Rapid Broad-Beam Acquisition of 3D Objects with Laser-Optical Transillumination Tomography

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The rationale: Tissue-engineered blood vessels

Obtain dermal biopsy

Expand cells in culture

Tissue sheet

Roll on mandrel and allow layers to fuse

Tissue-engineered vascular graft

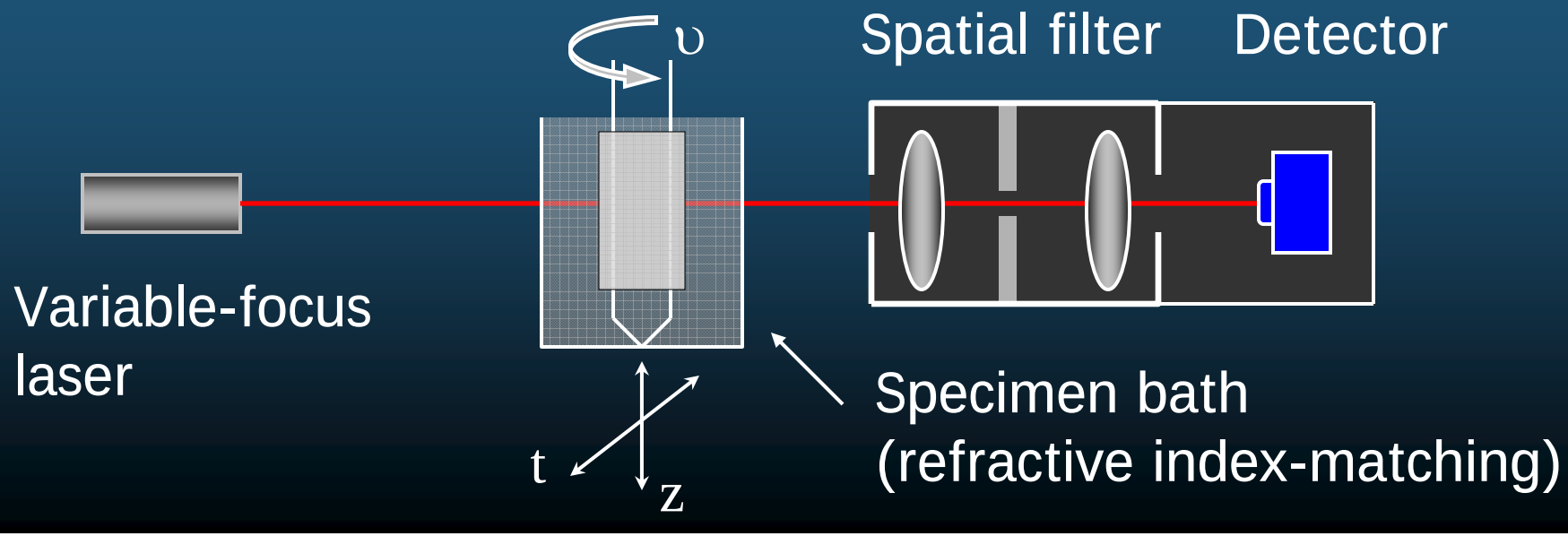
The rationale: Tissue-engineered blood vessels

- Grafts manufactured on an individual basis - no statistical monitoring possible
- High per-item costs
- At-risk patients may provide problematic cells
- Defects need to be identified

