A comparison of heterogeneity correction algorithms within a lung PTV

Paola Alvarez, Andrea Molineu, Nadia Hernandez, David Followill, Geoffrey Ibbott
Radiological Physics Center

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RPC Lung Phantom

-Plastic shell water fillable

-Designed based on patient anatomy

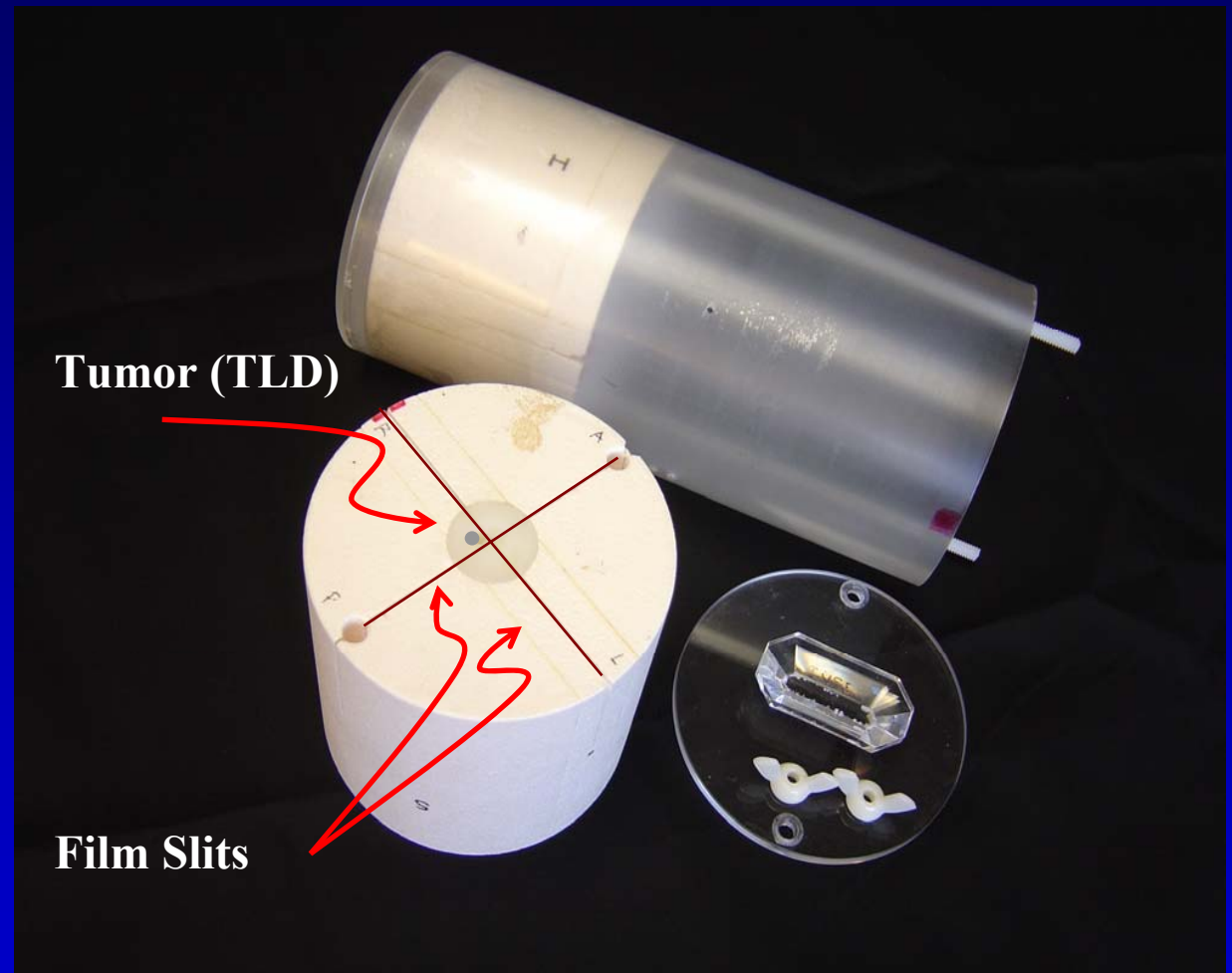-Imaging and dosimetric insert

RPC Phantom

Target dimension

Ovoid shape

3 cm diameter

5 cm long

Densities

Lung = 0.33g/cm^3

Heart= 1.1 g/cm^3

Cord = 1.31 g/cm3

Tumor = 1.04 g/cm^3

Tumor (TLD)

