BNL-ATF
Smith-Purcell experiment

Progress report
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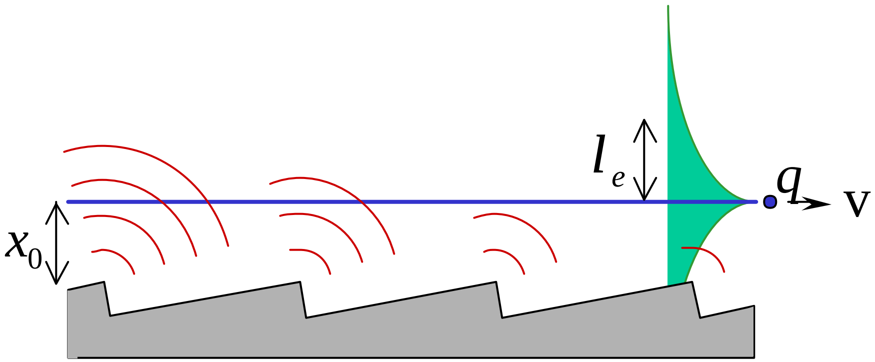
Smith-Purcell Radiation



Dispersion relation

$$n\lambda = c\,\ell/\mathrm{v} - \ell\cos\theta$$

$$\lambda_n = \frac{\ell}{n}\left(\frac{1}{\beta} - \cos\theta\right)$$

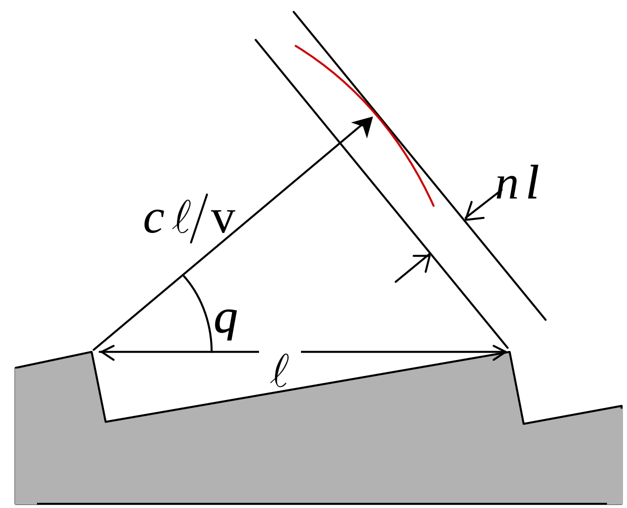
$$\omega_n = n\,\frac{2\pi\,\mathrm{v}}{1-\beta\cos\theta}$$

Evanescent length: $\lambda_e = \dfrac{\gamma\,\mathrm{v}}{\omega} = \lambda\,\dfrac{\gamma\beta}{2\pi}$

Optimum impact height: $\lambda_e = x_0 = \left(\sigma_X\right)_{\mathrm{beam}}$

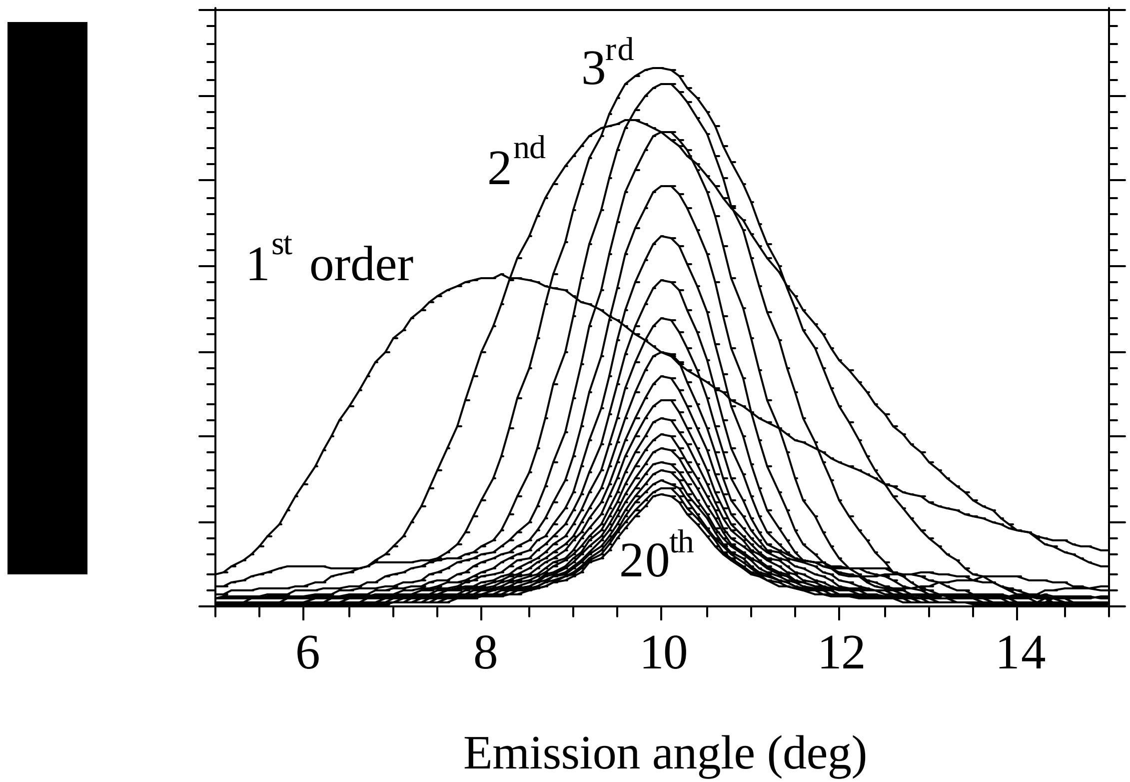
Rolloff frequency: $\omega_{\max} = \dfrac{\gamma\,\mathrm{v}}{\left(\sigma_X\right)_{\mathrm{beam}}}$

