```
 Sample directory:
/disk/bulk_atp/gator/Sample_Sim_and_Analysis_Results/Rerun_KarlPMT_R12699

 ========= Simulation input =========
 (See geometry below)
gatordir="/disk/bulk_atp/gator"
binary="/disk/bulk_atp/gator/simulations/gator_v2.0/bin/Linux-g++/gator_1.2"
datadir="/disk/bulk_atp/gator/Sample_Sim_and_Analysis_Results"
sample="Rerun_KarlPMT_R12699"
queue="5:00:00"
maxnodes=100
totevents= 10000000
n_beamOn= 100000
isotope_list=[ "238U","232Th","40K","60Co","137Cs","226Ra","235U","228Th"]

 ========= Line efficiency =========
See values in Table 1.


 ========= Livetime and inputs for the analysis =========

Measure life time: 1.5984e+06 s = 18.5 d
Background life time: 3.58559e+06 s = 41.4999 d

Background folder: /disk/bulk_atp/gator/background/BACKGROUND_2019_clean
Calibration folder: /disk/bulk_atp/gator/Calibrations/2015.08.07
Amount of material (kg or pieces): 2

 === List of SPE files used for the analysis ===
KarlPMT_R12699_2018_001.SPE
KarlPMT_R12699_2018_003.SPE
KarlPMT_R12699_2018_004.SPE
KarlPMT_R12699_2018_005.SPE
KarlPMT_R12699_2018_006.SPE
KarlPMT_R12699_2018_008.SPE
KarlPMT_R12699_2018_009.SPE
KarlPMT_R12699_2018_010.SPE
KarlPMT_R12699_2018_011.SPE
KarlPMT_R12699_2018_012.SPE
KarlPMT_R12699_2018_013.SPE
KarlPMT_R12699_2018_014.SPE
KarlPMT_R12699_2018_015.SPE
KarlPMT_R12699_2018_016.SPE
KarlPMT_R12699_2018_018.SPE
KarlPMT_R12699_2018_019.SPE
KarlPMT_R12699_2018_020.SPE
KarlPMT_R12699_2018_021.SPE
KarlPMT_R12699_2018_023.SPE
KarlPMT_R12699_2018_024.SPE
KarlPMT_R12699_2018_025.SPE
KarlPMT_R12699_2018_026.SPE
KarlPMT_R12699_2018_027.SPE
KarlPMT_R12699_2018_028.SPE
KarlPMT_R12699_2018_029.SPE
KarlPMT_R12699_2018_031.SPE
KarlPMT_R12699_2018_032.SPE
KarlPMT_R12699_2018_033.SPE
KarlPMT_R12699_2018_034.SPE
KarlPMT_R12699_2018_035.SPE
KarlPMT_R12699_2018_037.SPE
KarlPMT_R12699_2018_038.SPE
KarlPMT_R12699_2018_039.SPE
KarlPMT_R12699_2018_040.SPE
KarlPMT_R12699_2018_041.SPE
```

KarlPMT_R12699_2018_042.SPE
KarlPMT_R12699_2018_043.SPE

=== List of SPE files excluded from the analysis ===
KarlPMT_R12699_2018_000.SPE
KarlPMT_R12699_2018_002.SPE
KarlPMT_R12699_2018_007.SPE
KarlPMT_R12699_2018_017.SPE
KarlPMT_R12699_2018_022.SPE
KarlPMT_R12699_2018_030.SPE
KarlPMT_R12699_2018_036.SPE

========= Geometry of the sample =========
See figure of the geometry below.
The .wrl file is also saved in the sample directory. And the dimensions/material and position are specified in the code below.

