# Radiation Protection for Fluoroscopically-Guided Interventional Procedures: Patient Dose and Radiobiology

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# Session Objectives

- Briefly review basic fluoroscopic radiation dose metrics and how they relate to skin absorbed dose
- Using clinical fluoro procedure examples to discuss:
    - single procedure high doses
    - multiple procedure high doses
    - multi-discipline multiple procedures
- Review basic radiobiological principles
- Discuss potential applications of Radiation Oncology fundamentals

# Dosimetric and Radiobiologic Challenges

## Case Reports of Fluoroscopically-Guided Interventions (FGIs)

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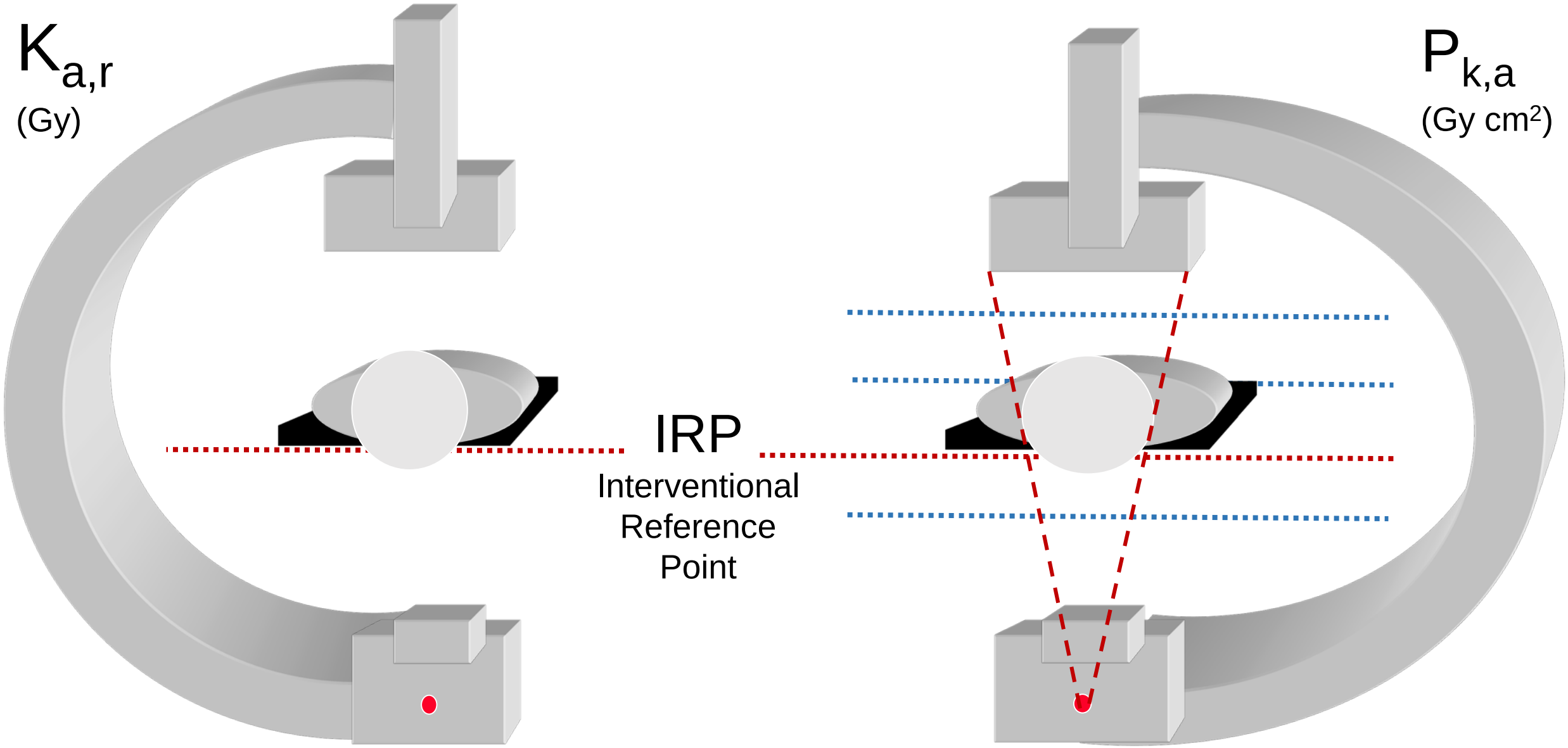
# From $K_{a,r}$ and $P_{ka}$ to Tissue Dose

