Results and measurement uncertainty of the CIEMAT TLD system in the IC2021area intercomparison

I. *Introduction*

II. *CIEMAT TLD system for Workplace and Environmental Dosimetry*

III. *Dose evaluation and measurement uncertainty*

IV. *Results in the IC2021area intercomparison*

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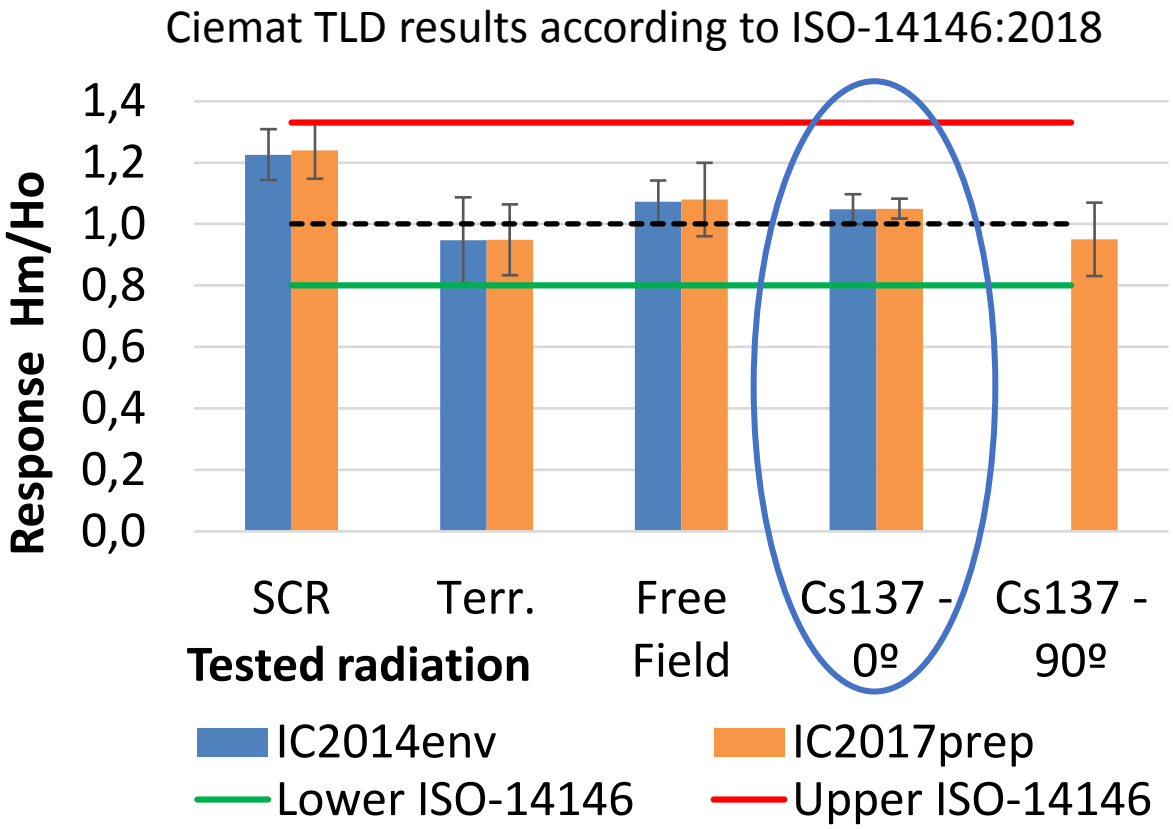
Keywords: *Environmental Radiation Monitoring, passive dosimetry, area dosimeter, measurement uncertainty, Intercomparison*

I. Introduction

➢ Background: CIEMAT participation in the two previous ICs organized by WG3-SG2

❑ Four references sites (PTB): Free Field, Platform, UDO-II and **Cs-137 source**

- IC2014env, irradiations:
  - ✓ Free field (3 or 6 moths)
  - ✓ SCR at the lake platform
  - ✓ **Cs-137 (0°): 5,5mSv**
  - ✓ Transport dose: UDOII
- IC2017prep, irradiations:
  - ✓ Free field (6 moths)
  - ✓ SCR at the lake platform
  - ✓ **Cs-137 (0°, 90°): 30mSv**
  - ✓ Transport dose: UDOII



