Clinical Practices of Managing Implanted Medical Devices for Proton Therapy

Chengyu Shi, PhD, DABR, FAAPM

City of Hope | ORANGE COUNTY

1884 Memorial Sloan Kettering Cancer Center

Mount Sinai Hospital

Montefiore HEALTH SYSTEM

ProHEALTH℠ Care

Disclosure

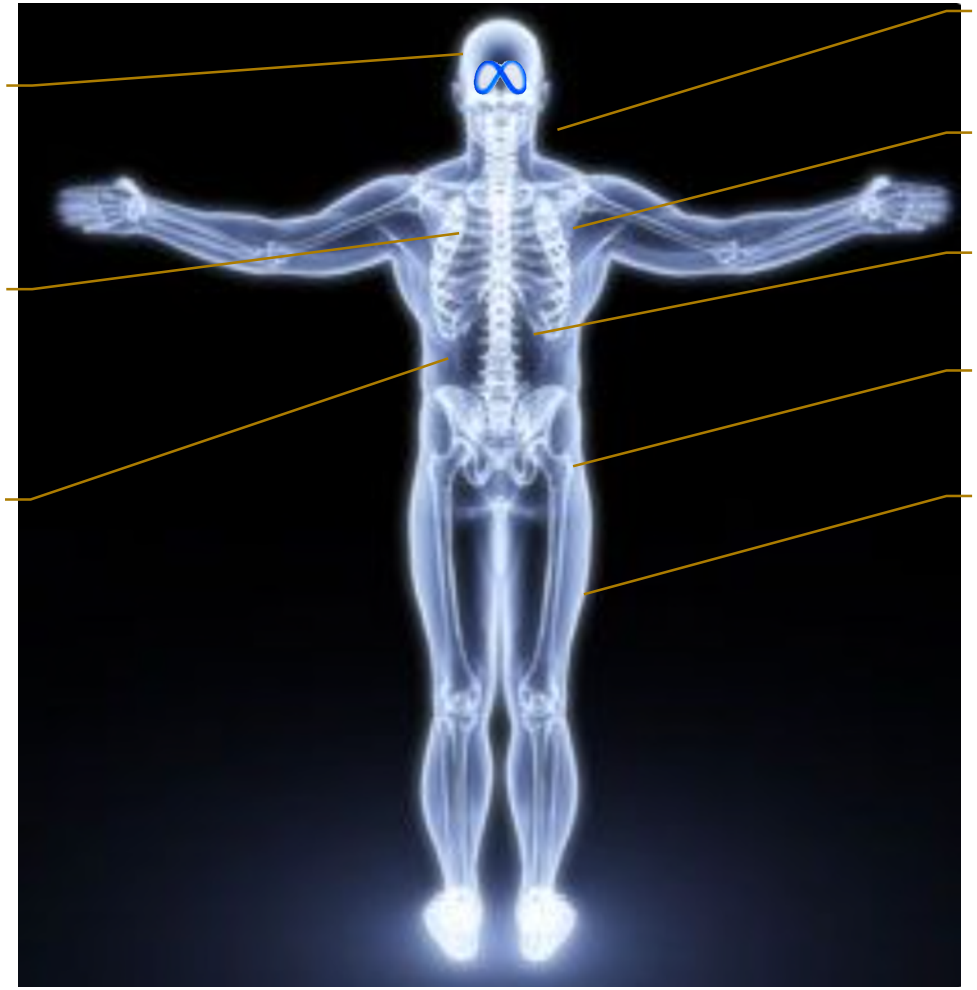
An employee of the City of Hope at Irvine, CA

No relevant conflict of interest in this presentation

Learning Objectives

- To be familiar with objects implanted in the human body
- To be familiar with how proton treatment planning (TP) handles the objects
- To be familiar with the adverse effects if the objects are not handled well for proton TP

What can be inside a human body?



Clips

CIEDs

Markers

Dental

Breast

Spine

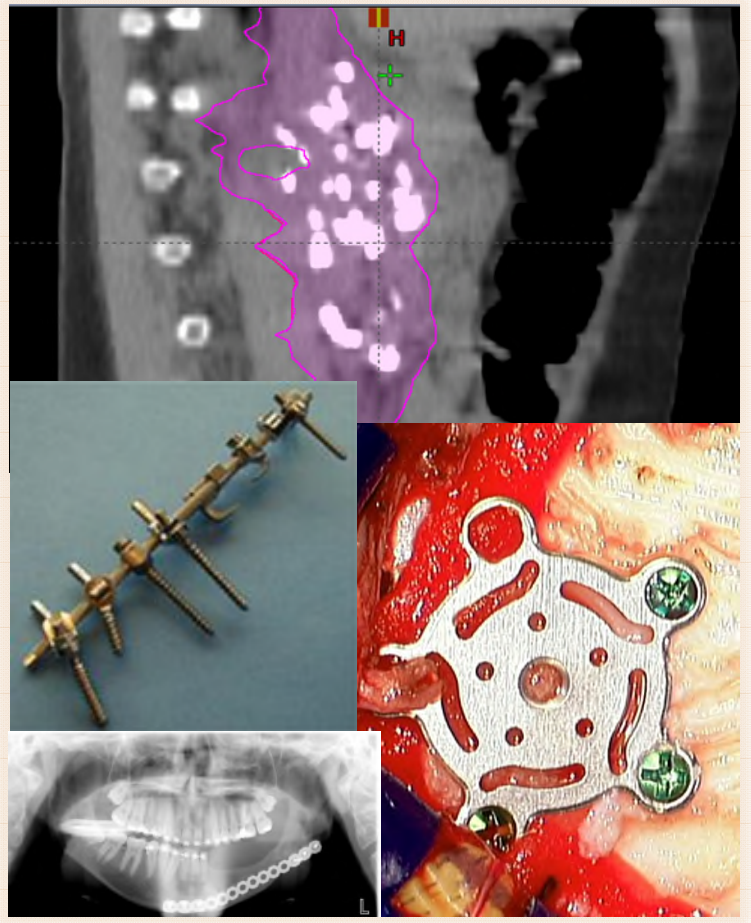
Hip

Bone

Device Materials

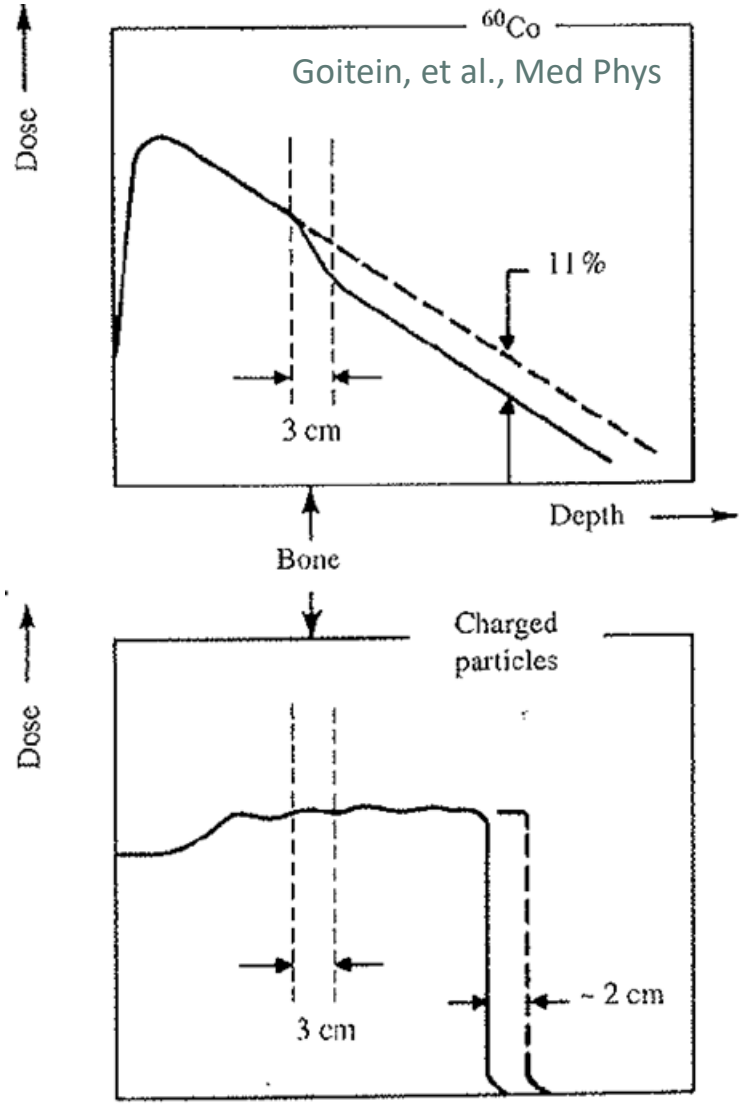
Metal implants

- Usually, the metals in a human body can be:
  - Titanium-Chrome-Cobalt (surgical clips, spine support)
  - Stainless Steel (breast expander, orthopedic surgery)
  - Silver (dental filling)
  - Gold (marker, dental filling)



Why is it a big deal in Proton RT?

