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M.-C. calculations of background index for LARGE setup

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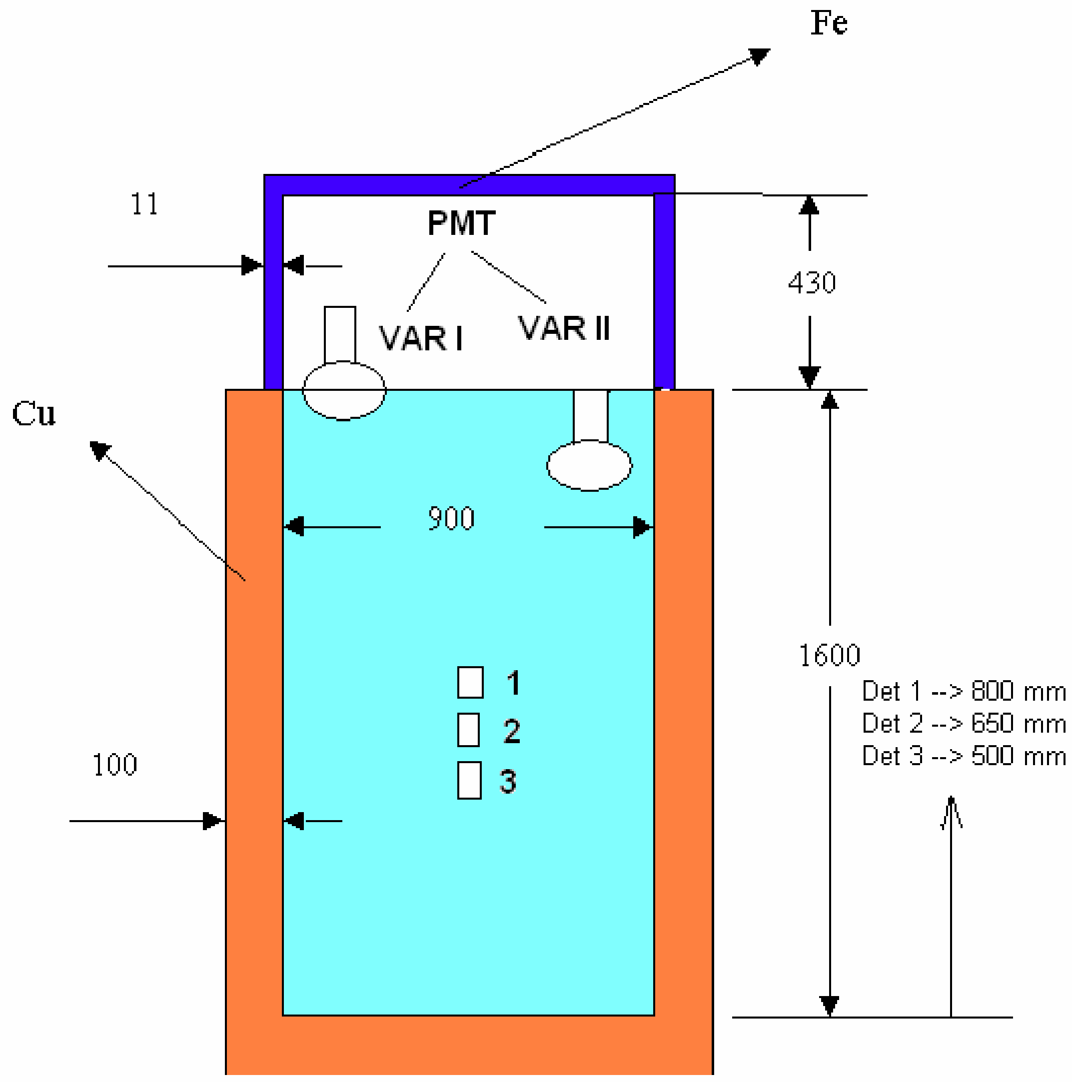
Scheme of the LARGE set up geometry



