Evaluation of heterogeneity correction algorithms through the irradiation of a lung phantom

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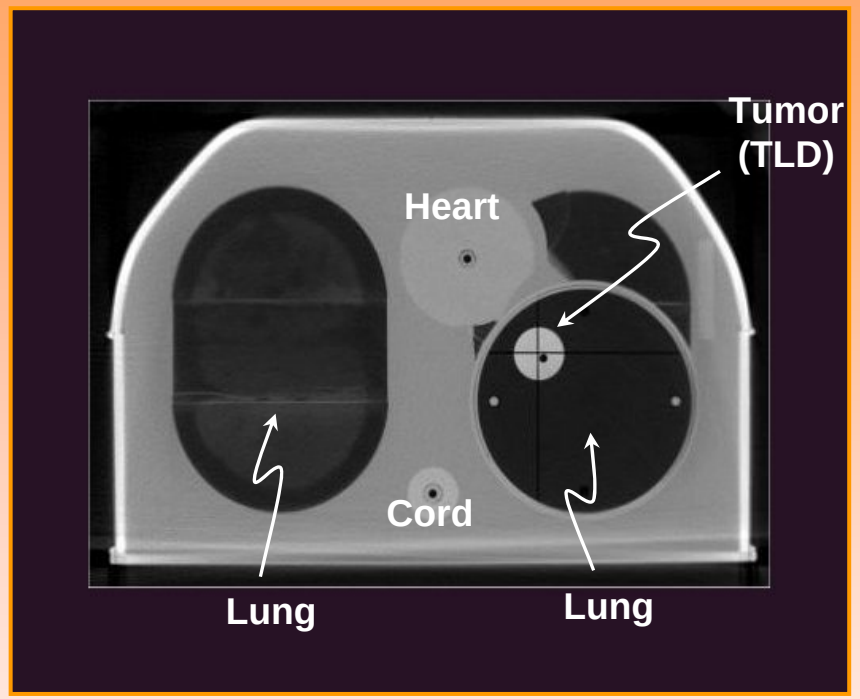
RPC Lung phantom

