

Electron Column Simulation Update

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Electron Column Meeting
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Updates

- Shortly after IPAC, the TeV cluster job scheduling system was updated from PBS to SLURM (Simple Linux Utility For Resource Management)
 - Previously working batch job scripts had to be updated to new syntax
 - Mostly successfully completed
- Beam distribution changed from Gaussian to KV
 - Transverse emittances now given
 - rswarp distribution generation function used
- Velocity spread of $\Delta v/v = 0.005$ implemented
- Additional diagnostics implemented
 - Detector planes 9.9 cm upstream and at the end of the Column added to record beam distribution before and after Column
- *First pass complete with & without ionization, second pass complete with ionization* (*see later slides)*

Sanity Check

- 100% emittance of KV distribution is 4x RMS emittance

$$\epsilon = 4 \epsilon_{RMS}$$

- RMS emittance calculated by

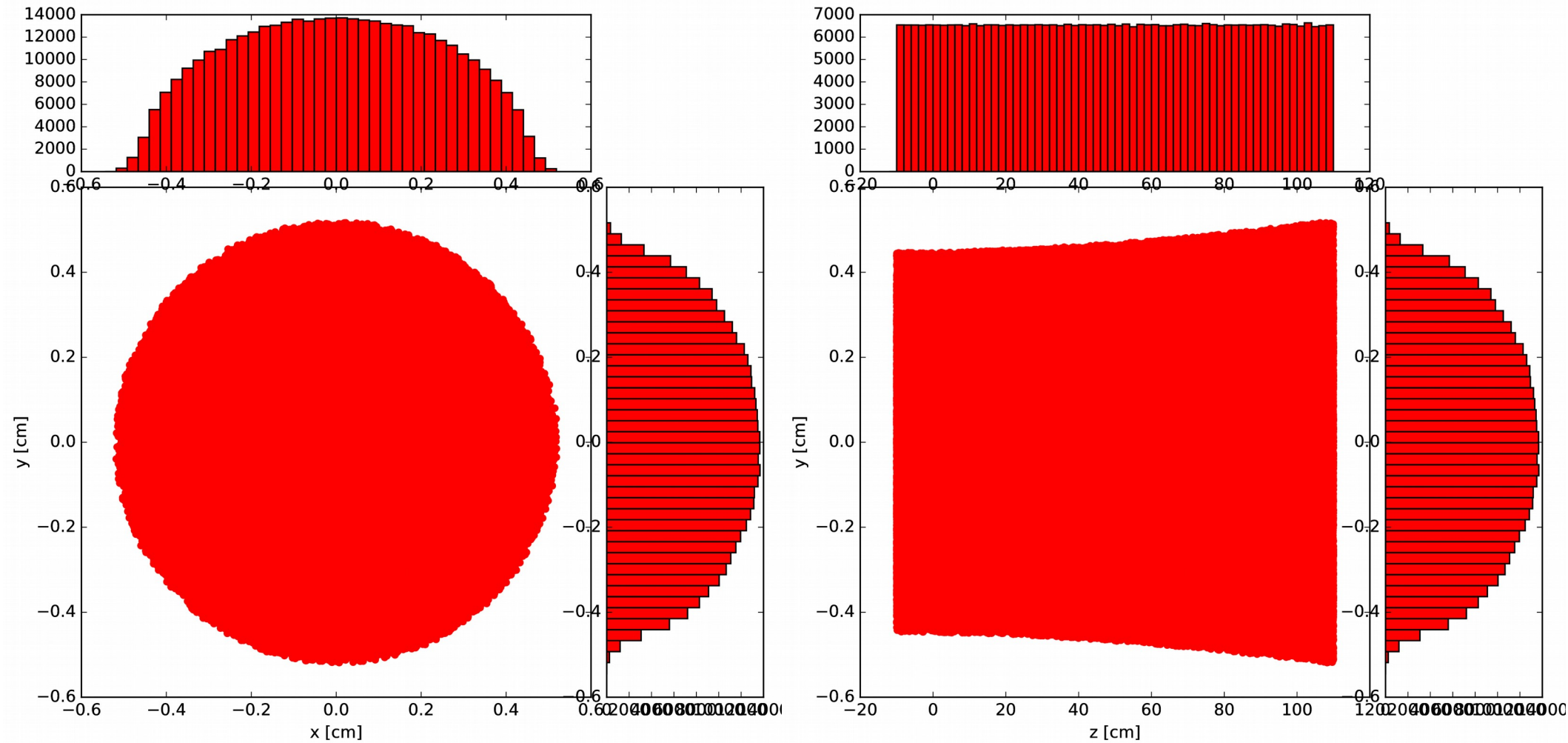
$$\epsilon_{x,RMS} = \left[\overline{x^2 x'^2} - (\overline{x x'})^2 \right]^{1/2} \quad x' = v_x/v_z$$

- Input 100% emittance given = 10 μm
- Input RMS emittance calculated as above, (x, y) = (2.500, 2.500) μm