Initial data

- The background index has been found for LARGE setup in the energy region of 2.029-2.039 keV.
- The calculations have been done by Valery Gurentsov Gamma Code (***2G code***), which directly simulate gamma rays transport to the detector through the cryostat material and LAr.
- Gammas from ^{214}Bi and ^{208}Tl in the cryostat material were taken into account:

  a) Simplified PMT form was taken for calculation with mass of 600 g with activities ^{208}Tl - 0.3 Bq/kg, ^{214}Bi - 2.0 Bq/kg;

  b) Mass of steel is 151 kg, ^{232}Th & ^{214}Bi activity = 10^{-3} Bq/kg;

  c) The thickness of the copper is 10 cm (including shielding) and ^{232}Th &^{214}Bi activity = 10^{-5} Bq/kg;
- String consists of three crystals with L = 100 mm (D68 mm) each and a spacing of 50 mm in between (total string length: 3x100 mm + 2x50 mm = 400 mm). The mass of the Ge crystal is 2 kg.

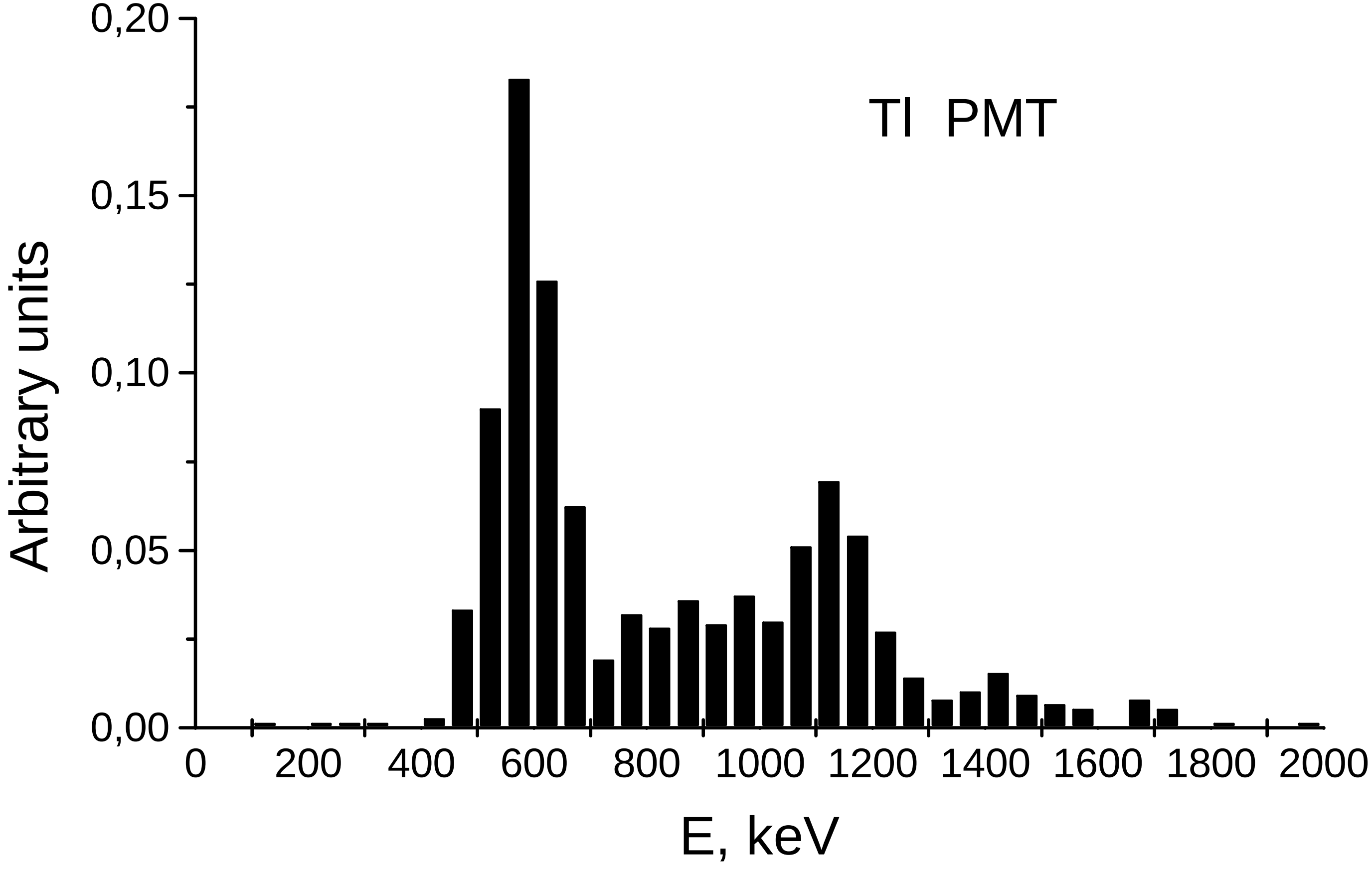
Background index at different PMT thresholds (/keV·year·kg) *for location 1* (80 cm above bottom of cryostat) for Var I

