Introduction to Radiotherapy Physics

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Introduction

- MPhys in Physics
- Started Scottish Medical Physics Training Scheme in September 2018
  - MSc in Medical Physics at University of Aberdeen
  - Foundation and Specialism Training in Inverness
  - Specialised in Radiotherapy Physics
- Currently at Edinburgh Cancer Centre

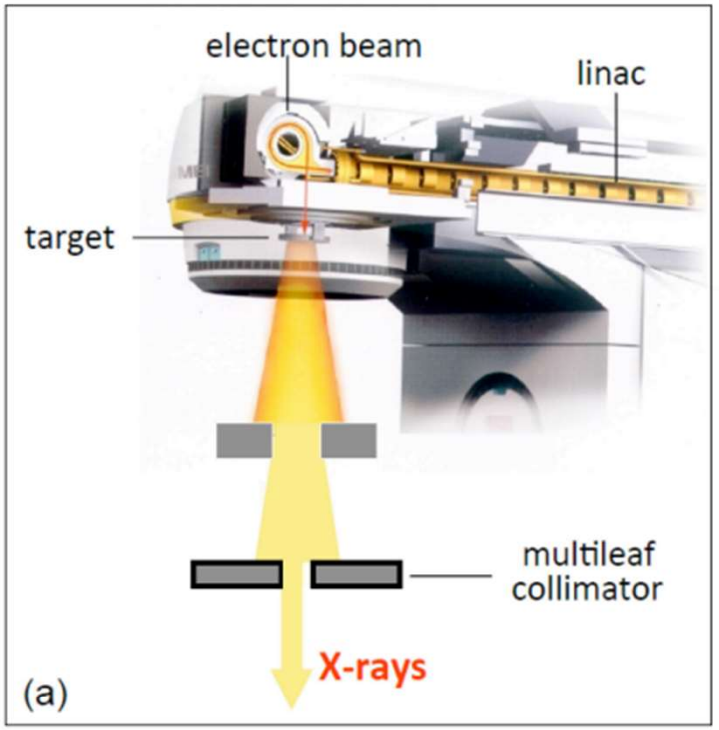
What is Radiotherapy?

- Technique to treat cancer
  - Contributes to 40% of cancer cures worldwide[1]
- Uses ionising radiation to kill cancer cells
- Usually delivered over a number of daily treatments, called fractions
- External beam radiotherapy most common

[1]: https://www.targetingcancer.com.au/about-radiation-oncology/benefits-and-effectiveness
Image: www.varian.com

