

CRT November 2019 Runs SCE Measurements

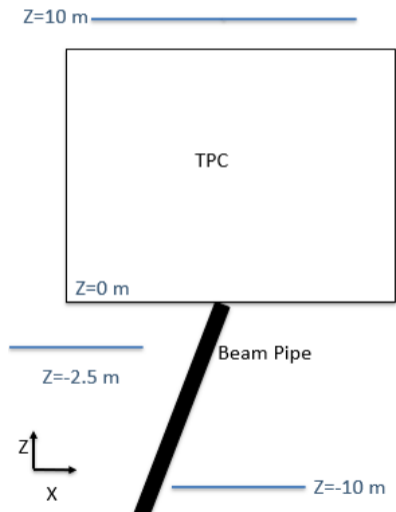
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November CRT Runs

- In November 2019, ProtoDUNE-SP ran for three weeks to collect data using the CRT. This included roughly two weeks of approximately 10 Hz CRT data to study the electron lifetime and SCE.
- The three weeks also included HV runs and a special CRT-triggered set of runs for attenuation studies.
- The CRT triggering to the CTB was changed to create a delay for the BL upstream CRT and prioritize CTB triggers from the CRT US BR.

Background on CRT Placement



Background on SCE Measurements

Two ways to measure the SCE effect.

- Measure the difference between the TPC wall and the first track point reconstructed for cosmic rays piercing the front, back, top, and bottom TPC faces. Use the CRT, cathode, and anode to measure the time and determine a position in X. Only way for the CRT to measure displacements in Z.



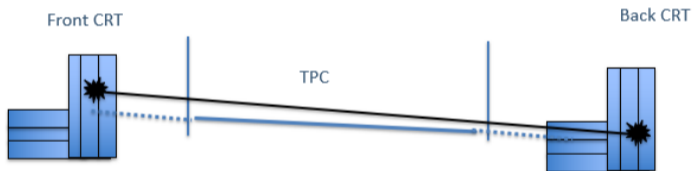
- Measure the difference between individual track points between the TPC track and a track reconstructed using an external method, like a laser or a CRT. Slice these measurements in Z to measure the SCE in the interior of the detector.



Week 1 of November CRT Runs at a Glance

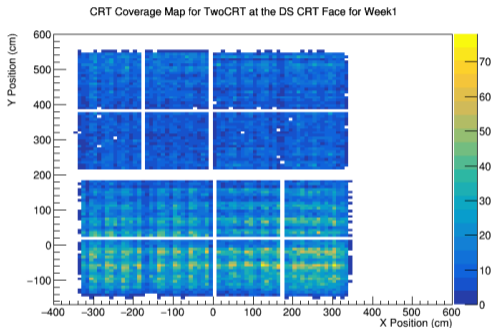
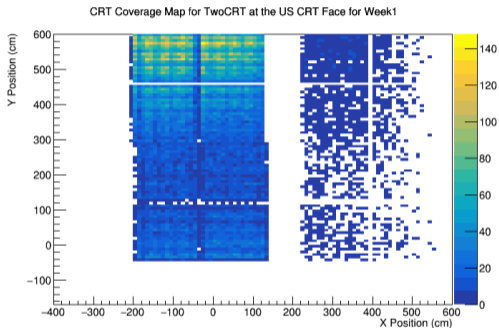
Week 1 Statistics

- 35k raw data files each with 31 events
- 25.7k reconstructed data files with around 31 events (796k events)
- 82.9k reconstructed CRT tracks matched to TPC tracks



