THz Pump Beam for LCLS

Henrik Loos

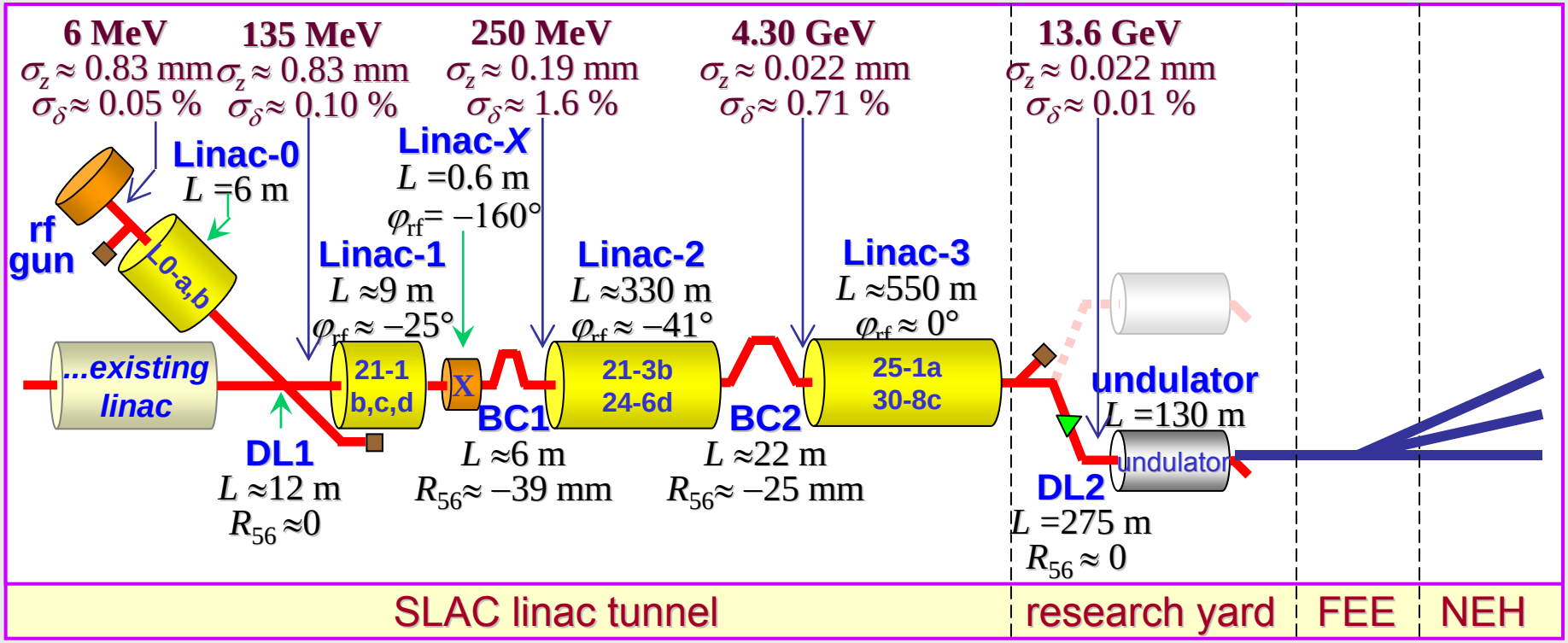
LCLS Hard X-Ray Upgrade Workshop
July 29-31, 2009