Parallellism condition: $\mathrm{Tilt} \le \lambda_e/L$



SPR intensity distribution by order

Emission predominantly in the specular direction (twice the blaze angle, 10 deg).



Motivation:

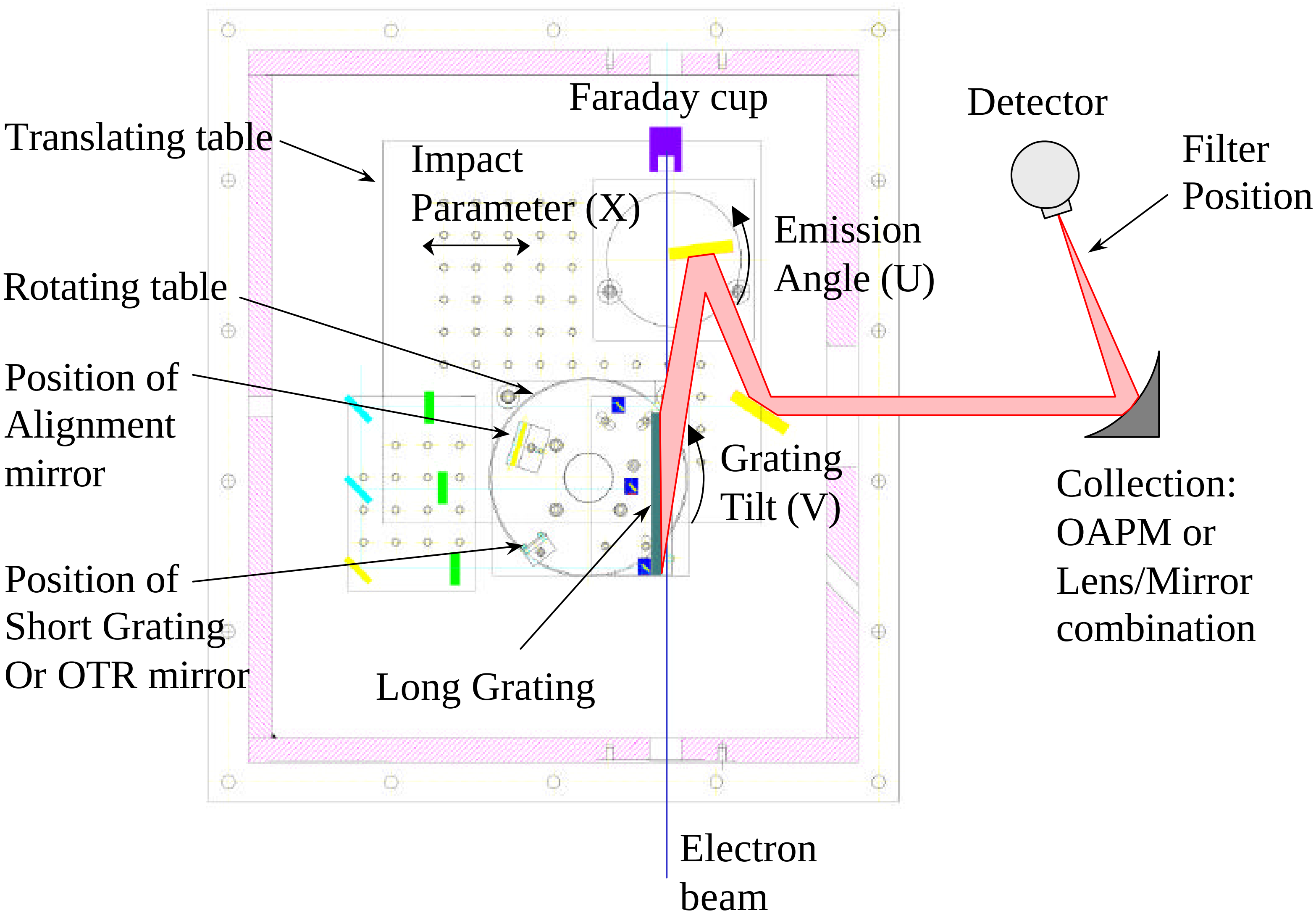
- Investigate Smith-Purcell interaction at high energy.
- Explore feasibility of Inverse S-P acceleration.