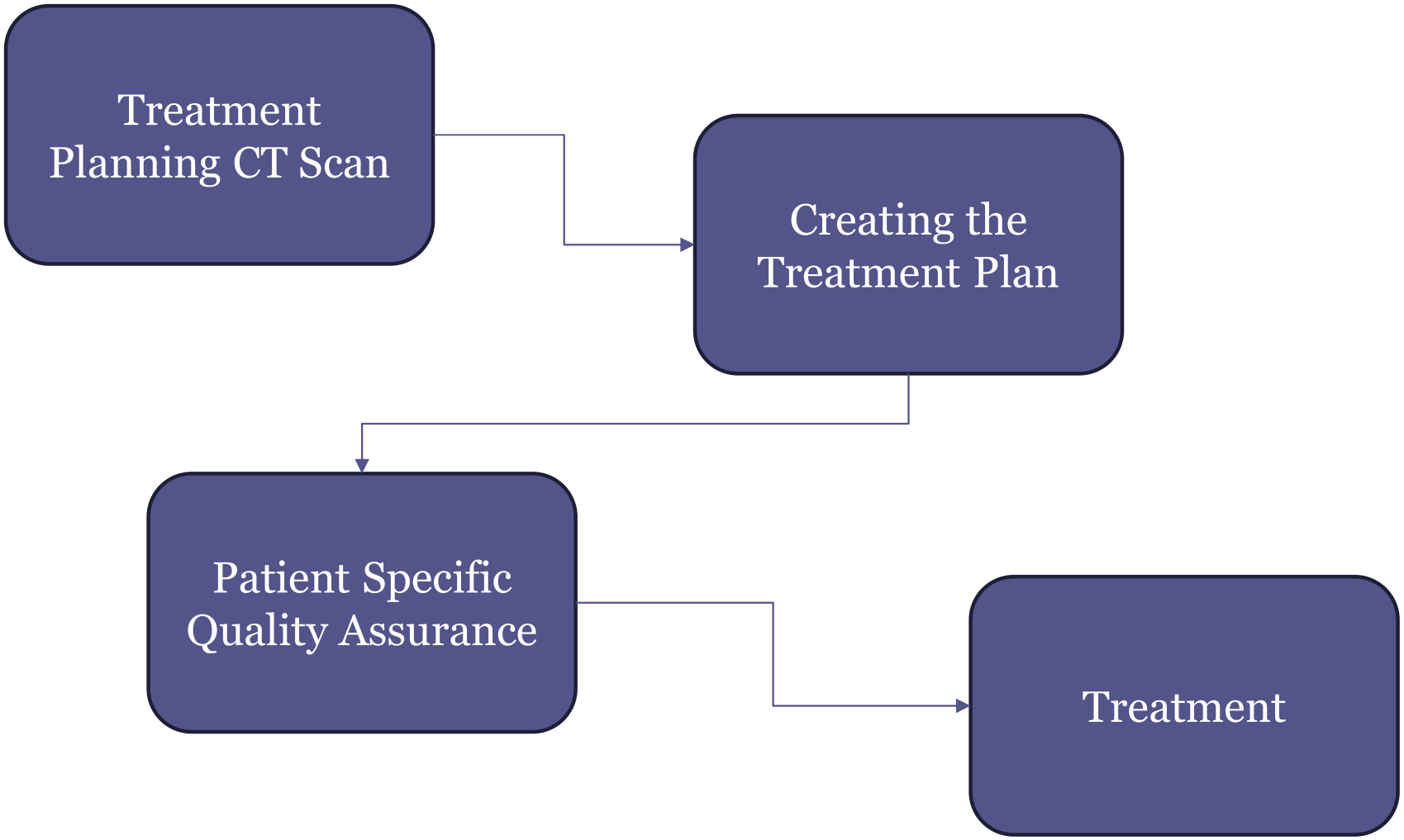
External Beam Radiotherapy

- Delivered by a linear accelerator
  - Linac
- Electrons accelerated along a wave guide
- Hit high density target
- Produce high energy x-ray beam
- Beam is shaped to conform to the target within the patient



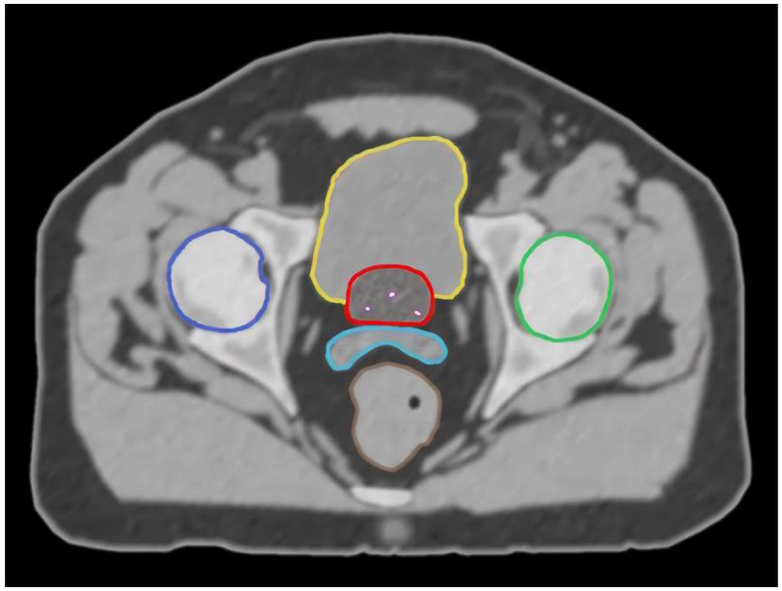
Images: A Facility for Tumour Therapy and Biomedical Research in South-Eastern Europe, Amaldi et al., CERN Yellow Reports: Monographs CERN-2019-002

