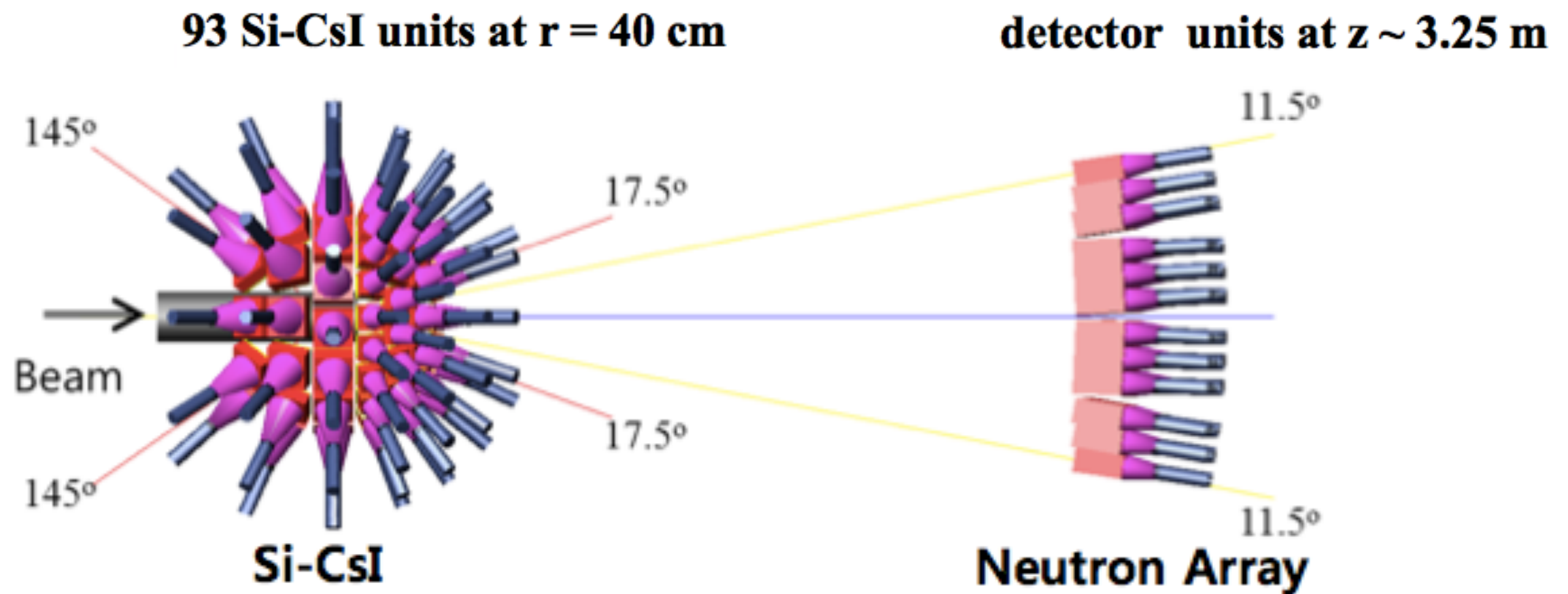


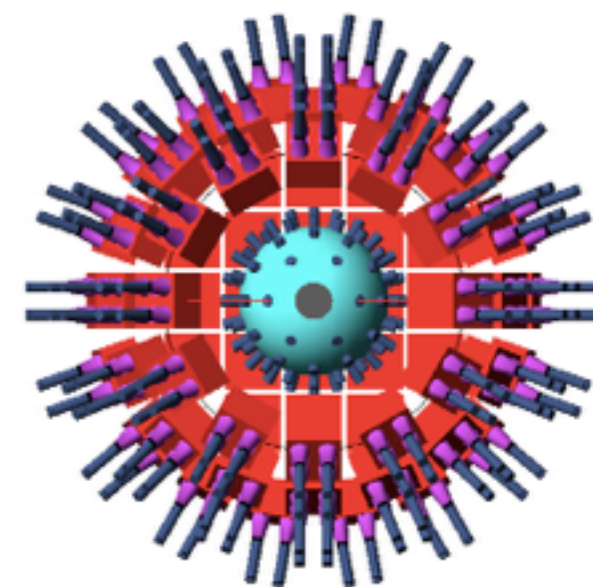
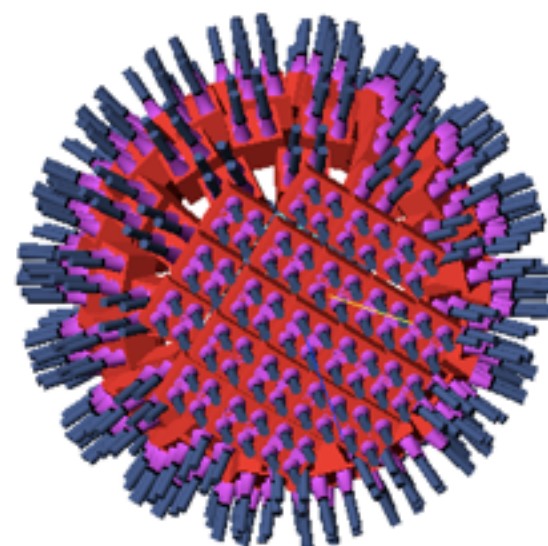
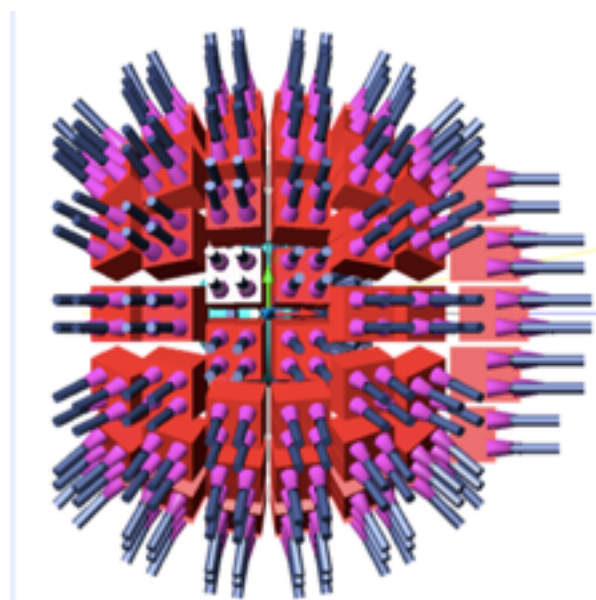
# Lab Meeting LAMPS-low

Jae Beom Park (Korea Univ.)

# Large Acceptance Multi-Purpose Spectrometer (LAMPS) – low energy



# Full Geometry



1 super module = 4 unit detector

Forward Detector Wall : Cover Range 0 ~ 36 degree, ToF Dist. : 1.3m  
# of unit detector 84

Sphere Detector : Cover Range 36 ~ 144 degree, ToF Dist. : 1.1m  
# of unit detector 368

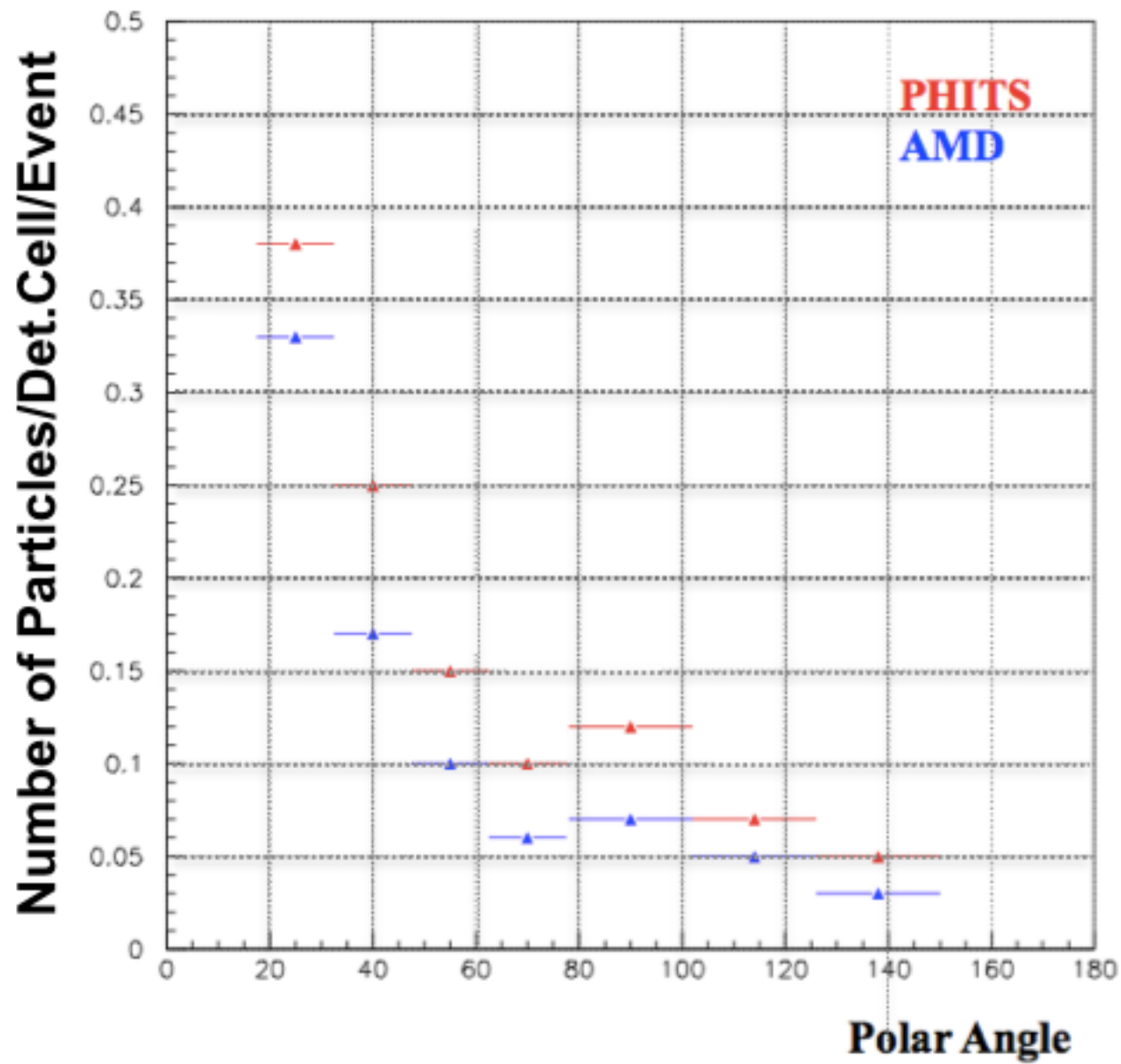
Total # of unit detector (0 ~ 144 degree) = 452

Total # of unit detector (0 ~ 90 degree) = 268

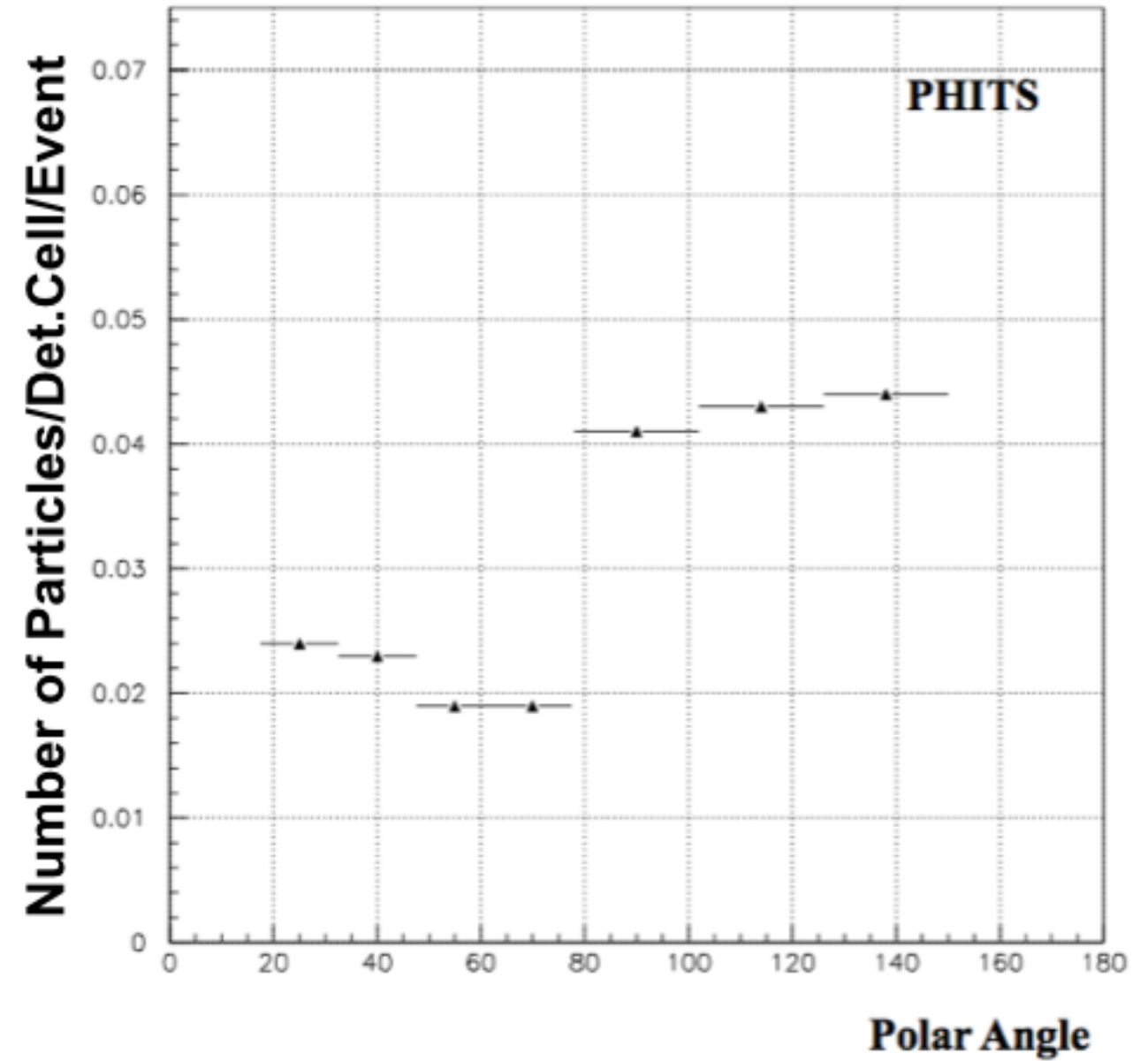
Theta angle	Phi angle division	# of super (unit detector)
45 degree	30.0 degree	12 (48)
63 degree	22.5 degree	16 (64)
81 degree	20.0 degree	18 (72)
99 degree	20.0 degree	18 (72)
117 degree	22.5 degree	16 (64)
135 degree	30.0 degree	12 (48)