➡ Design the experiment for 10 micron fundamental emission.

- Constraint on beam size: $\left(s_{X}\right)_{\text{beam}} \leq 80 m\text{m}/n$
- Parallelism constraint: Beam divergence $\leq 0.6\text{mrad}/n$
- Emittance constraint: $e_N \leq \left(4.5/n^2\right)p$ mm mrad

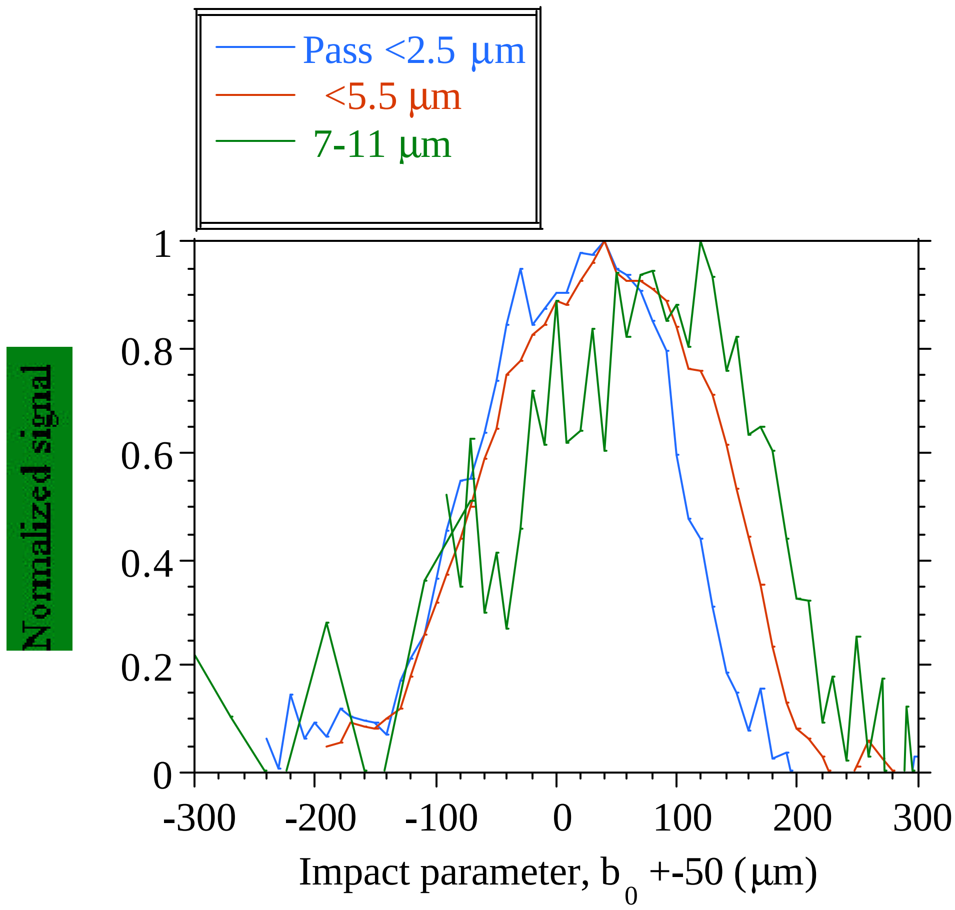
➡ Pushing the limit of the accelerator for higher orders.

