A Comprehensive Study on the Heterogeneity Dose Calculation Accuracy in IMRT using an Anthropomorphic Thorax Phantom

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Purpose

- Survey the accuracy of several commercial dose calculations
- Check the consistency of superposition-convolution implementations

- Baseline: RPC anthropomorphic thorax phantom

Methods & Materials

- IMRT Treatment Planning Systems (TPS)
  - Superposition-Convolution
    - Pinnacle
    - Eclipse AAA
    - TomoTherapy
  - Pencil-beam w/ effective pathlength correction
    - Corvus
    - Eclipse

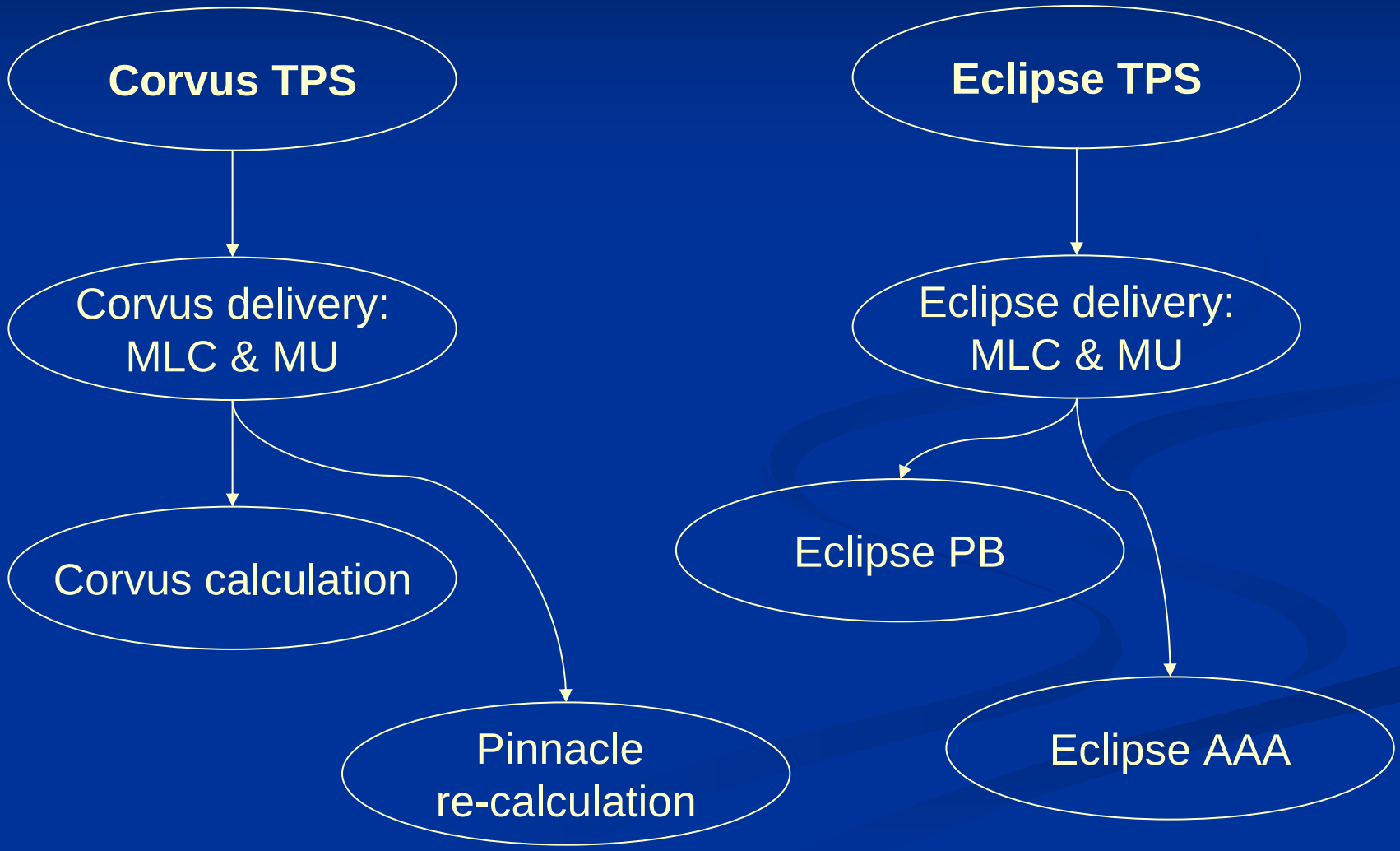
Methods & Materials

TPS	Beams	MLC

Pinnacle	• 5 beams
	  • 4 coplanar beams (35°, 90°, 150°, 190°)
	  • 1 non-coplanar beam (90° couch kick, 30° gantry angle)
		Static

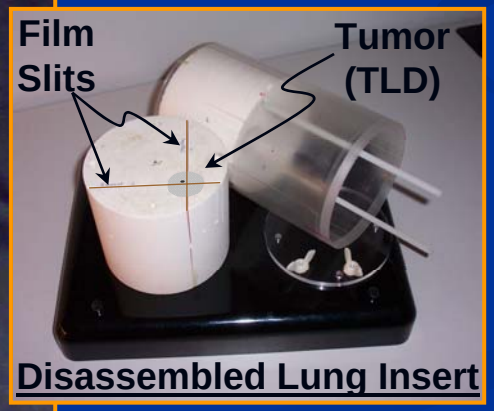
Corvus		Static
Eclipse, AAA		Dynamic
Eclipse, pencil-beam		Dynamic
TomoTherapy	Helical; pitch 0.3, field-width 2.5cm	

