

Toward First SCE Calibration at ProtoDUNE-SP

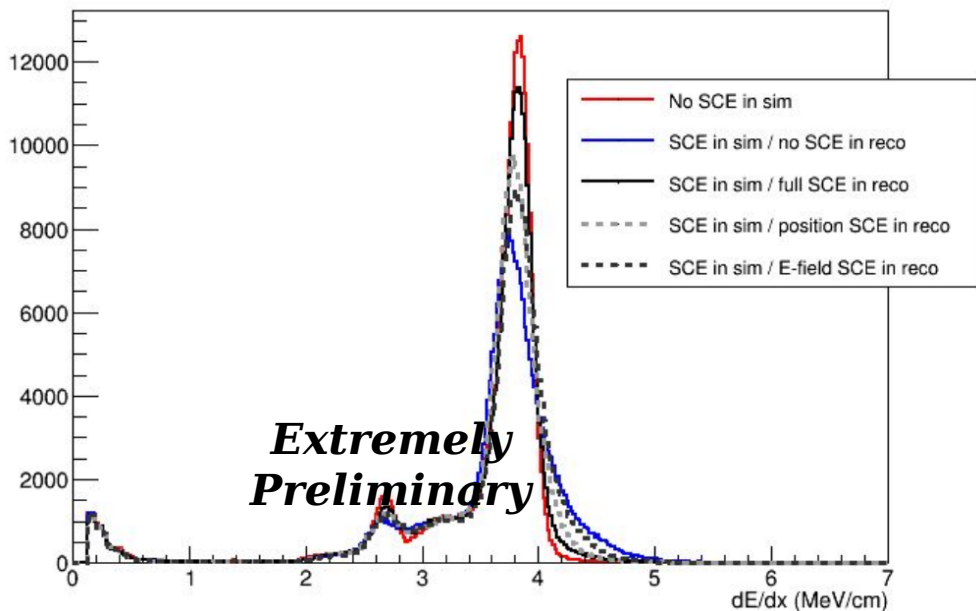
Michael Mooney, Hannah Rogers
Colorado State University

On Behalf of the ProtoDUNE SCE Analysis Team

ProtoDUNE Sim/Reco Meeting
January 9th, 2019

- ◆ Can use spatial offsets at TPC faces as “smoking gun” for space charge effects @ ProtoDUNE
 - Analysis is simple - use start/end points of t_0 -tagged tracks (cathode crossers for now), look at transverse deviation from TPC face position
- ◆ Can also use spatial offsets at TPC faces for simple SCE calibration
 - Use data/MC offset ratio at faces to obtain “scale factor map” for each of four faces
 - Use bilinear interpolation of scale factor maps to obtain per-voxel scale factor throughout 3D volume
 - Scale simulated (“true”) 3D SCE correction map by scale factors to obtain data-driven correction map
- ◆ Our goal: prepare this in **two weeks**

dE/dx for 1000 isotropic, quiet muons



**Missing Scale
Factor Here**

**(Why dE/dx Not
At “Correct”
Value)**

- ◆ SCE corrections implemented for MicroBooNE (spatial offsets and E field impact on recombination)
 - Validated with MC, perfect calib - see above (reco = calib)
- ◆ Plan is to use same implementation for ProtoDUNE
 - Hannah porting from MicroBooNE (straightforward)

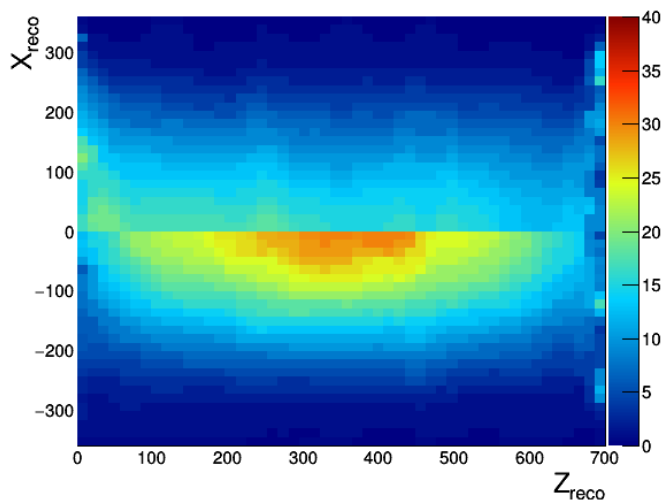
- ◆ In order to make first pass calibration with TPC face offsets, must procure precise offset maps at all faces for both data and MC
 - Repeat studies from before for both data and MC
 - For data, combine all runs from before that have cathode at 180 kV (as no significant variation found run-to-run)
 - Yields ~1M cathode crossers
 - For MC, run three variations: SCE off, SCE on and fluid flow off, SCE on and fluid flow on
 - Uses MCC11 reconstructed files (80-90k events each)
 - Also yields ~1M cathode crossers for each variation
- ◆ Many thanks to Francesca and Stefania for preparing data samples and to Richie for preparing MC samples!

Detector Measurement	Data Value	MC Value
TPC Active Top Edge	604.0 cm	606.9 cm
TPC Active Bottom Edge	5.2 cm	7.8 cm
TPC Active Upstream Edge	0.7 cm	0.0 cm
TPC Active Downstream Edge	694.7 cm	694.7 cm
TPC Active Pos. Drift Length	371.9 cm	358.3 cm
TPC Active Neg. Drift Length	369.6 cm	358.3 cm

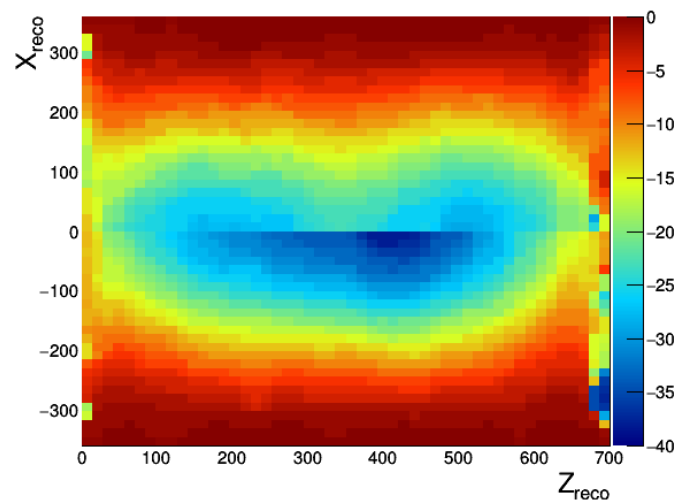
Note: drift length offset in data can be explained by ~ 2 K offset in temperature in calculating assumed drift velocity (e.g. 87 K vs. 89 K \rightarrow 3.5% bias); are we using the correct value in reconstruction?

- ◆ Plot start/end points of cathode-crossing tracks
 - Anode plane not at ± 360 cm? **Drift velocity wrong!**
 - Other data/MC differences... we should update our simulation!