ATF Experimental Setup

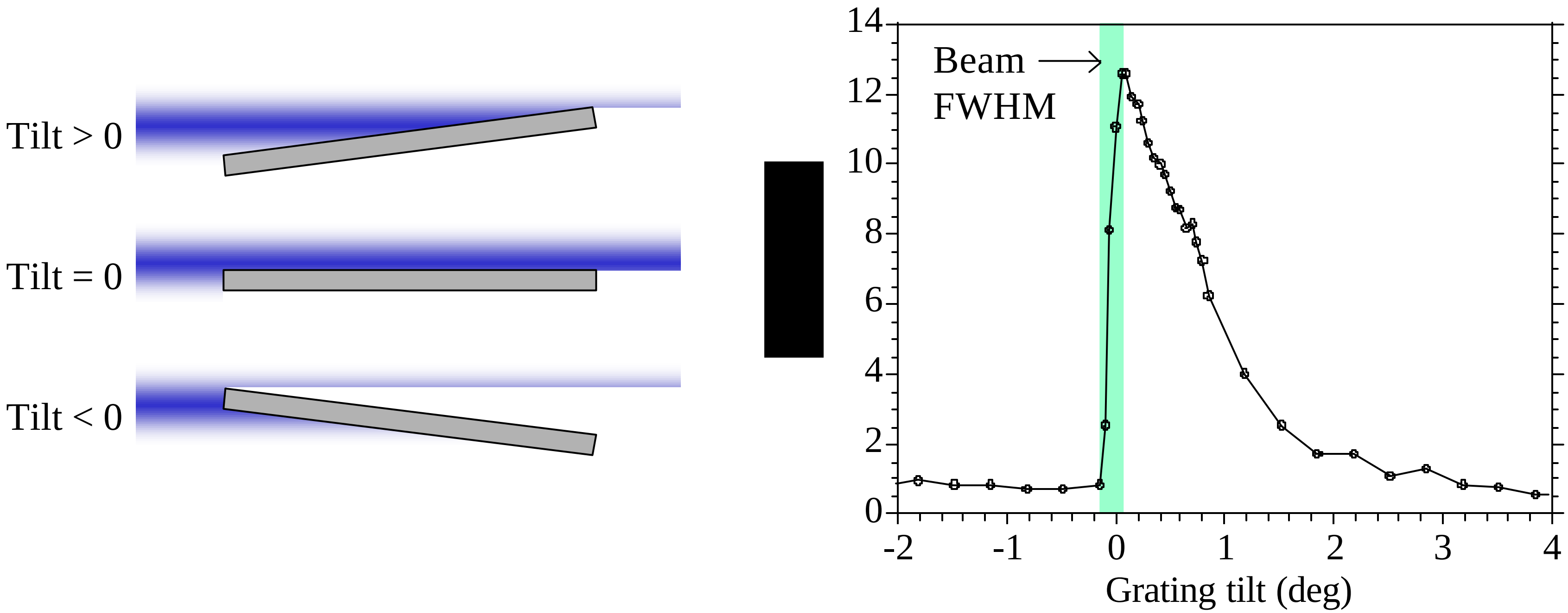


Impact parameter scans through transmission filters (7/27/99)

This is the clearest evidence of significant IR emission and a wavelength dependent interaction. The 80um shift to larger interaction length for 7-11um wavelengths is in good agreement with theory.



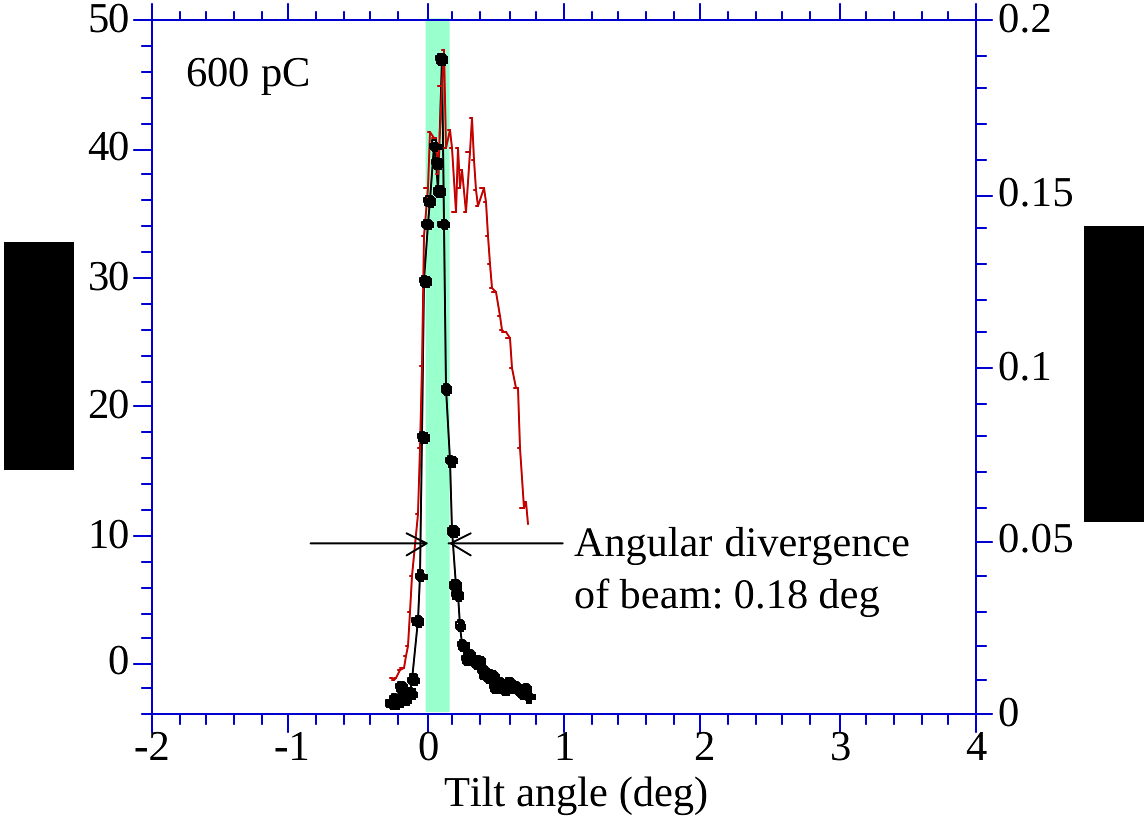
Typical grating tilt scan, with WIDE beam waist



