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Současná přístrojová technika pro LSC

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Kapalinová scintilační spektrometrie (LSC)

LSC = Liquid scintilation counting

Stanovení β izotopů
- ^{3}H, ^{14}C, ^{90}Sr, …

Lze i α zářiče
- ^{226}Ra, ^{222}Rn, ^{238}U, …

Přenosný LSC spektrometr

Triathler™ (HIDEX Oy)

19   33   25 cm
~ 9 kg
24 W

LSC: ^{3}H, ^{14}C, ^{32}P, ^{35}S, … (2   2000 keV)

$\eta \geq 45\%$
Interference lum. vs. $\beta < 0{,}1\%$

7 nebo 20 ml vialky, microtubes Eppendorf

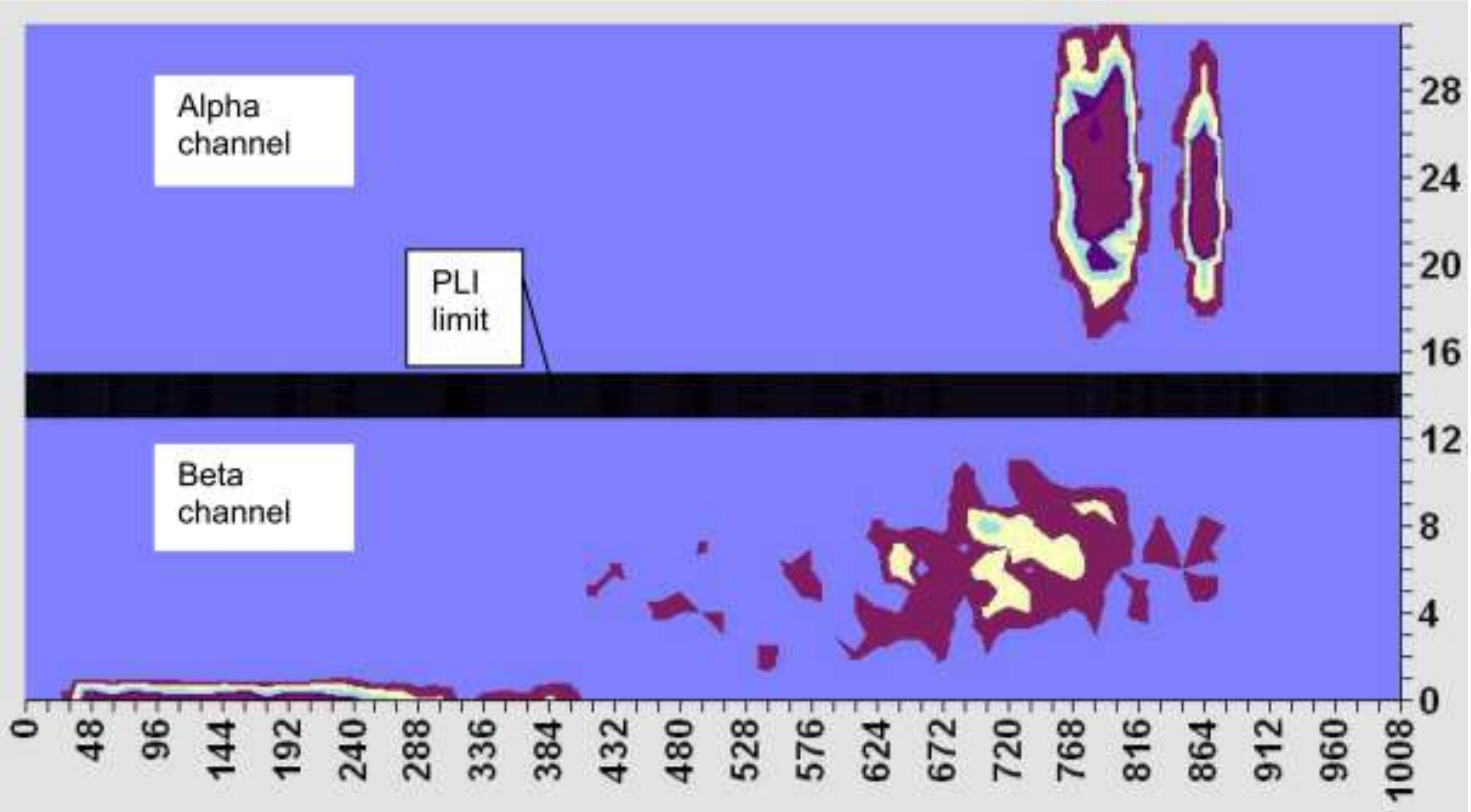
Přenosný LSC spektrometr

Přenosný LSC spektrometr

Přenosný LSC spektrometr

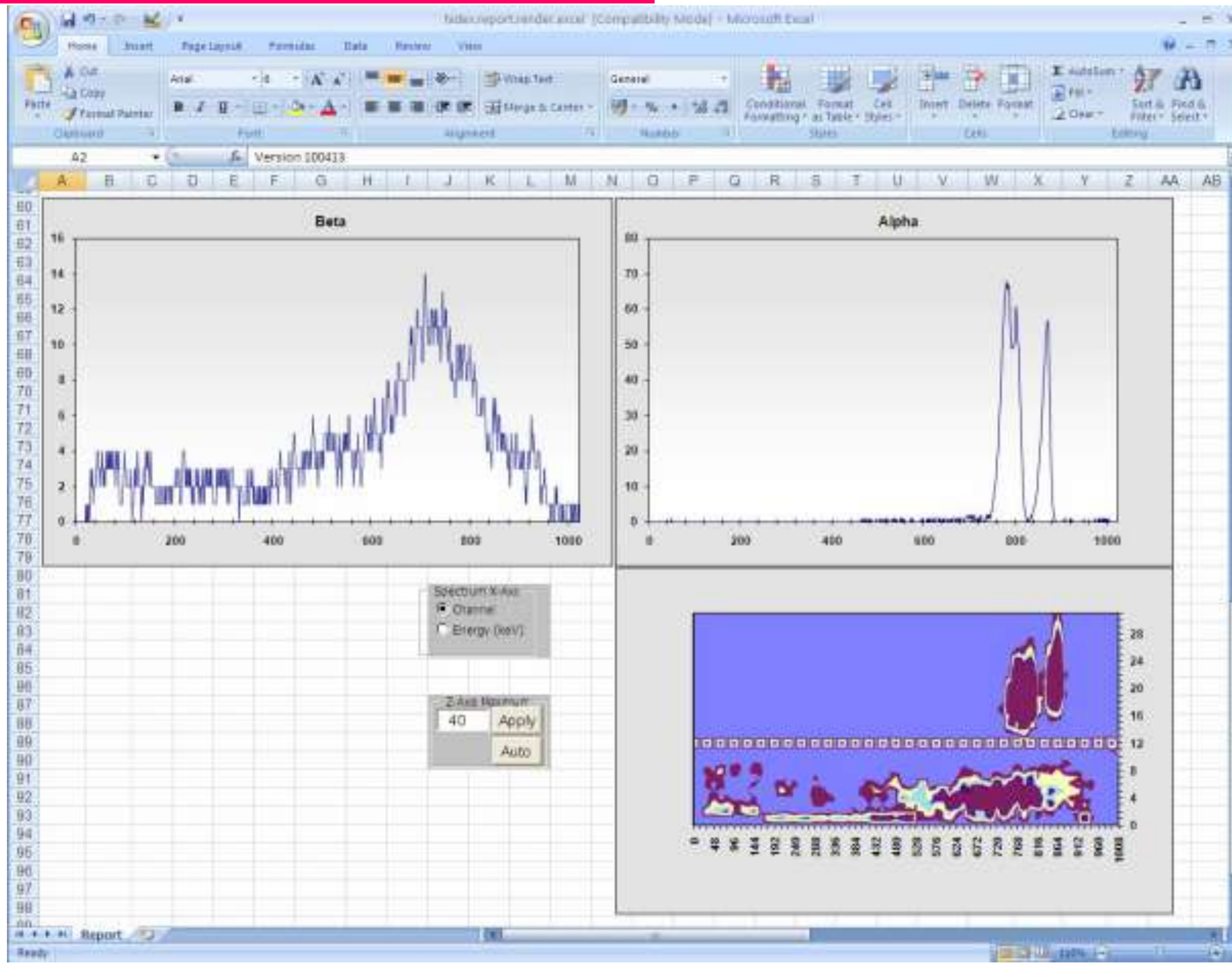
Doplněk: α/β diskriminace

PLI = puise lenght index



Přenosný LSC spektrometr

α/β diskriminace



Přenosný LSC spektrometr

- Wipe tests for α`s (e.g. U-238/U-234, Am-241,Pu-239)
- Wipe tests for β`s (e.g. H-3,C-14, Ni-63)
- Measurement of air filters
- Radon - 222 in water
- Radon - 222 equilibrium studies
- Radon - 222 in air
- Uranium - 234 / 238 in water
