3D Surface Cherenkov Mapping for Quantitative Beam Deviation Assessment and Cumulative Cherenkov Image Fusion in Non-Coplanar RT

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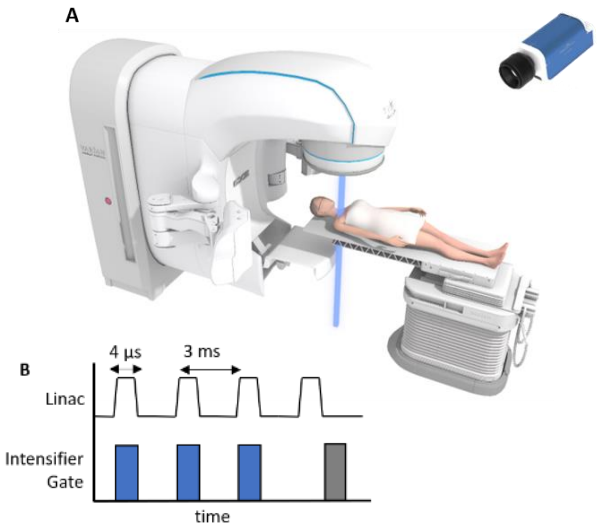
ASTRO'S 67TH ANNUAL MEETING
2025
REDISCOVERING RADIATION MEDICINE AND EXPLORING NEW INDICATIONS

Dartmouth Health

ROI Radiation Oncology Institute *The ASTRO Foundation*

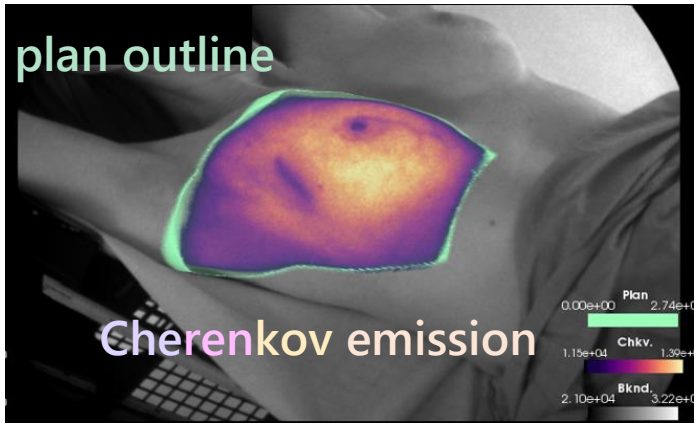
CENTER FOR IMAGING MEDICINE AT DARTMOUTH

Cherenkov Imaging



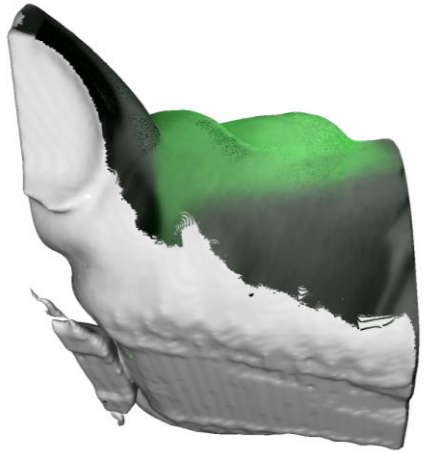
- Gated cameras visualize radiation delivery in patients “for free” during radiotherapy treatments

2D Image Analysis

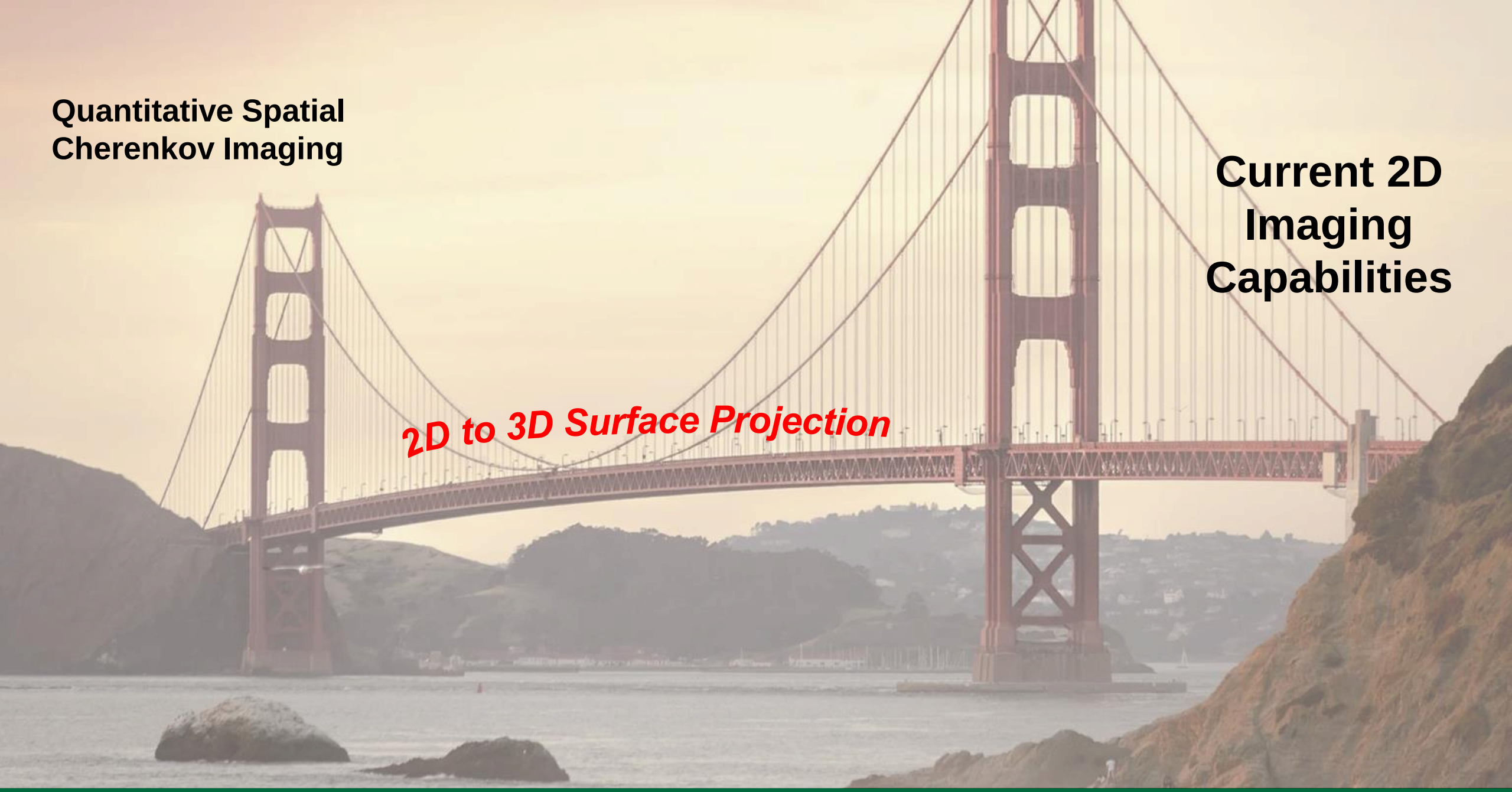


- Restricted to single camera views and limited by gantry occlusions
- Valuable qualitative information, but difficult to determine quantitative metrics

