The Injector Process Driven Setup Status

(Improving the Process for Setting Up the CEBAF Injector)

Alicia Hofler
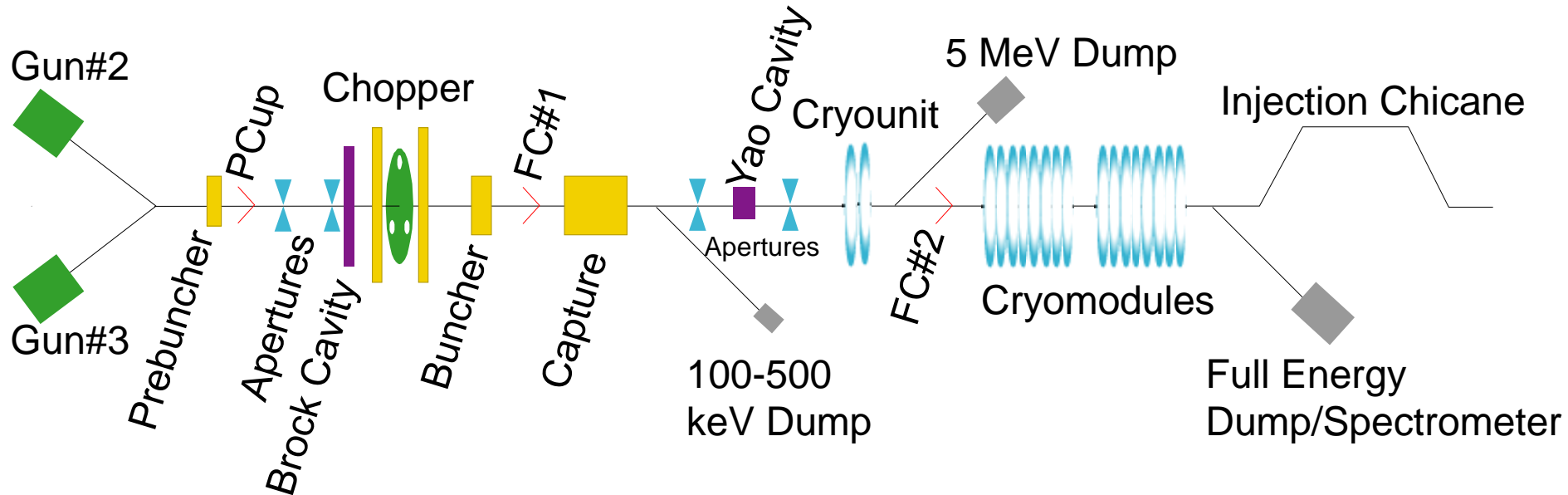
Fay Hannon

Reza Kazimi

Yan Wang

Outline

- Image problem
- Status and Plan
- Odds and ends requests
- Observation
- Summary

Problem: Perception vs. Reality

- Reza sits in the chair with little or no plan and does magic while his Injector acolytes watch
  - Reza has a standard set up process
  - On-going effort to update procedure documentation
  - Time spent diagnosing and working around unanticipated ramifications of injector hardware changes
    - RF calibration constants lost
    - Chopper solenoid setpoint reproducibility
    - Laser amplifiers and DC beam mode
    - 250 MHz laser phase changes
    - Chopper amplifier replacement
  - Available machine PSS configuration incompatible with beam set up goals

- Injector group makes rogue choices and changes
  - Undocumented solenoid changes – software bug
  - Linac quad change – outdated configuration file

- Poor communications
  - Routinely bring stakeholders together at group meetings to plan running and discuss operational problems
  - Room for improvement
    - Elog entries often sketchy and sporadic
    - Tech notes system underutilized
   - Follow-through on requests

The Plan

- Improve operational procedures
- Continue developing the injector model and optimization
- Verify model and operational settings
- Move to model-based injector set up

