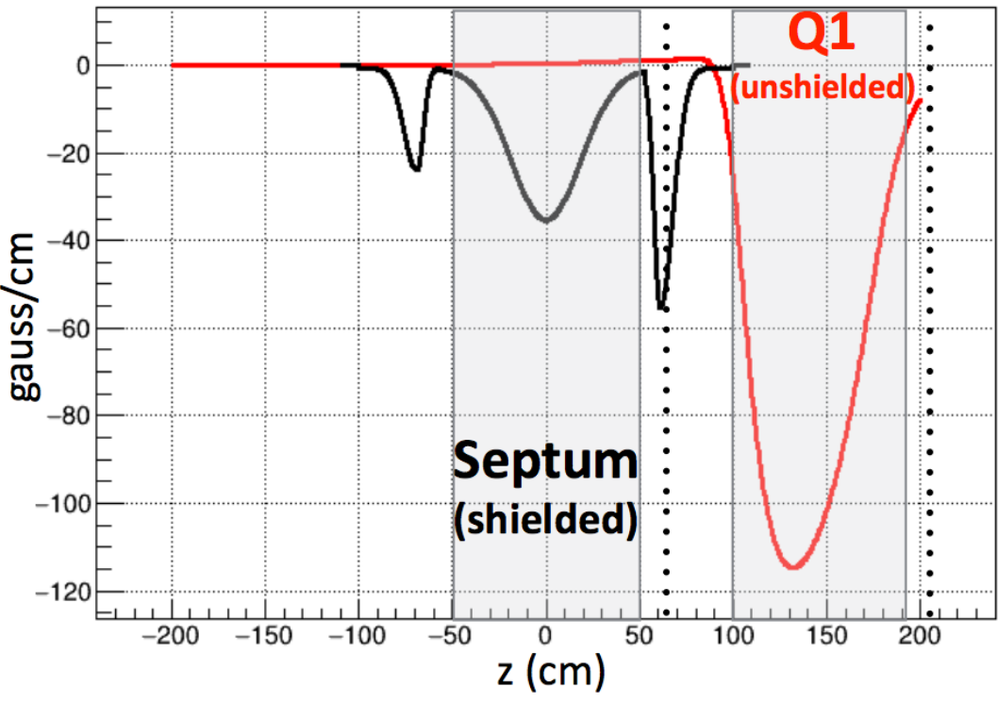
PREX Magnetic Modeling

work done by Jay Benesch

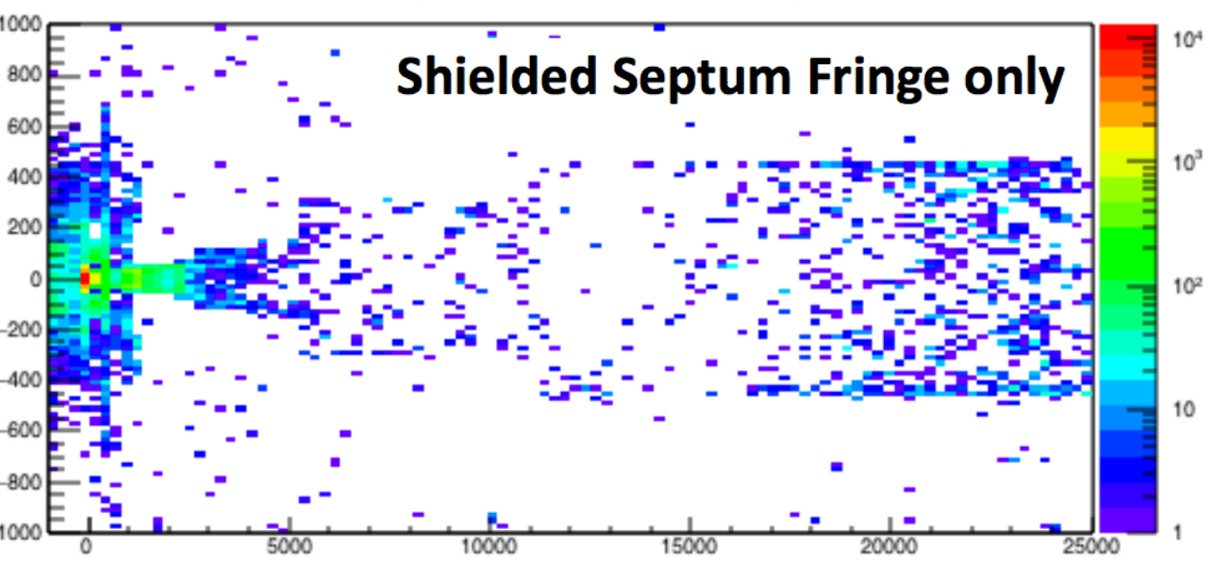
ERR Q1 status

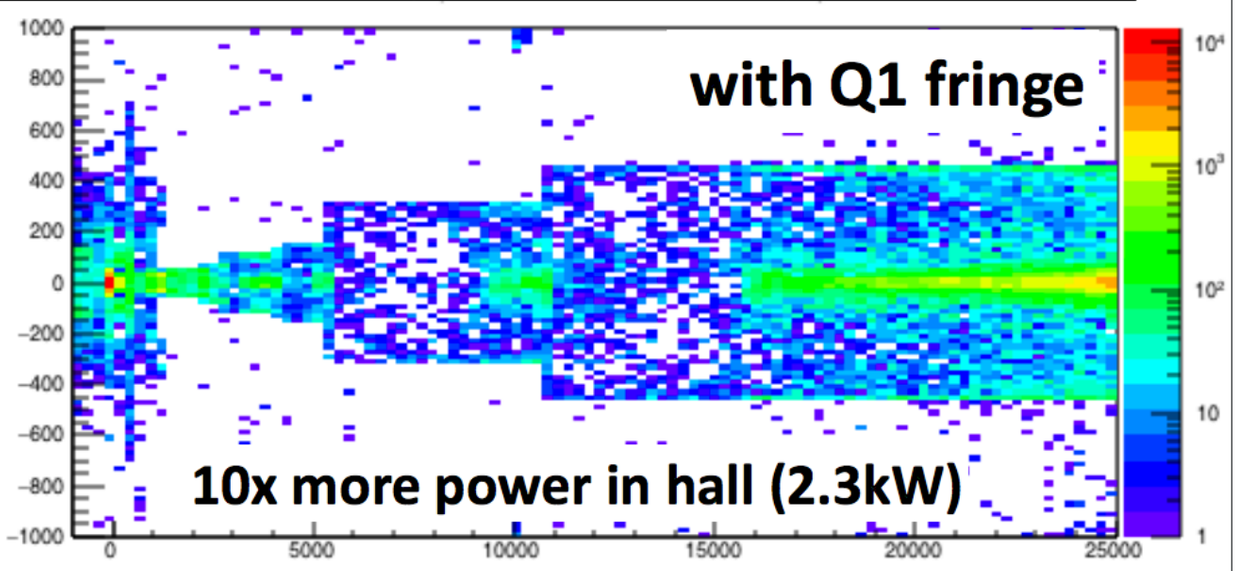


- The field we estimated had a large effect on radiation levels inside the hall (making PREX2 reach PREX1 levels)
- There were 2 problems with the setup:
  - The magnitude of the fringe was a factor of 2 too large
  - The sign of the field was wrong

