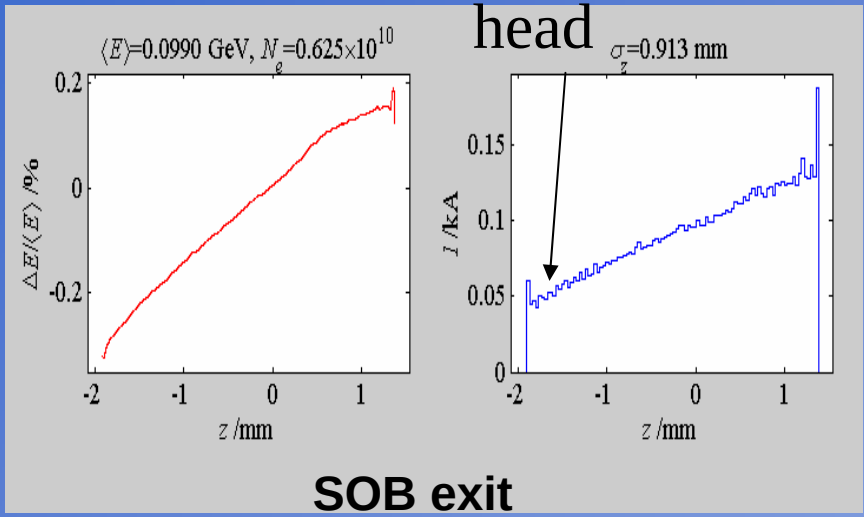
Ramping current distribution option for the FERMI@ELETTRA photoinjector

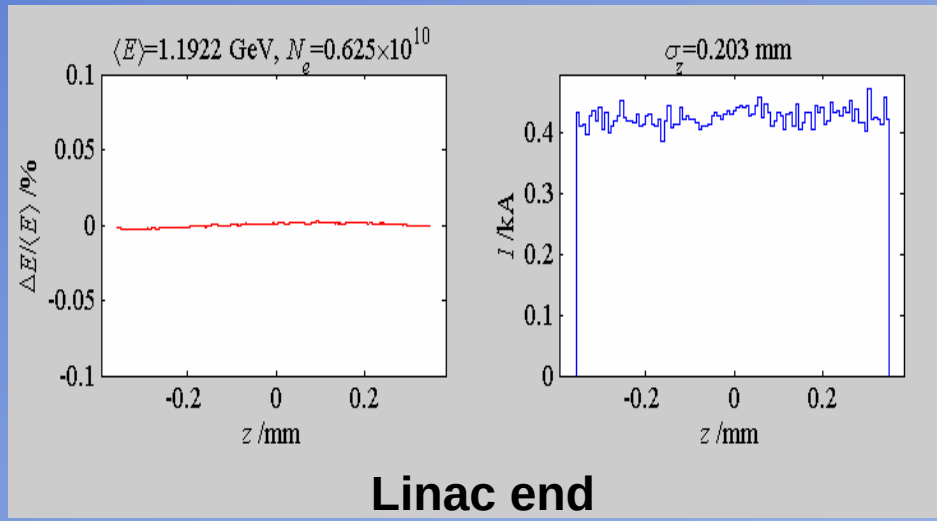
G. Penco

Why a ramping profile ?

