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Luminescence free counting of ^{3}H facilitated by Hidex 300 SL/600 SL TDCR triple coincidence counters

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Hidex 300 SL and 600 SL Automatic TDCR Liquid Scintillation Counters

› Automatic vial counters with triple-PMT detector facilitating:

- Exceptionally high counting efficiency,
- Absolute activity couting of beta isotopes (H-3, C-14,..) and Cherenkov isotopes (Y-90, Sr-89,..) using TDCR method without external radioactive standard source
- Luminescence free counting mode
- a/b separation with 2D graphical calibration & validation tool

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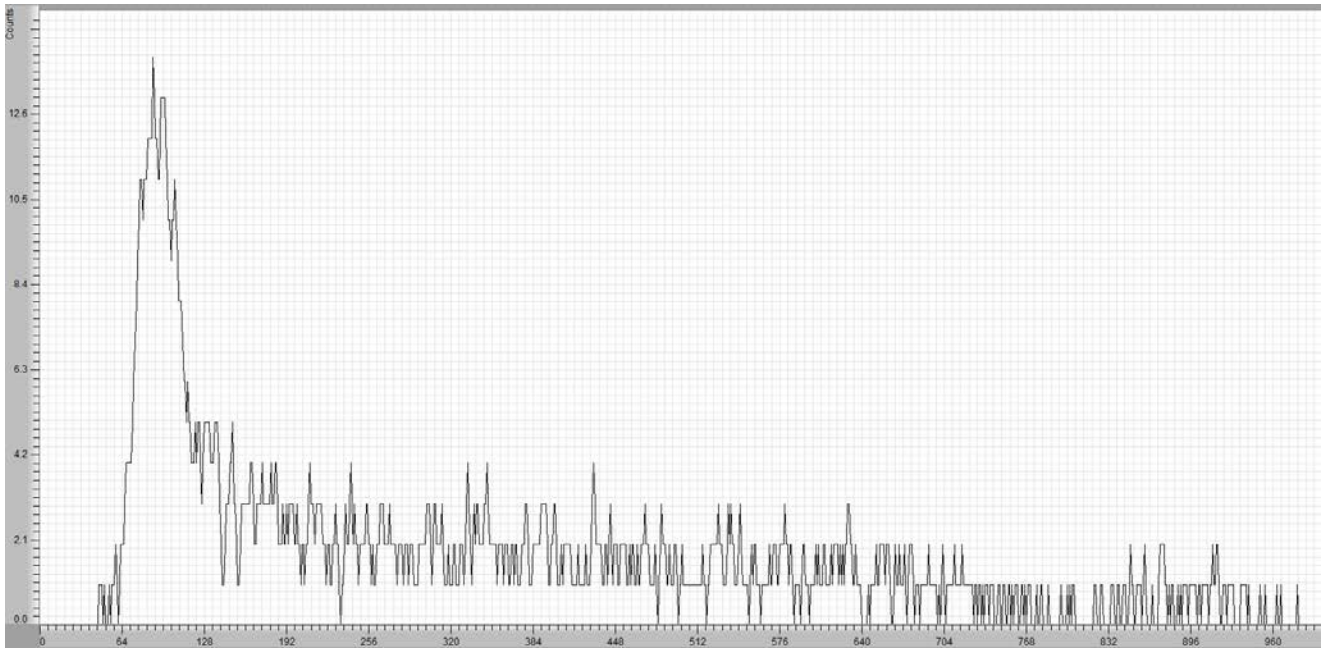
Luminescence interference

Luminescence is one of the main interferences in scintillation counting

Single photon event increasing the background and increases results variation



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Luminescence interference

Methods to reduce and correcting luminescence are
(1) Dark adaptation of sample
(2) Chemical methods
(3) Temperature control
(4) Counting region settings
(5) Delayed coincidence counting

Many labs are counting samples also with repeats, and removing outliers
- How to find outlier?
- Do I have to recount the sample or can I calculate the results using the data of remaining repeats?