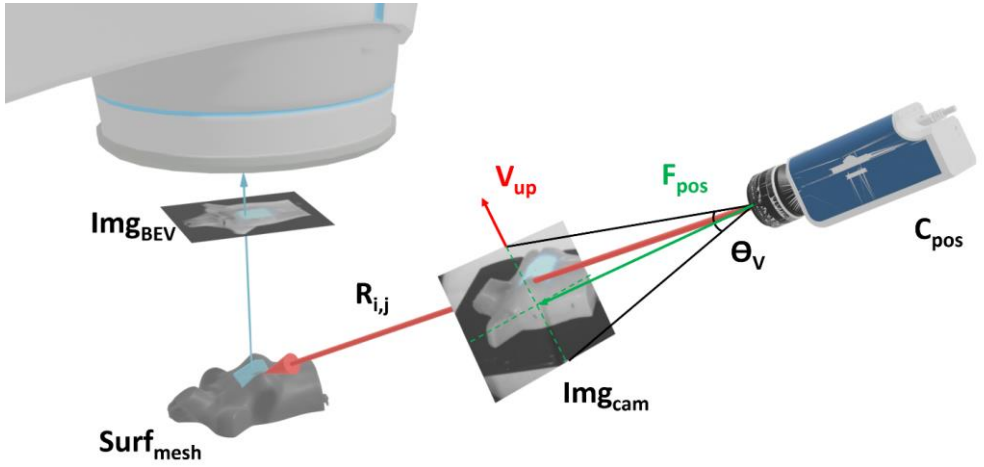
3D Surface Imaging



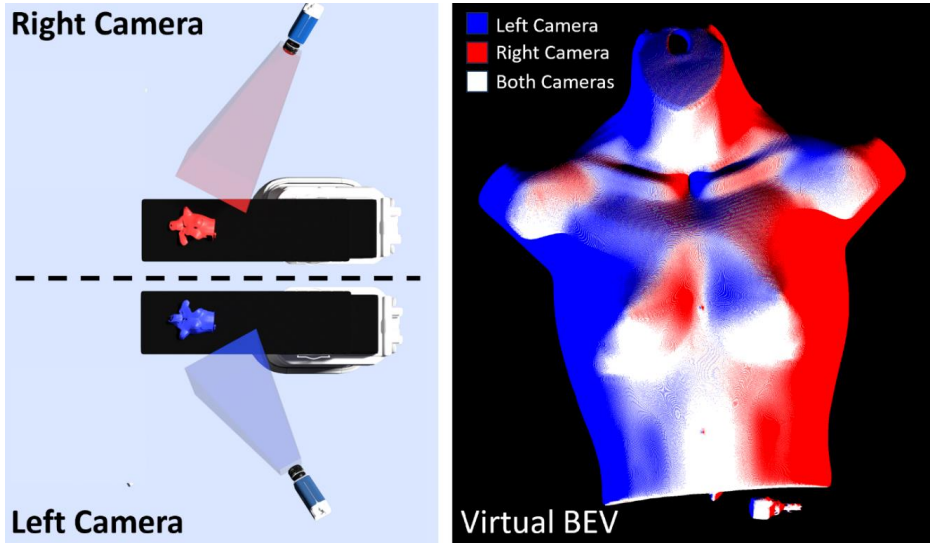
- Utilizes *all* camera views in a combined surface projection
- Provides quantitative analysis of beam’s eye view and spatial beam deviations on patient surface


Quantitative Spatial
Cherenkov Imaging
Current 2D
Imaging
Capabilities
2D to 3D Surface Projection