Patient Pathway



Treatment Planning Scan

- CT scan
- Exact same setup as they will have for treatment
- Target and organs at risk are outlined
- Provides electron density information
  - Allows software to calculate how radiation interacts with the different tissues
  - Patient specific

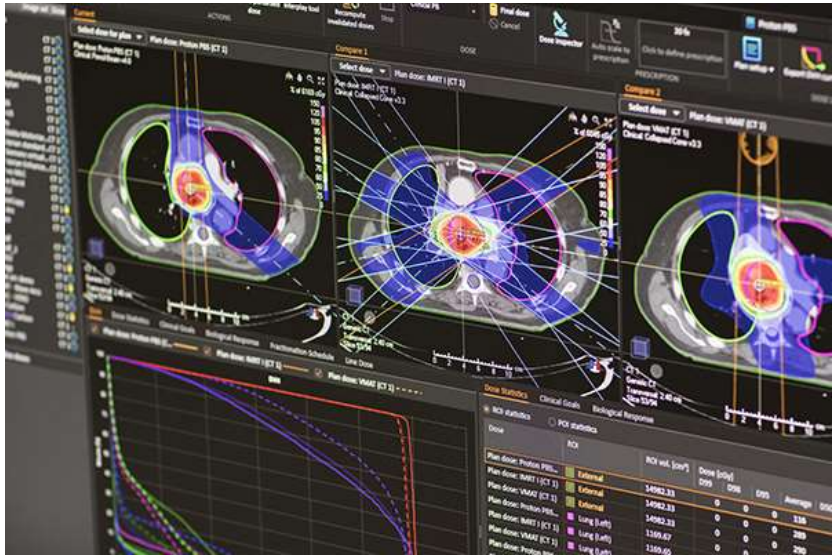


Prostate outlined in red

Organs such as bladder, rectum and femoral heads also outlined

Image: http://www.absoluteremotedosimetry.com/services/contouring-services/

Planning



Fundamental principles:

- Deliver prescription dose to the target
- Reduce dose normal tissue
- Reduce dose to particular organs at risk

