Status Report

Jae Beom Park

- COSMUS
  - Intrinsic Time Resolution Measurement
- J-PARC E42 FAC
  - Data analysis with Minho, Shinhyung, Wooseung, Junlee, Dr. Jong-won Lee, Dr. Sanghoon Hwang (J-PARC), Dr. Sun-young Ryu (Osaka Univ.)
- LAMPS
  - Charged Particle Mass Fitting
  - Neutron Detector

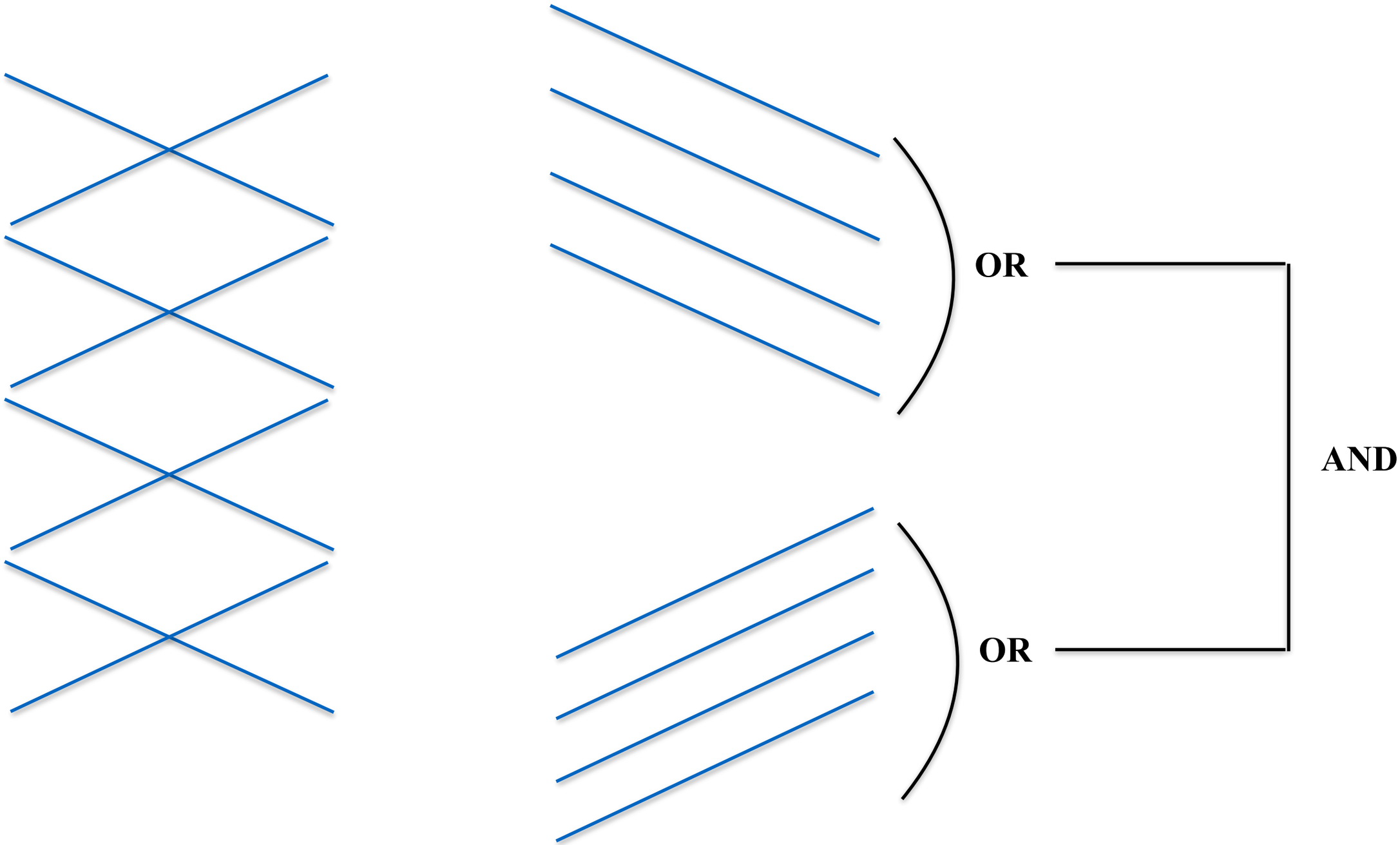
COSMUS

Intrinsic Resolution

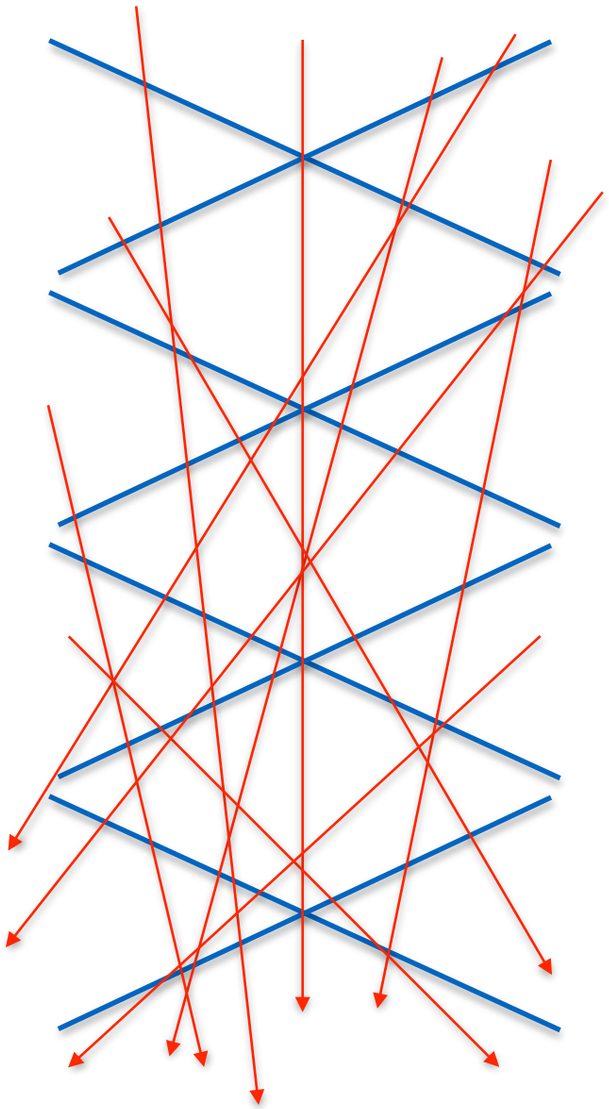
- Choose 3 Scintillators

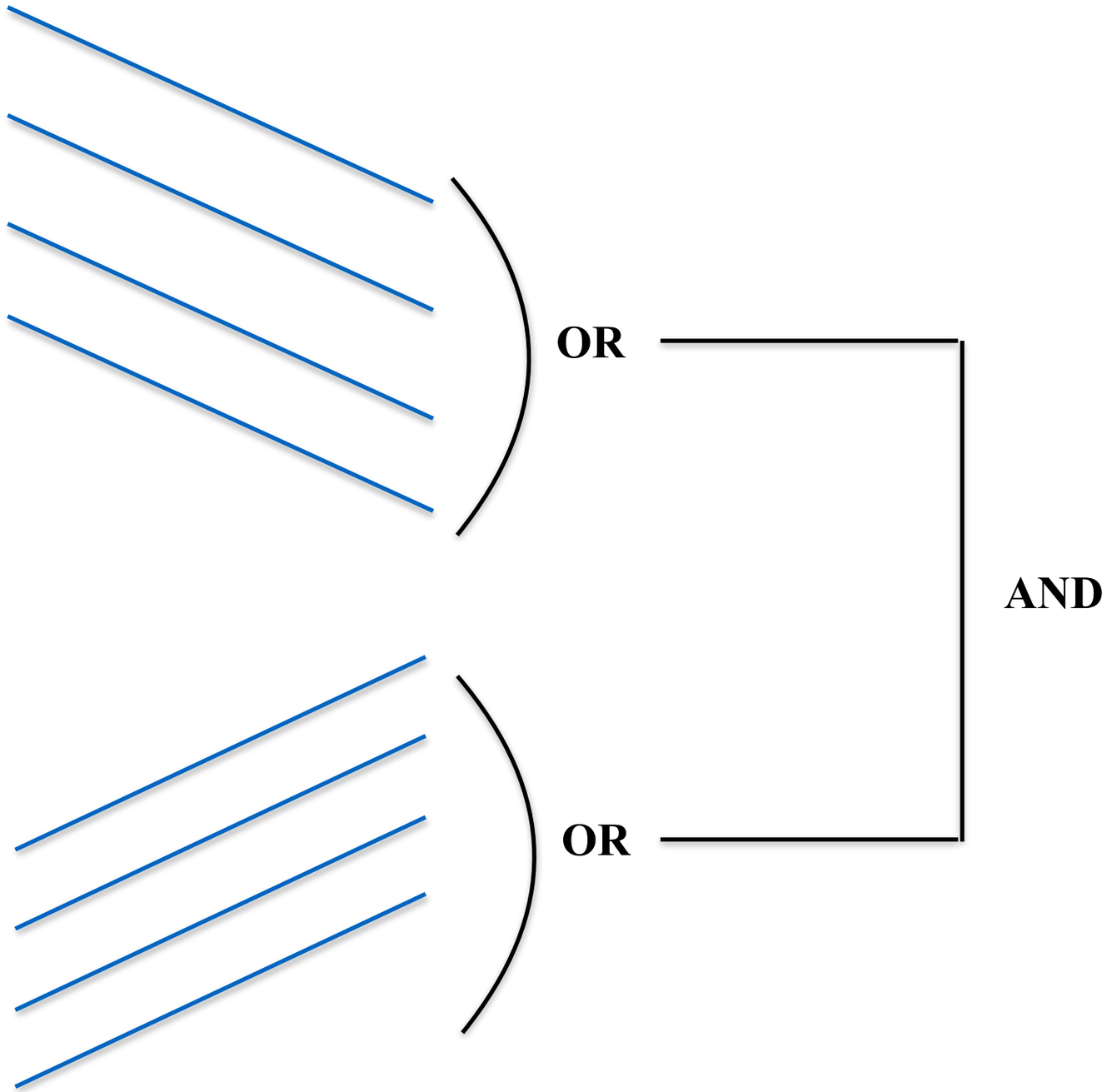
- $\sigma_{12} = \mathrm{sqrt}(\sigma_1^2 + \sigma_2^2)$
- $\sigma_{23} = \mathrm{sqrt}(\sigma_2^2 + \sigma_3^2)$
- $\sigma_{13} = \mathrm{sqrt}(\sigma_1^2 + \sigma_3^2)$

COSMUS Trigger Setup

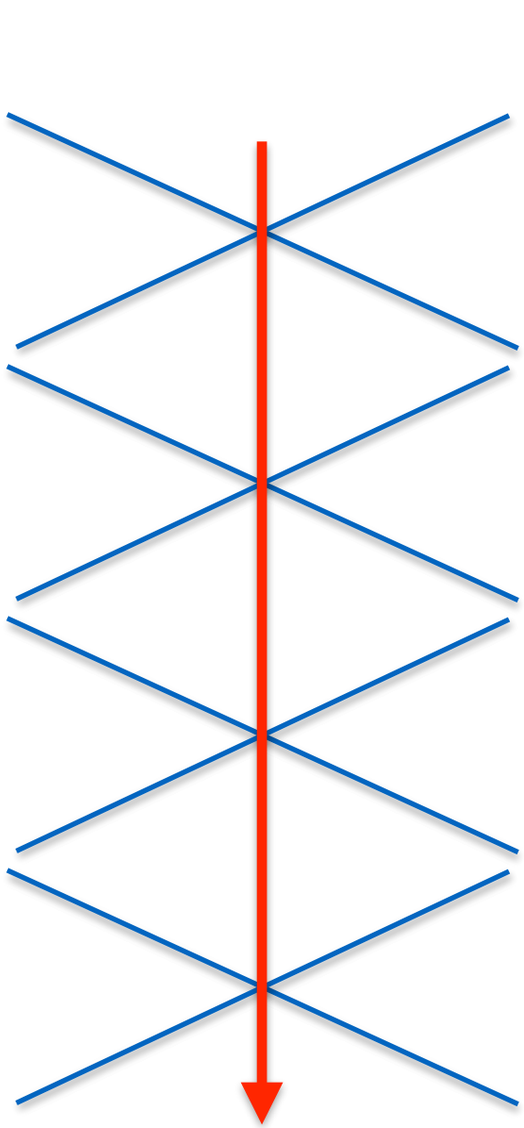


COSMUS Trigger Setup

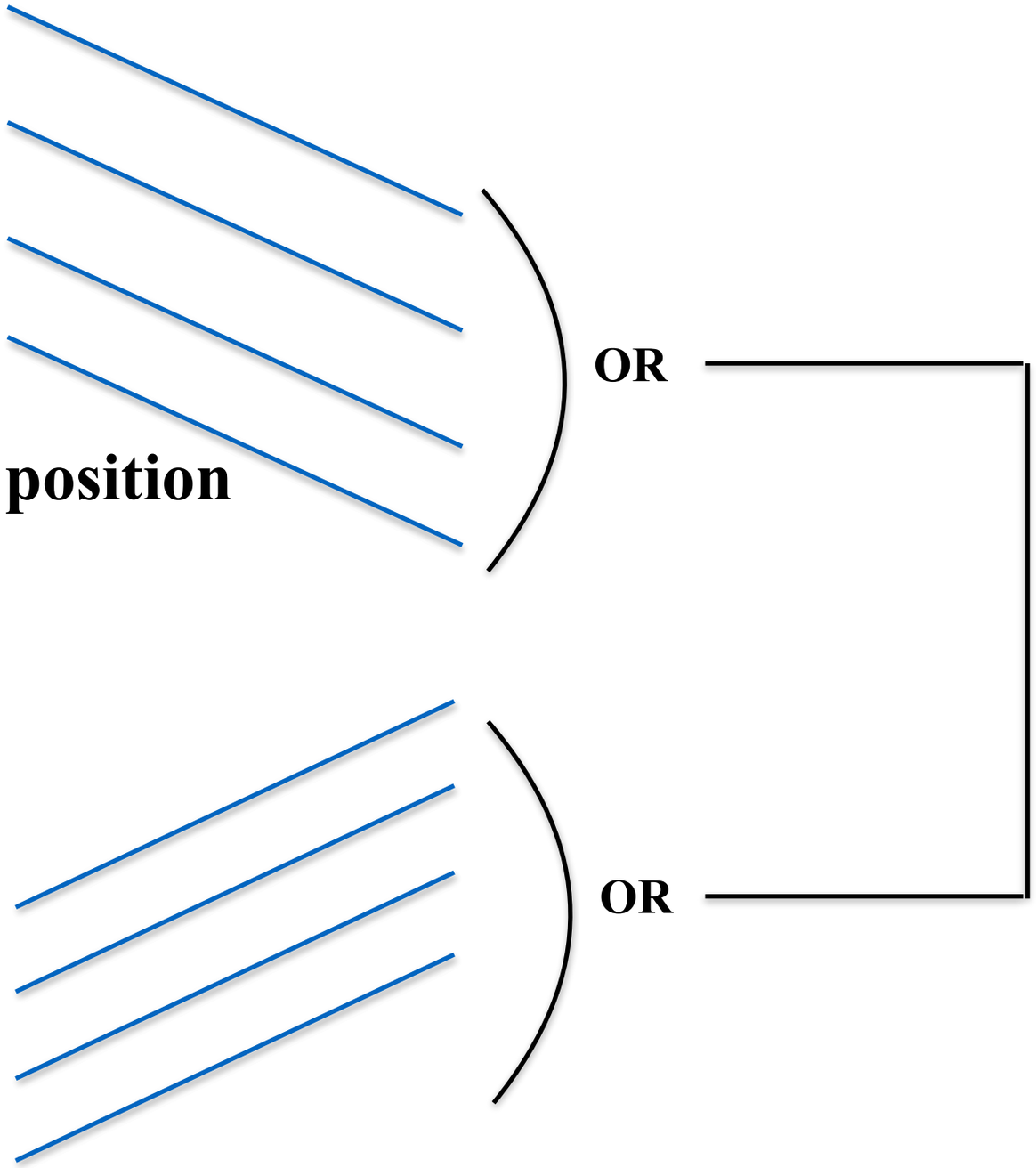




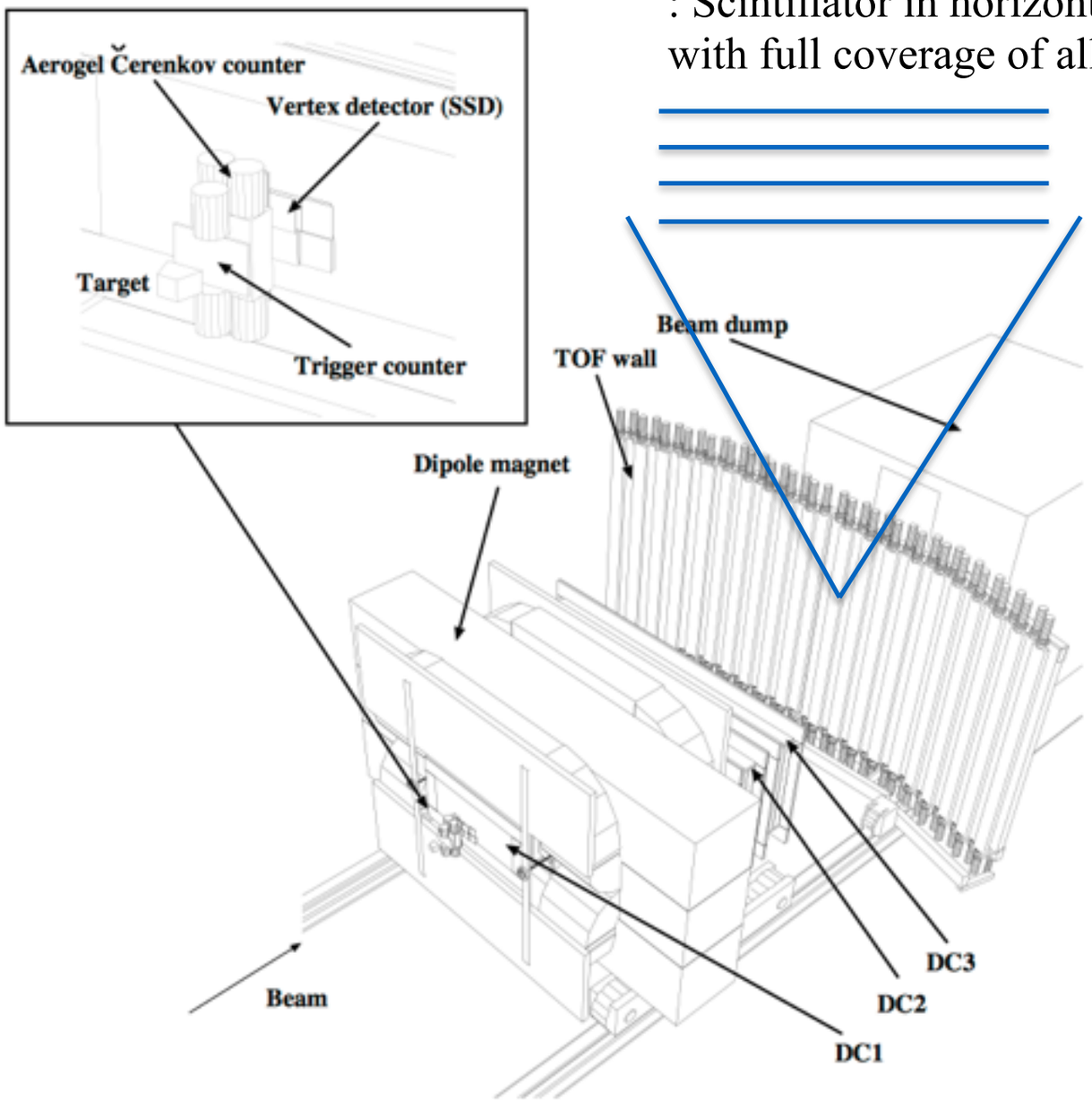
COSMUS Event Selection



Choose fixed position cosmic muon



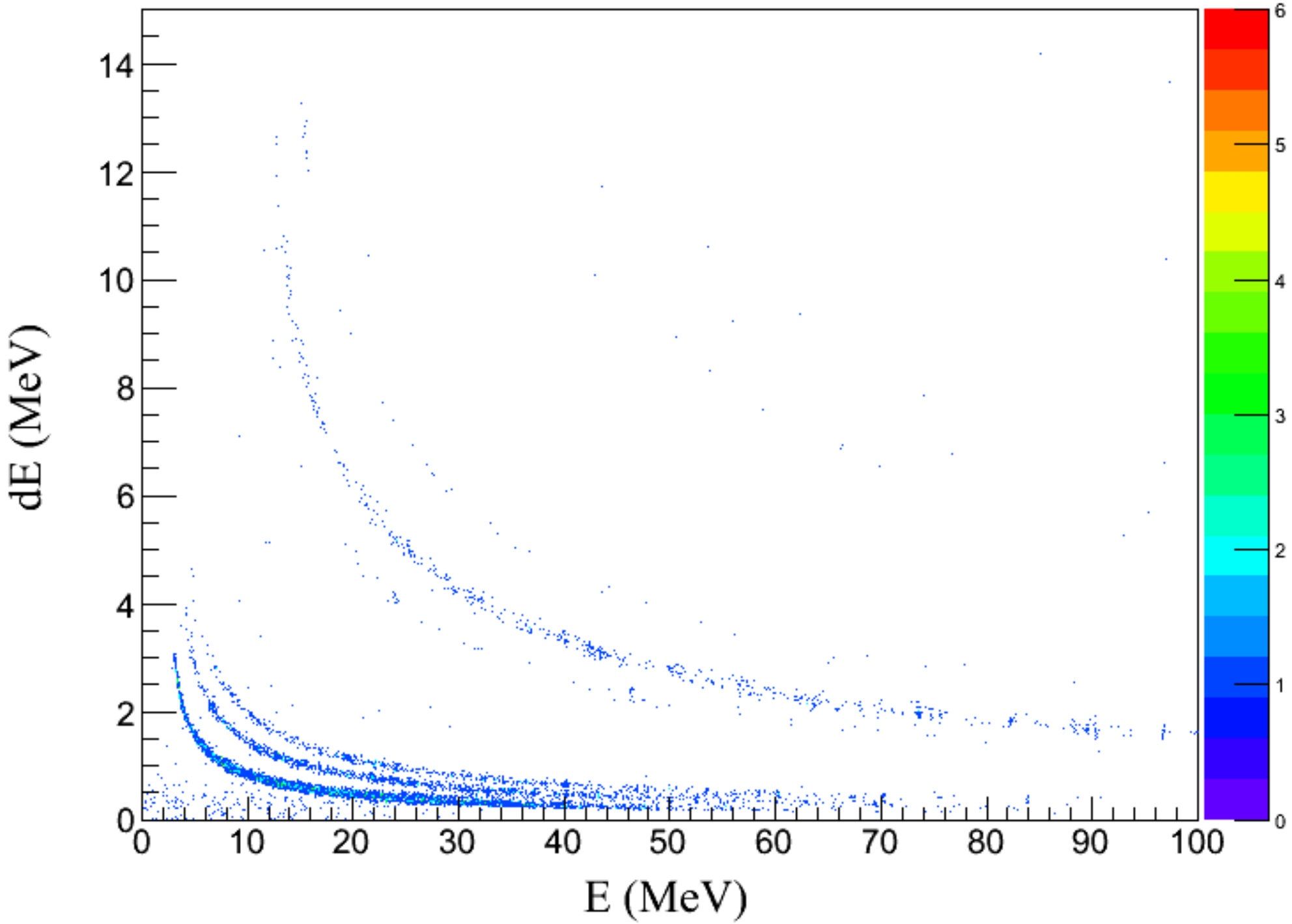
J-PARC E42 FAC Test at SPring-8 with the LEPS Experiment