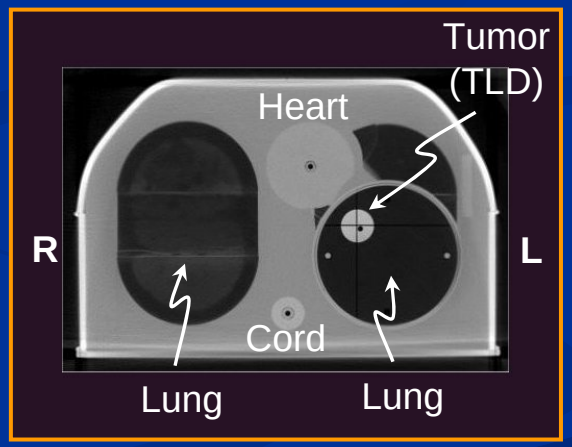
Methods & Materials



Methods & Materials

- Radiological Physics Center (RPC) Anthropomorphic Thoracic Phantom
  - CIRS Lung insert (cylinder) with embedded tumor
  - Fitted for TLD (tumor, heart, cord) and Radiochromic Film (tumor/lung)





Dimensions (cm):
40W x 30H x 30D

Methods & Materials

- TLD
  - Corrected for daily output
- Radiochromic Film
  - TLD normalization
- All plans repeated 3 times

Results & Discussion

- IMRT QA: IC in water phantom

Dose Calculation	Delivery MLC & MU	IMRT QA IC correction factor (calc-to-meas)
Pinnacle	**Pinnacle**	1.027
Corvus	**Corvus**	1.055
Pinnacle		1.043
Eclipse, PB	**Eclipse**	1.007
Eclipse, AAA		0.993
TomoTherapy	**TomoTherapy**	1.016

- Corvus beyond 5% in IMRT QA

Results & Discussion

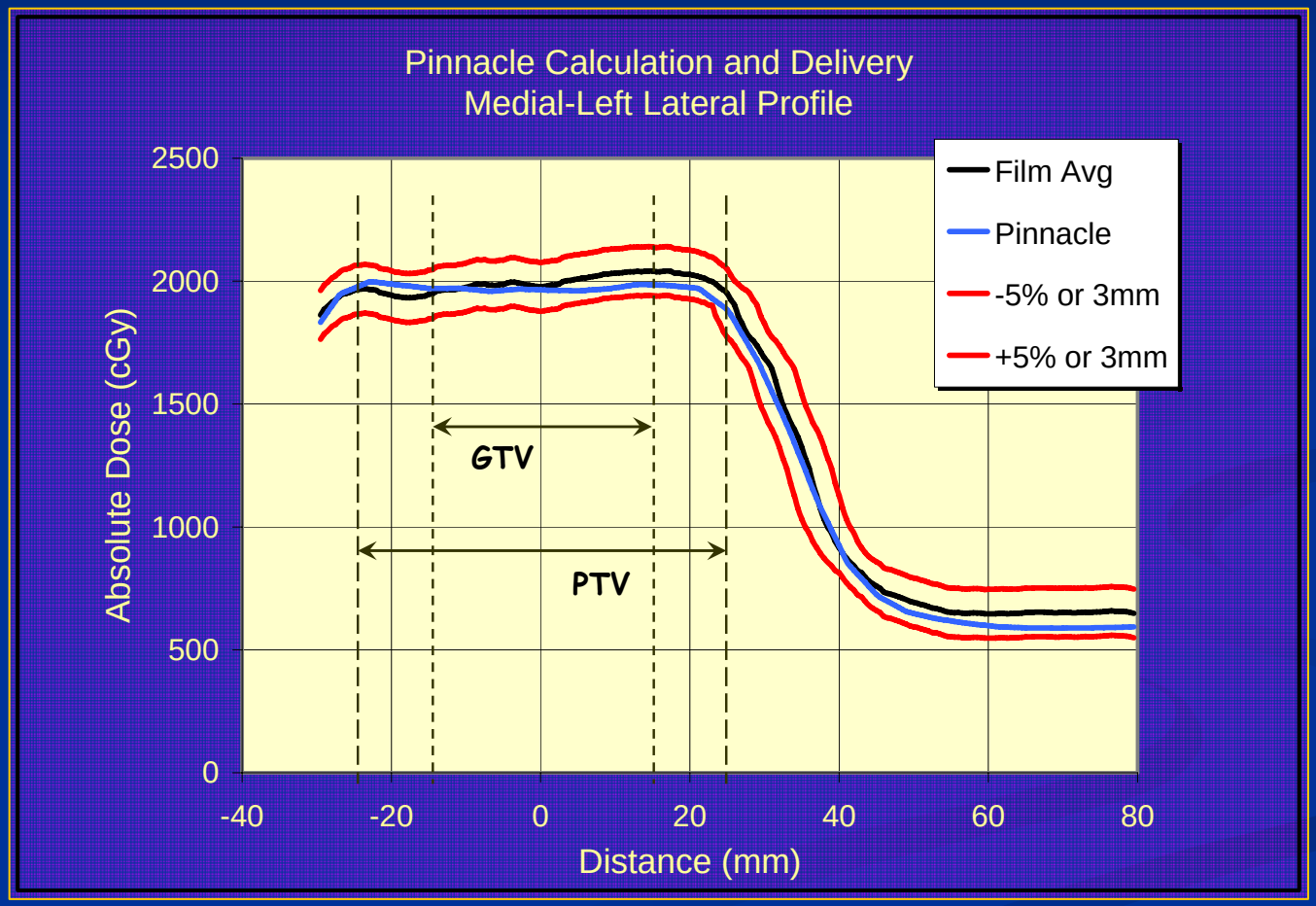
- Tumor Point Dose Comparison (corrected)