Emittance Growth

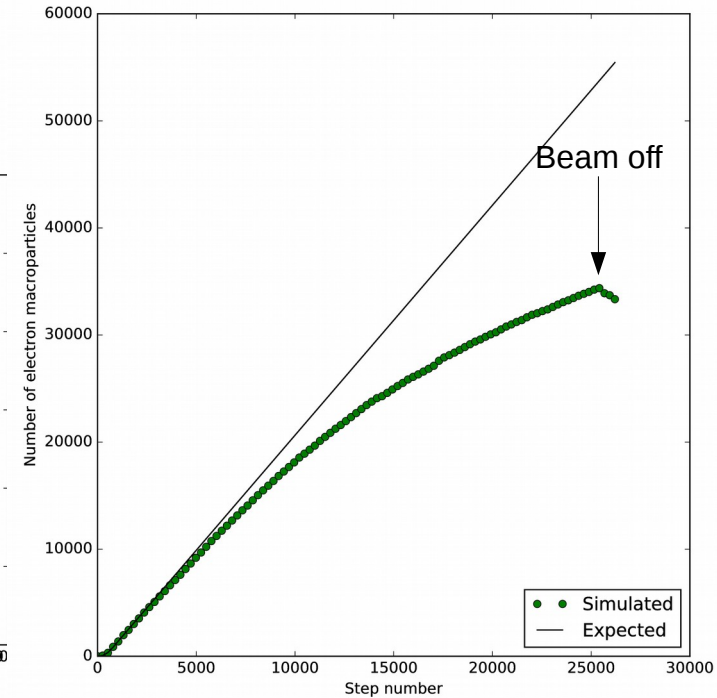
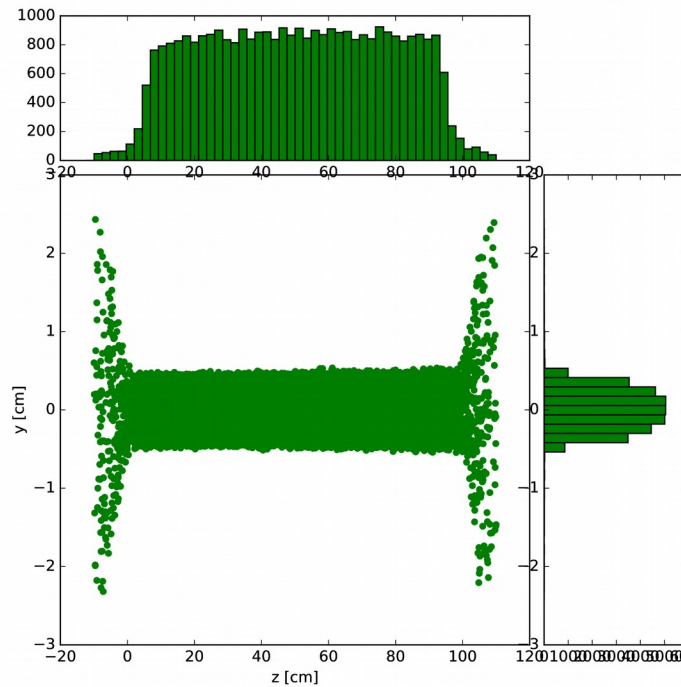
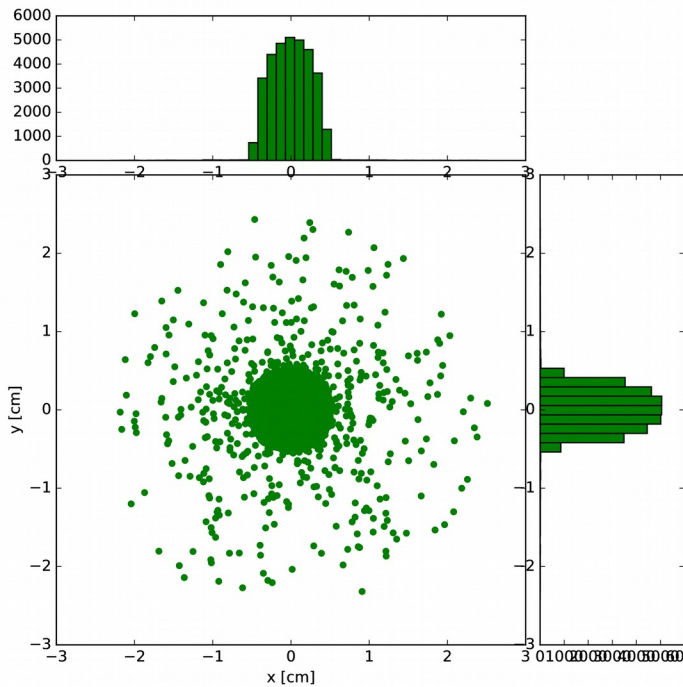
- Slight emittance growth observed after first pass
- Initial RMS emittance $(x, y) = (2.500, 2.500) \mu\text{m}$
- Final RMS emittance $(x, y) = (2.598, 2.597) \mu\text{m}$
 - Corresponds to 4% growth
 - Calculated from every particle with same PID to pass detector plane at end of Column
 - There could be a problem with PID (see later slide)