Water fillable plastic shell



Include

•different structures

•imaging and dosimetry insert

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RPC Phantom

Tumor dimension

Ovoid shape

3 cm diameter

5cm long

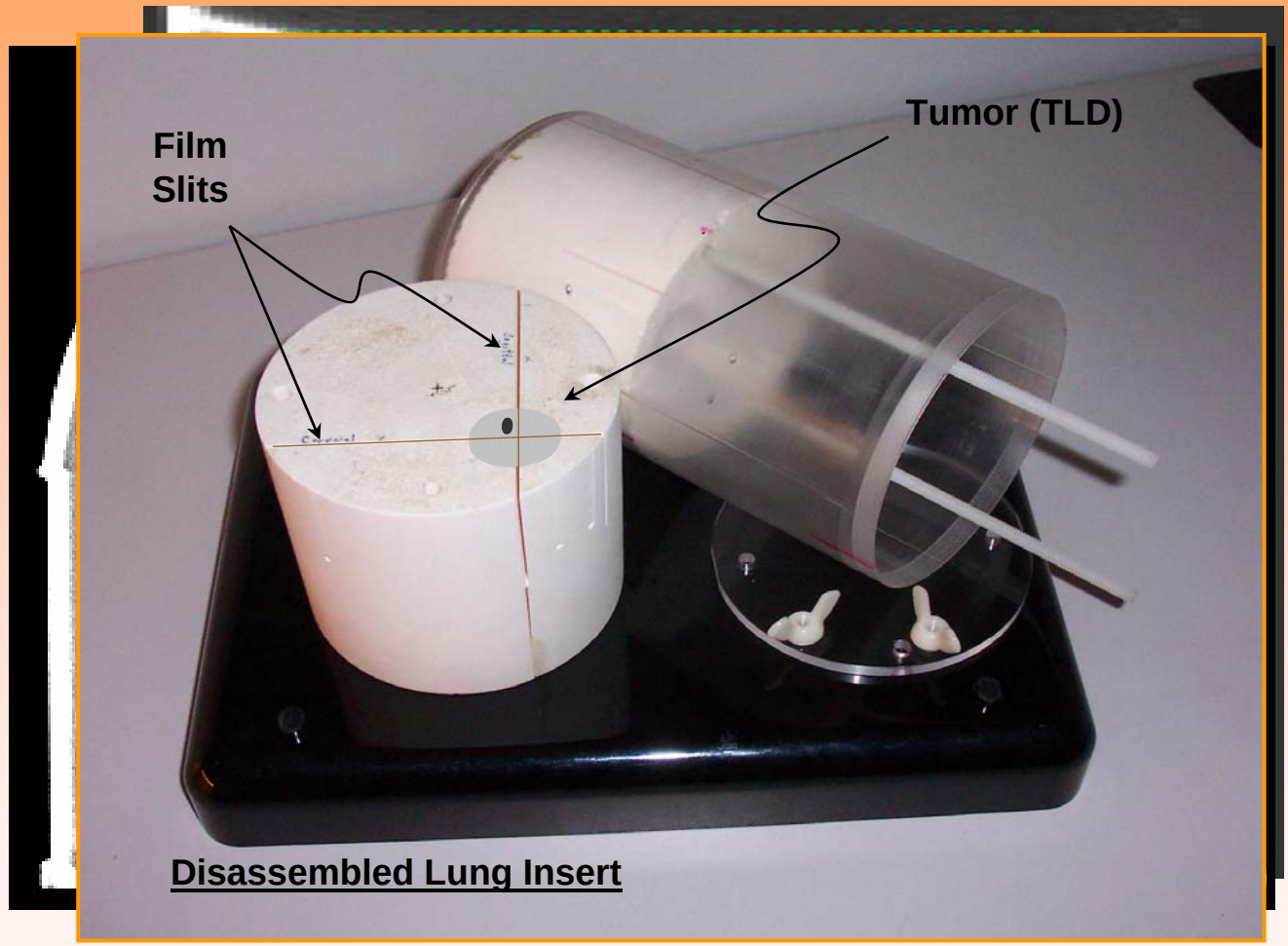
Densities

Lung = 0.33g/cm^3

Heart, cord = 1.1 g/cm^3

Cord = 1.31 g/cm3

Tumor = 1.04 g/cm^3



Dosimeters

TLD and Gafchromic film

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Prescription

- Based on RTOG 0236 (SBRT Radioablation study)

  - Energies: 4 – 10 MV
  - ≥ 7 non-opposing static fields or ≥ 340° arc rotation technique.
  - SBRT technique.
  - 20 Gy/fx to 95% of the PTV
  - Homogeneous planning and calculation of M.U.
  - Must submit heterogeneous plan based on homogeneous M.U. set

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Phantom Results

- A total of 21 irradiations were analyzed
- The 6 MV photon beam was used most often
- The TPS used to plan the cases were: Pinnacle, BrainLab, XiO, Precise, Eclipse, Ergo and RenderPlan.
- Convolution Superposition algorithm was used most often.

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Phantom Results

TPS	Dose Calc. Algorithm	# irradiations	Center of Tumor TPS D_{hetero}/D_{homo}
Precise	Scatter Int. Clarkson	2	1.19 ± 2.6%
BrainLab	Clarkson & Pencil beam	4	1.21 ± 0.1%
Eclipse	Pencil Beam	2	1.19 ± 4.6%
Ergo	3D Convol. Pencil Beam	1	1.19 ± 0.1%
RenderPlan	Change		1.20
Pinnacle	Adaptive convolve	8	1.13 ± 2.1%
XiO	Superposition/Convolution	3	1.12 ± 2.4%

