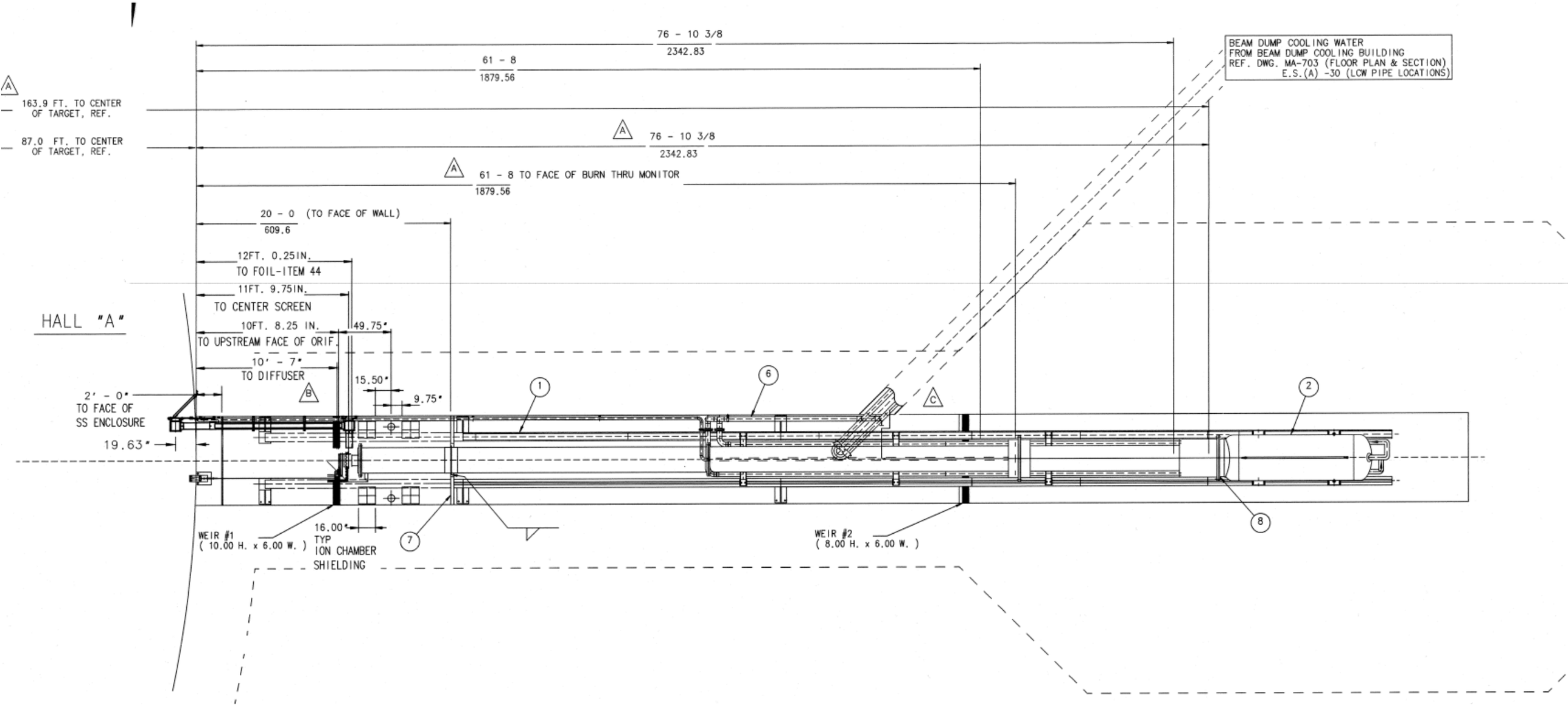
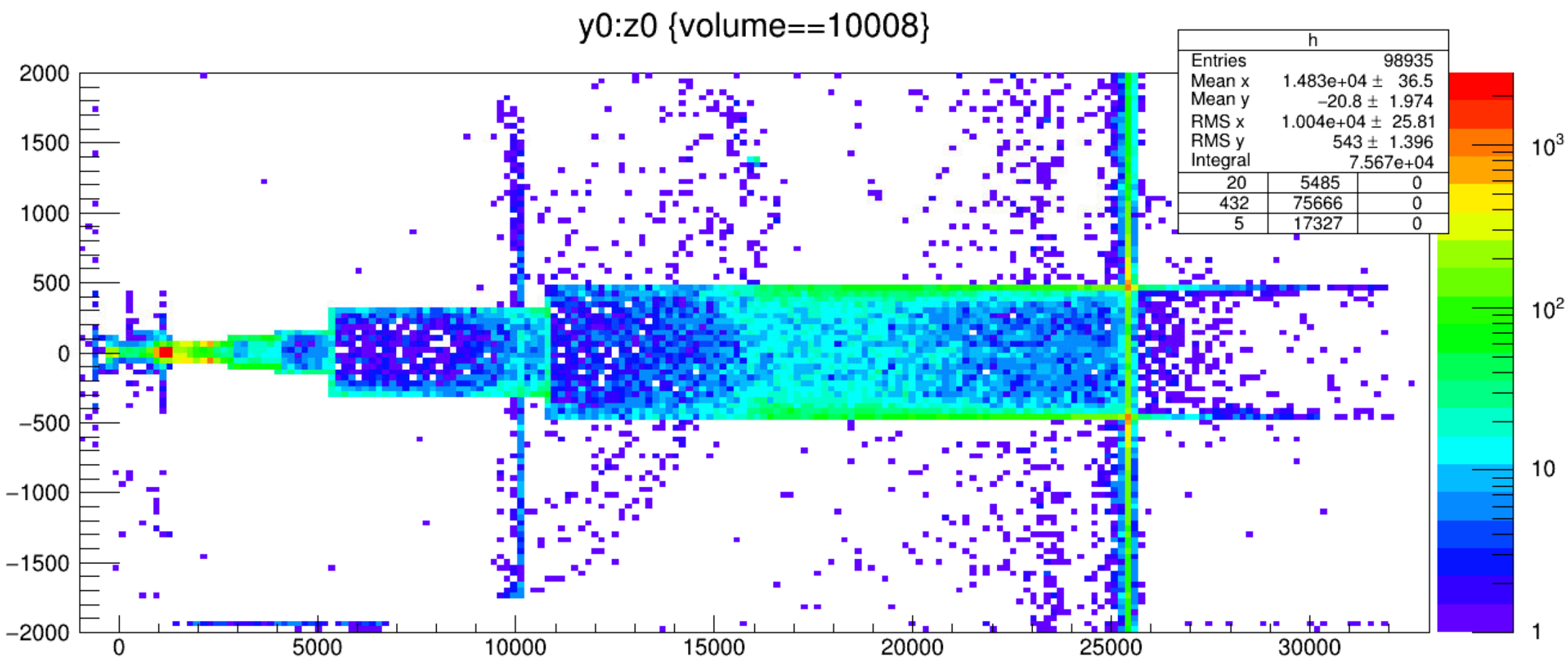
PREX 1 dump configuration

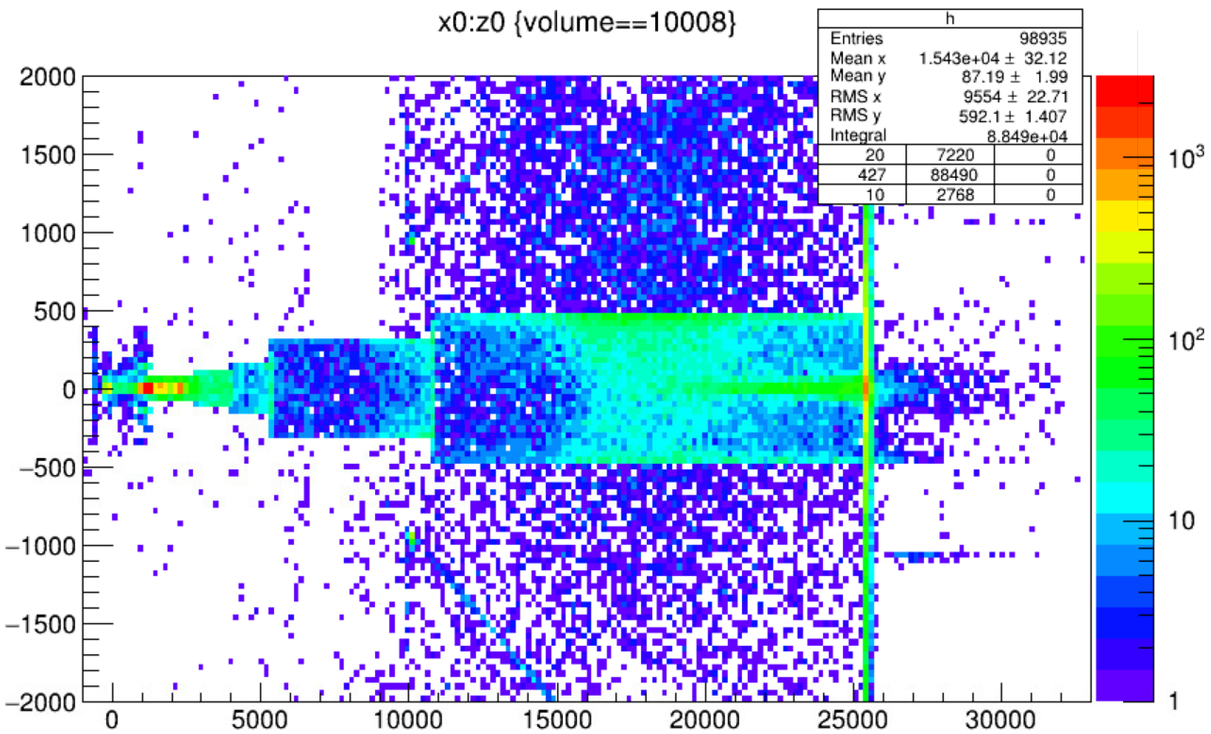


- Dump configuration was different than what we had in the simulation

- The beam pipe has an Aluminum aperture that is about 4in in diameter in about the same location as the donut is now

Dump configuration - PREX1

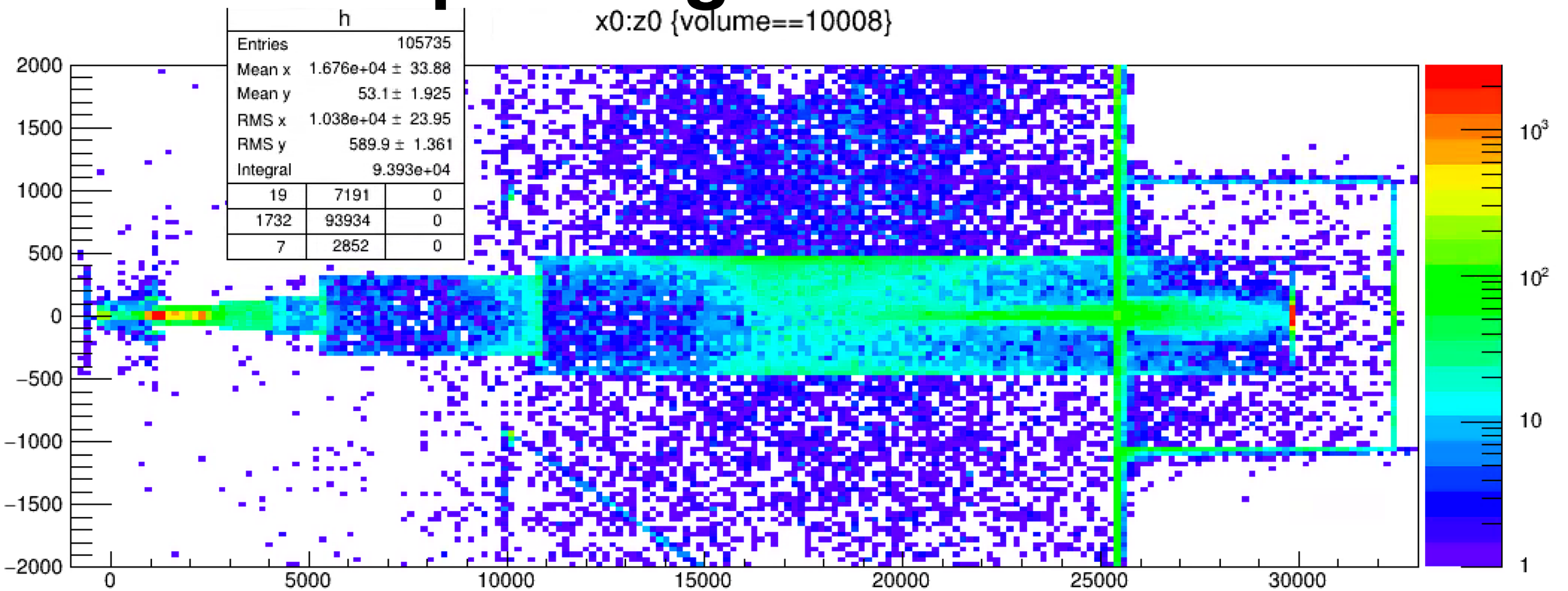




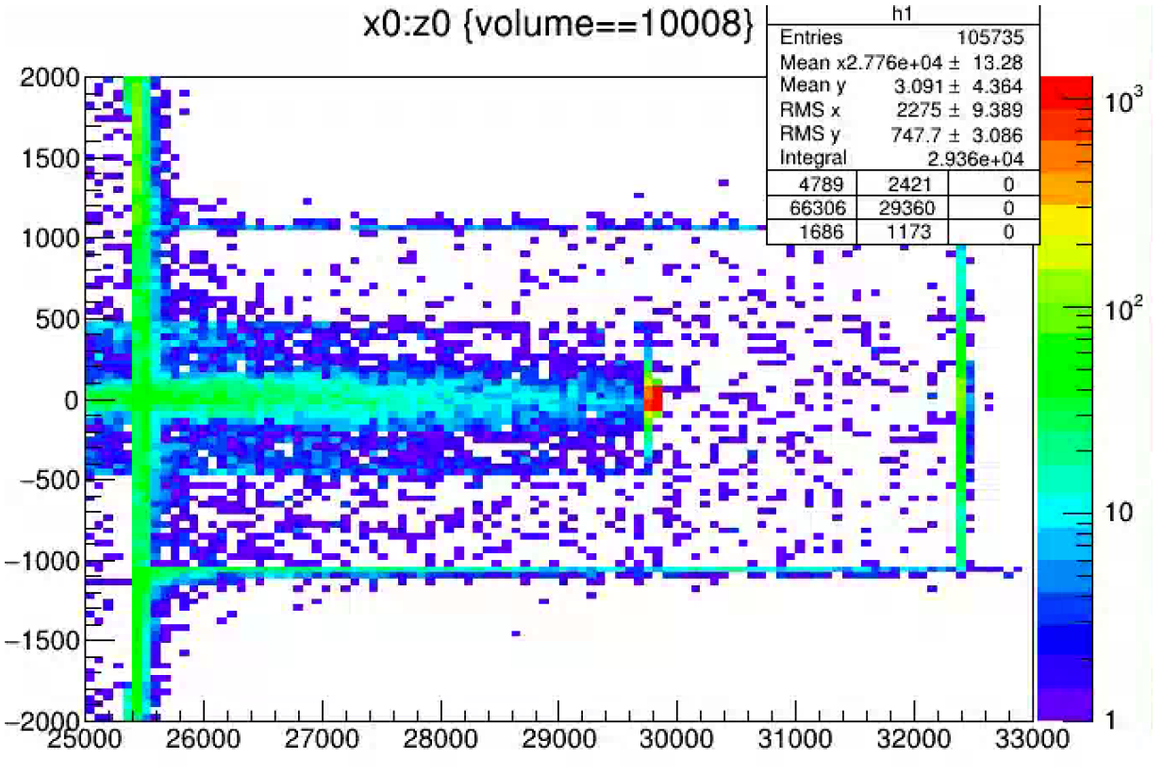
ERR dump configuration

- for the ERR our simulation had a stainless steel wall around the beam pipe at the exit of the hall
- it produced about the same level of radiation splash back (to the HRS detector) as the 4 in aperture ~4 m downstream

