CENTER FOR IMAGING MEDICINE AT DARTMOUTH

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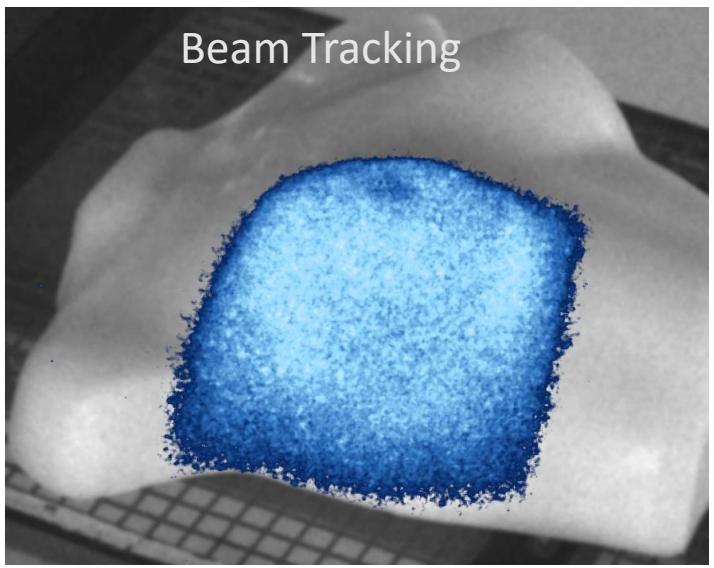
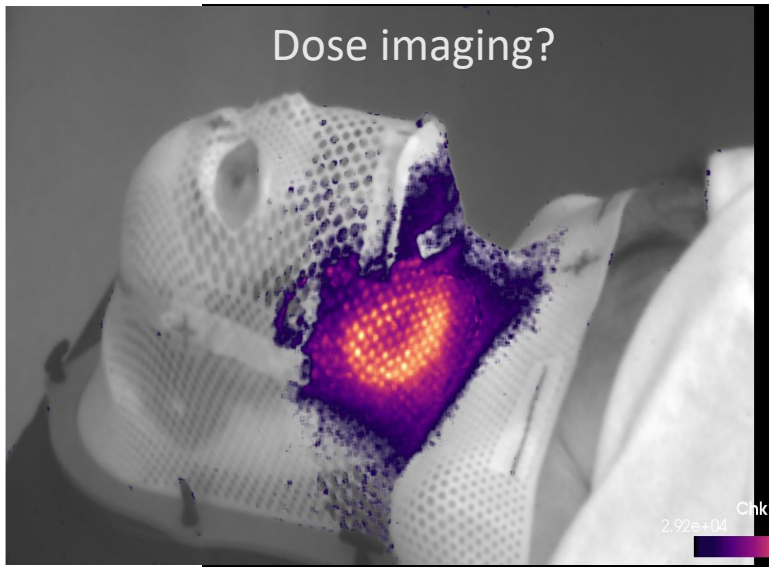
Treatment Verification with Cherenkov Imaging





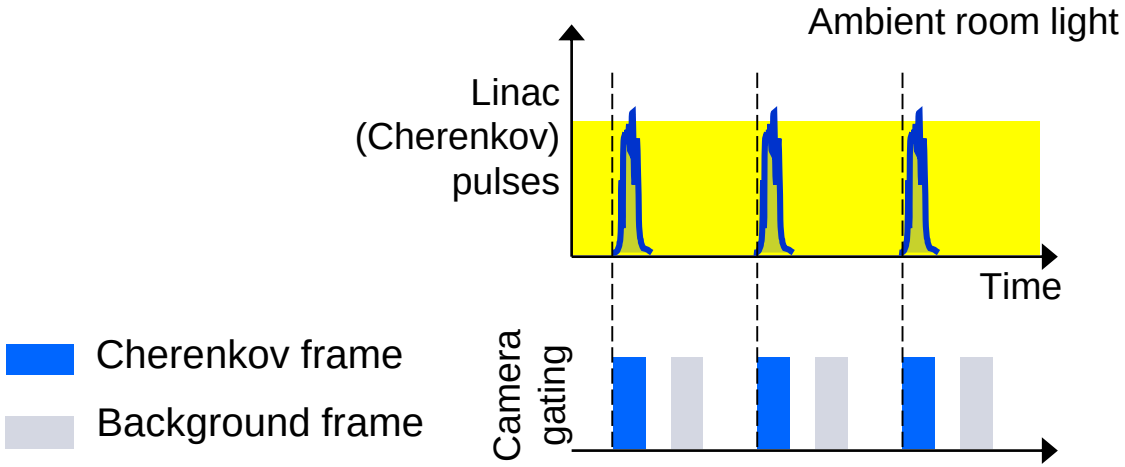
Brian W Pogue PhD
MacLean Professor of Engineering, Dartmouth
Editor-in-Chief, *Journal of Biomedical Optics*

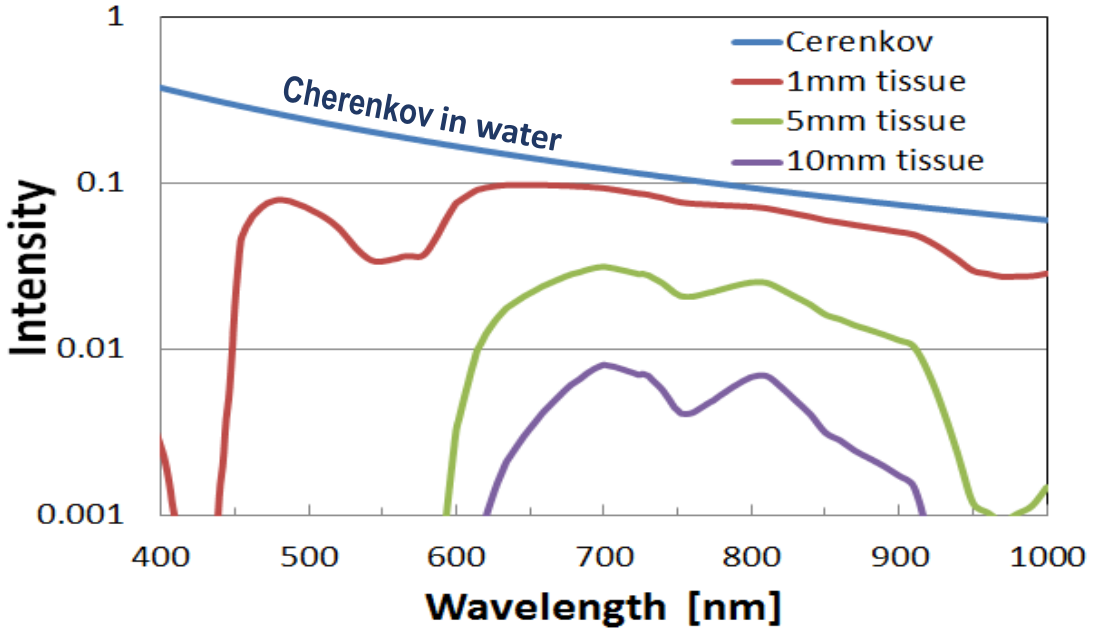
Disclosures

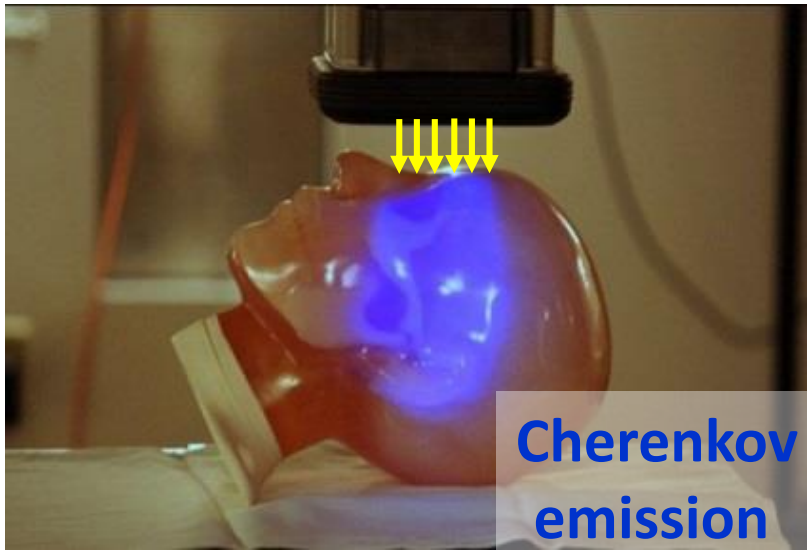
DoseOptics LLC: President and co-founder

Developing Cherenkov imaging cameras software and systems.

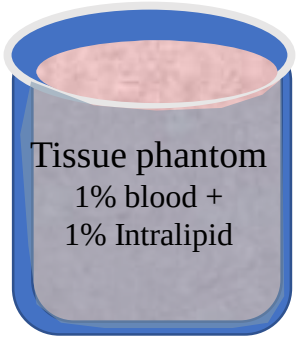
LINAC Radiation Dose produces pulses with Cherenkov light

