EXPRESSION OF INTEREST: Space-Charge-Induced Phase Mixing and Related Evolutionary Time Scales

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Probable Collaborators (at minimum):

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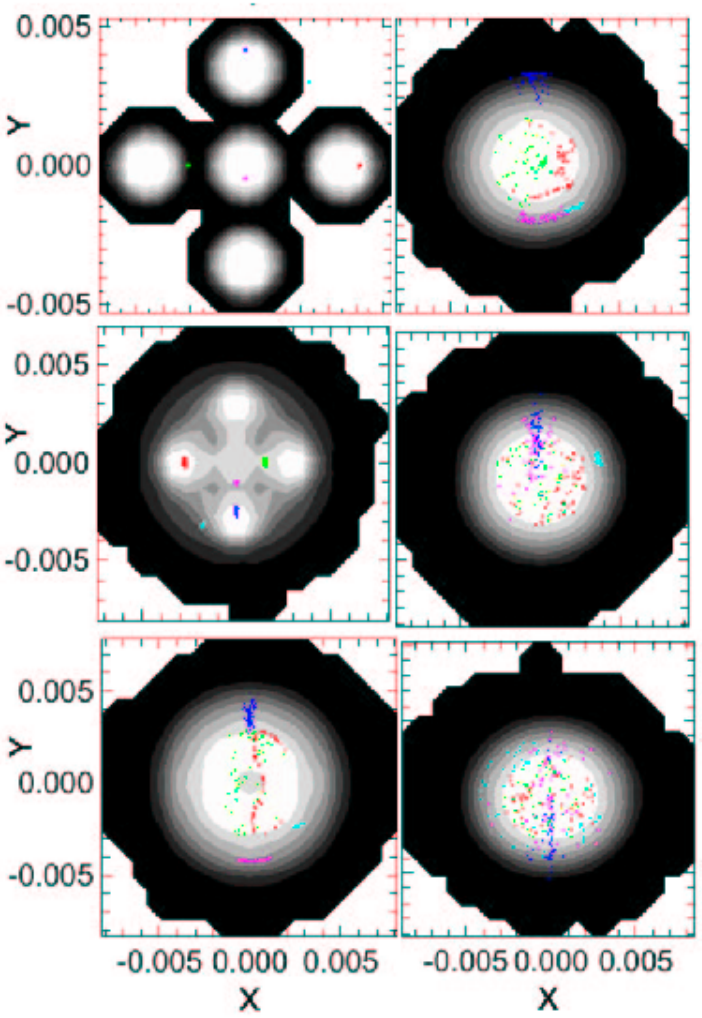
Some Fundamental Questions

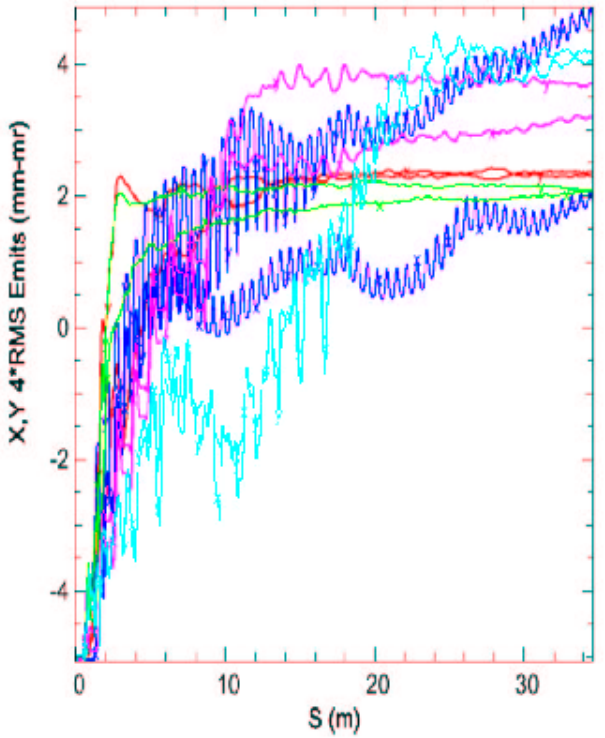
- How do beams with space charge equilibrate?
  - Need a dissipation mechanism other than particle-particle collisions (theoretical studies by C. Bohn et al)

- Is equilibration, and phase-space evolution in general, reversible?
  - Reversibility implies the possibility of correction resp. compensation.

- If evolution is irreversible, then need to know the time scale at which irreversibility sets in.
  - e.g., How often should one apply corrections to the beam?