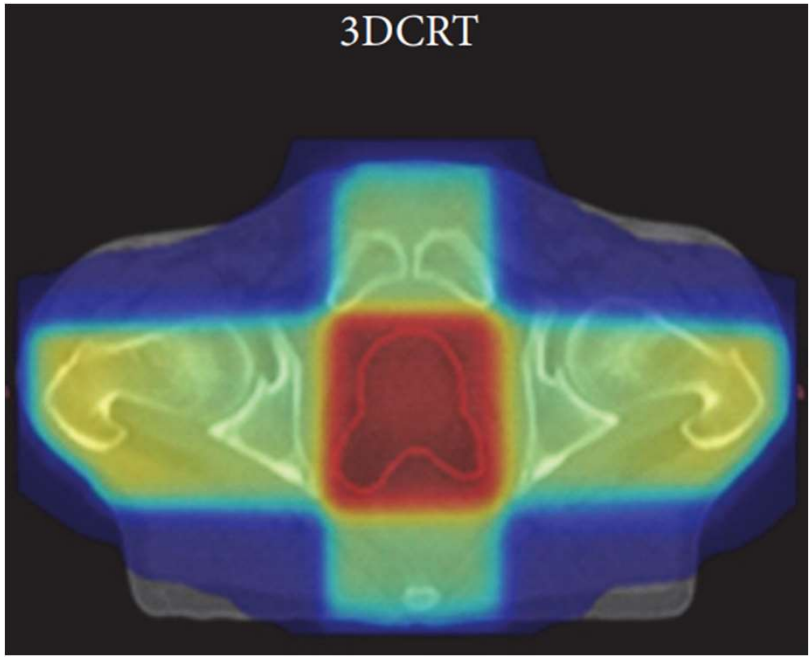
Image: www.raysearchlabs.com

Planning – Role of Physicist

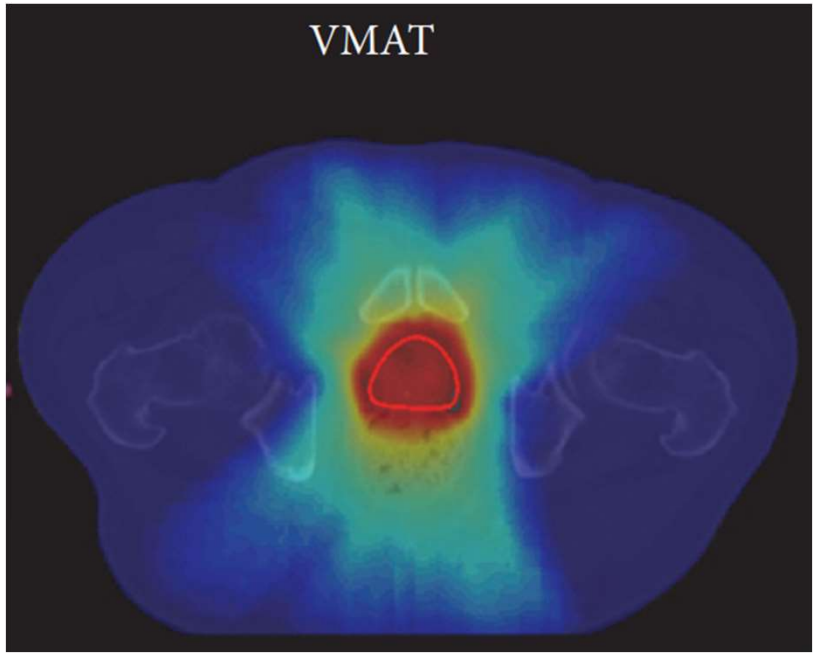
- Creating/checking plans
- Working with medics to determine best type of treatment for a patient
- Discussing potential compromises for plans
- Understanding the software and its limitations
- Implementing new techniques

Planning – Comparing Two Techniques

Implementing a new technique in a department involves physicists



4 static fields
Beam shaping does not change during delivery



Gantry continually moving around patient
Beam shaped during delivery

Images: Prostate Cancer Radiation Therapy: What Do Clinicians Have to Know?, Vanneste et al, BioMed Research International Volume 2016, Article ID 6829875

Patient Specific QA

- VMAT plans can be complicated
- How do we ensure they can be delivered by the machine?
  - Deliver the plan to a phantom and measure the dose

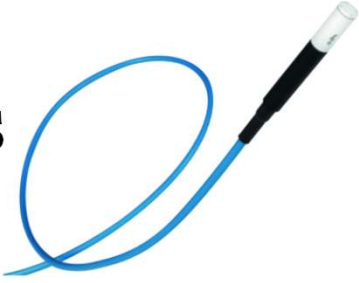
Images: www.ptwdosimetry.com, www.sunnuclear.com

