

SAM Practical Medical Physics

Session: TU-F-201 Radiochromic Film Dosimetry Update

Tuesday, July 14, 2015, 2:45 pm – 3:45 pm

# **Applications in brachytherapy**

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# Historically radiochromic film was used mostly in brachytherapy, since:

- Radiochromic film was available only in small sheets (5"x5")
- Required 30 (MD55) – 100 Gy (HD810 and earlier) in order to produce an useful exposure
- Was non-uniform as much as 15% across the sheets. Could be tolerated at acceptable in brachytherapy uncertainty levels
- Could be handled at light (except for sunlight) and marked using marker pens
- Did not require processing
- Is thin and could be easily bent and sandwiched in phantoms. Could be used in water.
- Has very high spatial resolution in the submillimeter range, good for high dose gradient areas

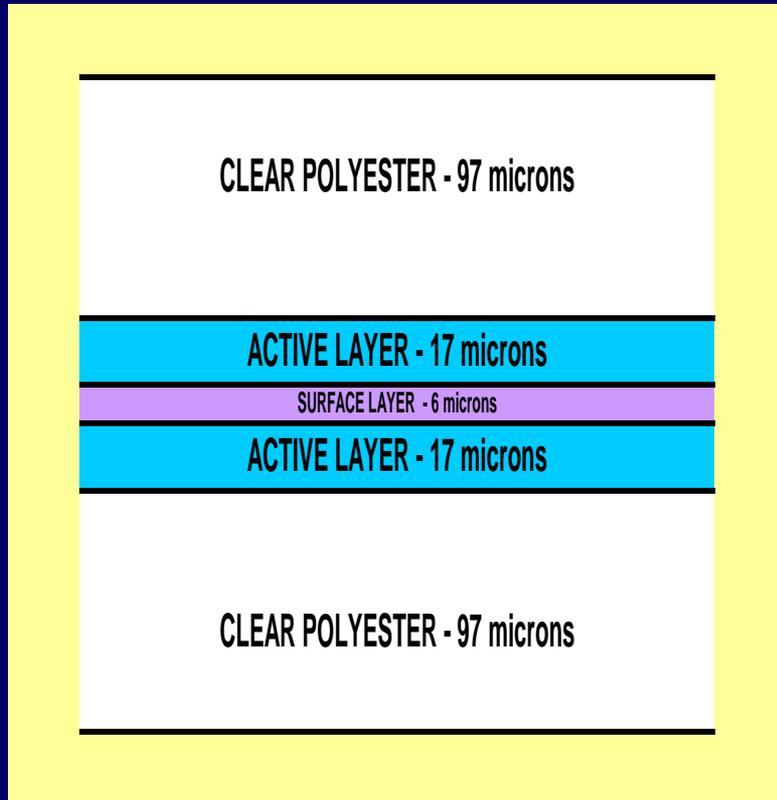
# Radiochromic film:

- Is nearly tissue equivalent
- New EBT films are significantly more sensitive (2 Gy per exposure vs. 30 Gy for MD-55 or 100 Gy for HD-810)
- New EBT films have uniformity similar to radiographic film
- New EBT films have less energy dependent dose response
- Has to be used in accordance with a strict protocol due to post-exposure growth of optical density
- Has to be always scanned in the same direction due to polarization effects
- Has to be pre-cut at least 48 hours prior to exposure in order to equilibrate moisture content

