

Optical simulations of the DarkSide-20k Outer Veto

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The comparison of configurations

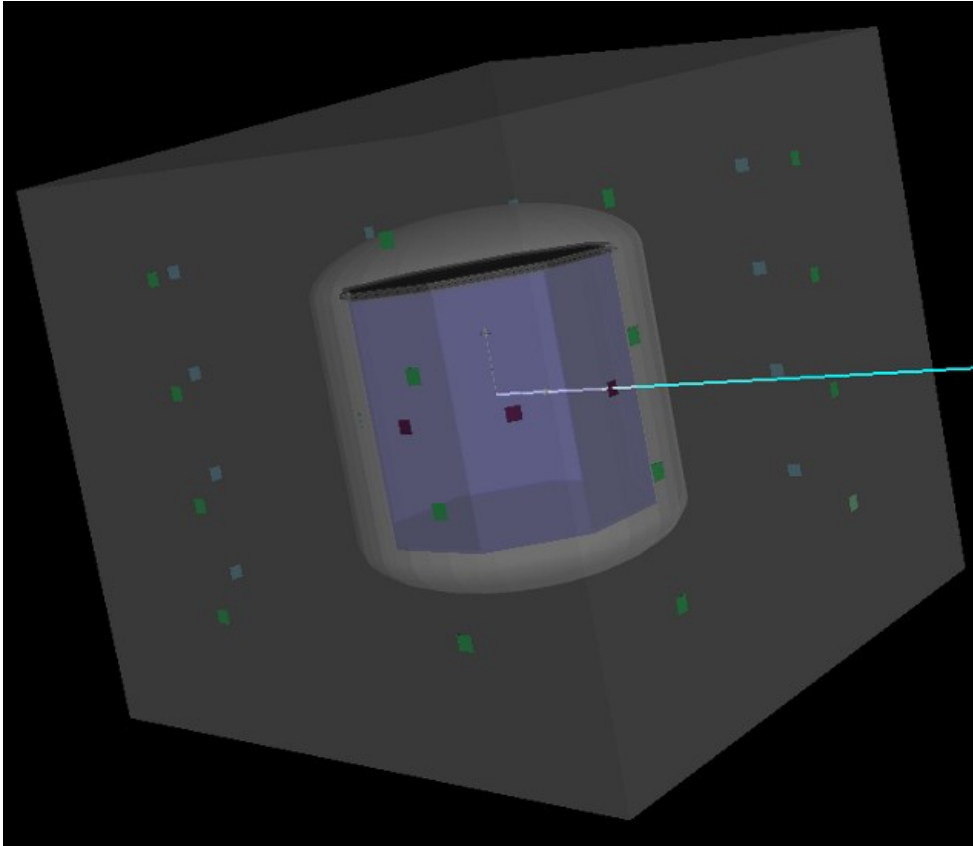


Figure.1. The old configuration of the flanges in Outer Veto

Compounds:

Cryostat reflector - Lumirror
PDUs cover - TPB

Old configuration

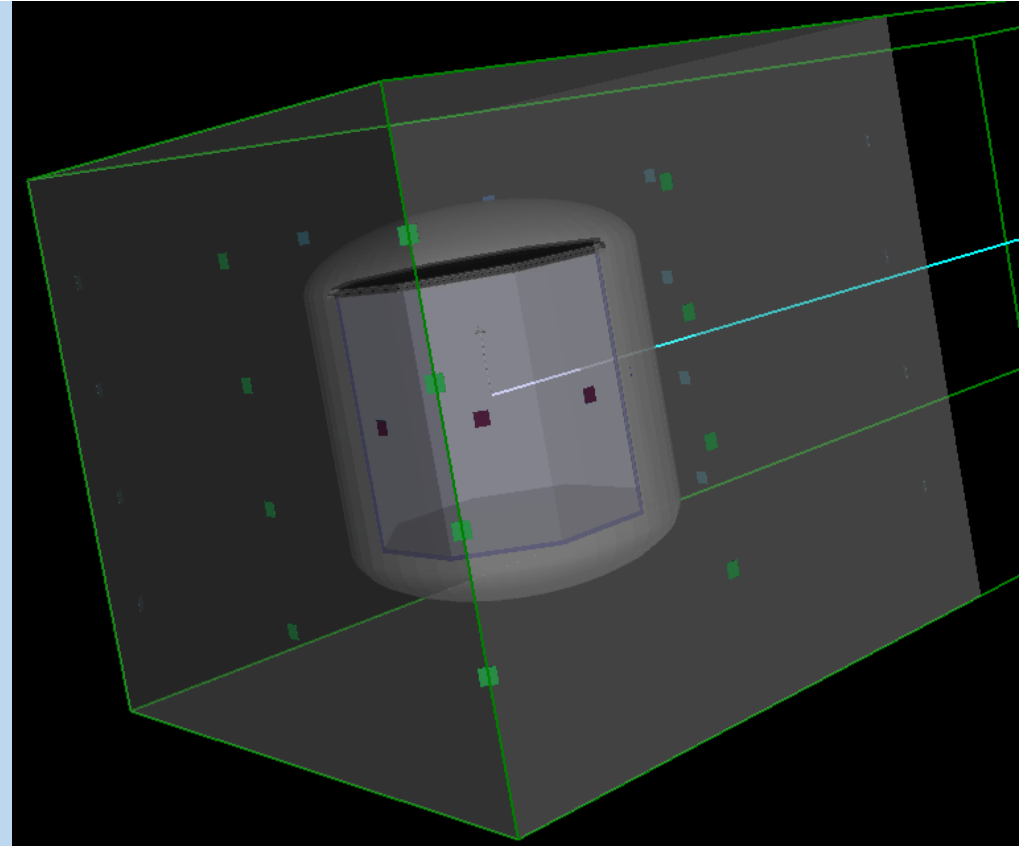
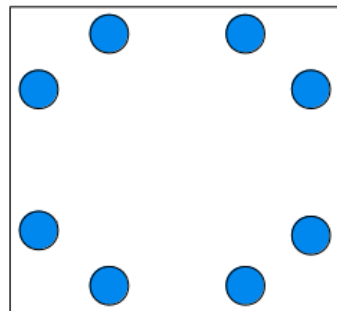
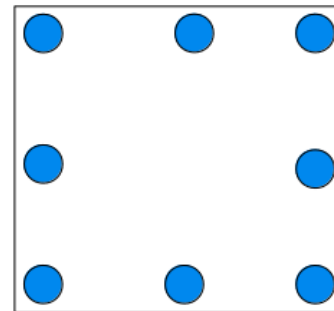


Figure.2. The new configuration of the flanges in Outer Veto

Compounds:

Cryostat reflector - Tyvek
PDUs cover - PEN

New configuration



The comparison of configurations

Simulation's parameters:

Cosmic muon, veto yield 0.02, events 1000

nPDUs	old configuration		new configuration	
	Mean LY, $\frac{p.e.}{MeV}$	RMS	Mean LY, $\frac{p.e.}{MeV}$	RMS
32	16.18	9.61	6.01	3.59
28	13.43	8.03	5.25	4.27
24	13.10	8.27	4.77	4.12
20	10.36	7.62	3.94	3.63
16	8.25	6.24	3.42	3.36
12	5.83	4.84	2.33	3.18
8	4.06	4.44	1.63	2.91
4	2.11	3.48	0.67	0.71

$$LY = \frac{N_{pe}/scale\ factor}{E_{dep}} \quad (1)$$

LY – light yield

N_{pe} – the number of photoelectrons obtained

$scale\ factor$ – a parameter veto yield factor from the simulations

E_{dep} – energy deposited

Table.1. The values of the light yield obtained from the simulations.