$K_{a,r}$
(Gy)

$P_{k,a}$
(Gy $cm^2$)



IRP
Interventional
Reference
Point

# From $K_{a,r}$ and $P_{ka}$ to Tissue Dose

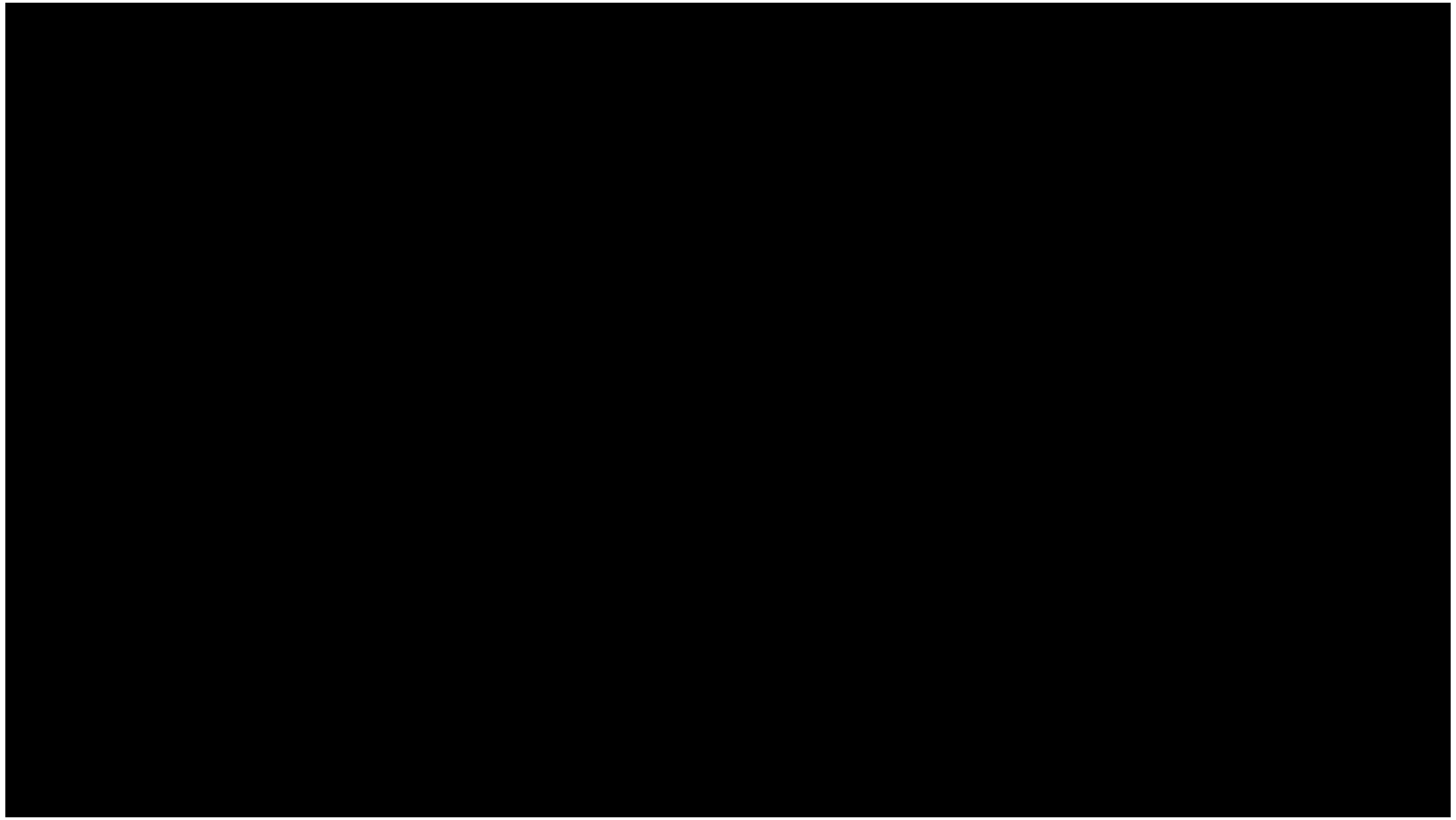
- Global corrections
  - Accuracy of the displayed air kerma (AAPM TG 190)
  - Table and pad attenuation for posteroanterior projections (~30% attenuation)