- Radium - 226 in water
- Thorium in water
- Sr – 90
- β-emitting radionuclides in water (e.g.:H-3,C-14,Ni-63,P-33, P-32,S-35)
- Field and In – Situ Measurements
- Gamma counting
- Cerenkov Counting
- Toxicity in water by luminescence measurement

Přenosný LSC spektrometr

LLoD

	without lead		with 6 - 8 mm lead	
	3600 s	60000 s	3600 s	60000 s
H – 3[1];V=0,008 l[2]	133 Bq / l	60 Bq / l	100 Bq / l	50 Bq / l
C – 14;V=0,008 l[3]	50 Bq / l	40 Bq / l	40 Bq / l	30 Bq / l
Ni-63 wipe test[4]	4 Bq/cm^2 in 600 s; n_0=100 cpm		2 Bq / cm^2 in 600 s; n_0=60 cpm	
	direct measurement, Aqualight		Extraction,MaxiLight	
Rn – 222	2 Bq /l in 10 minutes, 20 ml vial		< 0,5 Bq/l in 10 minutes, 20 ml vial	
Ra - 226	< 0,004 Bq / l with 14.000 seconds measuring time, emanation method			
U-238/U-234	< 0,01 Bq/l in 60 minutes measuring time, extraction from 250 ml with MaxiLight and HDEHP, accord. to sä. UBG modification			
α - Wipe test	< 0,005 Bq/cm^2 in 10 minutes measuring time, averaged over 100 cm^2, retention factor: 0,1			
α-gross counting	α: <u>0,2 Bq/l</u> in 24h; 5 ml sample; 4,6 σ			

