

Studying SCE Using TPC Face Offsets

Michael Mooney, Hannah Rogers
Colorado State University

On Behalf of the ProtoDUNE SCE Analysis Team

ProtoDUNE Sim/Reco Meeting
December 19th, 2018

- ◆ 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, look at transverse deviation from TPC face position
 - Requires relatively few tracks ($O(10k)$ or so) to have reasonably precise estimation of effect (albeit coarse spatial resolution)
 - Use cathode crossers and anode-piercing tracks to start with, but will want to extend to using CRT-tagged tracks which will especially help with TPC bulk calibration
- ◆ Make use of samples produced by Francesca, Stefania, and Richie
 - **A lot** of work done by them to make this quick study possible - good teamwork within SCE analysis team!

fx

Useful Beam Runs for Calibration Group

RunNumber	ProtoDUNE sample datasets	Date	Start Time CET	End Time CET	RunType	HV [kV] (nominal = 180kV -> 500V/cm)	purity [ms] Drifttime 2.6ms	Beam	Trigger	CRT	Comments
4594	NO	09.22.18	11:20	14:04	cosmics	180	0.2	NO	3Hz	OFF	
4650	NO	09.24.18	21:04	21:43	physics	180	0.8	YES, 3GeV	beam Trig	OFF	
4697	NO	09.26.18	04:32	08:08	physics	180	1.3	Yes, 4GeV	beam Trig	OFF	just before beam goes off
4755	NO	09.26.18	22:11	22:46	physics	180	1.5	Yes 5GeV	beam Trig	OFF	right after beam goes on again. First 20min with beam, then beam down
4842	NO	09.29.18	21:44	02:52	physics	180	0.4	yes 7GeV	beam Trig	OFF	This was before HV was ramped down for a bit. Oct 1 is interesting, we stopped recirculation for 3h from 10am to 2pm, the reactivation of the pumps jolted the system and also introduced strange behavior in the HV

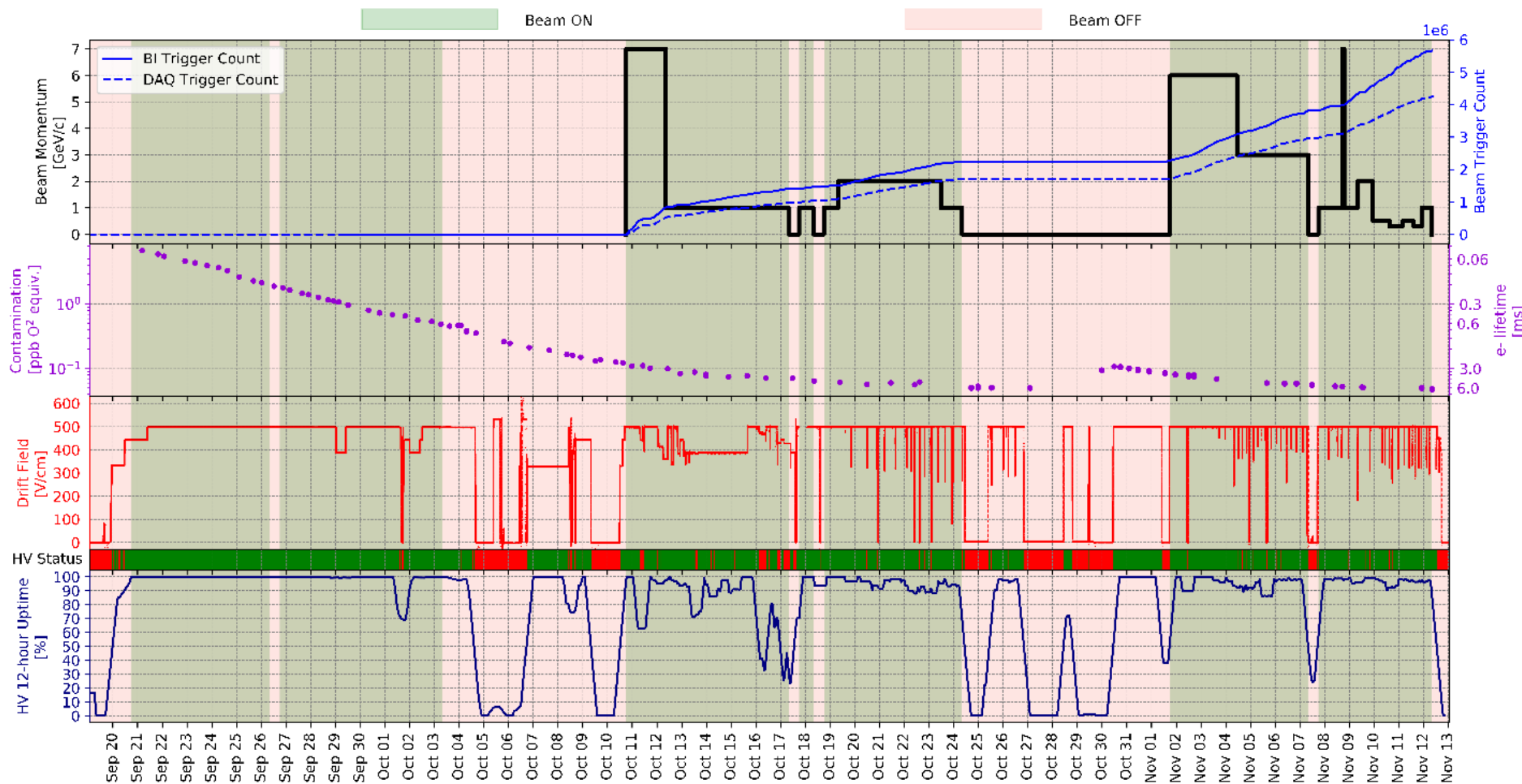
- ◆ Francesca prepared a list of runs of interest for SCE studies
 - Richie worked with Stefania to get us the capability of running jobs on FermiGrid (took a lot of work!)
 - Stefania subsequently ran Hannah's t_0 -tagging analysis module over as many runs as possible in the list
 - See list of runs [here](#)

