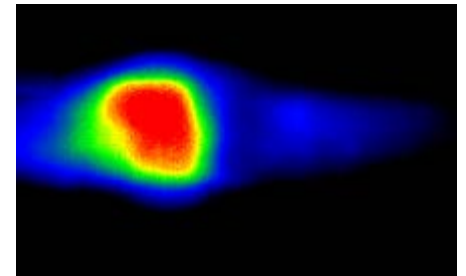
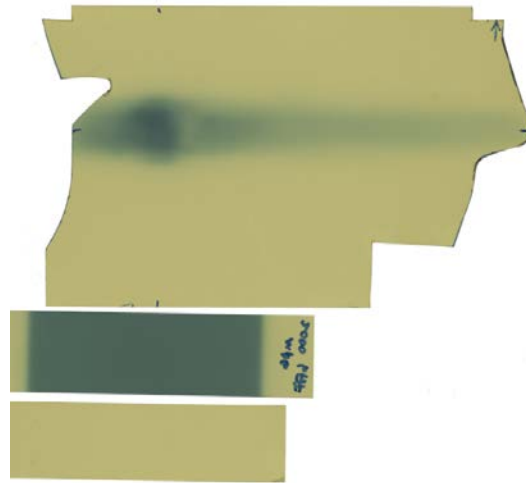
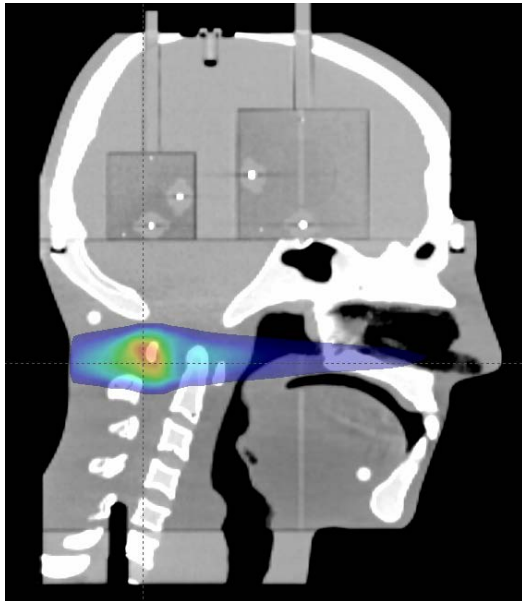


Radiochromic Film - Mayo experience



Satomi Shiraishi, Ph.D.

Michael P. Grams, Ph.D.

Luis E. Fong, Ph.D.

Gafchromic Film Research Meeting

November 27, 2016



MAYO CLINIC
Radiation Oncology

Mayo Clinic



- Located Rochester, Minnesota, USA
- ~35,000 staff on MN campus
- Radiation Oncology:
 - ~190 staff total
 - ~30 Physicians
 - ~35 Physicists
 - 6 Varian True Beam Linacs
 - HDR, LDR Brachytherapy
 - Gamma Knife
 - Proton



Mike Grams, Ph.D.

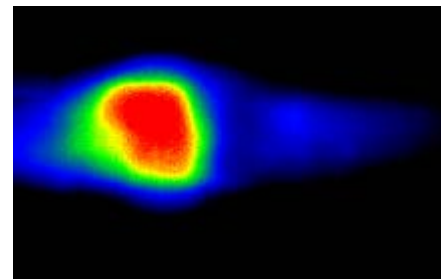
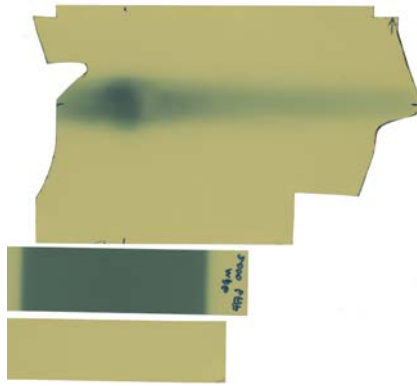
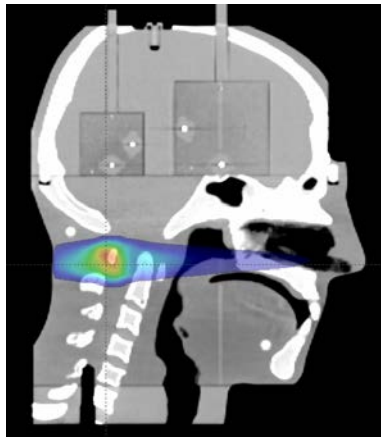


Luis Fong, Ph.D.
MAYO CLINIC
Radiation Oncology



Film is used daily in our clinic

- IMRT QA, surface dose/bolus measurements, buildup measurements, TSE in vivo dosimetry, research etc...



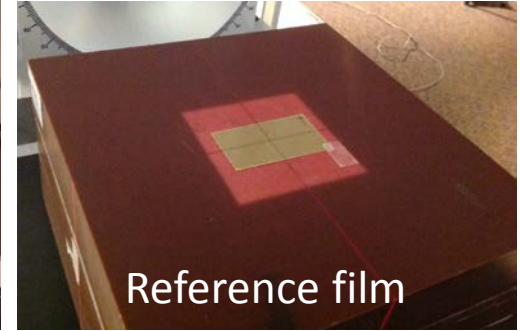
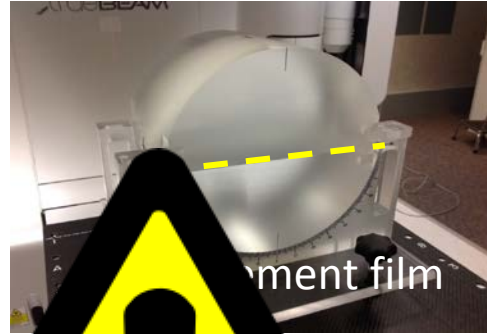
- Film is a very useful dosimeter because
 - Nearly water equivalent
 - Thin, flexible, and water resistant
 - Sub-millimeter spatial resolution
 - Energy independent in therapeutic range
 - One film for electrons, photons, brachy sources...

Single-Scan Protocol

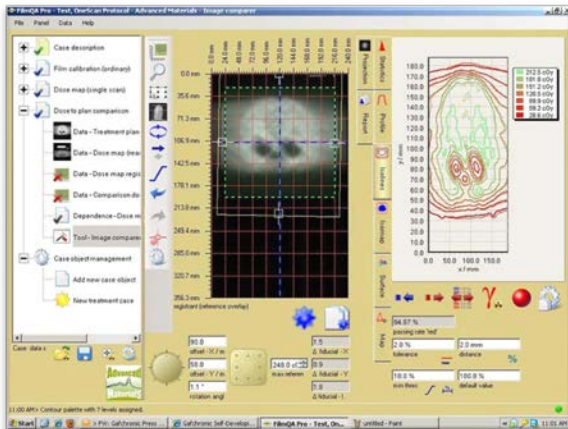
Prepare film: EBT3 and EBT-XD



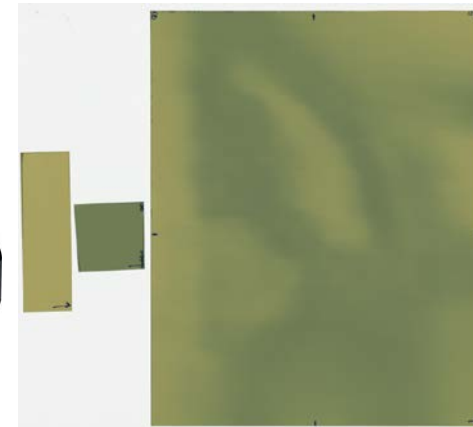
Irradiate



Analyze: FilmQA Pro



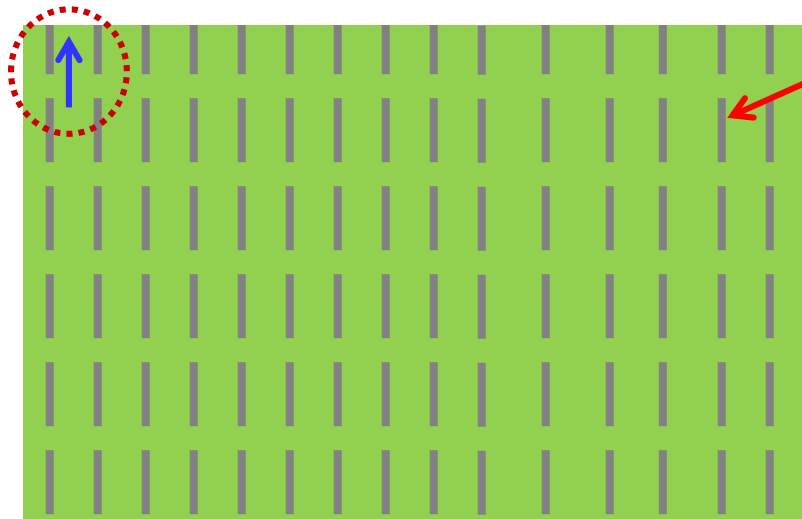
1000 XL



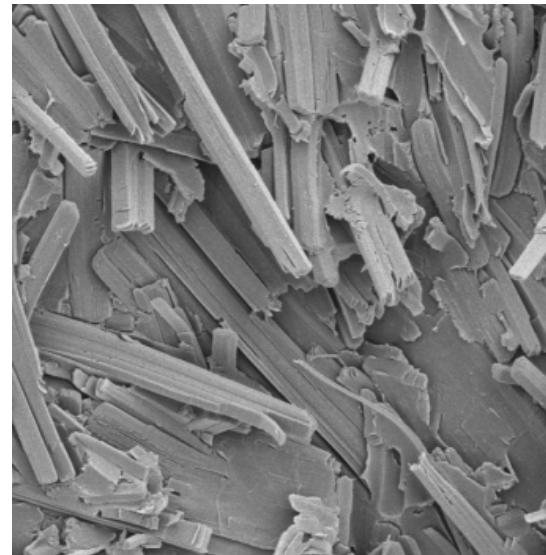
MAYO CLINIC
Radiation Oncology

Film orientation is important

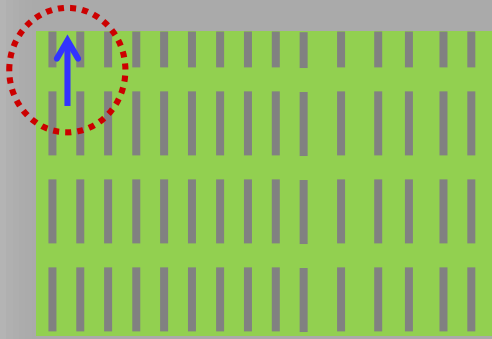
- The active ingredient has a preferentially oriented direction
 - It matters which way the film is placed on the scanner



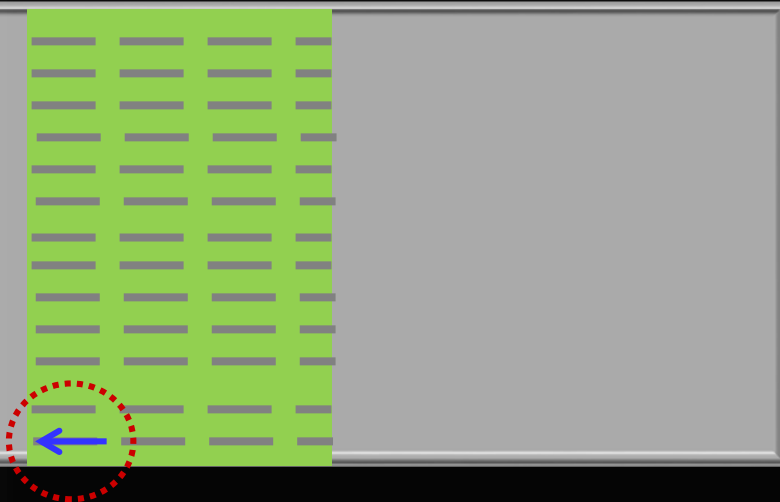
“Hair like” active ingredient is preferentially oriented parallel to the short side of the film



