



P. Piot on the behalf of the FNPL team

- **Beam dynamics associated to high-brightness electron beams**
 - beam manipulations: flat beam generation, bunch compression
 - diagnostics R&D
 - polarized rf-gun-based electron sources

- **Advanced accelerator Physics**
 - plasma-based acceleration
 - plasma-based electron source (laser-based acceleration)

- **Future plans**
 - energy upgrade
 - installation of a deflecting and accelerating 3.9 Ghz cavities

More details in this afternoon poster session



- 16 transverse profiles monitors,
- 3 slit-based emittance measurement stations,
- Streak camera (1 ps resolution),
- 8 electromagnetic beam position monitors,
- Frequency-based bunch length measurement (CTR interferometry),
- Accelerator can be remotely operated (e.g by teams at LBNL, DESY, MSU)

Main beam parameters:

$E = 16 \text{ MeV}$

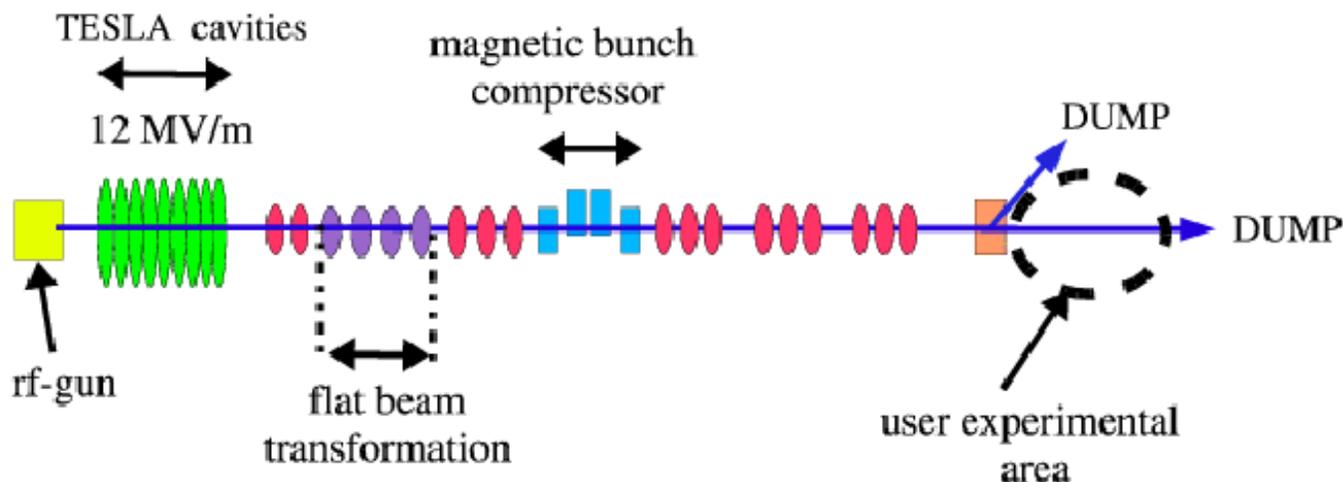
$Q = 0 \text{ to } 20 \text{ nC,}$

$\epsilon_T = 3.7 \text{ mm-mrad (1 nC)}$

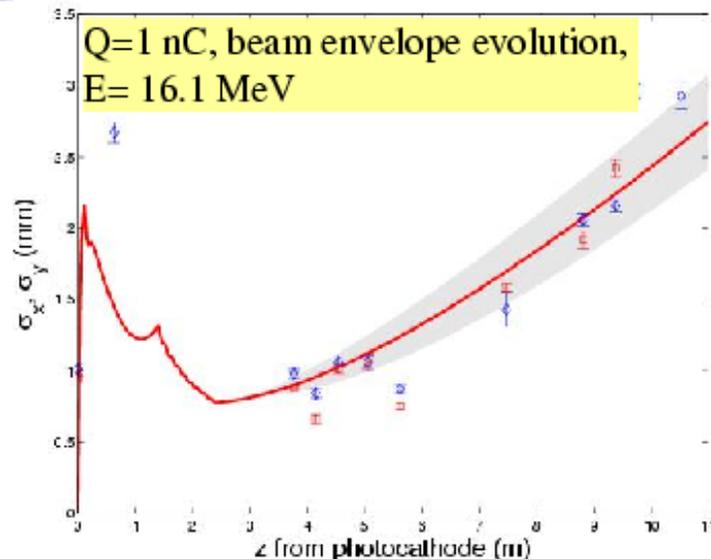
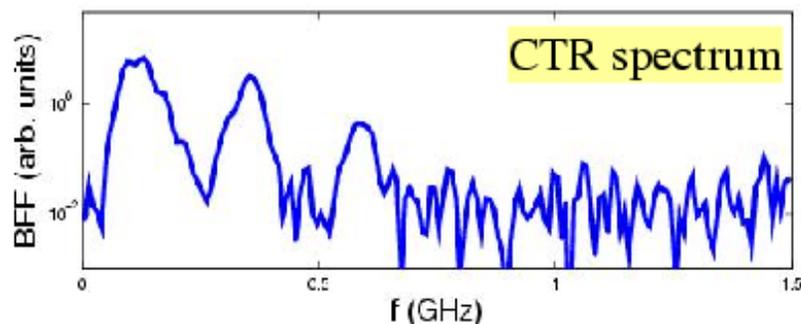
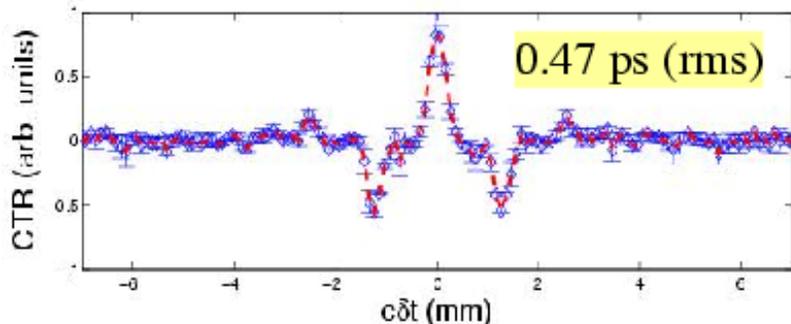
$\delta p/p = 0.25 \%$ (1 nC)

