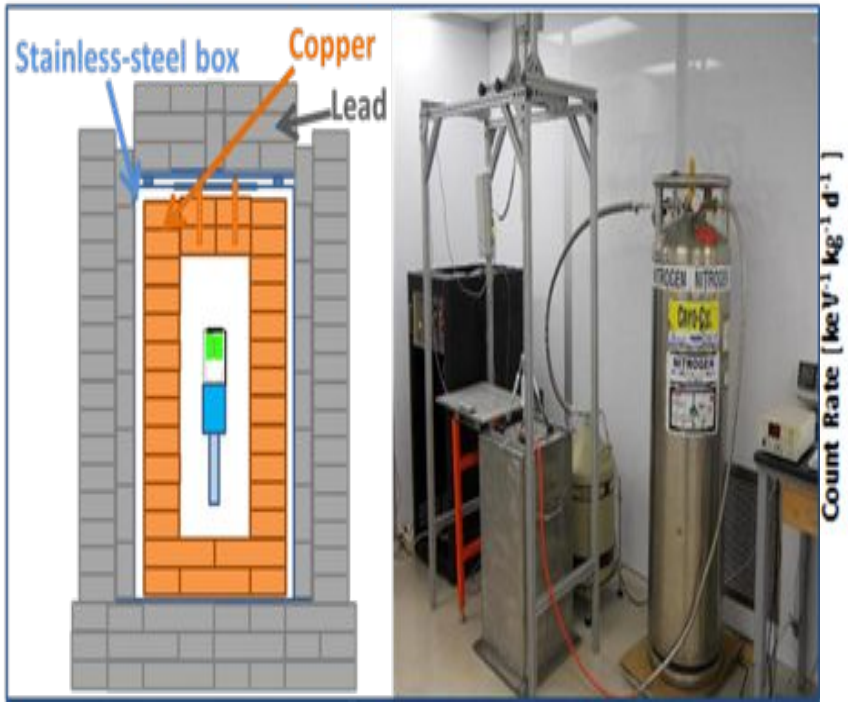
CUBED Low Background Counting

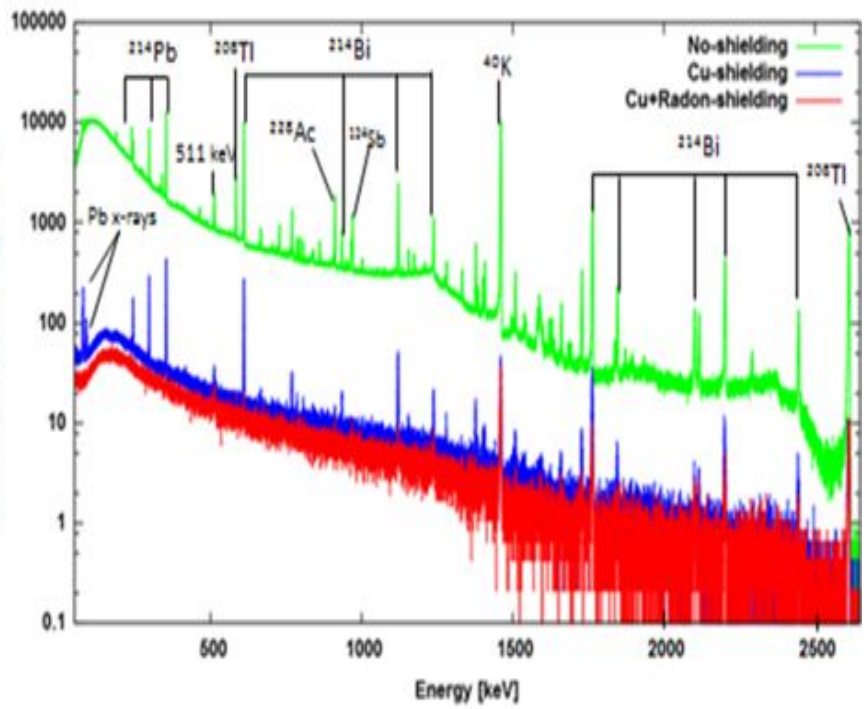
Dongming Mei for CUBED Collaboration

CUBED LBC

- LBC shielding
  - N-type



- Measured background spectrum

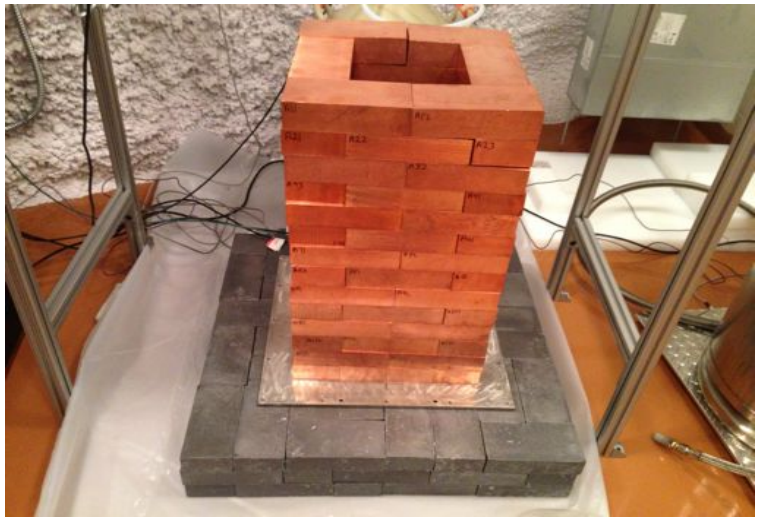


Sensitivity without lead shield

$$MDA = \frac{\alpha\sqrt{N_b}}{r_b \Delta T \varepsilon M}$$, where *(MDA)* is in Bq/kg or Bq/PMT, α is a constant that equals to 1.64 at 90%

Nuclei	Energy (keV)	NB	Time	B. Rati o	Effi cienc	Sensiti vit (mBq/kg)
226Rn	186.1		600000	0.0359	0.0319	
212Pb	238.0	38	600000	0.0743	0.0260	8.73
214Pb	295.2	112 (45)	600000	0.193	0.0242	6.20
214Pb	353.3	267 (64)	600000	0.3760	0.0224	5.30
208Tl	583.0	153	600000	0.3060	0.0139	7.94
214Bi	609.3	751 (84)	600000	0.4615	0.0143	11.36
228Ac	911.0	142 (48)	600000	0.1910	0.0116	14.66
40K	1461.0	6449 (120)	600000	0.1100	0.0100	199.55
214Bi	1764.5	1482 (150)	600000	0.1540	0.0094	72.90
208Tl	2614.5	2642 (190)	600000	0.3563	0.0051	76.85

