Recent Progress in the Study of Smith-Purcell Radiation as a Bunch Length Monitor

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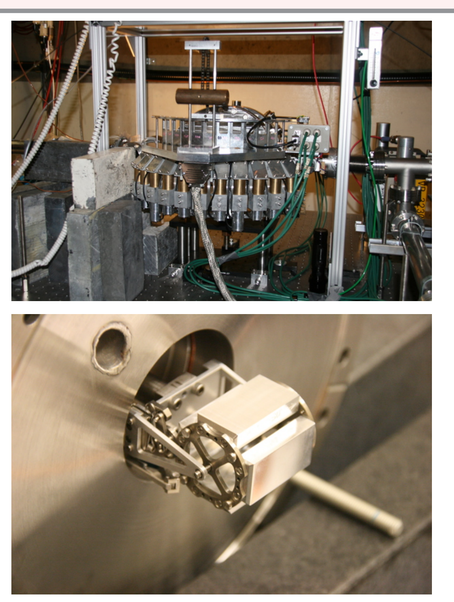
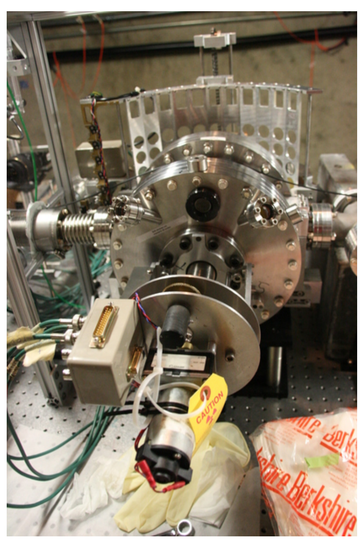
Coherent Radiation as a bunch profile monitor

- Smith-Purcell radiation is produced when a bunch of charged particles passes above a grating.
- Coherent emission encodes the form factor (Fourier transform) of the bunch longitudinal profile:

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

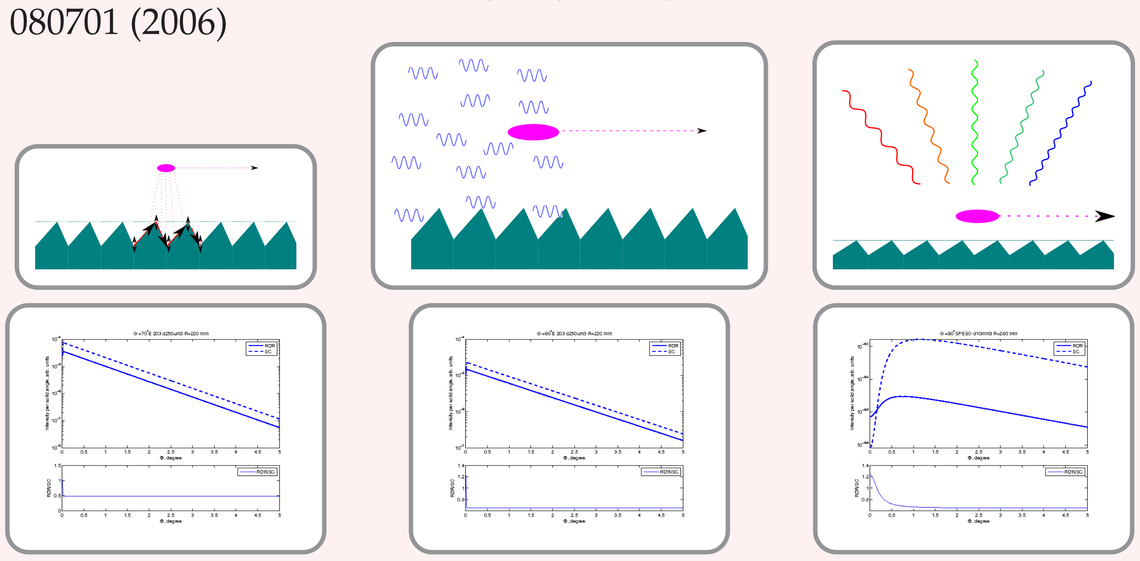
☞ Can be used as a diagnostic to measure the longitudinal profile of an electron bunch.
☞ See Andrews et al., Phys. Rev. ST Accel. Beams 17, 052802.
☞ Several theories to describe the single electron yield (SEY).