I. Introduction

- Last EURADOS Intercomparison organized by WG3-SG2: **IC2021area** (from Jul-21 to Feb-22):

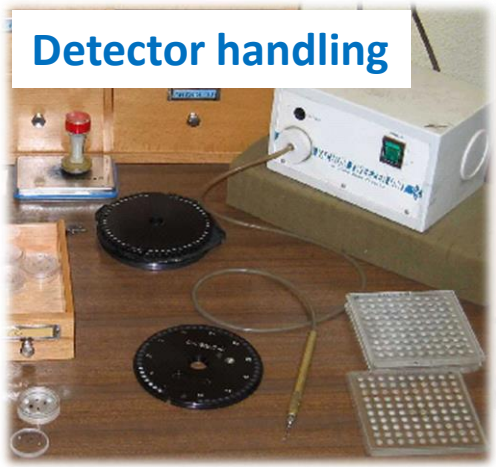
  - Outdoor location:
    - ✓ Outdoor 3 / 6 moths
    - ✓ Cs-137 irradiations (0°)
  - Indoor location:
    - ✓ Inside 3 moths
    - ✓ Cs-137 irradiations (0°)

- ❑ 2 irradiations at doses lower than 0.5mSv in the KIT calibration laboratory

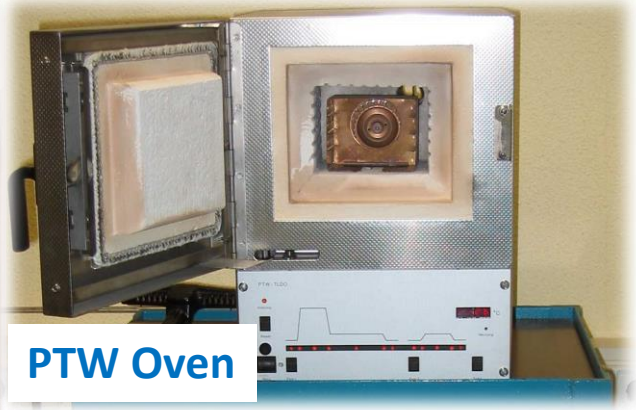
  - 6 dosimeters for exposure outdoor/indoor in free field
  - 2 groups of 3 dosimeters each for low dose irradiation: 300µSv and 150µSv
  - Reported doses by labs without transport dose correction

