Preparing the SPS complex alignment for future LHC runs

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Outline

- Introduction
- Long Shutdown 1
- Measurement and alignment strategy
- Planning
- Vertical alignment SPS ring
- Horizontal alignment of the SPS ring
- TI2 & TI8 Transfer lines
- TT10 Transfer line
Introduction

CERN's Accelerator Complex

- LHC (Large Hadron Collider)
- SPS (Super Proton Synchrotron)
- AD (Antiproton Decelerator)
- CTF3 (Clic Test Facility)
- AWAKE (Advanced WAKEfield Experiment)
- LEIR (Low Energy Ion Ring)
- LINAC (LINEar ACcelerator)
- HiRadMat (High-Radition to Materials)

- p (proton)
- ion
- neutrons
- \(\overline{p}\) (antiproton)
- electron
• Initially intended for the LHC consolidation
• Start of LHC Injector Upgrade Project
  • Working towards Higher Luminosity
  • LHC injectors need to push their boundaries to deliver the needed beam quality
• 15 Month of SPS shutdown is the unique opportunity to improve the alignment in the whole complex
• SPS ring Levelling + alignment 6 w
• SPS Sextant 6 Realignment H+V 8 w
• SPS Quads horizontal survey 6 w
• SPS Quads horizontal alignment 4 w
• SPS Dipole + inter. Alignment H+V 20 w
• TI2 Transfer line survey and alignment 6 w
• TI8 Transfer line survey and alignment 20 w
• TT10 Transfer line survey and alignment 12 w
• Change of Magnets / Upgrades and installation
Planning

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<th>Duration (days)</th>
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<td>Main Milestones</td>
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Notes:
- The data is obsolete.
- For detailed planning, refer to the latest update.
SPS vertical profile

- Measured and corrected every year
- 6.9km, DNA03 double run with 1800 observations
• Cumulated ground movements have built a sharp excursion in the vertical profile
• Limiting aperture and performance of the machine
Sextant 6 constraints

- Jacks were at the end of the range
- Exchange of PU Jacks and additional shimming
- TI2 extraction in the center of excursion
- Interconnects were kept closed
- Restricts roll angle and transversal offsets
- Delicate load transfer to jacks
- Double actuator hydraulic
- Independent adjustment of volume and pressure
New handling equipment
Strategy

• 3 Step approach to keep track
  • Relative vertical displacements for focussing Quadrupoles
    • Reference measurement
    • Lifting with exchange of jacks and shims
    • Realignement to new vertical, but initial horizontal position
  • Alignment of defocussing quadrupoles using the focussing as reference
  • Alignment of all intermediate components
SPS FoDo Lattice
Results

92 Quadrupole Magnets aligned

SPS Final Vertical Profile
LS1 2014

Vertical Deviation [mm]

Dcum [m]

Smoothline  Final  smooth-toll  smooth+toll  Initial
• Wire offset measurements
• Datum fixed on one Point with radial corridors for some straight sections
• Very final adjustments to Orbit
• Corrector Magnets not strong enough at 450GeV
• Measurements done by the operation team during each startup
• Cumulated 40 voluntary displacements
• Change from Q26 to Q20 Optics
• All displacements deleted during LS1
• Two iterations done with 10 Magnets in V and 10 in Horizontal direction
Q20 Orbit

- finished
Transfer Lines TI2 & TI8

- Geologically unstable
- Full realignment of TI8 in both planes
- Only Quadrupoles of TI2 in both planes
- Strategy is basically the same as the one for the SPS or LHC
TI2 Final Vertical Profile
LS1 2014

Vertical Deviation [mm]

Cumulated Distance [m]

-4.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
0 500 1000 1500 2000 2500 3000 3500 4000

Smooth 40-0.3 Rough Tol+ Tol- Limite SPS Limite TT60 Limite LHC
• Delivering beam from PS to SPS complex
• Showed invert heave plus compression racks in the crown and tension/shear cracks at the level of the shoulder
Measurements
Reinforcements
• Regular monitoring of Profiles
• Installation of new Network points all along TT10
• Installation of a fiber optic permanent monitoring system
With contributions of
Philippe Dewitte, James Ridewood, Richard Francis Morton, Stephan Cettour Cave