CeC PoP study status and plan

Vladimir N. Litvinenko (PI), I. Pinayev (GL), Ilan Ben-Zvi, Andrey Elizarov, Yue Hao, Dmitry Kayran, George Mahler, Wuzheng Meng, Gary McIntyre, Michiko Minty, Triveny Rao, Brian Sheehy, Yatming Roberto Than, Joseph Tuozzolo, Gang Wang, Stephen Webb, Vitaly Yakimenko
Brookhaven National Laboratory, Upton, NY 11973, USA

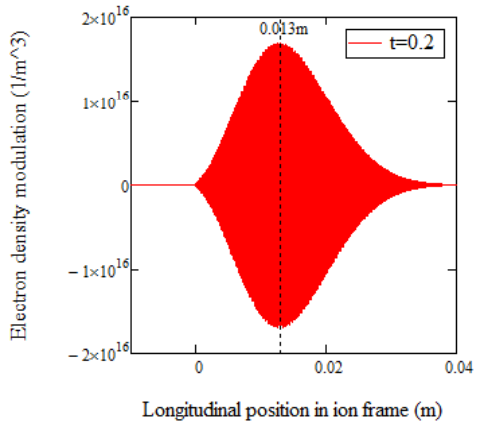
Matt Poelker (Co-PI), Andrew Hutton, Geoffrey Kraft, Robert Rimmer
TJNAF, Newport News, VA 23606, USA

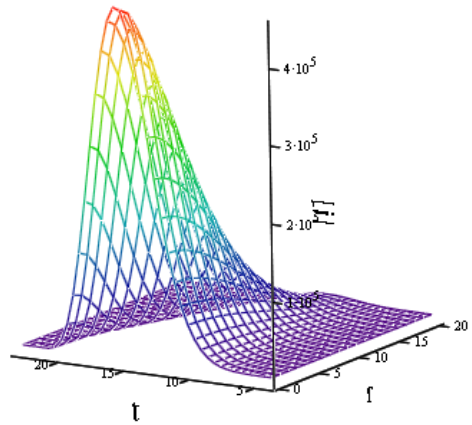
David L. Bruhwiler (Co-PI), Brian T. Schwartz, George I. Bell, Ilya V. Pogorelov
Tech-X Corp., Boulder, CO 80303, USA

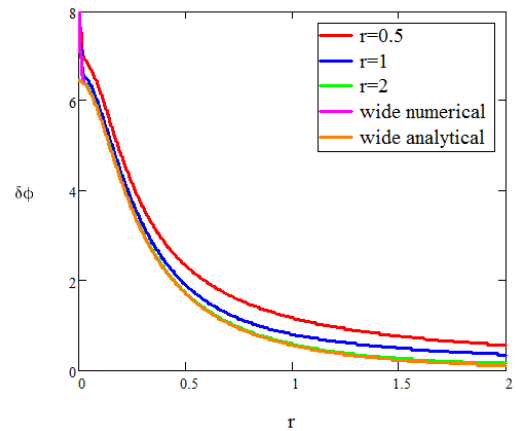
APEX workshop, 2012

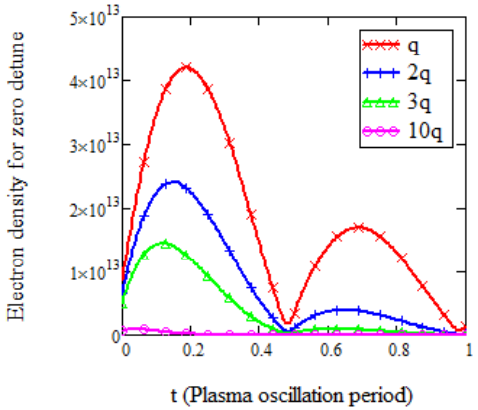
Status of Theoretical Studies

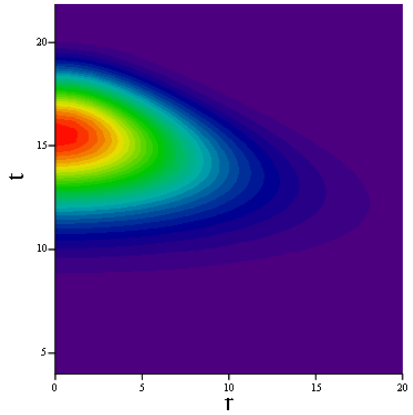
- Analytical model based on 1D FEL theory have been completed in 2010.
- Analytical model based on 1D Vlasov + 3D Maxwell system is on the way.
- We are making progresses on going beyond the infinite electron plasma model, which can be essential for benchmarking simulation code.

