Motivation for development and feasibility of the depleted reference detector

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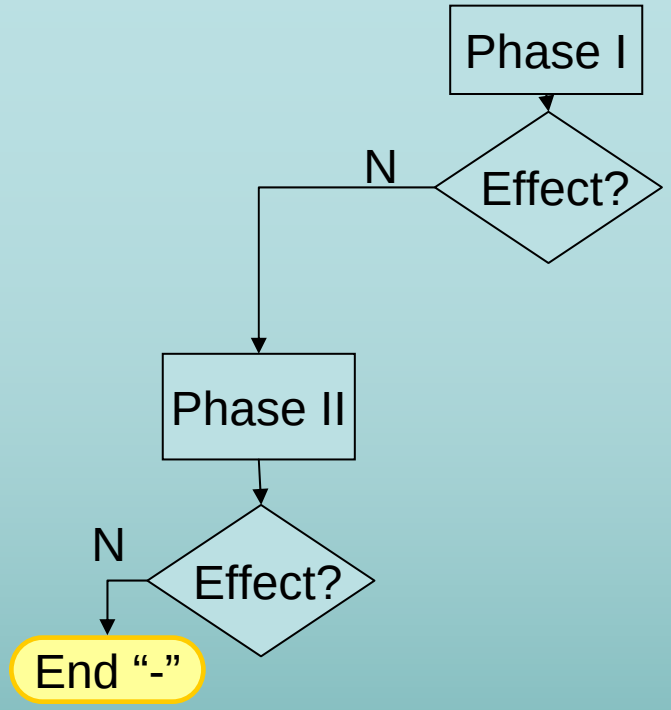
- When reference detector is certainly not needed.
- When reference detector is certainly needed.
- Backgrounds in enriched, natural, depleted, and double depleted detectors
- Comparison of natural, depleted and double depleted reference detectors
- Feasibility issues
- Conclusions



If result of the “Phase I” is compatible with flat background, and result of the “Phase II” is also compatible – no reference detector is required!

When do we need reference detector?

When we observe an effect and want to determine and subtract the background.

- Weak argumentation - $2\beta2\nu$ hinders us from determination of the background.

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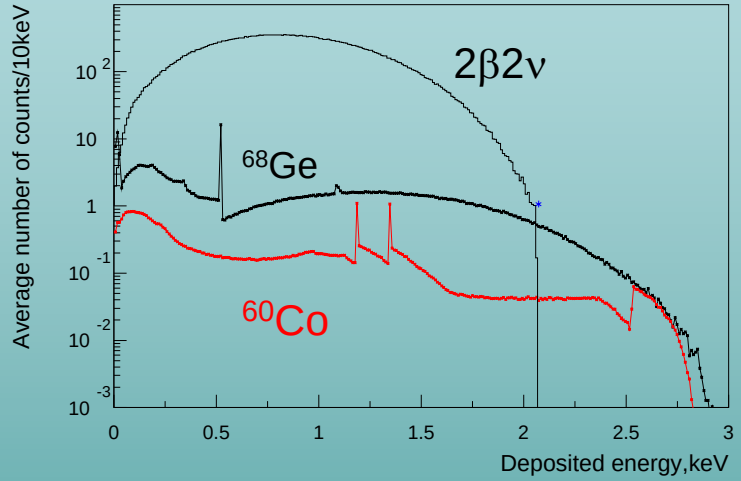

2 kg Ge-76 detector, 5 year measurement (thanks to X. Liu)

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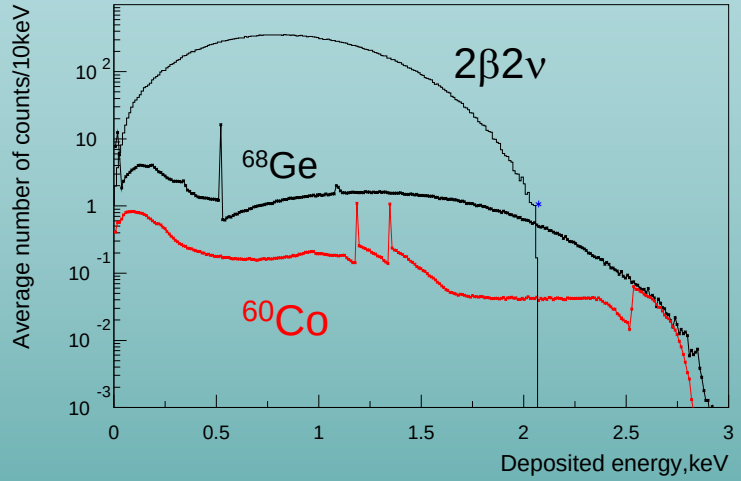
Solution without reference detector:

Coincidence between detectors (segments) may be required for these measurements.