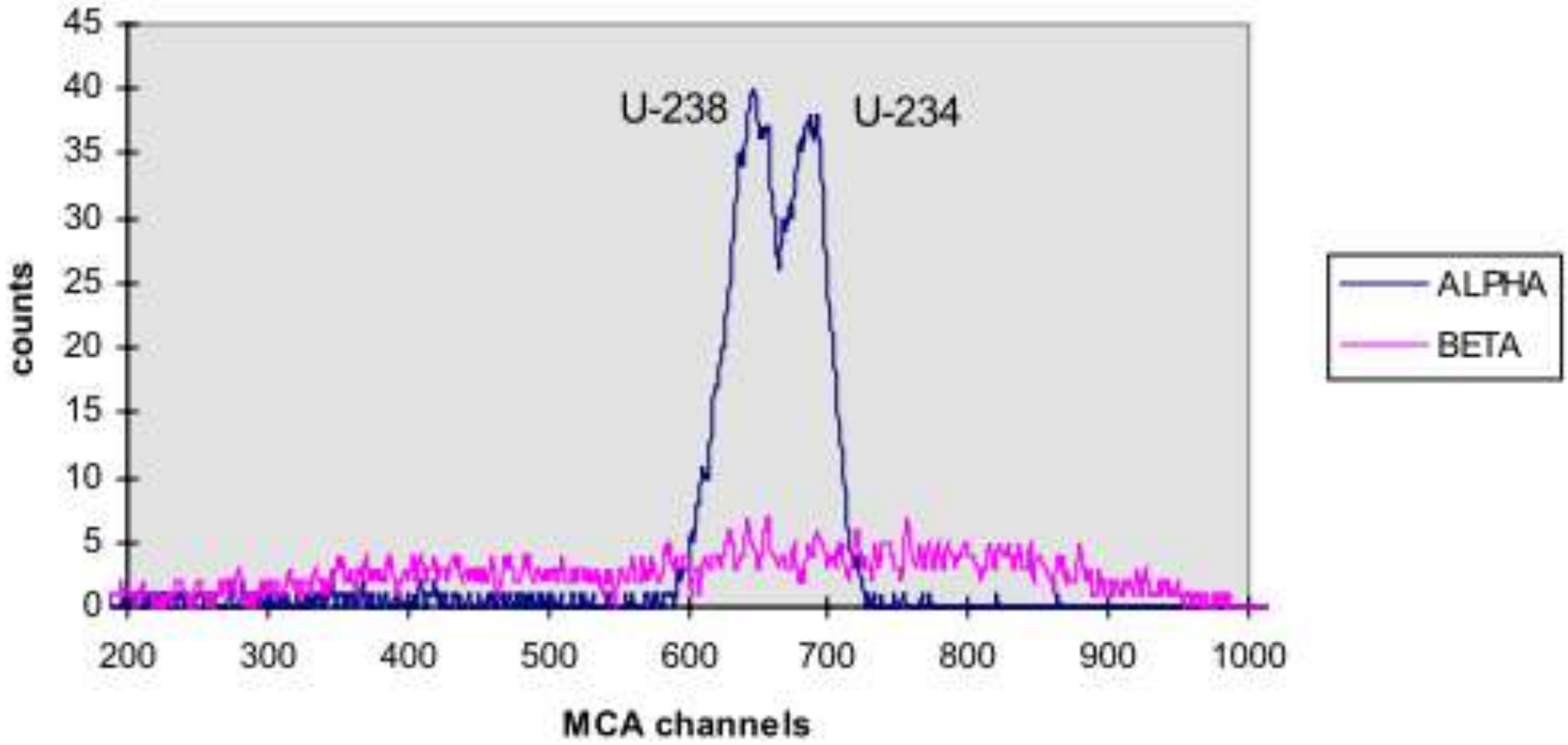
Přenosný LSC spektrometr

Rn-222

Lower Limit of Detection

	T = 1 minute Bq / l	T = 10 minutes Bq / l	T = 30 minutes Bq / l
Method 1, 20ml Background:500cpm	30	10	4
Method 2, 20ml AquaLight Background: 1 cpm	2	0,7	0,3
Method 2, 7ml AquaLight Background: 0,3 cpm	2	0,7	0,3
Method 3, 20ml MaxiLight Background: < 0,1cpm	0,8	0,2	0,08
Method 3, 7ml MaxiLight Background: < 0,05cpm	0,8	0,2	0,08

Přenosný LSC spektrometr



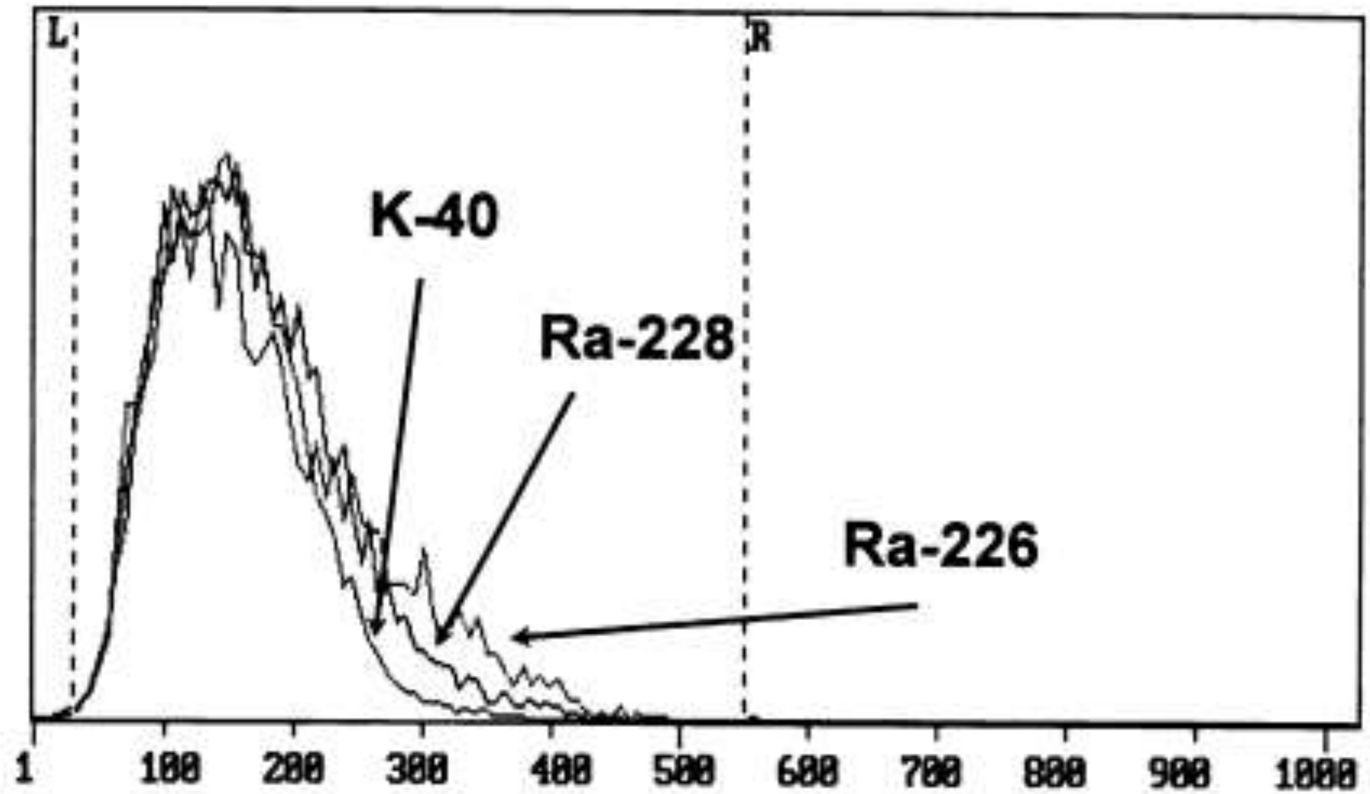
Čerenkovovo měření (Čerenkov counting)