# Design of Si/CsI for LAMPS-L

## Charged Particle for CsI(Tl) Detector



## Photon for CsI(Tl) Detector

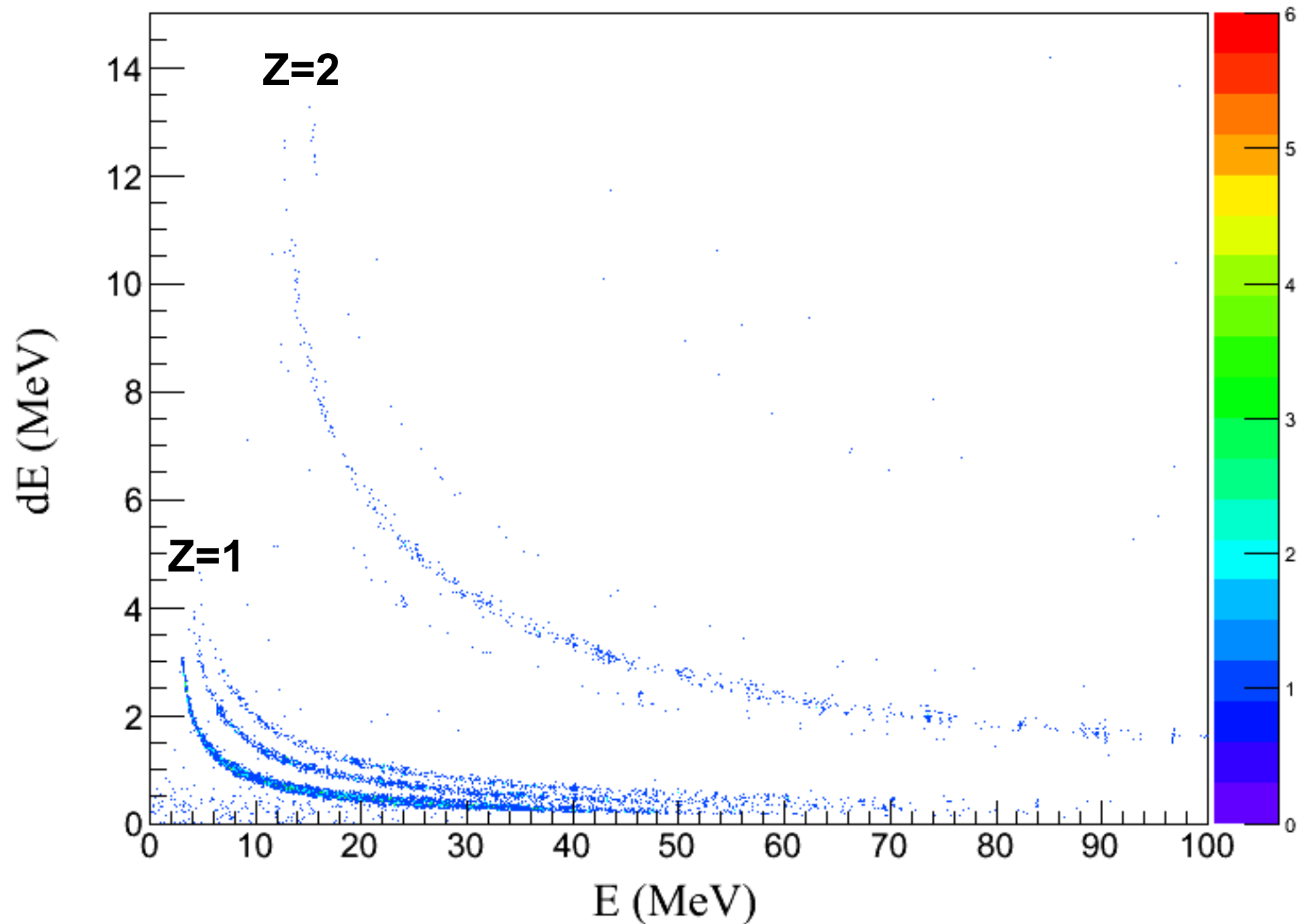


# Det.CoverRange

	N_gen( $\Delta\theta$ )	N_det( $\Delta\theta$ )	Det.CovRange (%) (simulation)	Det.CovRange (%) (geometrical)	# of particle/ Det.cell/event	Occupancy
1 : (17.5°< $\theta$ <32.5°)	2.67	1.53	57.25	58.43	0.191	0.0156
2 : (32.5°< $\theta$ <47.5°)	1.98	1.14	57.56	57.62	0.095	0.0077
3 : (47.5°< $\theta$ <62.5°)	1.71	1.14	66.88	67.81	0.063	0.0052
4 : (62.5°< $\theta$ <77.5°)	1.17	0.73	62.33	65.69	0.037	0.0030
5 : (77.5°< $\theta$ <102°)	1.10	0.84	76.36	79.11	0.056	0.0046
6 : (102°< $\theta$ <126°)	0.56	0.37	67.47	70.70	0.031	0.0025
7 : (126°< $\theta$ <150°)	0.25	0.14	57.03	64.35	0.018	0.0014

# PID : dE - E method

(used AMD events. CsI thickness : 5cm)



# Geant4 Simulation

- Package 1 : Hadron Physics - HadronPhysicsQGSP\_BERT
- Package 2 : Hadron Physics - HadronPhysicsQGSP\_BIC
- Package 3 : Hadron Physics - G4HadronElasticPhysics
- Package 4 : Decay Physics - G4RadioactiveDecayPhysics
- Tested 5 different combinations

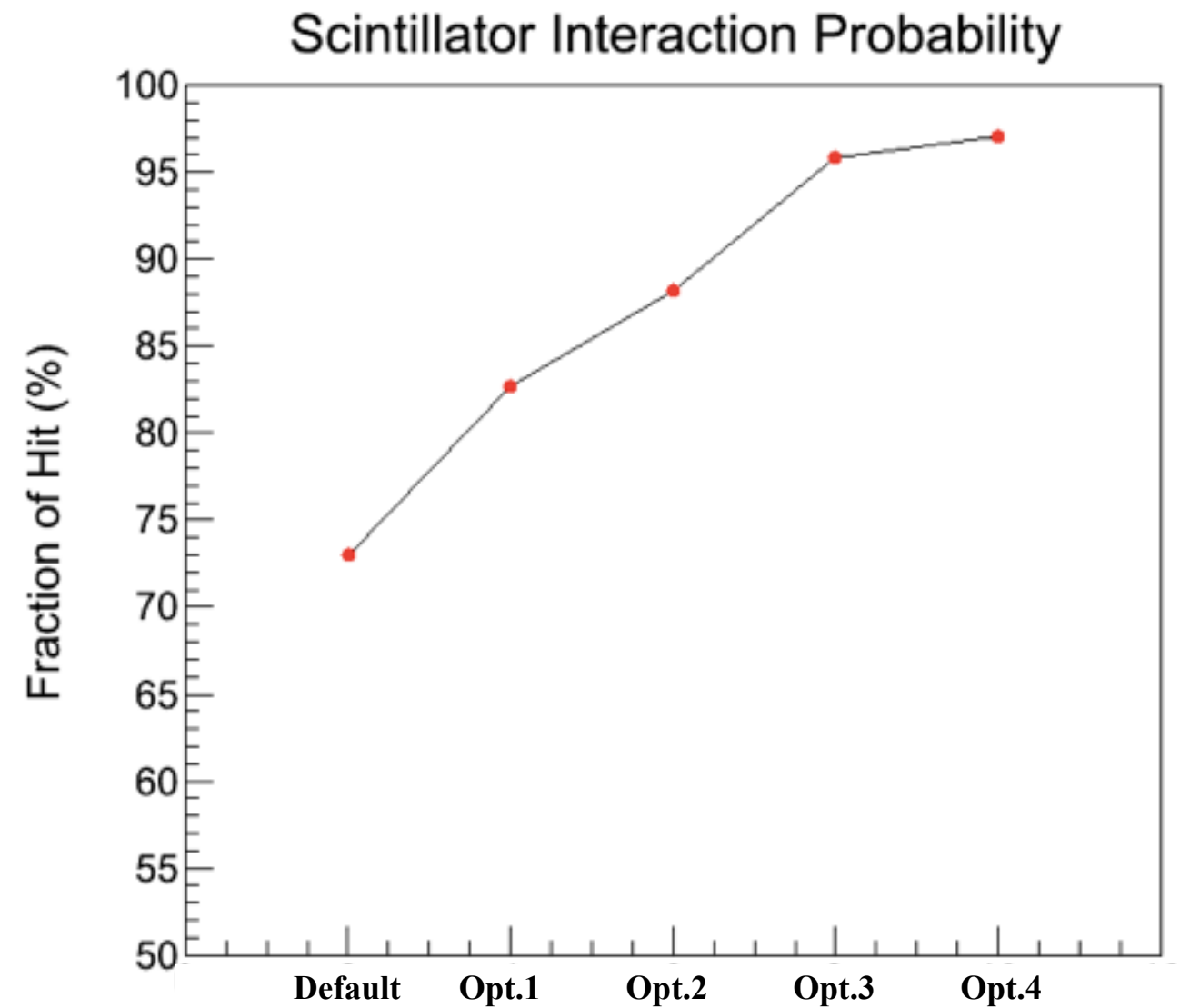
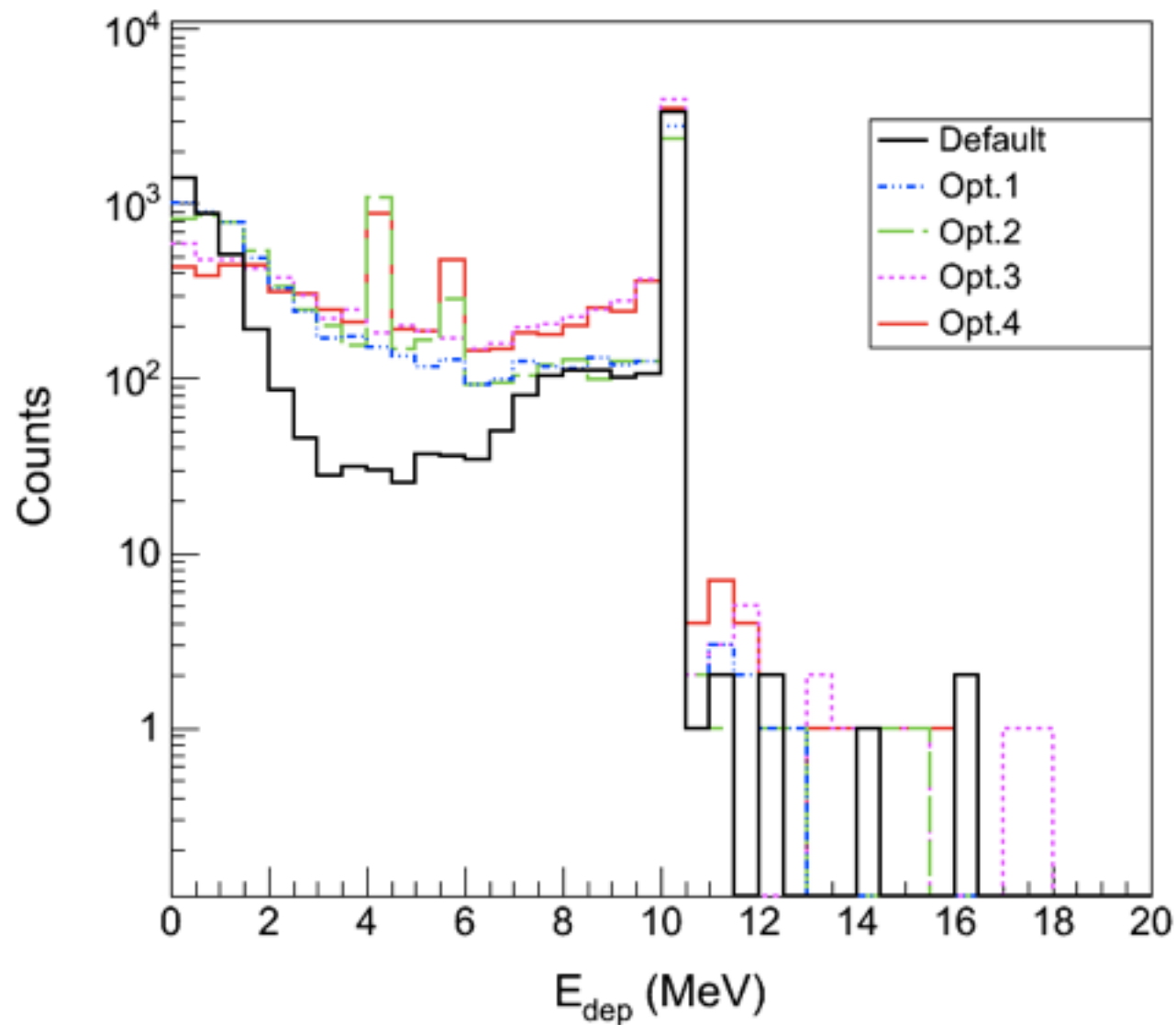
Default	Default
Opt.1	Default+Pack.1
Opt.2	Default+Pack.1 +Pack.2
Opt.3	Default+Pack.1+Pack.3 +Pack.4
Opt.4	Default+Pack.1+Pack.2 +Pack.3 +Pack.4



# Response of Neutron Detector

$E_{\text{beam}} = 10 \text{ MeV}$

# of Event = 10,000



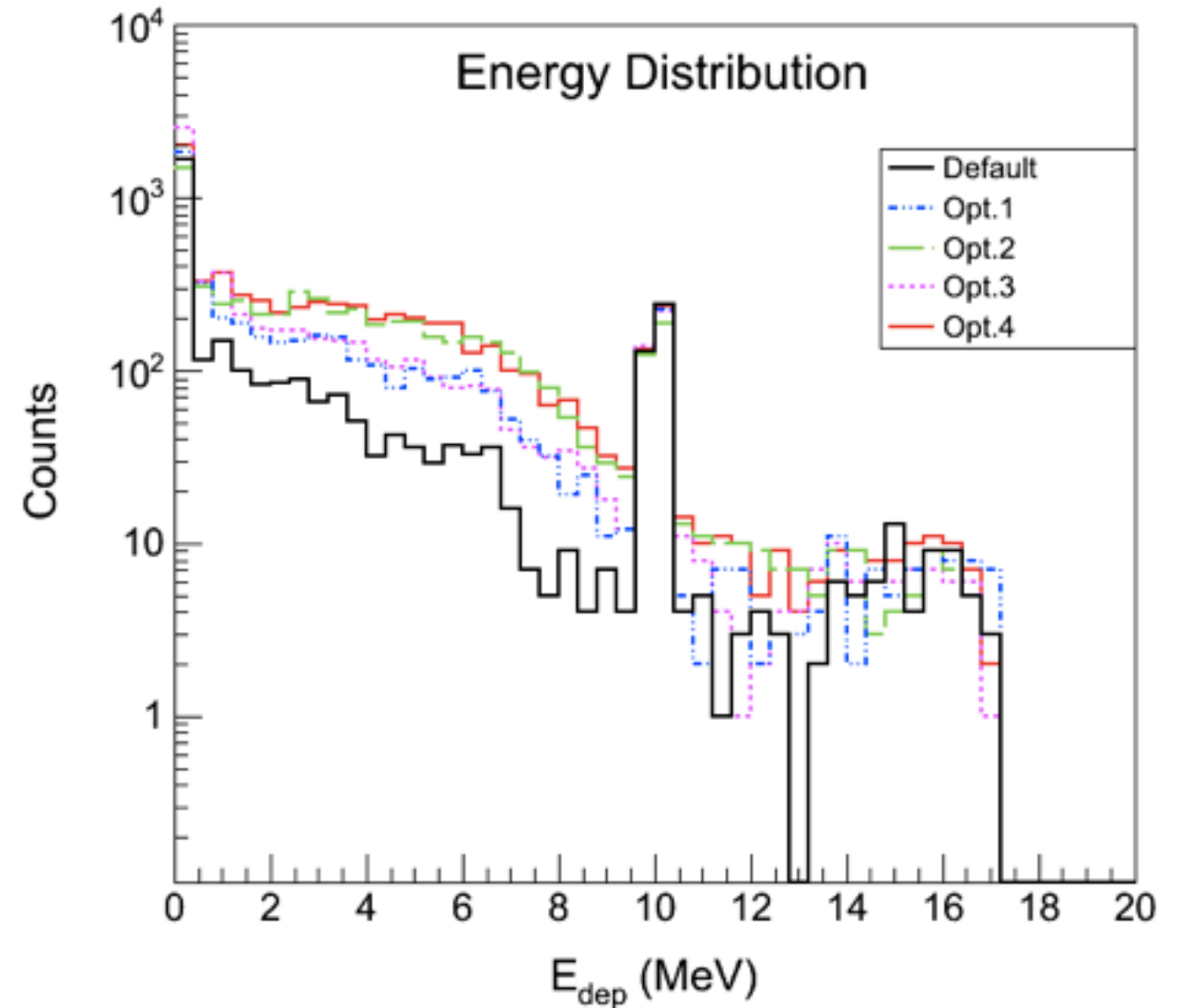
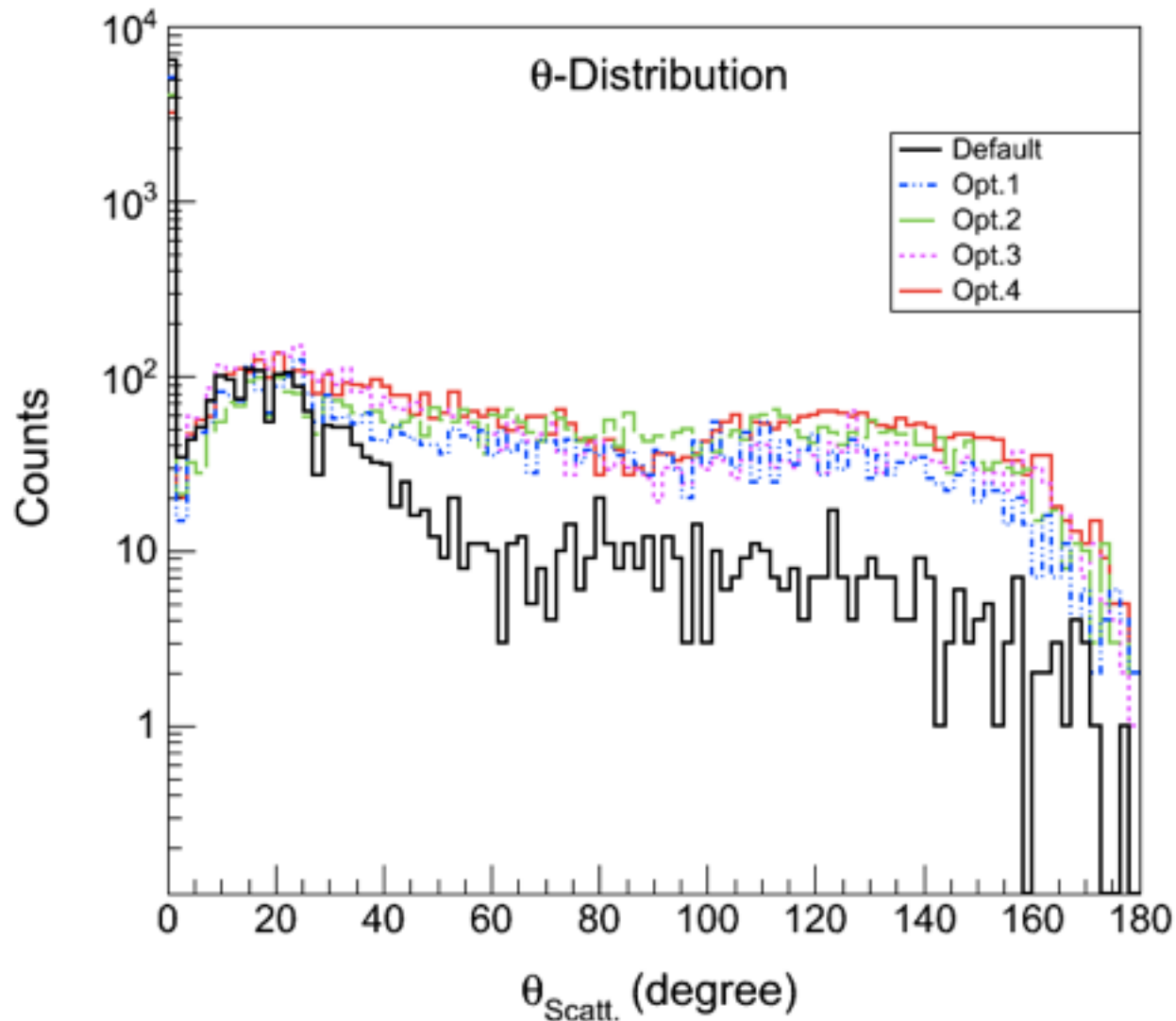
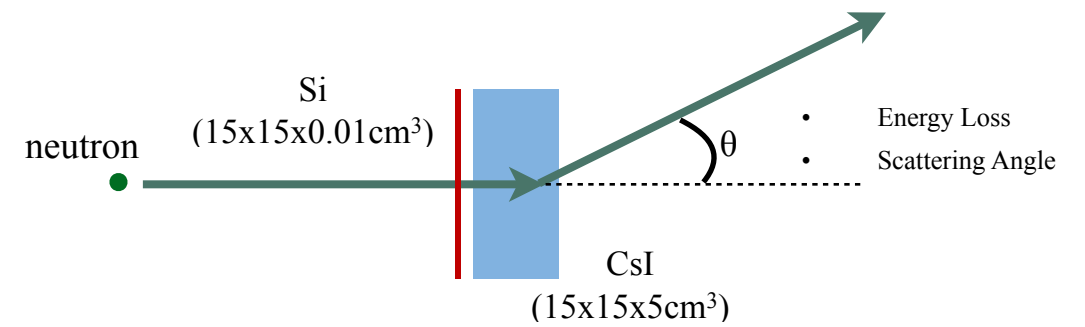


