

A Custom Small-Field AAA Beam Model for 6X FFF: Validation and Cross-Comparison on Three TrueBeams

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INTRODUCTION

Small-field dosimetry is challenging because of loss of lateral charged-particle equilibrium, source occlusion, detector perturbation, and complex MLC geometry Eclipse AAA v15.6 beam models require user-defined MLC transmission, effective spot size (ESS), and dosimetric leaf gap (DLG)

Study aim: optimize a 6X FFF AAA small-field model for SRS/SBRT and validate delivery accuracy across beam-matched TrueBeams

METHODS

Built a custom 6X FFF AAA model in Eclipse v15.6 with Millennium MLC parameters Evaluated DLG values 0.7–1.5 mm with ESS = 0.1 mm (x,y)

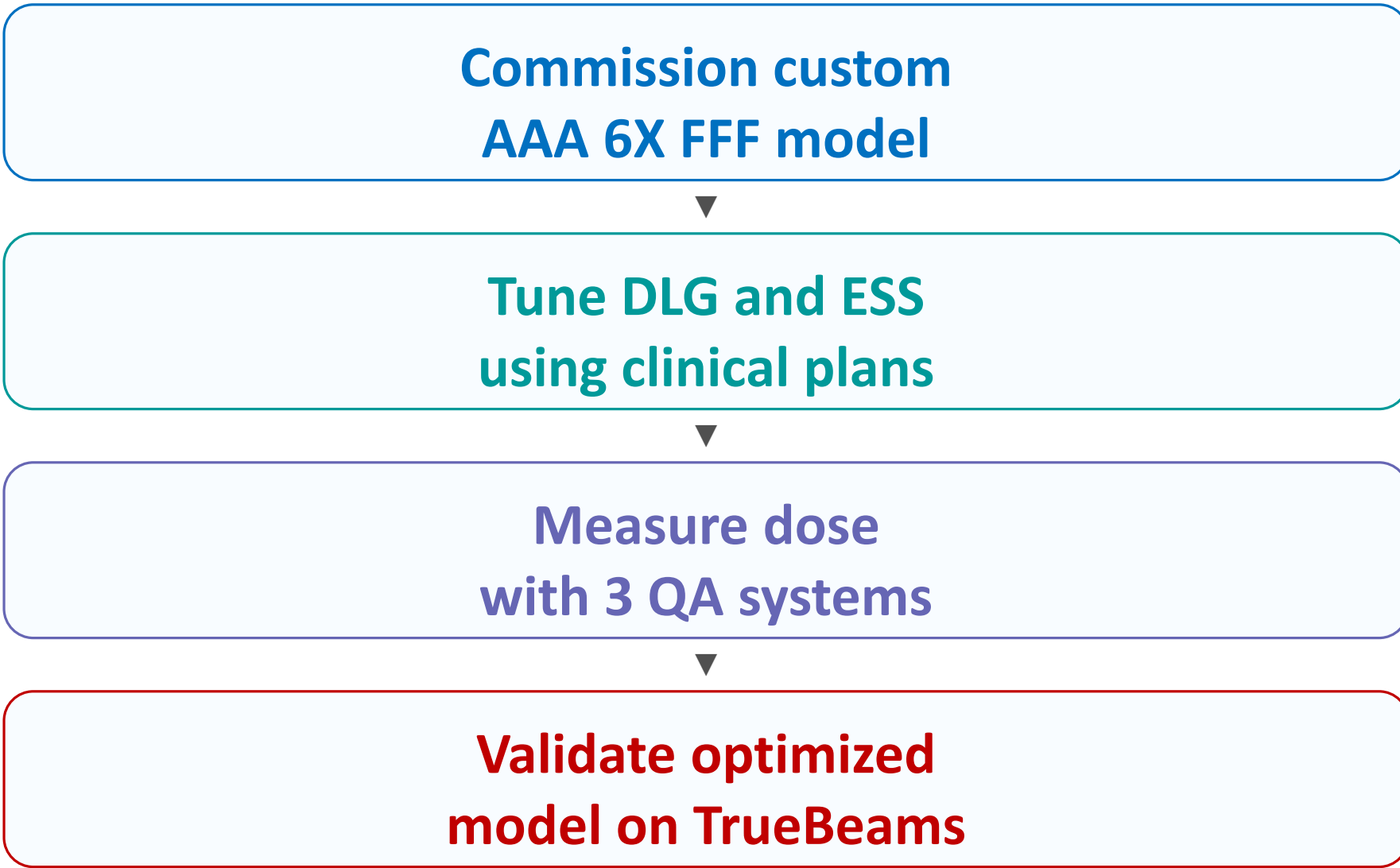
For each DLG/ESS iteration, clinical plans were calculated and measured with PinPoint chamber (PTW 31022), Portal Dosimetry, and SRS MapCHECK

