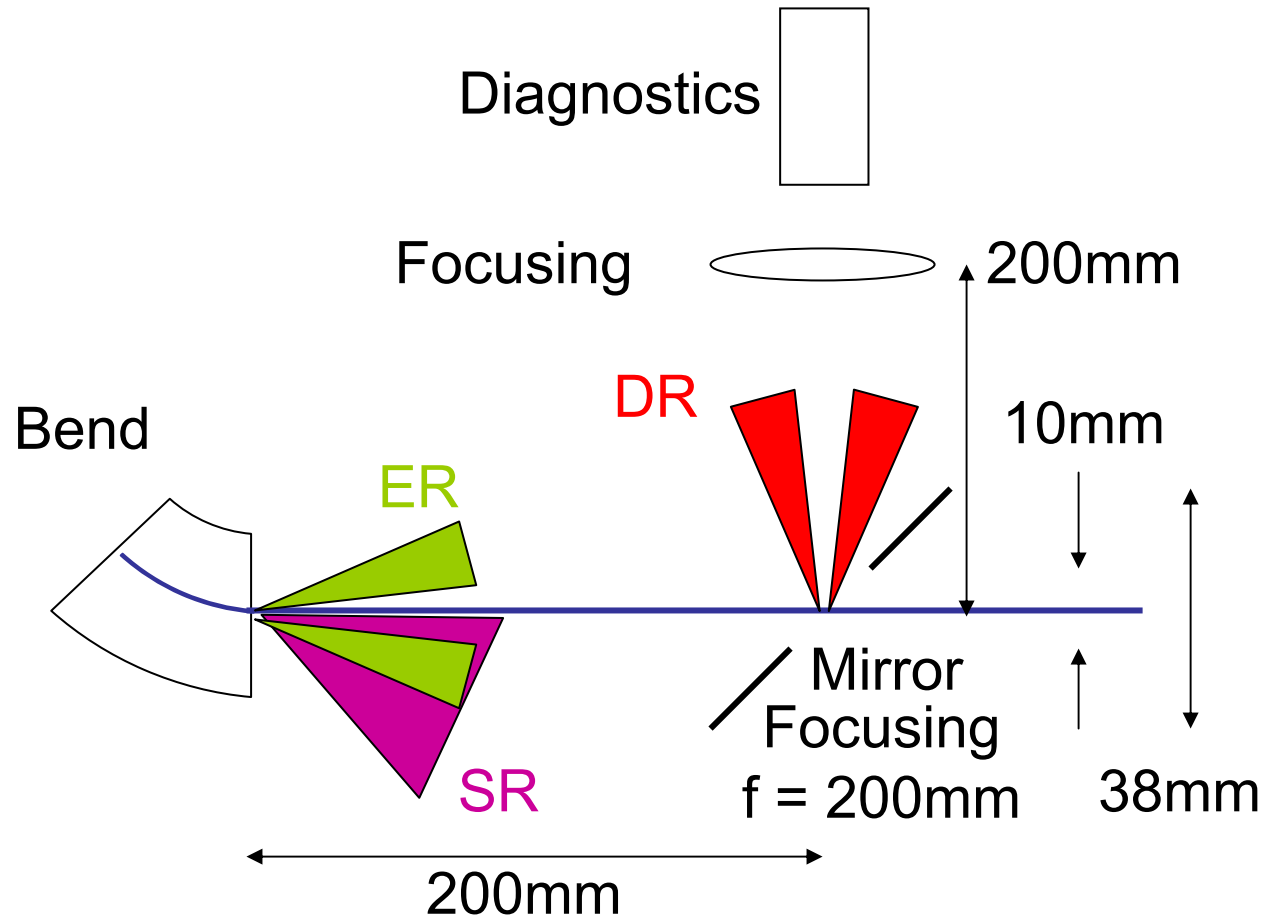


# Simulation of Edge and Diffraction Radiation Propagation in the LCLS Bunch Length Monitor

- Radiation sources
- Simulation of radiation propagation
- Bunch length sensitivity of detector signals