- **Input from the S2E group (S. Di Mitri, talk in the WG3):**



SOB exit

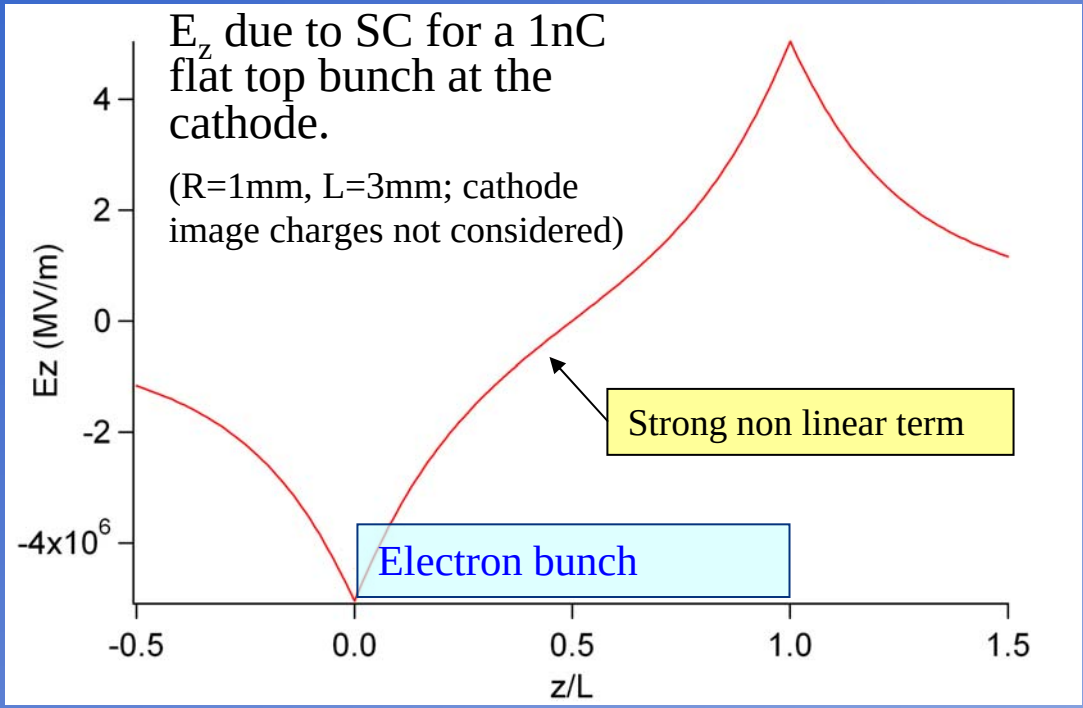


Linac end

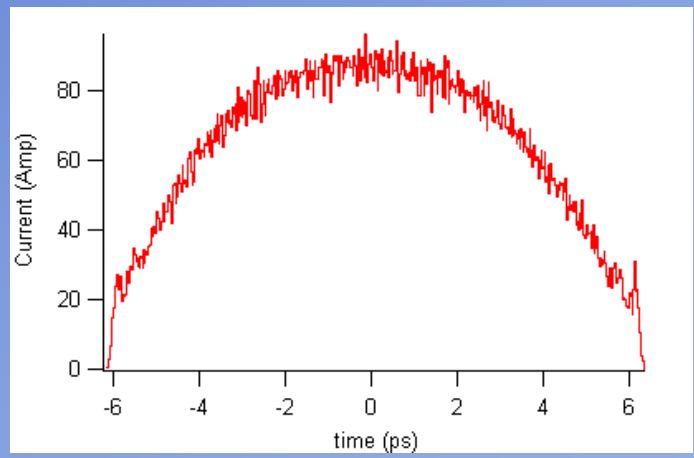
Ref: M. Cornacchia, S. Di Mitri, G. Penco, A.A. Zholents, *"Production of Electron bunches with a Flat Energy and Current Distributions in the FERMI FEL"*, ST/F-TN-06/06

Which current distribution at the cathode?

Space Charge Fields



A flat-top current profile at the cathode is deformed by this space charge field in a parabolic one after fews centimeters:



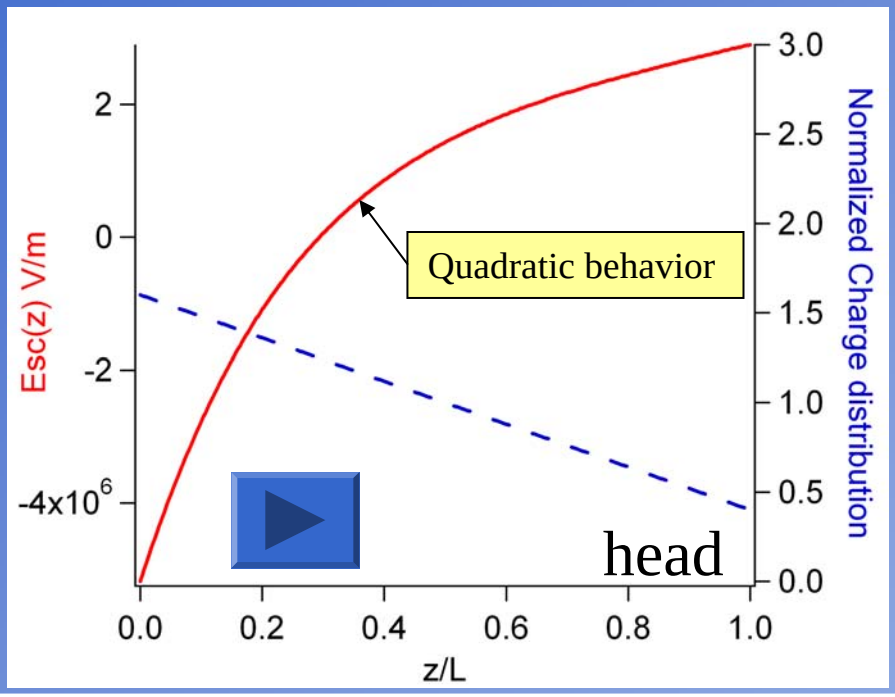
In order to have a defined ramping charge distribution at the end of the photoinjector, the strong non-linearity of the space charge field has to be considered.

Ramping charge distribution - linear

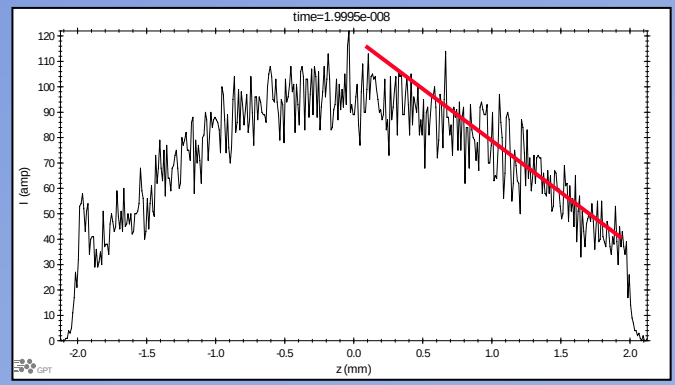
Long. SC field on axis @ the cathode (γ~1) in case of a charge distribution $\rho(z)$:

$$E_Z^{SC}(z) = \int_0^L \frac{Q}{2\pi\varepsilon_0 R^2 L} \cdot \rho(z') \left[\frac{z'-z}{\sqrt{(z'-z)^2 + R^2}} - \frac{|z'-z|}{z'-z} \right] \cdot dz'$$

