

E300 Simulation Meeting: Introduction and Goals

Spencer Gessner, SLAC

E300 Simulation Meeting

July 13, 2023

E300 Simulation Meeting Overview

The E300 Simulation Meeting is a recurring, monthly meeting with 3 objectives:

1. Develop a framework for running a large number of start-to-end simulations.
 - a. Which codes do we use?
 - b. How do we connect machine and PIC simulations?
 - c. How do we store the results of our simulations?
2. Develop a strategy for running a large number of simulations.
 - a. How many CPU-hours do we need?
 - b. How do we optimize our simulation search space?
3. Define goals for E300 simulations.
 - a. Use simulations to define acceptable beam parameters for experiments.
 - b. Use simulations to identify improvements to the experiment and the accelerator.
 - c. Use simulations to better understand experimental results.

E300 Simulation Meeting Overview

The E300 Simulation Meeting is a recurring, monthly meeting with 3 objectives:

1. Develop a framework for running a large number of start-to-end simulations.

a. Which codes do we use?

b. How do we connect machine and PIC simulations?

Work has started

c. How do we store the results of our simulations?

2. Develop a strategy for running a large number of simulations.

a. How many CPU-hours do we need?

To be defined

b. How do we optimize our simulation search space?

3. Define goals for E300 simulations.

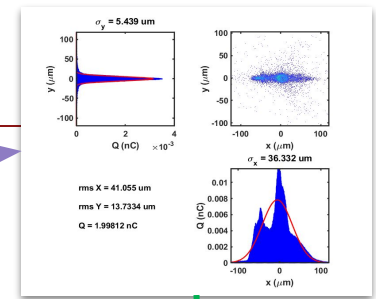
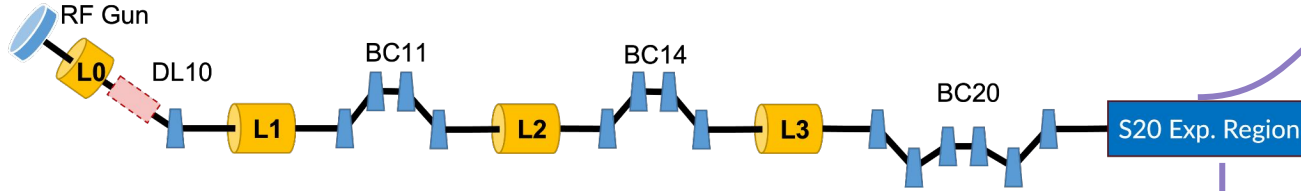
a. Use simulations to define acceptable beam parameters for experiments.

b. Use simulations to identify improvements to the experiment and the accelerator.

c. Use simulations to better understand experimental results.

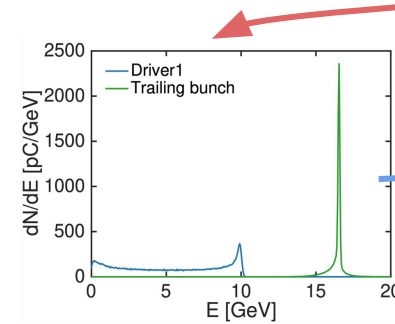
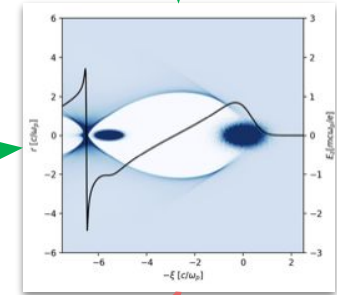
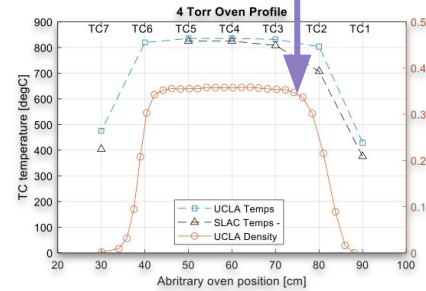
To be refined

Ideal Scenario

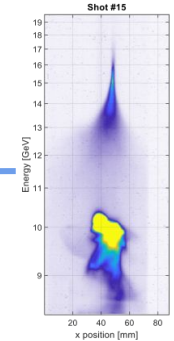


The ideal scenario we aim to achieve:

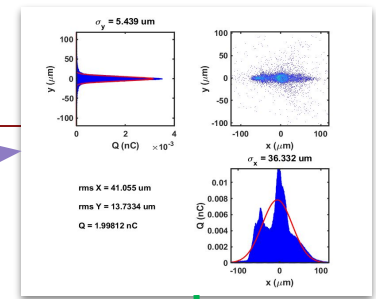
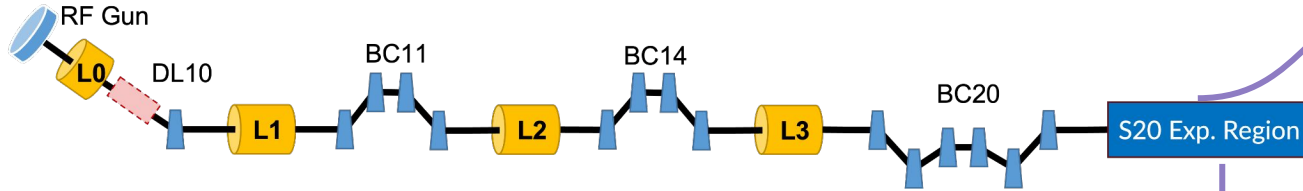
1. Perform GPT+Lucretia simulations of FACET-II up to plasma entrance.
2. Extract 6D phase space from Lucretia for PIC simulation.
3. Have an accurate model of plasma, including ramps, in PIC code.
4. PIC outputs energy spectrum, emittance etc.
5. Simulation agrees with experiment!



Sim = Exp

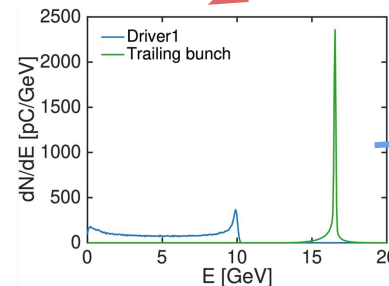
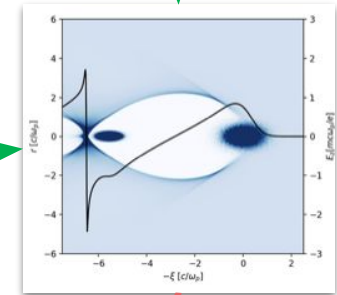
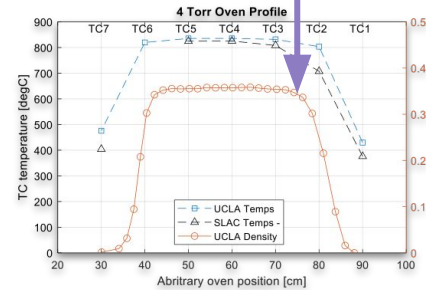


Ideal Scenario

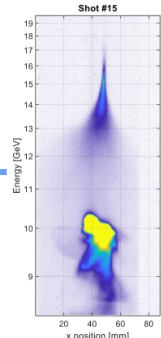


The ideal scenario we aim to achieve:

1. Perform GPT+Lucretia simulations of FACET-II up to plasma entrance.
2. Extract 6D phase space from Lucretia for PIC simulation.
3. Have an accurate model of plasma, including ramps, in PIC code.
4. PIC outputs energy spectrum, emittance etc.
5. Simulation agrees with experiment!

