Three-Dimensional Space Charge Oscillations in a Hybrid Photoinjector

M. Carillo[1,4], M. Behtouei[2], F.Bosco[1,4], L. Faillace[1,2], A.Giribono[2], L.Giuliano[1,4], A. Mostacci[1,4], M.Migliorati[1,4], B. Spataro[2], J. Rosenzweig[3], C. Vaccarezza[2], L.Palumbo[1,4]

[1]La Sapienza University of Rome, 00161 Rome, Italy

[2]INFN-LNF, 00044 Frascati, Italy

[3]UCLA, Los Angeles, 90095 California, USA

[4] INFN-Sez.Roma1, 00161 Roma, Italy

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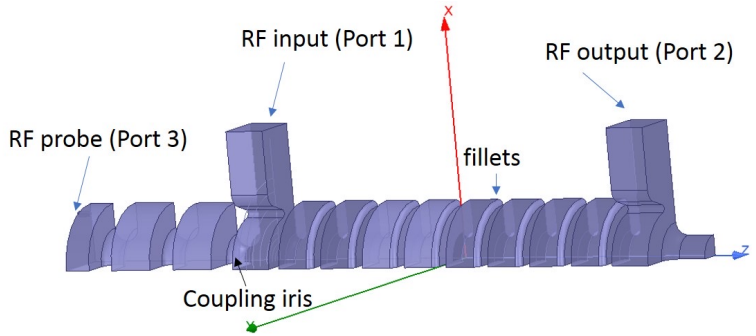
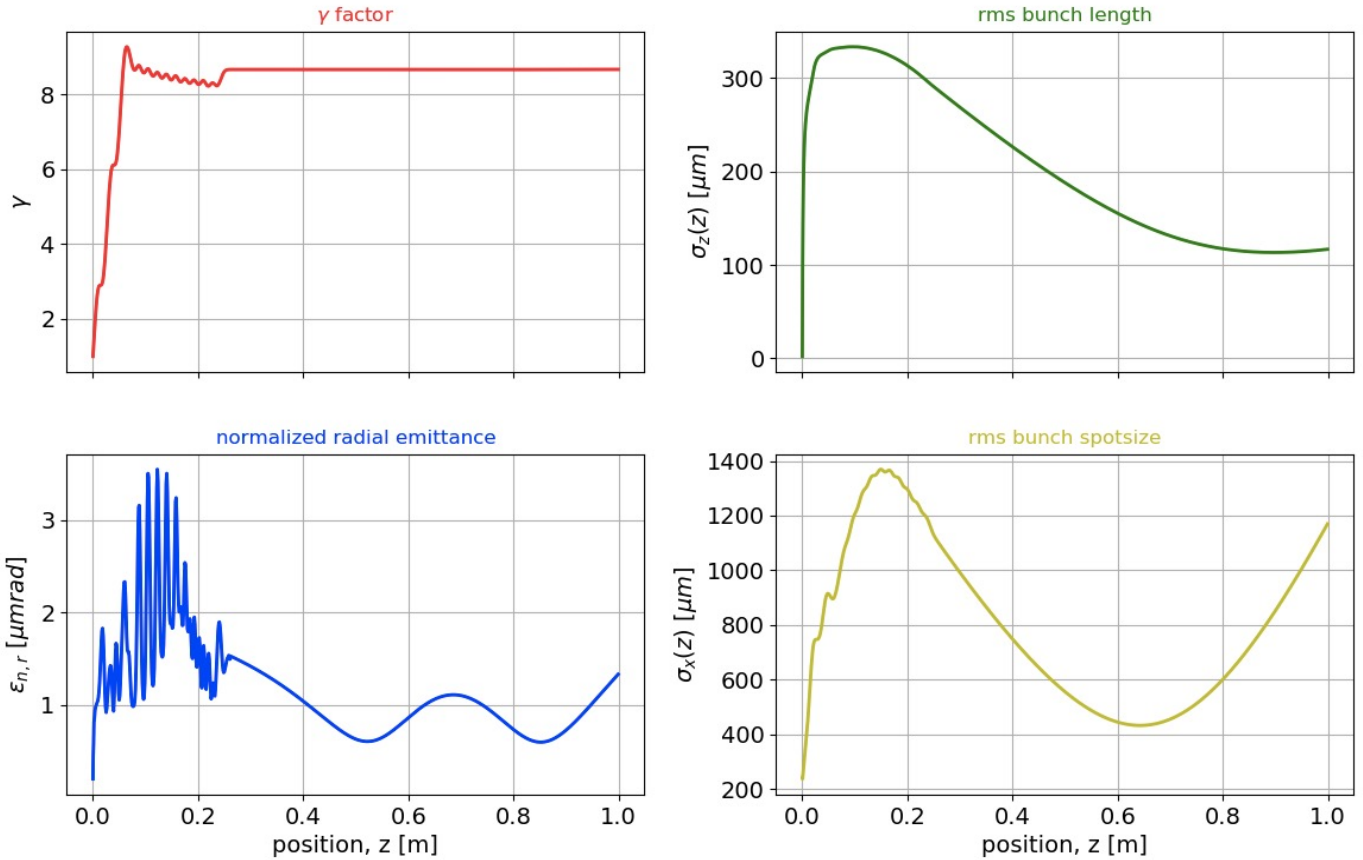
carillo.159653@studenti.uniroma1.it