Clearly, there are two groupings

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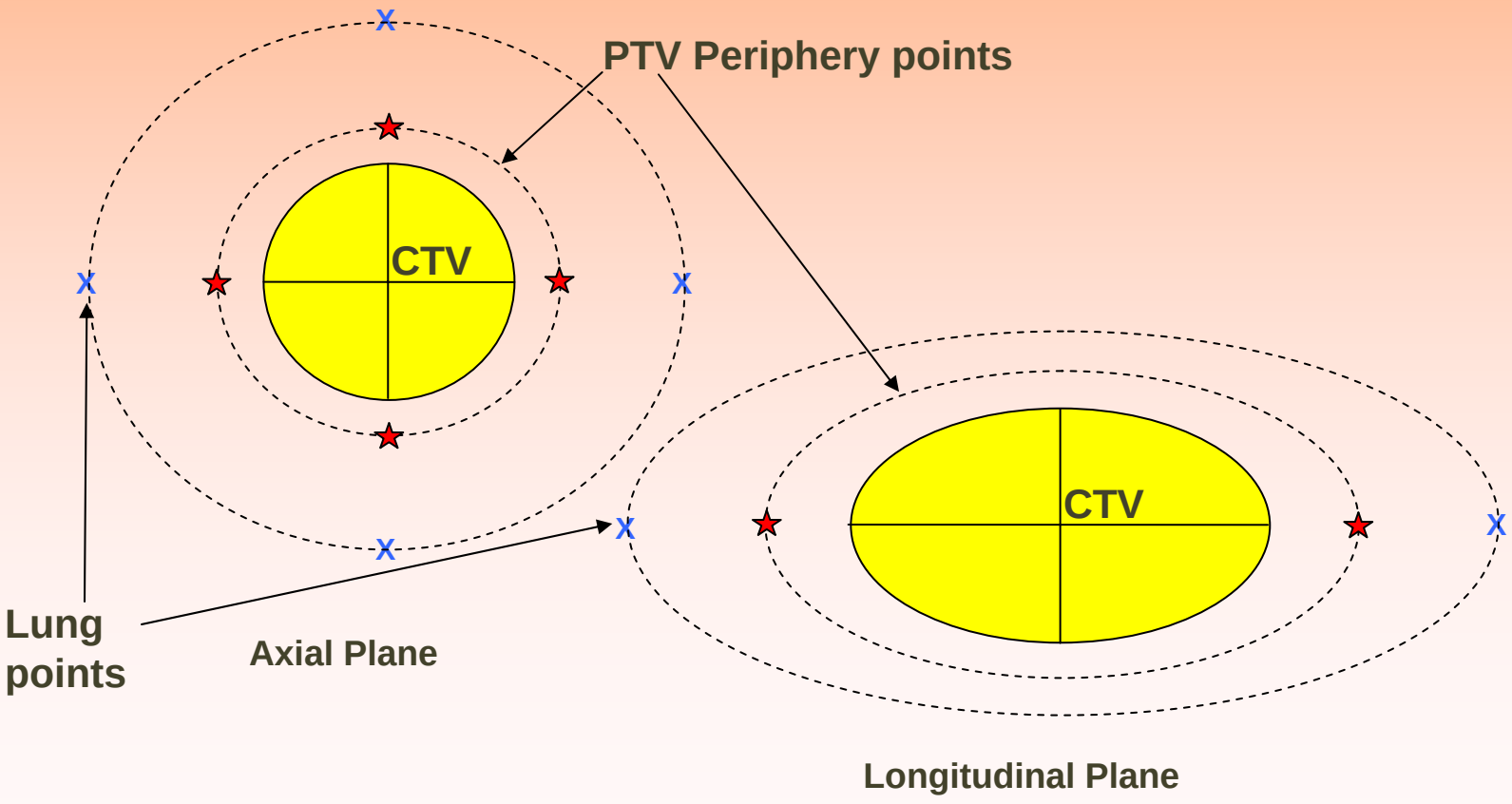
Phantom Results (cont'd)

TPS	Dose Calc. Algorithm	# irradiation	Center of Tumor Measured D_{TLD}/D_{hetero}
Precise	Scatter Int. Clarkson	2	0.99 ± 3.1%
BrainLab	Clarkson & Pencil beam	4	0.96 ± 2.7%
Eclipse	Pencil Beam	2	0.97 ± 1.6%
Ergo	3D Convol. Pencil Beam	1	0.98 ± 3.2%
RenderPlan	Change in primary attenuation	1	0.92
Pinnacle	Adaptive convolve	8	0.99 ± 2.3%
XiO	Superposition/Convolution	1	0.96

