Image Analysis of the Miller & Pellicori UV Fluorescence Images of the Turin Shroud

Samuel Pellicori

4/12/2020

Updated 10/5/2020

Objectives of the 1978 UV Fluorescence Investigation and Perspective

- Photography of the UV-induced fluorescence of the Turin Shroud was an important set of the optical investigations performed in 1978 (1).
- The objective was to determine if the optical properties, specifically fluorescent emission and UV absorption, could be useful in distinguishing the features and perhaps their origins.
- The spectral reflectance properties of the same features were simultaneously photoelectrically measured and reported in papers published in the peer-reviewed literature (2, 3, 4).
- Photographed fluorescent images of various areas have a visual greenish tone in qualitative agreement with the electronic spectra that also show higher fluorescence in the green-blue region (3)
- The data was (and is) used in lab simulations of body image, blood stains, scorches and burns, and water stains.
- Images recorded by Vern Miller were published on a web site (www.shroudphotos.com). However, the color rendition of the fluorescence photos do not match the original photos (1); they are shifted to the red, and thus do not display the true fluorescent properties of the various features. After notification, these photos are now labeled “UV photos”.
- An objective of this study is to assist in the correction of the original UV fluorescence photos to make information available that is otherwise obscured.

References to the Published Literature

1. Miller, V.D and Pellicori, S.F. : “Ultraviolet Fluorescence Photography of the Shroud of Turin”, J. Biological Photographers Assoc. 49, No. 3, 71 (1981).
2. Pellicori, S.F.: “Spectral Properties of the Shroud of Turin”, Appl Opt. 19, 1913-1920 (1980).
3. Roger. Gilbert and Marion. Gilbert, “Ultraviolet and Visible reflectance and fluorescence spectral of the Shroud of Turin”, Appl. Opt. 19, 1930-1936 (1980).
4. Jumper, J.J., Adler, A.D., Jackson, J.P., Pellicori, S.F., Heller, J.H., Druzik, J.R., “A Comprehensive Examination of the Various Stains and Images on the Shroud of Turin”, Archaeological Chem. III Adv. in Chem. Series, ACS (1984).

Objective of the Study is to Determine if the Spectral Discrimination Content of Features has been preserved in the web image scans

- Image analysis procedure:
- Copies of the Original Miller/Pellicori Fluorescence Image Transparences (labeled VM) were Digitized on an Epson V800 scanner at 8-bit RGB color depth at 1200 dpi.
- Copies of the D'muhala & Lavoire (D & L) web site: www.shroudphotos.com, were processed in the same way as the VM transparences.
- Main Image analysis and processing software was National Institutes of Health *Imagej 1.46r*. For some red-component images, contrast enhancements using Adobe Photoshop were done to permit contrast comparisons.

- Steps:
  - Crop, save as jpegs.
  - Plot intensity profile as computed over the image area
  - Separate R, G, B components
  - Ratio R, G, B to the colored (original) image to normalize (remove) the background intensity

Photoelectric Spectroscopy of the Reflectance and the Fluorescent Emission / Absorption of Cloth and Feature Details are Consistent with the Visual and Photographed Images

- Spectral reflectances and UV-induced fluorescent emissions of details were published [3].

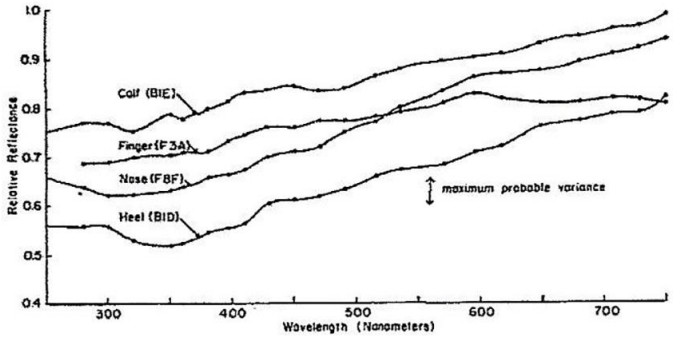


Fig. 10. Relative spectral reflectance of four body image areas on the Shroud (calf, finger, nose, and heel).

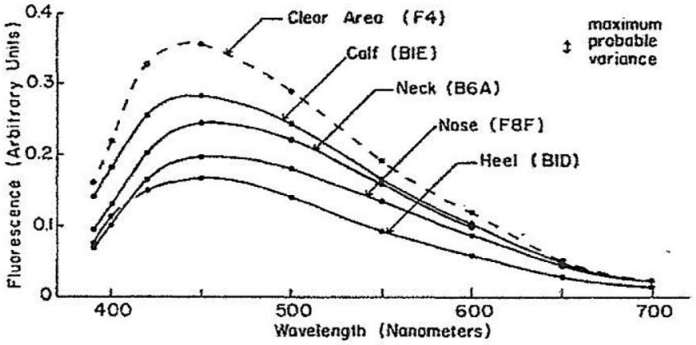


Fig. 11. Spectral fluorescence with excitation at 365 nm of four body image areas on the Shroud (calf, neck, nose, and heel) compared with one clear area.

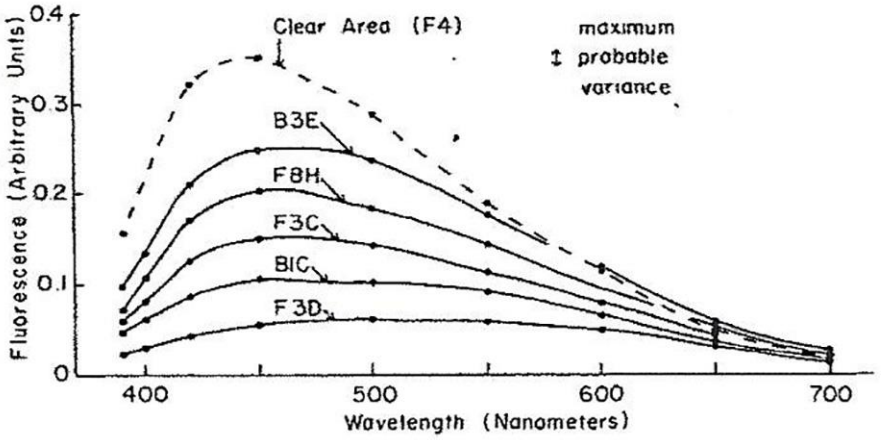


Fig. 13. Spectral fluorescences with excitation at 365 nm of six scorched areas on the Shroud compared with one clear area.

Reflectances are higher at long wavelengths where fluorescent emissions are lower.
All fluorescence emissions peak betw 450 and 550 nm, corresponding to the greenish visual color.
The relative spectral emission is different depending on feature

Photoelectric Spectroscopy of the Reflectance and the Fluorescent Emission / Absorption of Cloth and Feature Details are Consistent with the Visual and Photographed Images (cont)

- Spectral reflectances and UV-induced fluorescent emissions of details were published [3].

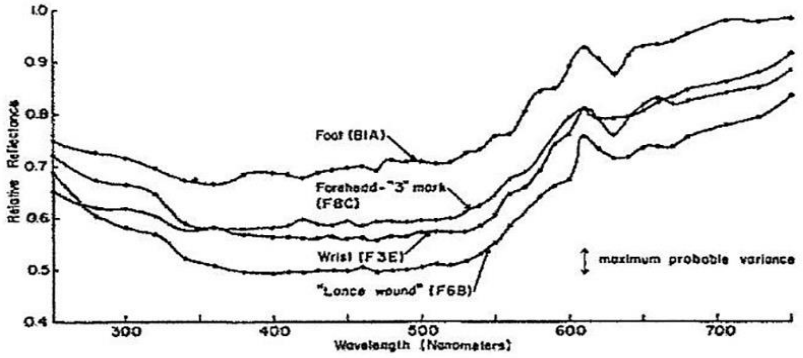


Fig. 16. Relative spectral reflectance of four bloodstained areas on the Shroud (foot, forehead-3 mark, wrist, lance wound).

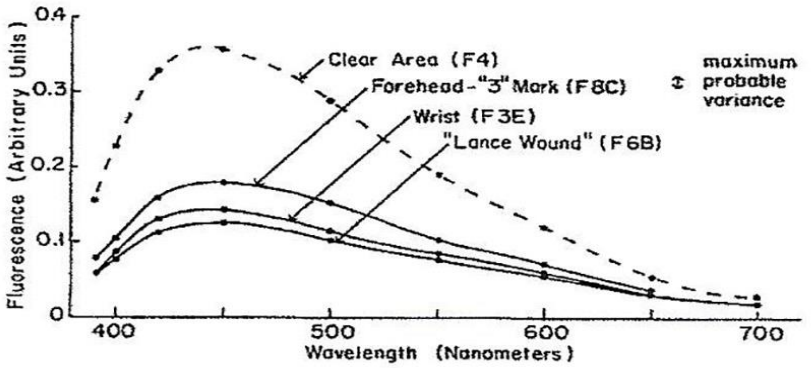


Fig. 17. Spectral fluorescence with excitation at 365 nm of three bloodstained areas on the Shroud (forehead-3 mark, wrist, and lance wound) compared with one clear area.

Blood absorbs green & blue. Features near 600 and 620 nm resemble the Soret porphyrin absorption band of hemoglobin.

Photoelectric Spectroscopy of the Reflectance Cloth and Feature Details

- Spectral relative reflectance ratios R/B emphasize the color differences among the features [2].
- R/B ratio indicates the excess of

  Red over blue. Hence, scorches are redder than body features which are redder than the clear cloth background.

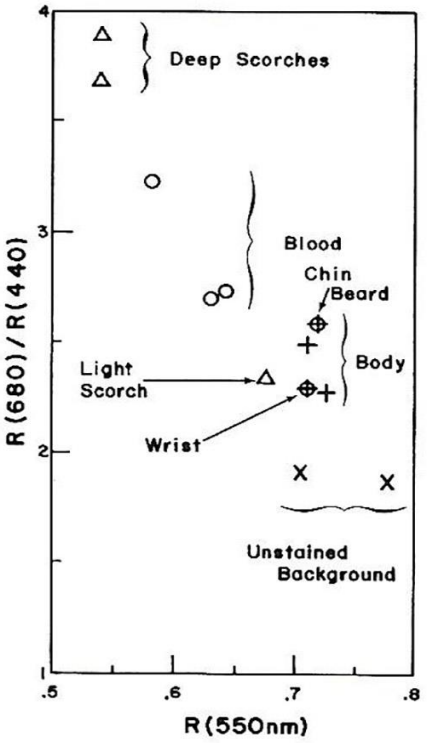
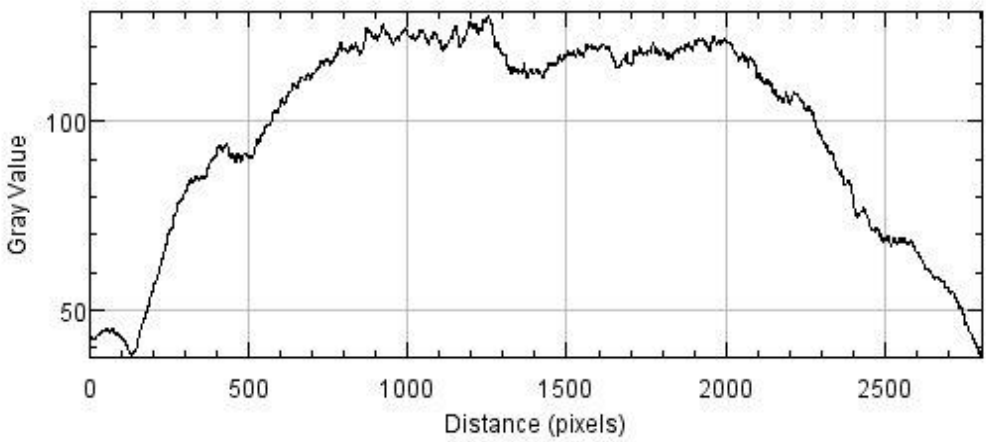


Fig. 3. Reflectance ratio of widely separated spectral points (440 and 680 nm) is plotted vs absolute reflectance at 550 nm. Grouping by stain type is evident. The darker the feature, the redder it is. Quick look spectrophotometer results.