Procedure Status

- Injector set up procedures
  - Solenoid and aperture centering
  - Warm RF
    - Prebuncher
    - Chopper
    - Buncher
    - Capture
- Development opportunities
  - Calibrated chopper viewer digitization (e.g. e-log 3321188)
  - Operational version of prototype "CircleABC" tcl script
  - Reliable seamless viewer video routing to the Wall/operator consoles
  - Viewer image persistence
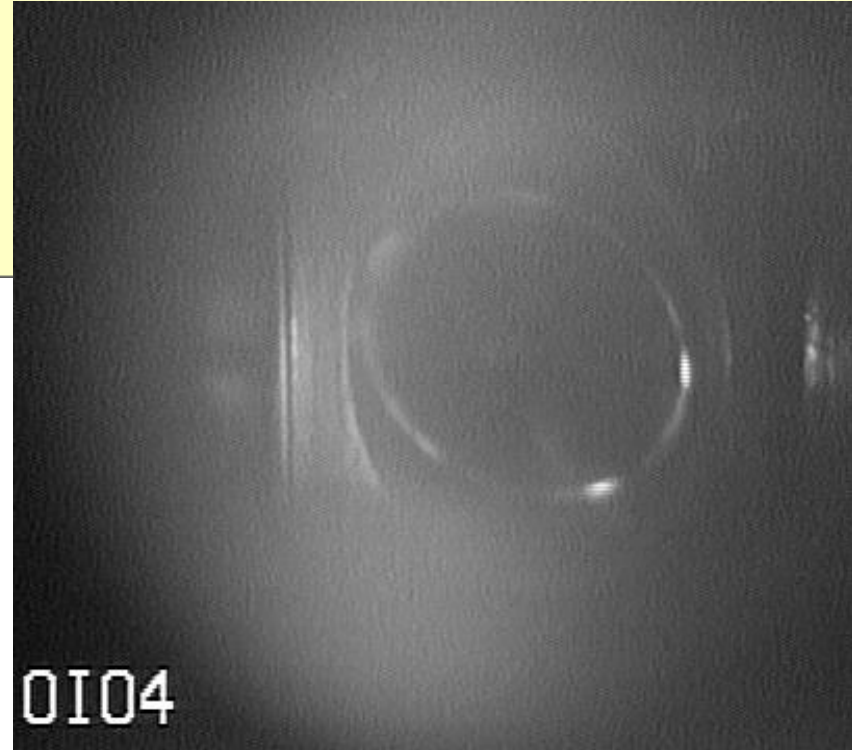
# Bunchlength Optimization System

- ## System owners/experts?
  - Orphan system
  - Calibration reliability

- ## Ganged phase for warm RF (lasers, prebuncher, and choppers)
  - 1500 MHz Prebuncher
  - 250 MHz lasers
    - Now 10º 250 MHz = 10º 500 MHz
    - With Increased phase shift?