Dose Calculation	Delivery MLC & MU	**corrected** ratio of calc/meas
Pinnacle	**Pinnacle**	0.992
Corvus	**Corvus**	1.050
Pinnacle		1.009
Eclipse, PB	**Eclipse**	1.049
Eclipse, AAA		1.036
TomoTherapy	**TomoTherapy**	1.025

- All calculations corrected in response to IMRT QA

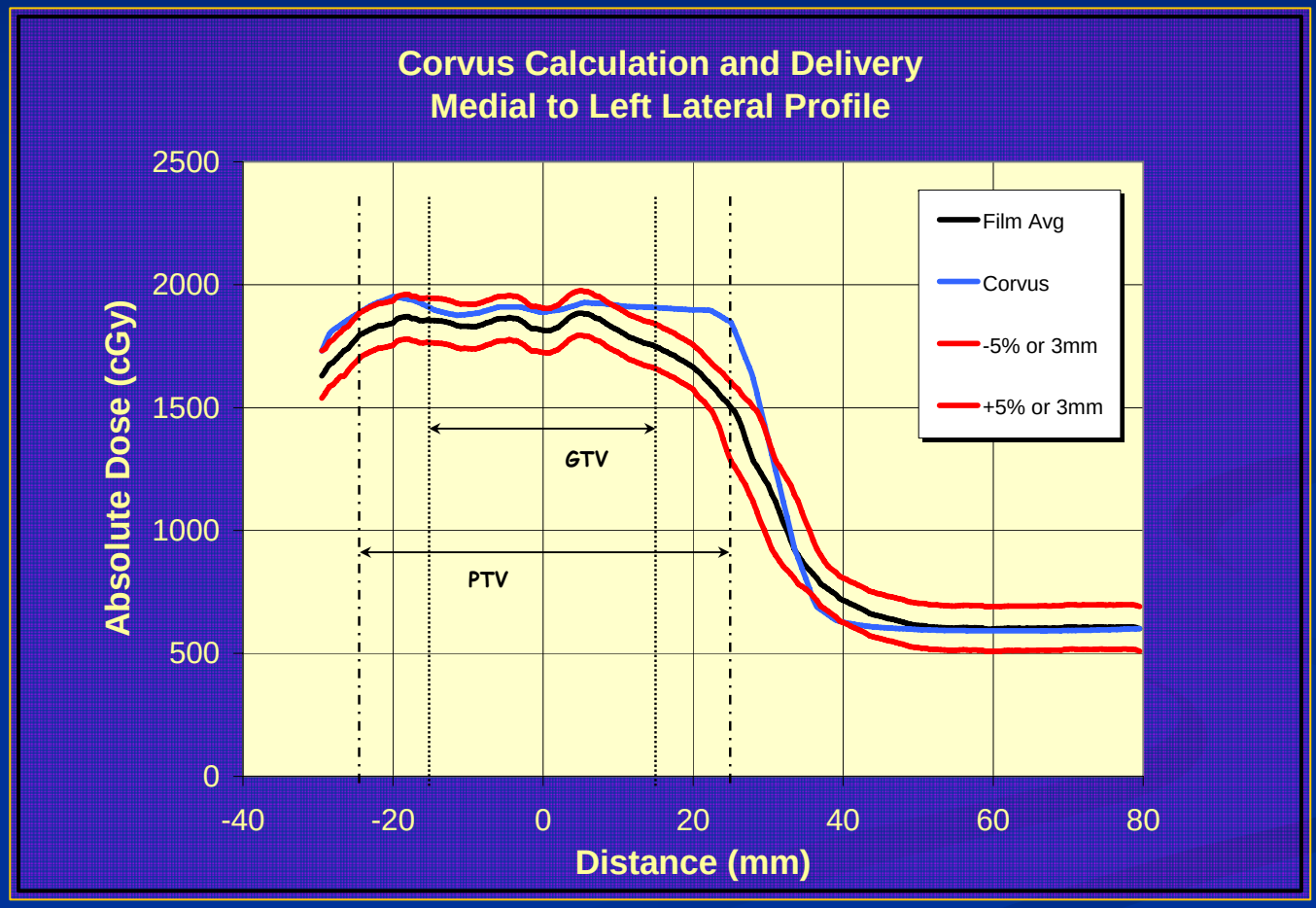
Results & Discussion

- Dose Profiles, Pinnacle



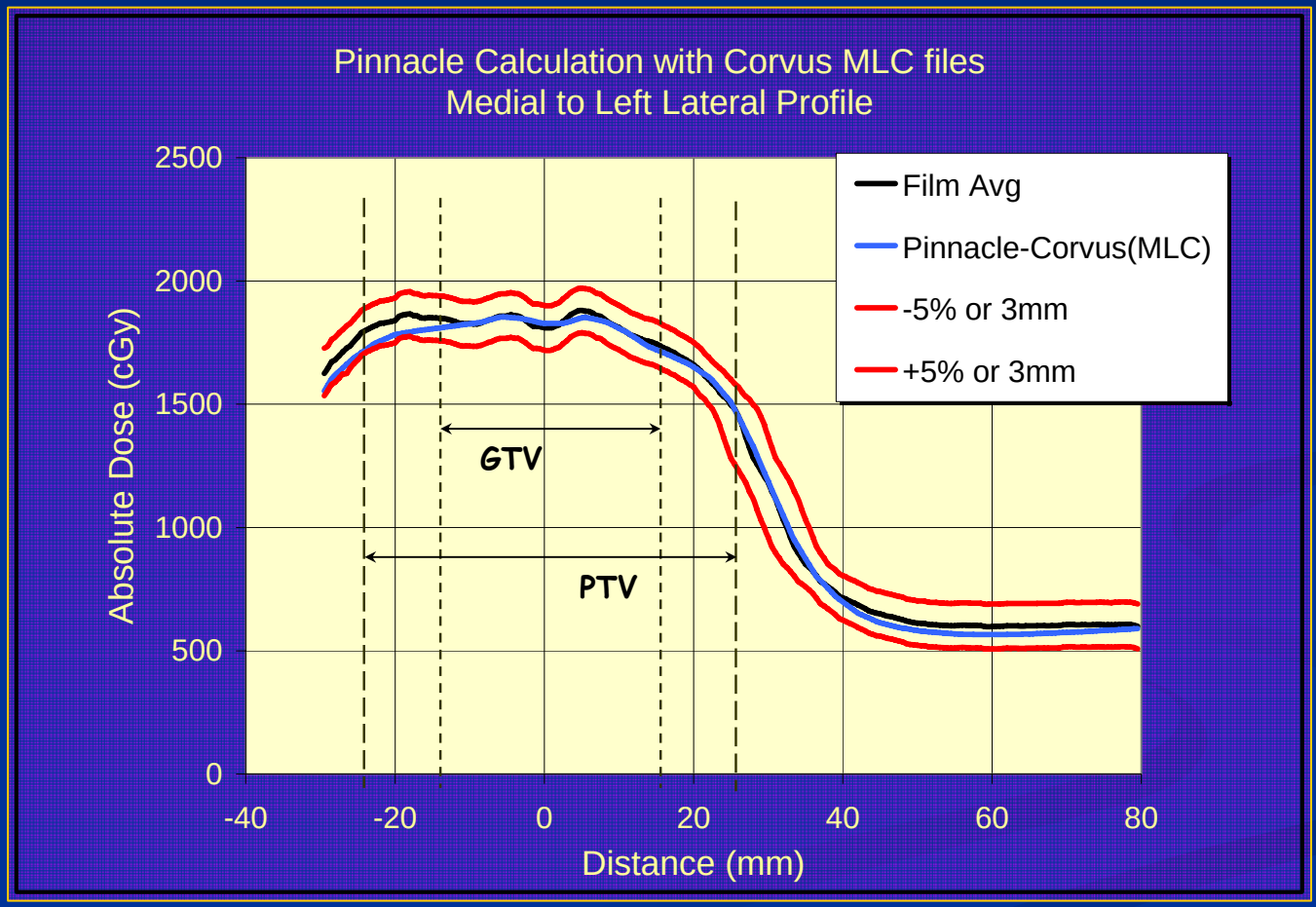
Results & Discussion

- Dose Profiles, Corvus



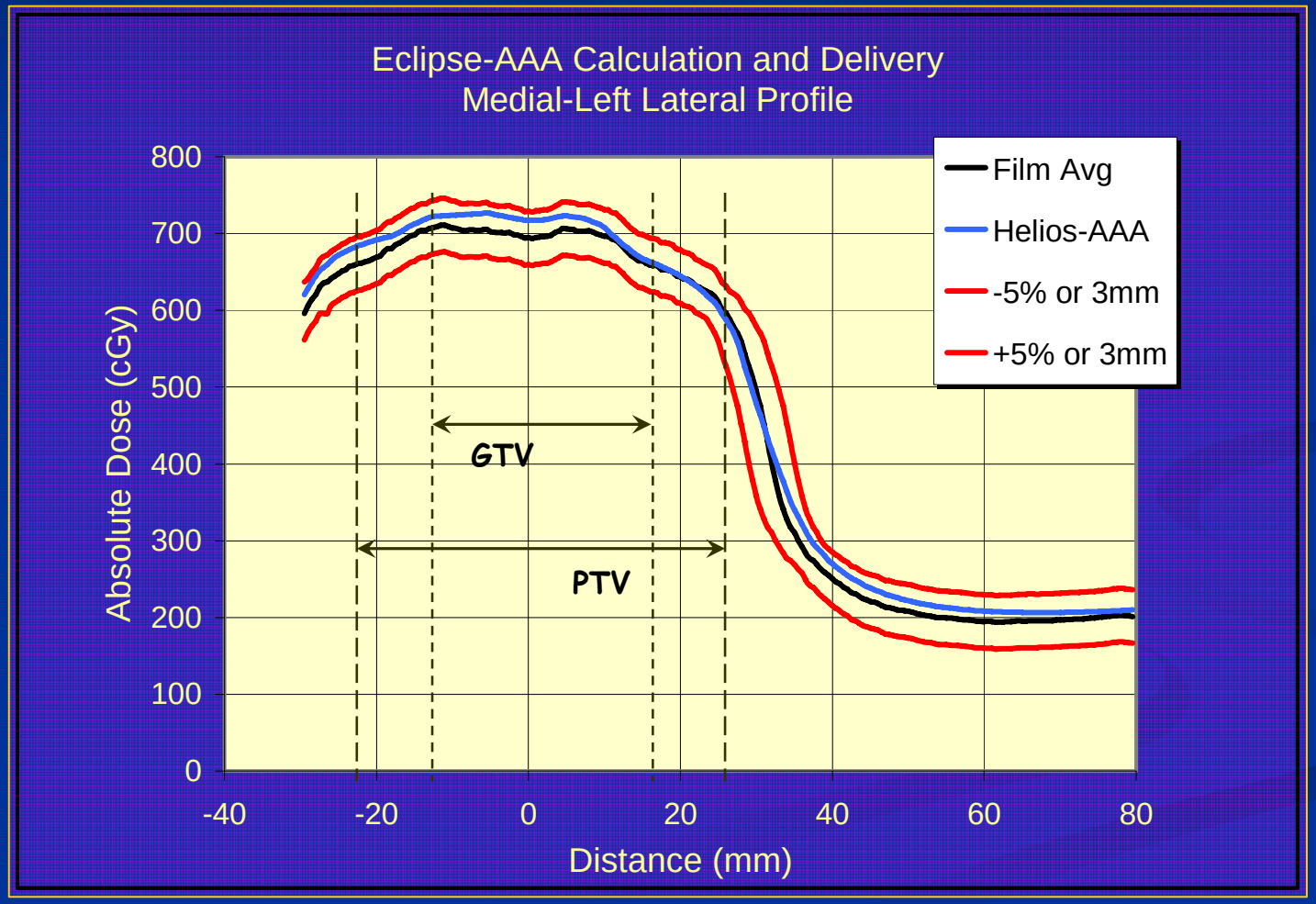