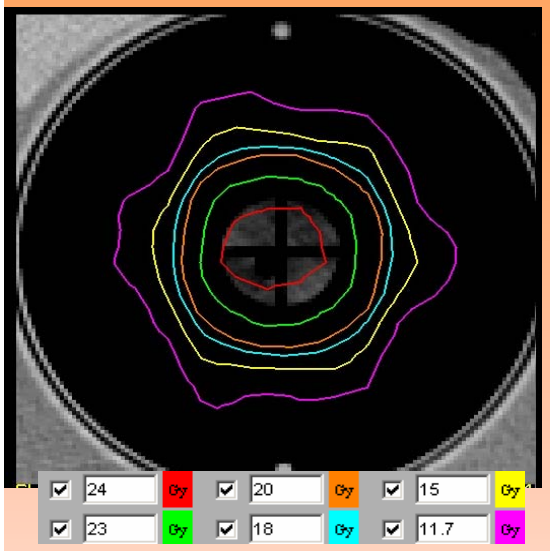
PTV Periphery and Lung Points

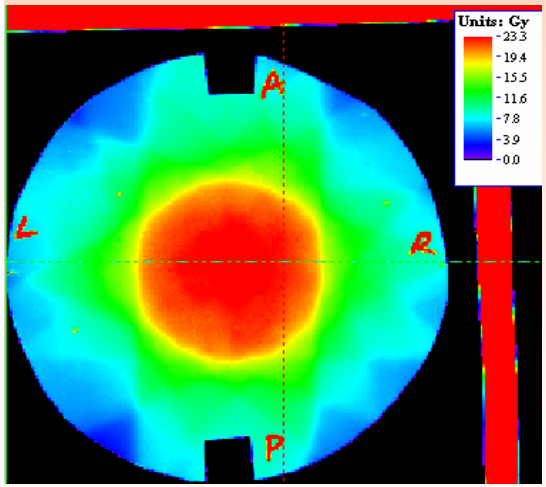
PTV = Tumor (CTV) + 0.5 cm in axial plane + 1 cm in longitudinal plane.

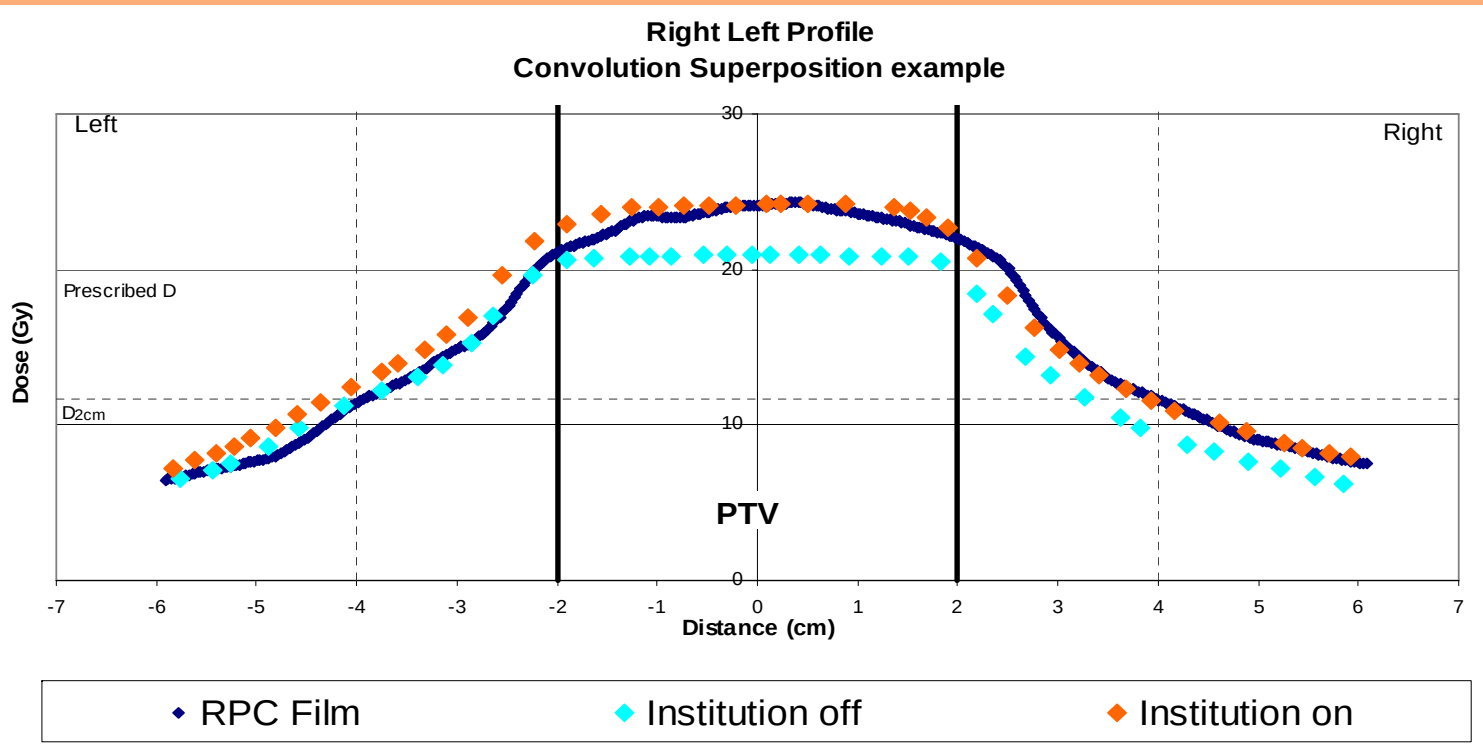
Lung constraint: points 2 cm from the PTV



