Generation of angular-momentum-dominated electron beams in a photo-injector

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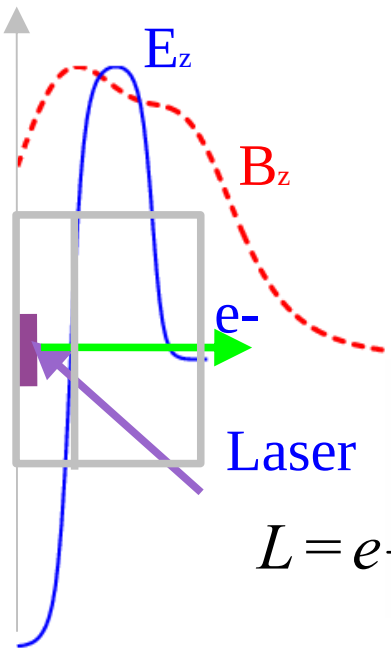
- understanding the generation of angular-momentum dominated e-beams is a first step toward understanding/optimizing the flat beam transformation (the main motivation at FNAL is ILC)
- It has also direct application to other project (i.e. RHIC e- cooling using an energy-recovery linac based on a photo-injector, and LUX proposal)

Angular momentum dominated and flat beam production in a photo-injector

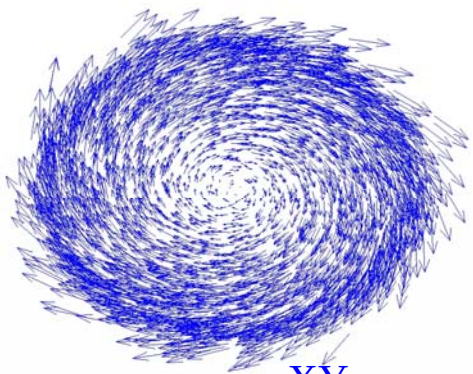
$$p_\vartheta = P_\vartheta + eA_\vartheta$$

Canonical momentum — Kinetic momentum — Vector potential

- Possible techniques:
  - Photoemission using angular-momentum-photons beam
  - **Non-zero axial magnetic field on cathode**
  - Ribbon laser transformed into round beam (Derbenev transform)