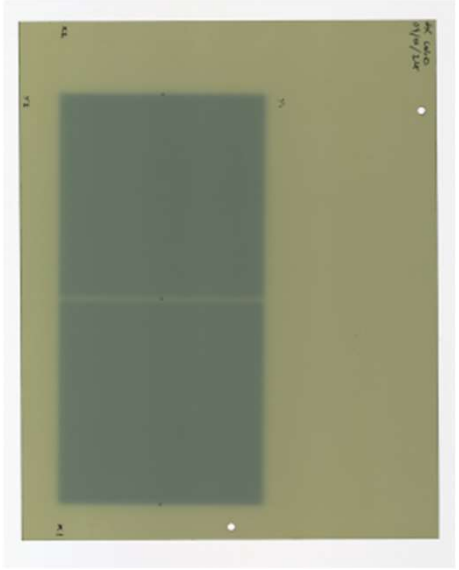
Treatment – Role of Physicist

- Review changes to anatomy – impact of dose distribution?
  - Example: weight loss for a head and neck patient
    - Less tissue to attenuate beam could mean dose to spinal cord has increased
    - Is it still safe to deliver radiation to the patient?
- Review gaps in treatment
  - If patient has missed some fractions, what effect does this have?

Dosimetry

- Behind the scenes but crucial!
- Measurement of dose
- Characteristics of the beam
- Different types of measurement detectors
  - Ionisation chambers
  - Diodes
  - Film
  - Arrays
  - Phantoms





Images: www.ptwdosimetry.com, www.sunnuclear.com

Dosimetry – Role of Physicist

- Plan, take and analyse the measurements required to ensure radiation can be delivered to patients safely
- Examples:
  - Determining attenuation of patient immobilisation devices
  - Implementing and reviewing QA programmes
  - Commissioning linacs before they go into clinical use

Image: https://www.macmillan.org.uk/cancer-information-and-support/treatment/types-of-treatment/radiotherapy/masks-for-radiotherapy

