Финансирано от Европейския съюз
NextGenerationEU

SUMMIT
SOFIA UNIVERSITY MARKING MOMENTUM FOR INNOVATION AND TECHNOLOGICAL TRANSFER

Национален план за възстановяване и устойчивост
НА РЕПУБЛИКА БЪЛГАРИЯ

СОФИЙСКИ УНИВЕРСИТЕТ - МАРКЕР ЗА ИНОВАЦИИ И ТЕХНОЛОГИЧЕН ТРАНСФЕР

Абсолютни измервания на активност в лаб. "Метрология на йонизиращите лъчения" на катедра АФ

доц. д-р Красимир Митев

КАТЕДРА „АТОМНА ФИЗИКА“ НА 80 ГОДИНИ

16 – 18 АПРИЛ 2026, СОФИЯ

Екип

Финансирано от Европейския съюз
NextGenerationEU

SUMMIT
SOFIA UNIVERSITY MARKING MOMENTUM FOR INNOVATION AND TECHNOLOGICAL TRANSFER

Национален план за възстановяване и устойчивост
НА РЕПУБЛИКА БЪЛГАРИЯ

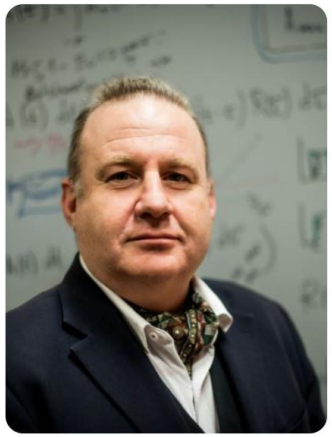
СОФИЙСКИ УНИВЕРСИТЕТ - МАРКЕР ЗА ИНОВАЦИИ И ТЕХНОЛОГИЧЕН ТРАНСФЕР

Нашият Екип

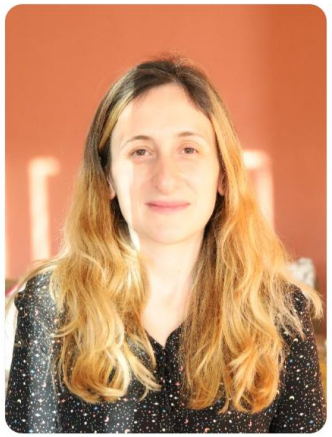
https://radmet.phys.uni-sofia.bg/

Утвърдени учени и млади изследователи

Повече за екипа →



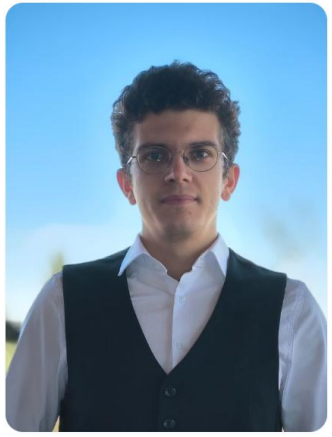
доц. д-р Красимир Митев
Ръководител на групата



доц. д-р Ивелина Димитрова

доц. д-р Страхил Георгиев

Philippe Cassette, PhD, HDR



Владислав Тодоров
Докторант

Божидар Кръстев
Докторант

Ангелика Попова

Екип

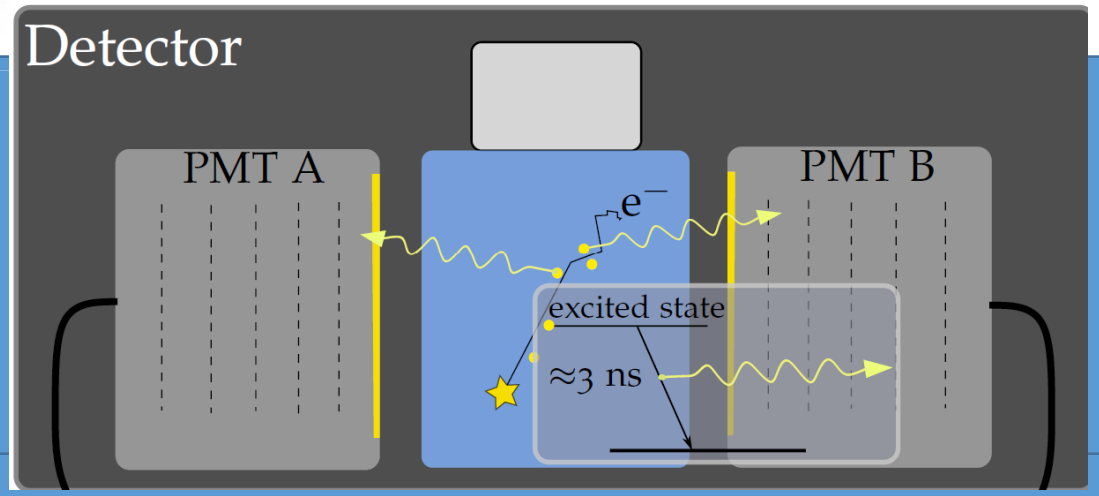
Финансирано от Европейския съюз
NextGenerationEU

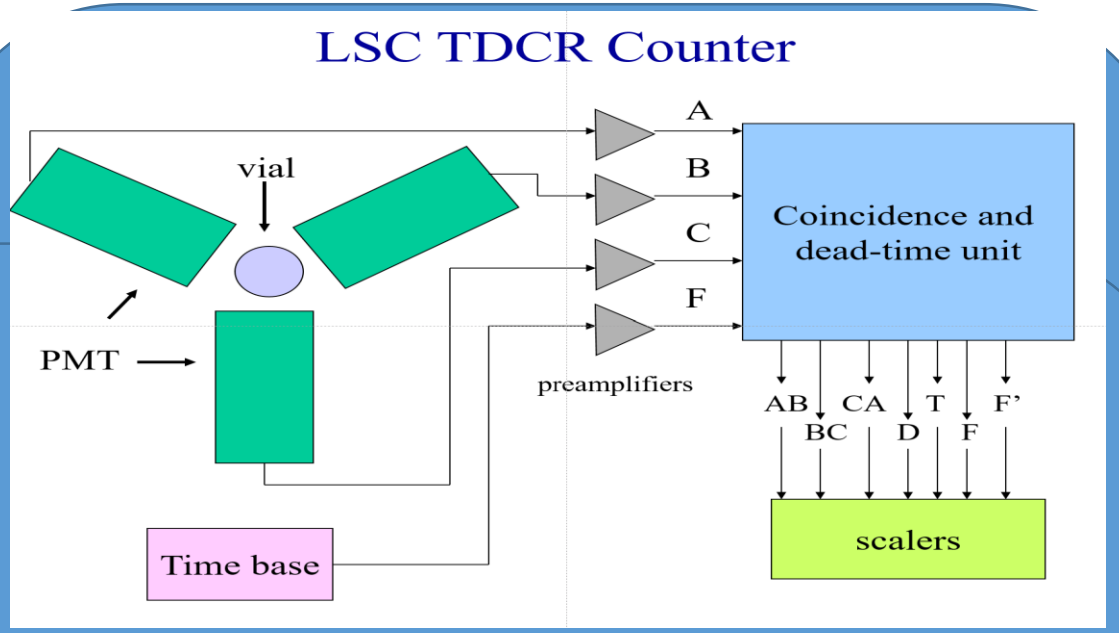
SUMMIT
SOFIA UNIVERSITY MARKING MOMENTUM FOR INNOVATION AND TECHNOLOGICAL TRANSFER

Национален план за възстановяване и устойчивост
НА РЕПУБЛИКА БЪЛГАРИЯ

СОФИЙСКИ УНИВЕРСИТЕТ - МАРКЕР ЗА ИНОВАЦИИ И ТЕХНОЛОГИЧЕН ТРАНСФЕР

The TDCR Method





$$\frac{\phi_T}{\phi_D} = \frac{\int_0^{E_{max}} S(E)\left(1-e^{-\varphi E Q(E)/3}\right)^3 dE}{\int_0^{E_{max}} S(E)\left[3\left(1-e^{-\varphi E Q(E)/3}\right)^2 - 2\left(1-e^{-\varphi E Q(E)/3}\right)^3\right] dE} = \frac{T}{D} \leftarrow \begin{matrix}\text{експериментално}\\ \text{измерено}\\ \text{отношение}\end{matrix}$$

формула на Бъркс за нелинейността на сцинтилатора:

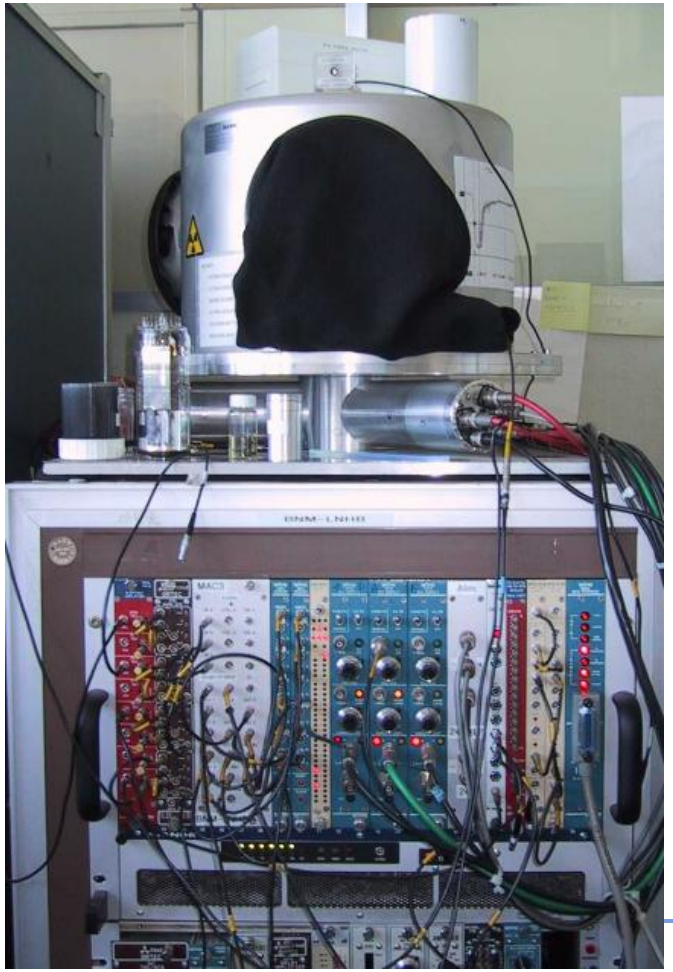
$$Q(E) = \frac{1}{E}\int_0^E \frac{dE}{1+kB(dE/dx)}$$

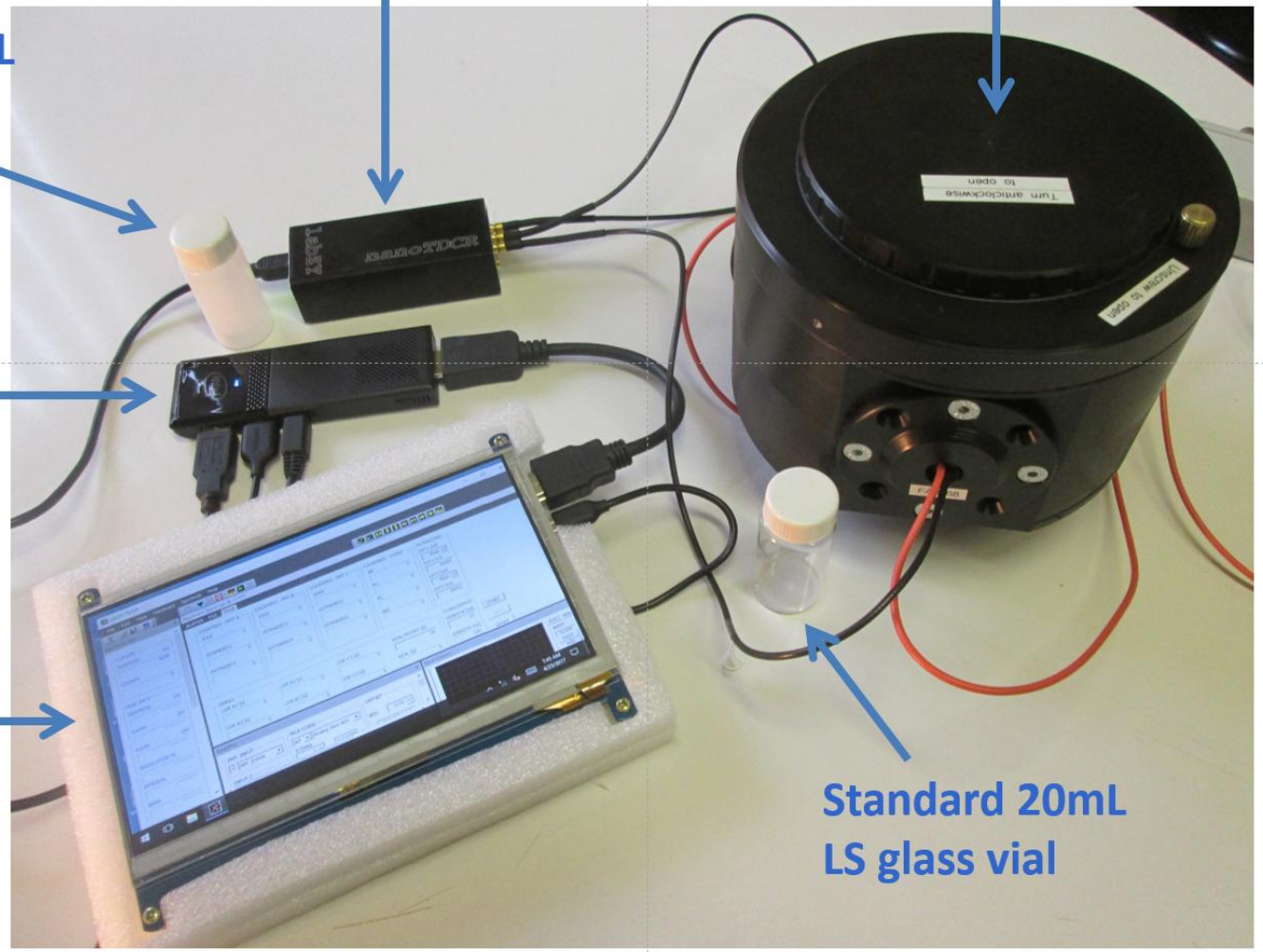
- φ [ph.e$^-$/keV] е параметър даващ броя регистрирани фотони за keV отдадена енергия
- kB [μm/MeV] е параметъра на Бъркс характеризиращ нелинейността на сцинтилатора
- За дадено kB можем да минимизираме $\Delta = \left(\frac{\phi_T(\varphi)}{\phi_D(\varphi)} - \frac{T}{D}\right)^2$ за да получим φ и от там:

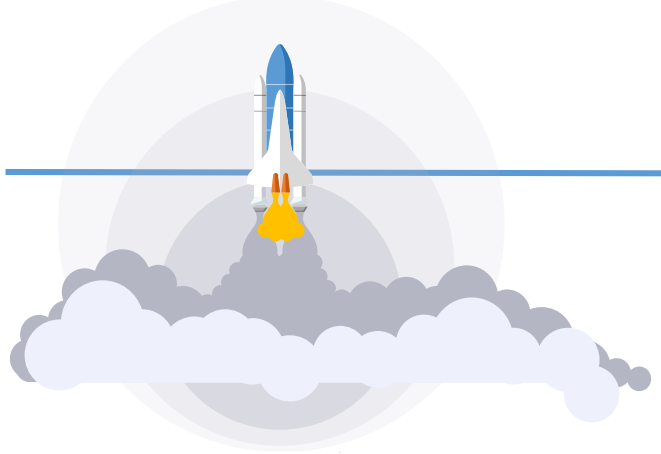
$$A = \frac{D}{\phi_D(\varphi, kB)}$$

Първата TDCR- SU система

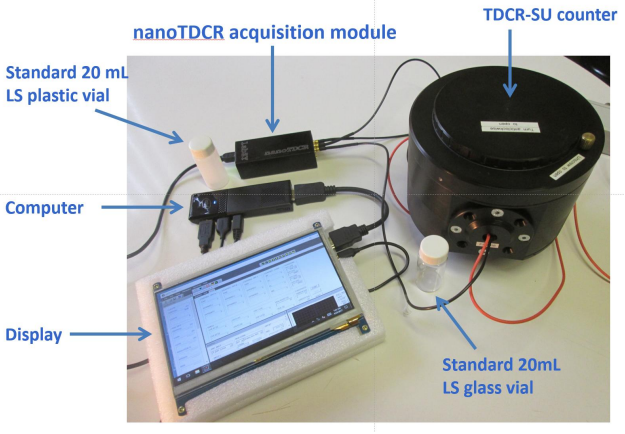
LNHB RCTD1



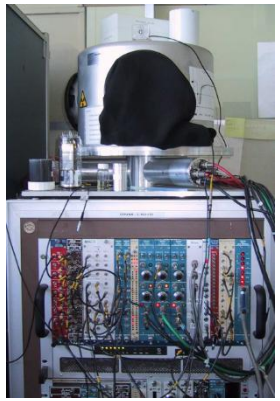




Първата TDCR система

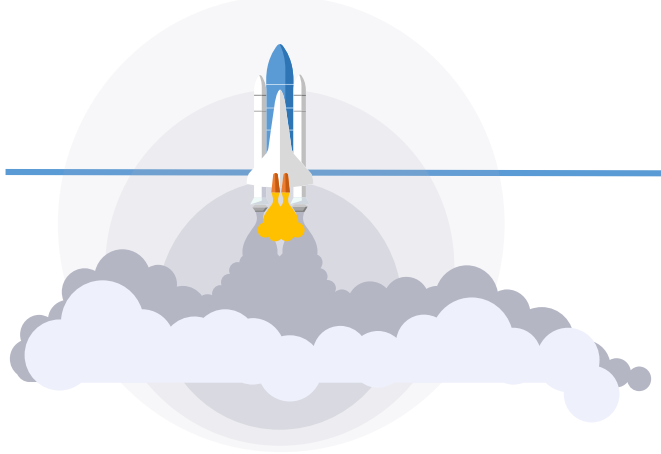


VS.