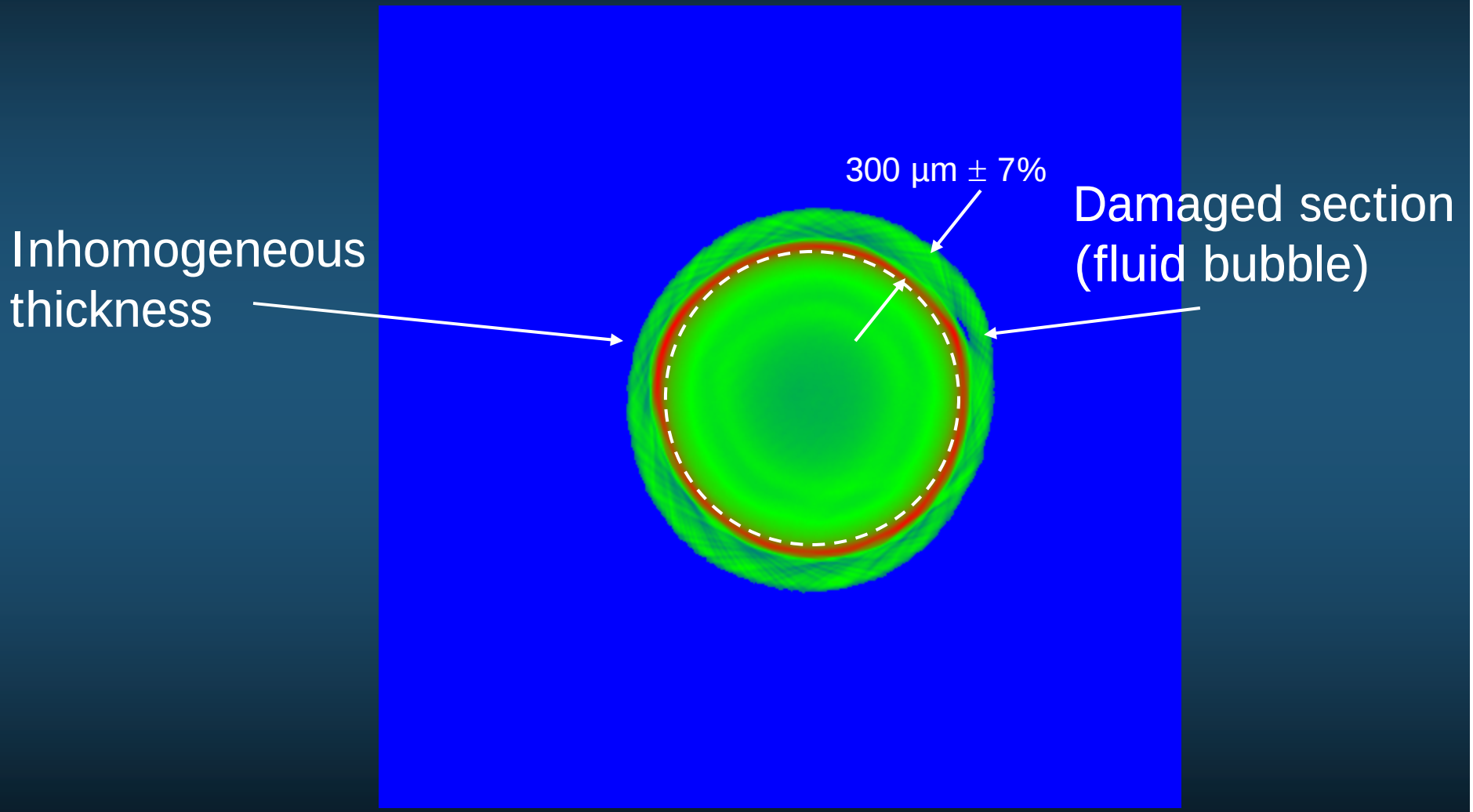
⇒ Each individual graft must be monitored and tested