- ## Yao cavity system in 1D line?
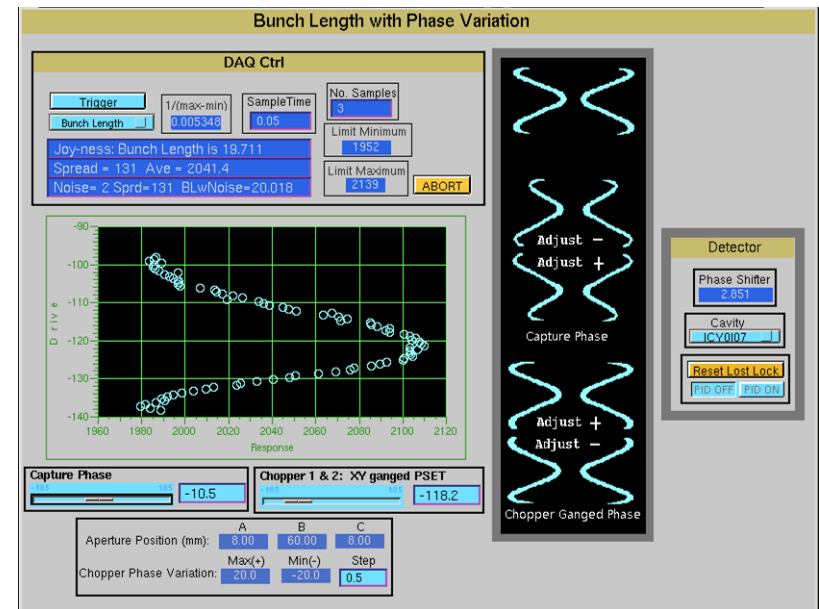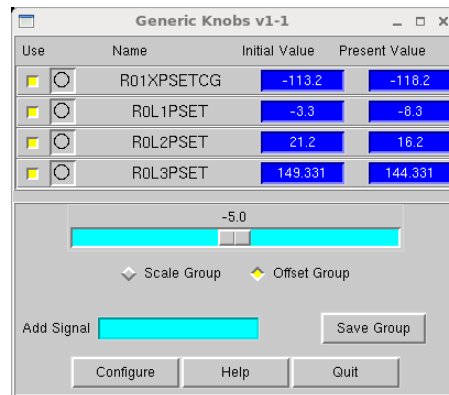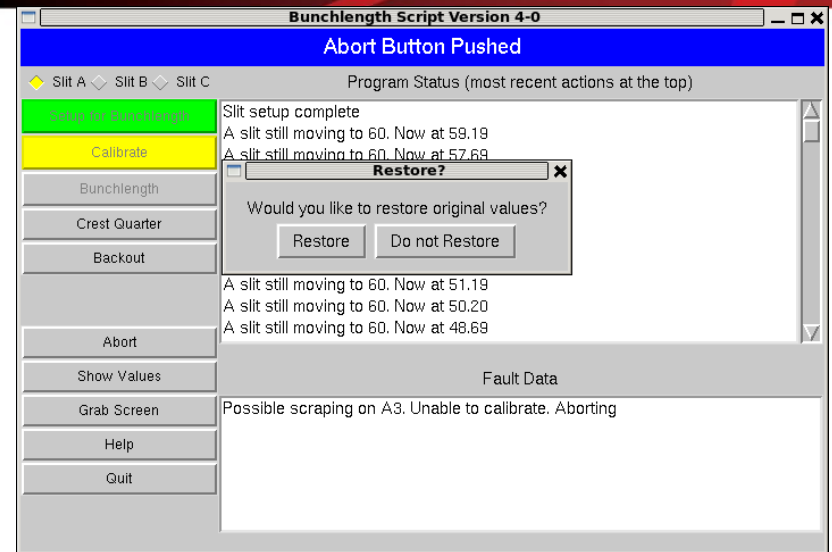
Modeling

Past:

- Injector modeling originally done in PARMELA

- Genetic Algorithm (GA) optimizations with A Space Charge Tracking Algorithm (ASTRA)

  - 130 kV gun injector (NA-PAC2011 WEP288)

  - 200 kV gun and new (2-7) quarter injector (NA-PAC2011 WEP288; IPAC2012 TUPPR055)

    - Simulation and optimization studies (beam, RF, BBU (NA-PAC 2011 WEP085), etc.) completed before cutting metal

- ASTRA models ➔ General Particle Tracer (GPT) (IPAC2012 TUPPR055)

- Model and machine comparison

 - Fast Optics (fOpt) difference orbits (IPAC2015 TUPMA037)

