Subatomic Physics Physikalisches Institut Eberhard-Karls-Universität Tübingen

Germanium: 76 + 1

GERDA Collaboration

Milano, November 15, 2006

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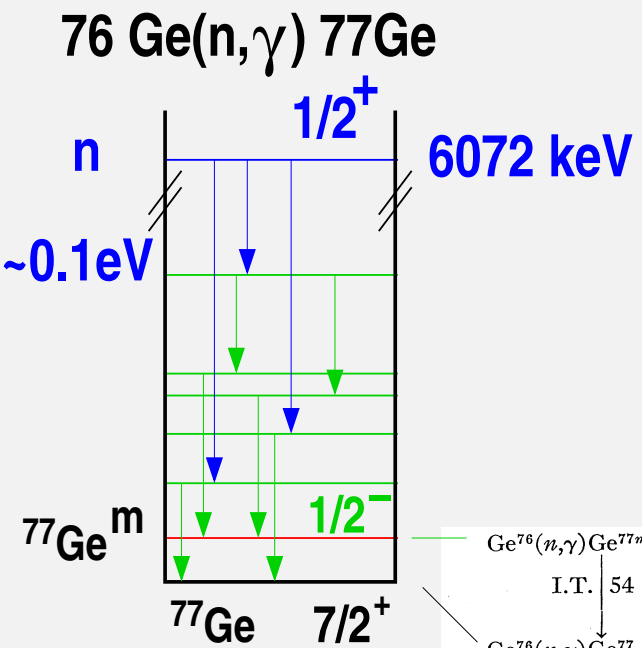
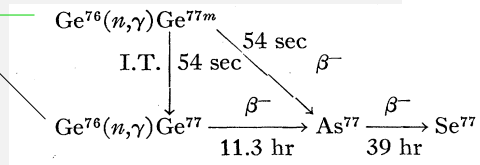
^{76}Ge as source of background

Luciano says: large background from n-capture on ^{76}Ge





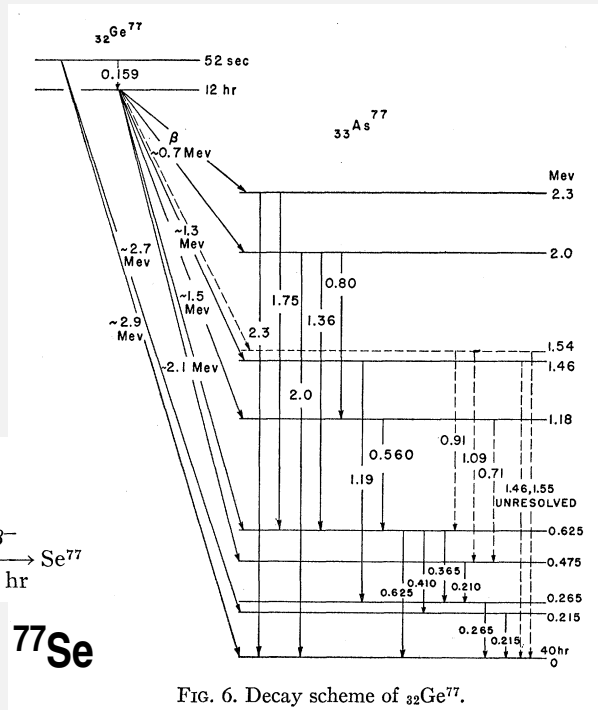


FIG. 6. Decay scheme of $_{32}$Ge^{77}.

^{77}Ge $\xrightarrow{\beta}$ ^{77}As $\xrightarrow{\beta}$ ^{77}Se

Q_β = 2703 690 keV

knowlegde: ⋆(⋆) wish : ⋆⋆⋆⋆

decay of ^{77}Ge, ...

n-capture on ^{76}Ge: Q-value 6072 keV

meta-stable state @ 159 keV ($T_{1/2}$=53 s)
groundstate ($T_{1/2}$=11,2h)

β-decay to ^{77}As: Q-value 2703 keV

following β-decay to ^{77}Se: Q-value 690 keV

transition in ^{77}As: 2037.76(5) keV

transition in ^{76}Ge: 2040.70(25) keV (inel. scattering for E_n >4 MeV)

understand background sources
in order to reduce their influence

- *neutron reactions*
- *auxiliary experiments*

some basics around ^{76}Ge

enriched material: ~86% in ^{76}Ge

natural isotopic composition: 7.61(38)% (7.44% ?)

