Treatment Planning Safety

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Introduction

Radiotherapy Treatment Planning

- It is the radiotherapy preparation process
- The treatment planning is defined in terms of planning target volumes (PTV) and dose distributions
- It plays a key-role in the advancement of radiotherapy.

Introduction

Radiotherapy Treatment Planning

- Commissioning treatment planning system
  - Requires accurate extensive measured beam data for each beam
  - Requires beam data accurately entered treatment planning system
  - Requires tests performed on the accuracy of commissioned treatment beams
    - Phantoms: homogeneous and inhomogeneous
    - Patient CT
    - Closed loop test
    - Calculation algorithm and limitations of accuracy

Introduction cont…

Radiotherapy Treatment Planning

- What makes a good treatment plan?
  - Target coverage
  - The OAR tolerance
  - Sensitivity to patient positioning errors
  - Accuracy of calculated dose distributions

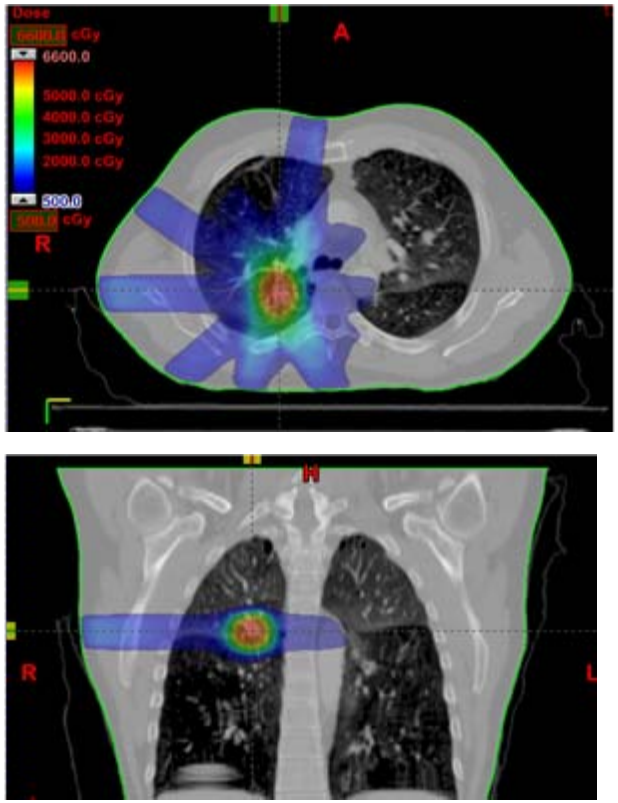
Planning safety concerns

Multiple isocenter treatment plans

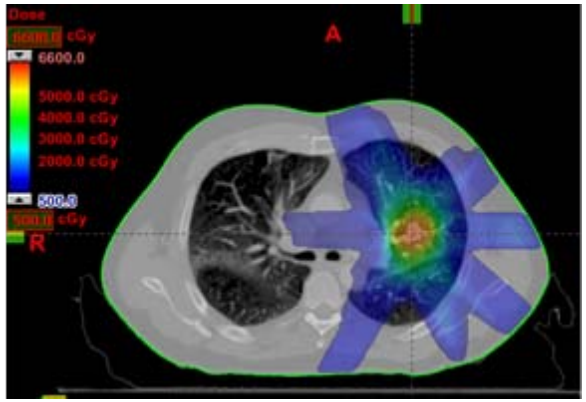
- Dose contributions from beams treating other isocenter.
- To each target
- To OAR from each targets
- Sum of dose distributions to each target and OAR