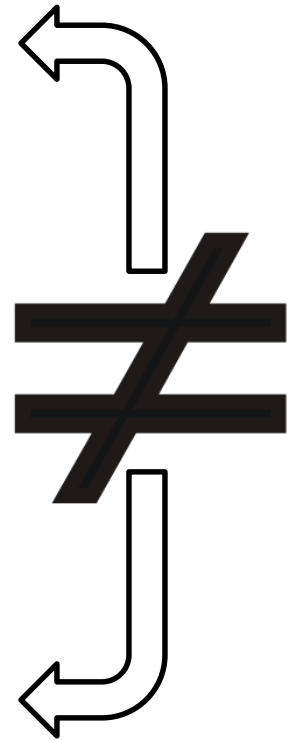
“landscape” orientation



“portrait” orientation



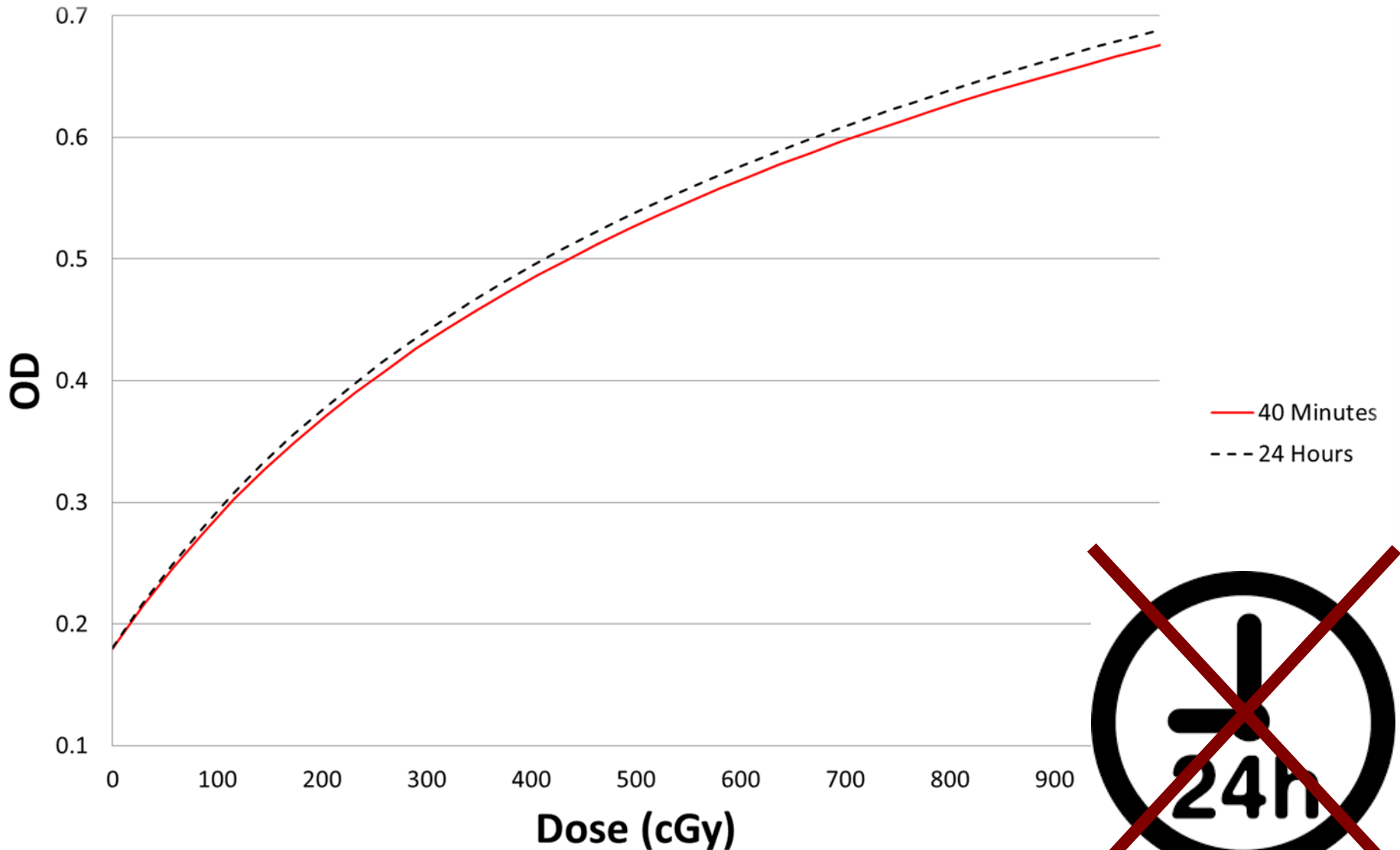
Keep track of
the orientation



Stay
consistent!

IC
ology

Film takes ~24hrs to fully develop



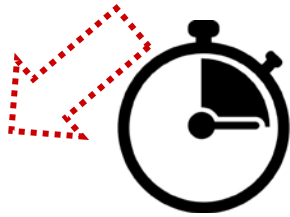
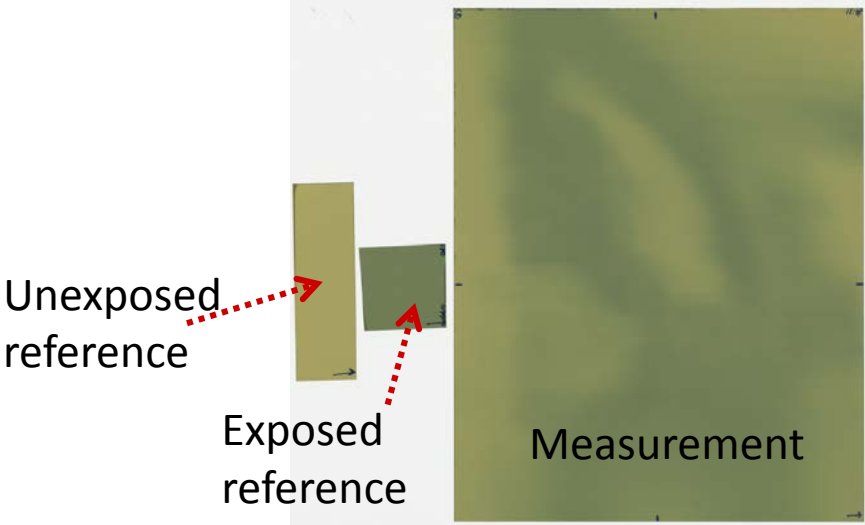
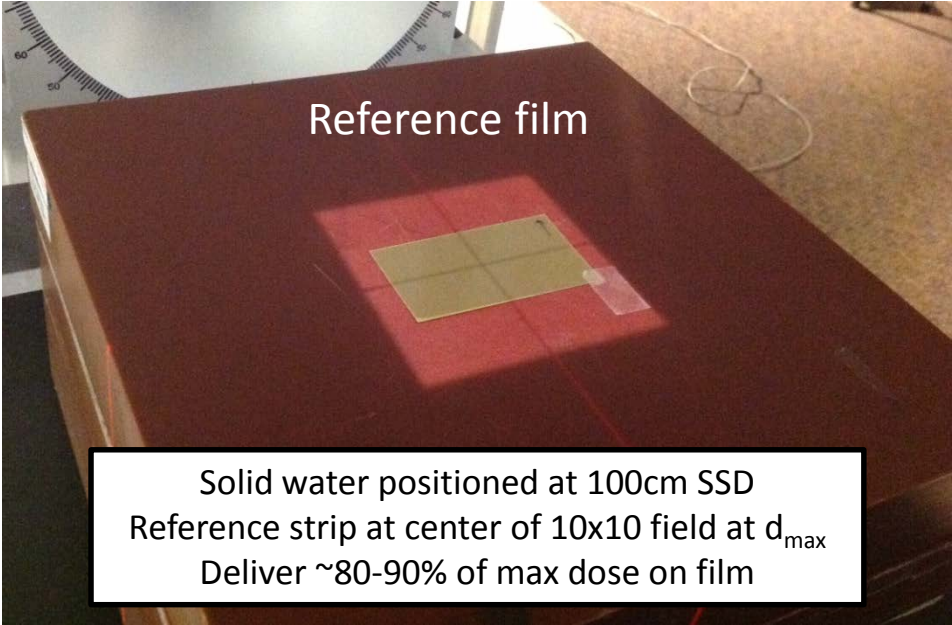
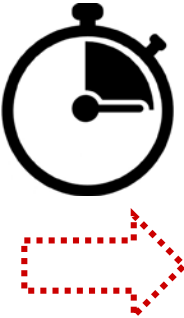
Dose (cGy)



MAYO CLINIC
Radiation Oncology

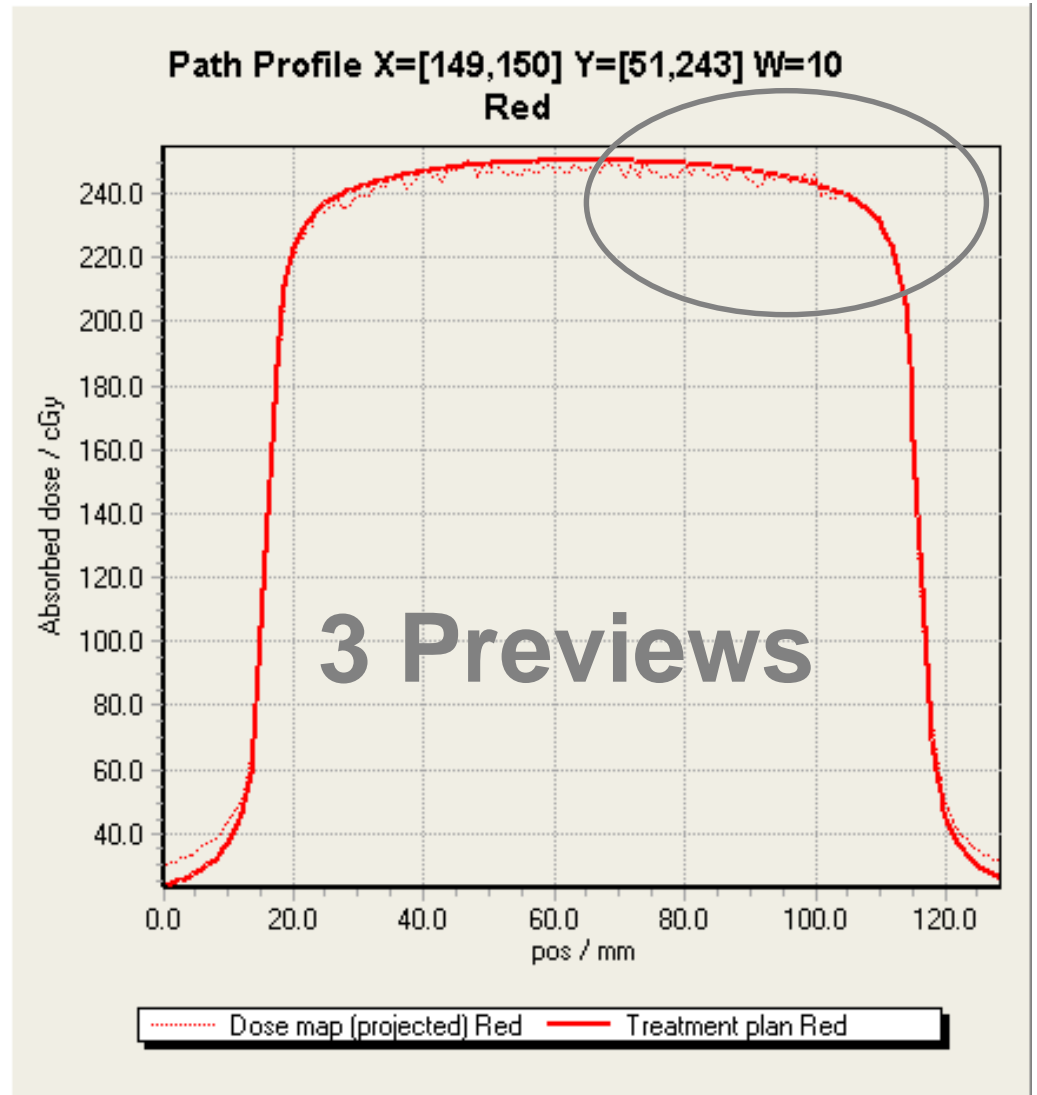
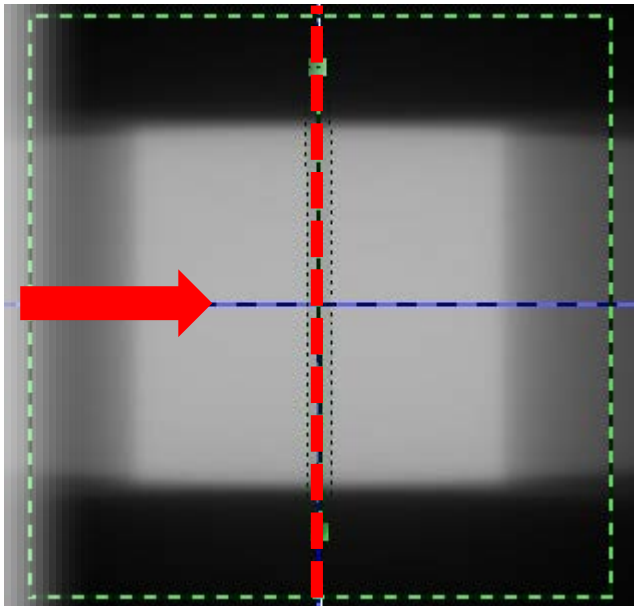


