THE MOMENTUM DISTRIBUTION OF THE DECELERATED DRIVE BEAM IN CLIC AND THE TWO-BEAM TEST STAND AT CTF3

Ch. Borgmann, M. Jacewicz, J. Ögren, M. Olvegård, R. Ruber, V. Ziemann
Uppsala University, Uppsala, Sweden

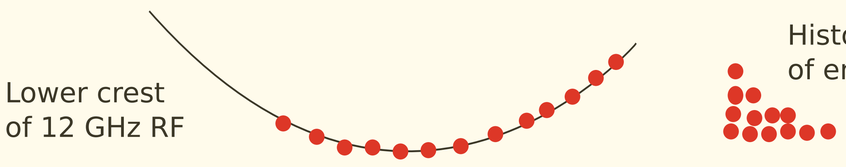
UPPSALA UNIVERSITET

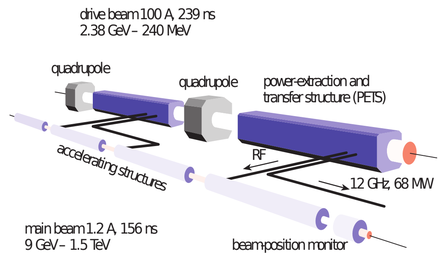
Radio-frequency power for the CLIC high-energy beam is generated by decelerating a high power low-energy drive-beam in power-extraction and transfer (PETS) structures.

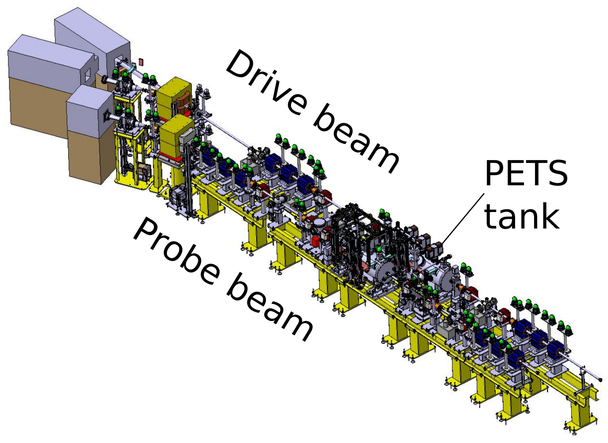
The few ps long drive-beam bunches are located near the lower crest of the built-up field to feed energy to the RF-field

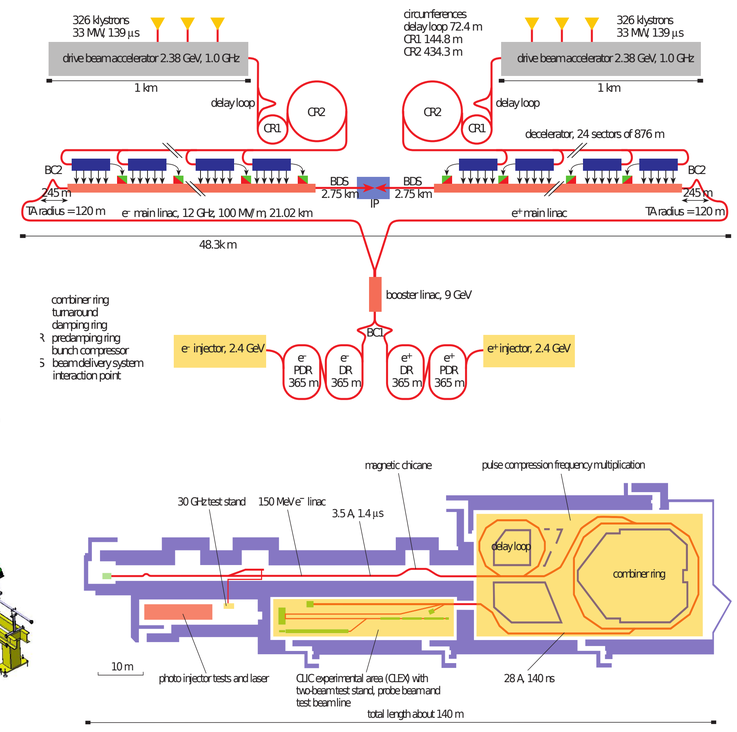
The energy loss depends on the arrival-phase of the electrons and is spread over several degrees of X-band (12 GHz) phase