$$L = e\frac{B_z\sigma_c^2}{2mc}$$



Skew quadrupole channel

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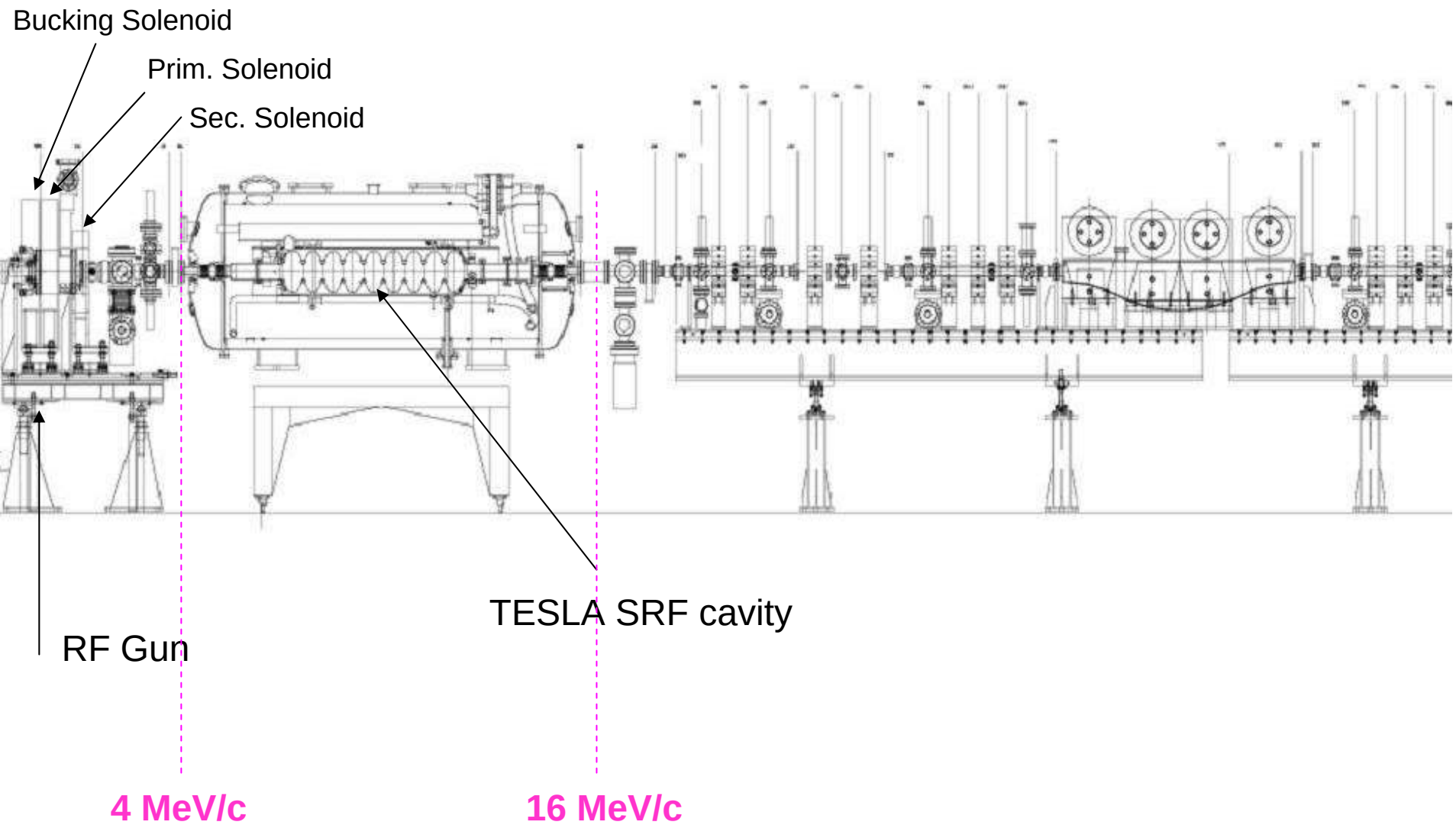
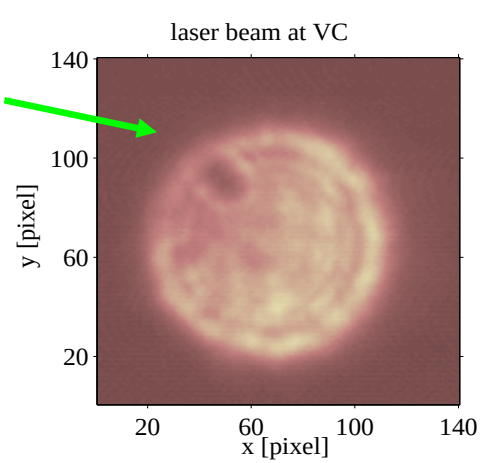
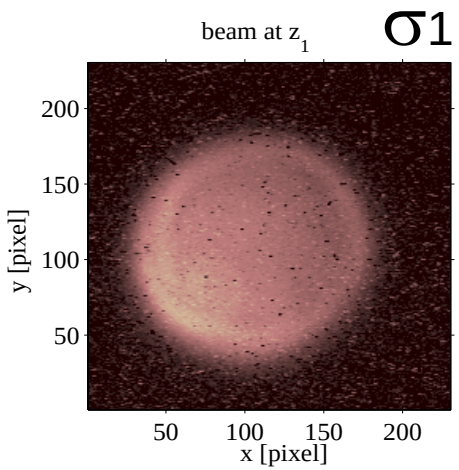
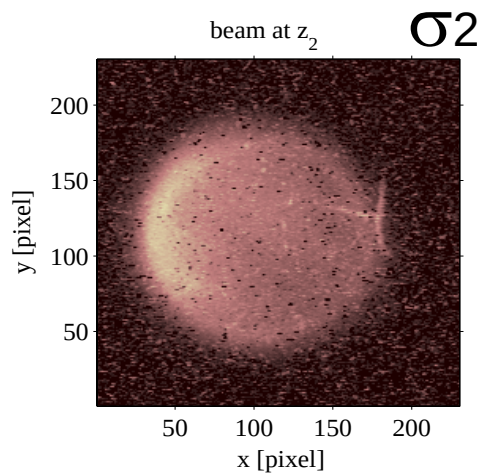