Dump configuration - PREX1

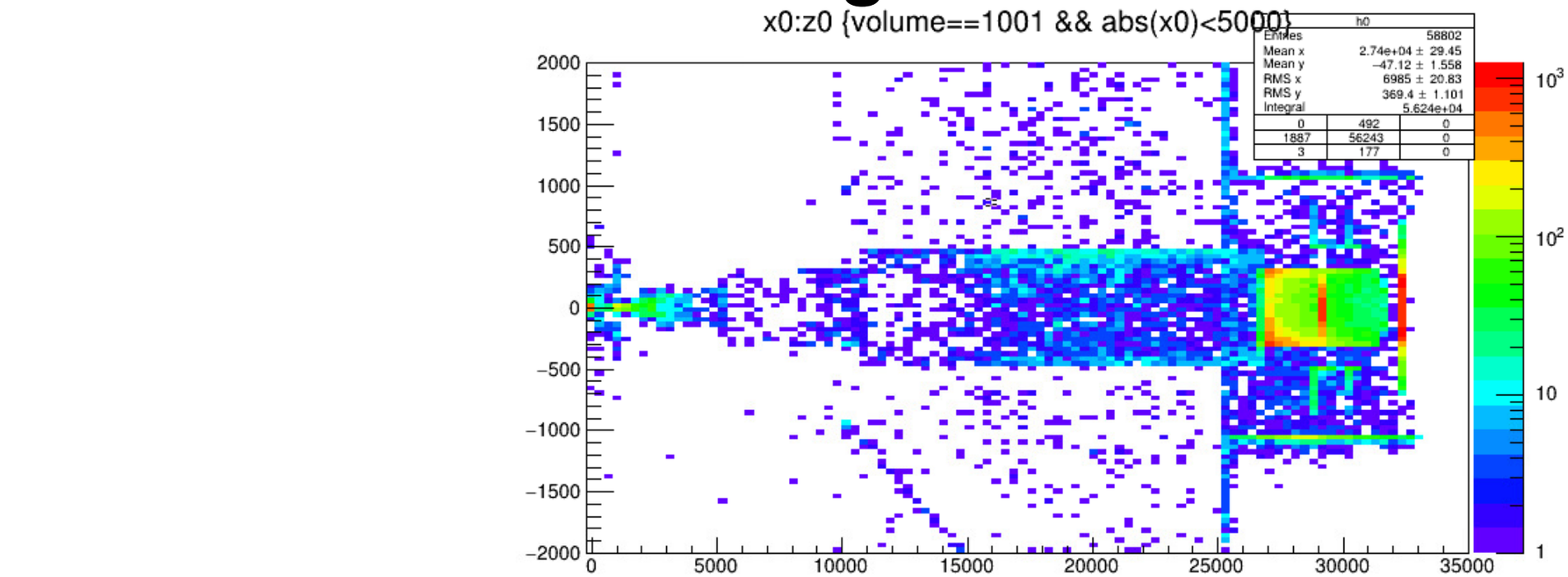


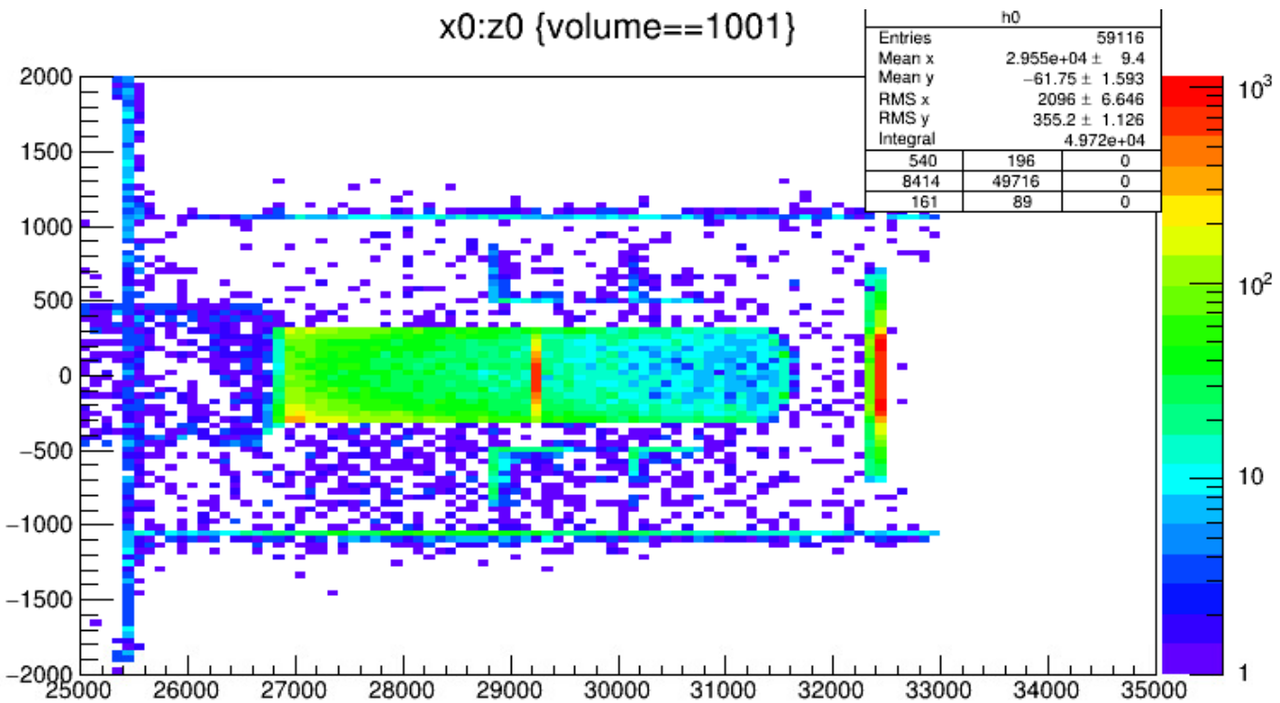
updated dump configuration

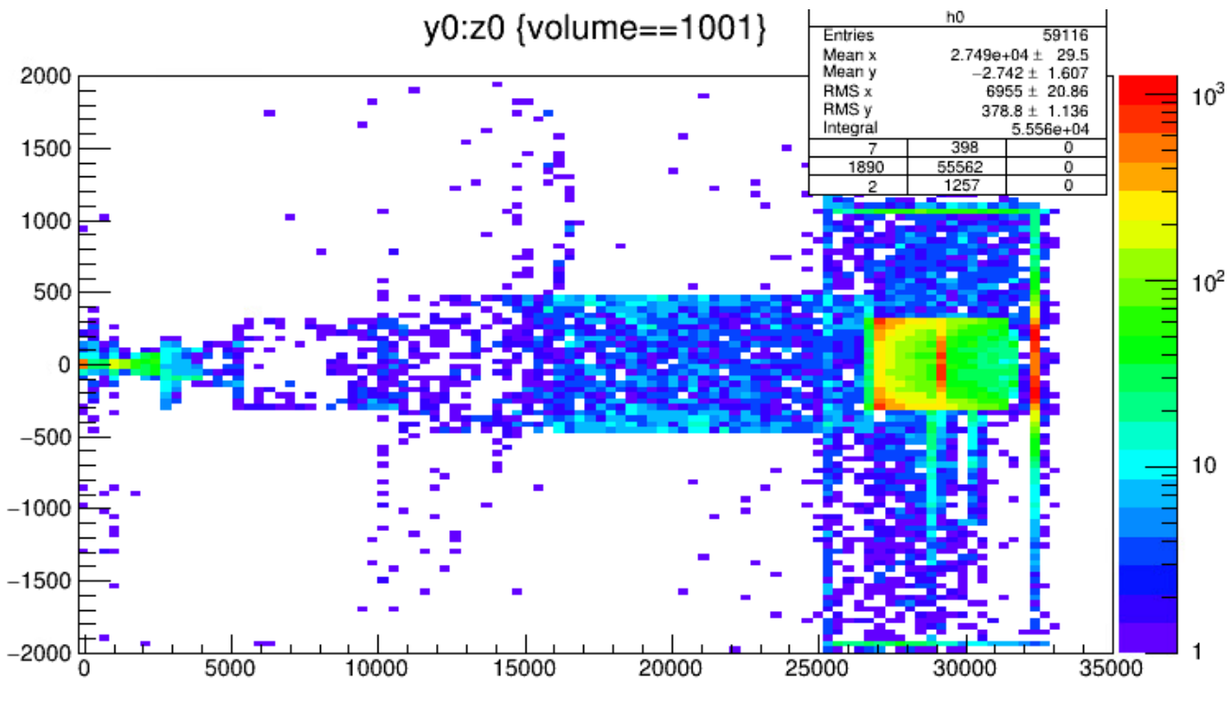


Wrong dump wall - PREX2

new config - stainless steel Wall

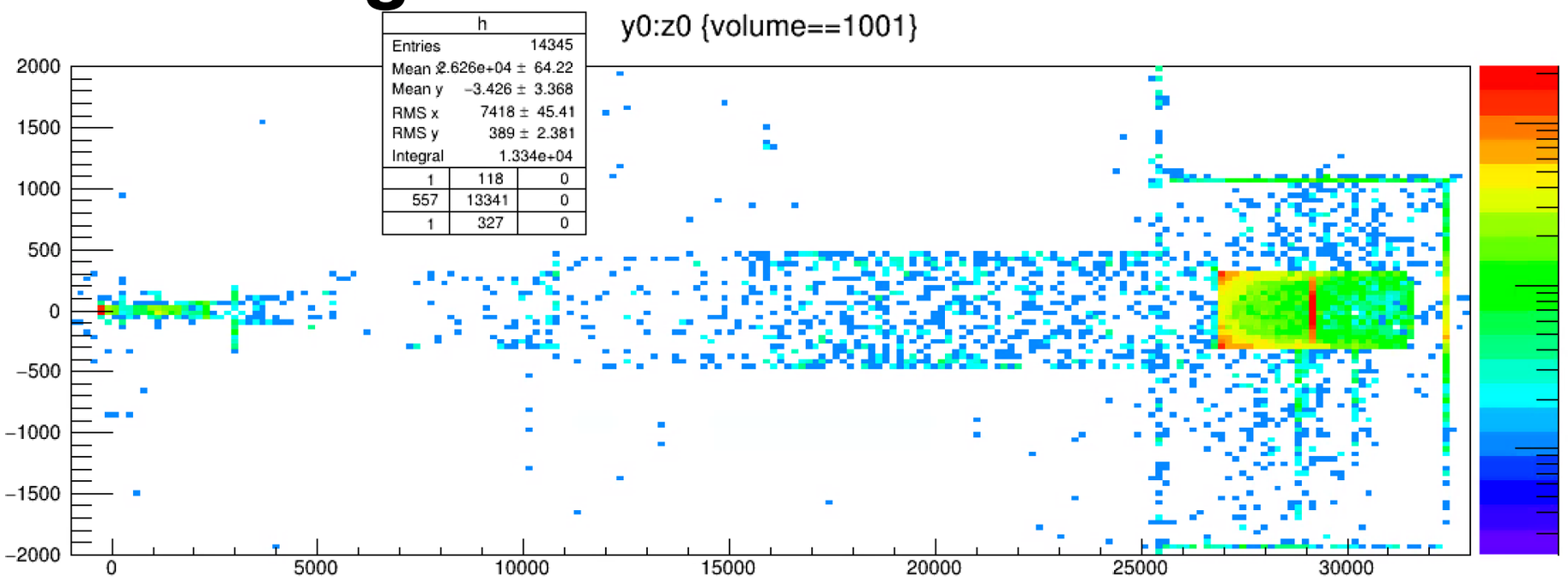




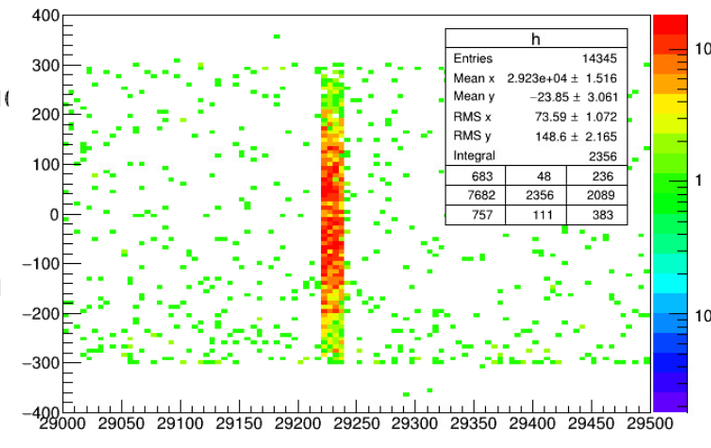


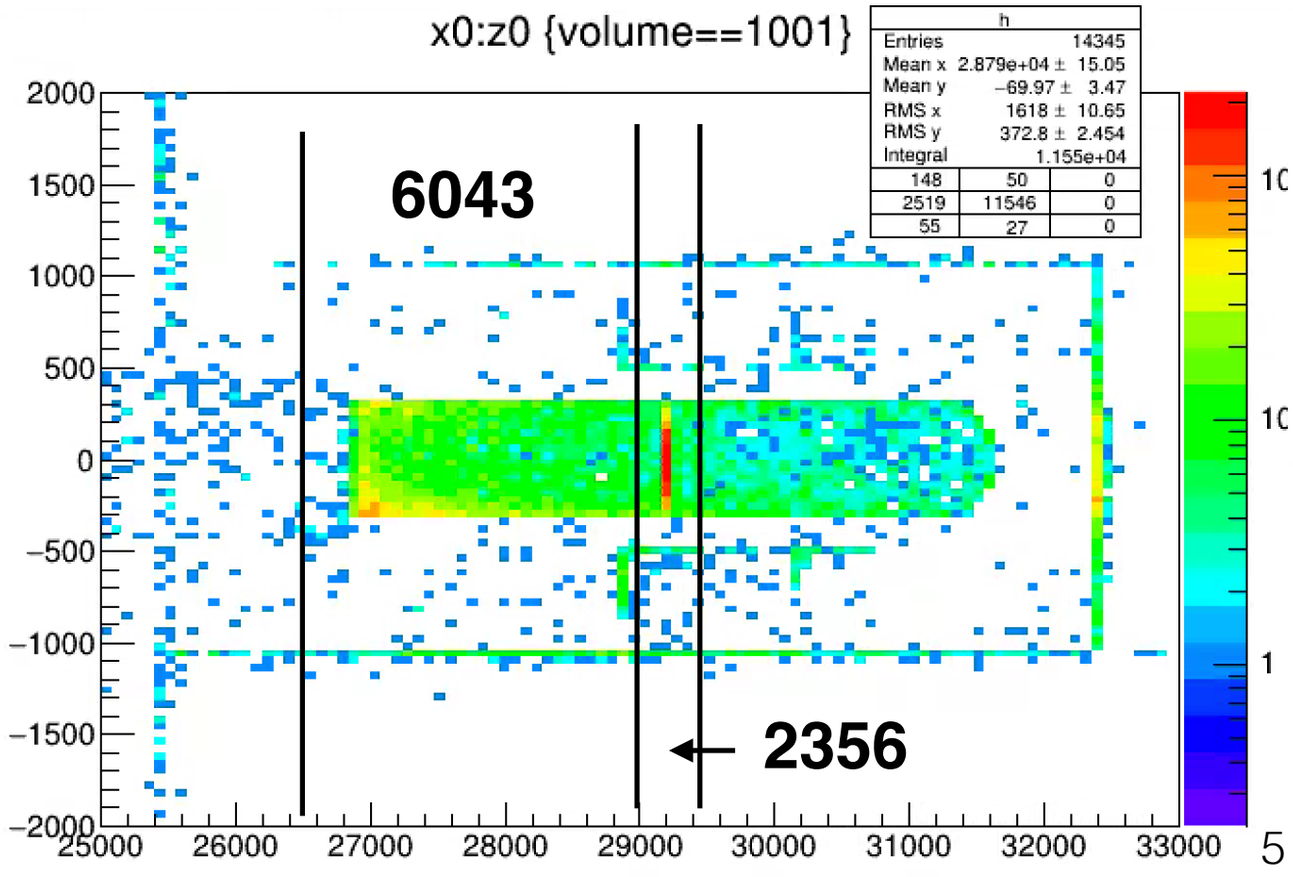
Radiation damage 2 HRS- PREX2

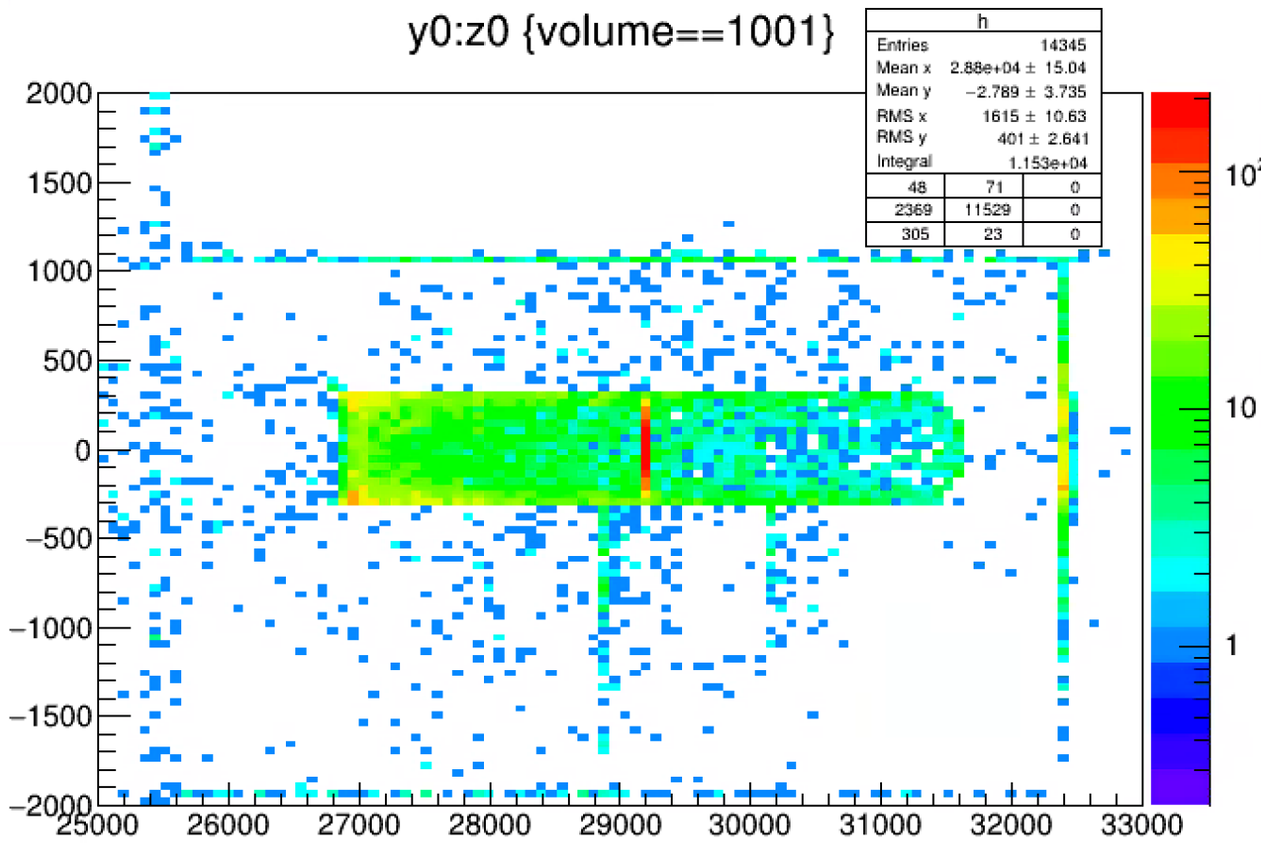
new config - Al wall



donut

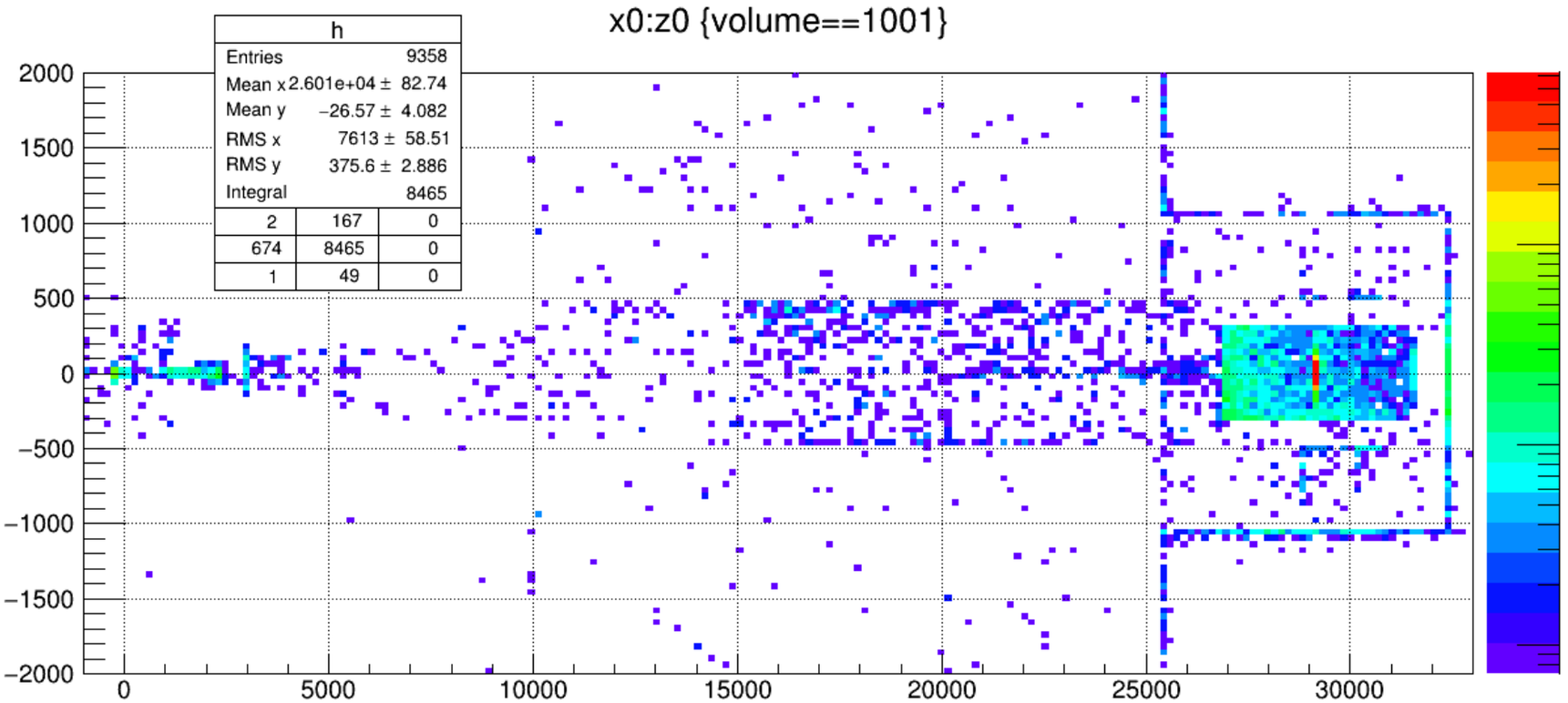




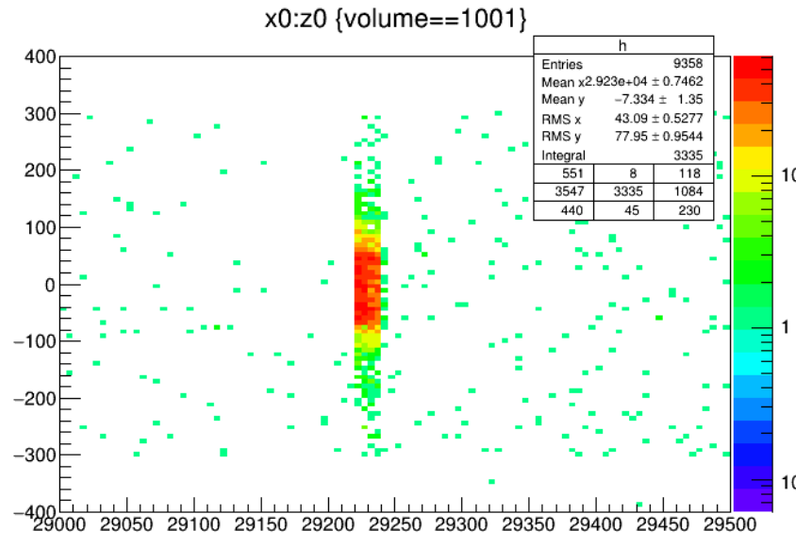


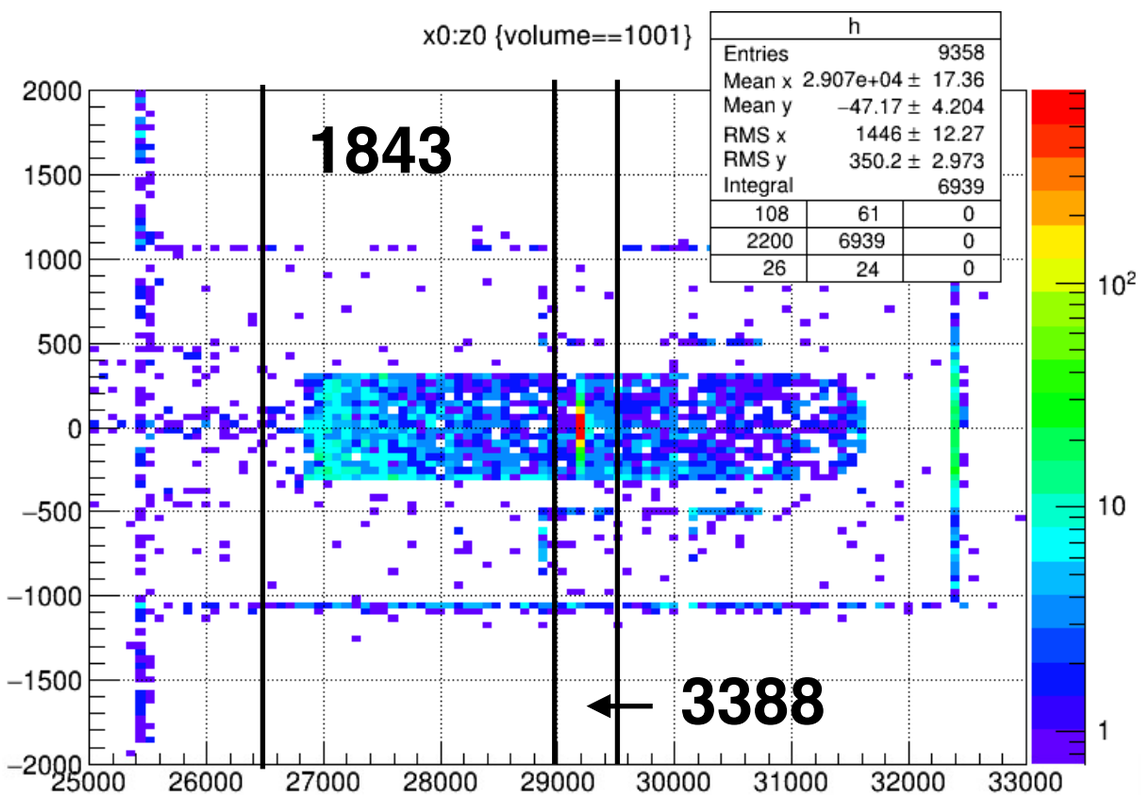
Radiation damage 2 HRS- CREX

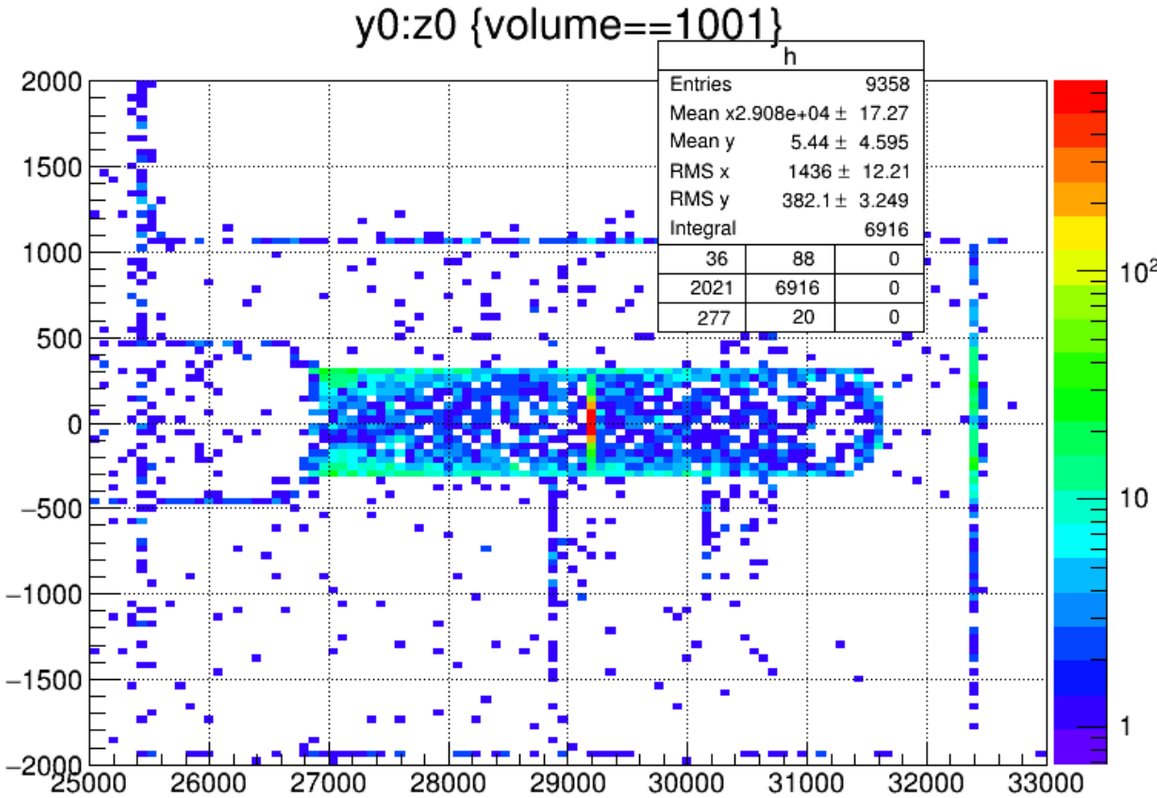
new config - Al wall



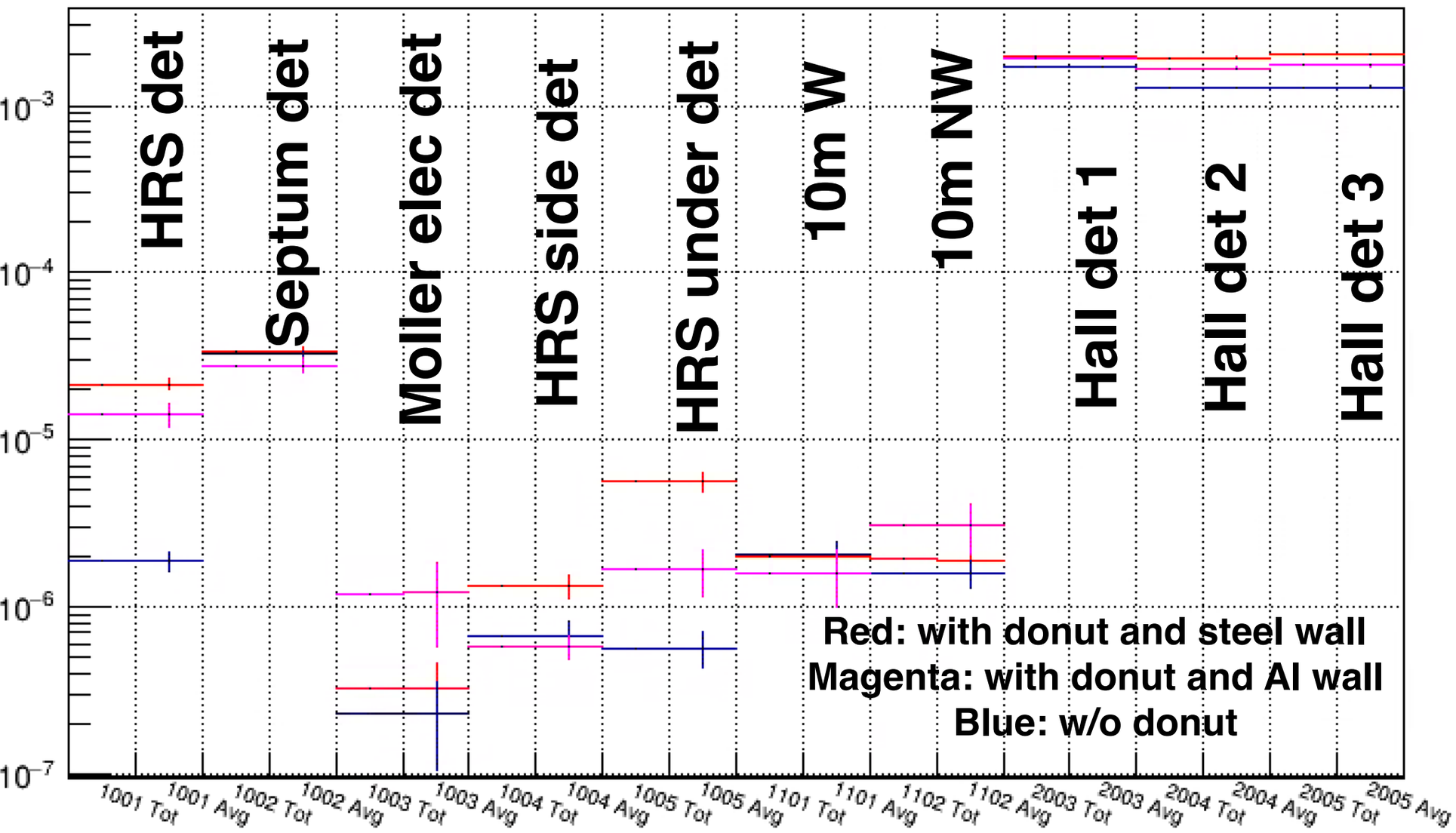
donut





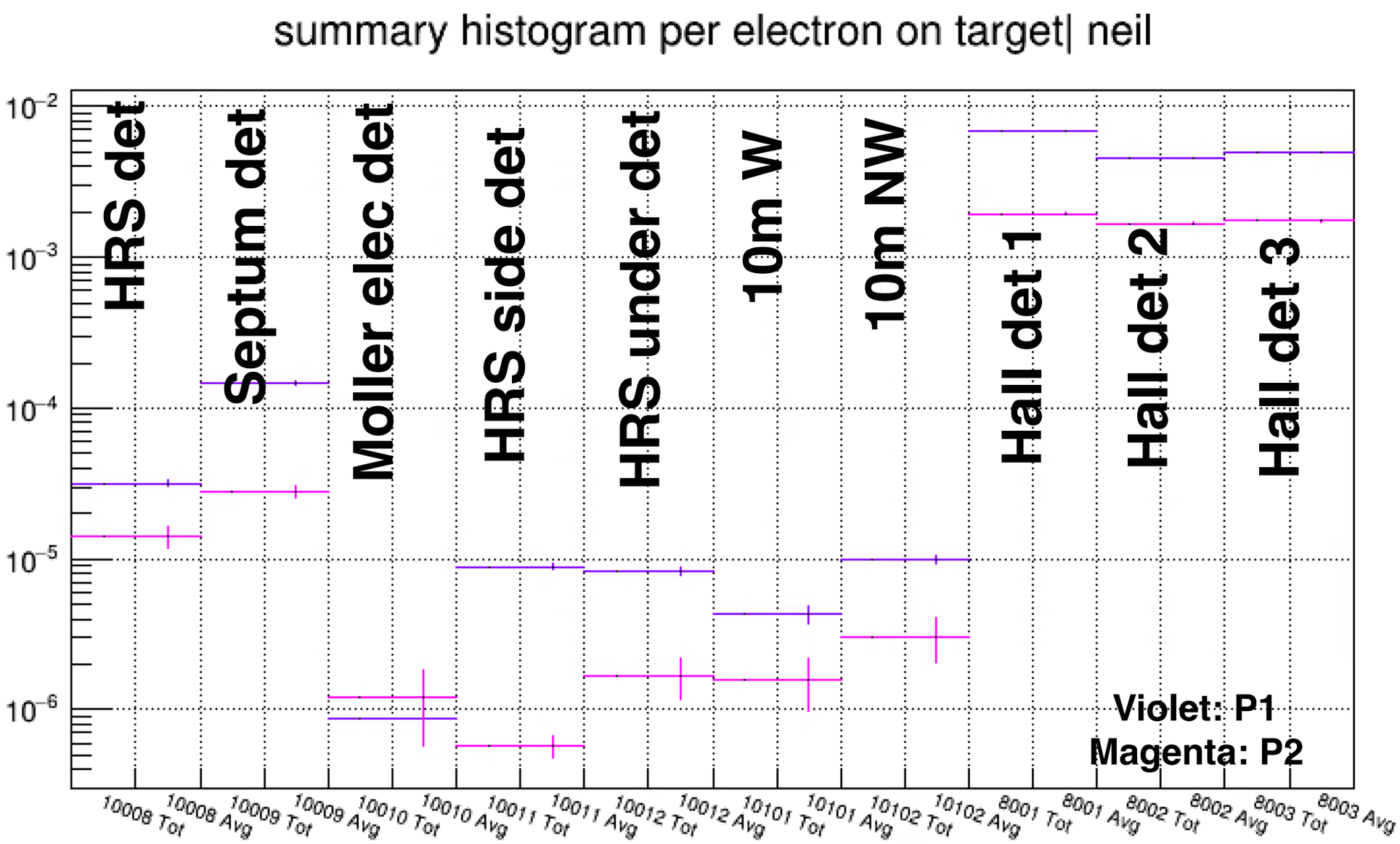


Radiation damage - PREX2



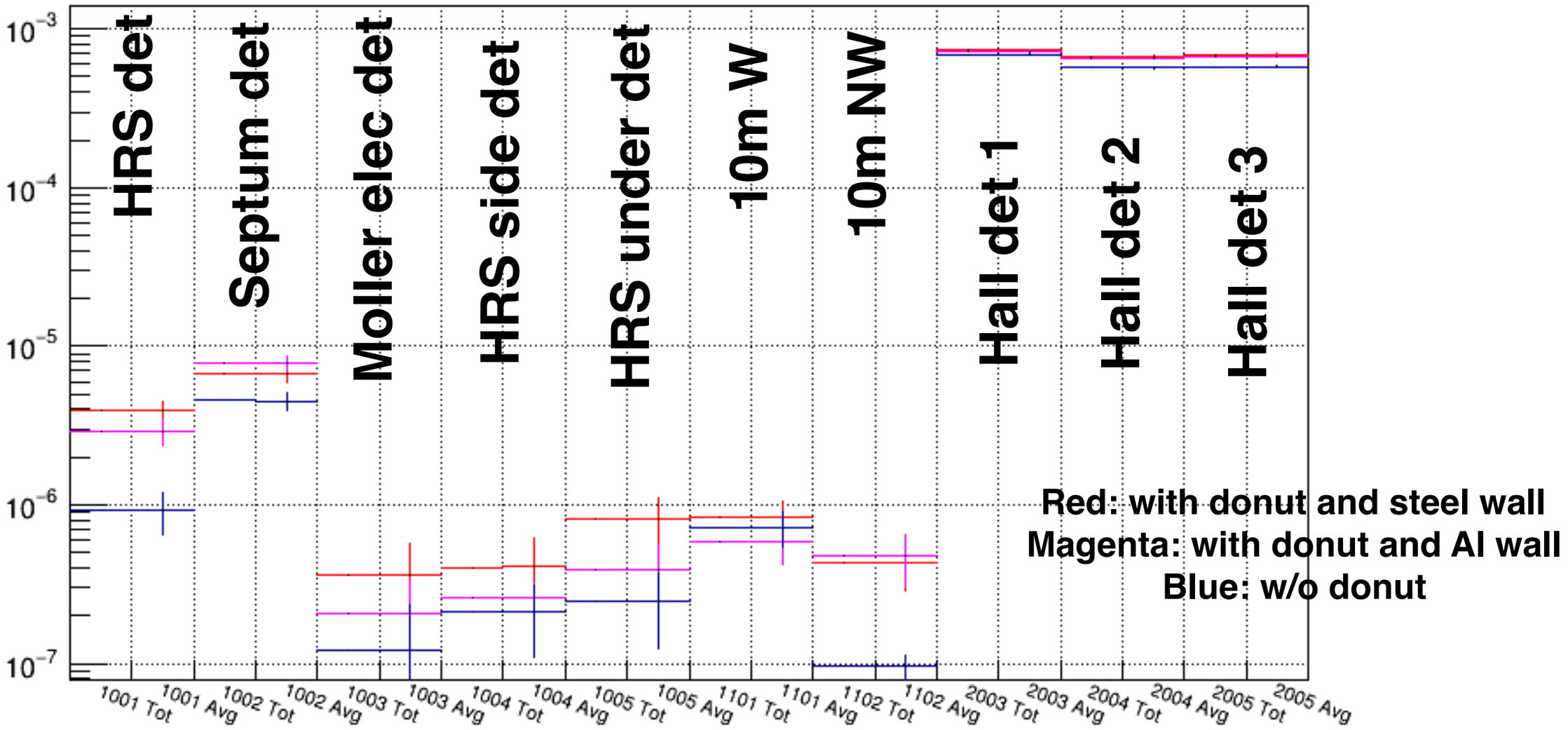
