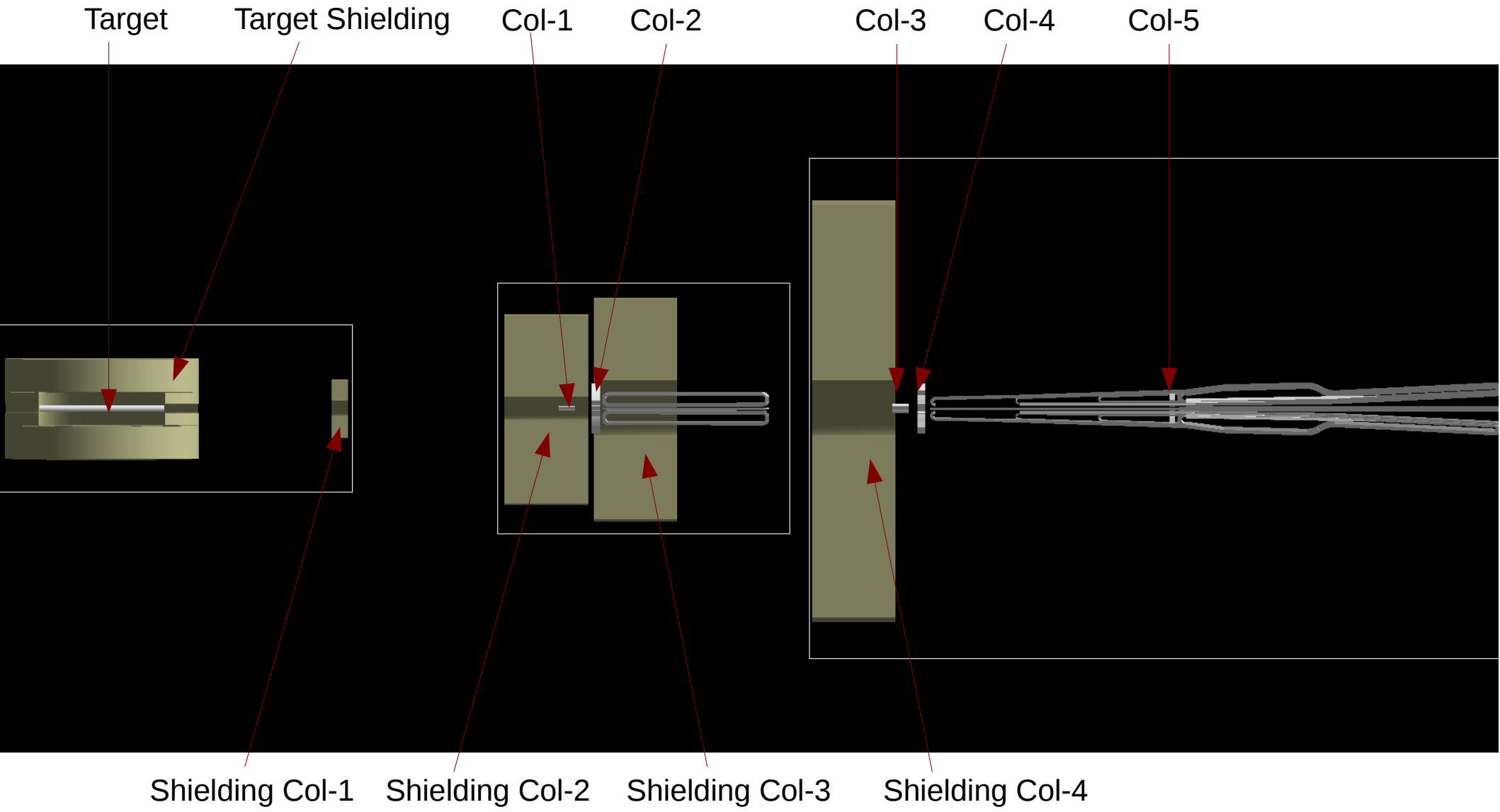


MOLLER_12GeV Shielding Update

Rakitha Beminiwattha

Simulation Status

All the collimators are Tungsten



All the shielding enclosures are Borated Concrete

Simulation Status

- Simulation done using 11 GeV electron beam on 150 cm hydrogen target
- Current simulation do not have the hall A enclosure included
 - Will add from now on
- Detectors used
 - Cylindrical detector at the hall radius with same height as the hall → This is same as PREX “Hall Detector” or “Cylin. Detector”
 - Two disk detectors at top and bottom of the cylindrical detector → “Top” and “Bottom” detector

Current Status of Shielding

Only comparing cylindrical detector "Hall Detector"					
		MOLLER N/Shield	MOLLER W/Shield	PREX_I	PREX_II
Type	E range	Power	Power	Power	Power
	(MeV)	(W/uA)	(W/uA)	(W/uA)	(W/uA)
Photons	E<10	1.1380	0.0342	0.7455	0.0763
	10<E	13.9730	6.9379	2.0330	0.1070
e±	E<10	1.7380	0.4050	0.1663	0.0091
	10<E	2.0085	1.0733	1.2880	0.0562
Neutrons	E<10	0.0011	0.0017	0.0023	0.0003
	10<E	0.5449	0.2723	0.0039	0.0012

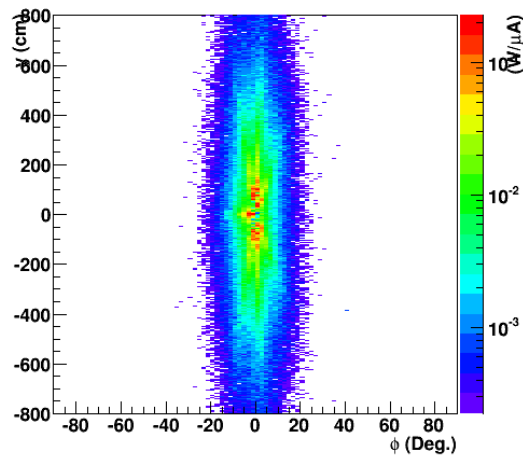
Note: Prex simulation had full concrete hall walls but missing them in MOLLER simulation

Only comparing cylindrical detector "Hall Detector"					
		MOLLER N/Shield	MOLLER W/Shield	PREX_I	PREX_II
Type	E range	Flux	Flux	Flux	Flux
	(MeV)	(per uA)	(per uA)	(per uA)	(per uA)
Photons	E<10	2.22E+12	6.25E+10	2.64E+12	5.13E+11
	10<E	1.02E+12	8.19E+10	1.68E+11	1.43E+10
e±	E<10	8.23E+12	1.85E+12	8.64E+10	6.66E+09
	10<E	3.89E+11	1.82E+11	8.51E+10	4.45E+09
Neutrons	E<10	9.92E+08	1.70E+09	4.44E+10	1.11E+10
	10<E	4.39E+10	3.85E+10	2.05E+08	1.06E+08

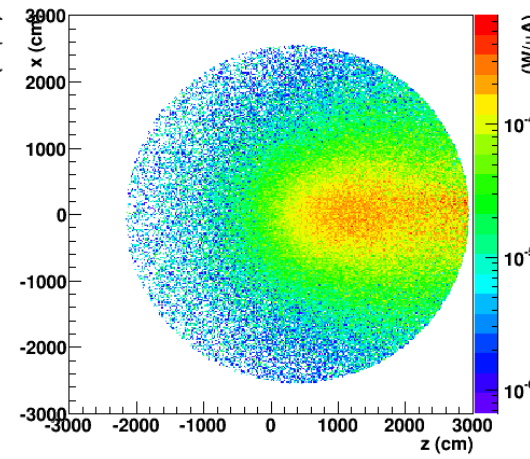
Note: Prex simulation had full concrete hall walls but missing them in MOLLER simulation

No Shielding Radiation Map vs. Current Shielding Radiation Map

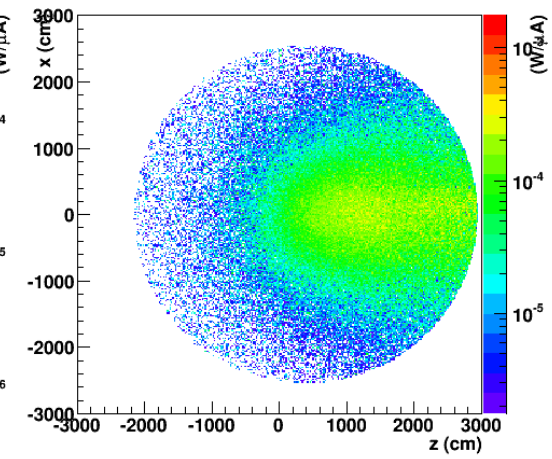
Cyl. Det: abs(electrons) from All Area



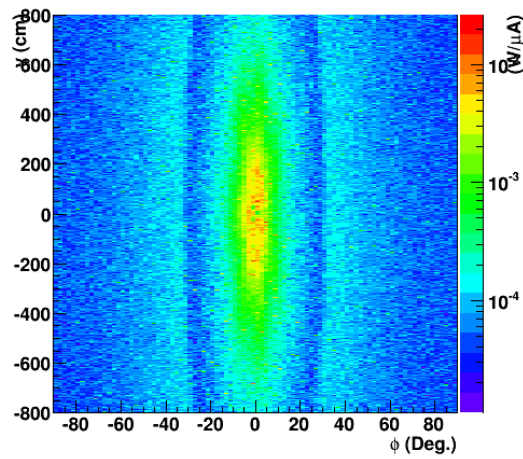
Top Disk. Det: abs(electrons) from All Area



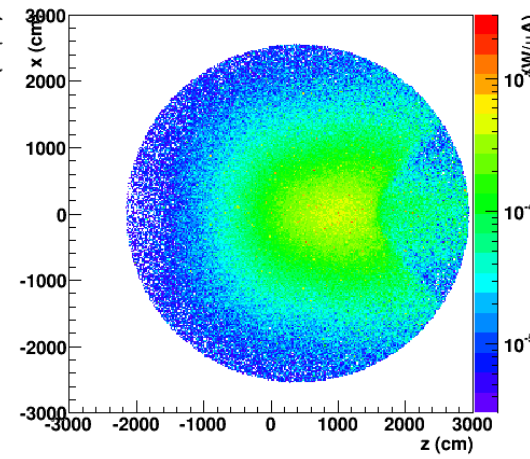
Bottom Disk. Det: abs(electrons) from All Area



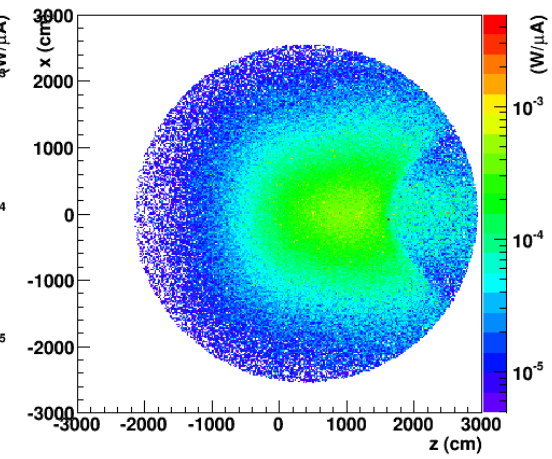
Cyl. Det: γ from All Area



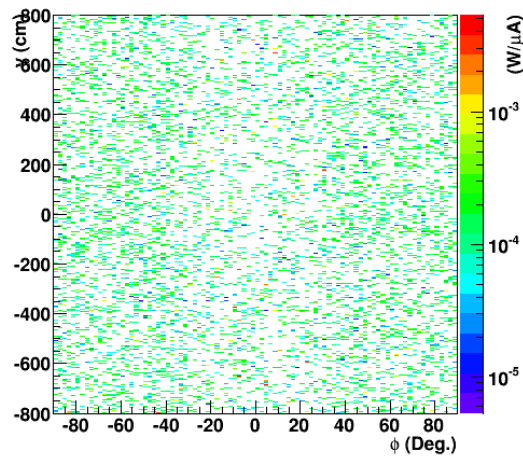
Top Disk. Det: γ from All Area



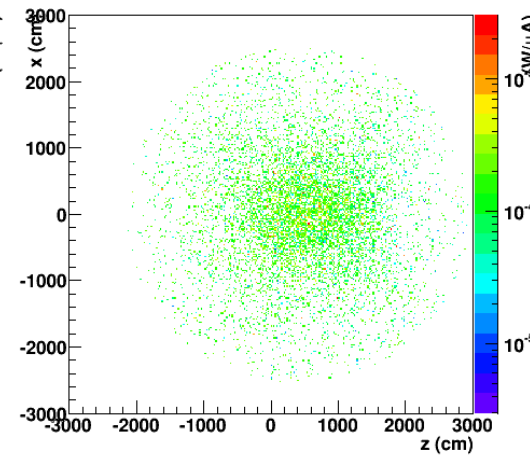
Bottom Disk. Det: γ from All Area



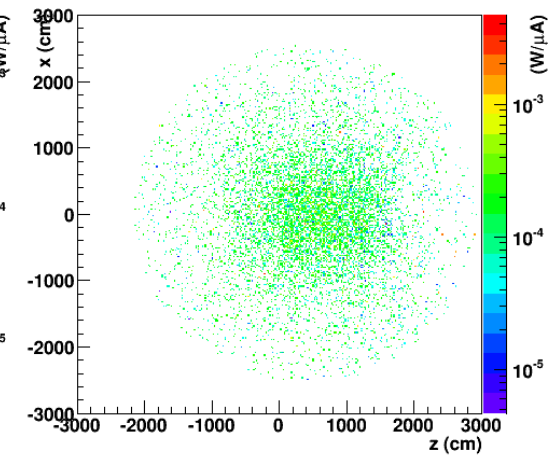
Cyl. Det: Neutron from All Area



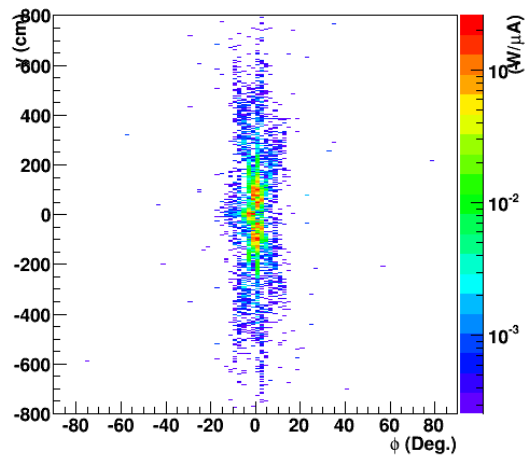
Top Disk. Det: Neutron from All Area



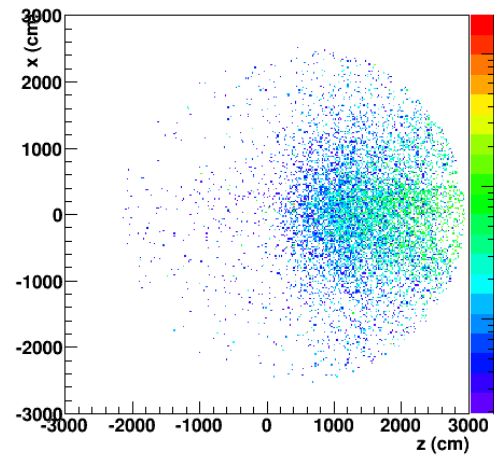
Bottom Disk. Det: Neutron from All Area



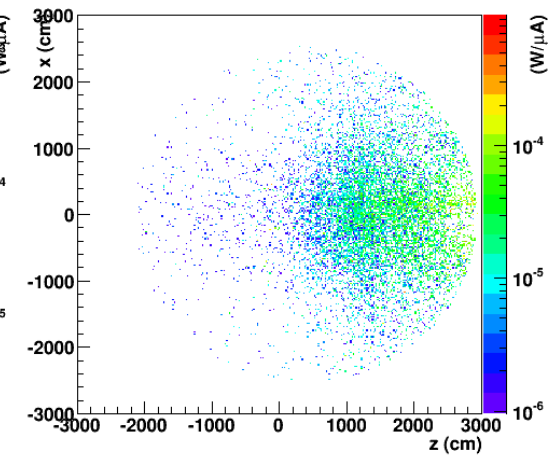
Cyl. Det: abs(electrons) from All Area



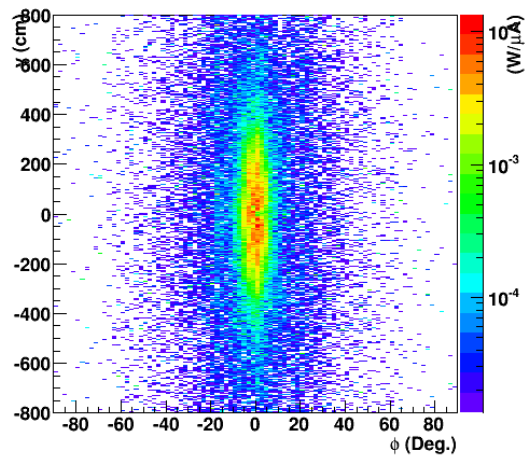
Top Disk. Det: abs(electrons) from All Area



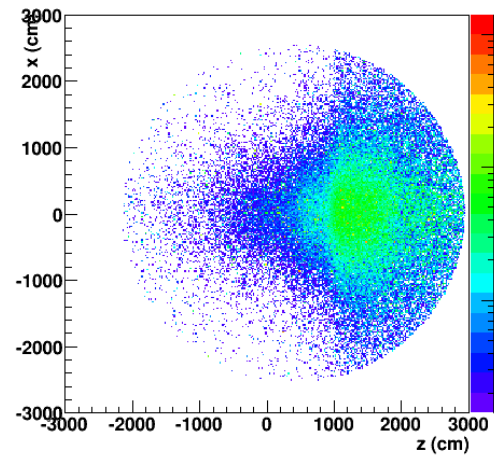
Bottom Disk. Det: abs(electrons) from All Area



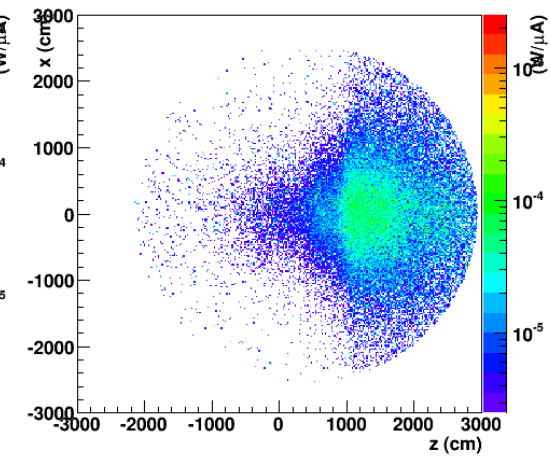
Cyl. Det: γ from All Area



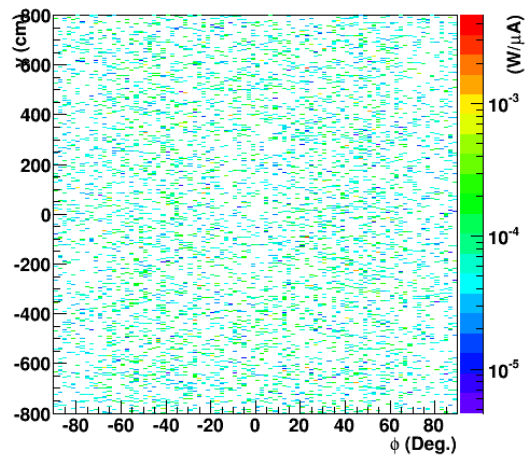
Top Disk. Det: γ from All Area



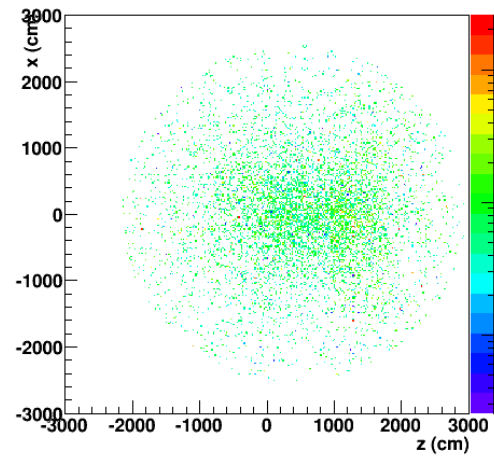
Bottom Disk. Det: γ from All Area



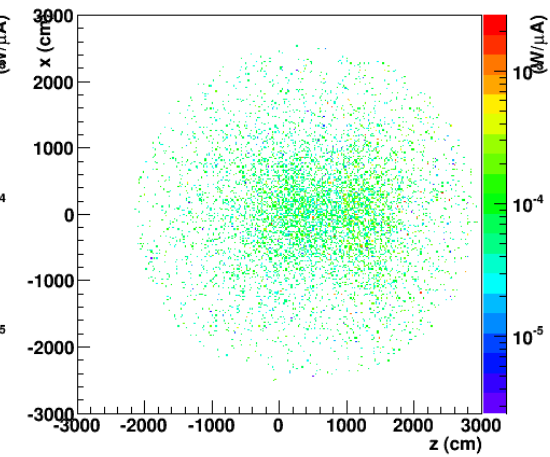
Cyl. Det: Neutron from All Area



Top Disk. Det: Neutron from All Area



Bottom Disk. Det: Neutron from All Area



Current Status of Shielding

- For MOLLER, our main issue is high energy neutrons ($E > 10$ MeV)
 - High energy e^\pm and γ are also an issue
- Low energy neutrons ($E < 10$ MeV) are at about same level as PREX and we could manage it by using polythene/boron/water to same or below the levels of PREX-II
- Material and size optimization for shielding are not done so far
- There are gains in optimizing collimator design
 - Bore radii and shapes (flat or tapered)
 - Col-1 and Col-3 optimization

Radiation by Vertex Region

- Radiation by vertex region can be extracted by using a z direction range cut on particles crossing detectors (Cylin., Top, and Bottom)
- Only used z direction range cut and no xy plane cuts
 - All radiation from selected z direction range is included → This can include secondary radiation generated from the shielding itself