<Neutron Bar>
: Scintillator in horizontal direction perpendicular to the TOF wall
with full coverage of all TOF counters behind the TOF wall

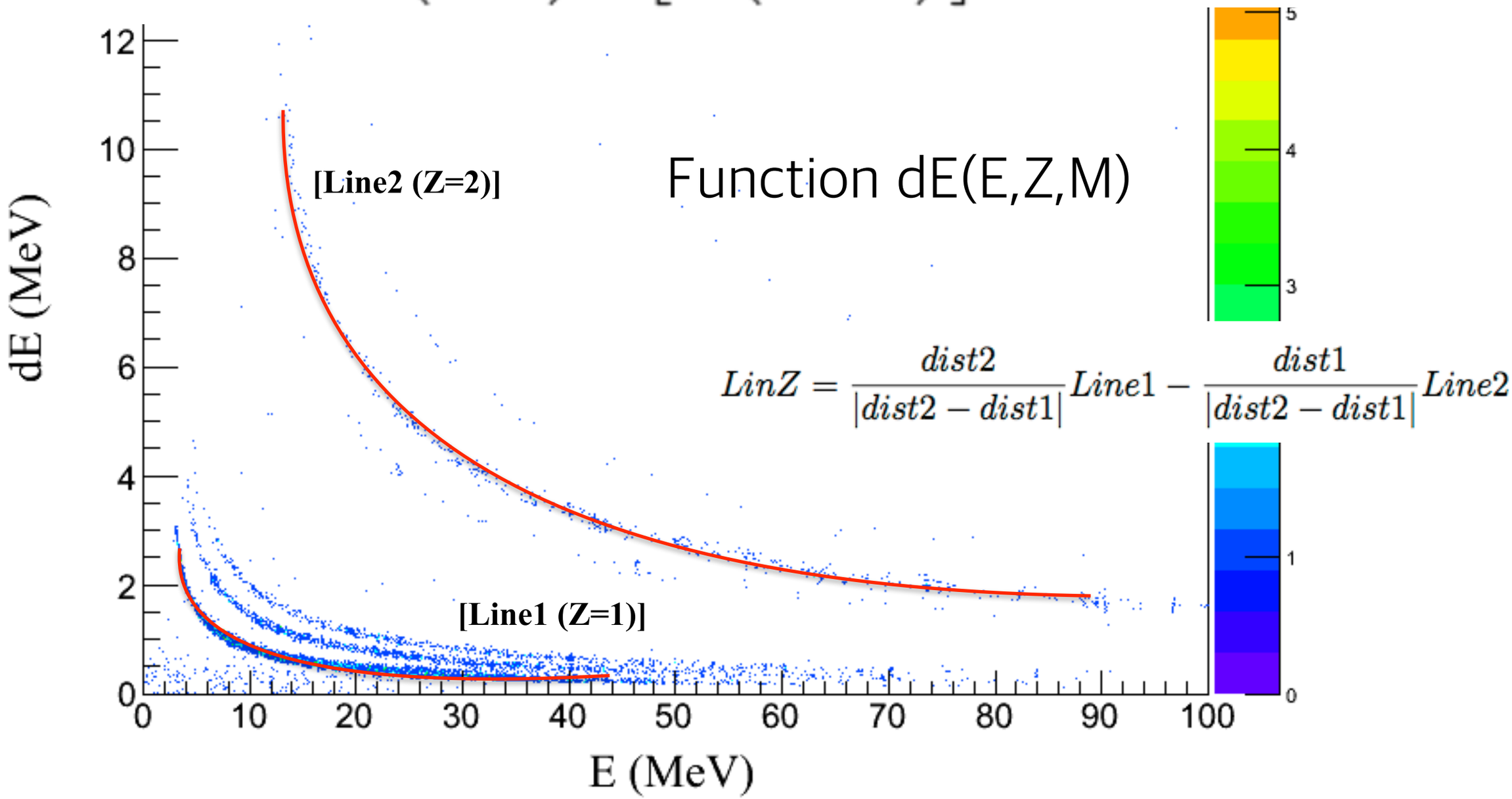
- Determine the ToF Counter & Neutron Bar of which the particle passes when it enters the E42 FAC
- Confirm the time resolution of those ToF counter
- Simulation to calculate the ratio of particles between the ToF & FAC (Shinhyung & Wooseung)

LAMPS – Charged Particle



Charged Particle

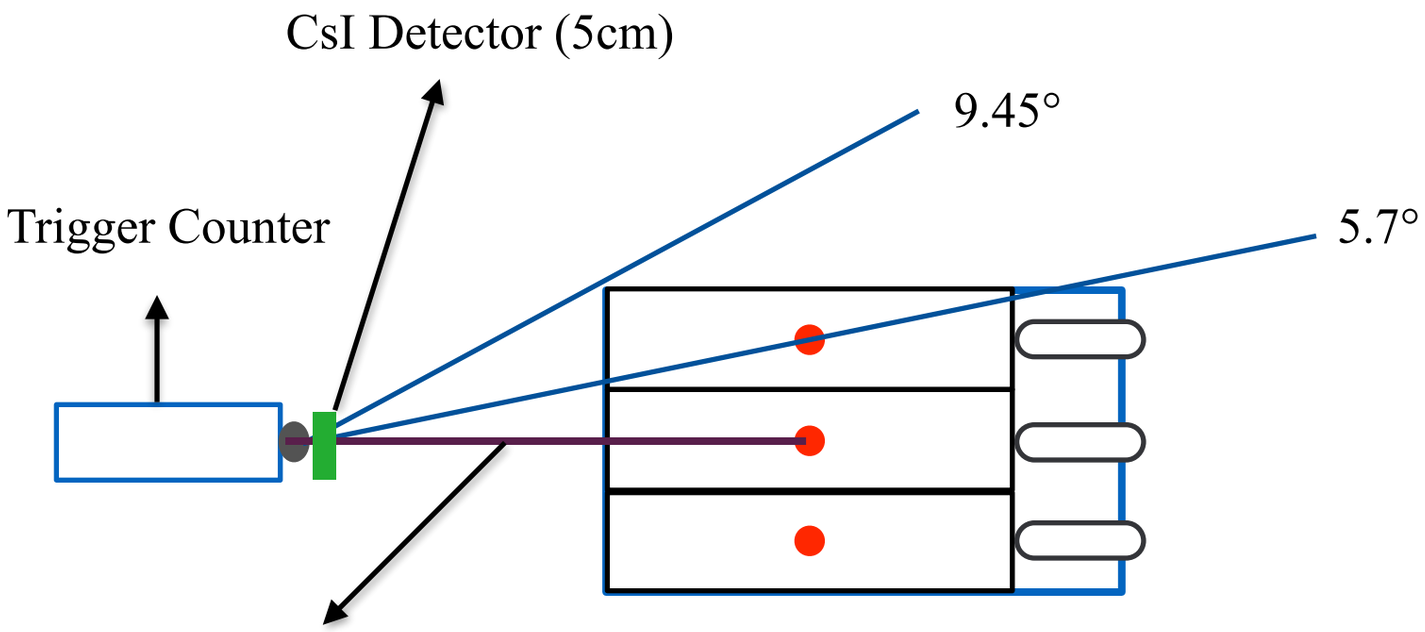
$$-\frac{dE}{dx} = \frac{4\pi n z^2}{m_e v^2} \cdot \left(\frac{e^2}{4\pi\varepsilon_0}\right)^2 \cdot \left[\ln\left(\frac{2m_e v^2}{I}\right)\right] \qquad n = \frac{N_A \cdot Z \cdot \rho}{A \cdot M_u}$$



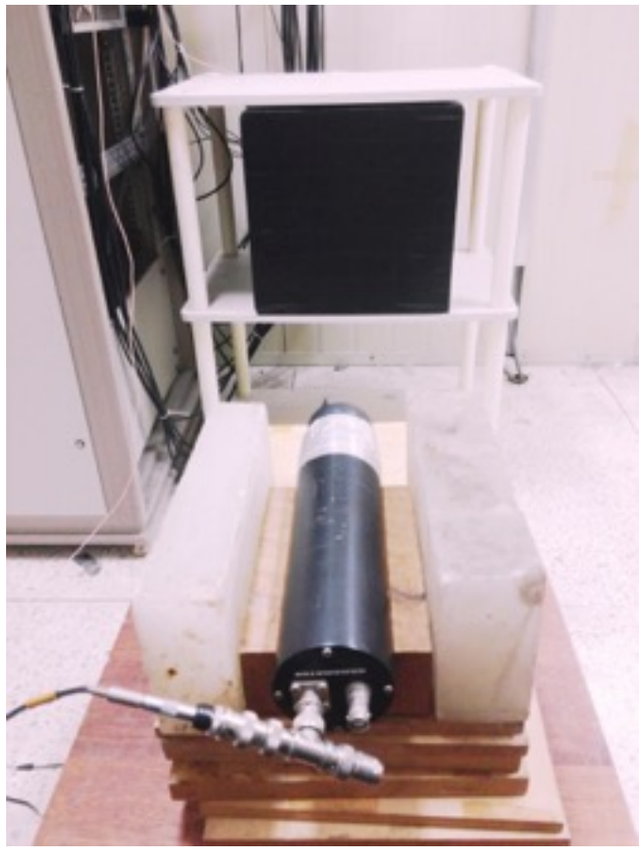
Function dE(E,Z,M)

$$LinZ = \frac{dist2}{|dist2 - dist1|} Line1 - \frac{dist1}{|dist2 - dist1|} Line2$$

LAMPS – Neutron Detector



[Side View]

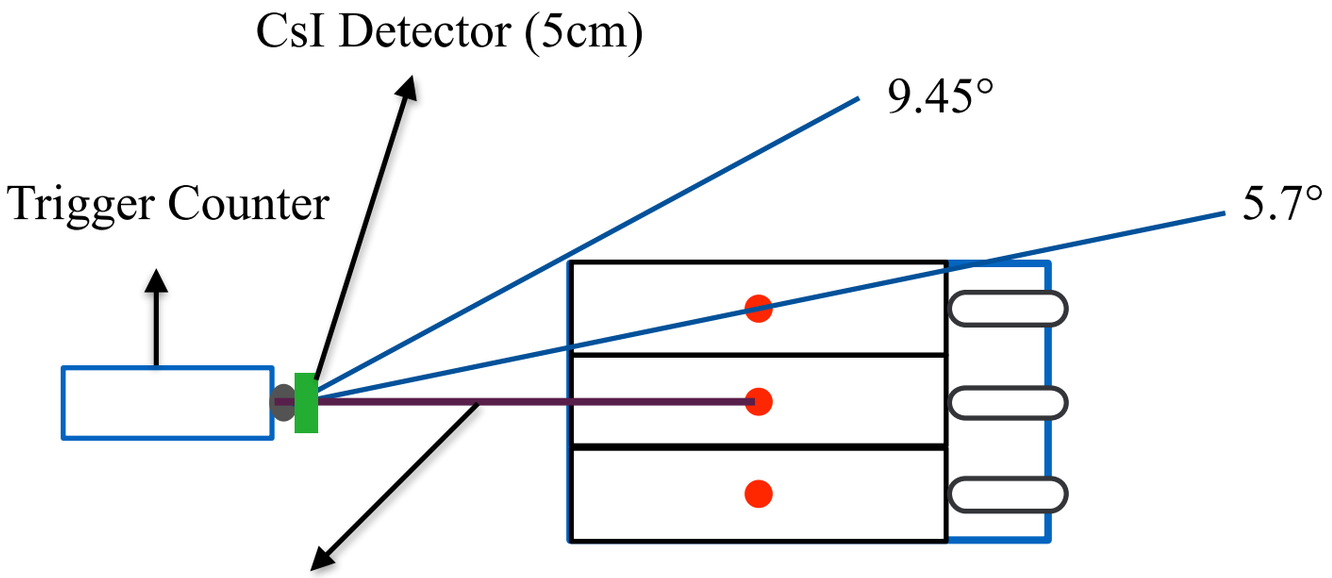


[Front View]

One more test for 2.5cm thickness CsI detector

Back-up

Simultaneous measurement problem



ToF distance : 100cm

- CsI detector is too close to the source
- Possibility of gamma & neutron go inside the CsI simultaneously
- Cannot distinguish the gamma and neutron signal in the CsI detector

For example

1. One neutron signal in neutron detector and one signal in CsI detector
2. Scattered neutron signal? OR neutron signal with no CsI interaction and gamma or neutron signal in CsI

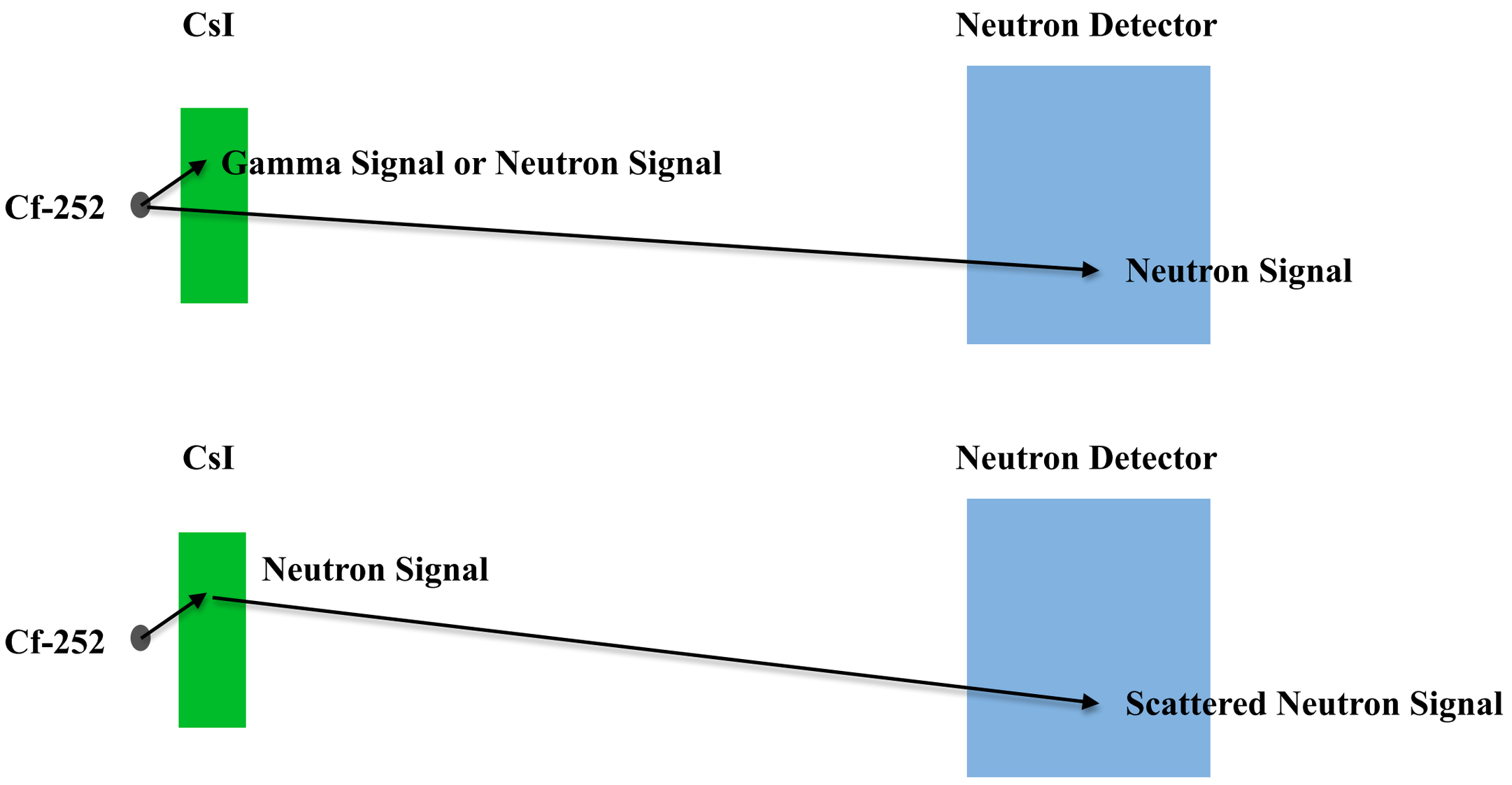
FADC Neutron Detector Test Report

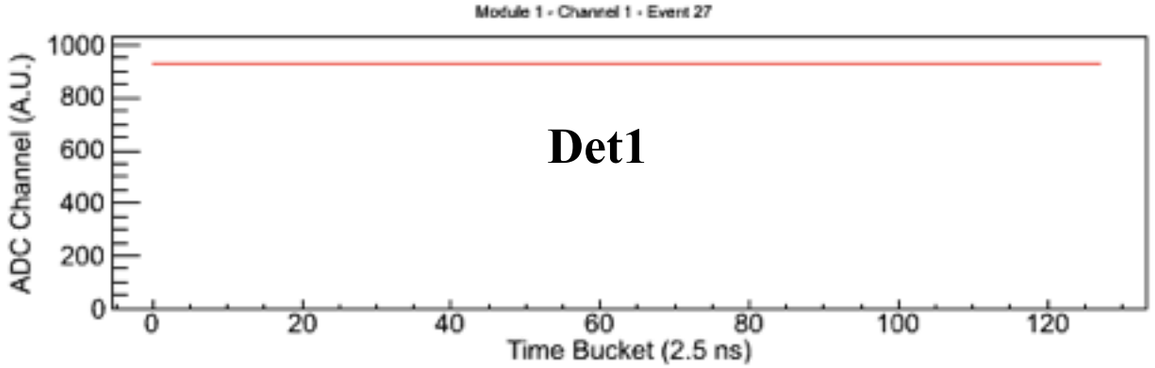
1. Neutron Detector experiment without CsI blocking measuring only Neutron Detector

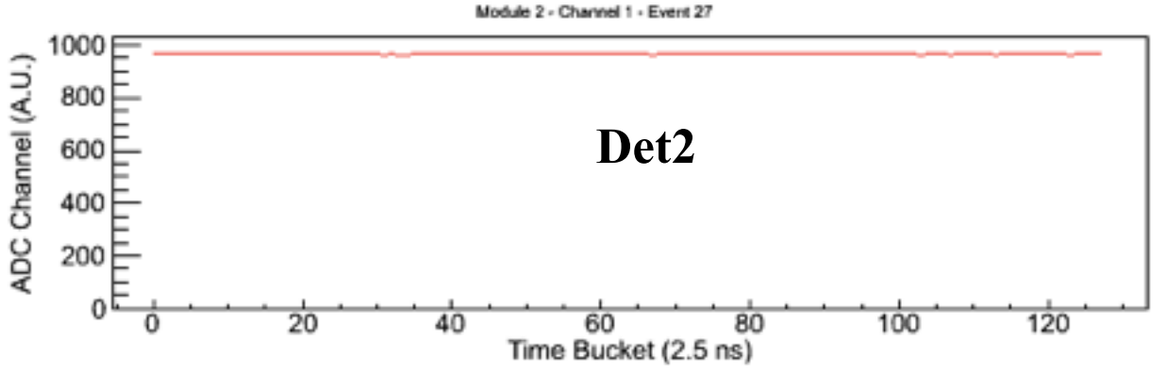
2. Same test with CsI blocking measuring only Neutron Detector

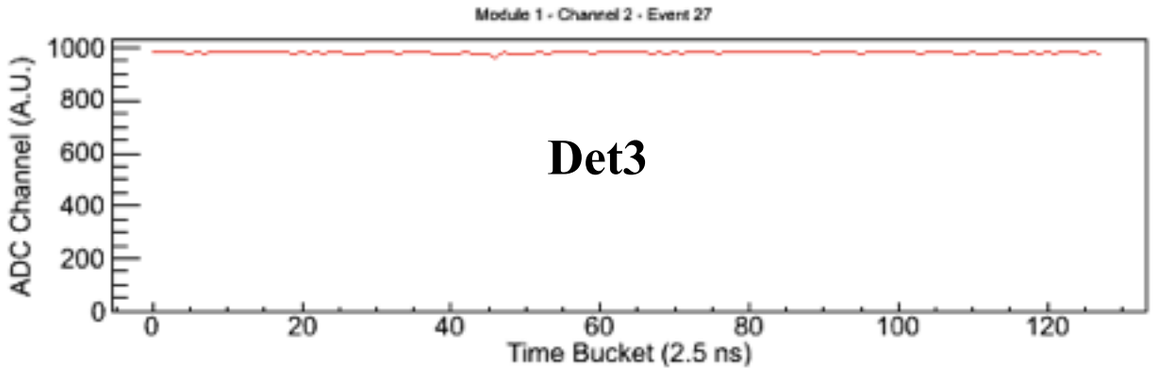
3. CsI test for two sources (Cf-252 & Co-60)