Film Slits

Dosimeters

TLD and Gafchromic film

Phantom Process

- **Phantom is imaged**

- **Treatment plan developed by institution**

- **Treatment is delivered to the phantom**

- **Phantom is returned to the RPC for data analysis**

- **Treatment plan is submitted electronically to the ITC**

- **The phantom is to be treated as if it were a patient**

Prescription

- **Energies: 4 – 10 MV**

- **SBRT technique: ≥ 7 non-opposing static fields**

  ≥ 340° arc rotation technique

- **Prescribed dose must cover 95% of the PTV**

- **Prescription isodose line between 60% to 90%.**

- **Ignore lung heterogeneity for calculation of M.U.**

- **Submit hetero. plan based on homo. M.U. set**

Phantom Results

- **A total of 33 irradiations were processed**

- **The 6 MV photon beam was used most often**

- **The TPSs used to plan the cases were: Pinnacle, BrainLab, XiO, Precise, Eclipse Ergo and Hi-ART.**

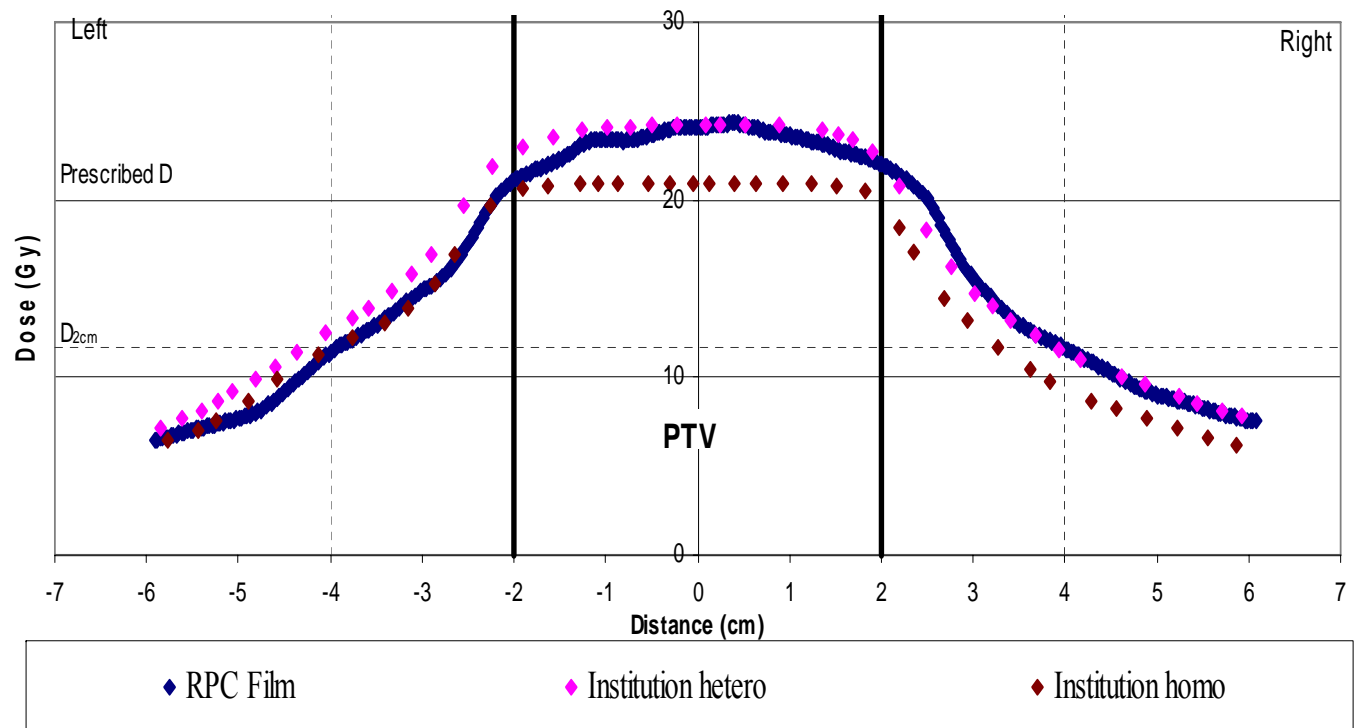- **Superposition/Convolution algorithm was used most often.**

Phantom Results

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	5	0.96 ± 2.4%
Eclipse	Pencil Beam	5	0.96 ± 1.8%
Ergo	3D Convol. Pencil Beam	2	0.98 ± 3.2%
Hi-ART	Superposition/Convolution	1	0.97
Pinnacle	Adaptive convolve	10	0.99 ± 2.1%
Eclipse	AAA	2	0.98 ± 3.8%
XiO	Superposition/Convolution	6	0.96 ± 1.8%
			0.97 ±2.8%