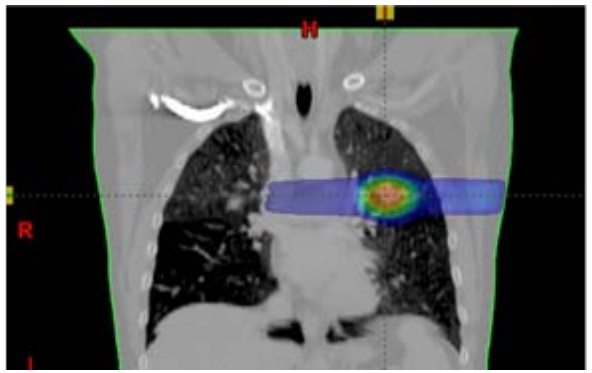
SBRT examples

Right lung target

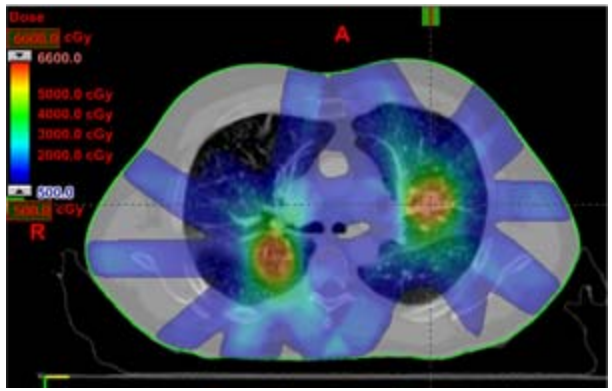


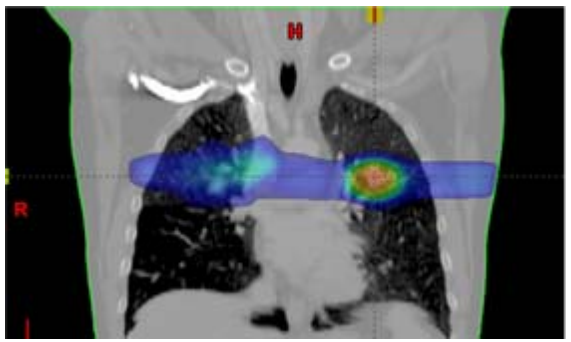
Left lung target





Plan sum



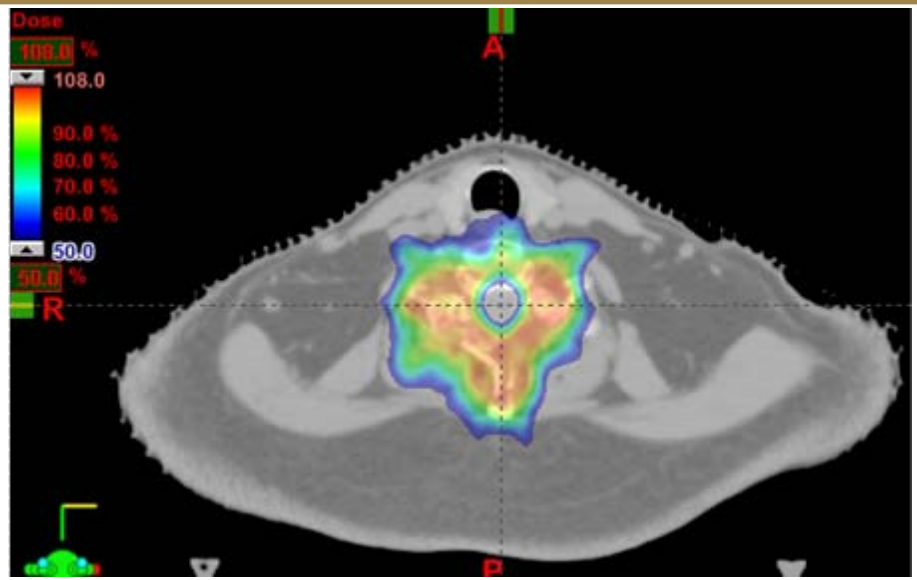


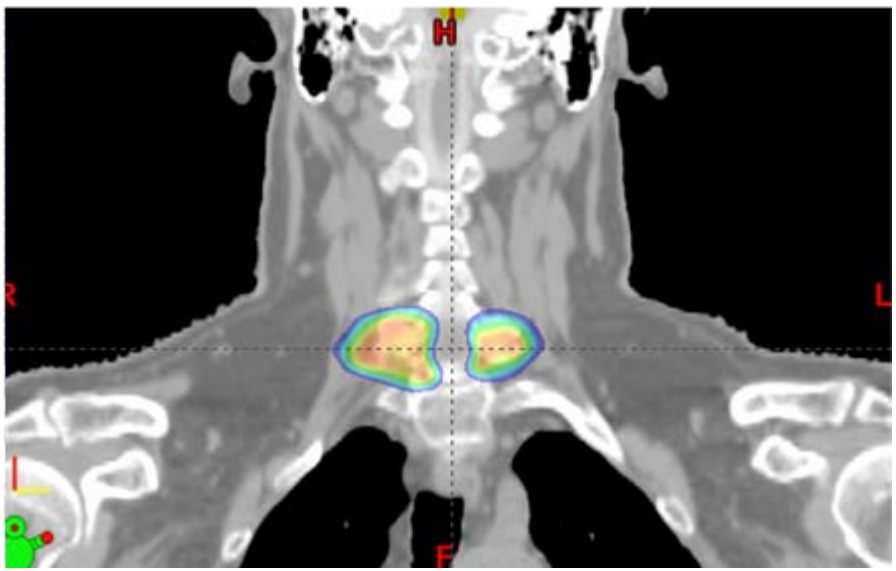
Plan delivery safety concerns

Image-guided radiation therapy (IGRT)