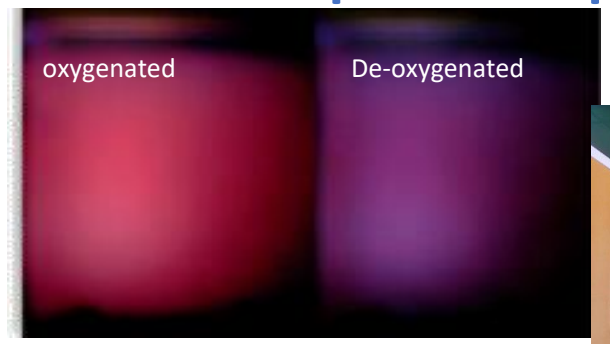






Cherenkov spectroscopy

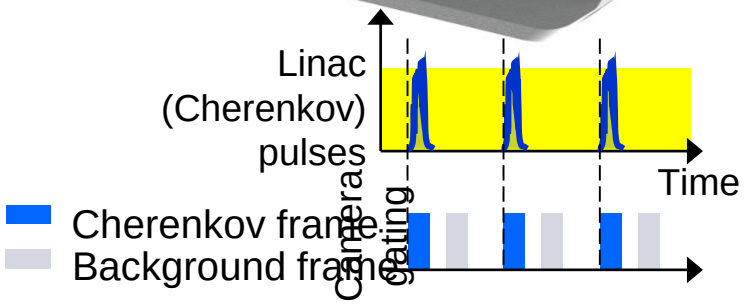


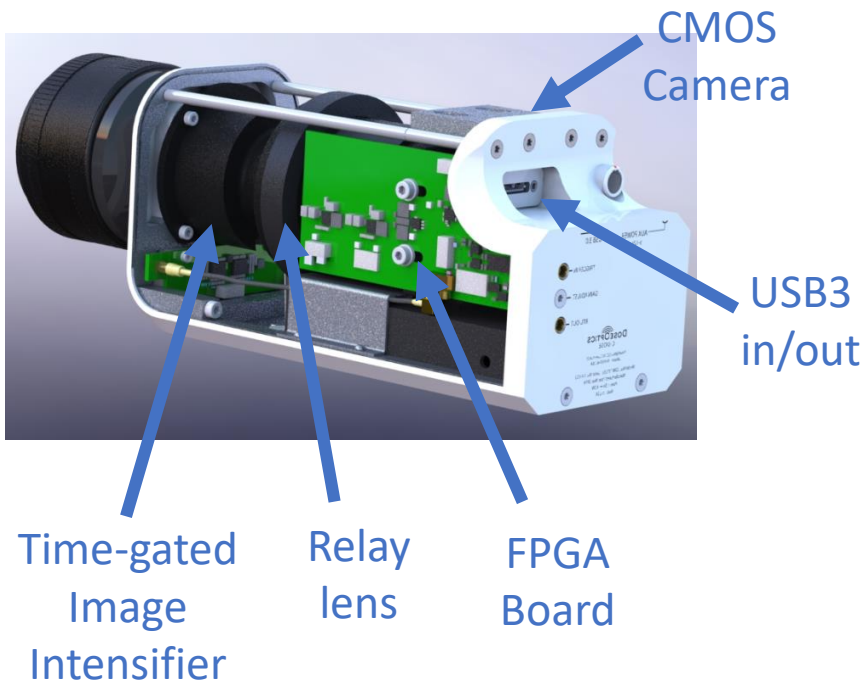


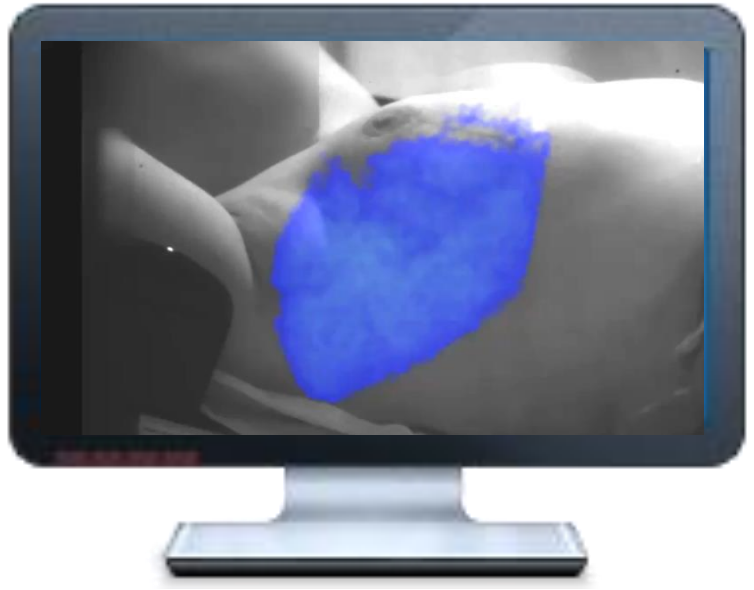
Zhang et al, Med. Phys. 2012

Axelsson e

Time-gated Intensified Camera System





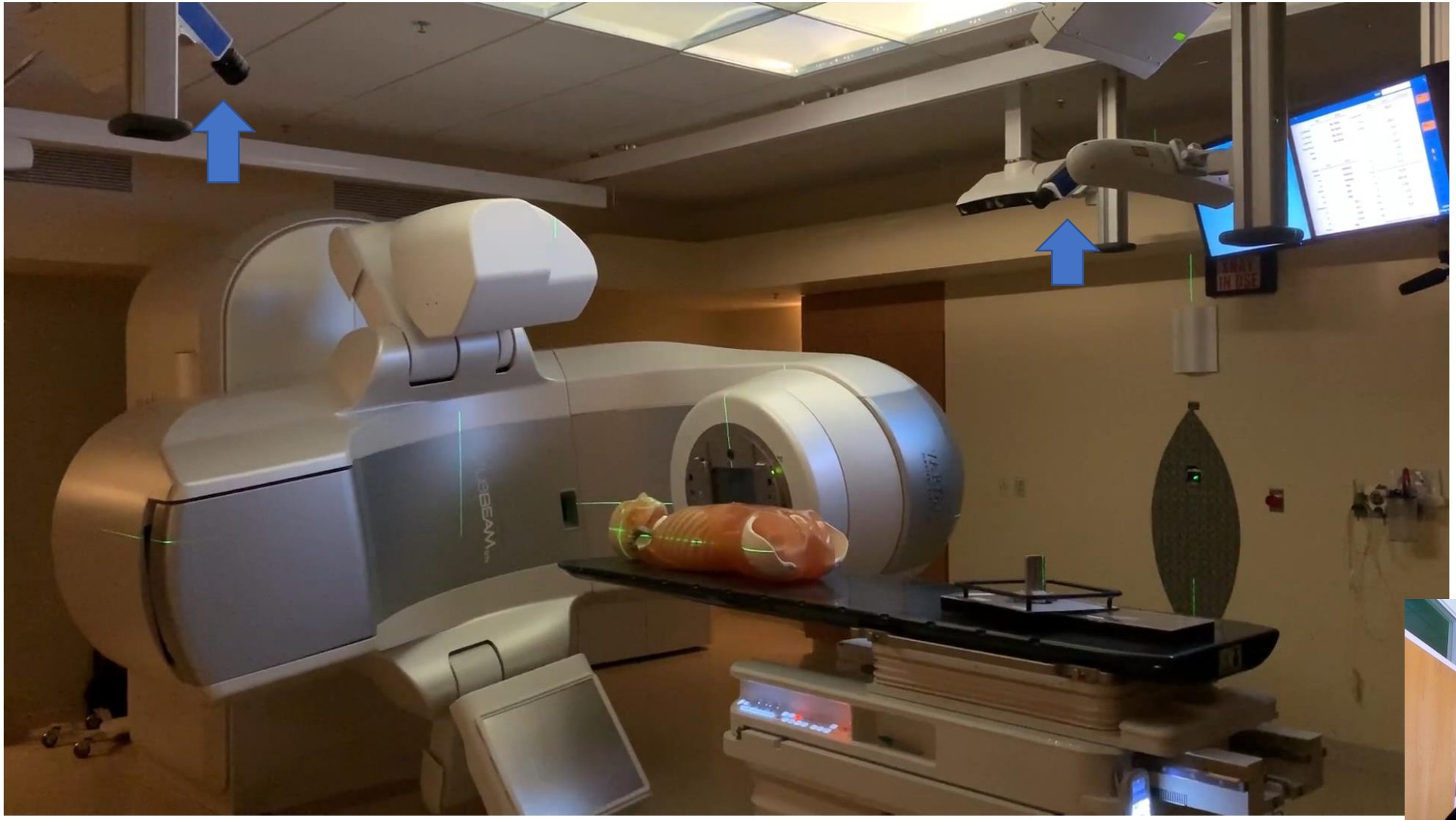


Single photon imaging with room lights on!

DOSEOPTICS
Visualize radiation therapy

DISCLOSURE: B. Pogue is founder & president of DoseOptics.

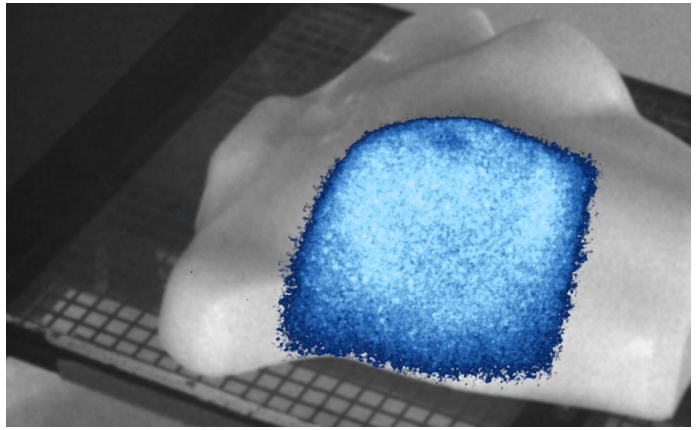
Cameras installed in all Dartmouth Linac Rooms



DOSEOPTICS
Visualize radiation therapy

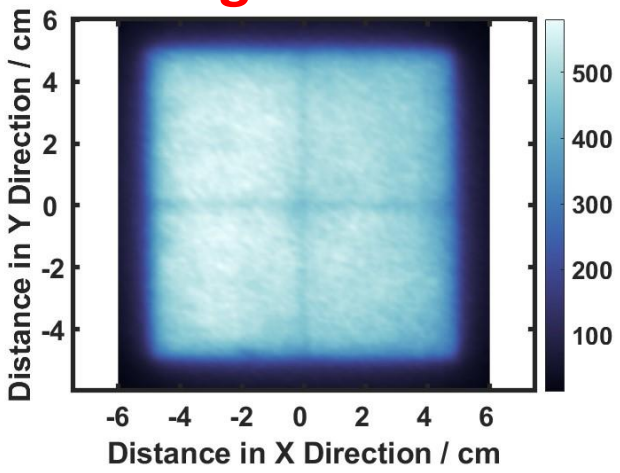
Additional User sites:
Dartmouth
U Penn
Wash U
Emory
Harvard/MGH