Protons – 1.761 μs



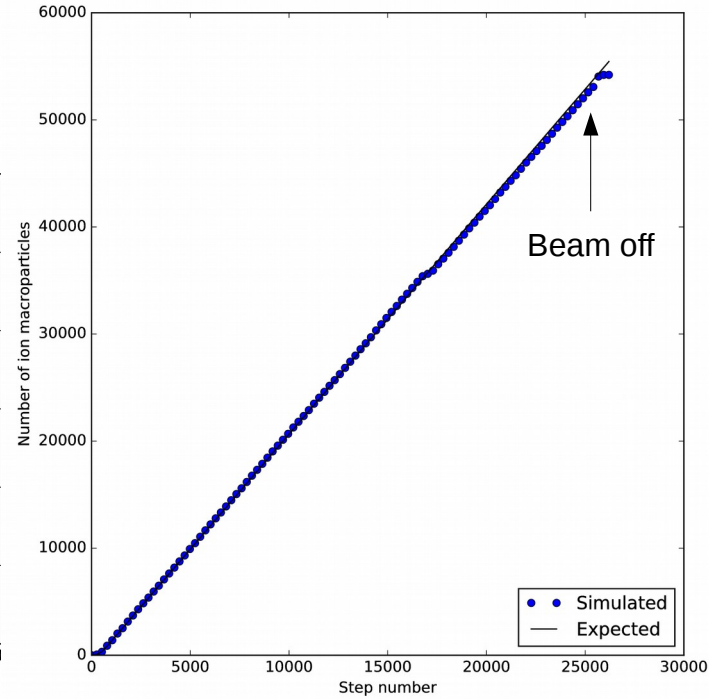
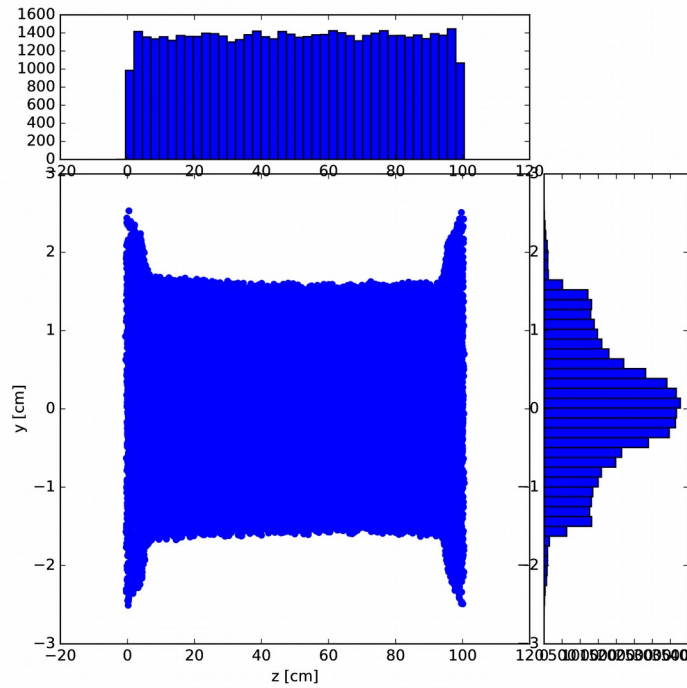
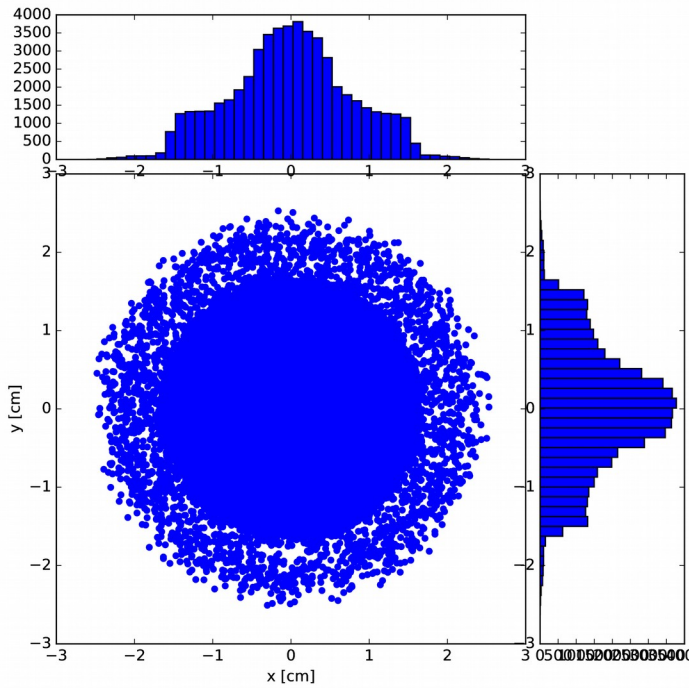
Electrons – 1.834 μs