Histogram of energies lost by the electrons









Initial distribution $$\psi(E,\phi) = \frac{1}{\sqrt{2\pi}\sigma_t} e^{-(\phi-\phi_0)^2/2\sigma_t^2} \Psi_0(E-E_0)$$

Final Energy $$E_1 = E - A\cos\phi$$

Final distribution $$\Phi(E_1) = \int\int \frac{1}{\sqrt{2\pi}\sigma_t} e^{-(\phi-\phi_0)^2/2\sigma_t^2} \Psi_0(E-E_0) \times \delta(E_1 - E + A\cos\phi)\, dE\, d\phi$$

$$= \frac{1}{\sqrt{2\pi}\sigma_t} \int e^{-(\phi-\phi_0)^2/2\sigma_t^2} \times \Psi_0(E_1 - E_0 + A\cos\phi)\, d\phi$$

Zero energy spread of incoming beam

$$\Phi(E_1) = \frac{1}{\sqrt{2\pi}\sigma_t} \int e^{-(\phi-\phi_0)^2/2\sigma_t^2} \delta(E_1 - E_0 + A\cos\phi)\, d\phi$$

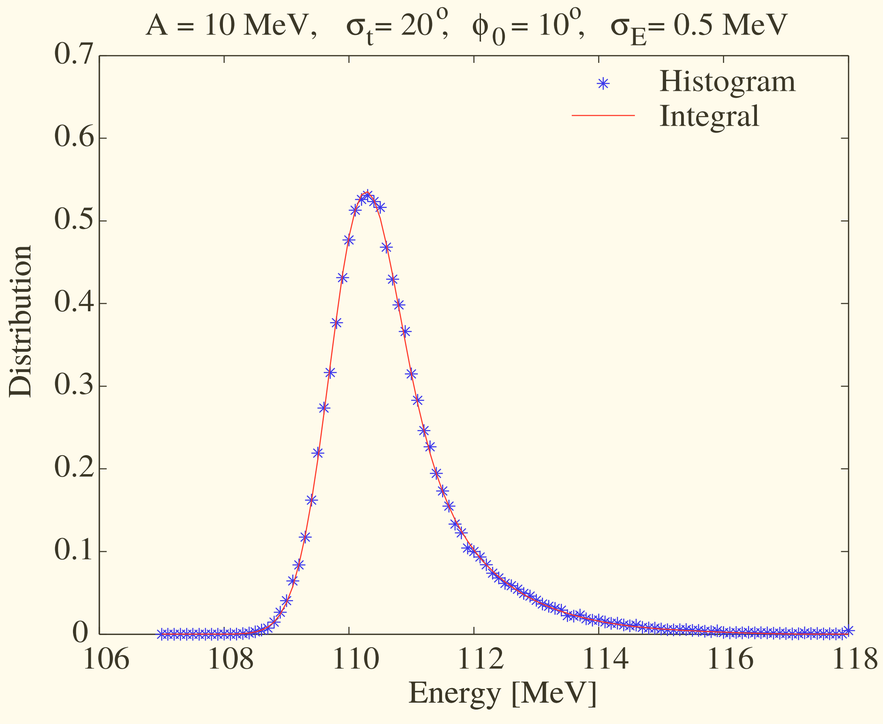
$$\delta(g(x)) = \sum_{zeros} \frac{\delta(x-x_0)}{|g'(x_0)|}$$