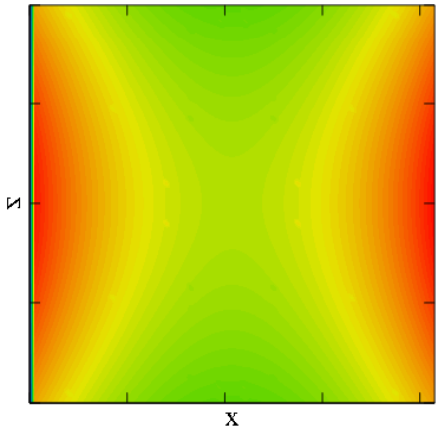






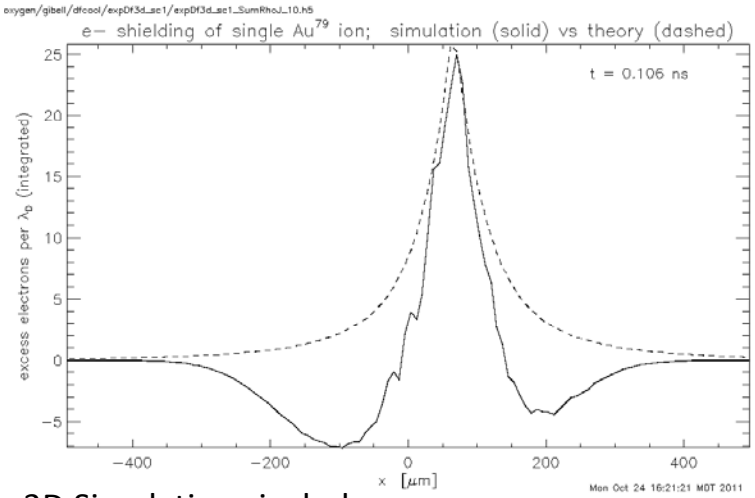




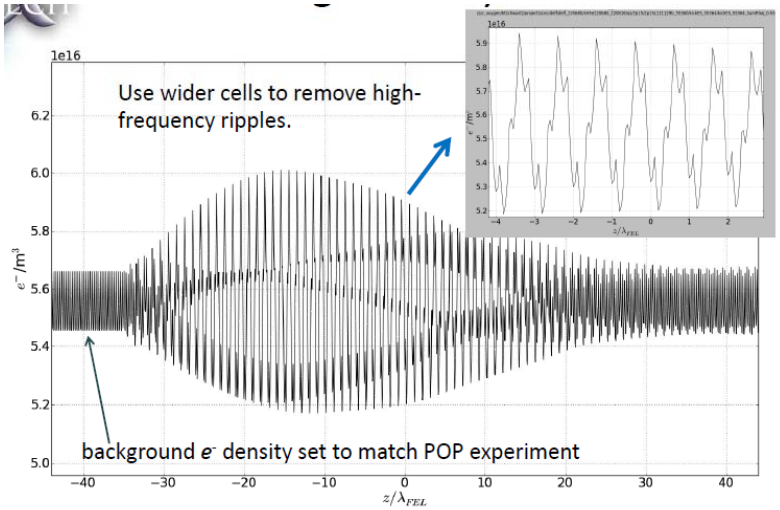


Simulation of E Field Induced by a Single Ion
Courtesy Tech-X

Modulator simulation with finite beam

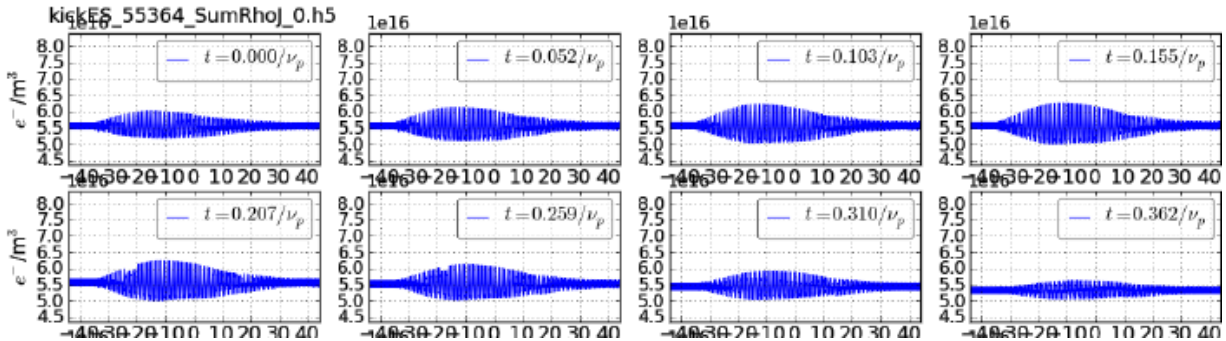


FEL Genesis output

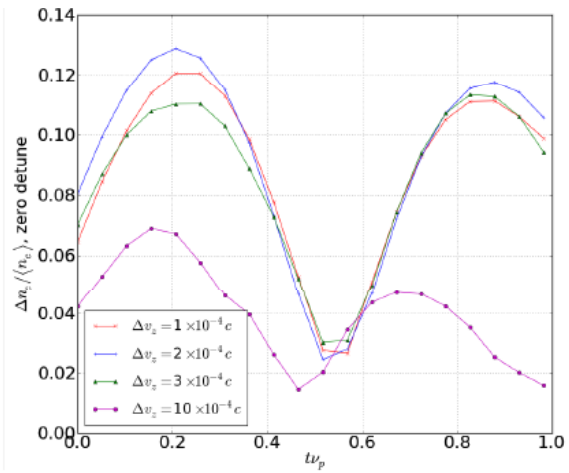


3D Simulations include:

- Entire beam (0.4mm in diameter), transversely Gaussian spatial distribution.
- Equilibrium maintained by external focusing
- Gaussian velocity distrib.
- Dirichlet transverse boundary condition.

