Cameron Clarke

Radiation Simulation Analysis Update

Update 9-7-2017

MOLLER Simulation Meeting

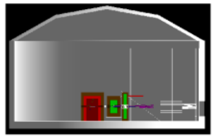
Changes

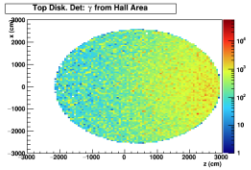
- Improving analysis code
  - Better cuts based on complete geometry and shielding block placements
  - Mapping where radiation comes from that is absorbed in shields
  - Mapping where radiation hits into shields when it gets absorbed
  - Uniform energy bin color weighting (scaled up by factor of 1e9)
  - Uniform x-y-z bin sizing (1 square cm per bin in most plots)

- 4 new geometry shifts
  - Ran original simulation again with slight tweaks
  - More collimator 1 shielding upstream
  - More collimator 1 shielding downstream
  - Added aluminum hybrid vacuum canister
  - Moved collimator 4 upstream (neglected lead photon collimator)

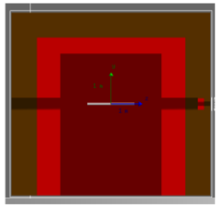
Radiation hitting the roof of the hall – hit positions

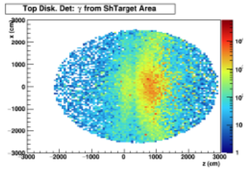
Vertex: 1 – Hall



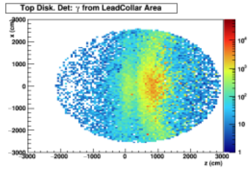


2 – Target

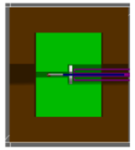


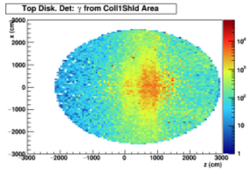


3 – Lead Collar

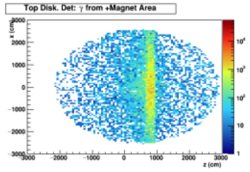


4 – Coll1Shld

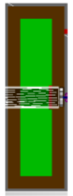


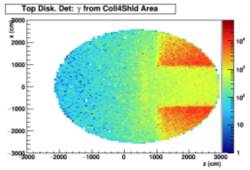


5 – Tail of US Magnet

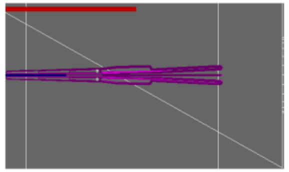


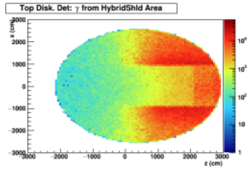
6 – Coll4Shld



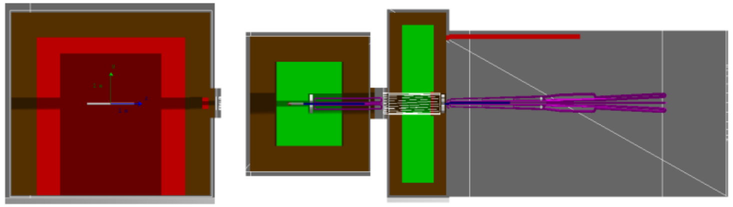


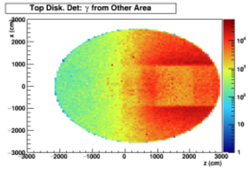
7 – Hybrid Shld



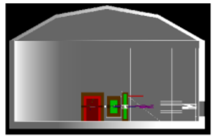


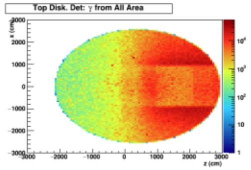
8 – All - Hall





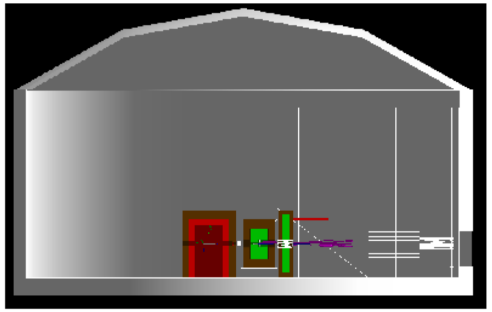
9 – All added equal this

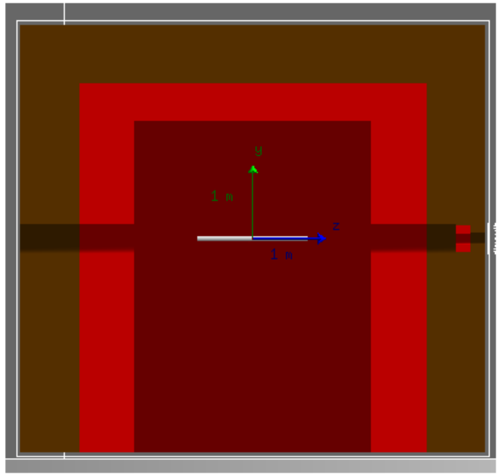


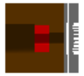


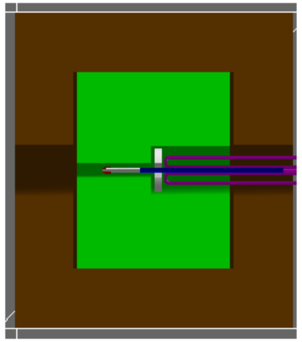
Vertex: 1 2 3 4

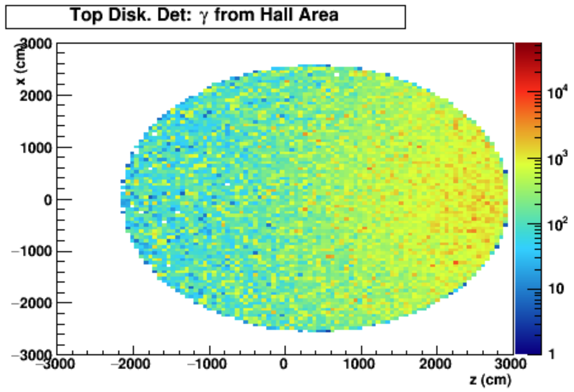