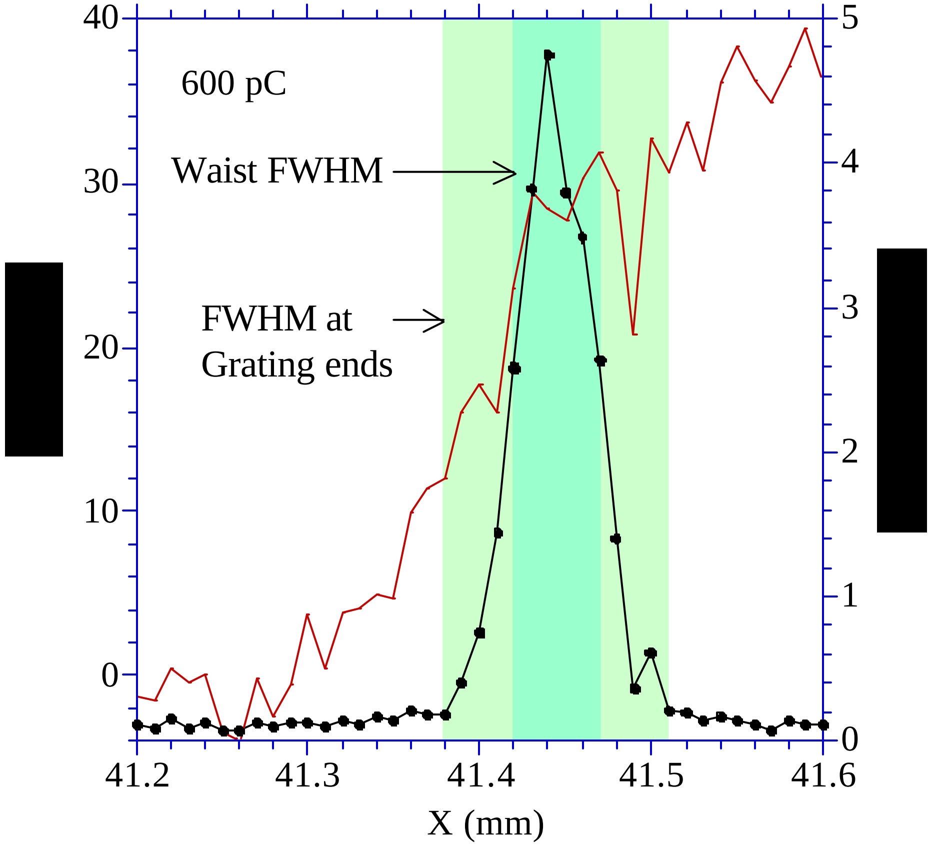
10/25/00 Grating Tilt scan
with NARROW beam waist

Waist FWHM ~ 50μm (normal) x 250μm (transverse).

No other beam tune less than 100mm (normal) and 1:2 aspect ratio.

