MOPAB026

Study of a Smith-Purcell Radiation-Based Longitudinal Profile Monitor at the CLIO FEL

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Intro

Smith-Purcell radiation (SPR) occurs when a charged particle move above a metallic periodic structure. The wavelength of the radiation for SPR depends on the observation angle Θ:

$$\lambda = \frac{l}{n}\left(\frac{1}{\beta} - cos\Theta\right) \quad (1)$$

where l is the grating period , Θ is the observation angle.

For one electron the emission spectrum (single electron yield) is given by:

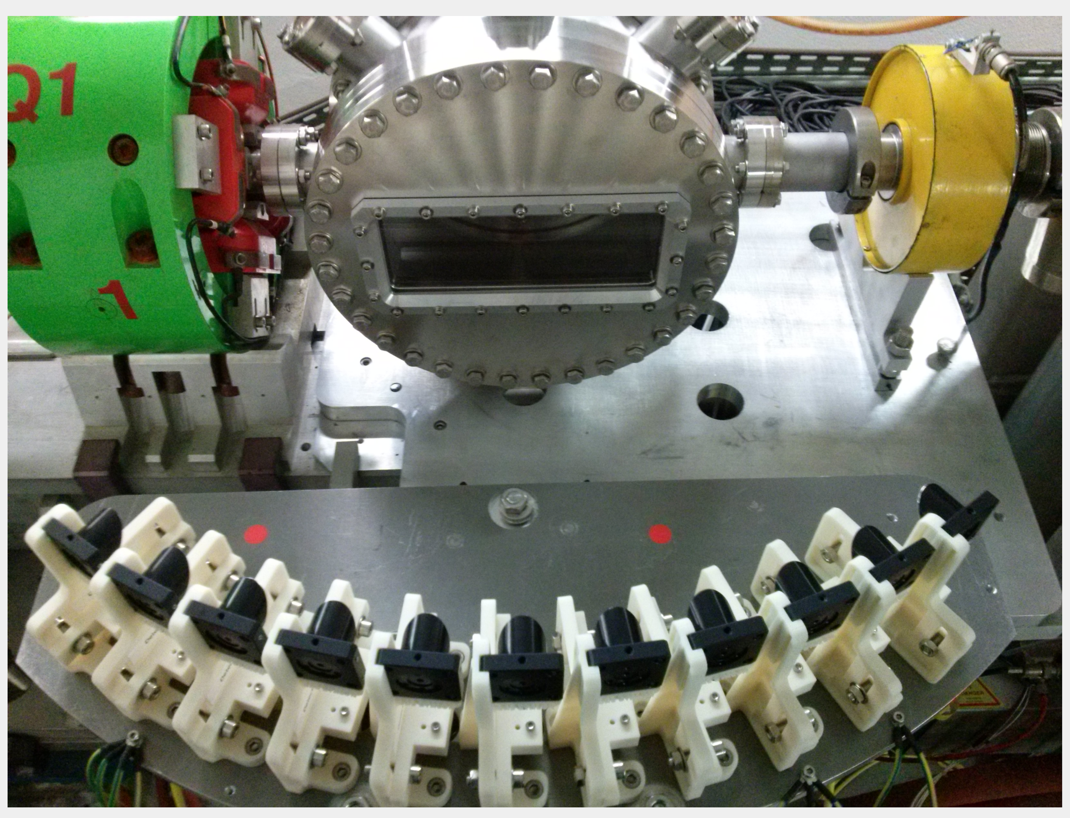
$$\frac{d^2 I_1}{d\omega d\Omega} = \frac{e^2\omega^2 l^2}{4\pi^2 c^3} R^2 exp(-2x_0/\lambda_e(\gamma,\Theta,\phi)) \quad (2)$$

where R^2 is the "grating efficiency factor", x_0 is the beam-grating separation (BGS) and λ_e is the evanescent wavelength. The total spectrum is proportional to the single electron yield:

$$\frac{d^2 I}{d\omega d\Theta} = \frac{d^2 I_1}{d\omega d\Theta}[N + N(N-1)F(\omega)] \quad (3)$$