- nabitá částice (např. elektron) se v opticky průhledném prostředí pohybuje rychleji než světlo v této látce

Pro elektrony v H_2O musí být E_e > ~ 265 keV

Čerenkovovo měření

- Není třeba scintilační koktejl
- Např. ^{32}P, $^{90}Sr/^{90}Y$, ^{40}K, ^{226}Ra



CHALUPNIK S., LEBECKA J., MIELNIKOW A, MICHALIK B. (1996): Determining Radium in Water: Comparison of Methods, Radiocarbon, 103-109

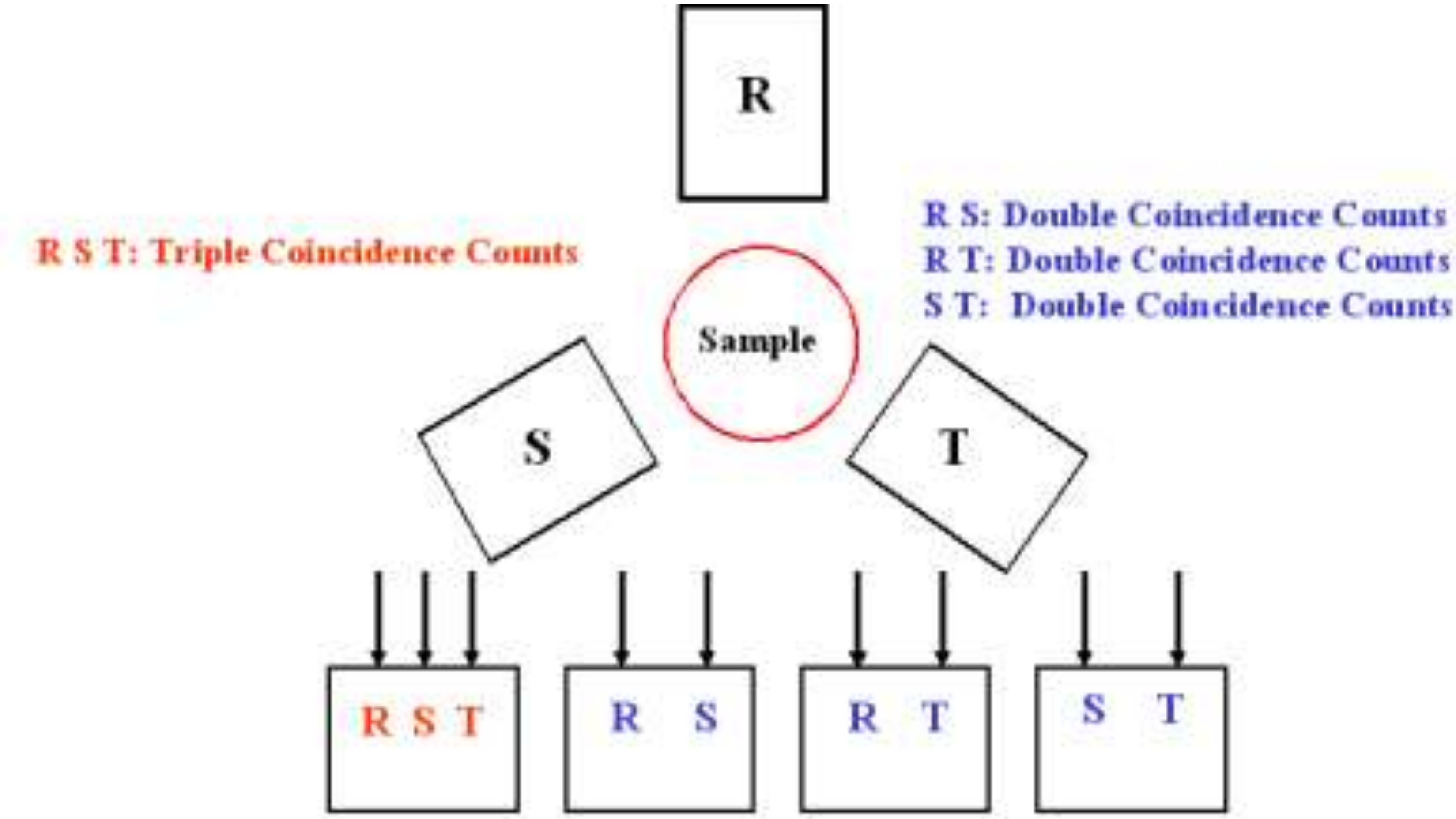
Čerenkovovo měření

Results of Comparison Measurements for Different Water Samples

Sample no.	(1) LSC (kBq m^{-3})		(2) γ spectroscopy (kBq m^{-3})		(3) Cerenkov counting (kBq m^{-3})
	^{226}Ra	^{228}Ra	^{226}Ra	^{228}Ra	^{226}Ra