Profile analysis
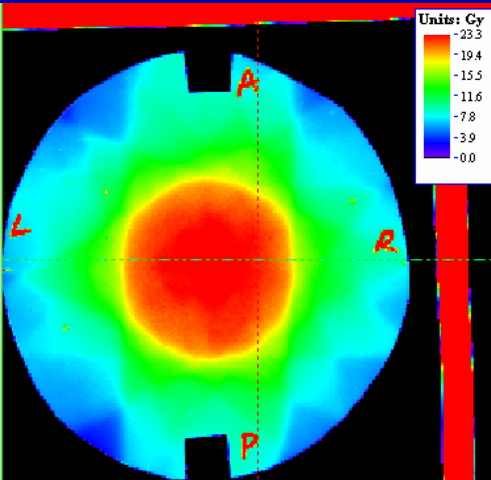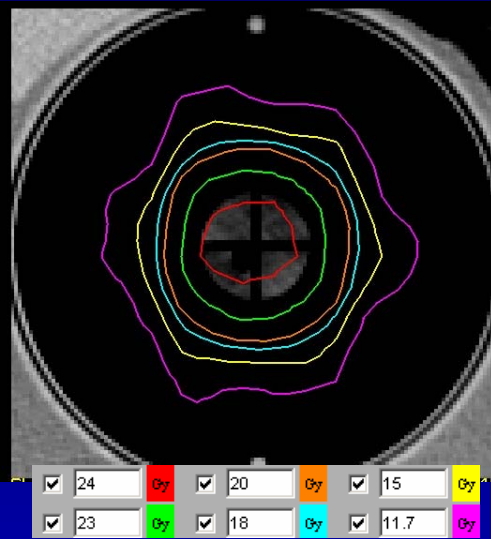
Right Left Profile
Convolution Superposition example

