Life Sciences: Activity Report from the Radioactivity Department at PTB

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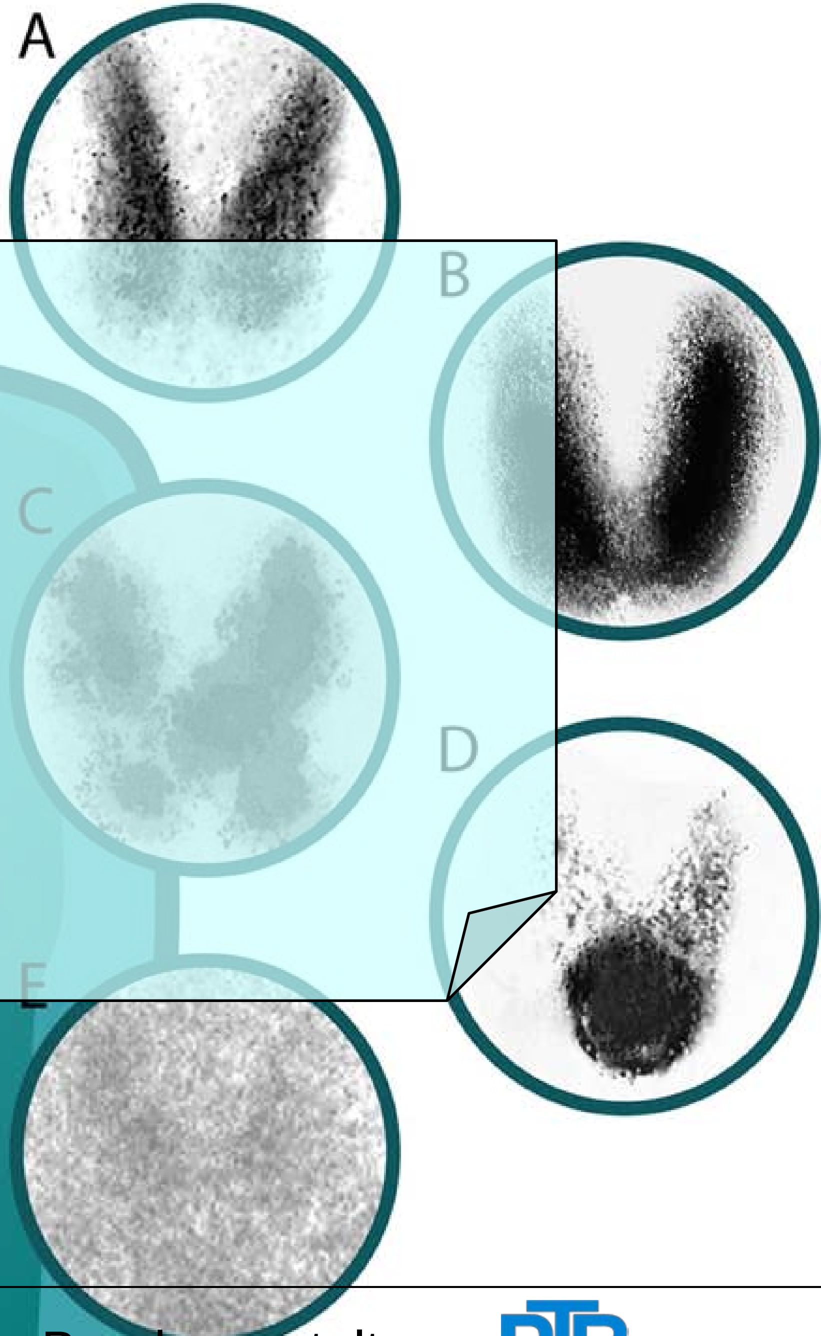
Department 6.1 „Radioactivity“

ICRM Life Sciences Working Group Meeting @ NPL, November 2008

Overview



- Past
- Present
- Future

Past

Calibrations of radionuclides for nuclear medicine in 2007/2008:

Examples: F-18, P-32, Cr-51, Co-57, Ga-67, Rb-81, Y-86, Sr-89, Tc-99m, Y-90, Ru-106/Rh-106, In-111, I-123, I-124, I-125, I-131, Sm-153, Lu-177, Re-186, Re-188, Tl-201, Tl-204, …

Past

Publications:

Schrader, Klein, Kossert: **Activity standardization of ^{18}F and ionization chamber calibration for nuclear medicine.** ARI 65 (2007), 581-592.

Kossert, Thieme: **Comparison for quality assurance of ^{99m}Tc activity measurements with radionuclide calibrators.** ARI 65 (2007), 866-871.

Schrader, Kossert, Mintcheva: **Calibration of a radionuclide calibrator system as a Bulgarian standard for activity.** ARI 66 (2008) 965-971.

Oropesa Verdecia, Kossert: **Activity Standardization of ^{131}I at CENTIS-DMR and PTB within the scope of a bilateral comparison**. ARI. Submitted.

In addition:

Papers on improvements of LSC methods and Technical Reports on SIR comparisions (e.g. ^{186}Re, ^{201}Tl)