Overview

- Coherent Radiation Sources
- THz Pump Timing
- THz Source Performance

Henrik Loos
loos@slac.stanford.edu

LCLS Layout



Use LCLS electron beam to generate synchronized THz pulses for x-ray experiments

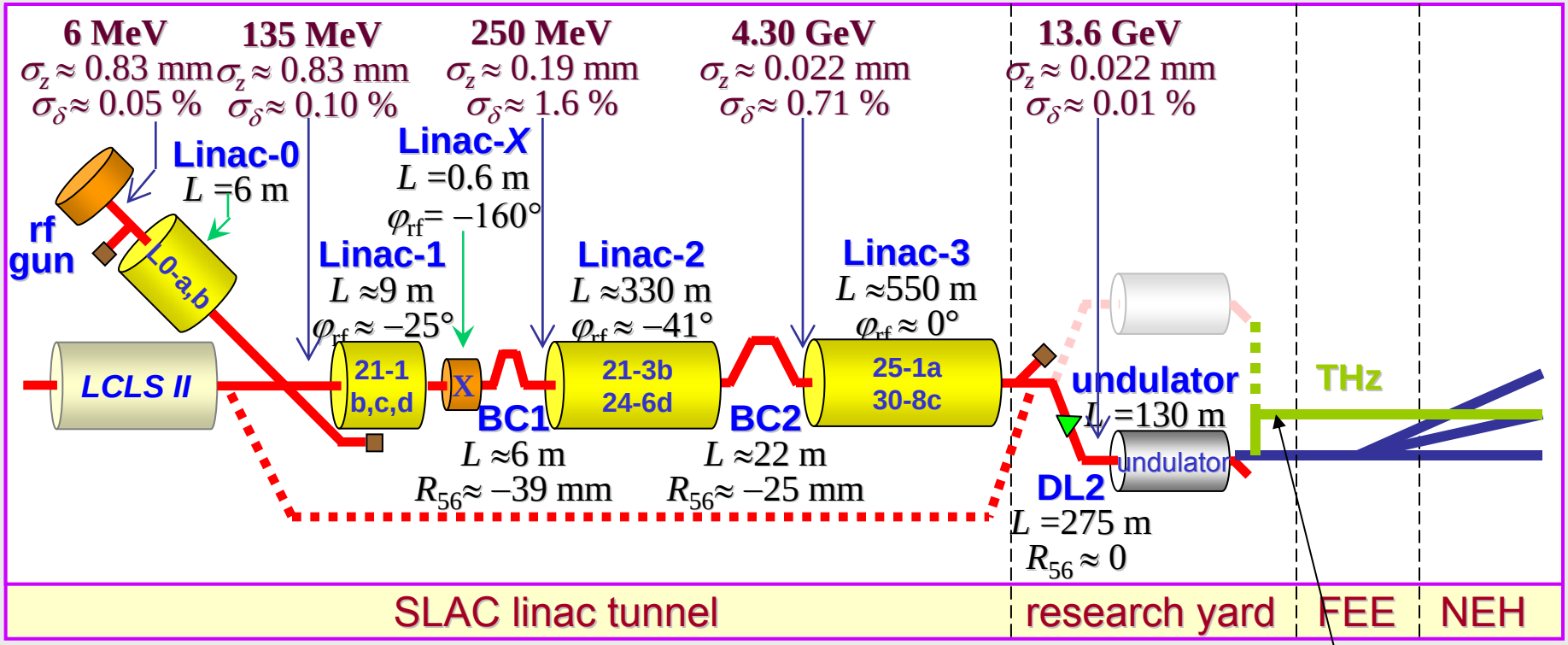
THz Sources

- Ultra-short electron beam carries broad-band electro-magnetic field from DC to ~10um
- Extract coherent radiation at any beam obstruction
  - Foil -> Transition Radiation (CTR)
  - Annular mirror -> Diffraction Radiation (CDR)
  - Bend magnet -> Edge Radiation (CER)
- THz pulse with radial polarization

THz Timing

- Pump THz pulse needs to be ahead of x-rays
- THz from same electron bunch requires delay of x-rays
- Generate THz from different electron bunch
  - In present accelerator layout use 2nd bunch 10s to 100s ns ahead of lasing bunch within same accelerator RF pulse
  - Spoil beam quality of pre-bunch to prevent lasing
  - THz pulse well synchronized with x-ray (« 50 fs) due to same drive laser pulse & RF pulse
- Generate THz from different accelerator
  - If first 2 km of SLAC linac are used for LCLS
  - RF timing can be set independently from existing LCLS accelerator
  - Still good synchronization with x-ray due to same RF master clock

Location of THz Generation



Use spend beam downstream of undulator in dump area

THz Generation after Undulator

- THz frequency range 1 – 10 THz
- Spectral range 30 – 300 cm^{-1}
- Radiation source
  - Diffraction radiation has high frequency cutoff
  - Transition radiation needs thin foil
  - Edge radiation from dipole non-interceptive
- Energy 13.6 GeV, $\gamma = 26700$
- Radiation source size clipped by beam pipe
- Near field calculation for $\lambda > 10$ nm