Selected the model minimizing calculated-vs-measured dose difference

Validated with 16 clinical SRS/SBRT plans and cross-comparison across three TrueBeam linacs

Gamma analysis: absolute 2%/1 mm criterion

STUDY DESIGN

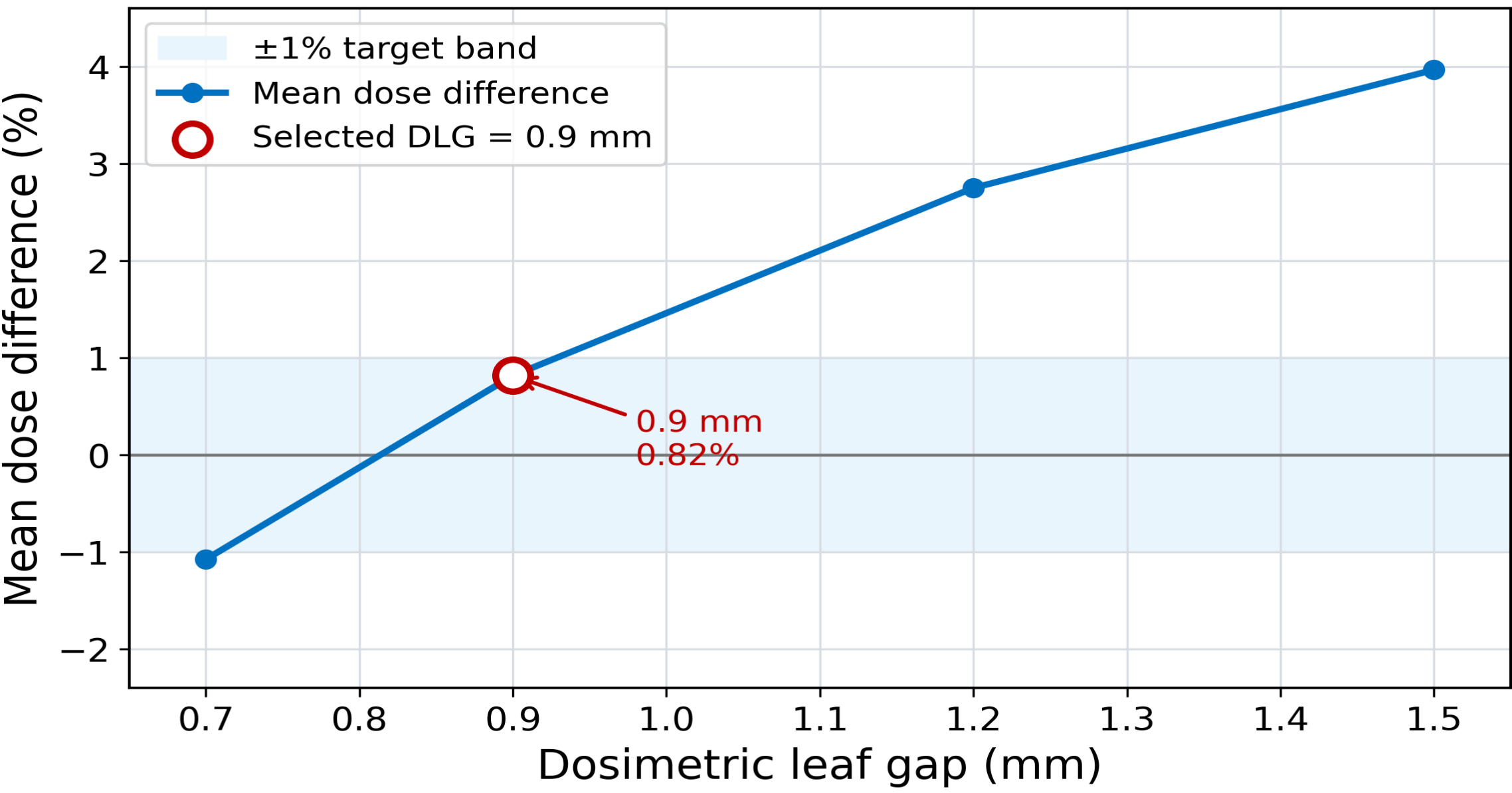


KEY RESULTS

DLG had the dominant effect on small-field dose prediction. The optimized model used DLG = 0.9 mm and ESS = 0.1 mm (x,y), producing sub-1% mean dose discrepancy during optimization and clinically acceptable validation across all plans.