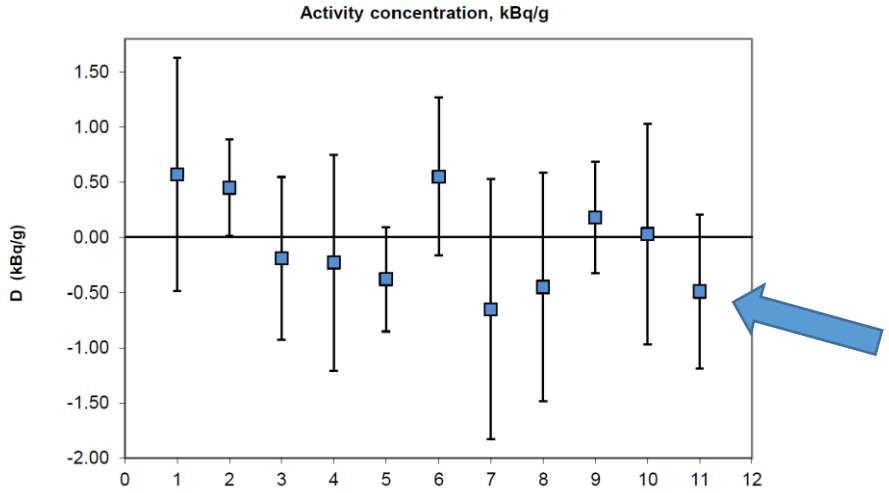
Source:	Activity measured by RCTD1, LNHB , Bq	Activity measured by TDCR-SU, Bq	$\Delta = \frac{A_{RCTD1} - A_{SU}}{A_{RCTD1}}$
H-3 in toluene-based LSC	1010.7(2.1) [0.21%]	1010.9(5.1) [0.50%]	-0.02 %
C-14 in toluene-based LSC	1728.2(2.4) [0.14%]	1731.3(4.7) [0.27%]	-0.18 %
Ni-63 in Ultima Gold LSC	1325.9(4.1) [0.31%]	1313.9 ± 4.9 [0.37%]	0.91 %

Coincidence window, ns	Dead time base, µs	TDCR-SU A_{SU} , Bq	RCTD1, LNHB A_{LNHB}, Bq	$\Delta = \frac{A_{RCTD1} - A_{SU}}{A_{RCTD1}}$
40	50	542.6 (1.2)	543.9 (1.1)	0.24 %
40	100	542.8 (1.2)		0.20 %
120	50	542.7 (1.2)		0.21 %
120	100	543.2 (1.2)		0.14 %



Първото участие в истинско трудно международно сравнение – BIPM'2018

11	SUN	52.68	0.36	0.69%



Results of the CCRI(II)-K2. H-3 Key Comparison 2018: Measurement of the activity concentration of a tritiated-water source

Philippe Cassette[1], Arzu Arinc[2], Marco Capogni[3], Chavdar Dutsov[4], Raphael Galea[5], Eduardo Garcia-Toraño[6], Karsten Kossert[7], Juncheng Liang[8], Krasimir Mitev[4], Ole Nähle[7], Youcef Nedjadi[9], Pilar Oropesa Verdecia[10], Marcell Takács[7], Tomasz Ziemek[11]

[1] *CEA, LIST, Laboratoire National Henri Becquerel, LNE-LNHB, CEA-Saclay, 91191 Gif sur Yvette Cedex, France.*
[2] *National Physical Laboratory, NPL, Queens Road, Teddington, Middlesex TW11 0LW, UK*
[3] *ENEA, National Institute of Ionizing Radiation Metrology, INMRI, Italy*
[4] *Lab. MIL, Faculty of Physics, Sofia University "St. Kliment Ohridski" (SUN), 1164 Sofia, Bulgaria*
[5] *National Research Council of Canada (NRC), 1200 Montreal Road, Ottawa, ON, Canada K1A0R6*
[6] *CIEMAT, Avenida Complutense 40, 28040, Madrid, Spain*
[7] *Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig, Germany*
[8] *Division of Ionizing Radiation Metrology, National Institute of Metrology, Beijing 100029, China*
[9] *Institut de Radiophysique, IRA-METAS, Lausanne, Switzerland*
[10] *Centro de Isótopos (CENTIS). Guanabacoa, La Habana 11100, Cuba*
[11] *National Centre for Nuclear Research Radioisotope Centre POLATOM (NCBJ RC POLATOM), Andrzeja Soltana 7, 05-400 Otwock, Poland*

Table 4. Degrees of equivalence

	laboratory	D	U	|D| / U	weight
1	CENTIS	0,57	1,1	1	
2	CIEMAT	0,45	0,4	1	18
3	ENEA	-0,19	0,7		
4	IRA-METAS	-0,23	1,0		
5	LNHB	-0,38	0,5	1	16
6	NIM	0,55	0,7	1	
7	NPL	-0,65	1,2	1	
8	NRC	-0,45	1,0		
9	POLATOM	0,18	0,5		15
10	PTB	0,03	1,0		
11	SUN	-0,49	0,7	1	

Още 2 TDCR системи

Nuclear Inst. and Methods in Physics Research, A 1034 (2022) 166721

Contents lists available at ScienceDirect

Nuclear Inst. and Methods in Physics Research, A

journal homepage: www.elsevier.com/locate/nima

Performance of portable TDCR systems developed at LNE-LNHB

Benoît Sabot [a,*], Chavdar Dutsov [b], Philippe Cassette [b], Krasimir Mitev [b]

[a] Université Paris-Saclay, CEA, LIST, Laboratoire National Henri Becquerel (LNE-LNHB), F-91120 Palaiseau, France
[b] Sofia University "St. Kliment Ohridski", Faculty of Physics, 5 James Bourchier Blvd, 1164, Bulgaria

Още електроника, независима система за TDCR броене с digitizer

Методично развитие – задълбаване във физиката на процесите

Applied Radiation and Isotopes 154 (2019) 108895

Contents lists available at ScienceDirect

Applied Radiation and Isotopes

journal homepage: www.elsevier.com/locate/apradiso

Study of two different coincidence counting algorithms in TDCR measurements

Ch Dutsov[a,*], K. Mitev[a], P. Cassette[b], V. Jordanov[c]

[a] Sofia University "St. Kliment Ohridski", Faculty of Physics, Bulgaria
[b] CEA, LIST, Laboratoire National Henri Becquerel, LNE-LNHB, France
[c] labZY LLC, Santa Fe, New Mexico, USA

Applied Radiation and Isotopes 226 (2025) 112094

Contents lists available at ScienceDirect

Applied Radiation and Isotopes

journal homepage: www.elsevier.com/locate/apradiso

MCLTDCR: A Monte Carlo code for generation of list mode TDCR files

K. Mitev[a,b,*], V. Todorov[a], P. Cassette[a], B. Sabot[b]

[a] Sofia University "St Kliment Ohridski", Faculty of Physics, 5 James Bourchier Blvd., Sofia, 1164, Bulgaria
[b] Université Paris-Saclay, CEA, LIST, Laboratoire National Henri Becquerel (LNE-LNHB), Palaiseau, F-91120, France

Nuclear Inst. and Methods in Physics Research, A 987 (2021) 164846

Contents lists available at ScienceDirect

Nuclear Inst. and Methods in Physics Research, A

journal homepage: www.elsevier.com/locate/nima

In quest of the optimal coincidence resolving time in TDCR LSC

Chavdar Dutsov[a,*], Philippe Cassette[a], Krasimir Mitev[a], Benoît Sabot[b]

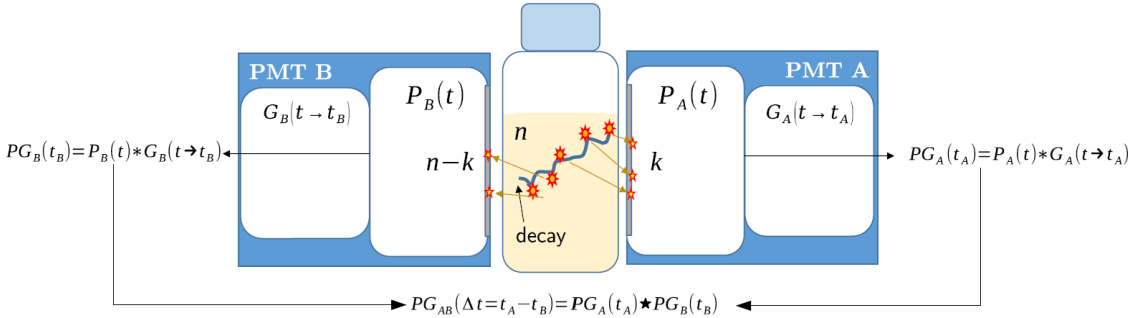
[a] Sofia University "St. Kliment Ohridski", Faculty of Physics, 5 James Bourchier Blvd, 1164, Bulgaria
[b] CEA, LIST, Laboratoire National Henri Becquerel, LNE-LNHB, 91191, Gif- sur-Yvette Cedex, France

www.nature.com/scientificreports

scientific reports

OPEN Time-domain based evaluation of detection efficiency in liquid scintillation counting