Pro: Using enriched detector for measurement of cosmogenic activity, one avoids uncertainties of isotope dependence of activation rates.

Contra: Statistics decreases, and uncertainties of coincidence efficiency enter into business.



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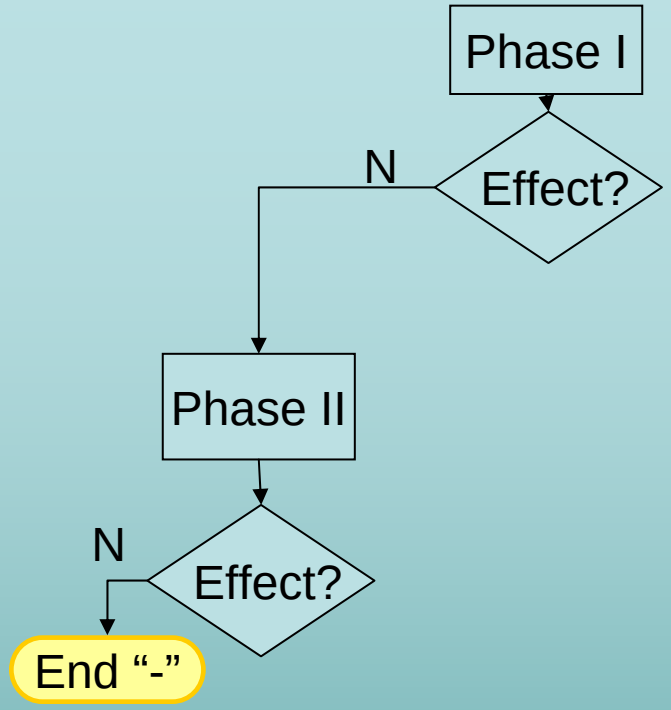
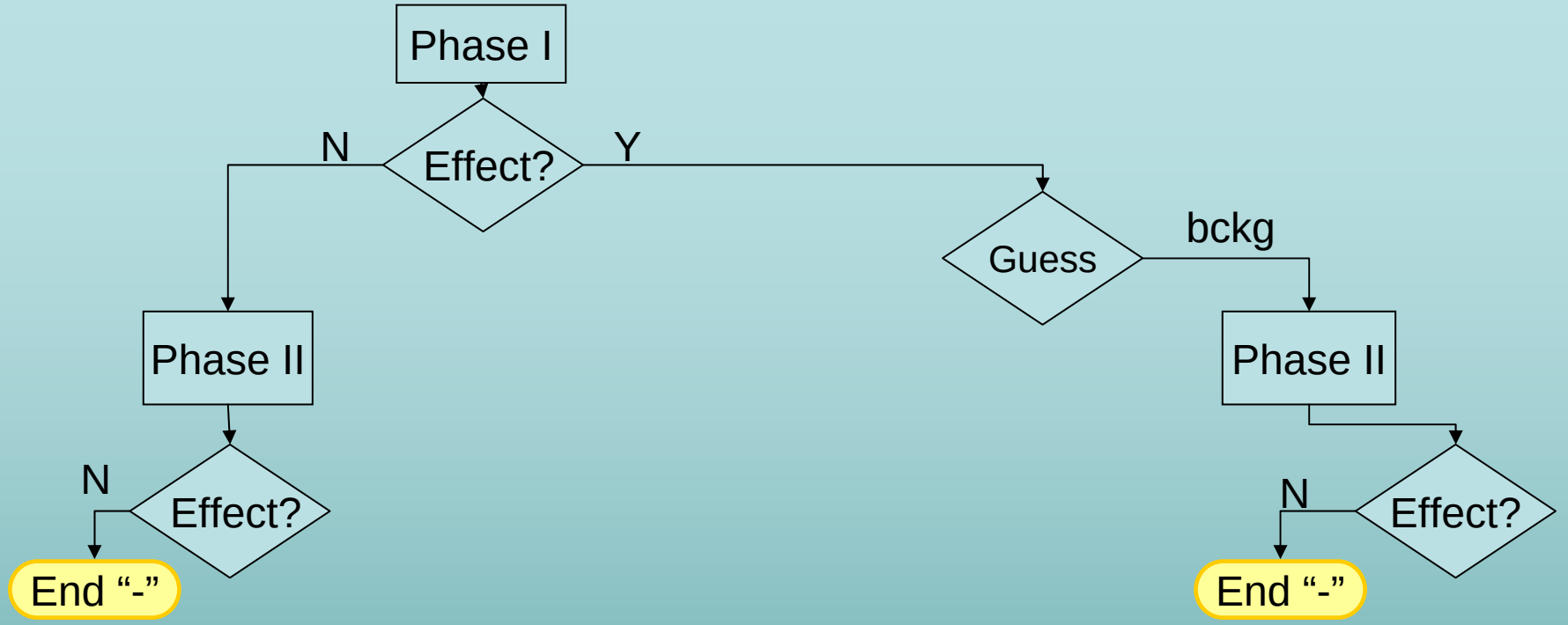
Strong argumentation – decreasing activity of the most active sources, we may start to see weak and/or unknown lines (e.g. μ- capture at Cu).