Samples Analyzed

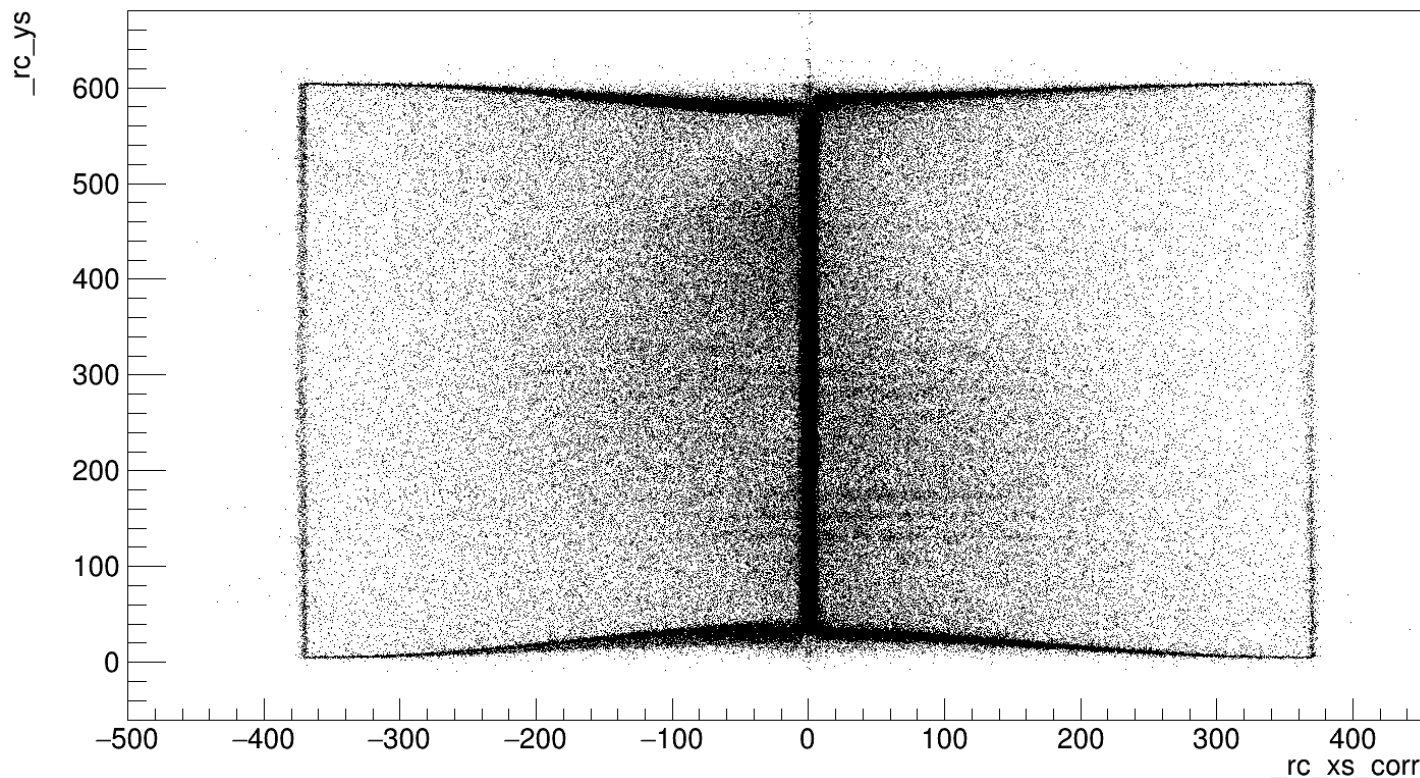
15	5115	NO	10.10.18	12:57	14:02	cosmics	120	2.4	NO	5Hz	OFF	NEW HV-power supply!
16	5121	NO	10.10.18	15:08	15:27	cosmics	160	2.4	No	5Hz	OFF	
17	5141	YES (run t0)	10.10.18	18:17	19:40	physics	180	2.6	Yes, 7Gev	beam Trig	OFF	back at nominal field and beam ON
18	5287	NO	10.14.18	15:45	21:20	physics	140	4	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 following runs: 5141, 5308, 5341, 5430, 5442, 5759, 5780, 5826, and 5841
- Most cosmic data not reconstructed... request this?



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

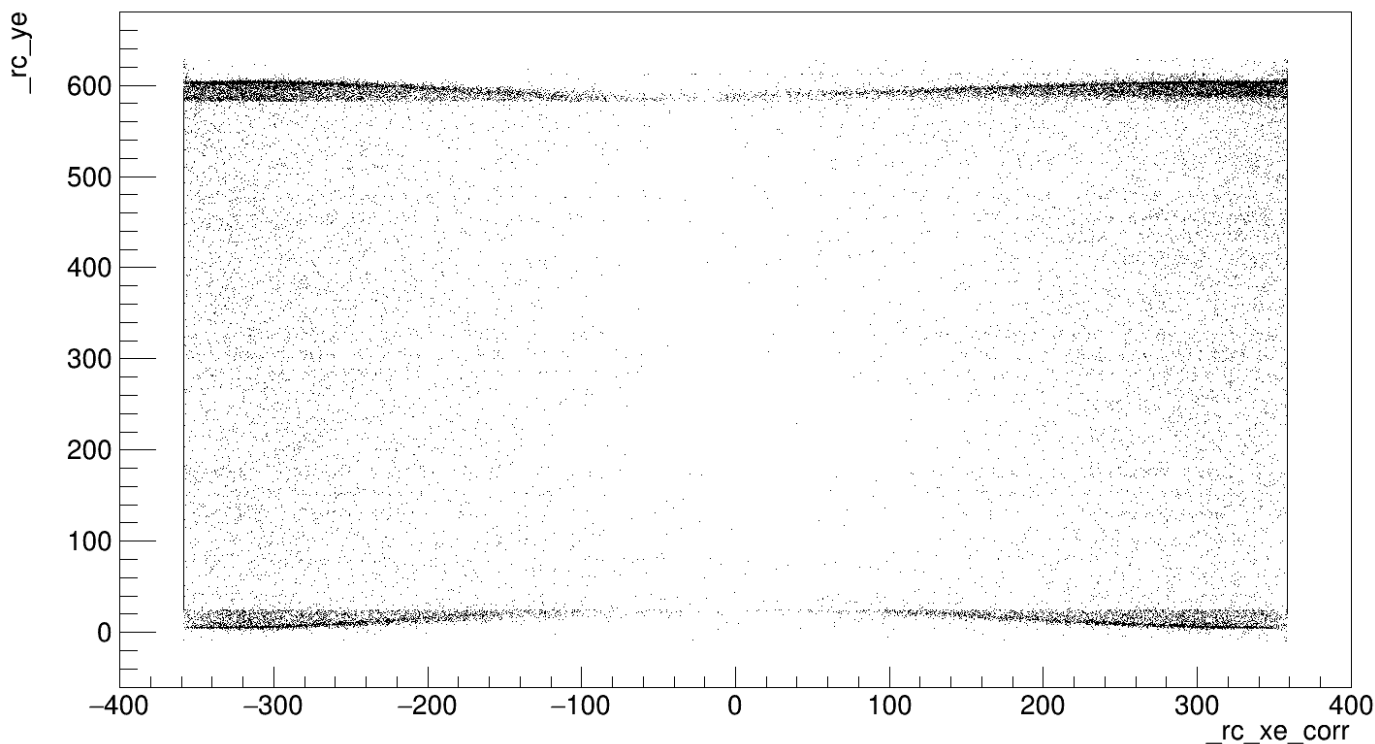


- ◆ Plot start/end points of cathode-crossing tracks in Run 5841
 - Roughly **240k tracks** in 57k events
 - Anode plane not at ± 360 cm? **Drift velocity wrong!**