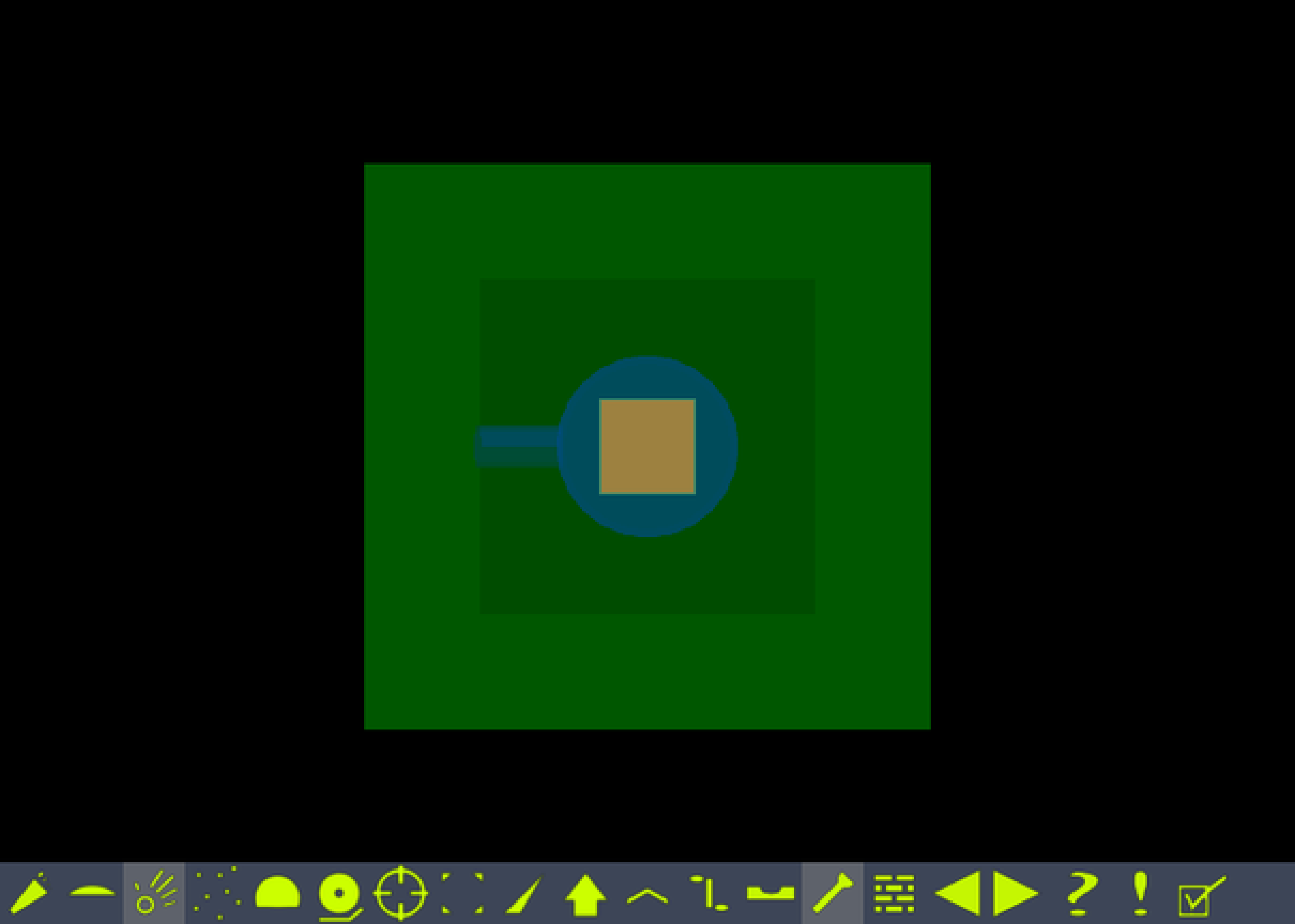
----------------------- icc file code ----------------

```
/*
#include "globals.hh"

#include "GeConstruction.hh"
#include "GeScintSD.hh"

#include "G4Material.hh"
#include "G4NistManager.hh"
#include "G4Box.hh"
#include "G4Tubs.hh"
#include "G4Torus.hh"
#include "G4Sphere.hh"
#include "G4EllipticalTube.hh"
#include "G4Polycone.hh"

#include "G4LogicalVolume.hh"
#include "G4ThreeVector.hh"
#include "G4PVPlacement.hh"
#include "G4VisAttributes.hh"
#include "G4Colour.hh"
#include "G4Cons.hh"
#include "G4UnionSolid.hh"
#include "G4SubtractionSolid.hh"
#include "G4RotationMatrix.hh"
#include "G4OpBoundaryProcess.hh"
#include "G4SDManager.hh"
#include "G4Transform3D.hh"

#include <math.h>
#include <string.h>
#include <stdio.h>

#include <TMath.h>
*/


//Colors for visualization properties
//G4Colour red (1.0, 0.0, 0.0);
//G4Colour blue (0.0, 0.0, 1.0);
//G4Colour yellow (1.0, 1.0, 0.0);
//G4Colour orange (0.75, 0.55, 0.0);
//G4Colour lblue (0.0, 0.0, 0.55);

//Elements and materials usefull
```

```
//G4Element* O = G4Element::GetElement("Oxygen");
//G4Element* Si = G4Element::GetElement("Silicon");
//G4Element* Al = G4Element::GetElement("Aluminum");
//G4Element* Ni = G4Element::GetElement("Nickel");

//G4Material* Steel_304 = G4Material::GetMaterial("Steel_304");
G4Material *kovar = G4Material::GetMaterial("PMTkovar_mat");

//Define the pmt envelope as a box
const G4double PMT_length = 52 * mm;
const G4double PMT_width = 52 * mm;
const G4double PMT_depth = 16.4 * mm;