1. Introduction: Hybrid Photoinjector



Parameter	Value
Beam Charge	250 pC
Sigma x (cut@1-sigma)	500 um
Laser Pulse Length	0.5 ps
E-field at cathode	120 MV/m
Peak Bz	0.27 T
# particles	50,000

L. Faillace *et al.*, *Beam dynamics for a high field C-band hybrid photoinjector*, this conference.



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2. Slice Analysis:

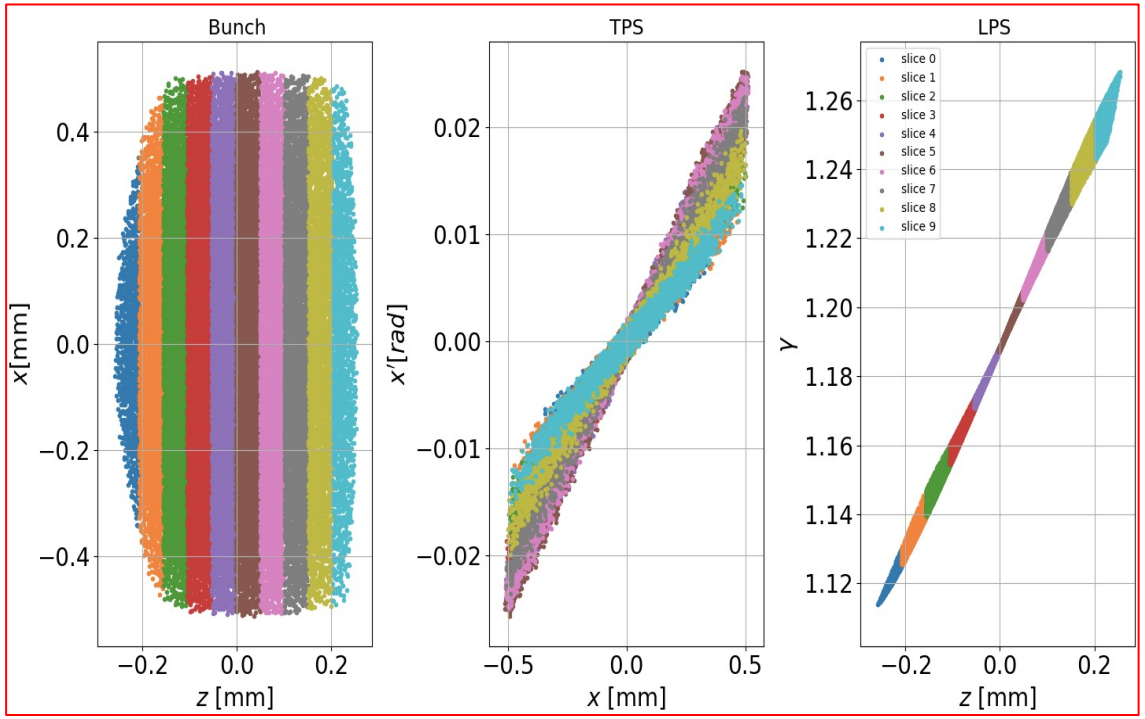
Bunch splitting in n=10 slice from cathode

