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Reconstruction for Interstitial Diffuse Optical Tomography (iDOT) for Human Prostate

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Outline

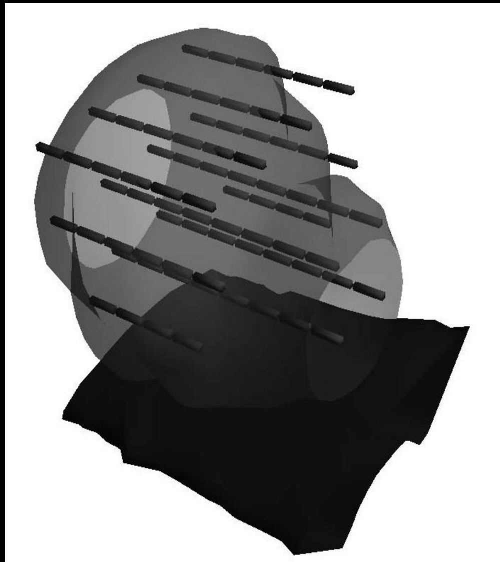
- Introduction to iDOT
- Why do we use it
- Experimental
- iDOT algorithm
- Results
- Summary and future directions

Introduction to iDOT

- DOT is used to obtain spatial distribution of optical properties in biological samples

- Usually light sources and detectors are placed on the surface of the samples, for instance, in optical brain imaging

- Interstitial DOT is used to predict the prostate optical properties, and the light sources and detectors are placed interstitially inside the prostate

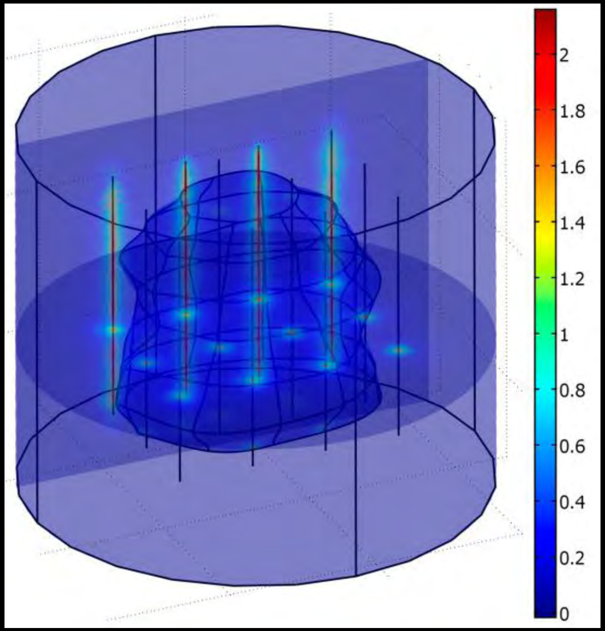


Why do we use iDOT

- iDOT is used for prostate photodynamic therapy (PDT); During PDT treatment, linear sources are used to deliver light dose to prostate
- In prostate PDT,

optical properties → light distribution → treatment efficacy

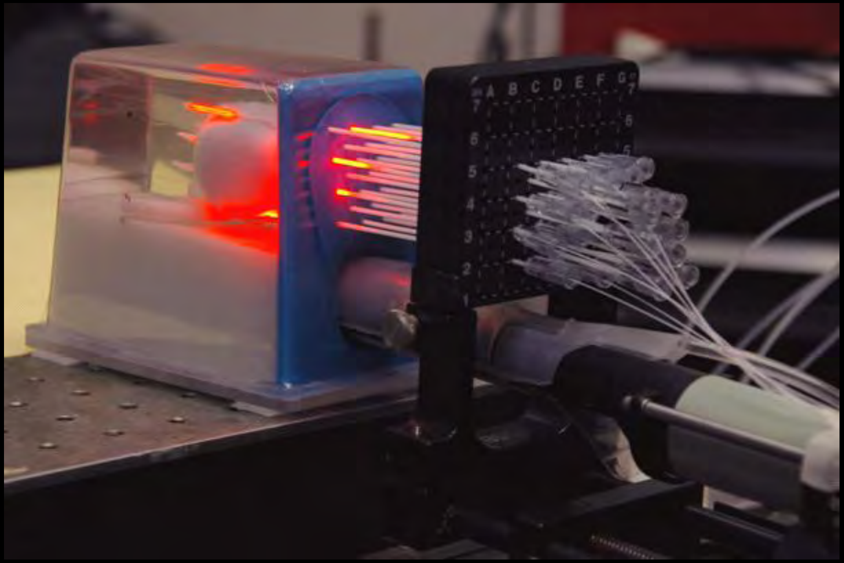
- Therefore, the goal of this study is to measure optical properties interstitially, and directly by the treatment linear sources to minimize the treatment time



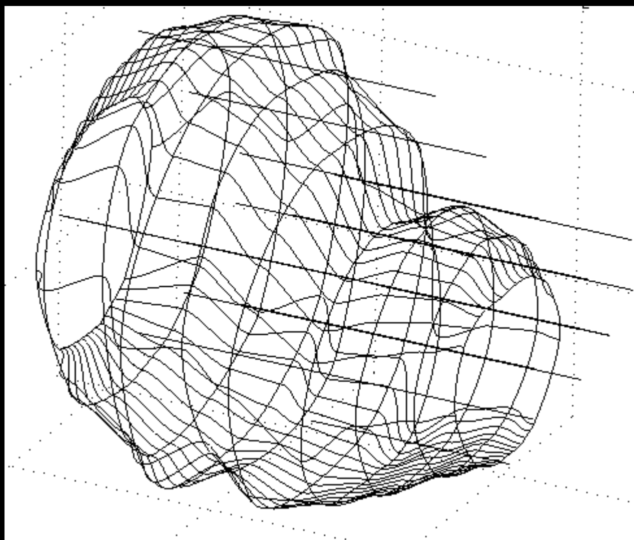
PDT dosimetry quantities $[^1O_2]_{rx}$ for treatment of 300 s in a homogeneous prostate