many experiments with natural Ge provide poor results for ^{76}Ge

Q-value and nuclear structure 'help to hide'

n-capture cross sections:

^{76}Ge : σ_c=10 cold

^{76}Ge : σ_0=140(20)mb (with Westcott$_g$=1.00)

^{76}Ge^m : σ_0=100(10)mb

(also 150/60 mb)

compare to:

^{nat}Ge : σ_0=2 300 mb

cross section and rates

L.P.(GSTR-06-12) estimates for SS-cryostat:

neutron flux ϕ=7 n/m^2/h=6,1 n/cm^2/y $\rightarrow$ 426 n/kg/y

thermalisation after 20-30 collisions in hydrogen

finally: 39 n/kg/y with $E < 1$keV

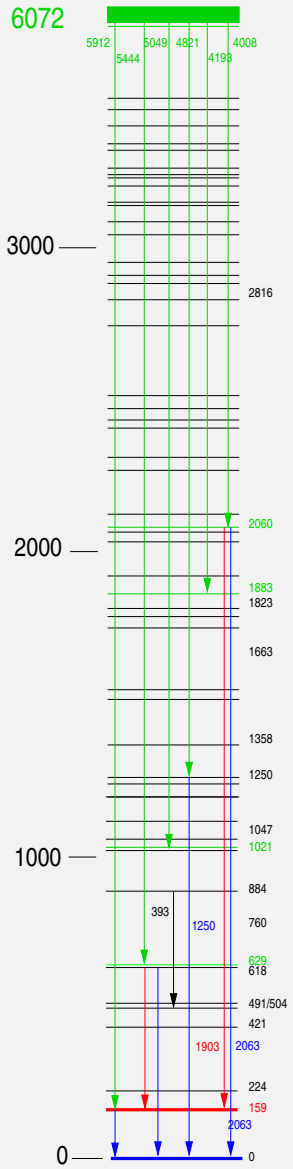
density ρ=5,32 g/cm^3 $\rightarrow$ n$_{Ge}$=7,9$\times 10^{24}$

rate: $r = \phi\ \sigma\ n_{Ge} = 1,1$ n-capture/kg/y

for estimate: used thermal cross sections

question: neutron spectrum within Ge ?