- **Sharp distal dose falloff – Double-edged sword**
  - A proton beam is much more sensitive to changes in the beam path than a photon beam -> range variations
  - The range variations eventually transfer to dose errors
  - Instead of resulting in a reduced dose, the target may be missed or the spared organs at the distal end may be flooded

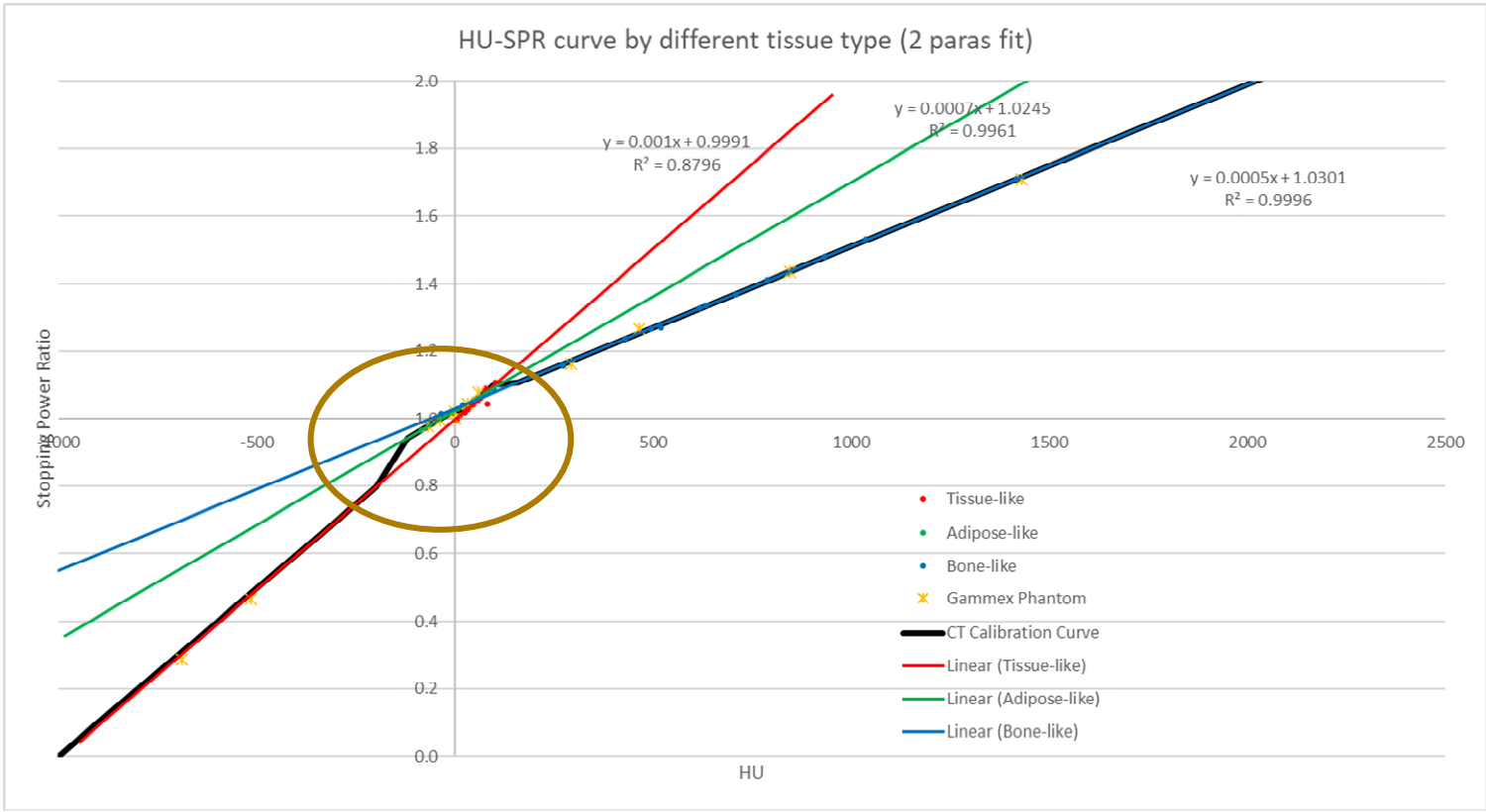


HU-SPR (Stopping Power Ratio) Curves

Fitted lines through the HU vs. SPR data using 3 different categories

HU	SPR	Comment
-1000	0.000	Therotical point
-200	0.797	Tissue-like
-120	0.943	Adipose-like
-20	1.011	Adipose-like
35	1.034	Tissue-like
100	1.100	Tissue-like
160	1.107	Bone-like
1500	1.751	Bone-like
3300	2.616	Bone-like, therotical point

HU Range	Category
-1000 to -200	Tissue
-120 to -20	Adipose
35 to 100	Tissue
160 and above	Bone



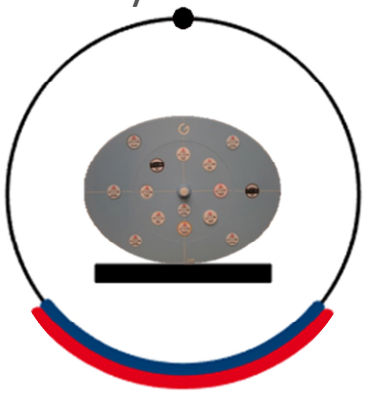
Clinical Considerations

Metal implants

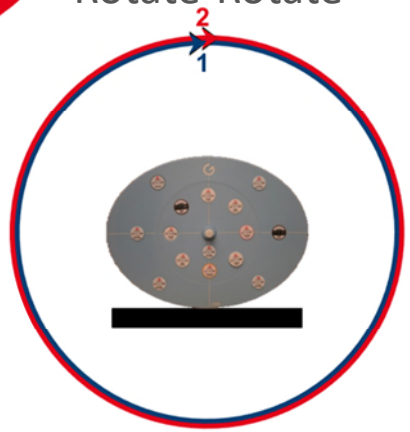
- Using a 16-bit scan can reveal more information about the implant, including ingredients and actual dimensions
- Physicists determine if overwrite HU and how to overwrite HU for metal cases
- Make sure metal HU (up to gold) is in SPR-HU curve
- More like a case-by-case scenario than one solution fits all
- Generally, we try to avoid shooting through metal
- During planning, the robustness settings should consider the metal material and size
- For Monte Carlo calculation, the material table is limited for metals
- Create a template for frequent metal implants