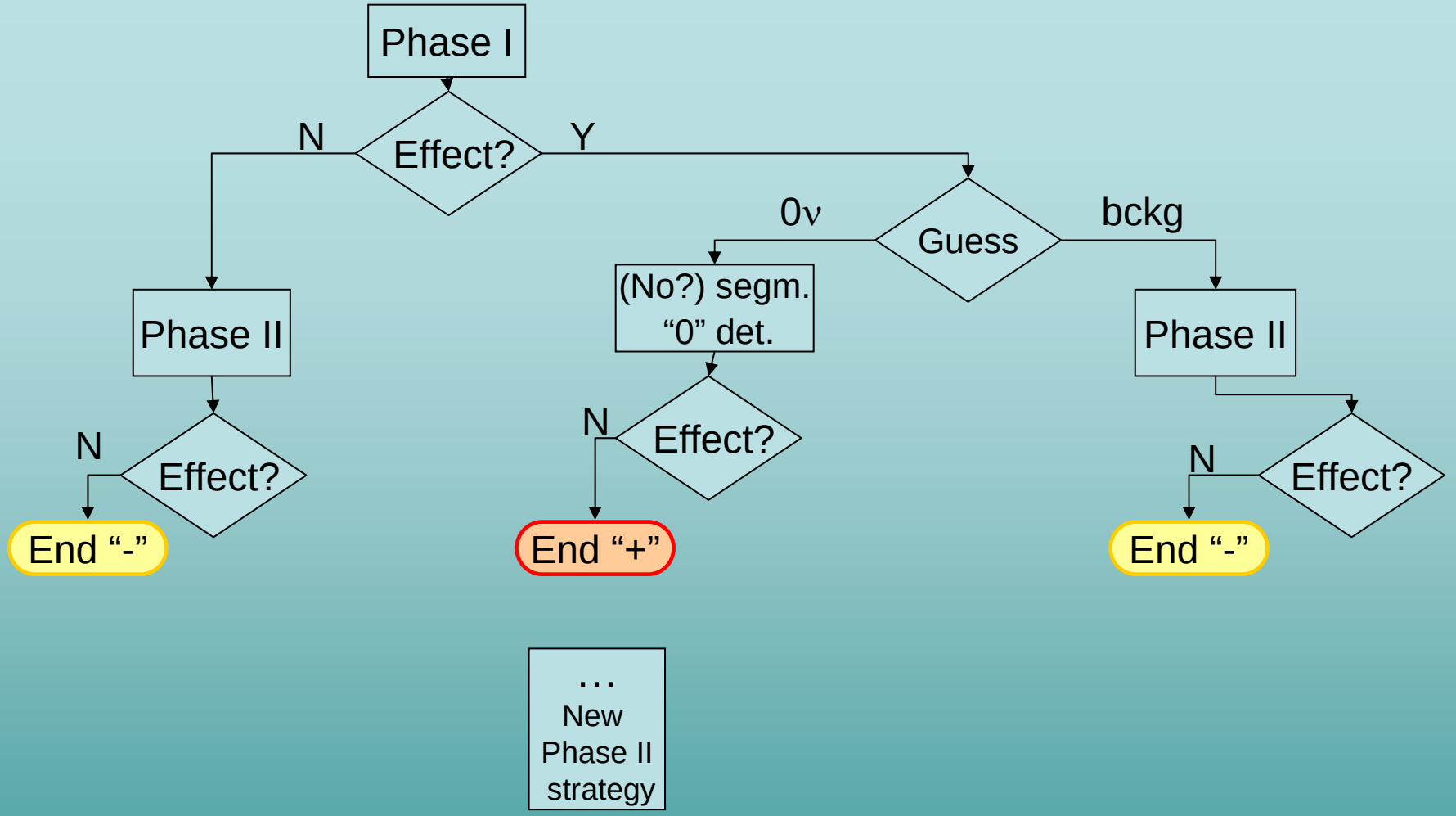
The fastest way to prove that the ***line*** is ***not*** a background is to use a reference detector with different Ge-76 contents.

