



ASTRO'S 67TH ANNUAL MEETING
REDISCOVERING RADIATION
MEDICINE AND EXPLORING
NEW INDICATIONS



Dartmouth
GEISEL SCHOOL OF
MEDICINE

DEPARTMENT of
Radiation Oncology
& Applied Sciences



DARTMOUTH
ENGINEERING
THAYER SCHOOL

Towards Endogenous Tissue Dosimetry and Radiotherapy Response Monitoring: Analyzing Blood Content and Oxygenation Tissue via Multispectral Cherenkov Imaging

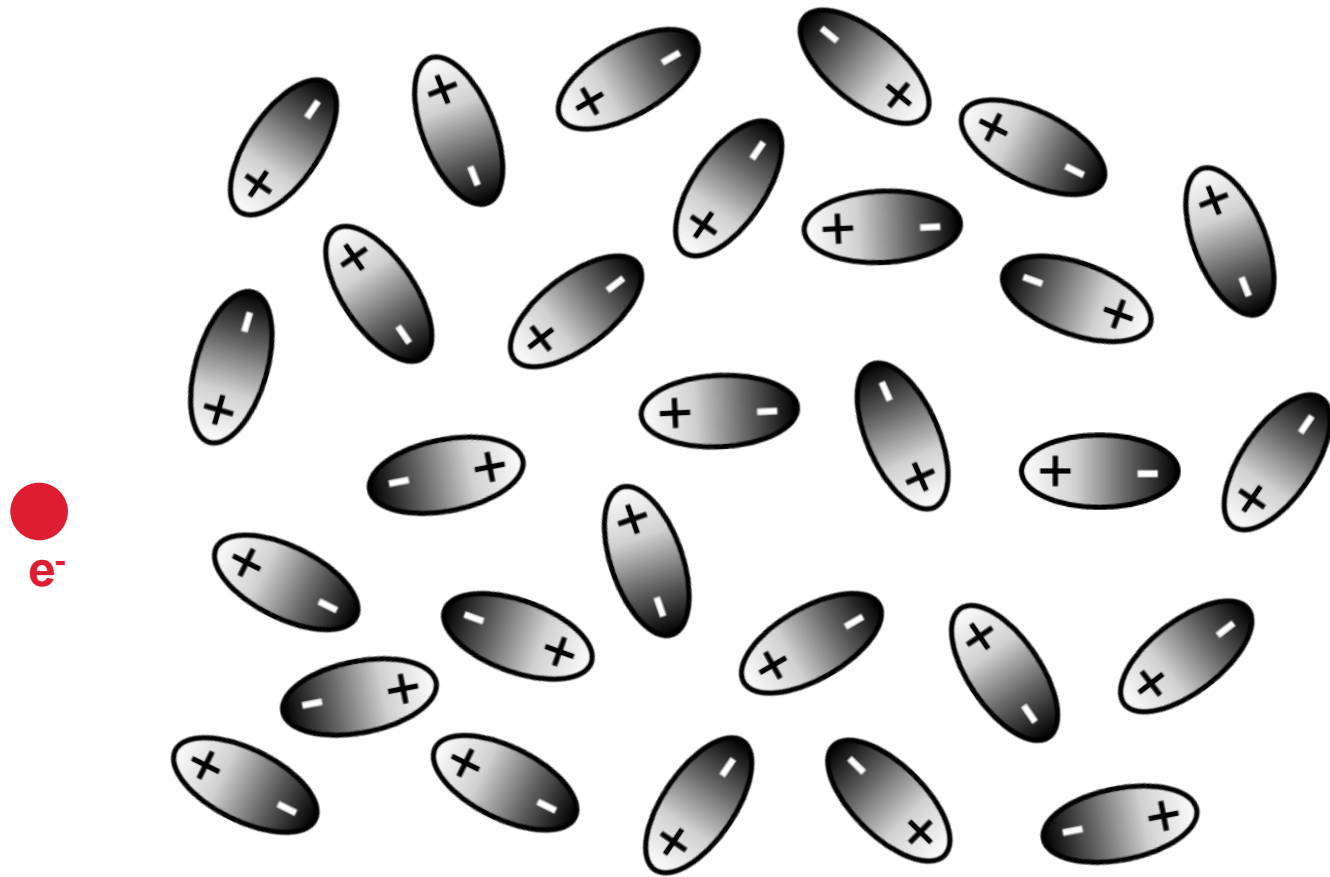
Roman Vasylytsiv¹, Allison Matous², Shiru Wang¹, David Gladstone¹, Lesley Jarvis², Petr Bruza¹

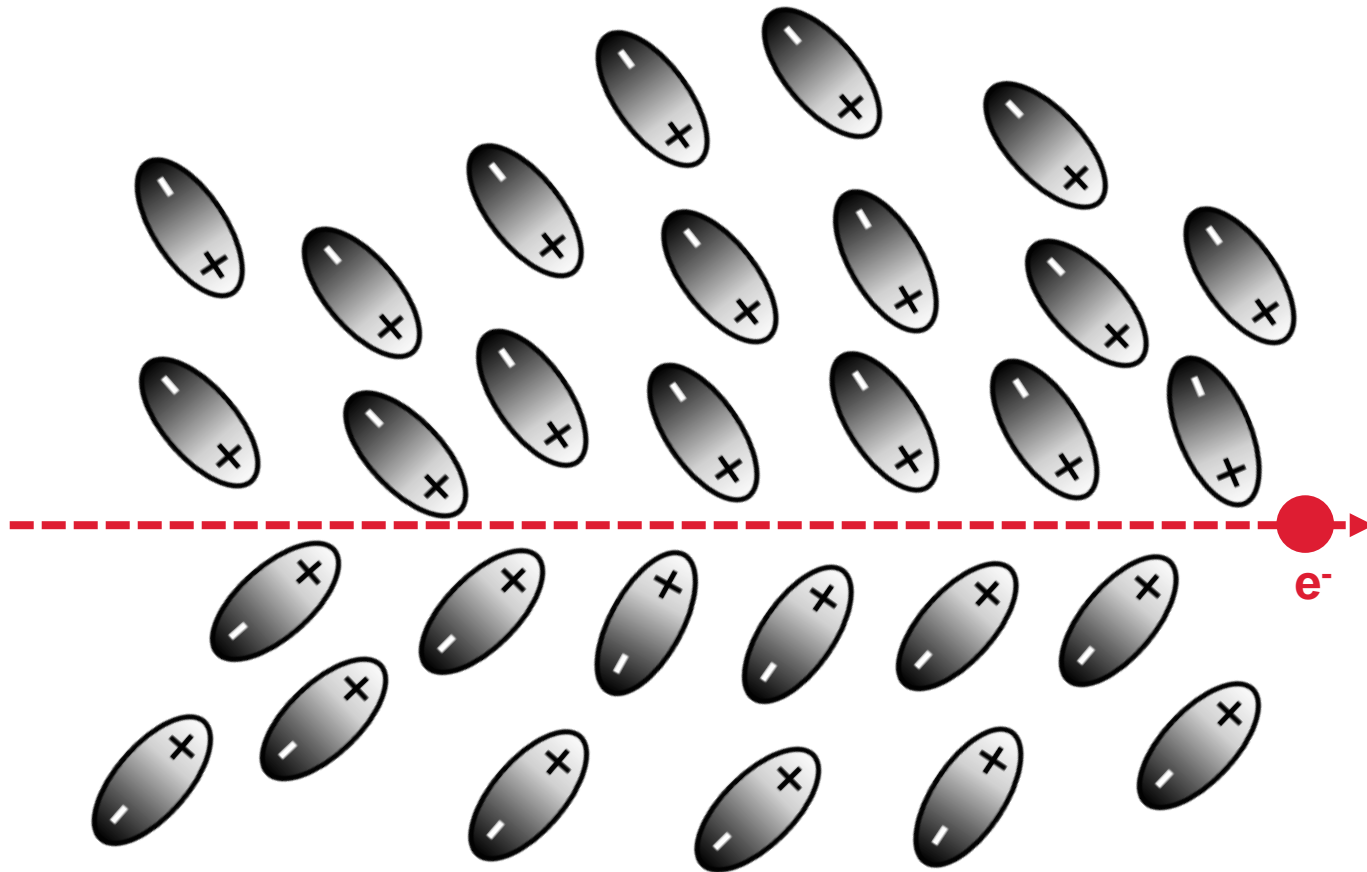
October 1, 2025

2025 American Society for Radiation Oncology Conference (San Francisco, CA)

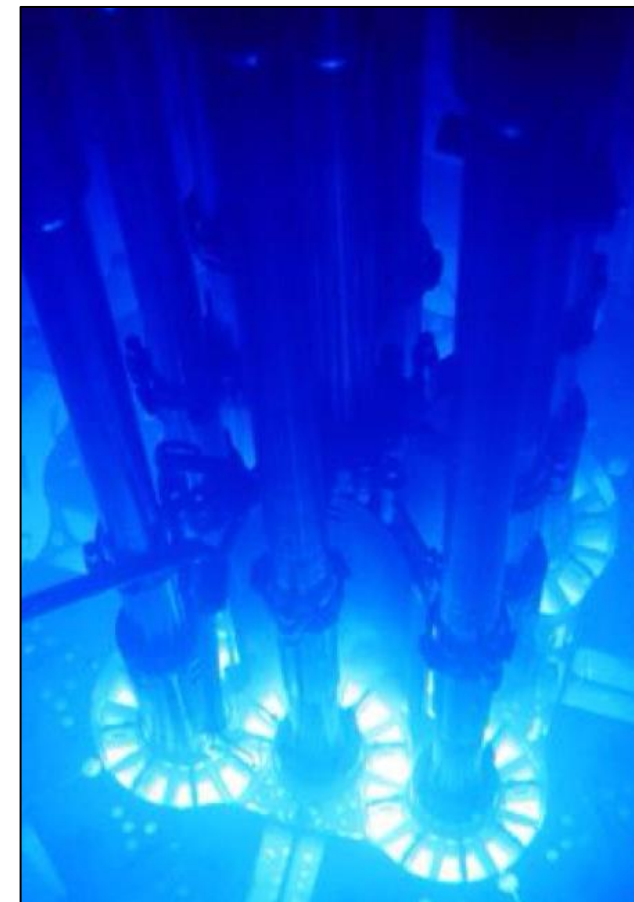
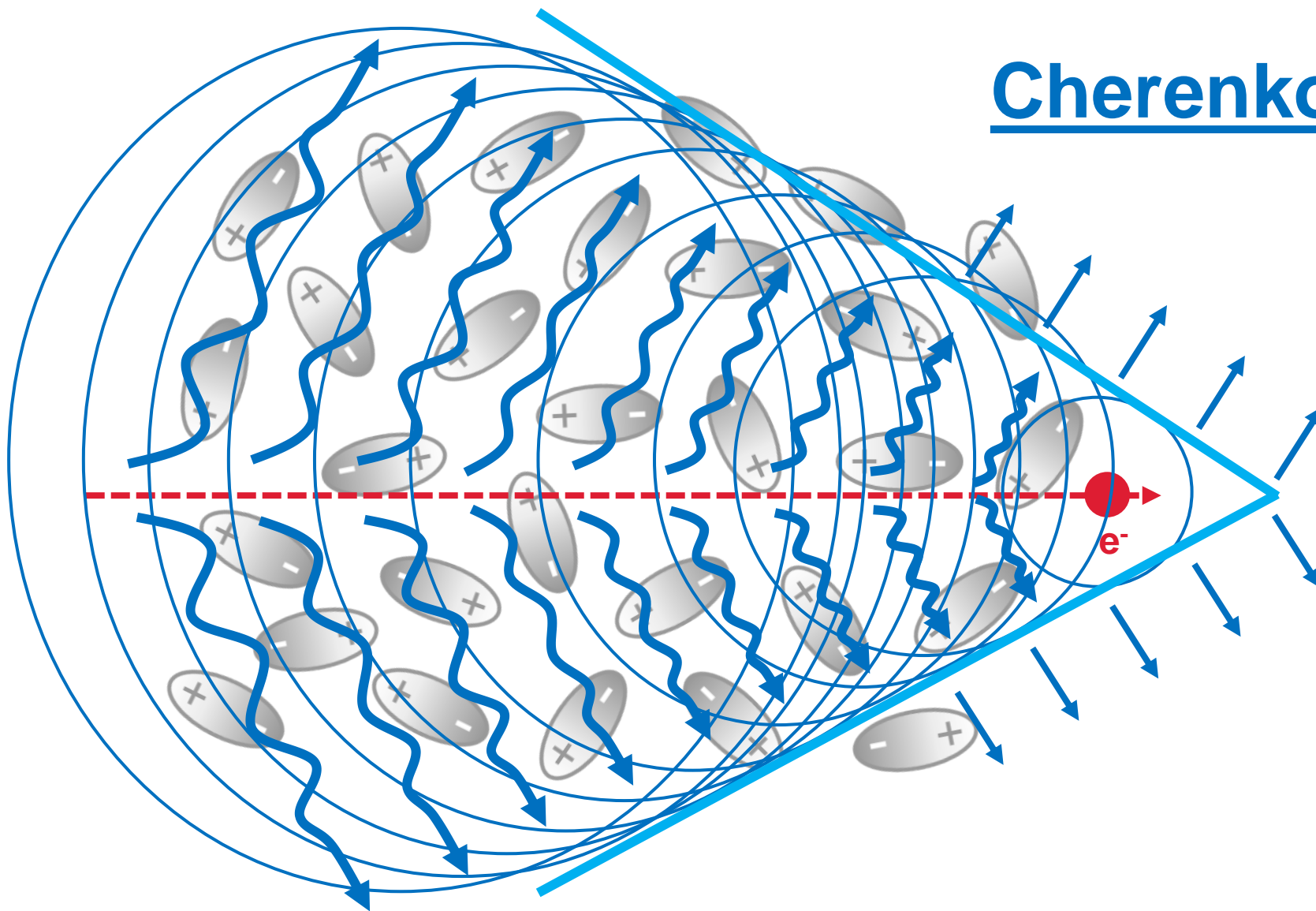
¹Thayer School of Engineering, Dartmouth College, Hanover, NH

²Department of Radiation Oncology, Dartmouth Health, Lebanon, NH

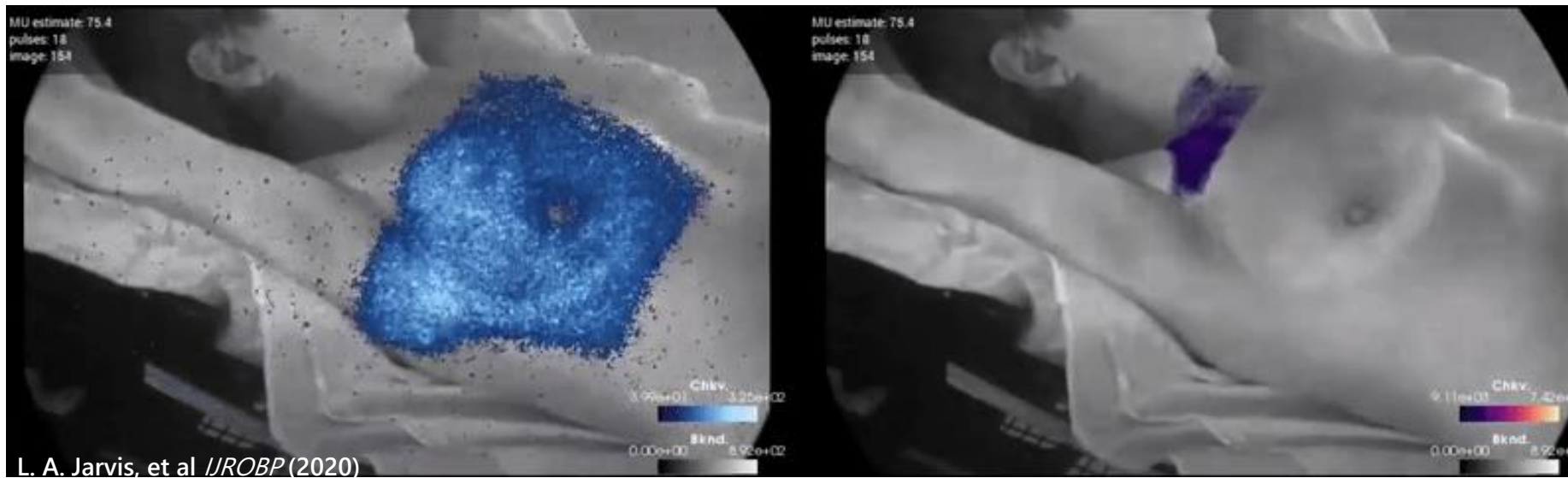




Cherenkov Radiation



Clinical Cherenkov Imaging Provides Real Time Dose Visualization for Treatment Field Verification



L. A. Jarvis, et al *IJROBP* (2020)

Live Cherenkov Video

Cumulative Cherenkov Image

> *Int J Radiat Oncol Biol Phys.* 2014 Jul 1;89(3):615-22. doi: 10.1016/j.ijrobp.2014.01.046. Epub 2014 Mar 28.