Dual Energy CT Acquisition

Dual Layer

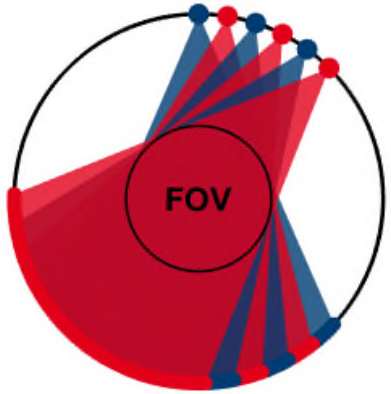


Rotate-Rotate

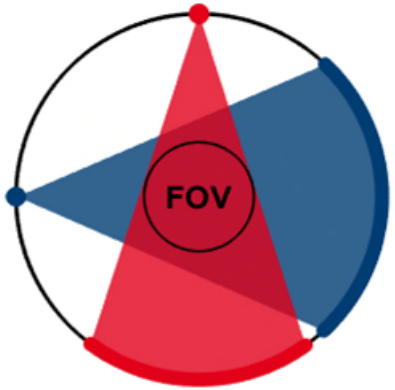


Low energy
High energy

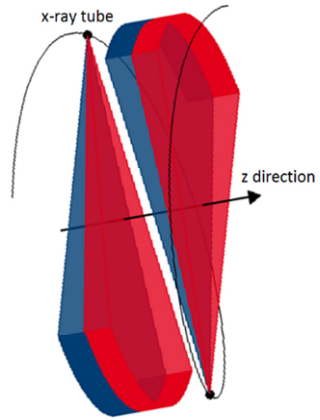
Fast kVp switching



Dual Source



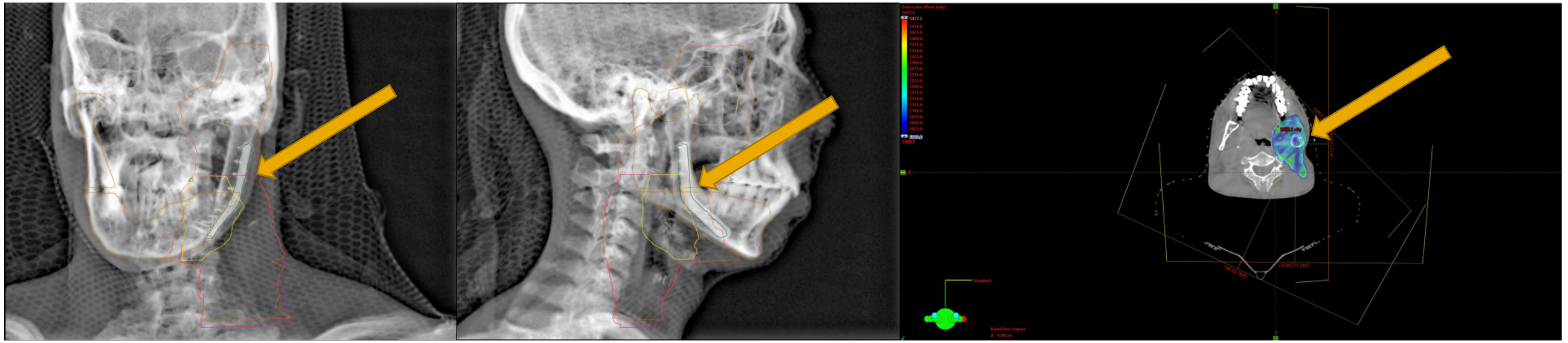
Split-filter(Siemens Twin Beam)



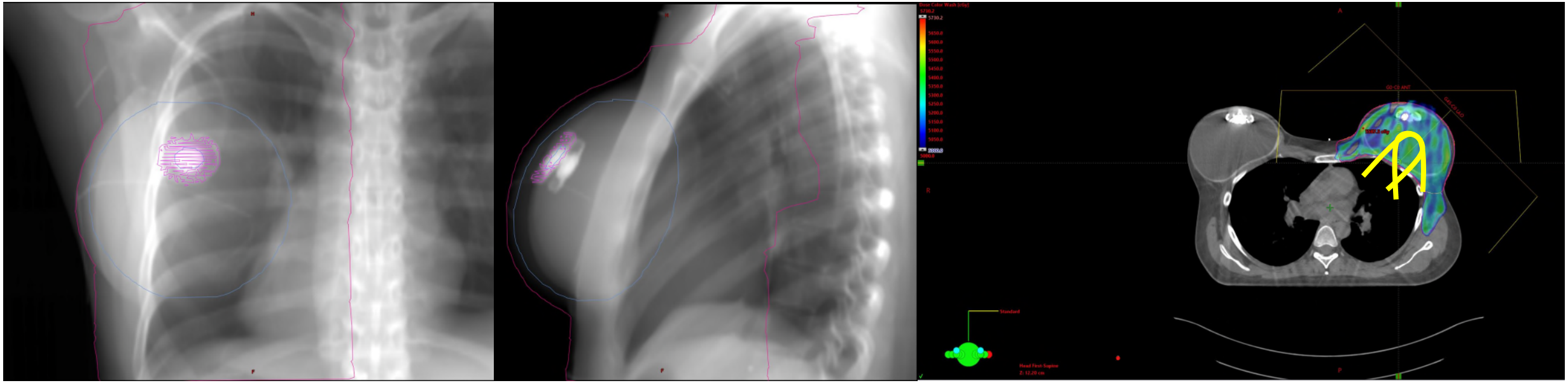
Dual Energy CT Advantages

- Rho_e and Z_{eff} image
- Get SPR directly
- Less uncertainty
- Contrast removal
- Virtual monoenergetic images
- Better target and OAR delineation

Clinical Case: Mandible Plate



Clinical Case: Breast



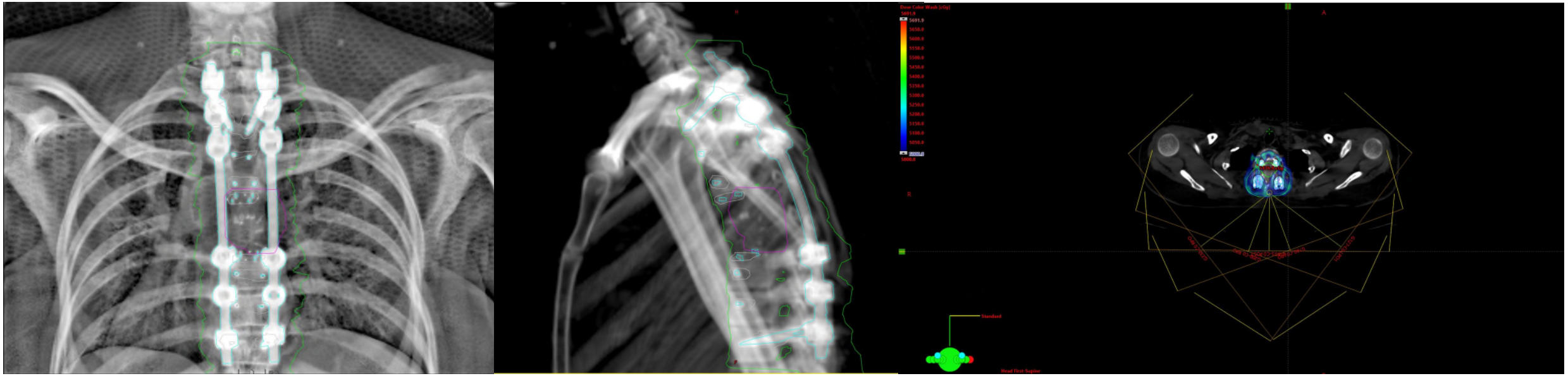
AAPM SPRING CLINICAL MEETING 2022

MARCH 26–29
NEW ORLEANS, LA
Hyatt Regency New Orleans

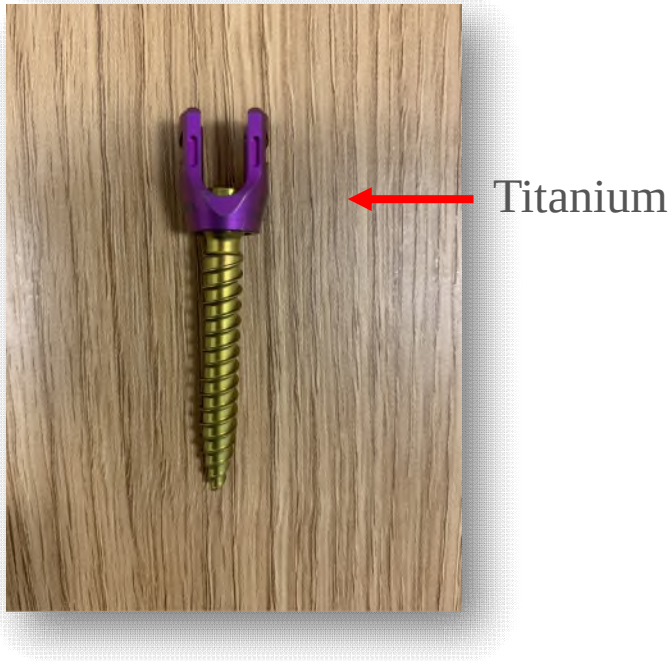
Cumulative Dose Reconstruction Using CBCT-Based Synthetic CT for Interfractional Tissue Expander Metallic Port Variability