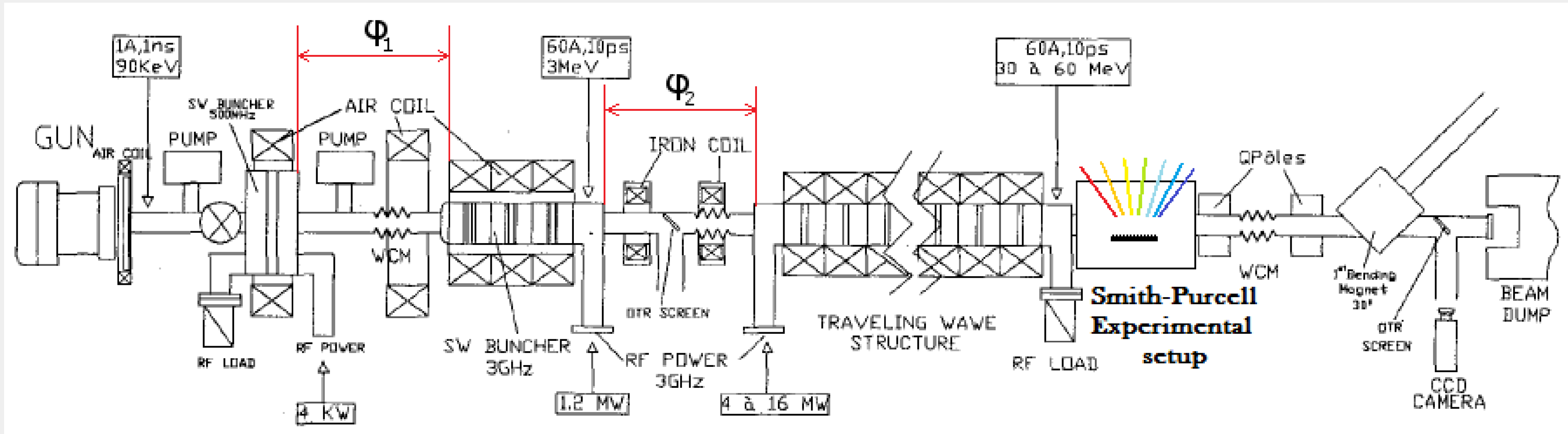
Where N is number of electron in bunch, $F(\omega)$ is the form factor of the time profile of the bunch. Using the phase recovery methods, such as Kramers-Kronig or Hilbert, it is possible to recover the phase and then the time profile of the bunch.

Experimental setup

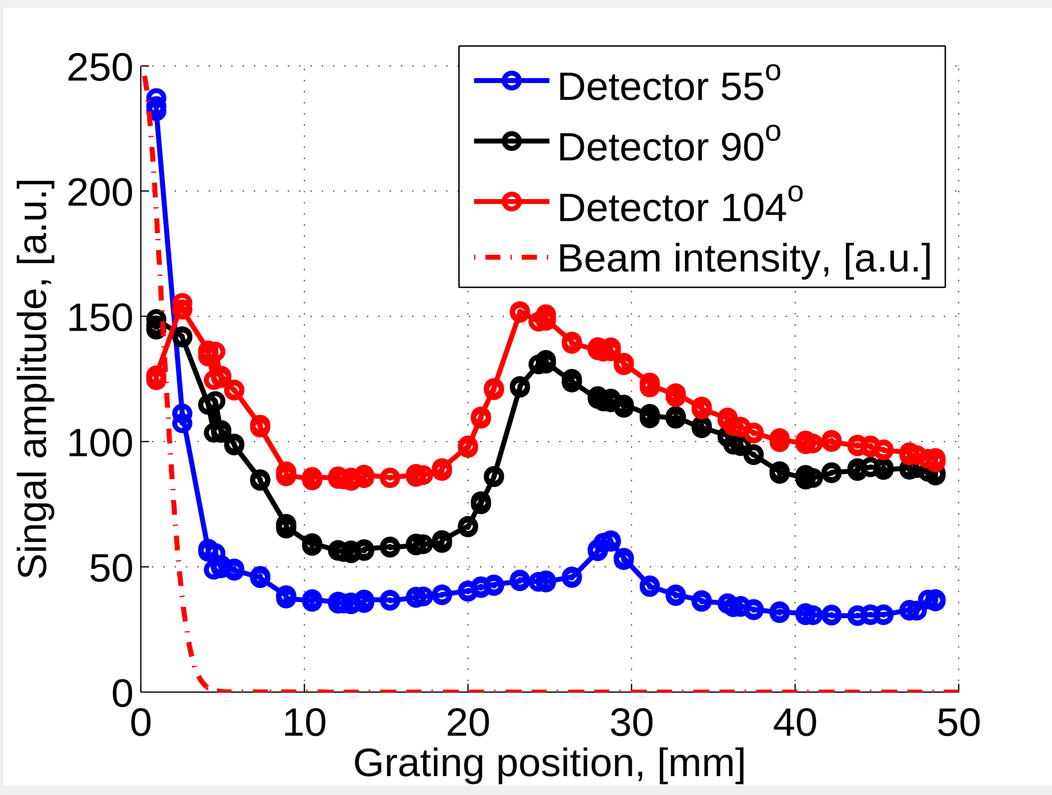


Set of pyrodectors with off axis parabolic mirrors placed equidistantly with 7^o separation and experimental chamber with the grating inside. The experiment uses a $40x20\ mm$ aluminium grating with $3\ mm$ pitch.