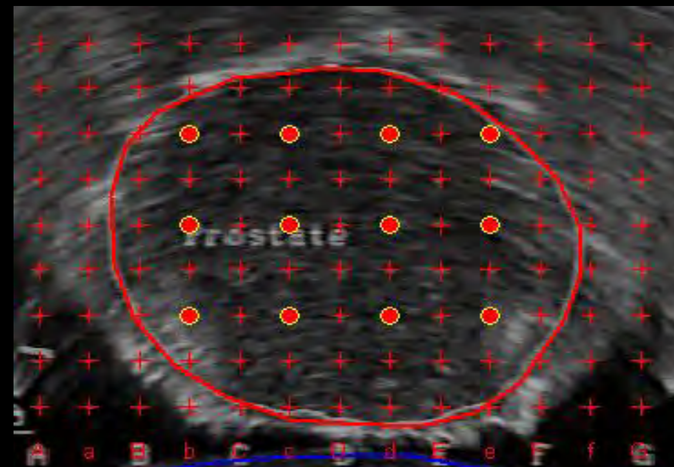
Experimental

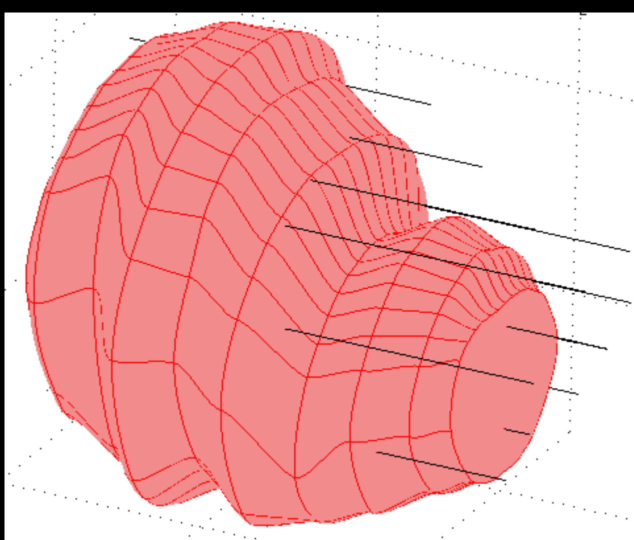
- A prostate phantom experiment was conducted mimicking prostate measurement
- 12 linear sources and 5 detector channels were used
- 3 anomalies were embedded in the phantom with different optical properties
- Ultrasound images were used to extract phantom contours