Cherenkov video imaging allows for the first visualization of radiation therapy in real time

Lesley A Jarvis ¹, Rongxiao Zhang ², David J Gladstone ³, Shudong Jiang ⁴, Whitney Hitchcock ⁵, Oscar D Friedman ⁴, Adam K Glaser ⁴, Michael Jermy ⁴, Brian W Pogue ⁶

Affiliations + expand

PMID: 24685442 DOI: 10.1016/j.ijrobp.2014.01.046

> *Int J Radiat Oncol Biol Phys.* 2021 Apr 1;109(5):1627-1637. doi: 10.1016/j.ijrobp.2020.11.013. Epub 2020 Nov 20.

Initial Clinical Experience of Cherenkov Imaging in External Beam Radiation Therapy Identifies Opportunities to Improve Treatment Delivery

Lesley A Jarvis ¹, Rachael L Hachadorian ², Michael Jermy ², Petr Bruza ², Daniel A Alexander ², Irwin I Tendler ², Benjamin B Williams ³, David J Gladstone ³, Philip E Schaner ⁴, Bassem I Zaki ⁴, Brian W Pogue ²

Affiliations + expand

PMID: 33227443 PMID: PMC10544920 DOI: 10.1016/j.ijrobp.2020.11.013

> *Phys Med Biol.* 2014 Jul 21;59(14):3789-811. doi: 10.1088/0031-9155/59/14/3789. Epub 2014 Jun 18.

Optical dosimetry of radiotherapy beams using Cherenkov radiation: the relationship between light emission and dose

Adam K Glaser ¹, Rongxiao Zhang, David J Gladstone, Brian W Pogue

Affiliations + expand

PMID: 24938928 DOI: 10.1088/0031-9155/59/14/3789

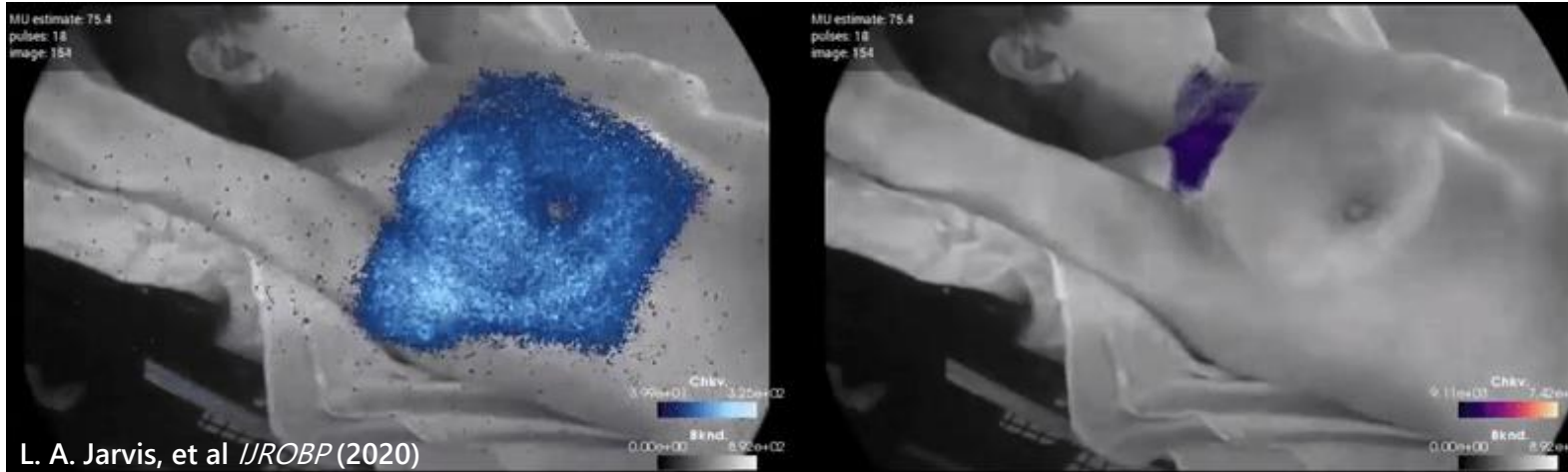
Review > *Pract Radiat Oncol.* 2023 Jan-Feb;13(1):71-81. doi: 10.1016/j.pro.2022.06.009. Epub 2022 Jun 29.

One Year of Clinic-Wide Cherenkov Imaging for Discovery of Quality Improvement Opportunities in Radiation Therapy

Daniel A Alexander ¹, Savannah M Decker ², Michael Jermy ², Petr Bruza ², Rongxiao Zhang ³, Erii Chen ⁴, Tatum L McGlynn ⁵, Rory A Rossetol ⁵, Jae Lee ⁵, Melanie L Rose ⁵, Benjamin B Williams ³, Brian W Pogue ⁶, David J Gladstone ⁷, Lesley A Jarvis ⁸

Affiliations + expand

PMID: 35777728 PMID: PMC10984217 DOI: 10.1016/j.pro.2022.06.009



L. A. Jarvis, et al *IJROBP* (2020)

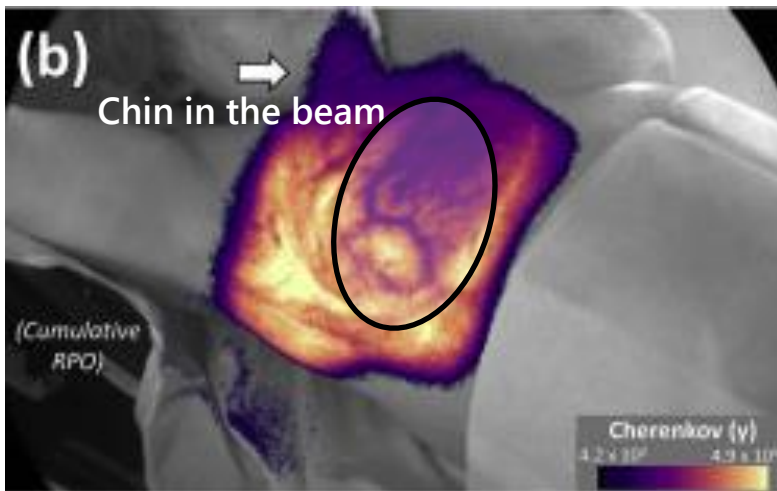
Live Cherenkov Video

Cumulative Cherenkov Image

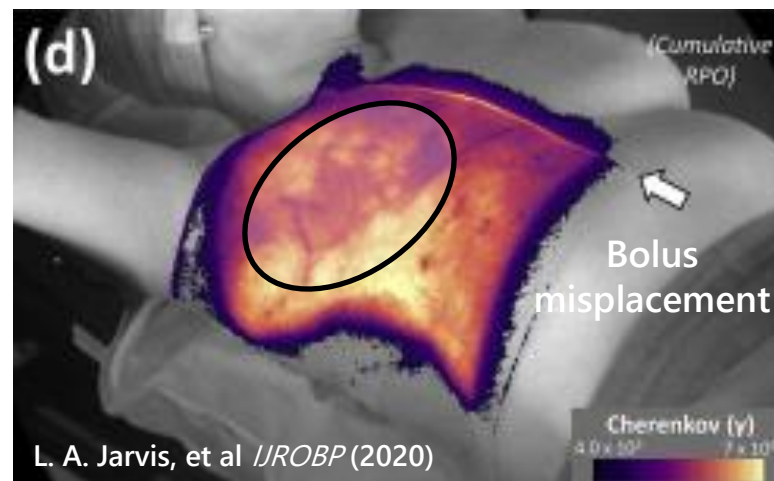
At the point of **generation**
Cherenkov is linearly
proportional to dose

BUT

The **imaged** profile loses
the proportionality due to
tissue attenuation

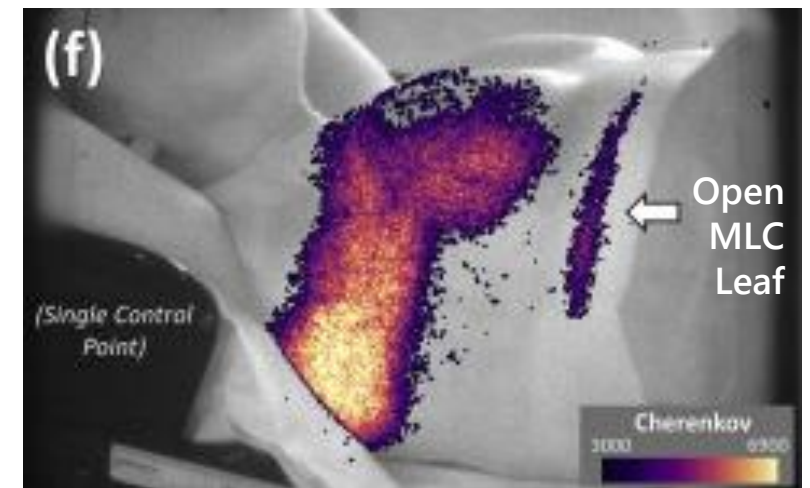


Unplanned anatomy in the beam

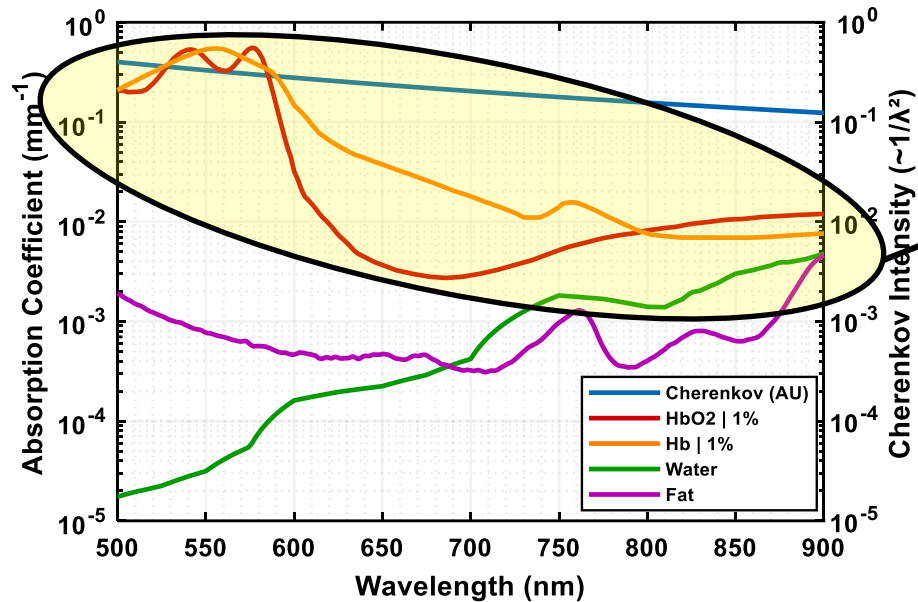


L. A. Jarvis, et al *IJROBP* (2020)

Accessory positioning

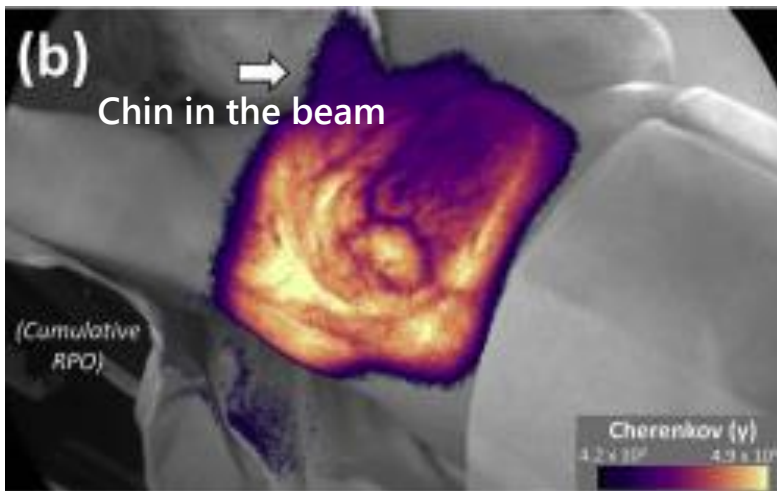


Plan errors

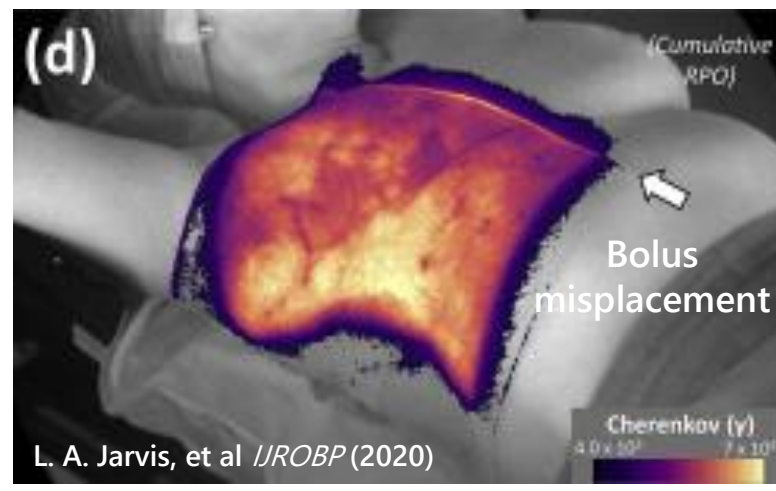


- Locally, the type and quantity of tissue attenuating constituents **cannot be predicted**
- Heterogeneous tissue attenuation is dominated by **blood content** and **variability in hemoglobin oxygenation**

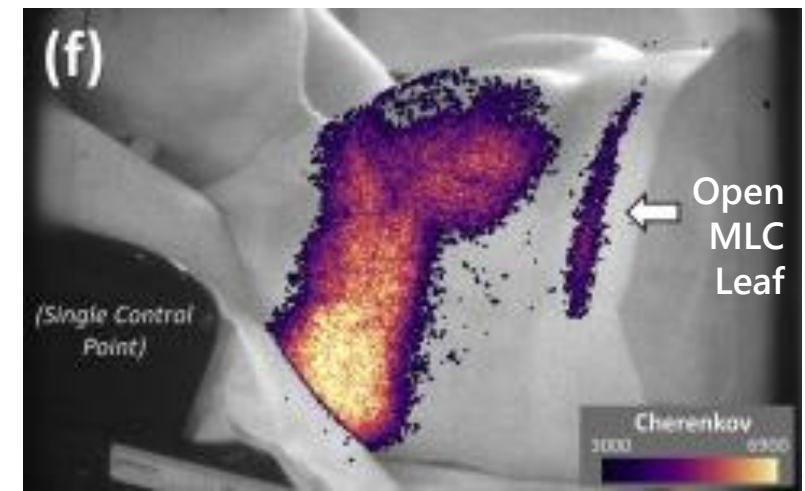
Correlate **Cherenkov spectral variability** with tissue properties to monitor for **physiological development** and **correct the signal attenuation**



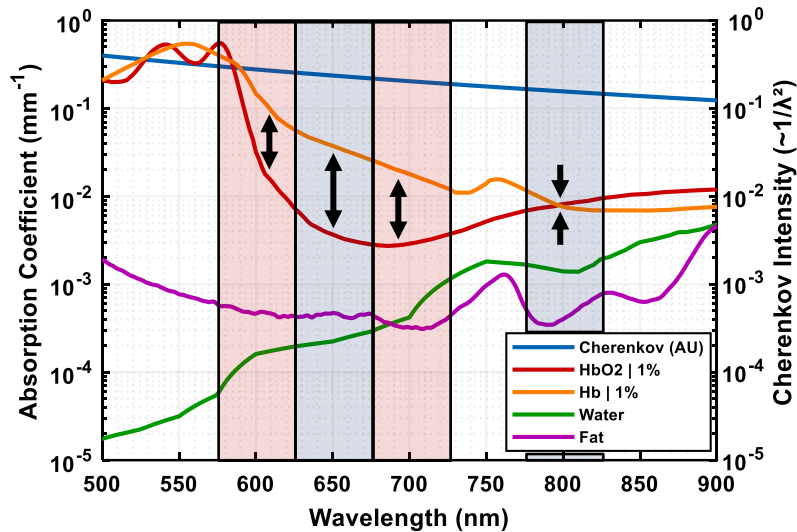
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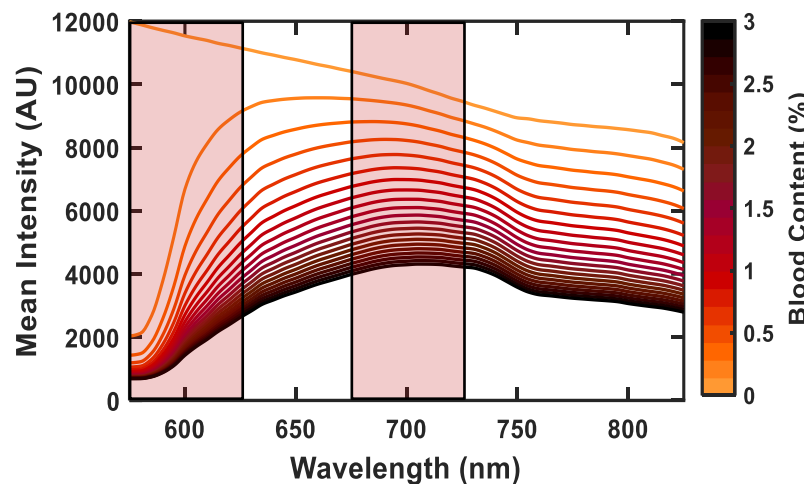
Accessory positioning