Detector Measurement	Value (Rough)
TPC Active Top Edge	604.0 cm
TPC Active Bottom Edge	5.2 cm
TPC Active Upstream Edge	0.7 cm
TPC Active Downstream Edge	694.7 cm
TPC Active Pos. Drift Length	371.9 cm
TPC Active Neg. Drift Length	369.6 cm

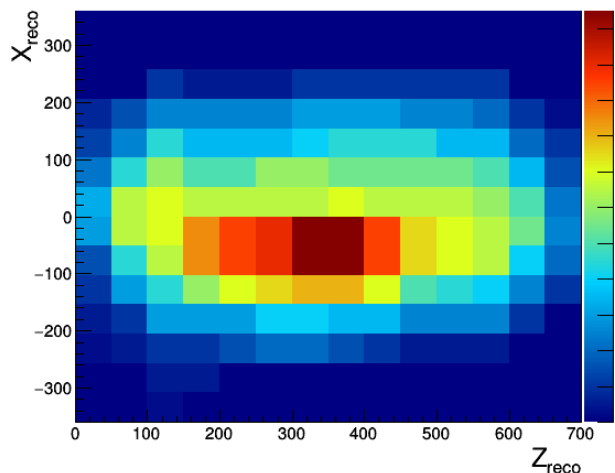
Note: drift length offset can be explained by ~ 2 K offset in temperature in calculating assumed drift velocity (e.g. 87 K vs. 89 K \rightarrow 3.5% bias); are we using the correct value in reconstruction?

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

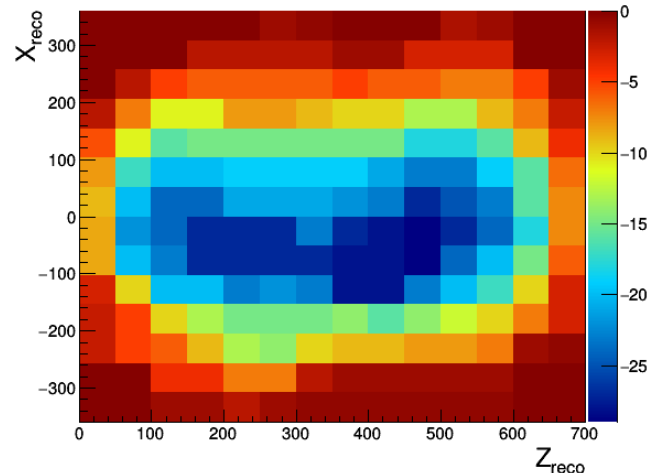


- ◆ Plot start/end points of anode-piercing tracks in Run 5841 (includes relative flash timing cut of 1 μ s)
 - Only **28k tracks** in 57k events - **tune flash cut!!**
 - Anode plane at ± 360 cm due to use in t_0 determination

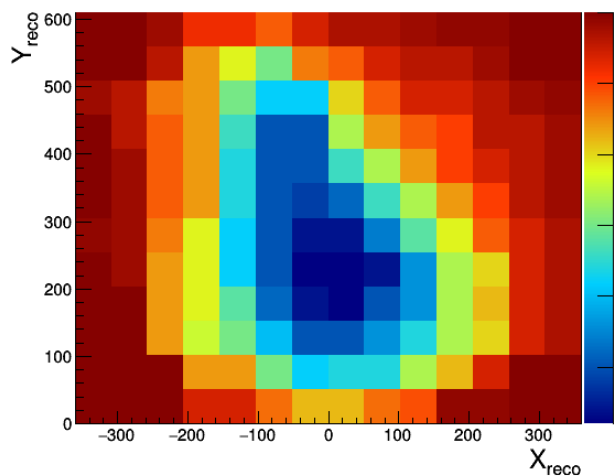
Run 5141: Top Face ΔY [cm]



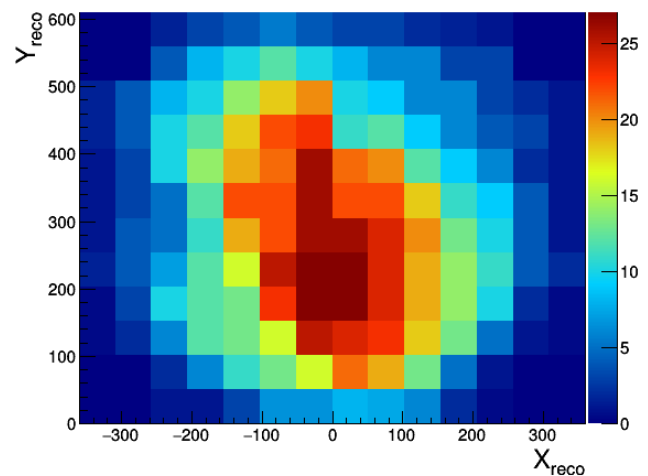
Run 5141: Bottom Face ΔY [cm]



