Could a burst of radiation create a Shroud-like coloration?

Summary of 5-years experiments at ENEA Frascati

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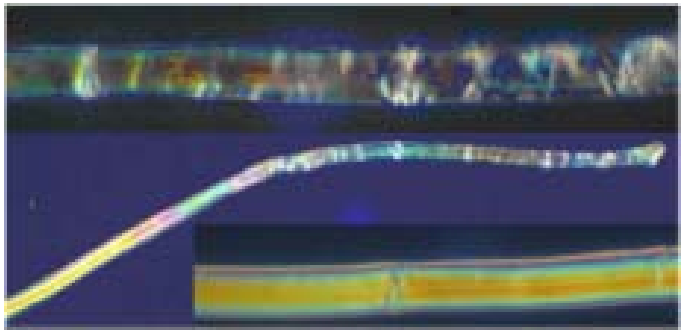

Outline

- **The body image on the Shroud**
- **Chemistry-based attempts**
- **Radiation-based attempts, our results**
- **Conclusion**
- **Appendix (Shroud vs. optical illusions)**

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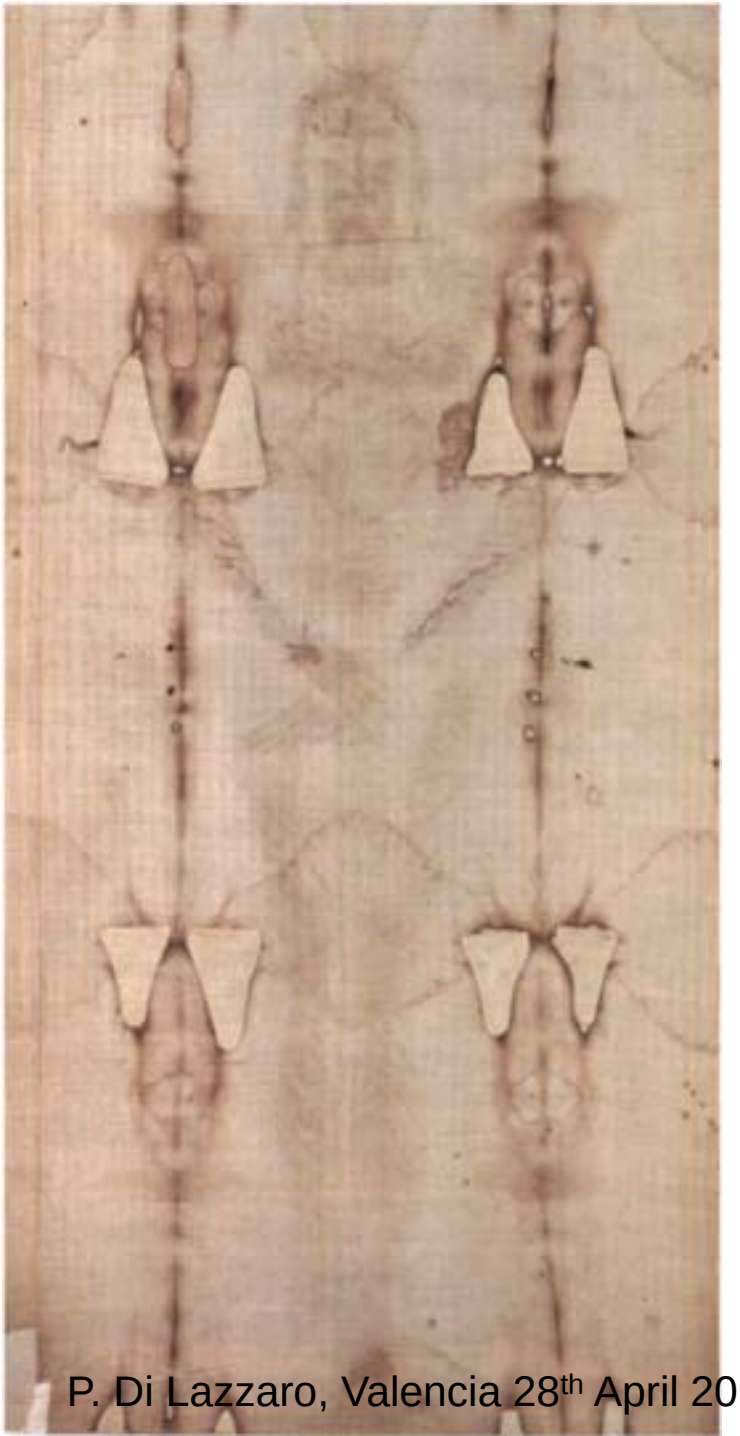
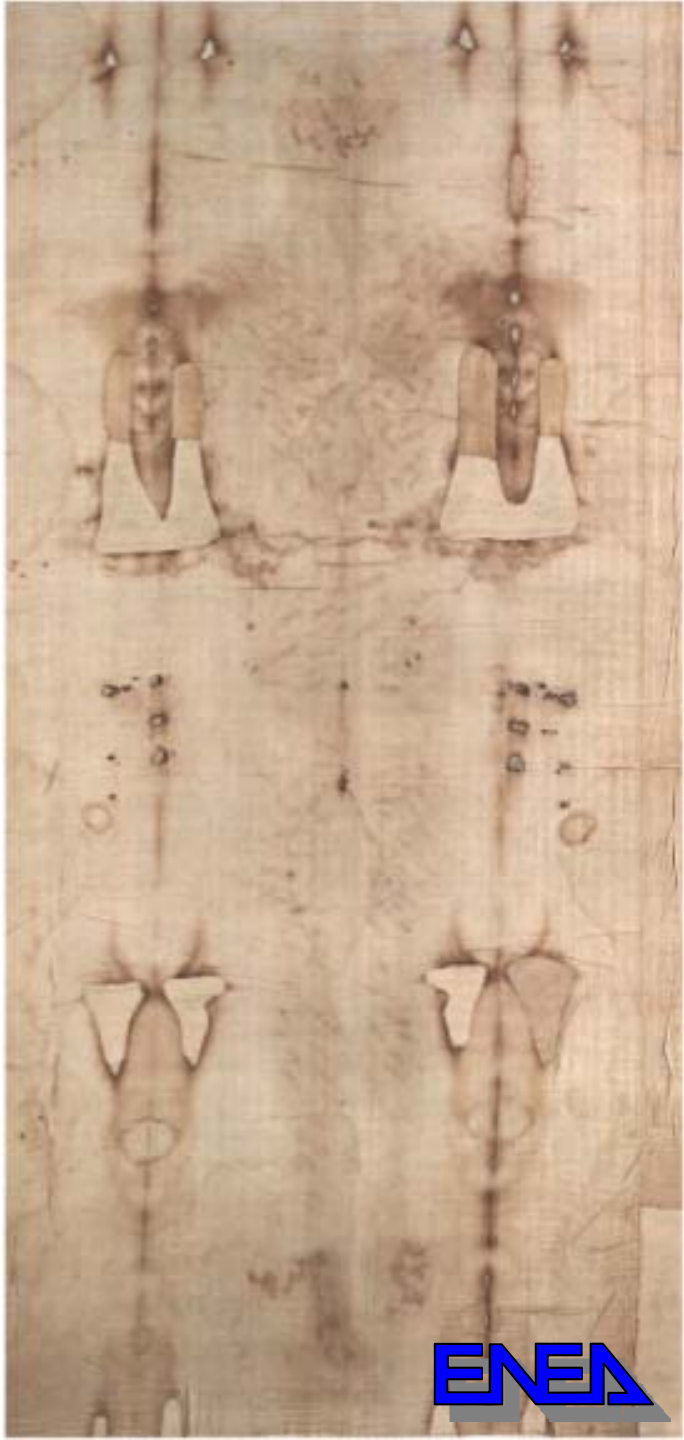
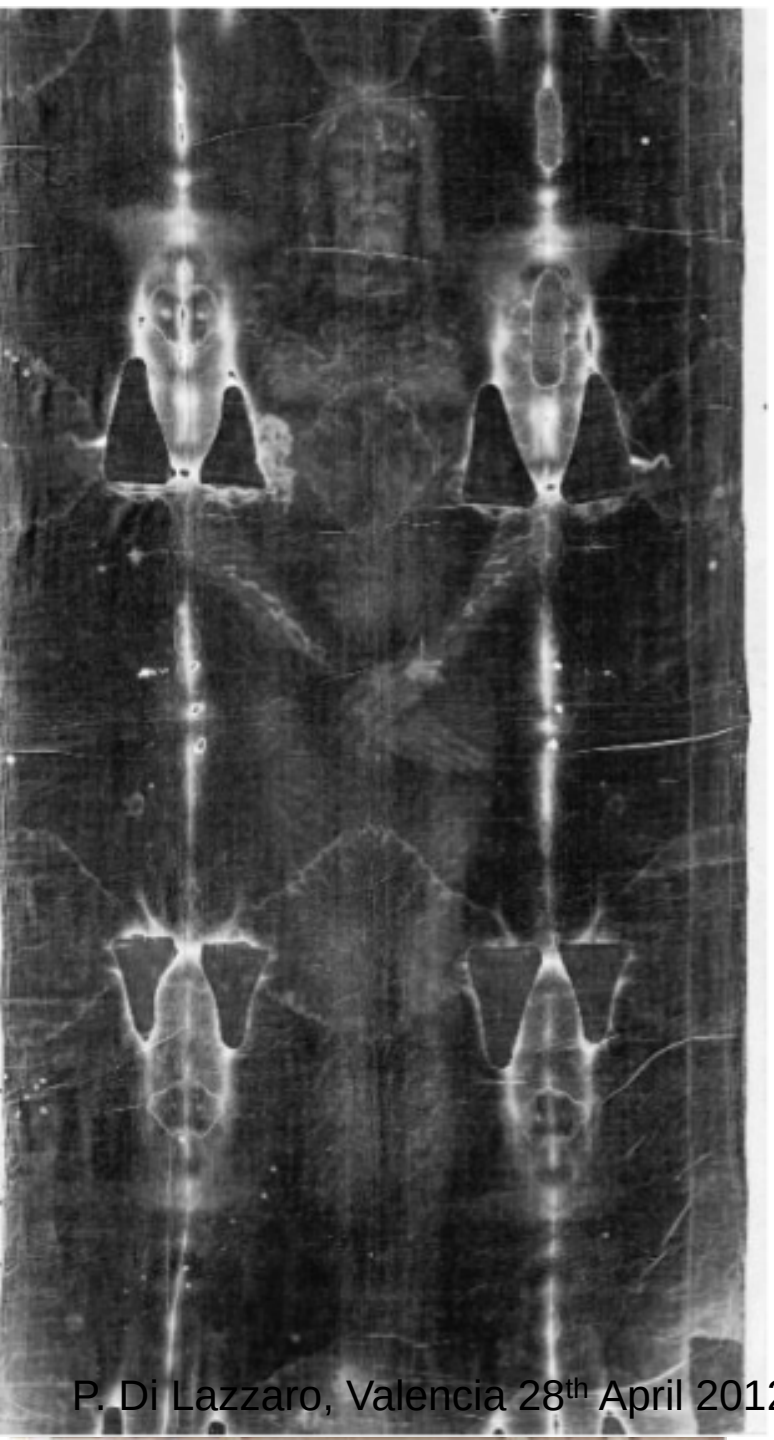
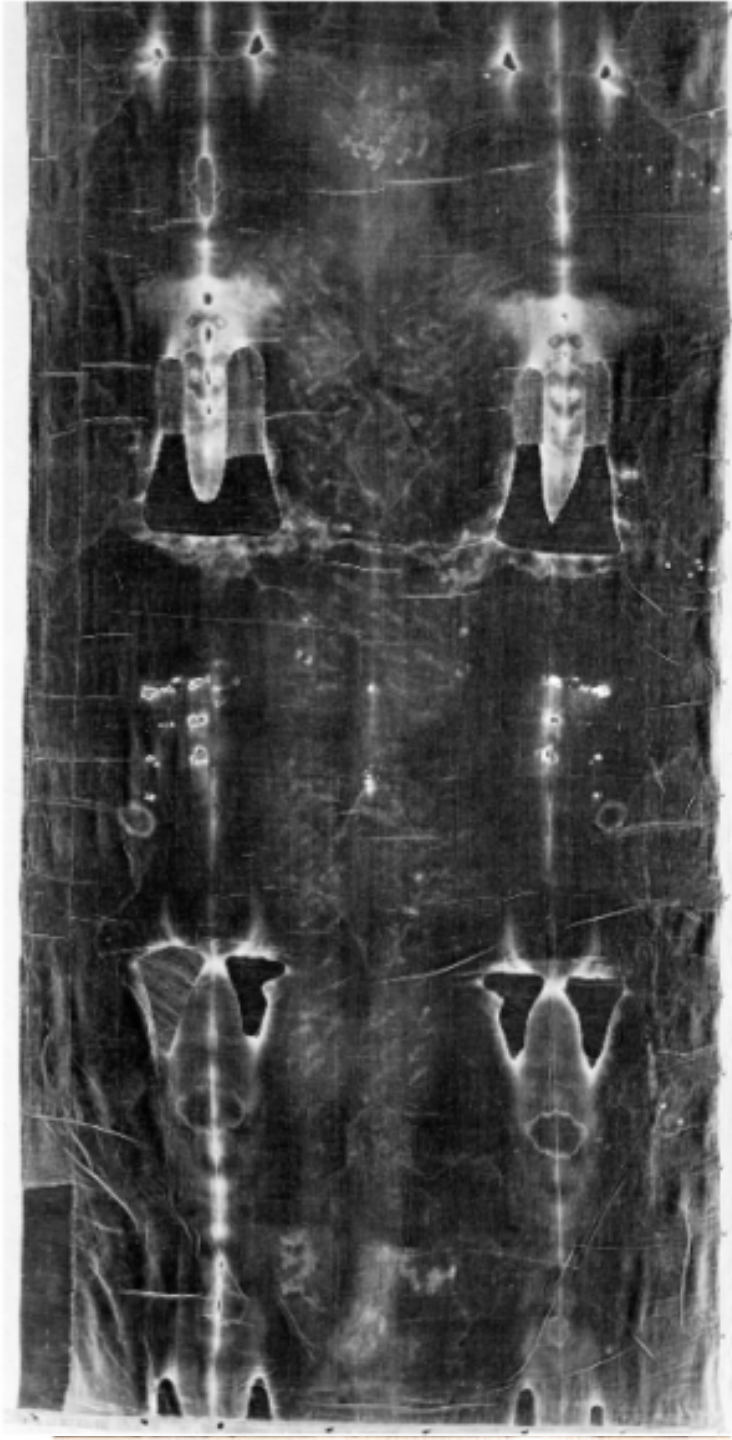






