# High Intensity Beams and their Performance

K. Cornelis

# Introduction:
# The performance formula

$$N_p = N_{days} * FLUX$$

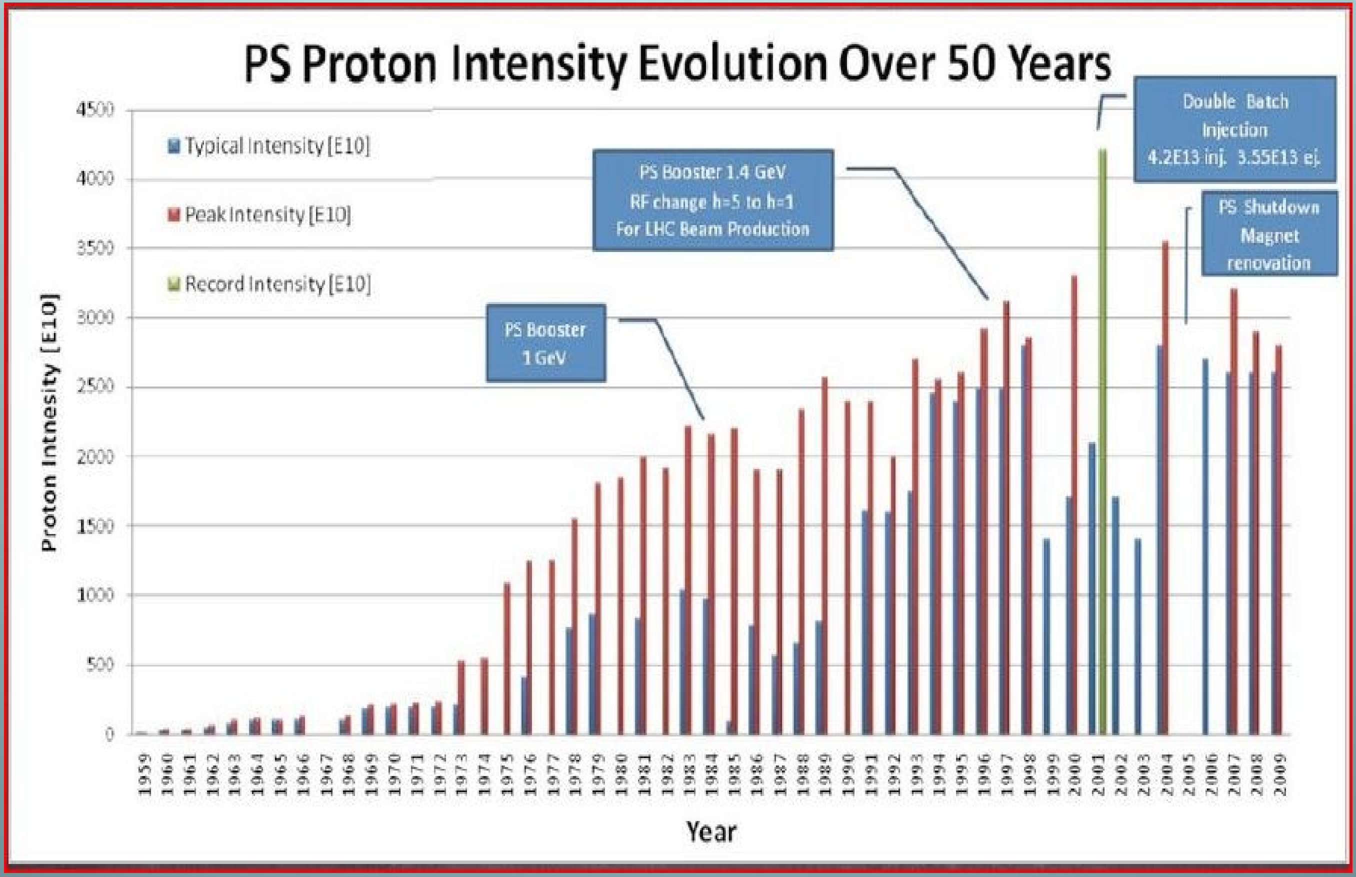
FLUX = INTENSITY * DUTYCYCLE * AVAILABILITY

# Introduction : Users looking for high proton flux

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

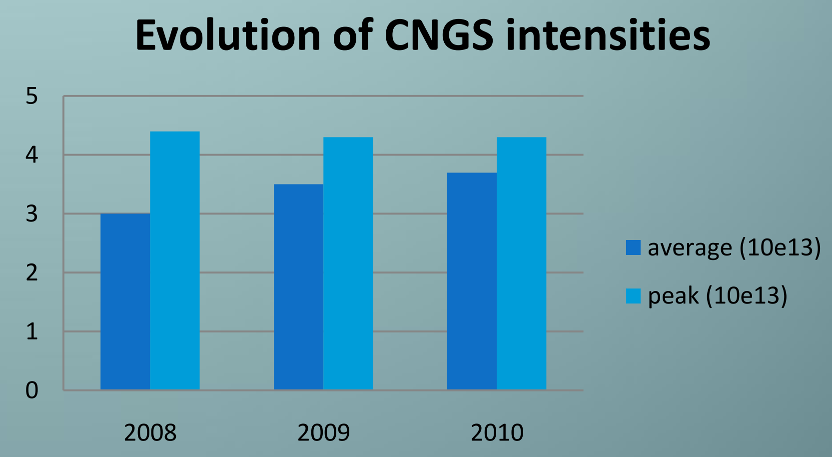