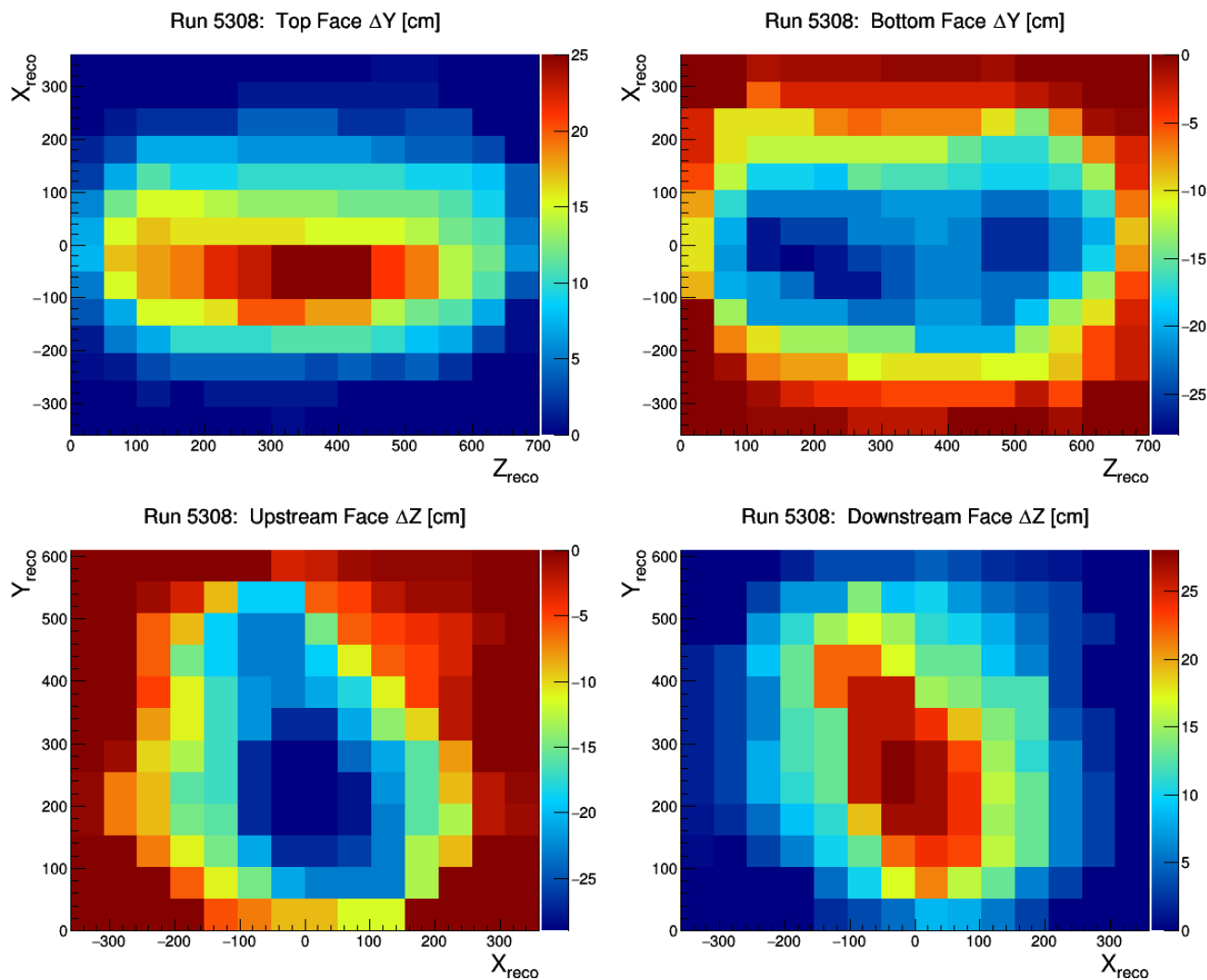
Run 5141: Upstream Face ΔZ [cm]



Run 5141: Downstream Face ΔZ [cm]

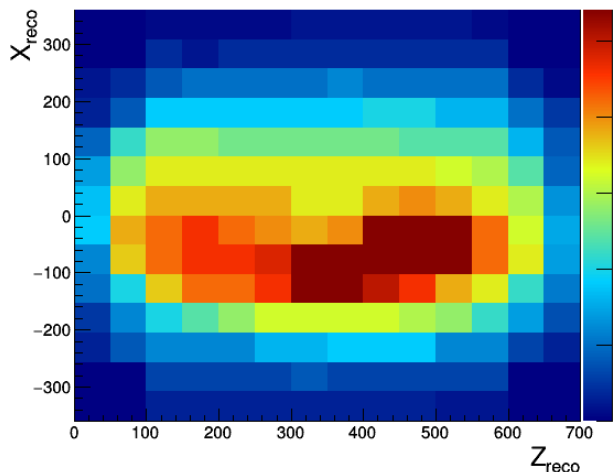


◆ Run 5141: HV at 180 kV, 7 GeV beam, 2.6 ms E.L.

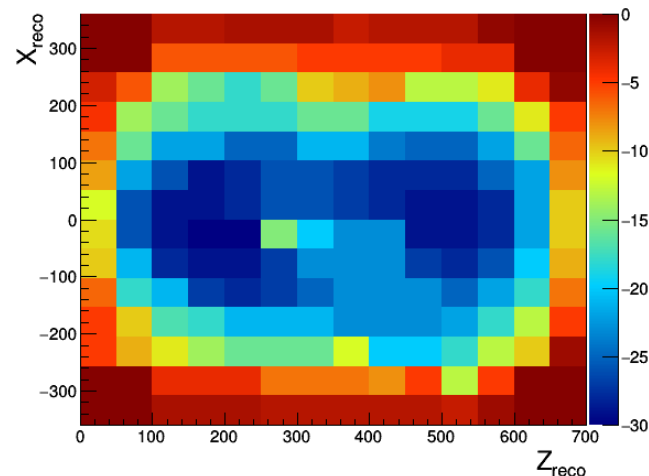


◆ Run 5308: HV at 180 kV, 1 GeV beam, 4.1 ms E.L.

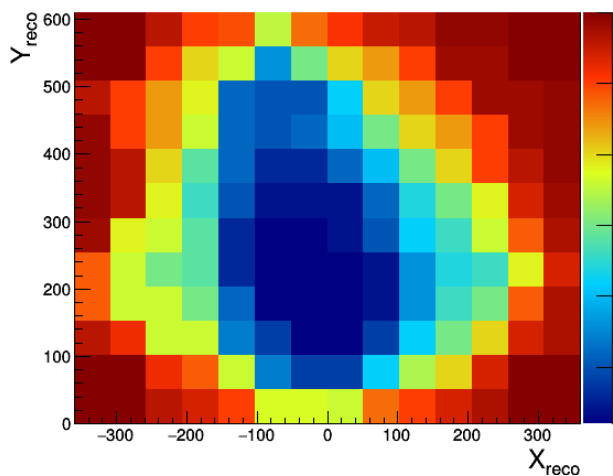
Run 5341: Top Face ΔY [cm]



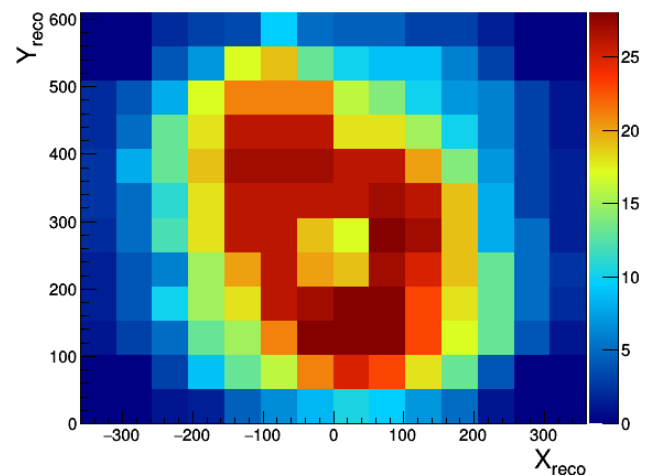
Run 5341: Bottom Face ΔY [cm]