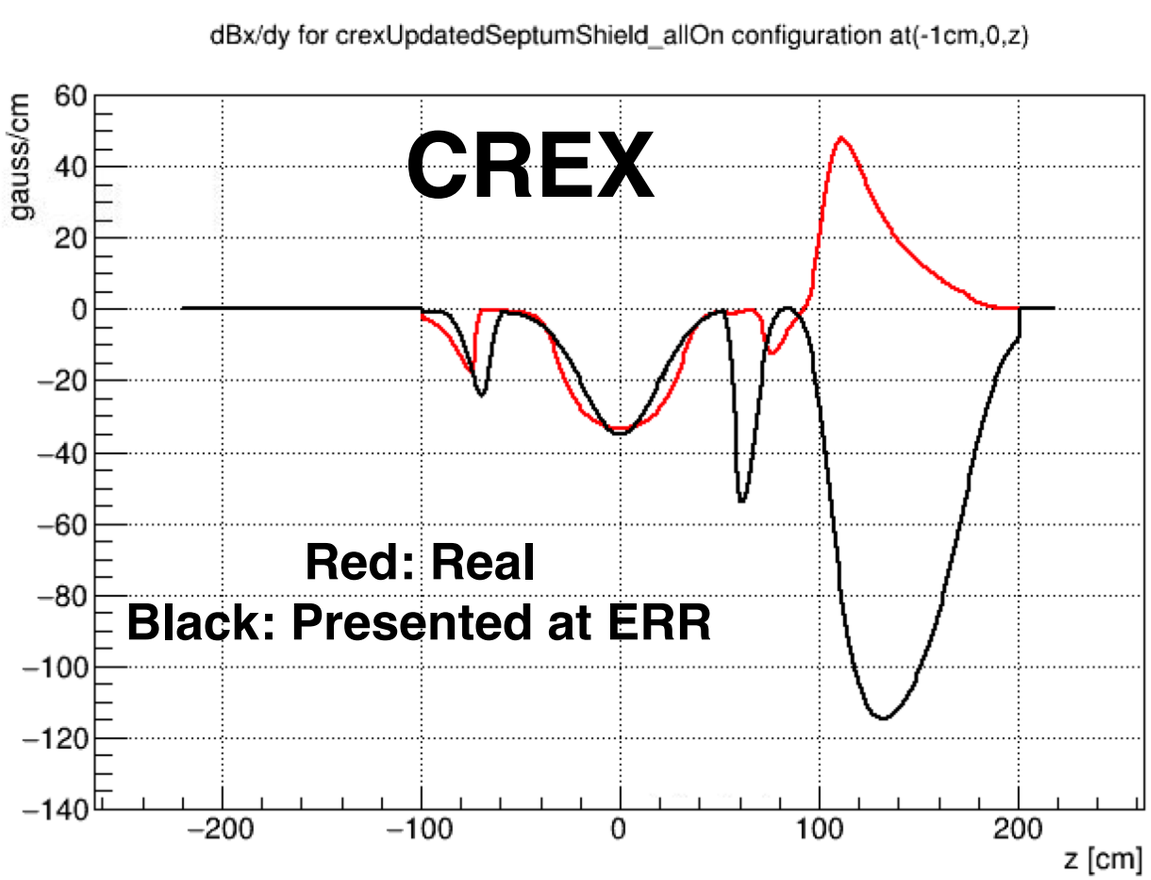
1MeV n_{eq} / cm^2

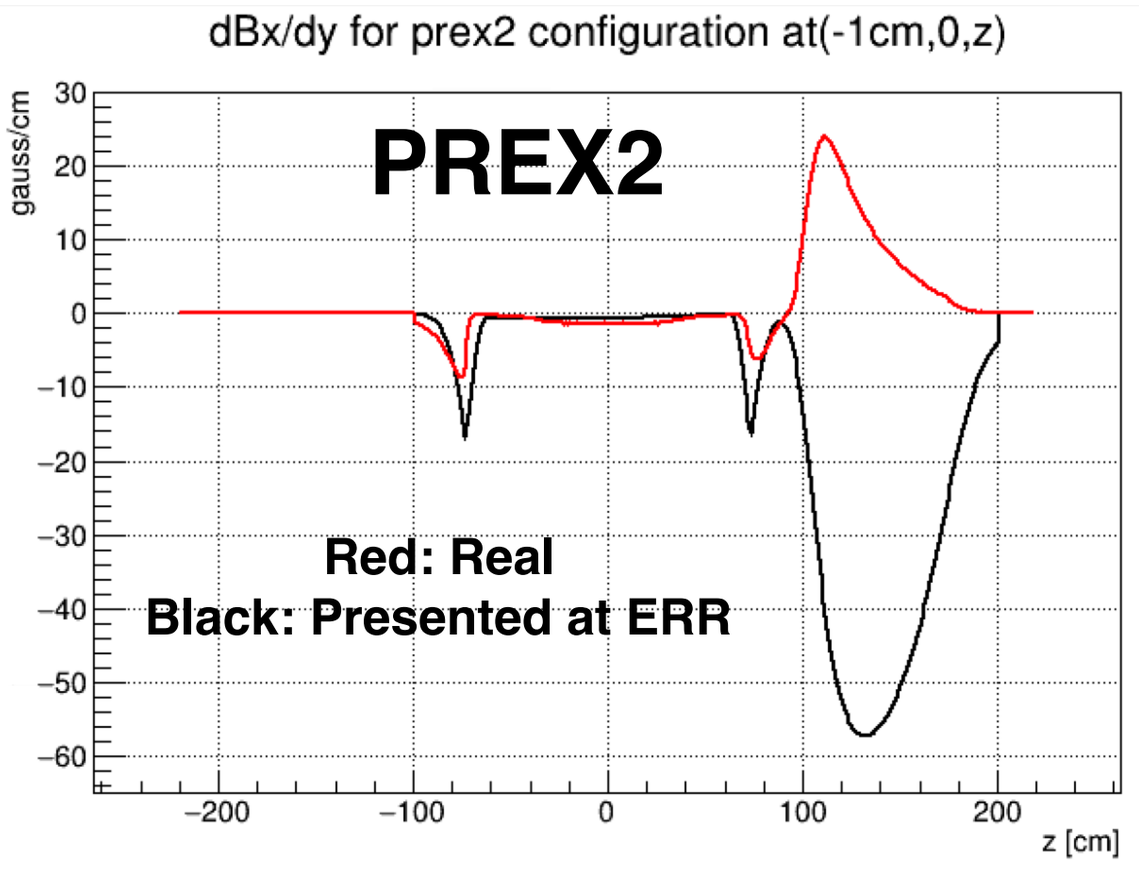
HRS power supply	PREX-I	PREX-II	CREX	PREX-II +Q1 fringe	CREX +Q1 fringe	PREX-II Q1/noQ1	CREX Q1/noQ1
total	**2.3E+11**	**2.1E+10**	**3.6E+10**	**3.3E+11**	**4.2E+11**	16	11.7