known prompt γ-spectrum



S_n = 6072 keV

start with $J^{\pi} = 1/2^+$

$\sum I \sim 36\%$

expect $>$ 200%

^{77}Ge ms $1/2^-$ @ 159 keV

$T_{1/2}$= 53 s$\rightarrow$ 20% IT and 80% β^-

^{77}Ge gs $7/2^+$ $T_{1/2}$= 11,3 h$\rightarrow$ 100% β^-

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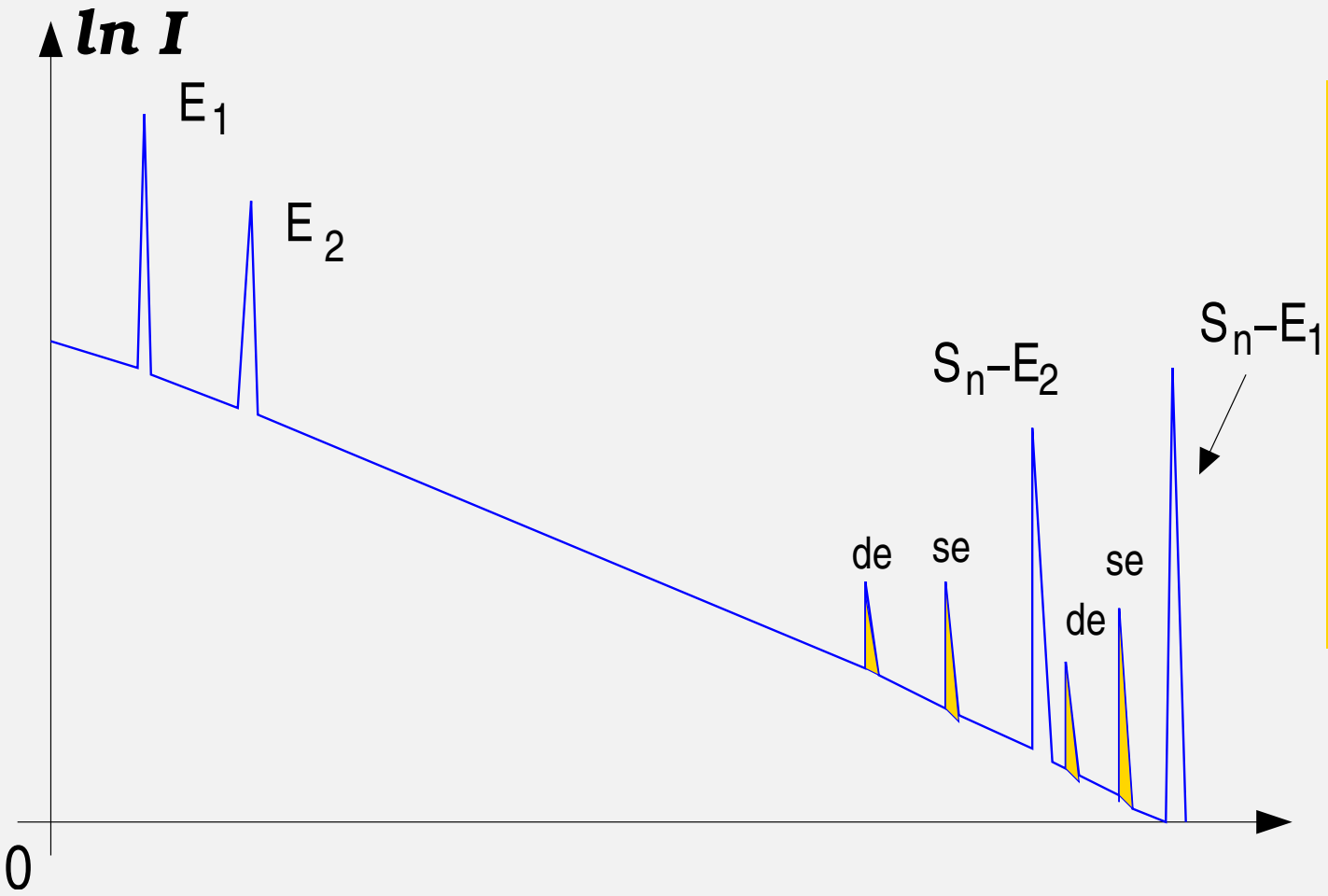
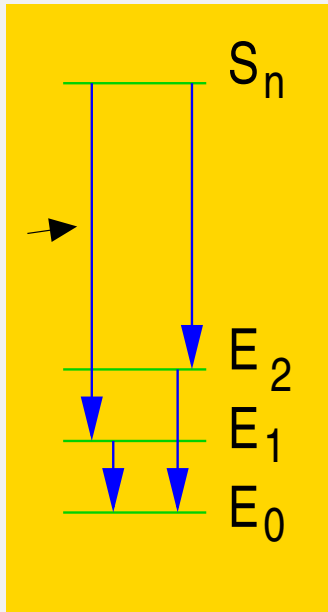
schematic γ-spectrum