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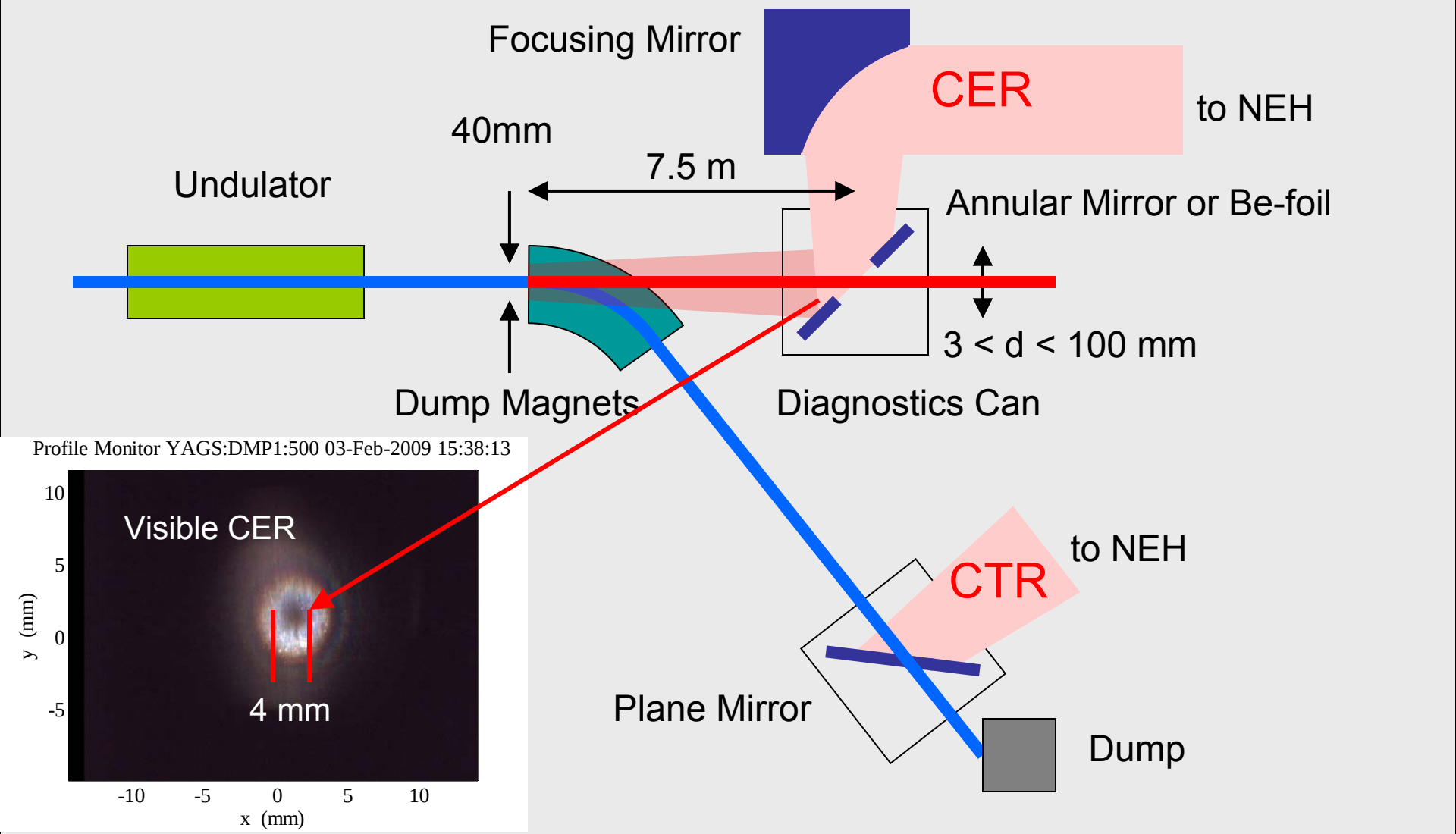
