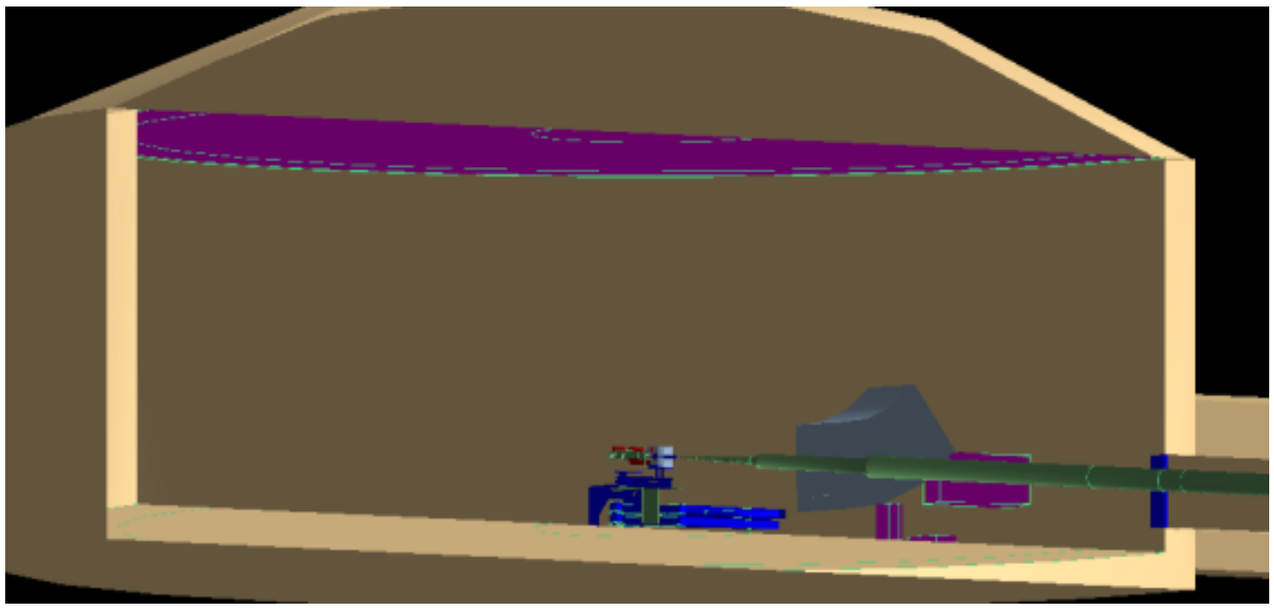
PREX Dump configuration

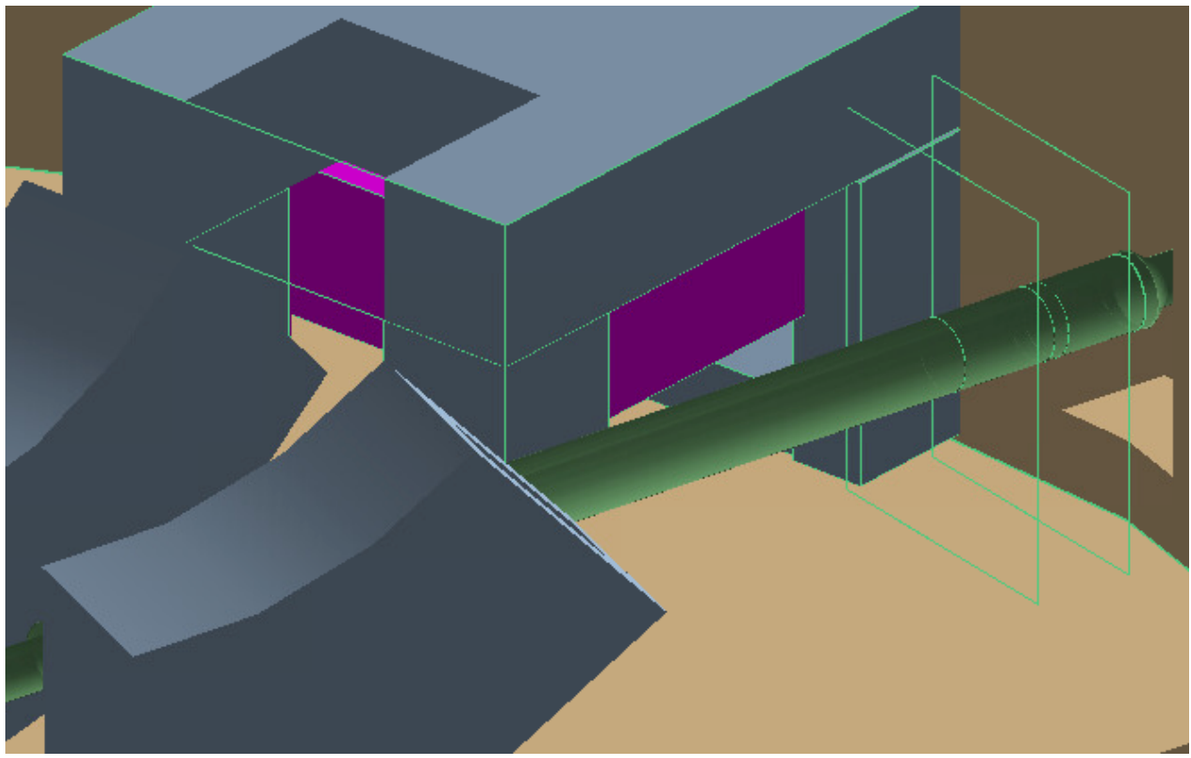
Ciprian Gal
UVa

Simulation updates

ERR



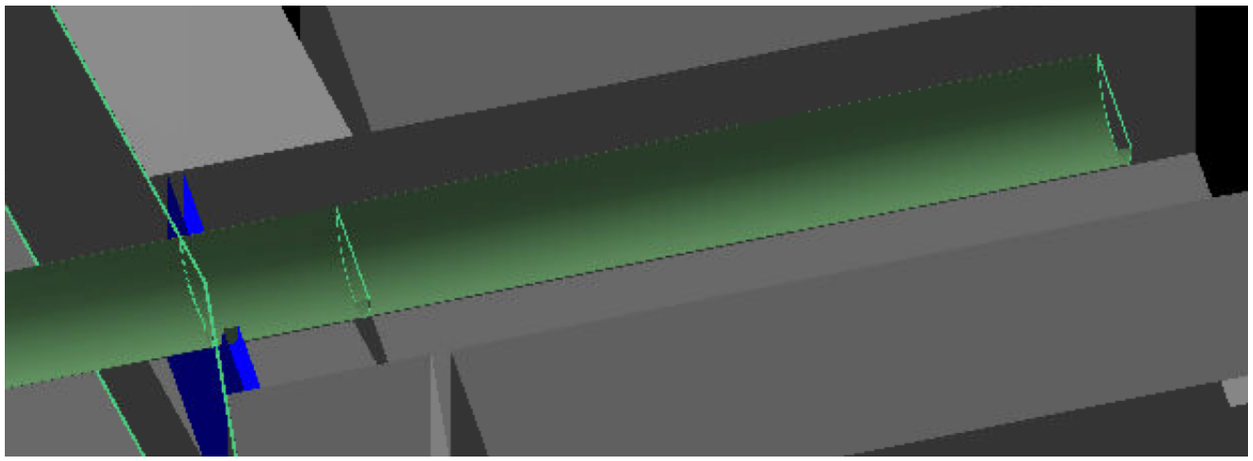
Update



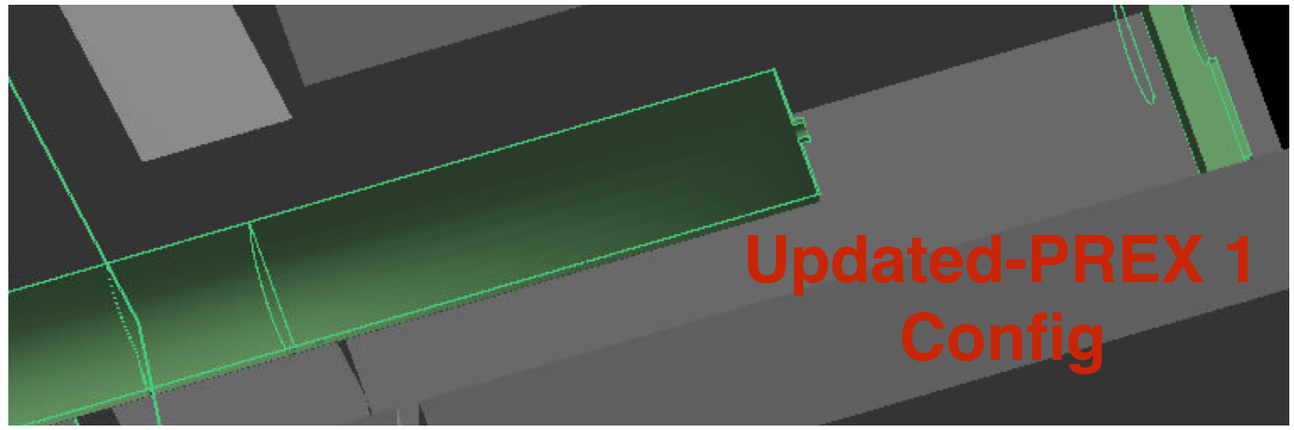
- Since ERR simulation geometry updated:
  - increased the size of the hall to ~26 m (from 25 m) — no visible effect on radiation calculations results
  - use APEX HRS platform geometry to add detail; in particular the legs around the HRS platform electronics
  - measured area where electronics could be placed and placed sensitive detectors to cover the entire area

