

# New Developments in Scanning Radiochromic Film

David F. Lewis

Advanced Materials Group

International Specialty Products

[dlewis@ispcorp.com](mailto:dlewis@ispcorp.com)

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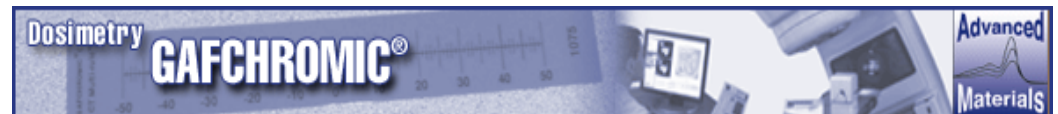
# Topics

- ❑ GAFCHROMIC EBT Dosimetry Film and the Vidar Red LED Dosimetry Pro Scanner
  
- ❑ Orientation of EBT Film on CCD Scanners
  - Vidar Scanners
  - Epson Flatbed Scanners



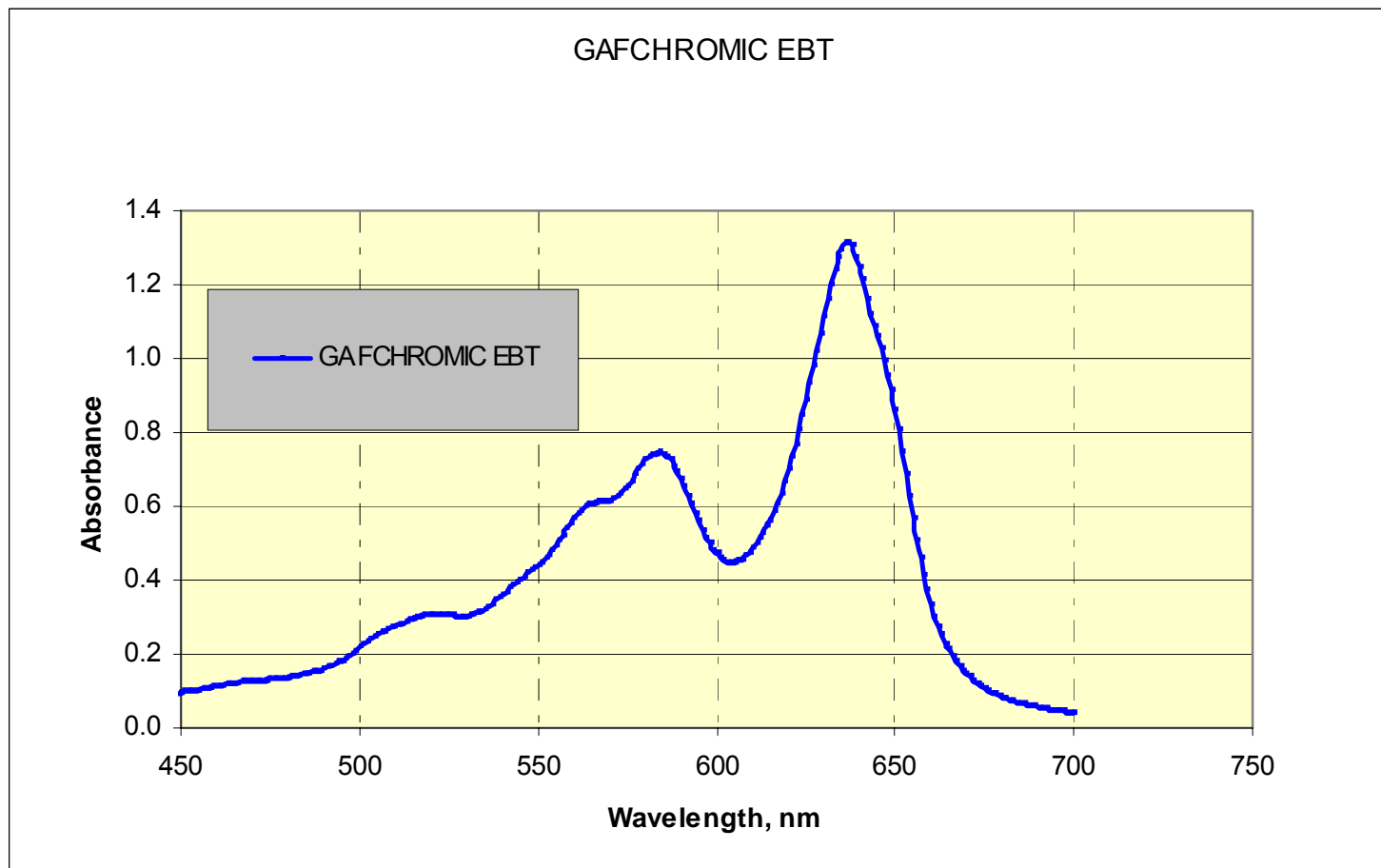
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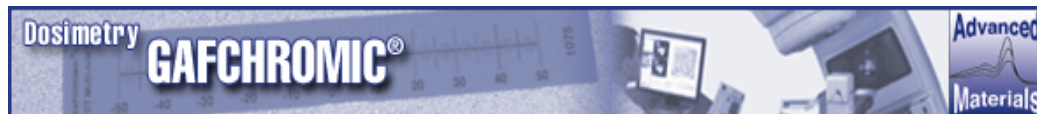
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# Visible Absorption Spectrum of GAFCHROMIC<sup>®</sup> EBT Dosimetry Film



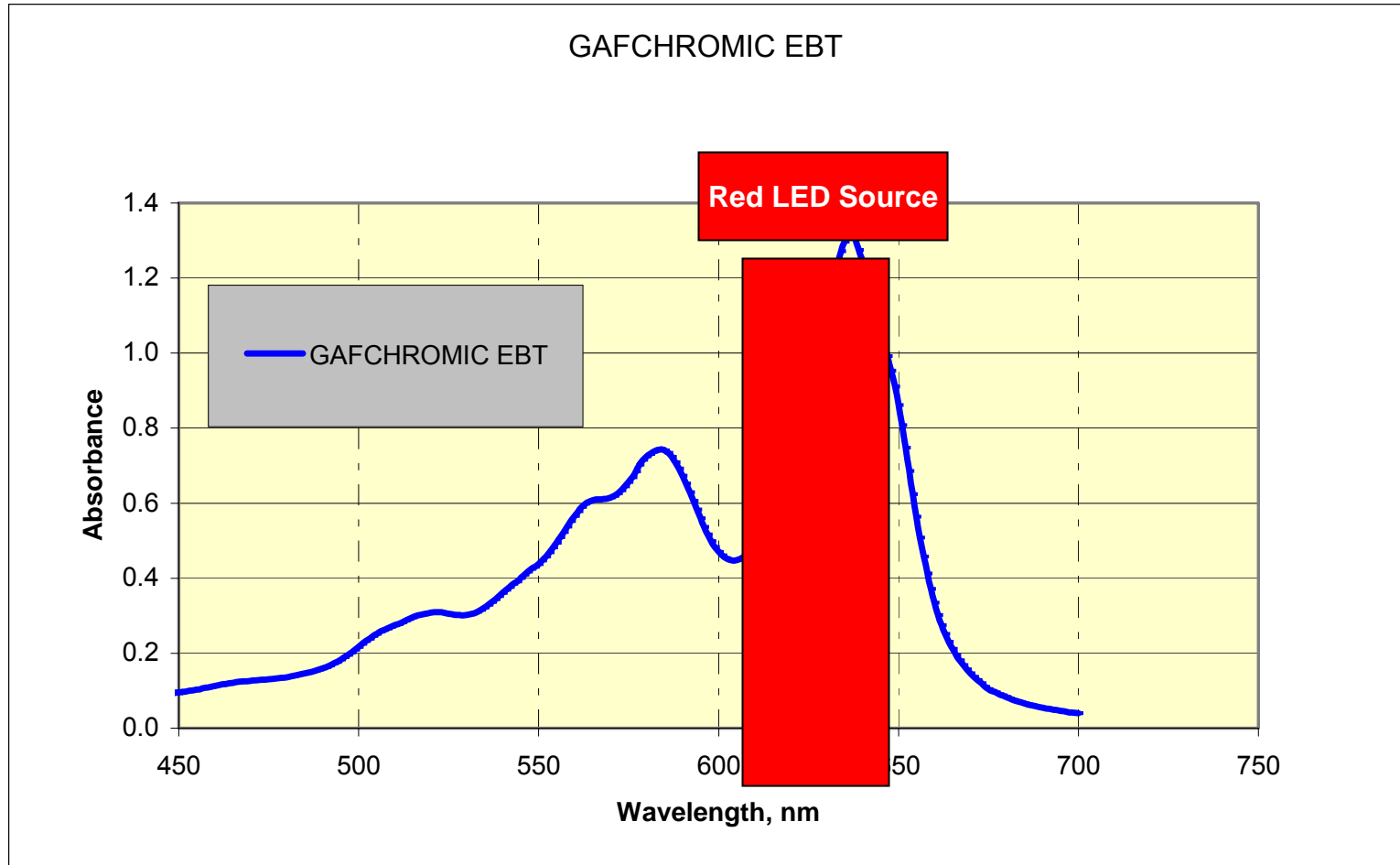
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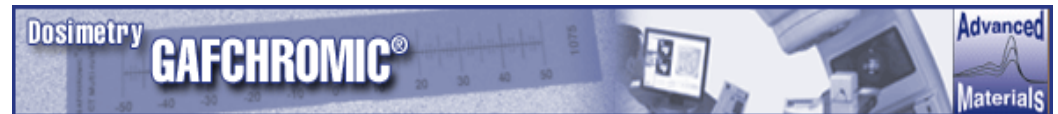
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# Light Source: Vidar Red LED Dosimetry Pro



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# Improvements: Vidar Red LED vs. Vidar VXR-16

## ❑ Red LED Light Source: 627nm; $\pm 20$ nm FWHM

- Increases Sensitivity/Contrast of EBT Film

## ❑ Light Source Close to the Film

- Minimizes Effects of Light Scattering

## ❑ Extra Rollers to Support Film During Scanning

- Eliminates banding



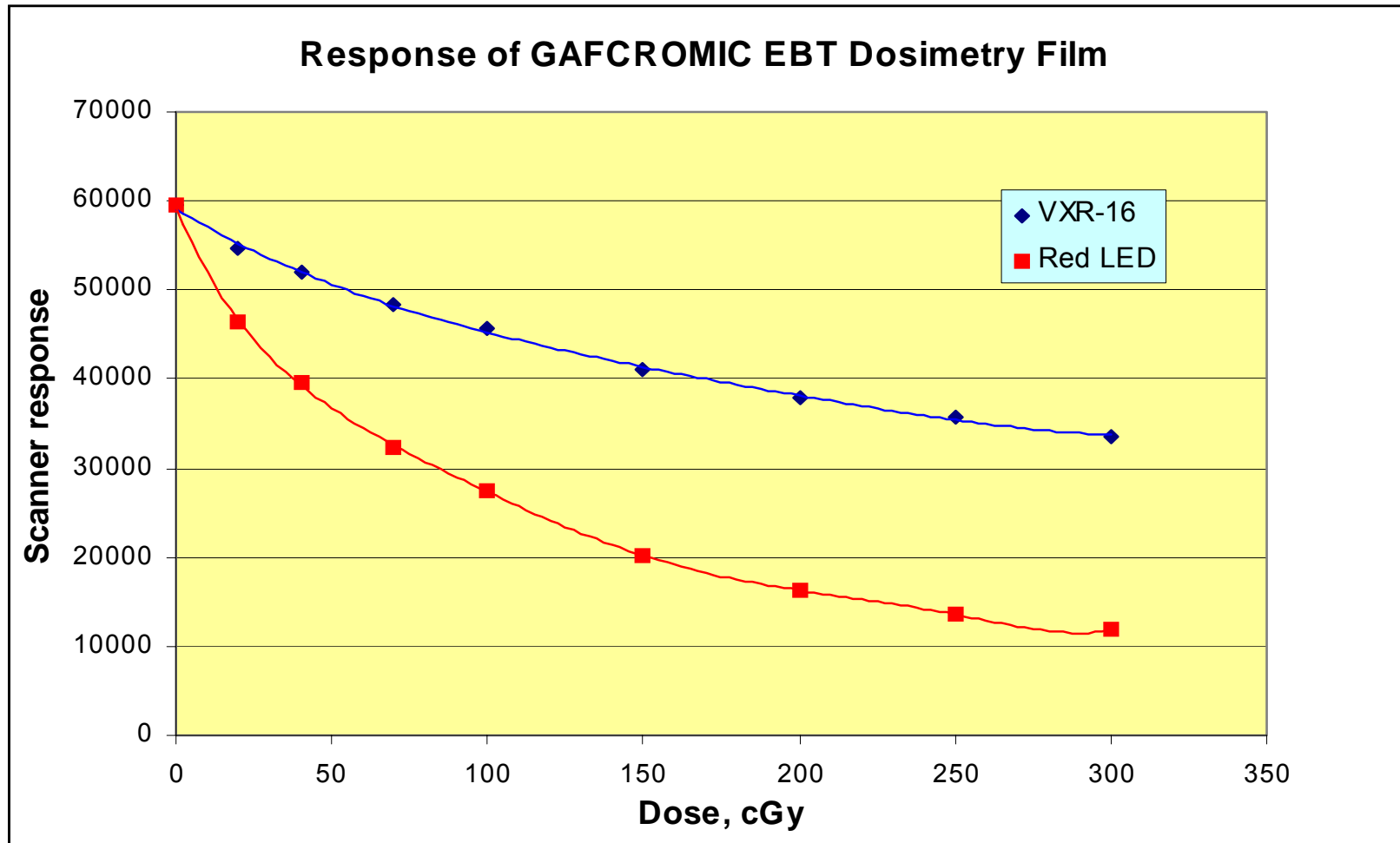
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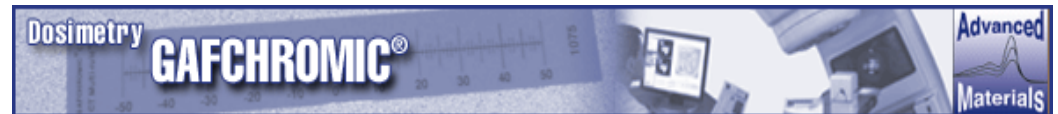
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# Response of EBT Film on Vidar Scanners