Verification of beam position on the patient

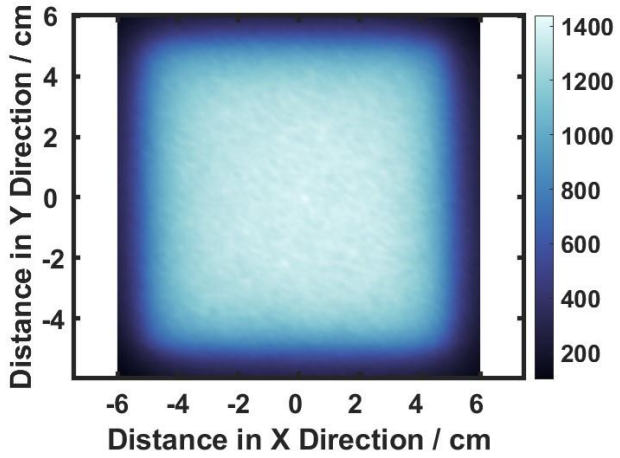


Cherenkov is a direct display of surface dose

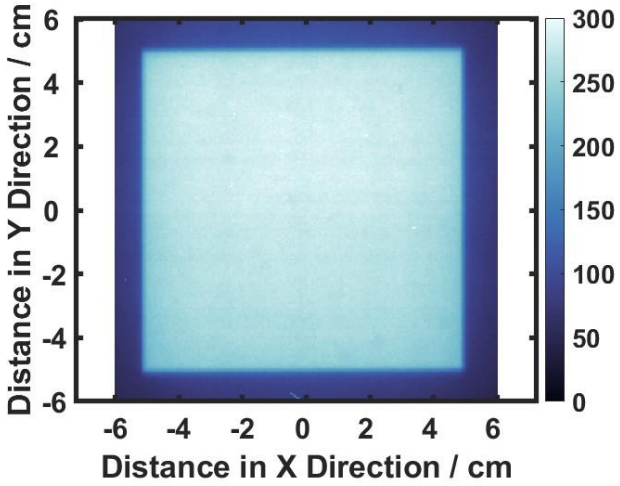
Light Field



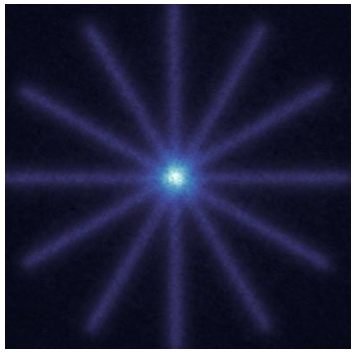
Cherenkov



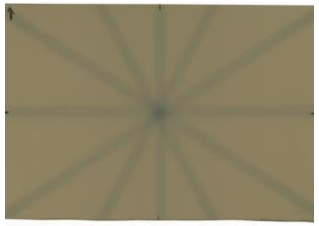
FILM



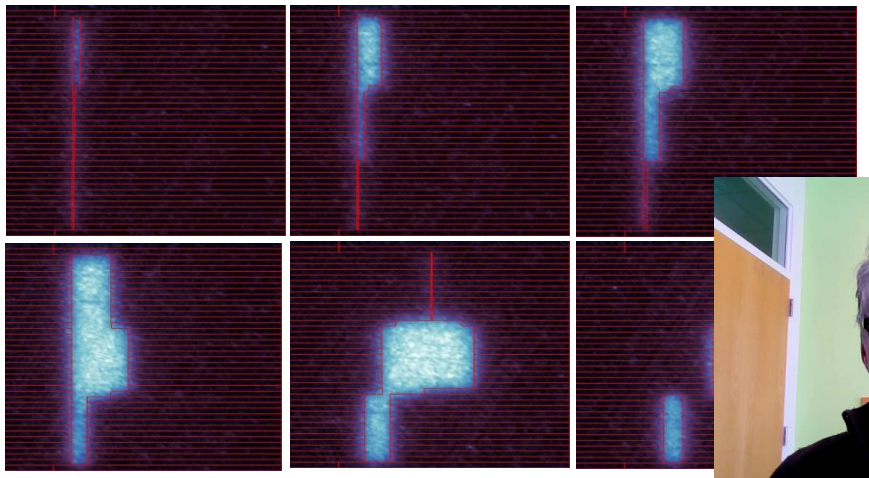
Cherenkov



FILM



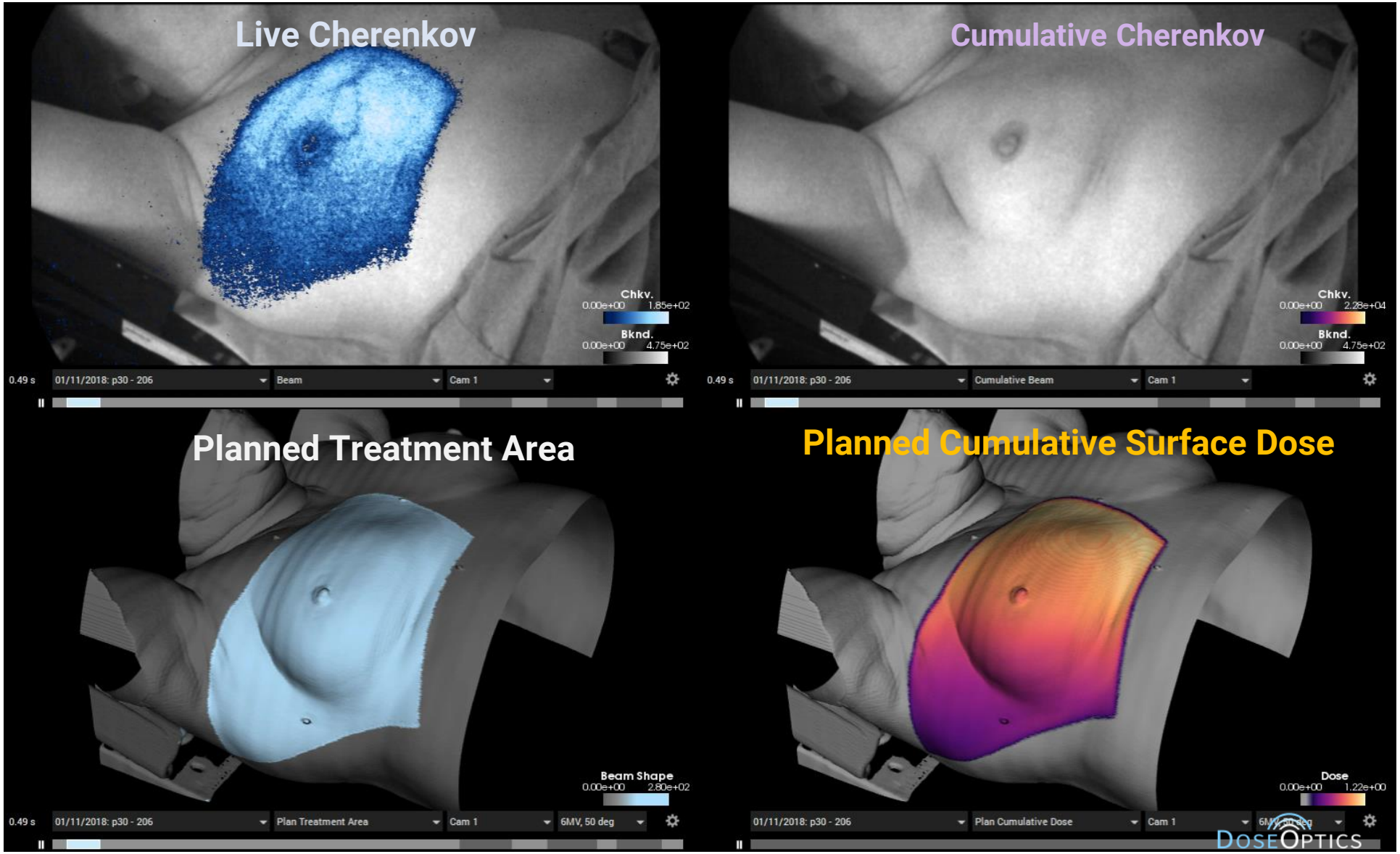
Cherenkov



Miao et al, Med. Phys. 2019

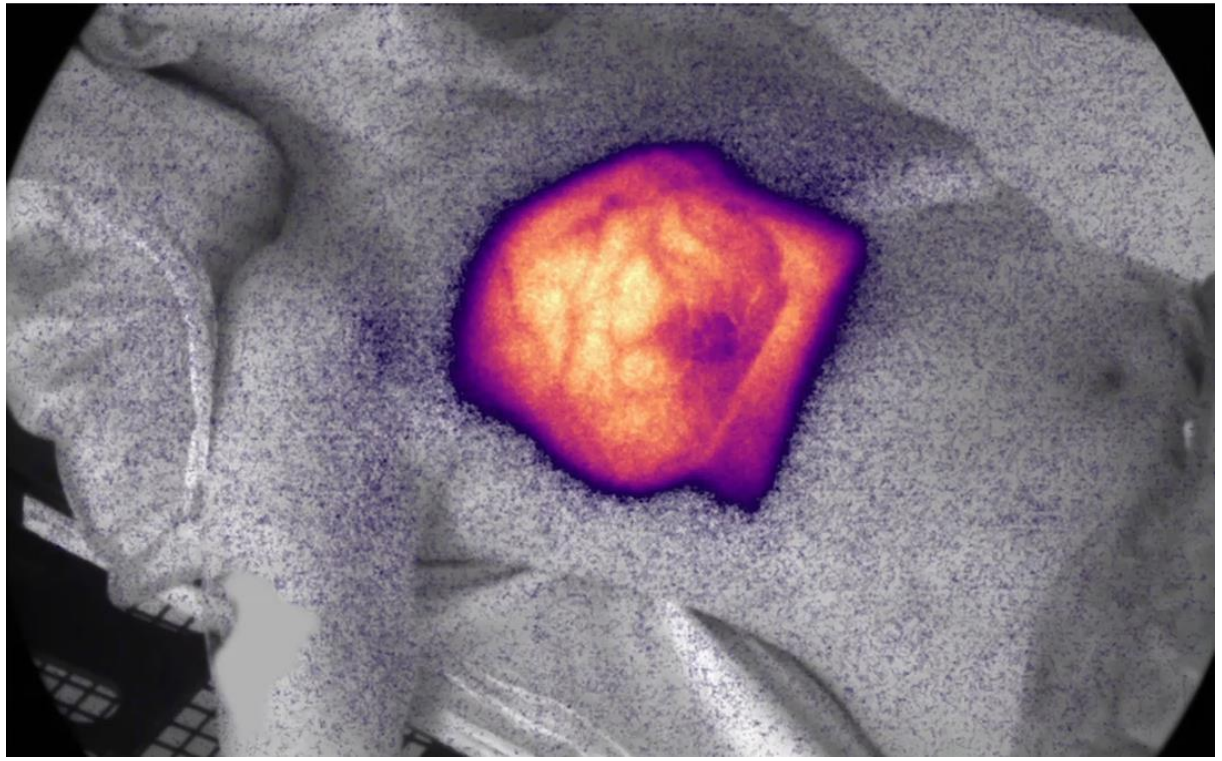
DOSEOPTICS
Visualize radiation therapy