The comparison of configurations

LY vs nPDUS Comparison of geometry

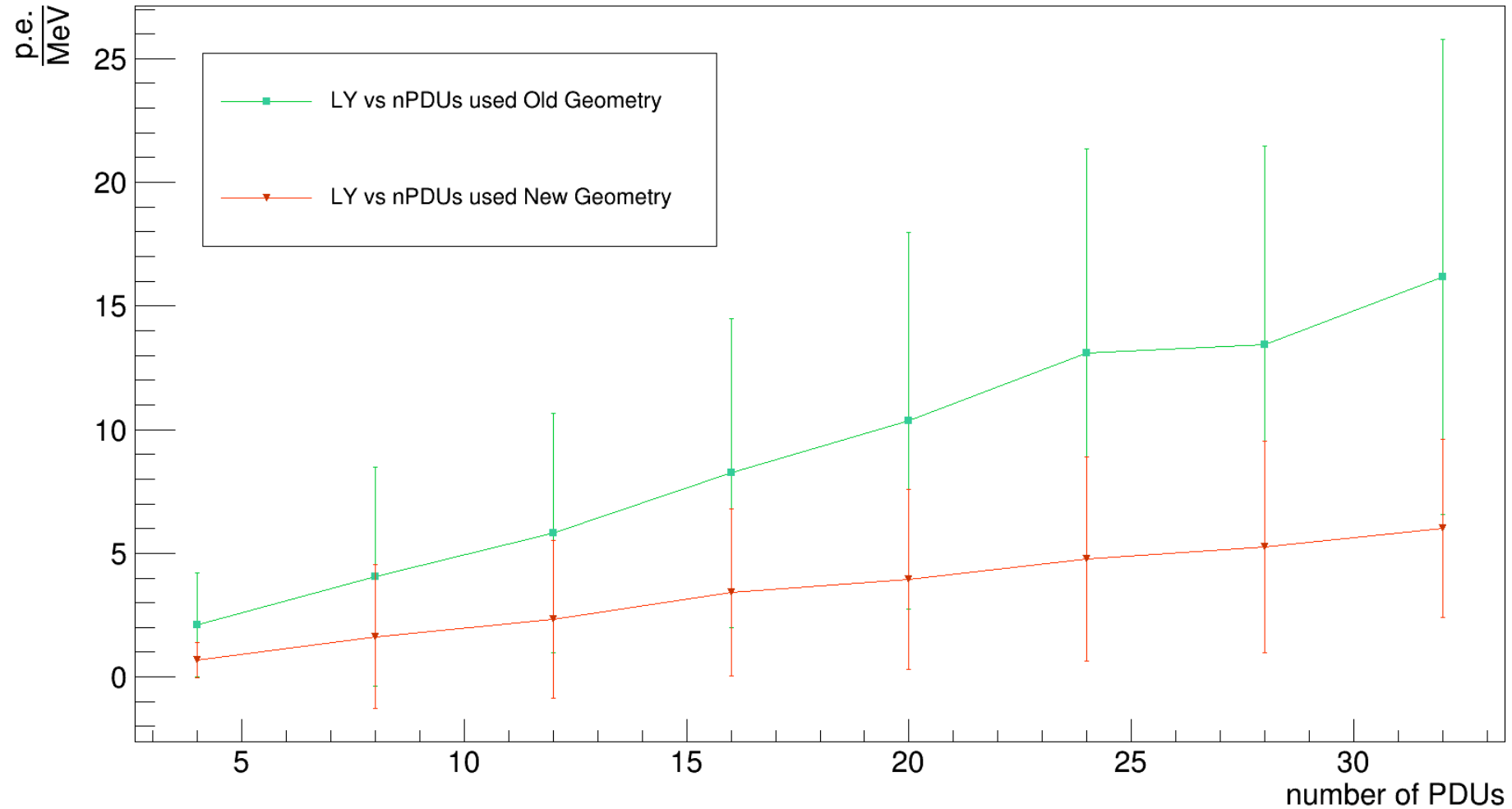
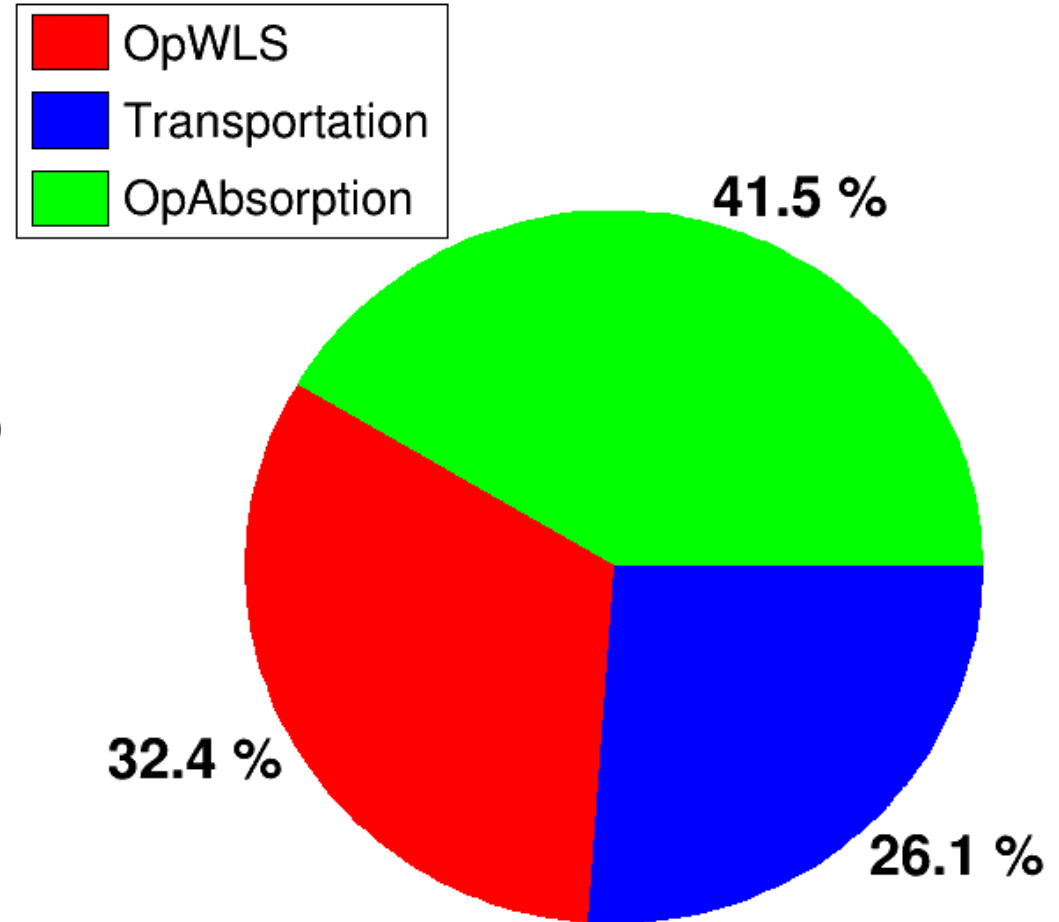


Figure.3. Comparison of light yield using different versions of geometry. The green graph is from simulations using old configuration. The orange graph is from simulations using new configuration.