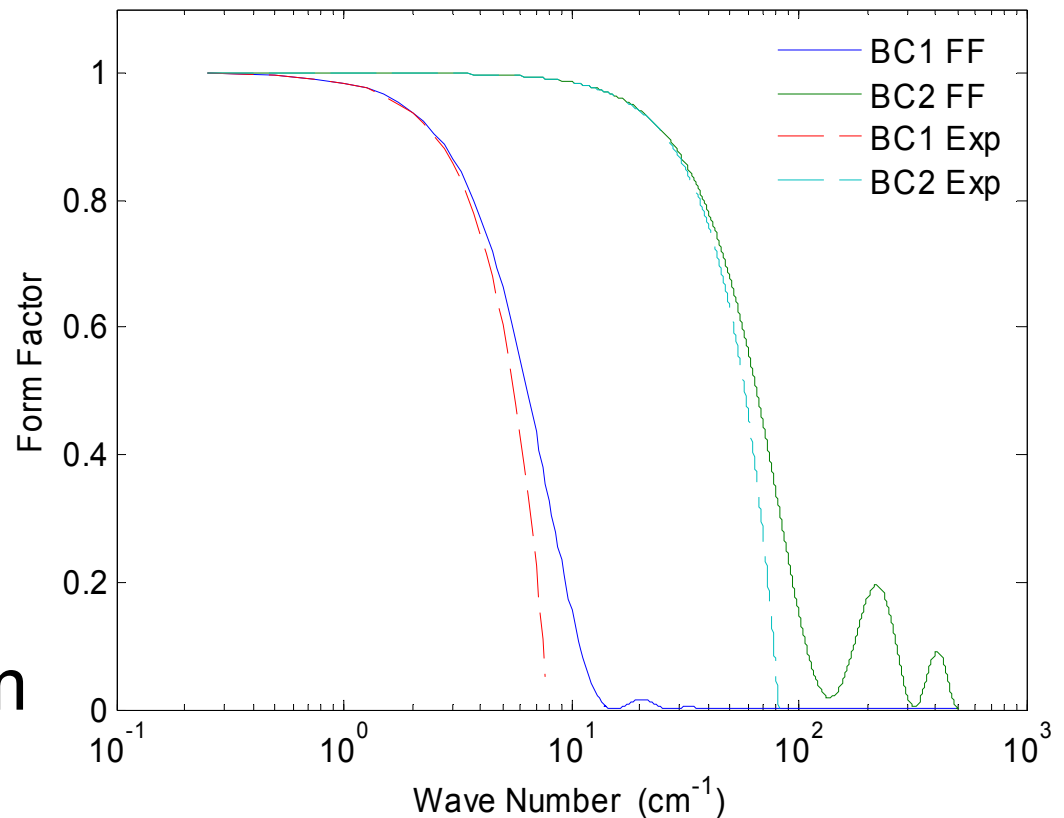
# Layout



# Bunch Form Factor

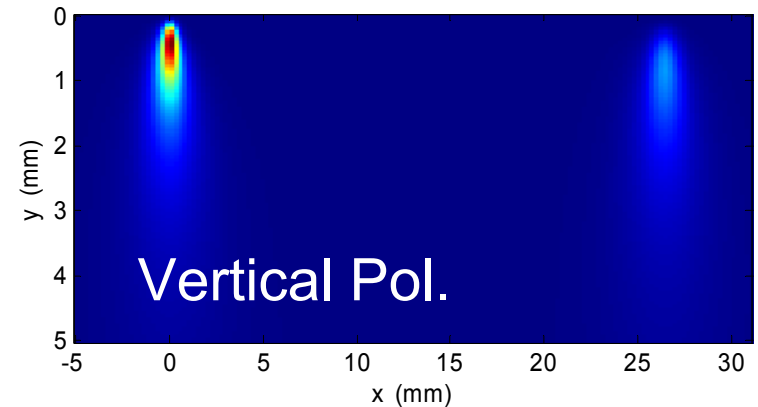
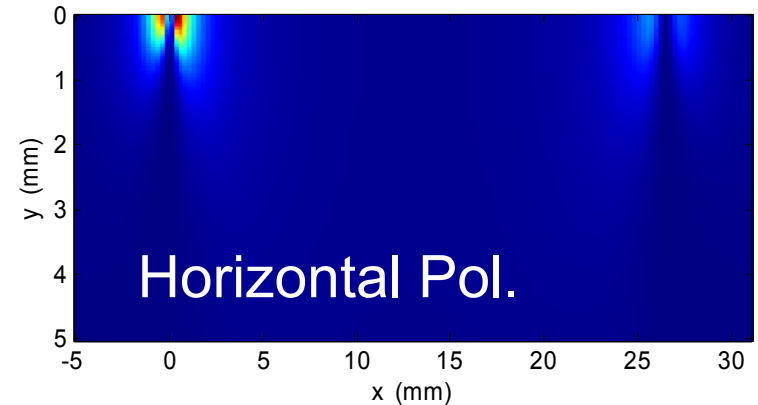
- Bunch length determined by low frequencies
- Expansion of FF  

$$f(k) = 1 - k^2 \sigma_{\text{rms}}^2$$
- $\lambda \gg 2\pi\sigma_{\text{rms}}$
- BC1: 1cm – 1mm
- BC2: 1mm - .1mm