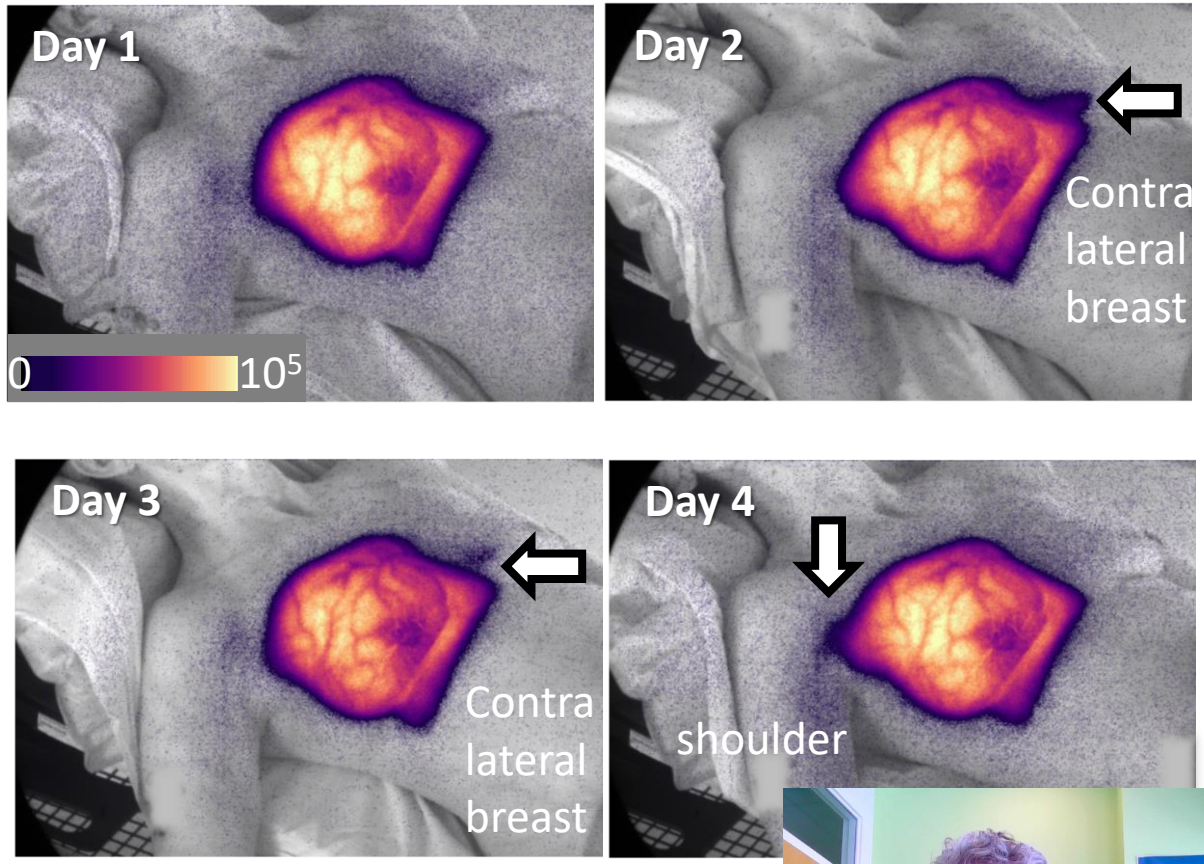
Whole breast radiotherapy verification



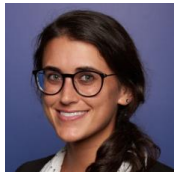
Incidents observed with Cherenkov images

‘arm down’ treatments on different days





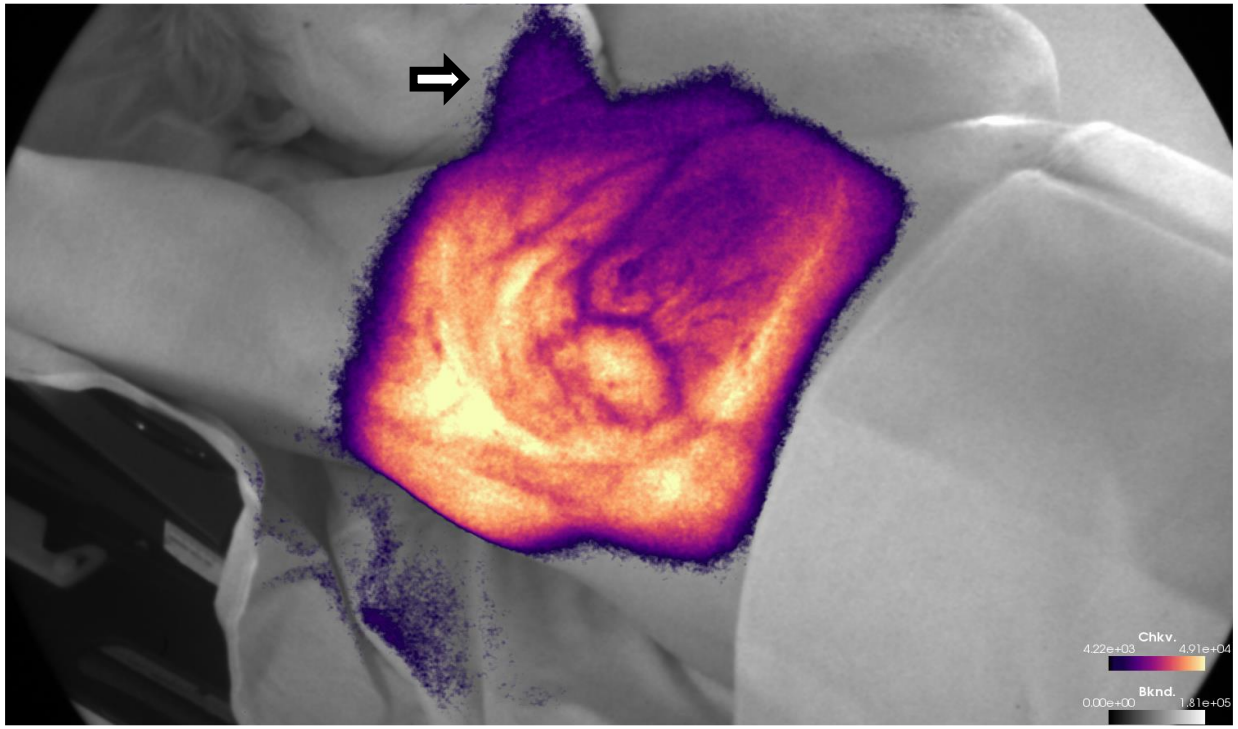
Jarvis et al, IJROBP (in review 2020)



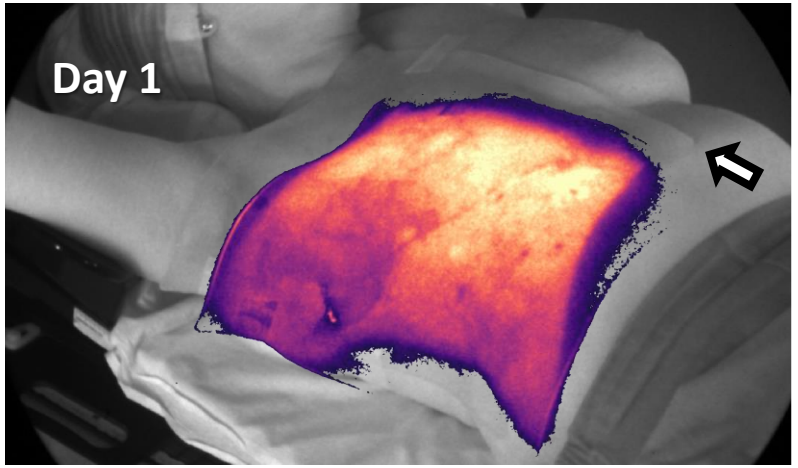
R Hachadorian, et al,
Session:Multi-Disciplinary ePoster
Poster #: PO-GeP-M-194

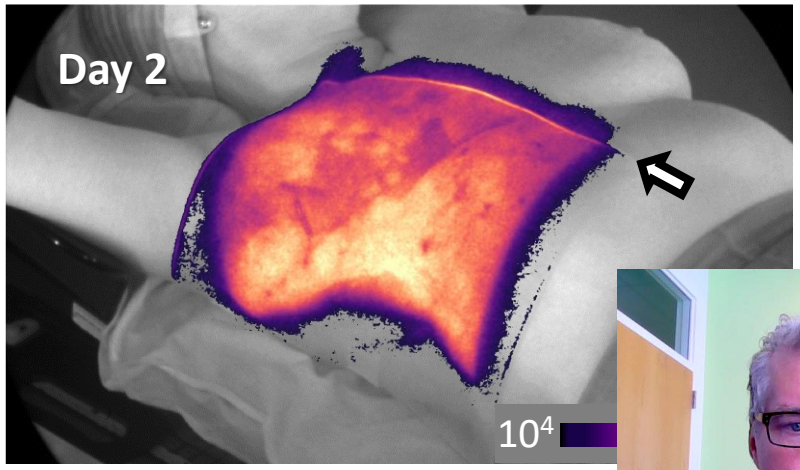
Incidents observed with Cherenkov images

