Time Dependent Phase-Space Characterization of Intense Charged Particle Beams

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Longitudinal Stability

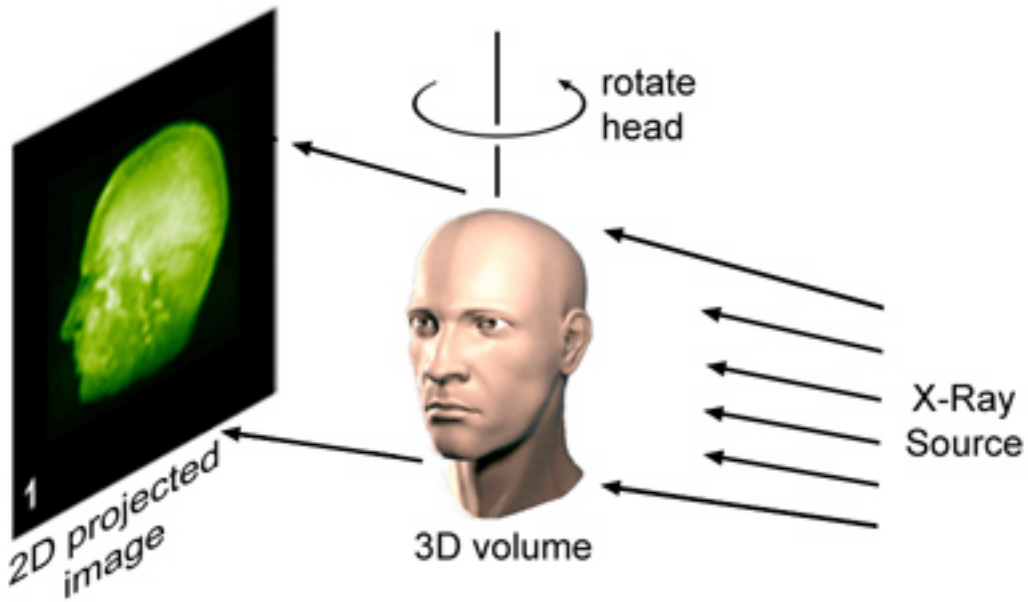
- Longitudinally stability is an important requirement to achieve a high brightness and low emittance beam
- But the actual beam is three dimensional, hence any investigation of longitudinal stability needs to account for possible correlations between longitudinal and transverse dynamics
- This talk:
  - Presents a novel method for the time-sliced mapping of the transverse phase-space of a space-charge (SC) dominated beam
  - Produces phase-space maps for two beams: one close to parabolic, and one with short perturbation atop a rectangular pulse