Radiation by Vertex Region : Power

Total Radiation Power to the hall with Shielding (W/uA)					
Type	E range	Cylinder	Top	Bottom	Total
	(MeV)	(W/uA)	(W/uA)	(W/uA)	(W/uA)
Photons	E<10	0.0342	0.0324	0.0330	0.0996
	10<E<100	0.2669	0.0506	0.0511	0.3687
	100<E	6.6710	0.0043	0.0045	6.6798
e±	E<10	0.4050	0.1434	0.1432	0.6916
	10<E<100	0.7420	0.0282	0.0265	0.7967
	100<E	0.3313	0.0115	0.0128	0.3555
Neutrons	E<10	0.0017	0.0023	0.0019	0.0058
	10<E<100	0.1994	0.2238	0.2228	0.6460
	100<E	0.0729	0.0771	0.0807	0.2308

Total Radiation Power to the hall with No Shielding (W/uA)					
Type	E range	Cylinder	Top	Bottom	Total
	(MeV)	(W/uA)	(W/uA)	(W/uA)	(W/uA)
Photons	E<10	1.1380	0.7179	0.7158	2.5717
	10<E<100	4.1600	0.2350	0.2344	4.6294
	100<E	9.8130	0.0023	0.0019	9.8172
e±	E<10	1.7380	1.4120	1.4210	4.5710
	10<E<100	1.4380	0.1412	0.1418	1.7210
	100<E	0.5705	0.0587	0.0545	0.6837
Neutrons	E<10	0.0011	0.0011	0.0011	0.0033
	10<E<100	0.2949	0.3808	0.3846	1.0603
	100<E	0.2500	0.2647	0.2882	0.8029

Radiation by Vertex Region : Power

Contribution to the Total Radiation Power : With Shielding									
Type	E range (MeV)	Target (%)	Col-1 (%)	Col-2 (%)	Col-3 (%)	Col-4 (%)	Col-5 (%)	Other (%)	Total (%)
Photons	E<10	16.03	2.58	0.51	21.92	7.79	1.66	49.51	100.0
	10<E<100	13.46	2.70	0.49	50.34	4.20	1.46	27.37	100.0
	100<E	23.57	1.00	0.10	3.82	0.05	0.05	71.40	100.0
e±	E<10	3.32	6.38	1.61	41.19	9.78	3.62	34.10	100.0
	10<E<100	2.39	11.19	2.10	44.44	4.70	1.68	33.51	100.0
	100<E	12.16	17.20	2.24	30.07	1.96	1.14	35.23	100.0
Neutrons	E<10	1.09	45.33	16.42	15.16	2.45	0.32	19.24	100.0
	10<E<100	1.67	25.41	9.10	23.30	3.21	0.91	36.42	100.0
	100<E	15.93	6.30	0.68	26.72	3.38	1.04	45.96	100.0

Contribution to the Total Radiation Power : With No Shielding									
Type	E range (MeV)	Target (%)	Col-1 (%)	Col-2 (%)	Col-3 (%)	Col-4 (%)	Col-5 (%)	Other (%)	Total (%)
Photons	E<10	80.46	11.02	1.93	3.79	0.49	0.05	2.28	100.0
	10<E<100	82.96	6.68	1.56	3.92	0.37	0.07	4.45	100.0
	100<E	42.13	1.70	0.23	2.63	0.04	0.03	53.24	100.0
e±	E<10	9.09	58.72	14.04	10.79	2.23	0.48	4.63	100.0
	10<E<100	21.03	30.30	13.44	19.85	2.43	0.47	12.51	100.0
	100<E	62.49	11.94	3.51	12.64	1.97	0.22	7.22	100.0
Neutrons	E<10	0.00	45.50	25.41	23.80	3.84	1.20	0.26	100.0
	10<E<100	0.01	50.74	22.70	21.33	2.67	0.71	1.85	100.0
	100<E	9.65	45.67	17.95	20.86	2.50	0.64	2.73	100.0

- “Other” definition : Vertices not from Target, Col-1, Col-2, Col-3, Col-4, and Col-5
- Due to introduction of shielding, contribution to the total has dropped from Target, Col-1, Col-2, Col-3, Col-4, and Col-5
 - The shielding has also introduced additional radiation seen at increase in “Other”

Radiation by Vertex Region : Flux

Total Radiation Flux to the hall with Shielding (per uA)					
Type	E range (MeV)	Cylinder (per uA)	Top (per uA)	Bottom (per uA)	Total (per uA)
Photons	E<10	6.25E+10	6.22E+10	6.36E+10	1.88E+11
	10<E<100	4.40E+10	1.52E+10	1.49E+10	7.40E+10
	100<E	3.79E+10	1.50E+08	1.50E+08	3.82E+10
e±	E<10	1.85E+12	1.42E+12	1.42E+12	4.69E+12
	10<E<100	1.71E+11	8.57E+09	8.46E+09	1.88E+11
	100<E	1.12E+10	3.62E+08	3.43E+08	1.19E+10
Neutrons	E<10	1.70E+09	2.19E+09	1.89E+09	5.77E+09
	10<E<100	3.63E+10	4.22E+10	4.15E+10	1.20E+11
	100<E	2.21E+09	2.40E+09	2.52E+09	7.13E+09

Total Radiation Flux to the hall with No Shielding (per uA)					
Type	E range (MeV)	Cylinder (per uA)	Top (per uA)	Bottom (per uA)	Total (per uA)
Photons	E<10	2.22E+012	1.98E+012	1.98E+012	6.18E+12
	10<E<100	8.86E+011	8.77E+010	8.77E+010	1.06E+12
	100<E	1.38E+011	1.19E+008	6.24E+007	1.38E+11
e±	E<10	8.23E+012	8.48E+012	8.52E+012	2.52E+13
	10<E<100	3.74E+011	5.69E+010	5.65E+010	4.87E+11
	100<E	1.56E+010	1.41E+009	1.34E+009	1.83E+10
Neutrons	E<10	9.92E+008	9.11E+008	1.06E+009	2.96E+09
	10<E<100	3.40E+010	4.30E+010	4.40E+010	1.21E+11
	100<E	9.97E+009	1.20E+010	1.24E+010	3.44E+10

Radiation by Vertex Region : Flux

Contribution to the Total Radiation Flux : With Shielding									
Type	E range (MeV)	Target (%)	Col-1 (%)	Col-2 (%)	Col-3 (%)	Col-4 (%)	Col-5 (%)	Other (%)	Total (%)
Photons	E<10	14.06	5.09	1.11	21.55	7.67	1.02	49.50	100.0
	10<E<100	15.69	1.78	0.42	42.27	5.87	1.79	32.20	100.0
	100<E	29.86	3.61	0.23	20.14	0.31	0.18	45.67	100.0
e±	E<10	3.13	6.95	2.71	23.45	6.82	2.76	54.16	100.0
	10<E<100	2.01	10.09	2.05	44.41	6.07	2.07	33.30	100.0
	100<E	8.02	16.77	2.31	33.81	1.99	0.94	36.17	100.0
Neutrons	E<10	2.38	42.48	14.81	13.08	2.05	0.22	24.97	100.0
	10<E<100	1.46	31.93	12.58	17.90	2.50	0.54	33.08	100.0
	100<E	6.56	5.51	0.79	40.16	5.25	1.92	39.81	100.0

Contribution to the Total Radiation Flux : With No Shielding									
Type	E range (MeV)	Target (%)	Col-1 (%)	Col-2 (%)	Col-3 (%)	Col-4 (%)	Col-5 (%)	Other (%)	Total (%)
Photons	E<10	84.11	8.69	1.87	3.41	0.42	0.03	1.47	100.0
	10<E<100	81.82	8.59	1.72	3.24	0.45	0.08	4.12	100.0
	100<E	70.55	3.56	0.48	5.52	0.11	0.02	19.78	100.0
e±	E<10	17.42	50.80	12.03	9.53	1.94	0.46	7.82	100.0
	10<E<100	17.91	36.03	14.80	16.99	2.59	0.52	11.15	100.0
	100<E	47.39	16.10	4.49	19.24	2.18	0.27	10.32	100.0
Neutrons	E<10	0.00	46.31	24.63	23.37	3.79	1.68	0.21	100.0
	10<E<100	0.01	49.27	24.02	21.75	2.75	0.72	1.50	100.0
	100<E	1.94	51.39	19.26	21.33	2.69	0.55	2.83	100.0

- “Other” definition : Vertices not from Target, Col-1, Col-2, Col-3, Col-4, and Col-5
- Due to application of shielding contribution to the total has dropped from Target, Col-1, Col-2, Col-3, Col-4, and Col-5

Summary

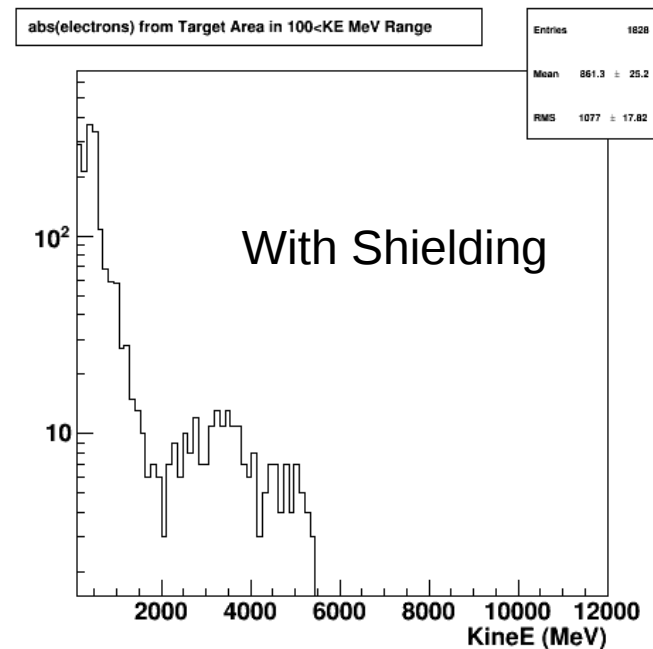
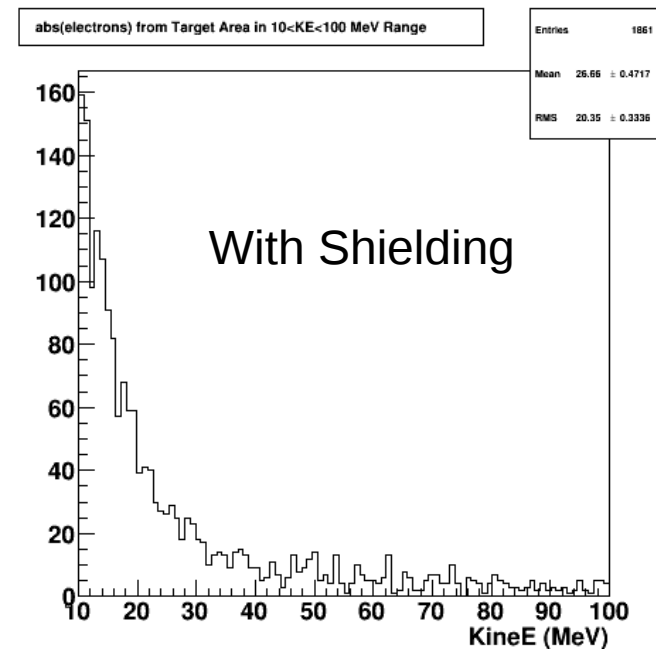
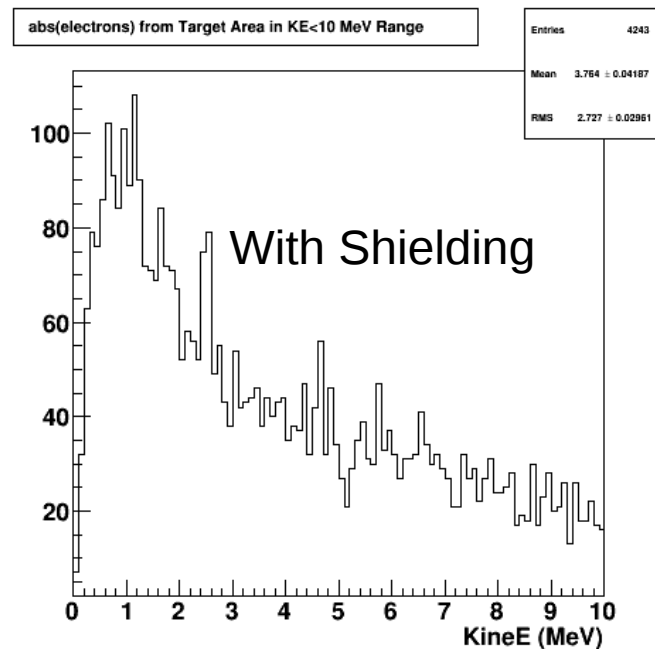
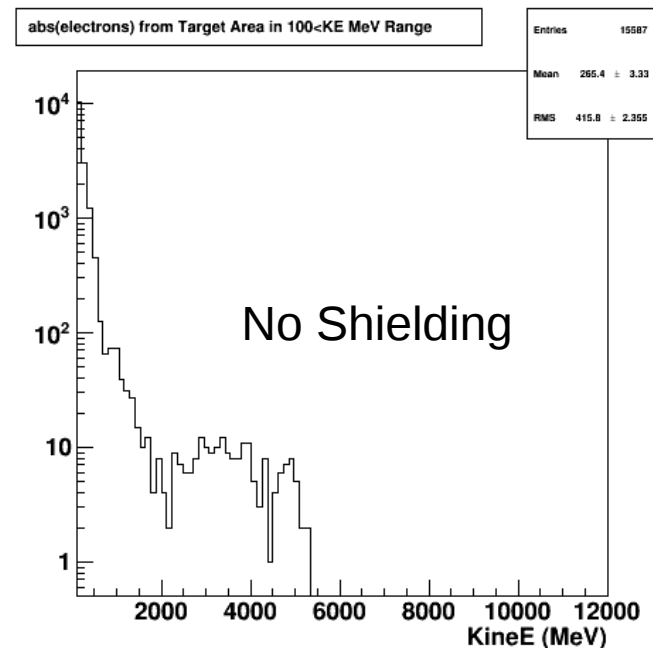
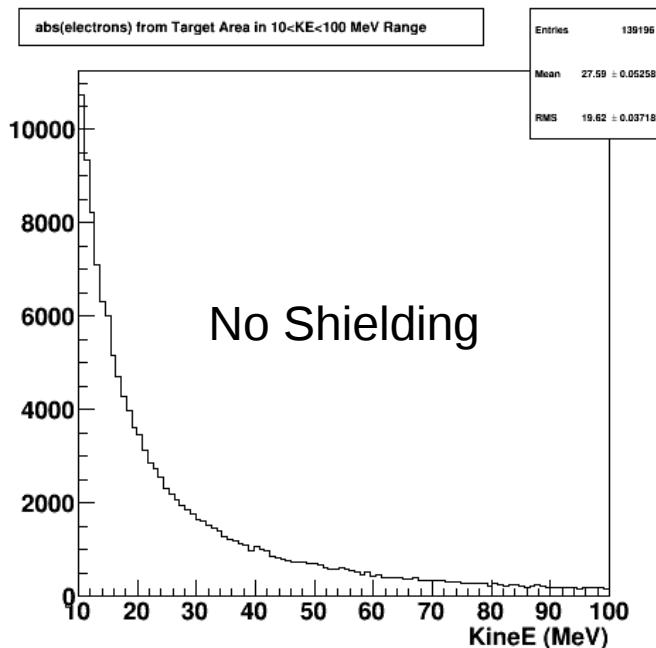
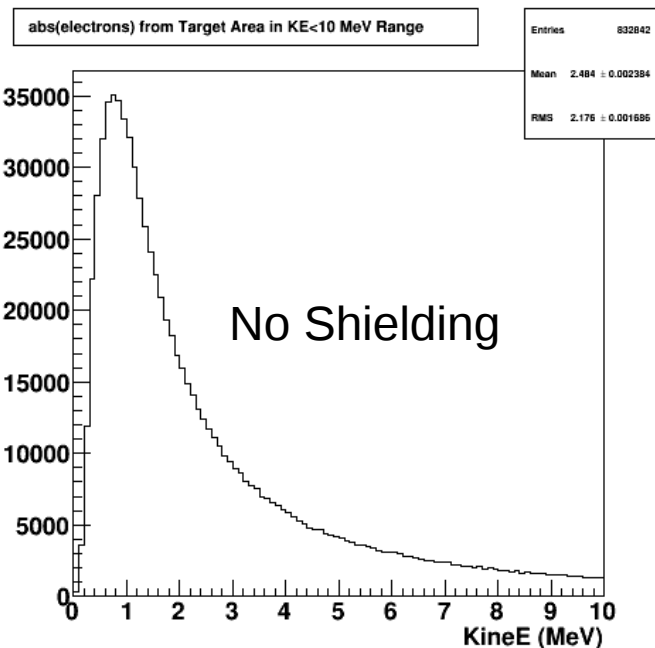
- Material and size optimization for shielding is not complete so far
- There are gains in optimizing collimator design
 - Bore radii and shapes (flat or tapered)
- Col-1 and Col-3 optimization
 - Move Col-3 into the shielding enclosure and this will further reduce the contribution to the total radiation (see slides : 11 and 13)
- Need further investigation into “Other” regions in the Moller setup and minimize the radiation

More Detailed Plots

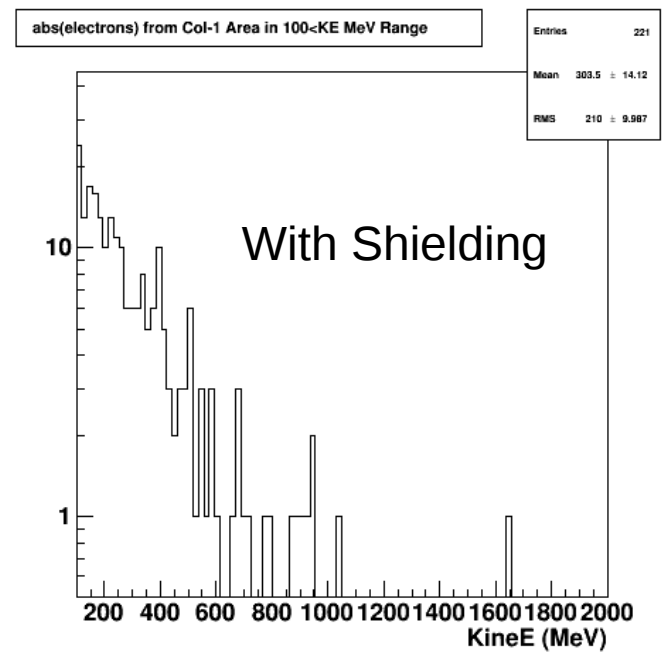
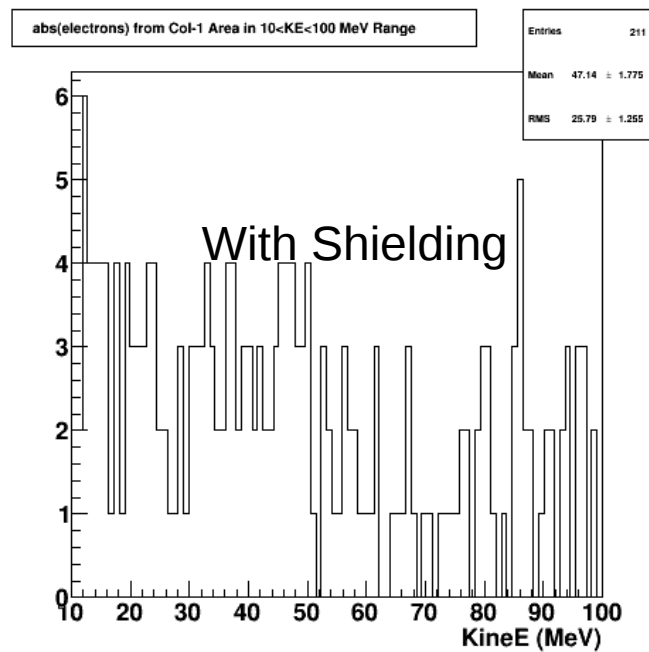
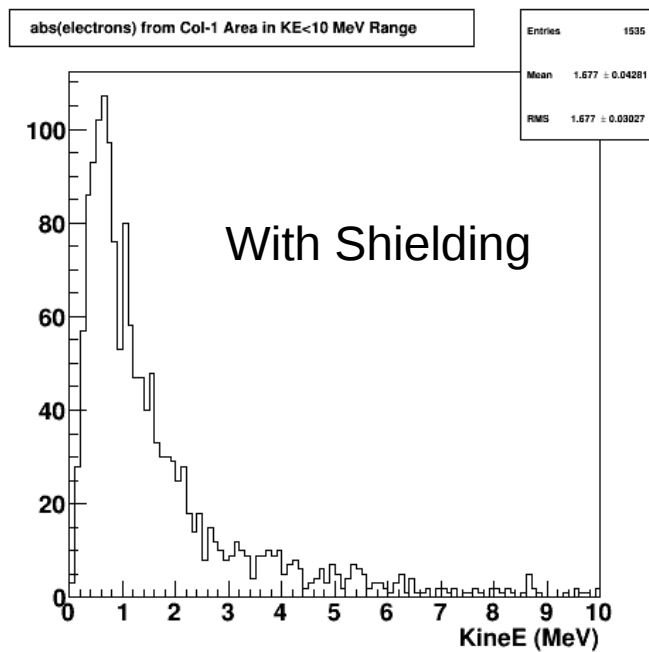
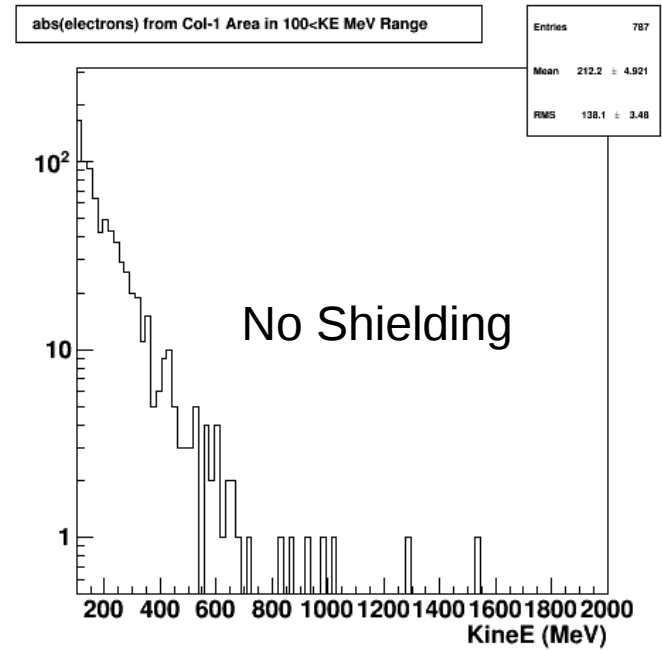
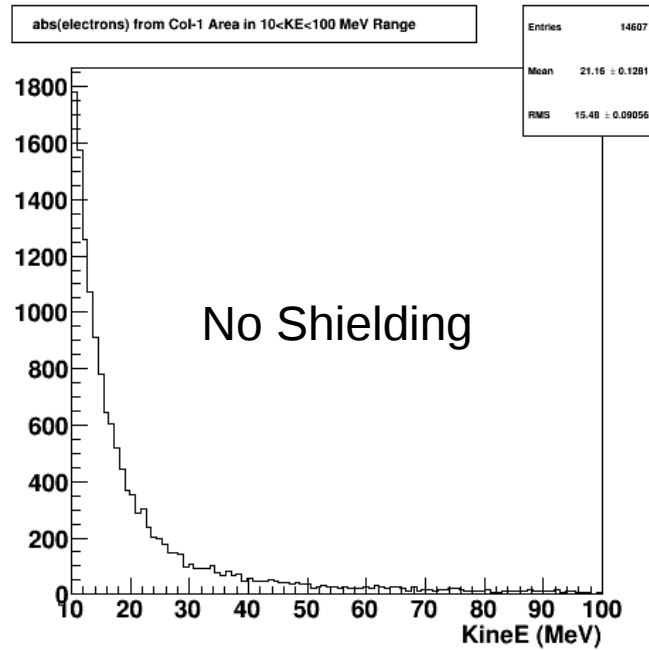
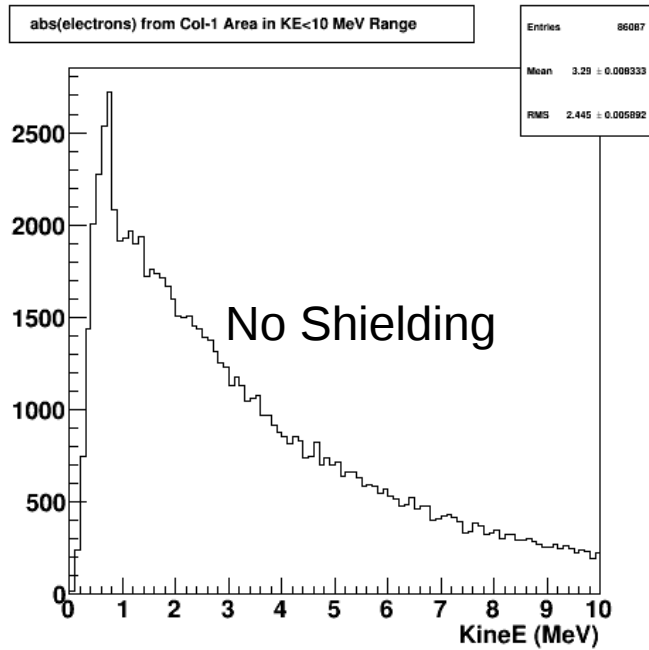
Radiation by Vertex Region

