



BrachyView: Tomographic Reconstruction Using TimePix in Post-Implant Dosimetry Checks for Prostate Brachytherapy

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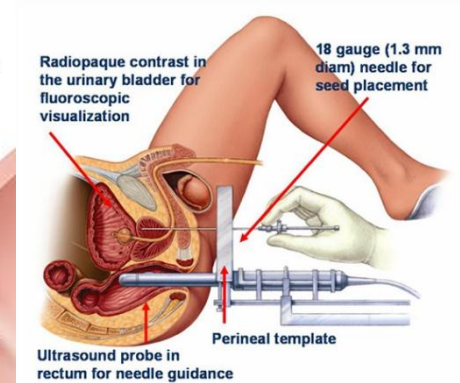
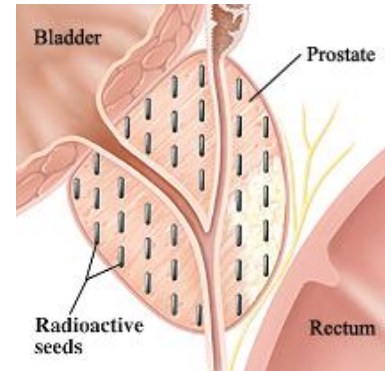
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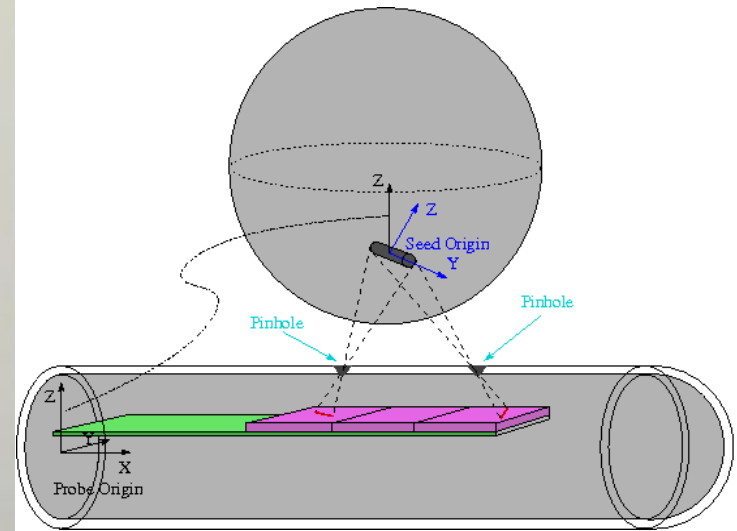
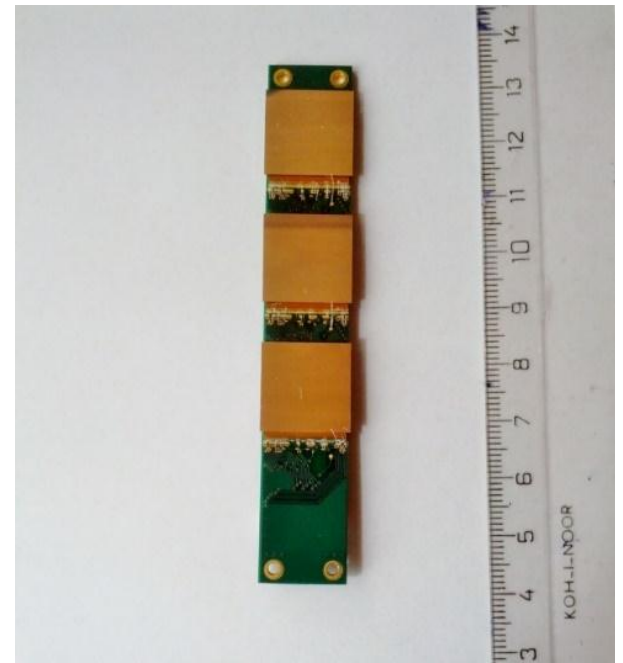
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Introduction – Prostate Cancer

- ▶ Treatment options
 - Radical prostatectomy
 - Radiation therapy
- ▶ LDR: I-125 sources
- ▶ Key steps:
 1. Pre-planning (ultrasound volumetric imaging)
 2. Implantation (ultrasound-guided)
 3. Post-implant dosimetry and QA (CT)
- ▶ Paradigm shift towards **intraoperative dynamic dose planning (IDDP)**

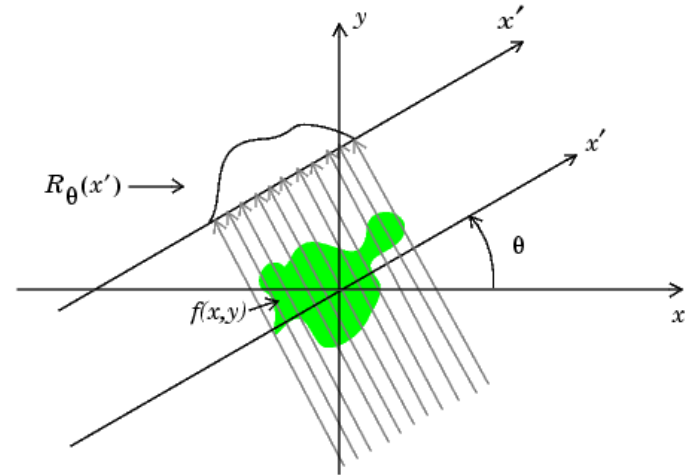


Zelefksy et al, 'Real-time Intraoperative Computed Tomography Assessment of Quality of Permanent Interstitial Seed Implantation for Prostate Cancer', 2010