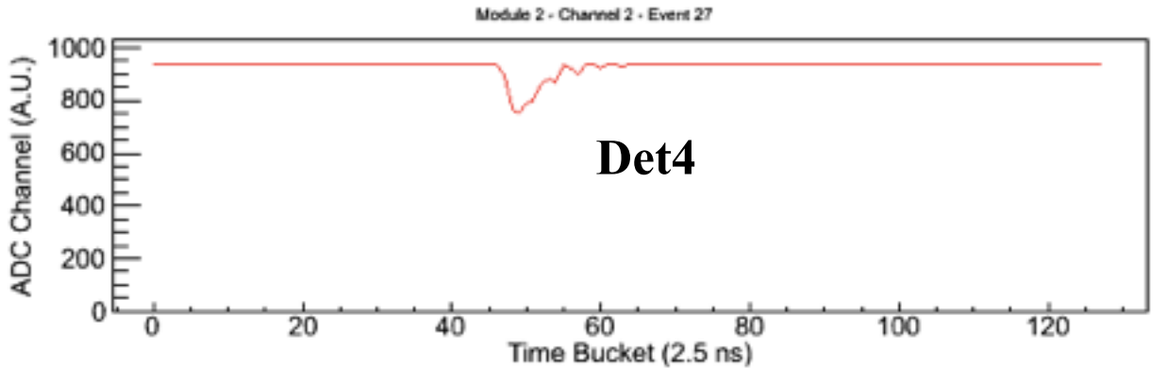
Simultaneous measurement problem

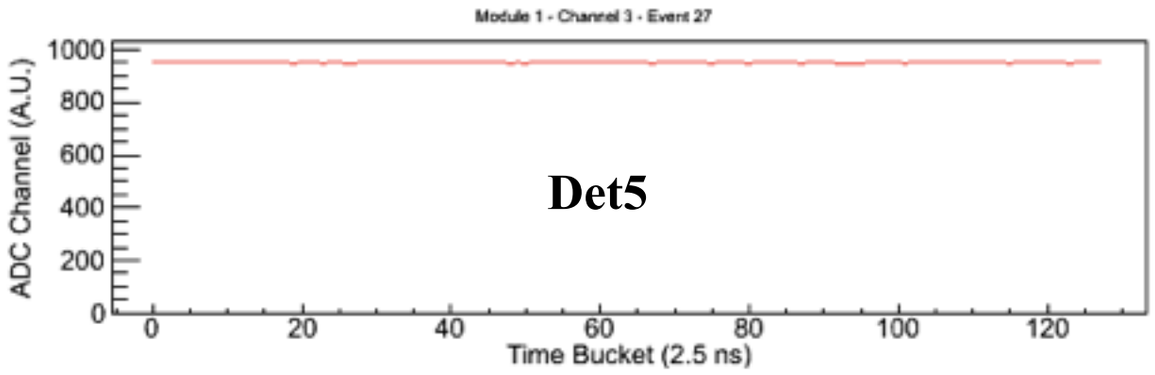


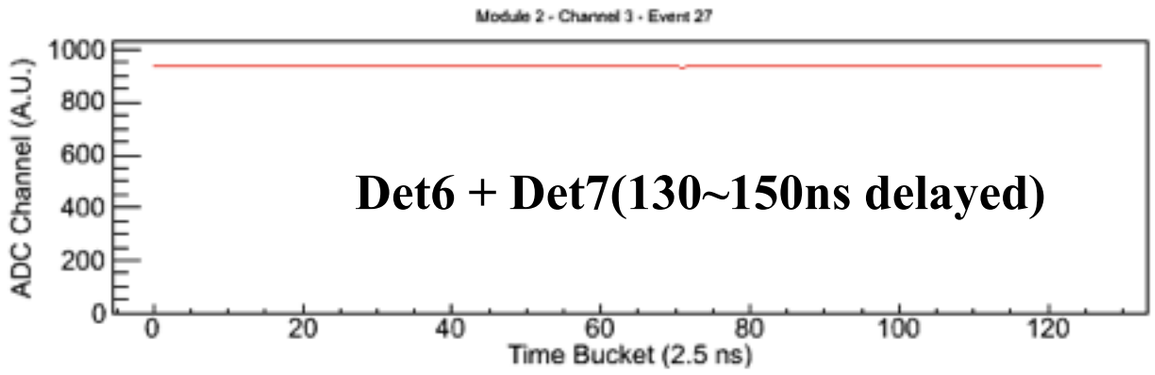

Module 1 - Channel 1 - Event 27
ADC Channel (A.U.)
Time Bucket (2.5 ns)
Det1

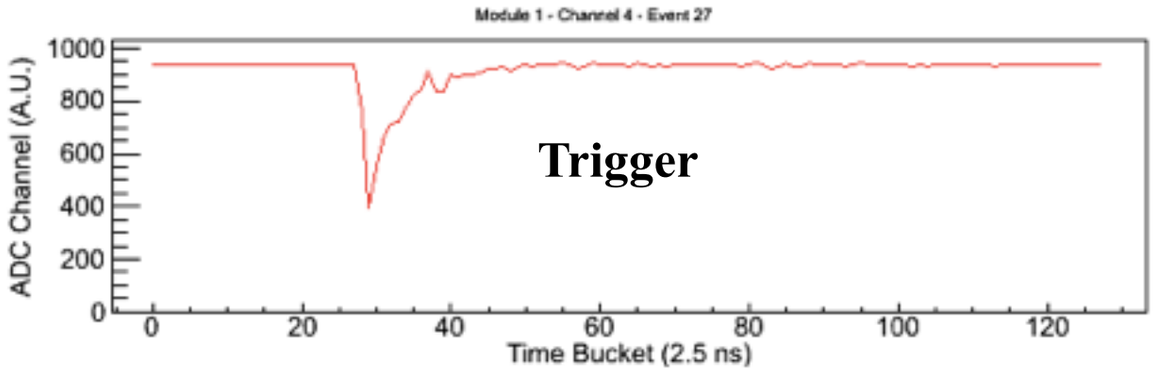

Module 2 - Channel 1 - Event 27
ADC Channel (A.U.)
Time Bucket (2.5 ns)
Det2

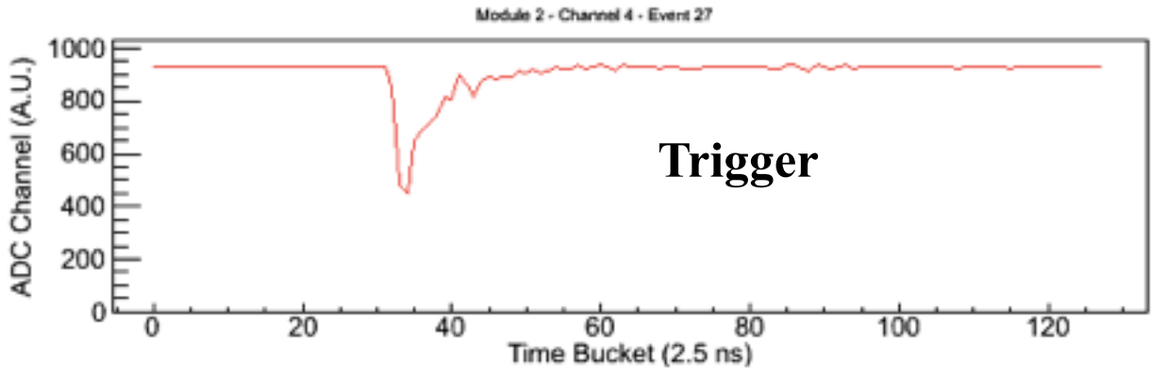

Module 1 - Channel 2 - Event 27
ADC Channel (A.U.)
Time Bucket (2.5 ns)
Det3

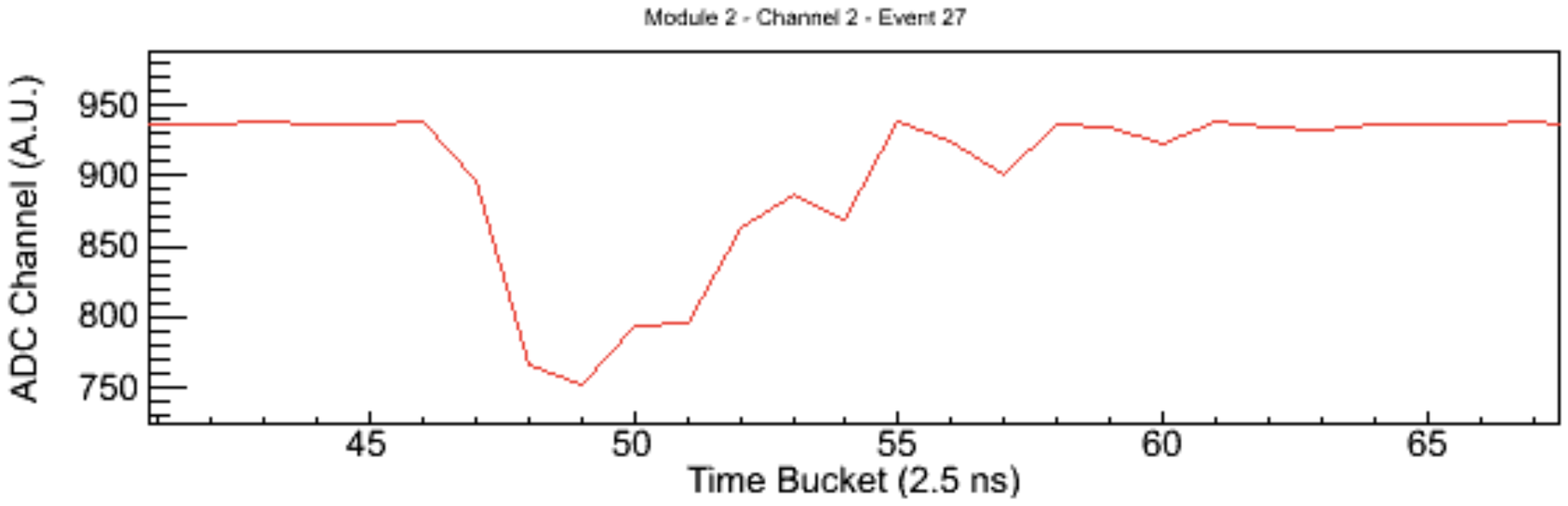

Module 2 - Channel 2 - Event 27
ADC Channel (A.U.)
Time Bucket (2.5 ns)
Det4

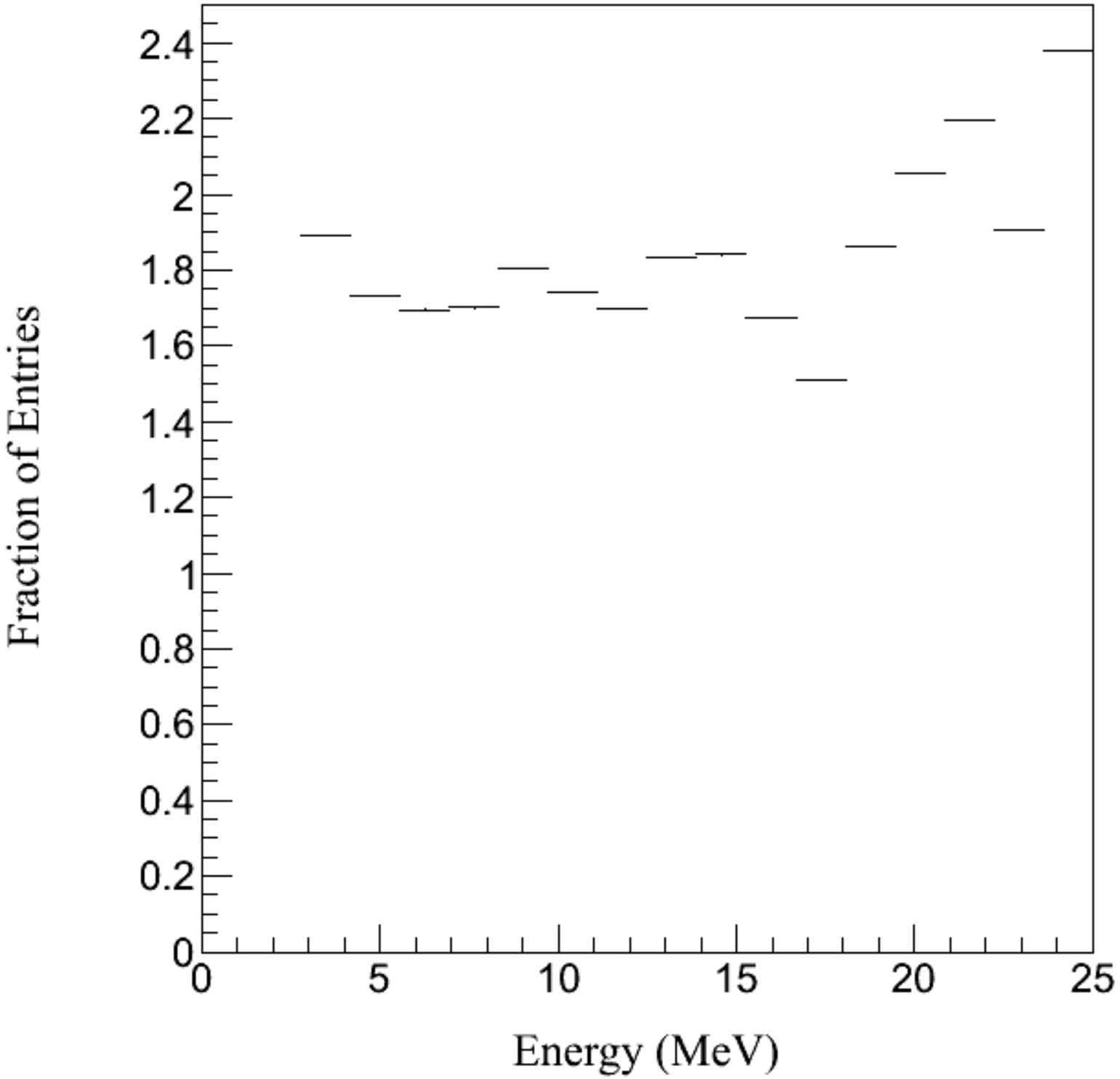

Module 1 - Channel 3 - Event 27
ADC Channel (A.U.)
Time Bucket (2.5 ns)
Det5

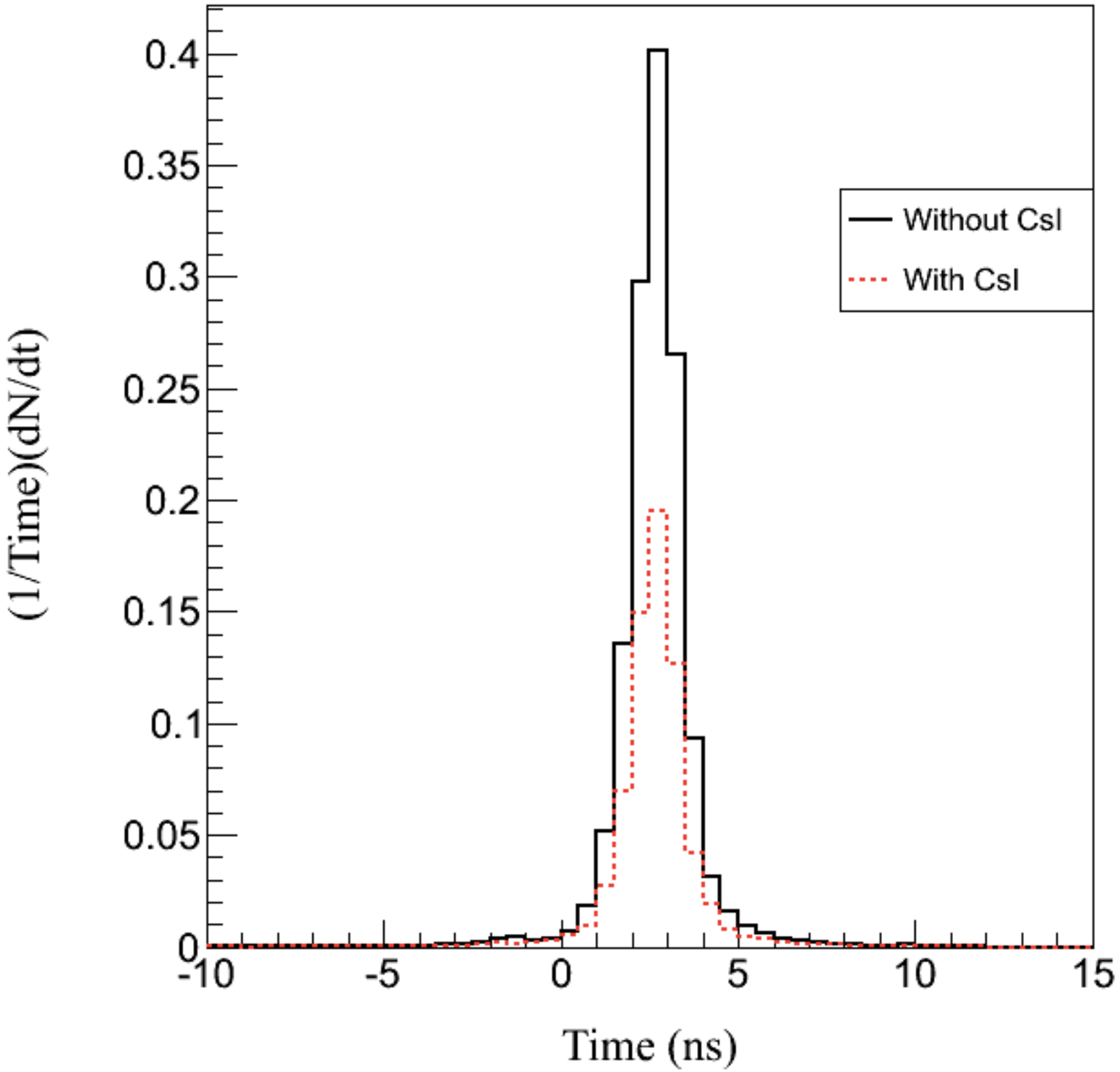

Module 2 - Channel 3 - Event 27
ADC Channel (A.U.)
Time Bucket (2.5 ns)
Det6 + Det7(130~150ns delayed)


Module 1 - Channel 4 - Event 27
ADC Channel (A.U.)
Time Bucket (2.5 ns)
Trigger

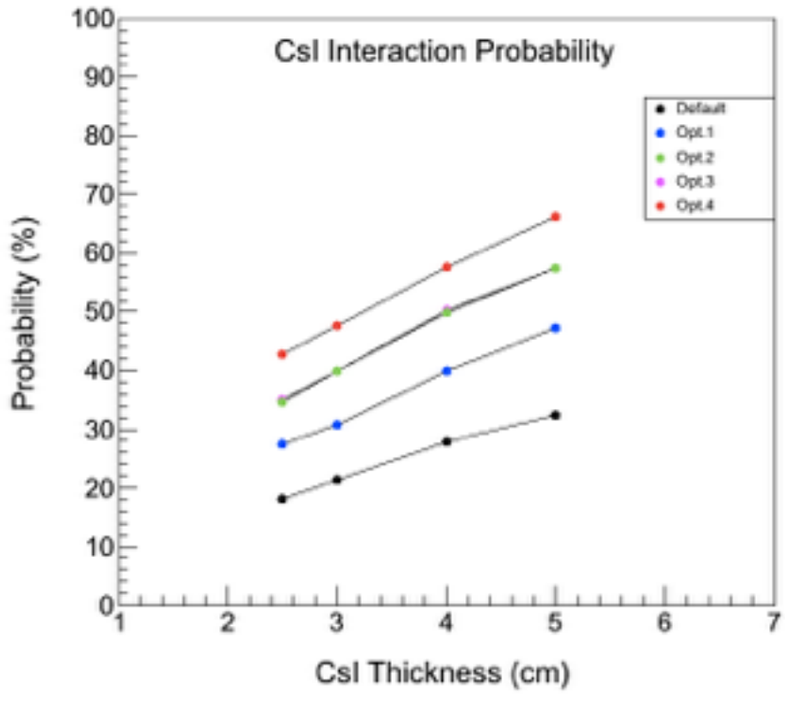

Module 2 - Channel 4 - Event 27
ADC Channel (A.U.)
Time Bucket (2.5 ns)
Trigger

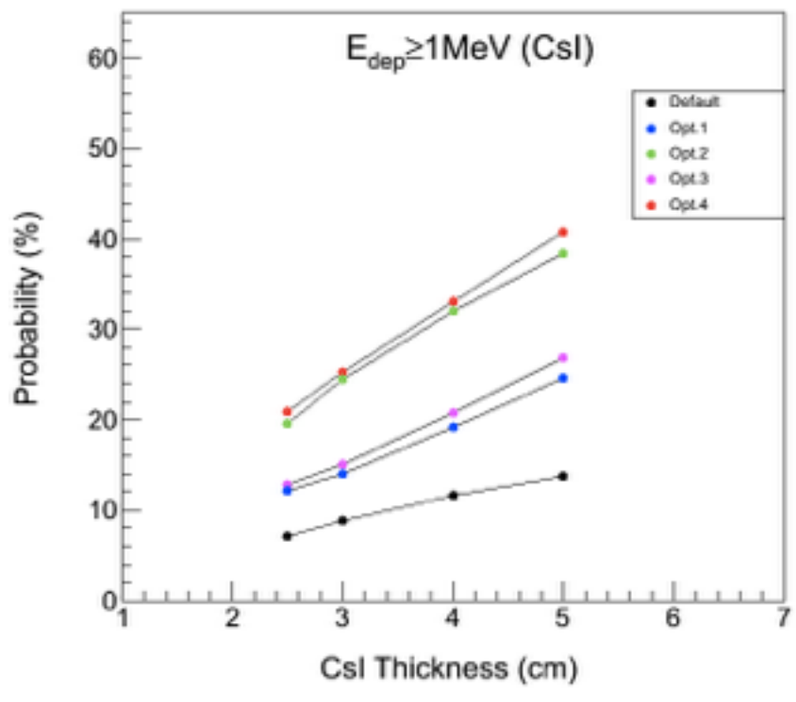

Module 2 - Channel 2 - Event 27
ADC Channel (A.U.)
950
900
850
800
750
45
50
55
60
65
Time Bucket (2.5 ns)