1	<0.5	182.3 ± 36.4	<1.0	178.4 ± 25.0	182.6 ± 36.5
2	94.84 ± 7.79	63.84 ± 13.47	100.4 ± 9.9	65.8 ± 9.3	125.6 ± 25.2
3	3.667 ± 0.360	5.20 ± 1.56	4.4 ± 1.8	6.2 ± 2.6	10.3 ± 2.2
4	63.52 ± 5.76	32.83 ± 7.39	67.4 ± 9.2	36.4 ± 7.4	74.4 ± 15.0
5	10.40 ± 0.91	16.88 ± 3.72	--	--	25.1 ± 5.2
6	0.020 ± 0.013	<0.06	--	--	5.02 ± 1.25
7	<0.005	<0.04	--	--	420.6 ± 84.1

CHALUPNIK S., LEBECKA J., MIELNIKOW A, MICHALIK B. (1996): Determining Radium in Water: Comparison of Methods, Radiocarbon, 103-109

TDCR technika (Triple to Double Coincidence Ratio)

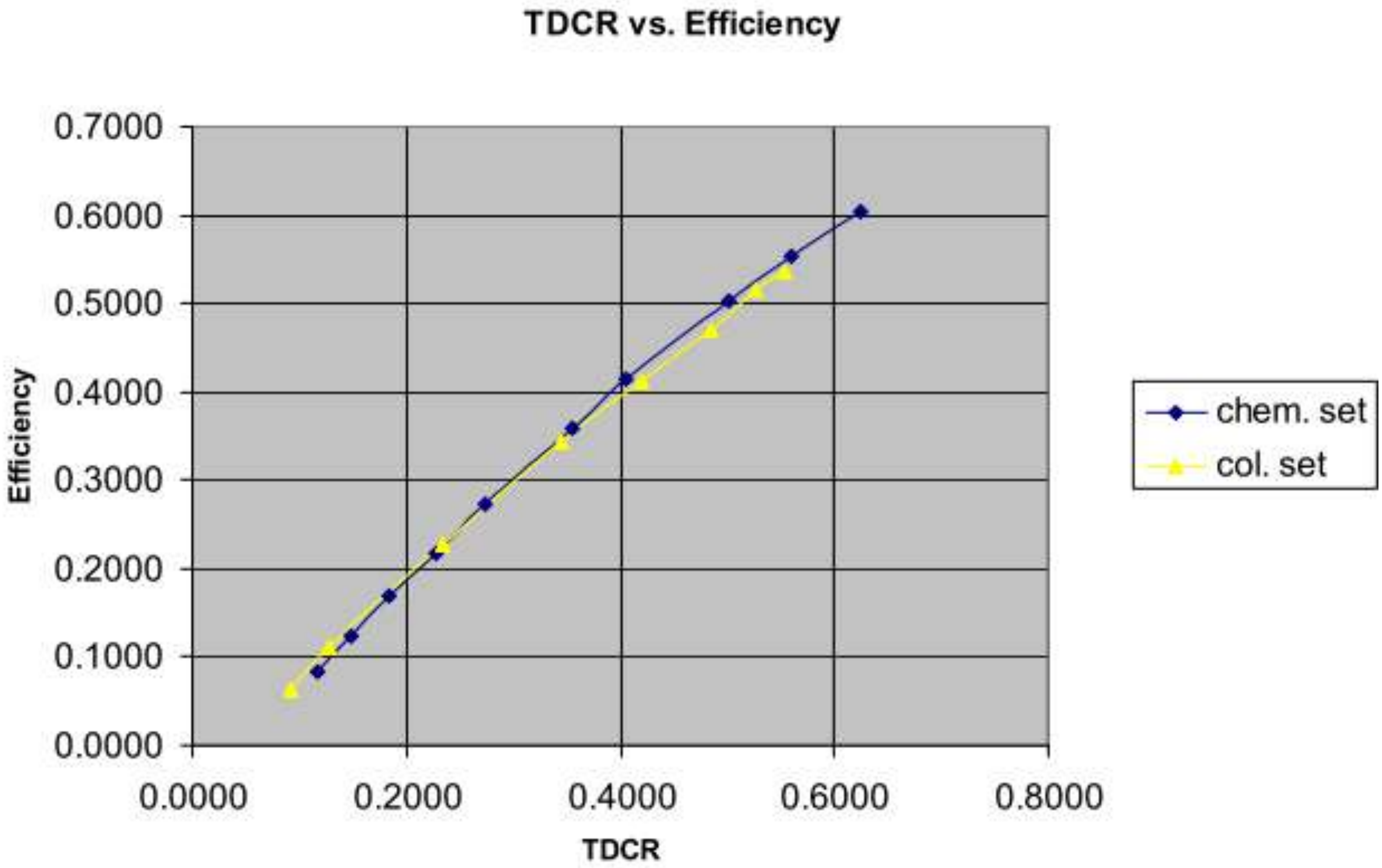


TDCR technika (Triple to Double Coincidence Ratio)