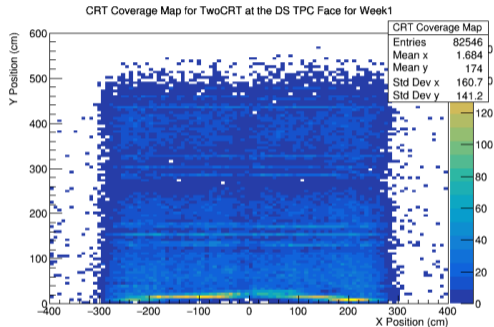
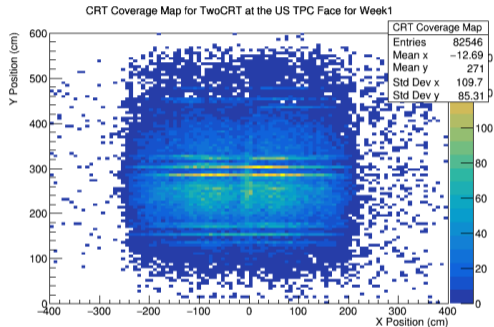
CRT matched to a TPC track by minimizing the displacement in X and Y between CRT hits and where the TPC track would hit the CRT if it extended beyond the front and back faces.

Coverage Map on the CRT



Coverage map for CRT matched track hits on the CRT planes

Coverage Map on the TPC

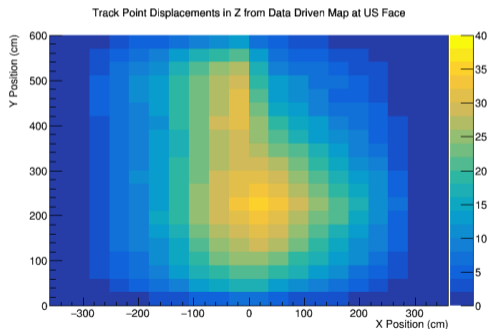
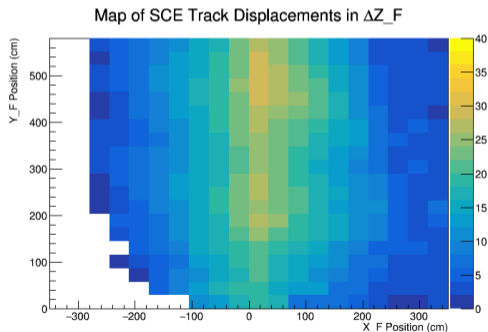


Coverage map for CRT matched track points on the TPC faces

SCE Measurement in Z from T0-Tagging

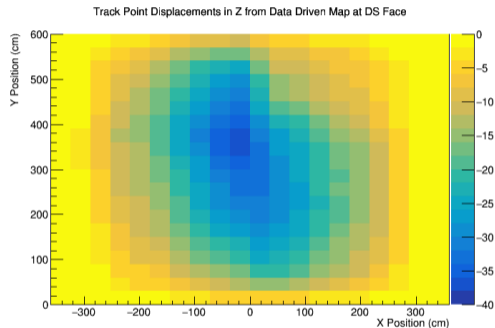
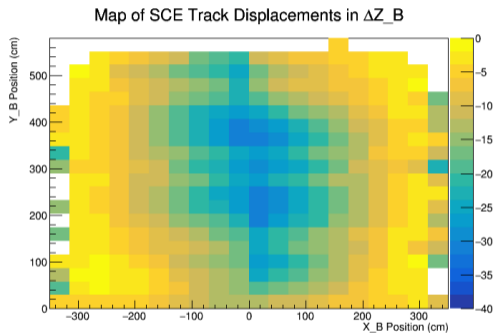
The current calibration map, referred to sometimes as the data driven map, measures displ. in Z by using cathode-crossers to t0-tag tracks that go through the front and back TPC faces.

This CRT map uses the same method, but using the CRT to t0-tag.