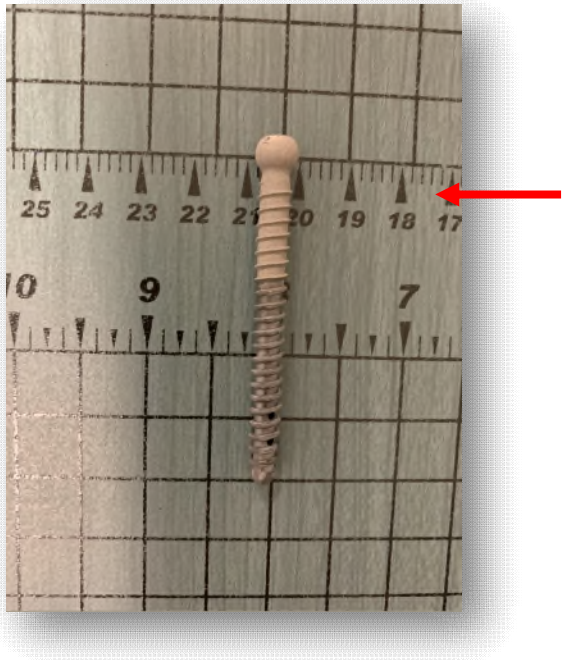
J Liu[1]*, C Chen[1], P Park[1], A Shim[1], P Tsai[1], C Shi[1], H Lin[1], JI Choi[1,2], (1) New York Proton Center, New York, New York, (2) Memorial Sloan Kettering Cancer Center, New York, NY