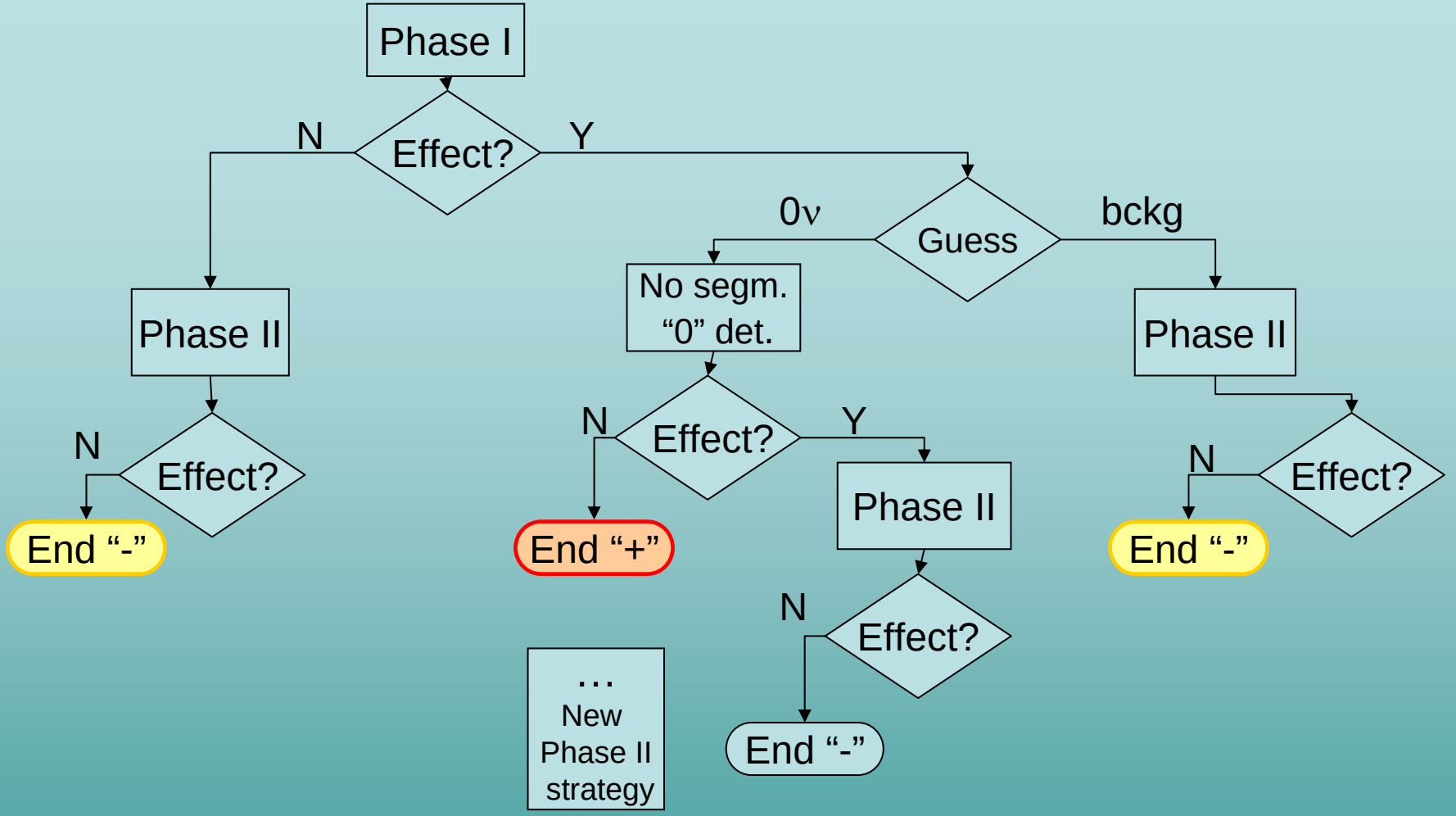
The bigger the difference, the better statistical validity of the proof is.