Run 5341: Upstream Face ΔZ [cm]

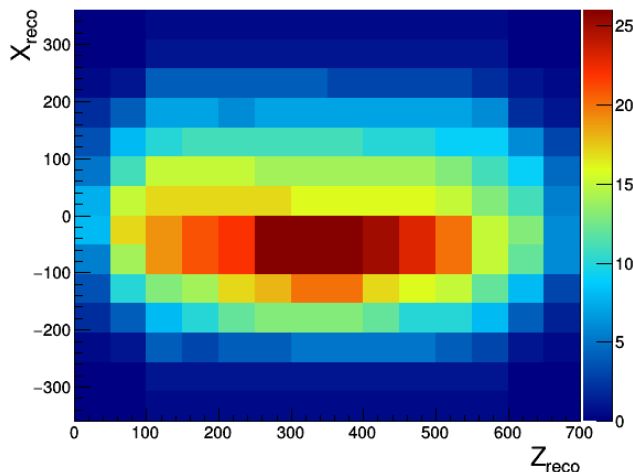


Run 5341: Downstream Face ΔZ [cm]

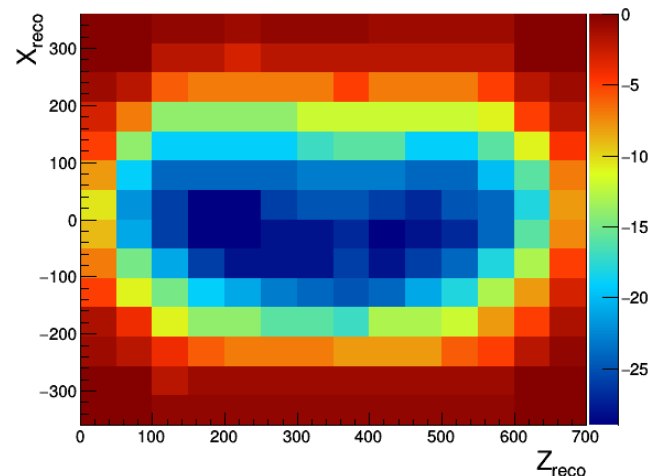


◆ Run 5341: HV at **160 kV**, 1 GeV beam, 4.2 ms E.L.

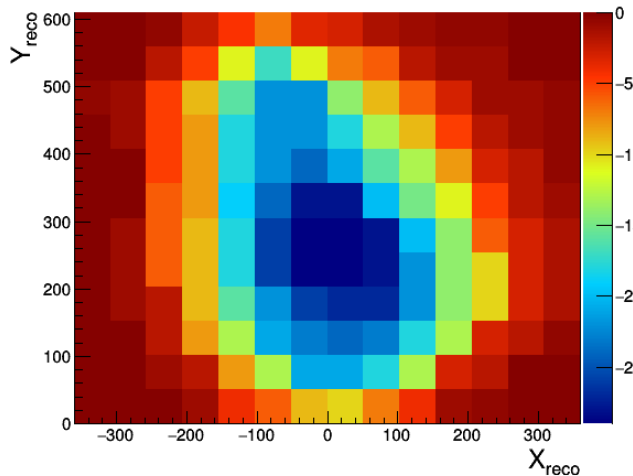
Run 5430: Top Face ΔY [cm]



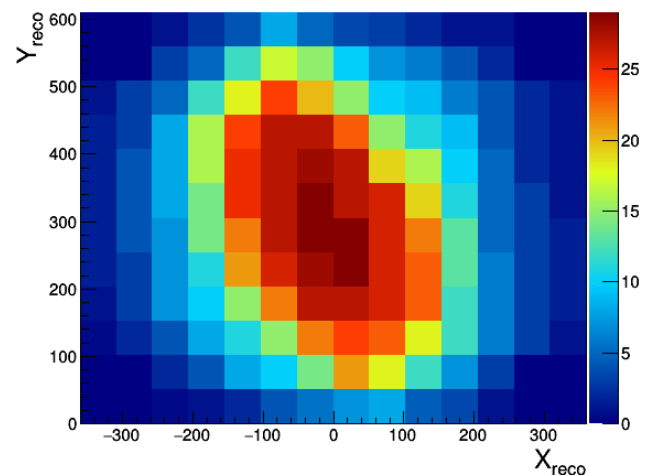
Run 5430: Bottom Face ΔY [cm]