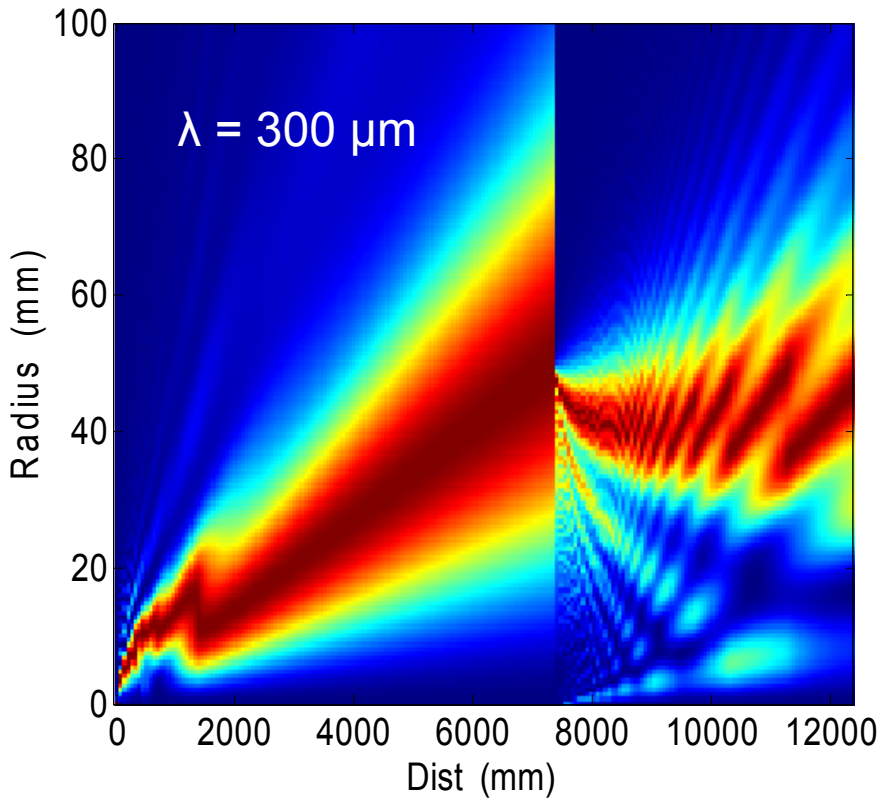
Layout Options for THz Extraction

