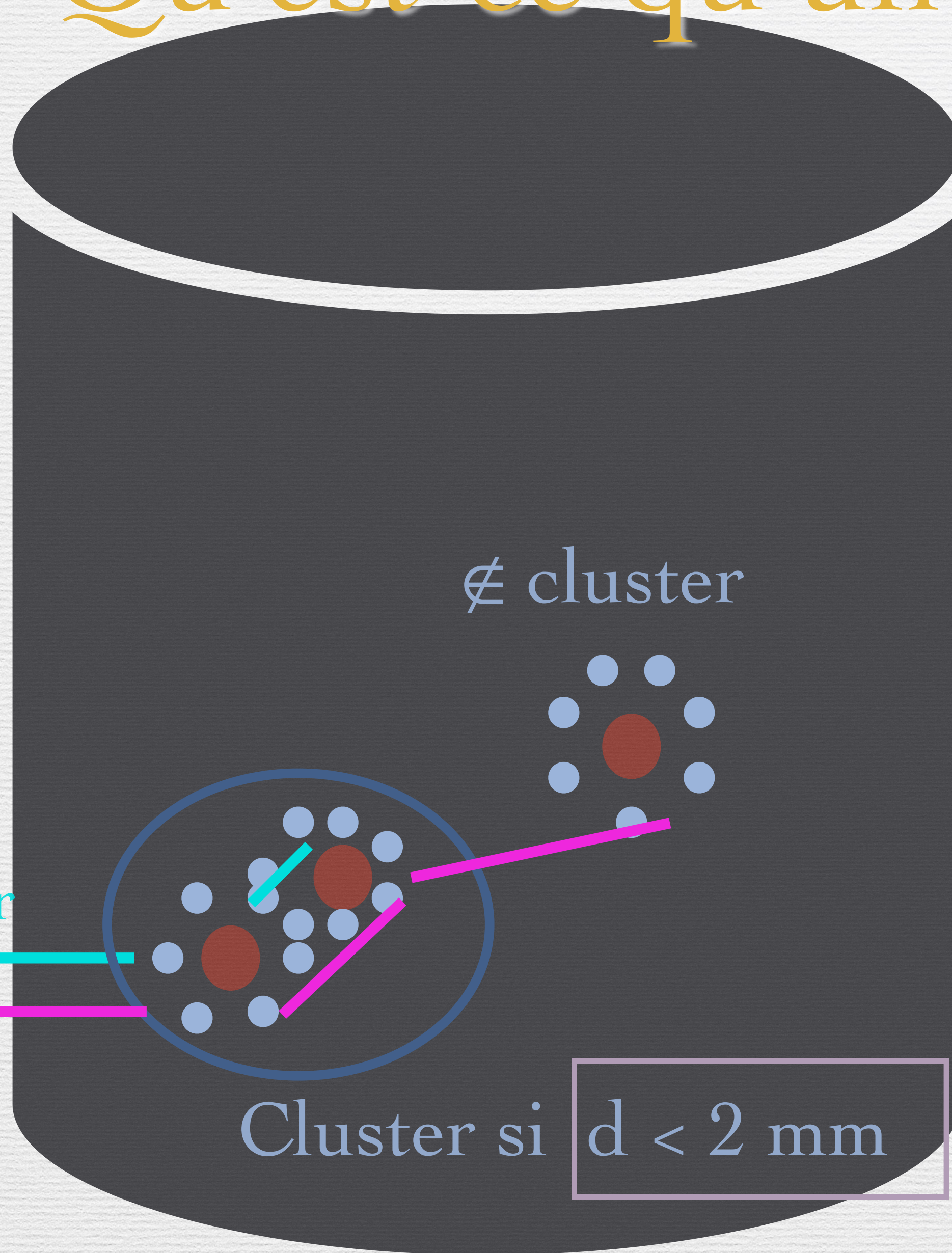
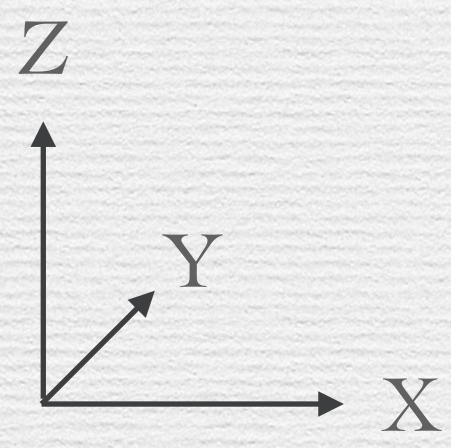


# Premières analyses simulations

Marie van Uffelen  
Stage M2 CPPM

# Qu'est-ce qu'un single scatter ?



Codé dans  
g4rootered\_nDS20k\_VETO.C

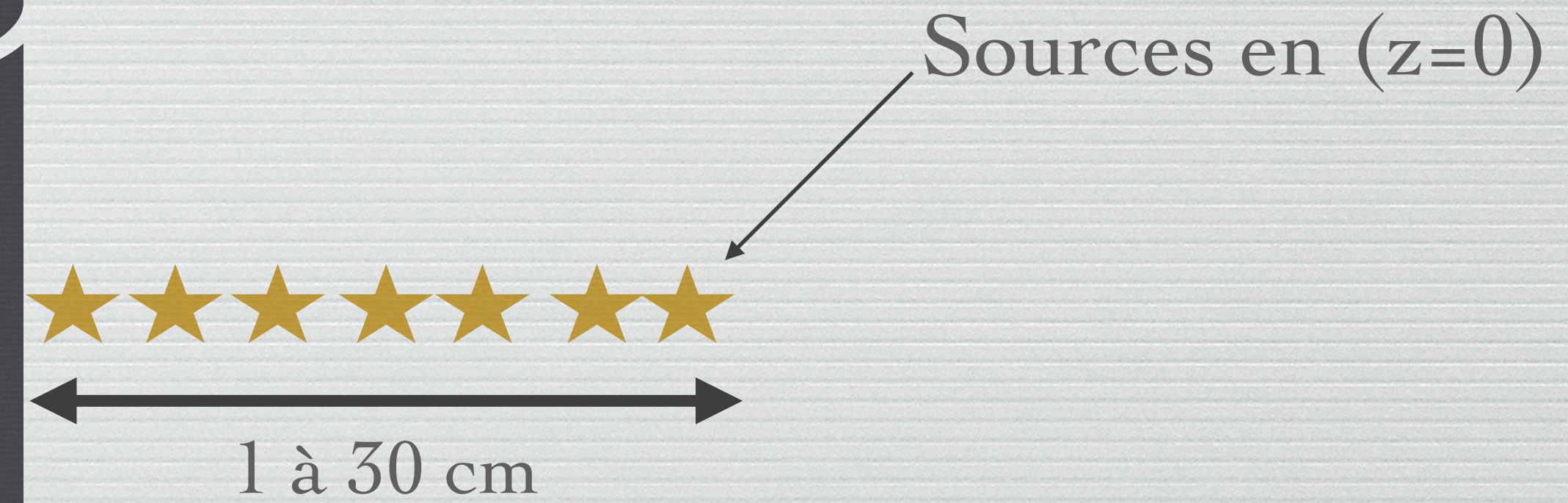
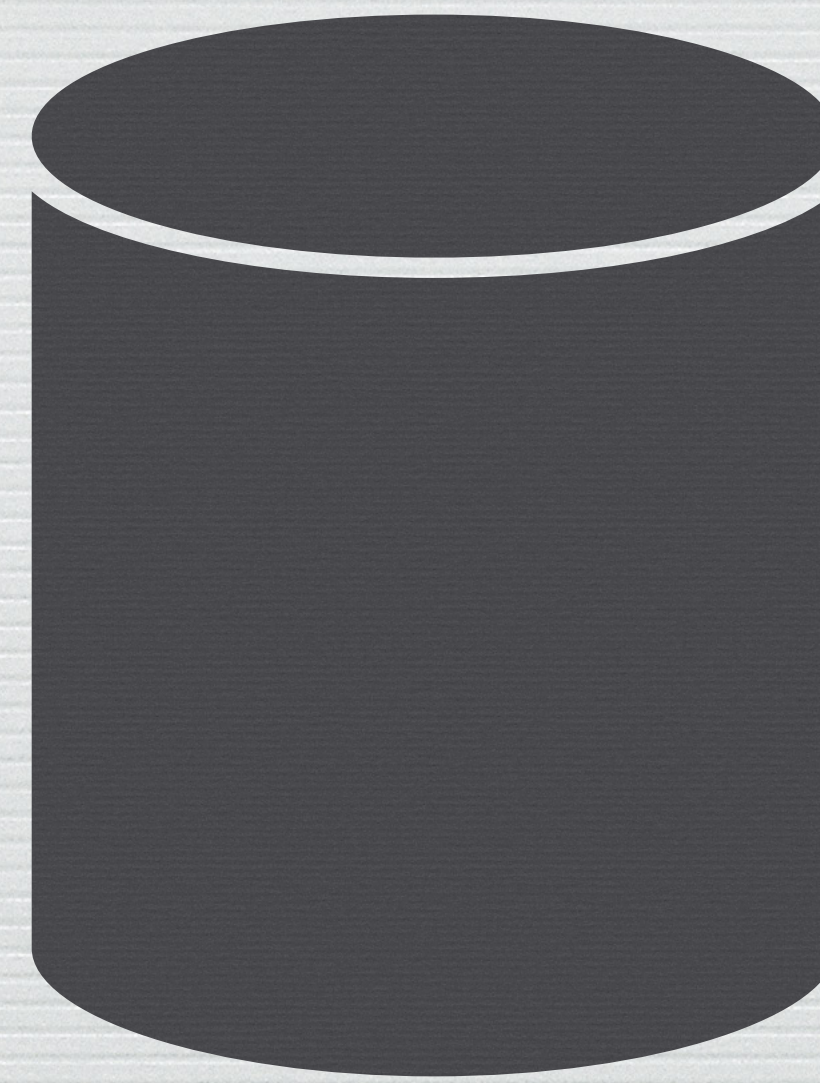
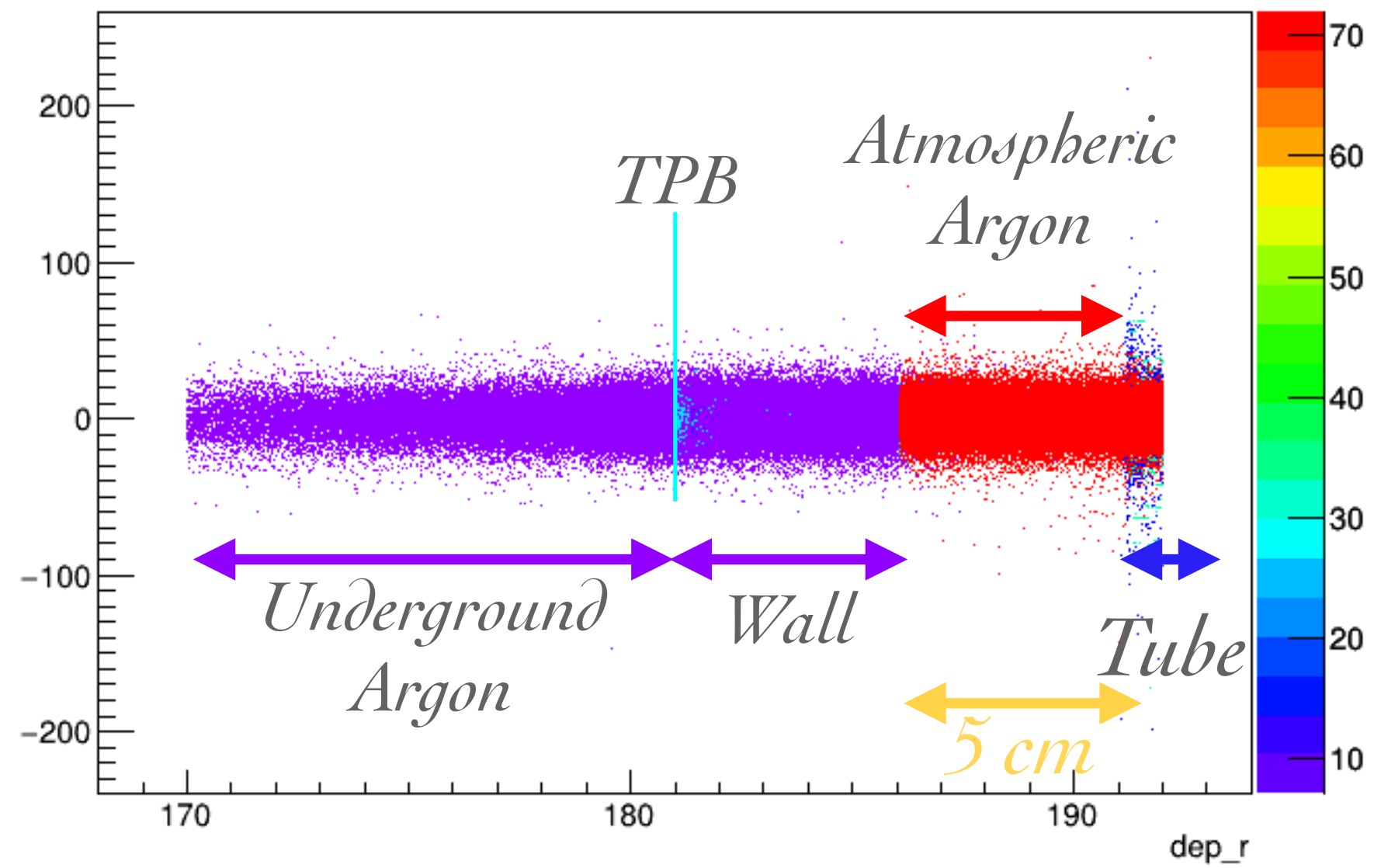
Single scatter

Not a single  
scatter

Cluster si  $d < 2 \text{ mm}$

Vient de la résolution lors  
de la reconstruction en z

dep\_z:dep\_r:dep\_mat {cuts2}

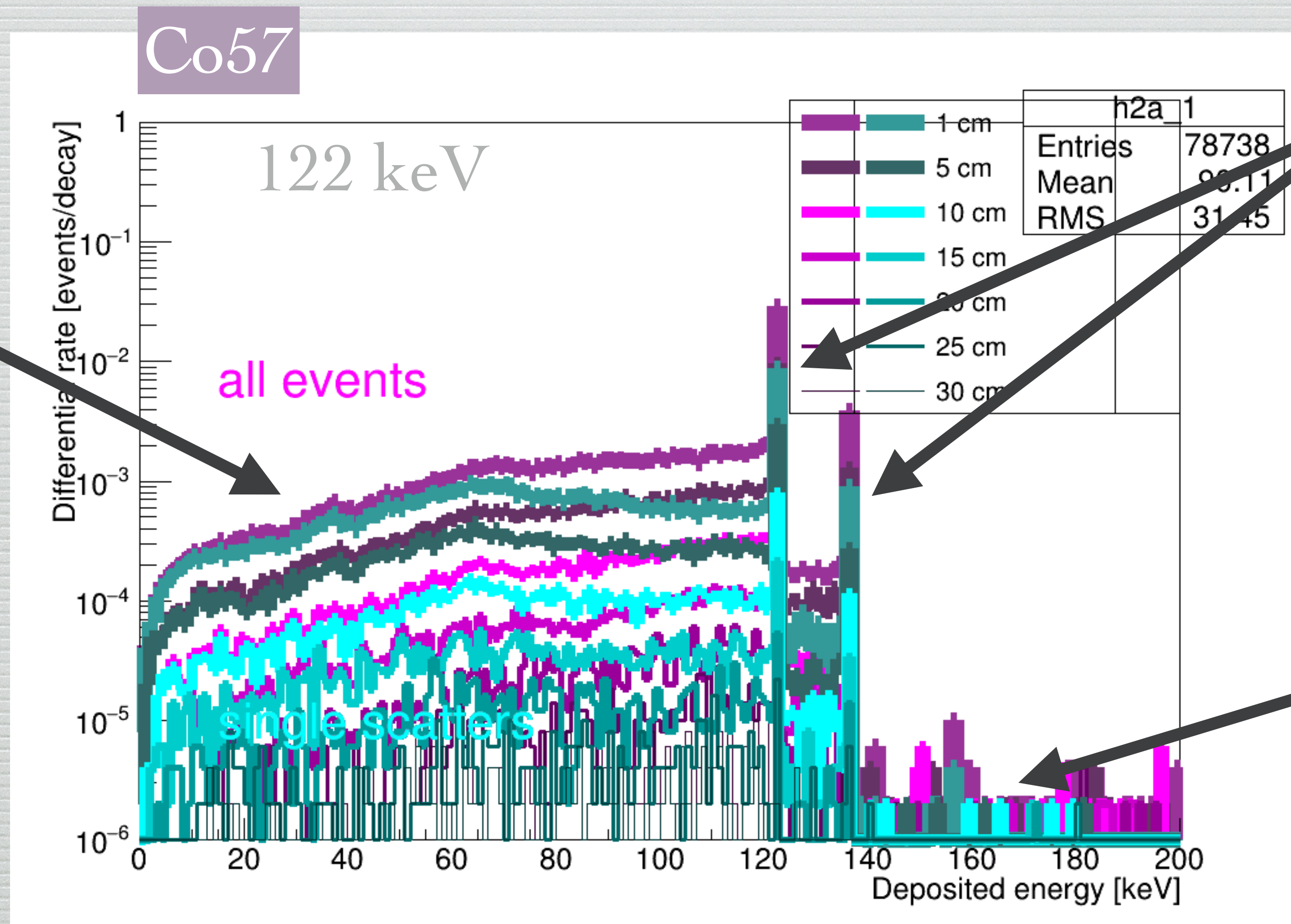


**PLAN A**

Sources placées en un point  
sur le côté de la TPC

# Plots photons

”Queue” à basse énergie : provient des diffusions Compton des photons

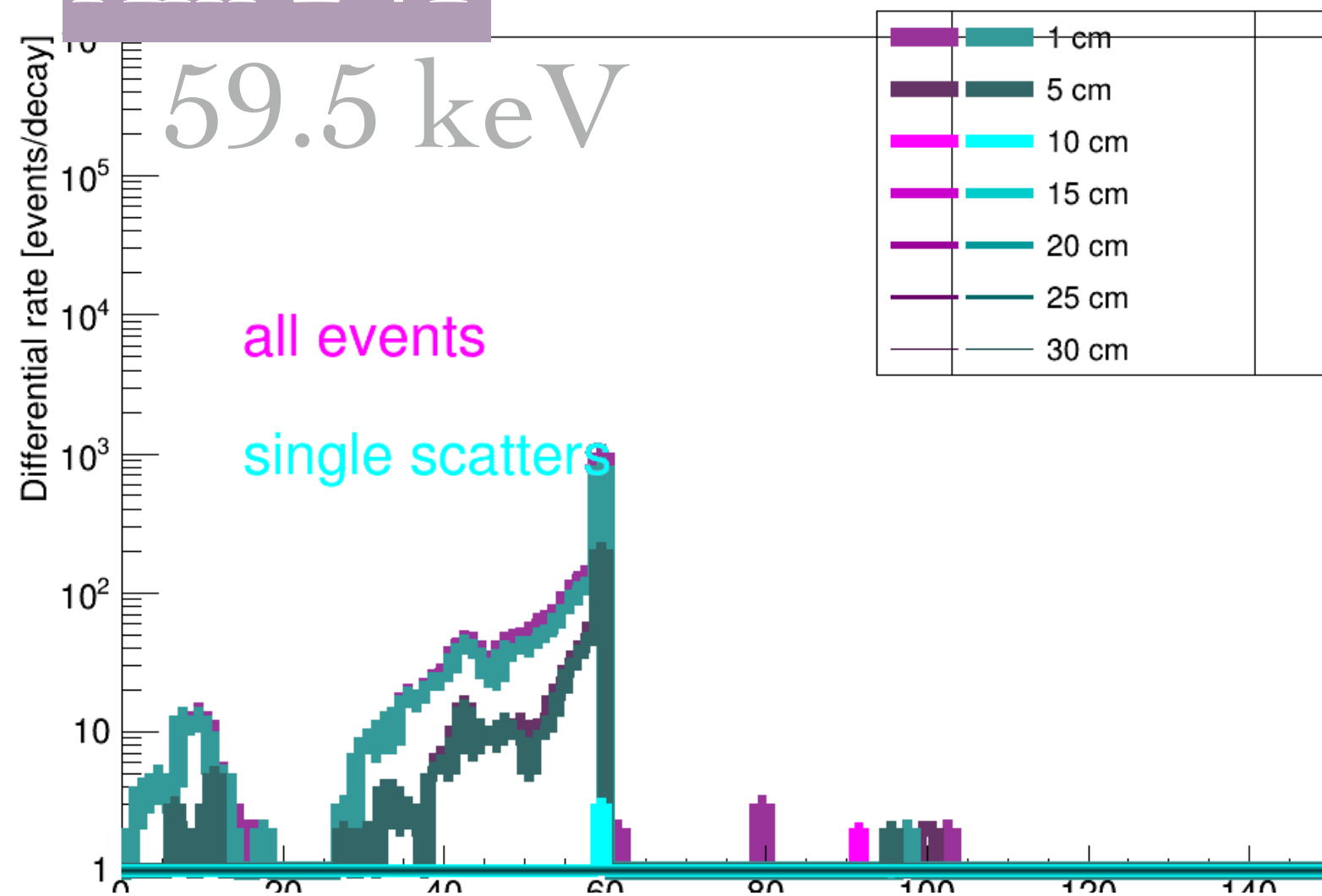


Les deux pics en énergie du Co57 : 122 et 136 keV

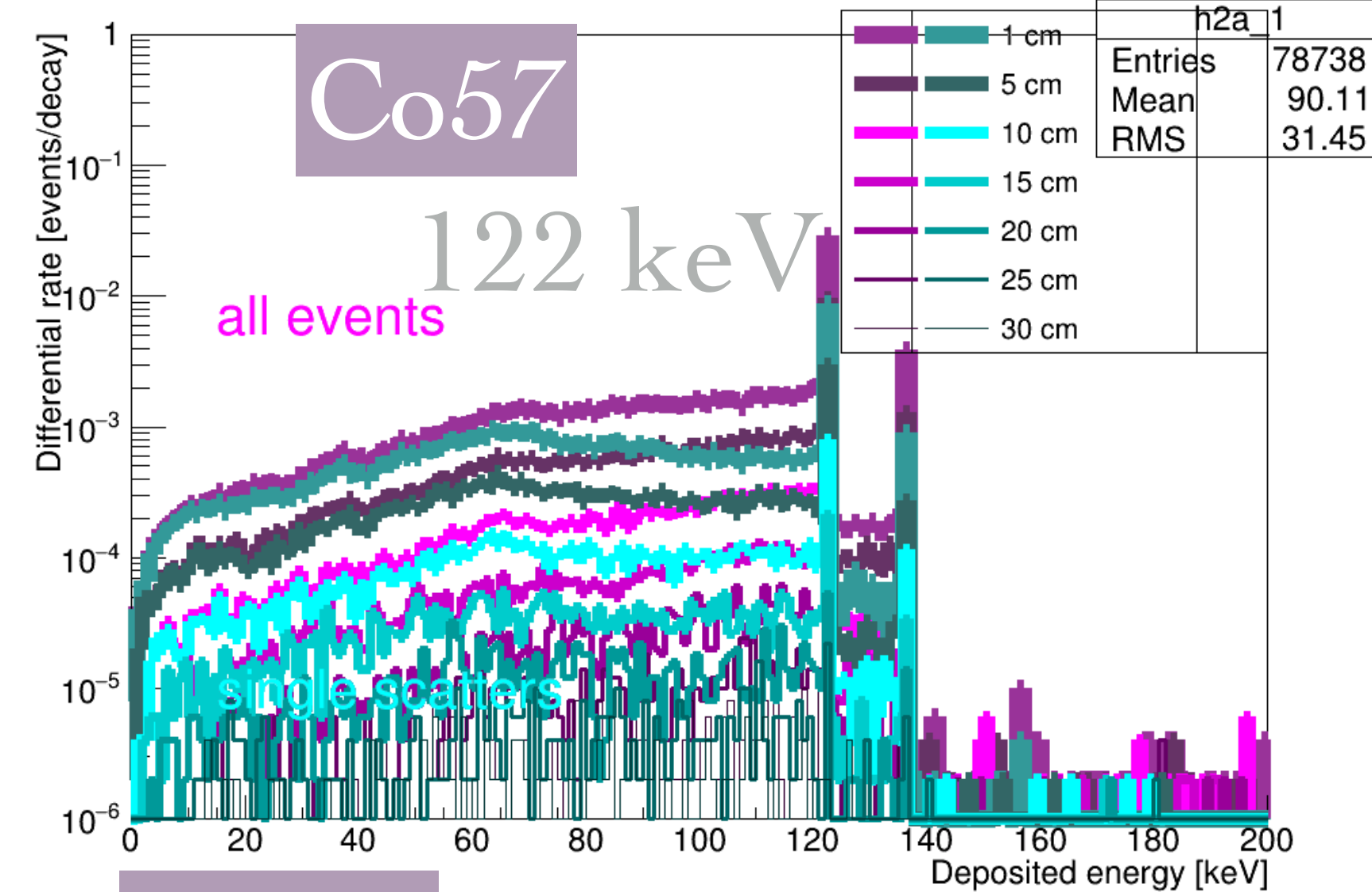
Queue à basse énergie des pics (de très faible section efficace) de plus haute énergie

