

BELdART: A Radiotherapy Dosimetry Audit Program Using Alanine/EPR and Film Dosimetry

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ABSTRACT

The Belgian External Dosimetry Audit in Radiotherapy (BELdART) program provides independent verification of radiotherapy treatment planning and delivery using alanine/EPR and radiochromic film dosimetry. The audit framework includes photon and electron beam output verification, end-to-end testing, and evaluation of advanced treatment techniques such as VMAT, SRS, and SBRT. Since 2016, over 100 audits have been performed across Belgian radiotherapy centers. Alanine measurements showed good agreement with reference doses, with most results within $\pm 5\%$ of the expected value. Film dosimetry analyses demonstrated high gamma passing rates, indicating strong agreement between planned and delivered dose distributions. These findings demonstrate the value of BELdART in assessing dosimetric accuracy and supporting quality assurance in clinical radiotherapy. The combined use of alanine/EPR and film dosimetry provides a comprehensive audit approach that contributes to treatment consistency, patient safety, and continuous quality improvement. Ongoing developments include implementing independent audit procedures for selected brachytherapy applications.

INTRODUCTION

External dosimetry audits are an essential component of quality assurance in radiotherapy, providing independent verification of treatment planning and dose delivery. In Belgium, the **BELdART audit program** supports radiotherapy centers by evaluating the commissioning and clinical implementation of photon and electron beam models in treatment planning systems (TPSs). Through a combination of basic dosimetric checks and end-to-end tests representative of clinical practice, the program helps ensure the accuracy and consistency of radiotherapy treatments are maintained. Current developments are expanding the program to include **brachytherapy audits**.

METHODS AND MATERIALS

A combination of alanine/electron paramagnetic resonance (EPR) dosimetry and radiochromic film dosimetry was employed for absolute point dose and two-dimensional dose distribution measurements, respectively. Photon beam audits consisted of independent **beam output verification in water [1]** and end-to-end (E2E) testing using anthropomorphic phantoms for volumetric modulated arc therapy (VMAT), intracranial stereotactic radiosurgery (SRS), and lung stereotactic body radiotherapy (SBRT) [2]. Radiochromic films were analyzed using a triple-channel dosimetry protocol with one-scan rescaling. Measured and planned dose distributions were compared using gamma analysis with global dose normalization. To facilitate the identification of potential error sources, all measurements for a given audited beam were performed on the same day. For electron beam audits, only beam output verification was performed. A brachytherapy dosimetry audit is currently under development and will include a basic test for independent verification of source strength and source position, and an E2E test for treatment plan verification of gynecological and prostate brachytherapy treatments using different applicators.