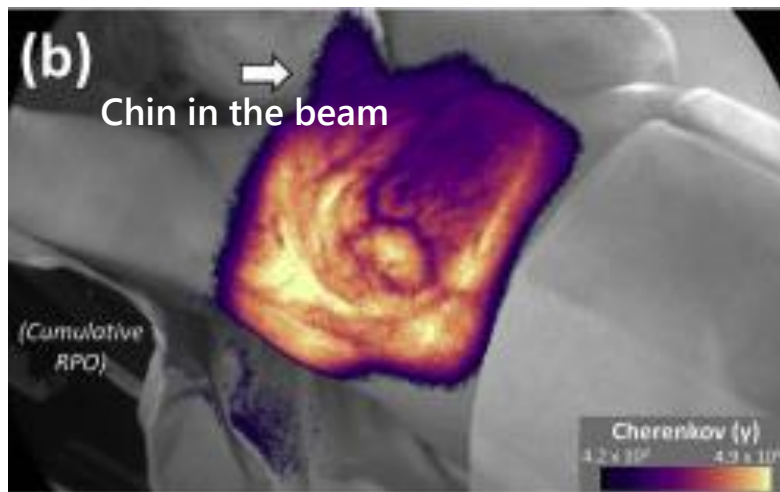
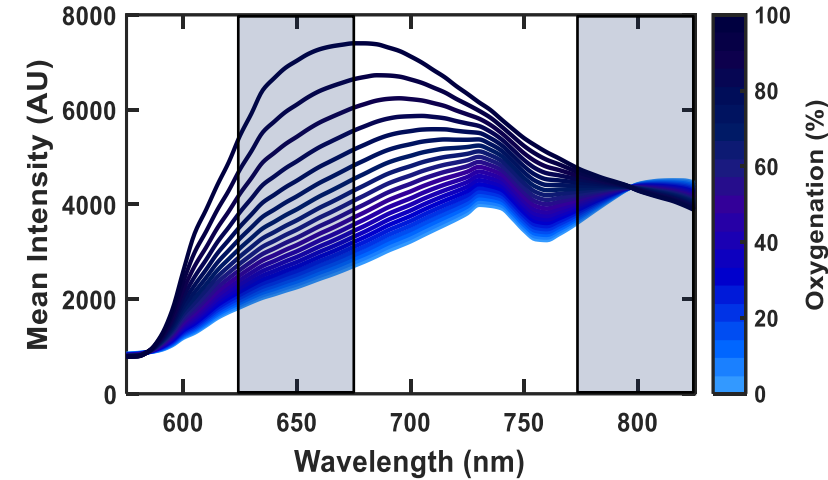
Plan errors



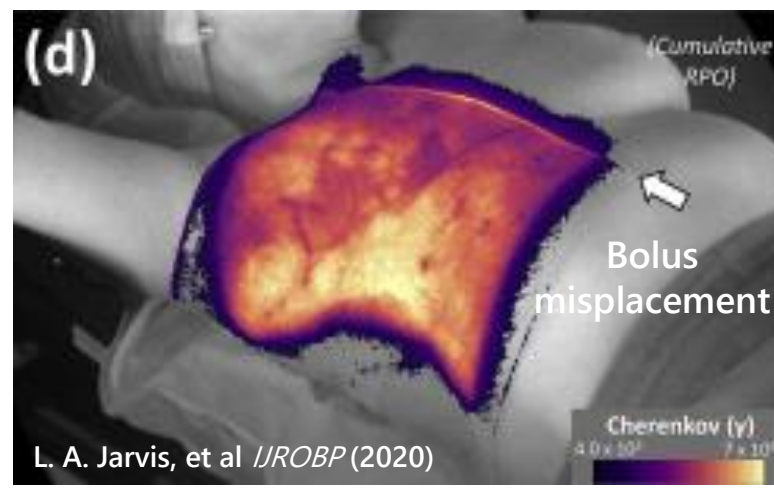
Spectral Response vs Blood Content



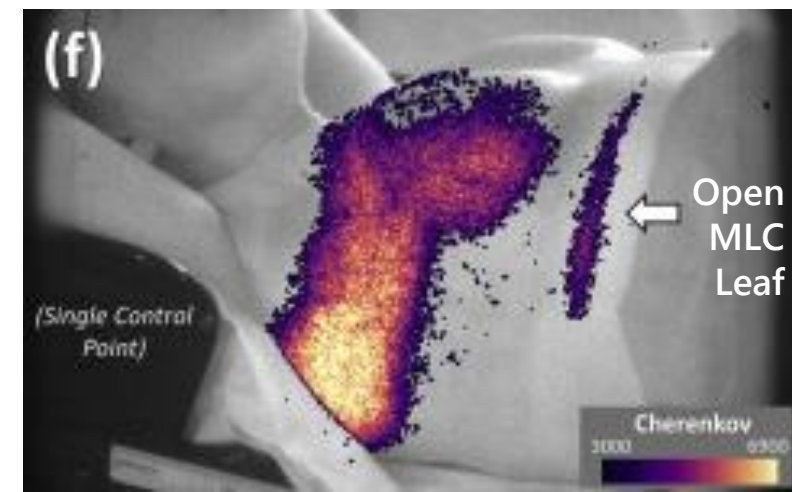
Spectral Response vs Oxygenation



Unplanned anatomy in the beam



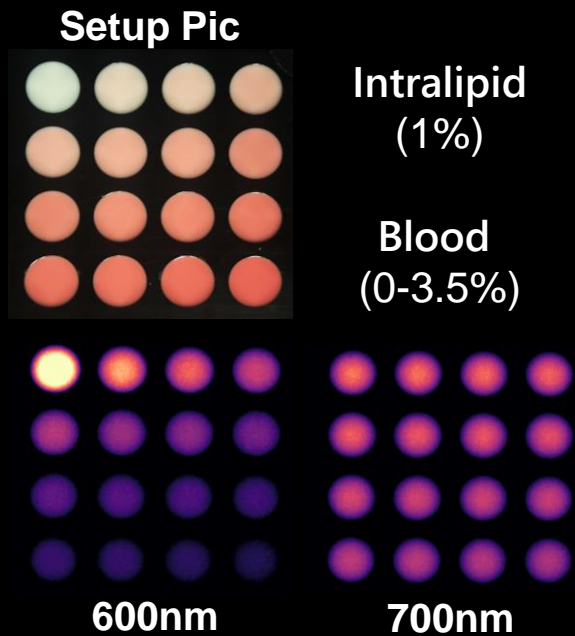
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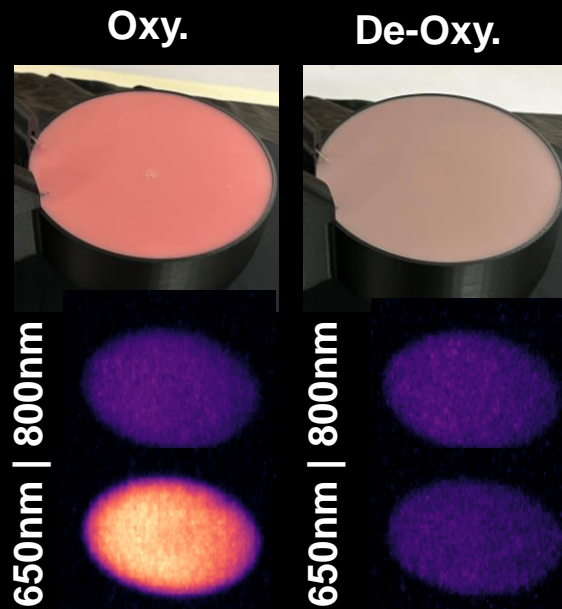
Plan errors

Incorporating Simulation Results – Blood and Oxygenation Phantom Analysis

Blood Phantom Testing

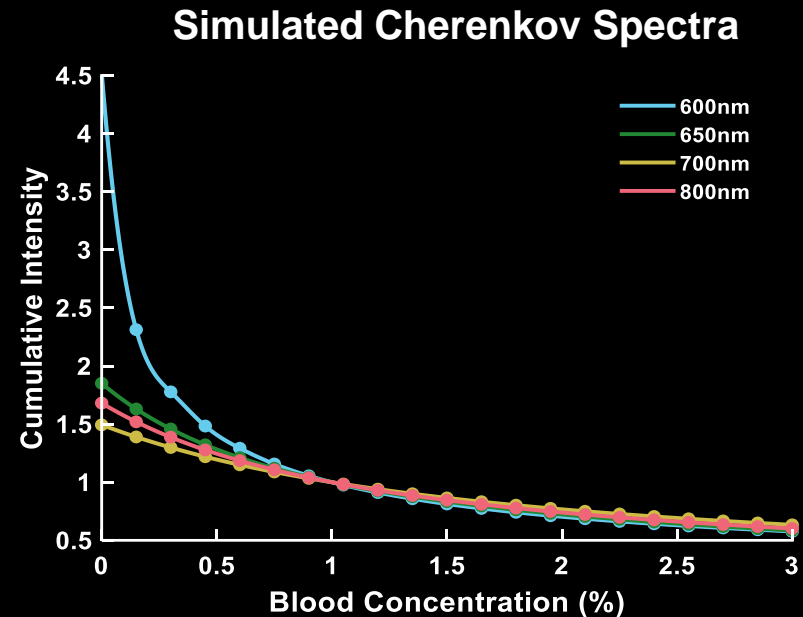
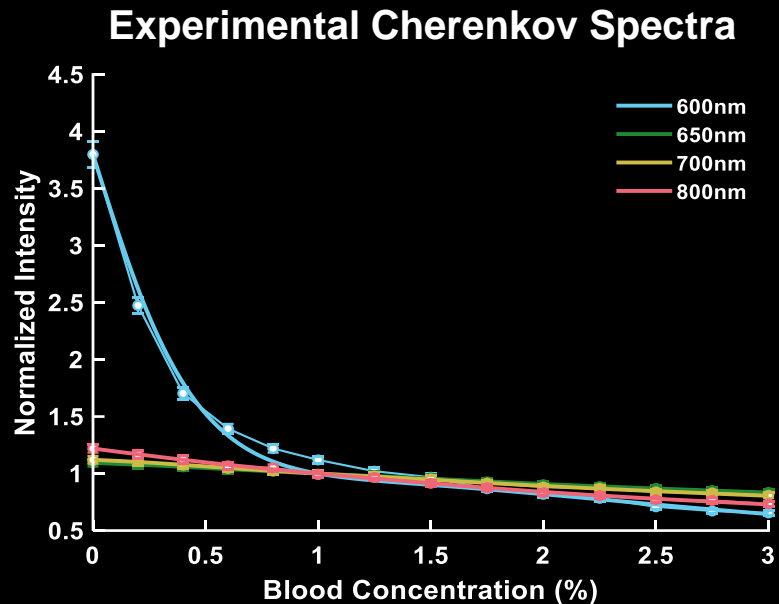
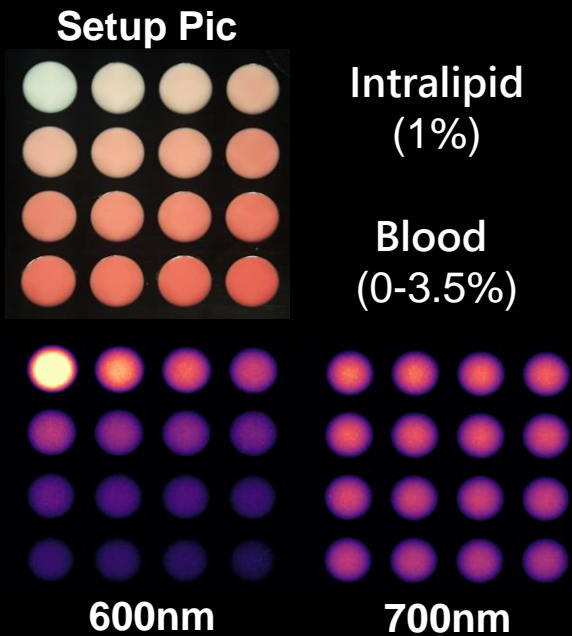


Oxygen Phantom Testing

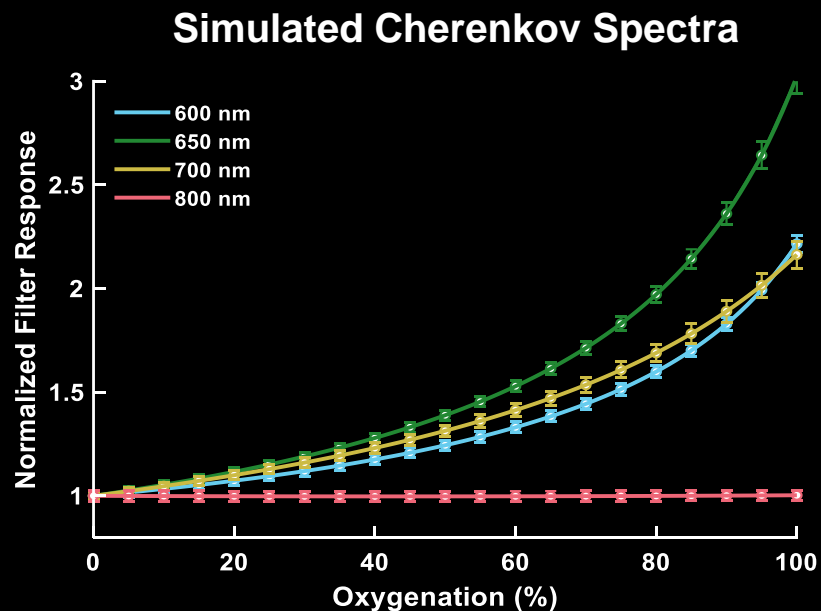
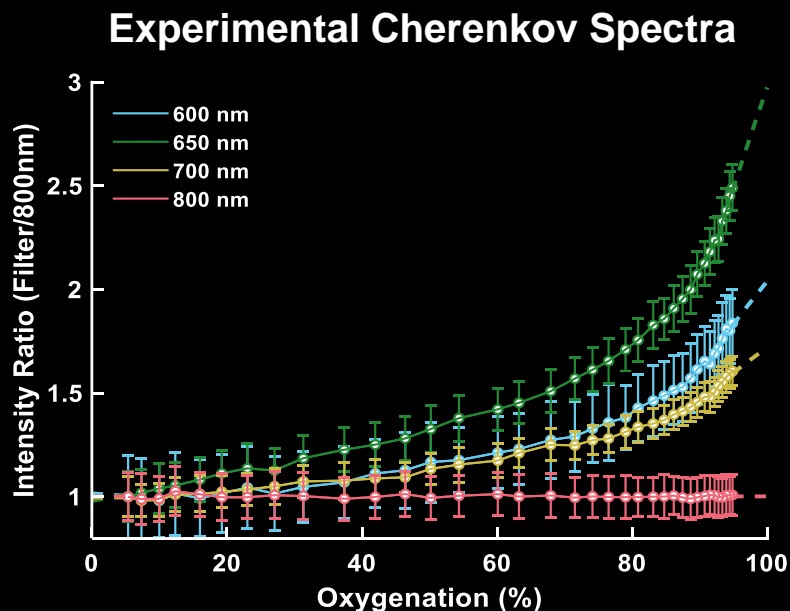
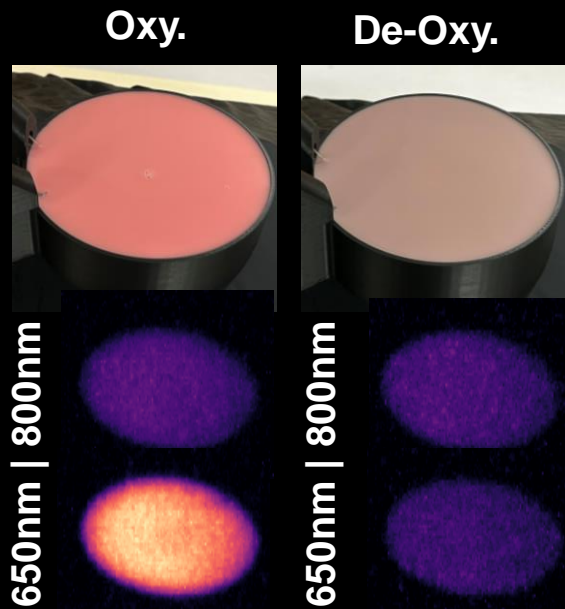