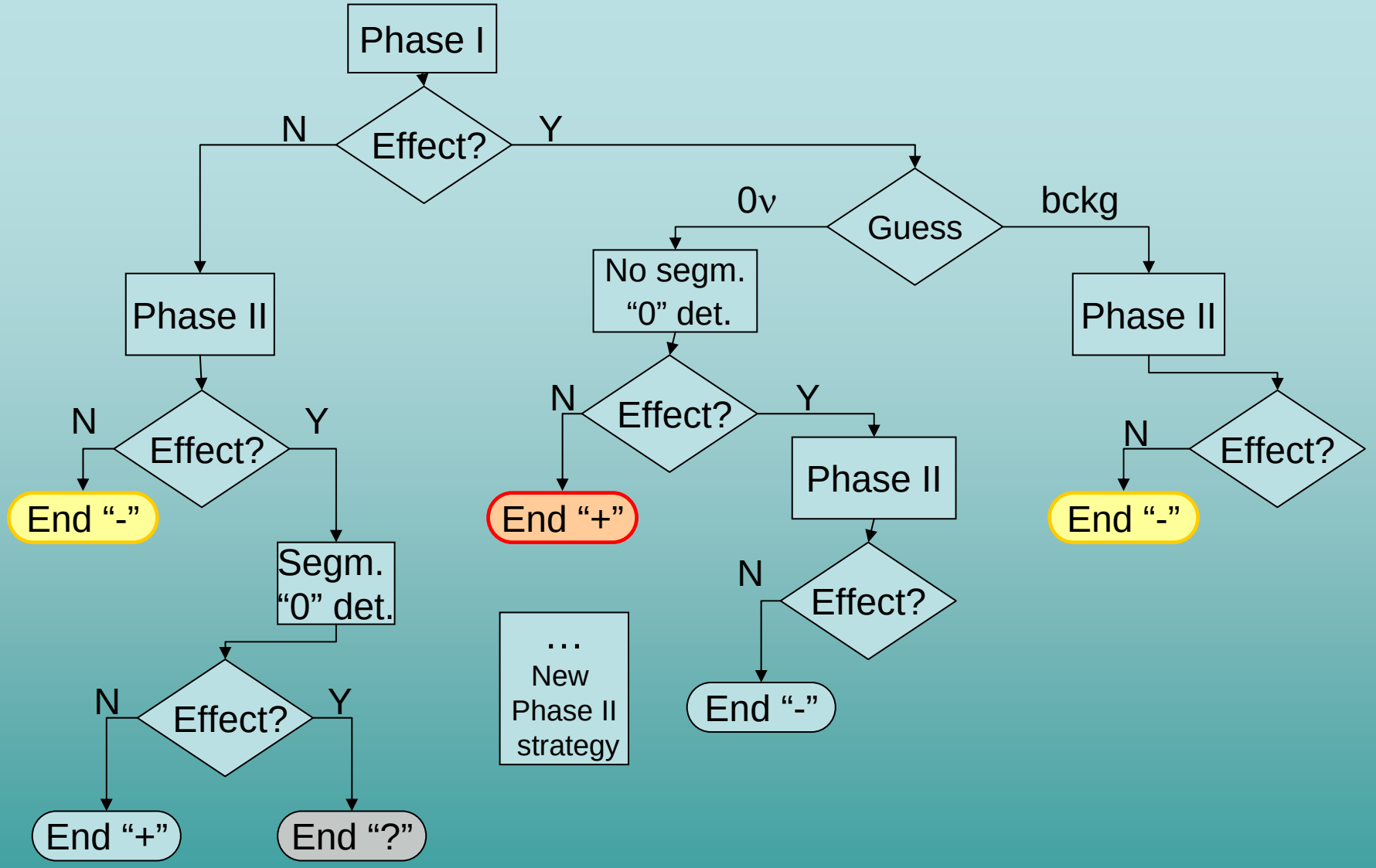
If one believes, that the ***line is*** background one, more advanced Ge-68 detector is preferable.