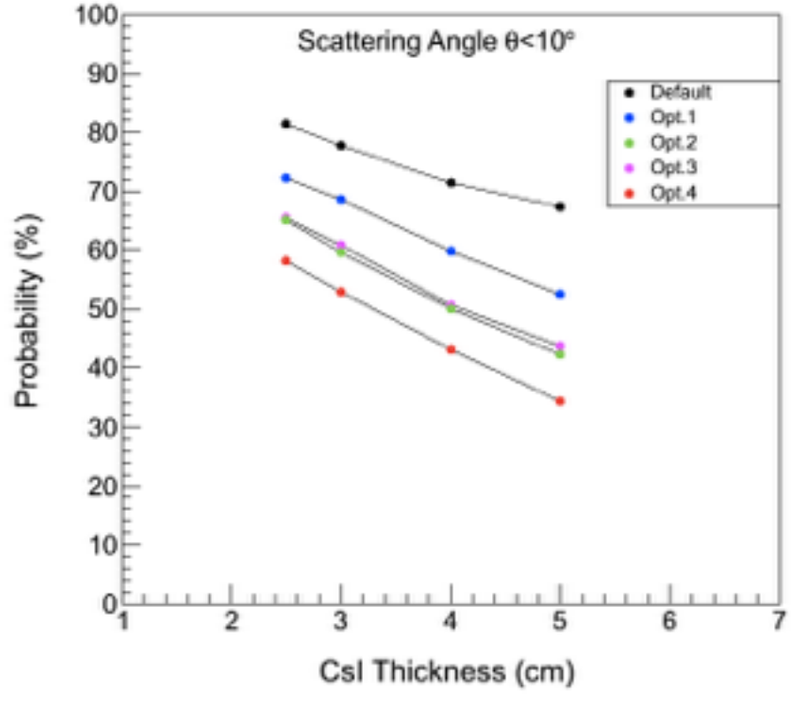

Fraction of Entries
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
5
10
15
20
25
Energy (MeV)


(1/Time)(dN/dt)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-10
-5
0
5
10
15
Time (ns)
Without CsI
With CsI

Summary of the Si-CsI effect

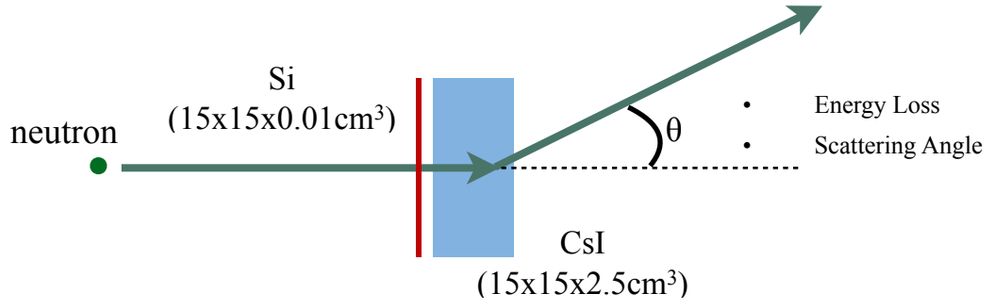


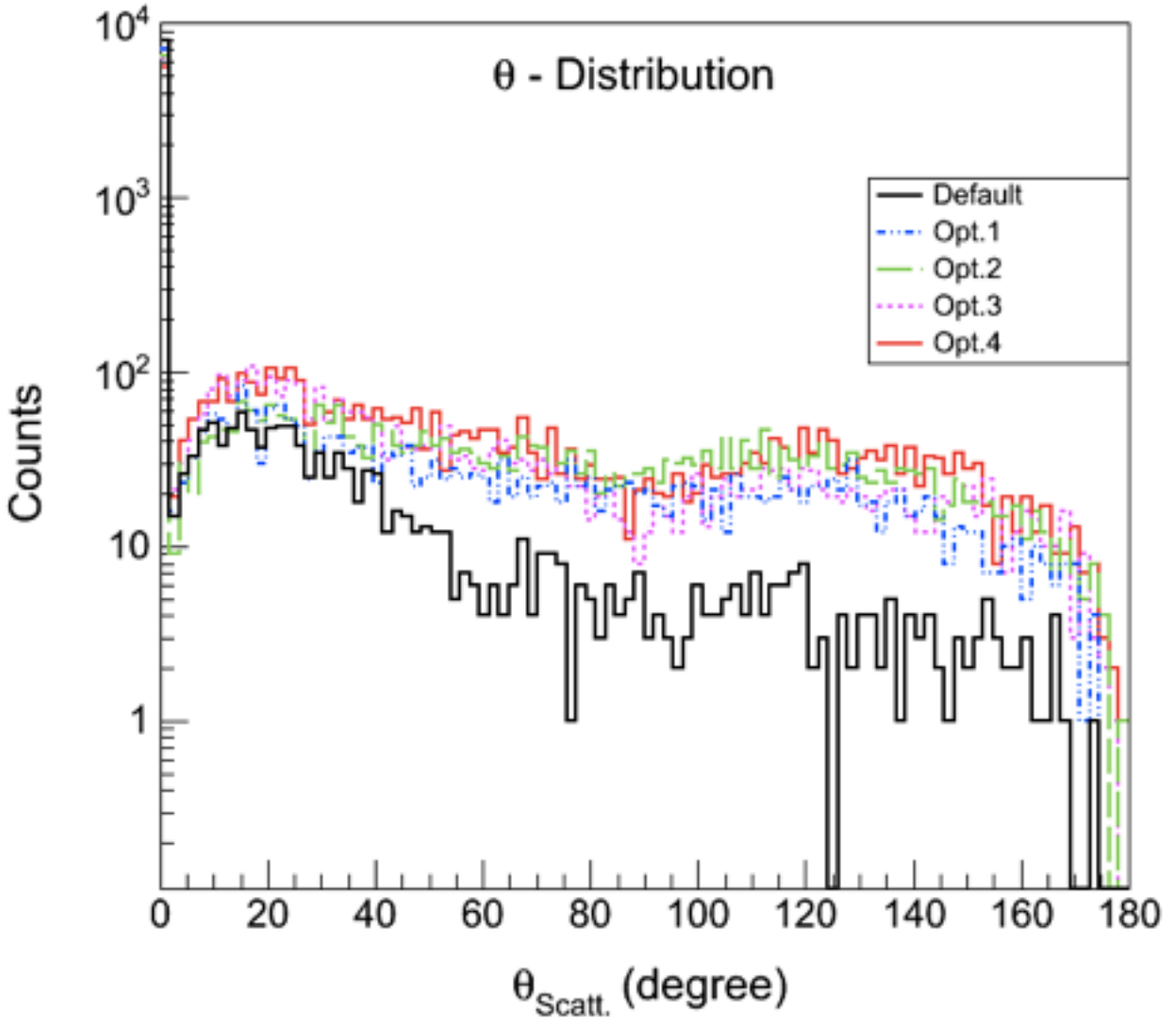


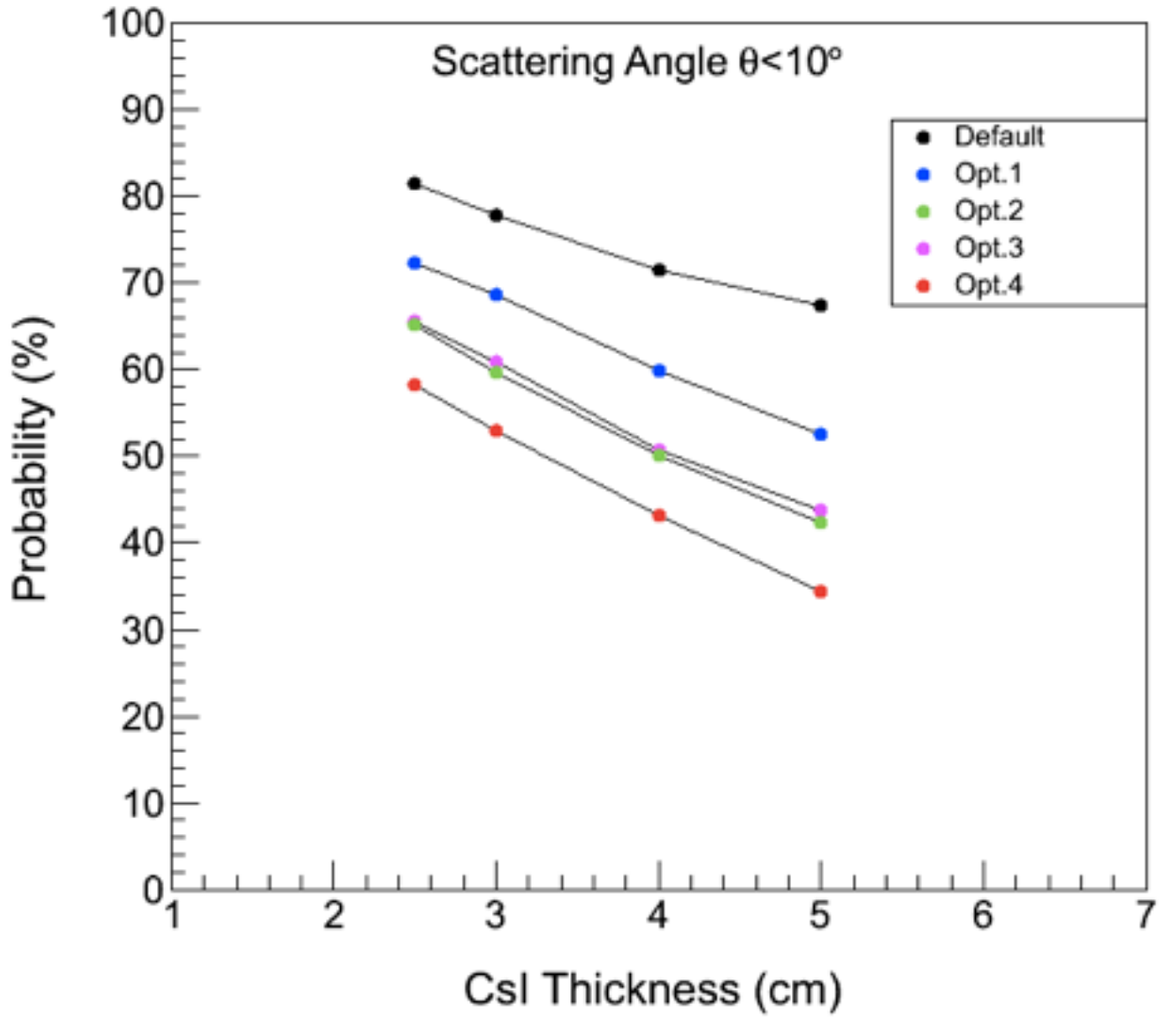


Effect of Si-CsI Detector

Beam Energy = 10 MeV
Depth of CsI = 2.5cm
# of Events = 10,000

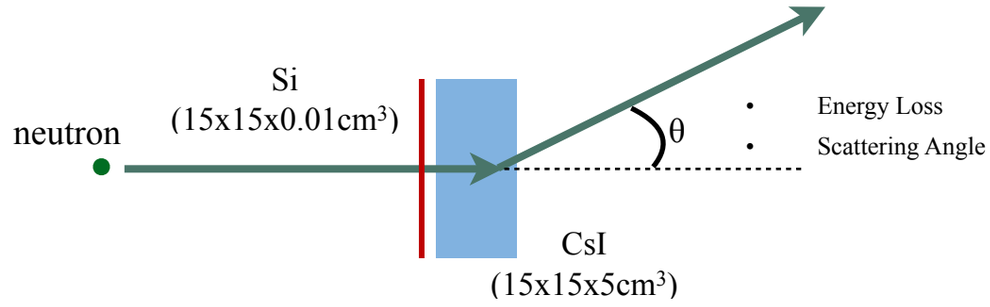


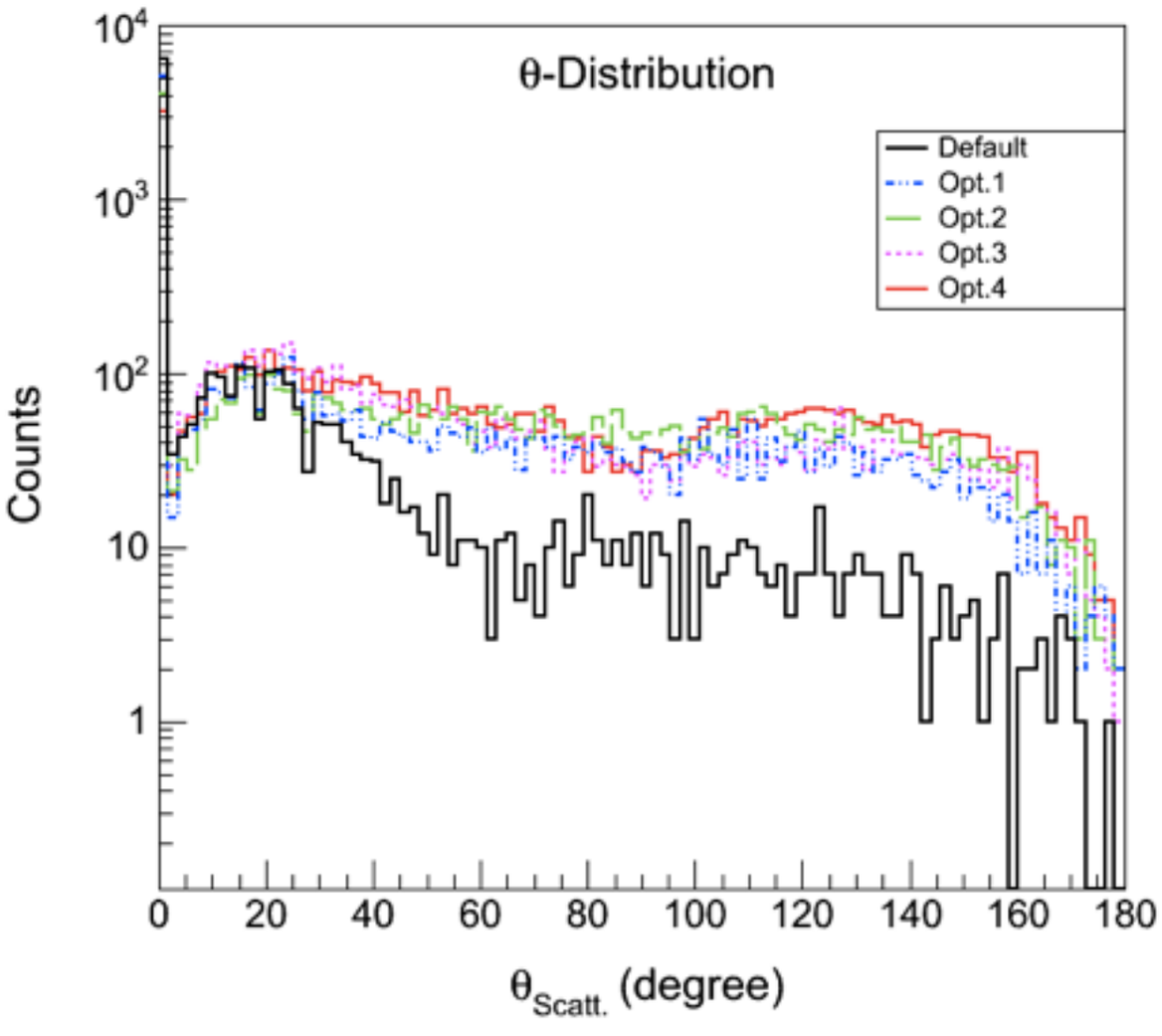


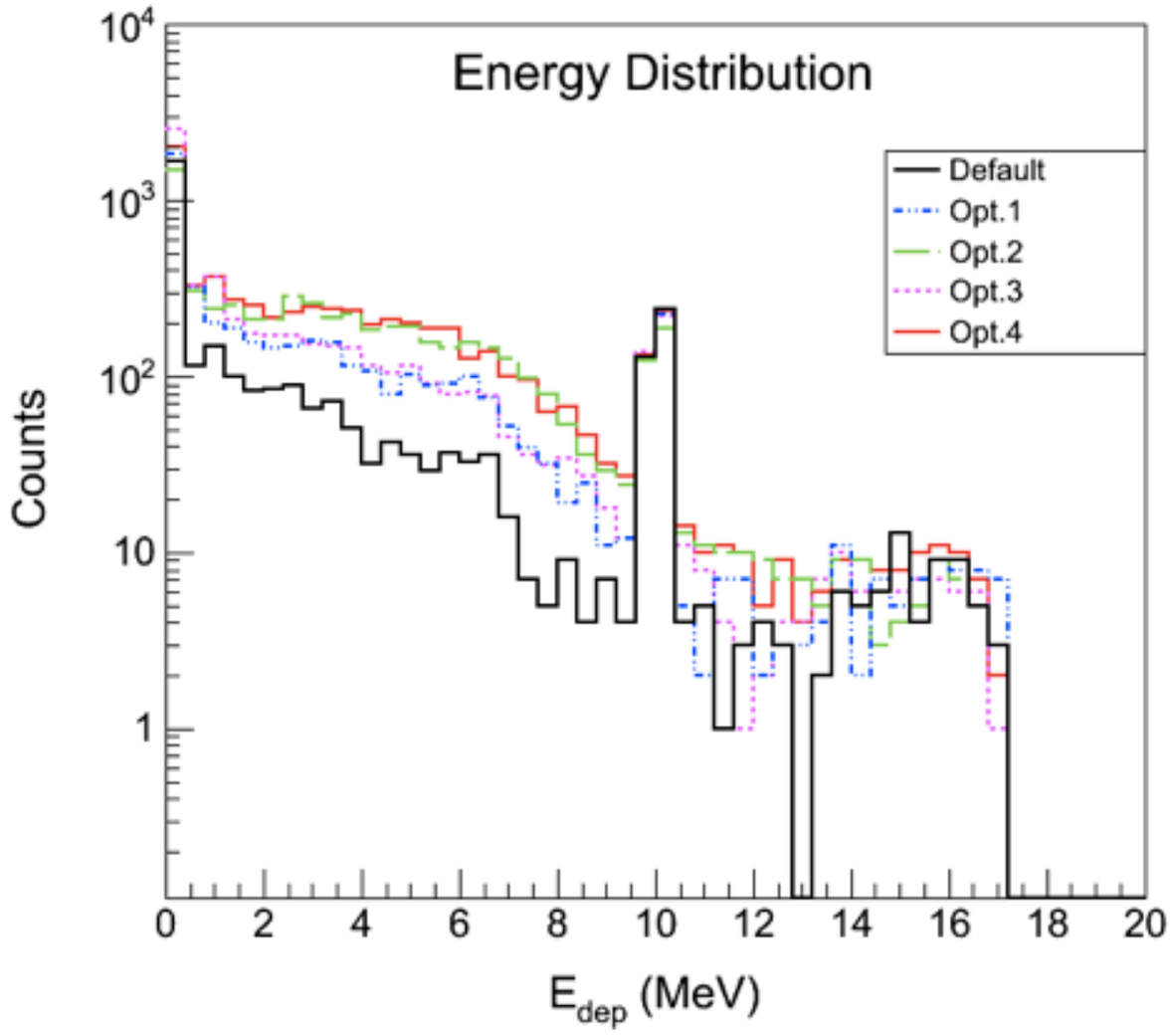


Effect of Si-CsI Detector

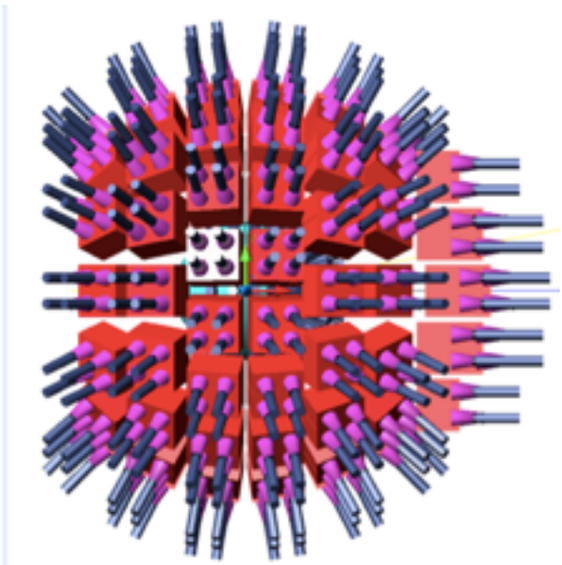
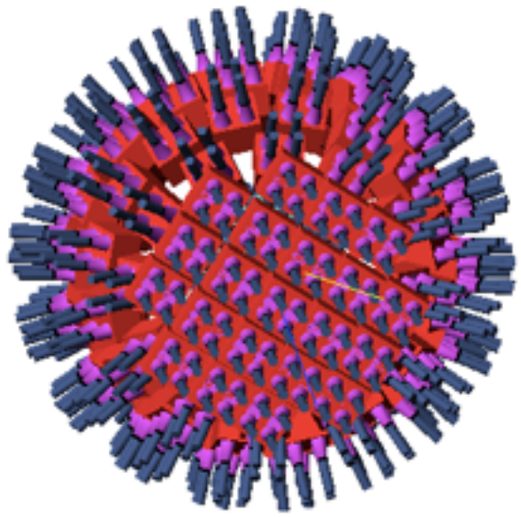
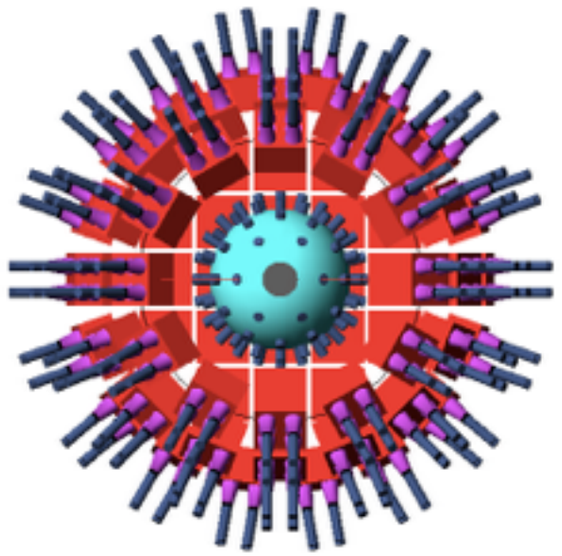
Beam Energy = 10 MeV
Depth of CsI = 5cm
# of Events = 10,000