# Plots photons

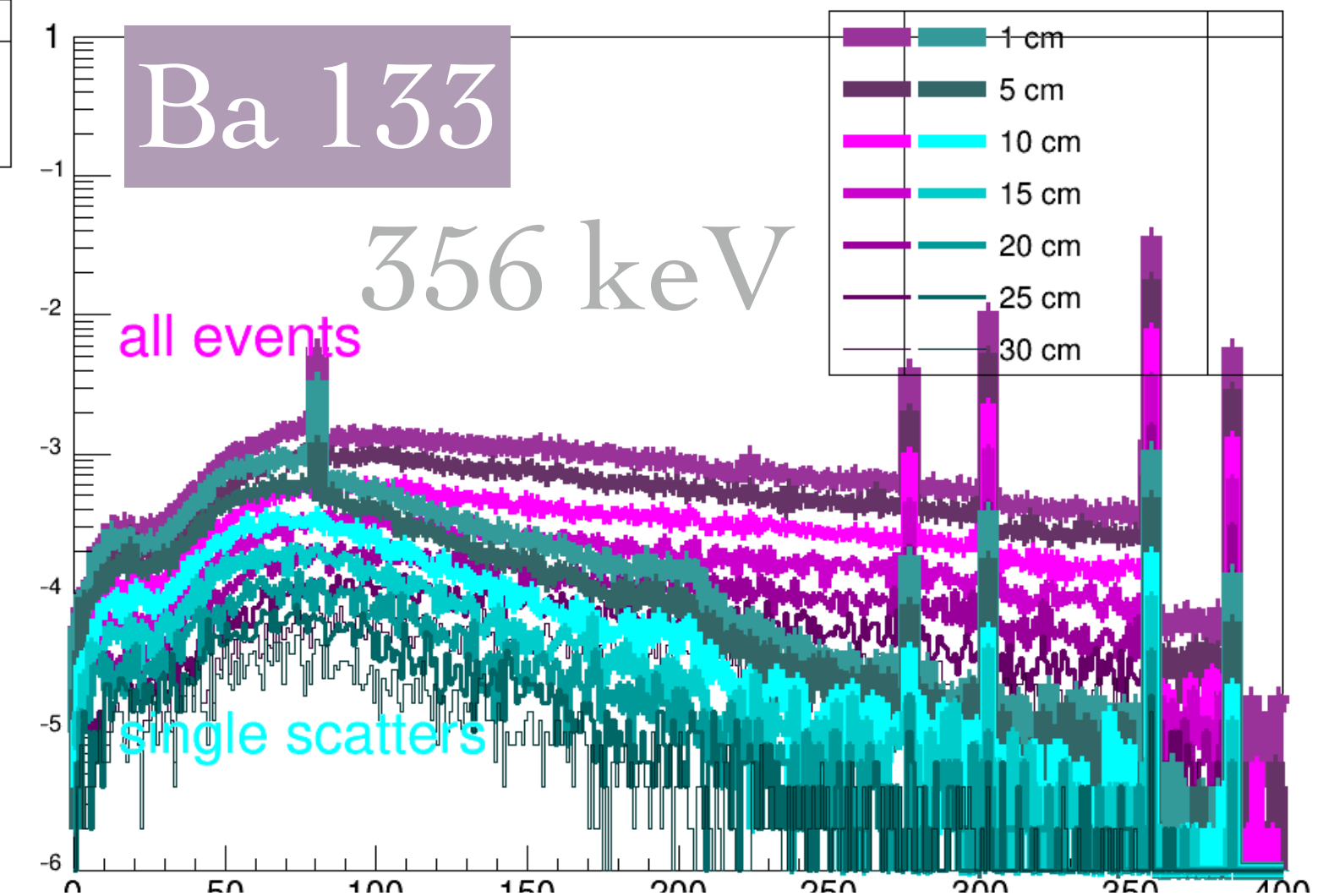
Am 241



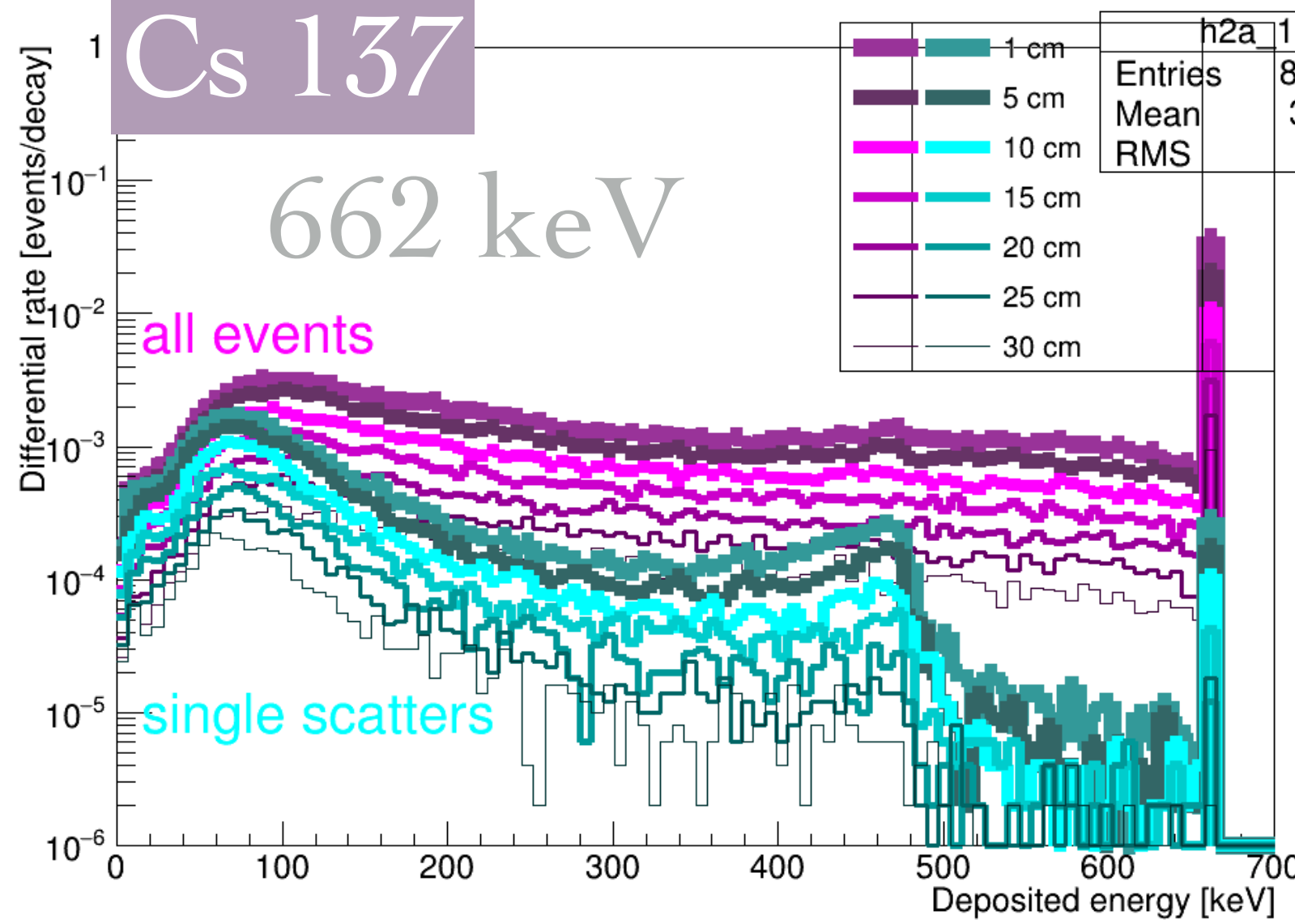
Co57



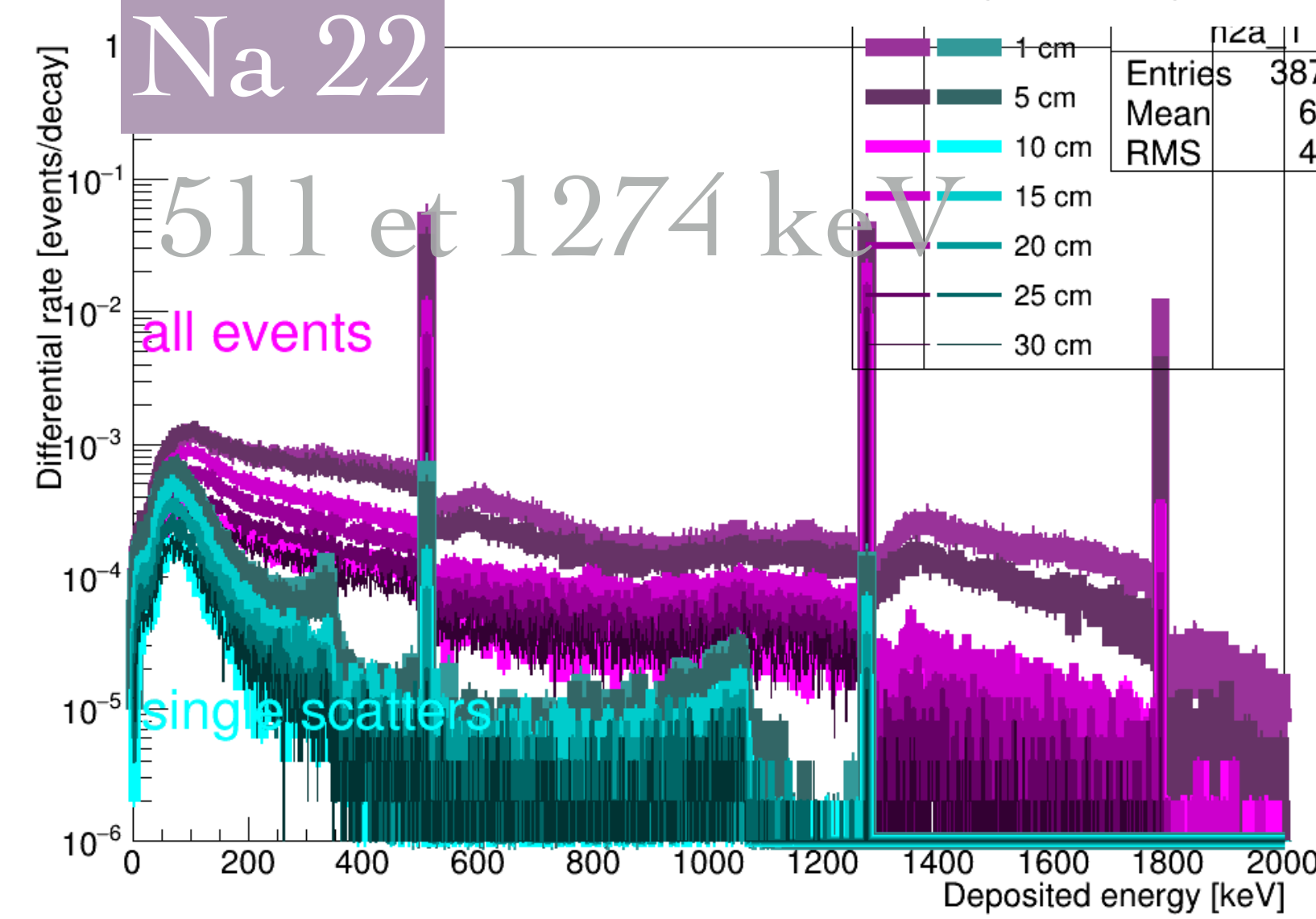
Ba 133



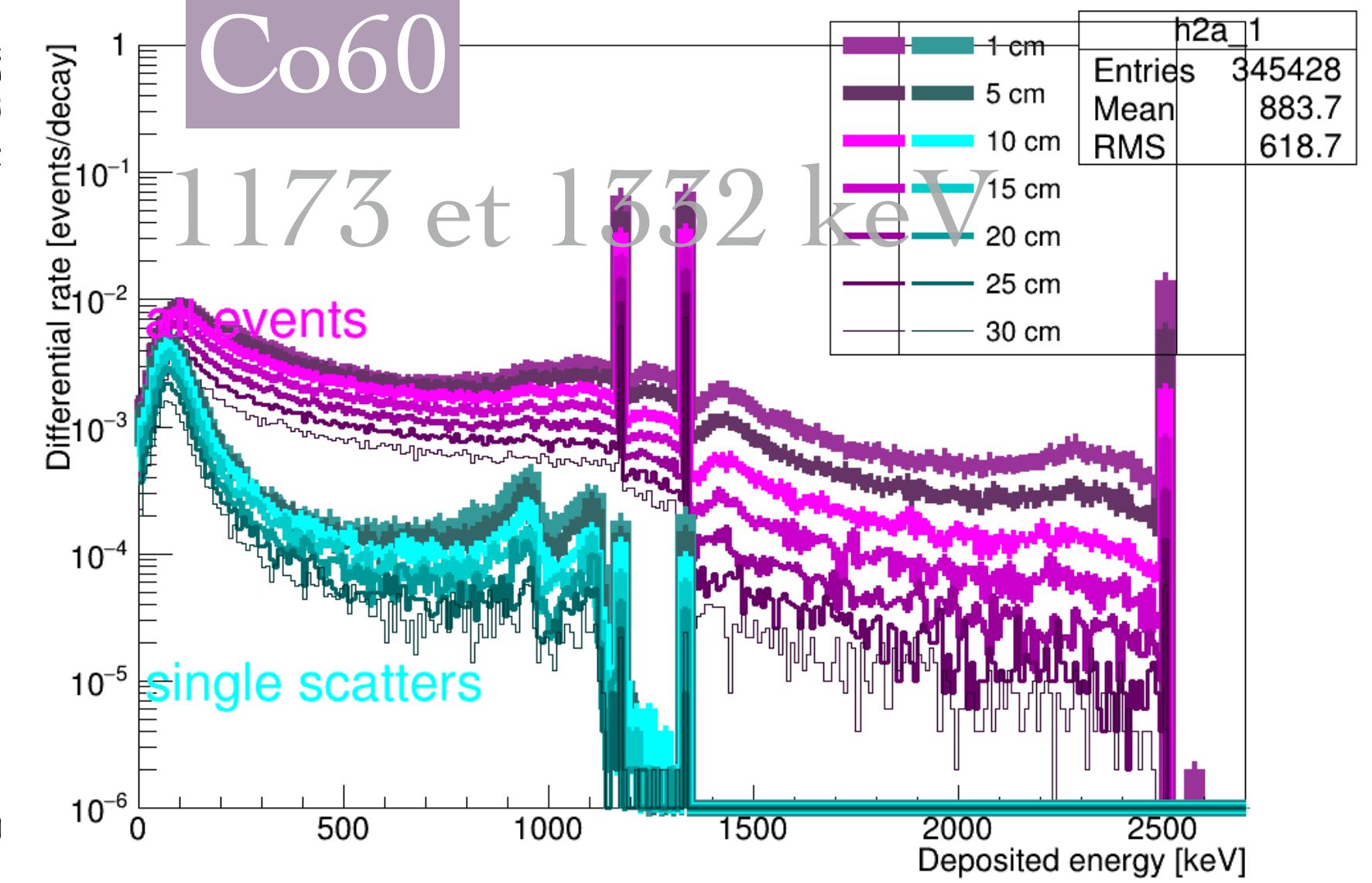
Cs 137



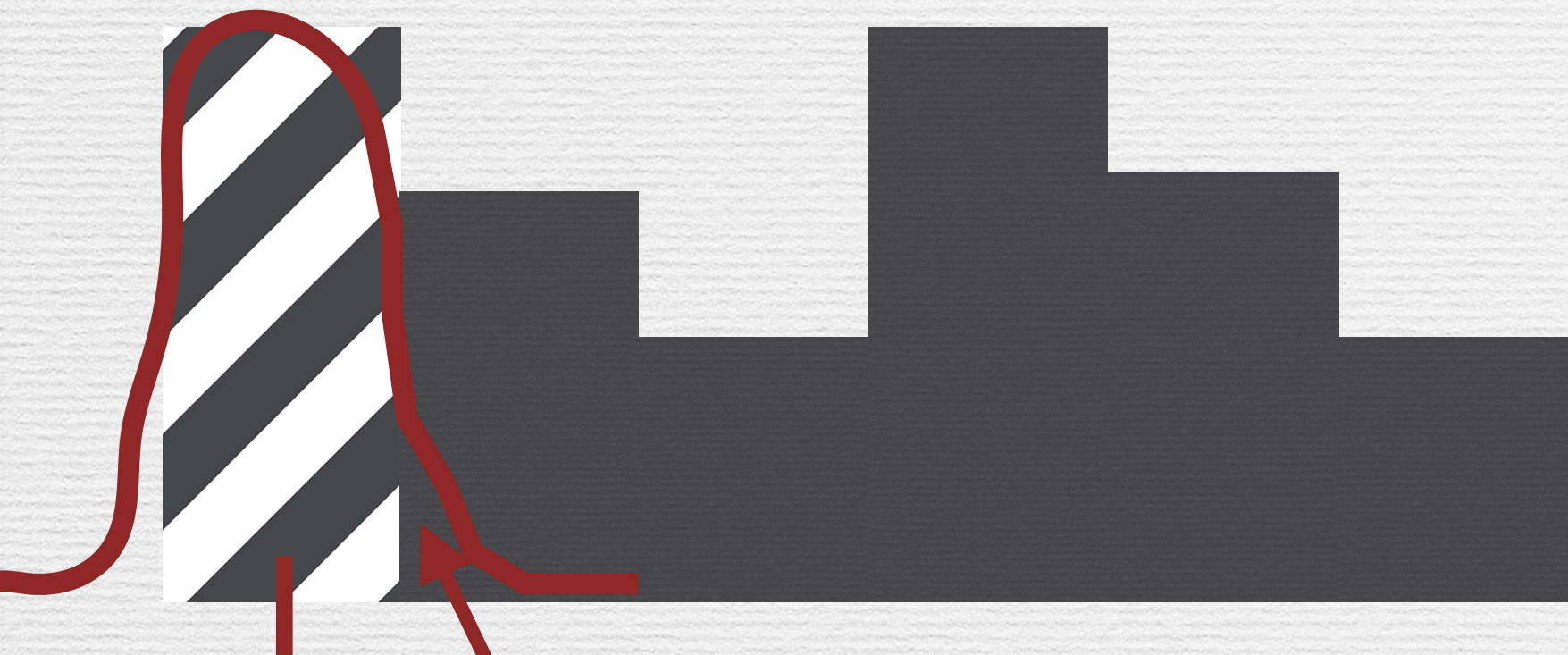
Na 22



Co60

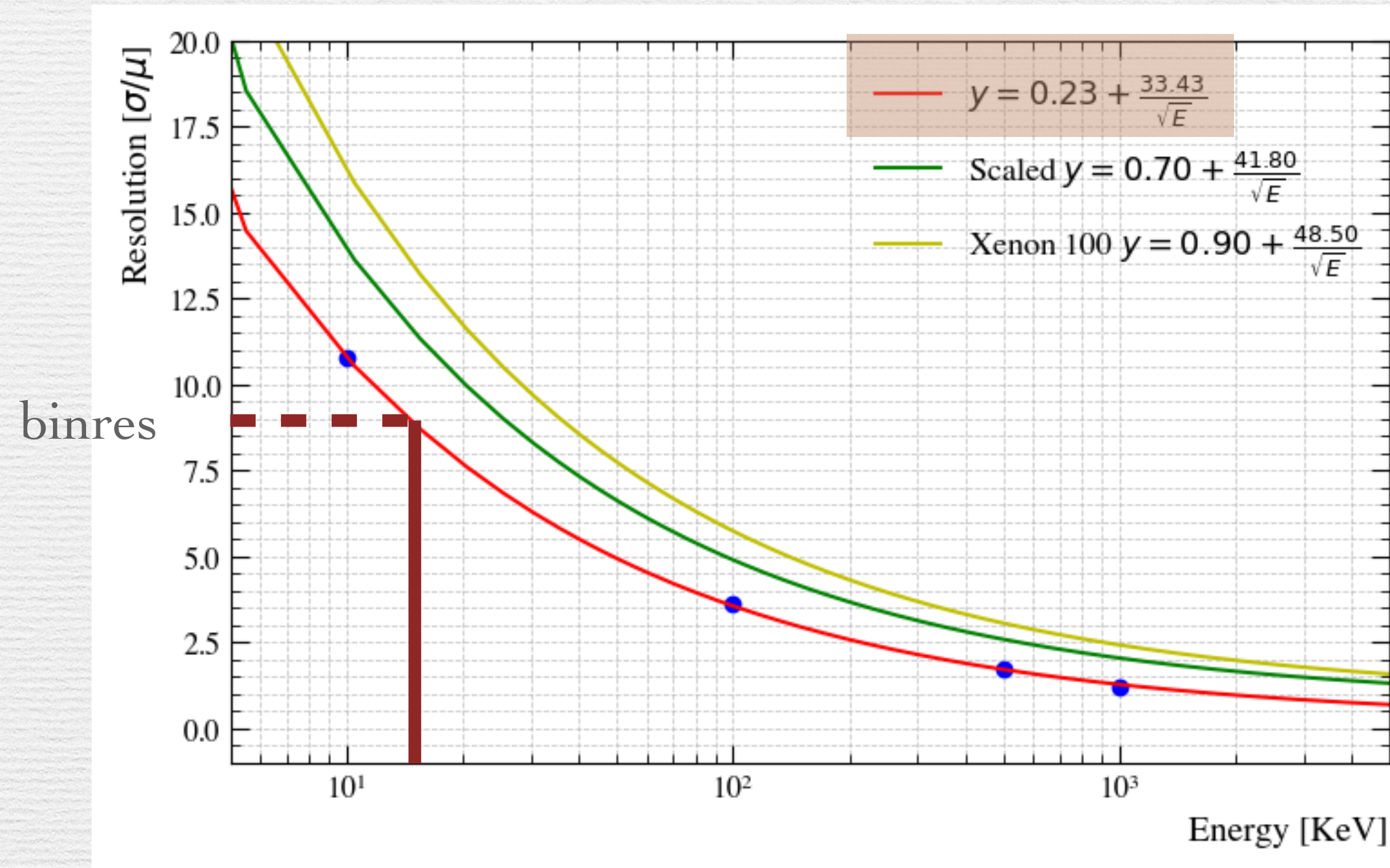


# Application de la résolution



Bincenter  
Binwidth  
Bincontent

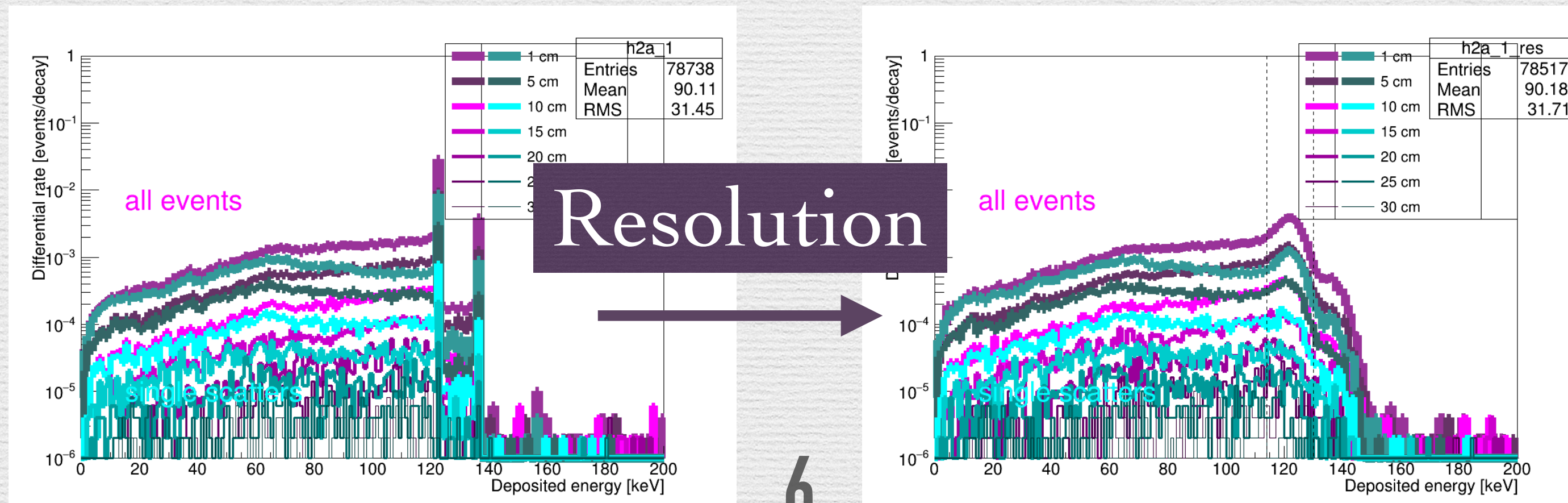
$$fct = e^{-\frac{(x - \text{bincenter})^2}{2 * (\text{binres} * \text{bincenter})^2}}$$



Coefficients obtenus par la simulation de Victor

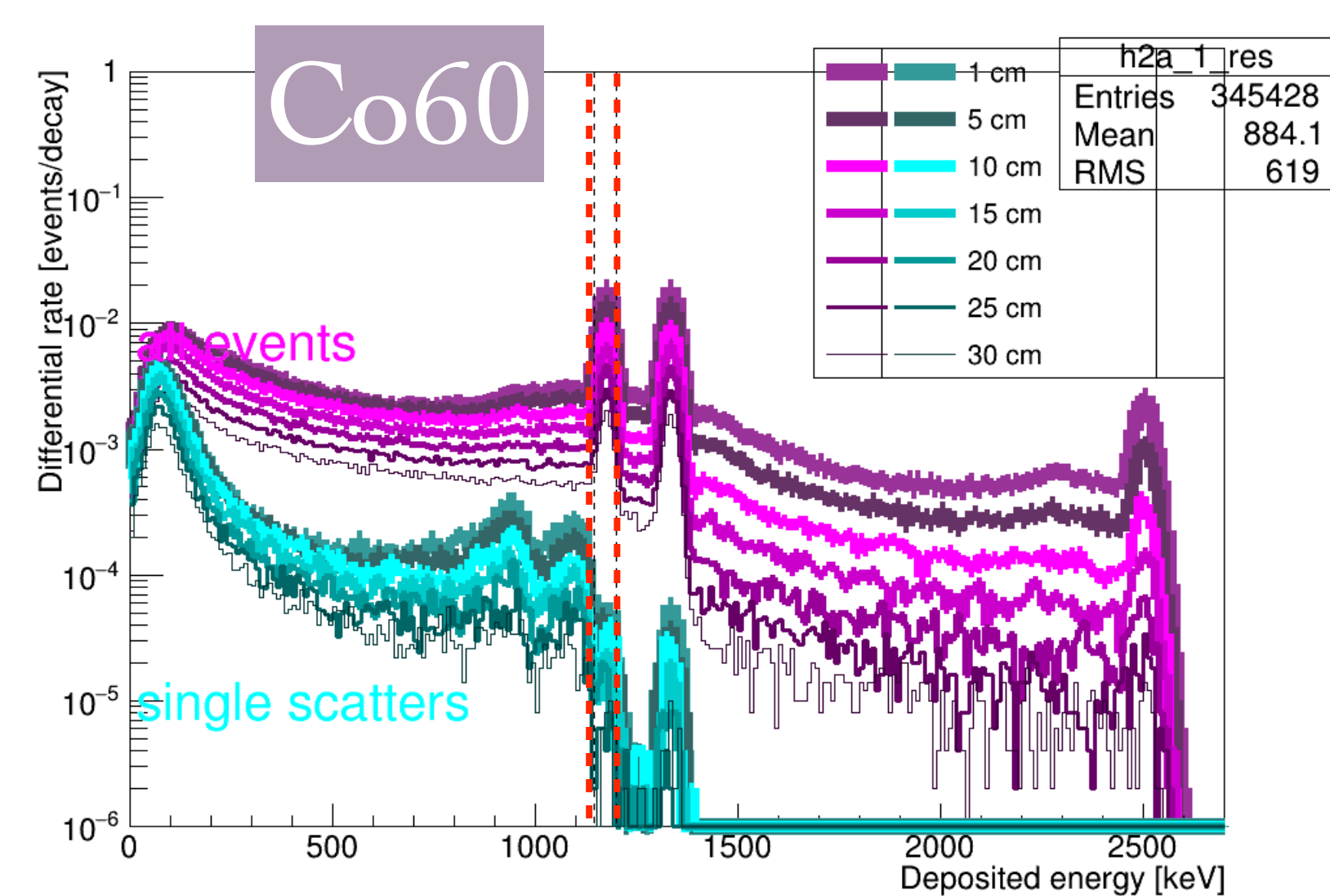
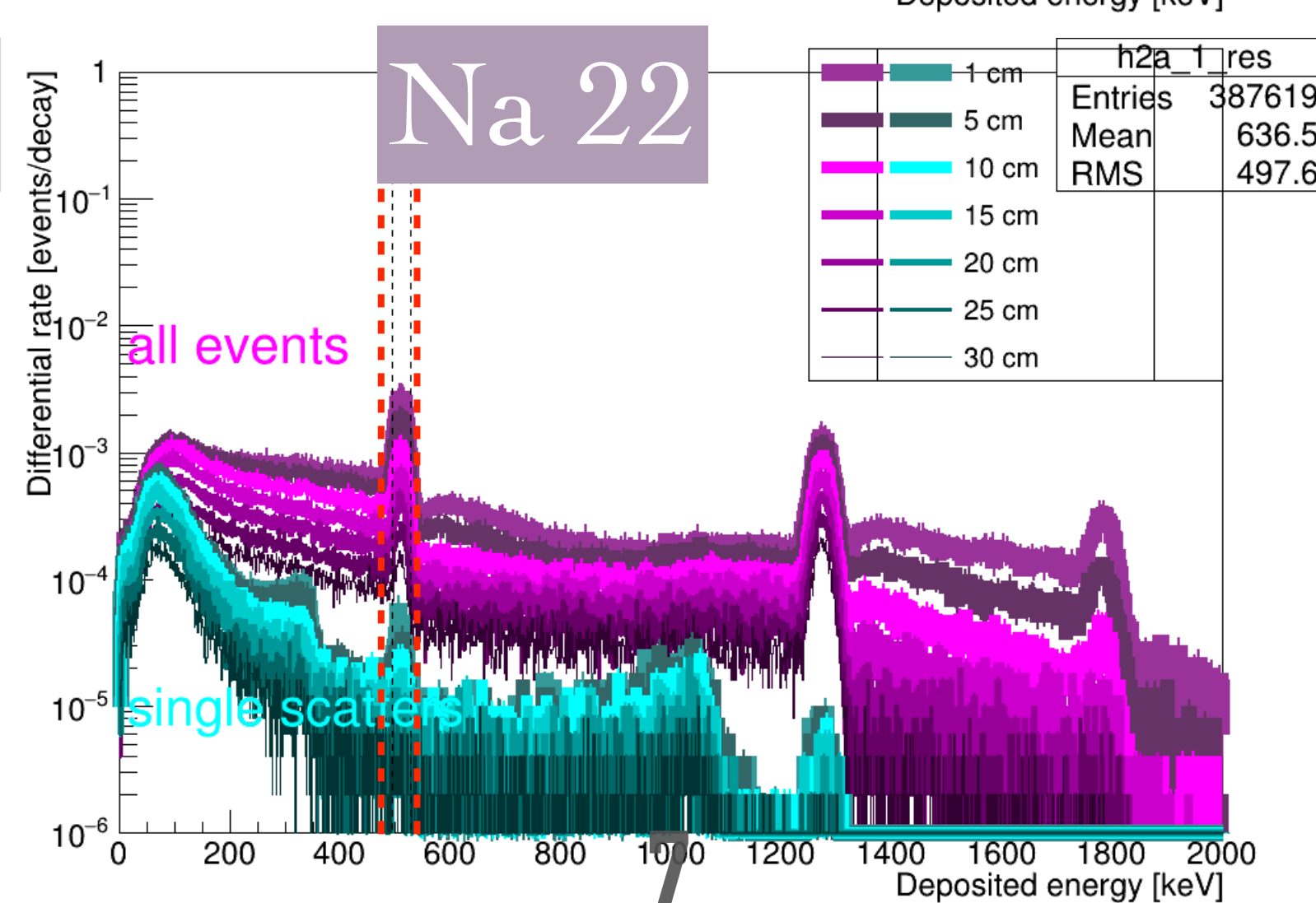
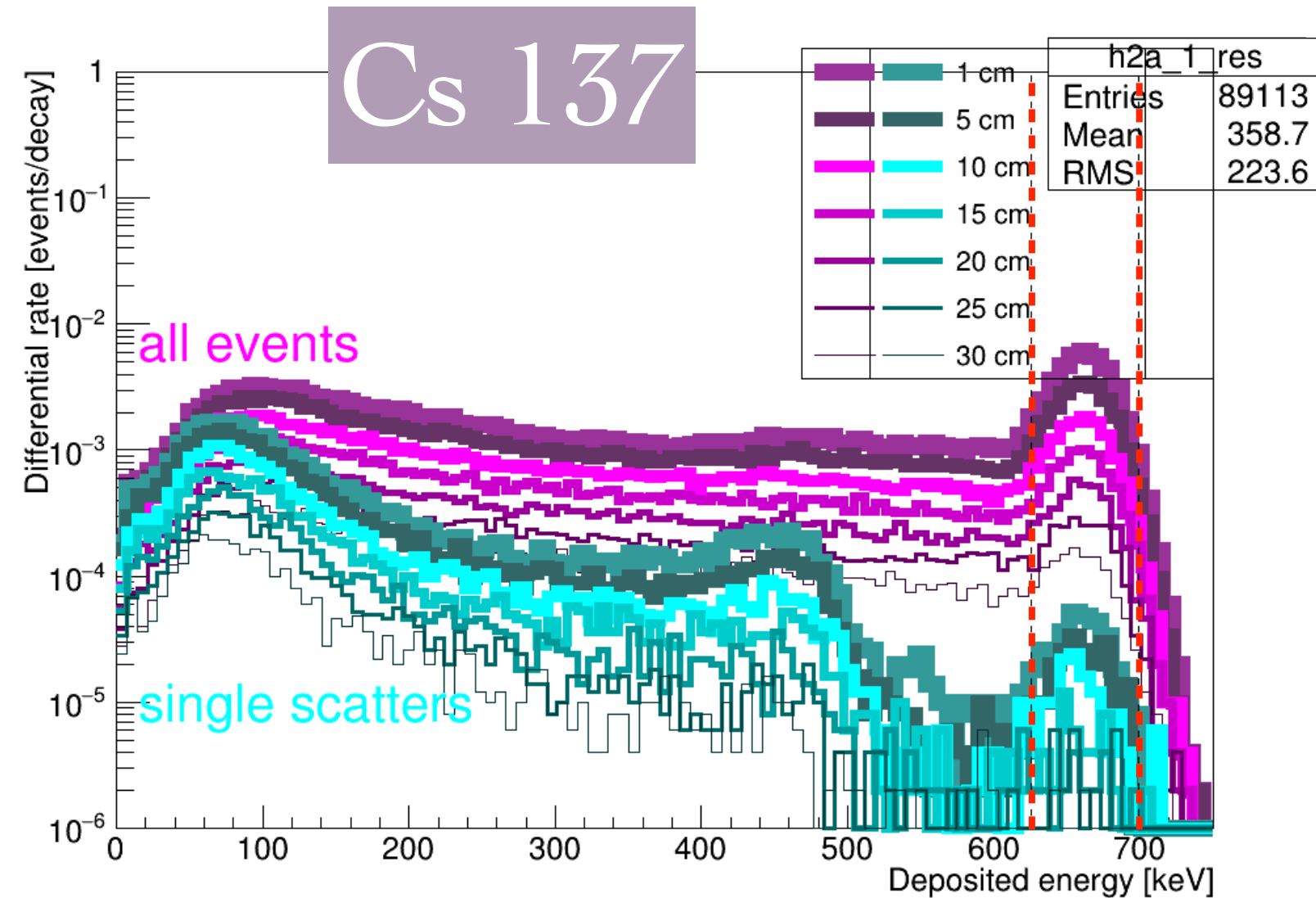
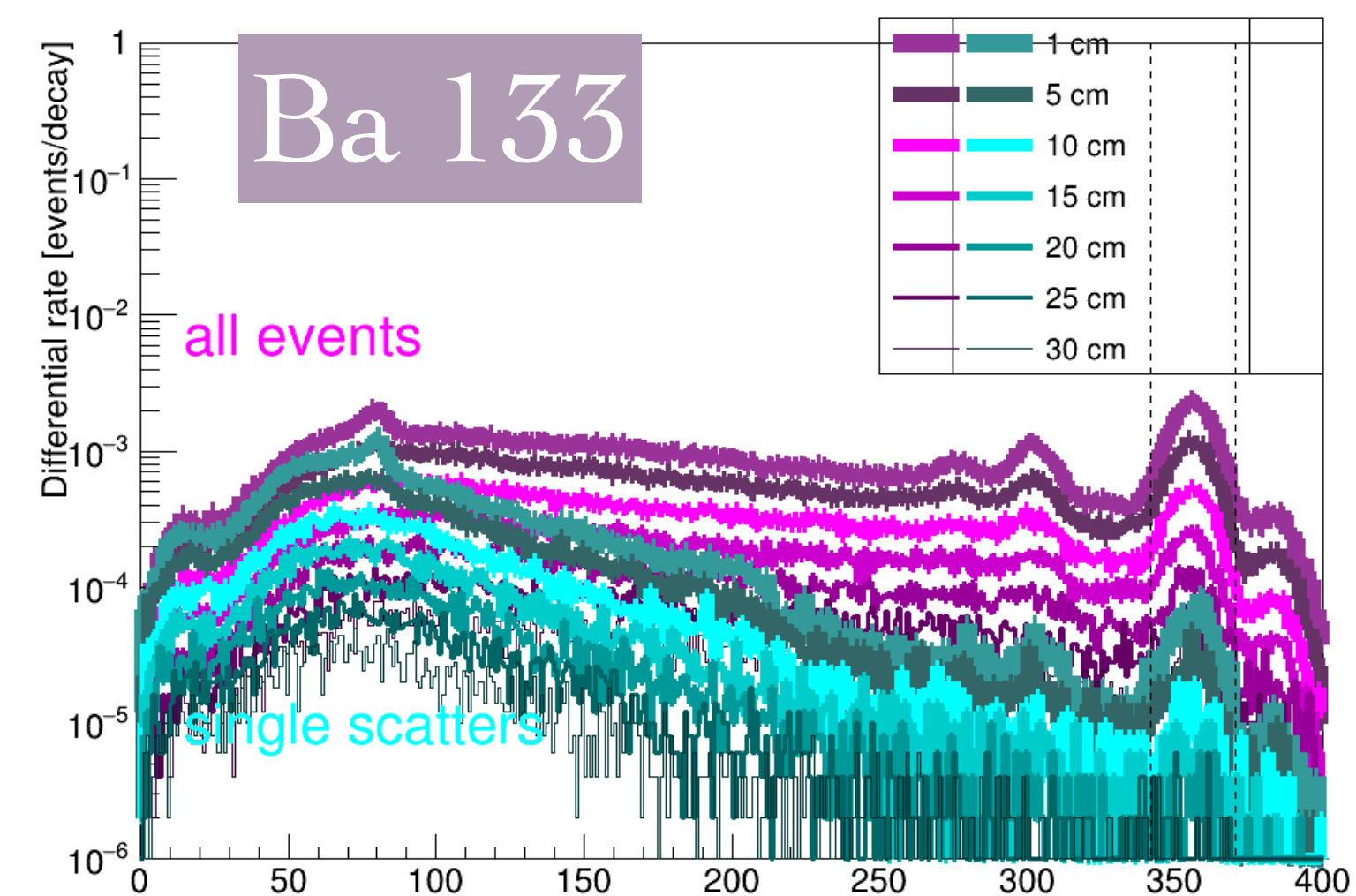
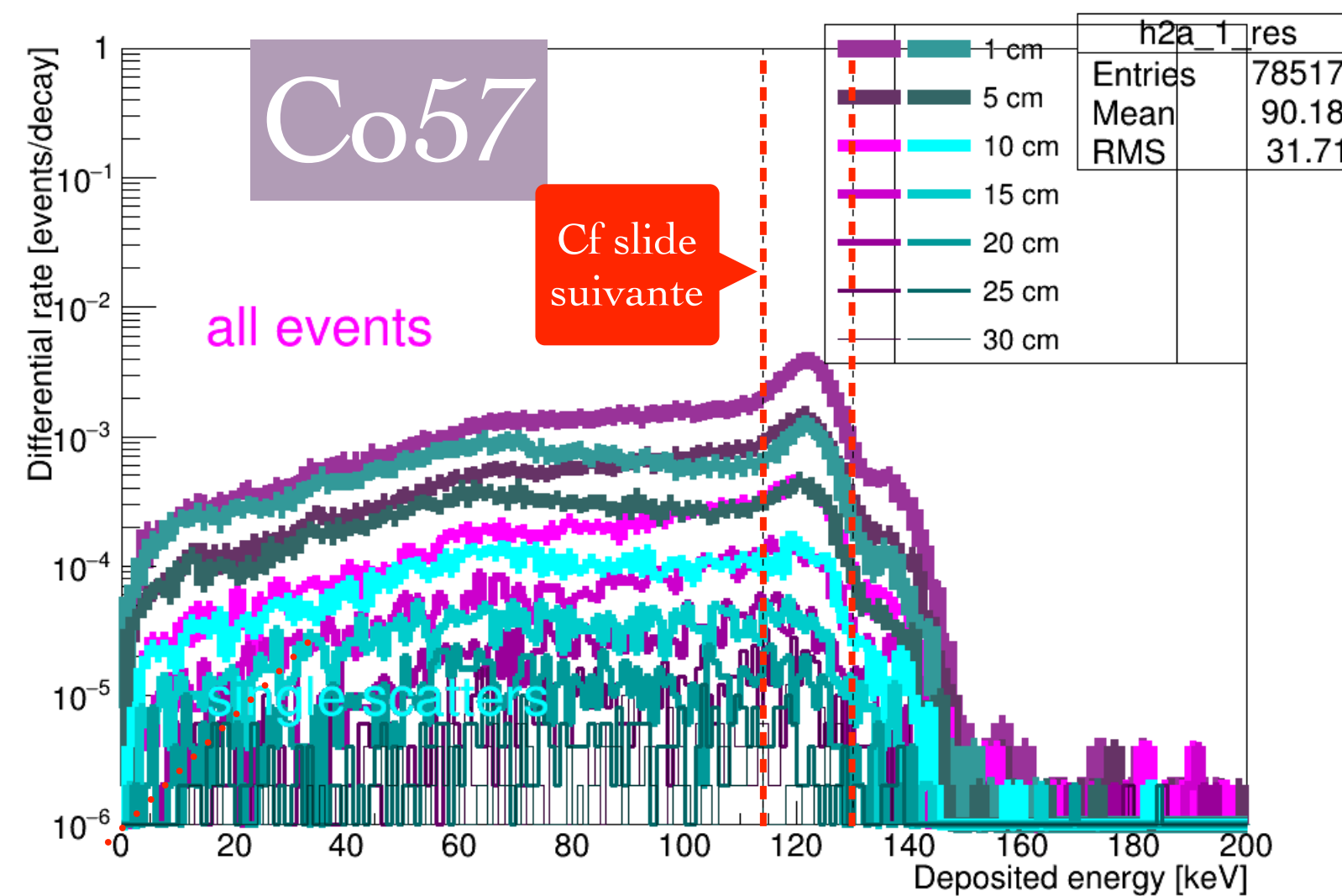
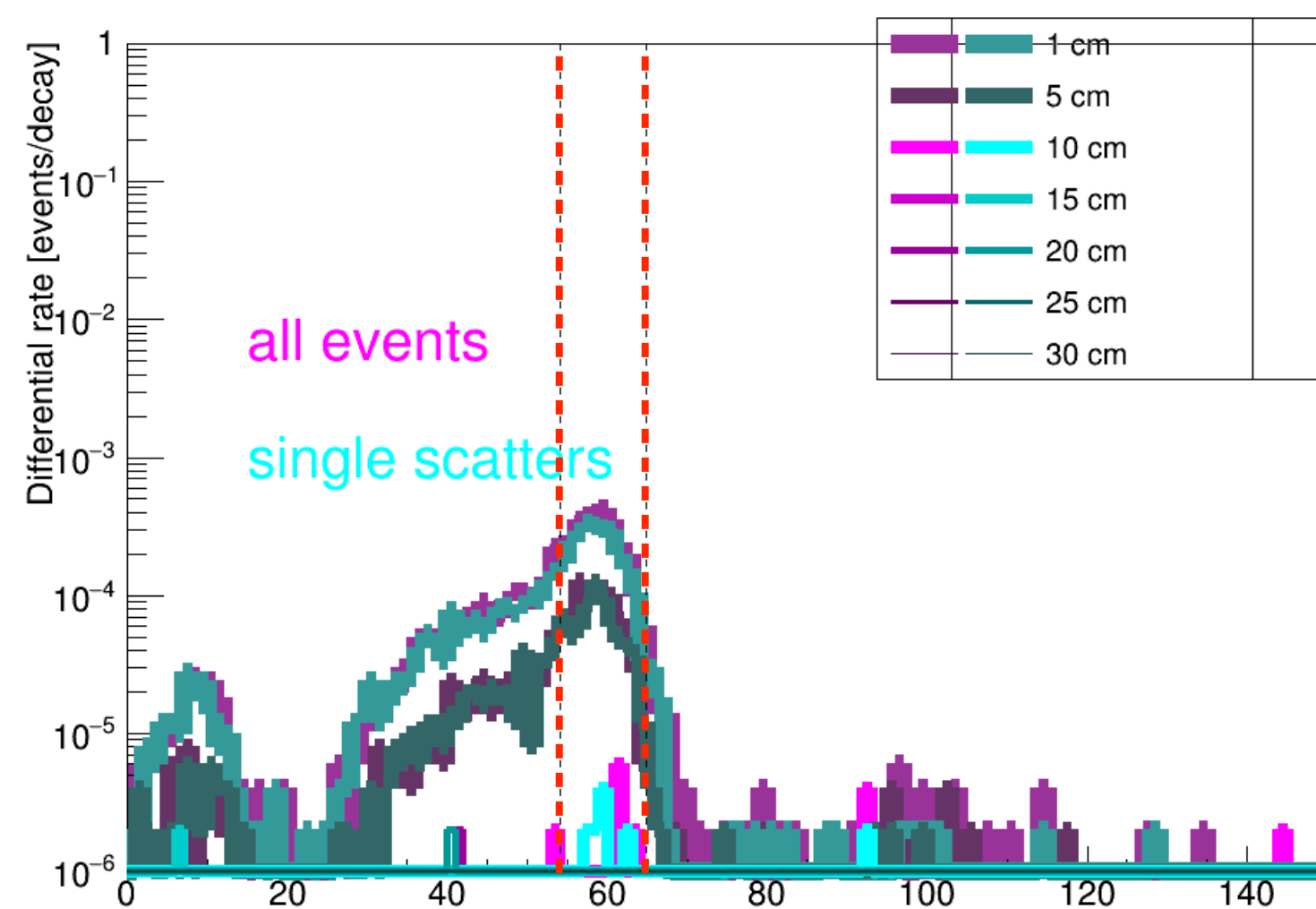
- 1) Injection d'un photon de X keV
- 2) Obtention de la réponse du détecteur = gaussienne
- 3) Sigma = largeur de la gaussienne
- 4) Idem avec un photon d'une autre énergie
- 5) Fit avec fct