# CNGS : Intensity (CPS)

- 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).*



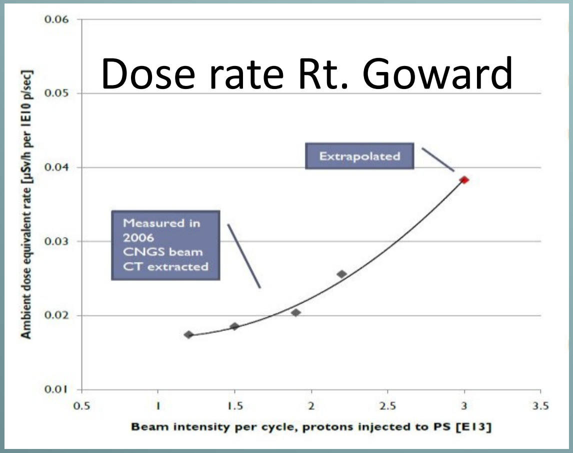
# CNGS : Intensity (SPS)

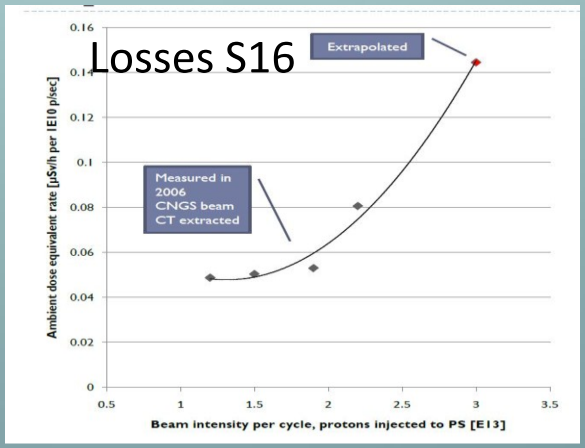
- Achieved 5.26 10e13, now running at 4.2 10e13 (will come back to this).
- Limiting factors :
  - RF power
  - vertical aperture <> vertical emittance from CPS