- Radiation event corrections (DICOM RDSR [structured report])
  - Patient location – table height, lateral and longitudinal table positioning
  - Gantry orientation – Primary (RAO,LAO) & secondary (CRA, CAU)
  - Image acquisition – FOV, Beam spectrum (kV, filtration)

# Additional Resources for Review

- NCRP 168 – Radiation Dose Management for Fluoroscopically-Guided Interventional Procedures (FGIs)
    - Background information and general overview relating to FGIs
- JACMP – 2011, 2012 – Jones & Pasciak – Calculating the peak skin dose resulting from FGIs Parts 1 and 2
    - Review of dose calculation approaches and mechanics

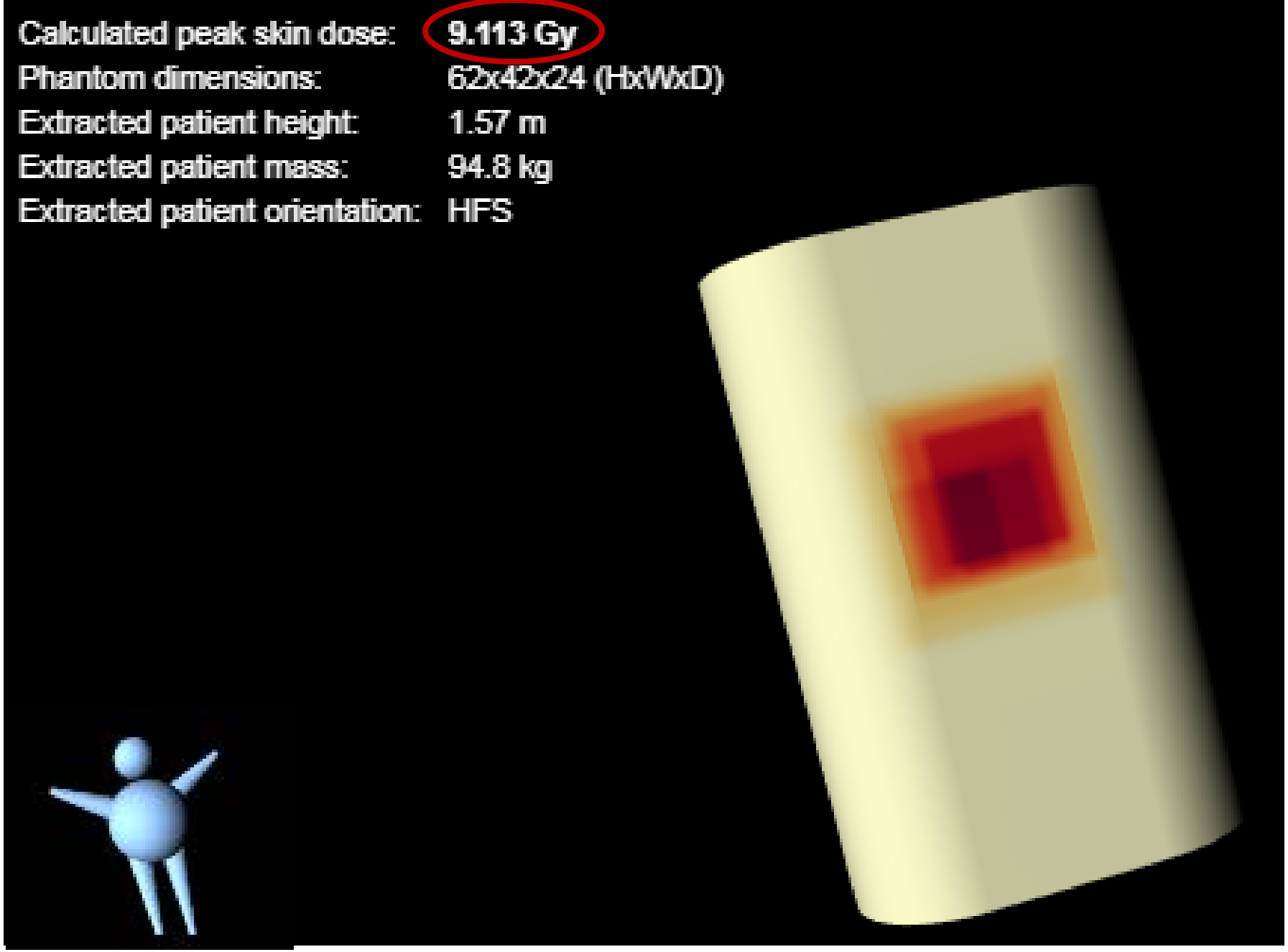
# Current Status of Radiobiology for FGIs