- The update (from stainless steel to Al door) drops the overall damage but it is still considerable compared to what we presented at the ERR

Radiation damage - PREX2 vs PREX1



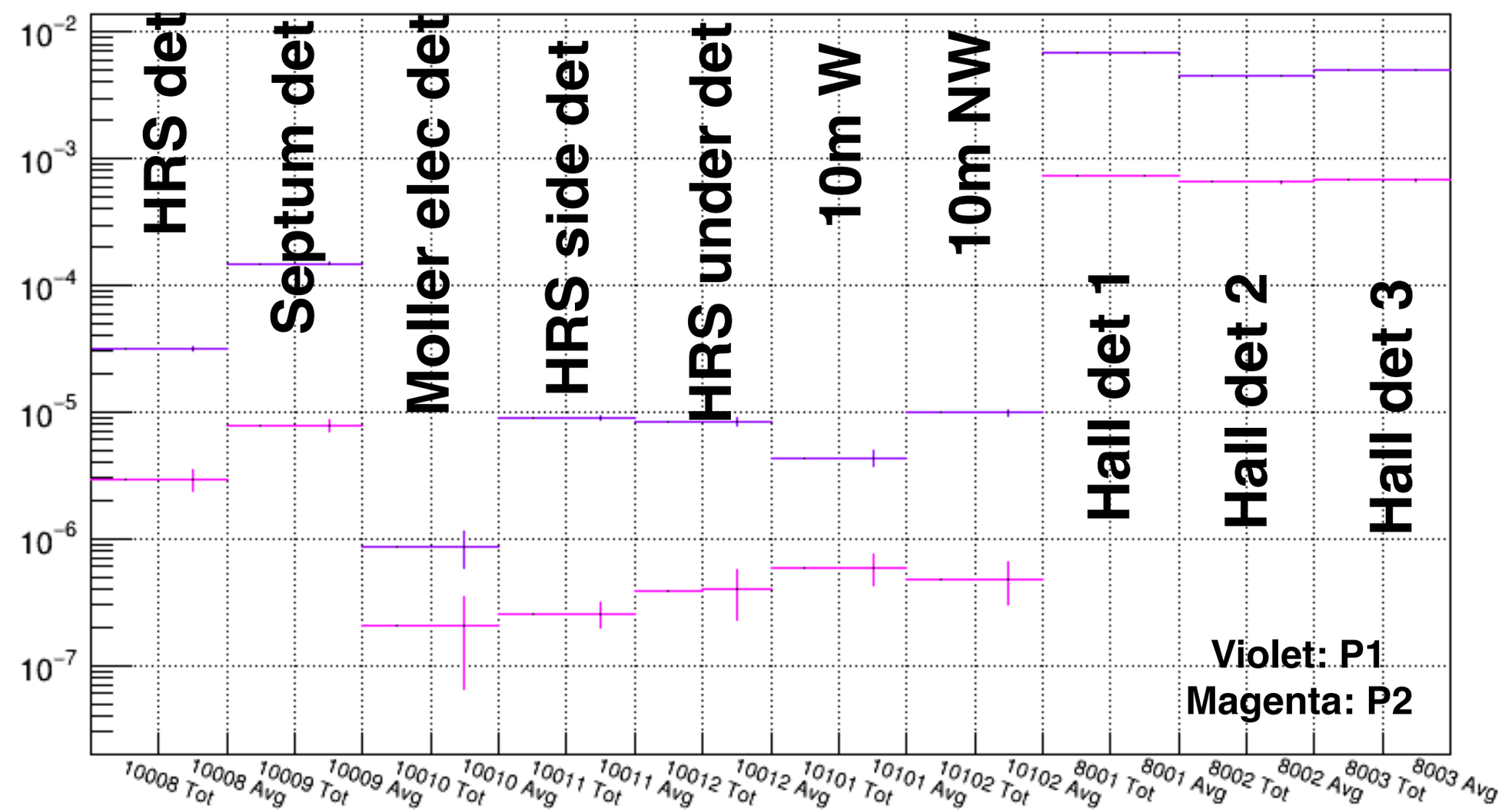
- On a per electron basis we are still better than PREX1

Radiation damage - CREX



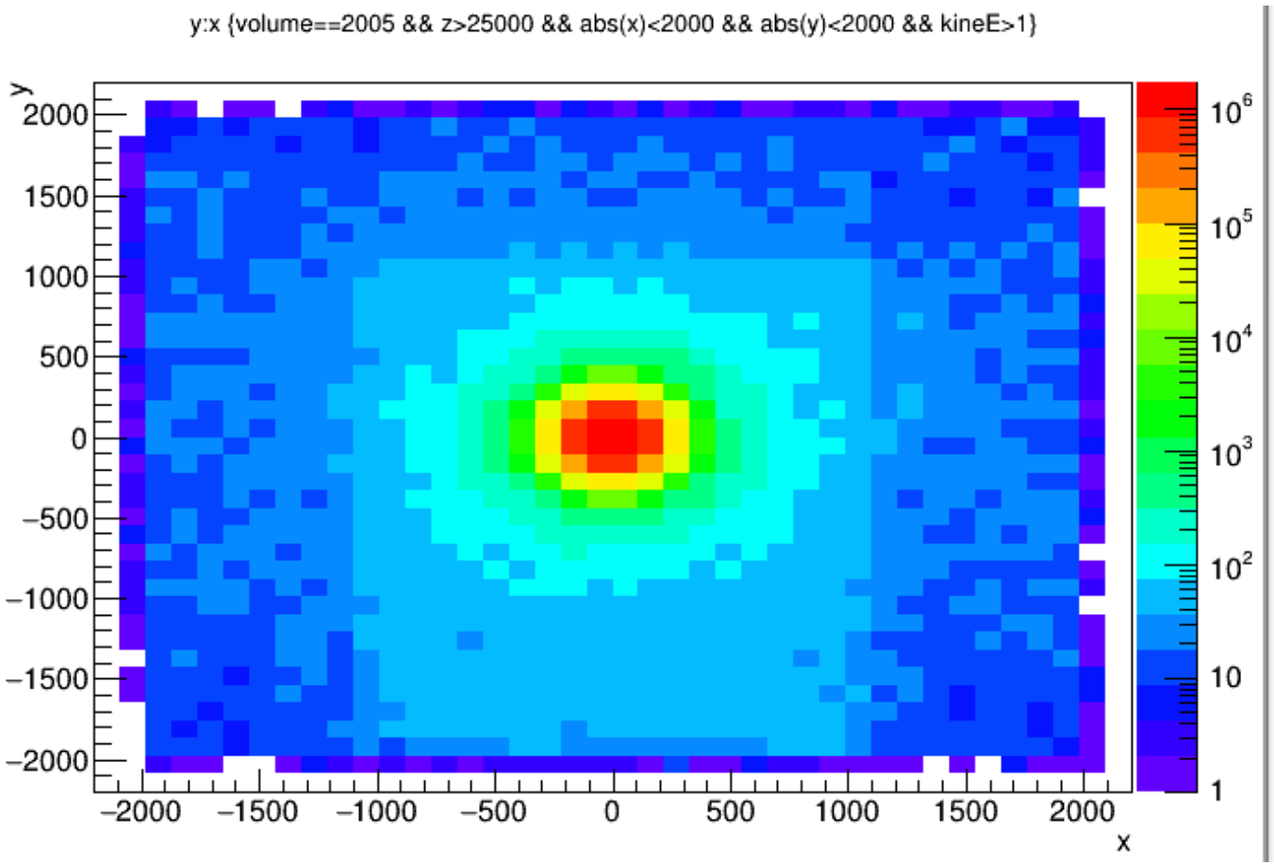
- Similarly for CREX the dump wall update decreased the radiation overall

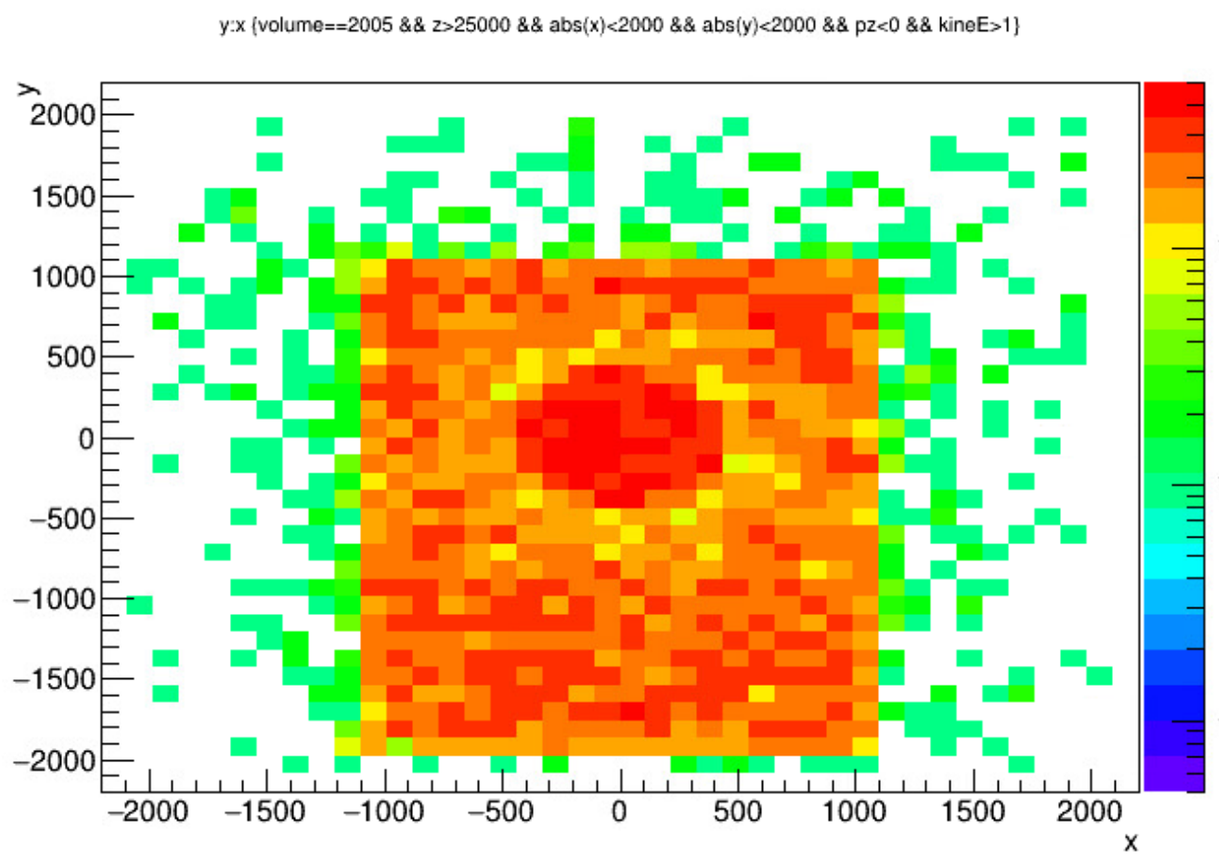
Radiation damage - CREX



- Because of the 2 GeV beam CREX is much better (per electron) compared to PREX1

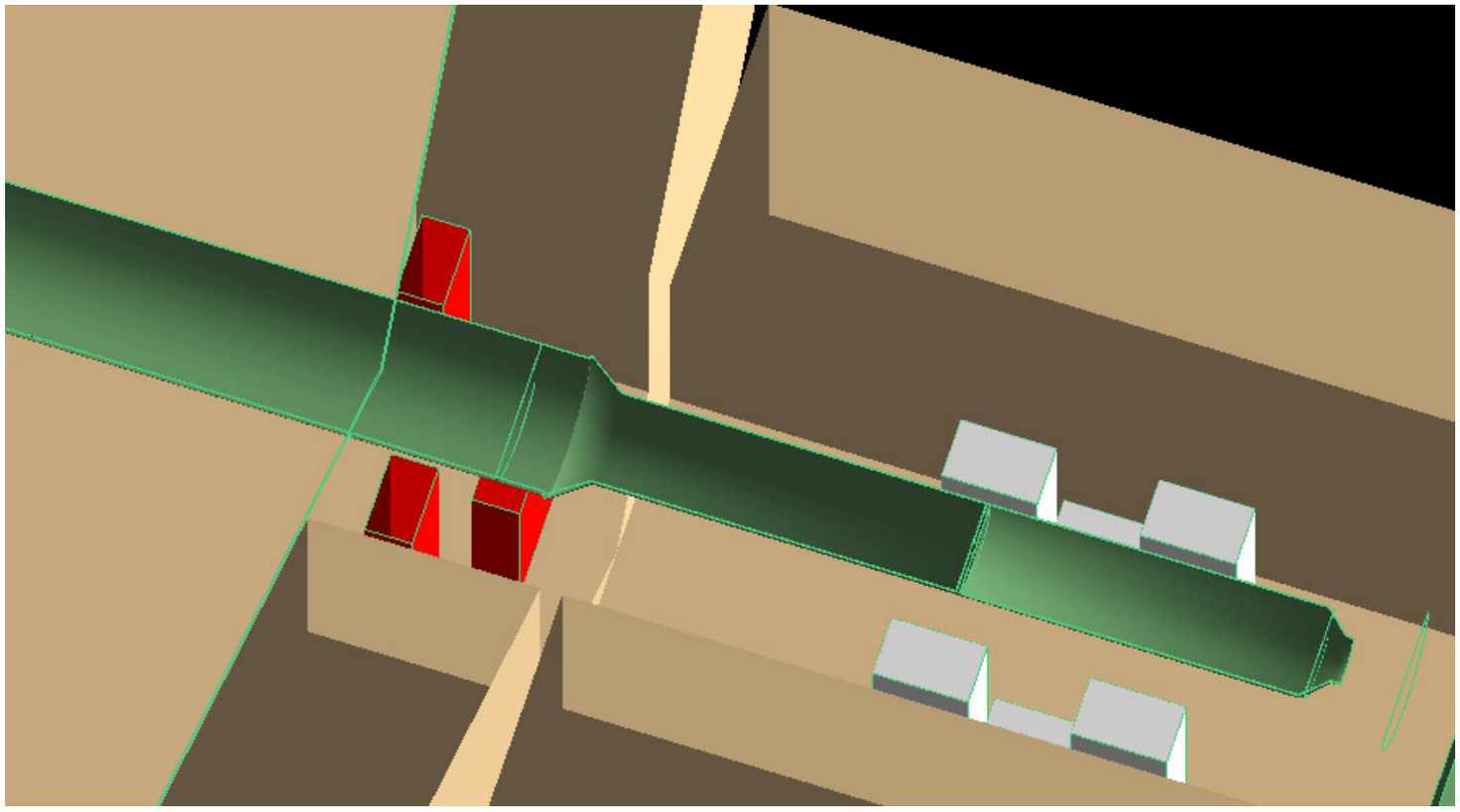
Particle heatmap

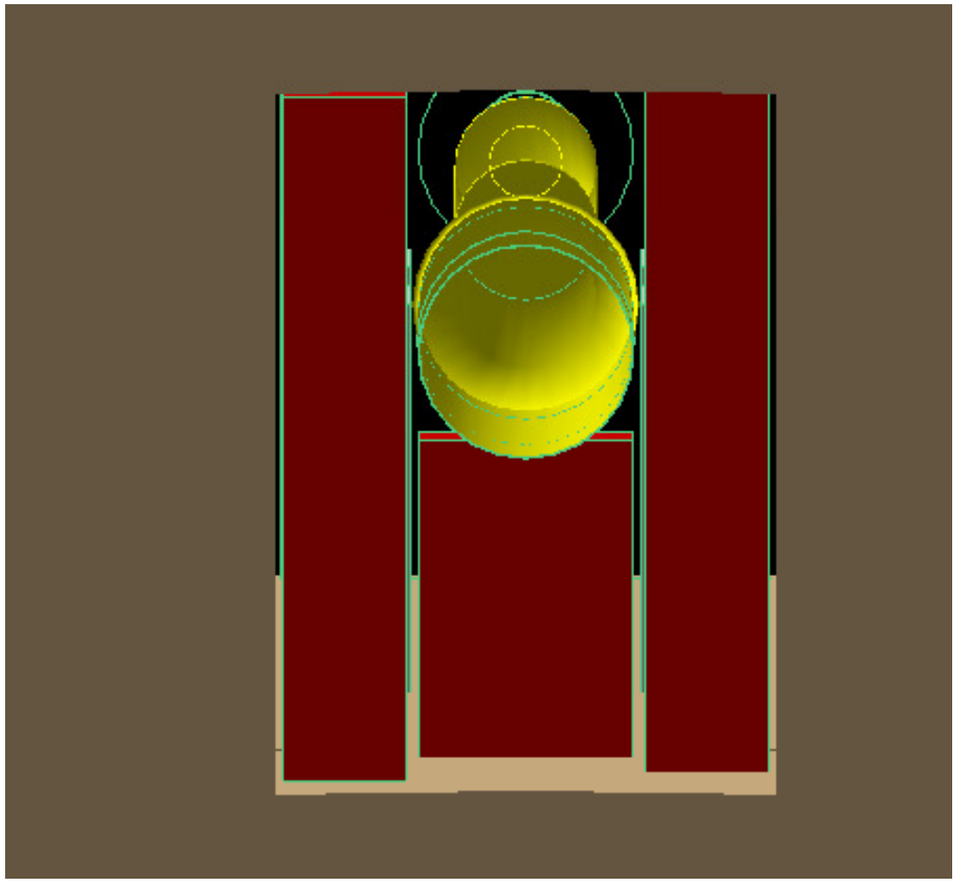




- Looking at the hall detector in the region of the dump can give us a heat map of the particles that come out of the dump
- PREX2 with the most up to date dump configuration
  - Left (all particles above 1 MeV crossing the detector); Right: those that have negative z momentum components

