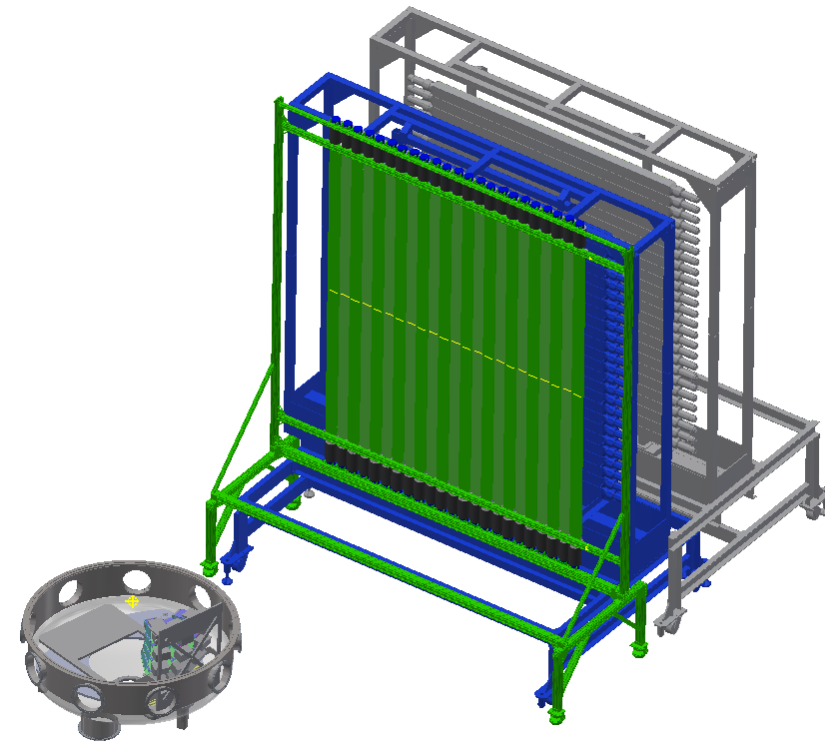
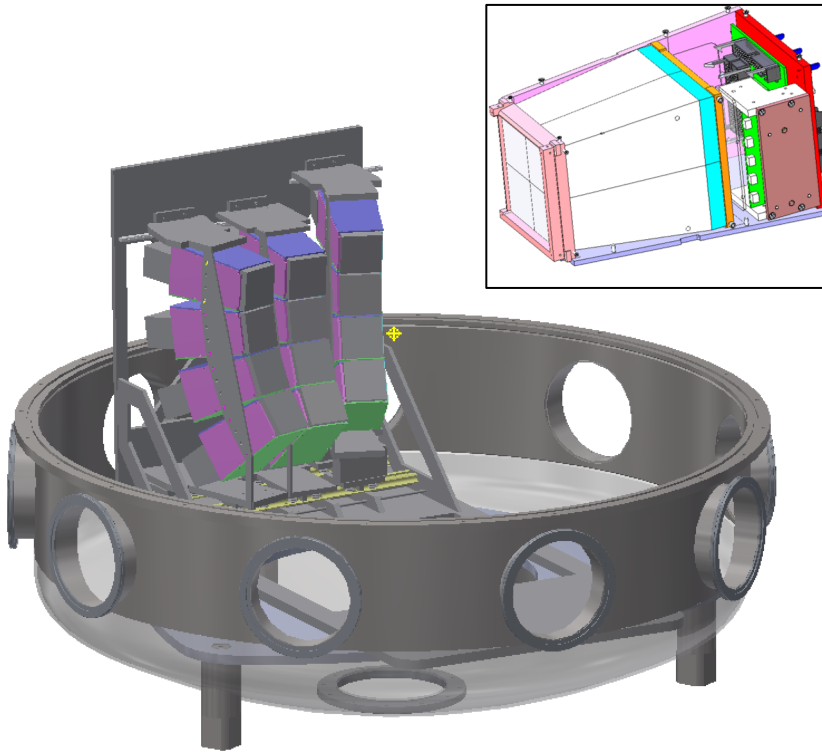


HiRA upgrade to improve constraints on symmetry energy and Δm^*

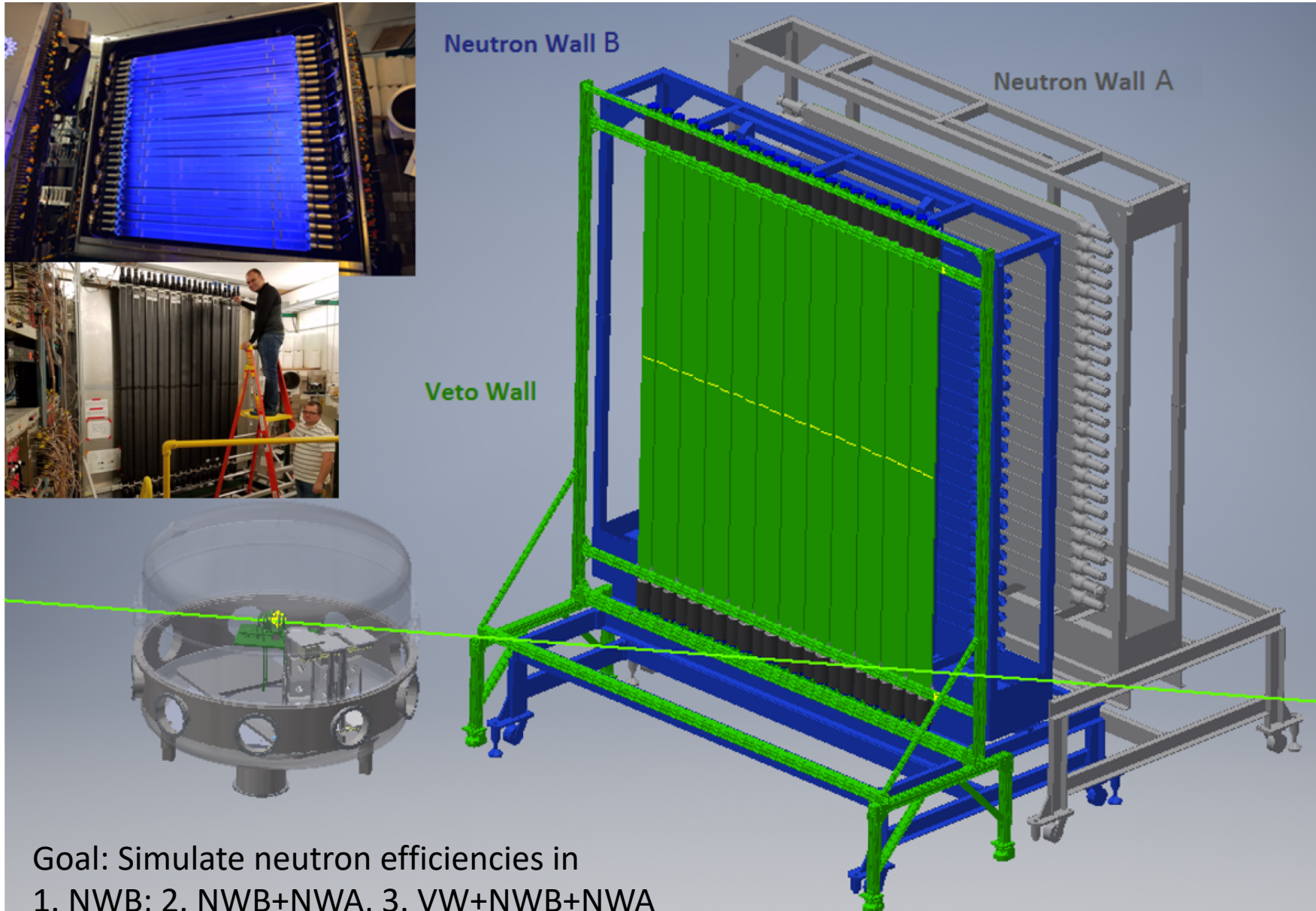
increase CsI from 4 cm to 10 cm;
the mass splitting effects increase
with particle energies.

Install a new charged
particle veto wall in front of
two neutrons walls

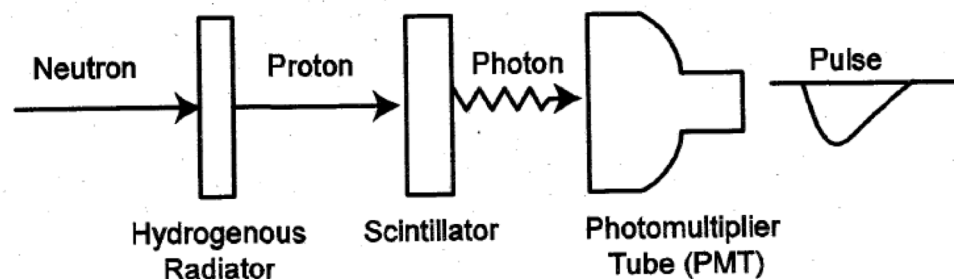


Experiments finished in Feb & March 2018 @ NSCL/MSU

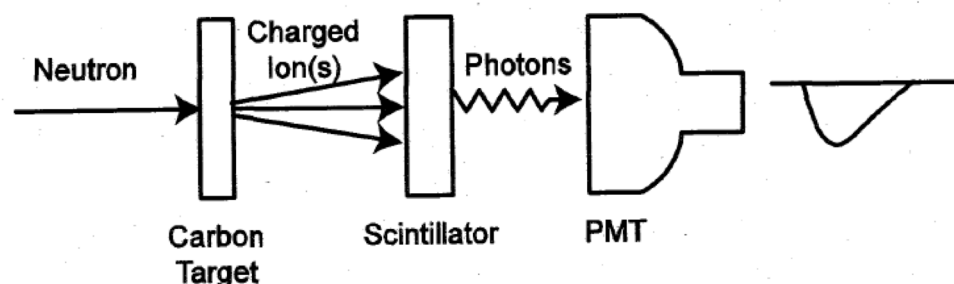
HiRA Veto Wall/Neutron Wall



(a) Proton Recoil:



(b) Interaction with Carbon:



(c) Combined

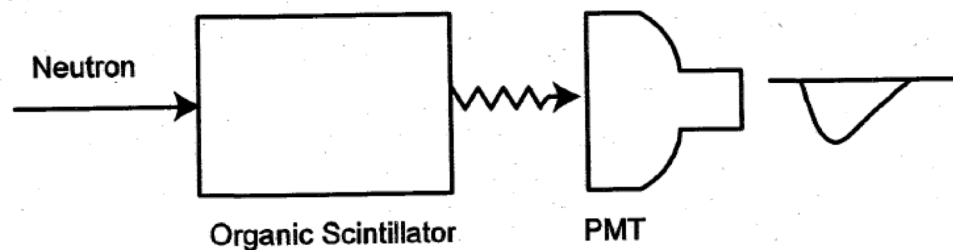
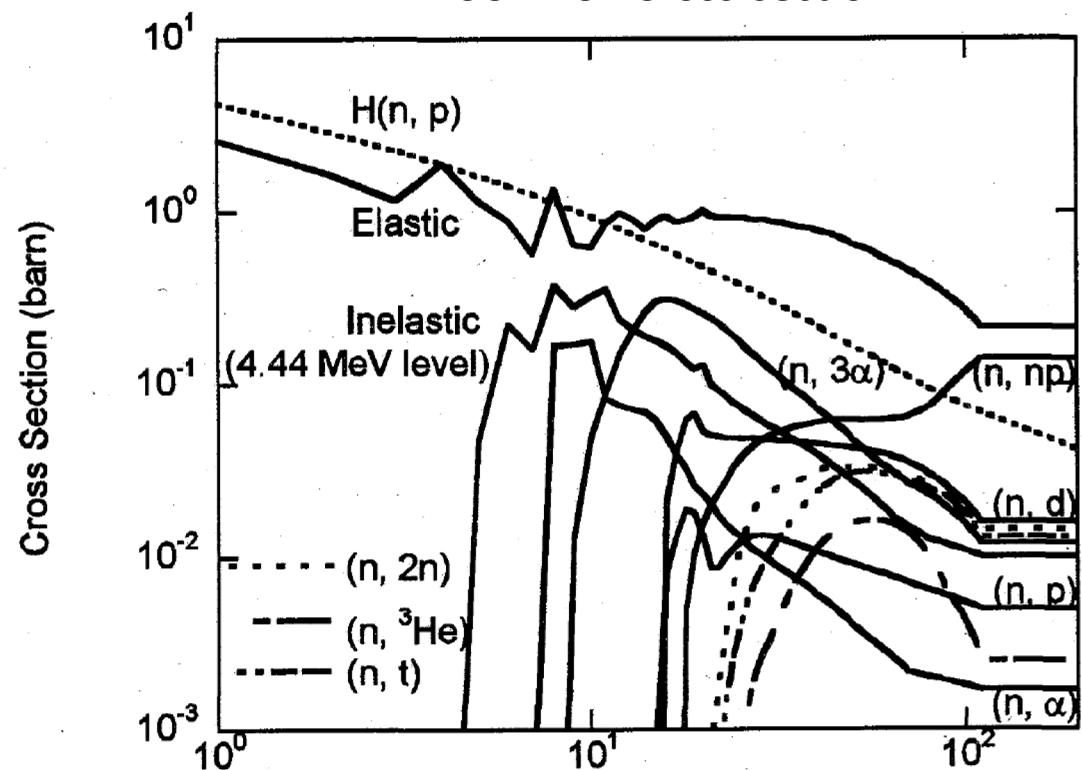


Figure 1. Schematic illustration of neutron detection. This figure is cited from Ref. 1

SCINFUL Cross-section



The signals mainly generated from neutron detector come from scattered hydrogen.

Not only from hydrogen, charged ions(proton, deuteron, triton, alpha) from inelastic scattering with carbon make signals.

Organic scintillator(neutron detector) is combined one.

Strategies

Extend Spanish G4 to $E_n > 20$ MeV up to 100 MeV

Proposed Improvement in G4

1. Incorporate SCINFUL light function
2. Incorporate SCINFUL cross-sections
3. Incorporate sequential decays

Progress:

1. Reproduce G4 results in NIM article
2. Incorporate SCINFUL light functions of p,d, α , add t and ^3He
3. Incorporate SCINFUL cross-sections
4. Incorporate sequential decays

Strategies

Extend Spanish G4 to $E_n > 20$ MeV up to 100 MeV

Proposed Improvement in G4

1. Incorporate SCINFUL light function
2. Incorporate SCINFUL cross-sections
3. Incorporate sequential decays

Progress:

1. Reproduce G4 results in NIM article
2. Incorporate SCINFUL light functions of p, d, α , add t and ^3He
3. Incorporate SCINFUL cross-sections
4. Incorporate sequential decays

Limited to $E_n < 20$ MeV

Nuclear Inst. and Methods in Physics Research, A 868 (2017) 73–81



Contents lists available at ScienceDirect

Nuclear Inst. and Methods in Physics Research, A

journal homepage: www.elsevier.com/locate/nima



New physics model in GEANT4 for the simulation of neutron interactions with organic scintillation detectors

A.R. Garcia^a, E. Mendoza^a, D. Cano-Ott^{a,*}, R. Nolte^b, T. Martinez^a, A. Algora^{c,d}, J.L. Tain^c, K. Banerjee^e, C. Bhattacharya^e

^a Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), Avenida Complutense 40, Madrid 28040, Spain

^b Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, Braunschweig D-38116, Germany

^c Instituto de Física Corpuscular (IFIC), CSIC–Universidad de Valencia, Valencia 46071, Spain

^d Institute of Nuclear Research of the Hungarian Academy of Sciences (ATOMKI), Debrecen H-4026, Hungary

^e Variable Energy Cyclotron Centre (VECC), 1/AF, Bidhannagar, Kolkata 700064, India

ARTICLE INFO

Keywords:

Organic scintillator
Neutron detectors
GEANT4
BC501A

ABSTRACT

The accurate determination of the response function of organic scintillation neutron detectors complements their experimental characterization. Monte Carlo simulations with GEANT4 can reduce the effort and cost implied, especially for complex detection systems for which the characterization is more challenging. Previous studies have reported on the inaccuracy of GEANT4 in the calculation of the neutron response of organic scintillation

Export PDF

Adobe Export PDF

Convert PDF Files to Word or Excel Online

Select PDF File

Spanish_NIMA.pdf

Convert to

Microsoft Word (*.docx)

Document Language:
English (U.S.) [Change](#)

Convert

Create PDF

Edit PDF

Comment

Fill & Sign

Send for Signature

Send & Track

More Tools

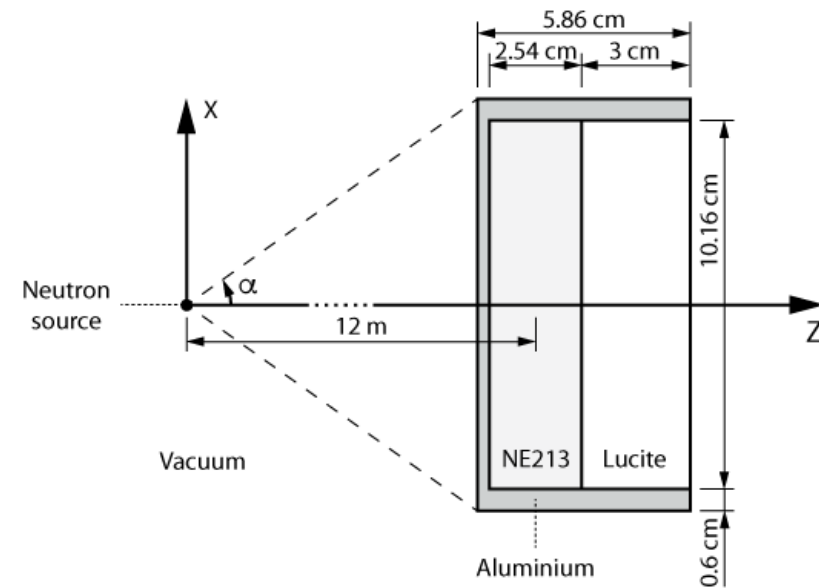
Store and share files in the
Document Cloud

[Learn More](#)

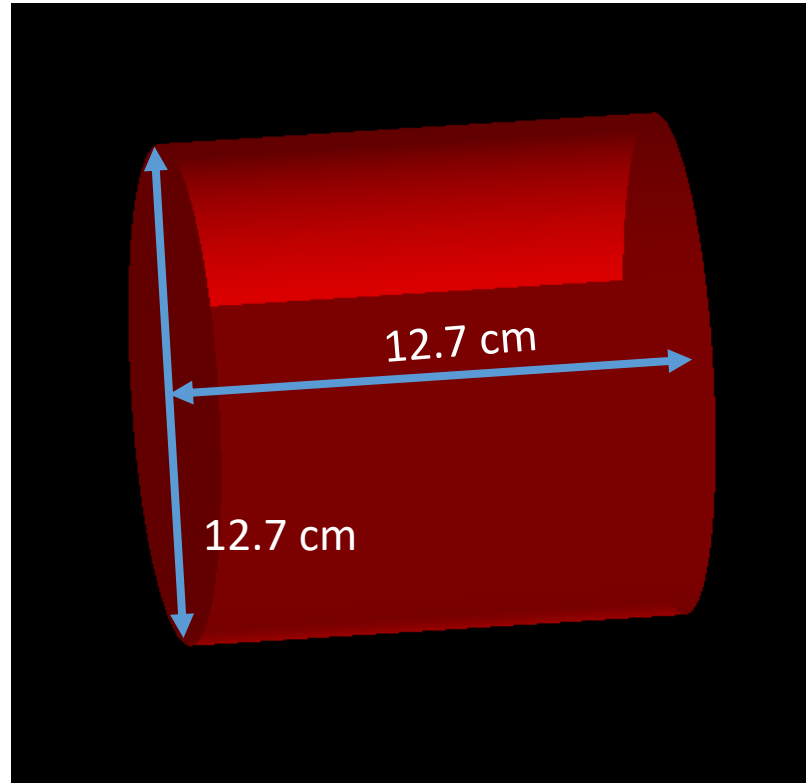
Geometries

SCINFUL geometry

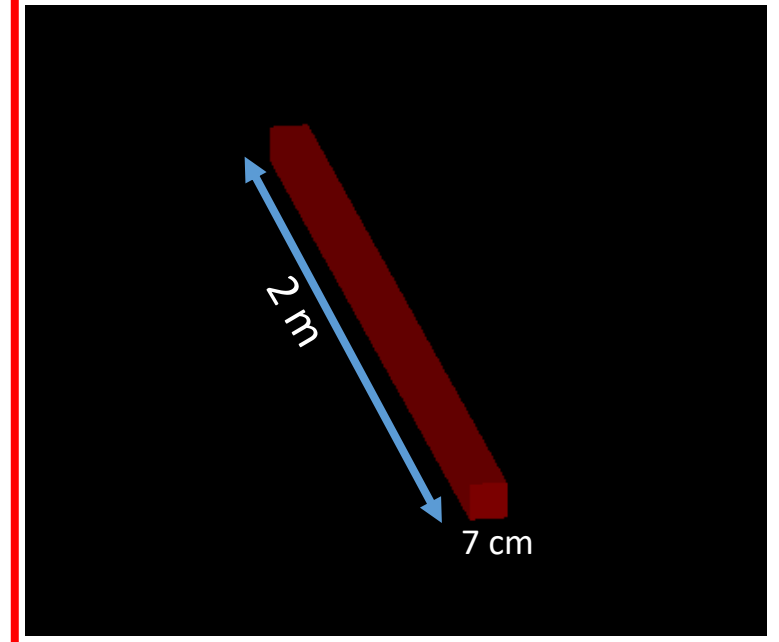
NIM geometry



The thickness of SCINFUL is 5 times as much as NIM.

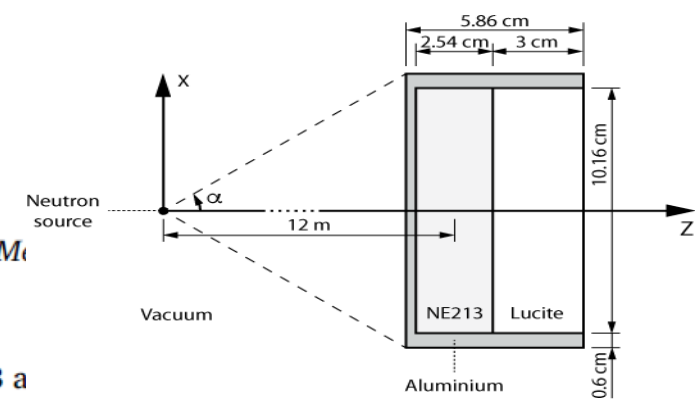


A bar of NW geometry



SCINFUL can only produce cylinder type of detector!

Reaction list in GEANT4



A.R. Garcia et al.

Table 1

Neutron-induced reactions on carbon between 0 and 20 MeV in NRESP7.1 [2]. The lowest excited states of ^{12}C denoted by L1, L2 and L3 a pseudo-states that represent groups of well-defined states at higher excitation energies.

Reaction	Q_I (MeV) [*]	Threshold (MeV)	Cross section	Angular distribution
$^{12}\text{C}(n,n)^{12}\text{C}$	0	0	ENDF/B-VI [8,9]	ENDF/B-VI [8]
$^{12}\text{C}(n,n')^{12}\text{C}^*(\text{L1})$	-4.439	4.81	ENDF/B-VI [8,9]	ENDF/B-VI [8,9]
$^{12}\text{C}(n,\alpha)^9\text{Be}$	-5.71	6.19	PTB [10,11]	PTB [10,11]
$^{12}\text{C}(n,\alpha)^9\text{Be}^* \rightarrow n + ^8\text{Be} \rightarrow 2\alpha$	-8.13	8.81	PTB	Isotropic ^{**}
$^{12}\text{C}(n,n')^{12}\text{C}^*(\text{L2}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	-7.653	8.29	PTB	Isotropic ^{**}
$^{12}\text{C}(n,n')^{12}\text{C}^*(\text{L3}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	-9.63	10.43	PTB	Isotropic ^{**}
$^{12}\text{C}(n,n')^{12}\text{C}^*(\text{L4}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	-10.8	11.70	PTB	Isotropic ^{**}
$^{12}\text{C}(n,n')^{12}\text{C}^*(\text{L5}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	-11.8	12.78	PTB	Isotropic ^{**}
$^{12}\text{C}(n,n')^{12}\text{C}^*(\text{L6}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	-12.7	13.76	PTB	Isotropic ^{**}
$^{12}\text{C}(n,n')^{12}\text{C}^*(\text{L7}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	-14	15.17	PTB	Isotropic ^{**}
$^{12}\text{C}(n,n')^{12}\text{C}^*(\text{L8}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	-15	16.25	PTB	Isotropic ^{**}
$^{12}\text{C}(n,n')^{12}\text{C}^*(\text{L9}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	-16	17.33	PTB	Isotropic ^{**}
$^{12}\text{C}(n,n')^{12}\text{C}^*(\text{L10}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	-17	18.42	PTB	Isotropic ^{**}
$^{12}\text{C}(n,p)^{12}\text{B}$	-12.59	13.7	ENDF/B-VI [8,9]	Isotropic ^{**}
$^{12}\text{C}(n,d)^{11}\text{B}$	-13.731	14.9	ENDF/B-VI [8,9]	Isotropic ^{**}

^{*} Q-value for the energy state of the residual nucleus (intermediate nucleus for multistep breakup reactions) [12].