$I_{\text{peak}} = 75\text{-}330 \text{ A (BC off)}$

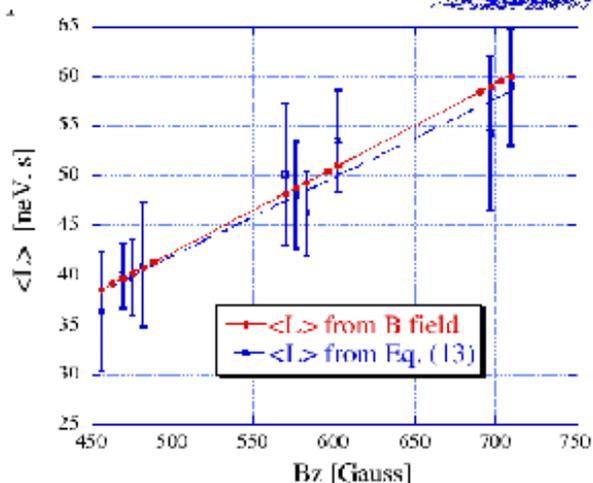
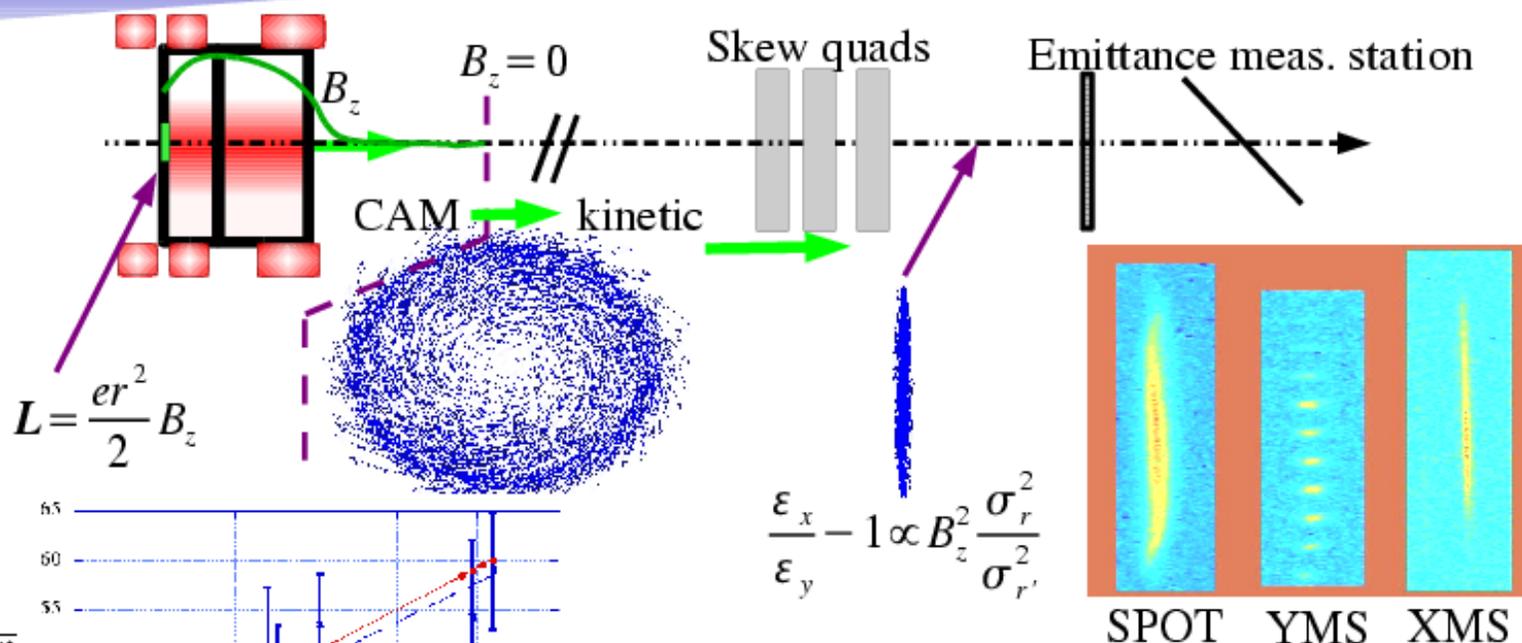
$I_{\text{peak}} = 200\text{-}1700 \text{ A (BC on)}$



- Experimental and numerical investigation of transverse and longitudinal dynamics of space-charge-dominated beams – benchmarking of different numerical models



- Bunch length measurement of sub-picosecond electron bunch using frequency-domain technique based on coherent transition radiation
- Future plans include the use of electro-optical sampling for a time-domain bunch length measurements



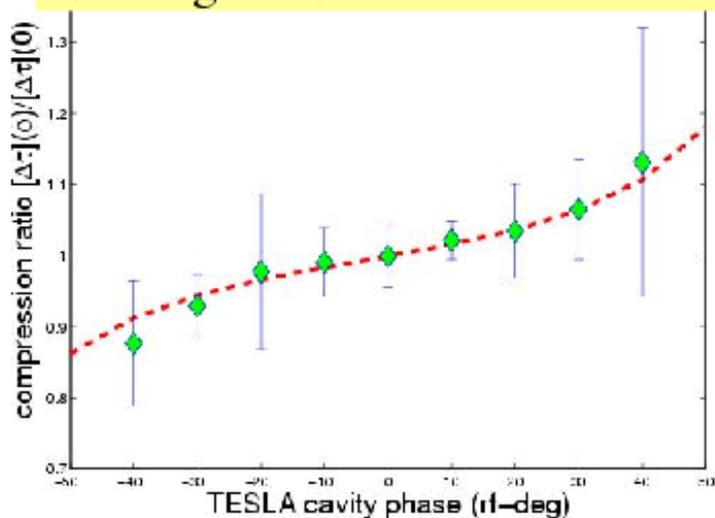
- ▶ Proof-of-principle experiment done
- ▶ Measured emittance: $\frac{\epsilon_y}{\epsilon_x} = 45/0.9 \simeq 50$
- ▶ Now working toward emittance ratio > 100

