ULGS prospects of the depleted germanium left after the enrichment of Ge-76 for the GERDA experiment

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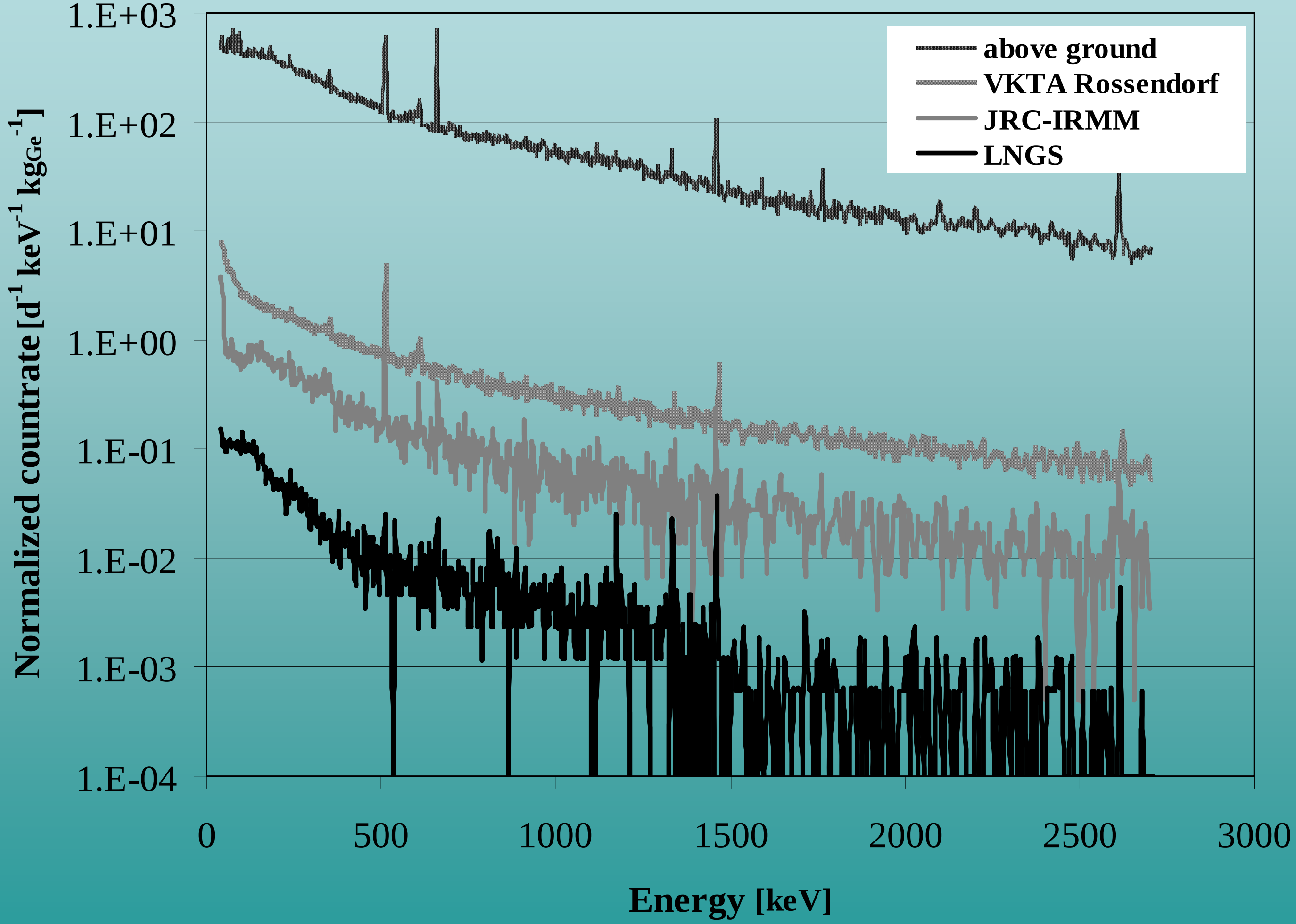
- The best blank spectra of ULGS facilities
- Background due to $2\beta2\nu$ decay of ^{76}Ge in the natural detectors
- Other intrinsic backgrounds: ^{68}Ge, ^{60}Co, ^{77}Ge
- Depleted and double depleted detectors and their backgrounds
- When depleted ULGS detector would be justified
- When depleted reference detector for GERDA would be justified
- Conclusions and open questions