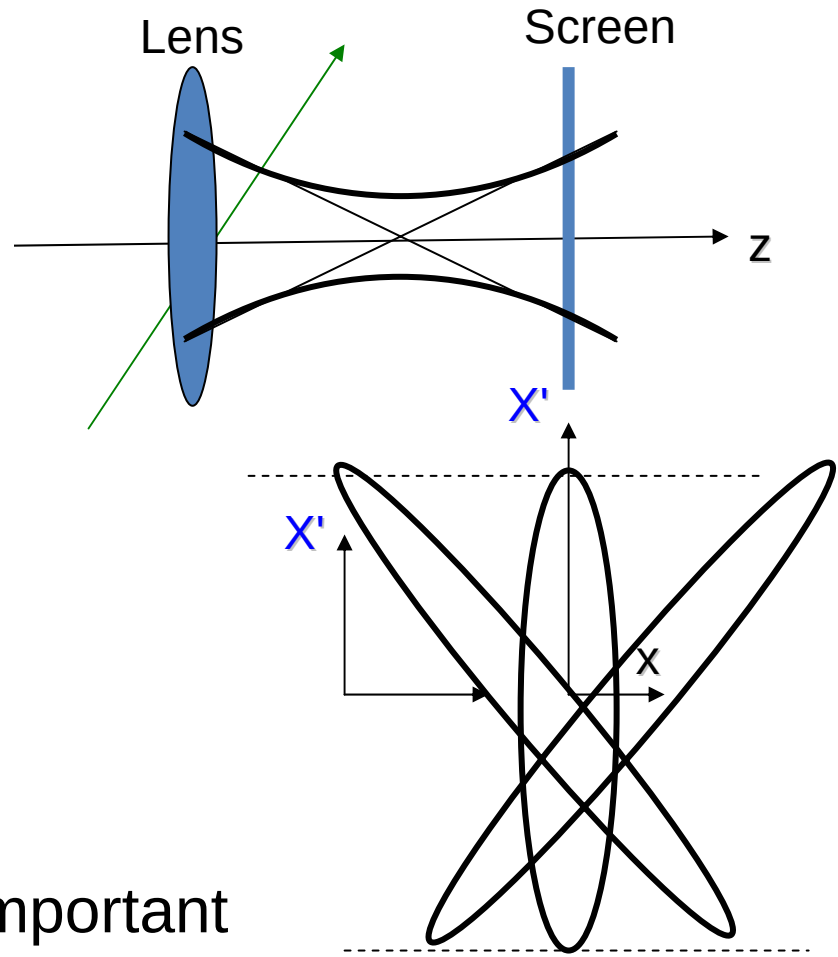
Introduction to Tomography

TOMOGRAPHY

MEDICAL

BEAMS

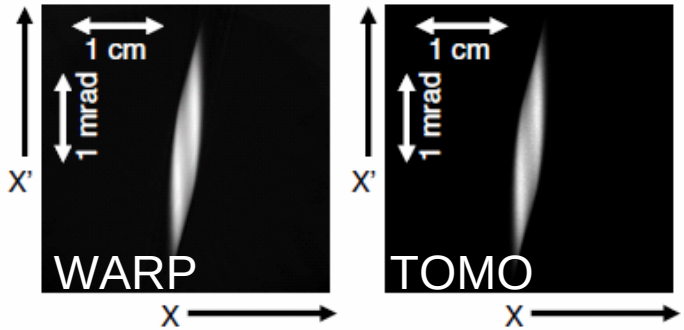




- If the phase space is known then important beam parameters like emittance, size and phase space orientation can be easily calculated

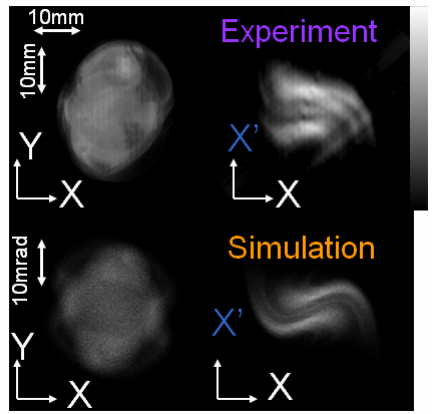
Our Previous Tomography Work – Concept Validation

- Tomography successfully reconstructed the phase-space of a SC dominated beam
- Comparison with simulation revealed good agreement
- Tomography was extended to use solenoids