II. CIEMAT TLD system for Workplace and Environmental Dosimetry

Detector handling



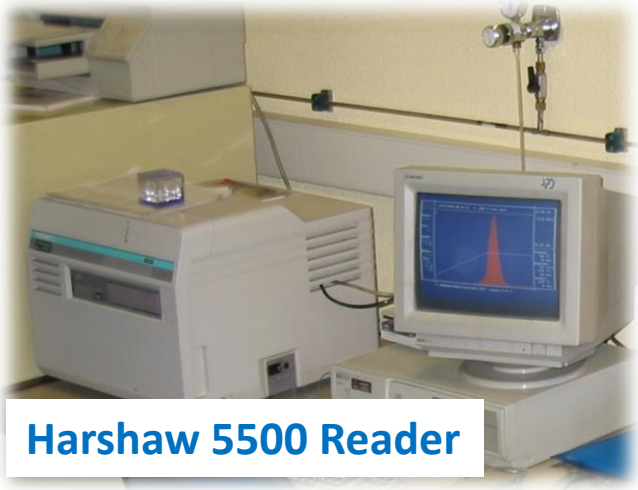
PTW Oven



- Annealing
- Pre-Reading cycle

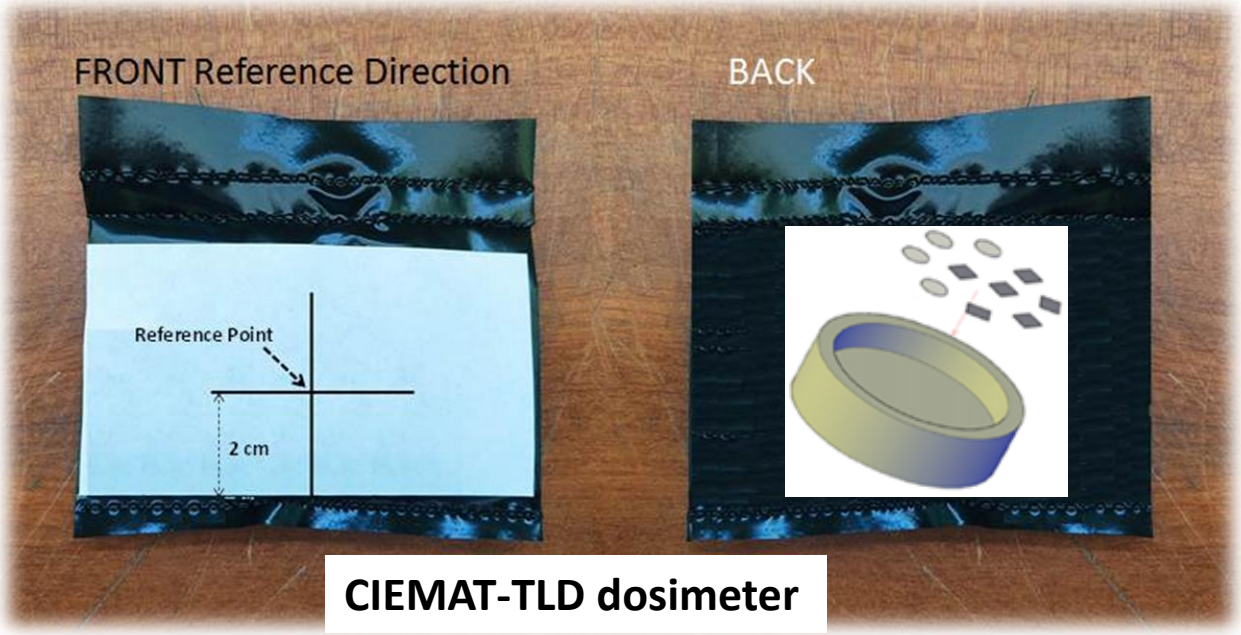
^{90}Sr-Y Irradiator

Harshaw 5500 Reader



CIEMAT Environmental Dosimetry Laboratory

- Outdoor for environmental monitoring
- Indoor for workplace monitoring



CIEMAT-TLD dosimeter

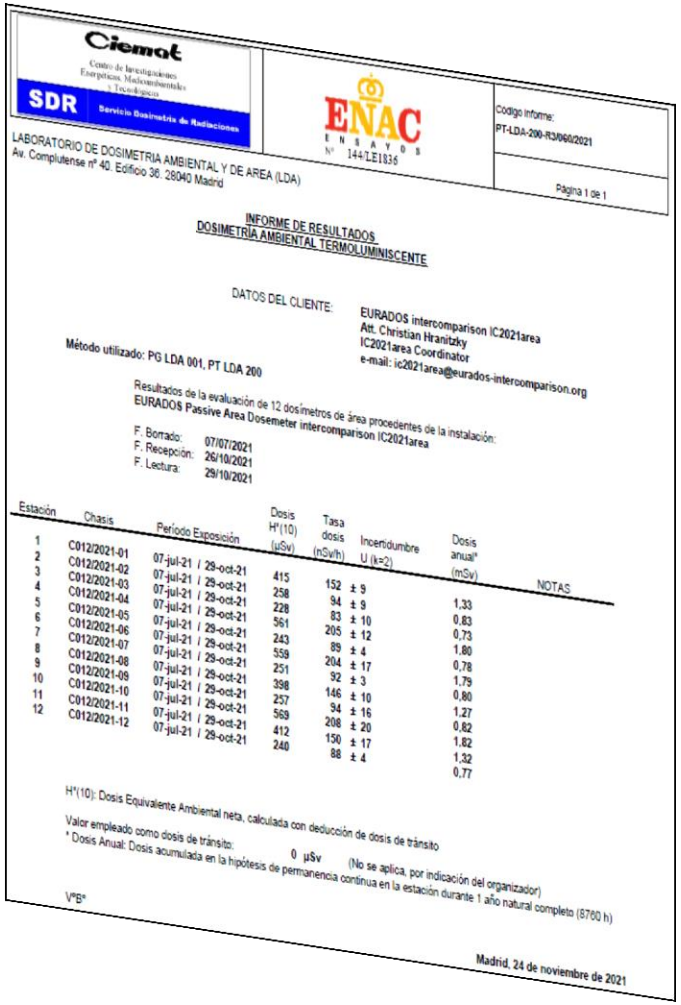
TLD materials: **LiF:Mg,Cu,P (GR-200)** and LiF:Mg,Ti (TLD-100)