Single-scan protocol speeds up the process

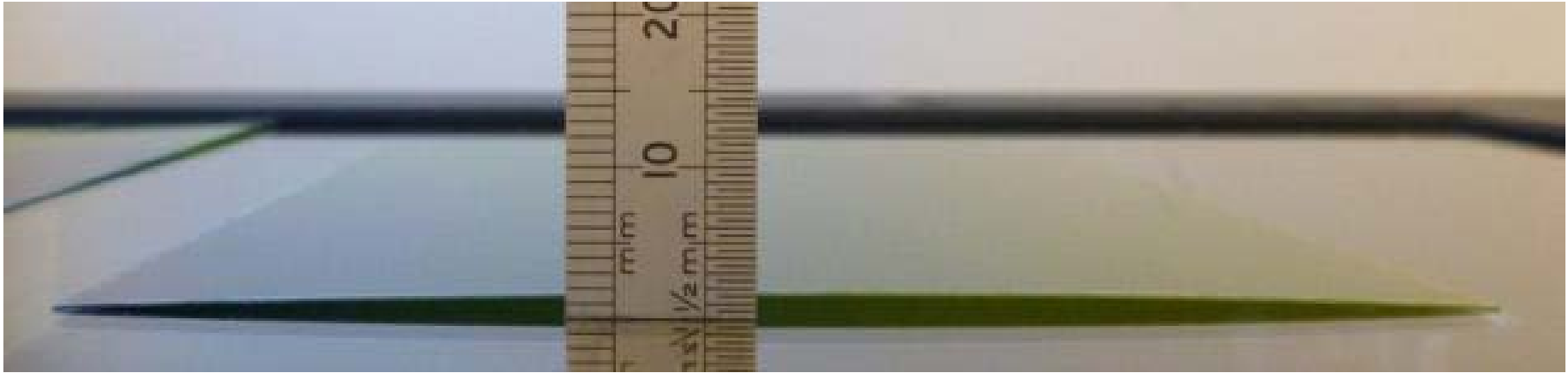


Wait 4x the time elapsed between measurement and reference films irradiation before scanning

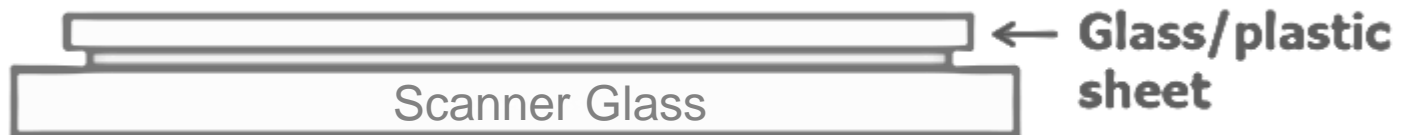
The scanner needs a warm-up



Film must be flat on the scanner

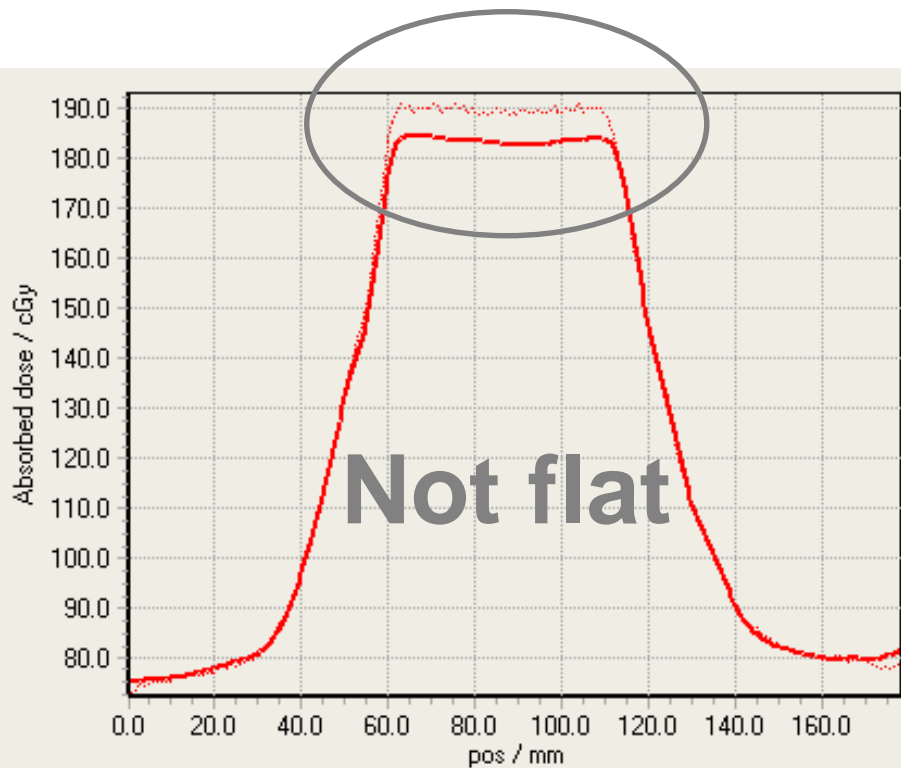


- Some pieces lay flat, others don't.
We force it flat with a glass plate.

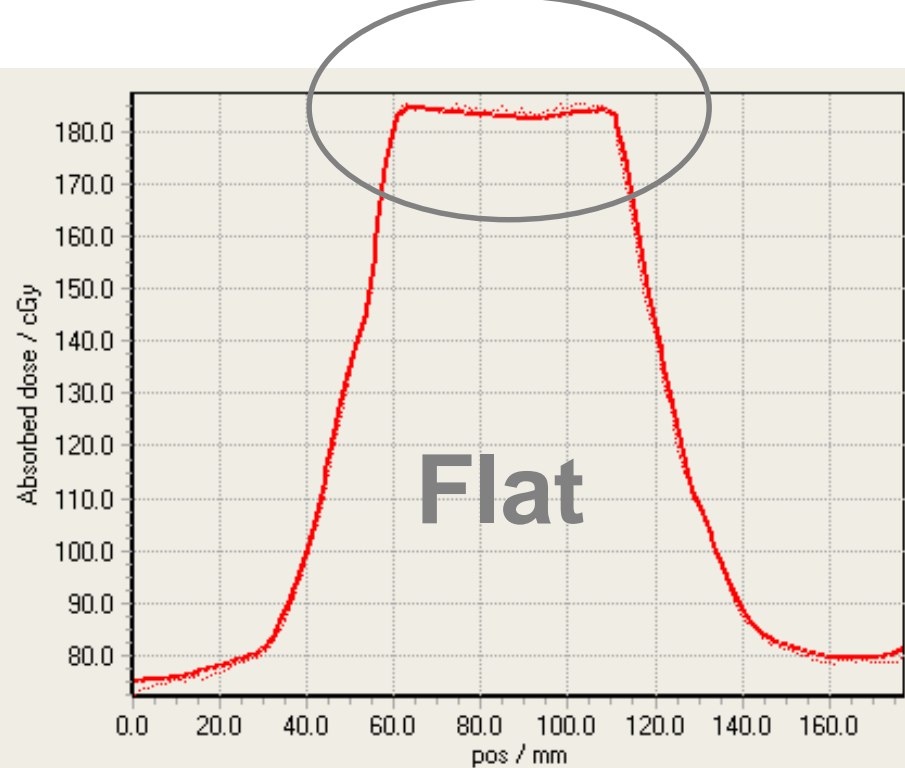


Palmer, A., Bradley, D., & Nisbet, A. (2015). *Journal Of Applied Clinical Medical Physics*, 16(2).

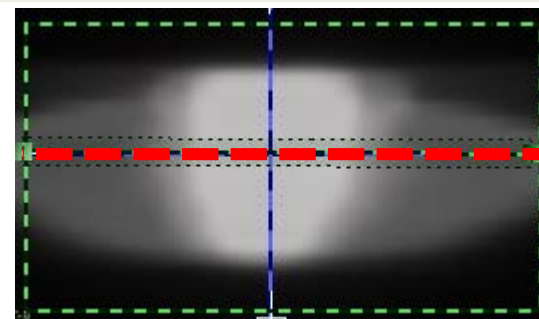
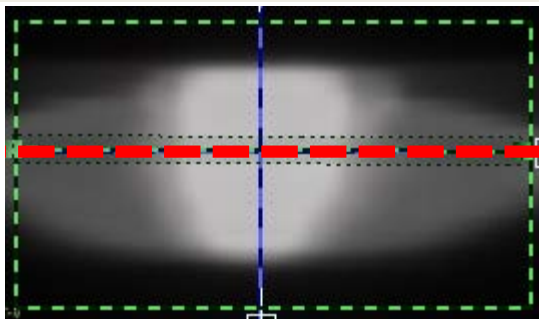
Film must be flat on the scanner



..... Dose map (projected) Red — Treatment plan Red



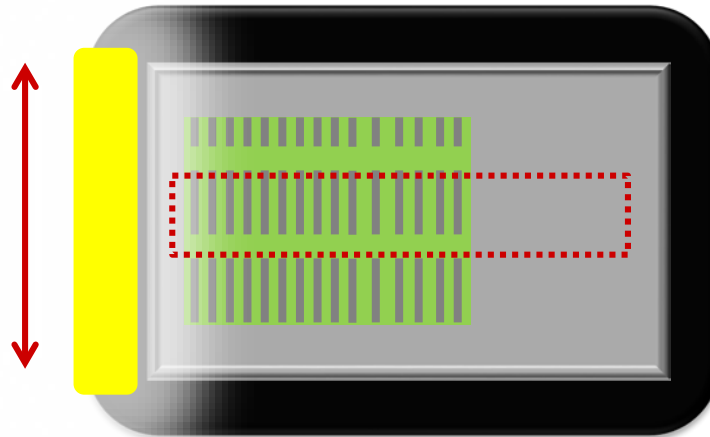
..... Dose map (projected) Red — Treatment plan Red



MAYO CLINIC
Radiation Oncology

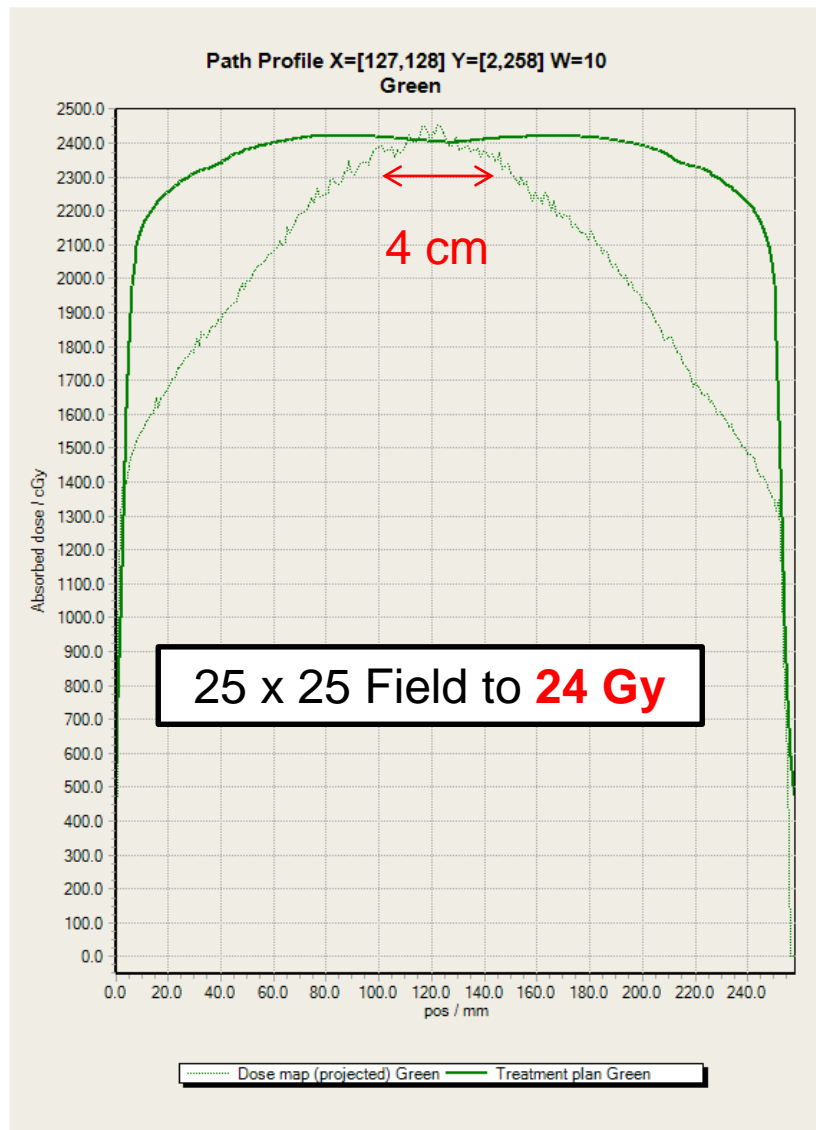
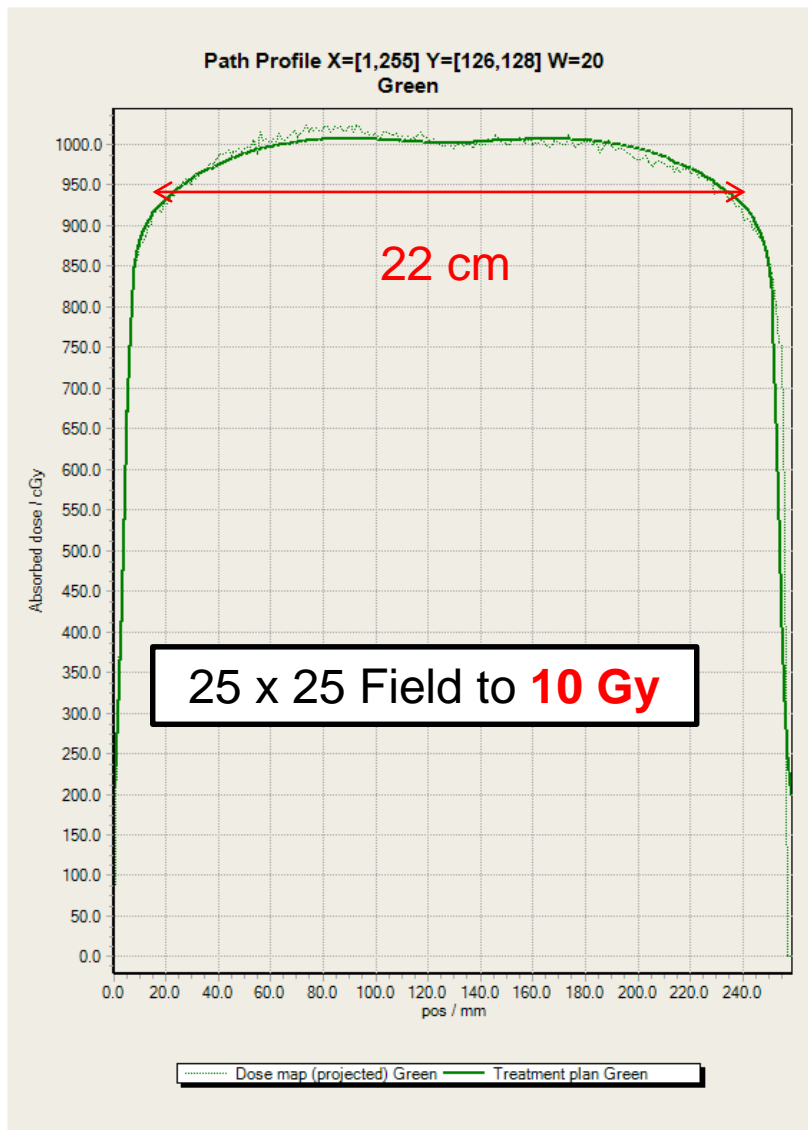
Lateral scan effect: Stay near the center of the scanner