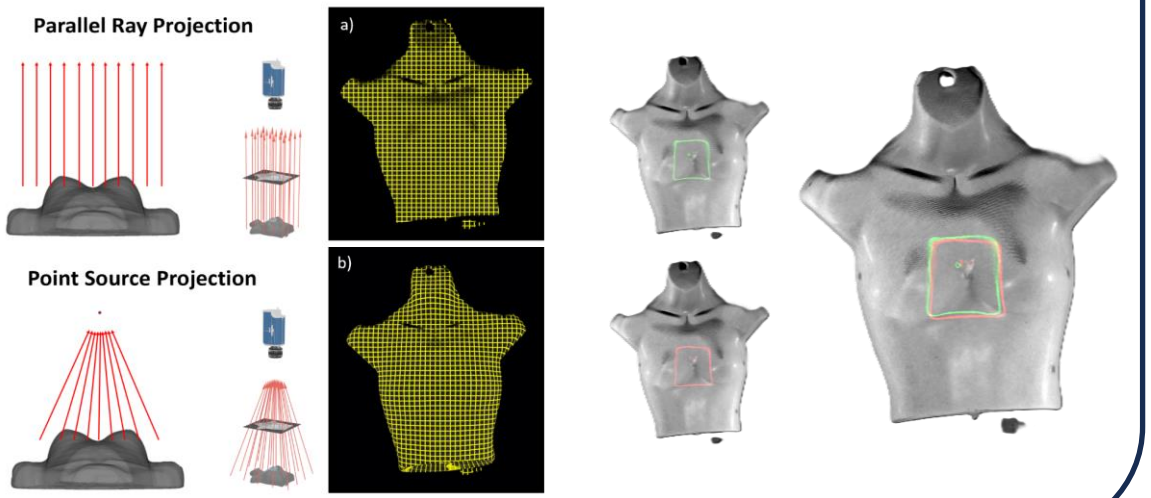
1) Required Data for Surface Imaging



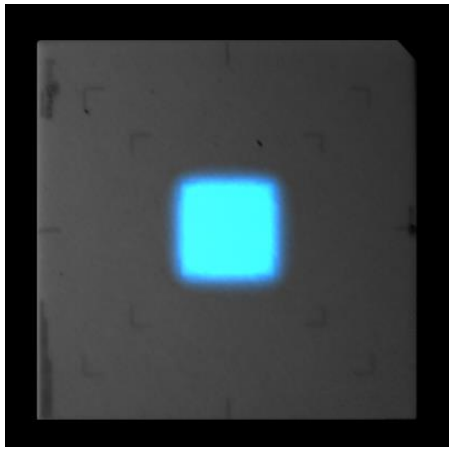
2) Camera View Combination

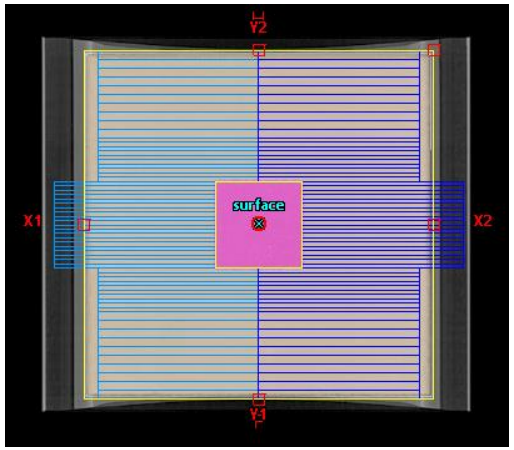


3) Beam's Eye View Projections and Metrics



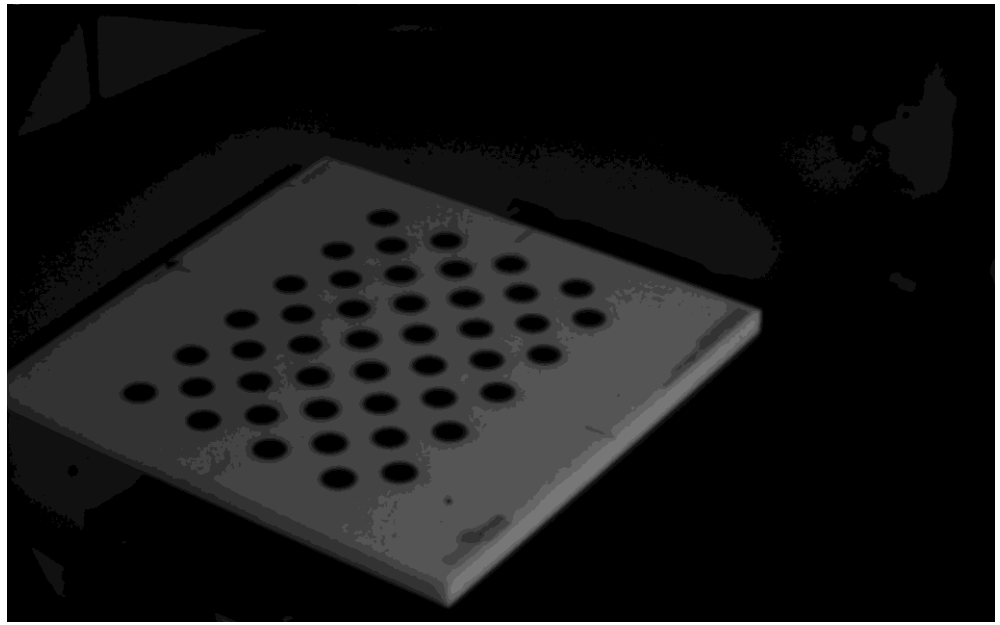
4) Plan BEV Comparison

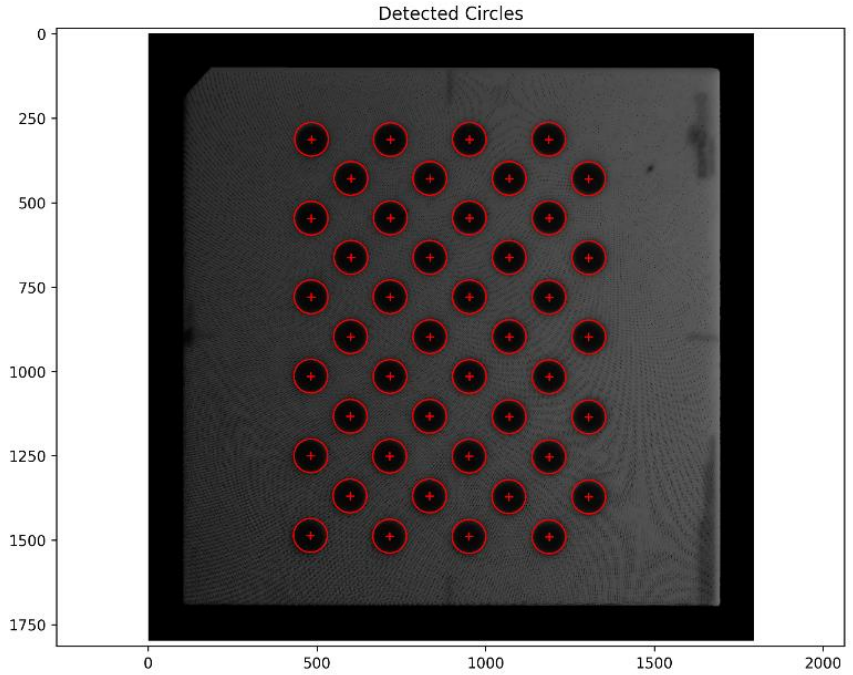


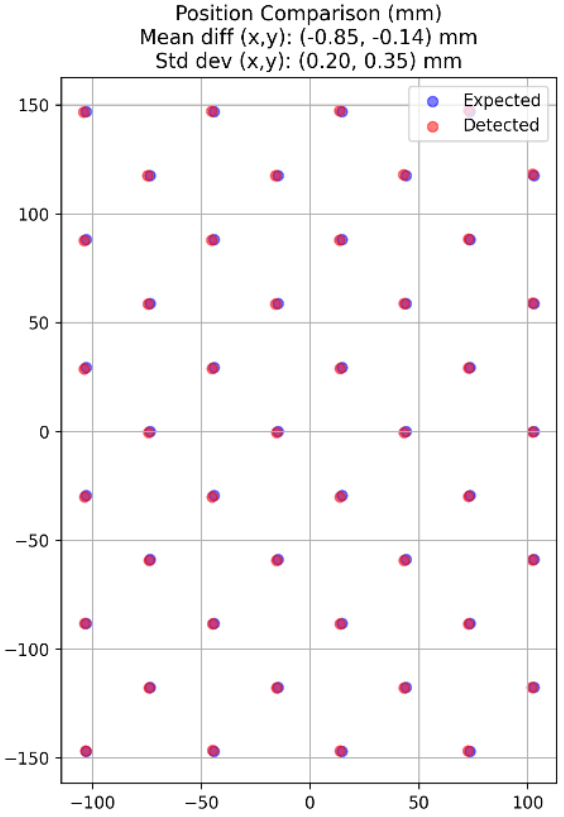


1) Verify Projection Accuracy

- Image flat calibration phantom with known circular spacing
- Transform to beam's eye view (BEV) and measure spatial discrepancies between centroids and known positions on CT surface
- ***Projection accuracy under 1 mm***