^{**} Referred to the center-of-mass system.

SCINFUL Light Output Function

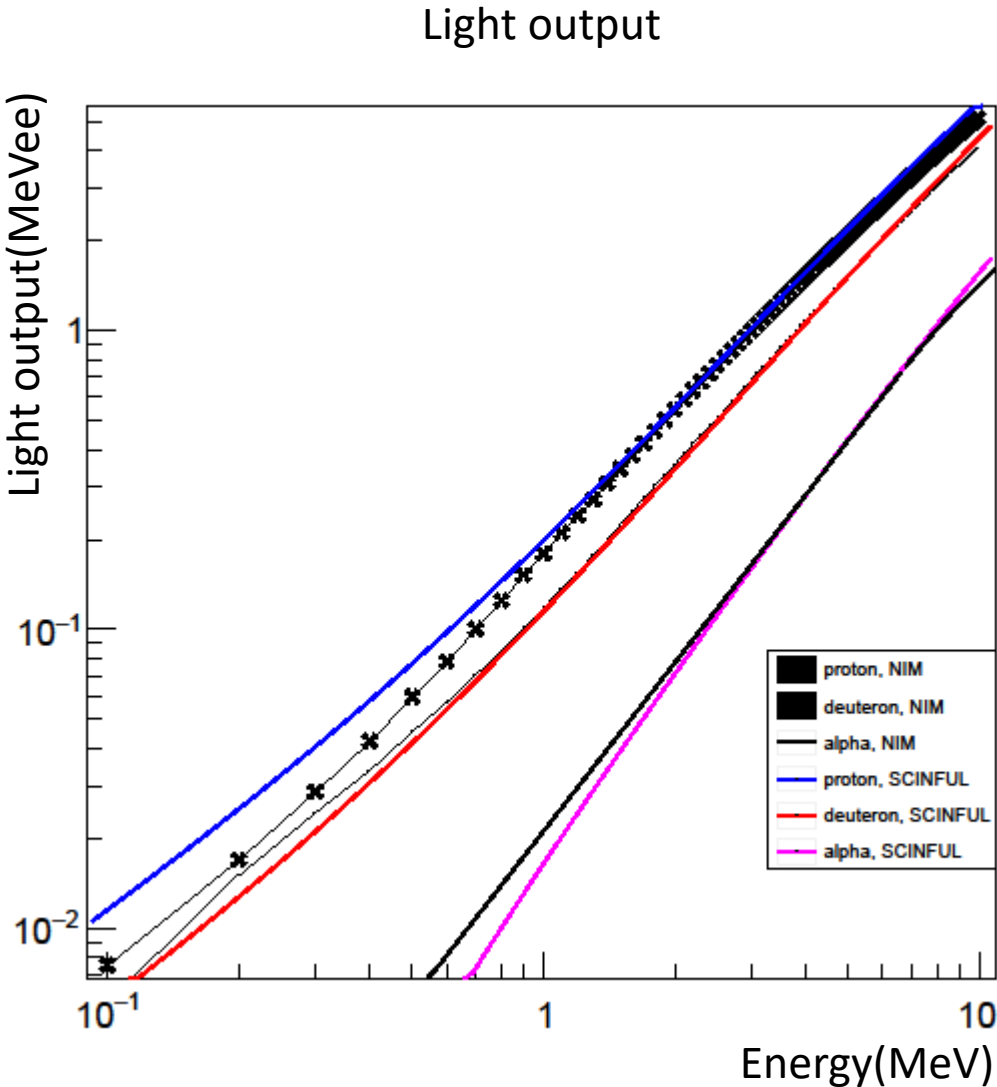
$$L = a_1 E - a_2 \{ 1.0 - \exp(-a_3 E) \}$$

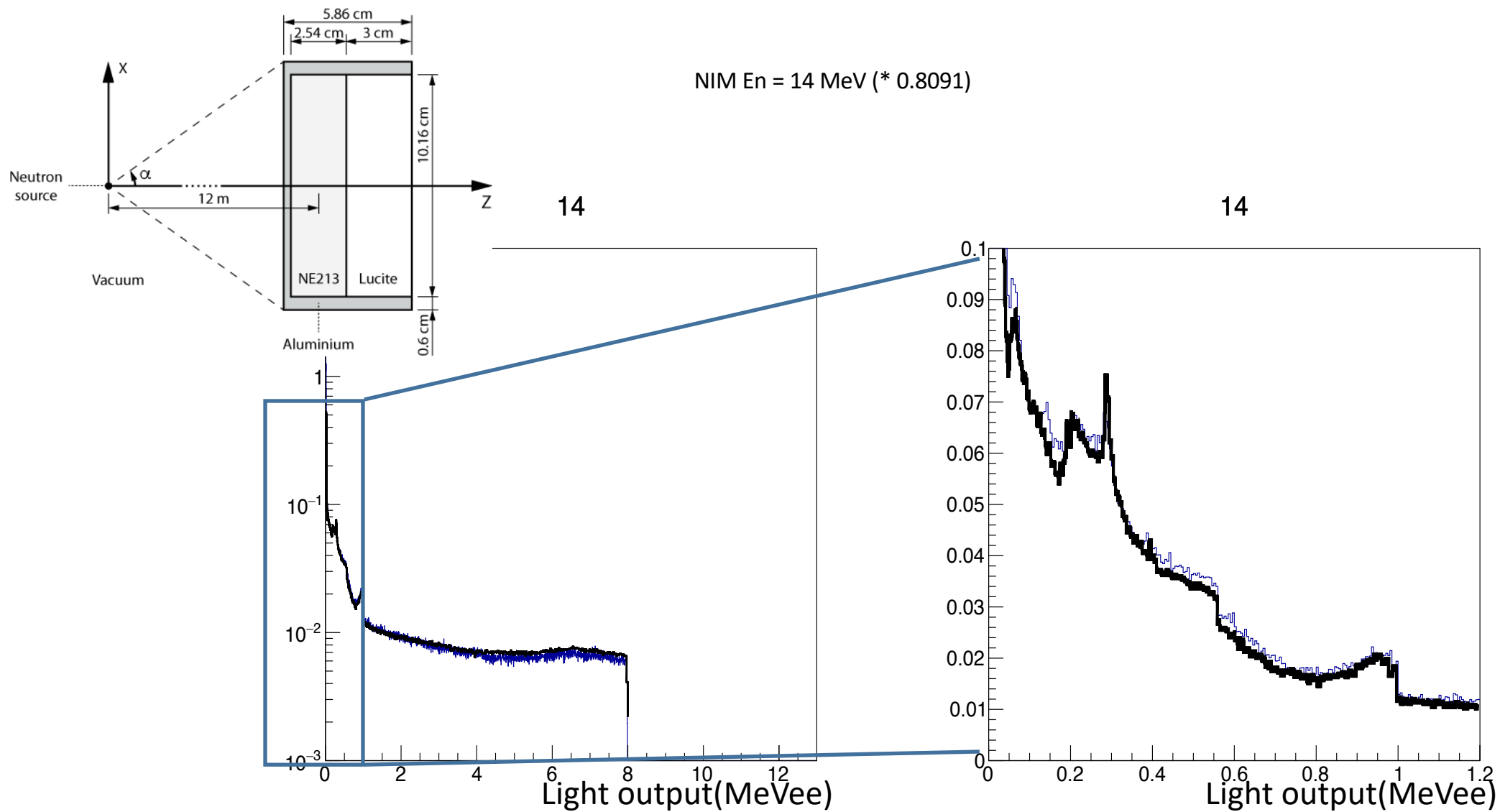
Table 1. Coefficients in Equation (1) for proton, deuteron, triton, ³He nucleus and alpha particle.

Particle	Coefficient		
	a ₁	a ₂	a ₃
p	0.81	2.43	0.29
d	0.74	3.45	0.20
t	0.72	7.19	0.07
³ He	0.54	3.97	0.20
α	0.51	6.42	0.08

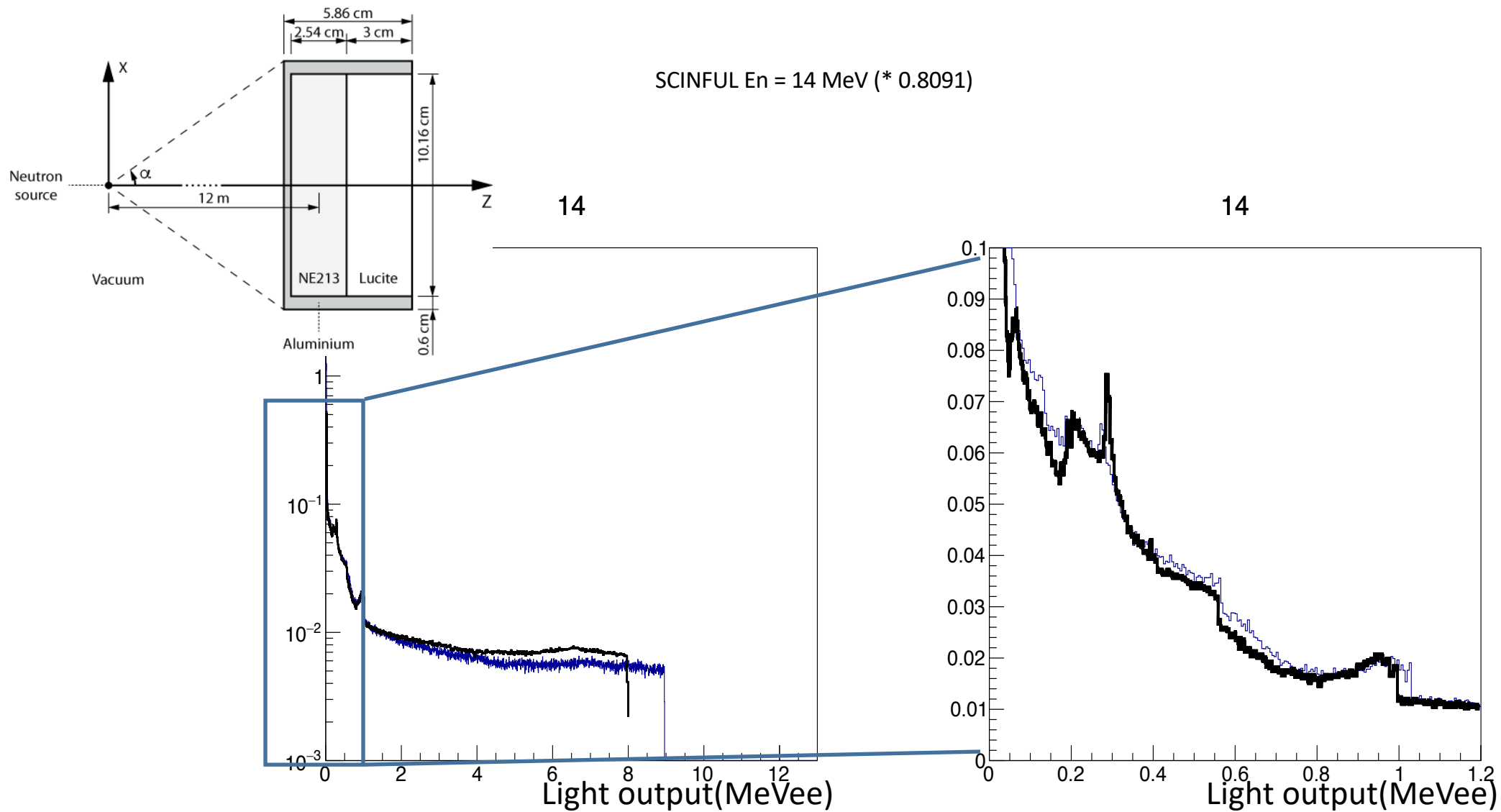
NIM Light Output Function

$$L_p(E_p) = -1.41945 + 0.6719 E_p \qquad E_p \geq 8 \text{ MeV}$$
$$L_d(E_d) = 2 L_p(0.5 E_d)$$
$$L_\alpha(E_\alpha) = \begin{cases} 0.0211 E_\alpha^{1.8712} & E_\alpha < 6.76 \text{ MeV} \\ -0.65665 + 0.20864 E_\alpha & E_\alpha \geq 6.76 \text{ MeV} \end{cases}$$
$$L_{Be}(E_{Be}) = 0.01 E_{Be}$$
$$L_{B,C}(E_{B,C}) = 0.007 E_{B,C}$$





Black line is digitized from NIM article



Black line is digitized from NIM article

Same data, but **SCINFUL light output** calculation

Strategies

Extend Spanish G4 to $E_n > 20$ MeV up to 100 MeV

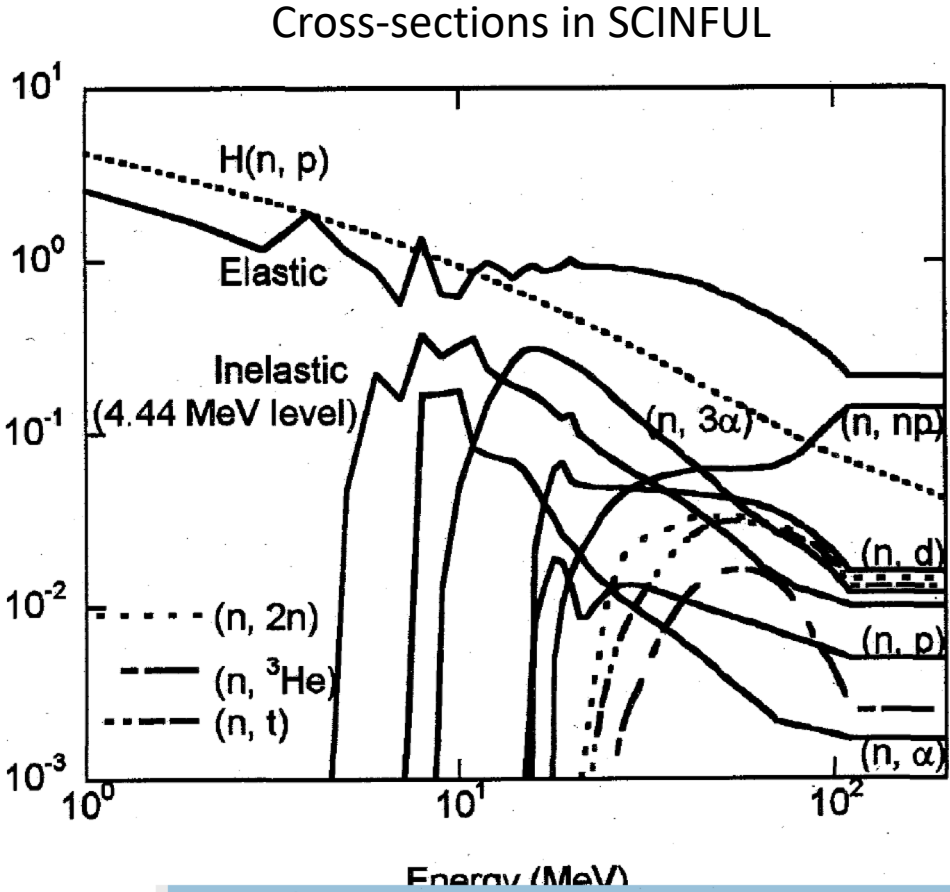
Proposed Improvement in G4

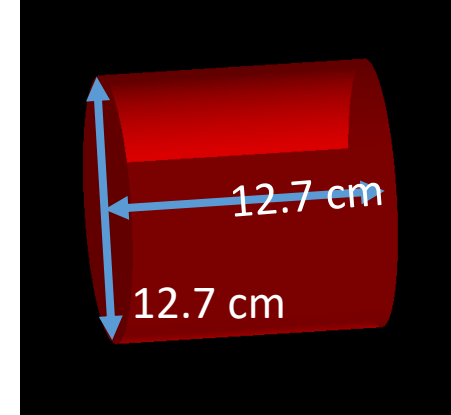
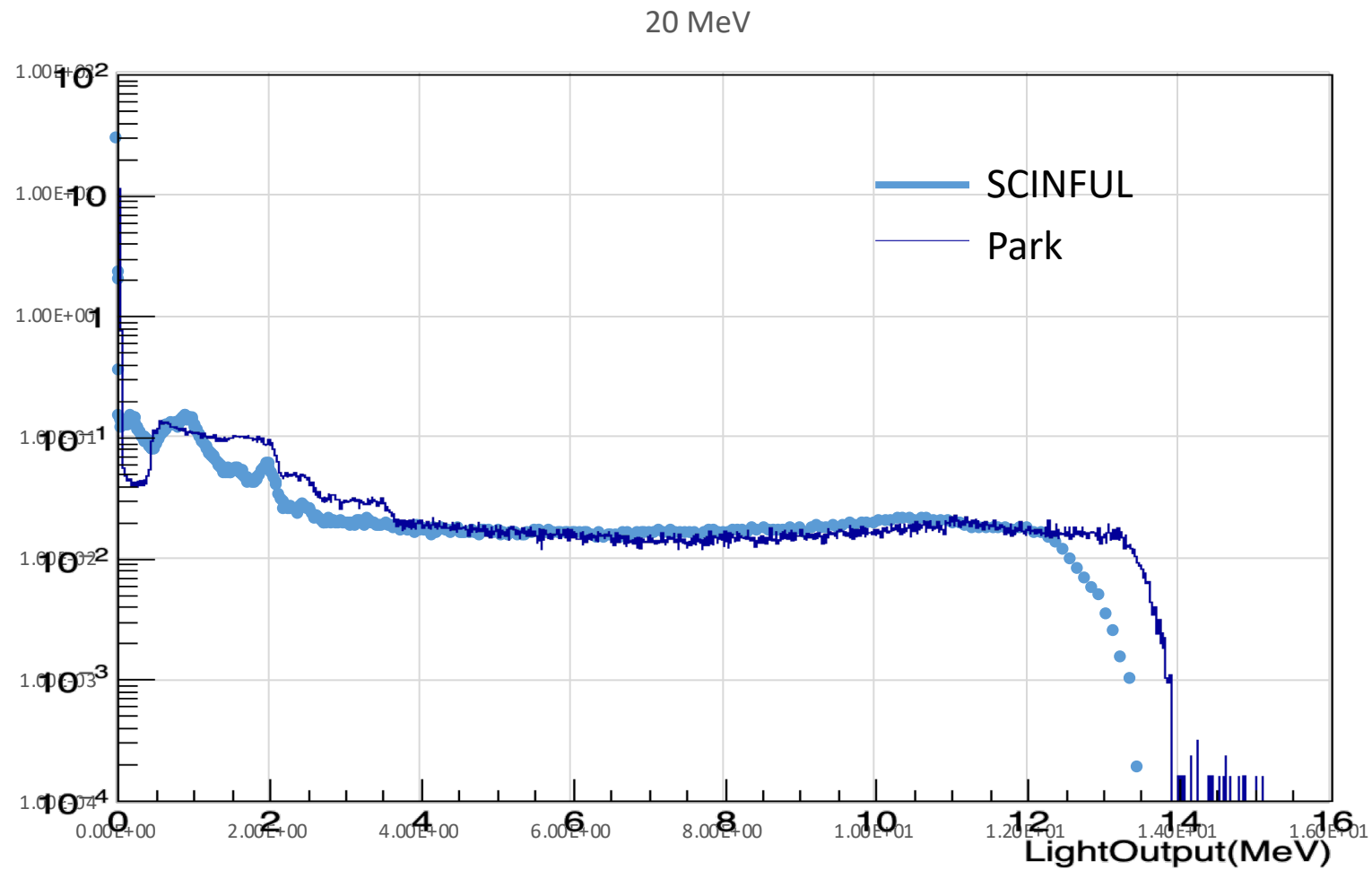
1. Incorporate SCINFUL light function
2. Incorporate SCINFUL cross-sections
3. Incorporate sequential decays

Progress:

1. Reproduce G4 results in NIM article
2. Incorporate SCINFUL light functions of p,d, α , add t and ^3He - done
3. Incorporate SCINFUL cross-sections – in progress
4. Incorporate sequential decays

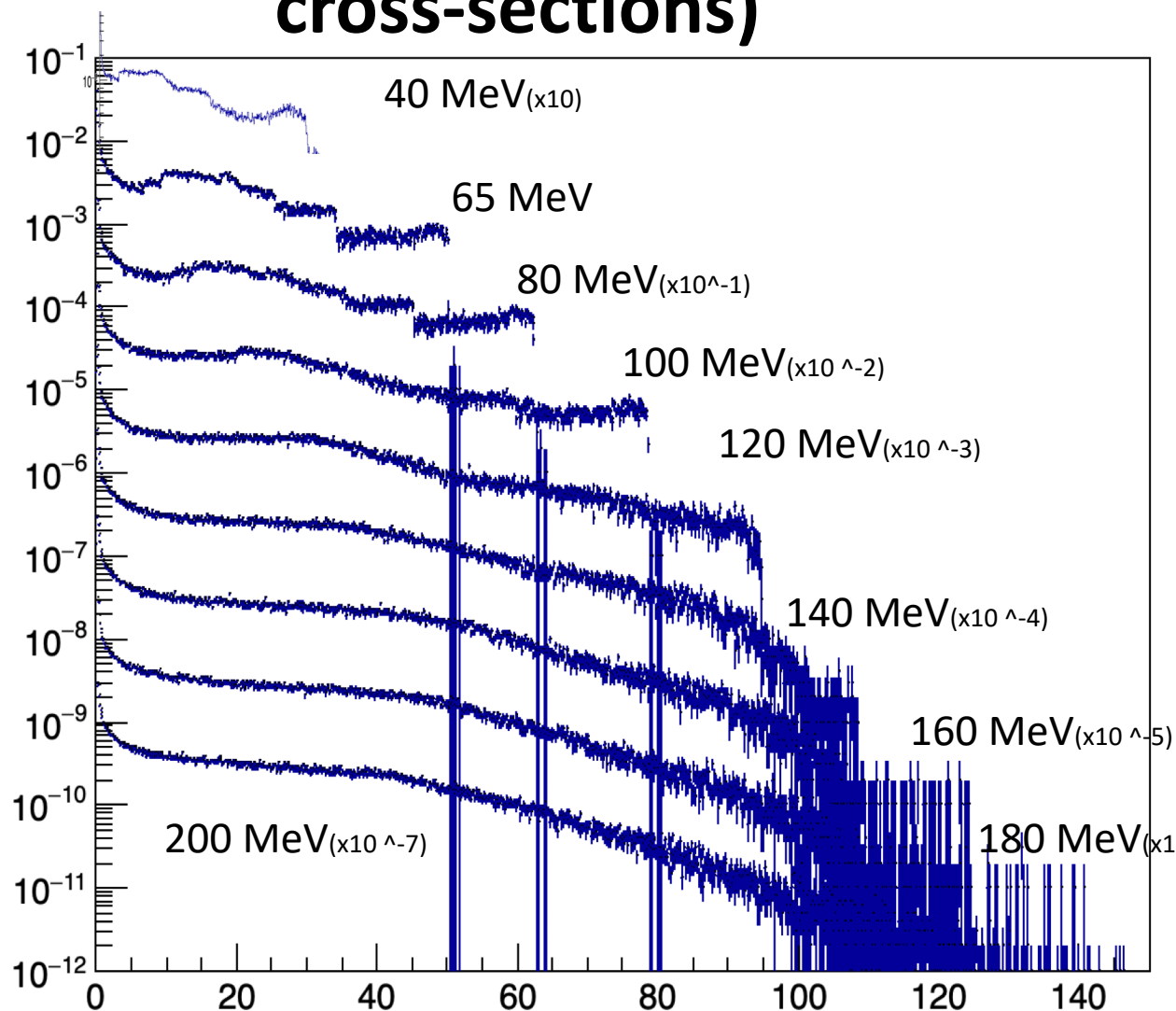
Reaction	Q(MeV)	Threshold (MeV)	MENAT E_R	SCINFUL_QMD (Export controlled)
P(n,n)p	0	0	Yes	Yes (SIGHYD/SIGHYD2)
12C(n,n)12C	0	0	Yes	Yes (SIGCELAS)
12C(n,n'γ)12C	-4.44	4.8	Yes	Yes (SIGCINEL)
12C(n,α)9Be	-5.70	6.2	Yes	Yes (SIGCNAL)
12C(n,n'3α)	-7.27	7.9	Yes	Yes (SIGCNN3A)
12C(n,p)12B	-12.59	13.6	Yes	Yes (SIGCNP)
12C(n,np)11B	-15.96	17.3	Yes	Yes (SIGCNPN)
12C(n,2n)11C	-18.72	20.3	Yes	Yes (SIGCN2N)
12C(n,3He)10Be	-19.467	21.10	No	Yes (SIGCN3HE)
12C(n,d)11B	-13.732	14.89	No	Yes (SIGCND)
12C(n,t)10B	-18.929	20.52	No	Yes (SIGCNT)
Total sigma				SIGTOT
total, nonelastic and elastic				sigrc