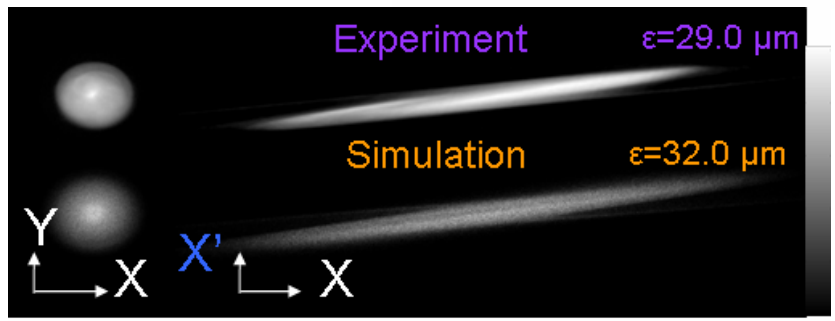


D. Stratakis, et al.
PRST-AB **9**, 112801 (2006)

D. Stratakis, et al.
PRST-AB (to appear in May)

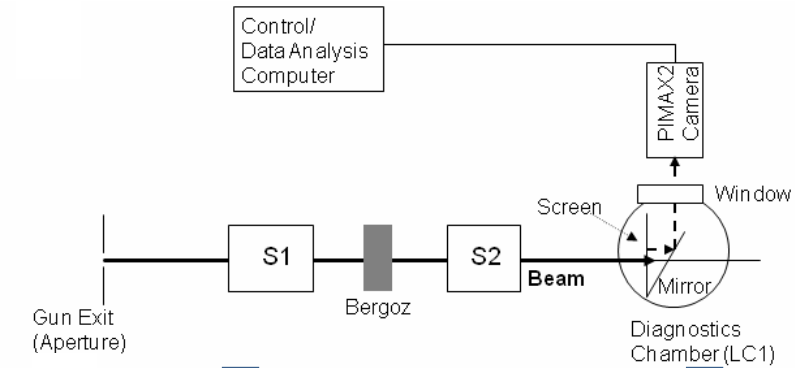


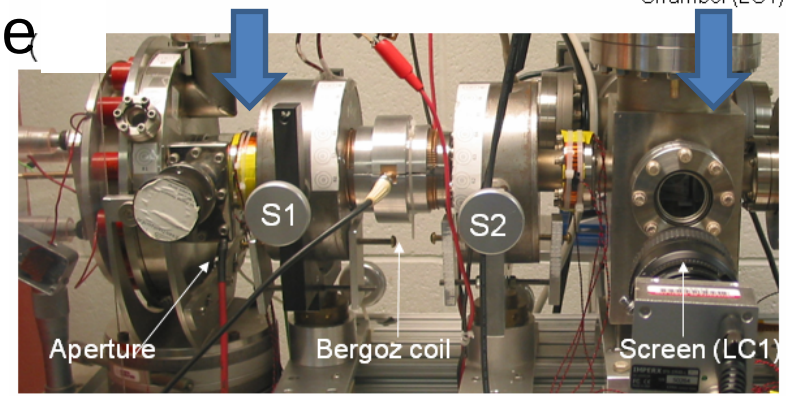
D. Stratakis, et al.
Phys. Plasmas **14 (Letters)**, 120703 (2007)



