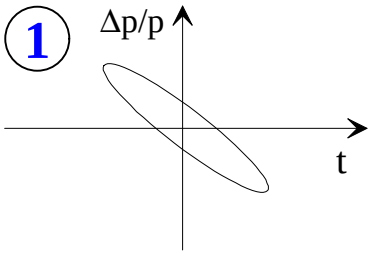
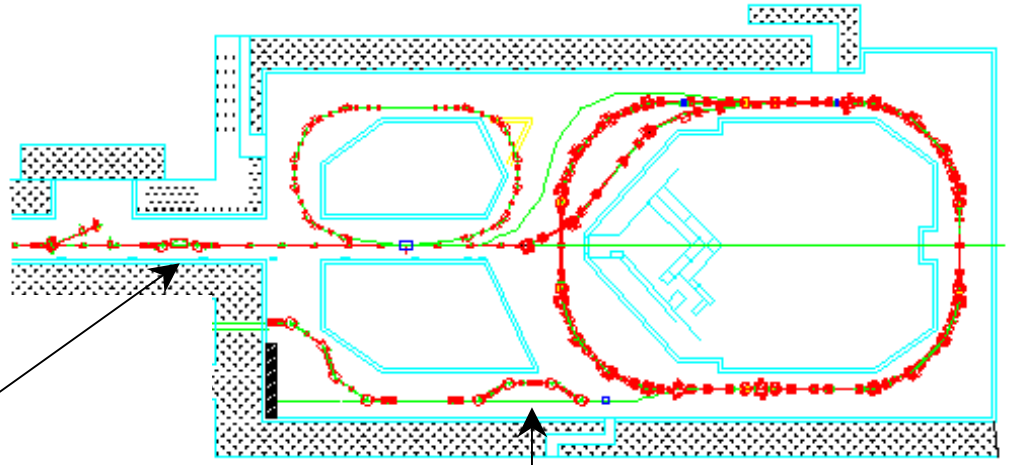
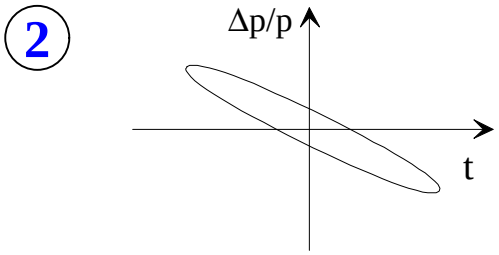
Bunch compression in CTF3

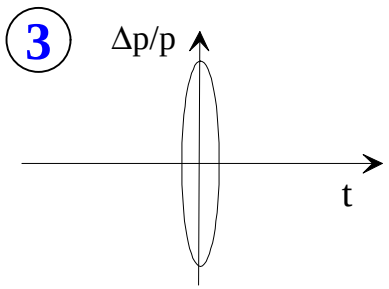


- Bunch length from accelerator ~ 1.5 mm rms
- Bunch energy spread from accelerator ~ 1% rms
- Correlation introduced in the accelerator by a combination of longitudinal wake-fields and RF phase





The bunch length can be increased in a magnetic chicane to a maximum of ~ 2.5 mm rms, to minimize CSR wake in delay and ring



The bunch is compressed after extraction from the ring, to the nominal bunch length (~ 0.4 mm rms)