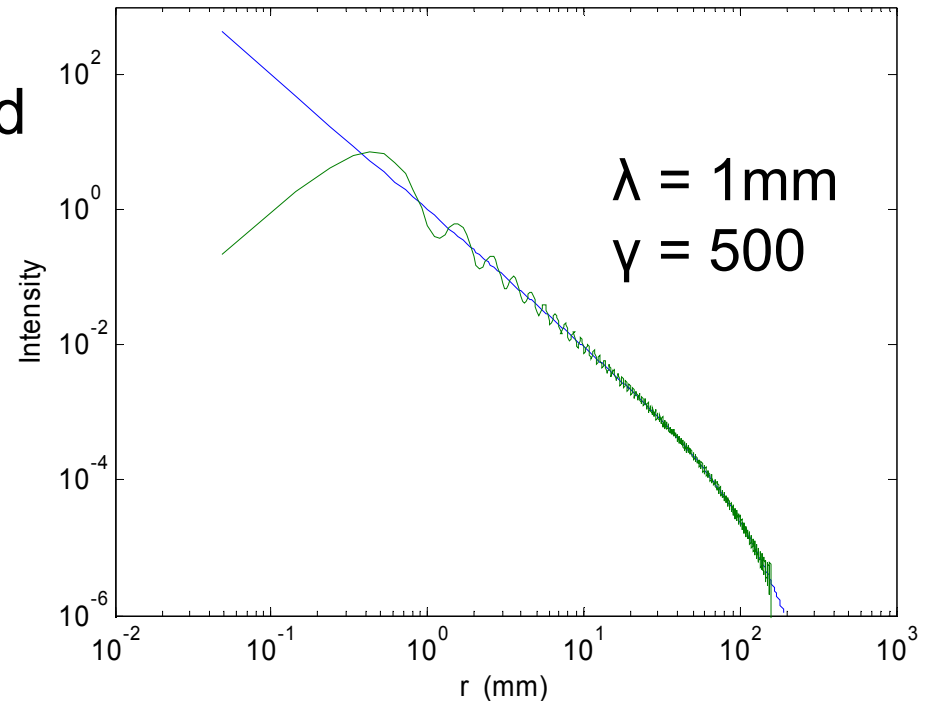
# BC1 Radiation Distribution

- Wavelength 1mm
- 200mm downstream of BC1
- Near field integration of “acceleration field”
- Edge length  $\ll \lambda\gamma^2$
- Mainly ER from both bend edges, 4x larger than SR
- Radiation from Entrance edge hits vacuum chamber