Optical Transillumination Tomography

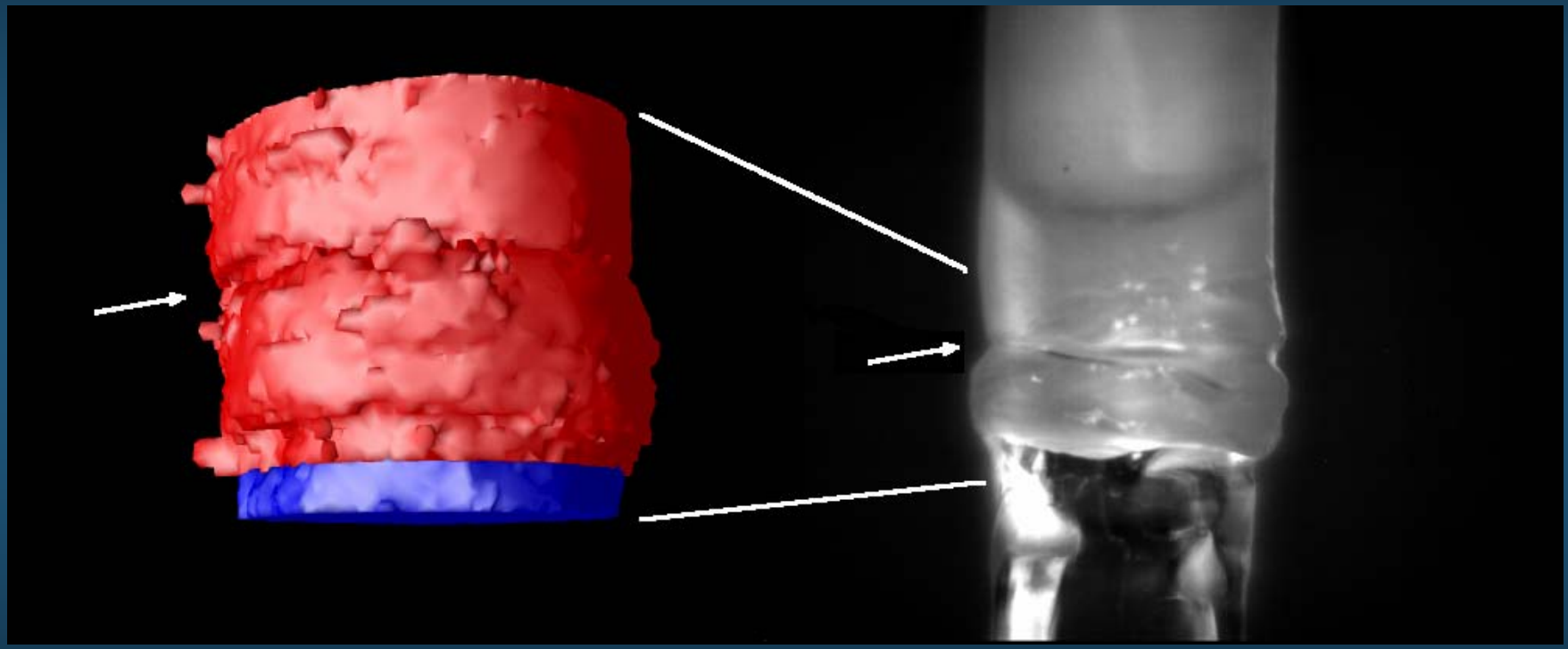
- Operation similar to X-ray CT
- Reconstruction using CT algorithms
- Uses unscattered photons
- Assumption: Thin tissue is a weak scatterer



