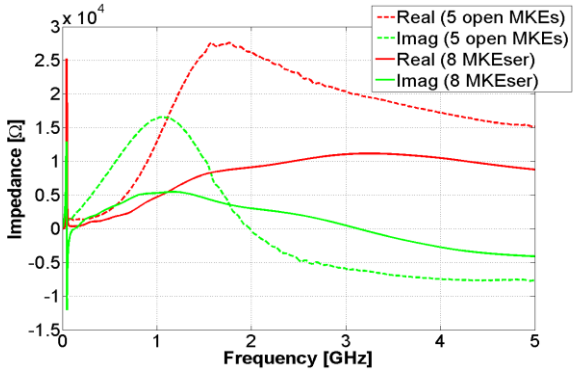
Major effort defining baseline

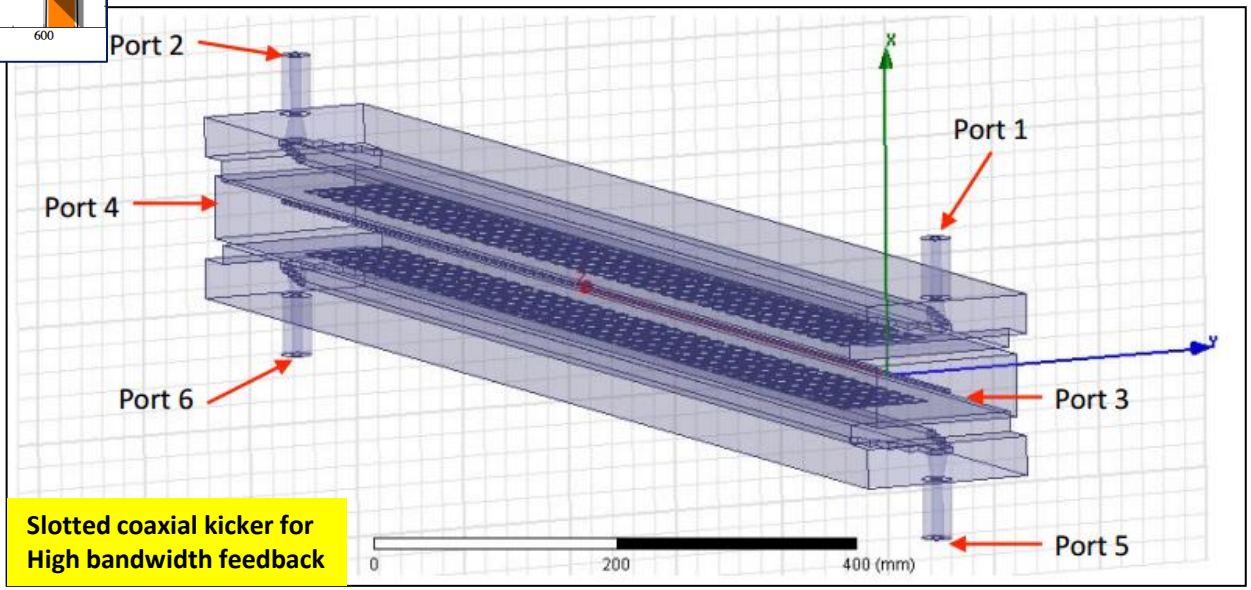
LIU-SPS reviews held in 2013

LIU SPS Orbit Correction Review 16 January 2013
LIU-SPS Beam Scraping System Review 22 January 2013
LIU-SPS Internal Beam Dump Review 30 January 2013
LIU-SPS ZS Electrostatic Septum Upgrade Review 20 February 2013
LIU-SPS Open 'C' Core MKE Extraction Kicker Review 20 March 2013
LIU-SPS High Bandwidth Damper Review 30 July 2013
LIU-SPS Beam Instrumentation Review 3rd October 2013
LIU-SPS 50 ns Injection System for Pb Ions Review 4 October 2013

LIU-SPS/LAGUNA Collimation System Review 21 November 2013

Longitudinal impedance of open C core extraction kicker (beam in gap)





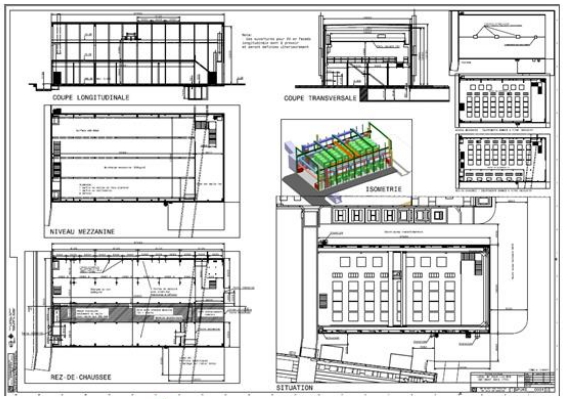
Slotted coaxial kicker for High bandwidth feedback