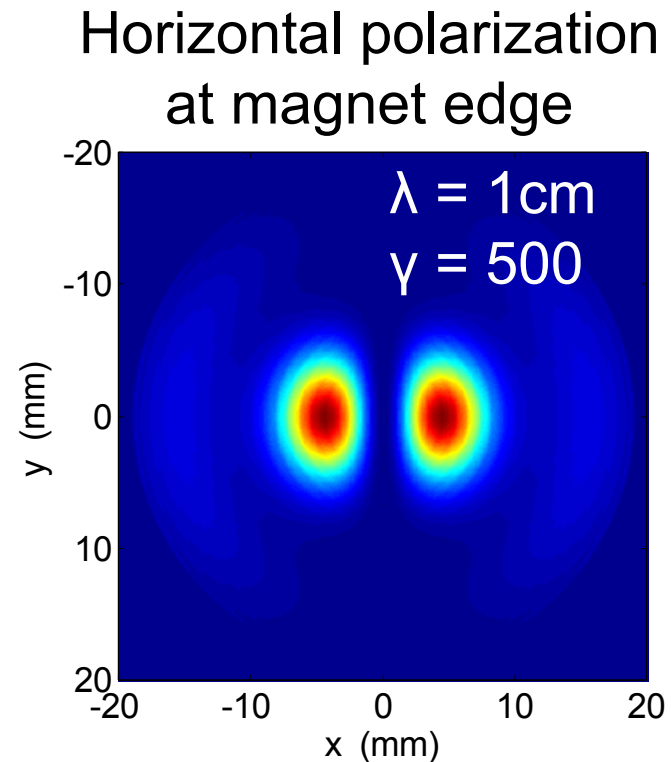
# Radiation Simulation

- Treat ER as TR
- Take virtual quanta transverse distribution and propagate radiating part through optical system.
- $E(r) = K_1(kr/\gamma)$
- Radiating part at  $\gamma \rightarrow \infty$ :  
 $E(r) = (1 - J_0(kr))/kr$
- Max intensity at  $r = \lambda$
- Intensity falls off at  $r = \gamma\lambda$

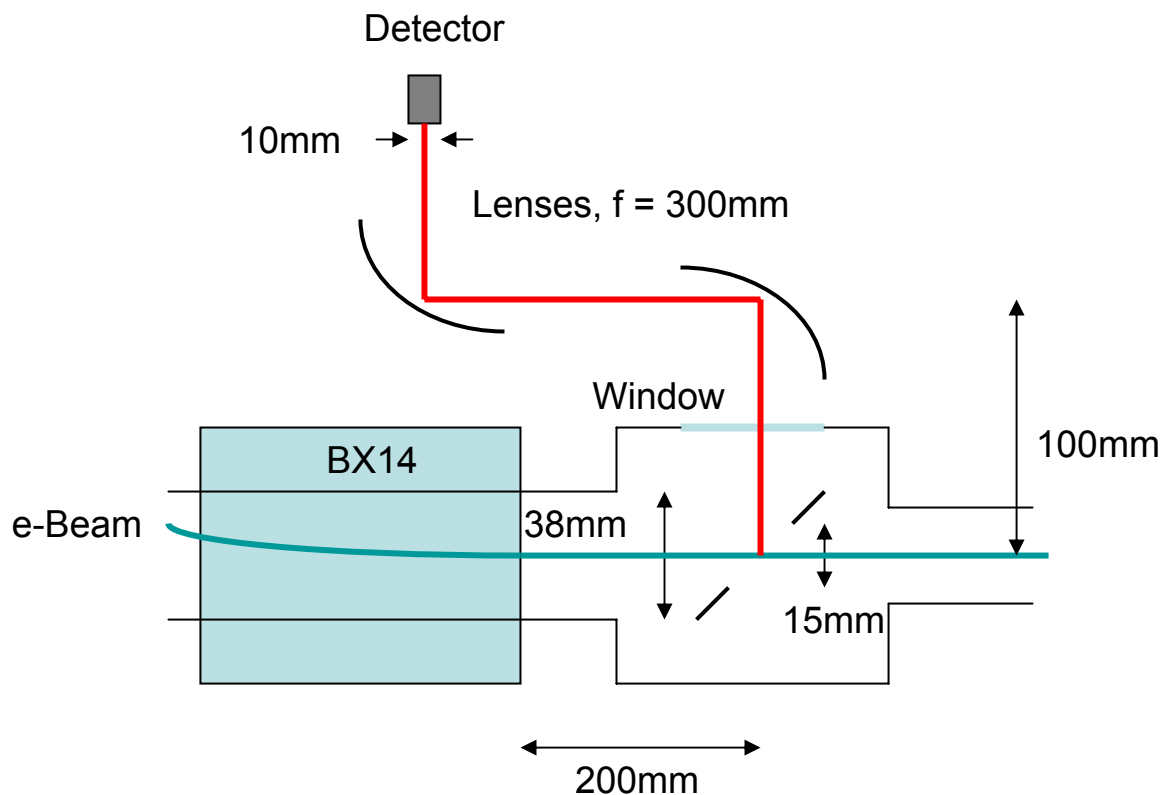


# Propagation with Gauss-Laguerre Modes

- Use Gauss-Laguerre modes with radial mode number 1 for field of each polarization
- Needs  $\gamma/2$  transverse modes to get correct far field distribution