November 2013

December 2013

z (m)
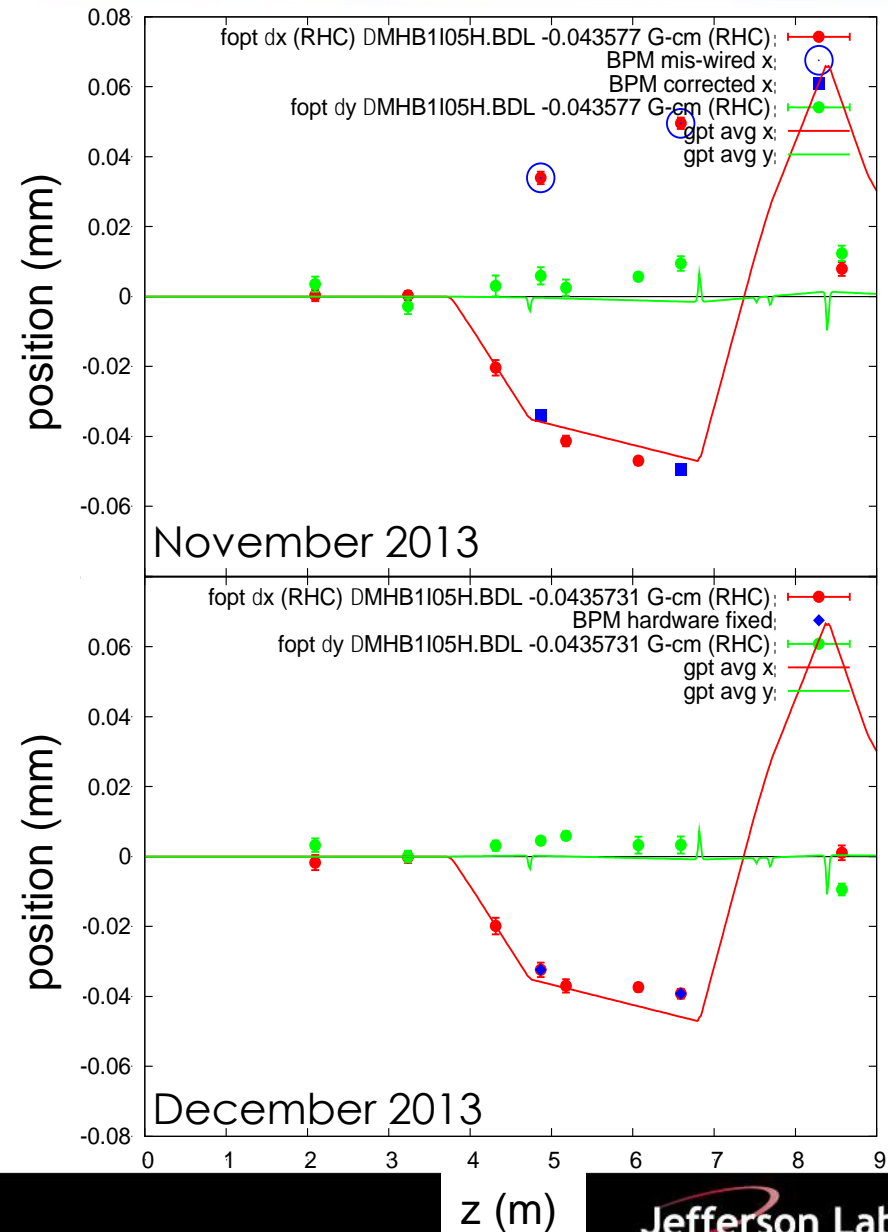
Modeling

Next steps:

- Model improvements
  - Accurate representation of the beam at the cathode
    - Spatial characteristics
    - Temporal profile
    - Momentum distribution
  - New solenoid field maps
  - Missing elements
  - Identify model limitations
- Vet ASTRA-GA system against GPT's GA capability
- Integrate Injector model with CED
- Reconcile differences between elegant and GPT for overlap region
- Higher-order effects

Initial particle distribution
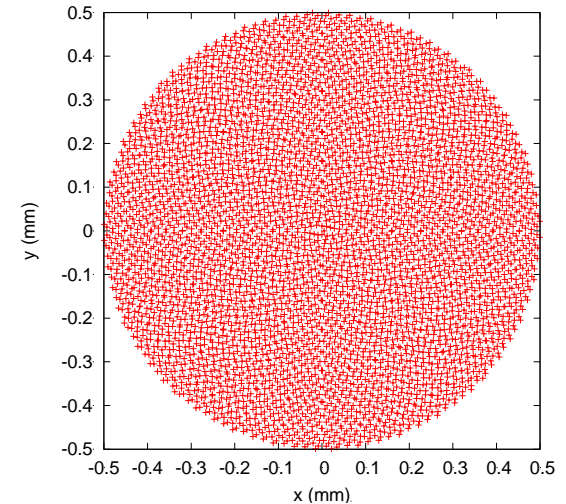
Cylindrically symmetric?

Gaussian?