G4Box* PMT_envel = new
G4Box("PMT_envel",0.5*PMT_length,0.5*PMT_width,0.5*PMT_depth);

//Envelope material definition (SS)
G4Material* PMT_steel = new G4Material("PMT_steel",8.03*g/cm3,1);
PMT_steel -> AddMaterial(Steel_304,1.0); //Just a trick to change the name of
the steel ==> I can use the routine to generate the random points in the proper
material

//Envelope Logical volume
G4LogicalVolume* PMT_envel_log = new G4LogicalVolume(PMT_envel, kovar,
"PMT_envel_log", 0, 0, 0);
G4LogicalVolume* PMT_envel_log_2 = new G4LogicalVolume(PMT_envel, kovar,
"PMT_envel_log", 0, 0, 0);

G4VisAttributes* PMT_envel_vis = new G4VisAttributes(red);
PMT_envel_vis -> SetVisibility(true);
PMT_envel_vis -> SetForceSolid(false);
PMT_envel_log -> SetVisAttributes(PMT_envel_vis);

G4ThreeVector KarlPMT_pos(0.,0.,endcapPos_z+0.5*(endcapHeight1+PMT_depth)
+0.01*mm);
G4VPhysicalVolume* PMT_envel_phys = new
G4PVPlacement(0,KarlPMT_pos,PMT_envel_log,"PMT_envel_phys", cavity1_log, false,
0,true);
G4ThreeVector KarlPMT_pos_2(0.,0.,endcapPos_z+0.5*(endcapHeight1+PMT_depth)
+PMT_depth+0.01*mm);
G4VPhysicalVolume* PMT_envel_phys_2 = new
G4PVPlacement(0,KarlPMT_pos_2,PMT_envel_log_2,"PMT_envel_phys_2", cavity1_log,
false, 0,true);


/******************************** Definition of the plastic base inside the PMTs
*************************************/

const G4double PMT_thickness = 0.5*(52.0-48.5) * mm; //Outer PMT dimensions
minus the effective PC dimension
/*
//Material definition for plastic base