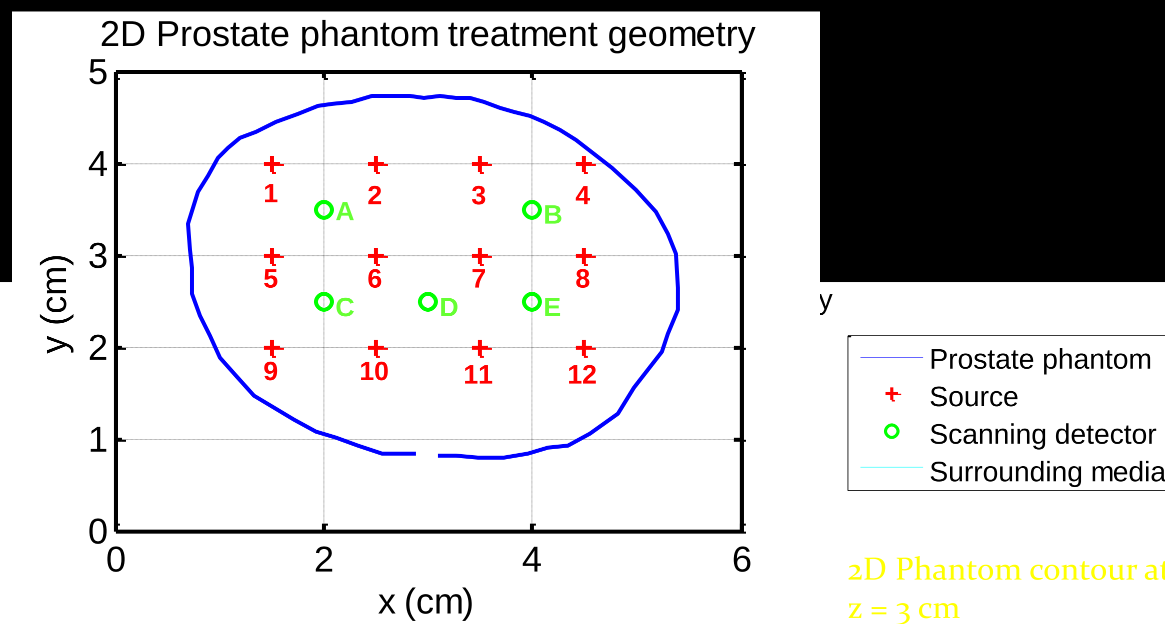


Experimental



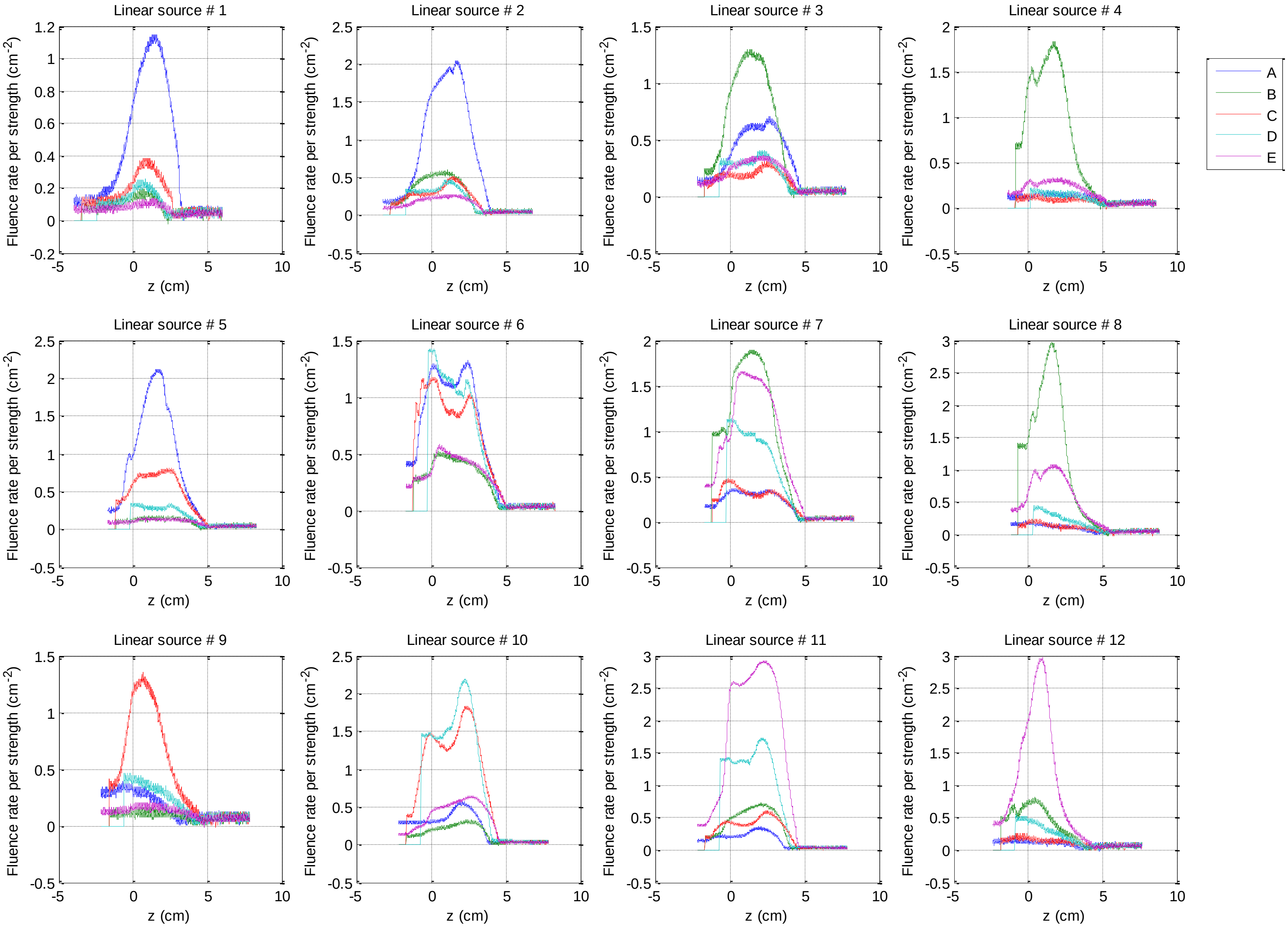






2D Phantom contour at z = 3 cm

Experimental



iDOT algorithm

1. Obtain prostate contour from Ultrasound

2. Input contour, source and detector locations into COMSOL to generate mesh for finite element calculation (FEM) for in 3D

3. Read iDOT measured fluence rate data (ϕ_m)

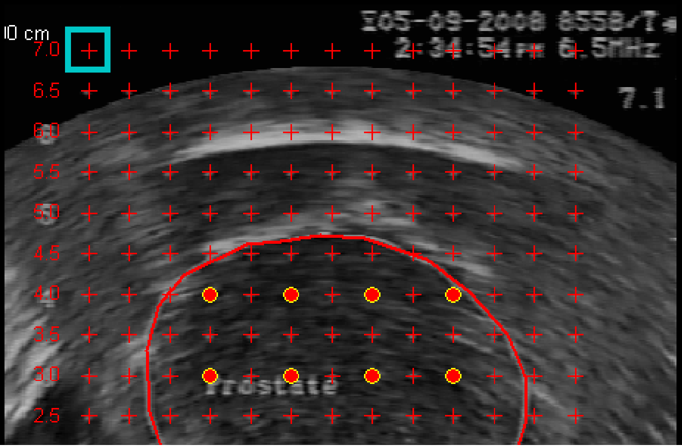
4. Calculate forward fluence rate data (ϕ_c using steady state diffusion Eq with FEM a initial μ_a and μ_s'.