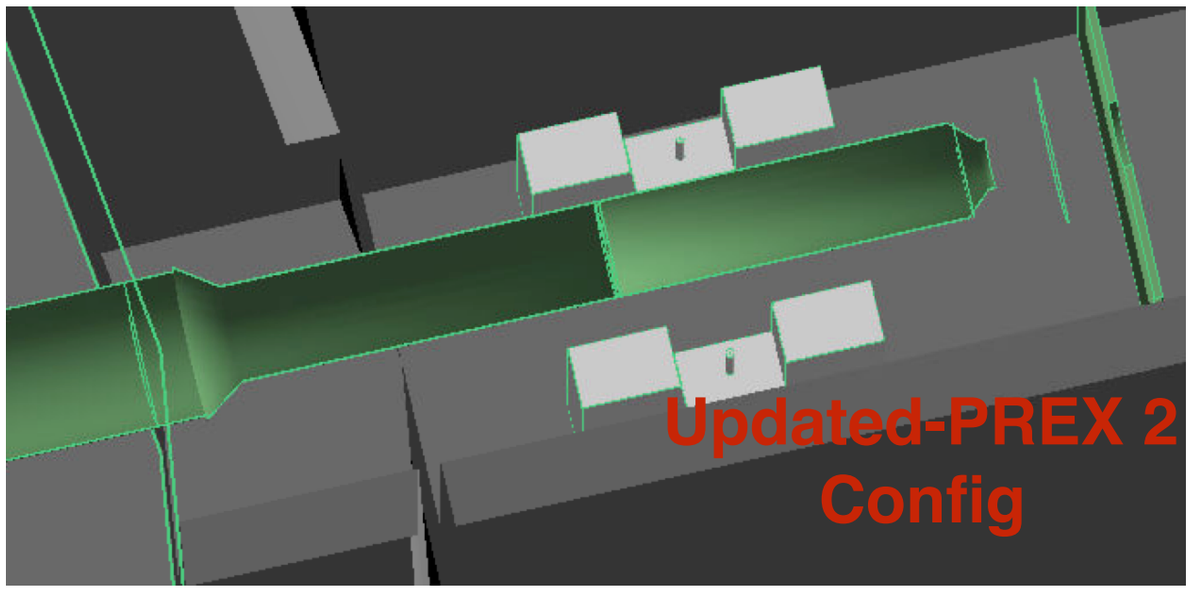
Simulation updates

ERR



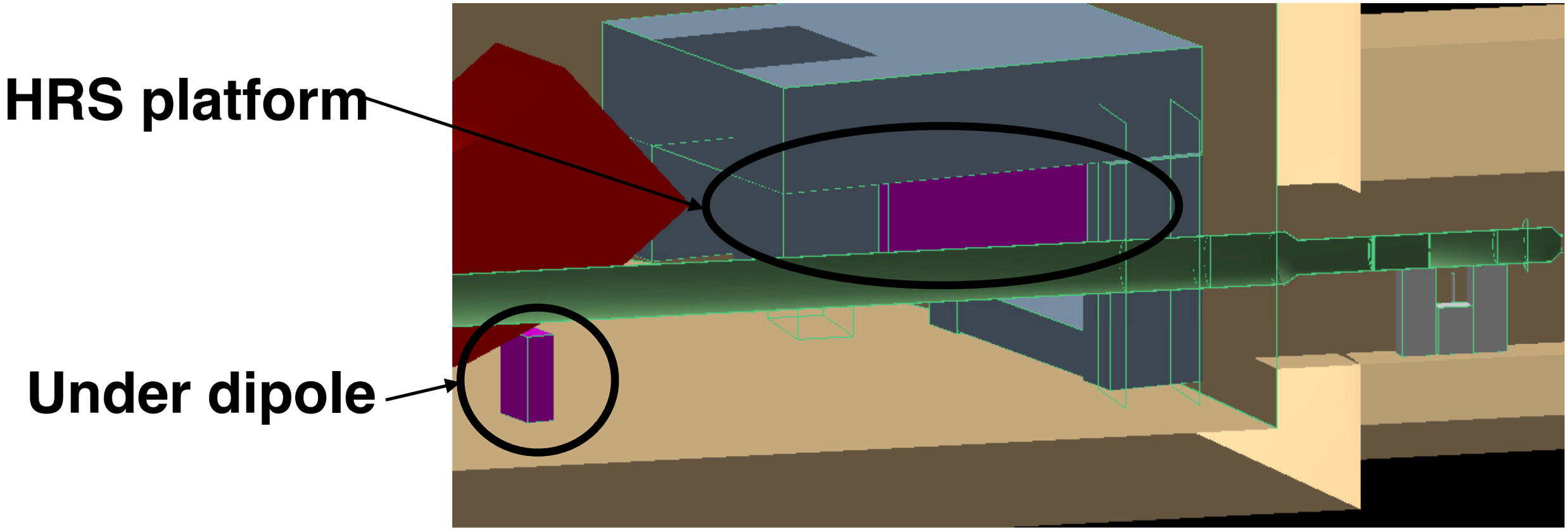
Update





- Dump configuration for ERR:
  - for the ERR we had a thick stainless steel covering the dump entrance to fake splash back from the dump
  - The beam pipe was also open to the back
- Dump configuration update:
  - updated with configurations consistent with JLab Drawings (obtained from Keith Welch) for both PREX1 and PREX2 including the limiting apertures
  - removed stainless steel wall from front and added aluminum wall separating the He region

Hall radiation (with update)



- Two regions are of interest where we can have softer electronics
- The HRS platform detector covers all possible areas where sensitive electronics could be placed
- The detector under the dipole iron has flow meters that could be affected by radiation

HRS radiation (with update)

HRS	PREX2 ERR	PREX2 Update	CREX5 ERR	CREX5 Update