- Caused by polarization of light by film
- Scales with dose: higher dose -> larger effect
 - <10 Gy, the effect is small near center of scanner
 - At 24 Gy, you may only have < 4 cm where the effect is manageable
 - Scanner dependent



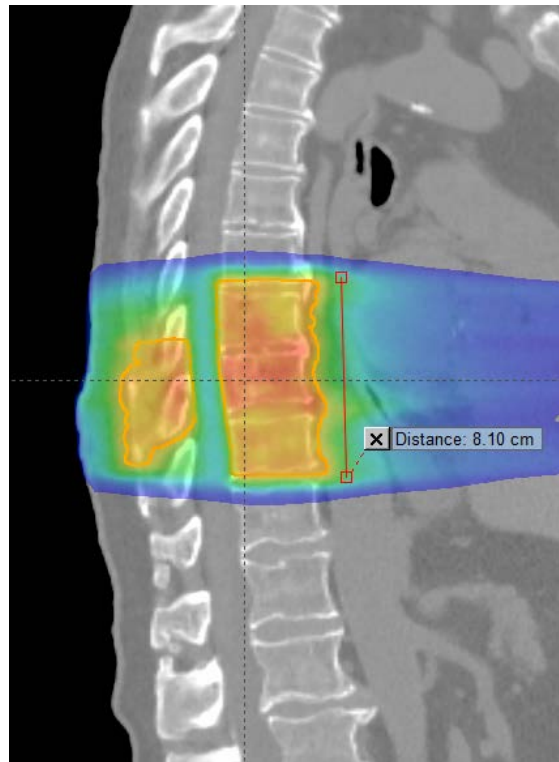
Battum et al., Phys. Med. Biol. 61 (2016) 625-649
Schoenfeld et al., Phys. Med. Biol. 59 (2014) 3575-3597

Lateral scan effect – EBT3



Problem...

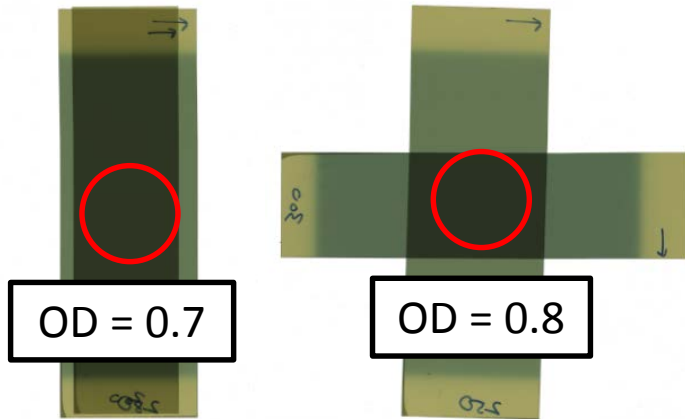
- SBRT prescriptions can go to 24 Gy and the volumes treated aren't always very small...



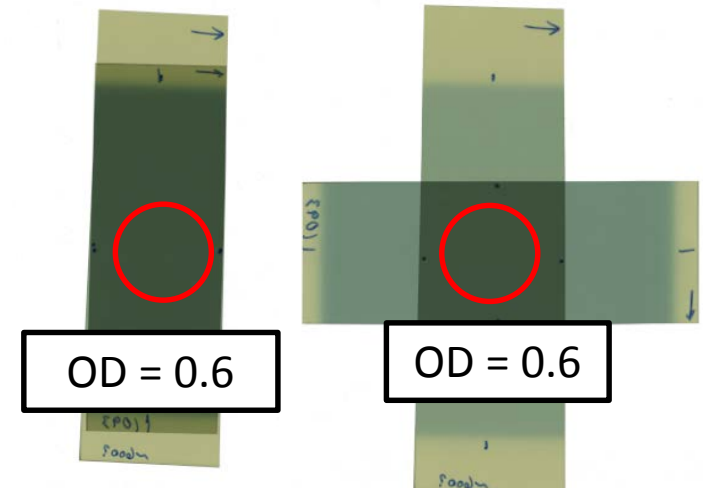
The solution: EBT-XD

- EBT-XD (eXtended Dose)
 - Shorter polymers – less polarizing
 - Less sensitive than EBT3 – higher accuracy at high doses
 - Lateral scan effect is considerably reduced

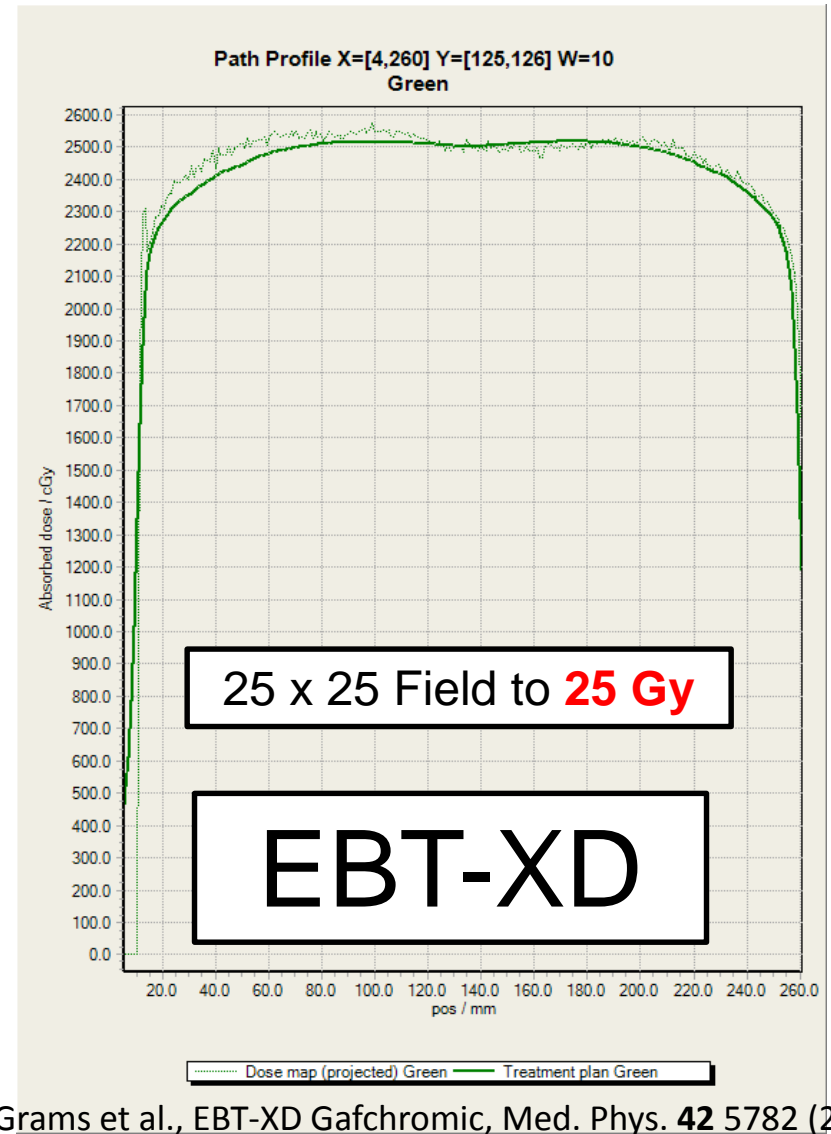
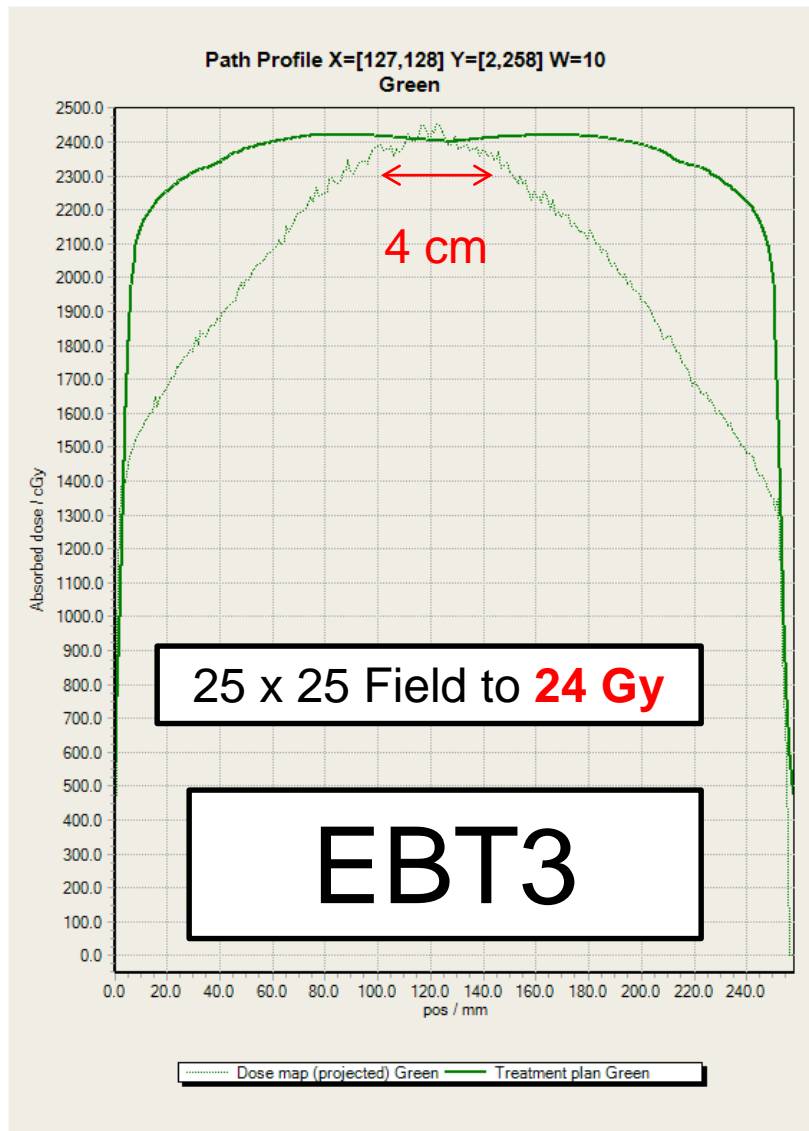
EBT3 Film