(Grad. Stud. Y.-E. Sun, U of Chicago)



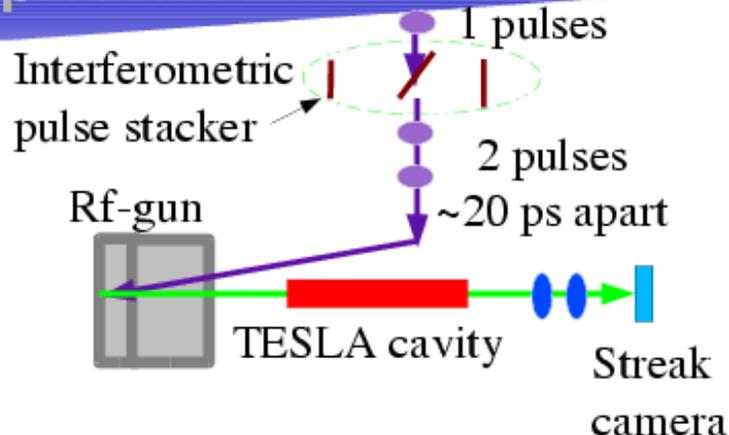
- Develop method to investigate the single-particle dynamics through the linac using two bunches within the same rf-bucket

Bunching evolution in TESLA cavity

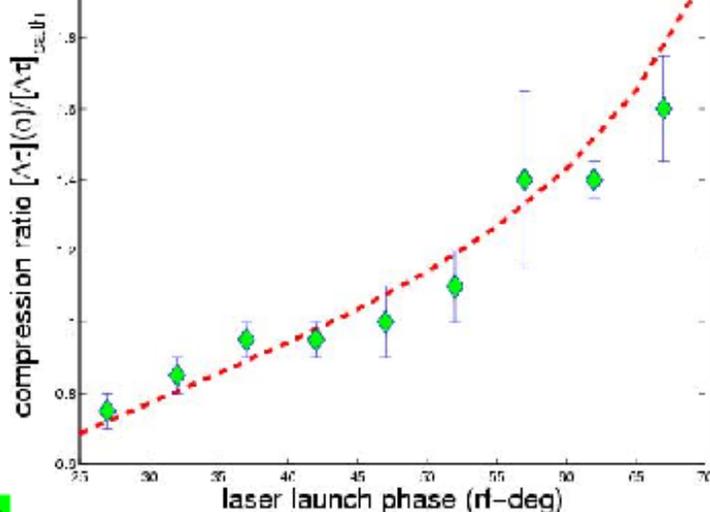


- Later extend to 4 macro-particles, and also study transverse beam dynamics

(Grad. Stud. R. Tikhoplav, U of Rochester)