"Results and measurement uncertainty of the CIEMAT TLD system in the IC2021area intercomparison"

II. CIEMAT TLD system for Workplace and Environmental Dosimetry

Dosimetry system features

- Validation of influence factors based in the IEC 62387 standard
- Traceability and QC procedure:
  - ✓ *H**(10), Cs-137 annual calibration in a metrology laboratory
  - ✓ QC process: ICFs calculation (after reading)
- Regular participation in the spanish IC (every 5 years)
- Accreditation according to ISO 17025, since April 2012



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ENAC ENSAYOS Nº 144/LE1836
Codigo informe: PT-LDA-200-R3/060/2021
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LABORATORIO DE DOSIMETRIA AMBIENTAL Y DE AREA (LDA)
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INFORME DE RESULTADOS
DOSIMETRÍA AMBIENTAL TERMOLUMINISCENTE

DATOS DEL CLIENTE: EURADOS intercomparison IC2021area
Att. Christian Hranitzky
IC2021area Coordinator
e-mail: ic2021area@eurados-intercomparison.org

Método utilizado: PG LDA 001, PT LDA 200

Resultados de la evaluación de 12 dosímetros de área procedentes de la instalación:
EURADOS Passive Area Dosemeter intercomparison IC2021area

F. Borrado: 07/07/2021
F. Recepción: 26/10/2021
F. Lectura: 29/10/2021

Estación	Chasis	Período Exposición	Dosis H*(10) (µSv)	Tasa dosis (nSv/h)	Incertidumbre U (k=2)	Dosis anual* (mSv)	NOTAS
1	C012/2021-01	07-jul-21 / 29-oct-21	415	152	± 9	1,33	
2	C012/2021-02	07-jul-21 / 29-oct-21	258	94	± 9	0,83	
3	C012/2021-03	07-jul-21 / 29-oct-21	228	83	± 10	0,73	
4	C012/2021-04	07-jul-21 / 29-oct-21	561	205	± 12	1,80	
5	C012/2021-05	07-jul-21 / 29-oct-21	243	89	± 4	0,78	
6	C012/2021-06	07-jul-21 / 29-oct-21	559	204	± 17	1,79	
7	C012/2021-07	07-jul-21 / 29-oct-21	251	92	± 3	0,80	
8	C012/2021-08	07-jul-21 / 29-oct-21	398	146	± 10	1,27	
9	C012/2021-09	07-jul-21 / 29-oct-21	257	94	± 16	0,82	
10	C012/2021-10	07-jul-21 / 29-oct-21	569	208	± 20	1,82	
11	C012/2021-11	07-jul-21 / 29-oct-21	412	150	± 17	1,32	
12	C012/2021-12	07-jul-21 / 29-oct-21	240	88	± 4	0,77	

H*(10): Dosis Equivalente Ambiental neta, calculada con deducción de dosis de tránsito

Valor empleado como dosis de tránsito: 0 µSv (No se aplica, por indicación del organizador)

* Dosis Anual: Dosis acumulada en la hipótesis de permanencia continua en la estación durante 1 año natural completo (8760 h)