# Effect of Si-CsI Detector

Beam Energy = 10 MeV

Depth of CsI = 5cm

# of Events = 10,000

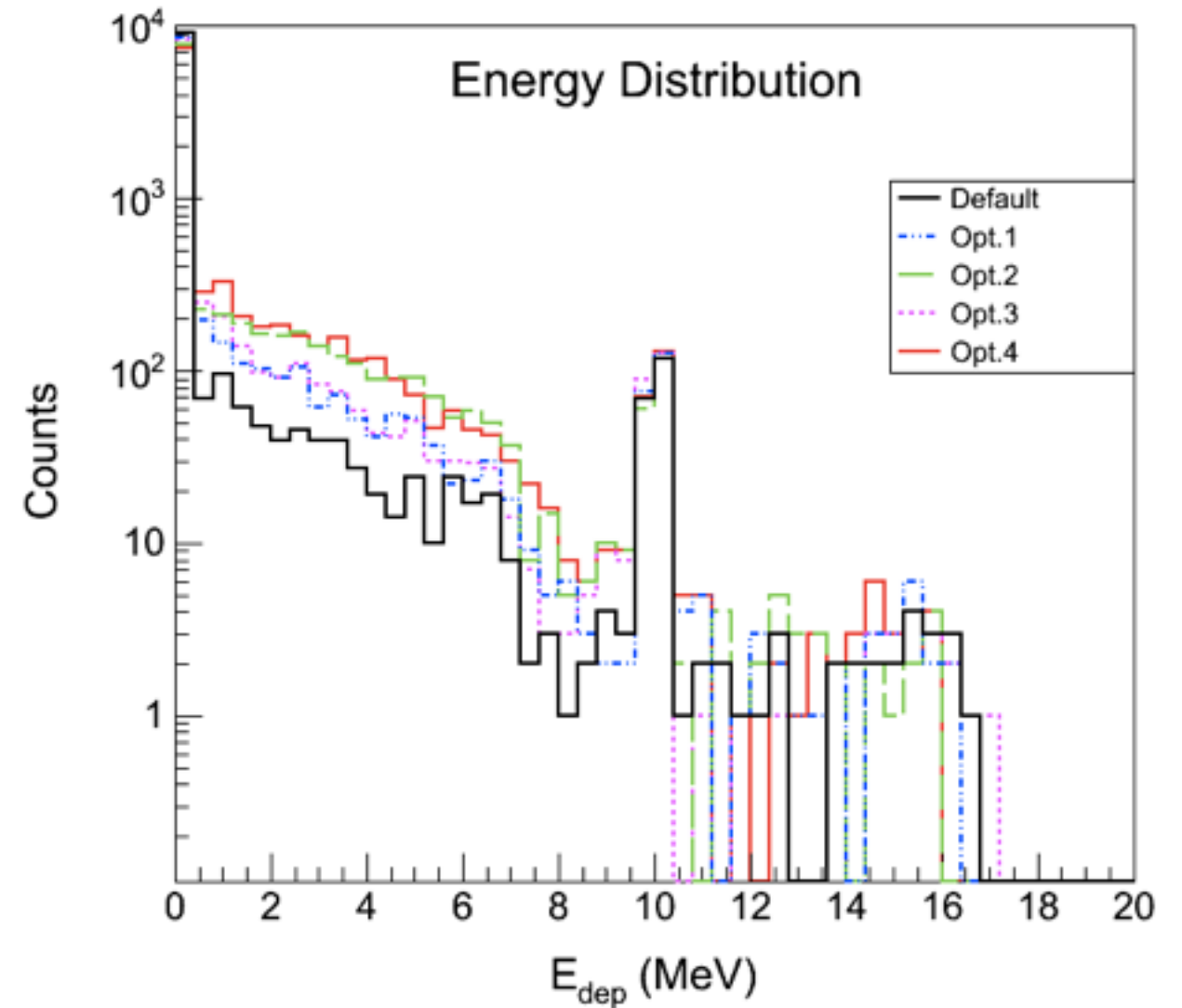
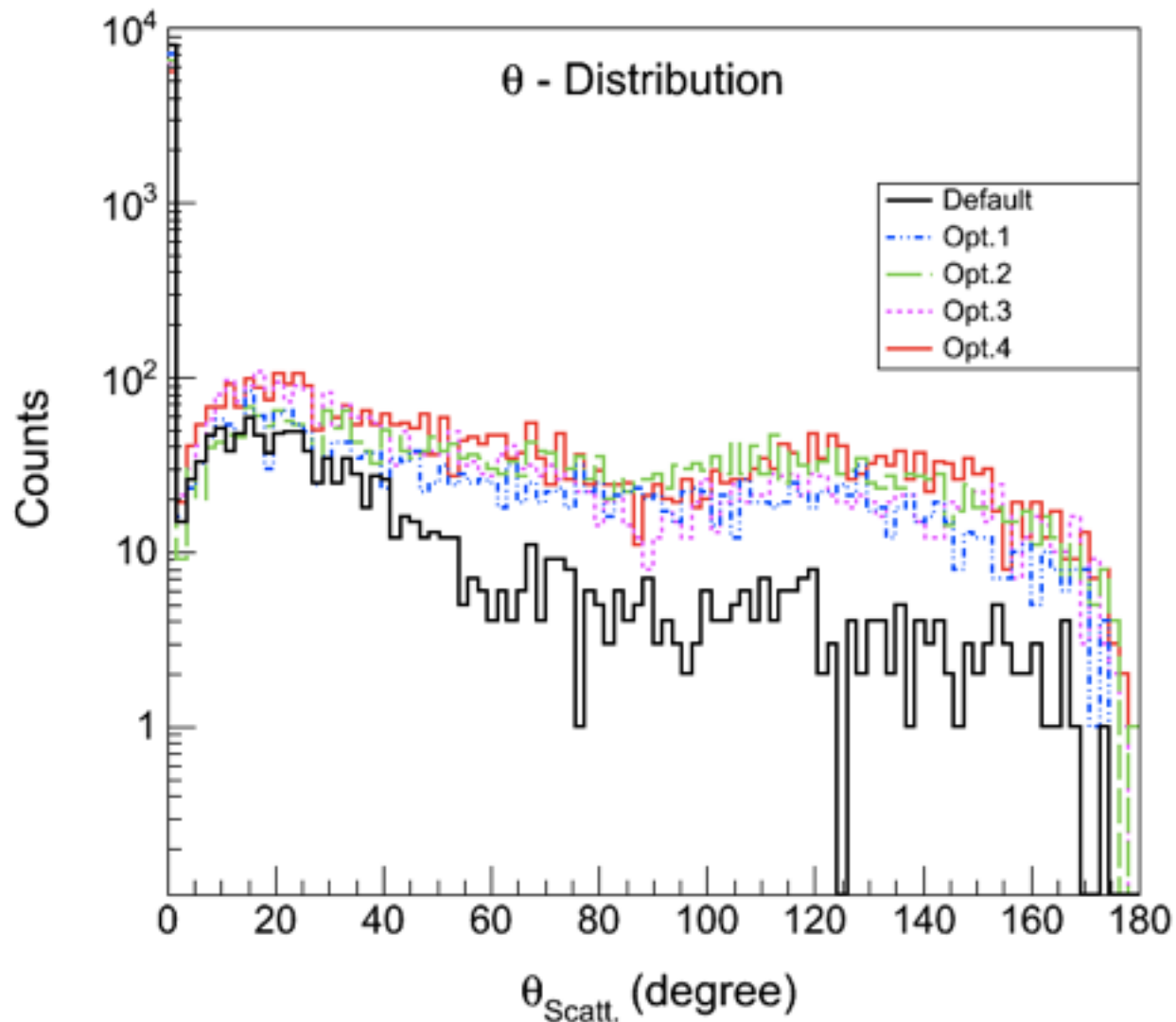
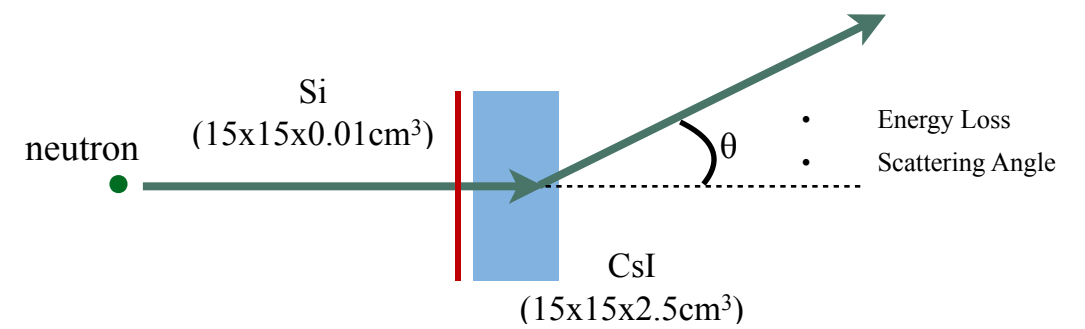