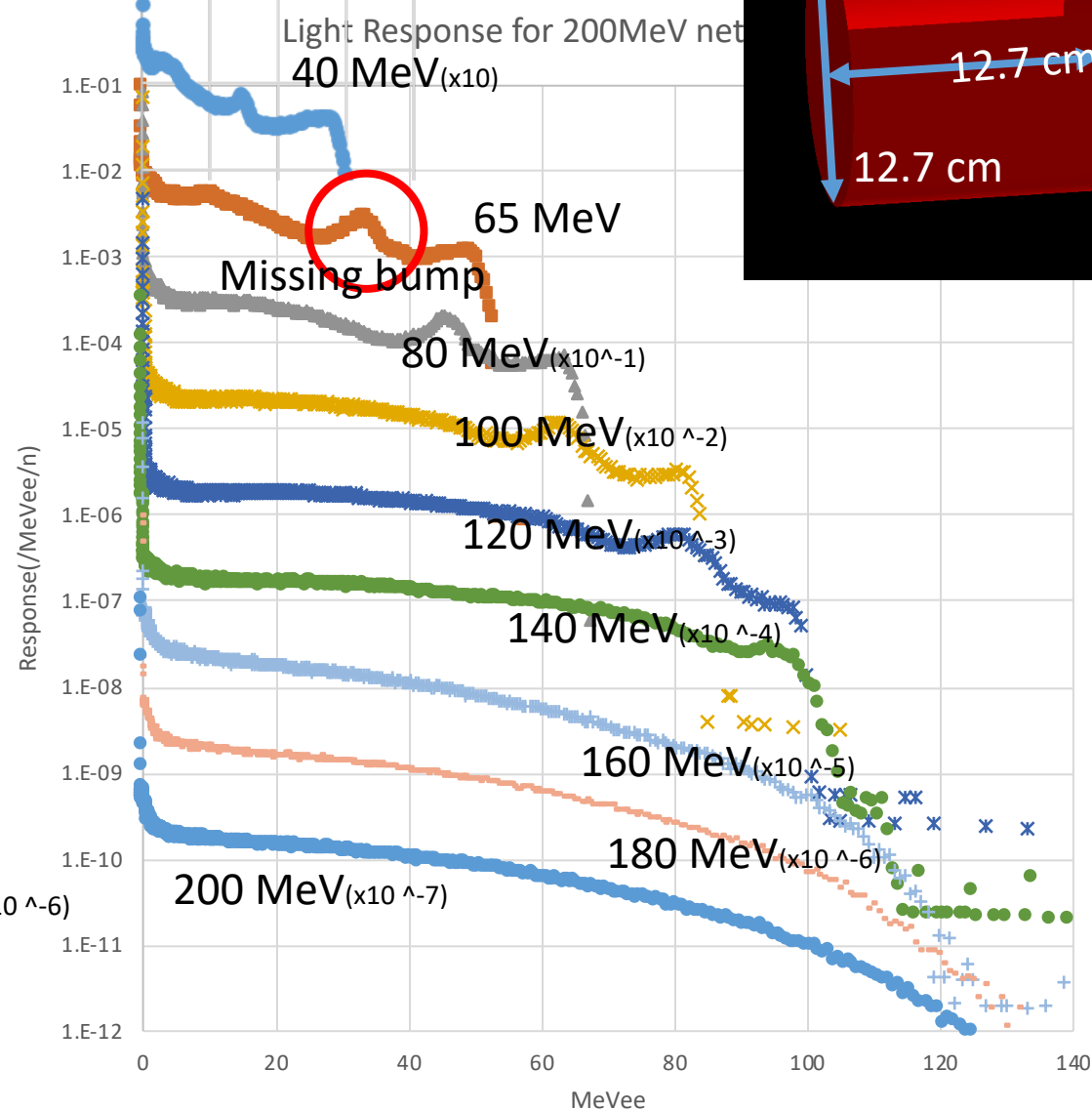
Below 20 MeV of neutron energy, most sequential decays affect light output < 3 MeVee

Park (include SCINFUL cross-sections)

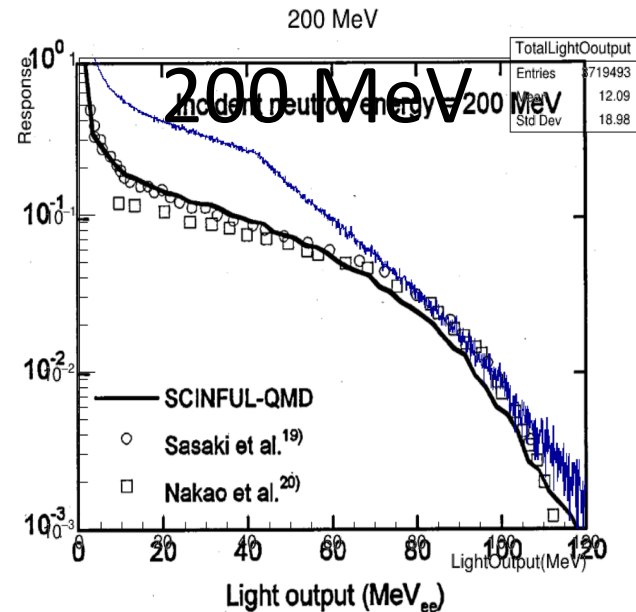


20MeV<En & En>200 MeV; GEANT4 is good
Main problem: En=20-200 MeV

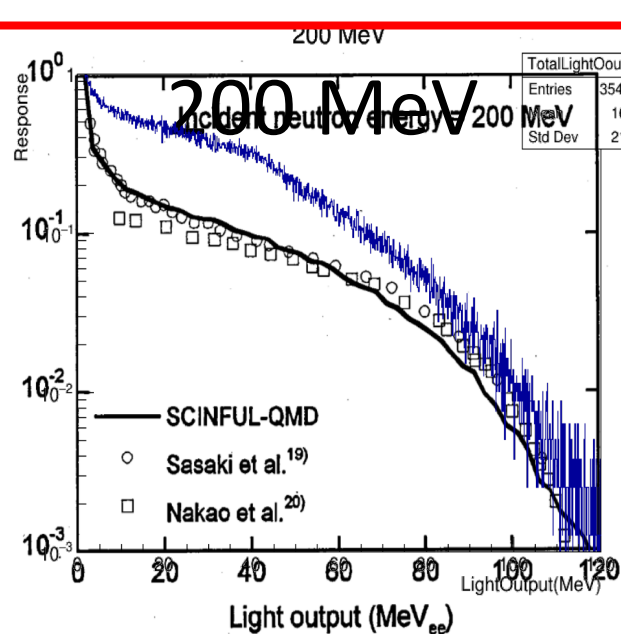
SCINFUL



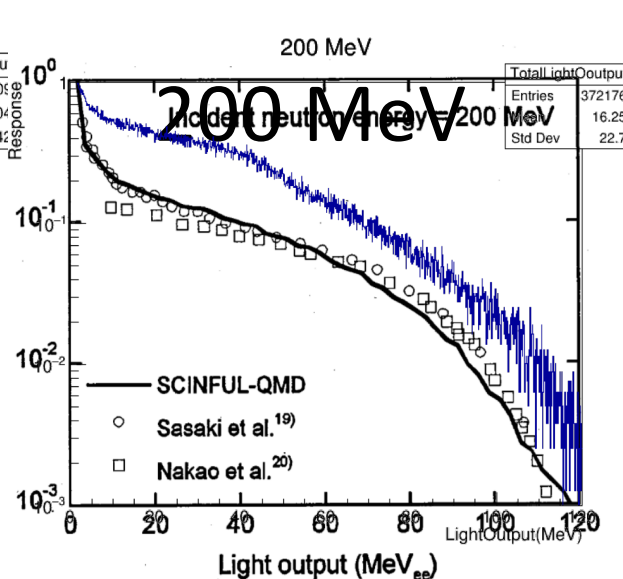
GEANT4 physics at high energy of neutron



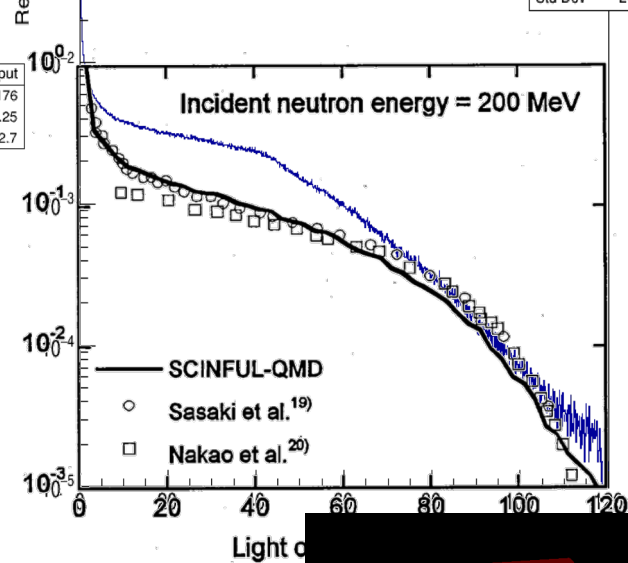
QGSP_BERT_HP



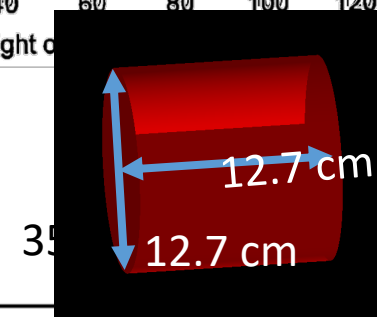
QGSP_BIC_HP



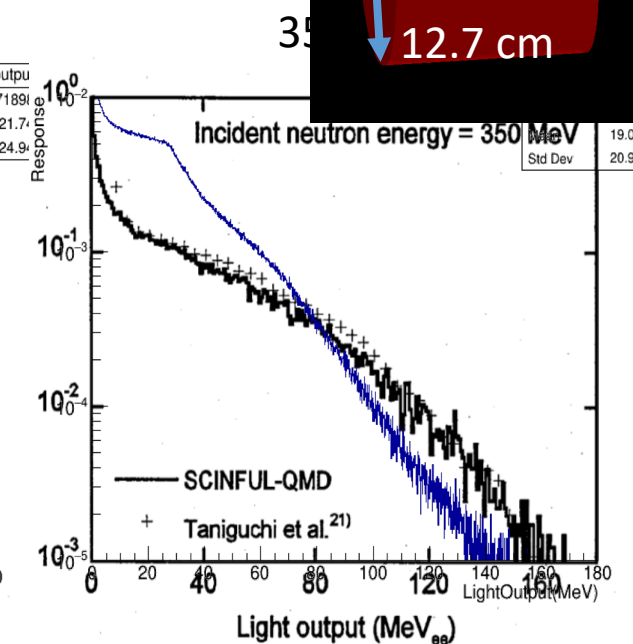
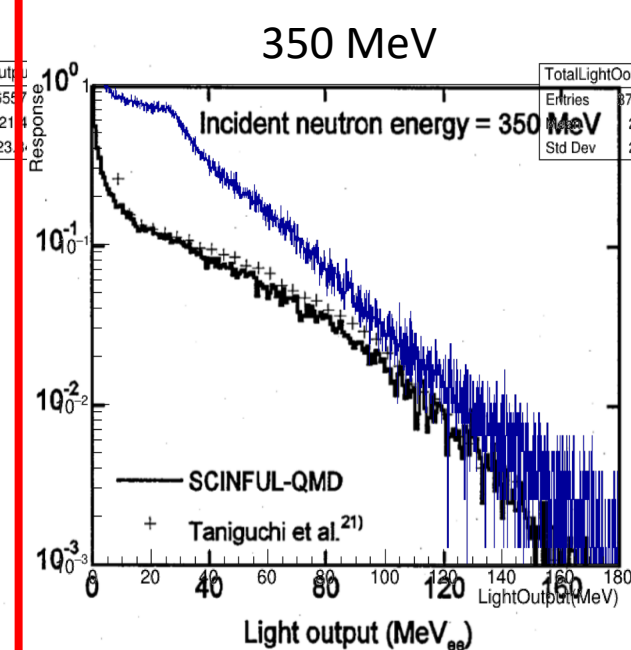
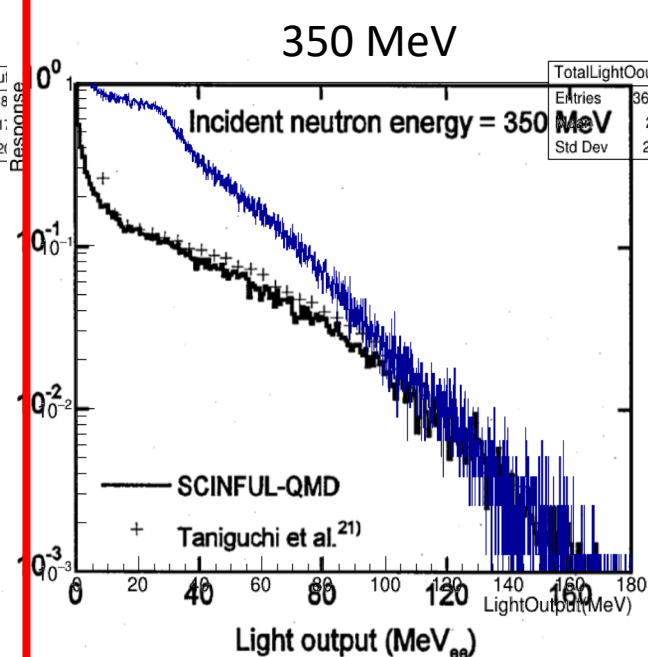
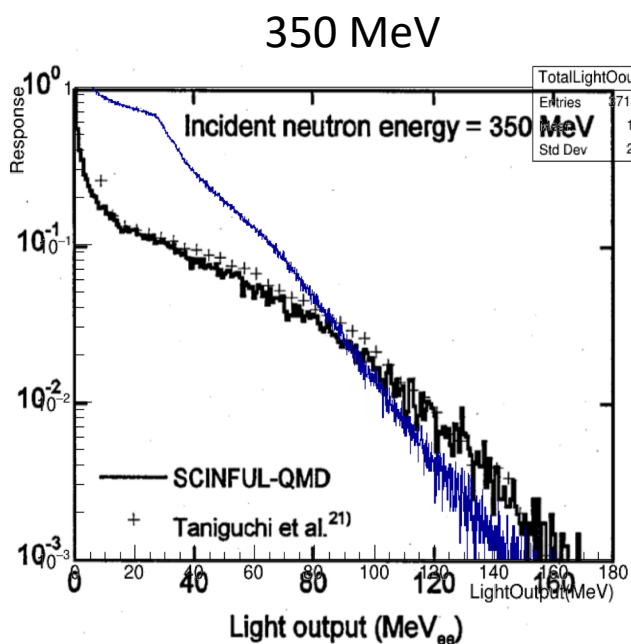
QGSP_INCLXX

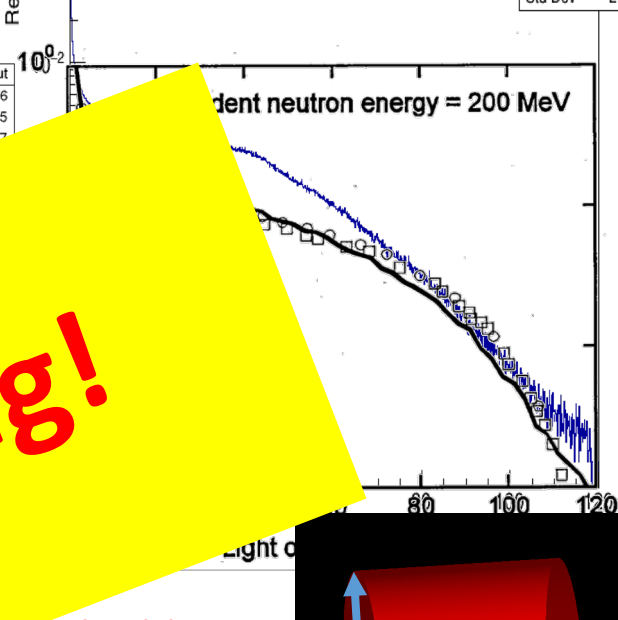
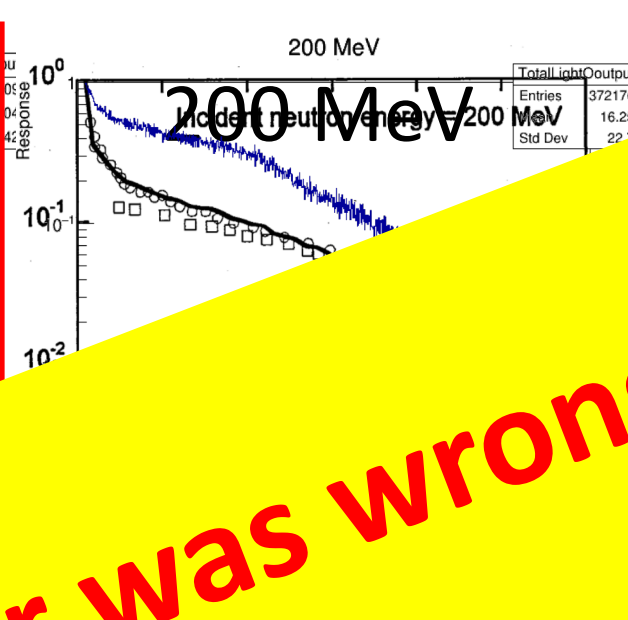
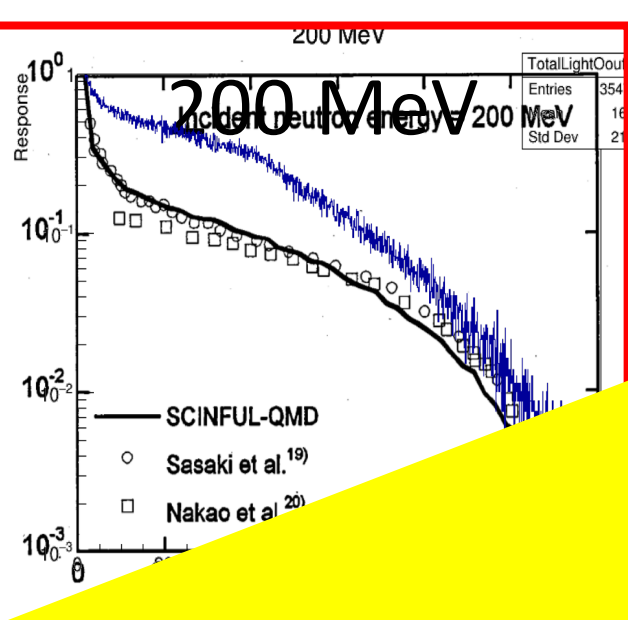
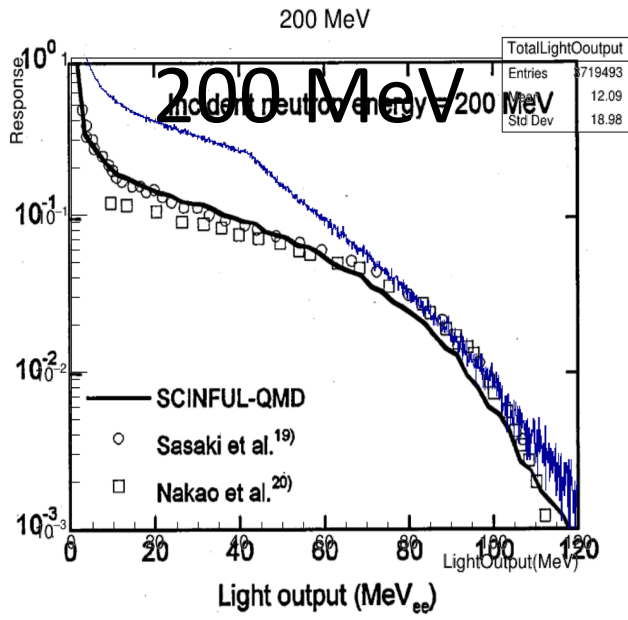


Shielding

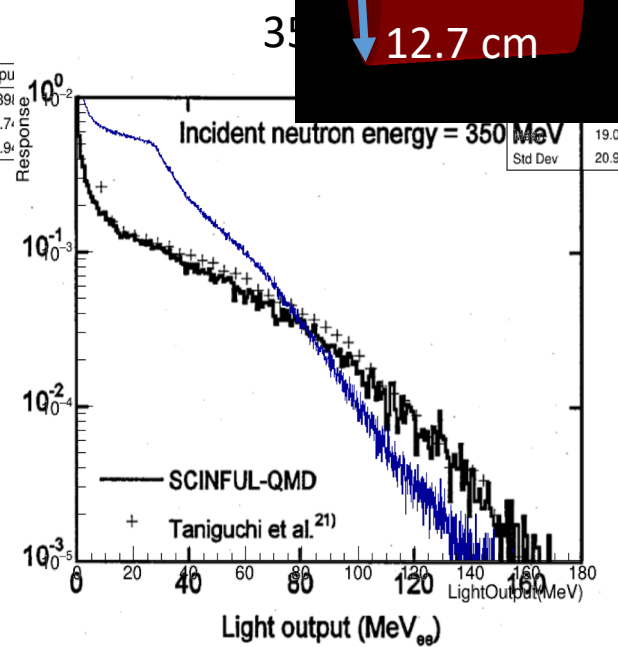
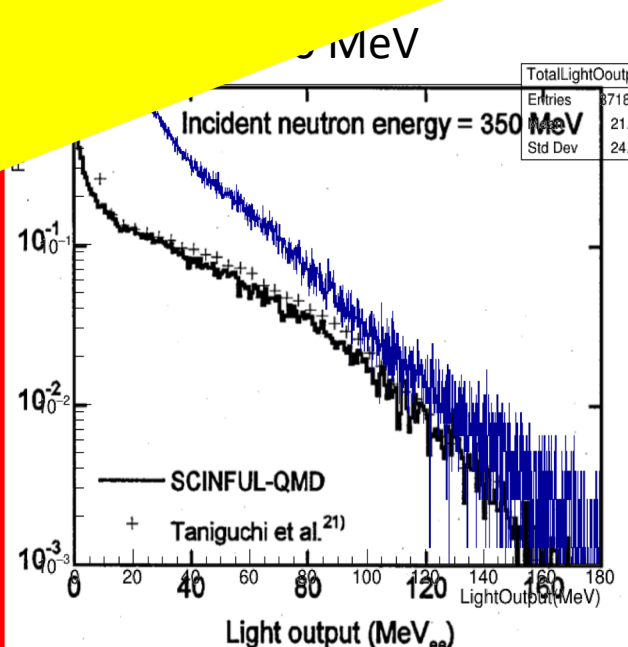
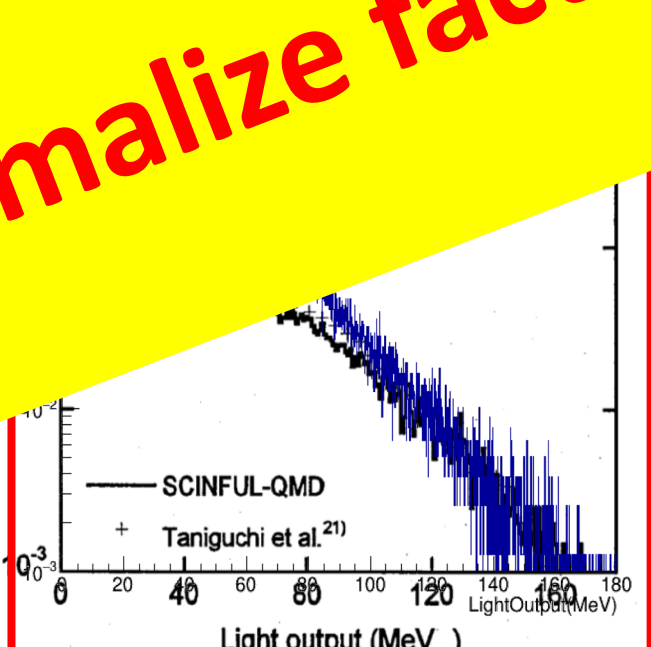
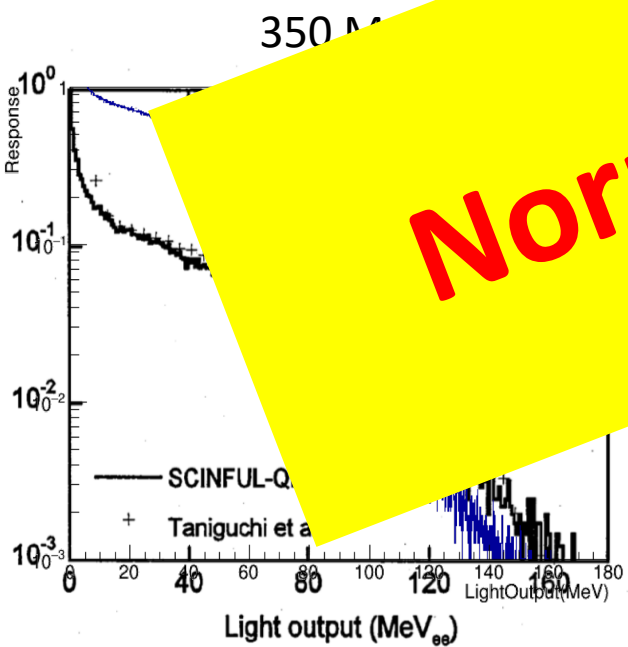