Jefferson Lab
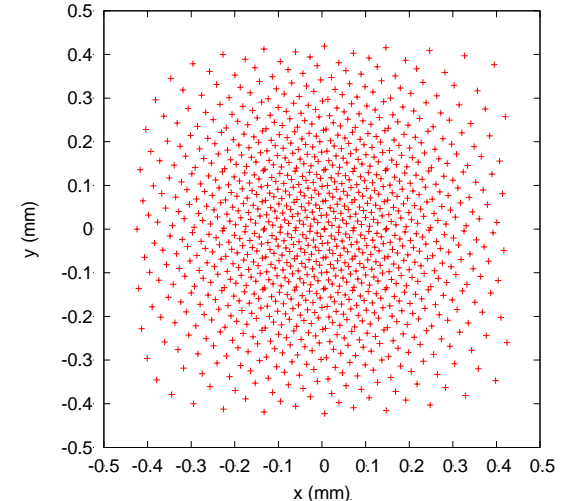
Verification: Machine Development

Functional checks:

- fOpt difference orbits
- Model and machine calibration
  - Model vs. control system units
  - 1D, 2D, 1st chicane dipole calibrations for energy measurements
- RF resolution
  - Attempts to download optimization derived settings have been problematic
  - Acheivable and verifiable
  - Reproducibility

Model and optimization verification:

- Identify sources of orbit drift and injector stability