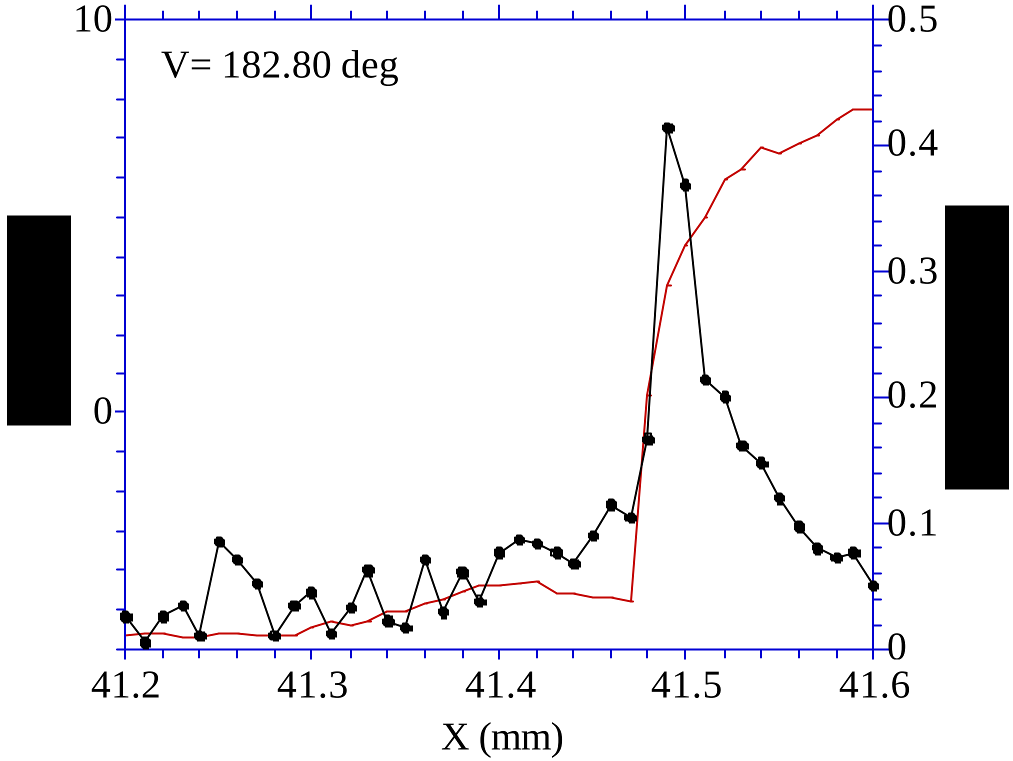


10/25/00 Impact Parameter scan with NARROW beam waist



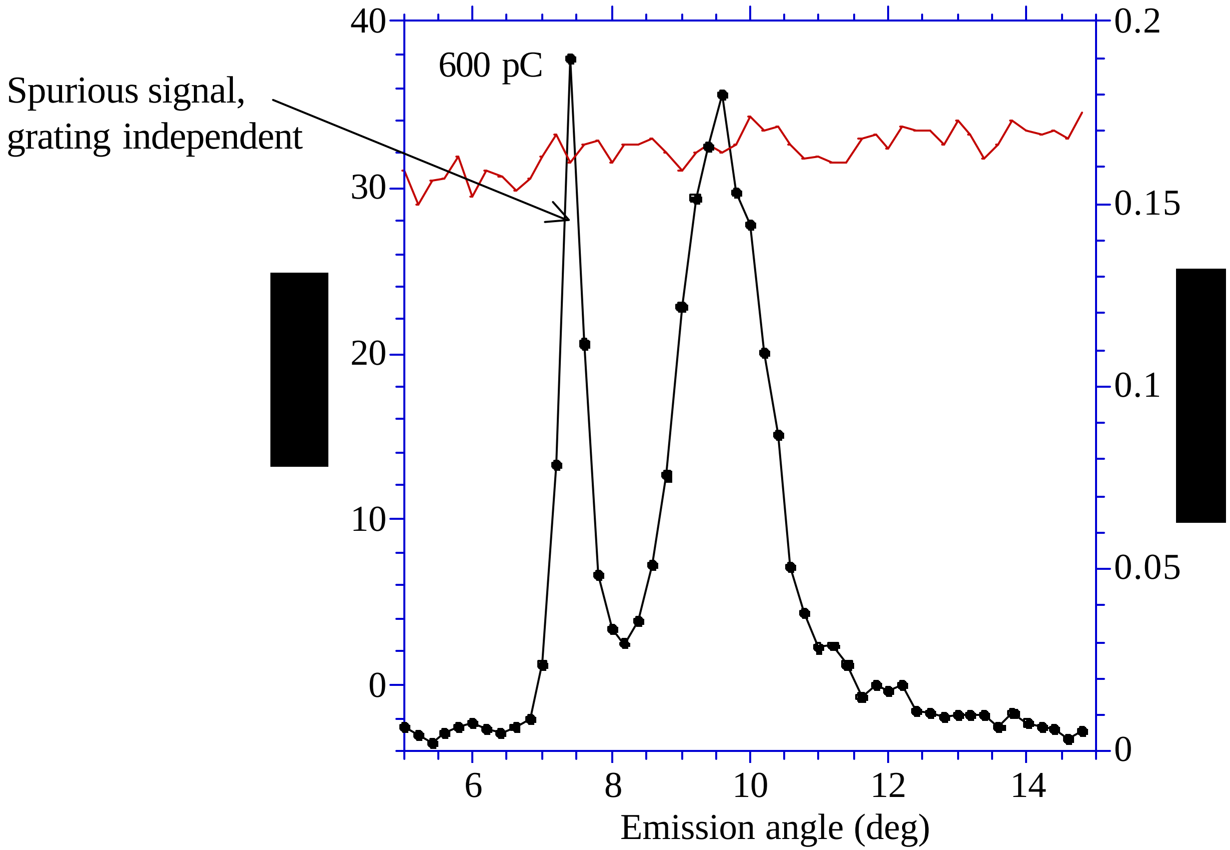
10/25/00 Impact Parameter scan with the grating face slightly closed

At V=182.80 deg, the grating is facing 0.05 deg away from the beam. Therefore, this plot is evidence for a wakefield emission process.



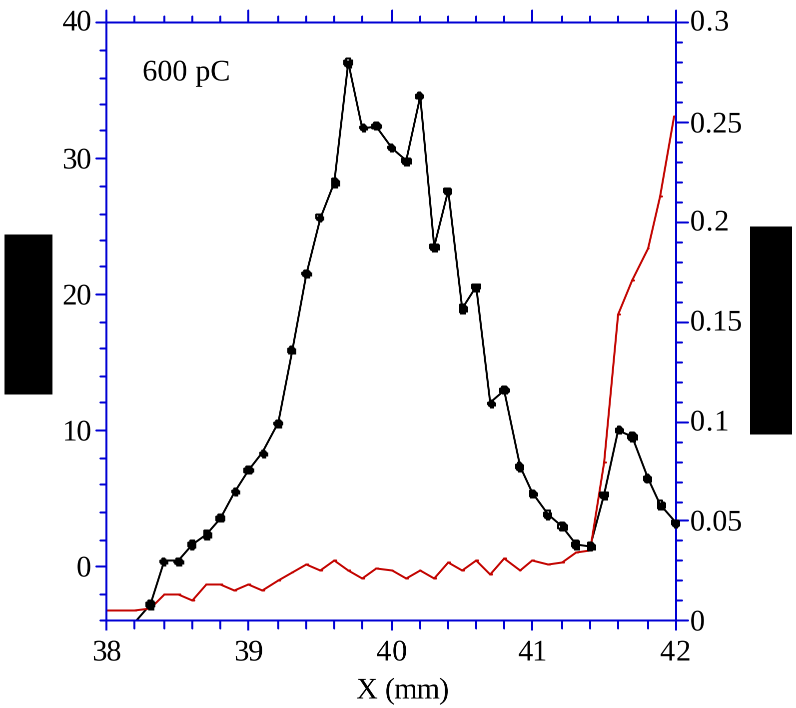
10/25/00 Emission Angle scan
with NARROW beam waist