	Without PMT signal	Threshold 0 keV	50 keV	100 keV	150 keV	200 keV
Tl PMT	$5.9 \cdot 10^{-2}$	$7.2 \cdot 10^{-5}$	$9.0 \cdot 10^{-5}$	$1.1 \cdot 10^{-4}$	$1.3 \cdot 10^{-4}$	$1.4 \cdot 10^{-4}$
Bi PMT	**$5.6 \cdot 10^{-2}$**	**$1.7 \cdot 10^{-4}$**	**$6.6 \cdot 10^{-4}$**	**$6.0 \cdot 10^{-3}$**	**$1.4 \cdot 10^{-2}$**	**$3.3 \cdot 10^{-2}$**
Tl Fe	$4.6 \cdot 10^{-3}$	$4.1 \cdot 10^{-5}$	$6.0 \cdot 10^{-5}$	$7.3 \cdot 10^{-5}$	$7.8 \cdot 10^{-5}$	$9.6 \cdot 10^{-5}$
Bi Fe	$6.1 \cdot 10^{-4}$	$9.1 \cdot 10^{-6}$	$3.2 \cdot 10^{-5}$	$6.6 \cdot 10^{-5}$	$1.6 \cdot 10^{-4}$	$3.2 \cdot 10^{-4}$
Tl Cu	$6.0 \cdot 10^{-3}$	$2.6 \cdot 10^{-4}$	$4.1 \cdot 10^{-4}$	$4.2 \cdot 10^{-4}$	$4.5 \cdot 10^{-4}$	$4.8 \cdot 10^{-4}$
Bi Cu	$1.1 \cdot 10^{-3}$	$9.8 \cdot 10^{-5}$	$1.6 \cdot 10^{-4}$	$1.9 \cdot 10^{-4}$	$3.6 \cdot 10^{-4}$	$7.3 \cdot 10^{-4}$
Total	**$1.2 \cdot 10^{-1}$**	**$5.8 \cdot 10^{-4}$**	**$1.3 \cdot 10^{-3}$**	**$6.7 \cdot 10^{-3}$**	**$1.5 \cdot 10^{-2}$**	**$3.5 \cdot 10^{-2}$**