Clinical Case: Spine

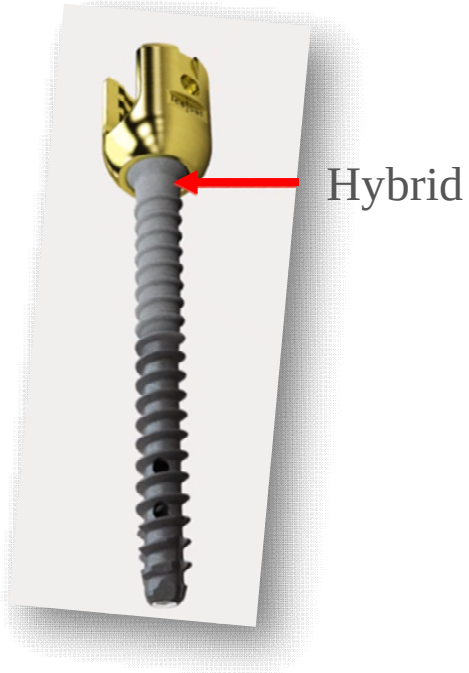


New materials might reduce the effect

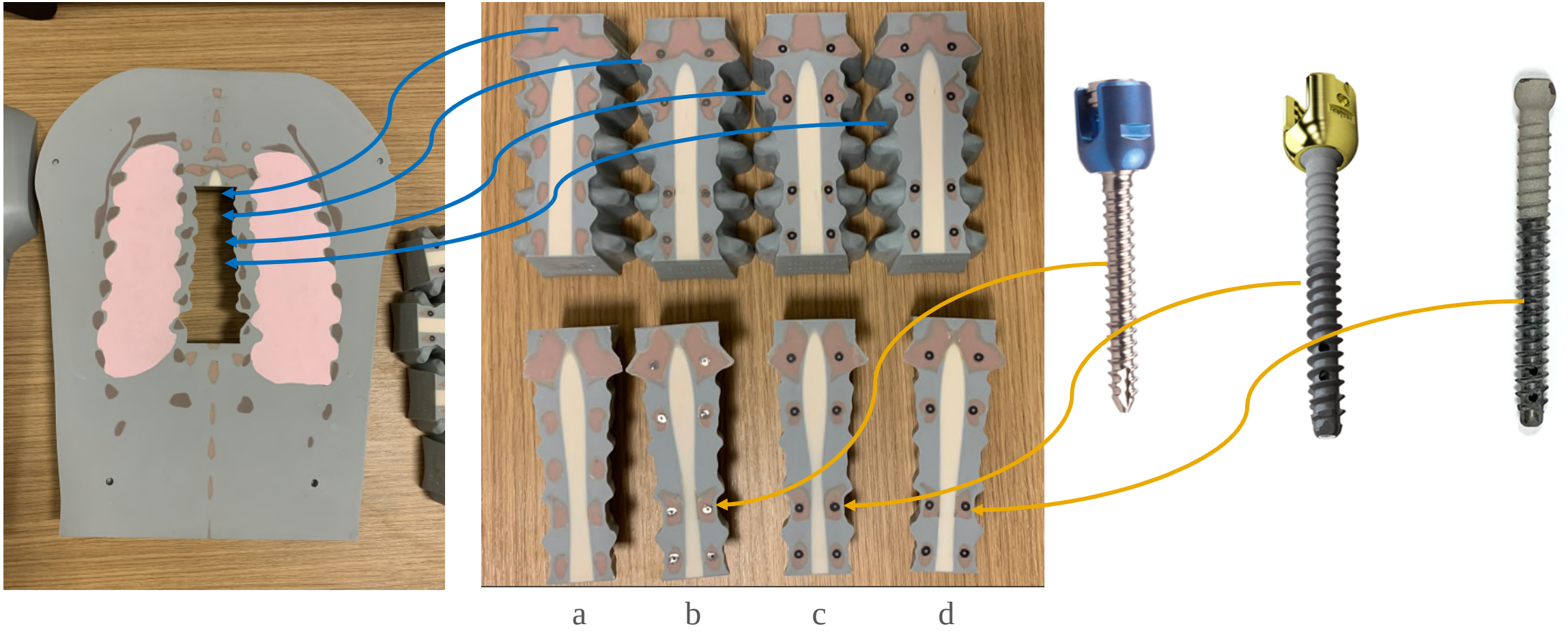

Titanium



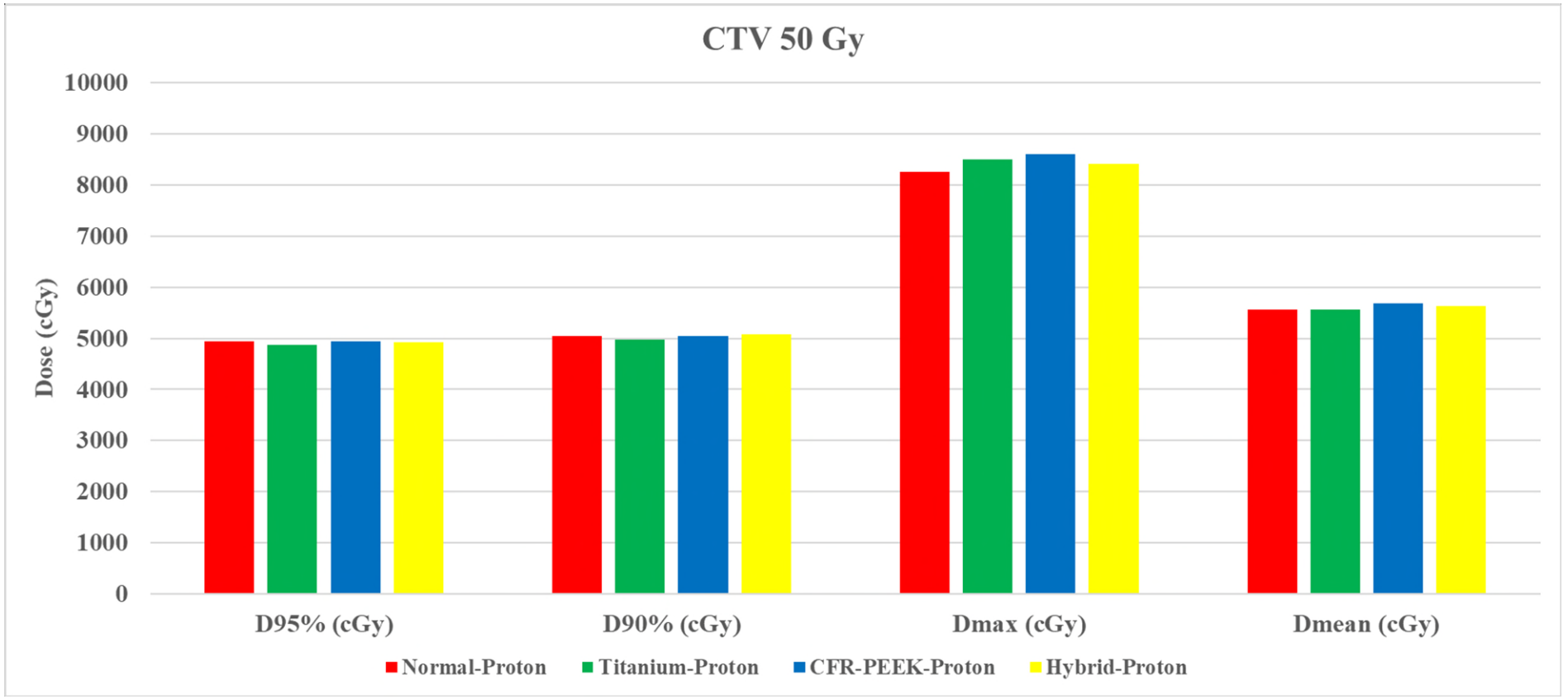
CFR-PEEK


Hybrid

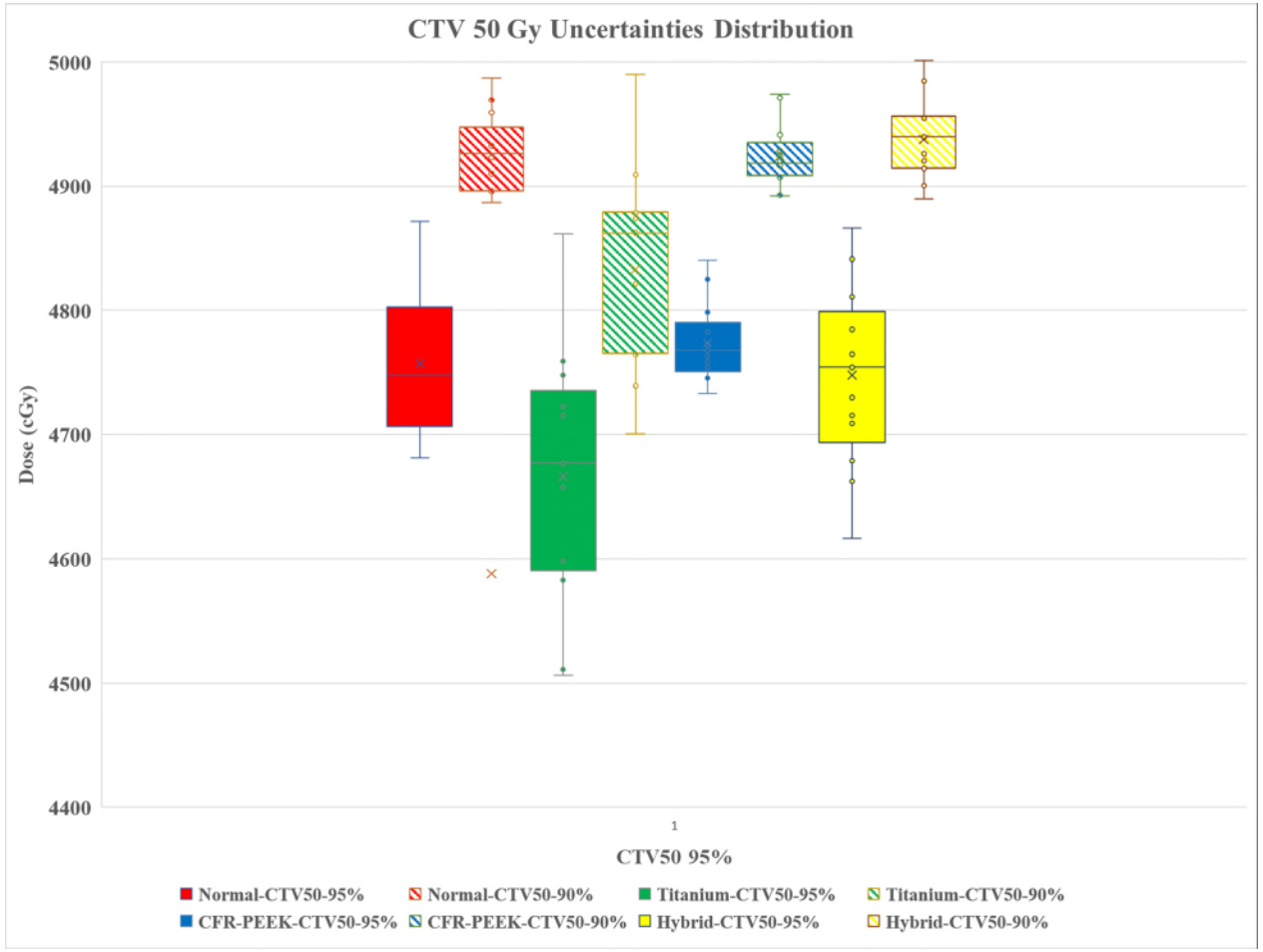
Testing Phantom



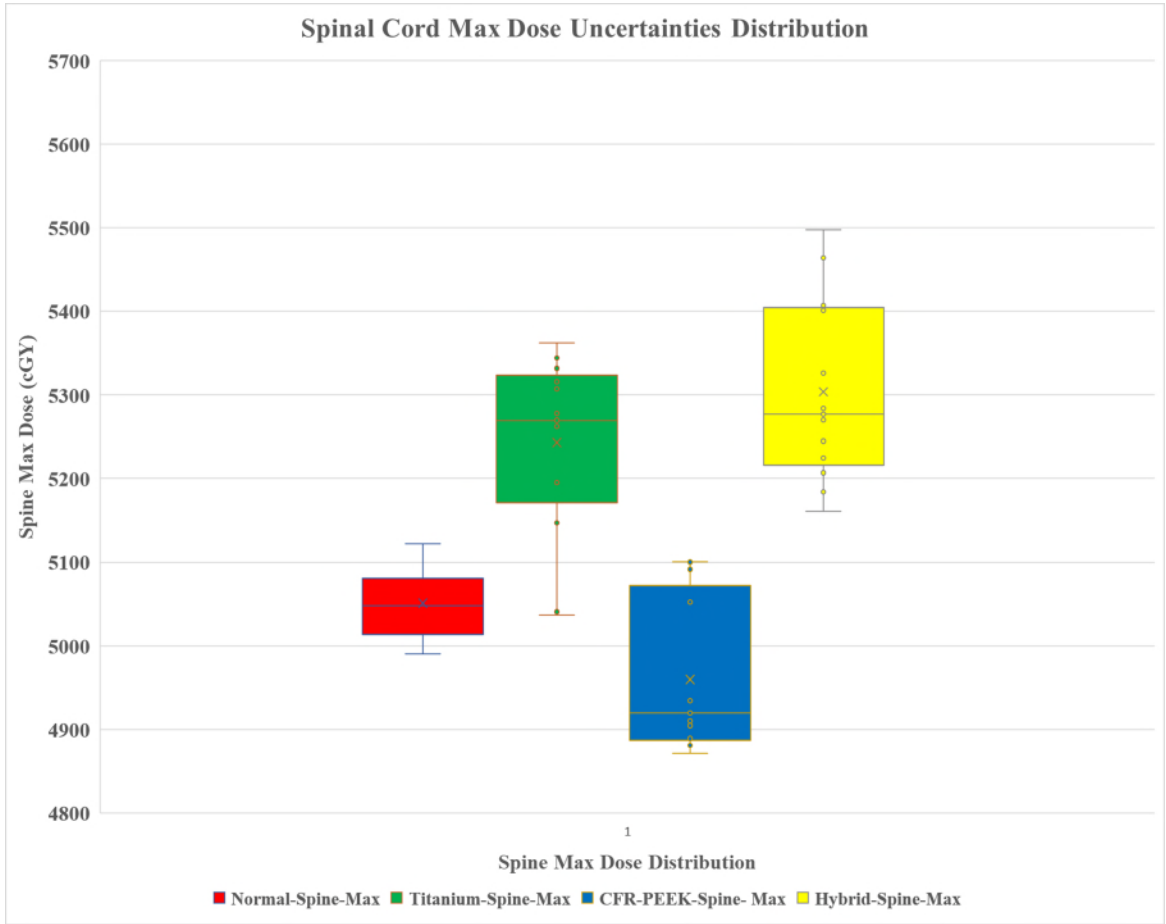
Comparison of CTV 50 Gy



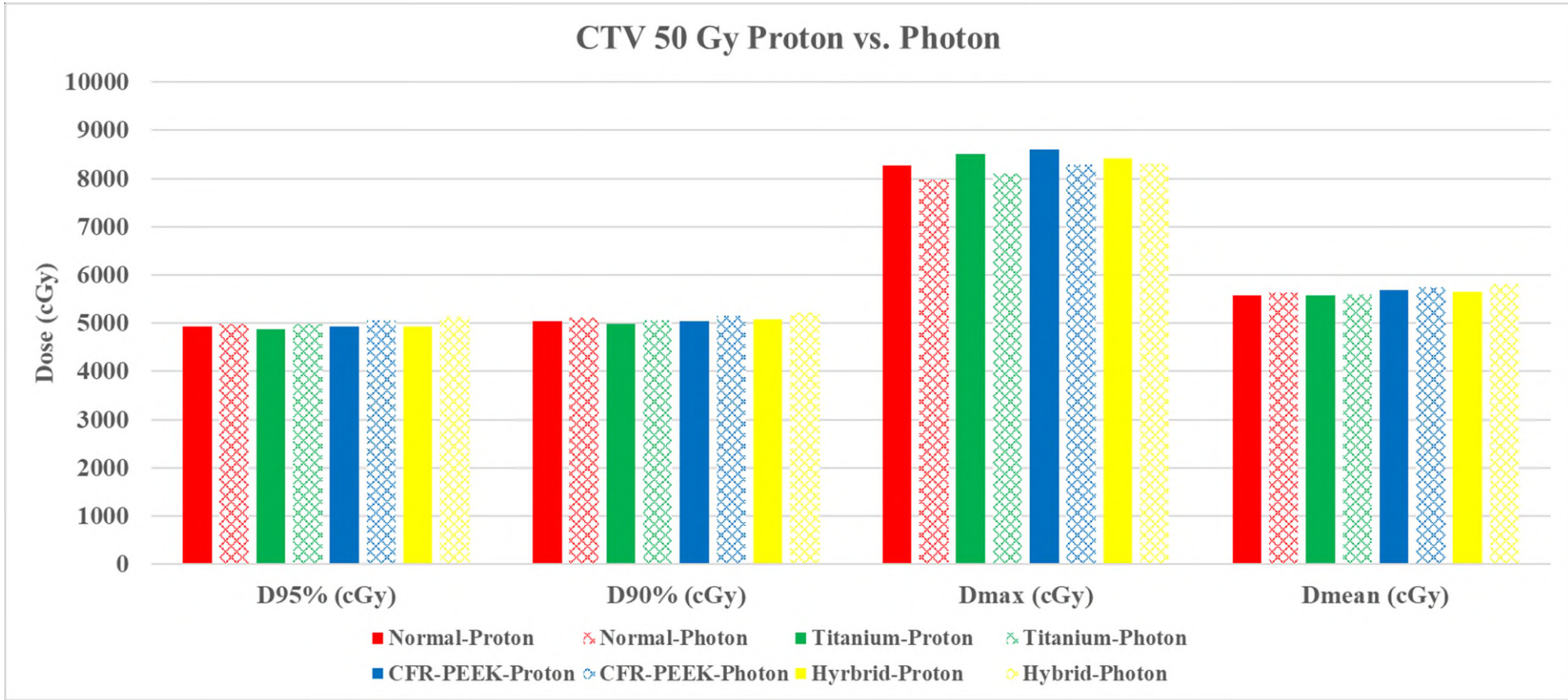
CTV 50 Gy Uncertainties



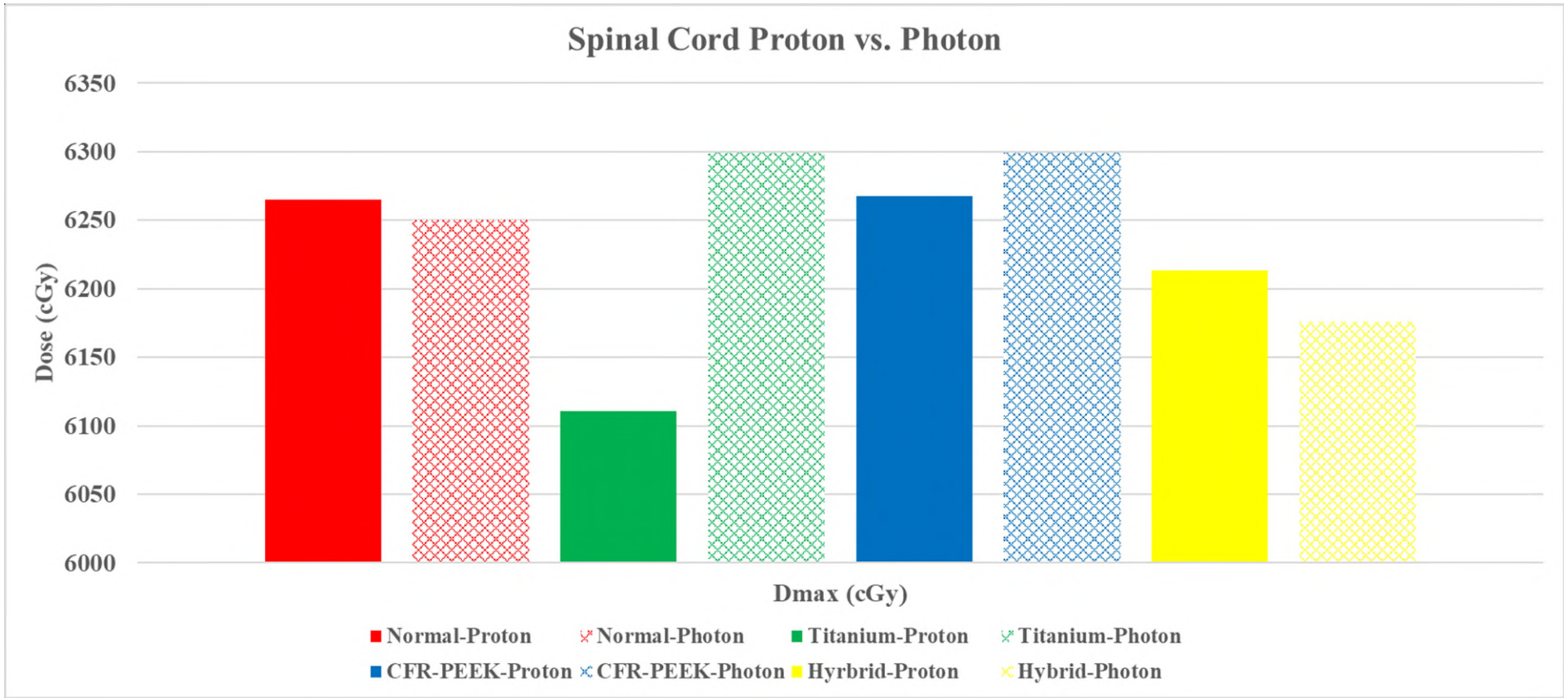
