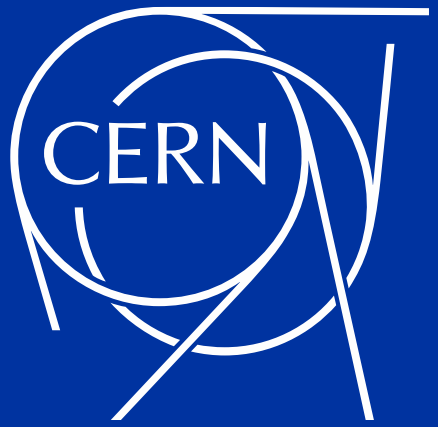

Improving the Luminosity Burn-Off Estimate by Considering Single-Diffractive Effects

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Luminosity and Burn-Off

- General concept in scattering theory to get event rate:

$$L = \frac{1}{\sigma}\frac{\mathrm{d}N}{\mathrm{d}t}$$

- Useful to calculate performance of particle collider:

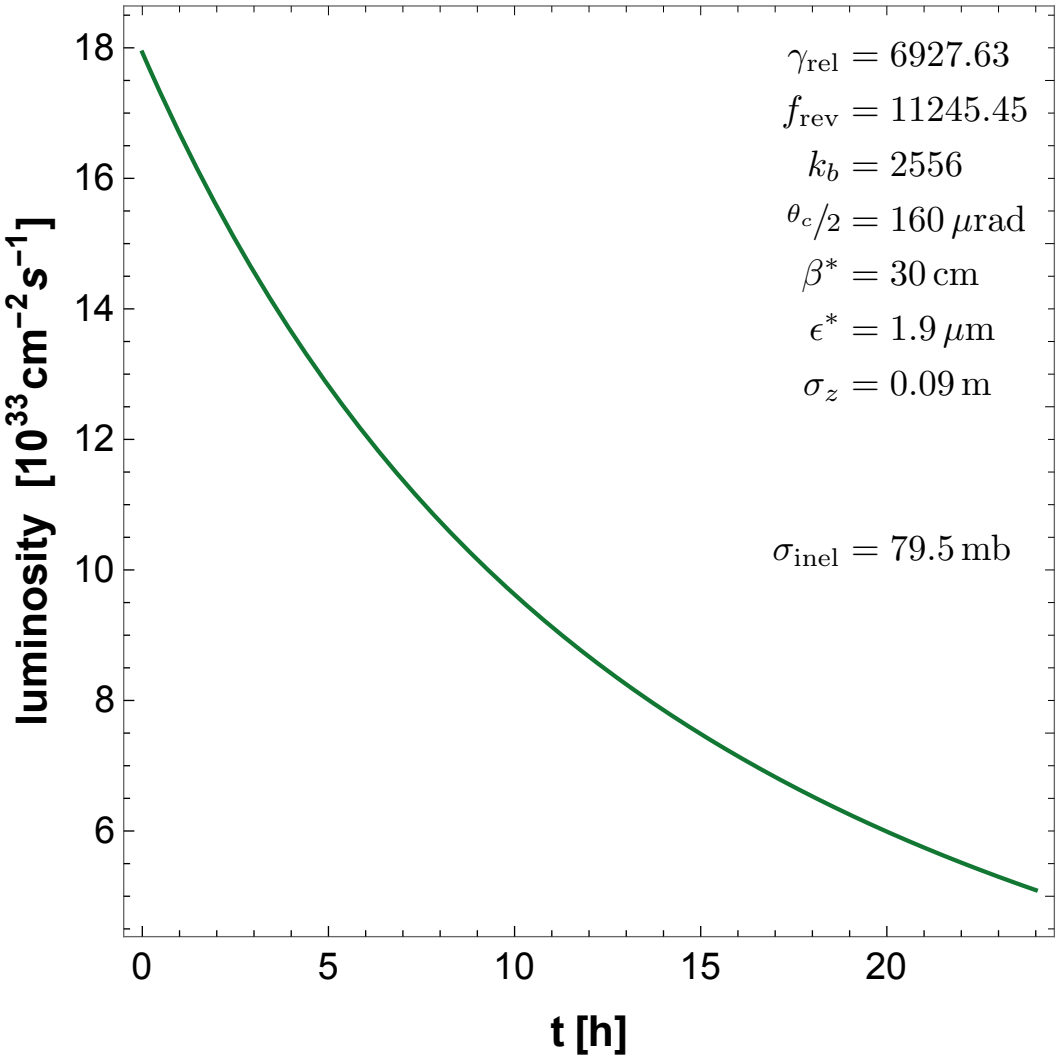
$$L = \Xi N^2 \qquad \Xi = \frac{\gamma_{\mathrm{rel}}\, f_{\mathrm{rev}}}{4\pi\epsilon^*\beta^* k_b}\left(\sqrt{1+\left(\frac{\theta_c}{2}\right)^2\frac{\sigma_z^2\,\gamma_{\mathrm{rel}}}{\epsilon^*\beta^*}}\right)^{-1}$$