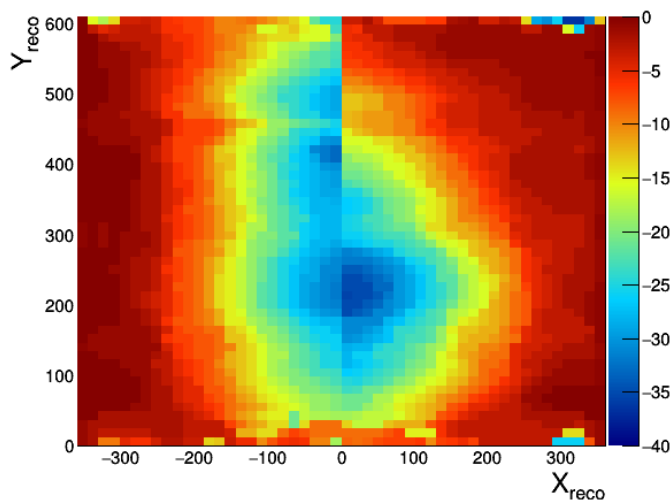
All Data: Top Face ΔY [cm]



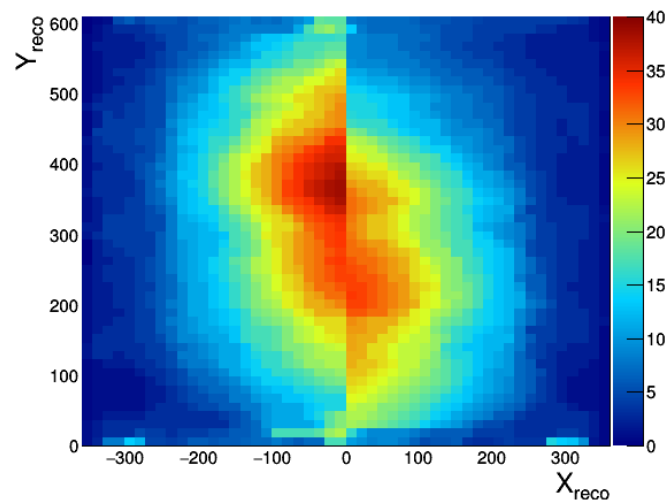
All Data: Bottom Face ΔY [cm]



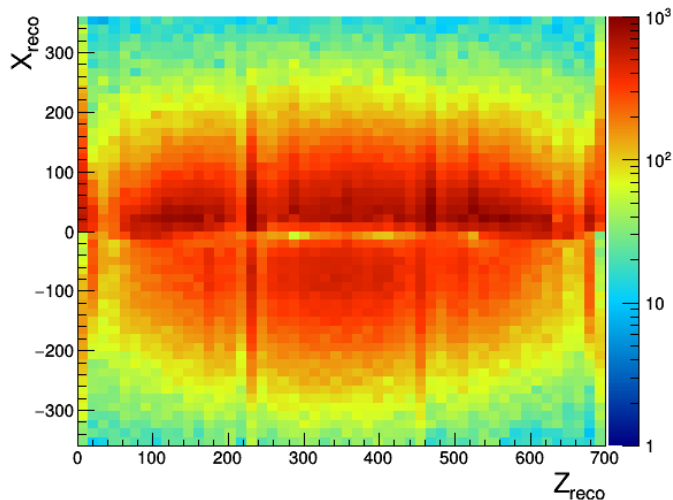
All Data: Upstream Face ΔZ [cm]



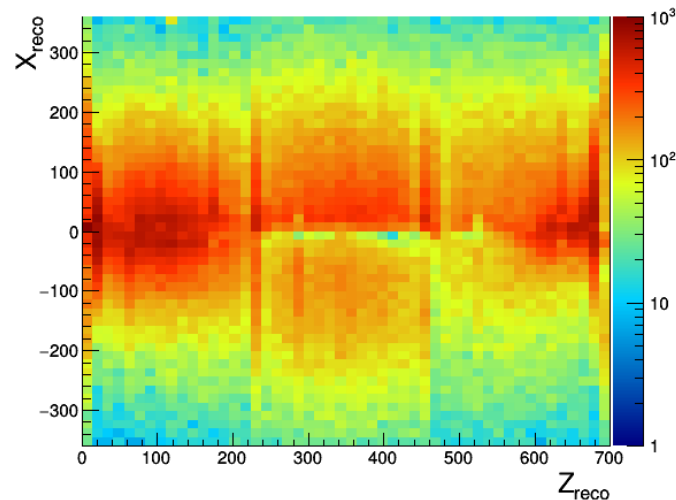
All Data: Downstream Face ΔZ [cm]