# Clinical Case Type 1 – High Dose Single Procedure
## (Mostly Known Knowns)

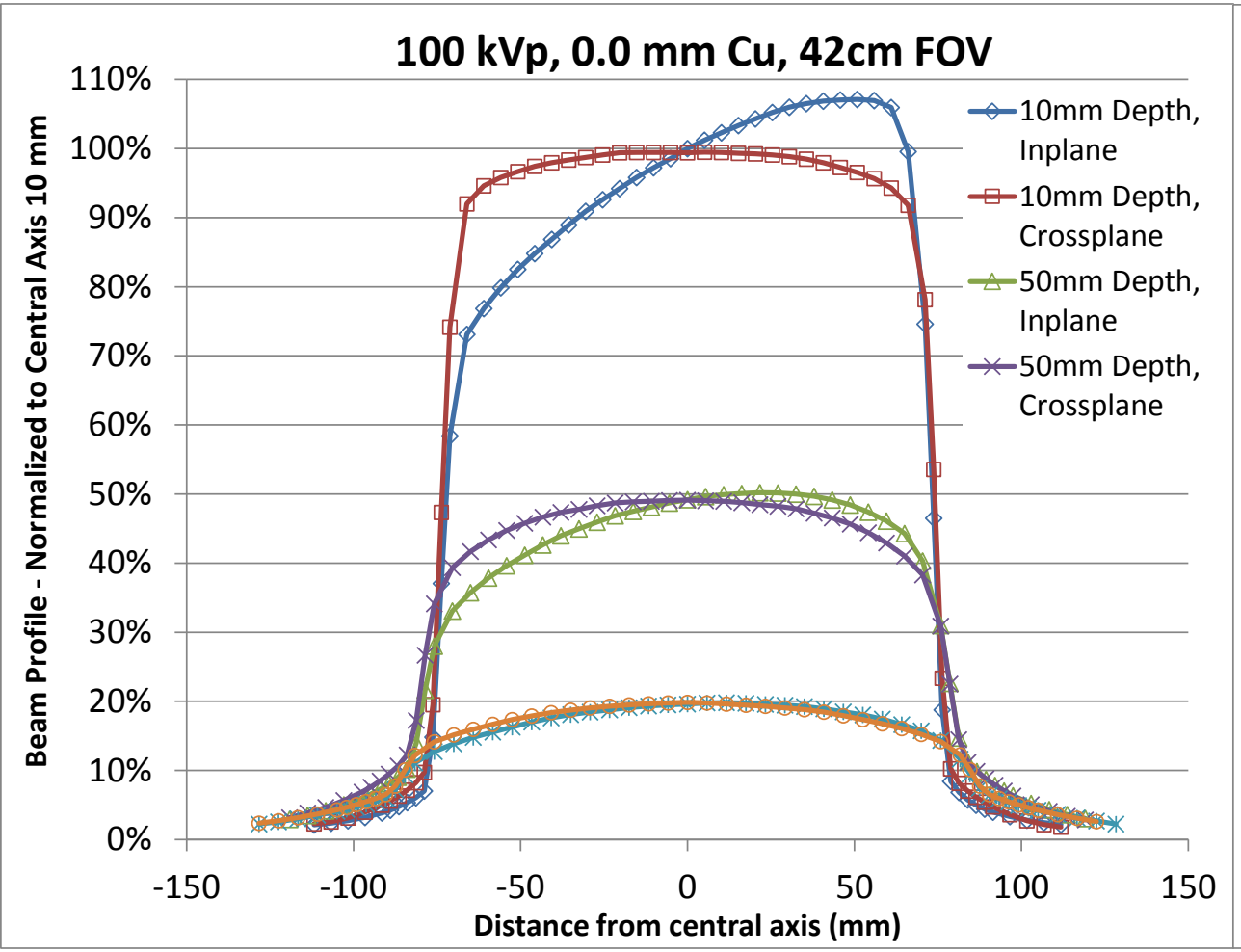
- Patient Information:
  - 66 y/o female patient
  - BMI 34.5 $kg/m^2$
  - Abdominal arterial / venous fistula embolization