Advantages due to the 3 photomultiplier TDCR concept:

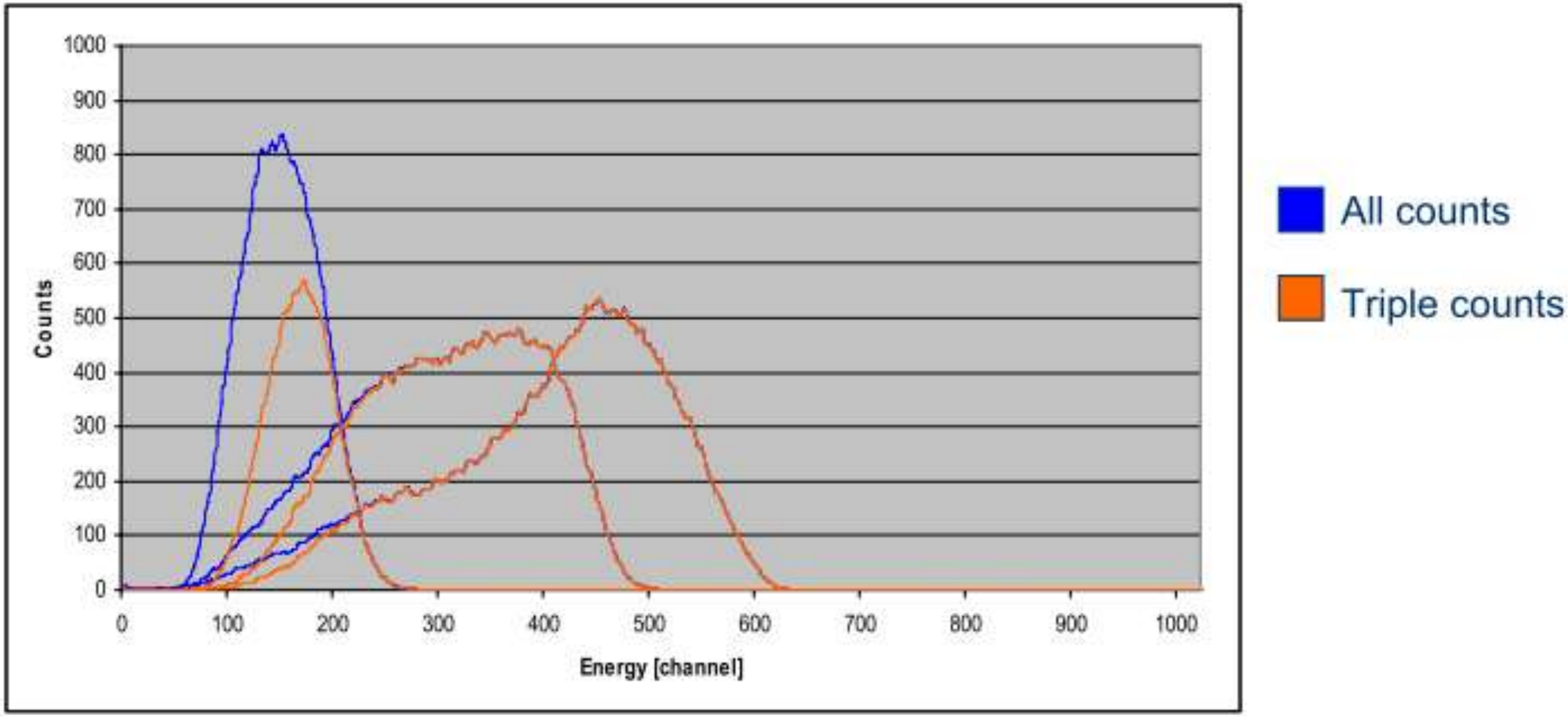
- **DPM counting of all pure beta emitting radionuclides**
- **tried and tested by many national standardization institutions**
- **proven mathematics**
- **no need for calibration with other radionuclides (see appendix)**
- **no need for quench curves (chemical and color)**
- **no need for use of external standard**
- **works excellent even for H-3 (see appendix)**
- **no need for pre-calibration in factory**
- **100 % luminescence-free measurement using the triple coincidences (important, when organic samples are counted)**
- **easy to use**

TDCR technika (Triple to Double Coincidence Ratio)