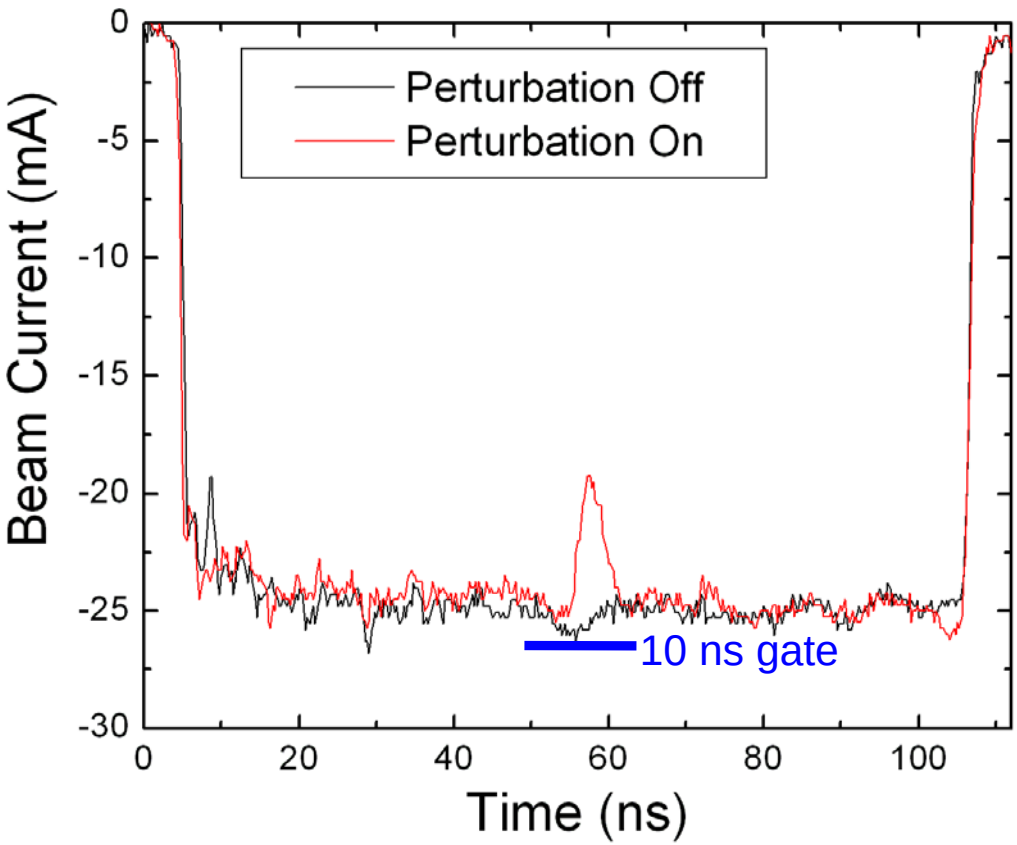
Experimental Configuration

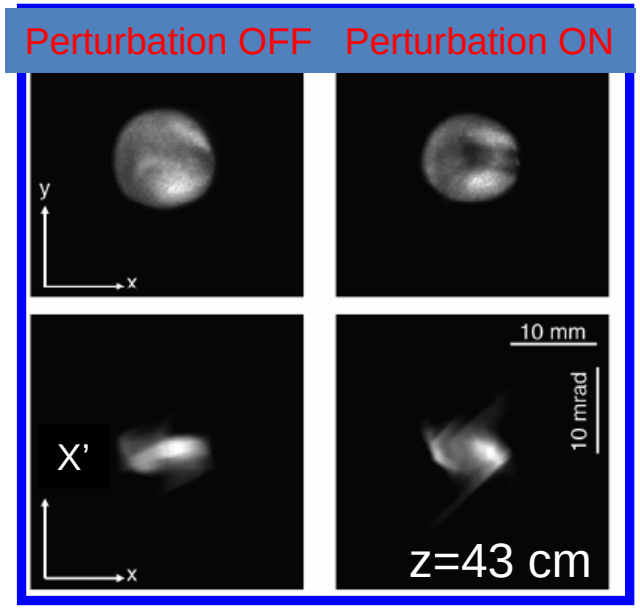
- Pierce geometry gun produces a 5 keV electron beam at 60 Hz
- A fast ZnO: Ga phosphor screen was used to map the beam distribution. Time response was 2.4 ns
- PIMAX2 ICCD was saving photos
- Reconstruction at z=0 (gun exit) and at z=43 cm (LC1)

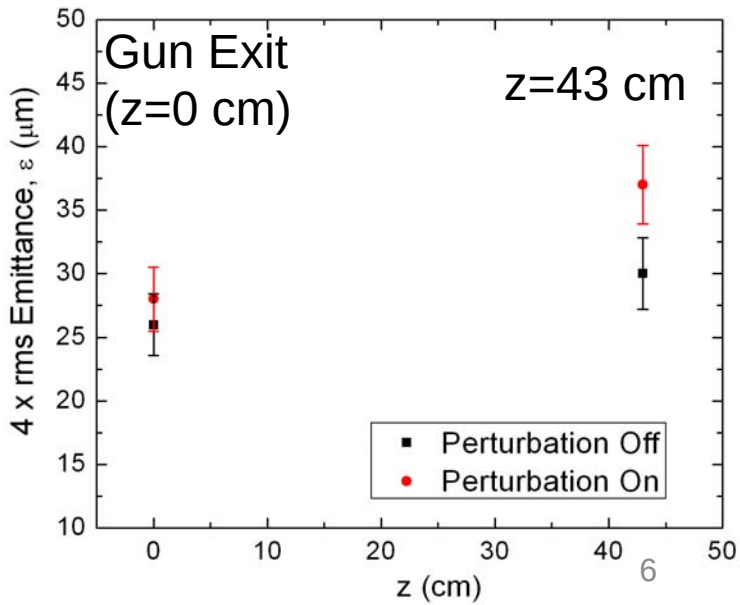




Rectangular Beam with Perturbation (1)