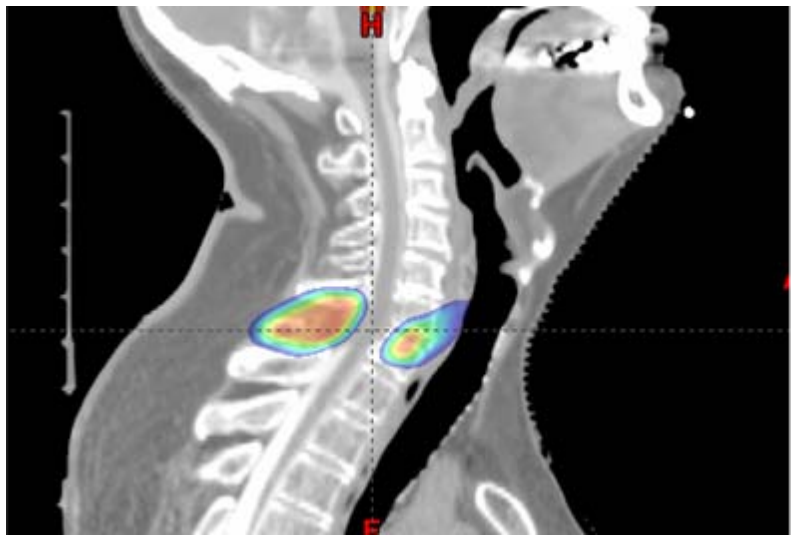
- To ensure the planned dose are delivered to the target
- To avoid unintended dose to OAR at the time of treatment
- X-ray imaging modalities
  - electronic portal imaging device (EPID)
  - kilovoltage digital radiography (kV DR)
  - megavoltage cone-beam CT (MV-CBCT)
  - kilovoltage cone-beam CT (kV-CBCT)
- Risk of additional dose to patients resulting from imaging guidance procedures

An example where IGRT is required and needed





Limiting dose to the spinal cord



Plan delivery safety concerns

Treatment Planned beams with accessory devices

- Physical wedges
- Lead blocks
- Beam physical compensators
- circular cone beam limiting device accessory

Mistakes can happen and have been reported

Plan delivery safety concerns

Circular cone beam limiting device accessory

- When the jaw field sizes extend beyond the shielded area of the SRS cone.
- It results radiation leakages
- The leakage can result significant unintended dose to normal tissues.