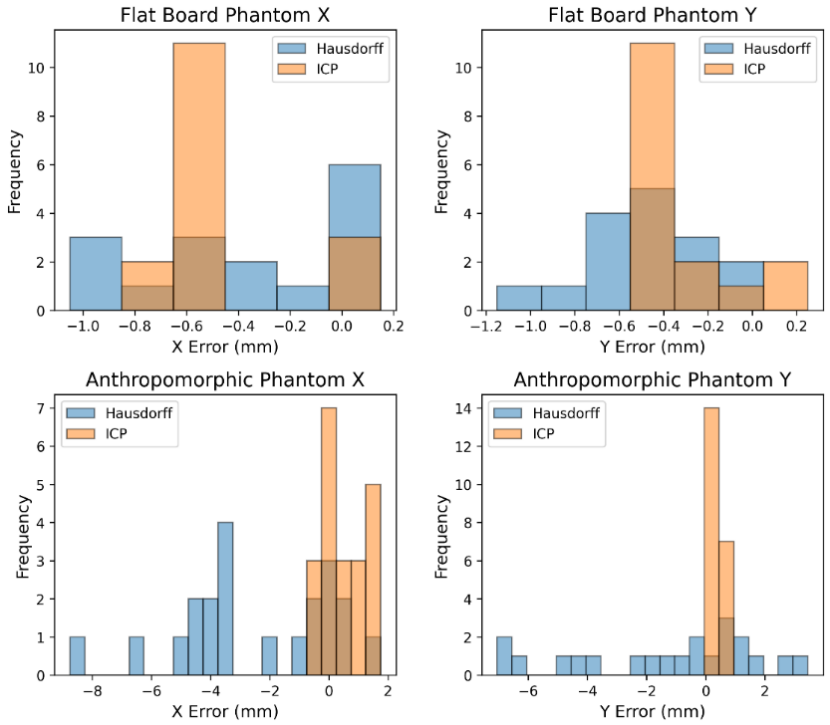


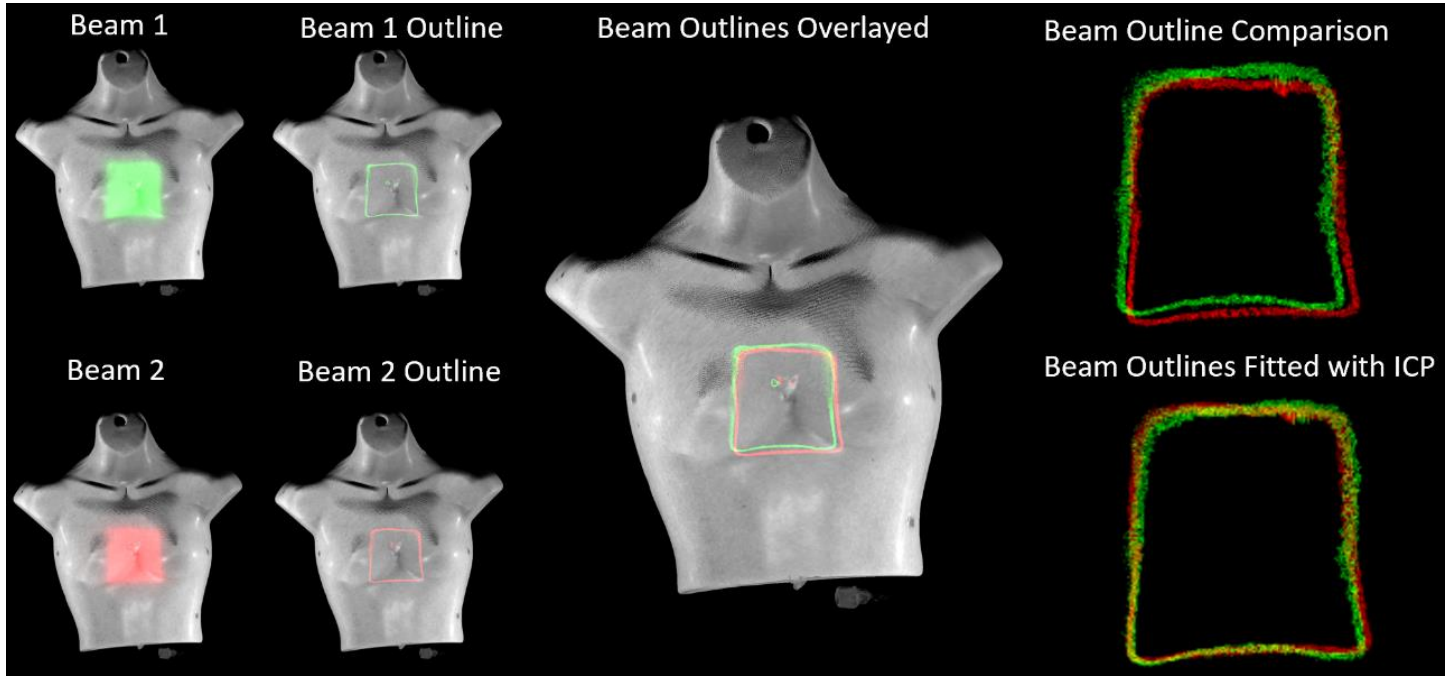


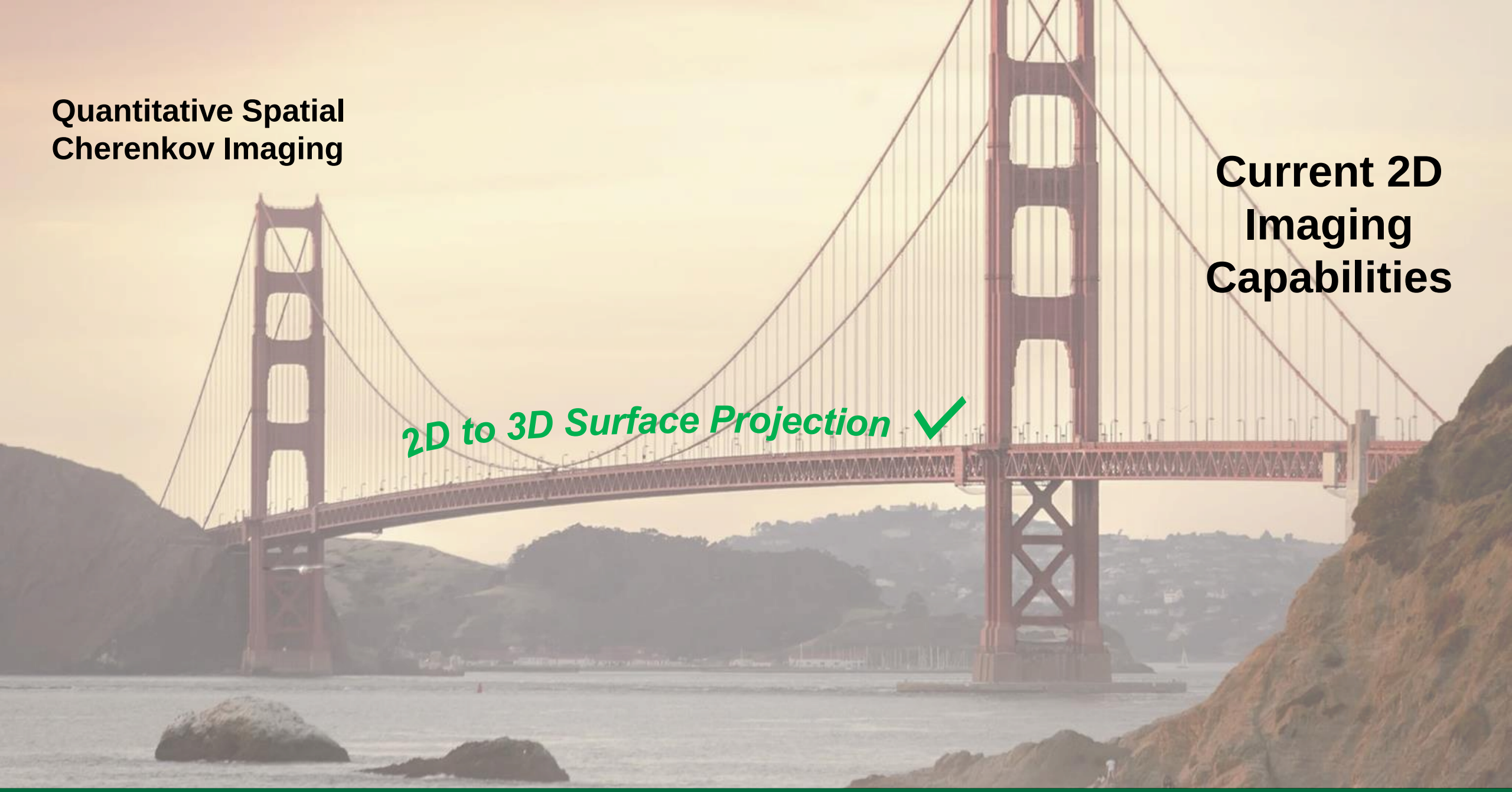


2) Apply Quantitative Spatial Metrics to BEV Images

- Phantom test on a flat board phantom and anthropomorphic phantom
- Apply shifts from -5 to 5 mm in the couch coordinates in 1 mm increments
- Selected two spatial metrics (Hausdorff and Iterative Closest Point) to compare shifted beam outlines to centered beam outline
- ***Iterative Closest Point shows sub mm accuracy on both phantoms***







