Reconstruction of longitudinal bunches profiles at FACET, SLAC

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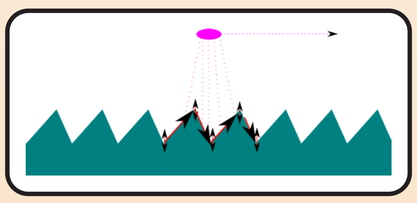
Radiation de Smith-Purcell

- Smith-Purcell radiation is emitted when a charged particle passes close to the surface of a metallic grating.
- If the bunch is short compared to the wavelength emitted then the radiation is emitted coherently.
- Coherent emission involves the Fourier transform of the longitudinal profile of the electron bunch:

$$\left(\frac{dI}{d\Omega d\omega}\right)_{N_e} \approx \left(\frac{dI}{d\Omega d\omega}\right)_{SP} \left[N_e + N_e^2 |F(\omega)|^2 G(\sigma_x, \sigma_y)\right]$$

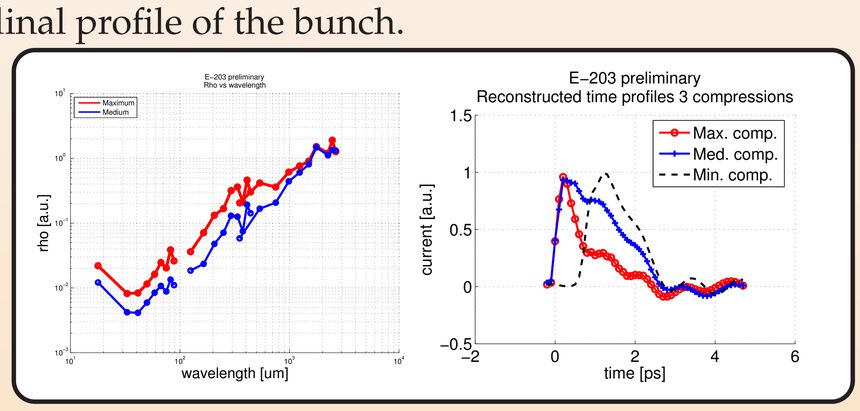


E-203 installation at FACET, SLAC

- FACET (Facility for Advanced Accelerator Experimental Tests) linear accelerator provides 23 GeV electron bunches, with a duration of hundred femtoseconds.
- E-203 is placed behind the bunch compressor chicane, so that several compressions are available for the bunches.
- 11 pyroelectric detectors measure the emitted radiation. An assembly of filters is placed in front of them to reject background.
- 3 gratings with 3 different pitches to cover a range from 20 μm to 2000 μm and a blank piece mounted on a carousel. A motorized arm can expose each grating to the beam.

Reconstructions of profiles

Measuring the intensity emitted by Coherent Smith-Purcell radiation allows us to reconstruct the bunch spectrum. Then we can access the longitudinal profile of the bunch.



Motivations to design a single-shot device

☞ Plasma wakefield accelerators have a limited shot to shot stability.

☞ Do faster measurements at conventional accelerators for a more accurate profile (when the accelerator is slightly unstable).

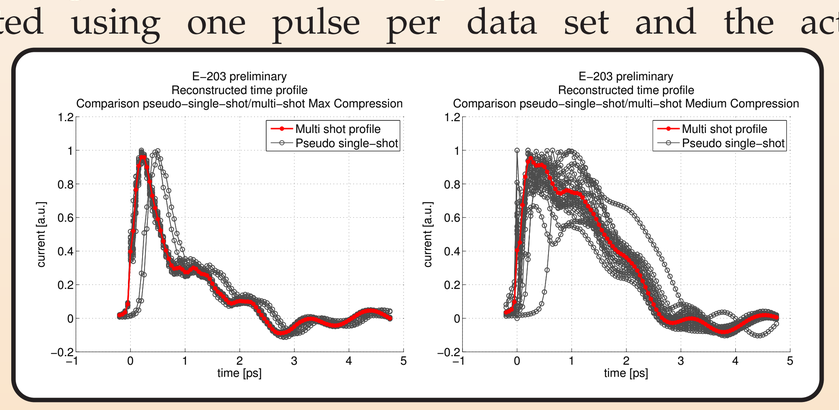
☞ Reduce the number of pulses needed.