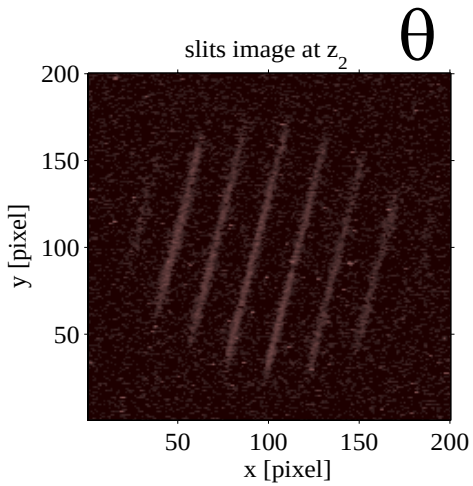
Measurement technique

Gives CAM with B_z









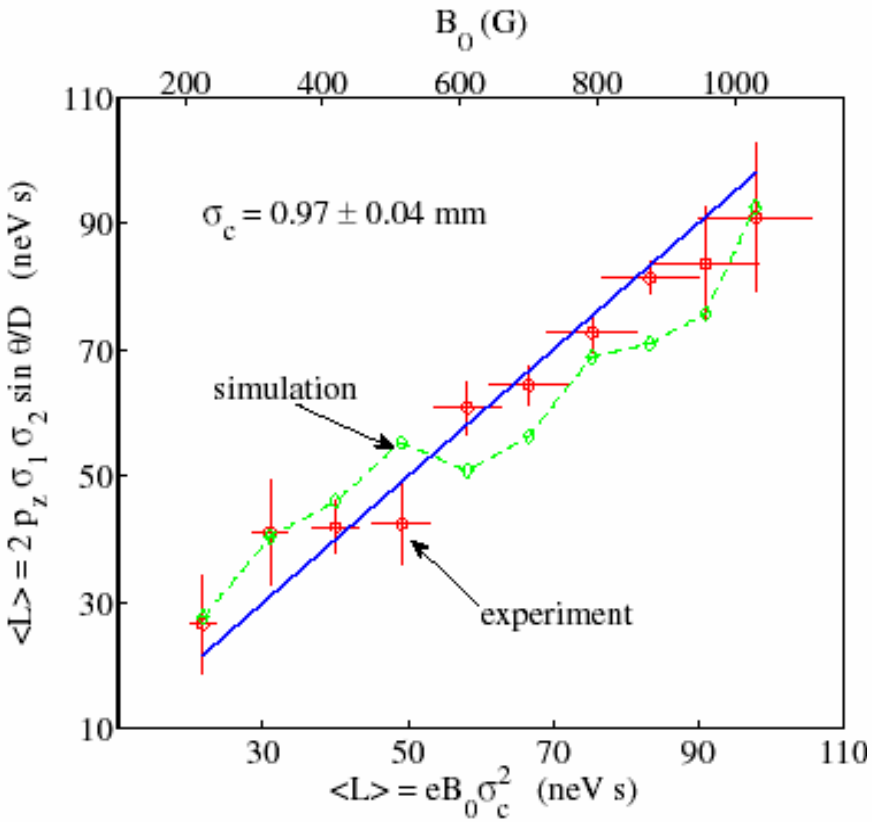
$$\langle L \rangle = 2P_z \frac{\sigma_1 \sigma_2 \sin\theta}{D}$$