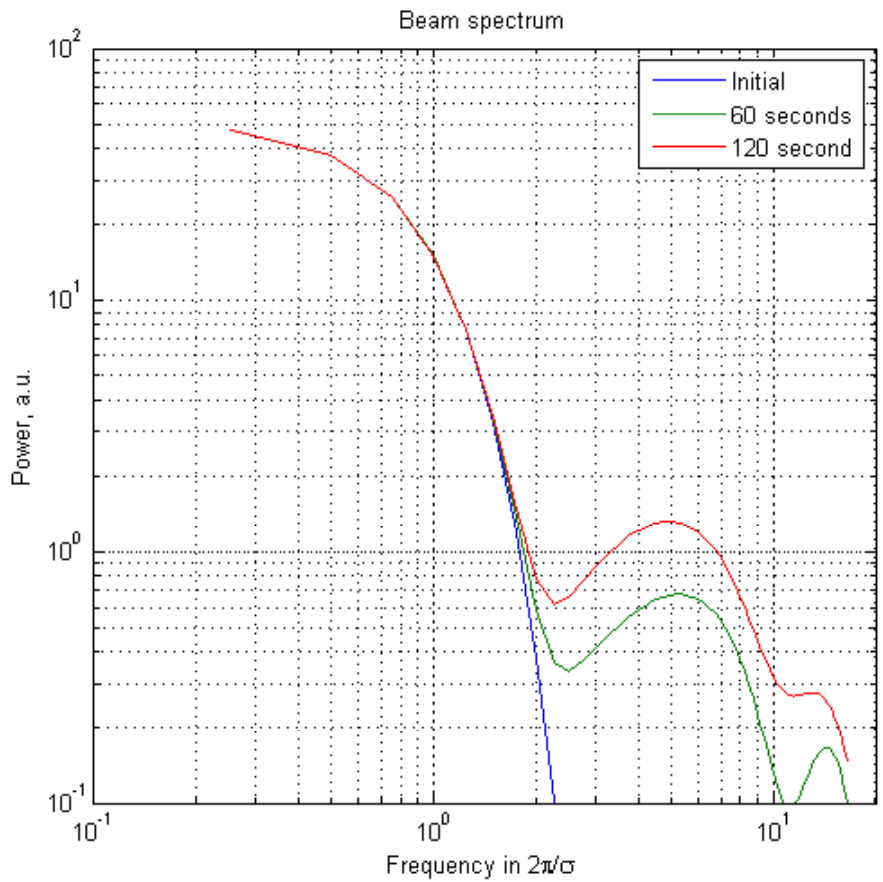


Density evolution inside kicker

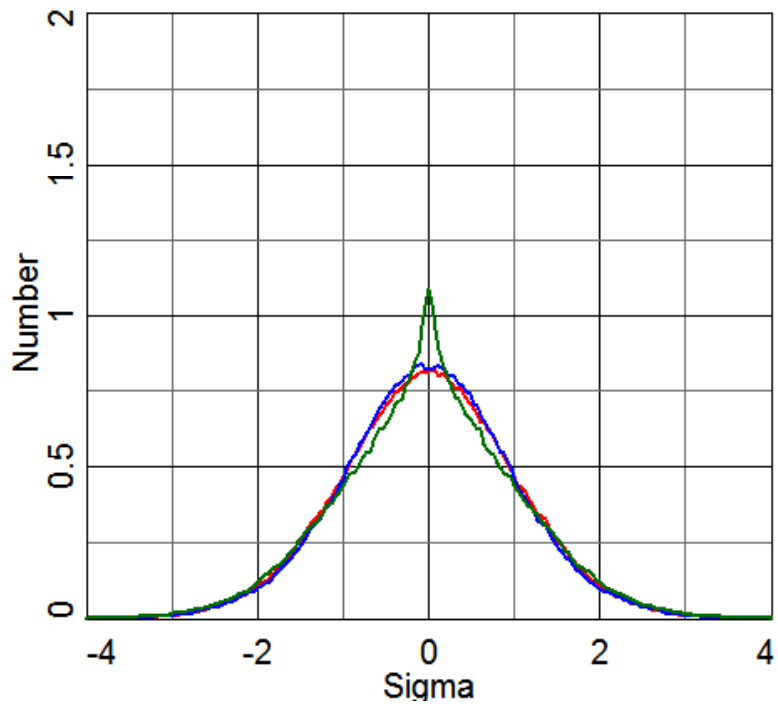


Simulation of cooling an ion bunch (Betacool)

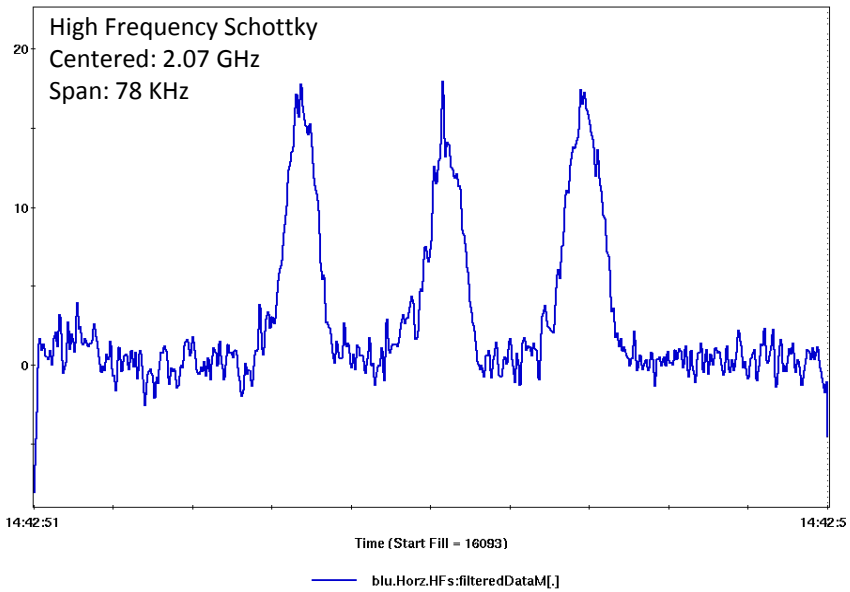
- For the Au ions r.m.s. bunch length is 1.5 ns
- That makes r.m.s. length of the cooled part 80-120 ps
- The cooling effects can be observed with oscilloscope 2 GHz or more bandwidth or spectrum analyzer with similar upper frequency