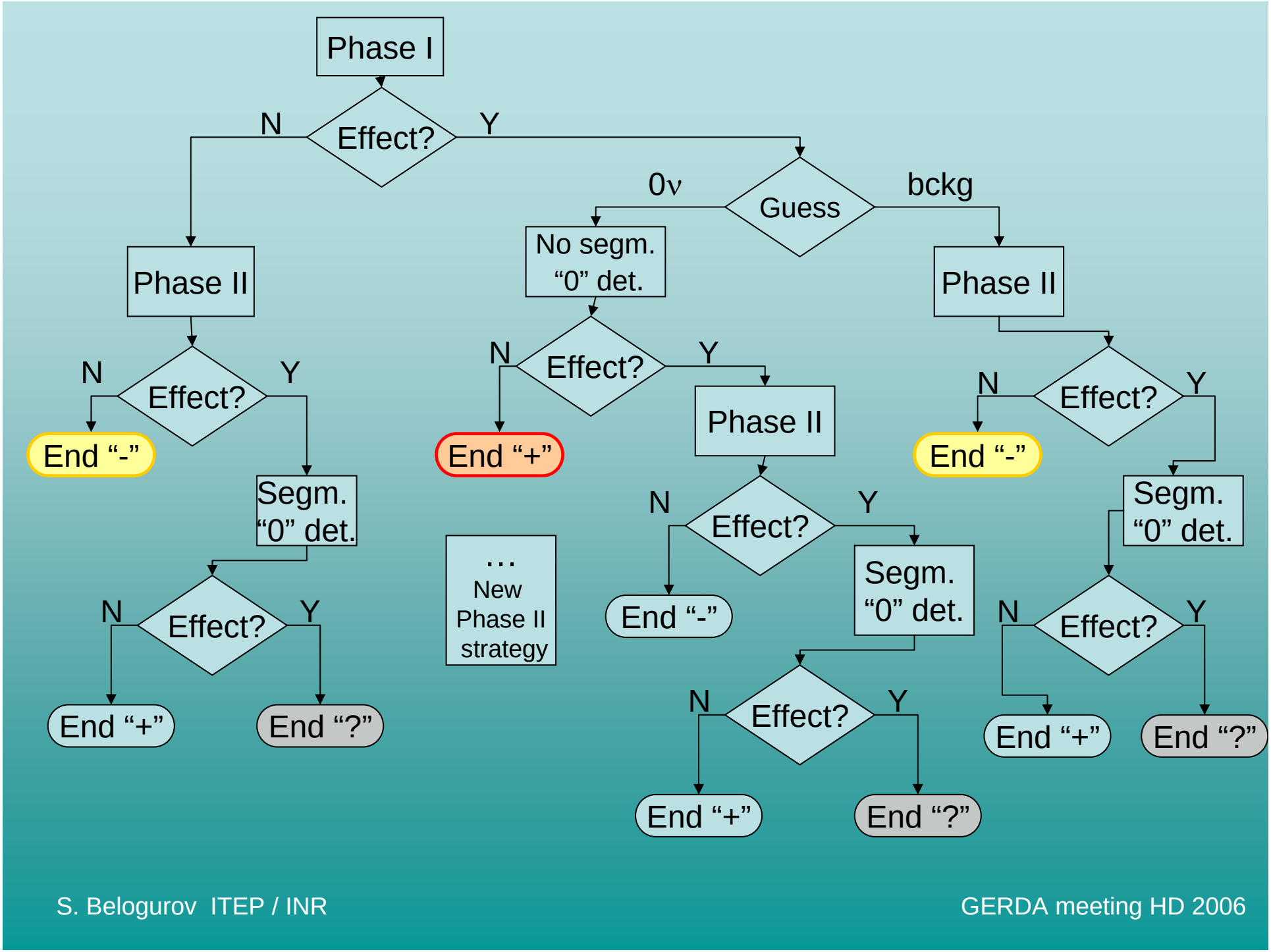

Phase I
Effect?
N
Phase II
Effect?
N
End “-”


Phase I
Effect?
N
Y
Phase II
Guess
bckg
Phase II
N
Effect?
N
Effect?
End “-”
End “-”


Phase I
Effect?
N
Y
Phase II
Guess
0ν
bckg
(No?) segm.
“0” det.
Phase II
N
Effect?
N
Effect?
N
Effect?
End “-”
End “+”
End “-”
…
New
Phase II
strategy


Phase I
Effect?
N
Y
Phase II
Guess
0ν
bckg
No segm.
“0” det.
Phase II
N
Effect?
N
Effect?
Y
N
Effect?
End “-”
End “+”
Phase II
End “-”
N
Effect?
…
New
Phase II
strategy
End “-”


Phase I
Effect?
N
Y
Phase II
Guess
0ν
bckg
No segm.
“0” det.
Phase II
Effect?
N
Y
End “-”
Segm.
“0” det.
Effect?
N
Y
End “+”
End “?”
Effect?
N
Y
End “+”
Phase II
Effect?
N
End “-”
…
New
Phase II
strategy
Effect?
N
Y
End “-”


Phase I
Effect?
N
Y
Phase II
Guess
0ν
bckg
No segm.
“0” det.
Phase II
Effect?
N
Y
End “-”
Segm.
“0” det.
End “+”
Effect?
N
Y
End “-”
Phase II
Effect?
N
Y
End “-”
Segm.
“0” det.
…
New
Phase II
strategy
Effect?
N
Y
End “+”
End “?”
Effect?
N
Y
End “+”
Segm.
“0” det.
Effect?
N
Y
End “+”
End “?”

Backgrounds in enriched, natural, depleted, and double depleted detectors

For external backgrounds isotopic composition of Ge detector is not important

Isotope dependence of Co-60 production rate is weak

The only thing to care of is Ge-68

Ge, depleted from Ge-76 contains all the saturated amount of Ge-68 from Initial natural Ge