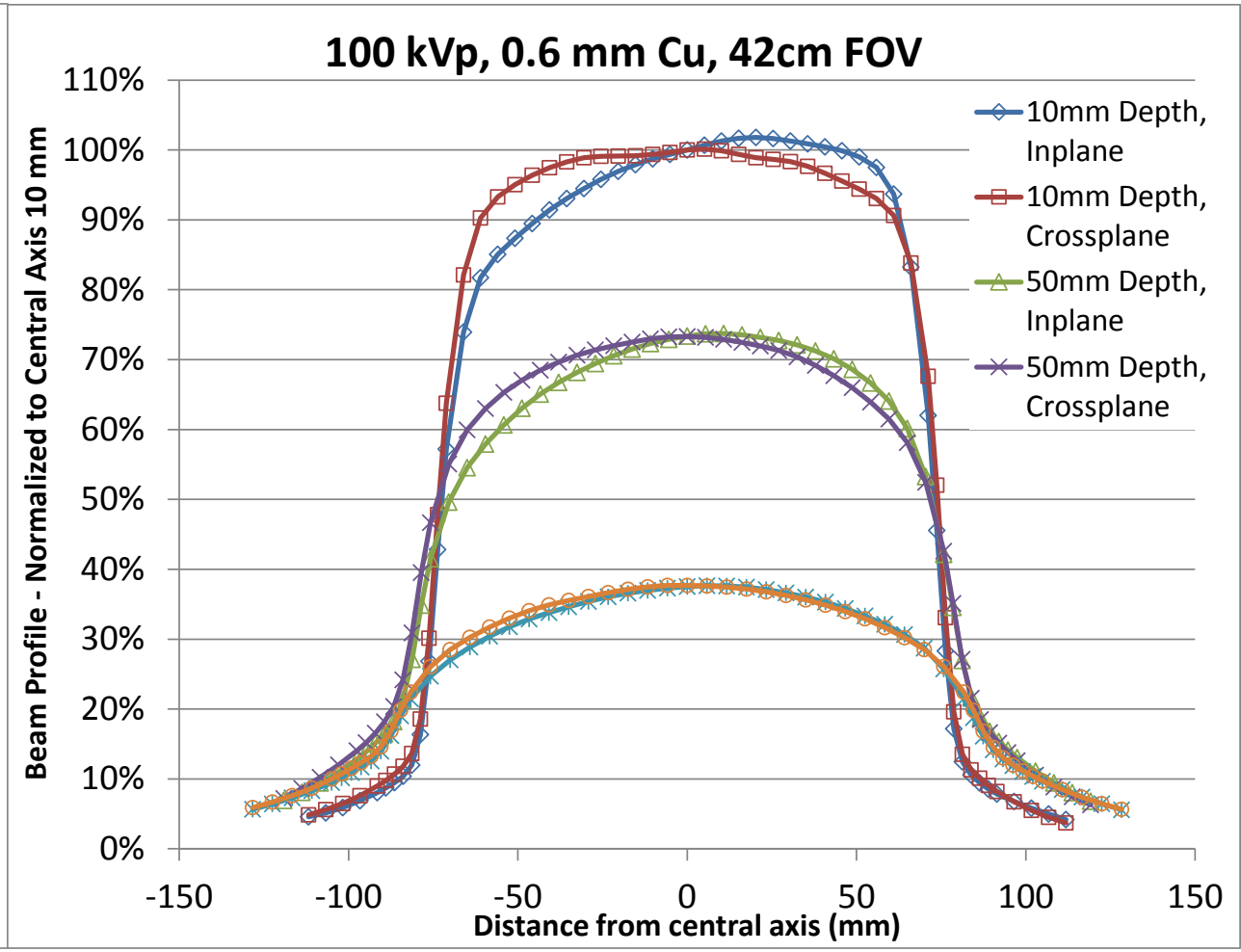
- DICOM RDSR Summary Information:
  - $K_{a,r}$ = 9.4 Gy
  - $P_{ka}$ = 2,158.4 $Gycm^2$