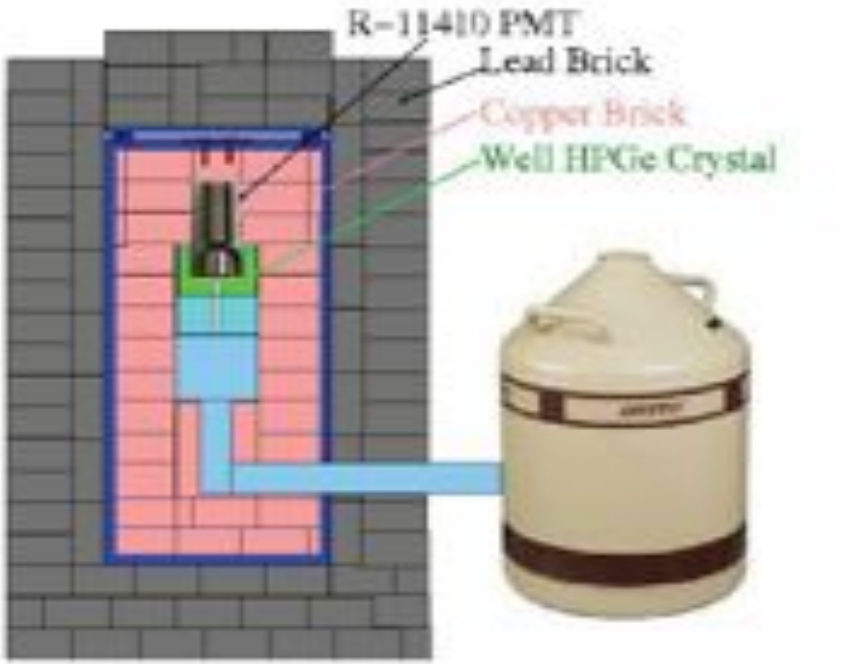
Started to build lead shield



15-cm thick lead bricks as the external shield which would reduce external gamma rays by factor of ~1000.

The final sensitivity for ^{238}U and ^{232}Th is at a level of ~0.5 mBq/kg (0.1 ppb) and for ^{40}K is ~2 mBq/kg

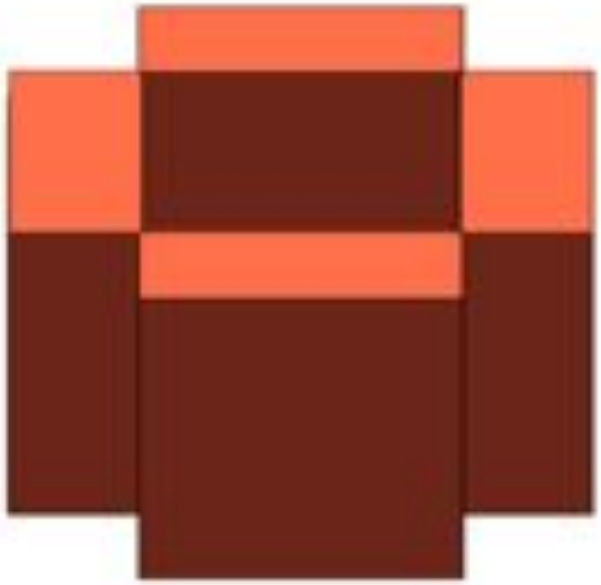
Germanium Well Detector



Screening PMTs
for a level of 1mBq

Sources	Germanium Well Detector (3.48 kg)					
^{238}U	186keV ^{226}Ra		352keV ^{214}Pb		609keV ^{214}Bi	
Parameters	ε	r_b	ε	r_b	ε	r_b
	0.45	0.06	0.31	0.46	0.21	0.414
Counting	0.7 days		0.133 days		0.218 days	
^{232}Th	239keV ^{212}Pb		727keV ^{212}Bi		911keV ^{228}Ac	
Parameters	ε	r_b	ε	r_b	ε	r_b
	0.34	0.825	0.19	0.055	0.17	0.229
Counting	0.068 days		1.816 days		0.489 days	