$$a + \frac{b}{\sqrt{E}}$$



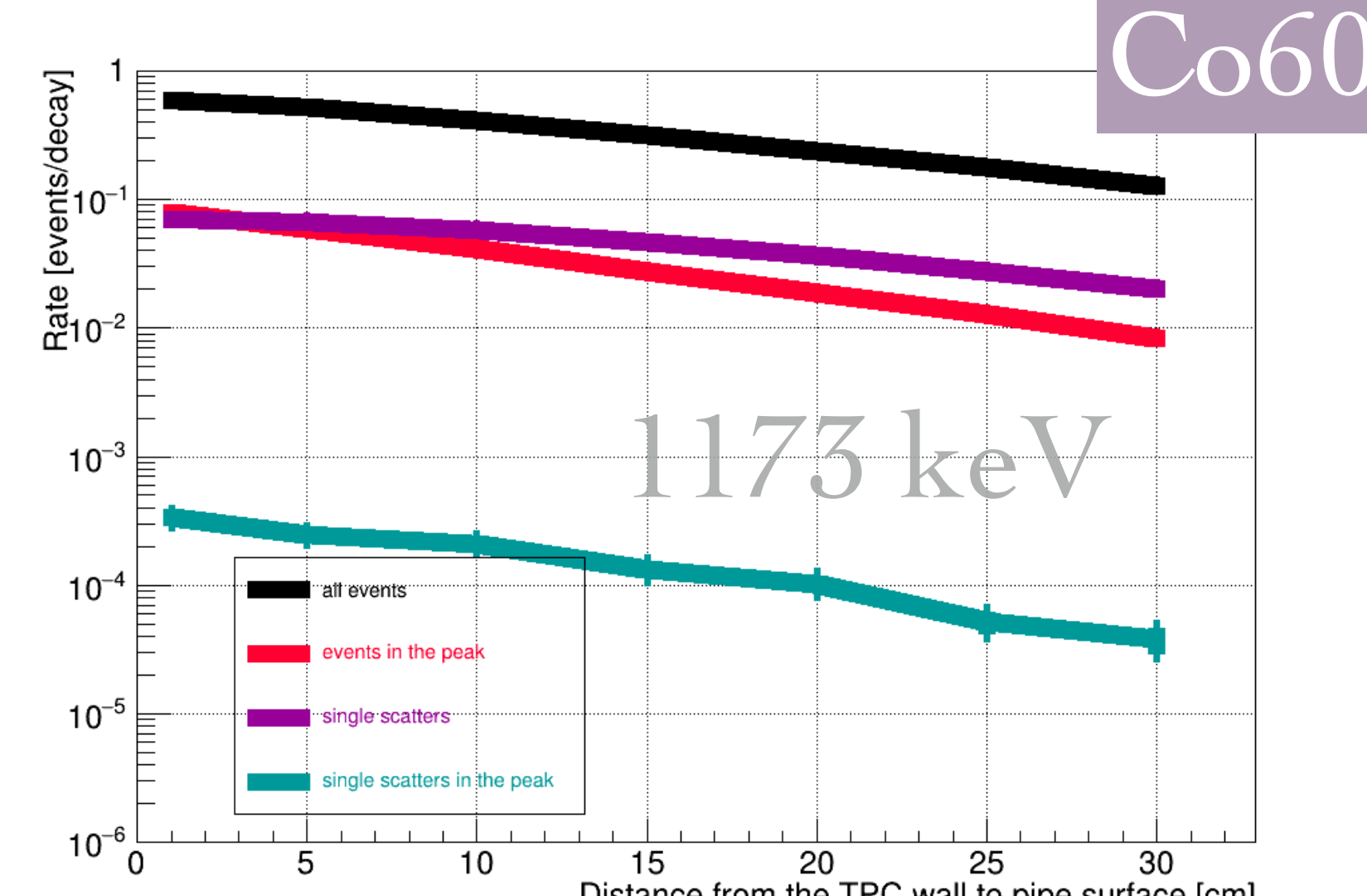
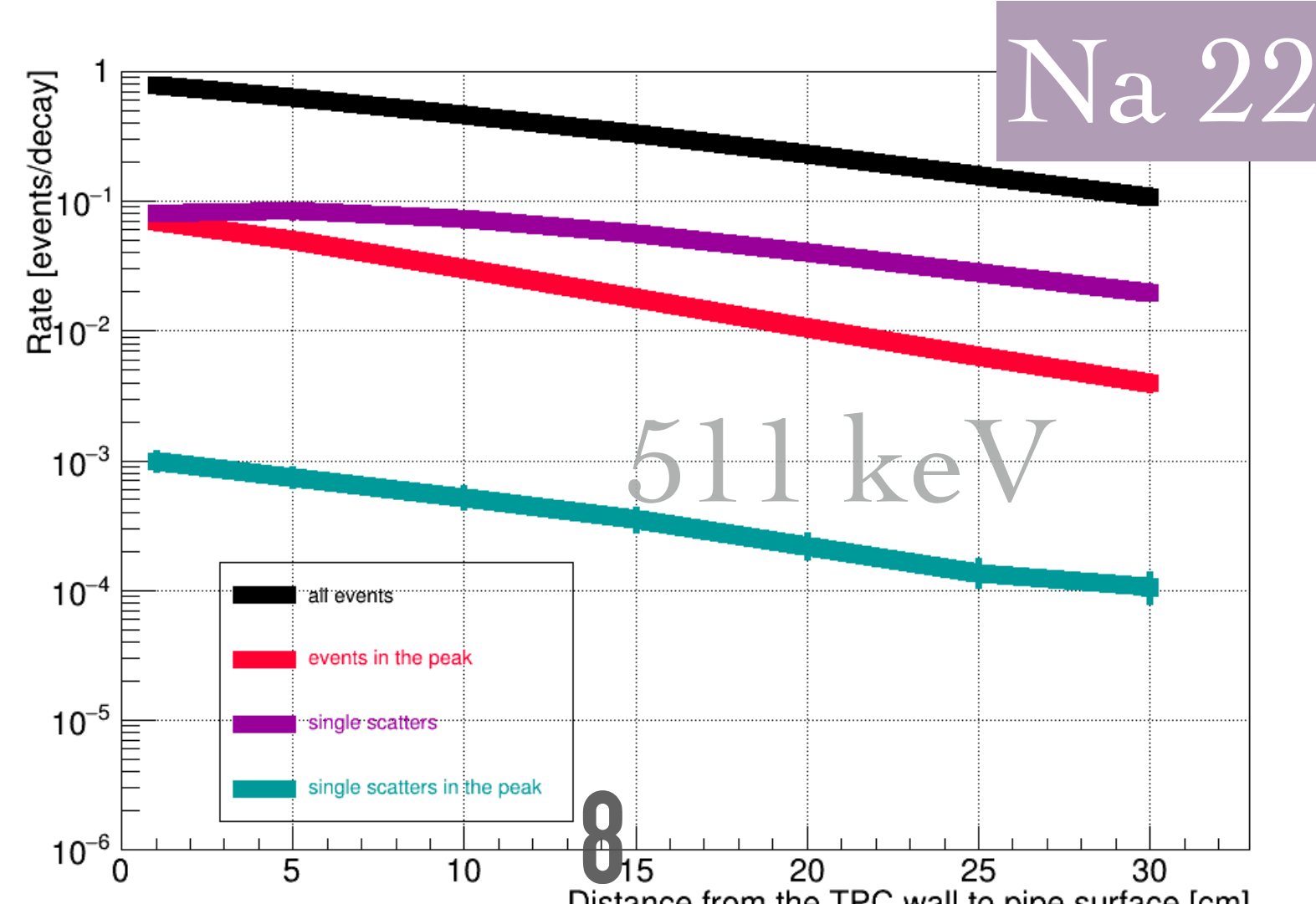
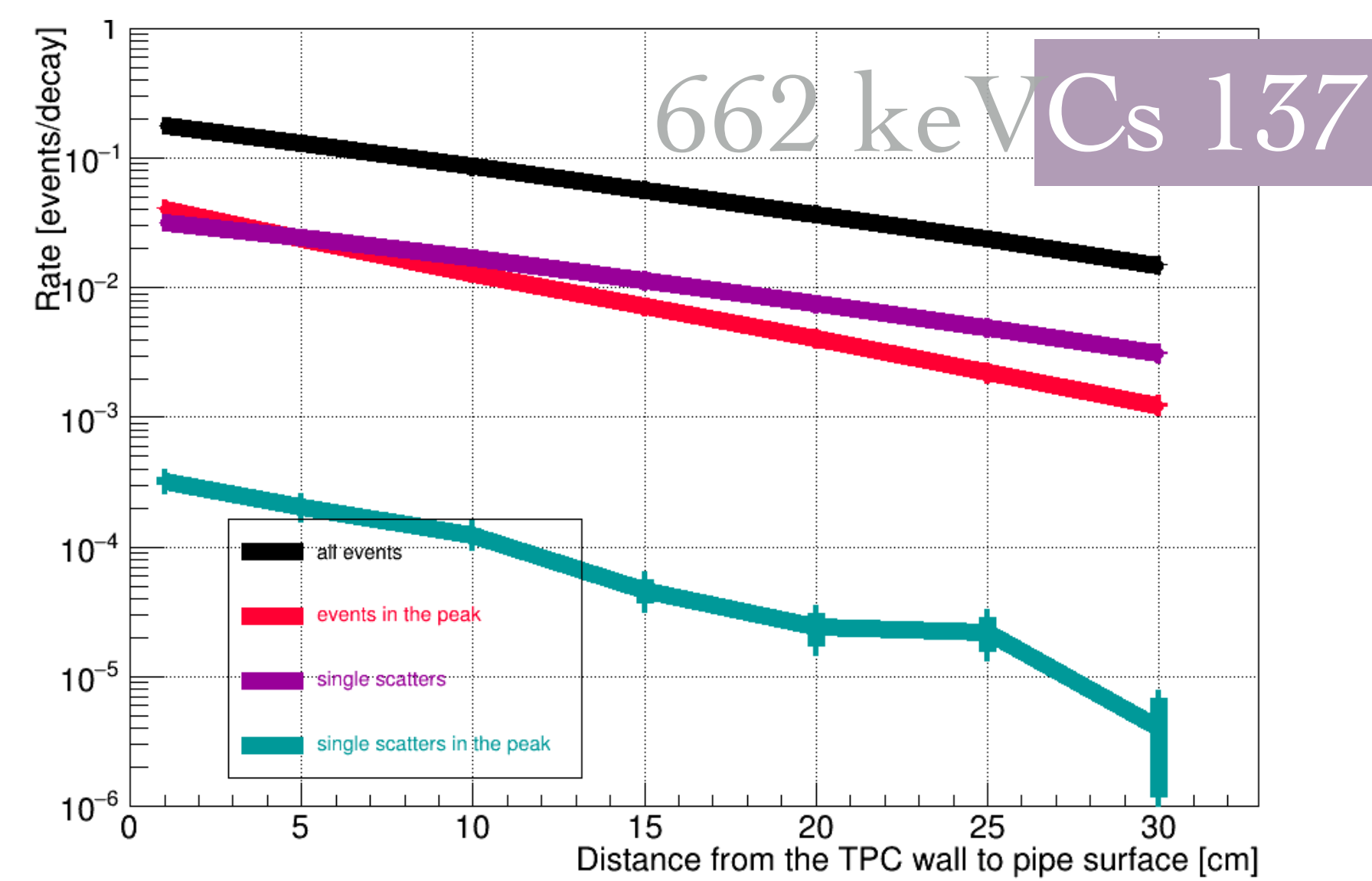
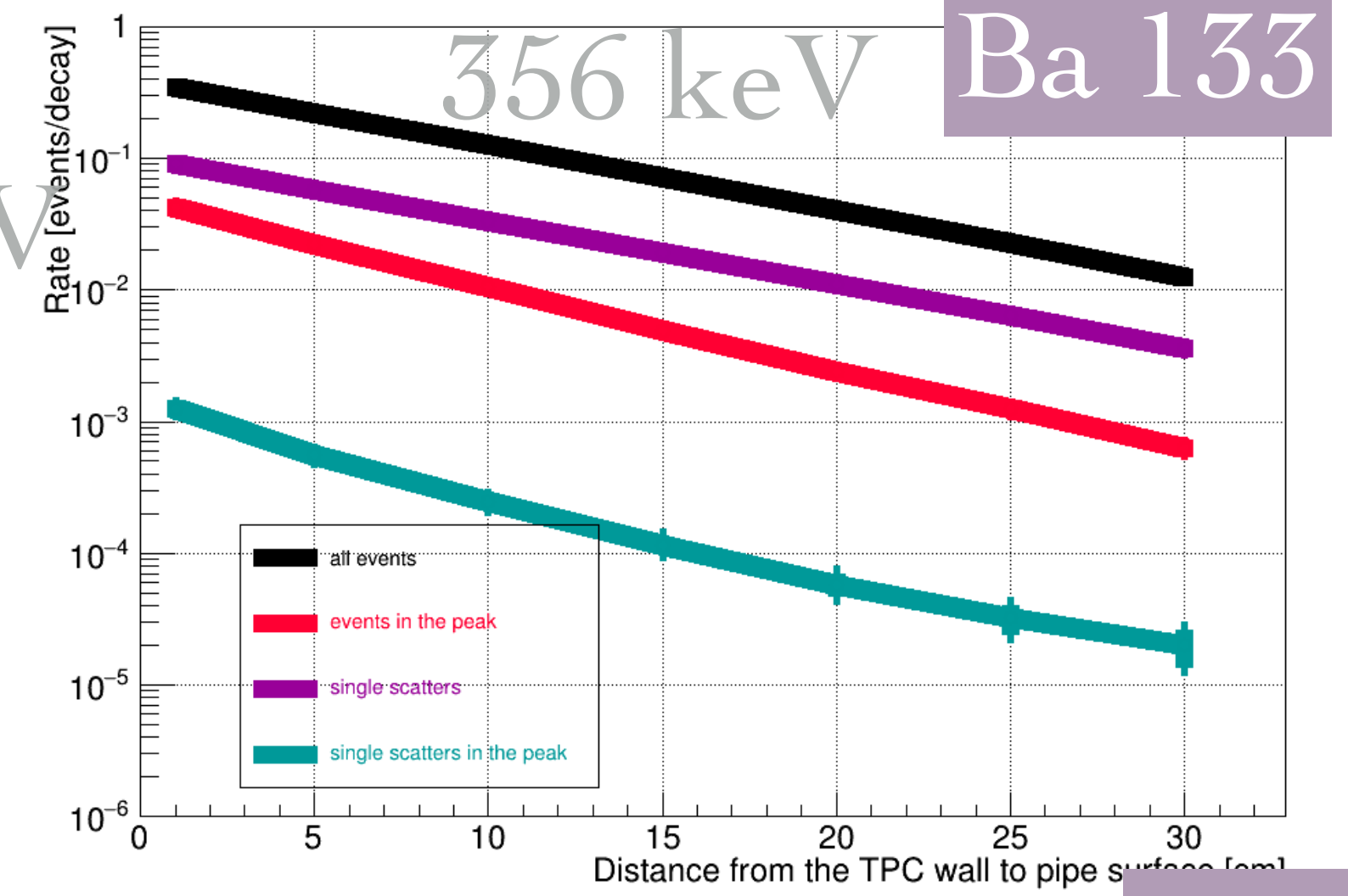
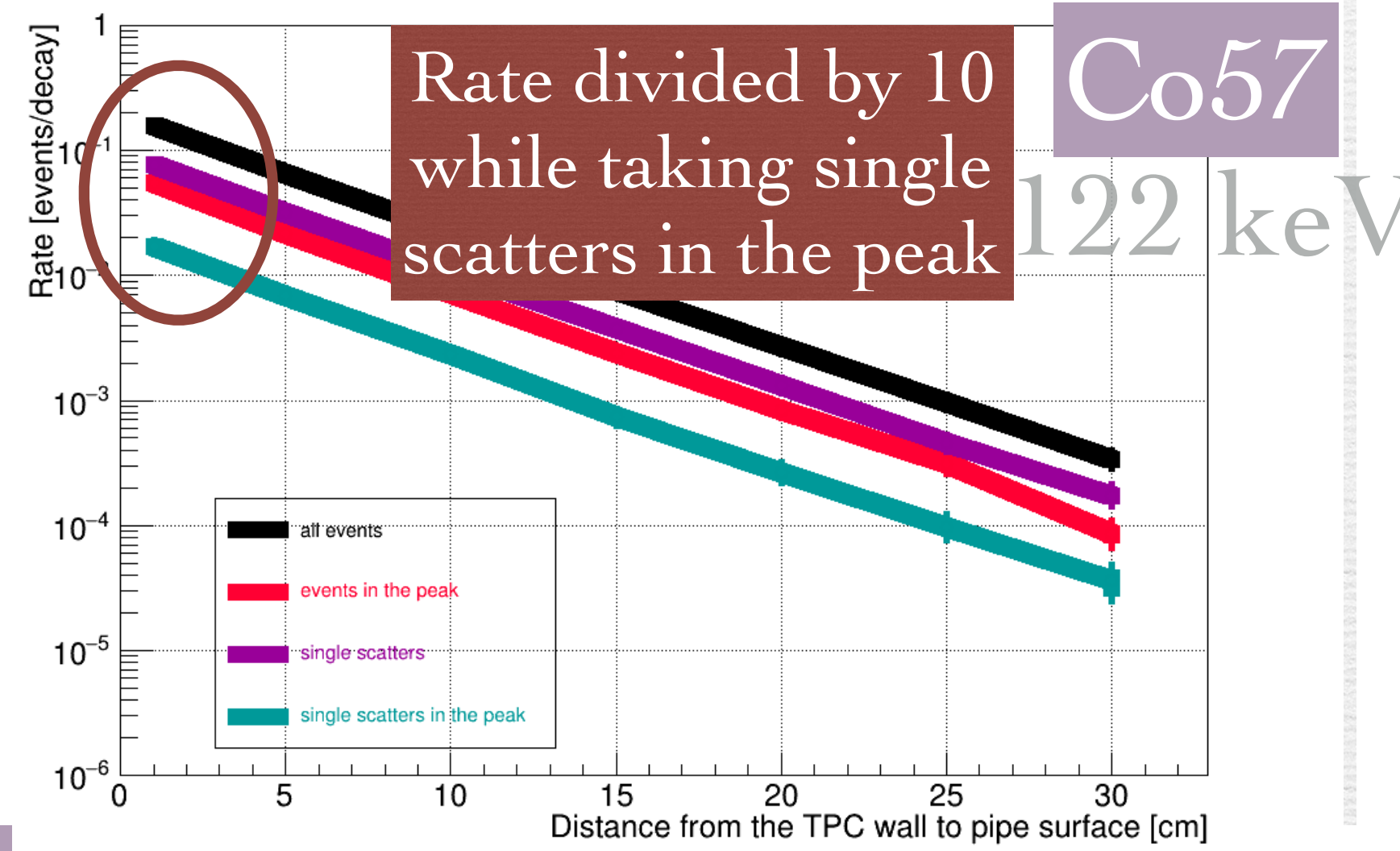
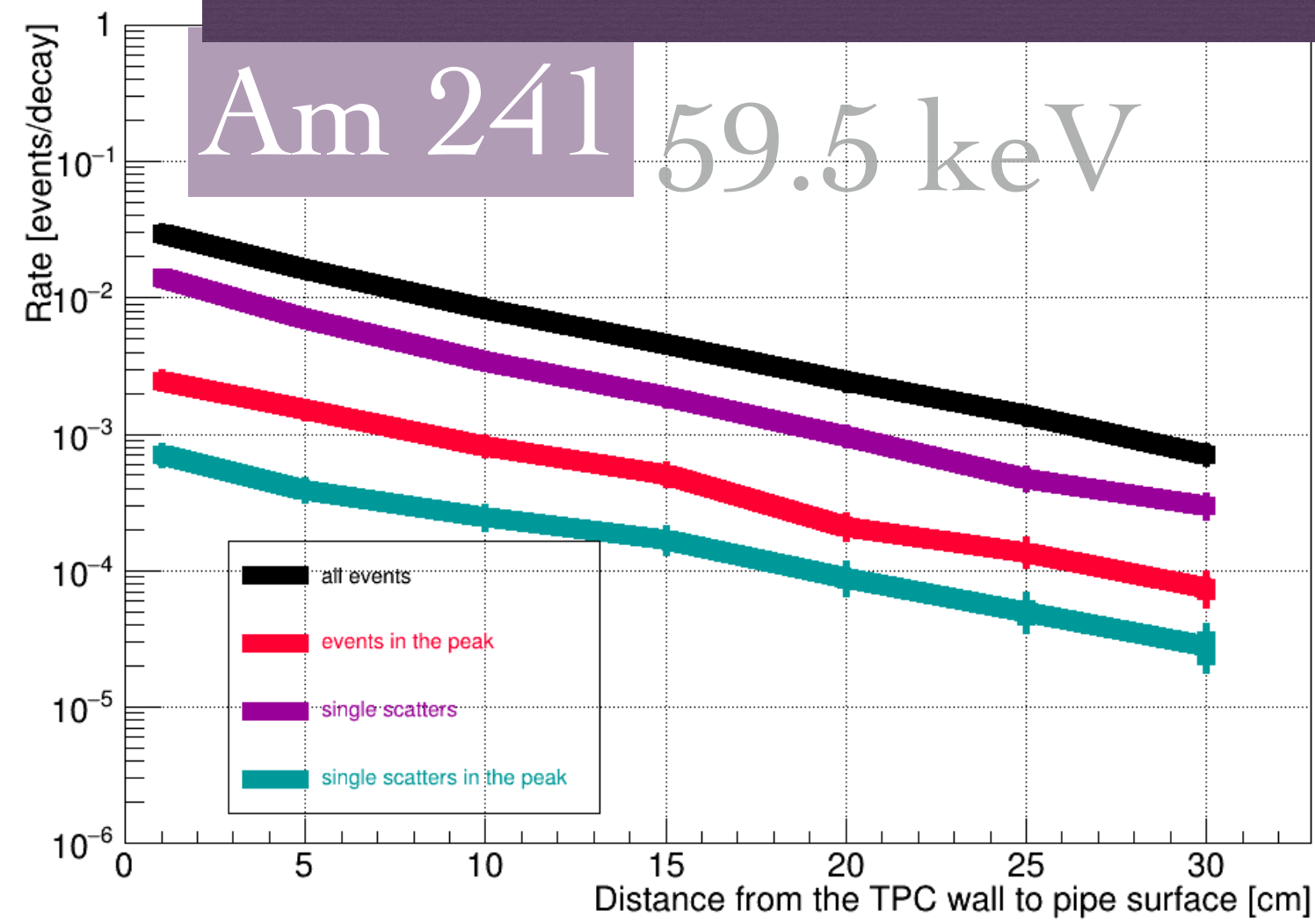
# Plots photons

resolution



# Plots photons

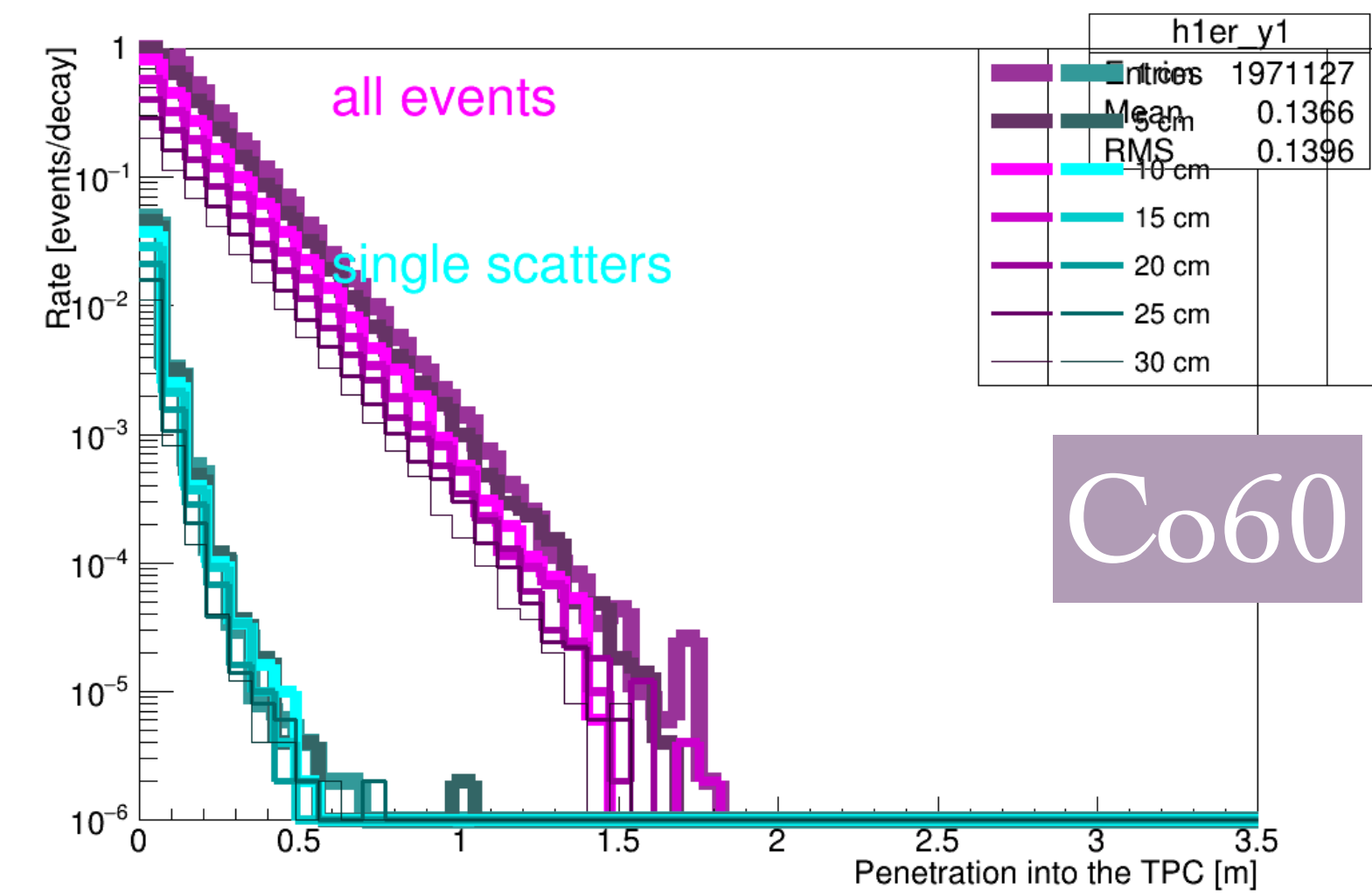
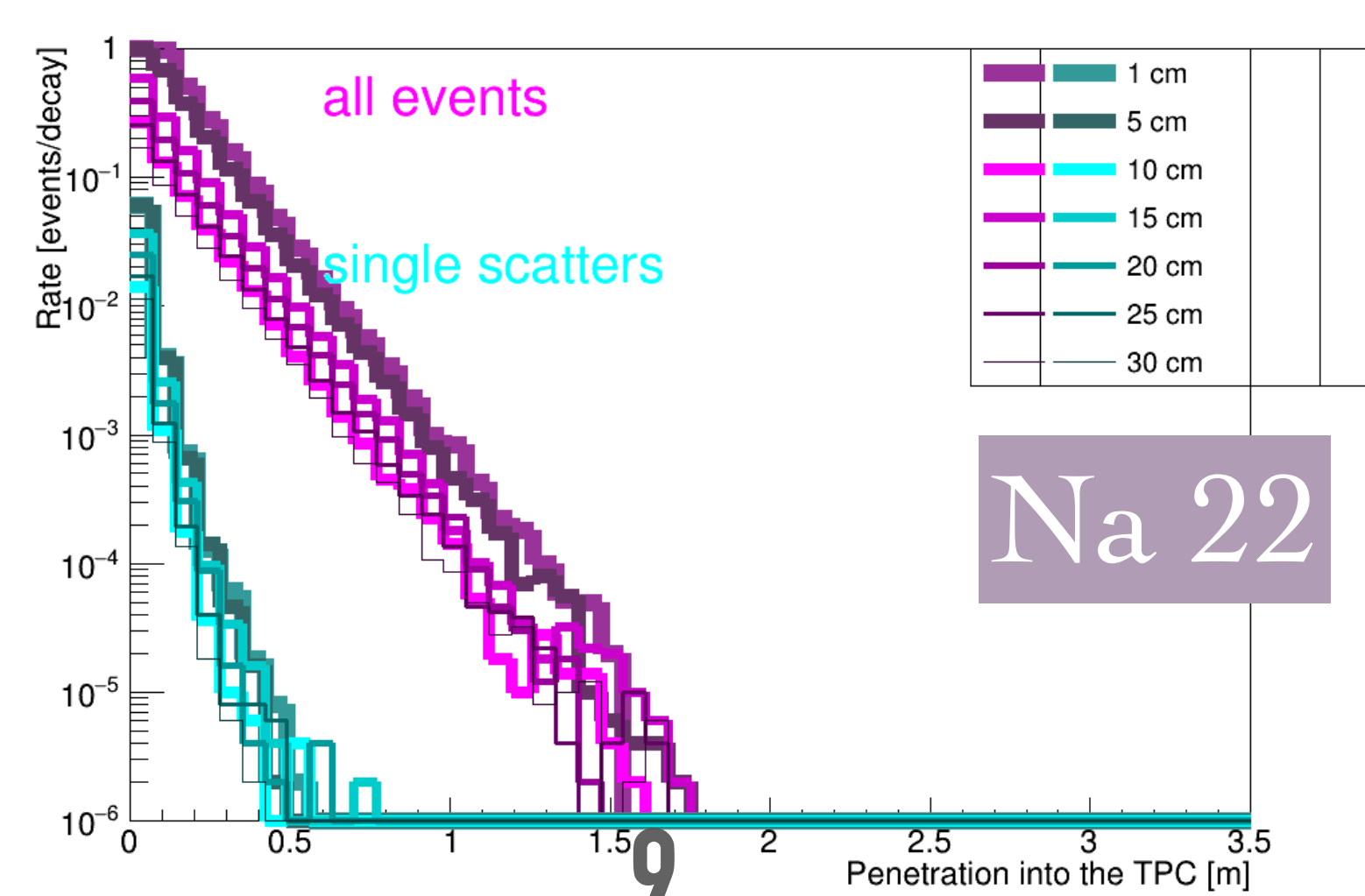
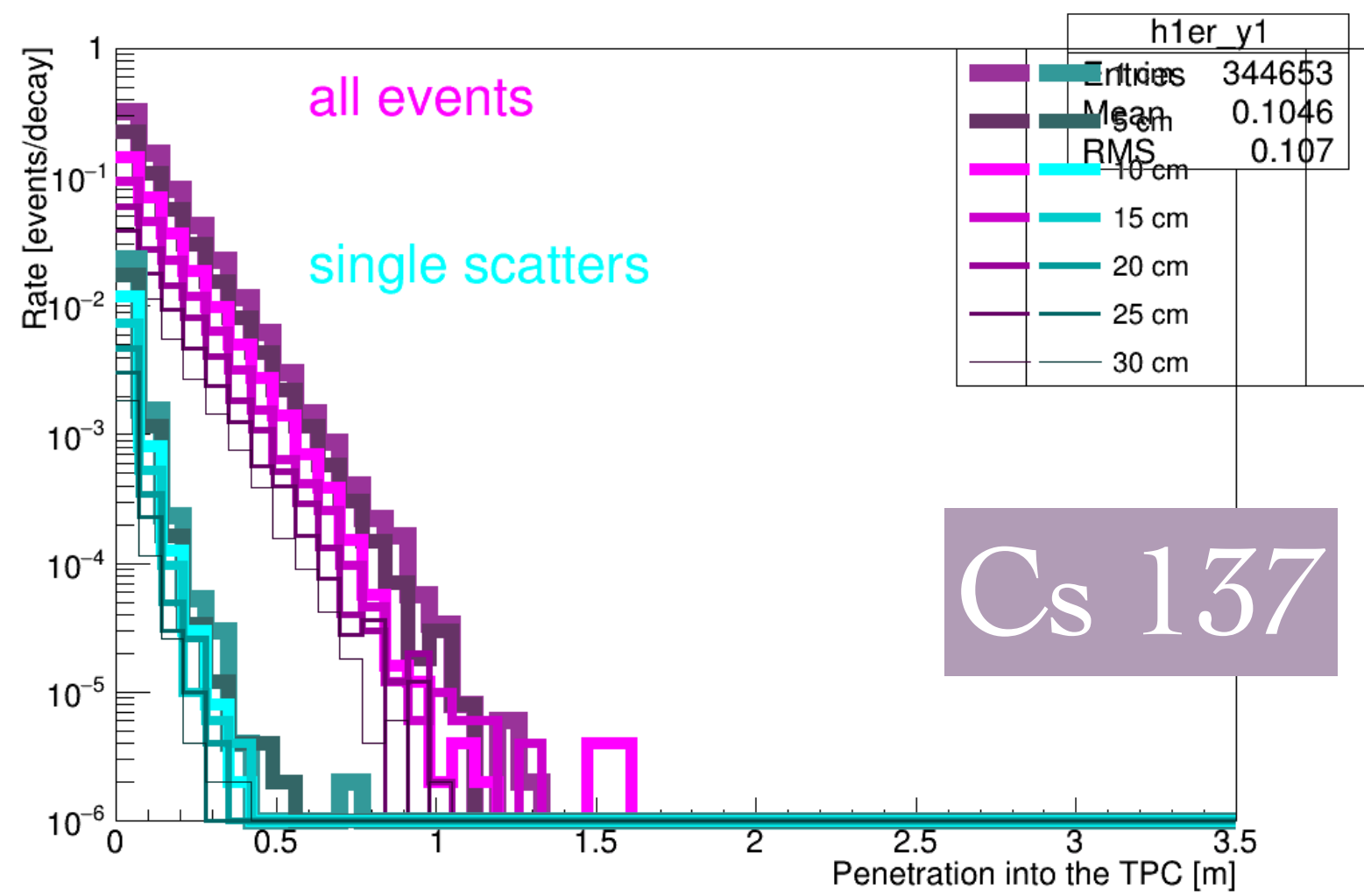
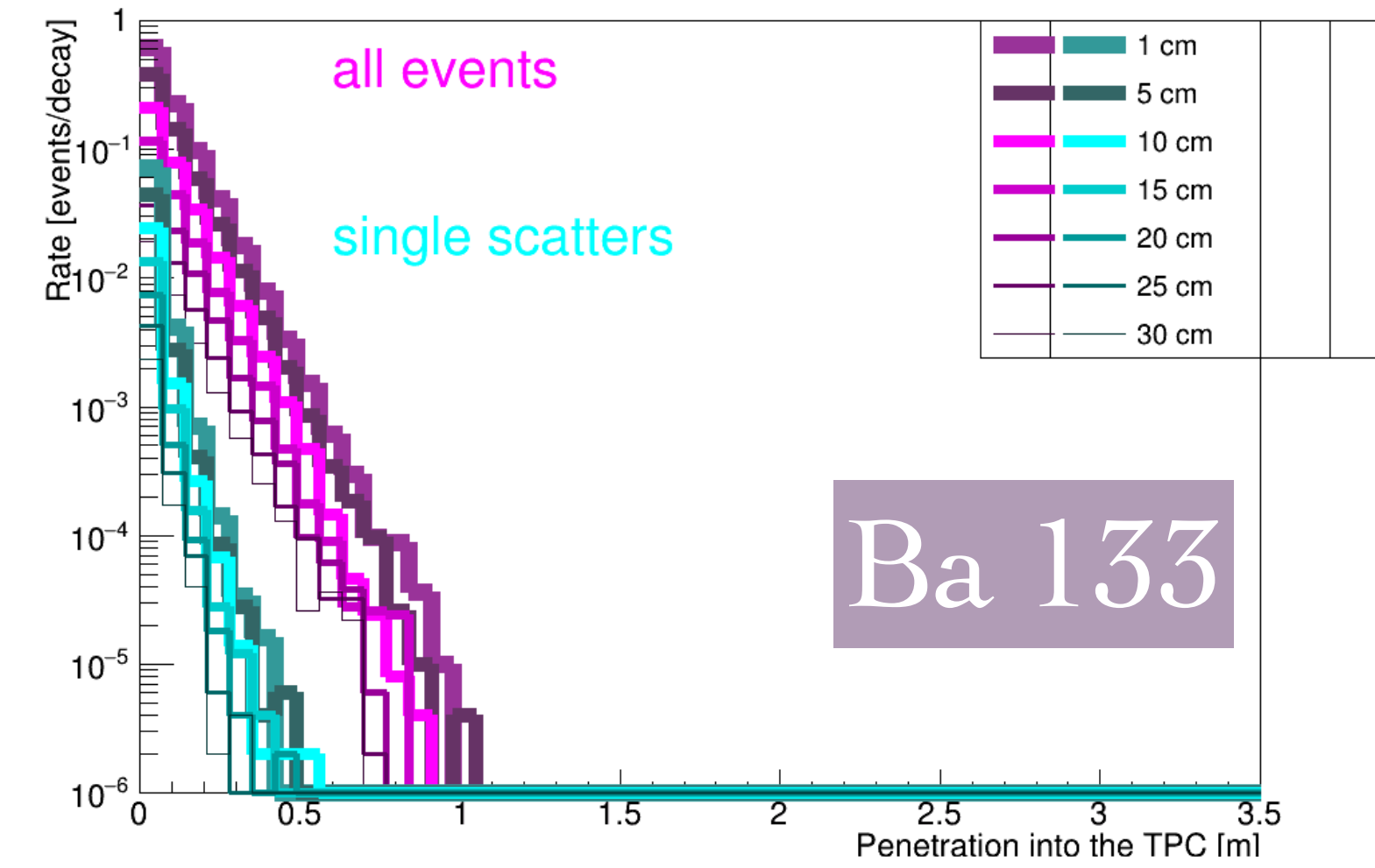
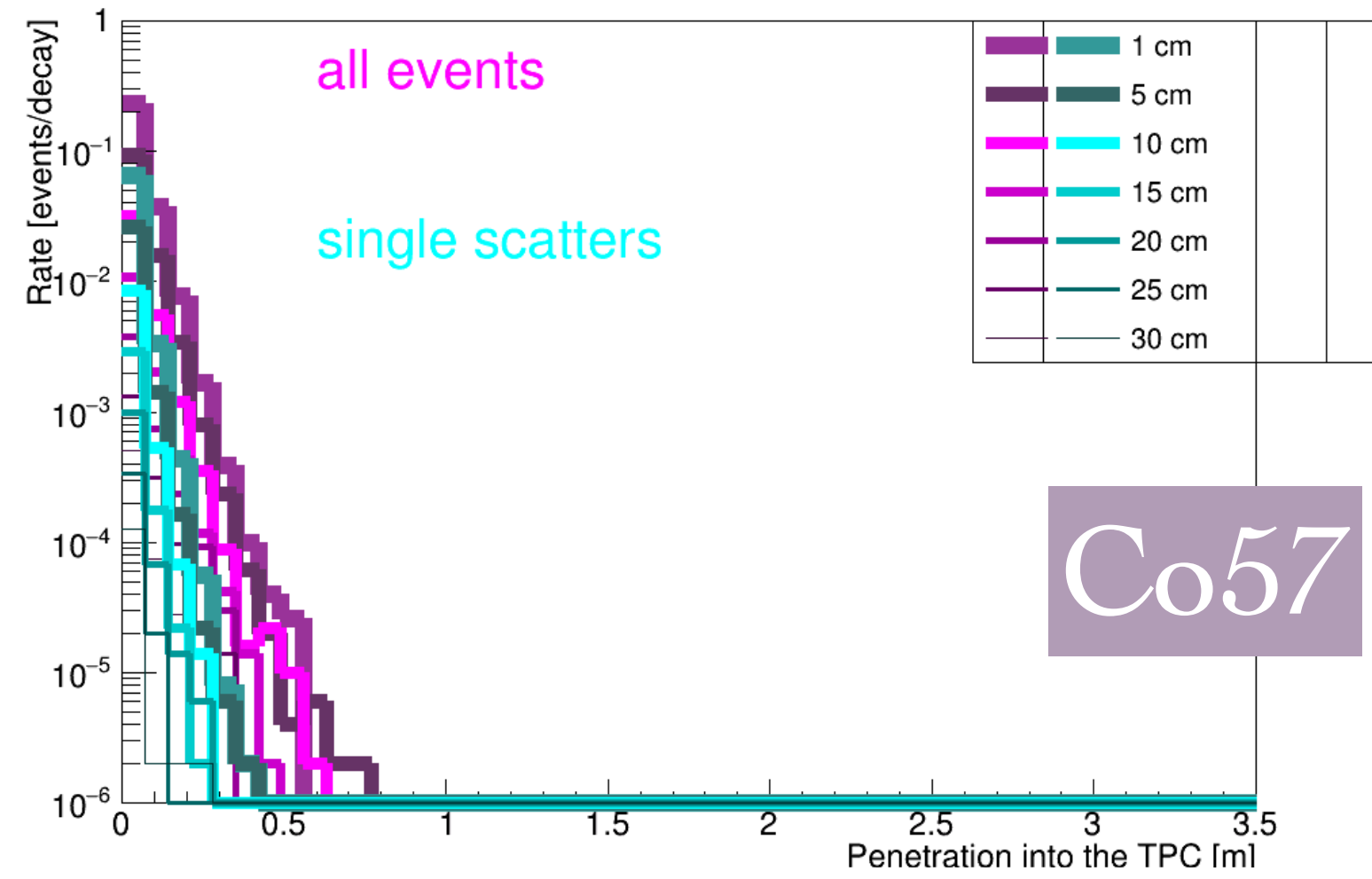
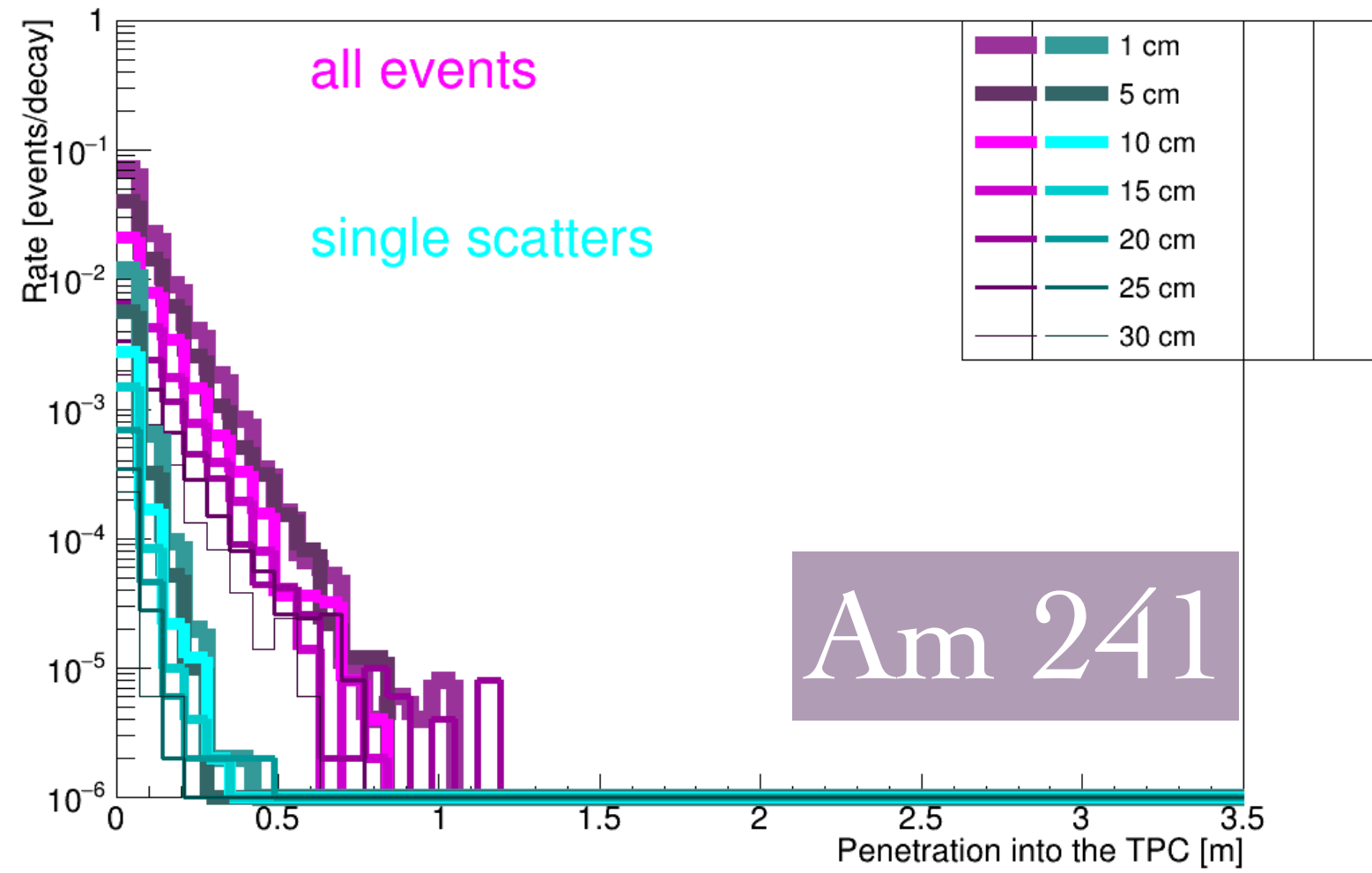
Rate vs pipe distance