HRS rad [NEIL/cm2] (% of PREX1)	4.1E+09 (9)	3.1E+10 (66)	7.4E+09 (16)	2.7E+10 (59)

The updated dump configuration brings the integrated radiation to the HRS platform to be level of PREX1 for the combined PREX2 and CREX run.

- The variable of interest is NEIL (which gives a higher importance to neutrons, as compared to EM radiation)
- The PREX1 estimate is done with the old detector configuration (the detector was smaller and not shielded by the HRS legs)
  - one would expect that the level would decrease for PREX1 by about 30% if we would run it with the detailed HRS platform
- Comparisons with the open detector put PREX2 and CREX each at the level of PREX1 radiation

HRS radiation (with update)

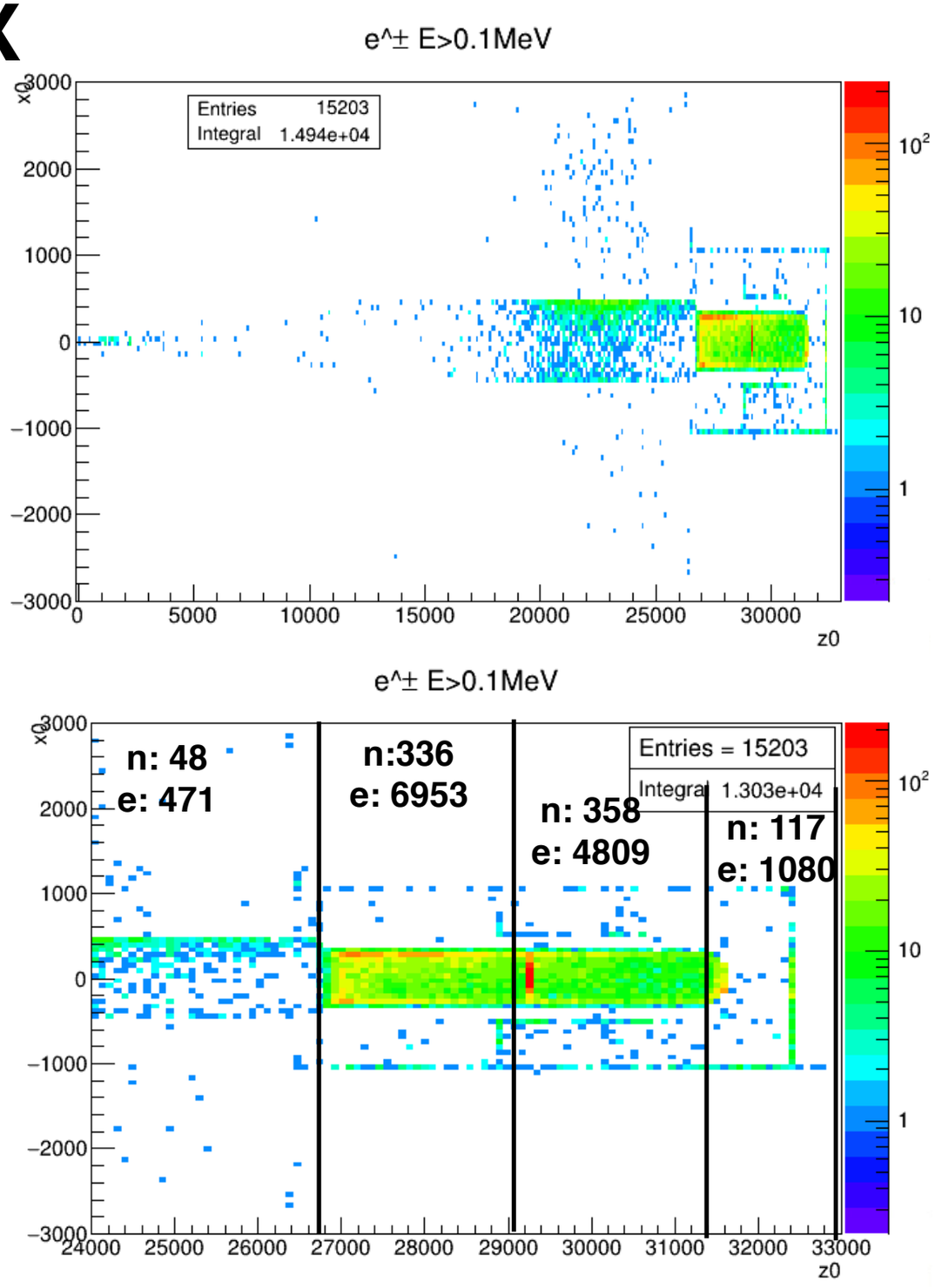
HRS	PREX2 Update	CREX5 Update
HRS rad [NEIL/cm2] (% of PREX1)	3.1E+10 (66)	2.7E+10 (59)
Precent coming from hall	30	29

HRS	PREX2 Update	CREX5 Update
HRS rad [NEIL/cm2] (% of PREX1)	3.1E+10 (66)	2.7E+10 (59)
HRS rad (EM) %of Total	22	13
HRS rad (N) %of Total	78	87