Possibilities to reach the patient

PTB

- Activity standards
- Determination of calibration factors

Manufacturer

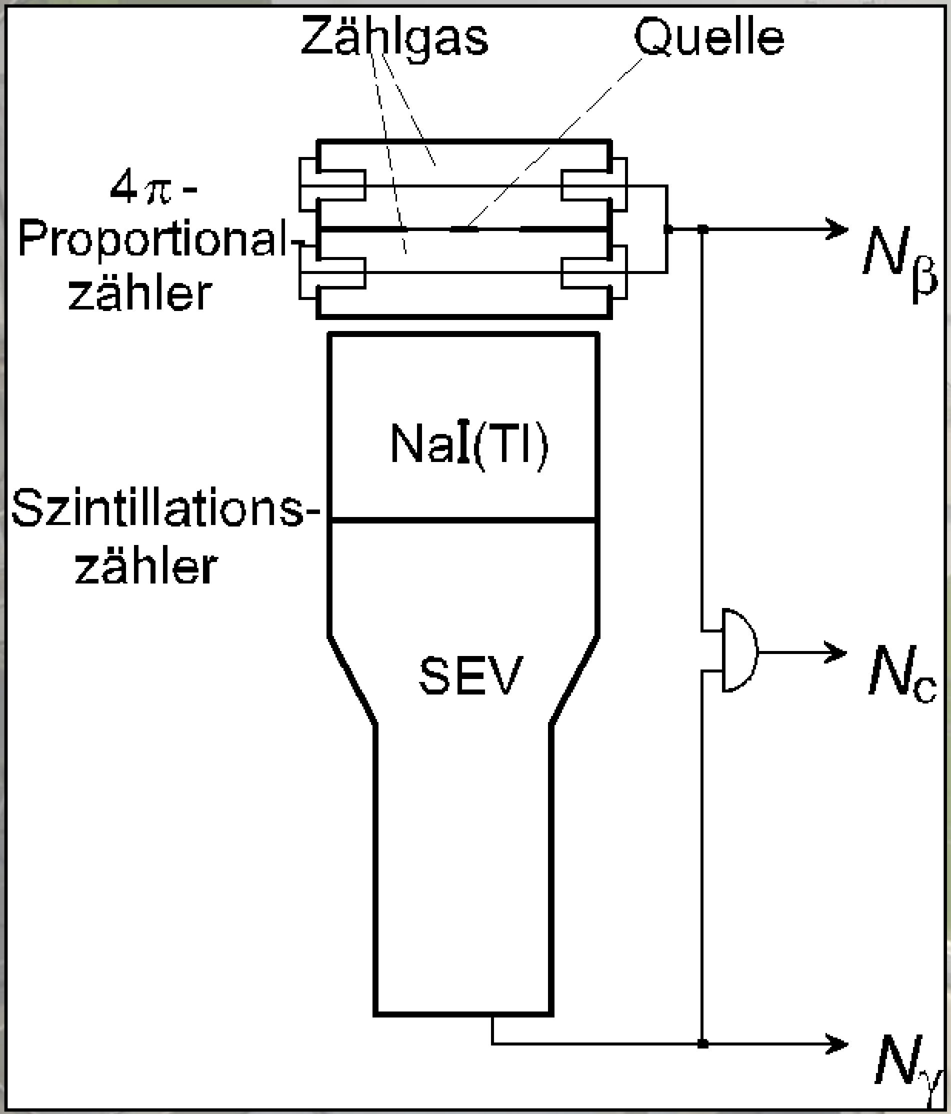
- Activity standards
- Calibrations at PTB
- Comparisons