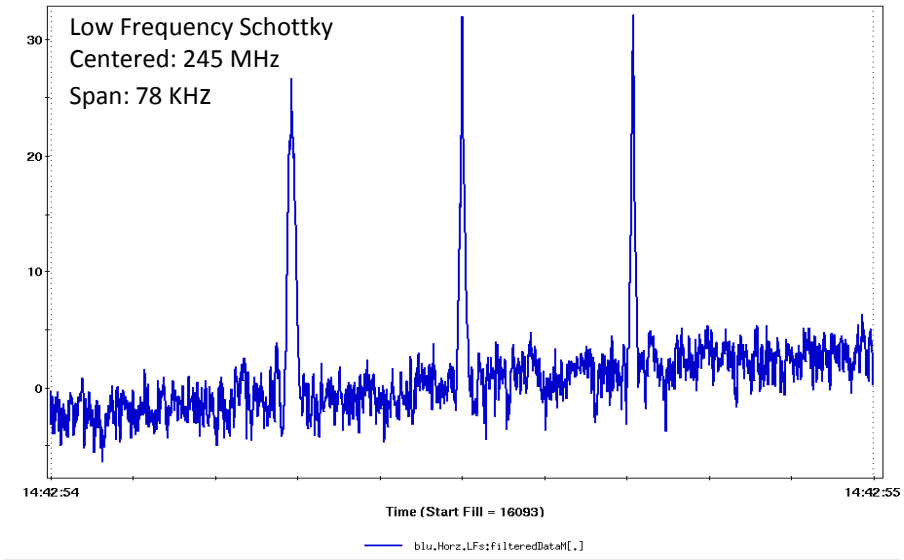


Courtesy I. Pinayev and A. Fedotov

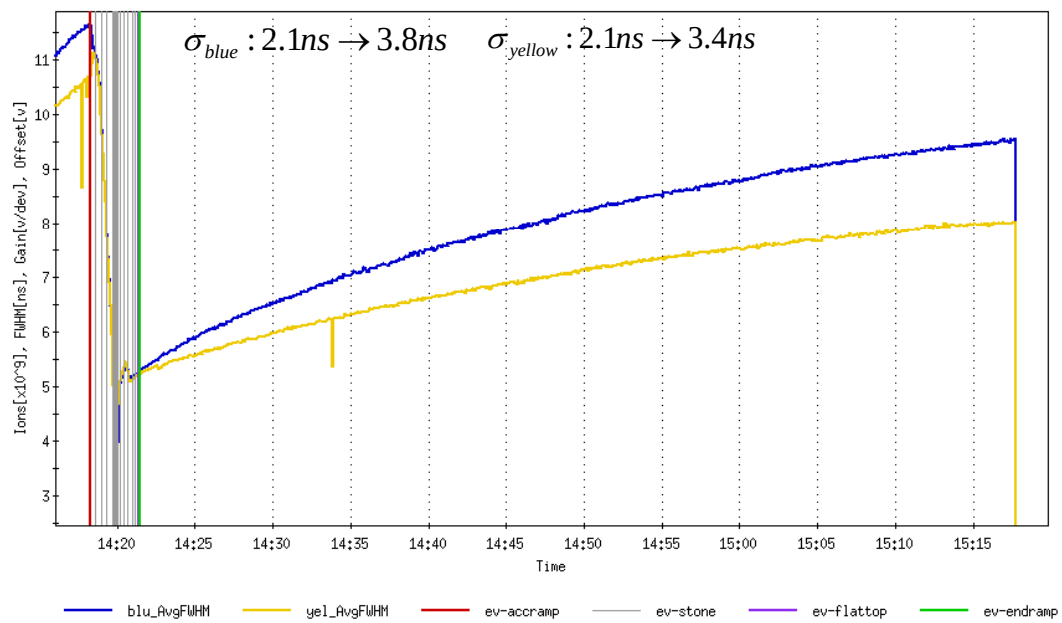


Data from APEX in run 12





Will we be able to see the power increase in high frequency Schottky spectrum if there is an effective local cooling?