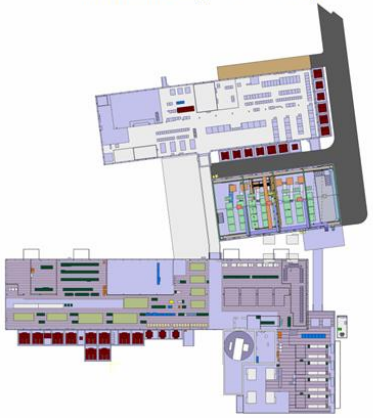
LIU-SPS

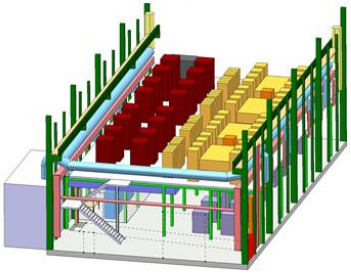
New BAFS building progress

Building BAF3

- ✓ Integration studies completed
- ✓ Enquiry 'Etude Genie Civil' sent out
- Construction to start January 2014
- Building ready by mid-2015 all inclusive (CV + EL)







Detailed planning for SPS aC coating (all main magnets)

Month	J				F				M				A				M				J				J				A				S				O				N				D		
Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
Average cadency [magnet/day]	0	0	0	0	3	3	3	3	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	3	3	3	3	0	0	0	0	0	0	0	0	0	0		
Treated [magnet / week]	0	0	0	0	15	15	15	15	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	15	15	15	15	0	0	0	0	0	0	0	0	0	0		
Treated magnets (cumulated)					15	30	45	60	90	120	150	180	210	240	270	300	330	360	390	420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870	900	915	930	945	960												
Sector					3-4								4-5					6-1					5-6						1-2						2-3																X-mas
Transport via					3-4-5								4-5					1-6-5					6-5						1-2-3-4-5						2-3-4-5																
Project phase	Preparation				Coating start				Coating																												Coating end				End of reinstallation				Tests and recommissioning							

CERN-ATS-Note-2013-019 MD
15 April 2013
Giovanni.Iadarola@cern.ch

Electron Cloud and Scrubbing Studies for the SPS in 2012

H. Bartosik, G. Iadarola, G. Rumolo,
F. Caspers, M. Driss Mensi, S. Federmann, M. Holz, H. Neupert, M. Taborelli

Keywords: SPS, electron cloud, scrubbing, amorphous carbon coating, 25 ns

Summary

It is important to collect all the relevant information to qualify the present status of the electron cloud in the SPS before the Long Shutdown (LS1). Therefore several electron cloud studies have taken place in the SPS during the 2012 run. At the beginning of the running period, five days were fully dedicated to electron cloud activities and scrubbing studies. After that, a few more MD sessions were devoted to following up on the studies started in the scrubbing week. These results, in combination with detailed simulation studies, will provide the basis for defining strategies of electron cloud mitigation as required for the production of future high intensity and high brightness beams within the LHC Injectors Upgrade (LIU) project.

Contents

Comprehensive ecloud studies report (50 pages)

LIU-Ions

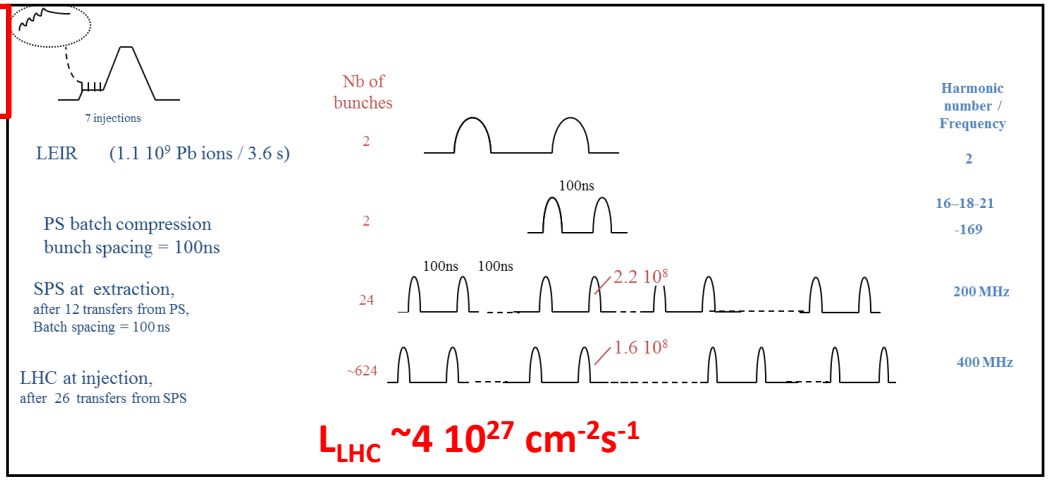
15:45 **LEIR model (plan for understanding/upgrading LEIR performance limitations) 10'+10' *20'***
Speaker: Michael Andreas Bodendorfer (CERN)