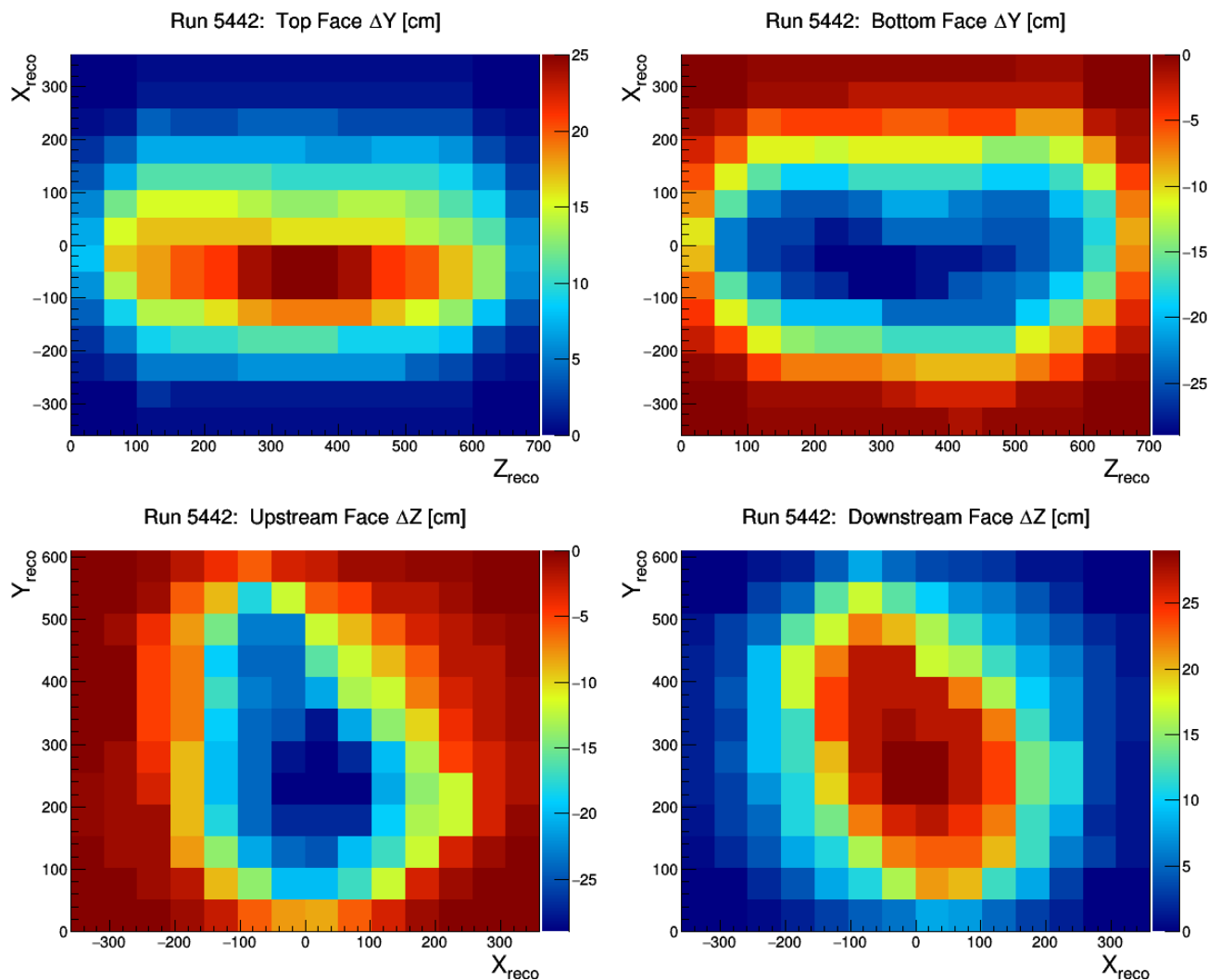
Run 5430: Upstream Face ΔZ [cm]



Run 5430: Downstream Face ΔZ [cm]

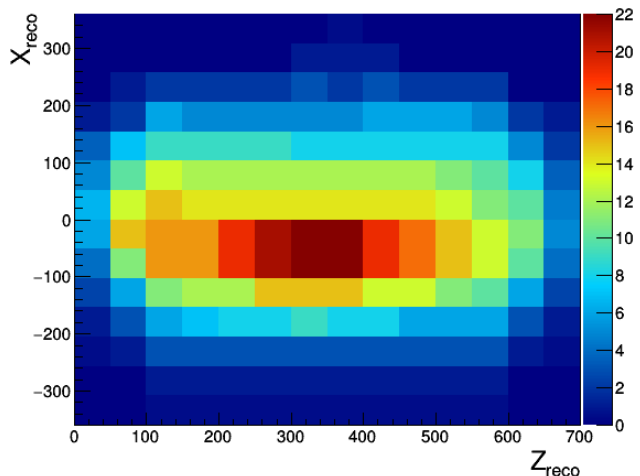


◆ Run 5430: HV at 180 kV, 2 GeV beam, 6 ms E.L.

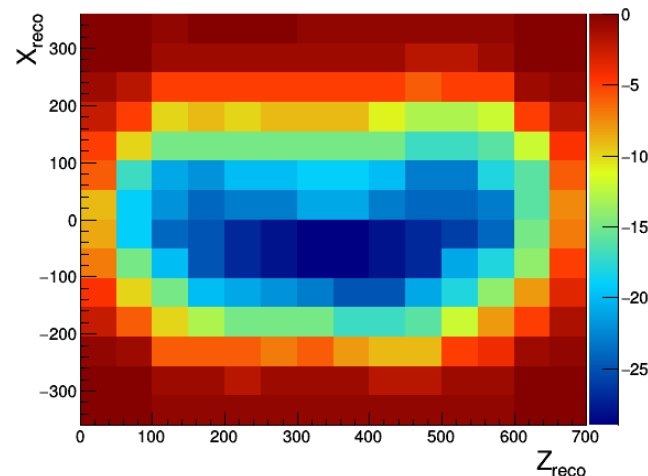


◆ Run 5442: HV at 180 kV, 2 GeV beam, 6 ms E.L.

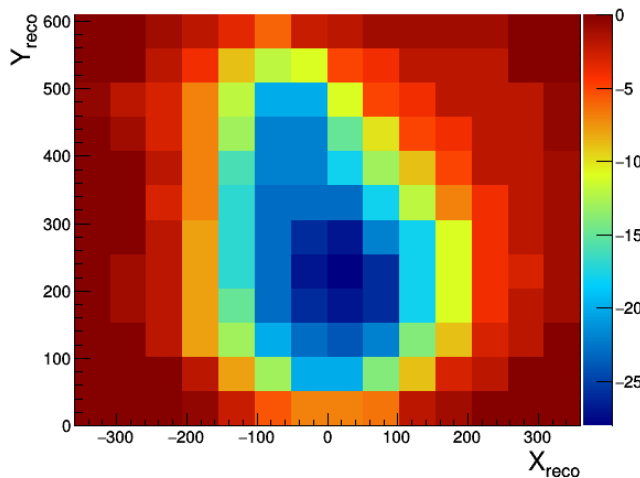
Run 5759: Top Face ΔY [cm]



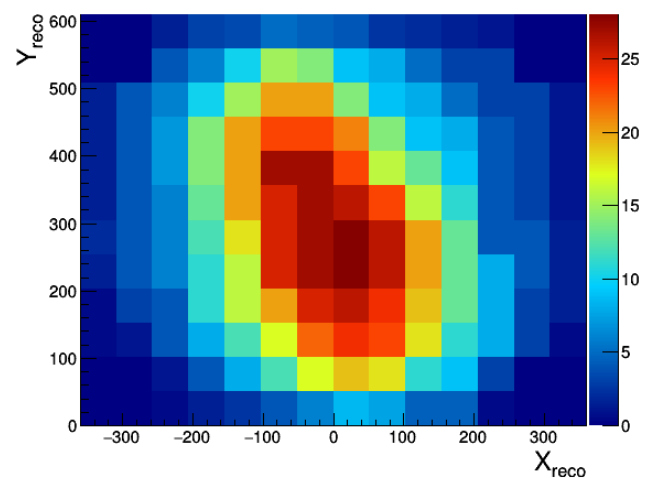
Run 5759: Bottom Face ΔY [cm]