The research of the process that destroy photons

Photon-killing processes



Simulation's parameters:

electrons with $E=100$ keV, veto yield 1.0, events 10
new configuration of Outer Veto

Figure.4. The pie chart of processes that destroy photons.

The dependence of the light yield on the absorption length

Simulation's parameters:

electrons with $E=100$ keV, veto yield 1.0, events 1000
the parameter LiquidArgonVisAbs = 1000 m
the values of the parameter LiquidArgonUVAbs were changed

The function for fitting:

$$y(x) = a + b \times \ln(x)$$

$$a = 4.9 \pm 3.5 \quad b = 2.4 \pm 0.9$$

$$\chi^2 = 0.53$$

LY vs value of LiquidArgonUVAbs

Abs Length , m	Mean LY, $\frac{p.e.}{MeV}$	RMS
1	3.50	4.37
5	9.14	5.80
10	11.95	5.85
50	16.56	6.61
100	17.83	7.11
500	18.65	6.80
1000	18.82	7.15

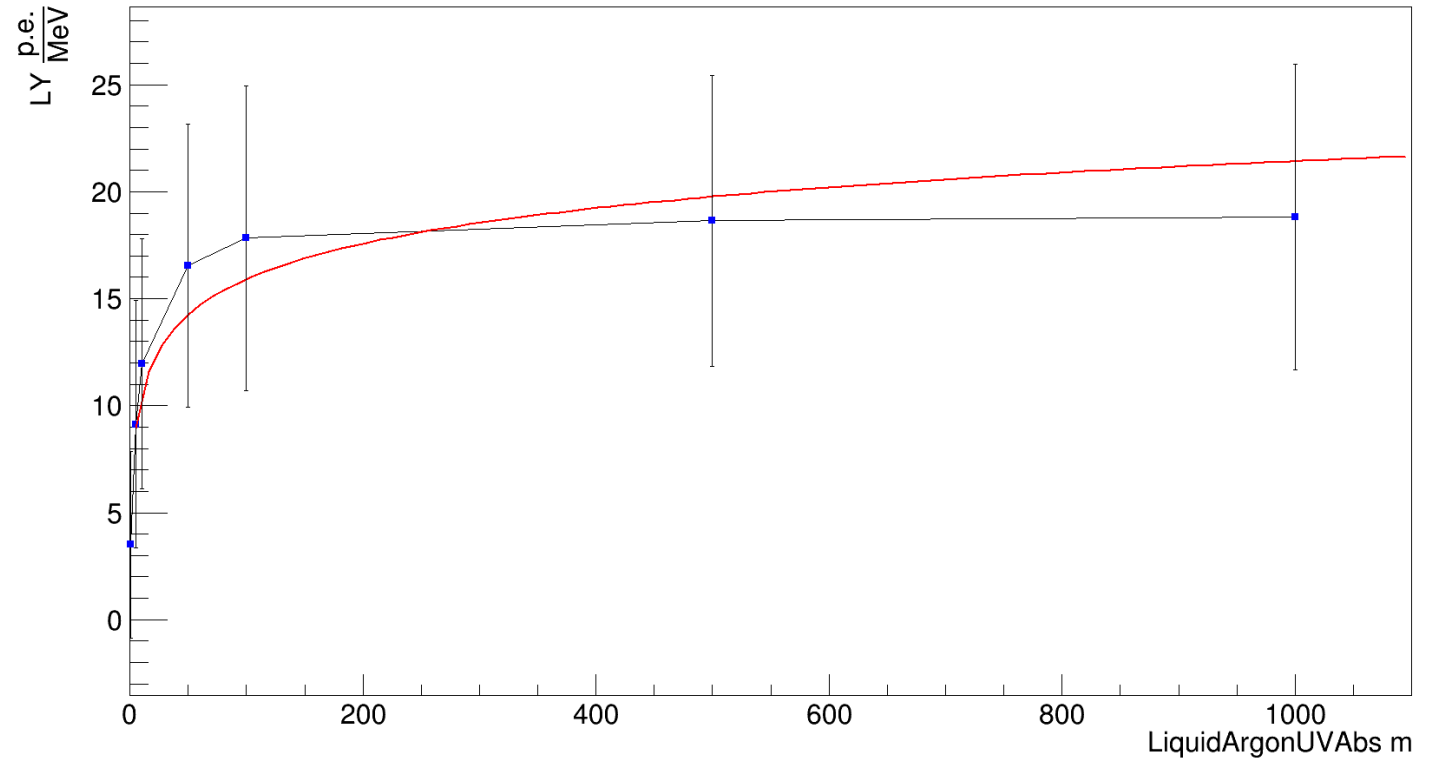


Table.2. The values of the light yield obtained from the simulations.

Figure.5. The dependence of the light yield on the absorption length

The dependence of the light yield on the absorption length

Simulation's parameters:

electrons with $E=100$ keV, veto yield 1.0, events 1000
 Parameters LiquidArgonUVAbs = LiquidArgonVisAbs
 have been changed

The function for fitting:

$$y(x) = a + b \times \ln(x)$$

$$a = 1.2 \pm 8.6 \quad b = 2.7 \pm 1.9$$

$$\chi^2 = 0.16$$

Abs Length , m	Mean LY, $\frac{p.e.}{MeV}$	RMS
10	6.79	5.25
100	15.86	6.13
1000	18.82	7.15

Table.3. The values of the light yield obtained from the simulations.