Quantitative Spatial Cherenkov Imaging

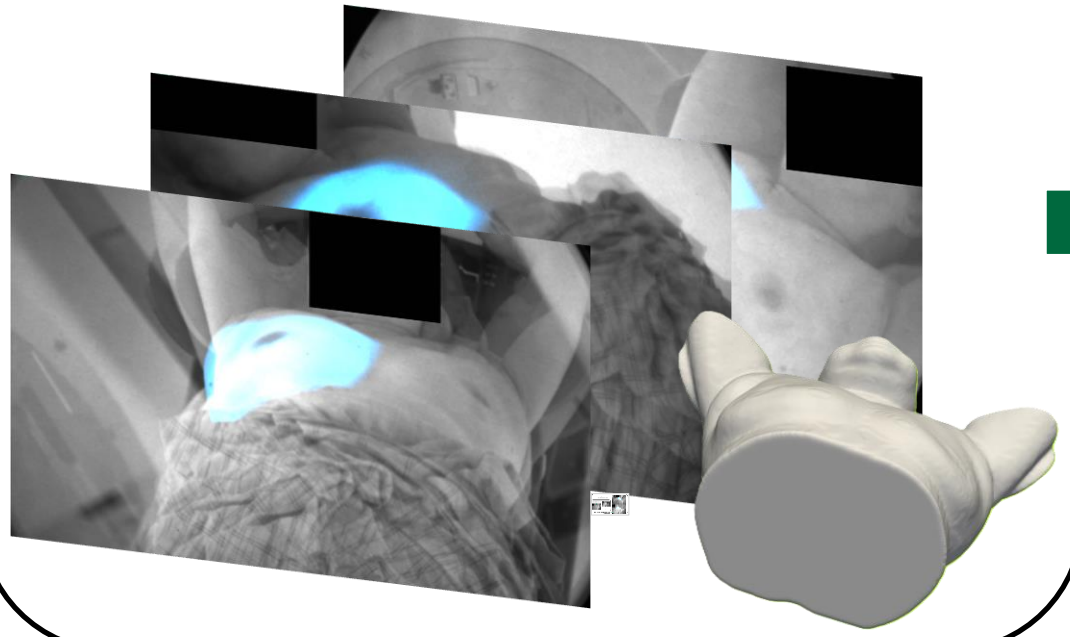
Current 2D Imaging Capabilities

2D to 3D Surface Projection ✓

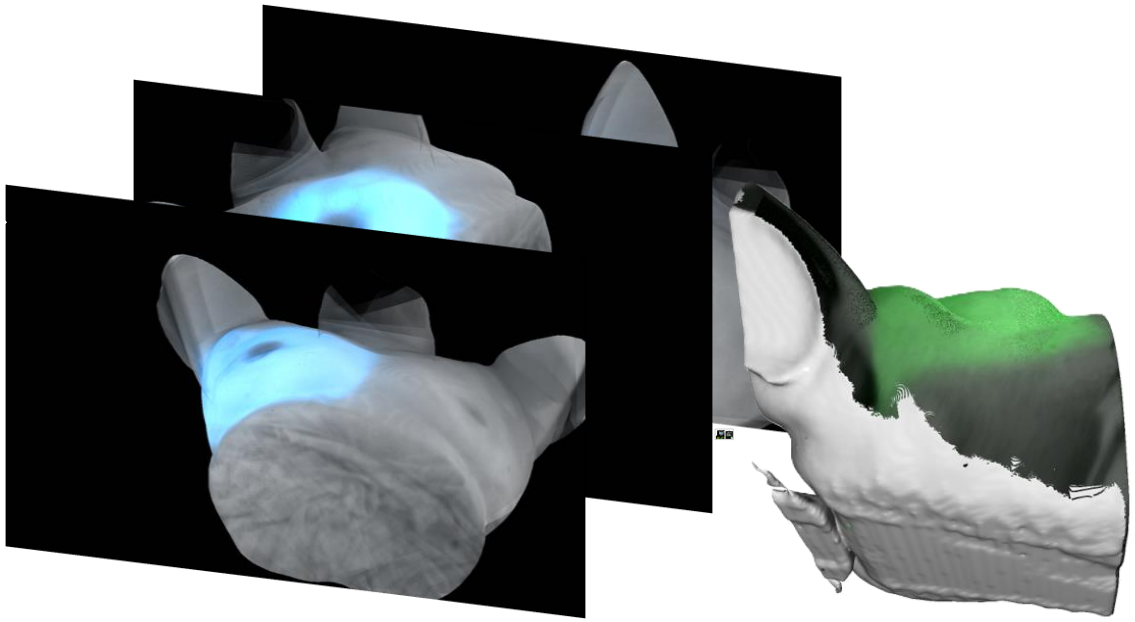
3) Enabling Cumulative View via Beam's Eye View in Non-Coplanar Treatments

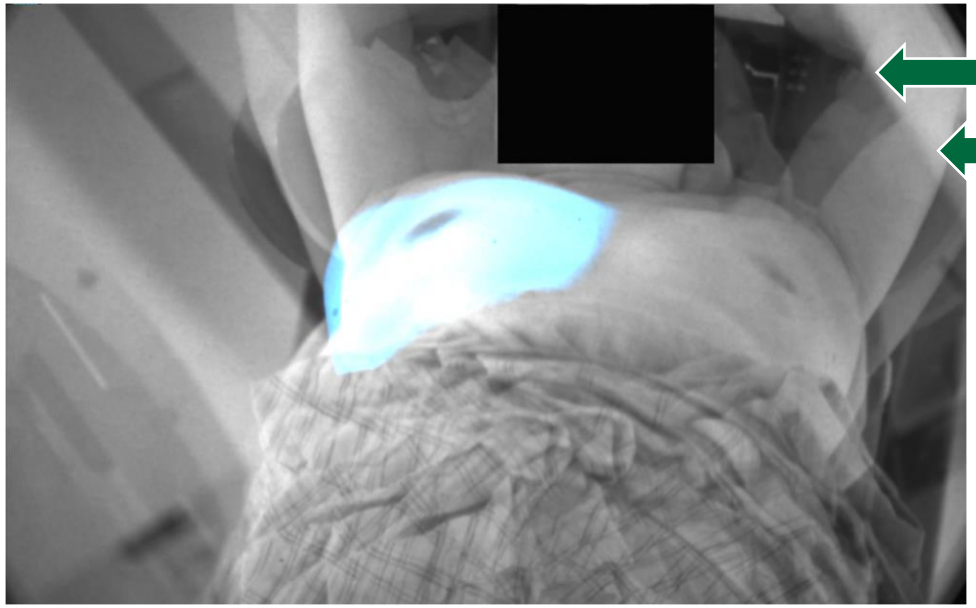
- Couch kicks in tangent breast and SCV plans inhibit accurate cumulative images and make qualitative assessment of Cherenkov imaging difficult