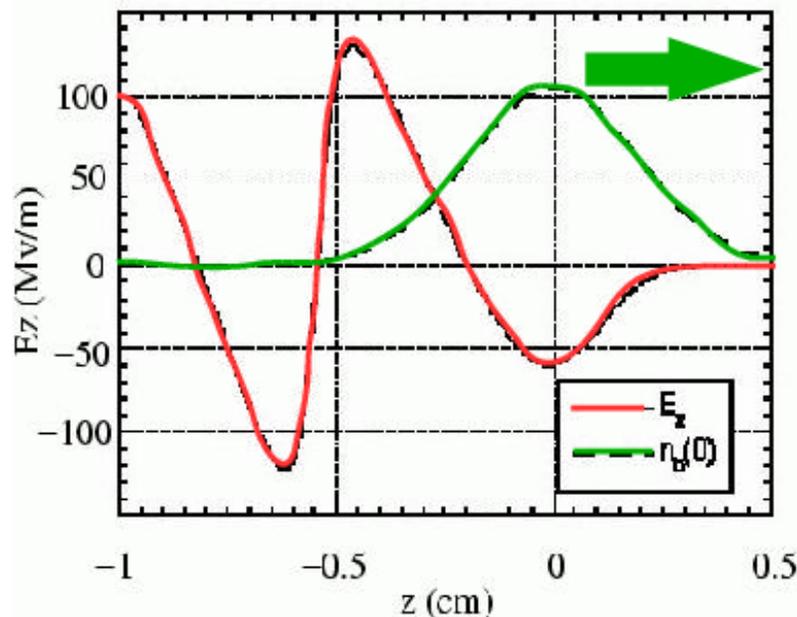


Bunching evolution in rf-gun



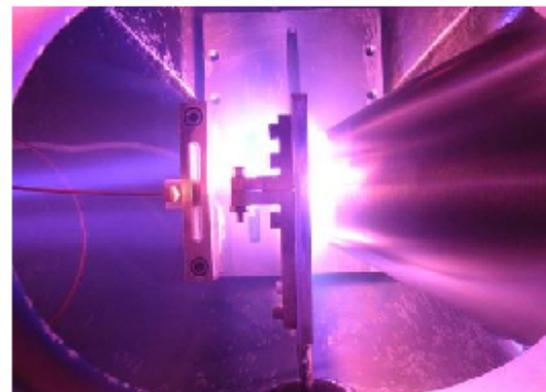
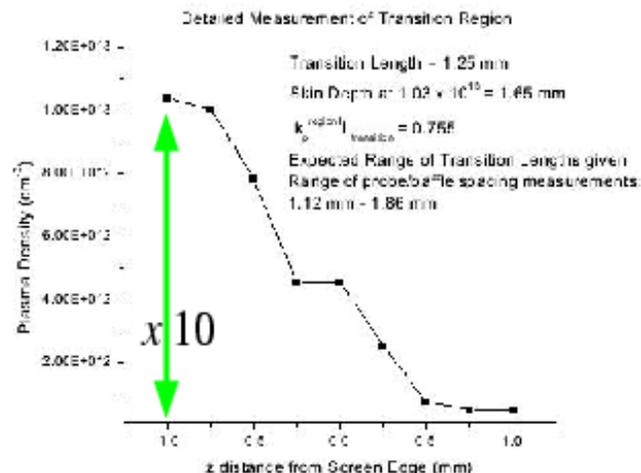
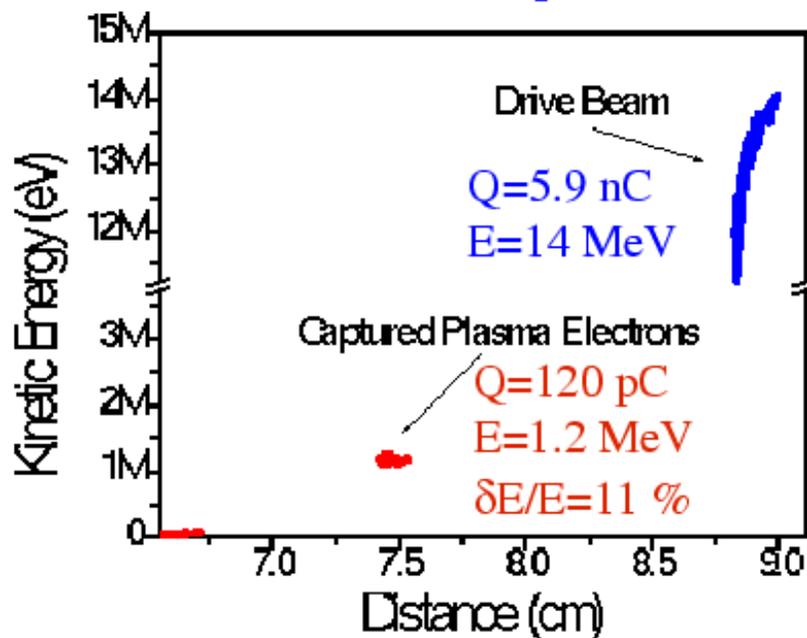
- High current e- beam injected in a plasma induces density modulation
- Energy in the bunch is modified according to the induced wake-field