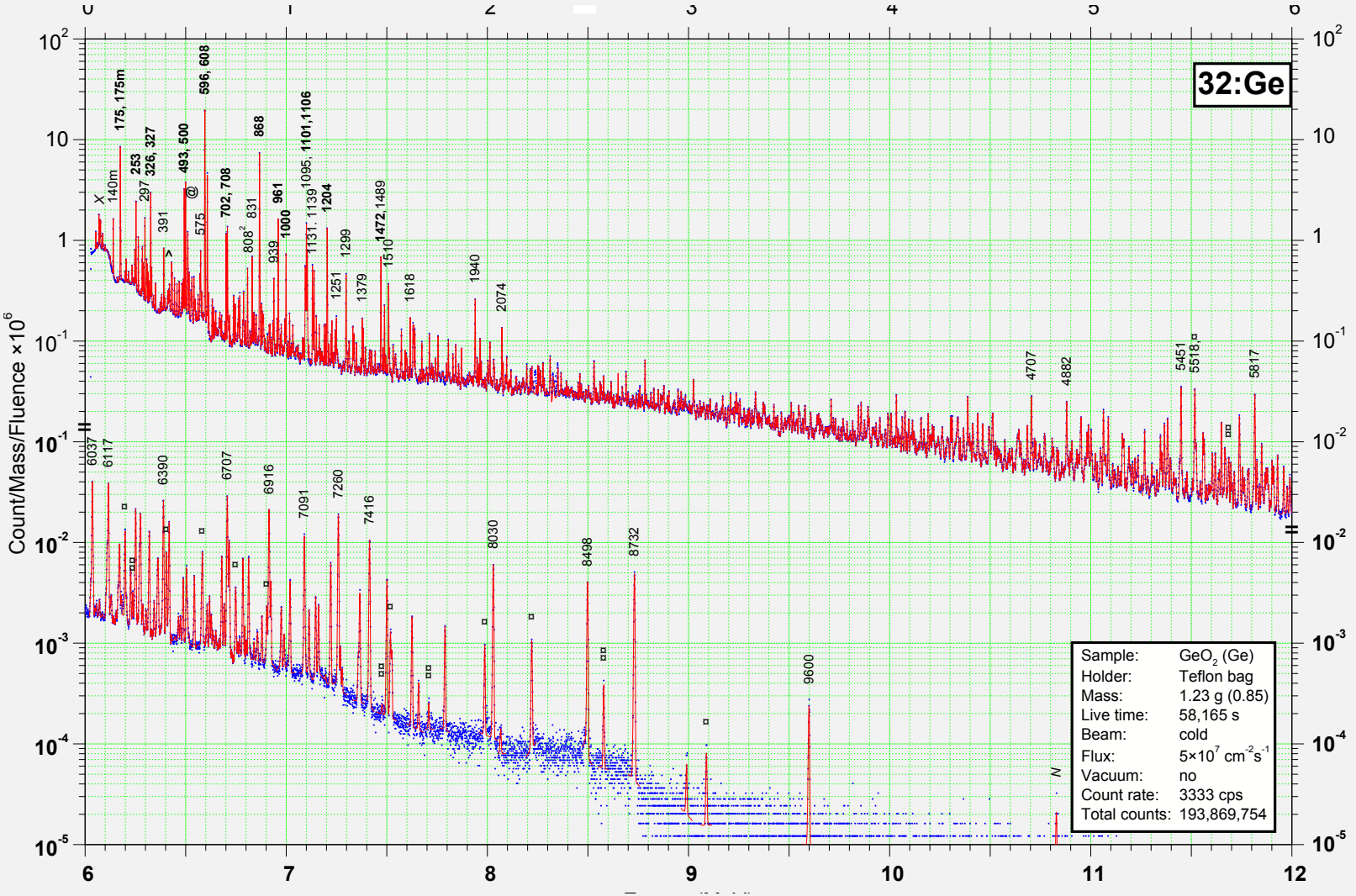


2 γ rays per n-capture !!

prompt γ-spectrum

^{nat}Ge, cold neutrons

Molnar etal., Budapest reactor



background from ^{7x}Ge

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delayed γ-spectrum (Geel)

