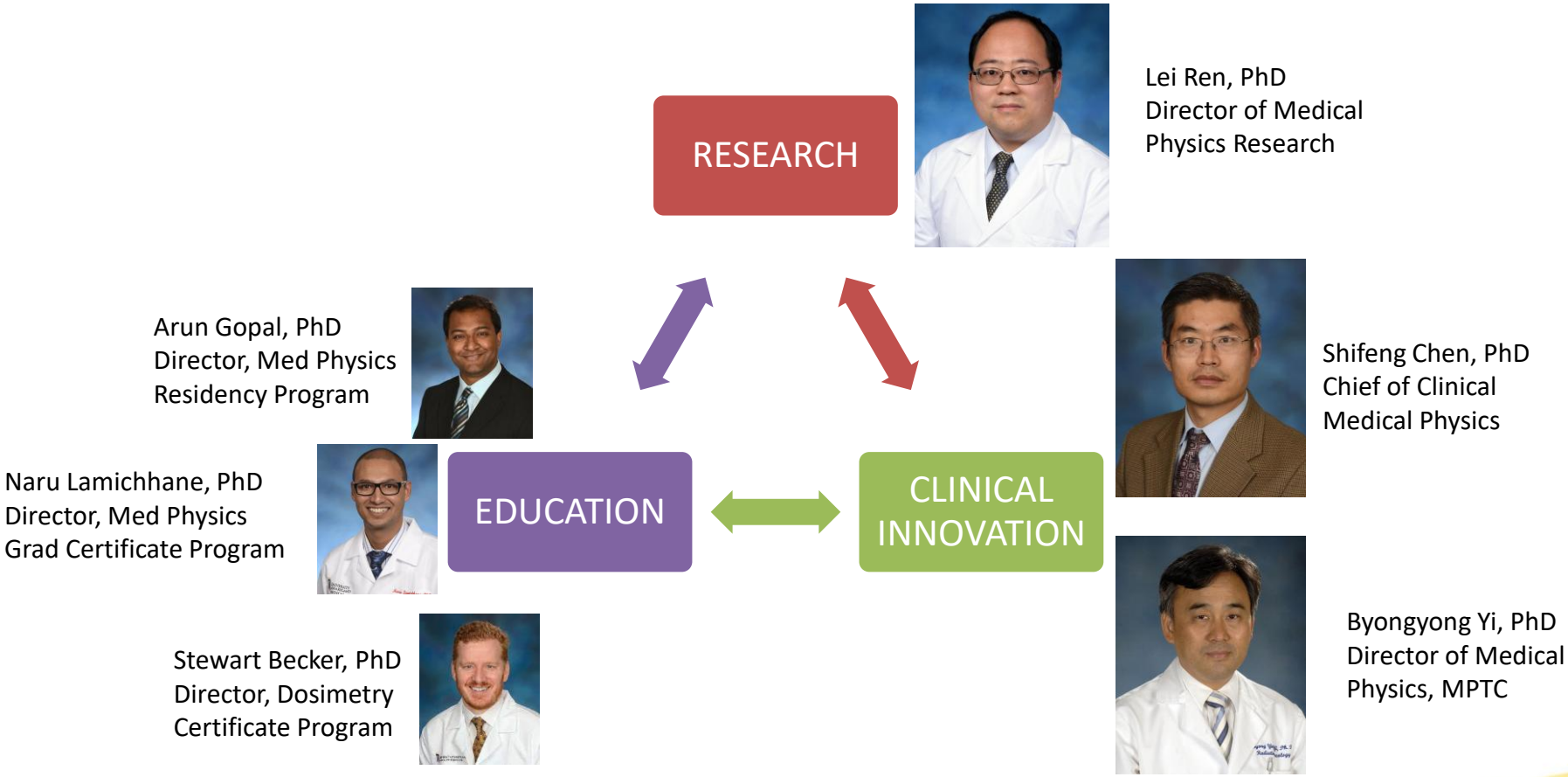
Overview of Radiation Oncology Physics Research

Amit Sawant, PhD, FAAPM
Vice Chair for Medical Physics
Department of Radiation Oncology
University of Maryland School of Medicine

Vision and Team

Harness physics to accelerate the development and translation of basic and technological research into clinical practice



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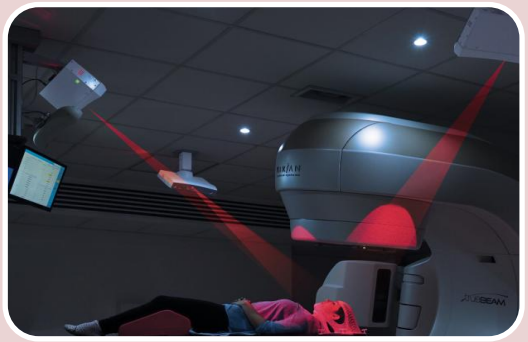
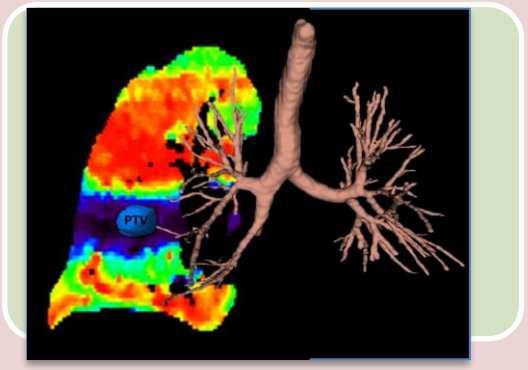
Department of Radiation Oncology
University of Maryland, Baltimore

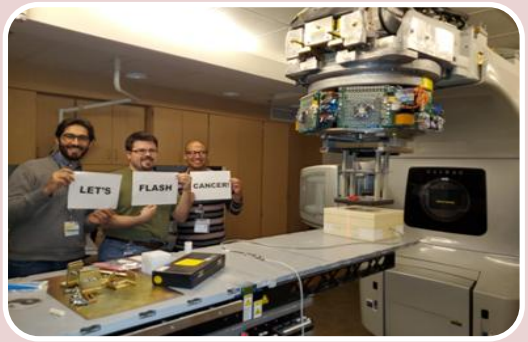
Research Areas



Multimodality Image-Guided Motion Modeling and Management



Functionally-Guided Radiotherapy



FLASH Radiotherapy

Artificial Intelligence in Radiation Oncology

- 5 active R01s and 1 U01 with UMB as primary
- >$15 million total costs in NIH funding

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Department of Radiation Oncology
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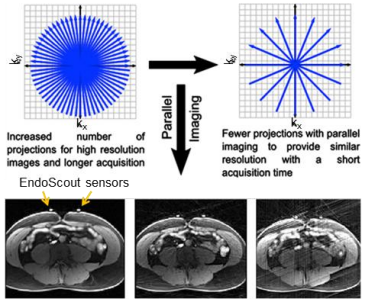
Respiratory Motion Management for Lung Radiotherapy