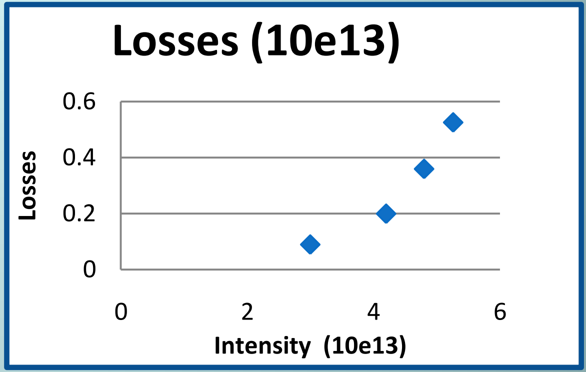
# CNGS : duty cycle (CPS)

- Limitation:
  - Other users
  - Intensity : non linear increase of losses with intensity (see MSWG 11/11/2010,*S. Gilardoni and M.Widorski* )
- MTE is needed to improve this.
- As a consequence, it is better to run with increased duty cycle and a lower intensity.

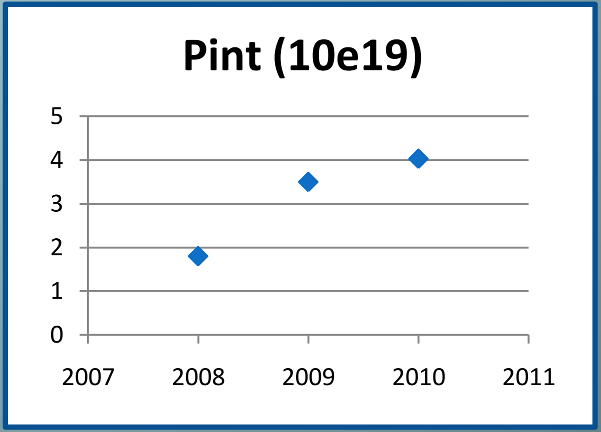


# CNGS : duty cycle (SPS)




- 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

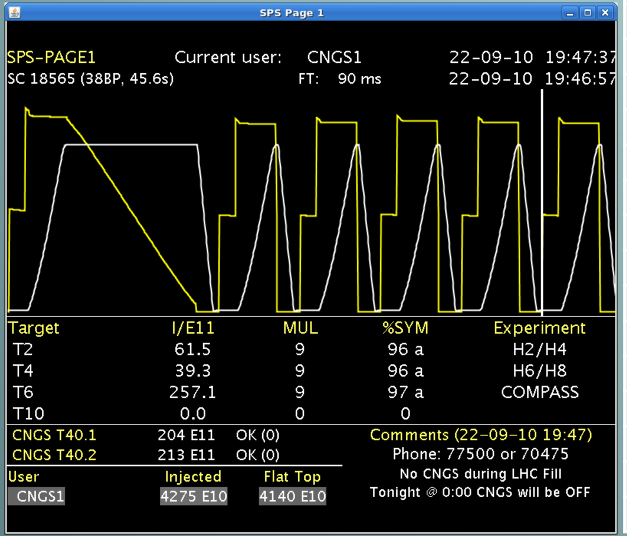
- The factors to consider are :
  - Intensity
    - increased losses
    - Power limitation of 600MW on SPS transmitters in order limit RF trips and broken tubes.