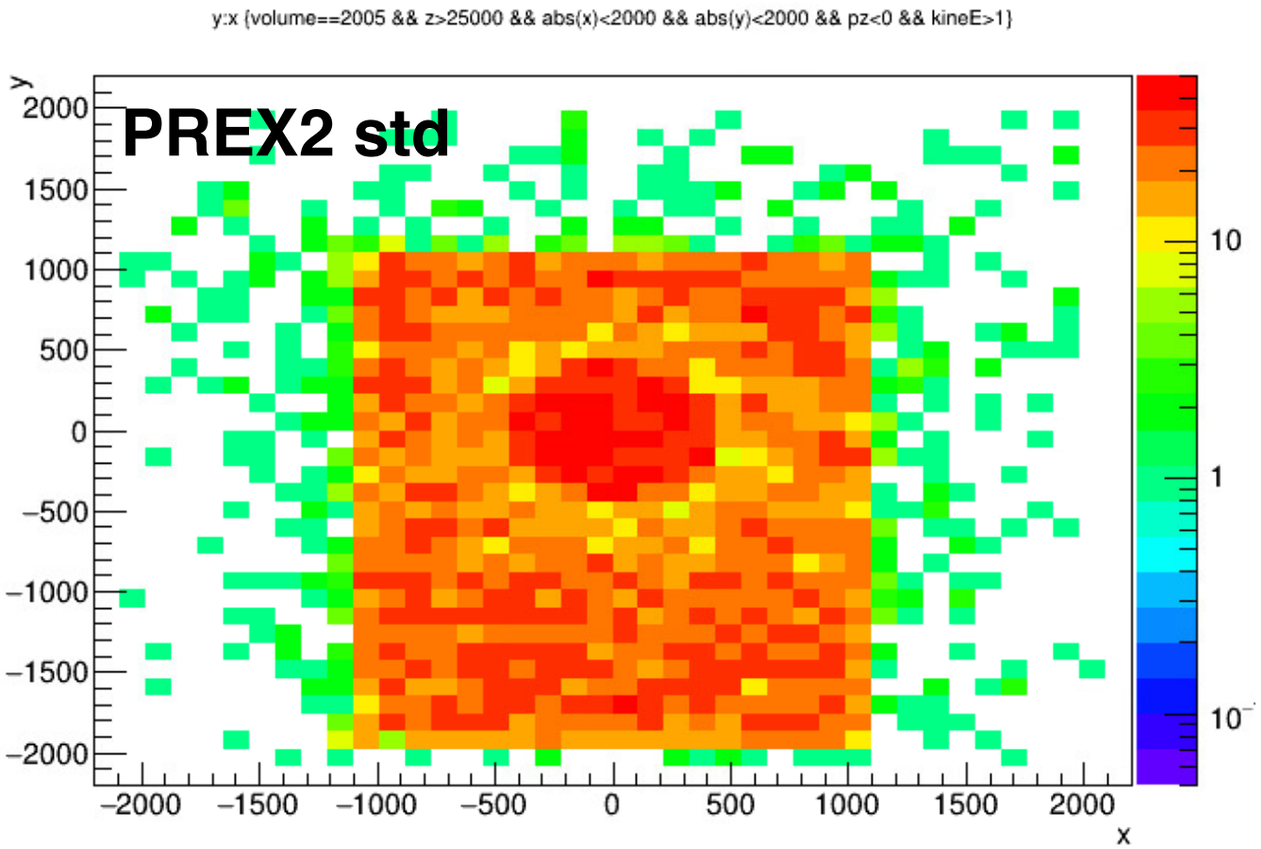
Particle heatmap

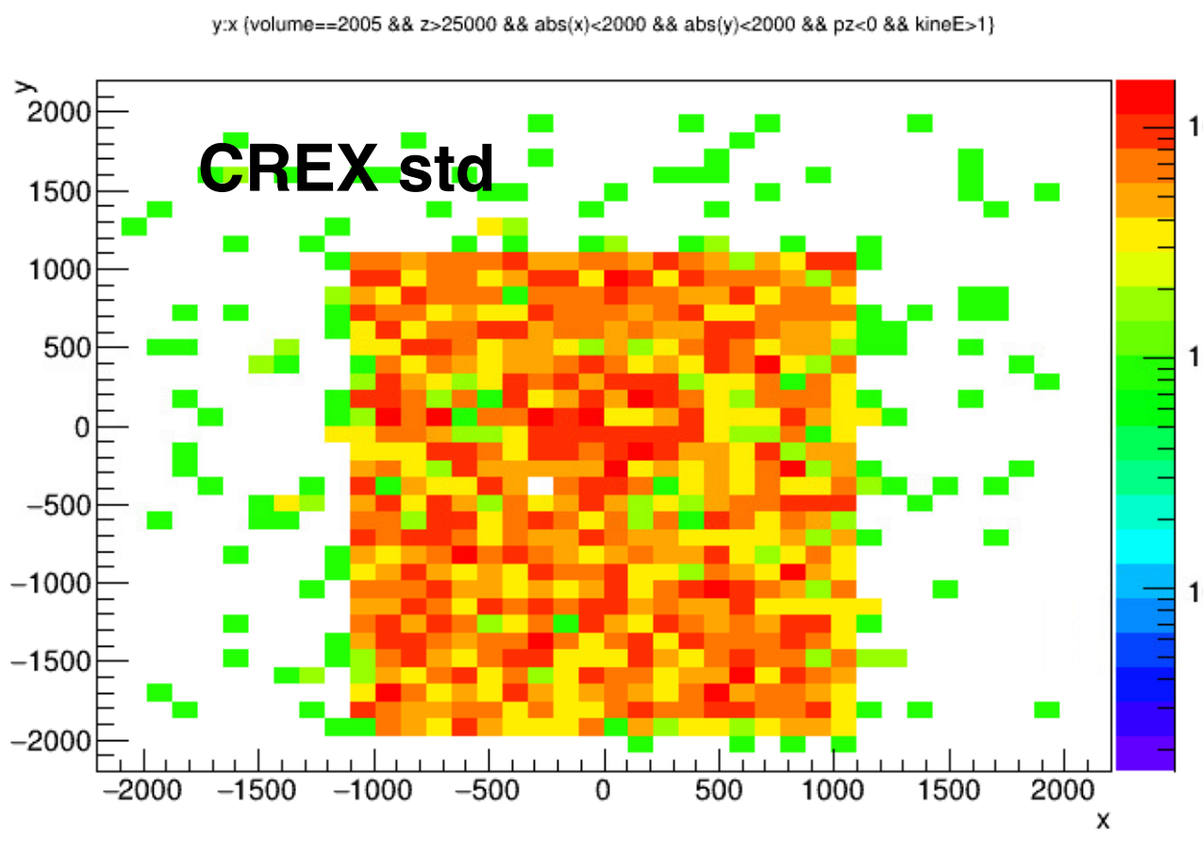


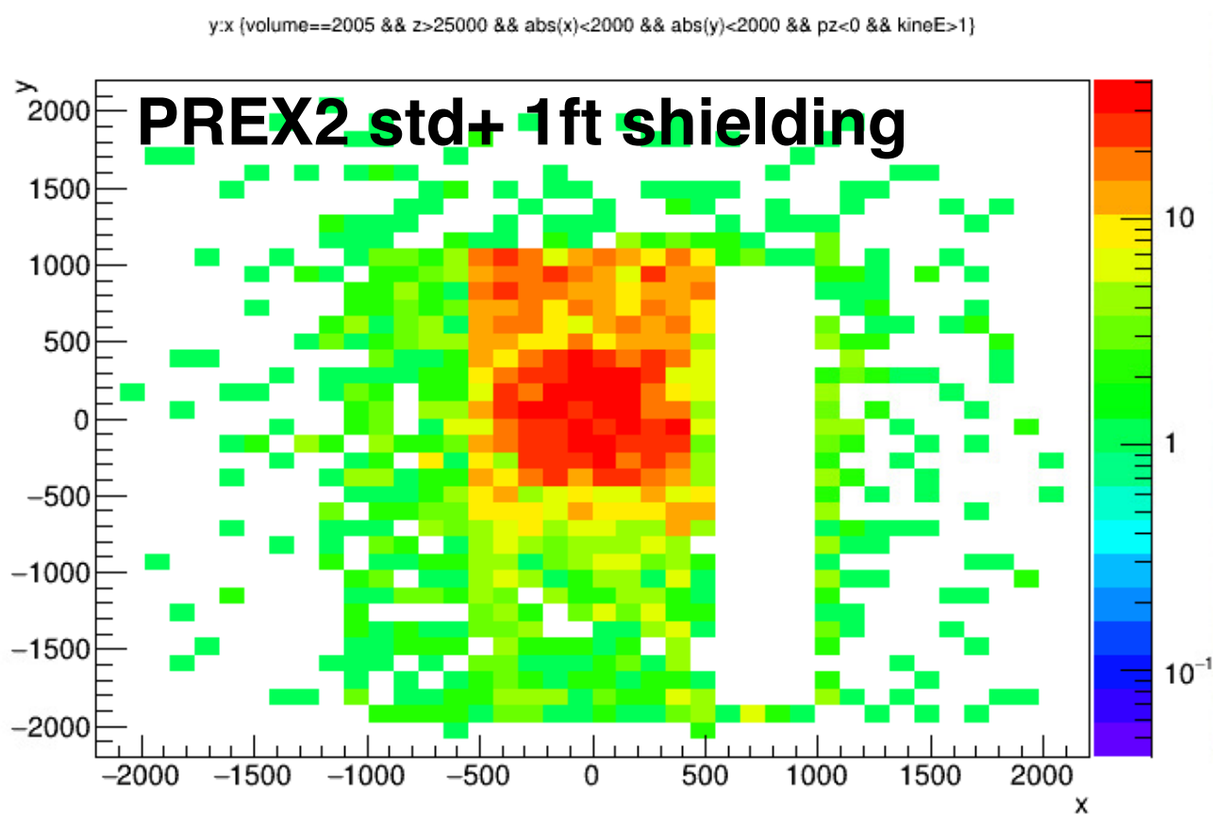


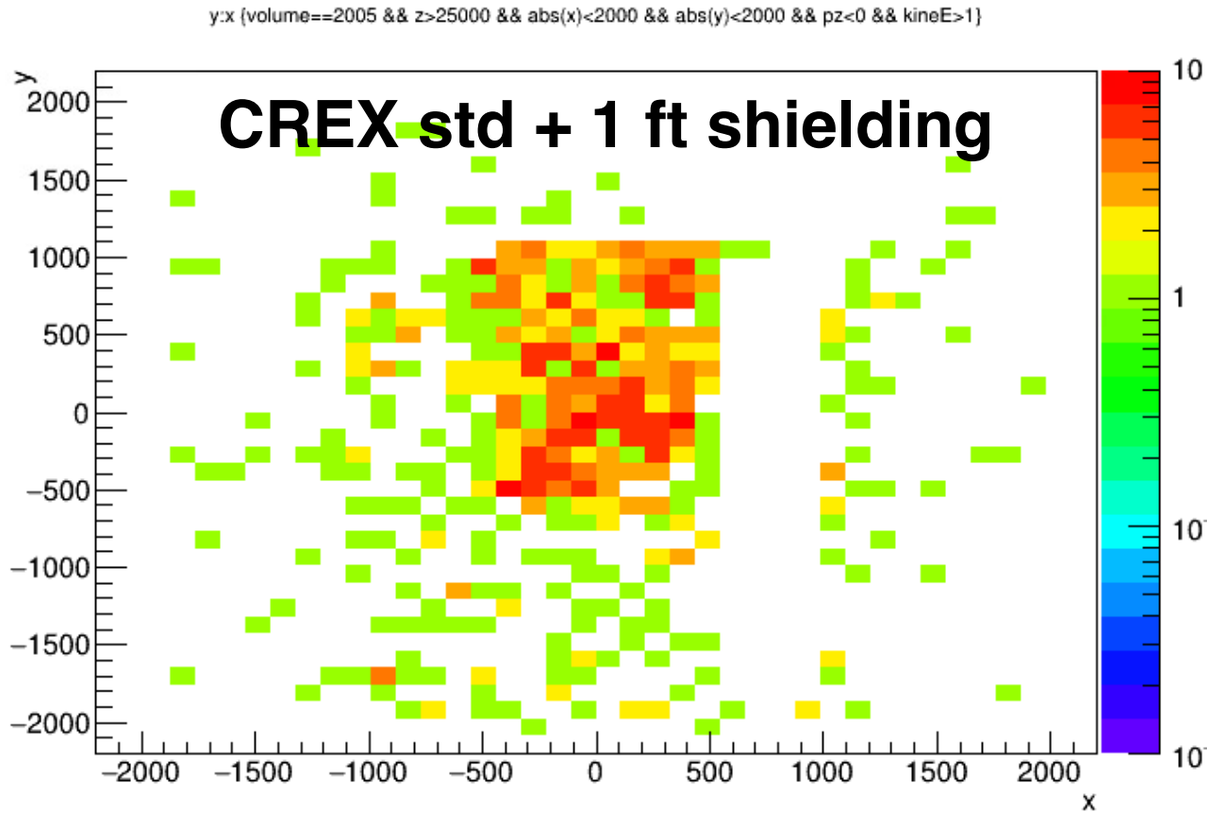
- Because the PREX2 radiation comes (mostly) from the neck down the best way to fix this is with local shielding of the dump area
  - increasing the donut to a larger aperture would certainly fix this problem for CREX but will not be sufficient for PREX
- Implemented 3 rectangular (1 foot thick) concrete blocks in the dump entrance (staggered so that we don’t remove access to the area)

Particle heatmap

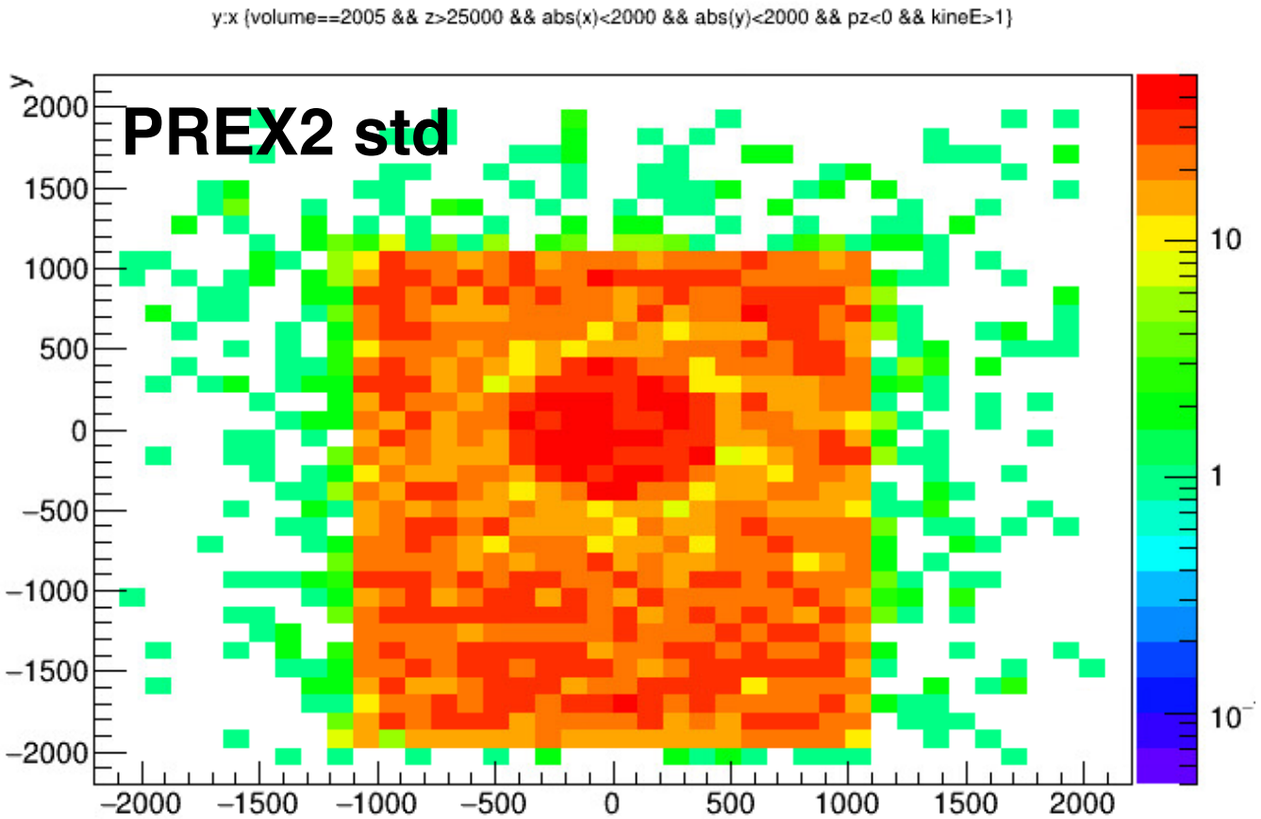




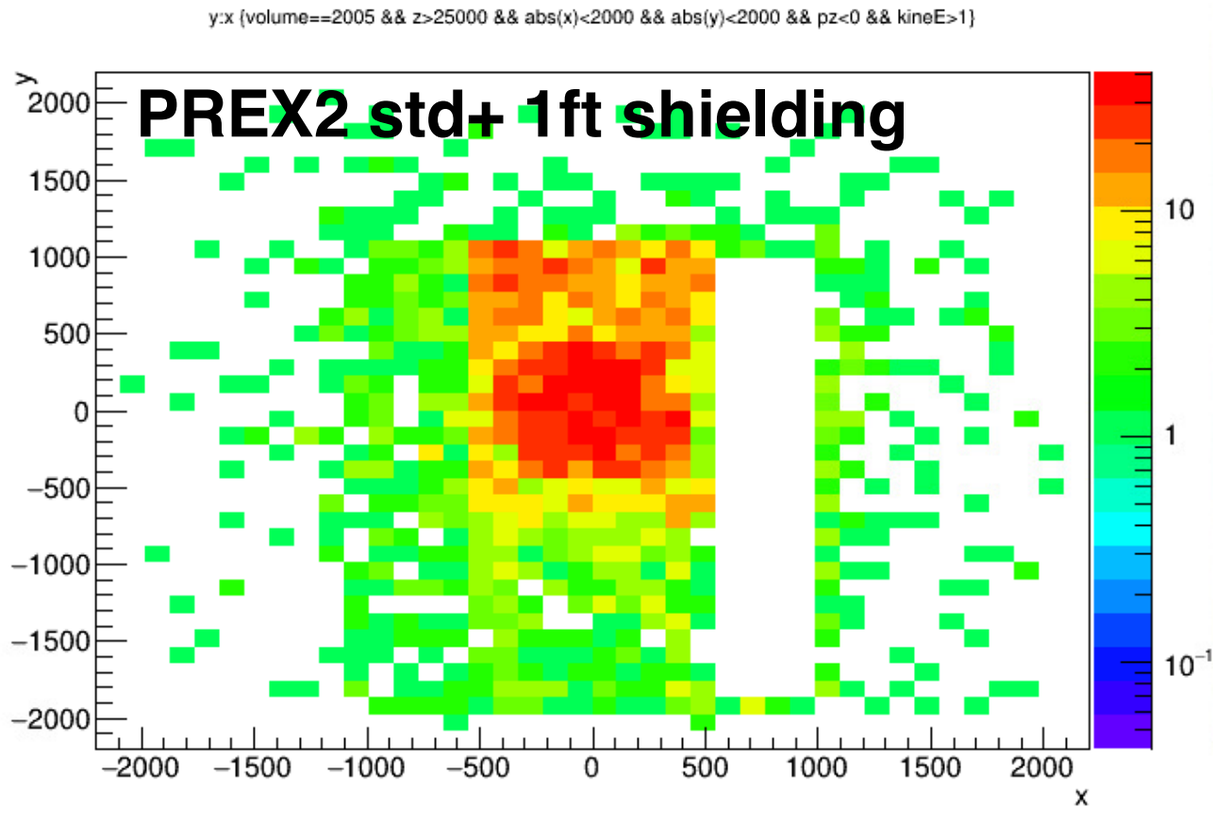


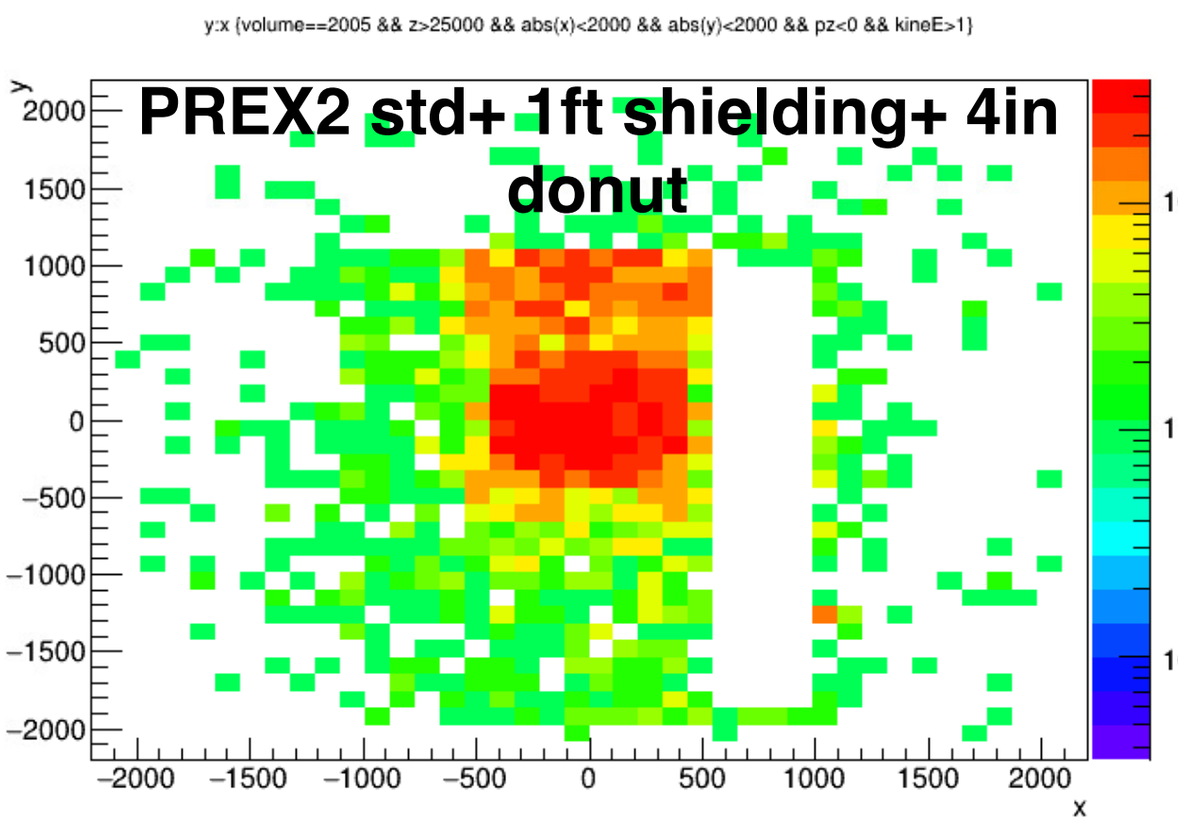


Particle heatmap



- Increasing the aperture for PREX did not produce and additional benefit
  - I did double check that I ran the correct geometry





HRS Tables - PREX

	PREX 1 (1 GeV updated dump, Al door)			
	HRS det	val	d(val)	
	NEIL Run total:	4.05E+10	1.68E+09	
	Power Run total:	1.35E+13	4.24E+10	
	EnergyRange	E/electron [MeV]	NEIL/electron	
e	0 to 0.11	9.90E-08	0.00E+00	EM power
e	0.11 to 10.96	1.32E-04	1.42E-05	5.05E-04
e	E > 10.96	1.07E-04	3.82E-06	EM NEIL
g	0 to 0.11	1.45E-05	0.00E+00	1.81E-05
g	0.11 to 10.96	2.26E-04	0.00E+00	N power
g	E > 10.96	2.59E-05	0.00E+00	9.52E-05
n	0 to 0.16	2.82E-08	3.30E-08	N NEIL
n	0.16 to 39.81	1.67E-05	1.09E-05	1.35E-05
n	E > 39.81	7.85E-05	2.59E-06	Total NEIL
				3.16E-05