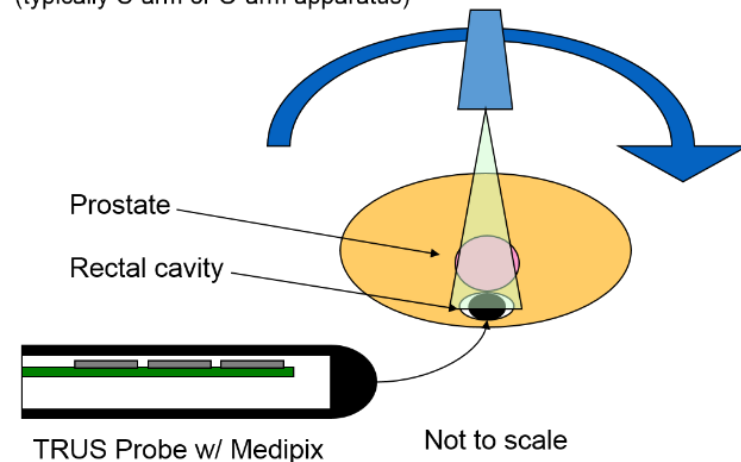


Methodology

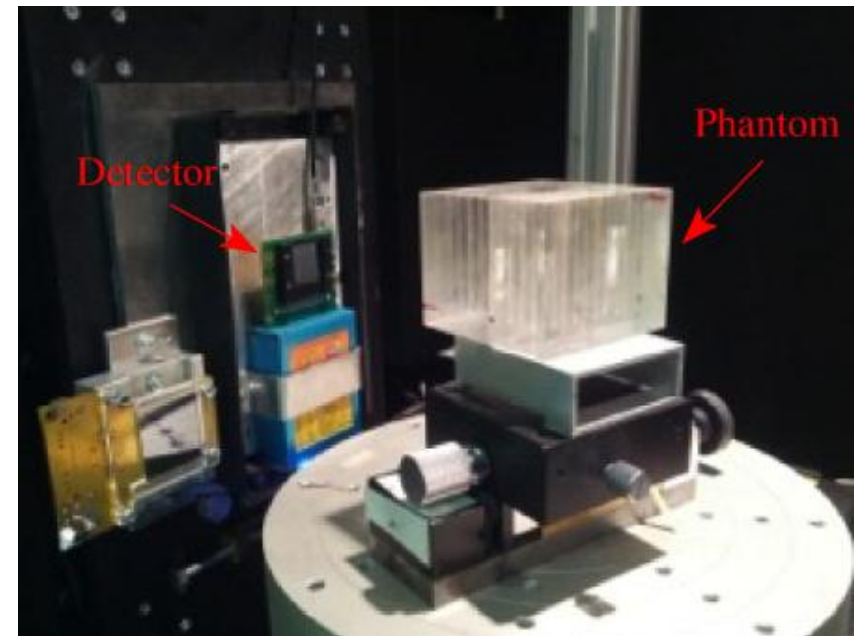
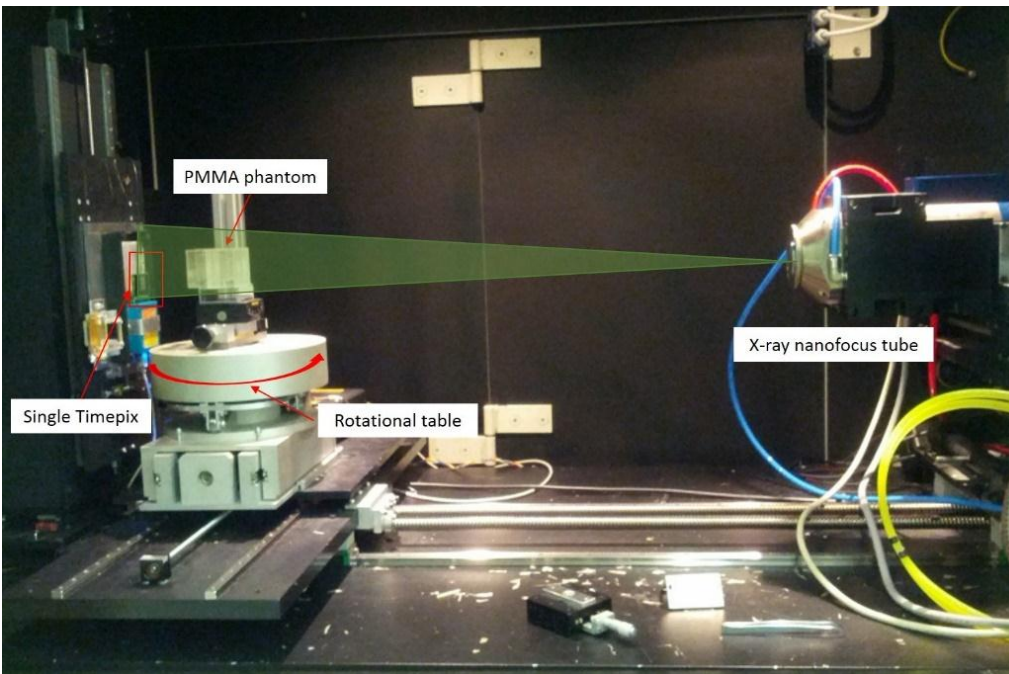
- ▶ Perform tomographic reconstruction on dummy I-125 seeds implanted into PMMA phantom designed to mimic brachytherapy implant template
- ▶ External X-ray source to obtain projection images
- ▶ Particular emphasis on partial FOV problem and later, on partial angle problem
- ▶ Use iterative approach:
 - Ordered Subset Expectation Maximisation (OSEM)
 - Known to be able to handle noisy and incomplete data well