**Achieved energy gradient of
130 MeV/m**



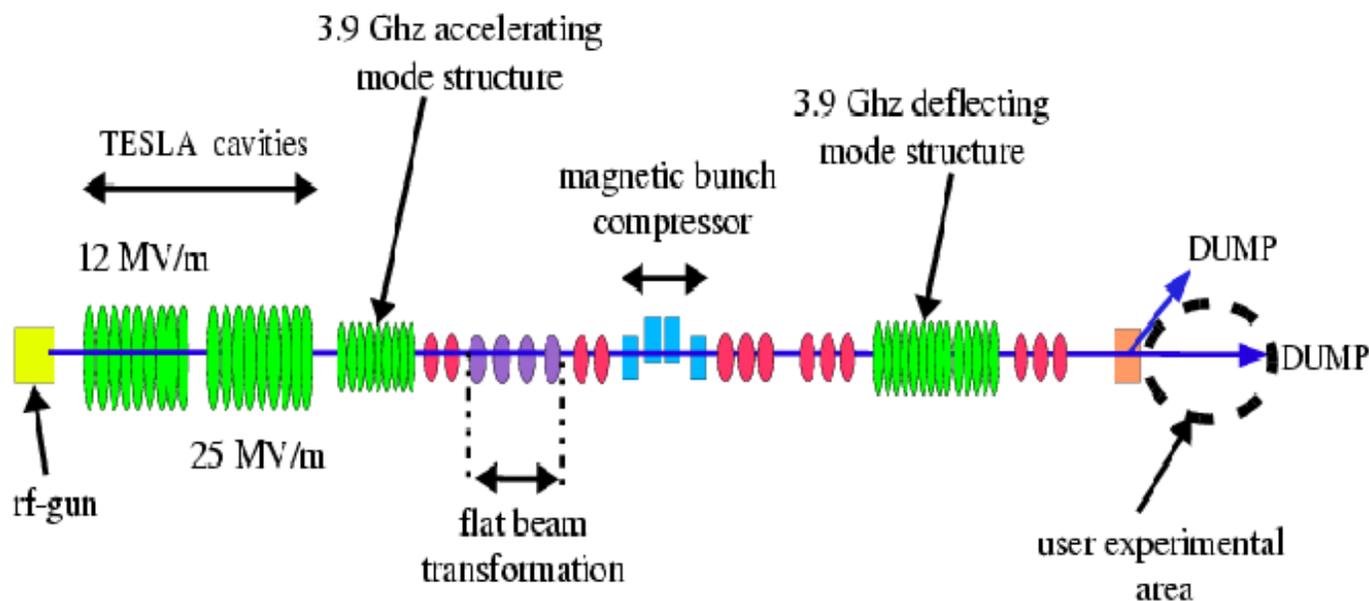
- A next set of experiments aims in sampling the plasma wake using a witness bunch following the drive beam at variable time delays

- Self-trapping mechanism based on rapid change in the wake-field wavelength at a steep transition in the plasma density
- Plasma electrons are dephased into an accelerating field of the plasma wake



(Grad. Stud. M. Thompson, UCLA)

