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Automated MPPG5b-Compliant Platform for Basic Photon Beam Model Validation Across an Integrated Health Care System

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ABSTRACT

To introduce a platform for automated comparative analysis of dose calculation algorithms in the Eclipse Treatment Planning System. Native TPS workflows are labor-intensive, manual, and lack the automated metric evaluation needed for efficient AAPM MPPG5b compliance. This work enables rigorous validation against commissioning measurements and streamlined comparison of algorithm implementations across a large integrated health care system.

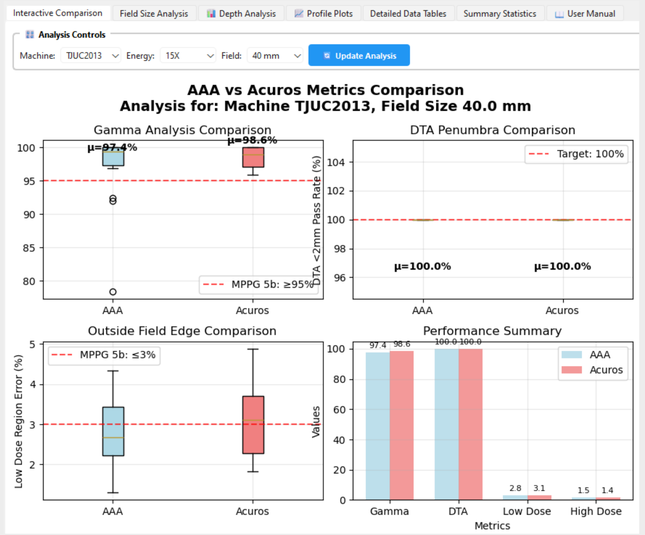
INTRODUCTION

Recent studies highlight significant variations in how validation testing is performed, with institutions often relying on disparate, in-house custom tools that lack standardization [1, 2]. This inconsistency is particularly pronounced in large, integrated health systems, where the heterogeneity of beam model implementation complicates network-wide quality assurance. Our developed tool addresses this gap by providing a centralized, automated framework that enforces basic photon beams MPPG 5b compliance across distributed clinical sites. By automating the extraction of commissioning measurements, the platform replaces labor-intensive manual comparisons with rapid, quantitative audits, ensuring uniform dosimetric quality throughout the entire health network. The impact of this work is threefold:

1. Efficiency: It reduces per-case evaluation time to less than 30 seconds, significantly decreasing the commissioning and model tuning iterations required for new linear accelerators.
2. Standardization: It enables a unified, network-wide characterization of beam models across a large integrated health care system, regardless of machine vendor (Varian or Elekta).
3. Clinical Policy: The tool facilitates quantitative cross-algorithm benchmarking (e.g., AAA vs. Acuros XB), directly informing algorithm-selection policies for complex modalities like VMAT and SBRT.