# Effect of Si-CsI Detector

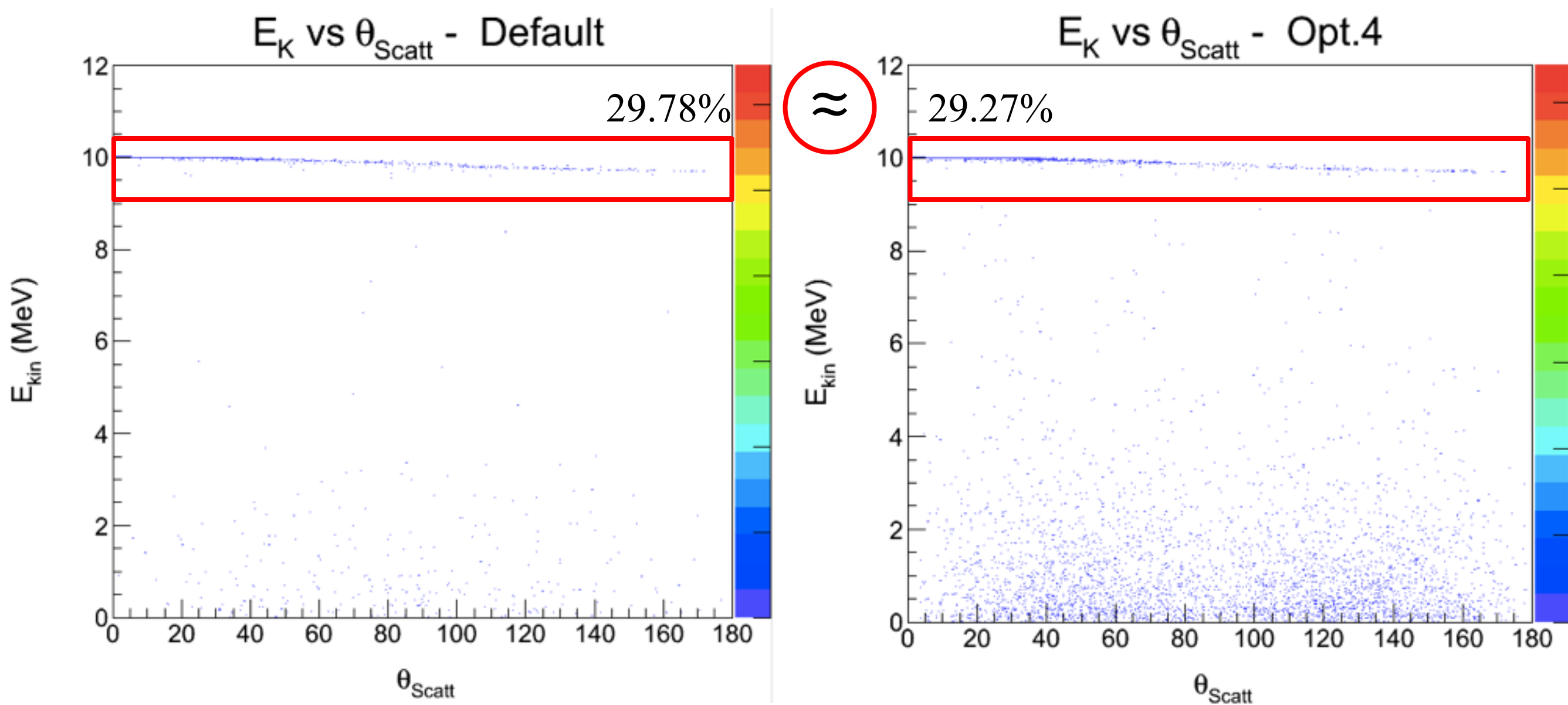
Beam Energy = 10 MeV

Depth of CsI = 2.5cm

# of Events = 10,000

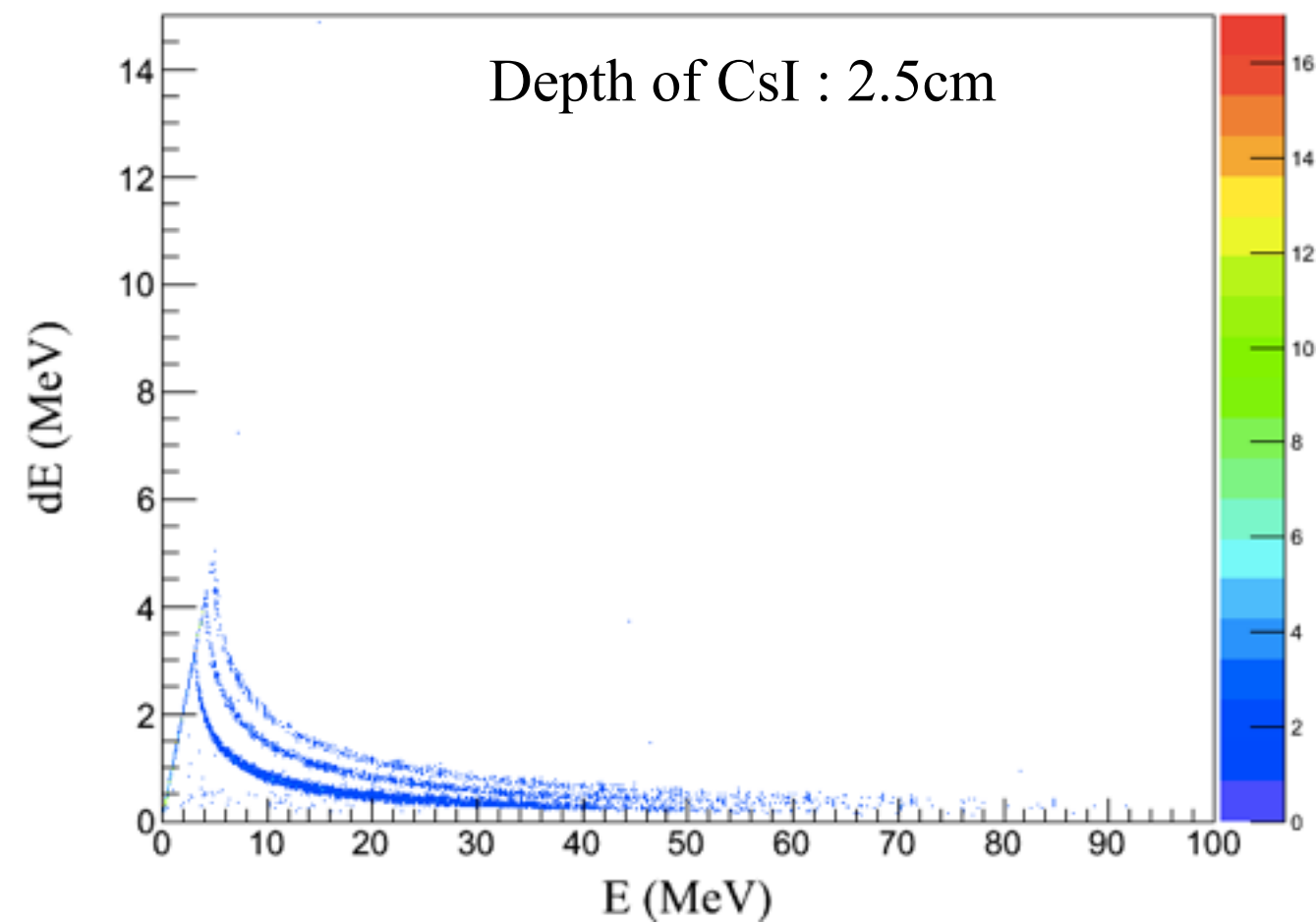
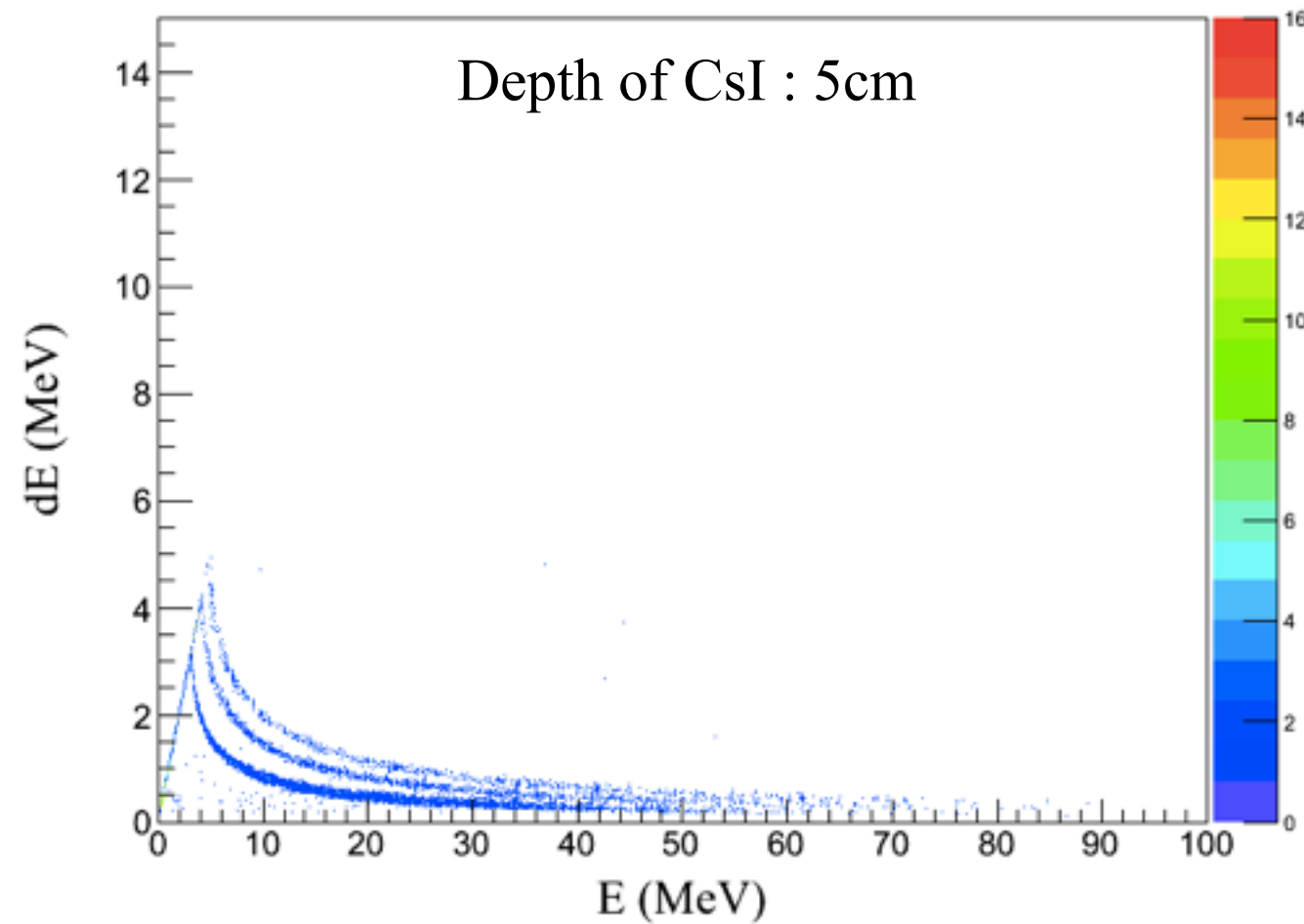


# Kinetic Energy vs Scattering Angle (CsI Thickness : 5cm)

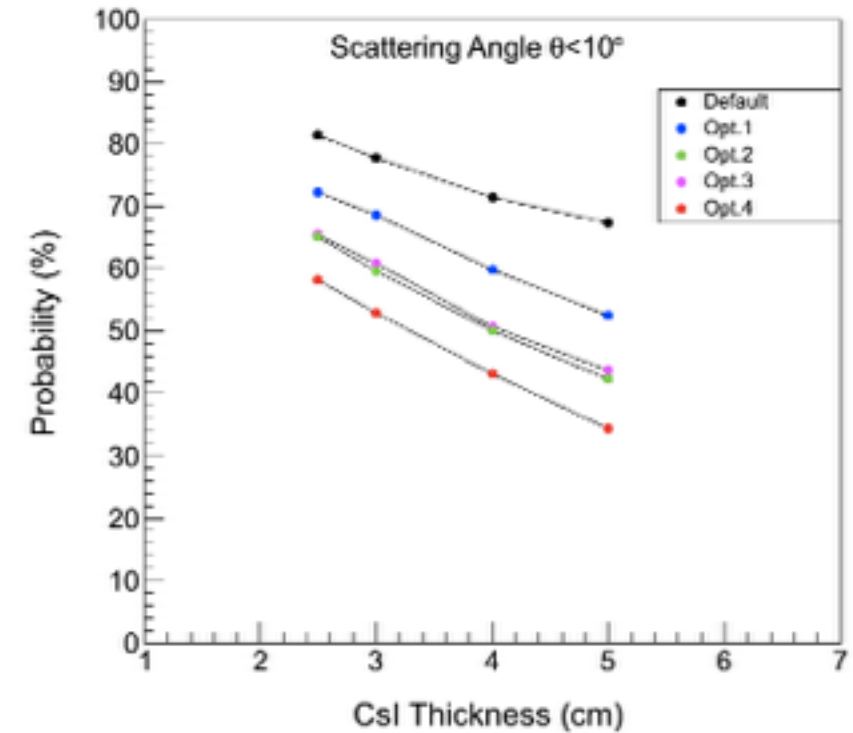
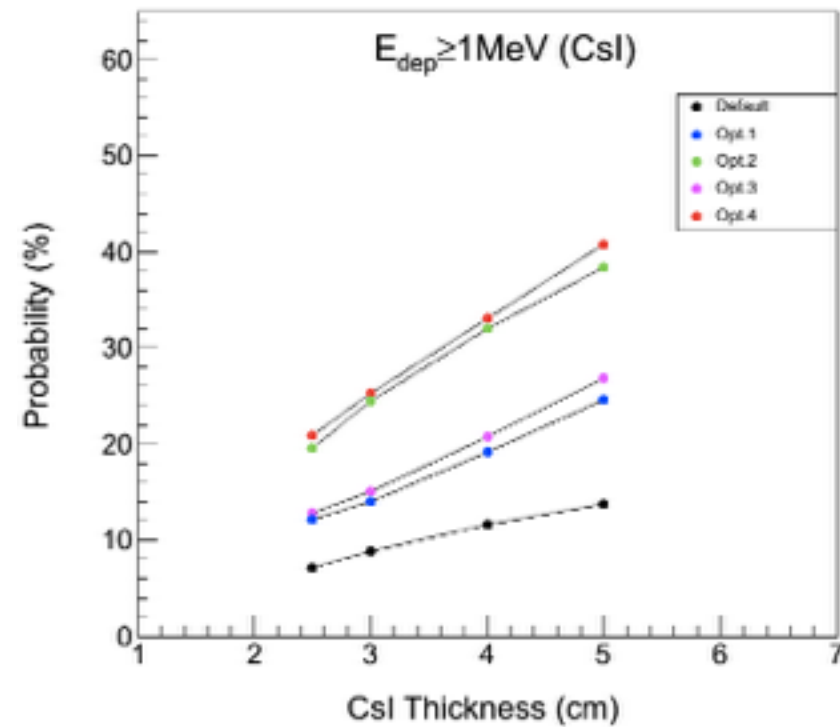
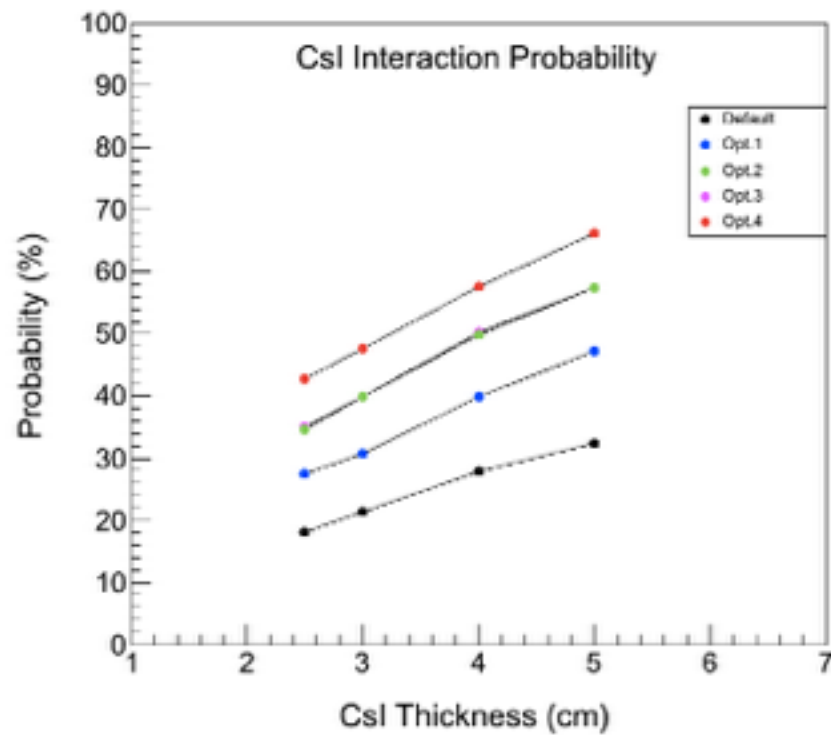