	PREX 1 ERR (1 GeV old dump, steel plate at front)			
	HRS det	val	d(val)	
	NEIL Run total:	4.60E+10	1.79E+09	
	Power Run total:	1.26E+13	4.11E+10	
	EnergyRange	E/electron[MeV]	NEIL/electron	
e	0 to 0.11	6.63E-08	0.00E+00	EM power
e	0.11 to 10.96	1.37E-04	1.45E-05	5.27E-04
e	E > 10.96	1.13E-04	4.13E-06	EM NEIL
g	0 to 0.11	1.07E-05	0.00E+00	1.86E-05
g	0.11 to 10.96	2.41E-04	0.00E+00	N power
g	E > 10.96	2.52E-05	0.00E+00	7.60E-05
n	0 to 0.16	2.72E-08	3.22E-08	N NEIL
n	0.16 to 39.81	2.08E-05	1.44E-05	1.73E-05
n	E > 39.81	5.52E-05	2.84E-06	Total NEIL
				3.59E-05

	PREX 2 (1 GeV Al door in dump. nominal donut)			
	HRS det	val	d(val)	
	NEIL Run total:	3.22E+10	3.21E+09	
	Power Run total:	1.27E+13	6.97E+10	
	EnergyRange	E/electron[MeV]	NEIL/electron	
e	0 to 0.11	8.72E-08	0.00E+00	EM power
e	0.11 to 10.96	2.18E-05	2.58E-06	1.23E-04
e	E > 10.96	1.31E-05	4.18E-07	EM NEIL
g	0 to 0.11	8.88E-06	0.00E+00	3.00E-06
g	0.11 to 10.96	7.22E-05	0.00E+00	N power
g	E > 10.96	6.96E-06	0.00E+00	5.22E-05
n	0 to 0.16	1.58E-08	1.89E-08	N NEIL
n	0.16 to 39.81	1.24E-05	7.81E-06	9.13E-06
n	E > 39.81	3.98E-05	1.30E-06	Total NEIL
				1.21E-05

	PREX 2: ERR			
	HRS det	val	d(val)	
	NEIL Run total:	4.96E+09	6.72E+08	
	Power Run total:	1.62E+12	2.10E+10	
	EnergyRange	E/electron [MeV]	NEIL/electron	
e	0 to 0.11	4.43E-09	0.00E+00	EM power
e	0.11 to 10.96	8.20E-06	8.97E-07	2.59E-05
e	E > 10.96	2.66E-06	9.90E-08	EM NEIL
g	0 to 0.11	6.90E-07	0.00E+00	9.96E-07
g	0.11 to 10.96	1.38E-05	0.00E+00	N power
g	E > 10.96	6.01E-07	0.00E+00	8.39E-07
n	0 to 0.16	1.52E-08	1.89E-08	N NEIL
n	0.16 to 39.81	8.24E-07	8.53E-07	8.72E-07
n	E > 39.81	0.00E+00	0.00E+00	Total NEIL
				1.87E-06

HRS Tables - PREX

	PREX 1 (1 GeV updated dump, Al door)			
	HRS det	val	d(val)	
	NEIL Run total:	4.05E+10	1.68E+09	
	Power Run total:	1.35E+13	4.24E+10	
	EnergyRange	E/electron [MeV]	NEIL/electron	
e	0 to 0.11	9.90E-08	0.00E+00	EM power
e	0.11 to 10.96	1.32E-04	1.42E-05	5.05E-04
e	E > 10.96	1.07E-04	3.82E-06	EM NEIL
g	0 to 0.11	1.45E-05	0.00E+00	1.81E-05
g	0.11 to 10.96	2.26E-04	0.00E+00	N power
g	E > 10.96	2.59E-05	0.00E+00	9.52E-05
n	0 to 0.16	2.82E-08	3.30E-08	N NEIL
n	0.16 to 39.81	1.67E-05	1.09E-05	1.35E-05
n	E > 39.81	7.85E-05	2.59E-06	Total NEIL
				3.16E-05

	PREX 2 (1 GeV Al door in dump. nominal donut)			
	HRS det	val	d(val)	
	NEIL Run total:	3.22E+10	3.21E+09	
	Power Run total:	1.27E+13	6.97E+10	
	EnergyRange	E/electron[MeV]	NEIL/electron	
e	0 to 0.11	8.72E-08	0.00E+00	EM power
e	0.11 to 10.96	2.18E-05	2.58E-06	1.23E-04
e	E > 10.96	1.31E-05	4.18E-07	EM NEIL
g	0 to 0.11	8.88E-06	0.00E+00	3.00E-06
g	0.11 to 10.96	7.22E-05	0.00E+00	N power
g	E > 10.96	6.96E-06	0.00E+00	5.22E-05
n	0 to 0.16	1.58E-08	1.89E-08	N NEIL
n	0.16 to 39.81	1.24E-05	7.81E-06	9.13E-06
n	E > 39.81	3.98E-05	1.30E-06	Total NEIL
				1.21E-05

	PREX2: Al door, nominal donut, dump shield			
	HRS det	val	d(val)	
	NEIL Run total:	1.04E+10	1.83E+09	
	Power Run total:	4.67E+12	4.98E+10	
	EnergyRange	E/electron[MeV]	NEIL/electron	
e	0 to 0.11	2.34E-08	0.00E+00	EM power
e	0.11 to 10.96	1.34E-05	1.52E-06	6.33E-05
e	E > 10.96	8.75E-06	3.58E-07	EM NEIL
g	0 to 0.11	2.97E-06	0.00E+00	1.88E-06
g	0.11 to 10.96	3.16E-05	0.00E+00	N power
g	E > 10.96	6.55E-06	0.00E+00	5.52E-06
n	0 to 0.16	1.61E-08	1.82E-08	N NEIL
n	0.16 to 39.81	2.15E-06	1.64E-06	2.05E-06
n	E > 39.81	3.35E-06	3.91E-07	Total NEIL
				3.92E-06

	PREX2: Al door, nominal donut, dump shield, 4in donut			
	HRS det	val	d(val)	
	NEIL Run total:	1.35E+10	2.32E+09	
	Power Run total:	4.50E+12	4.94E+10	
	EnergyRange	E/electron[MeV]	NEIL/electron	
e	0 to 0.11	2.41E-08	0.00E+00	EM power
e	0.11 to 10.96	1.26E-05	1.39E-06	5.67E-05
e	E > 10.96	9.47E-06	3.11E-07	EM NEIL
g	0 to 0.11	2.79E-06	0.00E+00	1.70E-06
g	0.11 to 10.96	3.05E-05	0.00E+00	N power
g	E > 10.96	1.38E-06	0.00E+00	3.06E-05
n	0 to 0.16	2.24E-08	2.33E-08	N NEIL
n	0.16 to 39.81	2.67E-06	2.29E-06	3.39E-06
n	E > 39.81	2.79E-05	1.07E-06	Total NEIL
				5.09E-06

HRS Tables - CREX

	PREX 1 (1 GeV updated dump, Al door)			
	HRS det	val	d(val)	
	NEIL Run total:	4.05E+10	1.68E+09	
	Power Run total:	1.35E+13	4.24E+10	
	EnergyRange	E/electron [MeV]	NEIL/electron	
e	0 to 0.11	9.90E-08	0.00E+00	EM power
e	0.11 to 10.96	1.32E-04	1.42E-05	5.05E-04
e	E > 10.96	1.07E-04	3.82E-06	EM NEIL
g	0 to 0.11	1.45E-05	0.00E+00	1.81E-05
g	0.11 to 10.96	2.26E-04	0.00E+00	N power
g	E > 10.96	2.59E-05	0.00E+00	9.52E-05
n	0 to 0.16	2.82E-08	3.30E-08	N NEIL
n	0.16 to 39.81	1.67E-05	1.09E-05	1.35E-05
n	E > 39.81	7.85E-05	2.59E-06	Total NEIL
				3.16E-05

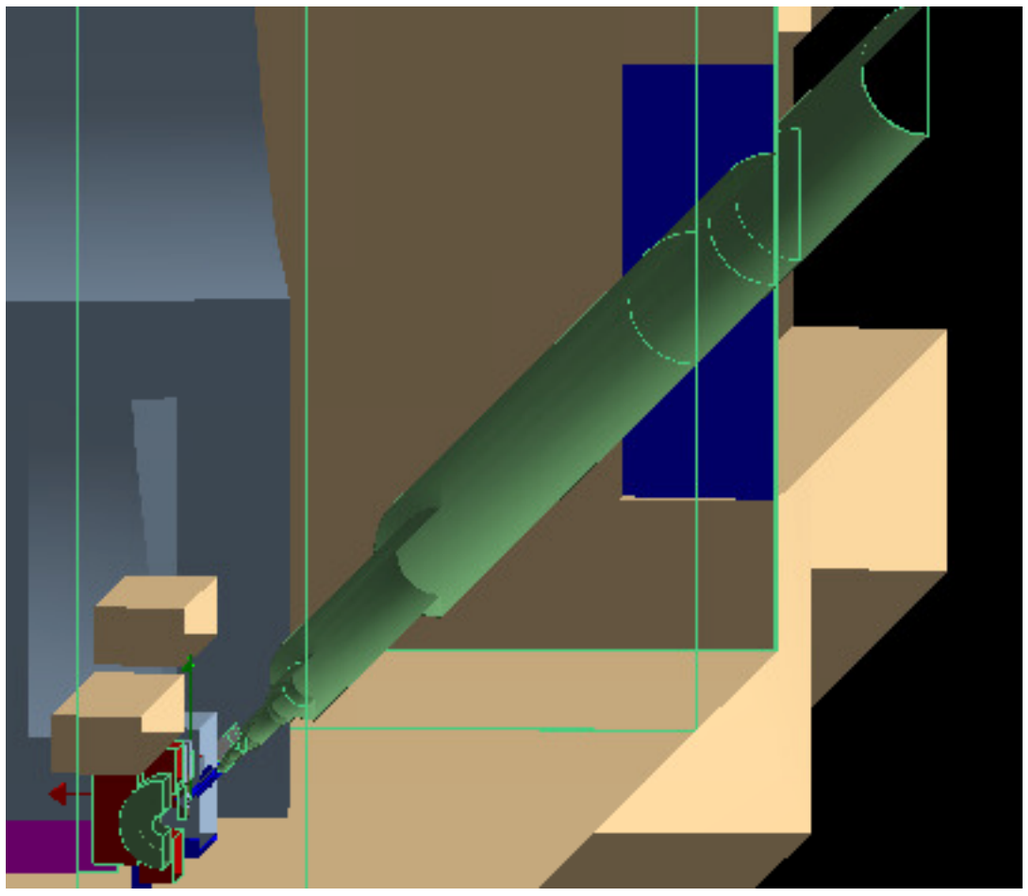
	CREX: 2 GeV, Al door, nominal donut			
	HRS det	val	d(val)	
	NEIL Run total:	2.14E+10	4.11E+09	
	Power Run total:	6.78E+12	7.11E+10	
	EnergyRange	E/electron[MeV]	NEIL/electron	
e	0 to 0.11	1.28E-08	0.00E+00	EM power
e	0.11 to 10.96	4.42E-06	5.07E-07	2.45E-05
e	E > 10.96	2.76E-06	1.05E-07	EM NEIL
g	0 to 0.11	1.79E-06	0.00E+00	6.13E-07
g	0.11 to 10.96	1.37E-05	0.00E+00	N power
g	E > 10.96	1.84E-06	0.00E+00	1.04E-05
n	0 to 0.16	2.53E-09	2.97E-09	N NEIL
n	0.16 to 39.81	1.98E-06	1.41E-06	2.32E-06
n	E > 39.81	8.38E-06	9.06E-07	Total NEIL
				2.93E-06

	CREX: 2 GeV, Al door, nominal donut, dump shield			
	HRS det	val	d(val)	
	NEIL Run total:	1.93E+10	5.44E+09	
	Power Run total:	2.70E+12	6.36E+10	
	EnergyRange	E/electron[MeV]	NEIL/electron	
e	0 to 0.11	2.34E-09	0.00E+00	EM power
e	0.11 to 10.96	3.29E-06	3.78E-07	1.35E-05
e	E > 10.96	2.55E-06	9.09E-08	EM NEIL
g	0 to 0.11	5.88E-07	0.00E+00	4.69E-07
g	0.11 to 10.96	6.85E-06	0.00E+00	N power
g	E > 10.96	1.85E-07	0.00E+00	2.94E-05
n	0 to 0.16	2.89E-09	1.93E-09	N NEIL
n	0.16 to 39.81	1.51E-06	1.27E-06	2.17E-06
n	E > 39.81	2.79E-05	9.06E-07	Total NEIL
				2.64E-06

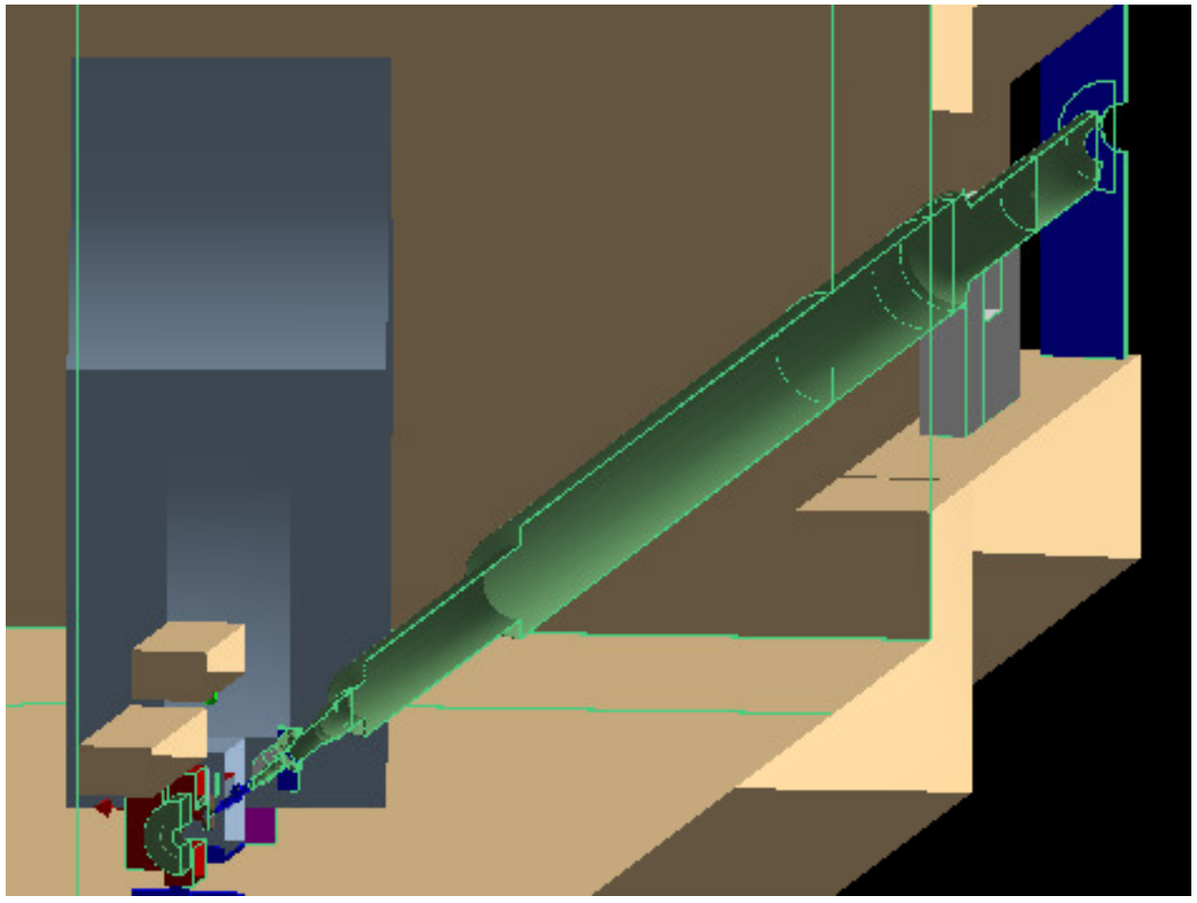
	CREX: ERR			
	HRS det	val	d(val)	
	NEIL Run total:	6.73E+09	2.05E+09	
	Power Run total:	1.52E+12	3.35E+10	
	EnergyRange	E/electron[MeV]	NEIL/electron	
e	0 to 0.11	2.65E-09	0.00E+00	EM power
e	0.11 to 10.96	2.25E-06	2.54E-07	8.65E-06
e	E > 10.96	1.09E-06	3.56E-08	EM NEIL
g	0 to 0.11	2.37E-07	0.00E+00	2.90E-07
g	0.11 to 10.96	4.46E-06	0.00E+00	N power
g	E > 10.96	6.11E-07	0.00E+00	2.13E-06
n	0 to 0.16	4.45E-09	5.80E-09	N NEIL
n	0.16 to 39.81	4.54E-07	4.25E-07	6.32E-07
n	E > 39.81	1.68E-06	2.02E-07	Total NEIL
				9.22E-07