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Luminescence Free Counting method (LF method) for ^{3}H in water

Method is based on counting region (ROI) settings

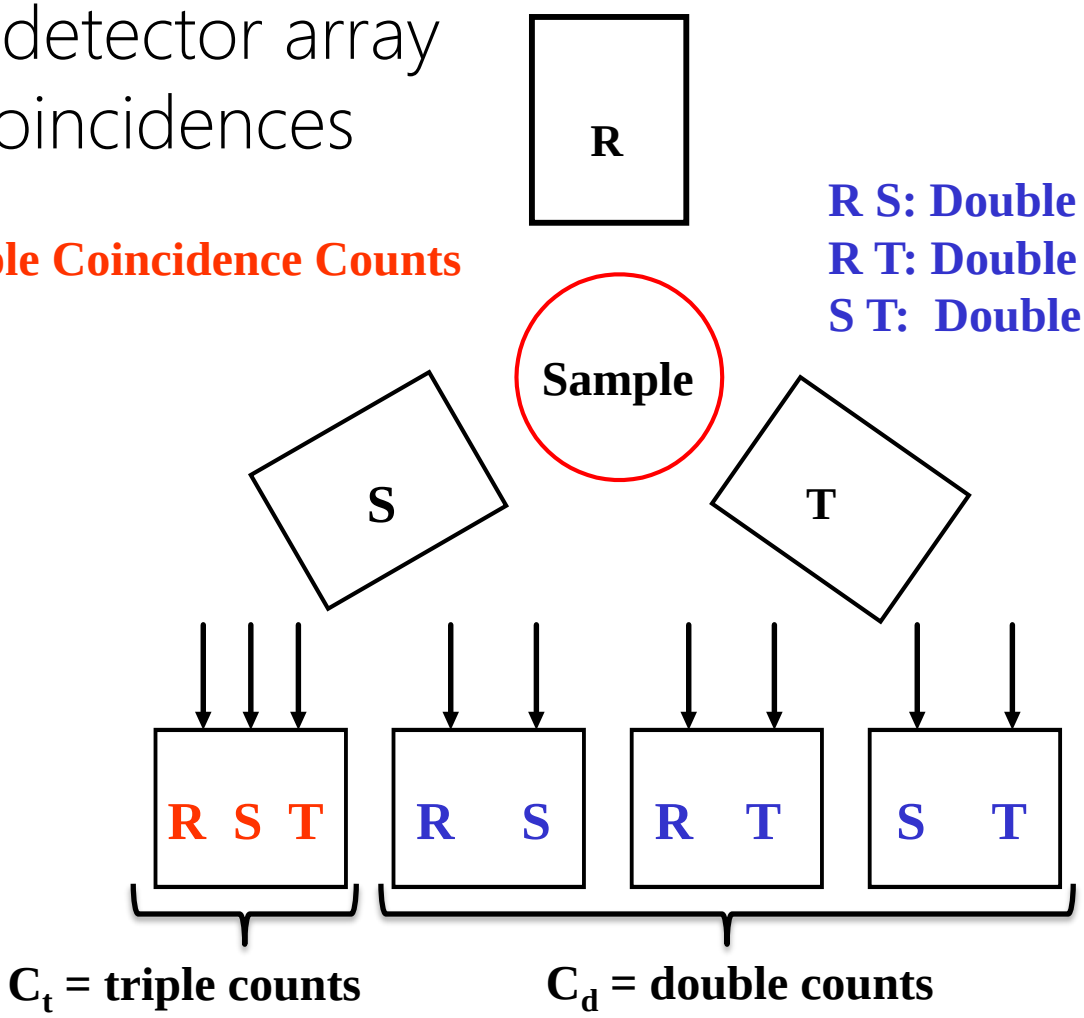
With double coincidence counters the conventional method based on counting regions (ROIs) works relatively well for higher energy isotopes like ^{14}C but yields in too low counting efficiency for ^{3}H water samples.