- ***Use projection to accumulate images in patient centric coordinate space***
- ***Create virtual non-rotational camera and beam's eye view images***

Couch Kick Artifacts

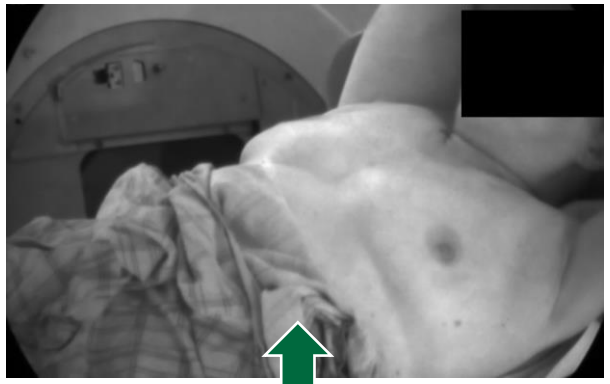


Artifact Free Images + BEV

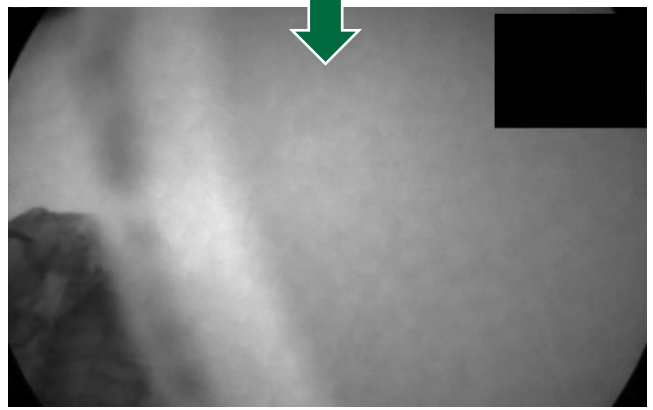




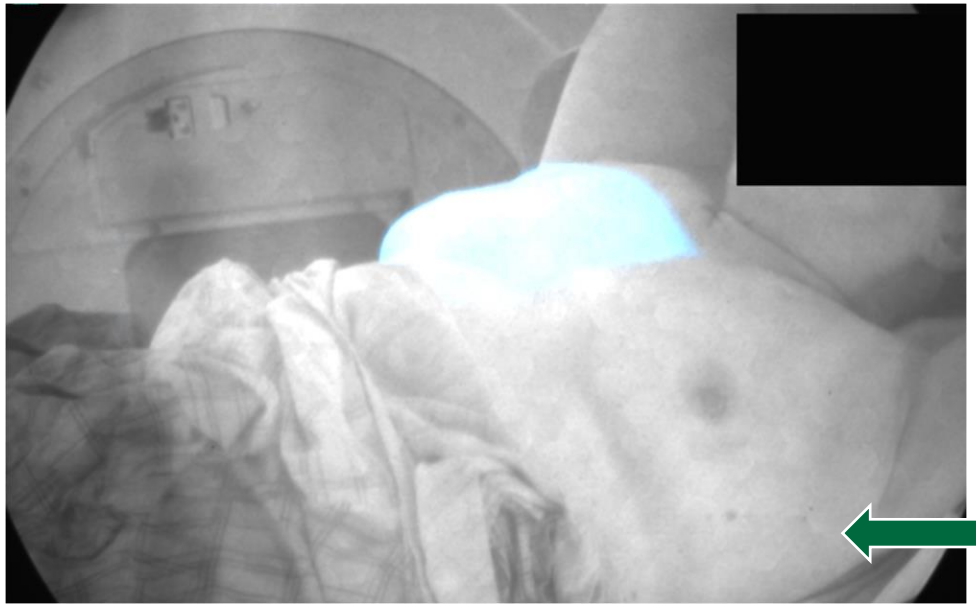
Treatment images with couch kicks have motion blur artifacts