Linear Current Profile

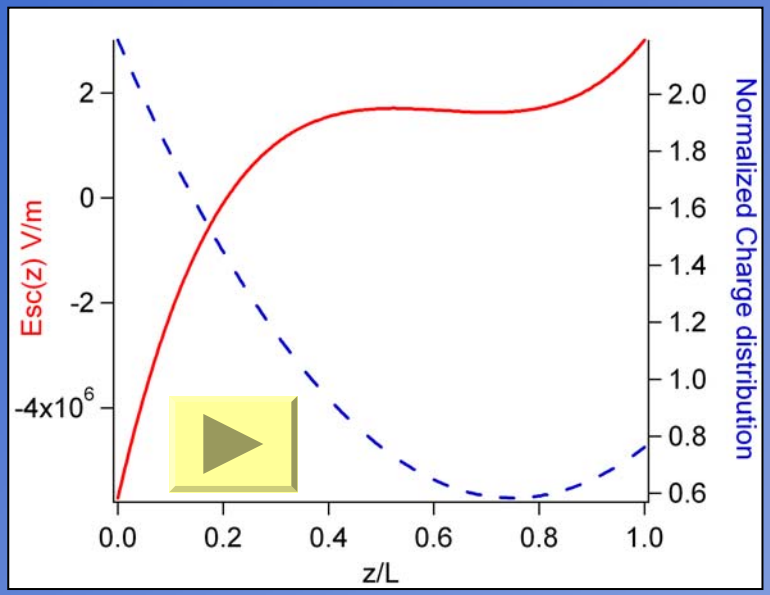


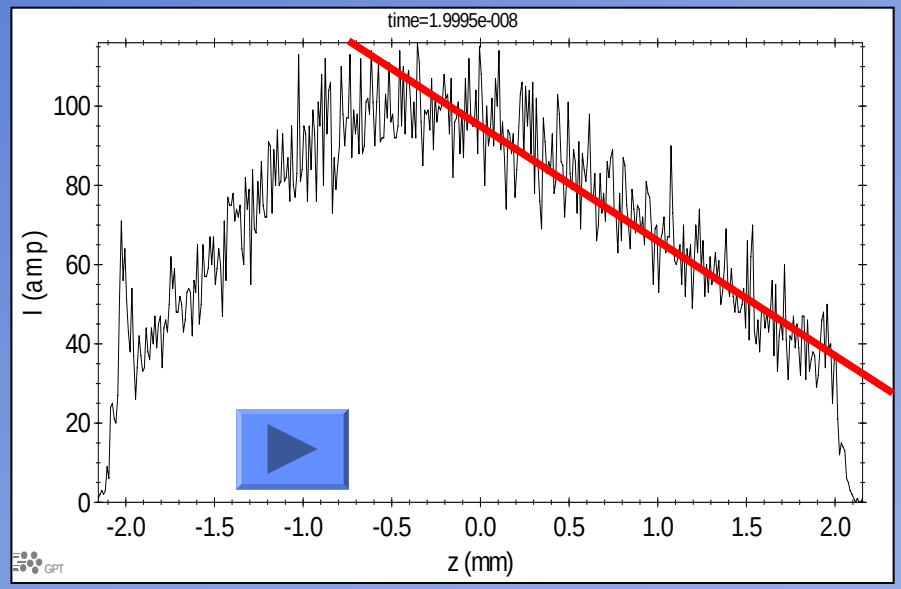
The ramp in the charge distribution is strongly deteriorated during the transport:



Ramping charge distribution - quadratic

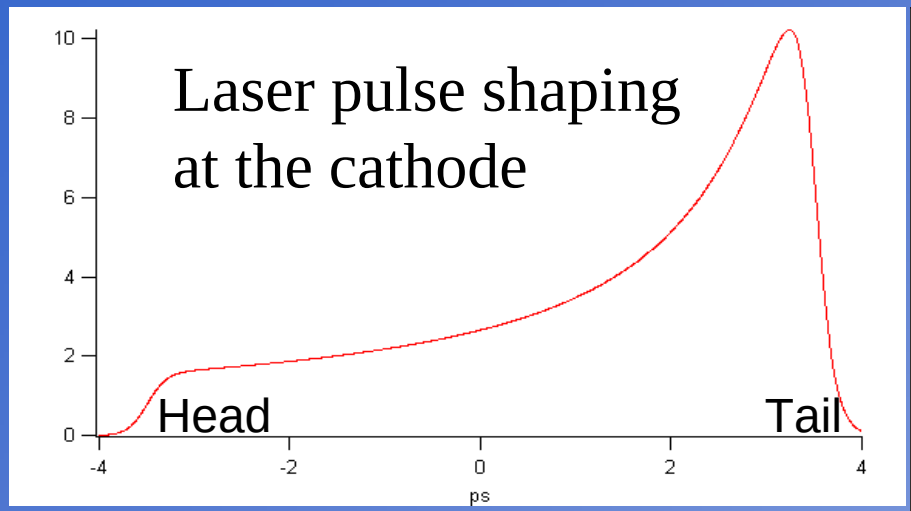
35% of the bunch

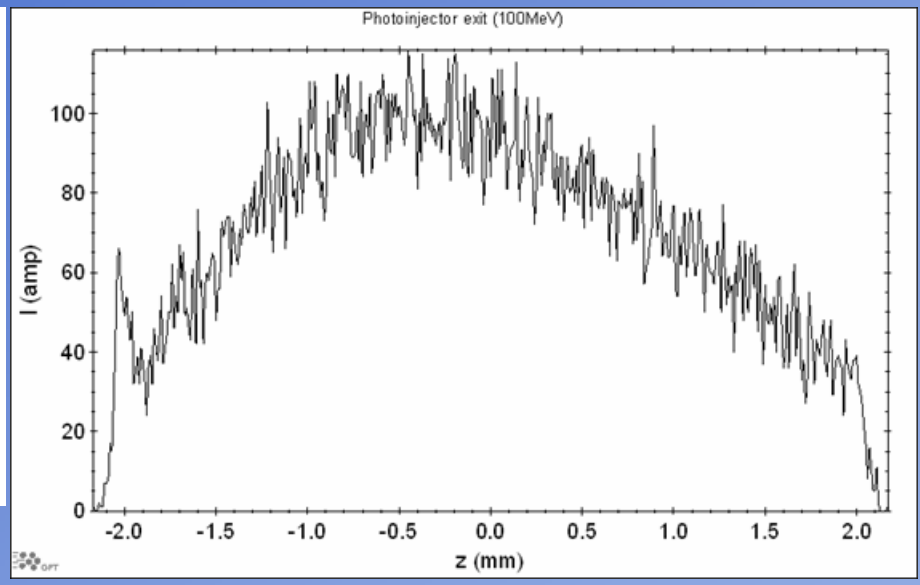




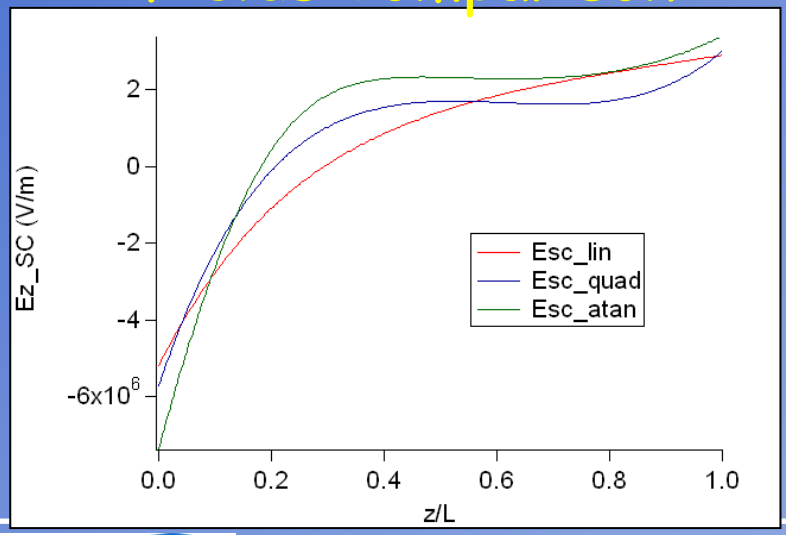
The quadratic ramp in the charge distribution is modified in a linear one during the transport and the high peak electrons are spread out on the left side.

An optional laser Shaping for Ramping case





Fields Comparison



For more details on the pulse shaping process:
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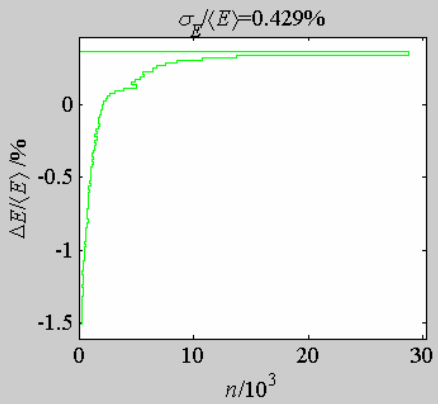
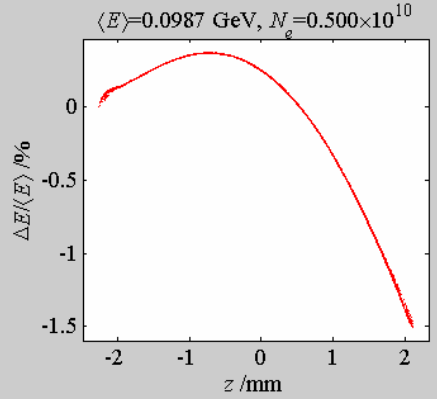
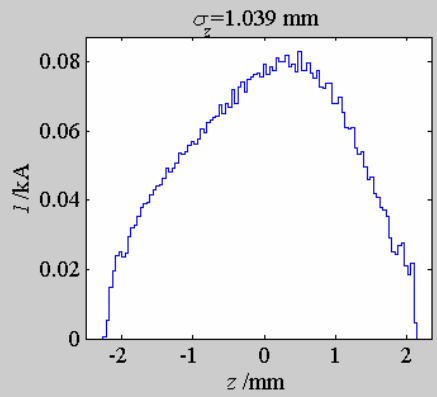
LiTrack results (courtesy of M.Cornacchia)