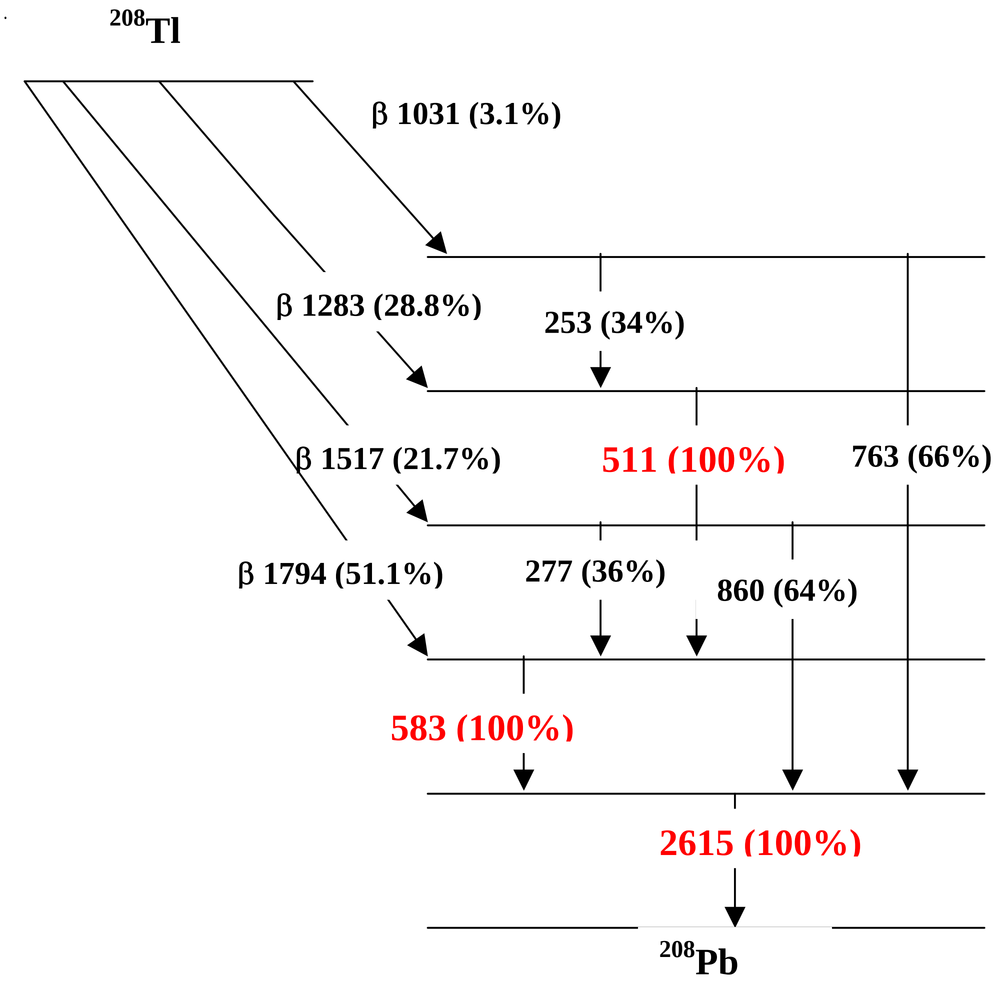
Background index at different PMT thresholds (/keV·year·kg) *for location 3* (50 cm above bottom of cryostat) for Var I

	Without PMT signal	**Threshold 0 keV**	**50 keV**	**100 keV**	**150 keV**	**200 keV**
Tl PMT	$1.0\cdot10^{-2}$	$3.0\cdot 10^{-5}$	$3.0\cdot10^{-5}$	$3.0\cdot10^{-5}$	$3.0\cdot10^{-5}$	$3.0\cdot10^{-5}$
Bi PMT	**$8.0\cdot10^{-3}$**	**$4.0\cdot10^{-5}$**	**$7.2\cdot10^{-5}$**	**$7.2\cdot10^{-4}$**	**$1.7\cdot10^{-3}$**	**$4.0\cdot10^{-3}$**
Tl Fe	$7.6\cdot10^{-4}$	$3.0\cdot10^{-6}$	$3.0\cdot10^{-6}$	3.0·10-6	$6.7\cdot10^{-6}$	$1.4\cdot10^{-5}$
Bi Fe	$1.2\cdot10^{-4}$	$1.7\cdot10^{-6}$	$7.3\cdot10^{-6}$	$1.6\cdot10^{-5}$	$4.2\cdot10^{-5}$	$8.2\cdot10^{-5}$
Tl Cu	$7.7\cdot10^{-3}$	$3.3\cdot10^{-4}$	$4.7\cdot10^{-4}$	$4.8\cdot10^{-4}$	$5.1\cdot10^{-4}$	$6.0\cdot10^{-4}$
Bi Cu	$1.2\cdot10^{-3}$	$8.0\cdot10^{-5}$	$1.6\cdot10^{-4}$	$2.2\cdot10^{-4}$	$4.0\cdot10^{-4}$	$7.5\cdot10^{-4}$
Total	**$2.8\cdot10^{-2}$**	**$4.1\cdot10^{-4}$**	**$7.1\cdot10^{-4}$**	**$1.4\cdot10^{-3}$**	**$2.7\cdot10^{-3}$**	**$5.5\cdot10^{-3}$**