# CsI thickness effect on charged particle

<Proton Isotope AMD Generated Events>



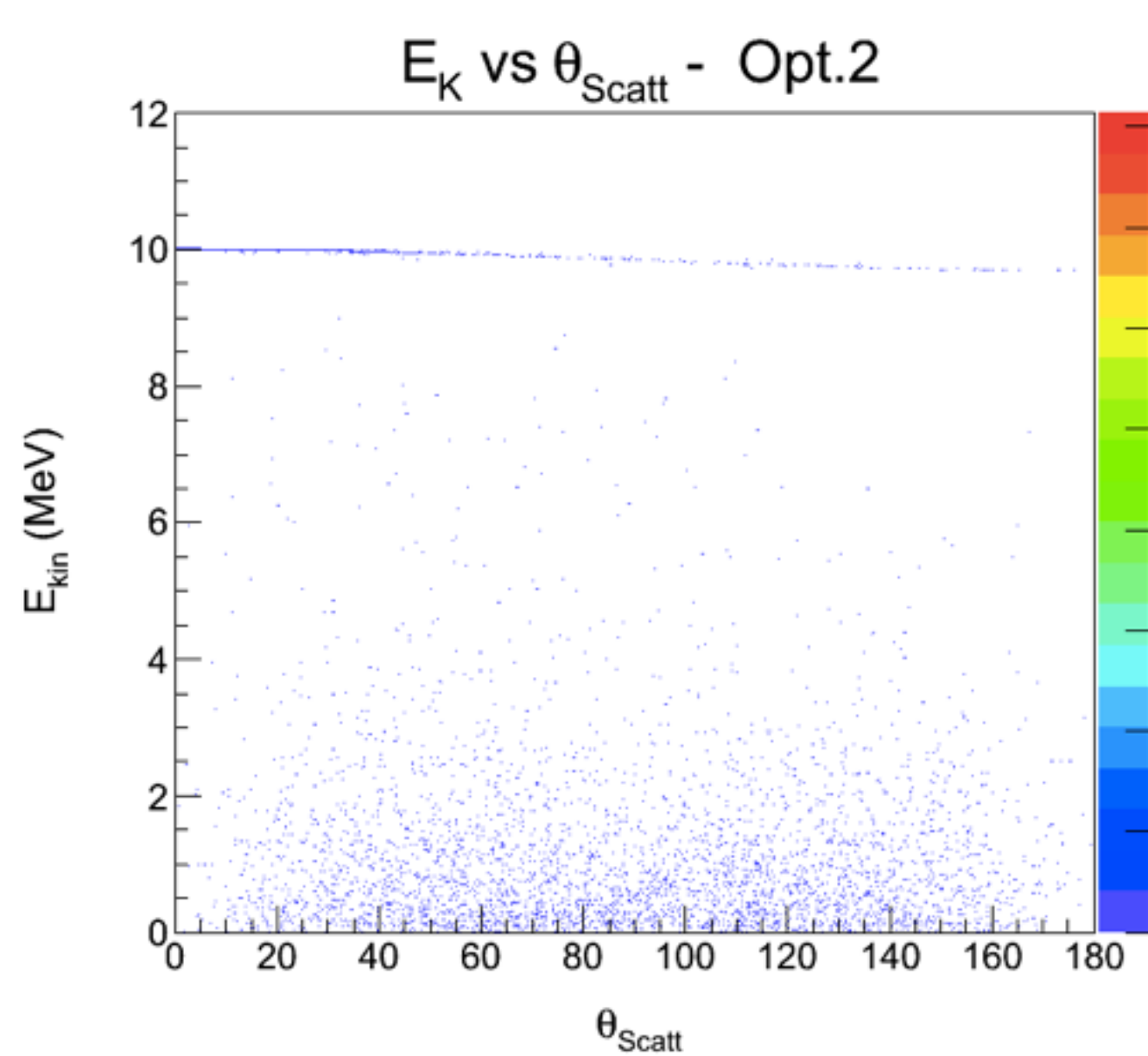
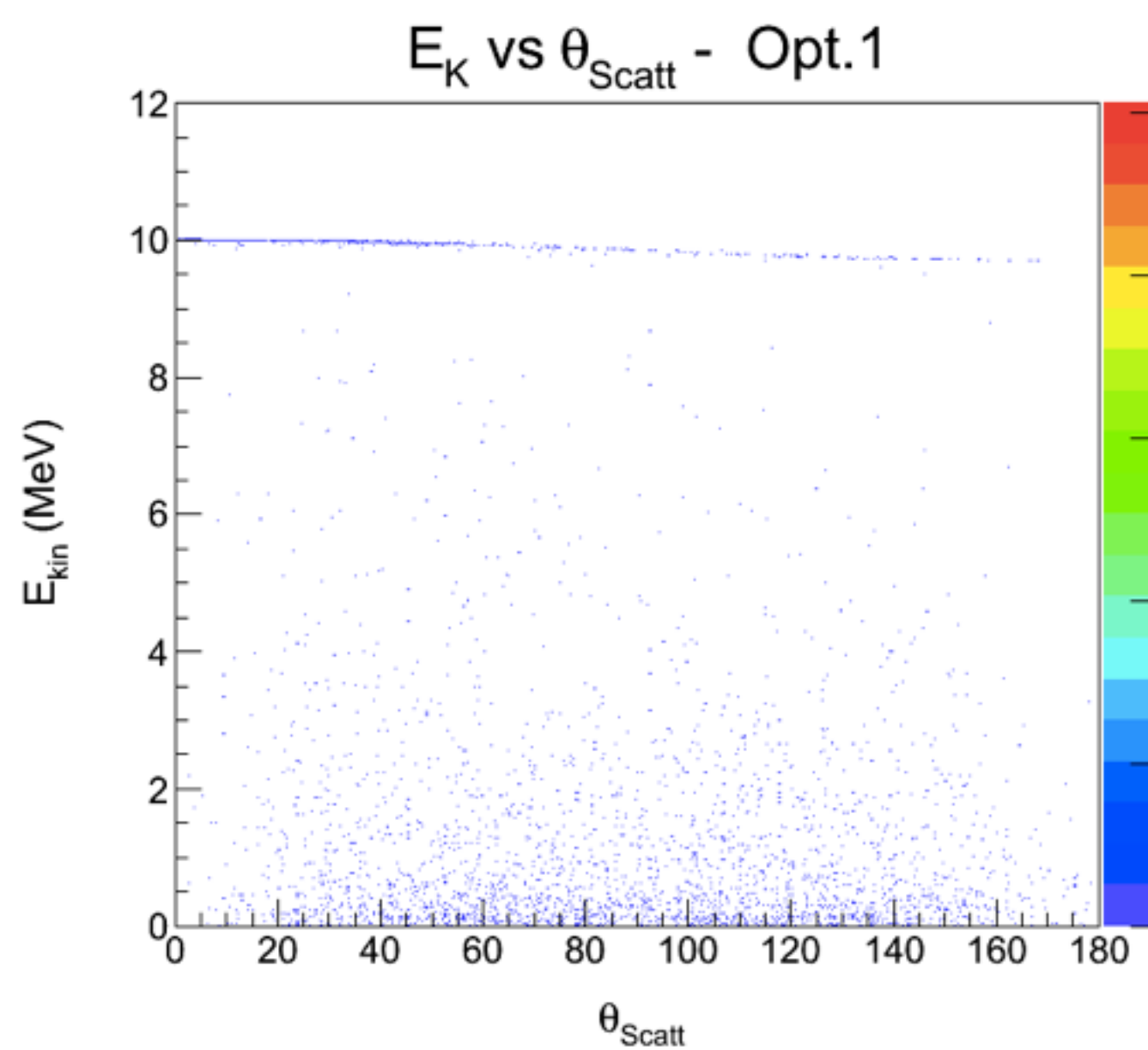
# Summary of the Si-Csl effect



# Summary & Plan

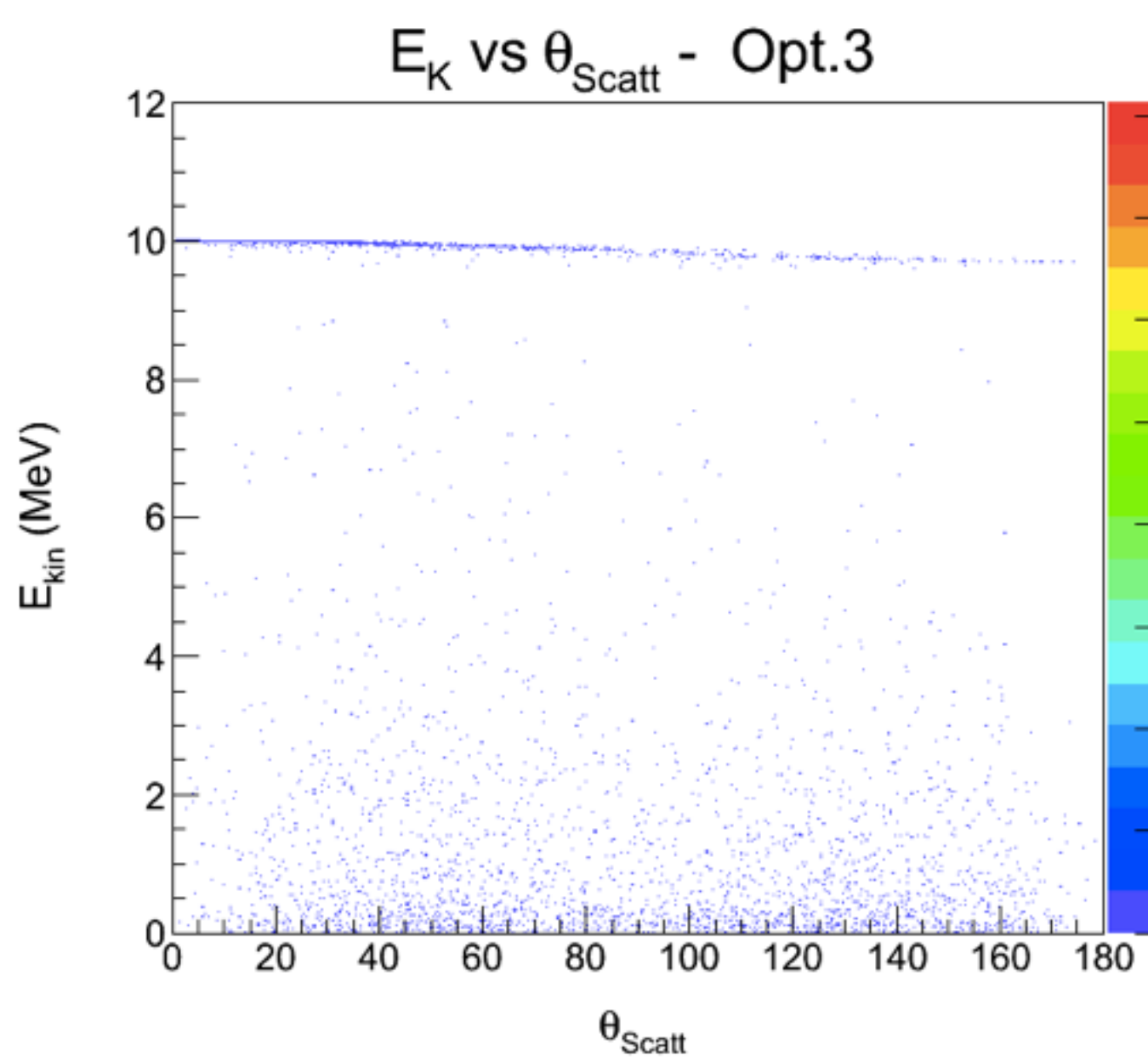
- Charged Particle full absorption check  
- veto scintillator?
- Background, Efficiency study for scattering neutrons in CsI - Paper? Experiment?

# Effect of Si-CsI Detector

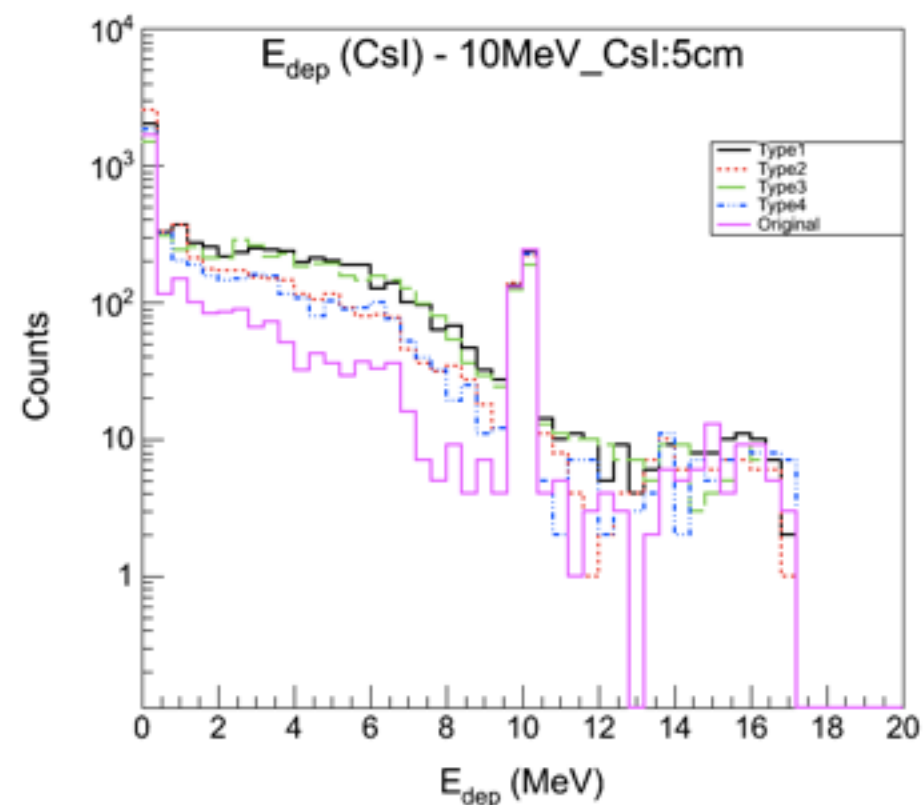
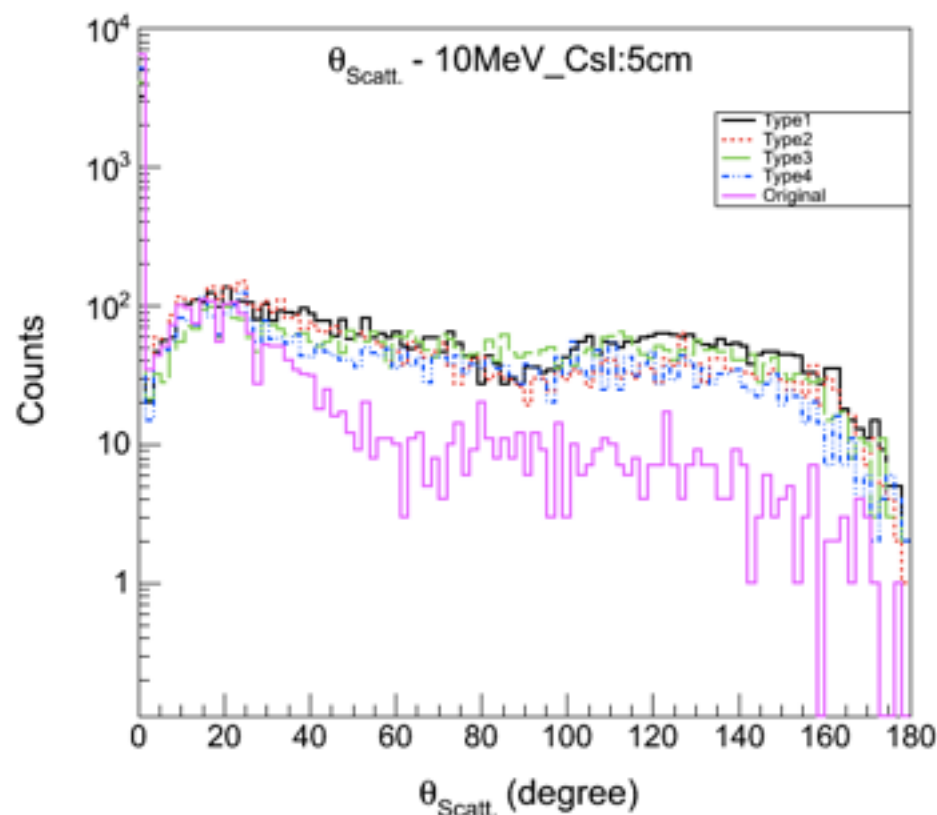




# Effect of Si-Csl Detector



# Neutron Scattering Angle in CsI (10MeV, 10000events, 5cm)



$N_{\theta < 10^\circ}$  : # of neutron  $\theta < 10^\circ$   
 $N_{\text{CsIHit}}$  : # of  $E_{\text{dep}}$  neutrons in CsI  
 $N_{E_{\text{dep}} > 1\text{MeV}}$  : # of  $E_{\text{dep}} > 1\text{MeV}$  in CsI

**Type3**  
 $N_{\theta < 10^\circ} = 4231$  (42.31%)  
 $N_{\text{CsIHit}} = 5748$  (57.48%)  
 $N_{E_{\text{dep}} > 1\text{MeV}} = 3833$  (38.33%)