Experiment by Reiser et al



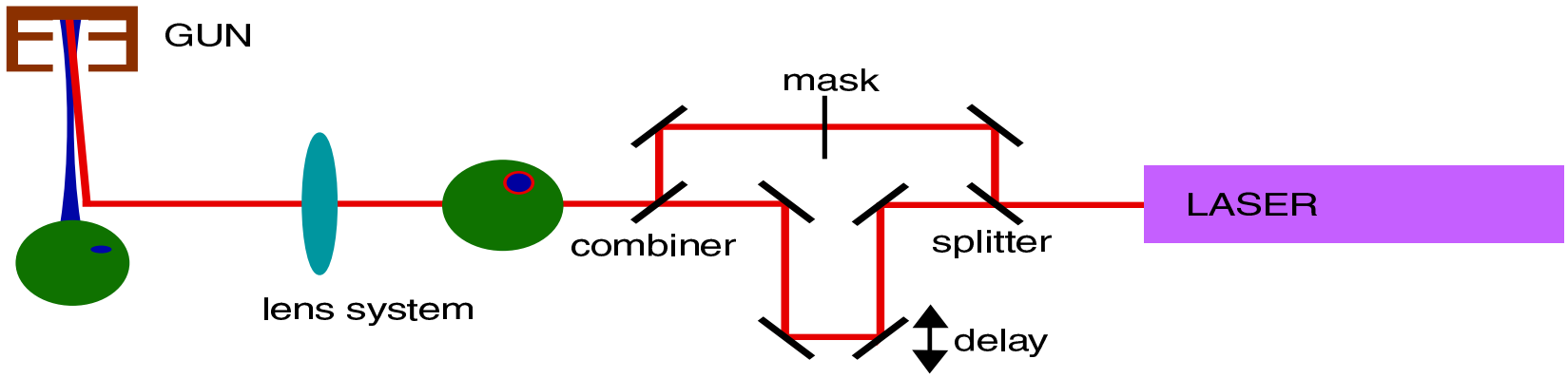


Generally clear exponential growth, indicating chaotic mixing is active.

Idea of Experiment

Scan a second, weaker laser beam across the cathode

- map the cathode downstream $\longrightarrow$ transfer functions
- probe the coulomb (and other nonlinear) forces



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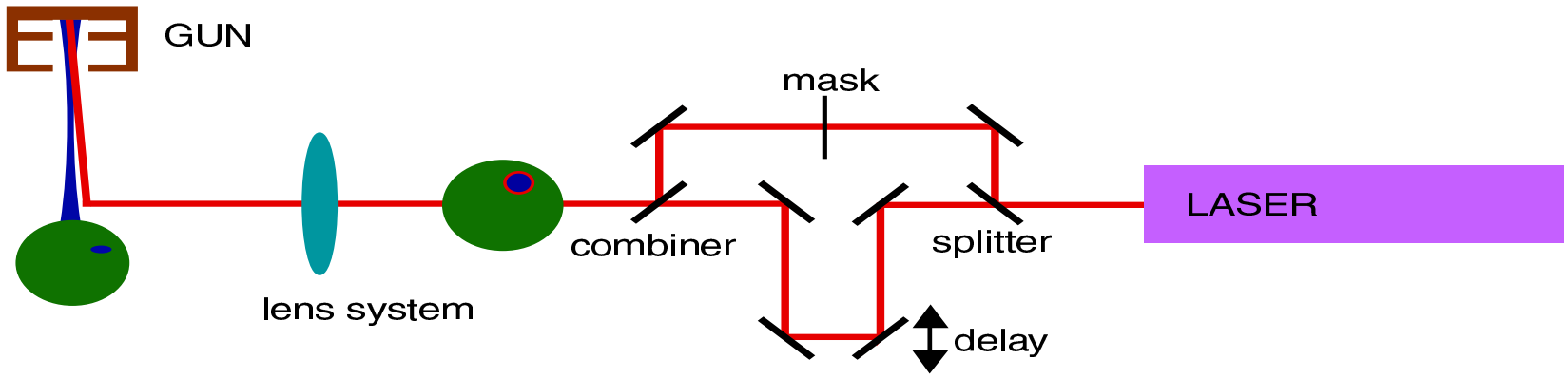

actual setup probably incorporated in pulse stacker

Parameters

- Density enhancement:
  - Minimize additional charge, so that the perturbation of the space charge effect is neglectable
  - Maximize enhancement for better visibility
  - Given the linear nature of the space charge 10% should be a reasonable trade-off
  - step-by-step increasing the intensity of the probe-bunch may allow for extrapolation towards zero
  - lock-in techniques may increase the sensitivity,
  - cameras with increased resolution and noise suppression may be required,
  - YAG-screens may be useful

Parameters

- Total Charge:
  - Coarse estimates yield a decay length of ≈ 1 m for the FNPL beam line with a bunch charge of 1 nC and an energy of 15 MeV, befor the booster cavity the decay length is correspondingly shorter $\longrightarrow$ does the structure sustain until it can be observed?
  - again step-by-step increasing the charge and/or energy may allow for extrapolation

- Laser:
  - the laser system is reportedly unstable, in this context fast pulse-to-pulse fluctuations are the major concern
  - additionally the production of a "nice" transverse and longitudinal profiles is not guaranteed
  - on-line verification of the pulse shape and intensity in connection with a selection process may give reasonable results

Longitudinal Phase Mixing

Phase mixing in the longitudinal phase space will be less pronounced than in the transverse, but still it will be present. There are plans to install diagnostics which would be very useful to study the effect in the longitudinal phase space

- Single-Shot far infrared spectrometer (U. Happek)
- Single-Shot electro-optic measurement (Yang Xi)

Remark

Besides the investigation of phase mixing the measurement described here can also be used as a means to adjust the accelerator.