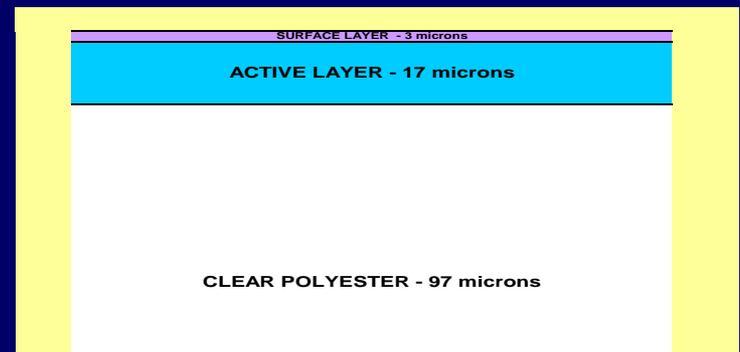
# Main brachytherapy applications

- Dosimetry and calibration of  $^{90}\text{Sr}/^{90}\text{Y}$  ophthalmic applicators
- Dosimetry and calibration of  $^{106}\text{Ru}/^{106}\text{Rh}$  eye plaques
- Dosimetry of  $^{125}\text{I}$  eye plaques
- Dosimetry and characterization of  $^{125}\text{I}$  and  $^{131}\text{Cs}$  brachytherapy seeds