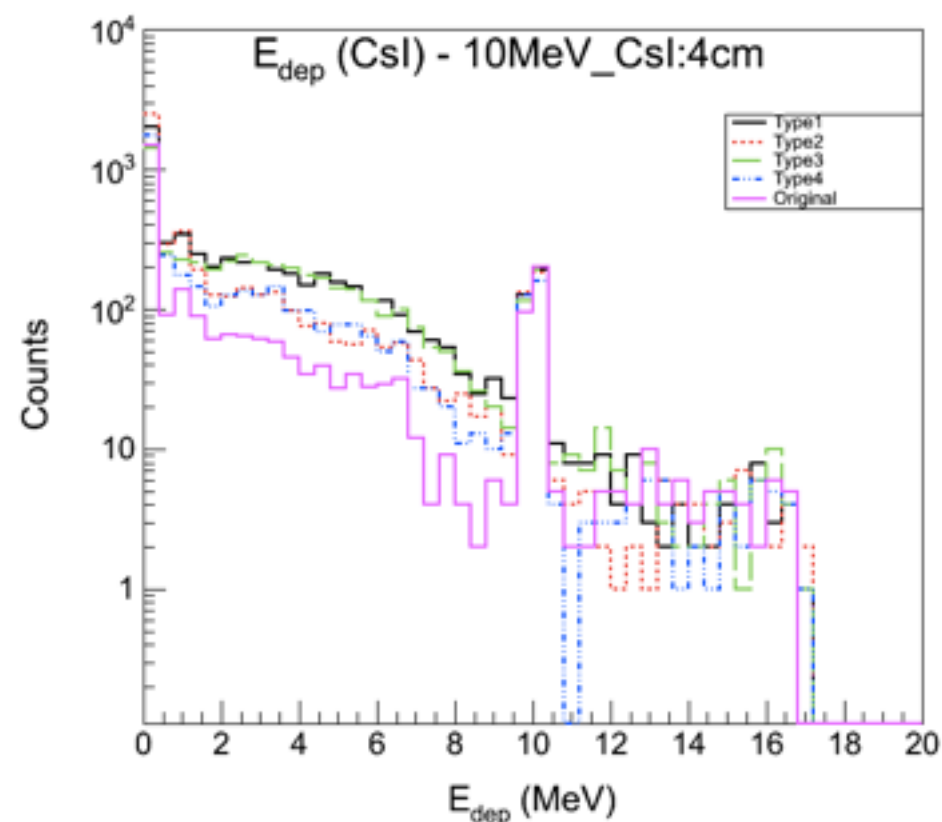
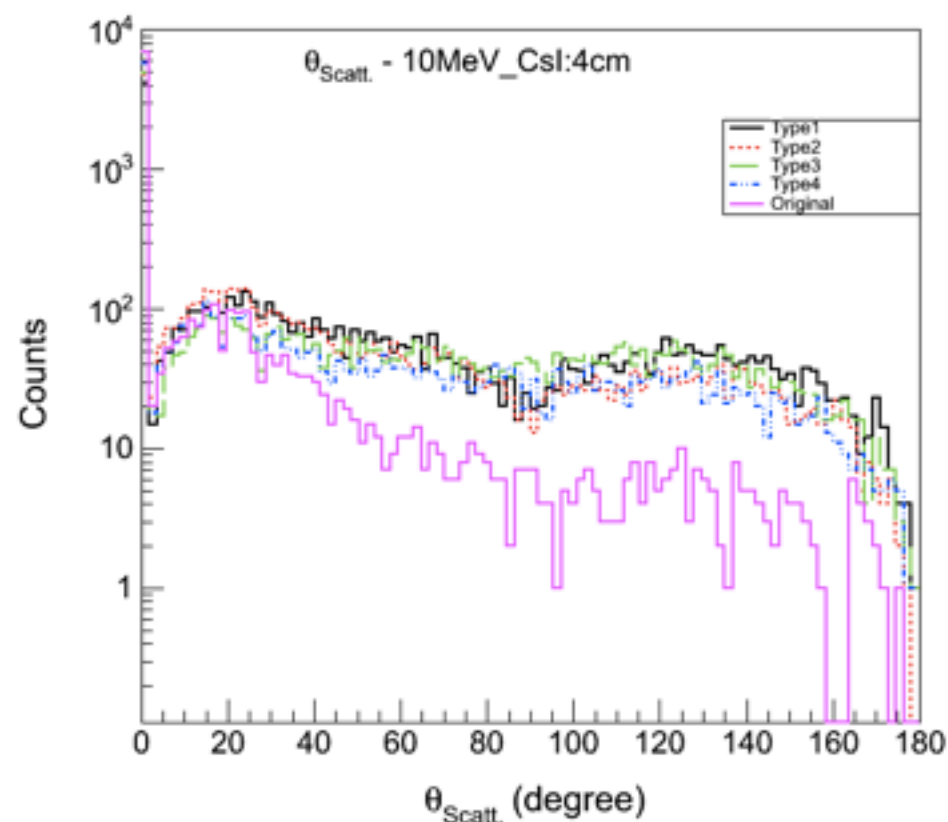
**Type1**  
 $N_{\theta < 10^\circ} = 3454$  (34.34%)  
 $N_{\text{CsIHit}} = 6620$  (66.20%)  
 $N_{E_{\text{dep}} > 1\text{MeV}} = 4077$  (40.77%)

**Type4**  
 $N_{\theta < 10^\circ} = 5262$  (52.62%)  
 $N_{\text{CsIHit}} = 4714$  (47.14%)  
 $N_{E_{\text{dep}} > 1\text{MeV}} = 2456$  (24.56%)

**Type2**  
 $N_{\theta < 10^\circ} = 4368$  (43.68%)  
 $N_{\text{CsIHit}} = 5752$  (57.52%)  
 $N_{E_{\text{dep}} > 1\text{MeV}} = 2681$  (26.81%)

**Original**  
 $N_{\theta < 10^\circ} = 6732$  (67.32%)  
 $N_{\text{CsIHit}} = 3245$  (32.45%)  
 $N_{E_{\text{dep}} > 1\text{MeV}} = 1371$  (13.71%)

# Neutron Scattering Angle in CsI (10MeV, 10000events, 4cm)



$N_{\theta < 10^\circ}$  : # of neutron  $\theta < 10^\circ$   
 $N_{CsIHit}$  : # of  $E_{dep}$  neutrons in CsI  
 $N_{Edep > 1MeV}$  : # of  $E_{dep} > 1MeV$  in CsI

**Type3**  
 $N_{\theta < 10^\circ} = 5000$  (50.00%)  
 $N_{CsIHit} = 4985$  (49.85%)  
 $N_{Edep > 1MeV} = 3205$  (32.05%)

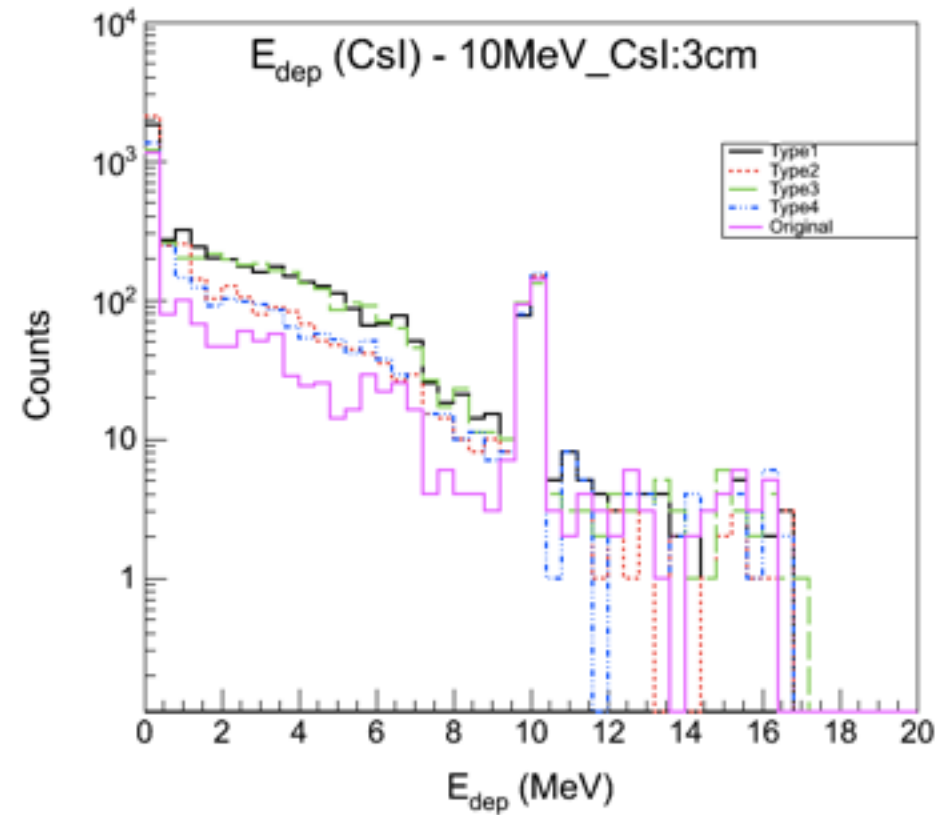
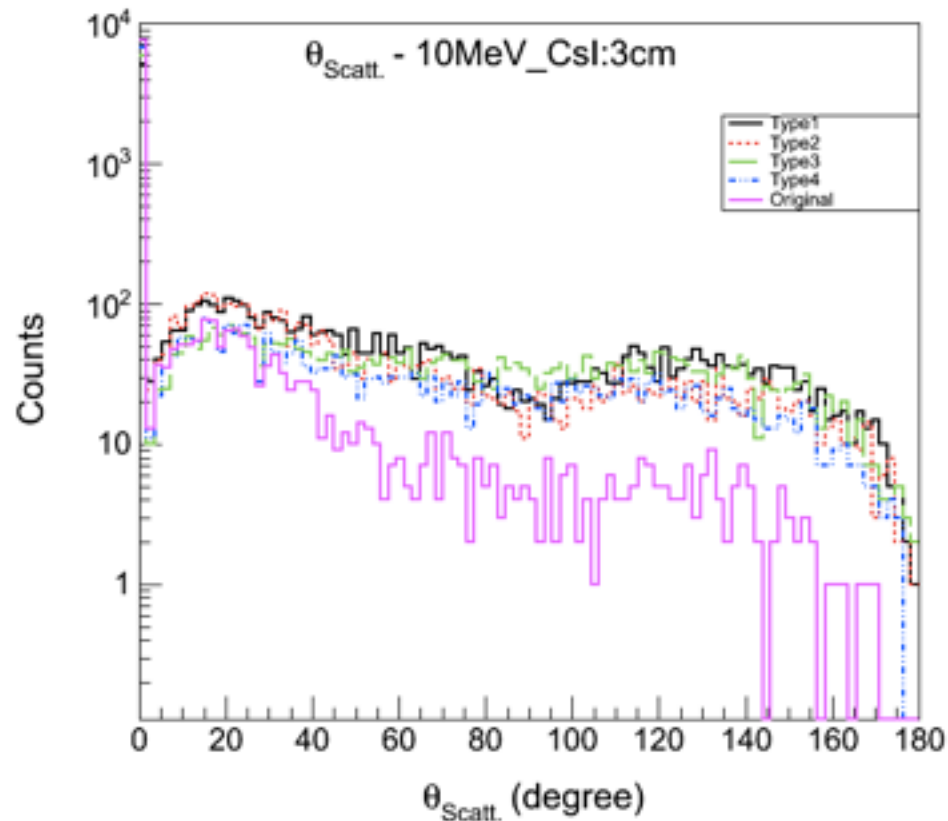
**Type1**  
 $N_{\theta < 10^\circ} = 4317$  (43.17%)  
 $N_{CsIHit} = 5769$  (57.69%)  
 $N_{Edep > 1MeV} = 3303$  (33.03%)

**Type4**  
 $N_{\theta < 10^\circ} = 5994$  (59.94%)  
 $N_{CsIHit} = 3991$  (39.91%)  
 $N_{Edep > 1MeV} = 1921$  (19.21%)

**Type2**  
 $N_{\theta < 10^\circ} = 5067$  (50.67%)  
 $N_{CsIHit} = 5035$  (50.35%)  
 $N_{Edep > 1MeV} = 2081$  (20.81%)

**Original**  
 $N_{\theta < 10^\circ} = 7157$  (71.57%)  
 $N_{CsIHit} = 2794$  (27.94%)  
 $N_{Edep > 1MeV} = 1160$  (11.60%)

# Neutron Scattering Angle in CsI (10MeV, 10000events, 3cm)



$N_{\theta < 10^\circ}$  : # of neutron  $\theta < 10^\circ$   
 $N_{\text{CsIHit}}$  : # of  $E_{\text{dep}}$  neutrons in CsI  
 $N_{E_{\text{dep}} > 1\text{MeV}}$  : # of  $E_{\text{dep}} > 1\text{MeV}$  in CsI

**Type3**  
 $N_{\theta < 10^\circ} = 5973$  (59.73%)  
 $N_{\text{CsIHit}} = 3996$  (39.96%)  
 $N_{E_{\text{dep}} > 1\text{MeV}} = 2452$  (24.52%)

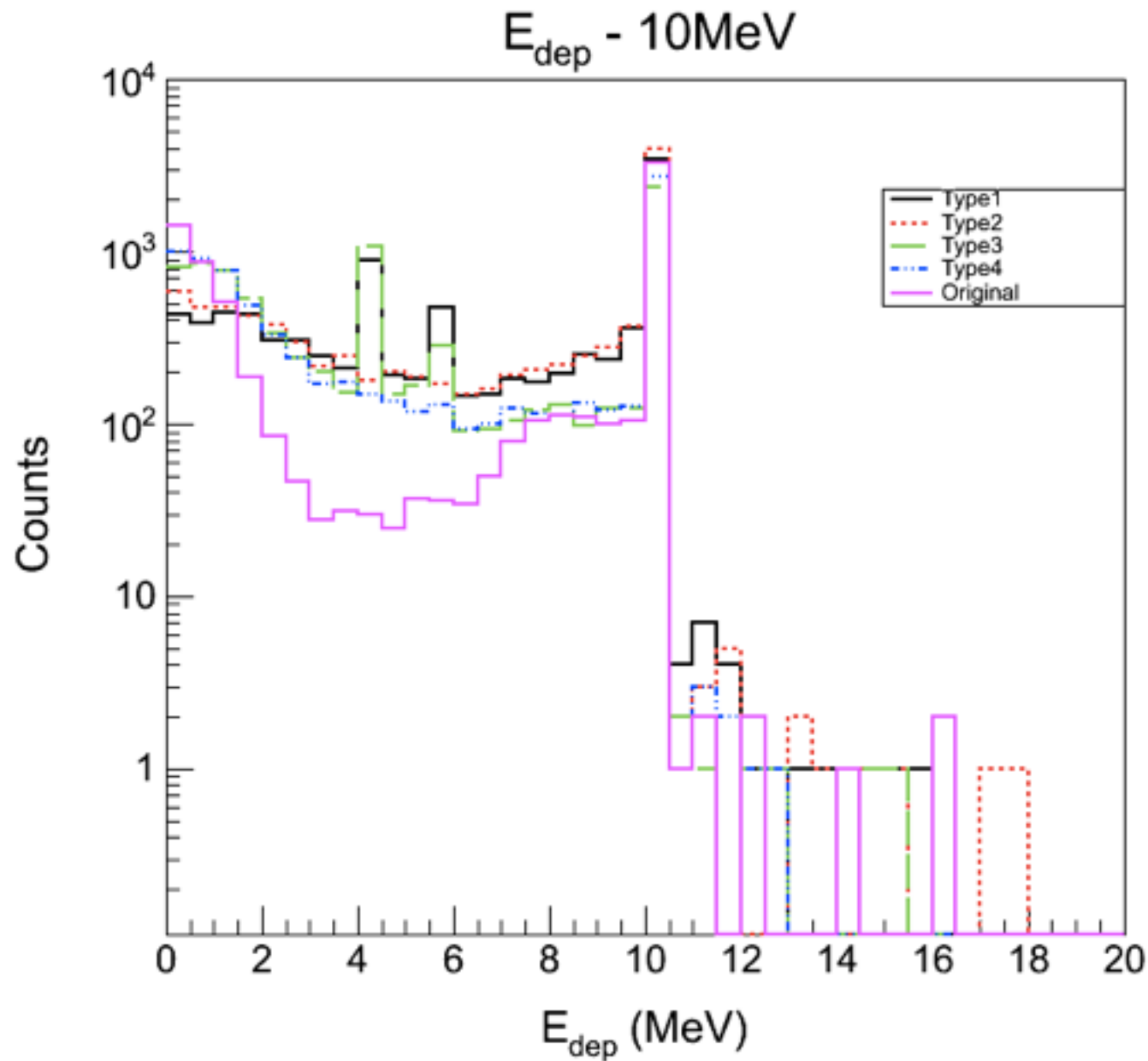
**Type1**  
 $N_{\theta < 10^\circ} = 5285$  (52.85%)  
 $N_{\text{CsIHit}} = 4766$  (47.66%)  
 $N_{E_{\text{dep}} > 1\text{MeV}} = 2521$  (25.21%)

**Type4**  
 $N_{\theta < 10^\circ} = 6867$  (68.67%)  
 $N_{\text{CsIHit}} = 3065$  (30.65%)  
 $N_{E_{\text{dep}} > 1\text{MeV}} = 1400$  (14.00%)