Fringe fields

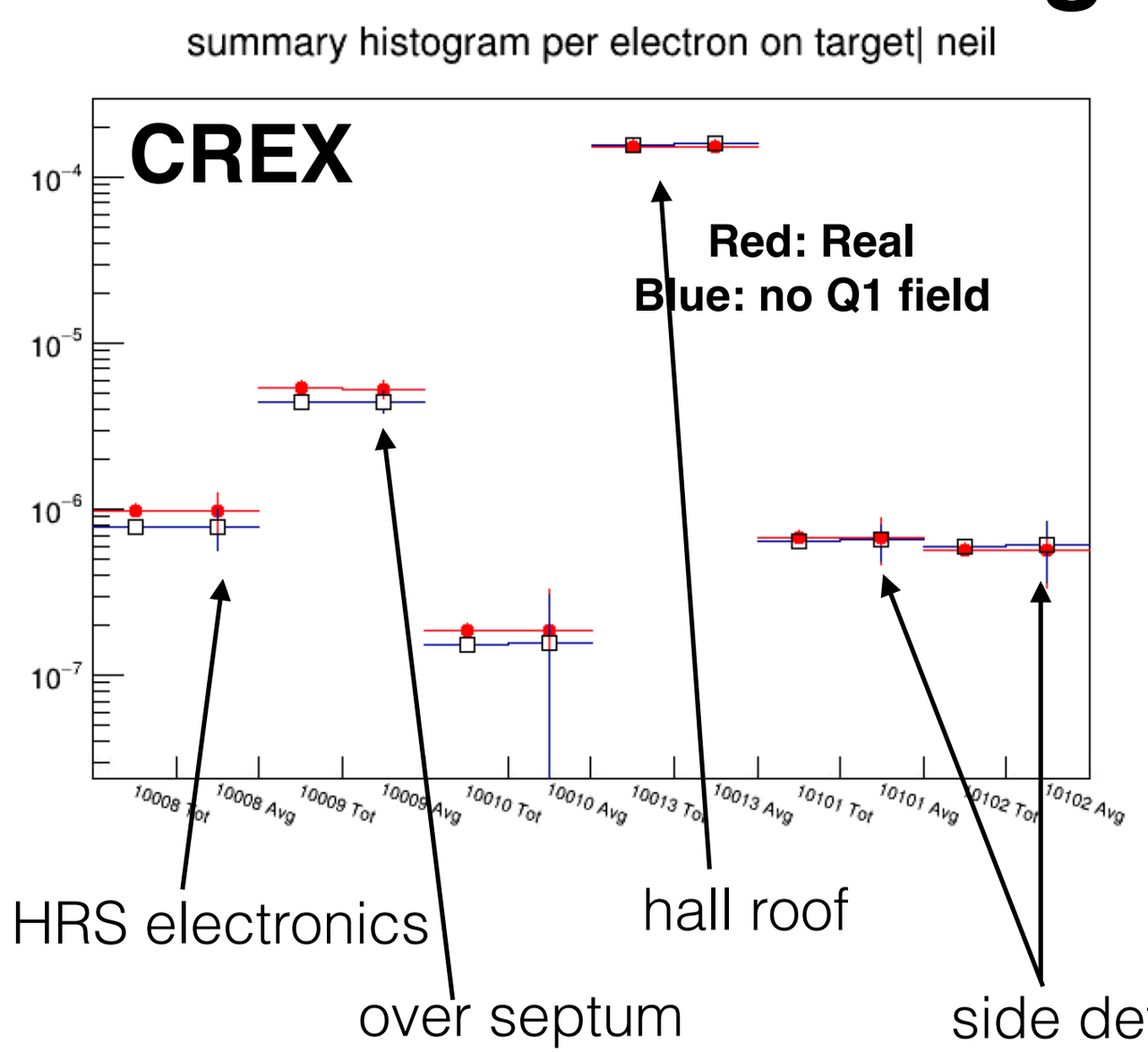


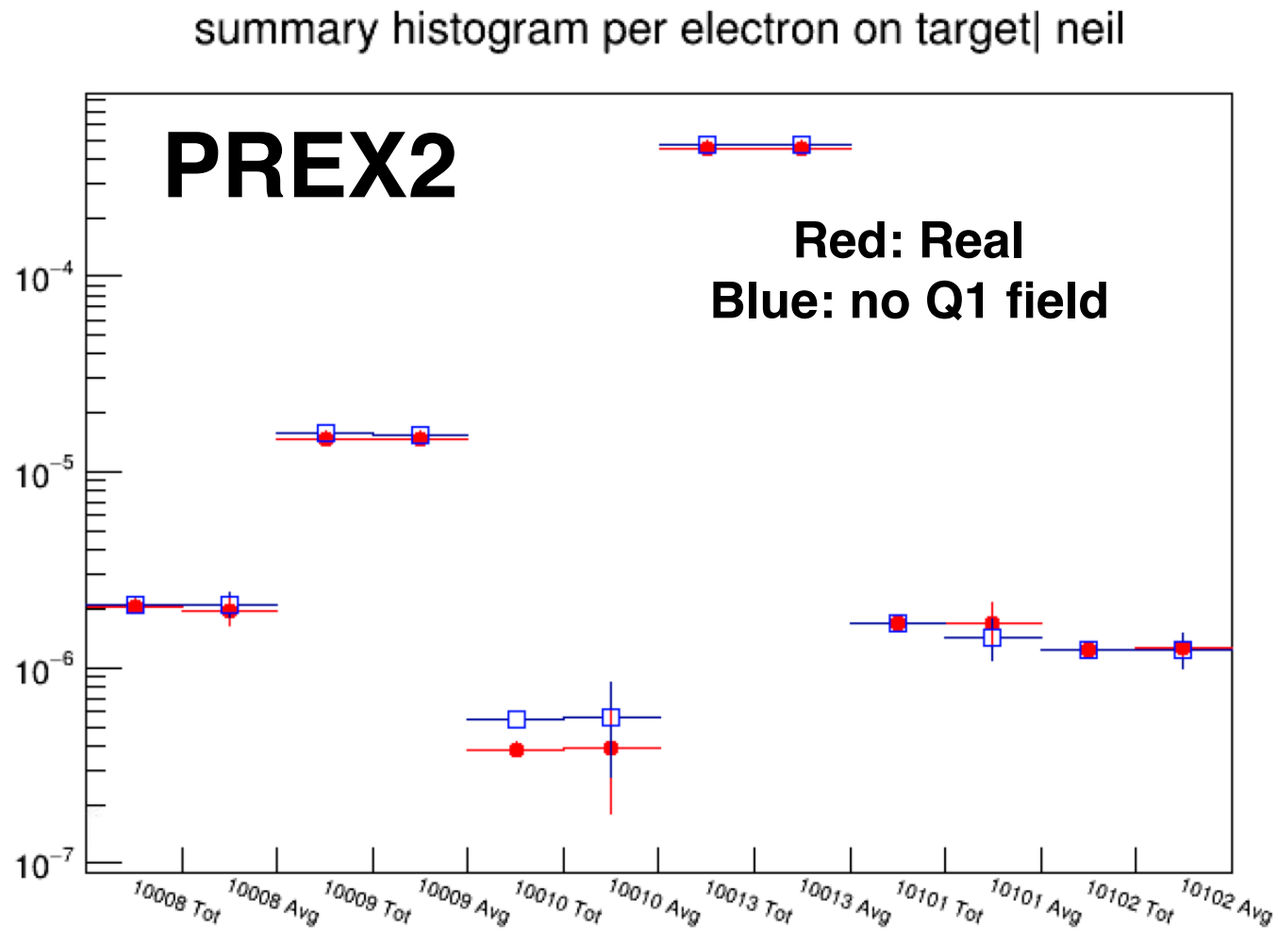


- Jay implemented a realistic septum beam pipe and now we have the whole fringe field around the beam pipe through both Septum and Q1

- The effect of opposite sign quad fields is not as simple as convergent-divergent pair of lenses (but it's a good first approximation)