The best blank spectra of ULGS facilities

M. Laubenstein et al. *Appl. Rad. Isotopes* 61 (2004) 167–172



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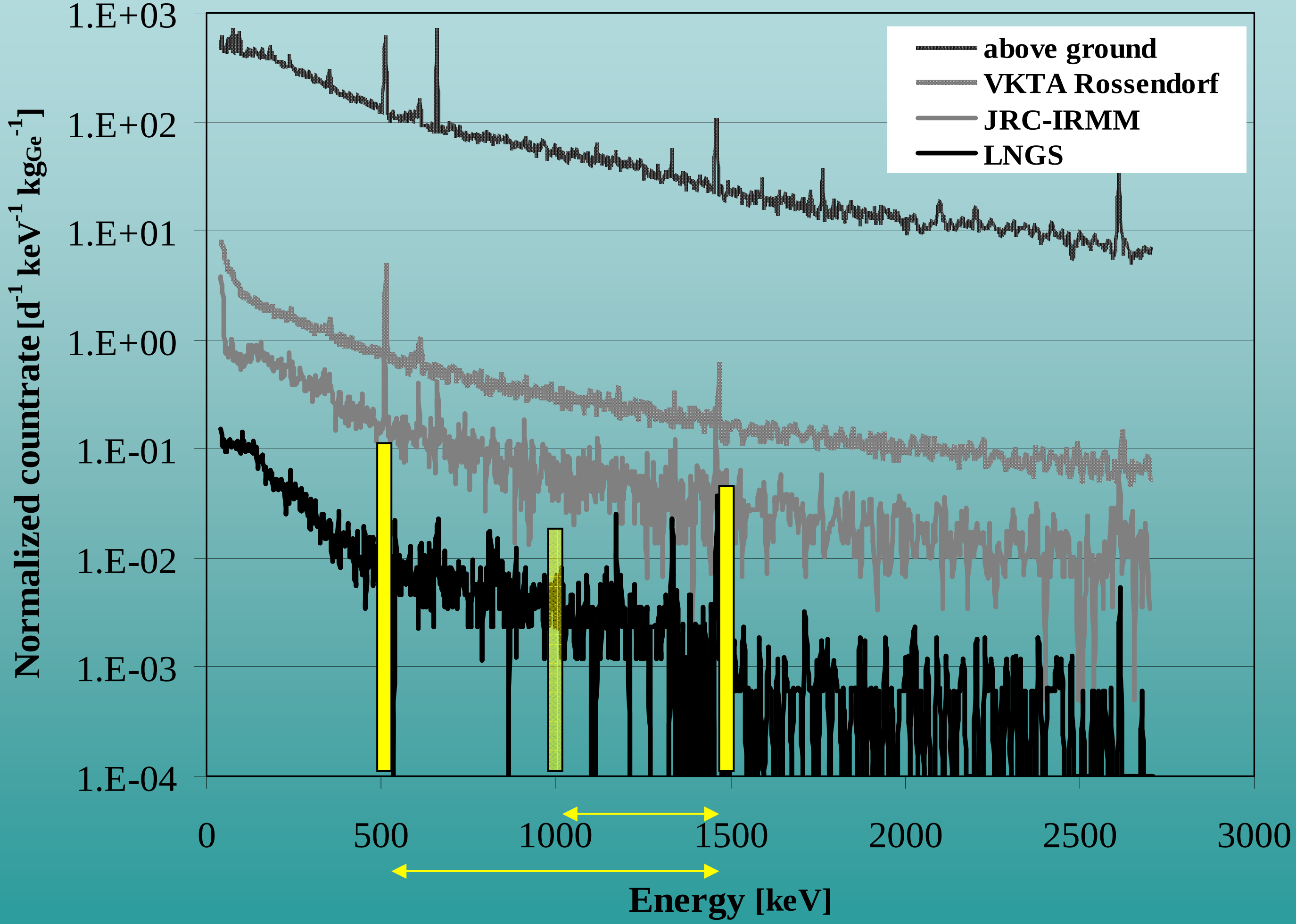