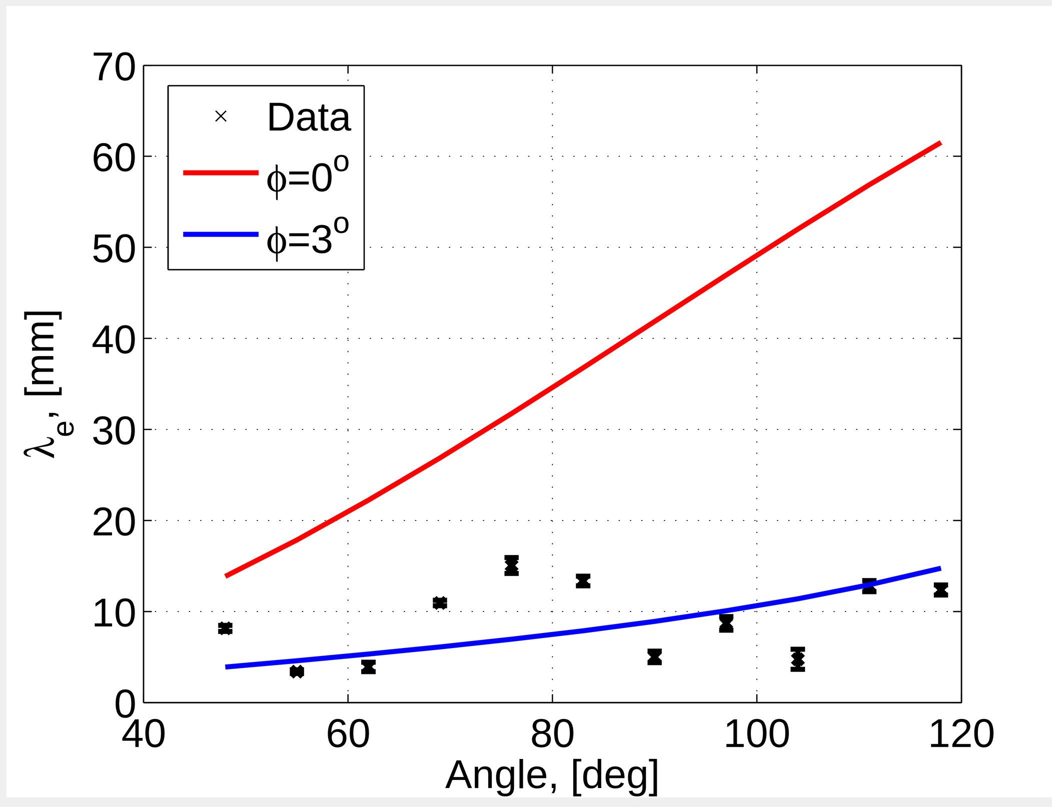
Results



Layout of the CLIO accelerator and position of the experimental setup. For bunch compression the most important parameters are the phases φ_1 and φ_2 . In our experiment we change bunch length by changing φ_1 and while keeping the beam energy constant at $44.3\ MeV$.



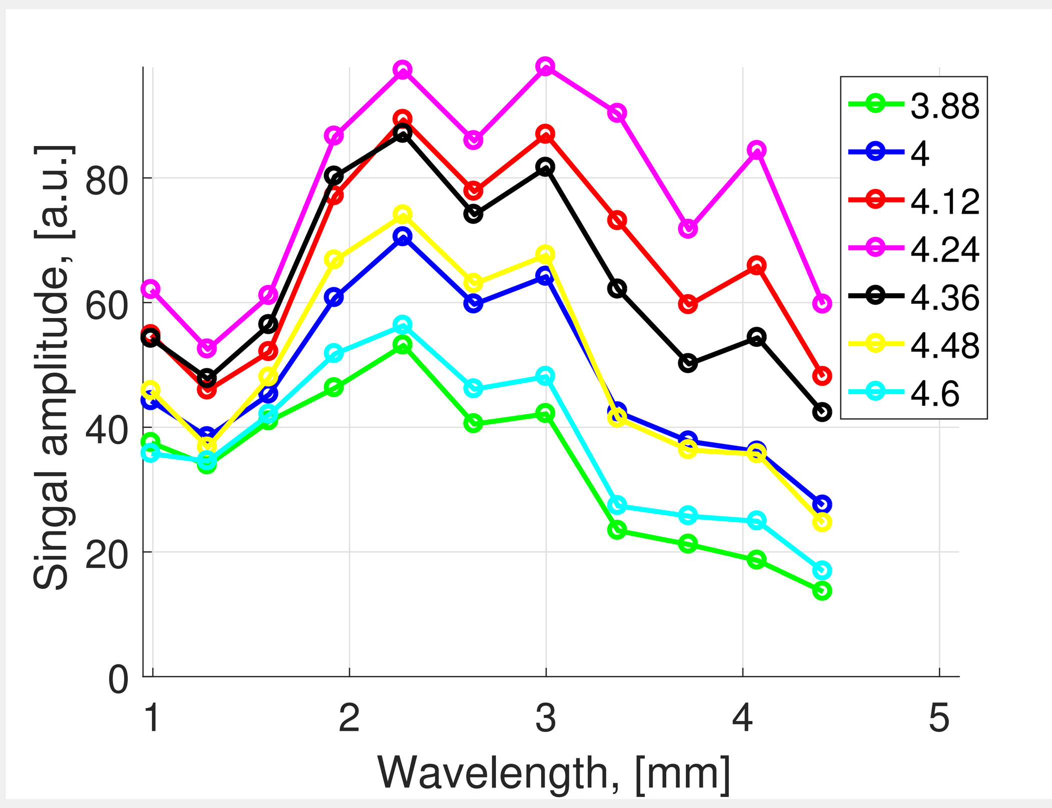
Preliminary results. Amplitude of the signal as function of BSG. FWHM of the beam is 3.1 mm. Zero point correspond to the center of beam. Radiative phenomena for beam-grating separation of about 25 mm which is still under investigation

