High Intensity Beams and their Performance

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Introduction:
The performance formula

\[ N_p = N_{days} \times FLUX \]

\[ FLUX = INTENSITY \times DUTYCYCLE \times AVAILABILITY \]
Introduction:
Users looking for high proton flux

- Beams discussed in this presentation
  - CNGS
  - FIXED TARGET (COMPASS + NA62)
  - N-TOF
  - Future $\nu$-facilities?
  - LHC25nsec
CNGS: Intensity (CPS)

- CPS: From the beam dynamics on the operational point of view the intensity of CNGS can be risen from the current 2500e10 (2200e10 today) to 2600-2800e10 per extraction (S. Gilardoni).
CNGS : Intensity (SPS)

- Achieved 5.26 $10^{13}$, now running at 4.2 $10^{13}$ (will come back to this).

- Limiting factors:
  - RF power
  - vertical aperture <> vertical emittance from CPS

![Evolution of CNGS intensities](chart.png)
CNGS: duty cycle (CPS)

• Limitation:
  – Other users

• MTE is needed to improve this.

• As a consequence, it is better to run with increased duty cycle and a lower intensity.
CNGS : duty cycle (SPS)

- Limitations :
  - Other users
  - Intensity (non linear increase of losses with intensity). No direct limit on environment but can have an influence on availability (break down and repair time).
  - Speed of MPS: a small increase in ramp time would mean a quantum jump of 1.2 sec in cycle length (watch new transformers).

- The flexibility of making different sequences of individual cycles was essential for the performance improvement.
CNGS : availability

• The factors to consider are :
  – Intensity
    • increased losses
    • Power limitation of 600MW on SPS transmitters in order limit RF trips and broken tubes.
Proton intensities for fixed target cycle

Reduced duty cycle due to CNGS and LHC competition led to request for intensities at the CNGS level

Limitations:

- Idem as for CNGS but with two more constraints:
  - ZS losses and spark rate (This puts an empirical limit at 4 10e13)
  - Losses in TT20 (especially splitters)

<table>
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<th>Year</th>
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<td>2.5</td>
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Evolution of P intensities to NA(SPS)
Fixed target : duty cycle

- Limitations : $I_{\text{rms}}$ of MPS (SPS FT-cycle cannot be used alone).

- Perturbations from LHC users much more severe. Measurement periods much shorter (even for COMPASS) and (especially unscheduled cycle changes can penalize a lot, especially if LHC would go to dedicated filling mode.)
Fixed target: beam availability

- High intensity losses on extraction and splitters.
- Technical stops on short and short notice changes.
N-TOF

- Intensity: 1 very intense bunch of $8.5 \times 10^{12}$ on $H=8$.
- Minor losses on S16 due to large $dP/P$.
- Duty cycle: 3 cycles during day, 4 cycles during night. The presence of other ‘demanding’ cycles had an influence on MPS generator limitations.
Future $\nu$-facilities?

- Ideas to use CPS with an n-TOF like beam (8 bunches).
- SPS with twice the power on target.
LHC 25nsec beam

- Intensity limitations from beam dynamics (RF, e-cloud, TMCI) (treated by LIU).
- Impact on damper (Kicker gap)
- Stress on beam dump if not extracted (setting up and MD’s).
- Heating of kickers.
Conclusions and final remarks

• Intensity limitations on cycles with high repetition rates due to losses.

• An alternative (MTE) to the classical CT is needed to improve losses in CPS and environmental radiation.

• SPS vertical aperture is a performance parameter for CT (or MTE) beams as well as RF power and ramp rates.

• Requests for high intensity beams will continue.

• Duty cycle optimisation is as important as record intensities.