- Radiation by vertex region can be extracted by using a z direction range cut on particle crossing a detectors
- Only used z direction range cut and no xy plane cuts
 - All radiation from selected z direction range is included → This can include secondary radiation generated at the shielding

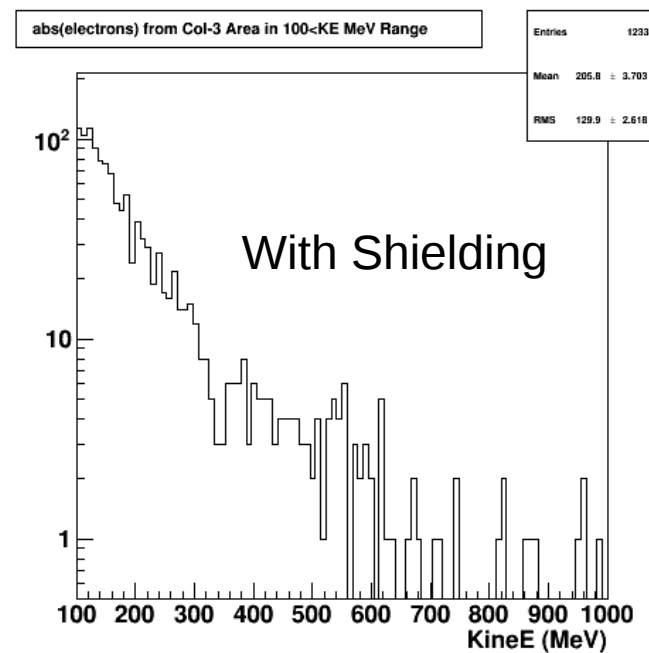
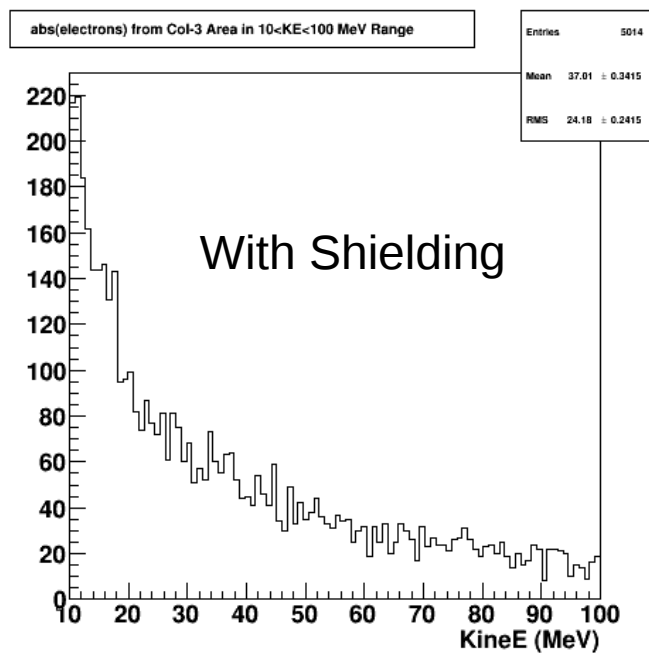
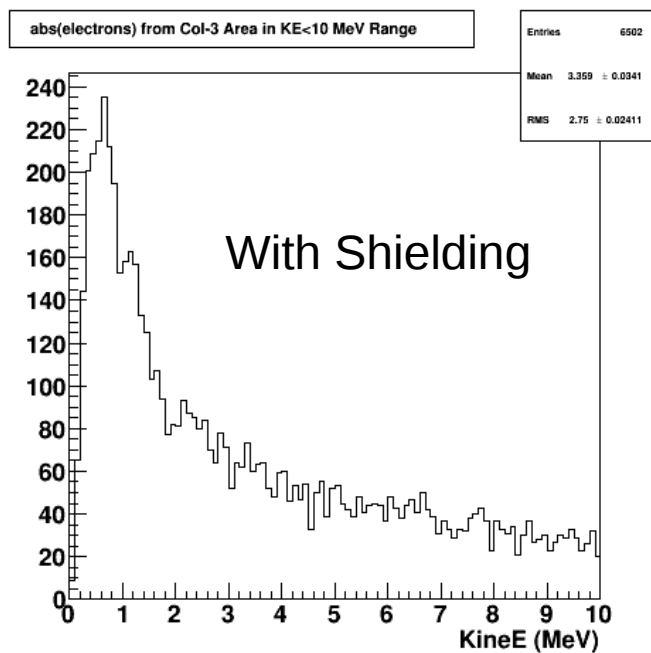
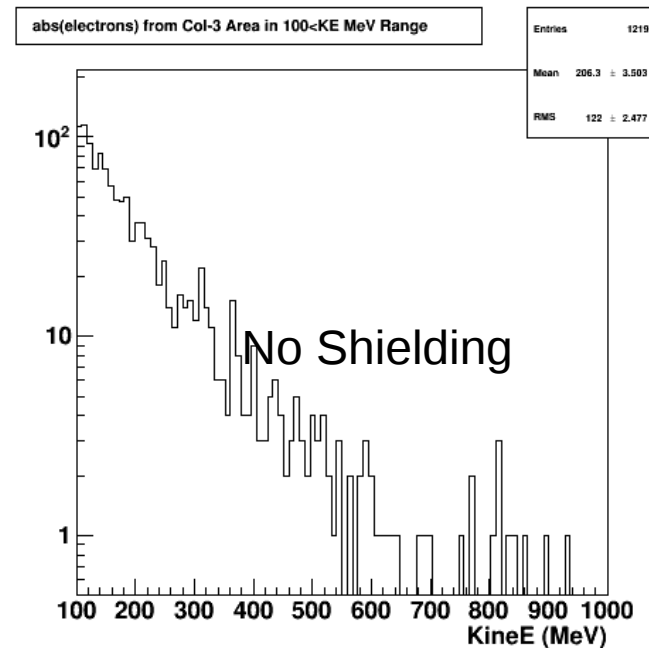
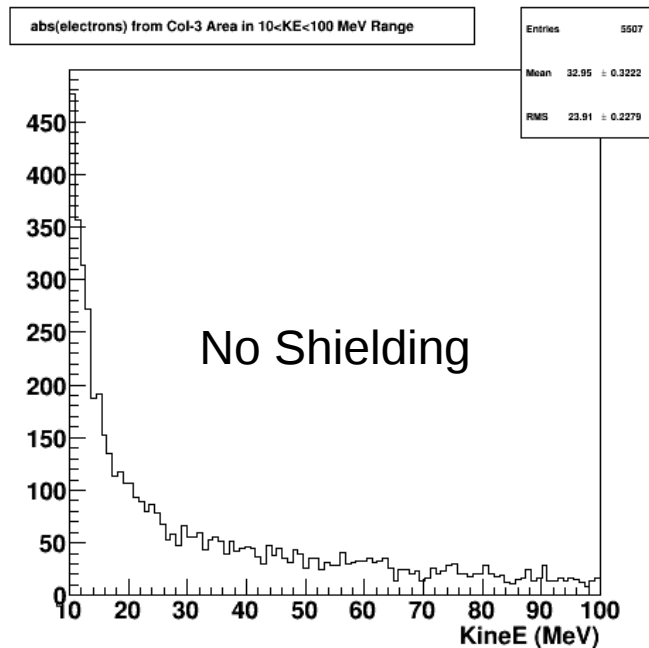
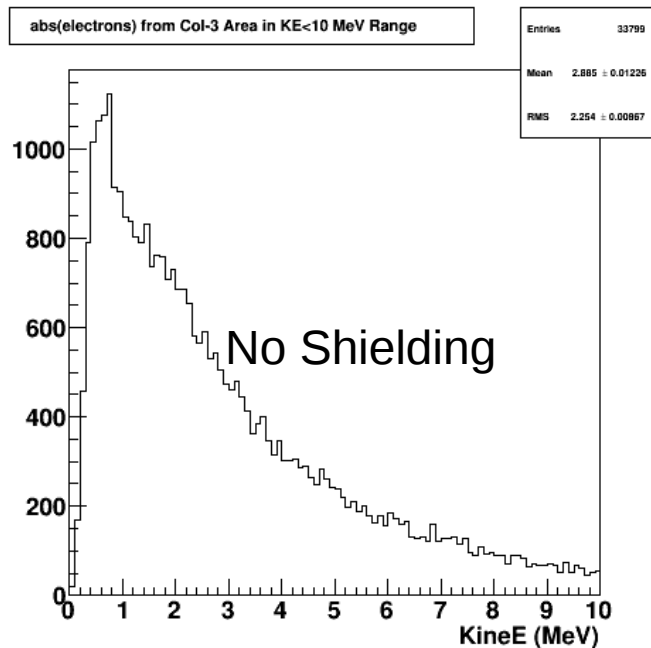
Shielding Electrons : Target



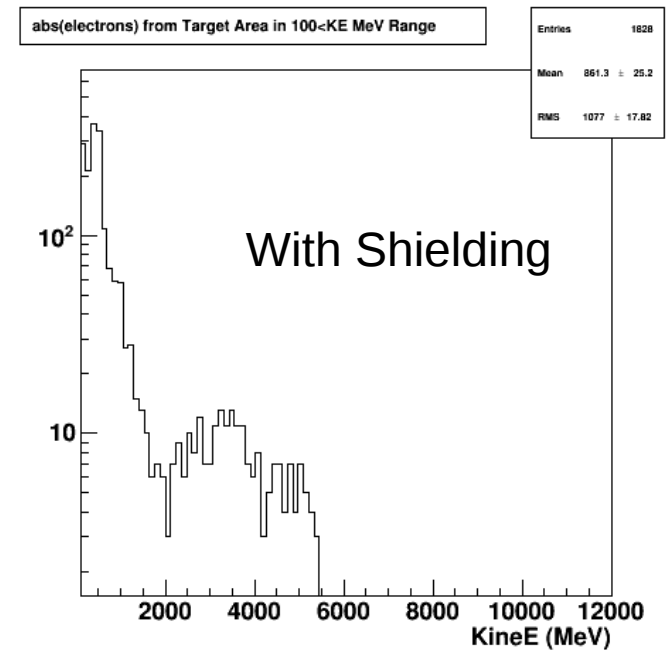
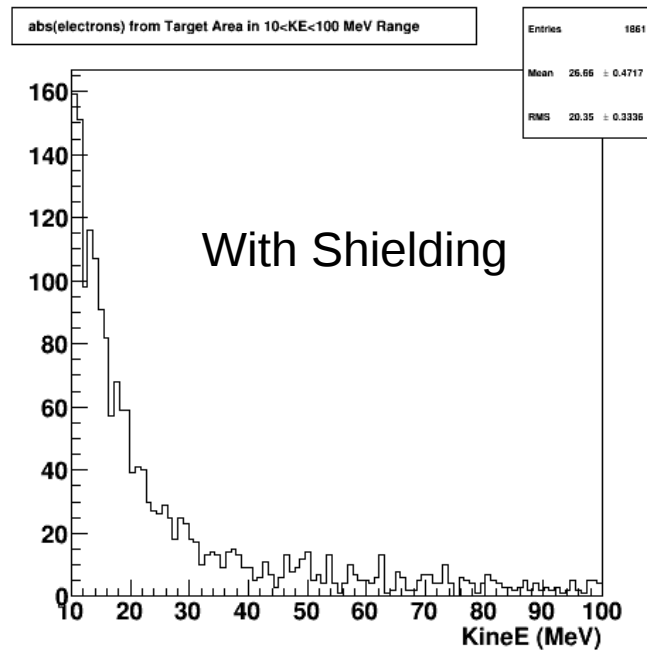
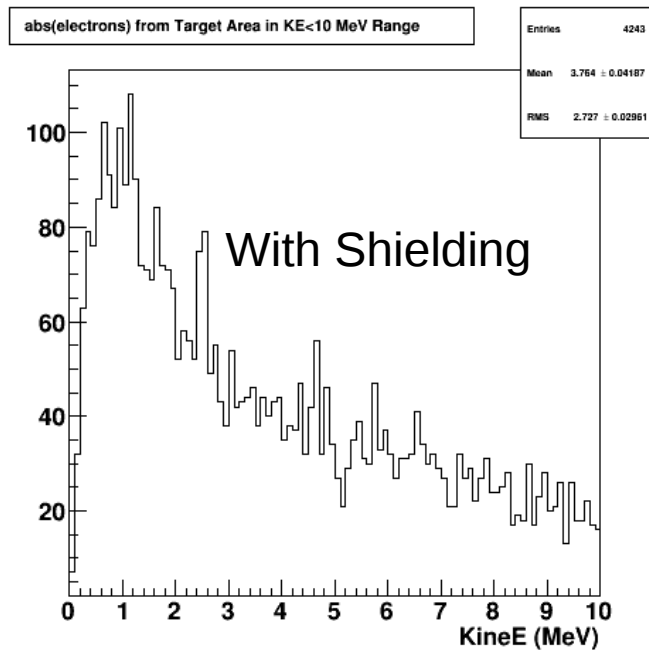
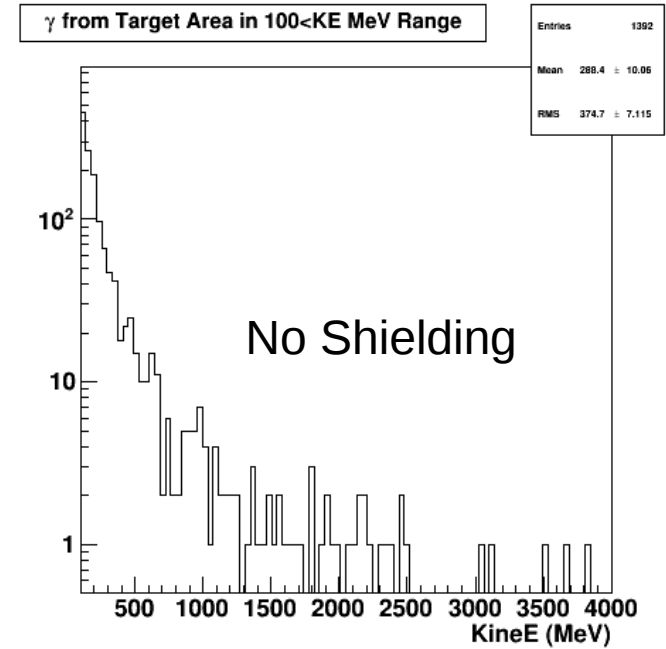
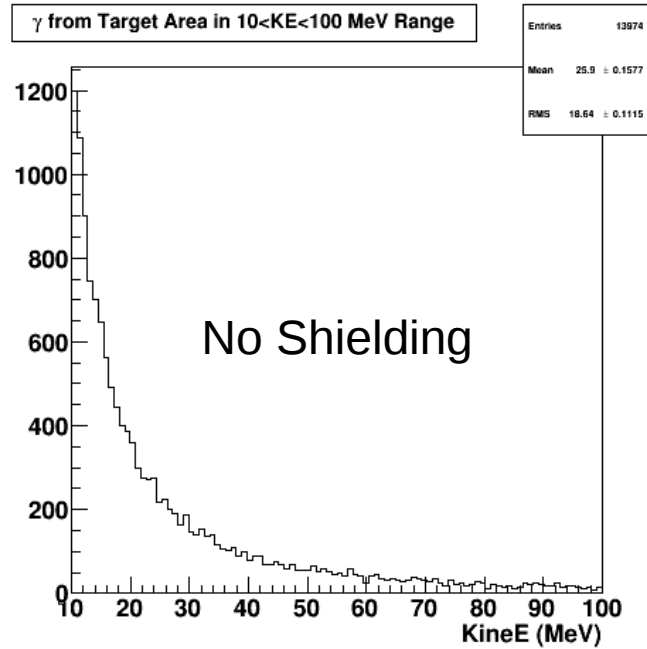
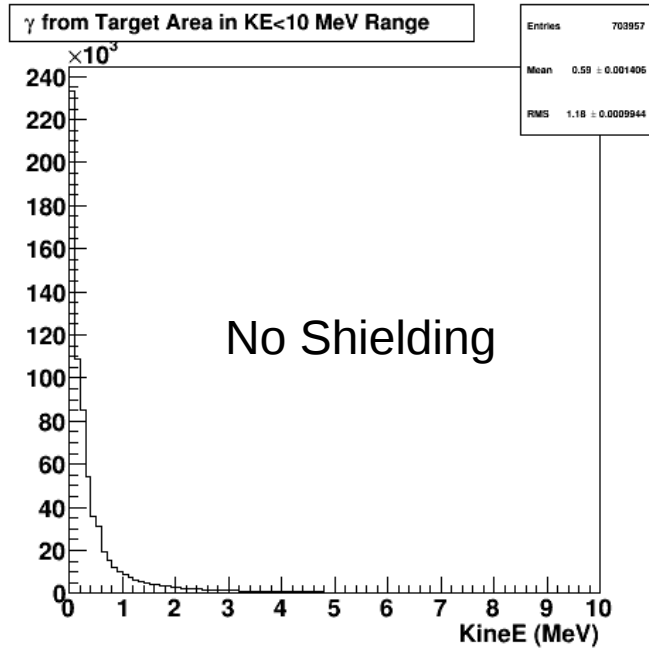
Shielding Electrons : Col-1