15 June 1980 / Vol. 19, No. 12 / APPLIED OPTICS 1915

Head Front and Back UV Fluorescent Photo – Digitized 35mm Slide Copy from Miller



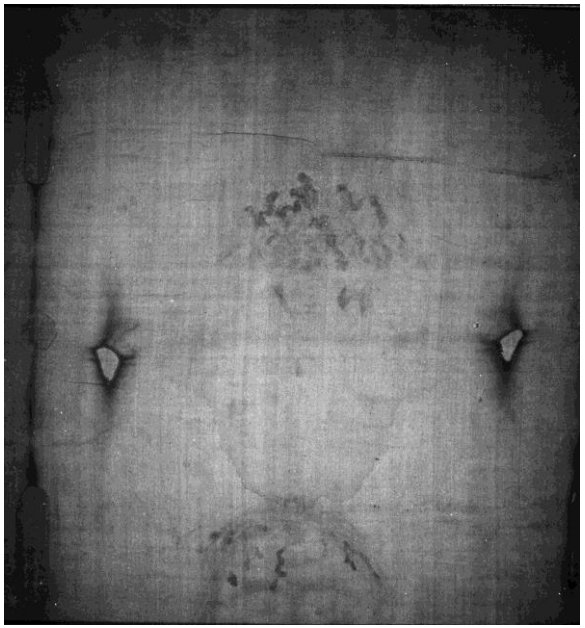
Area Intensity Profile shows
the non-uniform illumination. See ref 4..

Color differences between scorches, blood stains,
water border, and body image are apparent

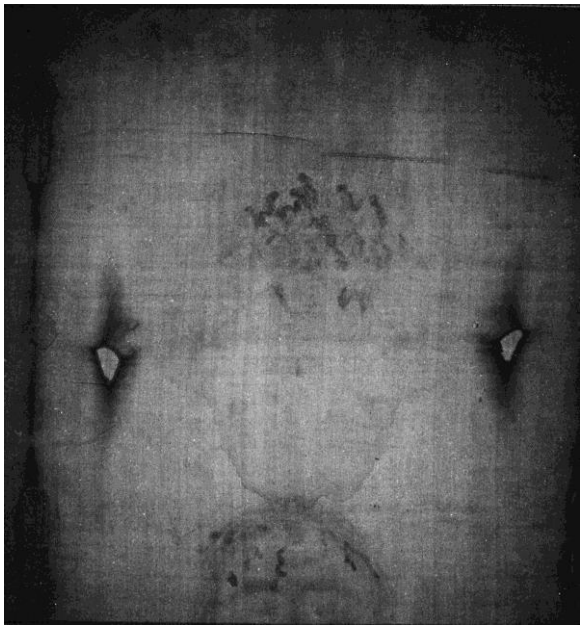
Separated R, G & B Components of the Head: VM Fluorescent Image:

Red

Green



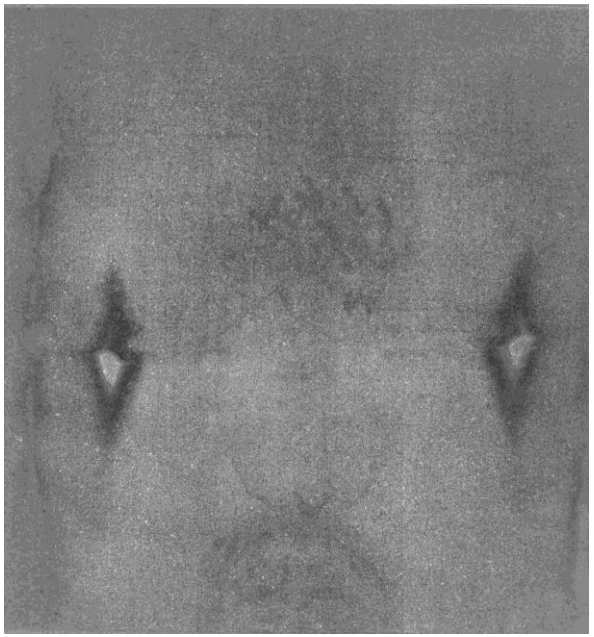
Blue



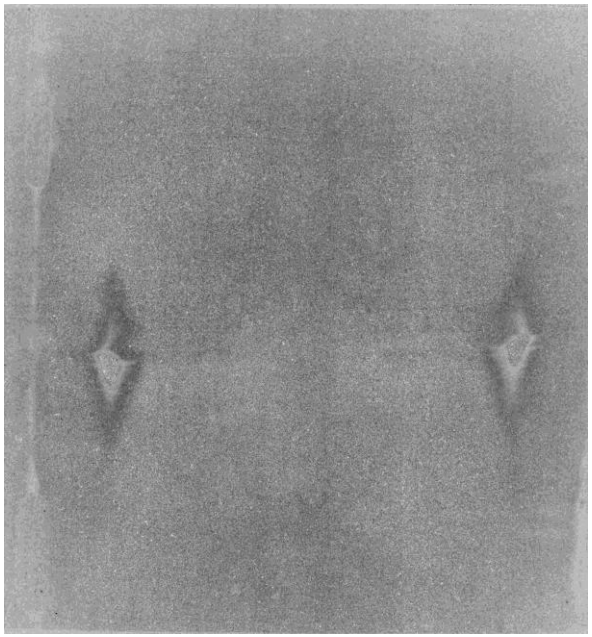
Fluorescence of the cloth is brightest in the Green component and lowest in Blue.
More absorption appears in the Blue wavelengths.
How does the contrast of the features vary with wavelength?

Head front & back: VM Color Components Subtracted

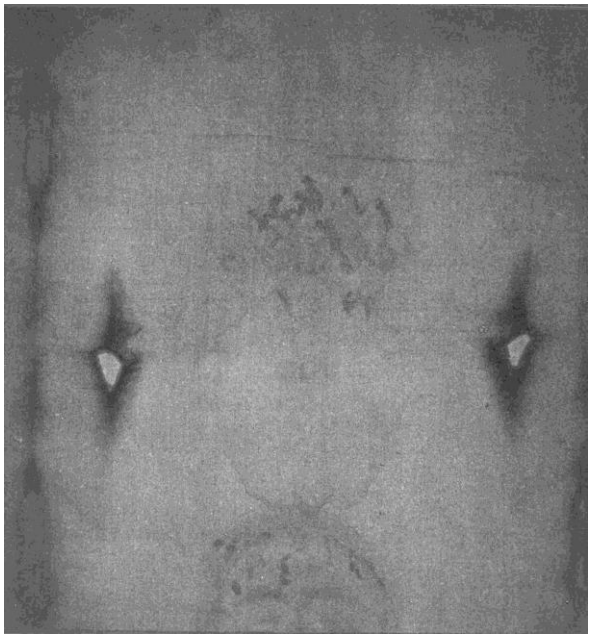
B-R



B-G

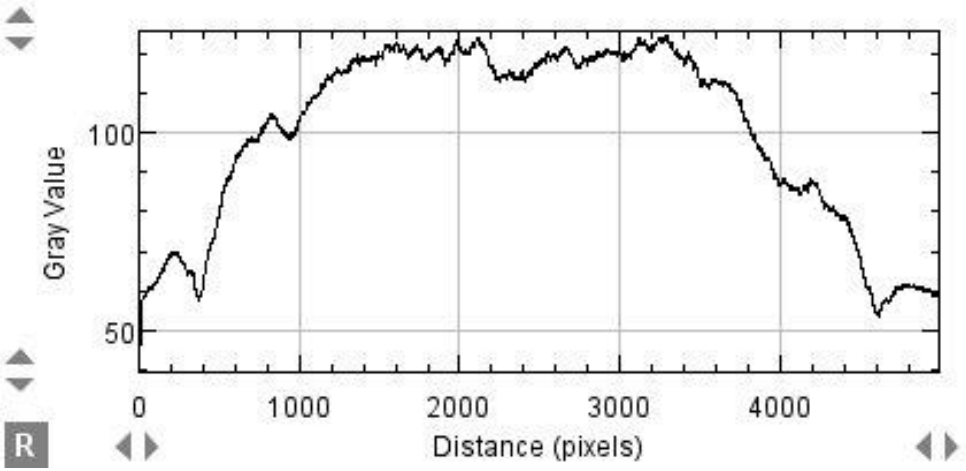


G-R



Greater contrast exists in the Blue component

Head Front and Back "UV Fluorescent Photo "– from D & L (shroudphotos.com)

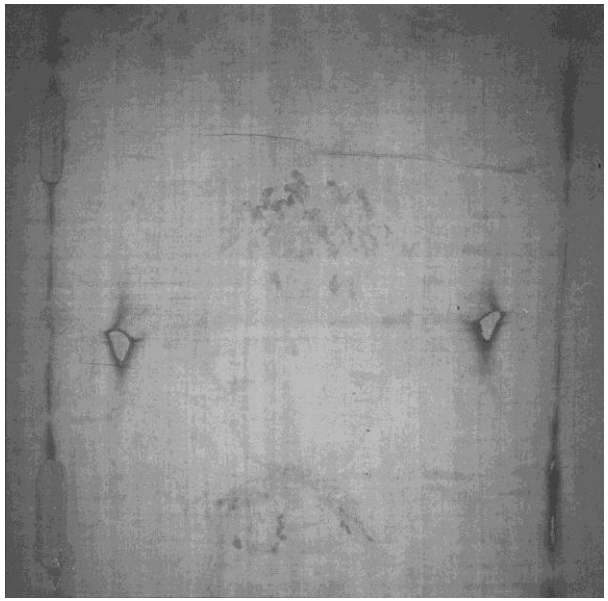


Area Intensity Profile shows
the non-uniform illumination. See ref 4..