References

- **G. Doucas et al.** First measurements of the longitudinal bunch profile of a 28.5 GeV beam using coherent Smith-Purcell radiation. Phys.Rev.ST Accel.Beams 12:032803,2009.
- **O. Grimm and P. Schmüser** Principles of Longitudinal Beam Diagnostics with Coherent Radiation, TESLA FEL 2006-03

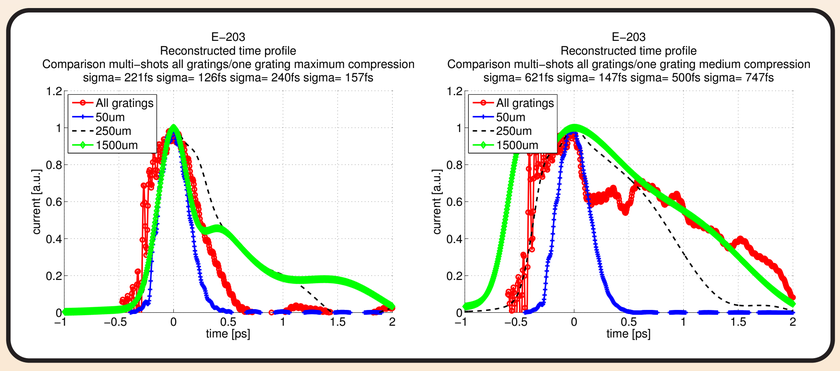
Averaging over many pulses

We use an averaging over a hundred pulses. We want to know if there is a good reproducibility between the pulses. The following images show the comparison between the profile reconstructed using one pulse per data set and the actual profile.



Use of a single grating

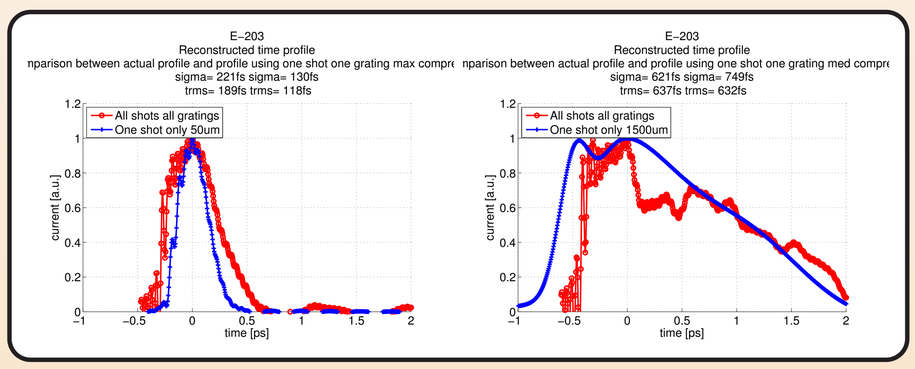
- We use one grating instead of three.
  ☞ One measurement is two data sets: one for the grating with the corresponding filters and one for the background with the corresponding filters.



- Highly compressed bunch: the 50 μm grating profile is the closest from the actual one. Indeed the high frequencies contribute the most.
- Medium bunch compression, the lowest frequencies dominate. Both 250 μm and 1500 μm grating profiles give good estimate of the actual one.

Toward a single-shot measurement

- We use one grating instead of three and one pulse per data set instead of 200.



☞ Reconstructed profile close to the actual one.

Conclusions and outlook

At the moment we use 6 data sets and about 100 shots per grating to reconstruct a profile. To come closer from a single-shot monitor, we can reduce the number of pulses from 1200 to 2 while still reconstructing an accurate profile. To build a real single-shot device will require a modification of the geometry of the experiment to measure simultaneously the signal and the background. This is being investigated in the LINAC of the french synchrotron SOLEIL. We also plan to design a single-shot detector for a laser driven plasma wakefield accelerator.