Hall Target Lead Collar Coll1Shld

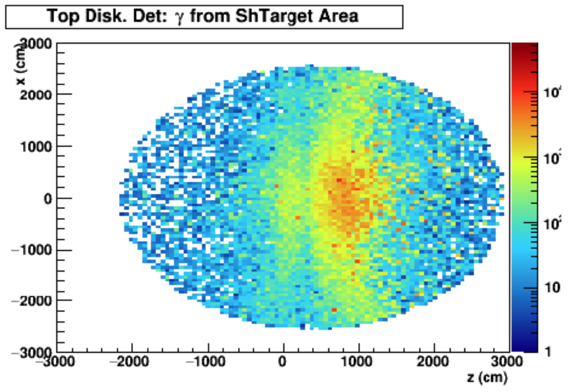


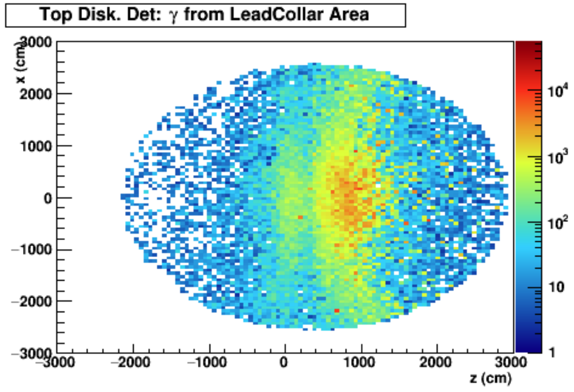


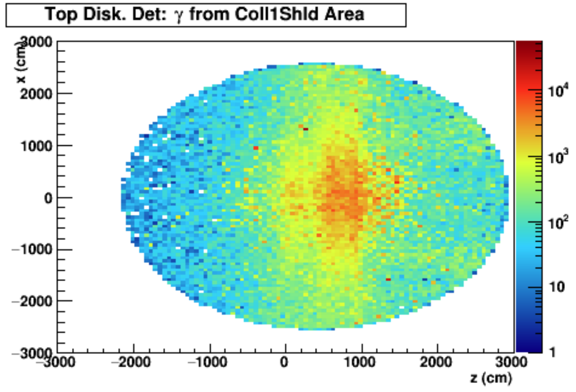






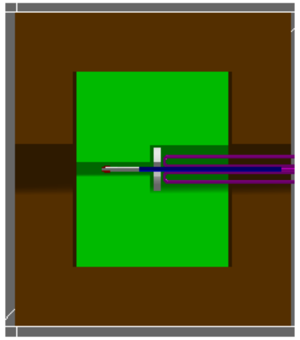


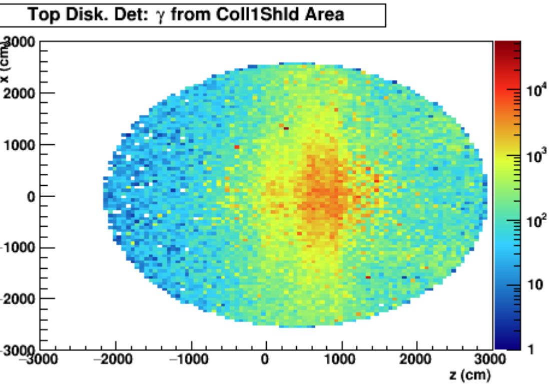




4

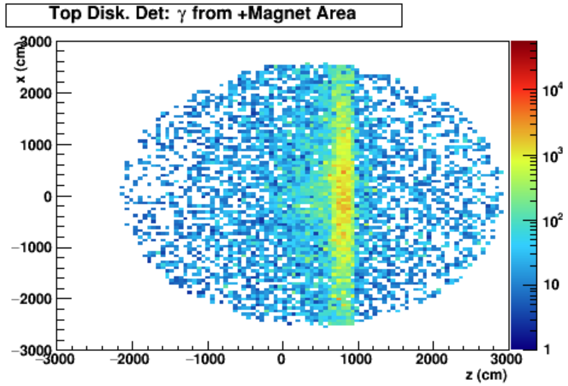
Coll1Shld





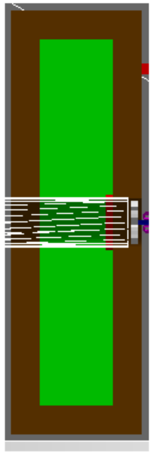
5

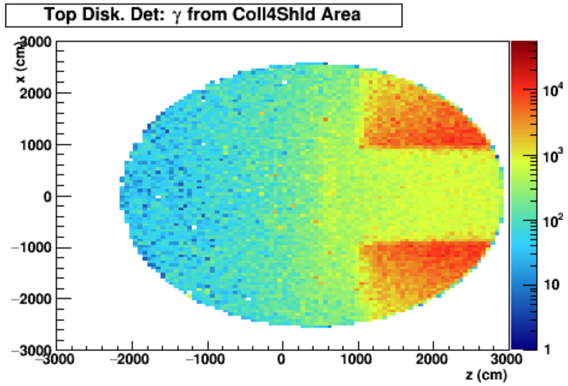
Tail of US Magnet



6

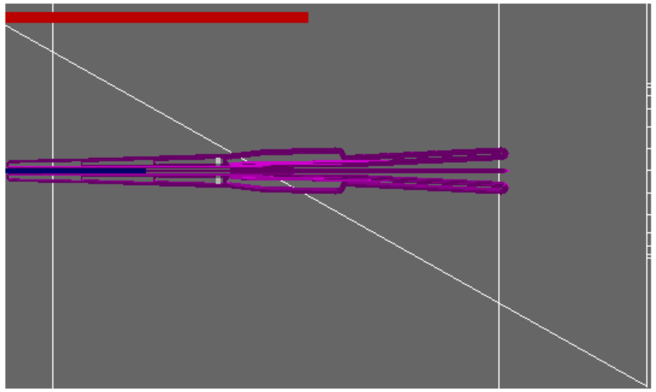
Coll4Shld

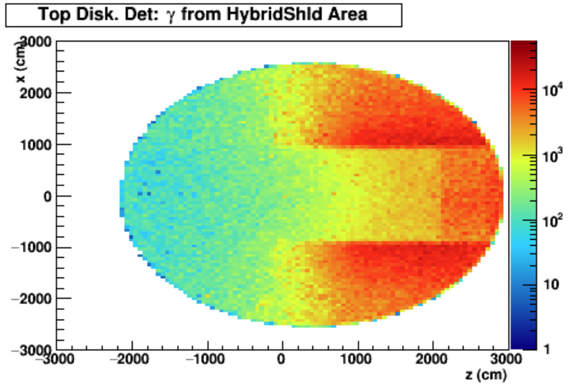




7

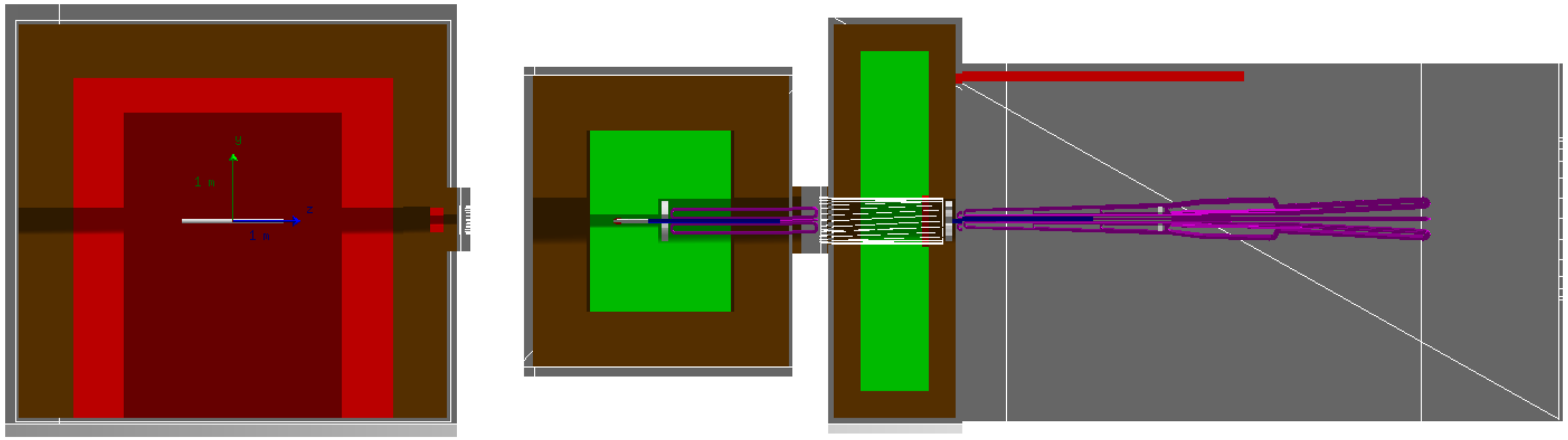
Hybrid Shld

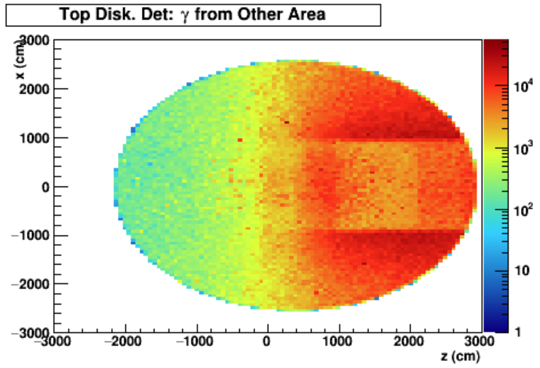




8

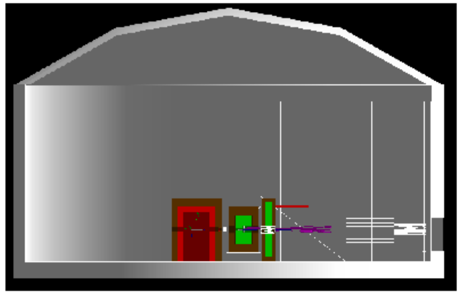
All - Hall

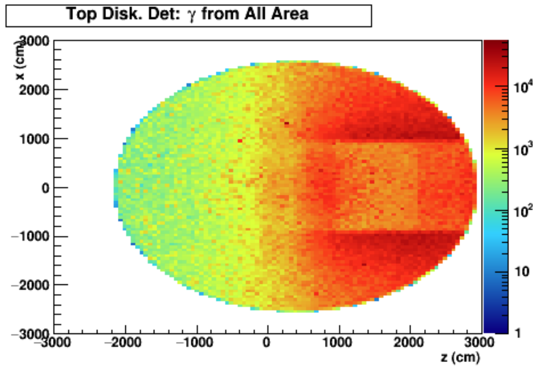




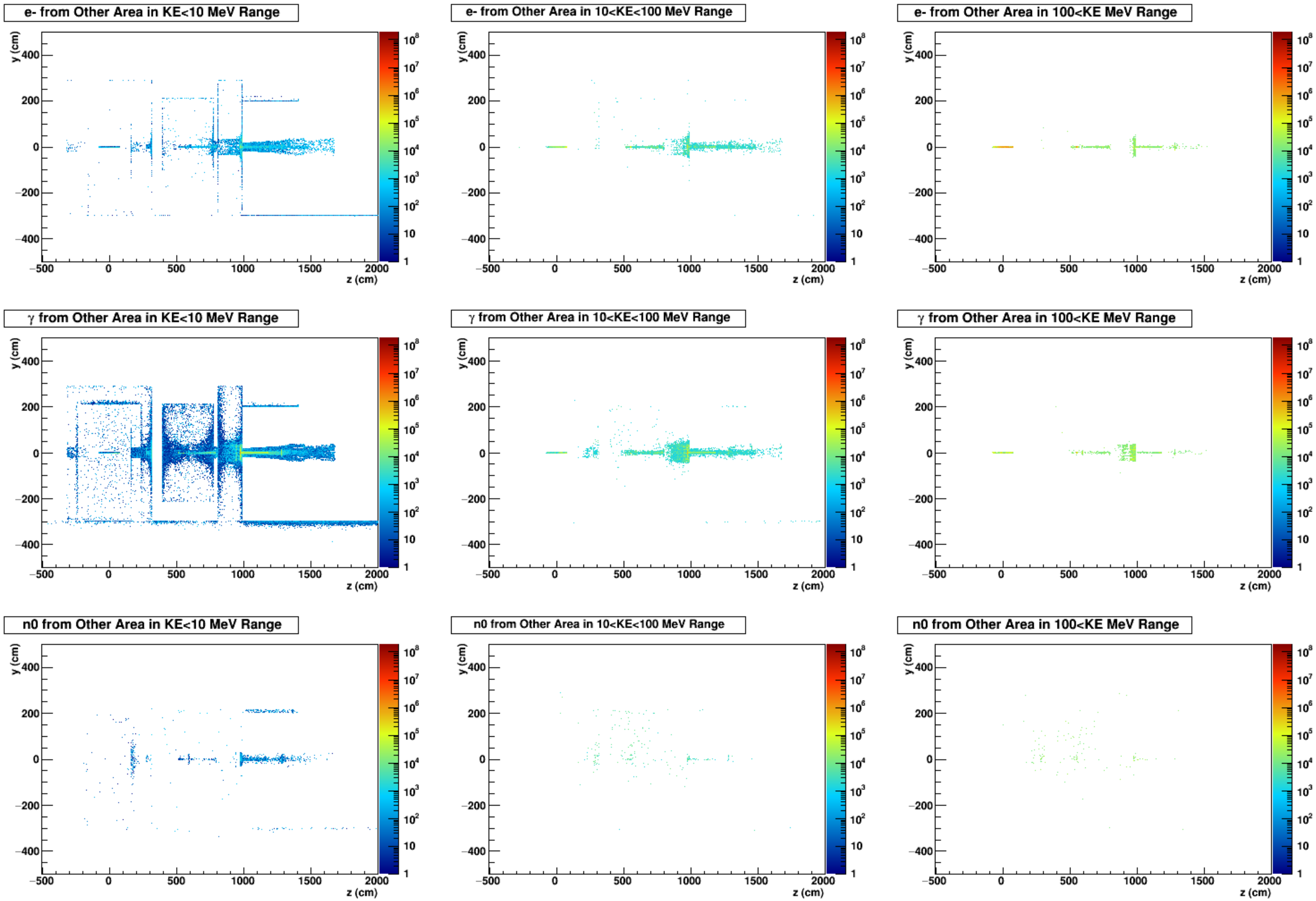
9

All added equal this

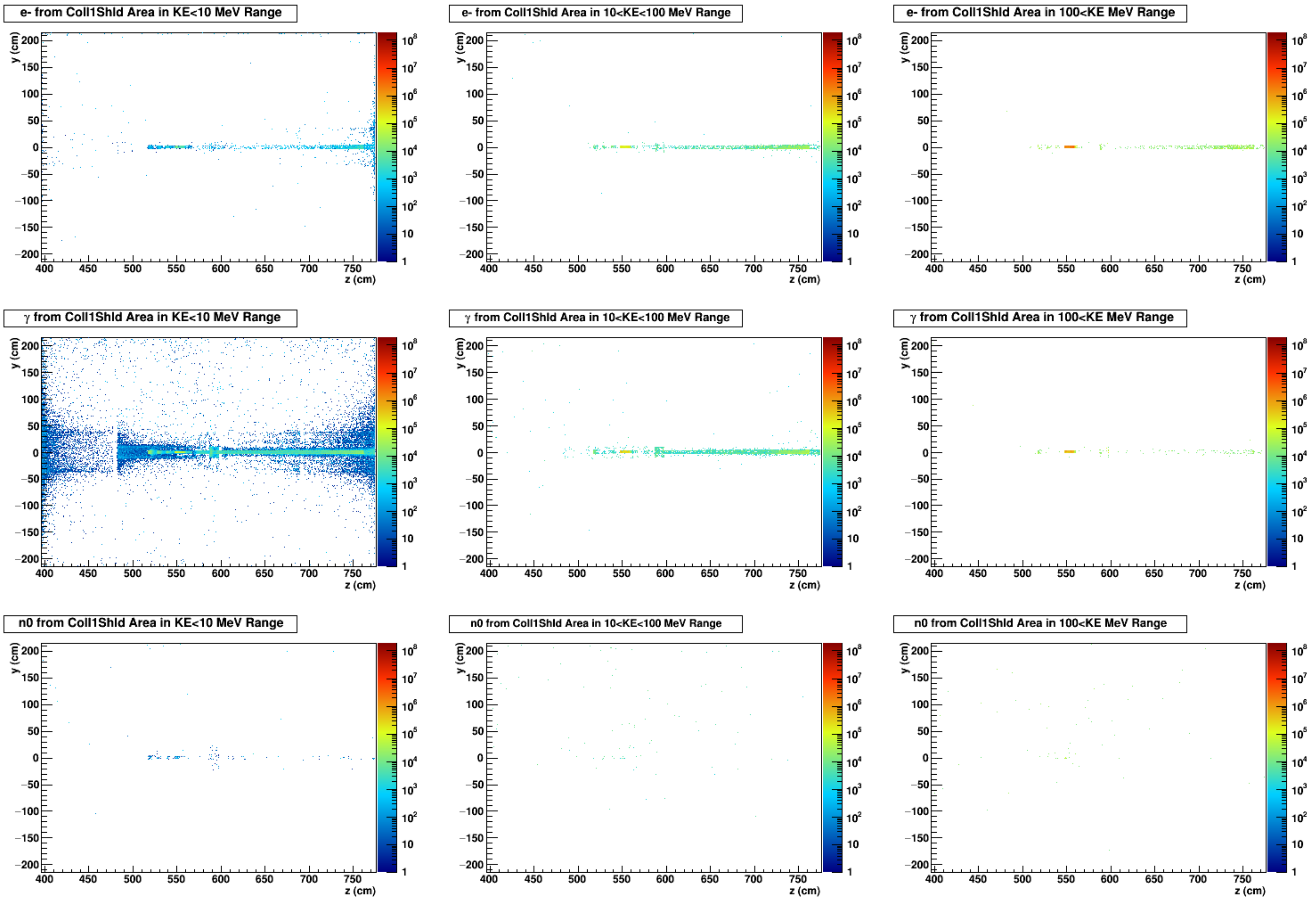




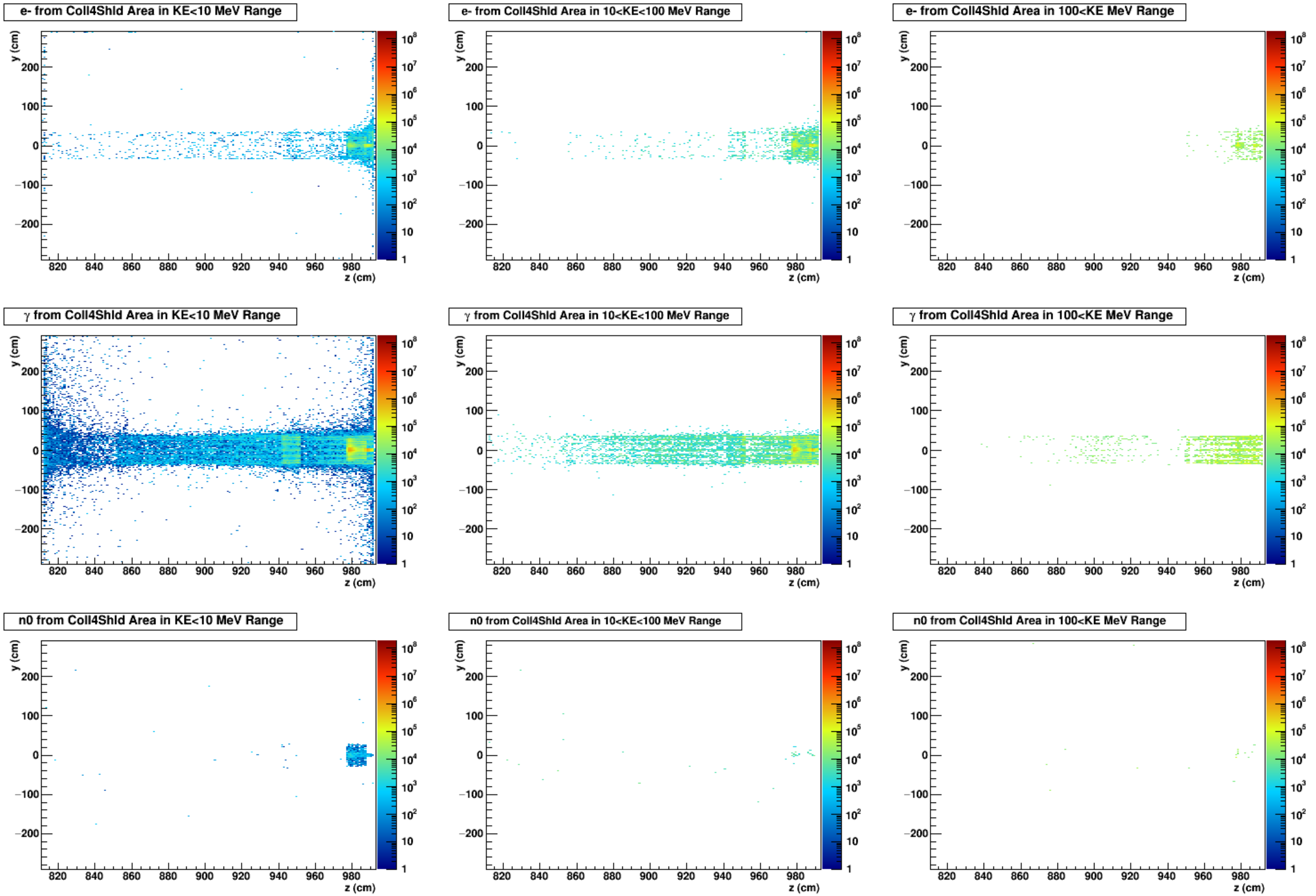
Uniformly energy weighted 1cm^2 binned plots of vertices that hit the roof