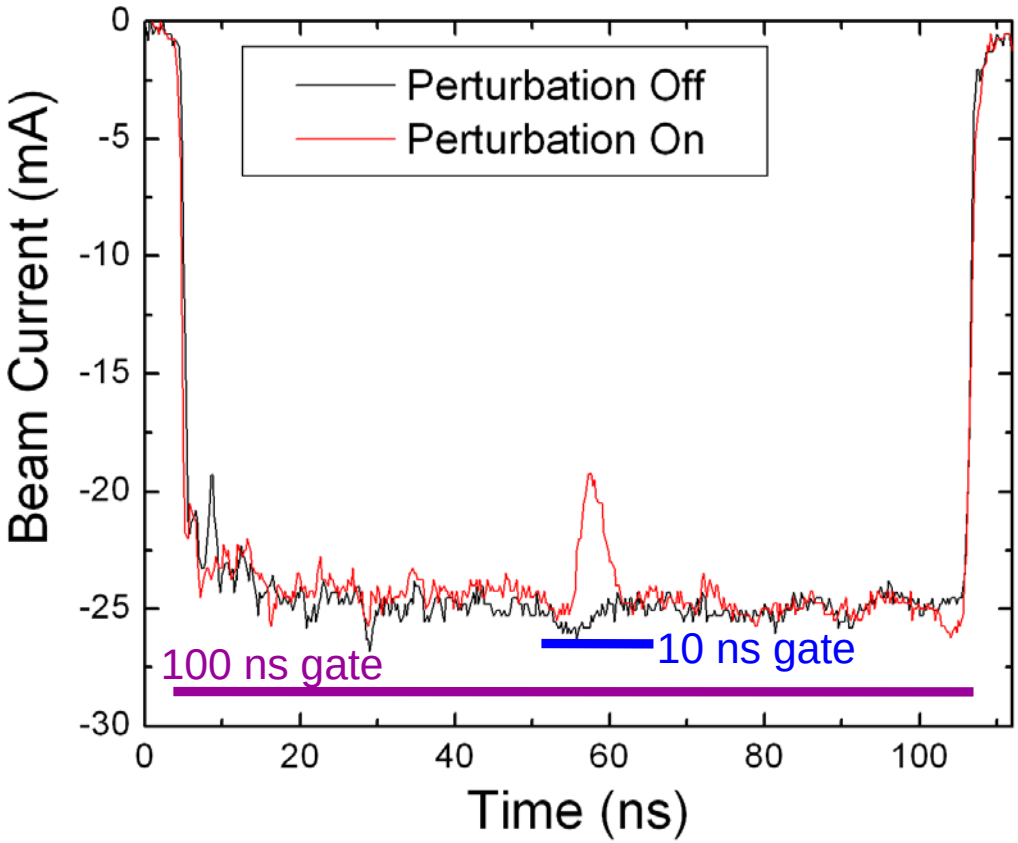


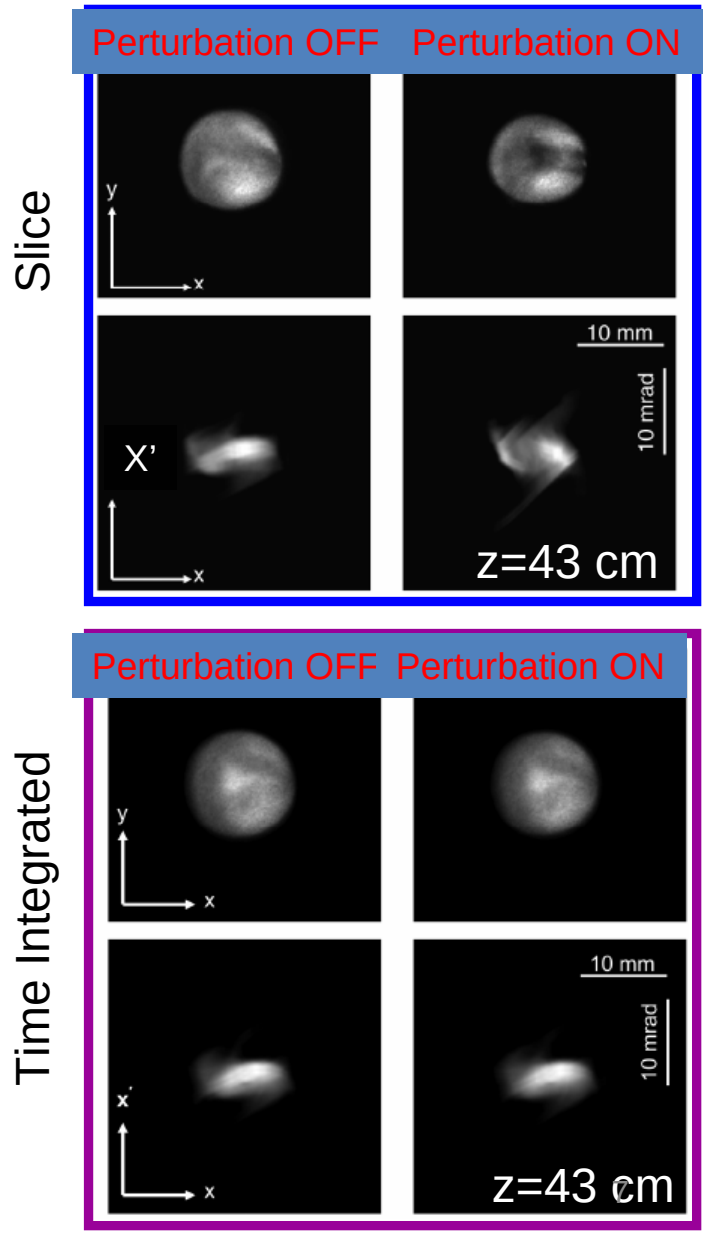




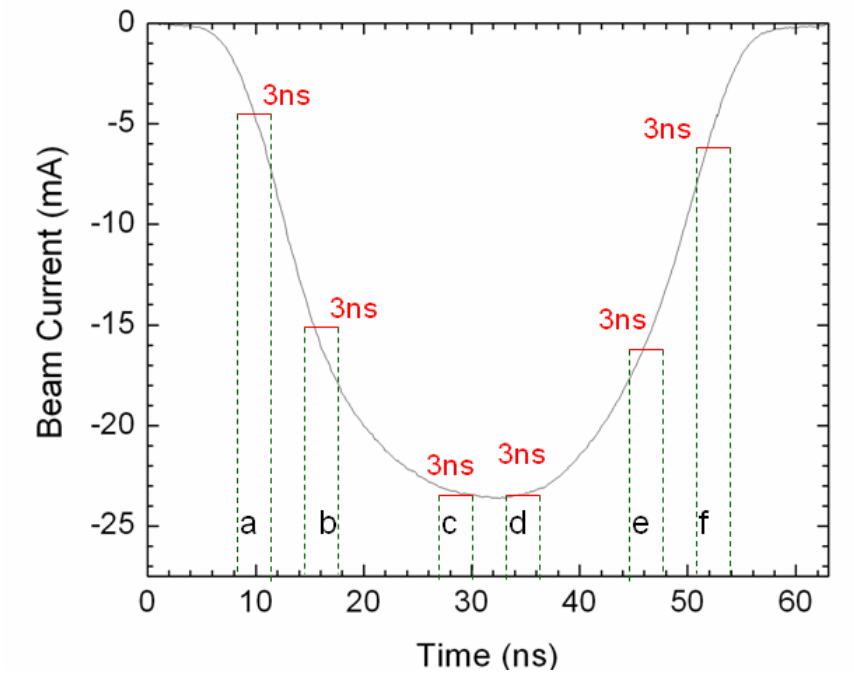
Longitudinal Perturbations:
See Posters of K. Tian (FR5PFP049)
and B. Beaudoin (FR5PFP058)

Rectangular Beam with Perturbation (2)