EBT-XD Film



EBT-XD reduces lateral scan effect

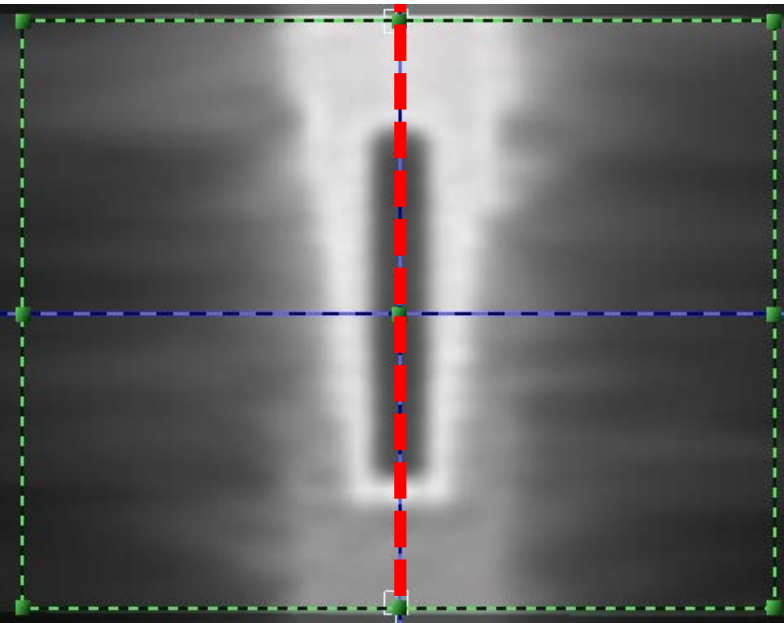


Grams et al., EBT-XD Gafchromic, Med. Phys. **42** 5782 (2015)



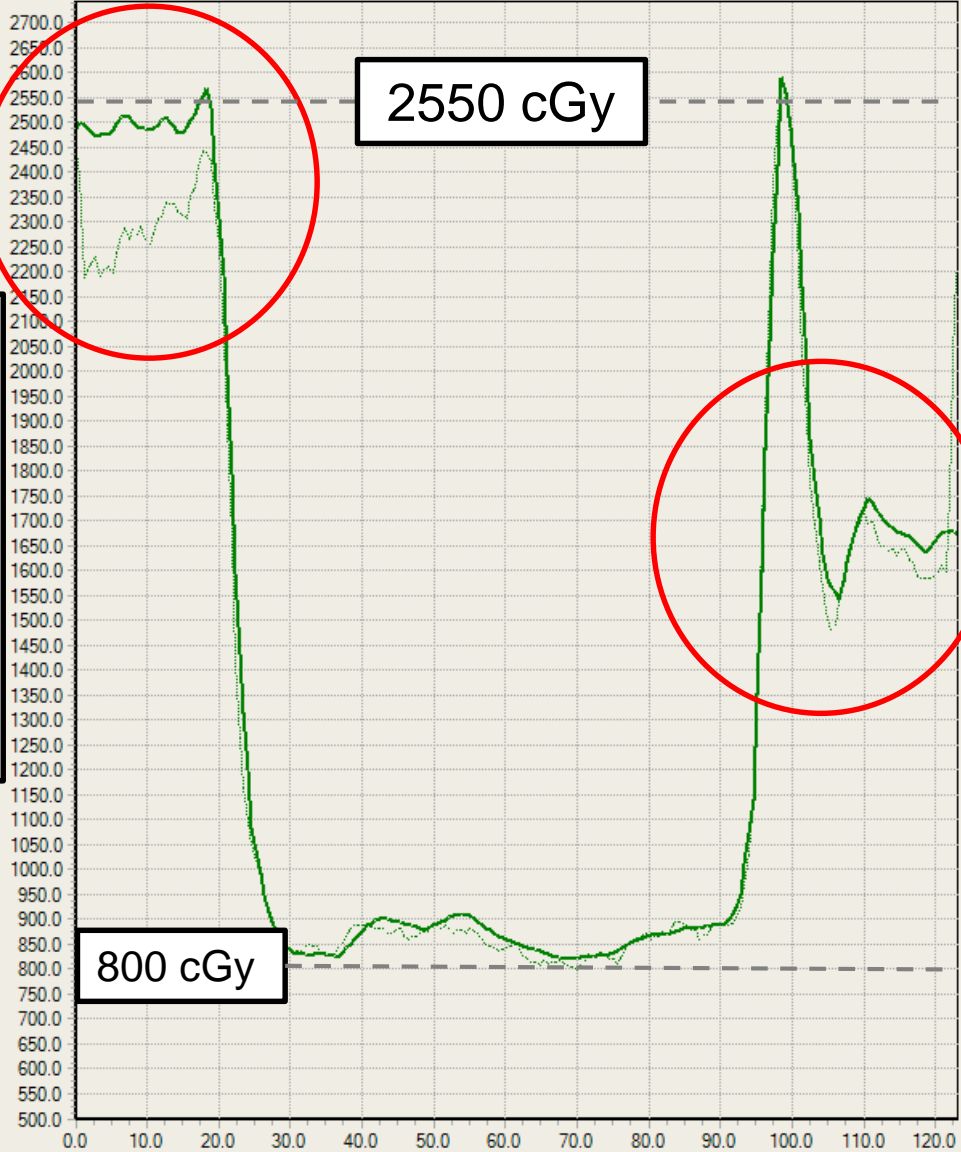
MAYO CLINIC
Radiation Oncology

EBT3



Dose (cGy)

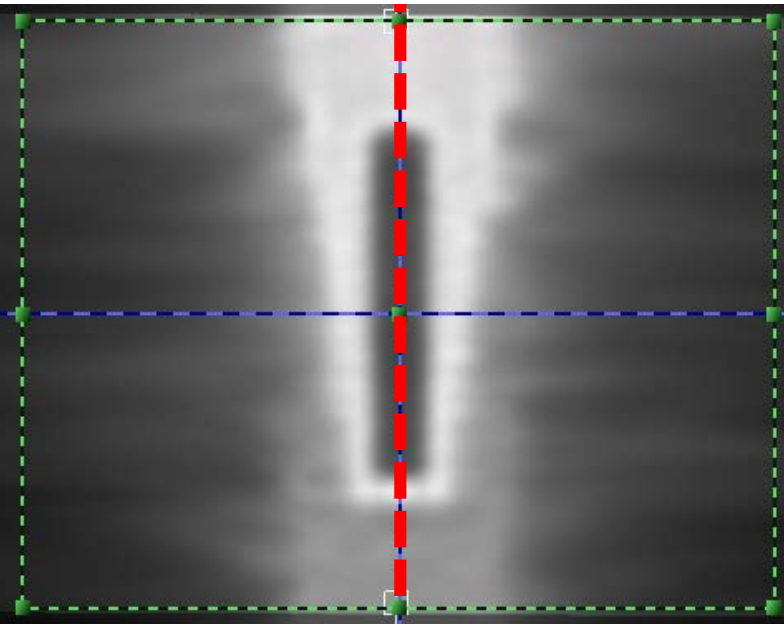
Path Profile X=[173,175] Y=[67,282] W=10
Green



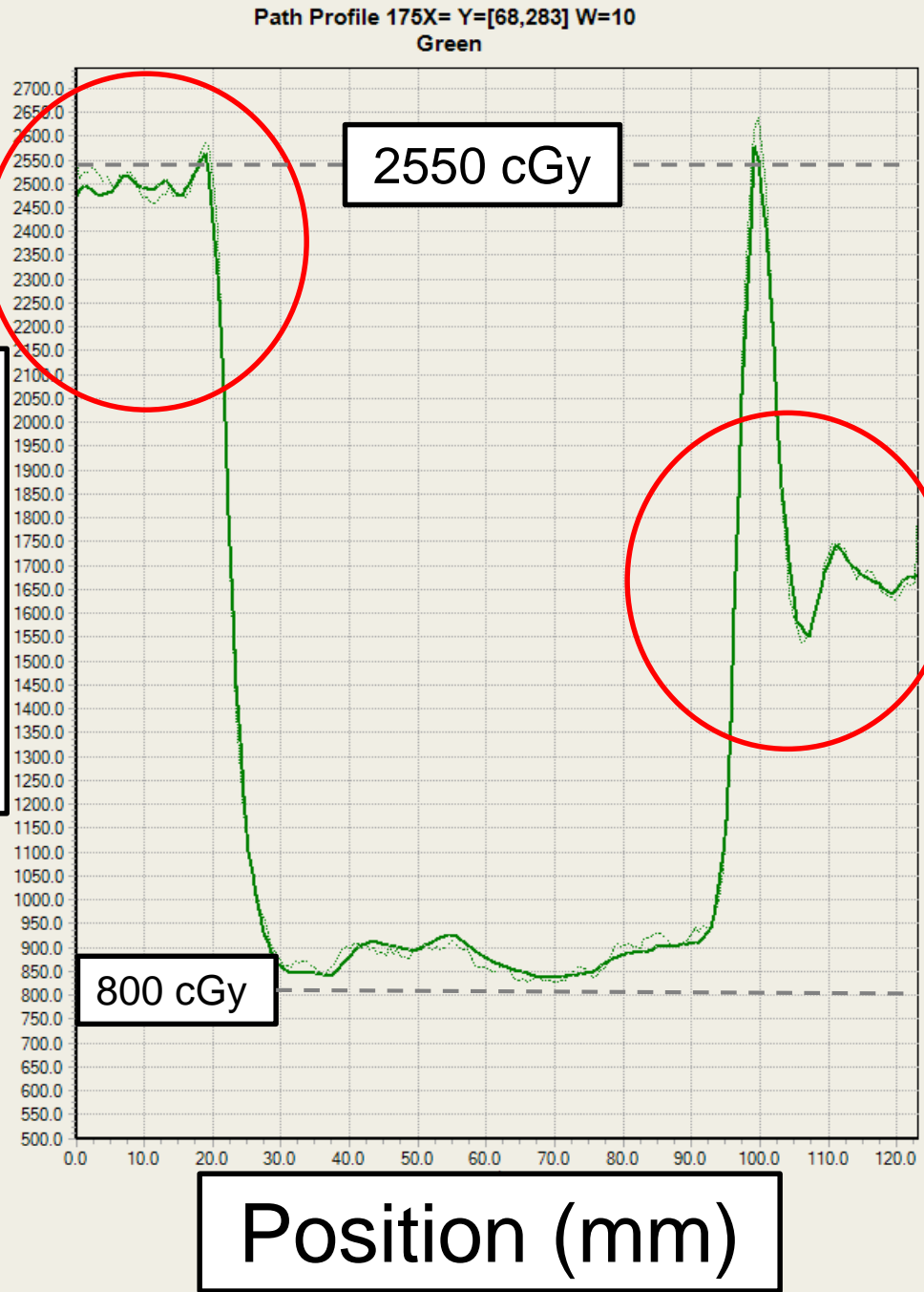
Position (mm)



EBT-XD

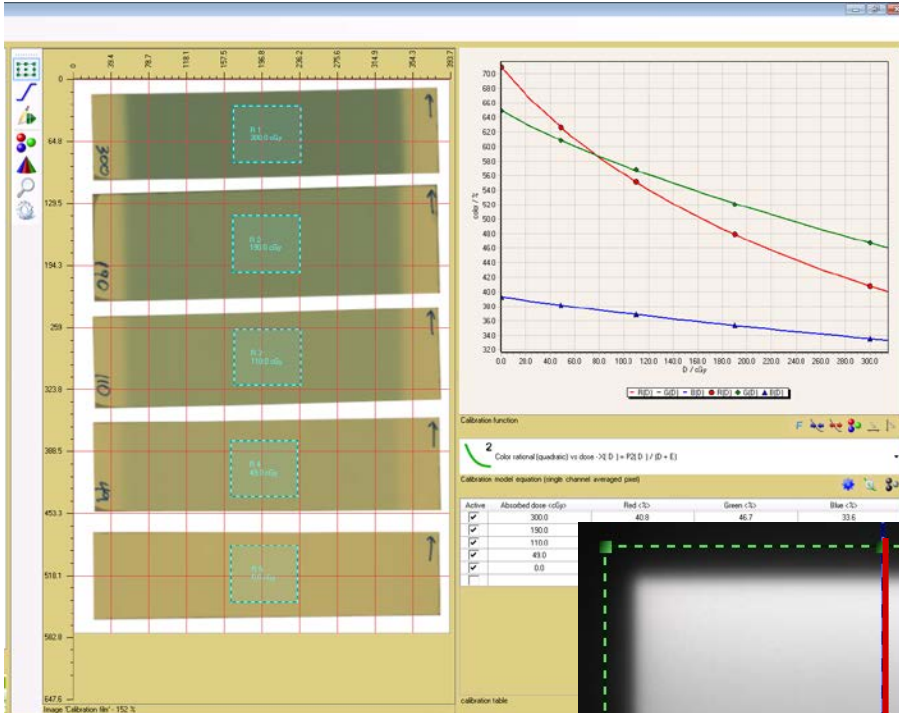


Dose (cGy)