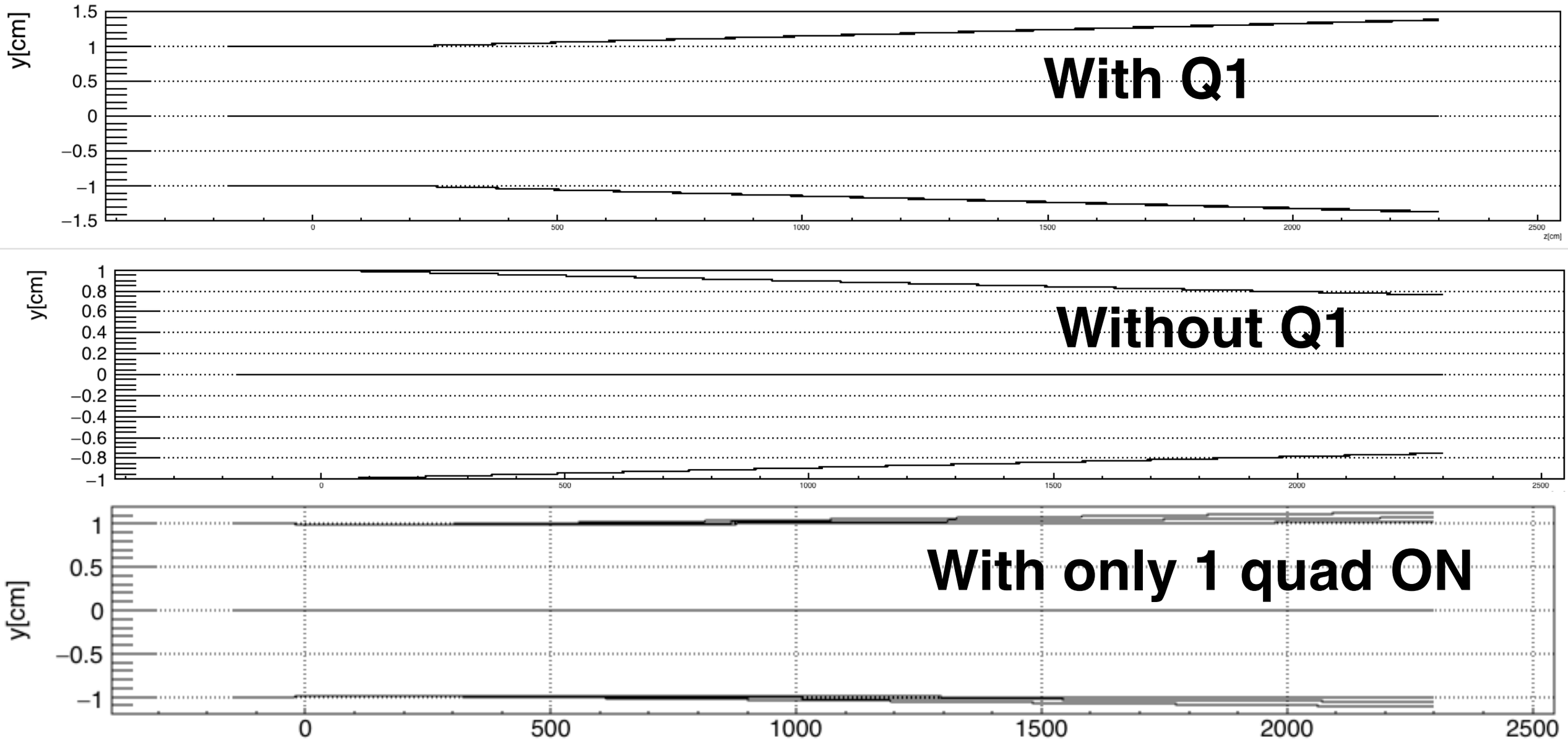
Fringe fields





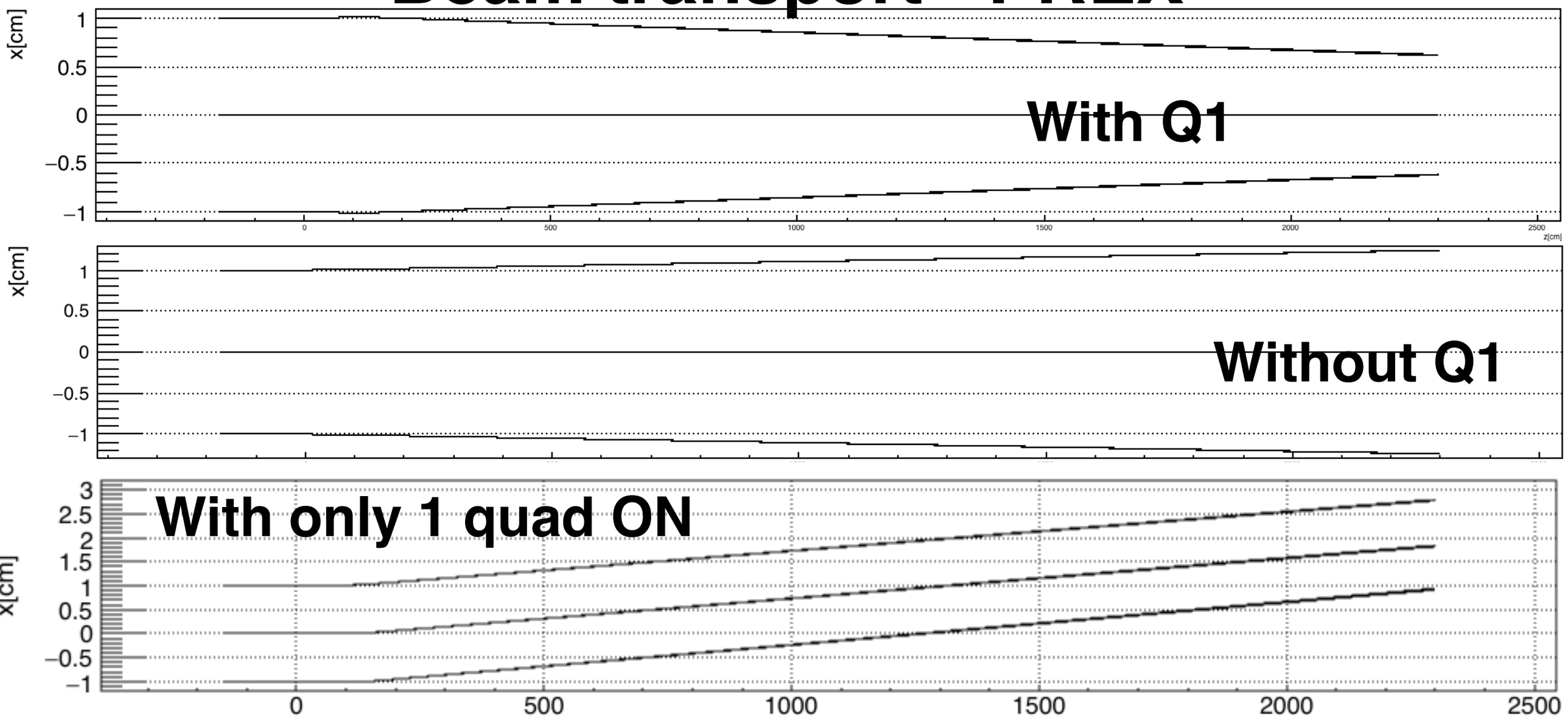
- If we look at the different detectors we have in the radiation simulation through the hall we can see that:
  - For CREX the Q1 fringe might help
  - For PREX the Q1 fringe does not seem to have any effect (or a slightly increased radiation field)