External x-ray source
(typically C-arm or O-arm apparatus)



Methodology



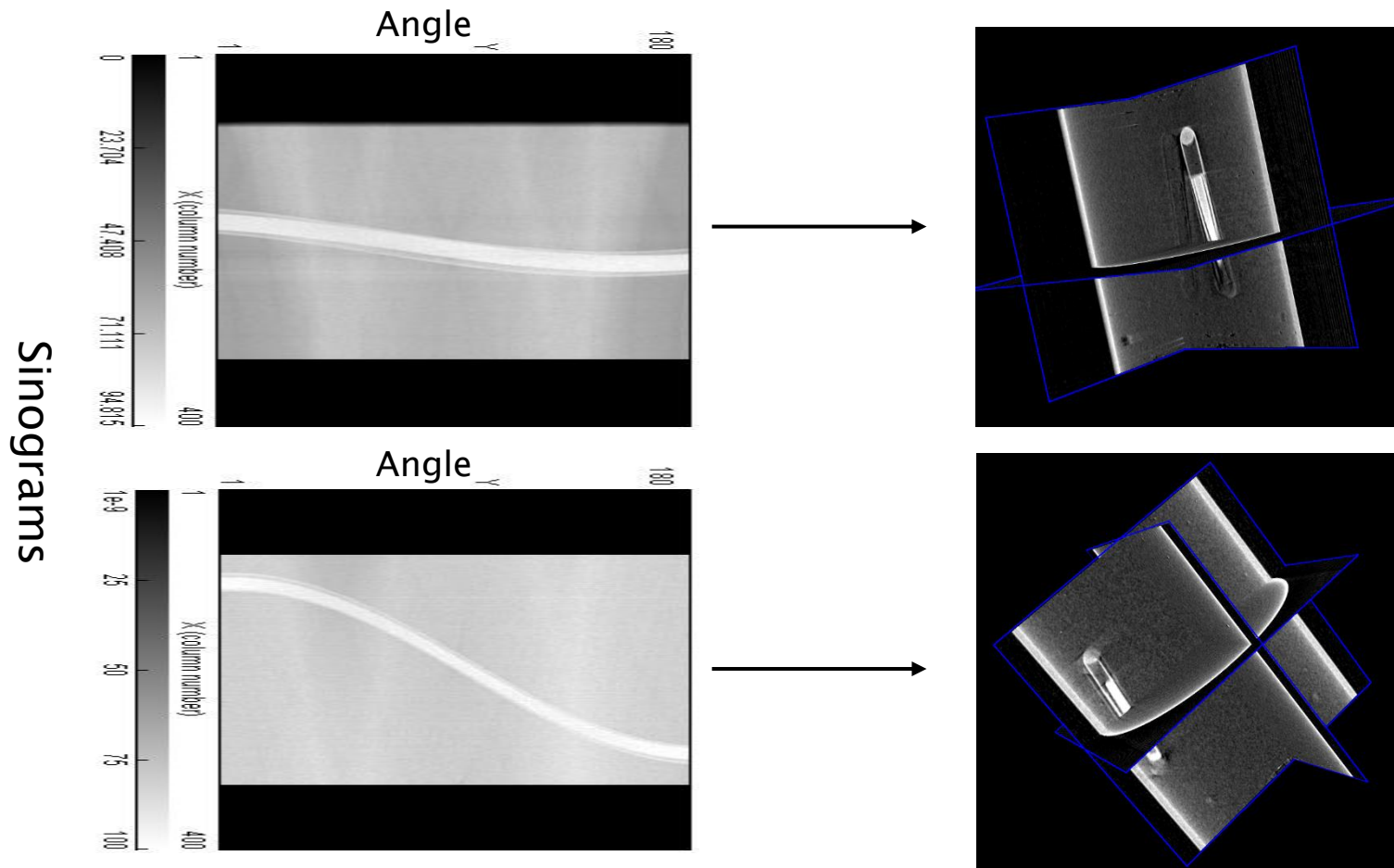
Methodology

- ▶ Phantom measurements: single dummy seed, then extended to multiple seed imaging
- ▶ Test within FOV and gradually shift outside
- ▶ Ideal tomographic reconstructions require complete 180° dataset of projections