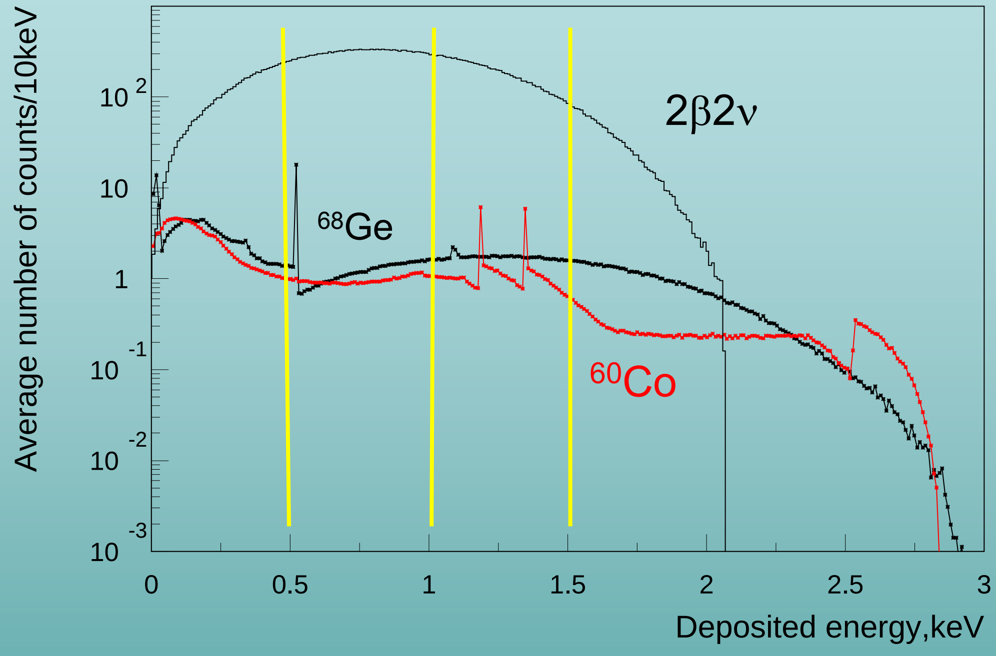
4.3 counts/kg/day
0.5 MeV to 1.5 MeV

1.1 counts/kg/day
1 MeV to 1.5 MeV

Background due to 2β2ν decay of 76Ge in the natural detectors

$T_{1/2}=(1.5\pm 0.1)\cdot 10^{21}$y

Ge-76 in natural detector:
0.7 counts/kg/day 0.5 to 1.5 MeV (1/6)
0.26 counts/kg/day 1 to 1.5 MeV (1/4)



Other intrinsic backgrounds

Ge-68 in saturation (nat. detector)
30 counts/kg/day 0.5 to 1.5 MeV

Co-60 20 d activation (nat. detector)
0.03 counts/kg/day 0.5 to 1.5 MeV

Ge-77 (nat. detector)
<0.005 counts/kg/day 0.5 to 1.5 MeV
(s=0.14 b, J= $(1.6 \pm 0.1)\cdot 10^{-6}$ n/cm^2/s)

2 kg Ge-76 detector, 5 year measurement (thanks to X. Liu). Efficient activation 20 d for Co-60, 40 d for Ge-68

Depleted and double depleted detectors and their intrinsic backgrounds

Isotope dependence of Co-60 production rate is weak

The only thing to care of is Ge-68

Ge, depleted from Ge-76 contains at the beginning all the saturated amount of Ge-68 from the initial natural Ge (33 counts/kg/day 0.5 to1.5 MeV)