35

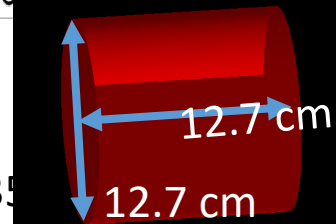




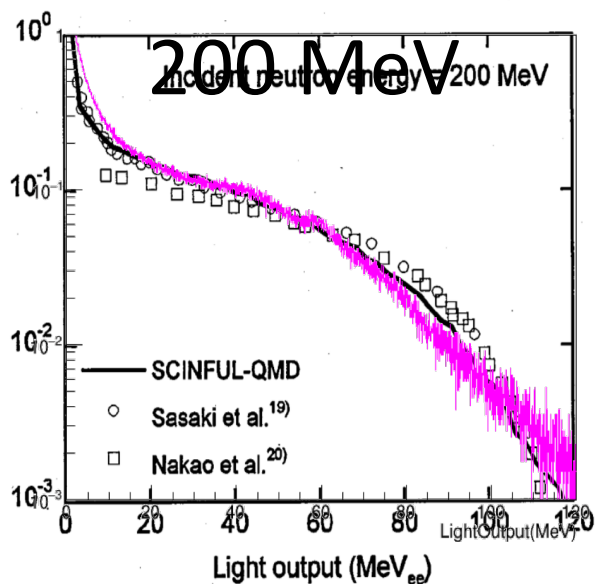
QGSP_BERT



Shielding

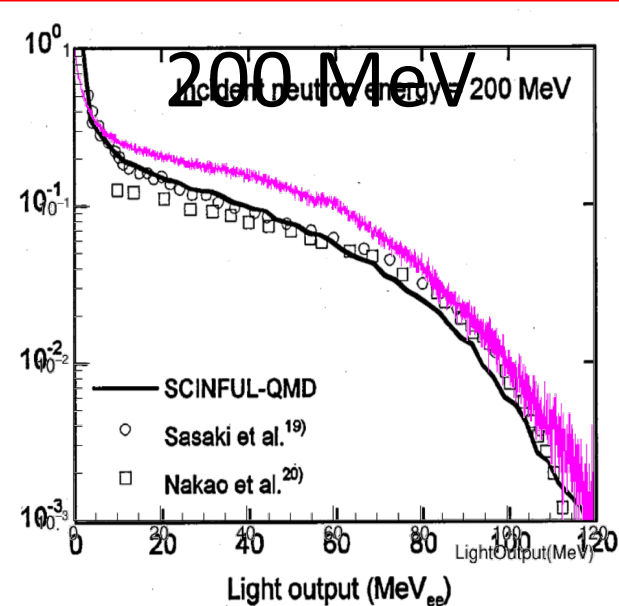
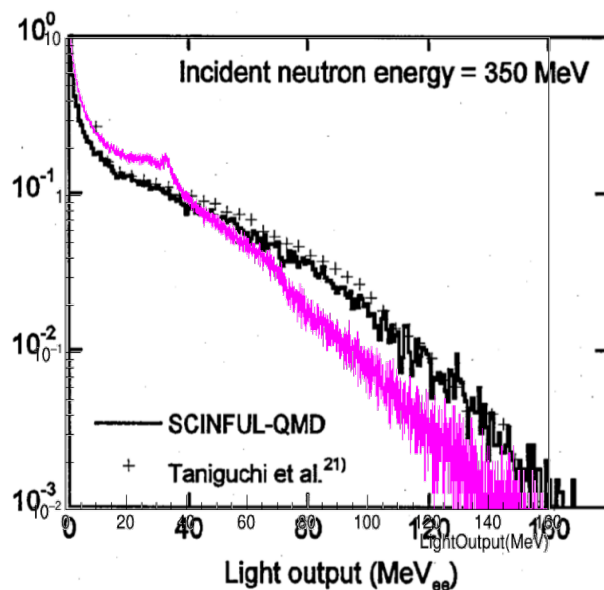


Normalize factor was wrong!



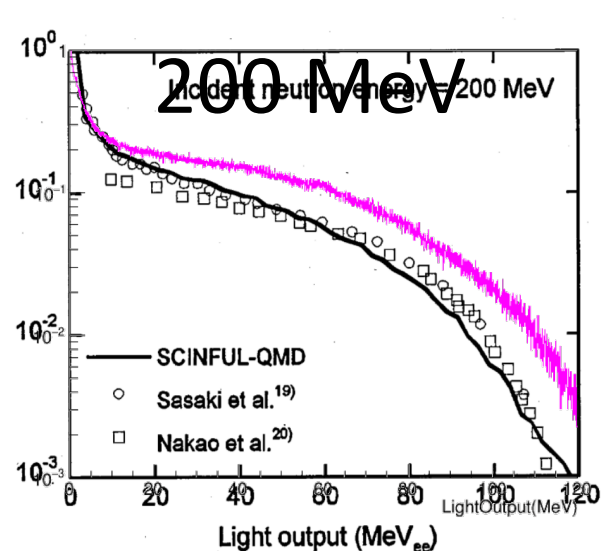
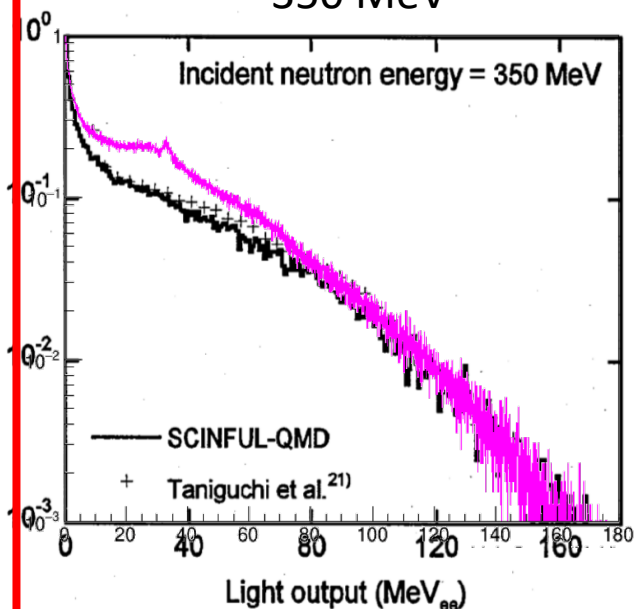
QGSP_BERT

350 MeV



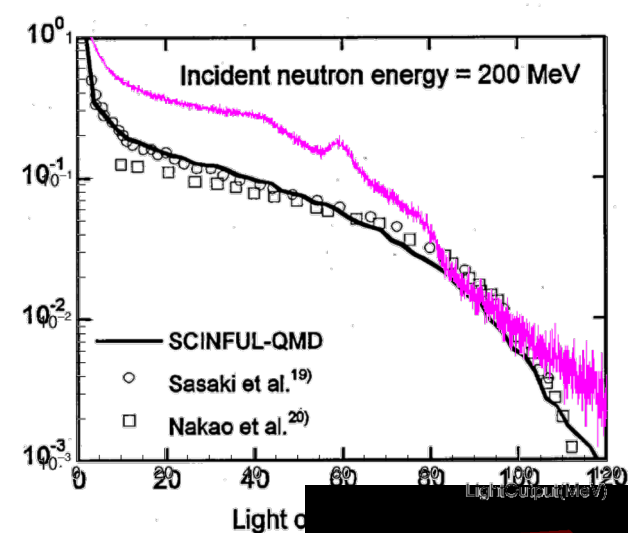
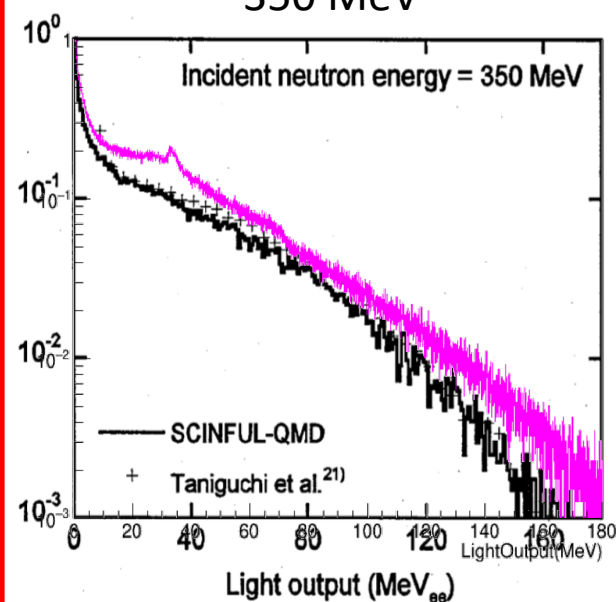
QGSP_BIC

350 MeV



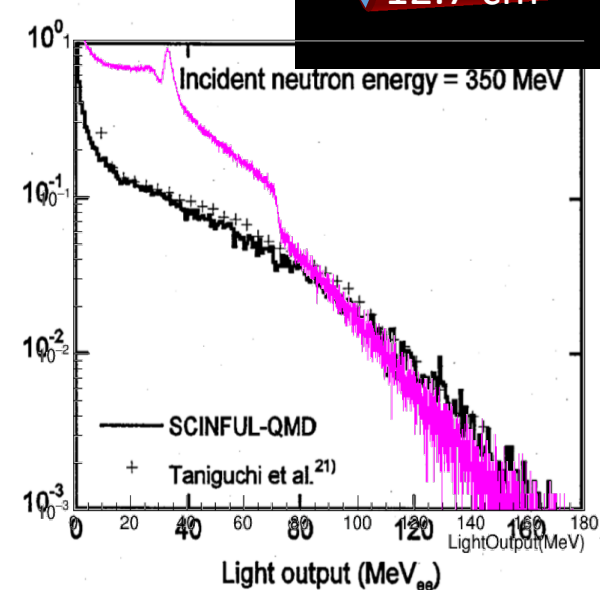
QGSP_INCLXX

350 MeV



Shielding

350 MeV



12.7 cm

12.7 cm

Strategies

Extend Spanish G4 to $E_n > 20$ MeV up to 100 MeV

Proposed Improvement in G4

1. Incorporate SCINFUL light function
2. Incorporate SCINFUL cross-sections
3. Incorporate sequential decays

Progress:

1. Reproduce G4 results in NIM article
2. Incorporate SCINFUL light functions of p,d, α , add t and ^3He - done
3. Incorporate SCINFUL cross-sections – done
4. Incorporate sequential decays – in progress

12C(n,n'3a) reaction

Table 1
Neutron-induced reactions on carbon between 0 and 20 MeV in NRESP7.1 [2]. The lowest excited states of ¹²C denoted by L1, L2 and L3 are well-defined states. The rest (L6 to L10) are pseudo-states that represent groups of well-defined states at higher excitation energies.

Reaction	Q_I (MeV) [*]	Threshold (MeV)	Cross section	Angular distribution
¹² C(n,n) ¹² C	0	0	ENDF/B-VI [8,9]	ENDF/B-VI [8]
¹² C(n,n') ¹² C*(L1)	−4.439	4.81	ENDF/B-VI [8,9]	ENDF/B-VI [8,9]
¹² C(n,α) ⁹ Be	−5.71	6.19	PTB [10,11]	PTB [10,11]
¹² C(n,α) ⁹ Be* → n + ⁸ Be → 2α	−8.13	8.81	PTB	Isotropic ^{**}
¹² C(n,n') ¹² C*(L2) → α + ⁸ Be → 2α	−7.653	8.29	PTB	Isotropic ^{**}
¹² C(n,n') ¹² C*(L3) → α + ⁸ Be → 2α	−9.63	10.43	PTB	Isotropic ^{**}
¹² C(n,n') ¹² C*(L4) → α + ⁸ Be → 2α	−10.8	11.70	PTB	Isotropic ^{**}
¹² C(n,n') ¹² C*(L5) → α + ⁸ Be → 2α	−11.8	12.78	PTB	Isotropic ^{**}
¹² C(n,n') ¹² C*(L6) → α + ⁸ Be → 2α	−12.7	13.76	PTB	Isotropic ^{**}
¹² C(n,n') ¹² C*(L7) → α + ⁸ Be → 2α	−14	15.17	PTB	Isotropic ^{**}
¹² C(n,n') ¹² C*(L8) → α + ⁸ Be → 2α	−15	16.25	PTB	Isotropic ^{**}
¹² C(n,n') ¹² C*(L9) → α + ⁸ Be → 2α	−16	17.33	PTB	Isotropic ^{**}
¹² C(n,n') ¹² C*(L10) → α + ⁸ Be → 2α	−17	18.42	PTB	Isotropic ^{**}
¹² C(n,p) ¹¹ B	−12.59	13.7	ENDF/B-VI [8,9]	Isotropic ^{**}
¹² C(n,d) ¹¹ B	−13.731	14.9	ENDF/B-VI [8,9]	Isotropic ^{**}

^{*} Q-value for the energy state of the residual nucleus (intermediate nucleus for multistep breakup reactions) [12].

^{**} Referred to the center-of-mass system.

12C(n,n'3a) reaction

NIM

SCINFUL

A.R. Garcia et al.

Table 1
Neutron-induced reactions on carbon between 0 and 20 MeV in NR pseudo-states that represent groups of well-defined states at higher

Reaction	Q_I (MeV)
$^{12}\text{C}(\text{n},\text{n})^{12}\text{C}$	0
$^{12}\text{C}(\text{n},\text{n}')^{12}\text{C}^*(\text{L1})$	-4.439
$^{12}\text{C}(\text{n},\alpha)^9\text{Be}$	-5.71
$^{12}\text{C}(\text{n},\alpha)^9\text{Be}^* \rightarrow \text{n} + ^8\text{Be} \rightarrow 2\alpha$	-8.13
$^{12}\text{C}(\text{n},\text{n}')^{12}\text{C}^*(\text{L2}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	-7.653
$^{12}\text{C}(\text{n},\text{n}')^{12}\text{C}^*(\text{L3}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	-9.63
$^{12}\text{C}(\text{n},\text{n}')^{12}\text{C}^*(\text{L4}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	-10.8
$^{12}\text{C}(\text{n},\text{n}')^{12}\text{C}^*(\text{L5}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	-11.8
$^{12}\text{C}(\text{n},\text{n}')^{12}\text{C}^*(\text{L6}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	-12.7
$^{12}\text{C}(\text{n},\text{n}')^{12}\text{C}^*(\text{L7}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	-14
$^{12}\text{C}(\text{n},\text{n}')^{12}\text{C}^*(\text{L8}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	-15
$^{12}\text{C}(\text{n},\text{n}')^{12}\text{C}^*(\text{L9}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	-16
$^{12}\text{C}(\text{n},\text{n}')^{12}\text{C}^*(\text{L10}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	-17
$^{12}\text{C}(\text{n},\text{p})^{11}\text{B}$	-12.59
$^{12}\text{C}(\text{n},\text{d})^{11}\text{B}$	-13.731

* Q-value for the energy state of the residual nucleus (intermediate)
** Referred to the center-of-mass system.

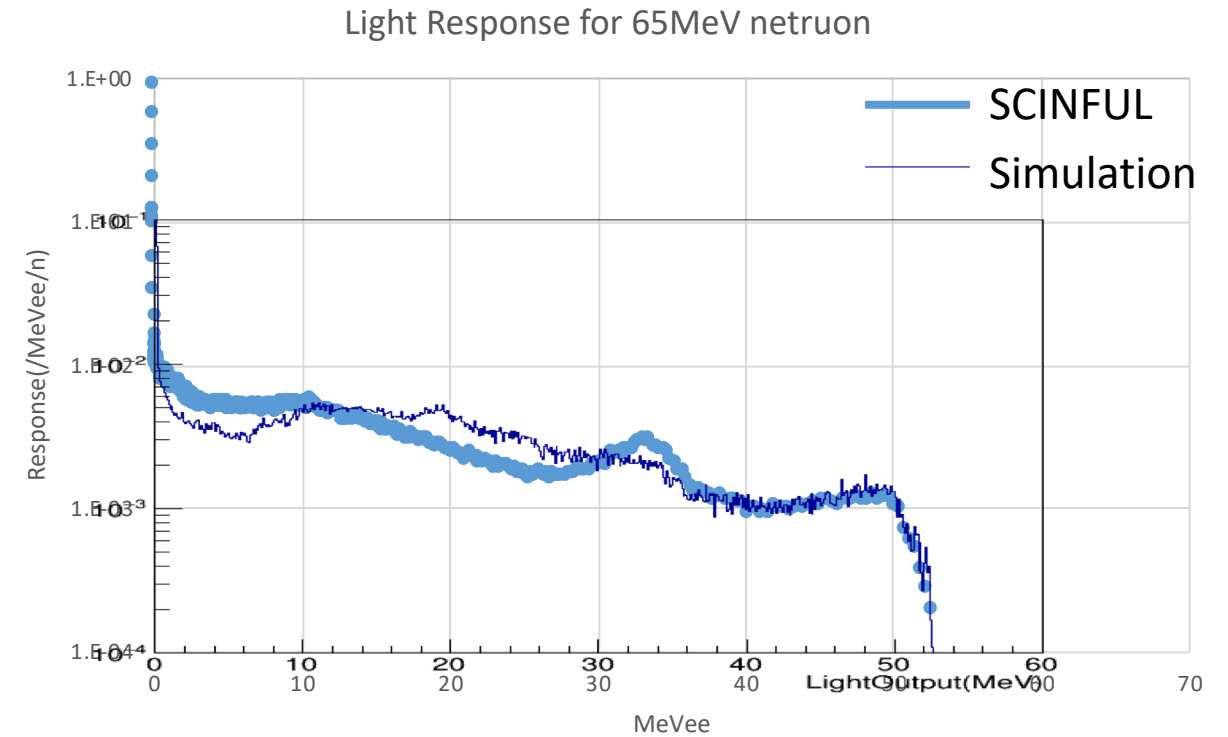
$^{12}\text{C}(\text{n},\text{n}')^{12}\text{C}^*(\text{L2}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	Q value : 7.65 MeV
$^{12}\text{C}(\text{n},\text{n}')^{12}\text{C}^*(\text{L3}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	Q value : 9.64 MeV
$^{12}\text{C}(\text{n},\text{n}')^{12}\text{C}^*(\text{L4}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	Q value : 10.84 MeV
$^{12}\text{C}(\text{n},\text{n}')^{12}\text{C}^*(\text{L5}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	Q value : (11.8, 12.7, 13.3) MeV
$^{12}\text{C}(\text{n},\text{n}')^{12}\text{C}^*(\text{L6}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	Q value : 14.08 MeV
$^{12}\text{C}(\text{n},\text{n}')^{12}\text{C}^*(\text{L7}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	Q value : (16.1-18.0) MeV
$^{12}\text{C}(\text{n},\text{n}')^{12}\text{C}^*(\text{L8}) \rightarrow \alpha + ^8\text{Be} \rightarrow 2\alpha$	continuum
$^{12}\text{C}(\text{n},\alpha)^9\text{Be}^*(\text{L1}) \rightarrow \text{n} + ^8\text{Be} \rightarrow 2\alpha$	Q value : 5.71(gs) + 2.43(Ex) = 8.14 MeV
$^{12}\text{C}(\text{n},\alpha)^9\text{Be}^*(\text{L2}) \rightarrow \text{n} + ^8\text{Be} \rightarrow 2\alpha$	Q value : (8.51, 8.76) MeV
$^{12}\text{C}(\text{n},\alpha)^9\text{Be}^*(\text{L3}) \rightarrow \text{n} + ^8\text{Be} \rightarrow 2\alpha$	Q value : 10.41 MeV
$^{12}\text{C}(\text{n},\alpha)^9\text{Be}^*(\text{L4}) \rightarrow \text{n} + ^8\text{Be} \rightarrow 2\alpha$	Q value : 12.47 MeV
$^{12}\text{C}(\text{n},\alpha)^9\text{Be}^*(\text{L5}) \rightarrow \text{n} + ^8\text{Be} \rightarrow 2\alpha$	Q value : 17.21 MeV
$^{12}\text{C}(\text{n},\alpha)^9\text{Be}^*(\text{L6}) \rightarrow \text{n} + ^8\text{Be} \rightarrow 2\alpha$	Q value : 19.71 MeV
$^{12}\text{C}(\text{n},\alpha)^9\text{Be}^*(\text{L7}) \rightarrow \text{n} + ^8\text{Be} \rightarrow 2\alpha$	continuum

Sequential decays from 11B from 12C(n, d)11B

Reaction	Q value(MeV)	
11B -> n+10B	-11.454	
11B -> a+7Li	-8.664	
10B -> p+9Be	-6.587	
10B -> a+6Li	-4.461	
10B -> p+n+2a	-8.160	9Be -> n+2a
10B -> d+2a	-5.935	10B -> d+8Be / 8Be -> 2a
10B -> p+d+7Li	-23.281	9Be -> d+7Li (-16.694 MeV)
9Be -> n+8Be	-1.665	
9Be -> p+8Li	-16.886	
8Be -> 2a	0.092	
8Li -> n+7Li	-2.032	
7Li -> n+6Li	-7.251	
7Li -> a+t	-2.468	