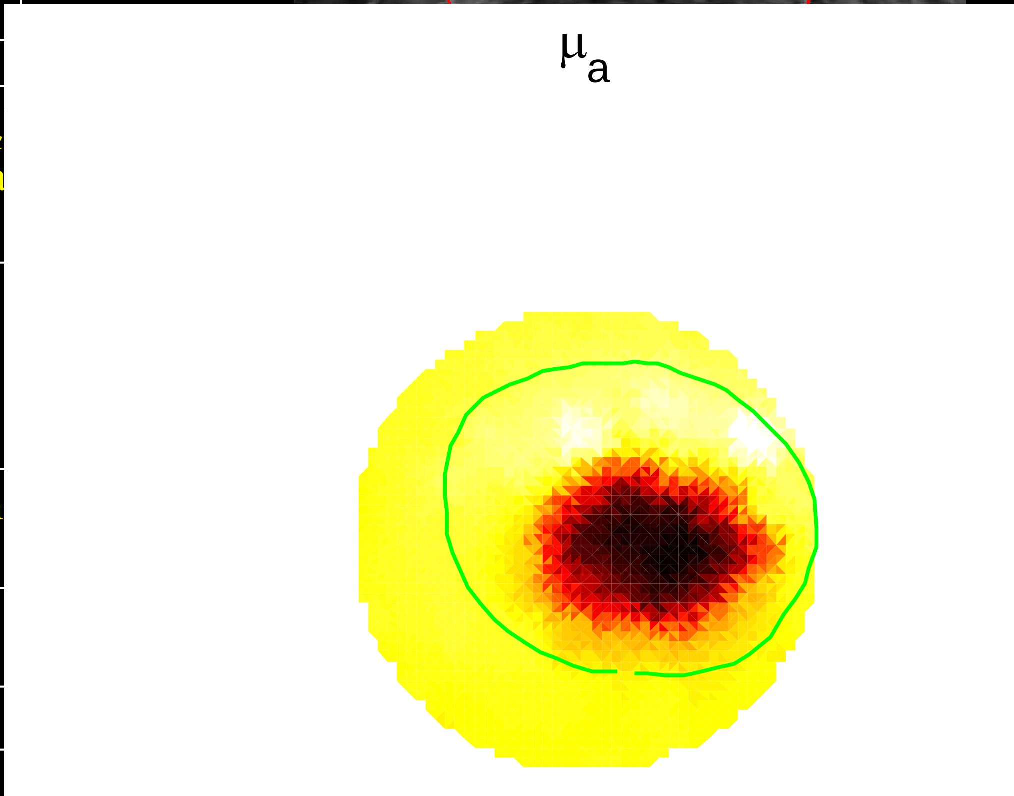
5. Build Jacobian matrix (J) in CW scheme