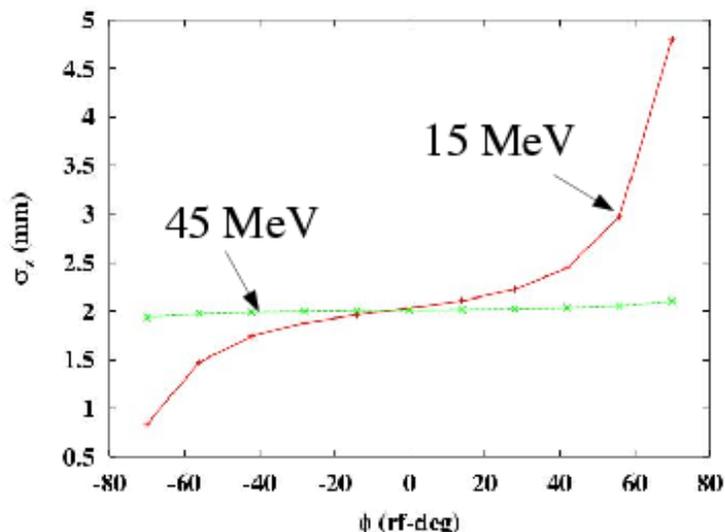
- DESY has offered to give a TESLA cavity (Grad.>25 MV/m)
- Proposed upgrade also incorporate the "CKM deflector" (3.9 GHz deflecting cavity) and a 3.9 GHz accelerating mode cavity both 3.9 Ghz cavities are being developed at FNAL.



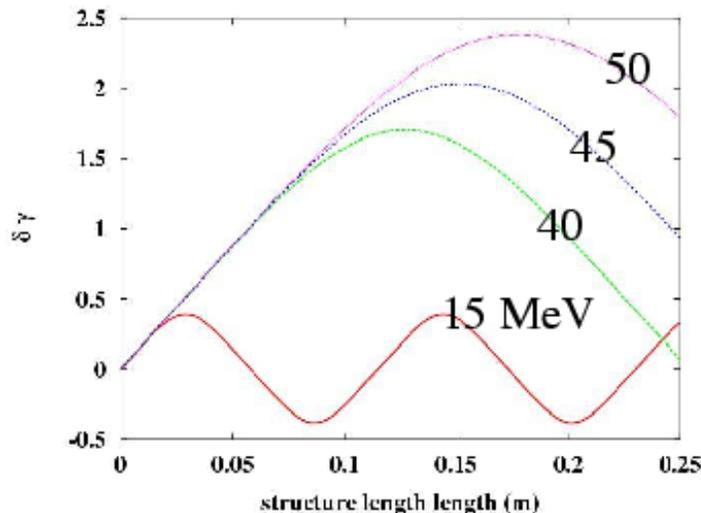


▶ Beam less space-charge-dominated
 ▶ better control of beam envelope

▶ "Rigid" longitudinal beam dynamics
 ▶ rf-based longitudinal phase space measurements possible