Uniformly energy weighted 1cm^2 binned plots of vertices that hit the roof



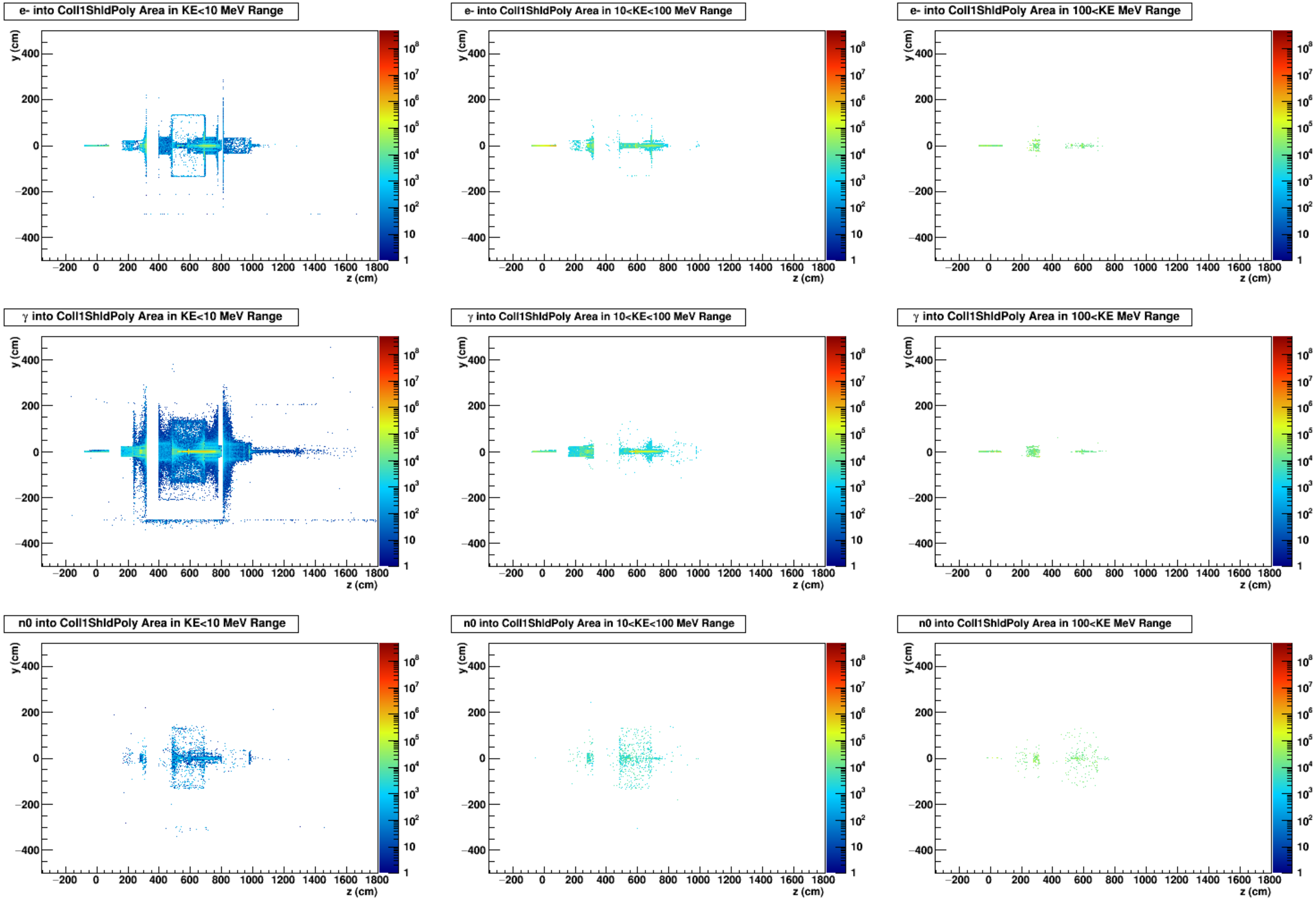
Uniformly energy weighted 1cm^2 binned plots of vertices that hit the roof



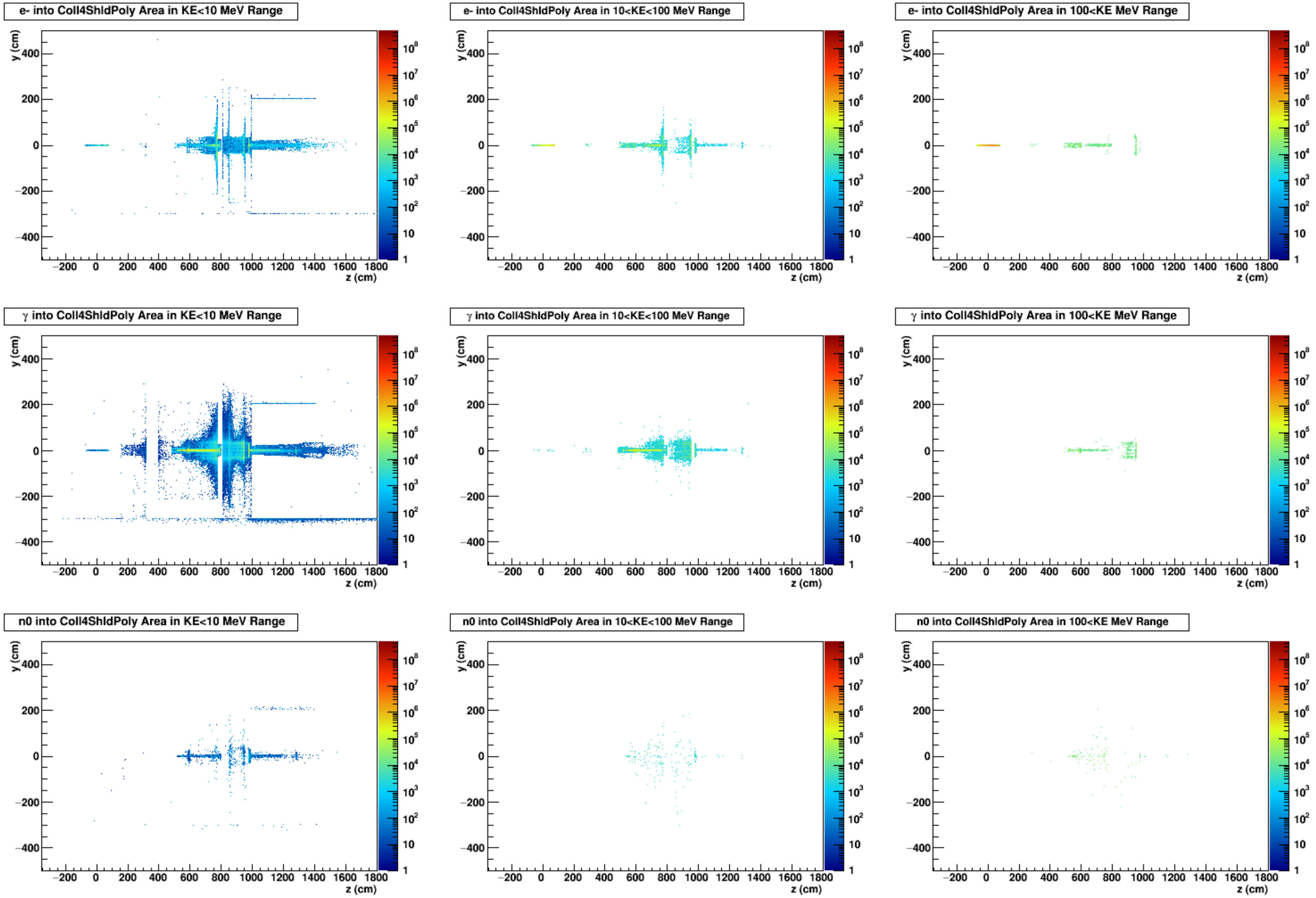
- This shows us that the brightest source of stuff hitting the roof and walls is coming from the collimator 4 area and the front of the hybrid magnet, as well as some from the gaps in-between shielding blocks.
- Moving collimator 4 upstream and closing the shielding blocks should be the first step to closing these bright spots up.

