IONS for LHC: LEIR and PS

Presented by M. CHANEL

June 28th 2002 – LHC Ions Workshop
 GENERAL SCHEME

LHC

100 to 200 μA Pb^{27+}

ECR

RFQ

LINAC3

4.2 MeV/u, β=0.094 rep. rate up to 5 Hz

LHC.LEAD.new.PUB

LEIR

PS

592 bunches and ~10mn filling time per ring.
PS batch pattern=3*(13,13,12)+1*(13,13, 8)
7 10^{7}/b, 2.76 TeV/u, L=1 10^{27} cm^{-2}s^{-1}
5h. Luminosity life, 2exp

~13 PS inj./ SPS cycle
1 ej./1. mn at 177 GeV/u
4 pairs of bunchlets recombined to 4b..(100ns)

Stacking of 0.9 10^{9} ions at 4.2 MeV/u, accel. to 72 MeV/u ,
2 bunches of 4.5 10^{8} ions each every 3.6 s.

accel. to 5.9 GeV/u
Two bunch splitting
4 pairs of bunchlets / 3.6 s.

Stripper Pb^{27+} to Pb^{54+}

Stripper in TT2 Pb^{54+} to Pb^{82+}
Nominal Performance for LEAD ions

- $7 \times 10^7$ Lead ions/bunch in LHC at 2.7 TeV/n in a normalised emittance of $1.5 \ \mu m(\beta \gamma \sigma^2/\beta_{h,v})$.
- Overall transfer efficiency (from Leir extraction to LHC coast) of 30%,
- $\varepsilon^* < 1.2 \ \mu m$ at the exit of SPS,
- $\varepsilon^* < 1 \ \mu m$ at the entrance of SPS after final stripping,
- $\varepsilon^* < 0.7 \ \mu m$ at the entrance of PS.
- A total of $0.9 \times 10^9$ ions extracted from LEIR
- Limit as much as possible LHC filling time.
To be pulsed between inj. and eject

New AnyWay

Due to ejection at 71 MeV/u
LEIR cycle for LEAD ions

Multiturn injection H+V+P planes
50 efficient turns
3.0 $10^8$ ions per injection

Ecooling max 400 ms reduce $\varepsilon_n$ from 2 to 0.5 $\mu$m, $\delta$ from 10$^{-3}$ to <0.2 10$^{-3}$
Density increase by 80

Dynamic Vacuum very good (10$^{-12}$ range)

4 injections in 1.6s

End cooling, bunching, space charge limit $\Delta Q<0.3$

Extraction at $B_p=4.8$ Tm, 2 bunches total $910^8$ ions $\varepsilon_n=0.7\mu$m

Cycle 3.6 s
LEAD IN THE PS

- Fast extraction
  - $B_p = 86.7 \text{Tm}$
  - RF $h = 21$ to $h = 169$ (80MHz)
  - Splitting RF $h = 169$ to $h = 423$
  - 4 pairs of bunchlets 100ns dist.

- Intermediate front porch
  - $B_p = 22 \text{Tm}$
  - RF $h = 16$ to $h = 14$ to $h = 12$
  - Splitting $h = 24$ then $h = 21$
  - 4 bunches

- 2 bunches b. to b. injection
  - RF $h = 16$
  - space charge limit $\Delta Q < 0.25$
Injection h=16

h=16 to 14

h=14 to 12

Splitting h=12 to 24

h=24 to 21 to 169

Splitting h~423 (200MHz)
\textbf{TT2} (from PS to SPS, has to be changed)

- At stripper $\beta_{h,v} \sim 20\text{m} \rightarrow 5\text{m}, \text{D} \sim 1\text{m}$
- Blow-up reduced by a factor 4 compared to old(normal)optic….needs MD for SPS matching. $\Delta\varepsilon \sim 0.2\mu\text{m}$ after re-matching in SPS?
- Need of 4 quads, 6 power supplies \textit{+building}, (mostly recuperated)
Other ions

- Ions should have the highest possible charge state already in LEIR:
  - Remove SPS limit
  - Better and faster cooling in LEIR(Z²/A)

- Limits are in LEIR and PS (space charge)

- PS RF not studied
## LEIR + PIL Cost

<table>
<thead>
<tr>
<th>Year</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>TOTAL PIL &amp; LEIR</th>
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<tbody>
<tr>
<td>TOTAL</td>
<td>2150</td>
<td>6050</td>
<td>6380</td>
<td>4289</td>
<td>610</td>
<td>19479</td>
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## Schedule

<table>
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<tr>
<th>Task Name</th>
<th>2002</th>
<th>2003</th>
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<th>2006</th>
<th>2007</th>
<th>2008</th>
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<tr>
<td>1. Source (ECR) upgrade (0.5 my)</td>
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<td>2. SPS fixed target Ion runs</td>
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<td>5. Leir studies</td>
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<td>28/11</td>
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<td>6. Vacuum studies (L3+Lear)</td>
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<td>7. Leir installation</td>
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<td>8. Leir Running-in</td>
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<td>11. 14 Power supplies L3 Dipoles</td>
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<td>12. 10 Power supplies Quad.</td>
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<td>13. 2 Power supplies Solenoid</td>
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<td>14. PS Supply for septum 26 (2.0 my)</td>
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<td>15. PS-New septum 26 (1.5 my)</td>
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<td>16. PS-Kickers 28 upgrade (1.0 my)</td>
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<td>17. PS-RF upgrade (1.0 my)</td>
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<td>18. PS Running-in with ions</td>
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<td>19. Stripping TT2 (2 my)</td>
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<td>20. SPS running-in with ions</td>
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<td>21. Lead ions possible in LHC</td>
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<td>22. Run physic LHC</td>
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Conclusions

• LEIR and PS well adapted for all ions.
• Flexible in terms of Nions/bunch.
• Can be operational for 2008

• More in http://chanel.home.cern.ch/chanel/Welcome.htm
Stacking tests of lead ions

Linac III rep rate: 2.5 Hz
Ion beam energy: 4.2 MeV/u
Electron energy: 2.35 keV
Electron current: 105 mA

Beam lifetime: 6.5s

Average accumulated intensity: 6E8 ions
Peak intensity: 7.1E8 ions

With the lattice used, it was not possible to accelerate the beam
Ion induced desorption tests at LINAC 3
J. Hansen, J.-M. Laurent, E. Mahner & LINAC 3-Team

(1) Change from single shots to continuous injection of Pb$^{53+}$
(2) Reduced Pb$^{53+}$ current, additional pumping (Turbo)
(3) System vented (5min); bakeout (24h) at 300°C
(4) Continuous injection of Pb$^{53+}$
(5) Power Cut; (2.6.2001)
(6) Changed to single shots and back to continuous injection

Study of Beam-Cleaning:
Test Chamber A, Φ = 14 mrad
Continuous injection of Pb$^{53+}$ ions
Periods without beam are cut-away

$LHC-VAC-PS$
not to be published