OpenREM / OpenSkin – PSD includes BSFs and table / pad transmission (not displayed $K_{a,r}$ accuracy)

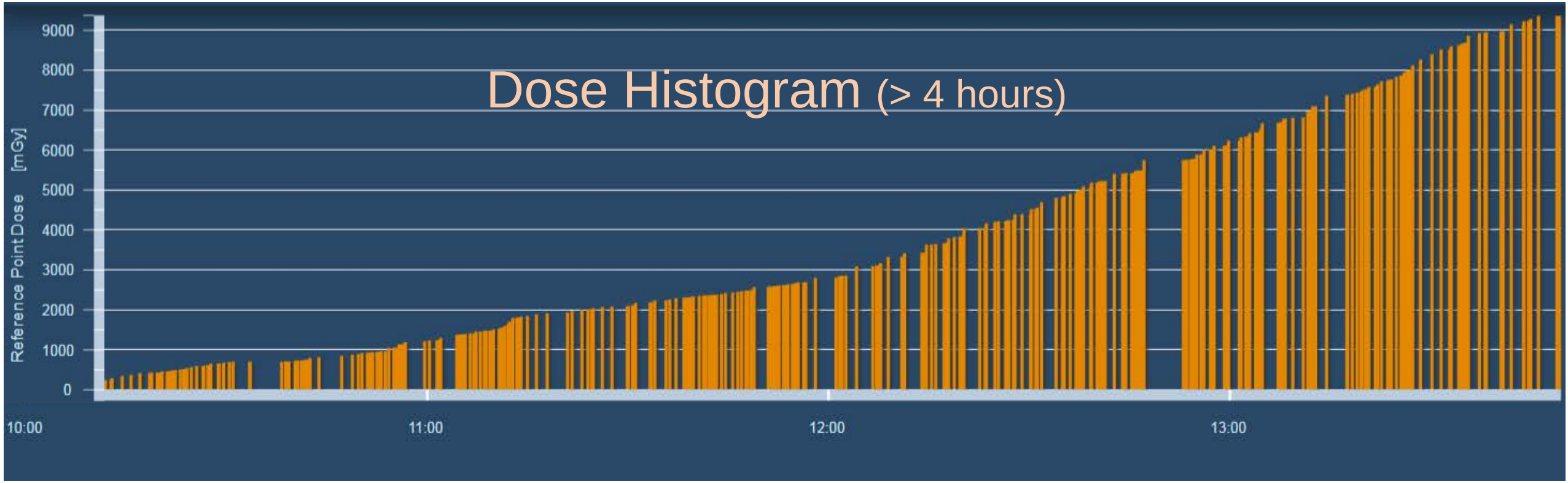
# X-ray Field – Heel Effect & Cu




What about the RBE, is it affected by the spectral shift due to Cu filtration?