Krasimir Mitev[1], Chavdar Dutsov[1*], Philippe Cassette[1] & Benoît Sabot[2]



$$D'(\Delta t;\varphi,\lambda,\varepsilon,\mu,\sigma)=\frac{1}{L'}\int_0^{E_{max}} S(E)\sum_{2}^{\infty}\frac{(\tilde{n}(E;\varphi))^n}{n!}e^{-\tilde{n}(E;\varphi)}\sum_{k=1}^{n-1}\sum_{m=1}^{n-k}\frac{n!}{k!m!l!}\epsilon_A^k\epsilon_B^m\epsilon_C^l\,A(\Delta t;k,m,\lambda,\mu,\sigma)\,dE,$$

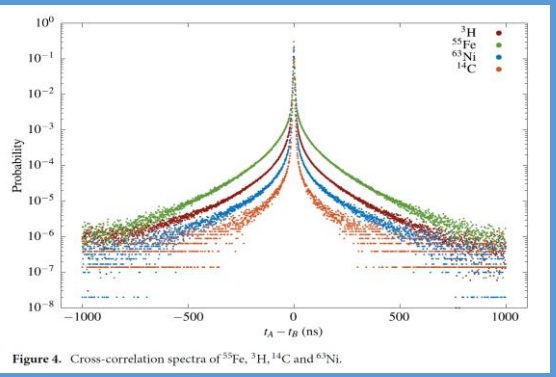
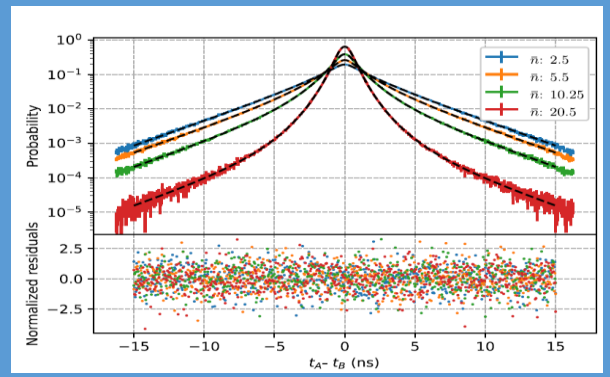


Figure 4. Cross-correlation spectra of ^{55}Fe, ^{3}H, ^{14}C and ^{63}Ni.



Методично развитие – Корекция за случайни съвпадения

Nuclear Inst. and Methods in Physics Research, A 977 (2020) 164292

Contents lists available at ScienceDirect

Nuclear Inst. and Methods in Physics Research, A

journal homepage: www.elsevier.com/locate/nima

Evaluation of the accidental coincidence counting rates in TDCR counting

Chavdar Dutsov [a,*], Philippe Cassette [b], Benoît Sabot [b], Krasimir Mitev [a]

[a] Sofia University "St. Kliment Ohridski", Faculty of Physics, 5 James Bourchier Blvd, 1164, Bulgaria
[b] CEA, LIST, Laboratoire National Henri Becquerel, LNE-LNHB, 91191, Gif- sur-Yvette Cedex, France

Journal of Radioanalytical and Nuclear Chemistry
https://doi.org/10.1007/s10967-022-08316-y

Significance of the corrections for accidental coincidences in liquid scintillation counting measurements

Chavdar Dutsov[1,2] · Benoît Sabot[3] · Philippe Cassette[1] · Krasimir Mitev[1]

Received: 1 December 2021 / Accepted: 6 April 2022

Applied Radiation and Isotopes 226 (2025) 112176

Contents lists available at ScienceDirect

Applied Radiation and Isotopes

journal homepage: www.elsevier.com/locate/apradiso

Study of a method to correct for accidental coincidences in TDCR measurements

Karsten Kossert *, Marcell Péter Takács

Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116, Braunschweig, Germany

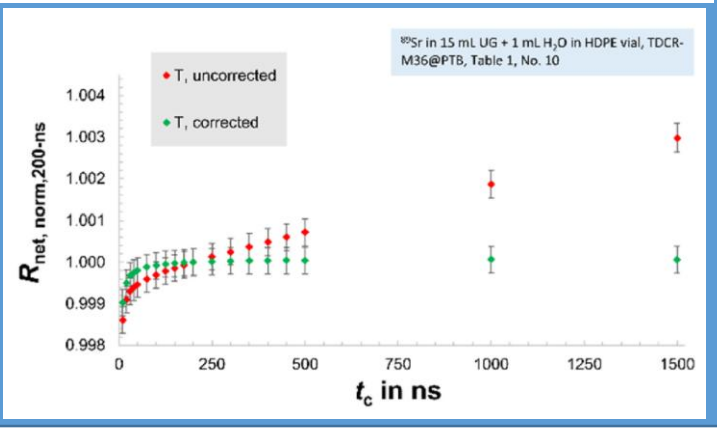
ARTICLE INFO

Keywords:
Liquid scintillation counting
TDCR counting
Accidental coincidences
Coincidence resolving time
Radionuclide metrology

ABSTRACT

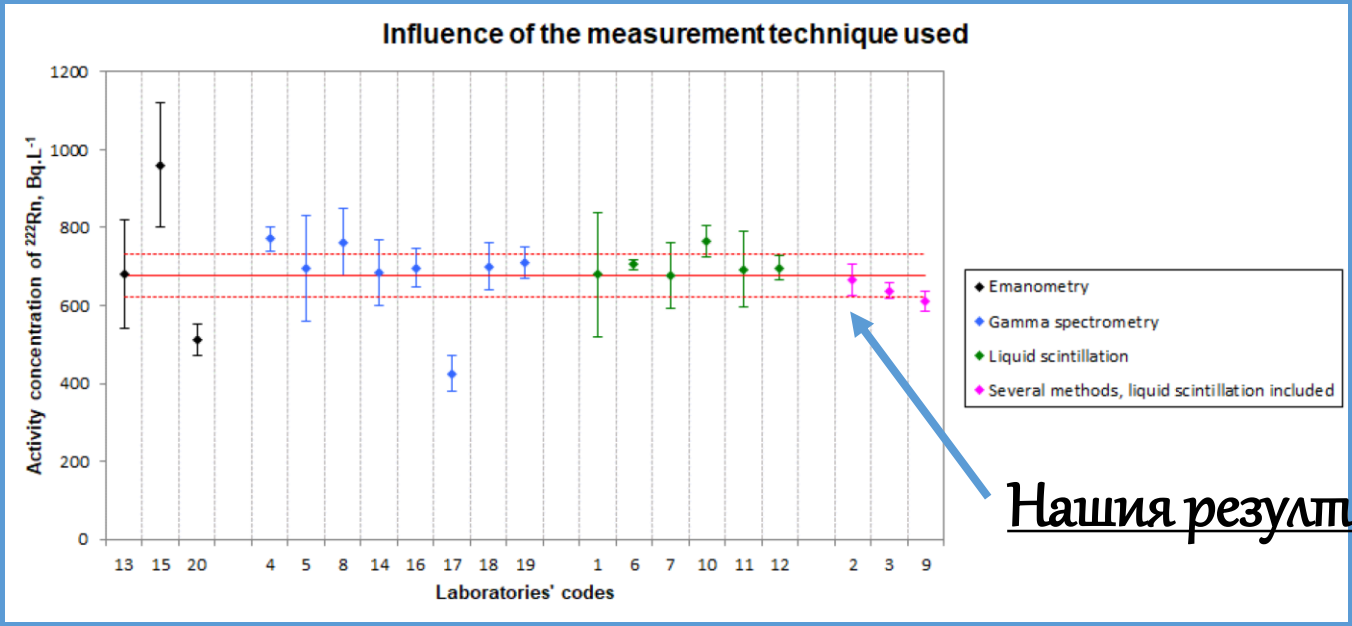
A recently proposed method from Dutsov et al. (2020) for correcting random coincidences in TDCR measurements was thoroughly examined. To achieve this, an extensive experimental study was conducted using various liquid scintillation (LS) samples. The study involved several radionuclides (^{3}H, ^{32}Si/^{32}P, ^{55}Fe, ^{89}Sr, ^{151}Sm, ^{238}Pu, and ^{241}Am) as well as background samples. Different LS cocktails and activity levels were also considered. Data acquisition was performed using a fast digitizer, and the resulting list-mode data were analyzed by systematically varying the coincidence resolving time over a range from 10 ns to 1500 ns. All data were evaluated both with and without correction for random coincidences.