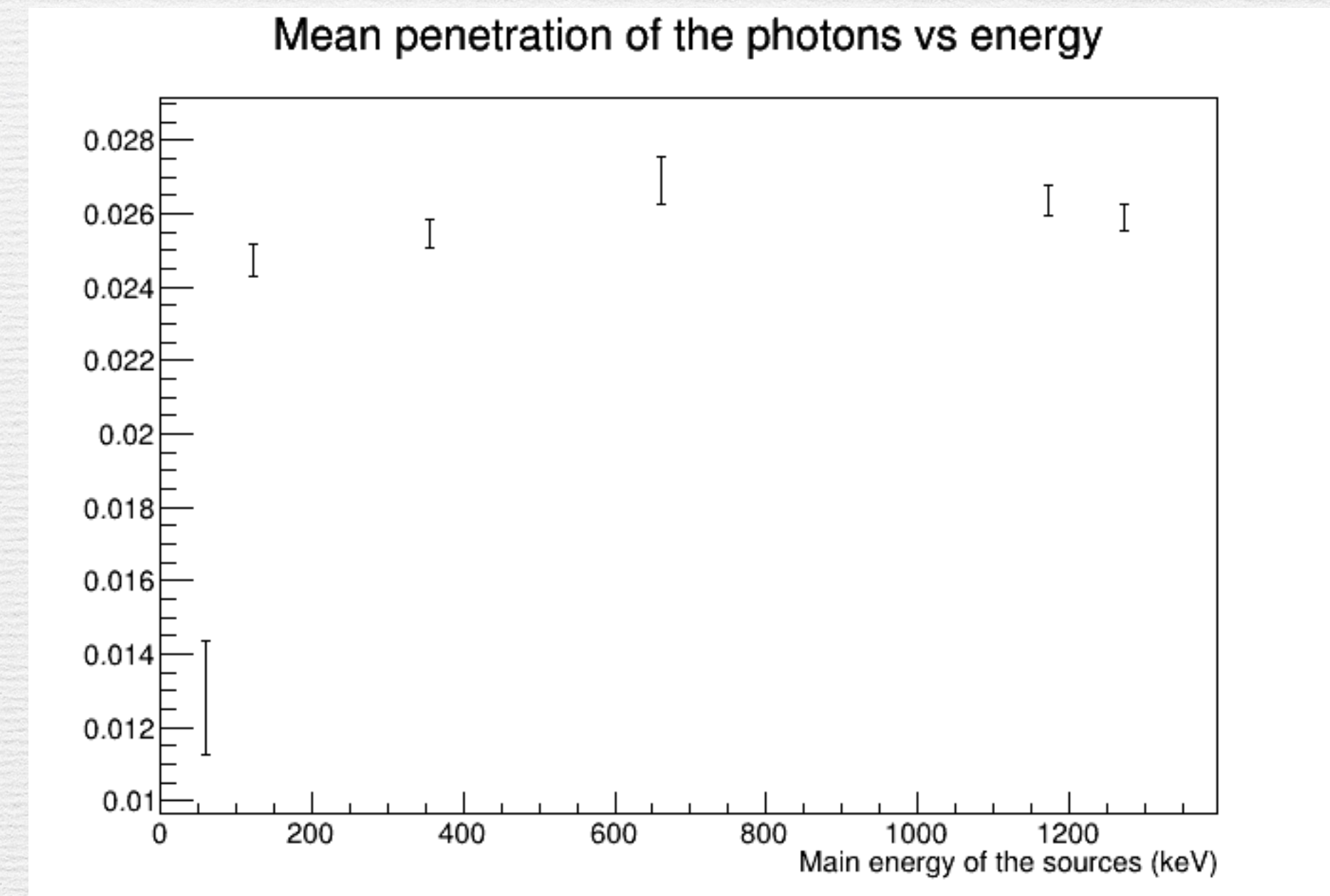
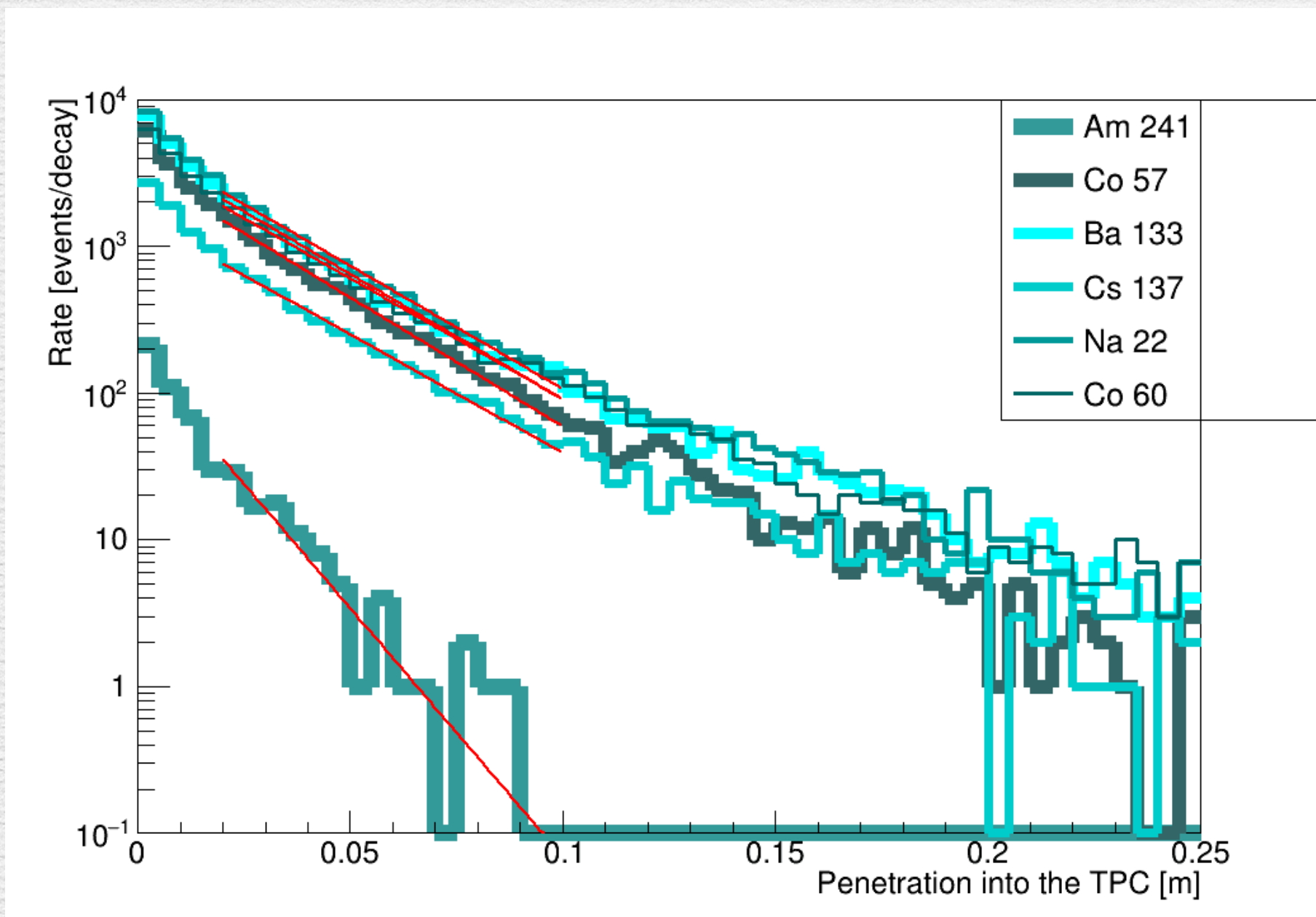
# Plots photons

Penetration



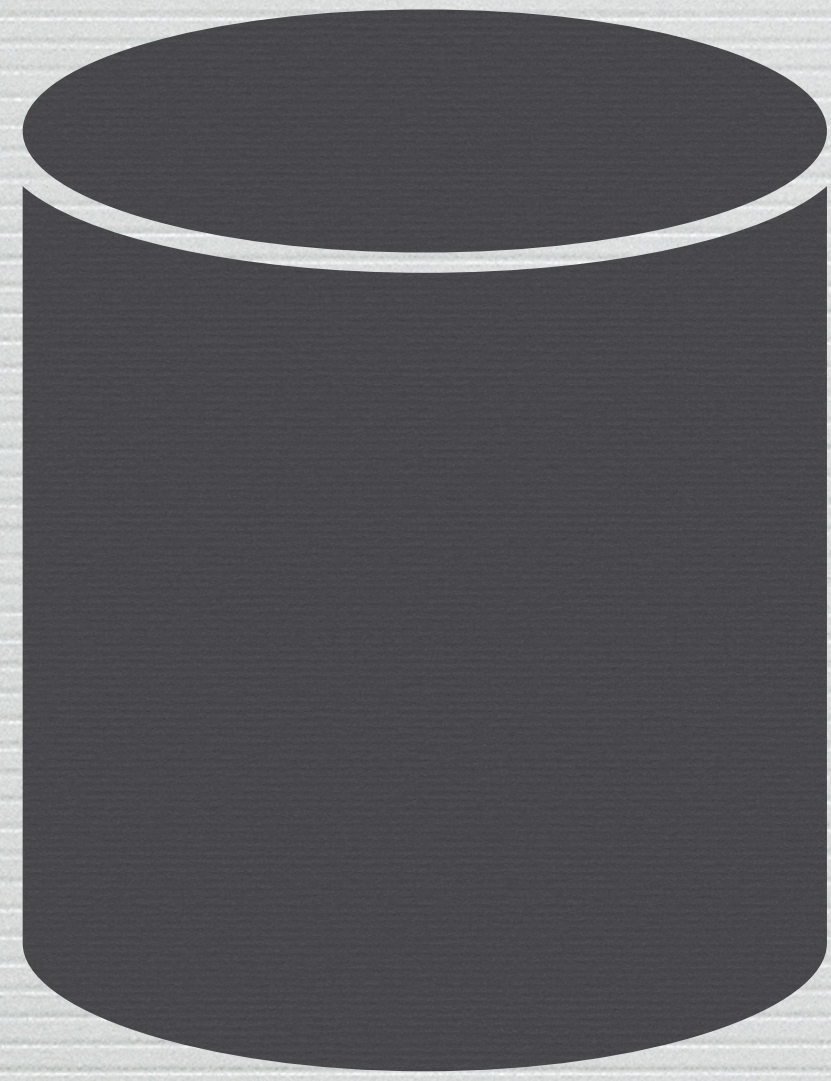
# Penetration vs energy

Les sources sont placées à 3cm sur le côté de la TPC



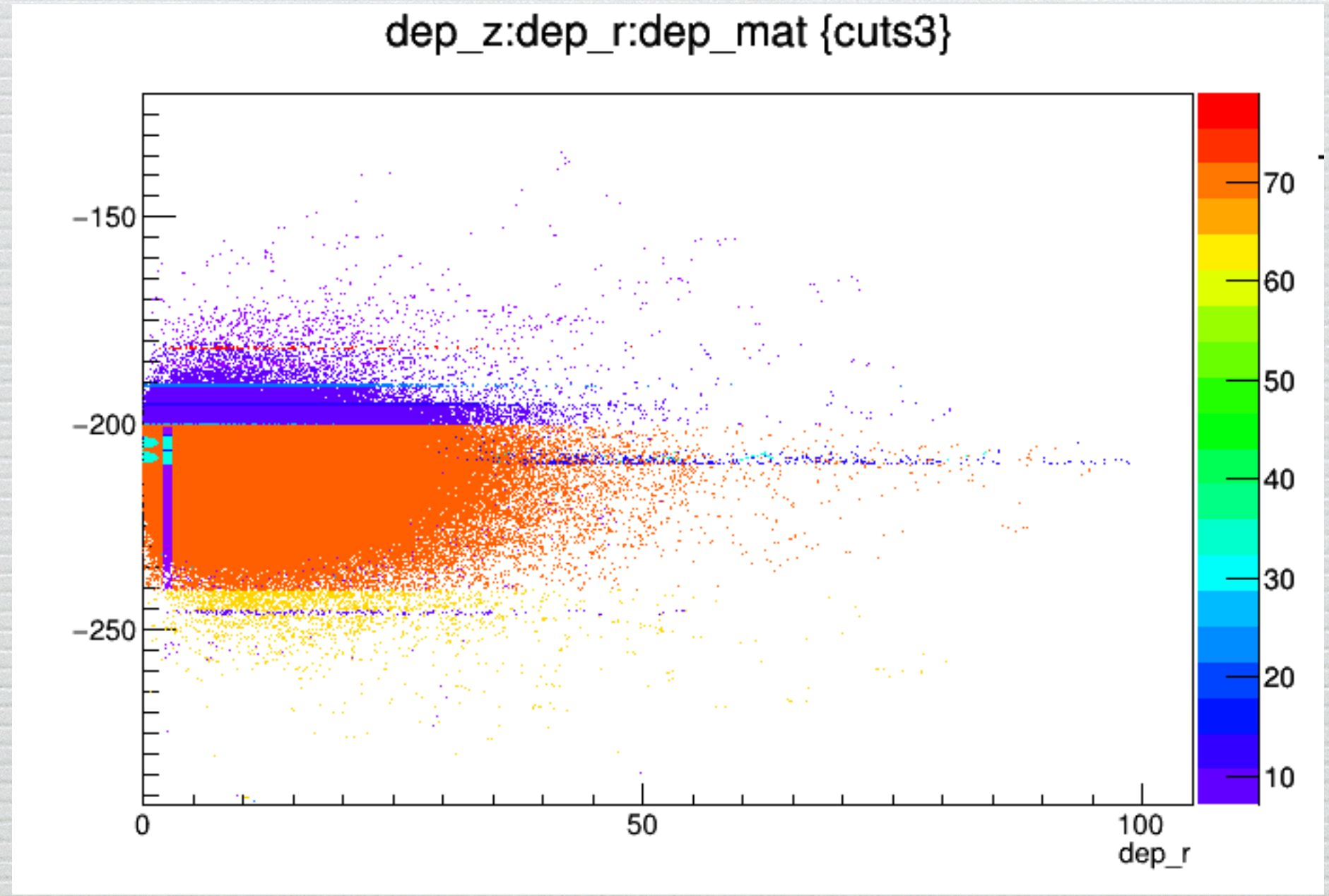
Au delà de 100 keV, la pénétration moyenne des photons qui font des SS dans la TPC est d'environ 2,5 cm => la calibration ne se fait que sur les bords.

# PLAN A



1 à 10 cm

Sources en  $(x=0, y=0)$



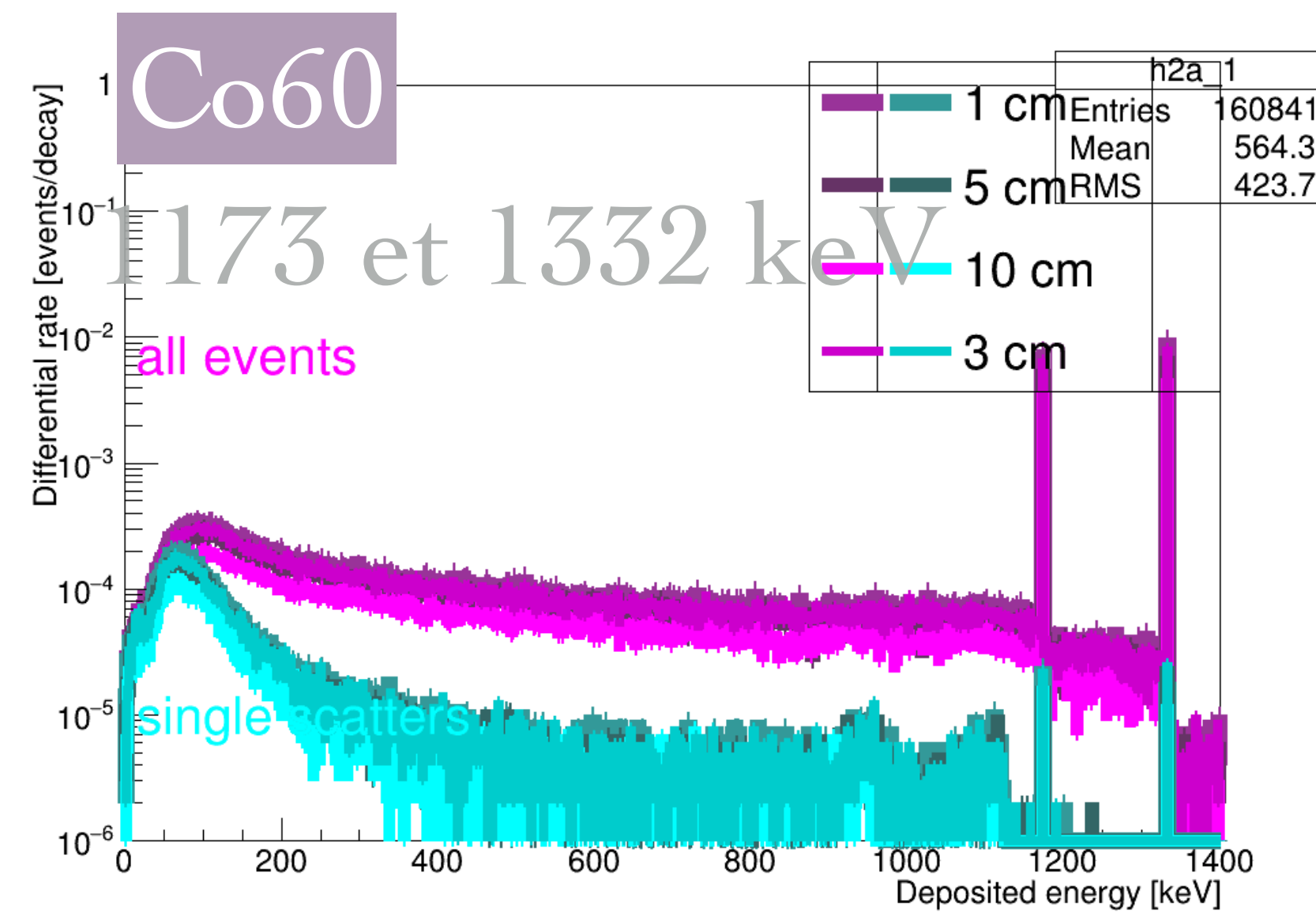
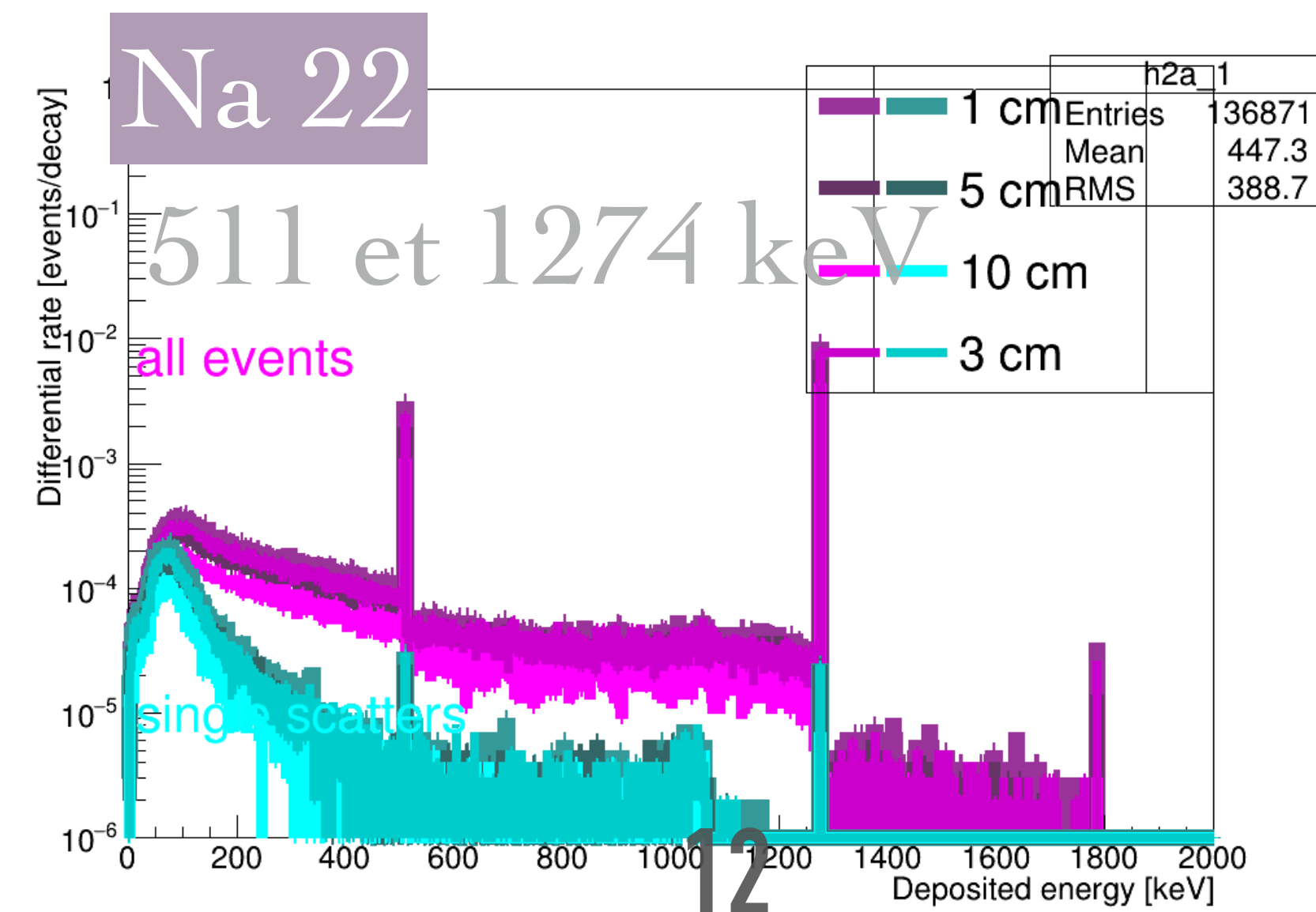
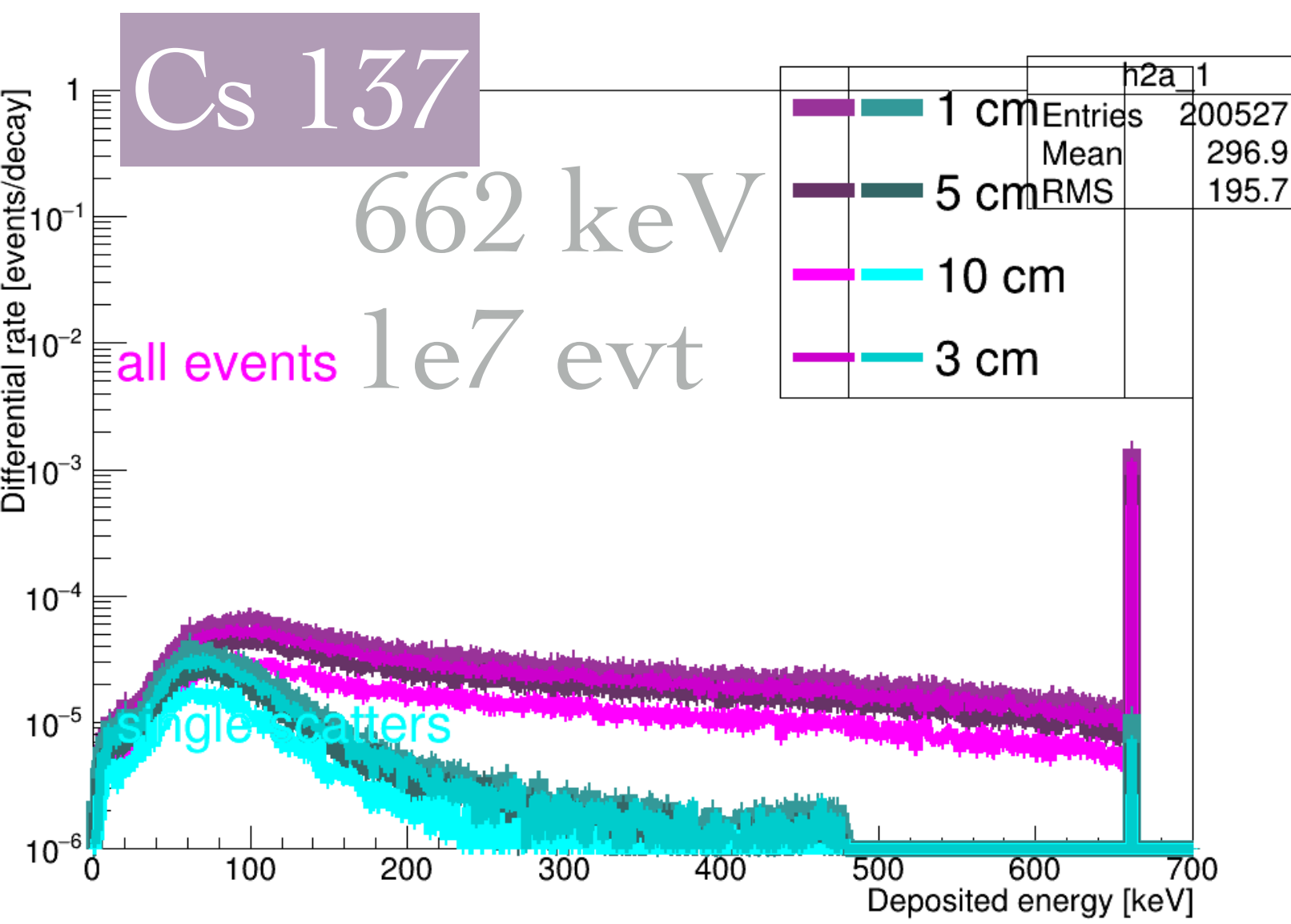
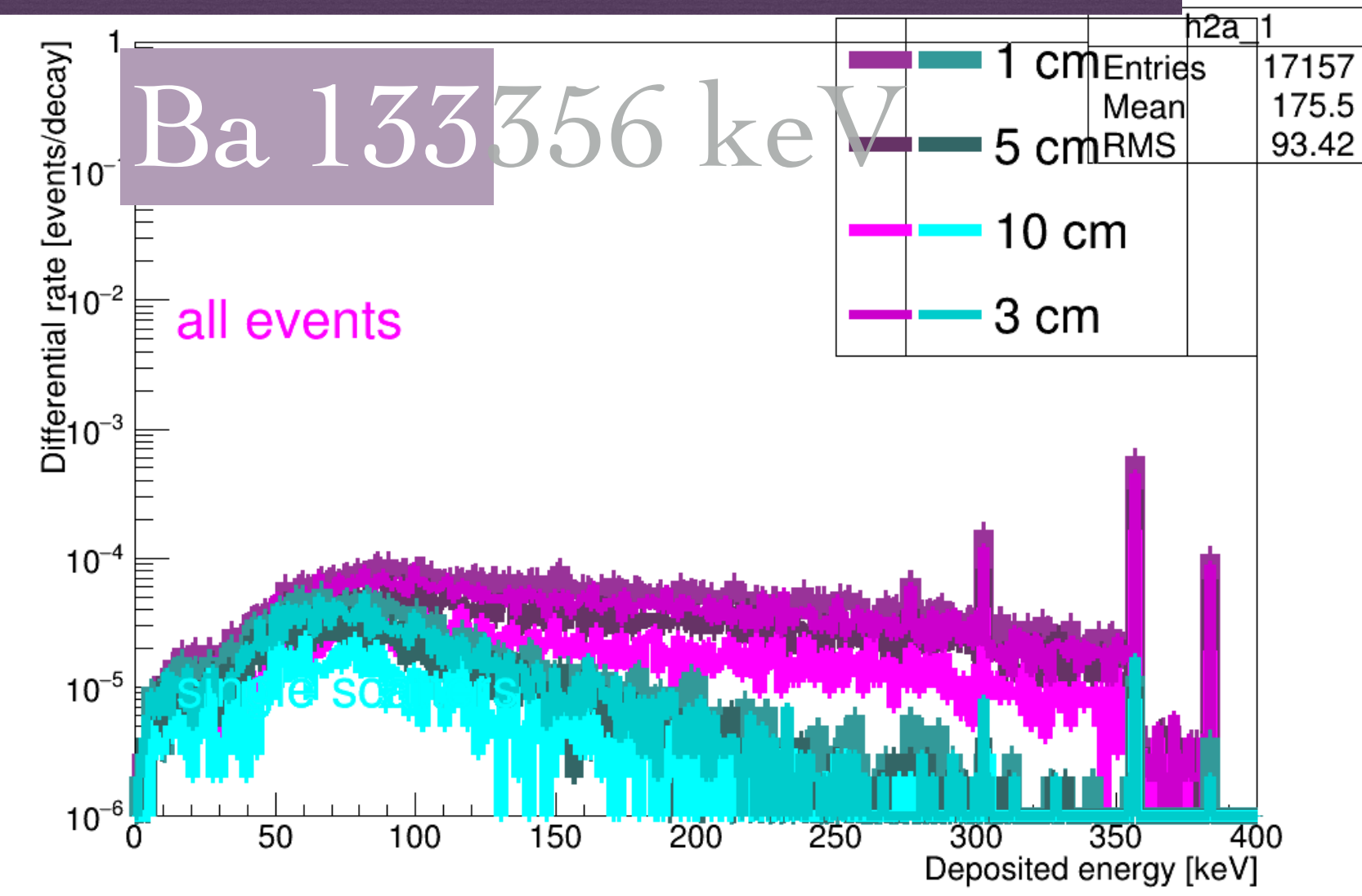
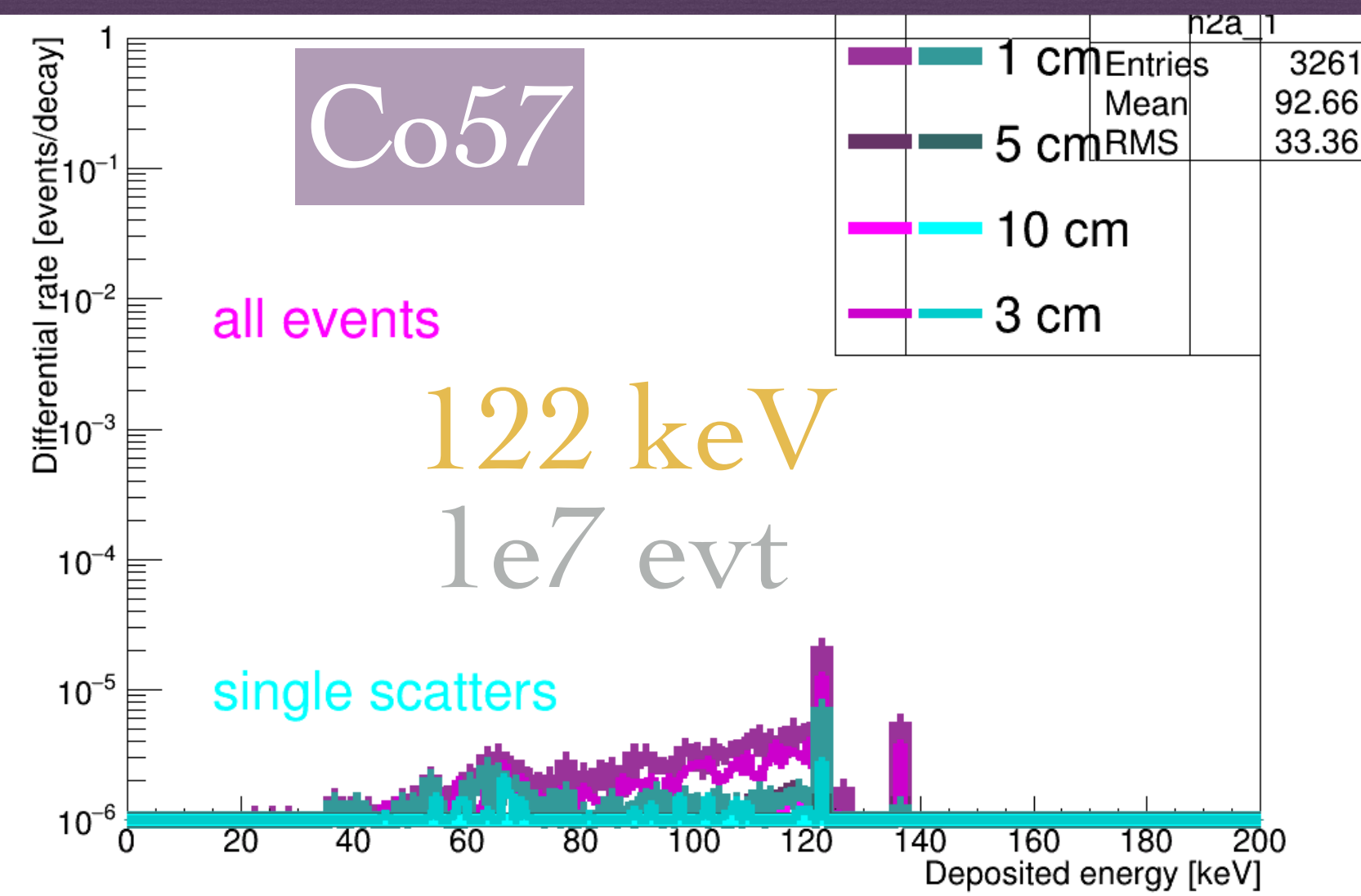
## Sources placées en un point sous la TPC

# Plots photons

bottom  
1 000 000 events  
1, 3, 5, 10 cm

Am 241

59.5 keV



# Plots photons

bottom + resolution  
 1 000 000 events  
 1, 3, 5, 10 cm

Am 241

59.5 keV

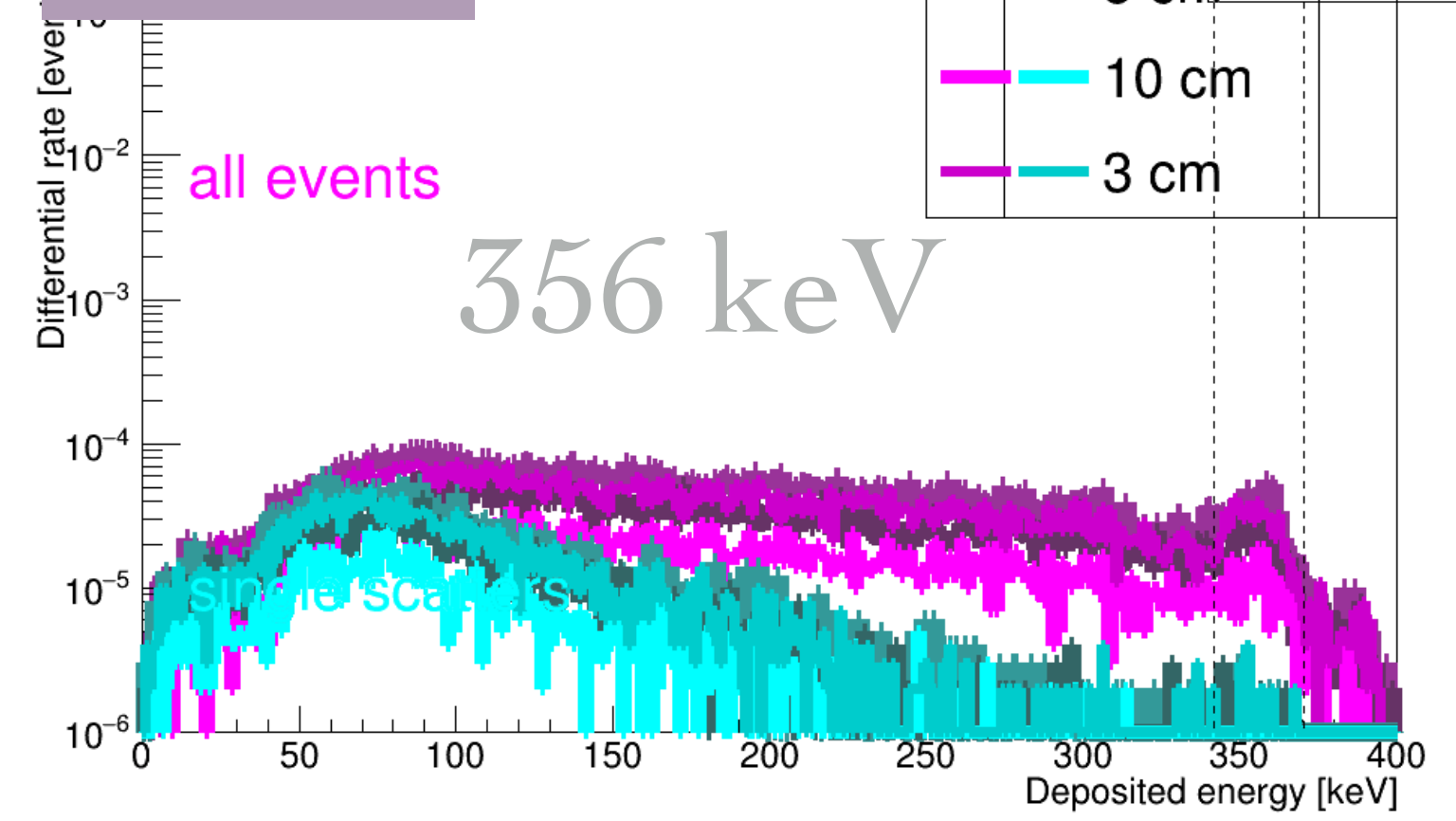
Co57

122 keV

Ba 133

356 keV

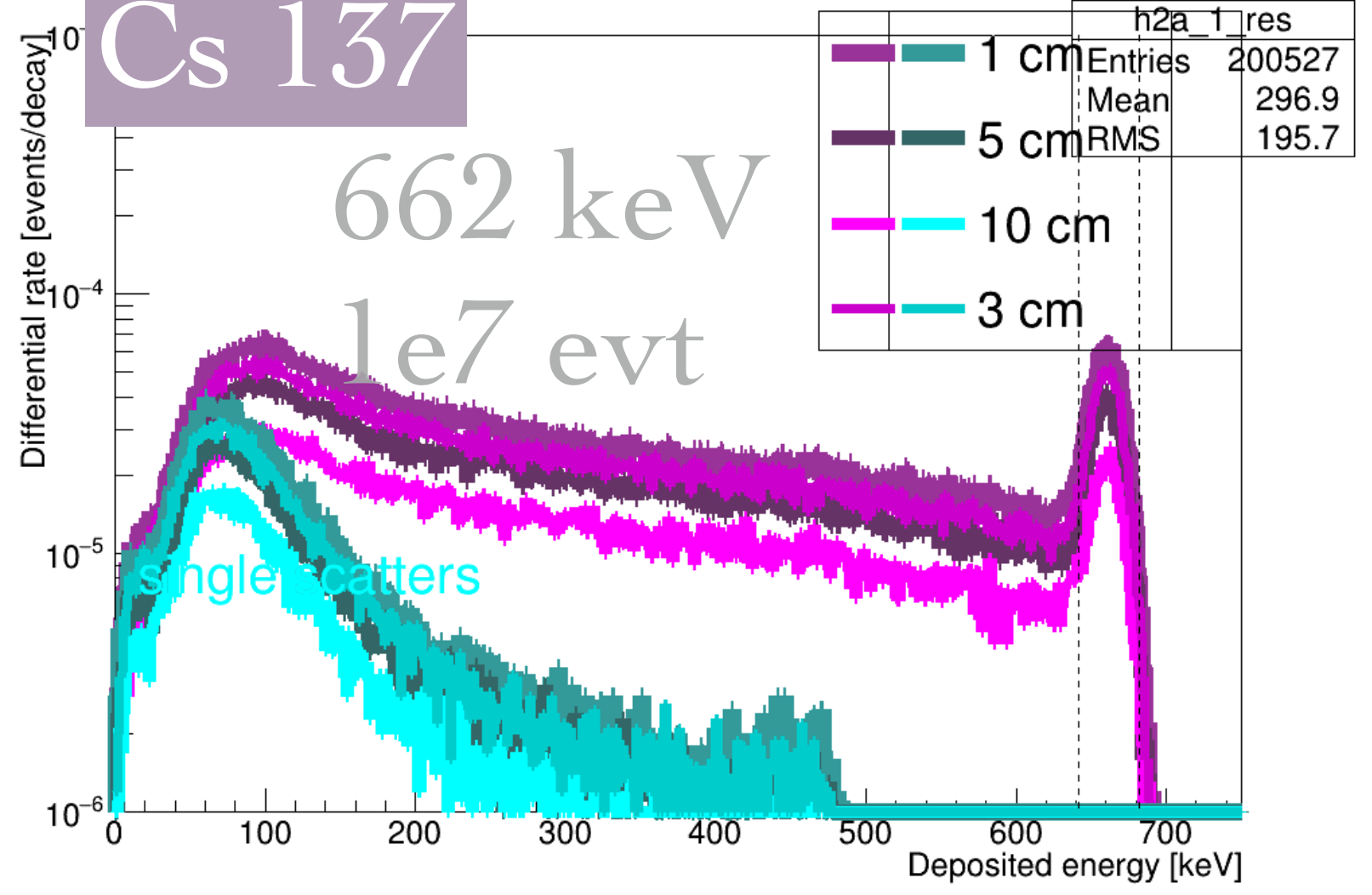
h2a_1_res	
1 cm	Entries 17157
5 cm	Mean 175.5
10 cm	RMS 93.6
3 cm	



Cs 137

662 keV  
 1e7 evt

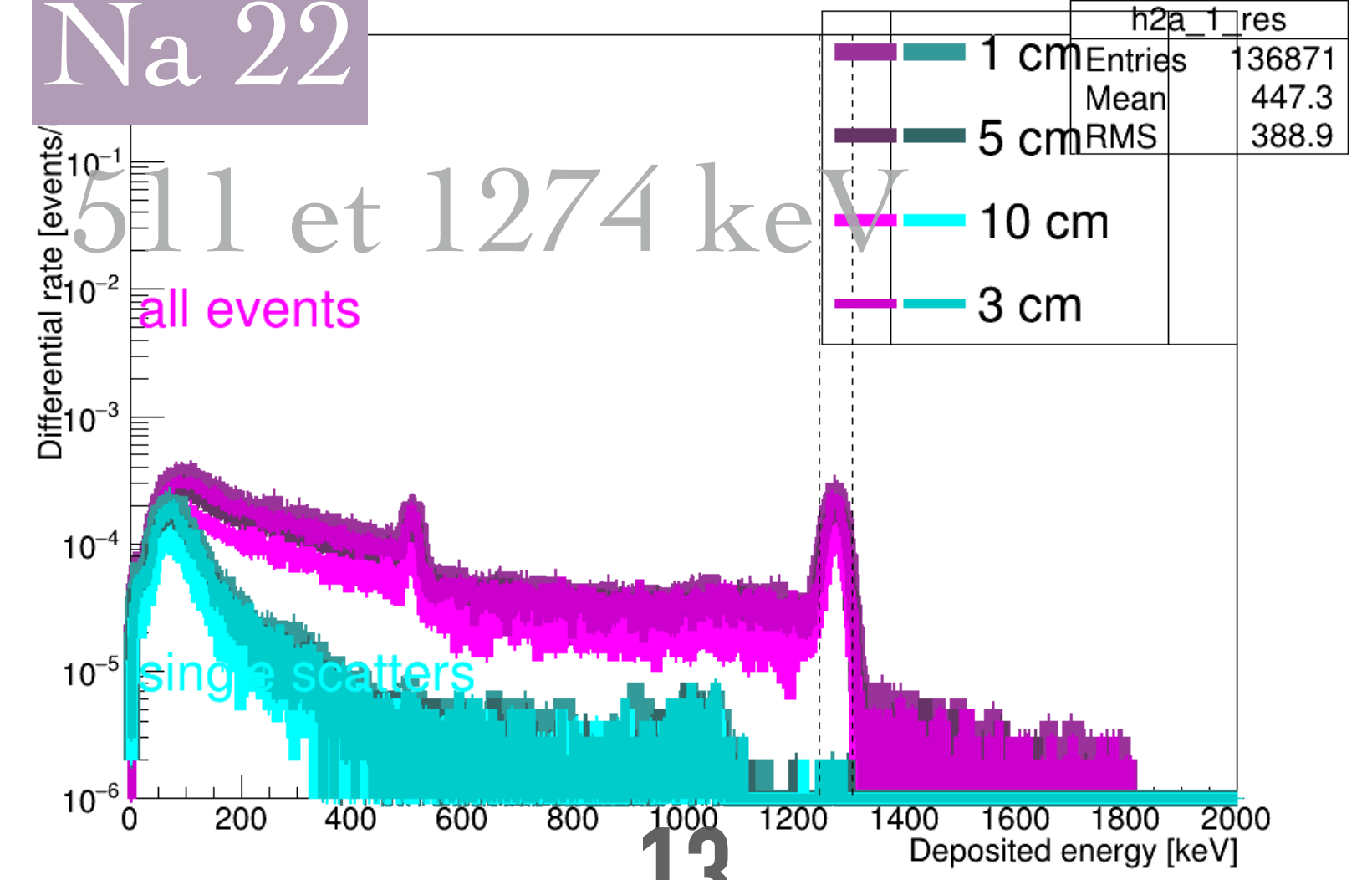
h2a_1_res	
1 cm	Entries 200527
5 cm	Mean 296.9
10 cm	RMS 195.7
3 cm	



