FUTURE POSSIBLE FIXED TARGET PROGRAM FROM NEW INJECTORS

Experimental Areas with upgraded LHC injectors: (LP)SPL, PS2, SPSU ...

Outline

- Impact on SPS North Area beams and Experimental Areas
- Experimental Areas for PS2 machine
- Experimental Areas for low energy beams
- Summary – Next Steps

EFTHymiopoulos, I (EN/MEF)

With input from: M. Benedikt, A. Ceccucci, J. Ellis, L. Gatignon, B. Goddard, E. Shaposhnikova
LHC Injector upgrade program

- **LEIR in operation (since 2010)**
  - 2011 ion extraction to NA possible
    - max $10^9$ Ions/pulse
    - Pb$^{82}$ and possibly light ions (for NA61)

- **PS2 replaces PS**
  - $\sim 5 \div 50$ GeV/c beams
  - $1.0 \times 10^{14}$ ppp
  - 2.4s cycle fast / 3.5 slow extraction

  - end of PS-EA, nTOF, AD
  - ISOLDE gets the beam SPL

- **SPS Upgrade**
  - Single injection form PS2 $\rightarrow$ shorter cycles
  - The machine is upgraded and can handle the PS2 delivered intensity!

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New Opportunities Workshop

I.Efthymiopoulos (EN/MEF), EDMS ID:999746
Implications for SPS North Area

### Beam Intensity

**Today**
- $I_{\text{max}}$ (integrated) : $3.5 \times 10^{13}$ ppp / 9.6s flat-top
  - instantaneous rate : $3.6 \times 10^{12}$ pHz
- $I_{\text{max}}$ (instantaneous) = $5.0 \times 10^{12}$ pHz
  - $2.4 \times 10^{13}$ ppp / 4.8s flat-top

**Future**
- The foreseen intensity from PS2/SPSU ($1.0 \times 10^{14}$ ppp) represents a factor 2.85 increase in overall beam intensity
  - In reality ~10% less due to losses at SPS and extraction line
  - Note this is the total – intensity, i.e. for all targets that then is split, etc.

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Can the NA infrastructure accept the $\times 2.5$ intensity increase and the shorter super-cycle (no CNGS, LHC? Is even higher intensity possible if requested for future experiments?

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## Implications for SPS North Area

### Beam cycles

#### Today

<table>
<thead>
<tr>
<th>FT flat top</th>
<th>Additional users</th>
<th>Super-cycle</th>
<th>FT duty cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.6(4.8)s</td>
<td>3×CNGS + LHCs + MD</td>
<td>48.0(43.2)s</td>
<td>20(11)%</td>
</tr>
<tr>
<td>9.6(4.8)s</td>
<td>LHCs + MD</td>
<td>30.0(25.2)s</td>
<td>32(19)%</td>
</tr>
</tbody>
</table>

#### Future

<table>
<thead>
<tr>
<th>FT flat top</th>
<th>Additional users</th>
<th>Super-cycle</th>
<th>FT duty cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.2(9.6)(14.4)s</td>
<td>3×CNGS + LHCs + MD</td>
<td>40.8(43.2)(48.0)s</td>
<td>18(22)(30)%</td>
</tr>
<tr>
<td>7.2(9.6)(14.4)s</td>
<td>LHCs + MD</td>
<td>26.4(28.8)(33.6)s</td>
<td>27(33)(43)%</td>
</tr>
</tbody>
</table>

- The single injection from PS2 implies a gain up to \(\sim 10\)% in cycle length
  - e.g. 43.2s instead of 48.0s for the case of a 9.6s flat top
- The 14.4s flat top, if technically possible, would correspond to \(6.95 \times 10^{12}\) pHz, 40% more of today’s maximum instantaneous rate for the experiments, and a \(\times 2.15\) gain in duty cycle compared to today
- **Note:** The MD cycle (and LHCs) are needed to maintain the average power in the magnets within limits.
Implications for SPS North Area

Limitations – *main issues*

Long flat-top:
- average power to magnets and magnetic extraction septa

Intensity increase:
- Electrostatic septa:
  - beam losses and induced activation
  - temperature of the wires; sparks
  - Heating and deformation of ion-trap plates
- Losses in *beam splitters*
- Cooling of *targets* and *TAX blocks*:
- Shielding in surface *experimental areas* (intensity, muons, dumps)
  - EHN1, and EHN2 experimental halls
SPS North Area

6 Beam splitters

TT20 Extraction line from SPS to NA

H-plane

V-plane

splitter-1

splitter-2

T2

T4

T6

Field-free region

Continues straight - no B-field

Horizontally deflected by the B-field

Losses

Fig. 5 Cross section of the single septum magnet.