# Proton intensities for fixed target cycle

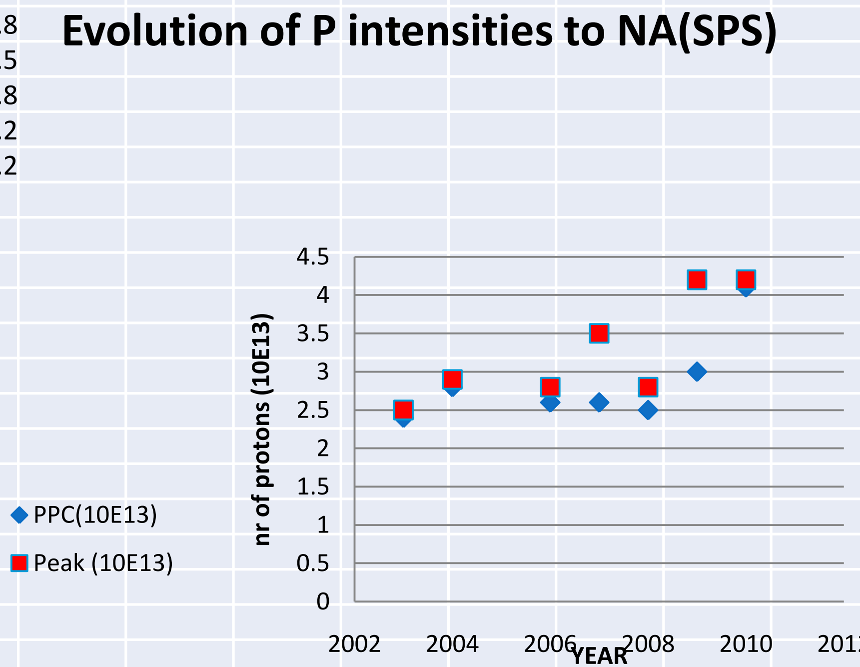
Reduced duty cycle due to CNGS and LHC competition led to request for intensities at the CNGS level

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)




| Year | PPC(10E13) | Peak (10E13) |
|---|---|---|
| 2003 | 2.4 | 2.5 |
| 2004 | 2.8 | 2.9 |
| 2005 | | |
| 2006 | 2.6 | 2.8 |
| 2007 | 2.6 | 3.5 |
| 2008 | 2.5 | 2.8 |
| 2009 | 3 | 4.2 |
| 2010 | 4.1 | 4.2 |



# Fixed target : duty cycle

- Limitations : $I_{rms}$ 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.