Incorporating Simulation Results – Blood and Oxygenation Phantom Analysis

Blood Phantom Testing

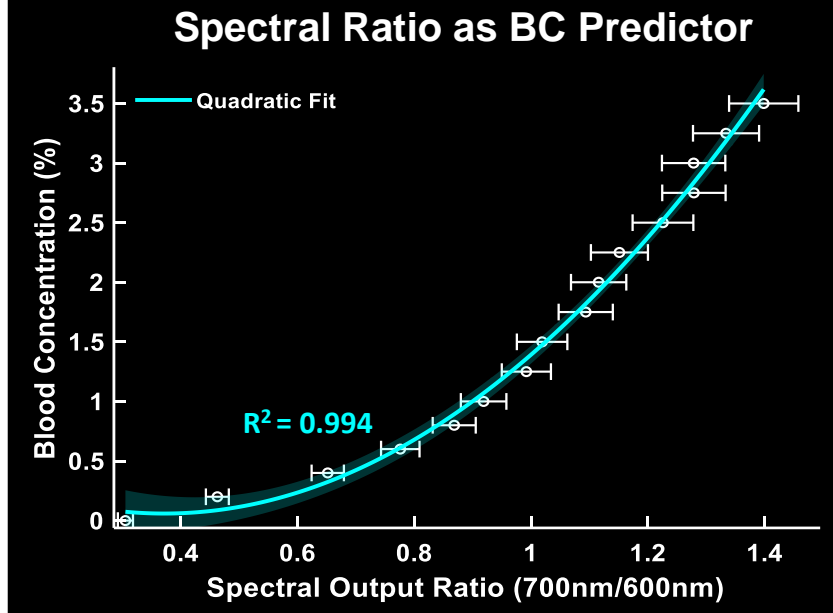
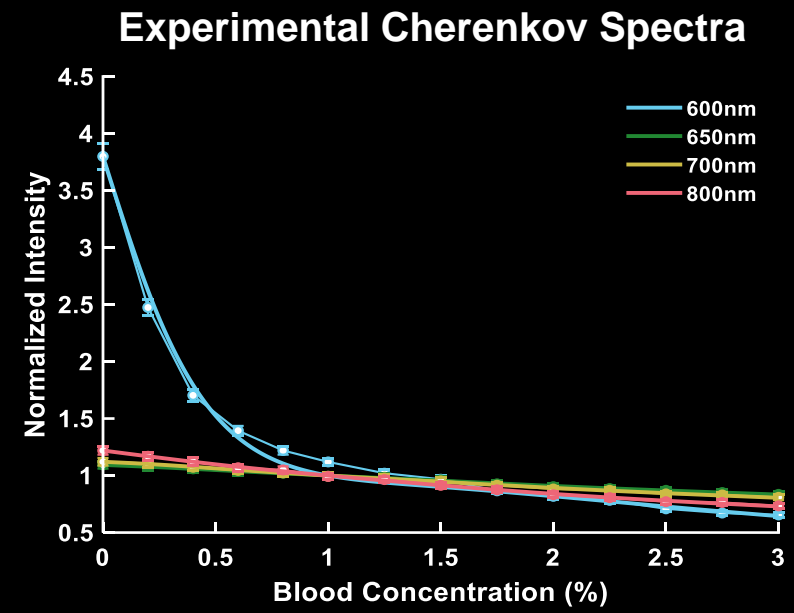
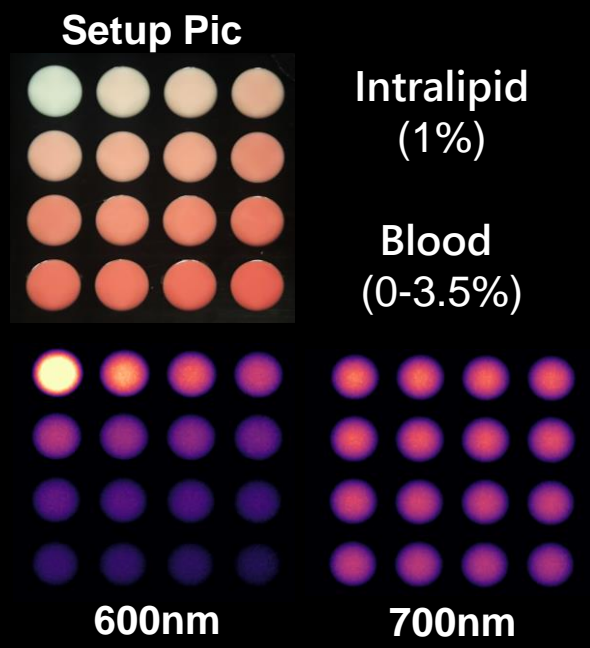


Oxygen Phantom Testing

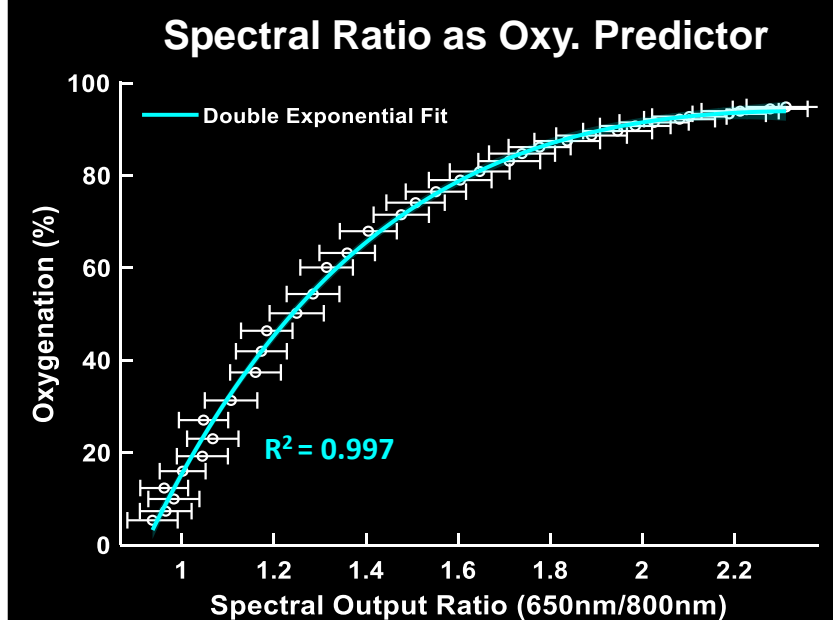
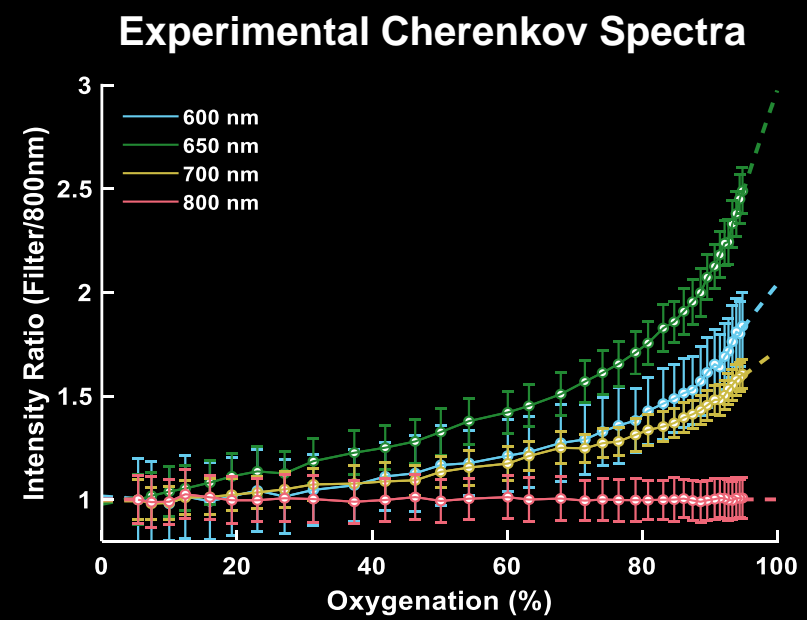
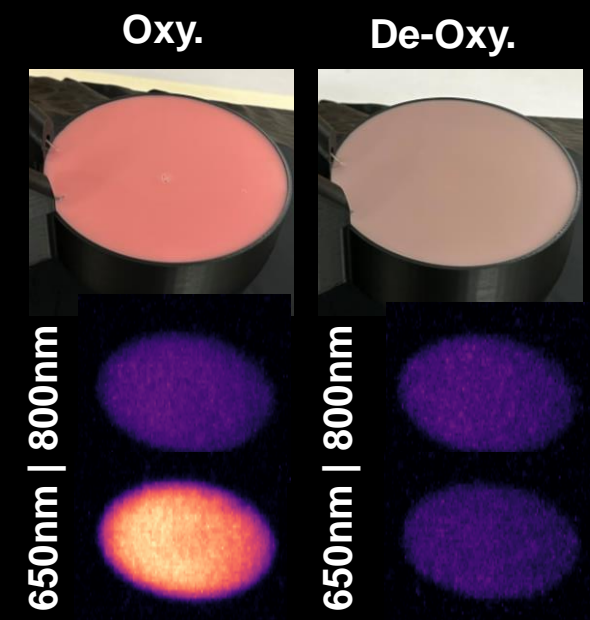


Cherenkov Spectral Comparison as a Predictor for Single Factor Tissue Constituents

Blood Phantom Testing

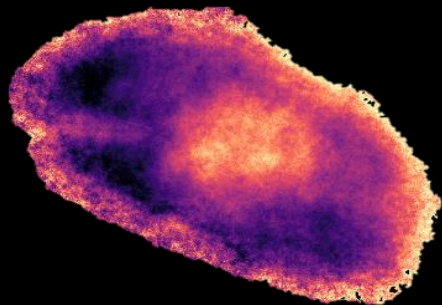
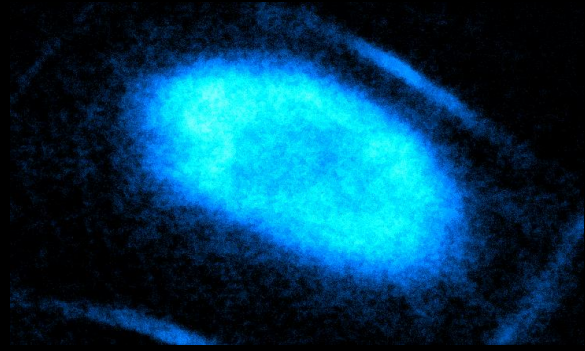


Oxygen Phantom Testing

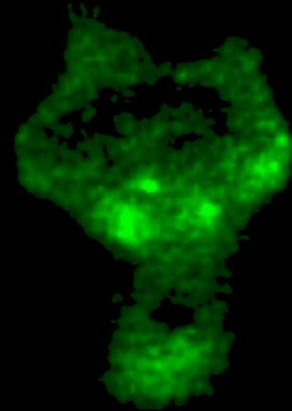
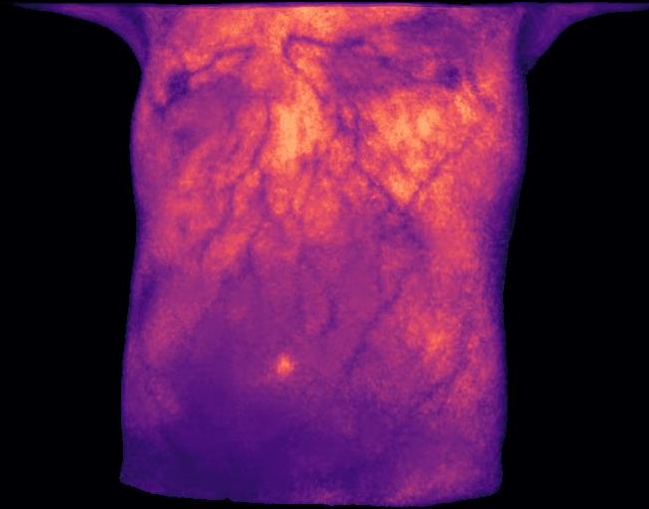


First Multispectral Cherenkov Clinical Imaging

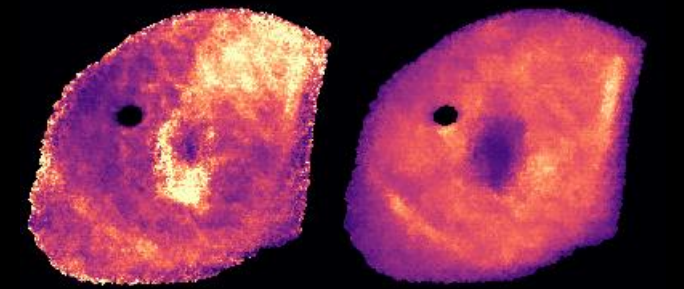
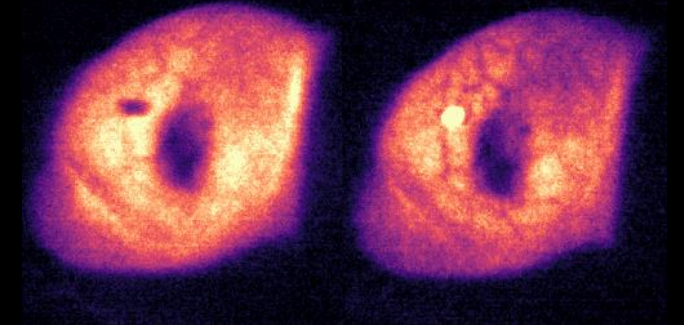
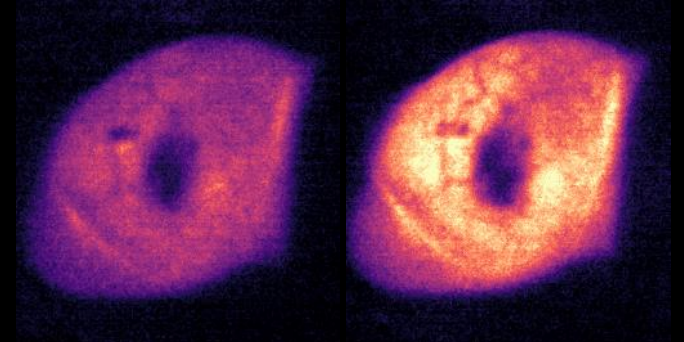
MCL Imaging