- Burn-off can be calculated by solving intensity evolution:

$$N' = -2\sigma\,\Xi N^2 \quad \Rightarrow \quad L^{\mathrm{b.o.}}(t) = \frac{\Xi N_0^2}{(1+2\sigma\,\Xi N_0 t)^2}$$

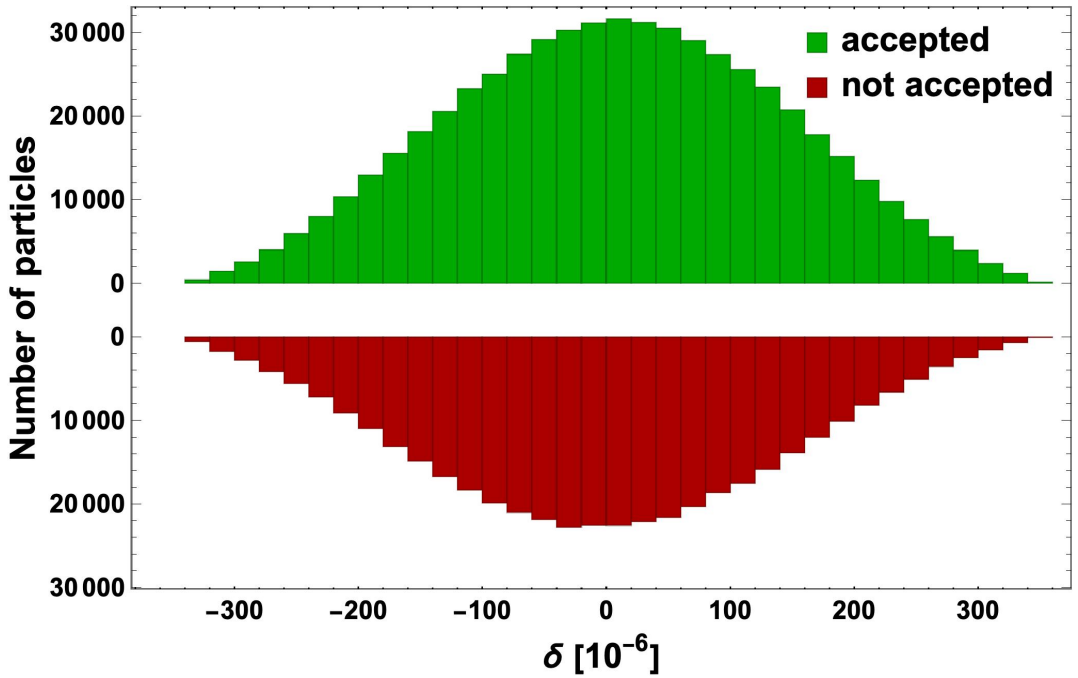
- Cross-section σ represents protons that are destroyed; typically inelastic cross-section used
- But collision can be single-diffractive too, where one proton survives… What is their chance to remain in the **machine acceptance**?

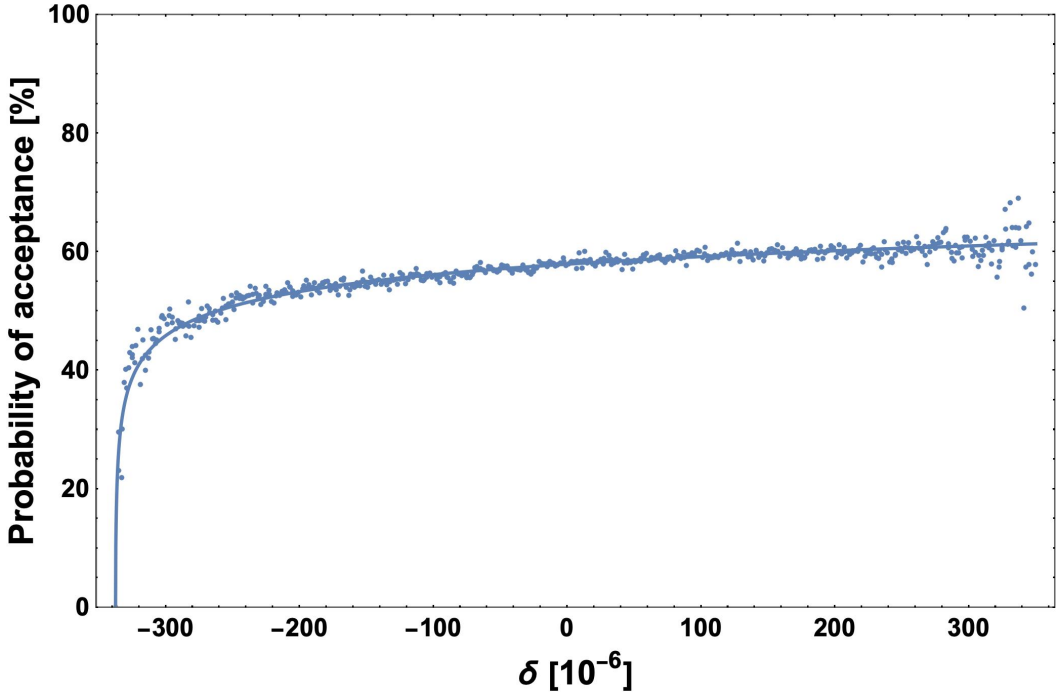
Example Simulation:
LHC Run 2 (without levelling)