VºBº

Madrid, 24 de noviembre de 2021

III. Dose evaluation and measurement uncertainty

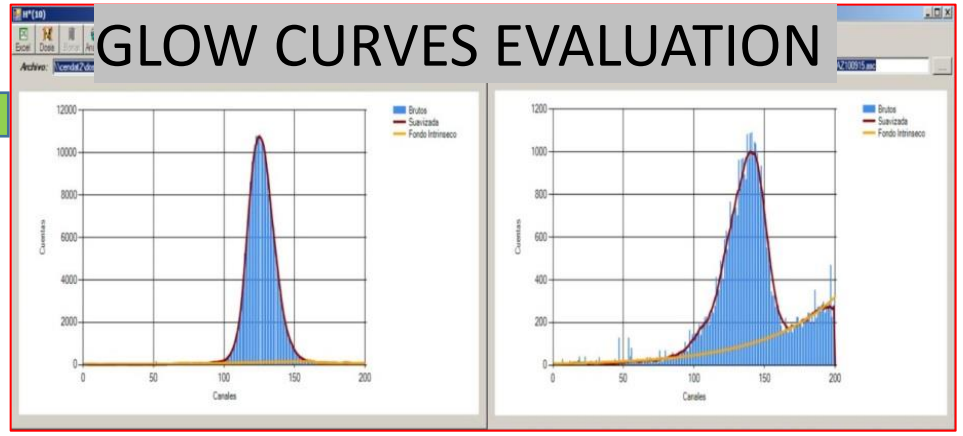
- Two methods based on GUM (JCGM 100:2008), linked to ISO/IEC Guide 98-3 (Part 3)
  - a) A general method based on the laboratory methods
    - Influence factors on the expanded measurement uncertainty U'(k=2):
      - ✓ Reader counts (2%)
      - ✓ Reader calibration factor (4%)
      - ✓ Energy response (2%) and angular response (5%)
      - ✓ Calculation of ICFs (3%), ^{90}Sr-Y Irradiator
      - ✓ Transport dose subtraction (depends on the trip)
    - Expanded measurement uncertainty: 16%, without trip dose subtraction
  - b) Method based on the standard deviation (nº detectors / dosimeter):

    Dose mean value, standard deviation (n-1) and t-distribution
    - IC2021area: TLDs uncertainties (k=2), range [4, 13]%, without trip dose subtraction

III. Dose evaluation and measurement uncertainty

- Dosimeter reading (counts)
- Reader calibration factor (trazability)
- Detector calibration (ICFs calculation), µSv/count
- Dose evaluation , *H**(10)

Net Doses (SGCA)



Calculation of the *H**(10) doses

ICFs calculation

Corrected counts

Dose evaluation

Calibration factor (25/11/2020)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R						
1																								
2			F.Borrado:	7-jul-21		L. Cero:	0 cta	U (k=1)			FCB (25/11/20)	24,06 µSv/v		1,49	PT-LDA-200-R2 (Ed. 5)									
3			F.Entrega:	15-jul-21	CIEMAT	Dosis Calibración:	120 µSv	7	6%	nº vueltas:	5			U (k=1)	PT-LDA-200-R3/060/2021									
4			Recepcion:	26-oct-21		Exposición:	95 días			Verif. Calibrac	201277 cta				Madrid, 24 de noviembre de 2021									
5			F.Lectura:	29-oct-21	GR200	Tránsito:	19 días			Calib. Lineal:	0,00068 3,01													
6			LECTOR :	EQ-LDA-002	Lector Thermo 5500	Dosis Grupo DTLs:	140 µSv																	
7						Cambio sensib.:	16,4%																	
8																								
9												FD=1												
10		FCI	Estación	Dosímetro	Observ.	Lectura Neta	Dosis	Media	STD	CV	U' (k=1)	Tasa Dosis	H*(10)	CV U (k=1)	Tasa Dos:	CV U (k=2)								
11		(µSv/cta)				(cta)	(µSv)	(µSv)	(µSv)		H*(10), µSv	(nSv/hora)	(µSv)	(µSv)	(nSv/hora)	nSv/hora)								
12																								
13	1	0,00052	1	1		789381	412				1,00													
14	2	0,00055	C012/2021-01	2		784017	428																	
15	3	0,00053	15-jul-21	3		798030	421				2,8%			2,8%		6%								
16	4	0,00055	18-oct-21	4		731894	401	415	11,7	2,8%	415	182	**415**	**11,7**	182	10								
17	5	0,00102	2	5		264865	271				1,00													
18	6	0,00081	C012/2021-02	6		317571	258																	
19	7	0,00094	15-jul-21	7		275605	260				4,9%			4,9%		10%								
20	8	0,00087	18-oct-21	8		276281	241	258	13	4,9%	258	113	**258**	**13**	113	11								
21	9	0,00062	3	9		354609	220				1,00													
22	10	0,00074	C012/2021-03	10		305059	226																	
23	11	0,00068	15-jul-21	11		364412	247				5,7%			5,7%		11%								
24	12	0,00053	18-oct-21	12		412312	219	228	13	5,7%	228	100	**228**	**13**	100	11								
25	13	0,00052	4	13		1034557	542				1,00													
26	14	0,00050	C012/2021-04	14		1149441	580																	
27	15	0,00056	15-jul-21	15		1001574	560				2,8%			2,8%		6%								
28	16	0,00056	18-oct-21	16		1004474	564	561	15,7	2,8%	561	246	**561**	**15,7**	246	14								
29	17	0,00053	5	17		473495	249				1,00													