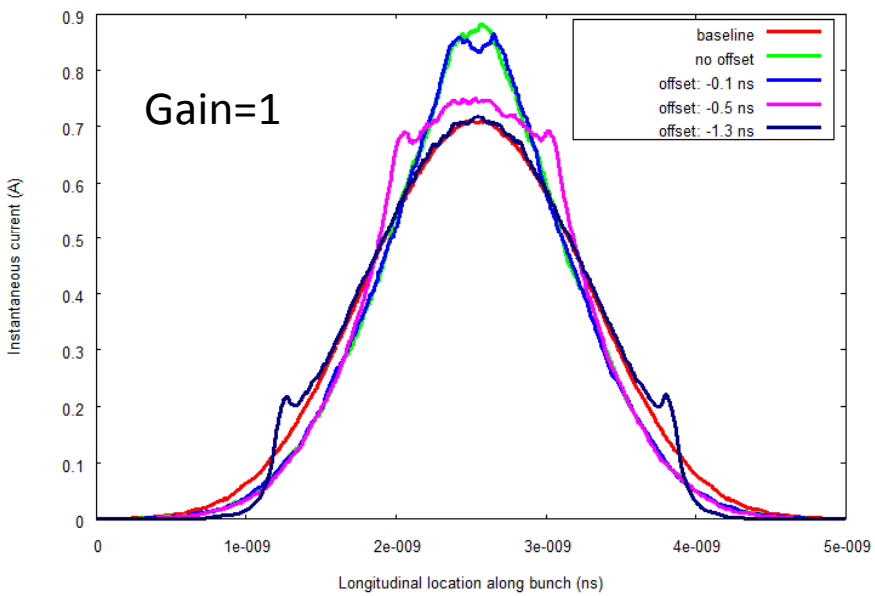


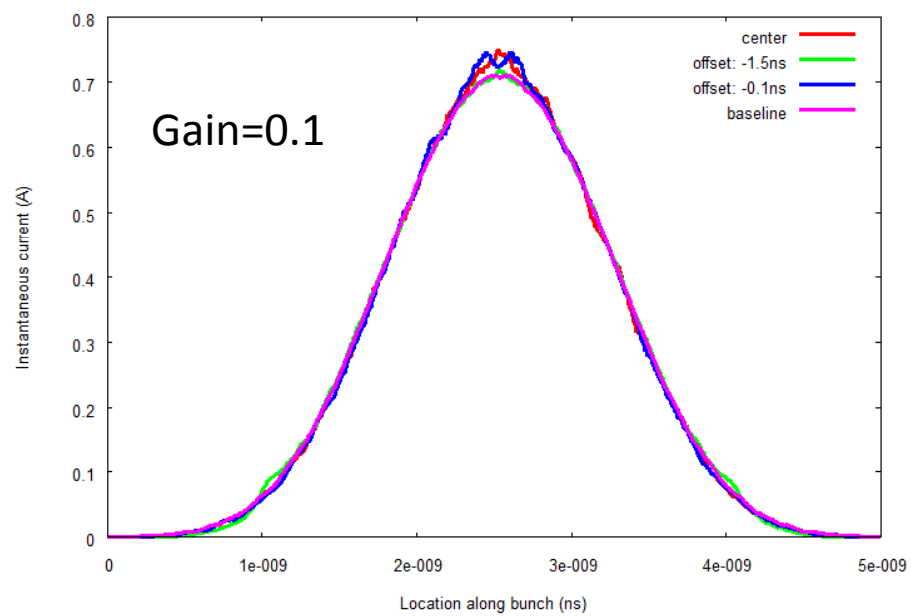
Courtesy K. Brown

Another Possible Approach:
Start From TRANFT (written by M. Blaskiewicz)

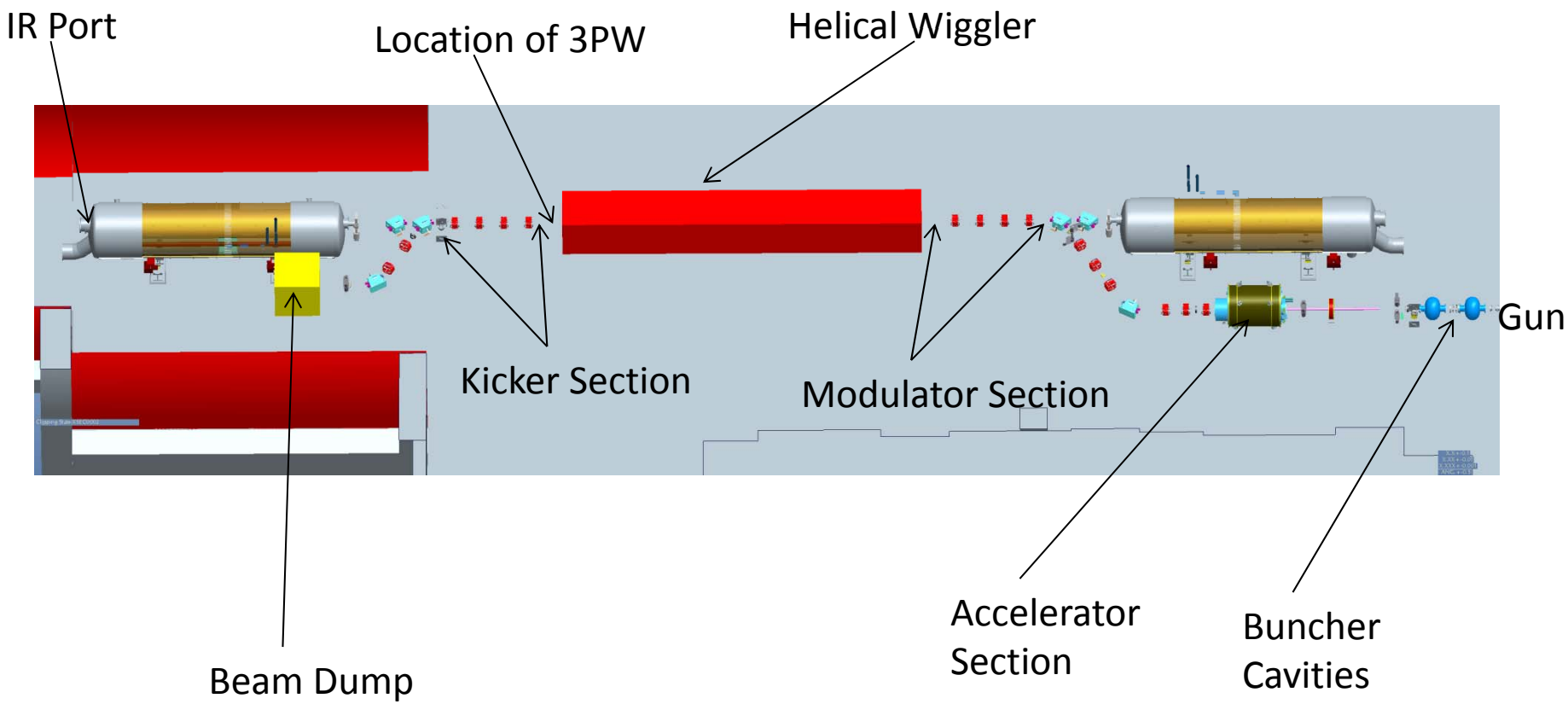
Stochastic longitudinal momentum cooling simulation for various cooling location (i.e. offsets of electron bunch with respect to ion bunch). I simply divided ion beam into samples and subtracted momentum of each ion by the average error of the sample. Correct wake-field due to electrons should be used in the future.