Profile analysis

Phantom analysis

Criteria on heterogeneous case
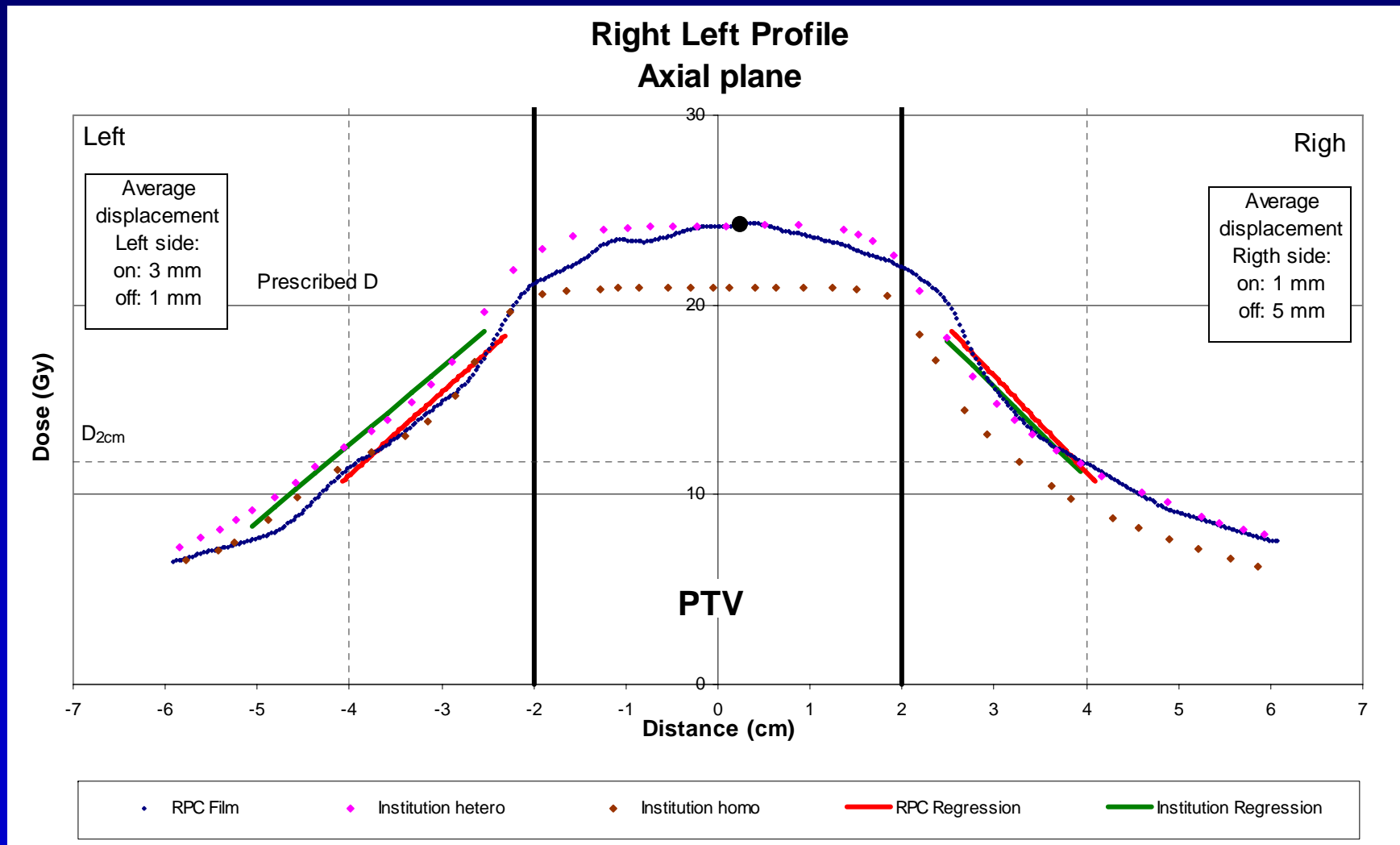
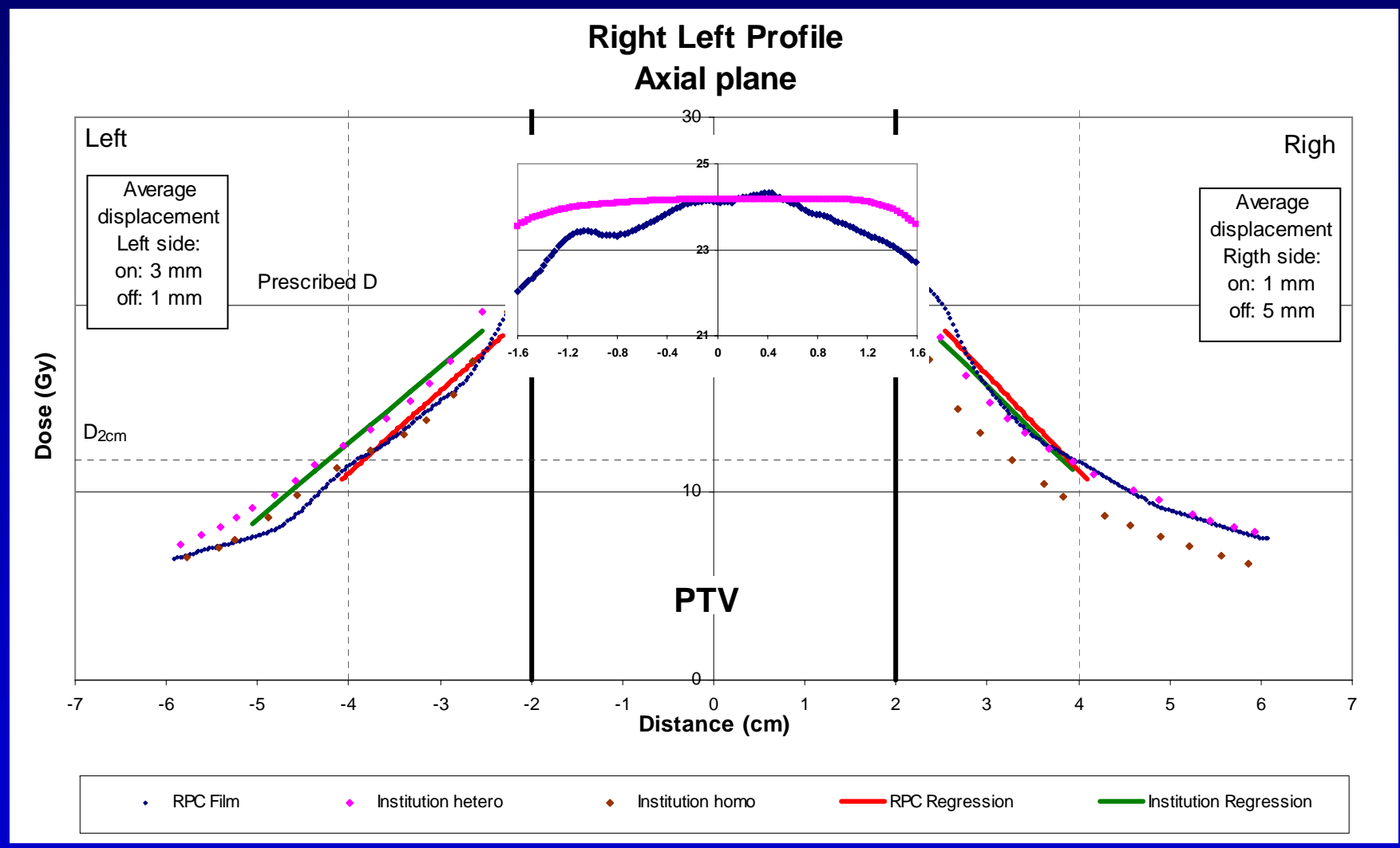DTLD/DInst : 0.97 +/- 5%