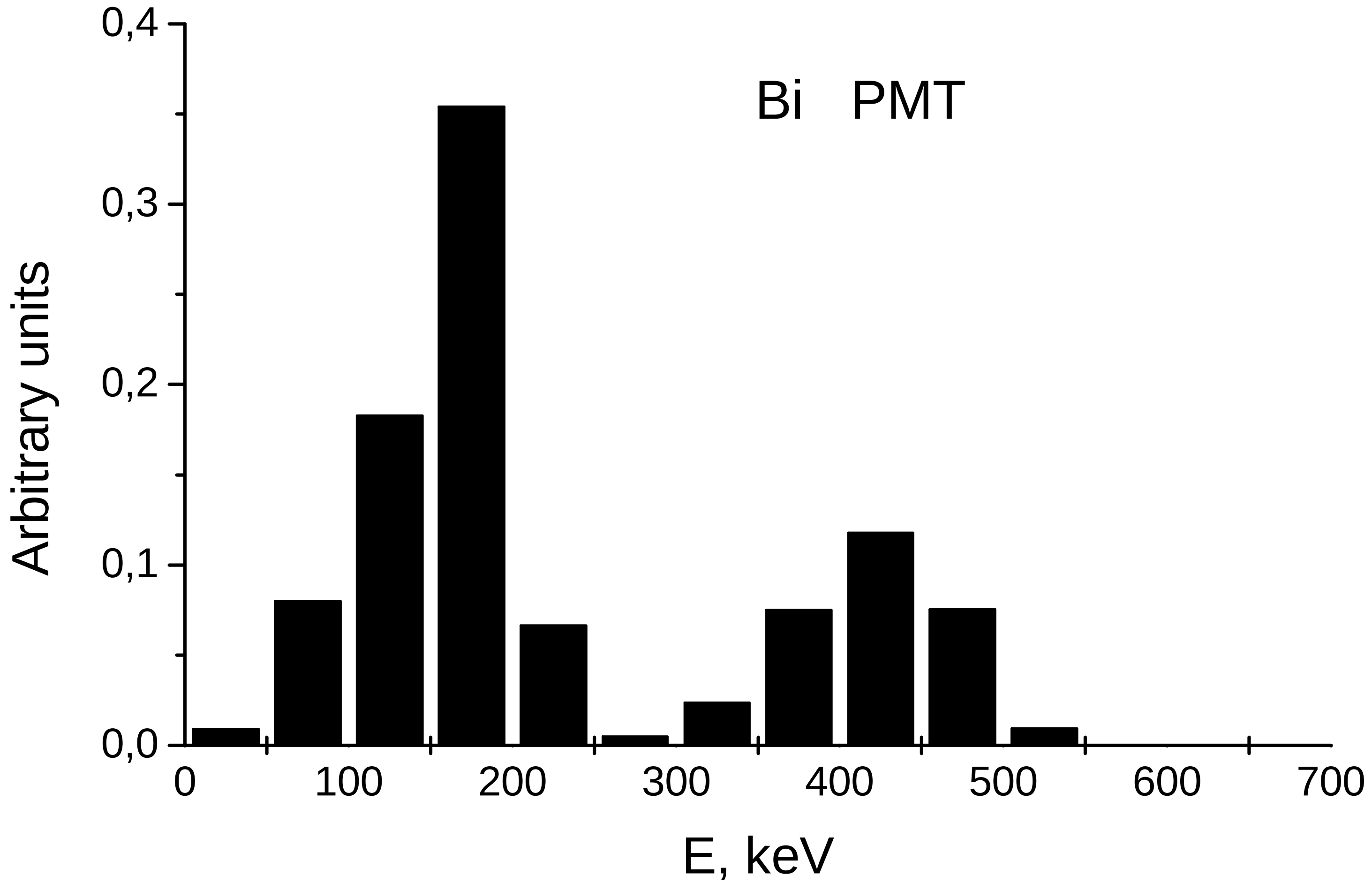
The spectrum of energy deposit in Ar in coincidence with signal in detector in the neutrinoless double beta decay region of ^{76}Ge from ^{208}Tl in PMTs