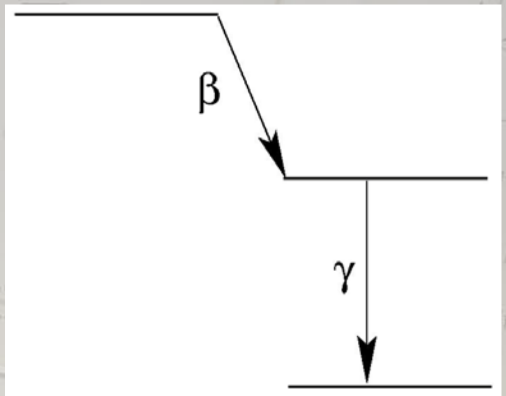
DKD

Application in nuclear medicine

Activity measurements

$4\pi\beta$-γ councidence counting





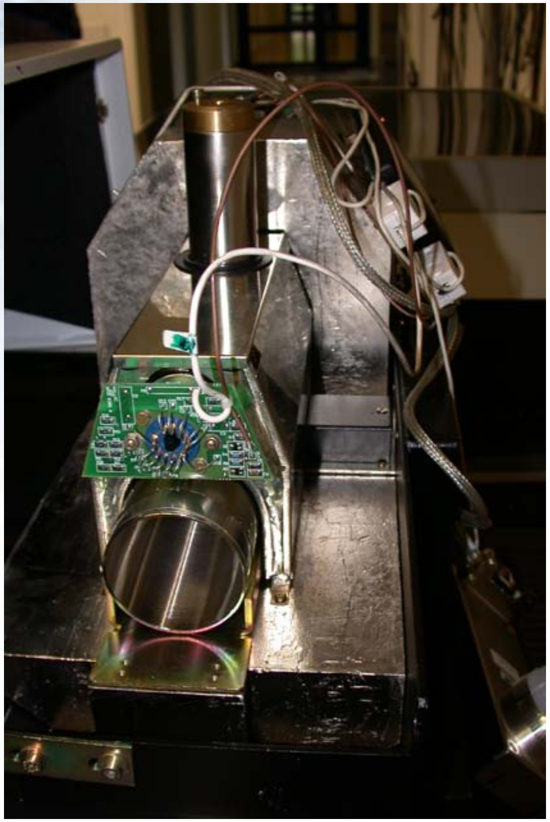
$$N_\beta = A \cdot \varepsilon_\beta$$

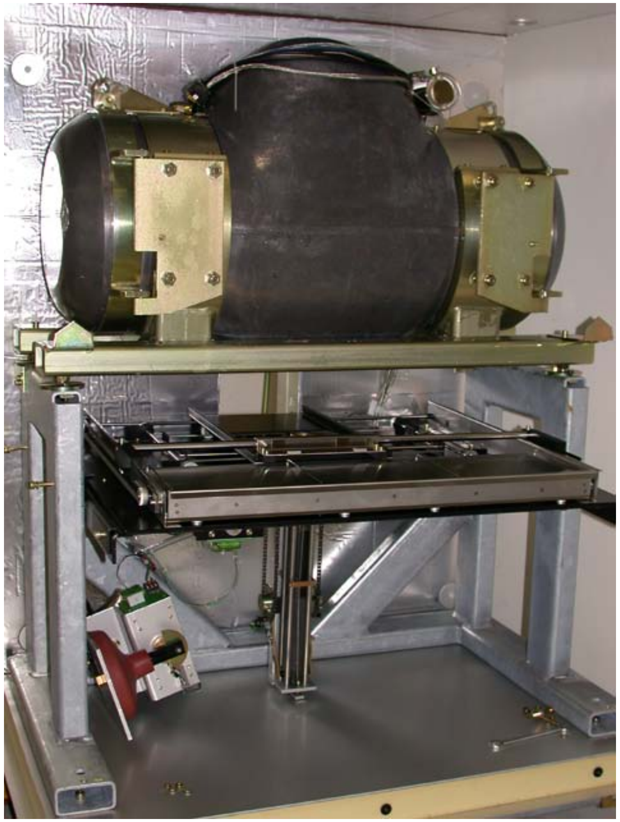
$$N_\gamma = A \cdot \varepsilon_\gamma$$