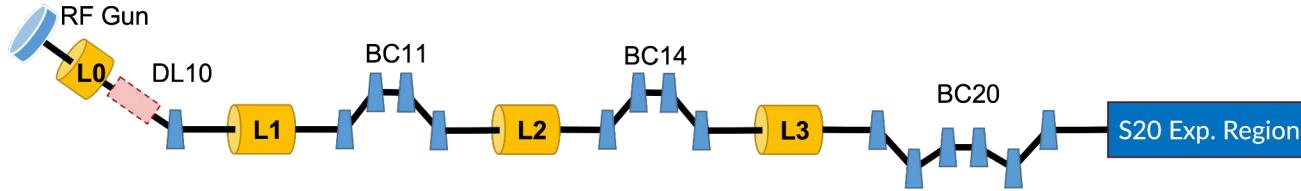


Sim = Exp

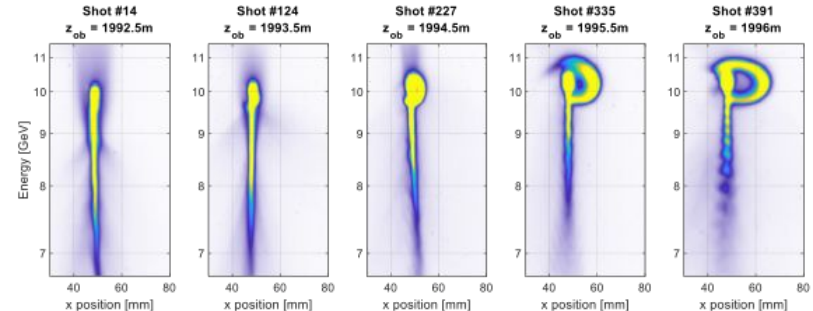
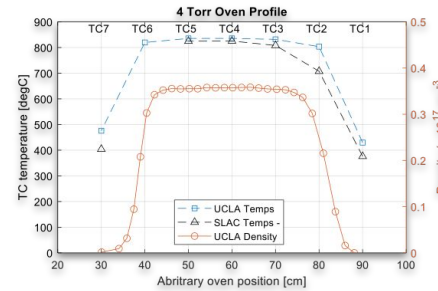
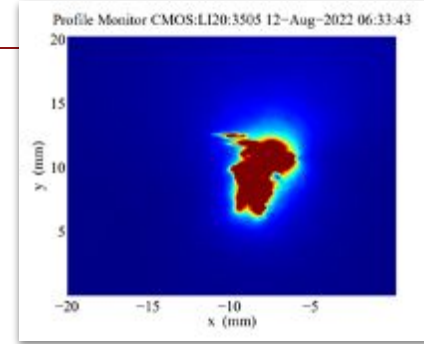


A quixotic project that may never converge...

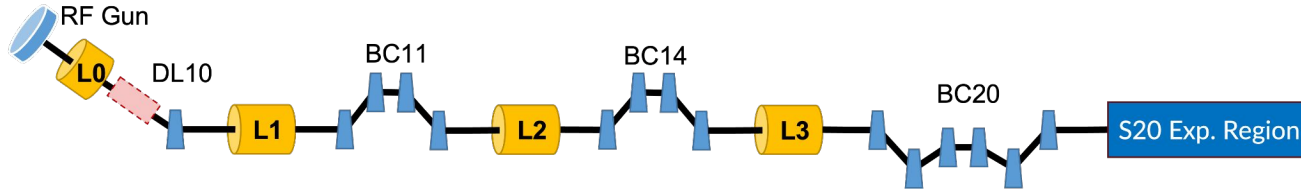
Reality



1. Not all inputs to Lucretia well-known.
2. Diagnostics do not provide full 6D phase space and are limited by intense beam.
3. Uncertainties in plasma density profile.
4. Not all physics modeled in simulations.
5. Simulation does not agree with experiment!

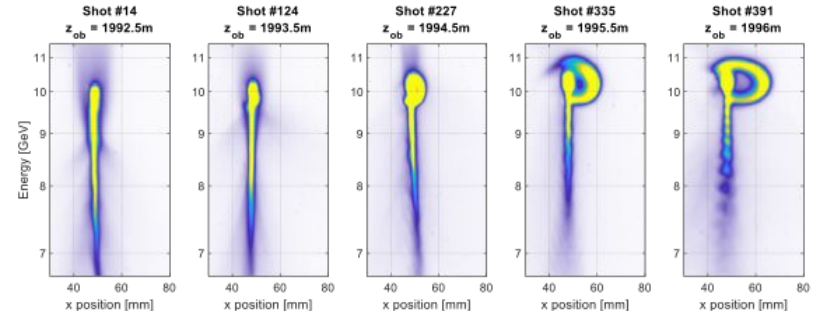
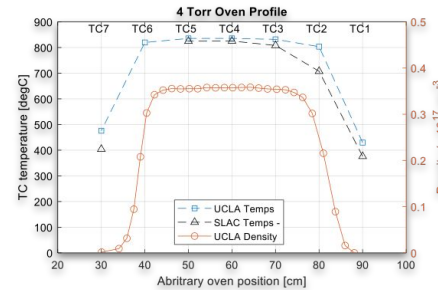
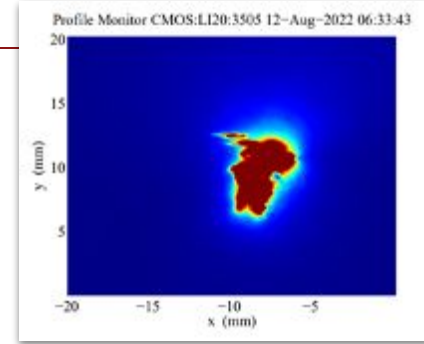


Reality



1. Not all inputs to Lucretia well-known.
2. Diagnostics do not provide full 6D phase space and are limited by intense beam.
3. Uncertainties in plasma density profile.
4. Not all physics modeled in simulations.
5. Simulation does not agree with experiment!