6. Calculate projection error between ϕ_c an and ϕ_m. Less than tolerance?

No → 7. update μ_a and D

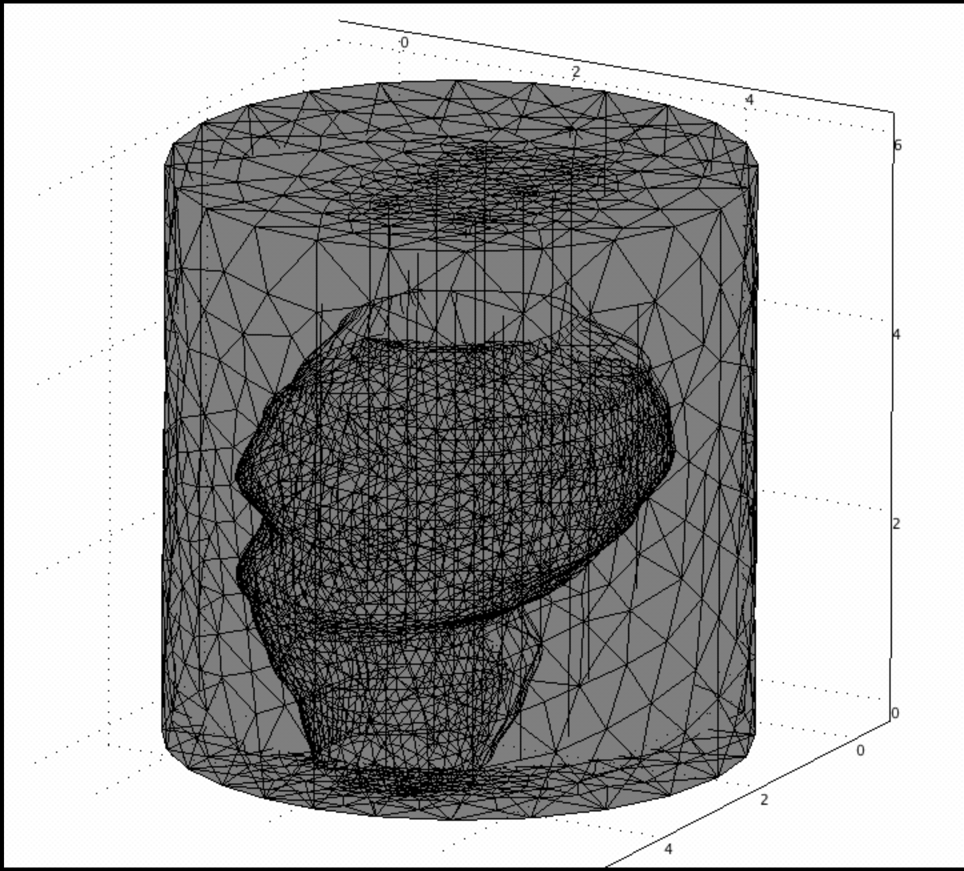
Yes → 7. Stop



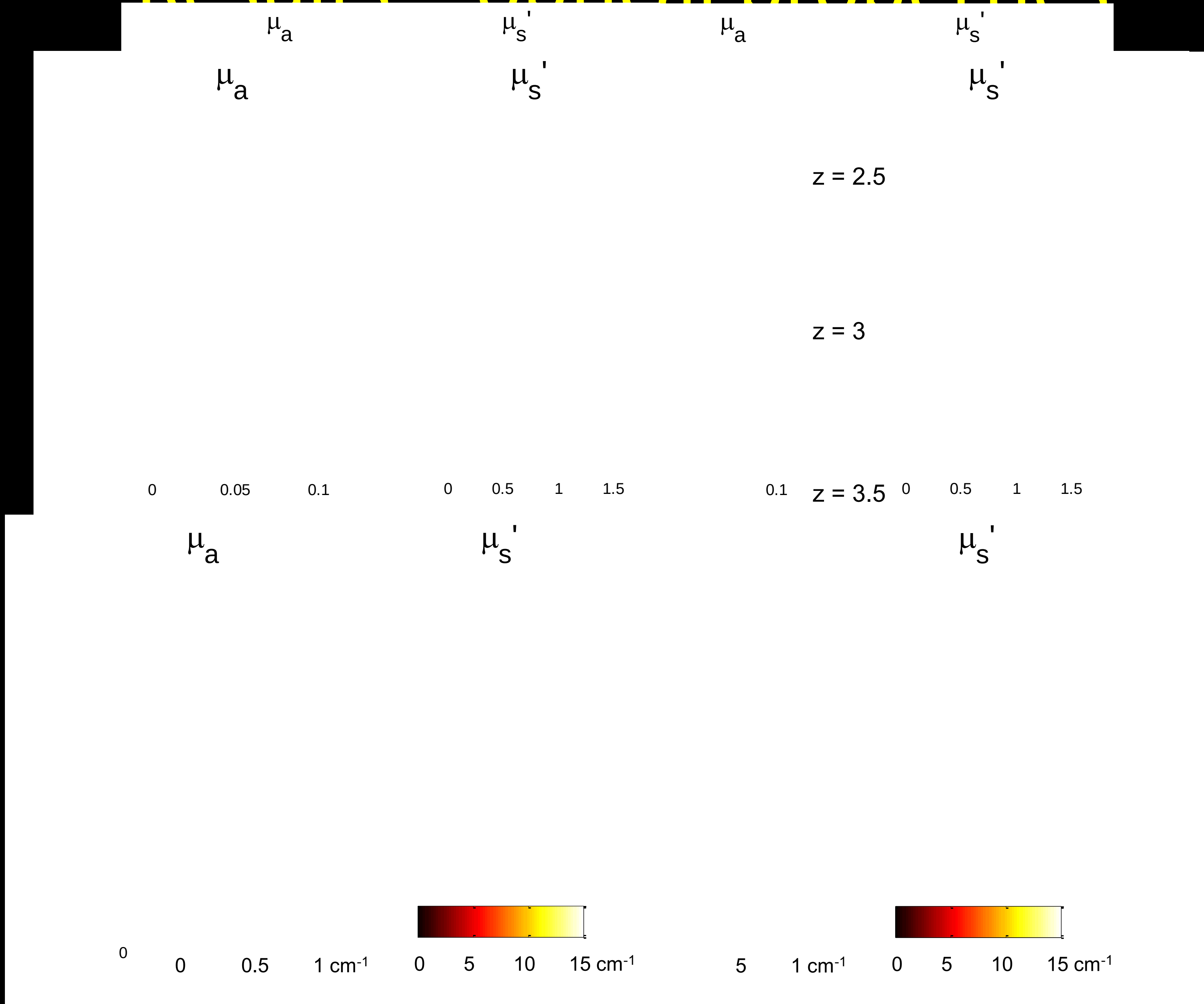


iDOT algorithm

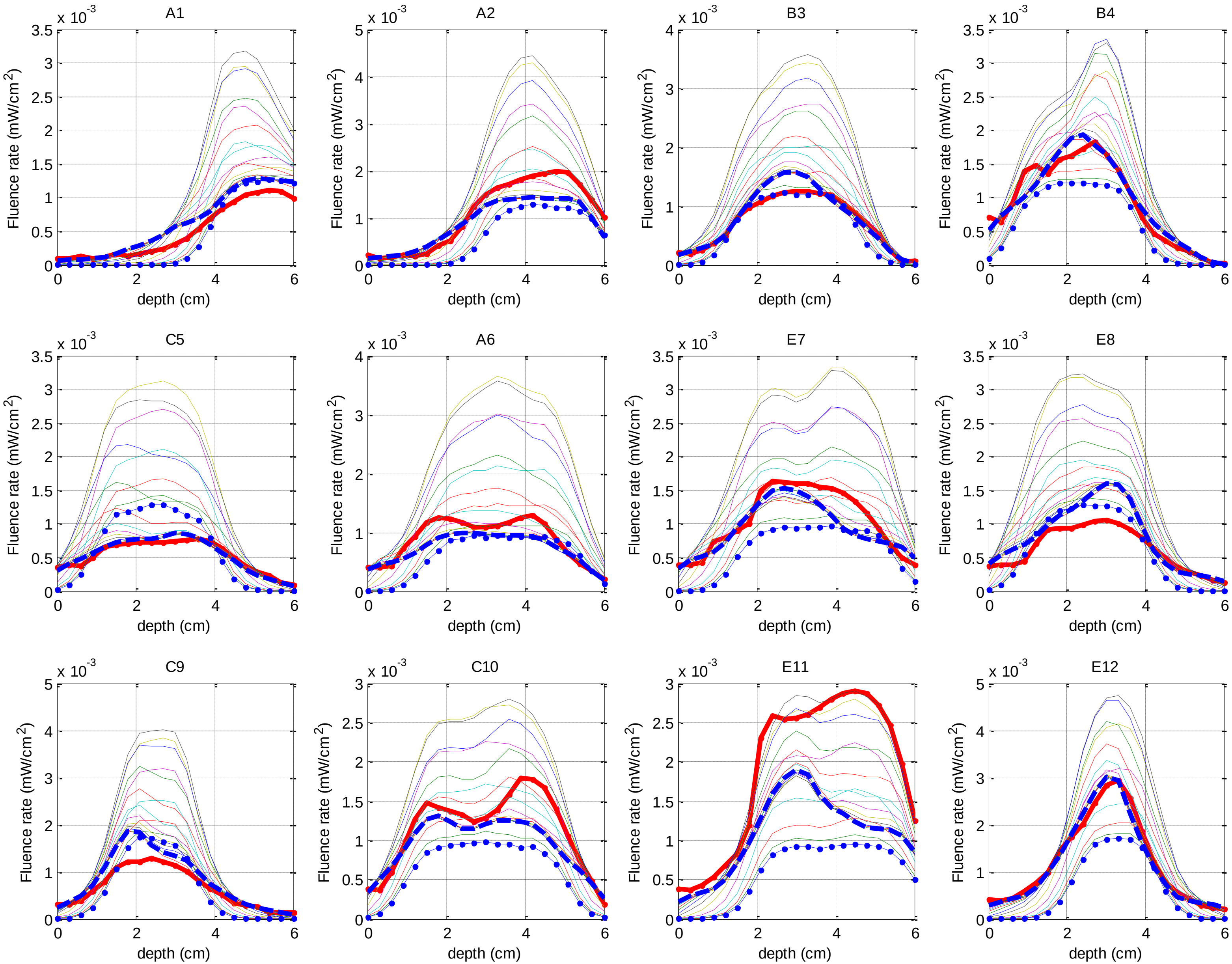
- The mesh is created by COMSOL
- 22830 nodes and 137539 elements
- A r=3 cm cylinder is used to mimic surrounding tissue for prostate
- The optical properties of the background are μ_a = 0.3 (cm^{-1}) and μ_s' = 15 (cm^{-1}) for the prostate and the surrounding medium