1.2E5 particles, 5000 turns, 20 ps electron bunch, sample size 2.2 ps

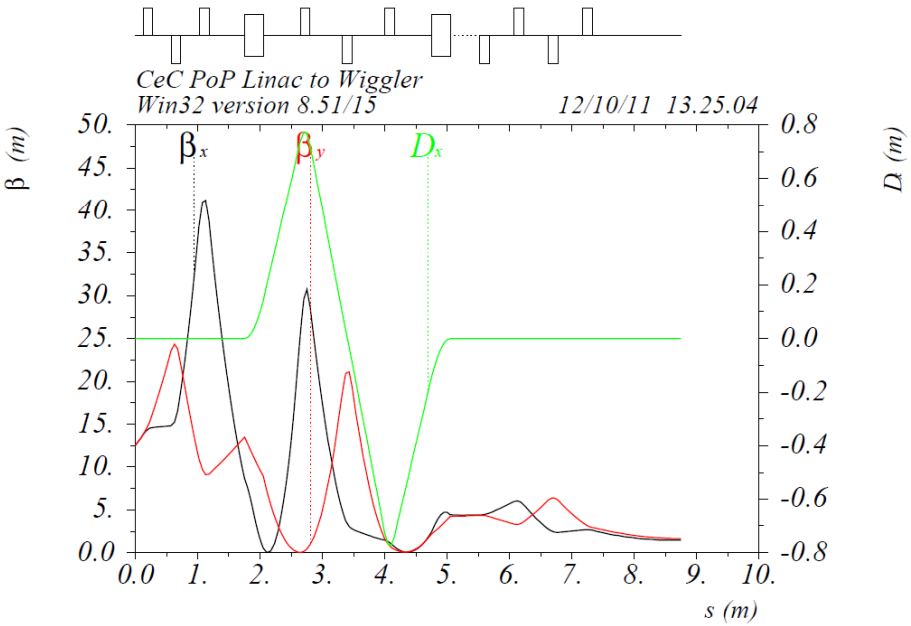


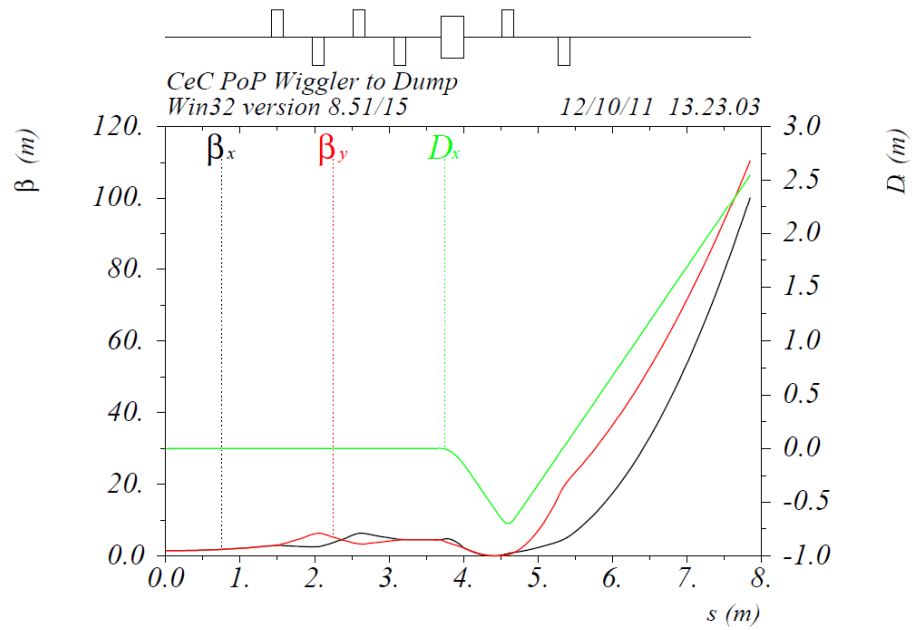


General Layout



Preliminary Lattice





- Triplet after the linac provides matching of the betatron functions
- Three quadrupoles provide zero dispersion at the exit of dogleg
- Quadruplet provides optimum β-functions for modulator and matching into the wiggler
- Second quadruplet provides optimum β-functions for kicker
- Doublet increases beam size in the dump to reduce heat load

Courtesy I. Pinayev

Plan in FY12

- Continue developing and improving theoretical model.
  - ✓Complete 1D Vlasov+3D Maxwell model.
  - ✓Study Debye screening for a bounded plasma.

- Make more realistic simulation for the front-to-end single ion dynamics simulation and benchmark it with theoretical model.