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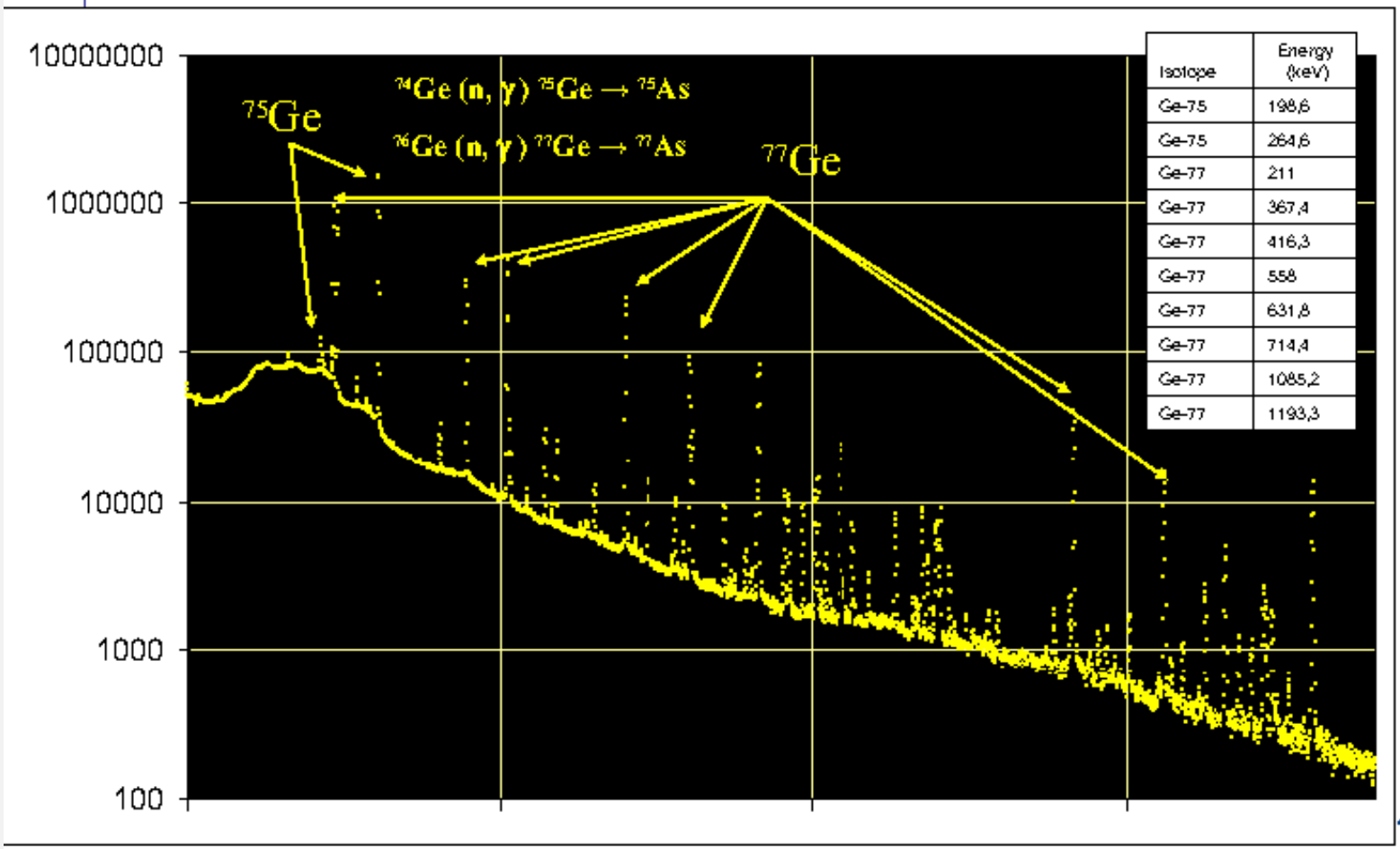