IV. Results in the IC2021area intercomparison

4. Table of results

In the upper part of the following table, the reported dose values M_0 of the 6 background dosemeters and the resulting average background dose $\overline{M_0}$ are listed. In the lower part, the reported dose values M of the 6 irradiated dosemeters as well as the background corrected dose values $(M - \overline{M_0})$, the reference dose values H_{ref} and the resulting dosemeter response values $R = (M - \overline{M_0}) \cdot H_{ref}^{-1}$ are shown.

Dosemeter	M_0
ID	µSv
S012-03	228
S012-12	240
S012-05	243
S012-07	251
S012-09	257
S012-02	258
Average	246

Dosemeter	M	M-$\overline{M_0}$	H_{ref}	R
ID	µSv	µSv	µSv	1
S012-08	398	152	150	**1,01**
S012-11	412	166	150	**1,11**
S012-01	415	169	150	**1,13**
S012-06	559	313	300	**1,04**
S012-04	561	315	300	**1,05**
S012-10	569	323	300	**1,08**

Background dosimeters

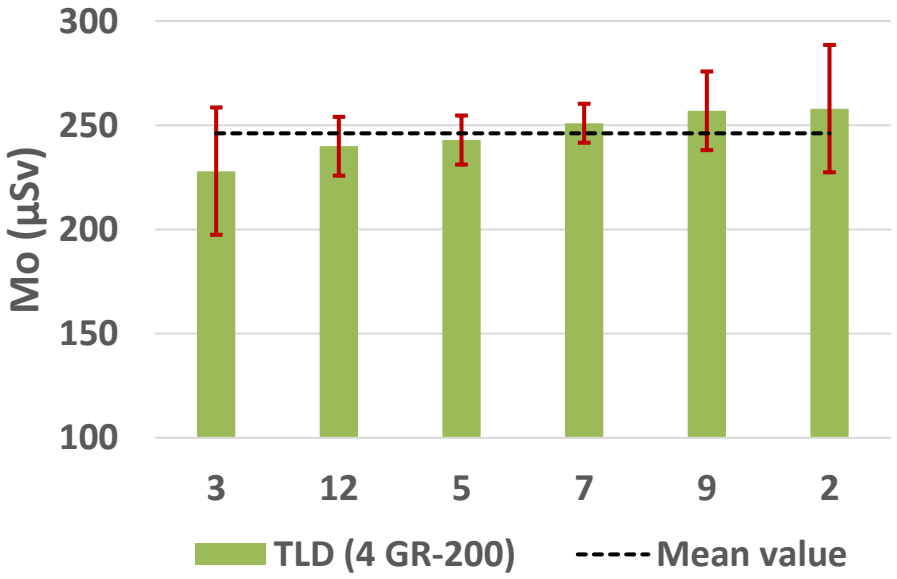
Dosimeter results for low doses

Cs-137 response for 0,3mSv and 0,15mSv

IV. Results in the IC2021area intercomparison

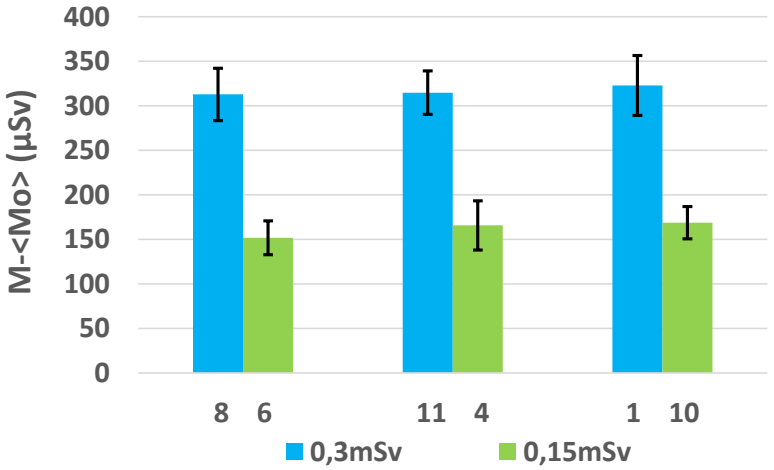
Background (outdoors) of the 6 TLDs (transport dose integrated) for 3 months