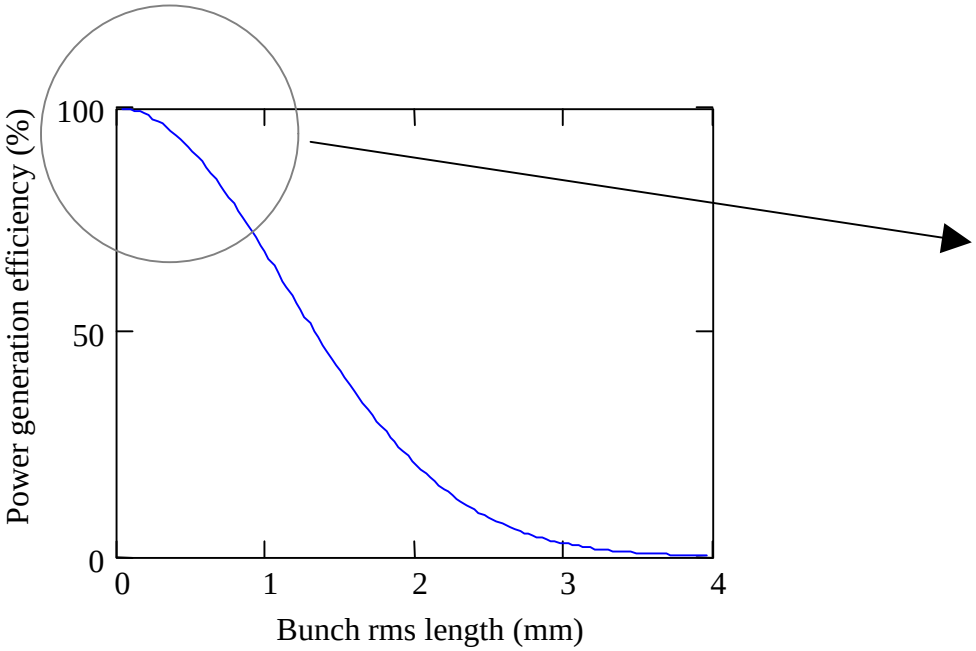
Final bunch length requirements

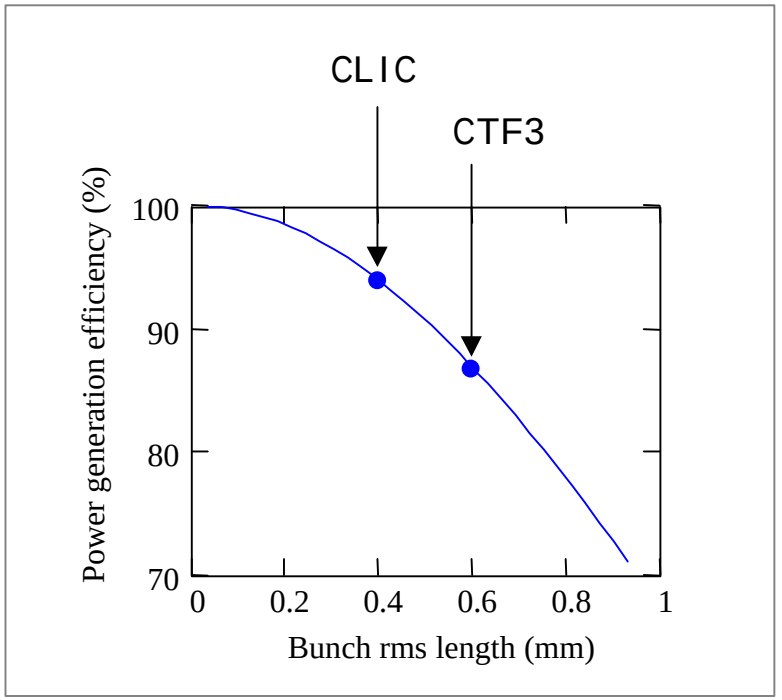
$$P_{PETS} \propto F^2 \, q_B^2 \quad \text{where} \quad F = \int e^{-2ipnt} \rho(t)\, dt \quad \Rightarrow \quad F = e^{-\frac{(2p s n)^2}{2}} \quad \text{for gaussian bunches}$$

In order to efficiently produce 30 GHz power in the PETS, the bunch must be short.