Results

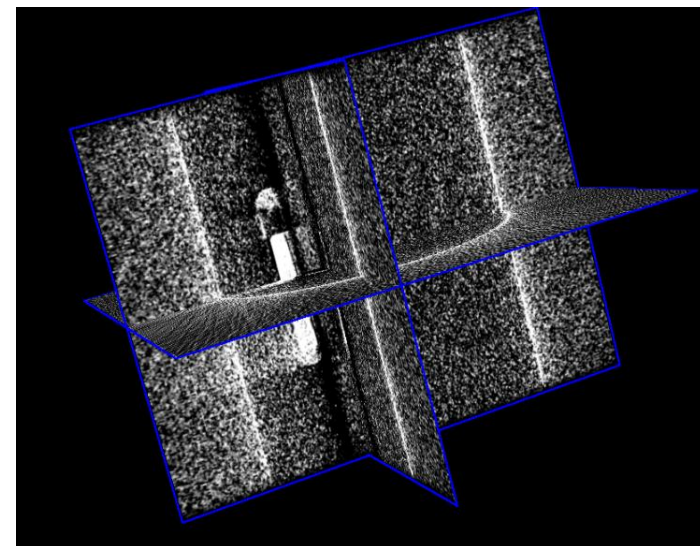
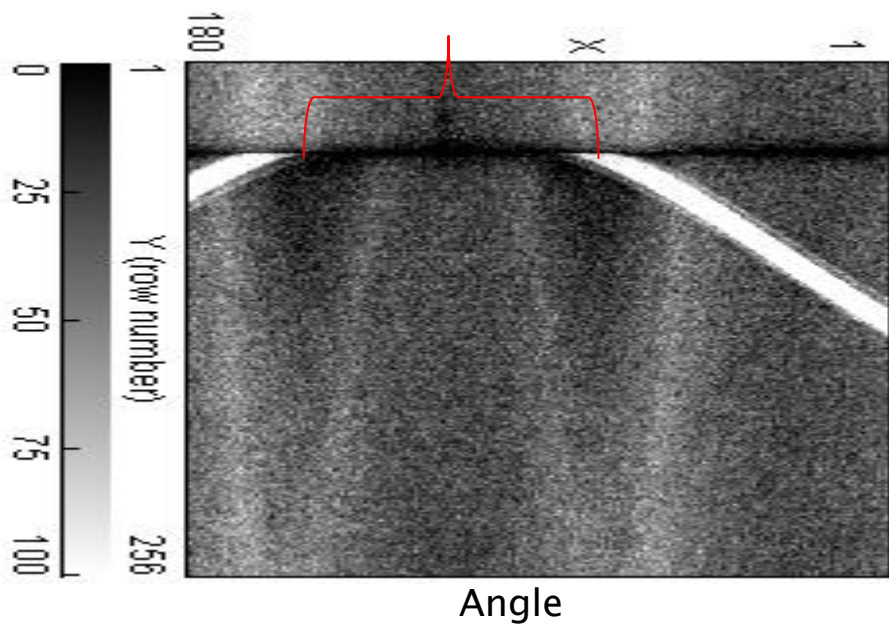
- ▶ Single seed: on central axis and off-axis measurements
- ▶ Can also be artificially combined



Results

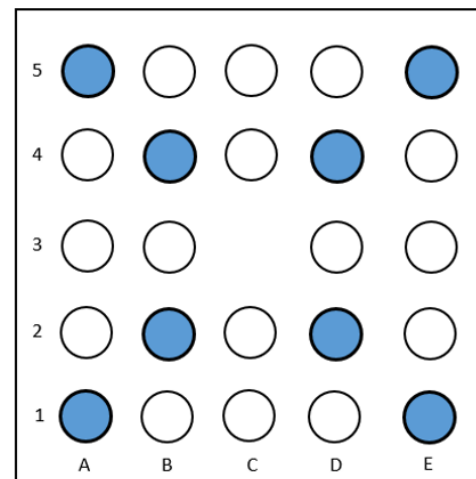
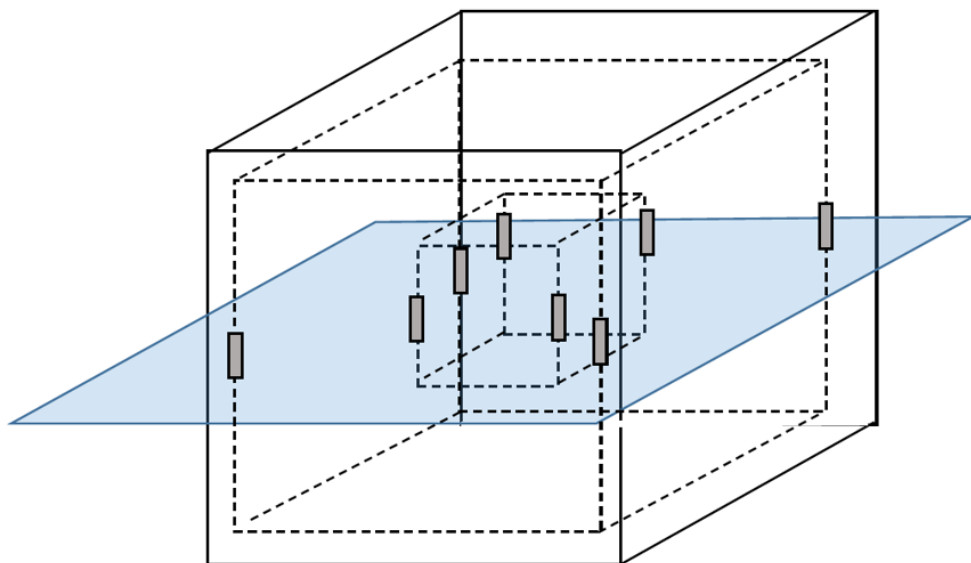
- ▶ Shift single seed outside FOV to evaluate capability of tomographic reconstruction