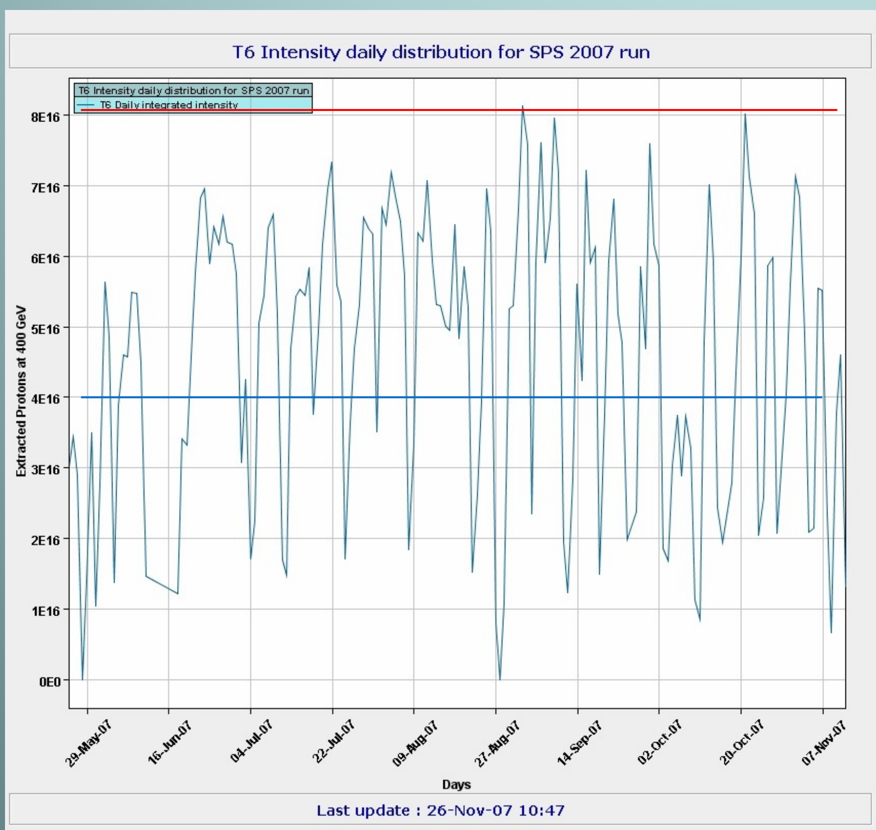
# Fixed target : beam availability

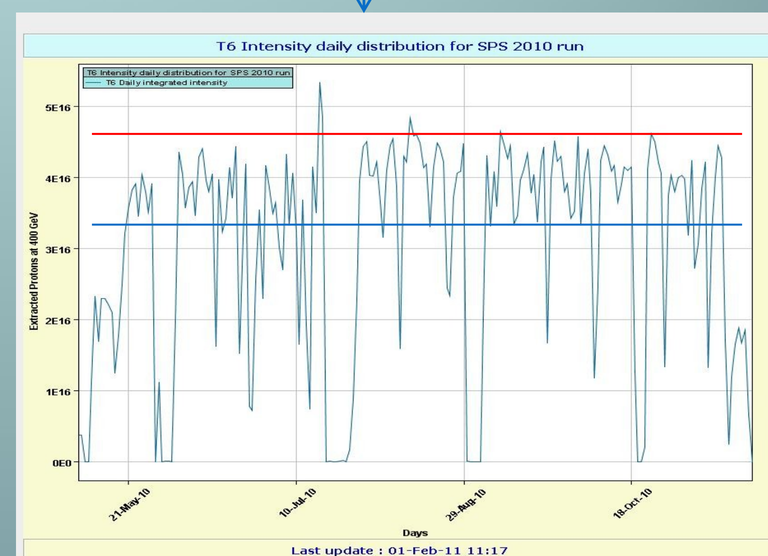
- High intensity losses on extraction and splitters.
- Technical stops on short and short notice changes.

2007

Daily protons on T6

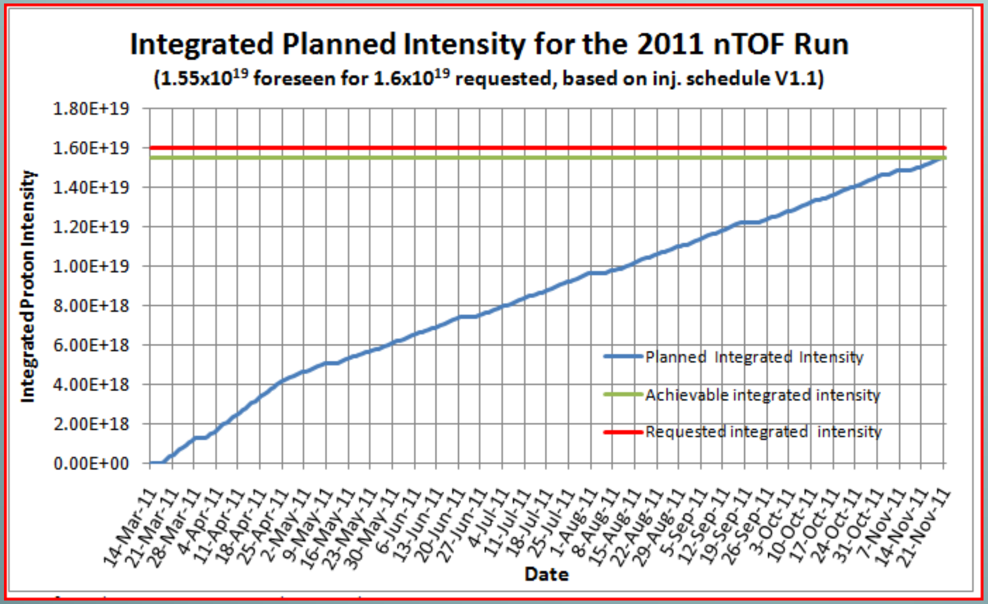
2010



# N-TOF

- Intensity : 1 very intense bunch 0f 8.5 10e12 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 environemental 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 importand as record intensities.