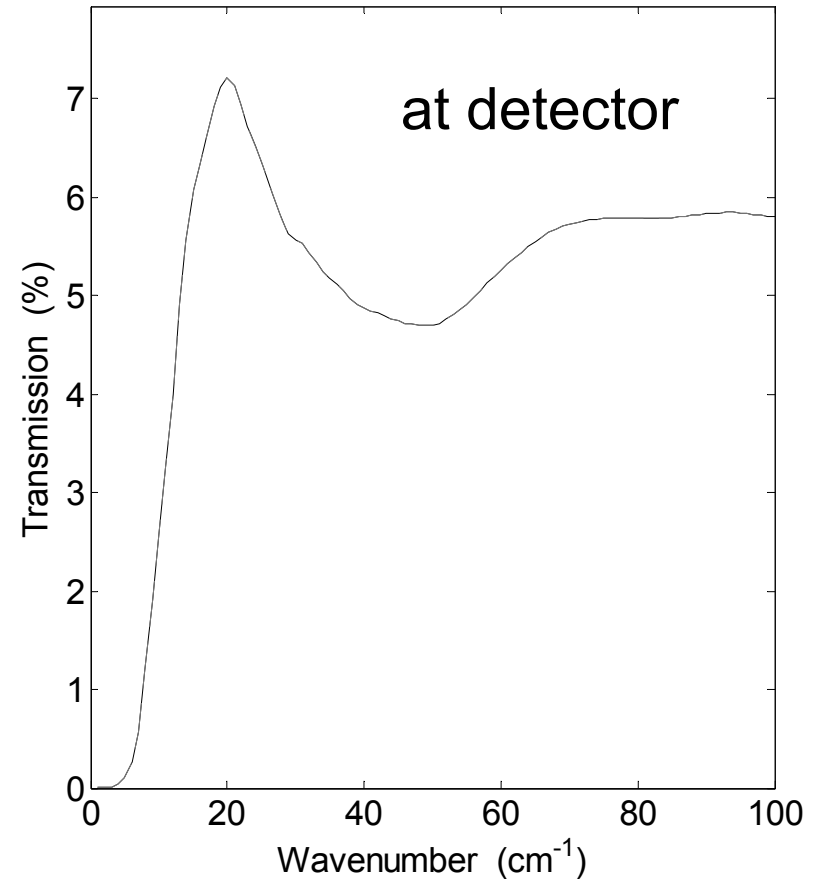
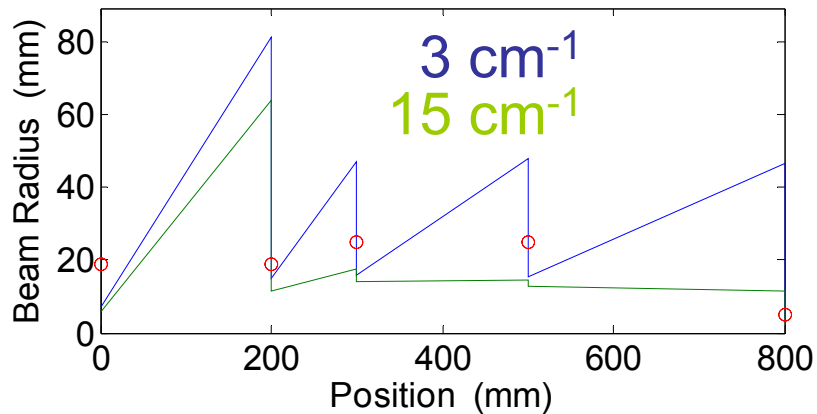
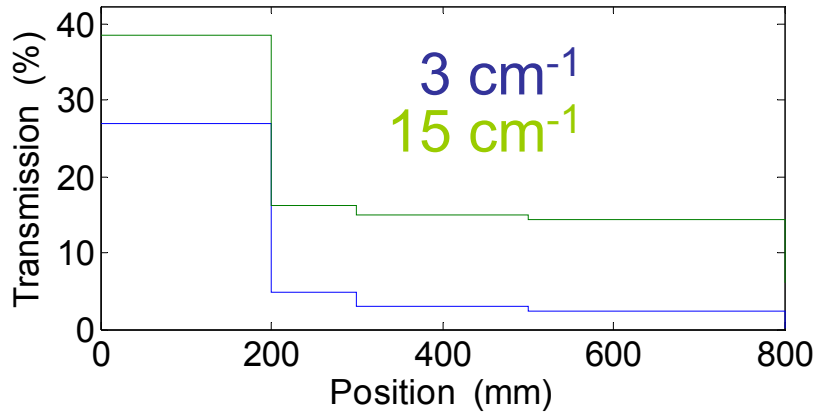