Even if simulations do not match experiments, simulations can guide us to better outcomes.



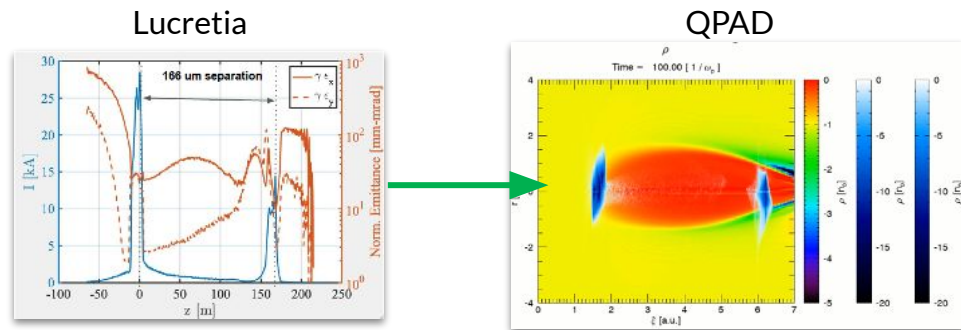
Goal #1: Use Sims to Define “Acceptable” Beam Parameters

Simulations and analytical tools can help us understand the acceptable range of beam parameters at a given working point:

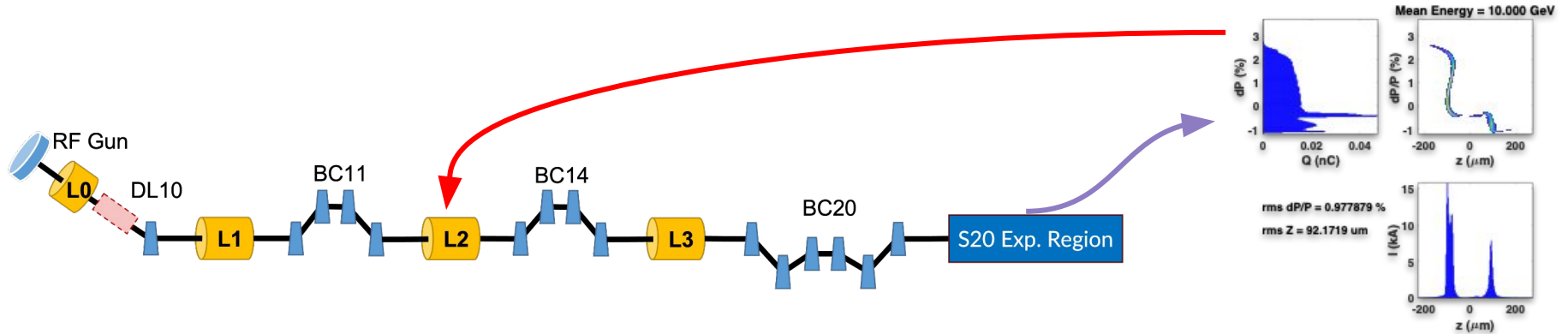
- Bunch-to-bunch separation jitter
- Bunch-to-bunch offsets
- Tilted bunches
- Charge jitter

Which beam inputs to the plasma preserve emittance and charge?

How sensitive are we to variations in the input distribution?