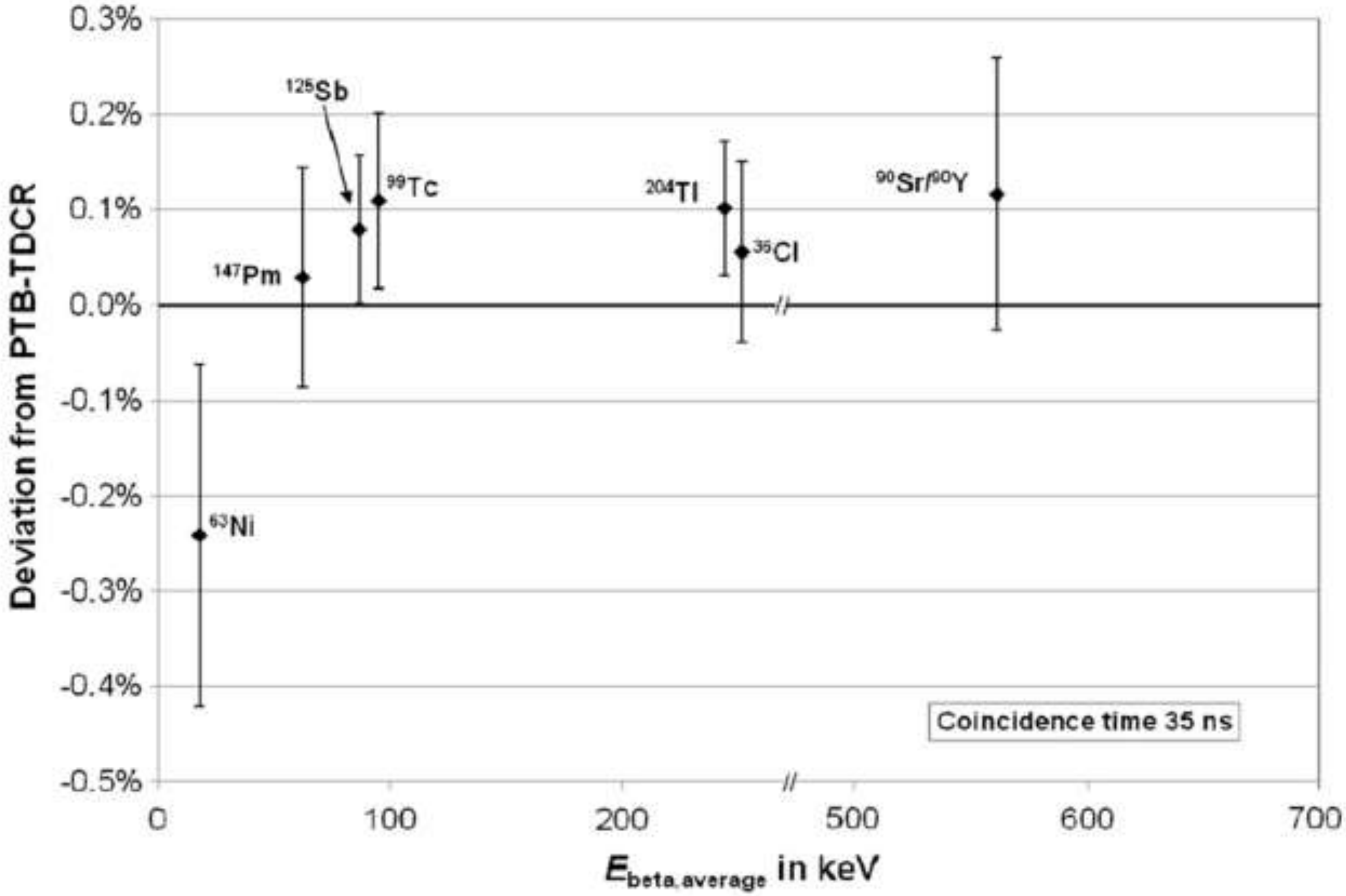


TDCR technika (Triple to Double Coincidence Ratio)

High quenched C-14 spectra



TDCR technika (Triple to Double Coincidence Ratio)

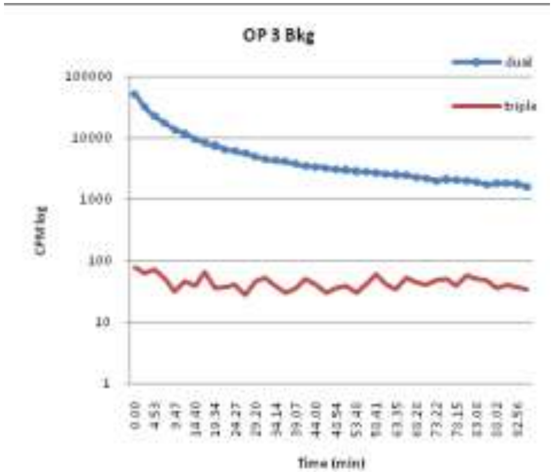


WANKE C., KOSSERT K., NÄHLE O. J. (2012): INVESTIGATIONS ON TDCR MEASUREMENTS WITH THE HIDEX 300 SL USING A FREE PARAMETER MODEL, APPL. RADIAT. ISOT. 70, 2176-2183

TDCR technika (Triple to Double Coincidence Ratio)

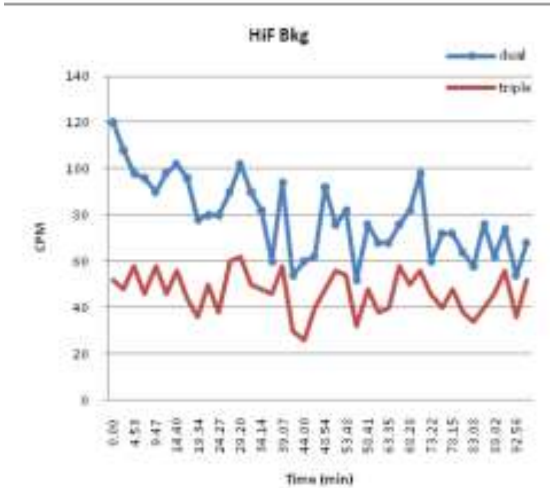
- Extrémě vysoká luminescence

(3ml 2M NaOH + 17 ml OptiPhase HiSafe 3)



- Luminiscence

(3ml 2M NaOH +17mL Hionic Fluor)