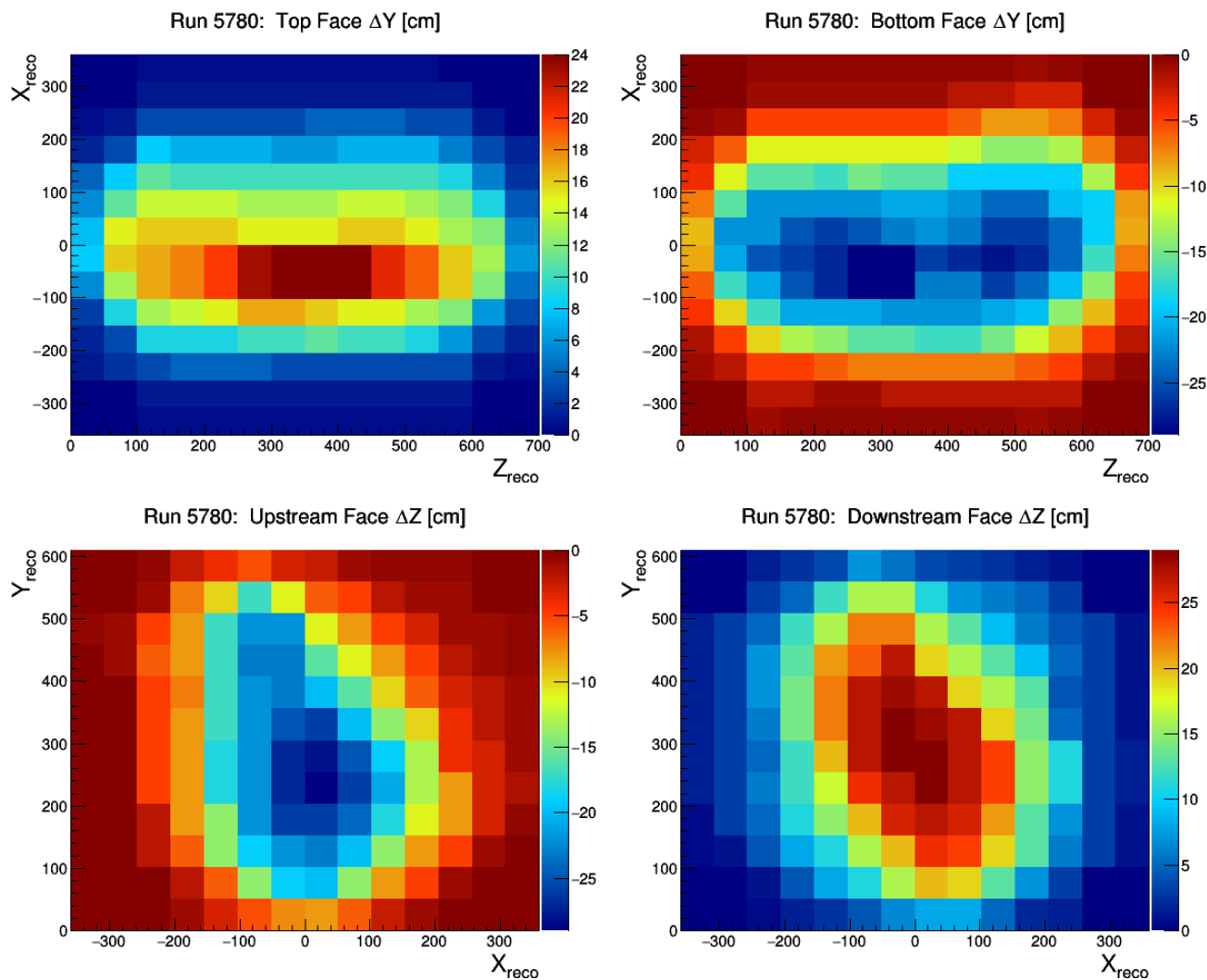
Run 5759: Upstream Face ΔZ [cm]



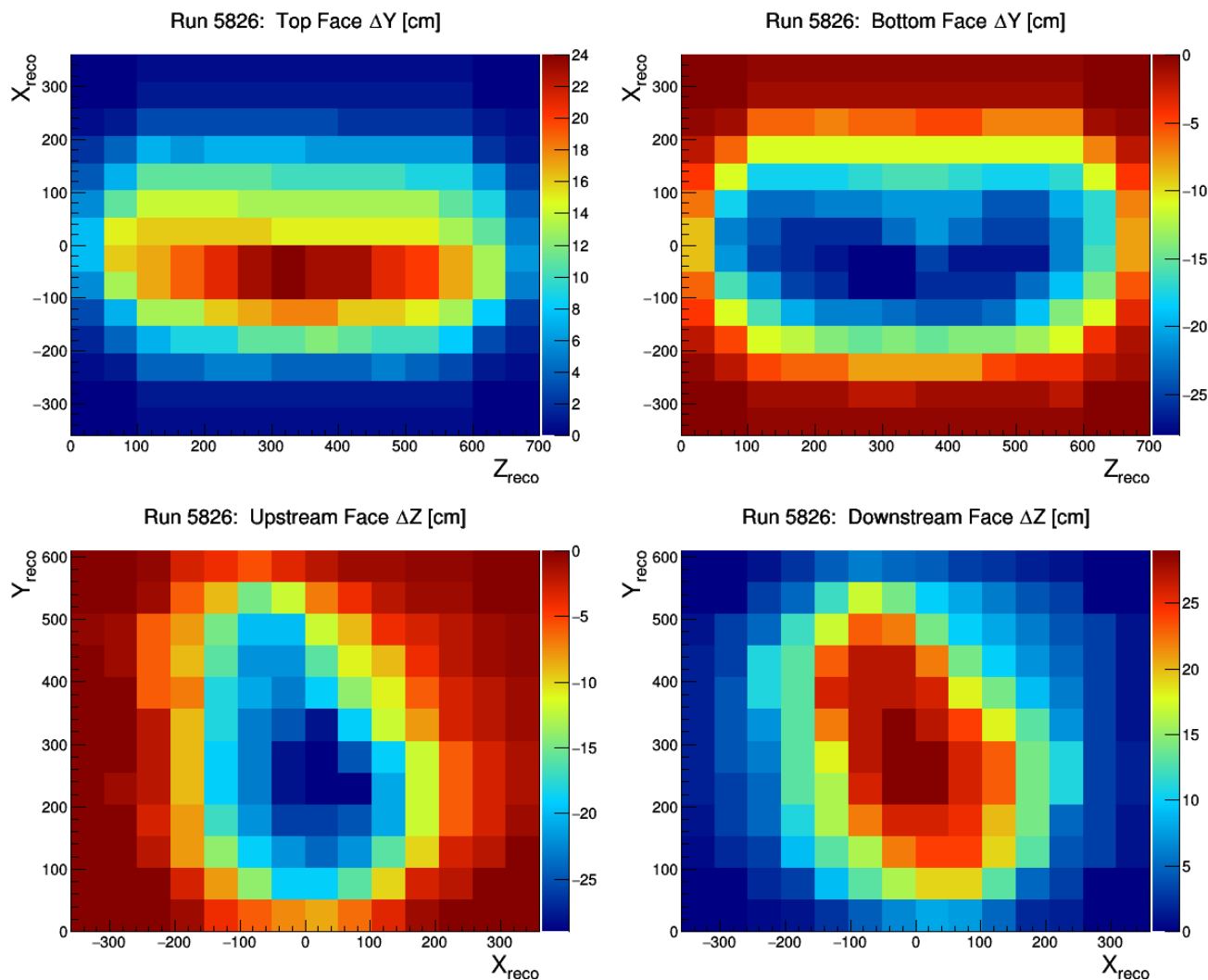
Run 5759: Downstream Face ΔZ [cm]