- As before, electrons escaping from ends of Column



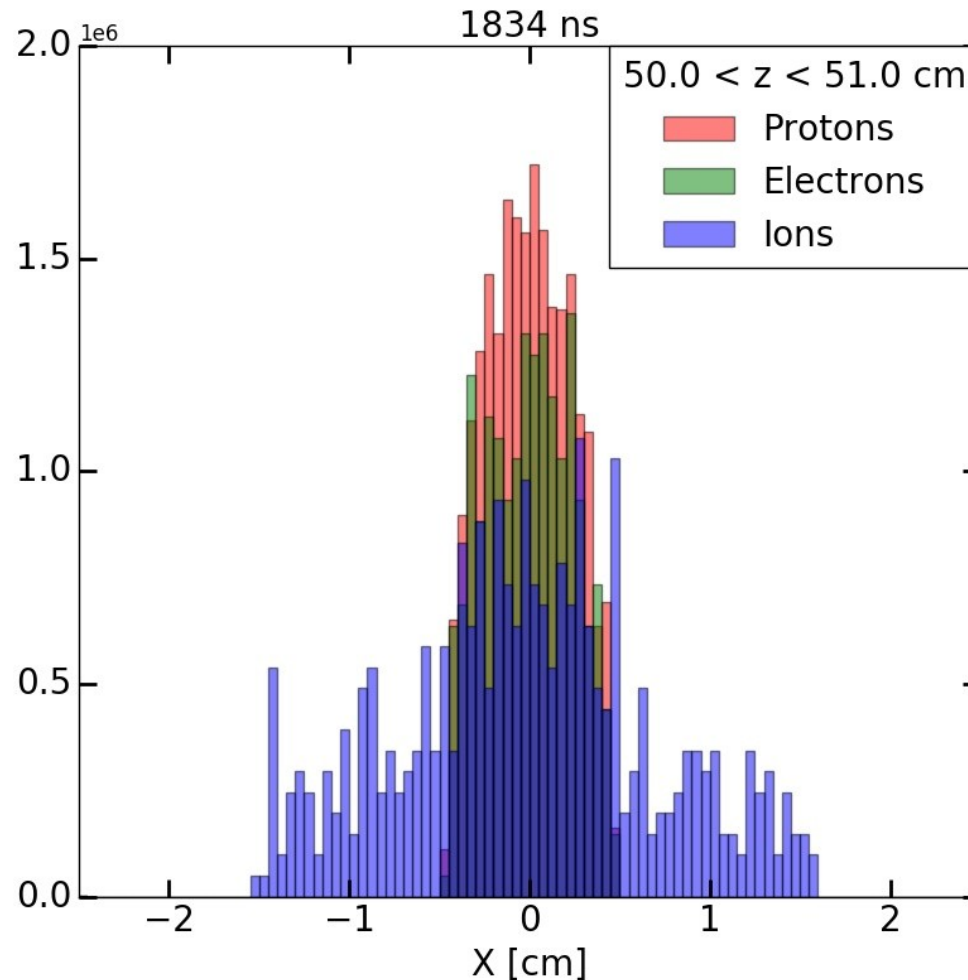
Ions – 1.834 μs

- As before, ions trapped, but diffuse radially



Profile Comparison

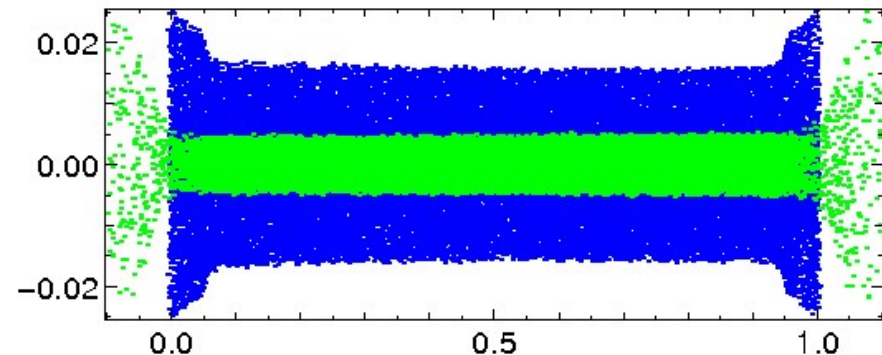
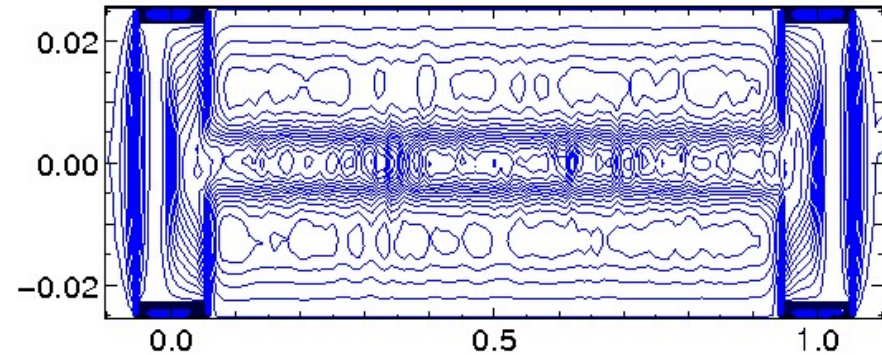
- Similar behavior as before – ions diffuse radially, electrons close to matching proton profile