- Next - Looking at the vertices of radiation that is being absorbed by these shielding blocks themselves, not the roof/walls, we see
  - which regions are doing to most blocking and
  - where the radiation the blocks are absorbing is actually coming from
  - Which again suggests closing the block and modifying the collimator 4 area

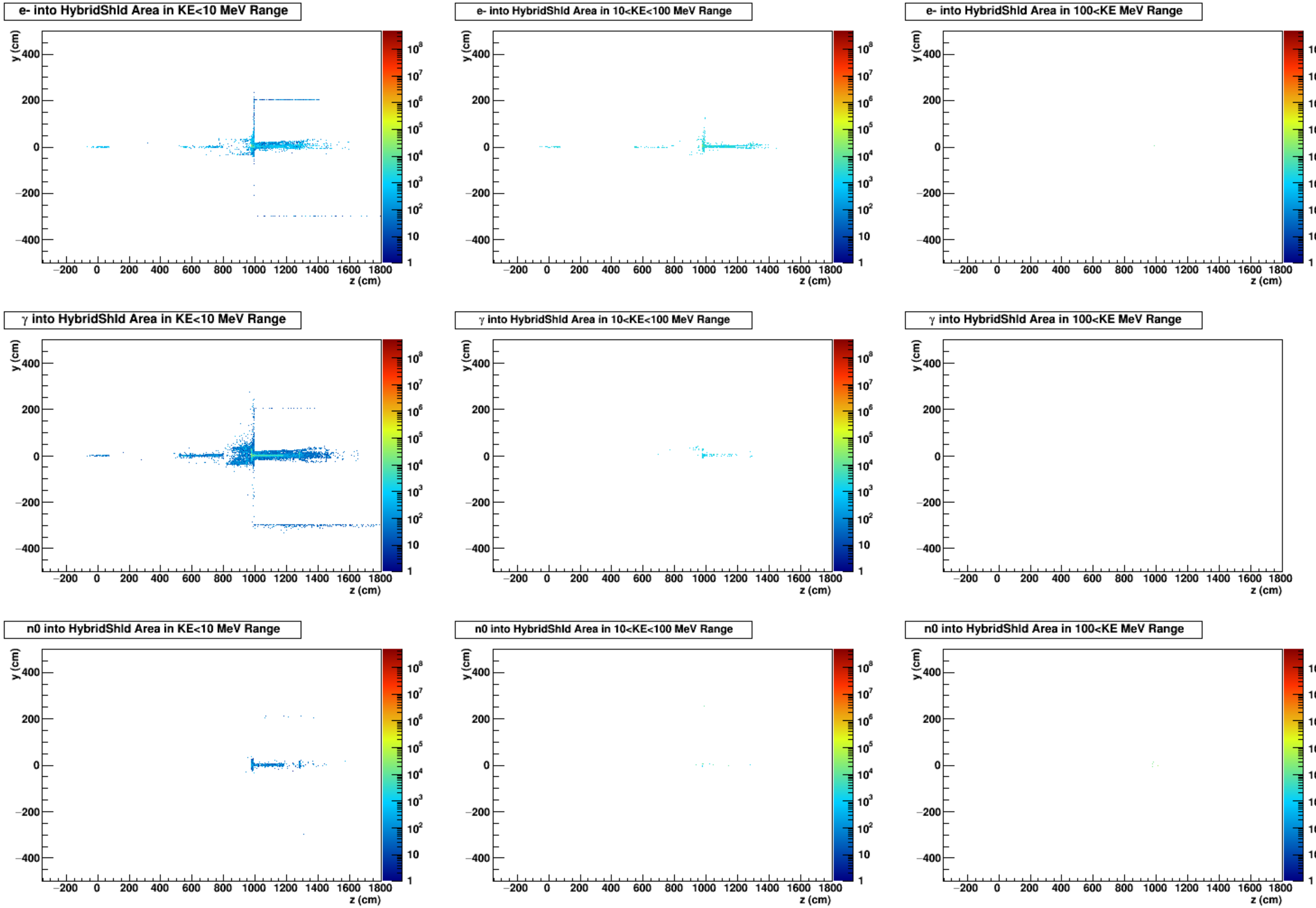
Uniformly energy weighted 1cm^2 binned plots of vertices that hit the shielding block



Uniformly energy weighted 1cm^2 binned plots of vertices that hit the shielding block

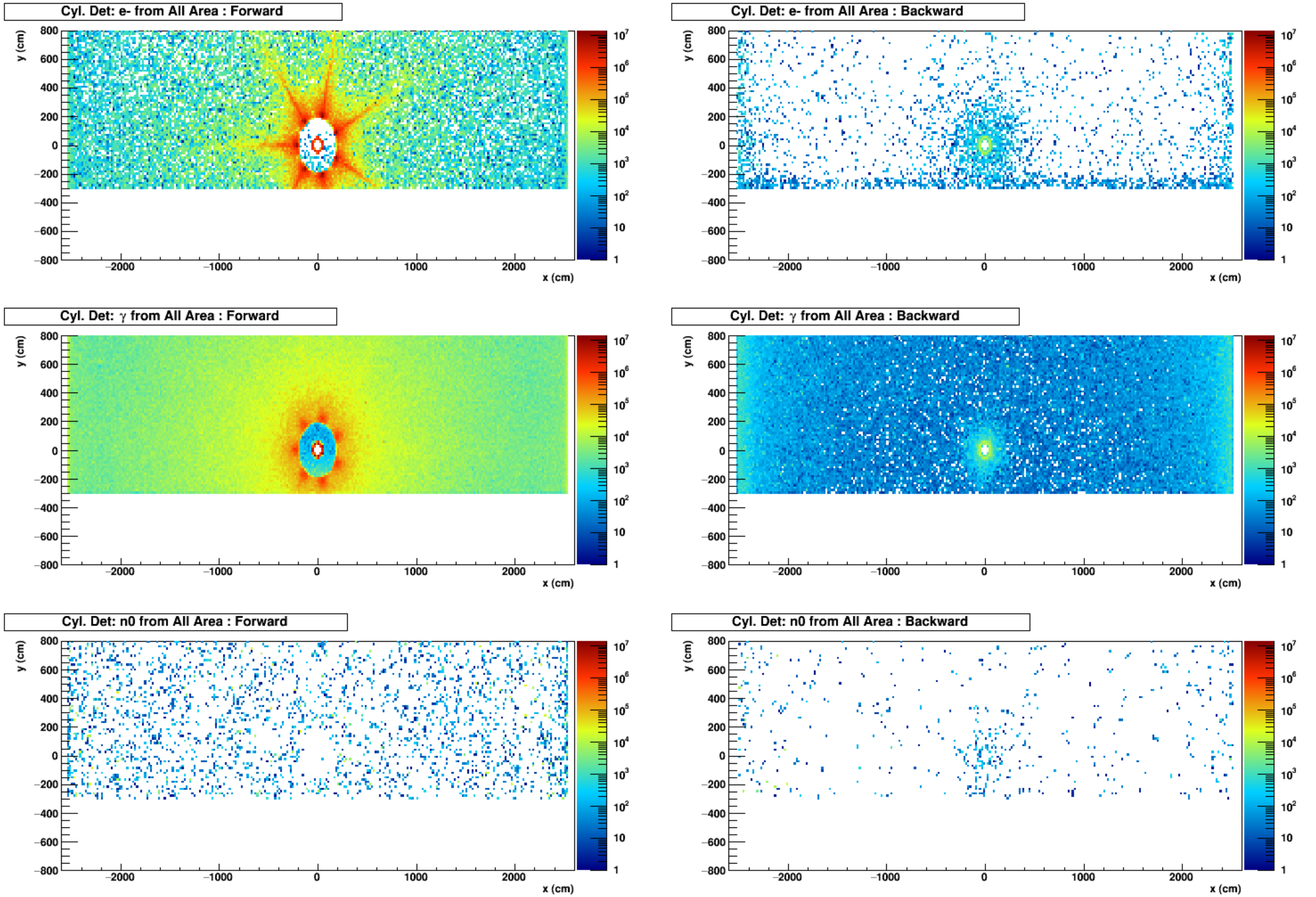


Uniformly energy weighted 1cm^2 binned plots of vertices that hit the shielding block



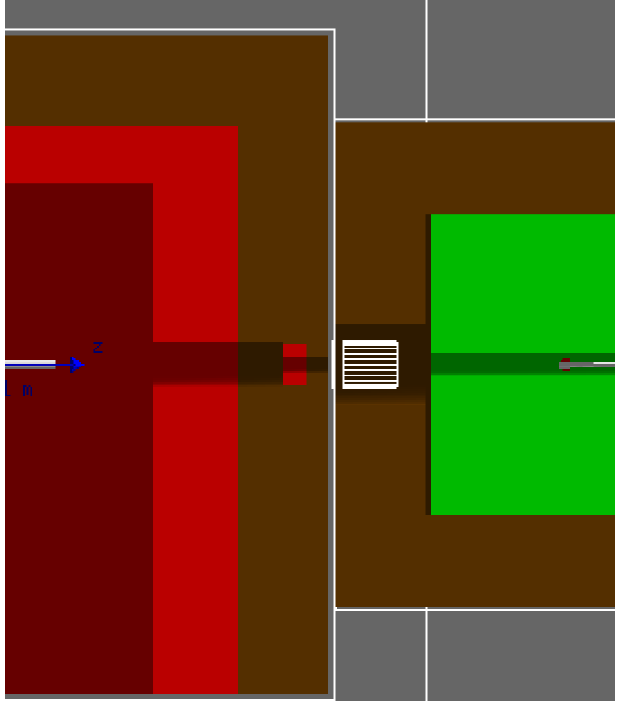
Uniformly energy weighted 1cm^2 binned plots of hits on the wall from all regions

R>50cm Almost completely dominated by the collimator 4 shielding block region, R<50cm by collimator 1 region