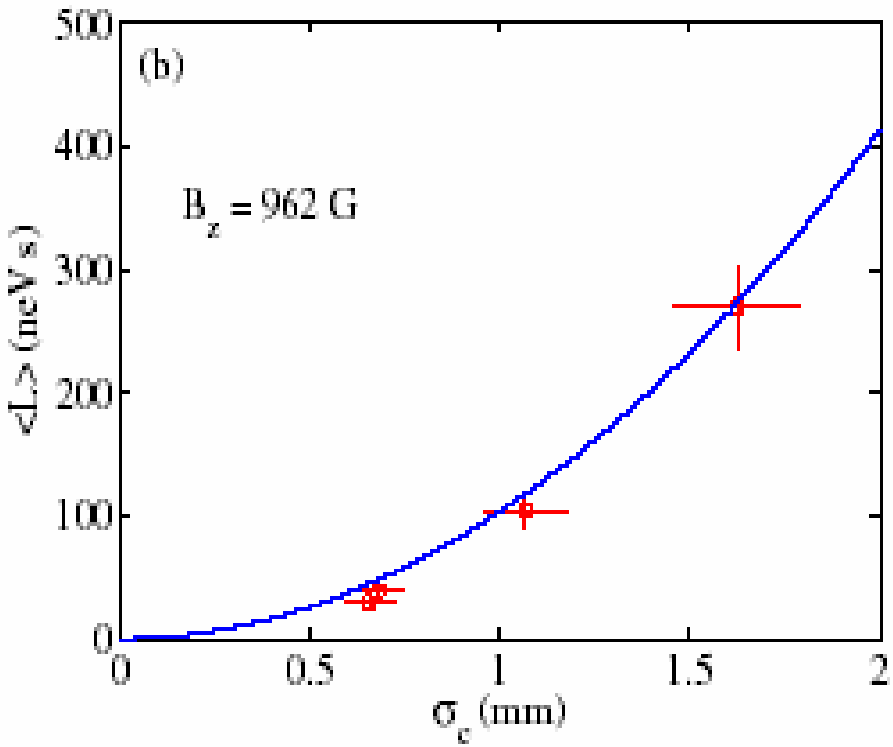
D: drift between (1) and (2)