Theoretical discrepancies

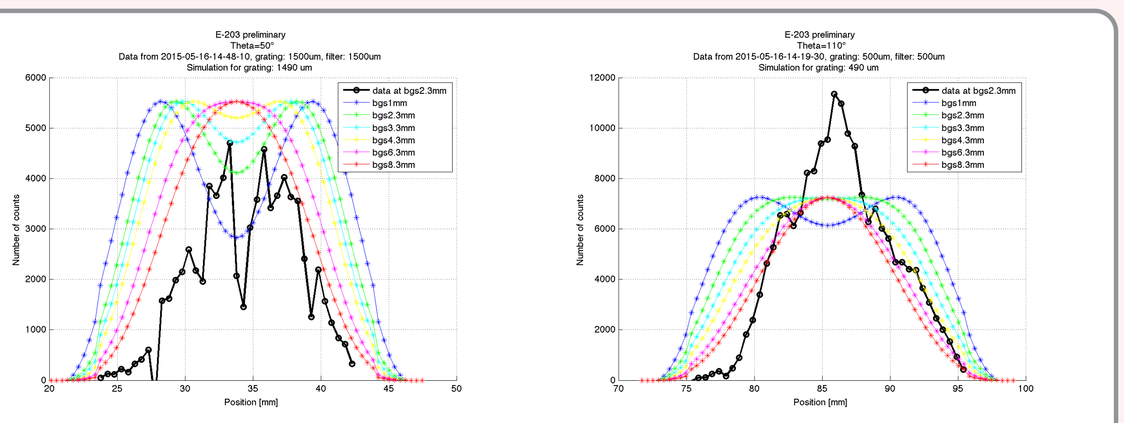
- There are several theories that describe the single electron yield
- Dipole radiation: Ishiguro and Tako, Optica Acta (GB) 8 1961 25
- Diffracted evanescent wave:
  G. Toraldo di Francia, Nuovo Cimento, 16 (1960) 61
- Comparison paper:
  D.V. Karlovets and A. P. Potylitsyn, Phys. Rev. ST Accel. Beams 9, 080701 (2006)



- The theoretical discrepancies lead to different SEY intensity and distribution.
- However at the facilities where we make our measurements these differences are of the same order than the experimental errors (pyro calibration, beam parameters,...).

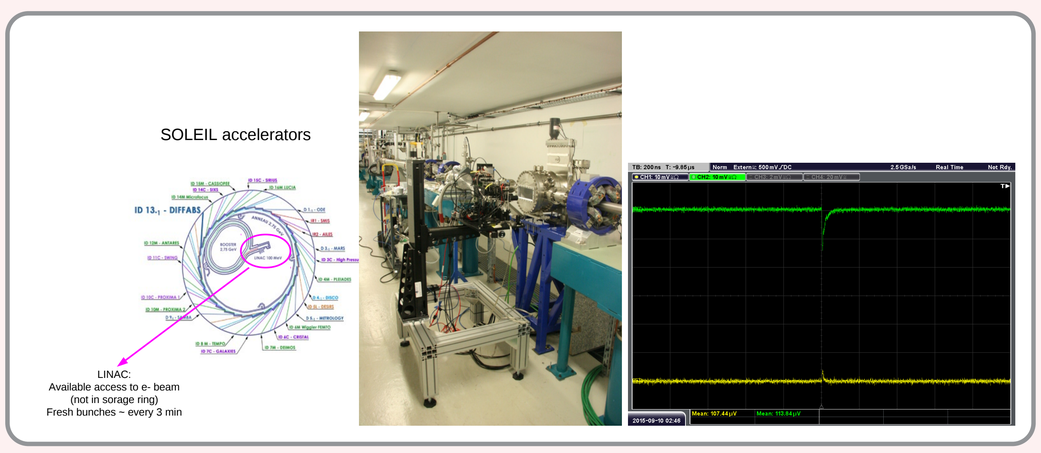
Polar signal distribution (E-203 at FACET)

- FACET: 20 GeV electrons, sub-picosecond bunches
- Charge 1-3nC, at up to 10Hz
- Longitudinal profile studied and published previously.
- New study: Polar distribution of the signal
  ☞ important for single shot operations
  ☞ interesting discrepancies with theoretical predictions



Test-stand in the SOLEIL LINAC

- The LINAC at SOLEIL can give 100 MeV electron bunches
- 104 x 37pC at 352MHz in multibunch mode every 3 minutes
  or 2 x 0.5 nC every 1.5 minutes



- A 5D robot (3 translations, 2 rotations) will scan the radiation emitted.
- Now regularly acquiring data to produce a 3D map of SPR.

Discussion

- Coherent Smith-Purcell Radiation can be used to reconstruct longitudinal bunch profiles
- Now aiming at improving theoretical description and bunch reconstruction
- New theoretical, simulations and experimental measurements contribute to these improvements.

Reconstruction accuracy

Studies to check the error introduced by the phase recovery.