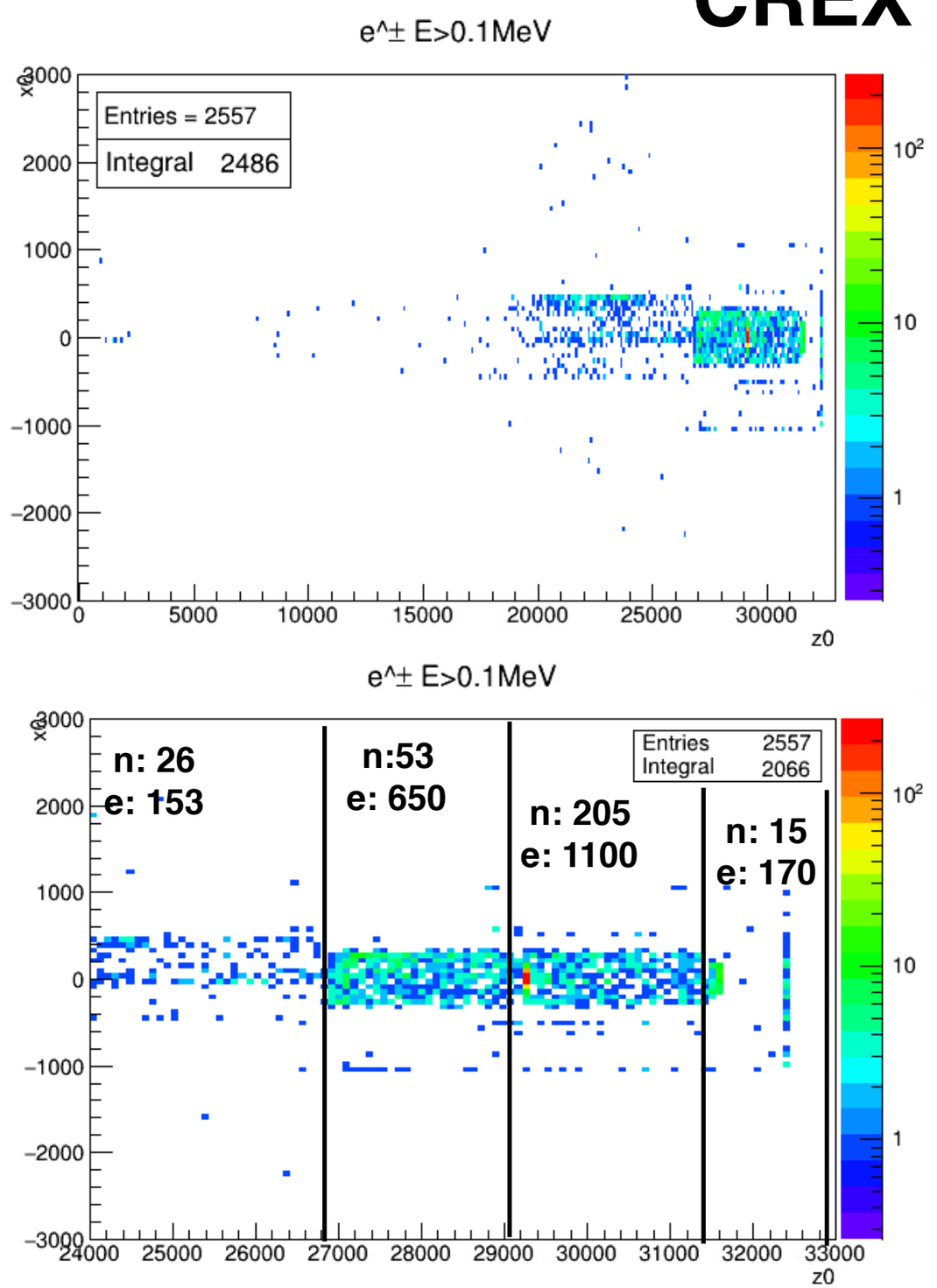
- With the update we can see that about two thirds of the radiation reaching the HRS platform comes from the dump
  - the ERR evaluation was basically only taking the hall into account (for PREX2 and CREX)
- If we look at the particles that produce the radiation at the HRS platform about 80% is caused by neutrons

HRS radiation (with update)

PREX



CREX

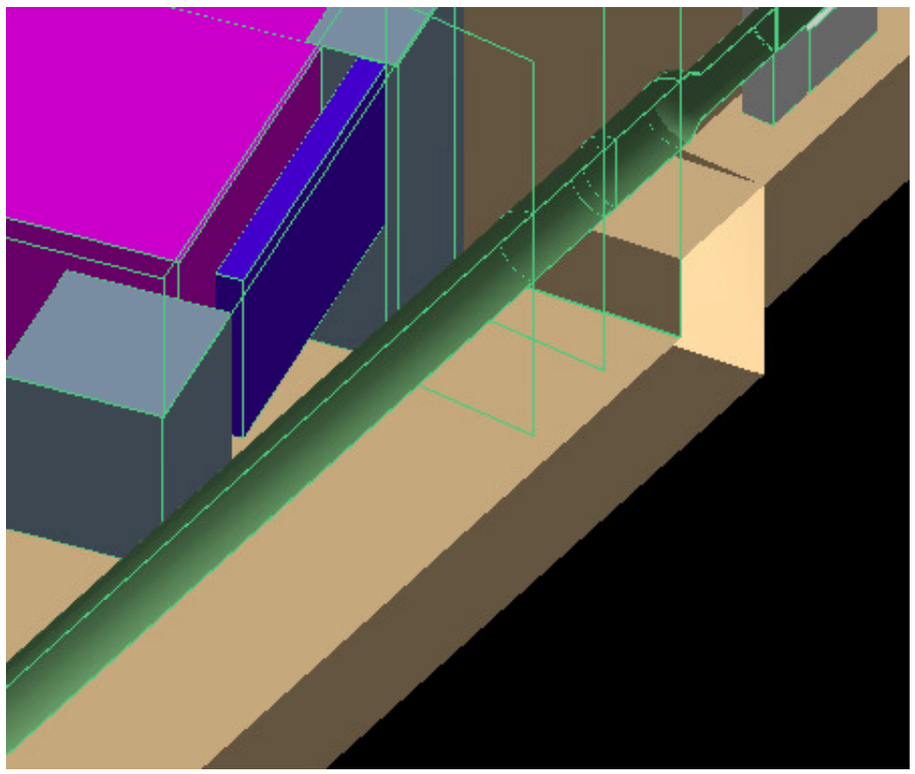


- While most of the problem for CREX is the donut, for PREX the neck down, the pipe and donut all contribute