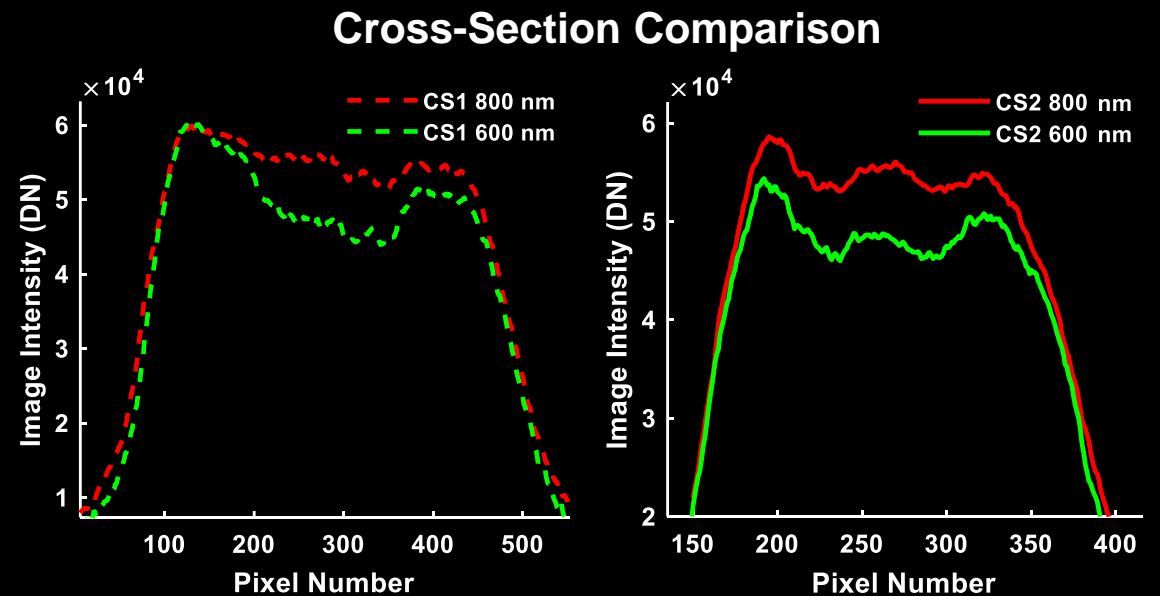
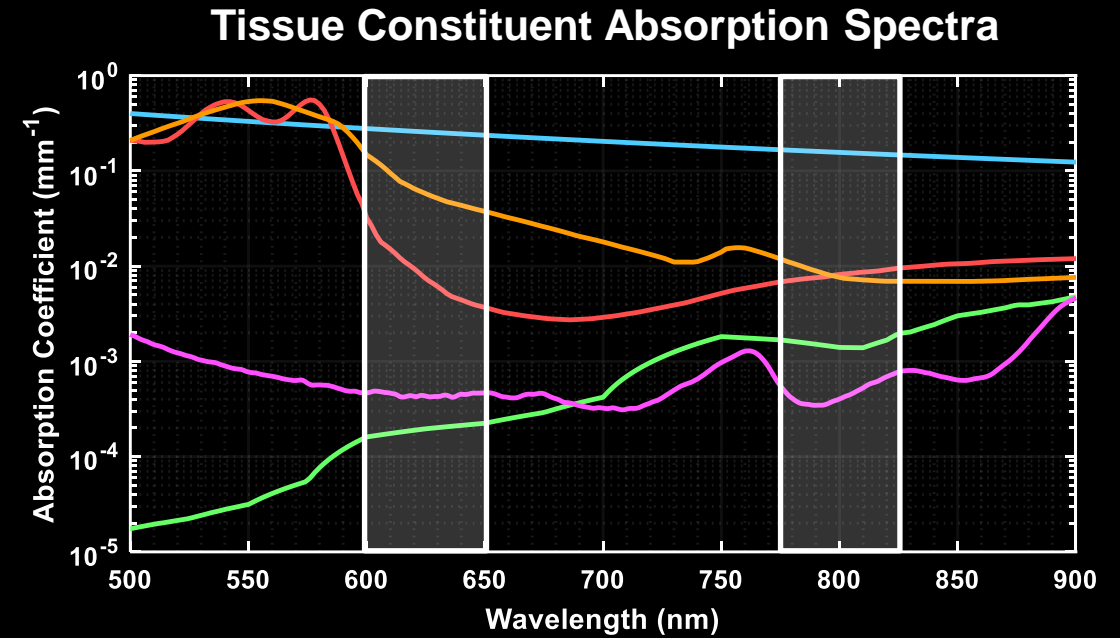
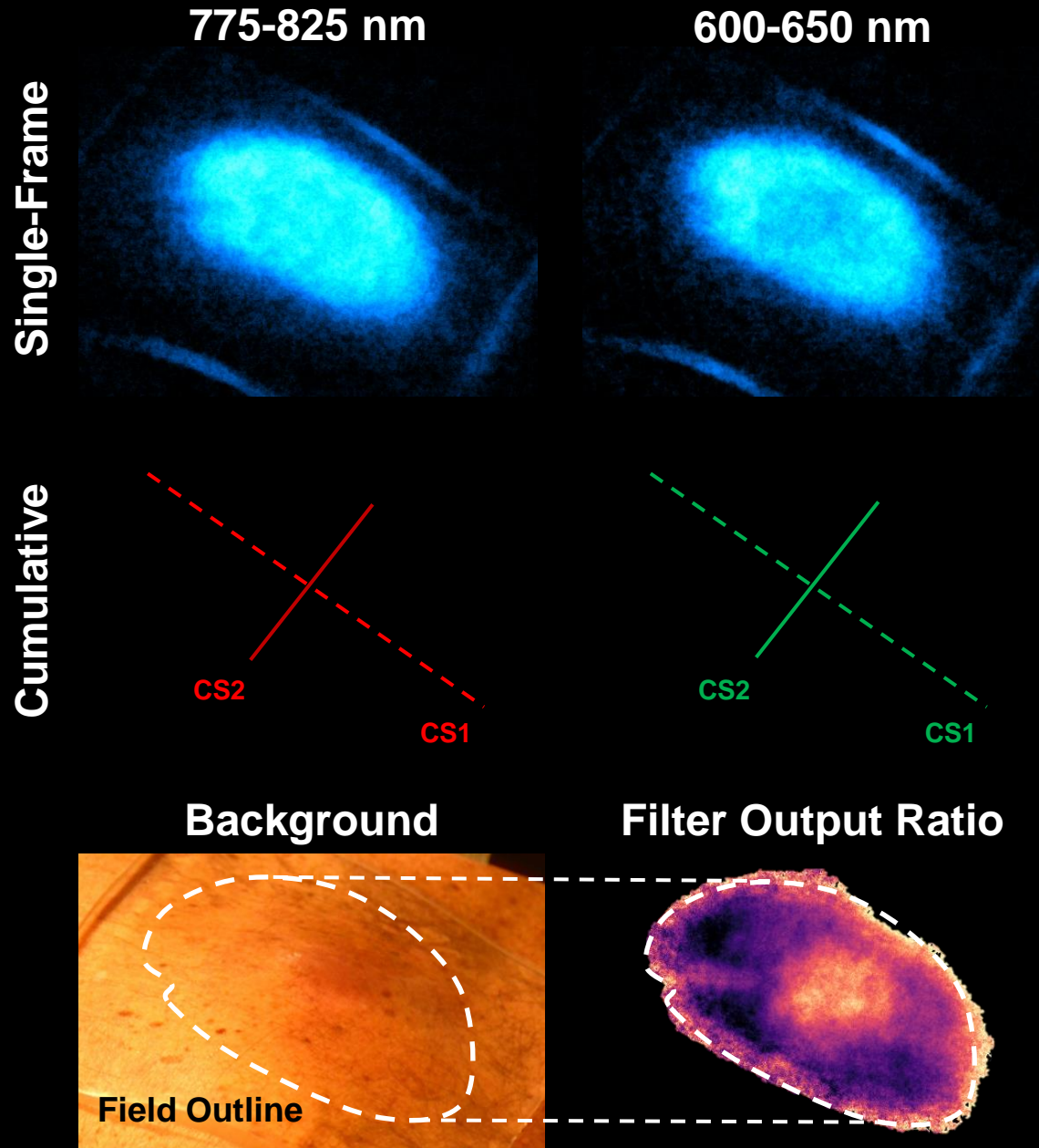
TSET Imaging



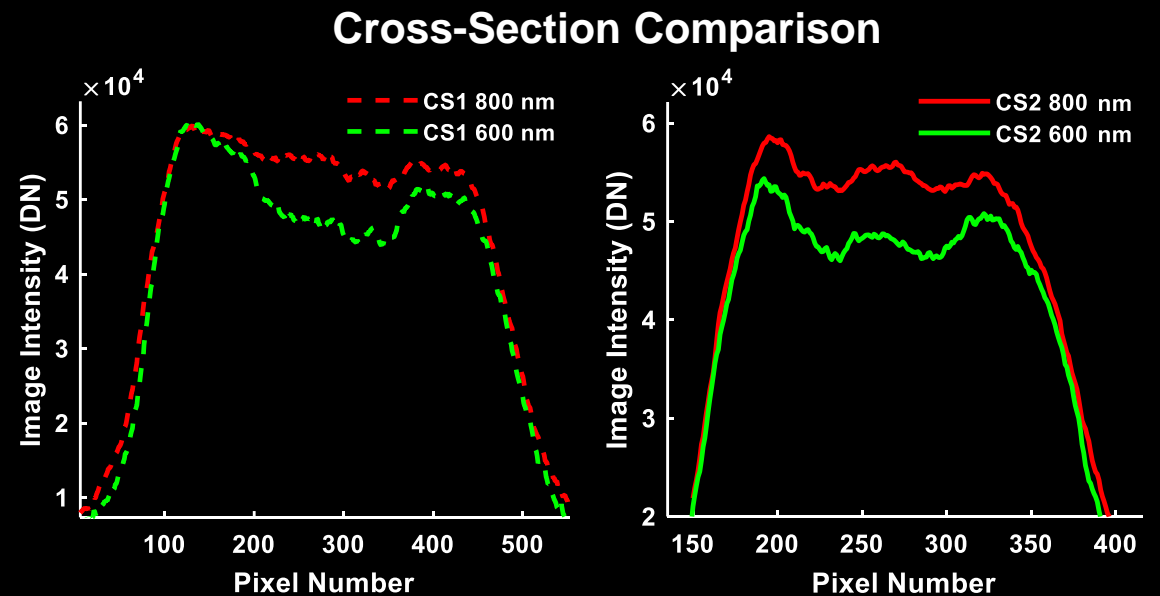
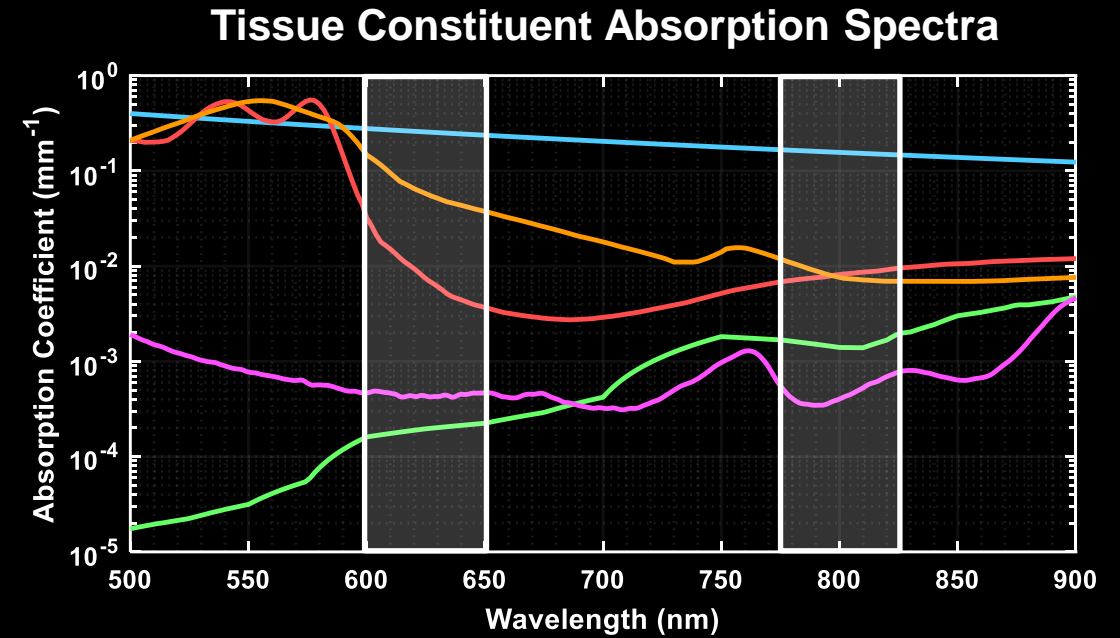
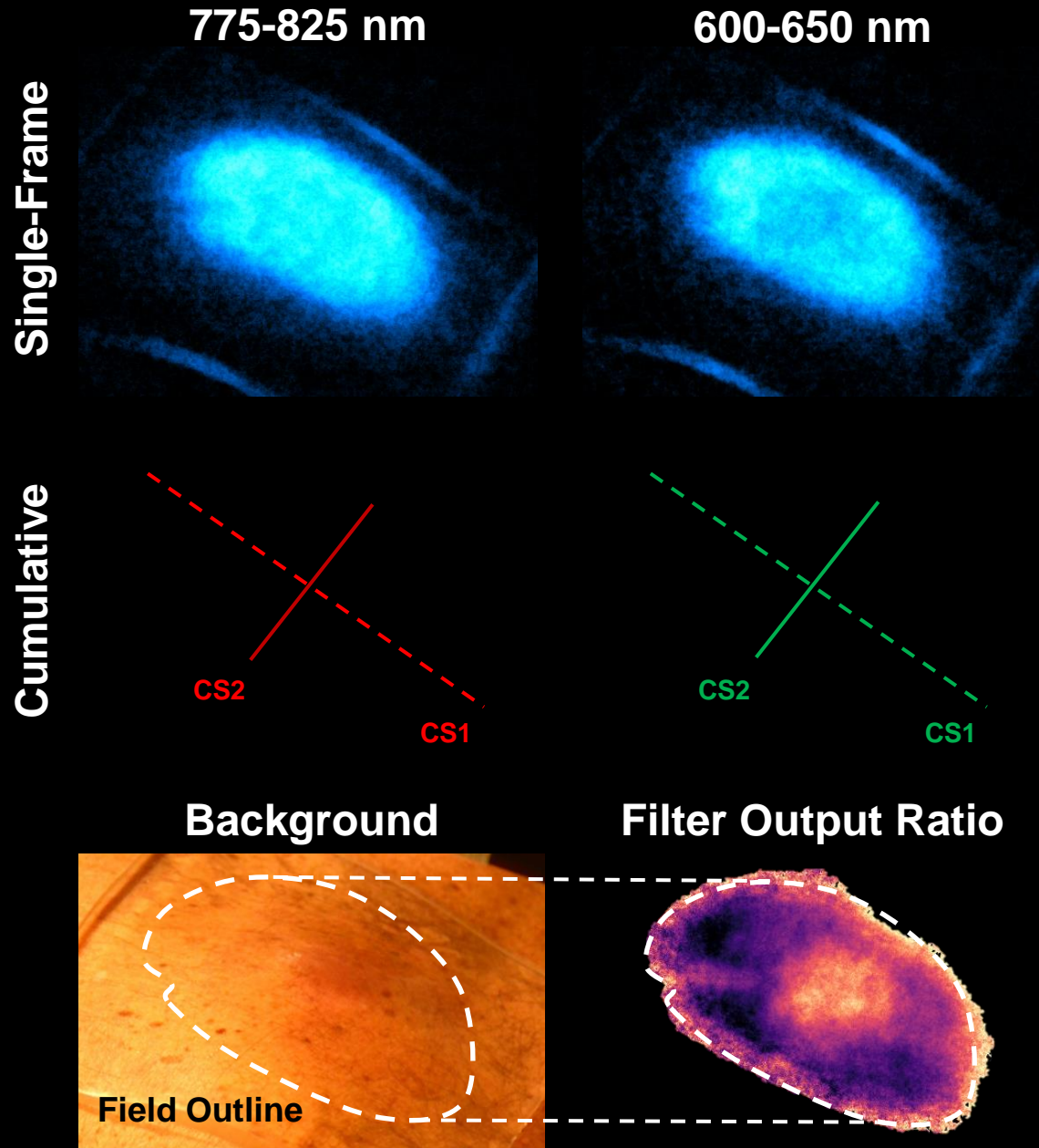
Breast RT Imaging



Mantle Cell Lymphoma Surface Imaging – Hypoxic Core Correlation

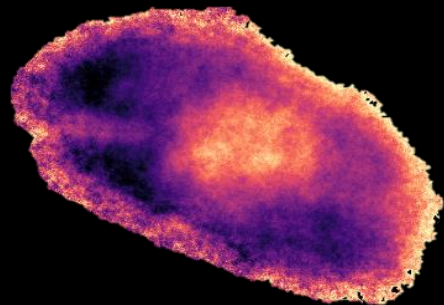
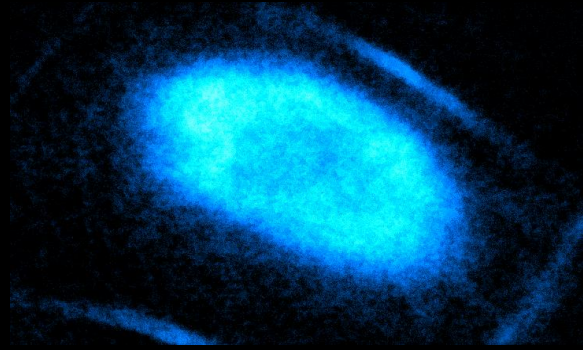


Mantle Cell Lymphoma Surface Imaging – Hypoxic Core Correlation

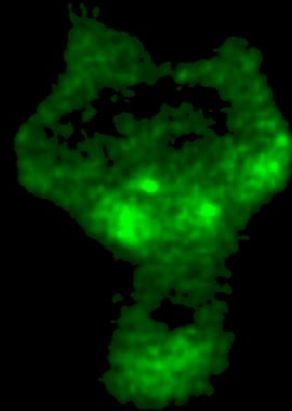
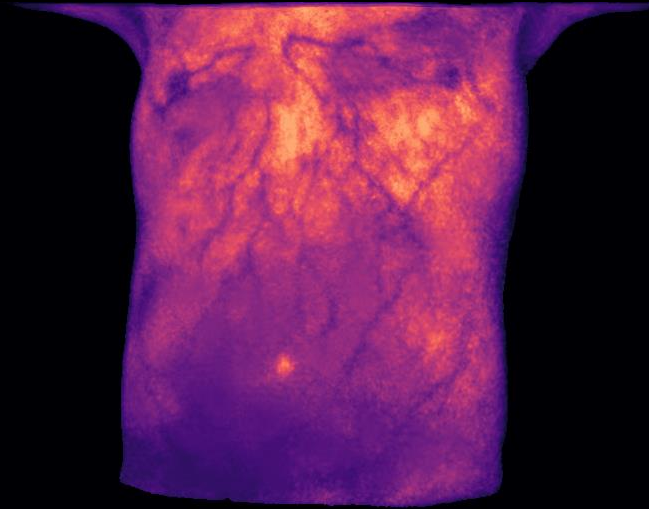