SCE Map taking $\Delta Z = Z_{track\ endpoint} - Z_{TPC\ face}$ on US TPC Face for CRT runs and the data

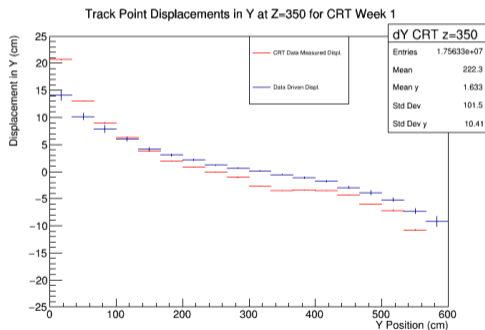
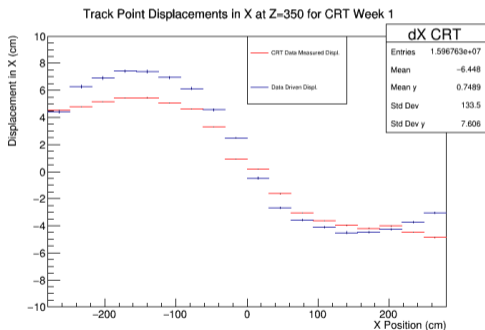
SCE Measurement in Z from T0-Tagging



SCE Map taking $\Delta Z = Z_{track\ endpoint} - Z_{TPC\ face}$ on DS TPC Face

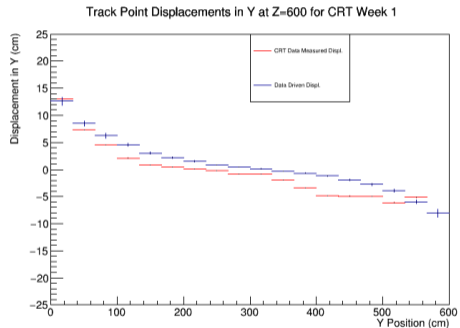
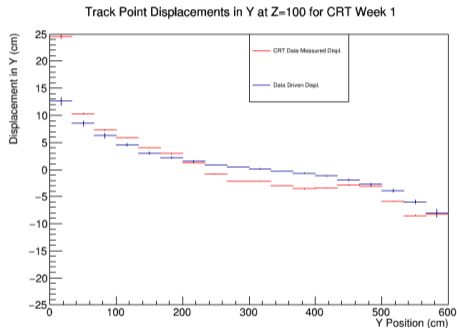
SCE Measurements in the Interior of the Detector

- Measure the distance between a TPC track's spacepoint and the CRT track to quantify the SCE displacement.
- Compare this in specific locations in Z to current SCE calibration map, in dunetpc as data driven map, which interpolates things inside the boundaries.

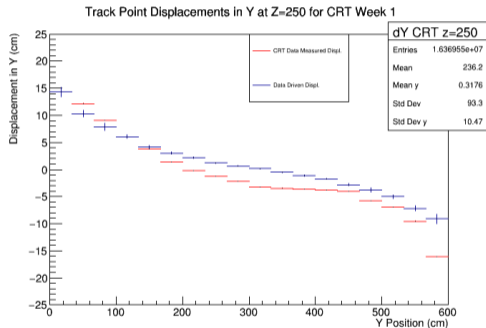
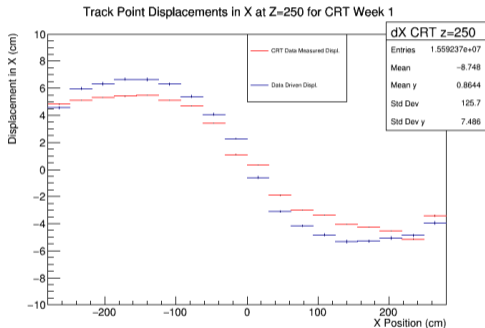


The bins at $y=0$ and $y=600$ in measuring displacements in Y at $Z=350$ cm contain little to no events given cosmic angles and the distance the cosmic ray has to travel from CRT US to CRT DS.