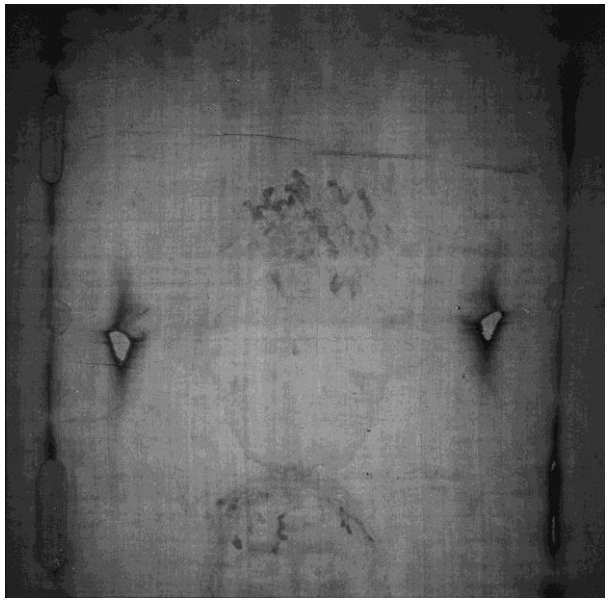
All features have a reddish-brown tint thereby disabling individual discrimination

Separated R, G & B Components of D & L (Web):

Red



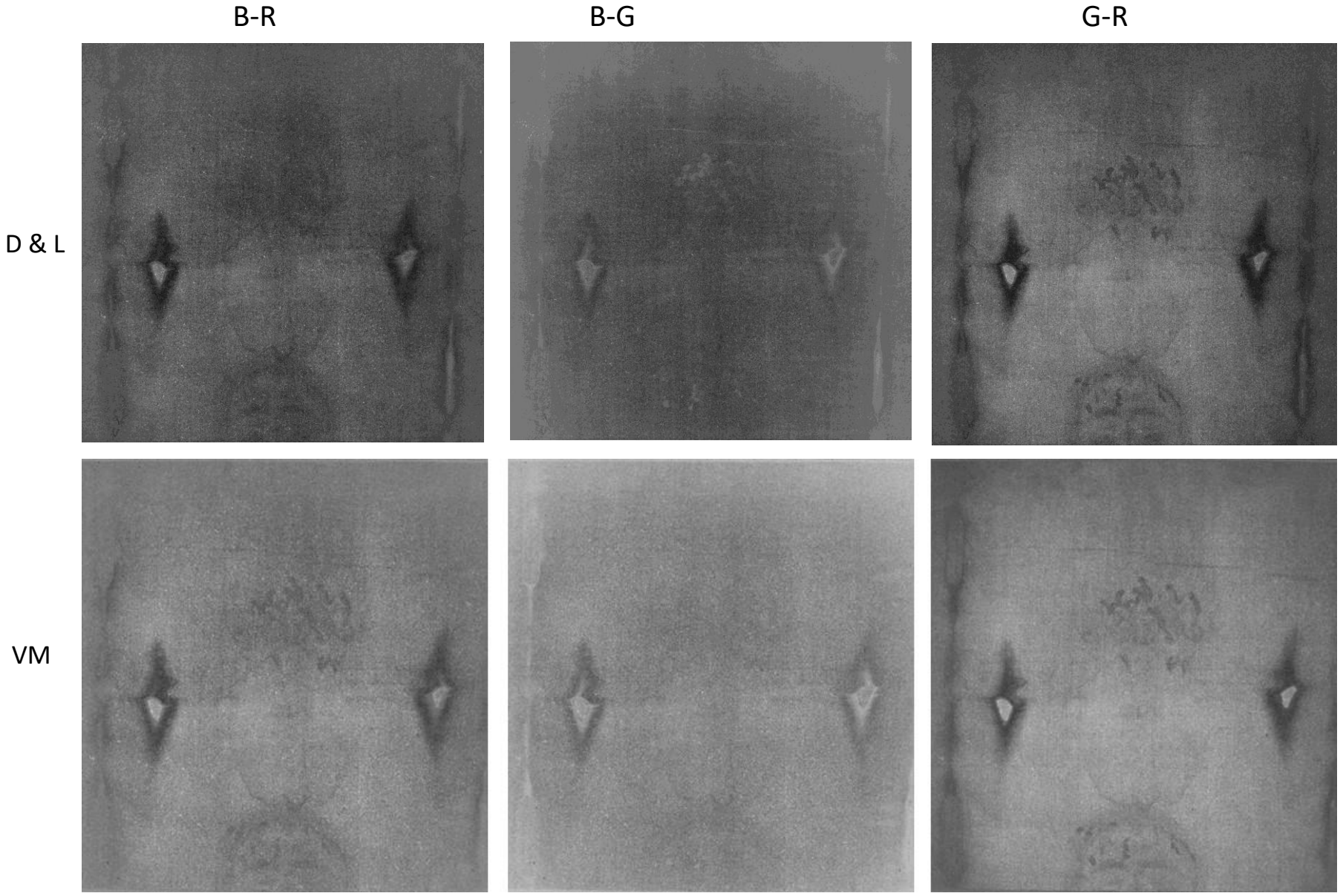
Green



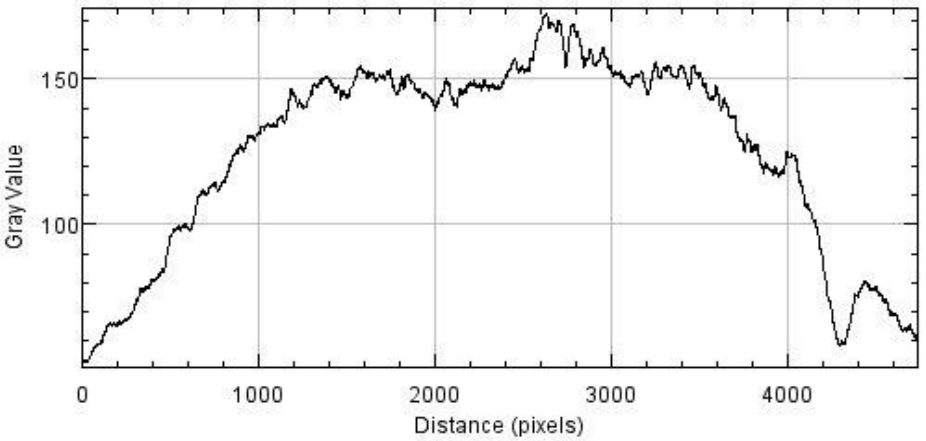
Blue

Fluorescence of the cloth is brightest in the red component and lowest in Blue.
More absorption appears in the Blue wavelengths.
How does the contrast of the features vary with wavelength?

Comparison: VM photos show larger color contrast against the background cloth



Feet: UV Fluorescent Photo - Digitized35mm Slide Copy from Miller

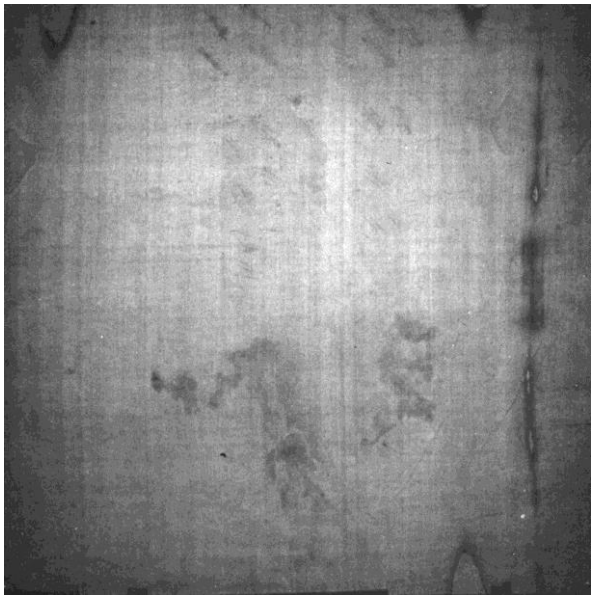


Area Intensity Profile shows
the non-uniform illumination. See ref 4..

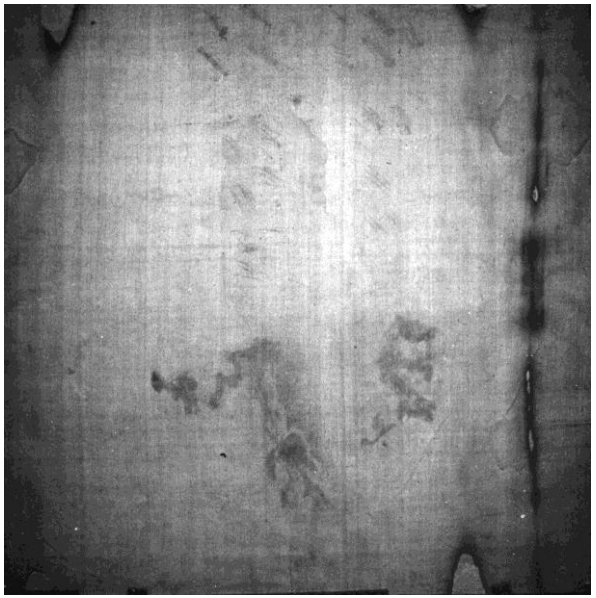
Color differences among the features are visible

Separated R, G & B Components of the Feet Fluorescent Image:

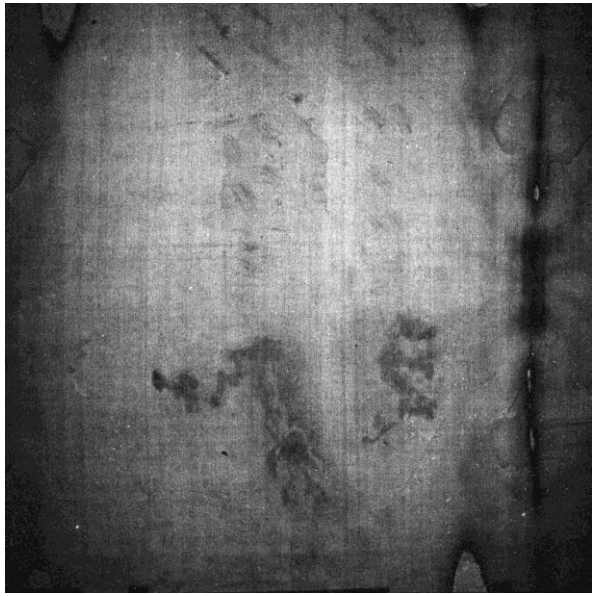
Red



Green



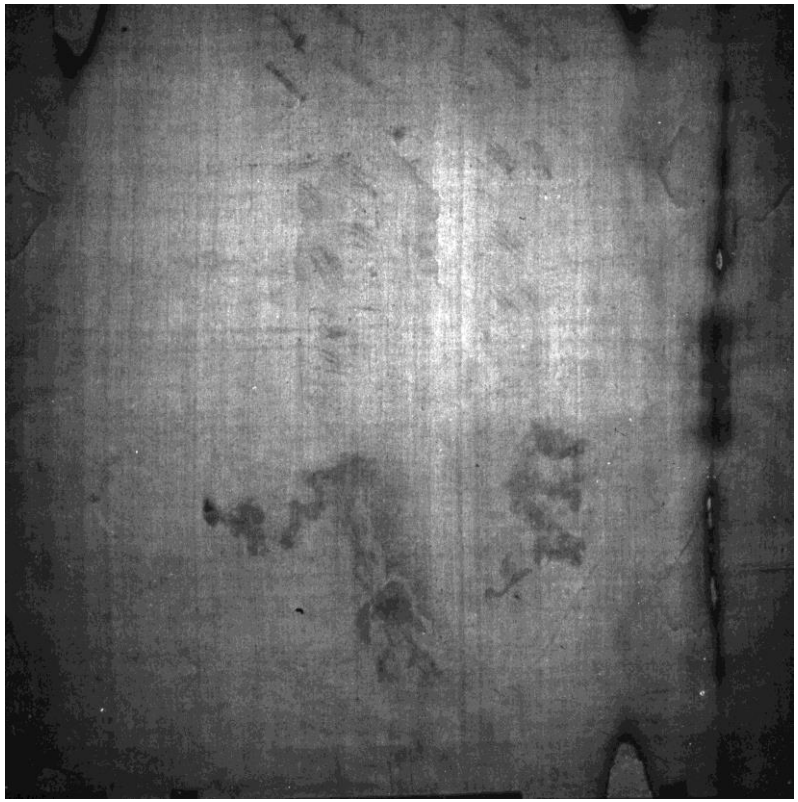
Blue

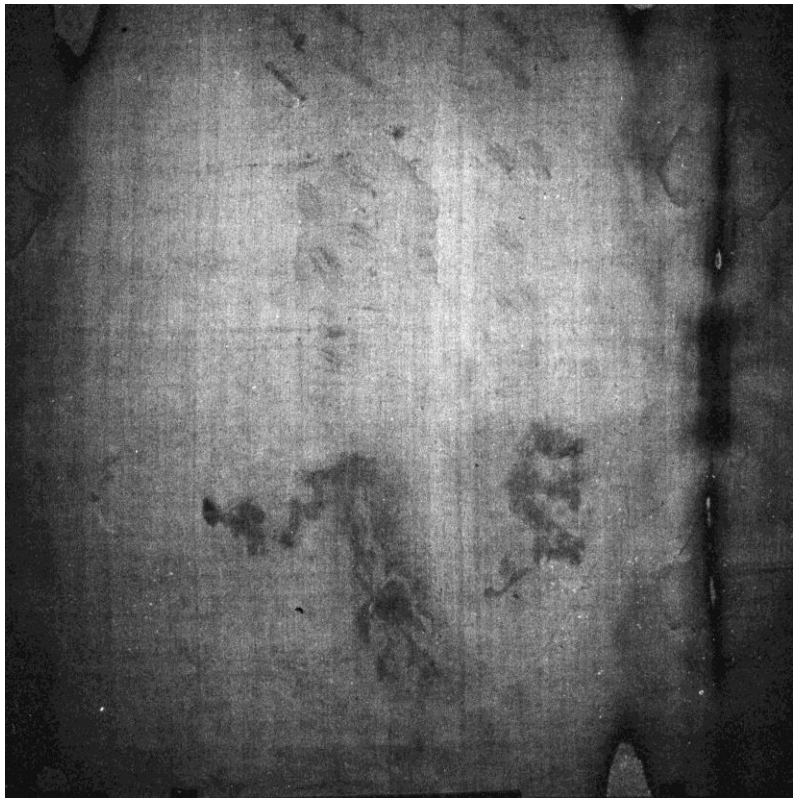


Fluorescence of the cloth is brightest in the Green component and lowest in Blue.
More absorption appears in the Blue wavelengths.
How does the contrast of the features vary with wavelength?

The Contrast between features and Background is Larger for the Blue Image

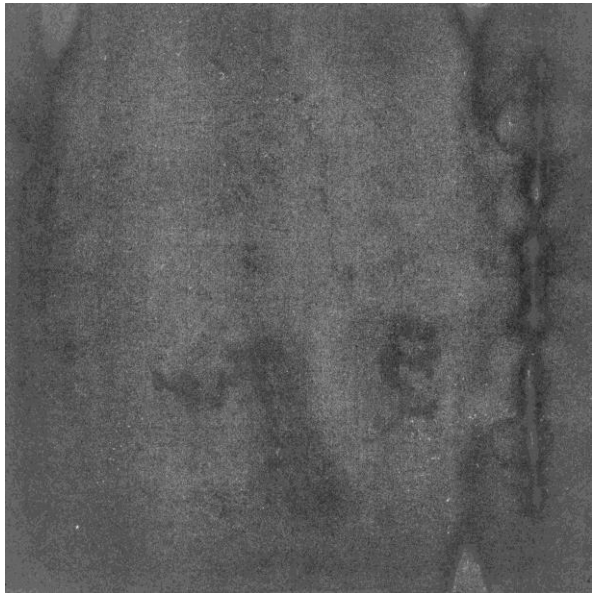
- To facilitate comparison, the brightness of the patches in the Green separation were made visually ~equal to the Blue image brightness.
- Slightly higher absorption in blood stains appears in the Blue image.
- Green darkened Blue



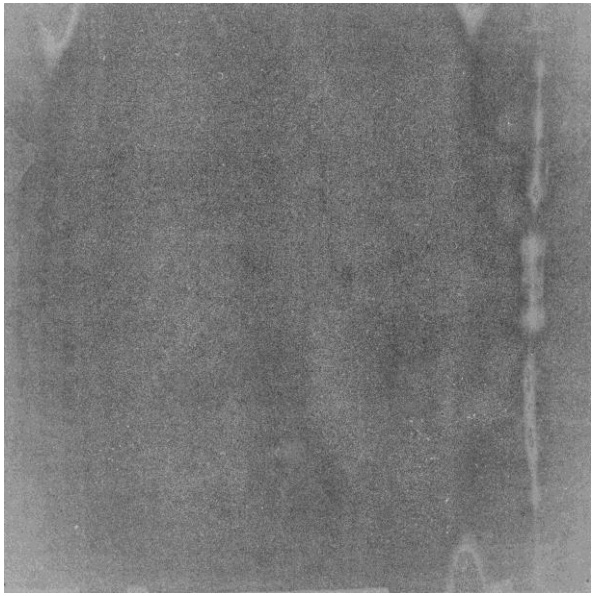


Feet: Color Components Subtracted

B-R



B-G

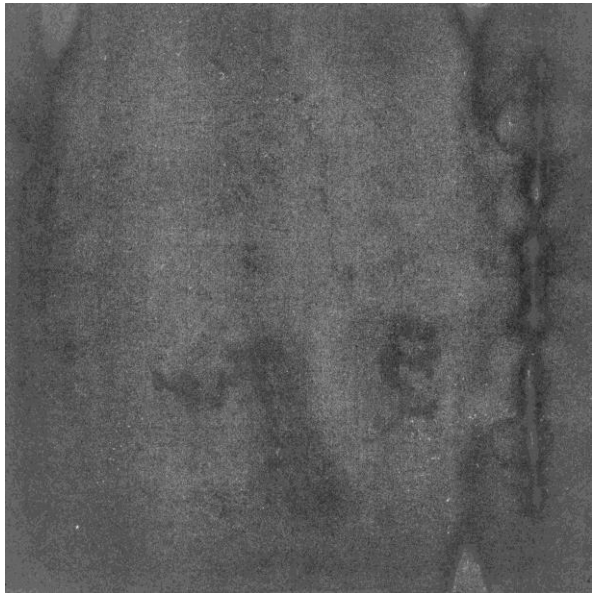


R-G

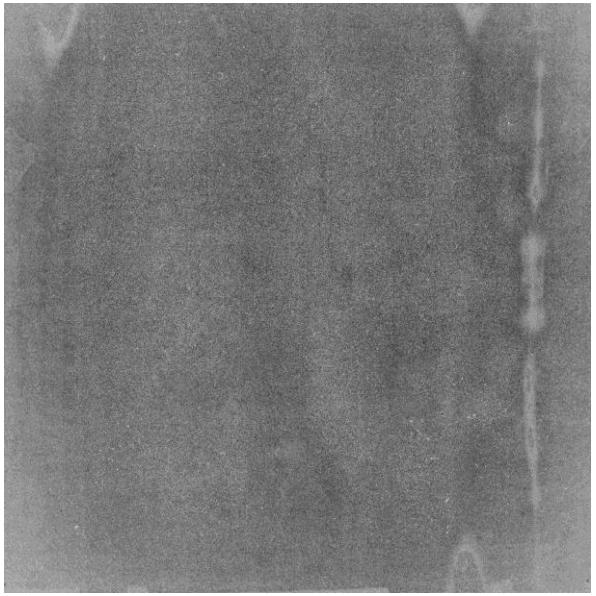
Blue component shows a higher color contrast against the Red component.

Feet: Color Components Subtracted

B-R

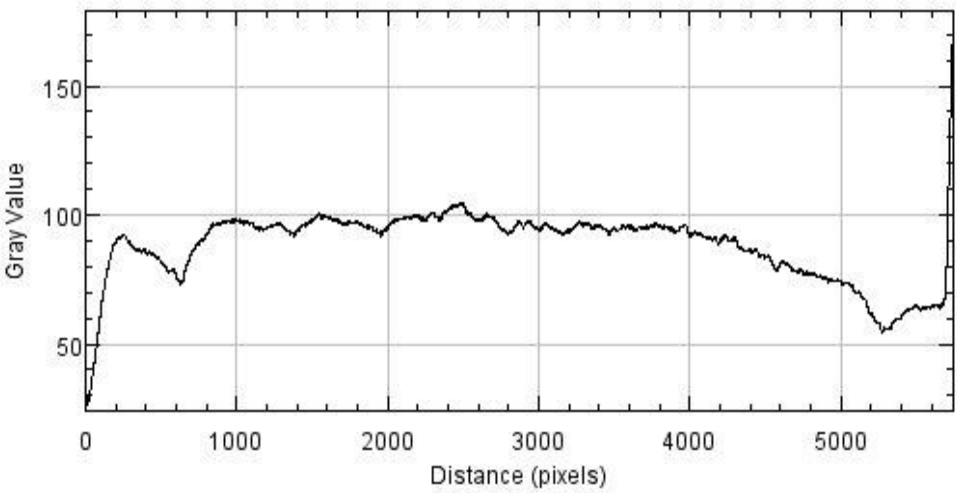


B-G



R-G

Dorsal Legs: "UV Image" D & L web site, Image 148 (B-E x 4-6)

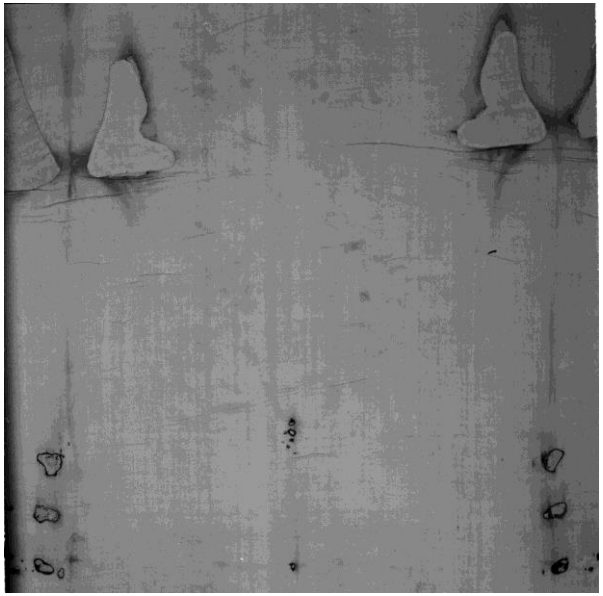


Area Illumination Intensity Profile is more uniform than that of the UV fluorescent image (pg. 22)

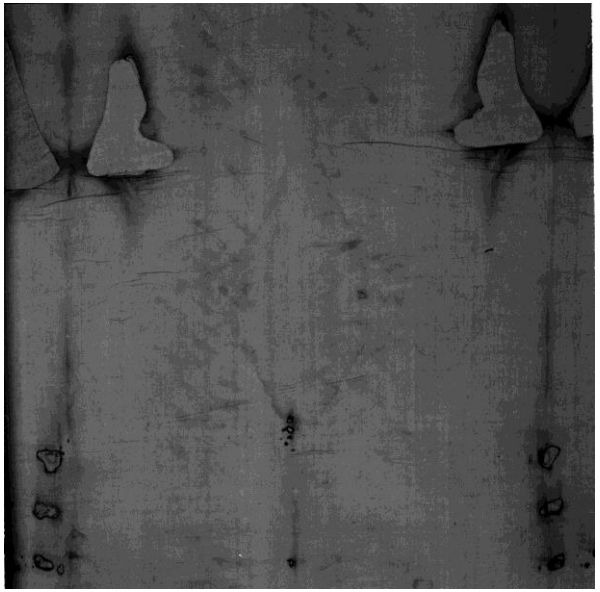
All features have a reddish-brown tint thereby disabling individual discrimination

Separated R, G & B Components of the Fluorescent Image from D & L. Features have Higher Contrast at the Shorter Wavelengths