Missing projections



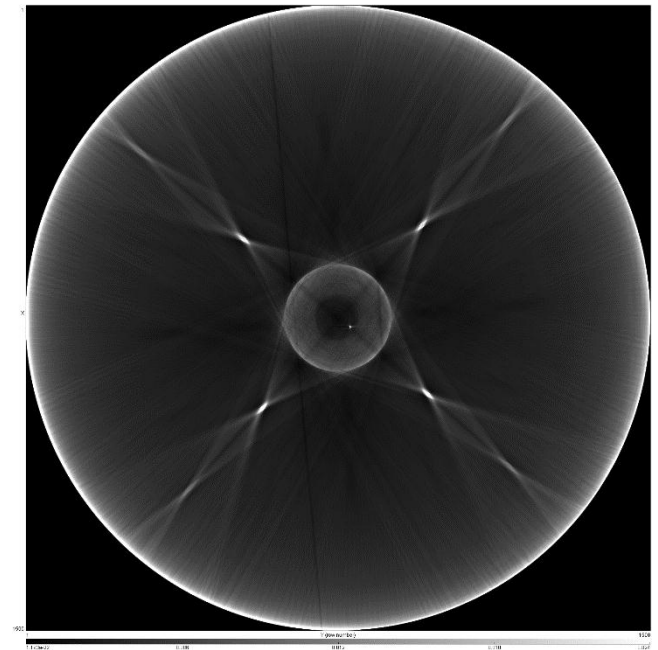
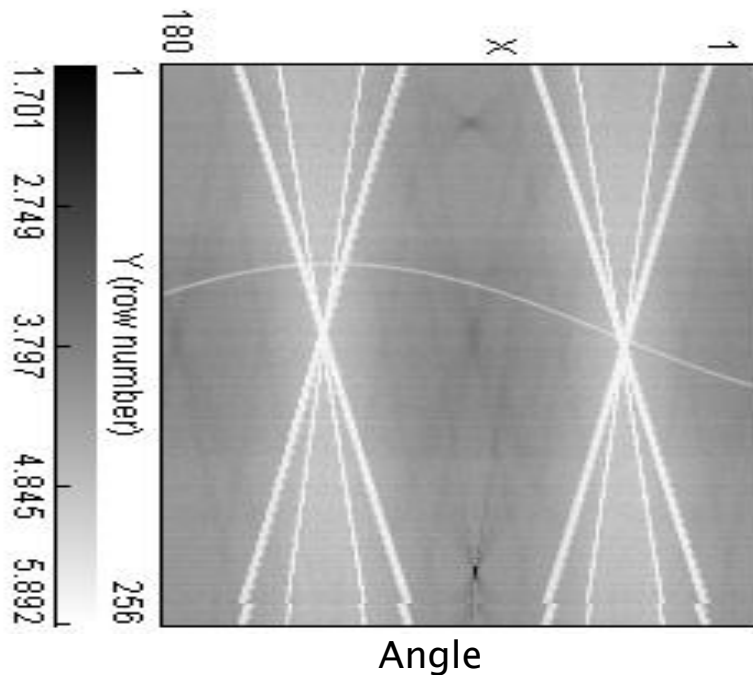
Results – Multiple Seeds

- ▶ Insert 8 seeds into phantom so as to cover ‘all possible cases’
 1. Inner cases near urethra
 2. Outer cases near prostate boundary



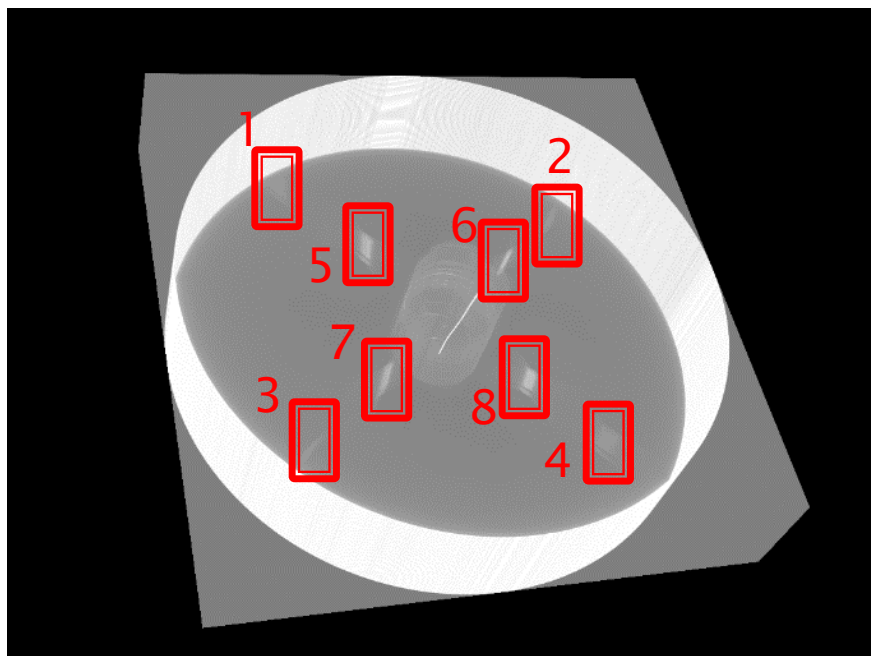
Results – Multiple Seeds

- ▶ Since these phantom measurements were not designed to keep seeds constrained within FOV of the single detector, partial sinograms move in and out rapidly