$$N_c = A \cdot \varepsilon_\beta \cdot \varepsilon_\gamma$$

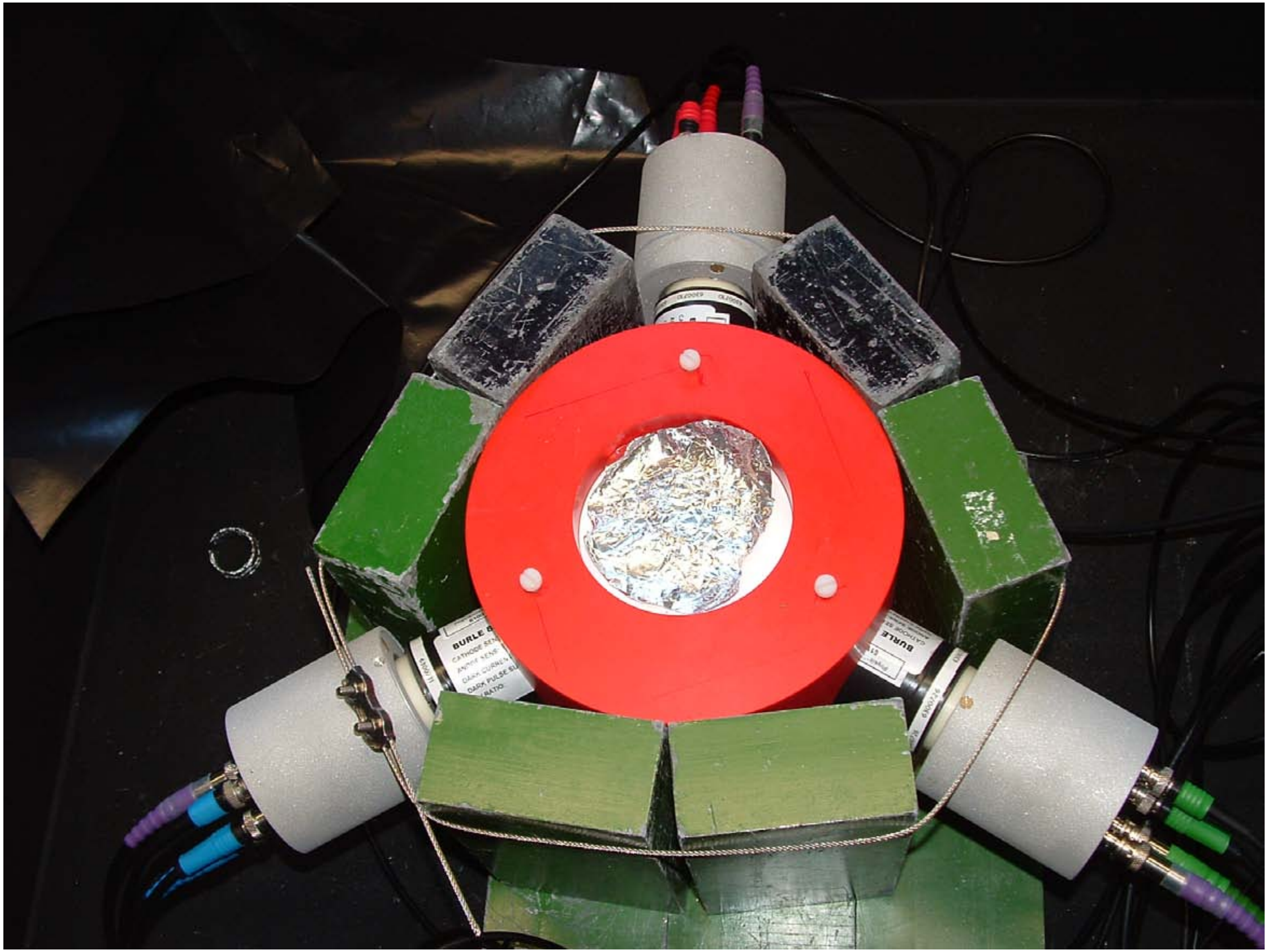
$$A = N_\beta \cdot N_\gamma / N_c$$

Liquid scintillation counting



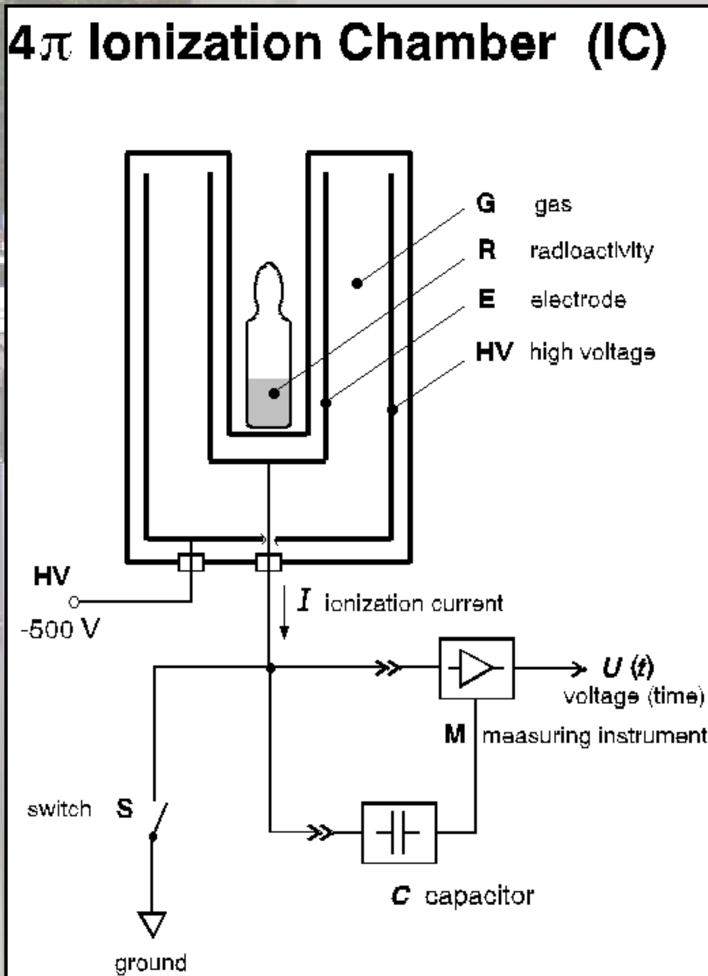


TDCR



Calibration of ionization chambers

Ionization chambers



Activity: $A = k_{\mathrm{N}}\, C_{\mathrm{geom}} m_{\mathrm{Ra\text{-}226}}\, R_{\mathrm{N}} \,/\, R_{\mathrm{Ra\text{-}226}}$

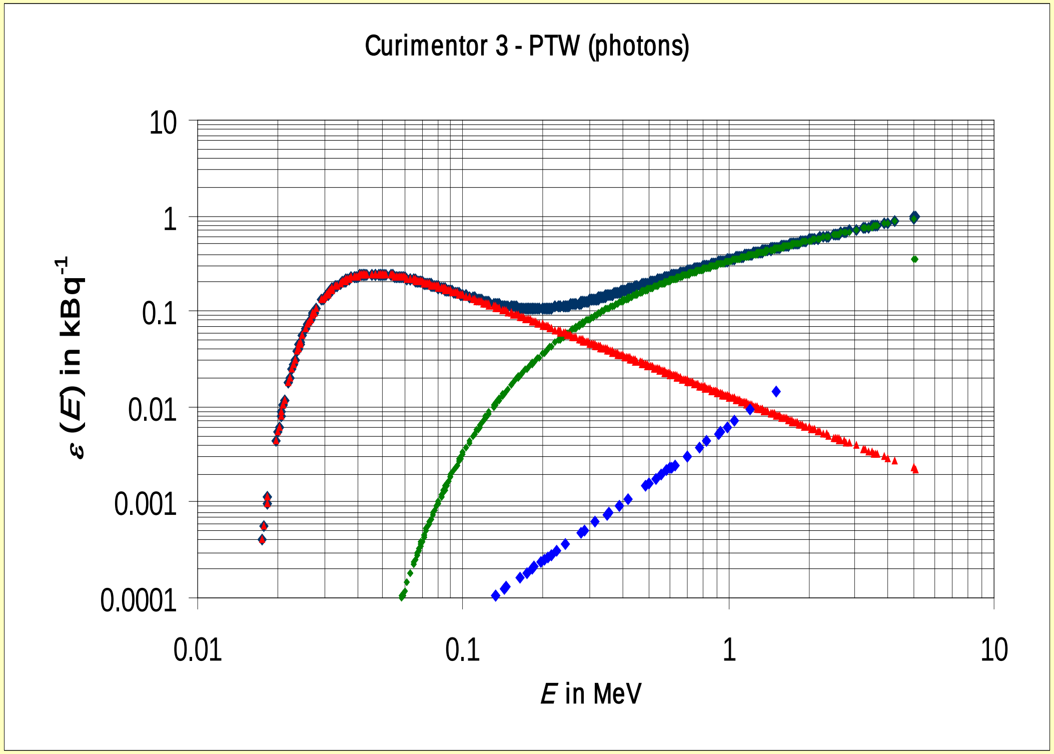
- $k_{\mathrm{N}} = 1/\varepsilon_{\mathrm{N}}$ calibration factor
- C_{geom} geometry factor ; C_{geom}=1 for standard geom.
- $R_{\mathrm{Ra\text{-}226}}$, $m_{\mathrm{Ra\text{-}226}}$ instrument reading and mass*
  of a Ra-226 reference source
- R_{N} instrument reading for the nuclide under study*

* (corrected for background and decay)

Ionization chambers

Energy dependent efficiency curves

(see e.g. Schrader & Svec, ARI 60 (2004) 369)



allows calculation of calibration factors

See also Euromet-Projekt 909:

Schrader, Kossert, Mintcheva: Calibration of a radionuclide calibrator system as a Bulgarian standard for activity. ARI 66 (2008) 965

Ionization chambers

Project with PTB and Company MED Nuklear-Medizintechnik Dresden GmbH.

- 3 ionization chambers + accessories
- Projects ends in March 2010

Aims of the project

- Investigation whether the chambers can be used in radionuclide metrology
- Improvement of measurements in nuclear medicine
- Maybe also R&D to improve electrometers for low current measurements (10^{-13} A bis 10^{-8} A, in particular linearity).