16:05 **New ion injection system in the SPS (mode of operation with beam, beam optics, hardware) 10'+10' *20'***
Speaker: Thomas Kramer (CERN)

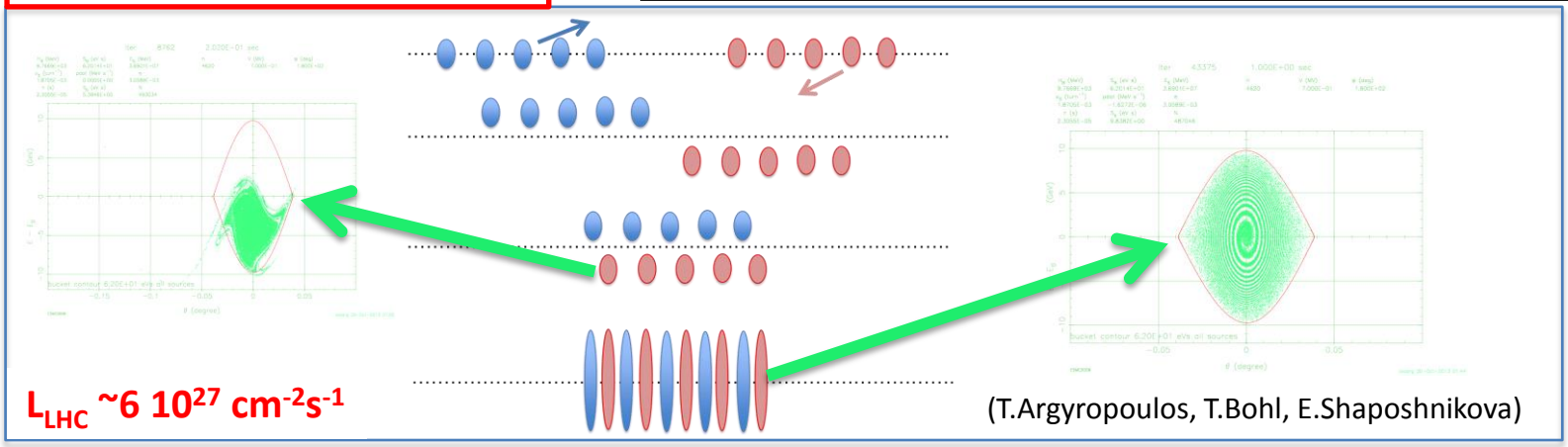
16:25 **Slip stacking in the SPS (mode of operation with beam, simulations, scheduled tests and implementation) 10'+10' *20'***
Speaker: Theodoros Argyropoulos

Ions in LIU 2014

Definition of baseline scheme with 100 ns bunch spacing



Potential scheme (with "bunch splitting" in the PS and "slip stacking" in the SPS) for a bunch spacing of 50 ns in LHC



(T.Argyropoulos, T.Bohl, E.Shaposhnikova)

- LIU summary
- LIU Highlights in 2013
- **Outcome of the «Review of LHC and Injectors Upgrade Plans» (Oct.2013)**
- «New» schedule for LHC and injectors
- The Challenges of 2014…

Review of LHC and Injectors Upgrade Plans

https://indico.cern.ch/event/260492/overview

29-31 October, 2013

Objectives:

- ✓ Review of the parameters of the LIU and HL-LHC projects following the experience and changes in the beam parameters experienced in the past two years.
- ✓ Produce a staged plan(beam parameters, technical work, all machines) of how we proceed from the performance at the end of 2012 to the required performance for the HL-LHC. In order to do this we need to know at what level of integrated luminosity will necessitate replacement of the inner detectors and the insertions. Also to see the importance of 3000fb-1 and what level of minimum integrated luminosity would be tolerated.