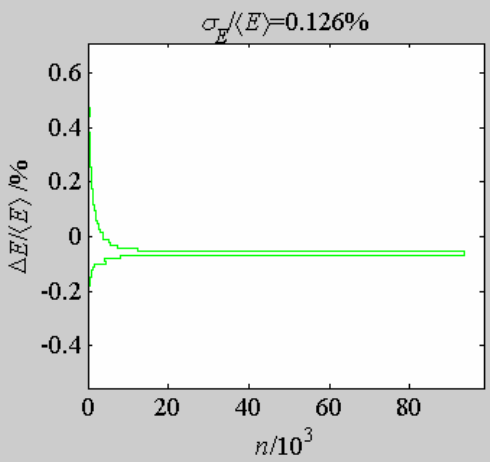
PHOTOINJECTOR EXIT

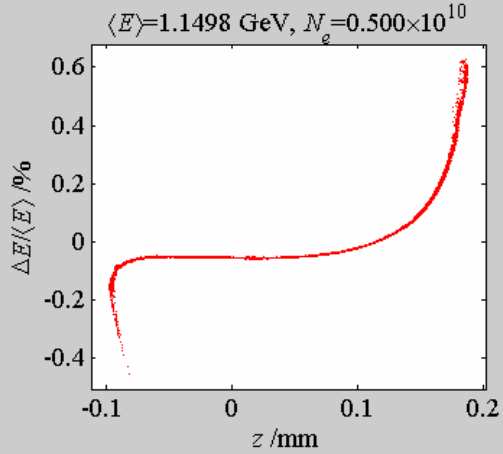


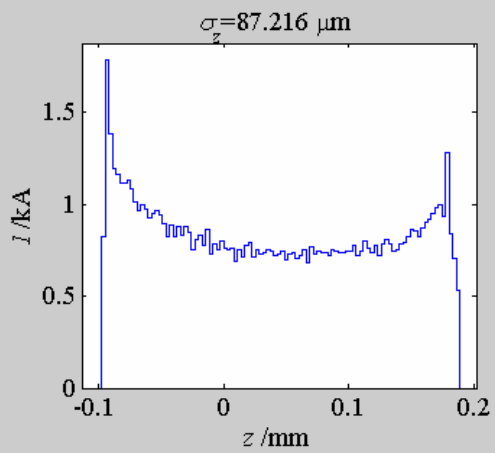




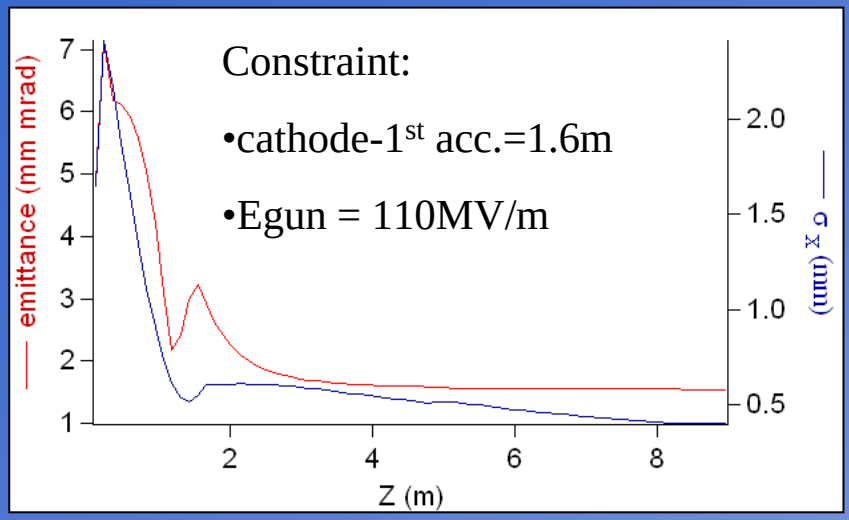
LINAC EXIT

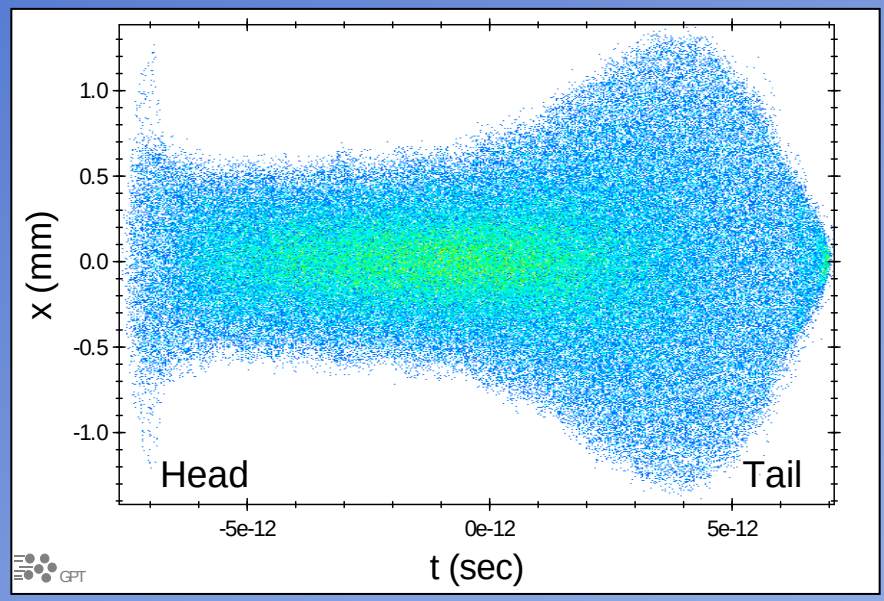


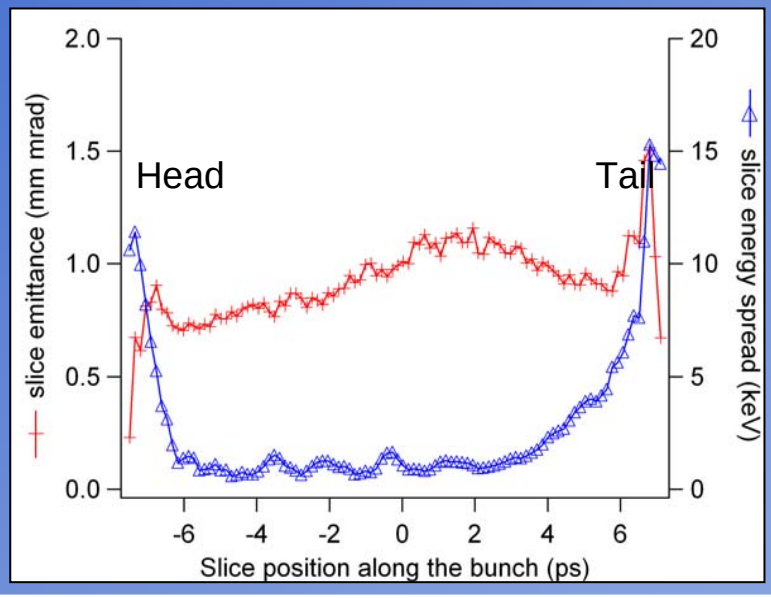




Emittance compensation issues







ε_{proj} = 1.39 mm mrad

$\varepsilon_{proj.\ 80\%}$ = 1.21 mm mrad

$\langle\varepsilon_{slice}\rangle_{0..100}$ = 0.92 mm mrad

$\langle\varepsilon_{slice}\rangle_{10..90}$ = 0.94 mm mrad

Work in progress…

- Study the evolution of the peak current;
- Finding the best longitudinal pulse shaping to obtain the required linear ramp (radial shaping can limit deterioration?);
- Sensitivities studies of the ramp configuration;
- Simulating a longitudinal distribution as much as possible close to a "realistic" laser pulse shaping profile;
- Optimize the emittance compensation process.