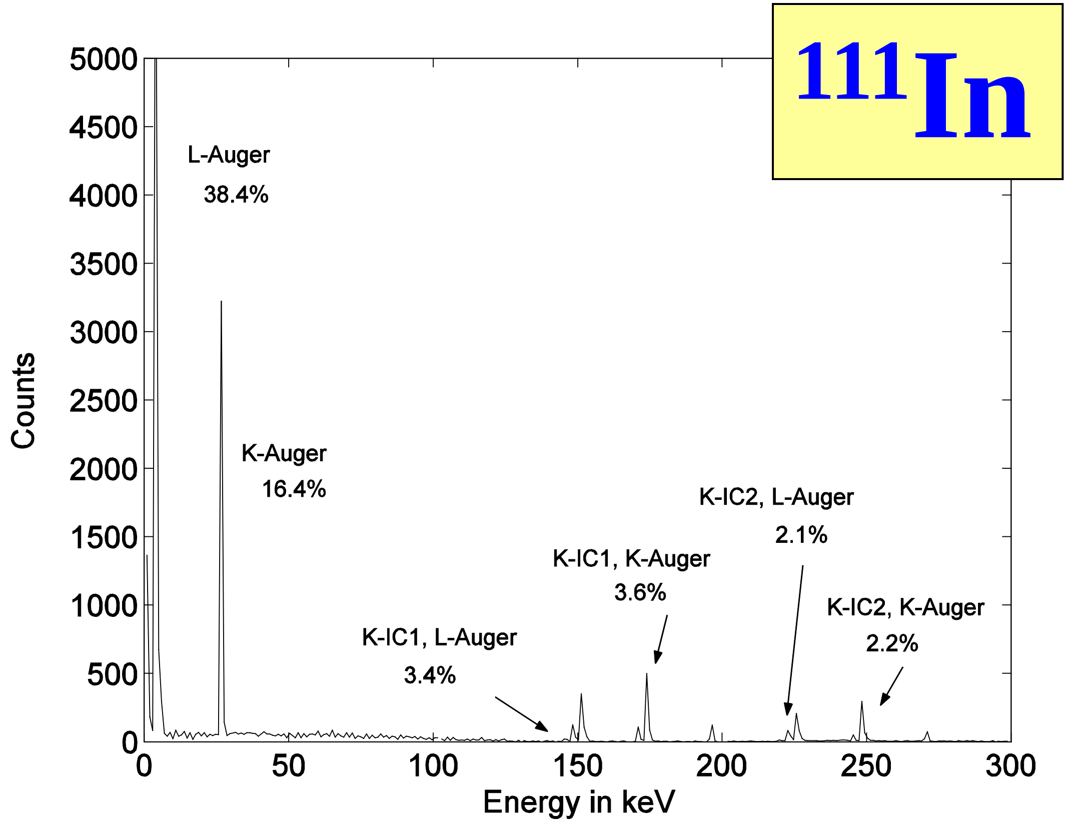
Future plans

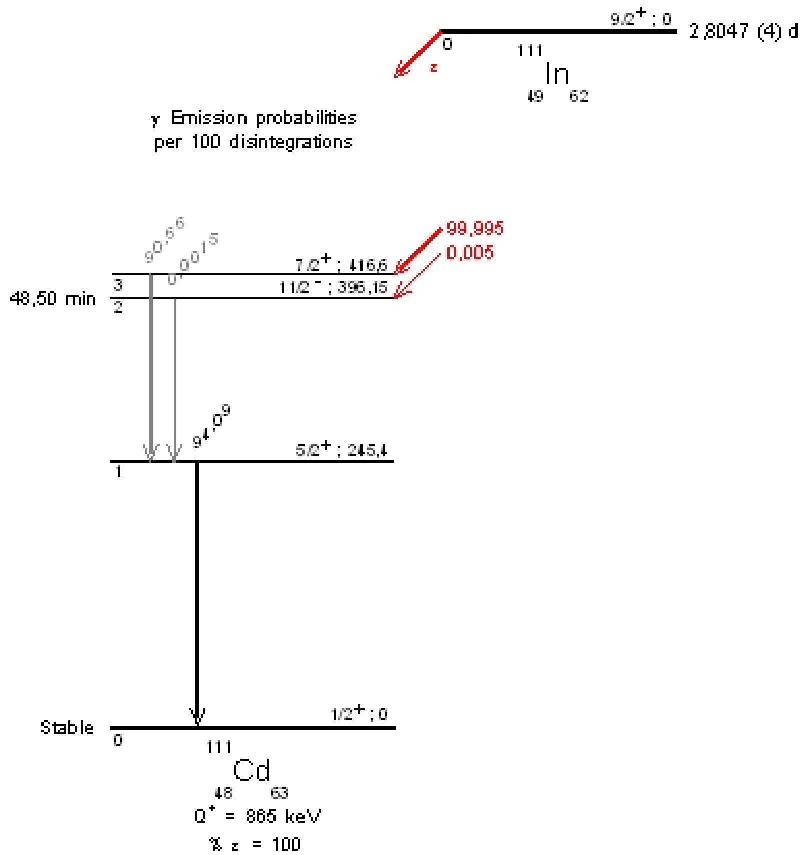
Application of the stochastic model

Potential application:

Calculation of emission spectra of radionuclides (not only electron-capture) to investigate the interaction with DNA

Grau Carles, Kossert: Monte Carlo simulation of Auger electron spectra. ARI. In press





Future plans

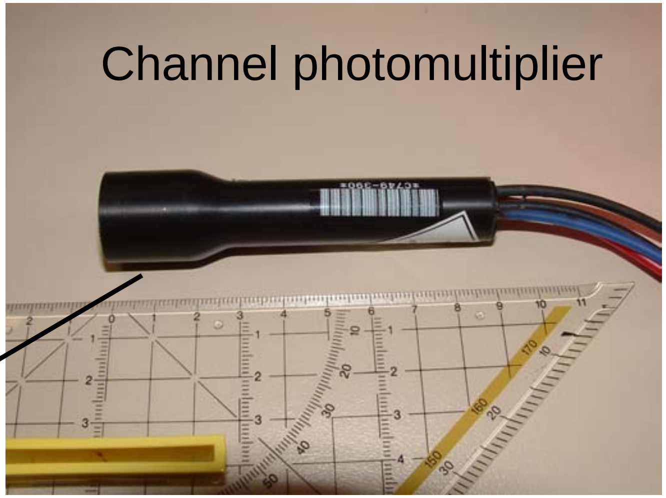
Work on parts of a proposal for iMERA-Plus JRP TP2 „Health“.