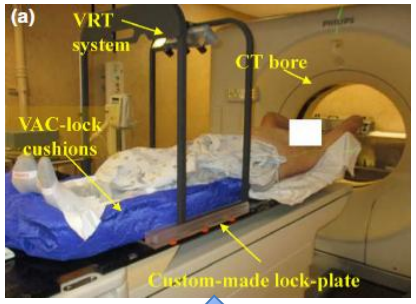
Multimodality real-time volumetric motion model [GCC 1619]

R01 CA 169102
R01 CA 262017
PI : Amit Sawant
coPI :Rao Gullapalli

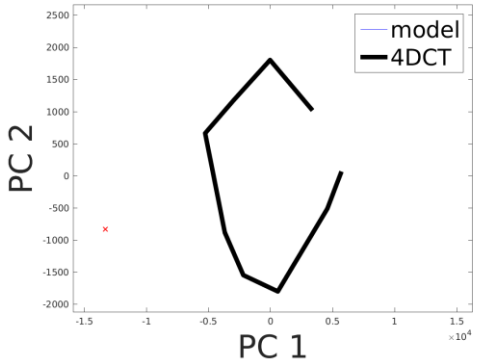
4D MRI



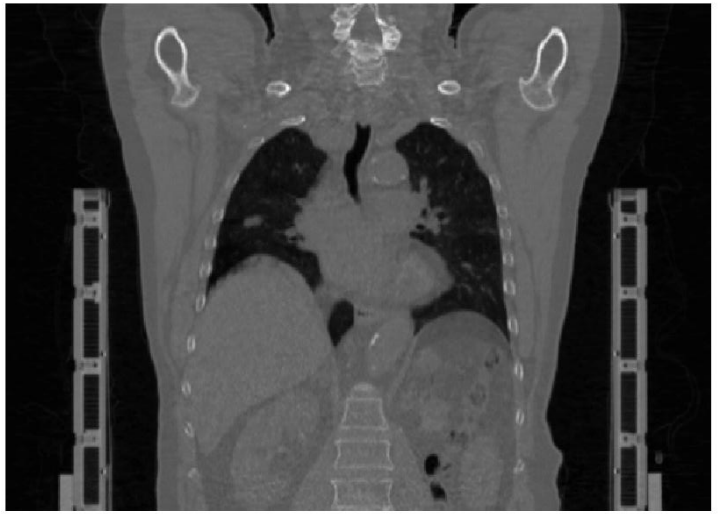
4D computed tomography



Build model in PC space



4D Motion Model – in-room, real-time, volumetric monitoring



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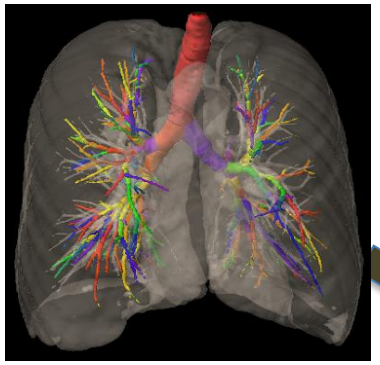
University of Maryland, Baltimore

Combining Virtual Bronchoscopy and Ventilation Imaging to Preserve Post-Radiotherapy Respiratory Function [GCC 1635]

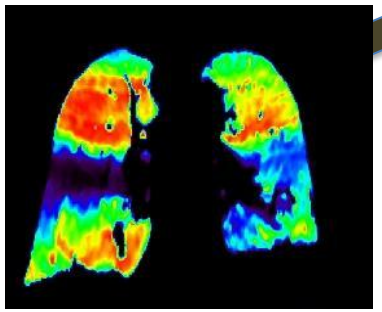
Esther Vicente, PhD

R01 CA 202761
PI : Amit Sawant
coPI : Robert Timmerman

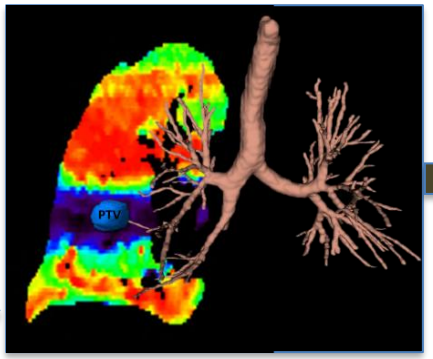
Virtual bronchoscopy



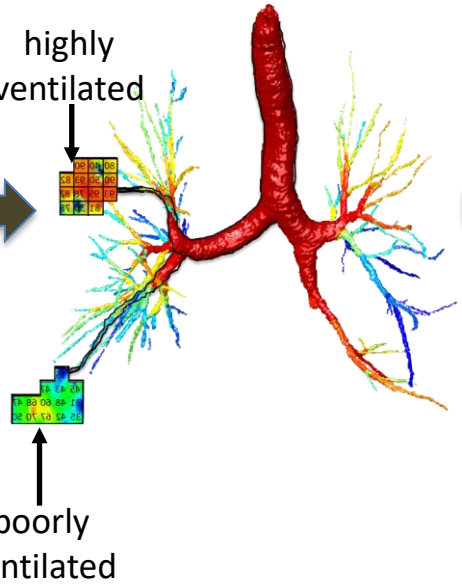
Lung ventilation imaging



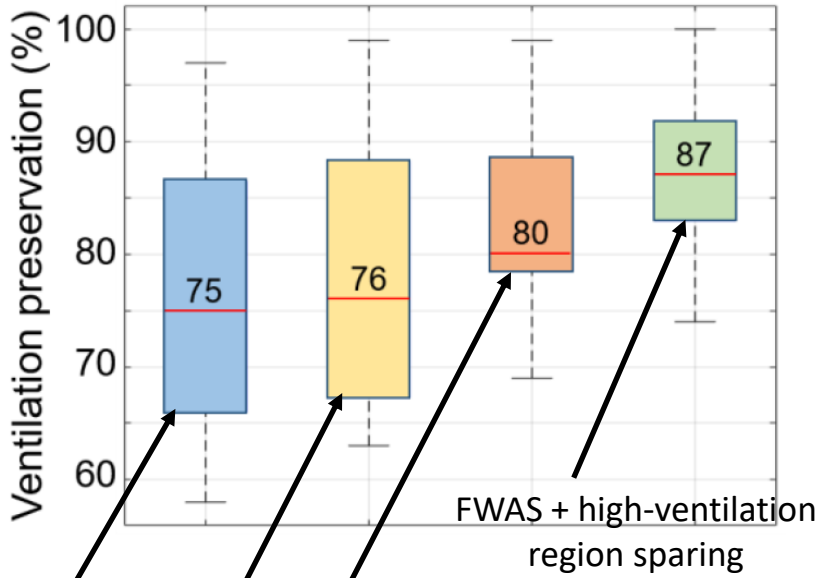
Connect terminal airways to sub-lobar regions