Neck involvement



Bolus placement differences

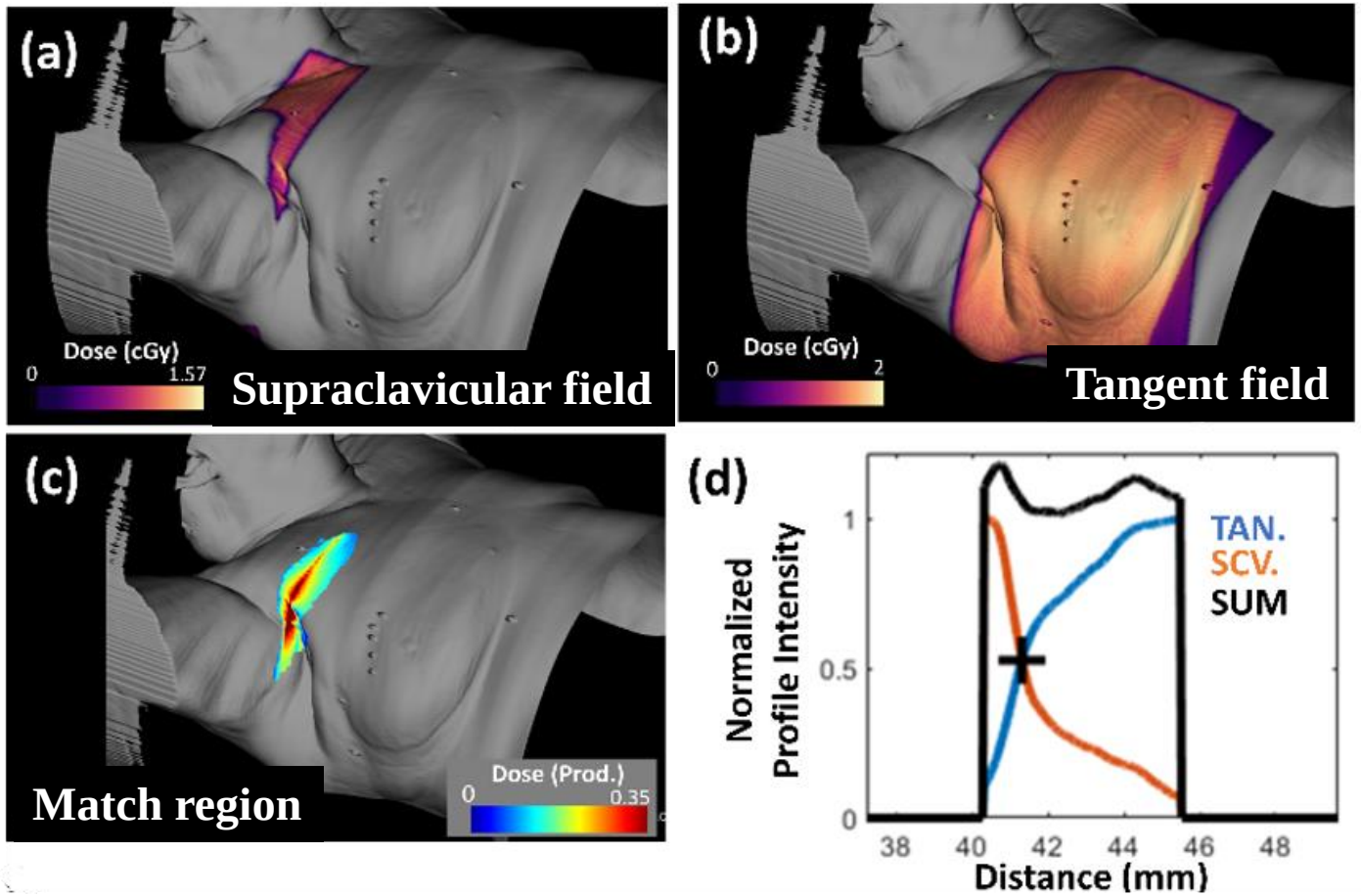


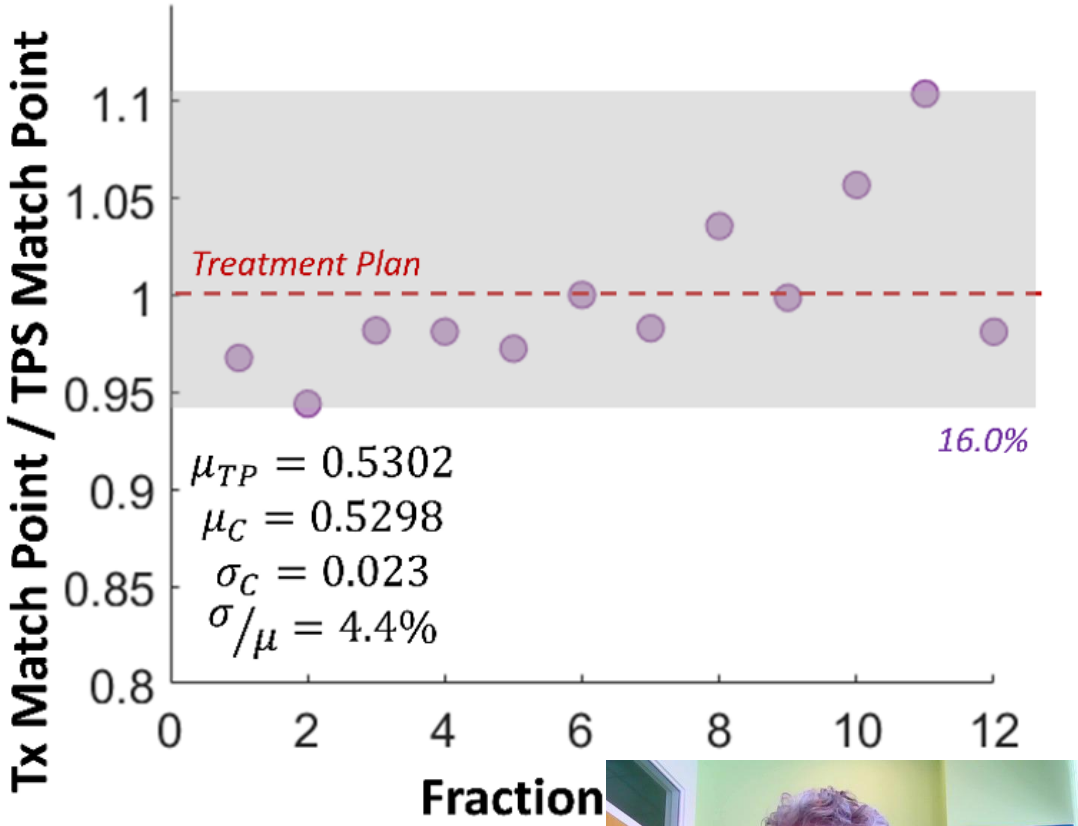


Jarvis et al, IJROBP (in review 2020)

R Hachadorian, et al,
Session:Multi-Disciplinary ePoster
Poster #: PO-GeP-M-194

Match line views from Cherenkov on skin



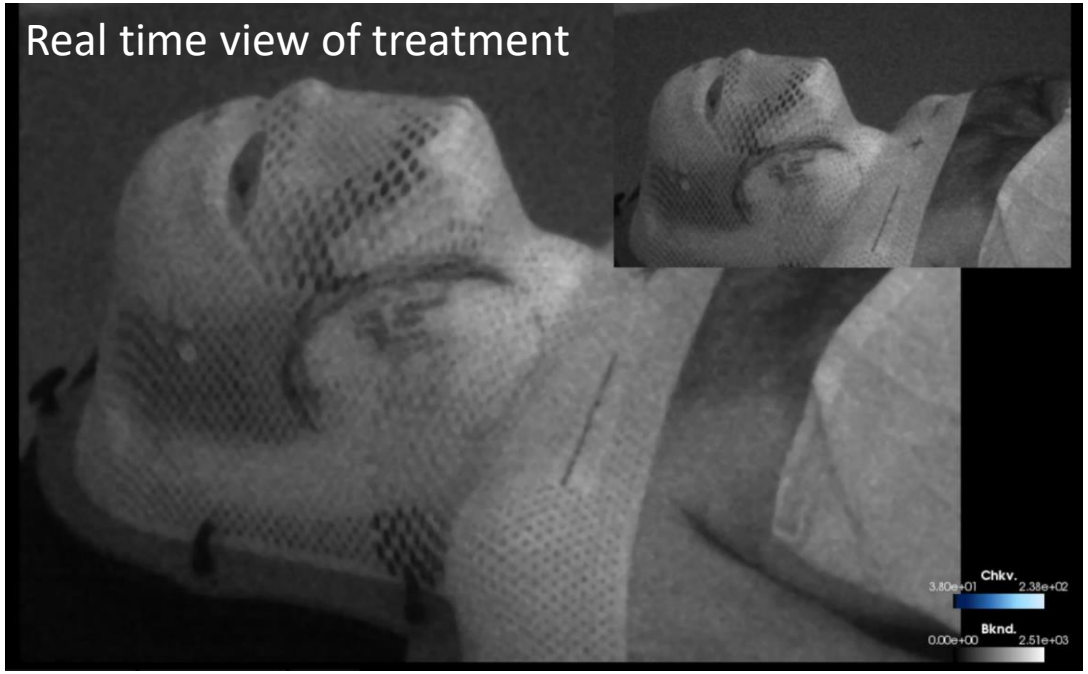


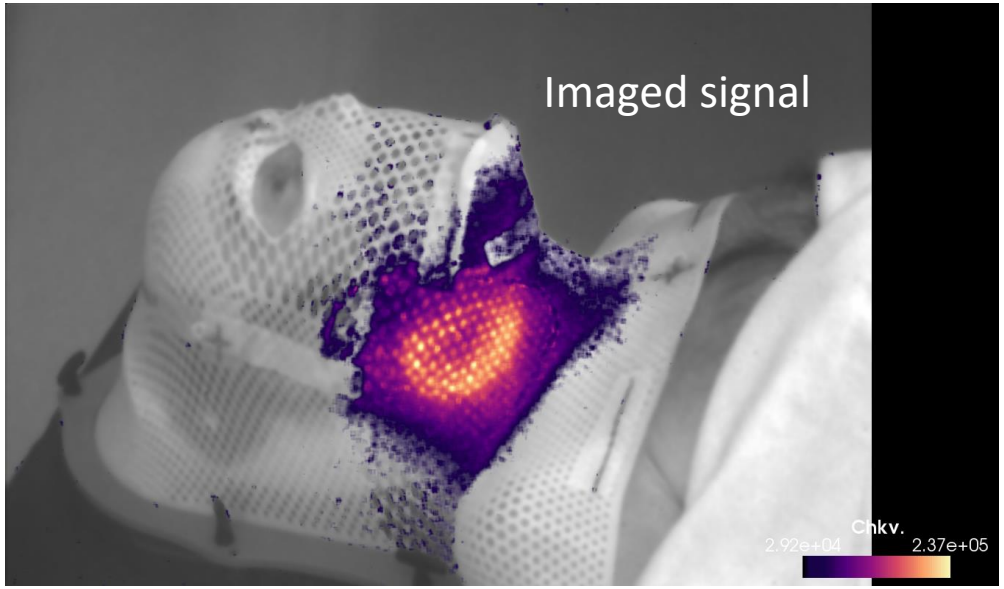
Hachadorian et al,
submitted 2020

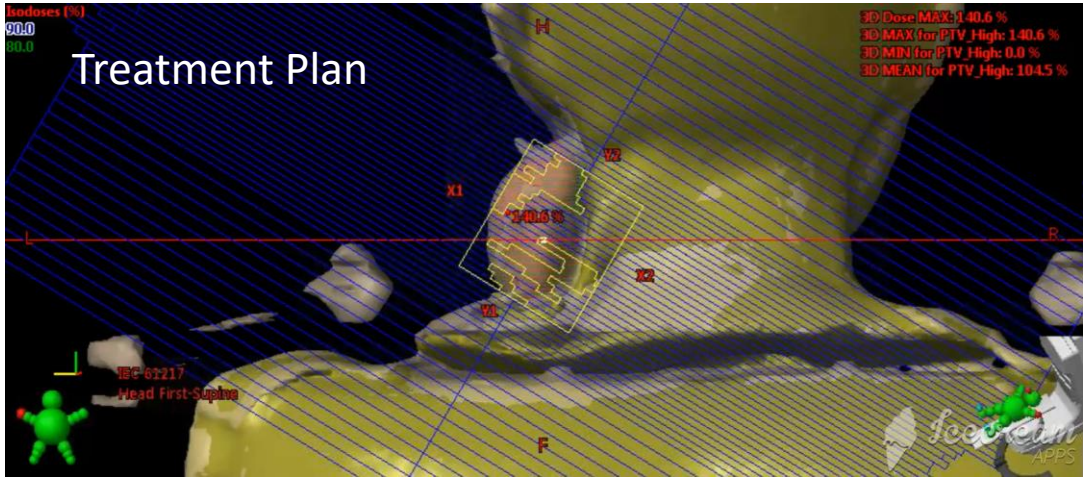
R Hachadorian, et al
Session Title: Multi-Disciplinary ePoster
Poster #: PO-GeP-M-75