Results & Discussion

- Dose Profiles, Pinn. Re-calc/Corvus Beams



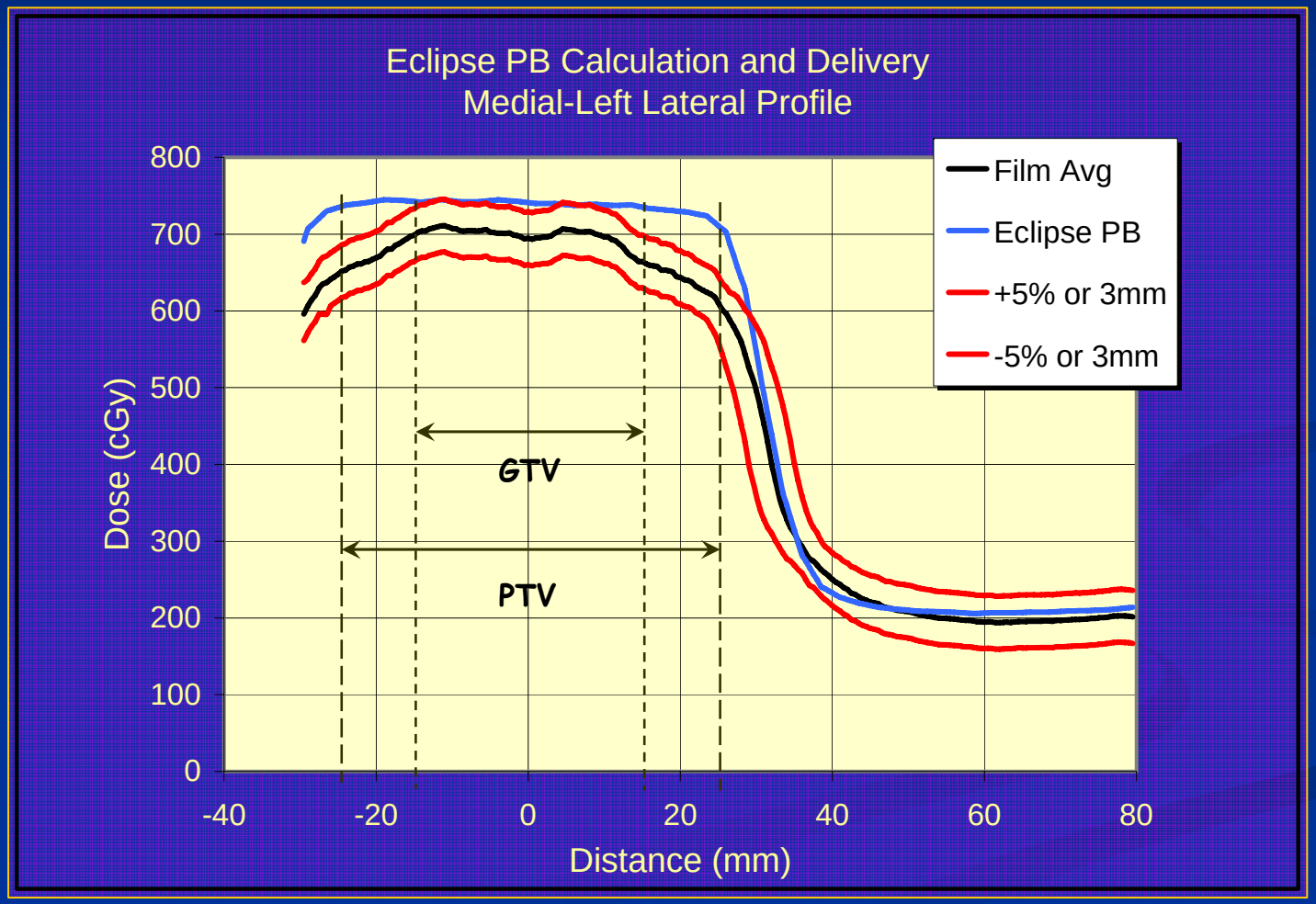
Results & Discussion

- Dose Profiles, Eclipse AAA



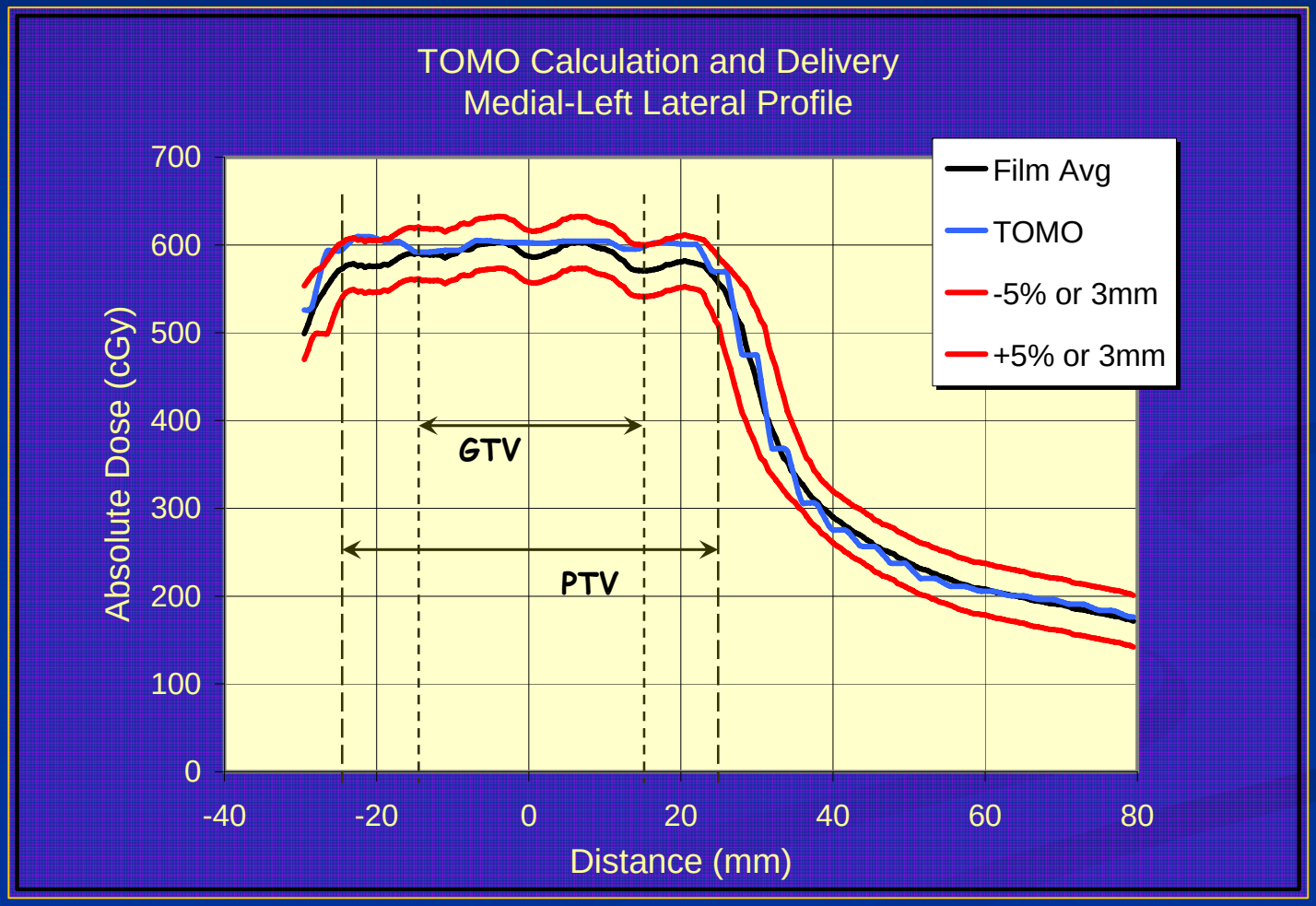
Results & Discussion