Second Pass

5

- Plasma distribution from last time step of first pass successfully loaded at beginning of simulation for second pass
- Beam recorded after crossing end of Column in first pass loaded sequentially at beginning of column in second pass

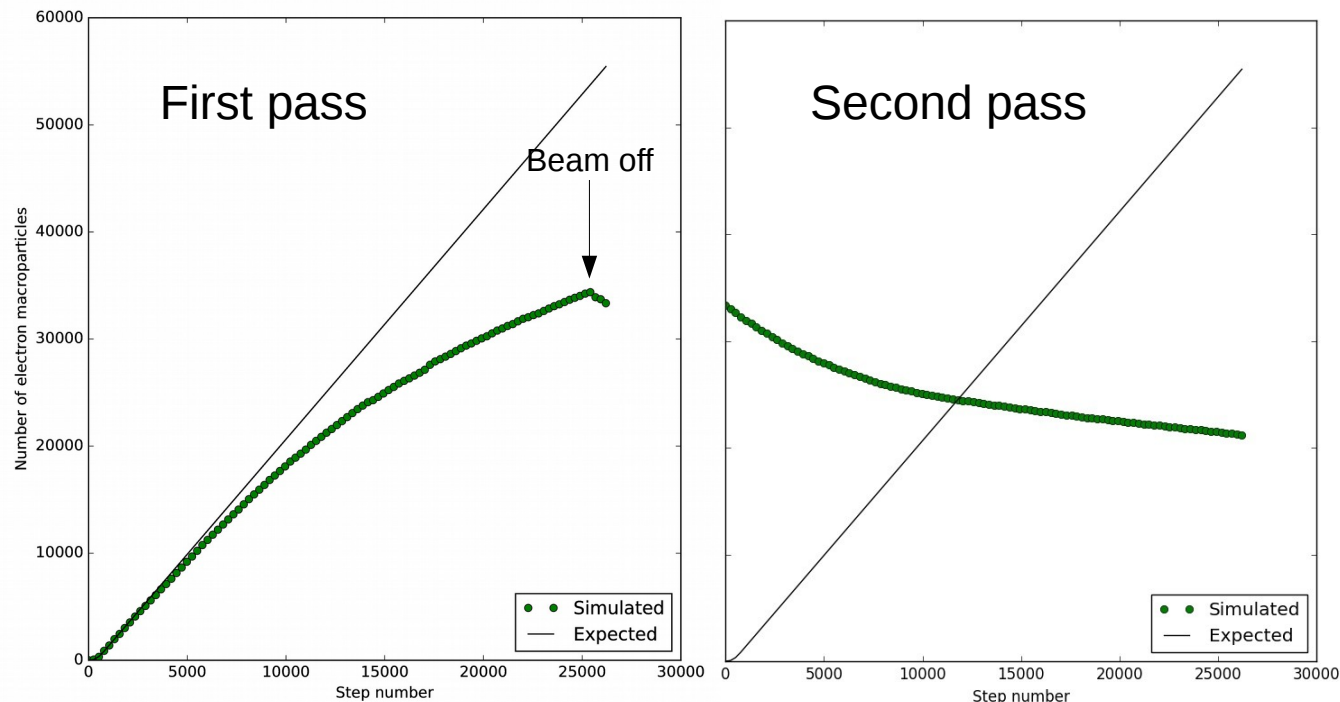


Step 0, T = 0.0000e+0 s, Zbeam = 0.0000e+0 m
Second pass of two passes
Electron Column