Full Geometry

1 super module = 4 unit detector

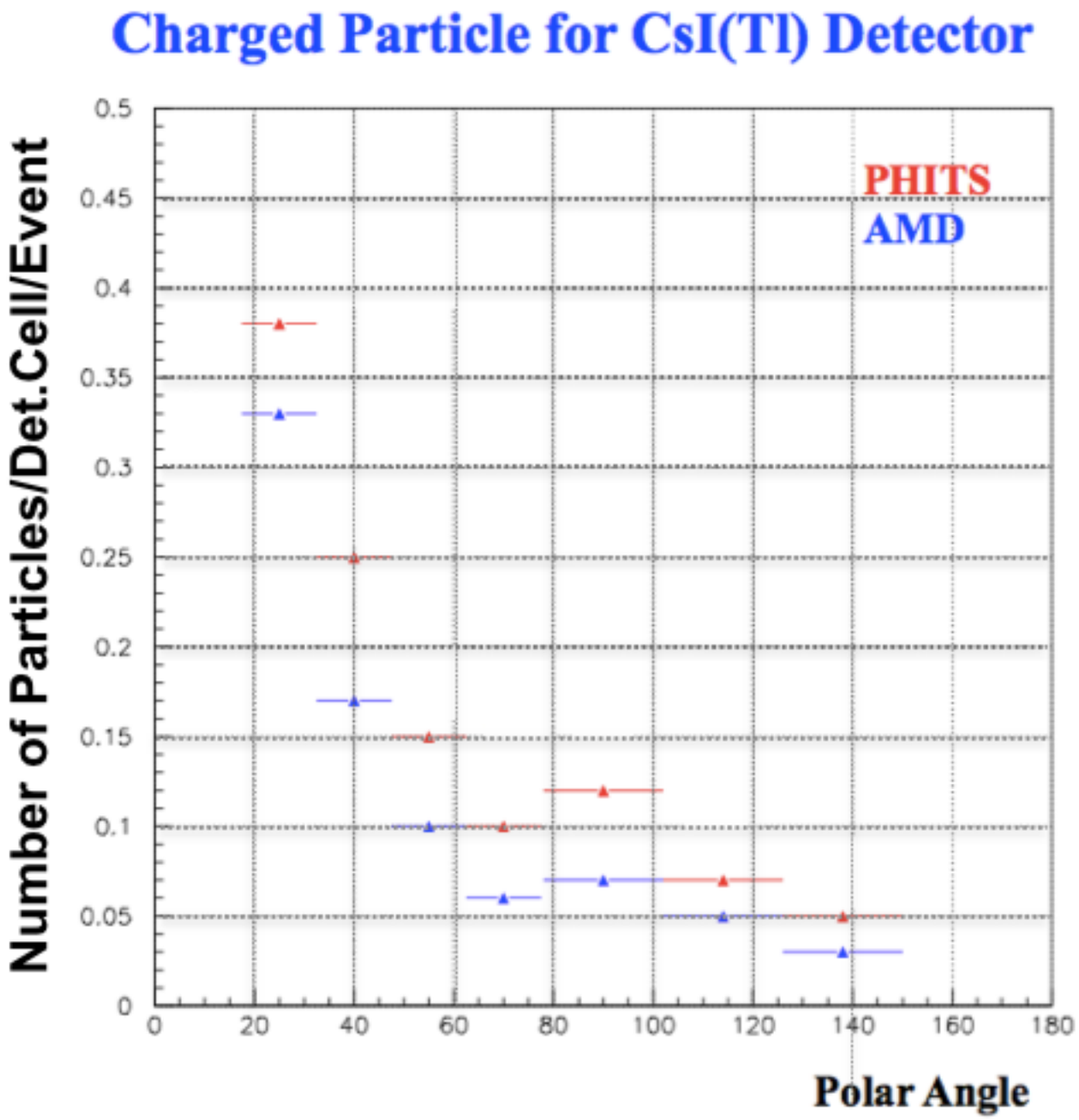
Forward Detector Wall : Cover Range 0 ~ 36 degree, ToF Dist. : 1.3m
# of unit detector 84

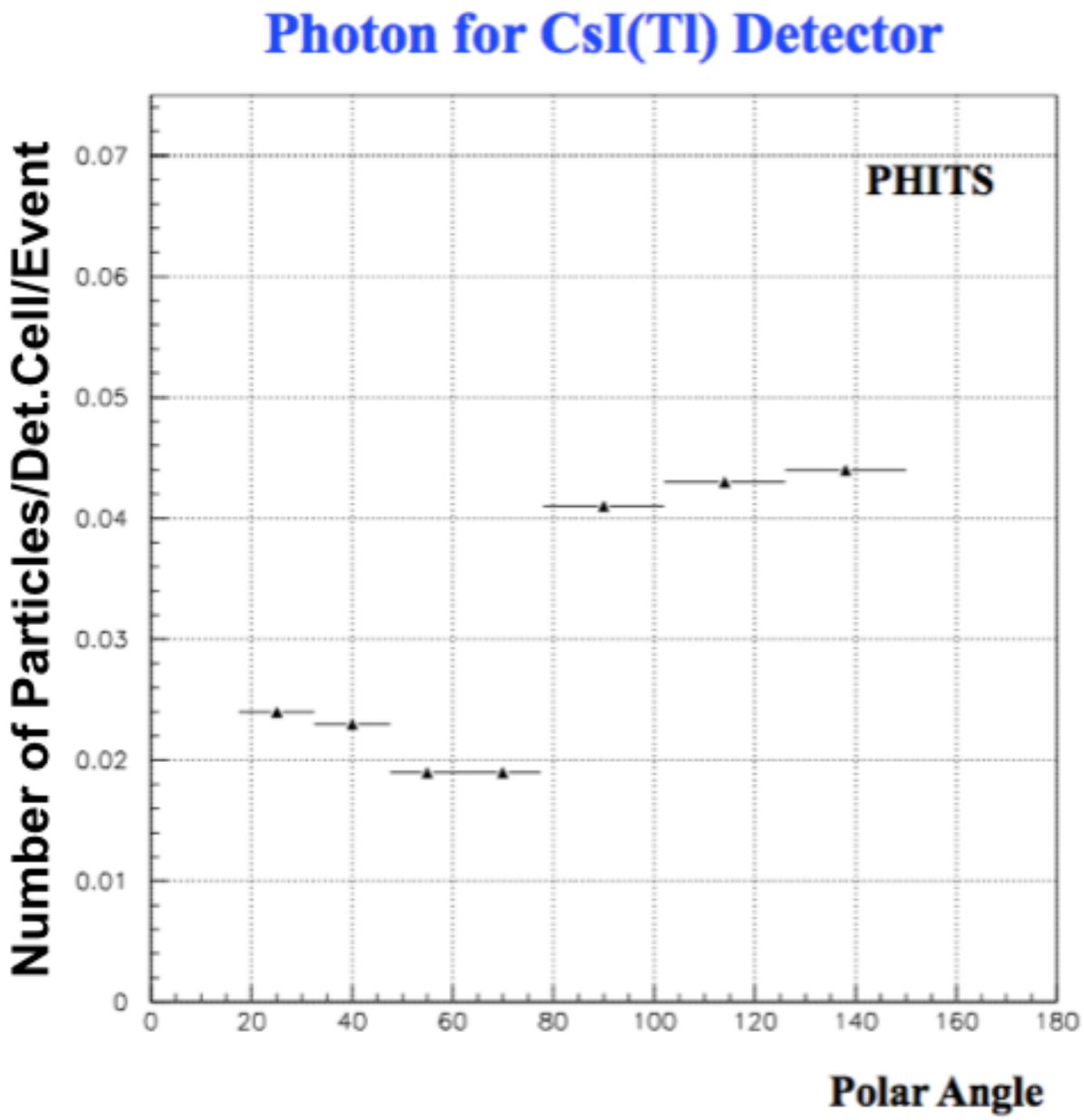
Sphere Detector : Cover Range 36 ~ 144 degree, ToF Dist. : 1.1m
# of unit detector 368

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



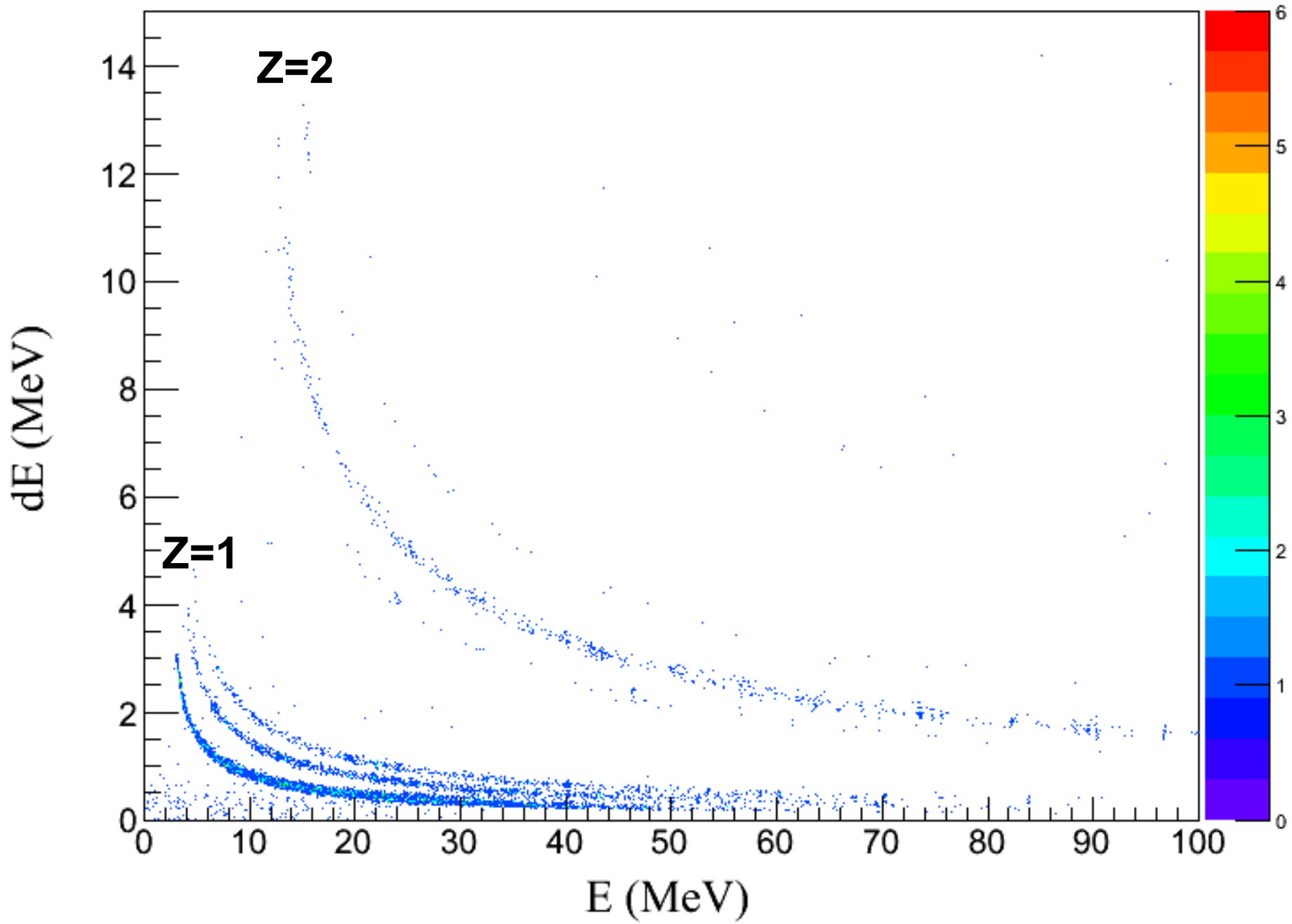


Det.CoverRange

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

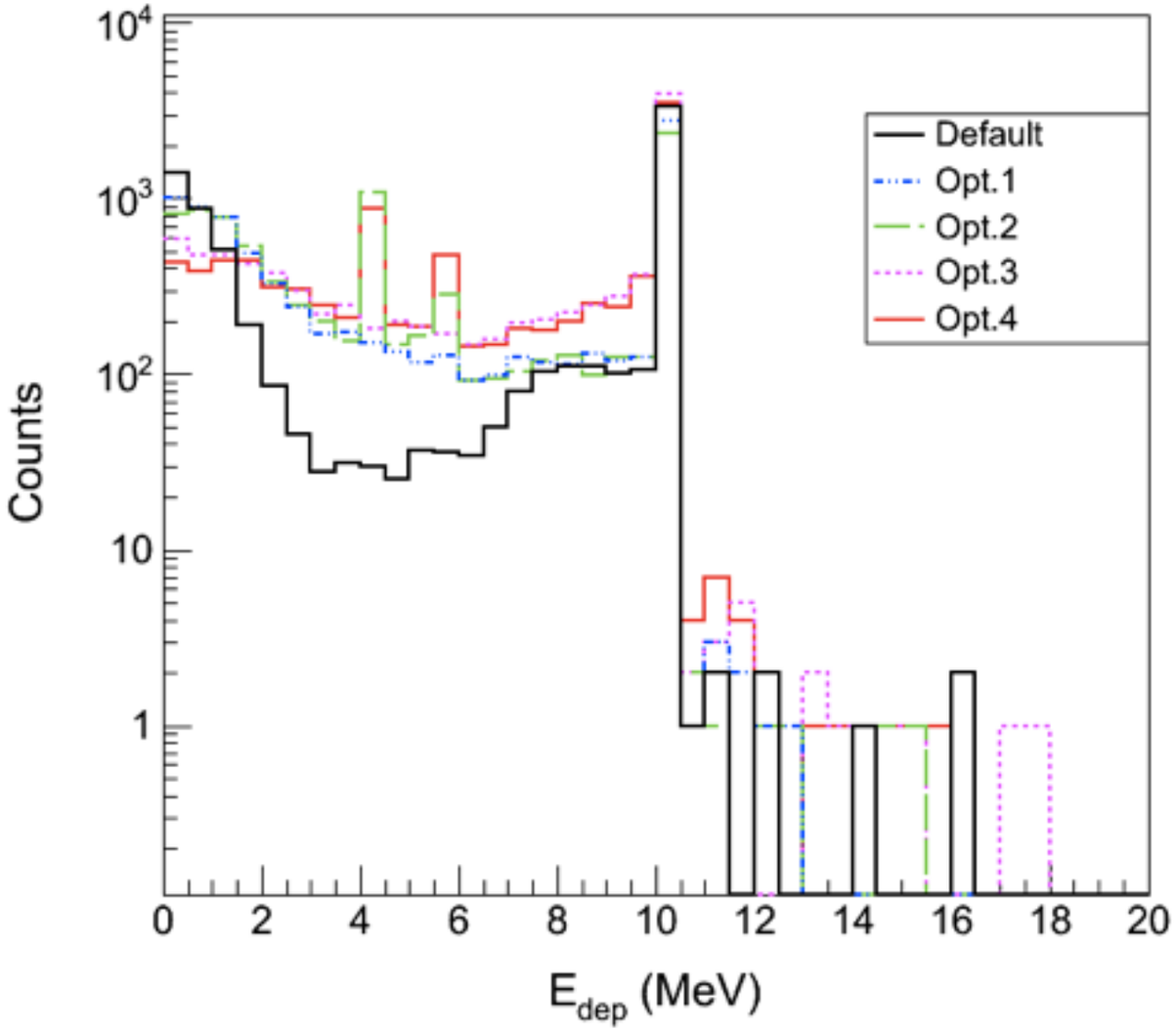
- Package 1 : Hadron Physics - HadronPhysicsQGSP_BERT
- Package 2 : Hadron Physics - HadronPhysicsQGSP_BIC
- Package 3 : Hadron Physics - G4HadronElasticPhysics
- Package 4 : Decay Physics - G4RadioactiveDecayPhysics
- Tested 5 different combinations

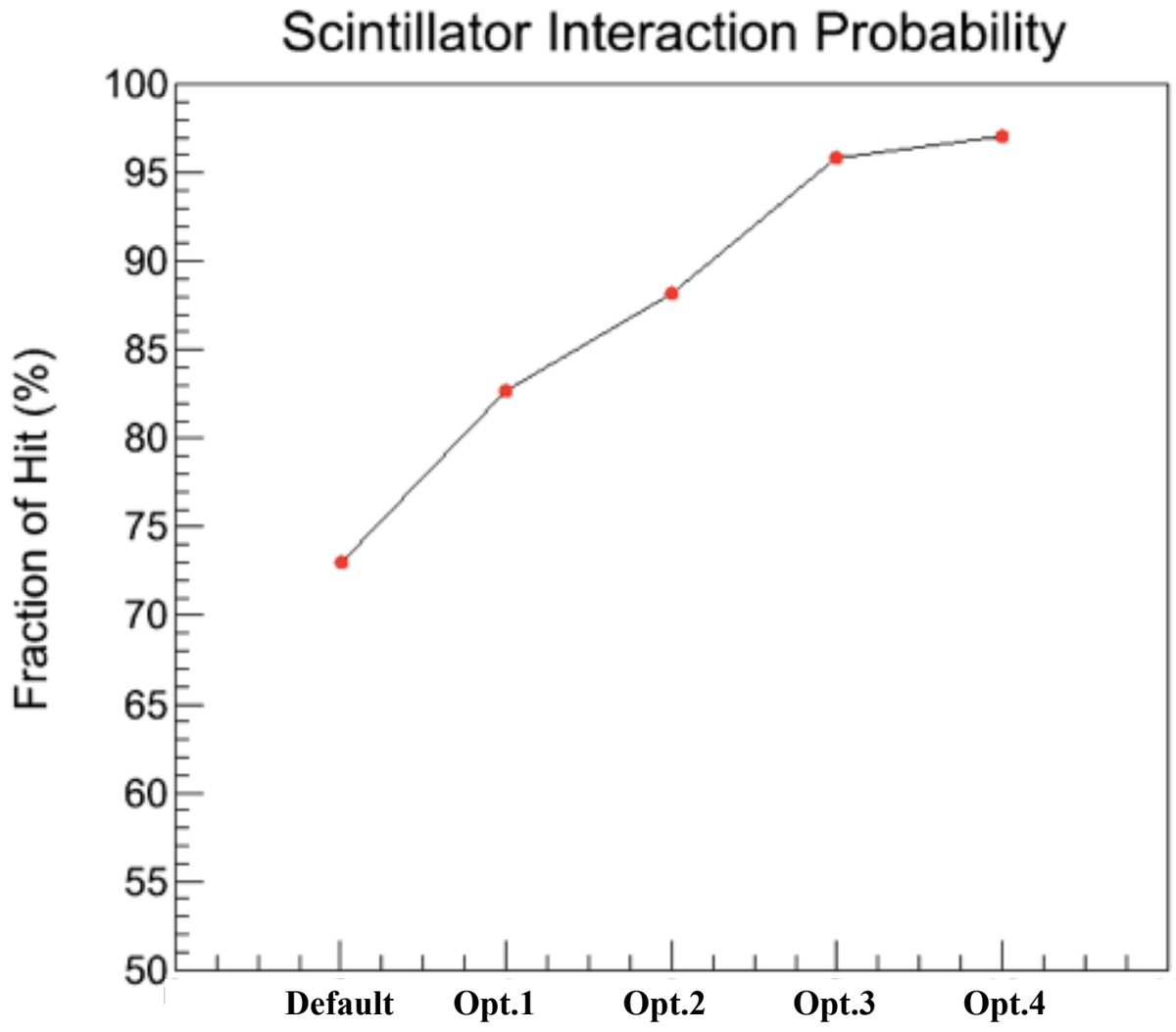
Default	Default
Opt.1	Default+Pack.1
Opt.2	Default+Pack.1 +Pack.2
Opt.3	Default+Pack.1+Pack.3 +Pack.4
Opt.4	Default+Pack.1+Pack.2 +Pack.3 +Pack.4