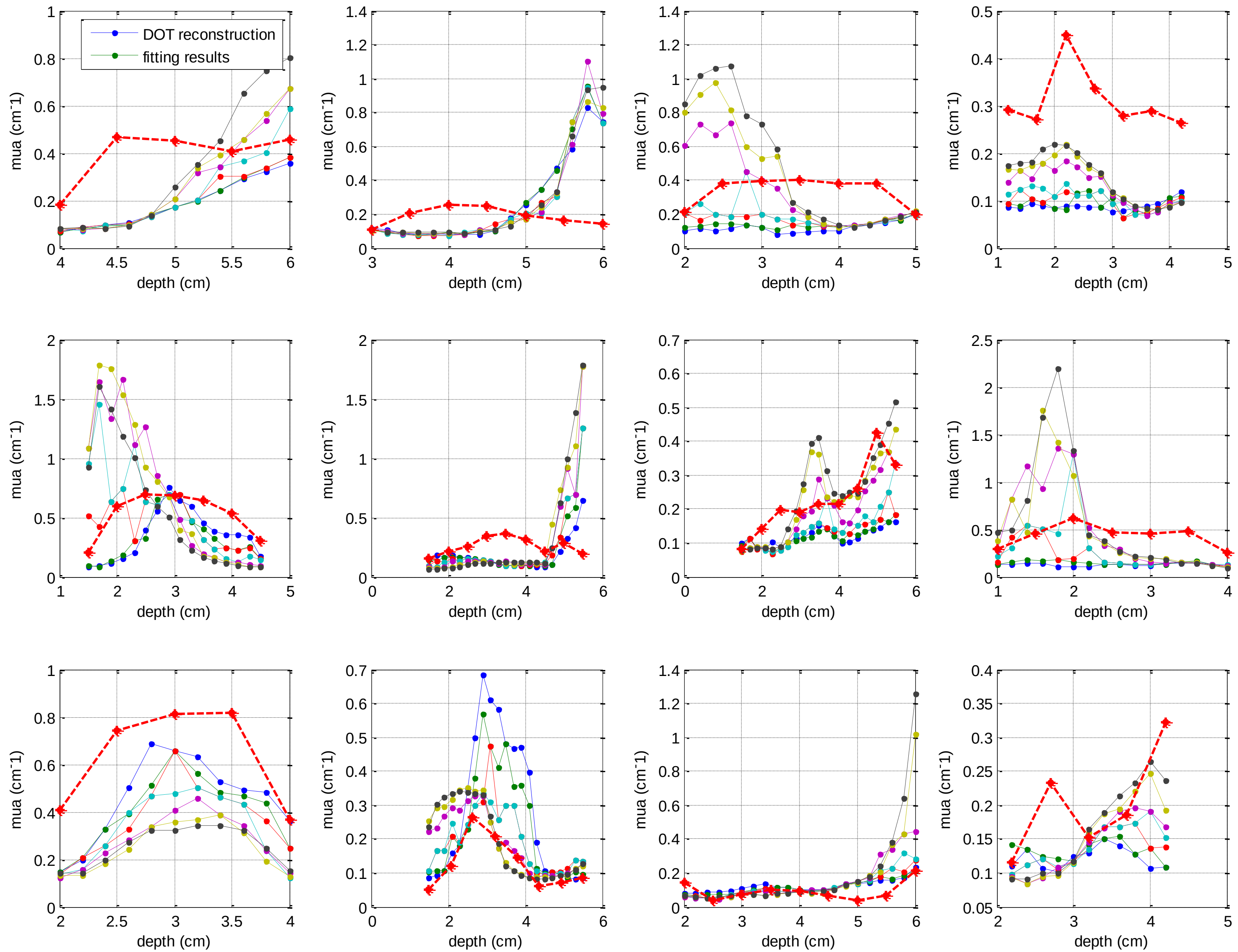
Results – optical properties



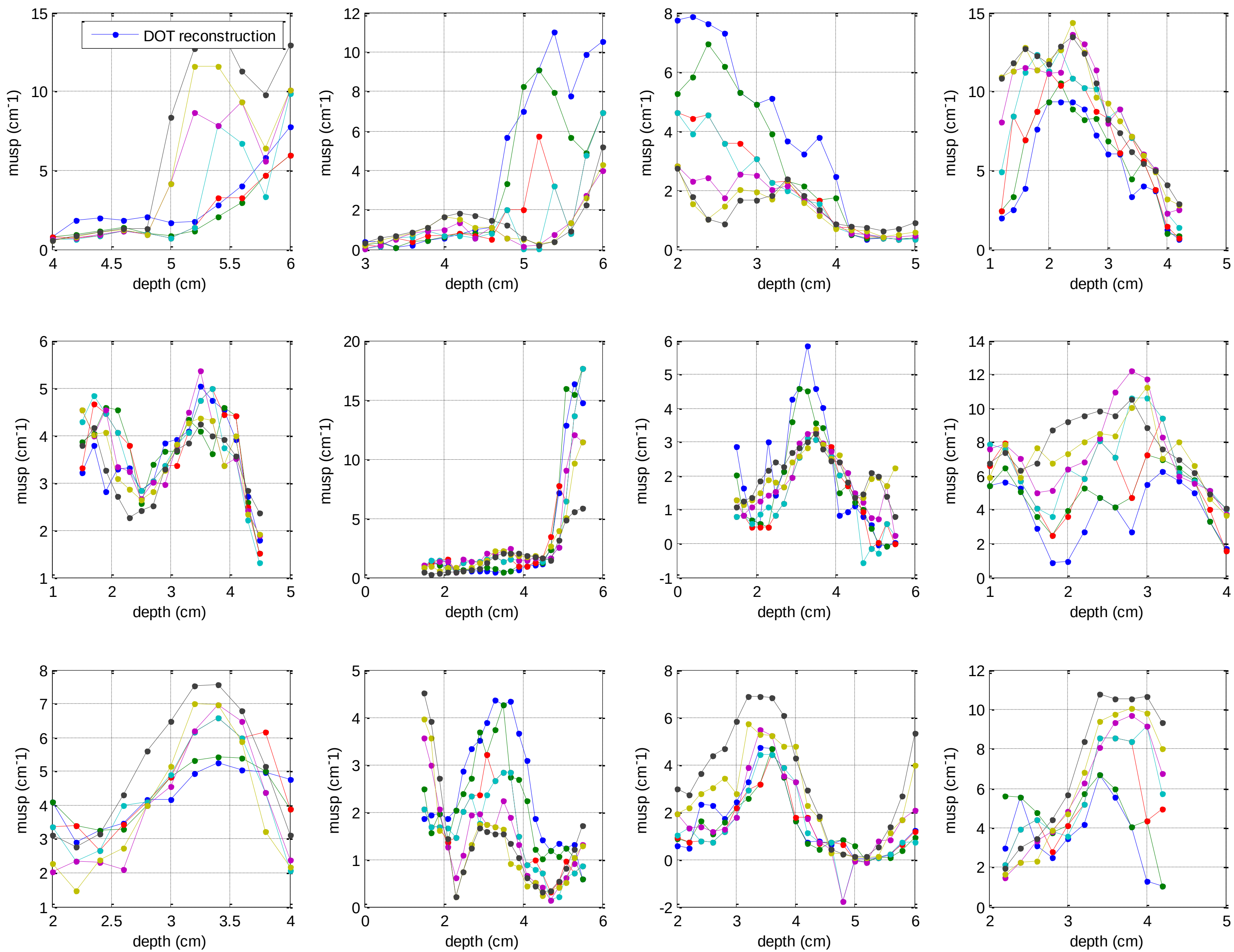
Results – light profile



Results – absorption coefficient



Results – scattering coefficient



Summary

- Established iDOT method to determine optical properties in prostate PDT
- Reconstructed optical properties using iDOT method
- Compared iDOT reconstruction results with experimental data