Ben Freemire (freeben@fnal.gov), Sat Jun 2 14:42:25 2018 ecolumn.001

Plasma Particle Count / Ionization

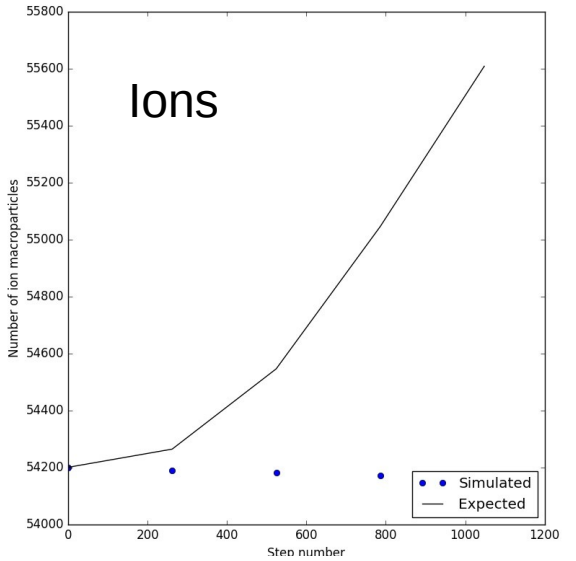
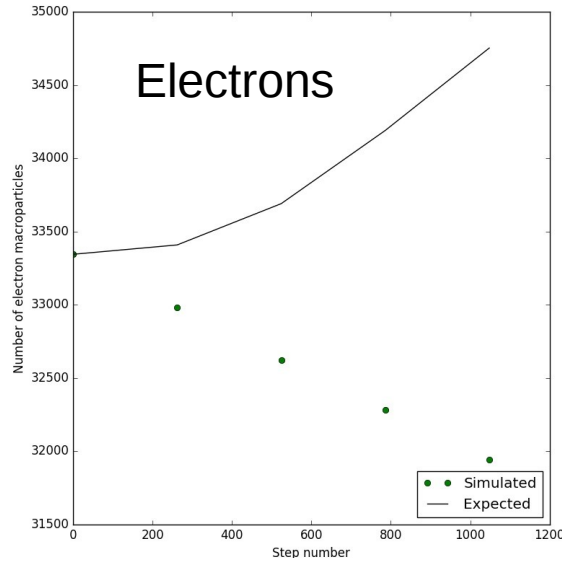
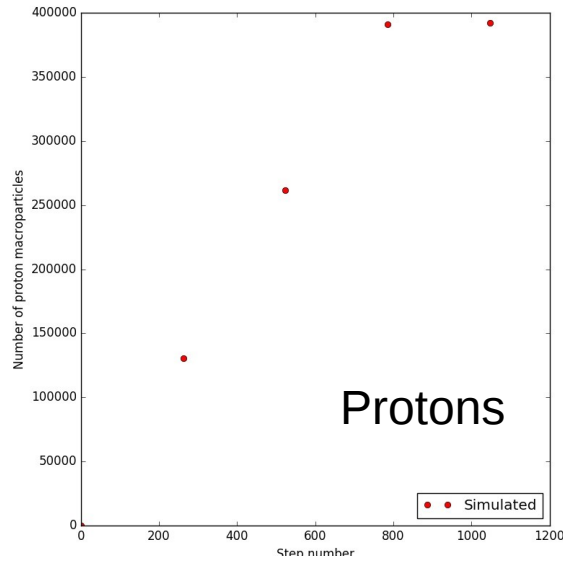
- Number of electrons in second pass decreases steadily
 - Some loss expected at ends of Column, but not to extent observed
 - Expected curve for second pass present only to maintain scale
- Appears as if ionization not working



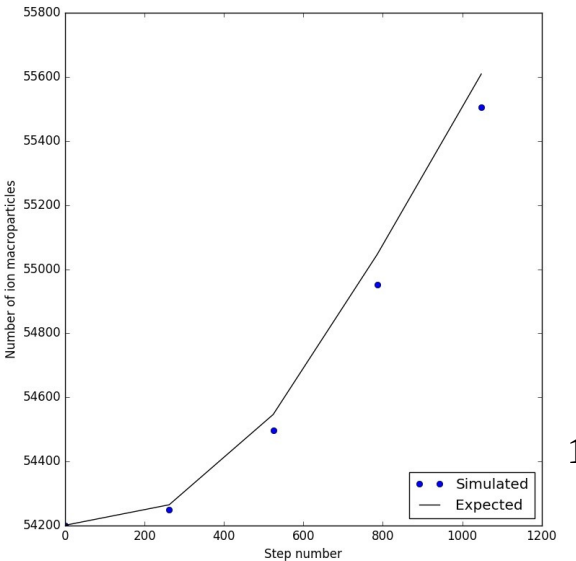
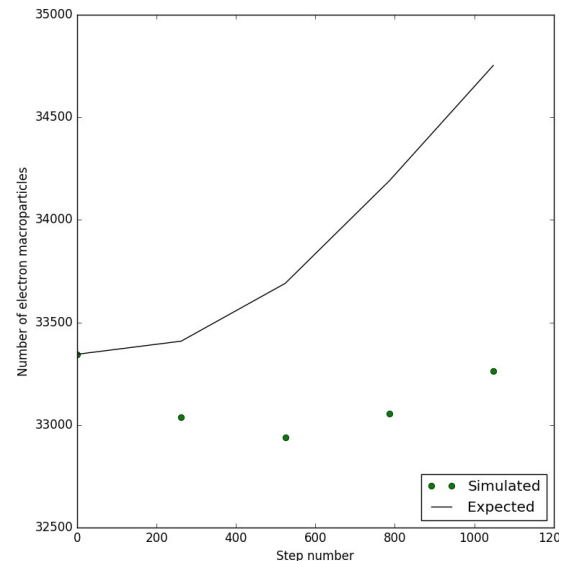
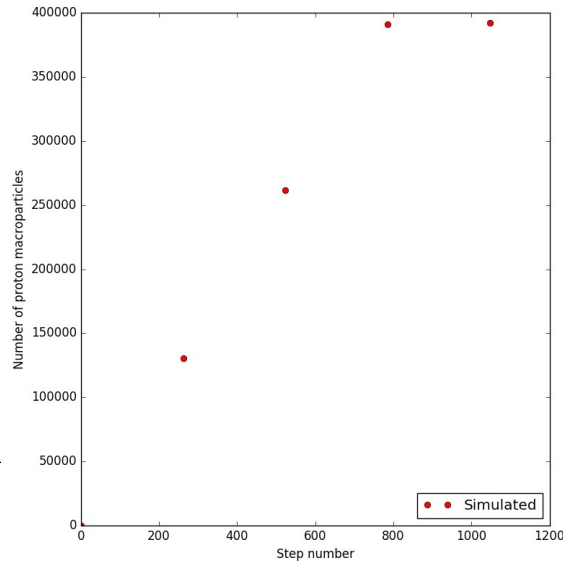
Further Investigation