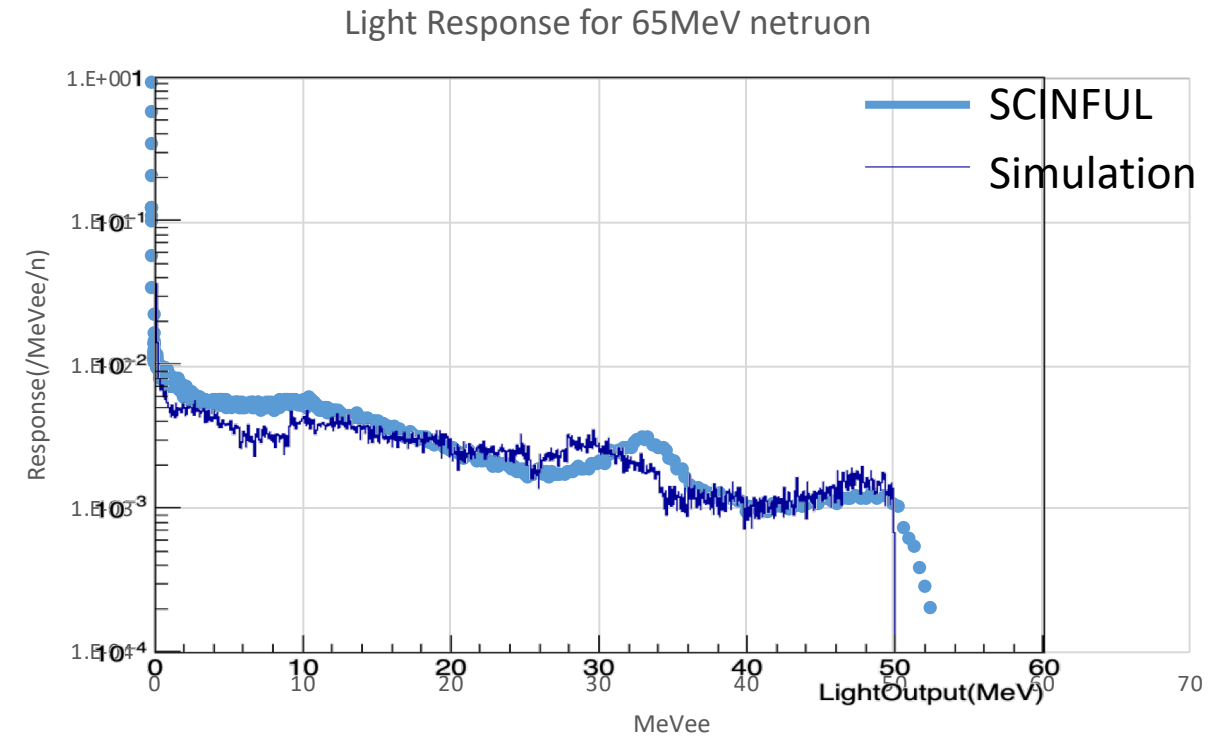
En = 62.5~67.5 MeV

Reaction	Q(MeV)	Threshold (MeV)	Sequential Decay
P(n,n)p	0	0	N/A
$^{12}\text{C}(n,n)^{12}\text{C}$	0	0	N/A
$^{12}\text{C}(n,n'\gamma)^{12}\text{C}$	-4.44	4.8	No
$^{12}\text{C}(n,\alpha)^9\text{Be}$	-5.70	6.2	No
$^{12}\text{C}(n,n'3\alpha)$	-7.27	7.9	No
$^{12}\text{C}(n,p)^{12}\text{B}$	-12.59	13.6	No
$^{12}\text{C}(n,np)^{11}\text{B}$	-15.96	17.3	No
$^{12}\text{C}(n,2n)^{11}\text{C}$	-18.72	20.3	No
$^{12}\text{C}(n,3\text{He})^{10}\text{Be}$	-19.467	21.10	No
$^{12}\text{C}(n,d)^{11}\text{B}$	-13.732	14.89	No
$^{12}\text{C}(n,t)^{10}\text{B}$	-18.929	20.52	No
Total sigma			
total, nonelastic and elastic			



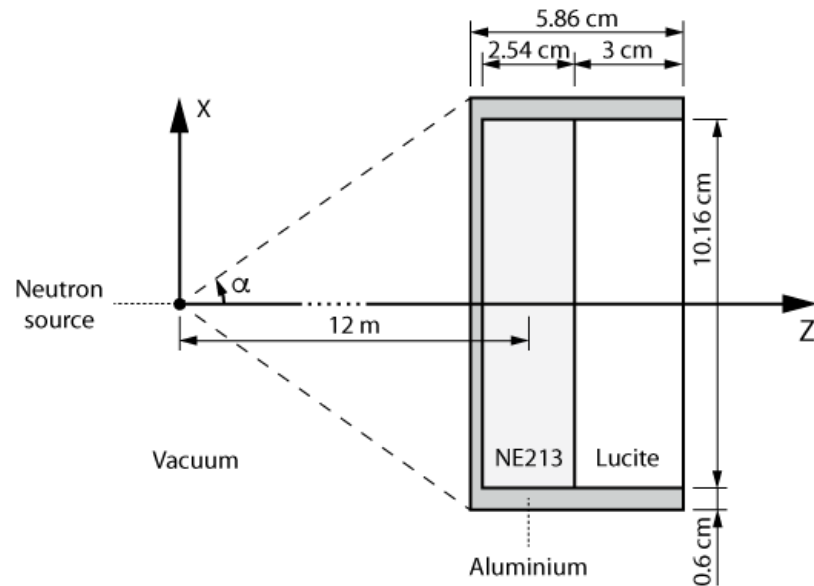
En = 62.5~67.5 MeV

Reaction	Q(MeV)	Threshold (MeV)	Sequential Decay
P(n,n)p	0	0	N/A
$^{12}\text{C}(n,n)^{12}\text{C}$	0	0	N/A
$^{12}\text{C}(n,n'\gamma)^{12}\text{C}$	-4.44	4.8	Yes
$^{12}\text{C}(n,\alpha)^9\text{Be}$	-5.70	6.2	Yes
$^{12}\text{C}(n,n'3\alpha)$	-7.27	7.9	Yes
$^{12}\text{C}(n,p)^{12}\text{B}$	-12.59	13.6	No
$^{12}\text{C}(n,np)^{11}\text{B}$	-15.96	17.3	No
$^{12}\text{C}(n,2n)^{11}\text{C}$	-18.72	20.3	No
$^{12}\text{C}(n,3\text{He})^{10}\text{Be}$	-19.467	21.10	No
$^{12}\text{C}(n,d)^{11}\text{B}$	-13.732	14.89	Yes
$^{12}\text{C}(n,t)^{10}\text{B}$	-18.929	20.52	No
Total sigma			
total, nonelastic and elastic			

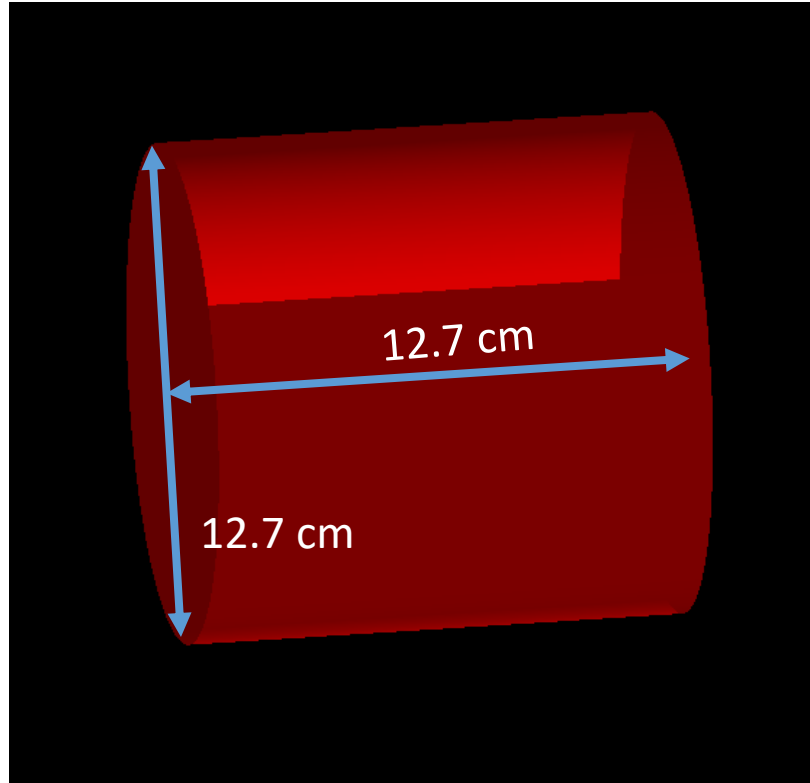


SCINFUL geometry

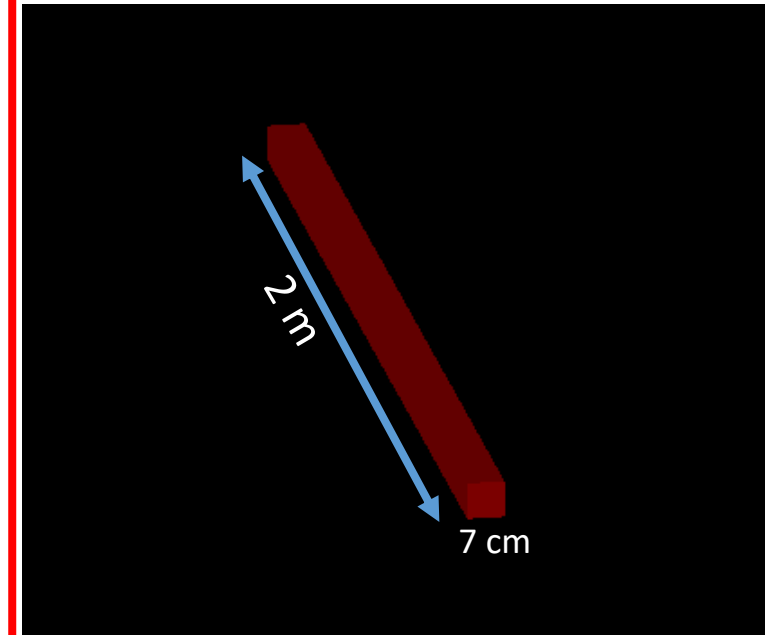
NIM geometry



The thickness of SCINFUL is 5 times as much as NIM.



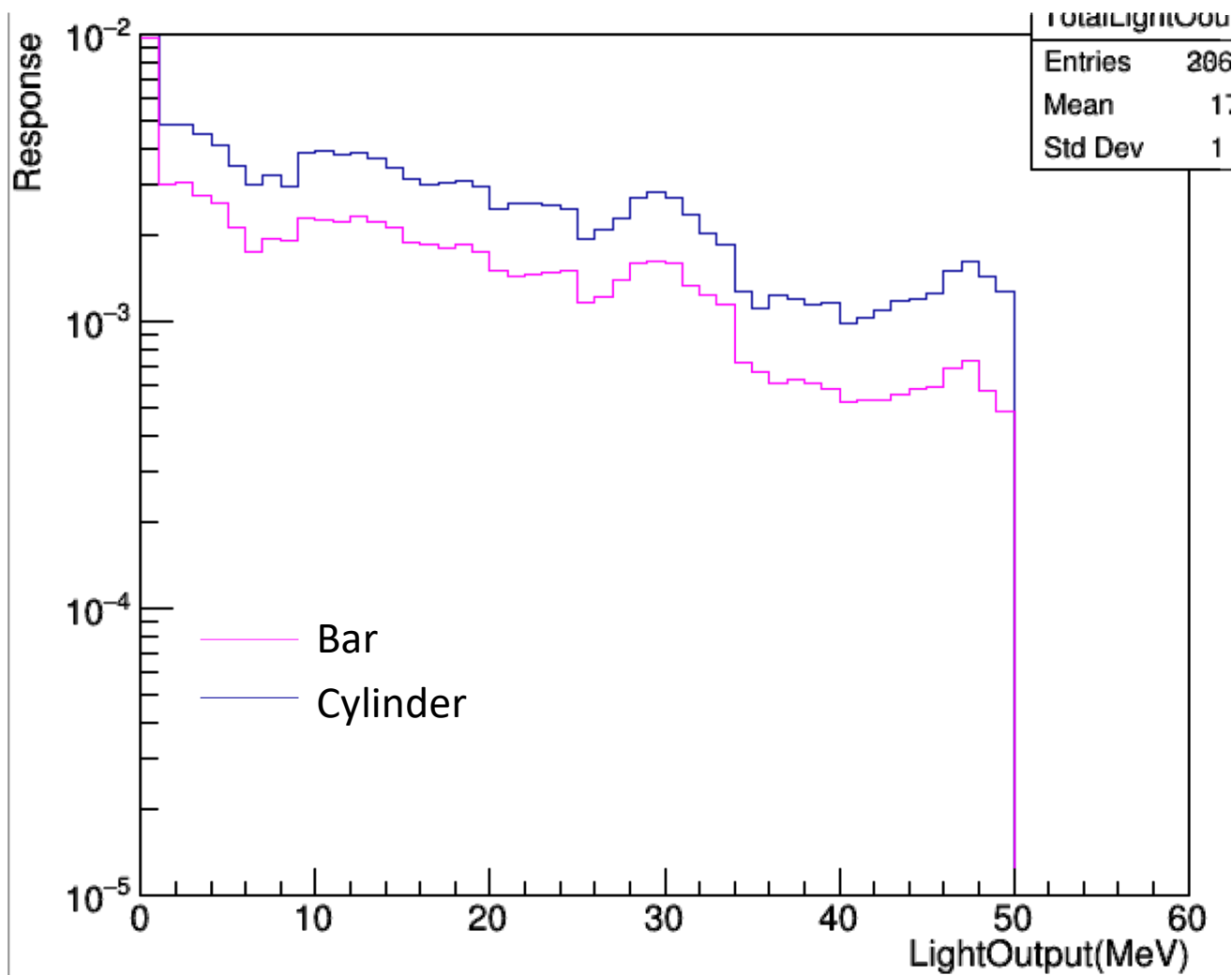
A bar of NW geometry



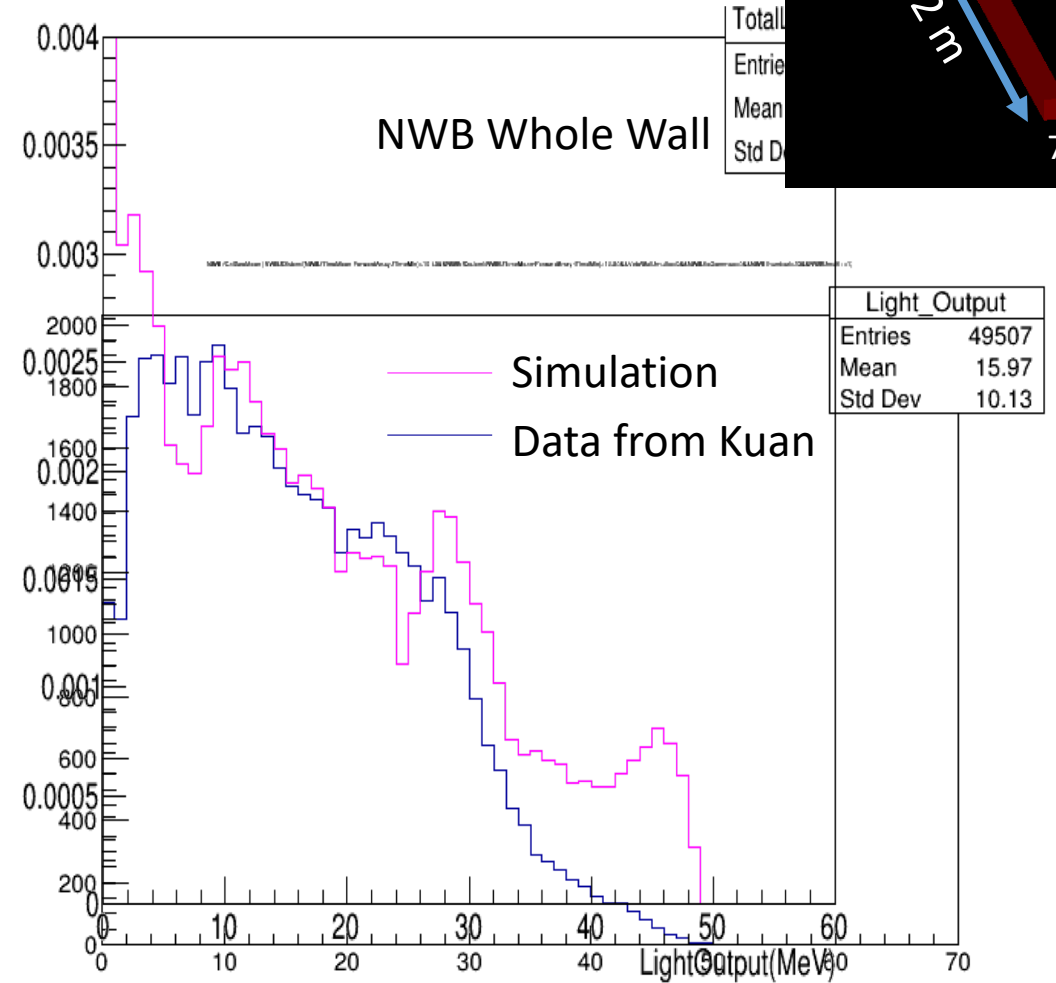
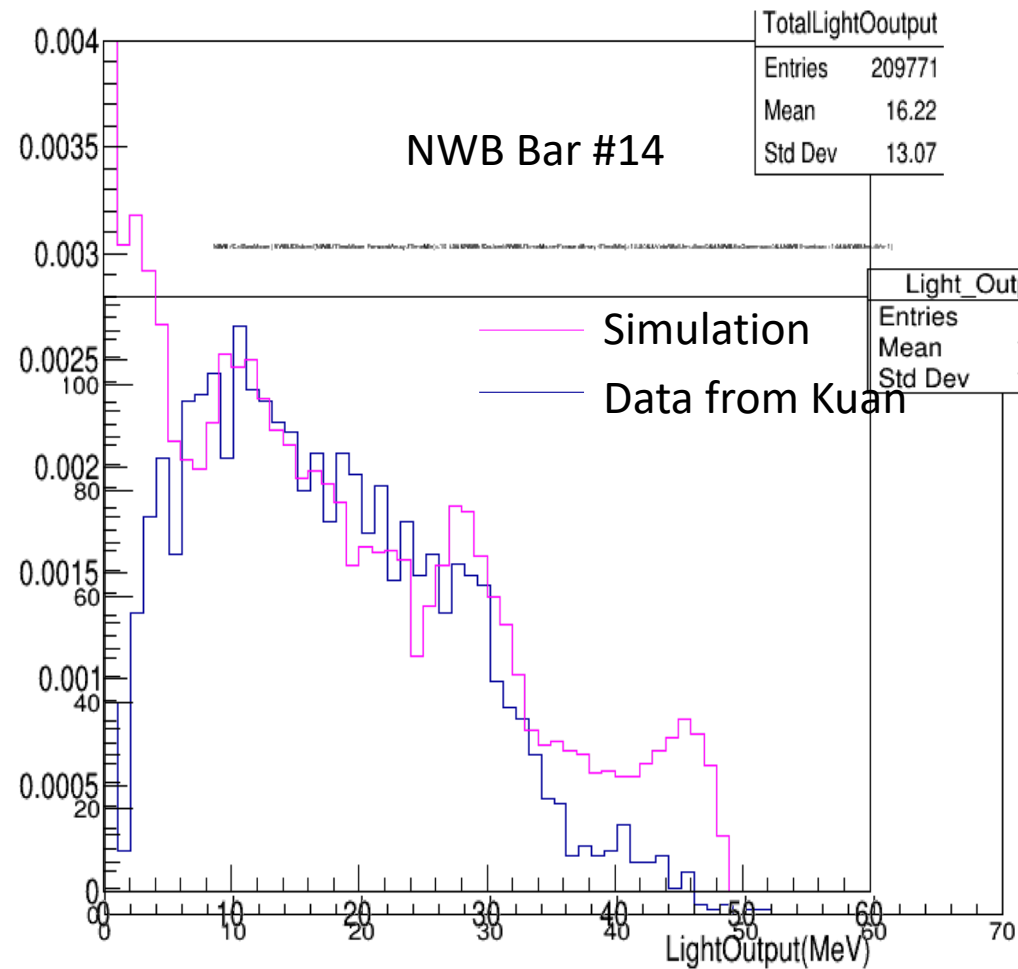
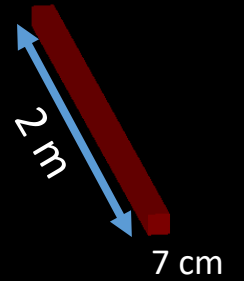
1. Do the simulation with the same geometry with SCINFUL, and see if the simulation is right or not.
2. Make a neutron bar to compare with experimental data.

Compare with different geometry

En = 65 MeV



En = 62.5~67.5 MeV

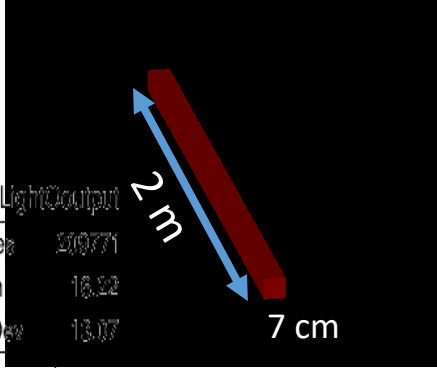
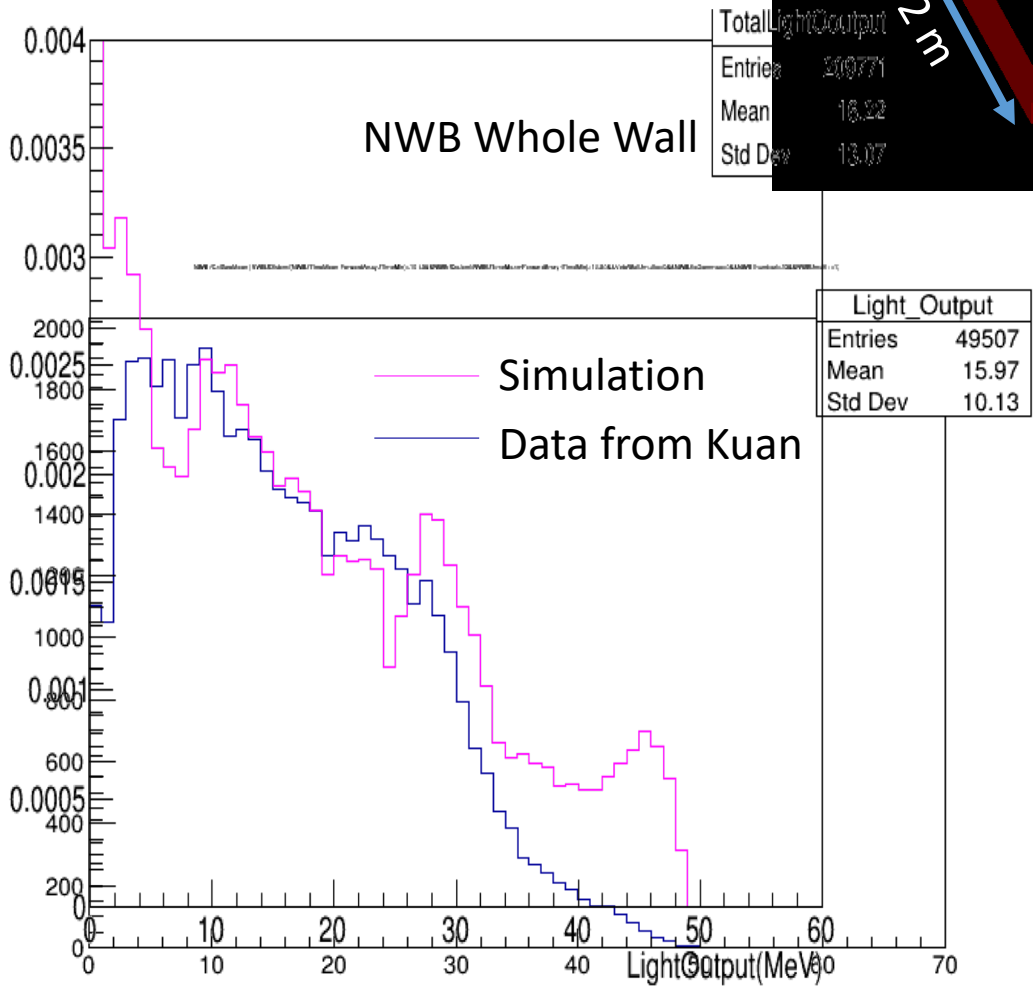


Light Output (MeVee)

Experimental data from Kuan. The experimental data is needed to compare from simulation.