The New York Times

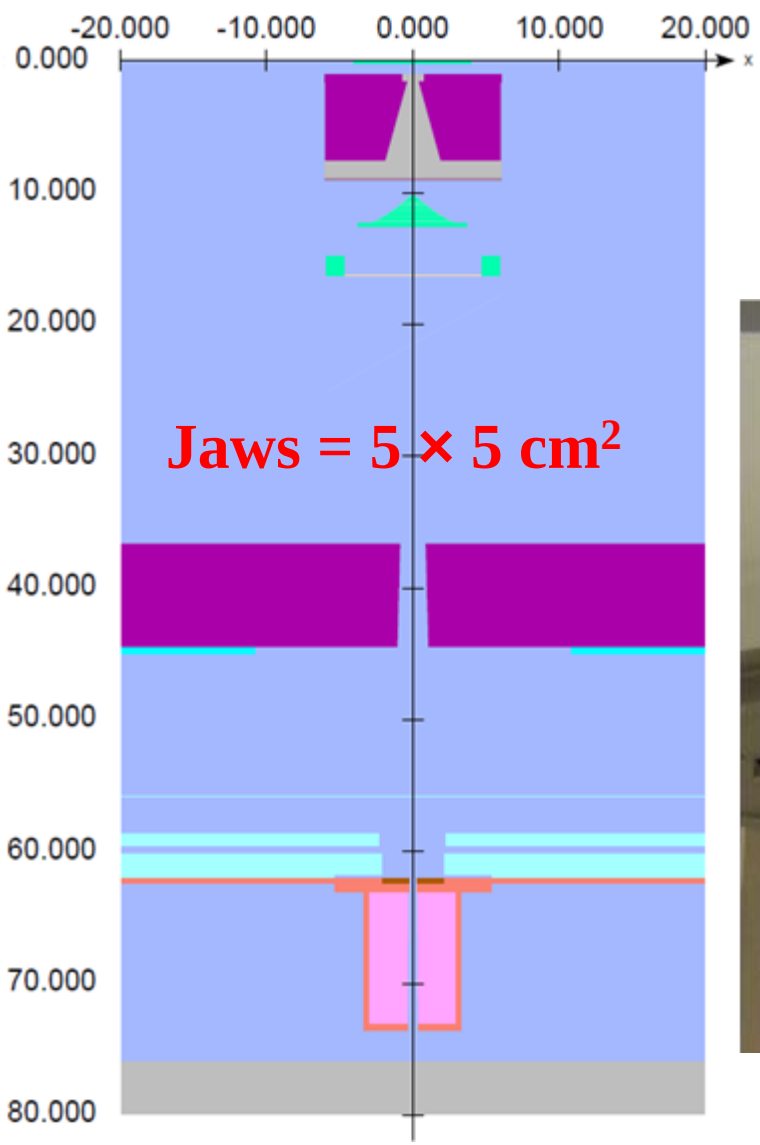
THE RADIATION BOOM

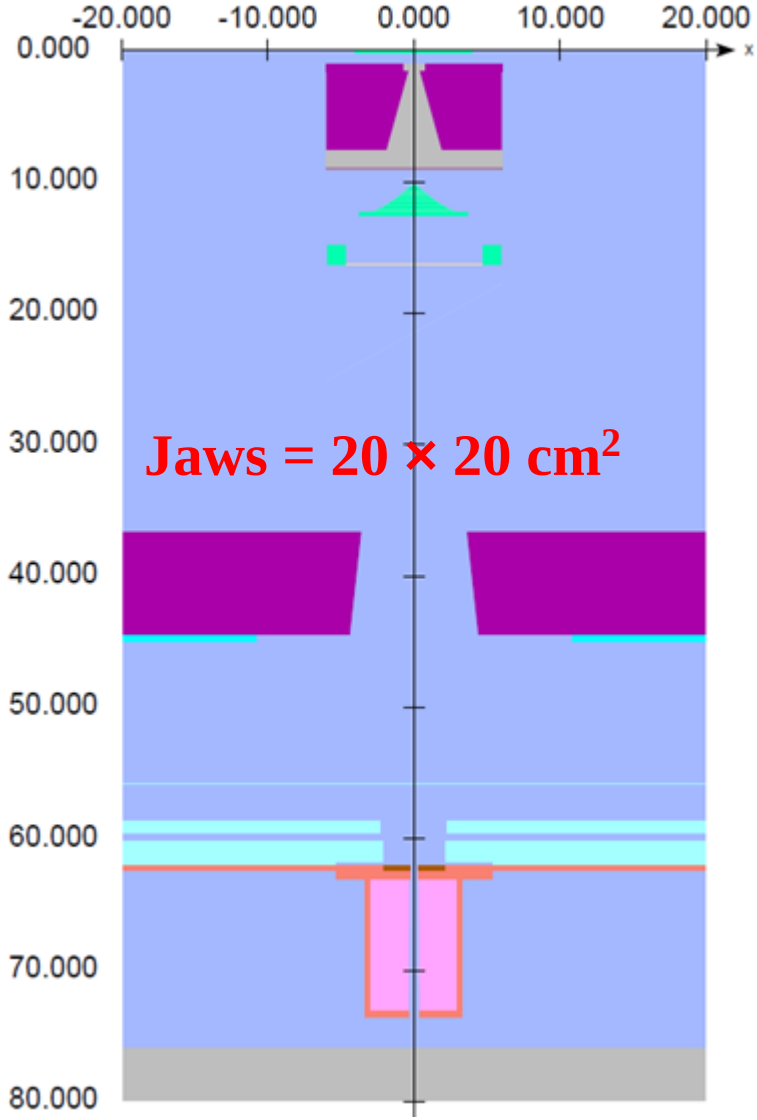
A Pinpoint Beam Strays Invisibly, Harming Instead of Healing