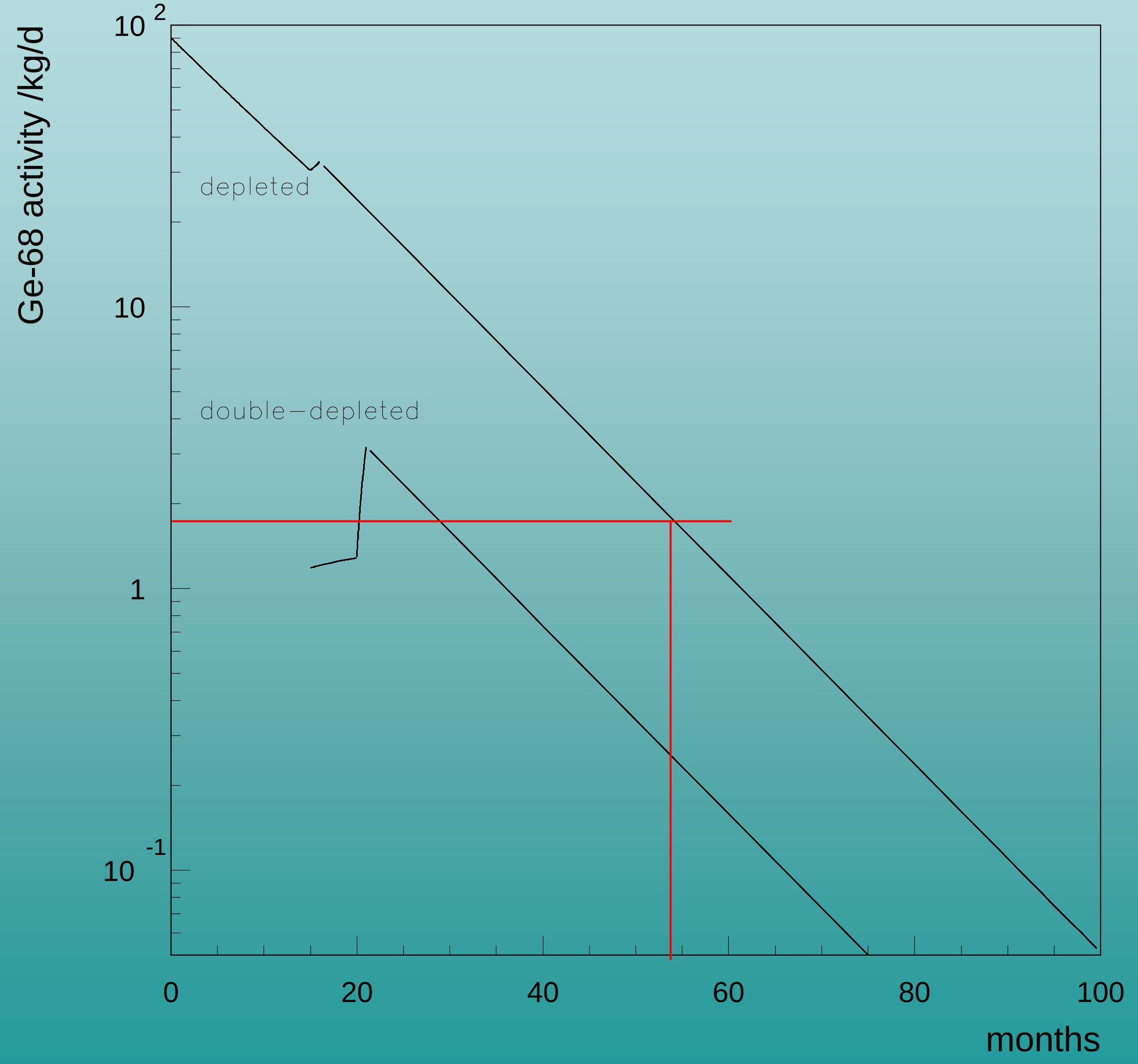
Production rates (per day per kg)
^{68}Ge

^{70}Ge	281.4
^{72}Ge	55.34
^{73}Ge	28.0
^{74}Ge	14.53
^{76}Ge	4.22

Germanium composition and activation rates

Ge isotope	70 (%)	72 (%)	73 (%)	74 (%)	76 (%)	^{68}Ge Activation rate, at/kg/d
enriched	0.015	0.075	0.165	12.5	87.25	5.6
natural	20.54	27.4	7.76	36.54	7.76	80.6
depleted	22	30	8.5	38.5	≤ 0.5	86.4
Double depleted	~1	38	11	48	≤ 0.5	37

Depleted and double depleted detectors and their backgrounds



Between depleted and double-depleted ΔT ~4.3 years of which more than 1 year is already passed

If after a long underground storage a 20 day activation happens, counting rate in the 0.5 to 1.5 MeV will be 1.7 counts/kg/d in a depleted detector, 0.6 counts/kg/d in double depleted one.