G4Material* Polypropylene = new G4Material(name="Polypropylene", density =
0.87*g/cm3, ncomponents = 2);
Polypropylene->AddElement(C,3);
Polypropylene->AddElement(H,6);

G4double PMTbase_length = 52. * mm - PMT_thickness;
G4double PMTbase_width = 52. * mm - PMT_thickness;
G4double PMTbase_depth = 0 * mm;

//Definition of the geometry
G4Box* PMT_base = new
G4Box("PMT_base",0.5*PMTbase_length,0.5*PMTbase_width,0.5*PMTbase_depth);
```

```
//Construction of logical volume
G4LogicalVolume* PMT_base_log = new
G4LogicalVolume(PMT_base,Polypropylene,"PMT_base_log");

G4VisAttributes* PMT_base_vis = new G4VisAttributes(red);
PMT_base_vis -> SetVisibility(true);
PMT_base_vis -> SetForceSolid(false);
PMT_base_log -> SetVisAttributes(PMT_base_vis);

//Placement of the base logical volume inside the PMT envelope volume
G4ThreeVector PMT_base_pos(0.,0.,0.5*(PMT_depth - PMTbase_depth));

G4VPhysicalVolume* PMT_base_phys = new
G4PVPlacement(0,PMT_base_pos,PMT_base_log,"PMT_base_phys", PMT_envel_log, false,
0,true);
*/

/******************** Definition of the quartz window as a flat box
*************************** *******************/

//Material definition for the ceramic inside the pmt
G4Material* PMT_quartz_mat = new G4Material("PMT_quartz_mat",2.648*g/cm3,2);
PMT_quartz_mat -> AddElement(Si,1);
PMT_quartz_mat -> AddElement(O,2);

//Dimensions
G4double PMTwindow_length = 52. * mm;
G4double PMTwindow_width = 52. * mm;
G4double PMTwindow_depth = 1.5 * mm;

//Definition of the geometry
G4Box* PMT_window = new
G4Box("PMT_window",0.5*PMTwindow_length,0.5*PMTwindow_width,0.5*PMTwindow_depth)