Beam transport - PREX



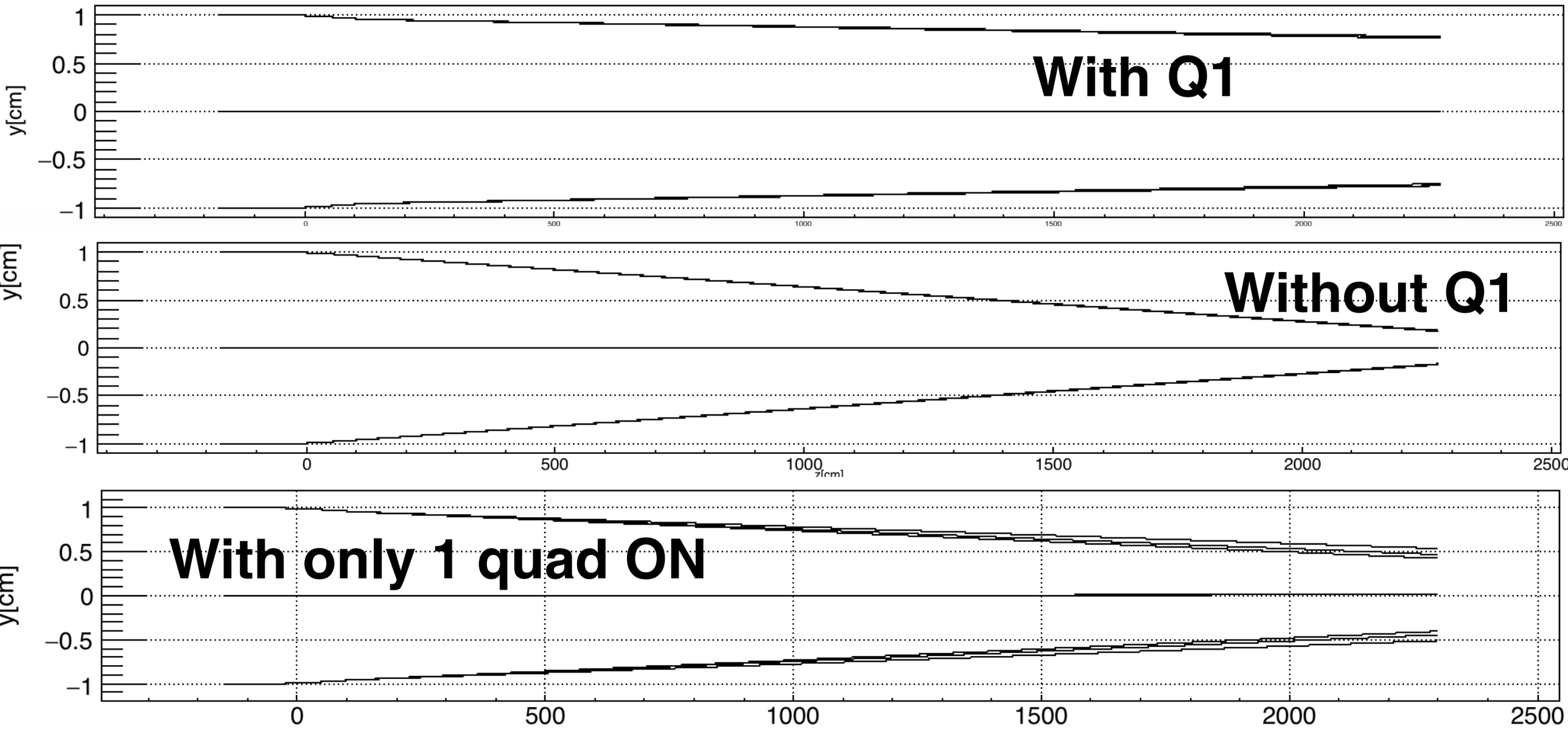
- Jay produced trajectories in TOSCA in a grid (1x1cm) at the target and propagated them through the fields all the way to the dump tunnel
  - the y “beam spot” increases with the Q1 fringe field from 0.8 -> 1.4
- The beam transport is not affected in y by more than 10% when we have only 1 quad on

Beam transport - PREX



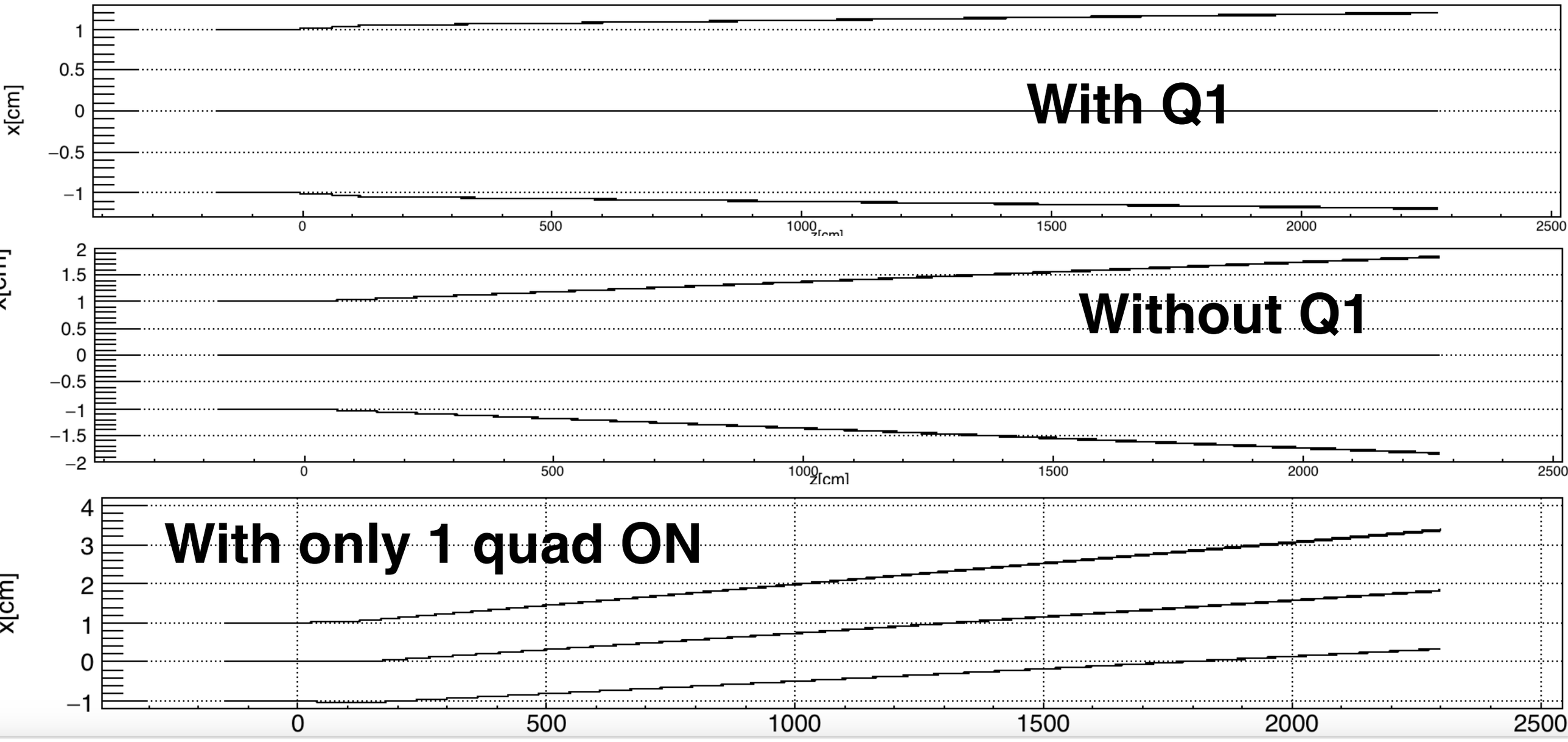
- Jay produced trajectories in TOSCA in a grid (1x1cm) at the target and propagated them through the fields all the way to the dump tunnel
  - the x “beam spot” decreases with the Q1 fringe field from 1.2 -> 0.6
- A x dipole is created when having only 1 quad on (an offset of ~1.8cm for 22.5m)