Response of Neutron Detector

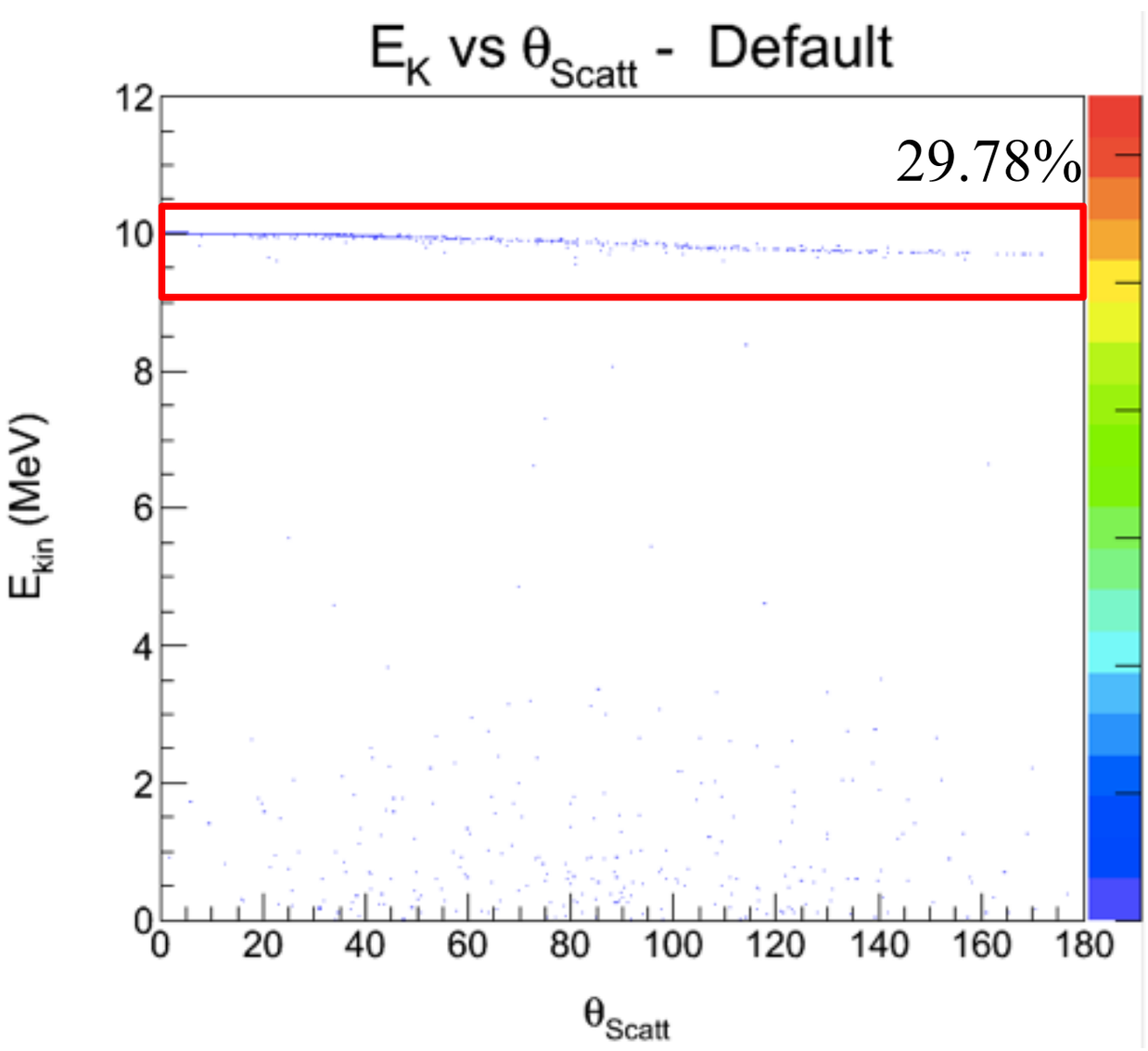
E_{beam} = 10 MeV

# of Event = 10,000





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



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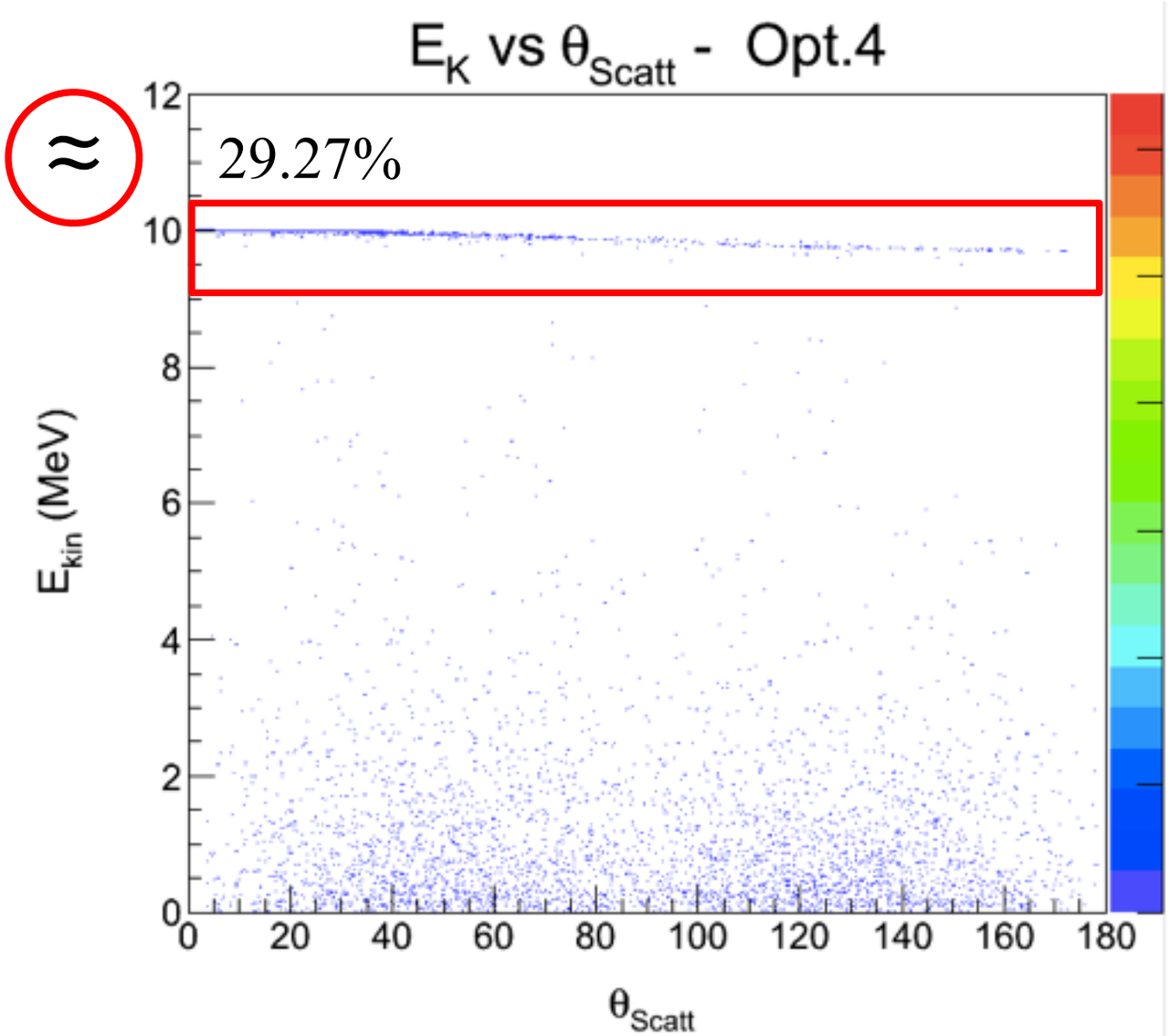
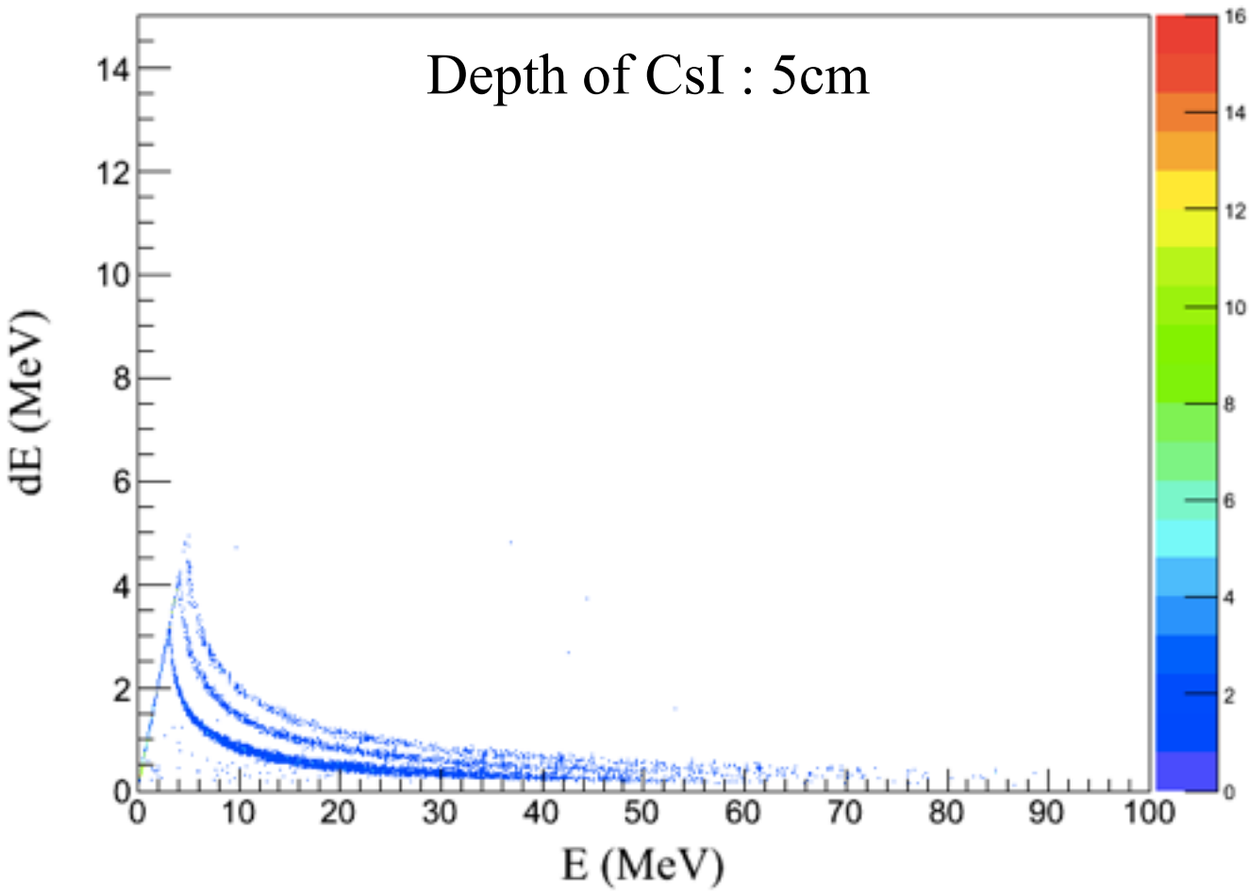
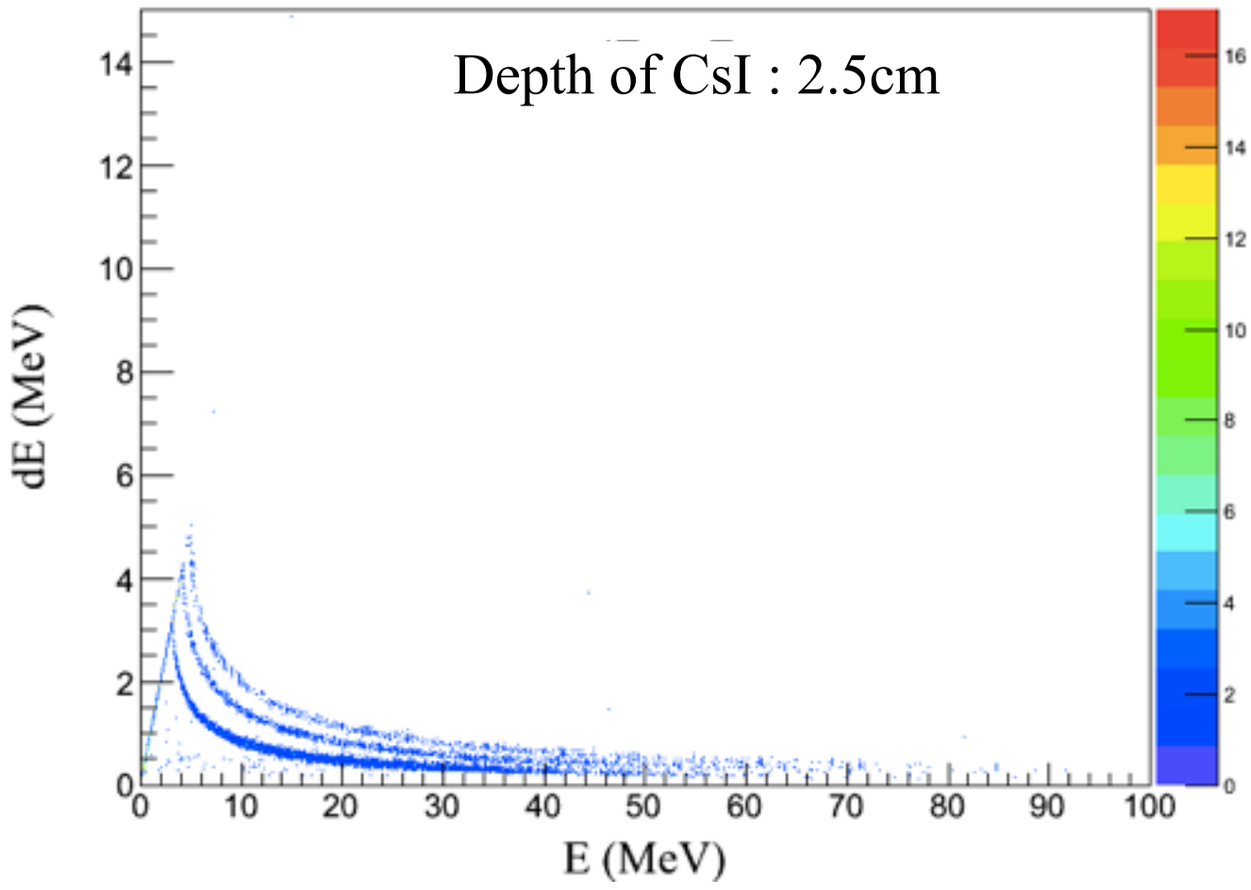


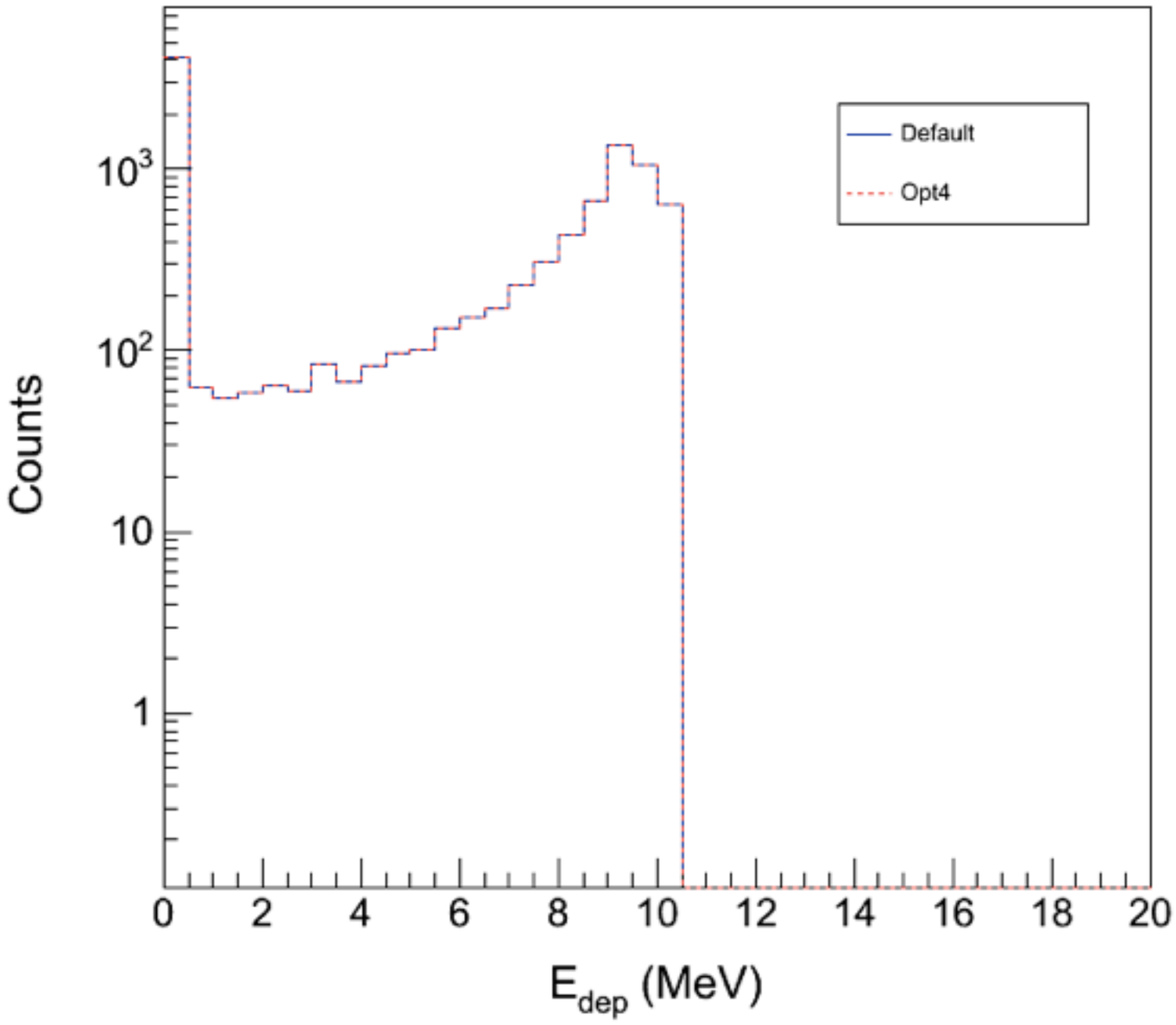
CsI thickness effect on charged particle