"Functional weighting" of airway segments based on cumulative ventilation



Estimated ventilation preservation for various treatment planning strategies (early results)



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Department of Radiation Oncology
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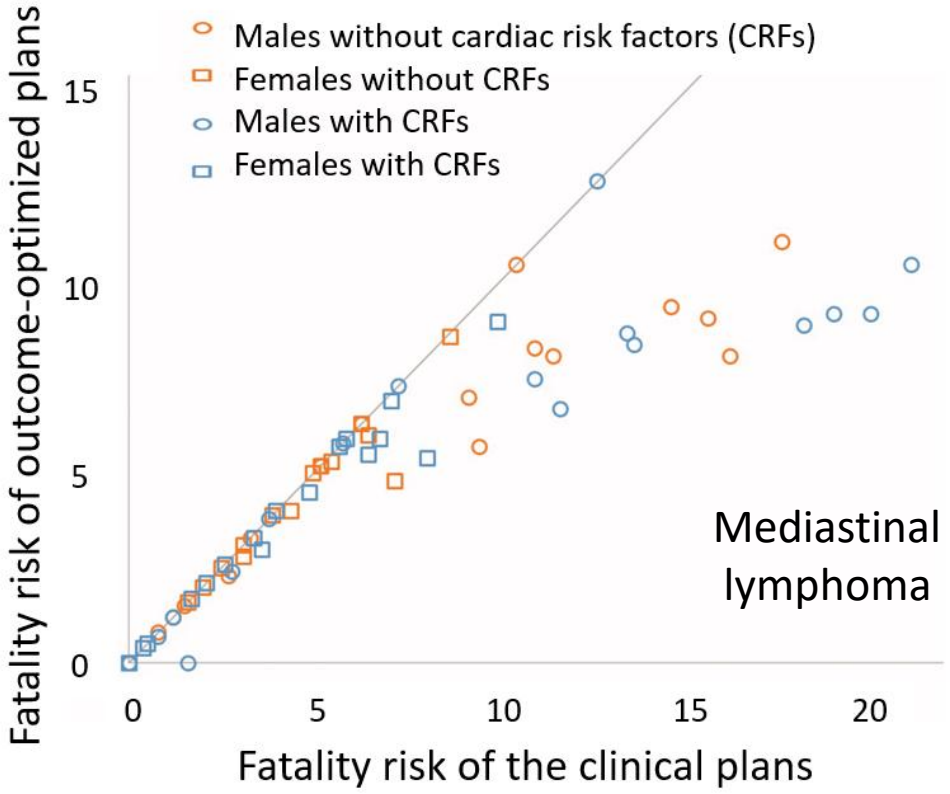
Outcome-Optimized Radiotherapy Planning in Lymphoma & Breast cancer

Reducing patient-specific risk of adverse outcomes

Instead of ***aggregated population-based dose constraints***, multi-parameter risk models lead the optimization.



MEDICAL PHYSICS

Individualized estimates of overall survival in radiation therapy plan optimization — A concept study

Arezoo Modiri, Line Bjerregaard Stick, Stephanie Renee Rice, Laura Ann Rechner, Ivan Richter Vogelius, Søren Møller Bentzen, Amit Sawant

Acta Oncologica ›

Biological optimization for mediastinal lymphoma radiotherapy – a preliminary study

Laura Ann Rechner[a,b]*, Arezoo Modiri[c]*, Line Bjerregaard Stick[a,b], Maja V. Maraldo[a], Marianne C. Aznar[d,e], Stephanie R. Rice[f], Amit Sawant[c], Søren M. Bentzen[g], Ivan Richter Vogelius[a] and Lena Specht[a]

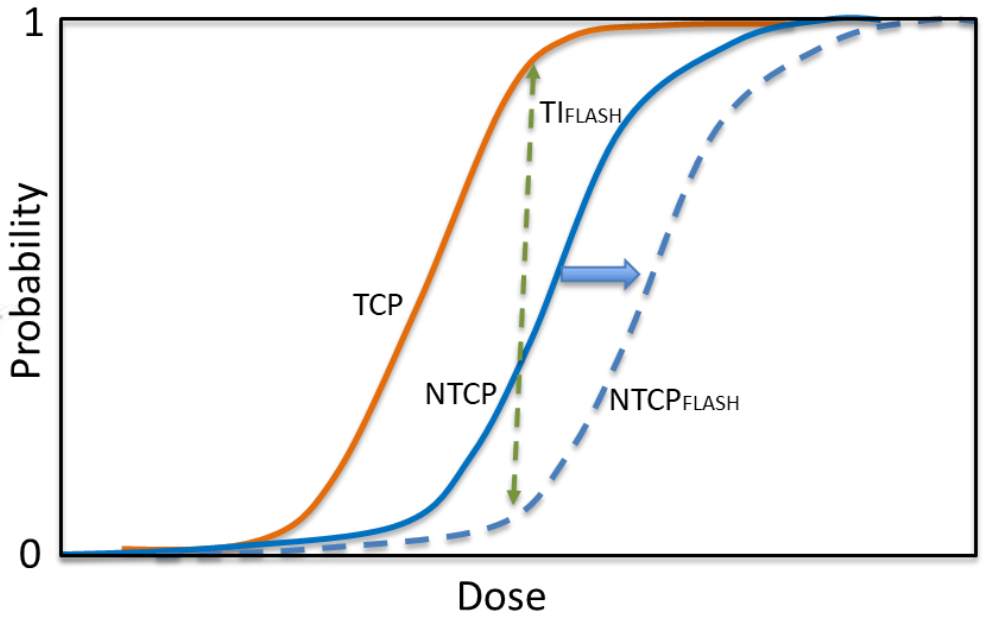
BIR The British Institute of Radiology

Outcome-based multiobjective optimization of lymphoma radiation therapy plans

[1]AREZOO MODIRI, PhD, [2]IVAN VOGELIUS, PhD, DMSc, [2]LAURA ANN RECHNER, PhD, [2]LOTTE NYGÅRD, MD, PhD, [3]SØREN M BENTZEN, PhD, DMSc, and [2]LENA SPECHT, MD,