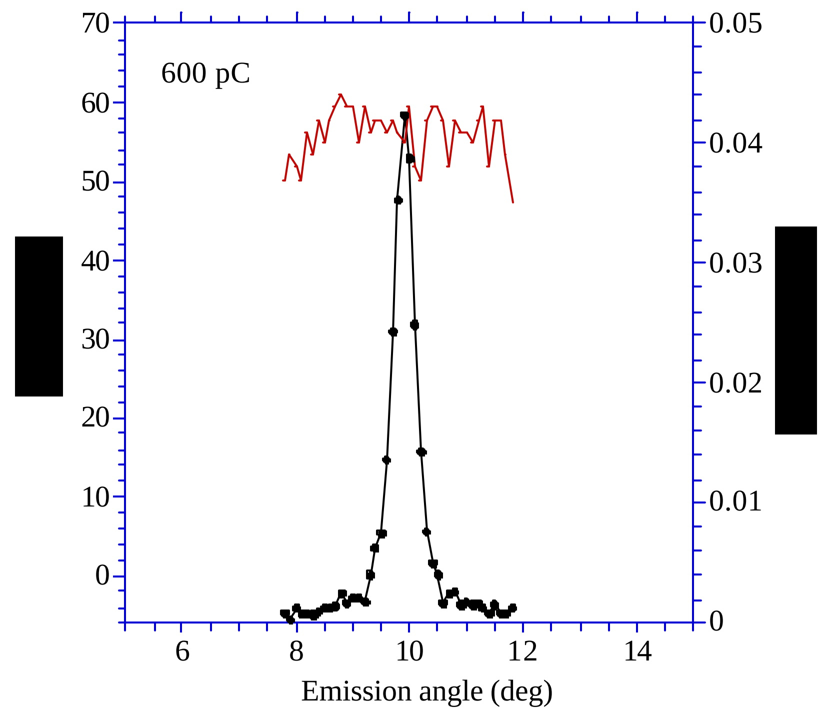
Emission in the specular direction (10 deg).



10/25/00 OTR MIRROR
Impact and Emission Angle scans
with NARROW beam waist

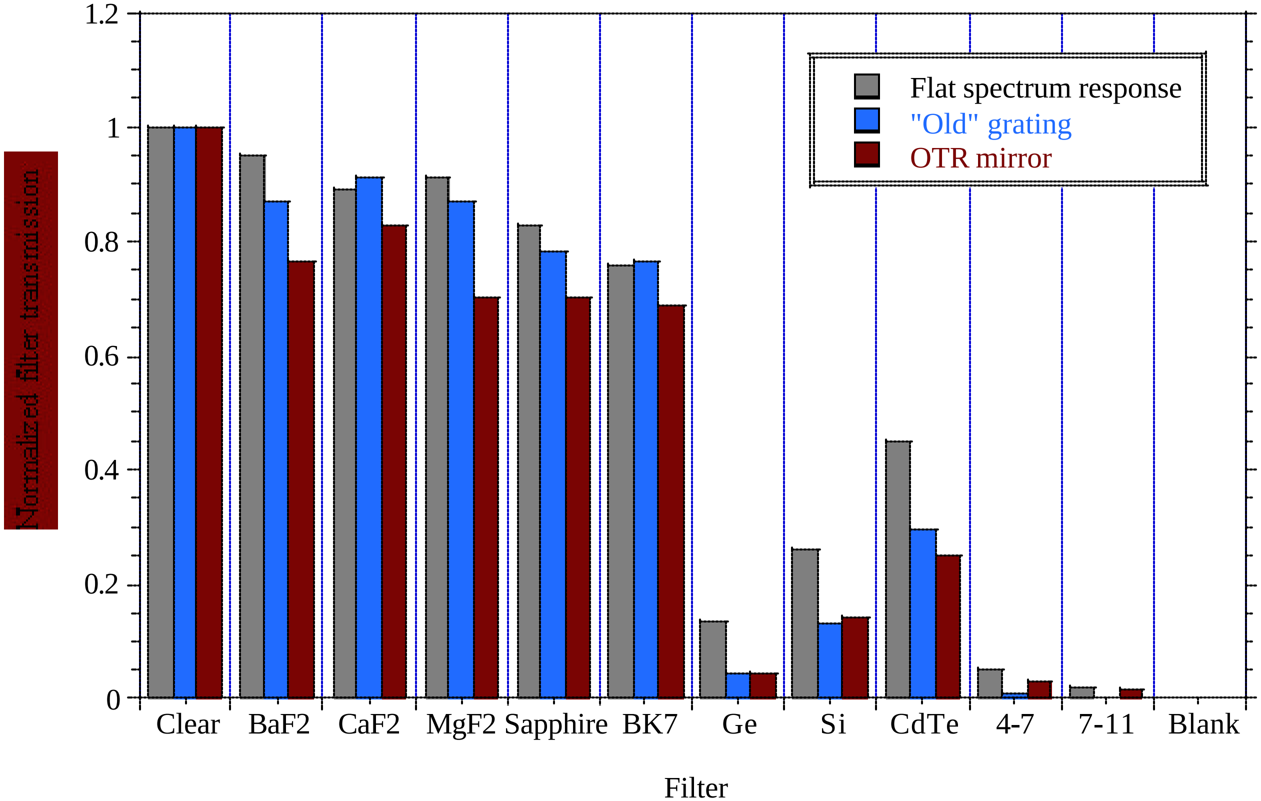
The impact width is much larger and the angular
spread is smaller than that for the grating emission.