<Proton Isotope AMD Generated Events>





Gamma Efficiency

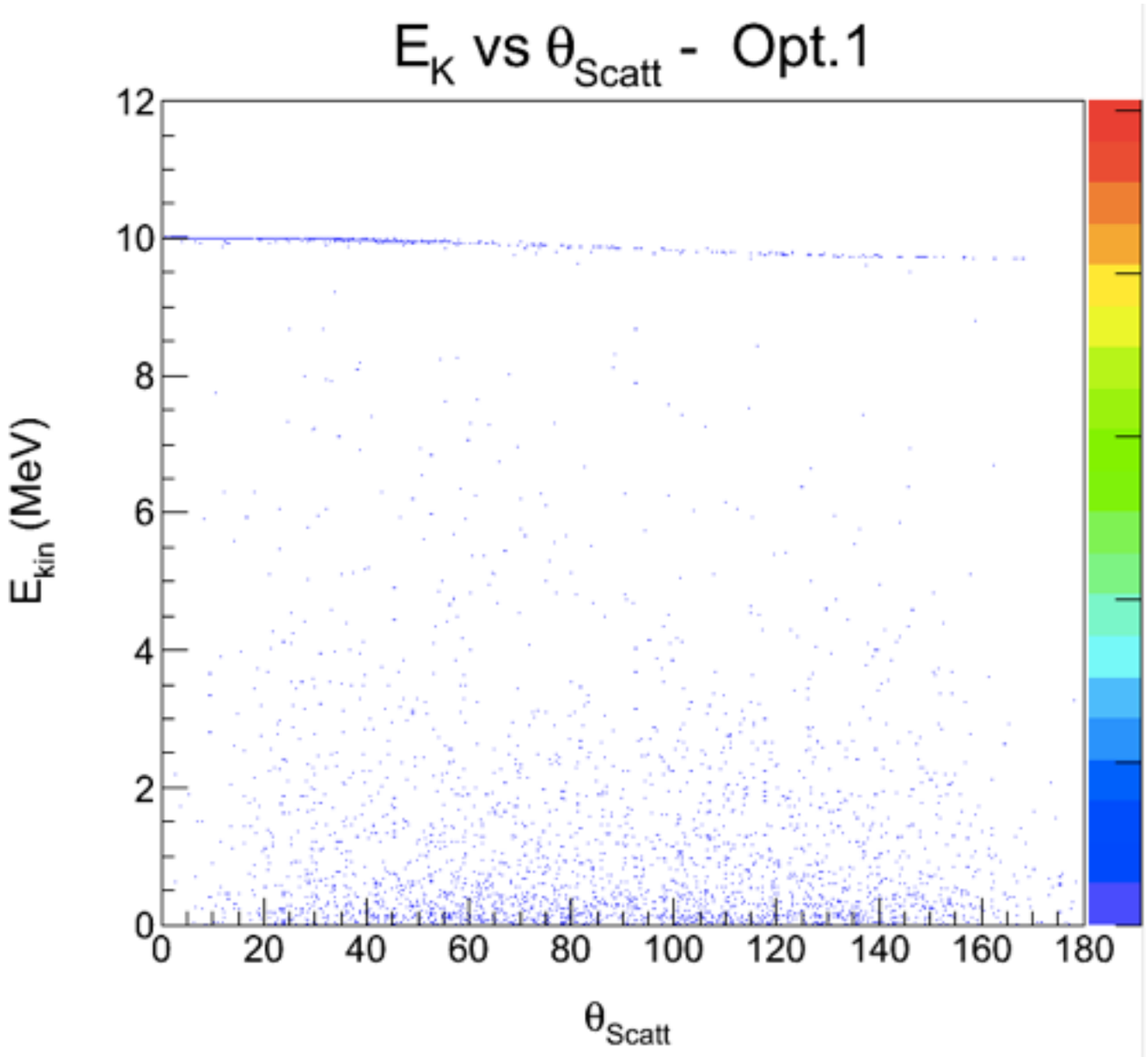


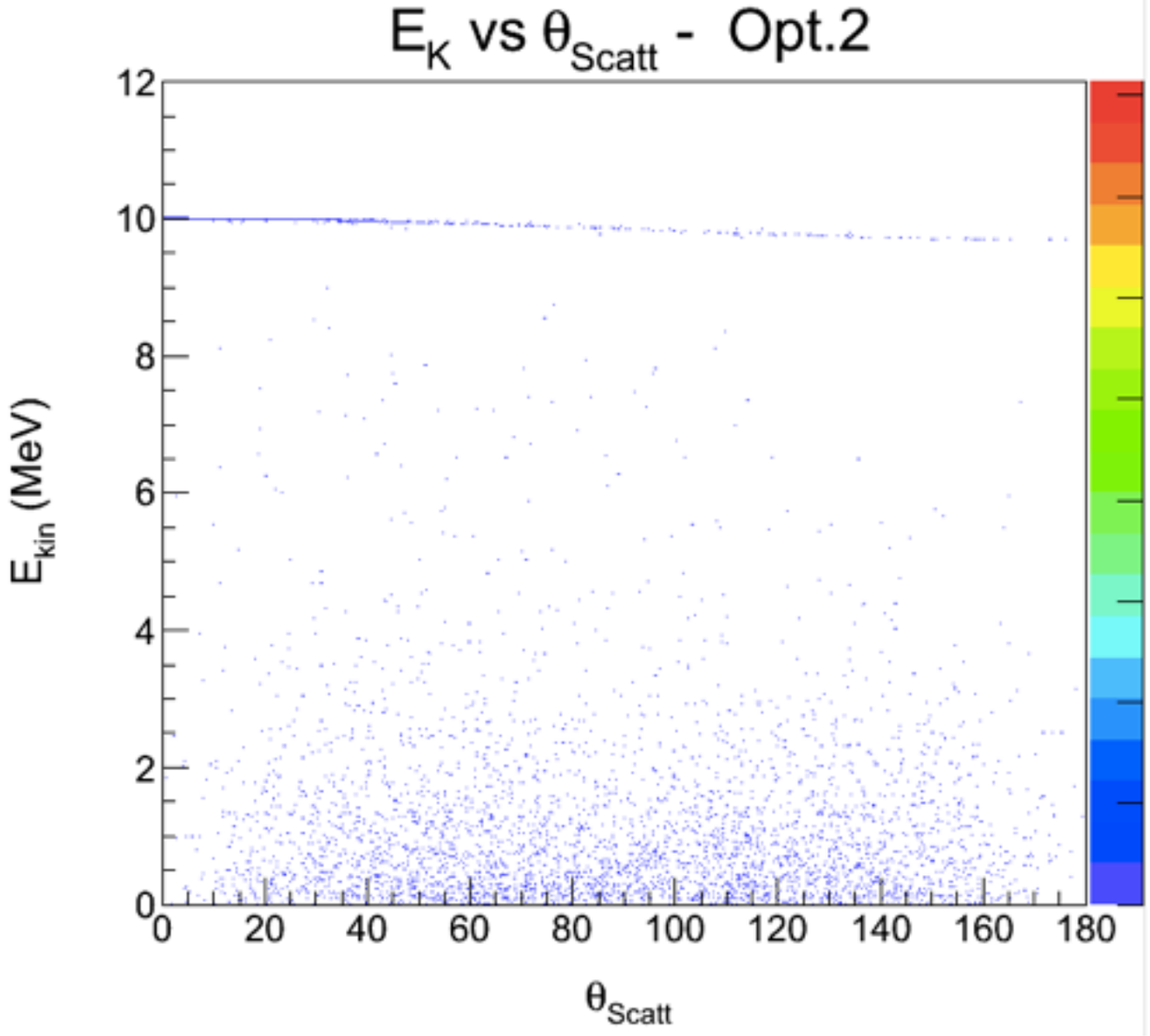
Total

Summary & Plan

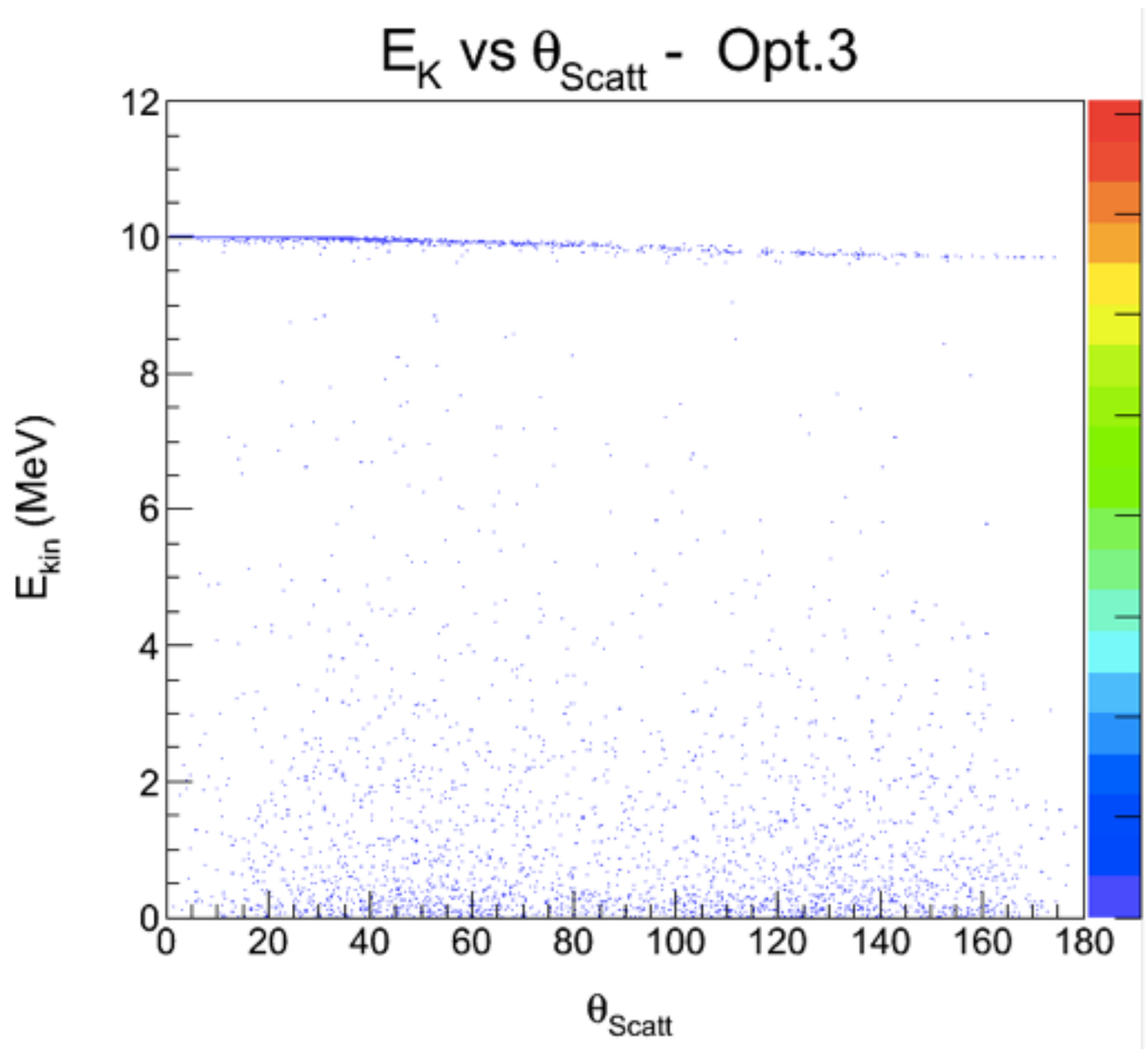
- Charged Particle full absorption check – veto scintillator?
- Background, Efficiency study for scattering neutrons in CsI – Paper? Experiment?

Effect of Si-CsI Detector

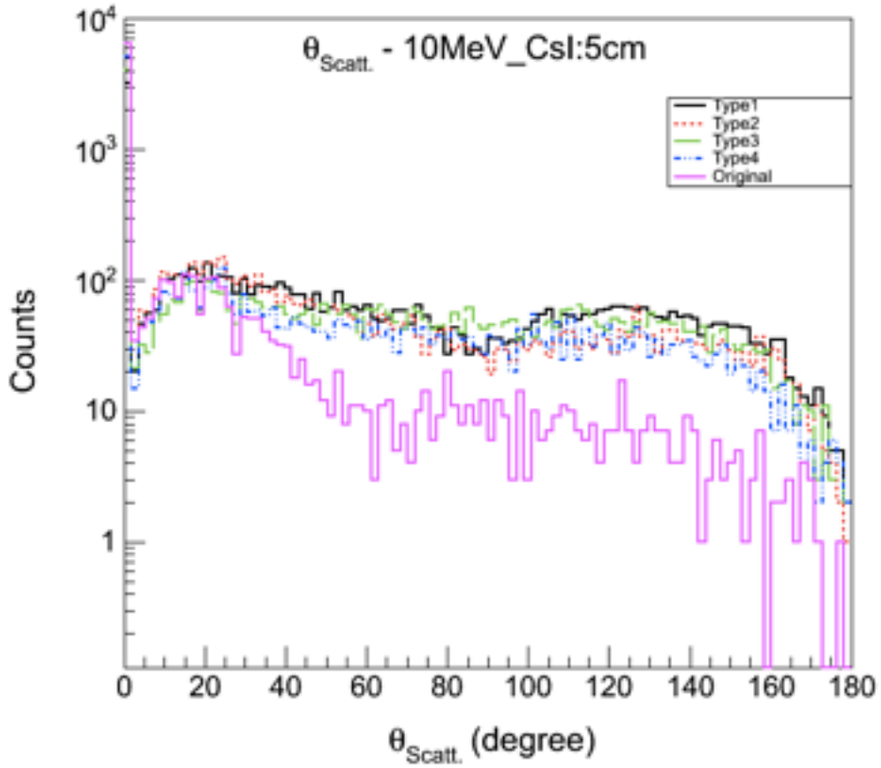


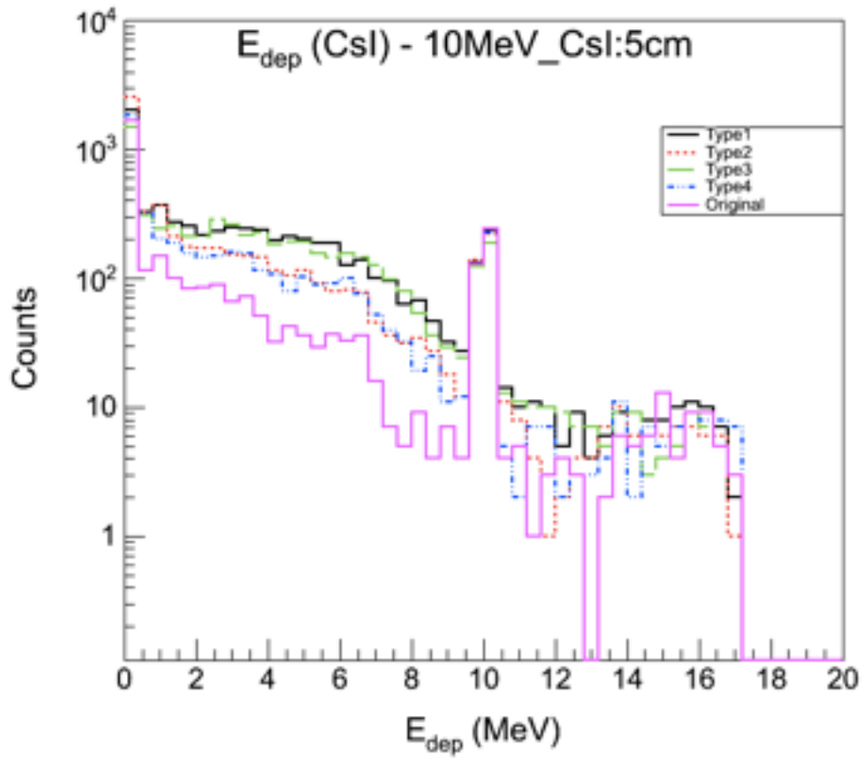


Effect of Si-CsI Detector



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



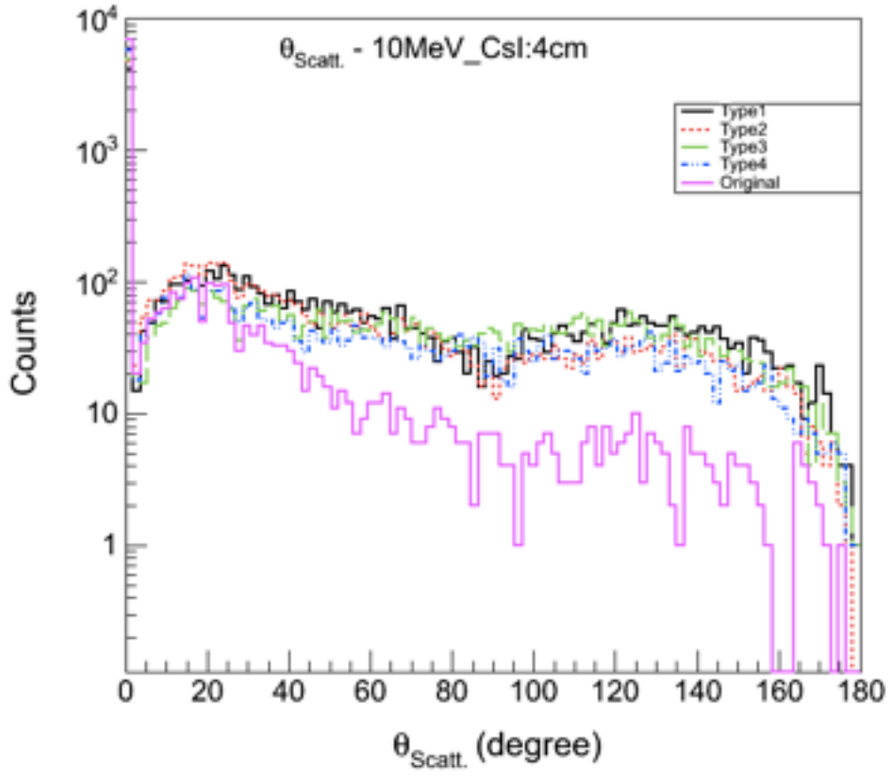


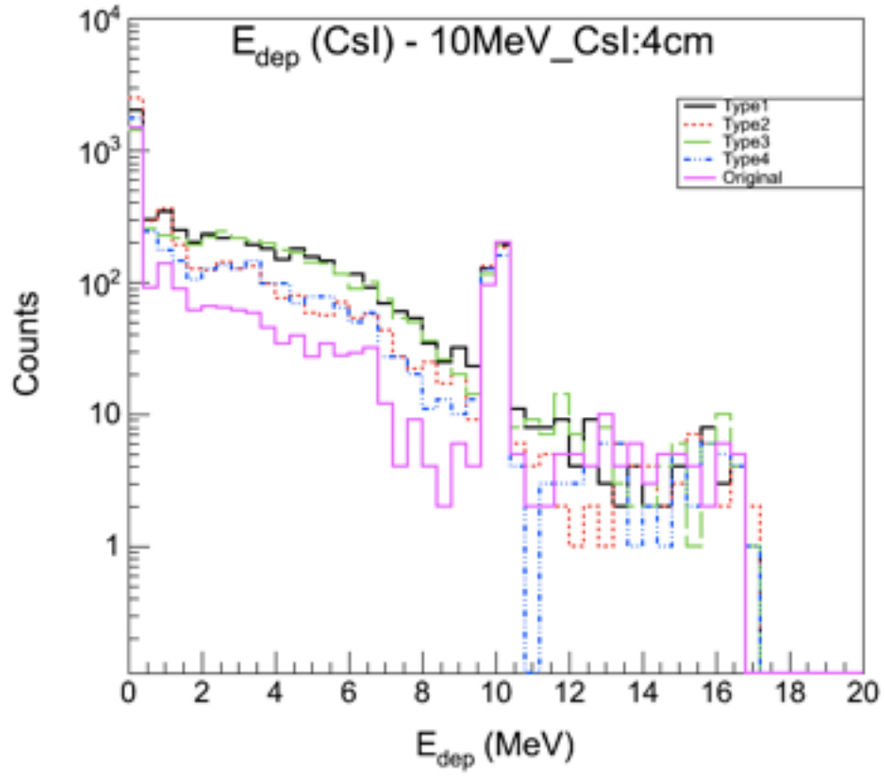
$N_{\theta<10^\circ}$: # of neutron $\theta<10^\circ$
N_{CsIHit} : # of E_{dep} neutrons in CsI
$N_{Edep>1MeV}$: # of E_{dep} > 1MeV in CsI

Type1	Type2
$N_{\theta<10^\circ}$ = 3454 (34.34%)	$N_{\theta<10^\circ}$ = 4368 (43.68%)
N_{CsIHit} = 6620 (66.20%)	N_{CsIHit} = 5752 (57.52%)
$N_{Edep>1MeV}$ = 4077 (40.77%)	$N_{Edep>1MeV}$ = 2681 (26.81%)

Type3	Type4	Original
$N_{\theta<10^\circ}$ = 4231 (42.31%)	$N_{\theta<10^\circ}$ = 5262 (52.62%)	$N_{\theta<10^\circ}$ = 6732 (67.32%)
N_{CsIHit} = 5748 (57.48%)	N_{CsIHit} = 4714 (47.14%)	N_{CsIHit} = 3245 (32.45%)
$N_{Edep>1MeV}$ = 3833 (38.33%)	$N_{Edep>1MeV}$ = 2456 (24.56%)	$N_{Edep>1MeV}$ = 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

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

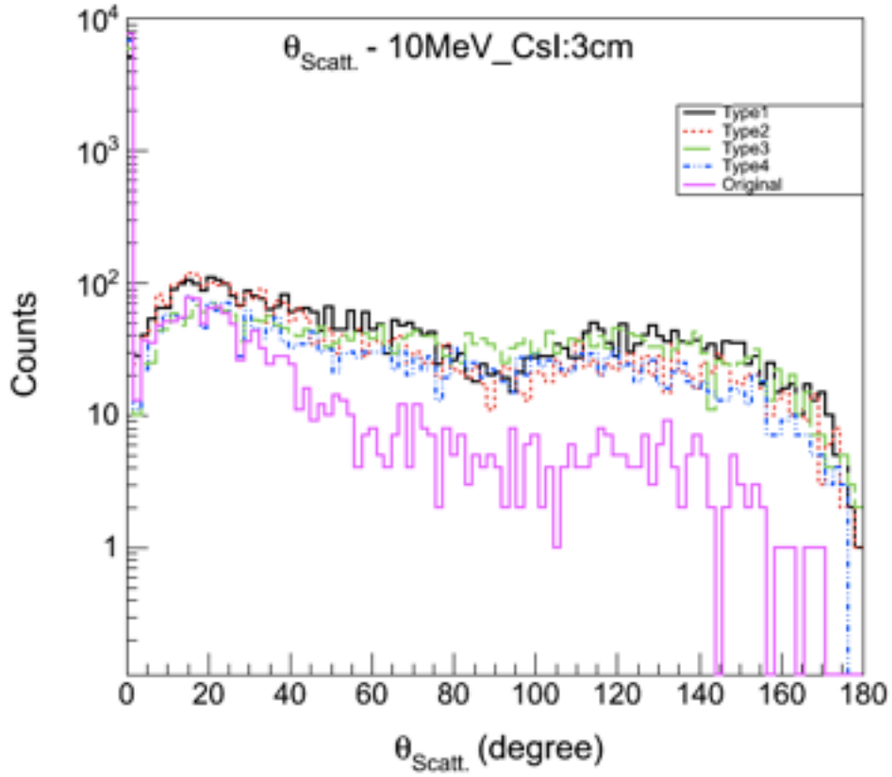
Type2
$N_{\theta<10^\circ}$ = 5067 (50.67%)
N_{CsIHit} = 5035 (50.35%)
$N_{Edep>1MeV}$ = 2081 (20.81%)

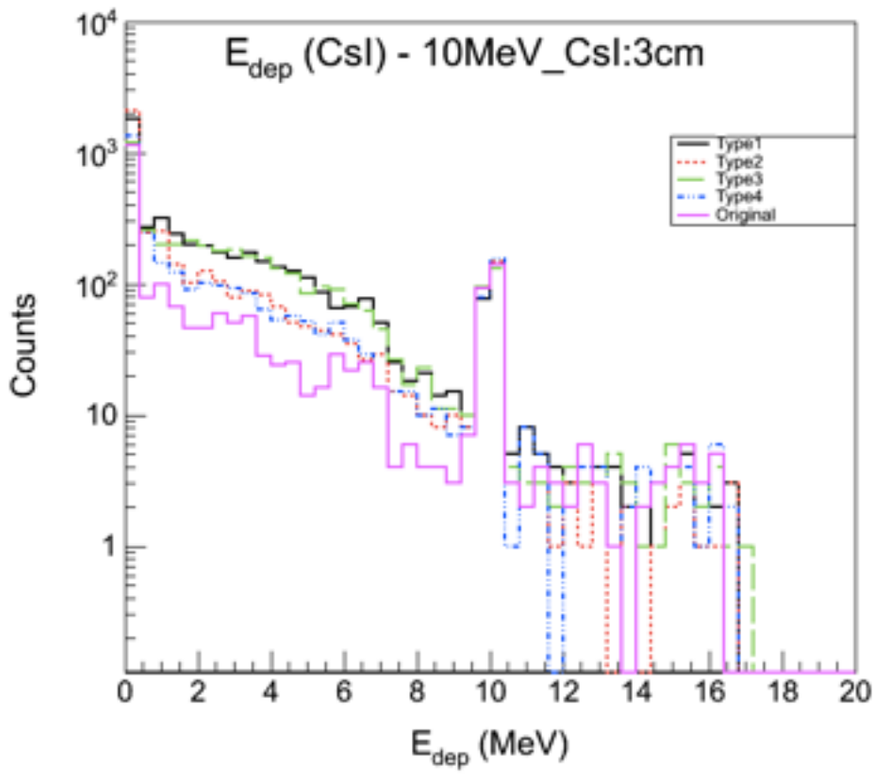
Type3
$N_{\theta<10^\circ}$ = 5000 (50.00%)
N_{CsIHit} = 4985 (49.85%)
$N_{Edep>1MeV}$ = 3205 (32.05%)

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

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_{CsIHit} : # of E_{dep} neutrons in CsI
$N_{Edep>1MeV}$: # of E_{dep} > 1MeV in CsI