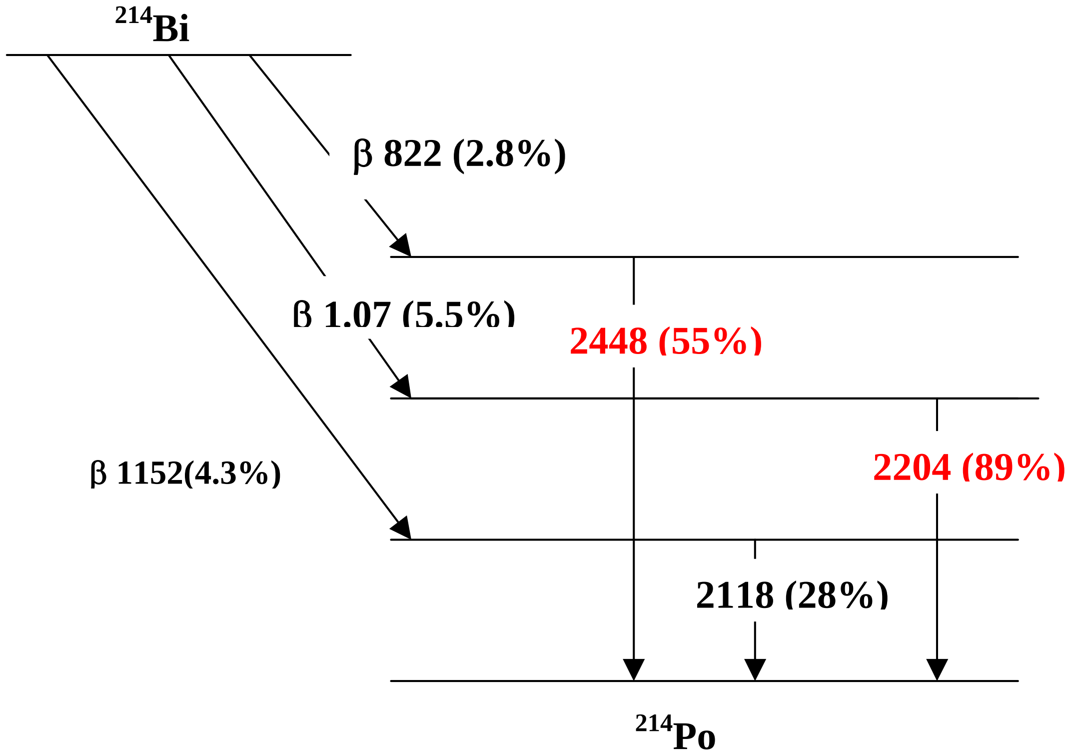


Decay scheme of ^{208}Tl



The spectrum of energy deposit in Ar in coincidence with signal in detector in the neutrinoless double beta decay region of ^{76}Ge from ^{214}Bi in PMTs





214Bi
β 822 (2.8%)
β 1.07 (5.5%)
2448 (55%)
β 1152(4.3%)
2204 (89%)
2118 (28%)
214Po

Conclusions

1. The main contribution is due to **PMTs** (as expected).
2. BI ~ **10^{-2}** can be achieved **if PMTs** are able to detect an energy of about **100 keV** (released in LAr).
3. The most dangerous background is due to **^{214}Bi**. If the threshold is **>200 keV**, the PMTs are **useless**. The energy of main ^{214}Bi line is 2204 keV and if it gives a signal in detector, the maximum energy deposit in Ar is about 200 keV.
4. The background from Cu is not negligible because:

   1) Cu mass is larger than steel and PMTs.

   2) the probability for gamma to lose a part of energy in material, and give a signal in detector is higher because of the essentially larger thickness of Cu.

The BI for different crystals in the string (the background from 214Bi in PMTs, Var II)

Detector	1	2	3
BI for the crystal In the string	$2{,}1*10^{-1}$	$5{,}6*10^{-2}$	$2{,}5*10^{-2}$
BI for individual crystals	$2{,}1*10^{-1}$	$7{,}0*10^{-1}$	$2{,}8*10^{-2}$