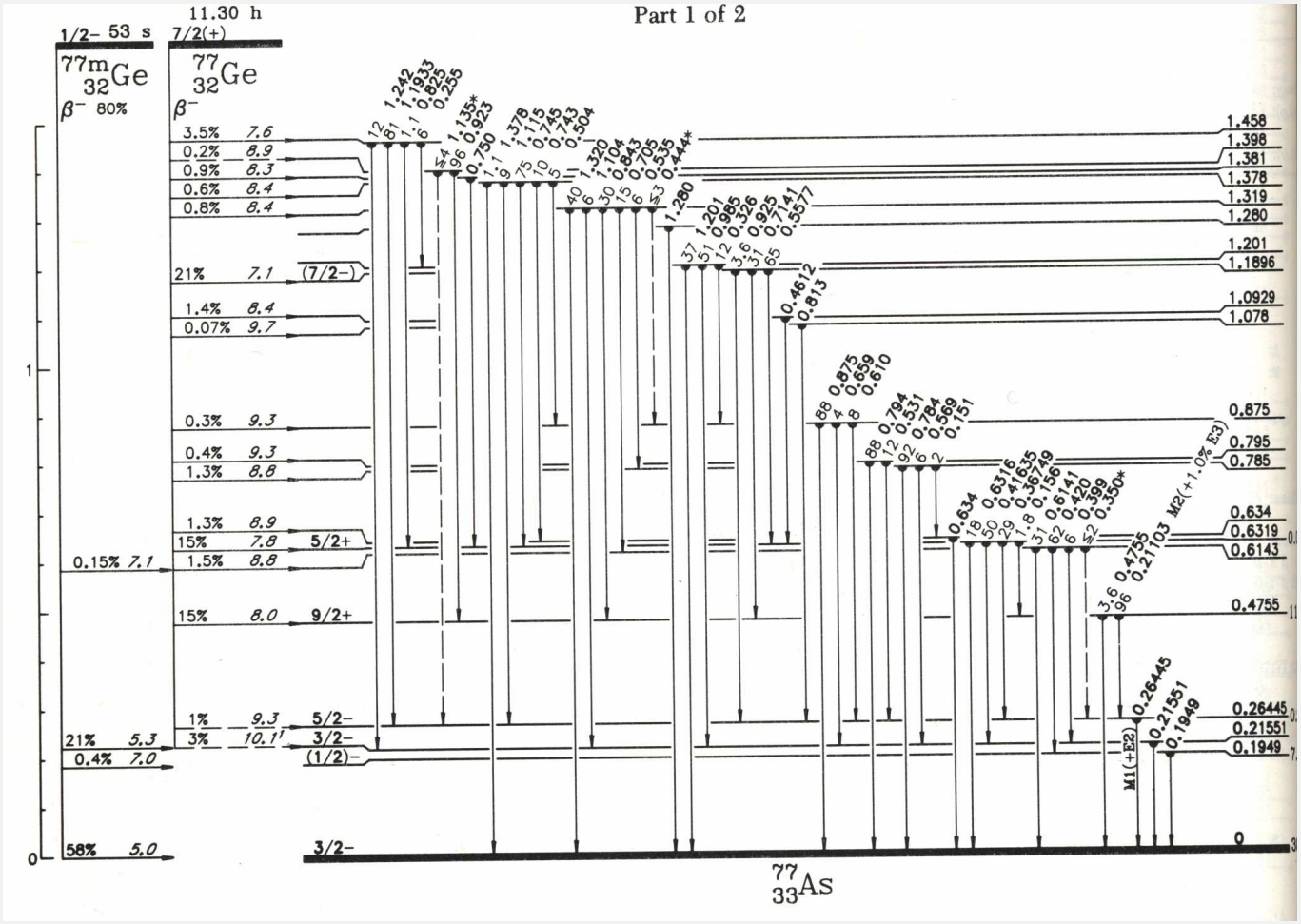
INAA – GeO_2 (enriched)