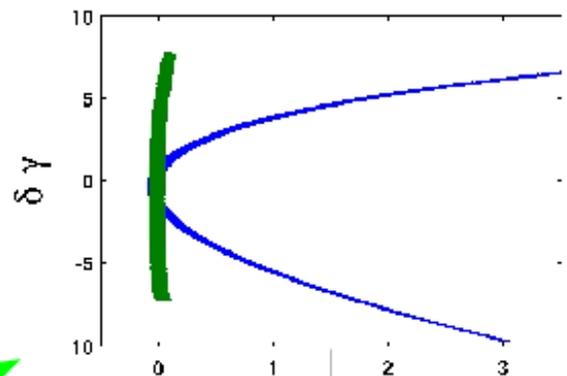


Laser acceleration: energy gain

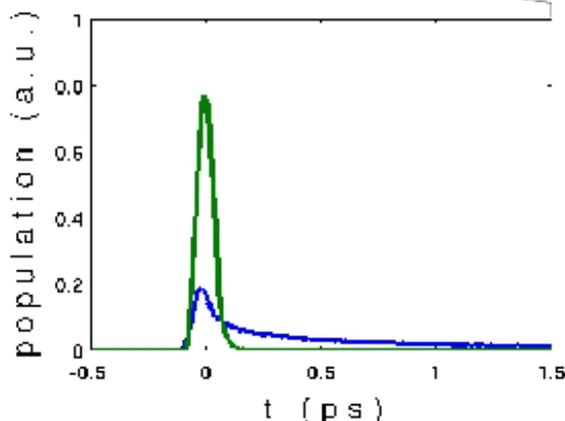


▶ Laser acceleration experiment:
 ▶ phase slippage between e- and laser field less important

- **Deflecting cavity** developed for CKM experiment. Other possible applications: crab-crossing technique, rf-separator, and beam diagnostics.
- Installation at FNPL : characterization with beam + provide beam diagnostics.
- **Accelerating cavity** used for linearization of the longitudinal phase space to achieve high peak current (applications to LUX proposal at BNL, TESLA VUV/X-Ray FELs, TESLA post-damping ring bunch compressor). We will be able to test the “linearization” concept at FNPL.

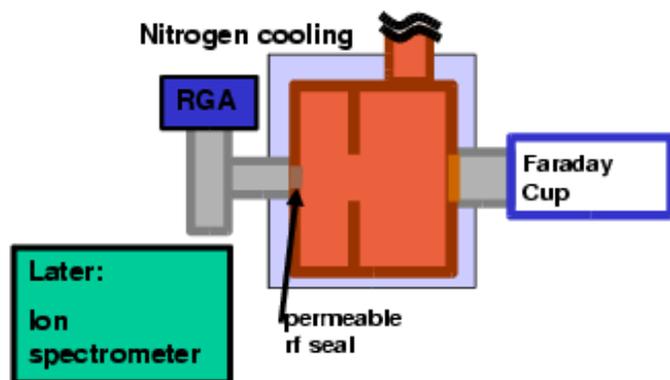


$(z, \delta\gamma)$ after magnetic compression



Charge density after compression

- To fully take advantage of the possibility to generate flat beams with an rf-gun in LC, demonstration of beam polarization needed
- Polarized e- beams are produced using GaAs photo-cathodes, which requires a high vacuum quality $< 10^{-12}$ Torr
- Investigate the use a cryogenic nc cavity to lower equilibrium temperature



- Demonstrate $< 10^{-12}$ Torr
- Measure flux and energy of ions and electrons hitting the cathode
- Long term goal being to operate a GaAs cathode in an rf-gun



Beam dynamics associated to high brightness e-beams:

- Presently, continue improving the modeling of our experiment (via a series of parametric studies) and our “macroparticle experiment” to study single-particle dynamics
- The flat beam study will resume very soon, with the goal of reaching a transverse emittance ratio of more than 100
- Continue working on instrumentation R&D

Advanced Accelerator Physics:

- The UCLA experiment is on-going, still in the commissioning phase, first results are expected with a few weeks from now
- The NIU/UCLA experiment will then be resumed with emphasis on trying to measure the wakefield dependence using a pump/probe beams set-up



Beam dynamics associated to high brightness e-beams:

- On-going effort of modeling and understanding the dynamics of space-charge-dominated beam
- Generation of compressed flat beams without spoiling emittance ratio
- Continue working on instrumentation R&D: the deflecting mode cavity will provide a unique diagnostic for probing the time dependence of parameters within the bunch (so-called slice parameters)
- Possibility to demonstrate emittance exchange between the longitudinal plane and one of the transverse plane

Advanced Accelerator Physics:

- Smith-Purcell radiation source (in discussion with Jlab)
- In vacuum laser acceleration using an open-iris structure (laser has been developed at FNPL by collaborator from Rochester)
- Continue/improve plasma wakefield acceleration experiments
- And more fun to come...

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