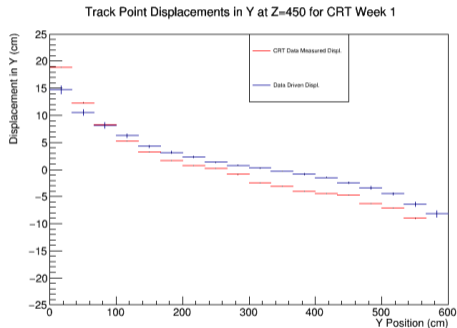
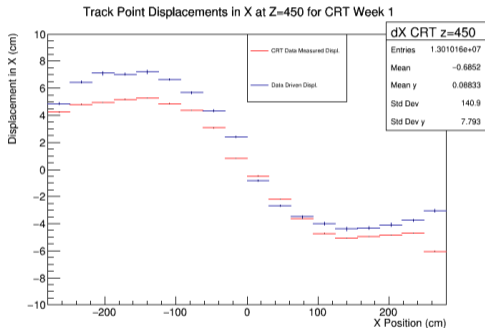
SCE Measurement in Y near Front and Back Faces



SCE Measurements at Z=250 cm

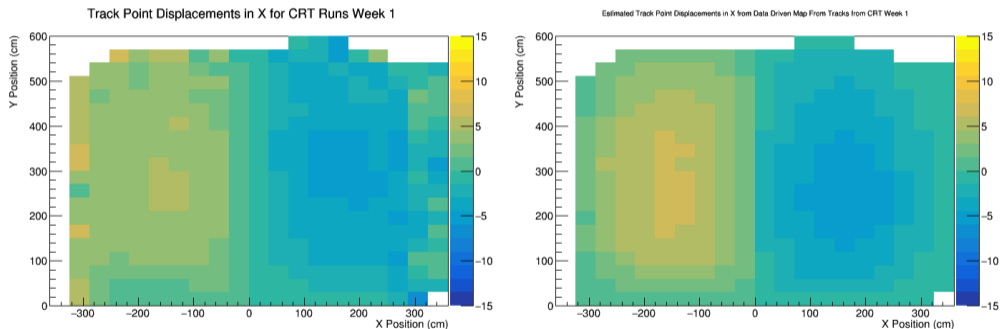


SCE Measurements at Z=450 cm



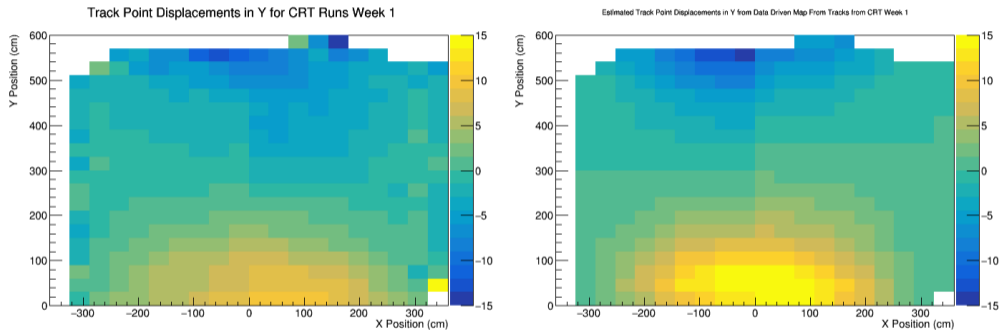
SCE Measurements Summing Over All Track Points

The data driven map was compared to the CRT map by feeding in all CRT track points into the data driven map to ensure equal coverage between both maps.



CRT SCE map of displacements in X (left) and the data driven map (right)

SCE Measurements Summing Over All Track Points



CRT SCE map of displacements in Y (left) and the data driven map (right)

Moving Forward

Conclusion: ProtoDUNE-SP November 2019 CRT Runs contain hundred of thousands of events that have been reconstructed, with at least 80k successfully matched tracks matched and analyzed for SCE measurements in one week alone.

Current Tasks

- SCE CRT maps and histograms were made and differences observed with the current SCE map. These differences are being understood.
- Currently working out how to turn these displacements into a 3D electric field map.
- ProtoDUNE-SP currently taking data with circulation on and off for random and CRT triggered events. Will look to analyze once data taking is complete and reconstructed.

Sibling Analysis: Electron lifetime studies for these runs is currently being analyzed and there will be an update next week.