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

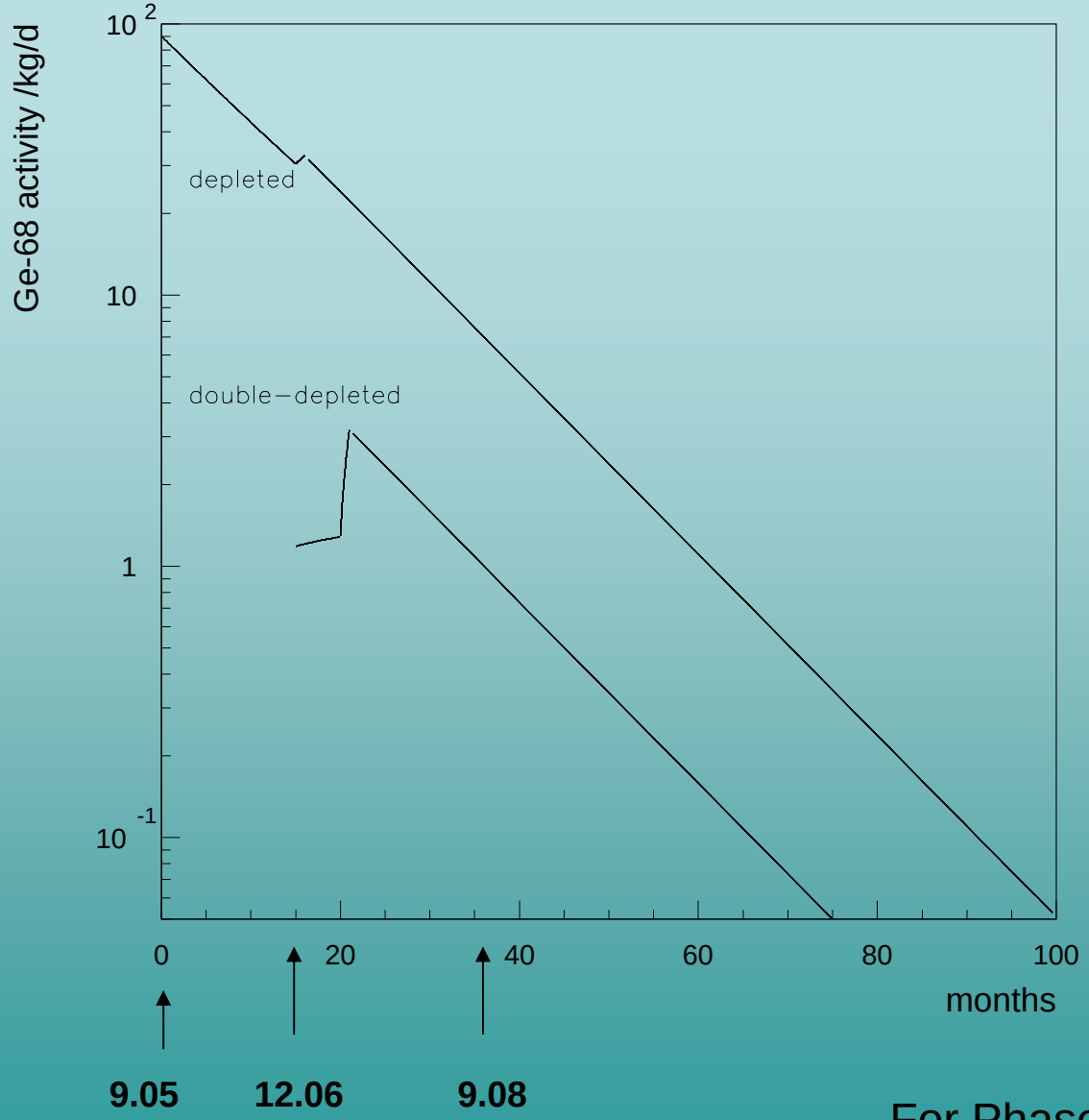
^{60}Co

^{70}Ge	1.73
^{72}Ge	2.88
^{73}Ge	3.14
^{74}Ge	3.35
^{76}Ge	3.31

Germanium composition and activation rates

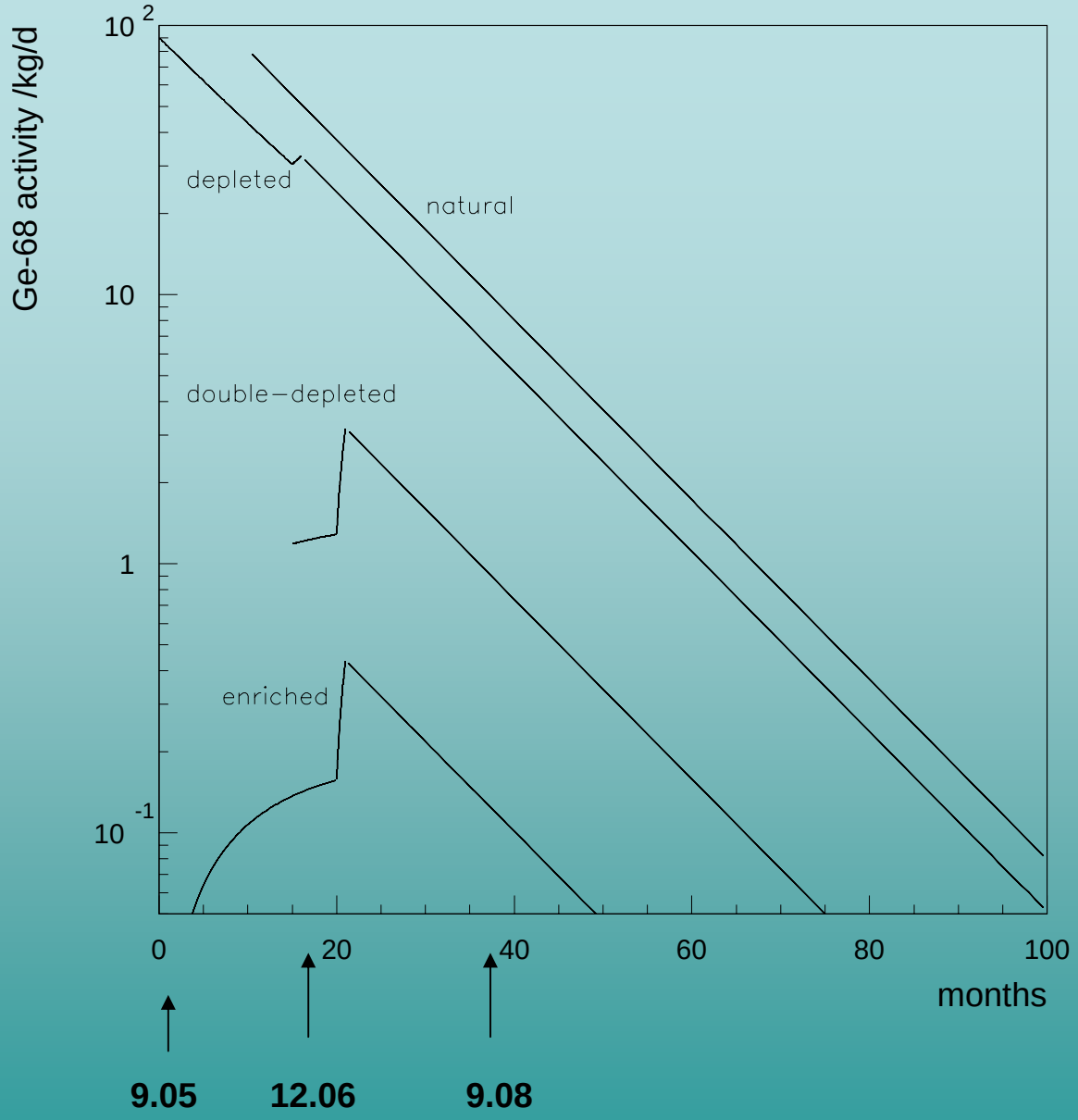
Ge isotope	70 (%)	72 (%)	73 (%)	74 (%)	76 (%)	^{68}Ge Activation rate, at/kg/d
enriched	0.015	0.075	0.165	12.5	87.25	5.6
natural	20.54	27.4	7.76	36.54	7.76	80.6
depleted	22	30	8.5	38.5	≤ 1	86.4
Double depleted	~2	38	11	48	≤ 1	37

Storage at ECP: factor ~ 30 attenuation compare to the Earth's surface



Between depleted
and double-depleted
ΔT ~2 year

For Phase I activity of 1 /kg/d
corresponds to BI= $6 \cdot 10^{-2}$ cpy/keV/kg



Between enriched and double-depleted ΔT ~2 year

For Phase II activity of 1/kg/d corresponds to BI= $8 \cdot 10^{-3}$ cpy/keV/kg

Feasibility Issues

- Currently depleted germanium is stored at ECP as fluoride.
- Storage at ECP: factor ~ 30 attenuation compare to the Earth's surface.
- Logical possibility of delay of reference detector (also required due to Ge-68).
