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Secondary Standards Dosimetry Laboratory (SSDL) - results of the activity in 2018-2022 years

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Laboratory accredited by the Polish Centre for Accreditation, accreditation No. AB 1499*

* an actual scope of accreditation No. AB 1499 is available on the PCA website: www.pca.gov.pl

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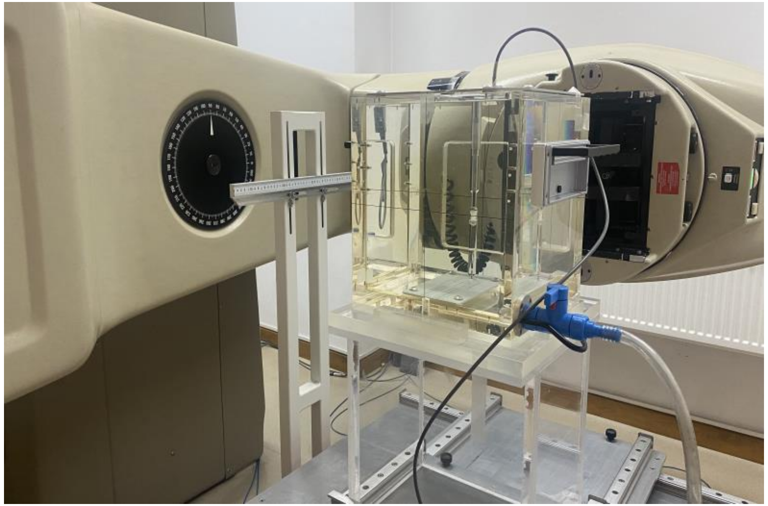
The Secondary Standards Dosimetry Laboratory (SSDL) which is part of the Medical Physics Department of the Maria Sklodowska-Curie National Research Institute of Oncology in Warsaw is a full member of the IAEA/WHO Network of SSDLs.
According to Polish law (i.e. Journal of Laws of 2021, item 1941), measuring equipment used to perform operational tests of radiological equipment and auxiliary equipment used in health care units should be calibrated. Current national regulations do not impose an obligation on radiotherapy centers to undergo a dosimetry audit. However, in accordance with good dosimetry practice, SSDL in Warsaw still organizes audits for radiotherapy centers in Poland.



Measuring system for calibration of cylindrical chambers

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Calibrations

At the SSDL in Warsaw, the calibrations are performed in a ^{60}Co beam, in terms of the absorbed dose to water, according to the IAEA TRS-398 code of practice. The calibration coefficients of the user's dosimeter (electrometer + chamber) is determined with the substitution method using the reference SSDL equipment (national secondary standard). In substitution method the standard is used for dose determination in a water phantom and then the calibration coefficient is determined after replacing standard with calibrated chamber. The laboratory calibrates all types of cylindrical ionisation chambers, as well as the most popular plane-parallel types of chambers (Markus, Roos). Practically, all of the dosimeters used in Polish hospitals are calibrated in the SSDL in Warsaw. The SSDL reference electrometers and chambers are regularly calibrated in laboratories which are participants of the Comité International des Poids et Mesures (CIPM) Mutual Recognition Arrangement (MRA) mainly at the IAEA (Austria), at the PTB (Germany) or at the GUM (Poland) depending on the type of a standard. Therefore traceability to the primary dosimetry standard is assured.

Cylindrical chamber

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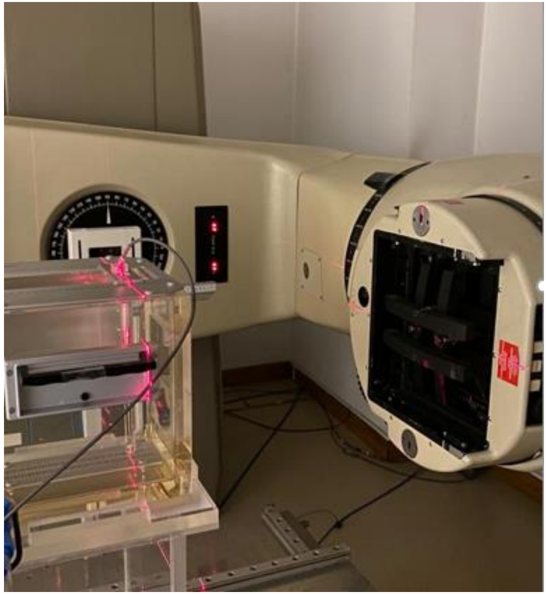
Since 2014, this SSDL activities have been accredited by the Polish Center for Accreditation (PCA) for compliance with the PN-EN ISO/IEC 17025 standard (accreditation No. AP 155). In the period of 2018-2022, users dosimeter were calibrated for teleradiotherapy in the ^{60}Co gamma beam of the Theratron 780E unit, and for high dose rate brachytherapy with the 192-Ir source operated with Microselectron or Flexitron afterloader.