- ✓ Dose values in the range [-7, +5]% referred to the mean value
- ✓ Uncertainties U'(k=2) in the range 4% - 13%
- ✓ Mean dose value (6 dosimeters): 246 (47) µSv; U'(k=2) = 19%



IV. Results in the IC2021area intercomparison

Cs-137 irradiations of 3 dosimeters (backgroud dose subtracted) for low doses < 0,5mSv



Referred to *H(10) = 150µSv**:

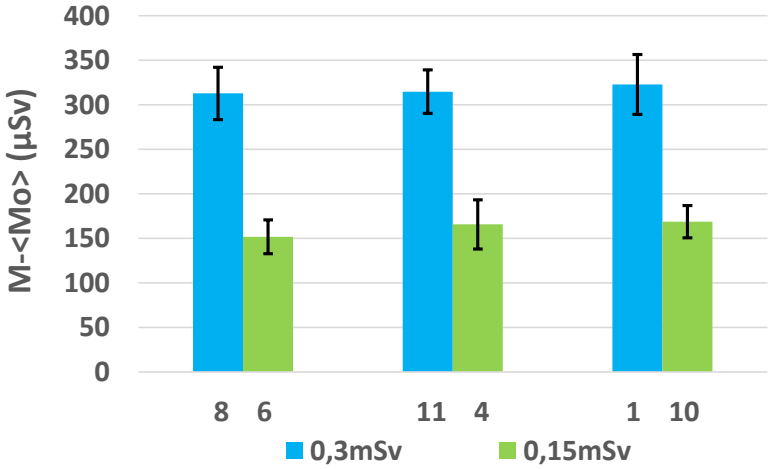
- Dose values in the range [+1, +13]%
- Uncertainties U'(k=1) in the range [11, 17]%

Referred to *H(10) = 300µSv**:

- Dose values in the range [+4, +8]%
- Uncertainties U'(k=1) in the range [8, 10]%

IV. Results in the IC2021area intercomparison

Cs-137 irradiations of 3 dosimeters (backgroud dose subtracted) for low doses < 0,5mSv



Referred to *H(10) = 150µSv**:

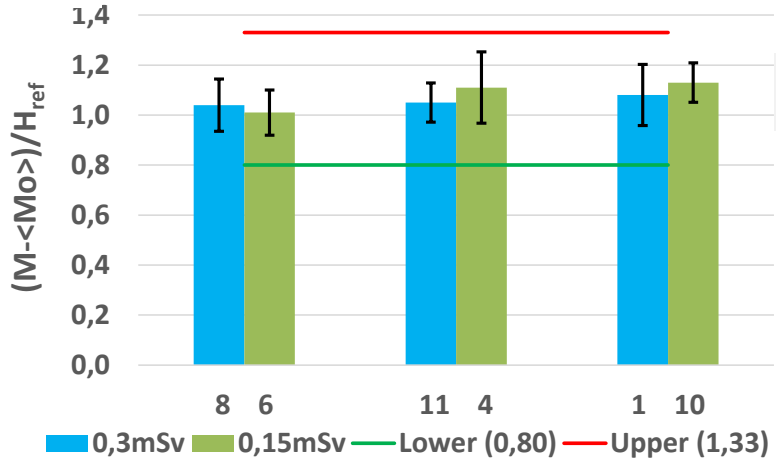
- Dose values in the range [+1, +13]%
- Uncertainties U'(k=1) in the range [11, 17]%

Referred to *H(10) = 300µSv**:

- Dose values in the range [+4, +8]%
- Uncertainties U'(k=1) in the range [8, 10]%