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SPS North Area

7 Targets

- **T6** target (M2, COMPASS)
- **T4** target (H6, H8, P0)
- **T2** target (H2, H4)

Wobbling magnets

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Target Absorber Attenuator - TAX

- Water cooled absorbers to protect the first beam quads from radiation
- Used also as beam dumps of the primary beam
SPS North Area

Experimental areas layout

- **ECN3 Exp Cavern**
  - underground

- **EHN1 Exp Hall**
  - ~surface building

- **EHN2 Exp Hall**
  - surface building

- **TCC2 target hall**
  - underground

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Implications for SPS North Area

10 Beam performance

- The \( \times 2.5 \) higher intensity and \( \times 2.15 \) potential gain in duty cycle, coupled to the high-energy of SPS open unique opportunities for fixed target physics

Example:

- Up to \( \sim \times 50 \) sensitivity increase in the challenging channel \( K^0_L \to \pi^0 \nu \overline{\nu} \) in a future Kaon experiment, continuation of NA48/NA62
  - parameters: 26% duty cycle, 50% efficiency, 120 day/year

Few remarks:

- To operate the North Area with an effective \( \times 5.3 \) increase a careful study is required on all critical beam elements of the SPS extraction, transfer lines and secondary beams and areas to address the technical and safety limitations

- By 2018 the SPS/NA will be celebrate its 42\(^{nd}\) anniversary!; an upgrade/consolidation program must also be planned to assure the operation of the beams and the experimental areas

- Finally, very likely SPS North Area, and the EHN1 Experimental Hall in particular, will by then be the ONLY experimental facilities of CERN that would have to accommodate FT experiments and test beams of constantly increasing number: LHC upgrades, detector R&D for CLIC/ILC, vFact, ...
Experimental Areas in PS2

- PS2 as LHC injector will be a machine that would remain idle most of the time!
  - LHC filling is only few times per day, and SPS cycles, in particular FT to NA, are long
  - Even the minimum SPS cycle, eg. CNGS: 4.8s → 75% idle time for PS2

- Is there a compelling physics program, also looking at competition world-wide, to justify building experimental area(s) attached to the PS2 machine and thus use the available machine time?
  - Relevant machine parameters:
    - Beam energy: ~5 to 50 GeV
    - Intensity: up to $1.0 \times 10^{14}$ ppp, 3.5s slow extraction cycle
      - fast extraction is also an option if required

- The presence or not of experimental areas must be integrated in the design of the new machine
  - in particular if a potential physics program would require intensities beyond what is presently foreseen as part of the LHC injector upgrade program, i.e. beyond $1.0 \times 10^{14}$ ppp
Experimental Areas in PS2

General considerations

- The PS2 machine will be at -50m underground to match the TT2/SPL injection and extraction to SPS

- Deep underground experimental areas can be suitable for high-intensity experiments but not for test beams

- Bringing the beam to the ~surface would require about 700m of beam transfer line (6% slope)

- Experimental areas are quite expensive as they require:
  - Electrical buildings for power supplies
    - secondary beam magnets powered individually, plus large spectrometers for the experiments
  - Infrastructure: cooling, cryogenics(?), cranes, large footprint
  - Offices for users, surrounding shielding
Experimental Areas in PS2

Possible implementation

**PS2 Exp. Areas layout (ideal scenario)**

- **Underground caverns:**
  - beam splitting switchyard
  - two underground areas
    - FT high-intensity experiment(s)
    - high-intensity test facility
  - nTOF

- **Semi-surface(-5m) Experimental Hall**
  - transport attenuated primary beam (or secondary beam) to medium-intensity targets
  - hall for FT experiments and test beams
    - nearby SPS Point-2 zone
    - PS East Area type of layout and beams

- Exp. Areas can be staged, but they must be included in the design of the machine
Exp. Areas for low energy beams

- SPS NA could provide beams from $5\div400$ GeV
- Producing tertiary beams of lower energies although technically possible is rather inefficient and challenging for the experiments (large backgrounds)
- Lower energy test beam areas could be envisaged coupled to the ISOLDE (or future EURISOL) facility with beams provided from SPL ($<\sim5$ GeV)
An overview of the Experimental Areas in about 10 years ahead when the new injectors will become operational was presented.

With the baseline program of the LHC injector upgrades (SPL, PS2, SPSU), and assuming a rigorous upgrade/consolidation program for the SPS North Area is realized, beams with \( \times 2.5 \) higher intensities and improved duty cycle could be provided.

The input from the user community, triggered by this workshop, is mandatory to setup a competitive physics program (protons and ions) with these beams for the SPS North Area, and make the case of experimental areas attached to the PS2 machine.
Next steps

- In particular for PS2 experimental areas, a **study group** was formed by the CERN management to
  - trigger discussions and collect experimental requests,
  - explore the possible fixed-target options using beams from PS2,
  - summarize in particular, any physics arguments for an intensity greater than that required for the LHC upgrade

**Members:** M. Benedikt, A. Ceccucci, I. Efthymiopoulos, J. Ellis, L. Gatignon

- A report will be provided to the CERN management by **June’09**

- Looking forward to your **input** during the workshop and/or afterwards ....