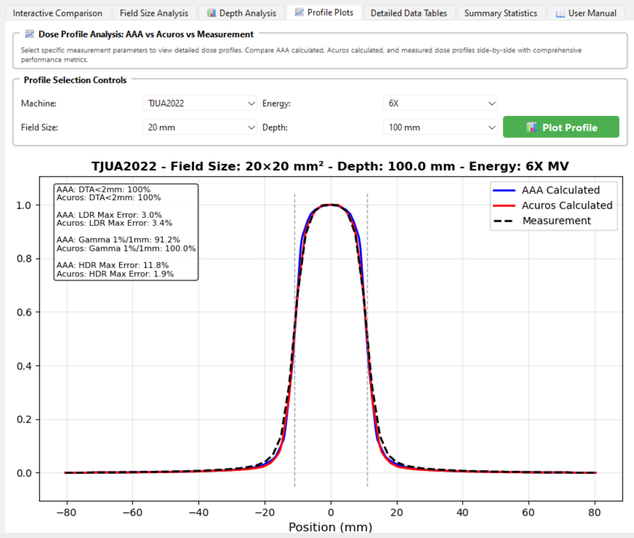
METHODS AND MATERIALS

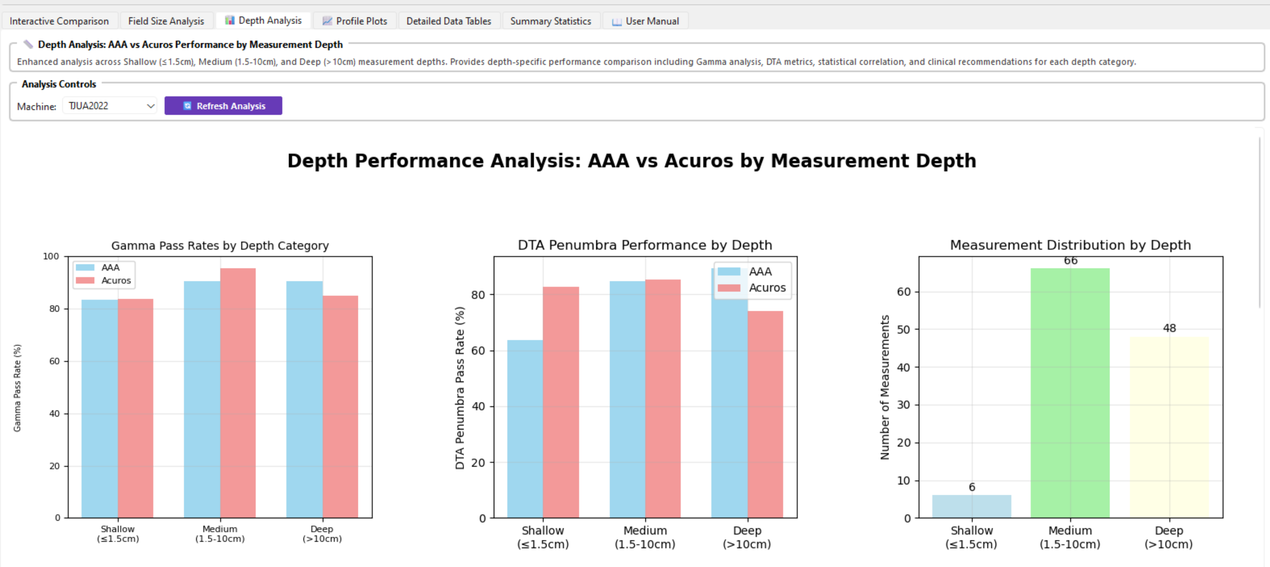
A software platform was developed to automate two key components of beam model validation: (1) data query, in which Eclipse beam model configuration files and commissioning measurement datasets are programmatically parsed to extract calculation parameters, reference water-tank curves, and field definitions; and (2) quantitative comparison, in which extracted model calculations are automatically evaluated against measurements using MPPG5b-recommended metrics. Two comparison modes are supported: (1) inter-machine consistency checks for commissioned models across different linacs, and (2) cross-algorithm benchmarking between distinct engines (AAA vs. Acuros XB) to quantify differences in homogeneous water conditions.



RESULTS

The platform parsed Eclipse v15.6 data without manual preprocessing, generating standardized MPPG5b-compliant summaries. Inter-machine comparisons demonstrated network-wide concordance within tolerances for profiles, PDDs, and output factors, while displaying outliers for further analysis. Cross-algorithm benchmarking (AAA vs. Acuros XB) revealed depth-dependent differences in the buildup region and systematic variations in penumbra and profile tails, particularly for small fields <5 cm. Models commissioned for VMAT/SBRT workflows showed improved small-field agreement with measurements when calculated with Acuros XB. Automated analyses reduced per-case evaluation time to under 30 seconds, significantly decreasing commissioning and model tuning iterations.





CONCLUSIONS

The platform provides a robust, model-agnostic framework for MPPG5b evaluation. Unified access to models from Varian and Elekta within a single interface enabled consistent characterization, identification of energy-specific outliers, and quantitative comparison of AAA and Acuros XB. These results informed algorithm-selection policies by site and modality, effectively streamlining system-level dosimetric validation.

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