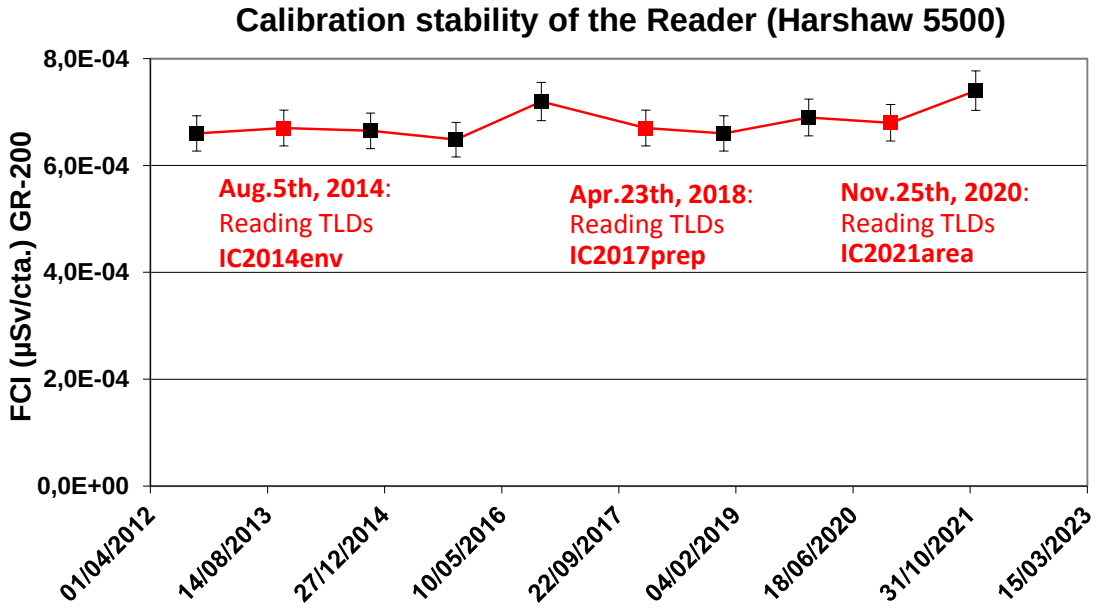
Mean dose values:

- 0,162 (18) mSv, U'(k=1) = 6%
- 0,32 (3) mSv, U'(k=1) = 17%

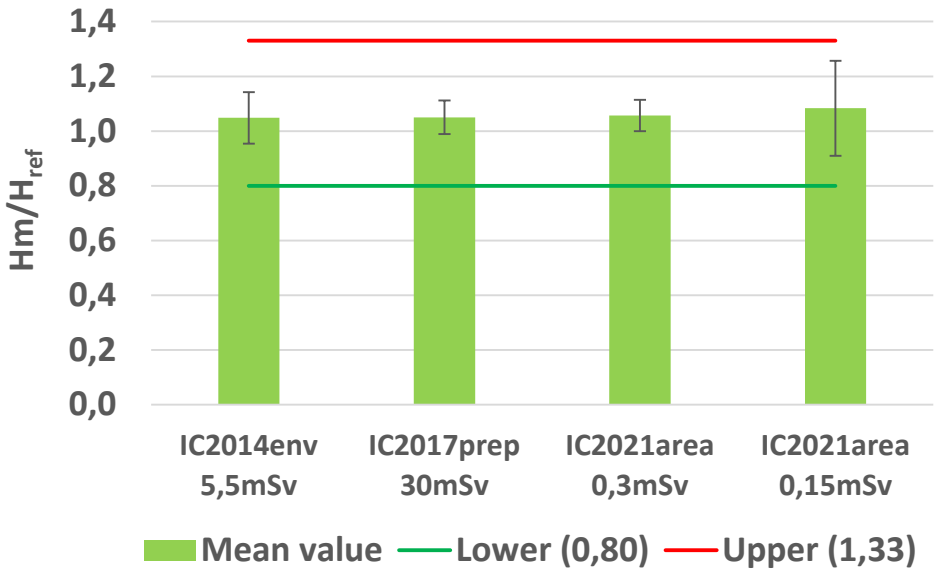


H_{ref} : U'(k=2) = 4,3%

IV. Results in the IC2021area intercomparison



Stability of the calibration factor



EURADOS ICs:
Linearity from 0,15mSv to 30mSv

CIEMAT TLD system in the three EURADOS ICs

"Results and measurement uncertainty of the CIEMAT TLD system in the IC2021area intercomparison"

V. Conclusions

- Cs-137 response **[+5, +8]%** in the three EURADOS ICs (2014-2021)
- Linear dose response (0,15 - 30 mSv) to Cs-137 has been checked
- Measurement uncertainty are consistent by the two methods