In all cases, the measurement results exhibited significantly better consistency when the correction for random coincidences was applied. This also holds for background measurements. The improvement was particularly evident at longer coincidence resolving times. Moreover, it is demonstrated that the correction is essential for accurately evaluating uncertainties.



Метрология на радон във вода

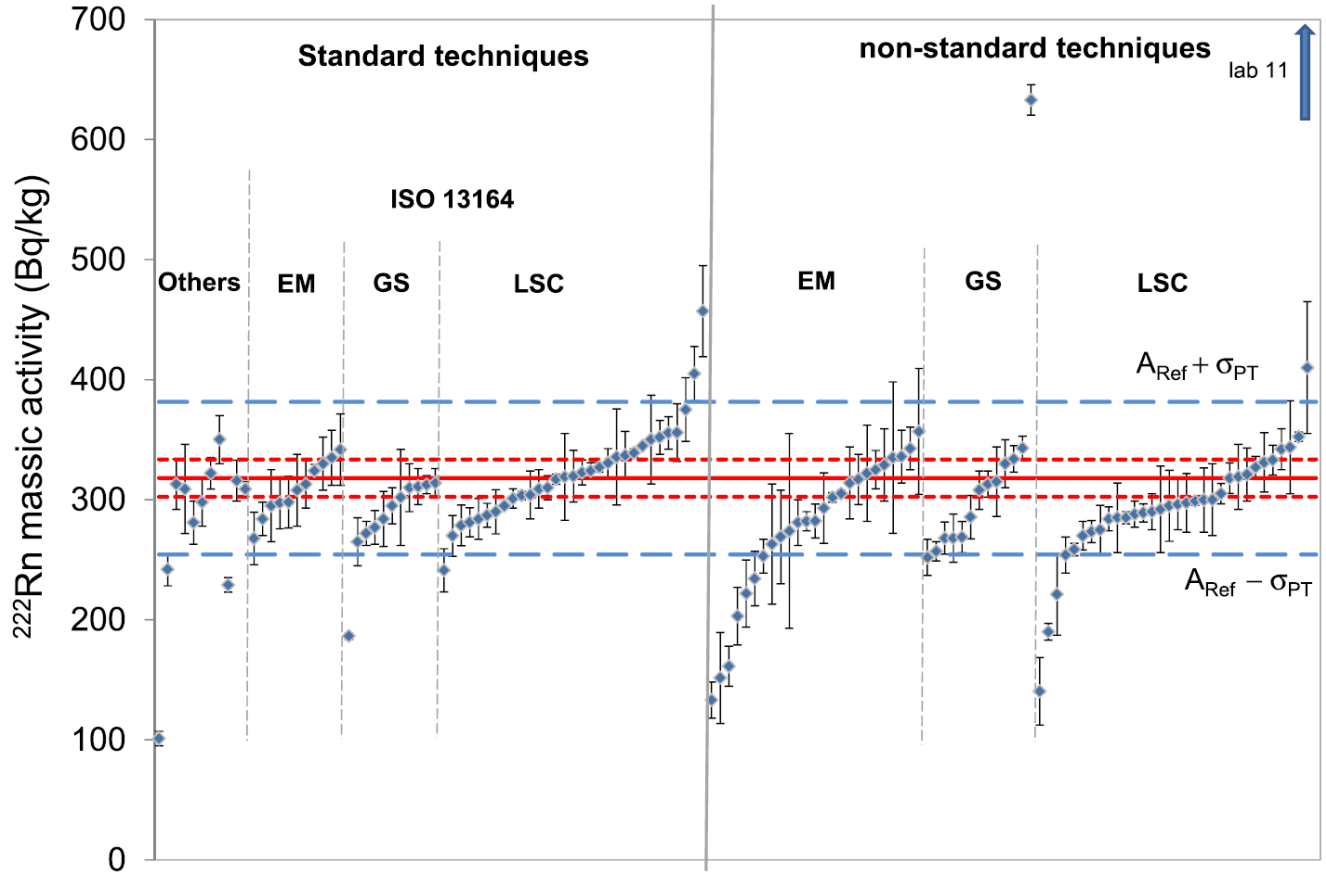
- Philippe Cassette разработи приложение на TDCR модела за измерване на ^{222}Rn
- Веднага започнахме абсолютни измервания на радон във води с TDCR, с типична неопределеност < 1%



Report IRSN/2020-00754 "Results of the Proficiency Test 163 RN 300"

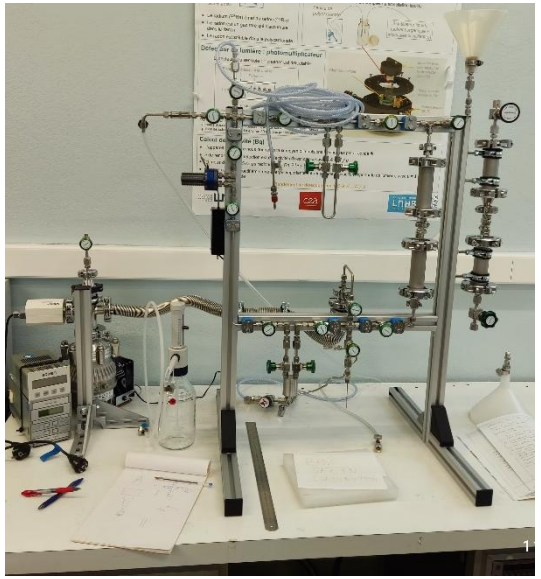
Метрология на радон във вода

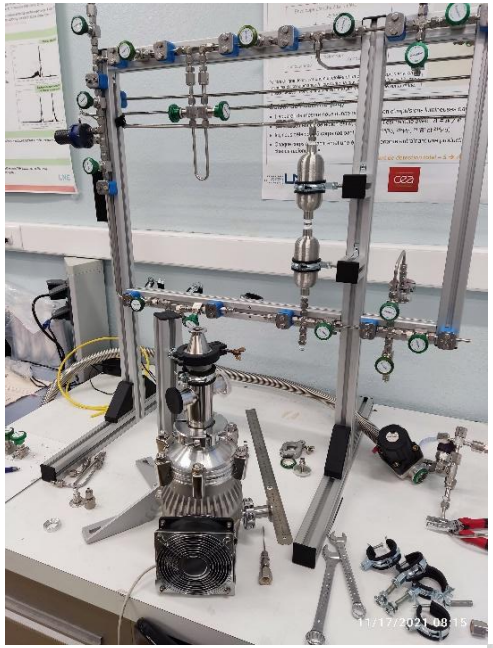
V. Jobbagy, M. Hult, Performance evaluation of a European scale proficiency test on radon-in-water measurements in Europe, ARI 160 (2020) 109111



- Проблеми с „традиционните“ методи

Ще направим истински първичен стандарт за радон във вода





Метрология на радон във вода

Applied Radiation and Isotopes 201 (2023) 111013

Contents lists available at ScienceDirect

Applied Radiation and Isotopes

journal homepage: www.elsevier.com/locate/apradiso

Towards a radon-in-water primary standard at LNHB

Krasimir Mitev [a,*], Benoit Sabot [b], Sylvie Pierre [b], Marie-Christine Lépy [b], Philippe Cassette [a]

[a] Sofia University "St. Kliment Ohridski", Faculty of Physics, 1164, Sofia, Bulgaria
[b] Université Paris-Saclay, CEA, LIST, Laboratoire National Henri Becquerel (LNE-LNHB), 91120, Palaiseau, France

OPEN ACCESS
IOP Publishing | Bureau International des Poids et Mesures Metrologia

Metrologia **62** (2025) 035010 (19pp) https://doi.org/10.1088/1681-7575/addf52

Development of a radon-in-water primary standard

Benoit Sabot[1,*], Philippe Cassette[2], Marie-Christine Lépy[1], Sylvie Pierre[1], Raphaël Martin[1] and Krasimir Mitev[2]

[1] Université Paris-Saclay, CEA, LIST, Laboratoire National Henri Becquerel (LNE-LNHB), Palaiseau 91120, France
[2] Faculty of Physics, Sofia University 'St. Kliment Ohridski', 1164 Sofia, Bulgaria