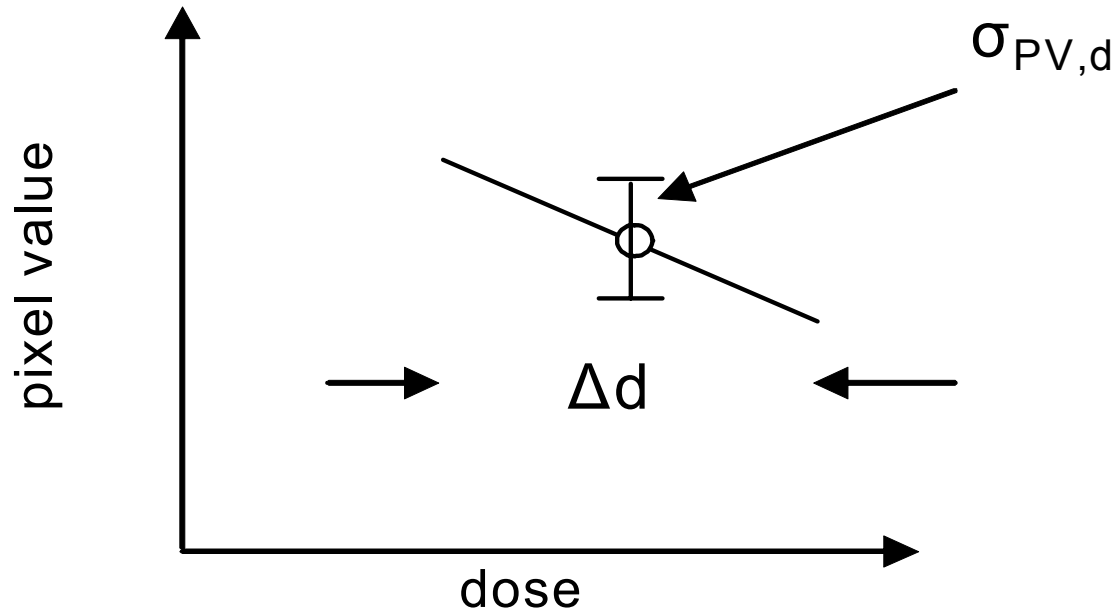
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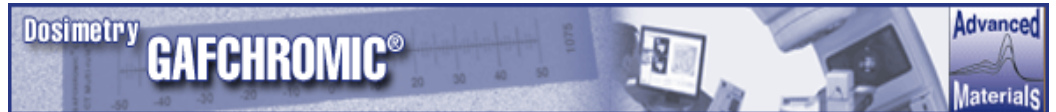
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# Contrast and Dose Resolution



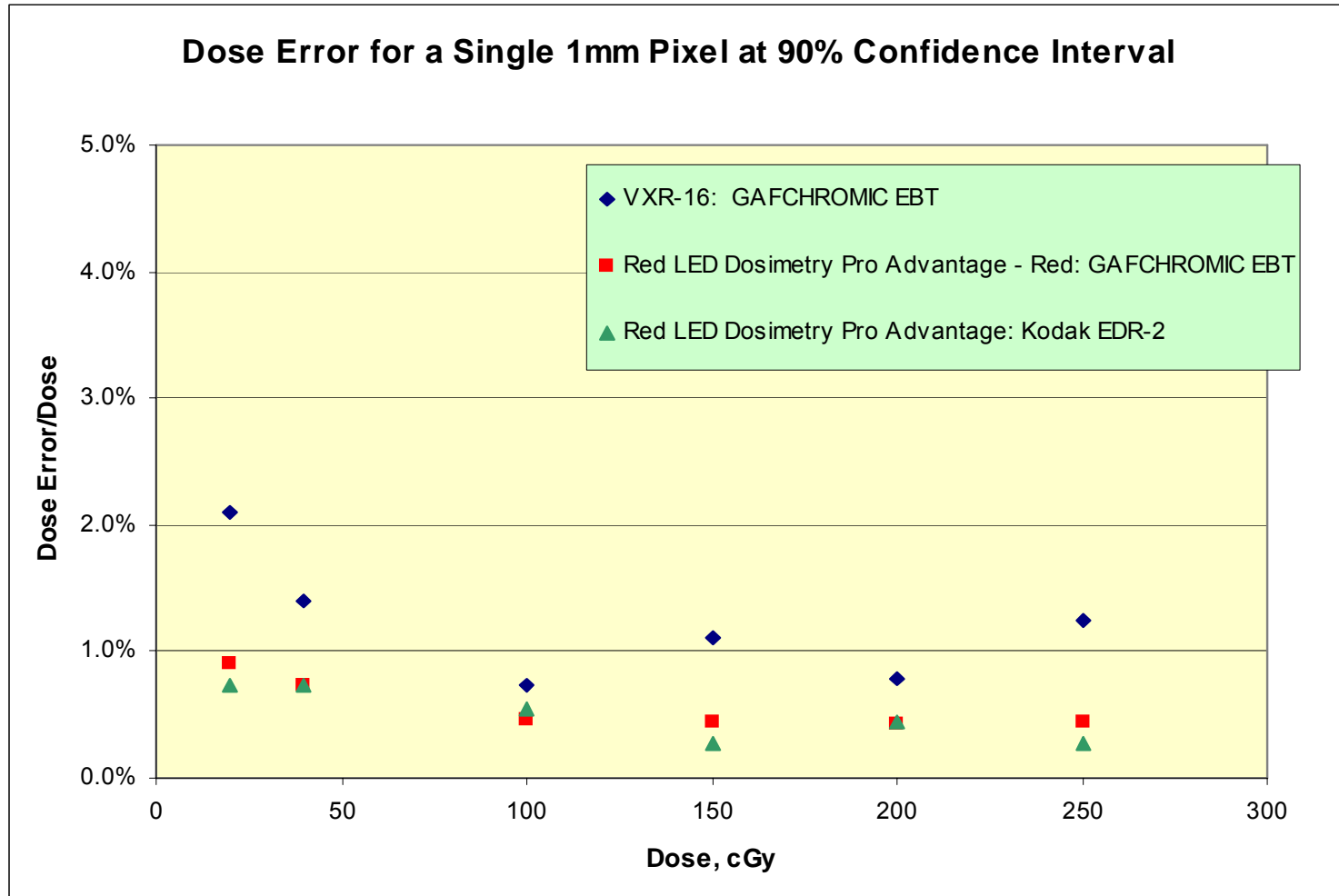
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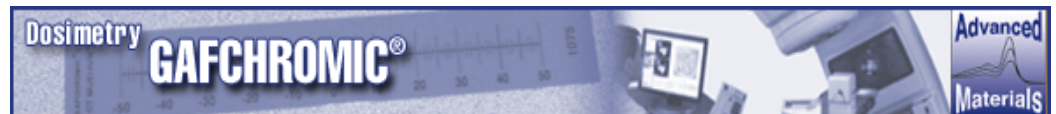
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# Dose Resolution



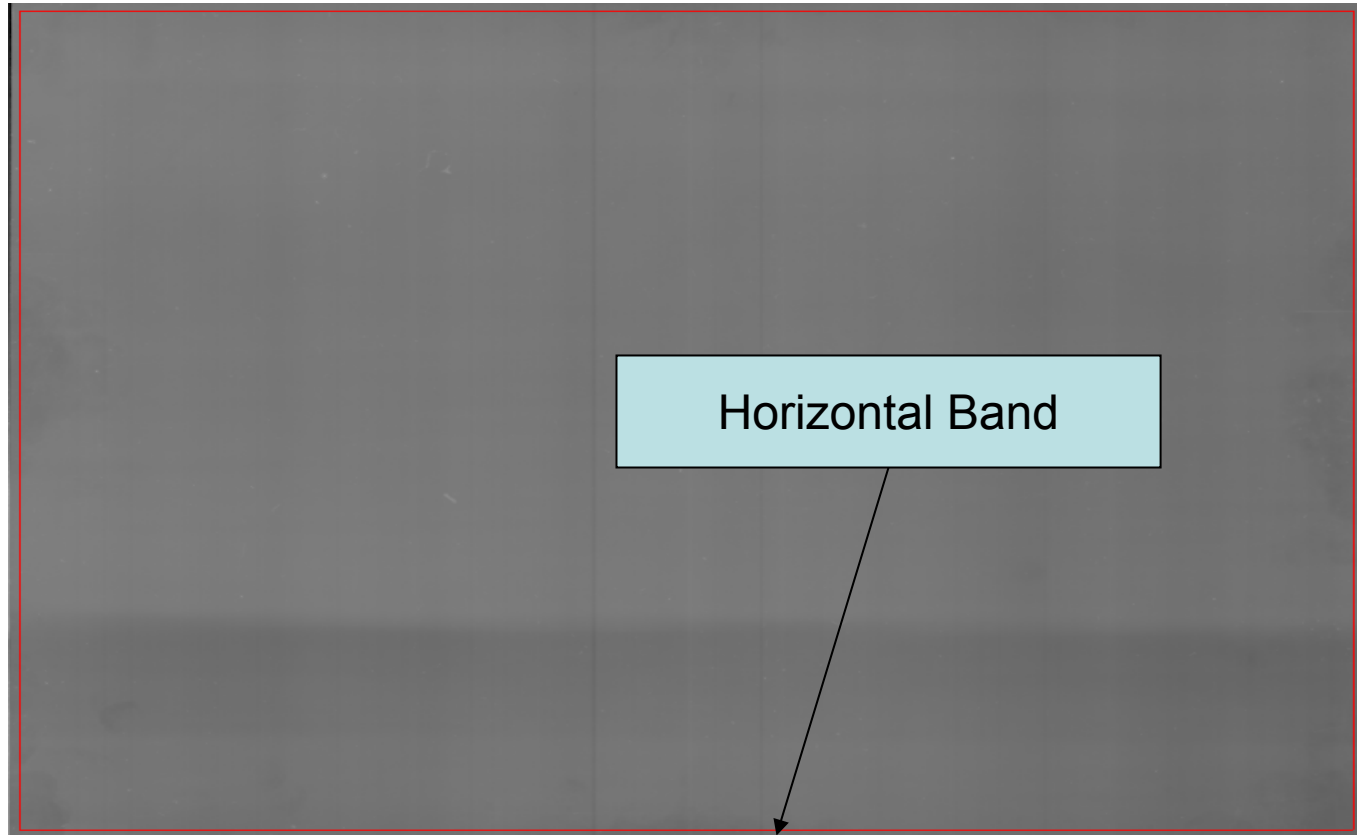
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# Banding Artifact: EBT Film on Vidar VXR-16 Scanner



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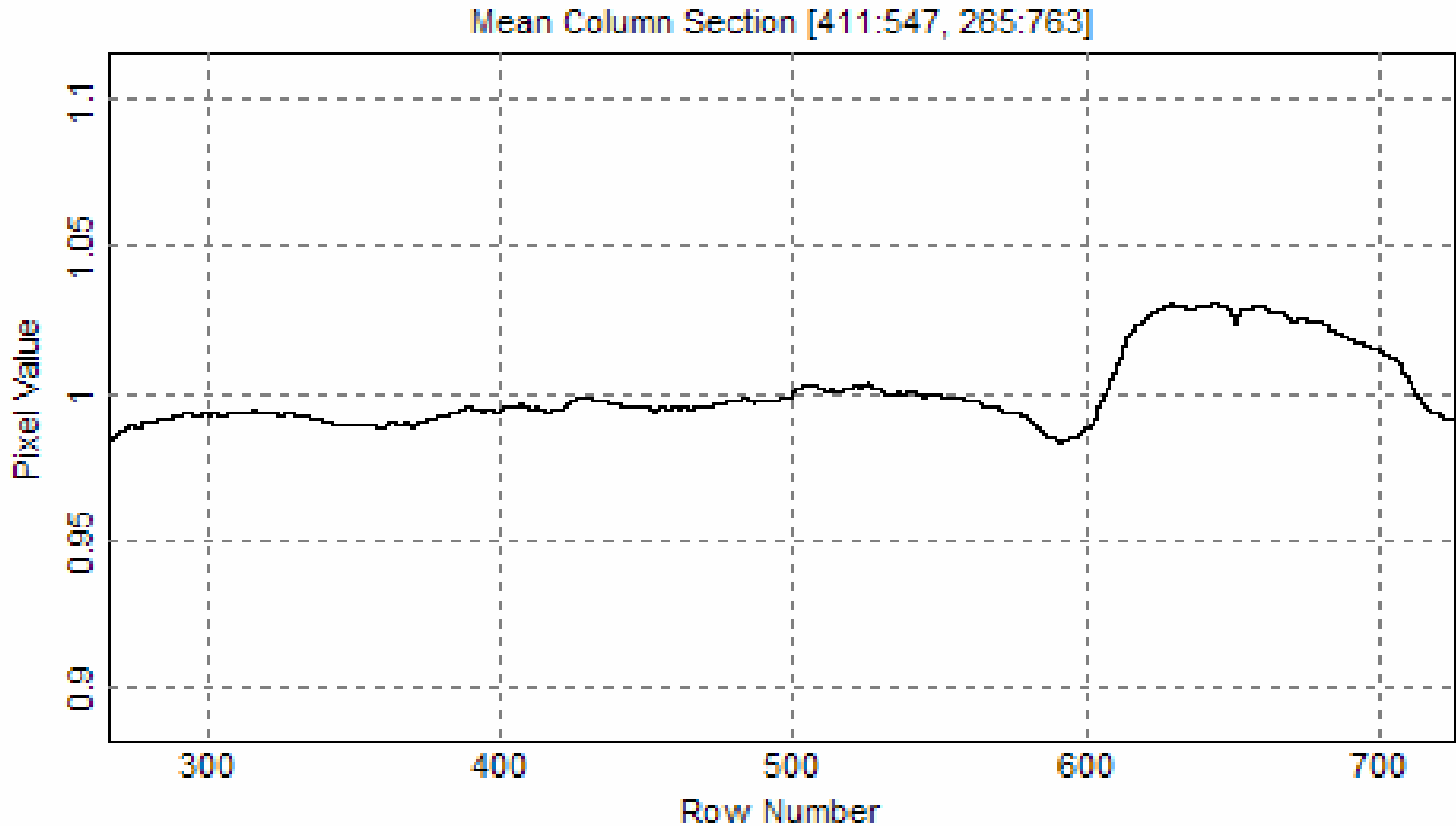
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# Banding Artifact - EBT Film on Vidar VXR-16 Scanner