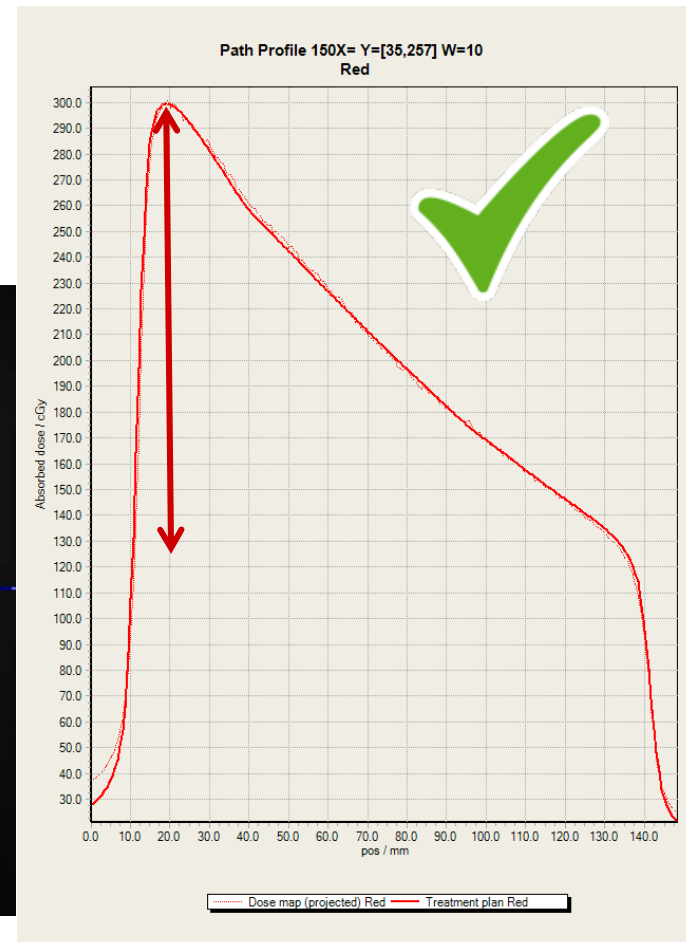
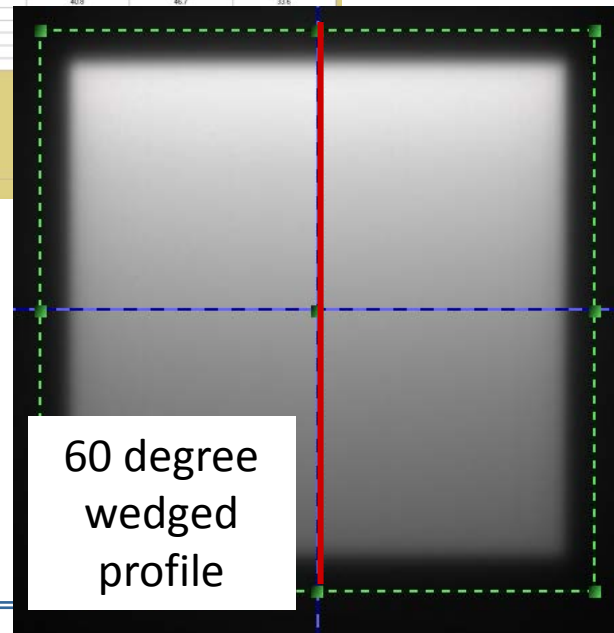


Film workflow at Mayo

Calibrate each lot following the rules



Check the calibration with wedged profile



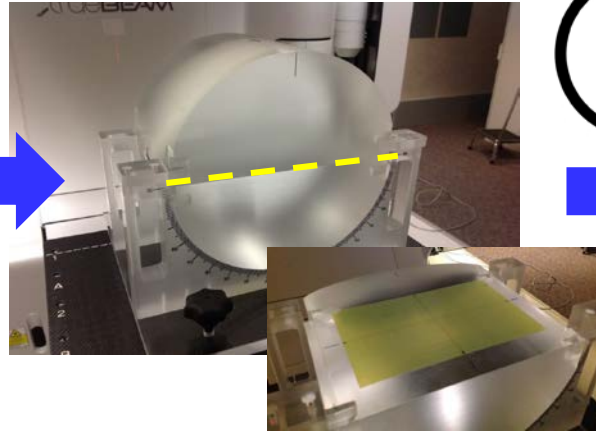
Film workflow at Mayo

Cut a film

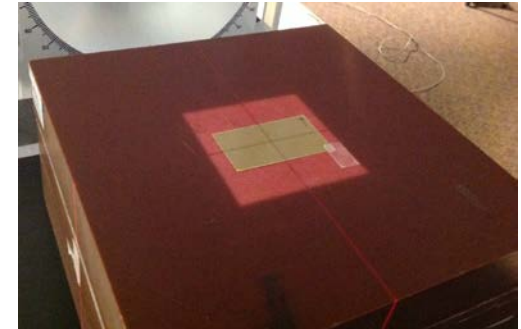


- *Mark the orientation (↑)
- Measurement film
- Reference film: no exposure
- Reference film: ~90% of max dose

Irradiate



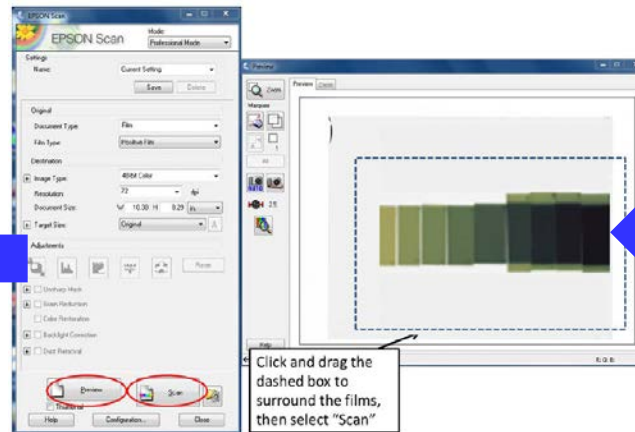
Irradiate ref film



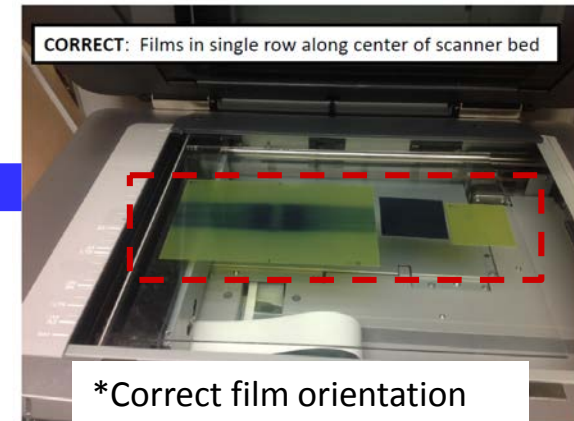
Wait at least 4 times the time



Warm up the scanner & scan

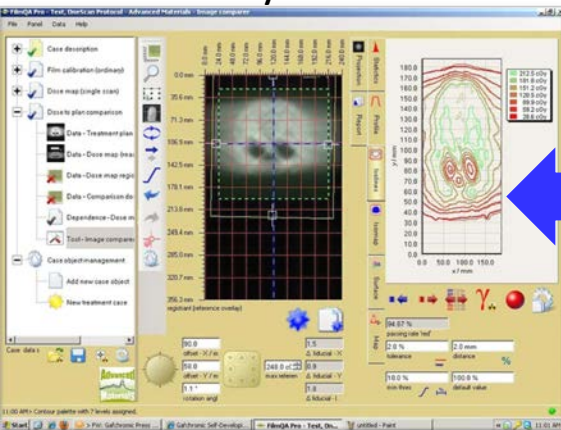


*Warm up scanner with 3 previews



- *Correct film orientation
- *Glass plate to flatten films

Analyze



MAYO CLINIC
Radiation Oncology

Every day clinical use: IMRT QA

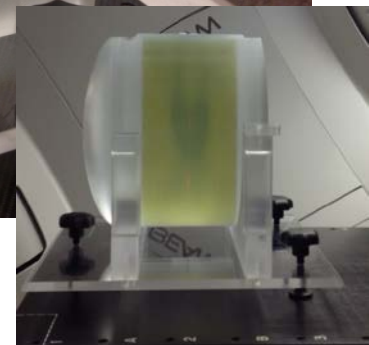
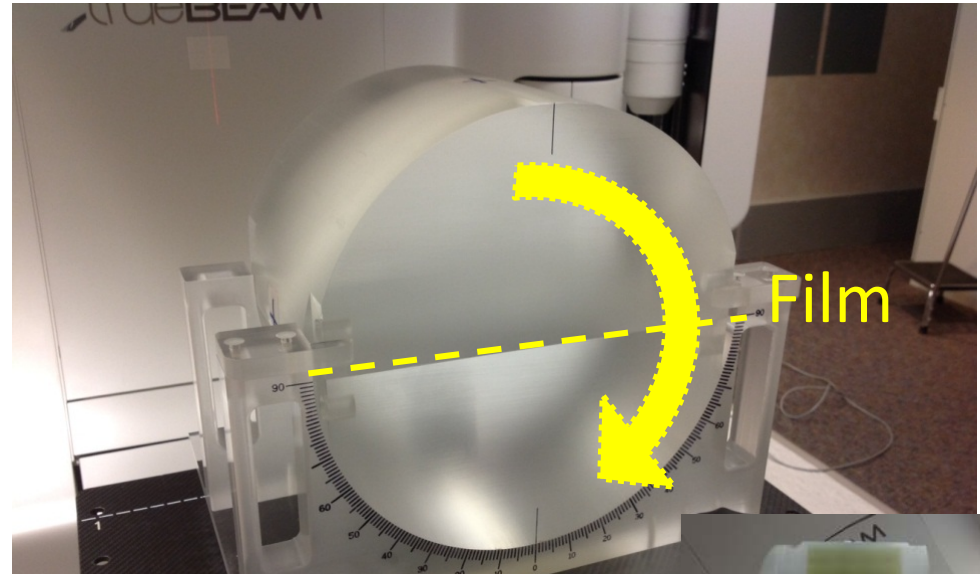
MatriXX System from IBA

Array containing

- 1020 ion chambers
- 7.6 mm spacing
- 4.5 mm x 5 mm detector size



OR
↔



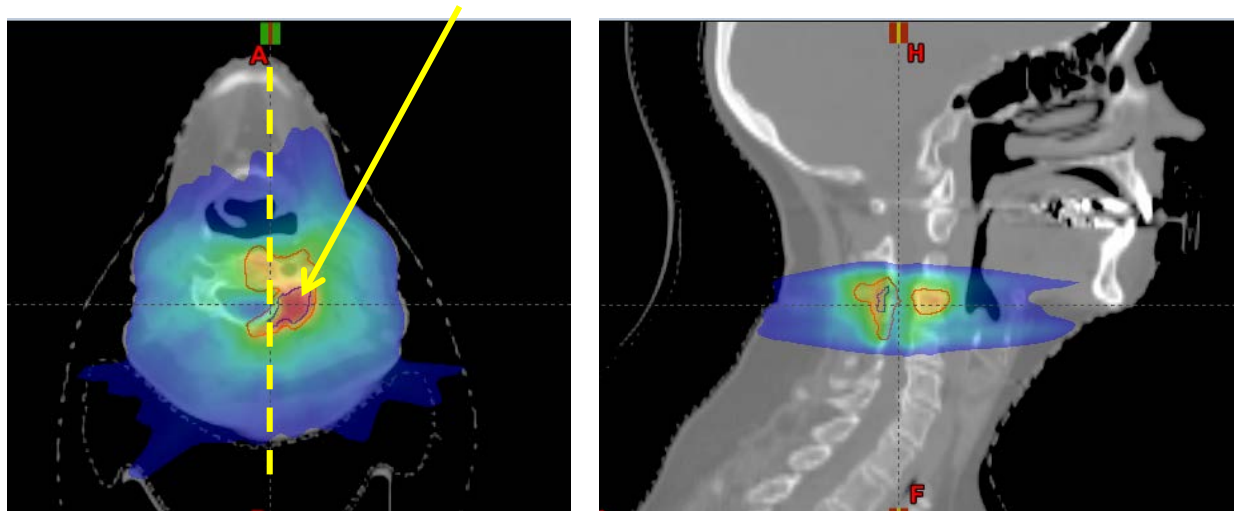
Film QA for:

- All spine SBRT cases
- Plans with small (≤ 2 cm) targets
- Plans with non-coplanar beams

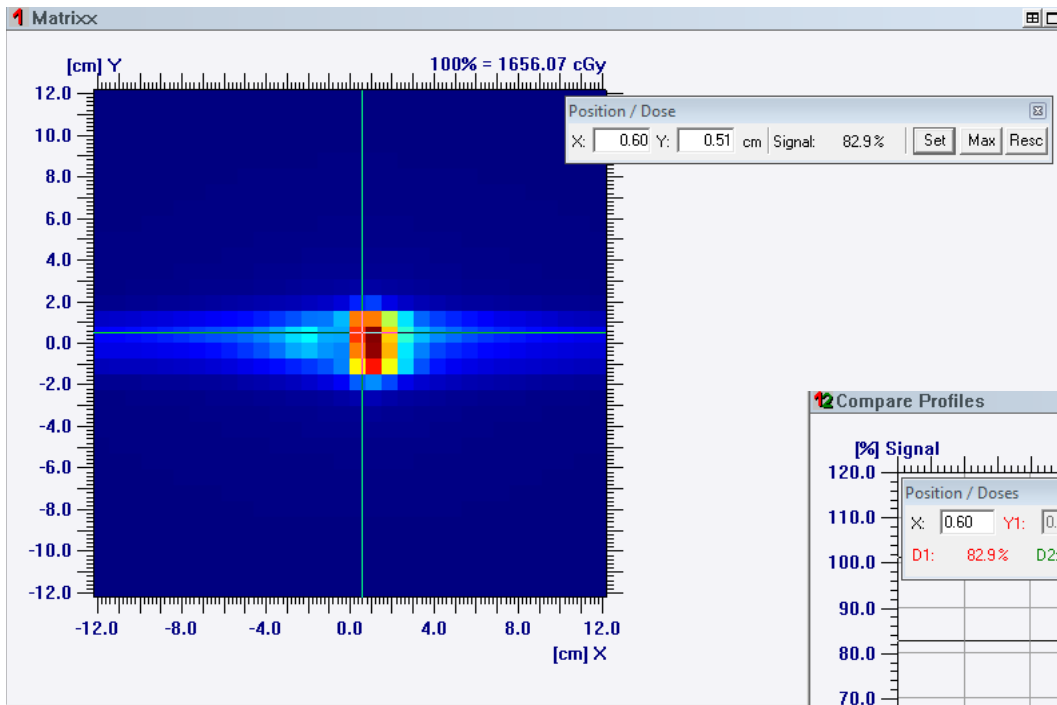
Example 1: C-spine SBRT QA

How do you check the spinal cord is spared?