First Multispectral Cherenkov Clinical Imaging

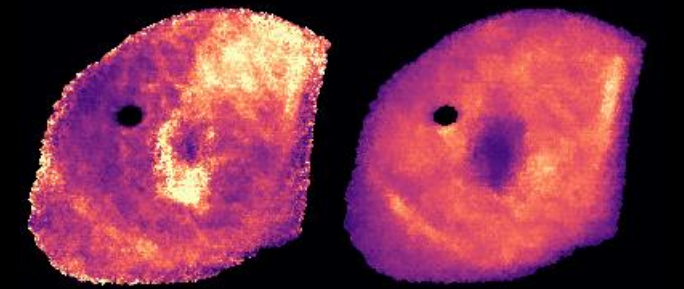
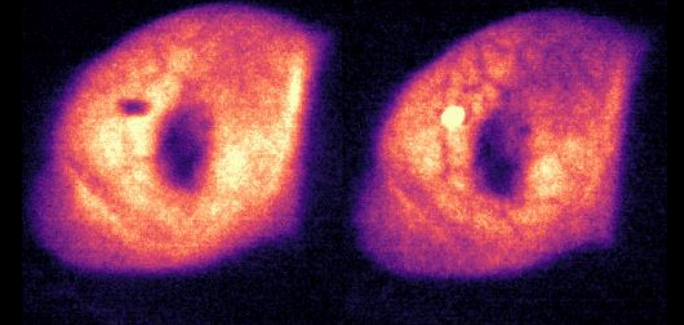
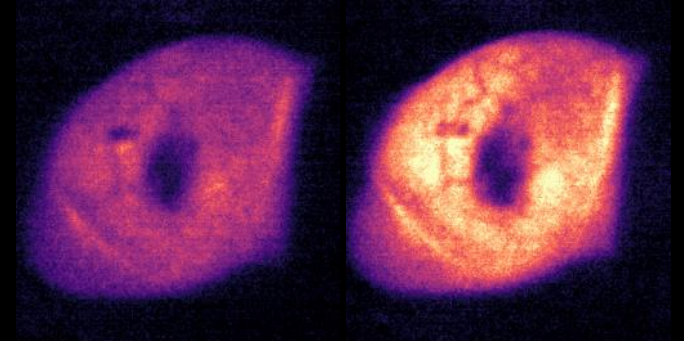
MCL Imaging



TSET Imaging

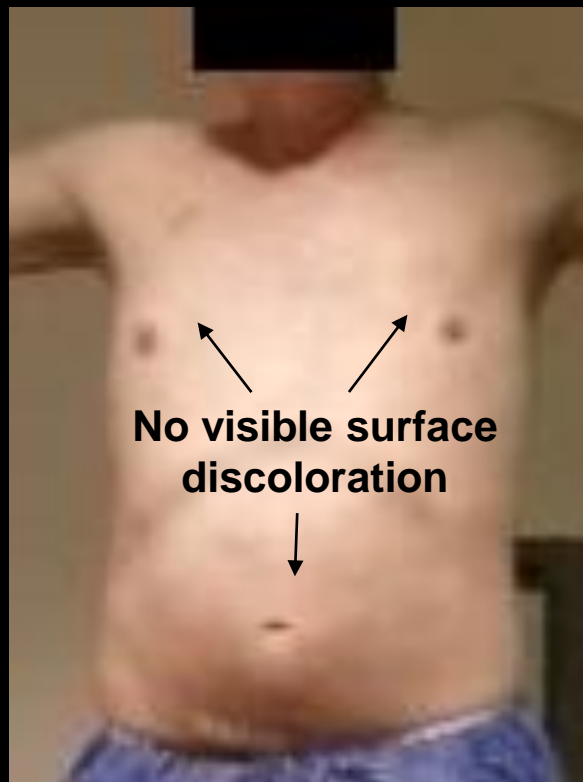


Breast RT Imaging

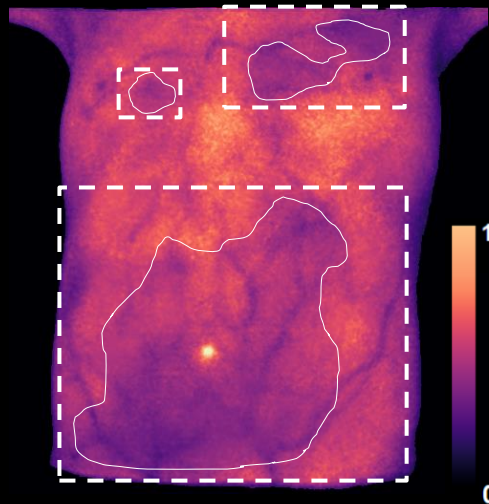


Total Skin Electron Therapy Imaging – Disease Correlation

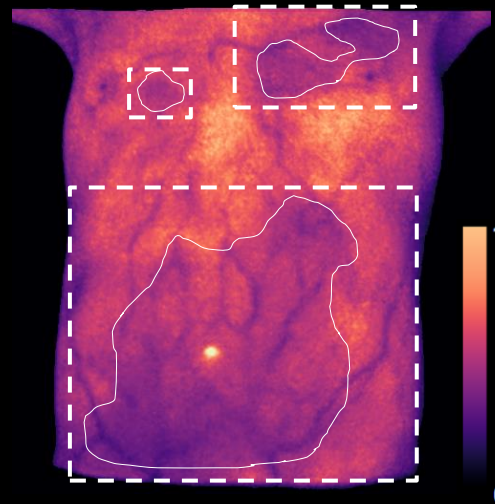
**Clinical
Surface Image**



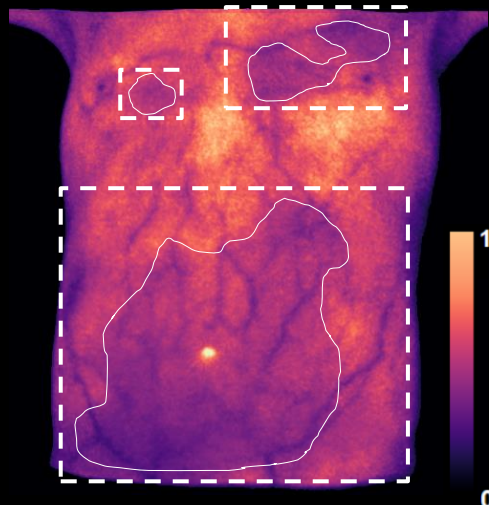
Filter 1
800 (775-825) nm



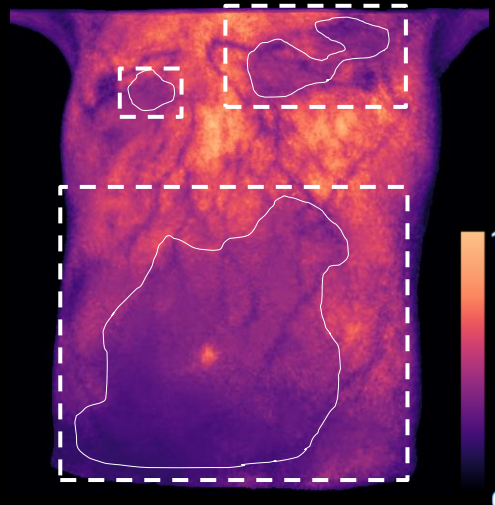
Filter 2
700 (675-725) nm



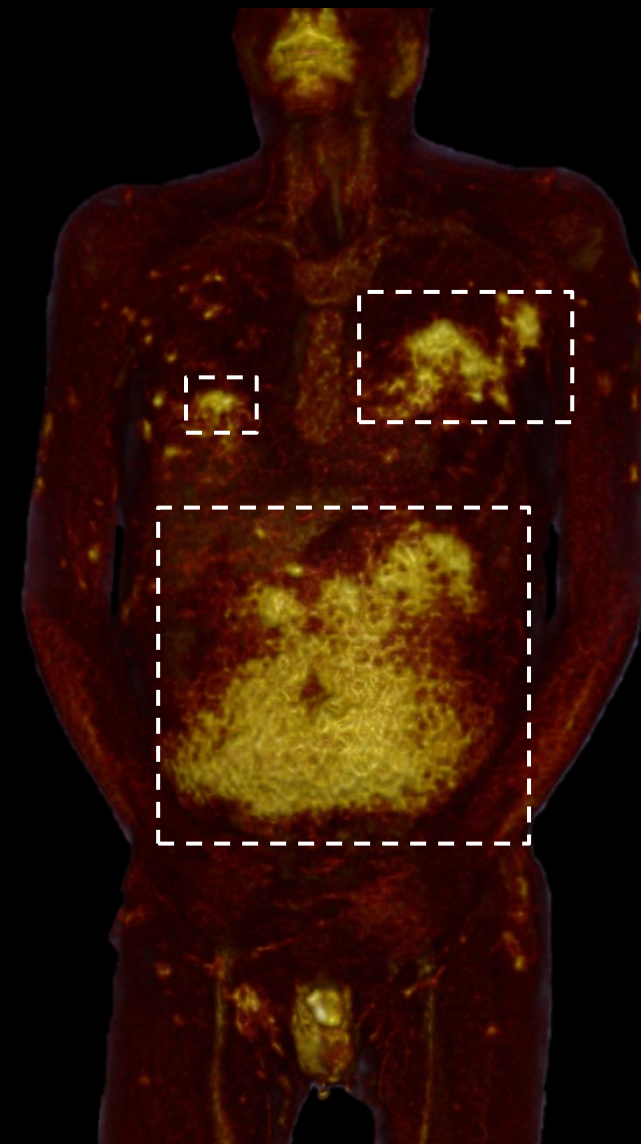
Filter 3
650 (625-675) nm



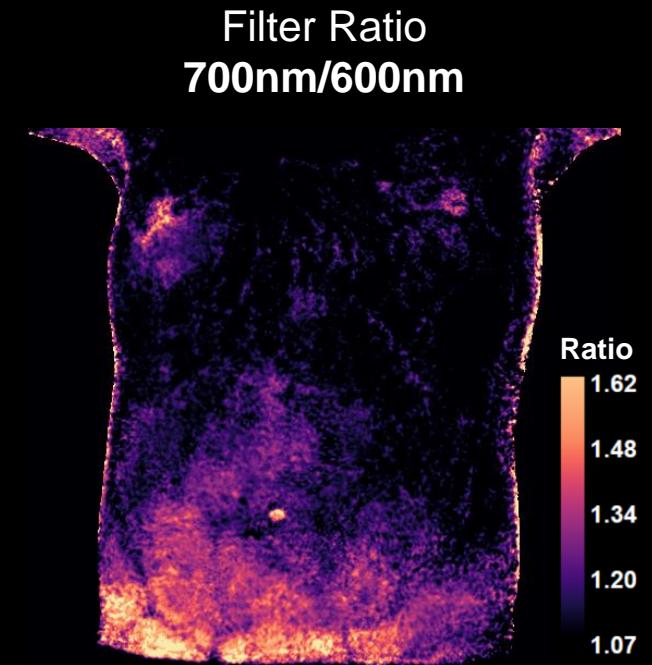
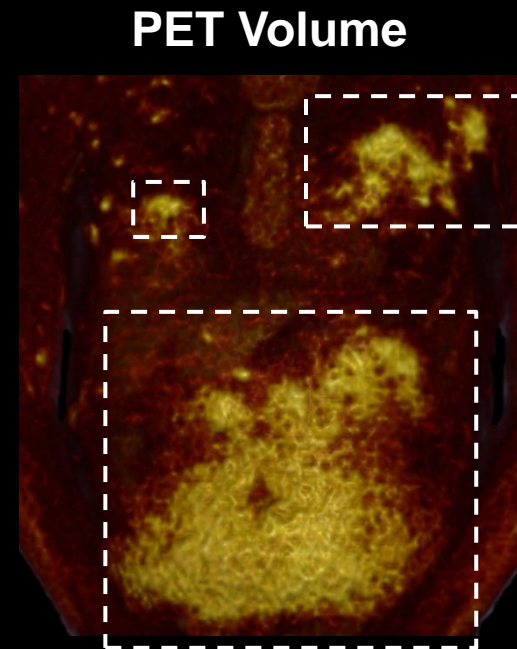
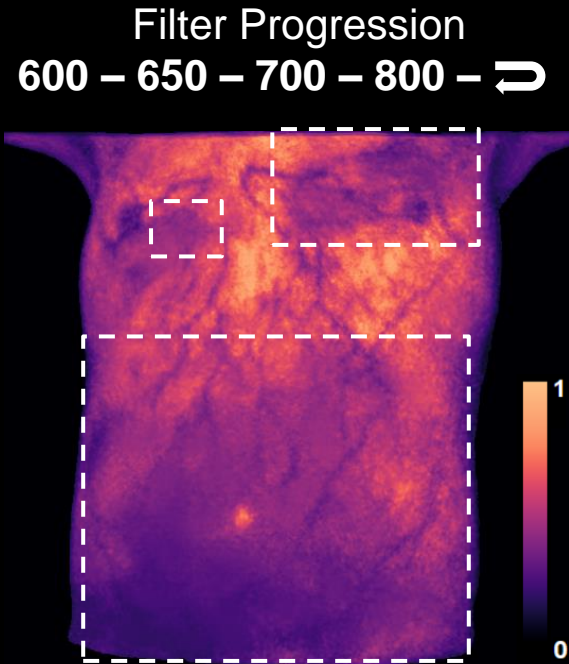
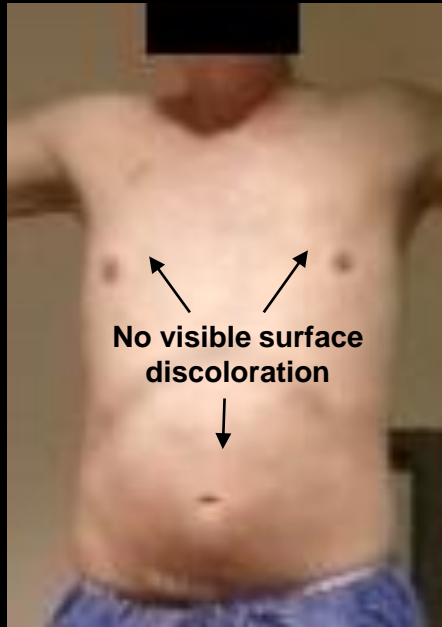
Filter 4
600 (575-625) nm



PET Volume

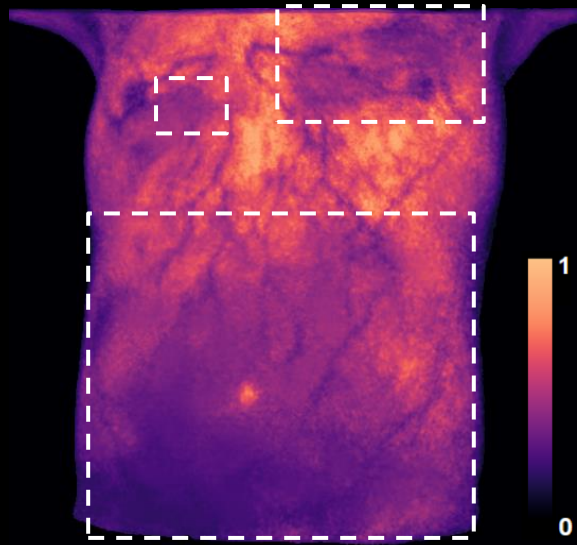


Total Skin Electron Therapy Imaging – Depth Correlation

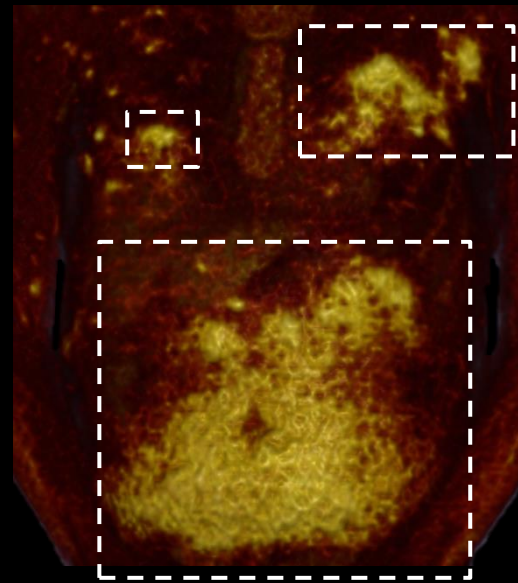


Total Skin Electron Therapy Imaging – Depth Correlation

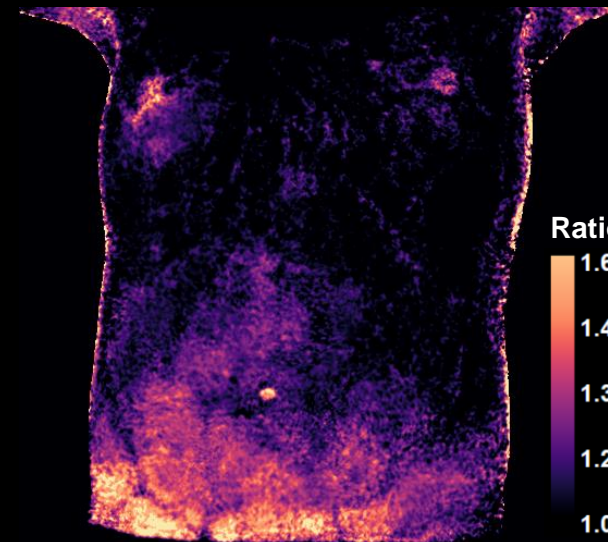
Filter Progression
600 – 650 – 700 – 800 – ↻