LY vs value of LiquidArgonUVAbs=LiquidArgonVisAbs

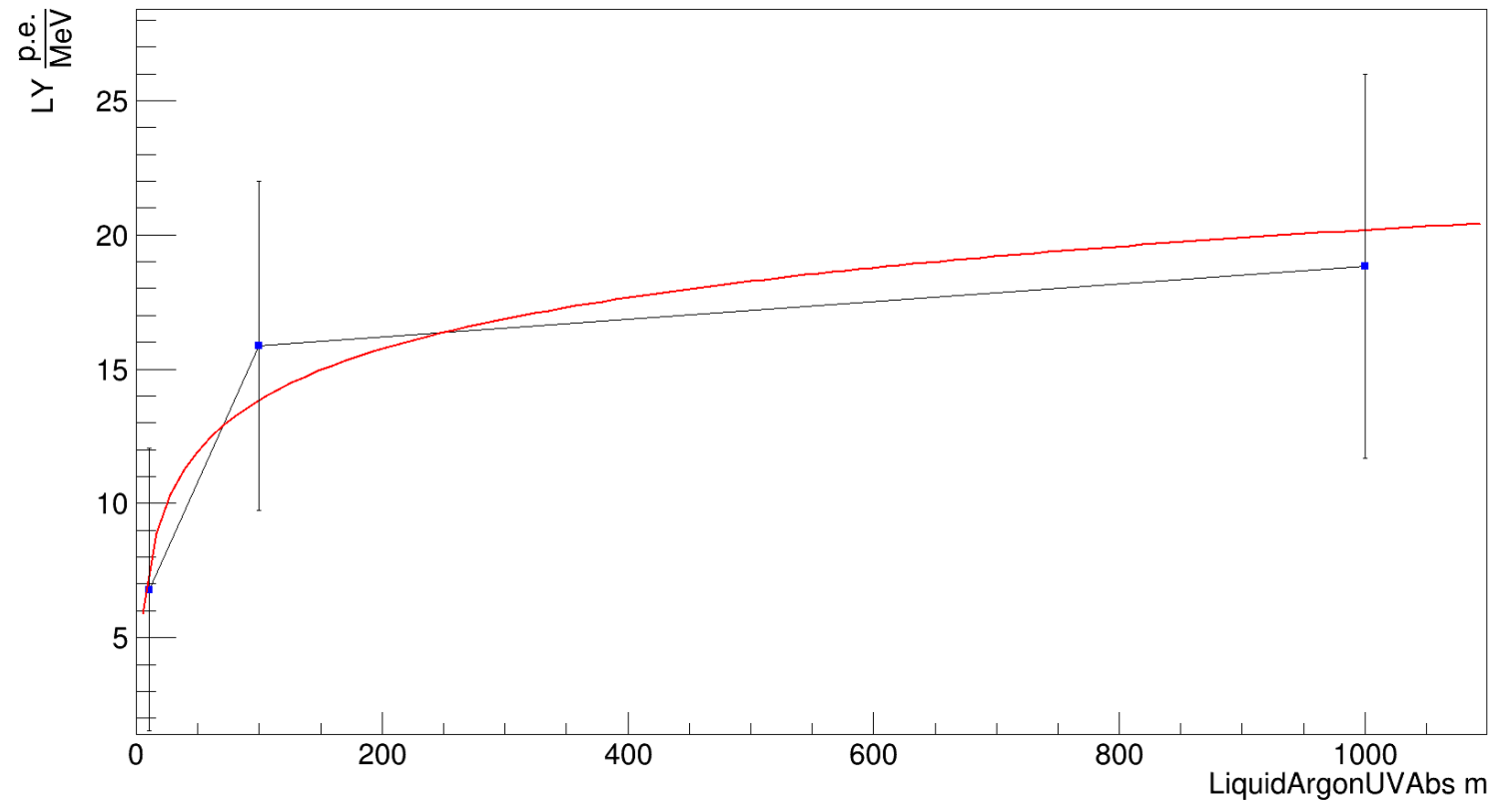


Figure.6. The dependence of the light yield on the absorption length

The simulations with more statistic

Simulation's parameters:
electrons with $E=10$ MeV,
veto yield 1.0, events 12419
Parameters of absorption:
LiquidArgonUVAbs = 50 m,
LiquidArgonVisAbs = 1000 m

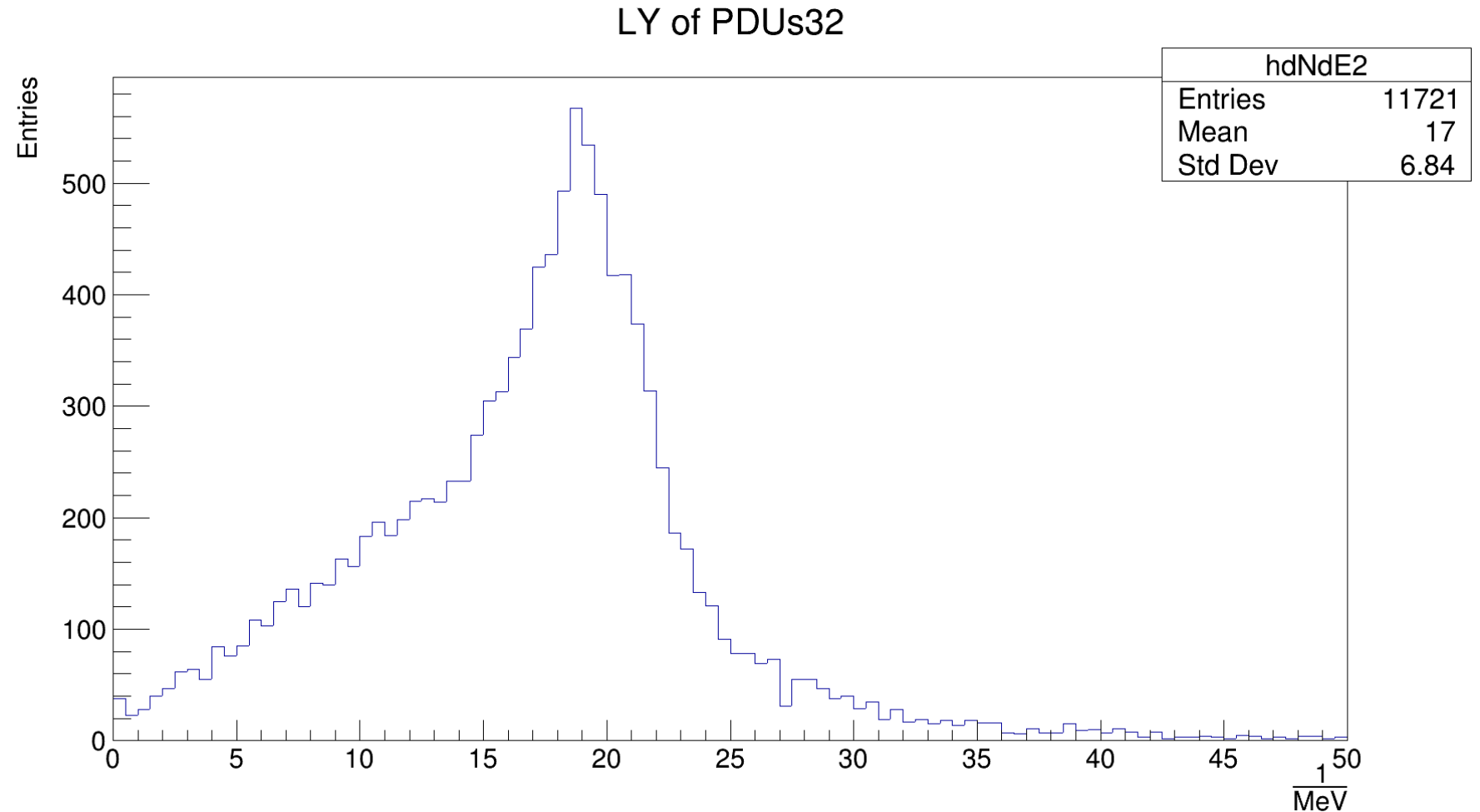
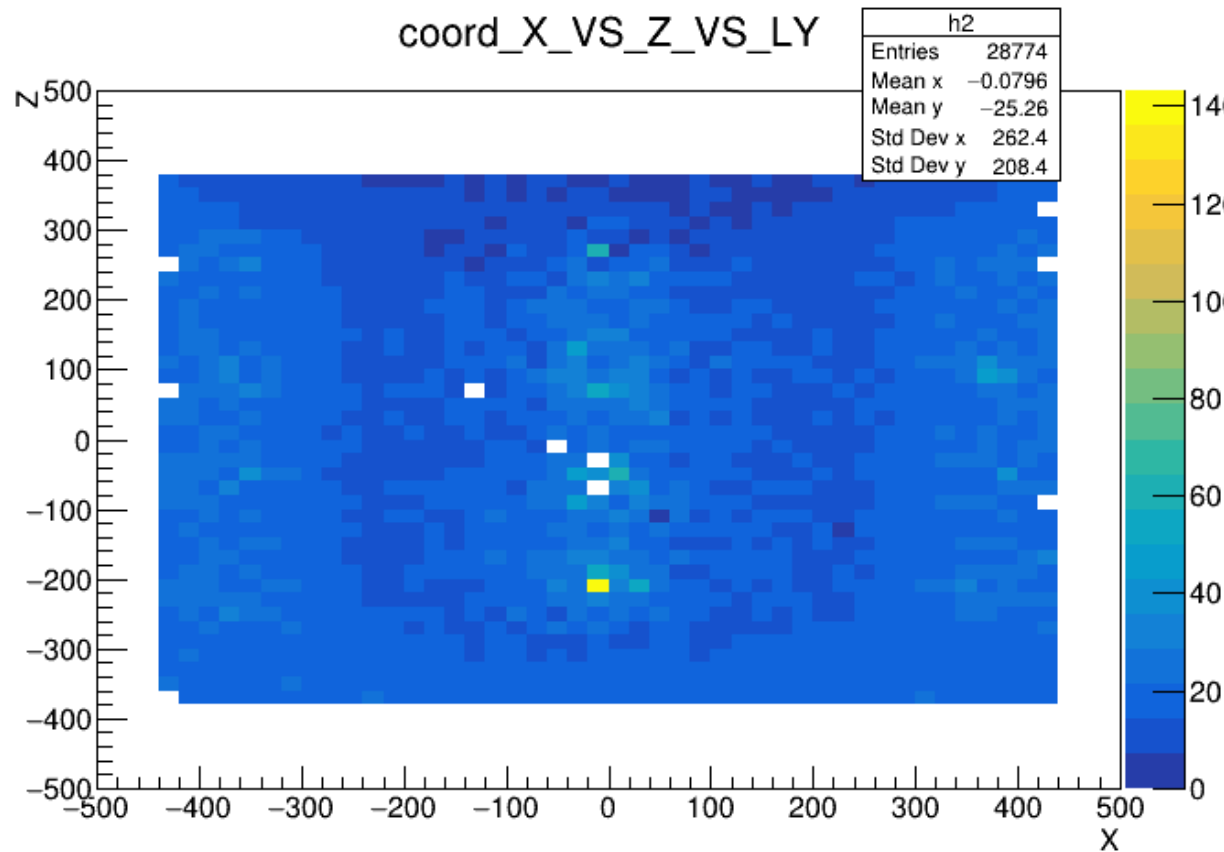