Backup

Dump implementation



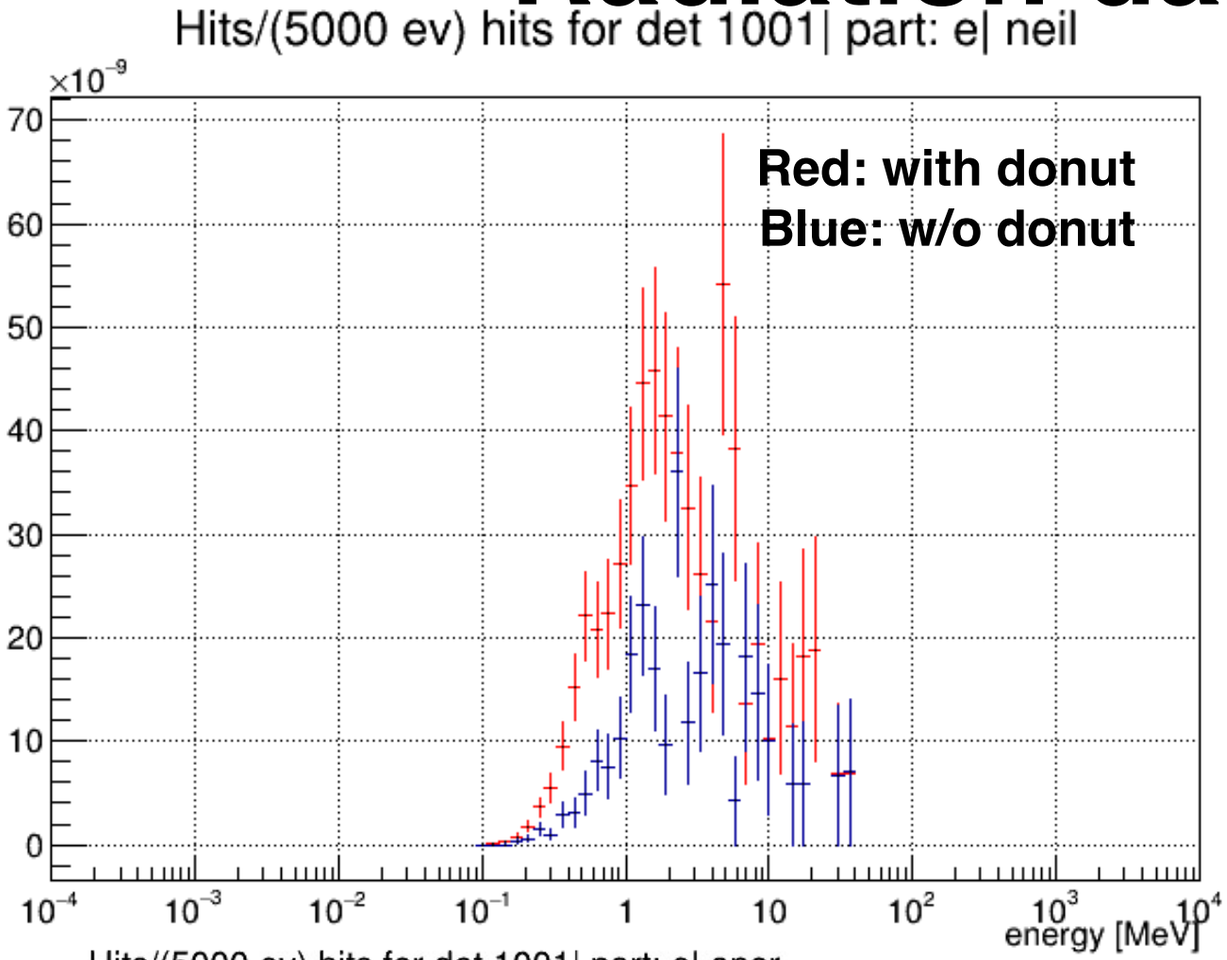
Old configuration

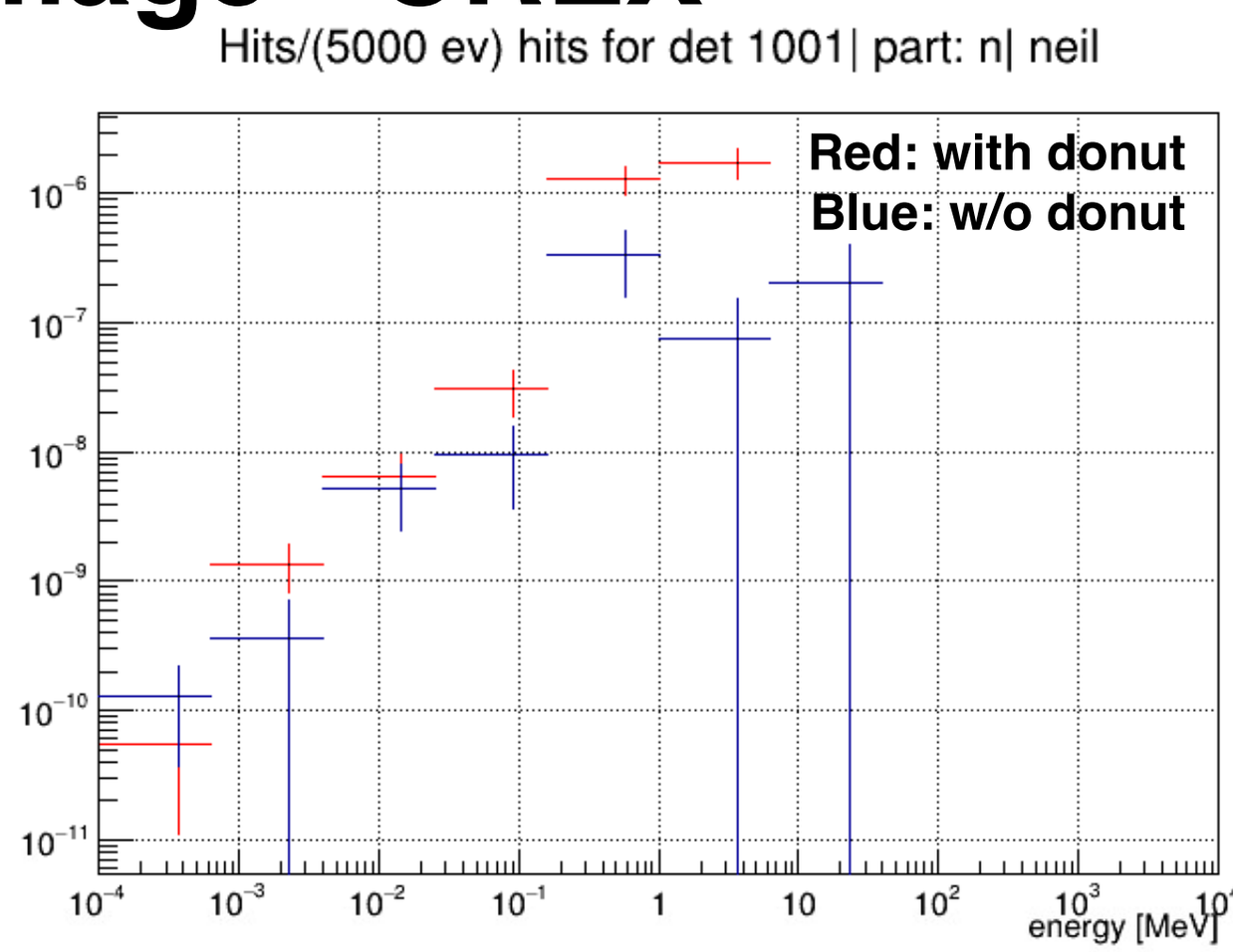


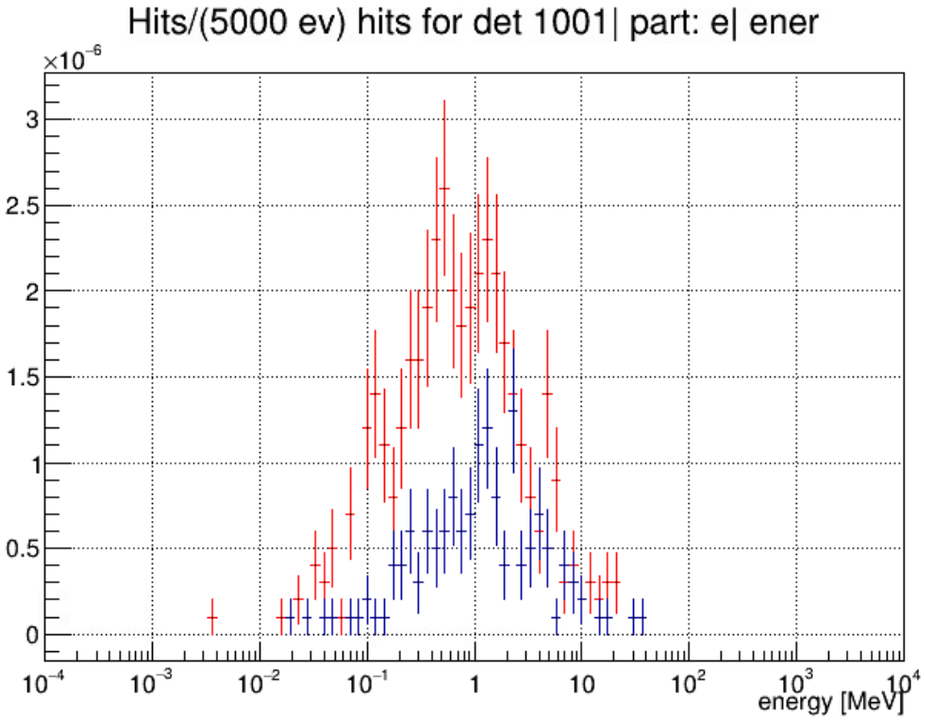
New configuration

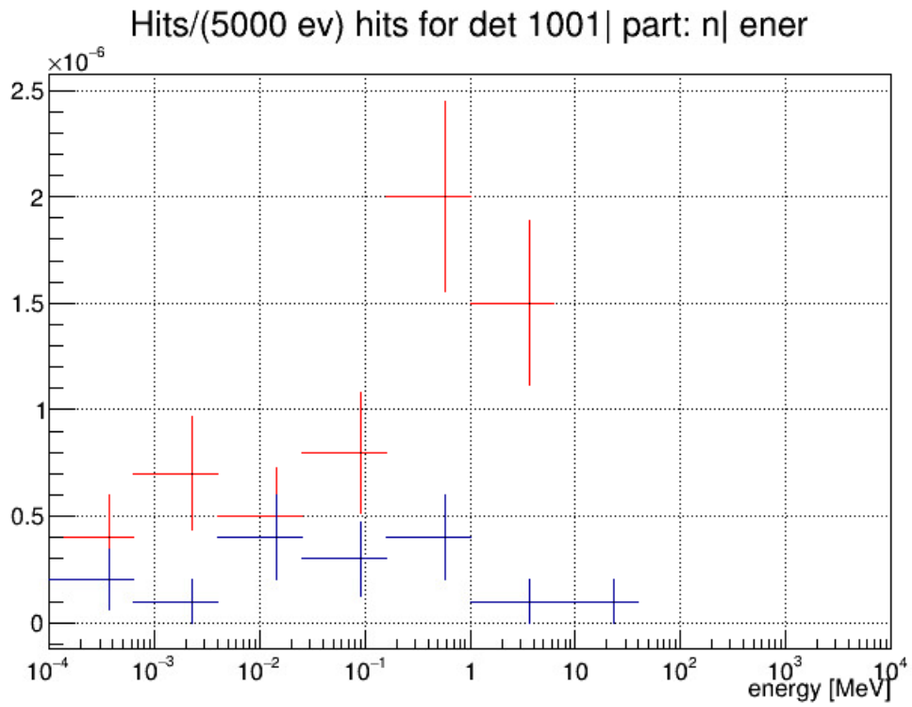
- Ran radiation study with the entire simulation
- Old dump configuration had a thick Stainless Steel cover at the entrance of the dump tunnel (to mimic splash back from the dump!?)
- The new configuration has the updated dump, donut and stainless steel divider behind beam pipe
- Both configurations have updates to the target region made by Adam

Radiation damage - CREX



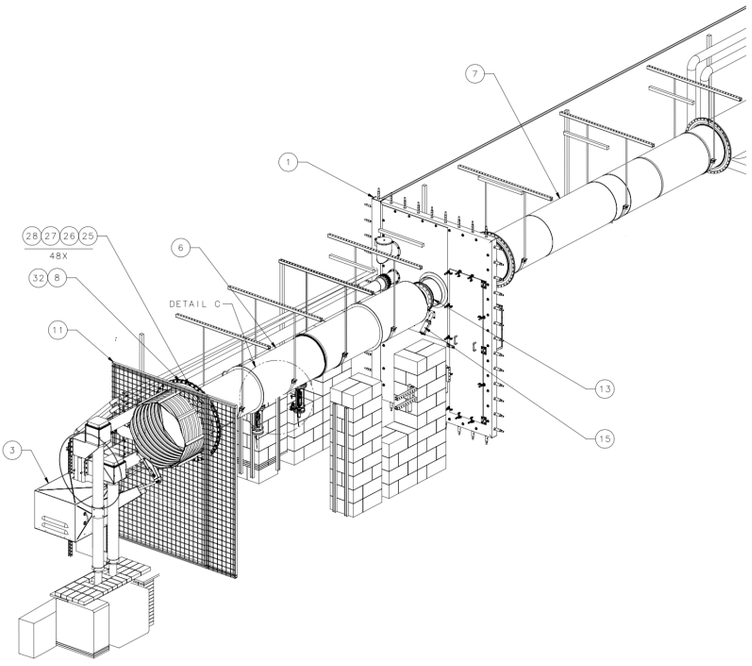


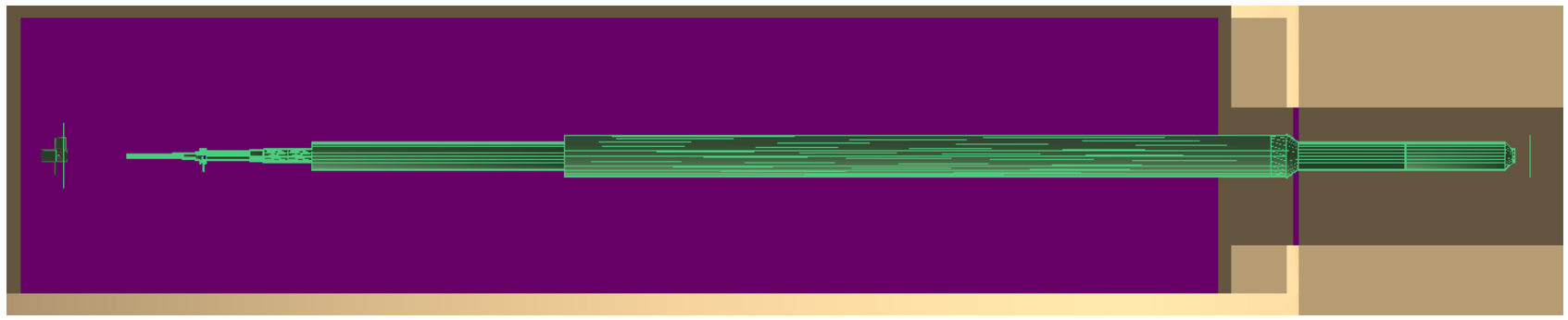




- The increase in CREX is mainly due to electromagnetic power

Conclusions





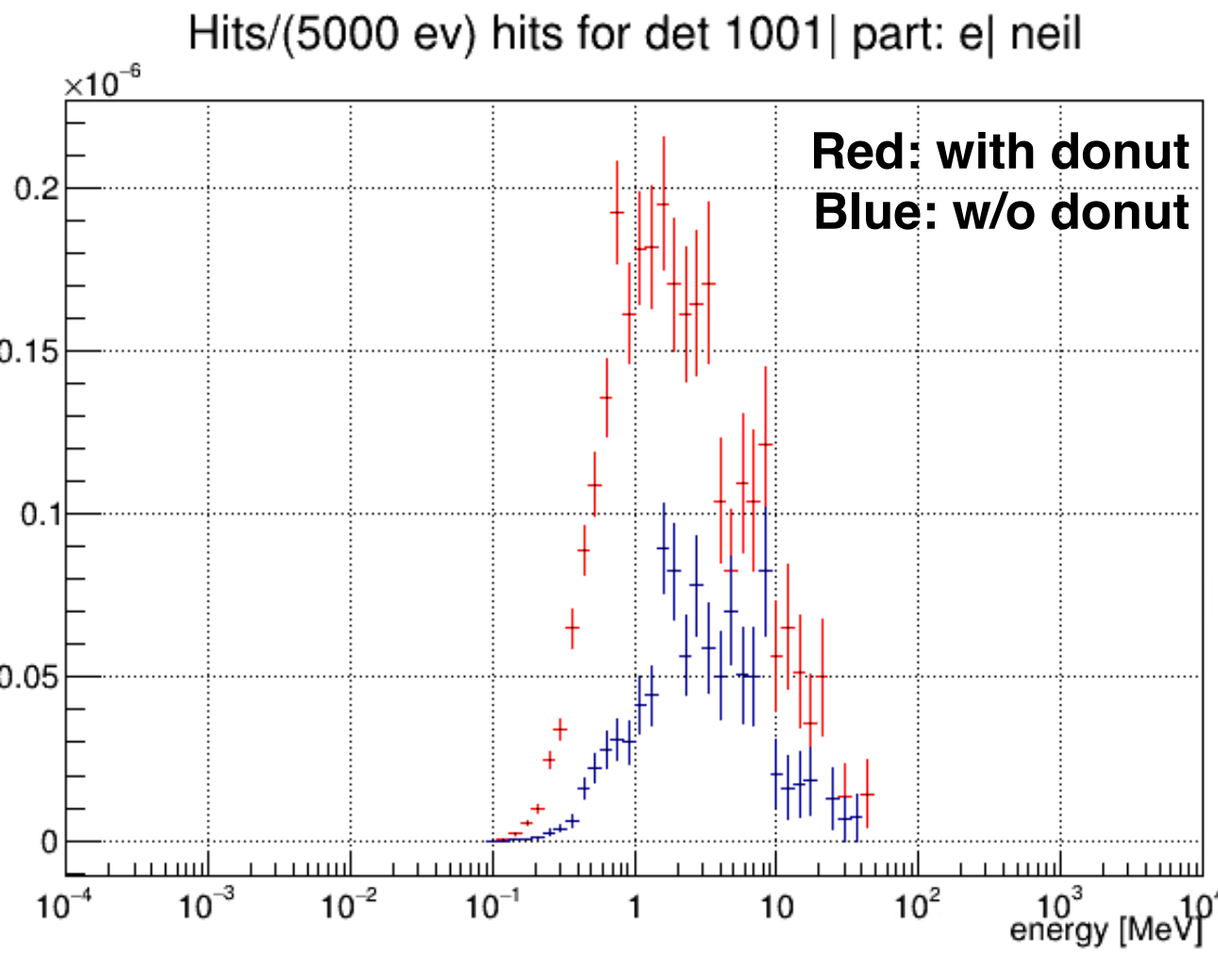
- Bob did a cross check of the current on the face of the donut and he finds reasonable agreement with my G4 simulation

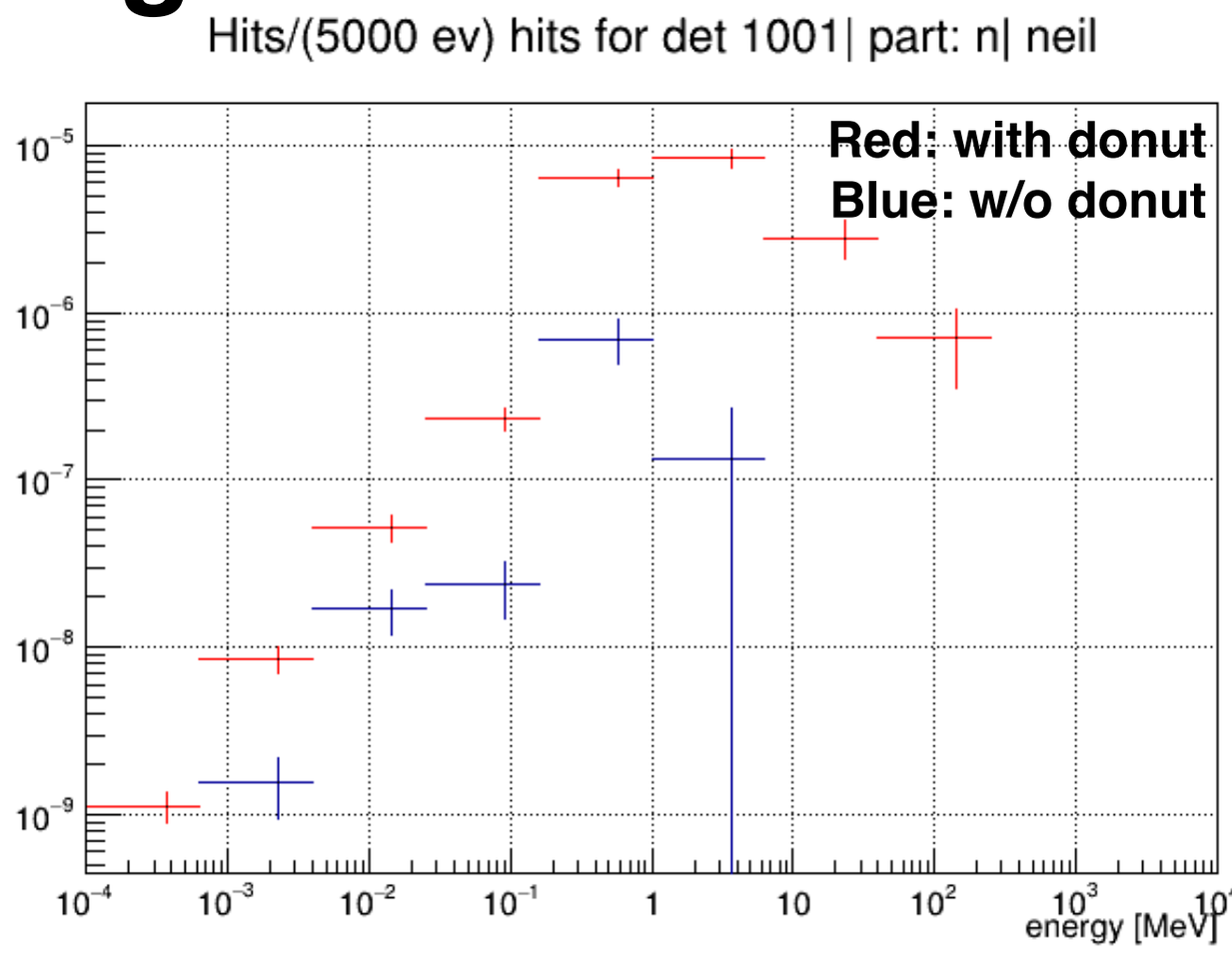
- There is a significant radiation increase in the hall from the new beam line configuration

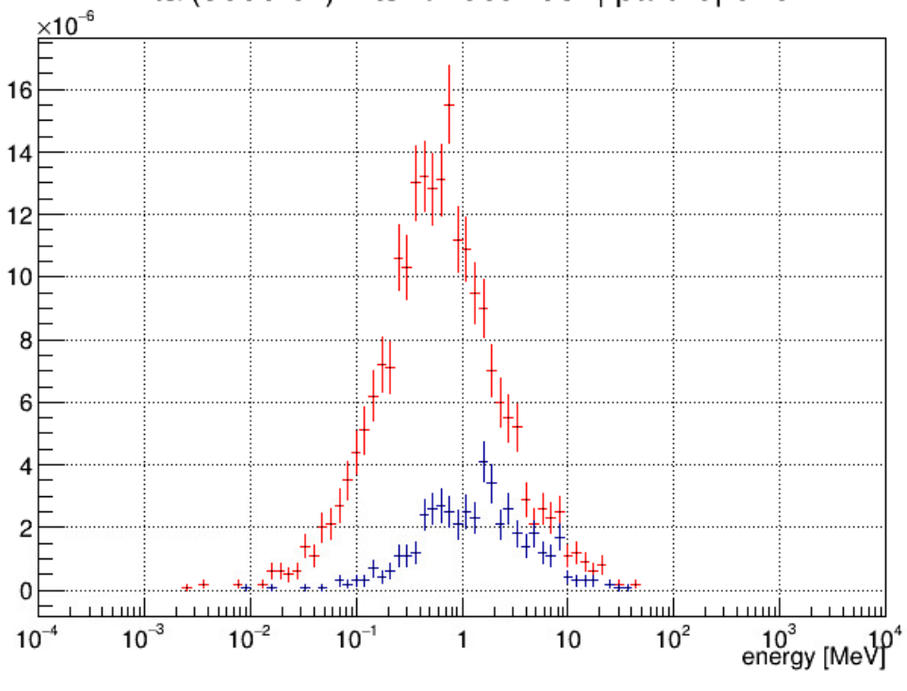
- The radiation inside the hall will be increased for both PREX and CREX (for PREX the increase will be more localized around the beam dump opening)

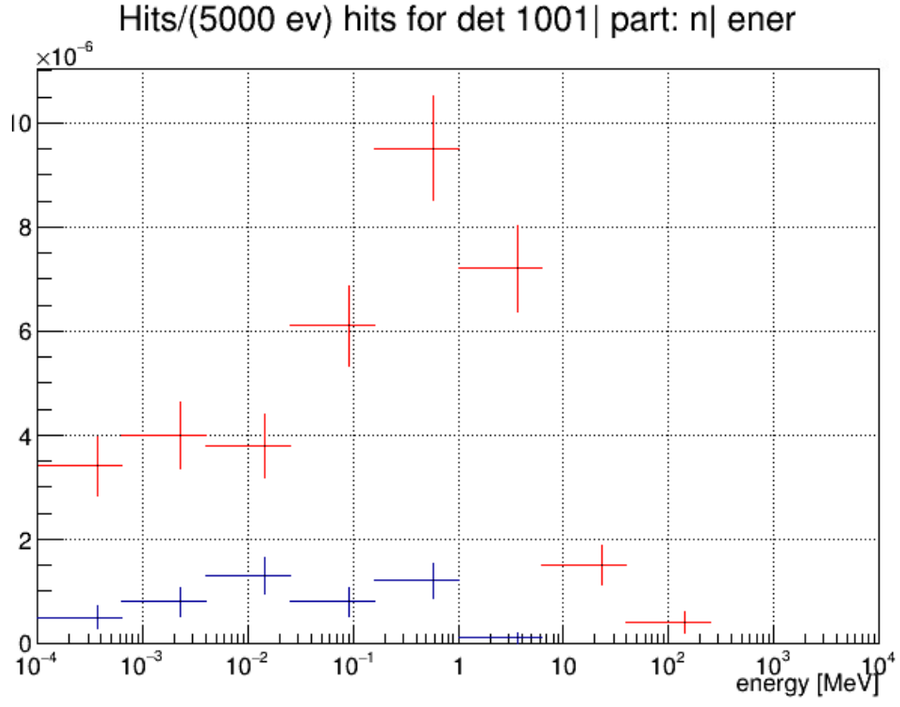
  - overall it seems to be a bigger problem for PREX

Radiation damage - PREX2



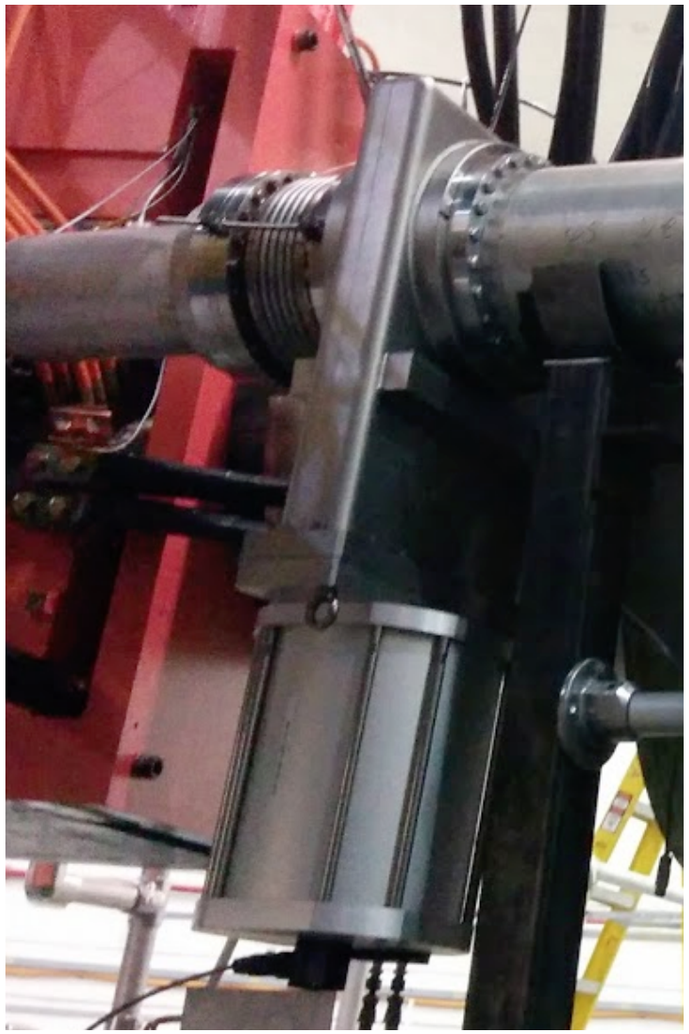




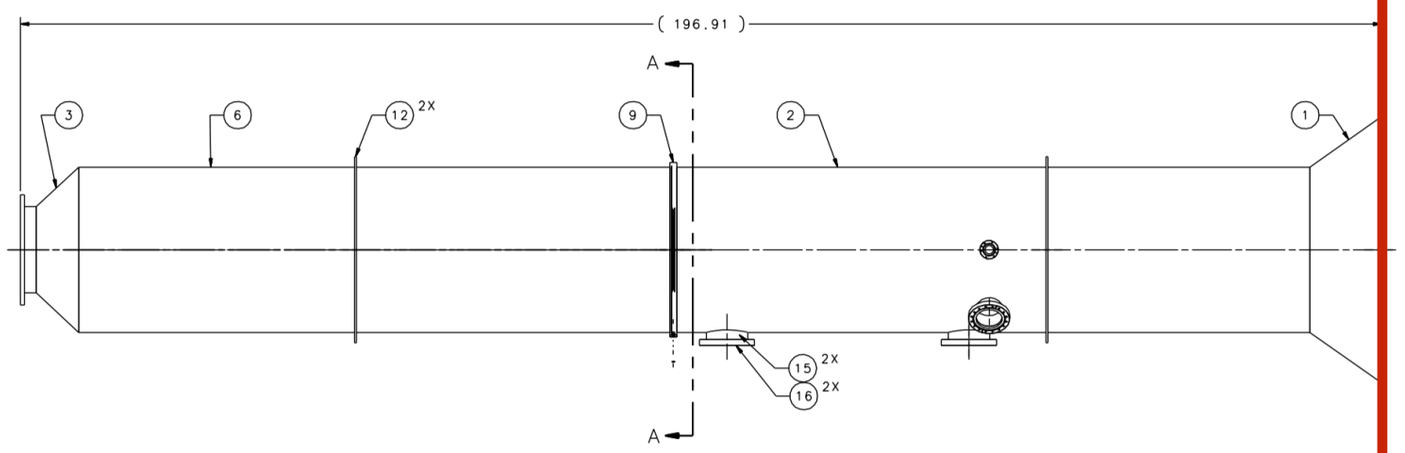


- We can see a significant increase in neutrons (with even some high energy neutrons) and electrons with the updated configuration