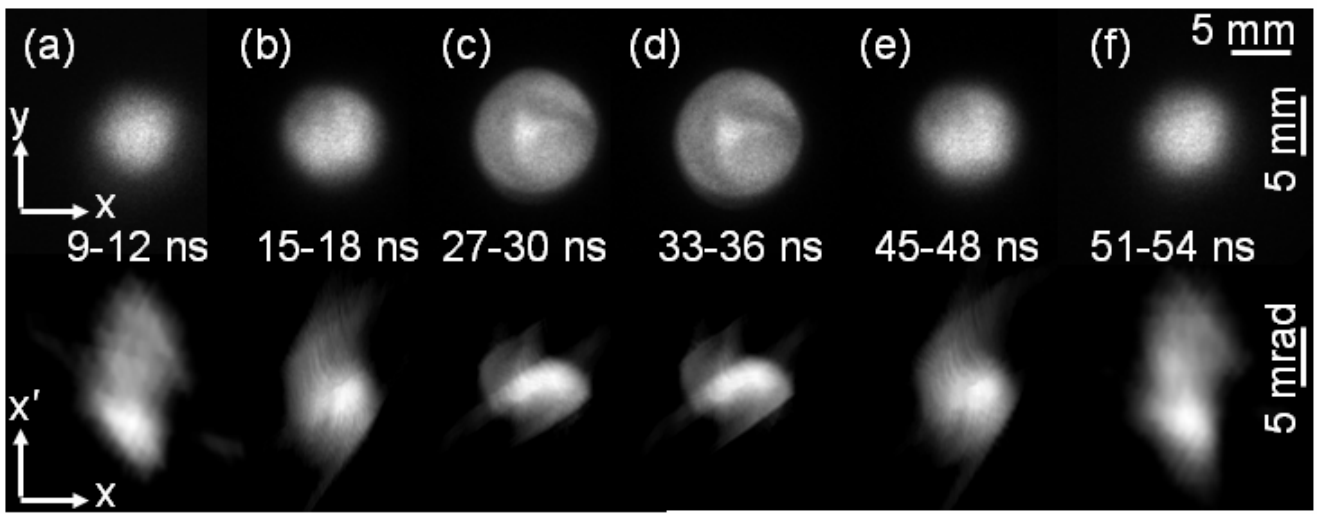




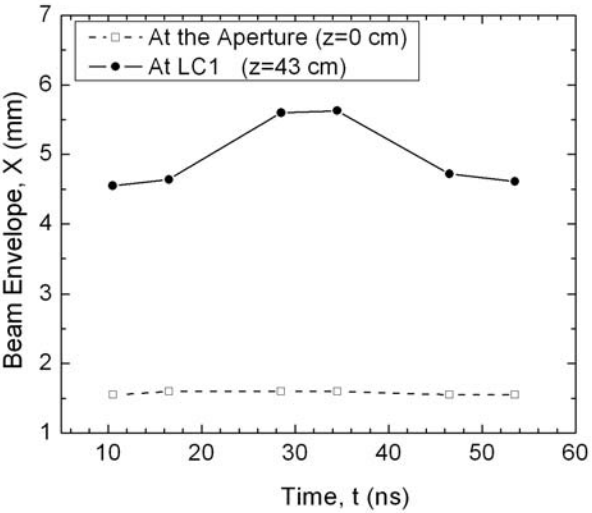
Parabolic Beam Pulse (1)