10/26/00 Power Spectra inferred from transmission filter data

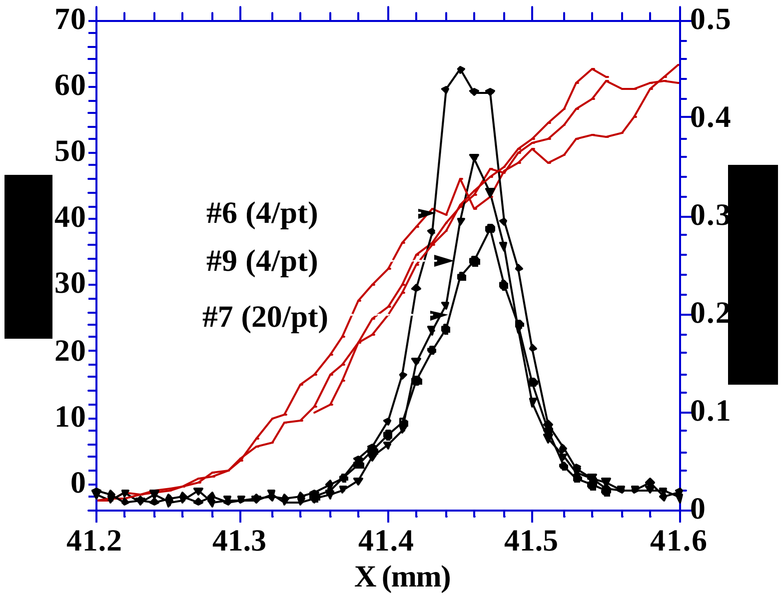
Both grating and OTR mirror emission consistent with a flat spectrum. Spectrometer results confirm significant visible-NIR component, but not sensitive enough to detect long wavelength signal.



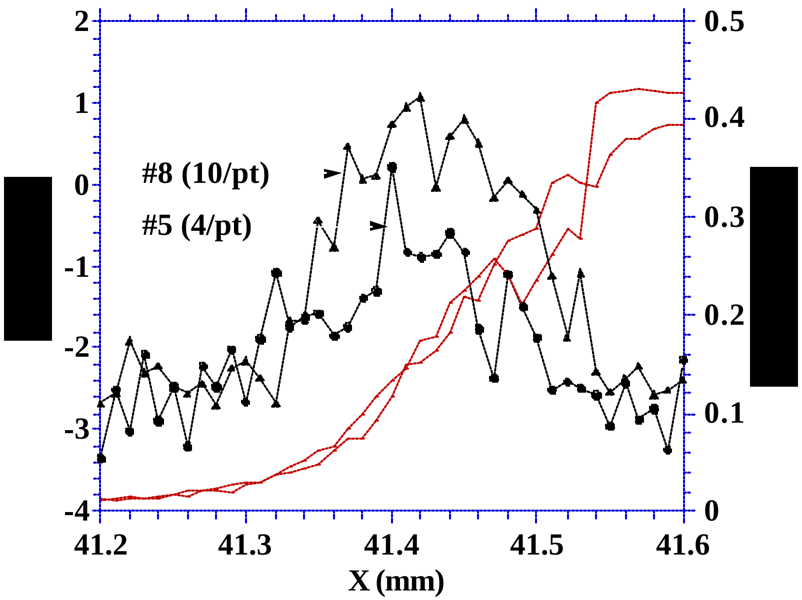
10/25/00 Impact parameter scan series
with NARROW beam waist

Five consecutive impact parameter scans. The only difference between scans is the gun phase in order to vary the charge. Note the 50x difference in power between high and low charge. A similar study the following day with a wider (100μm) waist produced linear charge dependence.

600 pC



400 pC



Conclusions:

- S-P signal may have been observed with the narrow beam.
- A wide beam produces visible-NIR radiation likely due to electron impact of the grating surface.
- Strong non-linear charge dependence observed with a narrow beam but not a wide one.
- Success of this experiment hinges on achieving the narrow beam tune again.