Comparison of Coherent Smith-Purcell radiation and Coherent Transition Radiation

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Intro

Smith-Purcell radiation and Transition Radiation are two radiative phenomenon that occur in charged particles accelerators.

Coherent Transition Radiation (CTR)

When a relativistic charged particle crosses the interface between two media of different dielectric properties, transition radiation (TR) is emitted.

Coherent Smith-Purcell Radiation (CSPR)

SP radiation occurs when a charged particle move above a metallic periodic structure. The wavelength of the radiation for SP depends on the observing angle according to the following:

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

where l is the grating period, n is the order of radiation, Θ is the observation angle and β is the relativistic velocity. Spectrum calculation is based on the surface current model.
For both phenomena, from the SEY $\frac{d^2 I_1}{d\omega d\Theta}$ the whole spectrum can be derived using the following formula:

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

Where N is the number of electrons in the bunch and $F(\omega)$ is the form factor of the time profile of the bunch.

Conclusion

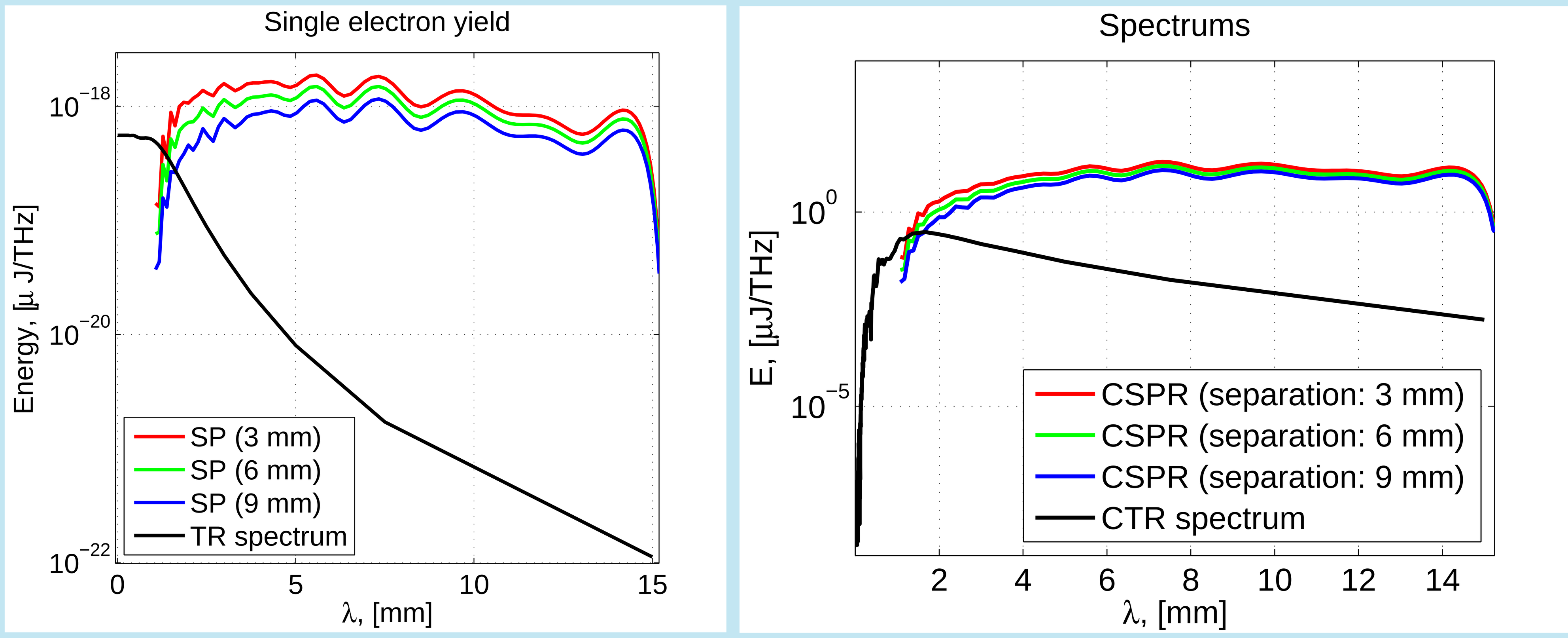
To choose the most appropriate grating pitch, one should use Smith-Purcell condition given in equation ??. For maximum emission at 90 deg. formula is applicable:

$$l \approx 8 \times 10^8 p_t,$$

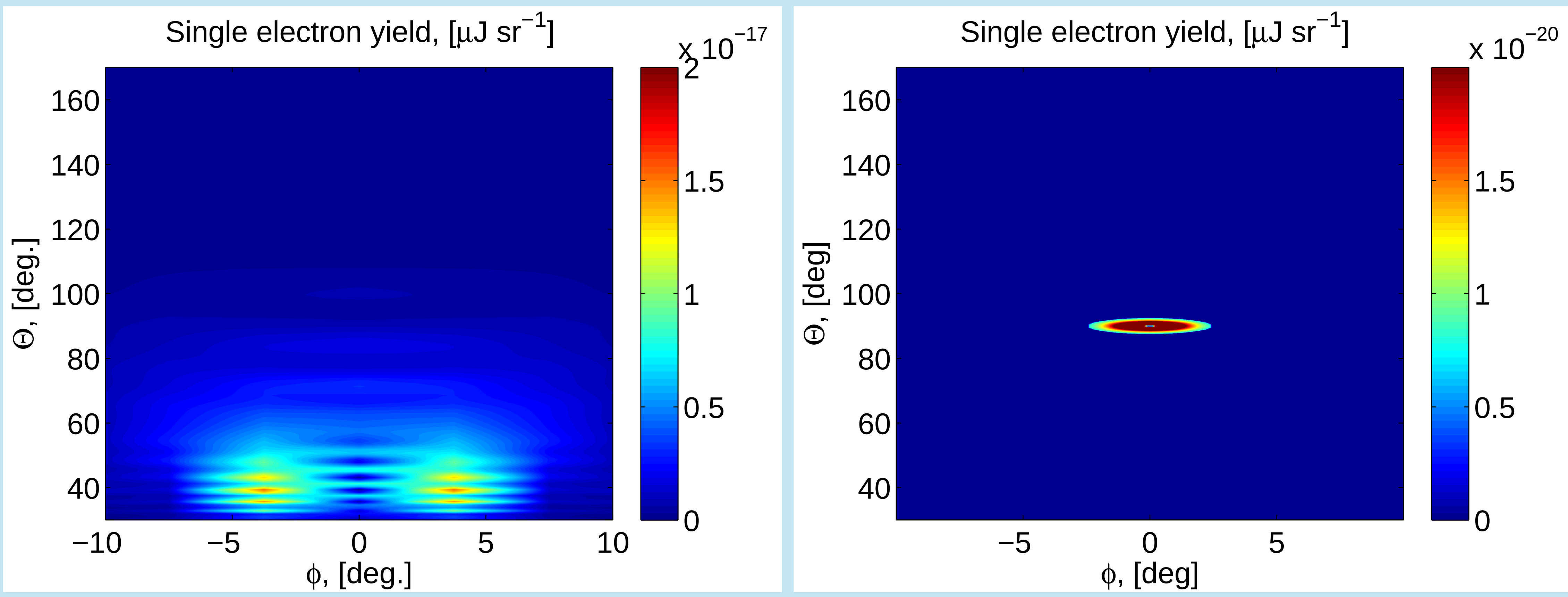
where l is grating pitch in meters and p_t is bunch width (fwhm) in seconds.
Using the CLIO parameters we expect a signal (in the range 0.03-3 THz [0.1 - 10 mm]) of 8.37e-7J for CSPR and 7.35e-08J for CTR.

Comparison

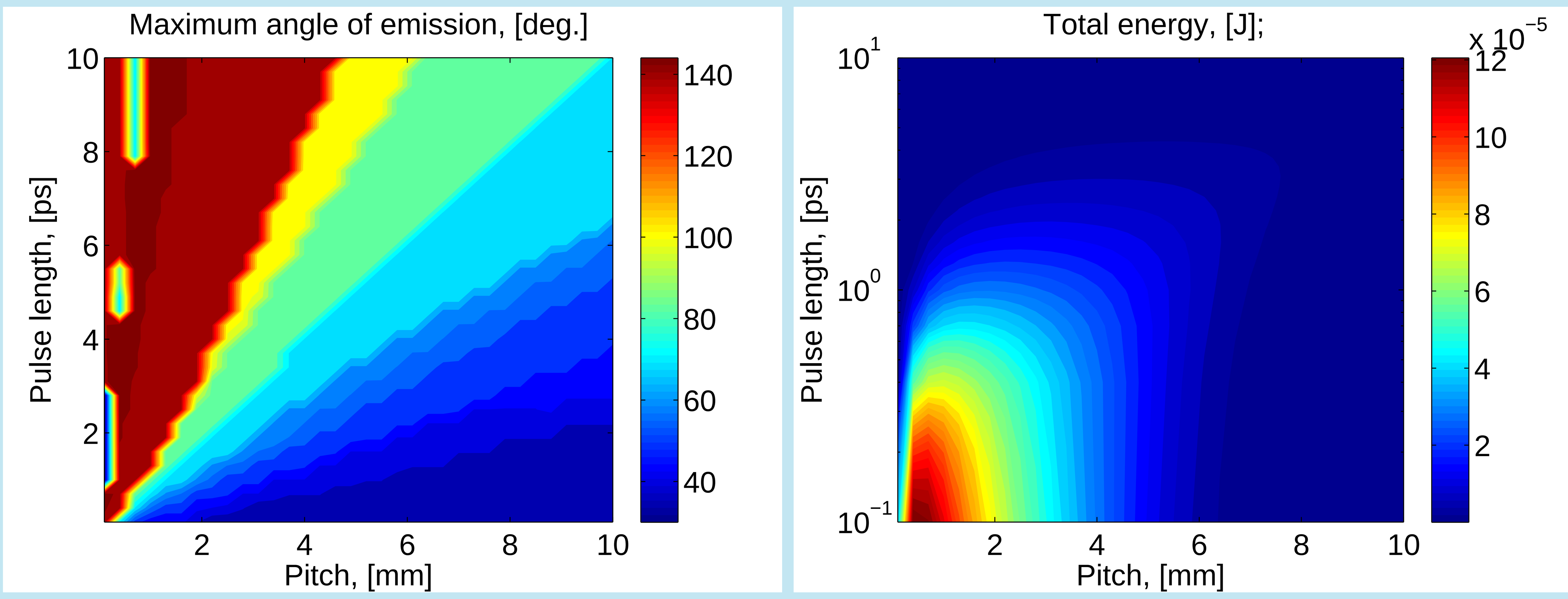
For SP grating is $40 \times 180\ mm^2$ with 30^o blaze angle and the screen diameter for TR is 40mm.