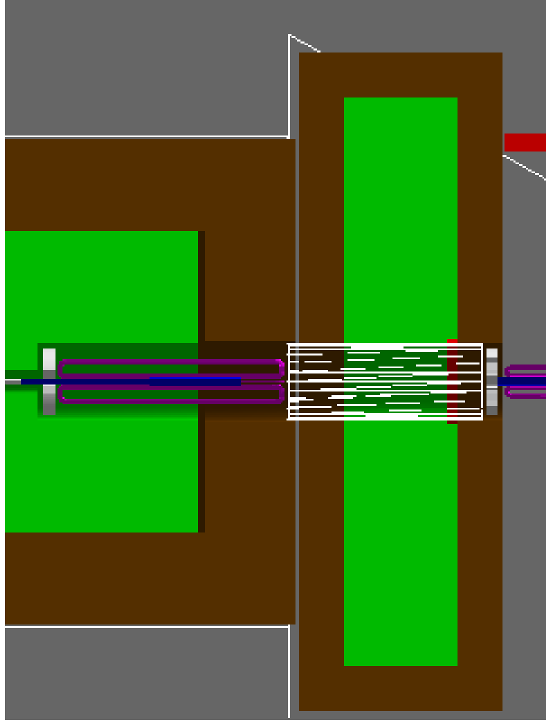
1

Added upstream shielding



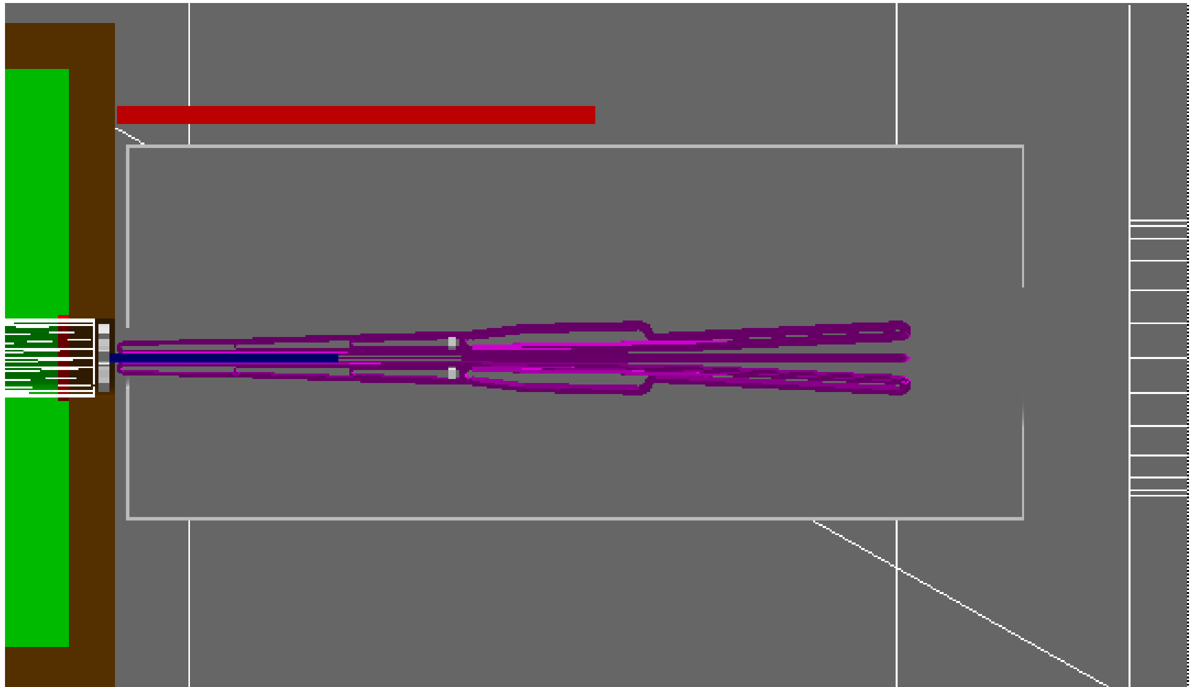
2

Added downstream shielding



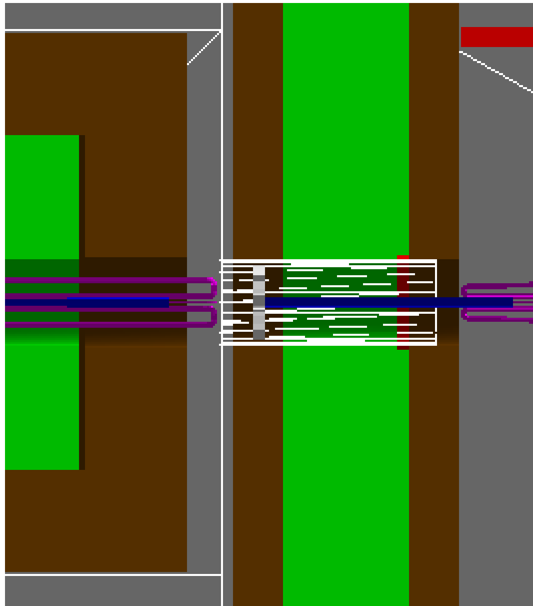
3

Added
aluminum
Can around
Hybrid magnet



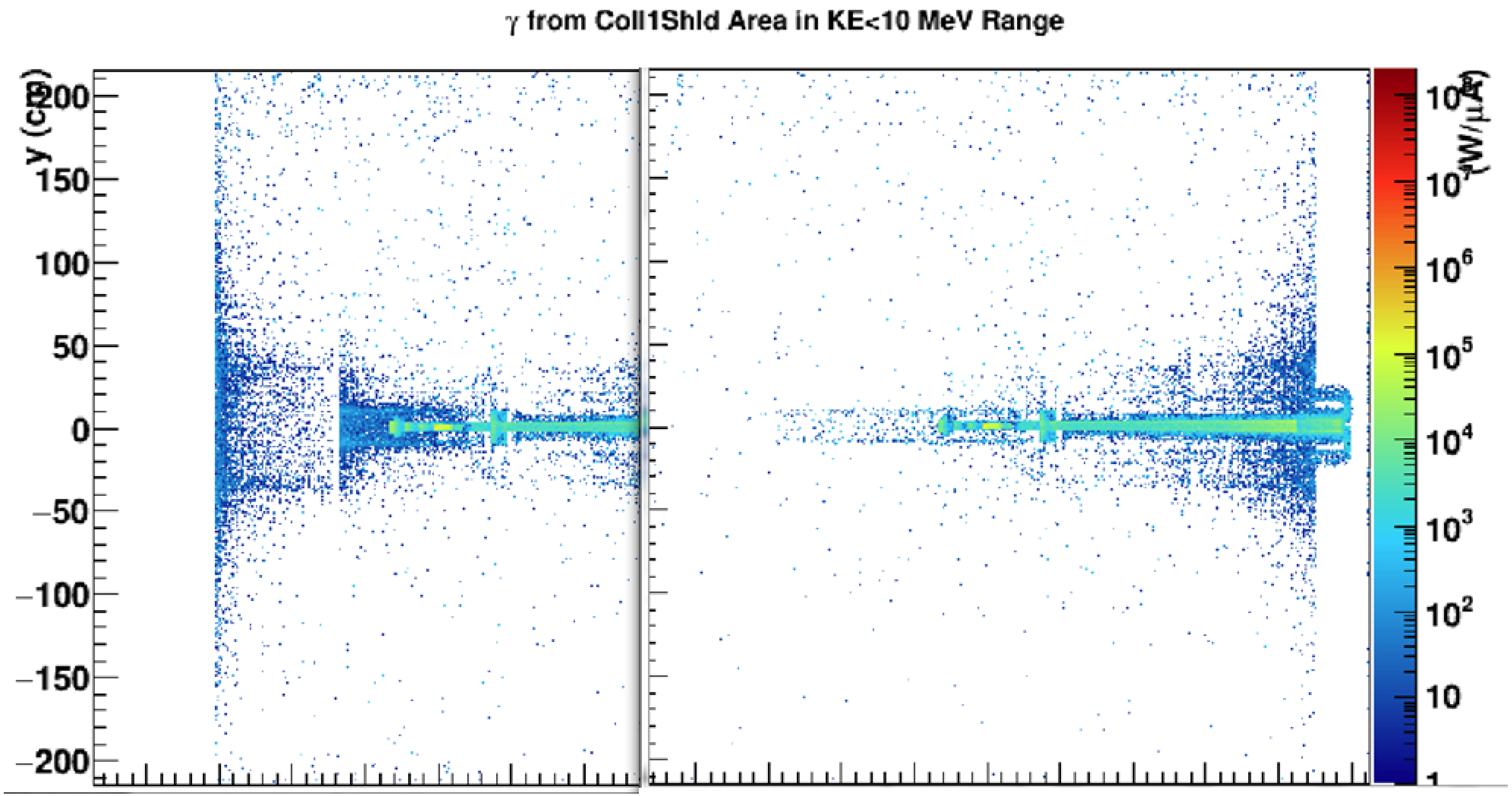
4

Moved just
The tungsten
Part of coll 4
Upstream some



The main effect of the upstream shielding addition is that the closed gap prevents radiation from shining into the hall.