Profile analysis







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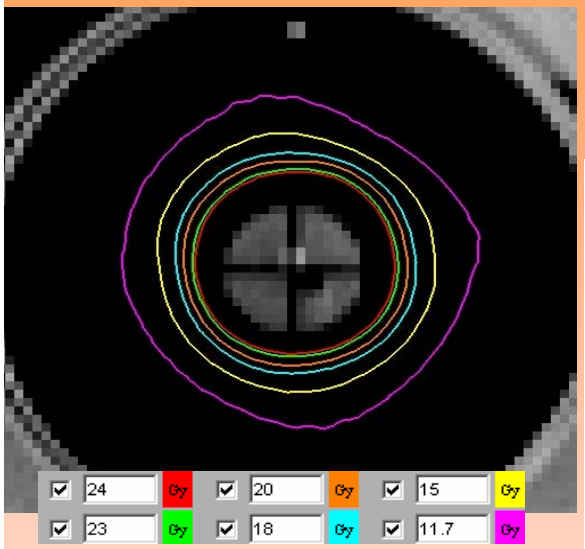
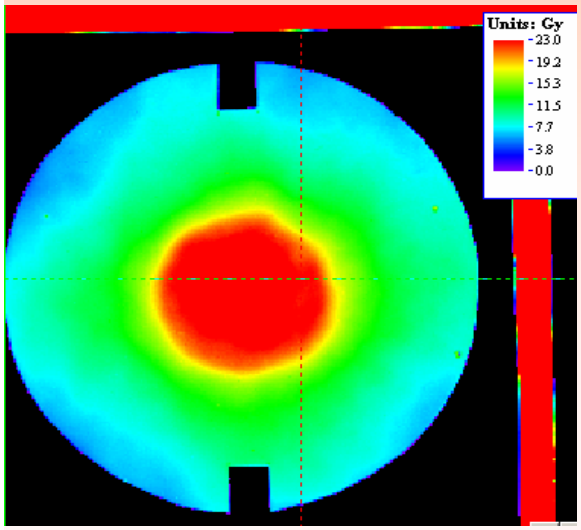
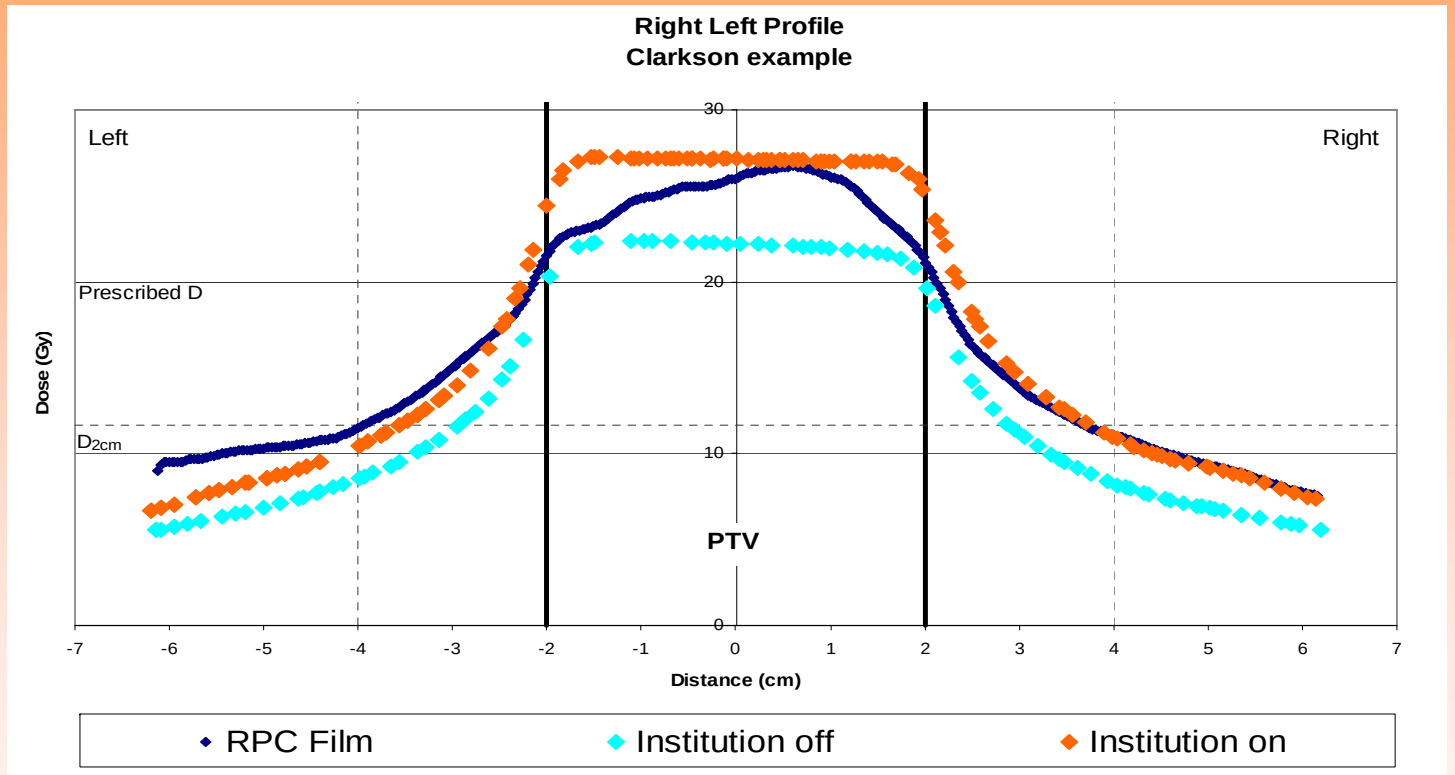
Profile analysis