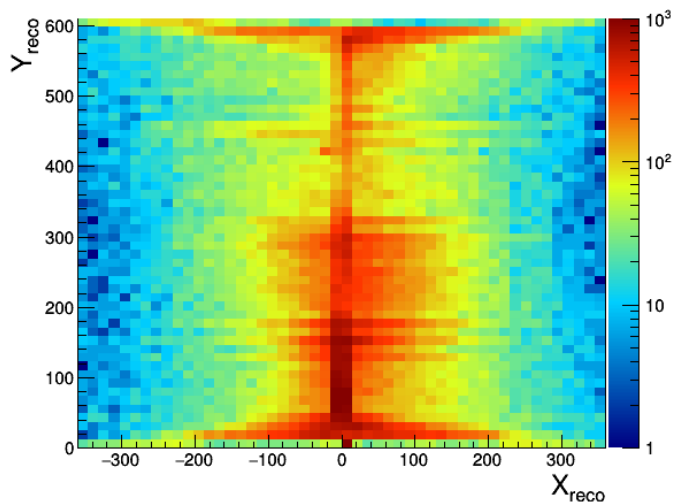
All Data: Top Face Coverage



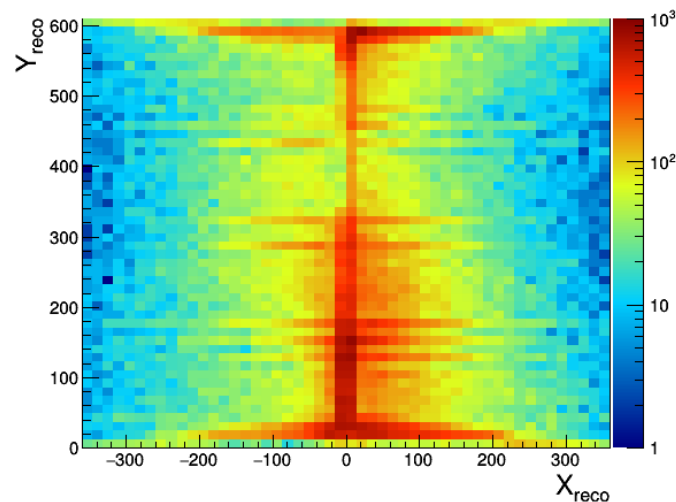
All Data: Bottom Face Coverage



All Data: Upstream Face Coverage

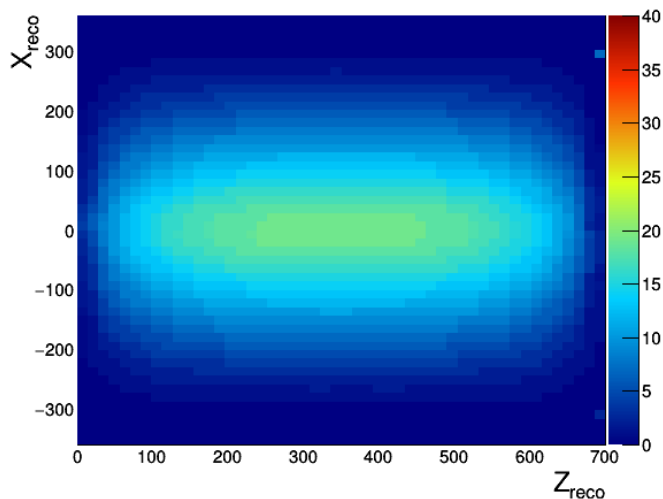


All Data: Downstream Face Coverage

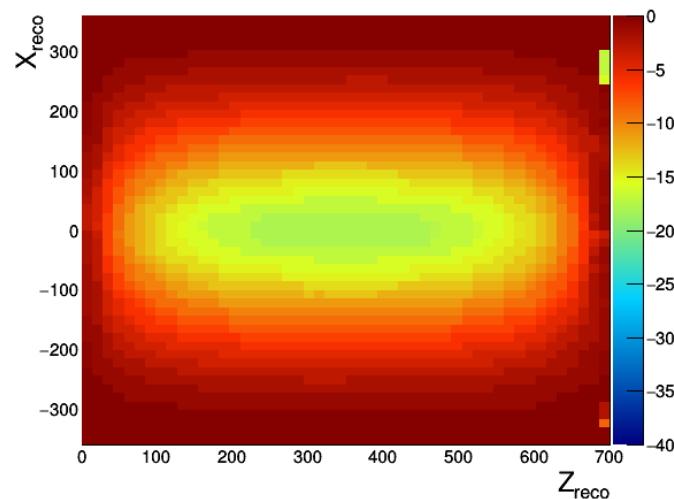


No-Flow MC Results

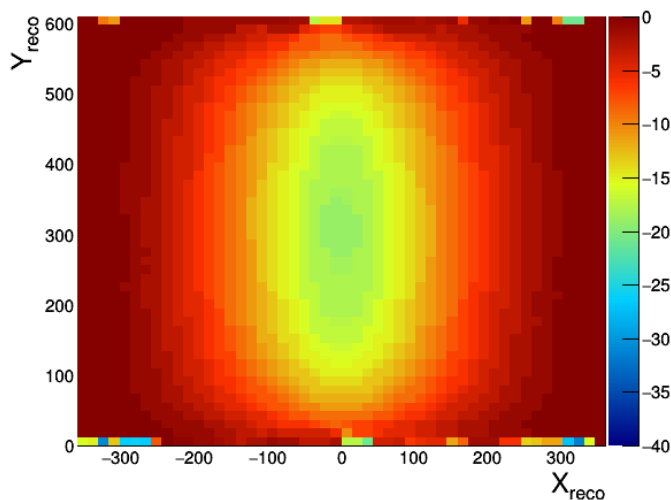
No-Flow MC: Top Face ΔY [cm]



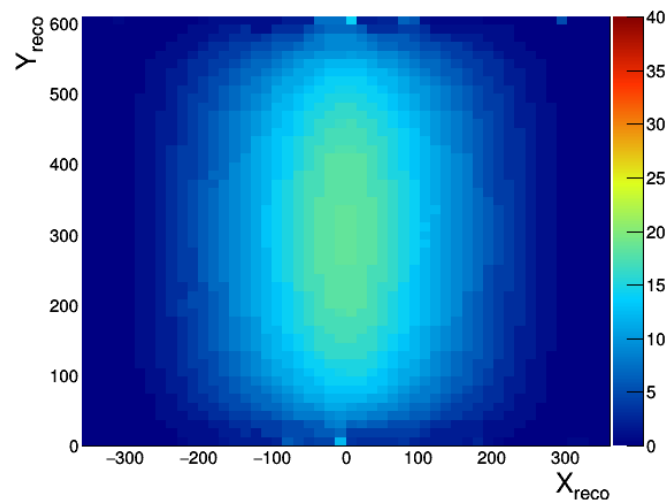
No-Flow MC: Bottom Face ΔY [cm]



No-Flow MC: Upstream Face ΔZ [cm]

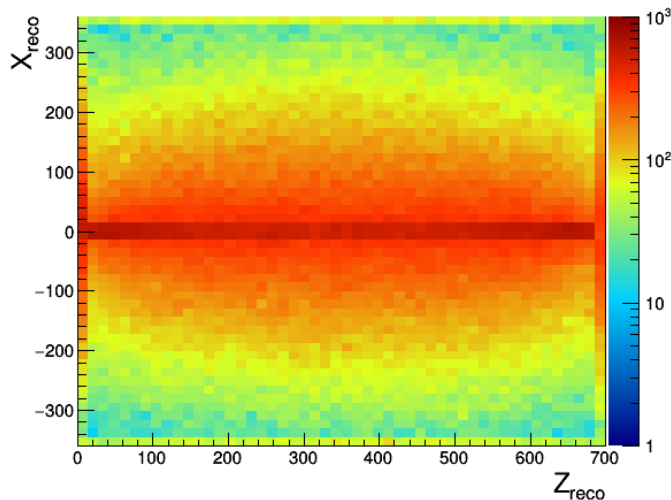


No-Flow MC: Downstream Face ΔZ [cm]