Well Ge Detector & PMT

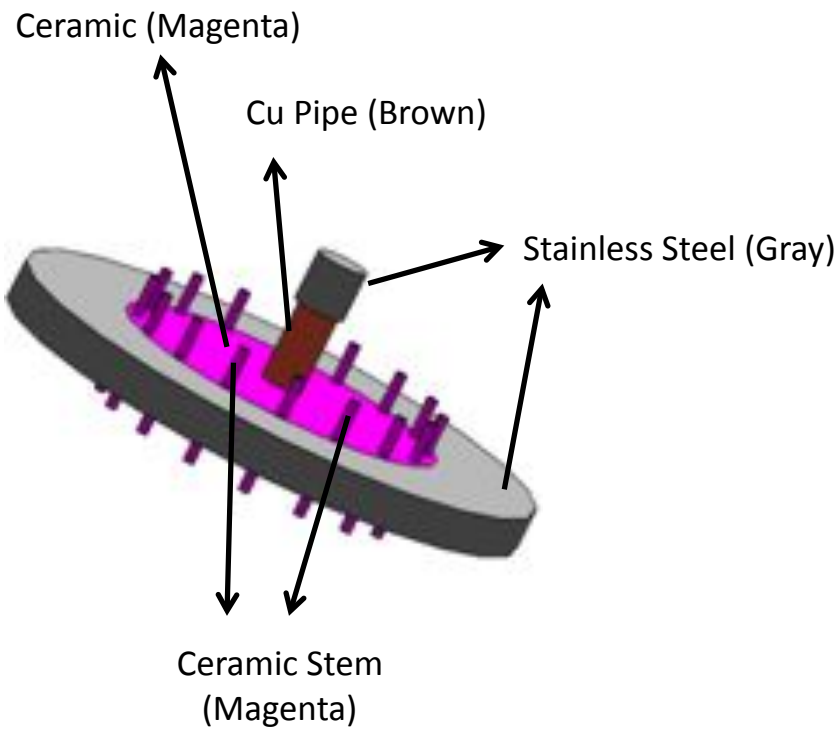


Well Ge Detector

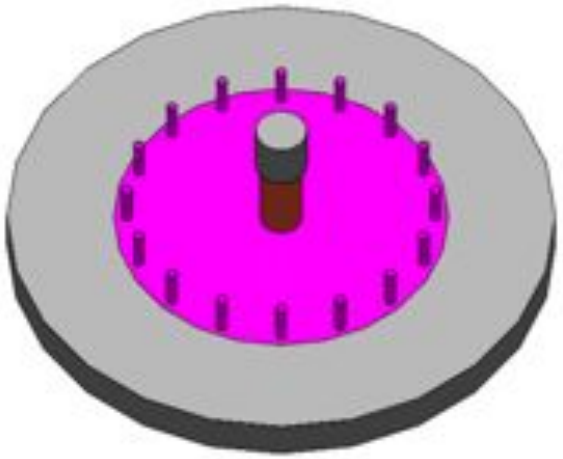
Well Detector + PMT

Crystal (Ge):10cm*10cm*4cm
Thickness of Copper: 2 mm