## Vertical Profile



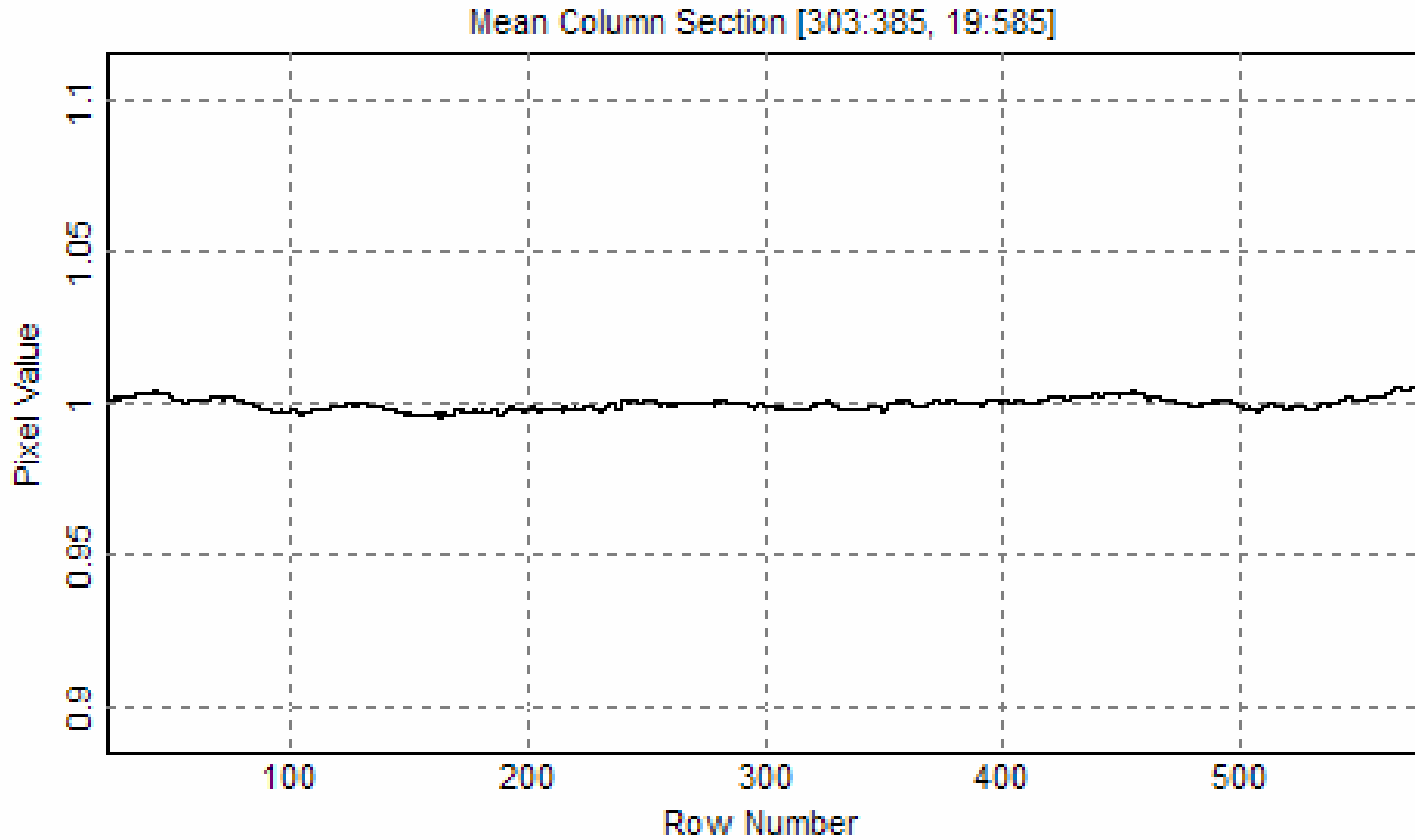
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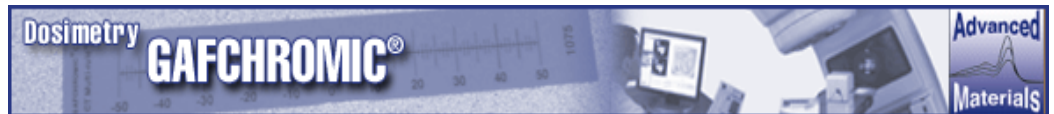
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# No Banding with EBT Film on Red LED Scanner Vertical Profile



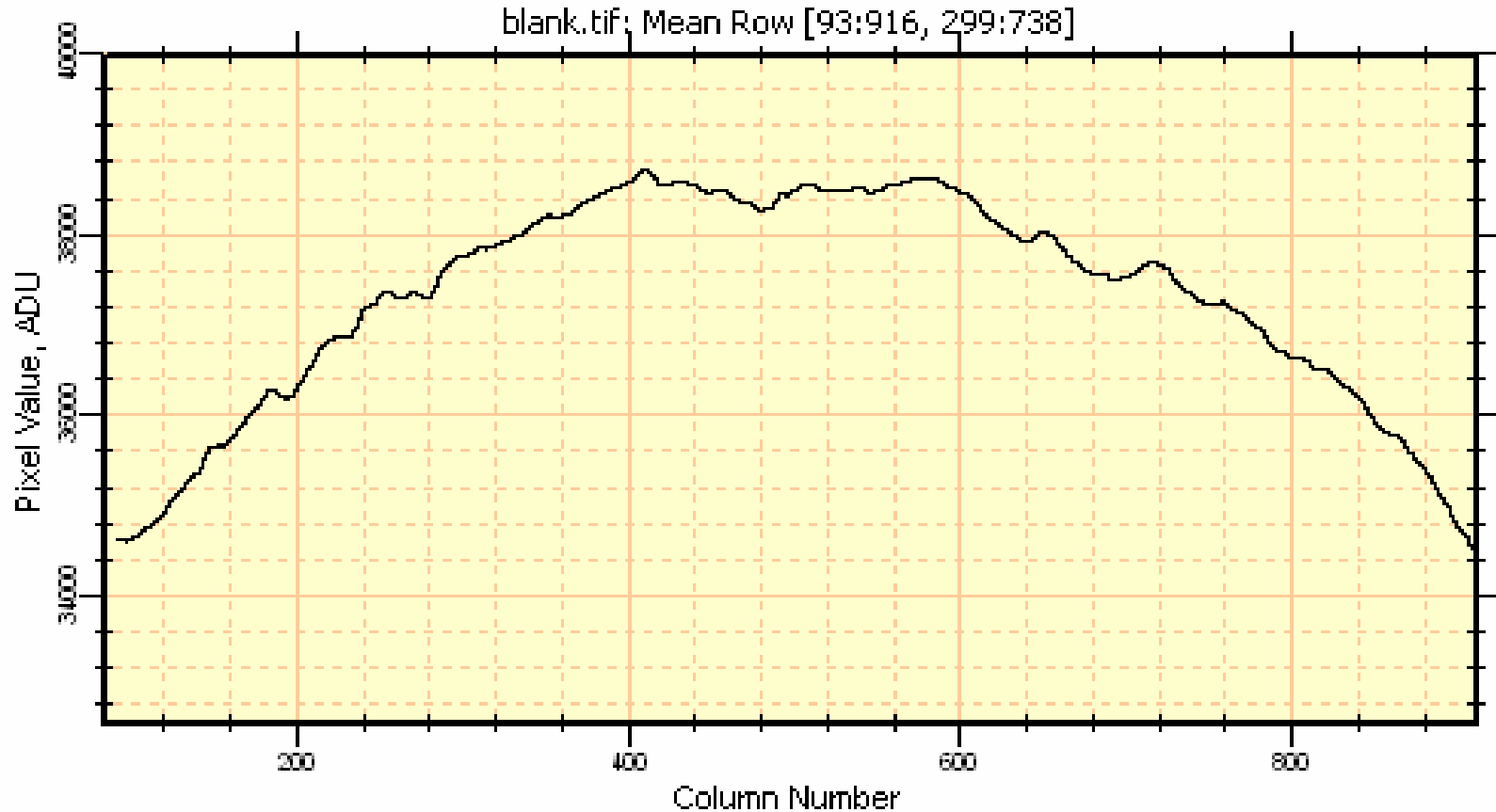
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# Effect of Light Scattering in VXR-16 Scanner: Horizontal Profile of Unexposed EBT Film



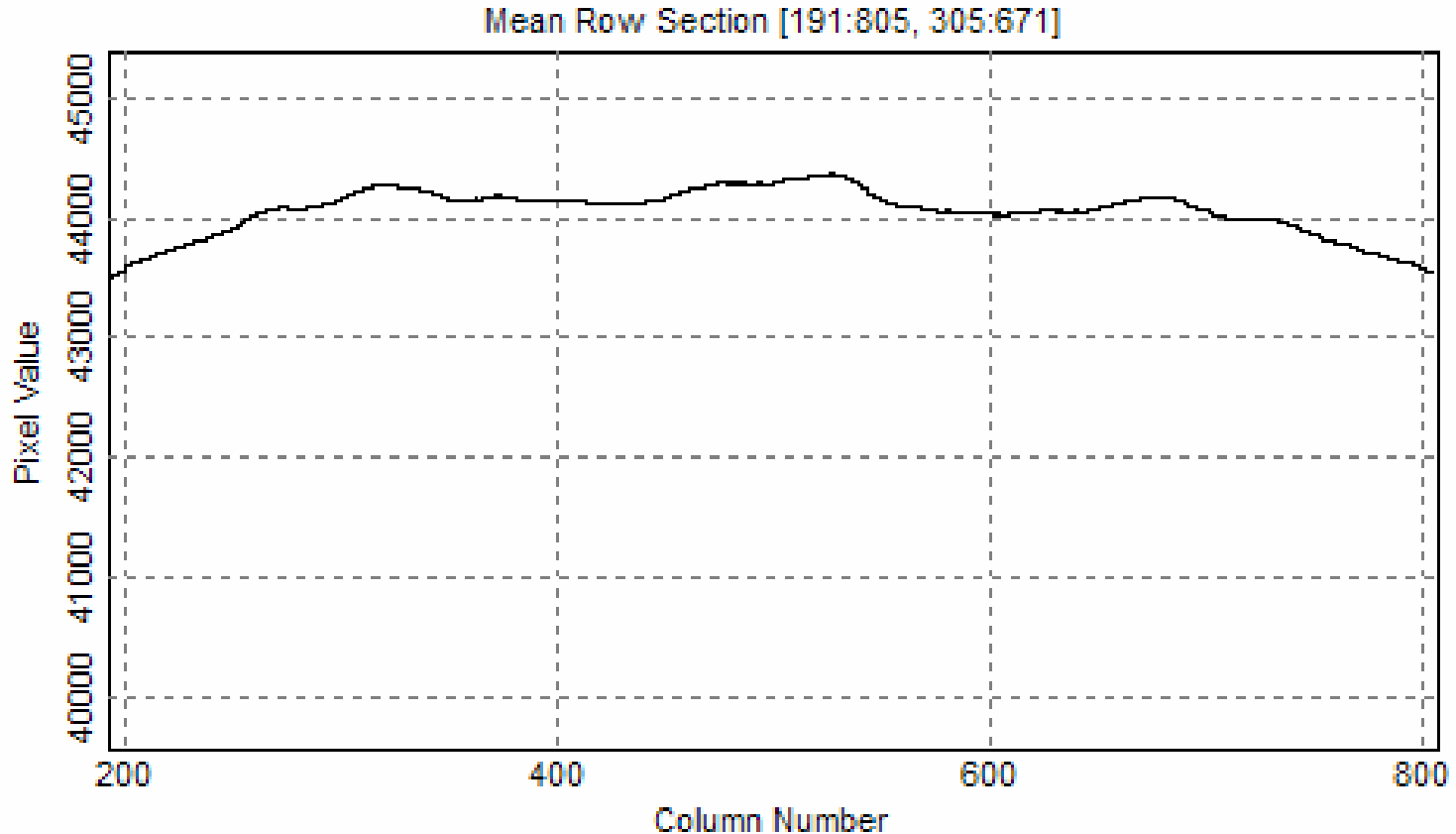
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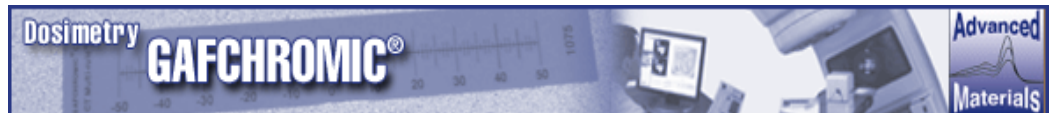
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# Effect of Light Scattering in Red LED Scanner: Horizontal Profile of Unexposed EBT Film



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## □ The Profile of Uniformly Exposed EBT Films Depends on Film Orientation

- Vidar Scanners
- Epson Scanners

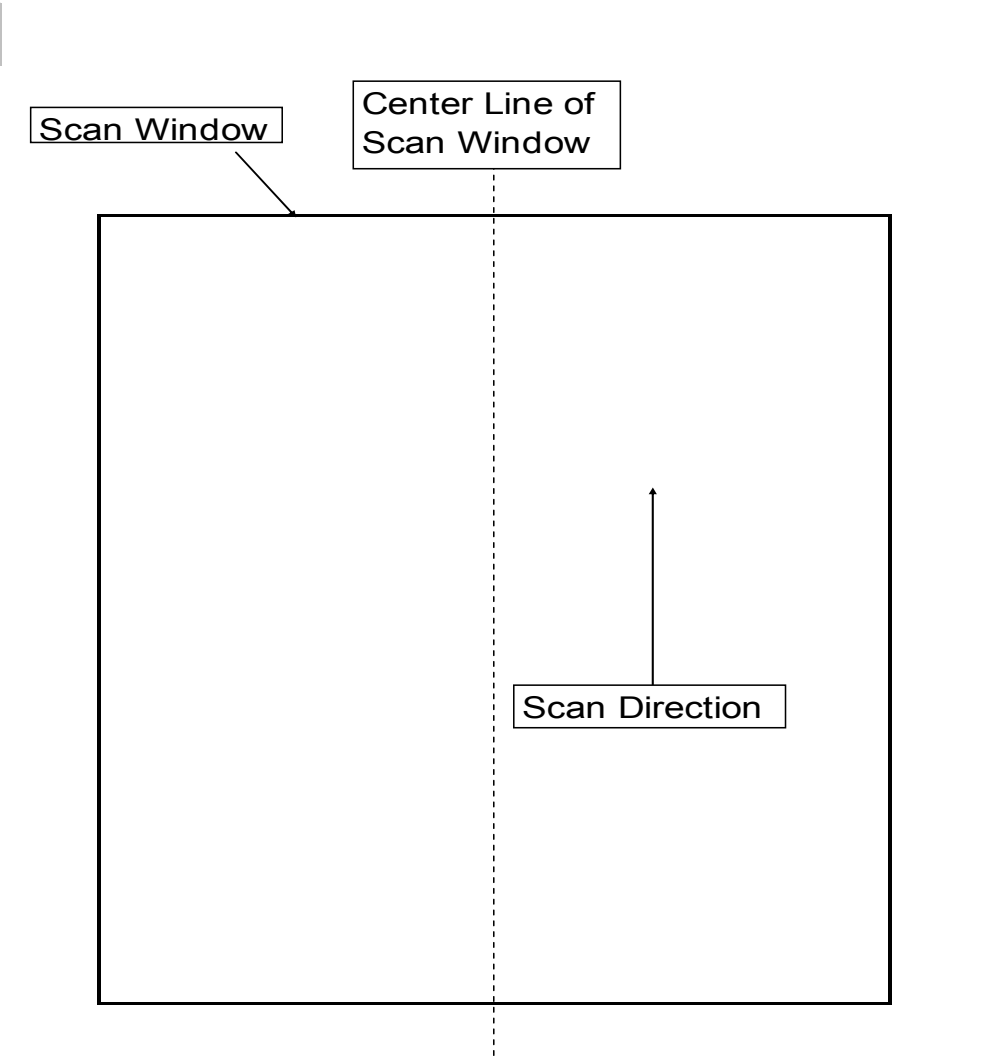


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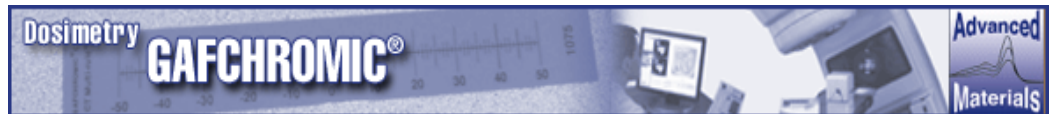