Spinal Cord Max Dose Uncertainties



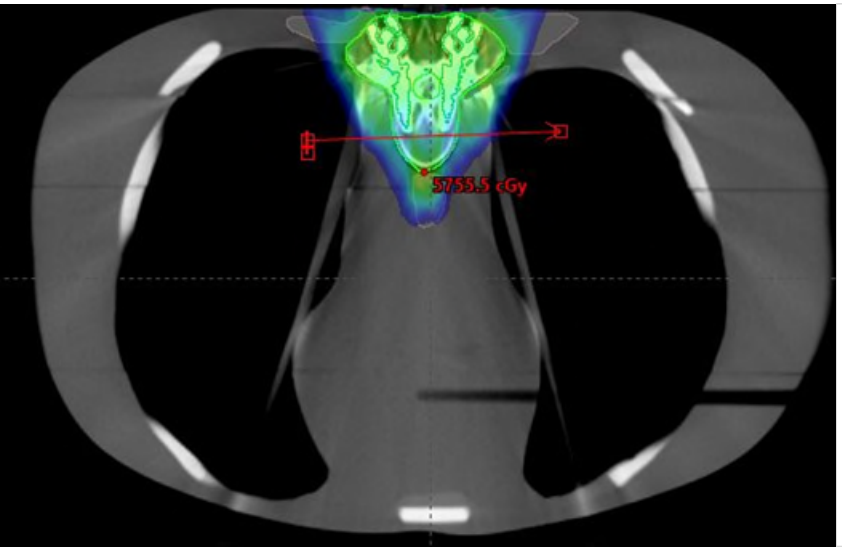
Comparison with Photon RT-CTV 50 Gy

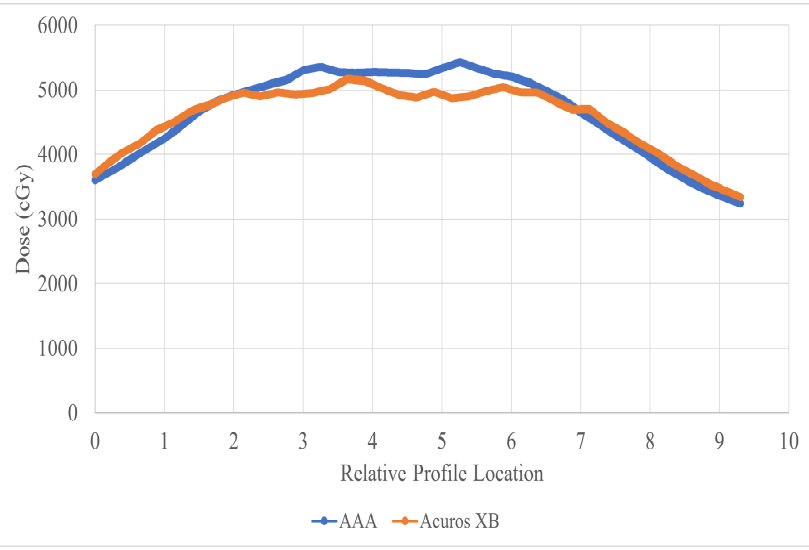


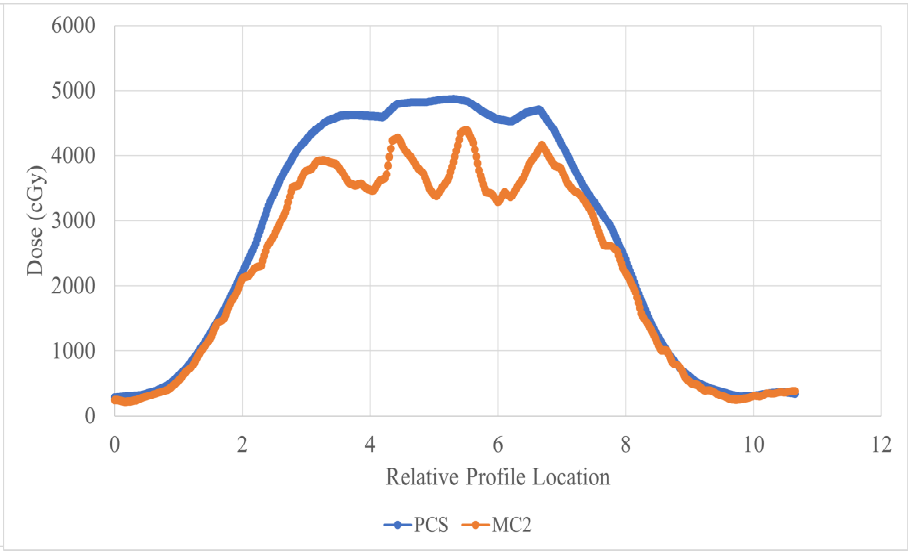
Comparison with Photon RT- Spinal Cord



Comparison of Dose Accuracy: AAA, Acuros XB, MC²







Original Article

Comprehensive Evaluation of Carbon-Fiber-Reinforced Polyetheretherketone (CFR-PEEK) Spinal Hardware for Proton and Photon Planning