Beam transport - CREX



- Jay produced trajectories in TOSCA in a grid (1x1cm) at the target and propagated them through the fields all the way to the dump tunnel
  - the y “beam spot” increases with the Q1 fringe field from 0.2 -> 0.8 (@22.5 m)
- With only one quad on the focusing in y is a bit better than with both quads on and no shielding

Beam transport - CREX



- Jay produced trajectories in TOSCA in a grid (1x1cm) at the target and propagated them through the fields all the way to the dump tunnel
  - the x “beam spot” decreases with the Q1 fringe field from 1.9 -> 1.2
- The dipole is stronger for CREX (@22.5m offset of ~2.4cm)

Beam transport

	PREX wi	PREX wo	CREX wi	CREX wo
y	1.4	0.8	0.8	0.2
x	0.6	1.2	1.2	1.9

- This is just a rough analysis but it does not see that leaving the Q1 fringe field in will be a huge disruption for beam transport to the dump

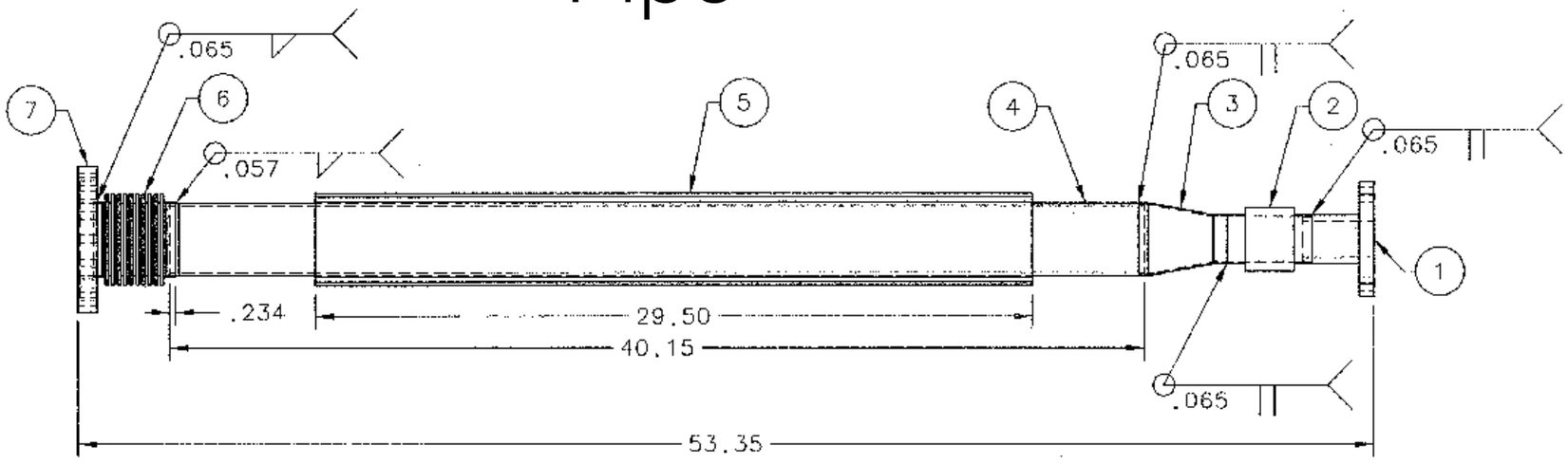
Conclusions

- In terms or radiation the Q1 fringe field might actually be useful (in particular for CREX)
- Seems beam transport will be ok with Q1 fringe
- Having only one quad on will create ~2cm offset of the beam envelope in the x direction
  - this analysis was done with only one quad in the TOSCA simulation (the iron from the other quad would in principle help but it is not clear it would enough to be able to run without shielding)
  - we have the Bfield for this configuration but need to include it into the simulation before a radiation simulation could be run (would expect to have significant increase)
  - Jay calculated the force for a conical shield, only one quad available in the simulation and higher quad currents than CREX and the resulting force on the shield is ~200N, meaning that for our conditions there is no concern that we would break vacuum while running with one quad alone