◆ Run 5759: HV at 180 kV, 6 GeV beam, 3.6 ms E.L.

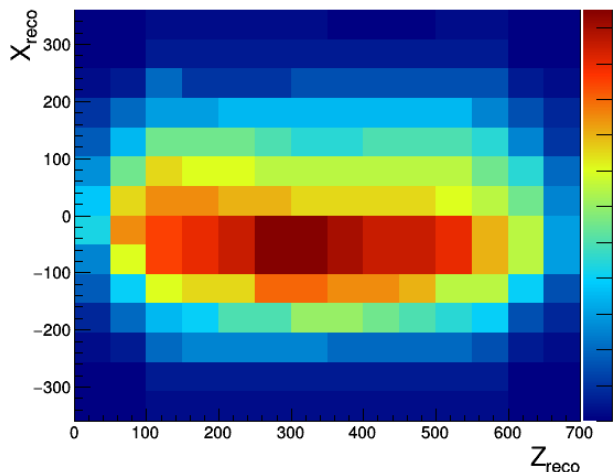


◆ Run 5780: HV at 180 kV, 3 GeV beam, 4.4 ms E.L.

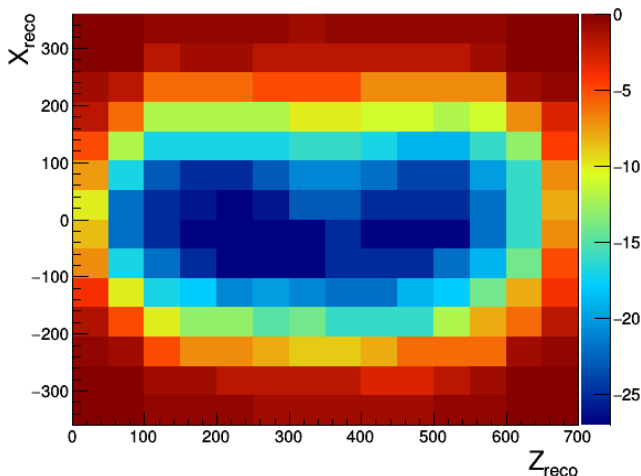


◆ Run 5826: HV at 180 kV, 0.5 GeV beam, 5.5 ms E.L. 16

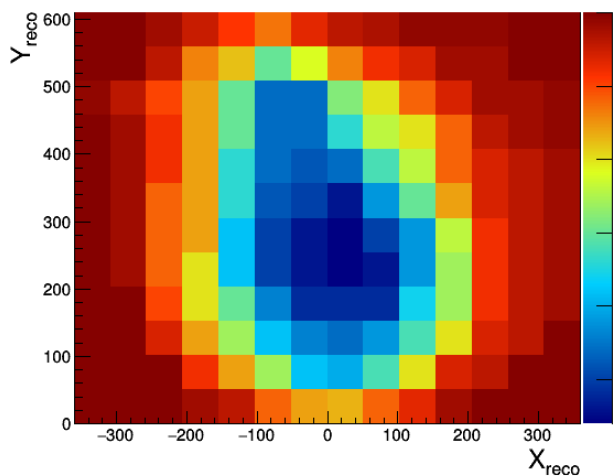
Run 5841: Top Face ΔY [cm]



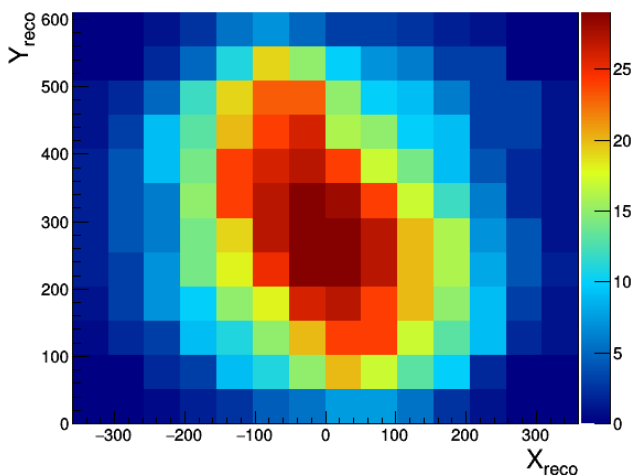
Run 5841: Bottom Face ΔY [cm]



Run 5841: Upstream Face ΔZ [cm]



Run 5841: Downstream Face ΔZ [cm]



◆ Run 5841: HV at 180 kV, 0.3 GeV beam, 5.5 ms E.L. 17

- ◆ Some preliminary comments/observations:
 - Does not seem to be a strong time-dependence
 - Maybe 5% variation in time? Similar to MicroBooNE
 - Beam conditions change things very little
 - Small increase in effect when cathode HV changes from 180 kV to 160 kV (as expected; should scale as $E^{-1.7}$)
 - Runs 5141, 5308, and 5341 may have larger fluctuations due to lower statistics of sample (less than 10k events instead of 50k+ events used in rest of runs)
- ◆ No strong dependence on electron lifetime in these studies
 - Maybe a small effect, needs more study (look at early data)
- ◆ Plan: use TPC faces to scale MC prediction for quick calibration, then carry out proper calib. in January

BACKUP SLIDES

- ◆ SCE offsets slightly larger than expected (TPC top)
 - This is not surprising - simulation very approximate
- ◆ Also asymmetric in two drift volumes - liquid flow?
- ◆ Seems to be changing in time! Why? Needs study!