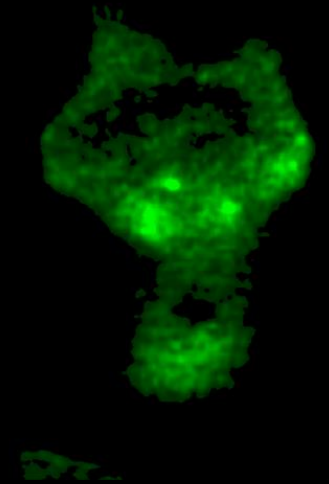
PET Volume



Filter Ratio
700nm/600nm

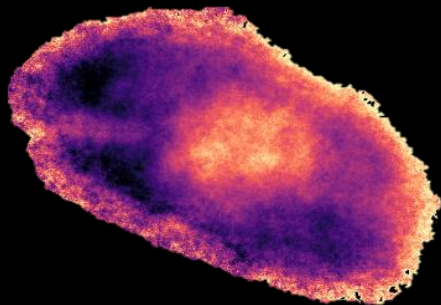
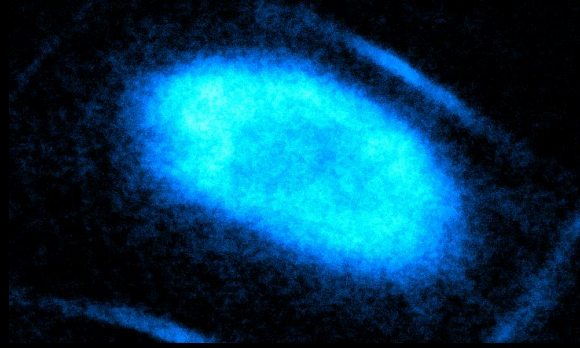


Shallow – Deep

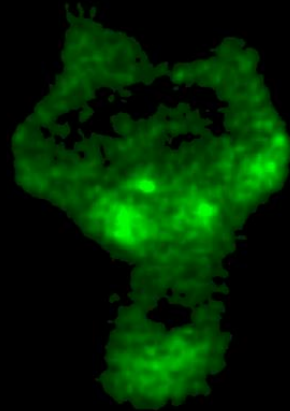
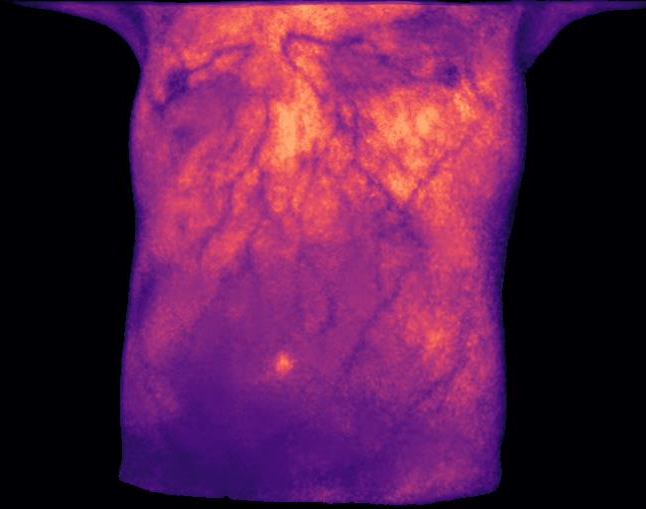


First Multispectral Cherenkov Clinical Imaging

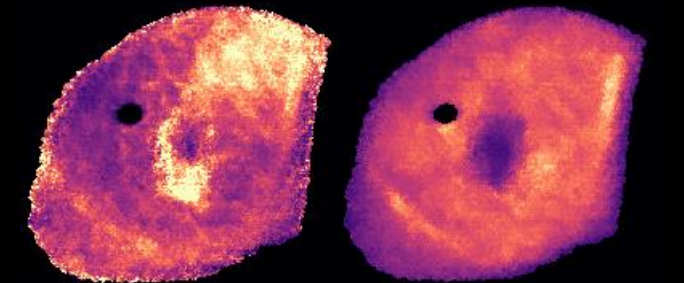
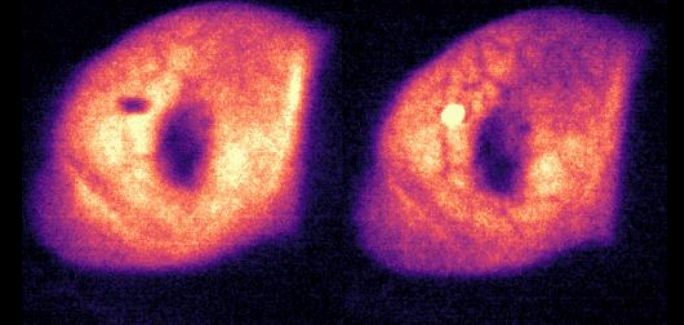
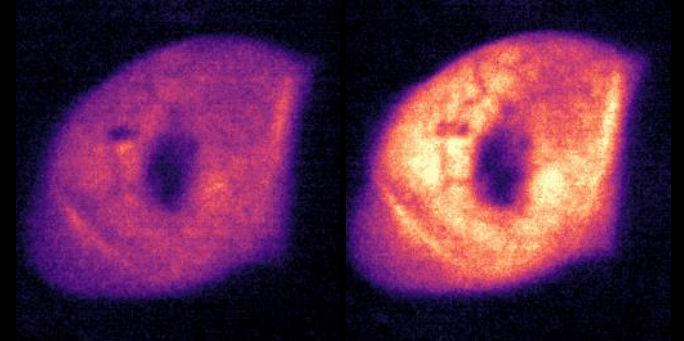
MCL Imaging



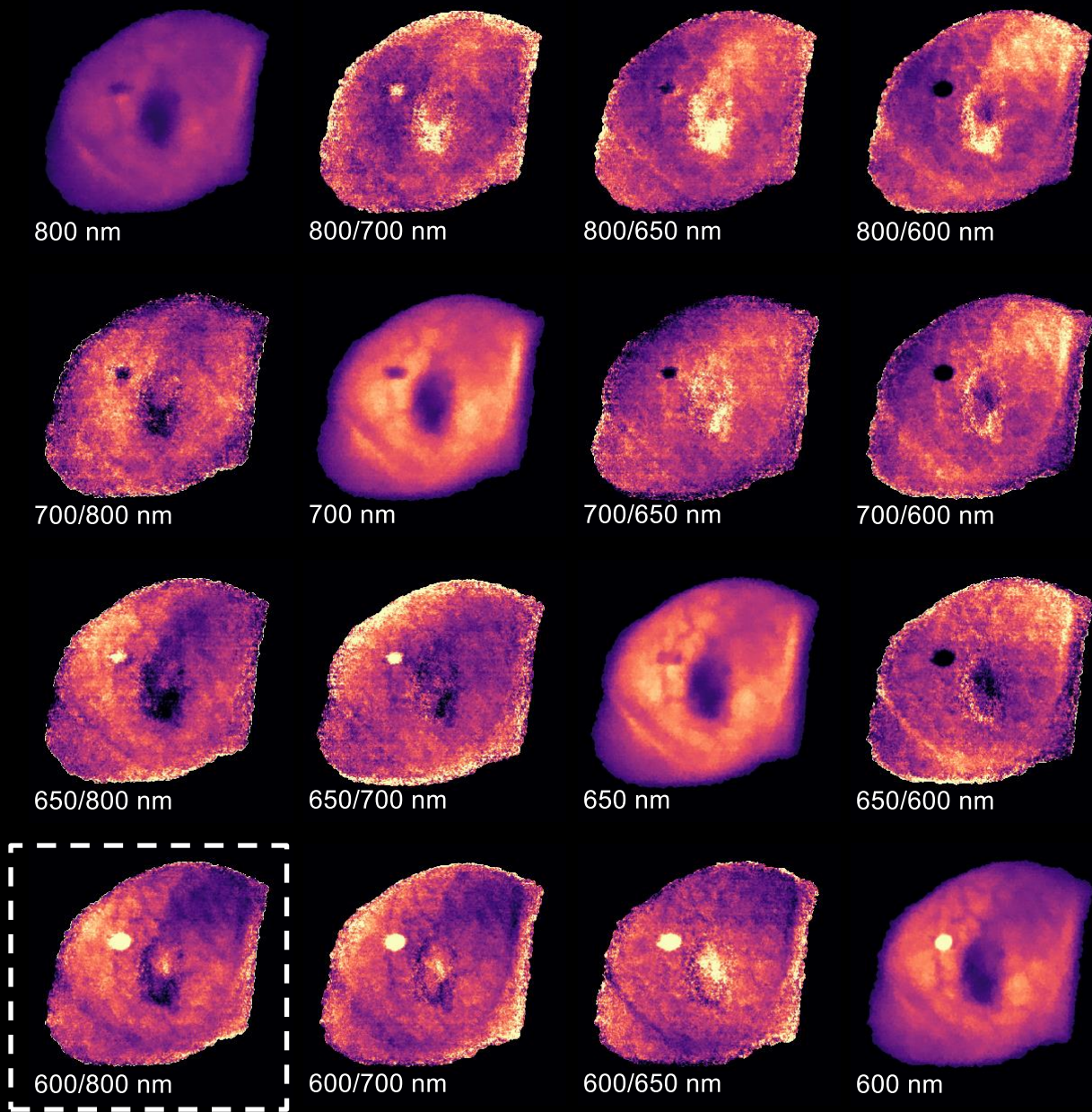
TSET Imaging



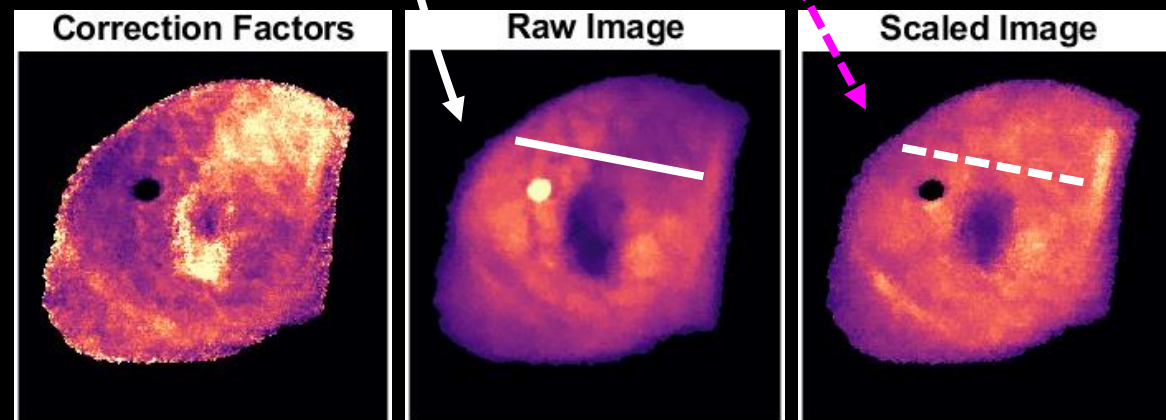
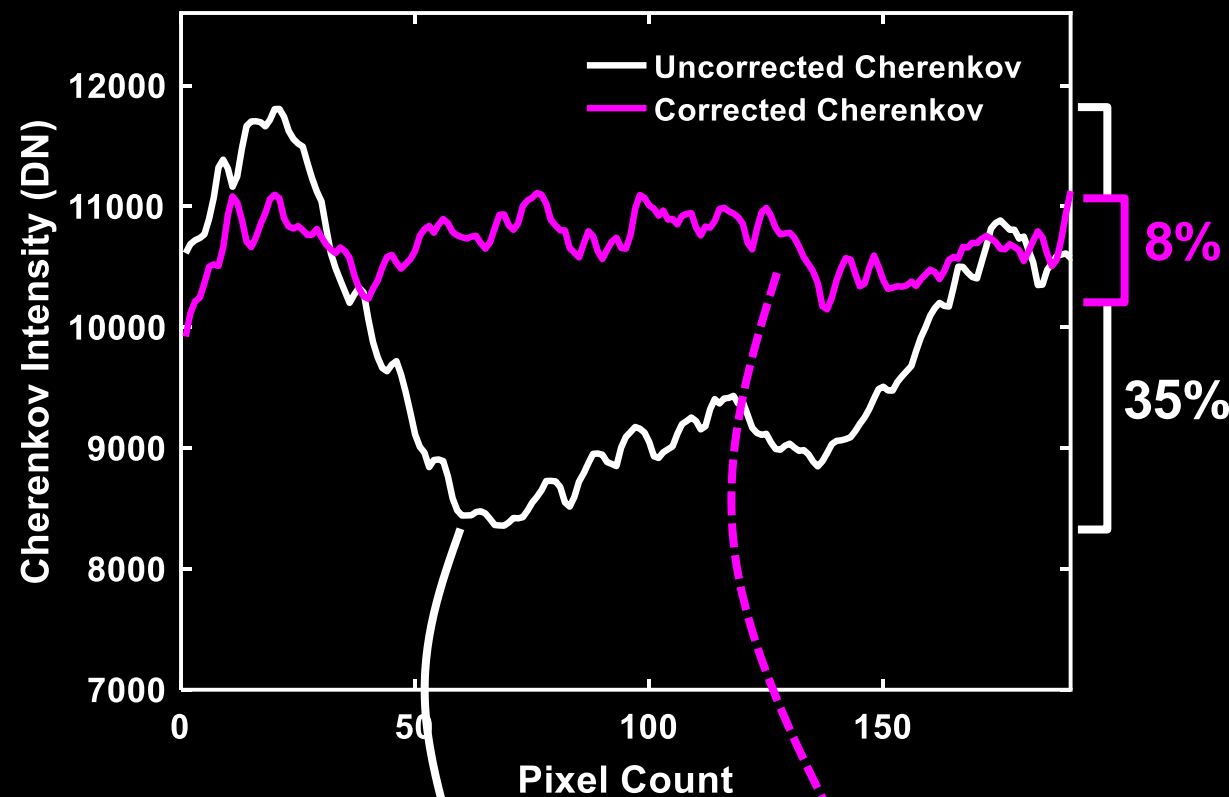
Breast RT Imaging