Optical Transillumination Tomography

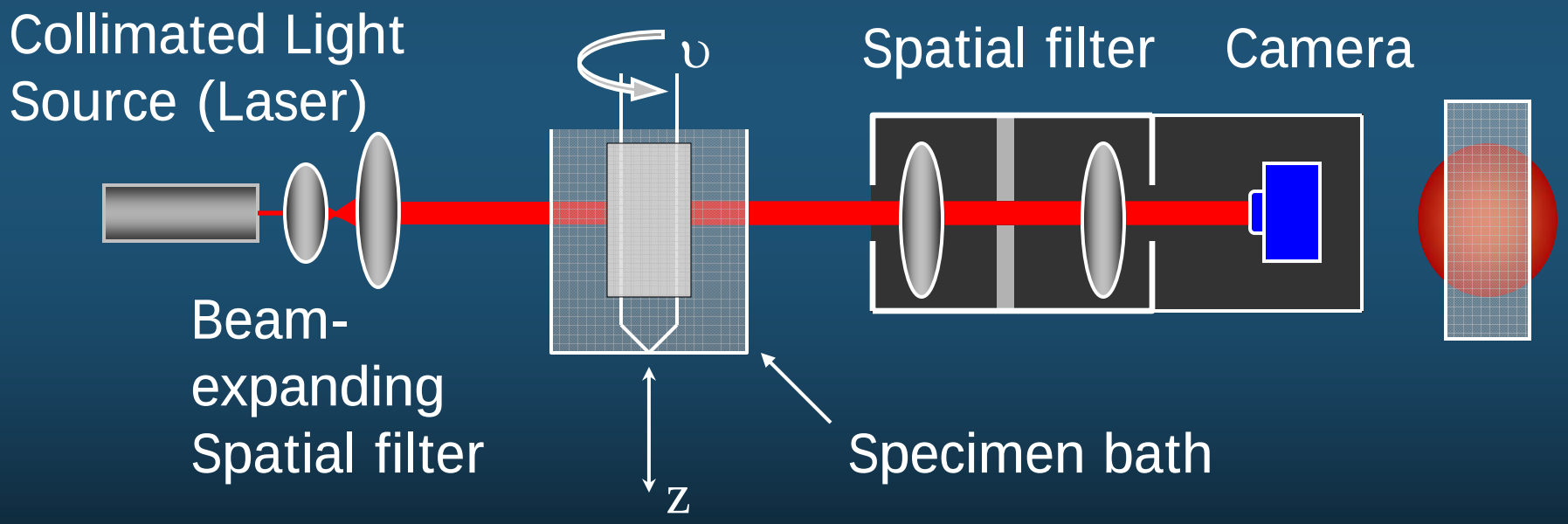


Optical Transillumination Tomography



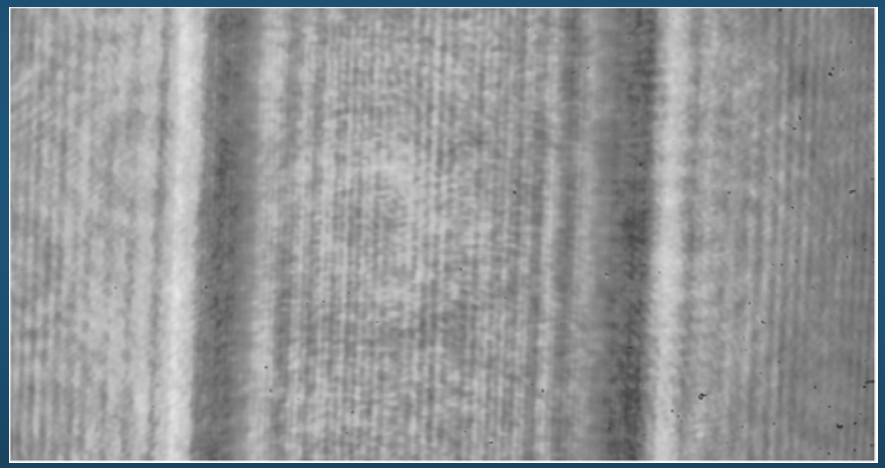
Broad-beam Acquisition Tomography

- Next generation scanner: Acquire projection with CCD camera and broad beam

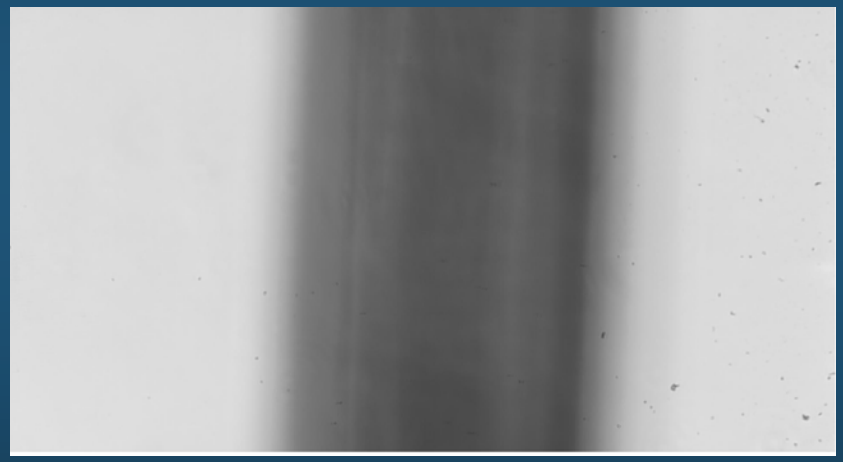


Broad-beam Acquisition Tomography

- Laser *versus* LED



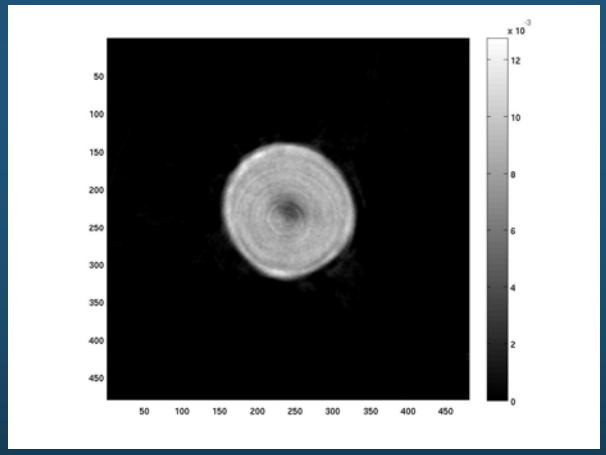
Laser:
Prominent interference pattern, causes ring artifacts