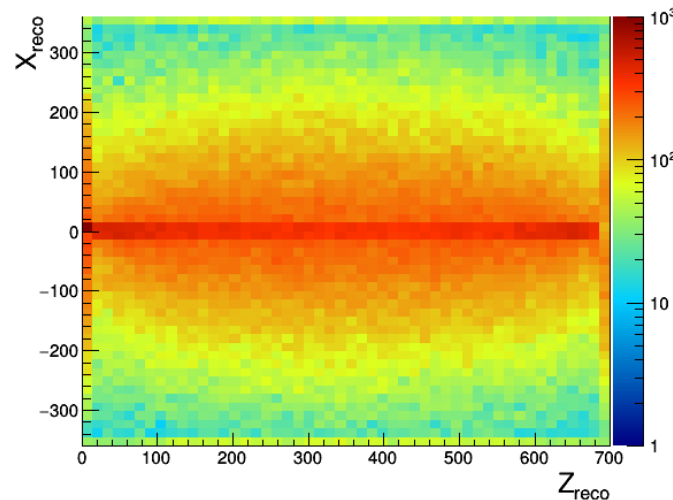


No-Flow MC Coverage

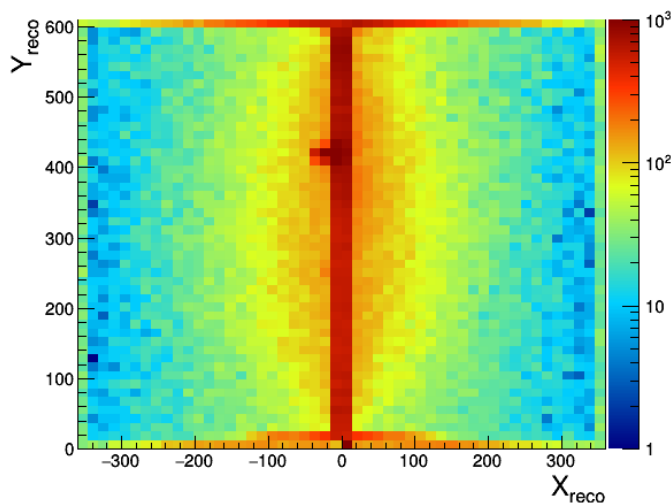
No-Flow MC: Top Face Coverage



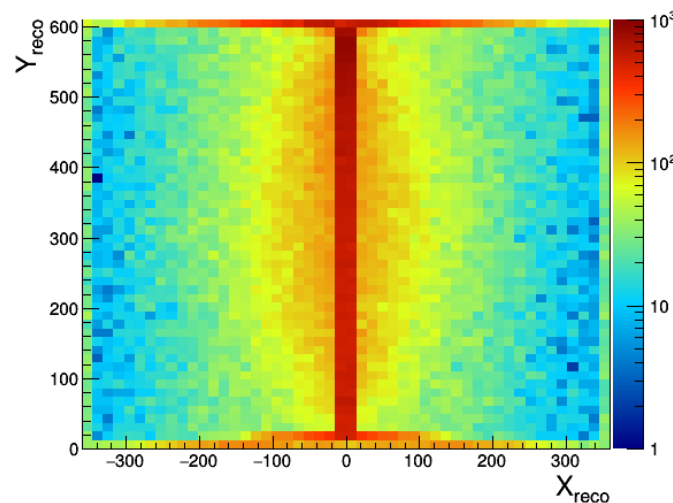
No-Flow MC: Bottom Face Coverage



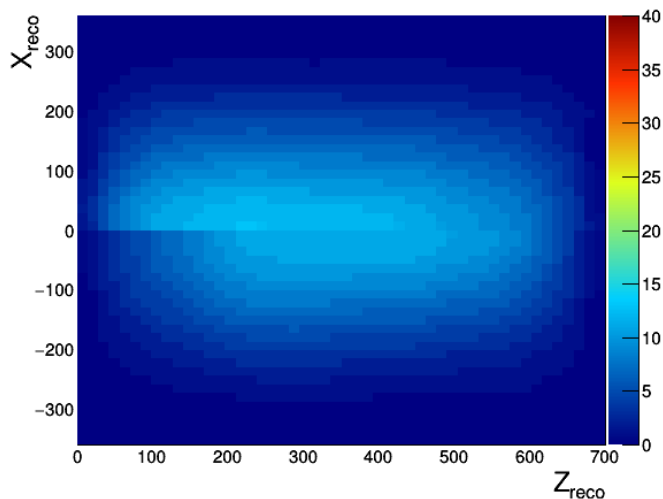
No-Flow MC: Upstream Face Coverage



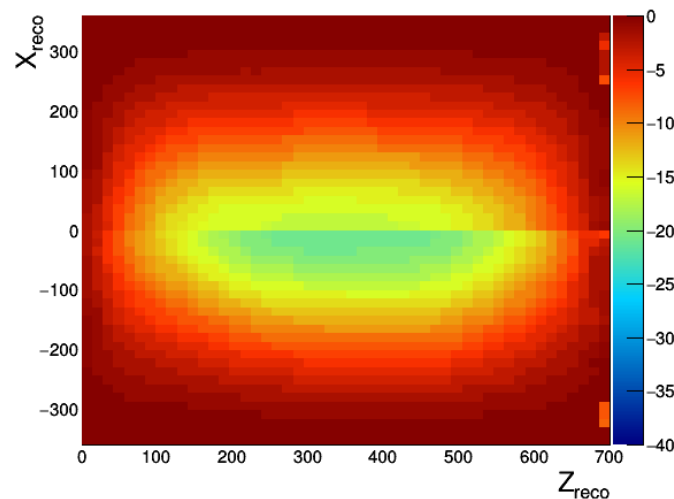
No-Flow MC: Downstream Face Coverage



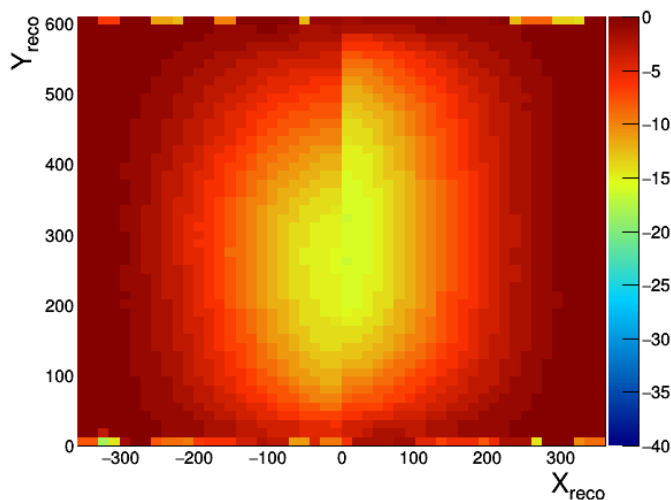
With-Flow MC: Top Face ΔY [cm]



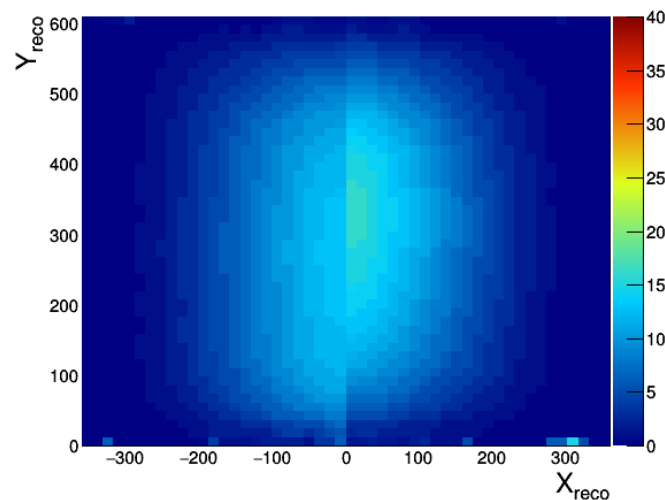
With-Flow MC: Bottom Face ΔY [cm]



With-Flow MC: Upstream Face ΔZ [cm]

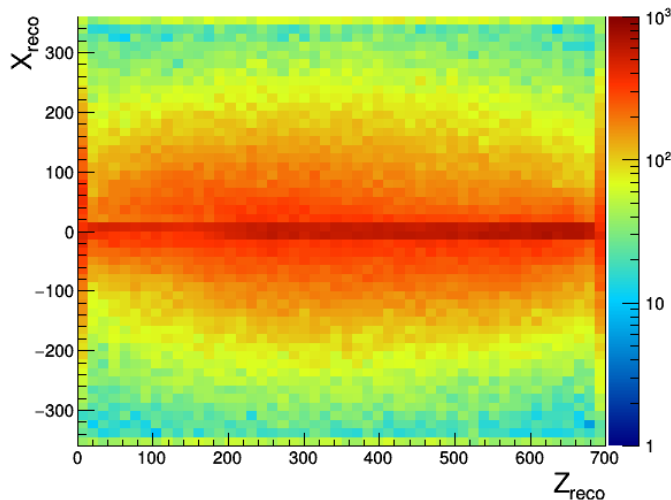


With-Flow MC: Downstream Face ΔZ [cm]

