Introduction
The accuracies of heterogeneity dose calculation algorithms from two commercially available IMRT treatment planning systems (TPS) were assessed using anthropomorphic thorax phantoms. The TPS used for this study were:
1) Pinnacle, ADAC
2) Corvus, Nomos

Pinnacle’s dose calculation algorithm is based upon superposition-convolution while Corvus employs the pencil-beam algorithm with an effective pathlength (EPL) correction. The AAPM Task Group No. 65 report on tissue inhomogeneity corrections for megavoltage photon beams suggests that superposition-convolution or Monte Carlo based dose calculations may better determine the dose in the presence of heterogeneities.

Clinically relevant IMRT treatment plans were created and delivered to an anthropomorphic thorax phantom that simulated realistic patient anatomical and geometrical conditions (Fig. 1). The phantom is part of the Radiological Physics Center’s (RPC) family of phantoms that are used in credentialing clinical trials sponsored by the Radiation Therapy Oncology Group (RTOG). In order to isolate the optimization algorithms from each TPS dose calculation, direct dose comparisons were made. This was accomplished by importing the Corvus MLC files into Pinnacle, then allowing Pinnacle to recalculate the dose distribution. Film and TLD measurements were made for comparisons to each of the TPS dose calculations.

Material & Methods
Anthropomorphic phantom
• Constructed from poly(vinyl) chloride (PVC) to form outer shell and designed to provide a water tight seal.
• Internally, materials and shapes represent the lung (p = 0.21 g/cm³), heart, spinal cord and tumor target.
• Target was located within the lung, anteriorly toward the mediastinum.
• Remaining space filled with water to simulate the surrounding tissue.

Dosimetry
• TLD: Capsules located in the target center, heart and spine.
• Film: MD-55 2 radiochromic film positioned in three anatomical planes (axial, coronal, sagittal) through the center of the target and located via registration pin marks.
• Ion chamber: IMRT QA hybrid plans created for delivery to a QA water phantom.  Single point dose was read in a low gradient region of the PTV.  TPS dose distributions within the anthropomorphic thorax phantom were then corrected using this ion chamber measurement.

Evaluation Criteria
95% of normalization point (target TLD) or 3mm distance-to-agreement (it is the expectation of TG-53 for TPS to meet criteria that lie within ±5% of 7mm.)

Results

<table>
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<th>Algorithm</th>
<th>Treatment Planning System</th>
<th>Film Measurements</th>
<th>TLD Measurements</th>
<th>TLD Corrected Measurements</th>
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<tr>
<td>Pinnacle 7.4E-76c</td>
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<tr>
<td>Corvus 5.0</td>
<td>Calculation: pencil-beam algorithm w/ EPL correction</td>
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Conclusions
• The superposition convolution algorithms used in the Pinnacle IMRT TPS calculated correct doses to the target and surrounding lung tissue heterogeneities using either the Pinnacle or Corvus MLC files.
• The pencil-beam algorithm with effective pathlength correction employed by Corvus was not able to sufficiently predict target and lung doses.  Corvus overestimated the dose in the GTV by nearly 5% and did not account for the extent of lateral spread from secondary particles.  This conclusion is consistent with the observations reported in TG-65. ²
• The superposition convolution algorithm, whether used for forward planned 3D conformal radiotherapy (3D CRT) (Fisher) ³ or inverse planned IMRT, calculates the dose correctly within lung heterogeneity.
• The introduction of intensity maps comprising of many small beamlets for IMRT treatment did not increase any dose calculation errors over those found with 3D CRT (Fisher) ³ for the Pinnacle TPS.

References