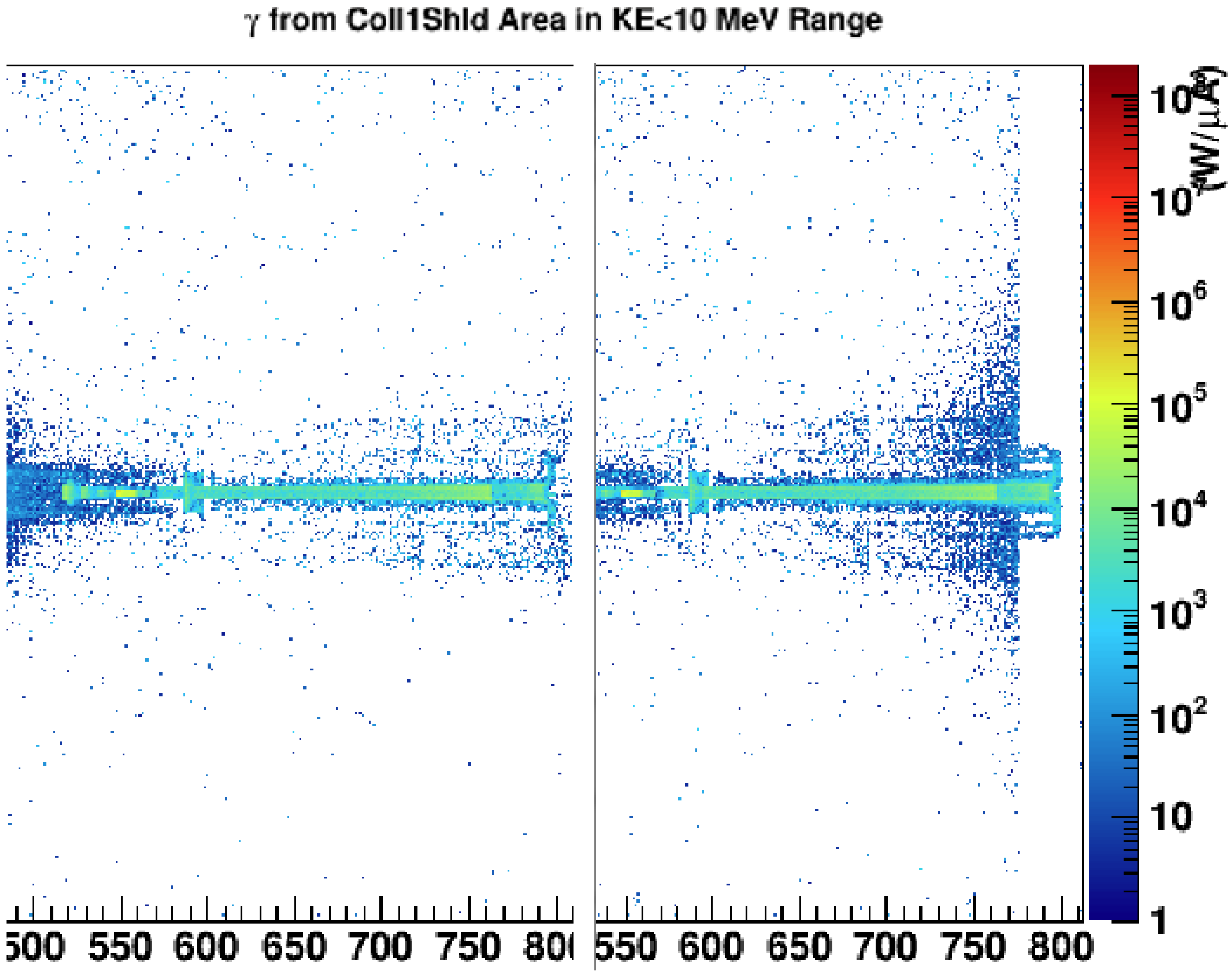
Original | More shielding



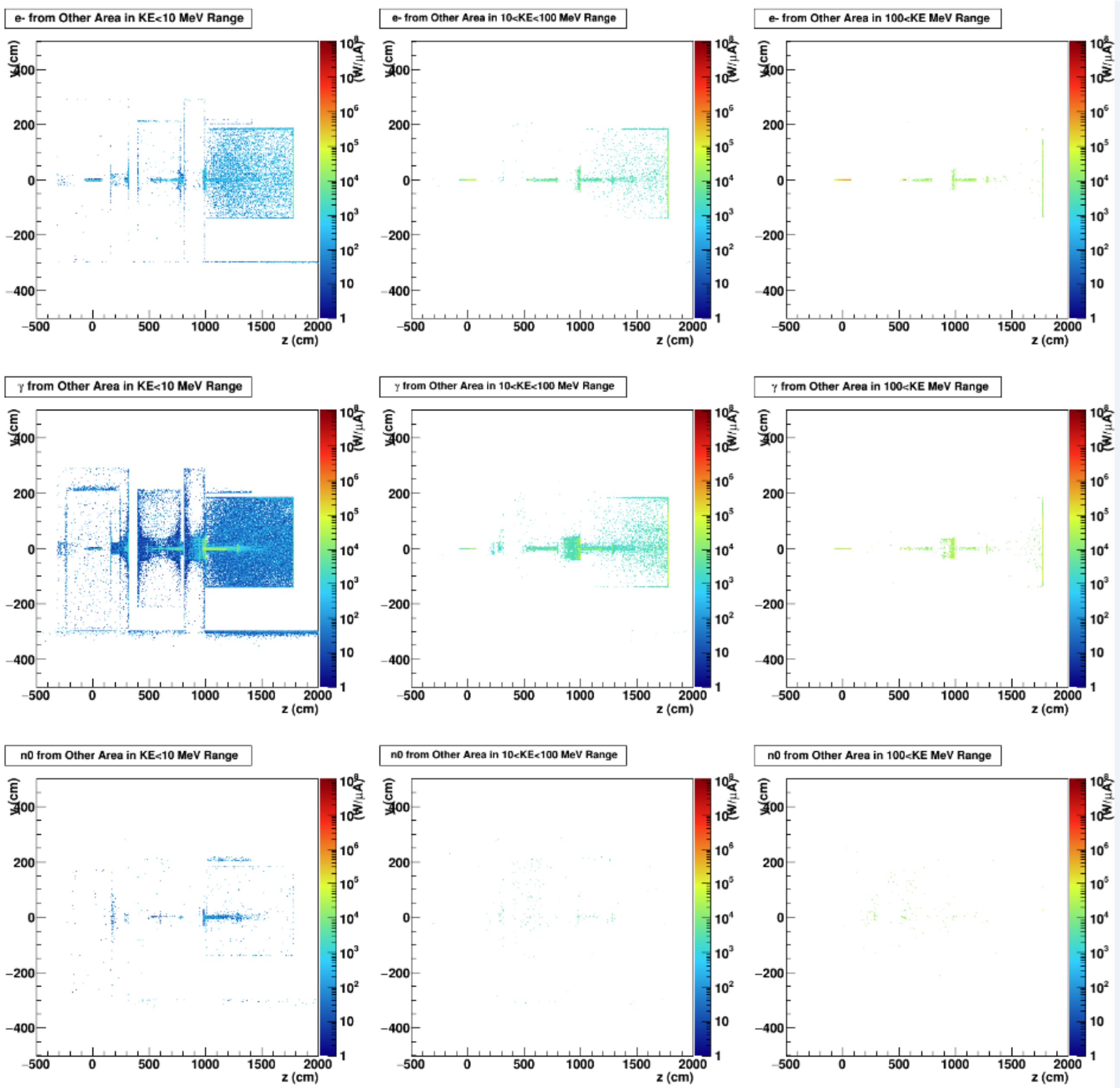
This effect is also present in the downstream shielding addition, though its net improvement is small – this will be important when paired with moving collimator 4 closer to this shielding block