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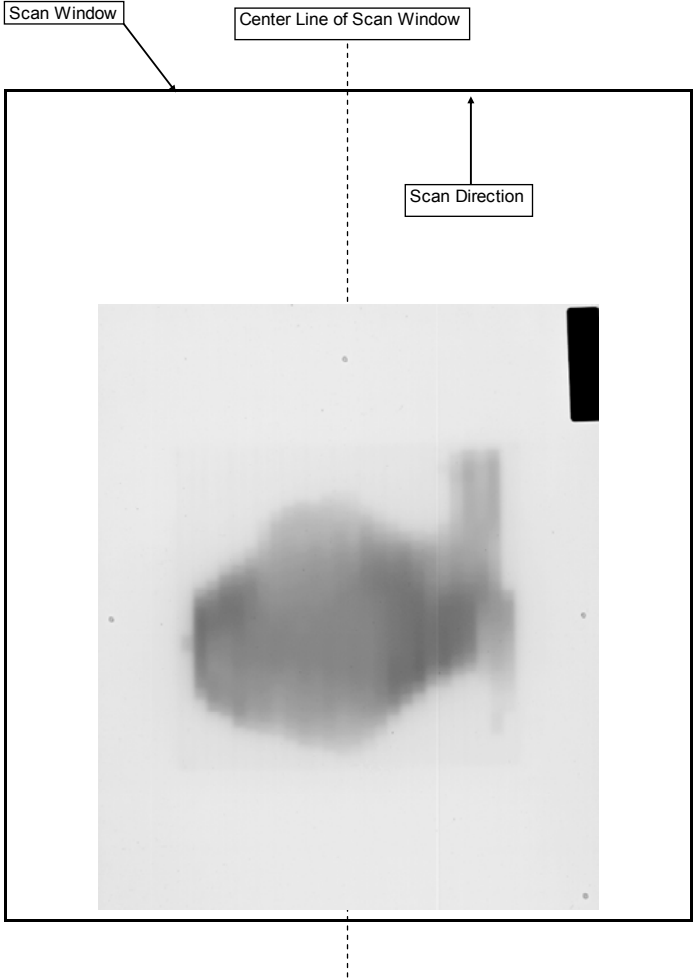
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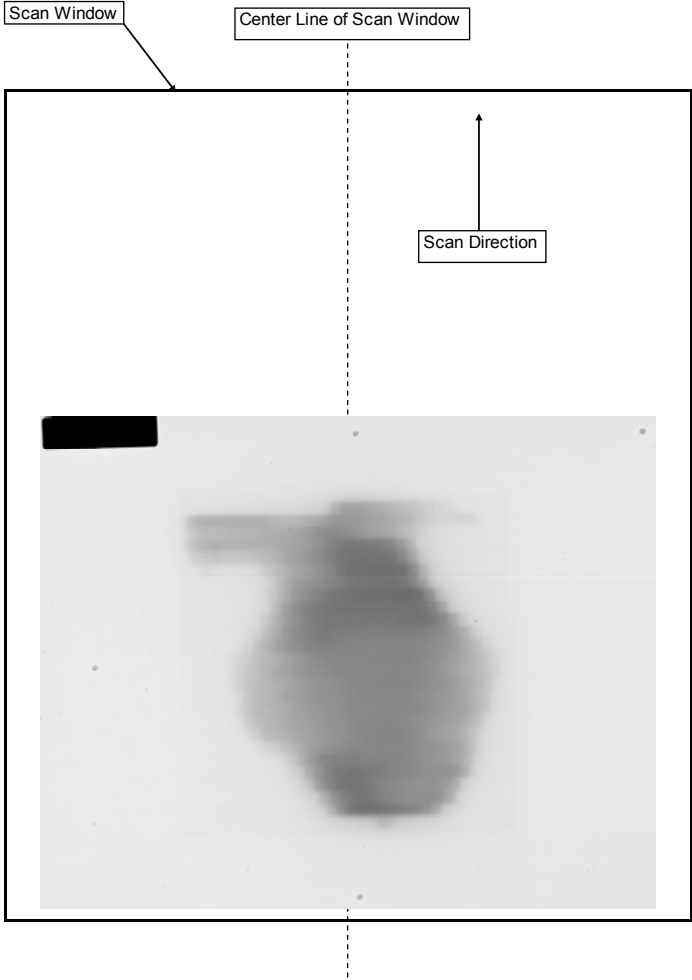


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# Portrait Orientation

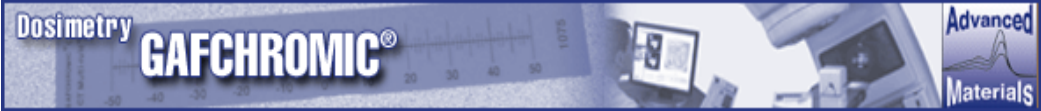


# Landscape Orientation



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# Scanning Procedure: Portrait and Landscape Orientations

- ❑ Uniformly Expose Four 1.5 cm x 2 cm Pieces of EBT
  - 0cGy; 25cGy; 139cGy; 225cGy
  
- ❑ Scan the Same Films at Different Positions Across the Scan Field
  
- ❑ Scan the Films in the Two Orientations



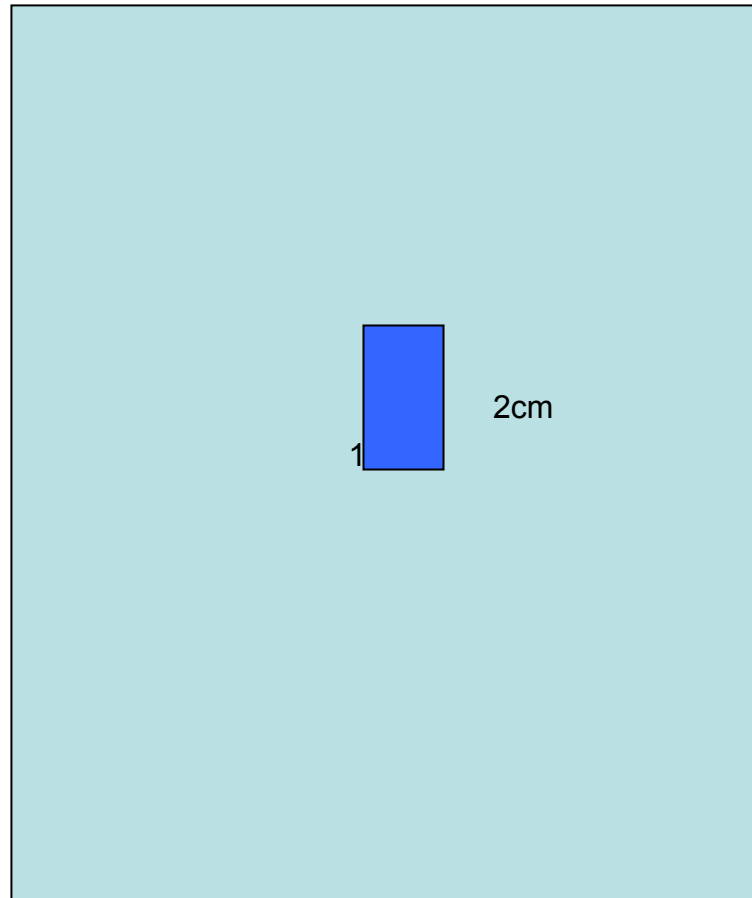
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# Relationship of Test Films to 8"x10" Sheet of EBT



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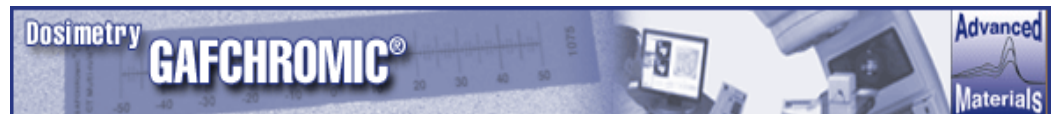
# Exposure, Scanning and Data Processing

- Expose a film sample to the required dose
- Attach the film to a holder
- Scan the film in portrait orientation in each of the locations
- Measure the scanner value for each position
- Normalize the values measured for each position to the average values at the central positions
- Repeat with film in landscape mode



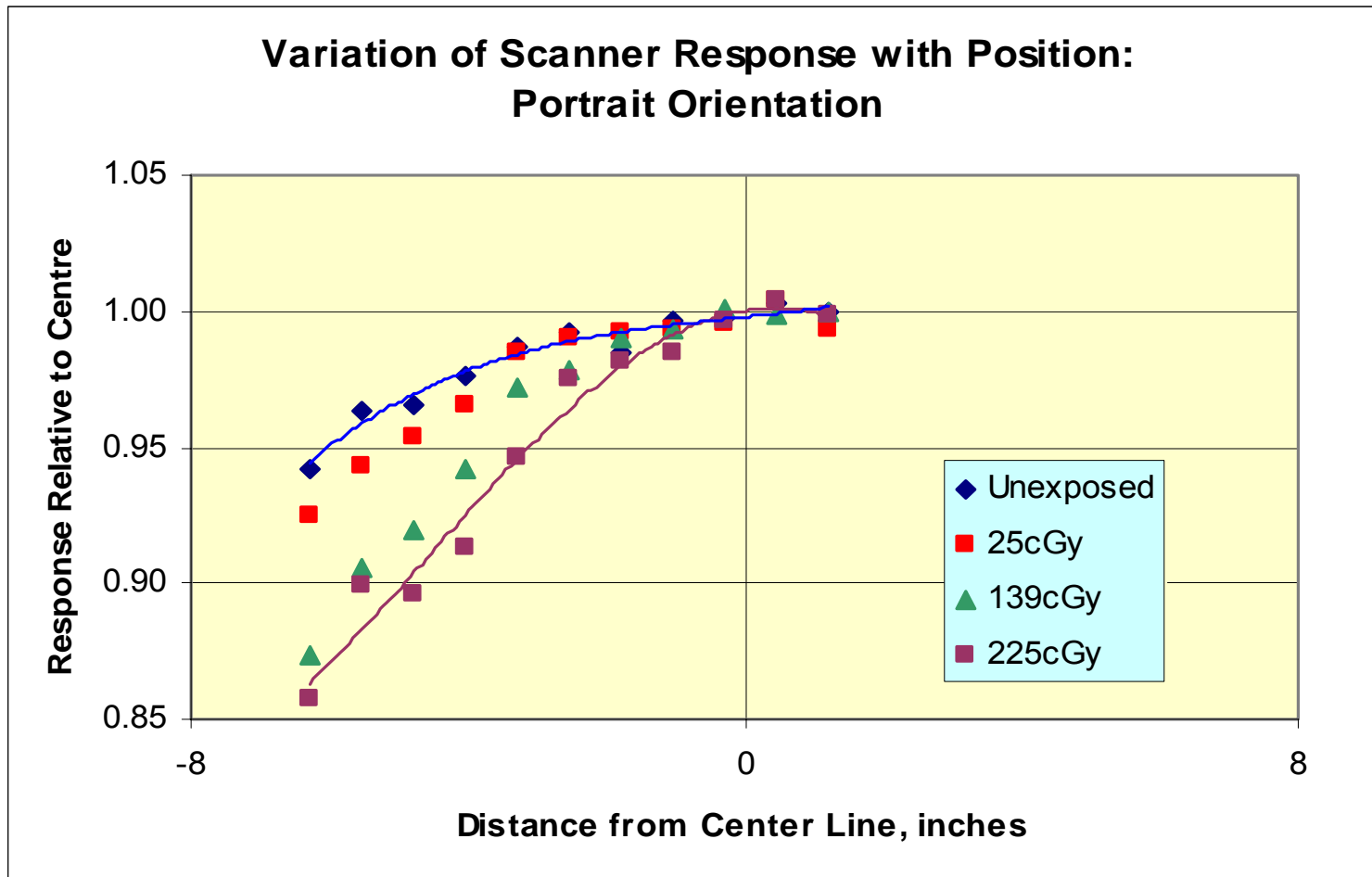
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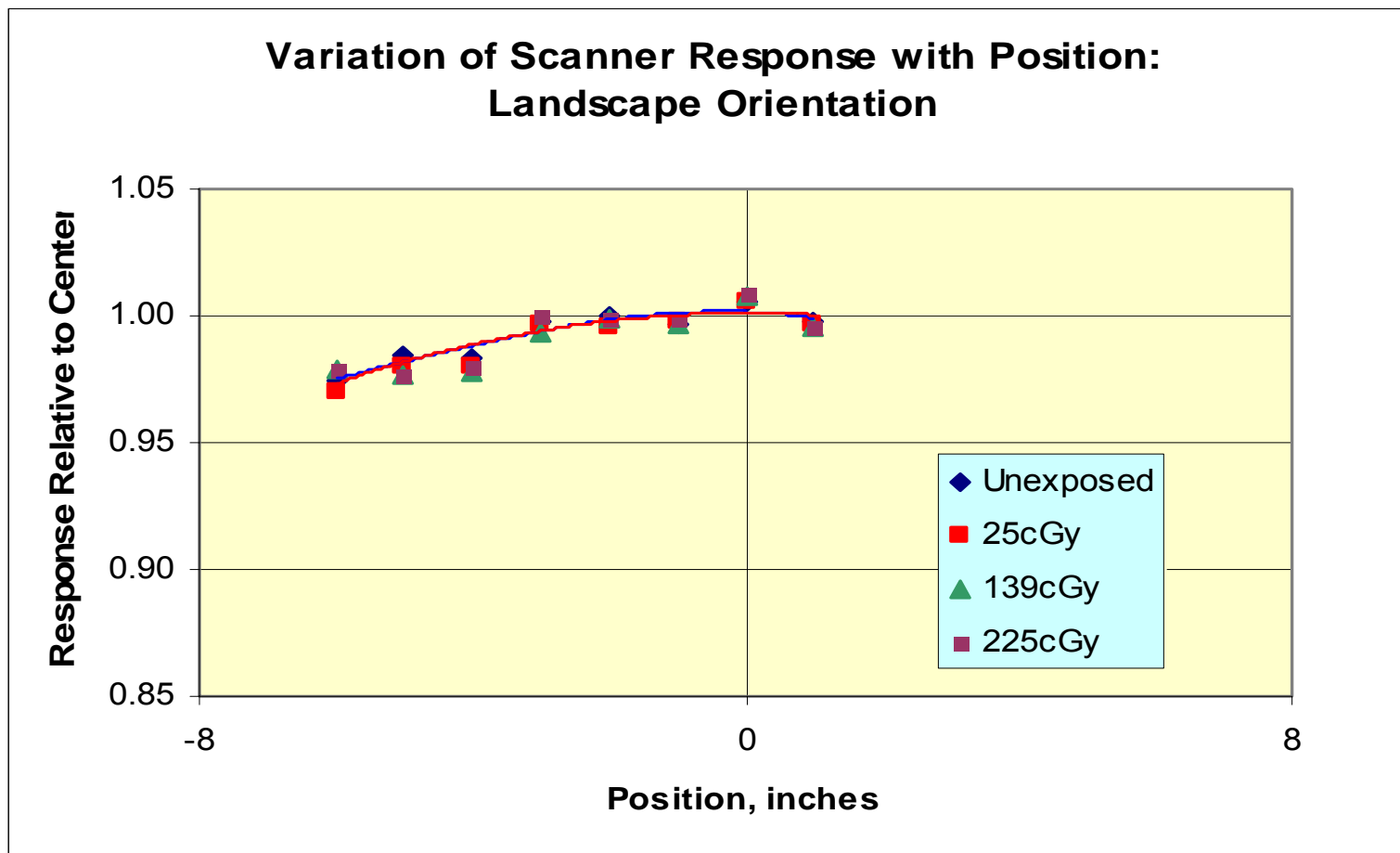