P_z: longitudinal momentum

Generation of angular-momentum-dominated electron beams in a photo-injector

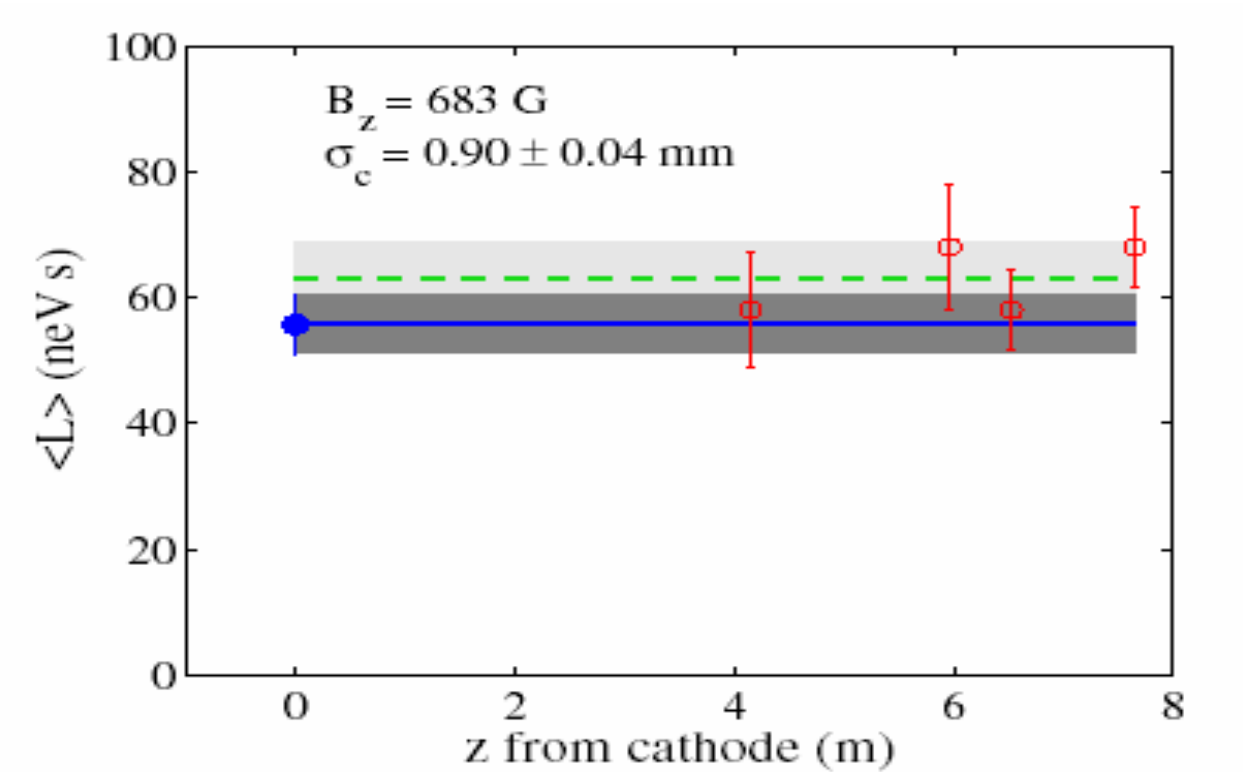
- study the conversion of canonical angular momentum (eA) into mechanical angular momentum [$p_r = r(d\theta/dz)$]
- measure the dependencies of mechanical angular momentum on initial laser parameters