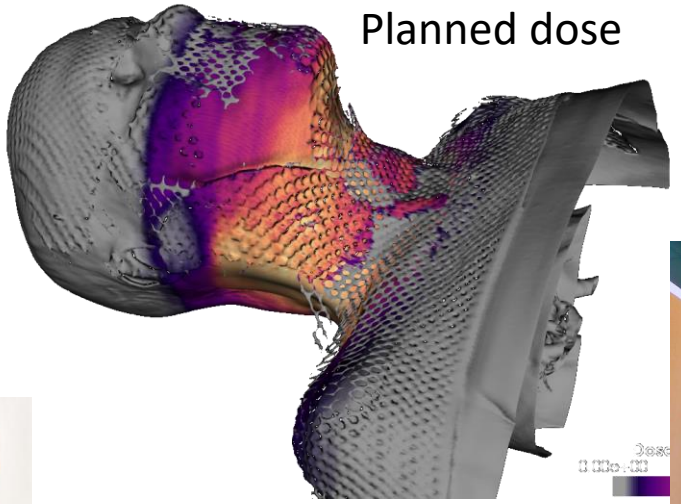
THAYER SCHOOL OF ENGINEERING AT DARTMOUTH
Dartmouth-Hitchcock NORRIS COTTON CANCER CENTER
CENTER FOR IM

Head and Neck Tumor Treatments



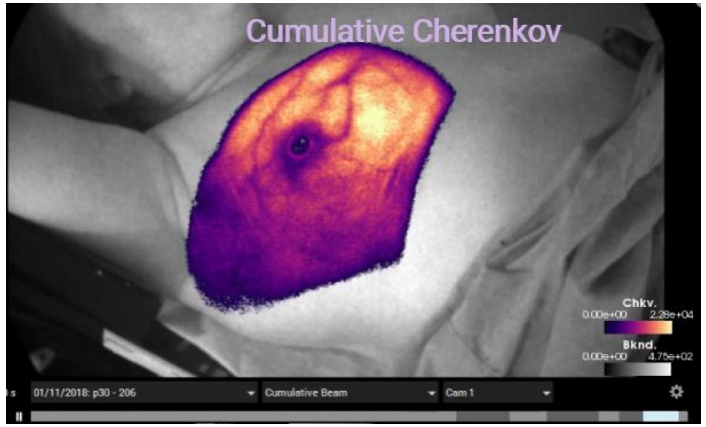


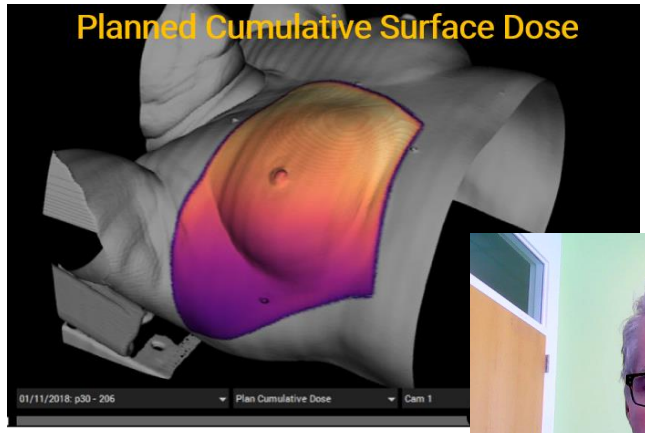




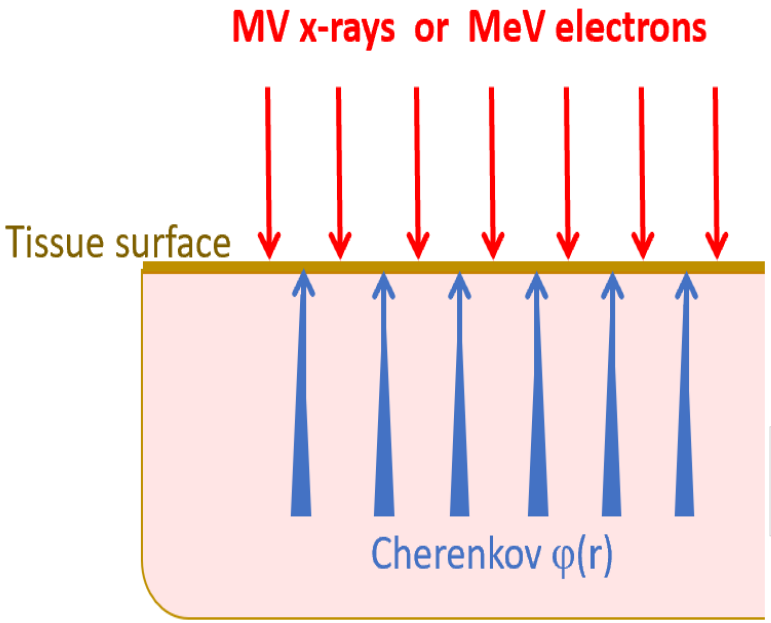
Dan Alexander

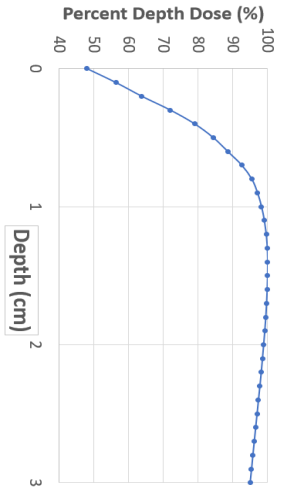
Cherenkov ≈ Surface Dose ?





X-ray dose builds up & Cherenkov is emitted



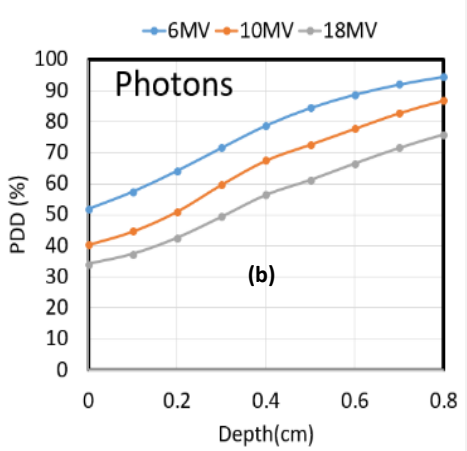


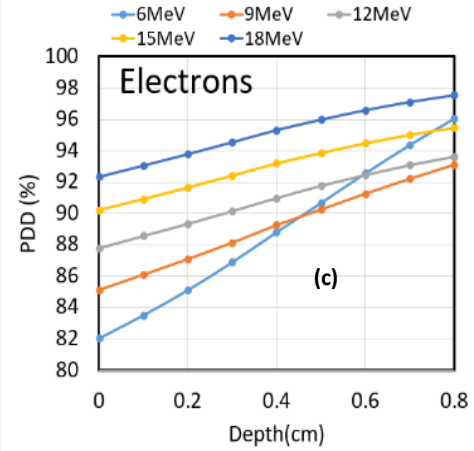
$$\varphi_R(z) = S(z)\sqrt{\frac{3\mu_s'}{\mu_a}}\,e^{-\mu_{eff}z}$$

$S(z) = S_0 (k_1 + k_2 z)$

Pogue et al, Proc SPIE BiOS 2020

Build up is always linear over the first 8 mm!!





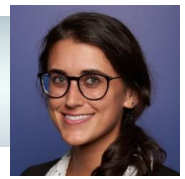
$$\varphi_{Ch}(z) = \frac{S_0\,k_1}{D\mu_{eff}}e^{-\mu_{eff}z} - \frac{S_0\,k_2}{2D\mu_{eff}^2}(e^{-\mu_{eff}z} - e^{\mu_{eff}z})$$

Signal is dependent upon:

- Build up rate with depth
- Absorption coefficient (≈blo

nature COMMUNICATIONS

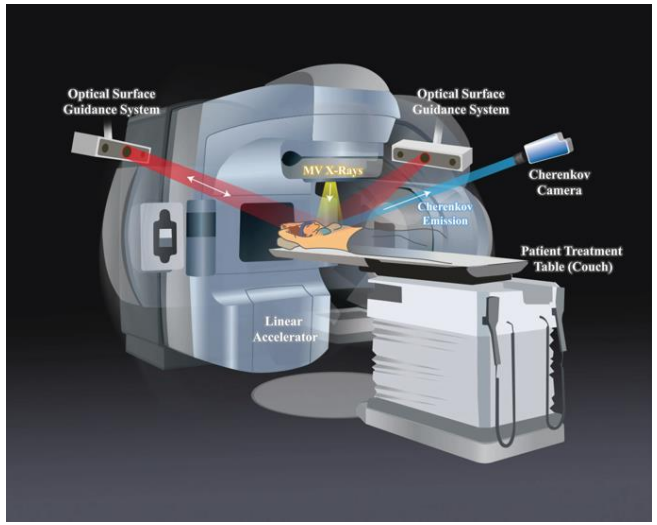
https://doi.org/10.1038/s41467-020-16031-z OPEN