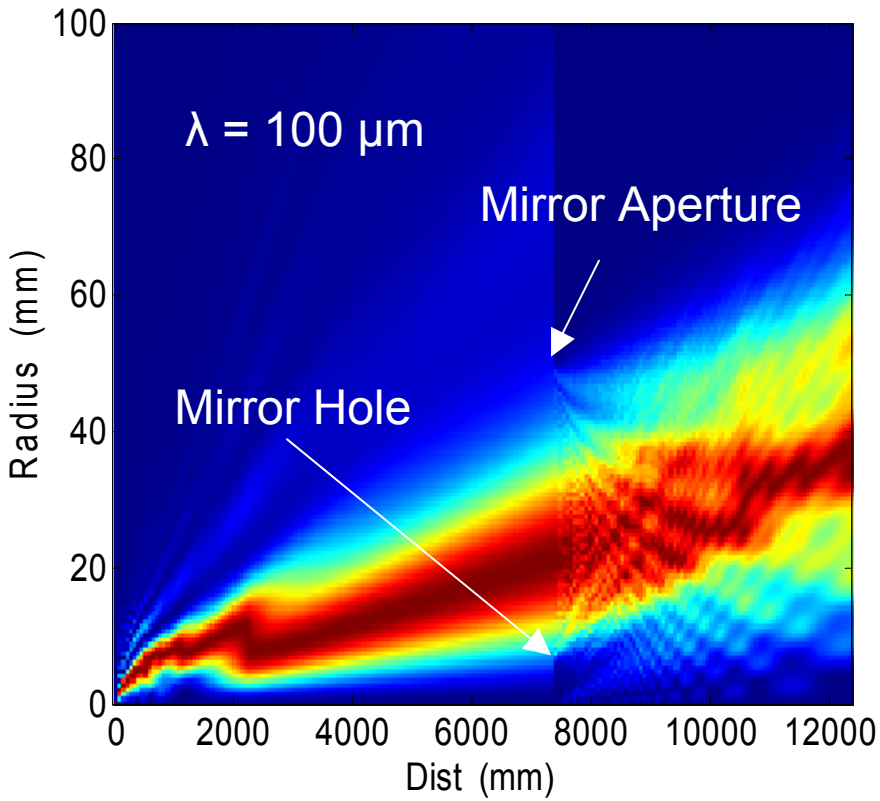


CER & Annular Mirror Option

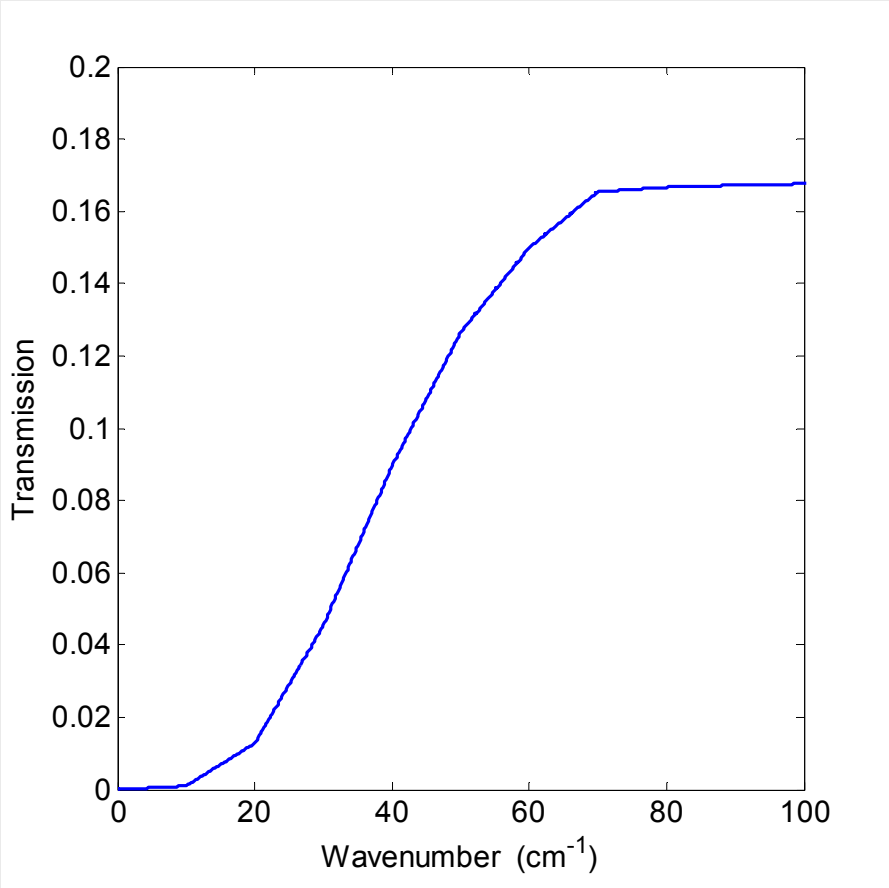
Peak of radiation at radius proportional to wavelength