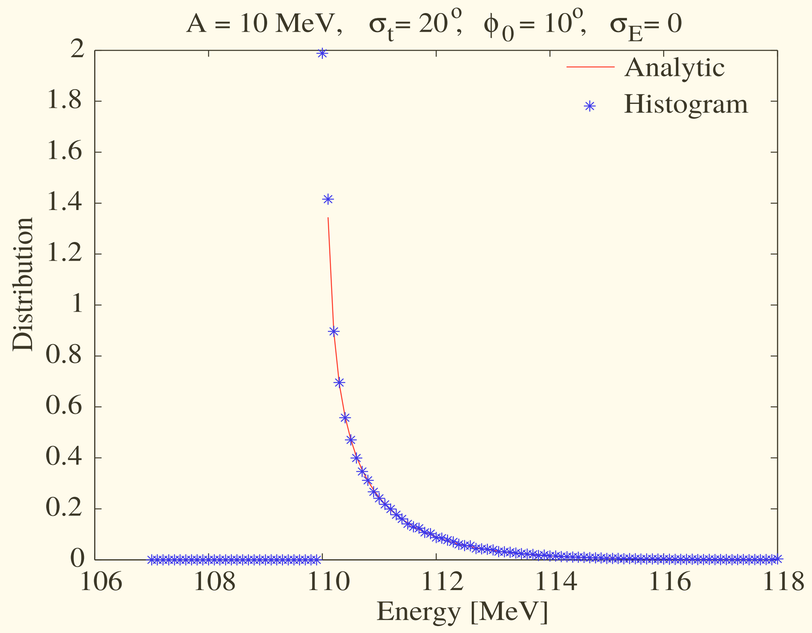
$$\Phi(E_1) = \frac{1}{\sqrt{2\pi}\sigma_t} \frac{1}{\sqrt{A^2 - (E_1 - E_0)^2}} \times \left\{ \exp\left[-\frac{(\arccos((E_0 - E_1)/A) - \phi_0)^2}{2\sigma_t^2} \right] + \exp\left[-\frac{(\arccos((E_0 - E_1)/A) + \phi_0)^2}{2\sigma_t^2} \right] \right\}$$

Finite initial energy spread of incoming beam

Initial $$\Psi_0(E-E_0) = \frac{1}{\sqrt{2\pi}\sigma_E} e^{-(E-E_0)^2/2\sigma_E^2}$$

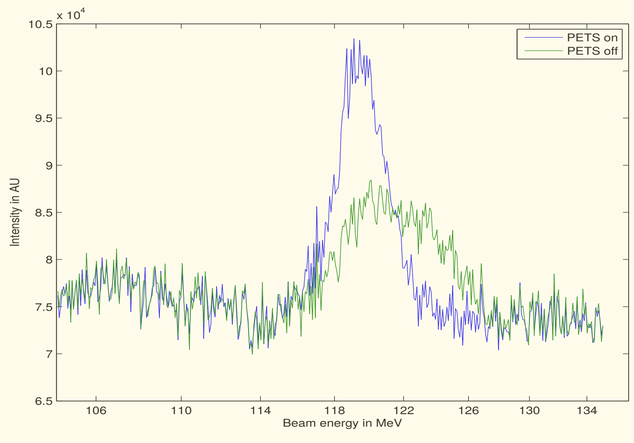
Final $$\Phi(E_1) = \frac{1}{2\pi\sigma_t\sigma_E} \int e^{-(\phi-\phi_0)^2/2\sigma_t^2} \times e^{-(E_1 - E_0 + A\cos\phi)^2/2\sigma_E^2}\, d\phi$$





Dedicated measurements in the TBTS

Contrary to expectations
- PETS OFF: energy spread has higher average (ok) and is wider (initially surprising).
- PETS ON: lower energy (ok) and narrower spread.



Interpretation: PETS OFF mechanism creates varying interference pattern of the RF field in the PETS that affects different bunches in a train with varying amplitude and phase.

We thank W. Farabolini for his help in the control room and R. Corsini with the CTF3 crew for support during the experiments. This work is supported by a grant from the Knut and AliceWallenberg Foundation and the Swedish Research Council DNR-2011-6305.