;

//Construction of logical volume
G4LogicalVolume* PMT_window_log = new
G4LogicalVolume(PMT_window,PMT_quartz_mat,"PMT_window_log");

//Set visibility properties
G4VisAttributes* PMT_window_vis = new G4VisAttributes(red);
PMT_window_vis -> SetVisibility(true);
PMT_window_vis -> SetForceSolid(false);
PMT_window_log -> SetVisAttributes(PMT_window_vis);

//Put the window in the PMT_envelop logical volume
G4ThreeVector PMT_window_pos(0.,0.,0.5*(-PMT_depth + PMTwindow_depth));

G4VPhysicalVolume* PMT_window_phys = new
G4PVPlacement(0,PMT_window_pos,PMT_window_log,"PMT_window_phys",PMT_envel_log,fa
lse,0,true);
G4VPhysicalVolume* PMT_window_phys_2 = new
G4PVPlacement(0,PMT_window_pos,PMT_window_log,"PMT_window_phys_2",PMT_envel_log_
2,false,0,true);


/****************************** Definition of the vacuum inside the PMTs
***********************************/

const G4double PMT_vac_length = PMT_length - 2*PMT_thickness;
const G4double PMT_vac_width = PMT_width - 2*PMT_thickness;
const G4double PMT_vac_depth = PMT_depth - PMTwindow_depth - PMT_thickness;
```

```
G4Box* PMT_vacuum = new
G4Box("PMT_vacuum",0.5*PMT_vac_length,0.5*PMT_vac_width,0.5*PMT_vac_depth);

//Material definition for the vacuum inside the PMT
G4Material* PMT_vacuum_mat = new G4Material("vacuum_PMT_mat",1.,1.*g/mole,1.e-
20*g/cm3,kStateGas,0.1*kelvin,1.e-20*bar);

//Vacuum Logical volume
G4LogicalVolume* PMT_vacuum_log = new G4LogicalVolume(PMT_vacuum,
PMT_vacuum_mat, "vacuum_PMT_log", 0, 0, 0);

