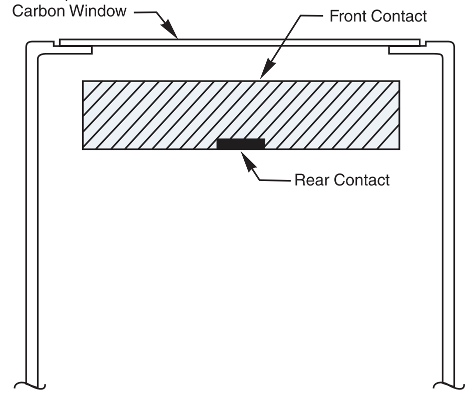
CANBERRA

Broad Energy Ge Detectors (BEGe)

Features

- Spectroscopy from 3 keV up to 3 MeV
- High efficiency at low to mid energies
- Thin and stable window
- High resolution at low and high energies
- Standardized geometries
- Diode FET protection
- Warm-up/HV shutdown

Description



The CANBERRA Broad Energy Ge (BEGe) Detector covers the energy range of 3 keV to 3 MeV like no other. The resolution at low energies is equivalent to that of our Low Energy Ge Detector and the resolution at high energy is comparable to that of good quality coaxial detectors.

Most importantly the BEGe has a short, fat shape which greatly enhances the efficiency below 1 MeV for typical sample geometries. This shape is chosen for optimum efficiency for real samples in the energy range that is most important for routine gamma analysis. This is in stark contrast to the traditional relative efficiency measurement – a ^{60}Co point source at 25 cm which is hardly a relevant test condition for real samples. See the adjacent figure comparing detector efficiencies for the extremes of coaxial vs. BEGe geometries each having approximately 50% relative efficiency.

In addition to higher efficiency for typical samples, the BEGe exhibits lower background than typical coaxial detectors because it is more transparent to high energy cosmogenic background radiation that permeates above ground laboratories and to high energy gammas from naturally occurring radioisotopes such as ^{40}K and ^{208}Tl (thorium). This aspect of thin detector performance has long been recognized in applications such as actinide lung burden analysis.

Most Low Energy Detectors are aptly named because they do not give good resolution at higher energies. In fact resolution is not usually specified above 122 keV. The BEGe represents a breakthrough in this respect. The BEGe is designed with an electrode structure that enhances low energy resolution *and* is fabricated from select germanium having an impurity profile that improves charge collection (thus resolution and peak shape) at high energies. Indeed, this ensures good resolution and peak shape over the entire mid-range which is particularly important in analysis of the complex spectra from uranium and plutonium.

In addition to routine sample counting, there are many applications in which the BEGe Detector really excels. In internal dosimetry the BEGe gives the high resolution and low background need for actinide lung burden analysis and the efficiency and resolution at high energy for whole body counting. The same is true of certain waste assay systems particularly those involving special nuclear materials.

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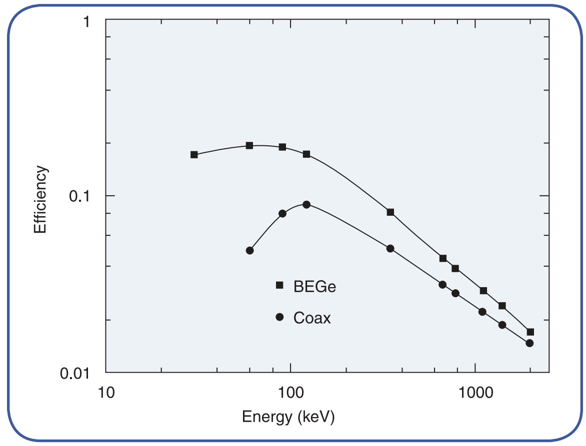
Broad Energy Ge Detectors (BEGe)

The BEGe detector and associated preamplifier are normally optimized for energy rates of less than 40000 MeV/sec. Charge collection times prohibit the use of short amplifier shaping time constants. Resolution is specified with an optimum shaping time constant and Lynx® digital peaking time equivalent.

Another big advantage of the BEGe is that the detector dimensions are virtually the same on a model by model basis. This means that like units can be substituted in an application without complete recalibration and that computer modeling can be done once for each detector size and used for all detectors of that model.