Flexitron afterloader



Theratron 780E unit

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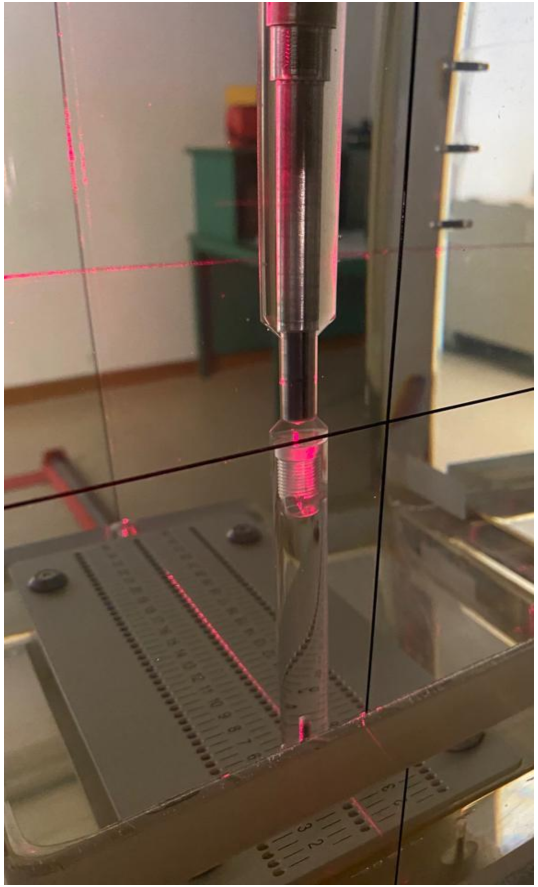
All calibrations were performed by the substitution method using the SSDL working standard (electrometr with the ionization chamber). More than 700 users electrometers were calibrated at SSDL. Along with the development of irradiation techniques and the related use of new types of radiotherapy devices, SSDL extends the scope of its activities to include the calibration of new types of chambers (e.g. for the needs of tomotherapy).

Dosimetry set (electrometer Supermax + well type chamber)



Calibration system in a beam of ^{60}Co gamma radiation

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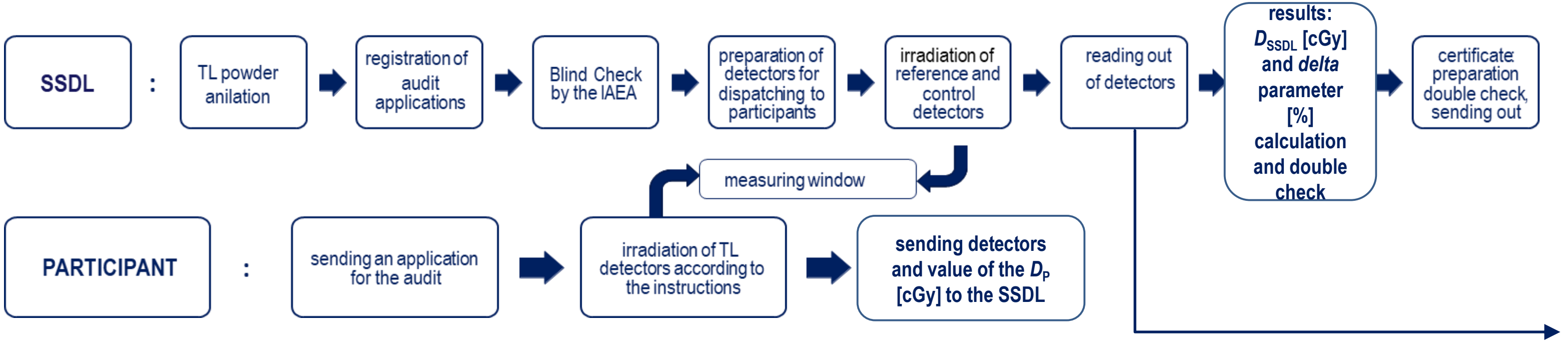
Dosimetry audits

In the years 2018-2022, SSDL conducted an annual dosimetry audits for teleradiotherapy centers in Poland using the thermoluminescence dosimetry (TLD) method with LiF powder as a TL detector. Since 2014, this SSDL activity has been subject to PCA accreditation for compliance with the mentioned norm (accreditation No. AB 1499).
In the years 2018-2022, a dosimetry audit was performed at the SSDL for radiotherapy centers in Poland using the TLD method for 680 beams. The most common non-reference terms are fields formed by the MLC.