# BLM11 Layout

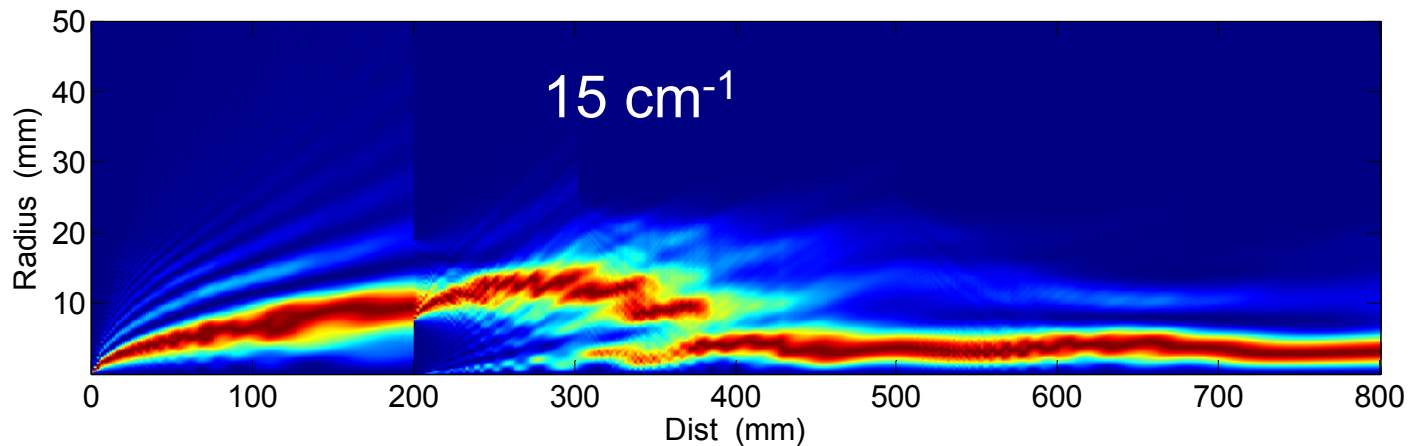
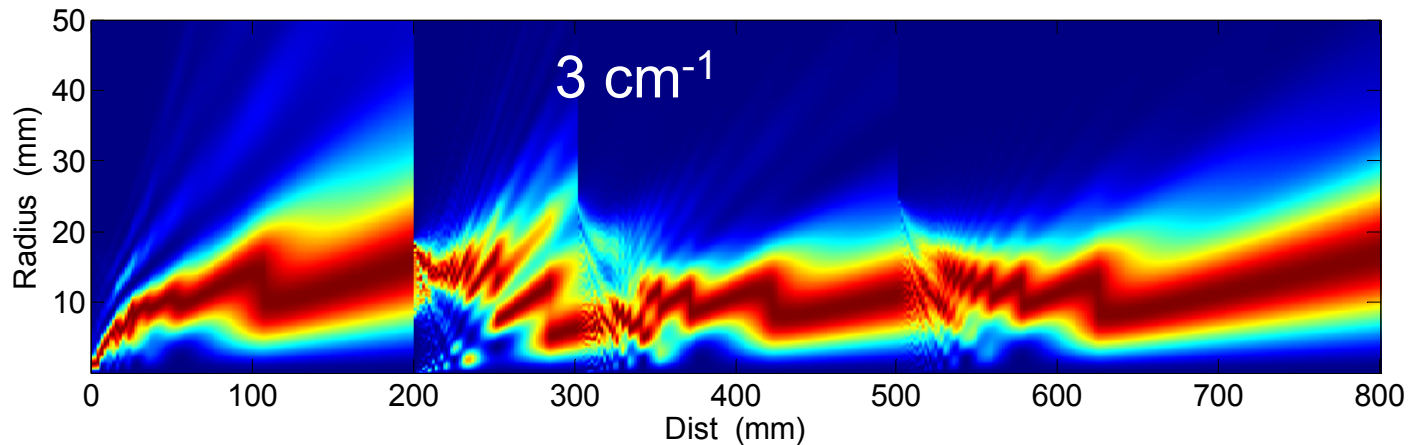