E-mail: benoit.sabot@cea.fr

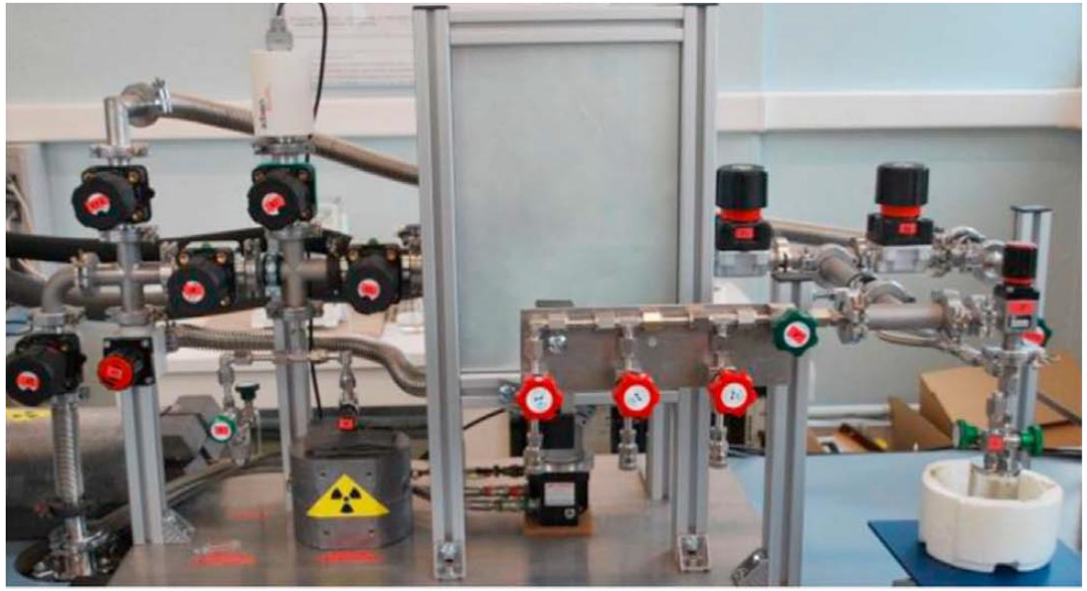
Jeudi, Science !

22 juin – 10 heures

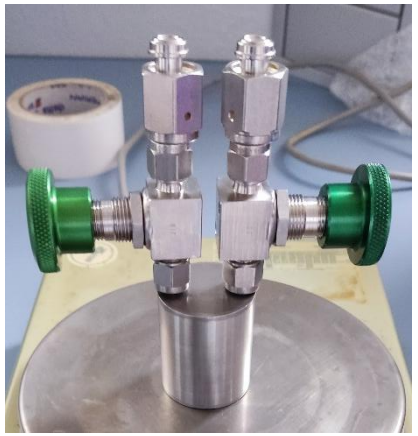
Rendez-vous en salle de réunion du bâtiment 602

Basic principle: Cryogenic transfer of ^{222}Rn to water

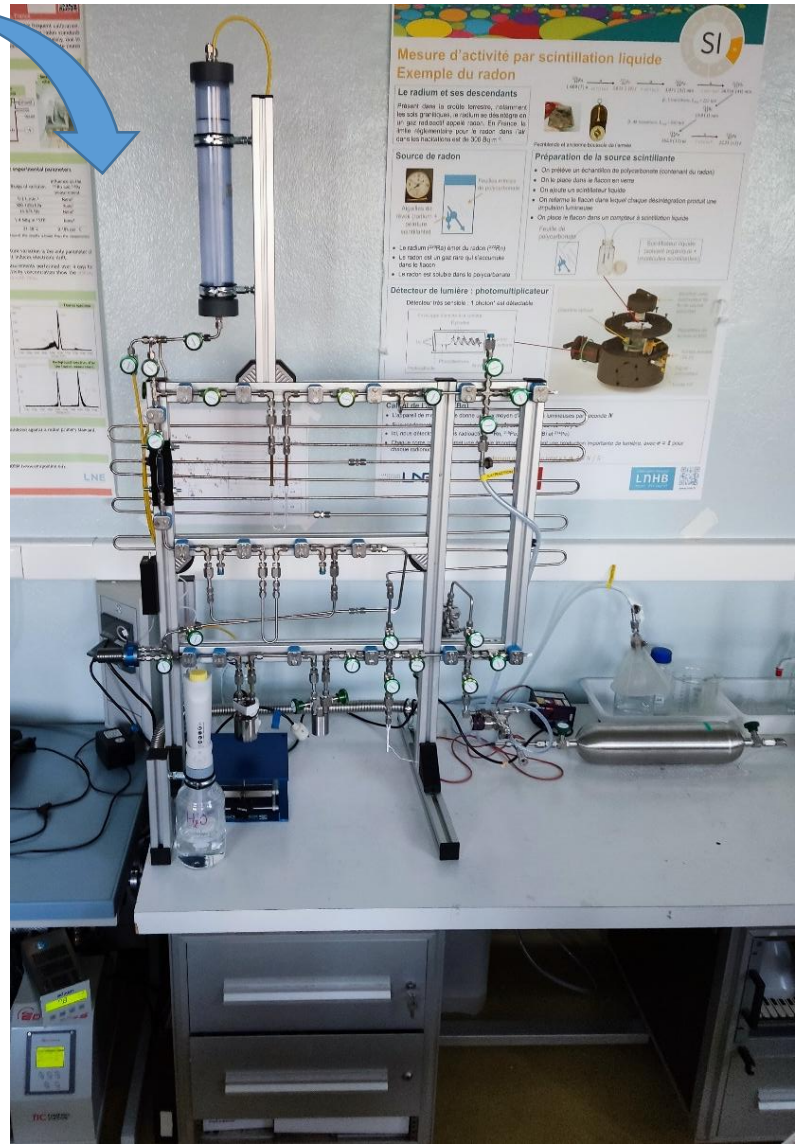
The fixed solid angle ^{222}Rn standard



^{222}Rn transfer



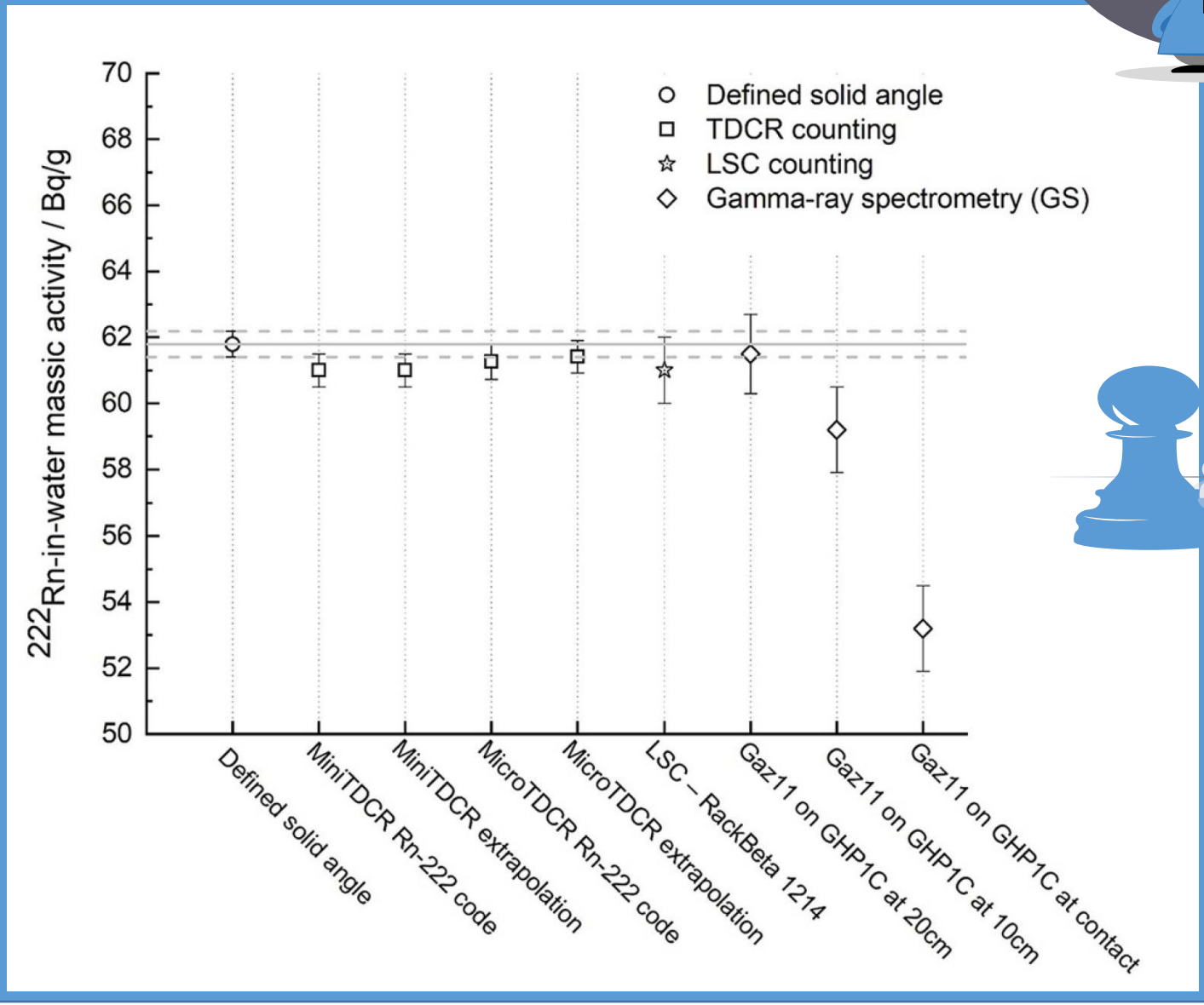
The new system (v. 1)