Goal #2: Use Sims to Identify Upgrade Opportunities



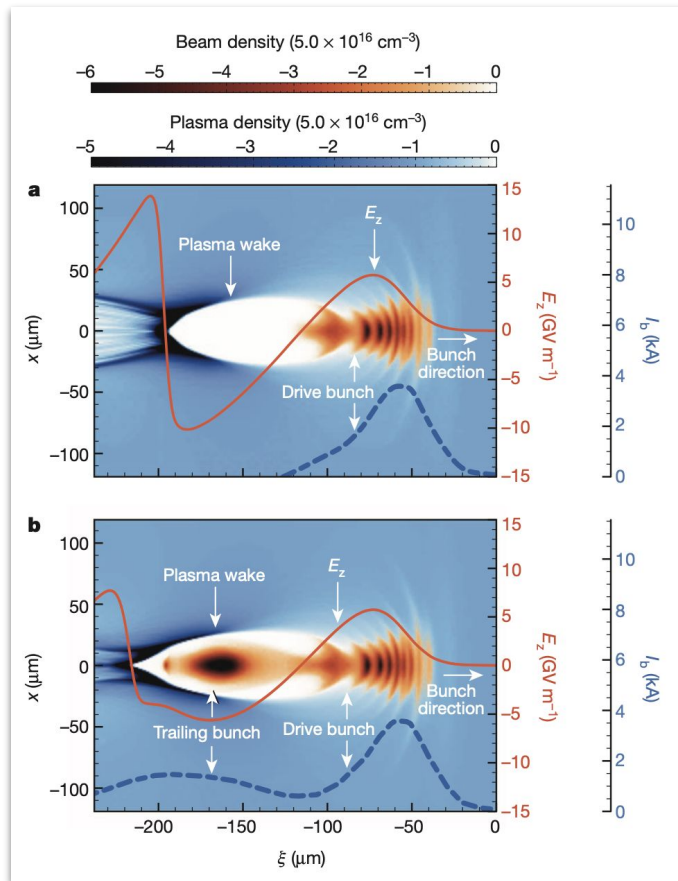
Machine simulations may show that sources of jitter are tied to specific machine elements that need to be upgraded.

Goal #3: Use Sims to Understand Experimental Outcomes

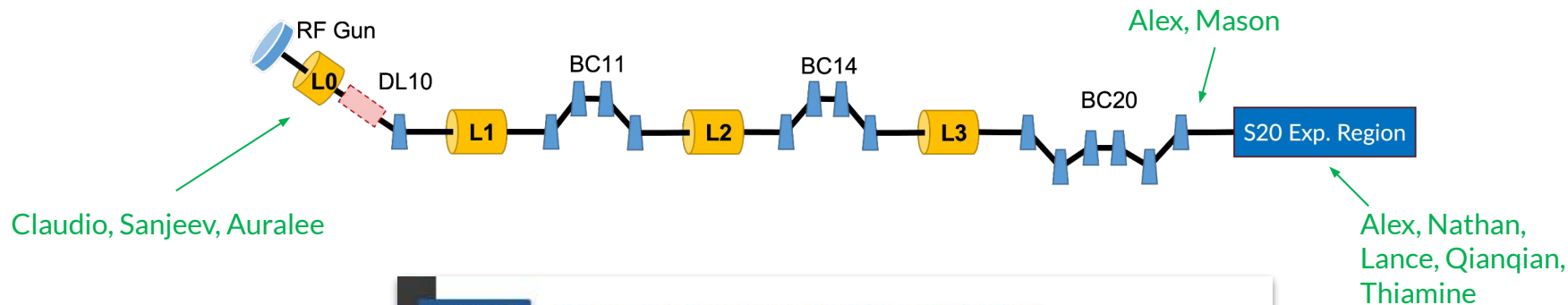
We often need to run many simulations to get good agreement with experiment.

Our simulation framework will:

- Constrain inputs to simulation with machine and diagnostic data.
- Allow for rapid comparisons between simulations and experiments with a well-defined pipeline.



Significant work is already underway!



- 11:10** → 11:25 **Performance of QPAD vs QuickPIC**
Speakers: Lance Hildebrand (UCLA), Qianqian Su (UCLA)
- 11:25** → 11:40 **Accelerator-Plasma Handshake Scripts**
Speakers: Alexander Knetsch (SLAC), Thamine Dalichaouch
- 11:40** → 11:45 **IP Simulator Demo**
Speaker: Mason Stobbe (CalPoly)
- 11:45** → 11:55 **Simulations at S3DF HPC Facility**
Speaker: Nathan Majernik (SLAC)

Agenda for next meeting (August 10)

- Carl Lindstrøm: Use of simulations at FLASHForward in support of emittance preservation experiment.
- Any: Updates on framework and simulations.

Feel free to suggest more topics!