# CER Transmission Through Optics

For one polarization, normalized to total  $2\pi$  emission

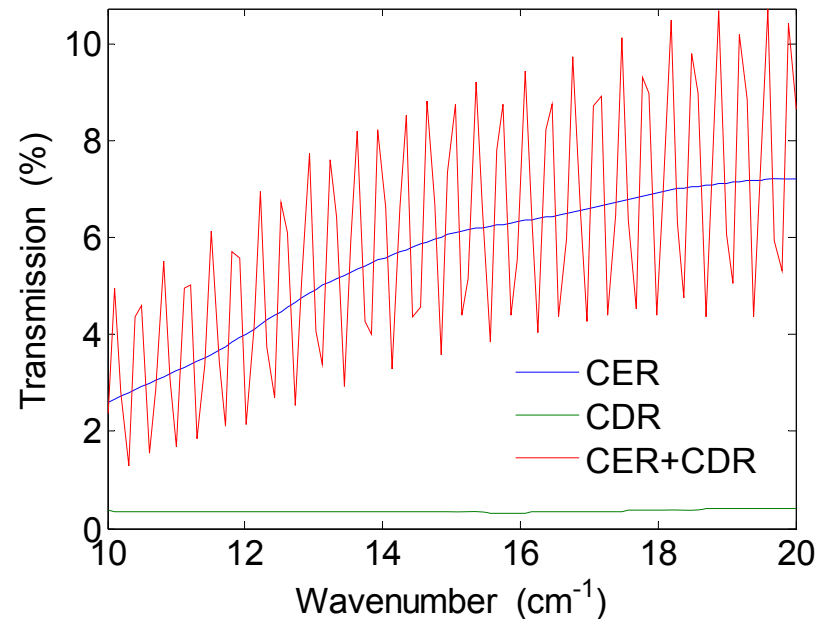


# Transverse Profile Through Optics

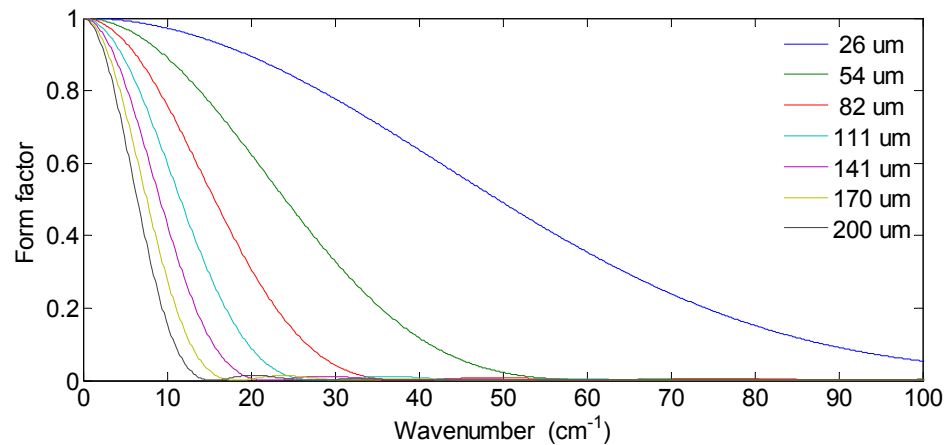
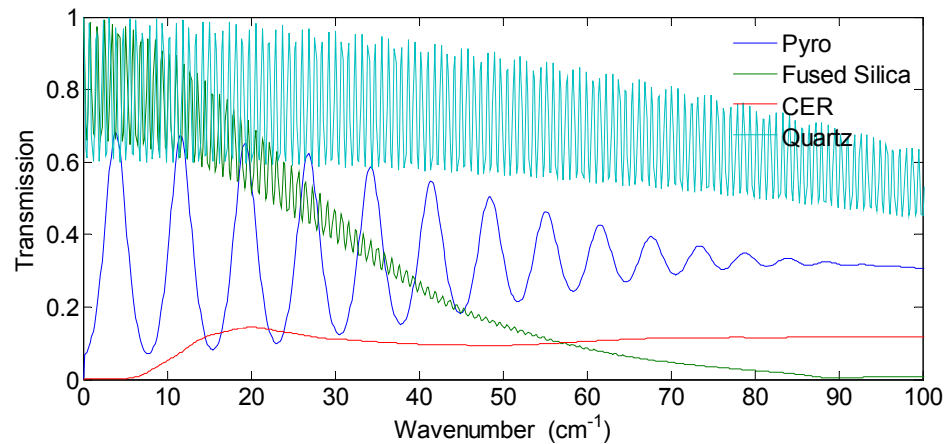