FLASH Primer

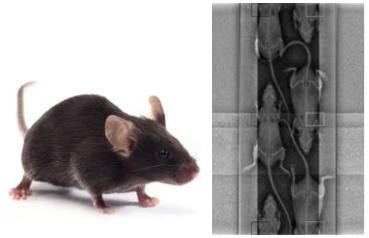
- Consensus Definition: Radiation dose rates >40 Gy/s
  - ~2 orders of magnitude > conventional irradiation
- "FLASH effect" spares normal tissue without compromising tumor control
- In essence, FLASH irradiation is a spatially-localized radioprotector that increases the therapeutic index



Amit Sawant, PhD, FAAPM
Department of Radiation Oncology
University of Maryland, Baltimore

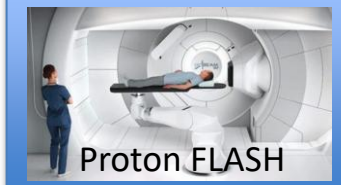
U Maryland FLASH Research Portfolio

Precision Image-Guided Proton FLASH

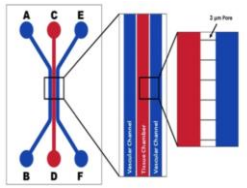


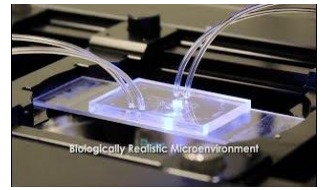
Normal Tissue Toxicity
Lung fibrosis
RiED

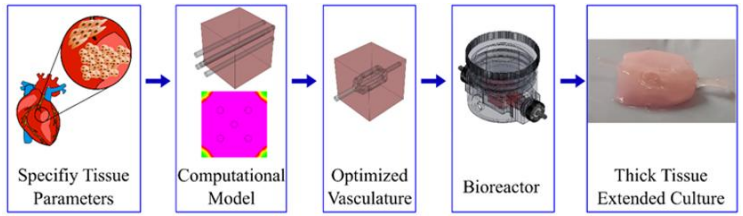
MODALITIES



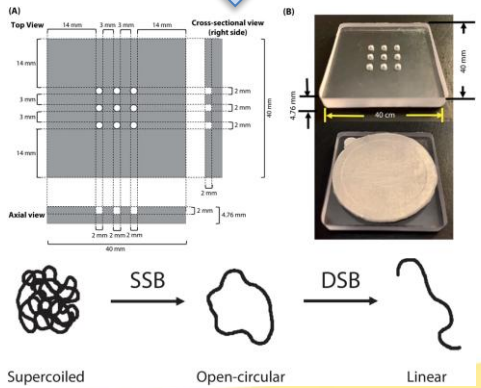
Organoids/Macrophysiological systems
Concurrent tumor and normal tissue studies





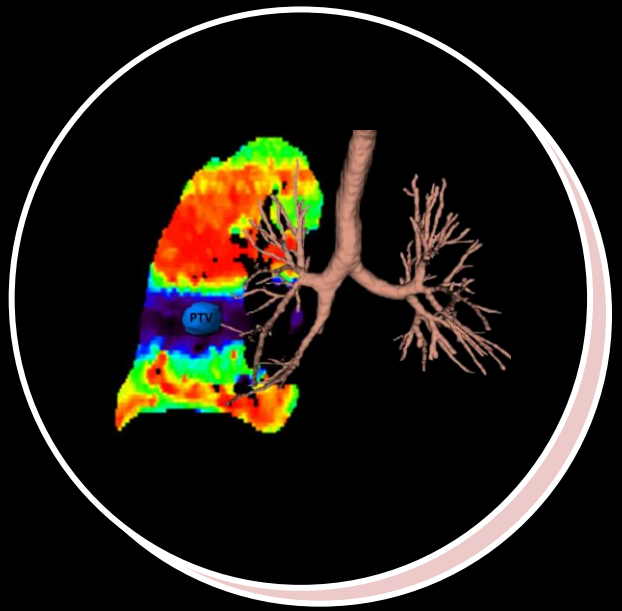


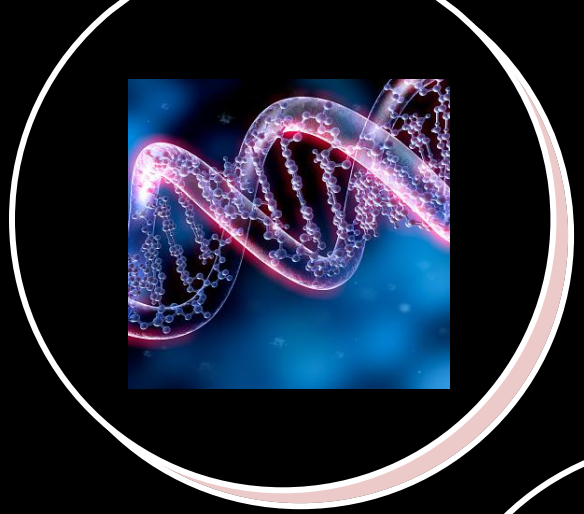
High-speed Cherenkov-based Plastic Dosimeter

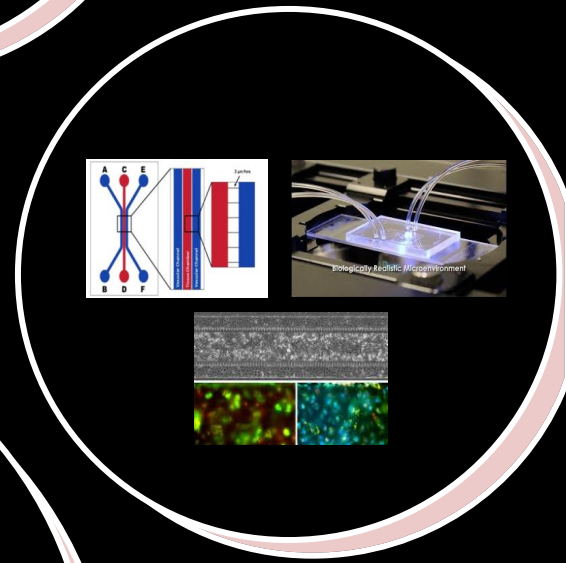


Plasmid DNA-based "Biological" Dosimeters

Amit Sawant, PhD, FAAPM
Department of Radiation Oncology
University of Maryland, Baltimore







Opportunities . . .