J.L, Picolo, NIM A 369 (1996), 452–457

B. Sabot, S. Pierre, P. Cassette, ARI 118 (2016) 167–174

Метрология на радон във вода



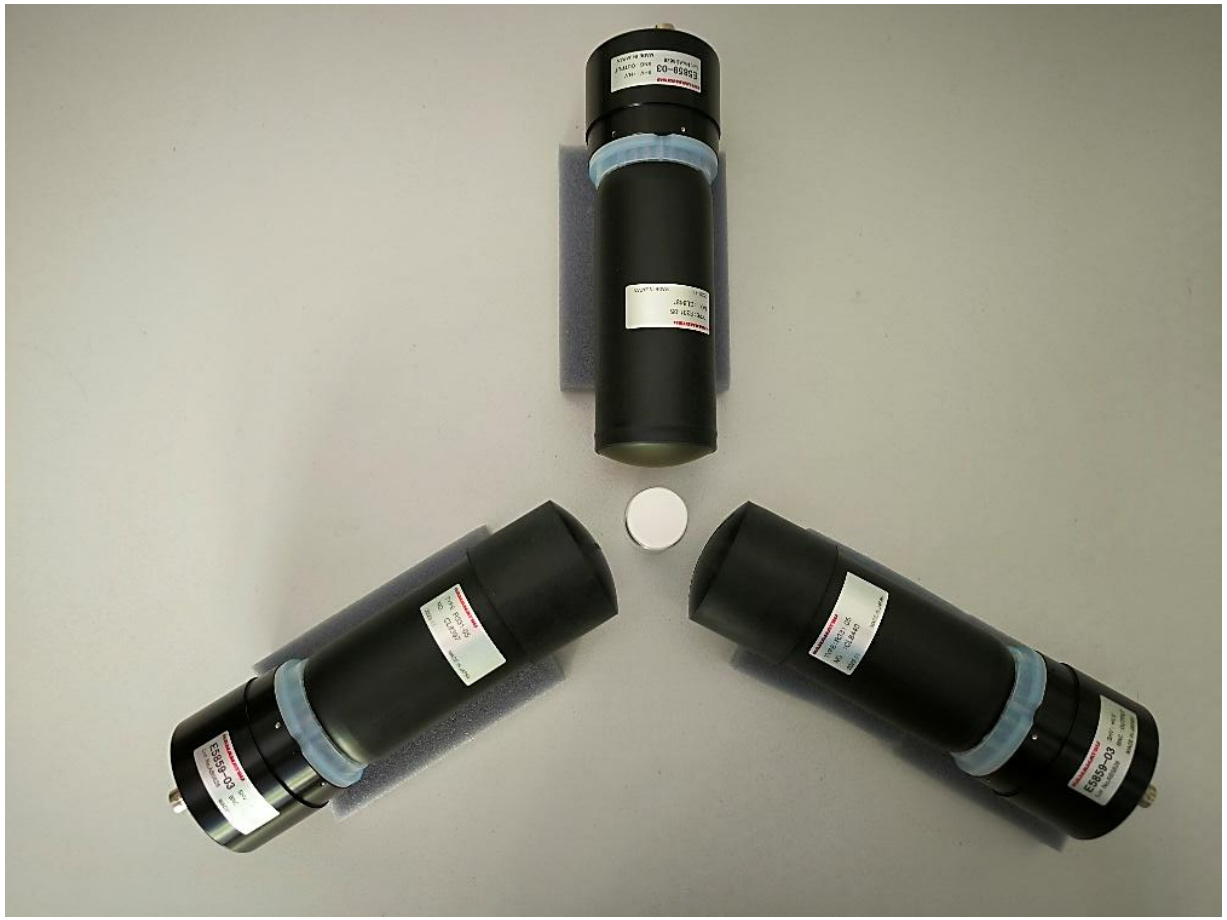
Колко е интересна метрологията?

Подобряване на детектора или електрониката

Подобряване на точността на измерването

Подобряване на разбирането ни за физиката на процесите

Ако не ви се вярва – започнахме отначало!