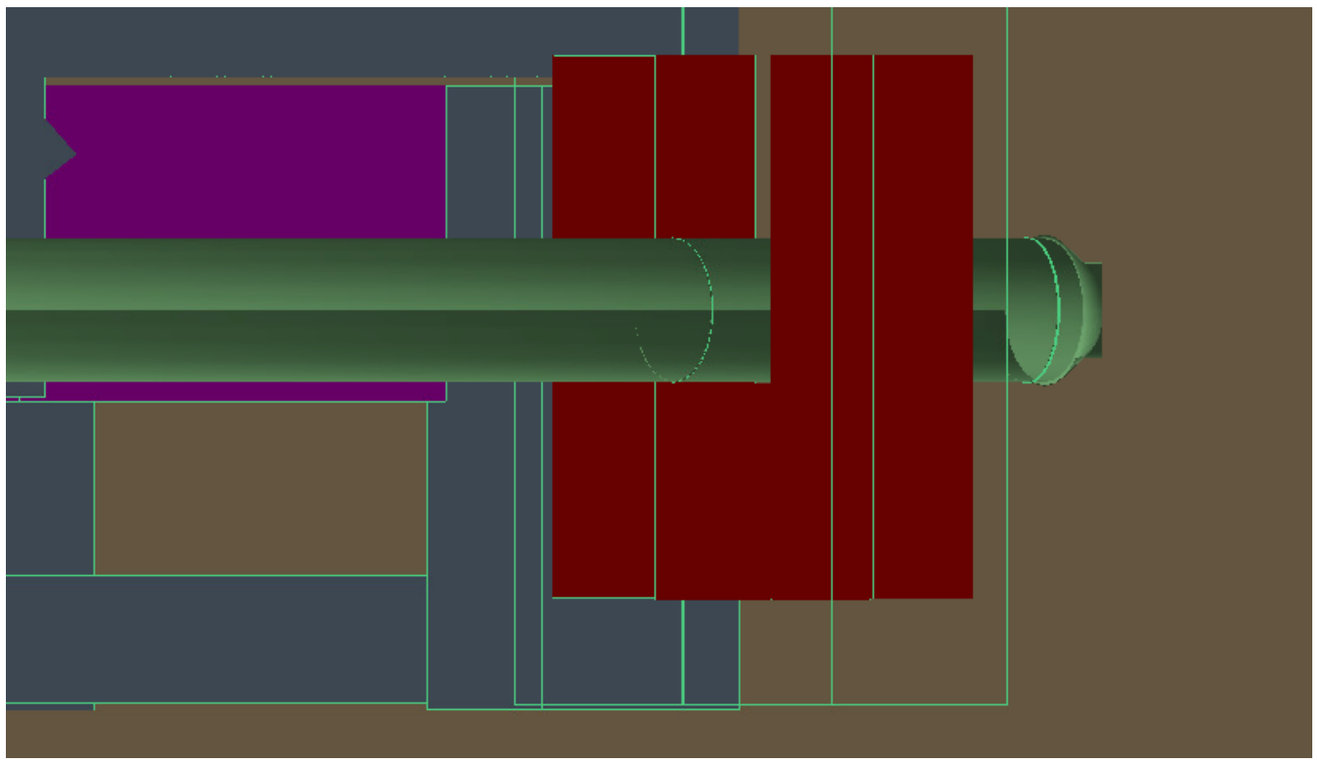
Considered mitigation strategies

- Increasing the size of the donut hole (fixes most of the problems for CREX)
- Replacing the pipe altogether to a PREX1 style pipe (fixes most of the PREX problems but CREX still needs some close consideration as the old connection to the He window and the old diffuser still cause significant issues)
- Hiding the neck down and/or donut in the shadow of the collimator:
  - to hide the neck down the collimator will have to be able to absorb more than double the power (the donut is more than a factor of 10)
  - the radiation at the HRS platform will increase if we don't provide additional shielding around the collimator (the area is already pretty much full)
- Shielding the dump/HRS region:
  - we can shield the dump with a wall between the two HRSs
  - we can shield the HRS platform alone with a wall facing the beampipe

Shielding



31x210x386 cm3 (5800kg)



Center: 134x137x45 cm3 (1900 kg)
Sides: 120x344x45 cm3 (4300 kg)

- Shielding the HRS platform with a 31 cm thick Concrete wall is very effective (for the HRS platform) but leaves the rest of the hall open (for example the flow meters under the dipole iron)
    - it would also be needed to do it on both platforms (two construction regions instead of 1)
- Shielding the dump with about 45 cm thick Concrete is almost as effective for the HRS platform and it provides additional shielding for the rest of the hall

Cumulative Radiation levels

		HRS detector				Under detector			
		Total NEIL/cm2	uncert	Ratio to P1	uncert	Total NEIL/cm2	uncert	Ratio to P1	uncert
	PREX1 (ERR dump)	4.60E+10	1.79E+09	1.00	0.06	7.43E+10	4.92E+09	1.00	0.09
PREX 2	NewHRSDet	3.05E+10	7.62E+08	0.66	0.03	7.09E+10	4.98E+09	0.95	0.09
	newHRSDet+sideShield (1ftConc)	9.81E+09	4.33E+08	0.21	0.01	6.66E+10	4.75E+09	0.90	0.09
	newHRS+sideShield(31cmConc) + 4inDonut	9.72E+09	4.36E+08	0.21	0.01	5.90E+10	4.49E+09	0.79	0.08
	newHRS+DSlargeU(45cmConc)+4inDonut	1.18E+10	4.34E+08	0.26	0.01	2.16E+10	2.29E+09	0.29	0.04
CREX 5	NewHRSDet	2.72E+10	1.29E+09	0.59	0.04	5.21E+10	7.38E+09	0.70	0.11
	newHRSDet+sideShield (1ftConc)	6.96E+09	6.19E+08	0.15	0.01	4.39E+10	6.83E+09	0.59	0.10
	newHRS+sideShield(31cmConc) + 4inDonut	3.15E+09	3.56E+08	0.07	0.01	3.10E+10	5.44E+09	0.42	0.08
	newHRS+DSlargeU(45cmConc)+4inDonut	5.26E+09	4.35E+08	0.11	0.01	9.55E+09	1.81E+09	0.13	0.03

- Shielding the HRS alone produces the best results when we consider both PREX and CREX
  - however if we look at the flow meter detector we can see that it could still use local shielding itself
- Increasing the donut hole to 4in (10.13 cm) solves most of the problems we see during CREX
- The 45 cm U shaped dump shielding can bring us to an overall (PREX2 + CREX) radiation level of 37% of PREX 1 (in the ERR we promised 25% of PREX 1)

Conclusions

- The detailed dump simulation indicates that we will have (after mitigation) a slightly higher radiation level inside the hall compared with what was presented at the ERR
  - To fix most of the radiation issue for CREX we propose and increase the donut hole to at least 4 in (10.13 cm)
- For PREX additional shielding is needed and we determined that a 45 cm thick U shaped wall around the beam pipe, approximately 2 meters in front of the dump is our most efficient configuration (after looking at different configurations and shielding materials)
- This shielding will weight approximately 8-11 tonnes (considering a density of 1750-2400 kg/m3)