Breast RT Spectral Imaging and Correction

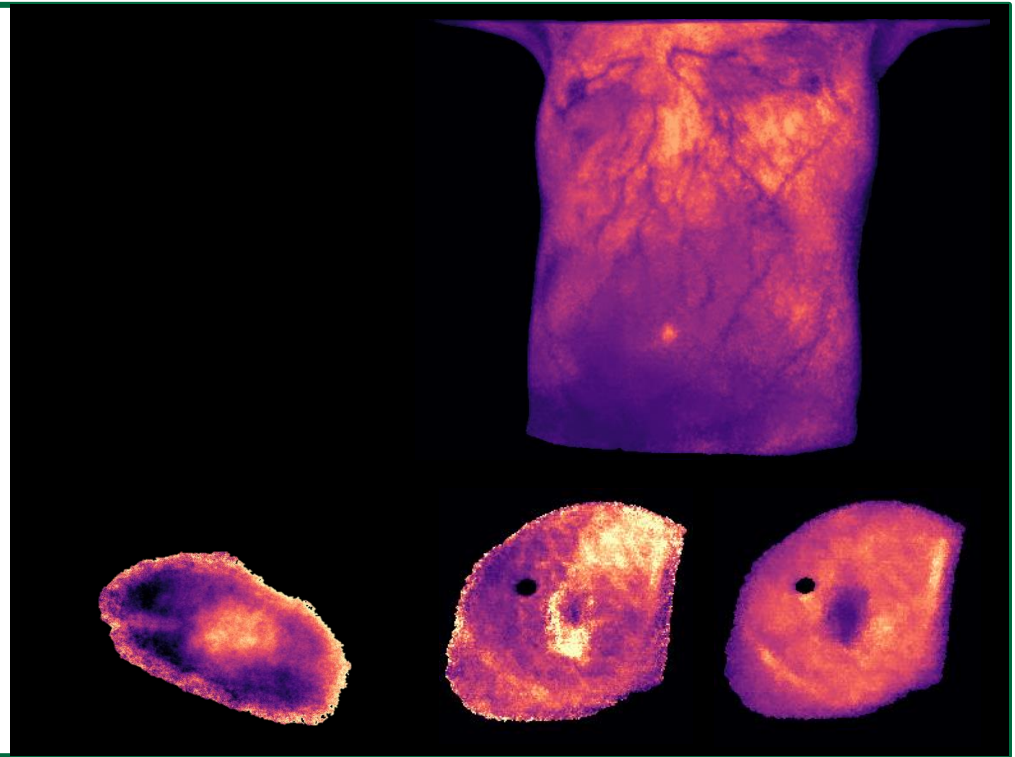


Cherenkov Image Line Profiles



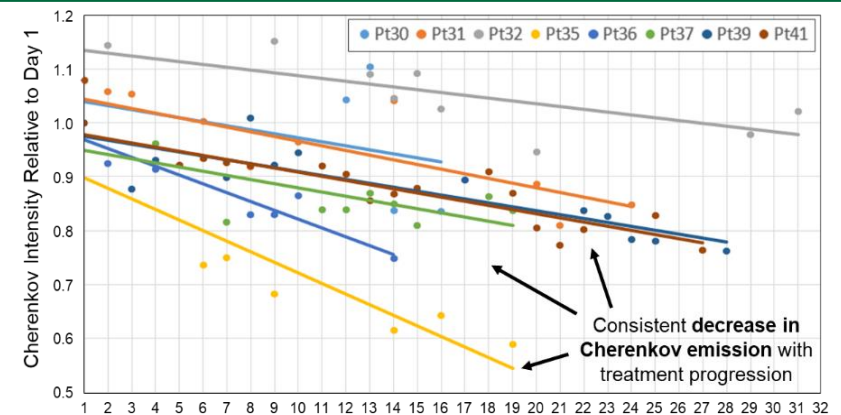
Conclusions

1. Developed an approach for **spectrally analyzing Cherenkov signal** during treatment delivery
2. Simulated and validated spectral variations with **blood content and tissue oxygenation** using **physical phantoms**
3. Clinically tested hardware, correlating spectral ratios to **disease progression, oxygenation** differences and **attenuation correction**



Future Directions

- Expand attenuation **correction to multiple factors** such as oxygenation, melanin, fat, and water
- Long term monitoring of treatment delivery and spectral correlation for **early prediction of skin effects/toxicity**



Thank You!



DARTMOUTH



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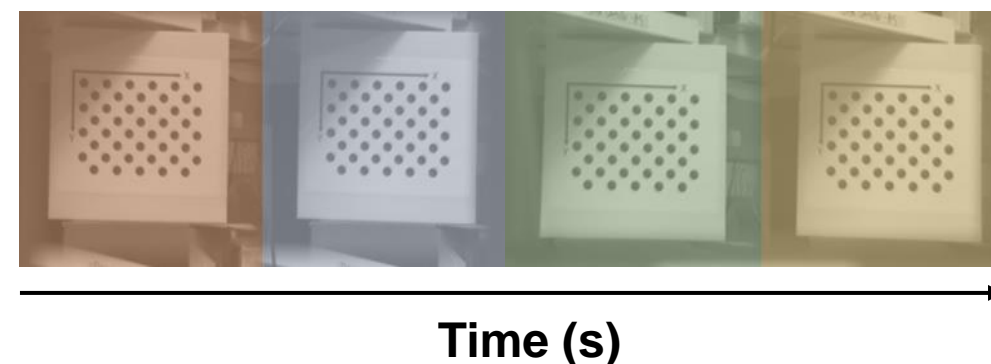
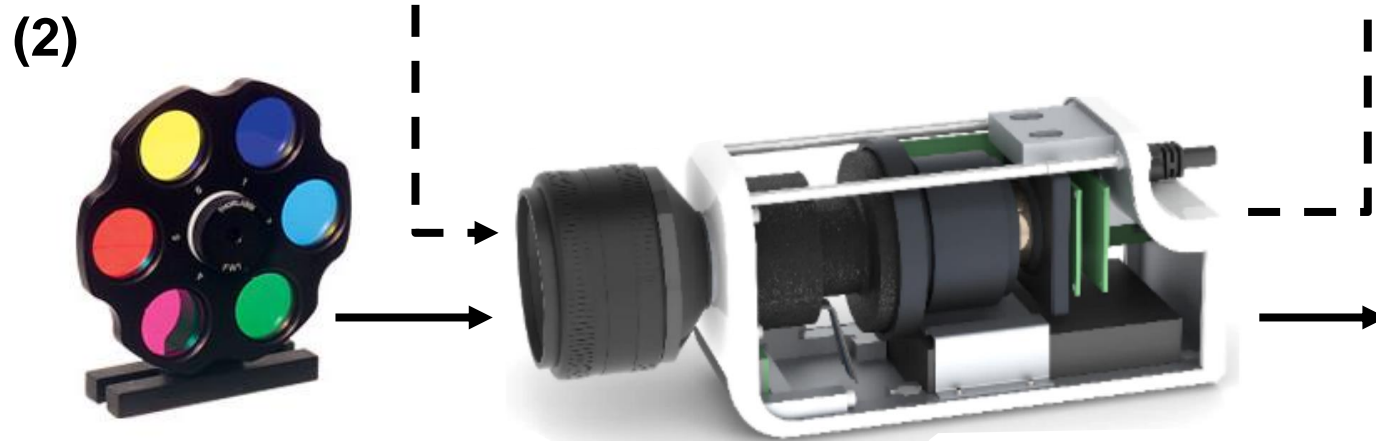
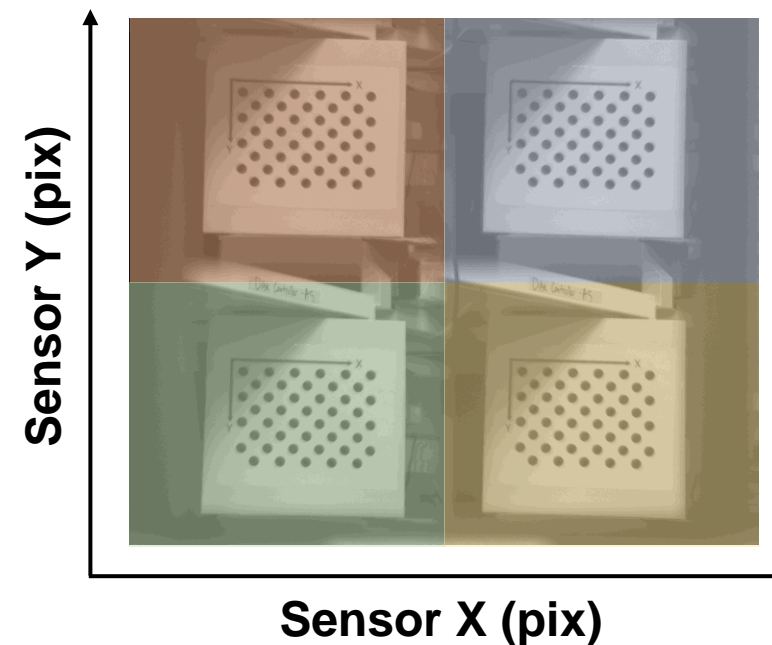
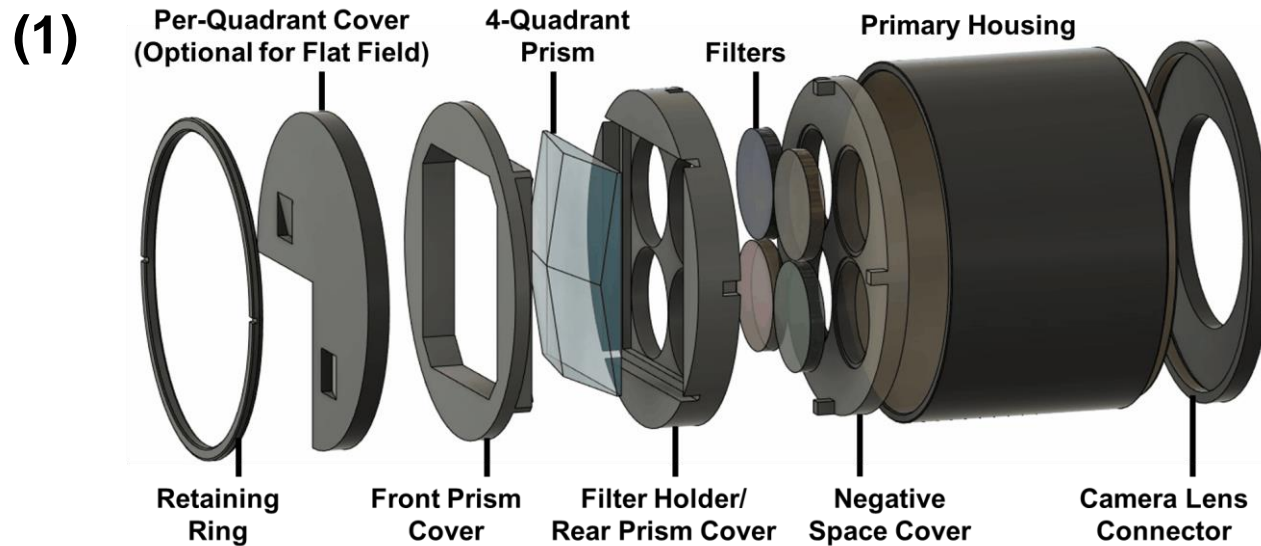
**Rongxiao Zhang,
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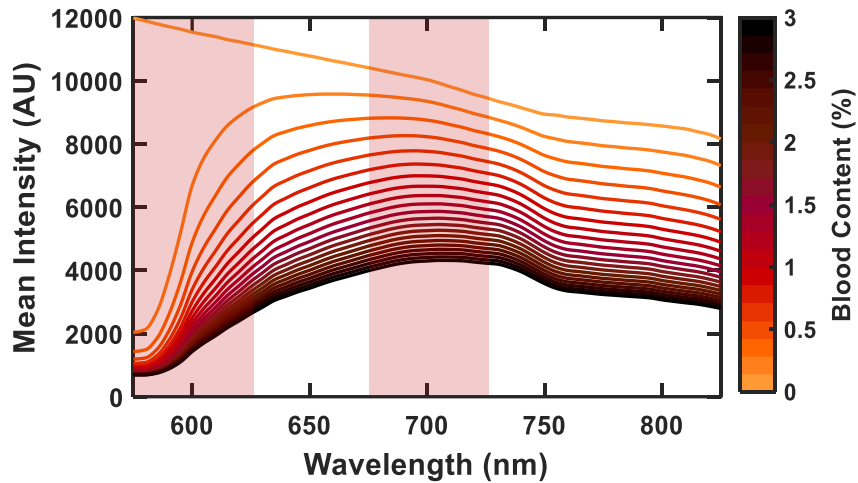
EXTRA SLIDES

Methods for collecting spectral Cherenkov images

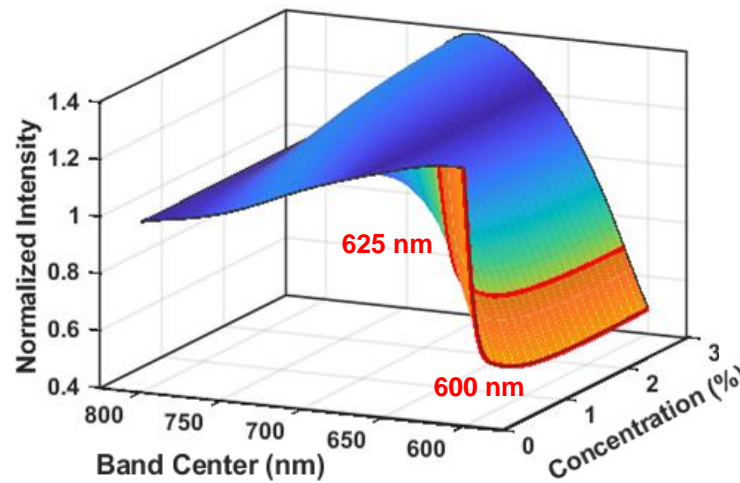


Best bands = highest dynamic range and greatest rate of change

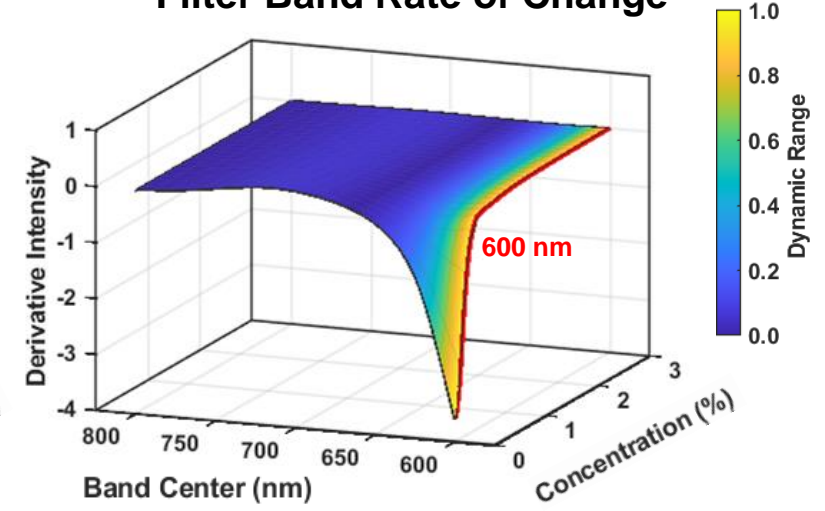
Spectral Response vs Blood Content



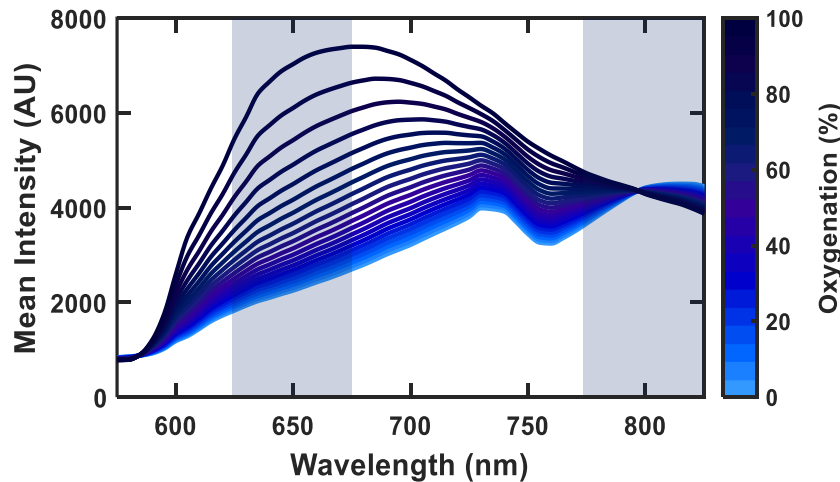
Filter Band Dynamic Range



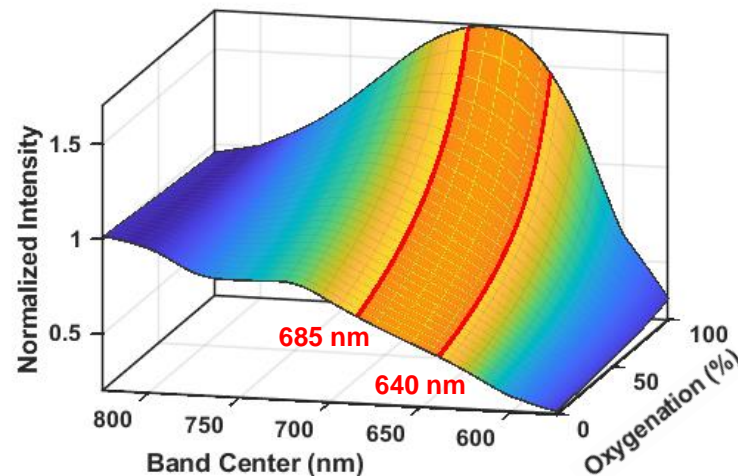
Filter Band Rate of Change



Spectral Response vs Oxygenation



Filter Band Dynamic Range



Filter Band Rate of Change

