



An open-source toolkit for modeling backgrounds from radioactive sources

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<https://github.com/bloer/bgexplorer-demo>

Background Explorer was originally designed to handle the 300+ components and 800+ simulation datasets needed to construct the background model for the SuperCDMS dark matter experiment. It has been adapted to be a general-purpose tool that anyone can use. The software is written in python, with a MongoDB backend and Flask providing a user-friendly web interface that allows models to be constructed with minimal programming expertise.

## Inputs

- + Record concentration of radioactive isotopes in materials around detector
- + Helpful tools to model cosmogenic activation and radon daughter deposition on surfaces from an exposure time

Edit Assay Reference

Name

Detector housing OFHC copper

Distribution

bulk

Category

RadioactiveContam

Isotopes

Isotope

Decay rate

Uncertainty

Limit?

U238

6 ppt\_U

0

☒

☒

Th232

45 microBq/kg

10%

☐

☒

K40

1 mBq/kg

300 microBq/kg

☐

☒

+ Add

Sample Details

Sample ID

2022-25

Description

1/4 in. plate

Sample owner

A. Professor

Owner contact info

Vendor/producer

Aurubis

Batch number/ID

12345

Additional Notes

Measurement Details

Operator

A. Chemist

Operator contact info

Unit-aware

Track metadata about measurement, including file attachments

- + Record components to be tracked and simulated
- + Allows arbitrarily deep nested assemblies and multiple placements of common parts (e.g., screws, resistors, etc.)
- + Each component has one or more radiation sources associated

Editing Model: HPGE Detector

Components

Specifications

Search

Create new:

Component

Assembly

Components

Name

Description

Status

Assembly Tree

HPGE System > Low background shielded HPGE detector

can

top lid

bottom lid

Max 1.5 brass screw

sample holder

shield >

copper box >

cuBox\_top

cuBox\_bot

cuBox\_side

cuBox\_fit

cuBox\_bot

lead shield

environment

Unplaced components

copper box (single element example)

cuBox\_right

cuBox\_bot

Edit Component

Name

cuBox\_top

Description

Comment

Additional Info

owner: <Part creator>designer: <Buyer> parttype: <Part number> vendor: <Part vendor> datasetref: <URL for datasetref>

Query Modifier

Emission specs

Name

Category

Dist.

Querrymod

copper contam

RadioactiveContam

bulk

0

copper activation

CosmogenicActivation

bulk

0

inner radon

RadonExposure

surface

0

outer radon

RadonExposure

surface

0

Material

copper

Mass

63.4 kg

Volume

0 cm³

Inner Surface

10 cm²

Outer Surface

20 cm²

Multiple radioactivity sources automatically normalized by correct physical values (e.g., mass, volume, surface area)

- + Upload radiation transport simulation outputs as JSON data
- + Map spectrum in detector from radiation sources at different locations
- + Each component associated with multiple datasets
- + Multiple components can point to the same dataset

volume	primary	ngprimaries
can1	19-40	100000
can1	19-40	10000000
can1	27-60	100000
can1	27-60	10000000
can1	82-210	100000
can1	82-210	10000000
can1	90-232	10000000
can1	90-232	100000
can1	92-238	100000
can1	92-238	10000000
cuBox_bot	19-40	100000000
cuBox_bot	19-40	100000
cuBox_bot	27-60	100000
cuBox_bot	27-60	10000000
cuBox_bot	82-210	100000
cuBox_bot	82-210	10000000
cuBox_bot	90-232	10000000
cuBox_bot	90-232	100000
cuBox_bot	92-238	10000000
cuBox_bot	92-238	100000
cuBox_bot	92-210	100000
cuBox_bot	92-210	10000000
cuBox_bot	92-232	10000000
cuBox_bot	92-232	100000
cuBox_bot	92-238	10000000
cuBox_bot	92-238	10000000