Isotope	Energy (keV)
Ge-75	198,6
Ge-75	264,6
Ge-77	211
Ge-77	367,4
Ge-77	416,3
Ge-77	558
Ge-77	631,8
Ge-77	714,4
Ge-77	1085,2
Ge-77	1193,3

background from ^{75}Ge

γ-spectrum in ^{77}As



Q_β=2703 keV > $Q_{\beta\beta}$; I_o= 58 %

Proposal at ILL

measure the prompt γ-spectrum

- high thermal neutron flux at ILL reactor: $1.8 \cdot 10^9$ neutrons/(cm^{2}s)
- enriched target (86% $^{76}GeO_2$)
- also normal and/or depleted GeO_2
- employ Ge-diodes (normal !)
- use coincidence technique
- after ILL cacle: measure delayed gammas

TECHNICAL FORM

EXPERIMENT TITLE Prompt Gammas in ^{77}Ge after Neutron Capture on ^{76}Ge

PROPOSAL NUMBER
(to be completed by ILL)

EXPERIMENTAL TEAM (names and affiliation)

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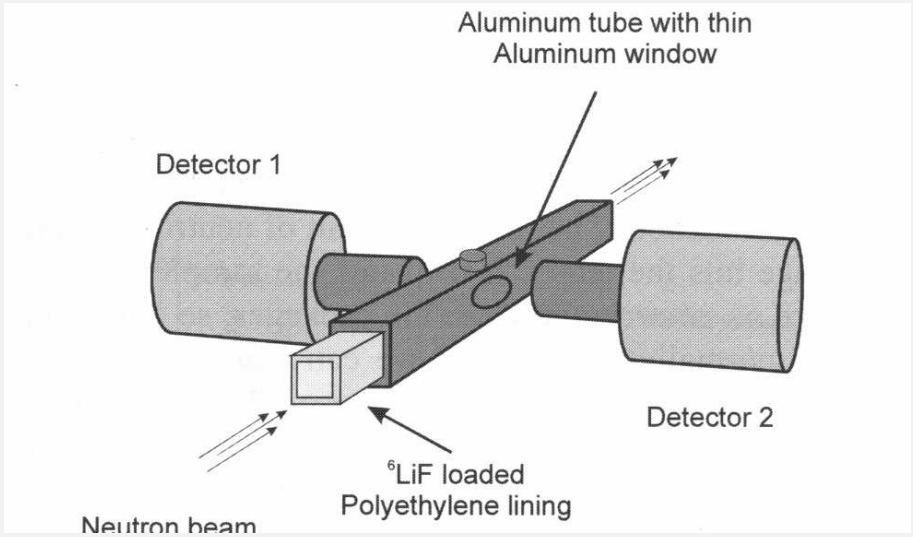
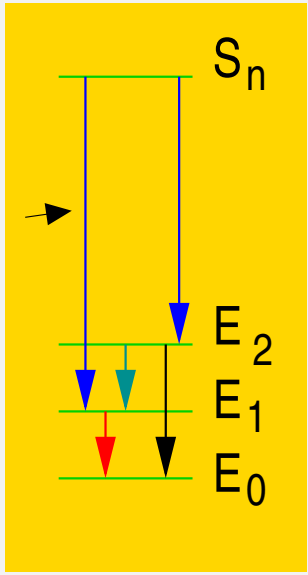
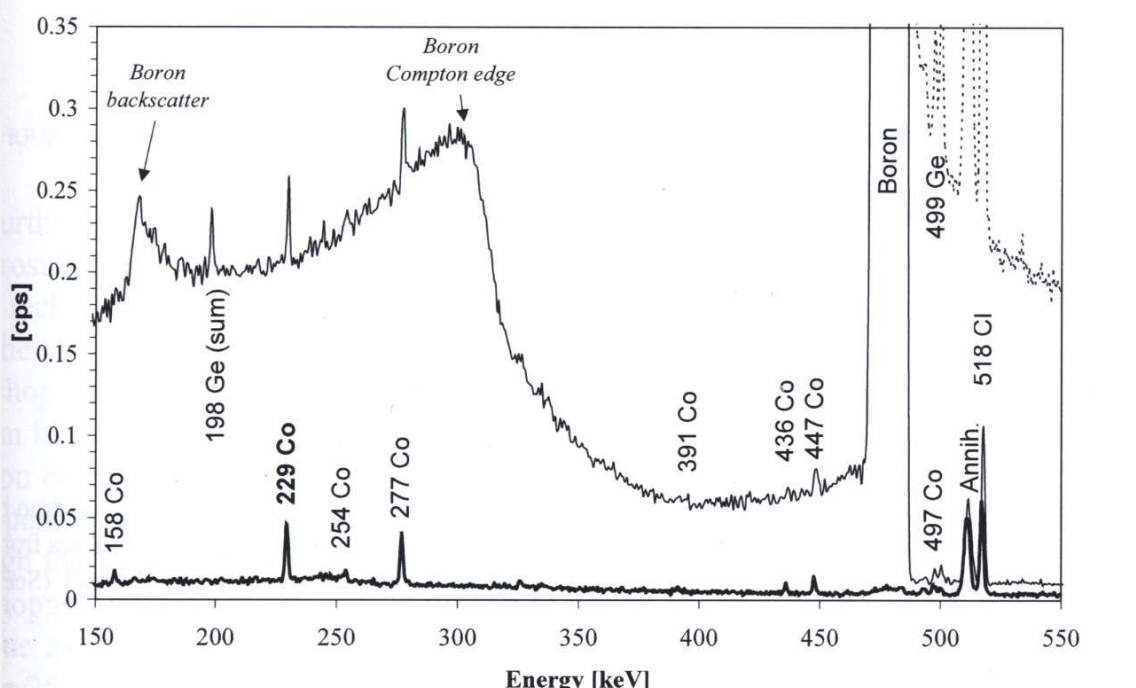
Physikalisches Institut der Eberhard Karls Universität Tübingen

H. Börner, U.Koester, T. Soldner
ILL

coincidence setup







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summary

rate: 1,12 n-capture/kg/year

if prompt/delayed spectrum known:

prompt E_γ measured in Ge-diode shows time of capture

analyse within time window the next signal for

delayed γ

or β

independent of μ-veto

probability for E_γ= 2037 keV: $6{,}4 \times 10^{-4}$

validity ?

measure neutron flux during GERDA operation:
parasitically inside Watertank