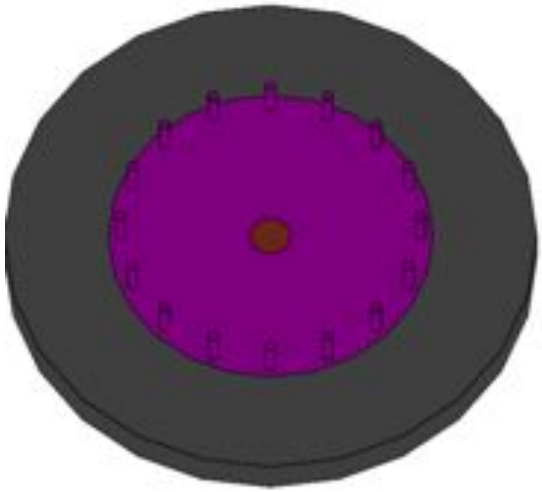
PMT Lid



Side View

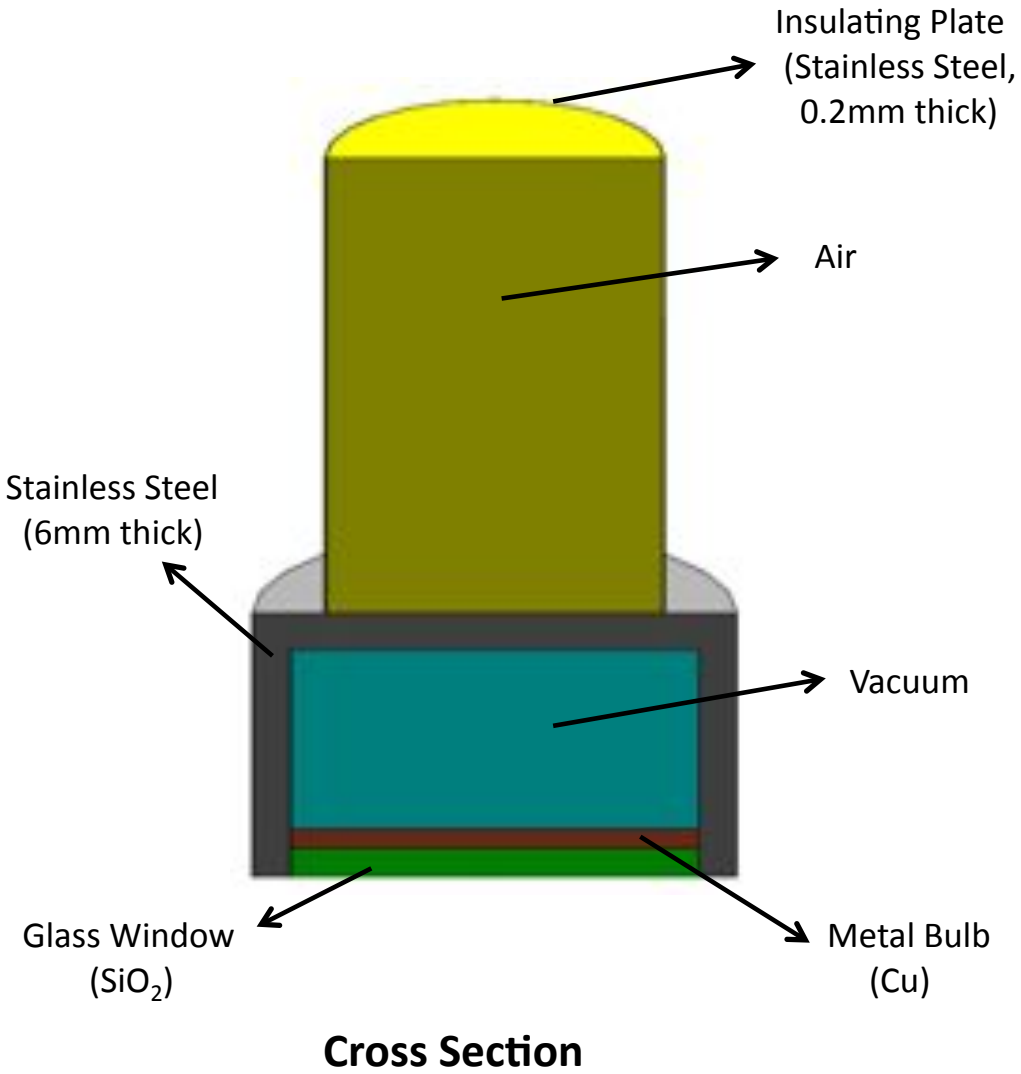


Top View

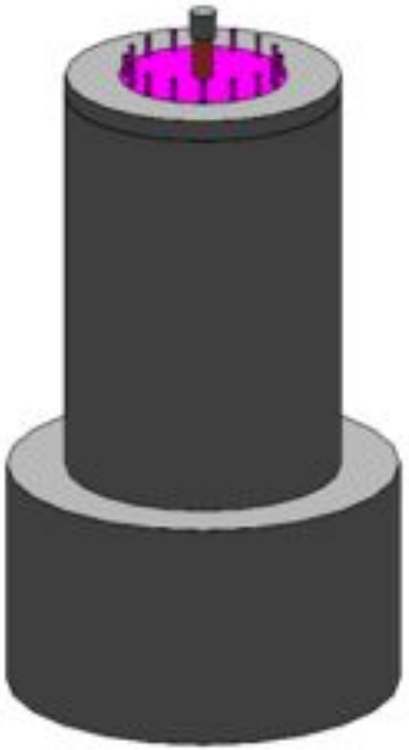


Bottom View

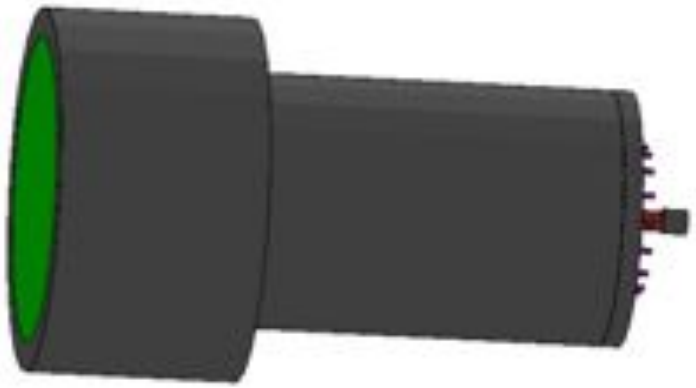
PMT (Cont.)