Amit Sawant, PhD, FAAPM
Department of Radiation Oncology
University of Maryland, Baltimore

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Artificial Intelligence (AI) for Radiation Oncology

Lei Ren, PhD, DABR, FAAPM

Professor and Associate Chief of Physics Research

Department of Radiation Oncology
University of Maryland School of Medicine

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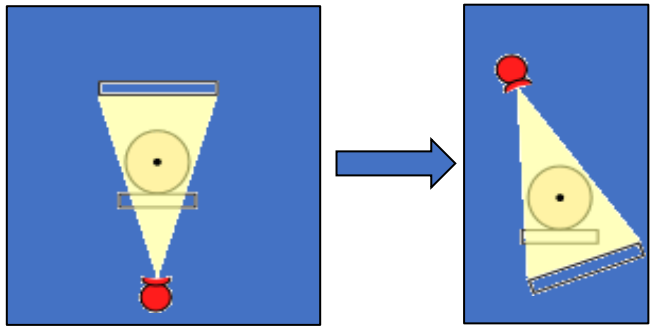
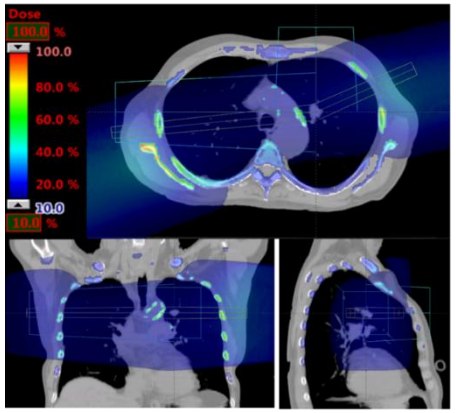
AI for Image Guided Radiation Therapy (IGRT)

Fast

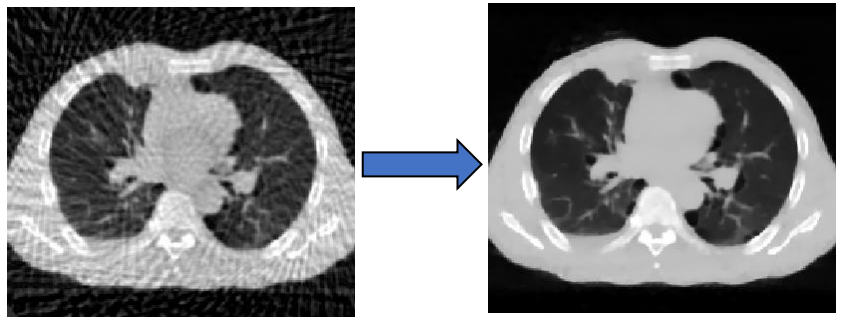


CBCT DTS

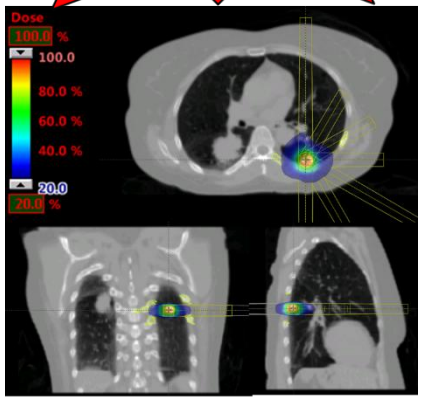
Low-dose



High-quality



4D-CBCT



Efficiency, Precision

Tumor control ↑

Toxicities ↓

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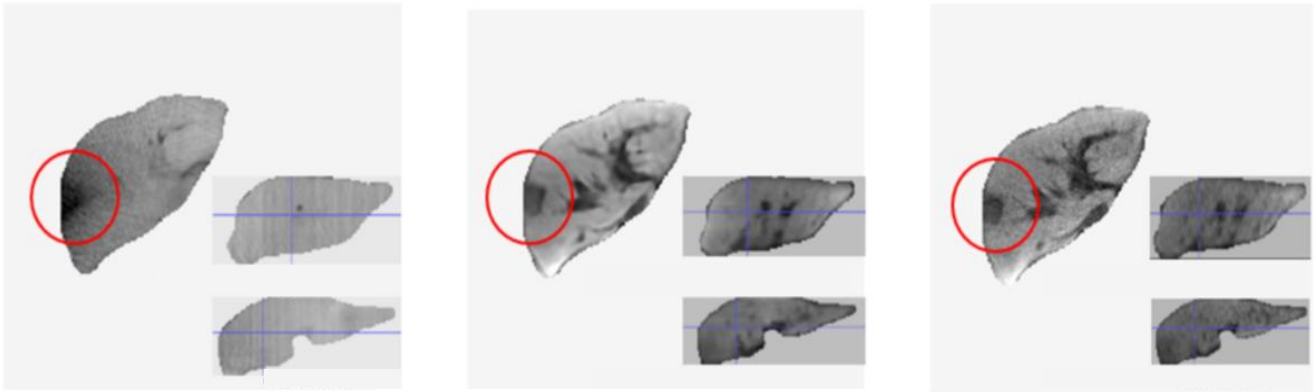
AI based Virtual-MRI Imaging for Liver Radiotherapy



CBCT **Virtual MRI** **Ground truth MRI**

- AI empowered technique to generate virtual MRI from CBCT to improve the precision of liver radiotherapy.
- Prospective trial started in Oct. 2022 (Lei Ren, Jason Molitoris)

R01-EB028324, PI: Lei Ren

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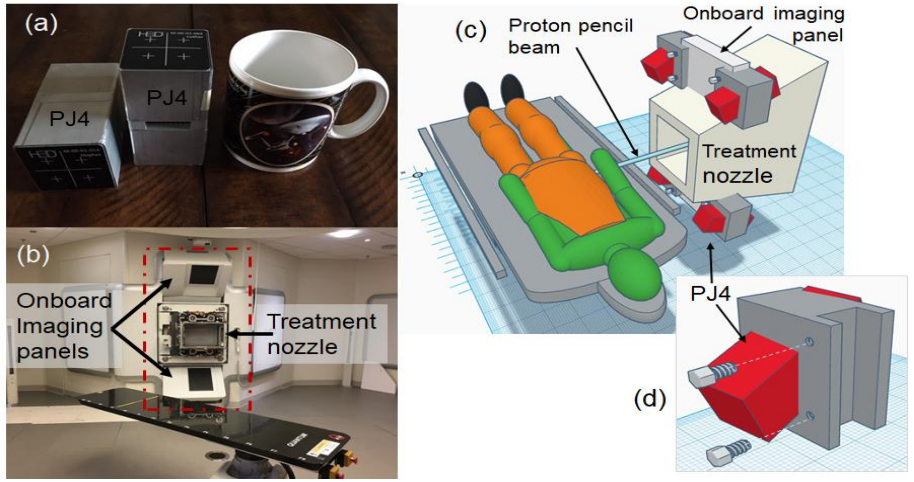
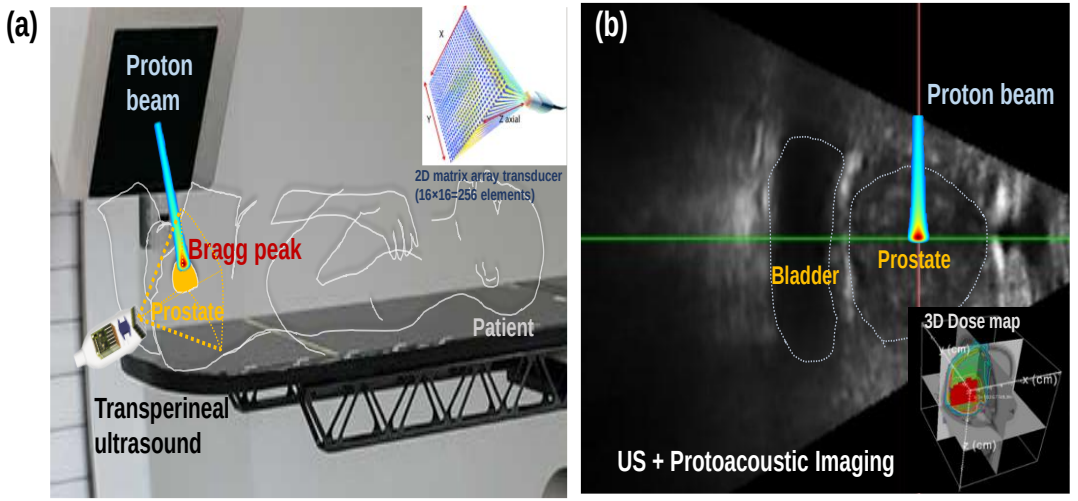
AI for Novel Imaging Modalities