## Interference of CER and CDR

- Get field at detector for CER and CDR
- CDR is not focused on detector
- Wave front curvature differs from CER
- Intensity at detector shows narrow fringe pattern
- Fringes much faster than changes in formfactor
- CDR can be ignored

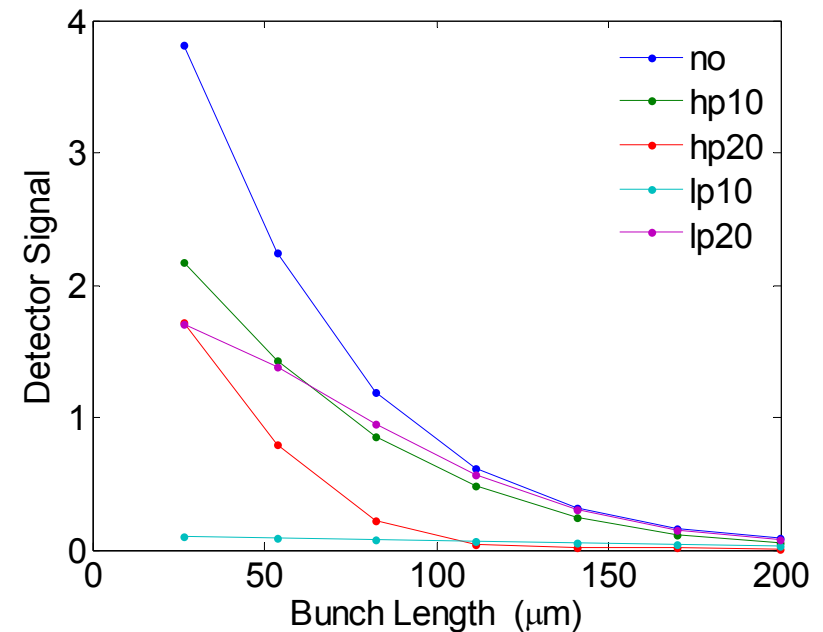
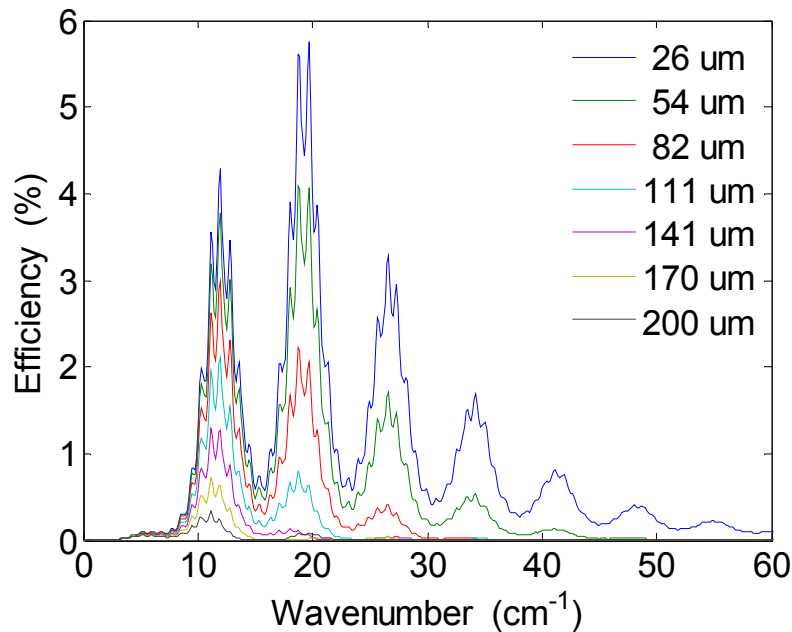


# Spectral Efficiency and Bunch Form Factor



# Bunch Length Sensitivity of Detector Signal

- Introduce high and low pass filters at  $10\text{cm}^{-1}$  and  $20\text{cm}^{-1}$ .
- Low signal for long bunches
- More transmission of radiation below  $10\text{cm}^{-1}$  needed



## Summary

- Study of proposed bunch length monitor after BC1
- Main radiation source is edge radiation
- Simulation of radiation transmission from dipole edge to detector
- Hole in out-coupling mirror is acceptable
- Small apertures in optical system cut radiation below  $10 \text{ cm}^{-1}$
- Monotonic dependence of detector signal to bunch length
- Good sensitivity for shorter bunches at 200pC but could be problematic for longer bunches at 1nC