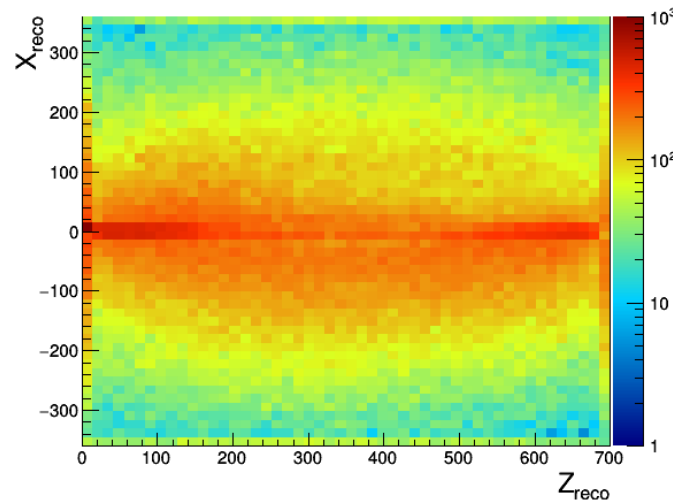


With-Flow MC Coverage

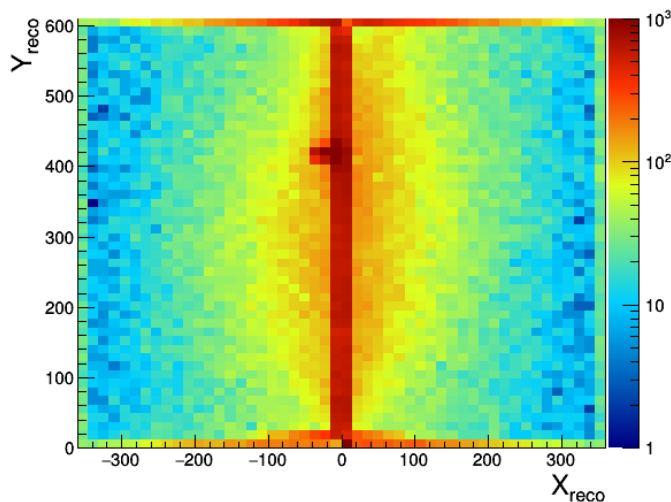
With-Flow MC: Top Face Coverage



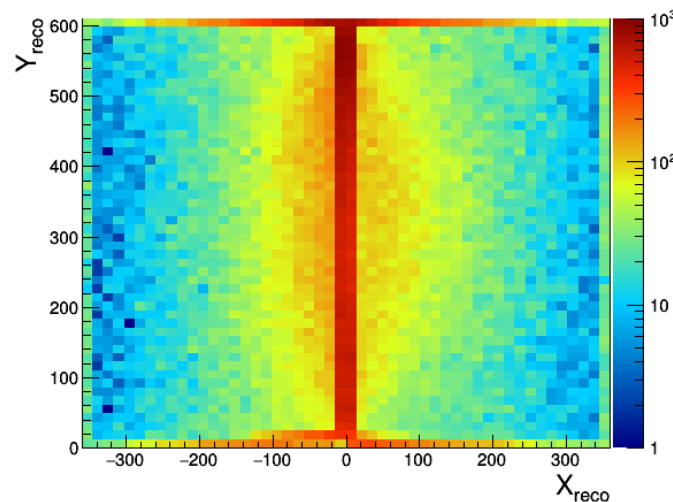
With-Flow MC: Bottom Face Coverage



With-Flow MC: Upstream Face Coverage

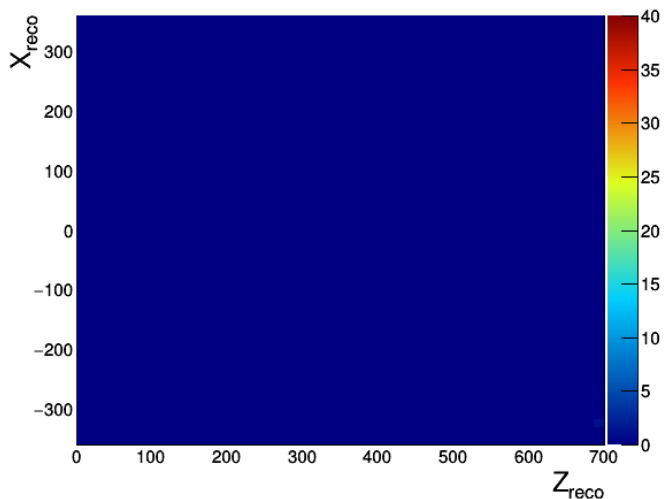


With-Flow MC: Downstream Face Coverage

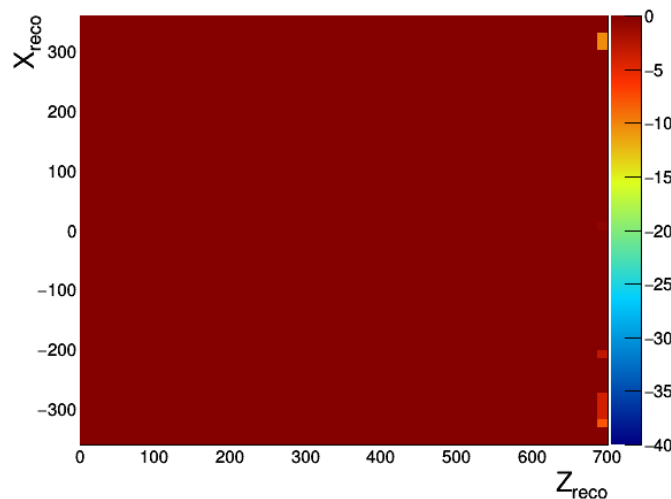


No-SCE MC Results

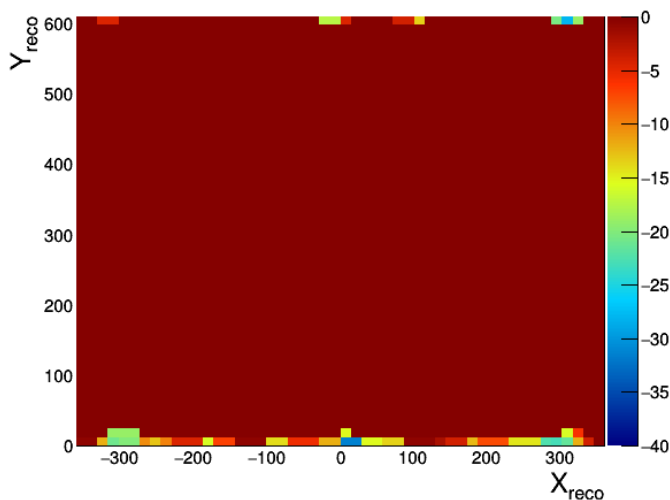
No-SCE MC: Top Face ΔY [cm]