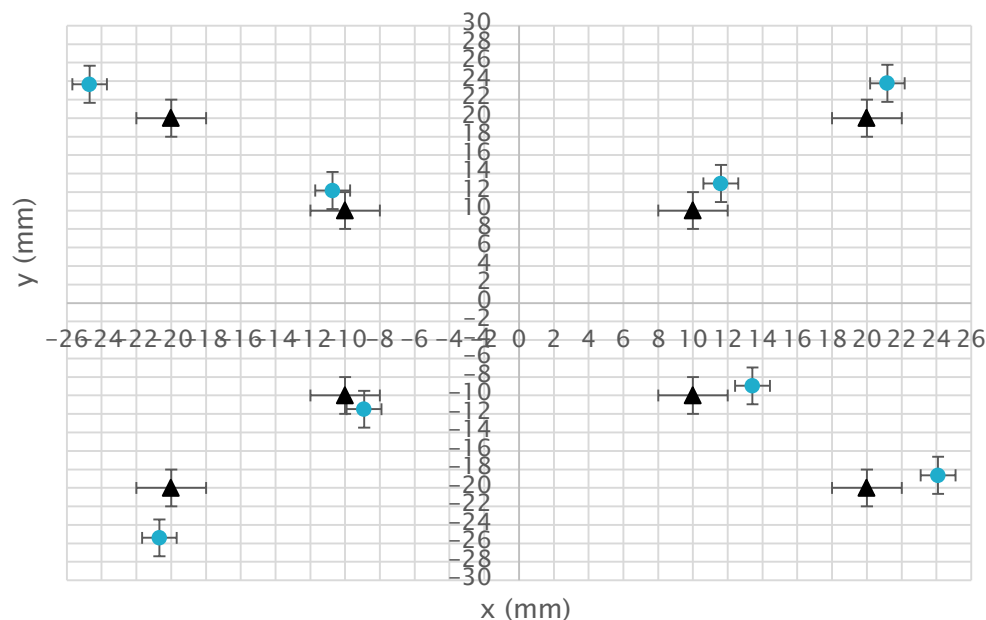


Results – Multiple Seeds

- Quantitatively evaluate by comparing with expected values in phantom positions A1, A5, B2, B4, D2, D4, E1, E5



Reconstructed Seed Positions – Tomography Slice

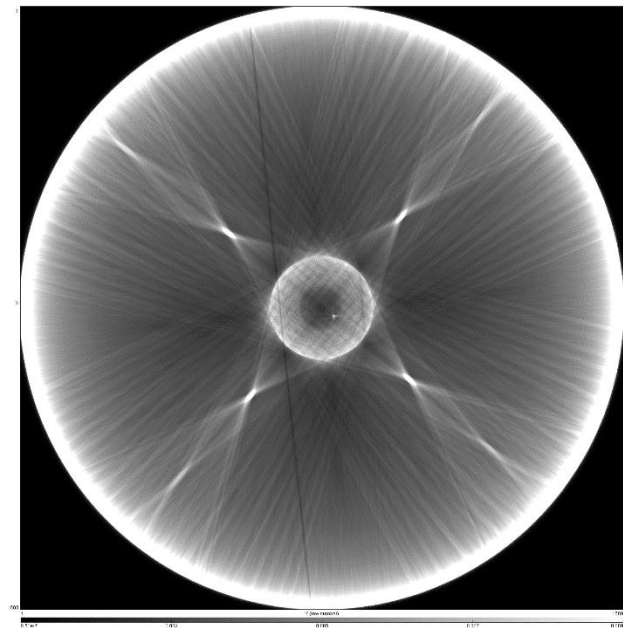
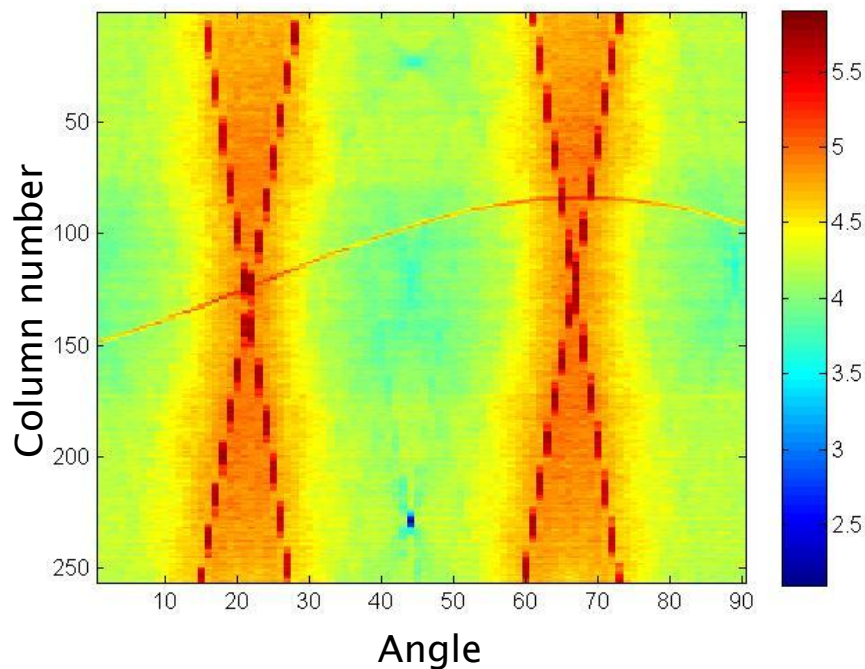


● OSEM Reconstructed Positions ▲ Expected Positions

Results – Partial angle reconstructions

- Evaluate the capability of the OSEM algorithm to reconstruct for sinograms of degrading quality