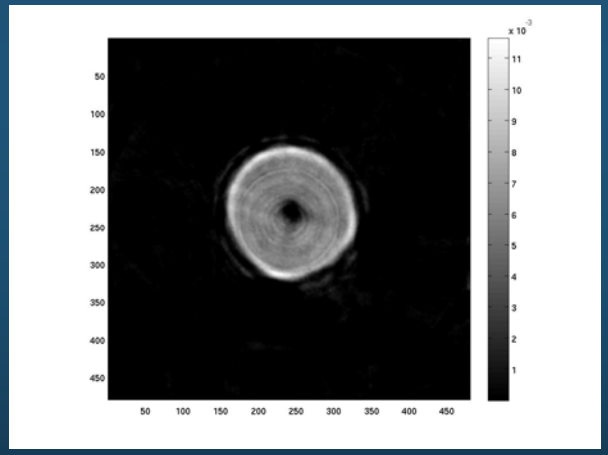


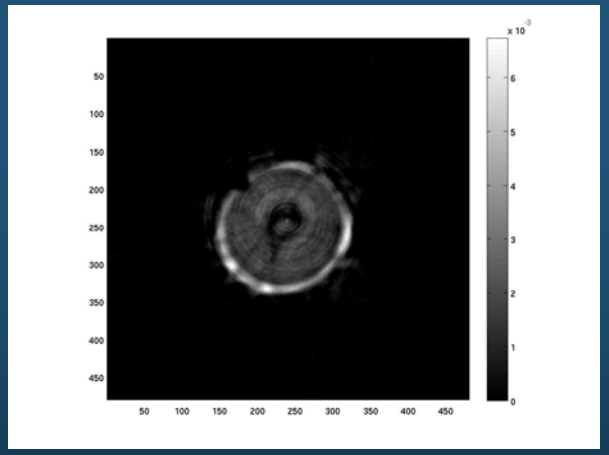
LED:
No interference pattern, better image quality

Validation

- (1) Ink phantoms (PTFE tubes filled with diluted ink)