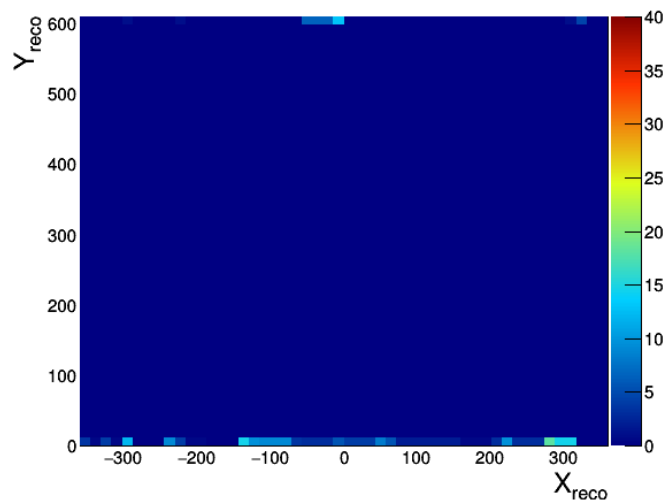
No-SCE MC: Bottom Face ΔY [cm]



No-SCE MC: Upstream Face ΔZ [cm]

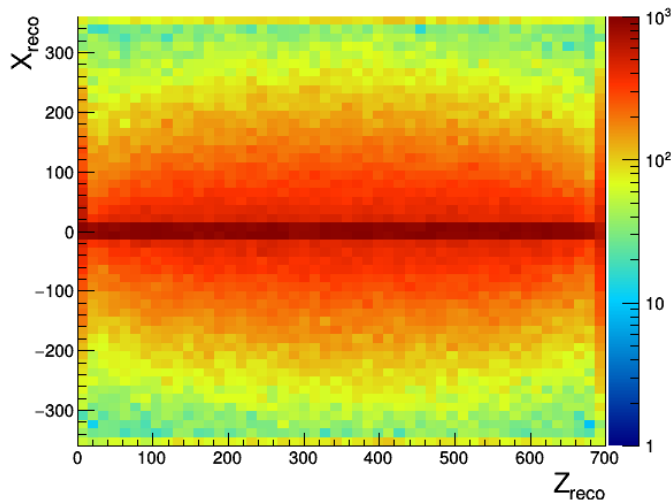


No-SCE MC: Downstream Face ΔZ [cm]

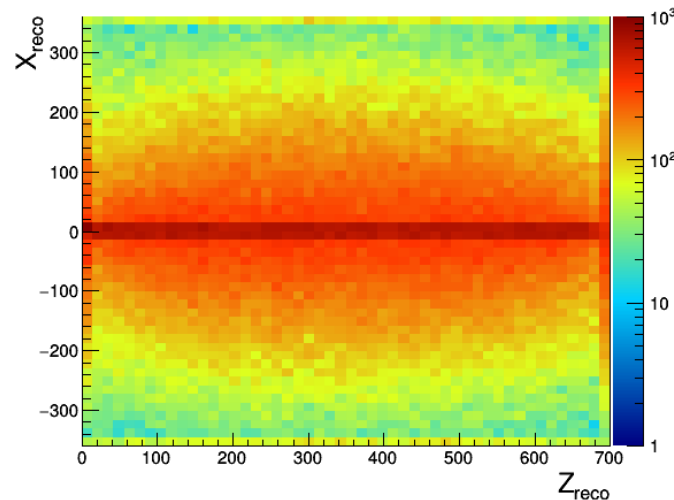


No-SCE MC Coverage

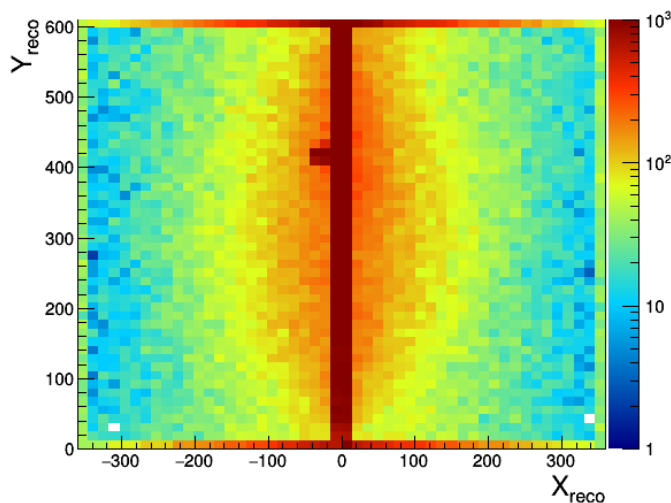
No-SCE MC: Top Face Coverage



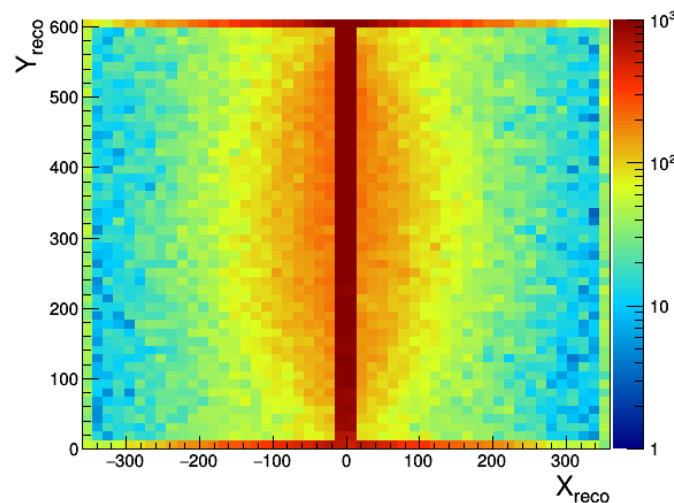
No-SCE MC: Bottom Face Coverage



No-SCE MC: Upstream Face Coverage



No-SCE MC: Downstream Face Coverage



- ◆ Some conclusions from looking at updated maps:
 - In both data and MC, coverage near anodes is limited; really need anode-piercing tracks included (will be important for producing precise scale factor maps)
 - SCE in data looks more pronounced with finer binning (up to 35-40 cm offsets in certain places!); on average roughly 50% larger than prediction
 - Offsets seen in data do not match predictions from liquid argon flow simulation - maybe we can use observation to improve liquid argon flow model?
 - Map edges need to be trimmed (fill in with extrapolation after producing scale factor map via data/MC ratio)
- ◆ Major to-do items: get anode-piercing tracks working with data, finish ProtoDUNE SCE calibration implementation in LArSoft (close!)