In CLIC the nominal bunch length is $\sigma \sim 0.4$ mm rms

In CTF3, to stay above 80% $\Rightarrow$ $\sigma \sim 0.6$ mm rms





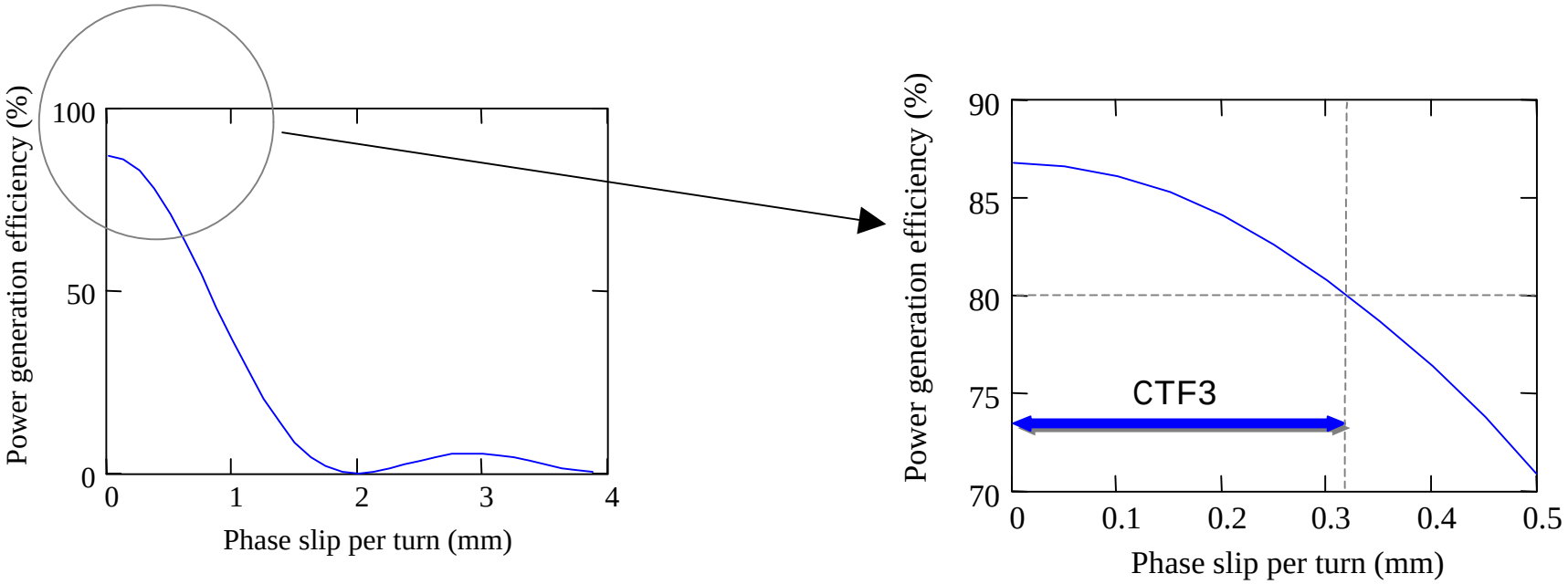
Requirements on bunch phase

The distance between bunches after combination is 2 cm (15 GHz). Any variation in bunch-to-bunch distance corresponds to a loss of efficiency.

Below - reduction in 30 GHz power generation efficiency, for a linear phase slip of the center of the injected bunches.