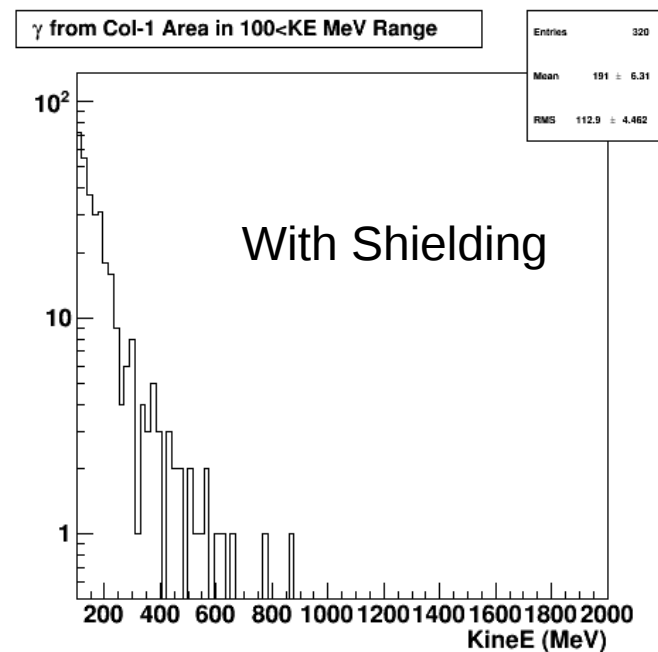
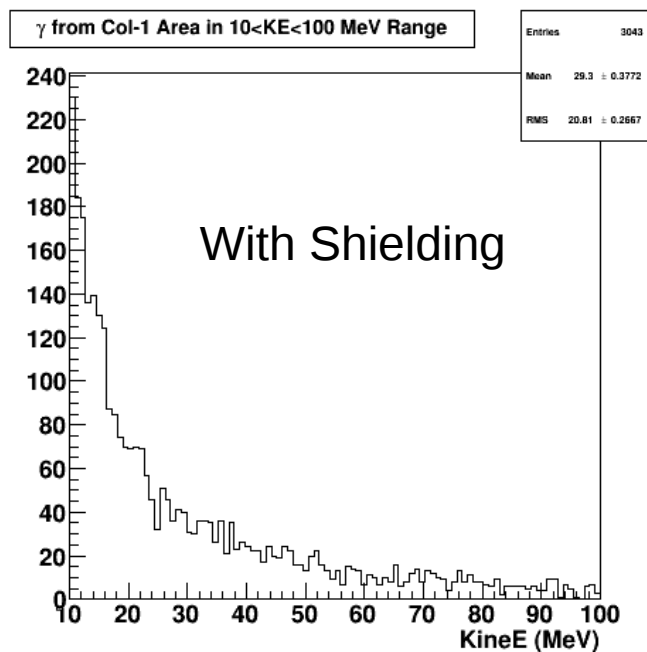
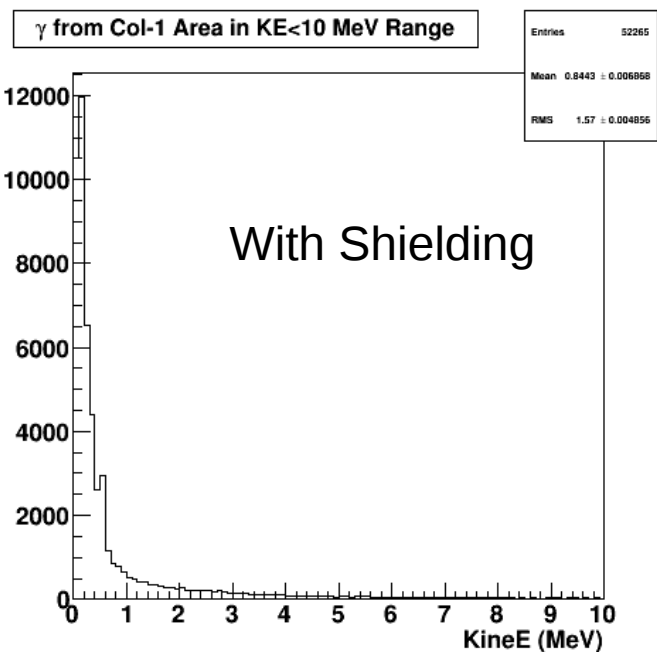
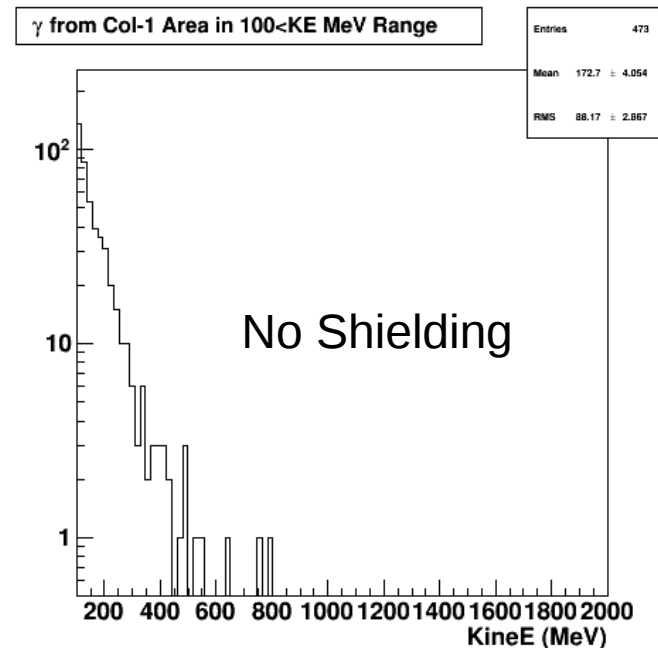
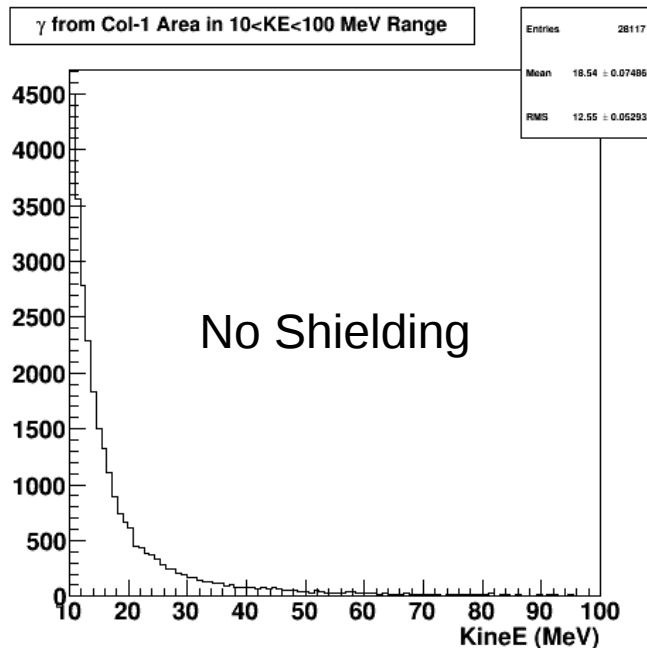
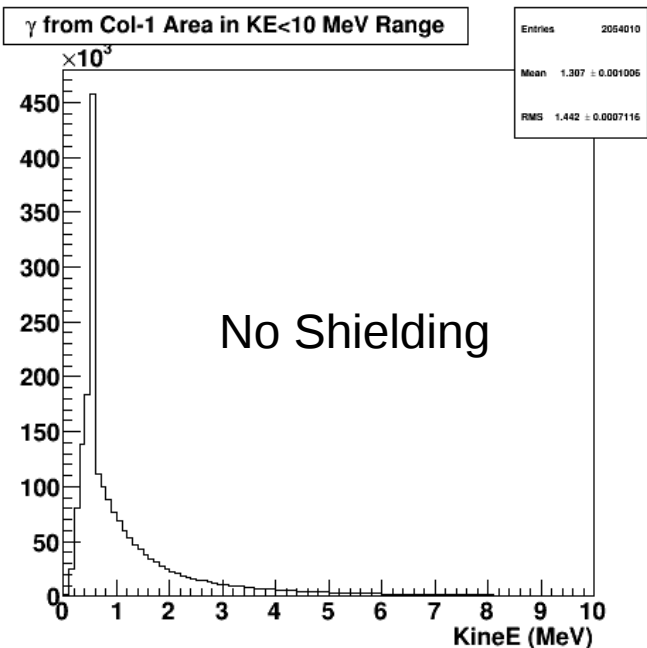
Shielding Electrons : Col-3



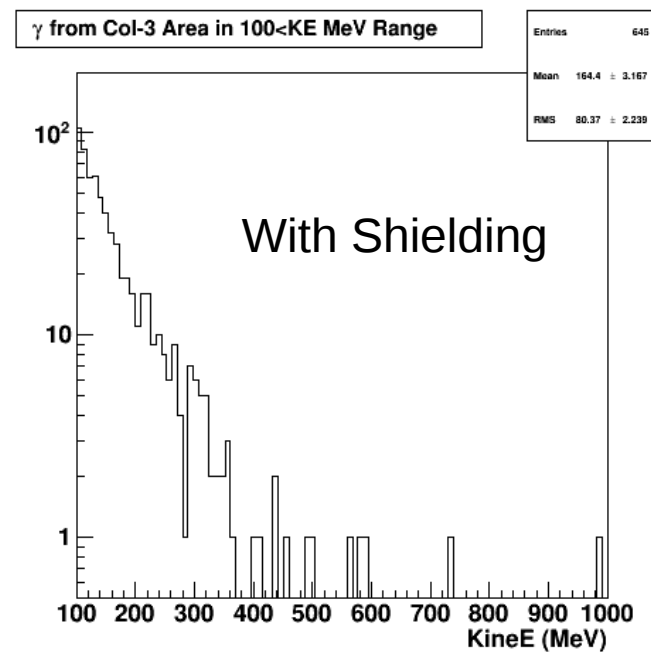
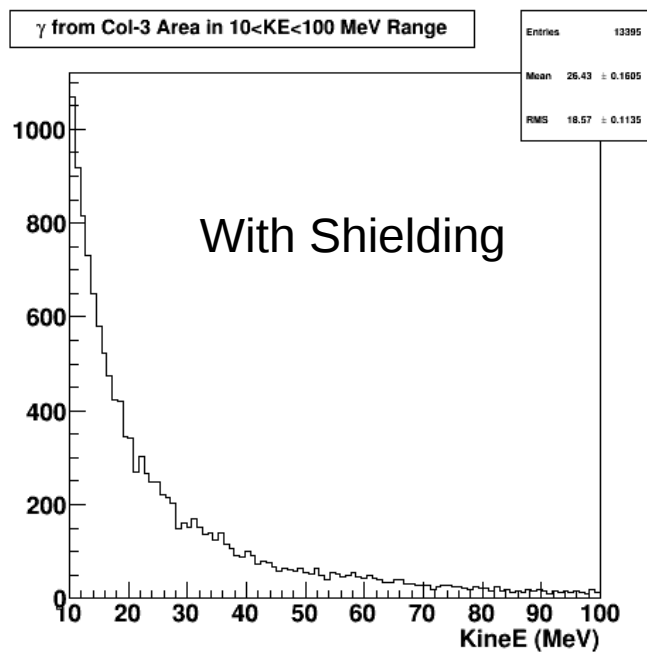
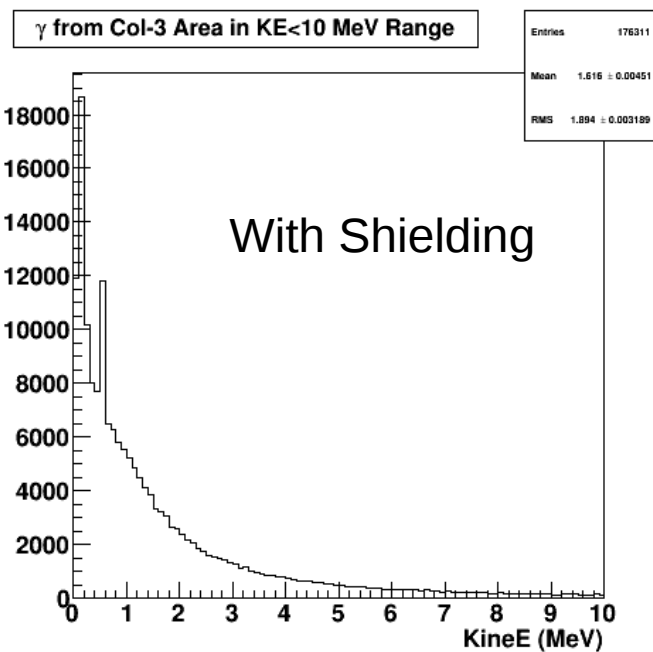
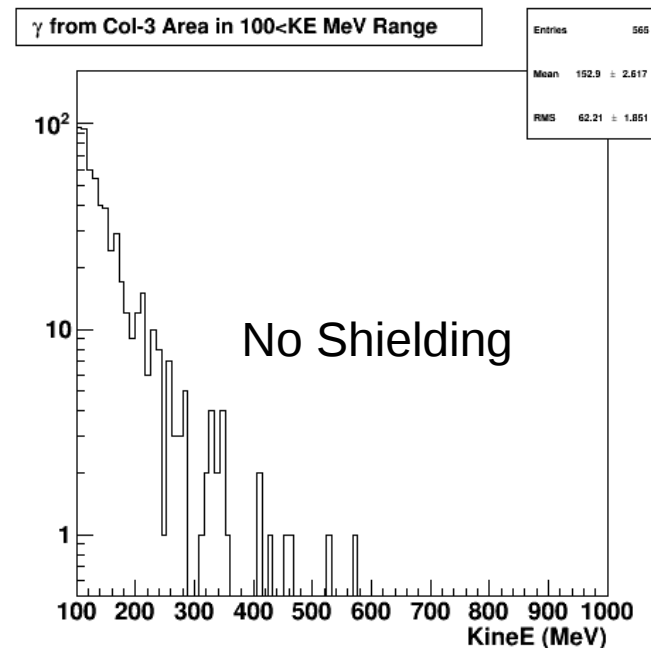
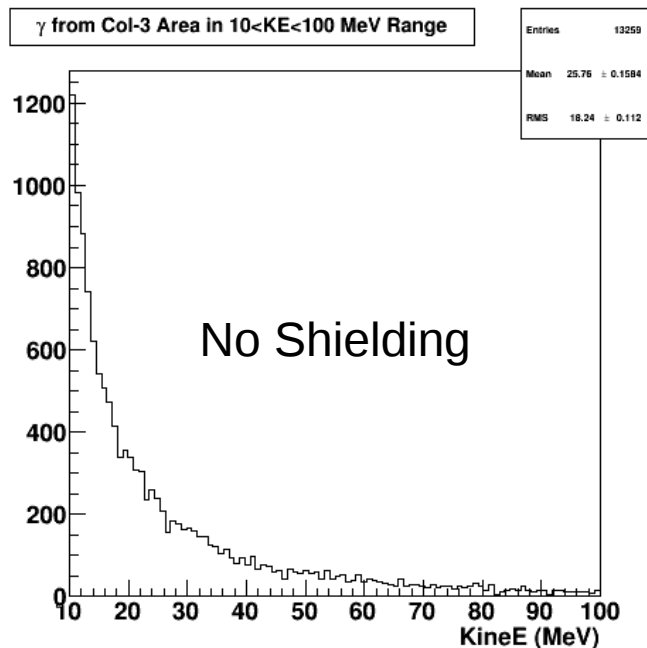
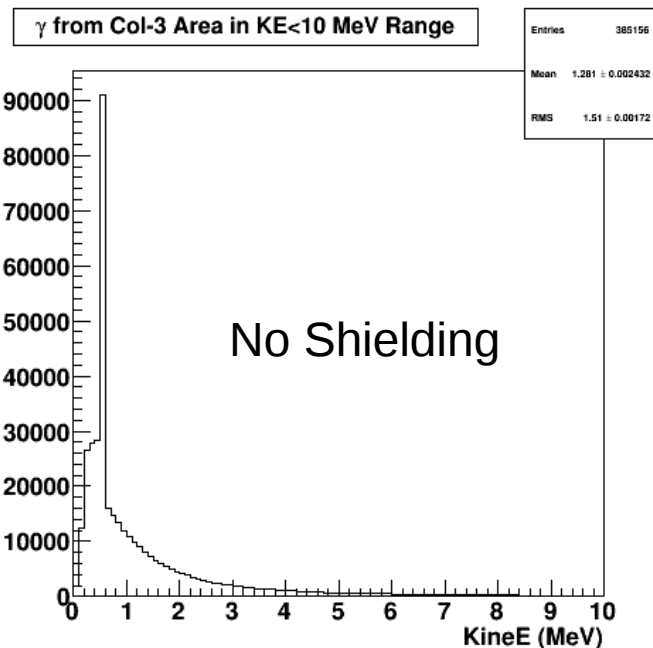
Shielding Gamma : Target



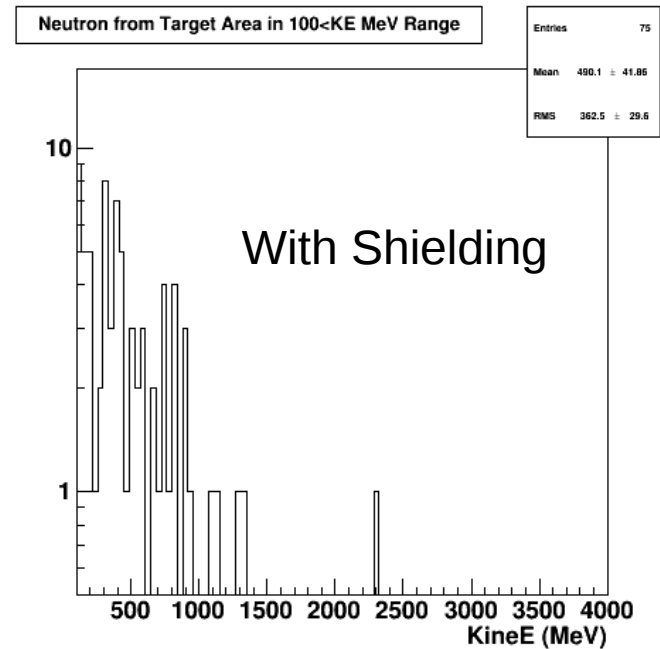
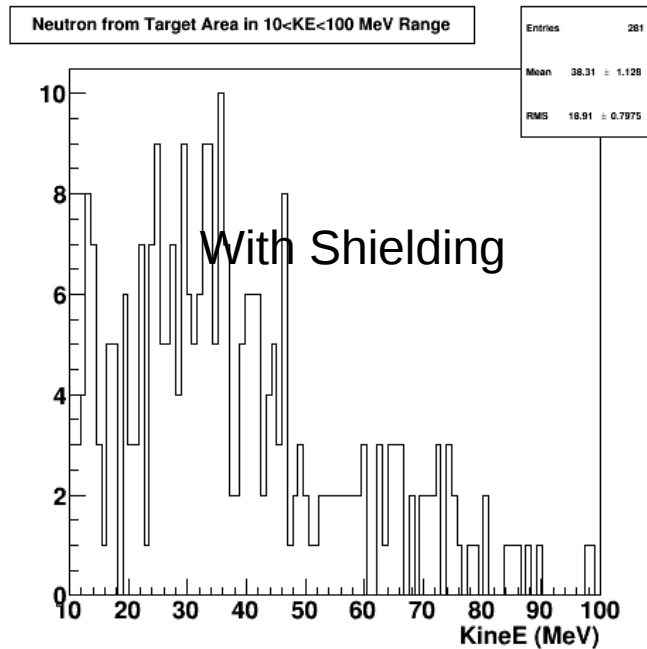
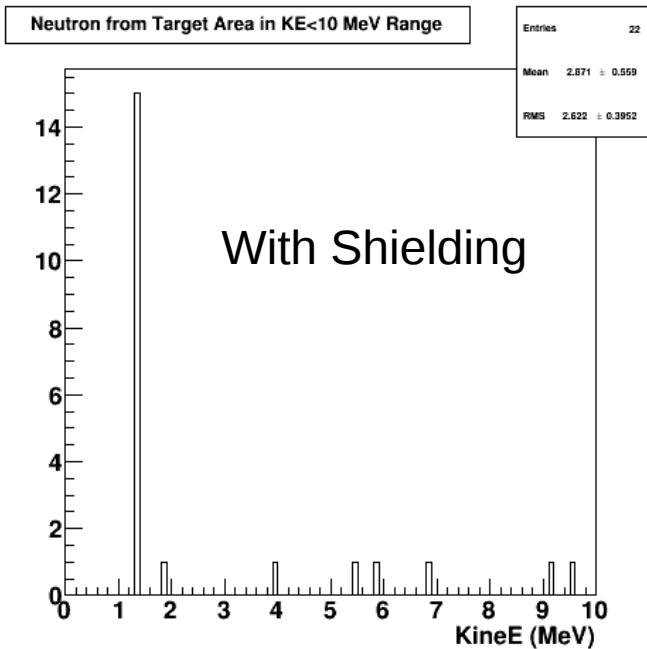
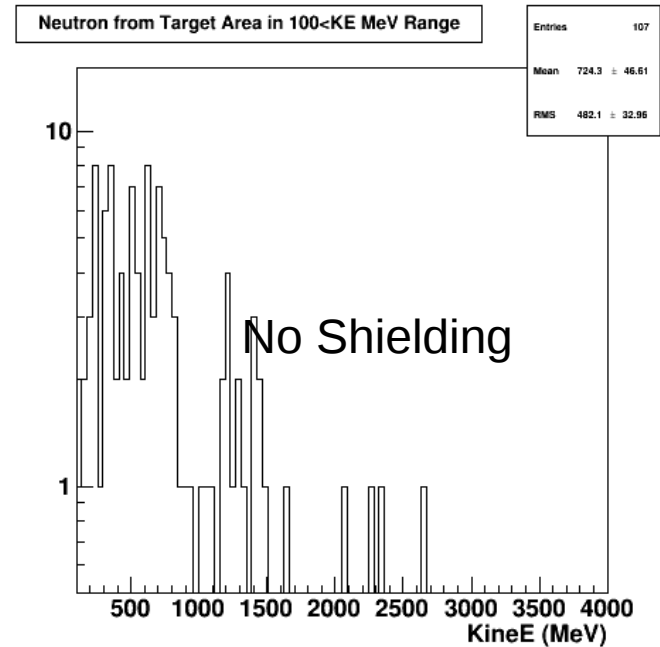
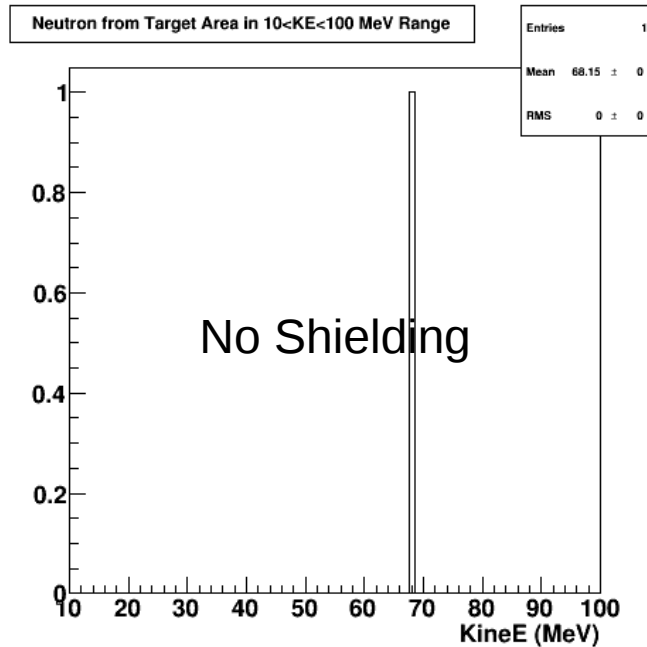
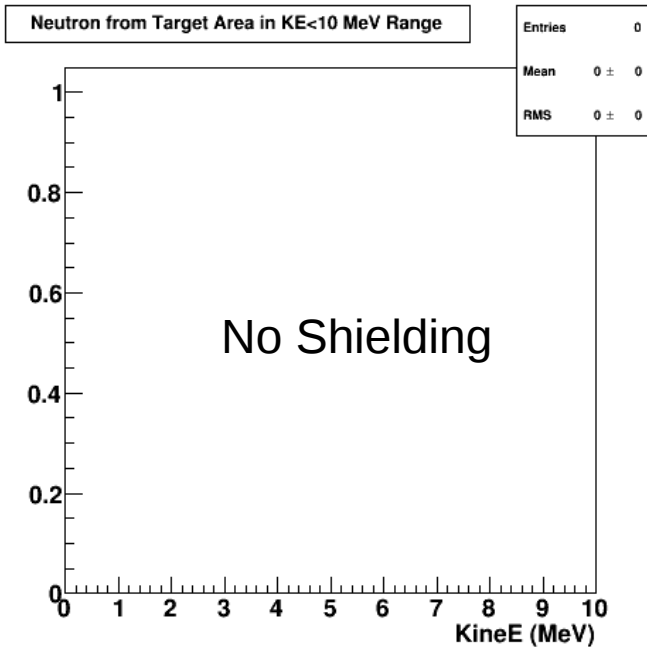
Shielding Gamma : Col-1