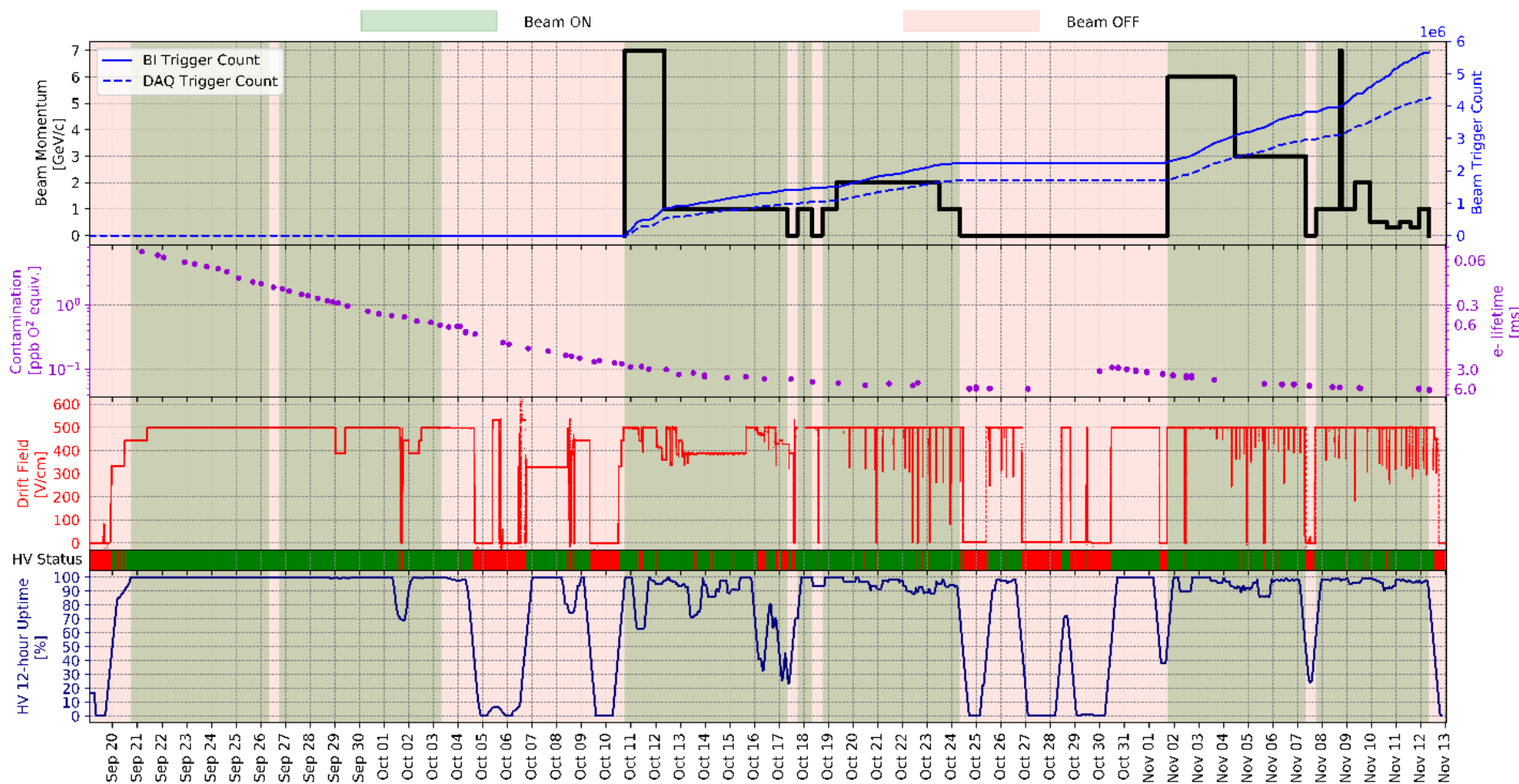
BACKUP SLIDES

Samples Analyzed

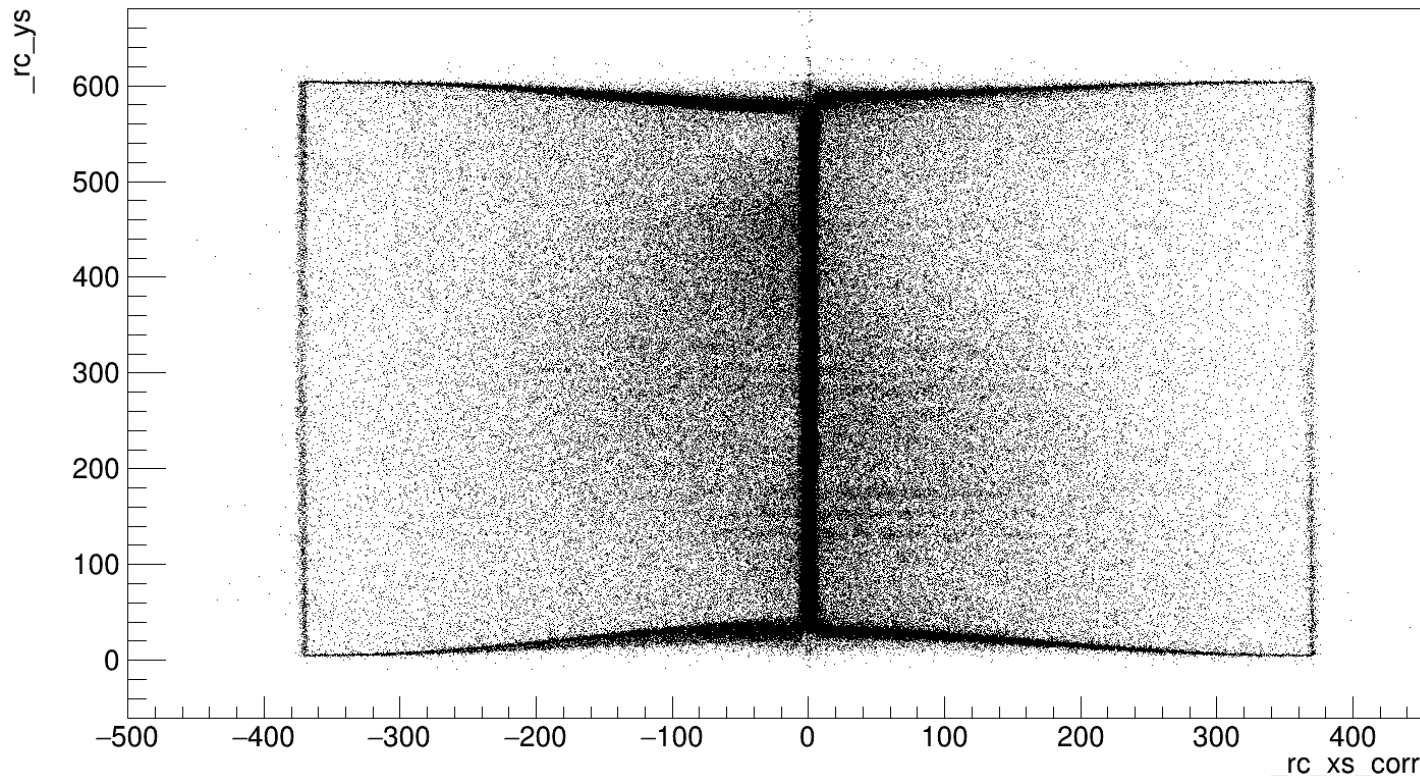
15	5115	NO	10.10.18	12:57	14:02	cosmics	120	2.4	NO	5Hz	OFF	NEW HV-power supply!
16	5121	NO	10.10.18	15:08	15:27	cosmics	160	2.4	No	5Hz	OFF	
17	5141	YES (run t0)	10.10.18	18:17	19:40	physics	180	2.6	Yes, 7Gev	beam Trig	OFF	back at nominal field and beam ON
18	5287	NO	10.14.18	15:45	21:20	physics	140	4	yes 1GeV	beam Trig	OFF	not nominal field
19	5308	YES (run t0)	15.10.18	15:59	18:23	physics	180	4.1	yes 1GeV	beam Trig	OFF	
20	5341	YES (run t0)	16.10.18	21:22	08:01	physics	160	4.2	yes 1GeV	beam Trig	OFF	LOOOOng run at 160kV, maybe interesting
21	5430	YES (run t0)	10.19.18	20:33	00:46	physics	180	6	yes 2GeV	beam Trig	OFF	
22	5442	YES (why?)	10.22.18	15:05	19:58	physics	180	6	yes 2GeV	beam Trig	OFF	
23	5461	NO	10.24.18	08:28	09:14	cosmics	180	5	OFF	2Hz	OFF	beam OFF for the following week until nov 2
24	5709	NO	10.30.18	19:30	02:06	cosmics	180	3	OFF	2Hz	OFF	this is the beam OFF week since 24.10. purity dropped due to a pump outage that was unnoticed for some time.
25	5759	YES (run t0)	11.01.18	23:17	07:44	physics	180	3.6	Yes 6GeV	beam Trig	ON	long beam run, contains current spikes/streamers but untriggered during those, maybe effect on SCE??
26	5780	YES (run t0)	11.05.18	05:44	08:54	physics	180	4.4	Yes 3GeV	beam Trig	ON	
27	5817	YES	11.09.18	00:10	07:52	physics	180	5.5	yes 1GeV	beam Trig	ON	
28	5826	YES (running t0)	11.10.18	00:33	06:14	physics	180	5.5	yes 0.5GeV	beam Trig	ON	
29	5841	YES (run t0)	11.11.18	20:04	21:59	physics	180	5.5	yes 0.3GeV	beam Trig	ON	last hours of beam
30	5849	NO	11.12.18	10:34	10:53	cosmics	180	6	NO	general CRT trig	ON	!!!large readout window ~7ms
31	5850	NO	11.12.18	11:03	11:12	cosmics	180	6	NO	general CRT trig	ON	!!!large readout window ~7ms
32	5851	NO	11.12.18	11:21	12:31	cosmics	180	6	NO	general CRT trig	ON	!!!large readout window ~7ms
33	5851	NO	11.12.18	11:21	12:31	cosmics	180	6	NO	general CRT trig	ON	!!!large readout window ~7ms
34	6119	NO	12.10.18	16:53	18:01	cosmics	180	6	NO	general CRT trig	ON	electron divertera off
35	6120	NO	12.10.18	18:10	09:40	cosmics	180	6	No	general CRT trig	ON	electron diverter off, run failed at 06:30am in the morning, still good run of 10h with CRT trig!!