- Dose Profiles, Eclipse pencil-beam



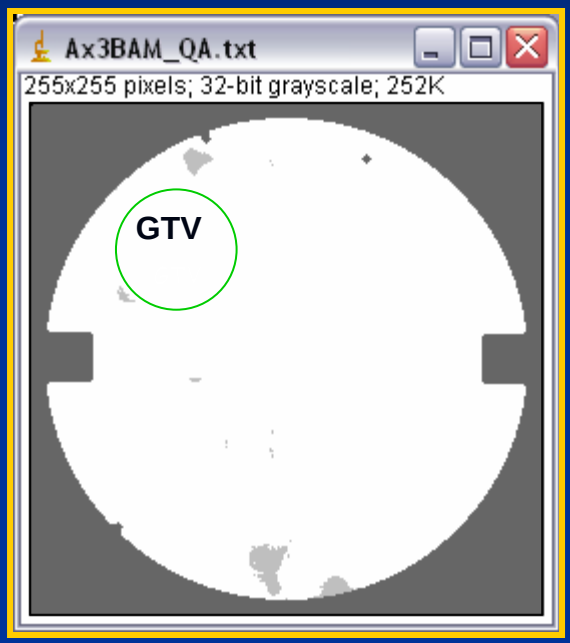
Results & Discussion

- Dose Profiles, TomoTherapy



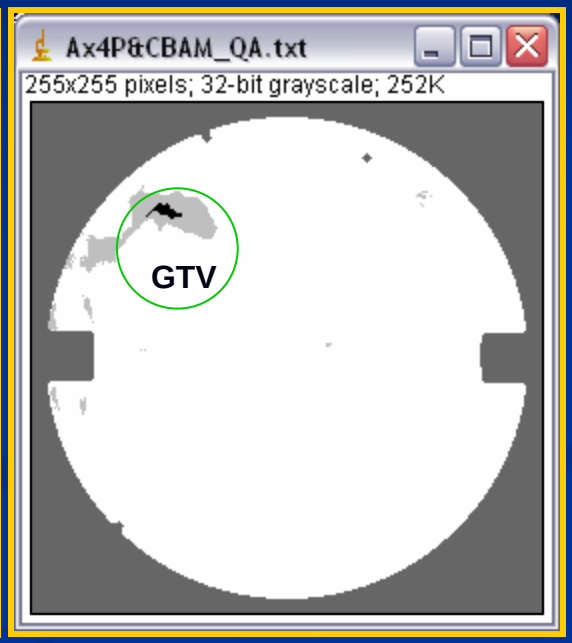
Results & Discussion

- Binary Agreement Maps:



Pinnacle