PREX radiation all studies

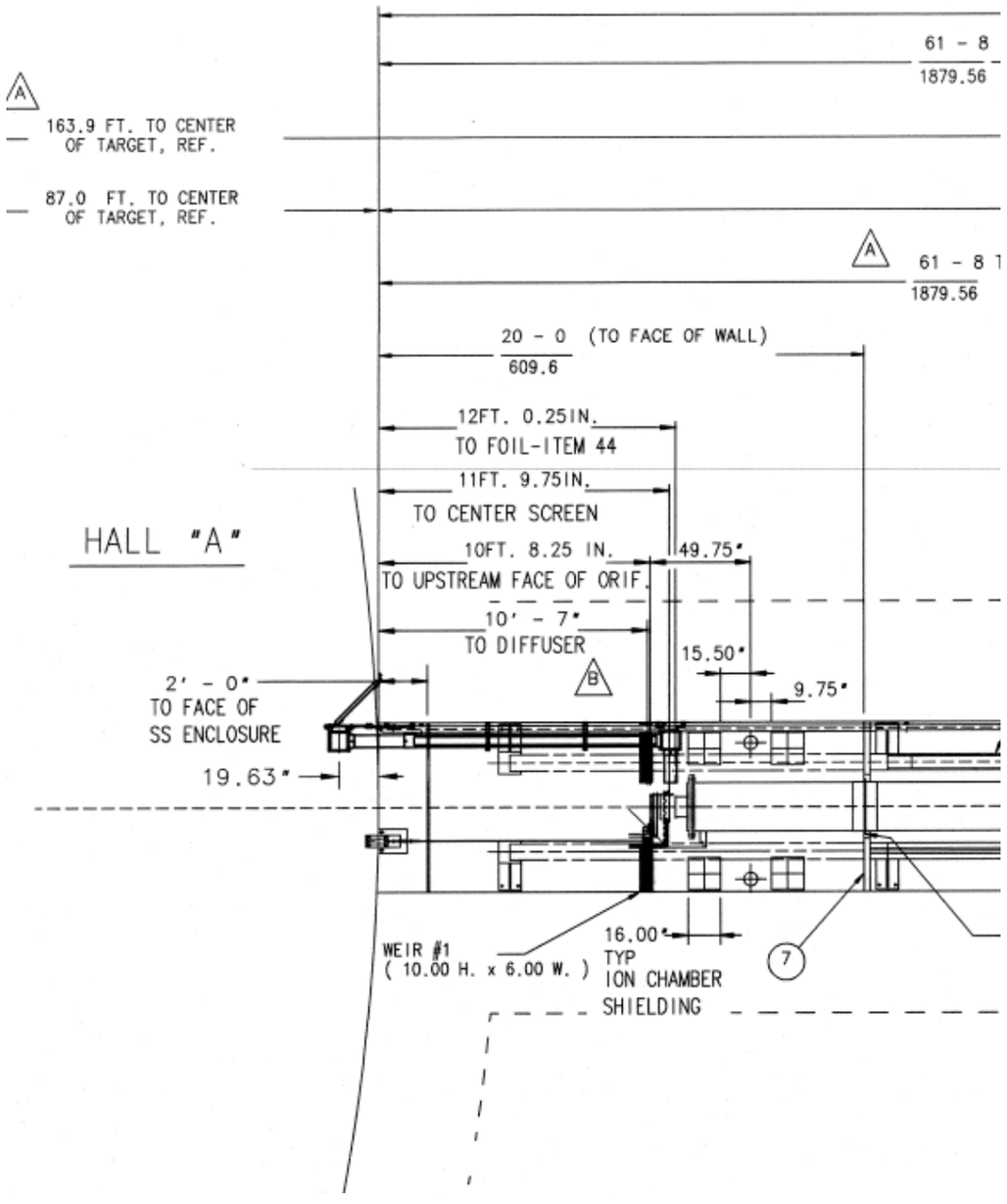
		HRS detector				Under detector			
		Total NEIL/cm2	uncert	Ratio to P1	uncert	Total NEIL/cm2	uncert	Ratio to P1	uncert
	PREX1 (ERR dump)	4.60E+10	1.79E+09	1.00	0.06	7.43E+10	4.92E+09	1.00	0.09
	PREX2 current	5.77E+10	5.69E+09	1.25	0.13	7.60E+10	1.85E+10	1.02	0.26
	C5 current	3.86E+10	7.80E+09	0.84	0.17	4.70E+10	1.96E+10	0.63	0.27
	current (farm)	5.23E+10	1.11E+09	1.14	0.05	8.03E+10	3.77E+09	1.08	0.09
	vacuum beamline	5.12E+10	1.55E+09	1.11	0.05	8.06E+10	5.34E+09	1.09	0.10
	no donut	3.90E+10	1.31E+09	0.85	0.04	5.04E+10	3.74E+09	0.68	0.07
	smaller Coll Neck	4.38E+10	1.02E+09	0.95	0.04	6.92E+10	3.19E+09	0.93	0.08
	smaller Coll Pipe2Donut	4.17E+10	9.59E+08	0.91	0.04	7.68E+10	3.29E+09	1.03	0.08
	smaller Coll MidDonut	5.77E+10	9.57E+08	1.25	0.05	1.21E+11	3.50E+09	1.63	0.12
	larger Hall	5.46E+10	1.63E+09	1.19	0.06	8.00E+10	5.32E+09	1.08	0.10
	new HRS	3.00E+10	1.45E+09	0.65	0.04	8.12E+10	5.42E+09	1.09	0.10
	New HRS + 2ft Iron	2.07E+10	1.17E+09	0.45	0.03	2.97E+10	2.81E+09	0.40	0.05
	NewHRSDet	3.05E+10	7.62E+08	0.66	0.03	7.09E+10	4.98E+09	0.95	0.09
	NewHRSDet+2ft Fe	1.79E+10	5.39E+08	0.39	0.02	2.32E+10	2.44E+09	0.31	0.04
	NewHRSDet+2ft Conc	1.55E+10	5.00E+08	0.34	0.02	2.23E+10	2.29E+09	0.30	0.04
PREX 2	NewHRSDet+1ftConc1ftFe	6.79E+09	1.95E+09	0.15	0.04	N/A	N/A	#VALUE!	#VALUE!
	NewHRSDet+1ftConc1ftFe+4inDonut	1.46E+10	4.81E+08	0.32	0.02	1.91E+10	1.94E+09	0.26	0.03
	newHRSDet+fat Pipe	1.07E+10	4.10E+08	0.23	0.01	3.23E+10	3.18E+09	0.43	0.05
	newHRSDet+sideShield (1ftConc)	9.81E+09	4.33E+08	0.21	0.01	6.66E+10	4.75E+09	0.90	0.09
	newHRS+sideShield(31cmConc) + 4inDonut	9.72E+09	4.36E+08	0.21	0.01	5.90E+10	4.49E+09	0.79	0.08
	newHRS+DStopCover(75cmConc)+4inDonut	1.03E+10	3.80E+08	0.22	0.01	1.88E+10	2.13E+09	0.25	0.03
	newHRS+DSlargeU(75cmConc)+4inDonut	1.11E+10	4.14E+08	0.24	0.01	2.20E+10	2.42E+09	0.30	0.04
	newHRS+DSlargeU(30cmConc)+4inDonut	1.35E+10	4.67E+08	0.29	0.02	1.75E+10	2.04E+09	0.24	0.03
	newHRS+DSlargeU(45cmConc)+4inDonut	1.18E+10	4.34E+08	0.26	0.01	2.16E+10	2.29E+09	0.29	0.04
	newHRS+DSlargeU(60cmConc)+4inDonut	1.15E+10	4.18E+08	0.25	0.01	2.39E+10	2.67E+09	0.32	0.04
	newHRS+sideShield(31cmConc) + 4inDonut == Hall Only	5.12E+09	3.03E+08	0.11	0.01	1.39E+10	1.58E+09	0.19	0.02
	newHRS+DStopCover(75cmConc)+4inDonut == Hall only	7.20E+09	2.96E+08	0.16	0.01	1.46E+10	1.71E+09	0.20	0.03
	newHRS+DSlargeU(75cmConc)+4inDonut == Hall only	7.30E+09	3.10E+08	0.16	0.01	1.33E+10	1.39E+09	0.18	0.02