Prompt Gamma Imaging



NIH R01CA279013
PI: Lei Ren, Jerimy Polf

Proton Acoustic Imaging



NIH U01CA288351
PI: Shawn Xiang, Lei Ren

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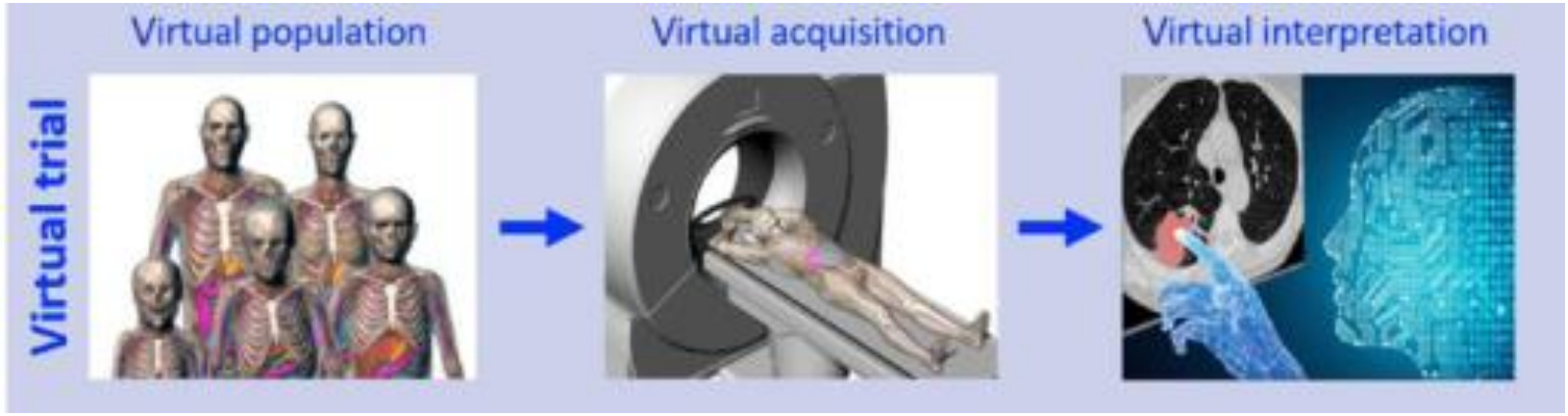
AI for Virtual Clinical Trial (VCT)

IRB, slow, costly, challenge to optimize



Efficient, low cost, flexibility for optimization

Abadi et al. *Journal of Medical Imaging* 7(4), 042805, 2020

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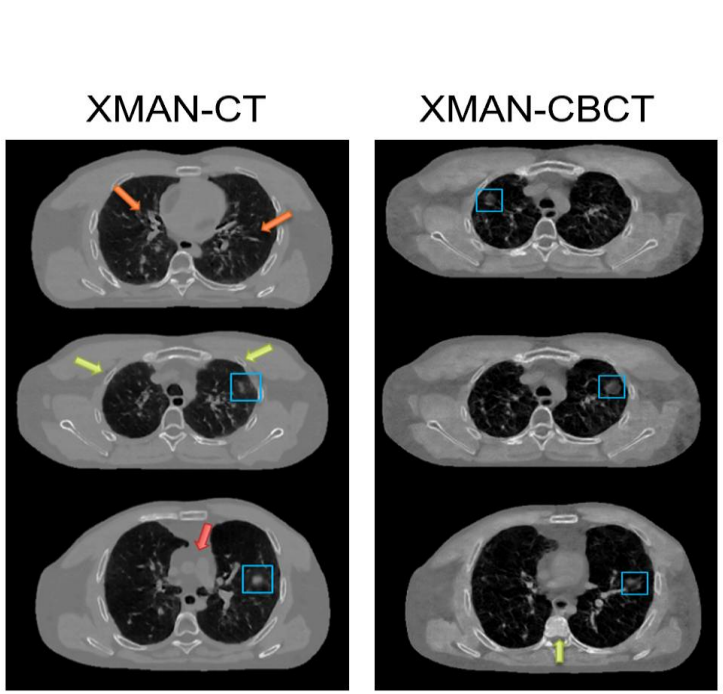
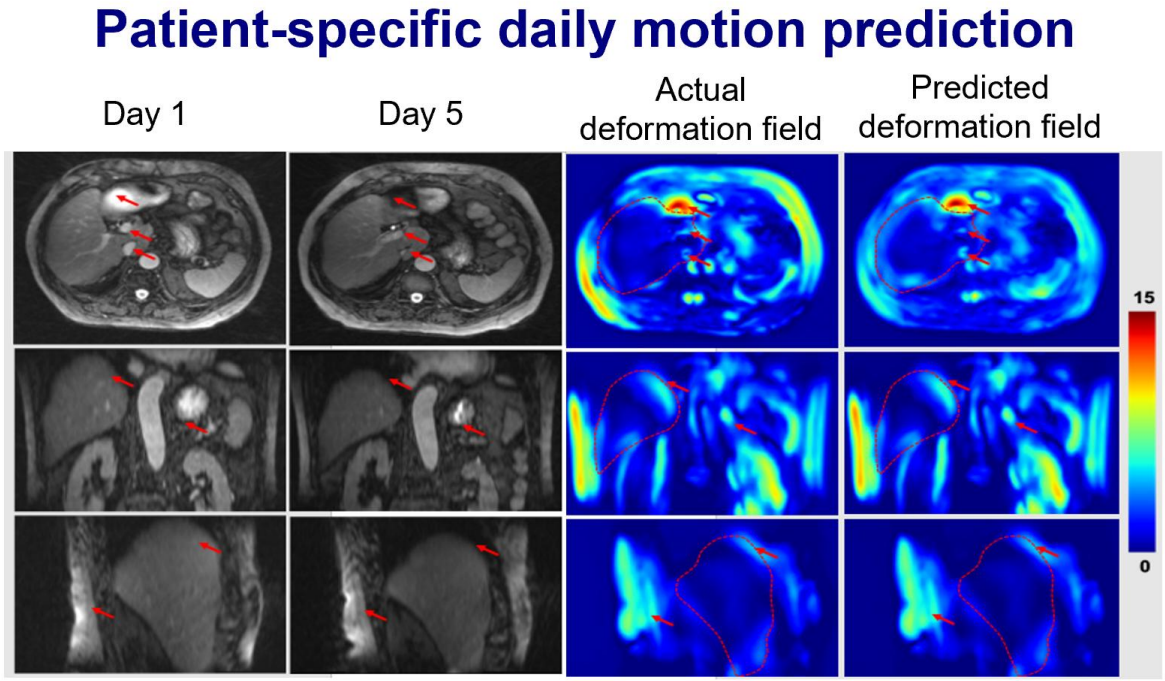
eXtended Modular ANthropomorphic (XMAN) phantom for VCT in Radiation Therapy