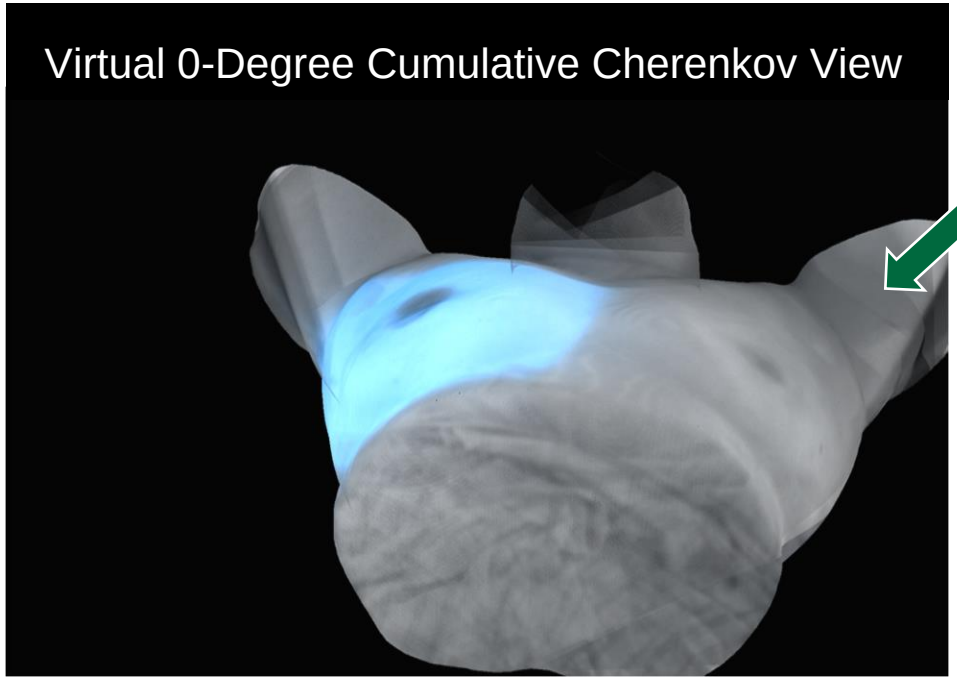
Occluded at 356 Degrees



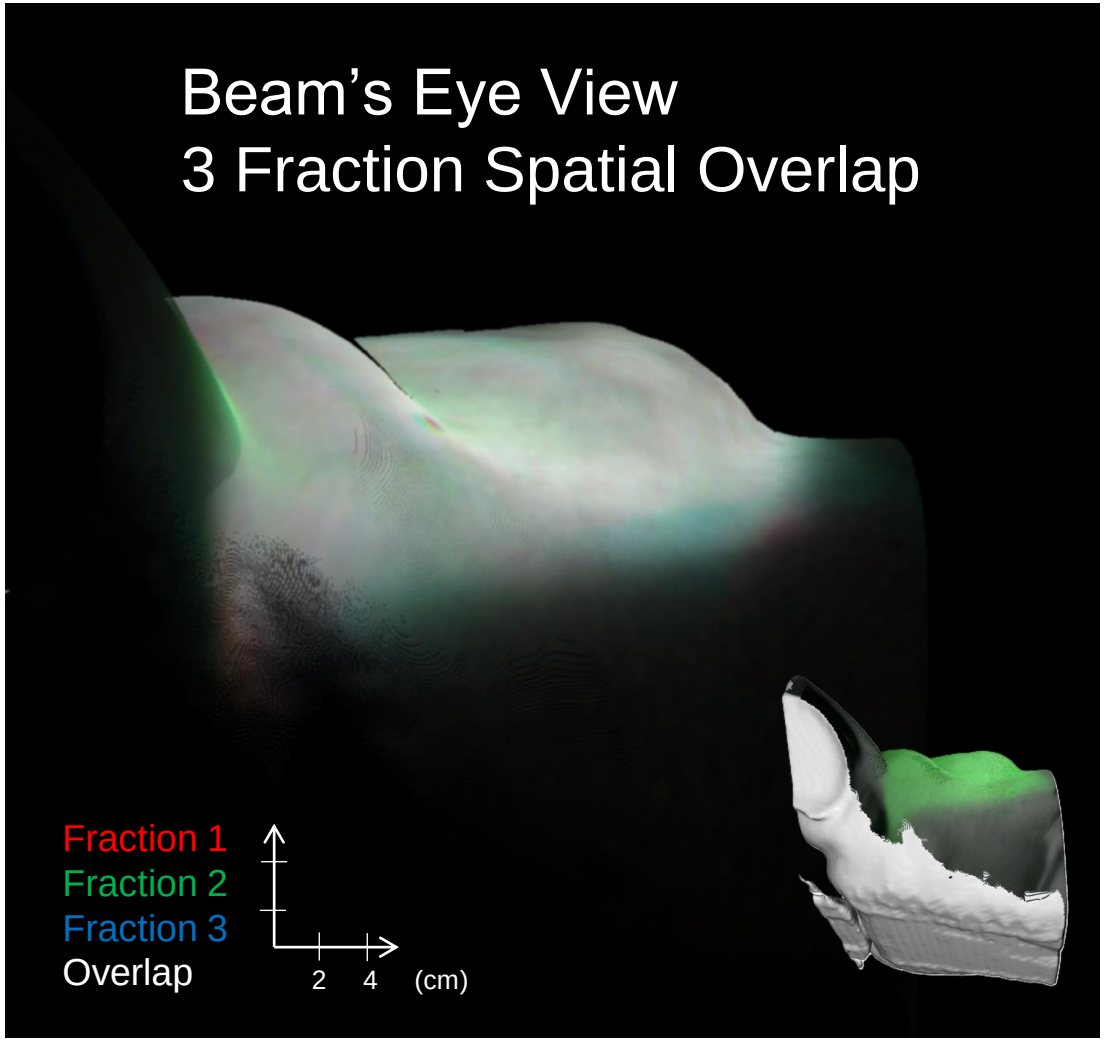
Visible to the camera at couch angle of 5 Degrees