Optimized DLG 0.9 mm ESS 0.1 mm	Optimization mean 0.82% dose difference	Validation plans 16 SRS/SBRT cases
Portal gamma 98.7 ± 1.0% absolute 2%/1 mm	SRS MapCHECK 98.3 ± 1.2% absolute 2%/1 mm	PinPoint agreement 1.3 ± 0.5% range 0.6–2.4%

DLG OPTIMIZATION



Mean calculated–measured dose difference across five clinical plans; ±1% target band shaded

DLG SENSITIVITY

DLG (mm)	Mean diff. (%)
1.5	3.97
1.2	2.75
0.9	0.82
0.7	-1.07

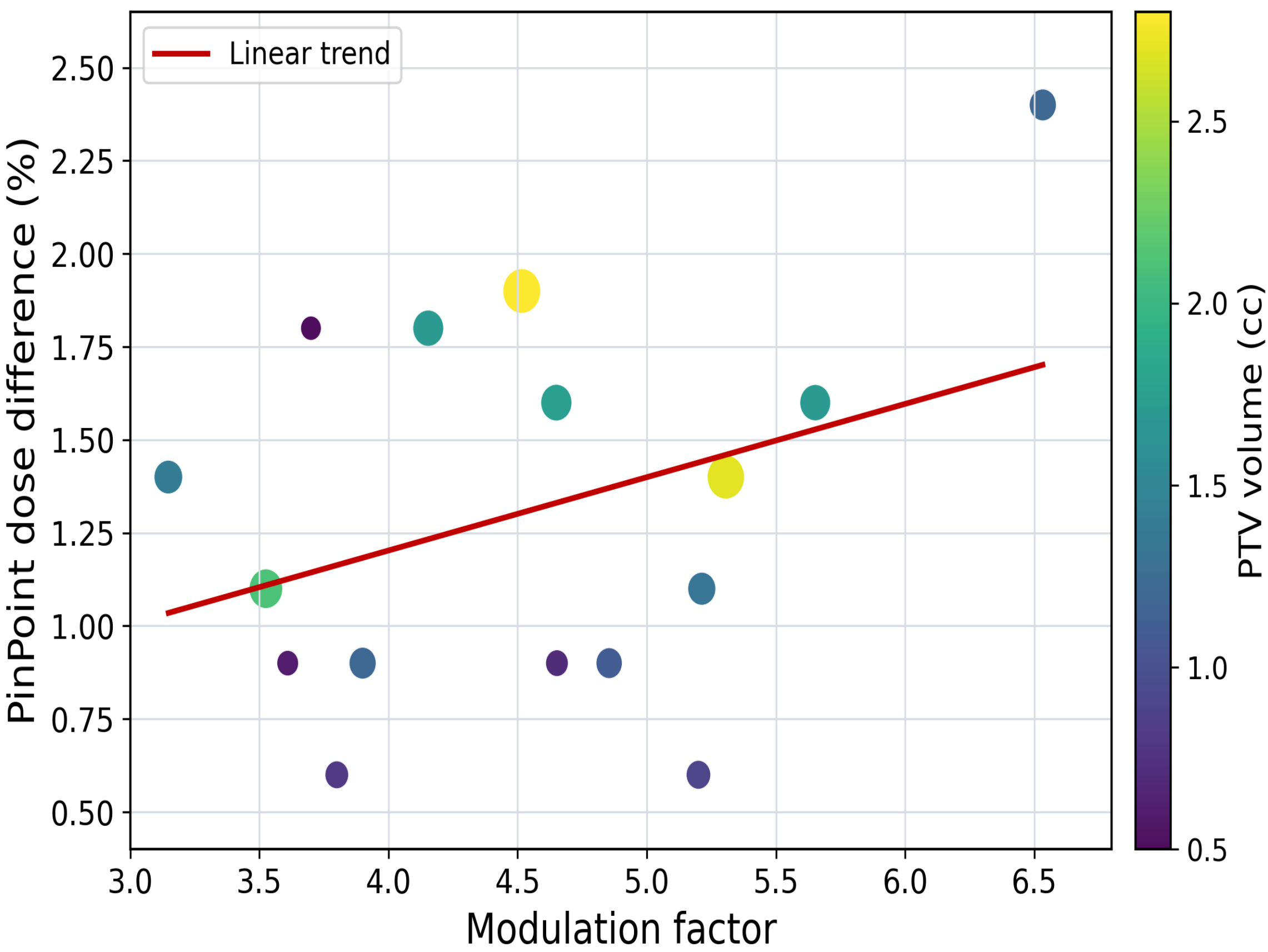
Clinical significance

A 0.1 mm change in DLG produced ~2% dose variation in highly modulated small targets, supporting institution-specific small-field validation