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# EBT on Red LED Scanner: Portrait Orientation

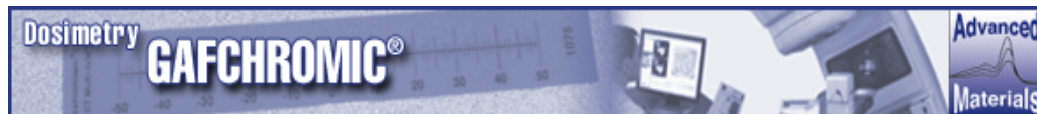


# EBT on Red LED Scanner: Landscape Orientation



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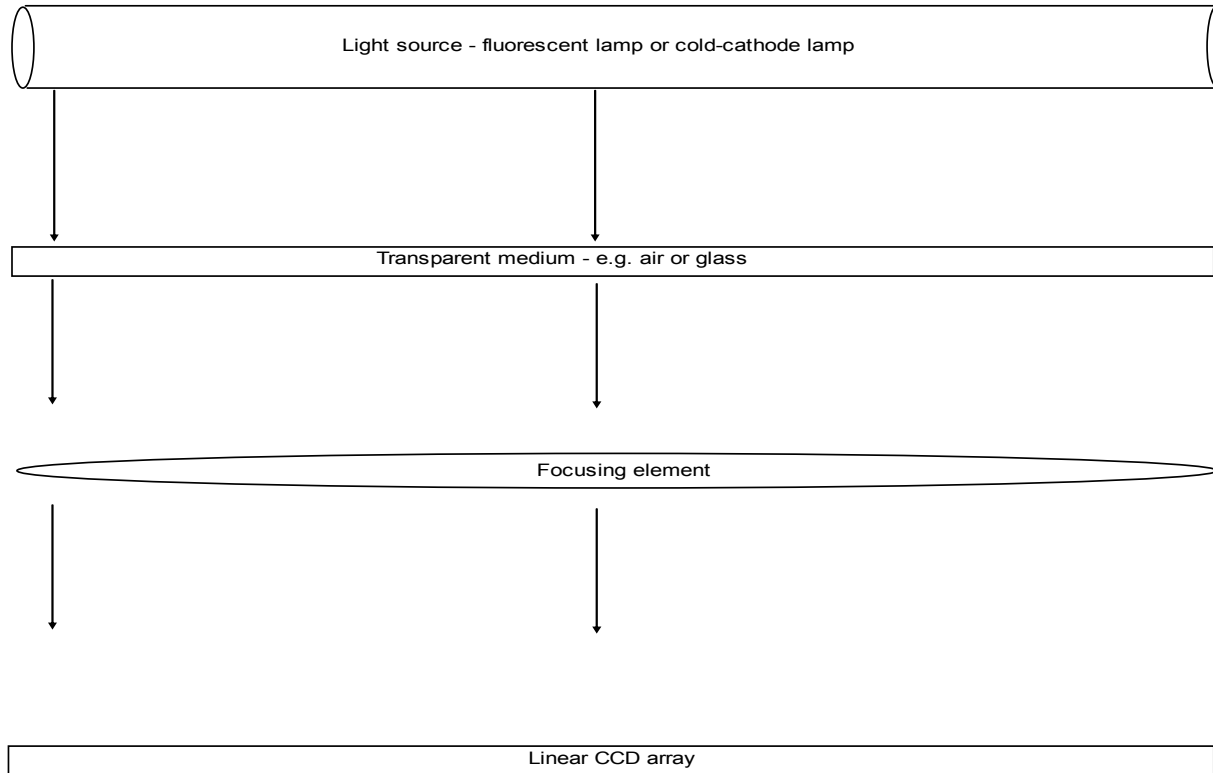
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# CCD Scanner Calibration

CCD Scanner Schematic - Air or other non light-scattering medium



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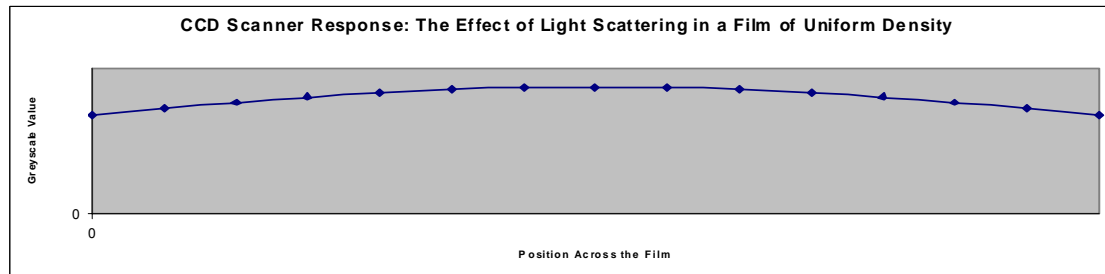
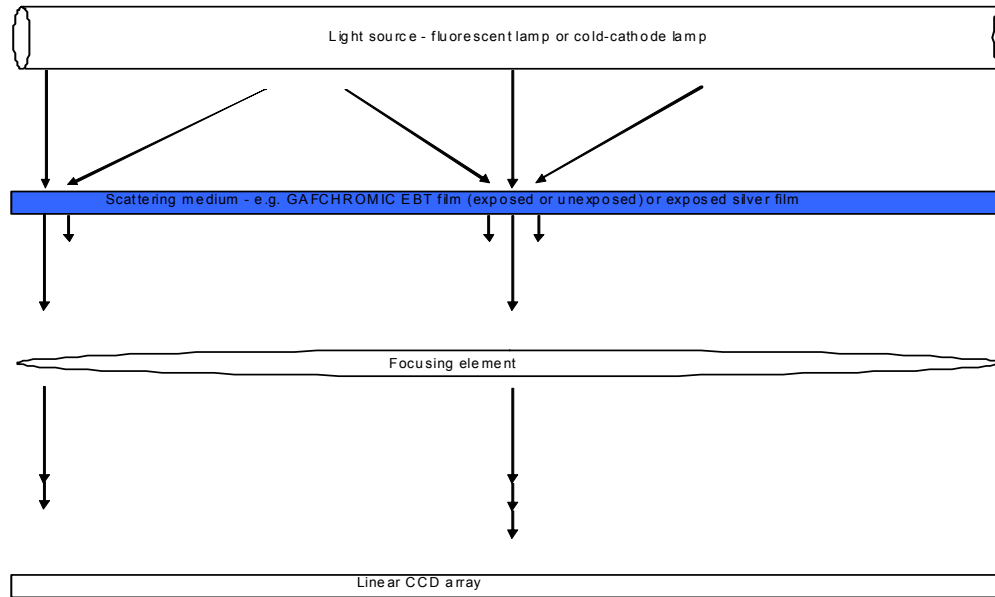
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# Light Scattering in CCD Scanners

CCD Scanner Schematic - Light scattering film



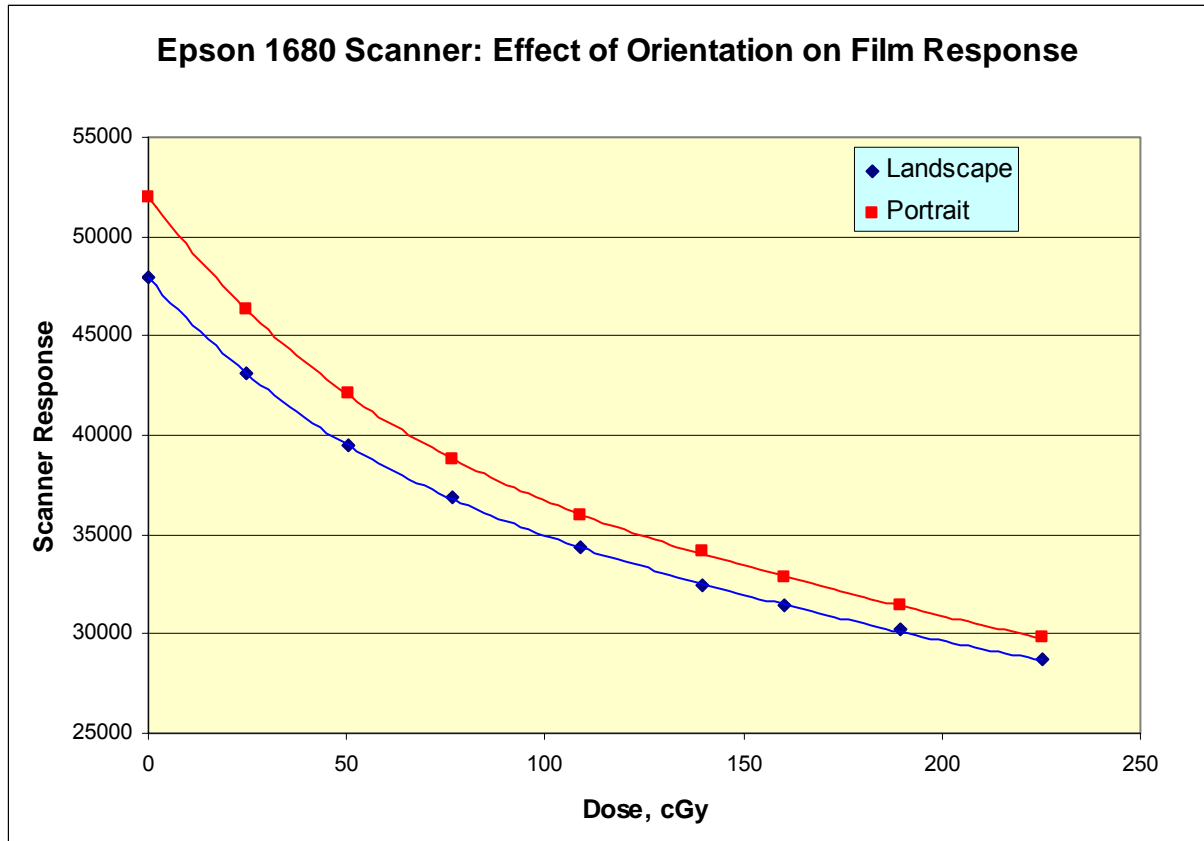
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# Anisotropic Light Scattering by EBT Film



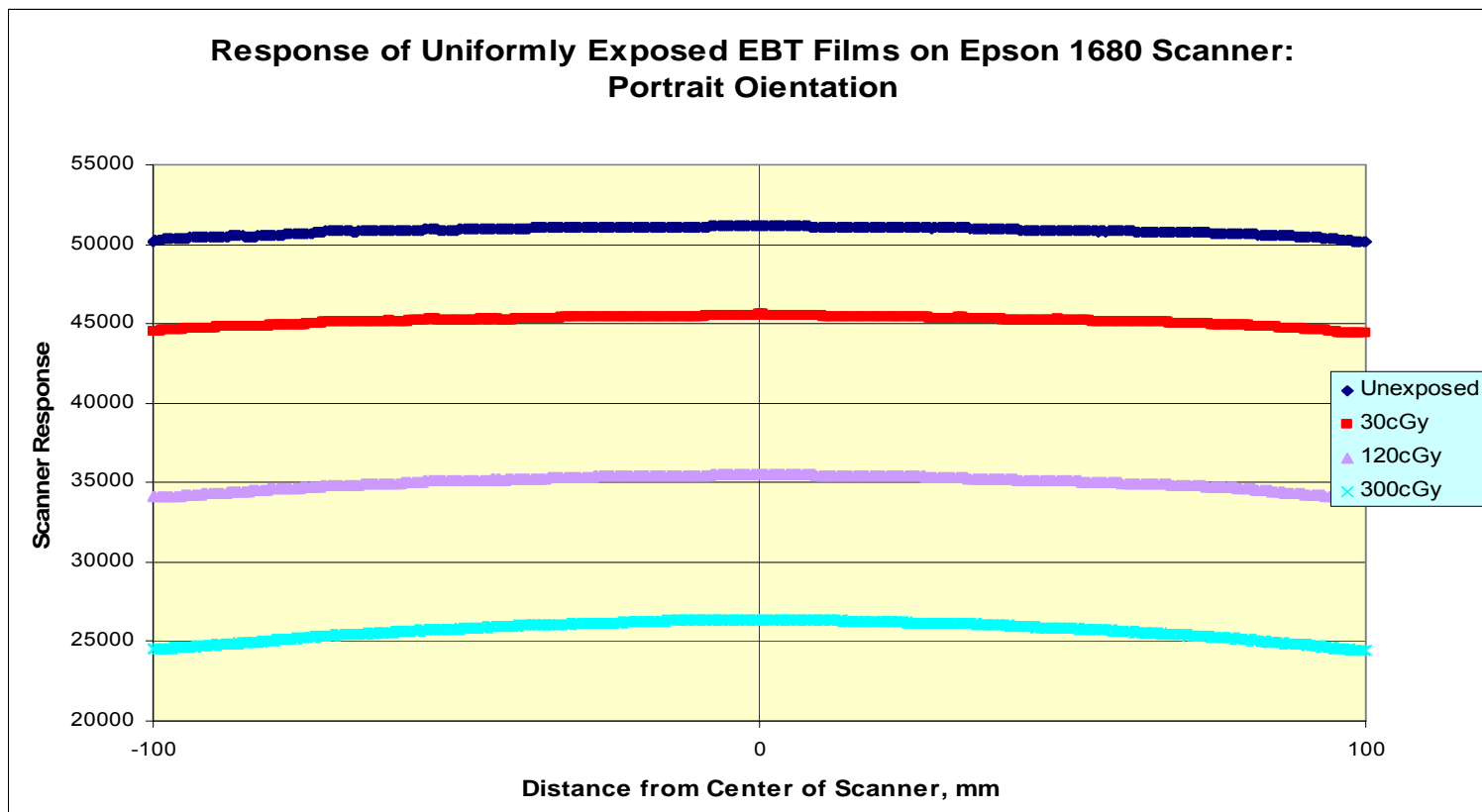
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# Profiles of Uniformly Exposed EBT Film: Portrait Orientation on Epson 1680 Scanner