By WALT BOGDANICH and KRISTINA REBELO

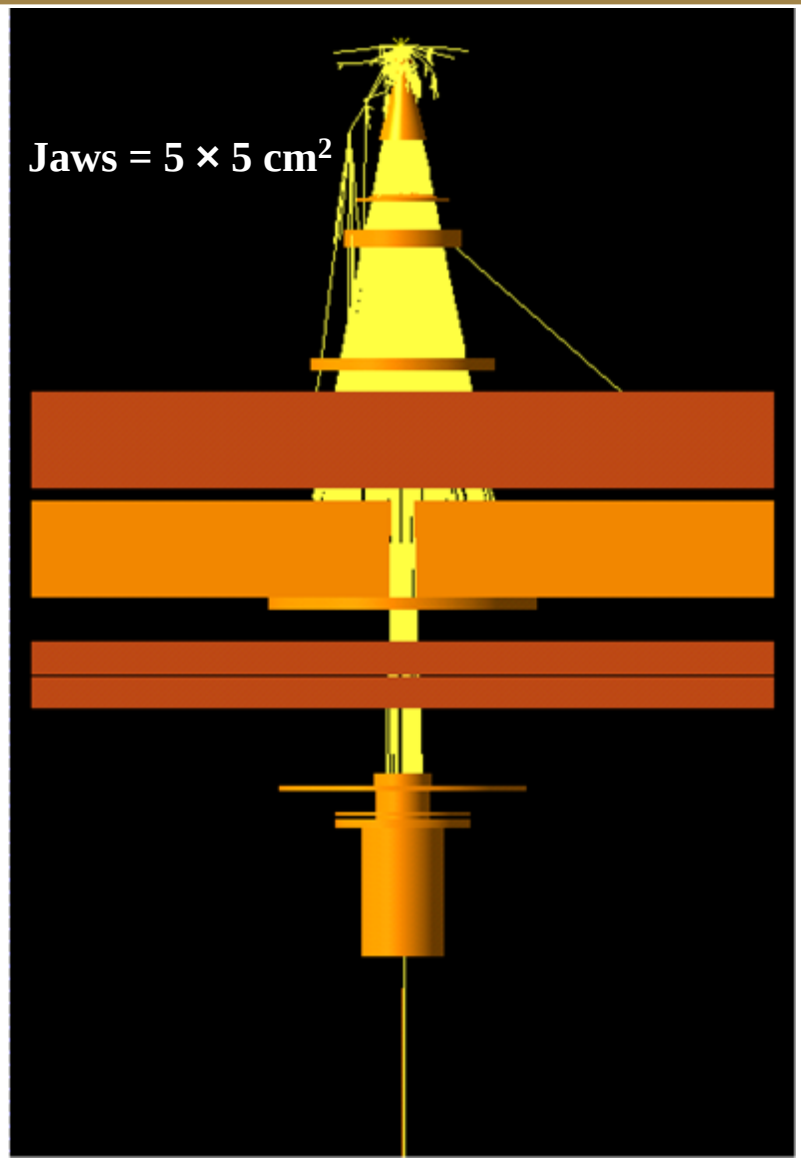
Published: December 28, 2010

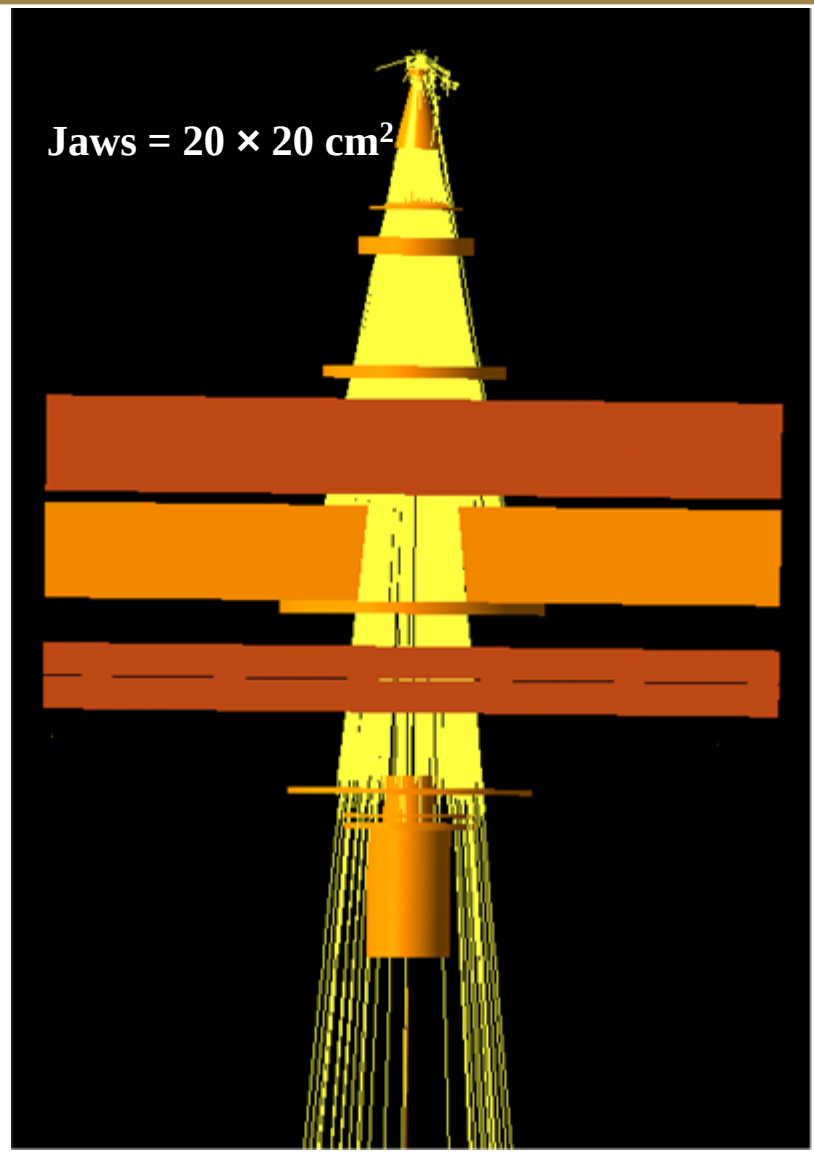
Circular cone accessory: where dose the leakage come from?