- I ran the same python code that was run on the TeV cluster on my laptop for 4 save periods

TeV



Laptop



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ZCrossing Diagnostic

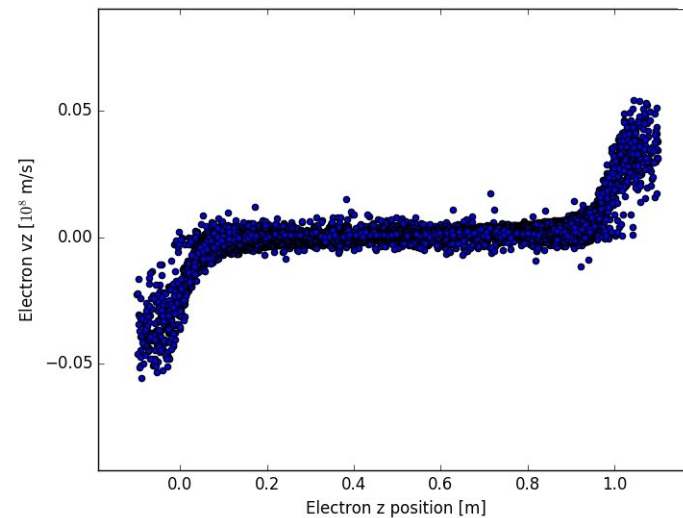
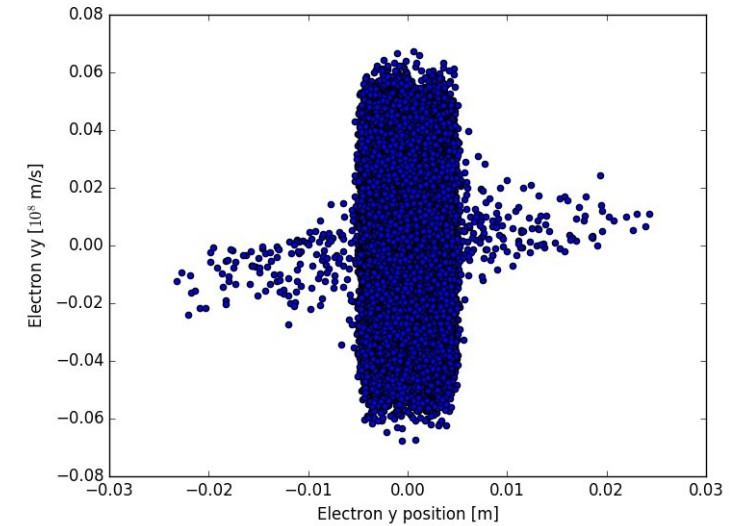
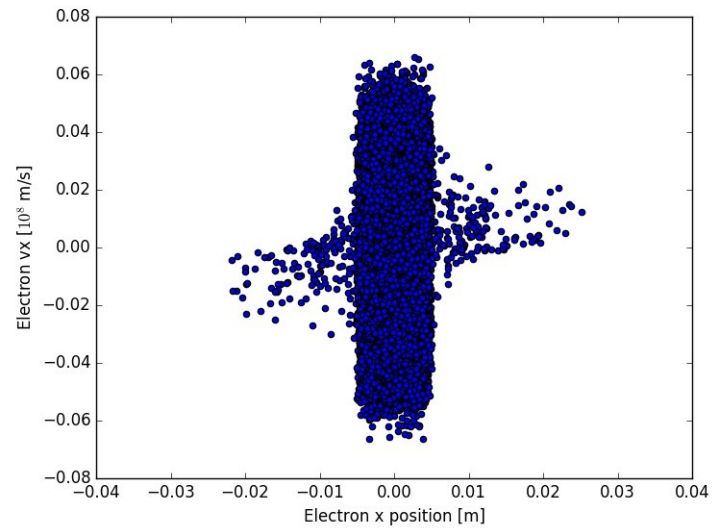
- Diagnostic used for tracking when and where particles cross specified z-plane not working as expected
- Expectation: All particles crossing plane at beginning and end of Column recorded
 - Used to measure plasma particle loss rate
- Result:
 - TeV first pass – Particles recorded before and after Column
 - TeV second pass – Only particles passing end of Column recorded (not before)
 - Laptop second pass – Particles recorded before and after Column