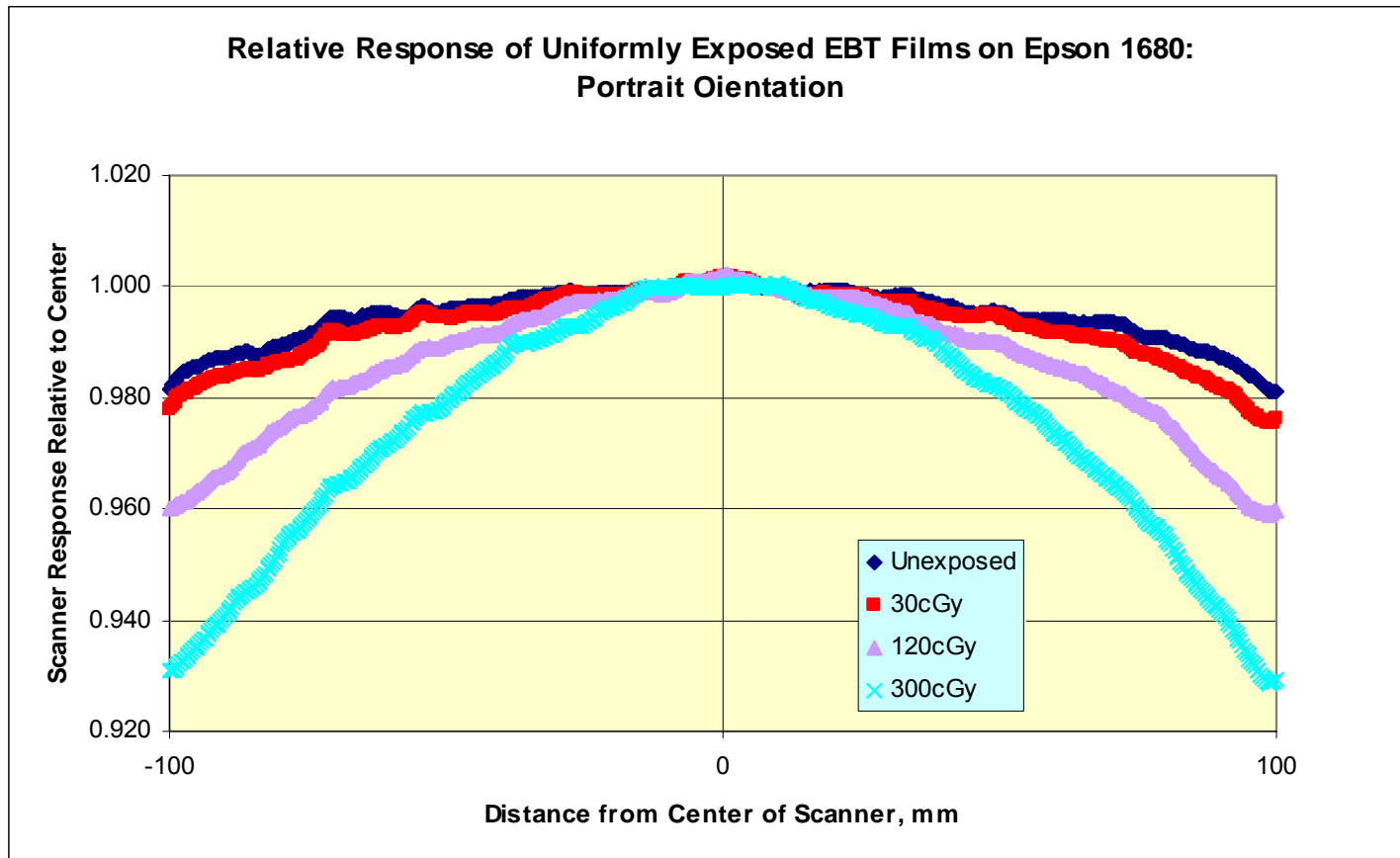
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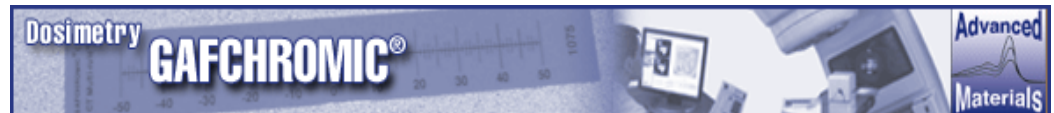
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# Normalized Profiles of EBT Film: Portrait Orientation on Epson 1680



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# Flatness Correction

## ❑ Response is Dependent on:

- Dose
- Position on Scanner

## ❑ Complex Correction Procedure

- Multiple films and measurements



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# Flatness Correction

- ❑ We would like a simple correction method
  - Single film with uniform exposure
  - Preferably an unexposed film
  
- ❑ Simplification proposed by Menegotti, Delana et al.
  - Invert the Pixel Values – Subtract the Values from  $2^{16}$



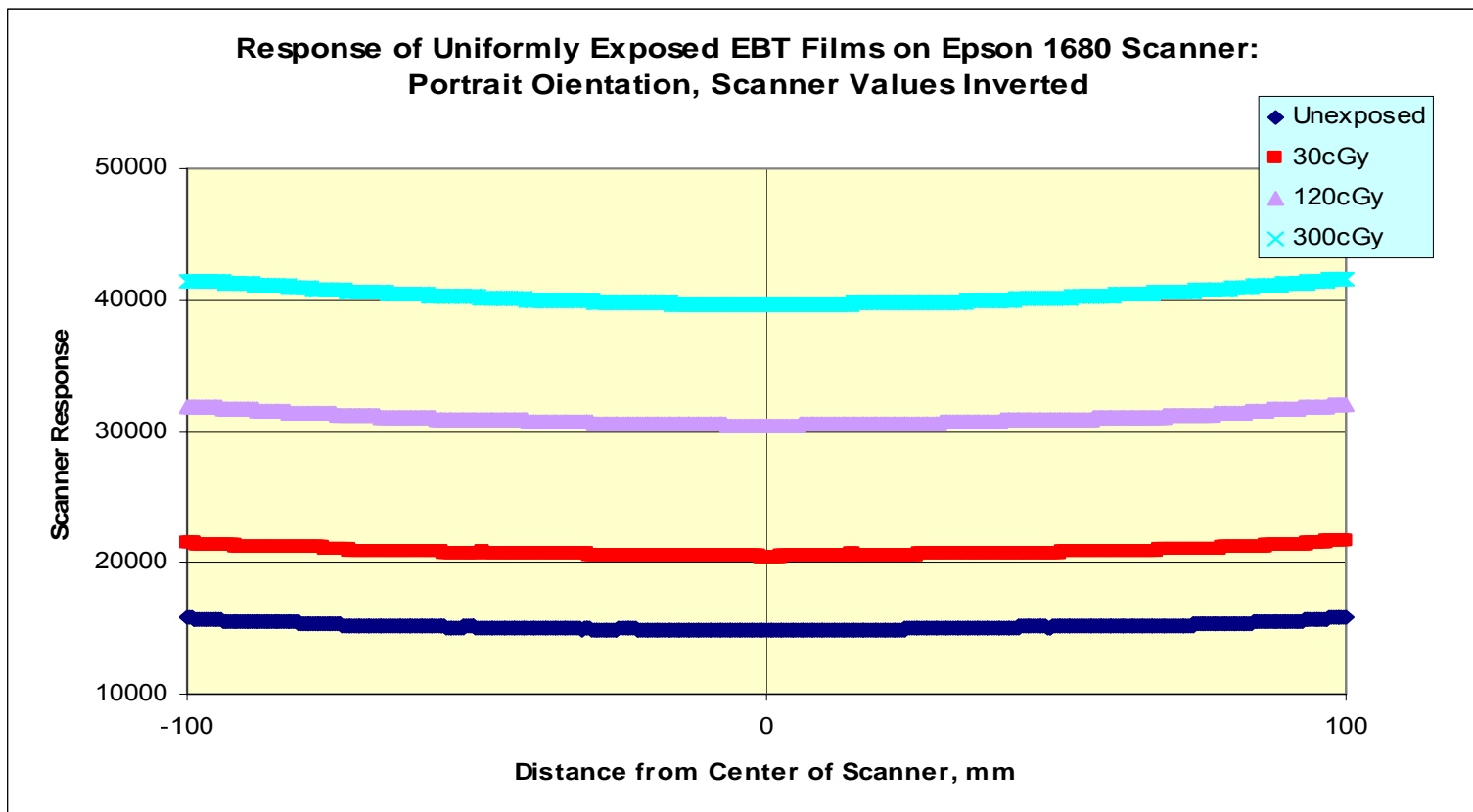
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# Inverted Profiles of EBT Film: Portrait Mode on Epson 1680



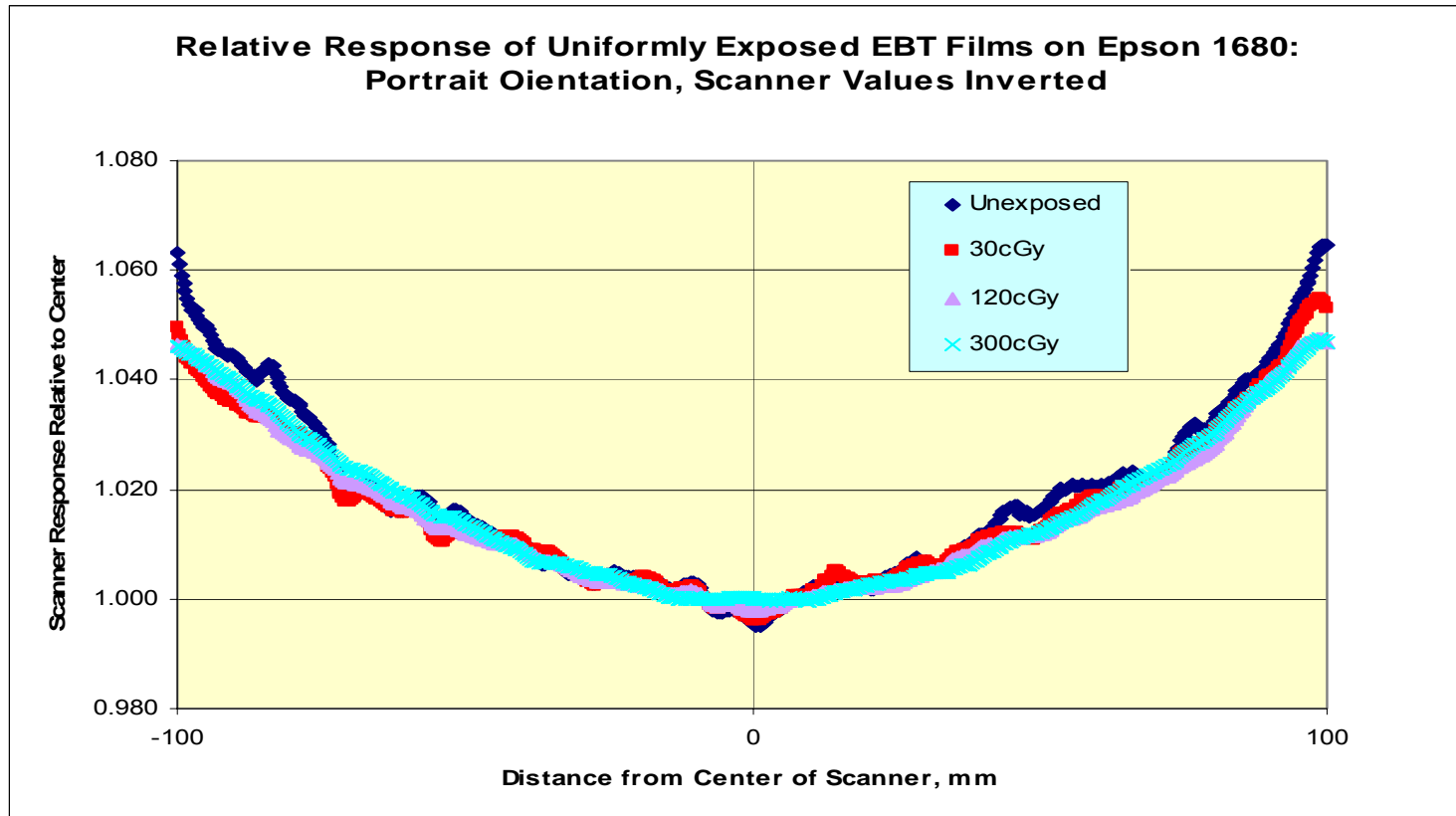
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# Normalized Inverted Profiles of EBT Film: Portrait Mode on Epson 1680



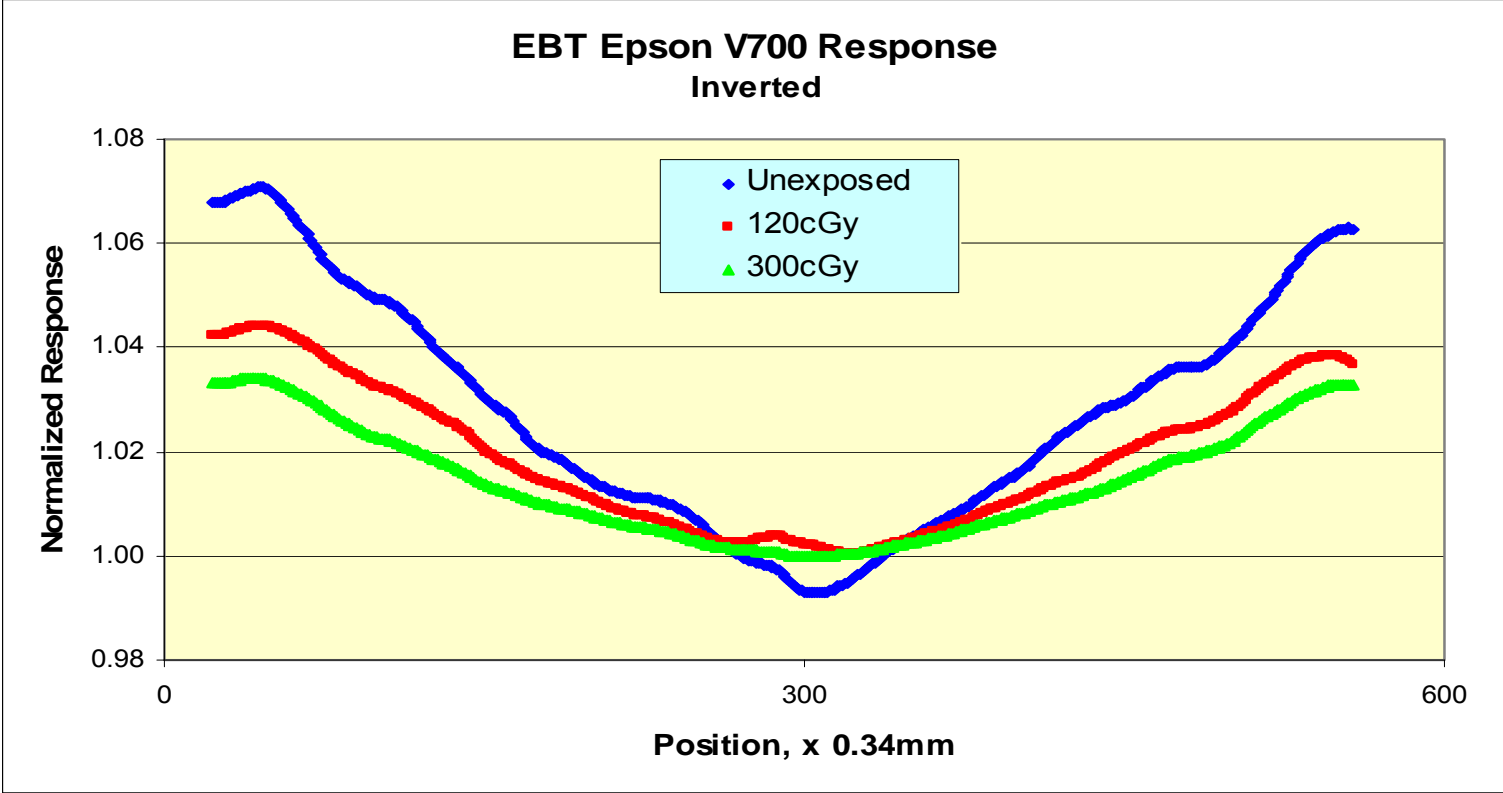
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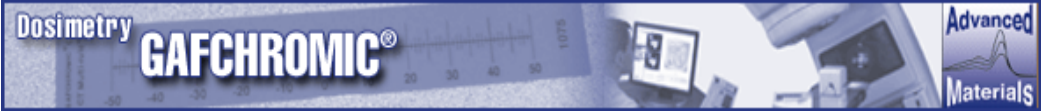
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# Normalized Inverted Profiles of EBT Film: Portrait Mode on Epson V700