Na 22

511 et 1274 keV

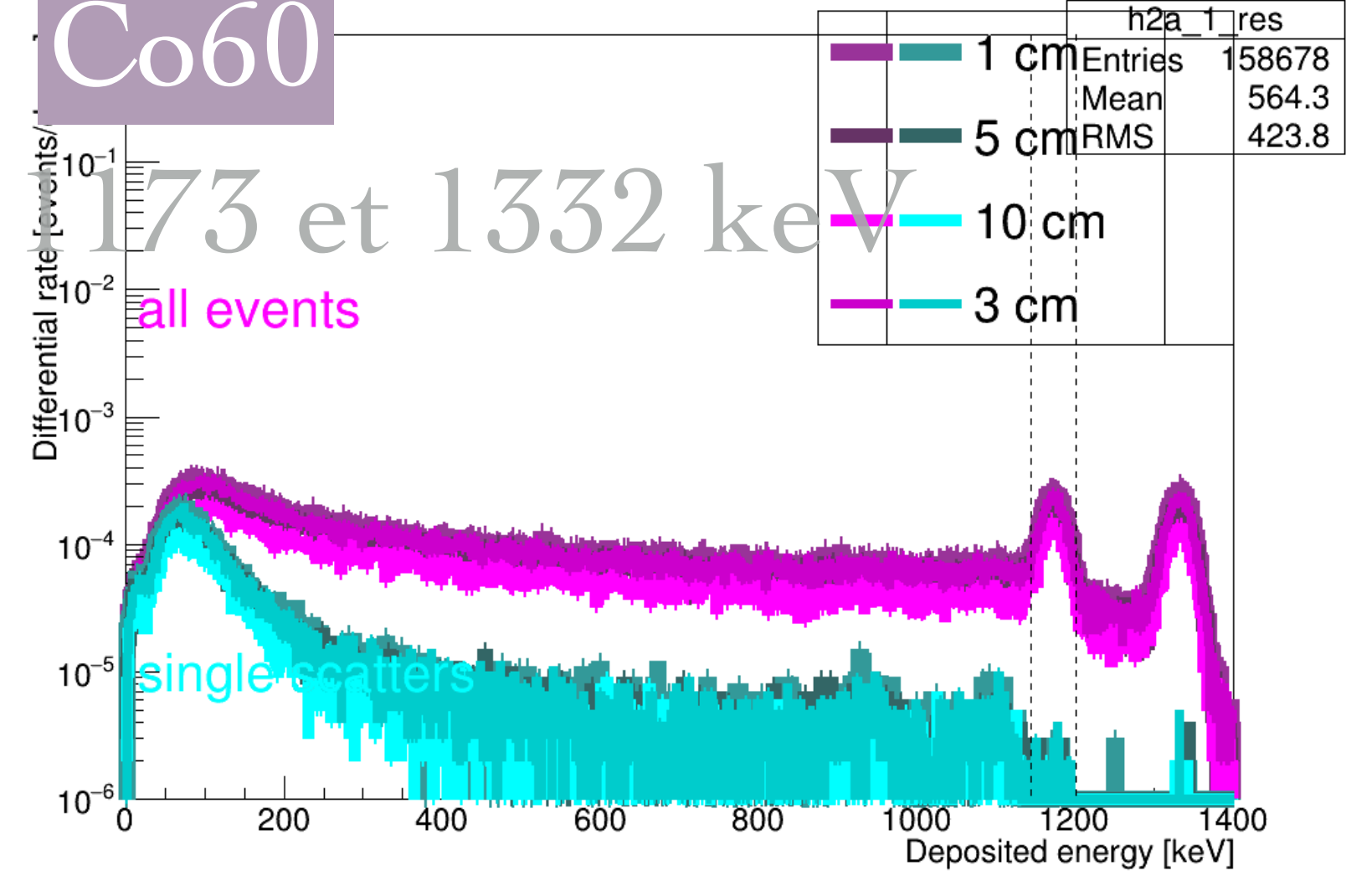
h2a_1_res	
1 cm	Entries 136871
5 cm	Mean 447.3
10 cm	RMS 388.9
3 cm	



Co60

173 et 1332 keV

h2a_1_res	
1 cm	Entries 158678
5 cm	Mean 564.3
10 cm	RMS 423.8
3 cm	



# Plots photons

Rate vs pipe distance

Am 241

59.5 keV

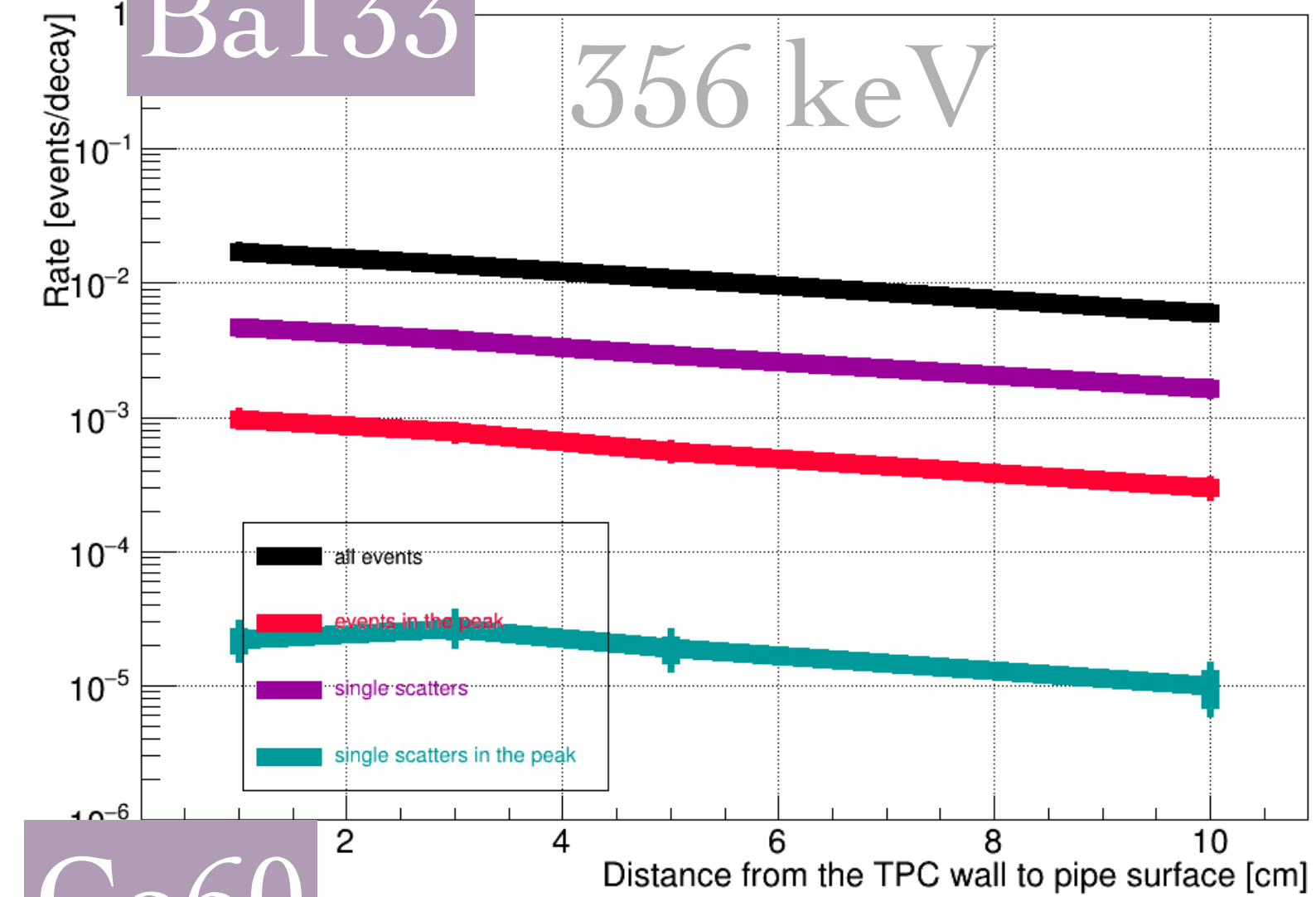
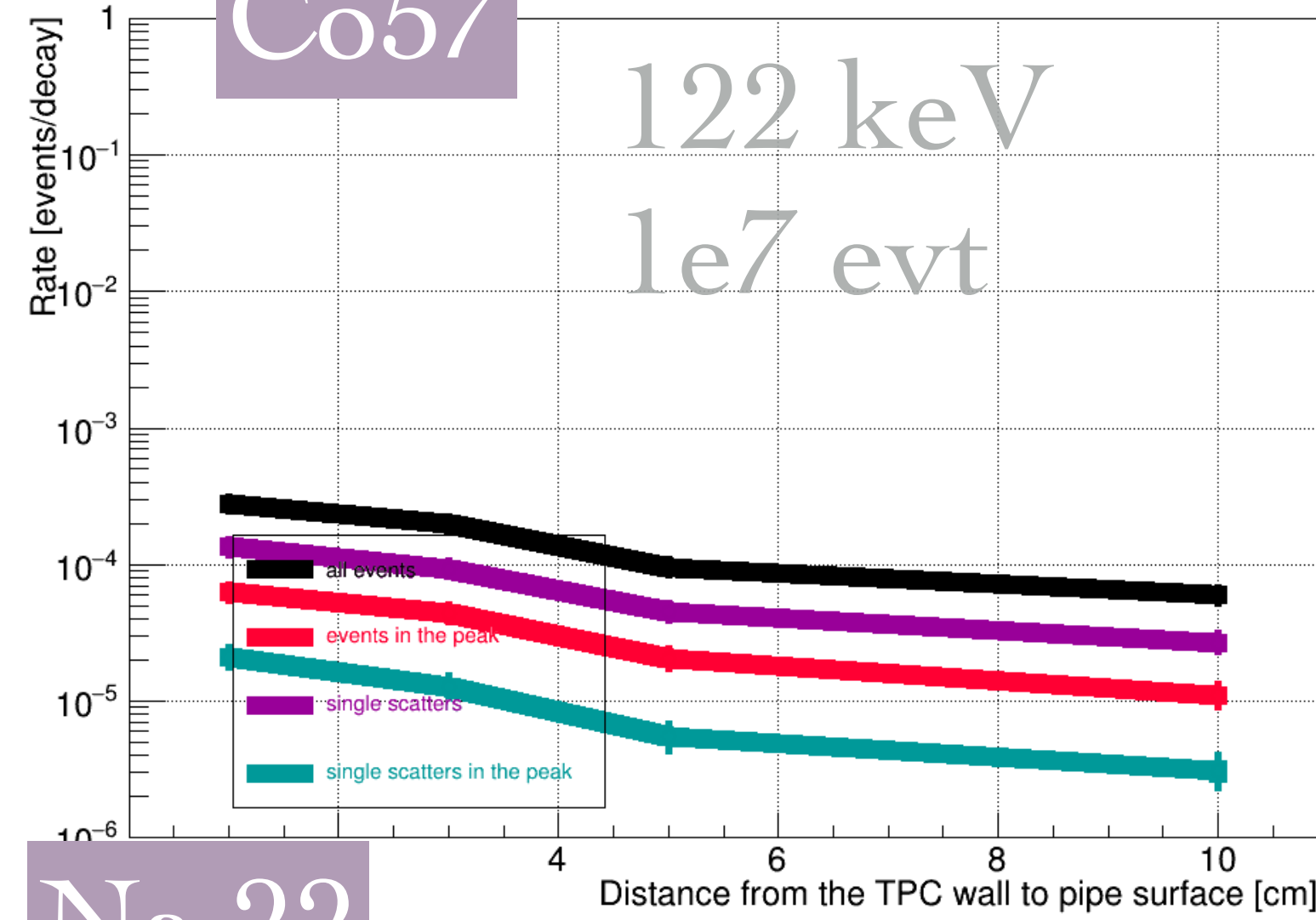
Co57

122 keV

1e7 evt

Ba133

356 keV



Cs 137

662 keV

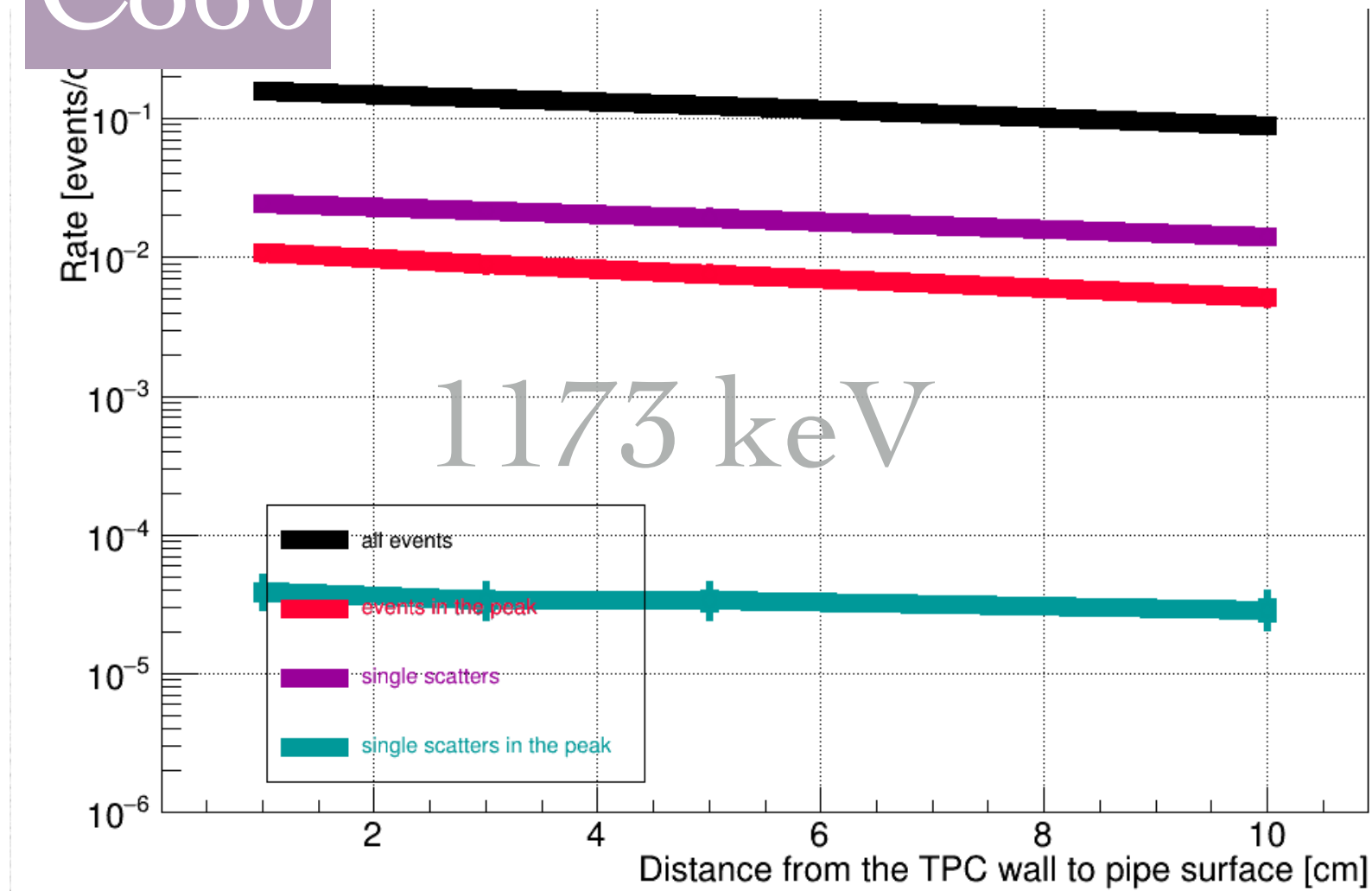
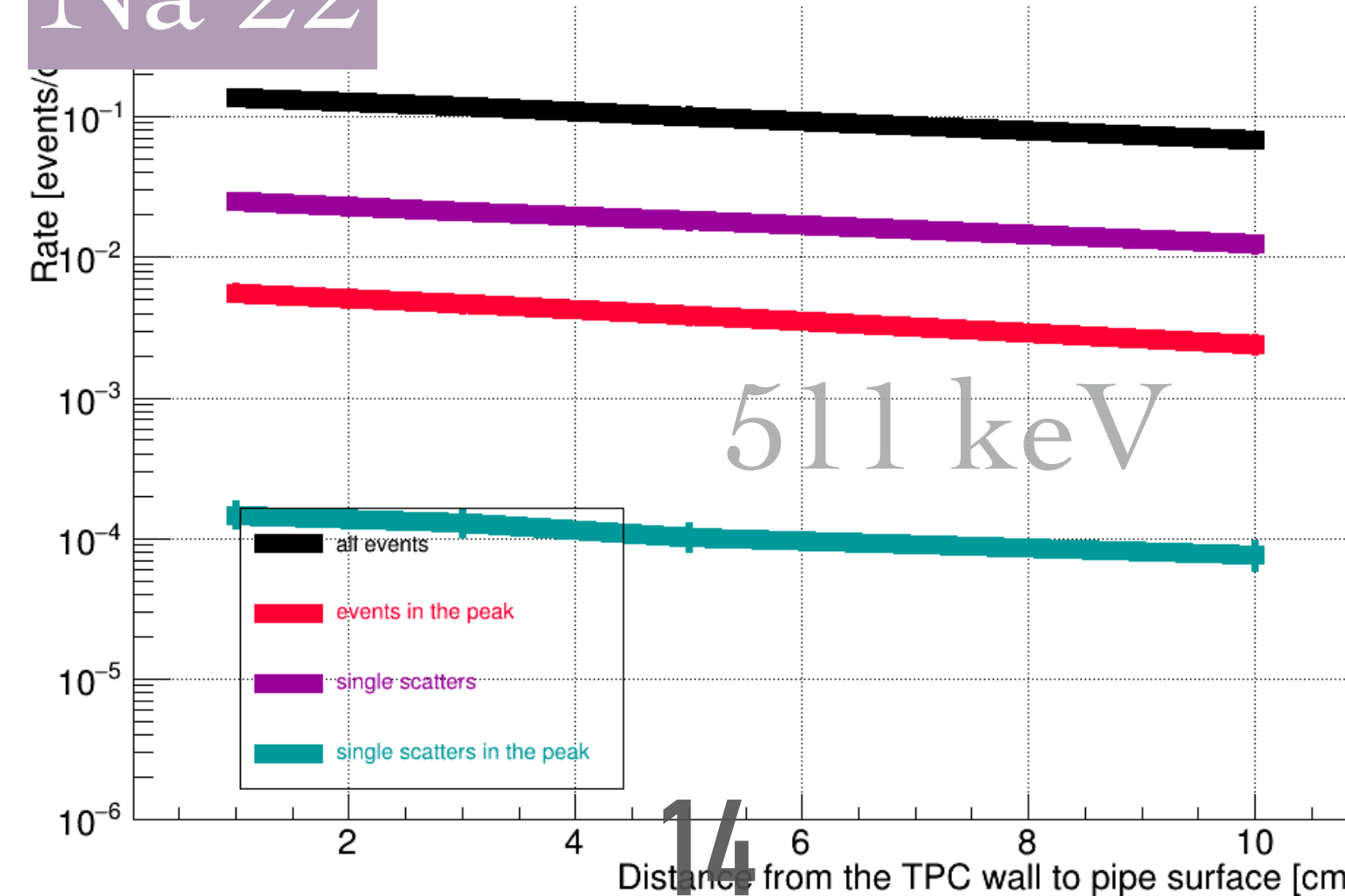
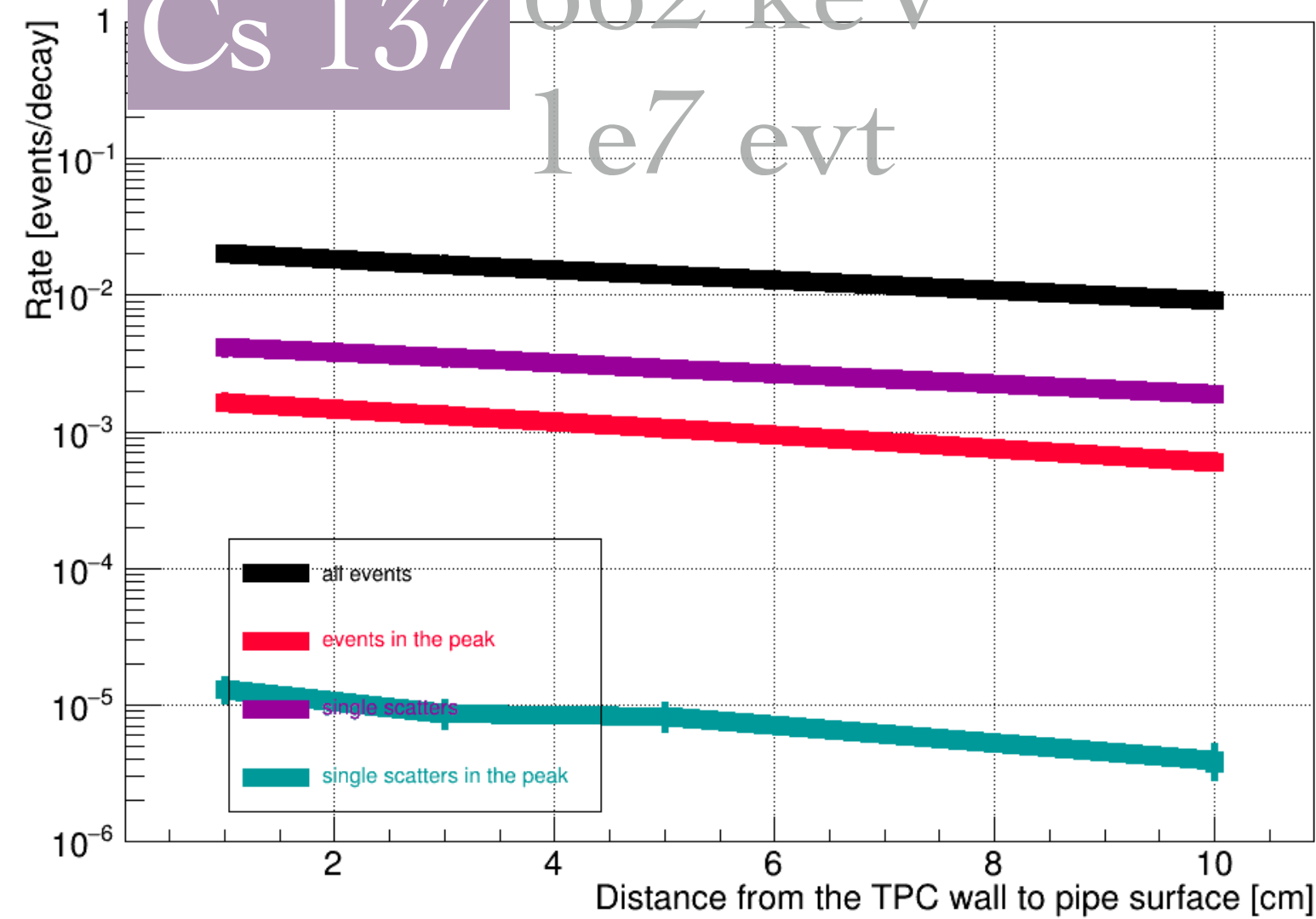
1e7 evt

Na 22

511 keV

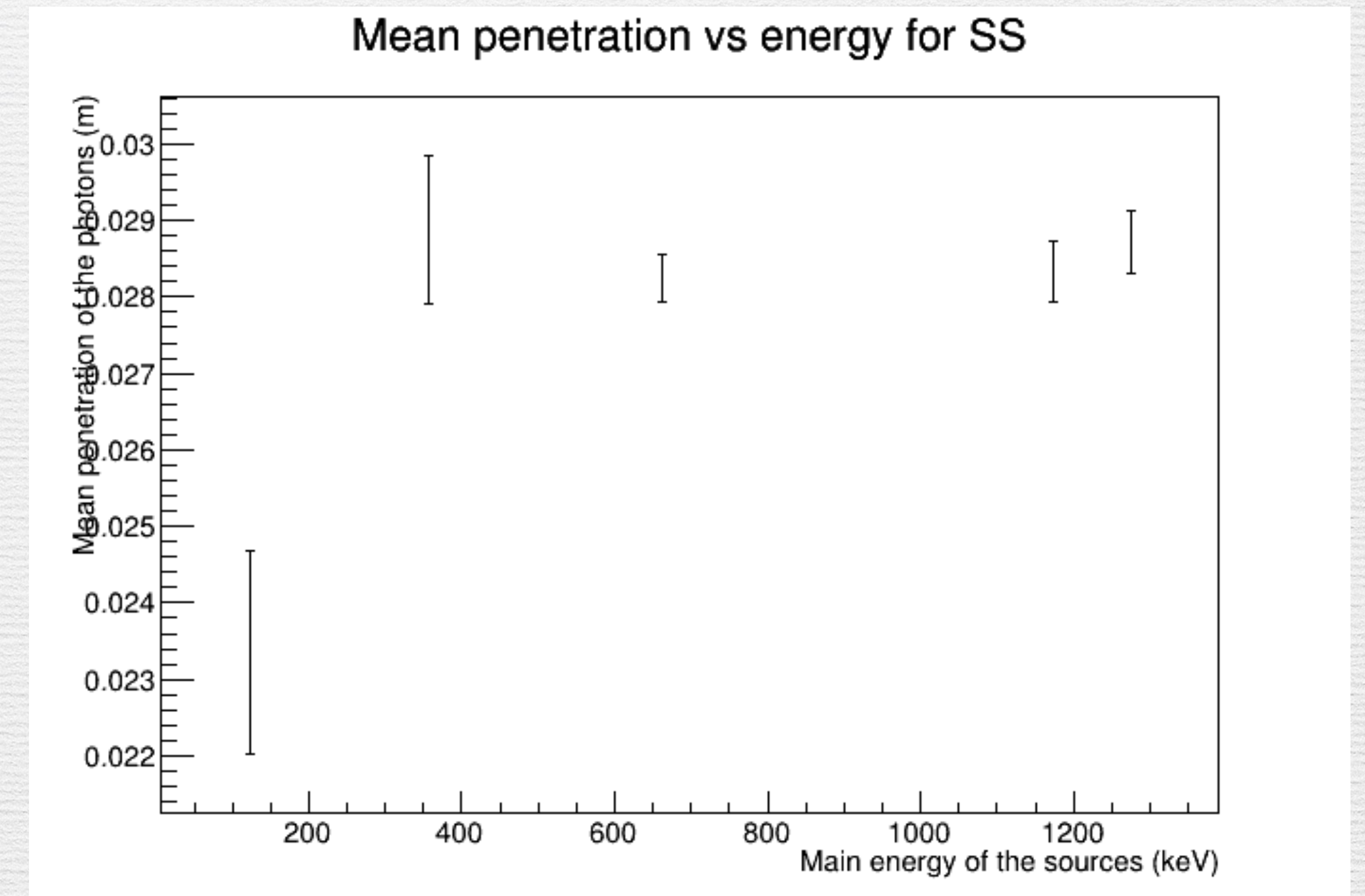
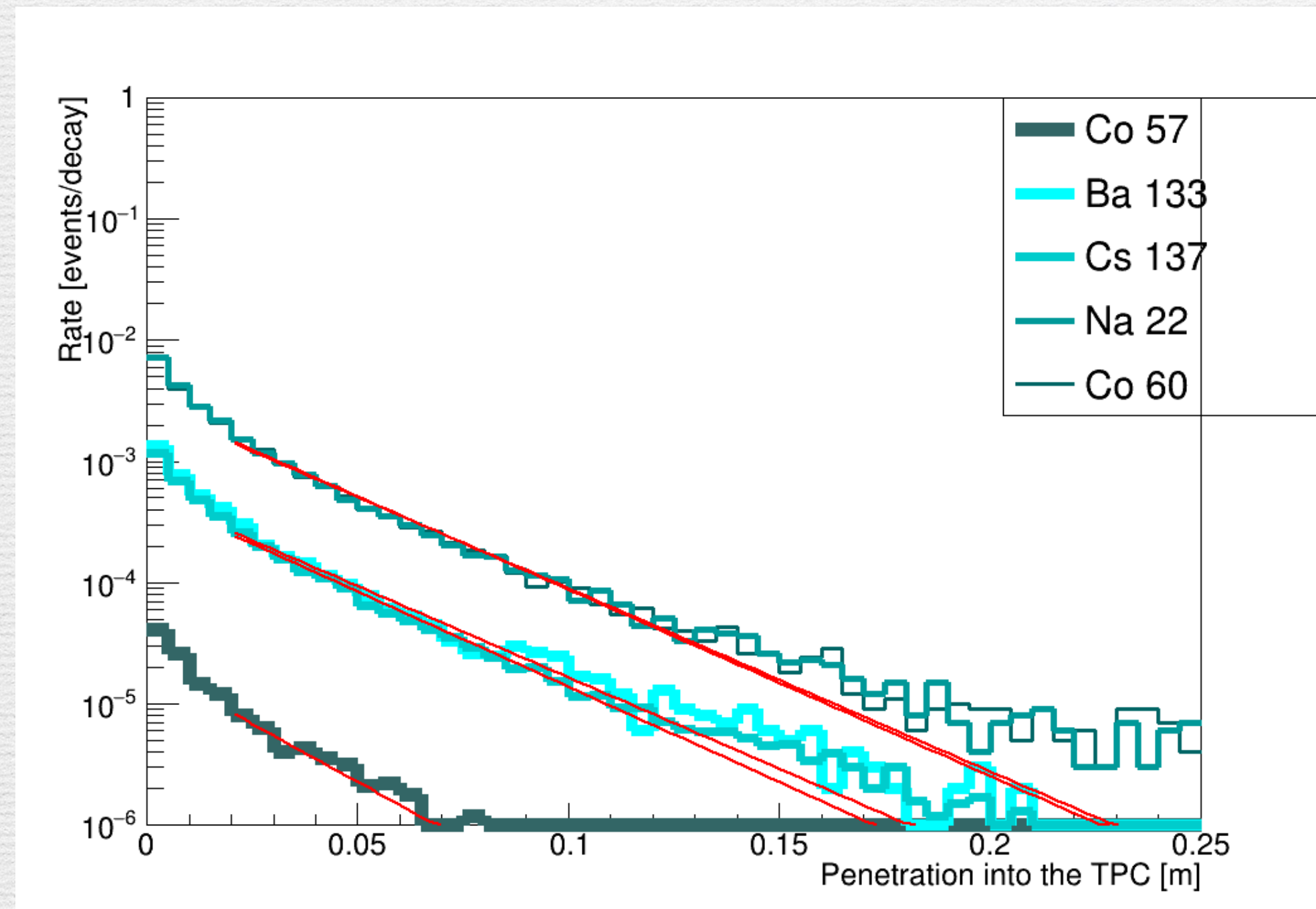
Co60

1173 keV



# Penetration vs energy

Les sources sont placées à 1cm sous la TPC



Au delà de 100 keV, la pénétration moyenne des photons faisant des SS dans la TPC est d'environ 2,5 cm => la calibration ne se fait que sur les bords.