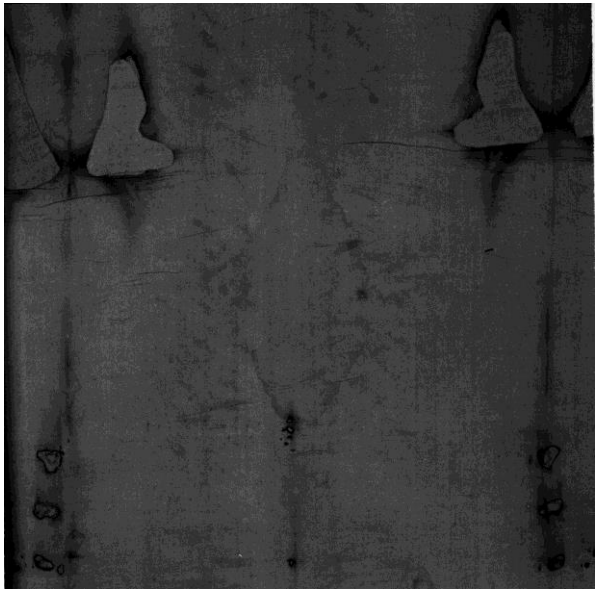
Red



Green



Blue

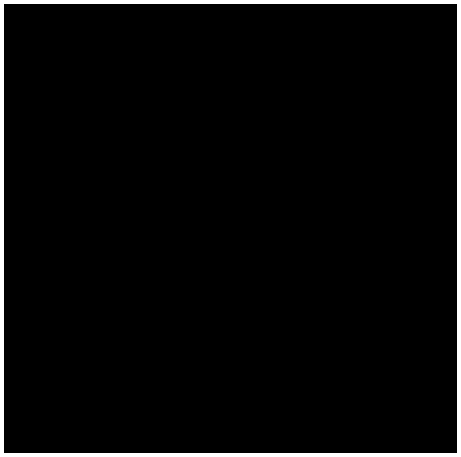


Fluorescence of the cloth is brightest in Red and lowest in Blue.

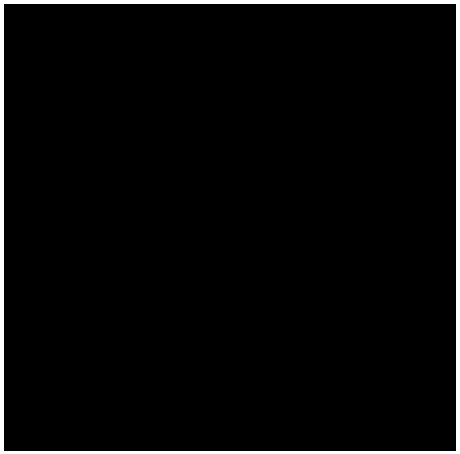
How does the contrast of the features against the background vary with wavelength?

Color Separation Subtractions (D & L)

B-R

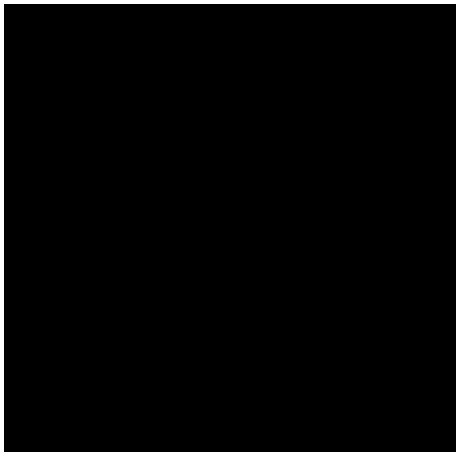


B-G



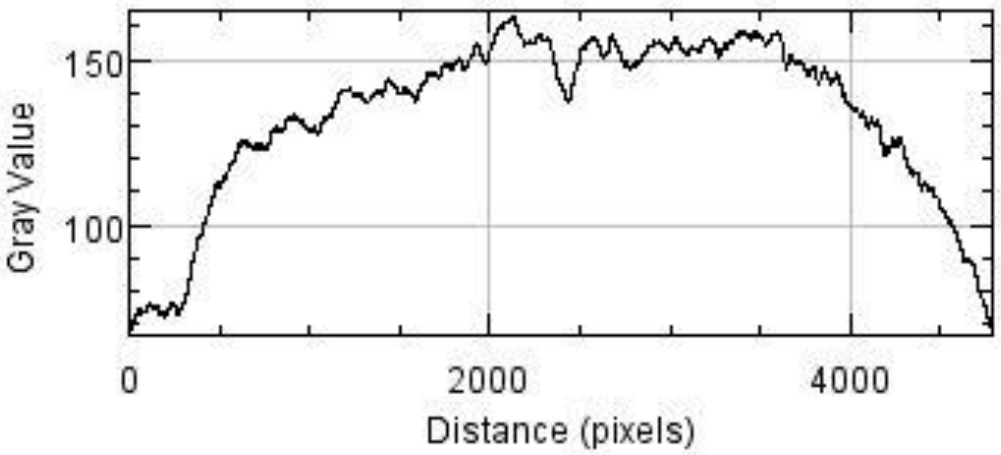
R-G

G-R



Except for faintly in R-g, color discrimination is absent

Dorsal Legs. Scan of UV fluorescence transparent slide copy (VM), section B-E x 4-6



Area Intensity Profile.

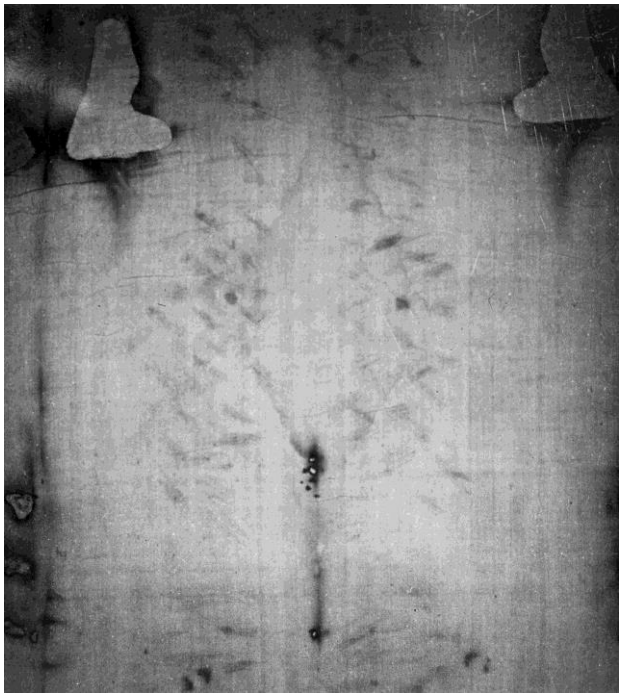
Bluish-green background (cloth)
Faint scorches: reddish.
Body markings: black (absorbing)

R, G & B Color Separations

Red

Green

Blue



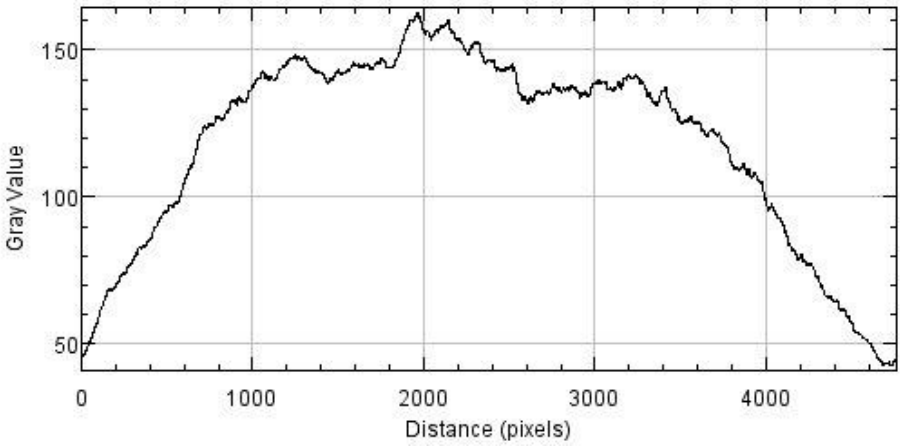
The red component shows features in the Red with higher contrast than D & L separation.

Color Separations Ratioed to Color Image and Normalized (web image)

Ratios: red / color | Green / color | blue / color

The red-ratioed image has been inverted because the colored image intensity is greater than the red component.
In the blue, body, water stains, blood and scorch features have greater contrast than the average background.

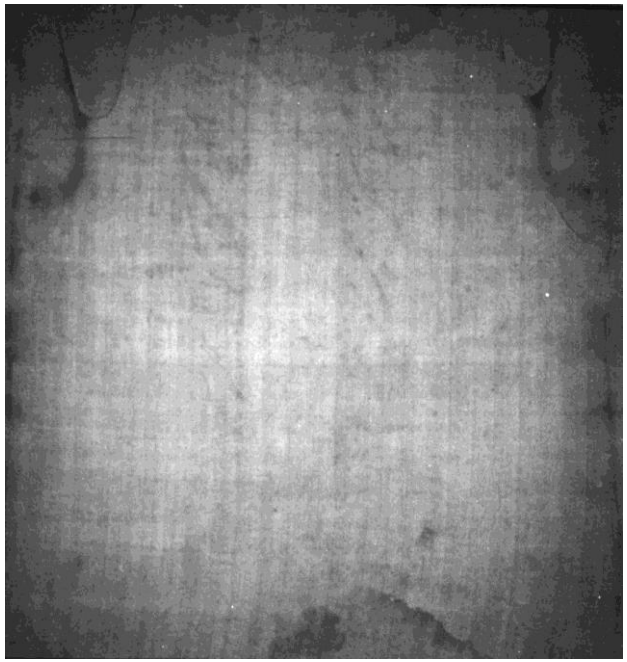
Frontal Legs *B-E x 19-22, Scan of UV Fluorescence Transparency Copy Provided by Miller*



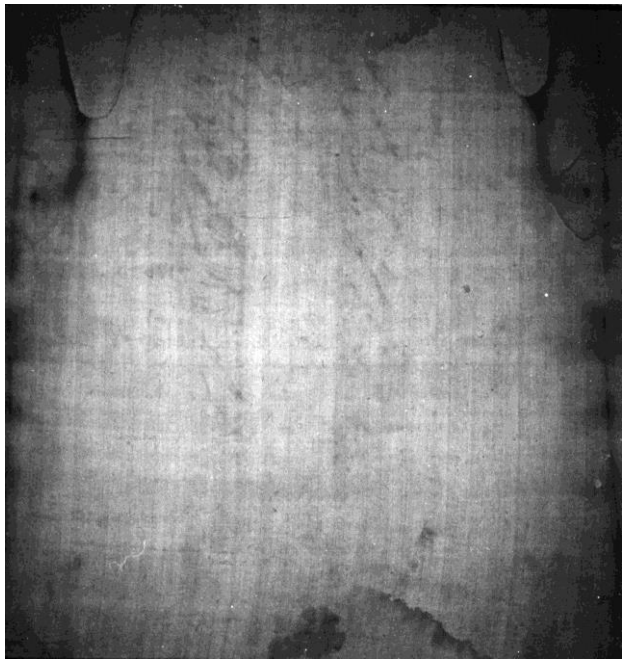
Intensity profile in the image area
Shows non-uniform UV lighting profile over the image area