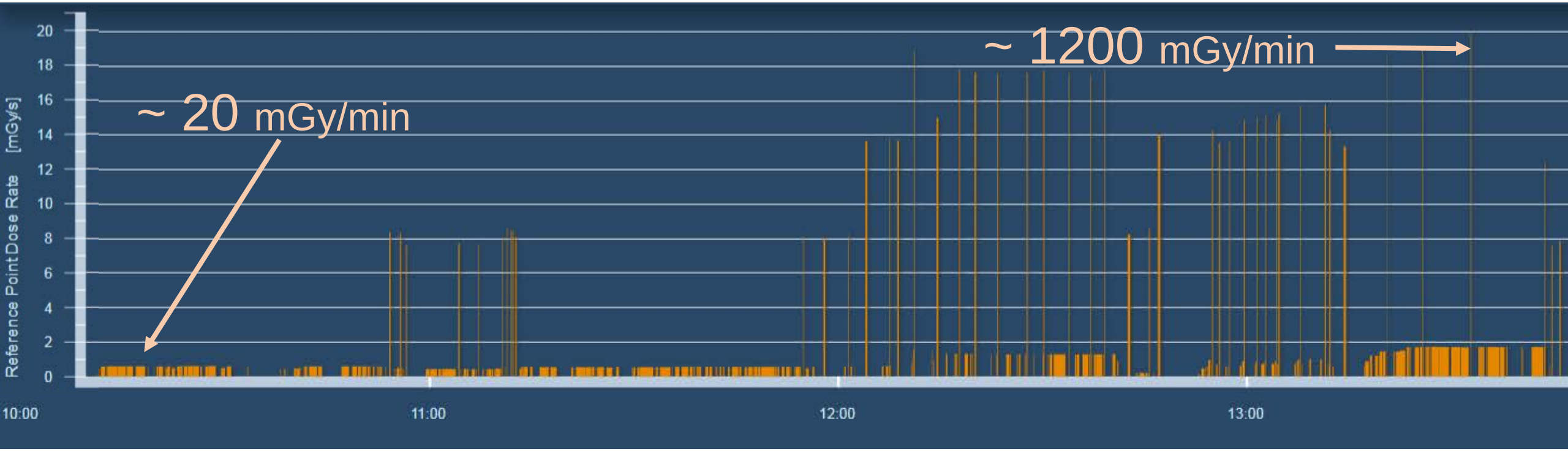
# Total Procedure Time / Dose




Does it matter that this dose delivery was protracted?

Typical halftime for double strand DNA break repair is ~ 1-2 hours

# Instantaneous Dose Rates




Instantaneous rates vary from ~ 20 mGy/min (Gy/hr) to 1200 mGy/min (Gy/hr) Does this affect outcomes?