Monte Carlo simulations: leakage

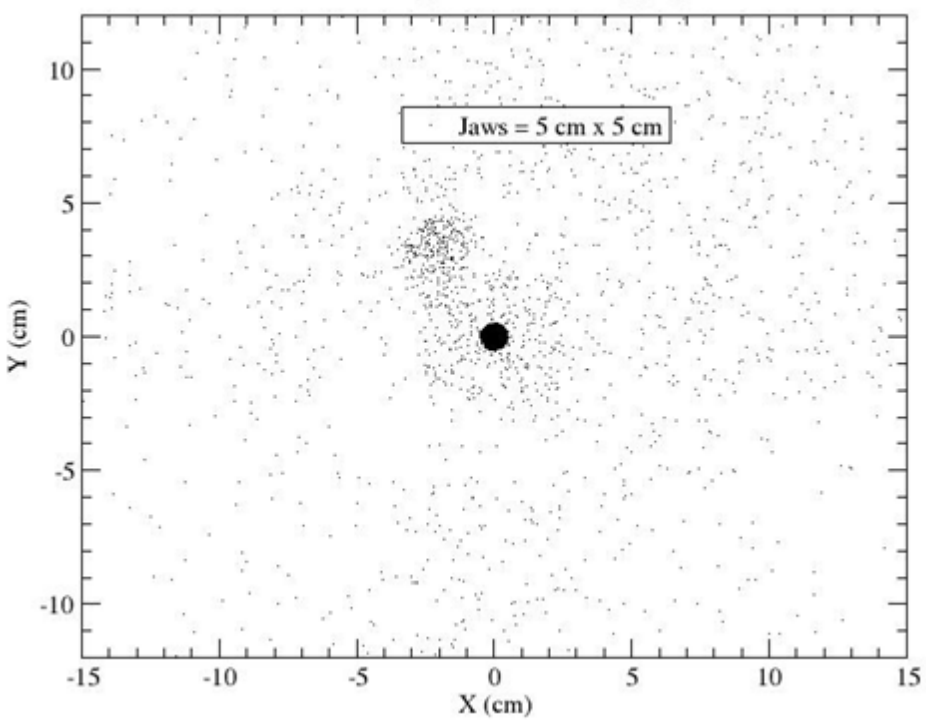




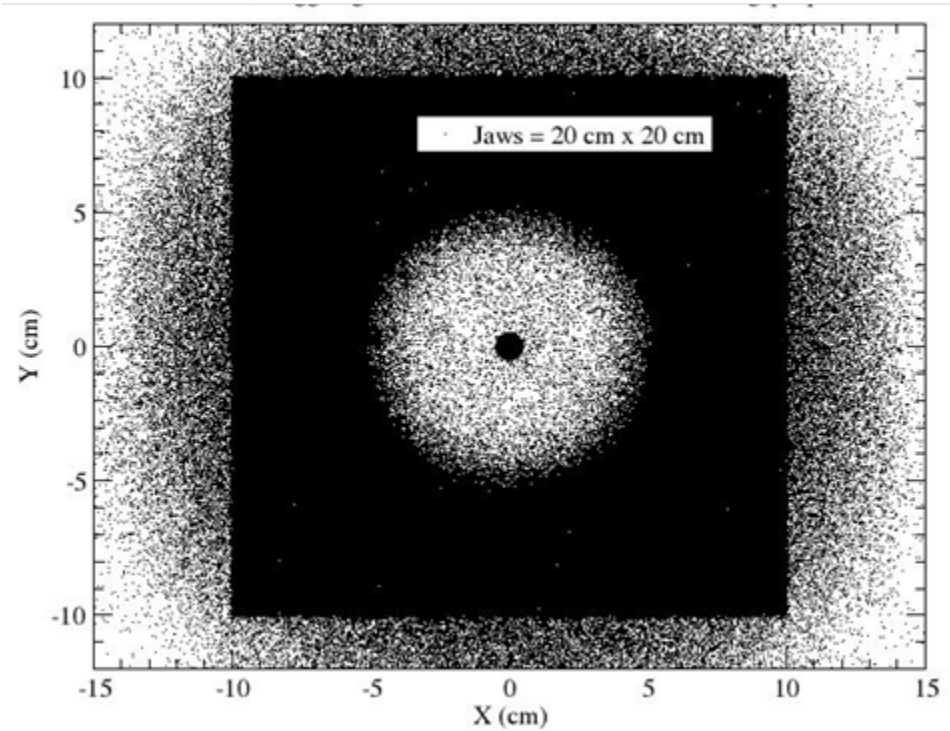
Scatter plot of simulated leakage

Circular cone size: 10 mm

Jaws = 5 × 5 cm²

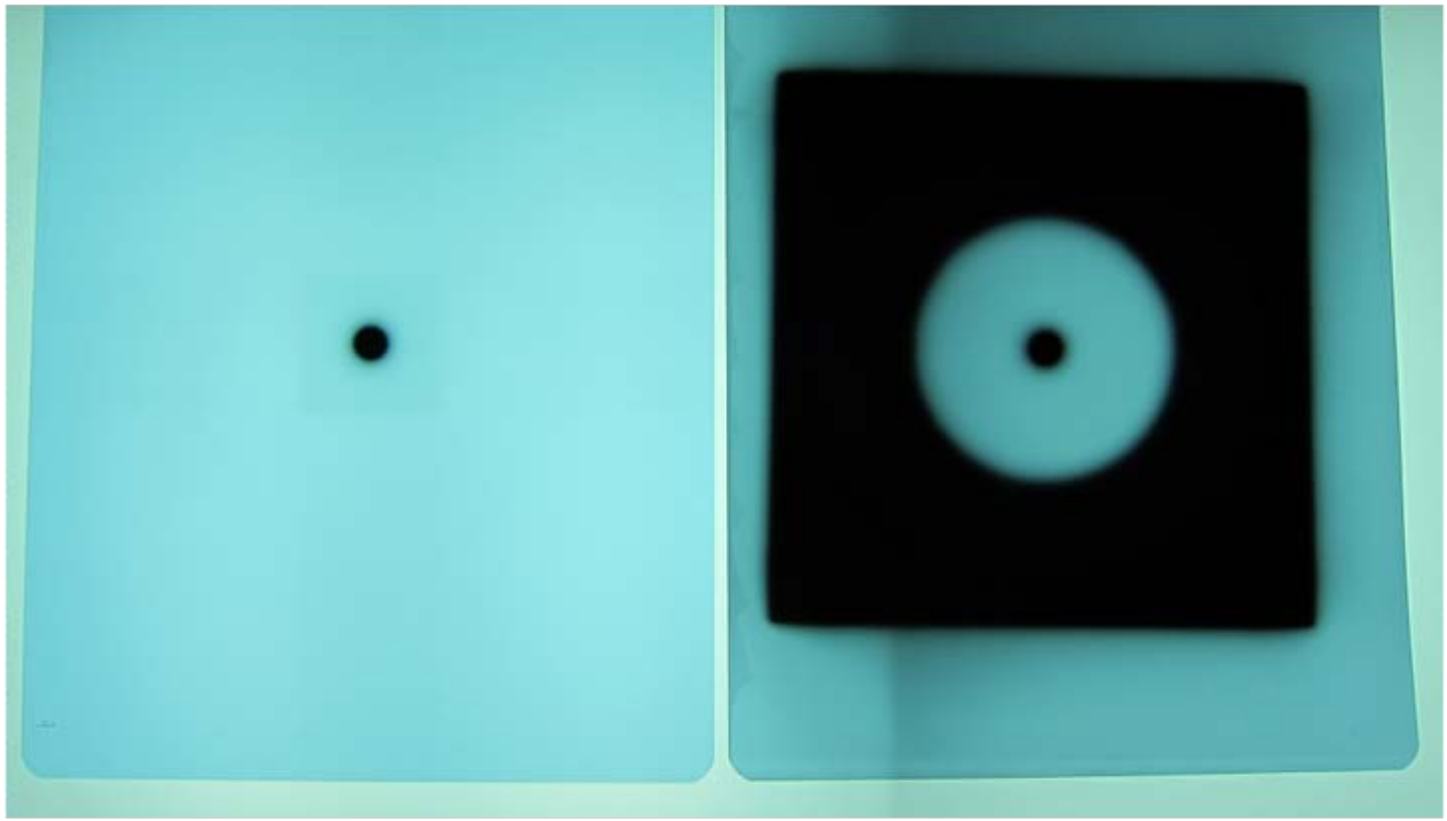


Jaws = 20 × 20 cm²



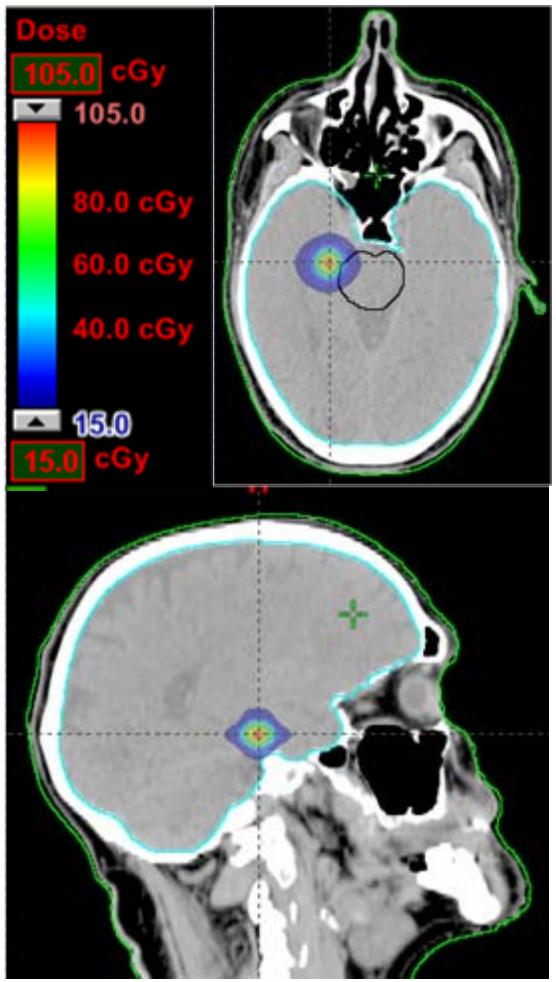
Measured leakage using films

Jaws = 5 × 5 cm² **Jaws = 20 × 20 cm²**

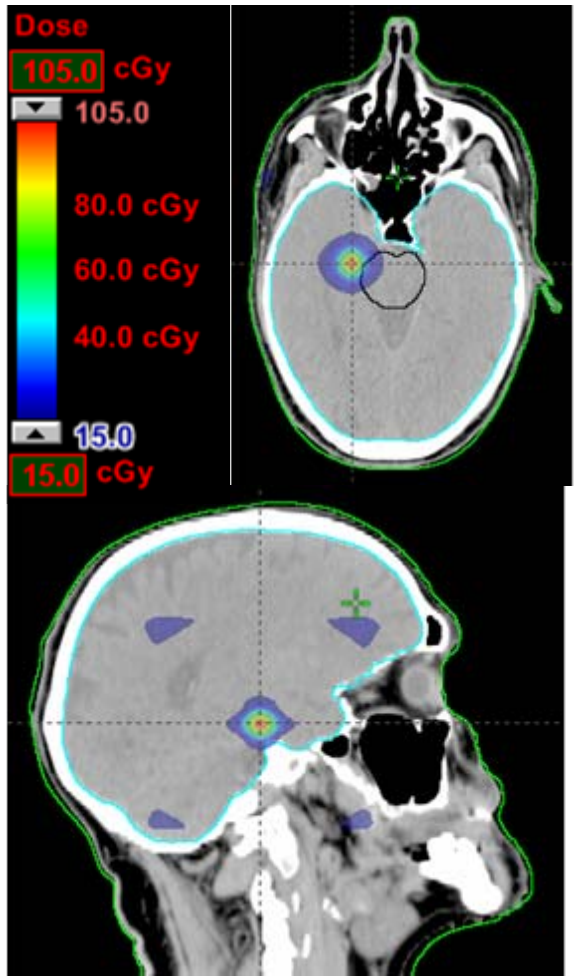


Effect of jaw sizes: dose distributions from multiple arcs