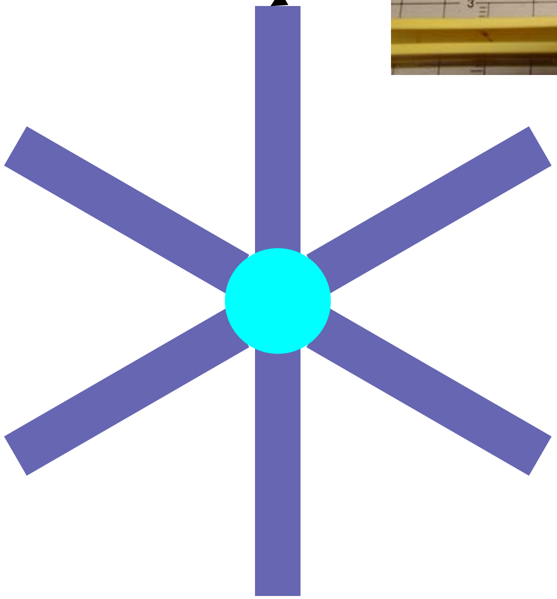
Determination of activity and nuclear decay data of emerging radionuclides in nuclear medicine and improvements for short-lived PET nuclides.

- Cu-64 (EURAMET-Project)
- Cu-67 (EURAMET-Project)
- Ga-68 andGe-68/Ga-68
- Lu-177 (CCRI(II) comparison 2009)

Future plans

Miniature-TDCR apparatus





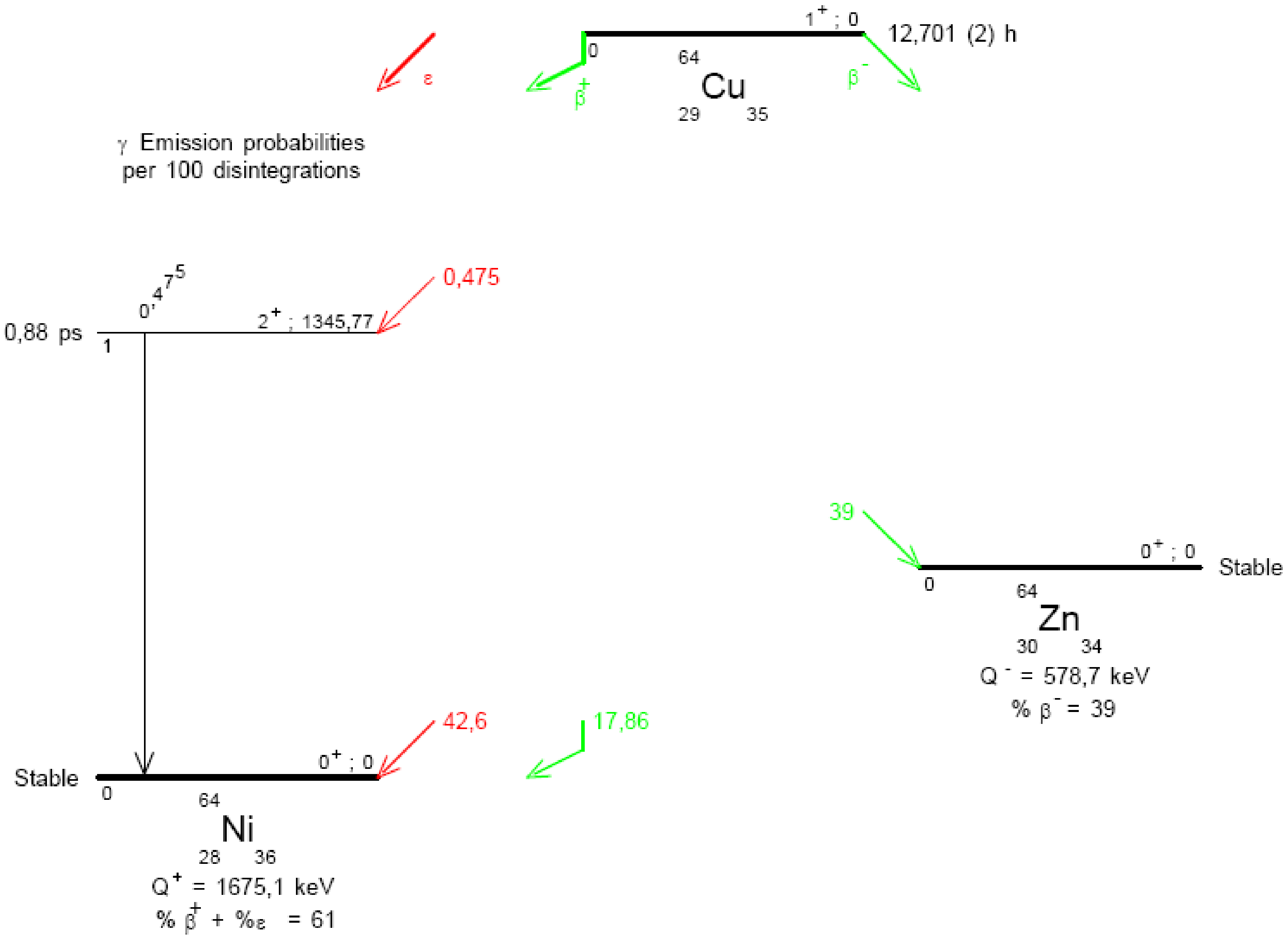
Small system, e.g. for mobile missions.