Absolute Efficiency of BE5030 compared to a Coaxial Detector of 65 mm diameter by 65 mm length for a source measuring 74 mm diameter by 21 mm thick located on the detector end cap. Both detectors have approximately 50% Relative Efficiency for a ^{60}Co point source at 25 cm.

With cross-sectional areas of 20 to 50 cm^2 and thickness' of 20 to 30 mm, the nominal relative efficiency is given below along with the specifications for the entire range of models. BEGe detectors are normally equipped with our low background composite carbon windows. Beryllium or aluminum windows are also available.



Typical Absolute Efficiency Curves of BE5030 and GC5019 Detectors with 74 mm in diameter and 21 mm thick sample positioned on endcaps

BEGe GERMANIUM DETECTOR

General Specifications and Information

Standard configuration includes:

- Vertical Slimline dipstick cryostat with 0.6 mm Carbon Composite window and 30 liter Dewar.
- Model 2002C preamplifier with 3 meter bias, high voltage inhibit, signal and power cables.

Specify cryostat option from options price list.

Relative efficiency is a ***typical value***, not a spec limit.

Model Number	Area (cm^2)	Thickness (mm)	Typical Rel. Eff. (%) ≥	Full Width Half Max (FWHM) Resolution (keV)			Endcap diameter mm (in.)
				At 5.9 keV energy	At 122 keV energy	At 1332 keV energy	
BE2020	20	20	9	0.35	0.65	2.00	76 (3.0)
BE2820	28	20	13	0.40	0.70	2.00	82 (3.25)
BE2825	28	25	19	0.40	0.70	2.00	82 (3.25)
BE3820	38	20	21	0.45	0.75	2.10	89 (3.50)
BE3825	38	25	28	0.45	0.75	2.10	89 (3.50)
BE3830	38	30	34	0.45	0.75	2.10	89 (3.50)
BE5020	50	20	28	0.50	0.75	2.20	102 (4.0)
BE5025	50	25	37	0.50	0.75	2.20	102 (4.0)
BE5030	50	30	50	0.50	0.75	2.20	102 (4.0)

Above specifications are in accordance with IEEE Std 325-1996. Resolution performance is tested with Lynx digital MCA. For resolution performance guarantee using other CANBERRA digital MCAs consult factory.

ISO 9001 SYSTEM CERTIFIED

Germanium Well Detector

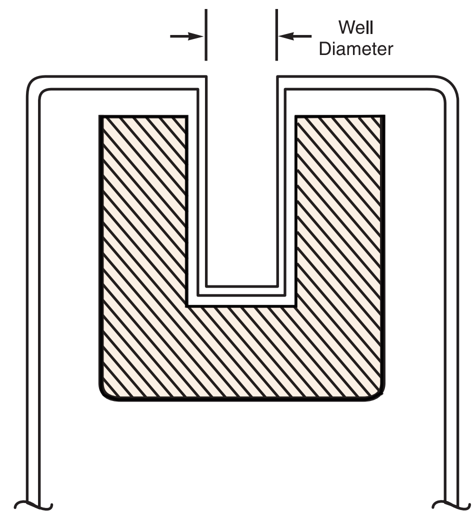
CANBERRA

Features

- Near 4π counting geometry
- Blind well for high efficiency
- Large well sizes available
- Diode FET protection
- Warm-up/HV shutdown
- High rate indicator

Description

The CANBERRA Germanium Well Detector provides maximum efficiency for small samples because the sample is virtually surrounded by active detector material. The CANBERRA Well detector is fabricated with a blind hole rather than a through hole, leaving at least 5 mm of active detector thickness at the bottom of the well. The counting geometry therefore approaches 4π.