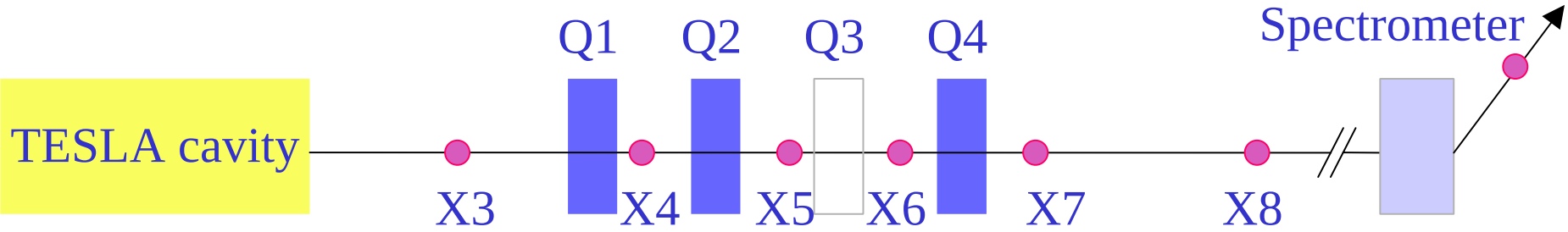


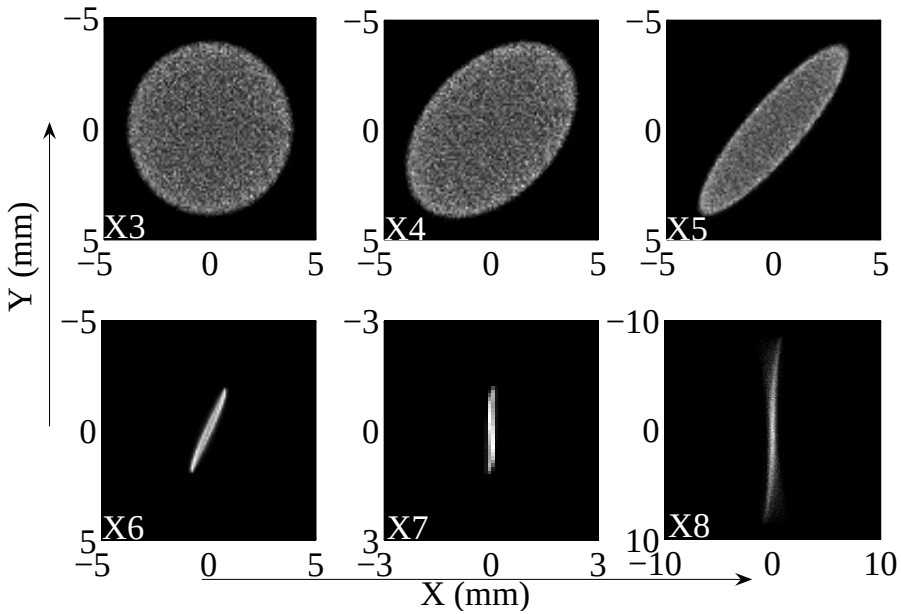
Generation of angular-momentum-dominated electron beams in a photo-injector

- Conservation of angular momentum along the beamline
- In our case (up to ~2 nC) the beam dynamics is dominated by angular momentum