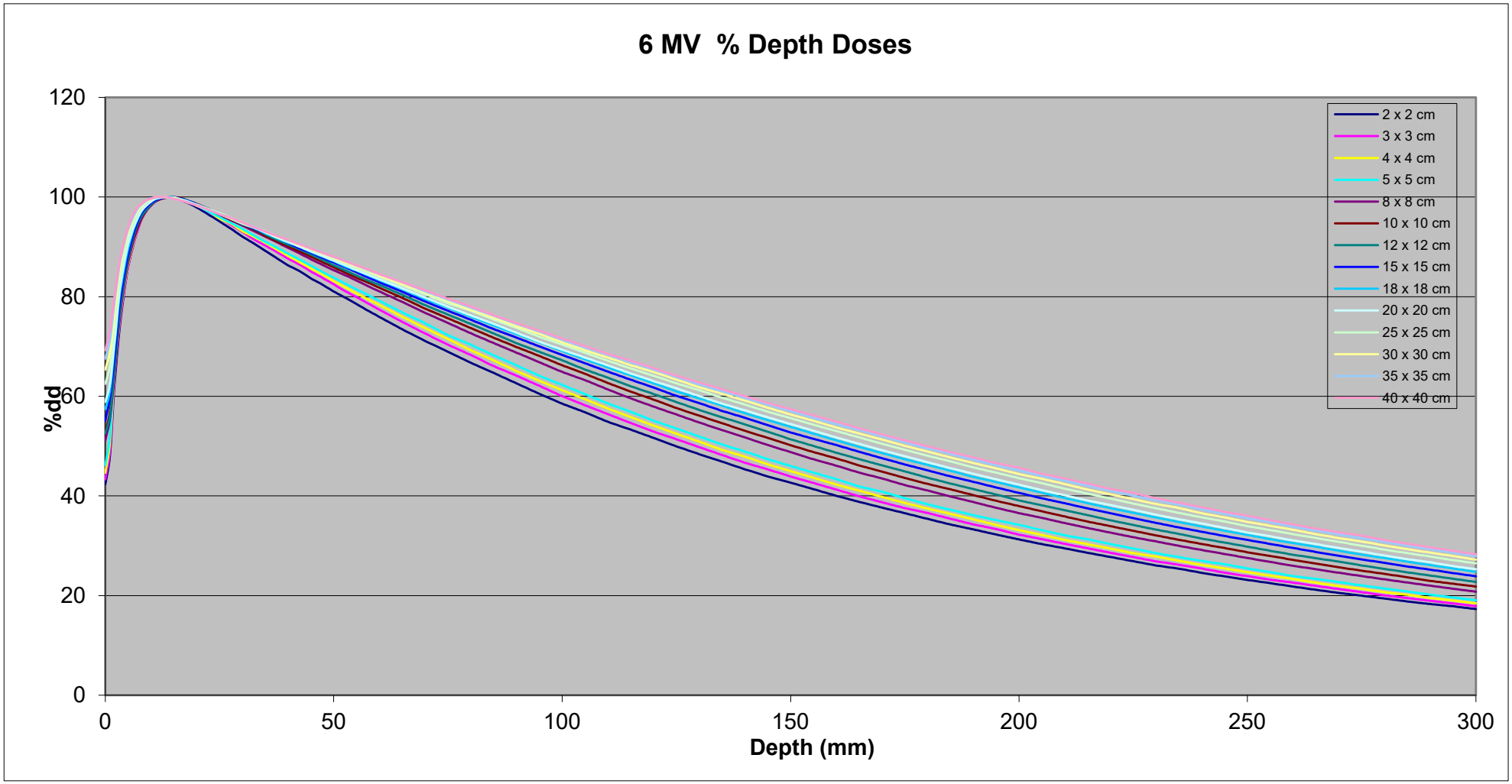
Dosimetry – Commissioning Data

Treatment planning software needs to know beam characteristics for calculations

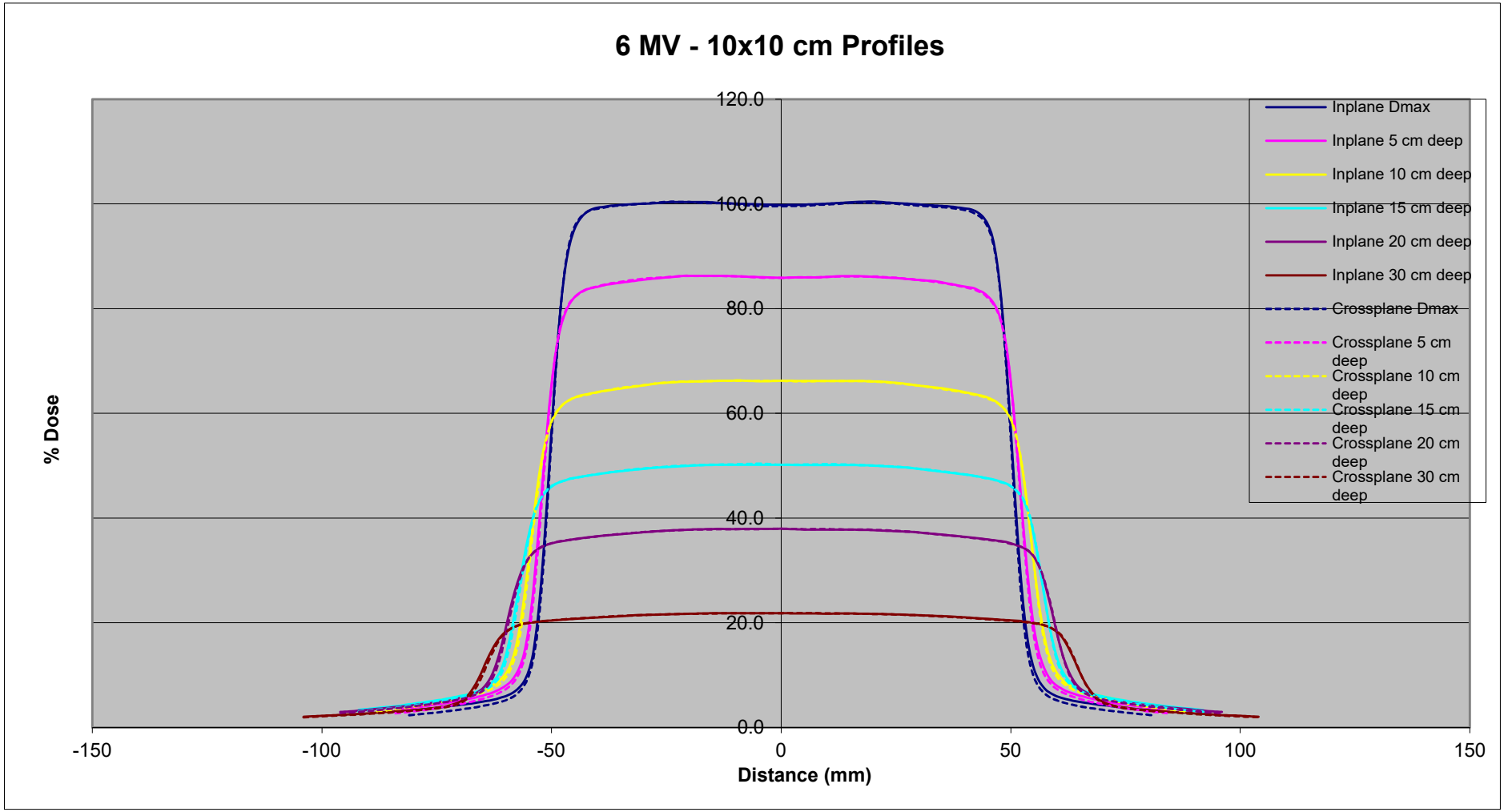
Commissioning data is measured using a detector in a large water tank.