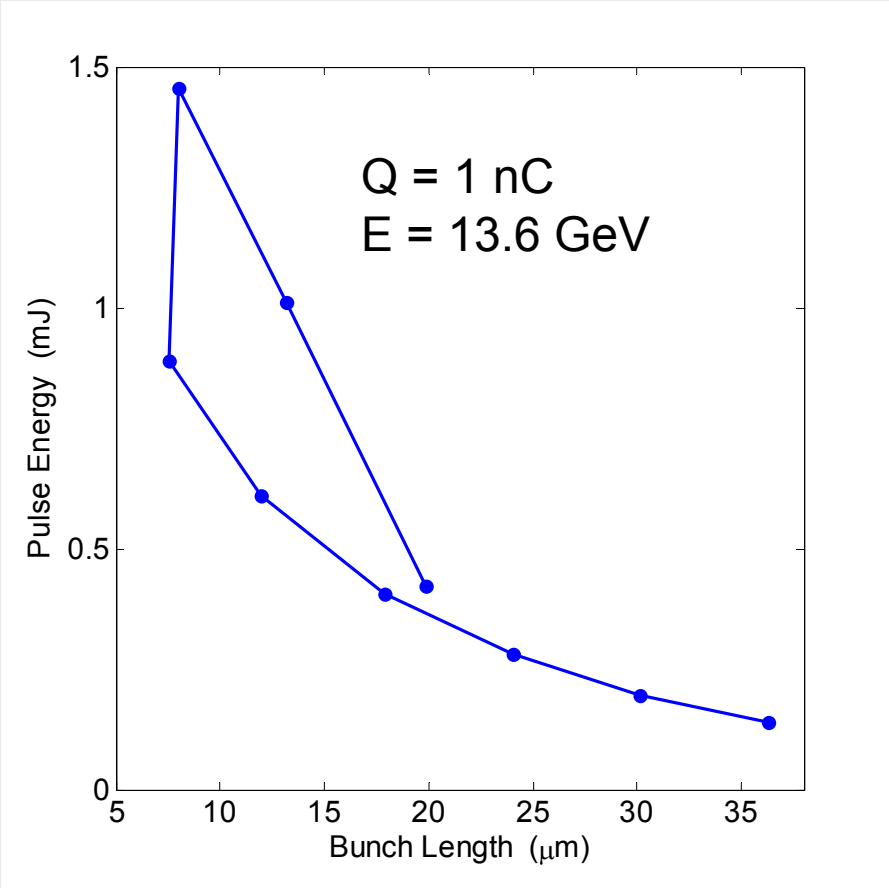
For 1 decade spectral range need mirror aspect ratio of 30:1





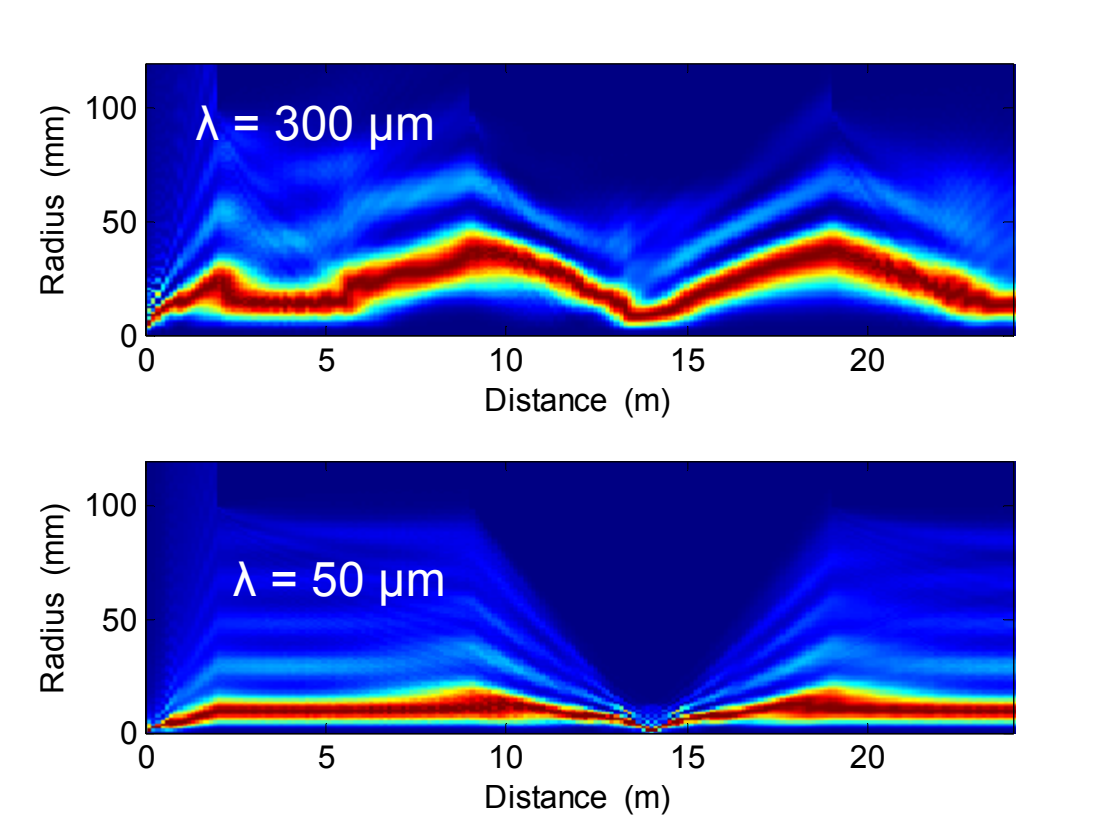
CER THz Pulse Energy





THz Beam Transport

- Transport from Dump area to Near Hall ~100 m
- Periodic focusing with 10 m drifts, 8” optics
- Transmission > 60% above 1 THz (only from diffraction)