Cross Section

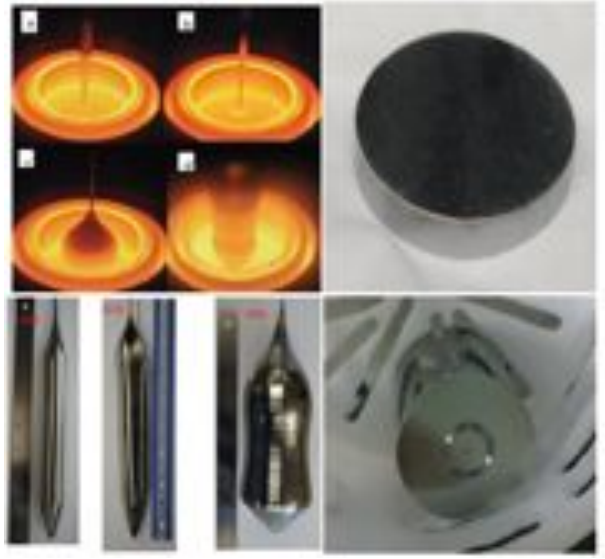


Front View

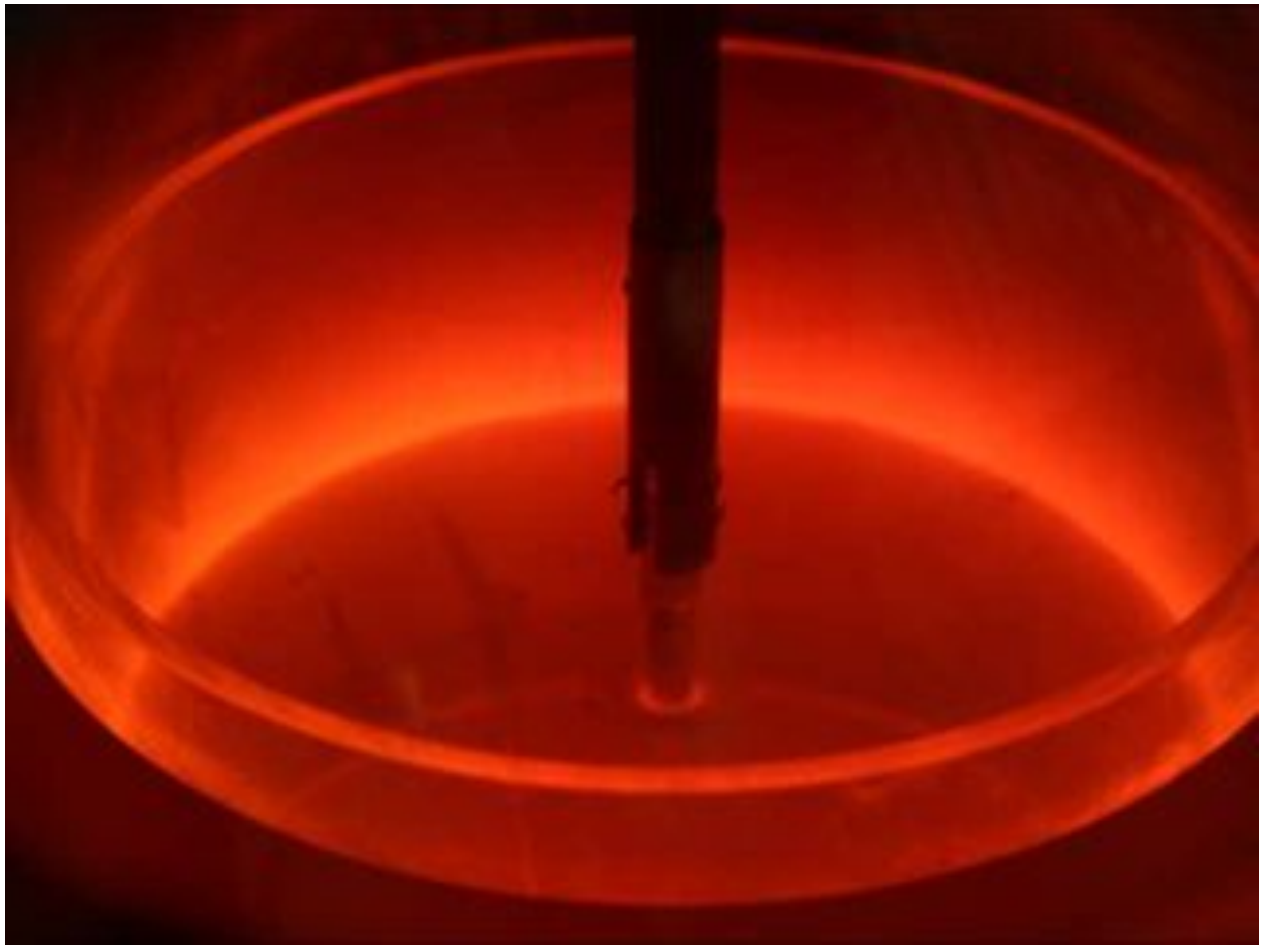


Side View

CUBED crystal growth



Zone Refining, HPGe Crystal Growth, Detector Development



Large-Size Germanium Crystal Growth

DE-FG02-10ER46709

Upper: diameter: 11.5 cm; length: 17 cm; weight: 4809 g

Lower: the useful detector portion: D >10 cm; thickness > 3.7 cm; weight > 2,000 g

Characterization of Crystals

Samples	Impurity Level	Mobility	Resistivity	Dislocation
1-Top	$2.9x10^{10}/cm^3$	42,710 cm^2/Vs	5,027 Ω•cm	$330/cm^2$
1-Bottom	$1.21x10^{11}/cm^3$	28,700 cm^2/Vs	1,807 Ω•cm	$5,280/cm^2$
2-Top	$2.2x10^{10}/cm^3$	41,340 cm^2/Vs	6,850 Ω•cm	$470/cm^2$
2-Bottom	$6.4x10^{10}/cm^3$	38,640 cm^2/Vs	2,520 Ω•cm	$6,140/cm^2$
3-Top	$3.4x10^{10}/cm^3$	40,780 cm^2/Vs	4,510 Ω•cm	$2,030/cm^2$
3-Bottom	$5.8x10^{10}/cm^3$	30,560 cm^2/Vs	3,510 Ω•cm	$6,350/cm^2$