AI empowered XMAN for VCT in Radiation Oncology

R01-EB032680, PI: Lei Ren

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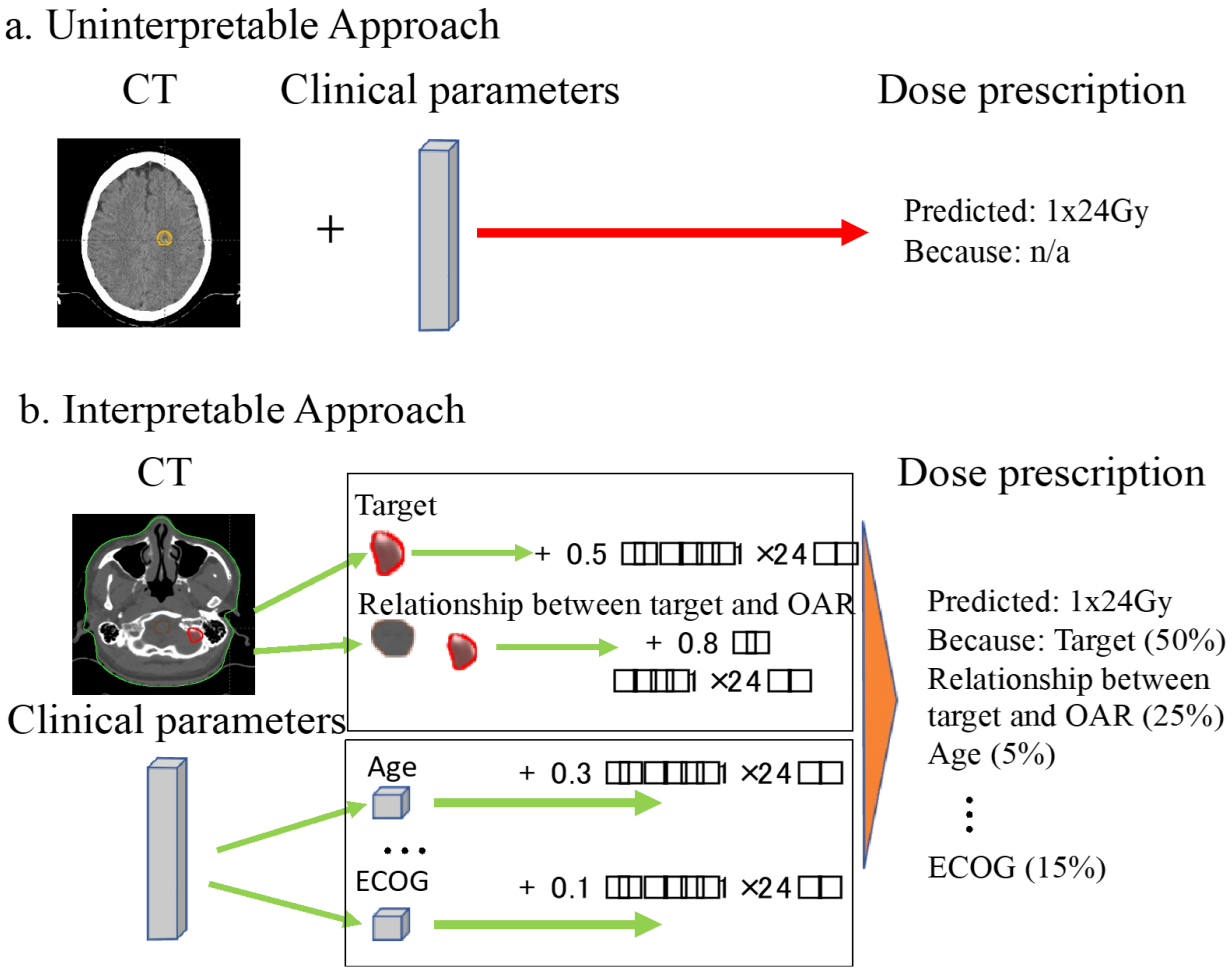
Interpretable AI for Clinical Decision Making