- Verify performance of optimized Injector set up
- Establish process for downloading optimized injector setup

Model-Based Injector Set Up

- Routine operations
  - Reproducible set up
  - Monitor for orbit drifts
  - Minimal measurement set to confirm meeting performance criteria
  - Identified set of knobs to re-establish performance
  - Procedure for operations
- Minimize cases where experts are needed
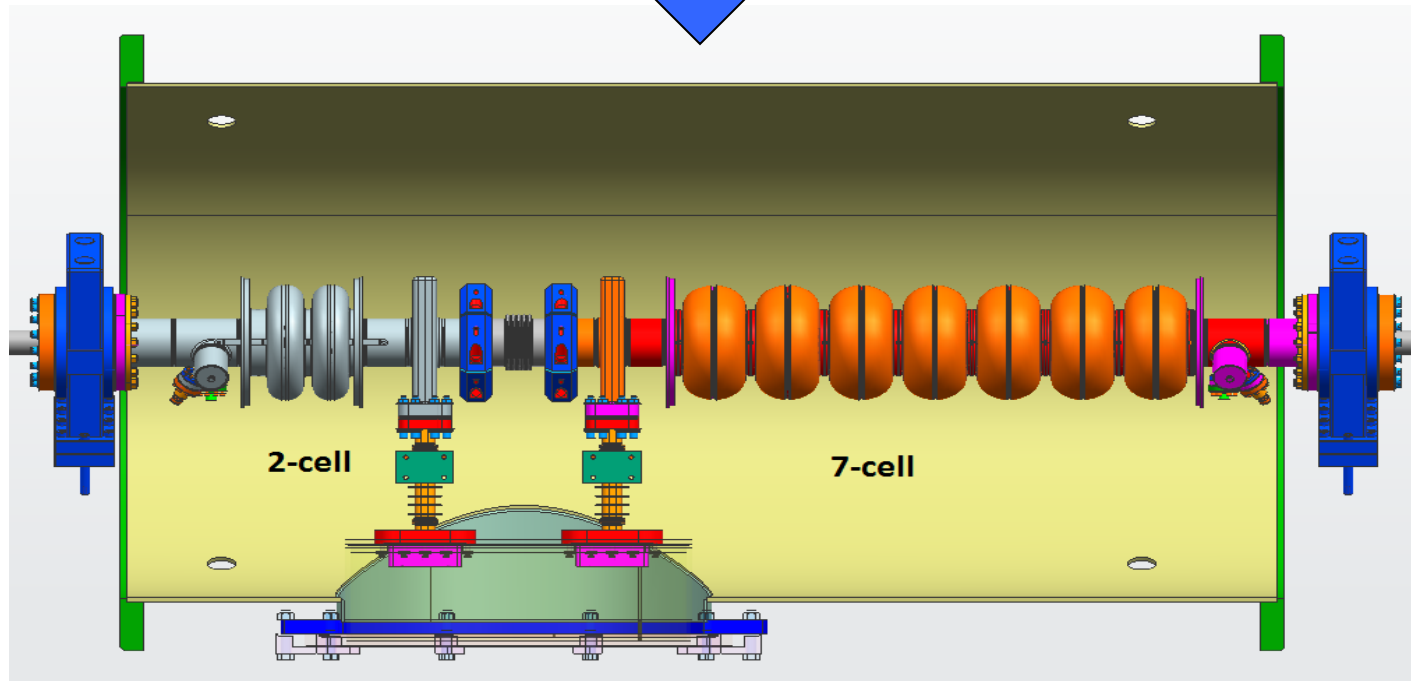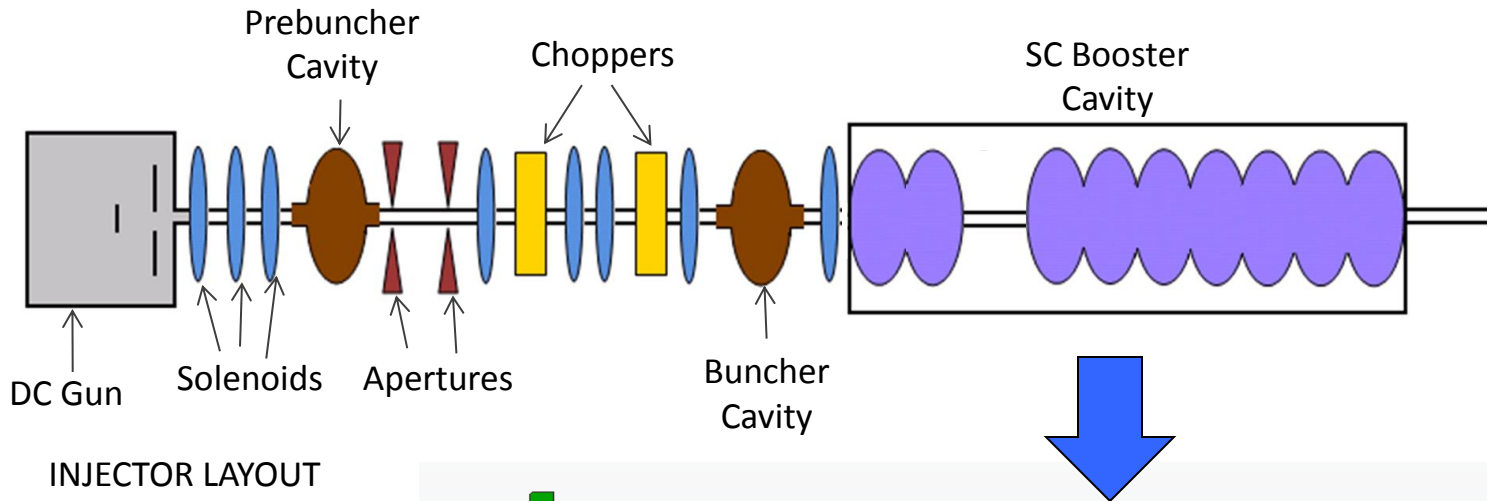
Communications Opportunity