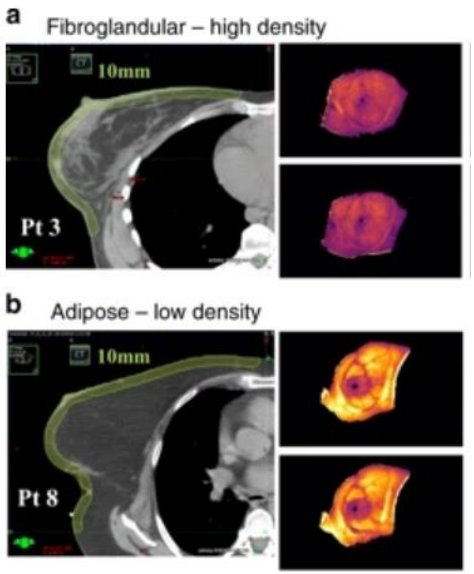


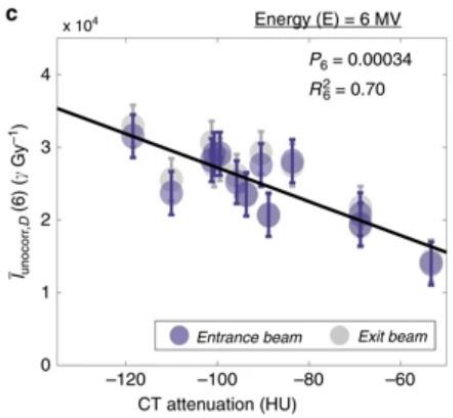
Imaging radiation dose in breast radiotherapy by X-ray CT calibration of Cherenkov light

R. L. Hachadorian [1], P. Bruza [1], M. Jermyn[1,2], D. J. Gladstone [1,3,4], B. W. Pogue [1,2,3,4] & L. A. Jarvis [3,4]✉

Article | Open Access | Published: 08 May 2020



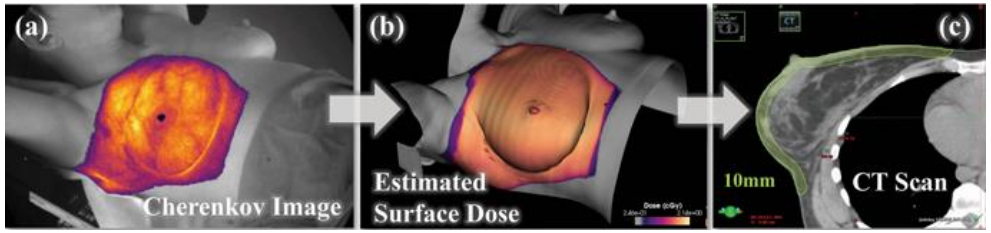




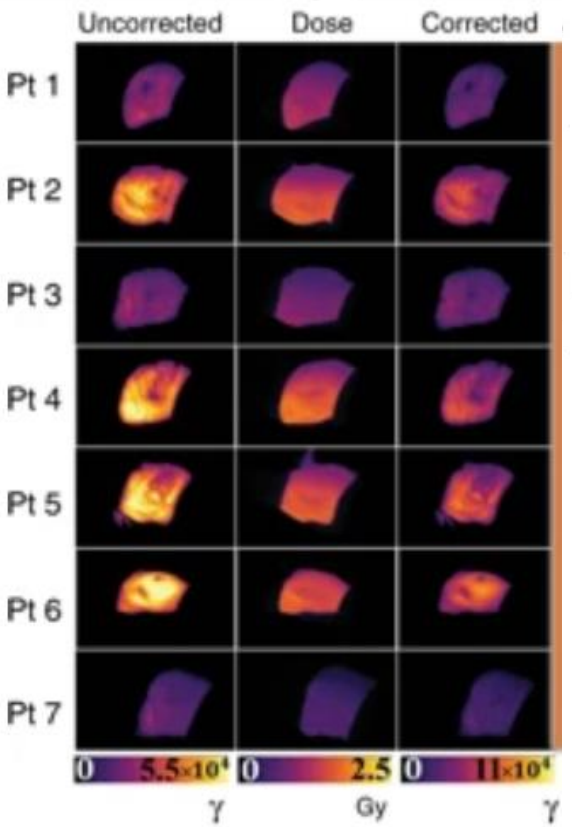
Cherenkov emission is decreases with CT number!

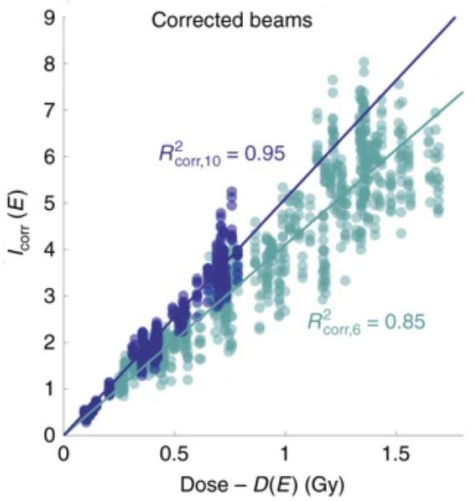
Higher CT number ≈ higher blood vol (blood attenuates light)

Blue Ribbon ePoster
Poster Number: BReP-SNAP-M-87



$$I_C(E) = c(CT,E) \cdot I_R(E)$$



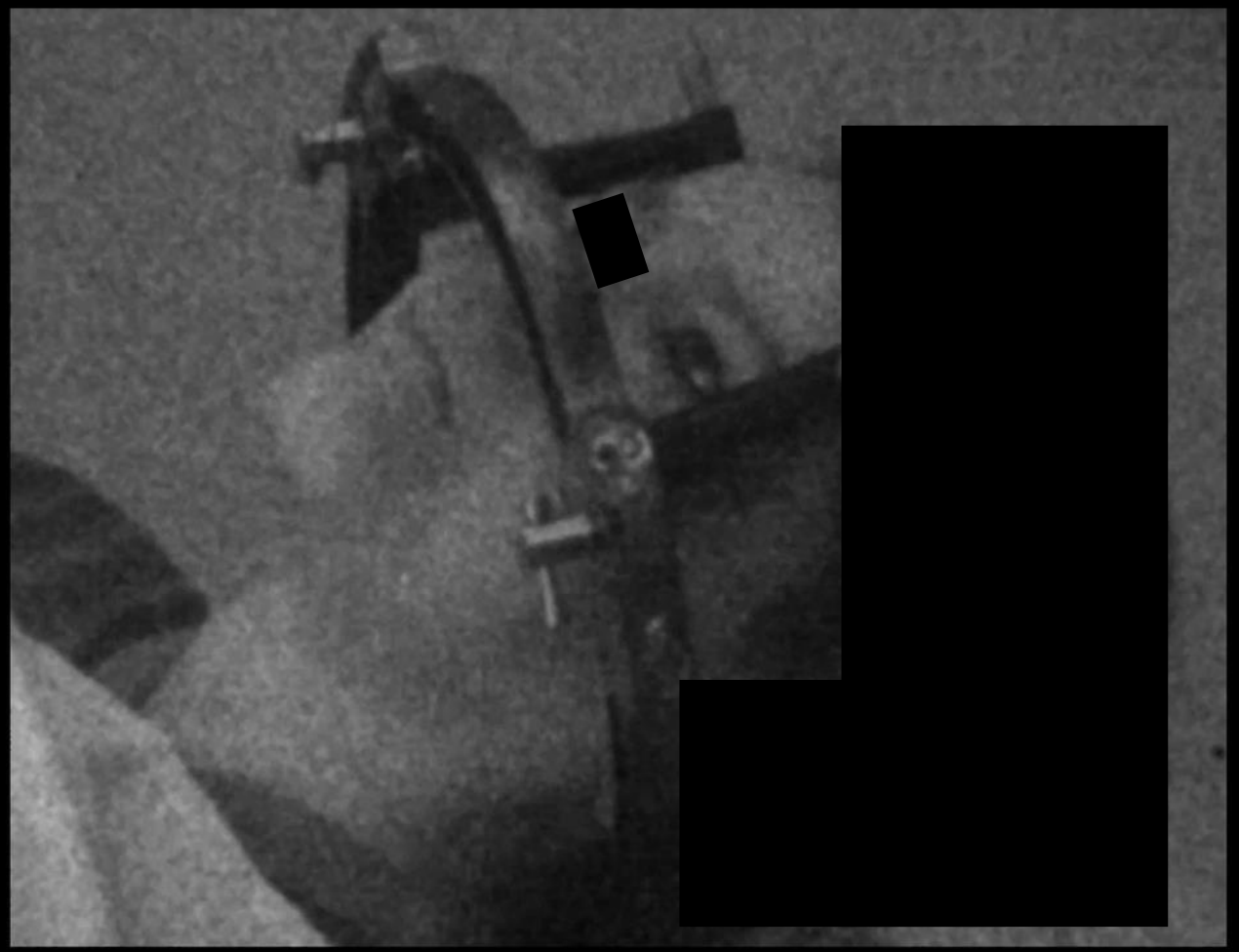


International Journal of Radiation Oncology biology • physics ASTRO

PHYSICS CONTRIBUTION | VOLUME 106, ISSUE 2, P422-429, FEBRUARY 01, 2020

Experimentally Observed Cherenkov Light Generation in the Eye During Radiation Therapy

Irwin I. Tendler, MEng • Alan Hartford, MD, PhD • Michael Jermyn, PhD • ... Brian W. Pogue, PhD • David J. Gladstone, ScD • Lesley A. Jarvis, MD, PhD • Show all authors