DTA $\leq$ 5mm at all side of PTV

23 irradiations passed the test.

An analysis of the dose distribution was done over the central 80% of the PTV for these 23 irradiations.

Superposition/Convolution R-L Profile

Right Left Profile
Axial plane

Superposition/Convolution R-L Profile

Right Left Profile
Axial plane

Left

Righ

Average displacement Left side:
on: 3 mm
off: 1 mm

Prescribed D

Average displacement Rigth side:
on: 1 mm
off: 5 mm

D_{2cm}

Dose (Gy)

PTV

Distance (cm)

RPC Film • Institution hetero • Institution homo —— RPC Regression —— Institution Regression
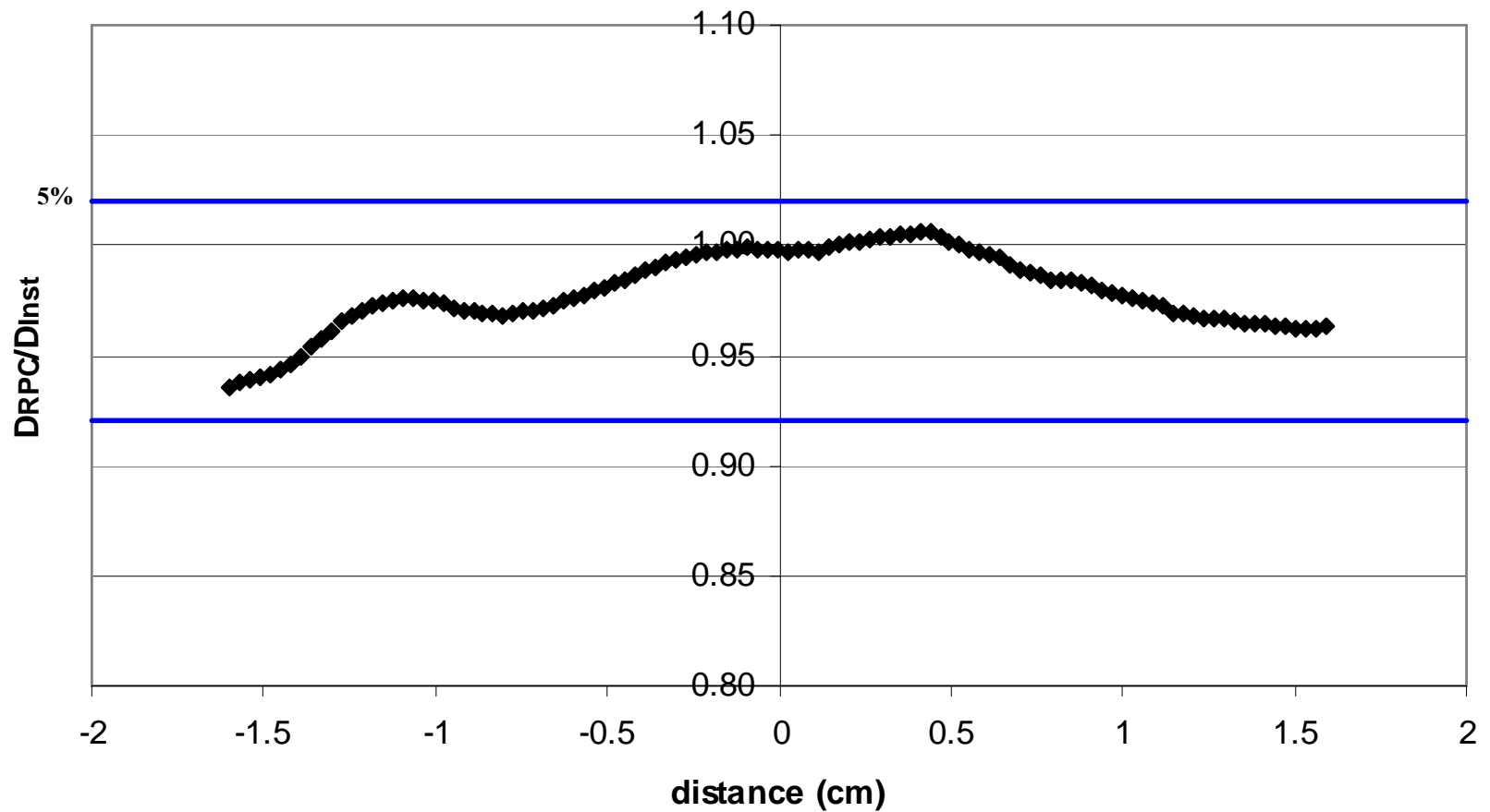
Superposition/Convolution D_{RPC}/D_{Inst}