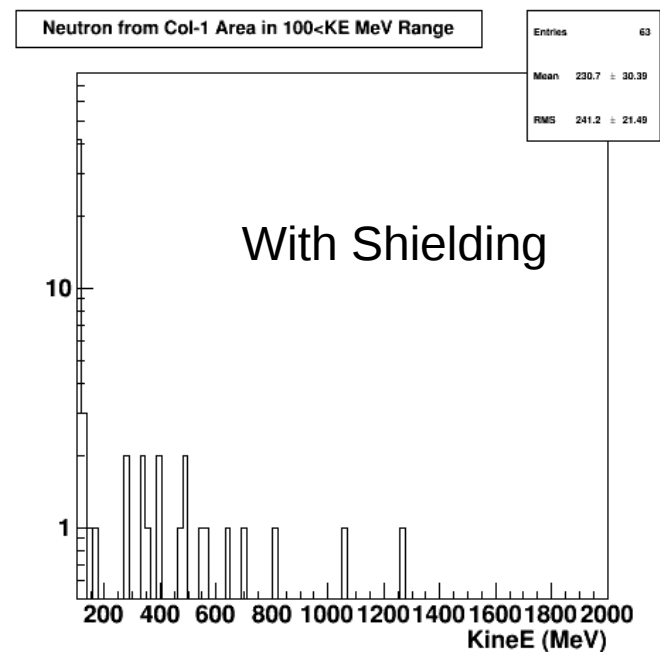
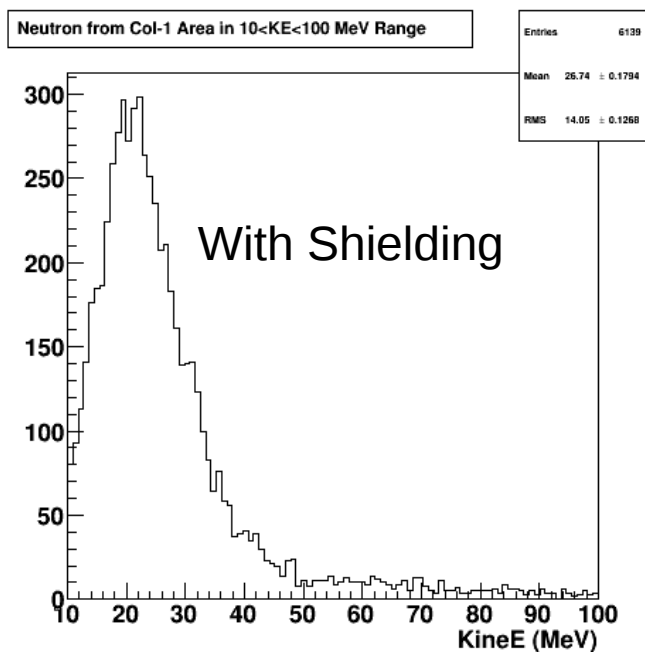
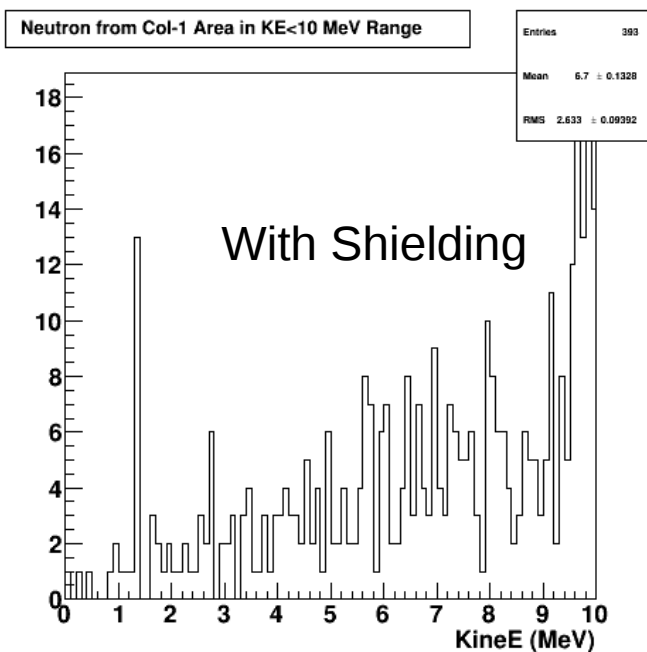
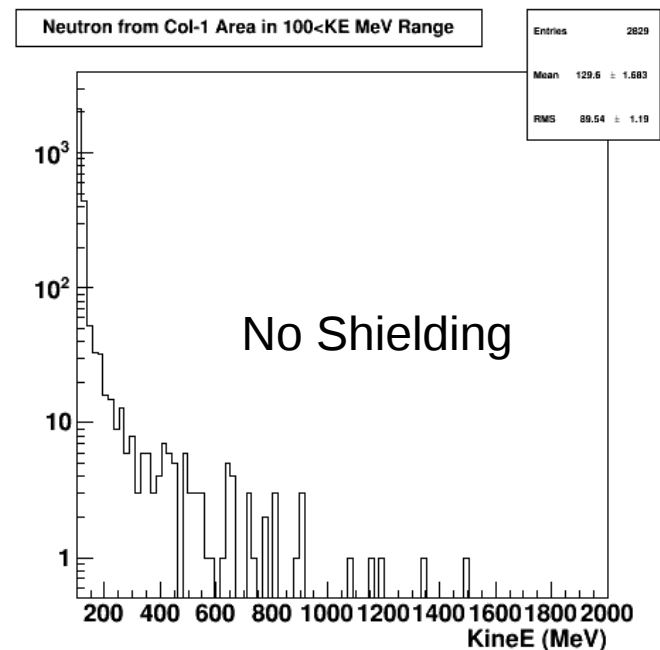
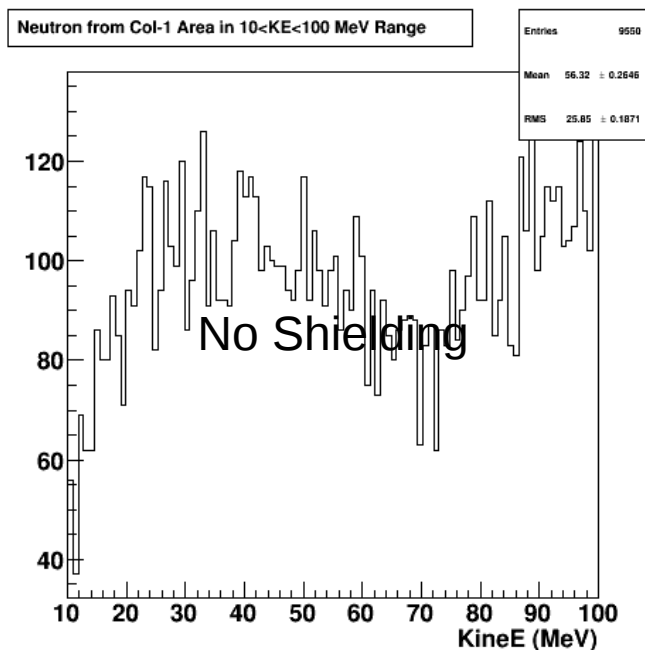
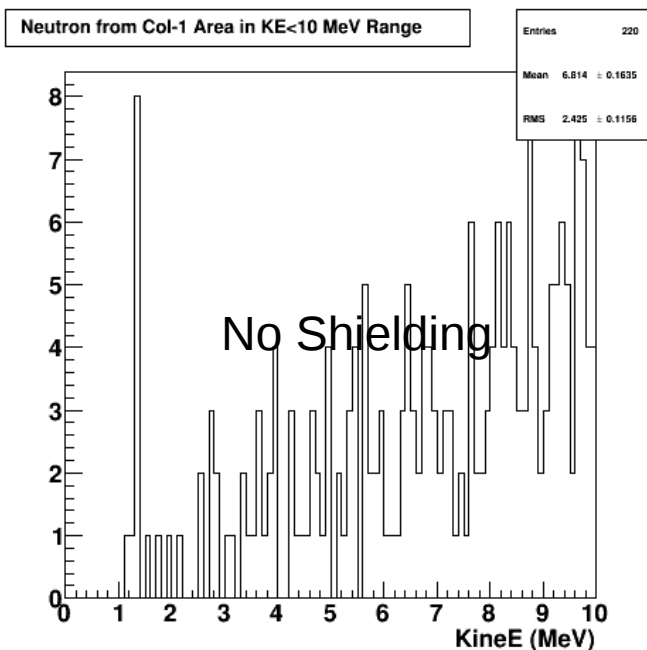
Shielding Gamma : Col-3



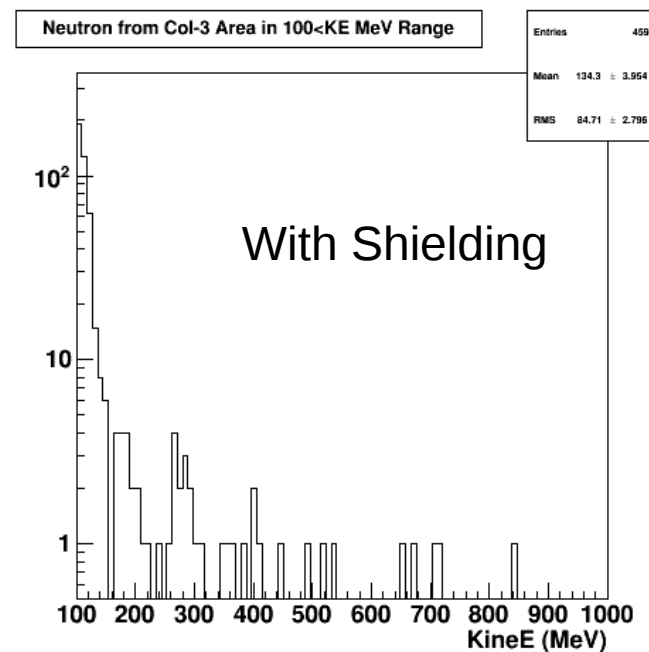
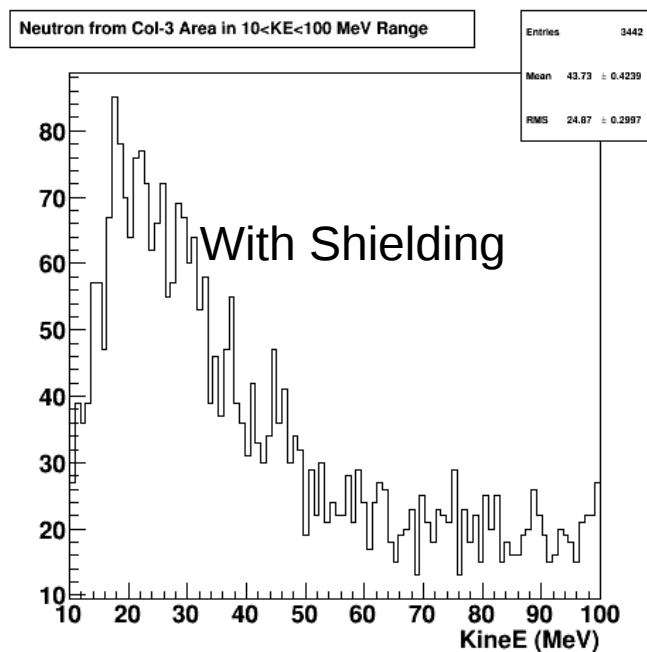
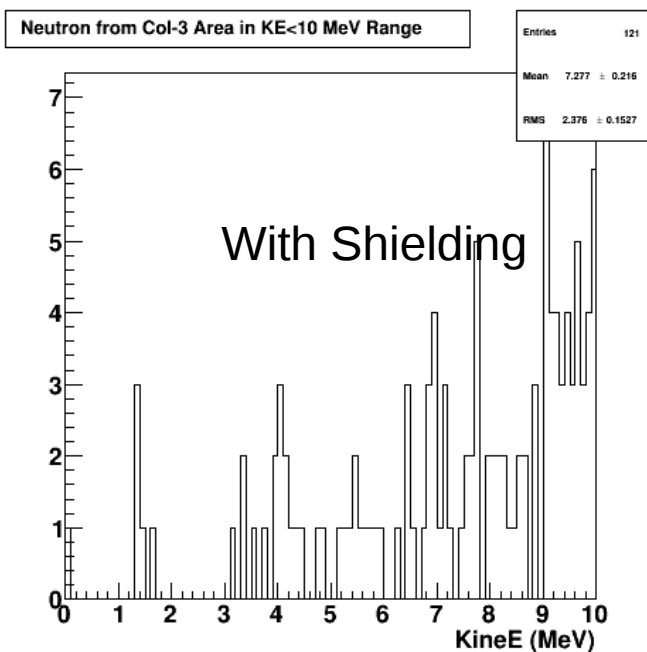
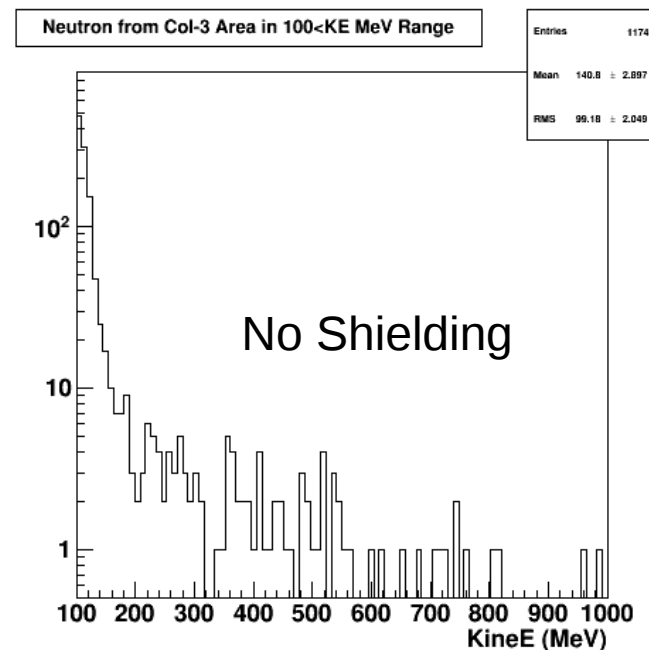
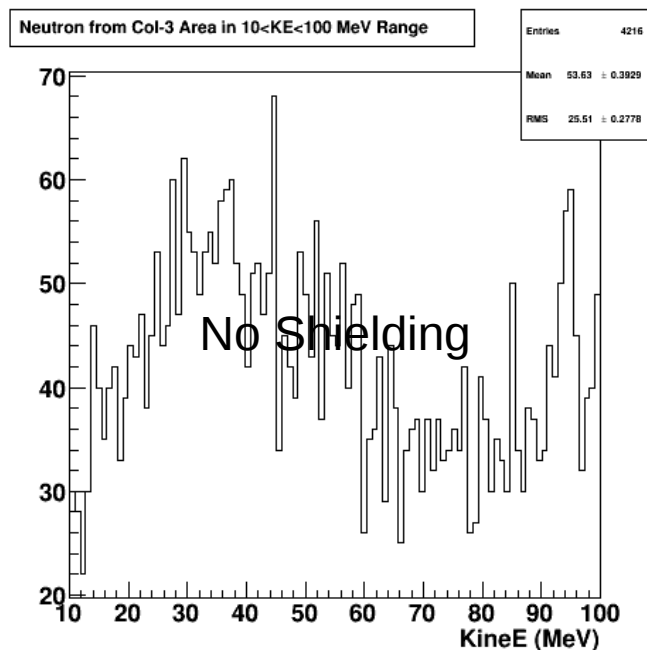
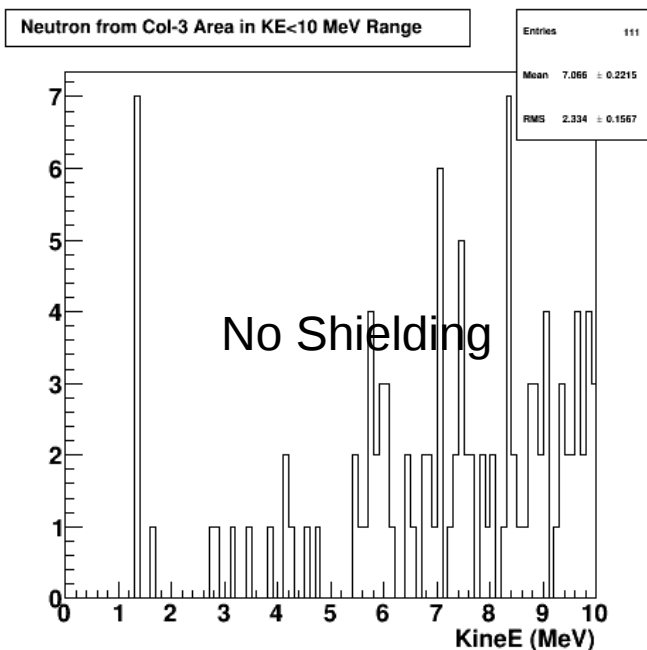
Shielding Neutrons : Target