Potential applications

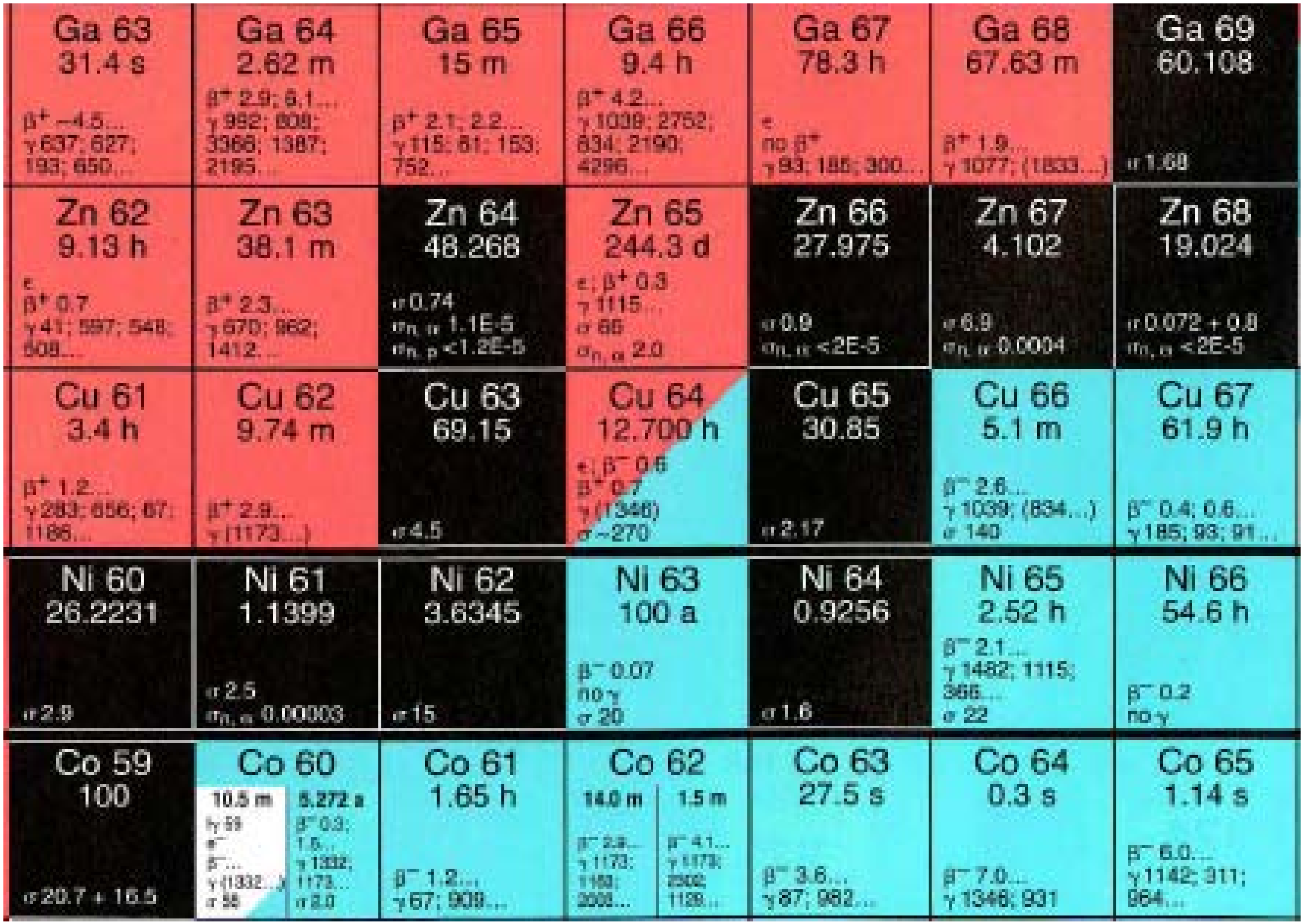
- ^{11}C (20,3 minutes)
- ^{13}N (10,1 minutes)
- ^{15}O (2,03 minutes)
- *^{18}F (110 minutes)*

at PET-centers or PTB (^{15}O ??)

Cu-64


1+ ; 0
12,701 (2) h
0
64
Cu
29
35
ε
β+
β-
γ Emission probabilities
per 100 disintegrations
0,475
2+ ; 1345,77
0,88 ps
1
0,475
39
0+ ; 0
Stable
0
64
Zn
30
34
Q- = 578,7 keV
% β- = 39
42,6
17,86
Stable
0+ ; 0
0
64
Ni
28
36
Q+ = 1675,1 keV
% β+ + %ε = 61

Cu-64



Ga 63 31.4 s
Ga 64 2.62 m
Ga 65 15 m
Ga 66 9.4 h
Ga 67 78.3 h
Ga 68 67.63 m
Ga 69 60.108
Zn 62 9.13 h
Zn 63 38.1 m
Zn 64 48.268
Zn 65 244.3 d
Zn 66 27.975
Zn 67 4.102
Zn 68 19.024
Cu 61 3.4 h
Cu 62 9.74 m
Cu 63 69.15
Cu 64 12.700 h
Cu 65 30.85
Cu 66 5.1 m
Cu 67 61.9 h
Ni 60 26.2231
Ni 61 1.1399
Ni 62 3.6345
Ni 63 100 a
Ni 64 0.9256
Ni 65 2.52 h
Ni 66 54.6 h
Co 59 100
Co 60
Co 61 1.65 h
Co 62
Co 63 27.5 s
Co 64 0.3 s
Co 65 1.14 s