Figure.7. The resulting light yield

The distribution of light yield by coordinates

Figure.8. The distribution of light yield by coordinates X Z



coord_Y_VS_Z_VS_LY

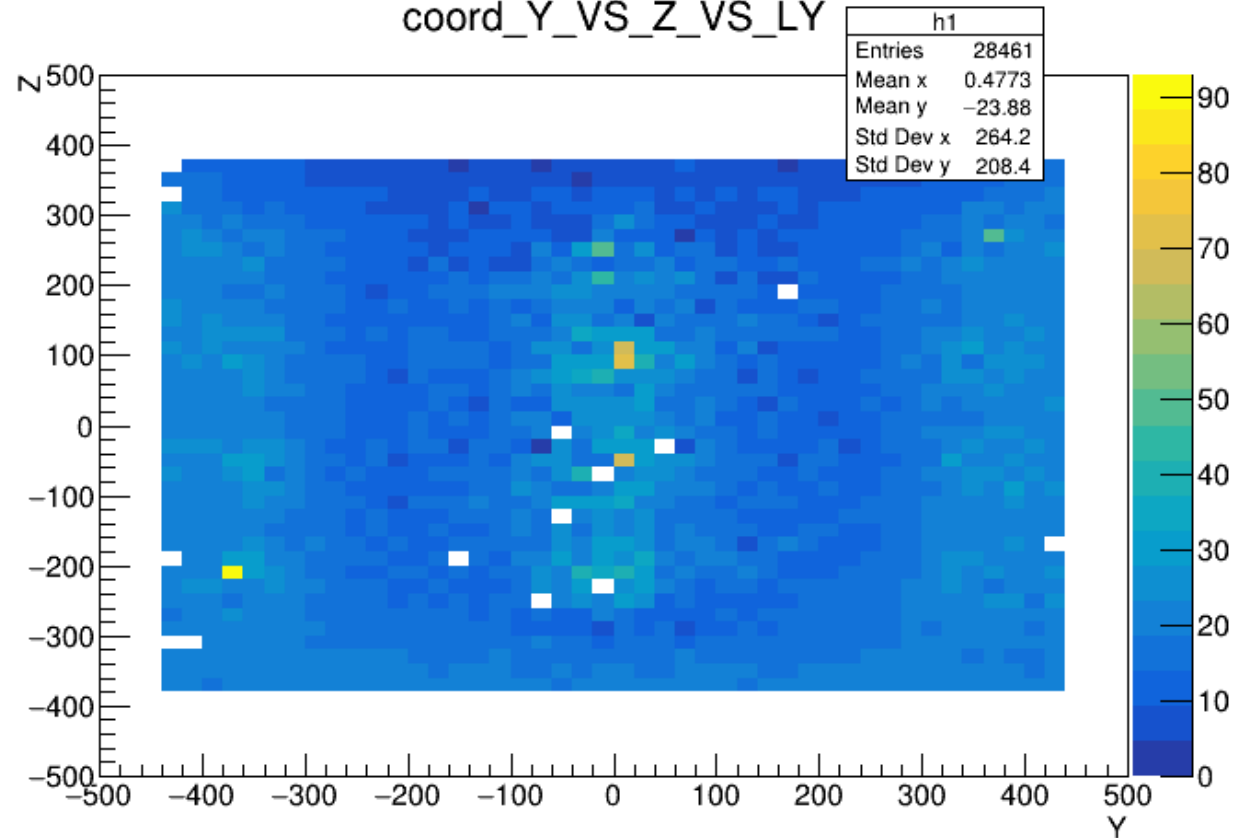


Figure.9. The distribution of light yield by coordinates Y Z

The distribution of light yield by coordinates

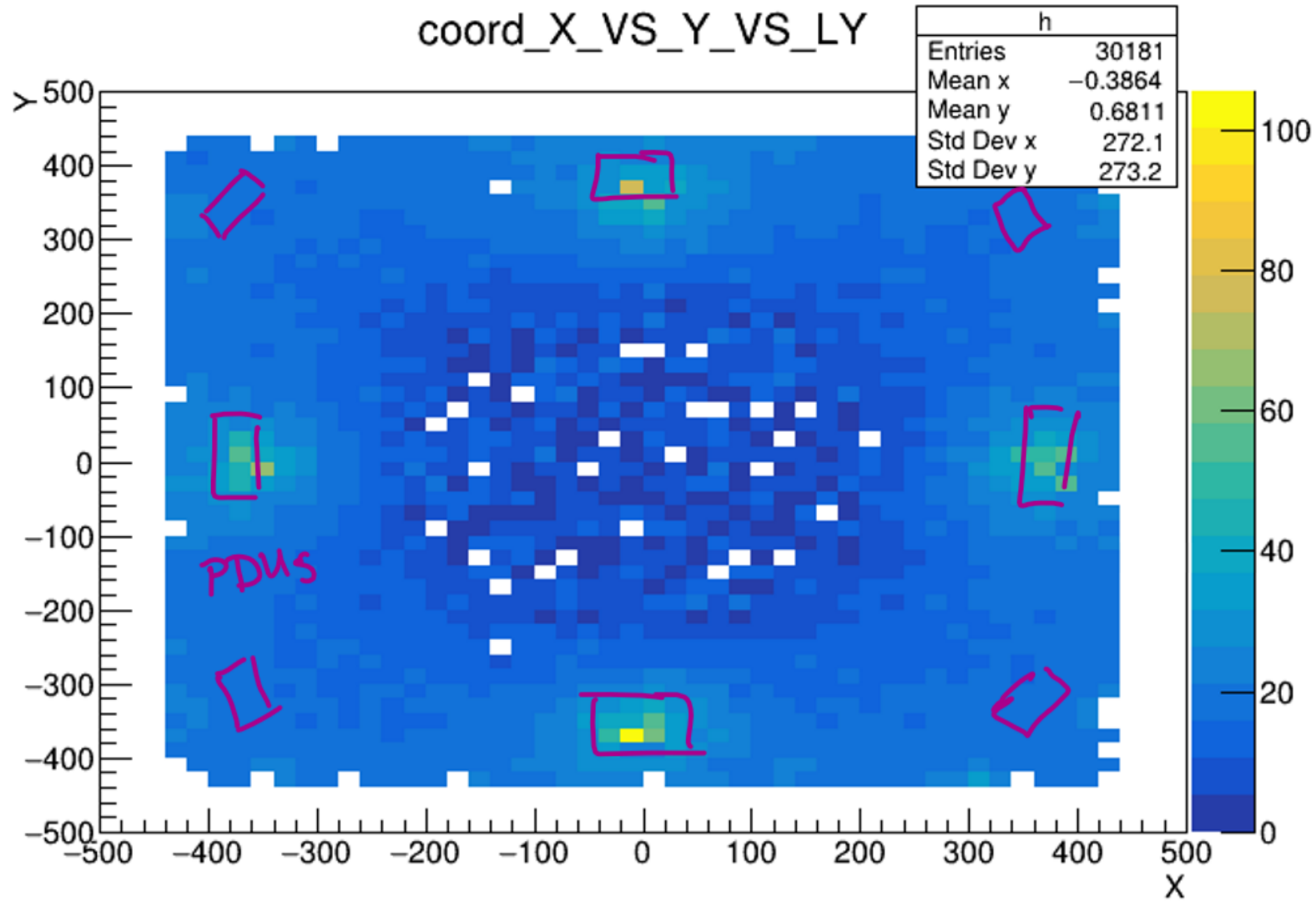


Figure.10. The distribution of light yield by coordinates X Y

The gamma background simulations

Simulation's parameters:

gamma with $E=2600$ keV, veto yield 1.0,
events 1000

nPDUs	Mean LY, $\frac{p.e.}{MeV}$	RMS
32	7.81	3.85
28	7.00	4.41
24	6.01	3.56
20	5.07	3.29
16	4.05	2.89
12	3.11	2.29
8	2.28	2.09
4	1.31	1.35

Table.4. The values of the light yield obtained from the simulations.

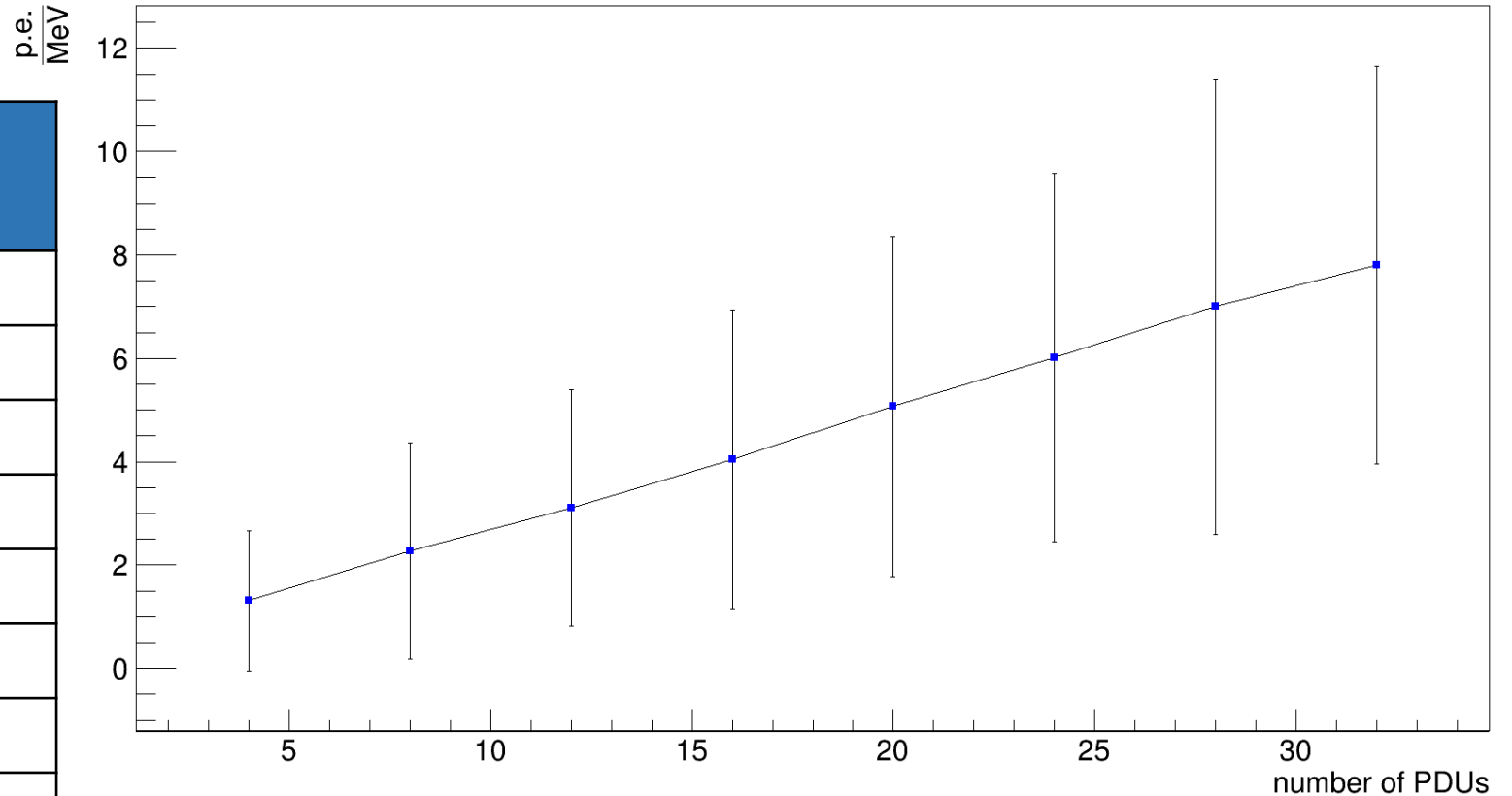


Figure.11. The dependence of the light yield on the amount of PDUs

Conclusions

- The new configuration was developed
- The light yield was calculated for new configuration