- Electronic brachytherapy calibration and dosimetry
- Dosimetry of liquid  $^{125}\text{I}$  – GliaSite
- $^{192}\text{Ir}$  dosimetry
- HDR machine QA
- QA of HDR applicators and plans

# GAFCHROMIC EBT film configurations



Standard double layer EBT

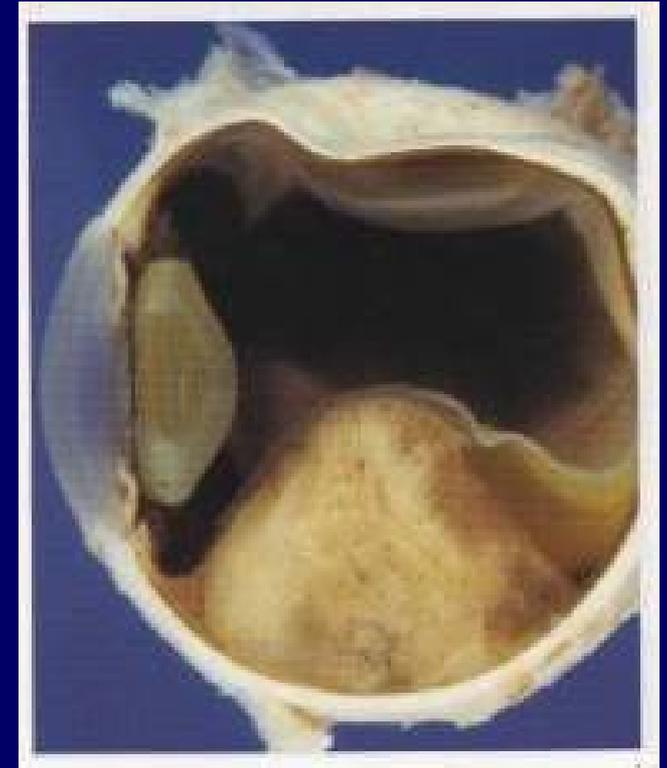
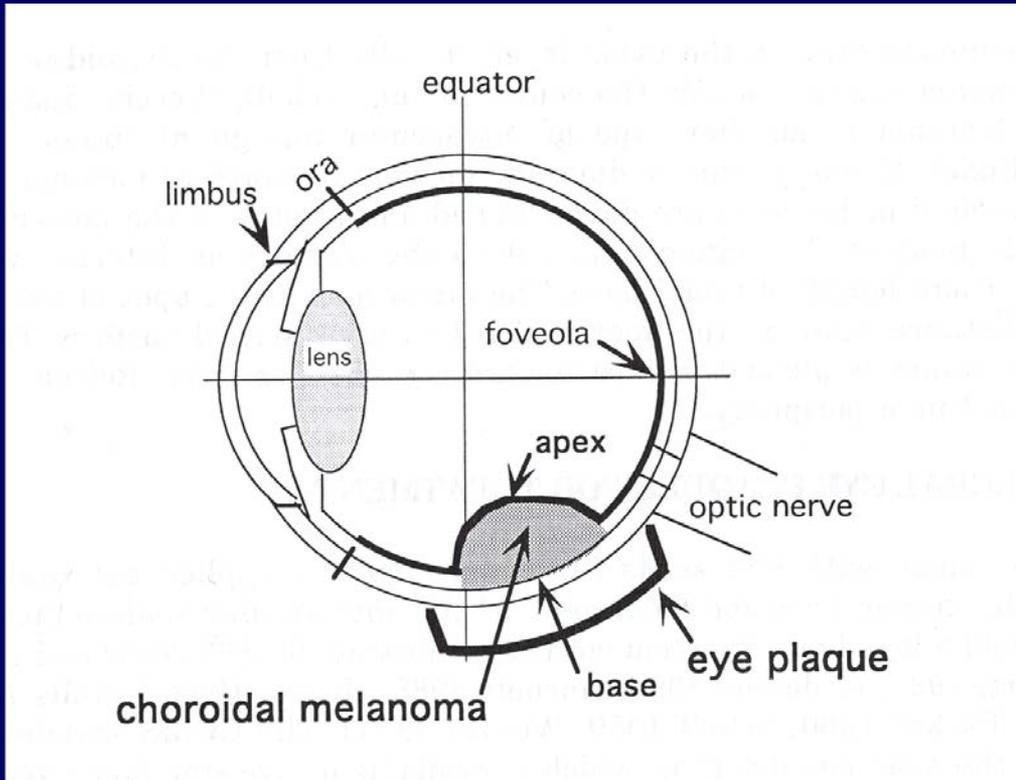