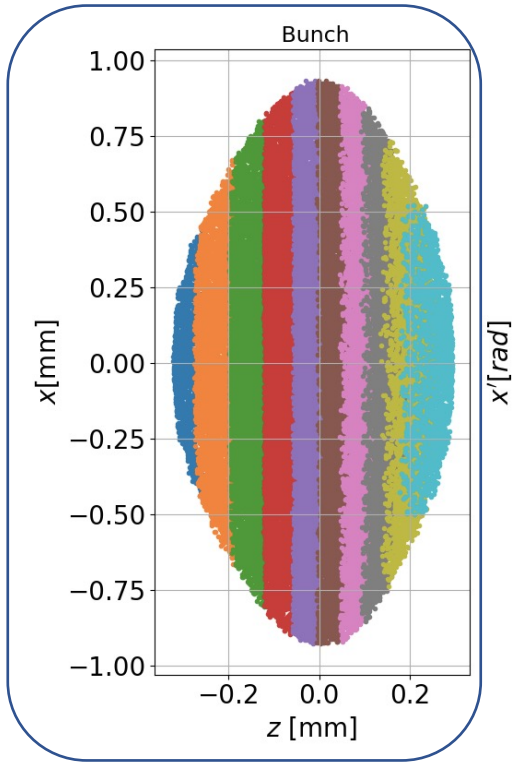
Slice dynamics observation

Bunch projection

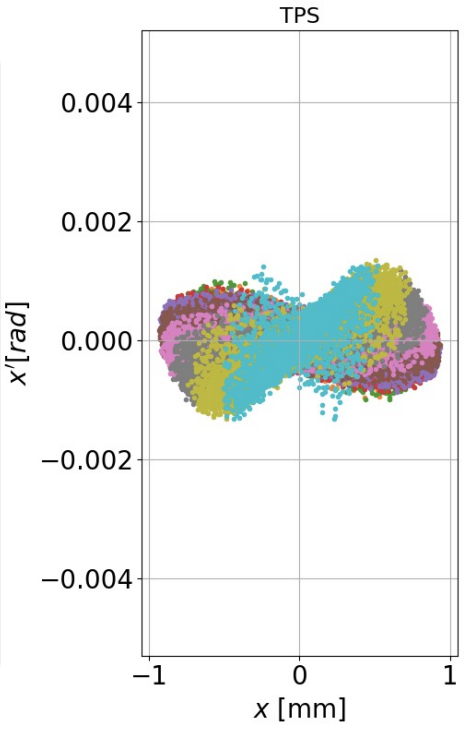
Transverse phase space

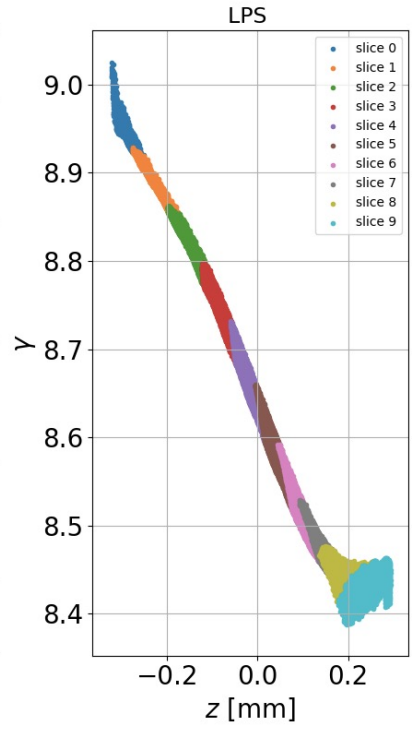
Longitudinal phase space





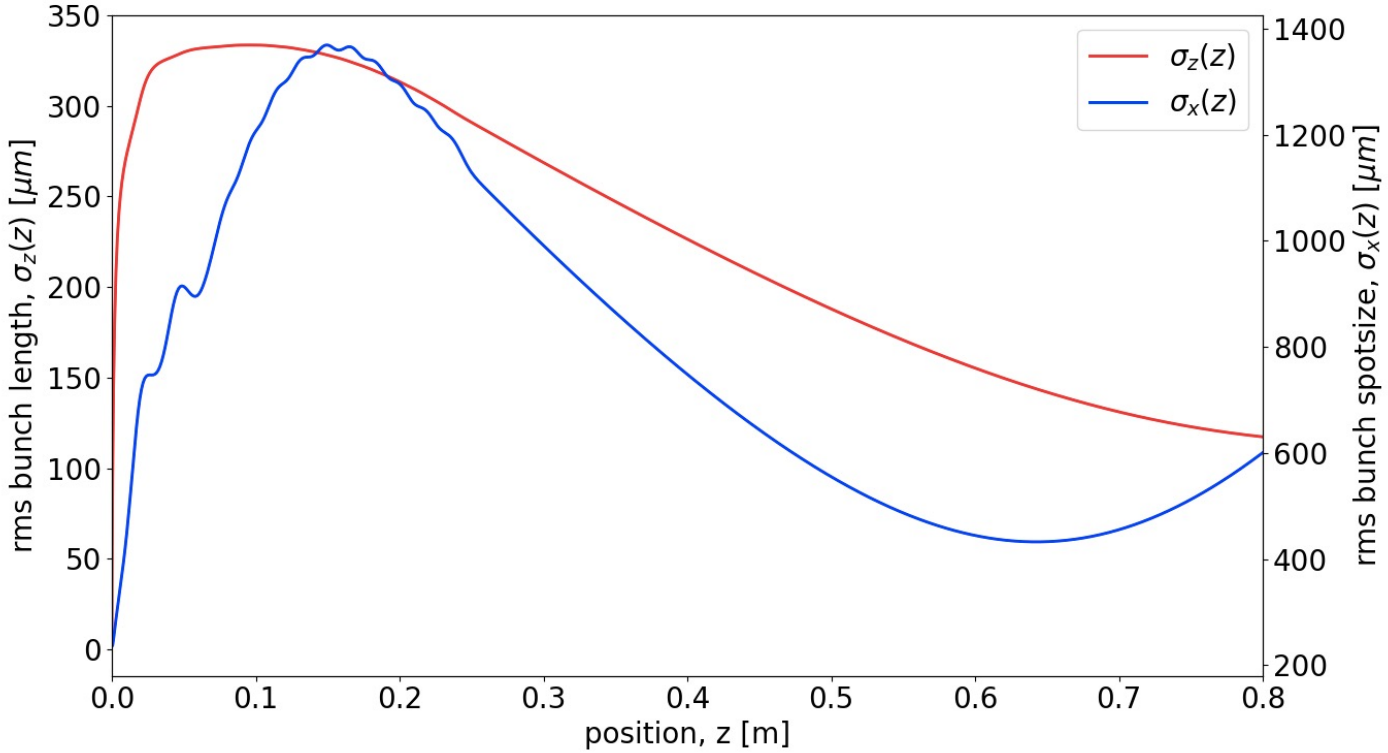
Elliptical shape





(waist)

3. Triple waist: Envelope equation



Drift region: only space charge term is dominant

$$\sigma_x'' = \frac{\kappa}{\sigma_x}$$

where: $\kappa = \frac{I}{2I_A}$ is the Perveance term and I is the bunch current, that is function of σ_z: $I \propto \frac{1}{\sigma_z}$

Triple waist approximation:

$\sigma_z \sim \sigma_x$

$$\sigma_x'' = \frac{k}{\sigma_x^2}$$

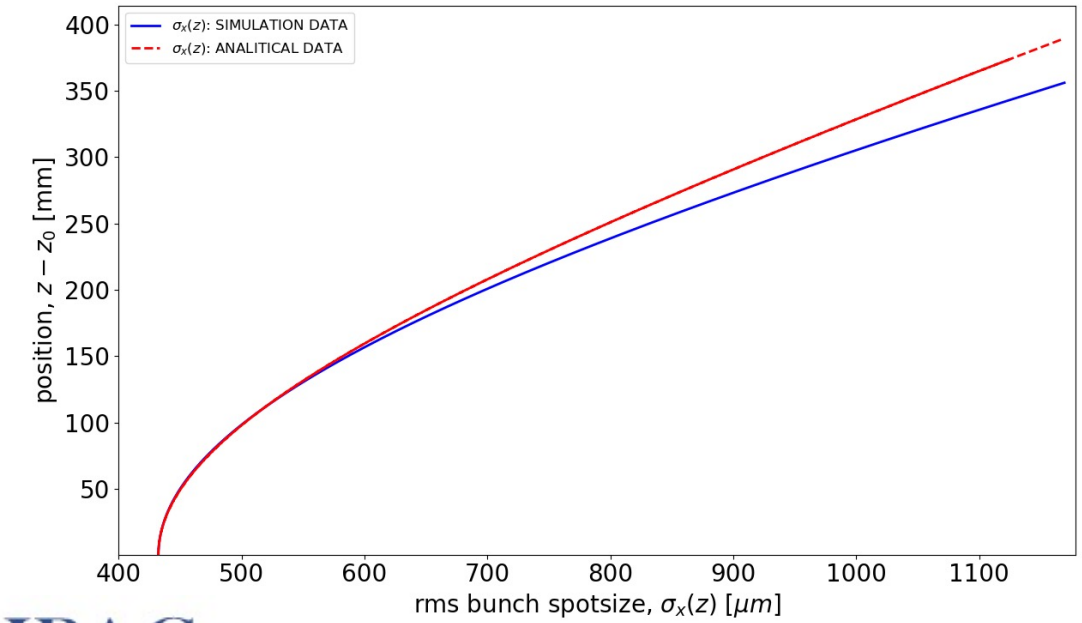
3. Triple waist: Envelope solution

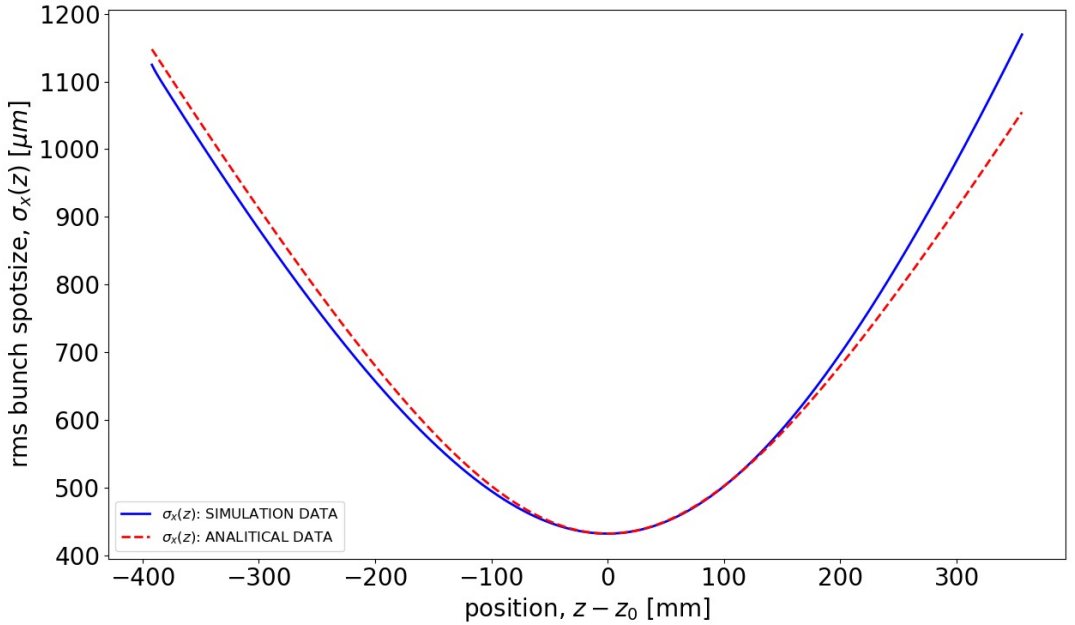
- Exact solution:

$$z = \frac{\sigma_0^{3/2}}{\sqrt{2k}}\left[ln\left(\sqrt{\frac{\sigma}{\sigma_0}} + \sqrt{\frac{\sigma}{\sigma_0} - 1}\right) + \sqrt{\frac{\sigma}{\sigma_0}\left(\frac{\sigma}{\sigma_0} - 1\right)}\right] + z_0$$

- Perturbative solution:

$$\sigma(z) = \sigma_0\left[\sqrt{\frac{k}{2\sigma_0}}\left(\frac{z}{\sigma_0}\right) \cdot \tan^{-1}\left(\sqrt{\frac{k}{2\sigma_0}}\left(\frac{z}{\sigma_0}\right)\right)\right]$$





4. Conclusion:

- ✓ Beam dynamics have been studied.
- ✓ Through the slice analysis, the properties and physical effects of the beam have been observed, in particular the evolution of the beam shape has allowed us to use the right distribution in analytic studies.
- ✓ The beam envelope equation in drift was analysed and compared with simulations, an excellent agreement was found.

Future goals:

- ➢ Solving the longitudinal equation in drift and so obtaining the exact transverse envelope equation.
- ➢ Studying emittance compensation.

Thank you for your attention!