Further plans

- Continue to look for the causes for the destruction of photons
- The results will be obtained on the background modeling Ar39

Links



https://gitlab.in2p3.fr/darkside/g4ds10/-/tree/other_geometry



https://www.overleaf.com/read/vh_qktgkwrgkp

Thank you for your attention!

The comparison of reflector's material for cryostat: Lumirror and Tyvek

Simulation's parameters:

Cosmic muon, veto yield 0.02, events 1000

nPDUs	Lumirror		Tyvek	
	Mean LY, $\frac{p.e.}{MeV}$	RMS	Mean LY, $\frac{p.e.}{MeV}$	RMS
32	5.25	3.95	4.57	4.05
28	4.84	3.93	4.26	4.21
24	4.03	3.40	3.53	2.95
20	3.30	2.71	2.70	1.94
16	2.73	2.08	2.33	2.76
12	2.11	2.42	1.72	2.36
8	1.11	1.17	1.14	1.91
4	0.71	1.24	0.61	0.94

Table.1. The values of the light yield obtained from the simulations

LY vs nPDUs Comparison of reflector's material

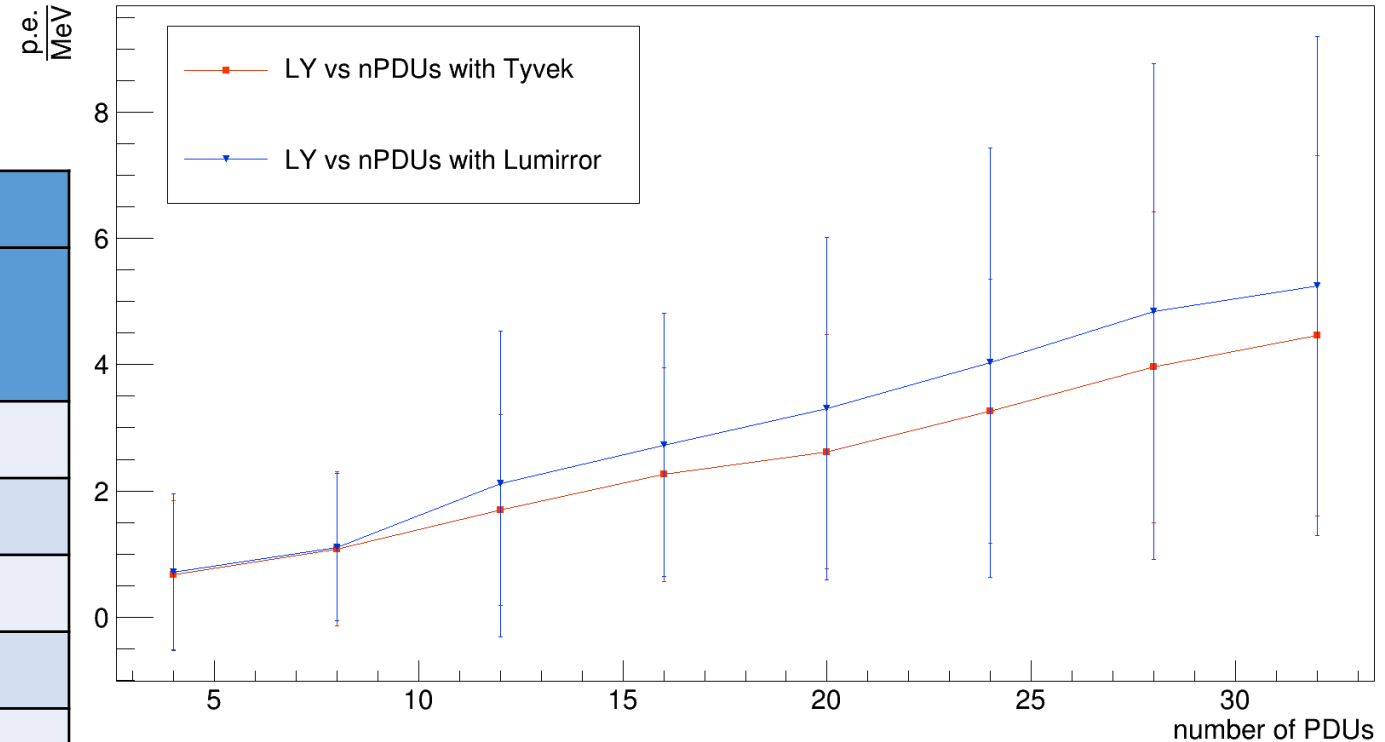


Figure.2. The comparison of light yield using different reflector materials. The blue graph is from simulations used Lumirror reflector. The orange graph is from simulations with Tyvek reflector.

The comparison of two types of Veto Argon with different optical properties: VetoMixture and VetoLiquidArgon2

Simulation's parameters:

Cosmic muon, veto yield 0.02, events 1000

nPDUs	VetoMixture		VetoLiquidArgon2	
	Mean LY, $\frac{p.e.}{MeV}$	RMS	Mean LY, $\frac{p.e.}{MeV}$	RMS
32	5.25	3.95	16.18	9.61
28	4.84	3.93	13.43	8.03
24	4.03	3.40	13.10	8.27
20	3.30	2.71	10.36	7.62
16	2.73	2.08	8.25	6.24
12	2.11	2.42	5.83	4.84
8	1.11	1.17	4.06	4.44
4	0.71	1.24	2.11	3.48

Table.2. The values of the light yield obtained from the simulations.