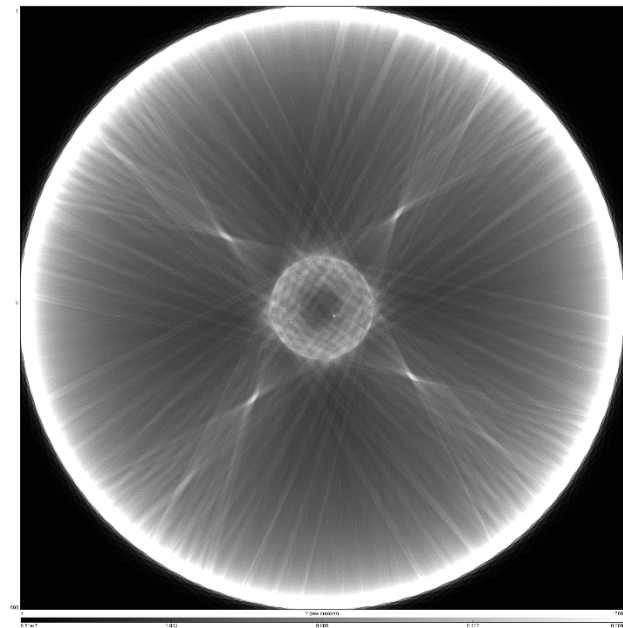
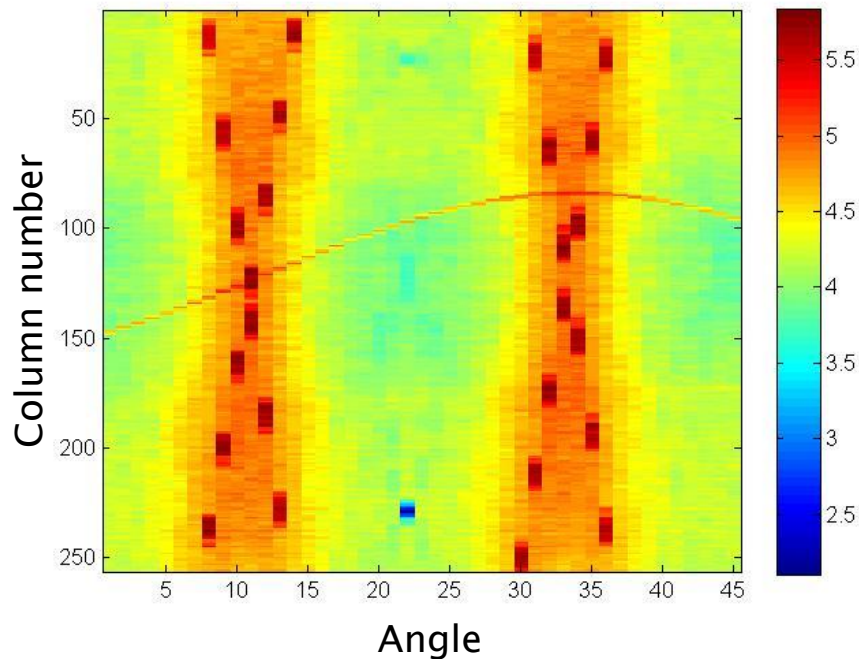
Angle iteration=2



Results – Partial angle reconstructions

- Evaluate the capability of the OSEM algorithm to reconstruct for sinograms of degrading quality

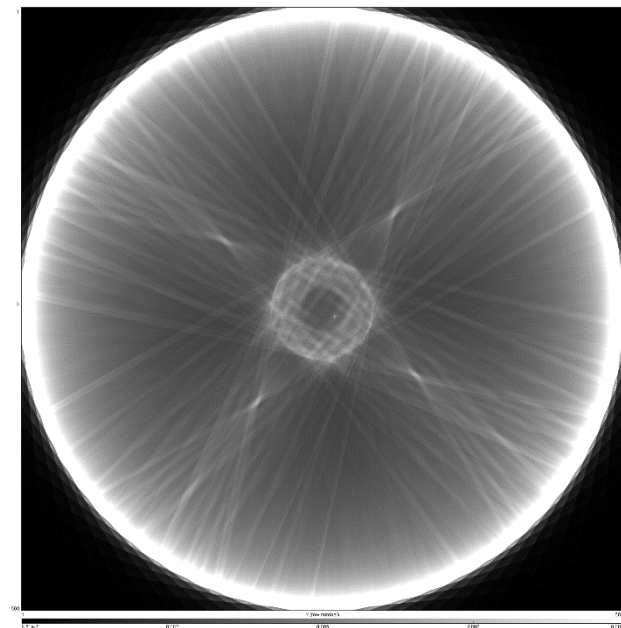
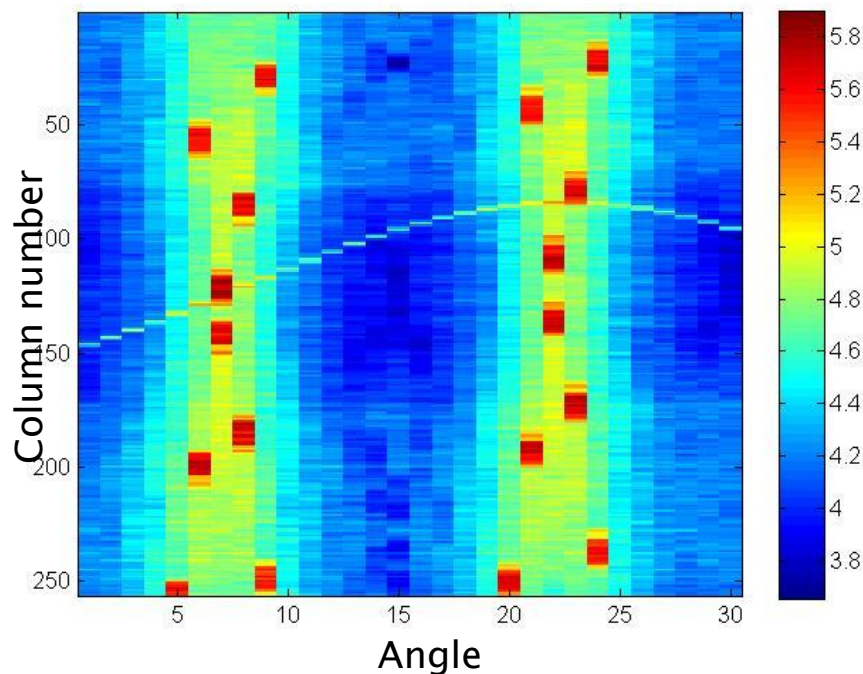
Angle iteration=4



Results – Partial angle reconstructions

- Evaluate the capability of the OSEM algorithm to reconstruct for sinograms of degrading quality