Special single layer EBT-1

EBT2 and EBT3 films available in thin unprotected single layer configuration

# Example of radiochromic film eye plaque dosimetry

Includes all elements of radiochromic film brachytherapy dosimetry.



(From Chiu-Tsao, AAPM 1994 Summer School)

Choroidal melanoma

New cases per year in the US:

- Choroidal melanoma – 1500
- Retinoblastoma – 600

# $^{106}\text{Ru}$ eye plaques

$^{106}\text{Ru}$  is a beta emitter, 3.54 MeV maximum energy, 373.6 days half-life



The CCX type is only 11.6 mm in diameter and 2.2 mm in height



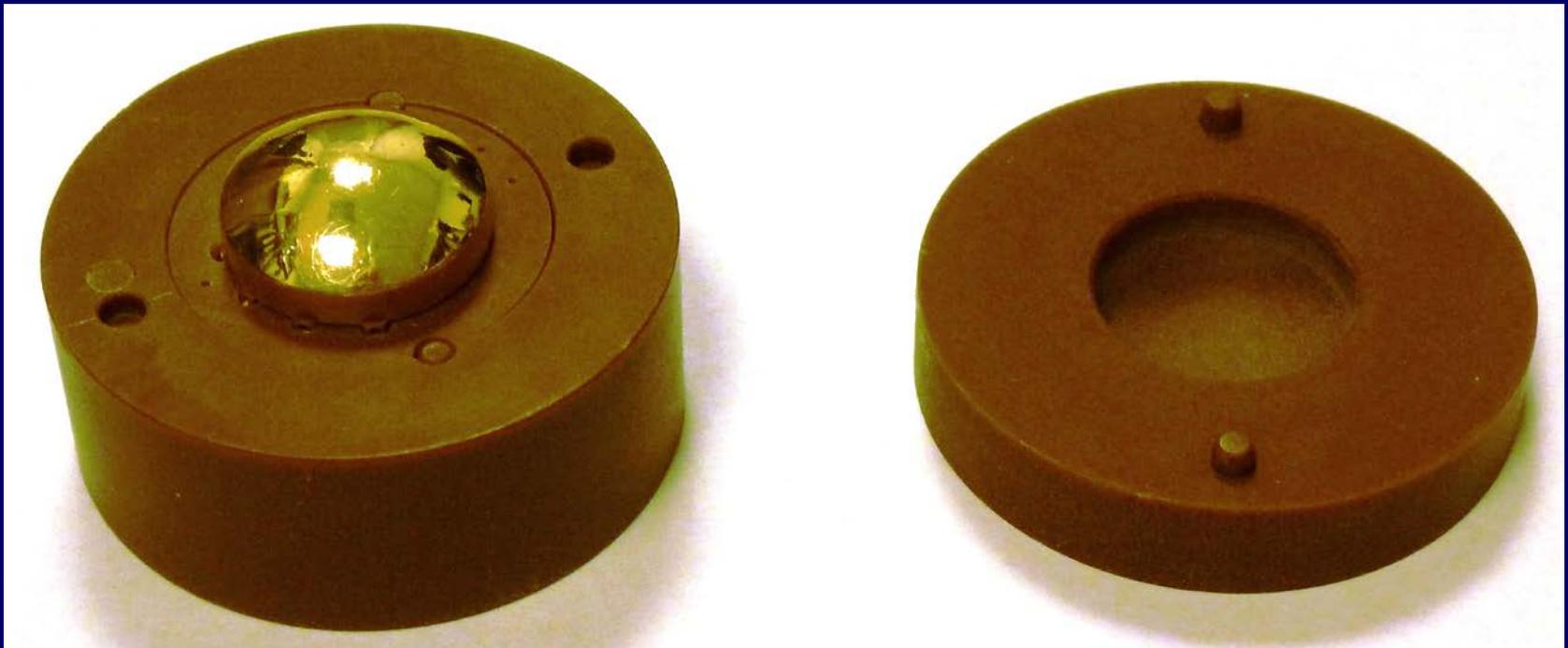
# Solid Water “Eye” phantom configured for a CCX $^{106}\text{Ru}$ eye plaque with an irradiated MD-55- film