R, G & B Color Separations

Red



Green



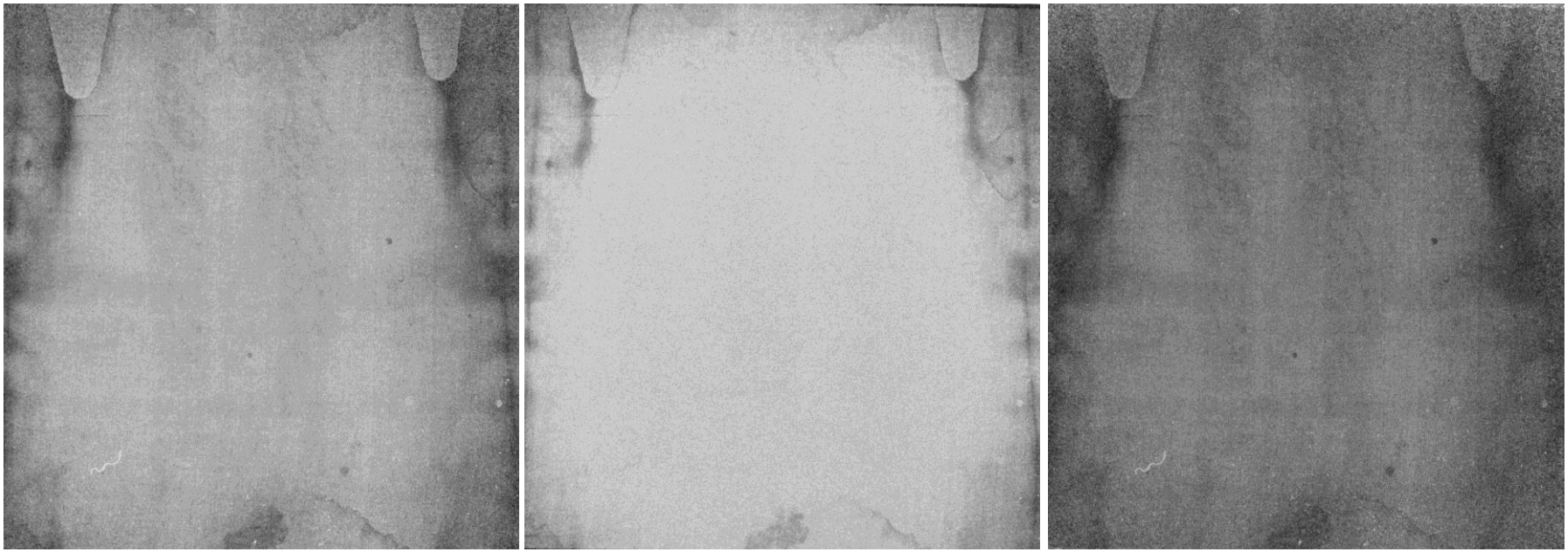
Blue

Fluorescence intensity of the cloth is brightest in Red & Green and lowest in Blue.

How does the contrast of the features against the background vary with wavelength?

Color Component Separations Ratioed to the Color Image to Remove the Background

Ratios: red / color | Green / color | blue / color

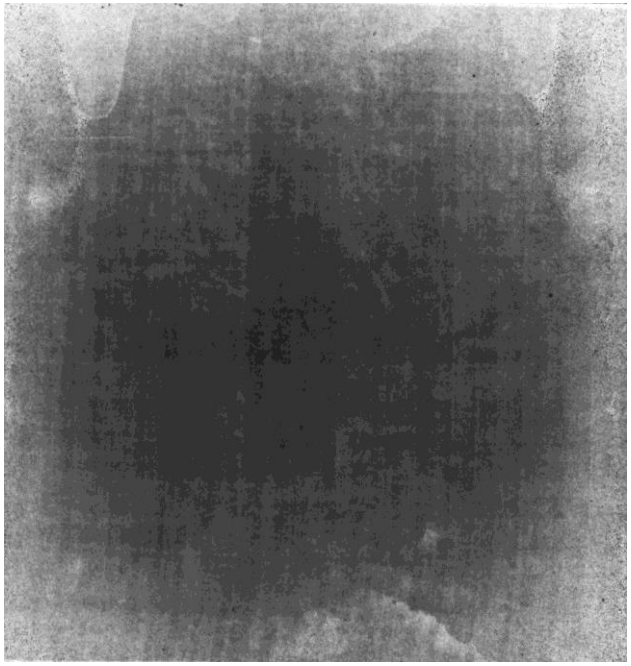


The green-fluorescing component is brightest; Body markings disappear.
Blue component intensity is lowest and features apparently show greater contrast .
The ratioing of the red separation produced an inverse image, Photoshop was used to invert the image for comparison to G and B.

Is the apparent Greater Contrast in the Blue Component Actually Higher?

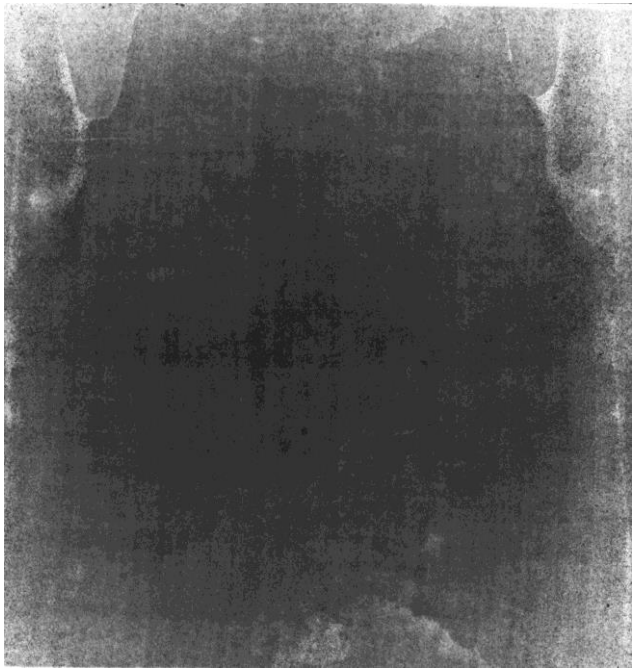
The previous normalized images were brightened in Photoshop

Brightened 150

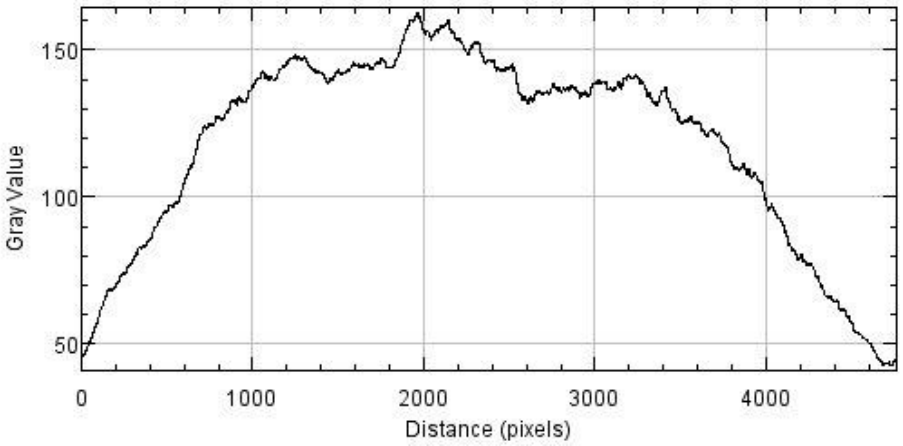


150

250



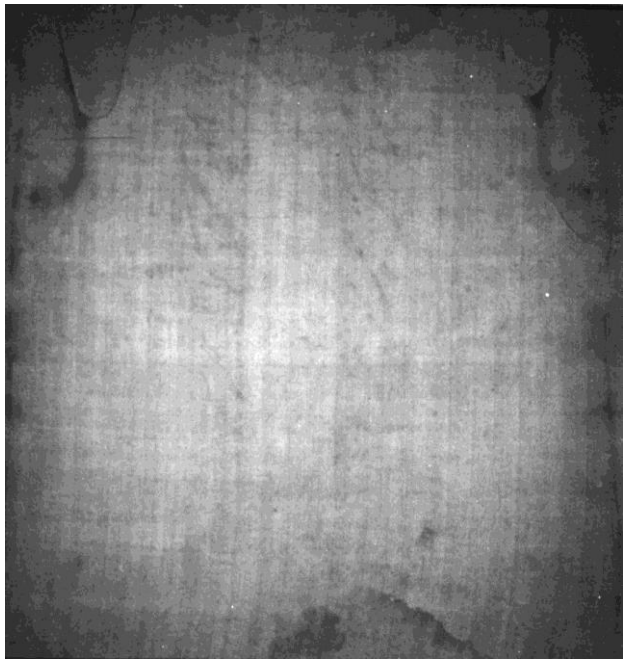
Frontal Legs *B-E x 19-22, Scan of UV Fluorescence Transparency Copy Provided by Miller*



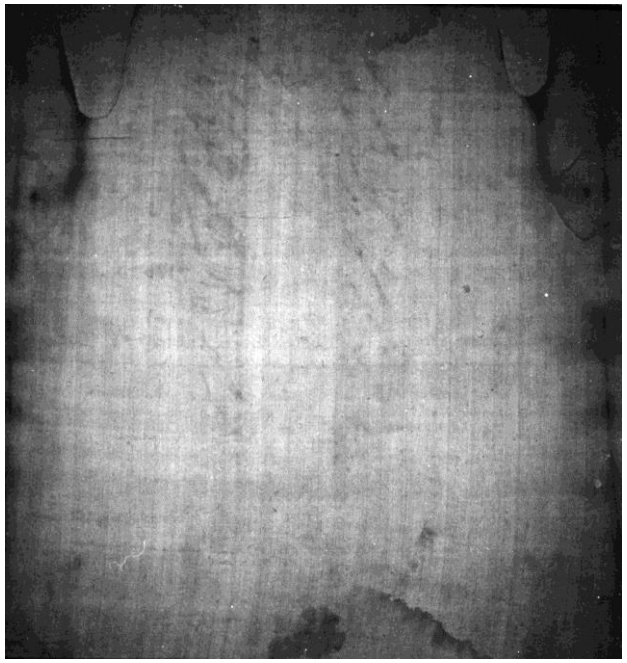
Intensity profile in the image area
Shows non-uniform UV lighting profile over the image area

R, G & B Color Separations

Red



Green



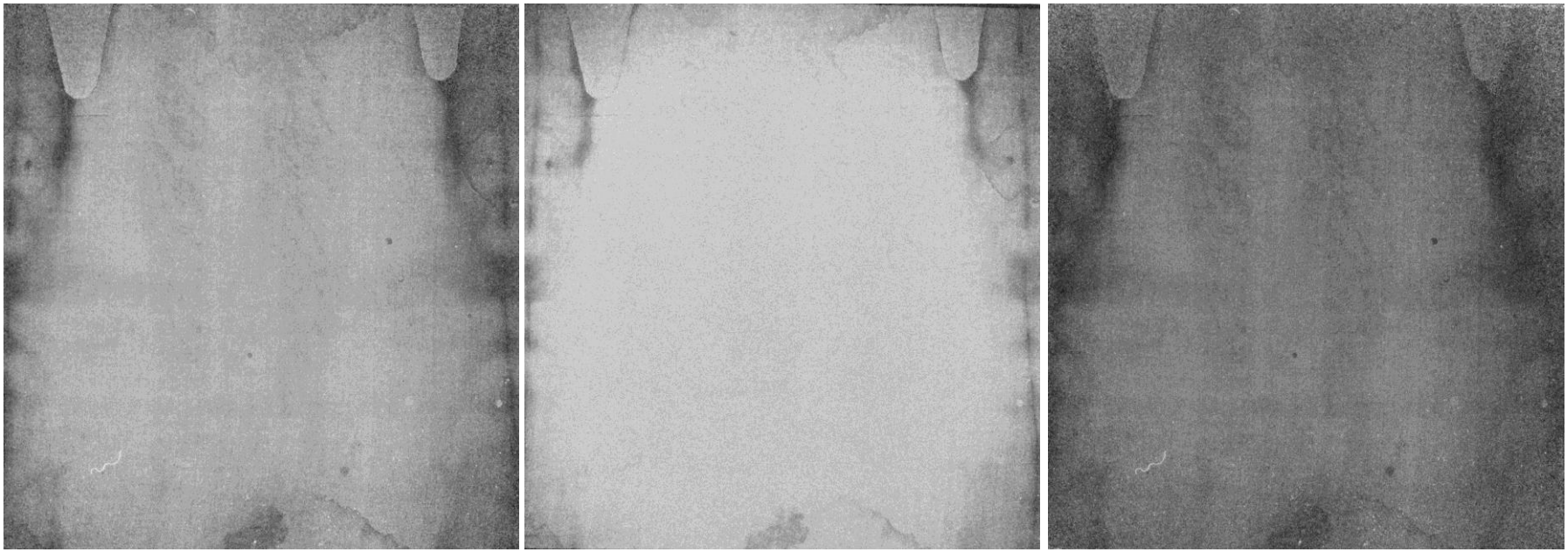
Blue

Fluorescence intensity of the cloth is brightest in Red & Green and lowest in Blue.