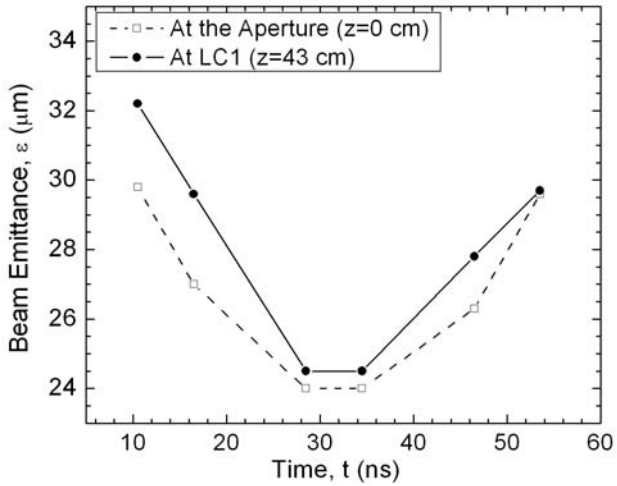


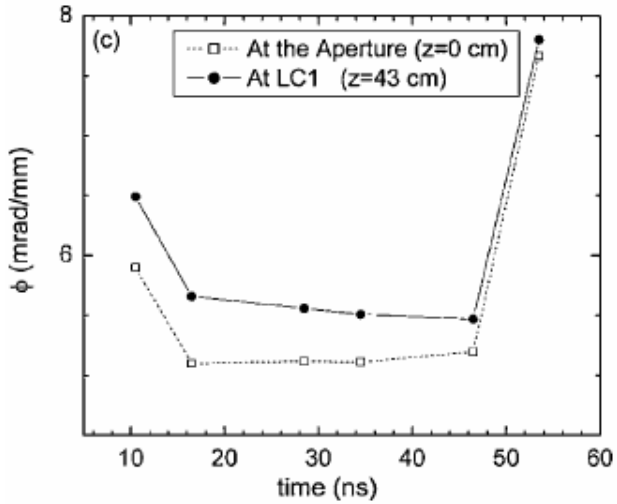
z=43 cm

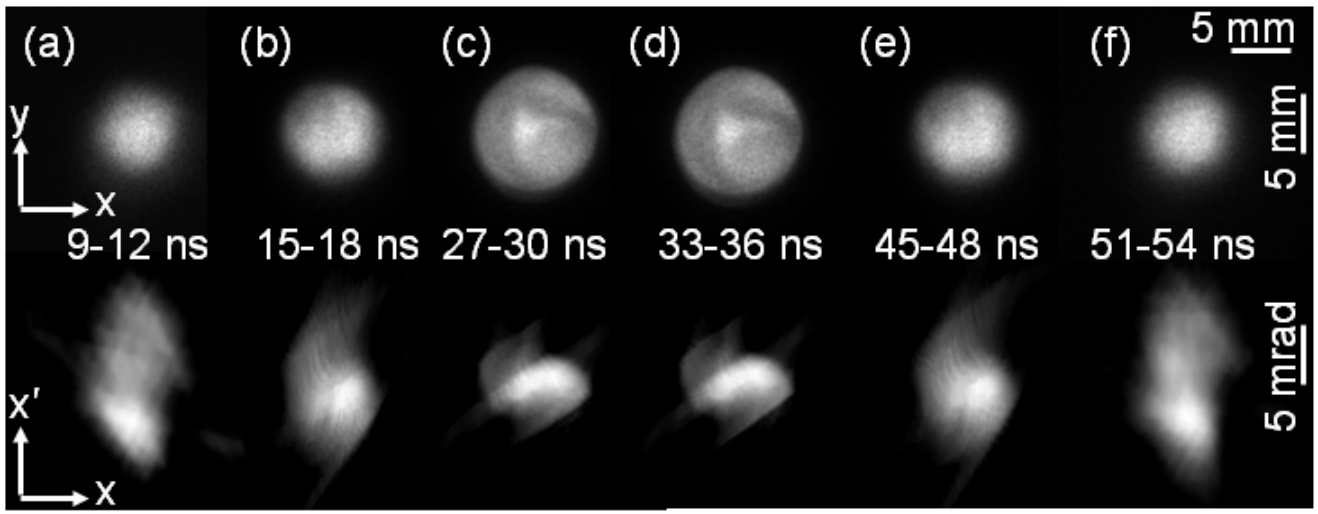


Parabolic Beam Pulse (2)







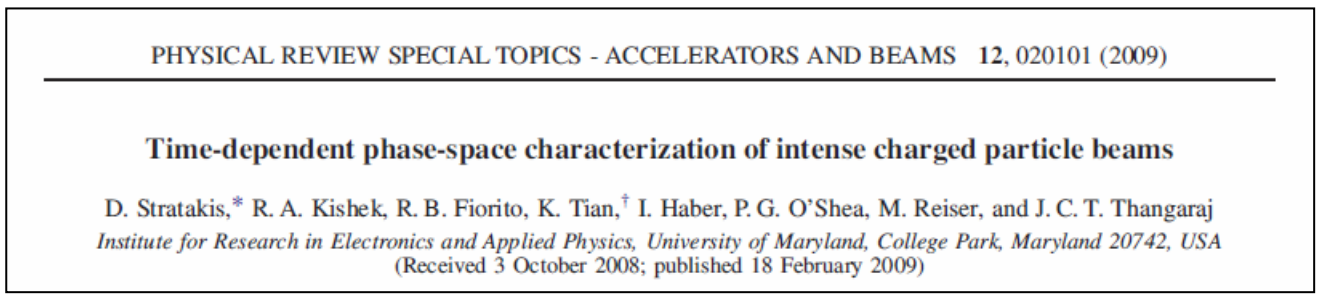


Data Interpretation

- It is not clear why the emittance is larger at the edges.
- One problem could the assumption of constant current within each slice – not the case at the edges.
- One solution is to decrease the camera gate so that the variation in current is reduced.
- Not possible in our experimental system.
- A simulation of the problem is also being pursued.

Summary

- A novel method was presented based on tomographic principles to reconstruct the time-resolved phase space that:
  - Provided detailed phase space-map and not just an emittance
  - Included the space-charge effect (assumes linear forces)
  - Projections are obtained by either using solenoids or quadrupoles
  - Fast measurement and does not occupy a long section of the beam pipe



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