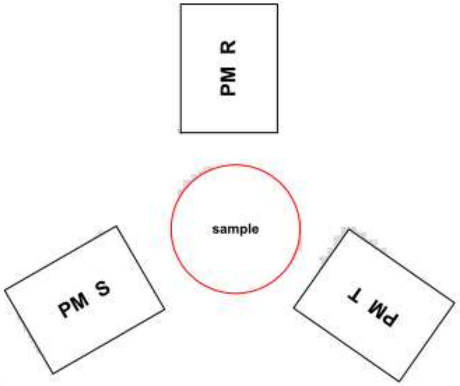


Triple Coincidence: okamžitě OK

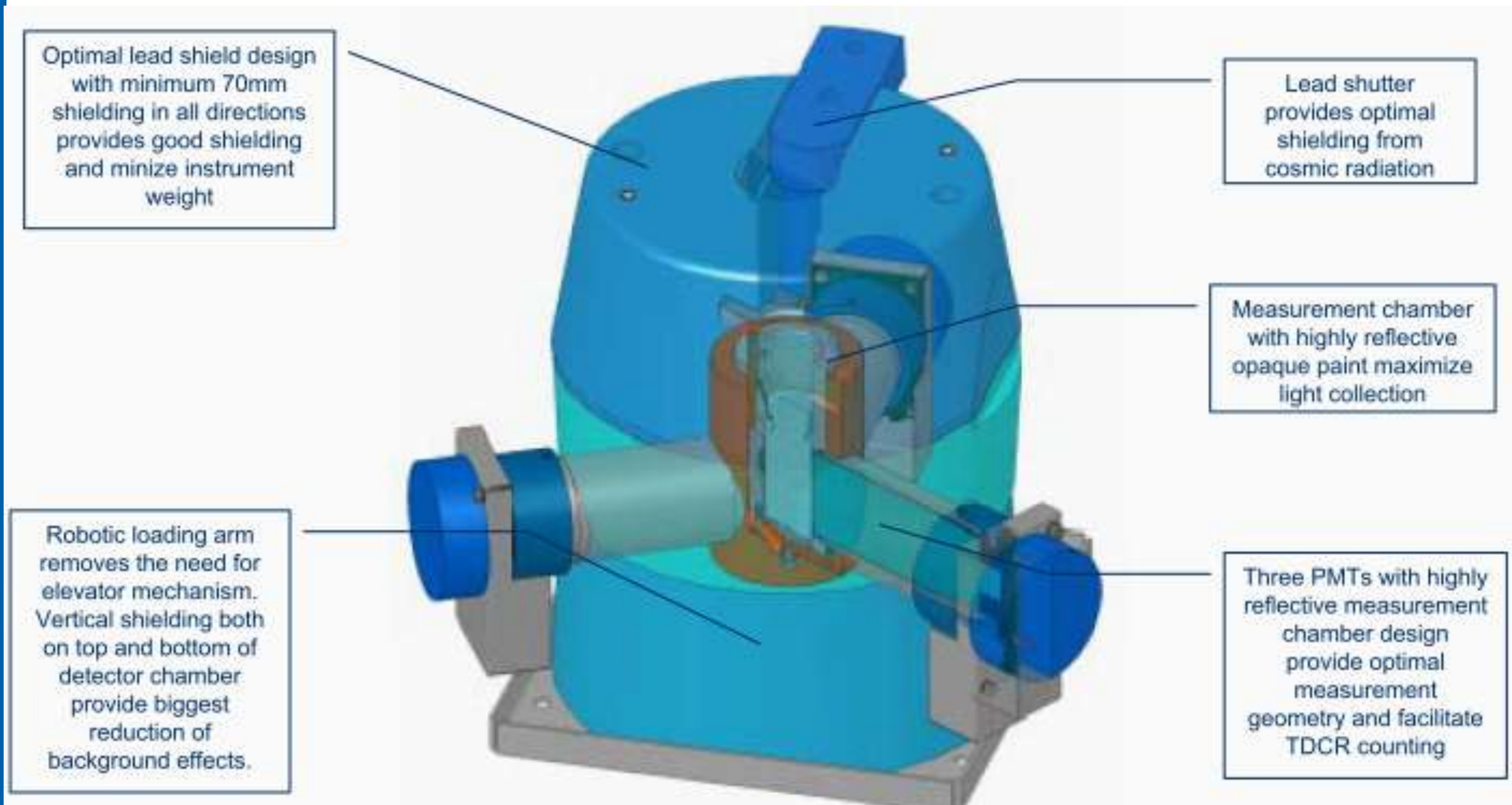
TDCR technika (Triple to Double Coincidence Ratio)

Vzorek krve – ^{3}H

TDCR technika 59000 DMP
Skutečnost 61000 DMP



TDCR technika (Triple to Double Coincidence Ratio)



TDCR technika (Triple to Double Coincidence Ratio)

300 SL™ (HIDEX Oy)

52 69 63 cm
~ 130 kg (SLL 180 kg)

- 7 nebo 20 ml vialky
- zásobník 96 nebo 40 ks

Options:
- α/β diskriminace
- měnič vzorků
- teplotní stabilizace vzorků

TDCR technika (Triple to Double Coincidence Ratio)

300 SL vs. 300 SL SLL

^{3}H ve vodě (8 ml vzorku + 12 ml koktejlu)

	300 SL	300 SL SLL
η [%]	30	33,5
BKG [CPM]	12	4,7
Detekční limit* [Bq/l]	10	2,6

* Doba měření 10 h

TDCR technika (Triple to Double Coincidence Ratio)

Key advantages of Hidex 300 SL:

- Compact instrument
- Small footprint
- Low weight
- Quench correction by TDCR technique
- No need for external standard for pure beta emitting radionuclides
- Optimized detector geometry for flexible quench correction
- Modern Windows based software
- Easy and quick α-/β-optimization using E^2/B method for best FOM
- Easy acces of primary data (code word: Excel)
- Export function fro MS Access database
- Unlimited number of customer protocols
- Easy parameter files for quick and easy measurements
- Quality control parameter files
- Modern ports