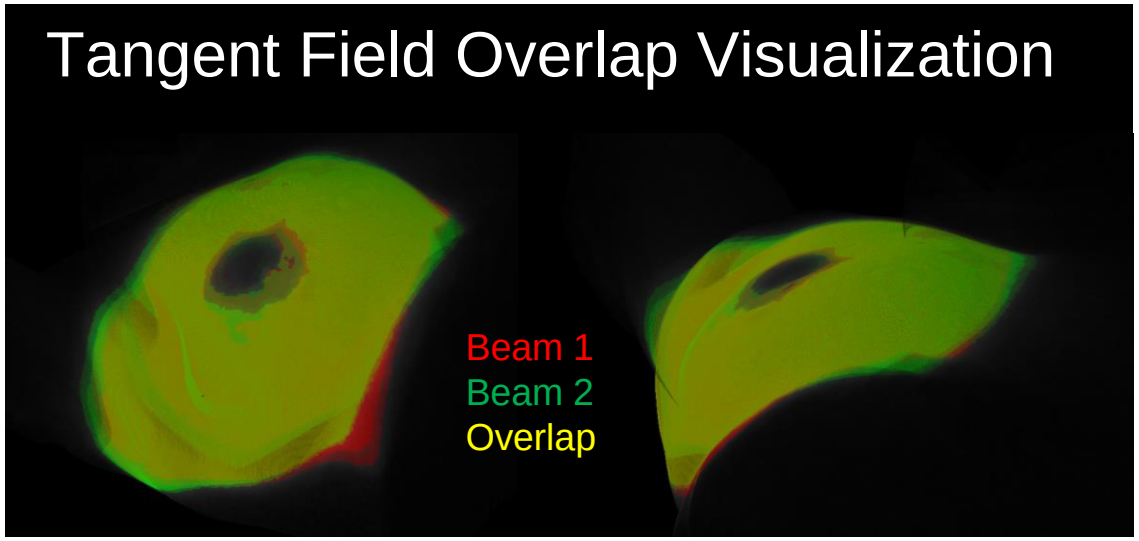


Semi-occluded views generate image intensity artifacts



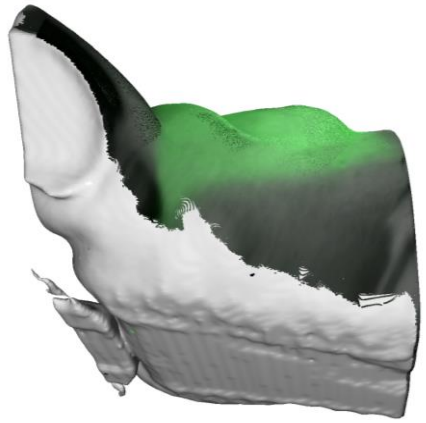
Motion Blur Image Artifacts Removed





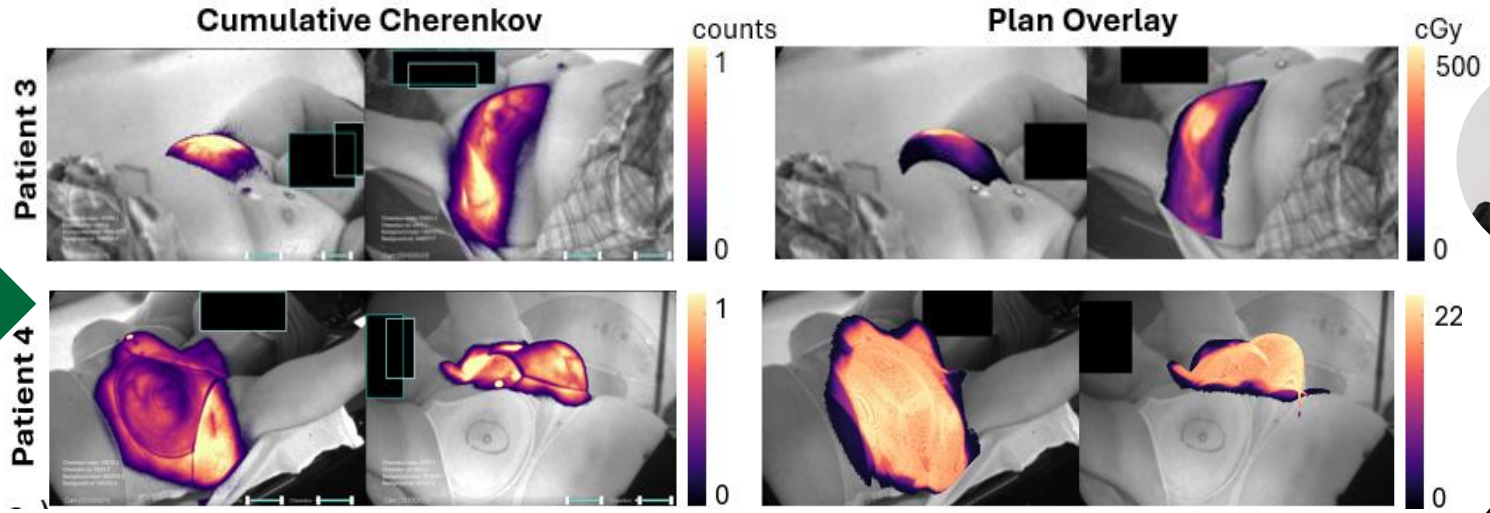
Conclusions

3D Surface Imaging

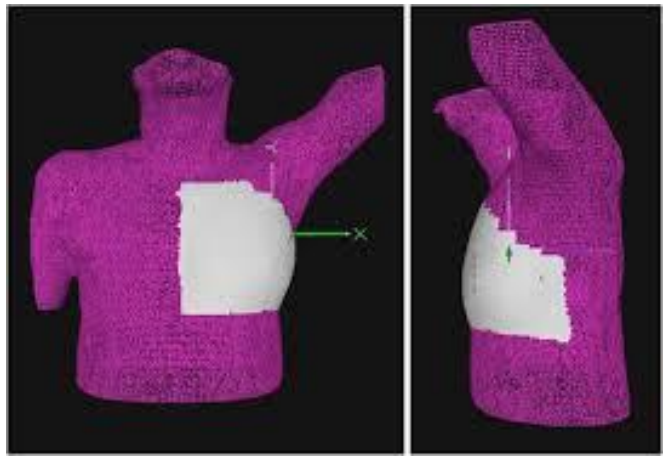


- Created and validated a projection framework to link 2D images to 3D surfaces via projection
- Generated virtual BEV images for spatial beam measurements

DoseDot Localization



Detecting and Quantifying Treatment Incidents



Thank you!

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Questions?

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