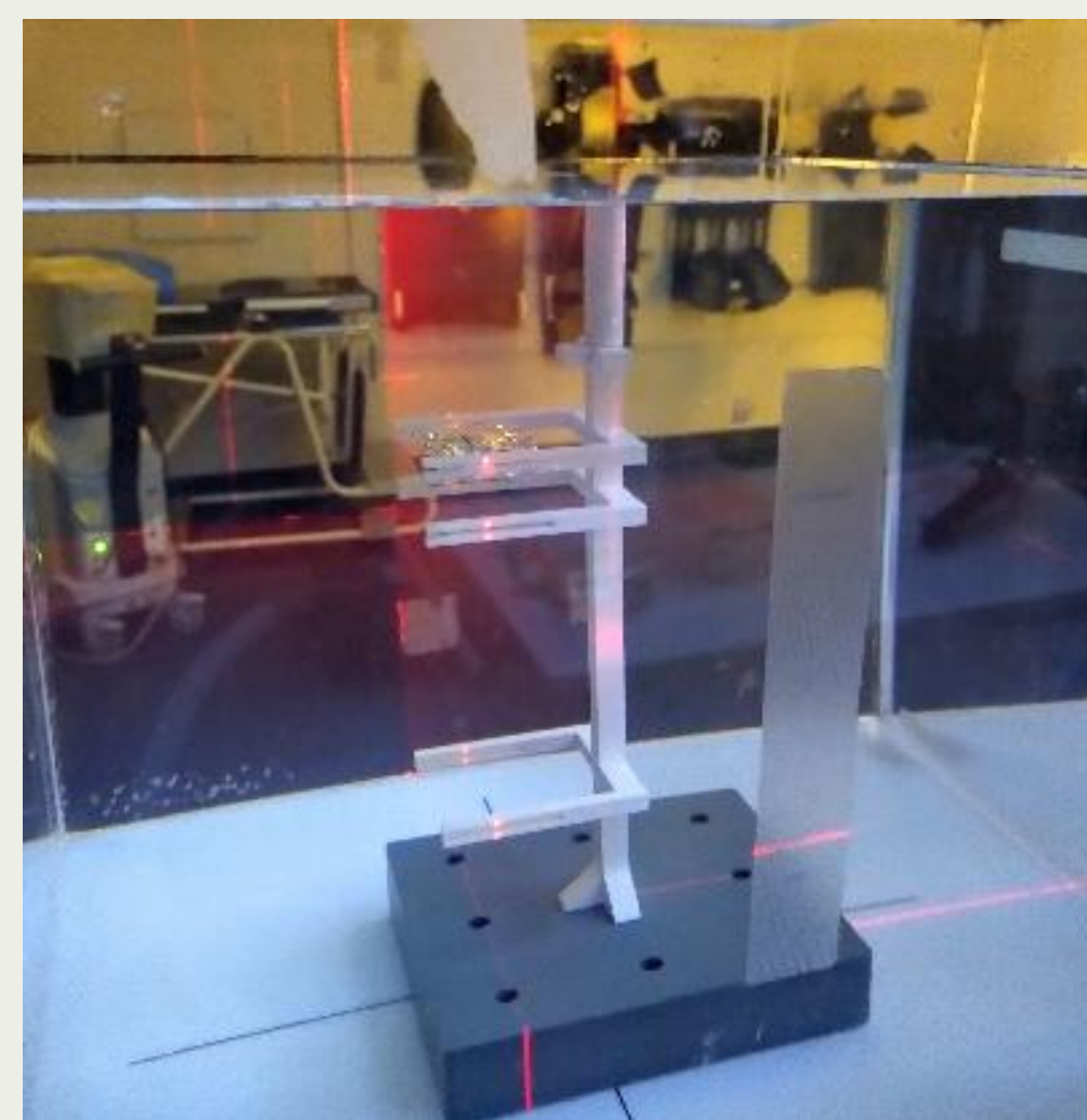


Figure 1. Holder for basic tests



Figure 2. Phantoms for E2E tests

RESULTS

Since September 2016, **106 audits** have been completed, comprising **261 photon beams** and **71 electron beams**.

- Basic audits: All photon beams and **95% of electron beams** were within $\pm 5\%$ of the reference dose.
- VMAT E2E audits (104 beams): **99% of alanine measurements** were within $\pm 3\%$ in the prostate and seminal vesicle targets. Film analysis showed $>90\%$ gamma passing rates (3%/3 mm) for **97% of beams**.
- SRS audits (61 beams): **95% of alanine measurements** were within $\pm 5\%$. Film analysis achieved $>90\%$ gamma passing rates (5%/1 mm) for **97% of beams**.
- SBRT audits (46 beams): All alanine measurements were within $\pm 5\%$. Film analysis yielded $>90\%$ gamma passing rates for 98% of target films (5%/1 mm) and 87% of lung-interface films (3%/2 mm).