Fimel PCL 3 TL reader

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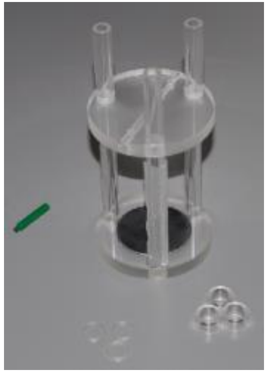

Reference conditions:

High-energy X-rays
Beam axis dose based on data from the TPS or measurements with a dosimeter with ionization chamber
- open field 10 cm x 10 cm
- capsule depth 5 cm or 10 cm.

Electron beams
Beam axis dose based on measurements with a dosimeter with ionization chamber
- open field 10 cm x 10 cm,
- d_{max} – depth of maximum dose in water.

Holders for irradiation of TL detectors

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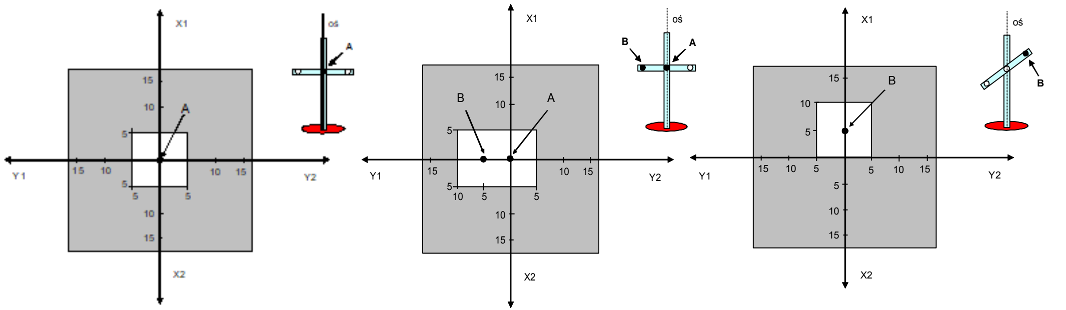


Non-reference conditions:

dose based on TPS data or measurement with ionization chamber

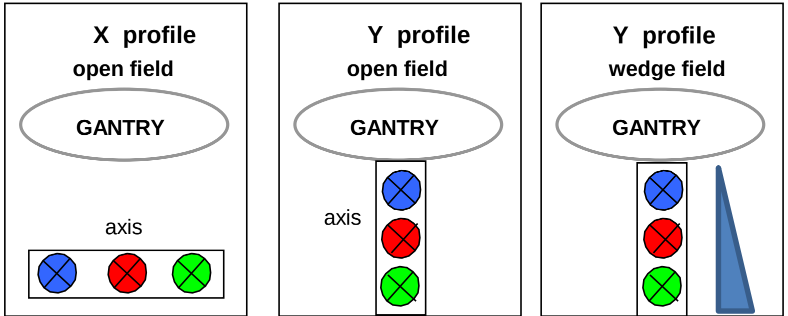
Non symetric fields

- dose on beam axis or 5 cm off axis

Symetric fields

- different field sizes
- two measurement depths (for 10x10 field)
- dose on axis and 5 cm off axis

Fields formed by MLC



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The deviation of the dose reported by the participant and the dose measured by the SSDL was calculated as follows:

$$delta = \frac{D_P - D_{SSDL}}{D_{SSDL}} \cdot 100\ [\%]$$

where:

D_P [cGy] – dose reported by the participant;

D_{SSDL} [cGy] – dose determined by the SSDL as follows:

$$D_{SSDL} = M \cdot N \cdot f_{lin} \cdot f_{en} \cdot f_{fad} \cdot f_{hol}$$

where:

M [counts] – the TL detector response;

N [cGy/counts] – calibration coefficient of the TLD system;

f_{lin} – non-linearity dose response correction factor;

f_{en} – energy correction factor;

f_{fad} – fading correction factor;

f_{hol} – holder correction factor.