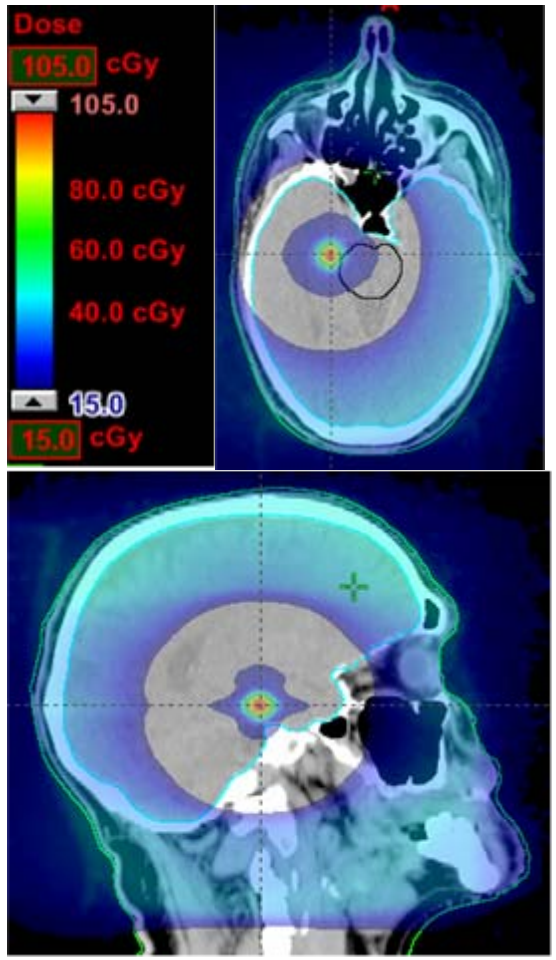
Jaws = 5 × 5 cm^2



Jaws = 10 × 10 cm^2



Jaws= 20 × 20 cm^2



How to catch this type error?

Can point dose measurement detect incorrect jaw size error? Not really!

The point dose at the isocenter only showed ~ 6% difference between jaws set to 20×20 cm^2 and 5×5cm^2!

A systematic and robust quality assurance protocol is needed:

- It is a team effort.
- Done by trained and qualified personnel.
- Closed-loop tests at commissioning of any new treatment procedure

Summary

Treatment planning safety:

- Commissioning treatment planning system

•Optimizing target coverage and OAR dose limit

•Feasibility and sensitivity of a treatment plan at treatment delivery.

•Beam defining accessory devices

•What is delivered dose = What is planned dose?

A team approach and a systematic quality assurance program are essential.