G4VisAttributes* PMT_vacuum_vis = new G4VisAttributes(red);
PMT_vacuum_vis -> SetVisibility(true);
PMT_vacuum_vis -> SetForceSolid(false);
PMT_vacuum_log -> SetVisAttributes(G4VisAttributes::Invisible);

//Placement of the vacuum logical volume inside the PMT envelope volume
//G4ThreeVector PMT_vacuum_pos(0.,0.,0.5*(PMTwindow_depth-PMTbase_depth));
G4ThreeVector PMT_vacuum_pos(0.,0.,0.5*(PMTwindow_depth-PMT_thickness));

G4VPhysicalVolume* PMT_vacuum_phys = new
G4PVPlacement(0,PMT_vacuum_pos,PMT_vacuum_log,"PMT_vacuum_phys", PMT_envel_log,
false, 0,true);
G4VPhysicalVolume* PMT_vacuum_phys_2 = new
G4PVPlacement(0,PMT_vacuum_pos,PMT_vacuum_log,"PMT_vacuum_phys_2",
PMT_envel_log_2, false, 0,true);
```

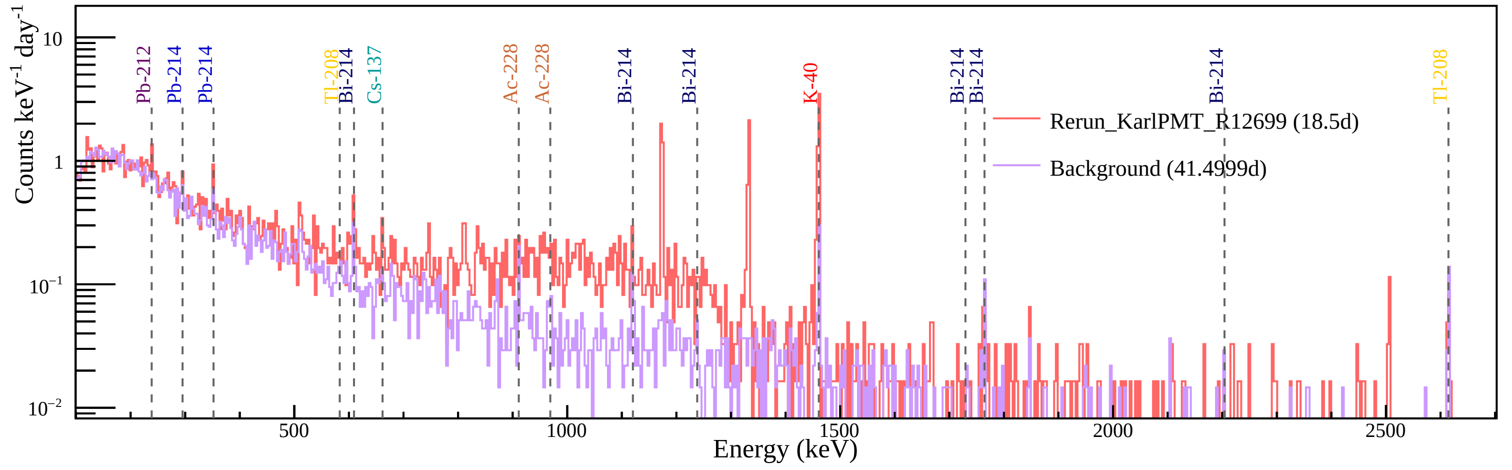


Isotope	Energy (keV)	Line BR	Effic	BRxEffic
^{234}Th	92.6	0.0433	0.0265	0.00115
^{235}U	185.72	0.572	0.00250	0.00143
^{212}Pb	238.632	0.436	0.0469	0.0204
^{214}Pb	295.224	0.184	0.0508	0.00934
^{228}Ac	338.32	0.114	0.0473	0.00540
^{214}Pb	351.932	0.356	0.0472	0.0168
^{208}Tl	583.187	0.3054	0.0263	0.00803
^{214}Bi	609.312	0.4549	0.0312	0.0142
^{137}Cs	661.657	0.8499	0.0424	0.0360
^{228}Ac	911.196	0.262	0.0252	0.00661
^{228}Ac	968.96	0.159	0.0247	0.00393
^{214}Bi	1120.29	0.1491	0.0225	0.00335
^{60}Co	1173.23	0.9985	0.0264	0.0264
^{60}Co	1332.49	0.9998	0.0245	0.0245
^{40}K	1460.88	0.1055	0.0277	0.00292
^{214}Bi	1764.49	0.1531	0.0208	0.00319
^{208}Tl	2614.51	0.3584	0.0106	0.00379

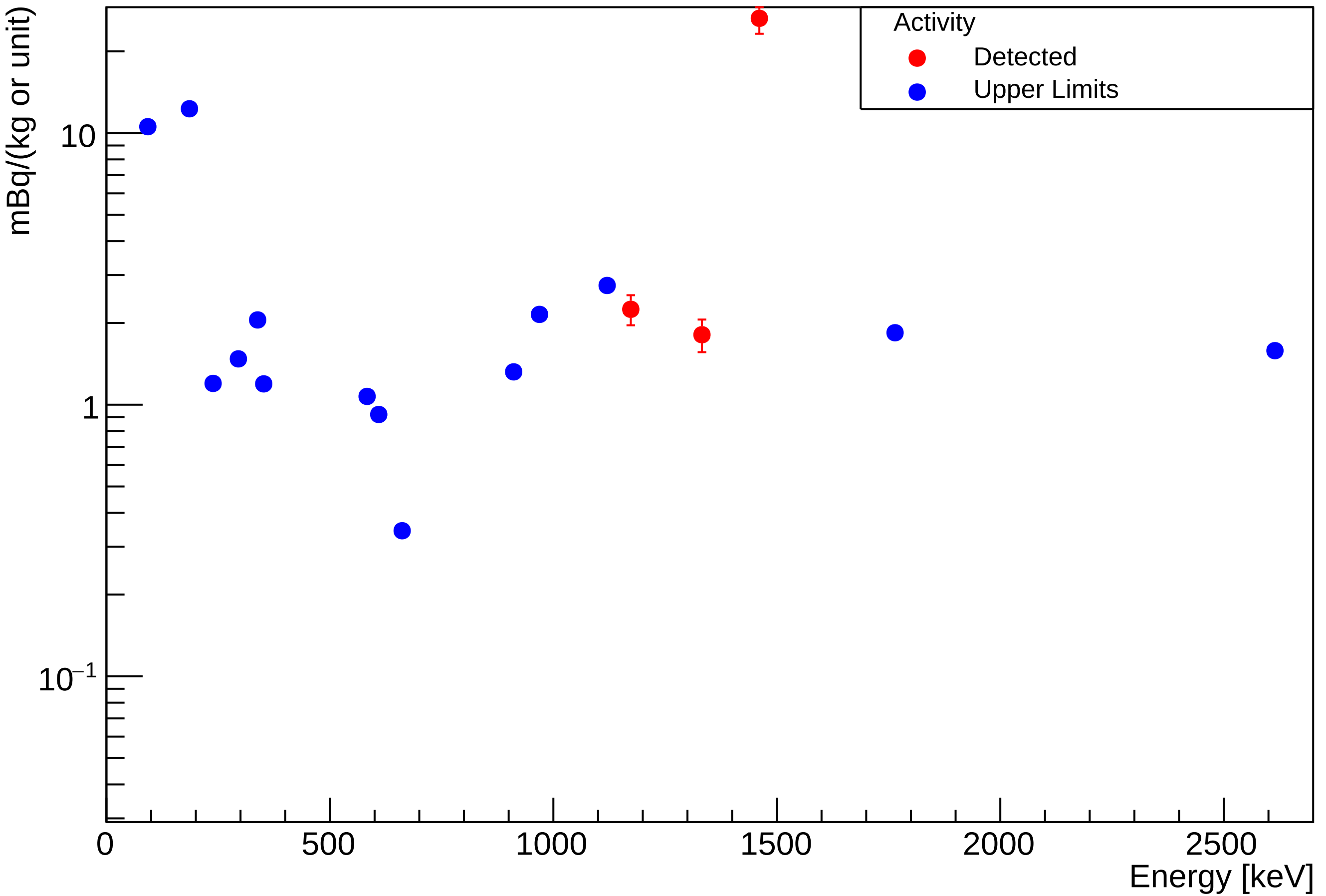
Table 1: Efficiency Table, as calculated by the simulation.