CREX radiation all studies

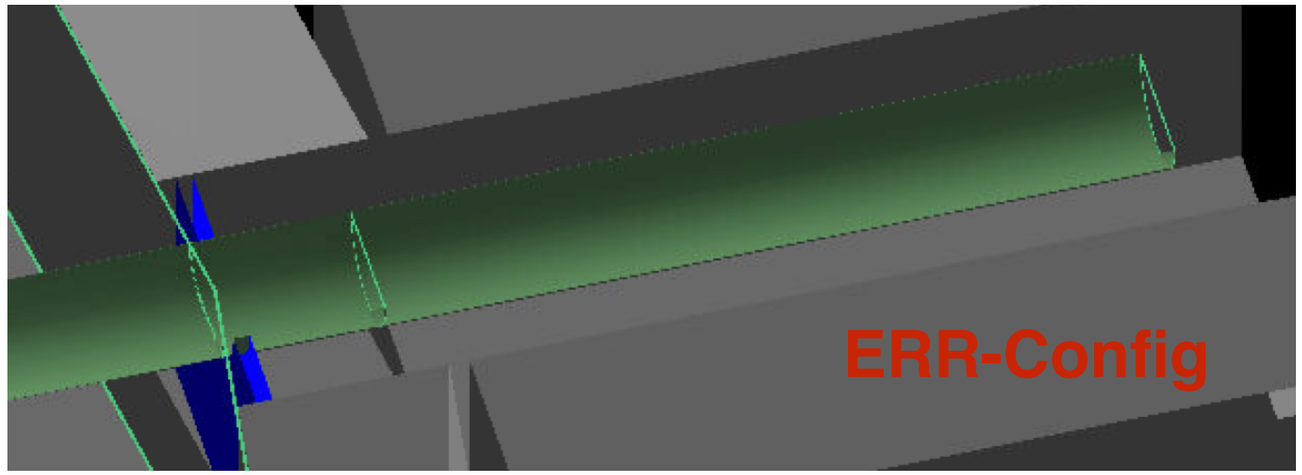
		HRS detector				Under detector			
		Total NEIL/cm2	uncert	Ratio to P1	uncert	Total NEIL/cm2	uncert	Ratio to P1	uncert
	PREX1 (ERR dump)	4.60E+10	1.79E+09	1.00	0.06	7.43E+10	4.92E+09	1.00	0.09
	current (farm)	4.47E+10	1.84E+09	0.97	0.06	5.78E+10	5.41E+09	0.78	0.09
	vacuum beamline	4.01E+10	2.50E+09	0.87	0.06	7.14E+10	8.97E+09	0.96	0.14
	no donut	1.37E+10	1.20E+09	0.30	0.03	2.29E+10	4.73E+09	0.31	0.07
	smaller Coll Neck	3.91E+10	1.77E+09	0.85	0.05	6.03E+10	5.70E+09	0.81	0.09
	smaller Coll Pipe2Donut	3.59E+10	1.65E+09	0.78	0.05	5.86E+10	5.46E+09	0.79	0.09
	smaller Coll MidDonut	1.50E+11	2.53E+09	3.26	0.14	2.84E+11	8.31E+09	3.83	0.28
	larger Hall	4.05E+10	2.53E+09	0.88	0.06	6.48E+10	8.34E+09	0.87	0.13
	new HRS	2.09E+10	2.04E+09	0.45	0.05	5.92E+10	7.85E+09	0.80	0.12
	New HRS + 2ft Iron	1.54E+10	1.76E+09	0.34	0.04	1.42E+10	3.21E+09	0.19	0.05
	NewHRSDet	2.72E+10	1.29E+09	0.59	0.04	5.21E+10	7.38E+09	0.70	0.11
	NewHRSDet+2ft Fe	1.37E+10	8.34E+08	0.30	0.02	1.76E+10	3.37E+09	0.24	0.05
	NewHRSDet+2ft Conc	1.15E+10	7.72E+08	0.25	0.02	1.17E+10	3.24E+09	0.16	0.04
CREX 5	NewHRSDet+1ftConc1ftFe	5.86E+09	2.46E+09	0.13	0.05	N/A	N/A	#VALUE!	#VALUE!
	NewHRSDet+1ftConc1ftFe+4inDonut	5.57E+09	4.21E+08	0.12	0.01	1.36E+10	2.75E+09	0.18	0.04
	newHRSDet+fat Pipe	2.70E+10	1.26E+09	0.59	0.04	9.70E+10	1.08E+10	1.31	0.17
	newHRSDet+sideShield (1ftConc)	6.96E+09	6.19E+08	0.15	0.01	4.39E+10	6.83E+09	0.59	0.10
	newHRS+sideShield(31cmConc) + 4inDonut	3.15E+09	3.56E+08	0.07	0.01	3.10E+10	5.44E+09	0.42	0.08
	newHRS+DStopCover(75cmConc)+4inDonut	5.51E+09	4.62E+08	0.12	0.01	1.20E+10	2.28E+09	0.16	0.03
	newHRS+DSlargeU(75cmConc)+4inDonut	6.04E+09	4.72E+08	0.13	0.01	1.07E+10	2.18E+09	0.14	0.03
	newHRS+DSlargeU(30cmConc)+4inDonut	5.54E+09	4.47E+08	0.12	0.01	1.20E+10	2.67E+09	0.16	0.04
	newHRS+DSlargeU(45cmConc)+4inDonut	5.26E+09	4.35E+08	0.11	0.01	9.55E+09	1.81E+09	0.13	0.03
	newHRS+DSlargeU(60cmConc)+4inDonut	4.80E+09	4.05E+08	0.10	0.01	1.05E+10	1.98E+09	0.14	0.03
	newHRS+sideShield(31cmConc) + 4inDonut == Hall Only	2.13E+09	2.65E+08	0.05	0.01	1.10E+10	2.43E+09	0.15	0.03
	newHRS+DStopCover(75cmConc)+4inDonut == Hall only	3.85E+09	3.18E+08	0.08	0.01	1.17E+10	2.28E+09	0.16	0.03
	newHRS+DSlargeU(75cmConc)+4inDonut == Hall only	4.57E+09	3.82E+08	0.10	0.01	1.05E+10	2.18E+09	0.14	0.03