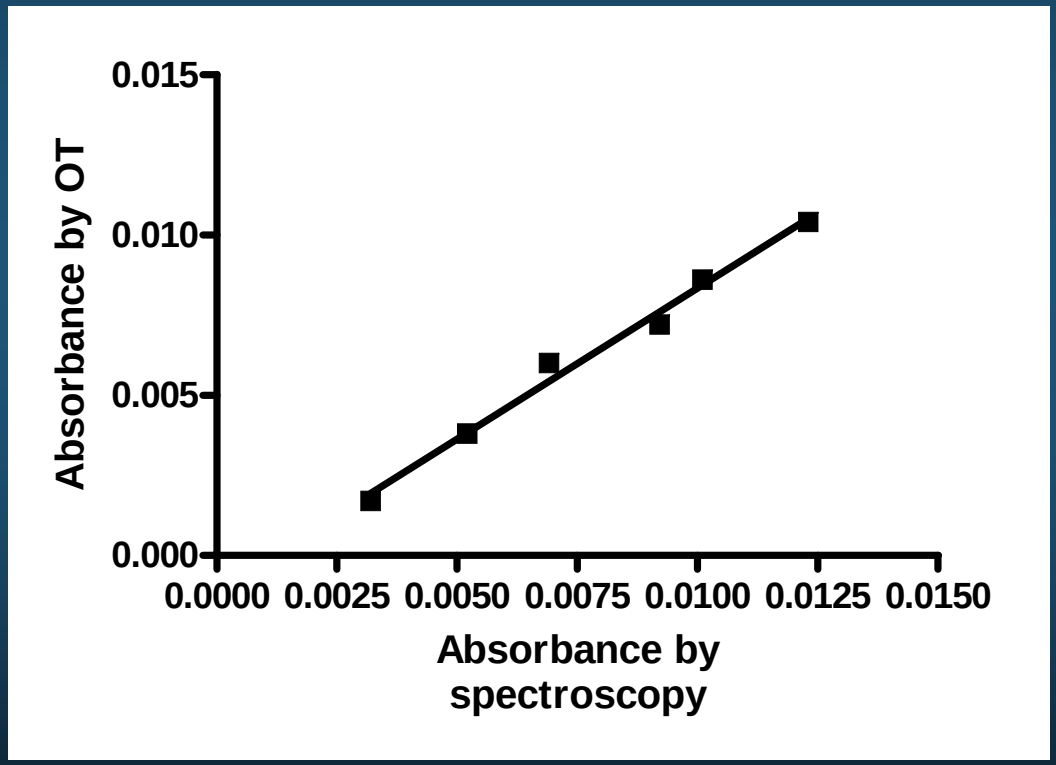




Lower absorbance ⇒ more artefacts in cross-section

Validation

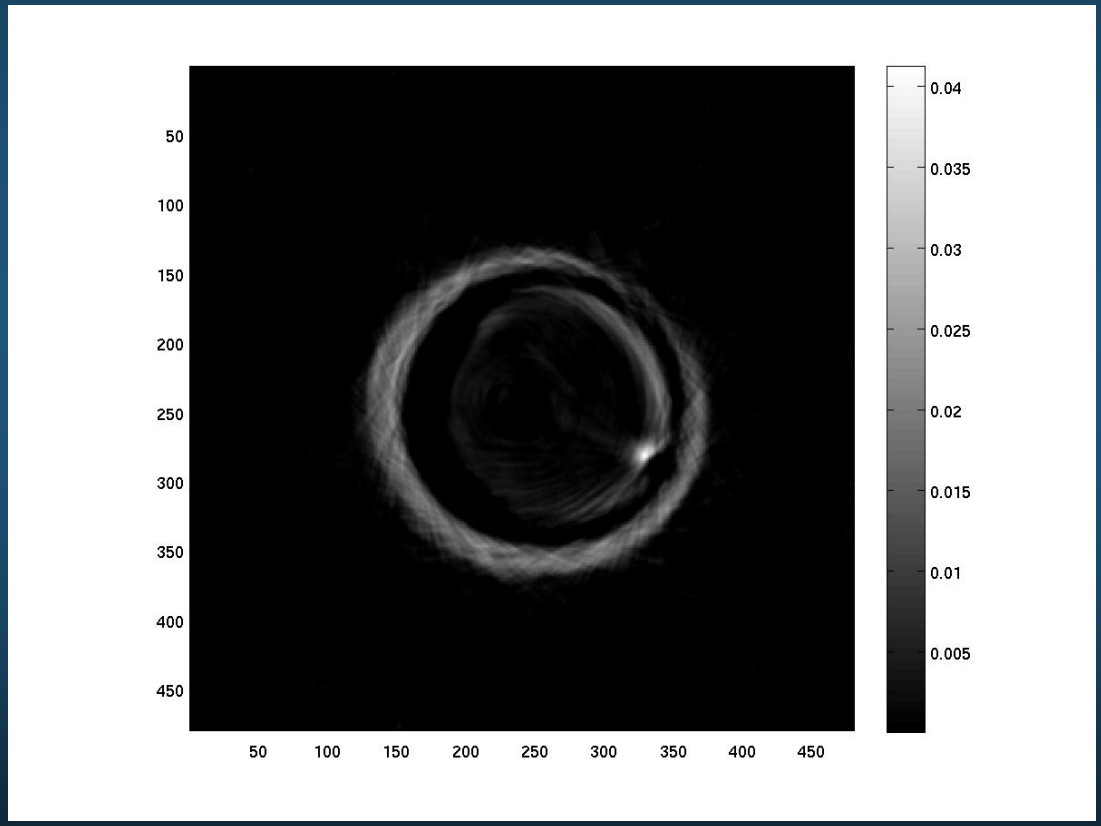
- (2) Ink phantoms – absorbance



Good correlation, but OT underestimates absorbance

Validation

- (3) Double-walled phantom



Center region of artefactually low absorbance – reflection?