Lei Ren, Dan Kunaprayoon, Mark Mishra, Ryan Cherng

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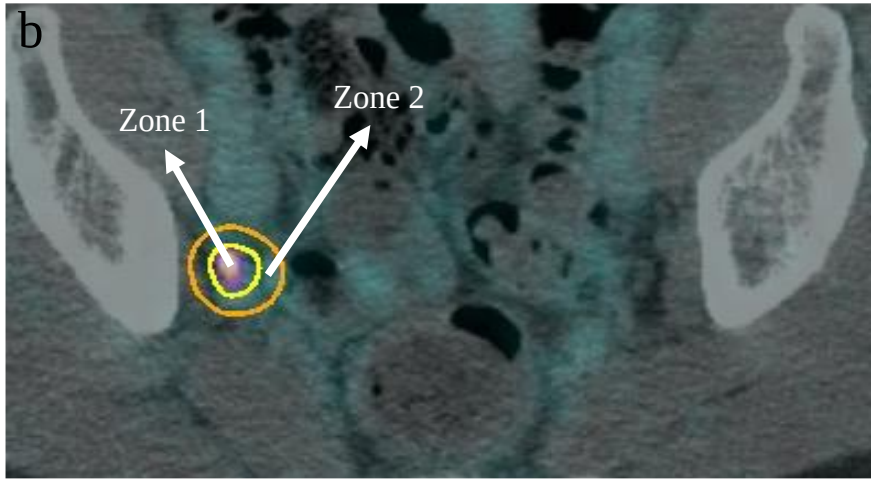
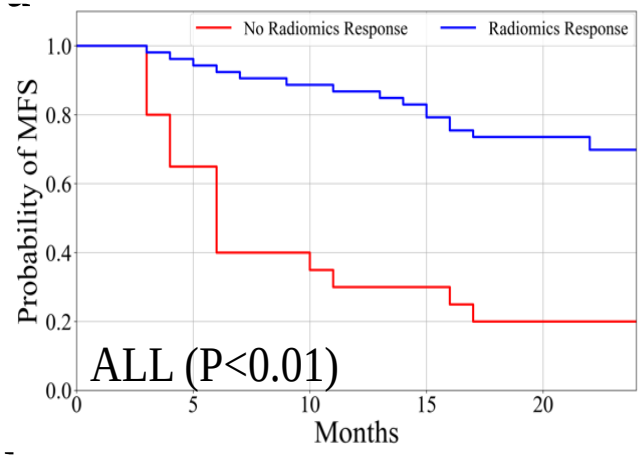
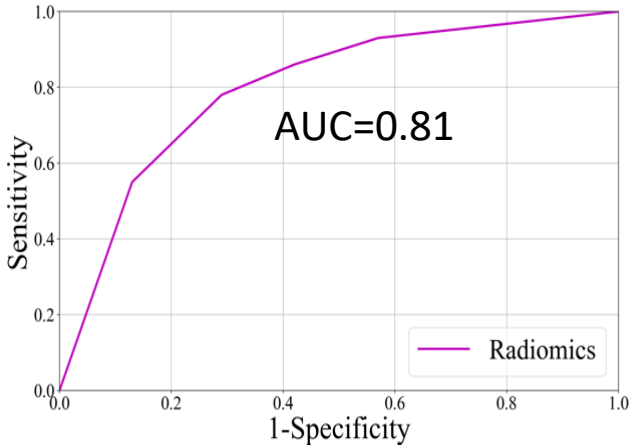
AI for Outcome Prediction

Predict 2-yr MFS for Oligomet prostate cancer patients treated by metastasis directed therapy







U54CA273956, Phuoc Tran, Amit Sawant, Lei Ren,

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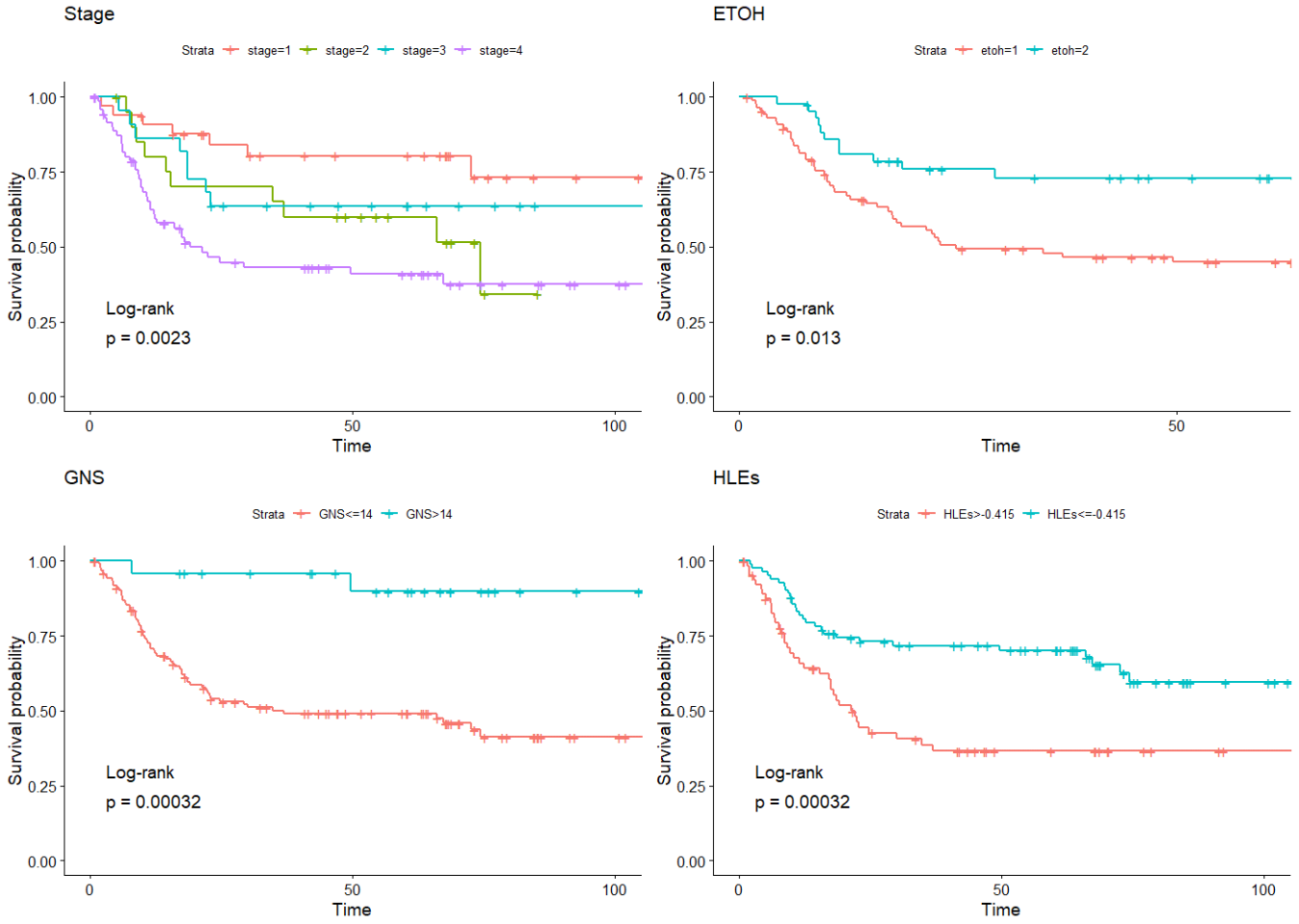
AI for Outcome Prediction

Predict overall survival for oral cavity squamous cell carcinoma patients using PET/CT radiomics



Daria Gaykalova, Lei Ren, Jason Molitoris, Ranee Mehra, R01DE033426