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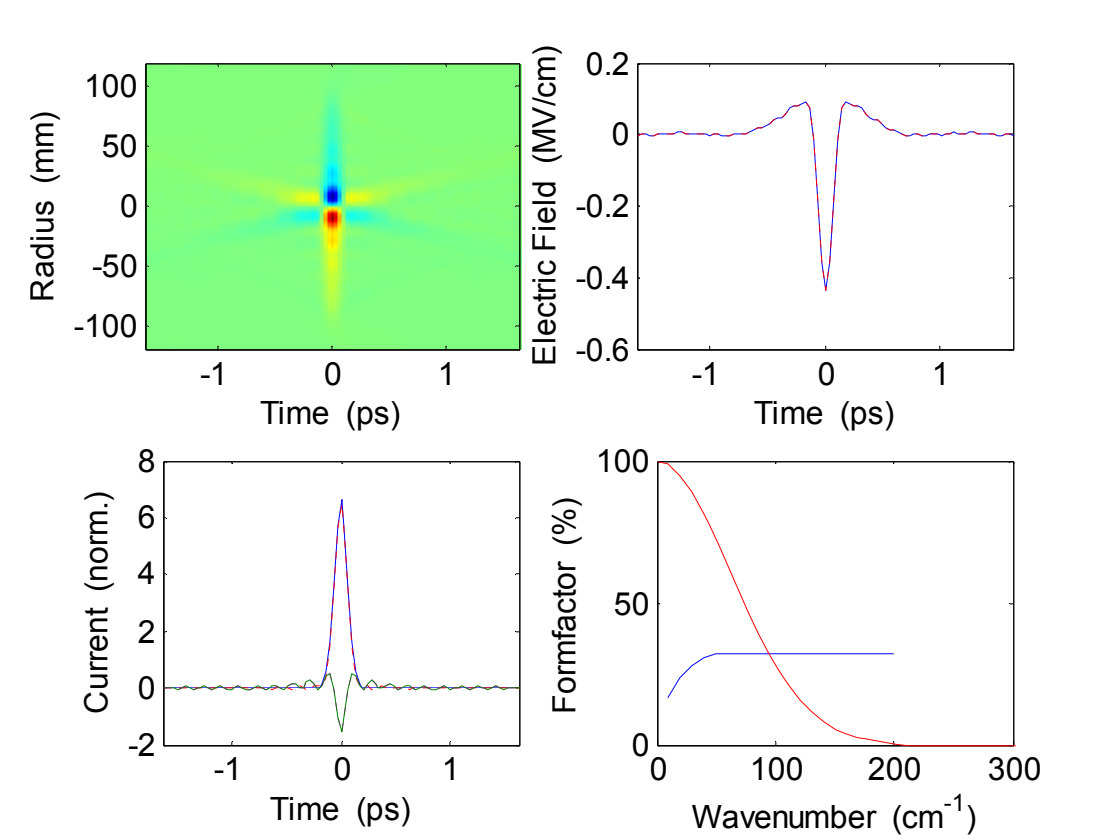
CTR THz Pulse Field & Energy

- Simulation for 1 nC, 60 fs, focus after 5 m lens
- THz pulse resembles e-bunch profile after ~1 ps low pass filter
- Peak electric field proportional to peak current
- With stronger focusing > 1 MV/cm
- Pulse energy > 1mJ
- At shortest bunch operation half cycle < 10 fs THz pulse possible



Summary

- Main issue is generation of THz pulse ahead of x-rays
- THz Pulse synchronized to x-ray beam
- Half cycle e-beam length (~25 fs) THz pulse with > 1MV/cm field possible

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