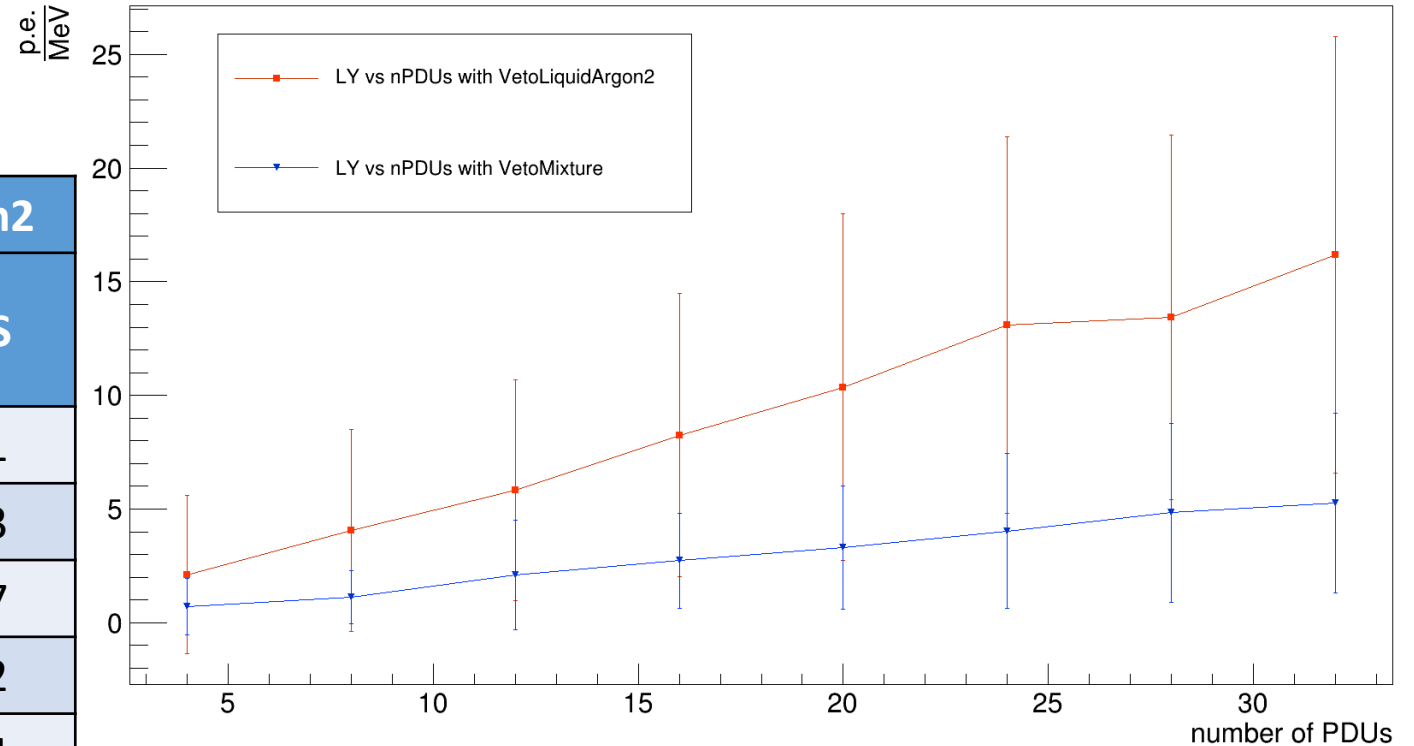


Figure.3. The comparison of light yield using different liquid argon. The blue graph is from simulations used VetoMixture. The orange graph is from simulations used VetoLiquidArgon2.

The comparison of cover's material for PDU: TPB and PEN

Simulation's parameters:

Cosmic muon, veto yield 0.02, events 1000

nPDUs	Without cover		PEN		TPB	
	Mean LY, $\frac{p.e.}{MeV}$	RMS	Mean LY, $\frac{p.e.}{MeV}$	RMS	Mean LY, $\frac{p.e.}{MeV}$	RMS
32	4.27	2.85	9.33	6.38	13.65	8.92
28	3.52	1.70	7.91	5.41	12.68	8.04
24	3.33	3.60	6.84	4.82	10.27	6.65
20	2.83	2.19	5.71	5.46	9.48	7.27
16	2.16	1.67	4.24	3.68	7.67	7.03
12	1.70	2.0	2.92	2.42	5.21	5.89
8	1.02	0.74	2.13	3.20	3.13	3.06
4	0.6	1.38	1.16	1.72	1.56	2.20

Table.3. The values of the light yield obtained from the simulations

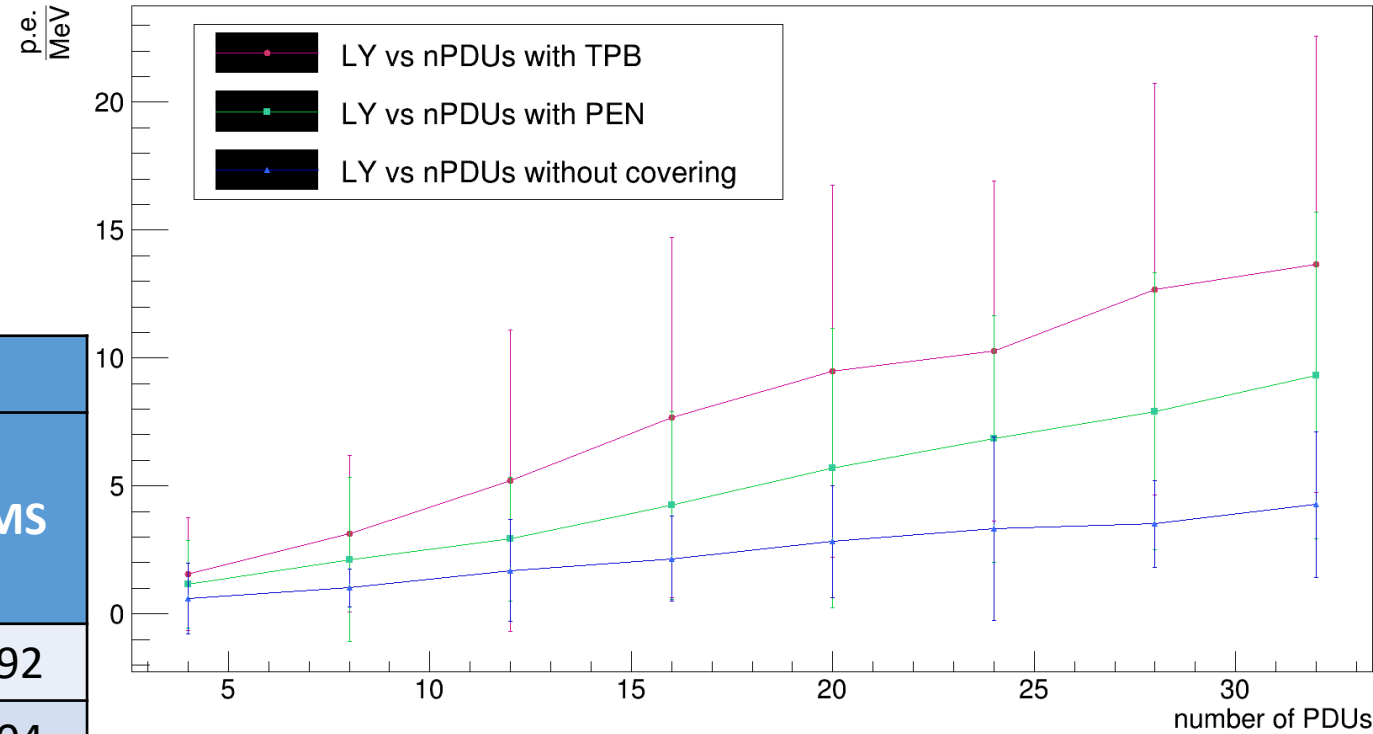


Figure.4. The comparison of light yield using different cover materials. The magenta graph is from simulations with TPB cover. The light green graph is from simulations with PEN cover. The blue graph is from simulations without covering.