Technology in Cancer Research & Treatment
Volume 21: 1-11
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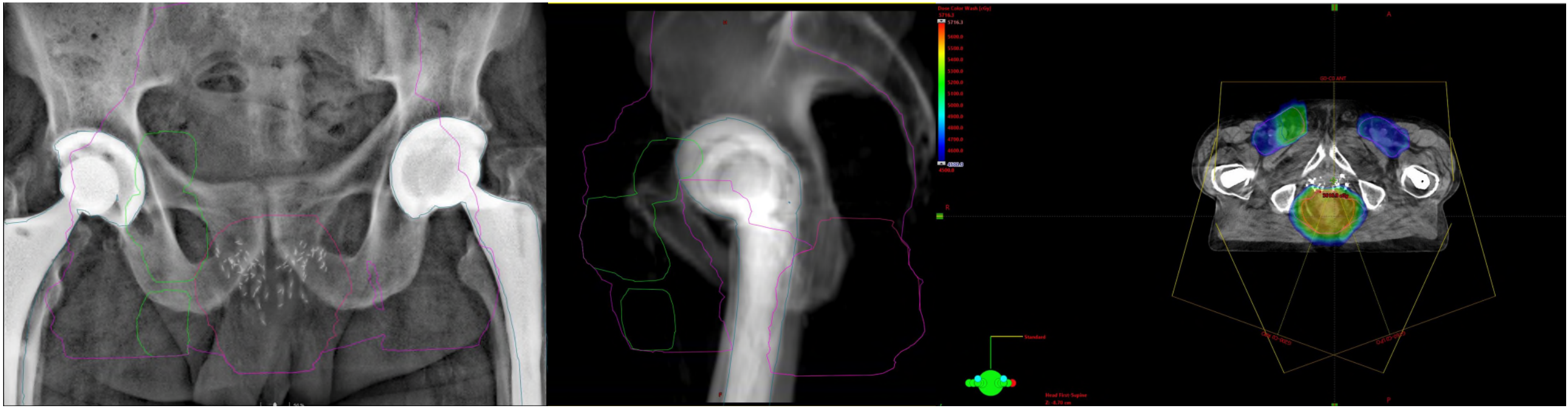
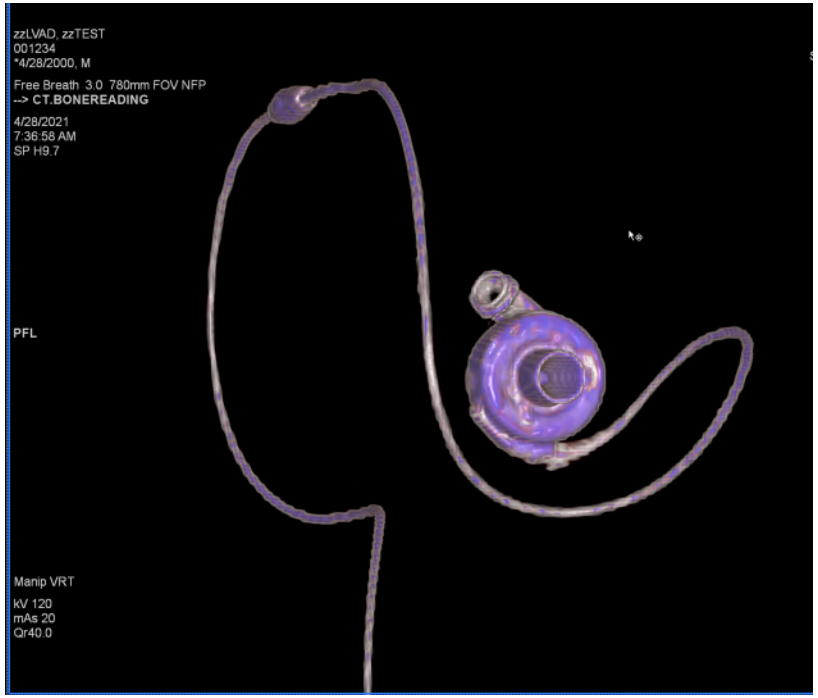
Chengyu Shi, PhD[1], Haibo Lin, PhD[1], Sheng Huang, PhD[1], Weijun Xiong, PhD[1], Lei Hu, PhD[1], Isabelle Choi, MD[1], Robert Press, MD[1], Shaakir Hasan, MD[1], Charles Simone, MD[1], and Arpit Chhabra, MD[1]