Shielding Neutrons : Col-1



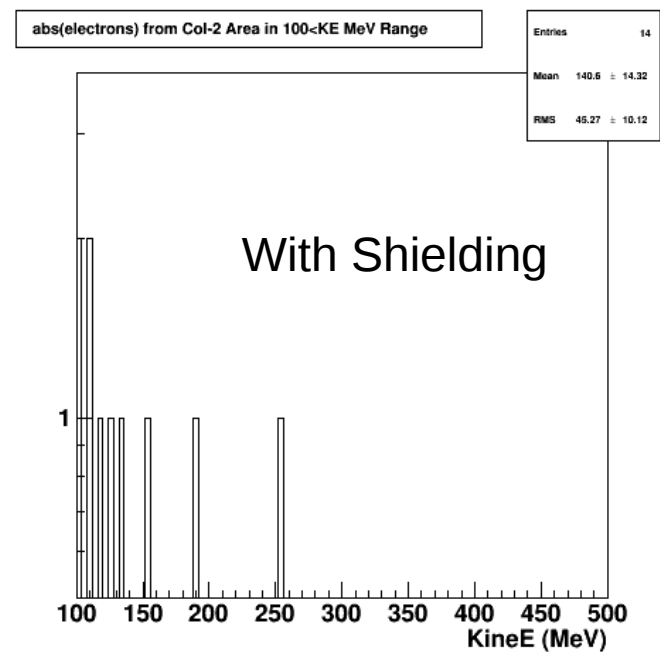
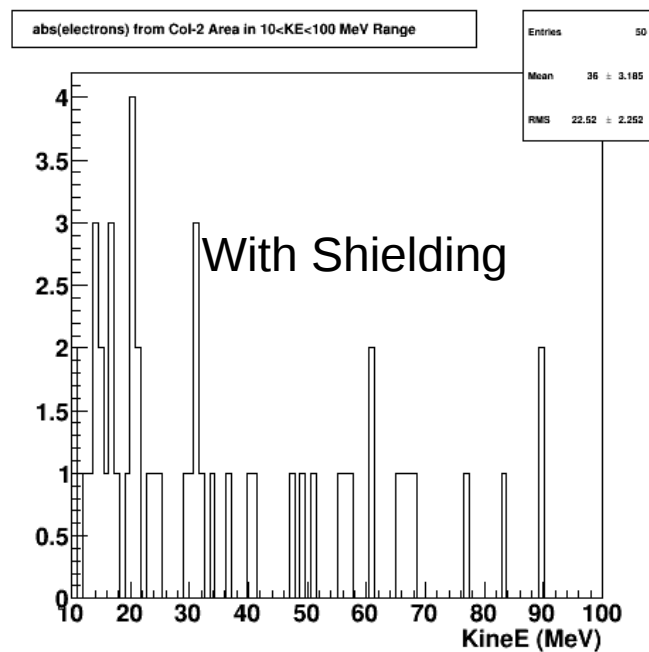
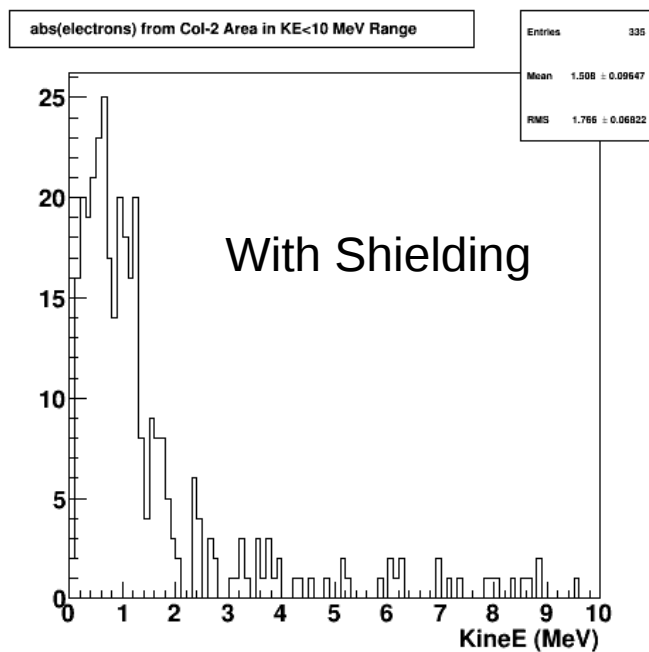
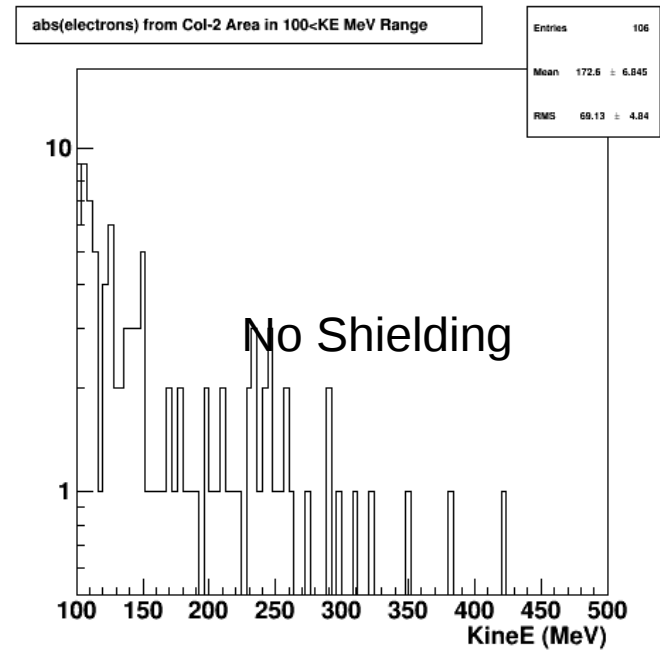
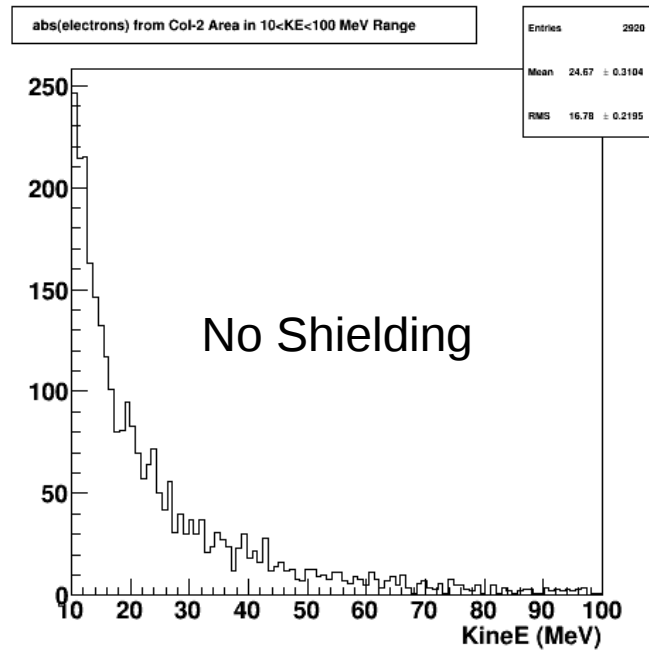
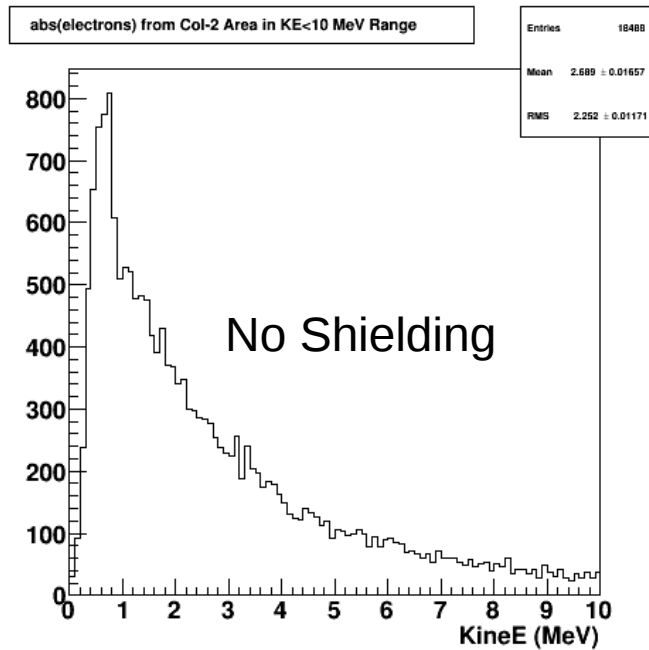
Shielding Neutrons : Col-3



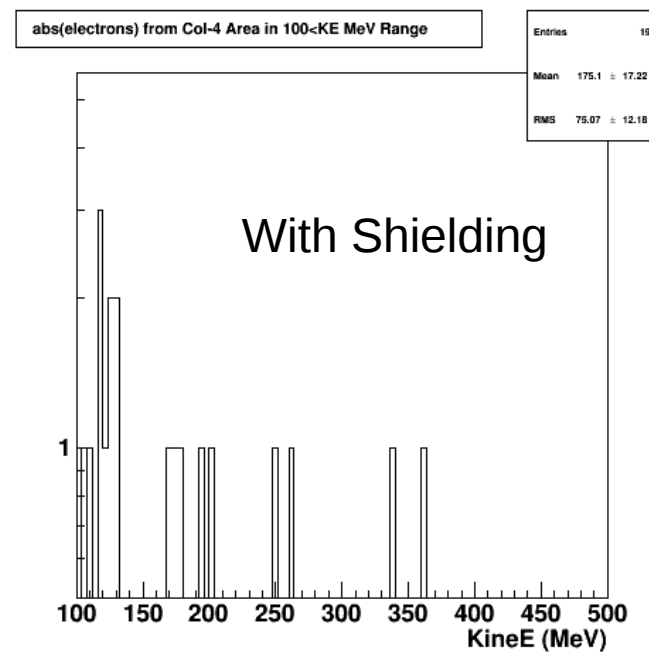
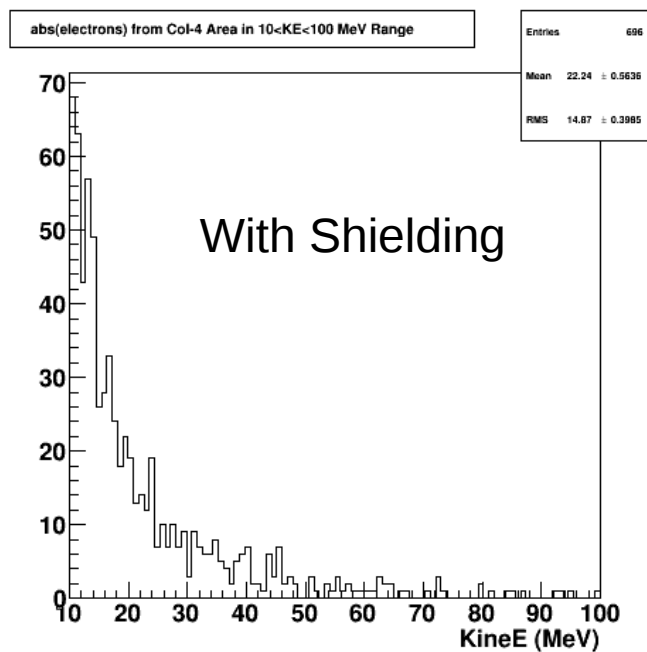
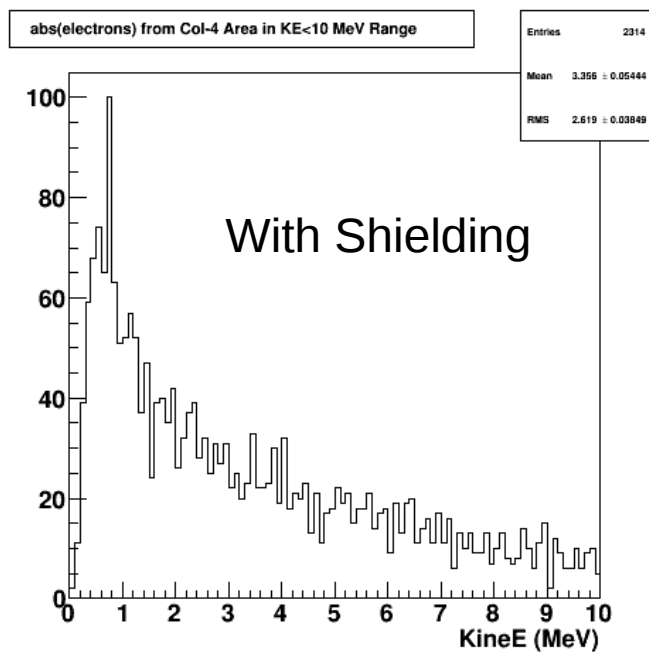
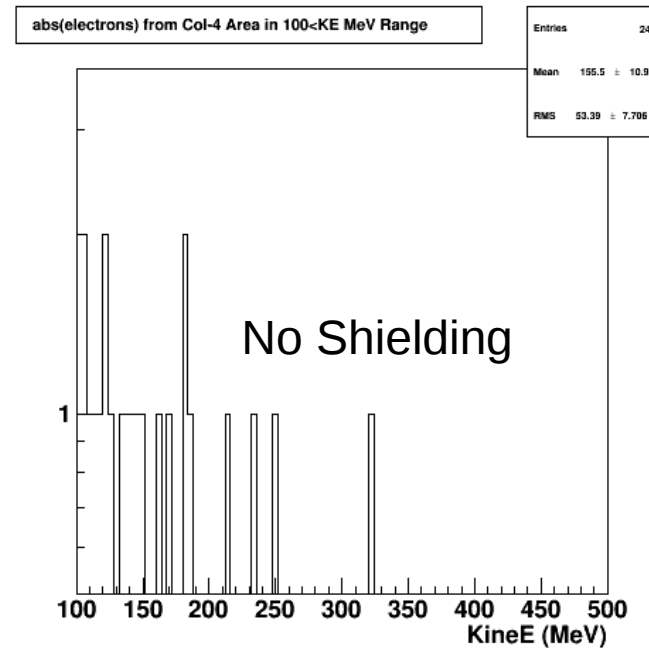
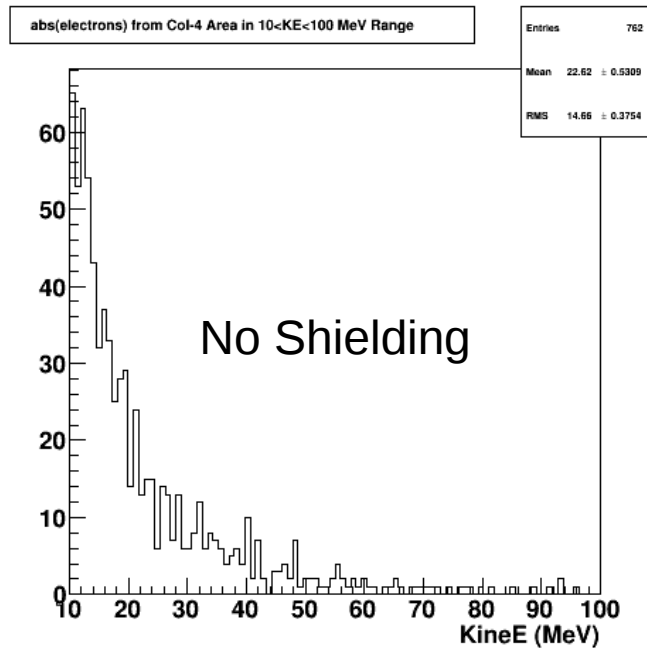
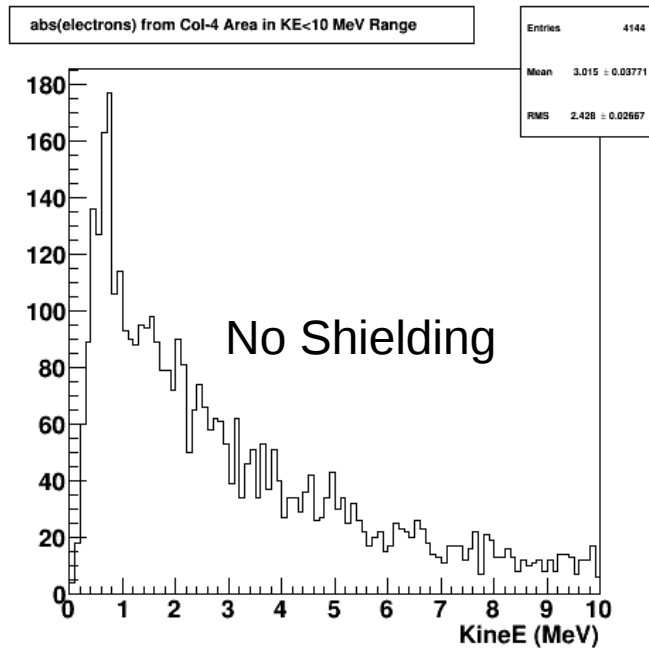
Radiation by Vertex Region

- Collimators 1 and 3 takes the most power hence generate more radiation
- Collimators 2, 4 and 5 generate less radiation
- Due to interaction from shielding materials collimator 5 has increased radiation after shielding

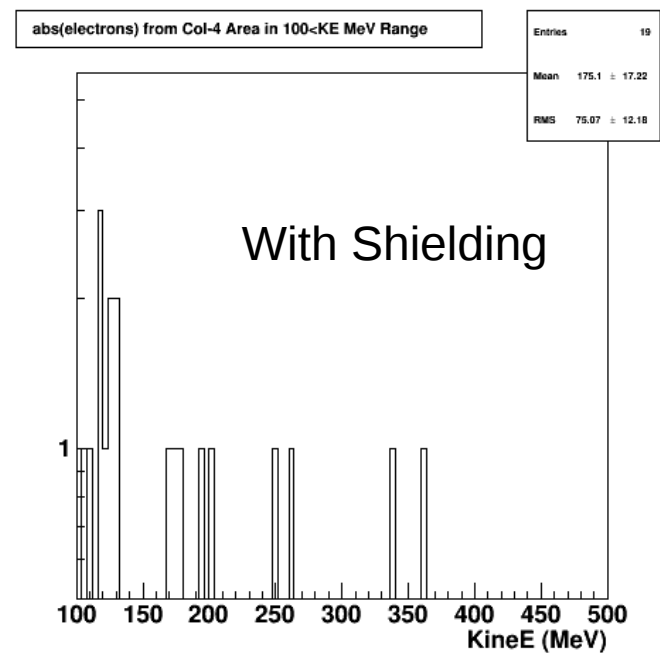
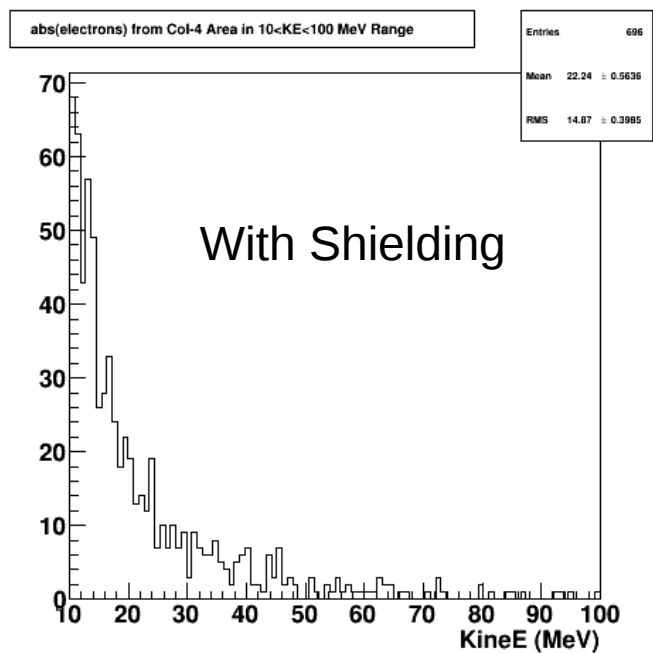
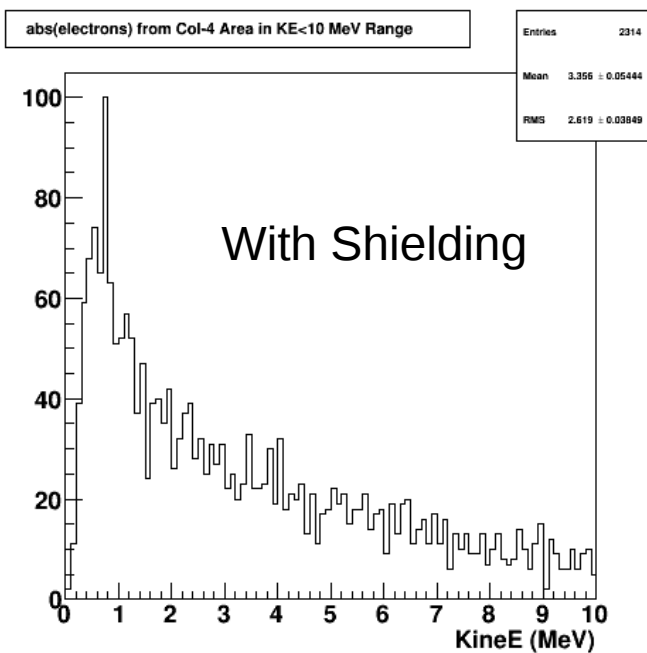
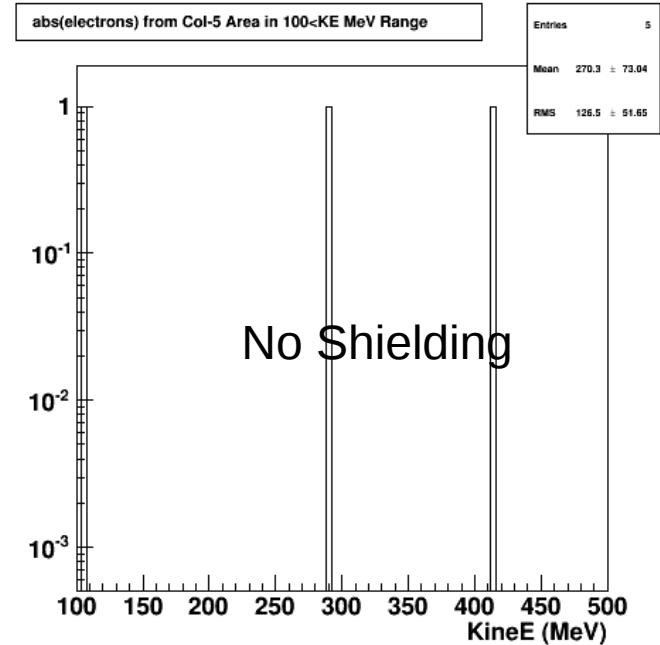
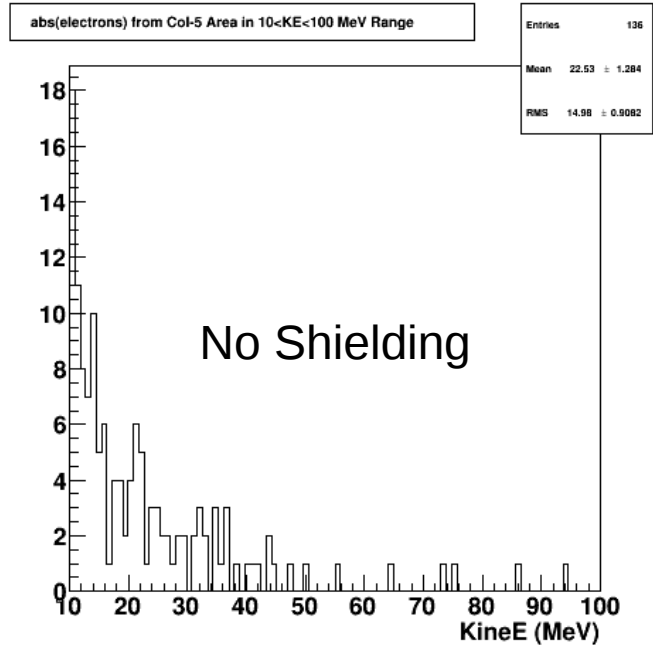
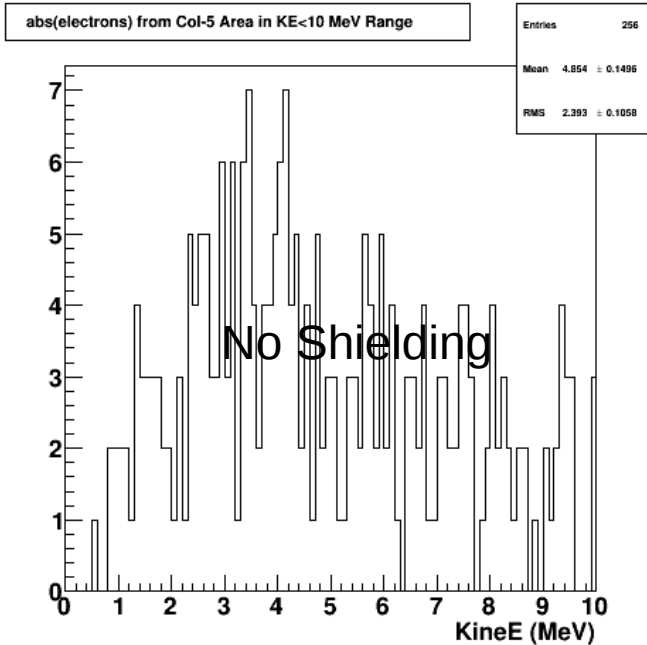
Shielding Electrons : Col-2