# Source de neutrons placée en un point sur le côté de la TPC

FV = fiducial volume  
ROI = region of interest

Energie du NR  
 $\in [30, 200] keV_{nr}$

Energie du neutron DD : 2,45 MeV

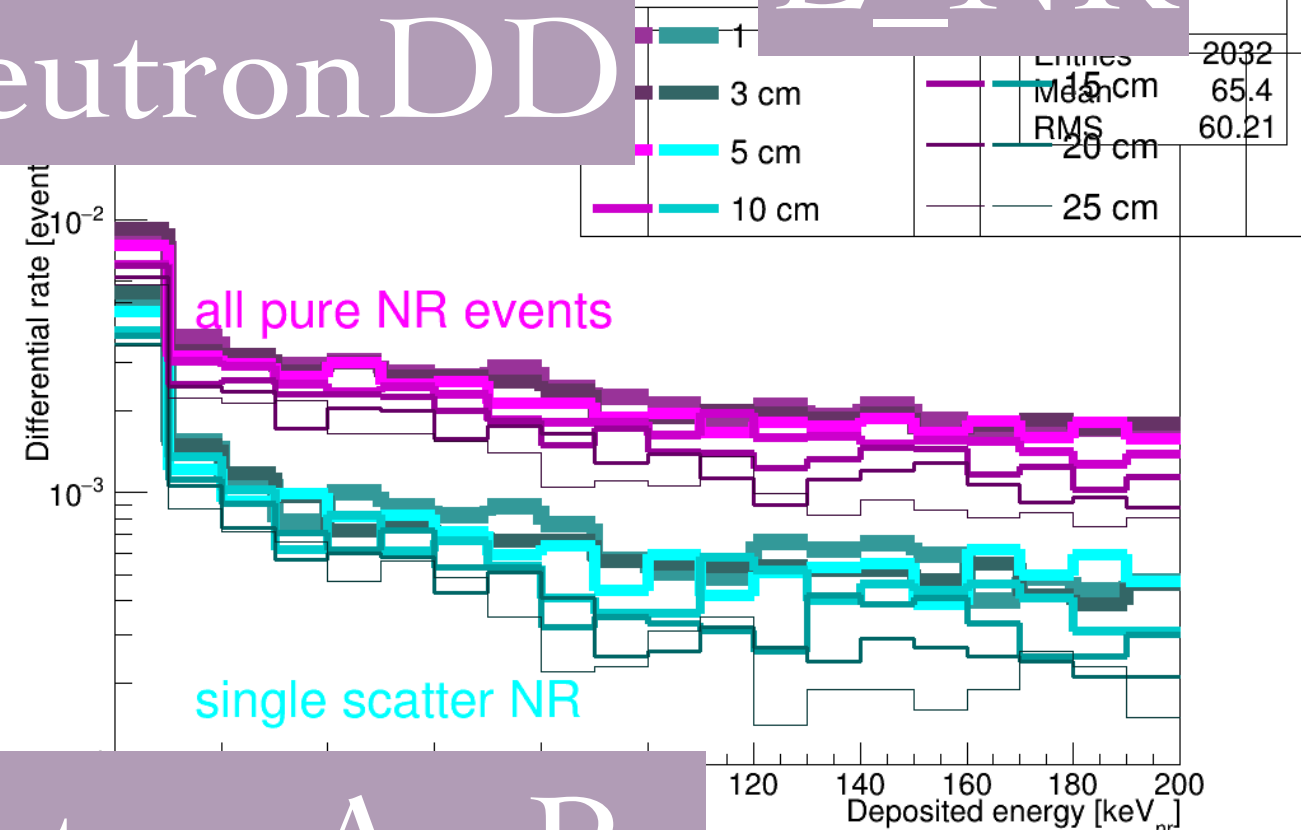


# Plots neutrons

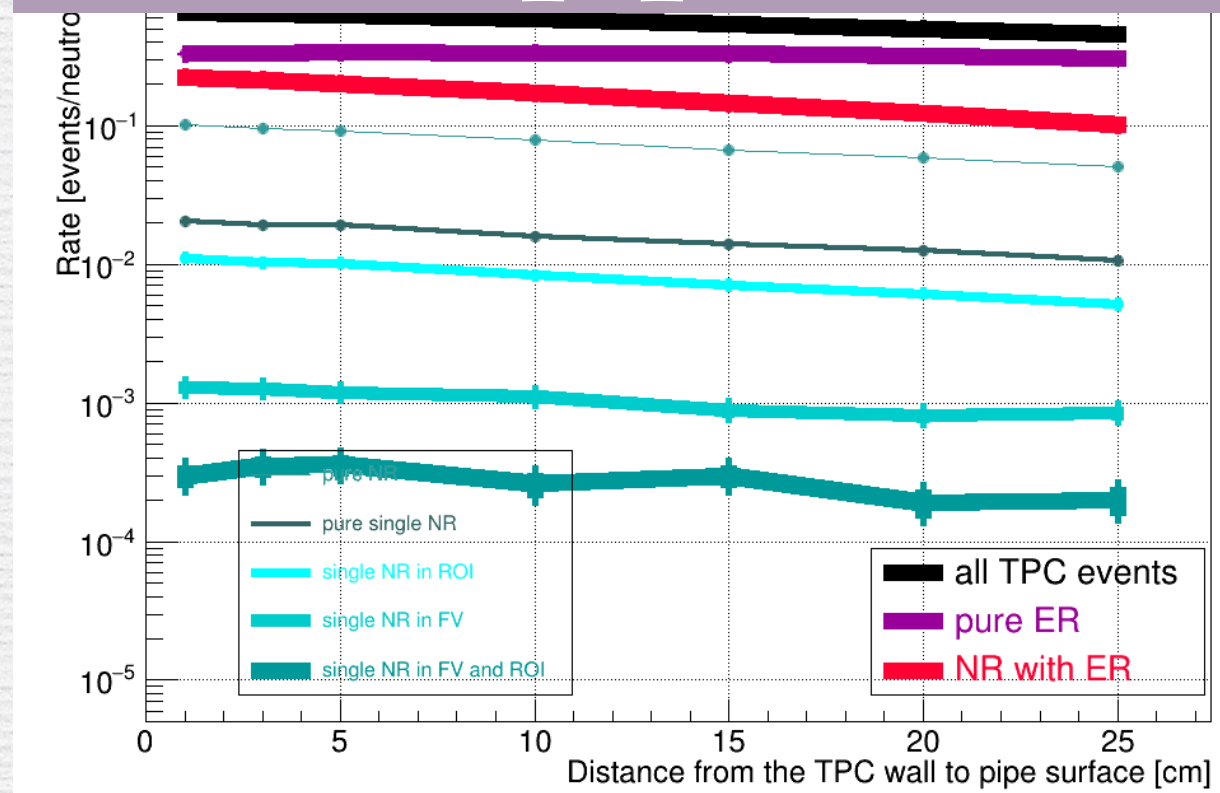
1e5 evt

NeutronDD

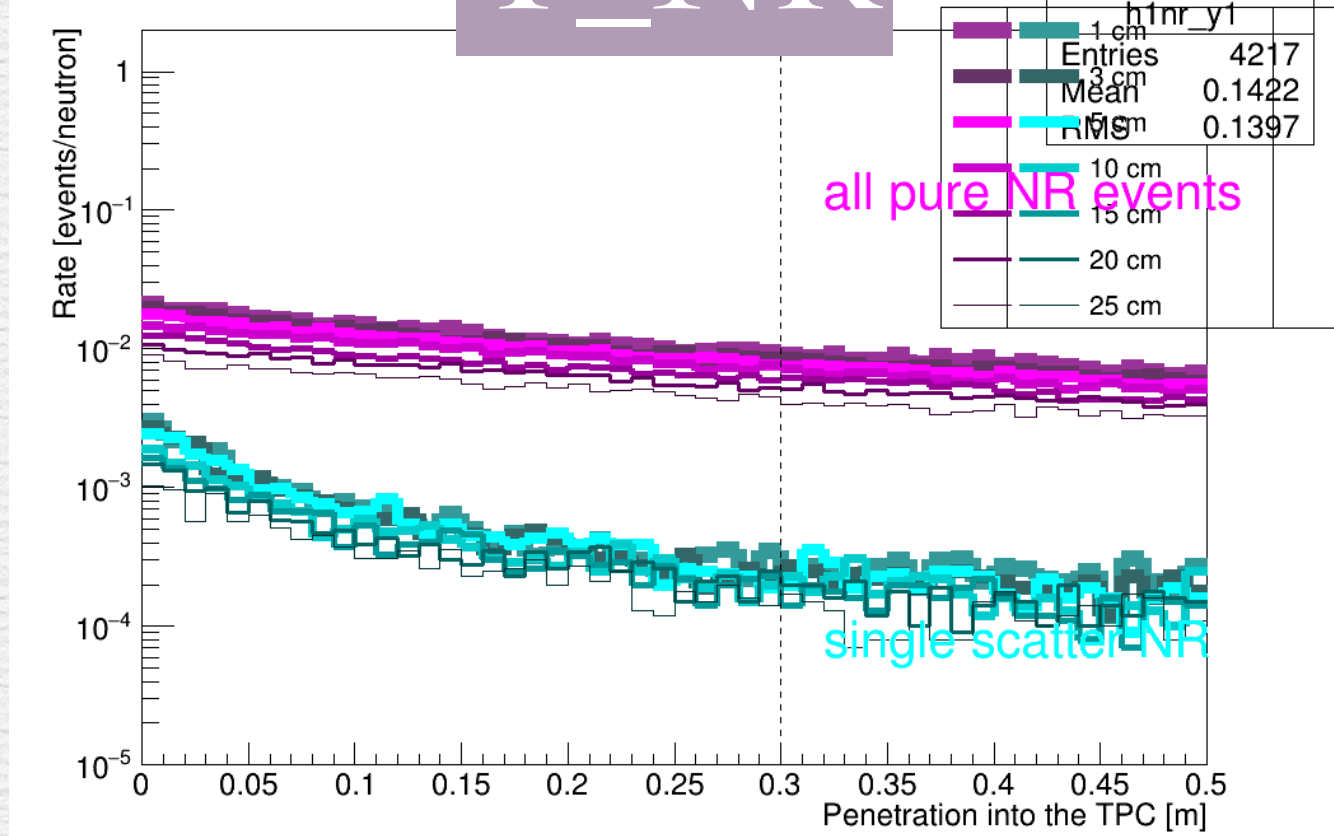
E\_NR



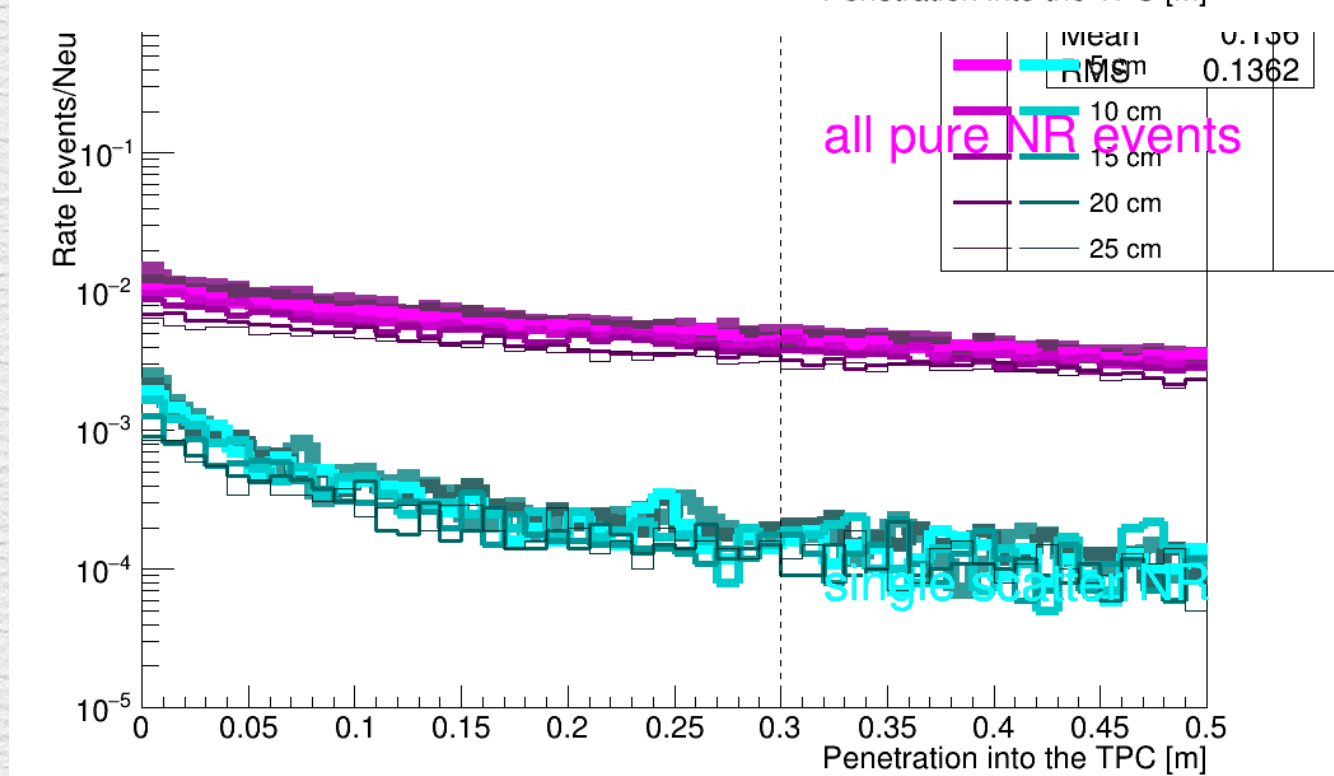
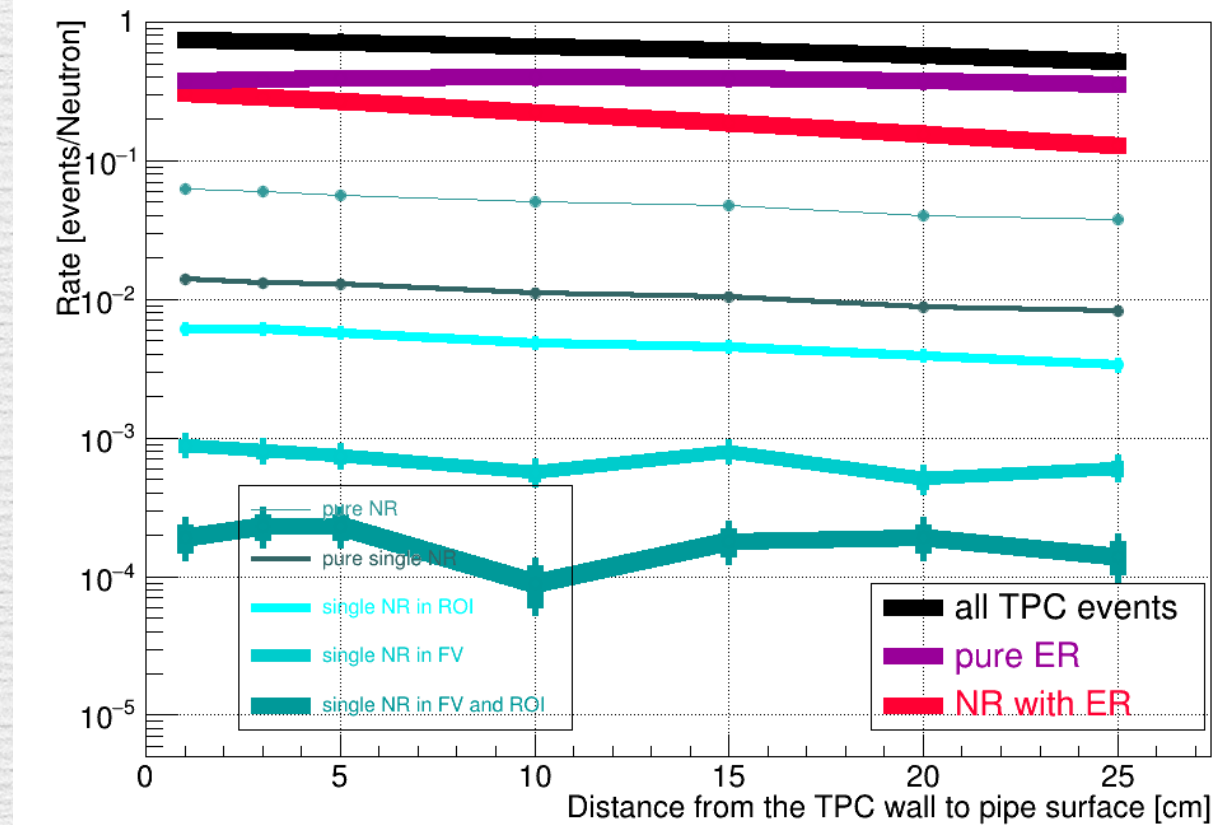
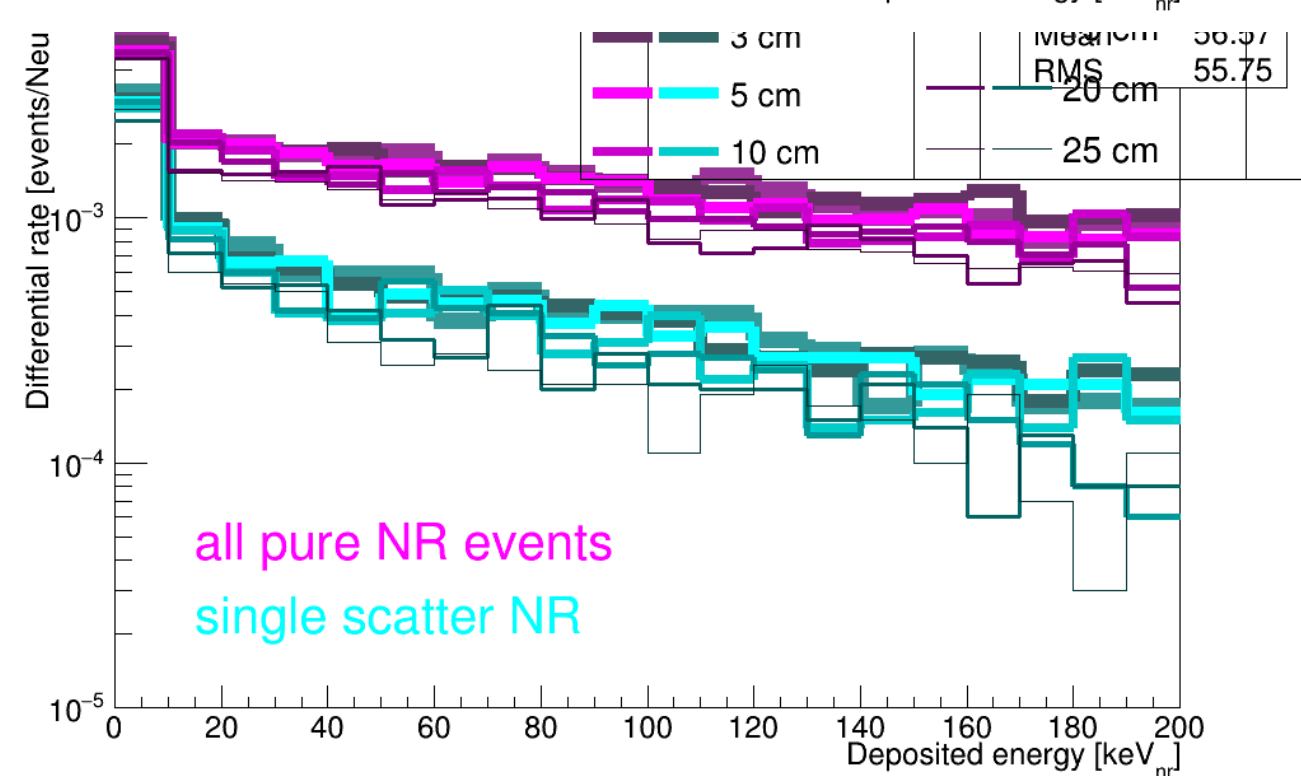
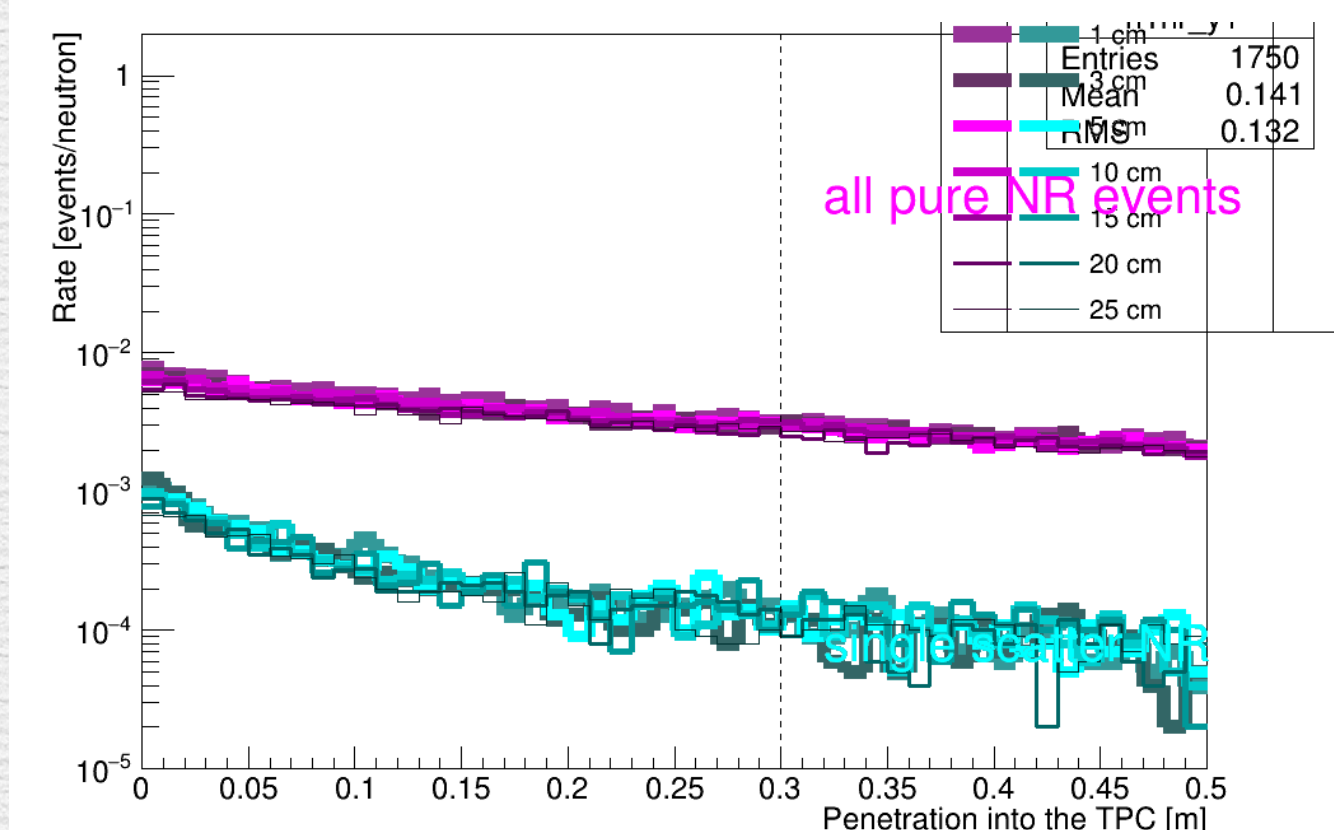
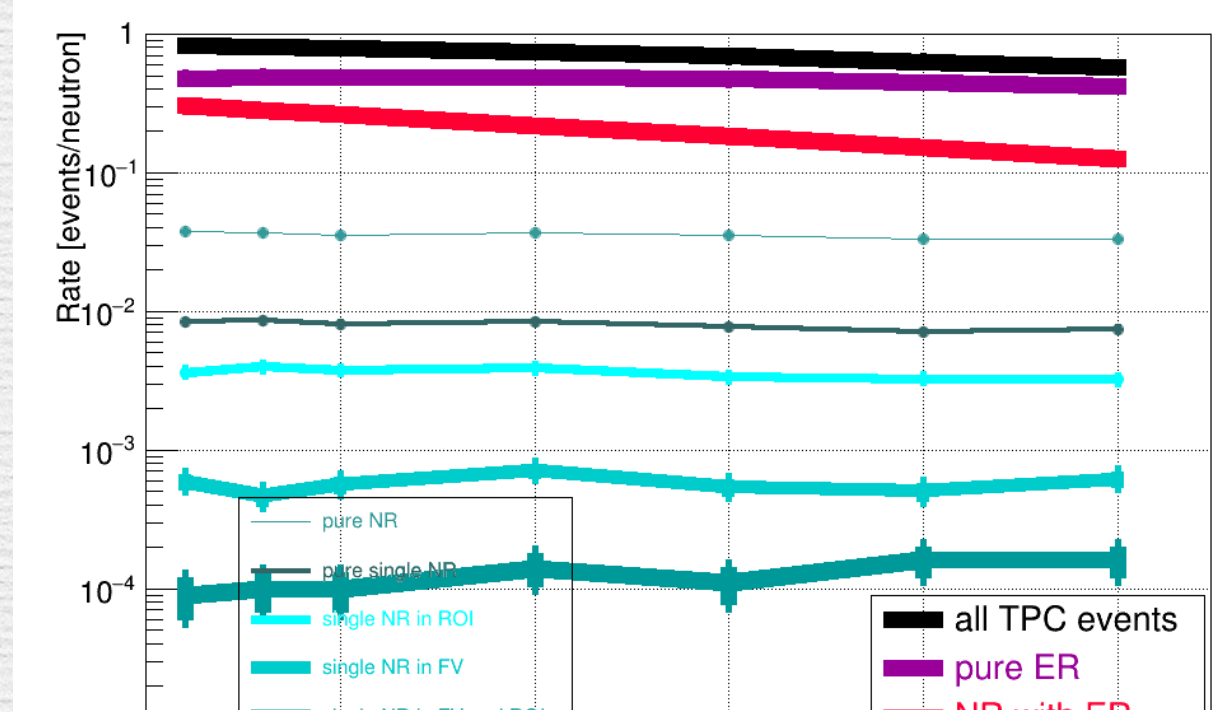
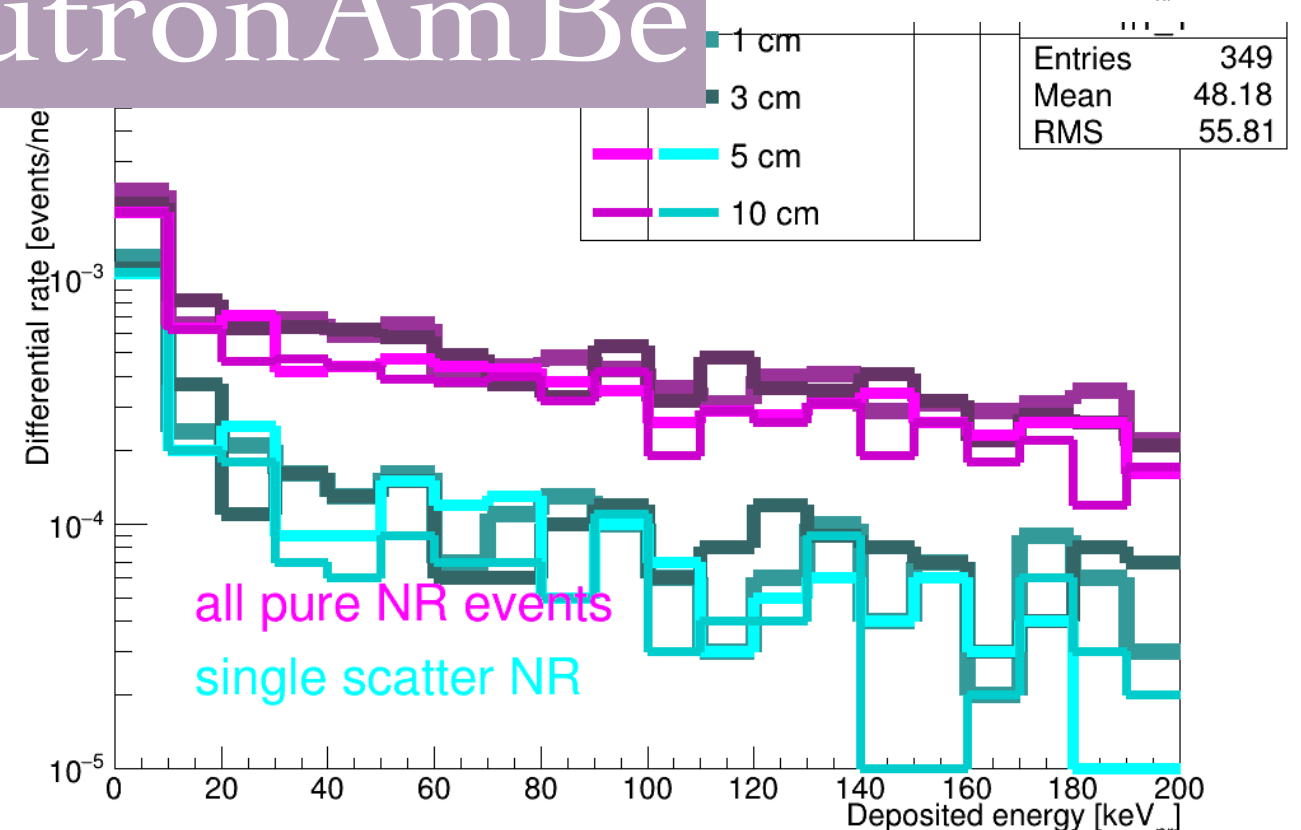
Rate vs pipe distance



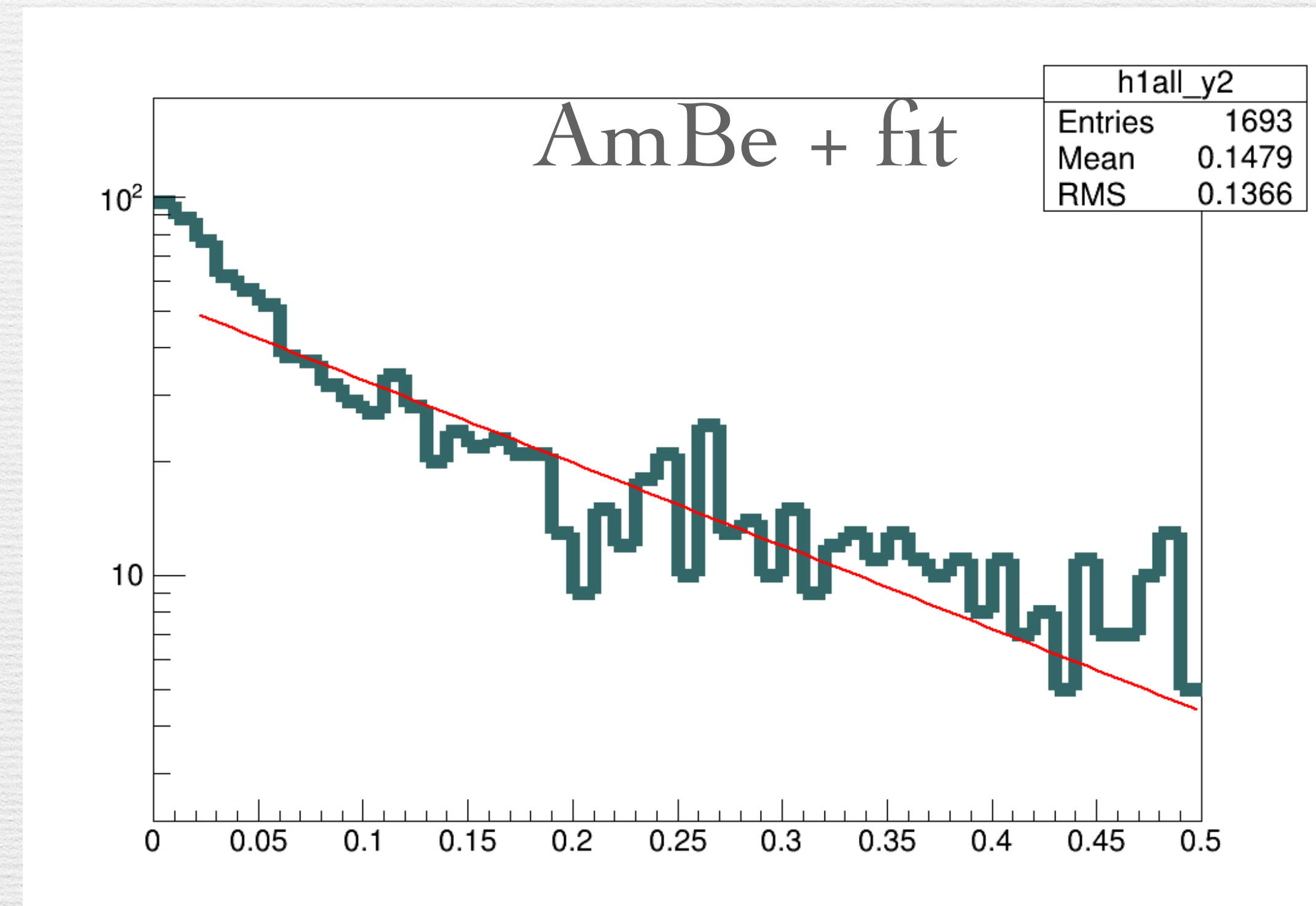
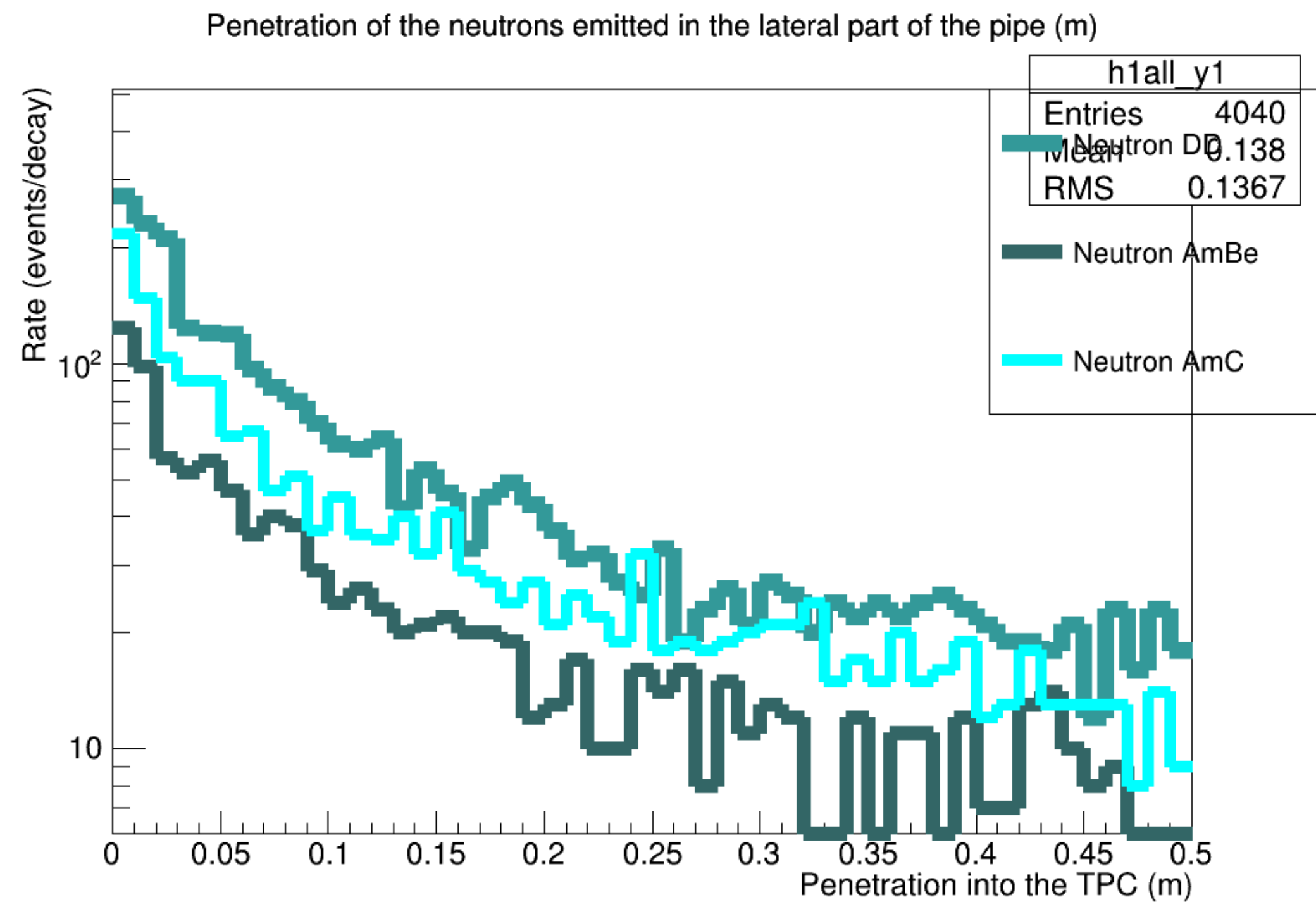
Y\_NR



NeutronAmBe



# Plots neutrons penetration



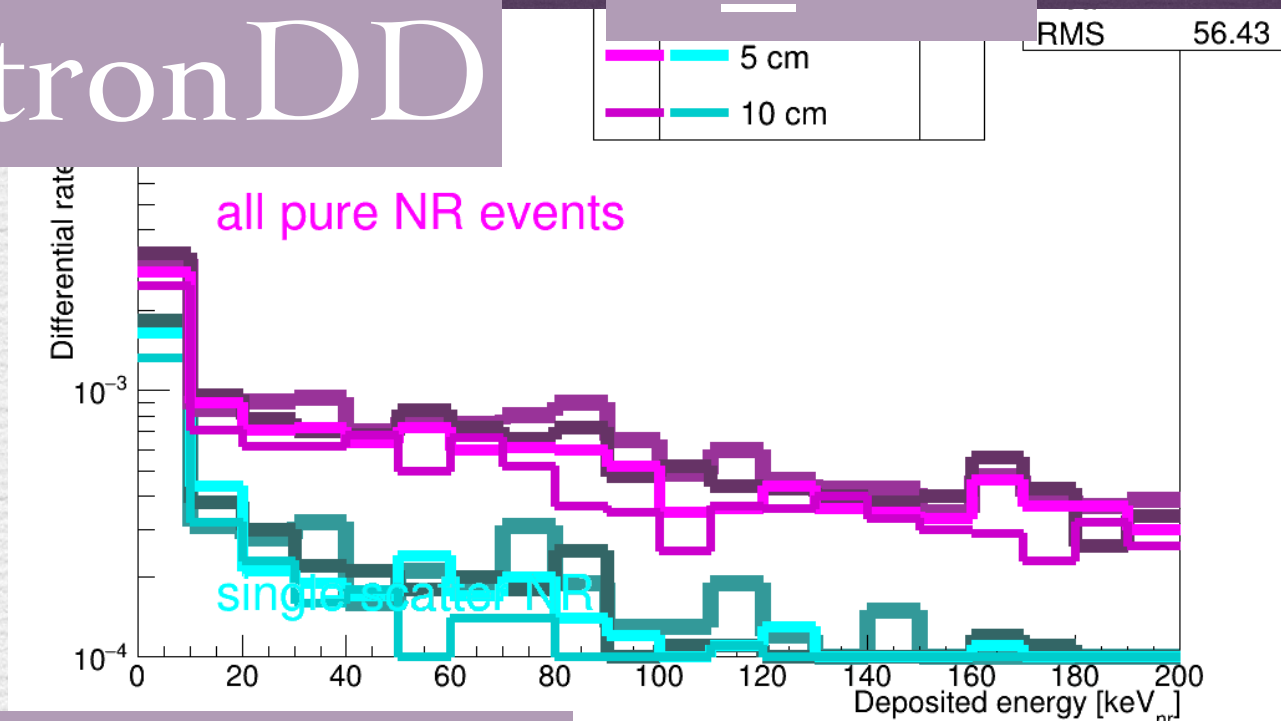
Source de neutrons placée  
en un point sous la TPC