# Solid Water “Eye” phantom configured for a 20 mm COMS eye plaque with a fully loaded eye plaque



# Solid Water “Eye” phantom with a 20 mm COMS eye plaque assembled for measurement.

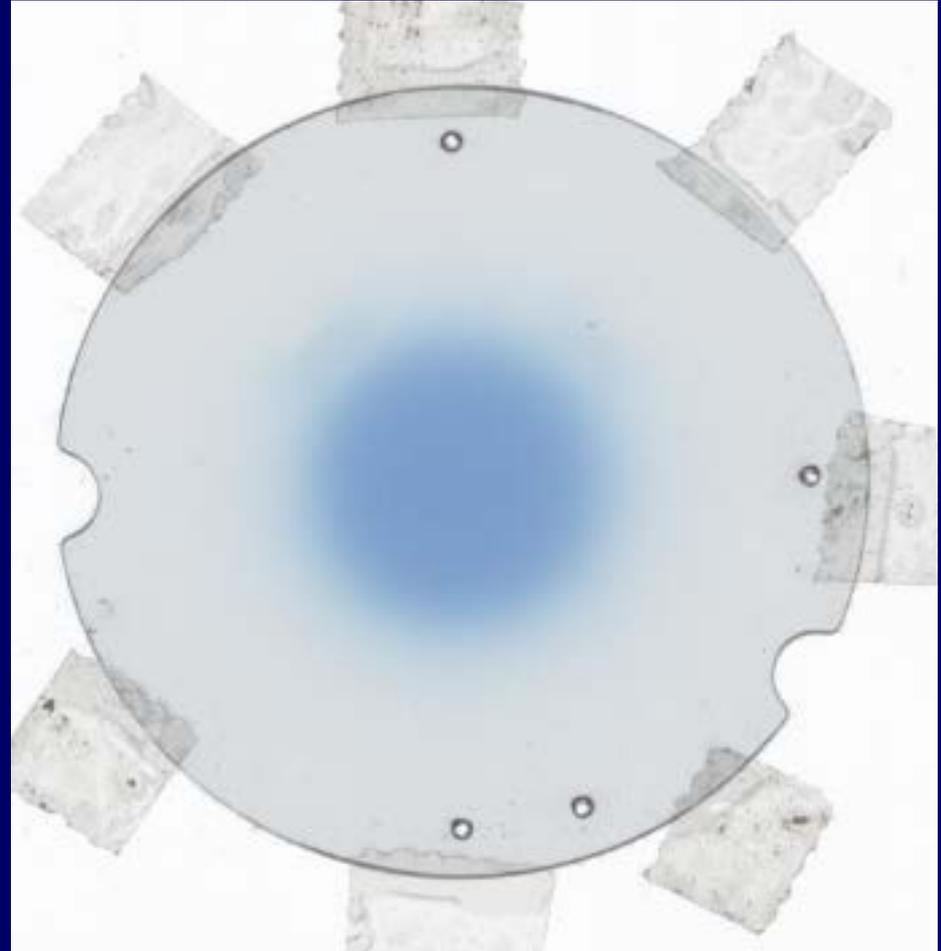
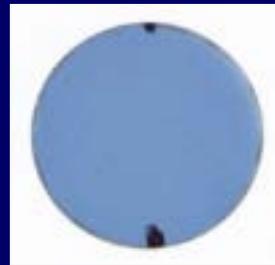
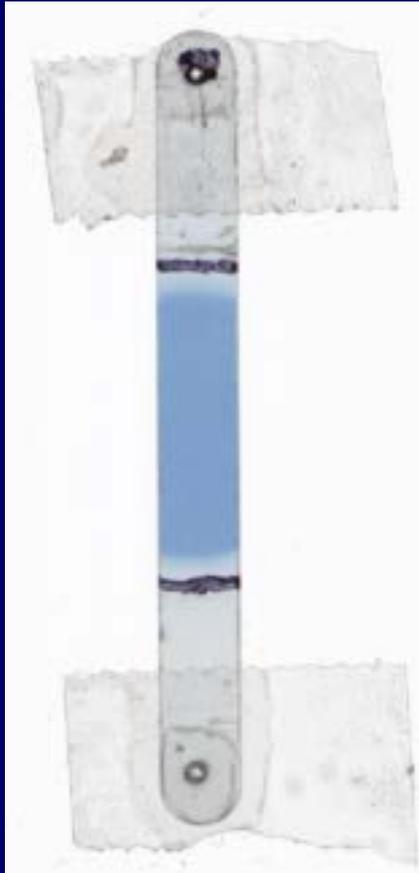