- **OPS-PRs not always effective or efficient means of communication**
  - Problems sit in system due to initial filing problem
  - JELI OPS-PR/CED selections/decision tree make it difficult to direct problems to correct parties
    - Solution: Separately access OPS-PR in web form and reassign
  - Recategorization between hardware and software does not happen routinely

- Directly contacting people to discuss problems is discouraged
  - Disruptive to individuals work flow
  - Subverts established communications pathway (OPS-PR system)
- Some groups have other problem management systems
  - Problems moved to alternate system and OPS-PR closed
  - Easy tracking from OPS-PR system lost

- Request: review for system effectiveness

Summary

- Injector group is working to cross-train and document our expertise

- Modeling effort is progressing

- Machine development time unconstrained by production beam delivery requirements needed

  - Better understanding of the differences between the model, the control system settings, and measurements for the 130 kV machine lays the ground work for commissioning the injector upgrade to a 200 kV gun with the 2-7 new quarter

- Injector reproducibility and stability are important to us
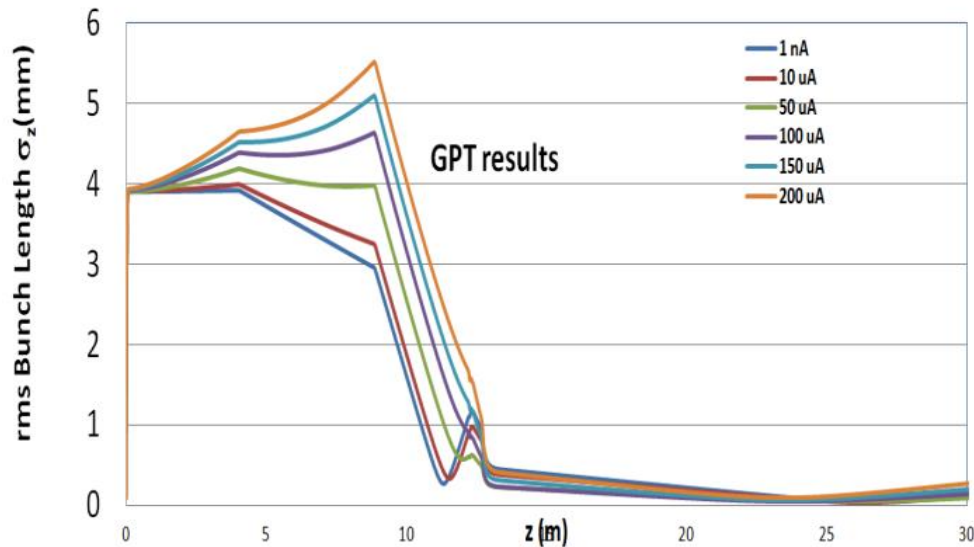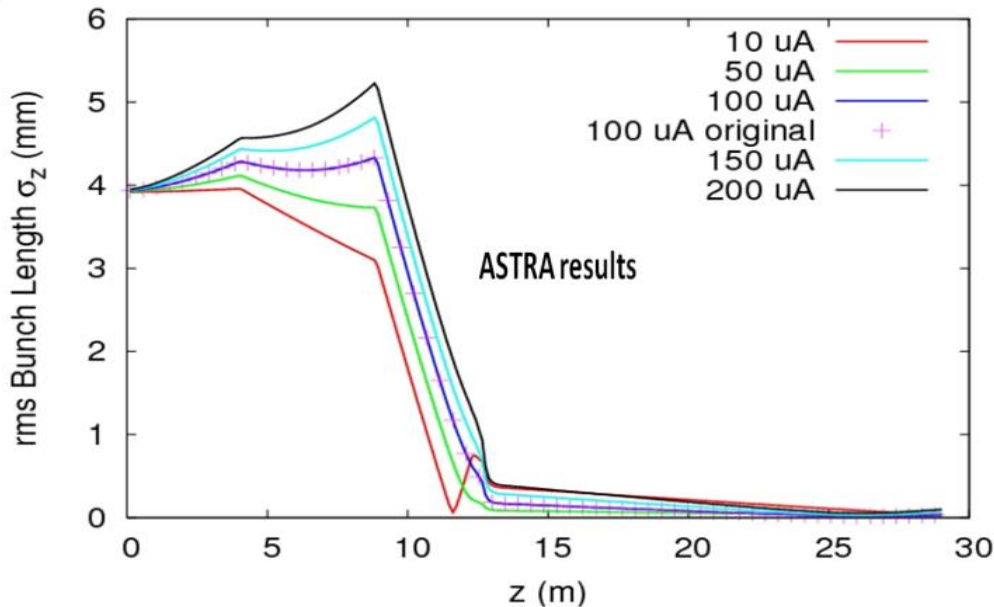
- Goal is model-based machine operations

Thank you.

Prebuncher Cavity

Choppers

SC Booster Cavity

DC Gun

Solenoids

Apertures

Buncher Cavity

INJECTOR LAYOUT

2-cell

7-cell

NA-PAC2011 WEP288
IPAC2012 TUPPR055

- Results checked with two codes
- Bunch length for different currents.
  - This accelerator has to work for both low and high beam currents at the same time!
- The currents are for 499 MHz cw beam structure.

NA-PAC2011 WEP288
IPAC2012 TUPPR055

Odds and Ends

- Viewer master light behavior
- PSS injector only mode: 100/500 keV dipole setting limits
- Real time bunchlength measurement in chicane

Jefferson Lab