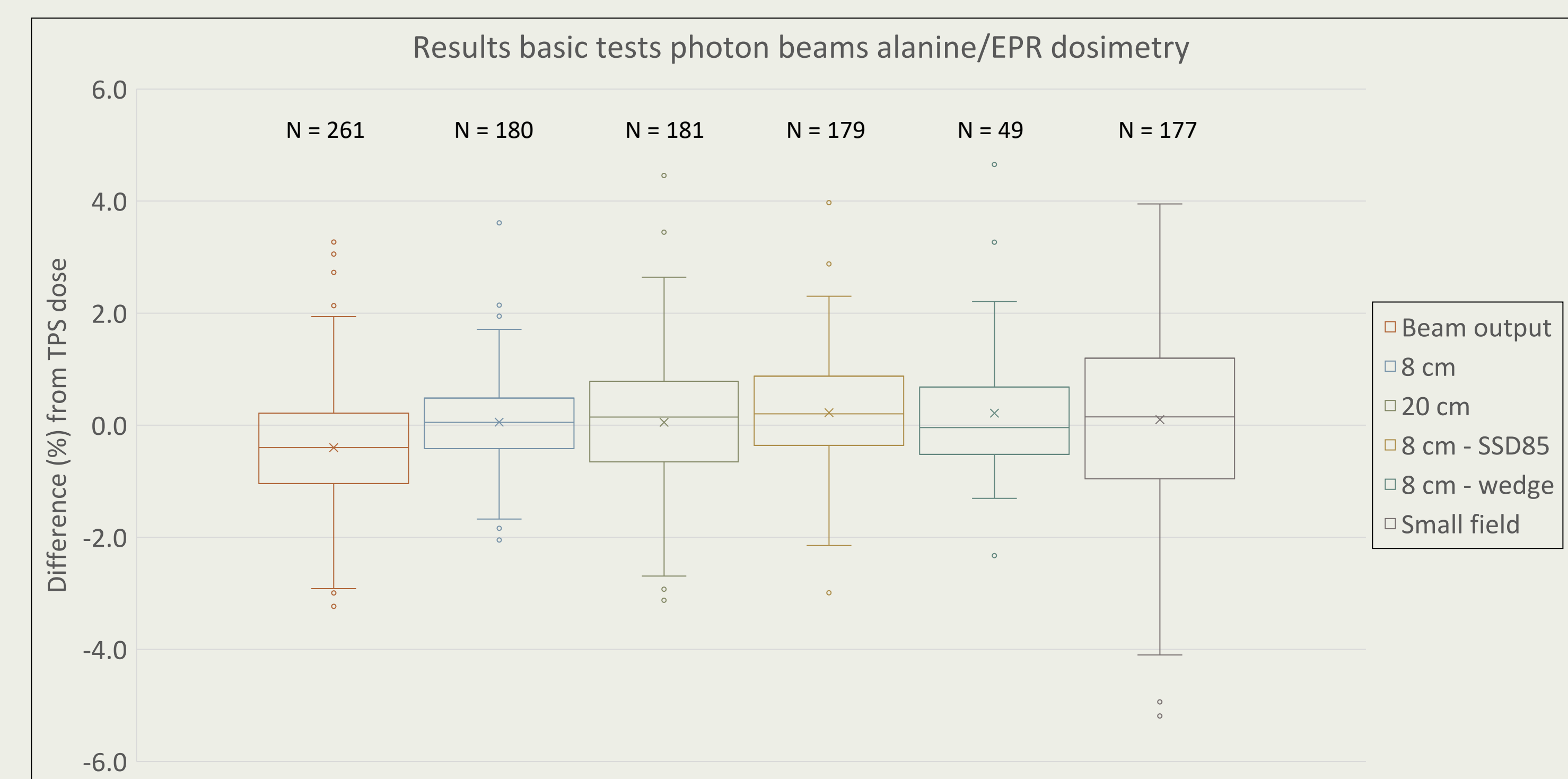


Figure 3. Audit results basic tests photon beams

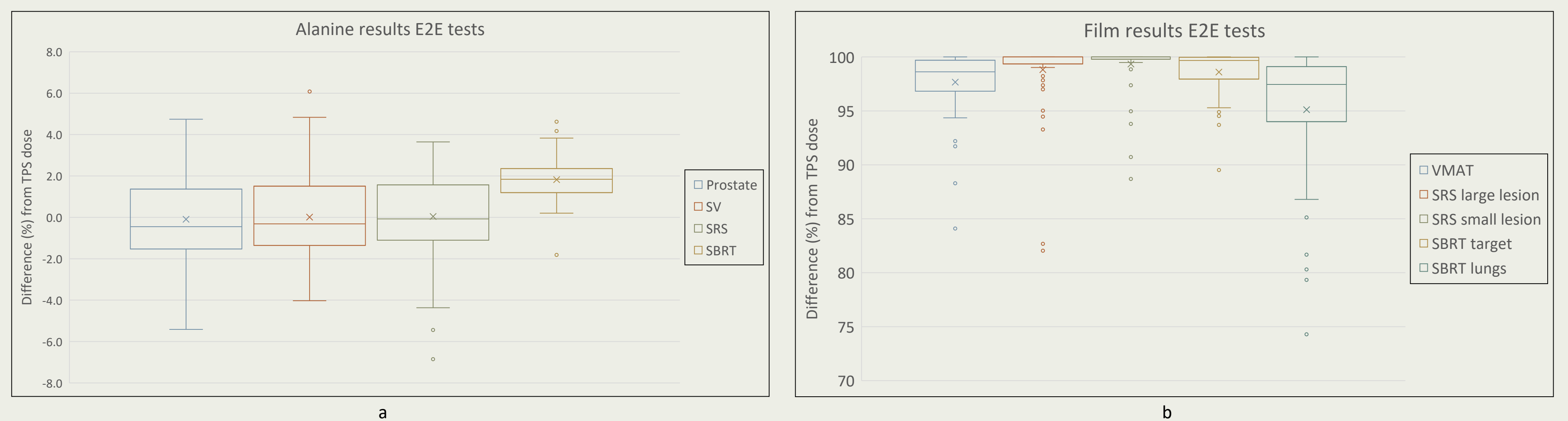


Figure 4. E2E audit results. a: Alanine results. b: Film results

DISCUSSION

The consistently high agreement observed across the basic and end-to-end audits indicates robust commissioning and clinical implementation of treatment planning systems and delivery workflows in participating centers. The strong performance in VMAT, SRS, and SBRT audits demonstrates that the combination of alanine dosimetry and radiochromic film measurements provides a reliable framework for independent verification of both absolute dose and dose distribution. Building on the successful experience gained with these external audits, a brachytherapy dosimetry audit is currently being developed using the same principles, including both basic verification and end-to-end testing of clinically relevant treatment scenarios.

CONCLUSIONS

The BELdART audit program provides effective independent verification of radiotherapy treatments and contributes to maintaining high standards of dosimetric accuracy and patient safety [3]. Ongoing developments will expand this framework to include brachytherapy treatments.

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