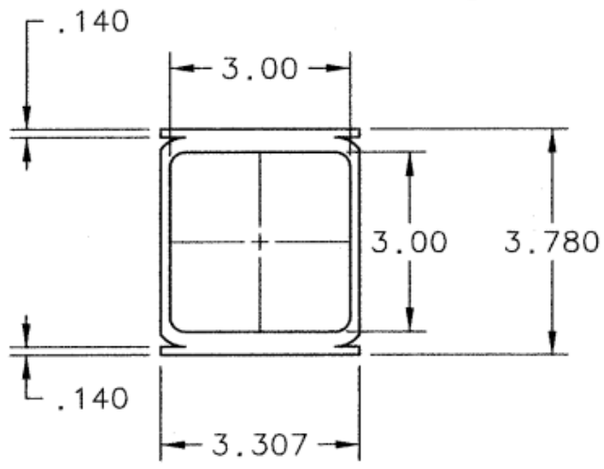
Backup

Septum beam pipe

Pipe



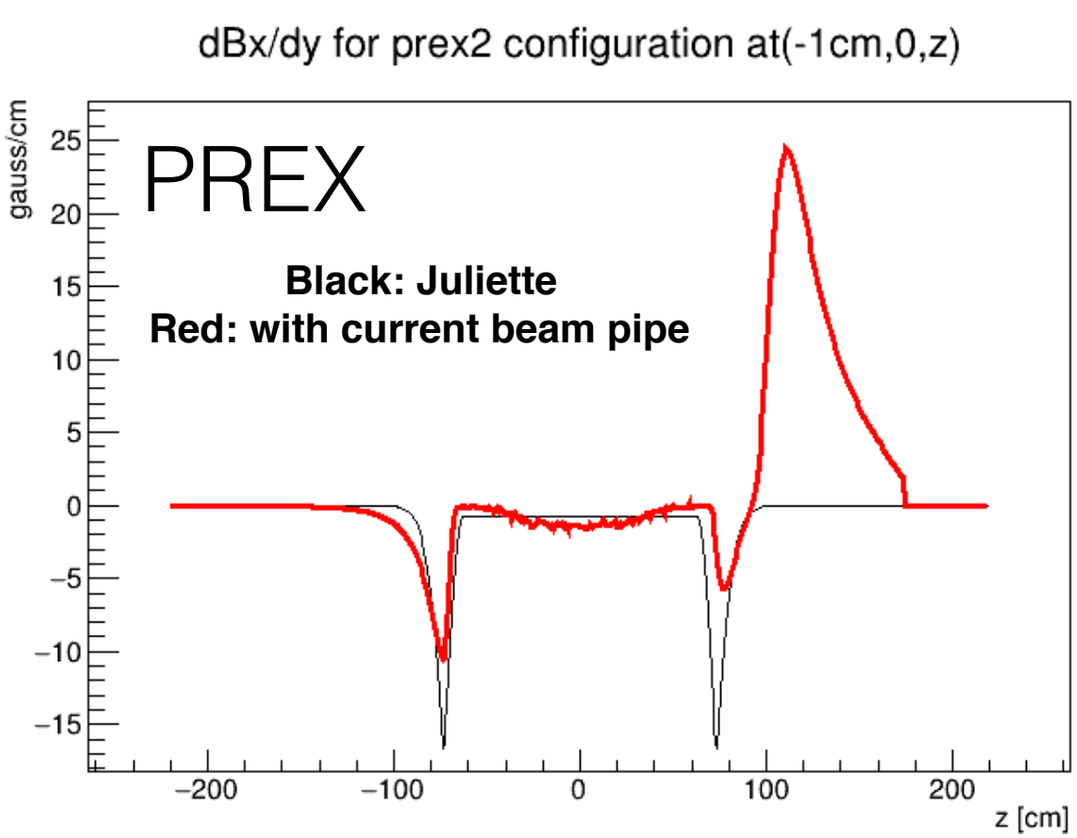
Shielding

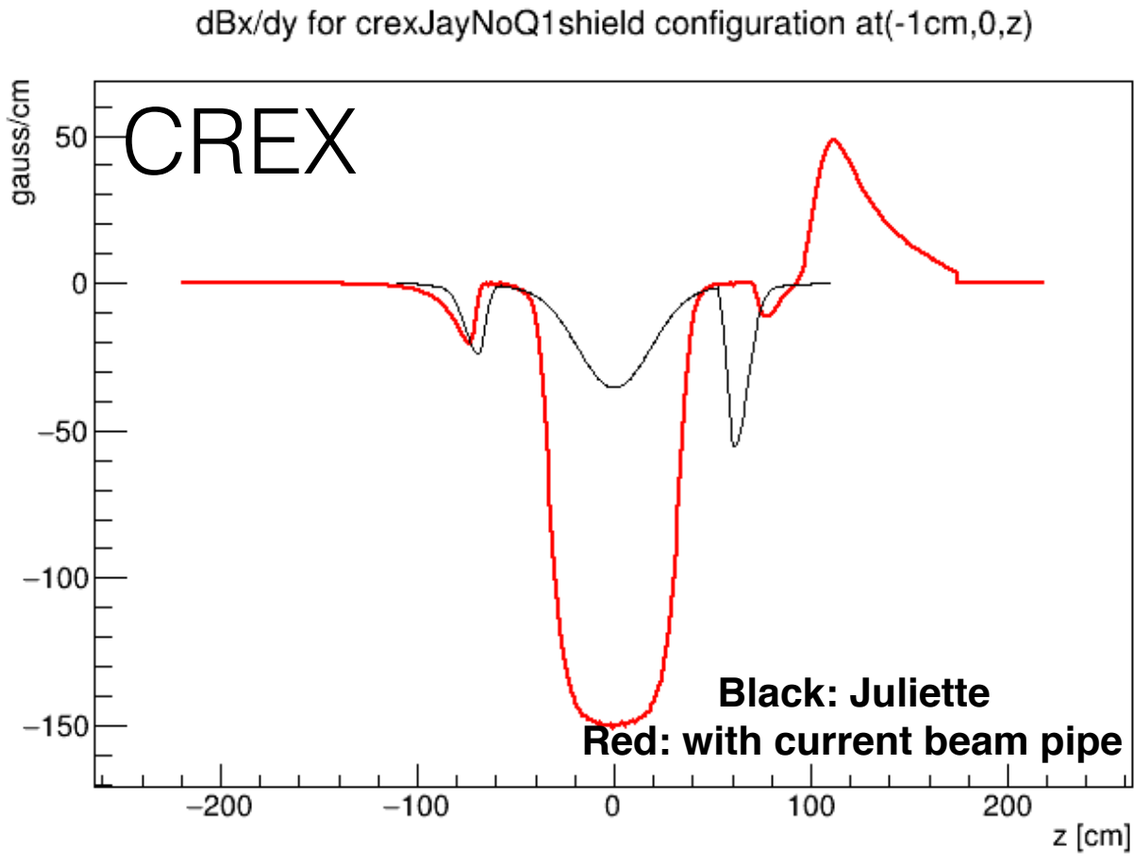


- Jay started working with the model Juliette and Iris provided

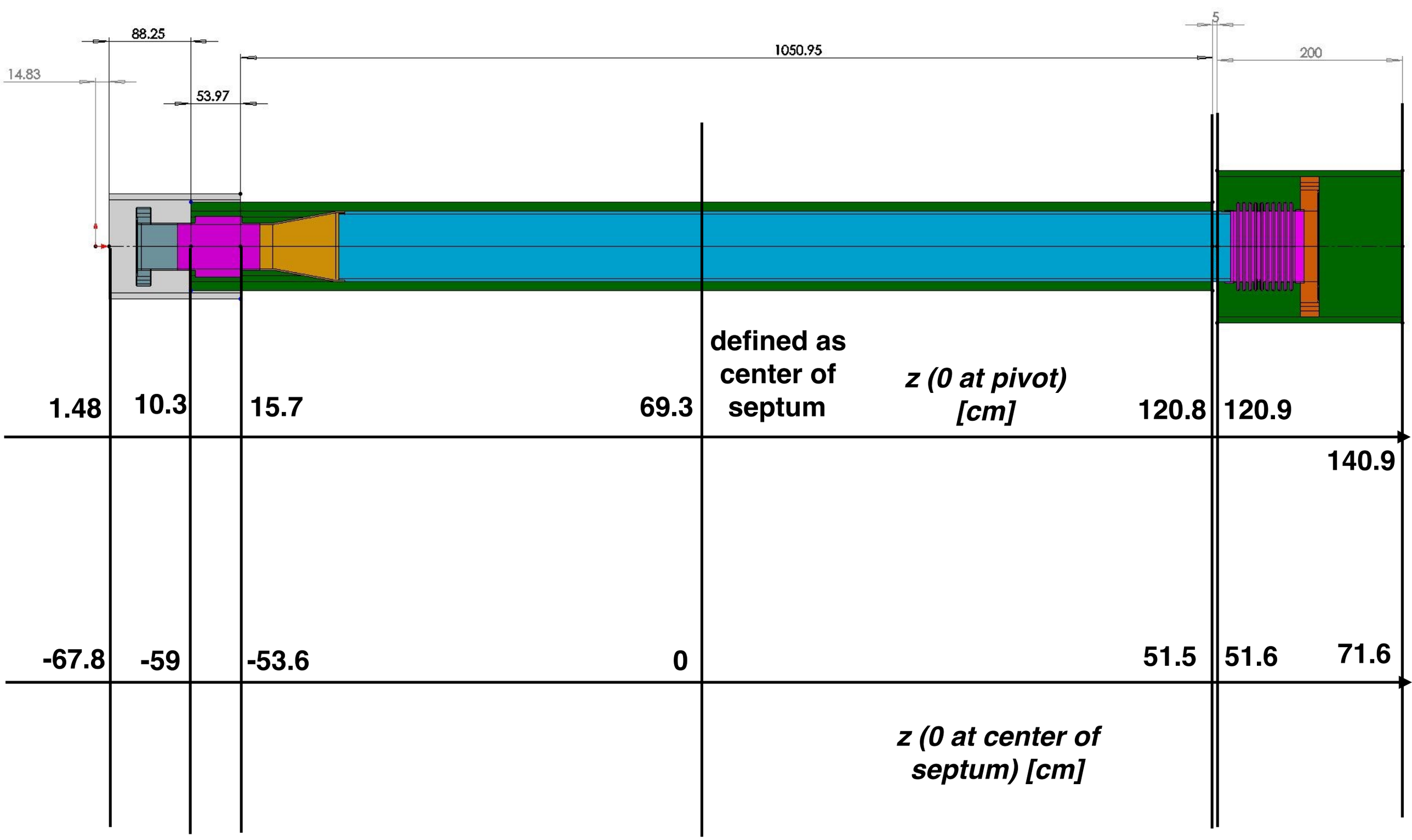
- The beam pipe through the septum in the configuration that ran for PREX1 (and is available now) has:
  - The shielding (# 5) is in actuality longer - 43.5”
  - The shielding box is made out of carbon steel and the openings at the top and bottom are filled in with weld
  - The pipe itself is made out of stainless steel