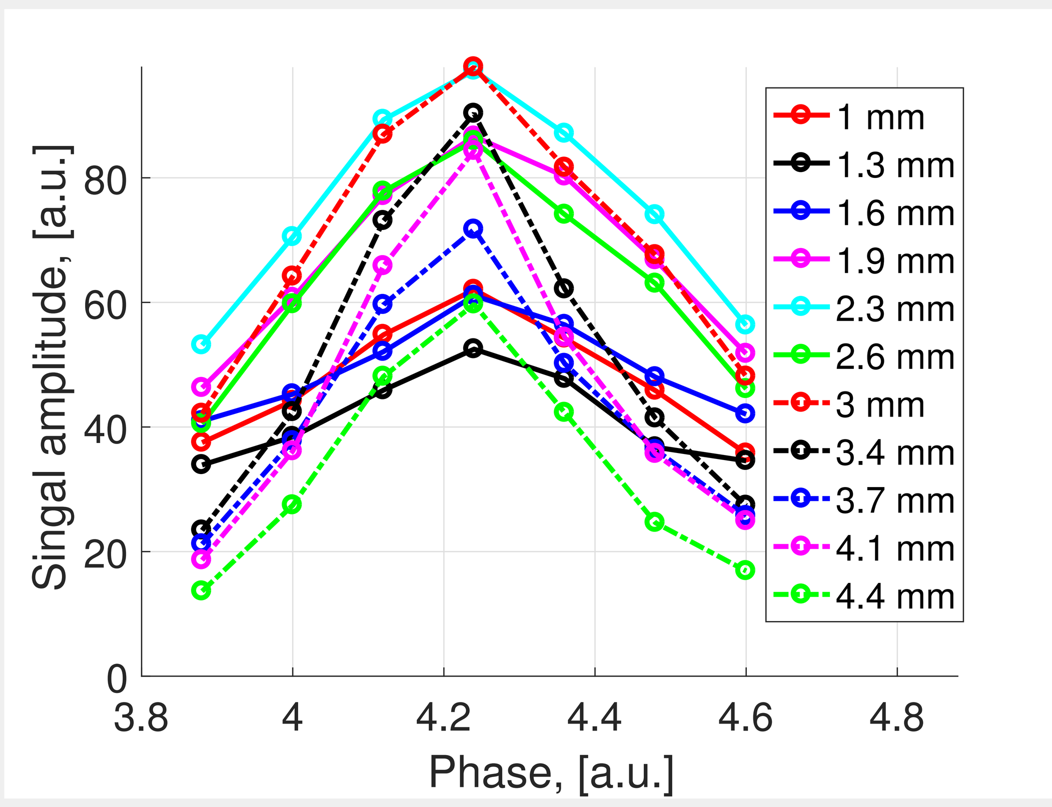


Preliminary results. The data is the decay length of the signal as function of the angle. The red line corresponds to evanescent wavelength of polar angle $\phi = 0^o$ and blue is for $\phi = 3^o$

The result of fit of decay curves for all angles and the average for all phases is presented on the top right figure. The error for the data on the plot correspond to fluctuation over phases, but it is relatively small, so we confirm that this parameter is not dependent on the phase φ_1.

To be sure that the radiation measured is dependent on the bunch length, we change the phase φ_1 between the subharmonic and fundamental bunchers. During this operation beam intensity was stable with $\pm 10\%$.





Preliminary results. Measured spectrum for different phase (left) and change of spectrum components as function of phase (right).

Observed peak at phase phi1 = 4.24 (arbitrary units) corresponds also to the largest emission from the free electron laser i.e. the shortest bunch.The largest emission increase occurs for the longest wavelength, as expected for coherent emission