En = 62.5~67.5 MeV

Reaction	Q(MeV)	Threshold (MeV)	Sequential Decay
P(n,n)p	0	0	N/A
12C(n,n)12C	0	0	N/A
12C(n,n'γ)12C	-4.44	4.8	Yes
12C(n,α)9Be	-5.70	6.2	Yes
12C(n,n'3α)	-7.27	7.9	Yes
12C(n,p)12B	-12.59	13.6	No
12C(n,np)11B	-15.96	17.3	No
12C(n,2n)11C	-18.72	20.3	No
12C(n,3He)10Be	-19.467	21.10	No
12C(n,d)11B	-13.732	14.89	Yes
12C(n,t)10B	-18.929	20.52	No
Total sigma			
total, nonelastic and elastic			



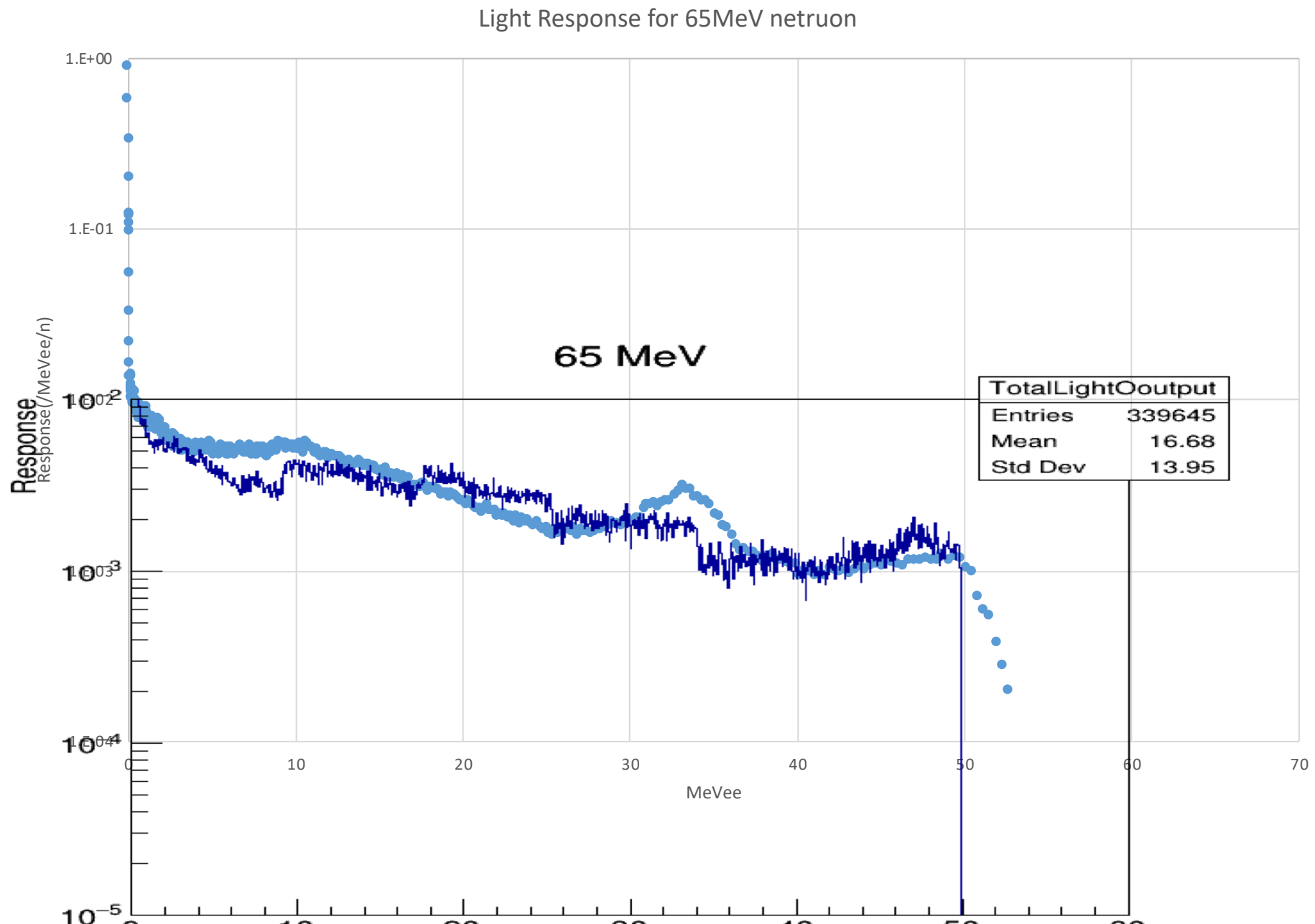
is needed to compare from simulation.

Summary

1. Incorporate SCINFUL light function - done
2. Incorporate SCINFUL cross-sections - done
3. Incorporate full sequential decays (in progress)
4. Incorporate SCINFUL angular distribution - done
5. Incorporate full Neutron wall array in the simulation(To do)
6. The experimental data is needed to compare with the simulation

Back up

Park
65 MeV
No decay



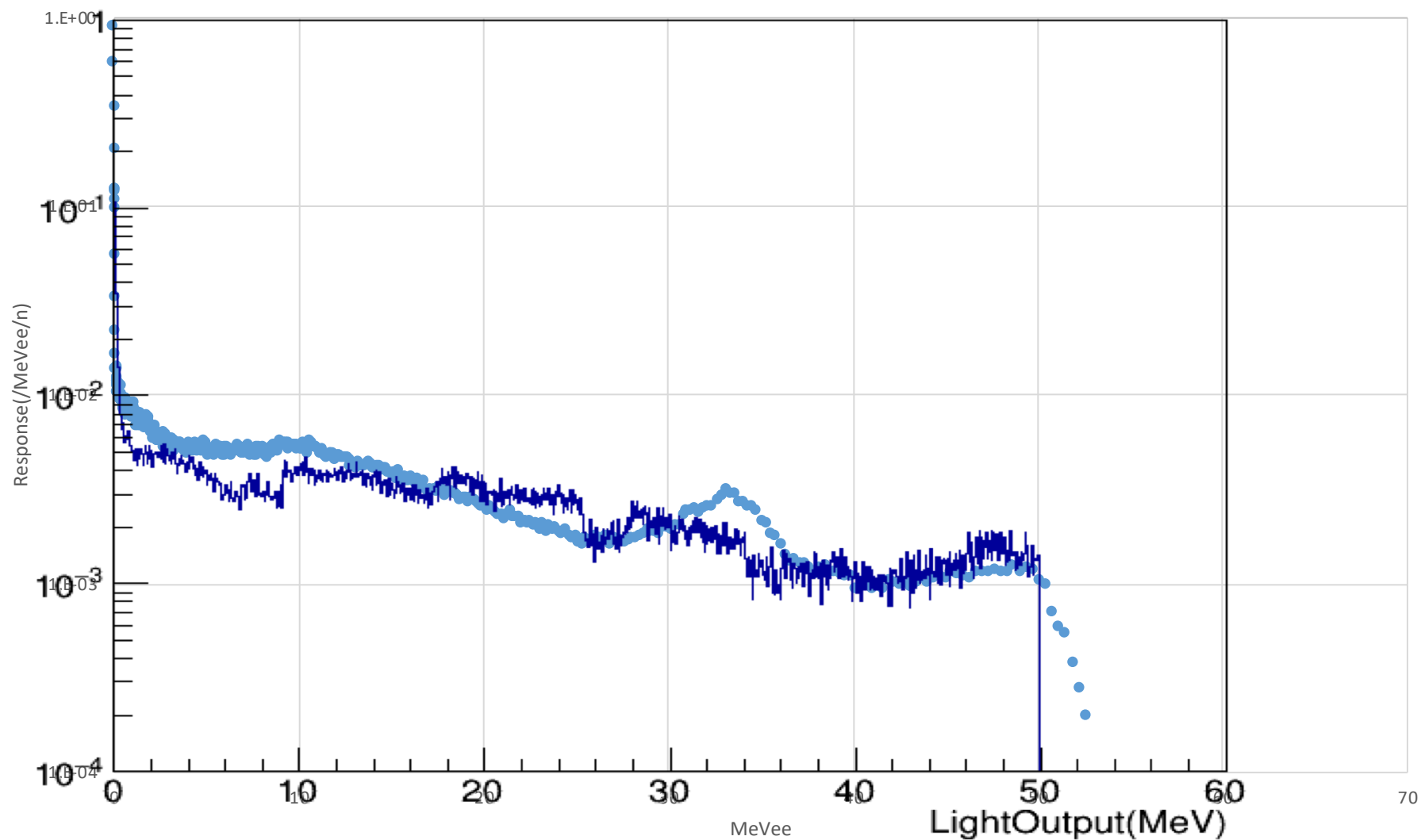
Park

65 MeV

^{11}B decay

Light Response for 65MeV netruon

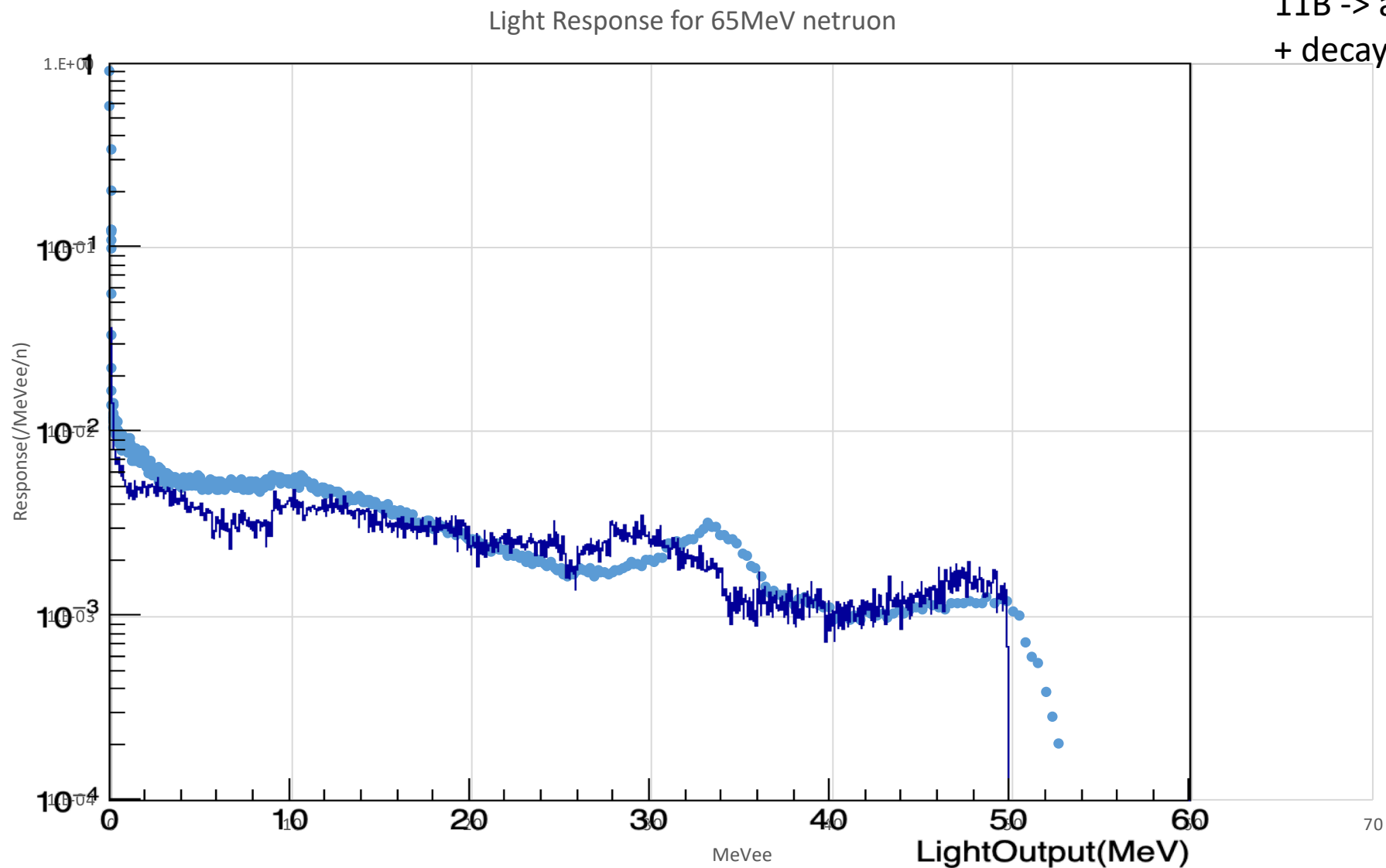
$^{11}\text{B} \rightarrow \text{n} + ^{10}\text{B}$
 $^{11}\text{B} \rightarrow \alpha + ^7\text{Li}$



Park

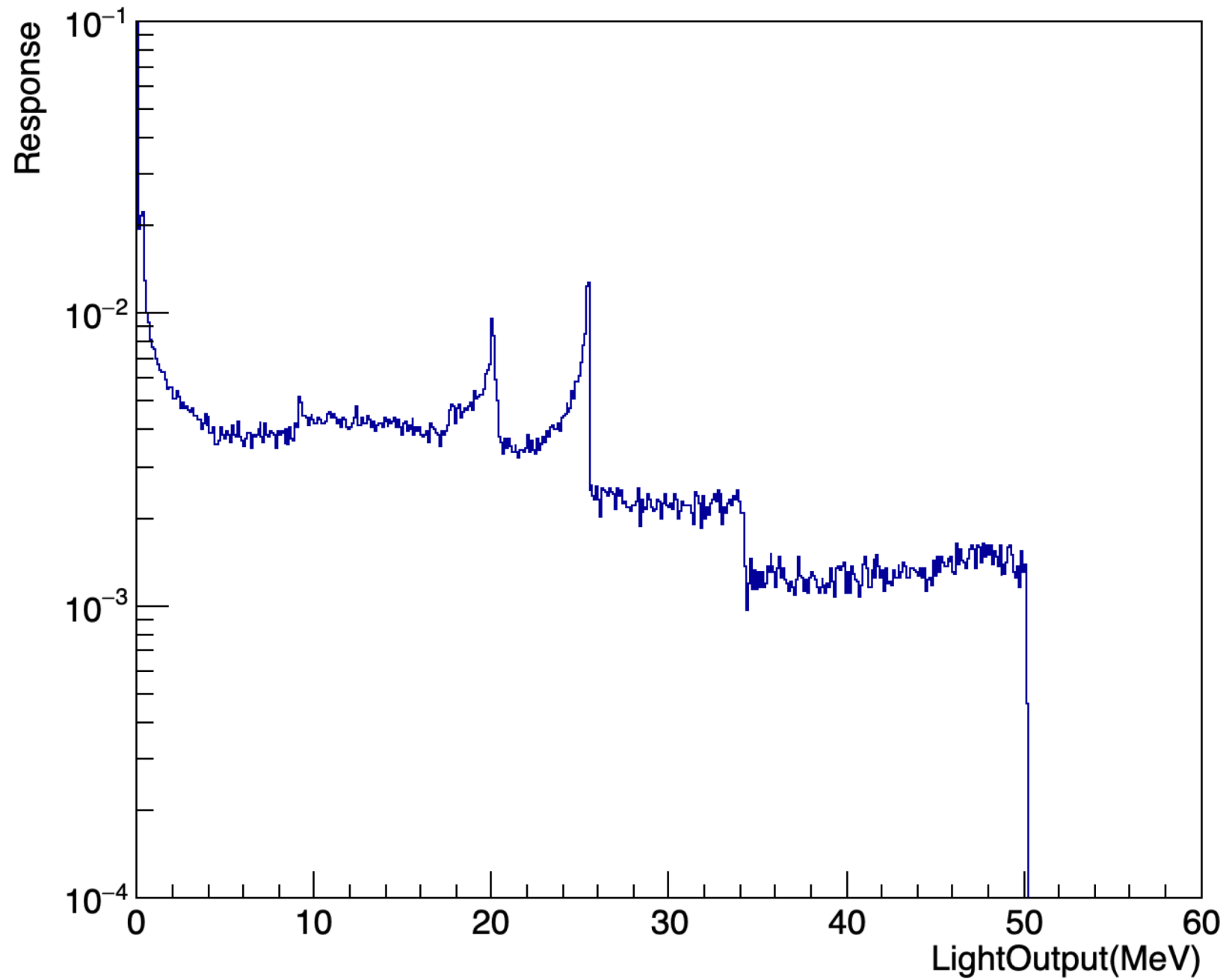
65 MeV

^{11}B decay



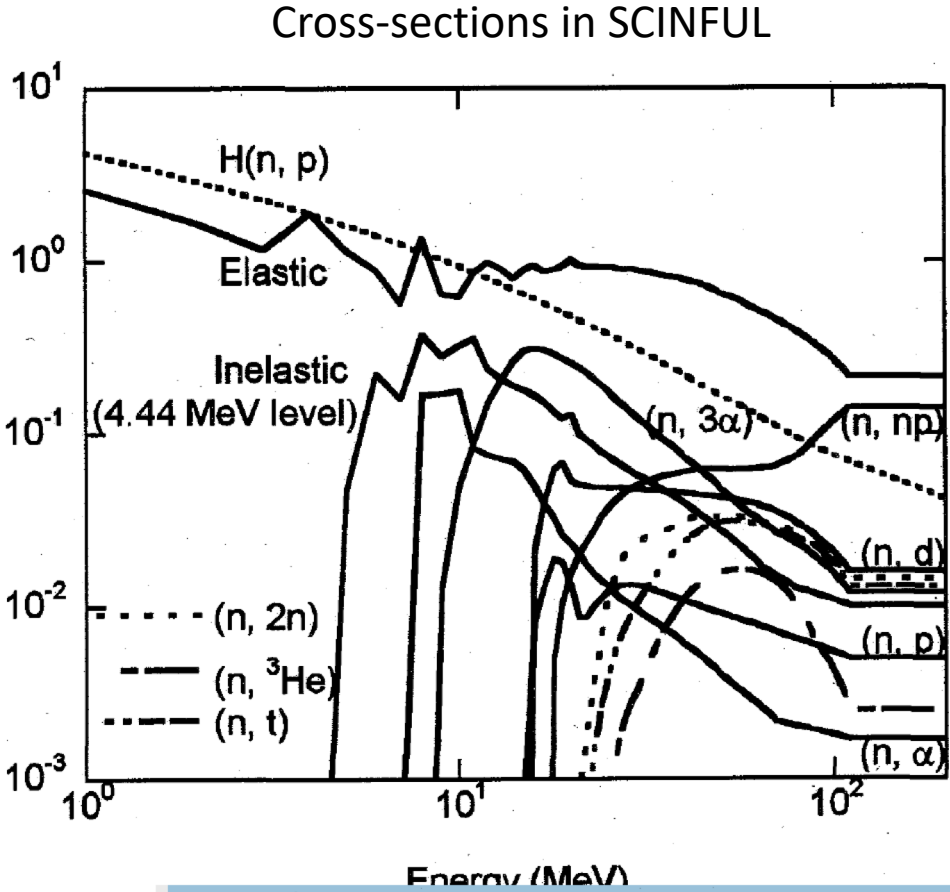
$^{11}\text{B} \rightarrow \text{n} + ^{10}\text{B}$
 $^{11}\text{B} \rightarrow \alpha + ^7\text{Li}$
+ decays of ^{10}B and ^7Li

65 MeV

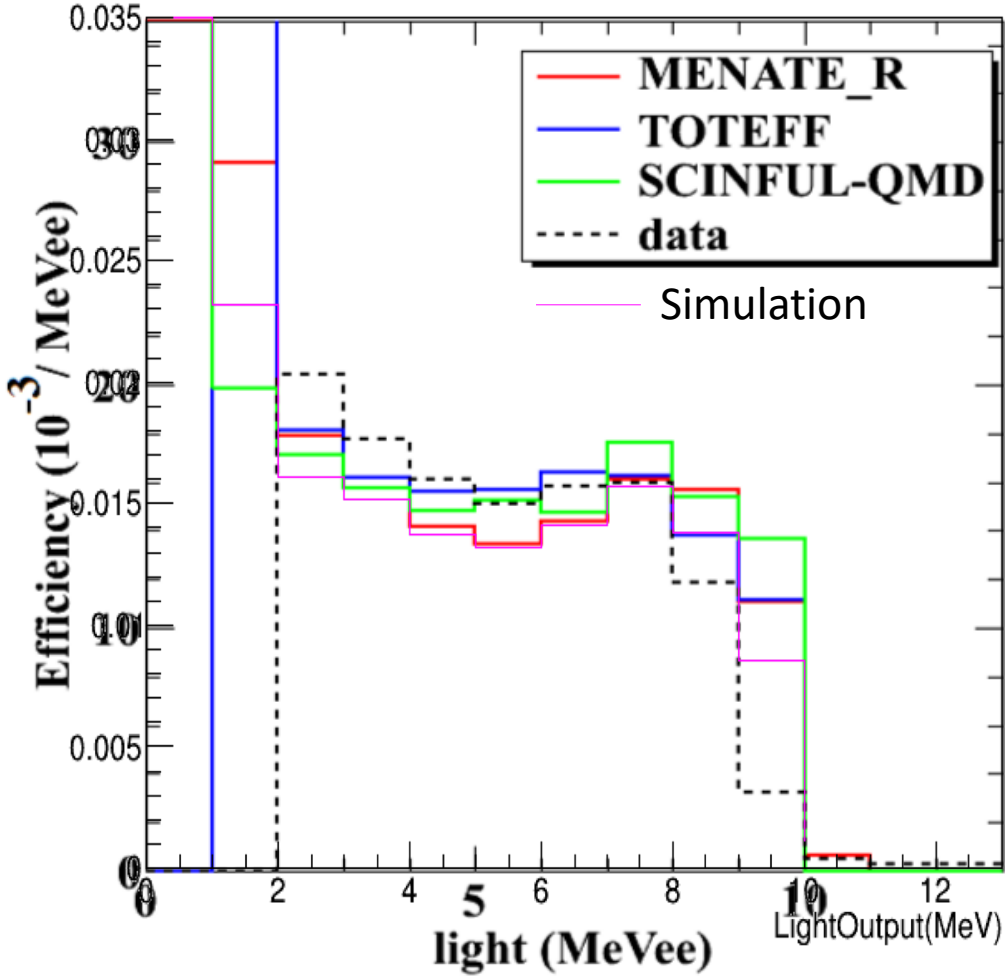


Tried to apply
Angular distribution

Reaction	Q(MeV)	Threshold (MeV)	Sequen tial Dec	SCINFUL_QMD (Export controlled)
P(n,n)p	0	0	N/A	Yes (SIGHYD/SIGHYD2)
12C(n,n)12C	0	0	N/A	Yes (SIGCELAS)
12C(n,n'γ)12C	-4.44	4.8	Yes	Yes (SIGCINEL)
12C(n,α)9Be	-5.70	6.2	Yes	Yes (SIGCNAL)
12C(n,n'3α)	-7.27	7.9	Yes	Yes (SIGCNN3A)
12C(n,p)12B	-12.59	13.6	No	Yes (SIGCNP)
12C(n,np)11B	-15.96	17.3	No	Yes (SIGCNPN)
12C(n,2n)11C	-18.72	20.3	No	Yes (SIGCN2N)
12C(n,3He)10Be	-19.467	21.10	No	Yes (SIGCN3HE)
12C(n,d)11B	-13.732	14.89	Yes	Yes (SIGCND)
12C(n,t)10B	-18.929	20.52	No	Yes (SIGCNT)
Total sigma				SIGTOT
total, nonelastic and elastic				sigrc