CLINICAL VALIDATION COHORT

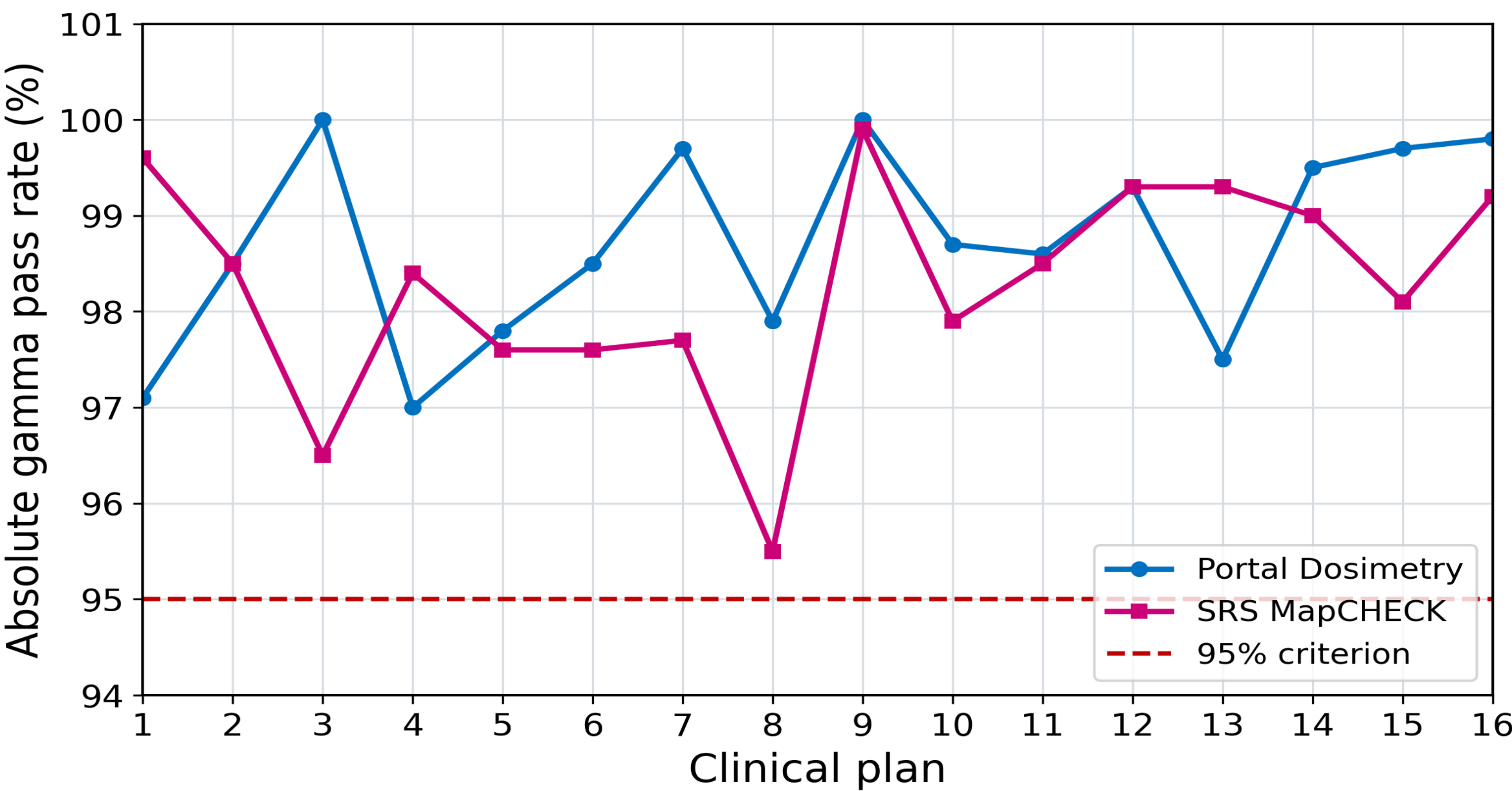
- **Modulation factor:** **4.53 ± 0.91** (range 3.15–6.53)
- **PTV volume:** **1.40 ± 0.69 cc** (range 0.5–2.8 cc)
- **All clinical plans achieved >95% absolute gamma passing** at 2%/1 mm.
- Cross-platform delivery agreement across beam-matched TrueBeams was clinically acceptable, with dose agreement within 2.4%.

PLAN MODULATION AND DOSE AGREEMENT



PinPoint chamber dose difference versus modulation factor; marker size/color reflect target volume.

ABSOLUTE GAMMA PASSING RATES



Portal Dosimetry and SRS MapCHECK validation for 16 clinical plans; dashed line marks 95% criterion

CONCLUSIONS

- DLG tuning is the principal driver of AAA small-field dose agreement for highly modulated SRS/SBRT plans
- DLG = 0.9 mm and ESS = 0.1 mm produced sub-1% optimization discrepancy and robust clinical QA results
- The optimized 6X FFF AAA model was reproducible across beam-matched TrueBeam linacs