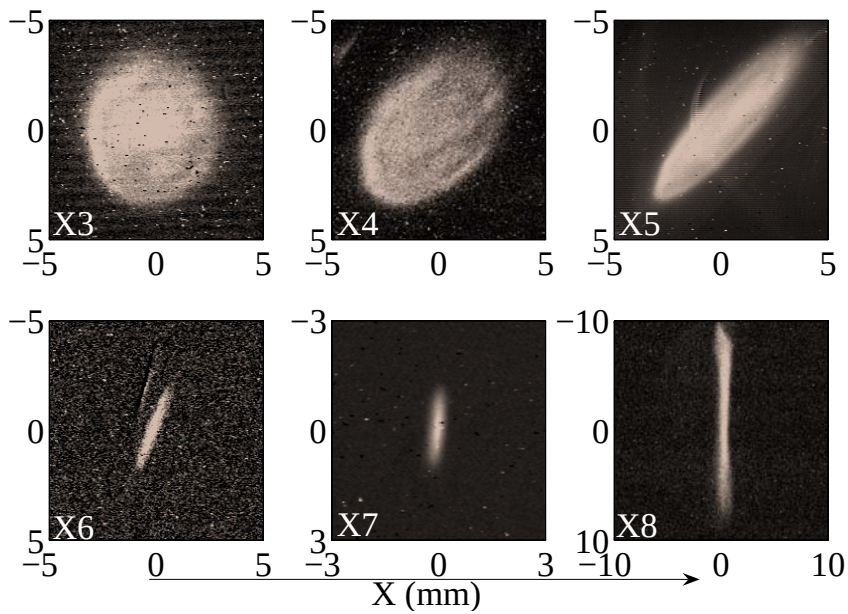


Removal of angular momentum: flat beam production





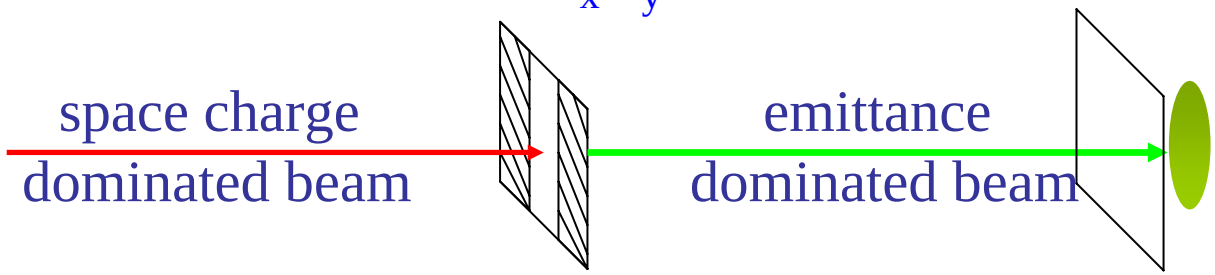
simulations

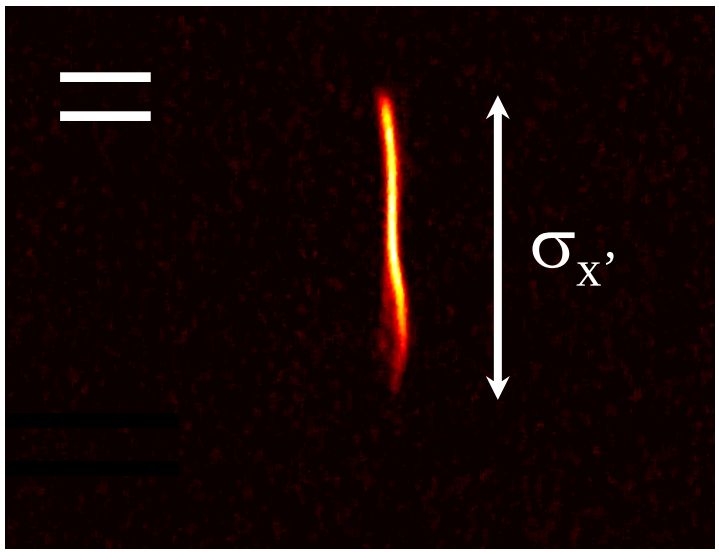


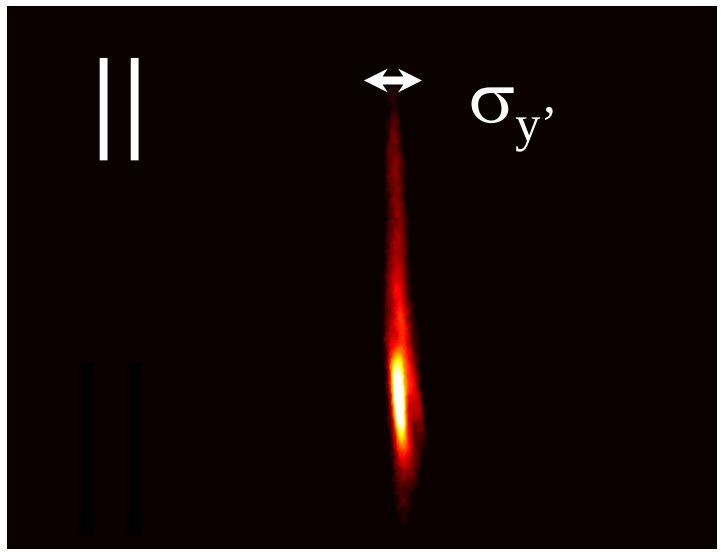
measurements

Flat beam with high emittance ratio

- Since December 2004:
  - Improved diagnostics (single slit + YaG)
  - Decreased spurious dispersion at ε measurement station
- Best ratio achieved to date: $\varepsilon_x/\varepsilon_y$=85+/-5