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

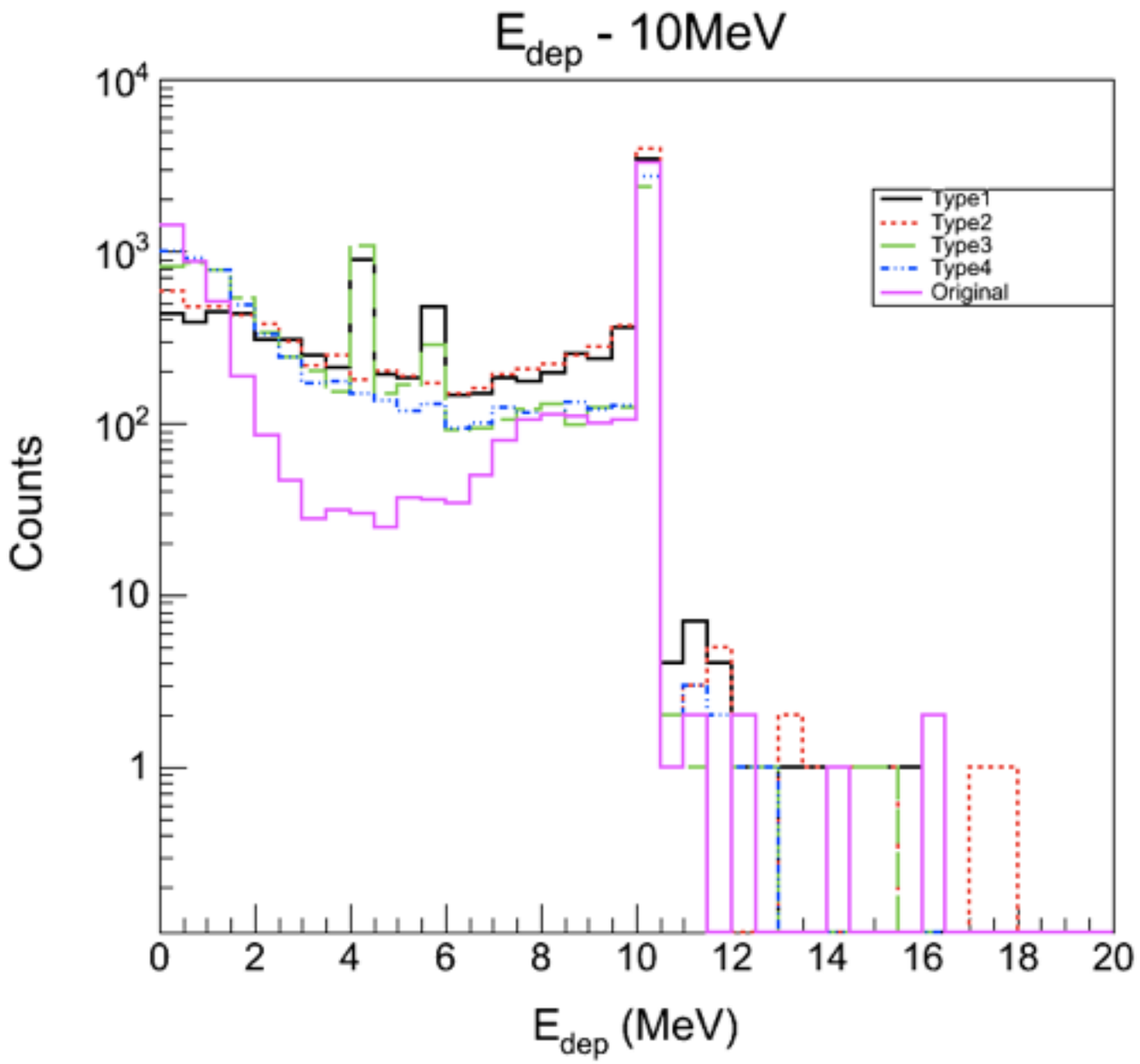
Type2
$N_{\theta<10^\circ}$ = 6089 (60.89%)
N_{CsIHit} = 3992 (39.92%)
$N_{Edep>1MeV}$ = 1507 (15.07%)

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

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

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

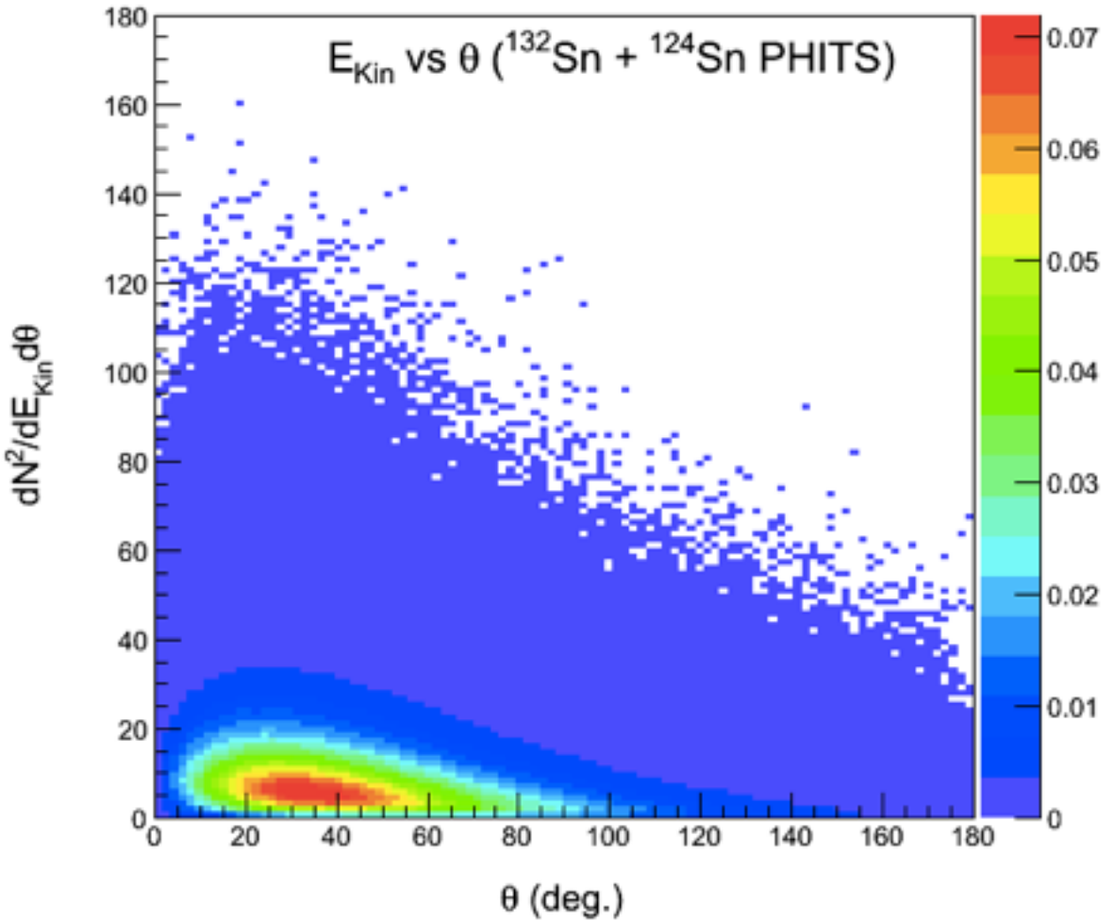
Neutron Scattering Angle in Scint (10MeV, 10000events)

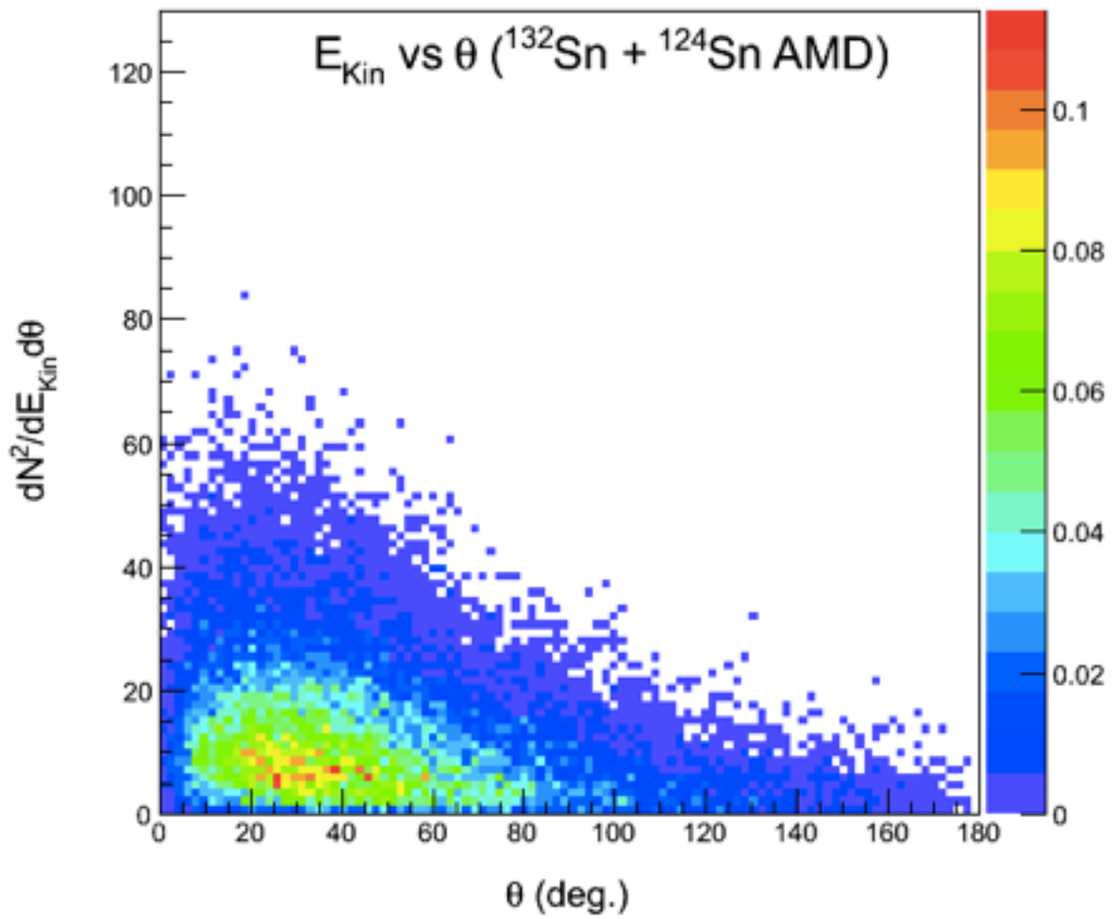


$N_{ScintHit}$: # of E_{dep} neutrons in Scint
N_{Full} : # of E_{dep} > 10MeV (Full absorption)

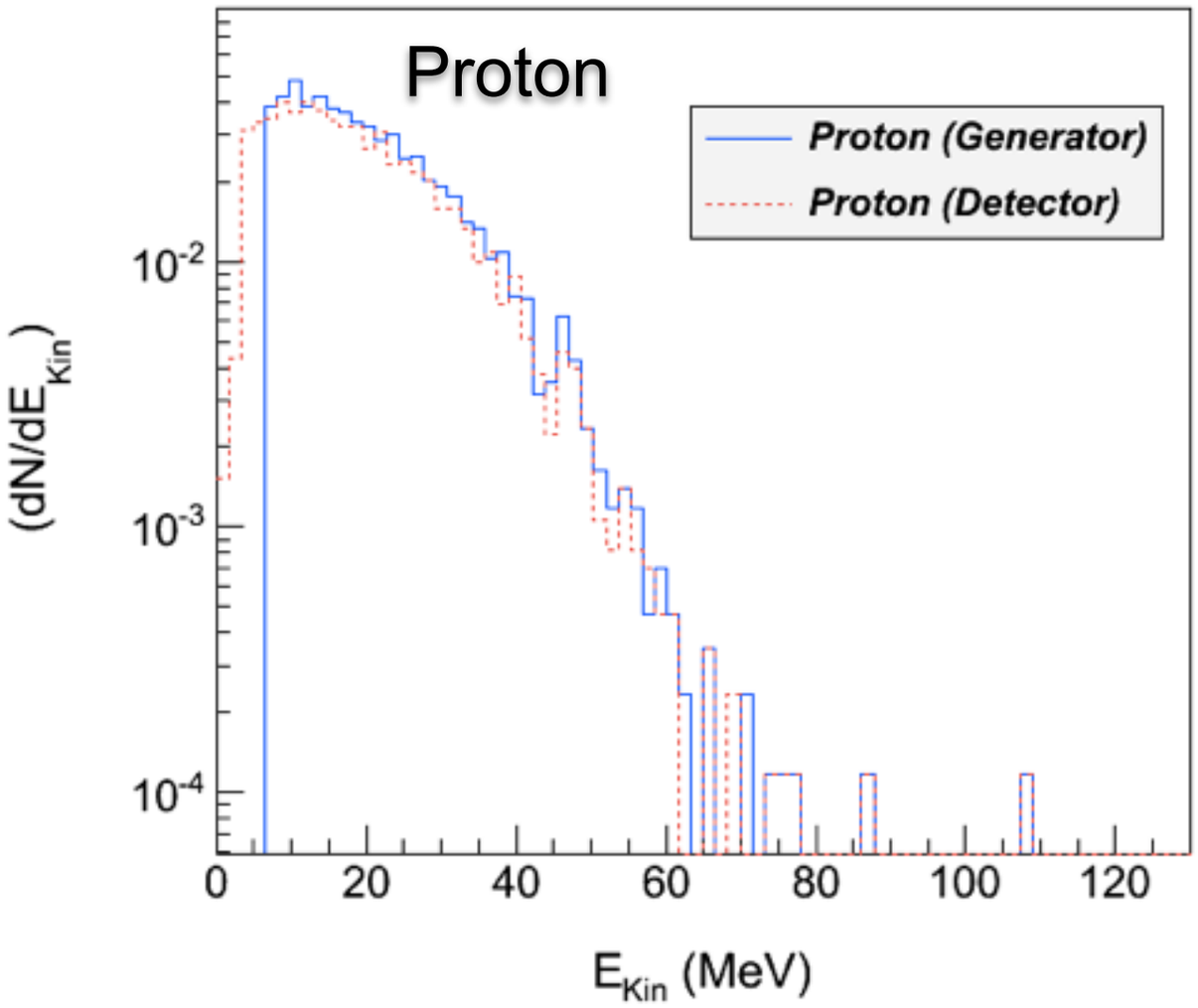
Type1 $N_{ScintHit}$ = 9701 (97.01%) N_{Full} = 3851 (38.51%)	Type2 $N_{ScintHit}$ = 9588 (95.88%) N_{Full} = 4302 (43.02%)
Type3 $N_{ScintHit}$ = 8820 (88.20%) N_{Full} = 2478 (24.78%)	Type4 $N_{ScintHit}$ = 8266 (82.66%) N_{Full} = 2873 (28.73%)
Orginal $N_{ScintHit}$ = 7305 (73.05%) N_{Full} = 3414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

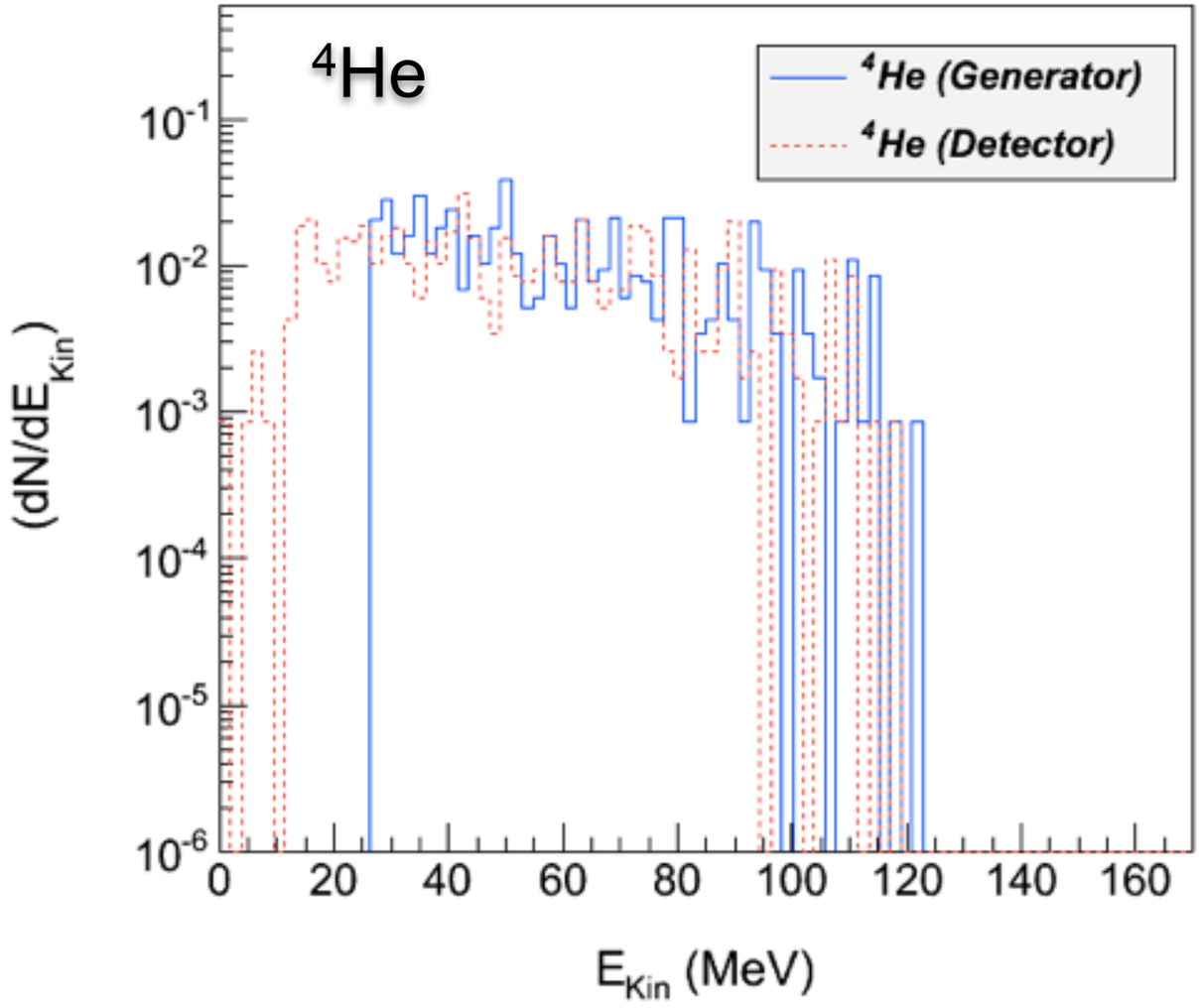
AMD & PHITS Neutron





Kinetic Energy Detector & AMD Generator Events

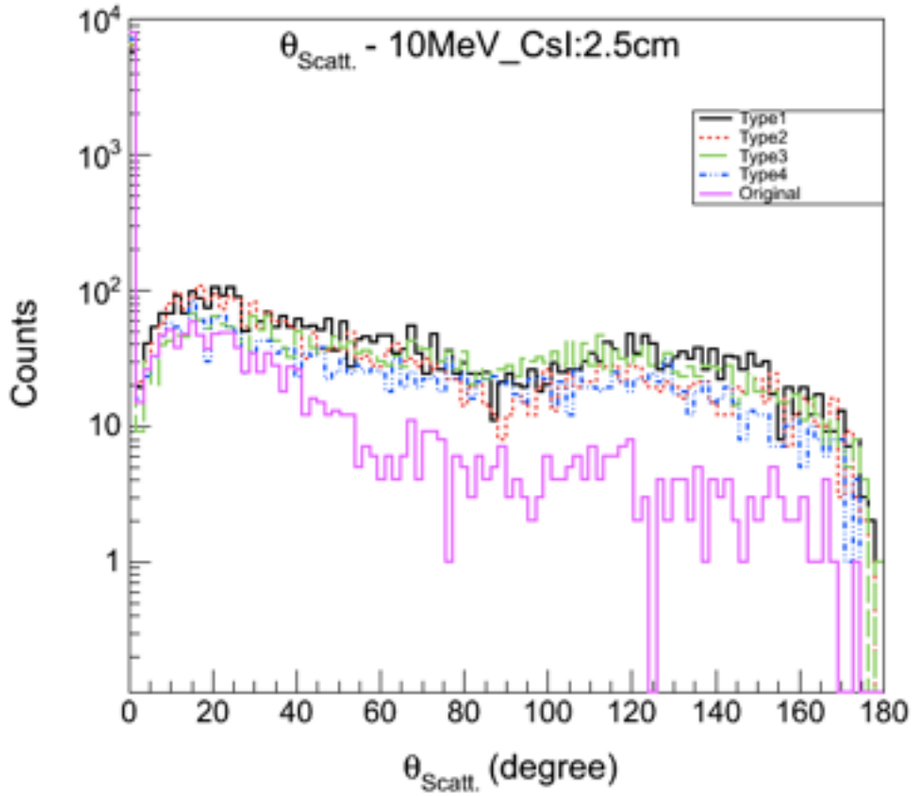


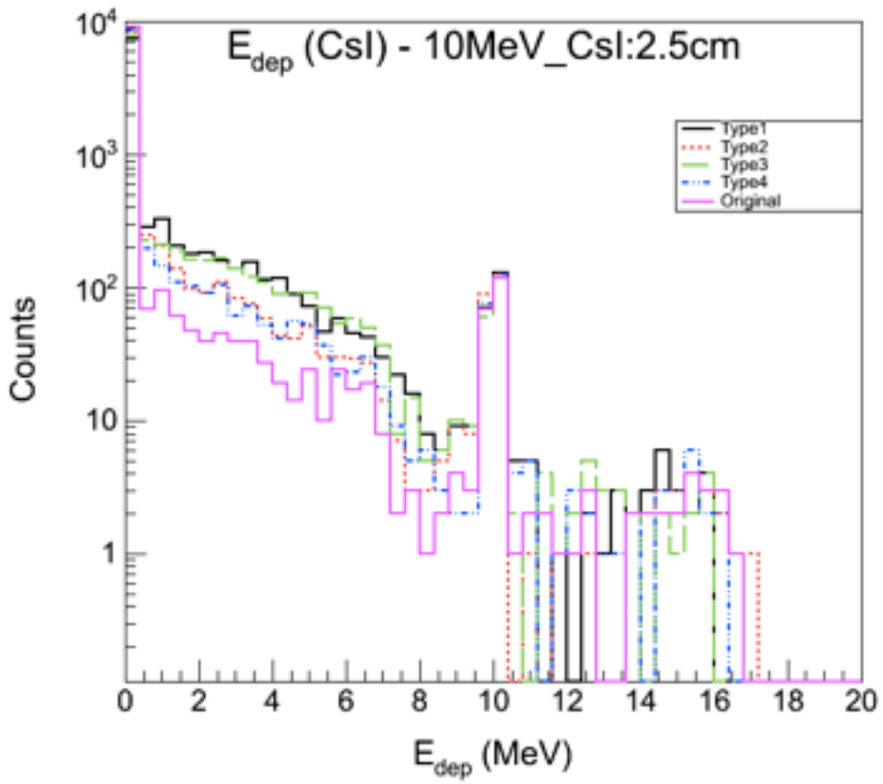


$^{132}Sn+^{124}Sn$ – AMD&PHITS

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

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





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

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

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

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

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

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

: PHITS, **Photons**

$< N_{photon} > = N_{Det} \times R$ (for **CsI Detector)**

S : Area of one detector (**X=√S)**, **r= 40cm** (Distance from target)**,**

N(△θ) : Number of particles per event, **N_Det** : Number of detectors.

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

: PHITS : AMD, **Charged Particles**

$< N_{charged} > = N_{Det} \times R$ (for **Si Detector**)

S : Area of one detector (**X=√S**), **r= 40cm** (Distance from target),

N(△θ) : Number of particles per event, **N_Det** : Number of detectors.

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

$< N_{neutron} > = N_{Det} \times R$ (for **Neutron Detector**)

S : Area of one detector (**X=√S**), **r= 300cm** (Distance from target),

N(△θ) : Number of particles per event, **N_Det** : Number of detectors.

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