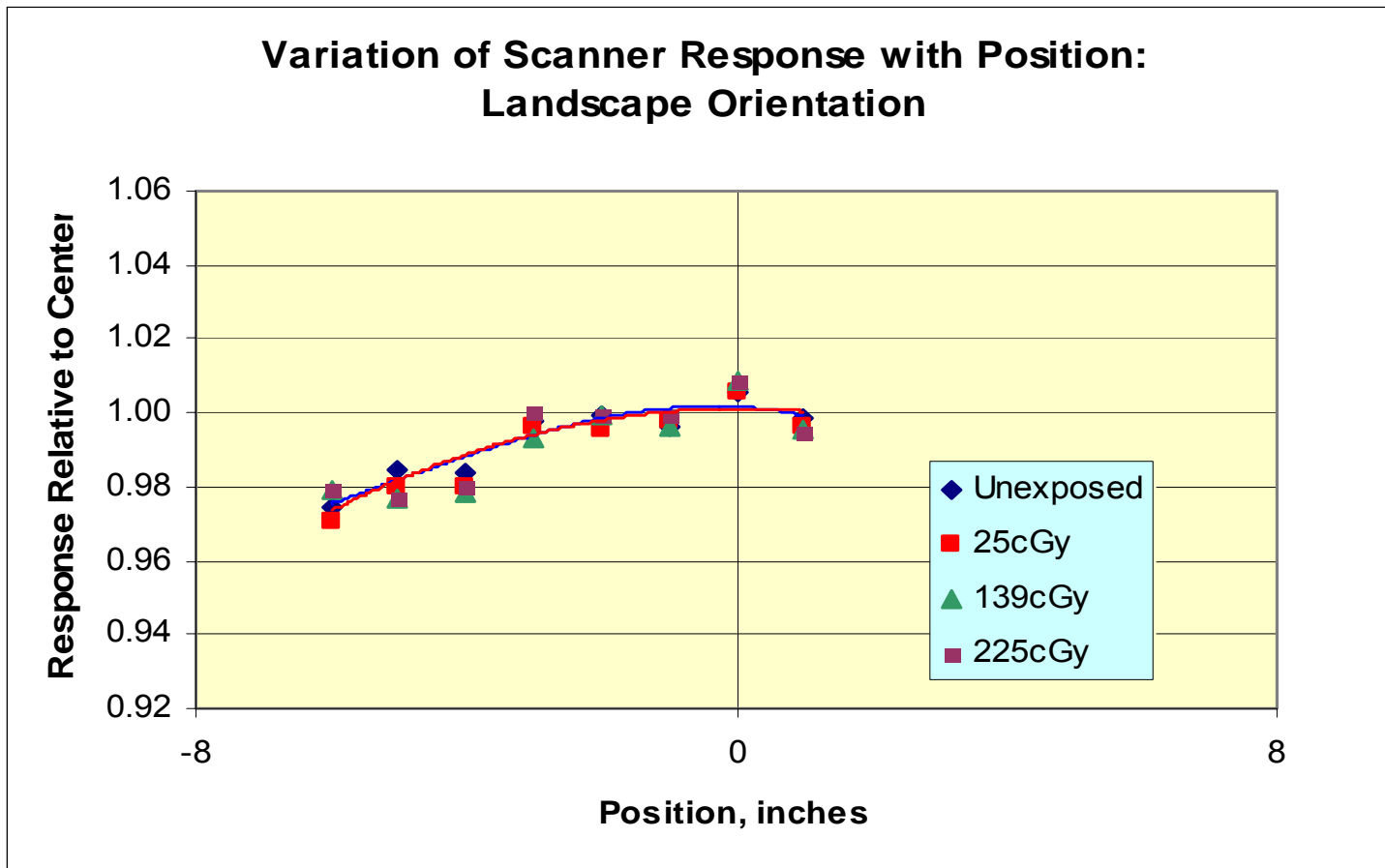
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# EBT on Red LED Scanner: Landscape Orientation



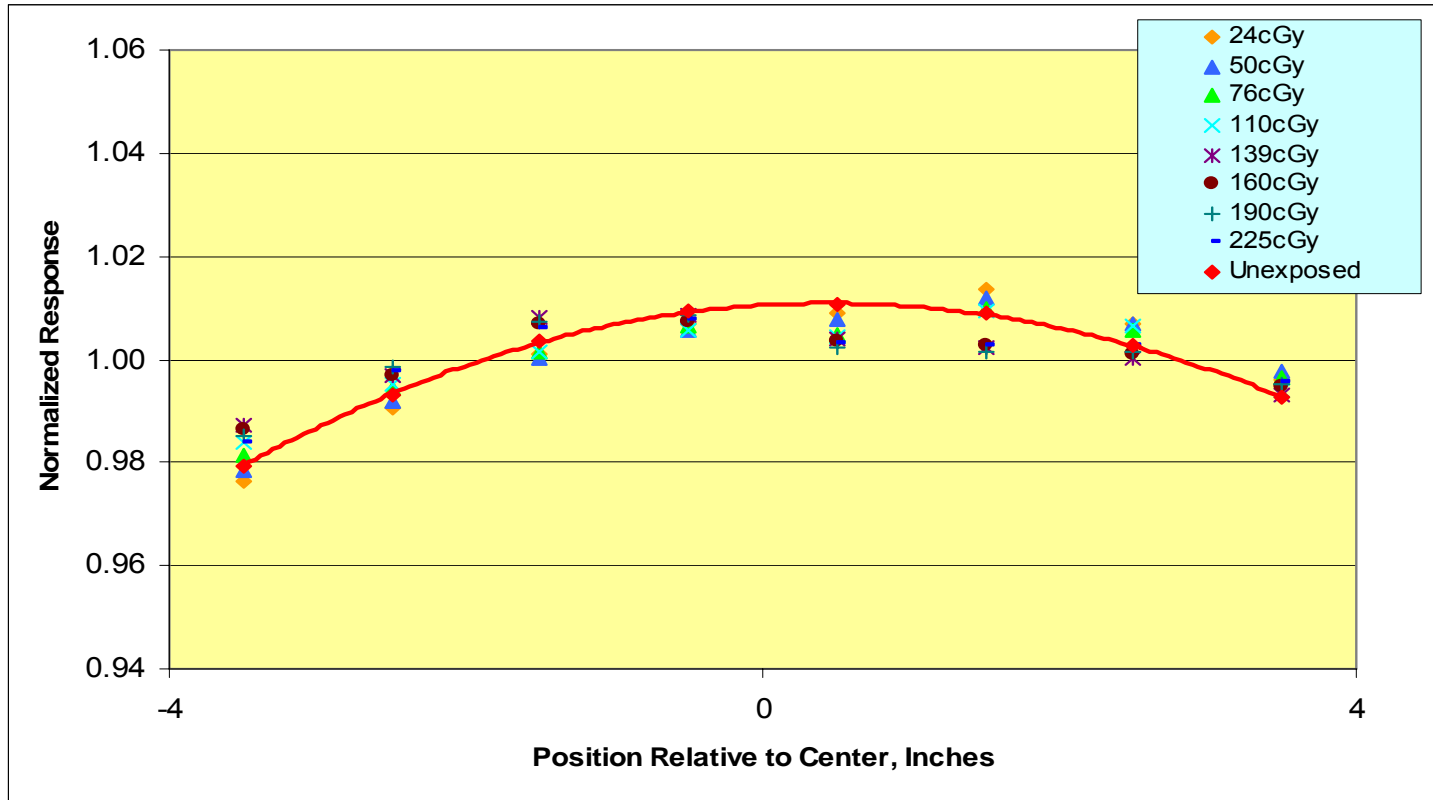
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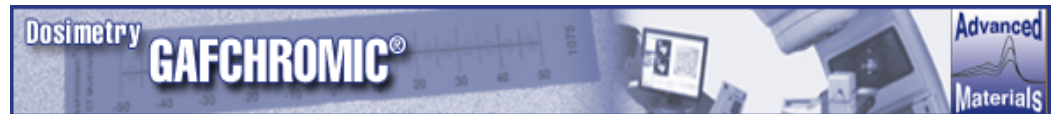
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# EBT on Epson V700 Scanner Landscape Orientation



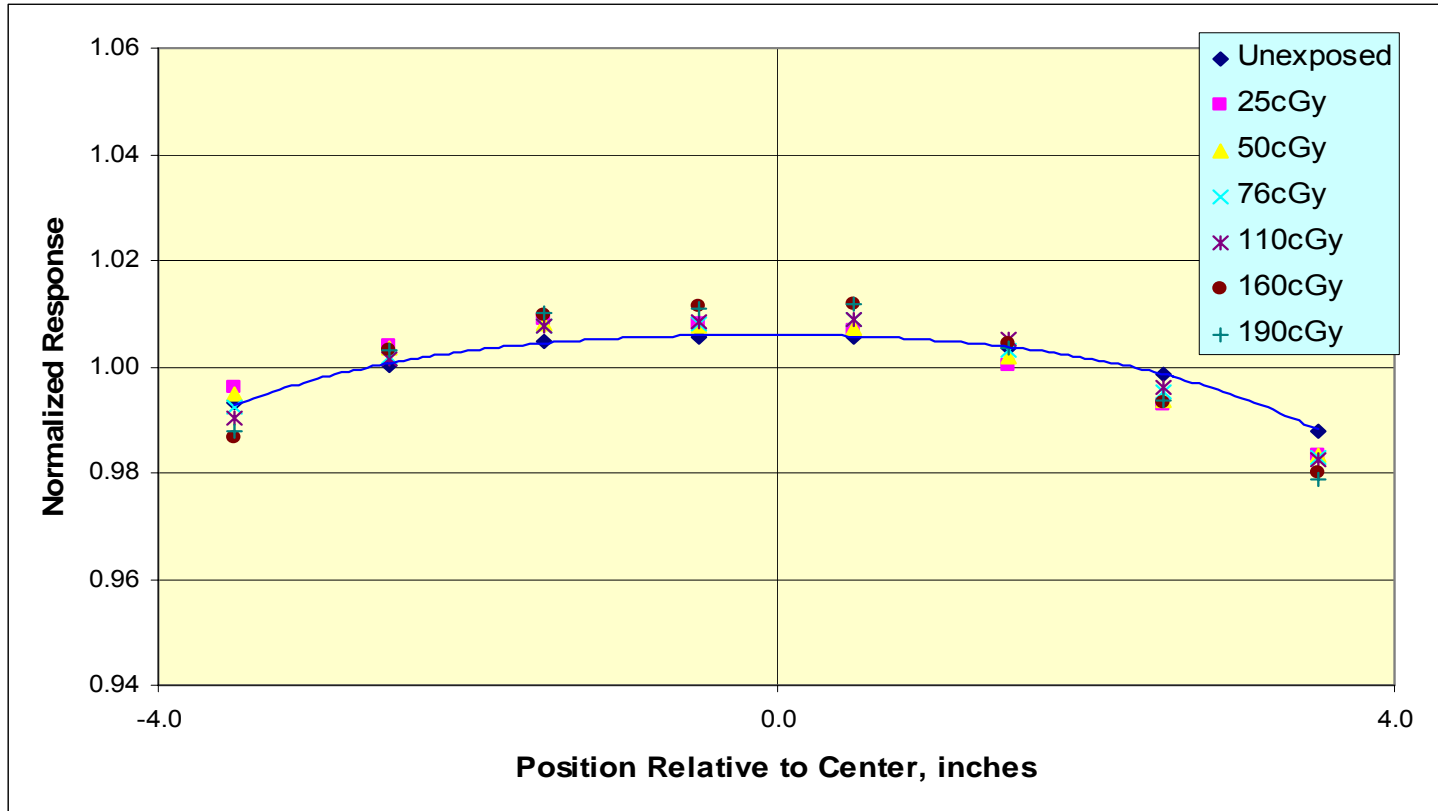
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# EBT on Epson 1680 Scanner Landscape Orientation



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Similar behavior on Epson 10000XL Scanner



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# Flattening Procedure

## ❑ Create a correction image

- Scan an unexposed or a uniformly exposed film
- Measure the average pixel values at the center of the image
- Normalize all pixel values to the average central value
- Correction image has values close to 1