B fringe field from current setup





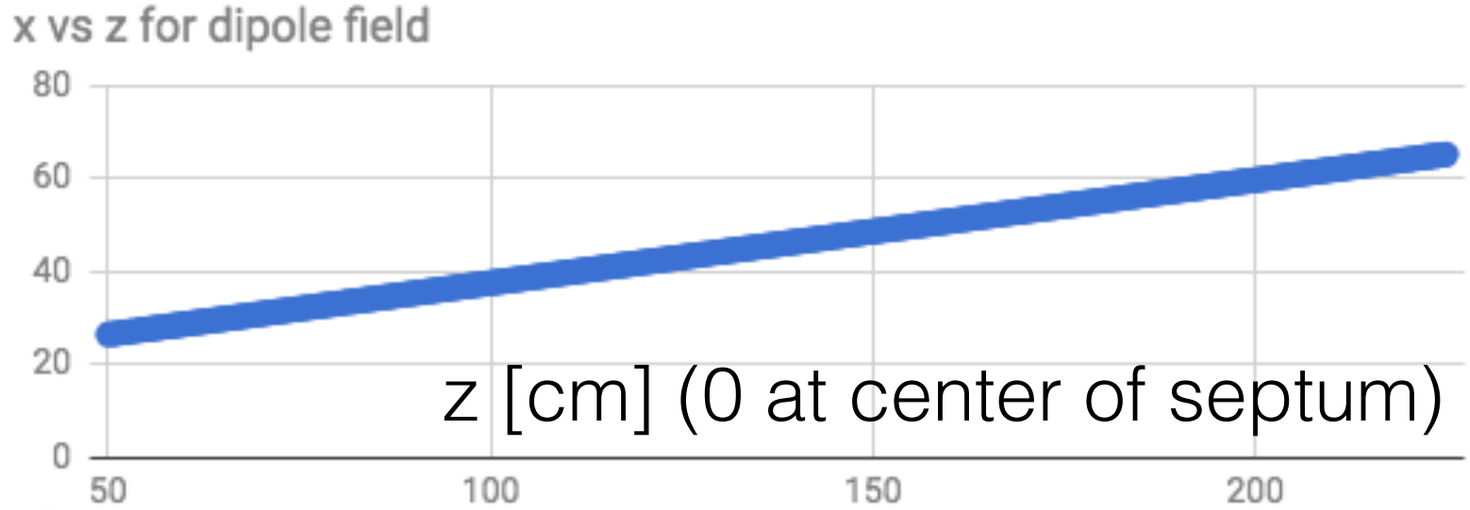
- Note that Juliette never got a fringe field for the Q1s
- The fringe field in the CREX case is probably unmanageable (radiation wise) if we keep the current setup
- Juliette must have already replaced the stainless steel pipe in her simulation with carbon-steel
- Jay has models running now with updated configuration

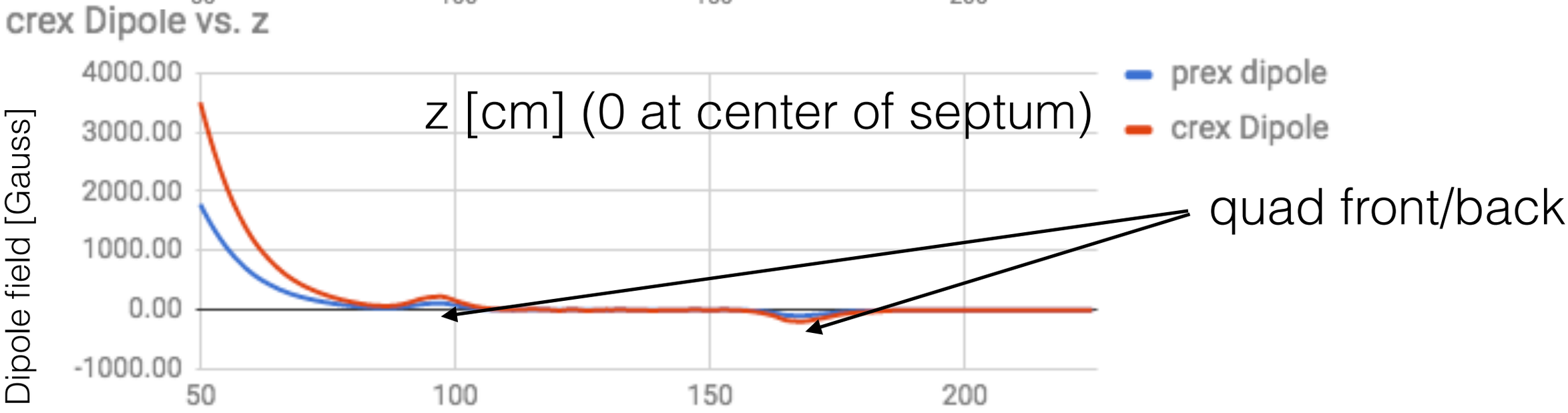

88.25
14.83
53.97
1050.95
5
200
1.48
10.3
15.7
69.3
defined as center of septum
z (0 at pivot) [cm]
120.8
120.9
140.9
-67.8
-59
-53.6
0
51.5
51.6
71.6
z (0 at center of septum) [cm]

Changes needed to the beam pipe

- Minimal changes:
  - the beampipe 3''OD 0.124'' thickness should be **carbon-steel** Z[-53.6, 51.6]. The rest should be left out because that is where we will have stainless steel bellows.
  - the rectangular carbon-steel box around the beampipe should extends Z[-59, 51.6] — already in place
  - the US carbon-steel plates with 0.25'' thickness should extend between Z[-67.8, -53.6] **— have to be designed and manufactured**
  - the DS carbon-steel plates with 0.25'' thickness should extend between Z[51.6, 71.6]**— have to be designed and manufactured**
- Alternative solution:
  - Take two carbon steel rectangular cross section beams (of the correct size) and drill a semi-circular cavity
  - Weld the two pieces together and connect to bellows at either end

Dipole field along signal particle path





- Jay's calculations show that there is a significant dipole field along the path of the particles being scattered into the HRS

- These are calculations made by Jay and provided to us in a spreadsheet of multipoles (the large

- These are with the updated septum beam pipe (the field around 50 is due to the fringe of the septum interacting with the iron in the Q1)s