- Developing codes to simulate cooling of an ion bunch.
  - ✓Include IBS into simulation (for TRANFT based approach.).
  - ✓ Incorporating simulation-based (or model-based) CeC kicks into code.

- Since this run is p-p, no dedicated APEX session is required.

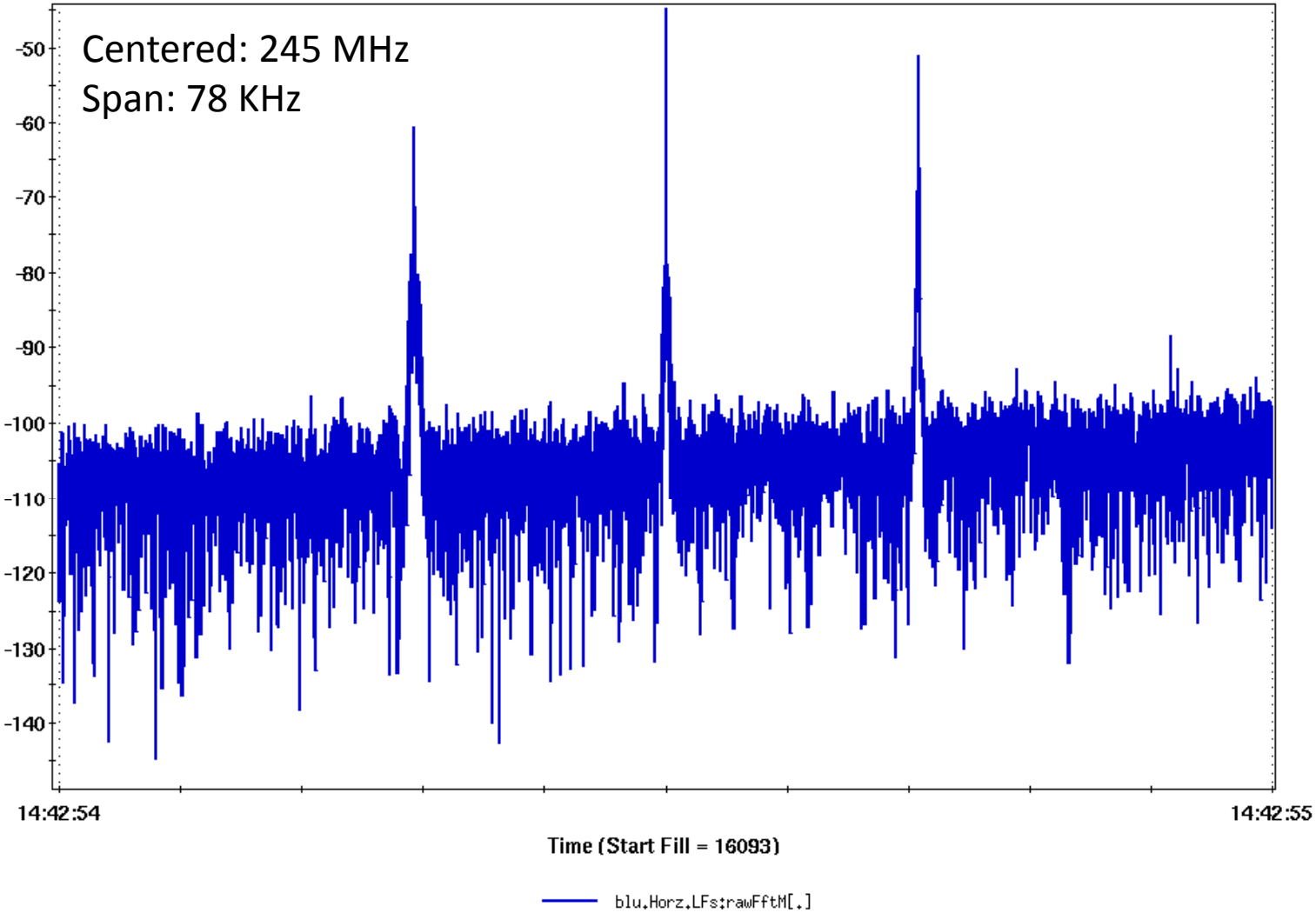
Milestones

- Ramp to Au 40 GeV/u was created
- Cathode stalk design nears completion
- Apertures for wiggler were approved warm apertures committee allowing to freeze ion energy and RF frequencies
- Preliminary technical schedule is created with early construction finish in December 2013
- Preliminary lattice is developed
- Diagnostics suite is defined
- Procurement of cryogenic started
- Procurement of RF system started
- Back-up plan for the electron gun started

