A versatile TDCR system with automated sample changer

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• Coincidence method
• Detection system
• Sample changer
• Electronics
• 4KAM module
• Summary
The PTB “reference TDCR”

- Hamamatsu R331-05 tubes
- Coincidence logic and dead-time realized by MAC3
- Dozens of nuclides standardized in routine use
- Throughput of samples is limited
A multi-method TDCR-system
Coincidence method

$\text{Hg}^{203}_{80}$

$T_{1/2} = 46.6 \text{ d}$

$\beta^-$

$\gamma$

$\text{TI}^{203}_{81}$

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

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

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

$A = \frac{N_\beta \cdot N_\gamma}{N_c}$
$4\pi (LS)_{\beta-\gamma}$-coincidence method
4π(LS)β–γ-coincidence method

- TDCR and coincidence measurements using the same source
- Simultaneous measurements
- Increased β-efficiency compared to PC counter
- Increased efficiency for photons in LS source
Optical chamber

Top view

Side view

Physikalisch-Technische Bundesanstalt
Optical chamber

- OP.DI.MA ODM98 from Gigahertz-Optik
- Reflectivity >98% (250 nm u. 2500 nm)
- Close to ideal diffuse reflection (Lambertian surface)
Photomultiplier

- Hamamatsu R331-05
- Q.E. (390 nm) typ. 25%
- Clear SEP separation
- Long term stability good

- Change from Burle to Hamamatsu R331-05
  - Increased efficiency
- PMT asymmetry significantly higher
  - one PMT replaced, symmetry improved
Sample changer

Light-tight housing

γ-detector
• Built by external company
• Siemens SPS process control system (compatible)
• SPS includes a set of commands:
  - move actual sample into chamber
  - move to position X
  - open doors
  - ...
• USB interface with 8bit digital encoder
Sample changer design

- Lead shield
- 24 samples in 3 logical racks
- Light-tight housing
- Sample feeding from above
- $\gamma$-detector below chamber
- Vacuum system for sample transport
Sample changer
Electronics and system stability

- All relevant data for each measurement are logged to a file:
  - Temperature
  - Humidity
  - HV status
  - NIM crate status
  - Status messages of sample changer
  - Adjustment of system time
Electrostatic charges

- Strange background effects after sample change
- Solved by adding an ionization blower
- Electrostatic charges within chamber? Dust?
4fach Koinzidenz-Aufnahme-Modul
Programmable Logic (FPGA)
Integrated counters
PC readout (RS-232)
Coincidence / Extendable dead time

Event sequence

Coincidence logic

A  BC

G

2 µs γ-delay

40 ns

Coincidence time

30 µs

Dead-time
4KAM: NIM module

Threshold

Input/output drivers

Programming interface
Counters (32-bit) for several events:

- Single hits A, B, C, G
- Double coincidences AB, BC, AC
- $D = (AB \text{ OR } BC \text{ OR } AC)$-coincidence
- Triple coincidence $T = ABC$
- Logical sum $S = (A \text{ OR } B \text{ OR } C)$
- $\gamma$-coincidence $DG = (AB \text{ OR } BC \text{ OR } AC) \ G$
- $\gamma$-coincidence $TG = ABCG$-coincidence
- Counter real and life-time (10 µs resolution)
• Sample changer works reliably

• Very good agreement with PTB reference

• $^3$H efficiency up to 70 % for double coincidences

• Test and comparison of 4KAM and MAC3 very successful

• $\gamma$-channel implemented, first $^{60}$Co measurements