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  "/bg/output/reducebytime": 1000000,
  "/bg/output/reducebyall": 0,
  "/bg/output/serializebydetectors": 1,
  "/bg/output/serializebysteps": 1,
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      "uid": 0,
      "volume": 0,
      "ngprimaries": 0
    }
  ]
}
```

## Outputs

- + Exportable bill of materials summarizing components and associated radioactivity

#	Name	Weight	Description	Comment	Partnum	Material	Vendor	Mass	Assay Ref	U238 [mBq/kg]	Th232 [mBq/kg]	K40 [mBq/kg]
1	HPGE System >	1	Low background shielded HPGE detector					7274915.15 g				
1	detector housing >	1						615.15 g				
1.1	can	1				aluminum		478 g	radiopurity.org	108+/-5	5.6+/-1.4	10+/-5
1.2	top lid	1				aluminum		33.25 g	radiopurity.org	108+/-5	5.6+/-1.4	10+/-5
1.3	bottom lid	1				aluminum		103.9 g	radiopurity.org	108+/-5	5.6+/-1.4	10+/-5
2	sample holder	1	HDPE blocks for placing large samples			HDPE		2 kg	N. Abgrail et al., Nucl. Instr. and Meth. A 828 (2016)	19.2+/-1.2	12.3+/-0.8	43+/-6
3	shield >	1	copper and lead shielding					7272.3 kg				
3.1	copper box >	1						242.3 kg				
3.1.1	cuBox_top	1				copper		40 kg	E. Aprile et al., Astropart. Phys. 35 (2011)	0.070+/-0.020	0.021+/-0.007	0.023+/-0.008
3.1.2	cuBox_bot	1				copper		56.3 kg	E. Aprile et al., Astropart. Phys. 35 (2011)	0.070+/-0.020	0.021+/-0.007	0.023+/-0.008
3.1.3	cuBox_side	2				copper		45 kg	E. Aprile et al., Astropart. Phys. 35 (2011)	0.070+/-0.020	0.021+/-0.007	0.023+/-0.008
3.1.4	cuBox_fit	1				copper		28 kg	E. Aprile et al., Astropart. Phys. 35 (2011)	0.070+/-0.020	0.021+/-0.007	0.023+/-0.008
3.1.5	cuBox_bot	1				copper		28 kg	E. Aprile et al., Astropart. Phys. 35 (2011)	0.070+/-0.020	0.021+/-0.007	0.023+/-0.008
3.2	lead shield	1				lead		7030 kg	N. Abgrail et al., Nucl. Instr. and Meth. A 828 (2016)	<0.12	<0.03279999999999999	0.71+/-0.34
4	environment	1	dummy component to attach room flux									

- + Summarize backgrounds by different contribution with expandable tables

Component	Gammas, 0.1-5 keV [dru]	Gammas, 3-100 keV [dru]	Gammas, 10-2000 keV [dru]
Total >	2.89 (9)	60 (10)	14 (1)
sample holder	0.53 (2)	1.77 (8)	0.32 (1)
detector housing >	2.19 (9)	8.4 (3)	1.48 (5)
bottom lid	0.111 (5)	0.37 (2)	0.067 (3)
can	1.76 (8)	6.8 (3)	1.19 (5)
top lid	0.32 (1)	1.23 (5)	0.23 (1)
shield >	0.167 (7)	50 (10)	12 (1)
lead shield	0.010 (2)	50 (10)	12 (1)
copper box >	0.157 (7)	0.219 (9)	0.095 (4)
cuBox_bot	0.009 (6)	0.015 (1)	0.005 (3)
cuBox_bot	0.025 (2)	0.036 (2)	0.014 (8)
cuBox_fit	0.030 (2)	0.040 (3)	0.019 (1)
cuBox_side	0.045 (3)	0.065 (5)	0.029 (2)
cuBox_top	0.028 (2)	0.034 (2)	0.015 (9)
hinge	0.020 (5)	0.029 (7)	0.011 (3)
Material	Gammas, 0.1-5 keV [dru]	Gammas, 3-100 keV [dru]	Gammas, 10-2000 keV [dru]
Total >	2.89 (9)	60 (10)	14 (1)
lead	0.010 (2)	50 (10)	12 (1)
copper	0.137 (5)	0.190 (7)	0.084 (2)
aluminum	2.19 (9)	8.4 (3)	1.48 (5)
HDPE	0.53 (2)	1.77 (8)	0.32 (1)
brass	0.020 (5)	0.029 (7)	0.011 (3)

- + Fractional contribution from nested assemblies in pie charts
- + Interactively filter different elements to drill-down to details

Interactive Charts

Gammas, 0.1-5 keV [dru]

Filter Info

55 / 55 (100.0%) records pass all filters.

2.89 / 2.89 dru (100.0%) rate pass all filters.

Active Filters reset all

Component:

Material:

Source:

Source Category:

Component

can

top lid

bottom lid

sample holder

detector housing

environment

Material

lead

aluminum

copper

HDPE

brass

Source

can

top lid

bottom lid

sample holder

detector housing

environment

Interactive Charts

Gammas, 0.1-5 keV [dru]

Filter Info

40 / 55 (72.7%) records pass all filters.

0.696 / 2.89 dru (24.1%) rate pass all filters.

Active Filters reset all

Component:

Material:

Source:

Source Category:

Component

can

top lid

bottom lid

sample holder

detector housing

environment

Material

lead

aluminum

copper

HDPE

brass

Source

can

top lid

bottom lid

sample holder

detector housing

environment

- + Detail views for each component, assay, etc. with abundant cross-links

Component: cuBox\_top

General Info

Description

None

Placements

Total weight: 1

HPGE System > shield > copper box > cuBox\_top

Physical Characteristics

material

copper

mass

63.4 kg

surface\_in

10 cm²

surface\_out

20 cm²

surface\_inner

0 cm²

volume

0 cm³

Emission specs

Name

Type

Dist.

Rate spec

Total Rate

Simulated Lifetime

copper contam

RadioactiveContam

bulk

1.1e+02 uBq/kg +/- 19%

U238

RadioactiveContam

bulk

70 uBq/kg +/- 20%

(3.8+/-1.1)e+02 day

(2.7+/-0.8)e+04 day

Th232

RadioactiveContam

bulk

21 uBq/kg +/- 33%

(1.1+/-0.3)e+02 day

(8.8+/-2.9)e+04 day

K40

RadioactiveContam

bulk

23 uBq/kg +/- 26%

(1.3+/-0.3)e+02 day

(8.0+/-2.1)e+04 day

copper activation

CosmogenicActivation

bulk

61.1 day/kg

Mn54

CosmogenicActivation

bulk

4.7.1 day/kg

3e+02 day

0 day

Co57

CosmogenicActivation

bulk

37.1 day/kg

2.3e+03 day

0 day

Co60

CosmogenicActivation

bulk

19.1 day/kg

1.2e+03 day

8.3e+03 day

inner radon

RadonExposure

surface

0.085 Bq cm/m²

0.22 day

0 day

outer radon

RadonExposure

surface

2.5 Bq cm/m²

6.6 day

0 day

- + Click a cell to draw the associated spectrum

For additional information, contact:

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