# Plots neutrons

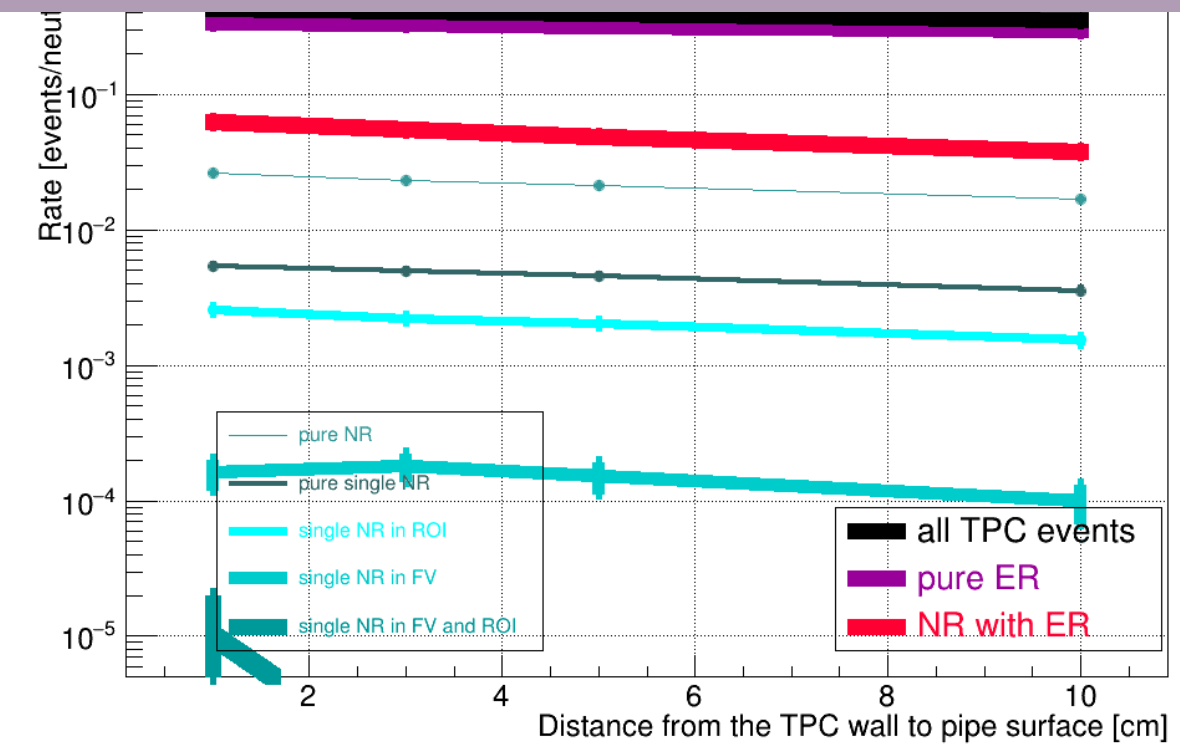
1e5 evt

NeutronDD

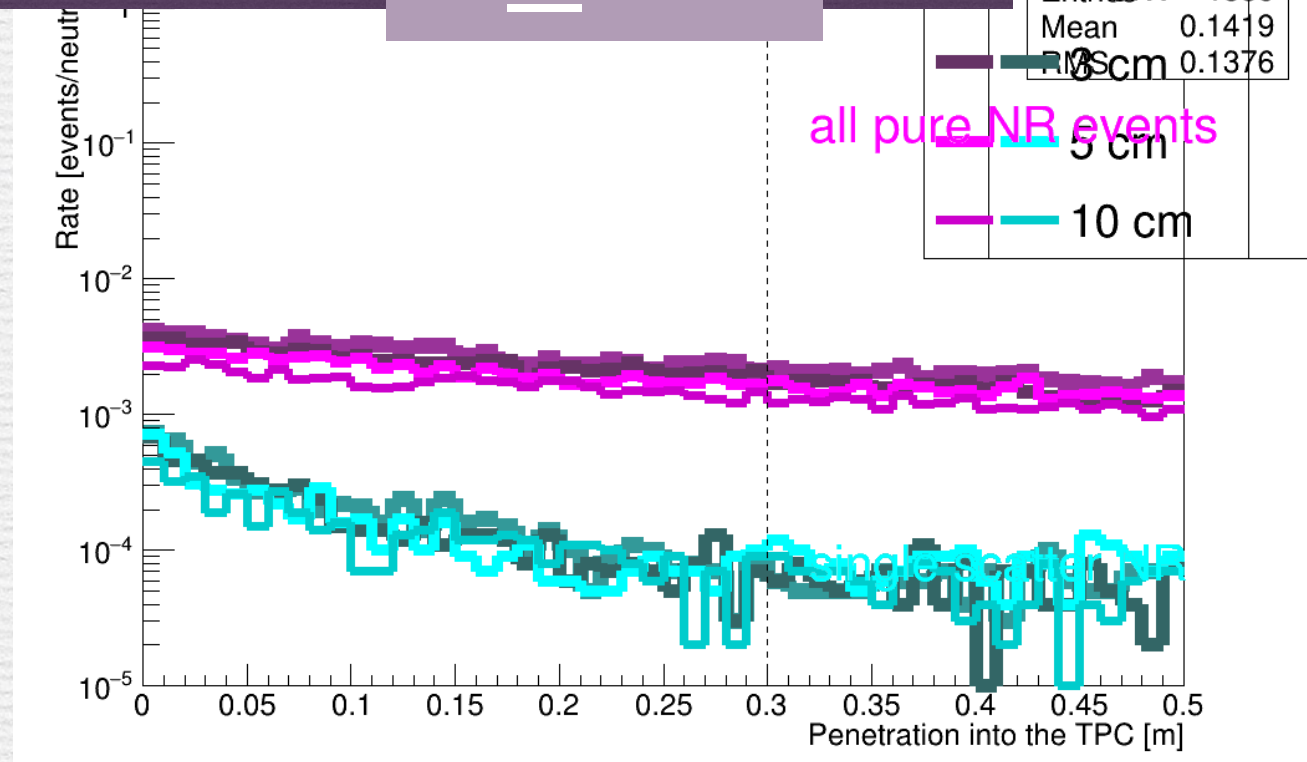
E\_NR



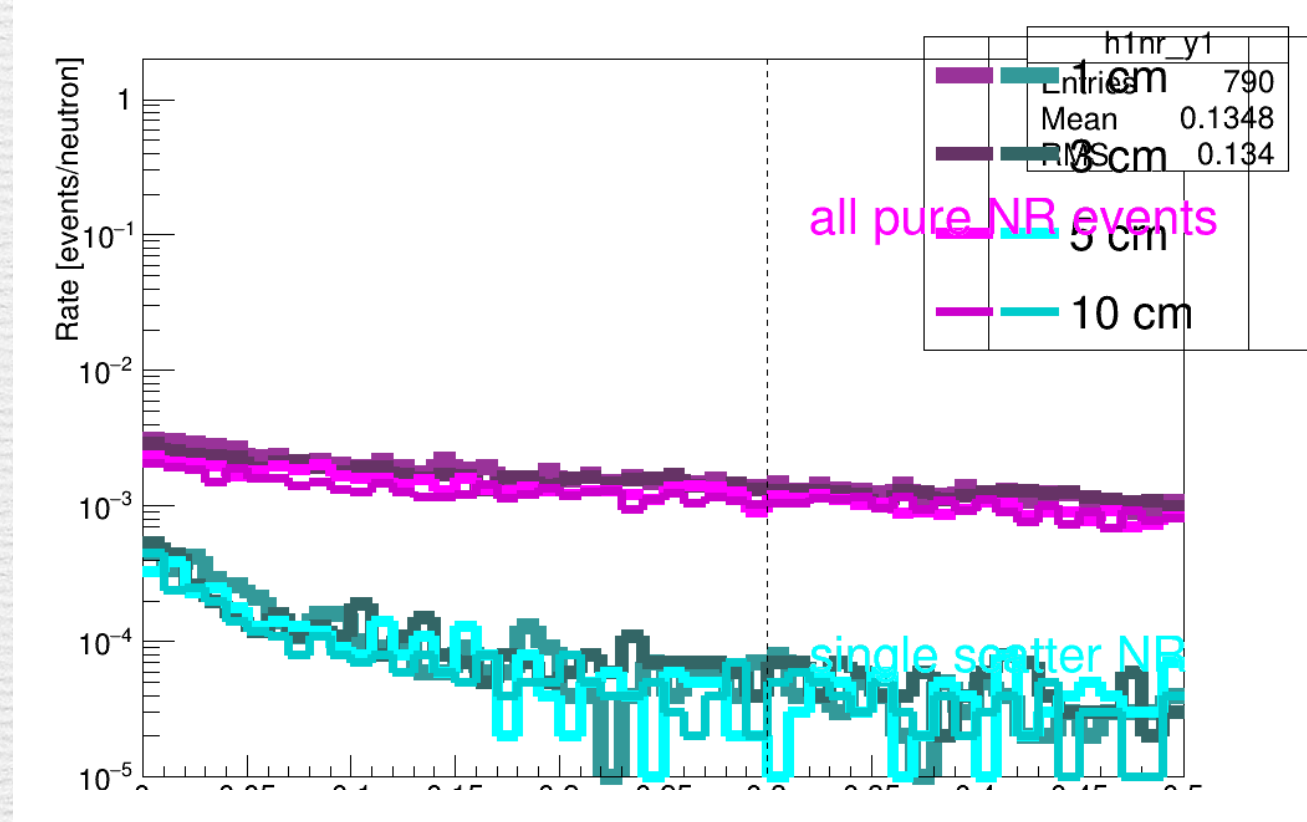
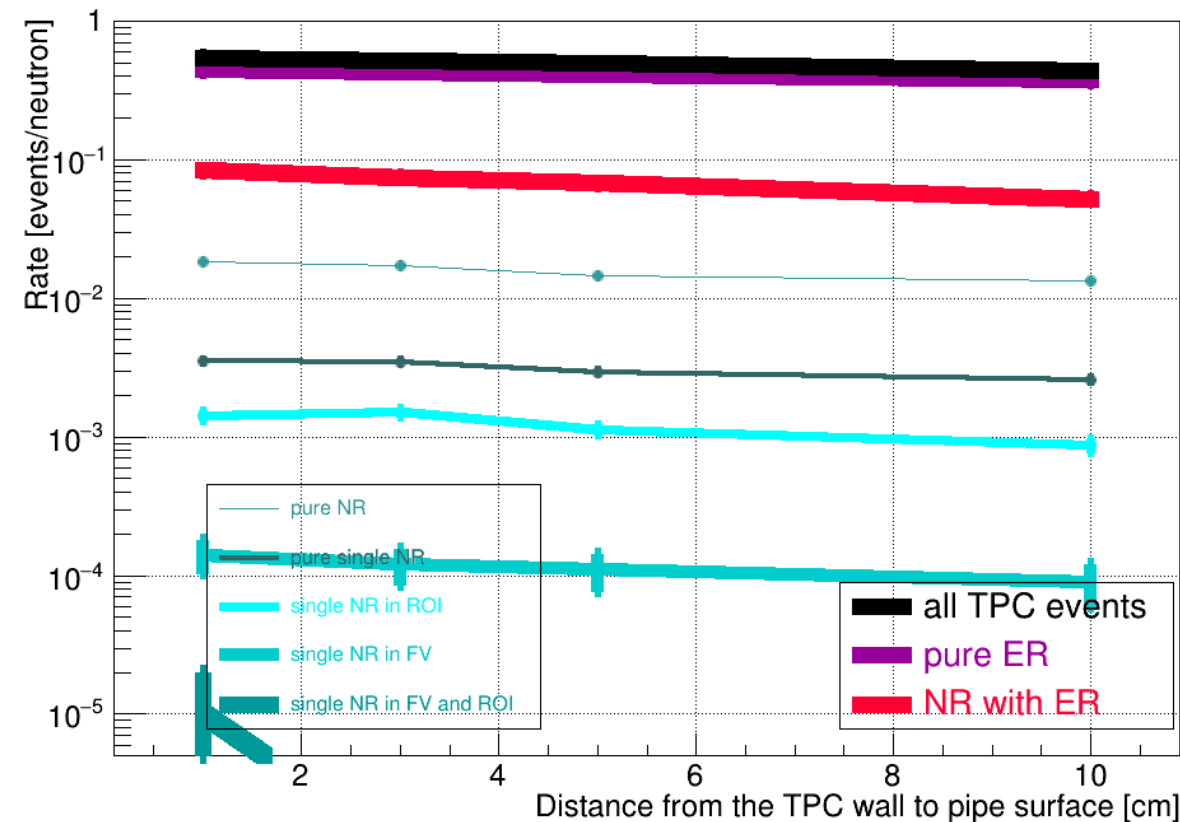
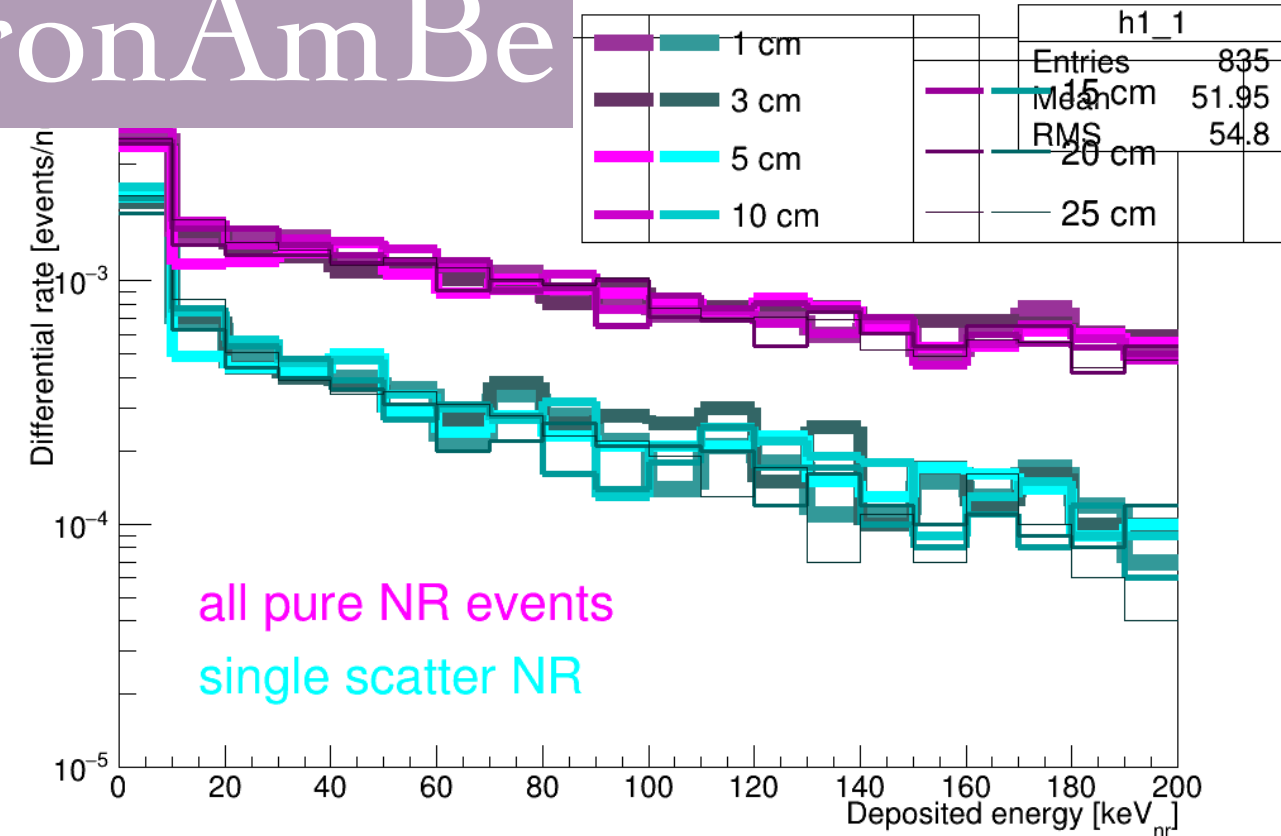
Rate vs pipe distance



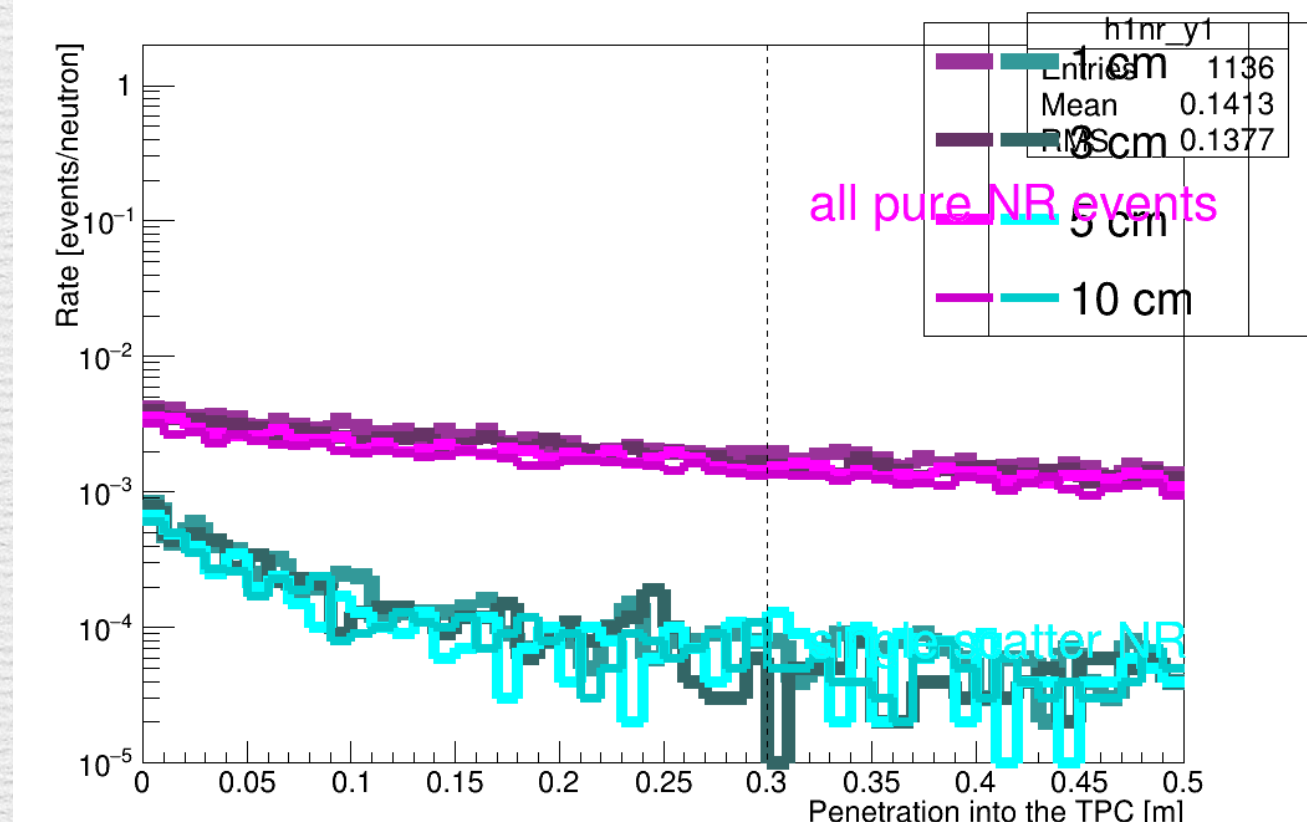
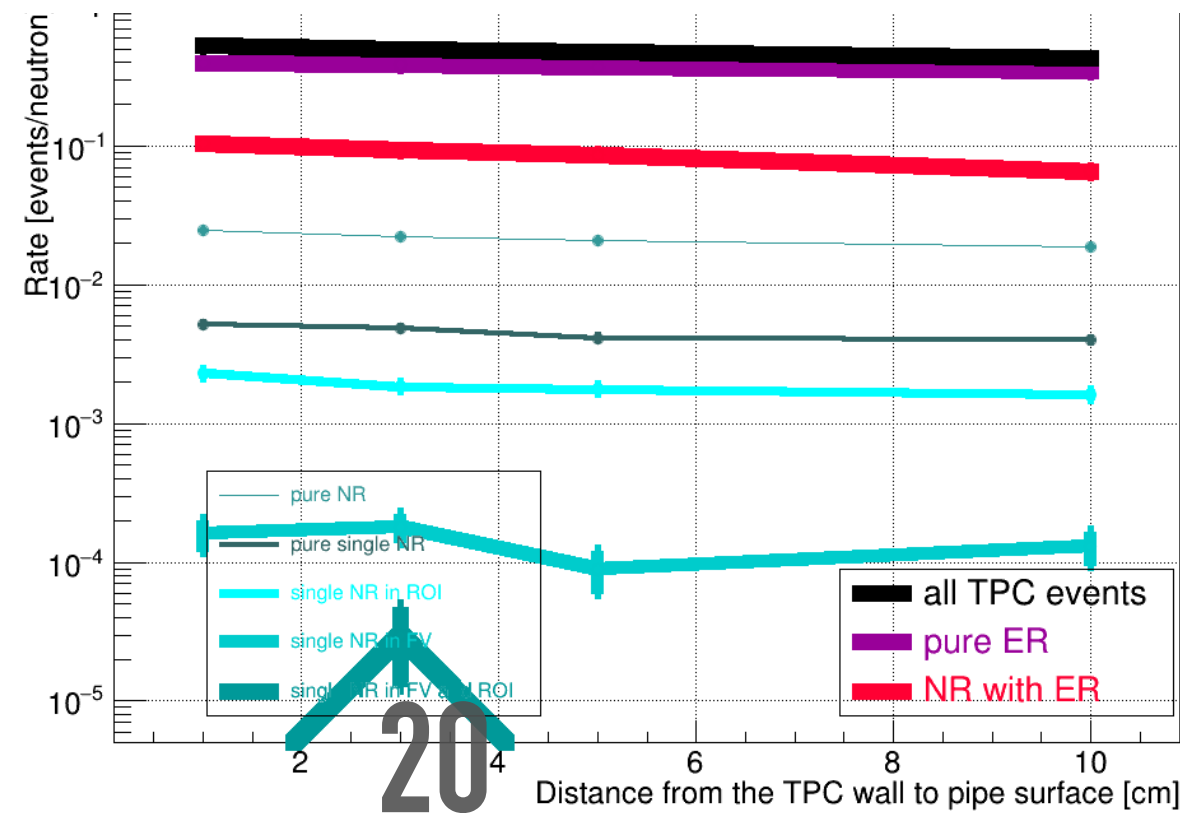
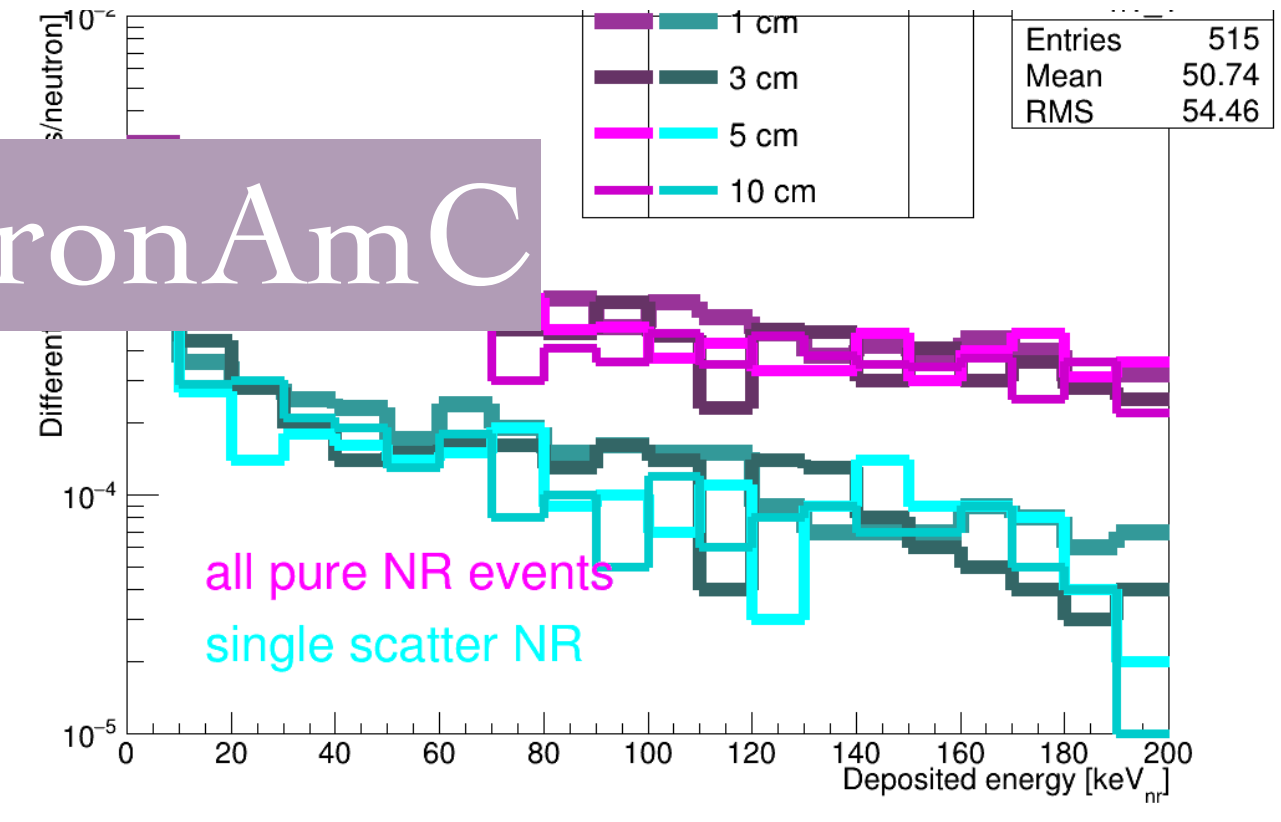
Y\_NR



NeutronAmBe

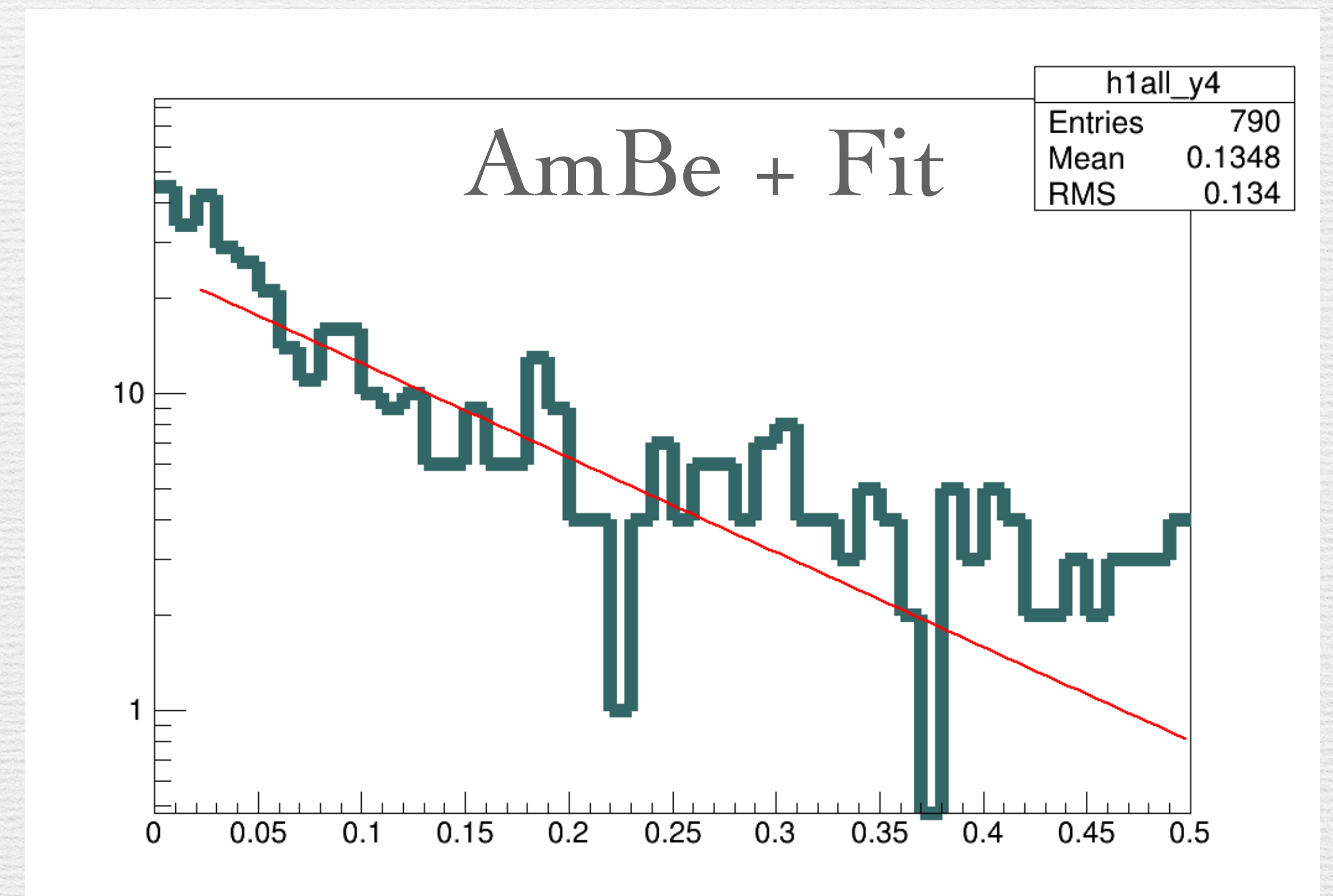
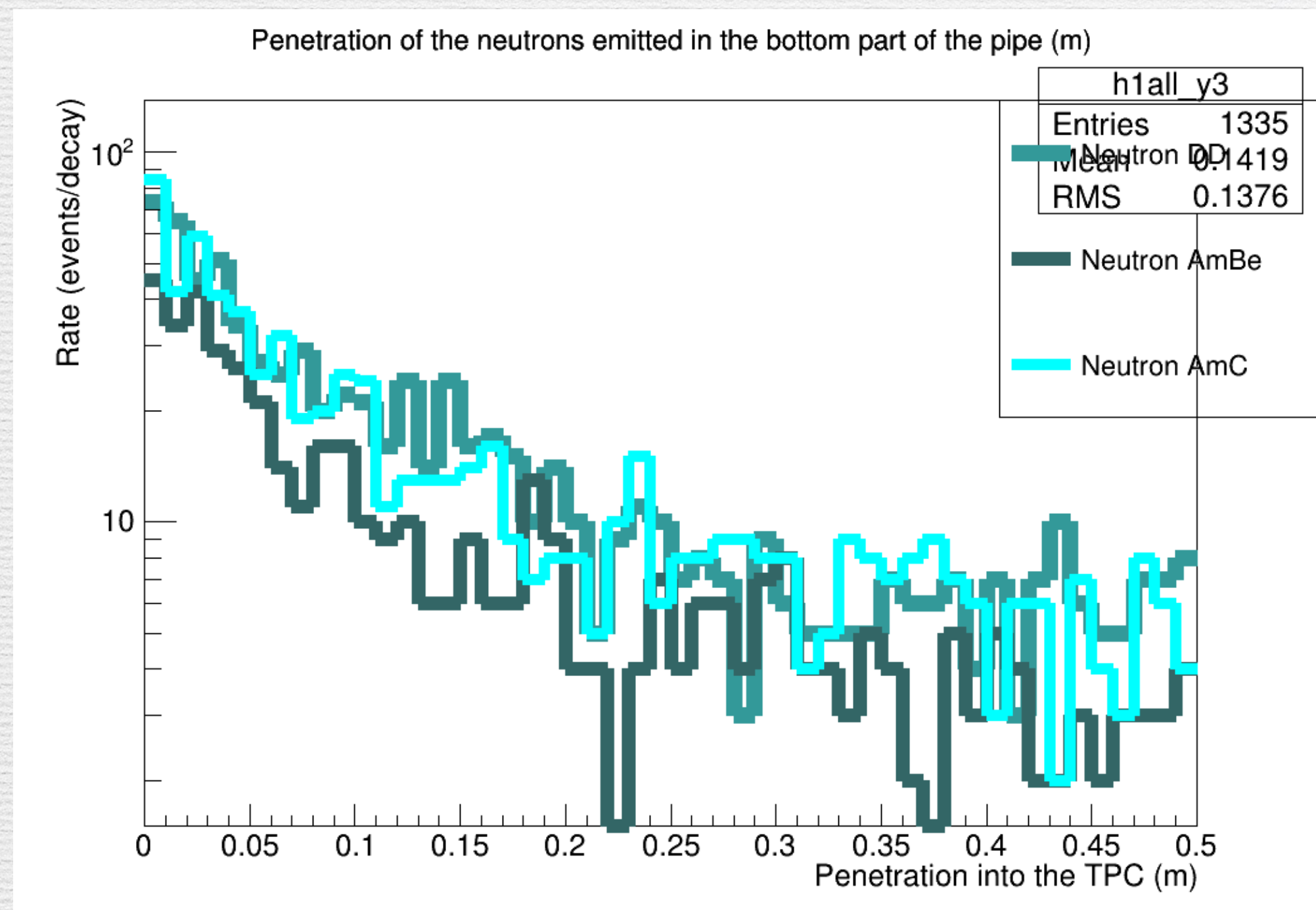


NeutronAmC



20

# Plots neutrons penetration



# Plots penetration

- Photons : pénètrent environ 2.5 cm
  - Neutrons : pénètrent environ 7.5 cm
- Les neutrons sont beaucoup moins impactés par le matériel séparant la TPC du tuyau guide
  - Photons : être sur le côté ou sous la TPC (i.e. traverser peu ou beaucoup de matière) ne modifie pas la pénétration mais modifie le taux d'événements à l'inverse des neutrons où le taux est quasiment inchangé

# Analyse temporelle

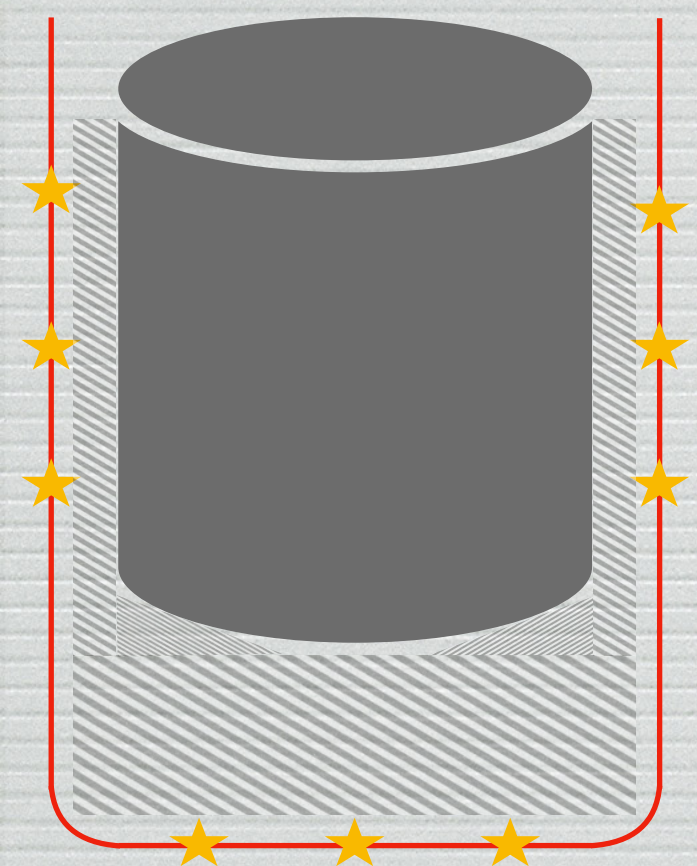
# Hypothèses

- Sur le côté de la TPC : tube à **3 cm** du mur
- Sous la TPC : tube à **1 cm**
- 6 positions sur le côté + 3 positions sous
- **100 Hz max** d'événements dans la TPC (max du système d'acquisition)
- On prend 10 000 événements dans la TPC (prise en compte du taux d'evt dans la TPC pour chaque source)
- Si source "**efficace**" -> sature à **100Hz** -> calcul du temps d'acquisition
- Si source "**pas efficace**" -> on suppose une source de **100 kBq** et on calcule le temps d'acquisition



# Analyse en temps

Energie augmente



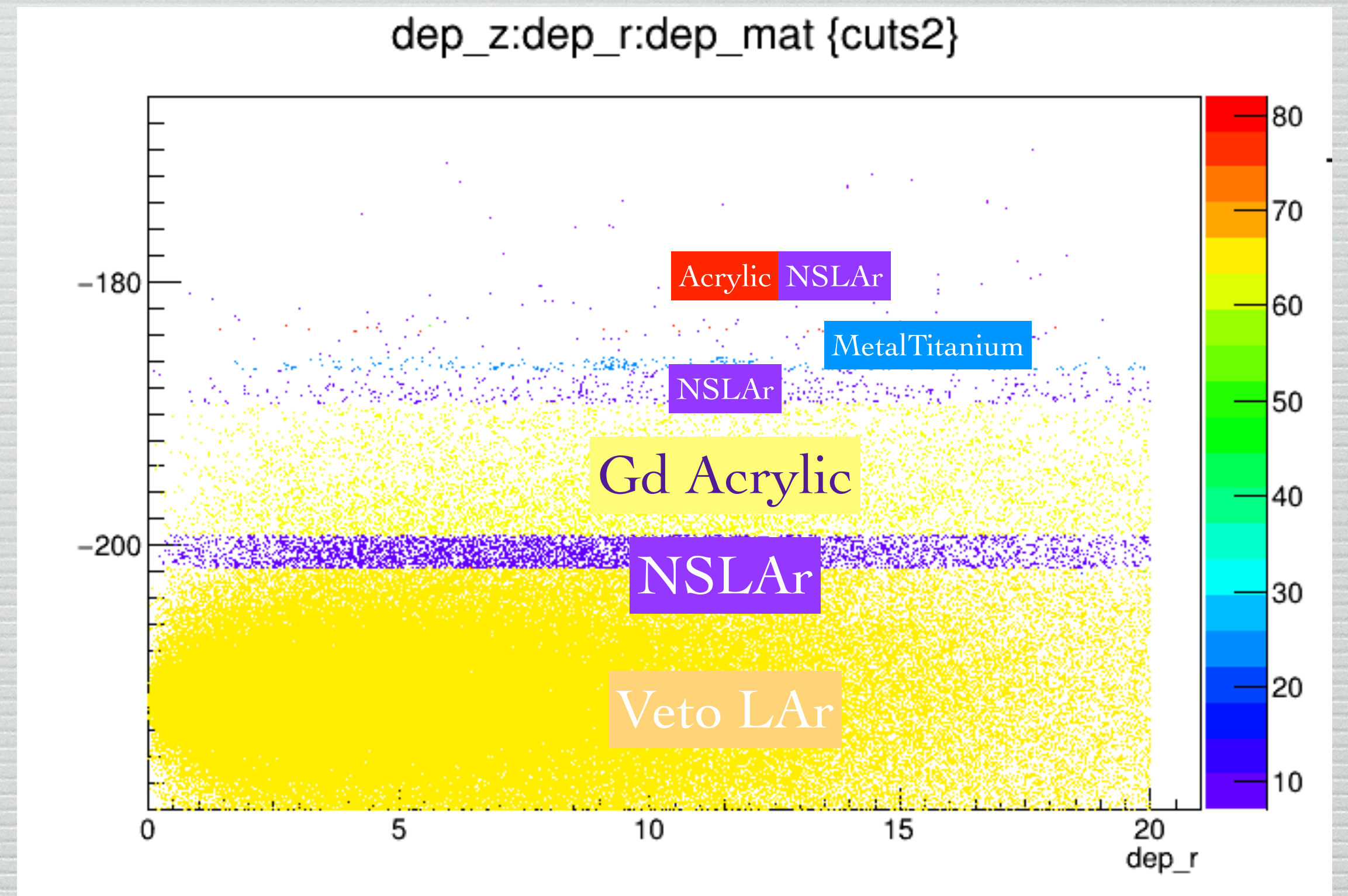
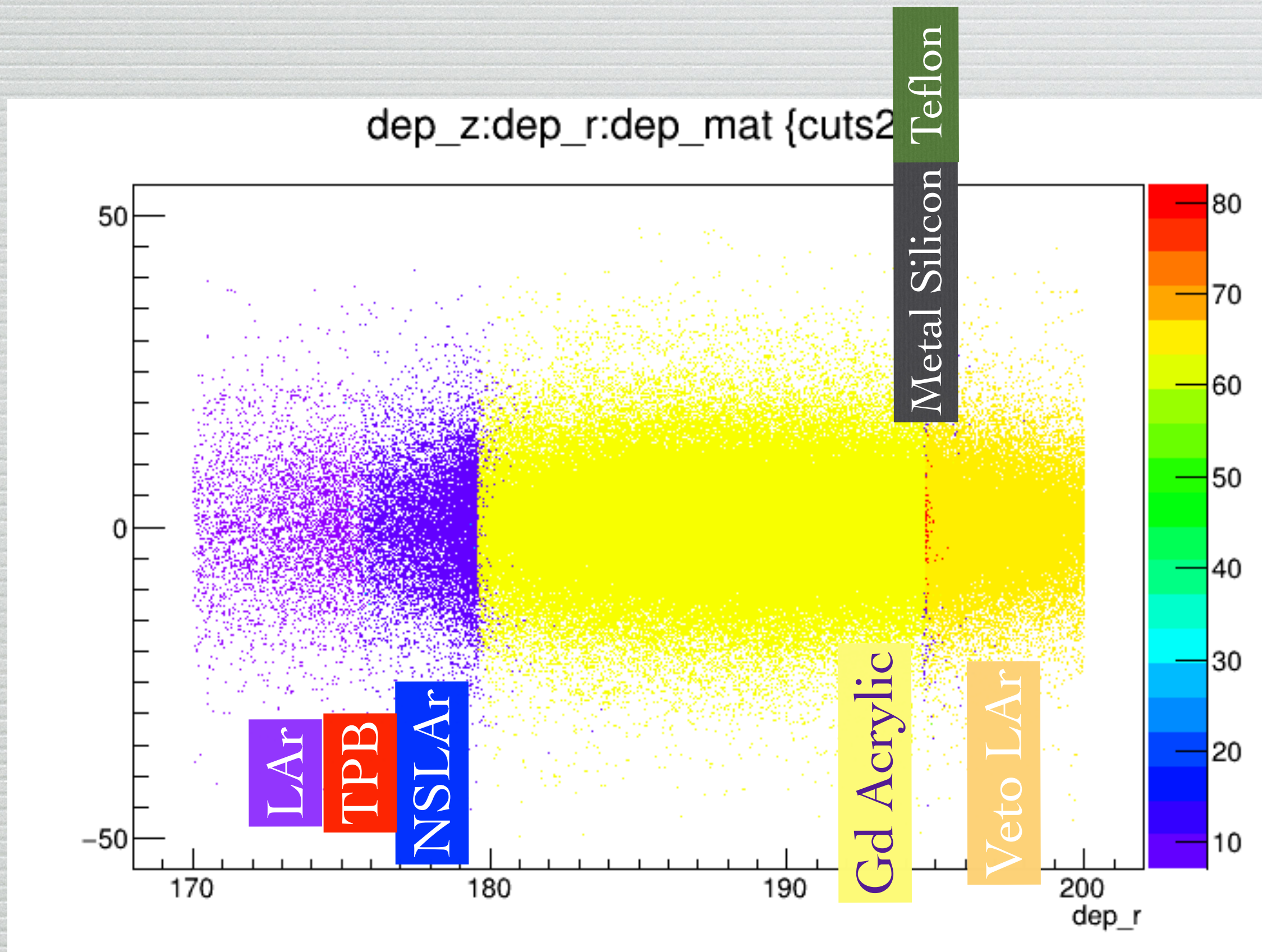
Sans  
trigger  
ONLINE

	$^{241}\text{Am}$	$^{57}\text{Co}$	$^{133}\text{Ba}$	$^{22}\text{Na}$	$^{137}\text{Cs}$	$^{60}\text{Co}$	Neutron gun	AmBe	AmC
Temps (h)	3,5	9,6	126,2	158,3	249,7	669,8	6,1	9,9	7,5

Avec  
trigger  
ONLINE

	$^{241}\text{Am}$	$^{57}\text{Co}$	$^{133}\text{Ba}$	$^{22}\text{Na}$	$^{137}\text{Cs}$	$^{60}\text{Co}$	Neutron gun	AmBe	AmC
Temps (h)	3,4	7,8	7,7	4,5	10,9	6,3	3,9	3,9	3,9