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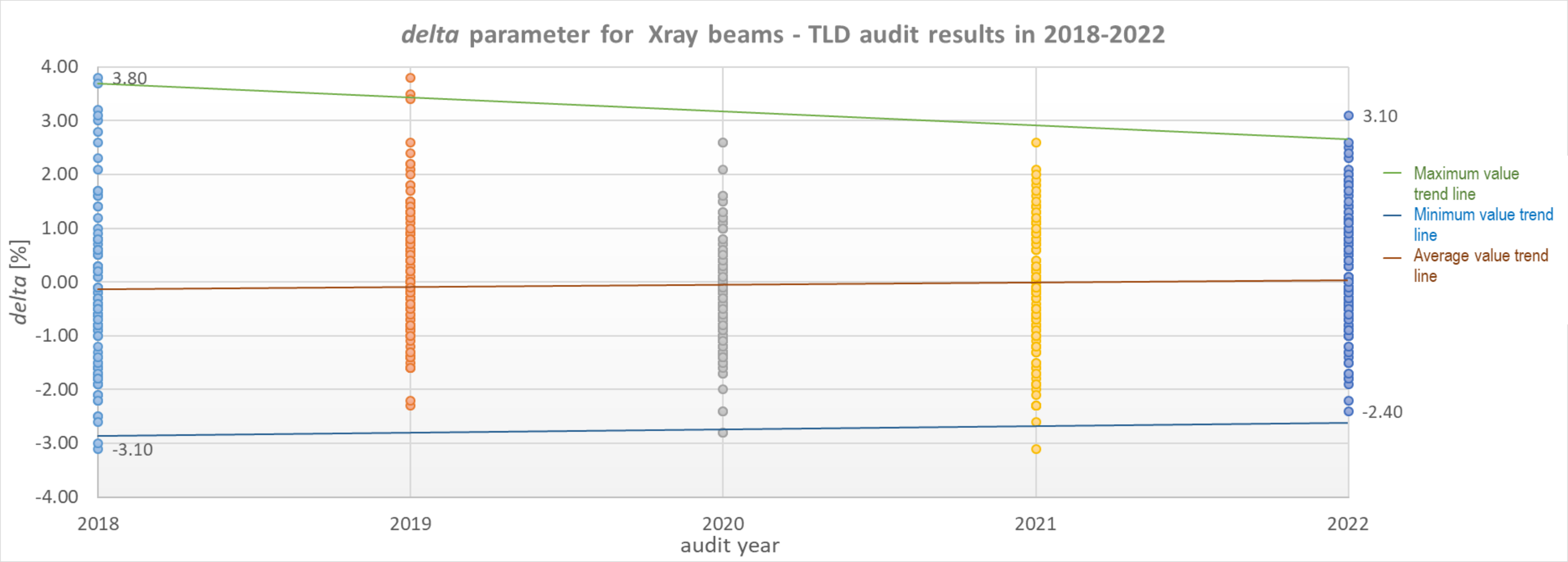
The total expanded uncertainty of D_{SSDL} with a coverage probability of approx. 95% and a coverage factor $k = 2$ is 3.4%.