Cu-64

Production

Reactor:

- ^{63}Cu (n,g) ^{64}Cu
  Impurities: ^{67}Cu
- ^{64}Cu (n,2n) ^{64}Cu
  Impurities: ^{65}Ni
- ^{64}Zn (n,p) ^{64}Cu
  Impurities: ^{67}Cu, ^{63}Zn, ^{65}Ni

Cyclotron:

- ^{64}Zn (d,2p) ^{64}Cu
  Impurities: ^{67}Cu
- ^{66}Zn (d,a) ^{64}Cu
- ^{nat}Zn (d,x) ^{64}Cu
  Impurities: ^{61}Cu

Cu-64

First test measurements at PTB: December 2008:

- 4πβ-γ coincidence counting

- LSC (CIEMAT/NIST)

- Ionization chambers (calculated calibration factor)

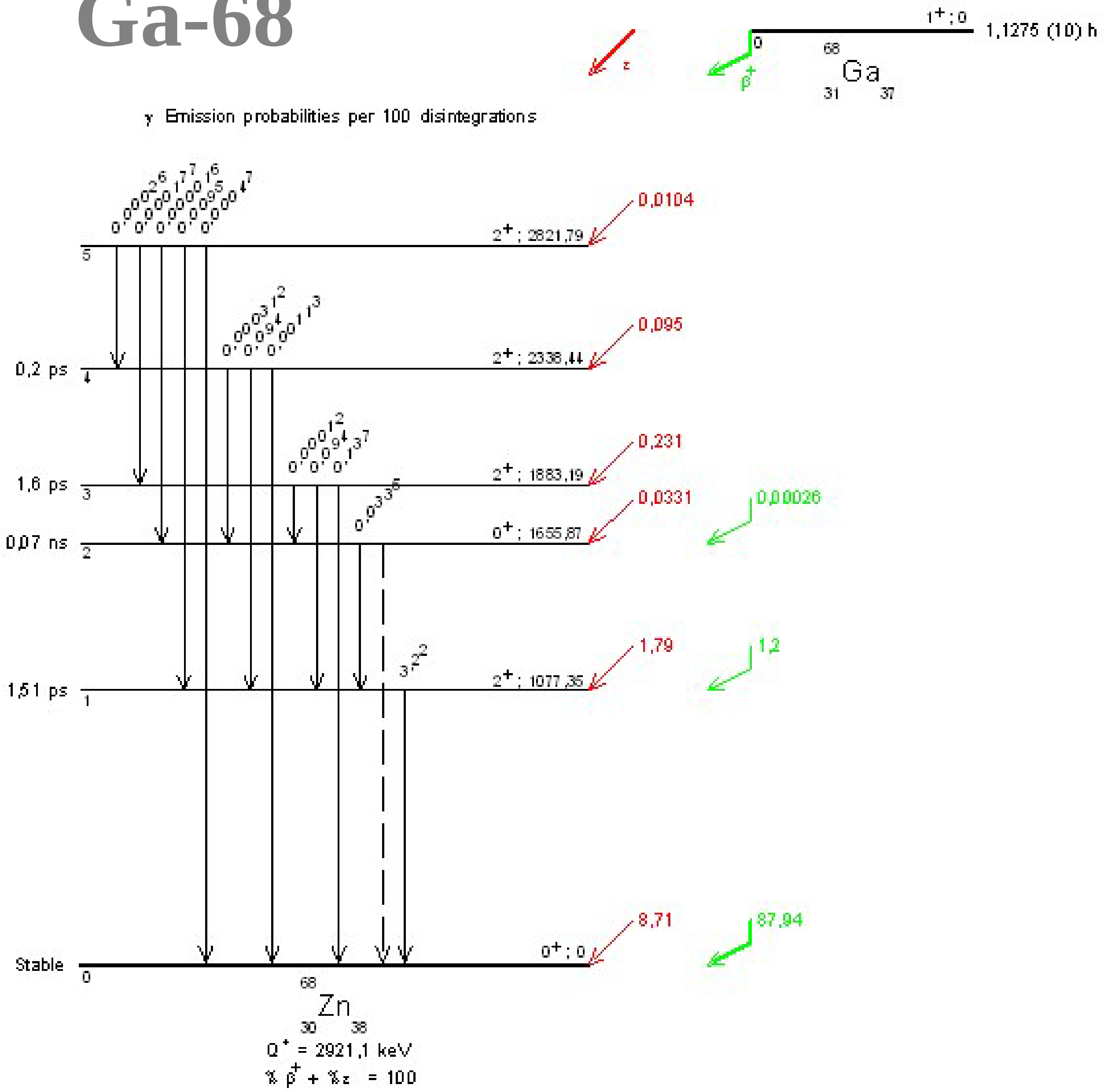
- Gamma-ray spectrometry (also for impurity checks)

- Photon-photon coincidence counting ?

If successful: Submission to SIR in 2009 + determination of decay data.

Cu-64 and Cu-67 were proposed as candidates for EUROMET exercises.

Ga-68



1+ ; 0
1,1275 (10) h
68
Ga
31
37
z
β+
γ Emission probabilities per 100 disintegrations
2+ ; 2821,79
0,0104
0,2 ps
2+ ; 2338,44
0,095
1,6 ps
2+ ; 1883,19
0,231
0,07 ns
0+ ; 1655,87
0,0331
0,00026
1,51 ps
2+ ; 1077,35
1,79
1,2
Stable
0+ ; 0
8,71
87,94
68
Zn
30
38
Q+ = 2921,1 keV
% β+ + %z = 100

Ga-68

First test measurements at PTB soon:

- $4\pi\beta$-γ coincidence counting

- LSC (CIEMAT/NIST)

- Ionization chambers (calculated calibration factor) also for half-life determination

- Gamma-ray spectrometry (also for impurity checks)

Thank you for your attention

www.ptb.de

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