# PLAN C



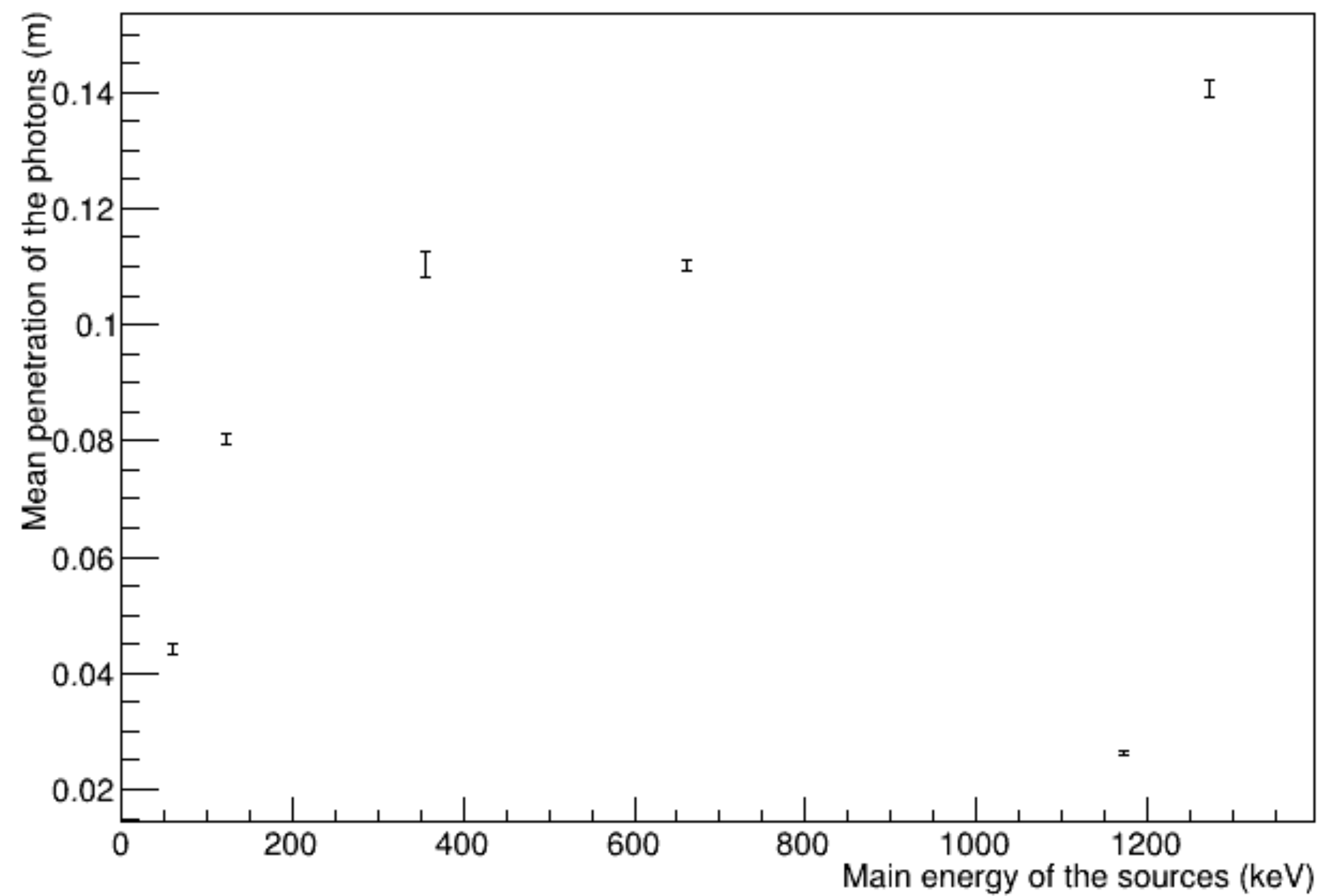
Back up

# Penetration vs energy

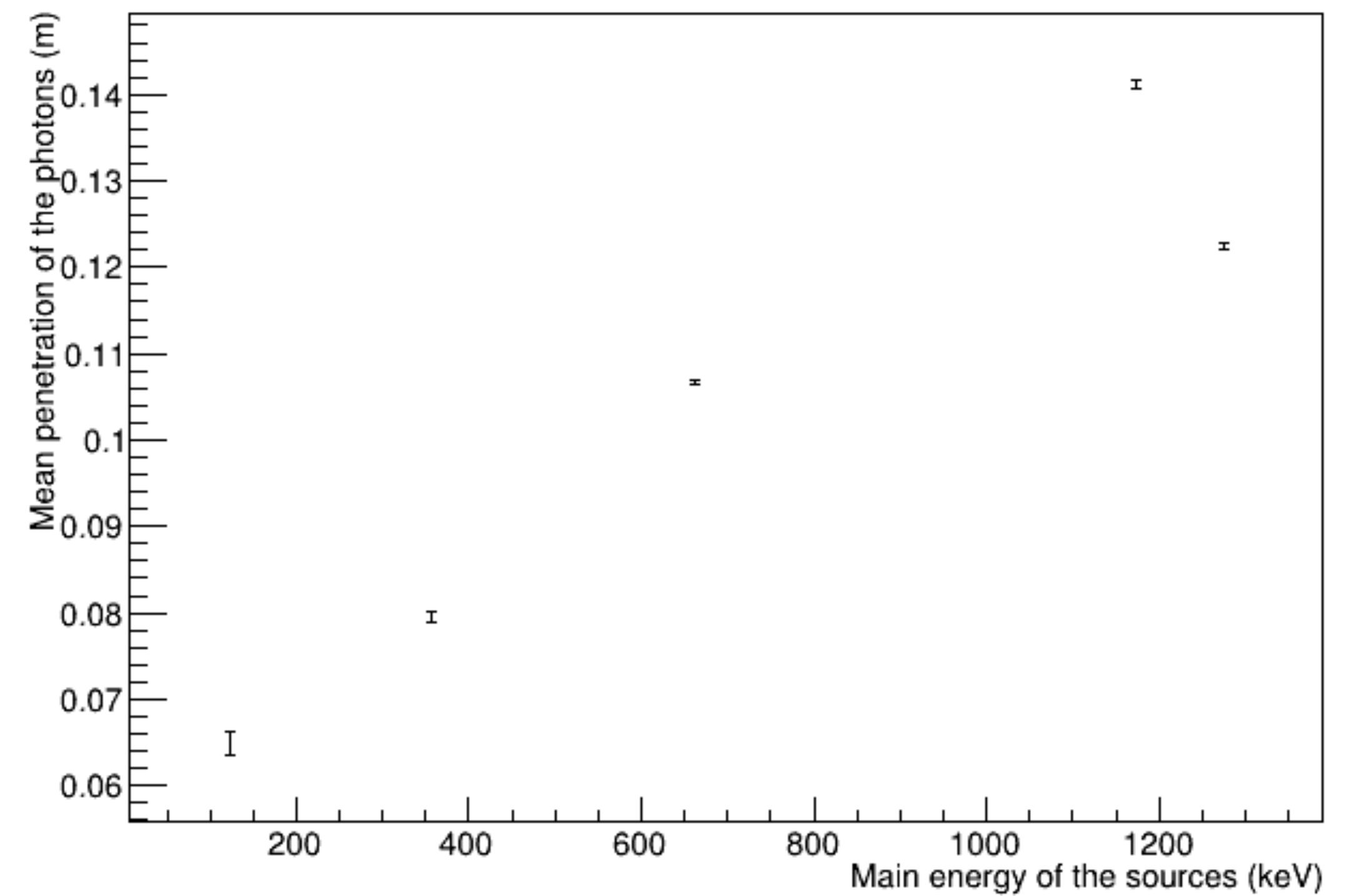
Côté : 3 cm

Sous : 1 cm

Mean penetration vs energy for all events



Mean penetration vs energy for all events

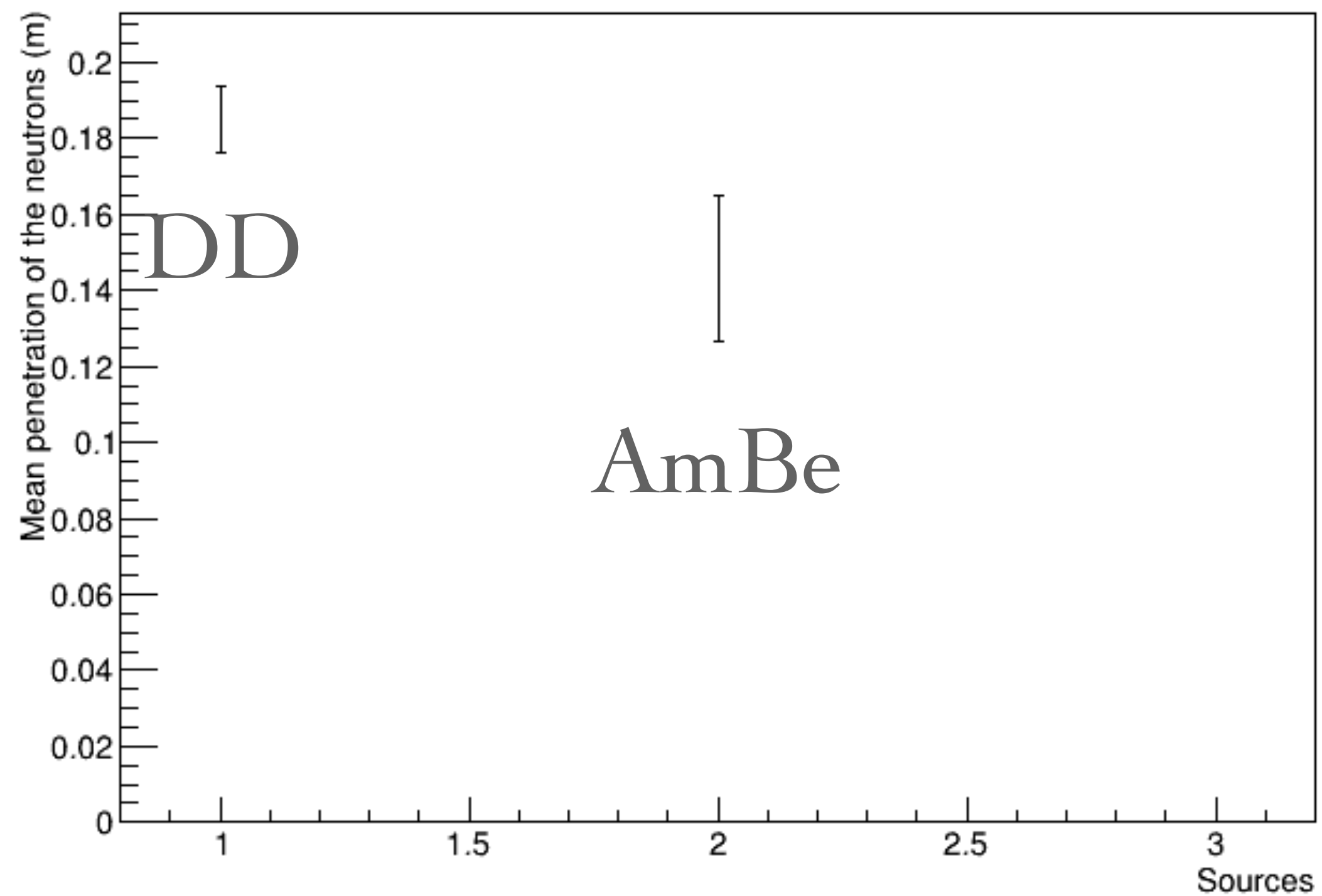


# Penetration vs energy Neutrons

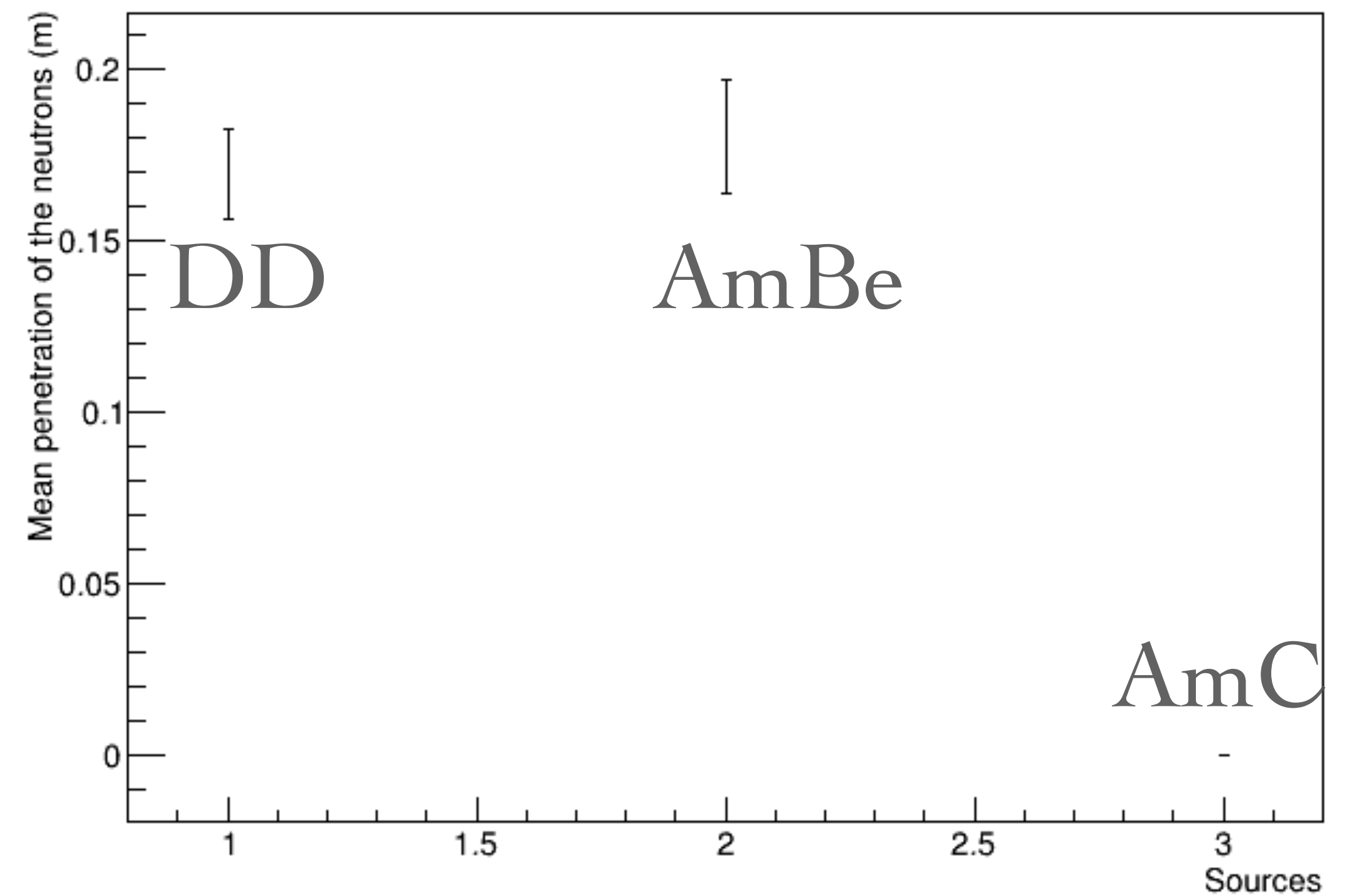
Côté : 3 cm

Sous : 1 cm

Mean penetration vs sources



Mean penetration vs sources

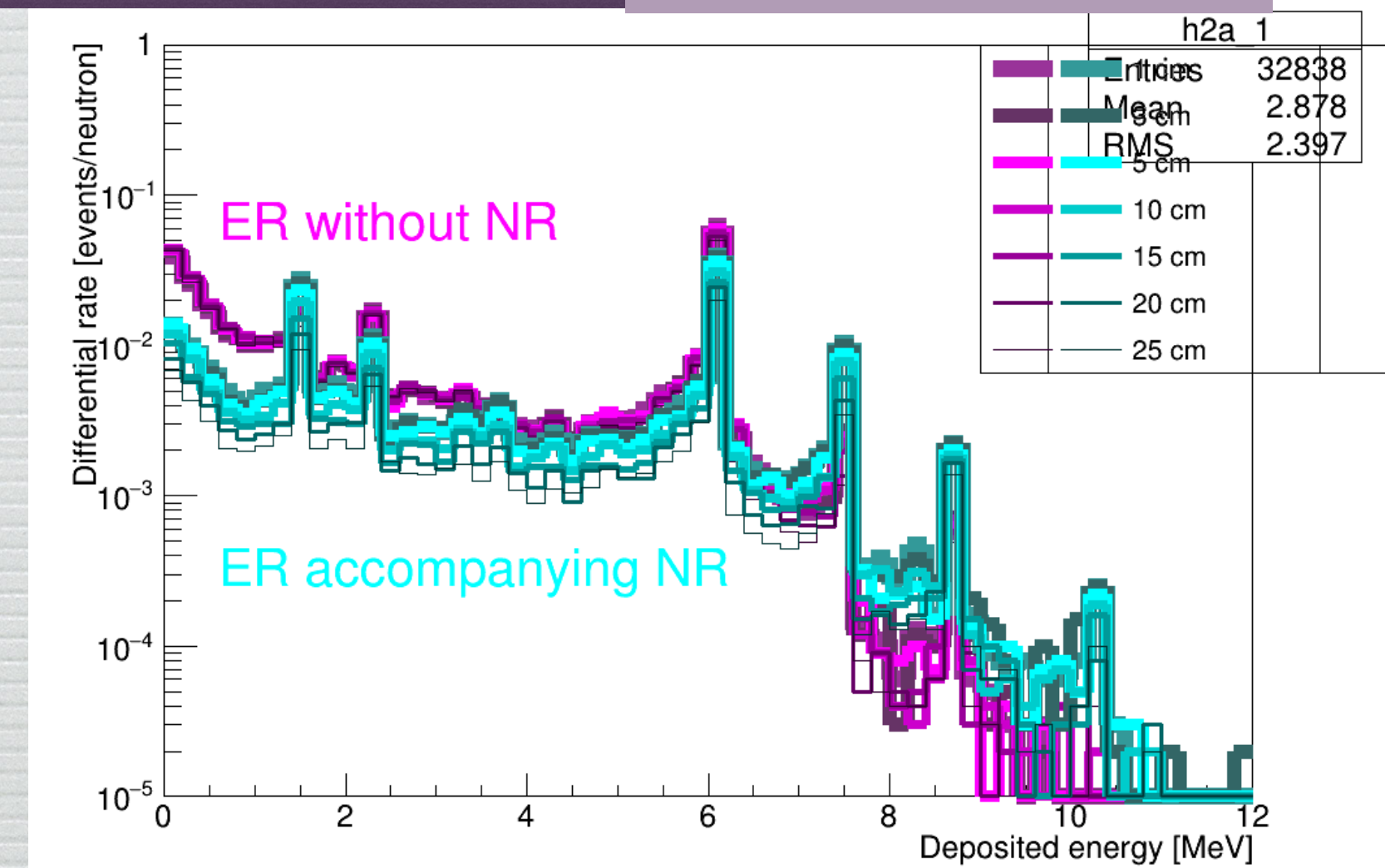
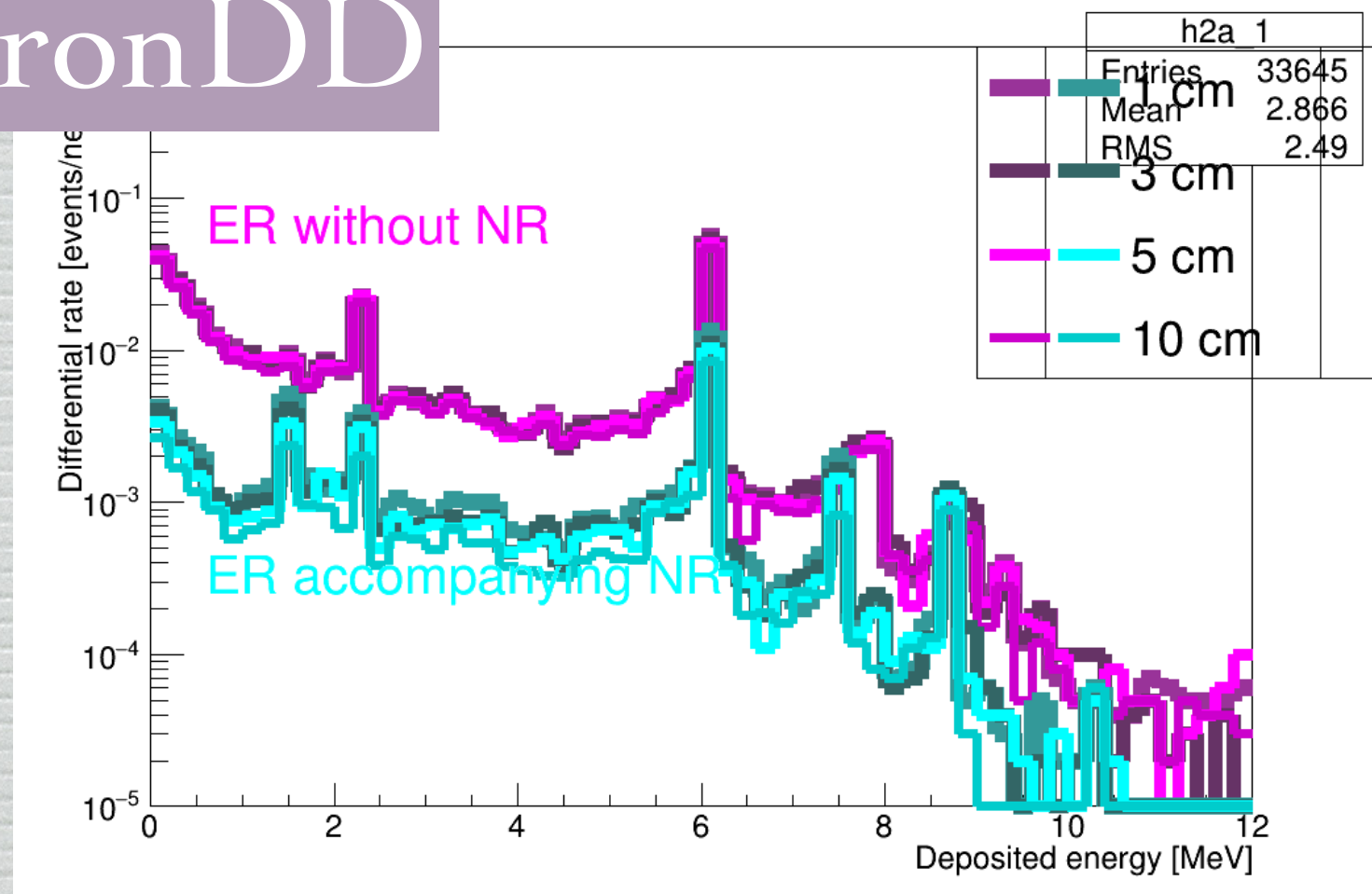


# Plots neutrons

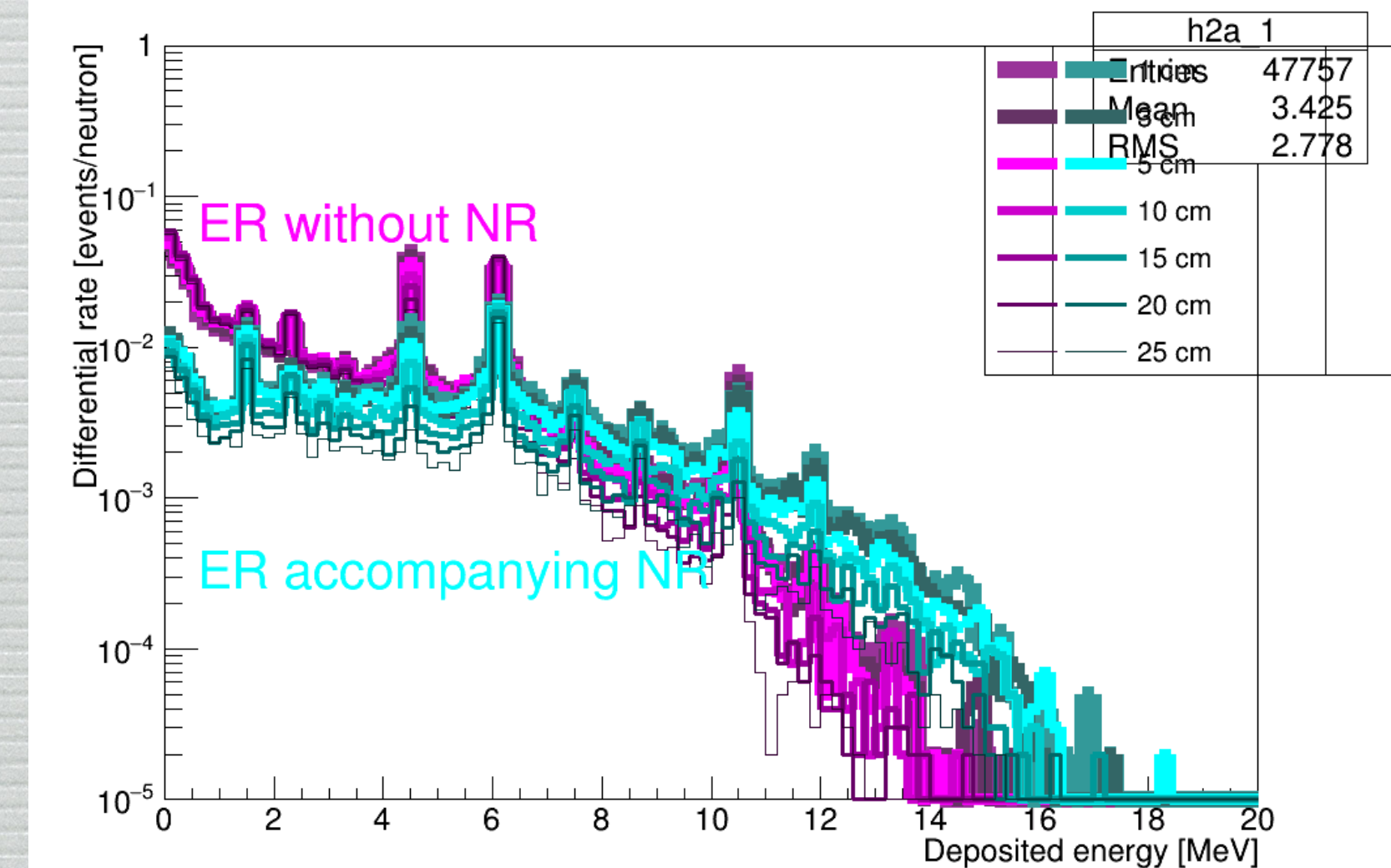
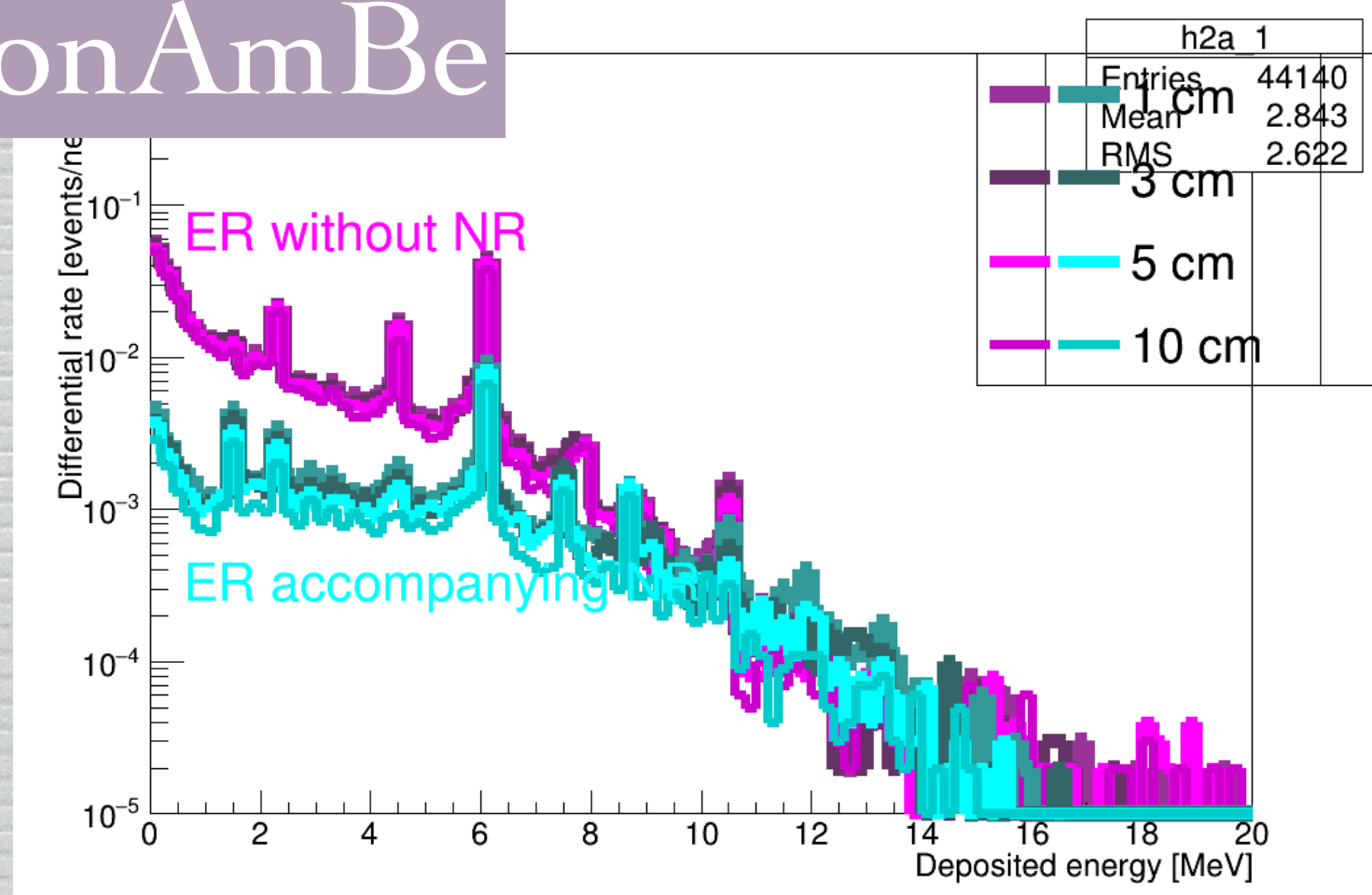
E\_ER - bottom

E\_ER - side

NeutronDD



NeutronAmBe



Si on a un trigger dédié aux SS dans le pic

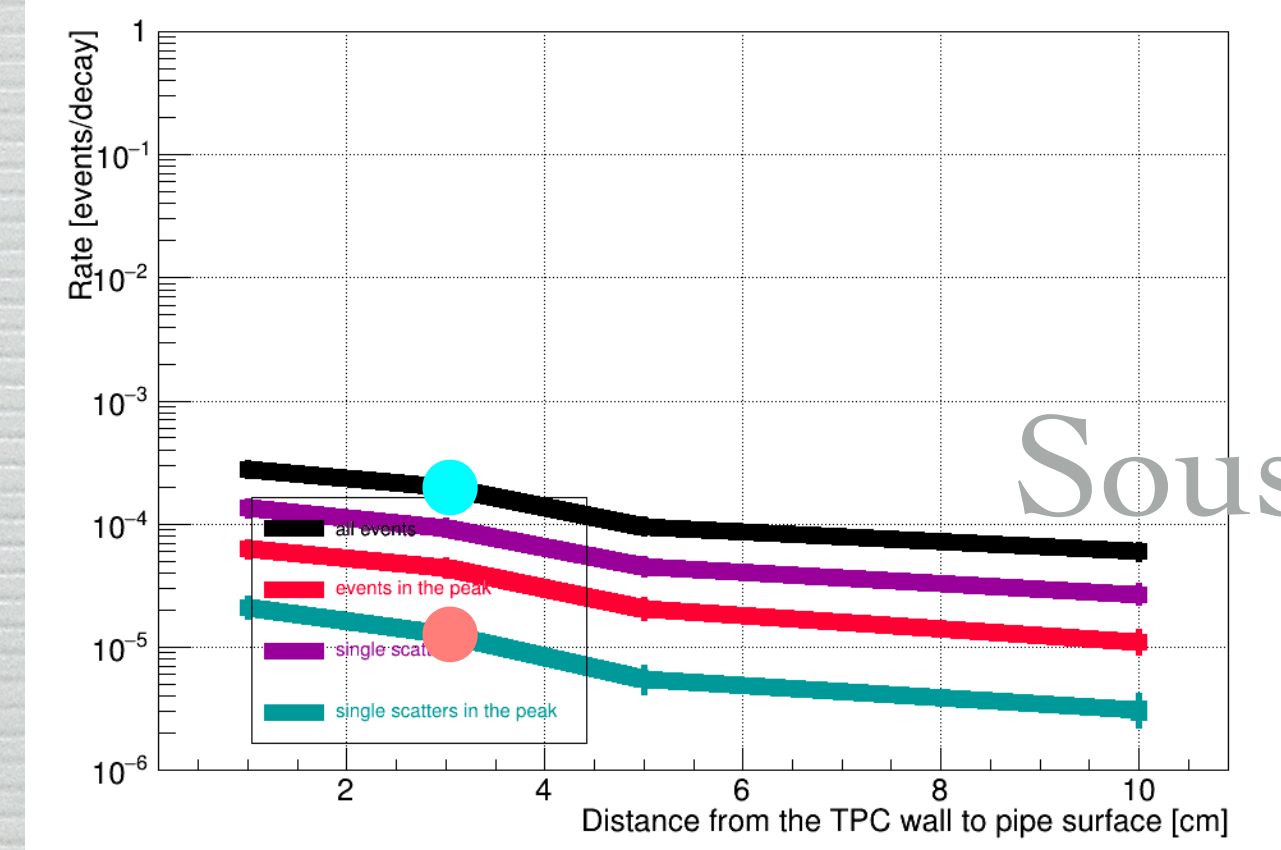
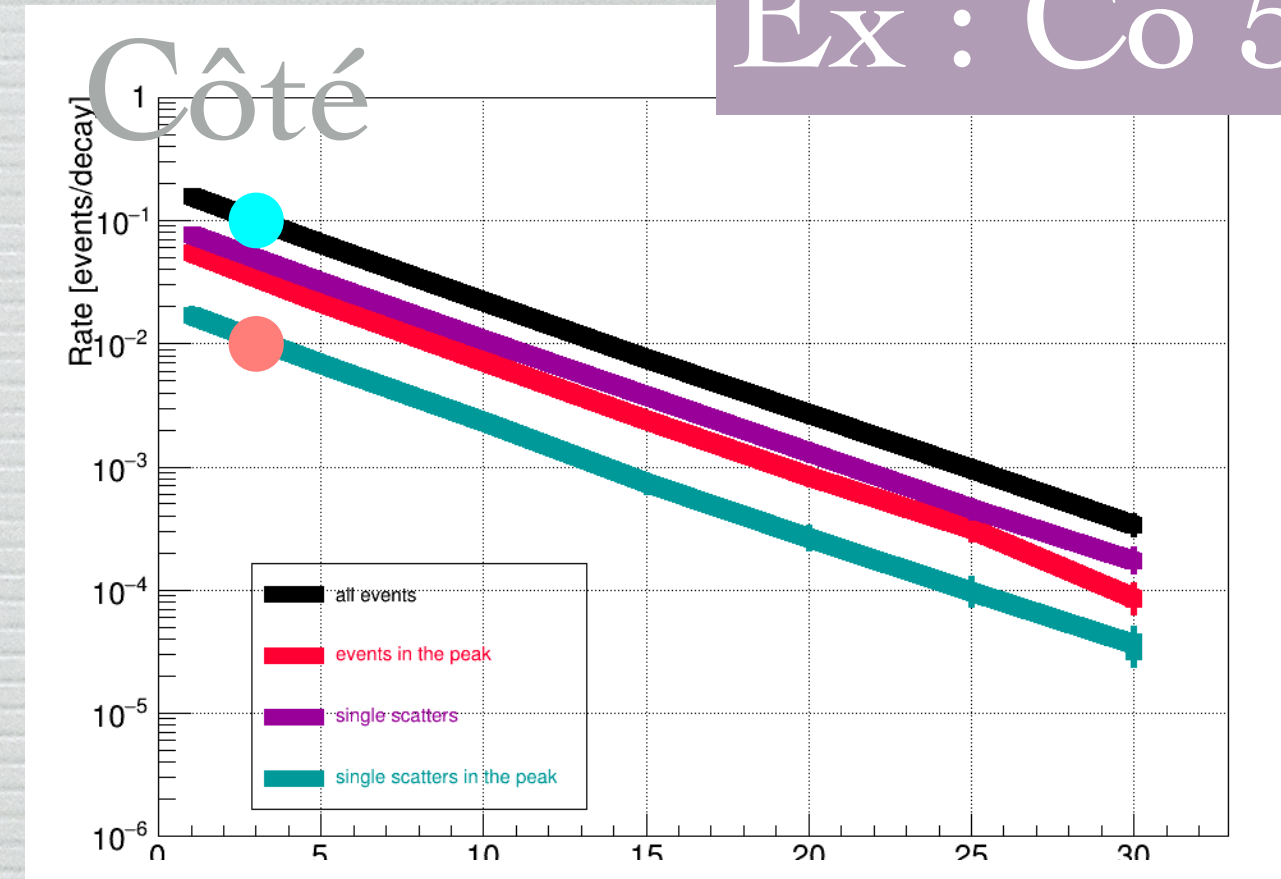
Si on n'a pas de trigger dédié aux SS dans le pic

# Analyse en temps

Photons

	Am241	Co57	Ba133	Cs137	Na22	Na22	Co60	Co60	Total
<b>C</b>	O	T	É				T	P	C
Energy (keV)	60	122	356	662	1274	511	1173	1332	
All everywhere (kBq)	76,22	0,99	0,36	0,66	0,14	0,23	0,16	0,193989	
Time(10 000 evt) (s)	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	
SS peak (kBq)	137,74	11,75	124,07	467,29	704,29	134,05	306,75	649,35	
Time(10 000 evt) (min)	2,30	1,67	2,07	7,79	11,74	2,23	5,11	10,82	
Time(10 000 evt) (h) * ratio	0,05	0,33	9,58	19,59	137,98	16,20	53,74	92,98	
<b>S</b>	O	U	S				T	P	C
All everywhere (kBq)		361,66	5,83	4,99	0,73	0,99	0,62	0,63	
Time(10 000 evt) (s)		361,66	100,00	100,00	100,00	100,00	100,00	100,00	
Time(10 000 evt) (min)		6,03	1,67	1,67	1,67	1,67	1,67	1,67	
SS peak (kBq)		4739,34	4545,45	7692,31	3846,15	680,27	2564,10	5555,55	
Time(10 000 evt) (h)		1,32	1,26	2,14	1,07	0,19	0,71	1,54	
Time(10 000 evt) (h) * ratio		1,32	21,66	42,85	146,23	19,13	114,56	244,44	
<b>T</b>	O	T	A	L			T	P	C
Total time calib per source (h)	3,40	7,78	7,66	10,86	8,05	4,46	6,31	9,38	
Total time all sources (h)									40,47
Time (h)	3,47	9,59	126,15	249,73	1270,24	158,29	669,78	1294,87	
Total Time all sources (h)									1217,01
Total Time all sources (day)									50,71

Ex : Co 57



$$\text{Time} = 2 + 10 \cdot 10 / 60 + 6 \cdot 1,67 / 60 + 3 \cdot 1,32$$

$$\text{Time} = 2 + 10 \cdot 10 / 60 + 6 \cdot (100 \cdot 11,75 / 0,99 / 3600) + 3 \cdot (361,66 \cdot 4739,34 / 361,66 / 3600)$$

Si on a un trigger dédié aux SS dans le pic

Si on n'a pas de trigger dédié aux SS dans le pic

# Analyse en temps

Neutrons

	AmBe	DD		AmBe	DD	Total
	CO	TE		SO	US	
All events						
Activity (kBq)	0,124852	0,1559		0,184128	0,235067	
Time (min)	1,66666666666667	1,66666666666667		1,66666666666667	1,66666666666667	
Pure NR						
Activity (kBq)	2,79799	1,05552		5,47645	3,77786	
Time per position (min)	1,66666666666667	1,66666666666667		1,66666666666667	1,66666666666667	
Total time per source (h)	3,91666666666667	3,91666666666667				
Total time (h)						7,83333333333334
Time (h) x ratio per position	0,622512610486373	0,188069275176396		0,82618401932955	0,446428276004525	
Temps (min) x ratio per position	37,3507566291824	11,2841565105837		49,571041159773	26,7856965602715	
Time per source (h)	9,88029438757355	6,13436714573862				
Total time (h)						16,0146615333122

$$\text{Time} = 2 + 10 \cdot 10 / 60 + 6 \cdot 1,67 / 60 + 3 \cdot 1,32$$

$$\text{Time} = 2 + 10 \cdot 10 / 60 + 6 \cdot (100 \cdot 11,75 / 0,99 / 3600) + 3 \cdot (361,66 \cdot 4739,34 / 361,66 / 3600)$$



Si on a un trigger dédié aux SS dans le pic

Si on n'a pas de trigger dédié aux SS dans le pic

# Analyse en temps

	Am241	Co57	Ba133	Cs137	Na22	Co60	
<b>C</b>	O	T	É	T	P	C	
Energy (keV)		60	122	356	662	1274	1332
All everywhere (kBq)		76,22	0,99	0,36	0,66	0,14	0,16
Time(10 000 evt) (s)		100,00	100,00	100,00	100,00	100,00	100,00
All peak (kBq)		112,36	3,66	3,25	3,44	1,94	1,47
Time(10 000 evt) (s)		112,36	100,00	100,00	100,00	100,00	100,00
Time(10 000 evt) (min)		1,87	1,67	1,67	1,67	1,67	1,67
SS everywhere (kBq)		88,34	2,01	1,37	3,53	1,19	1,42
Time(10 000 evt) (s)		100,00	100,00	100,00	100,00	100,00	100,00
SS peak (kBq)		137,74	11,75	124,07	467,29	7 142,89	306,75
Time(10 000 evt) (s)		137,74	100,00	124,07	467,29	7 142,89	306,75
Time(10 000 evt) (min)		2,30	1,67	2,07	7,79	119,05	5,11
Time(10 000 evt) (min) * rapport		3,01	19,73	574,97	1 175,17	83 963,82	3 224,41
Time(10 000 evt) (h) * rapport		0,05	0,33	9,58	19,59	1 399,40	53,74
<b>S</b>	O	U	S	T	P	C	
All everywhere (kBq)			361,66	5,83	4,99	0,73	0,62
Time(10 000 evt) (s)			361,66	100,00	100,00	100,00	100,00
Time(10 000 evt) (min)			6,03	1,67	1,67	1,67	1,67
All peak (kBq)			1 602,56	102,88	60,61	10,25	9,37
Time(100 000 evt) (s)			1 602,56	102,88	100,00	100,00	100,00
SS everywhere (kBq)			743,49	21,59	24,31	4,02	4,11
Time(10 000 evt) (s)			743,49	100,00	100,00	100,00	100,00
Time(10 000 evt) (h)			0,21	0,03	0,03	0,03	0,03
SS peak (kBq)			4 739,34	4 545,45	7 692,31	3 841,50	2 564,10
Time(10 000 evt) (s)			4 739,34	4 545,45	7 692,31	3 841,50	2 564,10
Time(10 000 evt) (h)			1,32	1,26	2,14	1,07	0,71
Time(10 000 evt) (min) * rapport			78,99	1 299,77	2 570,86	8 763,17	6 873,54
Time(10 000 evt) (h) * rapport			1,32	21,66	42,85	146,05	114,56
<b>T</b>	O	T	A	L	TP	C	
Total time calib per source (h)		3,40	7,78	7,66	10,86	18,77	6,31
Total time all sources (h)		54,78					
Time (h)		3,47	9,59	126,15	249,73	8 838,21	669,78
Time (day) = time (h) /24		0,14	0,40	5,26	10,41	368,26	27,91

	AmBe	DD	AmBe	DD
	CO	TE	SO	US
All events				
Activité (kBq)	0,124852	0,1559	0,184128	0,235067
Temps (s)	100	100	100	100
Temps (min)	1,66666666666667	1,66666666666667	1,66666666666667	1,66666666666667
Pure NR				
Activité (kBq)	2,79799	1,05552	5,47645	3,77786
Temps (s)	100	100	100	100
temps (min)	1,66666666666667	1,66666666666667	1,66666666666667	1,66666666666667
Temps (min) x rapport	37,3507566291824	11,2841565105837	49,571041159773	26,7856965602715
NR SS				
Activité (kBq)	12,4844	5,227	28,653	18,484
Temps (s)	100	100	100	100
Temps (min)	1,66666666666667	1,66666666666667	1,66666666666667	1,66666666666667
NR SS FV				
Activité (kBq)	200	79,365	714,286	625
Temps (s)	200	100	714,286	625
temps (min)	3,33333333333333	1,66666666666667	11,9047666666667	10,4166666666667
NR SS FV E				
Activité (kBq)	769,231	285,714	10000	10000
Temps (s)	769,231	285,714	10000	10000
Temps (min)	12,8205166666667	4,7619	166,666666666667	166,666666666667
Tot temps par source (h)	4,59523833333333	4,35416666666667		
Temps tot	8,949405			
Temps (s)	22369,0597952647	8883,721724659		
Temps (h)	6,21362772090686	2,46770047907194		
Temps tot (h)	9,88029438757353	6,13436714573861		