More shielding

Original

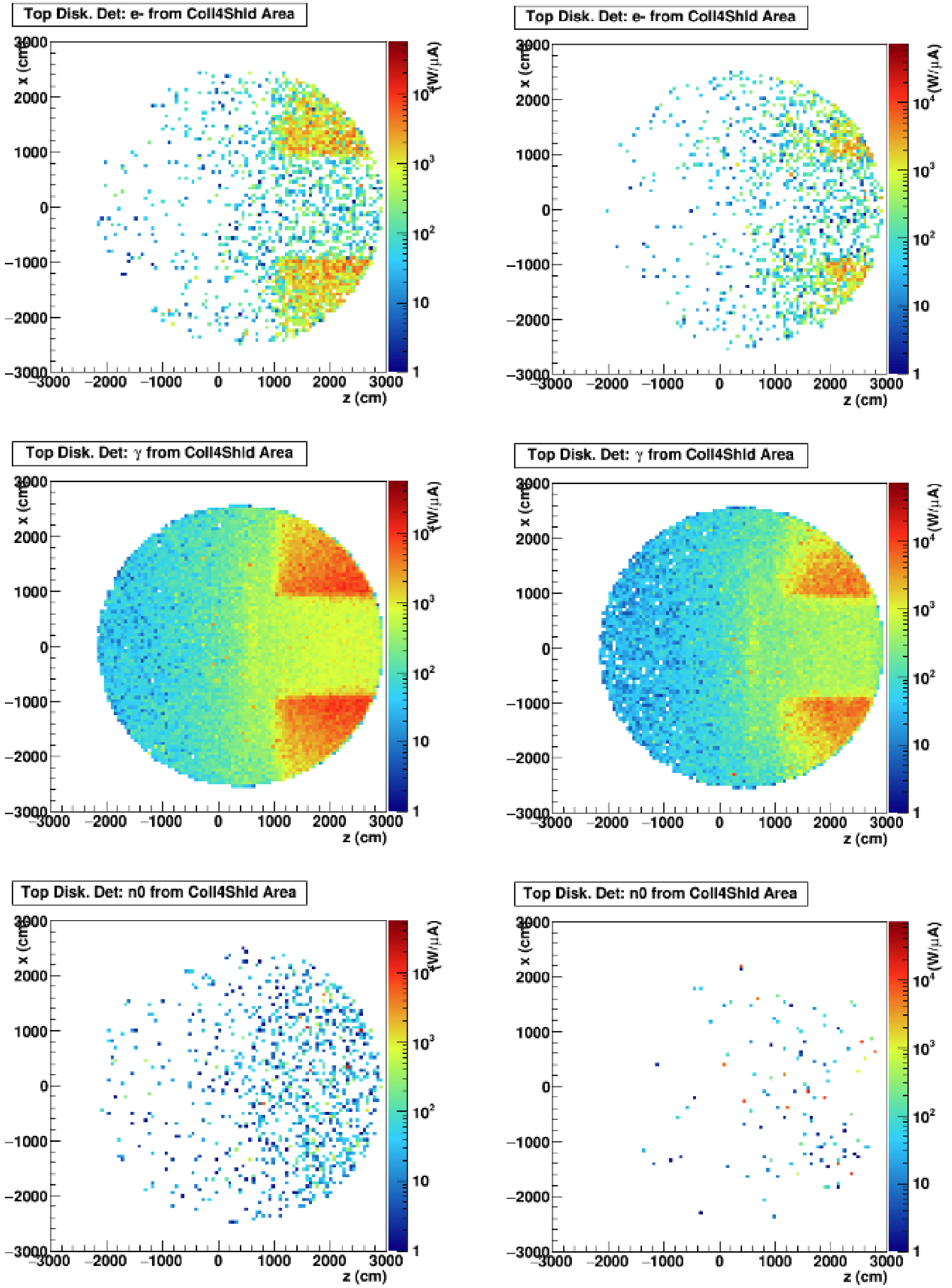


Vertices that hit the roof – Now with the Aluminum Can



Compare with slide 7 to see increased scattering into the hall, but a general decrease in radiation from the hybrid area

Original | Moved Col 4



Moving collimator 4 upstream has the desired effect that less radiation comes from it and hits the roof.

However, by not modifying the shielding or precisely updating its size and position to match the envelopes upstream it has a net increase on radiation coming from upstream.

New 9-6-2017

>>>> **Standard**

Removing 7/8 of the roof – 10M events NEW

Flux (10^9 Hertz/microAmp)			ΔFactor	Relative
Type	Range	Top	Proof	Shift
e^-	E<10	**7.45E+00**	6.9	591%
	10<E<100	**9.16E-01**	55.1	5406%
	100<E	**6.24E-04**	0.0	x
γ	E<10	**4.68E+02**	5.9	487%
	10<E<100	**7.83E-01**	2.9	187%
	100<E	**1.25E-03**	0.0	x
n^0	E<10	**9.86E+00**	4.2	321%
	10<E<100	**6.74E-02**	1.6	62%
	100<E	**4.18E-02**	1.7	67%

More Col1 Shld US

Flux (10^9 Hertz/microAmp)			ΔFactor	Relative
Type	Range	Top	Standard	Shift
e^-	E<10	**7.10E+00**	1.0	-5%
	10<E<100	**9.72E-01**	1.1	6%
	100<E	**6.24E-04**	1.0	0%
γ	E<10	**4.13E+02**	0.9	-12%
	10<E<100	**7.38E-01**	0.9	-6%
	100<E	**1.25E-03**	1.0	0%
n^0	E<10	**7.54E+00**	0.8	-24%
	10<E<100	**6.80E-02**	1.0	1%
	100<E	**4.06E-02**	1.0	-3%

More Col1 Shld DS

Flux (10^9 Hertz/microAmp)			ΔFactor	Relative
Type	Range	Top	Standard	Shift
e^-	E<10	**6.65E+00**	0.9	-11%
	10<E<100	**9.60E-01**	1.0	5%
	100<E	**1.87E-03**	3.0	200%
γ	E<10	**4.32E+02**	0.9	-8%
	10<E<100	**8.13E-01**	1.0	4%
	100<E	**4.37E-03**	3.5	250%
n^0	E<10	**9.48E+00**	1.0	-4%
	10<E<100	**7.68E-02**	1.1	14%
	100<E	**4.43E-02**	1.1	6%

Removing 7/8 of the roof – 10M events NEW

Flux (10^9 Hertz/microAmp)			ΔFactor	
Type	Range	Top	PREX II	
e^-	E<10	**7.45E+00**	0.4	-64%
	10<E<100	**9.17E-01**	0.1	-90%
γ	E<10	**4.68E+02**	0.7	-27%
	10<E<100	**7.84E-01**	0.0	-96%
n^0	E<10	**9.86E+00**	5.5	451%
	10<E<100	**1.09E-01**	0.8	-19%

More Col1 Shld US

Flux (10^9 Hertz/microAmp)			ΔFactor	
Type	Range	Top	PREX II	
e^-	E<10	**7.10E+00**	0.3	-65%
	10<E<100	**9.73E-01**	0.1	-90%
γ	E<10	**4.13E+02**	0.6	-36%
	10<E<100	**7.39E-01**	0.0	-96%
n^0	E<10	**7.54E+00**	4.2	321%
	10<E<100	**1.09E-01**	0.8	-19%

More Col1 Shld DS

Flux (10^9 Hertz/microAmp)			ΔFactor	
Type	Range	Top	PREX II	
e^-	E<10	**6.65E+00**	0.3	-68%
	10<E<100	**9.62E-01**	0.1	-90%
γ	E<10	**4.32E+02**	0.7	-33%
	10<E<100	**8.17E-01**	0.0	-96%
n^0	E<10	**9.48E+00**	5.3	429%
	10<E<100	**1.21E-01**	0.9	-10%

More Col1 Shld AlCan

Flux (10^9 Hertz/microAmp)			ΔFactor	Relative
Type	Range	Top	Standard	Shift
e^-	E<10	**5.46E+00**	0.7	-27%
	10<E<100	**2.21E-01**	0.2	-76%
	100<E	**1.25E-03**	2.0	**100%**
γ	E<10	**4.43E+02**	0.9	-5%
	10<E<100	**7.86E-01**	1.0	0%
	100<E	**3.12E-03**	2.5	**150%**
n^0	E<10	**9.57E+00**	1.0	-3%
	10<E<100	**8.18E-02**	1.2	21%
	100<E	**4.87E-02**	1.2	16%

More Col1 Shld MovedCol4

Flux (10^9 Hertz/microAmp)			ΔFactor	Relative
Type	Range	Top	Standard	Shift
e^-	E<10	**9.44E+00**	1.3	27%
	10<E<100	**1.28E+00**	1.4	40%
	100<E	**1.87E-03**	3.0	**200%**
γ	E<10	**6.17E+02**	1.3	32%
	10<E<100	**9.07E-01**	1.2	16%
	100<E	**3.12E-03**	2.5	**150%**
n^0	E<10	**1.02E+01**	1.0	3%
	10<E<100	**8.93E-02**	1.3	32%
	100<E	**4.18E-02**	1.0	0%

More Col1 Shld AlCan

Flux (10^9 Hertz/microAmp)			ΔFactor	
Type	Range	Top	PREX II	
e^-	E<10	5.46E+00	0.3	-73%
	10<E<100	2.22E-01	0.0	-98%
γ	E<10	**4.43E+02**	0.7	-31%
	10<E<100	**7.89E-01**	0.0	-96%
n^0	E<10	**9.57E+00**	5.3	434%
	10<E<100	1.30E-01	1.0	-3%

More Col1 Shld MovedCol4

Flux (10^9 Hertz/microAmp)			ΔFactor	
Type	Range	Top	PREX II	
e^-	E<10	**9.44E+00**	0.5	-54%
	10<E<100	**1.28E+00**	0.1	-86%
γ	E<10	**6.17E+02**	1.0	-4%
	10<E<100	**9.11E-01**	0.0	-95%
n^0	E<10	**1.02E+01**	5.7	468%
	10<E<100	**1.31E-01**	1.0	-2%

There are more details to go into, but the conclusion is this:

- The upstream col 1 shielding addition is good and helps out by a reasonable amount, though it is not incredibly significant.

- The downstream col 1 shielding addition is ok, but doesn’t give much improvement.
    - I made some logical volume mistakes that may need to be repaired before a conclusion on its efficacy can be made.

- The aluminum can addition is actually pretty good, though it scatters into the hall.
    - It kills a lot of low energy radiation, but it increases by a factor of 2 the overall high energy photons (though still a very tiny amount) into the hall and increases the neutron radiation a bit.

- Moving collimator 4 did not improve things as expected – decreases radiation downstream of collimator 4, but badly increases radiation coming from upstream of it.
    - I need to correctly reshape the collimator and move the accompanying lead photon collimator.
    - Modifying the surrounding shielding, especially in front of the collimator, should fix the increase as well.