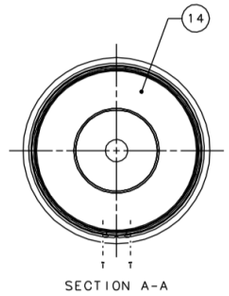
New beam pipe features



beam direction



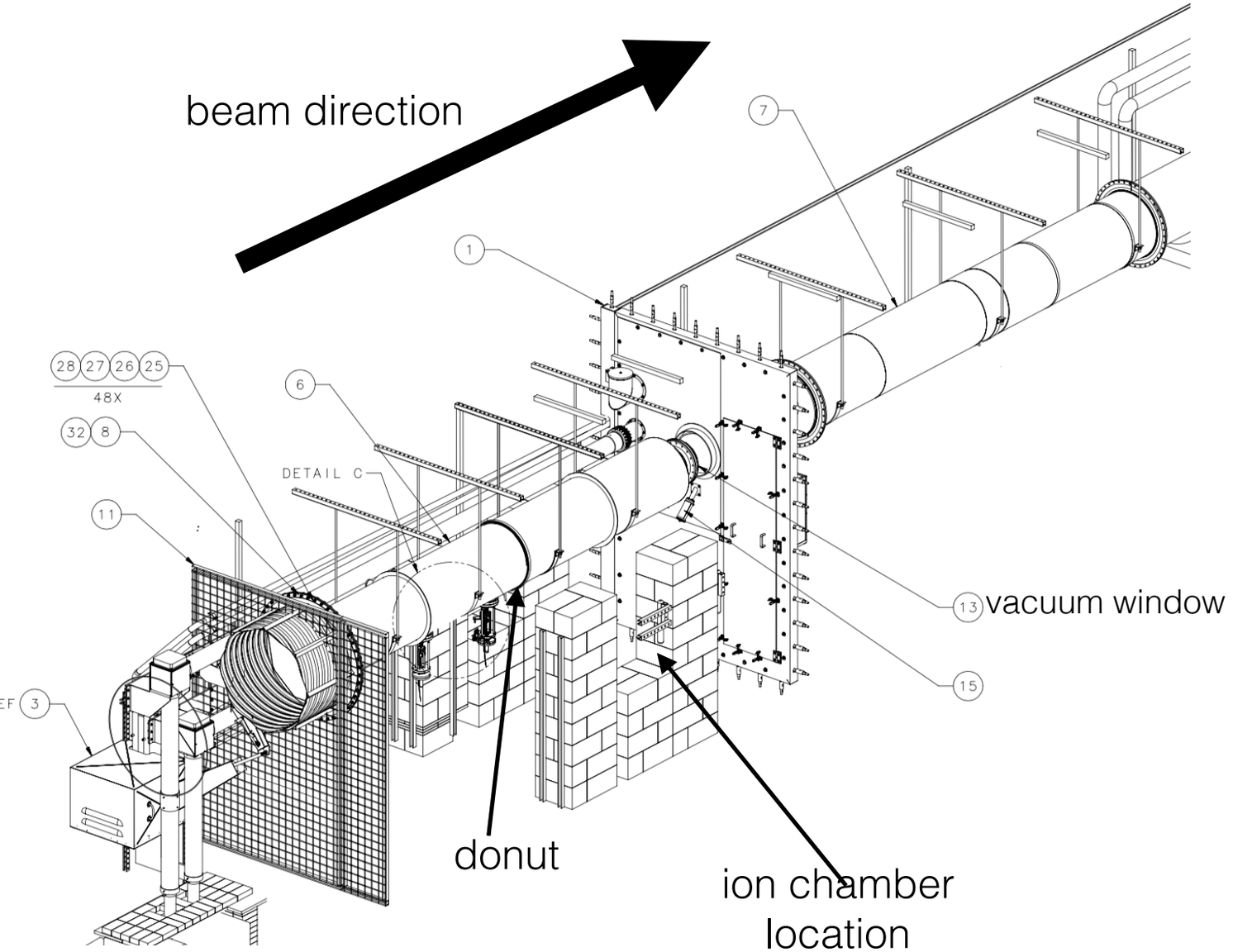
donut



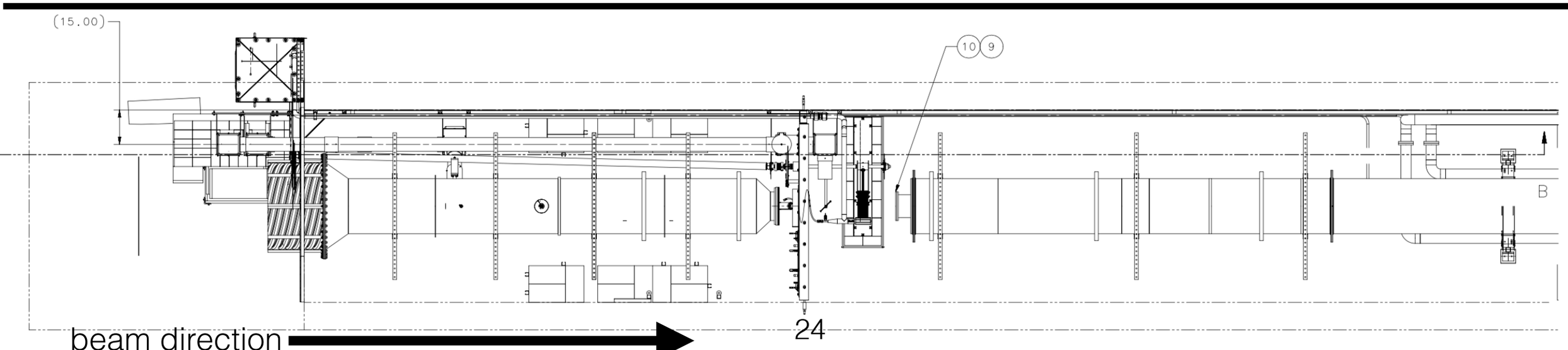
edge of hall

- gate valve: from drawings it seems that it's a 8'' gate valve joining two 8'' pipe sections
- neck down: at the hall wall (before going into the dump tunnel) the beam pipe is reduced in size
- diffuser donut: in order to protect the edge of the diffuser from beam mis-steer an Al donut is placed in front with ion chambers close behind

Dump region

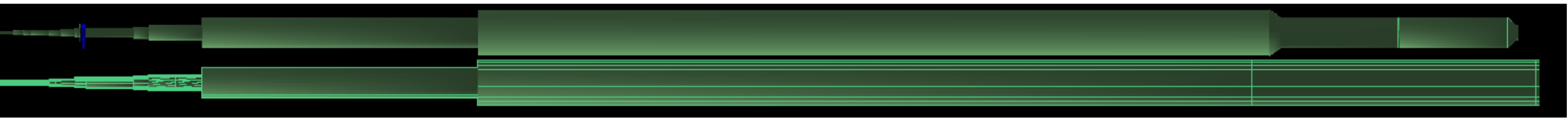


- For PREX2/CREX we will not need to use the diffuser
- The donut is removable in the Hall C design
  - not sure how difficult it would be to remove/ redesign it for Hall A
- I have only implemented the beam pipe until the vacuum window

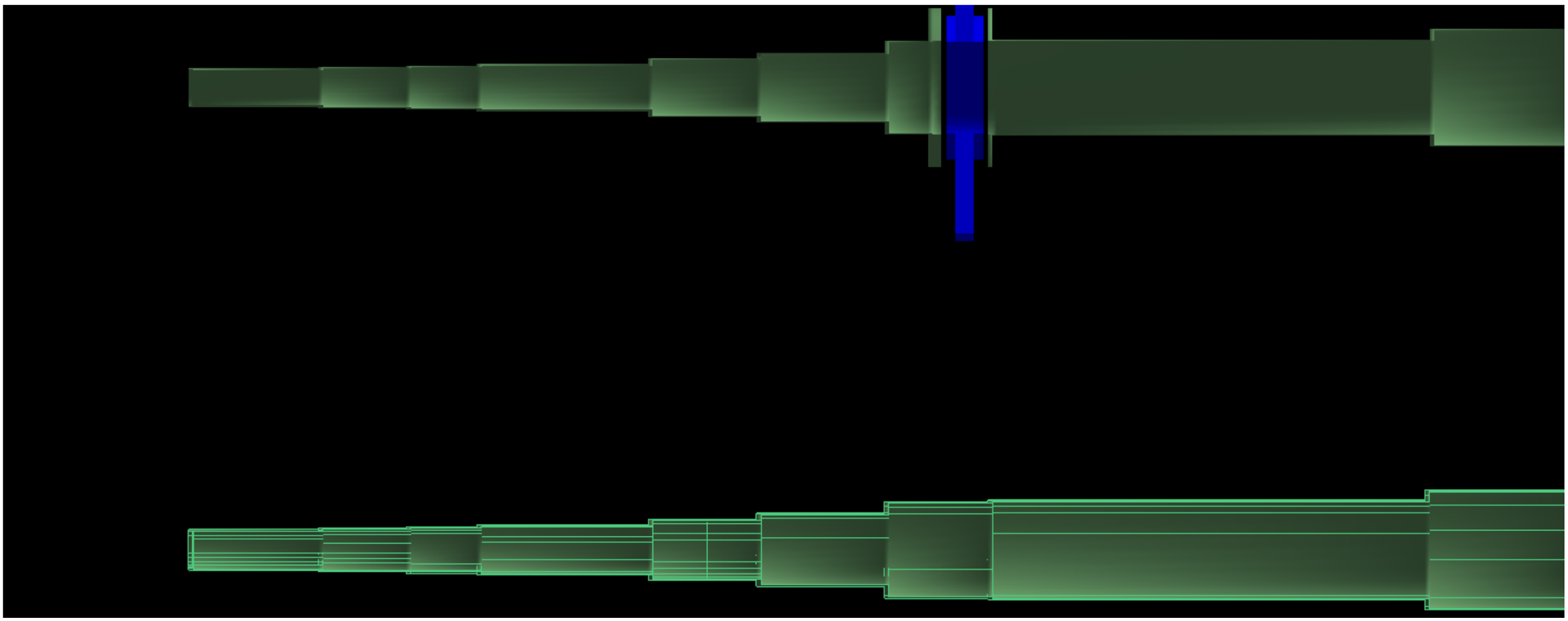


Beam pipe comparison

side by side gdml comparison: whole pipe



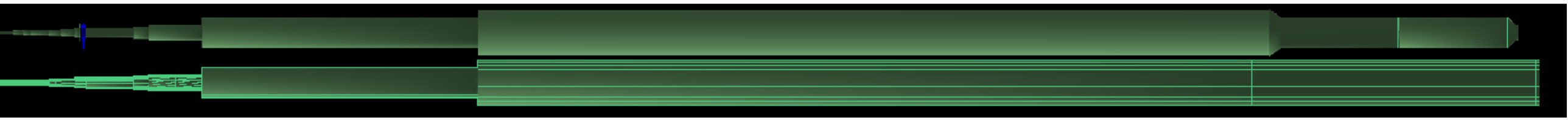
side by side gdml comparison: telescoping beam pipe



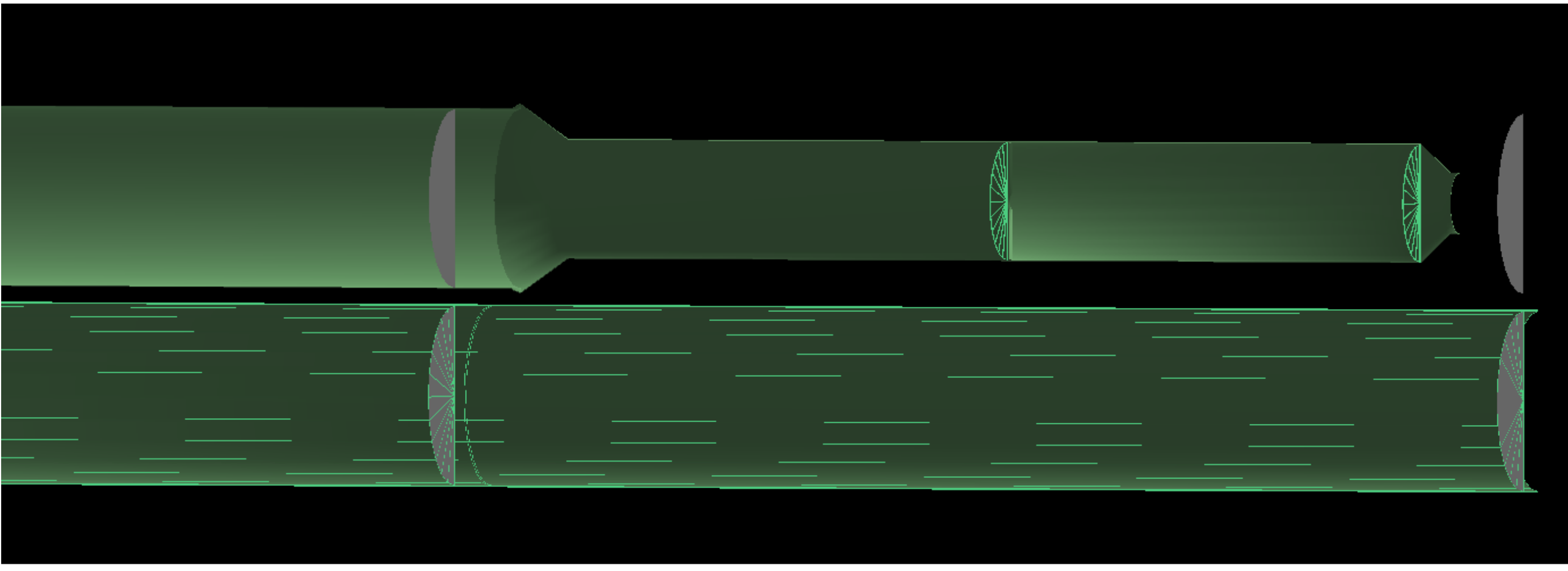
- Now there is a discontinuity in the beam pipe to allow for a stainless steel object as a stand-in for the gate valve
  - Put in Al flanges. The dimensions are from the documents (will need to check thickness of flange and z positioning)

Beam pipe comparison

side by side gdml comparison: whole pipe

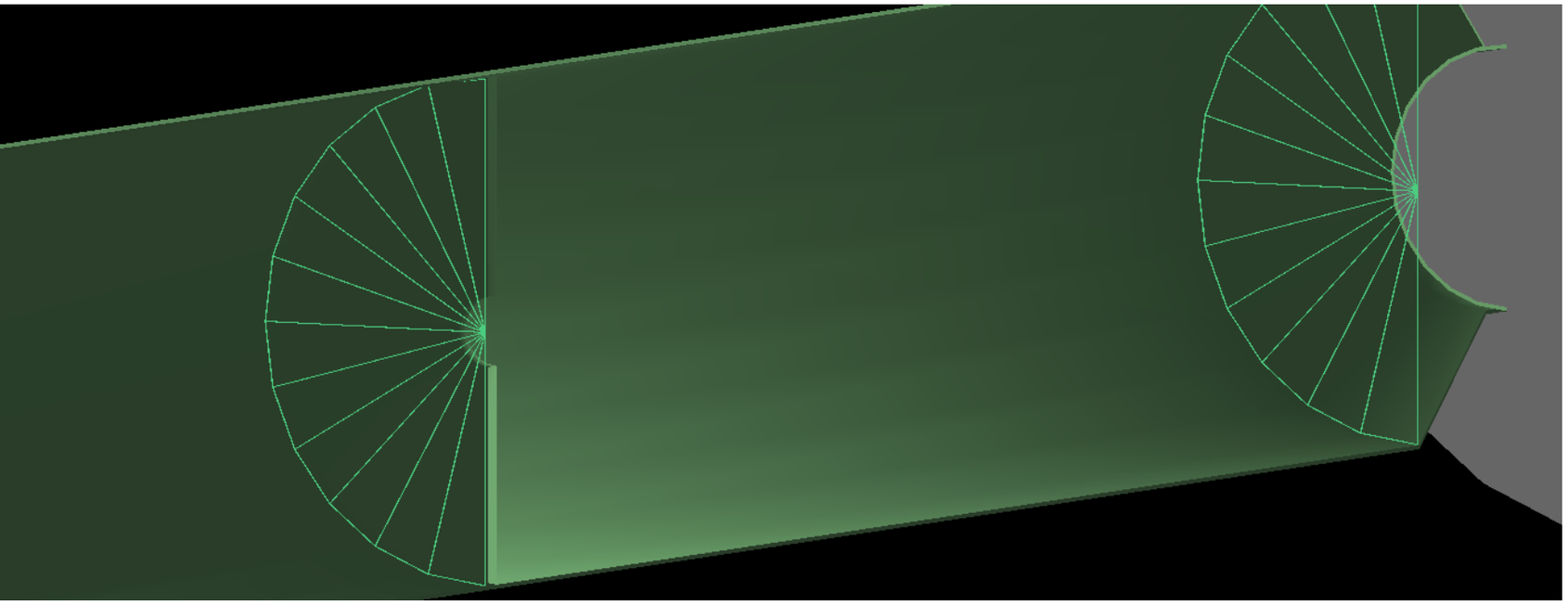


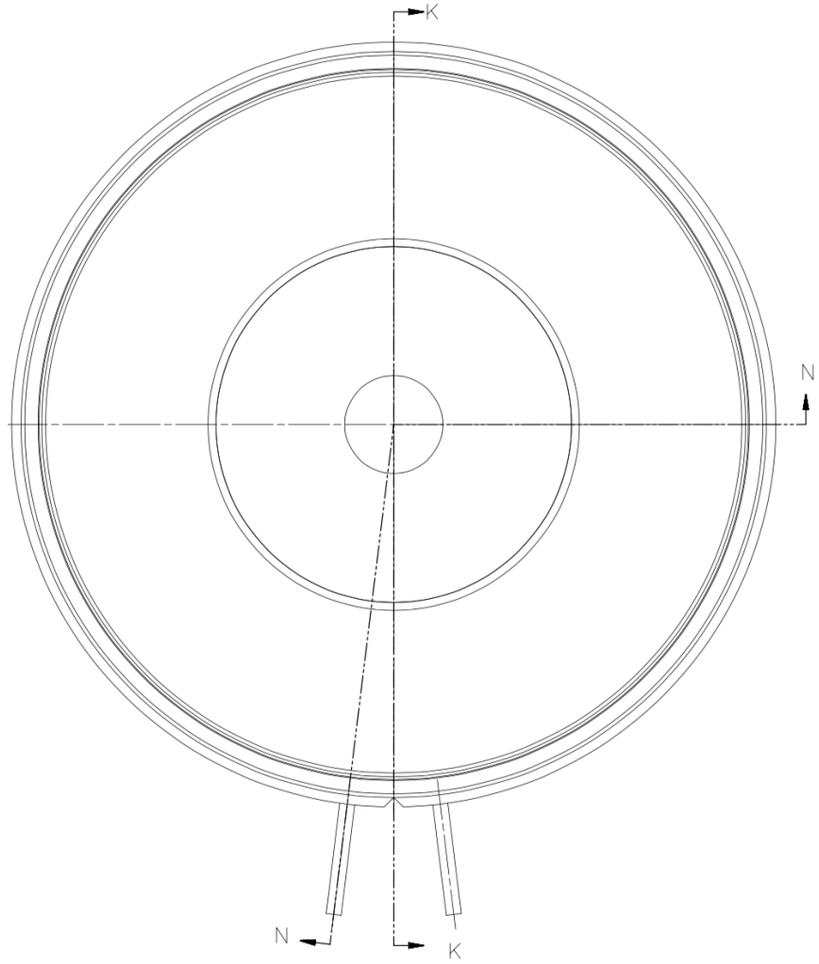
side by side gdml comparison: dump region



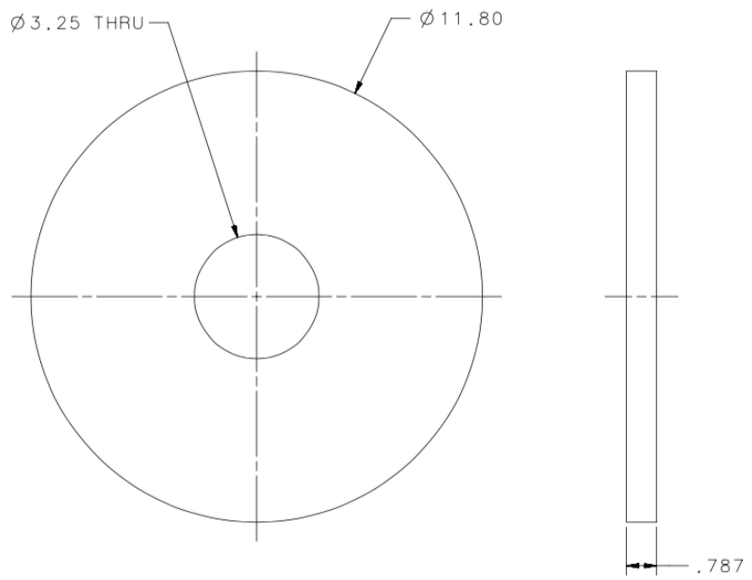
- Again the dimensions are from the drawings
- The grey disks are detectors

Donut - as implemented

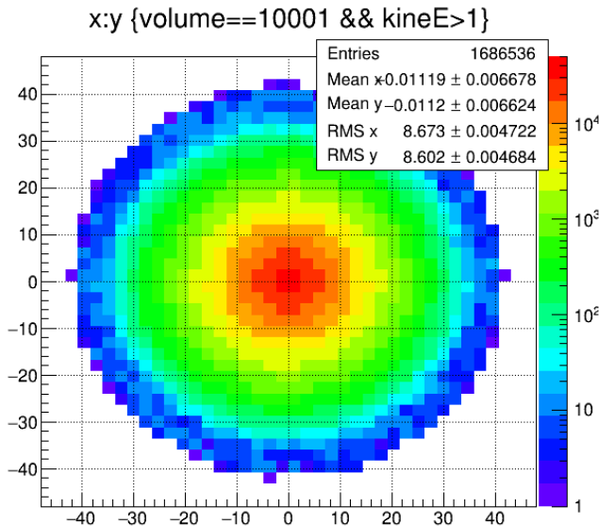


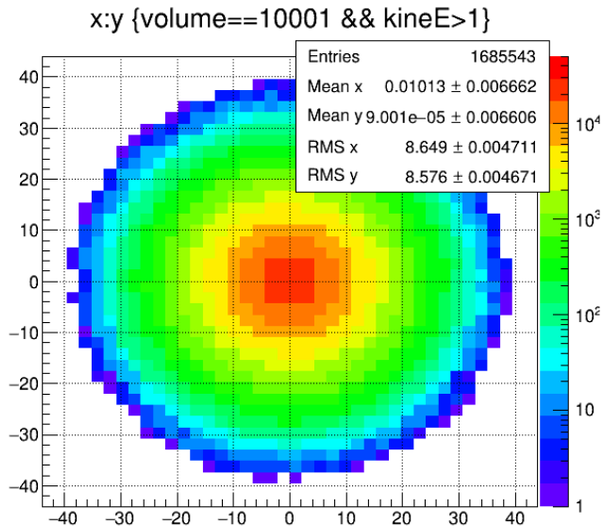


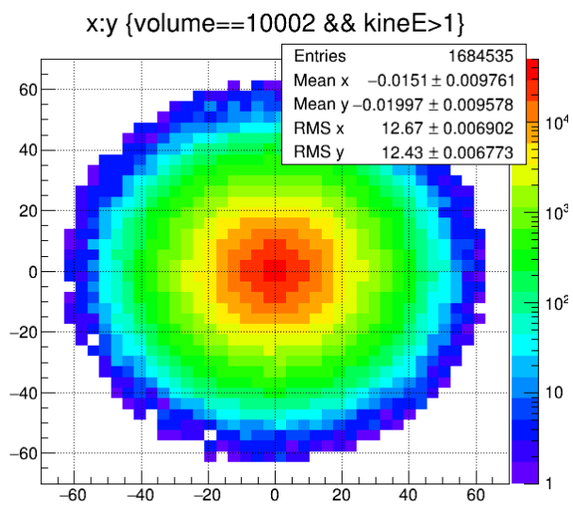
- From what I can tell the donut is 2 cm thick and has an opening of radius 4.13 cm at position ~3021 cm away from the target