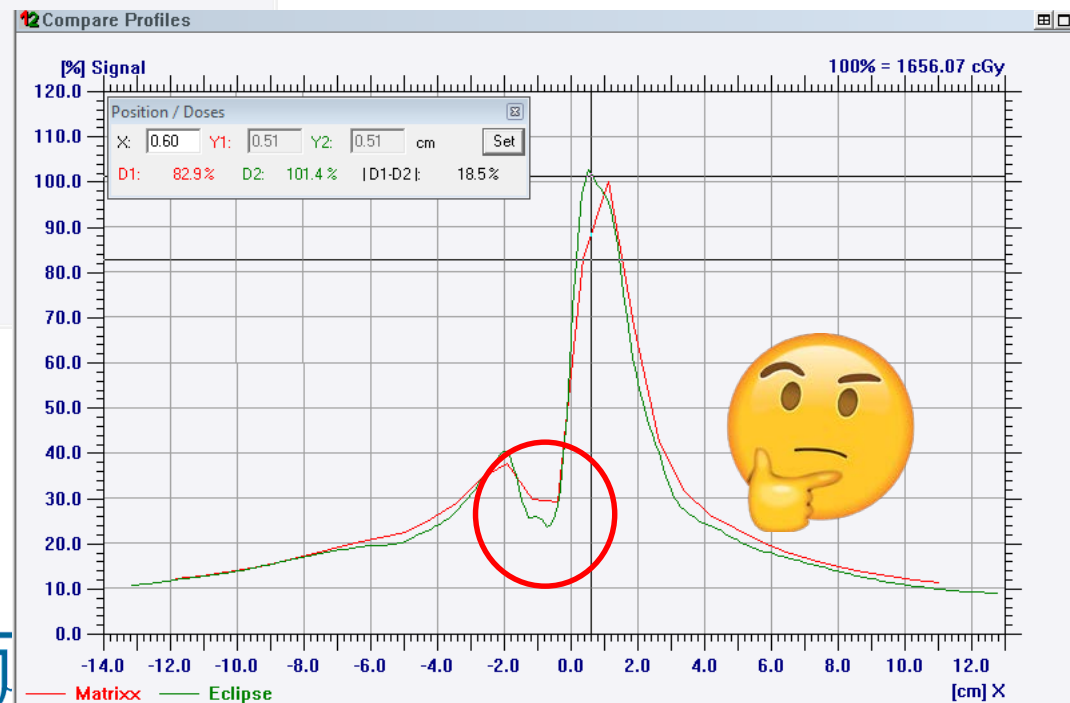
PTV2400: 2 cm x 1 cm x 1 cm



Example 1: C-spine SBRT QA

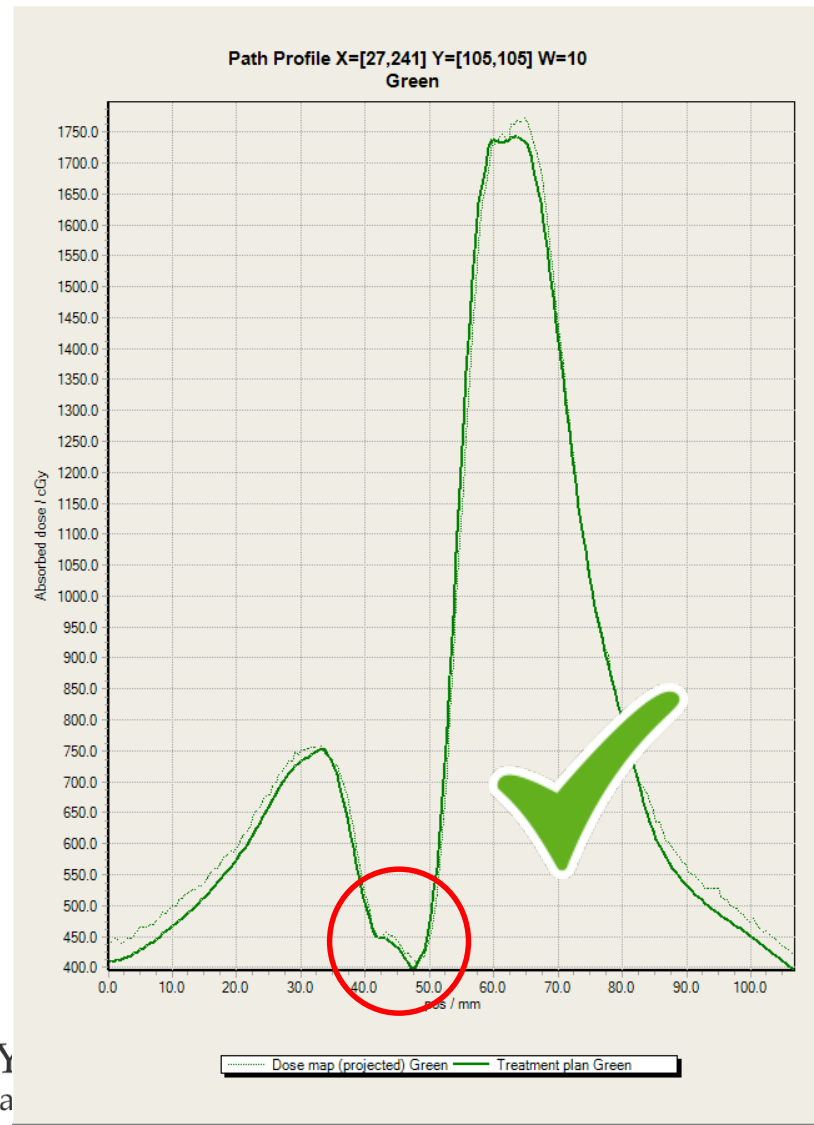
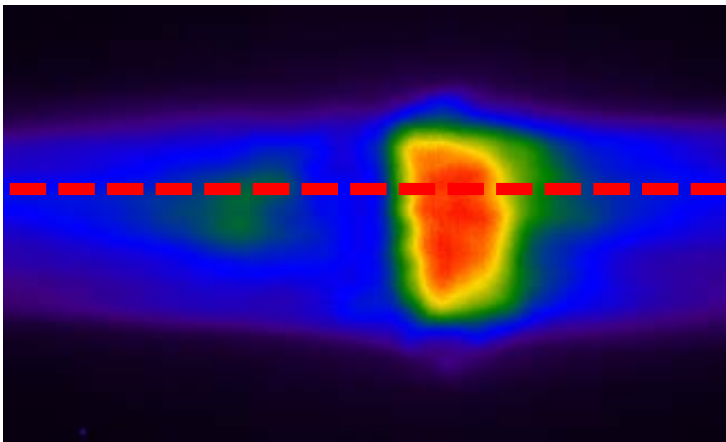


MatrixXX



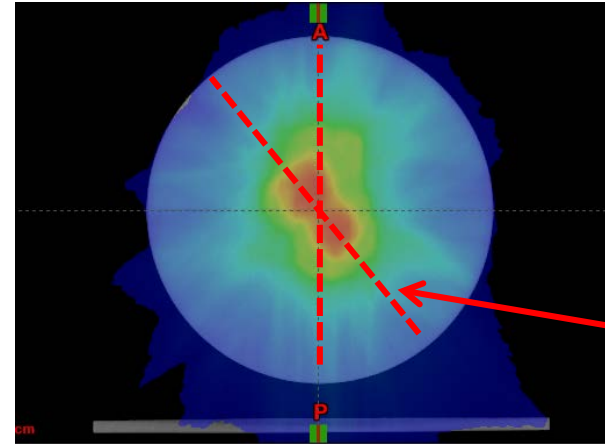
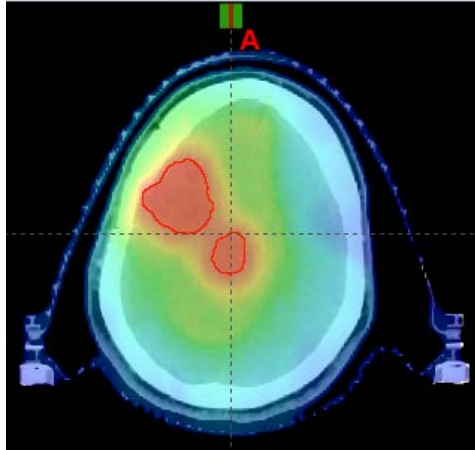
Example 1: C-spine SBRT QA

Film

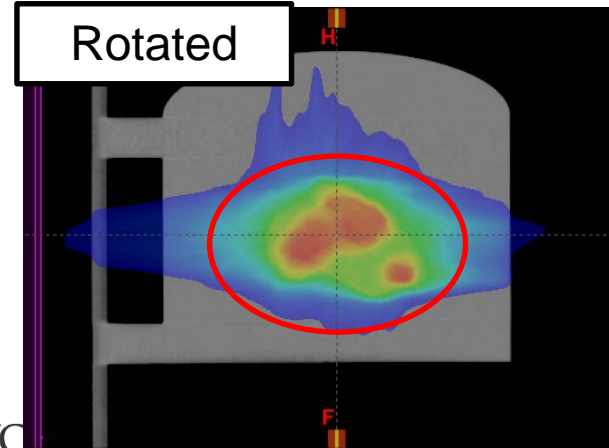
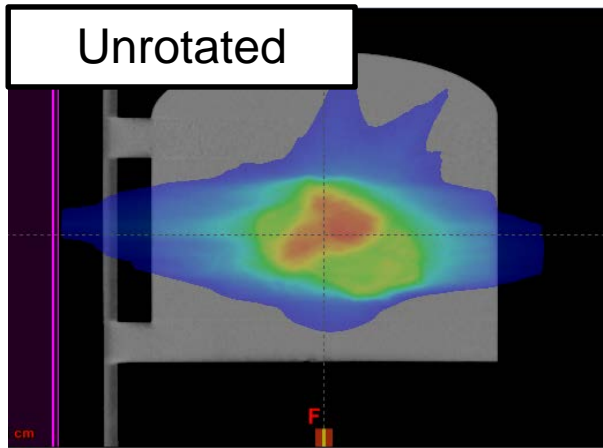


Example 2: Multiple brain lesions

Multiple measurements or single measurement?