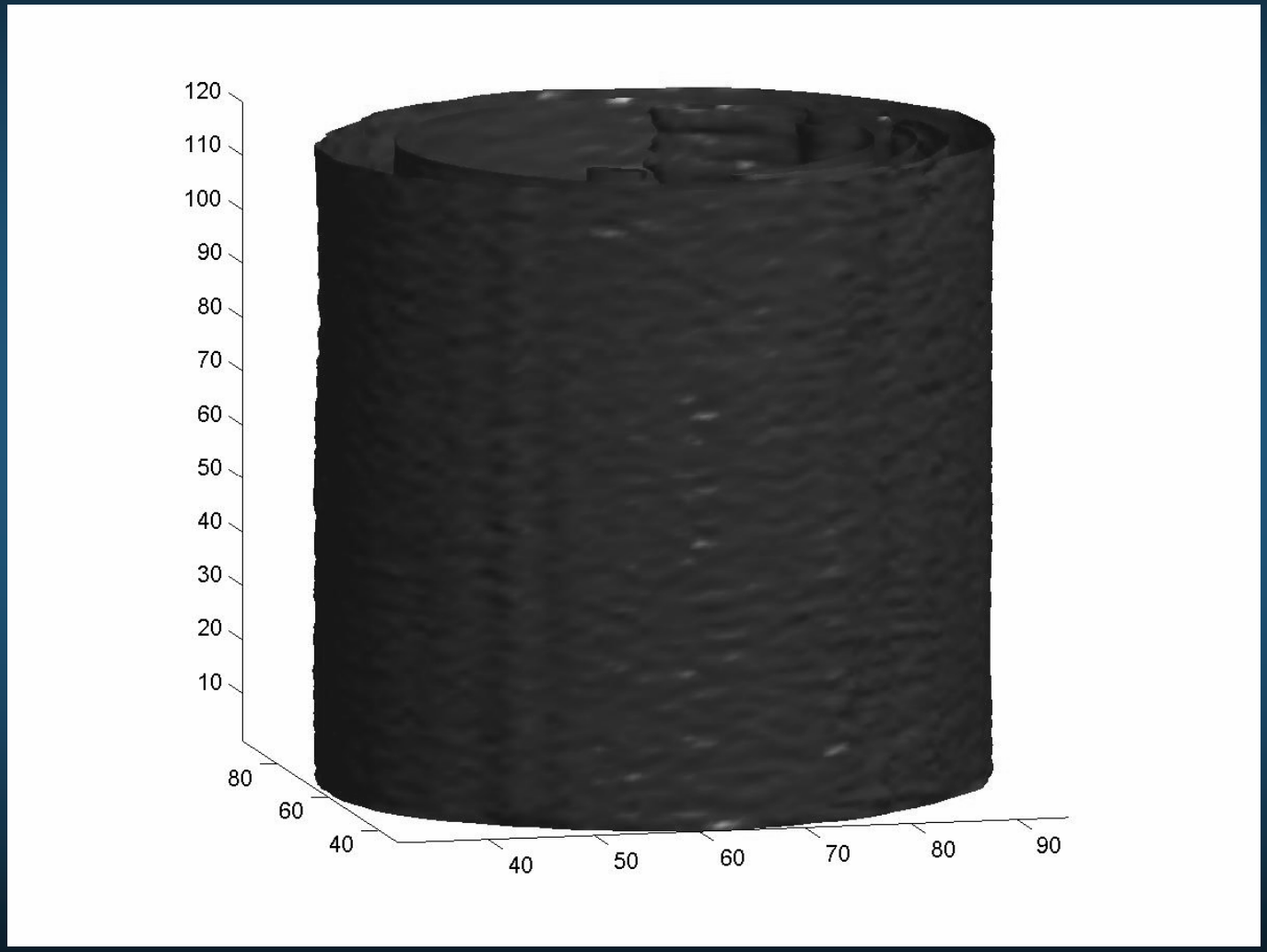
Speed of Reconstruction

- Used simultaneous arithmetic reconstruction technique (SART) for higher reconstruction quality
- Slow, iterative algorithm
- Special techniques to accelerate reconstruction:
  - OS-SART (SART with ordered subsets)
  - Ray-tracing method to pre-calculate system matrix

Speed of Reconstruction

Algorithm	**Time (s)**	**SNR**
Filtered backprojection	10	8.2
Conventional SART	550	13.9
OS-SART, 20 iterations, 5 subsets	320	13.8
OS-SART, 5 iterations, 20 subsets	92	13.7
OS-SART 5-20 with 200 projections	46	10.5
OS-SART 5-20 with 100 projections	24	8.2

Ability to Perform 3D Acquisition



Summary

- Acquisition of a 6mm x 3 mm section in one revolution (400 projections = frames)
- Frame rate ~ 10 fps
- Full 3D scan in 5 minutes or less
- But: Refraction problem not easily solved

⇒ *OT reserved for special-purpose research applications*