- Possibility of common efforts with low background labs

(for low background gamma spectroscopy $2\beta 2\nu$ decay may became a problem even with natural detector !)

Conclusions

- Reference detector is certainly needed if the effect is observed.
- Depleted reference detectors have advantages compare to natural ones and have good prospects in gamma spectroscopy
- Depleted and even double depleted reference detector must be stored underground for few years due to Ge-68
- Logically reference detector is needed after measurements with enriched one.
- Currently there exists a possibility of procurement of the depleted material

In natural Ge (kg^{-1} d^{-1})

	HMS-ALICE +YIELDX	GENIUS	Miley'92	Shield	Avignone'92 (MC)	Avignone'92 (exp)
^{68}Ge	77+12=89	58.4	26.5	81	29.6	30±7
^{60}Co	0.3+4.5=4.8	6.6	4.8	2.9		
^{65}Zn	36+41=77	79.0	30.0		34.4	38±6
^{58}Co	0.5+13=14	16.1	4.4		5.3	3.5±0.9
^{57}Co	0.3+9.4=9.7	10.2	0.5		4.4	2.9±0.4
^{54}Mn	0.01+7.2=7.2	9.1			2.7	3.3±0.8
^{63}Ni	1.7+3.5=5.2	4.6				
^{55}Fe	0.06+7.9=7.9	8.4				