For measurements the “Eye” phantom is inserted into a full scatter 30 cm x 30 cm x 30 cm Solid Water phantom

# Punches for precise cutting of film



# Exposed special single layer EBT-1 films



# CCX-129 eye plaque dosimetry using special single layer EBT-1 film

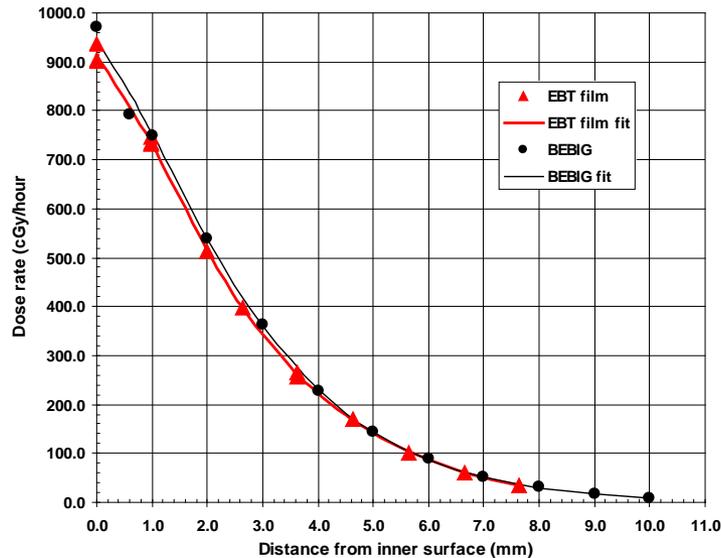
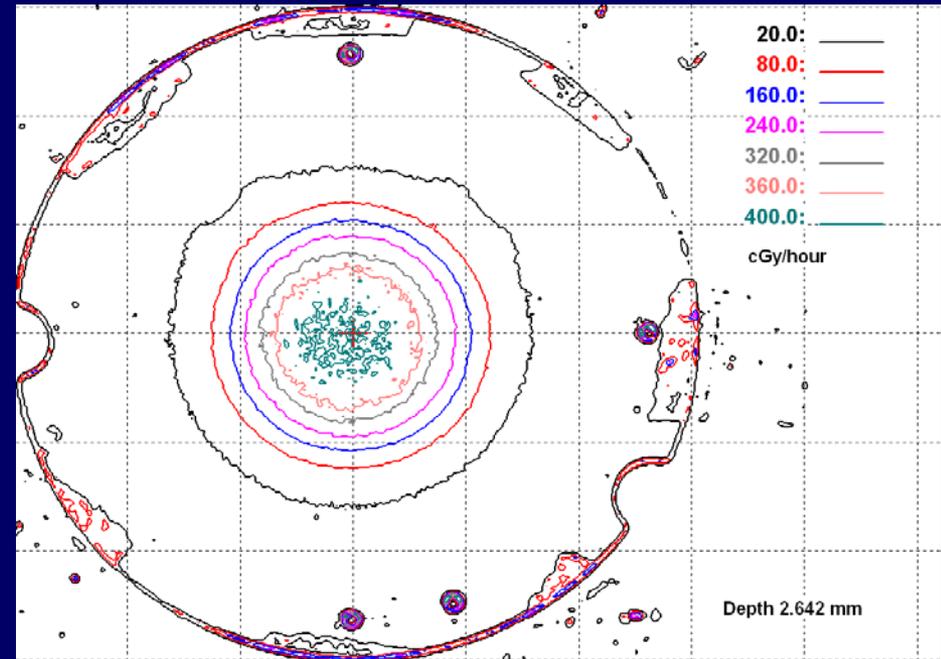