Improved LF method was tested for ^{3}H water samples and requires triple coincidence counter like Hidex 300 SL or 600 SL.

Triple detector array and coincidences

R S T: Triple Coincidence Counts

R S: Double Coincidence Counts
R T: Double Coincidence Counts
S T: Double Coincidence Counts



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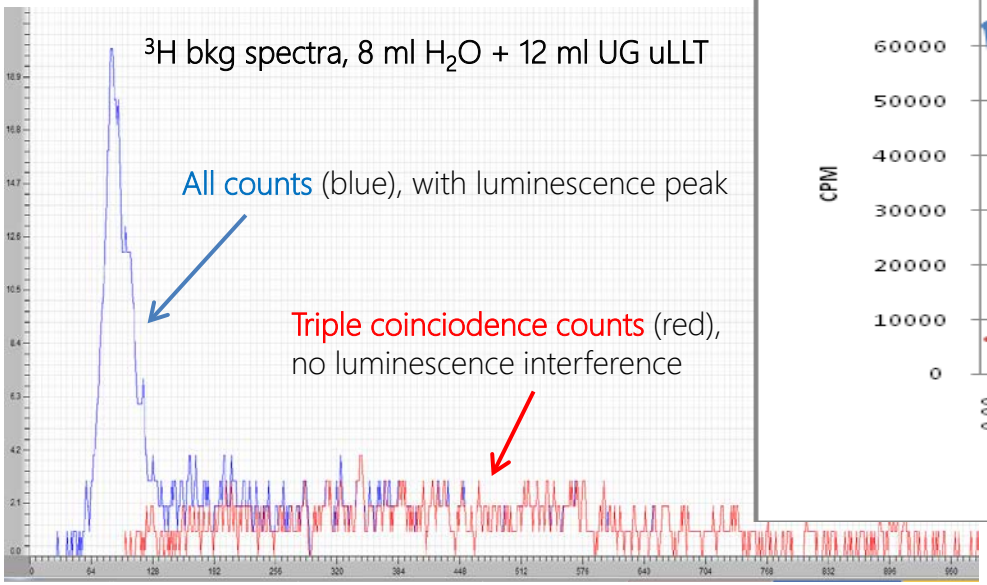
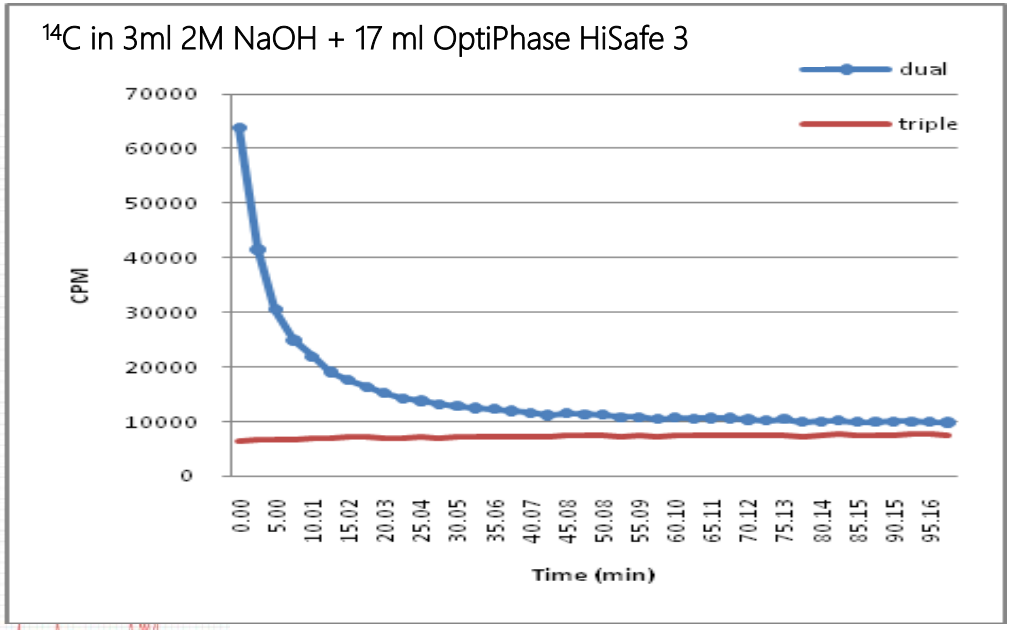
Luminescence do not interfere with triple counts