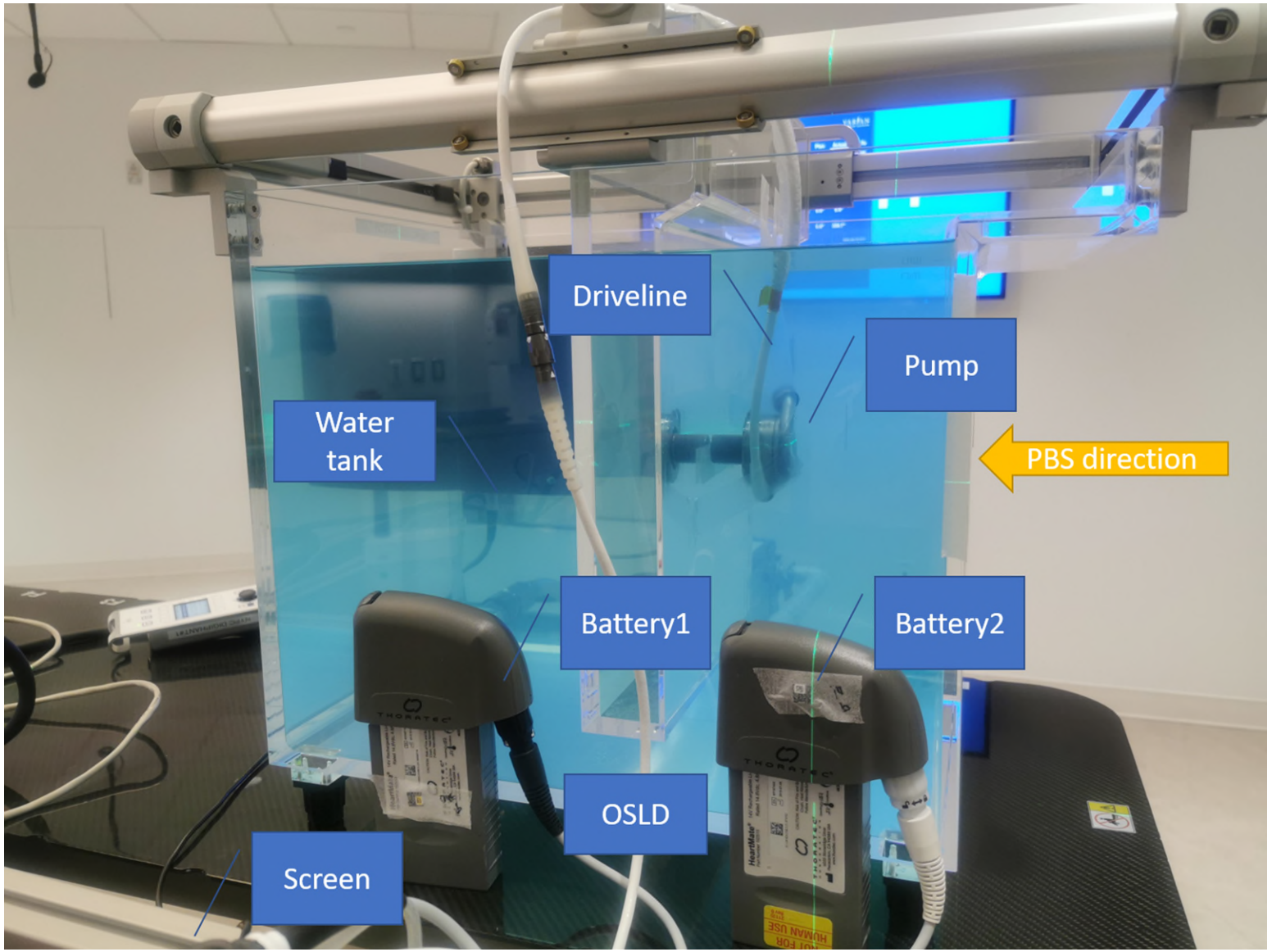
Clinical Case: Hip Replacement



LVAD - Left Ventricular Assist Device



LVAD Experiments



LVAD Results

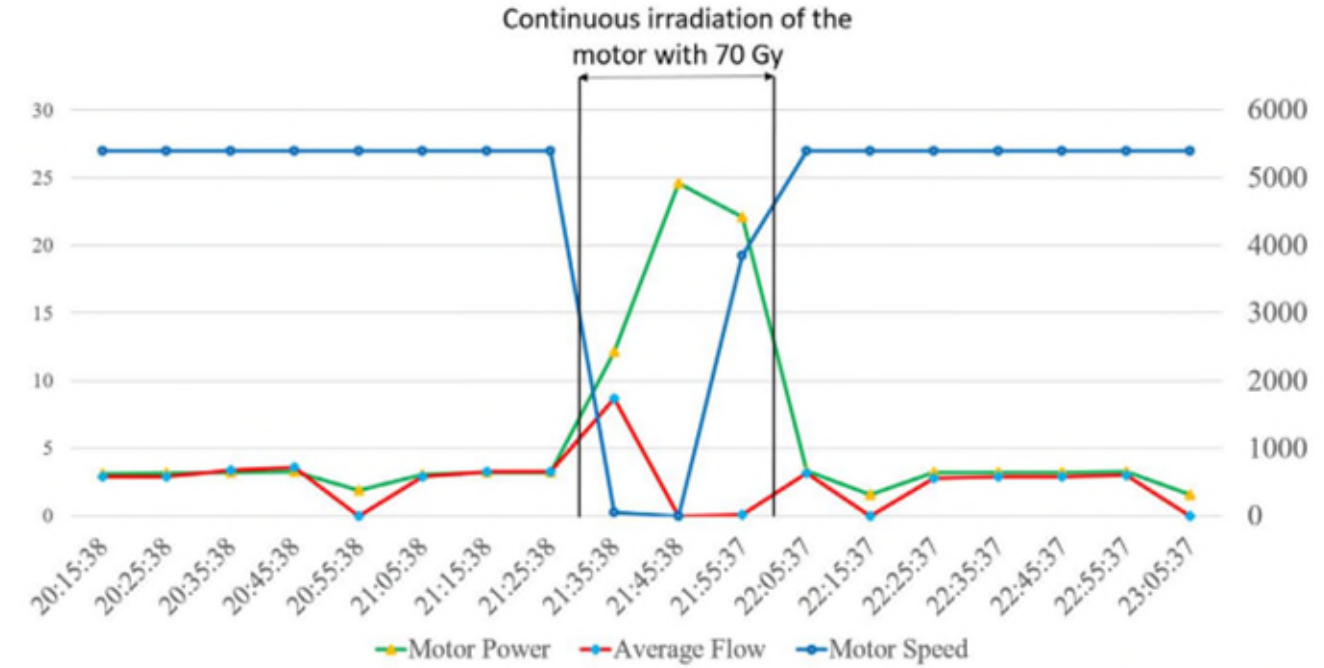


Figure 2. The LVAD's motor power, average flow, and motor speed during continuous irradiation of the pump. Note that the values on the y axis on the left side of the figure refer to the motor power (watts) and average flow (liters per minute), while the values on y axis on the right side of the figure refer to the motor speed (revolutions per minute). LVAD, left ventricular assist devices.

ASAIO Journal 2022 Adult Circulatory Support

The Effects of Pencil Beam Scanning Proton Beam Therapy on a HeartMate 3 Left Ventricular Assist Device: Implications for Patient Safety

Kunal K. Sindhu,* Chengyu Shi,† Noah Moss,‡ Haibo Lin,† Jingqiao Zhang,† Lei Hu,† Sonam Sharma,*† Richard L. Bakst,*† Arpit Chhabra,† Charles B. Simone, II,† and Lucas Resende Salgado†§

Discussions

- Limited beams angles limit the target
- Multibeam angles might reduce the uncertainties, but increase the treatment time
- Larger dose uncertainties exist if not considered well
- Daily treatment shifts of the objects will cause clinical challenges-multi plans or adaptive plans are needed
- Building up a clinical database for common devices is very helpful

Summary

- Management of Implanted Devices is important in Proton RT
- For known devices, needs to assign correct HUs corresponding to RSP
- For unknown devices, try not to direct shoot it and assign relative larger uncertainty if needed
- Use Monte Carlo algorithms to double-check the dose accuracy

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