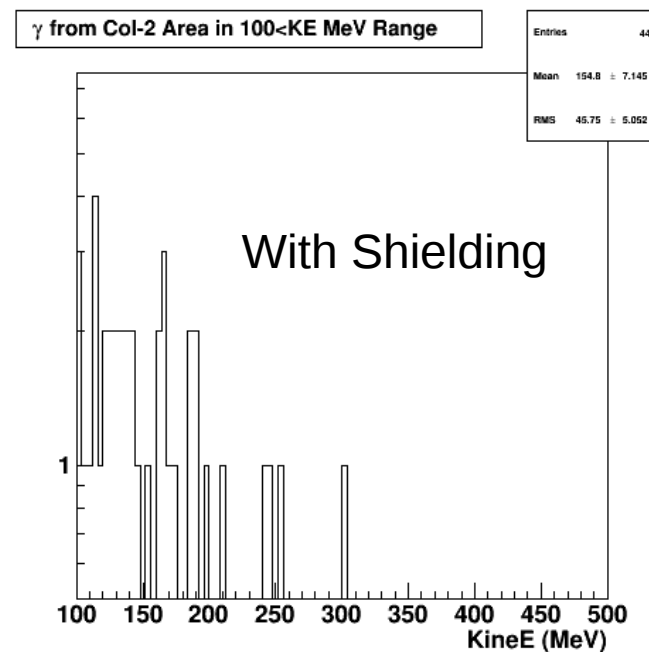
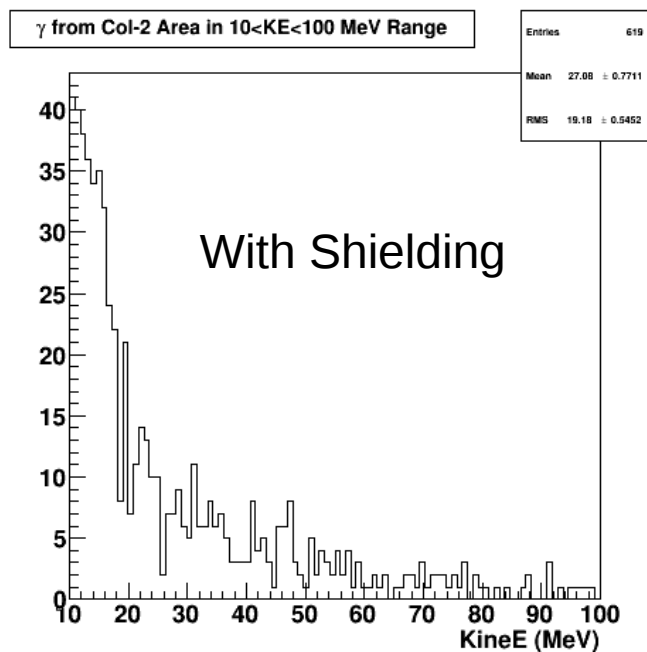
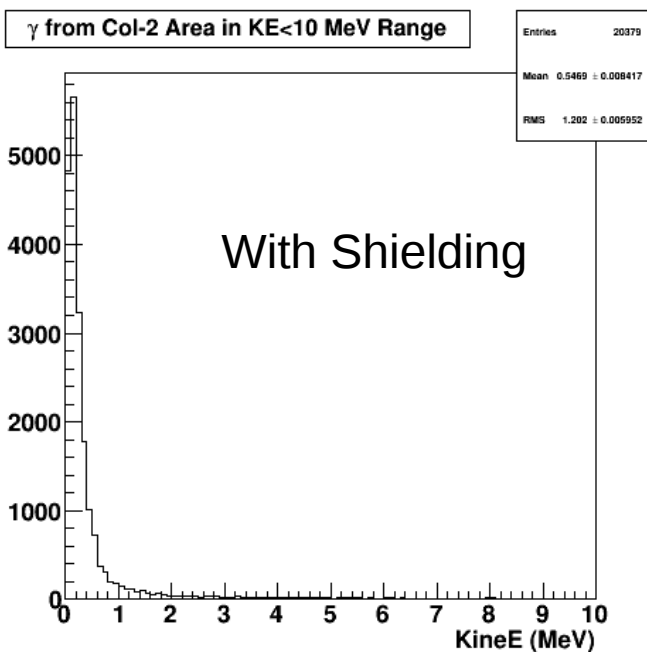
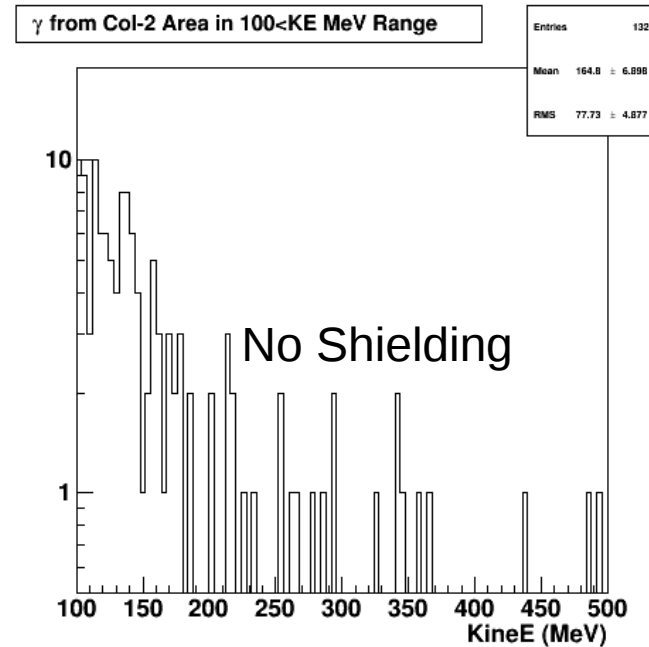
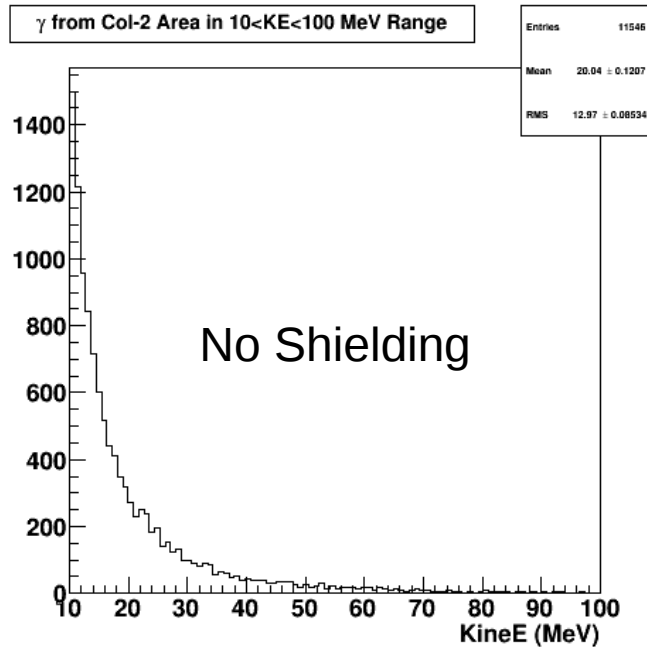
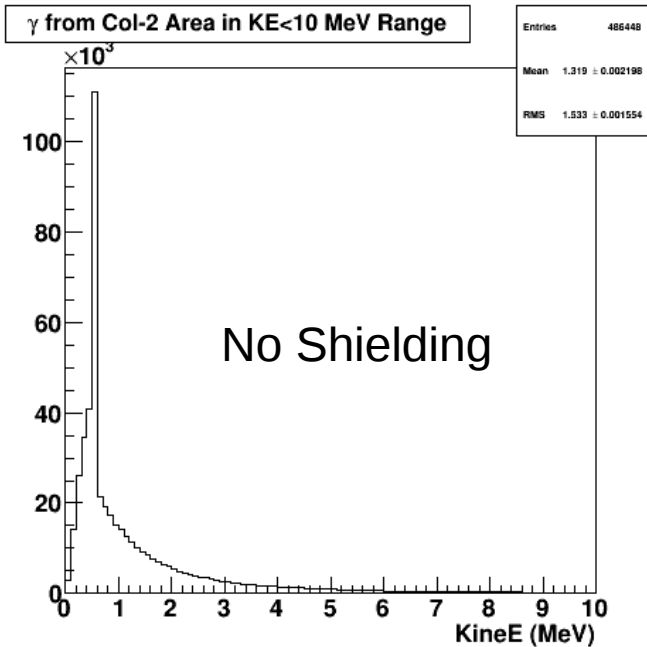
Shielding Electrons : Col-4



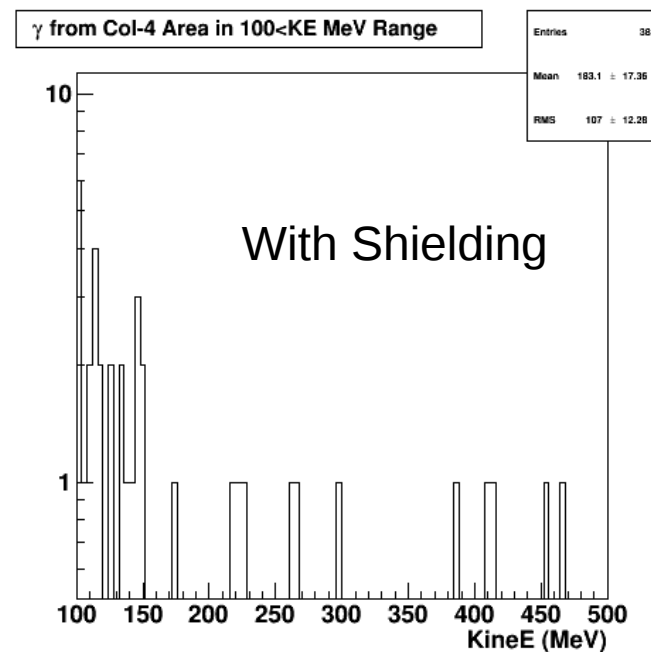
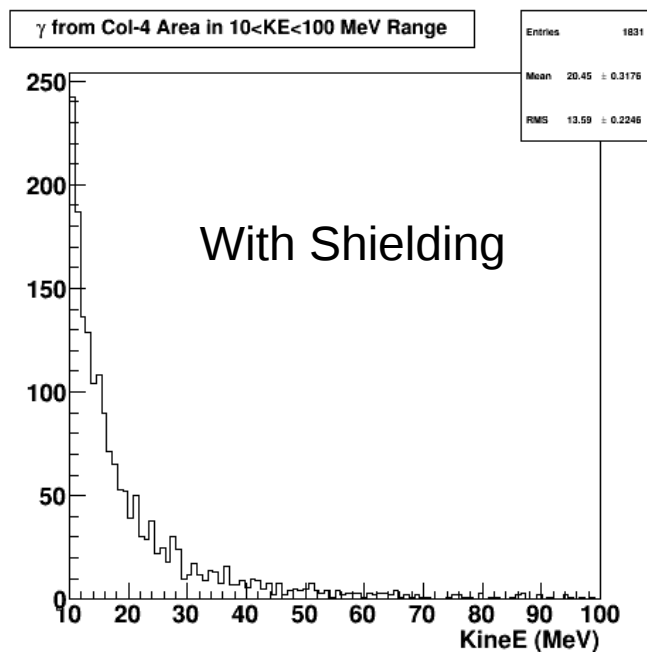
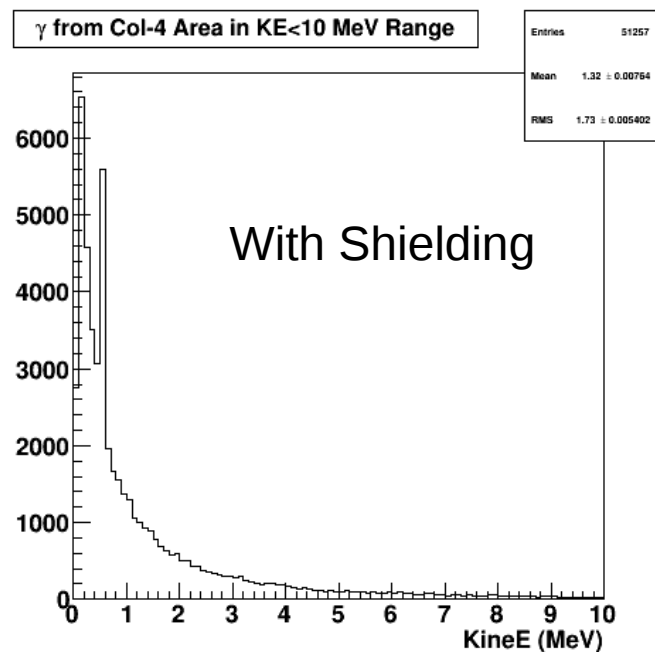
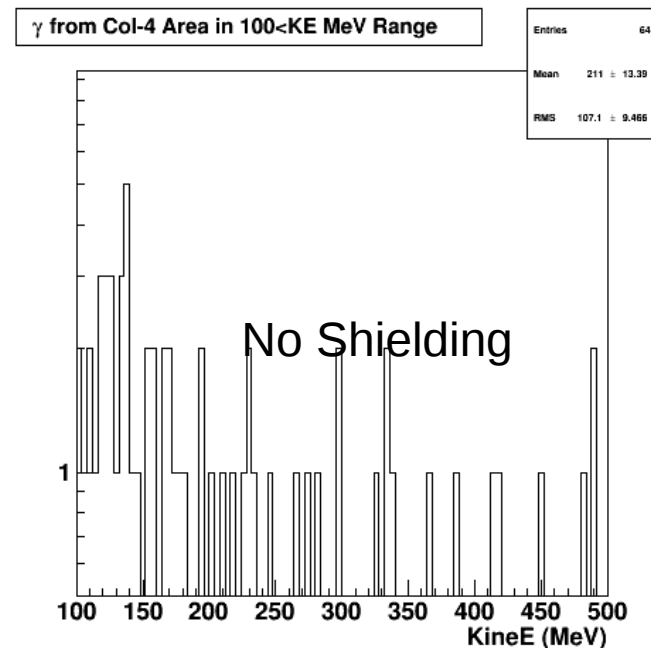
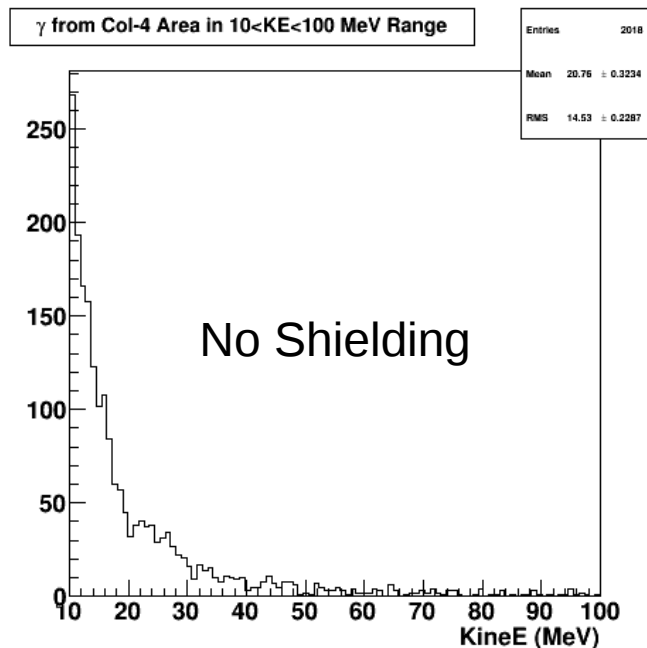
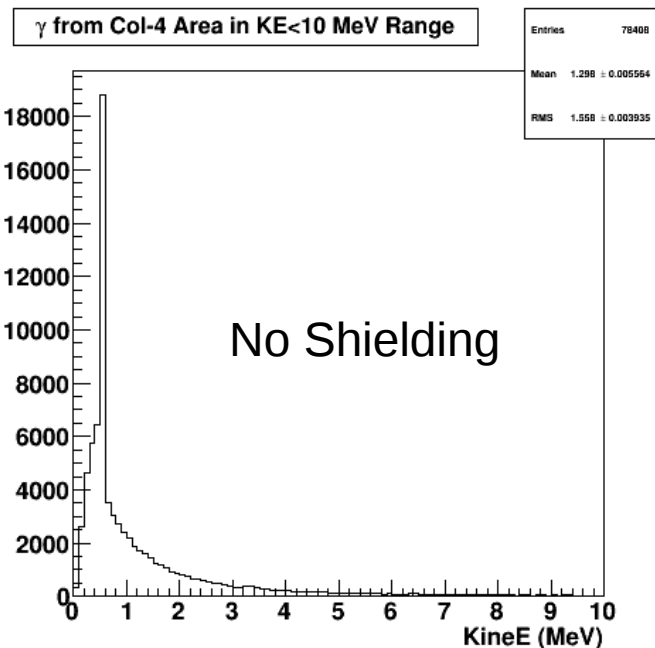
Shielding Electrons : Col-5