How does the contrast of the features against the background vary with wavelength?

Color Component Separations Ratioed to the Color Image to Remove the Background

Ratios: red / color | Green / color | blue / color

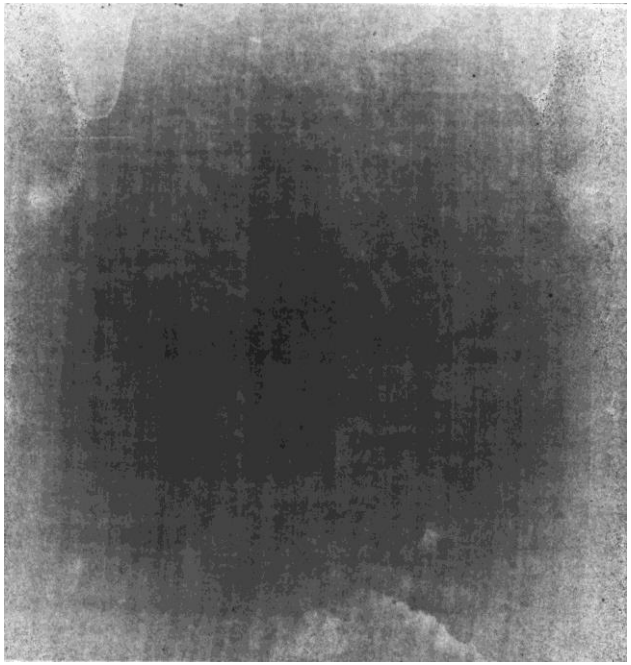


The green-fluorescing component is brightest; Body markings disappear.
Blue component intensity is lowest and features apparently show greater contrast .
The ratioing of the red separation produced an inverse image, Photoshop was used to invert the image for comparison to G and B.

Is the apparent Greater Contrast in the Blue Component Actually Higher?

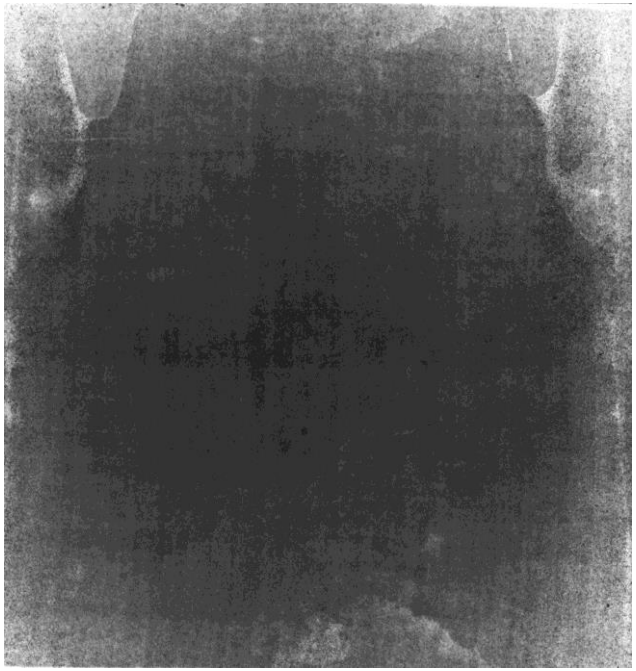
The previous normalized images were brightened in Photoshop

Brightened 150

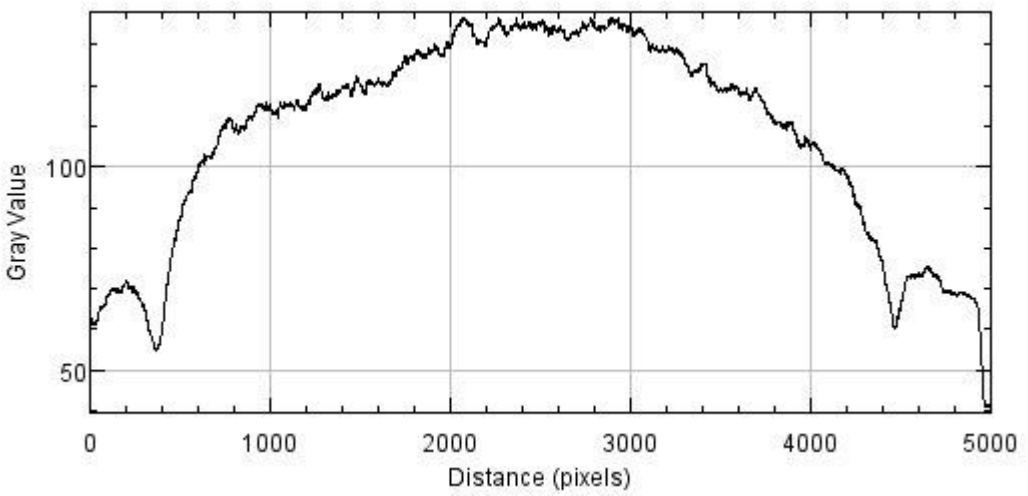


150

250



Folded Arms 7c-uv-S3-17 (B-E x 16-19) from Web site shroudphotos.com
Processed Similarly to Miller photos

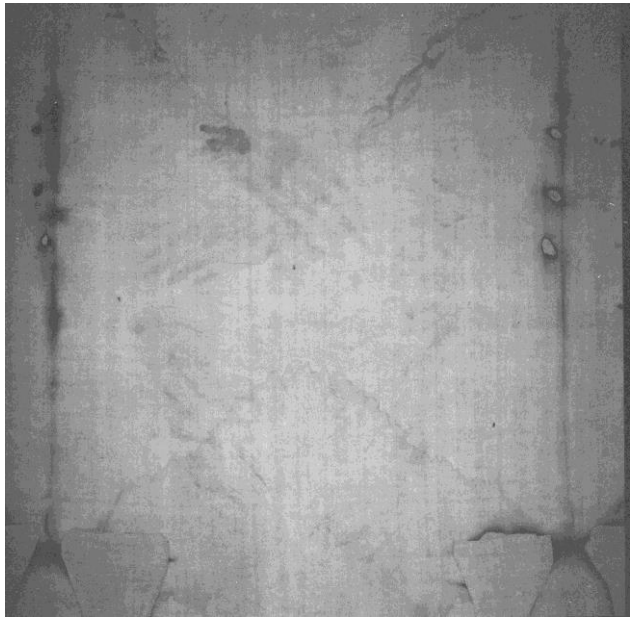


Intensity area profile

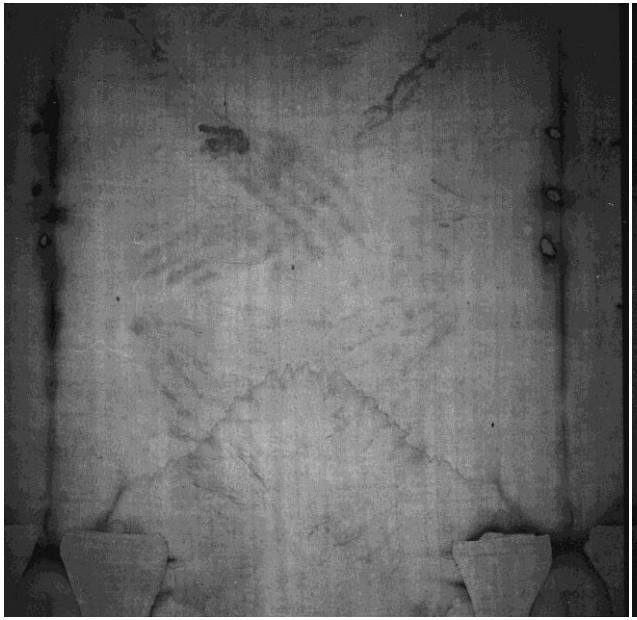
All features have a reddish-brown tint thereby disabling individual discrimination

Separated R, G & B Components of the Fluorescent Image from the Web site

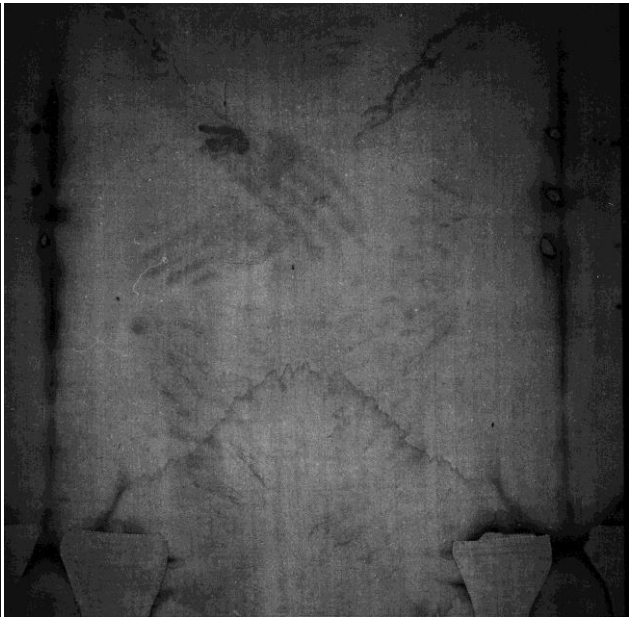
Red



Green



Blue

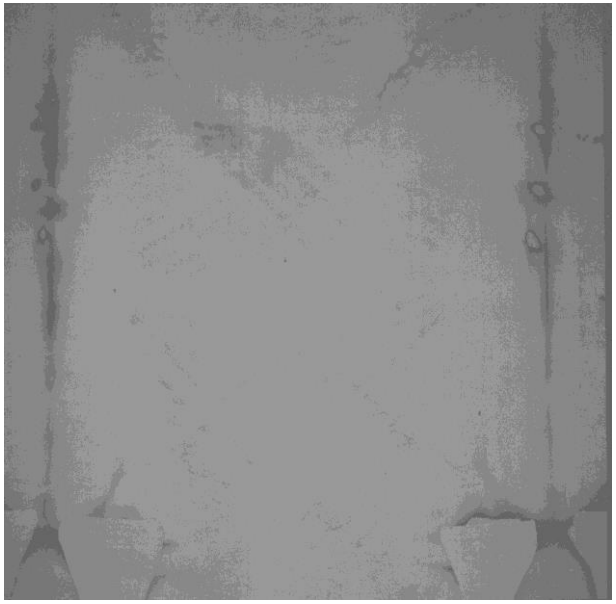


Blue component intensity is lowest and features apparently shows greater contrast .