Corvus

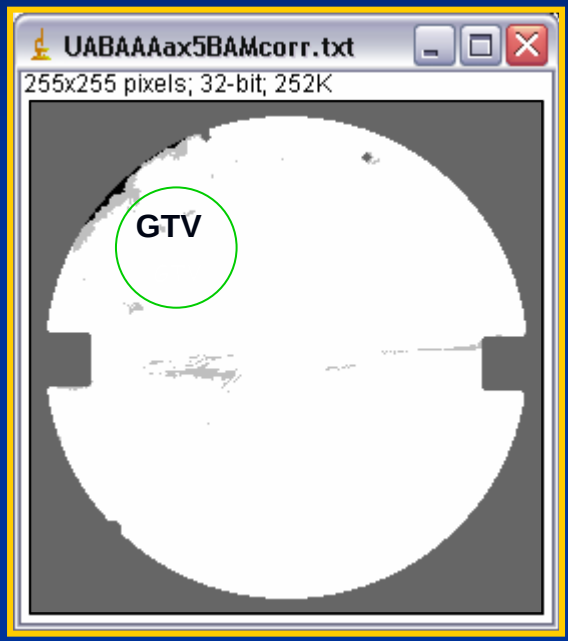


Pinnacle calc/Corvus

Test Criteria	±5%/3mm	±7%/7mm	Fails all criteria	*not tested*
Color Code				

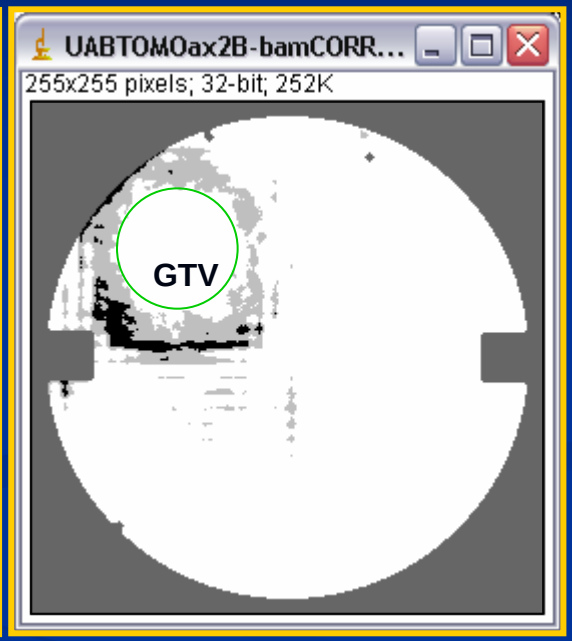
Results & Discussion

- Binary Agreement Maps:



Eclipse AAA

Eclipse PB

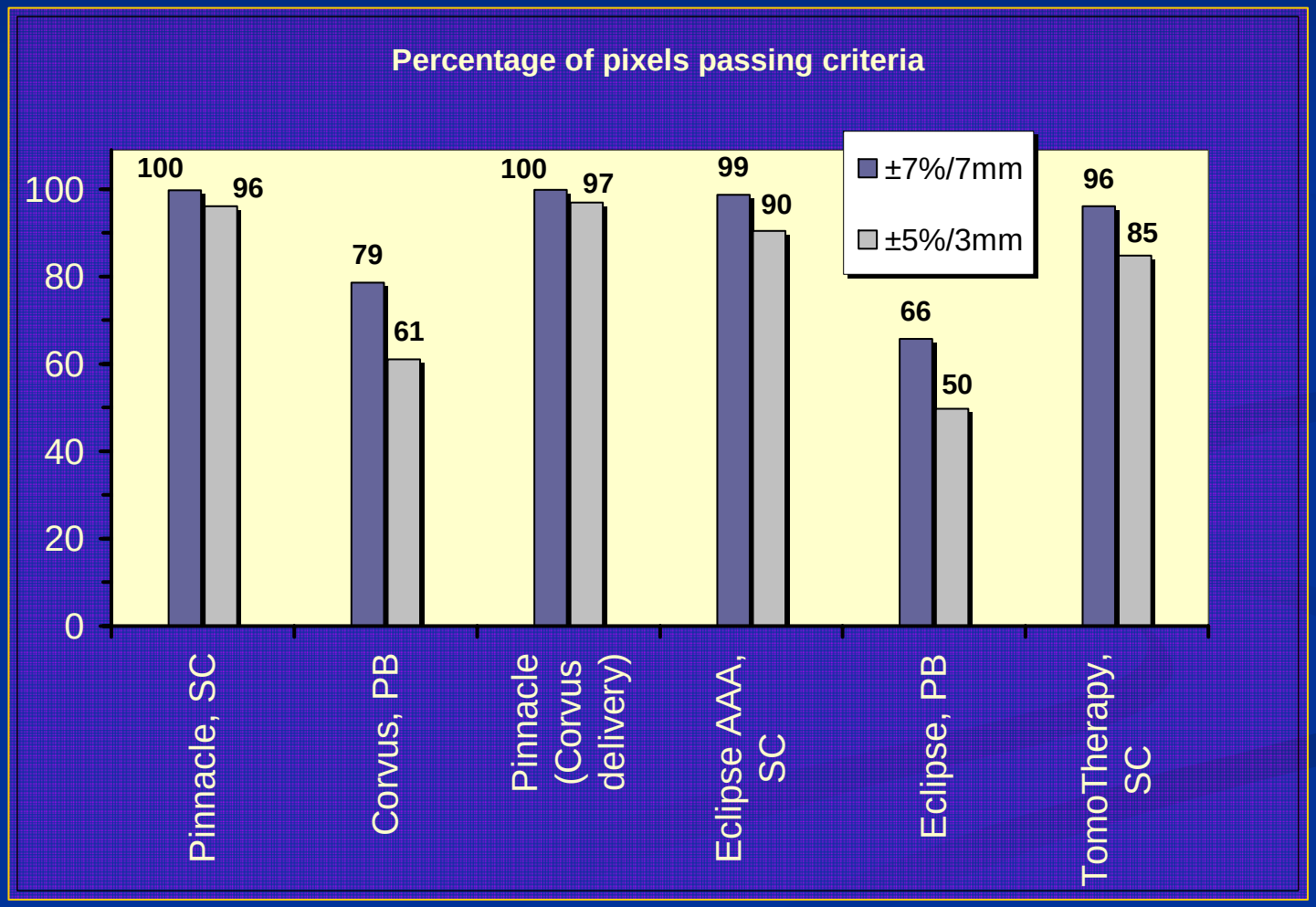


TomoTherapy

Test Criteria	±5%/3mm	±7%/7mm	Fails all criteria	*not tested*
Color Code				

Results & Discussion

- Binary Agreement Maps: Summary



Conclusions

- The accuracy of dose calculations from several common IMRT TPSs was evaluated.
  - Superposition convolution based- algorithms met the ±5%/3 mm criteria
  - Pencil-beam with an effective pathlength correction did not meet the criteria
- Pinnacle, Eclipse AAA, and TomoTherapy apply superposition convolution accurately.

References

1 S. Davidson, K. Prado, G. Ibbott, and D. Followill, "SU-FF-T-255: Hetergeneity Dose Calculation Accuracy in IMRT Using An Anthropomorphic Thorax Phantom," Medical Physics **33** (6), 2106 (2006).

2 N. Papanikolaou, J. J. Battista, A. L. Boyer, C. Kappas, E. E. Klein, T. R. Mackie, M. Sharpe, and J. Van Dyk, "Tissue Inhomogeneity Corrections for Megavoltage Photon Beams," AAPM Task Group #65 Radiation Therapy Commitee (2004).