The detector can move in 3 directions and measures scans of the beam.

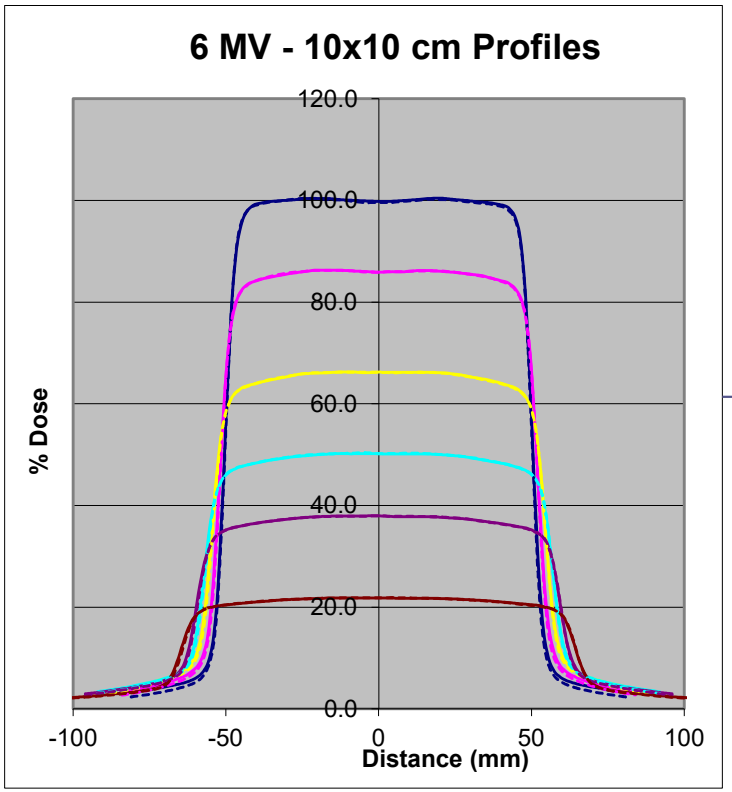
Dosimetry – Commissioning Data



Dosimetry – Commissioning Data



Dosimetry → Planning → Treatment



Images: www.raysearchlabs.com
https://actionkidneycancer.org/stereotactic-ablative-radiotherapy-for-primary-kidney-cancer/

Thank you for listening!

Image: www.varian.com