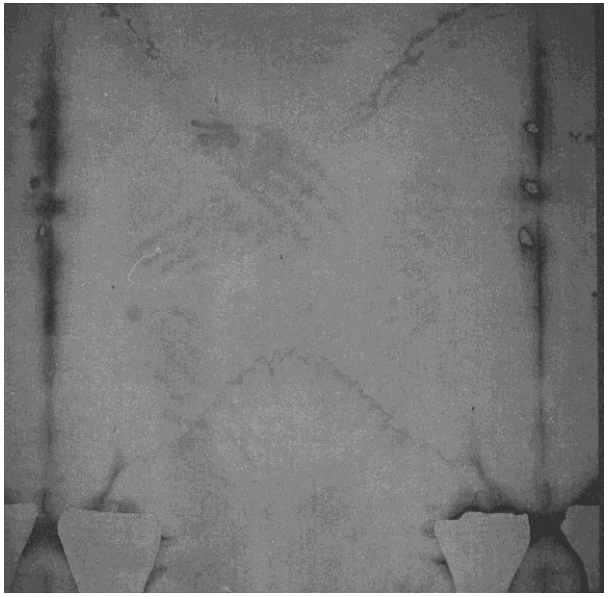
Color Separations Ratioed to the Color Image to Remove the Background (web image)

Red / color

Green/ color

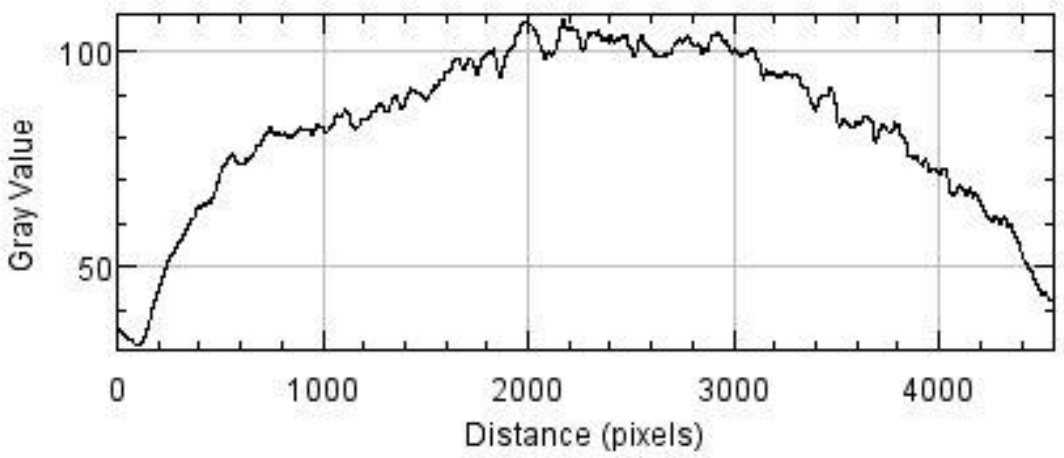


Blue / color



Color component features show low contrast.
The ratioing of the red separation produced an inverse image, Photoshop was used to invert the image here for comparison to G and B.

Folded Arms: scanned copy of Miller UV Fluorescence Transparency

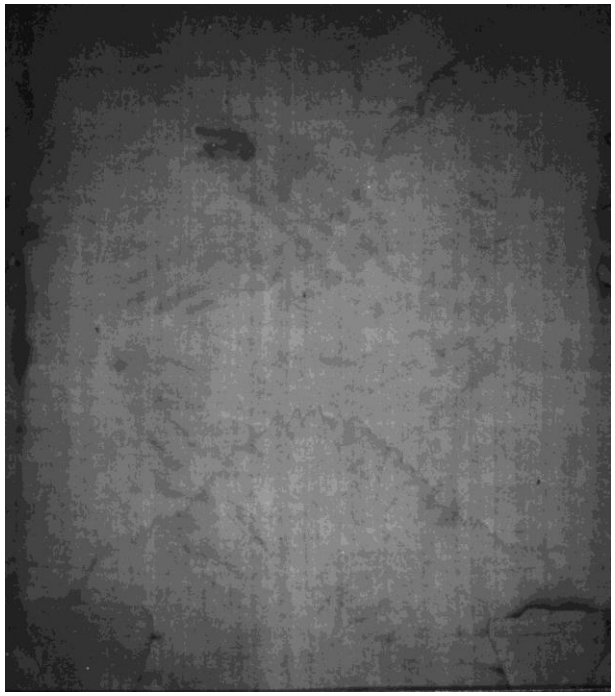


Intensity area profile

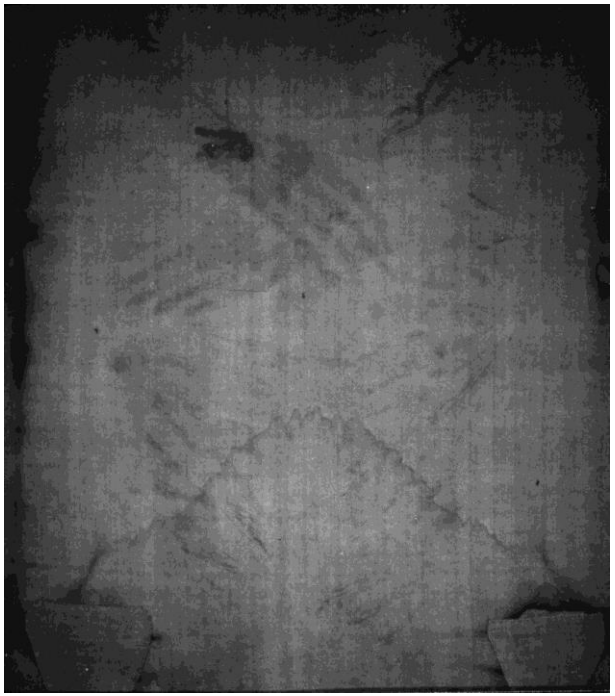
A (subtle) color contrast between body, blood, and scorch features is visible

Separated R, G & B Components of the Fluorescent Image from Miller Transparency

Red



Green



Blue

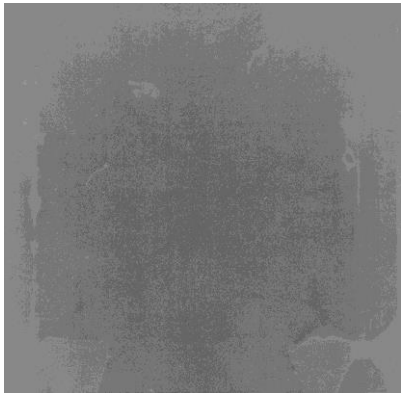
There is a different color separation contrast compared with the web rendition.
Blue component intensity is lowest and features apparently show greater contrast .

Comparison: VM photos show larger color contrast discrimination against the background

- B-R B-G R-G R-B
- VM



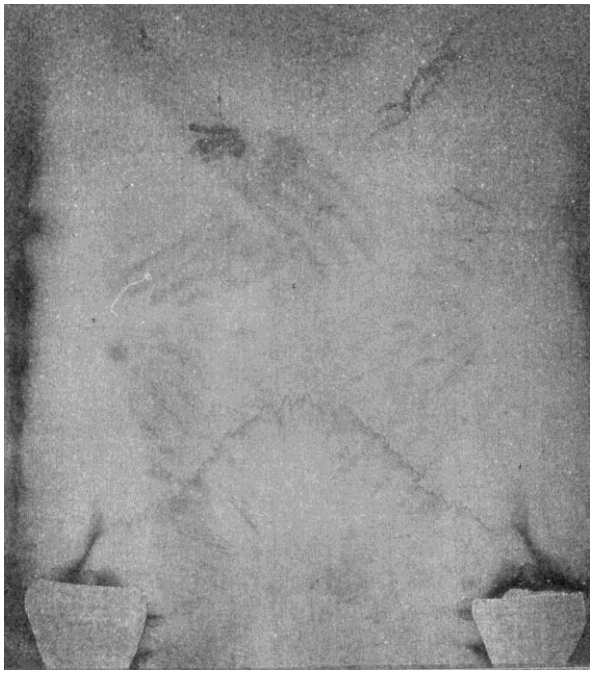

- D & L

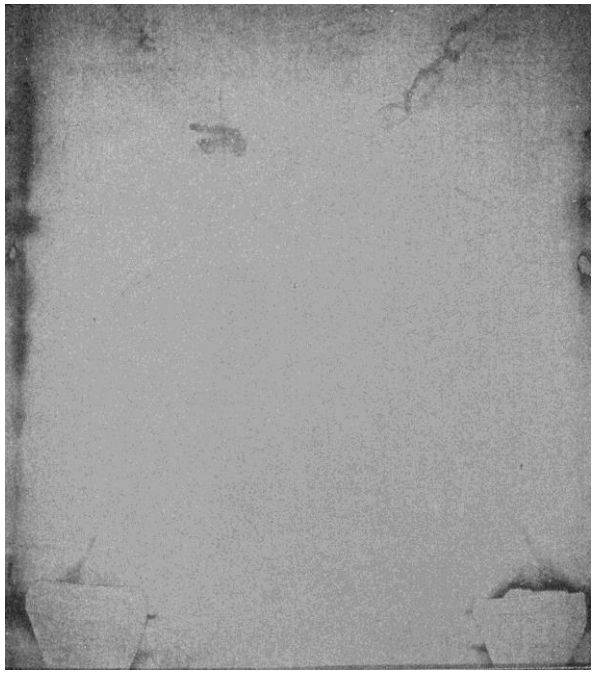
Greater color contrast info exists in the VM photos than in the D & L scans

Color Separations Ratioed to the Color Image to Remove the Background

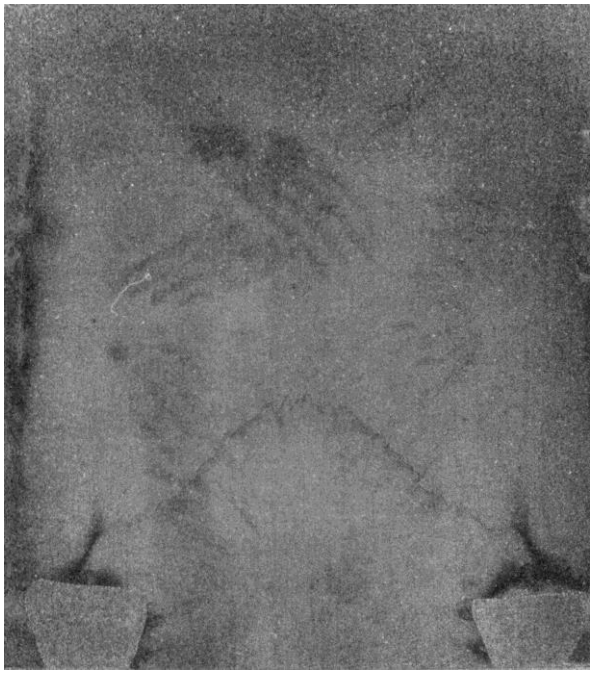
Red / color



Green/ color



Blue / color



Blue component features apparently show greater contrast .
The ratioing of the red separation produced an inverse image, Photoshop was used to invert the image here for comparison to G and B.

Observations

- Color-difference information is contained in the Miller/Pellicori fluorescent images. The differences are visually evident in the original images.
- The spectral differences have been quantified by fluorescence spectrophotometry [3, 2].
- The contrast differences among the colors as quantified are small but appear with image processing.
- The color rendition of the shroudphotos.com website images of the UV fluorescence photos is shifted to the red, thus obscuring the visual color differences that are associated with characteristic fluorescent spectral properties of different features.
- Those images are being reprocessed; until they are replaced with properly processed images, the D & L “UV photo” images should be used with caution.