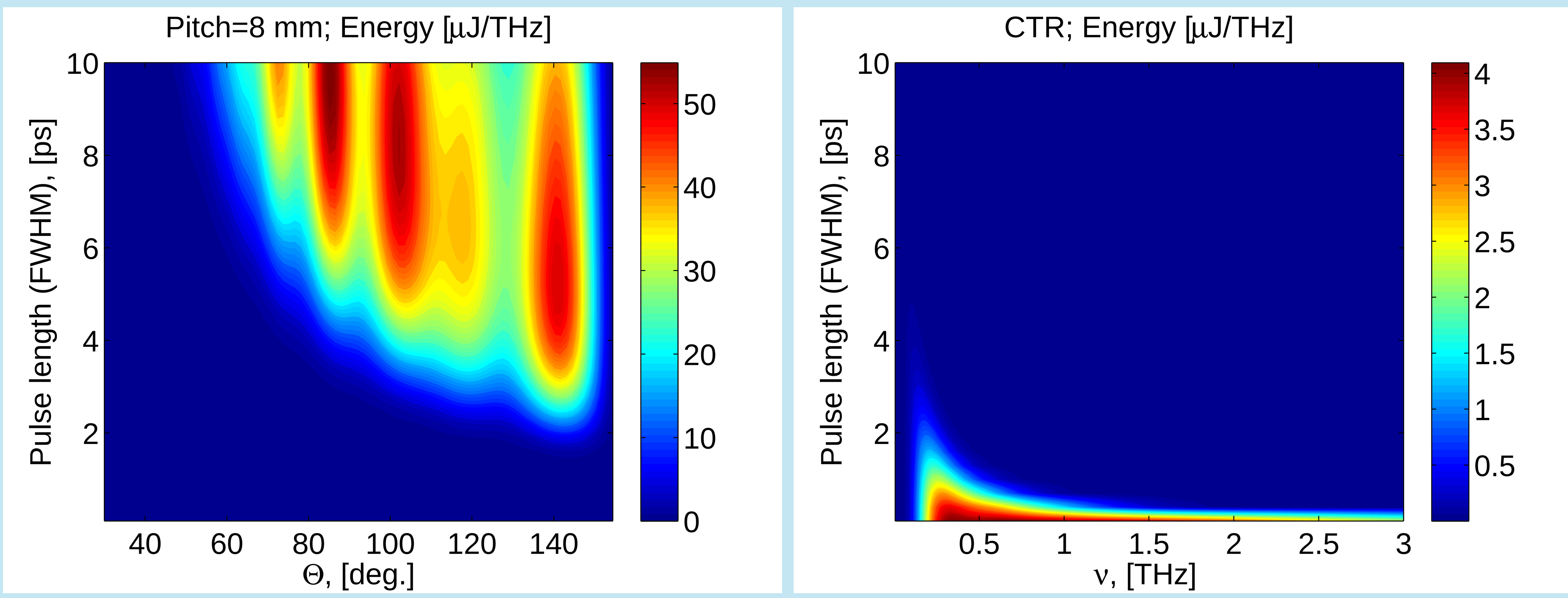
Single electron yield for TR and SP (left) and CSPR and CTR energy density (right).SP SEY is presented for different beam-grating separation (3,6,9 mm). The grating has a 8 mm pitch.



Angular distribution of SEY for SPR (left) and TR (right). The grating has a 8 mm pitch. Screen for TR is turned at 45^o to beam propagation direction.



Maximum angle of emission for SP effect as function of pulsewidth and grating pitch. The beam-grating separation is 3 mm. Total energy for SPR presented as function of pulsewidth and grating pitch.



Evolution of the CSPR spectrum with a constant grating pitch and changing bunch width (left). The grating has a 8 mm pitch. Evolution of CTR spectrum with changing bunch width (right).