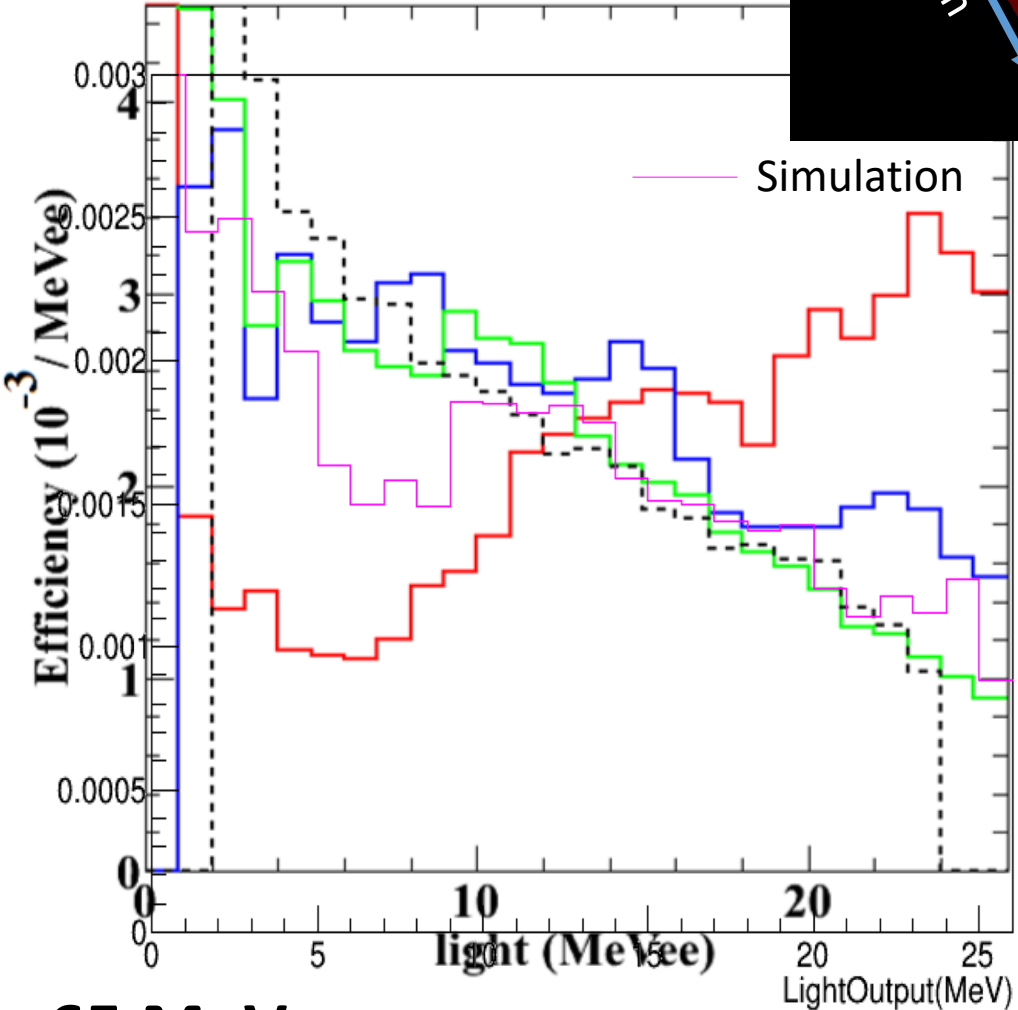


Comparison from Coupland's thesis



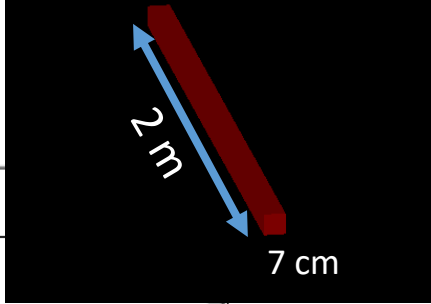
15 MeV

200x7x7 cm3 of box



65 MeV

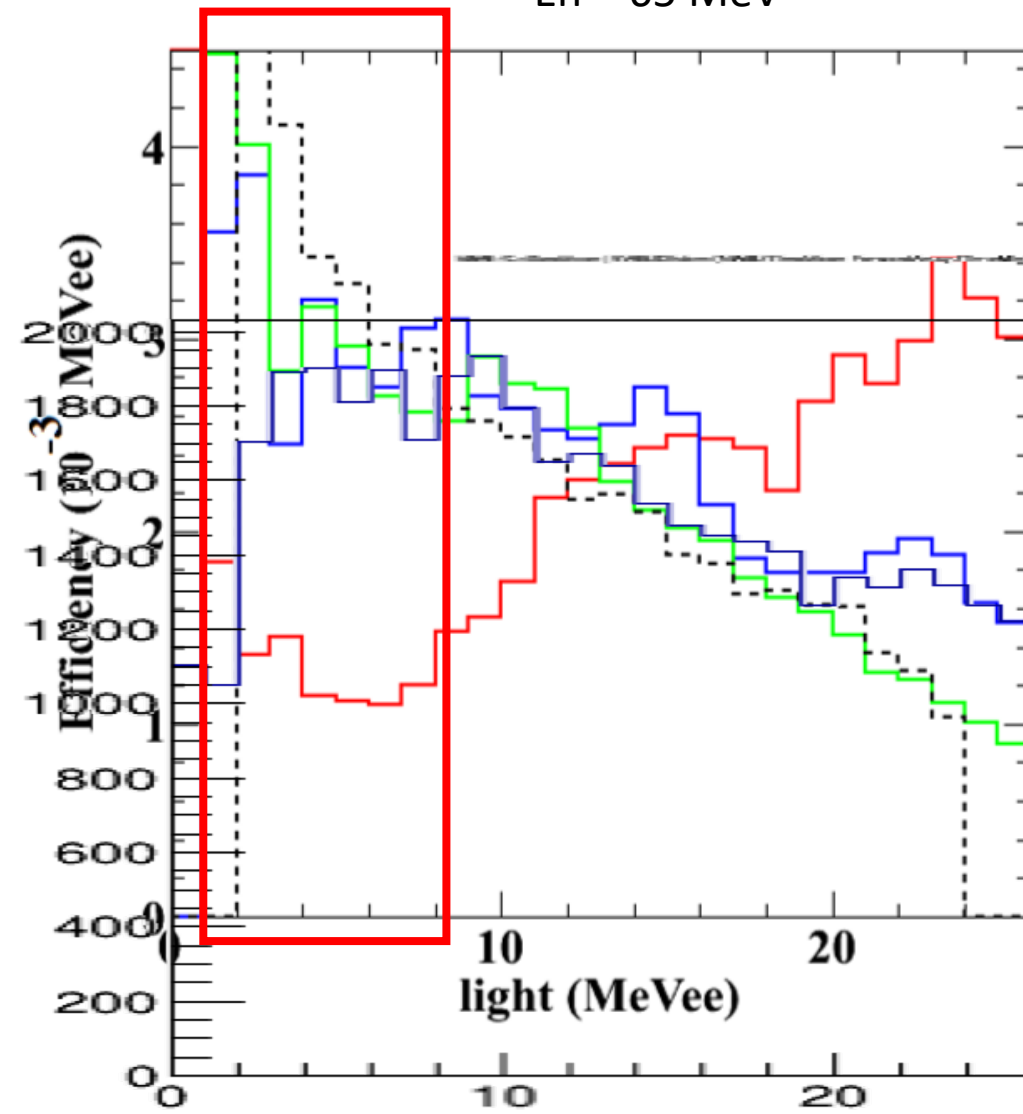
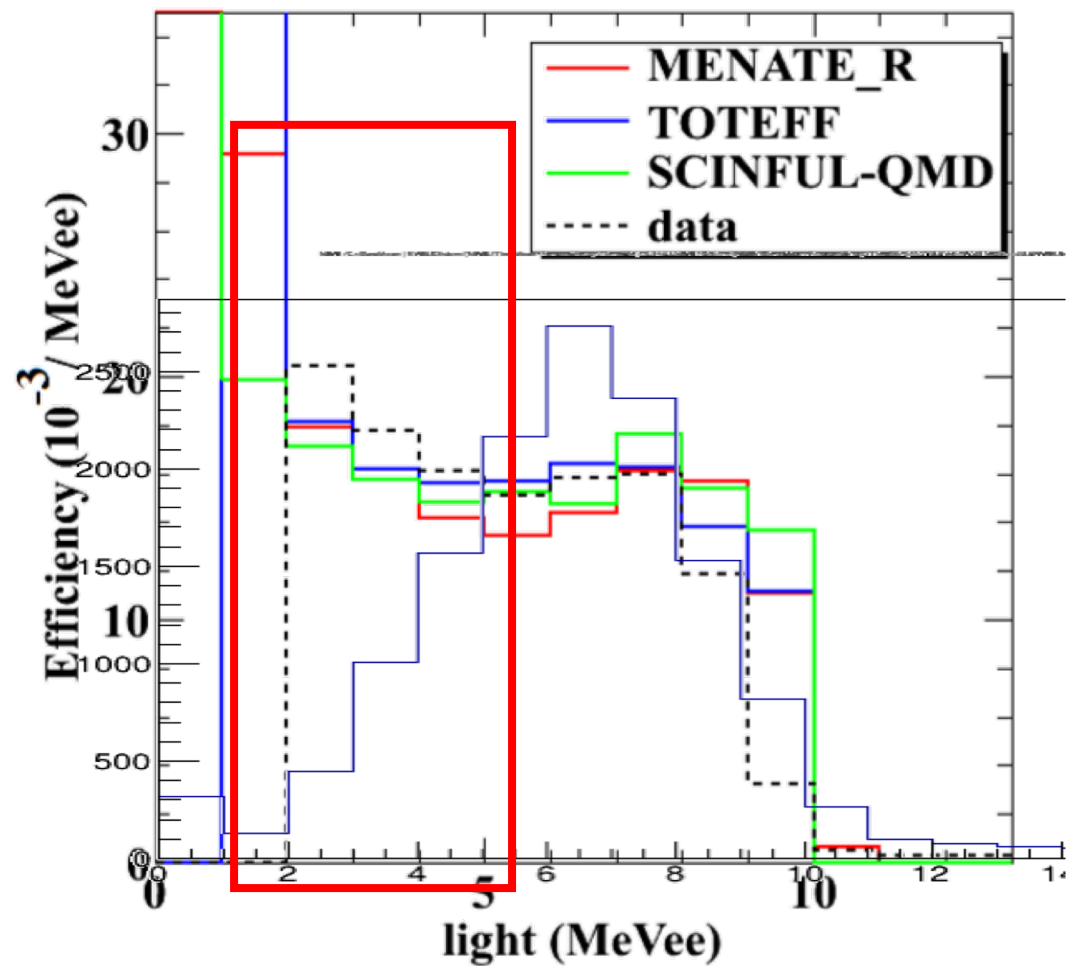
200x7x7 cm3 of box



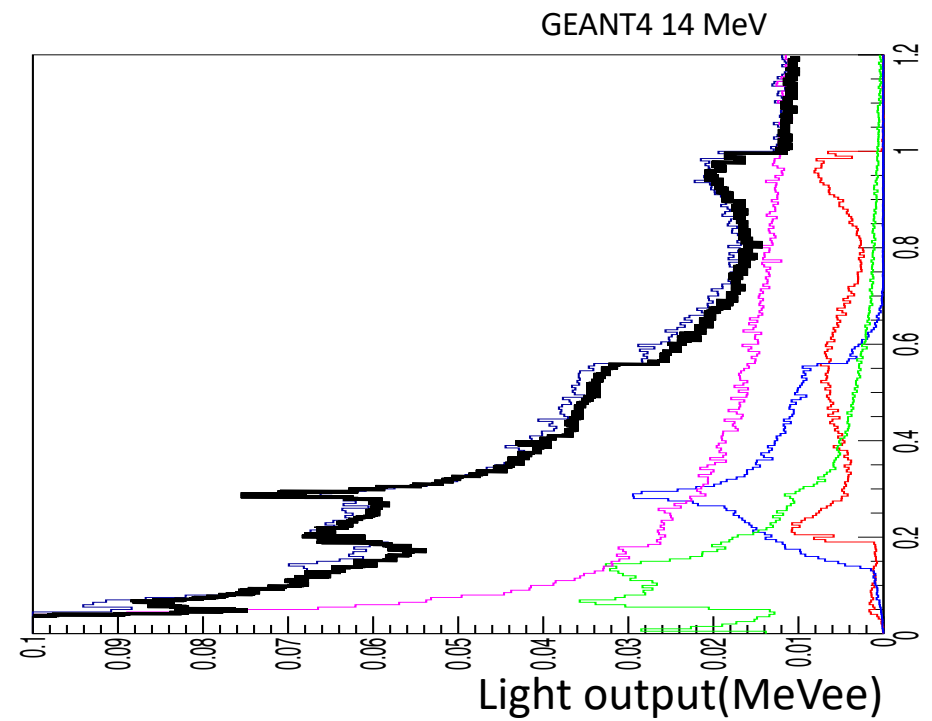
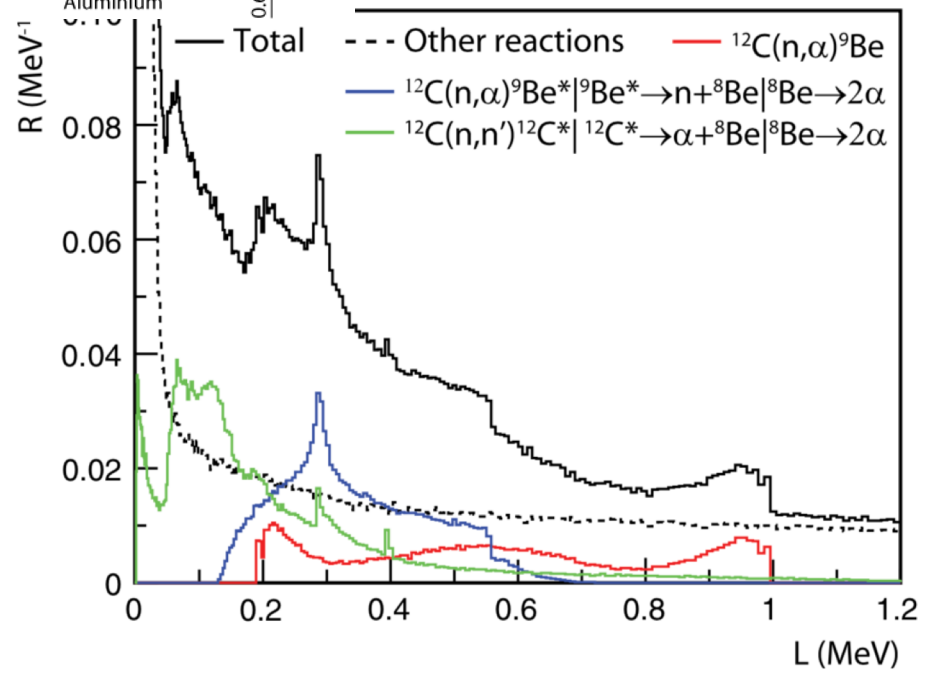
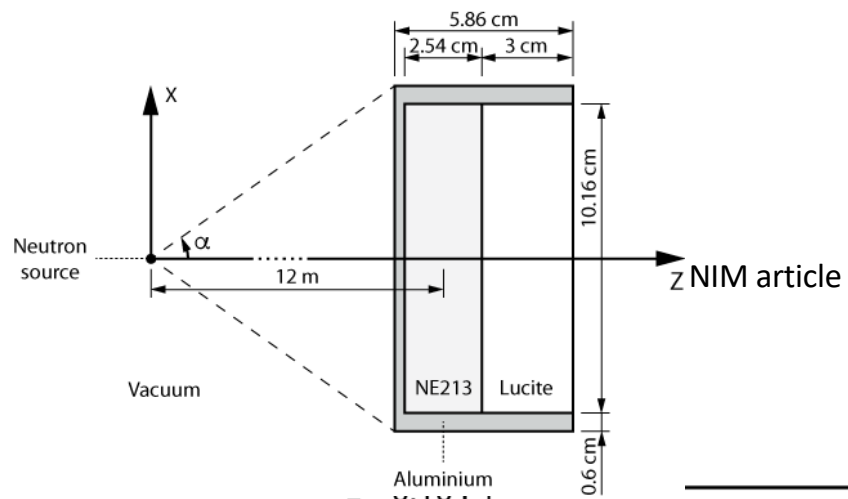
En = 15 MeV

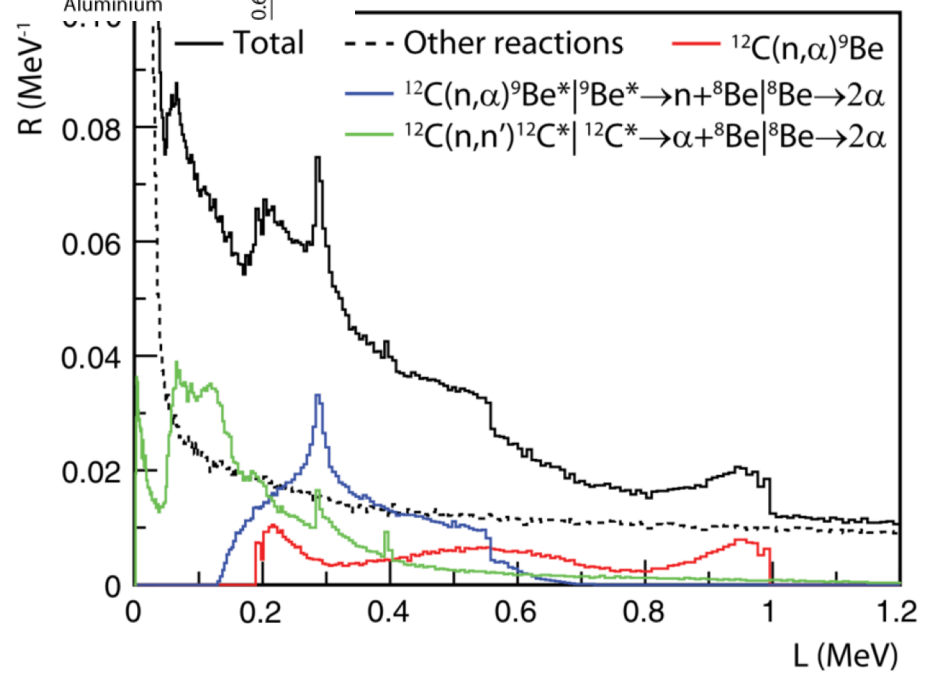
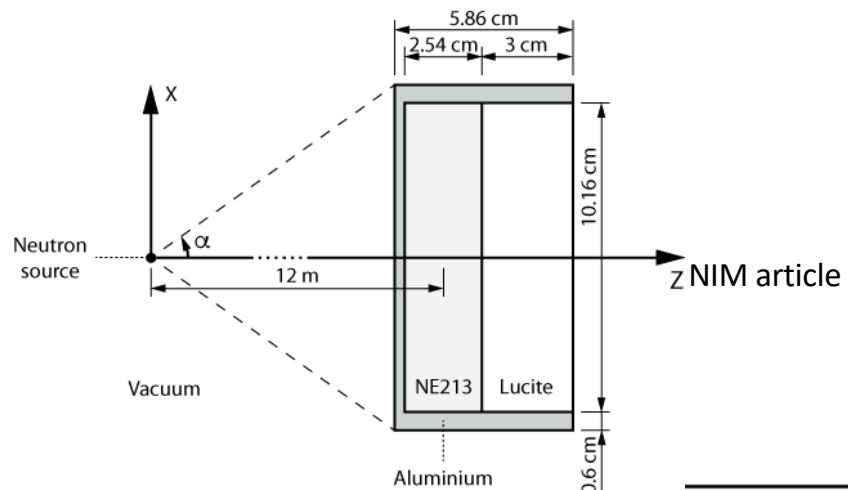
Coupland vs Kuan

En = 65 MeV

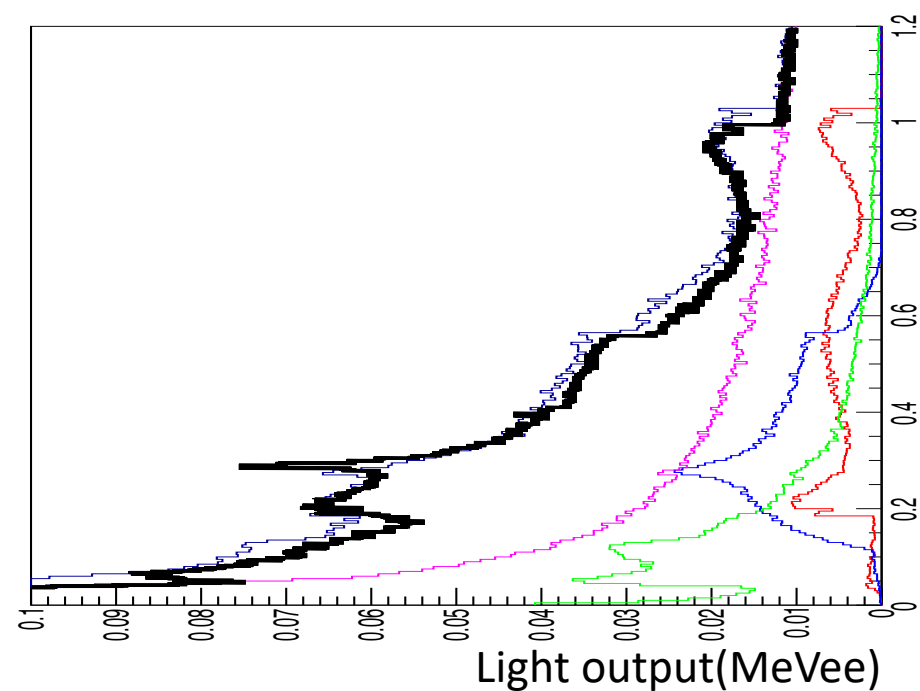


There are no agreements at low channels of light output.
We should look at what happened.



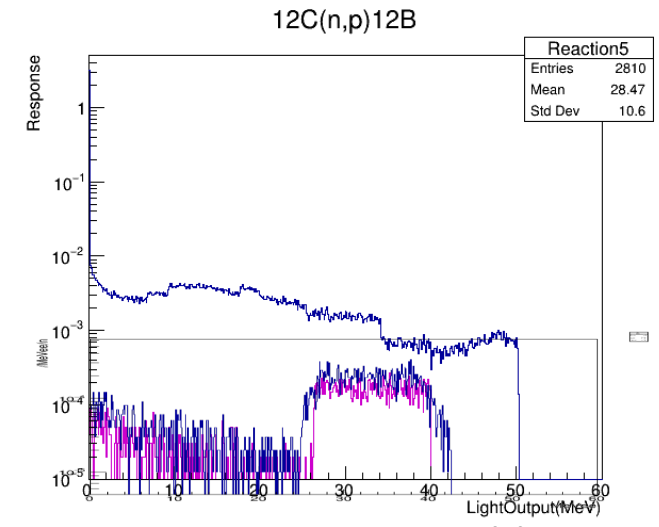
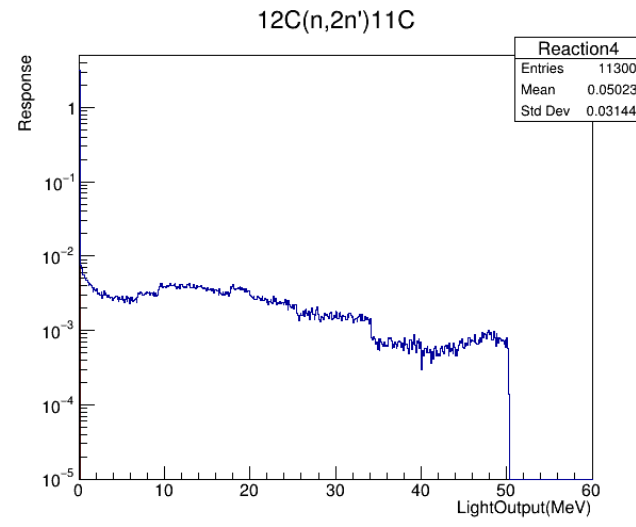
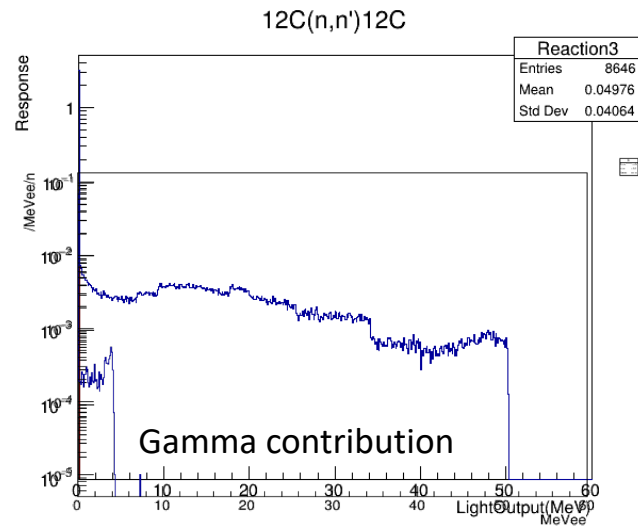
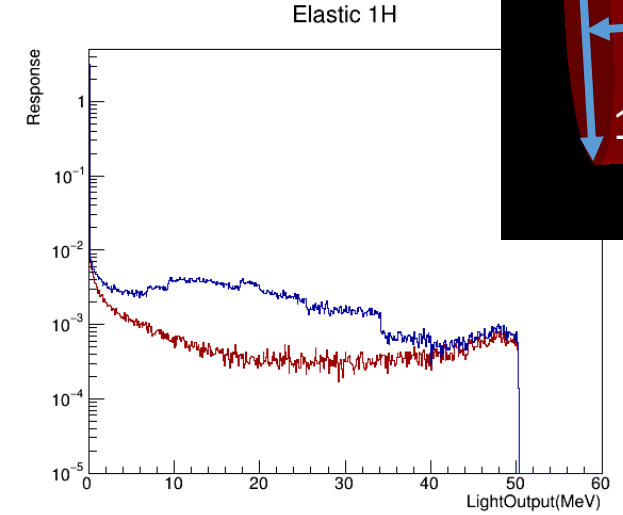
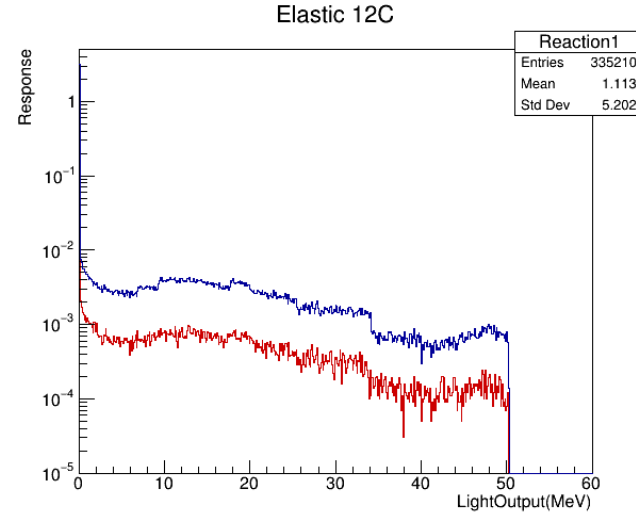
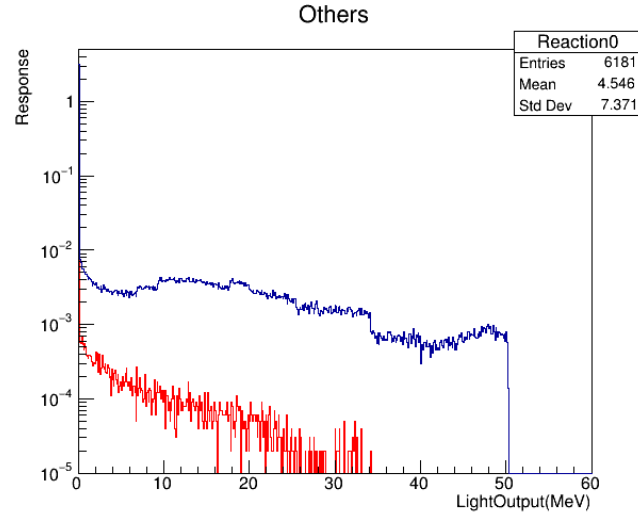
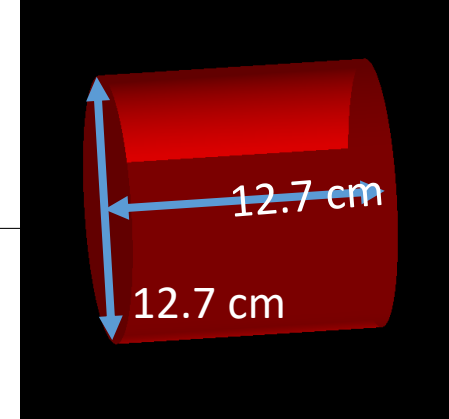