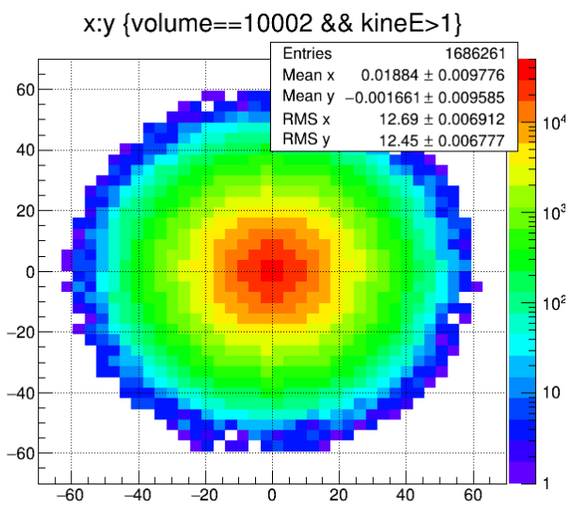


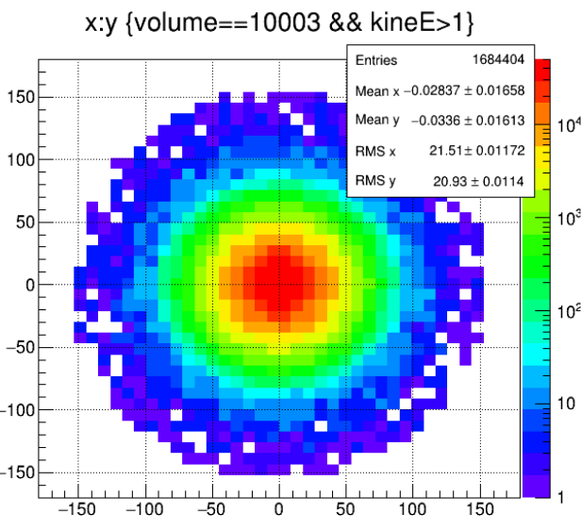
Comparisons by detectors

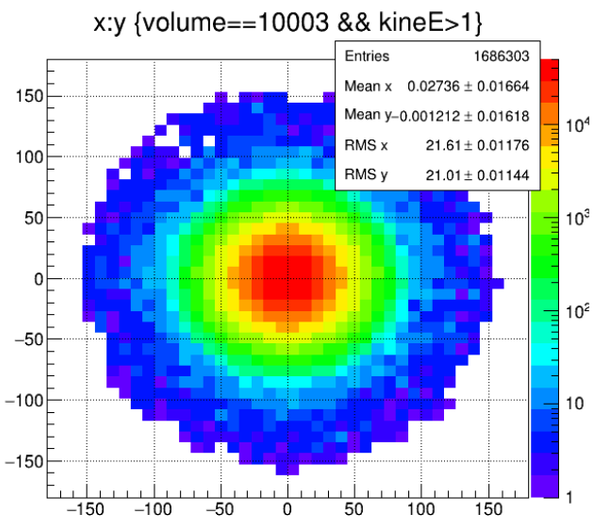


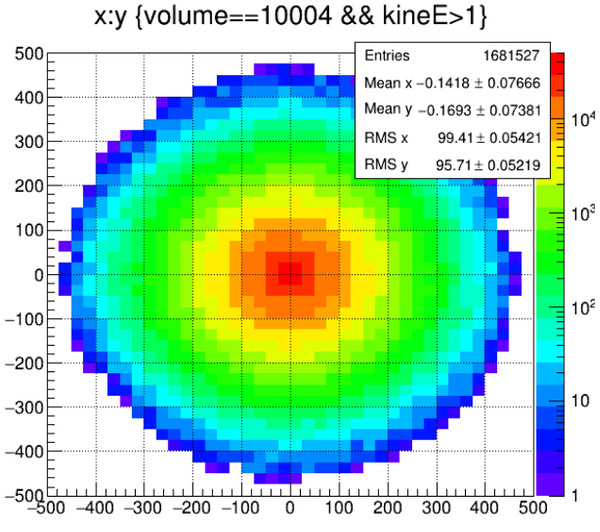


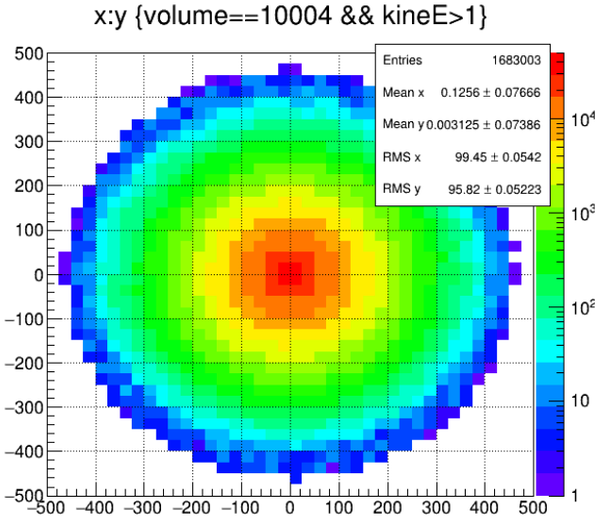




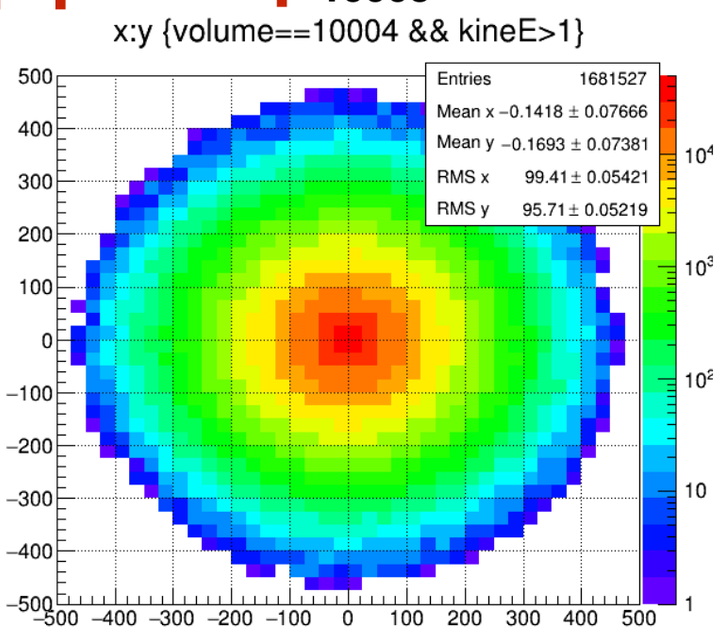


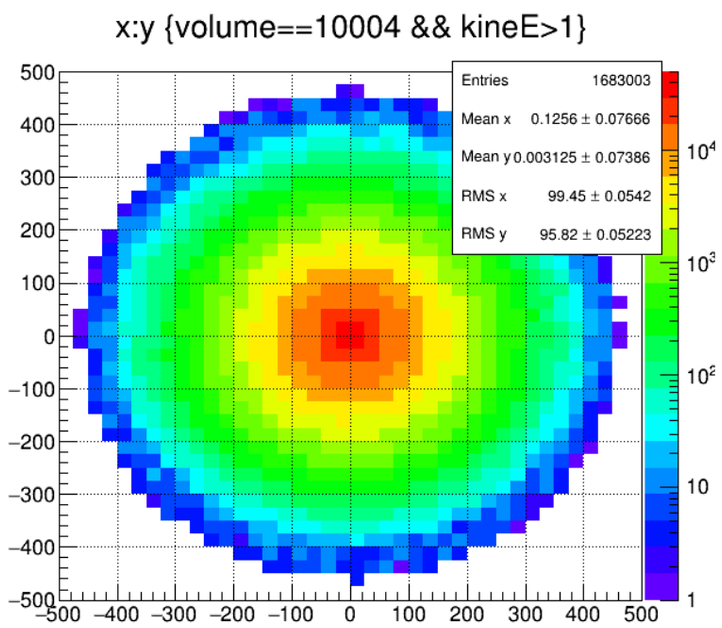


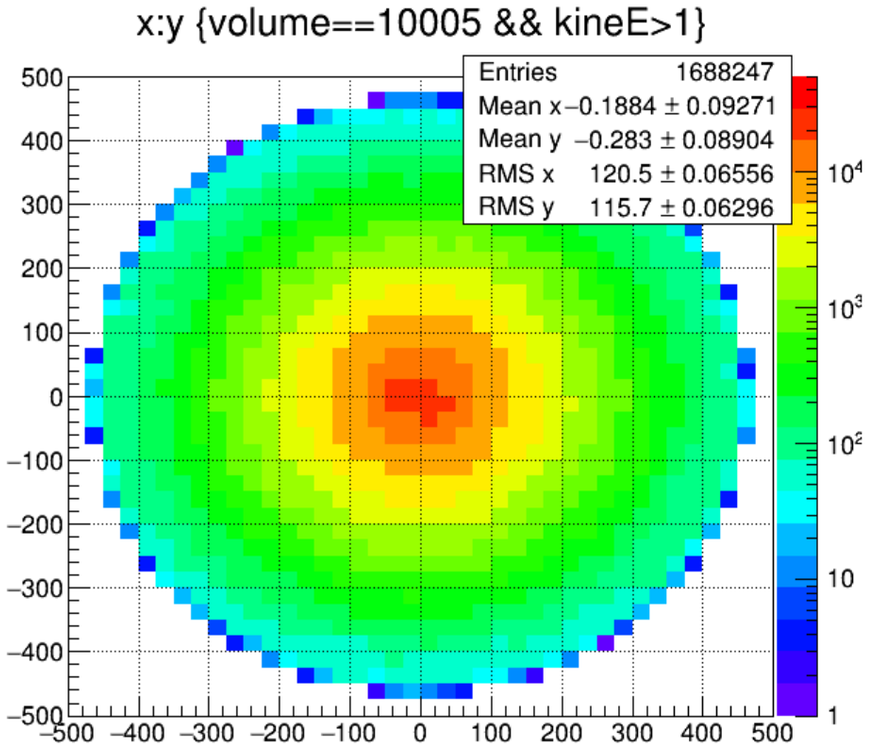


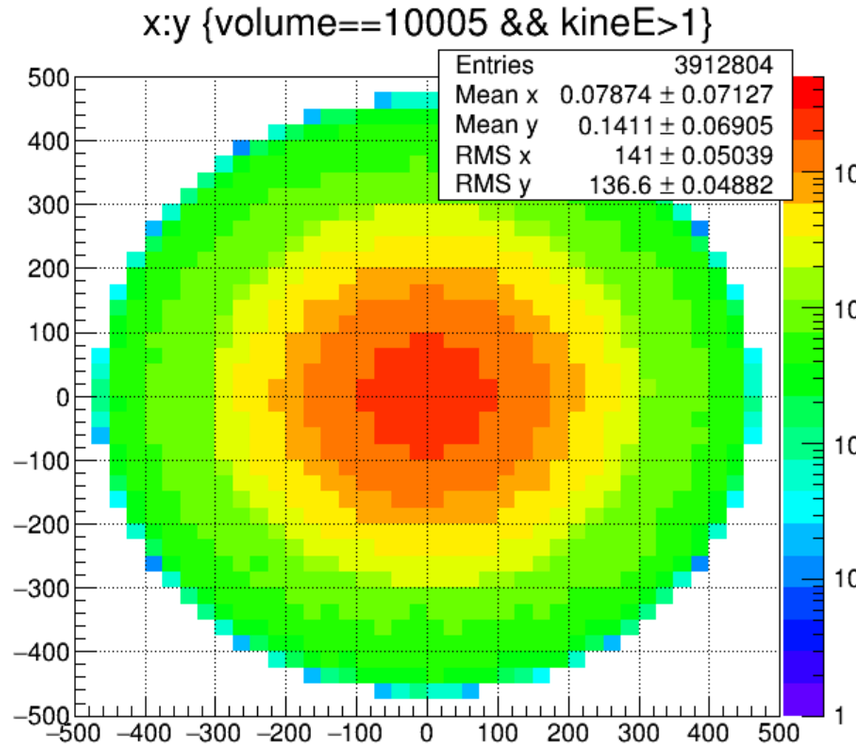


Comparisons by detectors

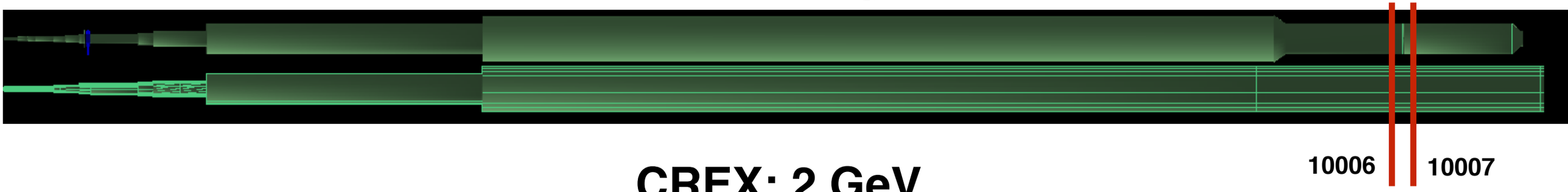




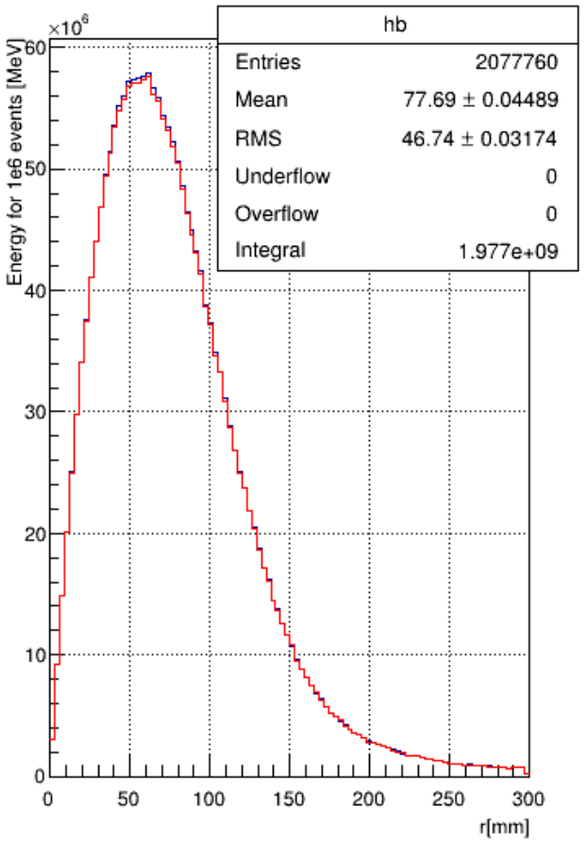


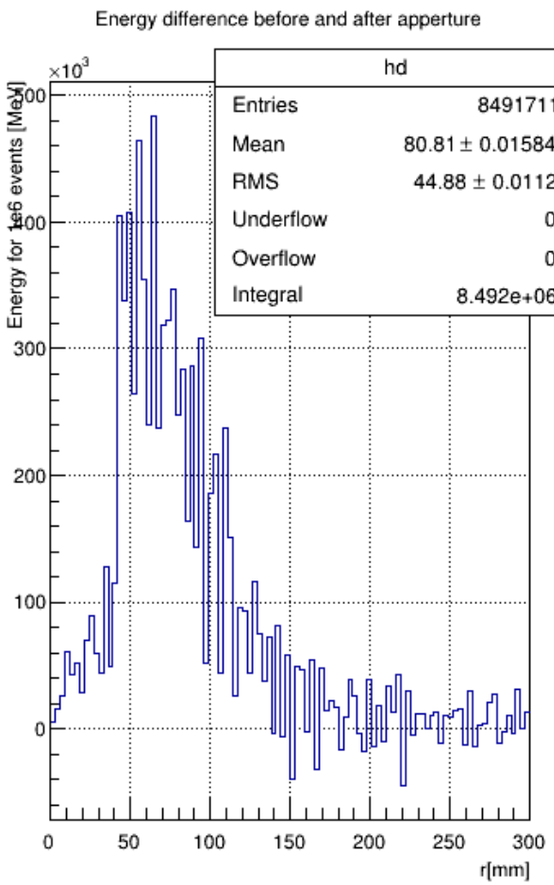


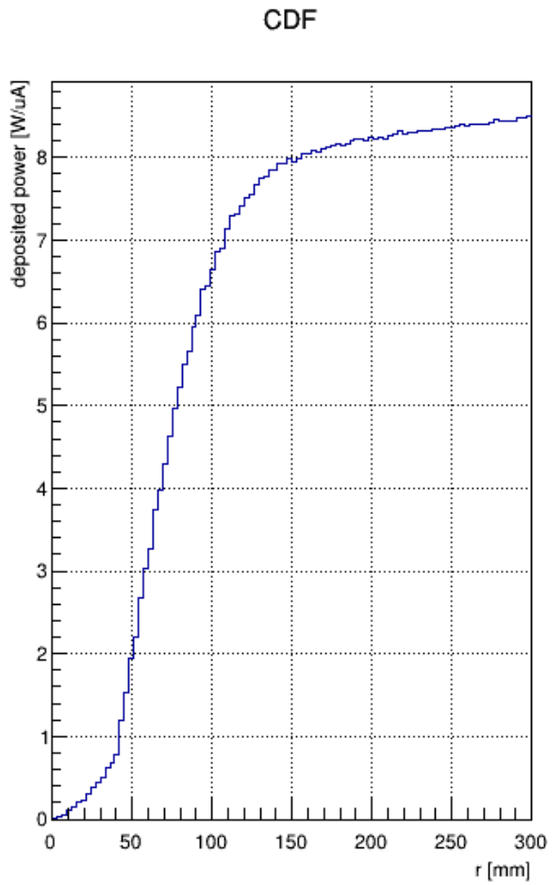
Comparisons by detectors

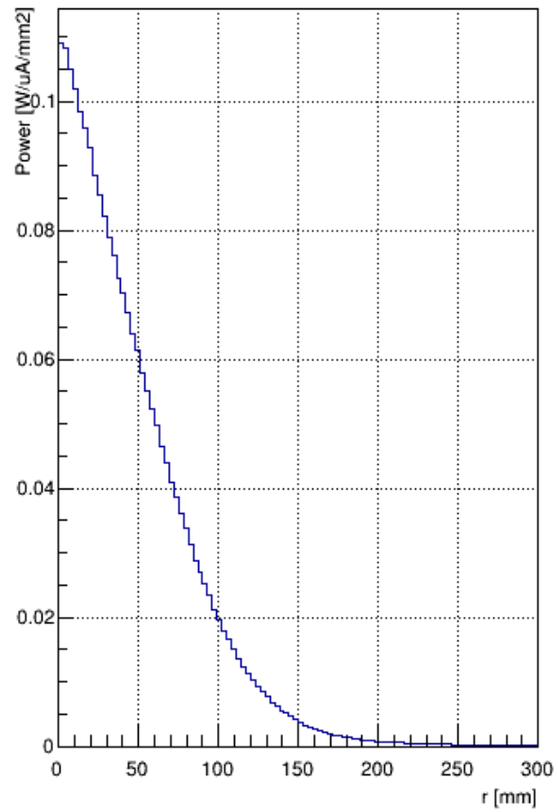


CREX: 2 GeV



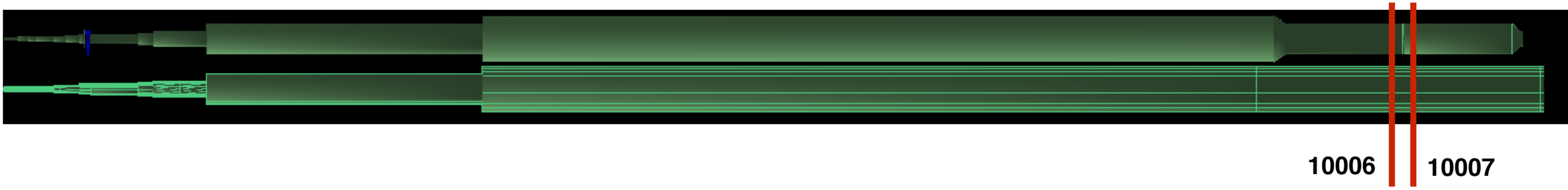




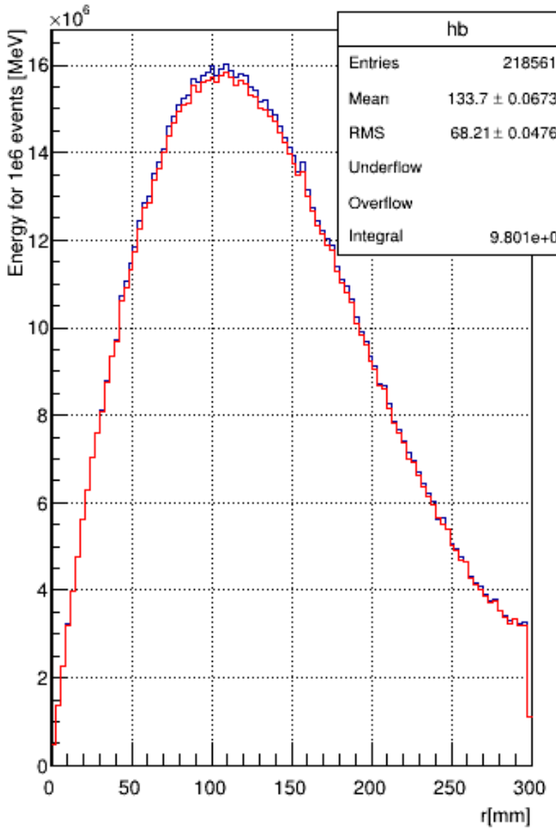


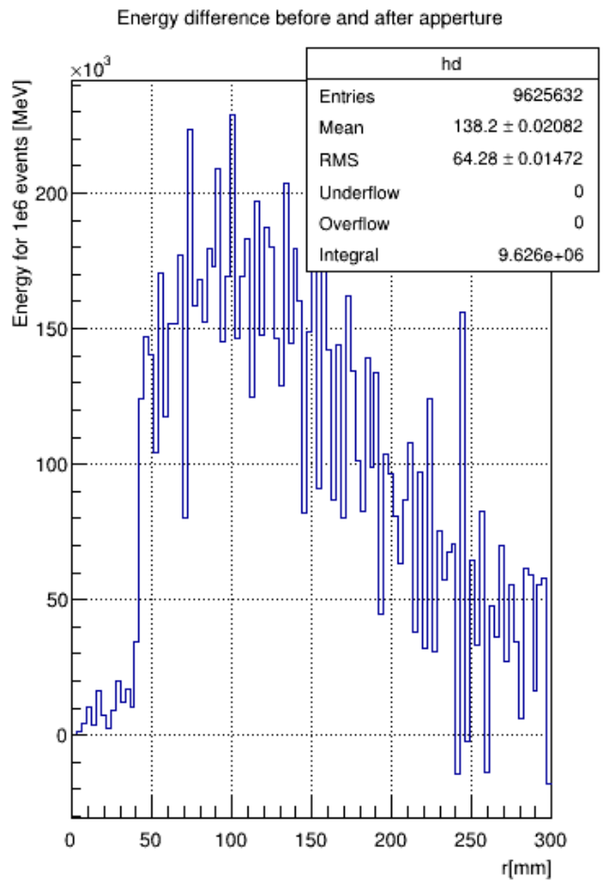
- The only panel that divides by the area is the right most one

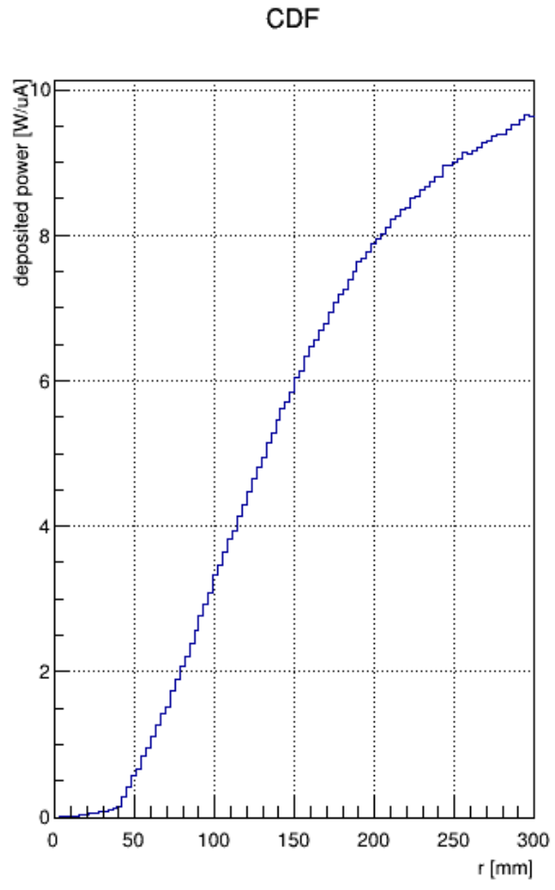
Comparisons by detectors

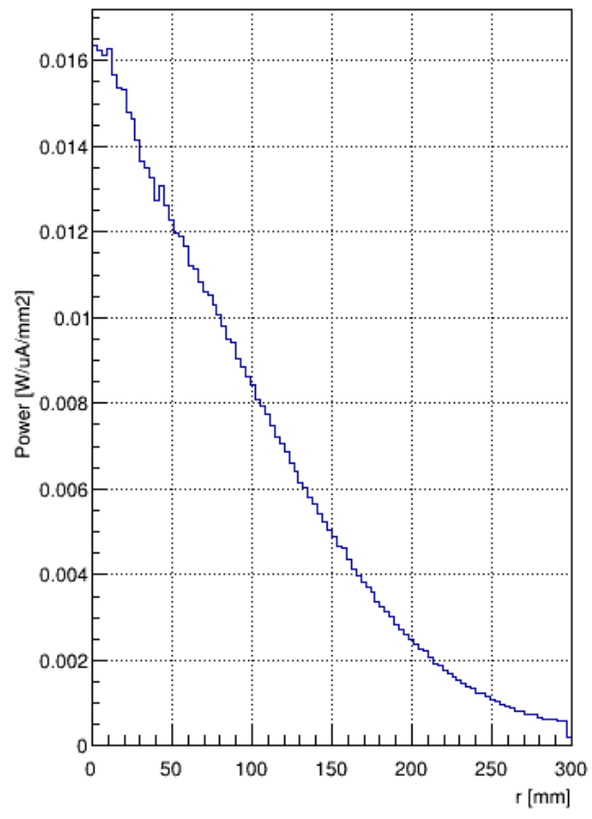


PREX: 1.05 GeV









- The only panel that divides by the area is the right most one