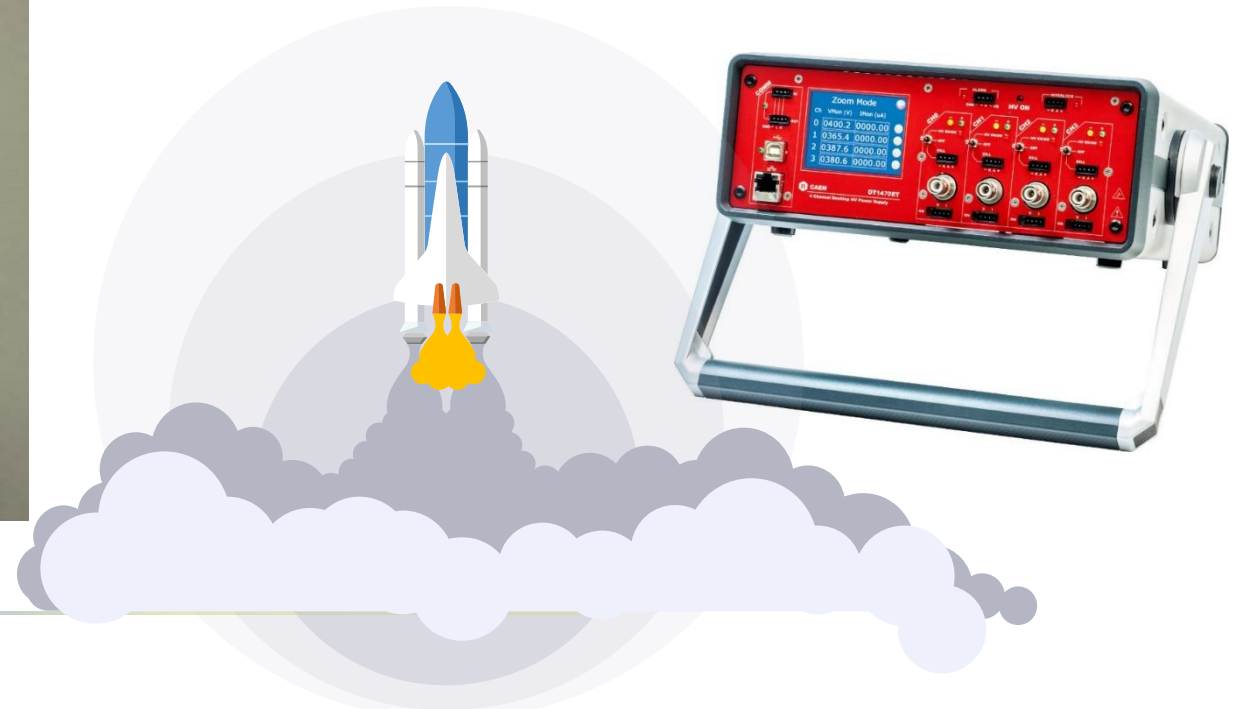
HAMAMATSU FINAL TEST SHEET

JNO. 765611
PAGE 1 OF 1

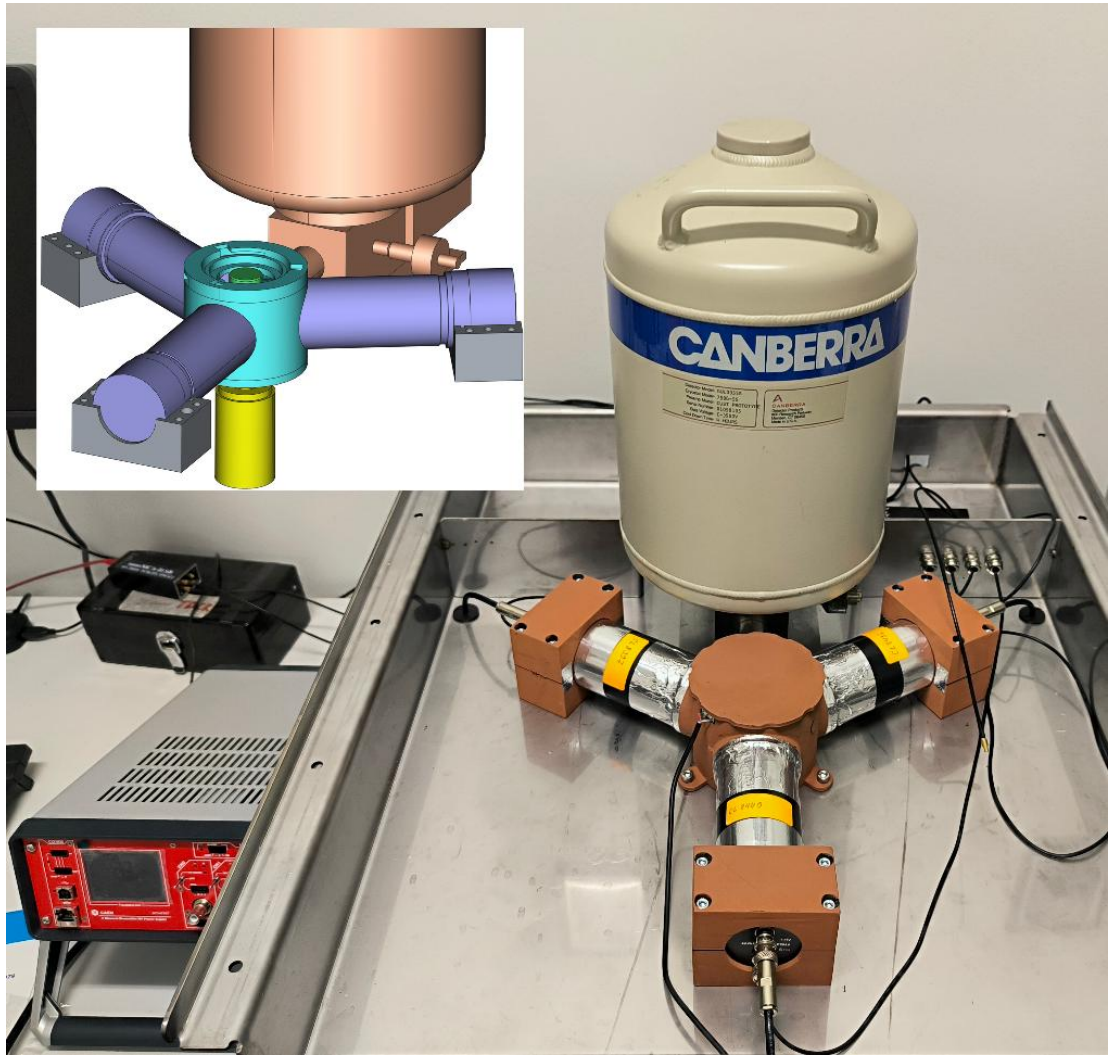
PHOTOMULTIPLIER TUBE TYPE: R331-05

HPD/UNIV SOFIA(BG) QUANTITY: 3 pcs.

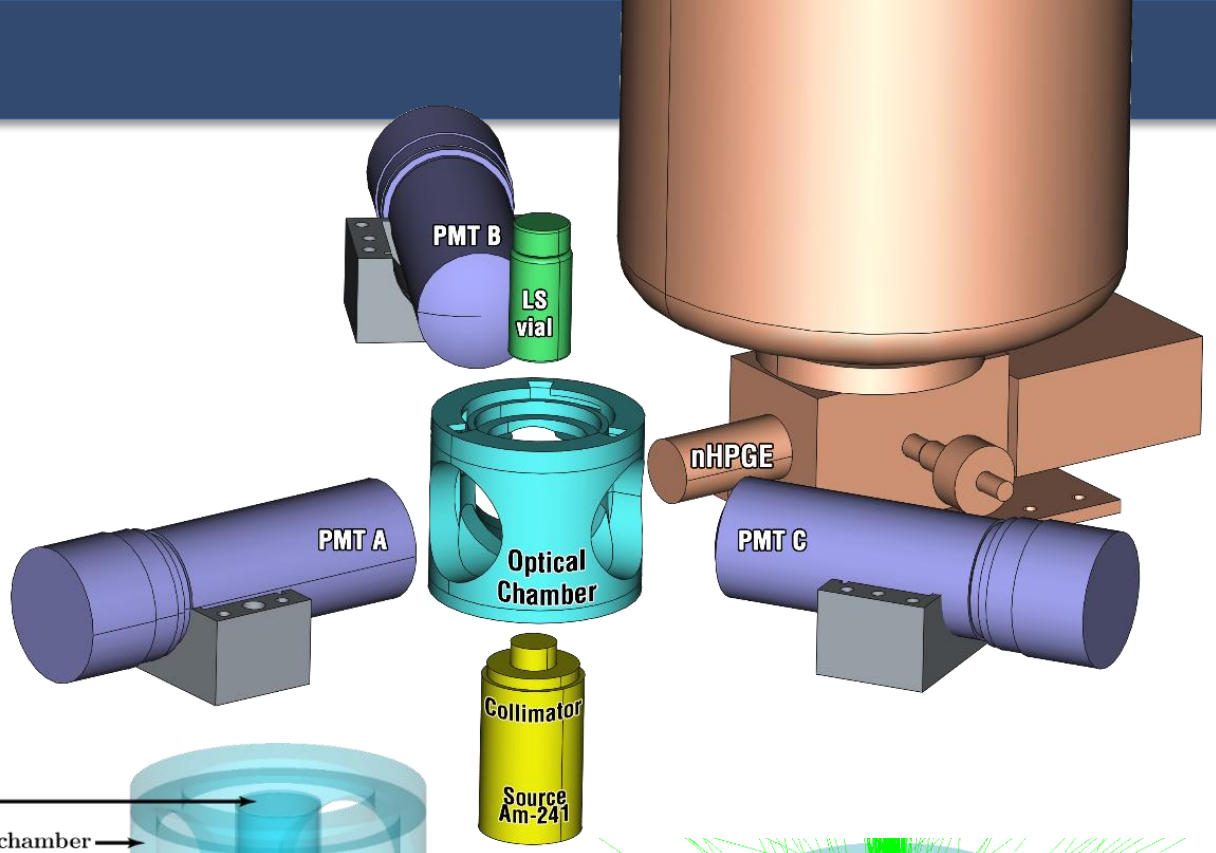
Serial Number	(1) Cathode Luminous Sens. μA/lm	(2) Anode Luminous Sens. A/lm	(3) Anode Dark Current nA	(4) Cathode Blue Sens. Index			
CL8397	88.9	621.0	7.60	10.20			
CL8431	80.9	437.0	0.96	10.70			
CL8440	100.0	601.0	1.90	10.90			

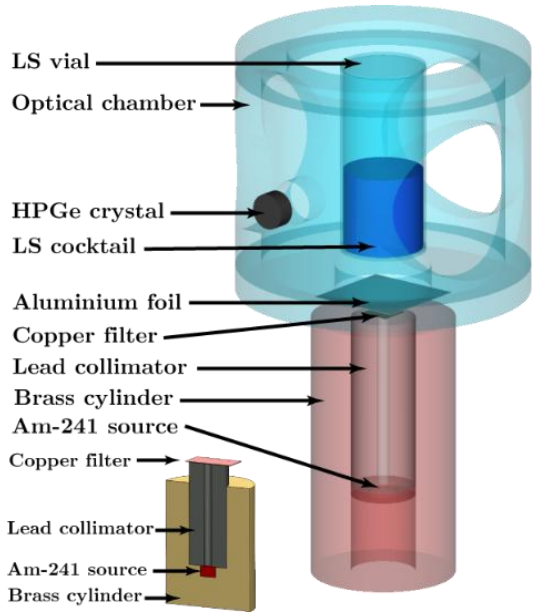


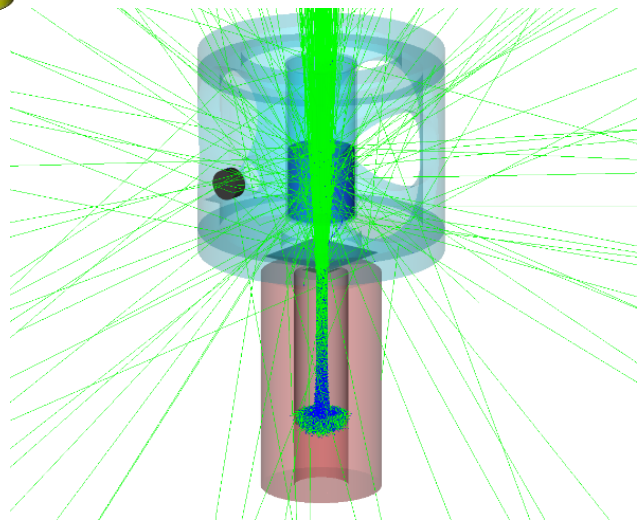
Compton-TDCR система



Колиматор и симулации направени от Симеон Иванов







Благодарности за финансирането !

10. **RadonNET - Radon Metrology: Sensor Networks for Large Buildings and Future Cities (Sep 2024 -)**

The project 23IND07 RadonNET has received funding from the European Partnership on Metrology, co-financed from the European Unio Programme and by the Participating States.

9. **SPIRAD: Проучване и анализ на динамиката на радон в сгради (2020 - 2024)**

Финансиран от националния Фонд научни изследвания към МОН, България

8. **MetroRadon: Metrology for radon monitoring (2017 - 2020)**

The project has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Ho

7. **POLYRAD: Изследване на нови полимерни материали и технологии за измерване на радон (2015 - 2017)**

Финансиран от националния Фонд научни изследвания към МОН, България

Благодаря за вниманието!