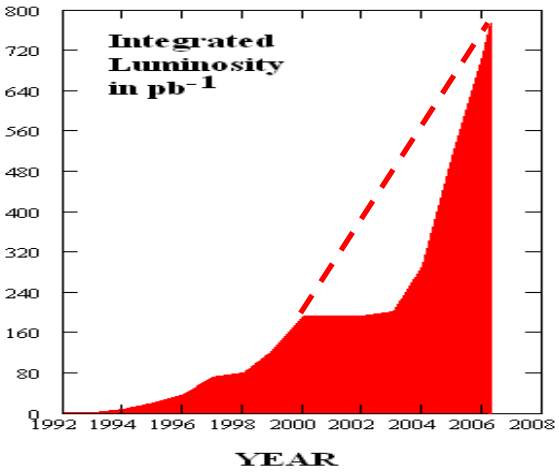
Impact:

- ✓ Intense activity preparing the event with the study of multiple scenarios and the analysis of implementation plannings in tight connection with HL-LHC (subject of 8 dedicated LIU Technical Meetings*). **Very worthwhile investment resulting in the confirmation of the LIU baseline choices, and improved coordination with HL-LHC and providing to the management the necessary information to update the LHC schedule.**

* http://indico.cern.ch/category/4985/

RLIUP Summary (S. Myers on Nov.7, 2013) (1/3)

Maximise LHC Performance (Useful integrated luminosity)



Peak Luminosity

- Pile-Up in the detectors
- Accelerators performance

Useful Integrated Luminosity (4 detectors)

- Time available for physics (iterative with shutdowns)
  - Play-off between upgrades and time lost for physics
- Timing of Upgrades (sooner the better)

Beam Energy??

- During discussion with CMAC possibility of energy increase came up.

RLIUP Summary (S. Myers on Nov.7, 2013) (2/3)

Structure of the Review

- 5 different scenarios for comparison of performance and cost
- Each scenario encompasses all accelerators in the LHC chain
- For each scenario:
  - Identify the technical requirements (work needed and shutdowns)
  - evaluate the peak and integrated yearly luminosities (time available for physics)

Note: In the preparation for the review, these scenarios were meant for comparison. Later, it became apparent that they could be better used for the evaluation of the evolution of the performance with time over the long time scale examined

RLIUP Summary (S. Myers on Nov.7, 2013) (3/3)

Strategy

- LHC has been constructed, operated and will continue to be operated on a CONSTANT BUDGET
- We have a beautiful scientific facility, unique in the world.
- The community has invested (and are investing) a huge amount of their resources in this unique facility both for construction and for operation

The goal of 3000 fb^{-1} by ~2035 is challenging but attainable

- **Both Upgrades, LIU and HL-LHC, should aim for the maximum useful integrated luminosity possible**
- LS3 should come as soon as possible in order to maximize the integrated luminosity (every delay by one year of LS3 "costs" 200 fb^{-1})
- LS2 should not delay LS3.

- LIU summary
- LIU Highlights in 2013
- Outcome of the «Review of LHC and Injectors Upgrade Plans» (Oct.2013)
- **«New» schedule for LHC and injectors**
- The Challenges of 2014…

LHC Schedule beyond LS1

Only EYETS (19 weeks) (no Linac4 connection during Run2)

LS2 starting in 2018 (July) 18 months + 3months BC (Beam Commissioning)

LS3 LHC: starting in 2023 => 30 months + 3 BC

injectors: in 2024 => 13 months + 3 BC

LHC schedule approved by CERN management and LHC experiments spokespersons and technical coordinators
Monday 2nd December 2013

- LIU summary
- LIU Highlights in 2013
- Outcome of the «Review of LHC and Injectors Upgrade Plans» (Oct.2013)
- «New» schedule for LHC and injectors

The challenges of 2014…

The Challenges of 2014…

- Restart the accelerators. Absorb impact of «Controls renovation» (300 new FECs, new OS version, new hardware…) + upgrades (Digital LLRF, New cavity feedback loops…) + maintenance/repair interventions…

  ⇒ **Recover 2012 beam characteristics for all users**

- Progress with commissioning of Linac4. Start testing the upgrades (PSB Finemet cavity, PS longitudinal damper, SPS wide band transverse damper, new Beam Instrumentation, aC coating in SPS magnets…)

  ⇒ **Prepare decision on options.**

- Pursue MDs and studies for understanding sources of limitations and finding solutions for improvement

  ⇒ **Progress in beam performance.**

- Continue designing/building well-defined equipment.

  ⇒ **Prepare for installation as scheduled.**

I AM CONFIDENT YOU WILL SUCCEED, AS IN 2013!

LET'S LISTEN TO YOU…

AND CELEBRATE!

[16h45 – cafeteria bdg.30/7th floor]