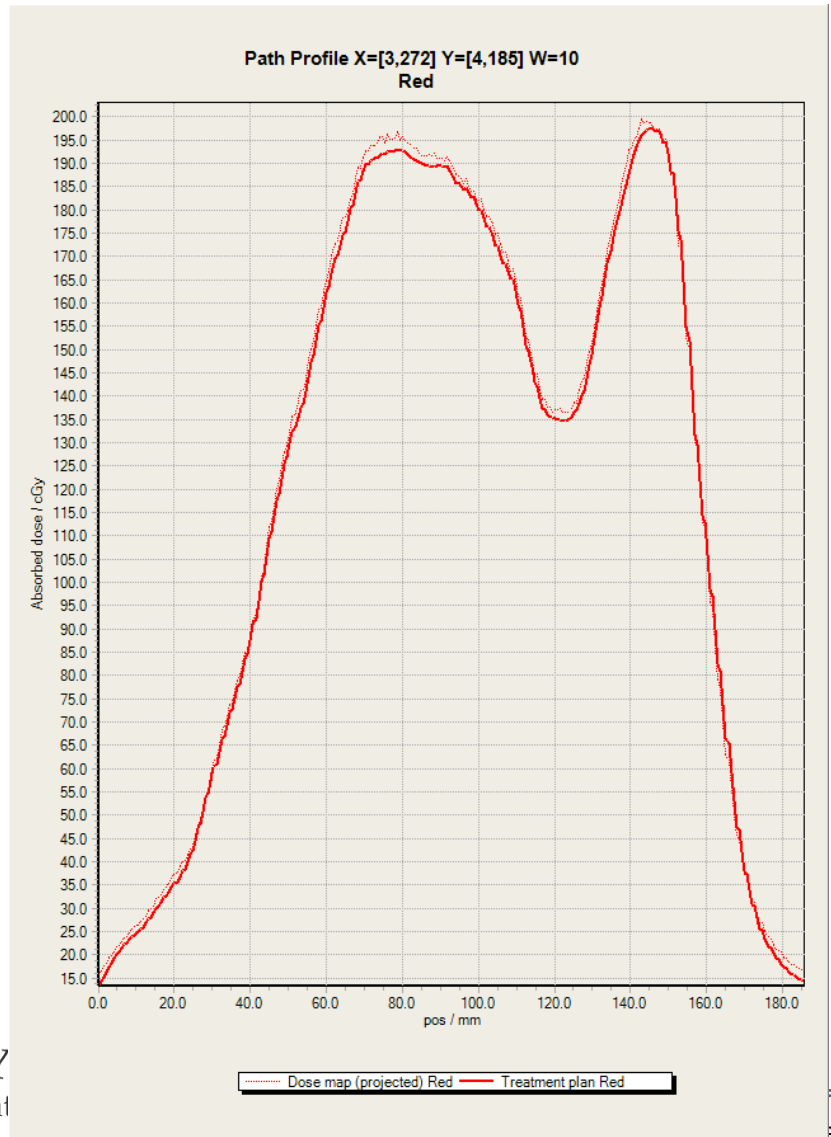
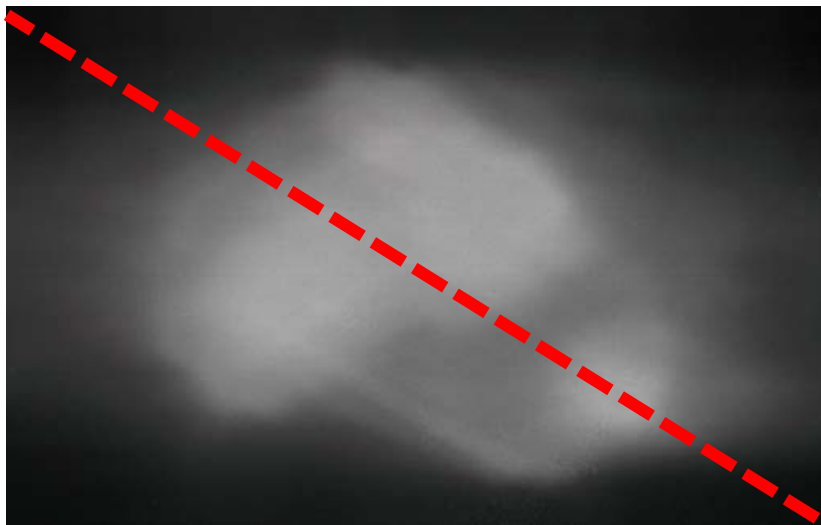
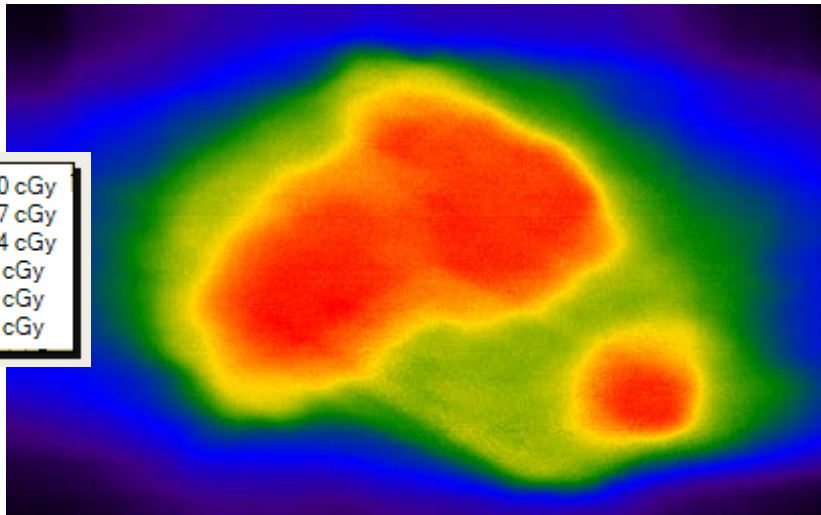


Would like to measure in this plane



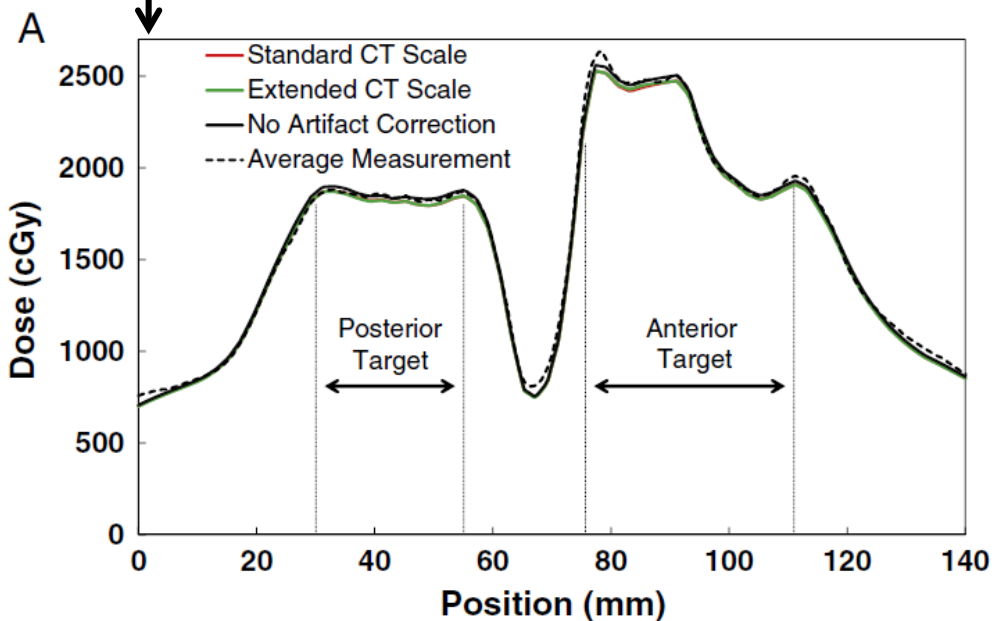
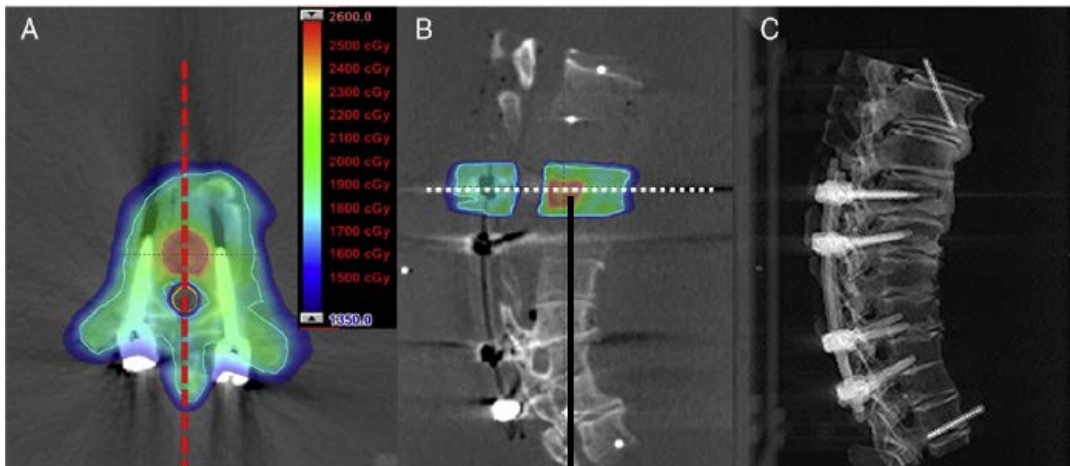
Example 2: Multiple brain lesions

Single measurement!



Example 3: Spine with hardware

How can we measure dose to spine with Ti implant?



Grams, M. P. et al., PRO (2016) 6, 131-141



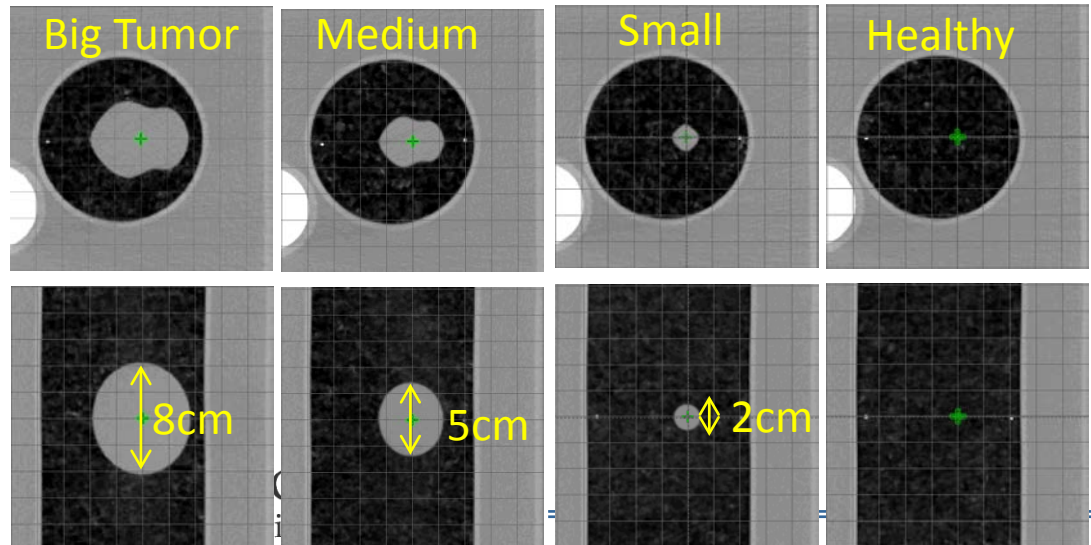
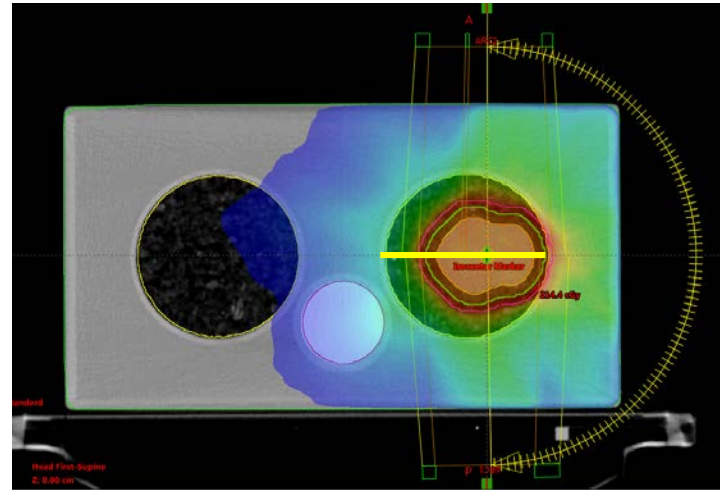
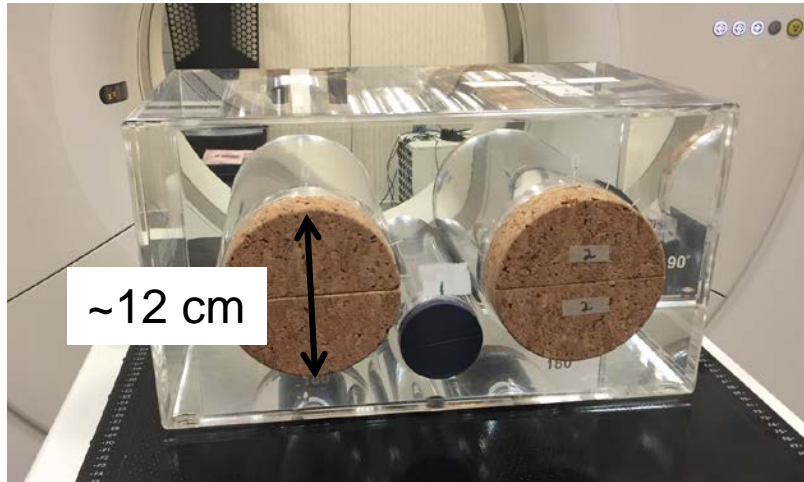
radiation Oncology

November 2016

Example 4: Lung treatment

How can we measure dose in lung tumor?

What happens if a tumor shrinks?



Summary

- Can we use film as efficient and reliable dosimeter in the clinic?
 - Yes, we can!
- But, very important to follow the protocol consistently. Details, details, and details...
- When you follow the rules, Gafchromic film provides many opportunities for clinical solutions and research projects