DRPC / DInst over 80% of PTV on Rt Lt profile

Pencil-Beam profile

Right Left Profile
Axial plane

Left

Right

Average displacement Left side:
on: -2 mm
off: -4 mm

Average displacement Right side:
on: -4 mm
off: 0 mm

Prescribed D

D2cm

PTV

Dose (Gy)

Distance (cm)

· RPC Film · Institution homo · Institution hetero — RPC Regression — Institution Regression

Pencil-Beam profile
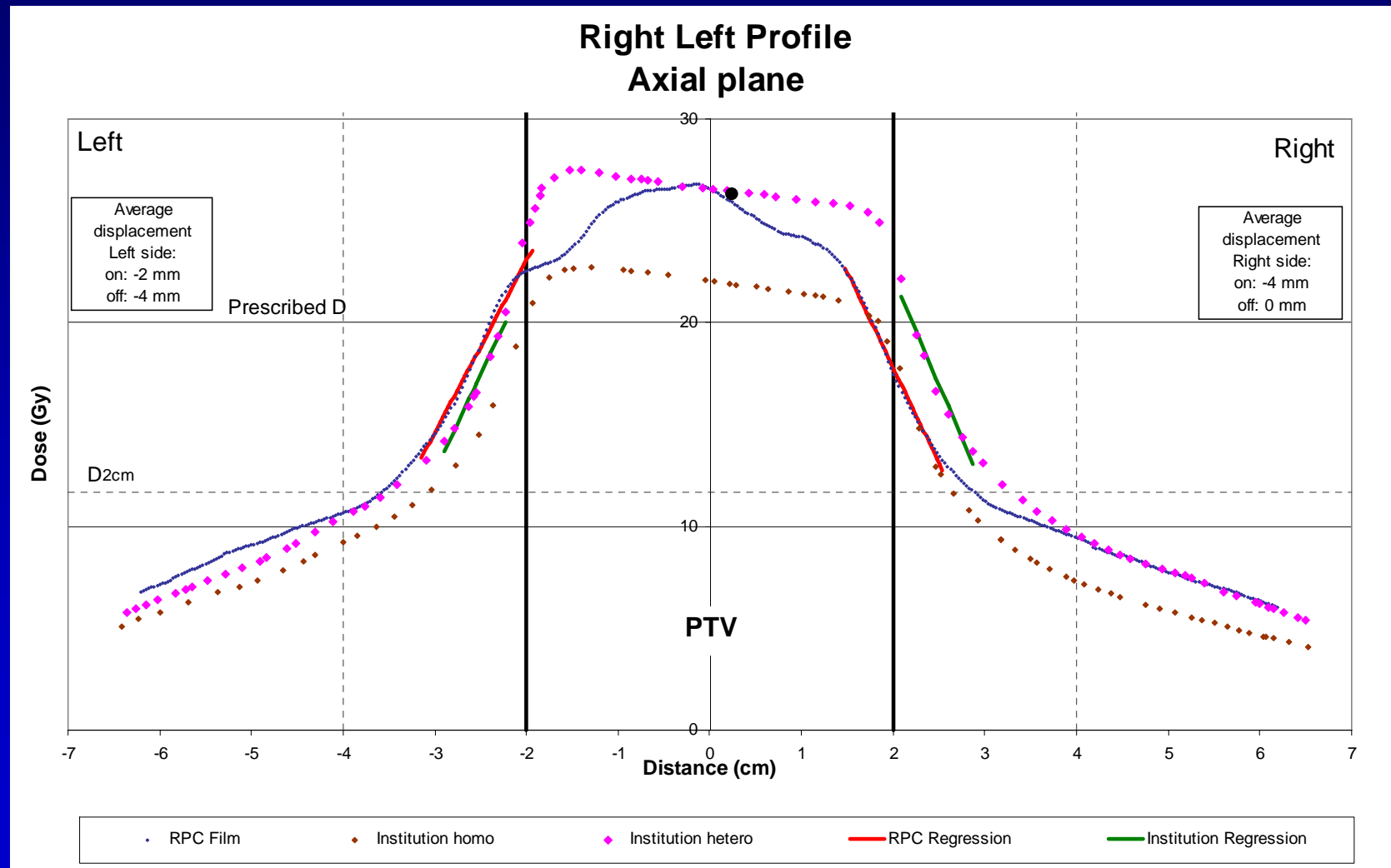
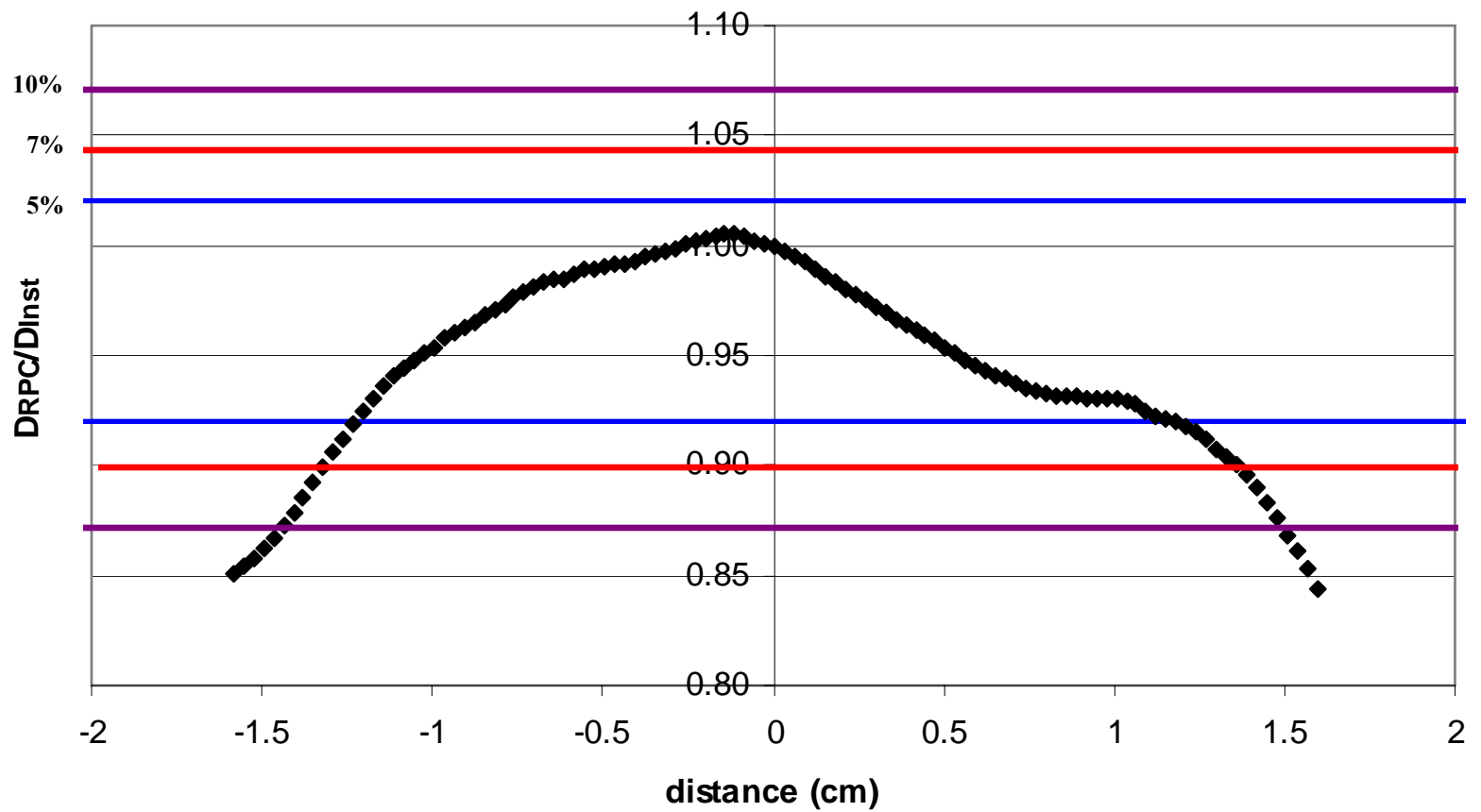**Right Left Profile**
Axial plane
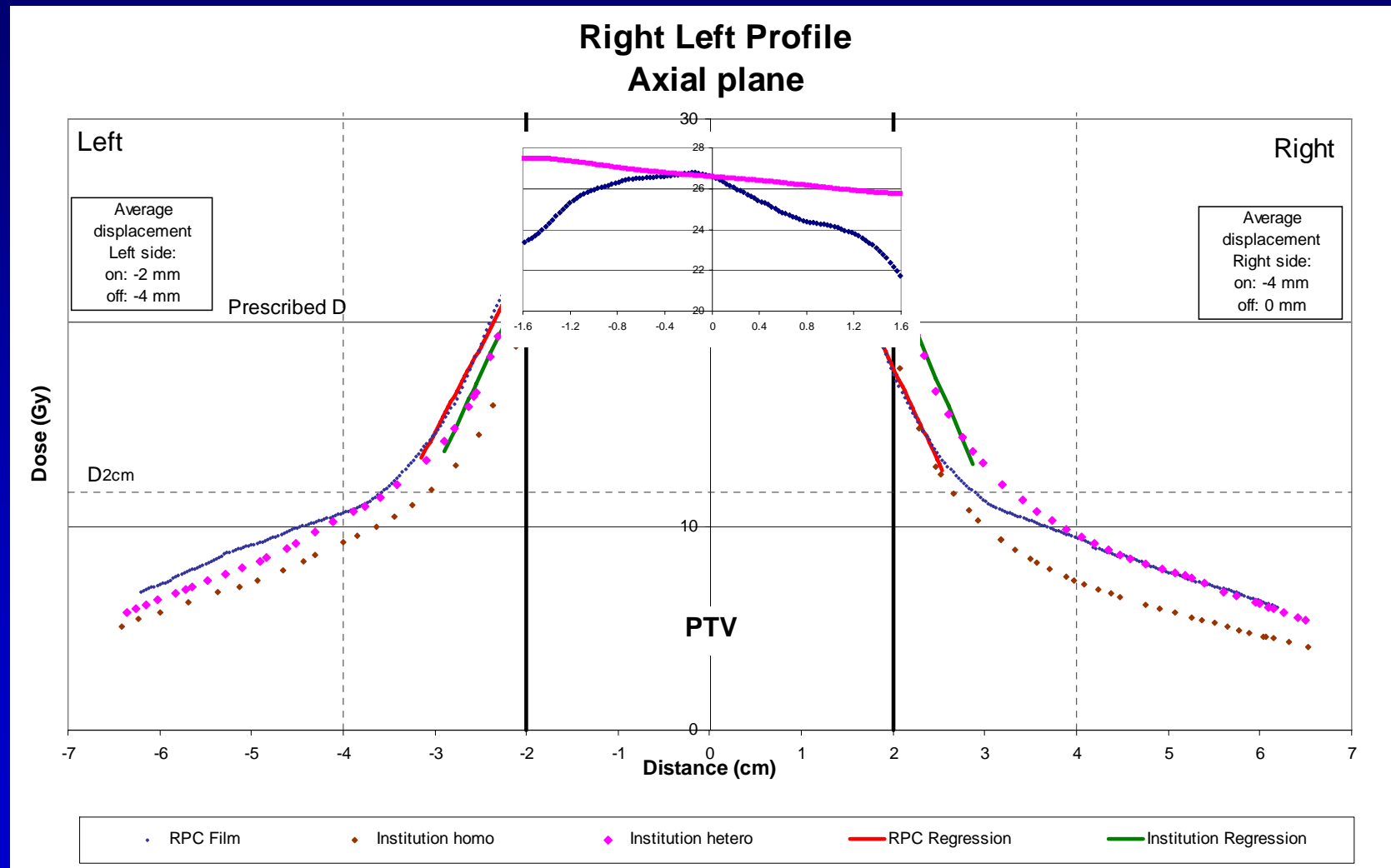
Pencil Beam D_{RPC}/D_{Inst}

D_{RPC}/D_{Inst} over 80% of PTV on Rt Lt profile

Summary of Systems Passing Existing Criteria

System/Algorithm	Percent of Points Within:		
	5%	7%	10%
Pencil Beam-Clarkson (n=9)	69 ±27%	83 ±14%	92 ±8%
SuperpositionConvolution/ AAA (n=14)	87 ±20%	95 ±13%	99 ±5%

Conclusions

- The average target TLD/Inst ratio is 0.97 (range 0.96 to 0.99).

- The calculation from Superposition Convolution and AAA algorithms agree well with the measurements.

- New evaluation methods needed to assess each algorithm's accuracy.

Thank you