**Type2**  
 $N_{\theta < 10^\circ} = 6089$  (60.89%)  
 $N_{\text{CsIHit}} = 3992$  (39.92%)  
 $N_{E_{\text{dep}} > 1\text{MeV}} = 1507$  (15.07%)

**Original**  
 $N_{\theta < 10^\circ} = 7786$  (77.86%)  
 $N_{\text{CsIHit}} = 2142$  (21.42%)  
 $N_{E_{\text{dep}} > 1\text{MeV}} = 883$  (8.83%)

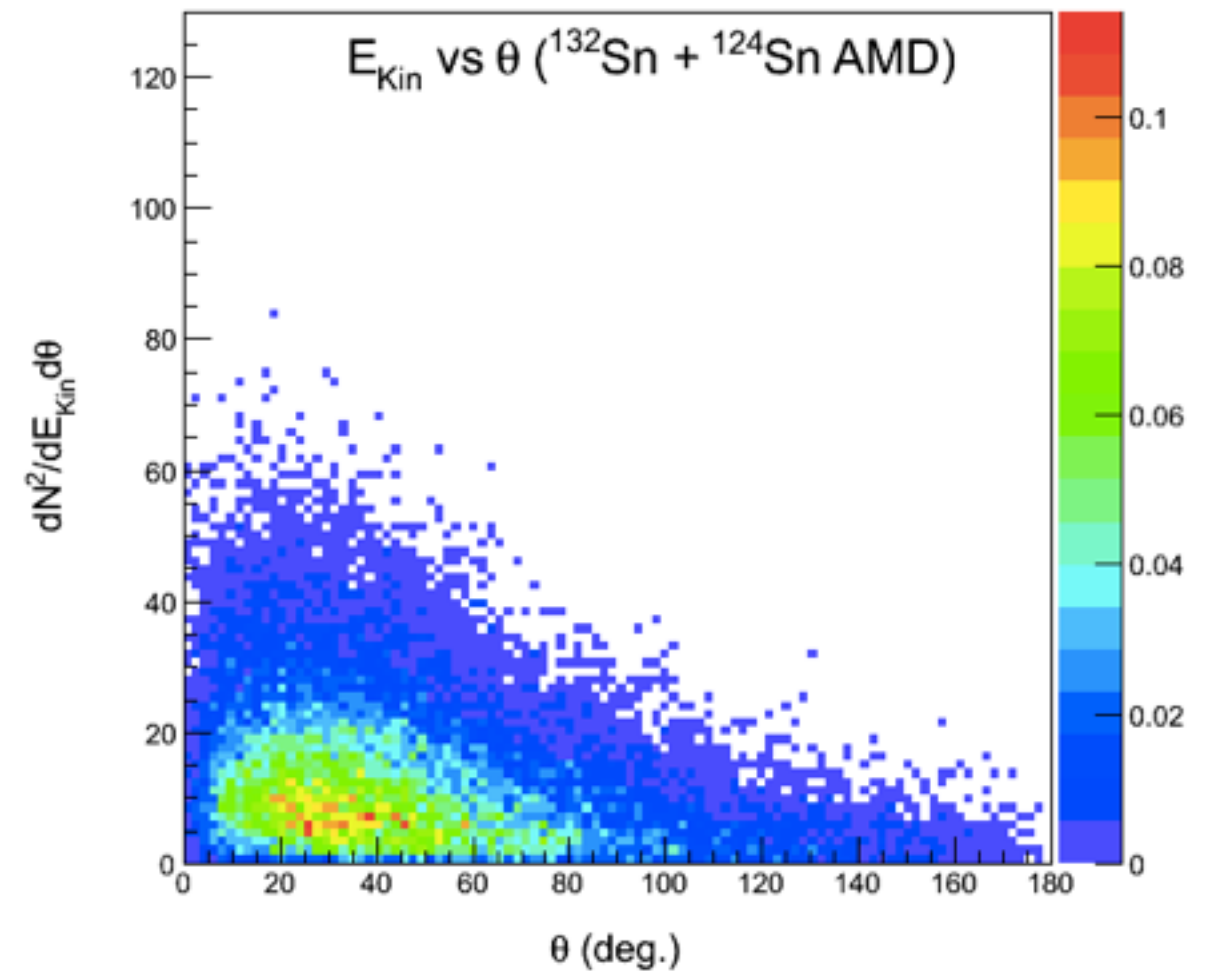
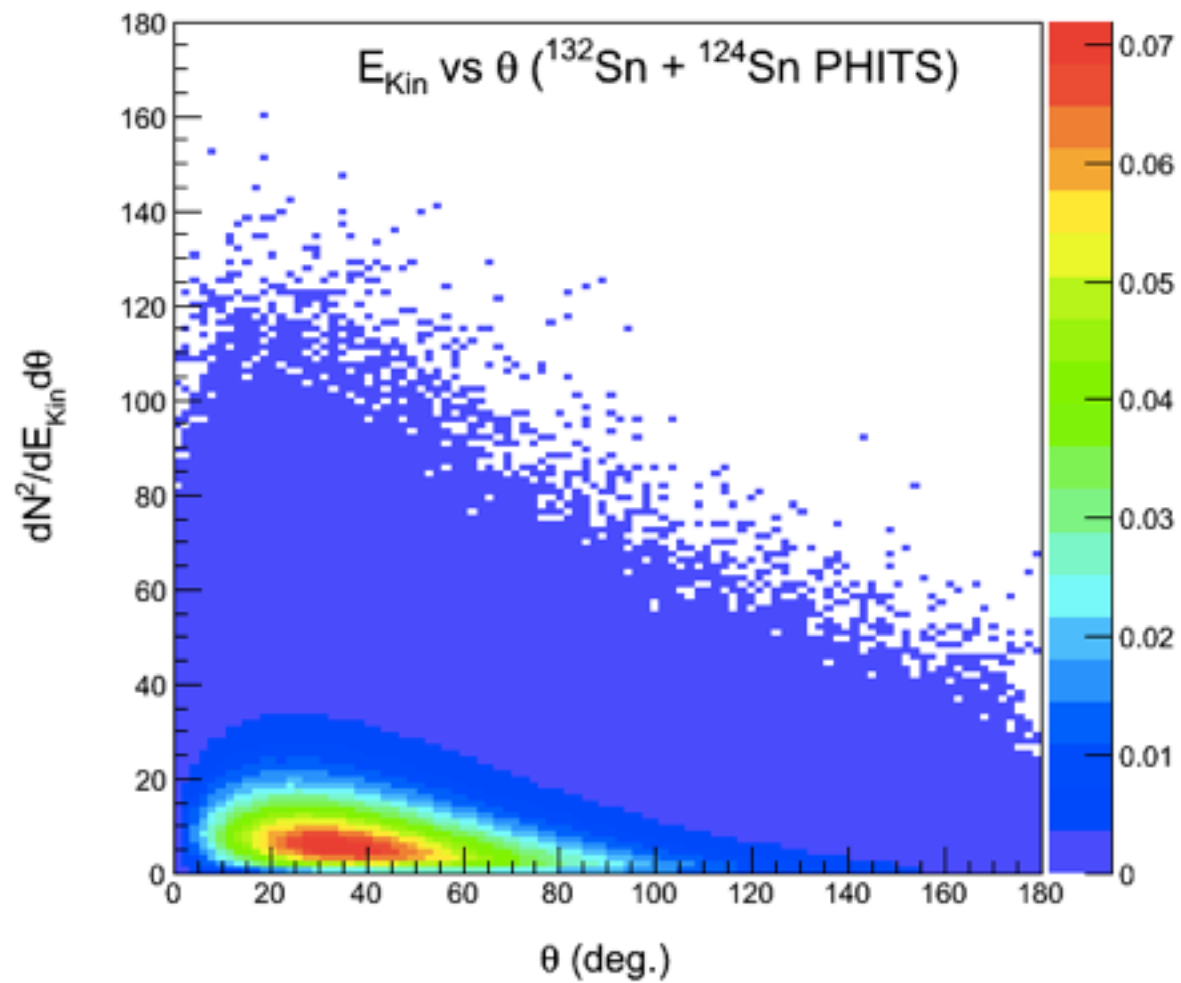
# Neutron Scattering Angle in Scint (10MeV, 10000events)



$N_{\text{ScintHit}}$  : # of  $E_{\text{dep}}$  neutrons in Scint  
 $N_{\text{Full}}$  : # of  $E_{\text{dep}} > 10\text{MeV}$  (Full absorption)

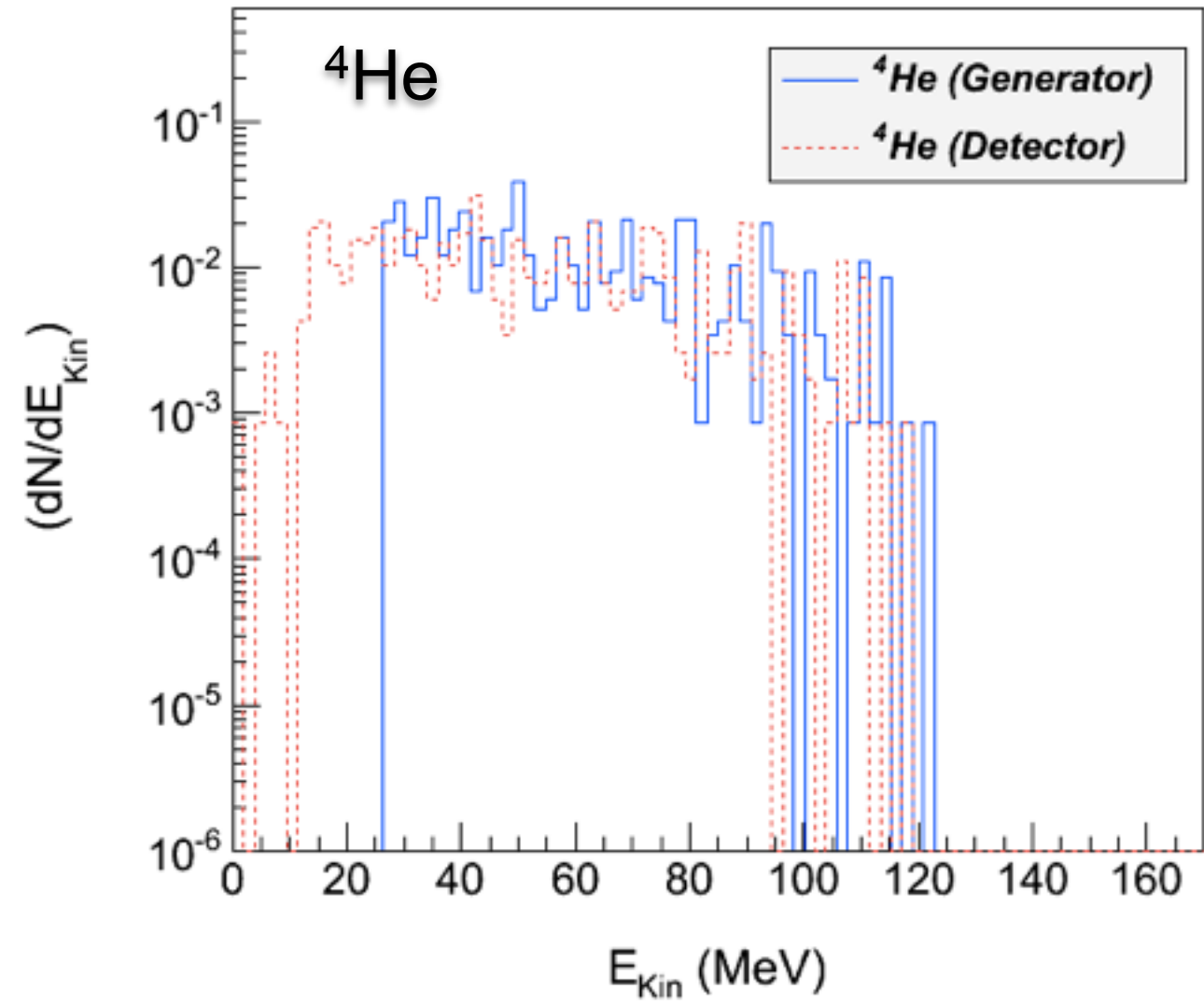
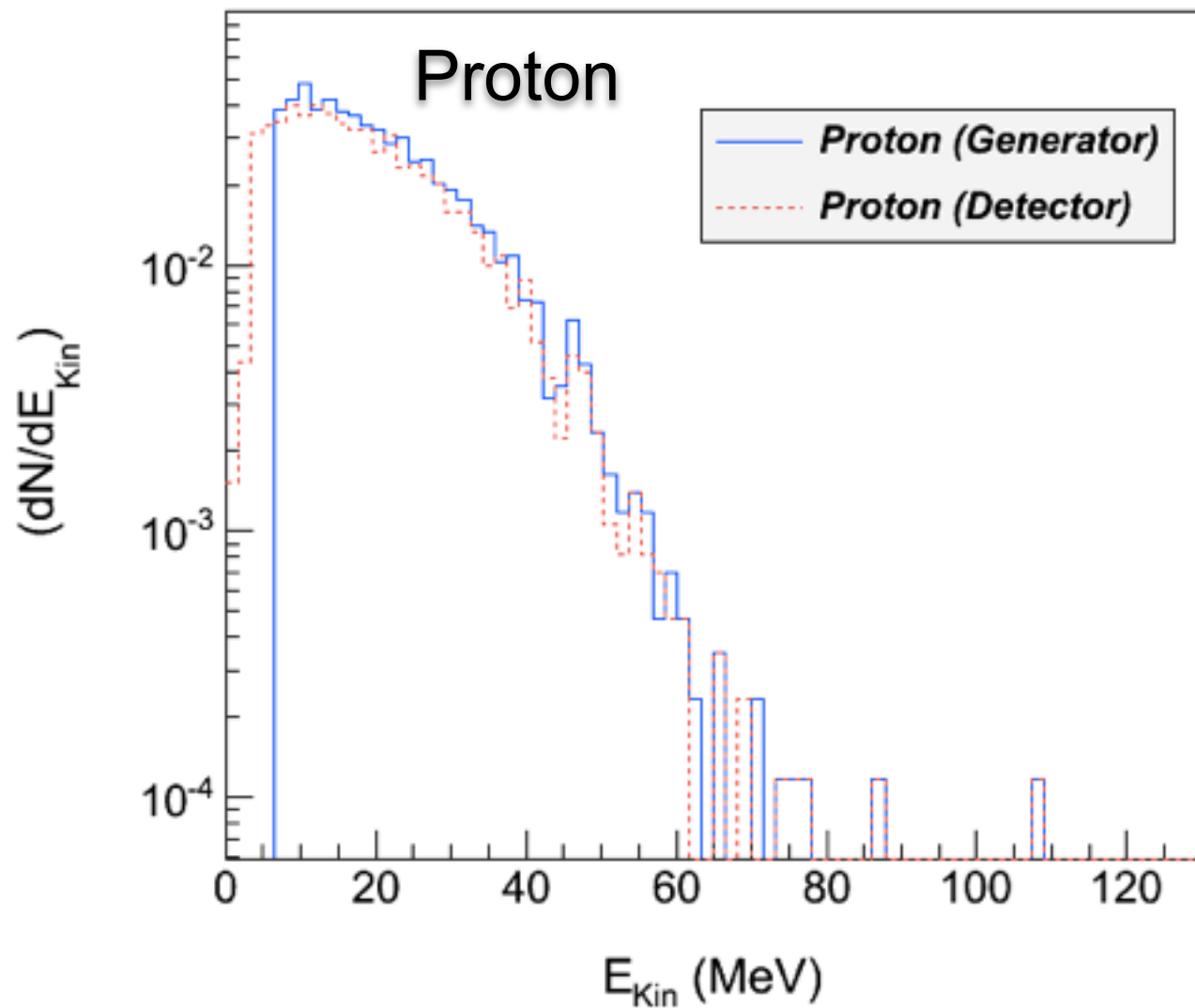
Type1 $N_{\text{ScintHit}} = 9701$ (97.01%) $N_{\text{Full}} = 3851$ (38.51%)	Type2 $N_{\text{ScintHit}} = 9588$ (95.88%) $N_{\text{Full}} = 4302$ (43.02%)
Type3 $N_{\text{ScintHit}} = 8820$ (88.20%) $N_{\text{Full}} = 2478$ (24.78%)	Type4 $N_{\text{ScintHit}} = 8266$ (82.66%) $N_{\text{Full}} = 2873$ (28.73%)
Original $N_{\text{ScintHit}} = 7305$ (73.05%) $N_{\text{Full}} = 3414$ (34.14%)	