◆ Hannah ran SCE study code on processed runs

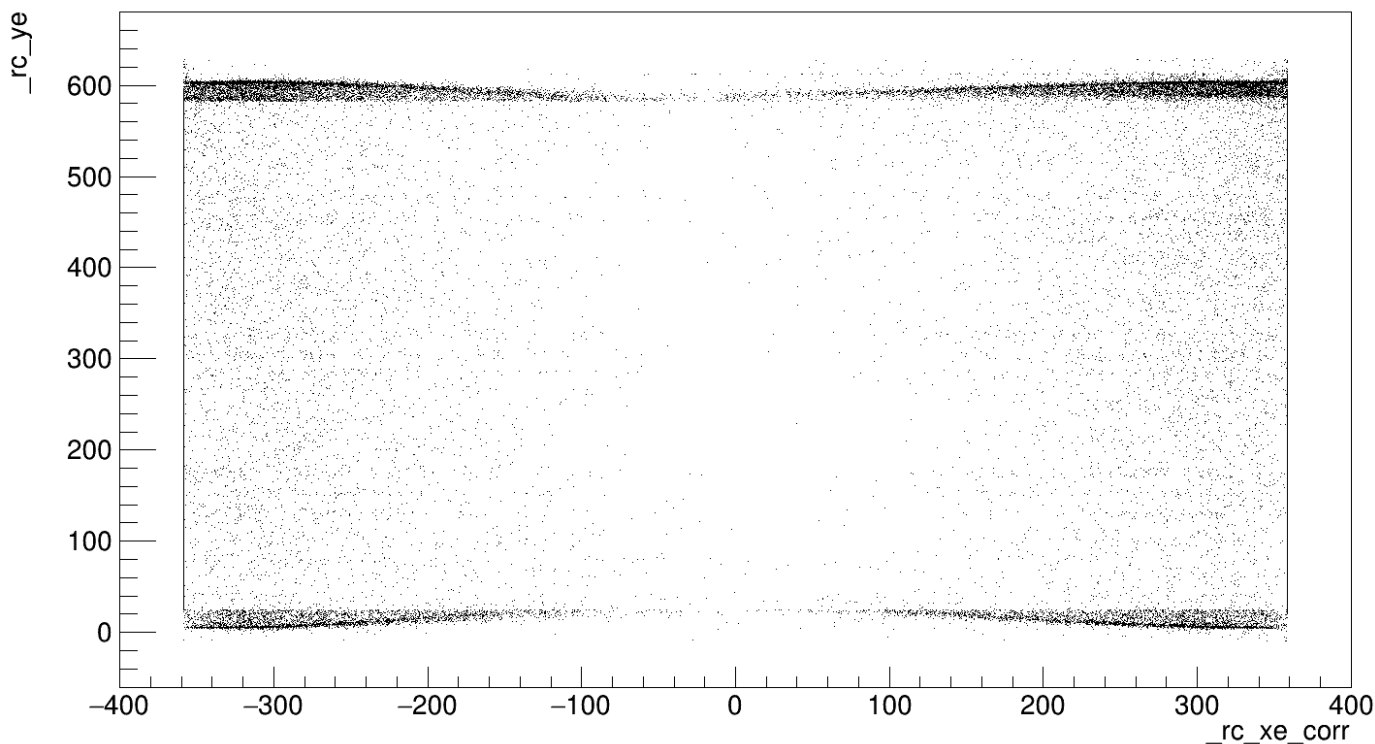
- Includes 5141, 5308, 5341, 5430, 5759, 5780, and 5841
- Also ready to analyze, but not included: 5442 and 5826
- Most cosmic data not reconstructed... request this?



- ◆ Francesca pointed us to Kevin's plot on detector conditions throughout ProtoDUNE data-taking



- ◆ Plot start/end points of cathode-crossing tracks in Run 5841
 - Roughly **240k tracks** in 57k events
 - Anode plane not at ± 360 cm? Longitudinal SCE offset?



- ◆ Plot start/end points of anode-piercing tracks in Run 5841 (includes relative flash timing cut of 1 μ s)
 - Only **28k tracks** in 57k events - **tune flash cut!!**
 - Anode plane at ± 360 cm due to use in t_0 determination