Isotope	E(keV)	PeakCnts	CompCnts	BkCnts	isBkdet	LineCnts	LdCnts	LdActiv	Activity (mBq/u.)
^{234}Th	92.6	27.9 +- 5.4	28.7 +- 5.4	-2.0 +- 5.3	T	-0.8 +- 9.3	34.9	10.6	< 10.6
^{235}U	185.72	65.4 +- 8.2	54.7 +- 7.5	8.1 +- 7.3	T	3 +- 13	48.1	11.7	< 12.3
^{212}Pb	238.632	75.5 +- 8.7	42.9 +- 6.6	0.3 +- 6.0	T	32 +- 12	41.3	0.703	< 1.20
^{214}Pb	295.224	46.2 +- 6.9	36.0 +- 6.1	11.7 +- 5.3	T	-1 +- 11	39.6	1.47	< 1.47
^{228}Ac	338.32	25.2 +- 5.1	19.7 +- 4.6	9.4 +- 4.4	T	-4.0 +- 8.1	31.8	2.05	< 2.05
^{214}Pb	351.932	59.0 +- 7.7	20.8 +- 4.7	11.7 +- 5.0	T	27 +- 10	33.8	0.699	< 1.19
^{208}Tl	583.187	10.0 +- 3.3	11.0 +- 3.5	7.5 +- 2.9	T	-8.5 +- 5.6	24.8	1.07	< 1.07
^{214}Bi	609.312	39.6 +- 6.4	10.4 +- 3.4	19.4 +- 3.7	T	9.8 +- 8.1	28.7	0.704	< 0.920
^{137}Cs	661.657	24.7 +- 5.1	7.3 +- 2.9	0.7 +- 2.9	T	16.8 +- 6.5	20.5	0.198	< 0.344
^{228}Ac	911.196	16.0 +- 4.1	10.0 +- 3.3	12.1 +- 2.6	T	-6.1 +- 5.9	25.1	1.32	< 1.32
^{228}Ac	968.96	18.3 +- 4.4	11.5 +- 3.5	6.2 +- 2.3	T	0.5 +- 6.1	23.9	2.11	< 2.15
^{214}Bi	1120.29	20.5 +- 4.6	8.5 +- 3.1	8.0 +- 2.5	T	3.9 +- 6.1	23.0	2.38	< 2.75
^{60}Co	1173.23	201 +- 14	10.7 +- 3.4	1.3 +- 1.9	T	189 +- 15	21.5	0.283	2.25 +- 0.28
^{60}Co	1332.49	159 +- 13	15.0 +- 4.0	2.2 +- 1.6	T	142 +- 13	24.0	0.340	1.81 +- 0.25
^{40}K	1460.88	283 +- 17	17.0 +- 4.2	18.9 +- 3.3	T	247 +- 18	31.0	3.68	26.5 +- 3.3
^{214}Bi	1764.49	6.0 +- 2.6	2.0 +- 1.7	5.7 +- 2.1	T	-1.7 +- 3.8	16.9	1.84	< 1.84
^{208}Tl	2614.51	9.0 +- 3.2	0.0 +- 1.0	9.4 +- 2.3	T	-0.4 +- 4.0	17.2	1.58	< 1.58

Table 2: Activity Table, as calculated by the analysis code and given per unit, as indicated in the analysis input. Limits are given at 95CL, activities at one sigma.



Counts keV^{-1} day^{-1}
10
1
10^{-1}
10^{-2}
500
1000
1500
2000
2500
Energy (keV)
Pb-212
Pb-214
Pb-214
Tl-208
Bi-214
Cs-137
Ac-228
Ac-228
Bi-214
Bi-214
K-40
Bi-214
Bi-214
Bi-214
Tl-208
Rerun_KarlPMT_R12699 (18.5d)
Background (41.4999d)


Activity
Detected
Upper Limits
mBq/(kg or unit)
10
1
10^{-1}
0
500
1000
1500
2000
2500
Energy [keV]