## ❑ Correct all other images using the correction image

- Use image arithmetic to divide each image by the correction image



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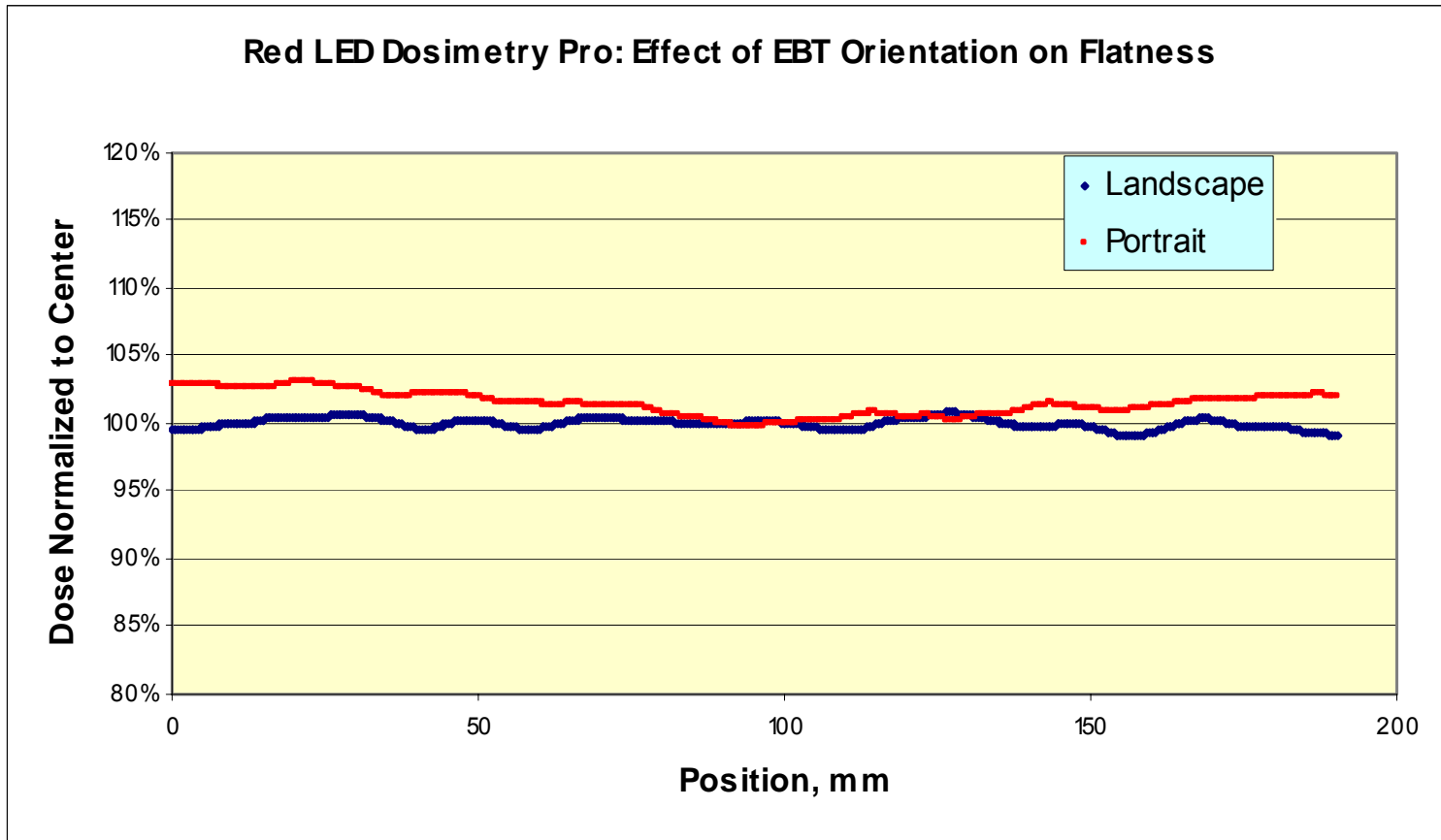
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# Profiles of Corrected Images

## Uniformly Exposed EBT Film on Red LED Scanner



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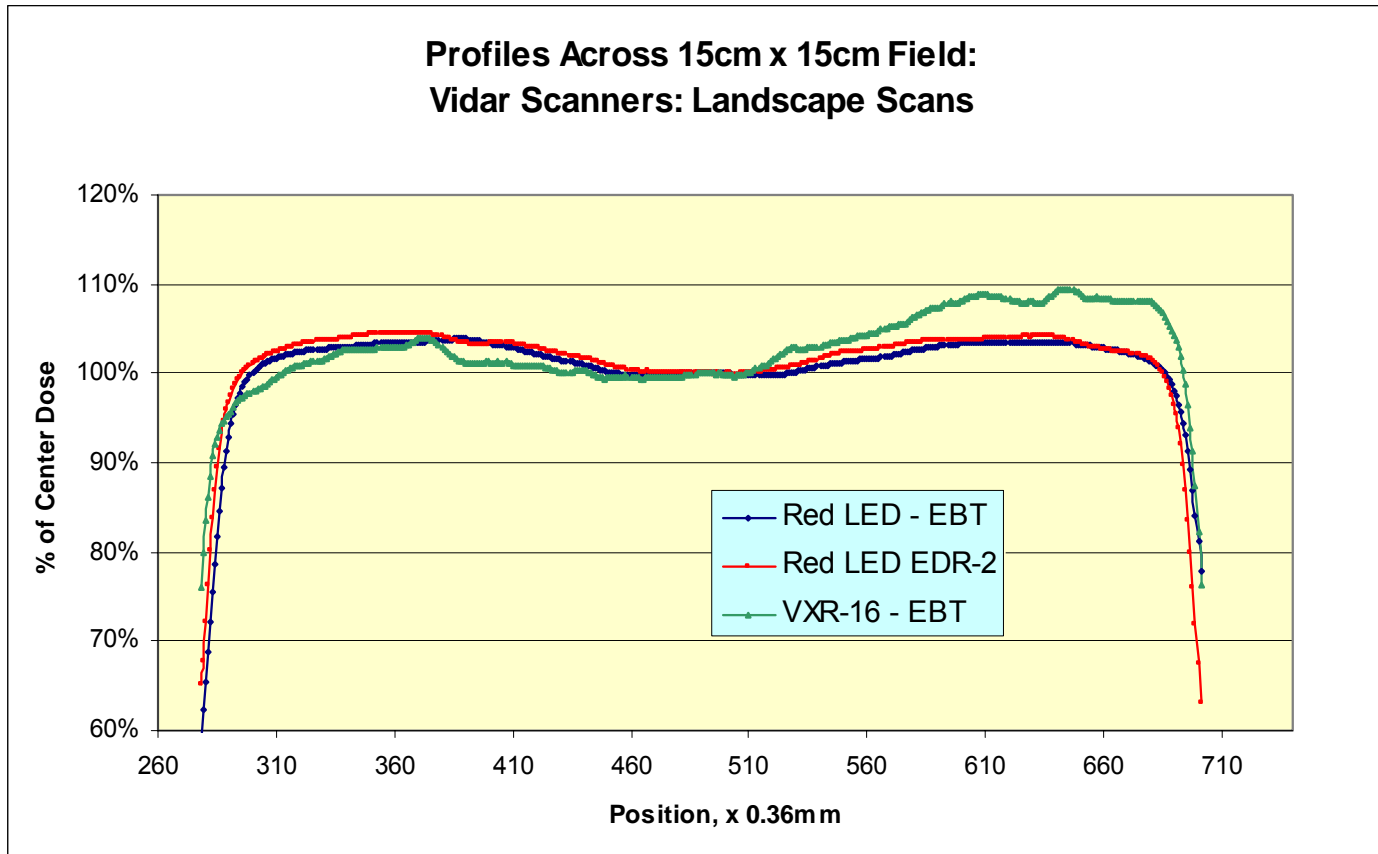
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# Profiles of Corrected Images

## 15cm x 15cm Flatfields on Vidar Scanners



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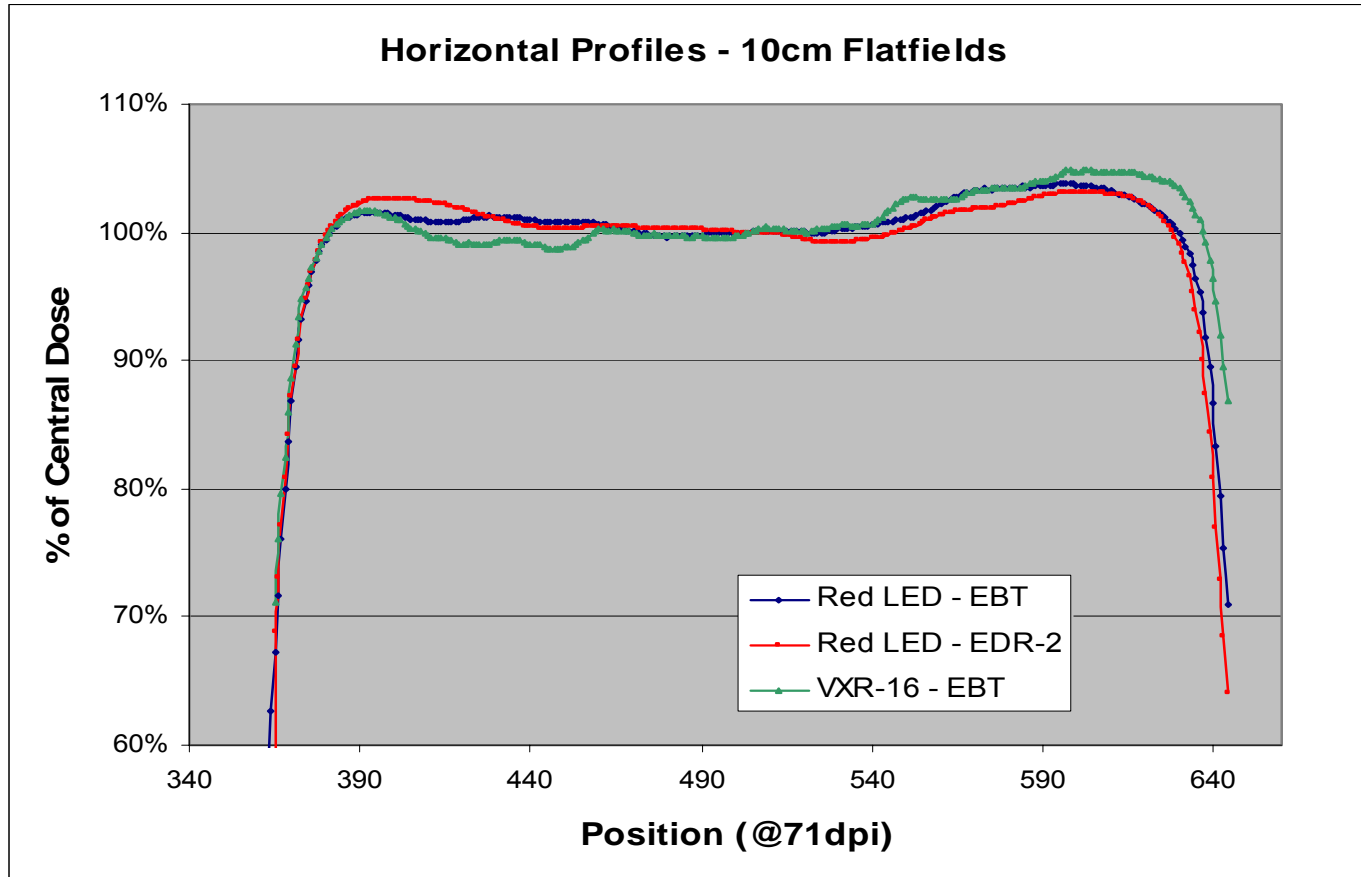
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# Profiles of Corrected Images

## 10cm x 10cm Flatfields on Vidar Scanners



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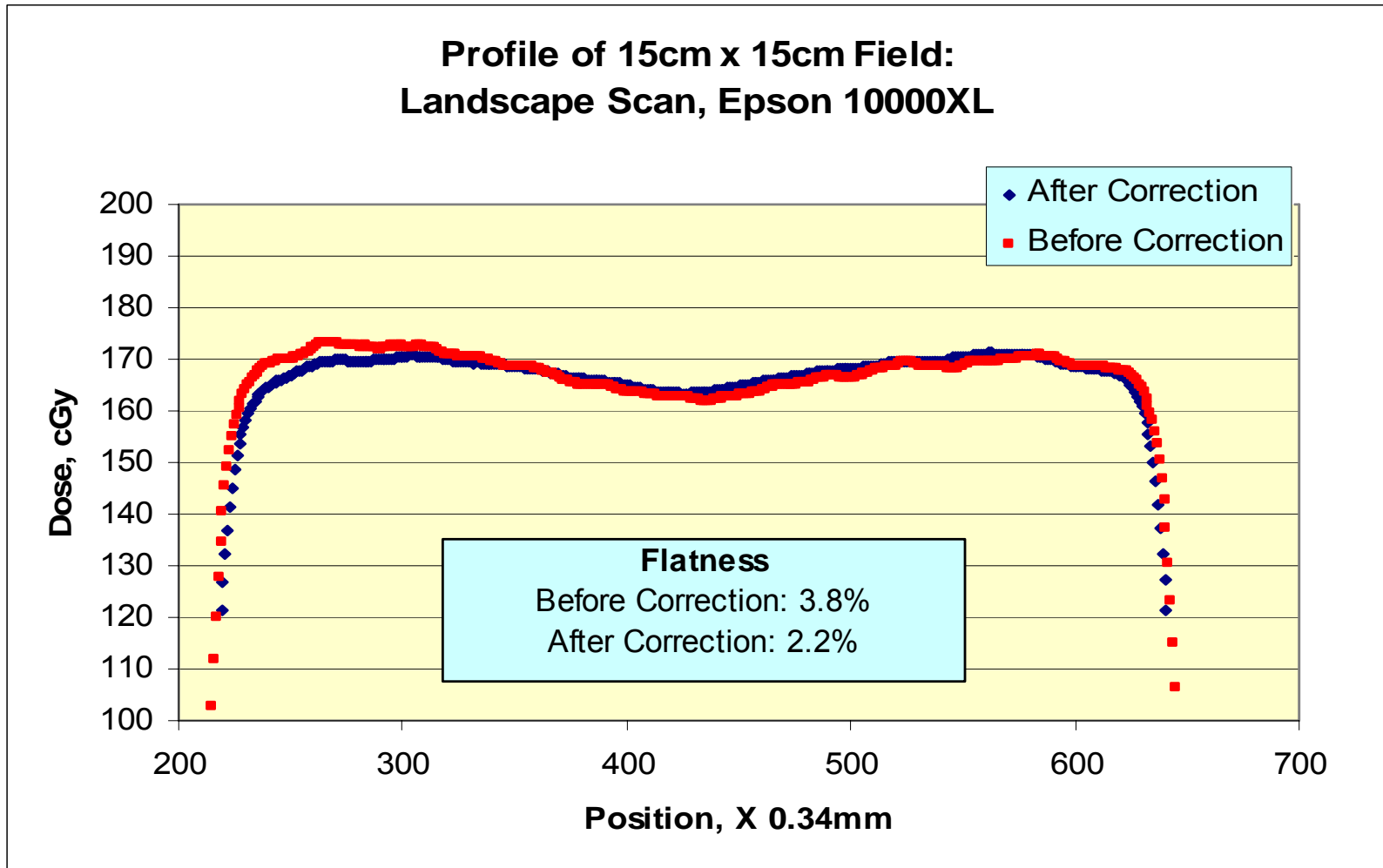
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# Profiles of Images

## 15cm x 15cm Flatfield on Epson 10000XL Scanner



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