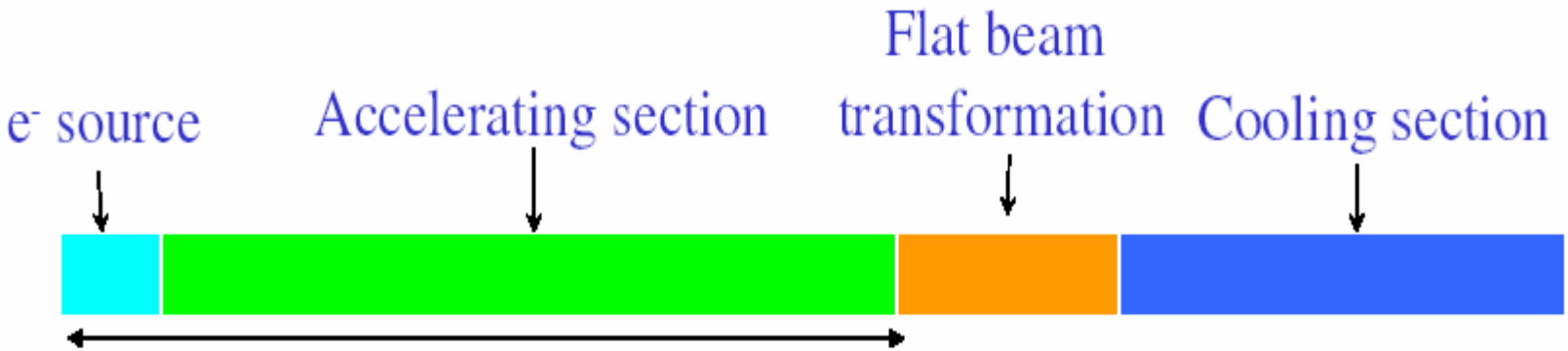




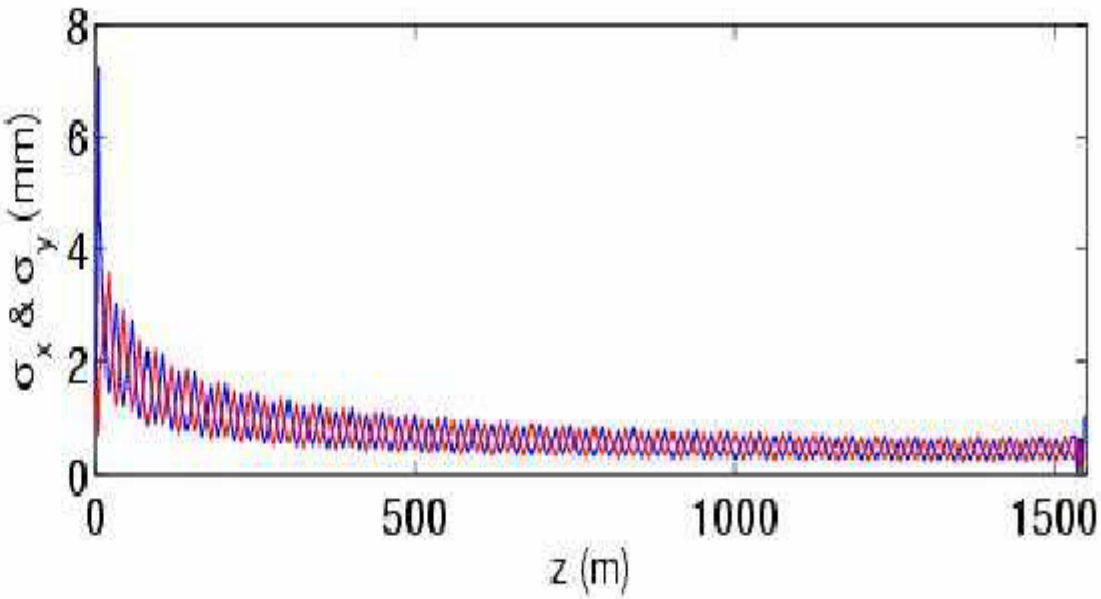


(Sun, U. of Chicago, Piot, FNAL)

R&D on flat electron beam injector



Optimized to minimize ε_{4D} while transporting an angu-lar momentum dominated beam



polarized electron sources iniector for ILC

- DC gun cannot provide high E-field
- Polarized injectors have complicated bunching scheme (compromise between ε and bunch length)
- Higher field on the cathode would help