# AMD & PHITS Neutron



# Kinetic Energy Detector & AMD

## Generator Events

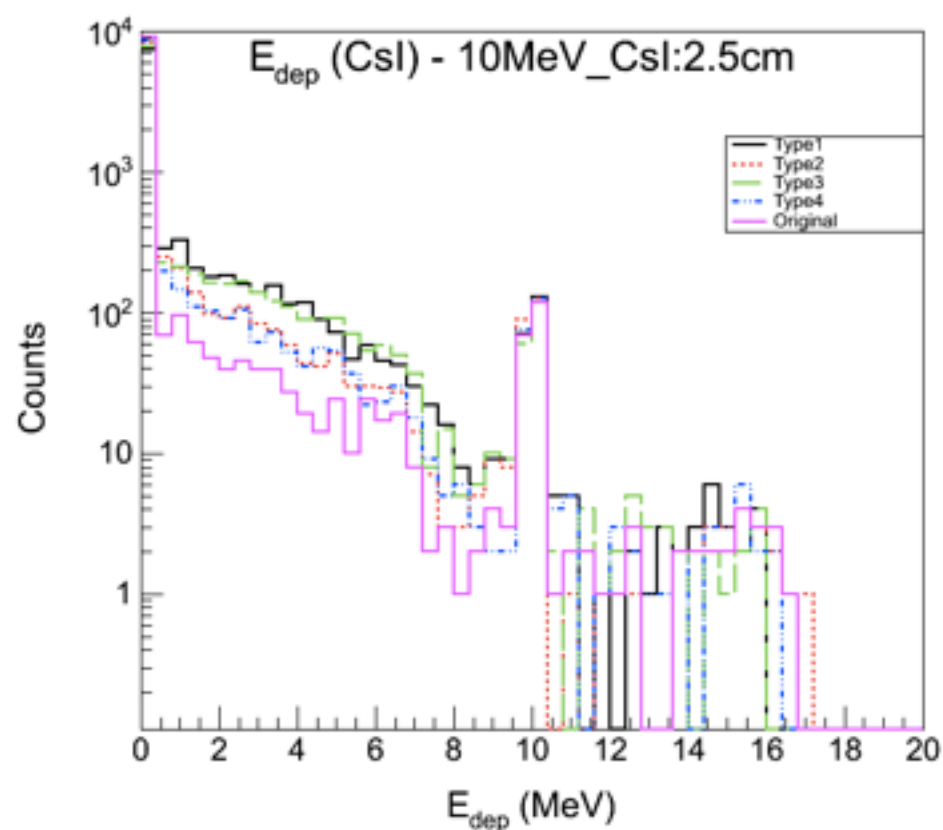
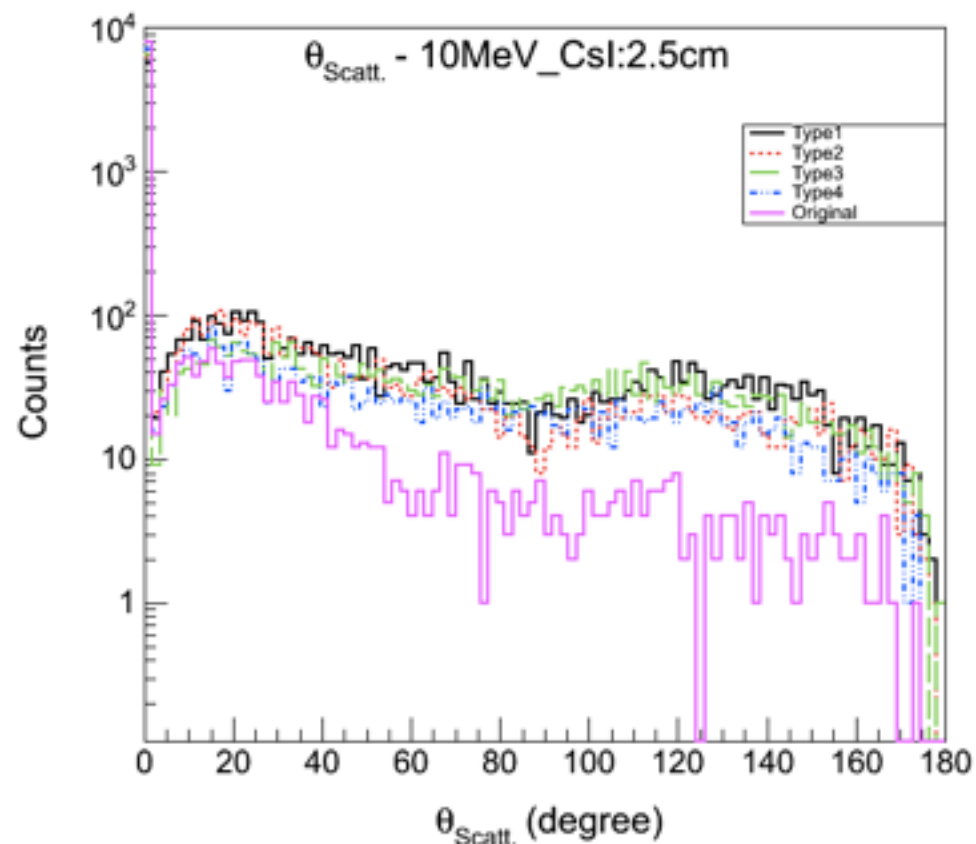




# $^{132}\text{Sn} + ^{124}\text{Sn}$ - AMD&PHITS

	AMD	PHITS
Number of Events	$N(\text{event}) = 2010$	$N(\text{event}) = 272018$
Number of particles (per event)	$\langle N \rangle = 62.047$	$\langle N \rangle = 52.040$
Number of Neutrons (per event)	$\langle \text{neutron} \rangle = 49.783$ (80.23%)	$\langle \text{neutron} \rangle = 33.138$ (63.68%)
Number of Charged Particles (per event)	$\langle \text{charged} \rangle = 12.265$ (19.77%)	$\langle \text{charged} \rangle = 15.986$ (30.72%)
Number of Protons (per event)	$\langle \text{proton} \rangle = 5.213$ (8.40%)	$\langle \text{proton} \rangle = 10.059$ (19.33%)
Number of Gammas	no gammas	$\langle \text{gammas} \rangle = 2.916$ (5.60%)

# Neutron Scattering Angle in CsI (10MeV, 10000events, 2.5cm)



$N_{\theta < 10^\circ}$  : # of neutron  $\theta < 10^\circ$   
 $N_{\text{CsIHit}}$  : # of  $E_{\text{dep}}$  neutrons in CsI  
 $N_{E_{\text{dep}} > 1\text{MeV}}$  : # of  $E_{\text{dep}} > 1\text{MeV}$  in CsI

**Type3**  
 $N_{\theta < 10^\circ} = 6517$  (65.17%)  
 $N_{\text{CsIHit}} = 3456$  (34.56%)  
 $N_{E_{\text{dep}} > 1\text{MeV}} = 1956$  (19.56%)

**Type1**  
 $N_{\theta < 10^\circ} = 5824$  (58.24%)  
 $N_{\text{CsIHit}} = 4265$  (42.65%)  
 $N_{E_{\text{dep}} > 1\text{MeV}} = 2092$  (20.92%)

**Type4**  
 $N_{\theta < 10^\circ} = 7221$  (72.21%)  
 $N_{\text{CsIHit}} = 2754$  (27.54%)  
 $N_{E_{\text{dep}} > 1\text{MeV}} = 1212$  (12.12%)

**Type2**  
 $N_{\theta < 10^\circ} = 6562$  (65.62%)  
 $N_{\text{CsIHit}} = 3493$  (34.93%)  
 $N_{E_{\text{dep}} > 1\text{MeV}} = 1278$  (12.78%)

**Original**  
 $N_{\theta < 10^\circ} = 8148$  (81.48%)  
 $N_{\text{CsIHit}} = 1805$  (18.05%)  
 $N_{E_{\text{dep}} > 1\text{MeV}} = 713$  (7.13%)

 : PHITS, Photons

$\langle N_{\text{photon}} \rangle = N_{\text{Det}} \times R$  (for CsI Detector)

$S$  : Area of one detector ( $X = \sqrt{S}$ ),  $r = 40\text{cm}$  (Distance from target),

$N(\Delta\theta)$  : Number of particles per event,  $N_{\text{Det}}$  : Number of detectors.

Bin	$N(\Delta\theta)$	$N_{\text{Det}}$	$S(\text{cm}^2)$	$X(\text{cm})$	$R$
1 : (17.5°< $\theta$ <32.5°)	0.19	8	81.0	9.0	0.024
2 : (32.5°< $\theta$ <47.5°)	0.28	12	81.0	9.0	0.023
3 : (47.5°< $\theta$ <62.5°)	0.34	18	81.0	9.0	0.019
4 : (62.5°< $\theta$ <77.5°)	0.38	20	81.0	9.0	0.019
5 : (77.5°< $\theta$ <102°)	0.61	15	225.0	15.0	0.041
6 : (102°< $\theta$ <126°)	0.51	12	225.0	15.0	0.043
7 : (126°< $\theta$ <150°)	0.35	8	225.0	15.0	0.044
Sum	2.66	93			

 : PHITS  : AMD, Charged Particles

$\langle N_{\text{charged}} \rangle = N_{\text{Det}} \times R$  (for Si Detector)

$S$  : Area of one detector ( $X = \sqrt{S}$ ),  $r = 40\text{cm}$  (Distance from target),

$N(\Delta\theta)$  : Number of particles per event,  $N_{\text{Det}}$  : Number of detectors.

Bin	$N(\Delta\theta)$	$N_{\text{Det}}$	$S(\text{cm}^2)$	$X(\text{cm})$	$R$	$N(\Delta\theta)$	$N_{\text{Det}}$	$S(\text{cm}^2)$	$X(\text{cm})$	$R$
1 : (17.5°< $\theta$ <22.5°)	0.99	24	9.0	3.0	0.041	0.99	24	9.0	3.0	0.041
2 : (22.5°< $\theta$ <27.5°)	1.05	24	9.0	3.0	0.044	0.87	24	9.0	3.0	0.036
3 : (27.5°< $\theta$ <32.5°)	1.02	24	9.0	3.0	0.043	0.81	24	9.0	3.0	0.033
4 : (32.5°< $\theta$ <37.5°)	1.00	36	9.0	3.0	0.028	0.68	36	9.0	3.0	0.019
5 : (37.5°< $\theta$ <42.5°)	1.00	36	9.0	3.0	0.028	0.68	36	9.0	3.0	0.019
6 : (42.5°< $\theta$ <47.5°)	1.00	36	9.0	3.0	0.028	0.63	36	9.0	3.0	0.018
7 : (47.5°< $\theta$ <52.5°)	0.97	54	9.0	3.0	0.018	0.62	54	9.0	3.0	0.011
8 : (52.5°< $\theta$ <57.5°)	0.92	54	9.0	3.0	0.017	0.59	54	9.0	3.0	0.011
9 : (57.5°< $\theta$ <62.5°)	0.84	54	9.0	3.0	0.016	0.49	54	9.0	3.0	0.010
10 : (62.5°< $\theta$ <67.5°)	0.76	60	9.0	3.0	0.013	0.42	60	9.0	3.0	0.008
11 : (67.5°< $\theta$ <72.5°)	0.68	60	9.0	3.0	0.011	0.39	60	9.0	3.0	0.007
12 : (72.5°< $\theta$ <77.5°)	0.58	60	9.0	3.0	0.010	0.36	60	9.0	3.0	0.006
13 : (77.5°< $\theta$ <86°)	0.82	45	25.0	5.0	0.018	0.45	45	225.0	15.0	0.010
14 : (86°< $\theta$ <94°)	0.60	45	25.0	5.0	0.014	0.38	45	225.0	15.0	0.008
15 : (94°< $\theta$ <102°)	0.46	45	25.0	5.0	0.010	0.27	45	225.0	15.0	0.006
16 : (102°< $\theta$ <110°)	0.36	36	25.0	5.0	0.010	0.21	36	225.0	15.0	0.006
17 : (110°< $\theta$ <118°)	0.28	36	25.0	5.0	0.008	0.18	36	225.0	15.0	0.005
18 : (118°< $\theta$ <126°)	0.22	36	25.0	5.0	0.006	0.16	36	225.0	15.0	0.004
19 : (126°< $\theta$ <134°)	0.17	24	25.0	5.0	0.007	0.11	24	225.0	15.0	0.005
20 : (134°< $\theta$ <142°)	0.13	24	25.0	5.0	0.005	0.08	24	225.0	15.0	0.003
21 : (142°< $\theta$ <150°)	0.10	24	25.0	5.0	0.004	0.06	24	225.0	15.0	0.003
Sum	13.95	837				9.43	837			

: PHITS  : AMD, Neutron

$\langle N_{\text{neutron}} \rangle = N_{\text{Det}} \times R$  (for Neutron Detector)

$S$  : Area of one detector ( $X = \sqrt{S}$ ),  $r = 300\text{cm}$  (Distance from target),

$N(\Delta\theta)$  : Number of particles per event,  $N_{\text{Det}}$  : Number of detectors.

Bin	$N(\Delta\theta)$	$N_{\text{Det}}$	$S(\text{cm}^2)$	$X(\text{cm})$	$R$	$N(\Delta\theta)$	$N_{\text{Det}}$	$S(\text{cm}^2)$	$X(\text{cm})$	$R$
1 : ( $0^\circ < \theta < 5^\circ$ )	0.37	14	100.0	10.0	0.026	0.66	14	100.0	10.0	0.047
2 : ( $5^\circ < \theta < 10^\circ$ )	1.09	36	100.0	10.0	0.030	2.13	36	100.0	10.0	0.059
3 : ( $10^\circ < \theta < 15^\circ$ )	1.74	64	100.0	10.0	0.027	3.01	64	100.0	10.0	0.047
4 : ( $15^\circ < \theta < 20^\circ$ )	2.25	96	100.0	10.0	0.023	3.66	96	100.0	10.0	0.038
5 : ( $20^\circ < \theta < 25^\circ$ )	2.59	128	100.0	10.0	0.020	4.18	128	100.0	10.0	0.033
6 : ( $25^\circ < \theta < 30^\circ$ )	2.76	158	100.0	10.0	0.017	4.28	158	100.0	10.0	0.027
7 : ( $30^\circ < \theta < 35^\circ$ )	2.78	188	100.0	10.0	0.015	4.07	188	100.0	10.0	0.022
8 : ( $35^\circ < \theta < 40^\circ$ )	2.66	216	100.0	10.0	0.012	3.85	216	100.0	10.0	0.018
9 : ( $40^\circ < \theta < 45^\circ$ )	2.46	242	100.0	10.0	0.010	3.47	242	100.0	10.0	0.014
10 : ( $45^\circ < \theta < 50^\circ$ )	2.21	266	100.0	10.0	0.008	3.24	266	100.0	10.0	0.012
11 : ( $50^\circ < \theta < 55^\circ$ )	1.93	288	100.0	10.0	0.007	2.63	288	100.0	10.0	0.009
12 : ( $55^\circ < \theta < 60^\circ$ )	1.67	308	100.0	10.0	0.005	2.20	308	100.0	10.0	0.007
13 : ( $60^\circ < \theta < 77^\circ$ )	3.97	1141	100.0	10.0	0.003	5.57	1141	100.0	10.0	0.005
14 : ( $77^\circ < \theta < 94^\circ$ )	2.16	1281	100.0	10.0	0.001	3.11	1281	100.0	10.0	0.002
15 : ( $94^\circ < \theta < 111^\circ$ )	1.18	1225	100.0	10.0	0.001	1.77	1225	100.0	10.0	0.001
16 : ( $111^\circ < \theta < 128^\circ$ )	0.66	1036	100.0	10.0	0.0006	0.96	1036	100.0	10.0	0.0009
17 : ( $128^\circ < \theta < 145^\circ$ )	0.37	756	100.0	10.0	0.0005	0.58	756	100.0	10.0	0.0007
Sum	32.85	7443				49.37	7443			