In Luminescence Free mode (LF mode) only Luminescence Free Counts are recorded:

1) All Triple Coincidence counts
2) Pure Double Coincidence counts at above luminescence ROI (> ch 120)

Improved eff. Allows also ^{3}H water measurements in LF mode

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Performance comparison of Lum Free mode and Normal count mode for ^{3}H in water

Hidex 300 SL 425-020, 8 + 12 ml sample, 10 x 50 min, ka = kb = 1.645

	Normal Mode	LF Mode
Bkg	4.7 CPM	2.8 CPM
Eff.	37 %	24 %
Ld	2.6 Bq/L 1.2 DPM	3.1 Bq/L 1.5 DPM
Outliers	High risk	Negligible risk

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IAEA TRIC2012 ^{3}H Refence samples in LF mode

- Hidex SL300 test for low-level tritium. I
- AEA TRIC2012 reference samples were measured,
- pre-distilled by ion-exchange,
- 500 mL electrolytic enrichments,
- deuterium and spike method were compared to determine 3H enrichment factors,
- full error propagation applied,
- data was processed using IAEA TRIMS software.

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IAEA TRIC2012 ^{3}H Refence samples in LF mode

Sample	Hidex 300 SL, LF mode				TRIC Ref. labs		TRIC Top lab	
	8 mL + 12 mL UGuLLT, 20 x 50 min						2000 min	
	Deuterium		Spike					
	TU (^{2}H)	Unc.	TU (spike)	Unc.	TU (known)	Unc.	TU (known)	Unc.
TRIC-20	0	0	0	0	0	0,10	0,02	0,01
TRIC-21	0,26	0,16	0,28	0,17	0,43	0,10	0,44	0,02
TRIC-22	1,13	0,18	1,17	0,18	1,12	0,10	1,12	0,15
TRIC-23	2,71	0,20	2,81	0,20	2,74	0,07	2,70	0,04
TRIC-24	4,25	0,11	4,45	0,21	4,37	0,13	4,45	0,06
TRIC-25	7,57	0,29	7,61	0,25	7,51	0,23	7,45	0,09

*Data provided by IAEA Hydrogeology lab, Vienna

Hidex 300 SL can be used to produce accurate data on LF mode for low level ^{3}H water samples.

Quench Correction in LF mode

TDCR cannot be used directly in LF mode as luminescence interferes with double coincidence counts (c_d)

$$\mathbf{TDCR} = \frac{c_t}{c_d + c_t} = \frac{c_t}{c_{all}}$$

Availabel methods:

1. Constant quench correction factor (preferred when quenching is constant)
2. External std curve method
3. Corection of TDCR with Chemi CPM

$$\mathbf{TDCR} = \frac{c_t}{c_d - Chemi + c_t} = \frac{c_t}{c_{all} - Chemi}$$

4. Triple Coincidence Channel Ratio method

- Ratio of Triple Coincidences in two different region used as quench parameter => (tROI1/tROI2) vs. Eff.

Summary

- Luminescence do not interfere with triple coincidence counts
- LF mode = all triples + pure doubles above luminescence ROI
  ⇒Improved eff. allows also ^{3}H water measurements in LF mode
- In LF mode the Eff. and Bkg are reduced, Ld only slightly higher
- Total counting time is reduced as in LF mode counting can be started more or less immediately after sample preparation
- Negligible risk for outliers
- In LF mode the preferred quench correction method is the use of Constant Quench Correction Factor (other methods are applicable)
- Hidex 300 SL and 600 SL provide accurate data in LF mode for low level ^{3}H water samples

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Thank You!

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