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Phantom Results (PTV Periphery)

TPS	Dose Calc. Algorithm	# irradiation	TPS D_{hetero}/D_{homo}
Precise	Scatter Int. Clarkson	2	1.21 ± 2.7%
BrainLab	Clarkson & Pencil beam	1	1.26 ± 3.5%
Eclipse	Pencil Beam	2	1.18 ± 4.0%
Ergo	3D Convol. Pencil Beam	2	1.19 ± 1.8%
Pinnacle	Adaptive convolve	8	1.04 ± 6.1%
XiO	Superposition/Convol.	2	1.11 ± 6.4%

Two separate groupings again

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Phantom Results (Lung points)

TPS	Dose Calc. Algorithm	# irradiation	TPS D_{hetero}/D_{homo} Axial plane
Precise	Scatter Int. Clarkson	2	1.19 ± 4.2%
BrainLab	Clarkson & Pencil beam	1	1.23 ± 5.7%
Eclipse	Pencil Beam	2	1.18 ± 11.2%
Ergo	3D Convol. Pencil Beam	2	1.20 ± 5.3%
Pinnacle	Adaptive convolve	8	1.12 ± 6.0%
XiO	Superposition/Convol.	2	1.14 ± 6.5%

Two separate groupings again

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Phantom Results (PTV Periphery) Measurements

TPS	Dose Calc. Algorithm	# irradiation	PTV Periphery measured D_{film}/D_{hetero}
Precise	Scatter Int. Clarkson	2	0.88
BrainLab	Clarkson & Pencil beam	1	0.79
Eclipse	Pencil Beam	2	0.92
Ergo	3D Convol. Pencil Beam	2	0.84
Pinnacle	Adaptive convolve	8	0.98
XiO	Superposition/Convol.	1	0.96

Two separate groupings again

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Conclusions

- The average tumor TLD/Inst ratio is 0.97 (range 0.92 to 0.99). Good agreement for Convolution Superposition algorithms in the tumor.
- Large differences exists between the Convolution Superposition heterogeneity corrected dose calculations and other algorithms (ratios of 1.13 vs. 1.20).
- Heterogeneity corrected doses at the PTV periphery and lung points are higher than uncorrected doses.
- The Convolution Superposition algorithm calculations agree with the RPC measurements.


Thank you