Dislocation density from the top

Dislocation density from the bottom

First Detector Fabricated at LBL by Mark Amman

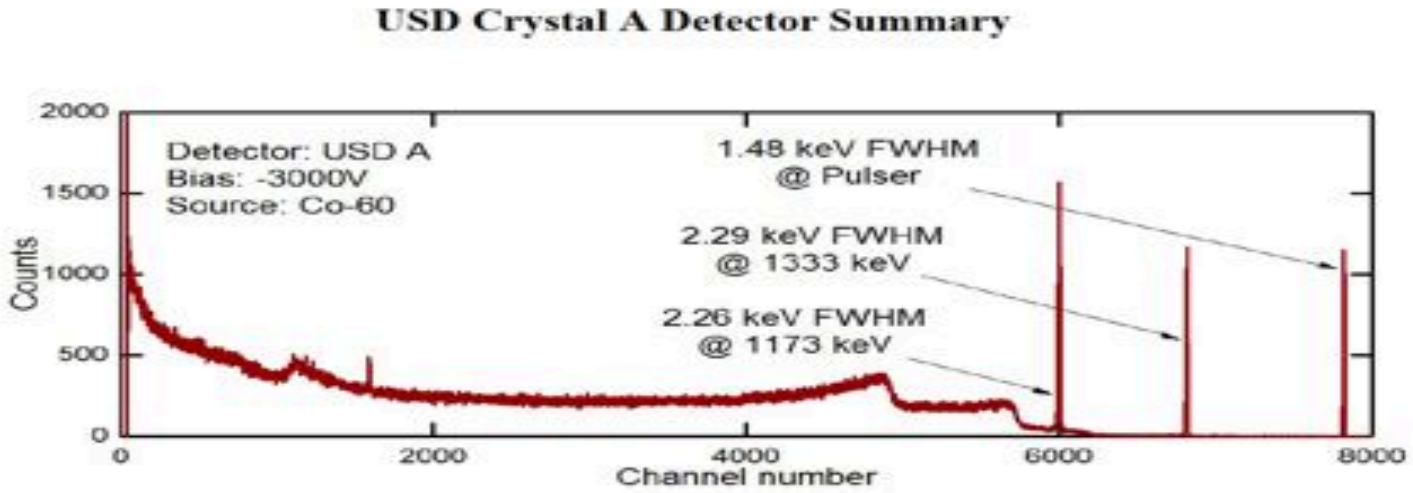


Figure 1: Spectrum from a Co-60 source measured with the USD crystal A detector. The source was positioned facing the top of the detector. The bias voltage of -3000 V was applied to the bottom electrical contact on the detector while the signals were measured from the top.

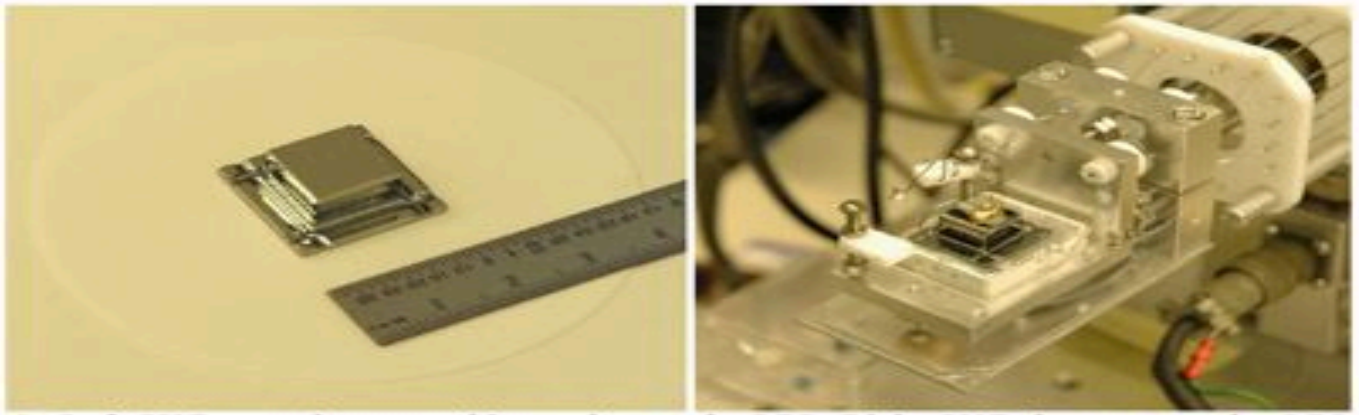


Figure 2: Left: USD crystal converted into a detector by LBL. Right: USD detector tested at LBL.