Cumulative View

Real-Time Vie

I. Tendler et al, IJROBP 2020

YOUNG INVESTIGATOR SYMPOSIUM

Session: MO-CD-TRACK 1-2

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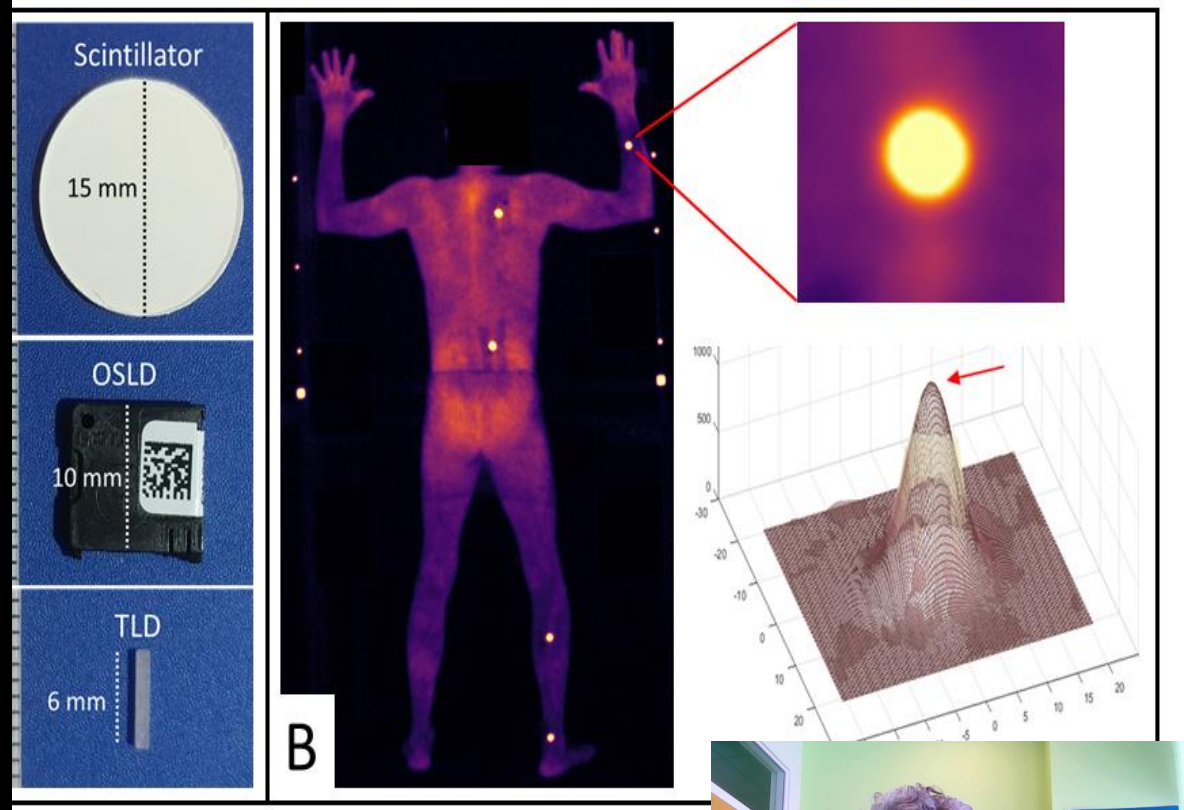
Official Journal of the American Society for Radiation Oncology ASTRO

< Previous Article | March 1, 2019 Volume 103, Issue 3, Pages 767–774 | Next Article >

Rapid Multisite Remote Surface Dosimetry for Total Skin Electron Therapy: Scintillator Target Imaging

Irwin Tendler, MEng*, Petr Brůža, PhD*, Jacqueline Andreozzi, PhD*, Michael Jermyn, PhD*, Benjamin Williams, PhD†,‡, Lesley Jarvis, MD, PhD†,‡,*, Brian Pogue, PhD*,†, David Gladstone, ScD*,†,‡



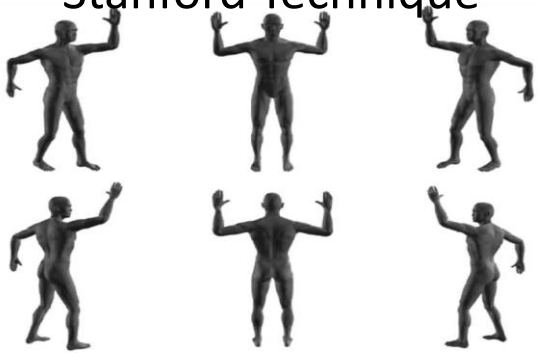
Automated
Non-contact
Dose readout

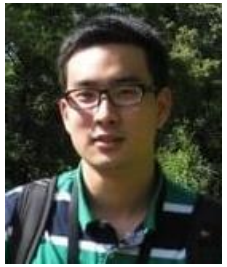
Journal of Medical Imaging
SPIE. DIGITAL LIBRARY

Computer animation body surface analysis of total skin electron radiation therapy dose homogeneity via Cherenkov imaging

Tianshun Miao,[a] Heather Petroccia,[b] Yunhe Xie,[b] Michael Jermyn,[a] Maxine Perroni-Scharf,[c] Namit Kapoor,[c] James M. Mahoney,[c] Timothy C. Zhu,[a] Petr Bruza,[a] Benjamin B. Williams,[d] David J. Gladstone,[d] and Brian W. Pogue[a,*]

Stanford Technique



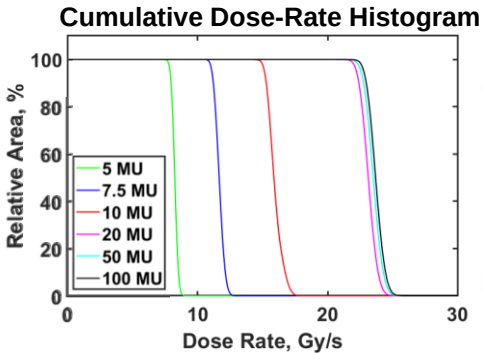


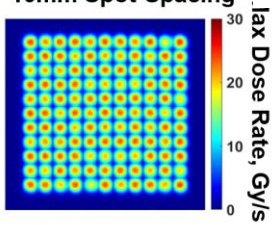
T Miao & T. Zhu
Blue Ribbon ePoster
BReP-SNAP-M-141

Prof Tim Zhu UPenn

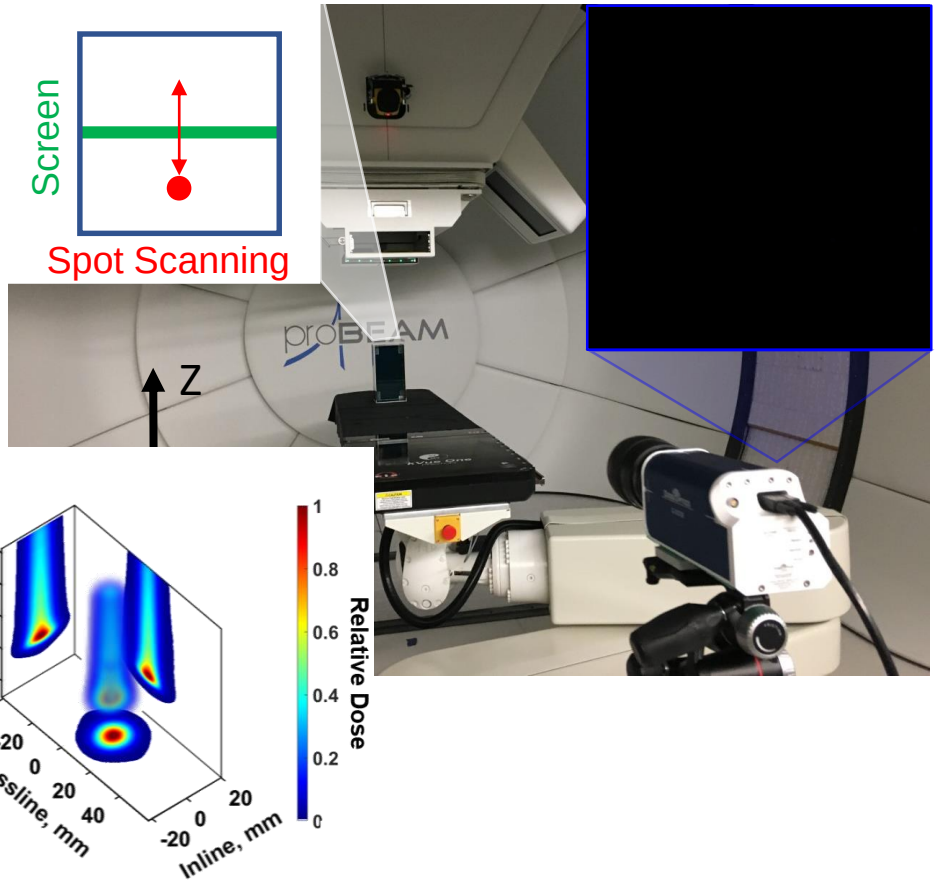
Radioluminescence Imaging of Proton Beam Dose

Dose Rate Dynamics



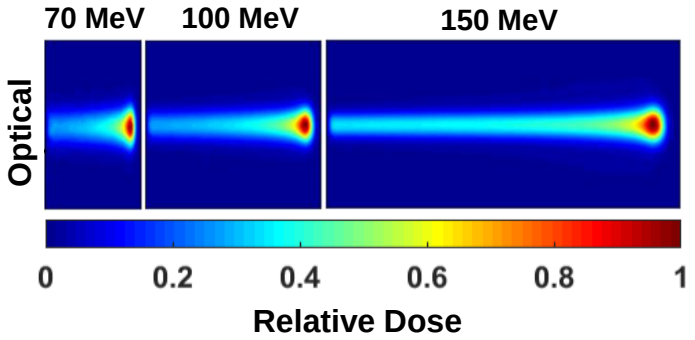


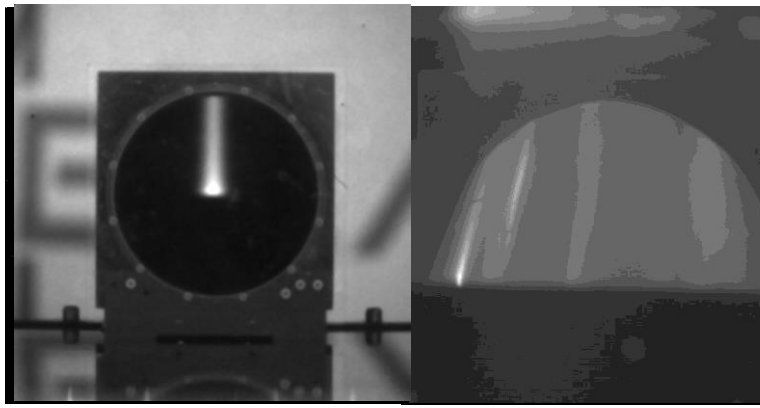
Volumetric LET and Dose



M Rahman: Therapy General
ePoster PO-GeP-T-388

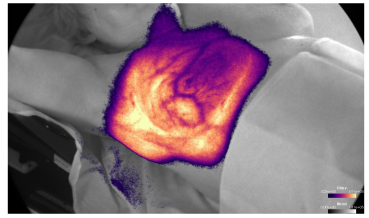
Patient Plan Imaging



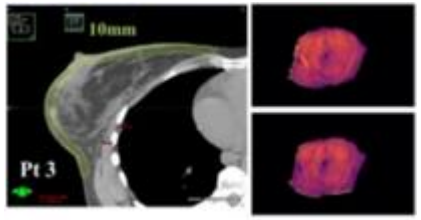


Summary of observations:

- Cherenkov imaging allows real time view of delivery & incidents
  neck, shoulder, contralateral, bolus, plan incidents



- Quantitative dose imaging with CT and optical corrections



- Match lines can be visualized at adjacent fields

- Absolute dose point values obtained with scintillator imaging
- Total skin electron therapy mapping is possible

- Small beam dosimetry
- Proton beam dosimetry via scintillation