SCINFUL 14 MeV



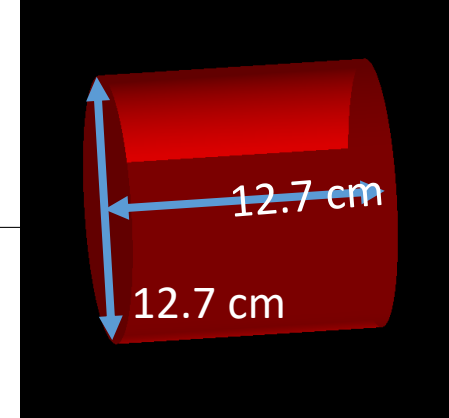
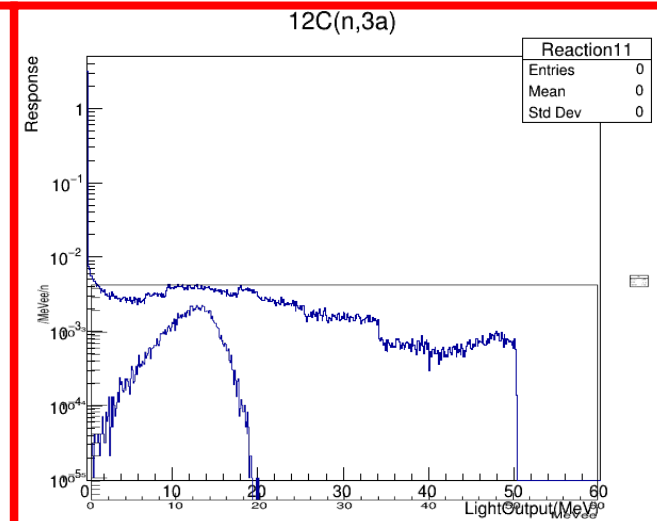
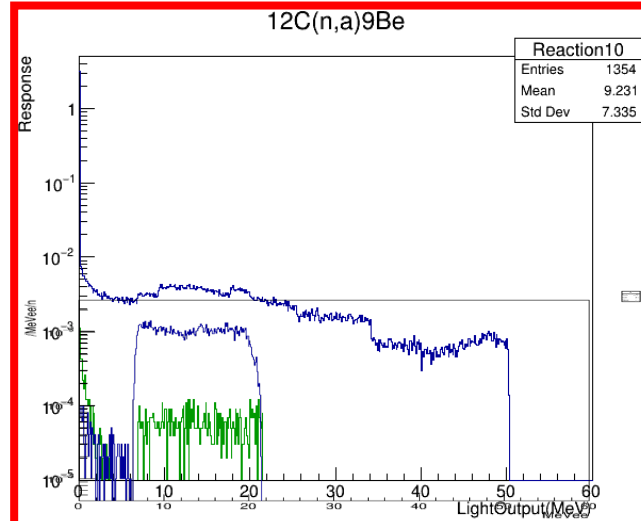
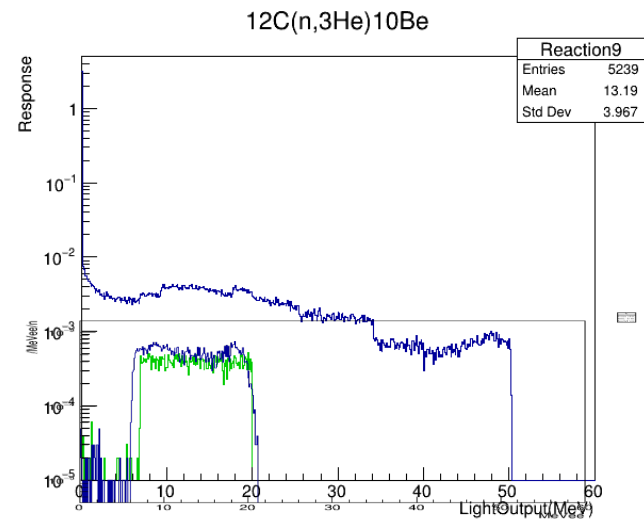
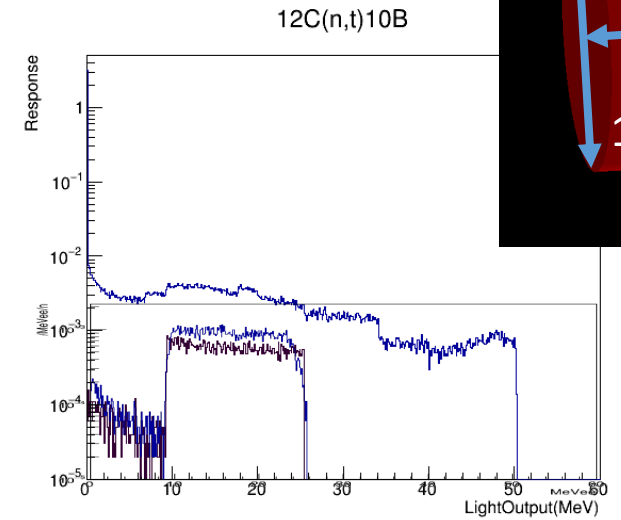
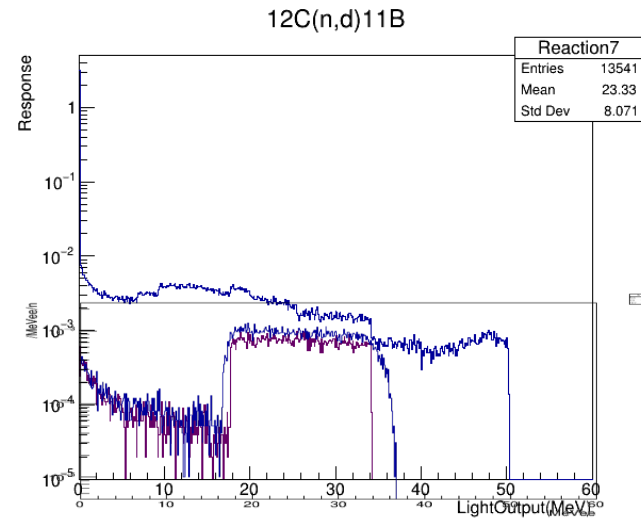
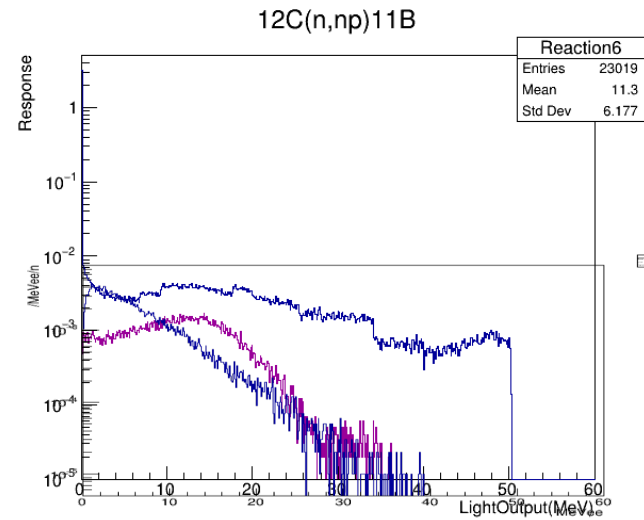
Same data, but SCINFUL light output calculation

Light response for each reaction (En = 65 MeV)



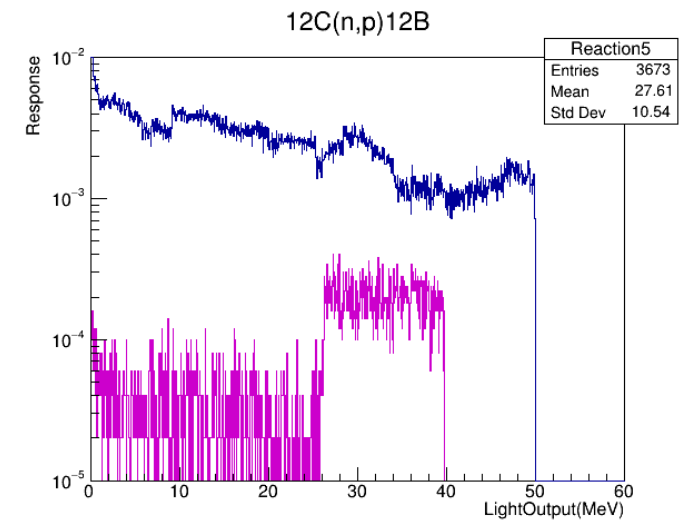
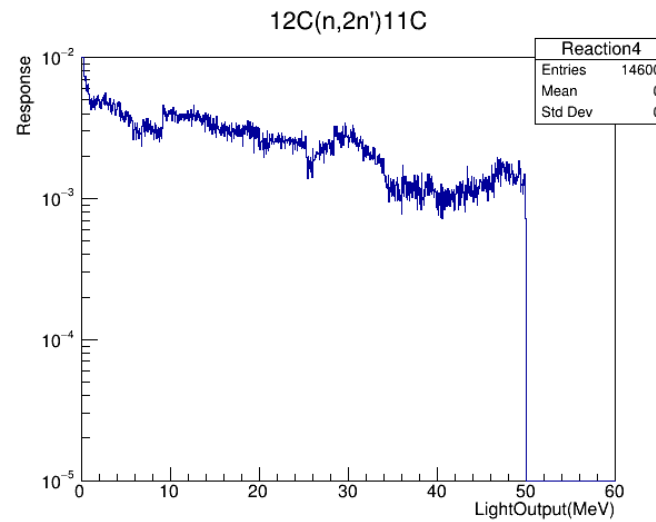
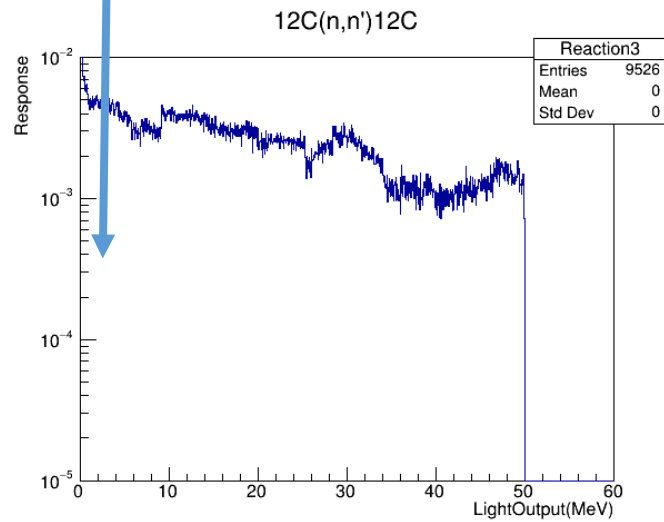
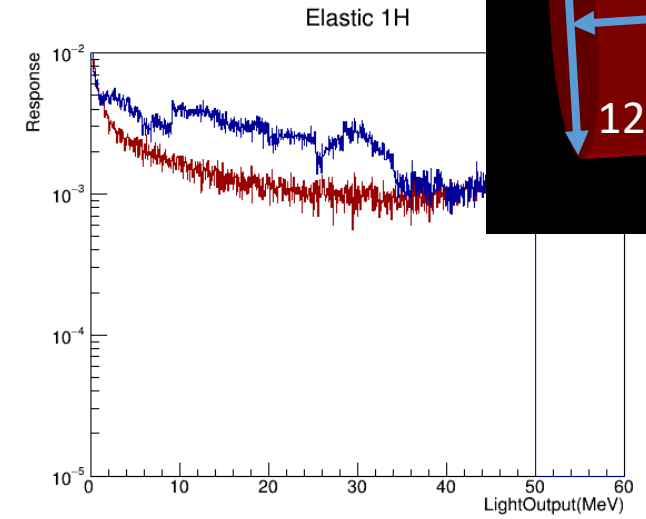
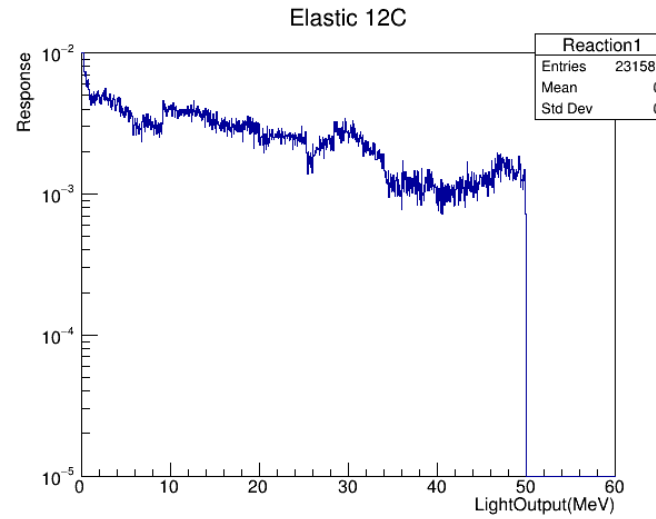
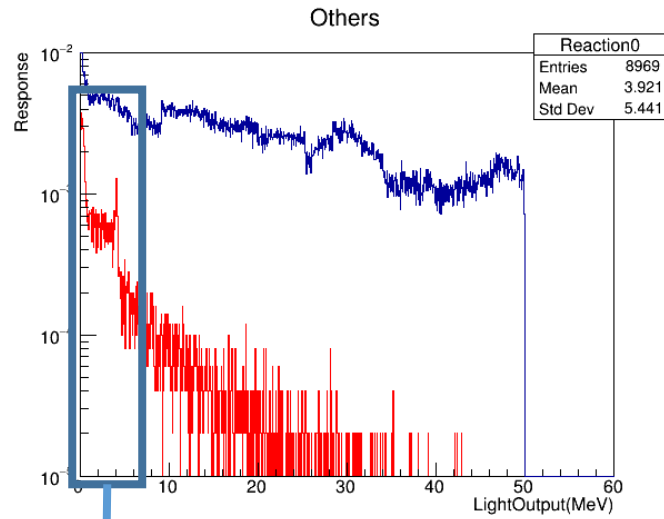
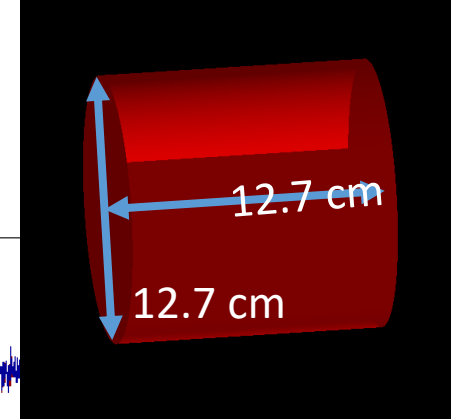
Old one

Light response for each reaction ($E_n = 65$ MeV)

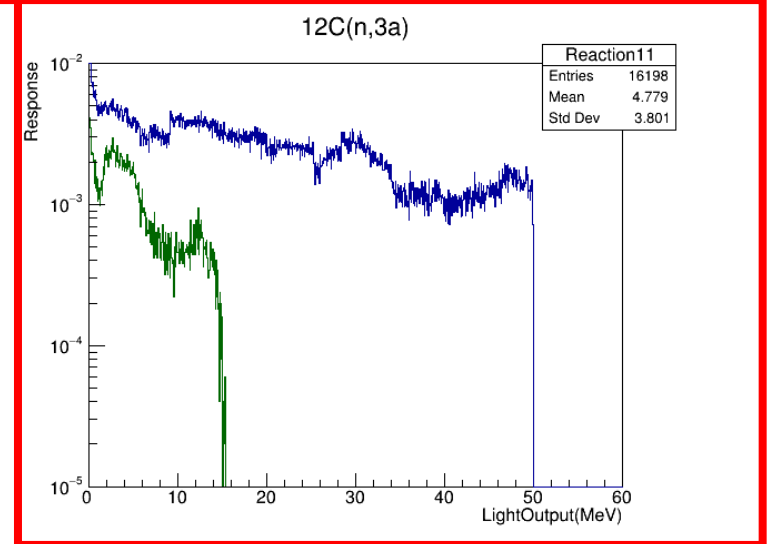
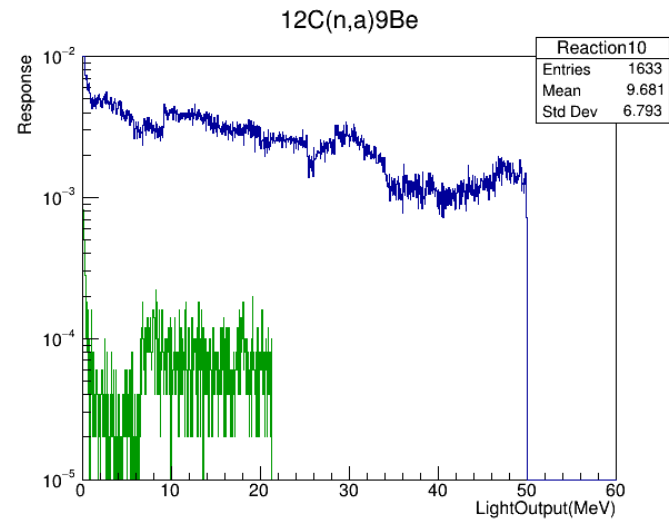
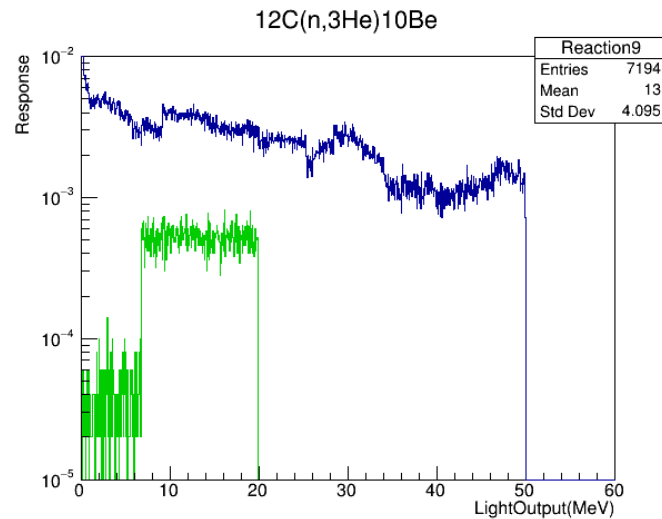
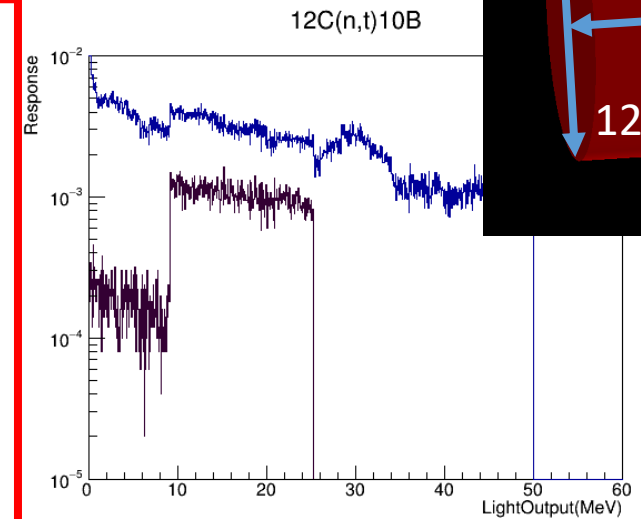
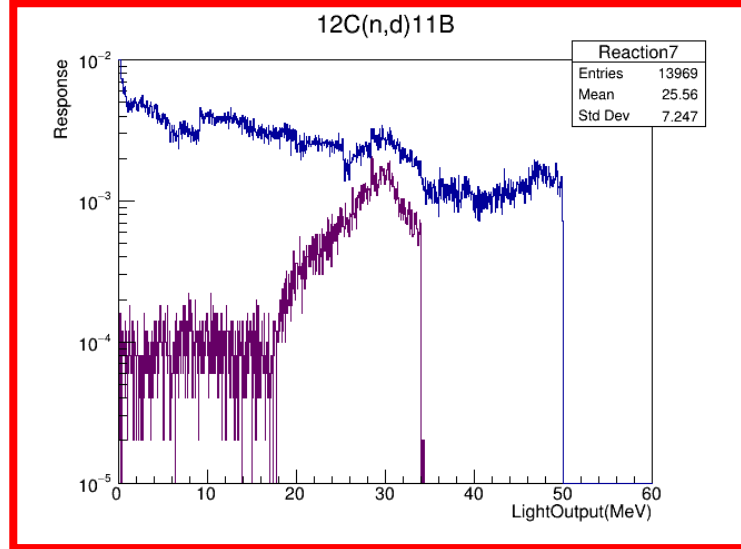
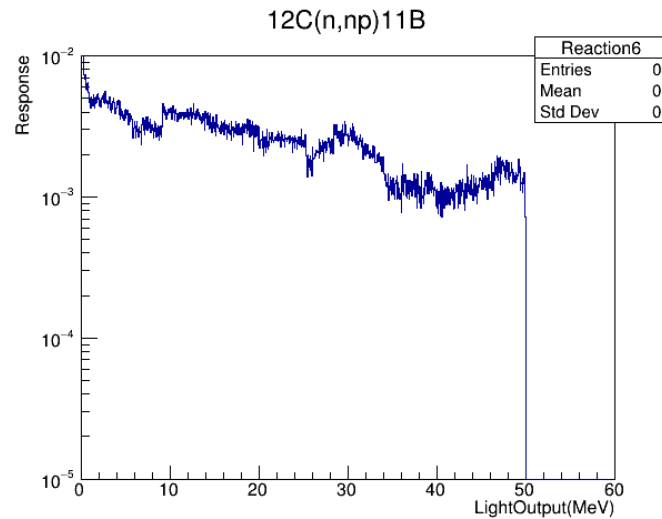
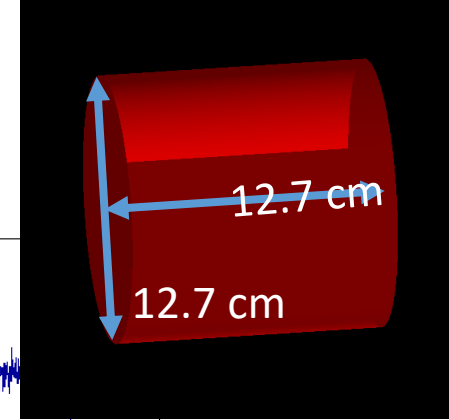


Cross section for $^{12}\text{C}(n,a)^9\text{Be}$ used by wu was wrong
Not implemented for sequential decays.

Light response for each reaction (En = 65 MeV)



Light response for each reaction (En = 65 MeV)



12C(n,n'3a) and sequential decay of 12C(n,d)11B are done. The other reactions will be also applied with sequential decays. 12C(n,np) has problem -> It will be fixed.