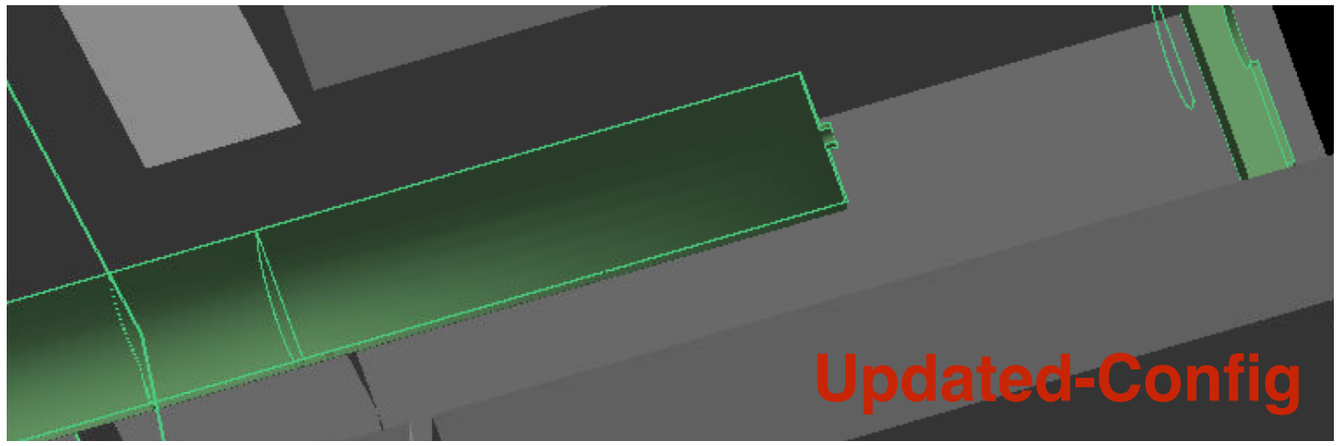
PREX 1 radiation estimation

Hall A dump configuration from Keith W. for 2010:



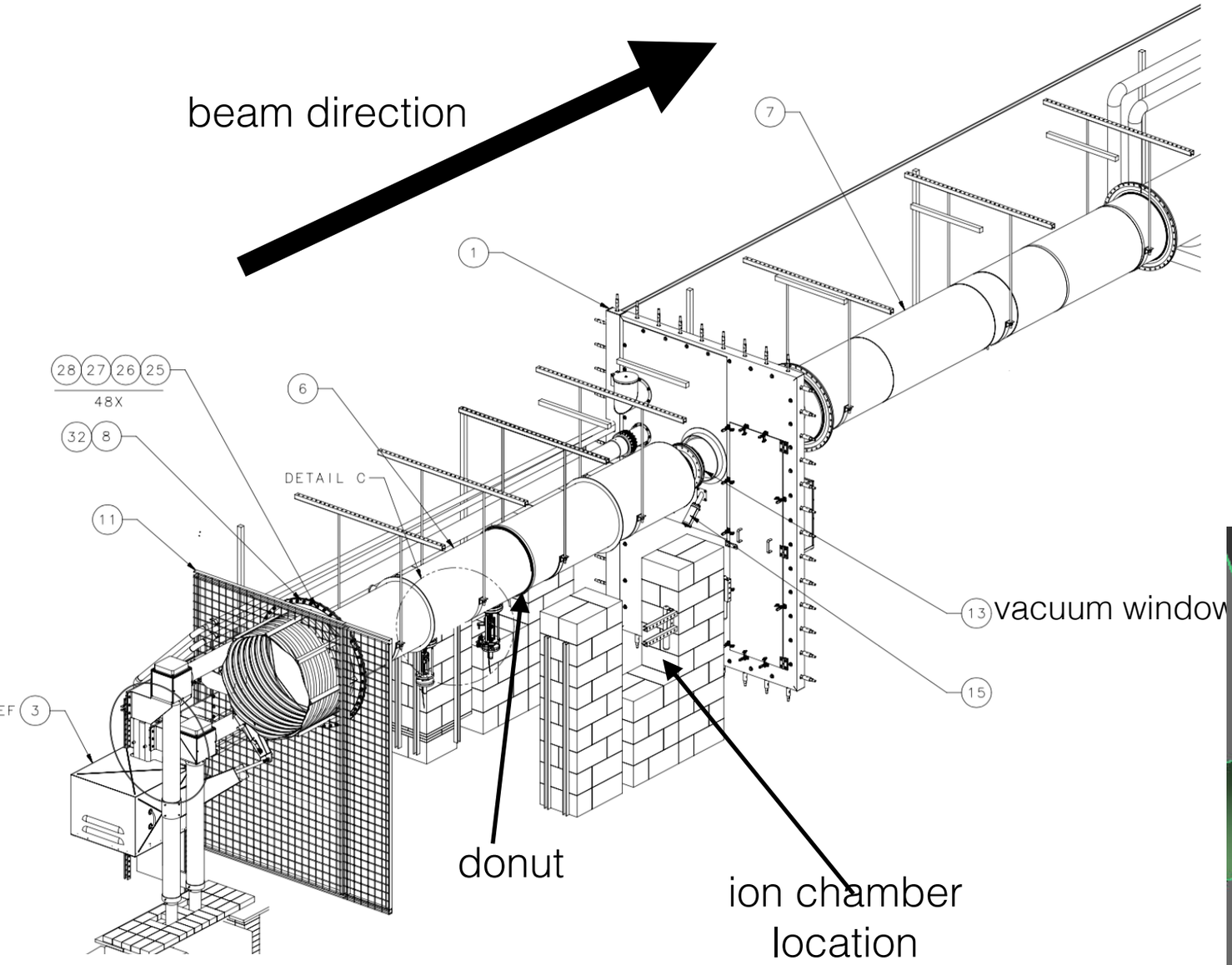
	ERR	Update
HRS rad [NEIL/cm2]	2.3E+11	2.1E+11





- PREX 1 estimates were done with a rudimentary dump configuration (most of the radiation to electronics came from within the hall proper)
  - The splash back from the dump was simulated by putting a stainless steel wall at the entrance of the dump tunnel
- The updated configuration with 2in aperture and the Al wall produced similar levels of radiation to the HRS platform

Current Hall A Dump configuration



- For PREX2/CREX we will not need to use the diffuser
- We implemented the major features of the current design in the simulation
  - including the 4 cm Al aperture at ~midway until the Al door