Anyway waiting is needed, but for ULGS it should be OK

When depleted ULGS detector would be justified

- Background rate in the newer natural detectors is appreciably less than in the shown spectrum.
- There are application, when the searched line in the range 0.5 to 1.5 MeV is not present in a background (continuous background is relevant)
- There exists possibility to share the batch of depleted material with other than ULGS consumers (e.g. ref. detectors for GERDA

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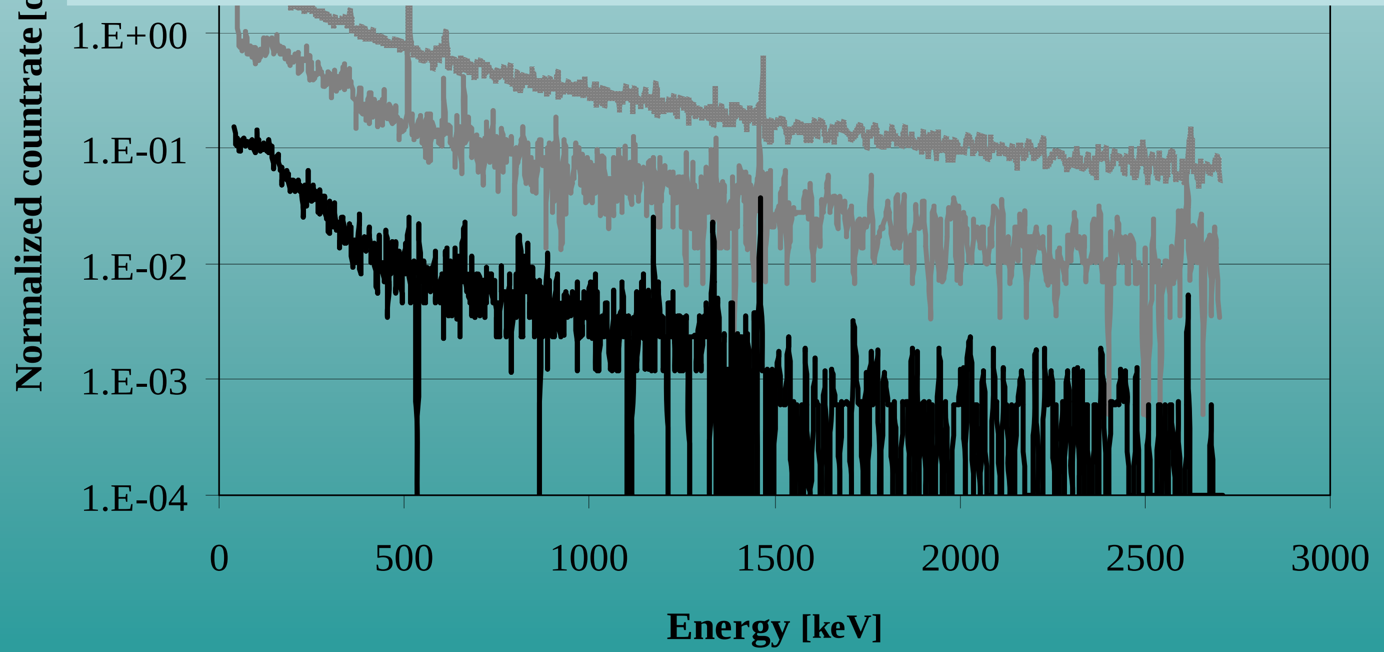

When depleted reference detector for GERDA would be justified

The role of a reference detector in the GERDA would be to measure the background **in a case** of positive signal observation.

In principle the bigger is the difference in the Ge-76 contents in the enriched and the reference detector, the higher is the statistical significance of a result.

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A numerical example (suppose that $2\beta0\nu$ decay exists):

$<{}^{enr}N_{0\nu2\beta}> = 5.6$ events over some exposure.

$<{}^{nat}N_{0\nu2\beta}> = 0.5$events

$<{}^{depl}N_{0\nu2\beta}> = 0.05$ events

$<{}^{depl}N_{bckg}> = <{}^{nat}N_{bckg}> = 0.25$ events

${}^{enr}N_{observed} = 6.$

Claiming discovery with a desired CL:

${}^{ref}N_{observed} < 2$

Probability to reject a discovery:

$P({}^{ref.nat}N_{observed} \geq 2) = 17.3\ \%$

$P({}^{ref.deplt}N_{observed} \geq 2) = 3.7\%$

Conclusions

- Observation of a good blank spectrum from one of the recent detectors is essential for a decision about depleted detectors. What is the counting rate of GeMPI-2 in the range 0.5 to 1.5 MeV ?
- Are there applications where low continuous background in the range 0.5 to 1.5 MeV is important?
- Observation of very low background in GERDA experiment with enriched detectors and observation of a small positive signal would be a strong arguments for depleted reference detector.
- At the time being it seems reasonable to provide formal reservation of the depleted material and its underground storage until new information essential for a decision about depleted detectors will be available.