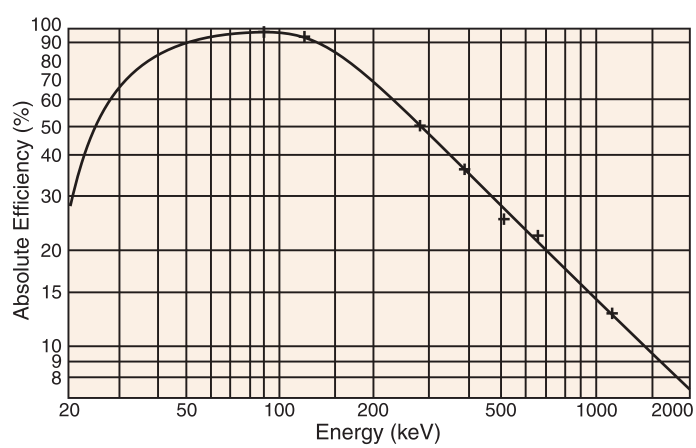


Ge Well Detector

Germanium Well Detectors are made from high-purity germanium and can therefore be shipped and stored at room temperature without harm. Unlike lithium-drifted detectors, high-purity germanium detectors may be cycled repeatedly between LN_2 and room temperature with no compromise in performance.

The cryostat end cap and well are fabricated from aluminum with a thickness of 0.5 mm in the vicinity of the well. The ion implanted or surface barrier contact on the detector element is negligibly thin compared to 0.5 mm of aluminum so these detectors have intrinsically good low energy response.

A variety of detector sizes and well diameters are available. The standard well depth is 40 mm for all detectors. Consult the accompanying table for information on standard units. Special well sizes and cryostat configurations are also available.



Measured efficiency of a Model GCW2522 with a mixed point standard located at the bottom of the 10 mm diameter Well.

Phone contact information

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For other international representative offices, visit our web site: **www.canberra.com** or contact the CANBERRA U.S.A. office.

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Germanium Well Detector

GERMANIUM WELL DETECTOR

General Specifications and Information

Standard configuration includes:

- Vertical slimline cryostat with 30 liter Dewar.
- Model 2002C preamplifier with 3 meter bias, H.V. inhibit, signal and power cables.

Specify cryostat option from options price list.

Resolution at 122 keV is typical value, not spec limit.

Model Number	Rel. Eff.	Well Dia.	Nominal Volume (cc)	Resolution	
				FWHM (122 keV)	FWHM (1332 keV)
GCW1020 GCW1022	10 10	10 16	70 80	1.2 1.4	2.0 2.2
GCW1521 GCW1522	15 15	10 16	90 100	1.2 1.4	2.1 2.2
GCW2021 GCW2022	20 20	10 16	110 120	1.2 1.4	2.1 2.2
GCW2522 GCW2523	25 25	10 16	130 140	1.2 1.4	2.2 2.3
GCW3022 GCW3023	30 30	10 16	150 160	1.2 1.4	2.2 2.3
GCW3522 GCW3523	35 35	10 16	170 180	1.2 1.4	2.2 2.3
GCW4022 GCW4023	40 40	10 16	190 200	1.2 1.4	2.2 2.3

Consult the factory for information on the availability of larger well detectors.

For Ra-228

$$^{228}\mathrm{Ra} \xrightarrow{\lambda_1} {}^{228}\mathrm{Ac} \xrightarrow{\lambda_2}$$

Sampling time : T_0 → $^{228}Ra=A1_0$

Precipitation time : T_1 → $^{228}Ra=A1_1$, $^{228}Ac=A2_1=0$

Mid of counting time : T_2 → $^{228}Ra=A1_2$, $^{228}Ac=A2_2$

$$A2_2 = A1_1 \times \frac{\lambda_2}{\lambda_2 - \lambda_1}[e^{-\lambda_1(T_2-T_1)} - e^{-\lambda_2(T_2-T_1)}]$$

$$A1_1 = A1_0 \times e^{-\lambda_1(T_1-T_0)}$$

isotope	half life	half life (d)	decay constant (d^{-1})
Ra-228	5.75 yr	2100.188	0.000330041
Ac-228	6.13 hr	0.255417	2.71378994
Th-228	1.913 yr	698.7233	0.00099202
Ra-224	3.62 d	3.62	0.191477122
Pb-212	10.643 hr	0.443458	1.563049172
Tl-208	3.053 min	0.00212	326.9347986
Ra-226	1600 yr	584400	1.18608E-06
Rn-222	3.823 d	3.823	0.181309752
Pb-214	26.8 min	0.018611	37.2437291
Bi-214	19.9 min	0.013819	50.15738392

For Ra-226

$$^{226}\mathrm{Ra} \xrightarrow{\lambda_1} {}^{222}\mathrm{Rn} \xrightarrow{\lambda_2} {}^{214}\mathrm{Pb} / {}^{214}\mathrm{Bi} \xrightarrow{\lambda_3}$$