Future questions

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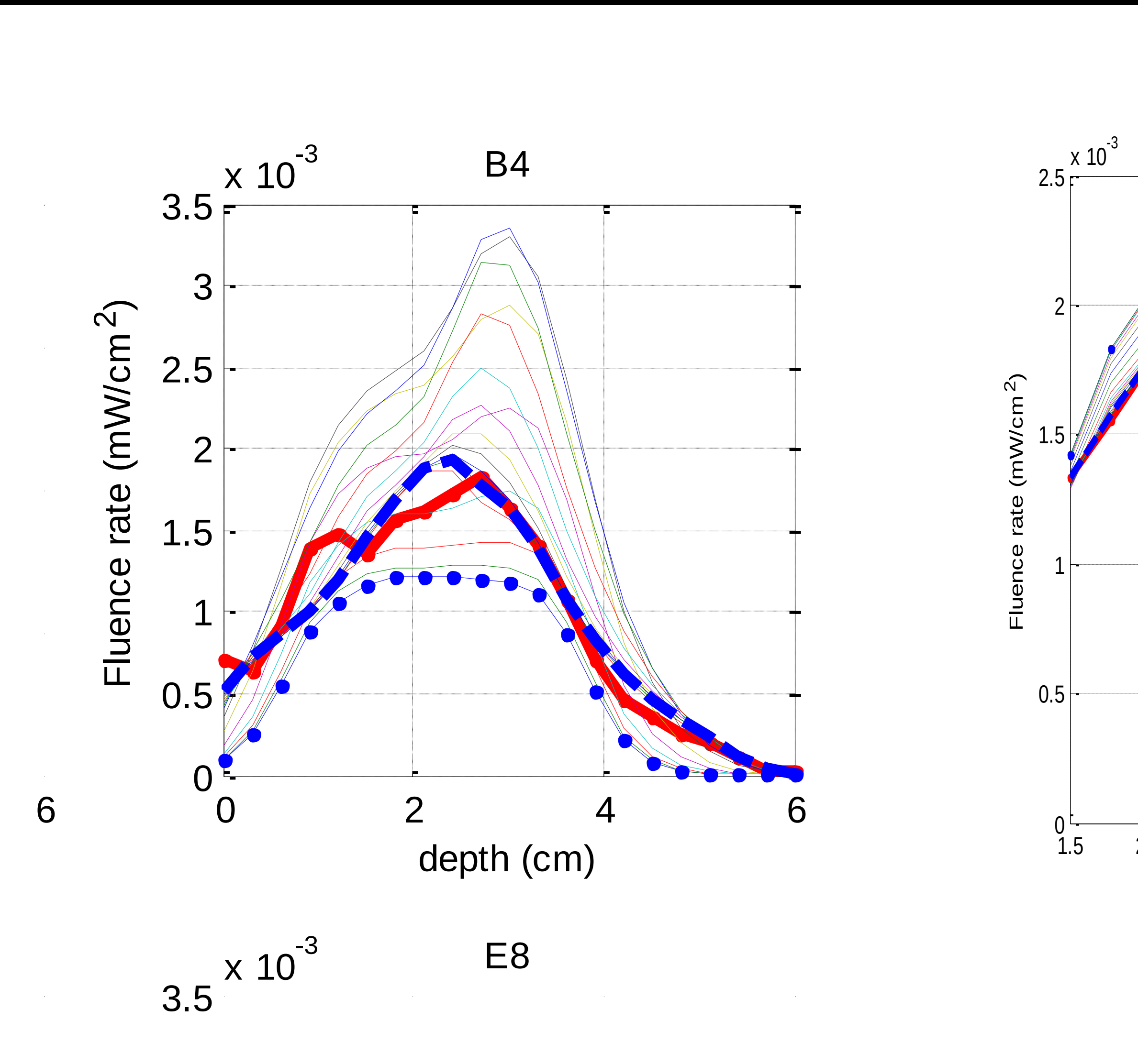

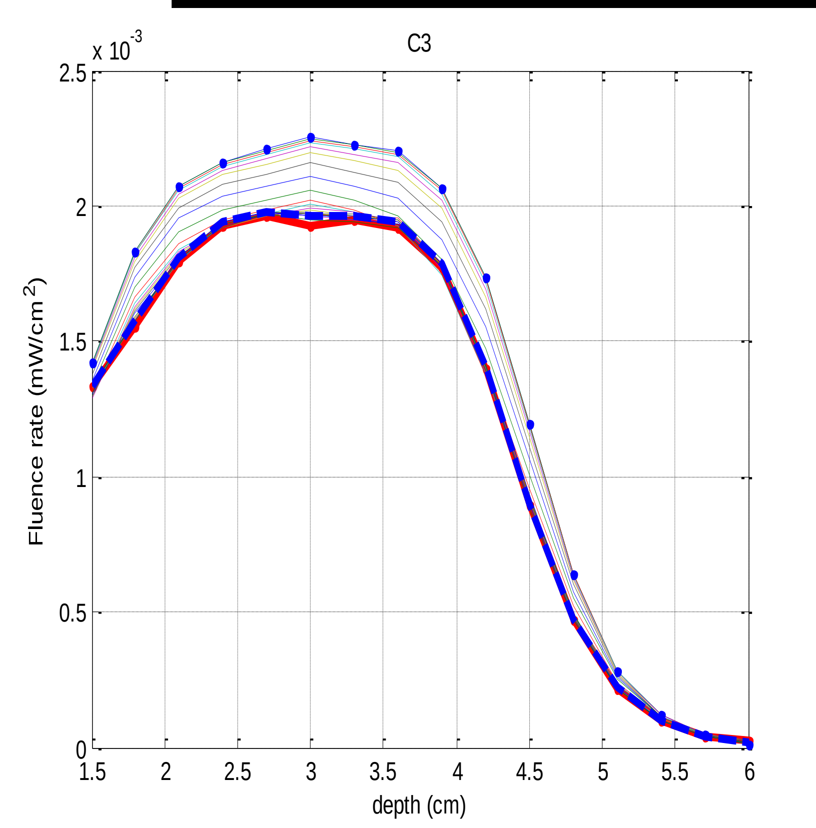

for initial condition

Future directions

- Reconstruct single data pairs for iDOT, and use the reconstructed optical properties as initial condition

- Reduce cross talking between μ_a and μ_s' to improve the accuracy of the algorithm

Thank you!