Courtesy I. Pinayev

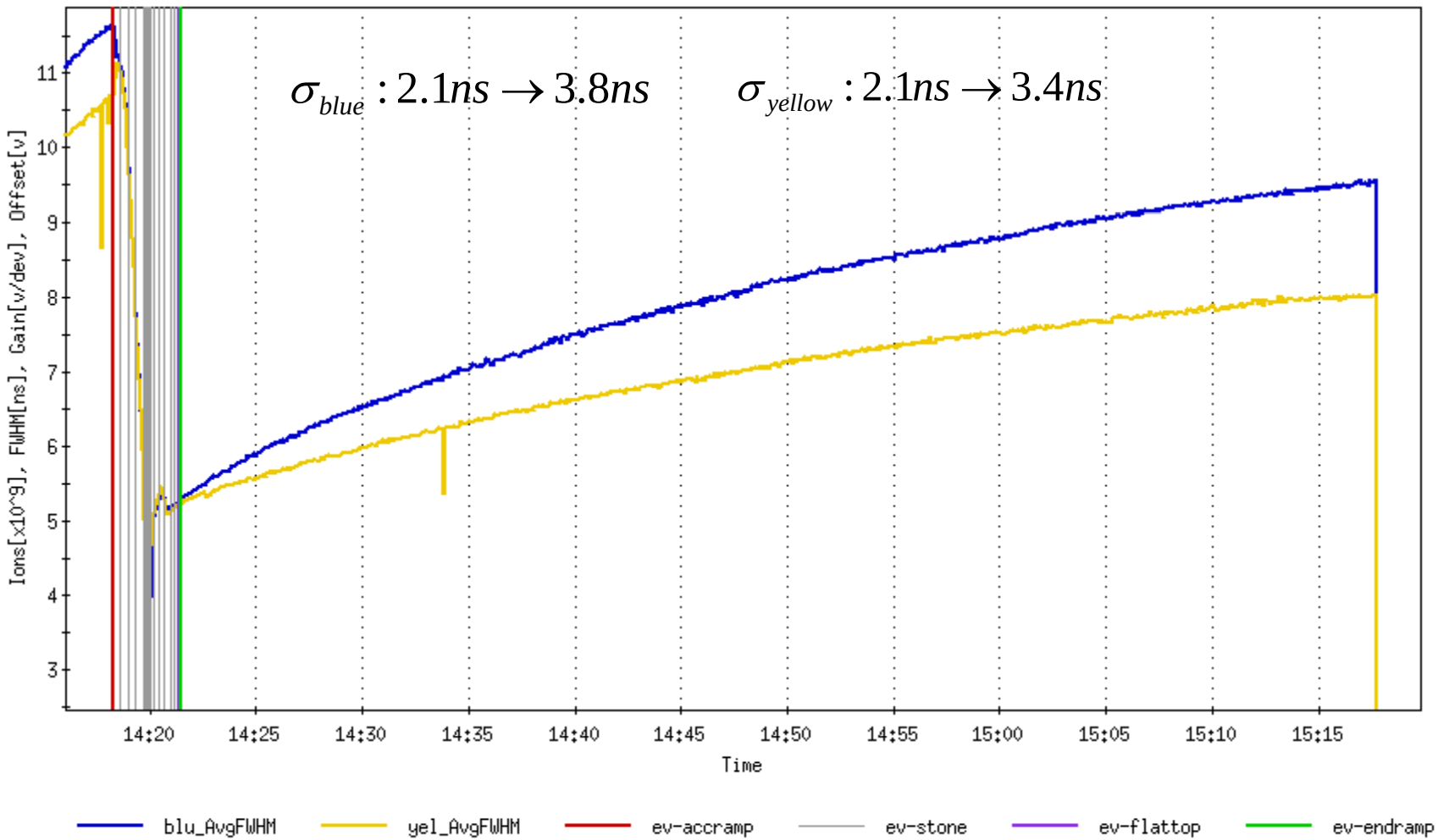
Backup Slides

Low Frequency Schottky (raw)



Bunch Length (WCM)

$$\sigma = \frac{\tau_{FWHM}}{2\sqrt{2\ln(2)}} = \frac{\tau_{FWHM}}{2.355}$$



$$V_{//}(t) = \int_{-\frac{\tau_e}{2}}^{\frac{\tau_e}{2}} W(t-\tau)\left[I\left(\tau+\tau_{delay}\right) - I(\tau)\right] d\tau$$

Diagnostics

- Two fast current transformers for charge (current and transmission monitoring)
- Emittance measuring system (slits or pepper pot) for low energy beam
- Beam position monitors with Libera Brilliance Single Pass receivers
- Fluorescent flags for 22 MeV beam emittance and energy spread measurements
- Double solenoid system allows beam length and slice emittance measurement
- Infrared port for FEL amplifier tuning
- Visible synchrotron radiation port for continuous beam monitoring
- Schottky pick-up for ion beam spectrum monitoring
- Wall current monitor for ion beam profile monitoring