(unsupported)

Sampling time : T_0 → $^{226}Ra=A1_0$

Precipitation time : T_1 → $^{226}Ra=A1_1$, $^{222}Rn=A2_1=0$

Sealed time : T_2 → $^{226}Ra= A1_2$, $^{222}Rn=A2_2=0$, ^{214}Pb / $^{214}Bi=A3_2=0$

Mid of counting time : T_3 → $^{226}Ra=A1_3$, $^{222}Rn=A2_3$, ^{214}Pb / $^{214}Bi=A3_3$

$$A3_3 = A1_2 \times \left\{ \frac{\lambda_2\lambda_3}{(\lambda_2-\lambda_1)(\lambda_3-\lambda_1)} e^{-\lambda_1(T_3-T_2)} + \frac{\lambda_2\lambda_3}{(\lambda_1-\lambda_2)(\lambda_3-\lambda_2)} e^{-\lambda_2(T_3-T_2)} + \frac{\lambda_2\lambda_3}{(\lambda_1-\lambda_3)(\lambda_2-\lambda_3)} e^{-\lambda_3(T_3-T_2)} \right\}$$

$$A1_2 = A1_0 \times e^{-\lambda_1(T_2-T_0)}$$

Fact and calculation sheets are revised from the version provided by Weifang Chen. The std sheet is calculated based on the fact sheet.

Sample ID	PN08_2m

Detector #	Mid of sampling time (T_0)
1599	2011/5/16 18:37

$BaSO_4$ P.P. time (T_1)	Sealed Time (T_2)
2013/1/6 17:03	2013/1/7 14:26

Counting Started	Elapsed time (s)	Mid of counting time (T_3)
2013/2/7 11:02	84404.5	2013/2/7 22:45

isotope	half life	half life (d)	decay constant (d^{-1})
Ra-228	5.75 yr	2100.1875	0.000330041
Ac-228	6.13 hr	0.255416667	2.71378994
Th-228	1.913 yr	698.72325	0.00099202
Ra-224	3.62 d	3.62	0.191477122
Pb-212	10.643 hr	0.443458333	1.563049172
Tl-208	3.053 min	0.002120139	326.9347986
Ra-226	1600 yr	584400	1.18608E-06
Rn-222	3.823 d	3.823	0.181309752
Pb-214	26.8 min	0.018611111	37.2437291
Bi-214	19.9 min	0.013819444	50.15738392

Ra-228 → Ac-228

Time elapsed (d): T_3-T_1= 32.238 T_1-T_0= 600.935

Decay corr. (1)= 0.990 Decay corr. (2)= 0.820

For Ra-228

isotope	Factor	energy	counts		Uncertainty	Ac-228 activity at T_3 (dpm)			Ra-228 activity at T_1 (dpm)			Ra-228 activity at T_0 (dpm)			Average (dpm)	std
Ac-228	**30.23**	338.4	387	±	10.29	8.316	±	0.856	8.404	±	0.865	10.248	±	1.055	**10.28**	**0.68**
Ac-228	**34.45**	911.07	342	±	8.22	8.375	±	0.688	8.464	±	0.696	10.321	±	0.848		

Ra-226 → Rn-222 → Pb-214/Bi-214

Time elapsed (d): T_3-T_2= 31.347 T_2-T_0= 601.826

Decay corr. (1)= 0.997

Decay corr. (2)= 0.997 Decay corr. (3)= 0.999

For Ra-226

isotope	Factor	energy	counts		Uncertainty	Pb-214/Bi-214 activity at T_3 (dpm)			Ra-226 activity at T_2 (dpm)			Ra-226 activity at T_0 (dpm)			Average (dpm)	std
Pb-214	**14.3**	295.22	653	±	7	6.657	±	0.477	6.680	±	0.478	6.685	±	0.479	**5.72**	**0.28**
Pb-214	**8.5**	351.99	789	±	6	4.744	±	0.282	4.760	±	0.283	4.764	±	0.283		
Bi-214	**24.2**	609.32	367	±	9	6.303	±	0.570	6.325	±	0.572	6.330	±	0.572		