Tracking Single-Diffracted Protons

- Integration of PYTHIA into SixTrack: single-diffractive scattering + track for 10.000 turns
- Proton remains in the **machine acceptance** if:
  - Longitudinal: remains in **bucket area**
  - Transverse: did not hit **collimators**





- SD scattering translates as loss in energy ($\delta = \frac{P - P_0}{P_0}$)
- Protons at lower end of bucket have lower probability to remain in the machine acceptance after scattering
- Final acceptance expectation $\mathcal{P}$ is weighted average:

$$\mathcal{P} = \int \mathrm{d}\delta \; P(\delta) f(\delta)$$

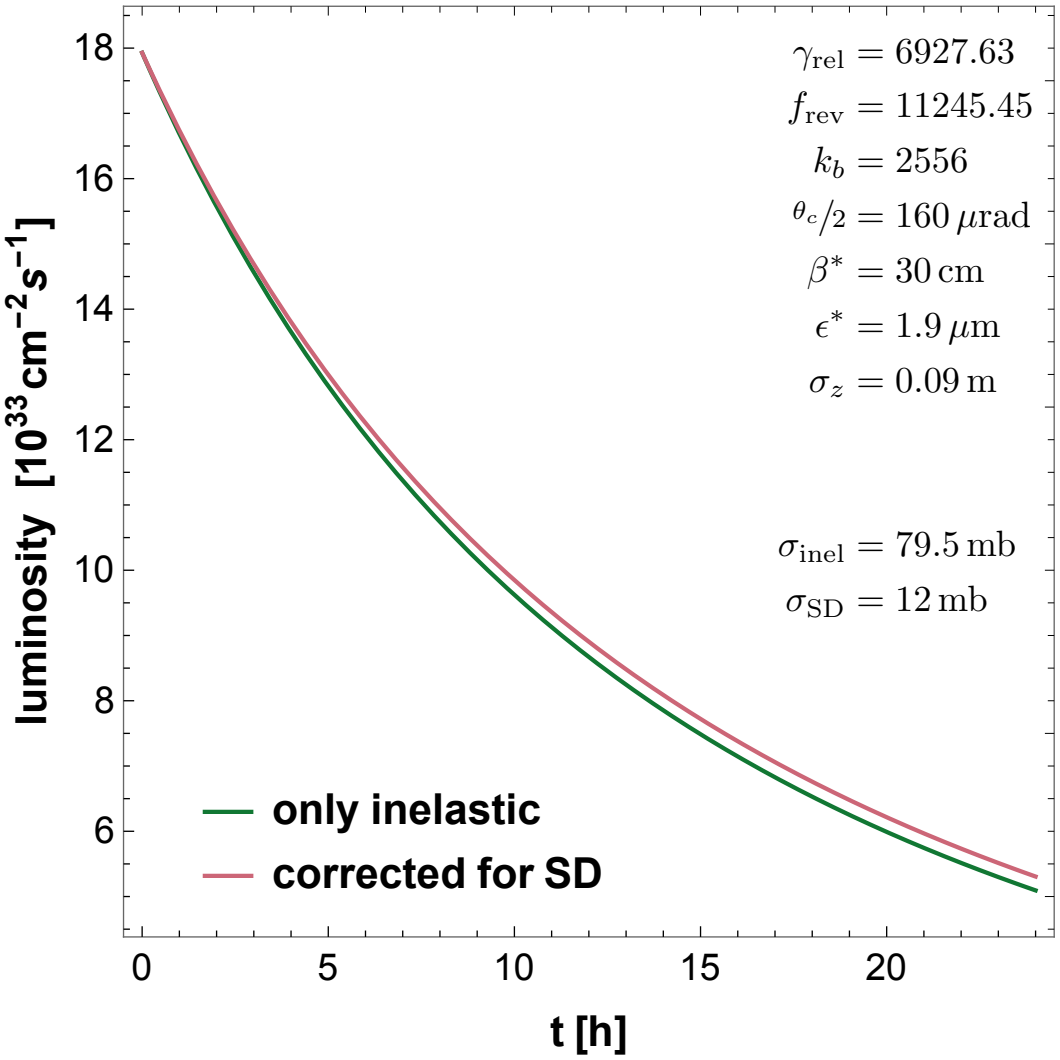
Improving Burn-Off Estimate

- Simulations have been repeated for different operational setups and different machine realisations (magnetic errors) of the LHC
- Results are very consistent: a proton that is scattered single-diffractively has a probability $\mathcal{P} = \mathbf{57\%}$ to remain in the machine acceptance
- In single-diffractive processes, half of the protons survive, hence in the burn-off estimate we make the substitution:

$$\sigma_{\text{inel}} \to \sigma_{\text{inel}} - \frac{1}{2}\mathcal{P}\,\sigma_{\text{SD}}$$

- Single-diffractive cross-section σ_{SD} not measured yet at Run 2 energies, but estimated at around 12mb
- Difference in luminosity evolution is small but noticeable

Example Simulation:
LHC Run 2 (without levelling)



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