For instance, in order to stay above 80% $\Rightarrow$ $\Delta s < 0.3$ mm

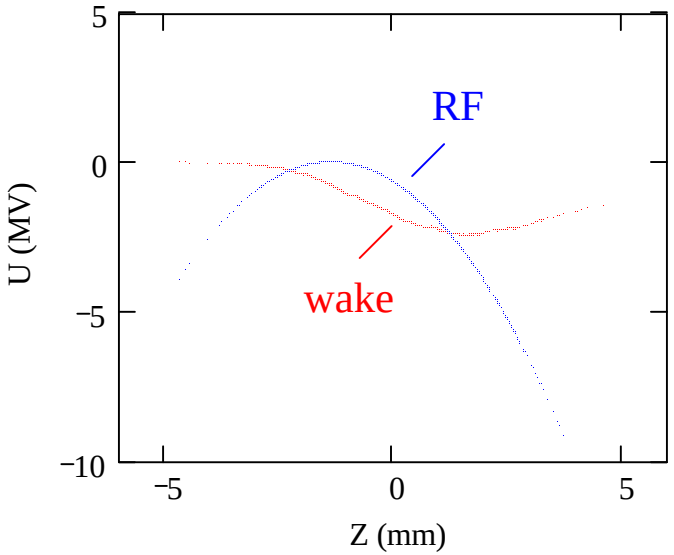
$\sigma \sim 0.6$ mm rms



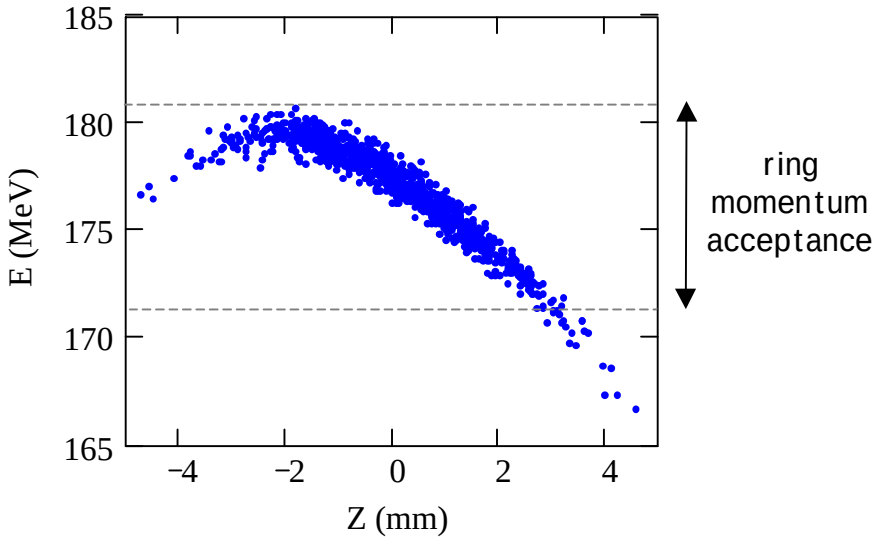
Bunch phase space at the end of the drive beam accelerator

The particle distribution in the longitudinal phase space is determined by the longitudinal wake-field and by the RF curvature

σ_Z = 1.5 mm - Qb = 2.33 nC



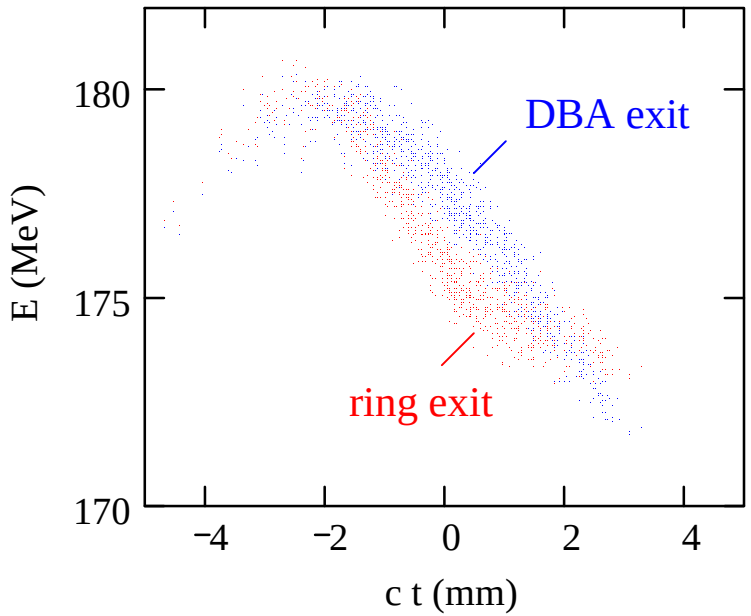
Comparison between longitudinal wake in the linac and the effect of the RF curvature (5º off-crest)