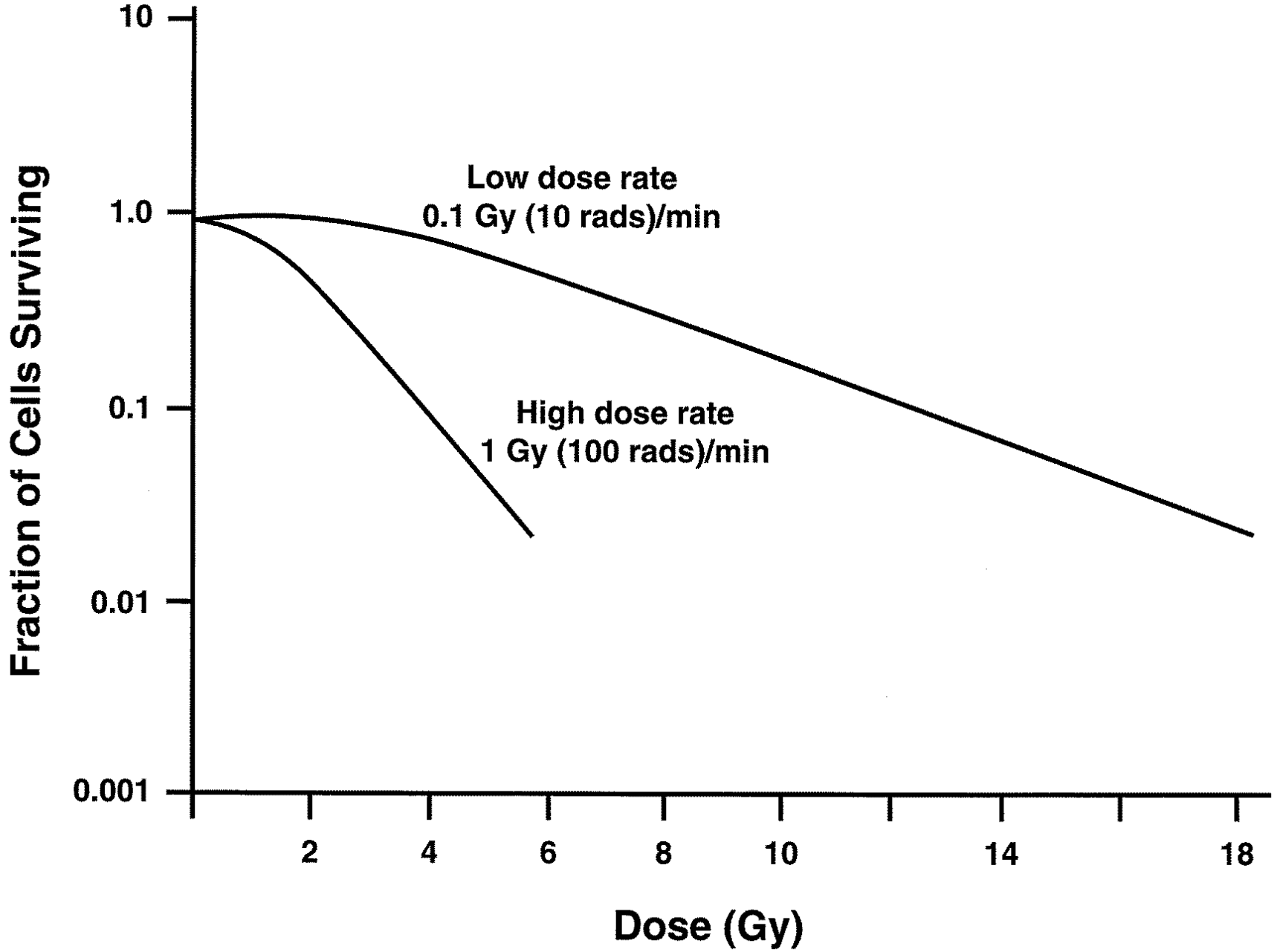



Figure barrowed from “Essential Physics of Medical Imaging” by Bushberg et al.

# Clinical Case Type 2 – Multiple Procedures
## (Known Unknowns)

- Patient Information:
  - 41 y/o male
  - BMI 36.2 kg/$m^2$
  - Pelvic ArterioVenous Malformation
- Estimated maximum skin dose to a given area of skin:
  - 1$^{st}$ procedure – 8/20 – 5.1 Gy
  - 2$^{nd}$ procedure – 10/29 – 4.9 Gy
  - 3$^{rd}$ procedure – 12/19 – 12.6 Gy
- Total PSD = 22.6 Gy (JC Sentinel Event)

# Case Type 2 – Cont’d

Image taken ~6 weeks after the last procedure

# Case Type 2 – Cont’d

- 4th procedure needed 4 months later
- Clinical team contacted physics and asked “is it safe”?
- Still within the 6 month JC “quasi window”
- Pre-procedure reaction image:

# Radiobiological Questions

- How can we better predict early and late effects?
- How can we use that information to assist our clinical colleagues in guiding patient care?

To Be Continued….