Results obtained as part of accreditation activity No. AB 1499



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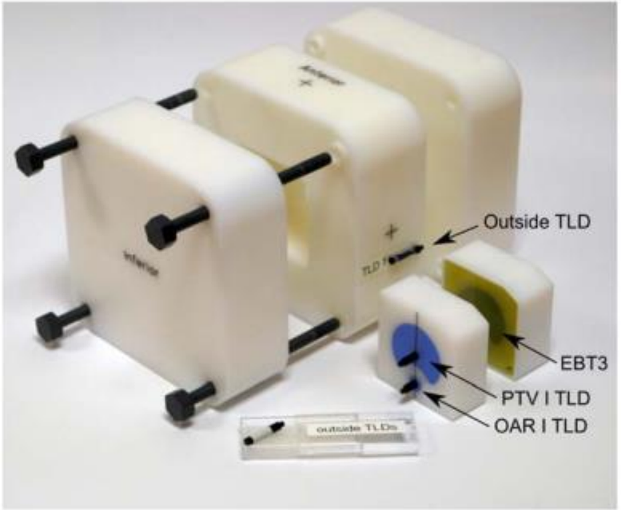
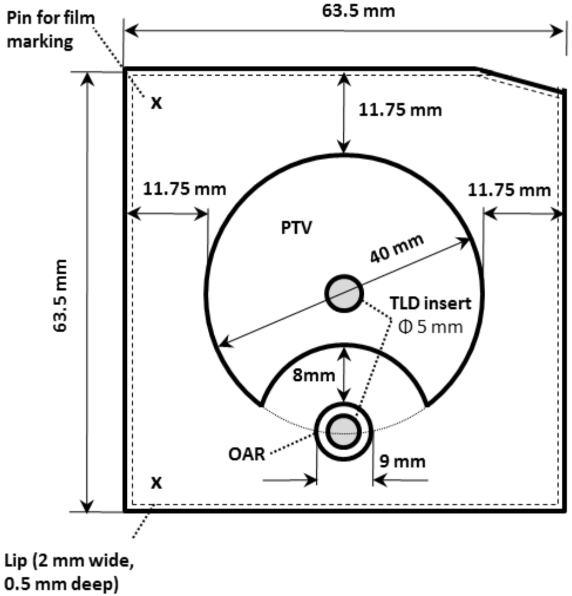
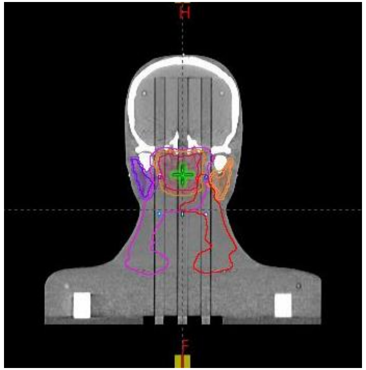
For stereotactic radiotherapy, 13 centers were audited. In comparisons of films with plans, the obtained Percentage passing rate" of the gamma index (3 mm/3% of dose at isocenter) was greater than 95% at 11 sites. The doses read for the TL detectors placed in the PTV and OAR differed from the planned ones by no more than 5% in 10 and 9 enters, respectively.





Phantom and insert for the film and TLDs

SSDL also conducted pilot "end-to-end" dosimetry audits. For stereotactic radiotherapy 13 radiotherapy centers were audited using a polystyrene phantom designed and manufactured at SSDL. This phantom, contains defined volumes of PTV and OAR (made of Solid Water HD tissue-like material), which are separate elements of the phantom allowing to place radiochromic films and TL detectors in them. For radiotherapy with dynamic head and neck techniques the CIRS Shoulder, Head and Neck End-to-End Verification Phantom (SHANE) was used. The SHANE phantom audit was performed in 8 centers for seven linac/beam/TPS combinations.



Pictures of the antropomorfic CIRS SHANE Phantom

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Measurement results showed differences between the doses calculated in the planning system and those measured with the ionization chamber during the audit, which were tolerance of 5% for PTV points and 7% for spinal cord points (maximum deviations of 4.5% for PTV and 5.3% for spinal cord). Comparison of dose distributions measured with dosimetry films and those calculated in the treatment planning system yielded gamma parameter results in the range from 91.5% to 99.7%, with an acceptance criterion of at least 90% of points meeting the criteria of the gamma parameter.

Hospital #	Relative output of the day	Dose difference (%)				Gamma (%)	
		IC_PTV _7000	IC_PTV n1_6000	IC_PTV n2_5400	IC_Spin alCord	global 3% 3mm	local 3% 2mm
1	0,984*	-3,6*	-3,4*	-4,5*	-1,6*	-*	-*
2	1.006	0.6	1.0	1.8	1.5	99.7	97.4
3	0.987	-1.9	-0.4	1.8	2.0	98.4	90.9
4	0.992	-4.5	-1.7	-2.4	-1.7	98.8	92.0
5	0.994	-2.3	-1.7	-1.4	-4.5	98.8	89.0
6	0.990	-3.5	-2.9	-1.1	-2.9	98.5	89.2
7	1.001	-2.1	-0.7	0.4	-5.3	91.5	83.5
8	0.998	-1.3	-2.0	-1.1	-2.1	96.3	91.4
AVG	**0.996**	**-2.1**	**-1.2**	**-0.3**	**-1.9**	**97.4**	**90.5**
SD	**0.7%**	**1.6**	**1.3**	**1.6**	**2.8**	**2.8**	**4.2**

*technical problem with the measurement; were not included in further analysis

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Conclusions

dosimetry audit is a key component in quality management programmes in radiotherapy. Annual postal dosimetry audits have shown an improvement in the quality of radiotherapy and thus patient safety.

The activity of the SSDL in the field of calibrations and external dosimetry audits is an important tool to ensure the quality of treatment and safety of patients undergoing radiotherapy in oncology centers in Poland.

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Thank you for your attention.