Longitudinal phase space distribution at the end of the DBA

Phase space distortion

The CSR wake causes an average energy loss and a distortion in phase space



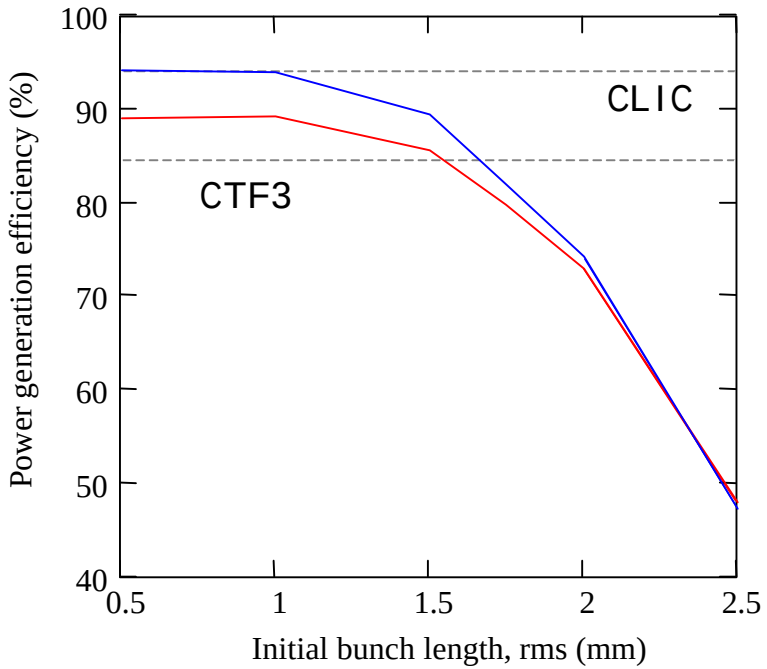
$\sigma_z = 1.5$ mm

Qb = 2.33 nC

Longitudinal phase space, at the exit of the accelerator, and after 9/2 turns in the ring

- The RF phase in the linac (5°) has been chosen to maximize correlation (filling the ring momentum acceptance, and accepting a 5% beam loss localized in the tail of the gaussian distribution)
- Shielding included, momentum compaction of the ring not included

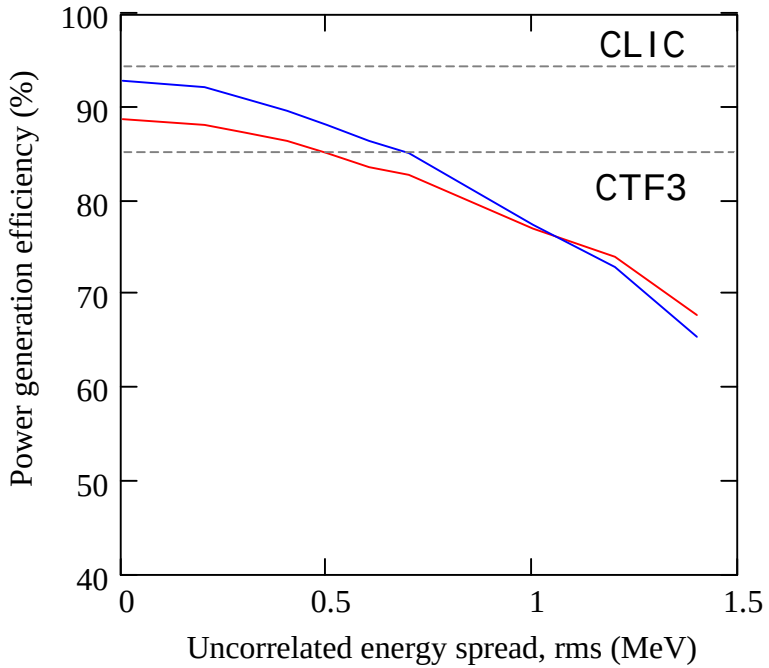
Dependence of power generation efficiency from initial bunch length



no bunch stretching,
no shielding

bunch stretching to 2.5 mm rms
& shielding

Dependence of power generation efficiency from initial (uncorrelated) energy spread



no bunch stretching,
no shielding

bunch stretching to 2.5 mm rms
& shielding