Figure 3. Measured dose rate along the central axis of the CCX 129 plaque compared to the data provided by BEBIG.



Dose rate along the central axis of the plaque

Isodose distribution perpendicular to the central axis at distance 2.642 mm from the plaque's inner surface

The dose rate at the surface of the eye plaque is actually measured<sup>14</sup>

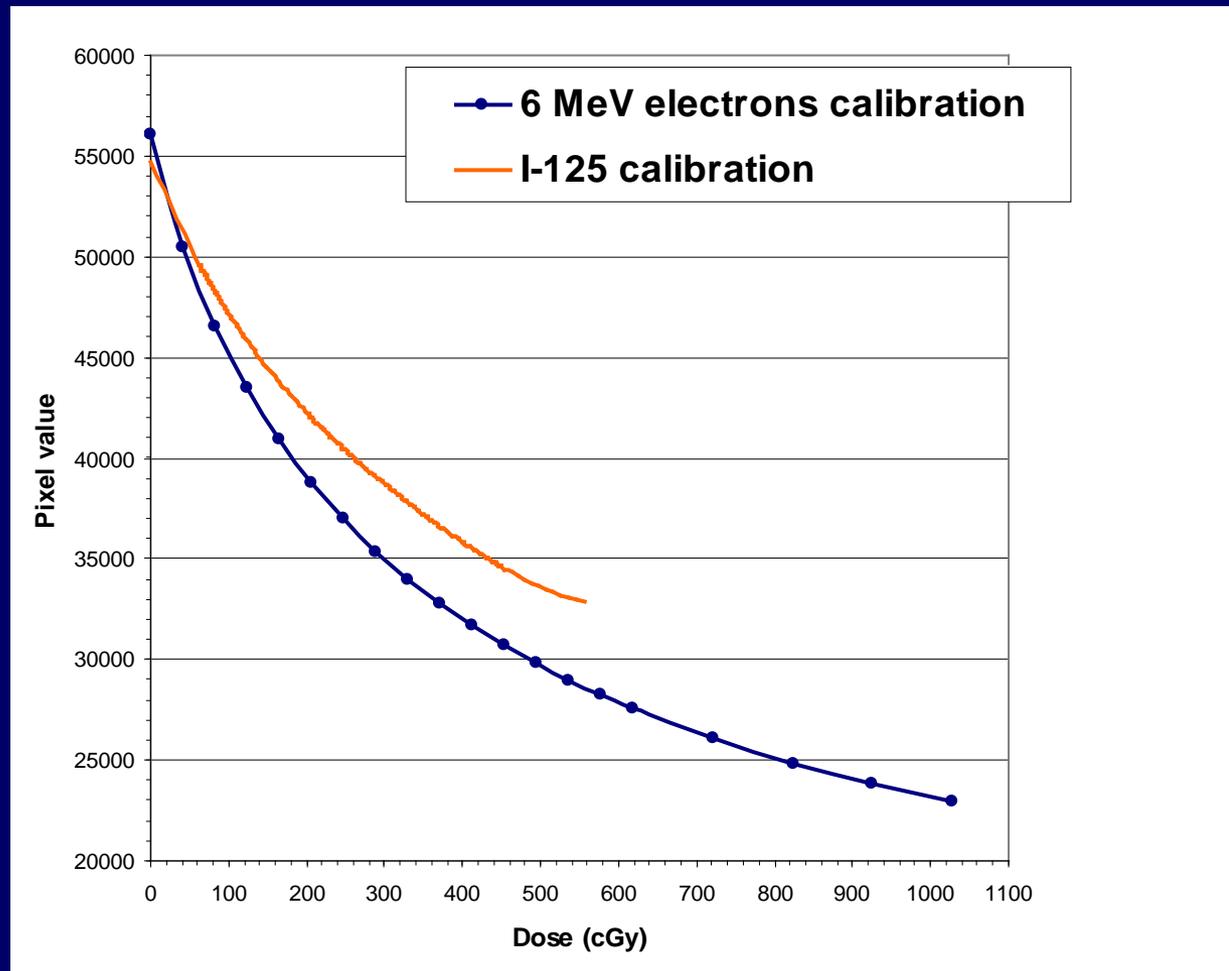
# Calibration of radiochromic film

- Calibration films should be preferably irradiated in the same conditions as the “unknown” films – water equivalent plastic (Solid Water, Polystyrene) or liquid water
- Calibration films should be irradiated to preferably same radiation quality and dose rate as expected dosimetric measurements. These can be large uniform linac and  $^{60}\text{Co}$  beams, brachytherapy sources like  $^{90}\text{Sr}$  or  $^{125}\text{I}$ .
- The calibration beams and sources should be well characterized with traceability to NIST (ADCL calibrated beams are traceable to NIST).
- Small films precut in advance should be used in brachytherapy.