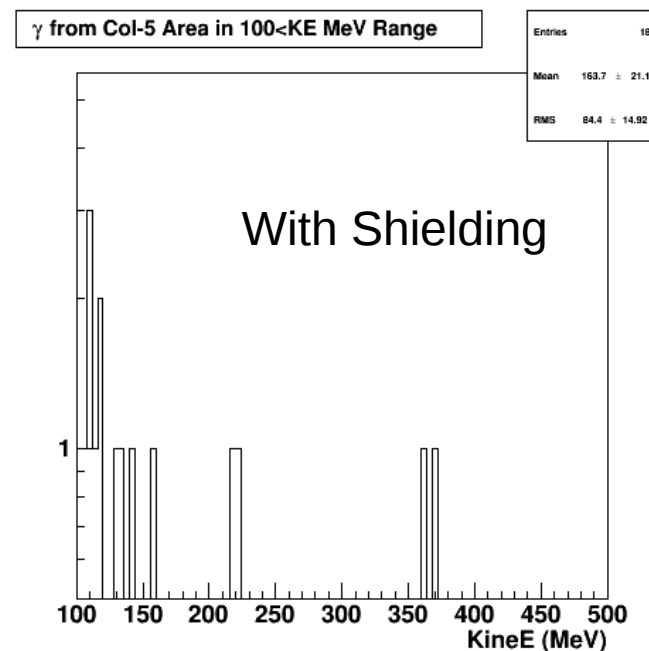
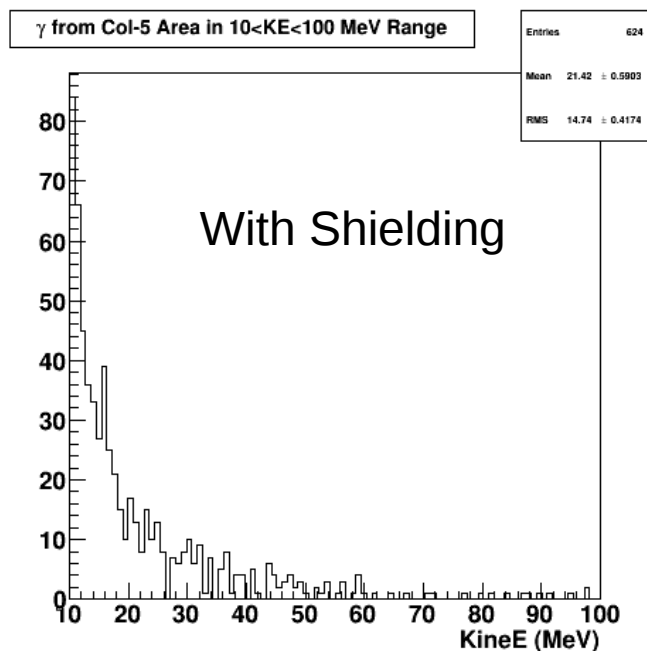
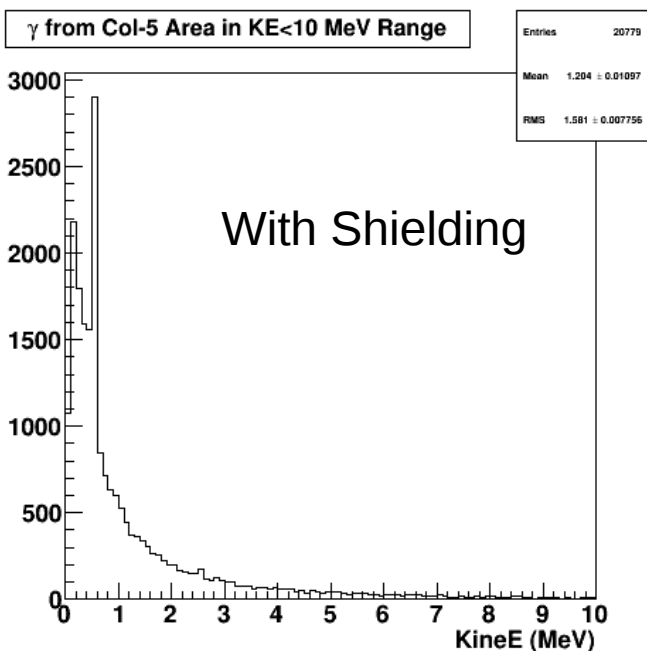
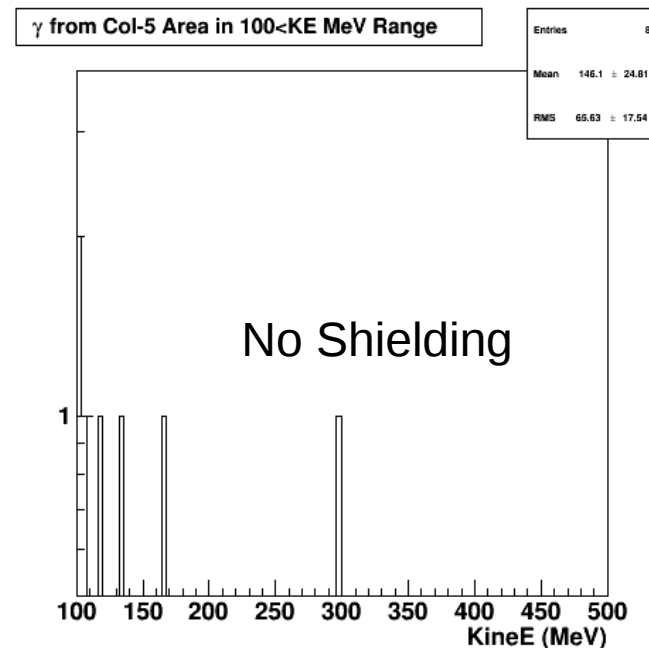
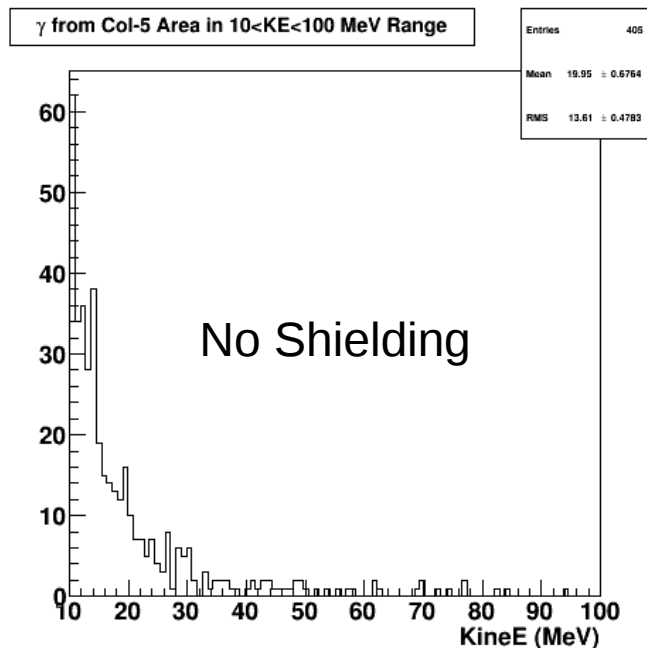
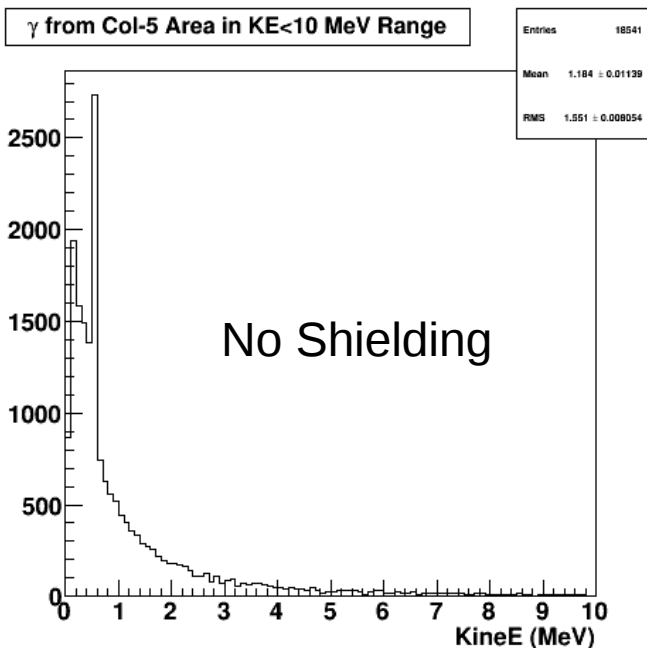
Shielding Gamma : Col-2



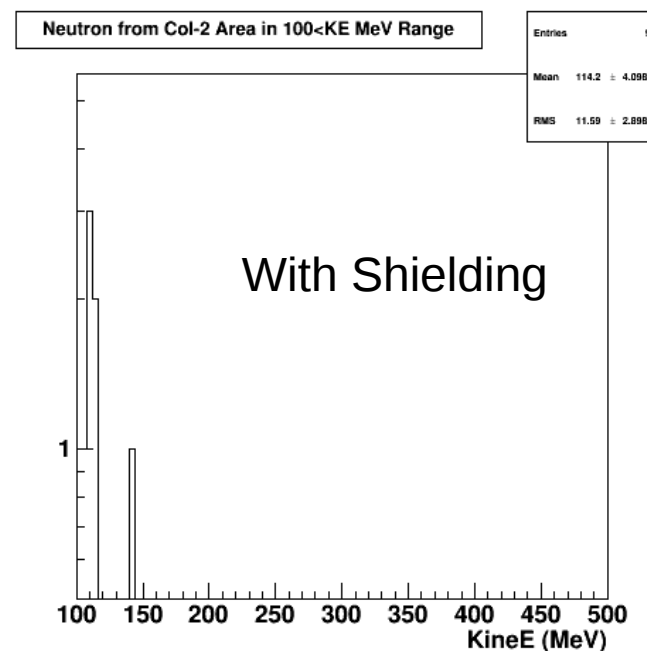
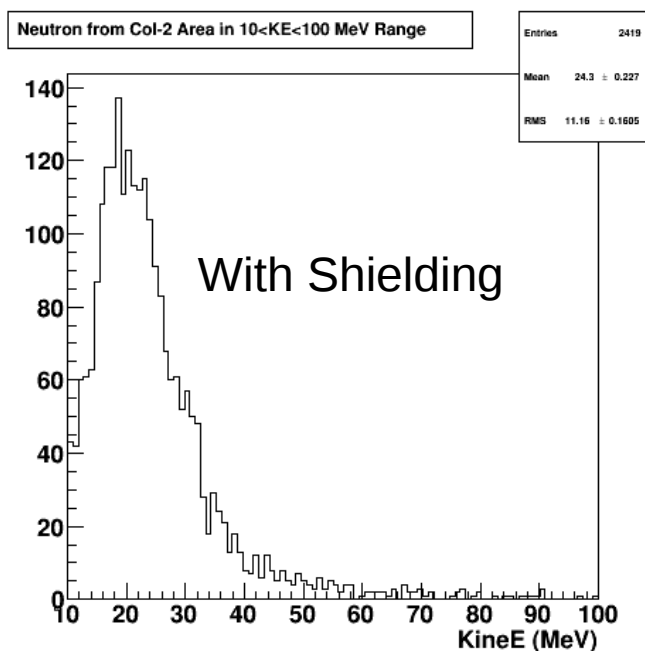
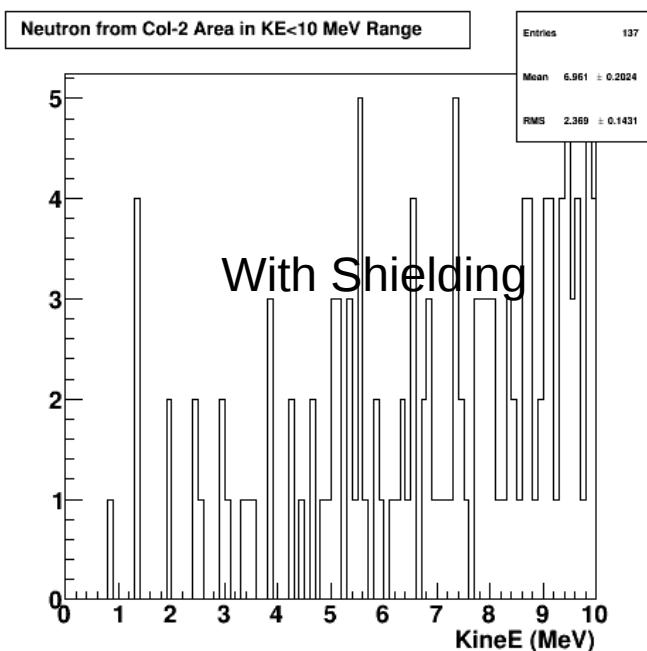
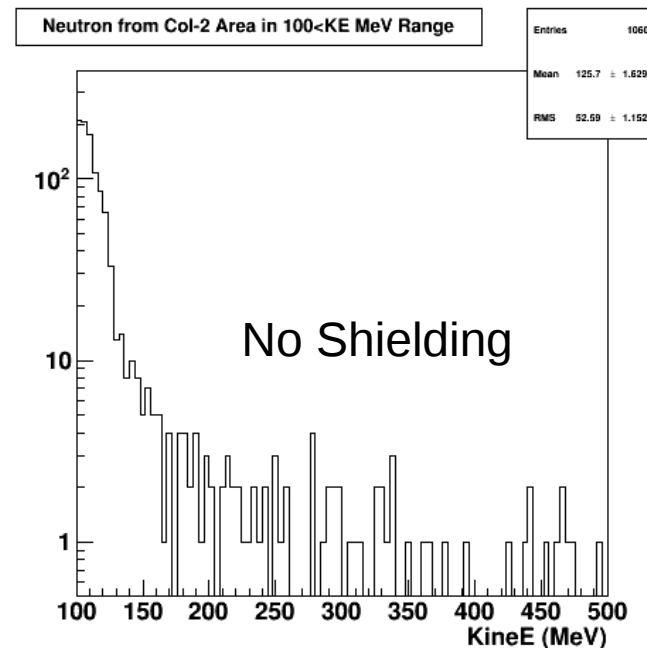
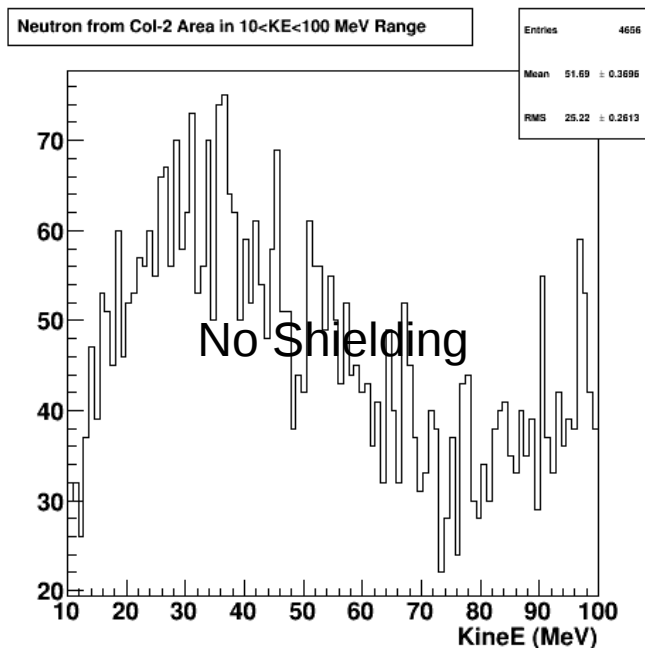
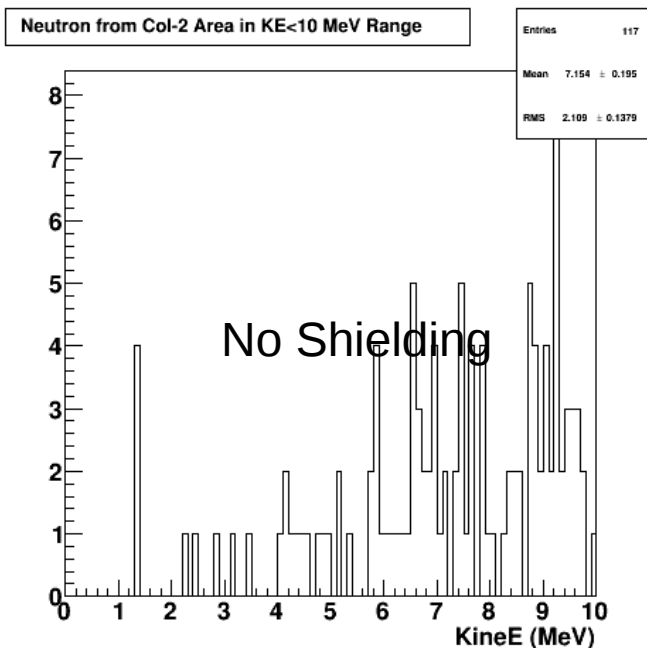
Shielding Gamma : Col-4



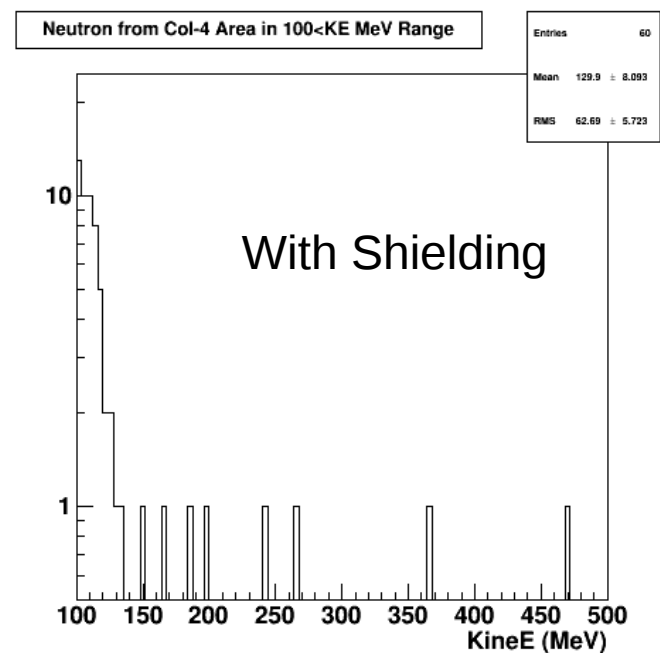
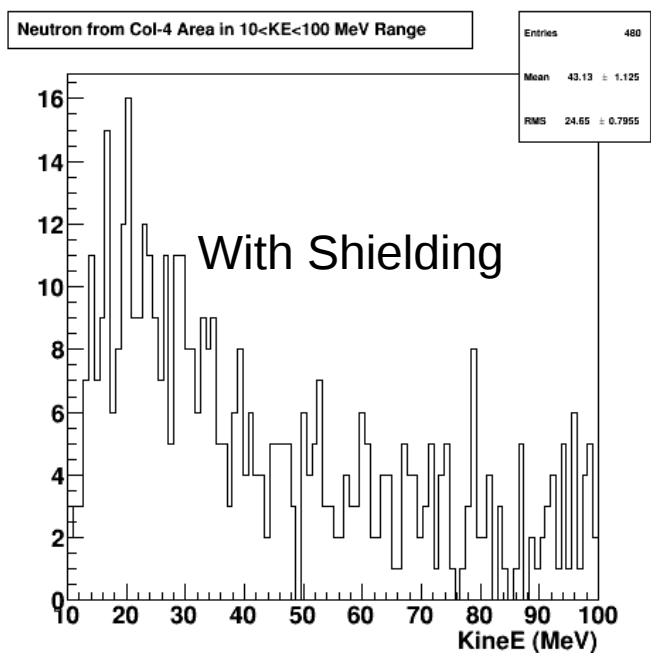
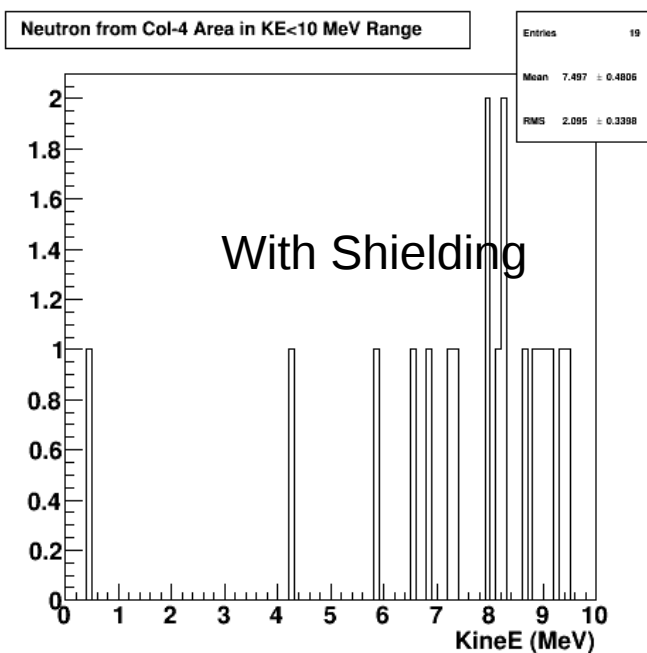
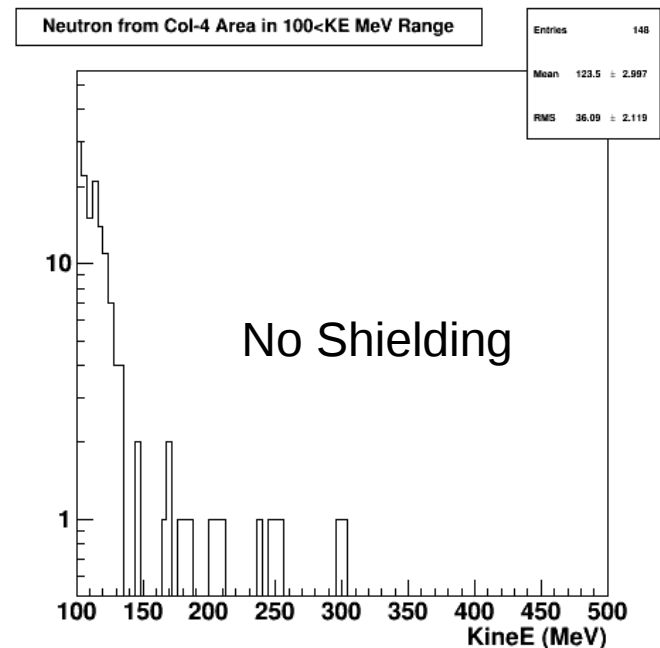
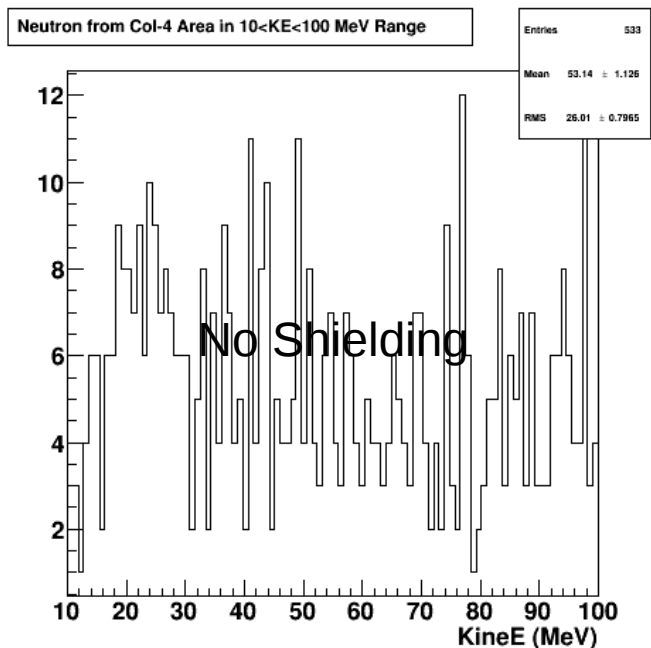
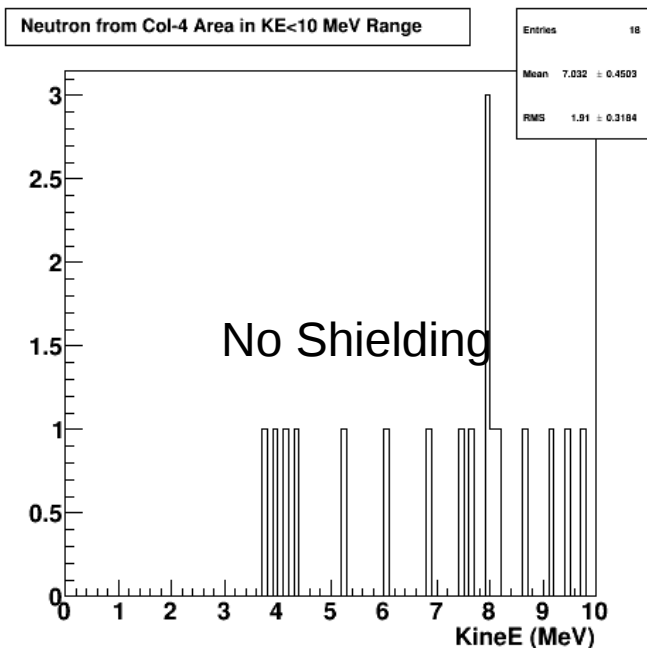
Shielding Gamma : Col-5



Shielding Neutrons : Col-2



Shielding Neutrons : Col-4



Shielding Neutrons : Col-5