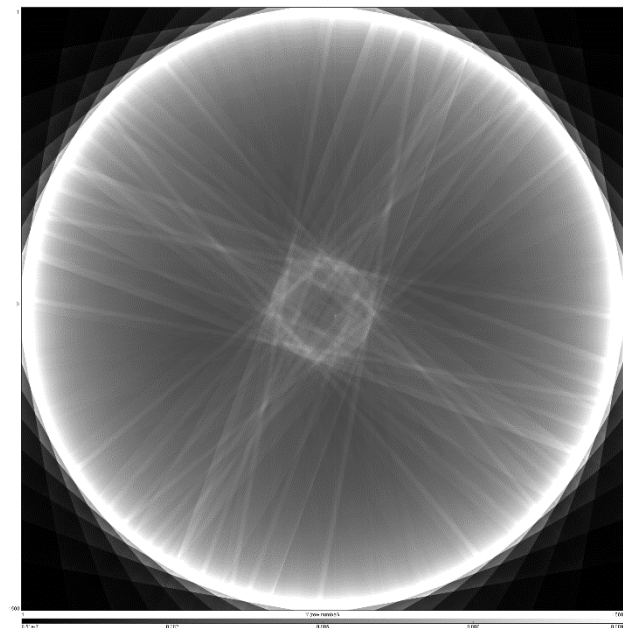
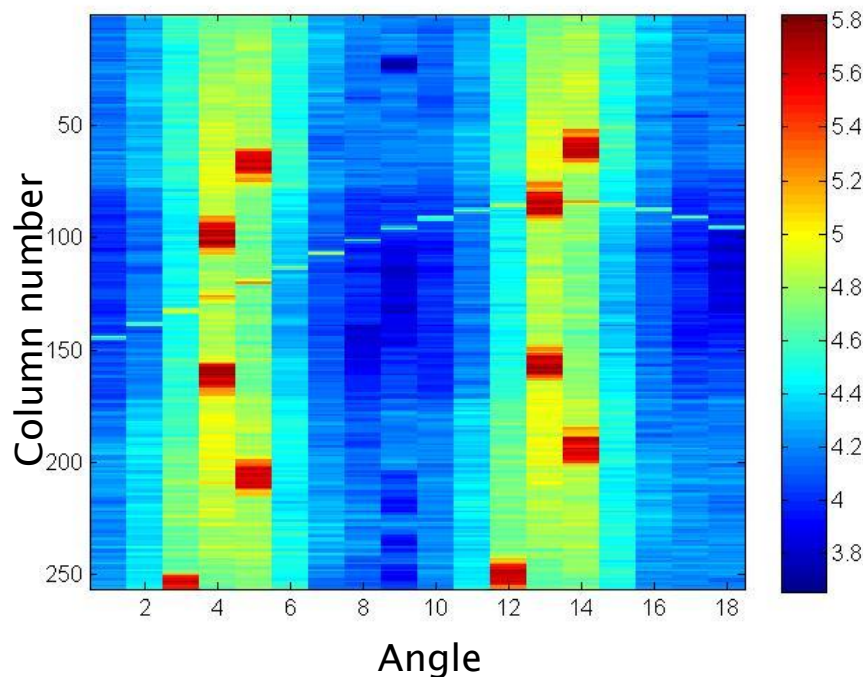
Angle iteration=6



Results – Partial angle reconstructions

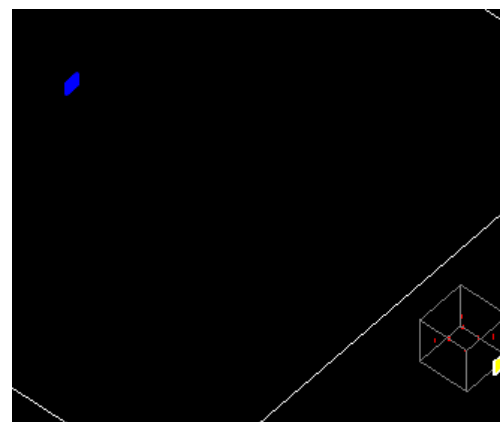
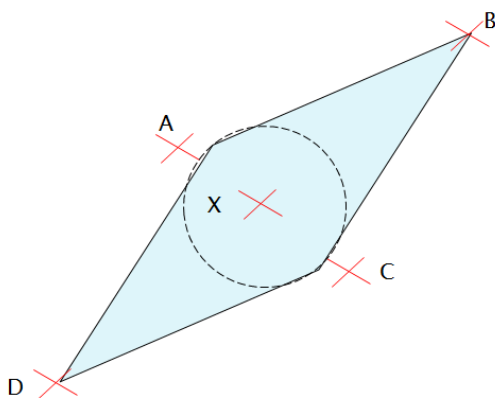
- Evaluate the capability of the OSEM algorithm to reconstruct for sinograms of degrading quality

Angle iteration=10



Future Work

- ▶ Further investigation into possible correction/calibration factor for offset distortion
- ▶ Simulation work in GATE (GEANT4) to confirm this correction factor
- ▶ Ongoing work in refining/redesigning reconstruction algorithms for best results. Masters students carry on CT project



Discussion & Conclusion

- ▶ The BrachyView system is a transrectal, ultra-functional imaging probe for PPB
- ▶ Capable of performing:
 - Pre-planning
 - Intra-operative treatment planning (or IDDP)
 - Post-implant dosimetry measurements
- ▶ This proof of concept study indicates that BrachyView is capable of resolving seeds accurately for post-implant CT dosimetric studies
- ▶ Further work is required to refine this approach, but the feasibility concept has been shown using TimePix as an in-body imaging plane for CT measurements of the prostate and LDR PPB implants

Acknowledgments

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