# Calibration of radiochromic film

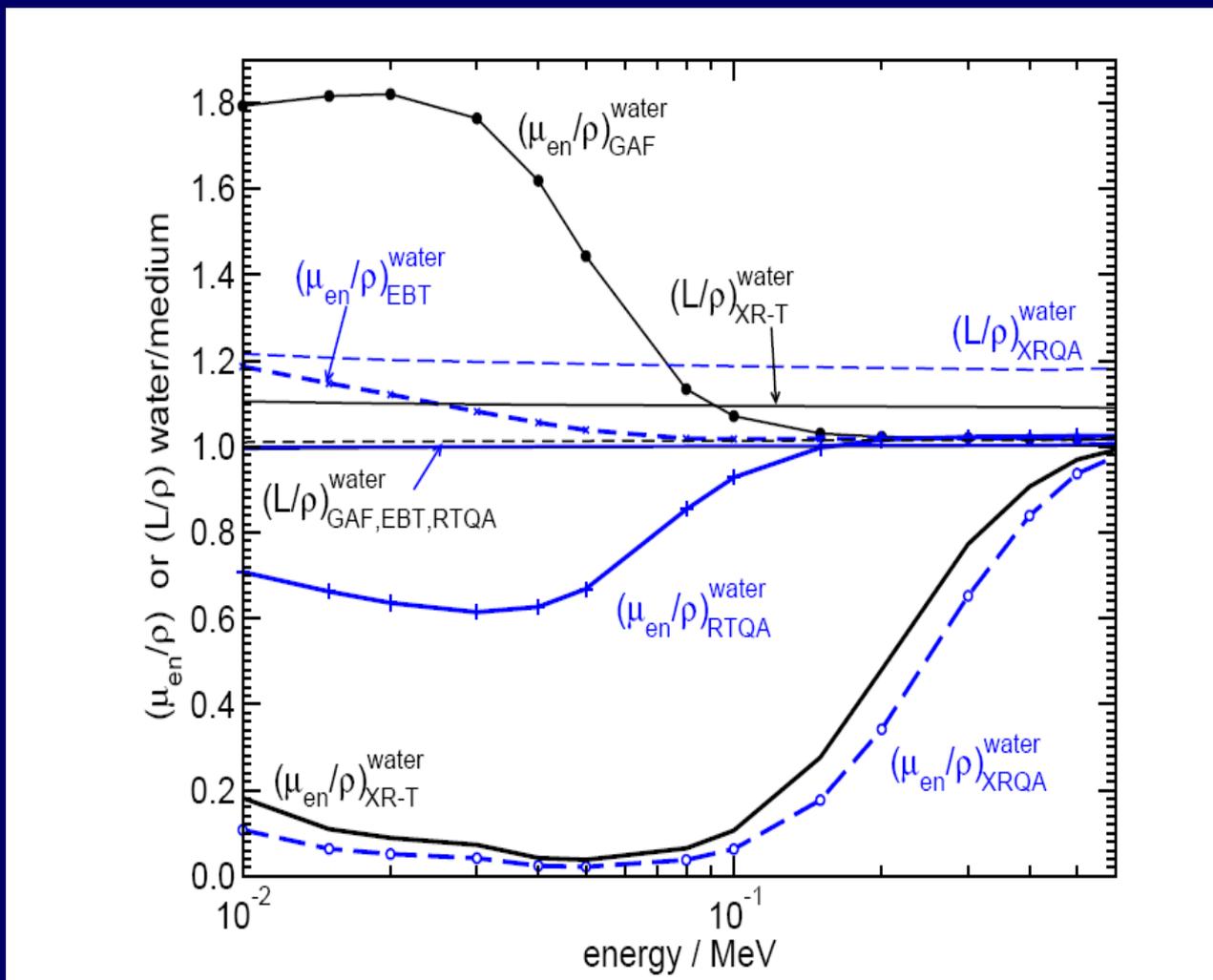
- There should be enough dose points to cover more than the expected measurement range. Extrapolating calibration curves is dangerous.
- The final curve can be fitted to an analytical expression and smoothed.
- It is recommended to test the calibration curve irradiating and evaluating known fields.

# EBT-1 Lot 35314-4H Energy Dependence



The films were calibrated for  $^{125}\text{I}$  using a calibrated model 6711  $^{125}\text{I}$  seed in the "eye" phantom

# Corrections: Absorbed-Dose Energy Dependence



# Monte Carlo corrections

- The measured absorbed dose is usually dose to film in solid water equivalent phantom
- The quantity of interest is absorbed dose to liquid water
- It is important to know exact chemical composition of the phantom material and of the film used
- The calcium content in Gammex RMI 457 Solid Water can be either 1.7% or 2.3%
- Can result in 5% or 9% conversion factor difference from Solid Water to liquid water for  $^{125}\text{I}$  or  $^{103}\text{Pd}$  seeds respectively

Updated Solid Water™ to water conversion factors for  $^{125}\text{I}$  and  $^{103}\text{Pd}$   
brachytherapy sources

Ali S. Meigooni, Shahid B. Awan, Nathan S. Thompson, and Sharifeh A. Dini

Med. Phys. 33 (11), November 2006

- Including the film in the calculations has additional effect on the conversion factors

# Conclusions

- Radiochromic film in a Solid Water phantom is a convenient, accurate, and reproducible dosimeter for brachytherapy dosimetry
- Properly calibrated radiochromic film can be used for absolute brachytherapy dosimetry
- A calibrated  $^{125}\text{I}$  seed and the TG-43 formalism can be used for calibrating radiochromic film for absolute dosimetry
- The special single layer films enable direct dose measurements virtually at the surface of brachytherapy sources and applicators
- Monte Carlo simulations enable conversion of dose to film in a solid phantom to dose to liquid water

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