Particle Identification

- It appears my understanding of how particle identification works in Warp is incorrect
- I believed each particle type was assigned an integer at creation (i.e. protons are all 1)
- It turns out that all particle IDs are 1
- How are individual PIDs specified?
 - I do not see this as a parameter in the Species declaration
- This would allow for discerning particle species at detector planes

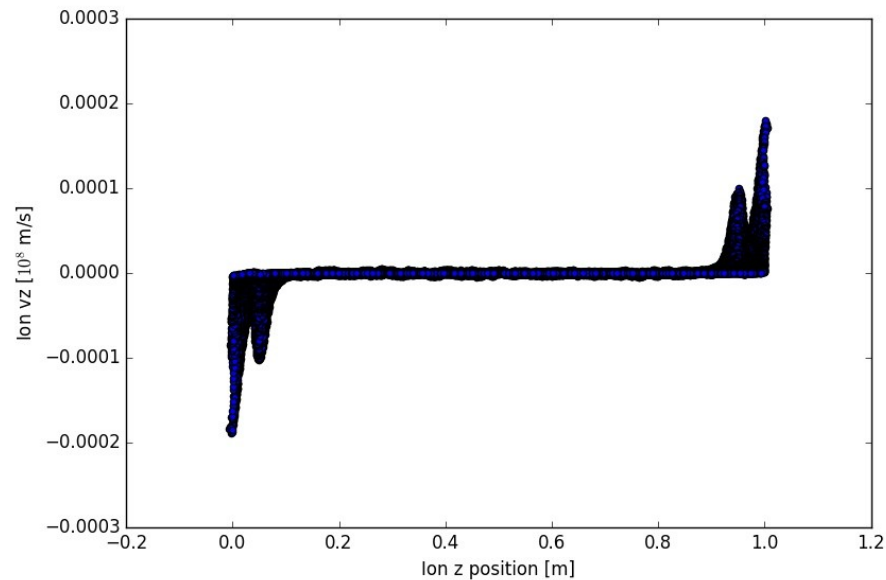
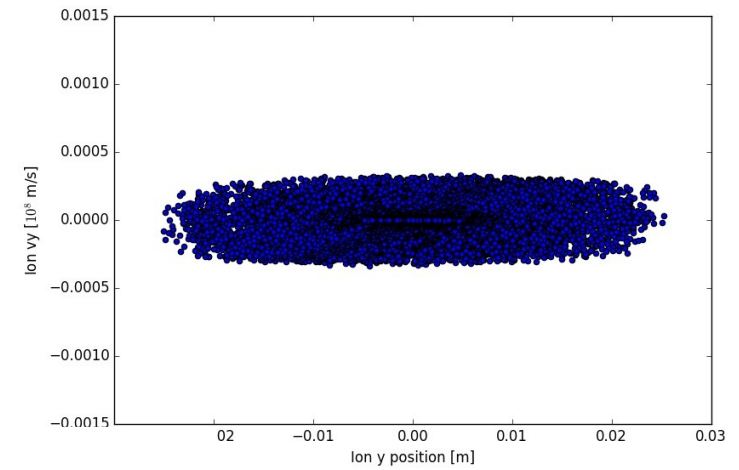
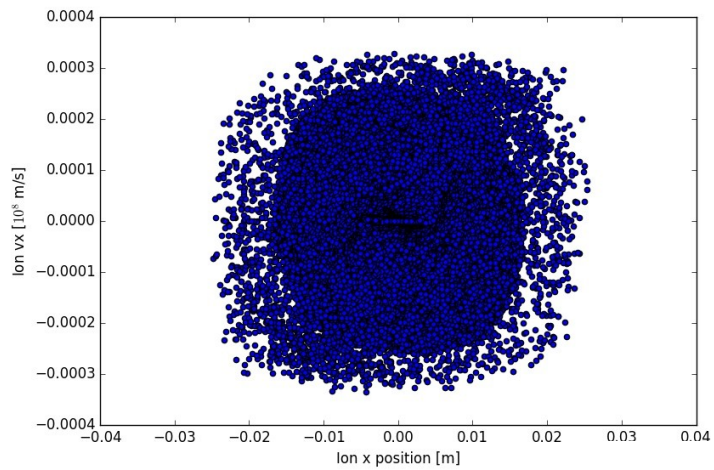
Electron Velocities

- At end of first pass



Ion Velocities

- At end of first pass



Comments

- Two main changes implemented
 - KV beam distribution with transverse emittance and longitudinal velocity spread
 - Additional detector planes added to measure input & output emittance and plasma escape rate
- Code to load plasma from first pass operational
- Code to load beam from first pass operational
- Issue with ionization during second pass on TeV
- First detector plane not working in second pass on TeV
- Better PID needed