Enrie, 1931



Under the blood there is no image. This means that the blood stains occurred physically on the Shroud before the body image. All the bloodstains have sharp outlines

Then, the image was formed after the deposition of the corpse, which was not removed from the sheet

There are no signs of putrefactions, occurring at the orifices about 40 hours after death.

The image does not depend on the gases of putrefaction and the corpse was in contact with the Shroud not longer than two days.

How the Shroud enveloped the body?

The images correspond to a well proportioned body, and images of the sides of the body are absent. Images do not show the typical geometric deformations of a three dimensional body put in contact on a sheet in two dimensions, the so called “mask of Agamemnon effect”.

How the Shroud enveloped the body?

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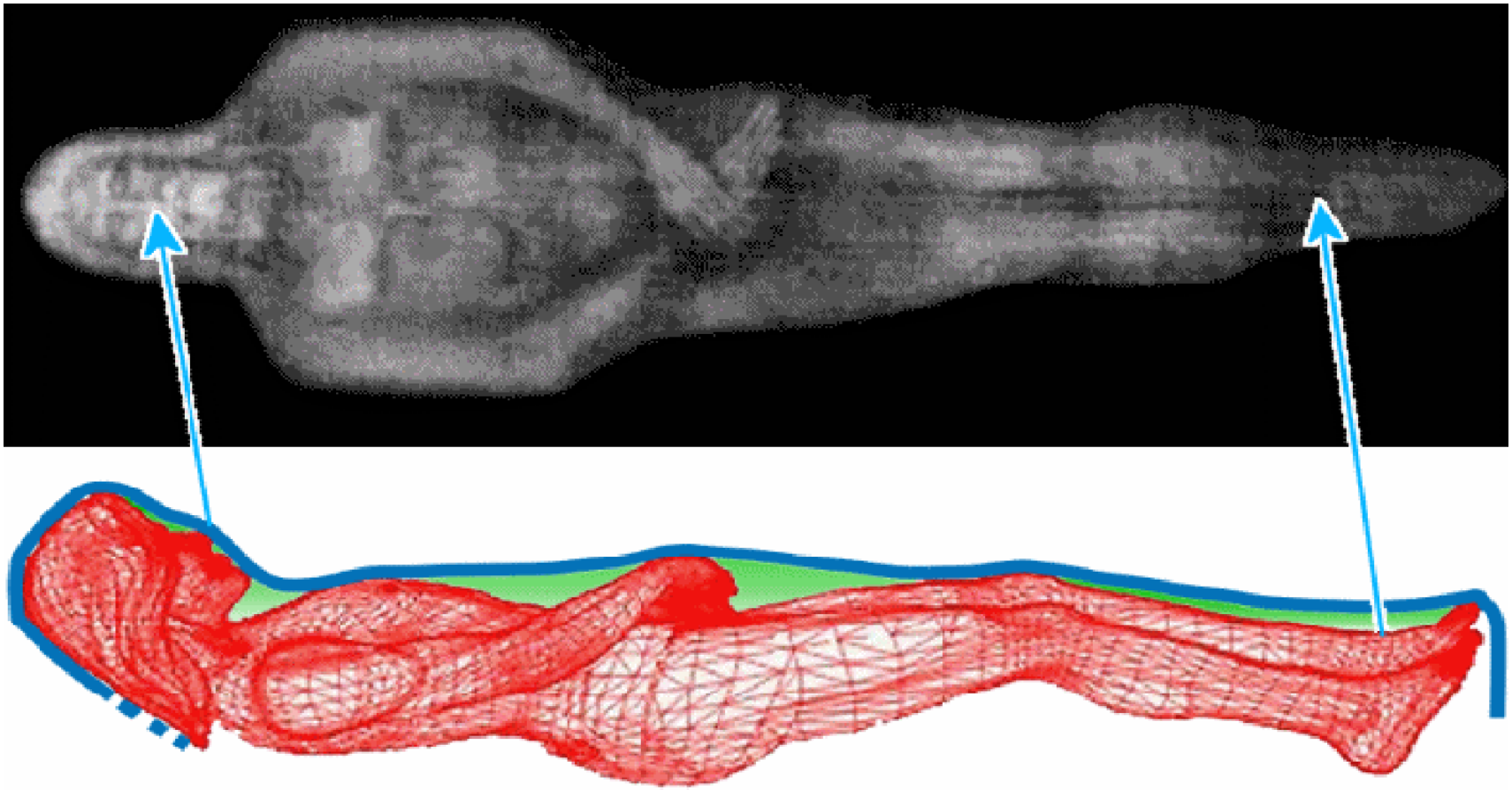
As a consequence, it is likely the Shroud was not pressed on the body and tied.
More probably it was draping naturally the body.

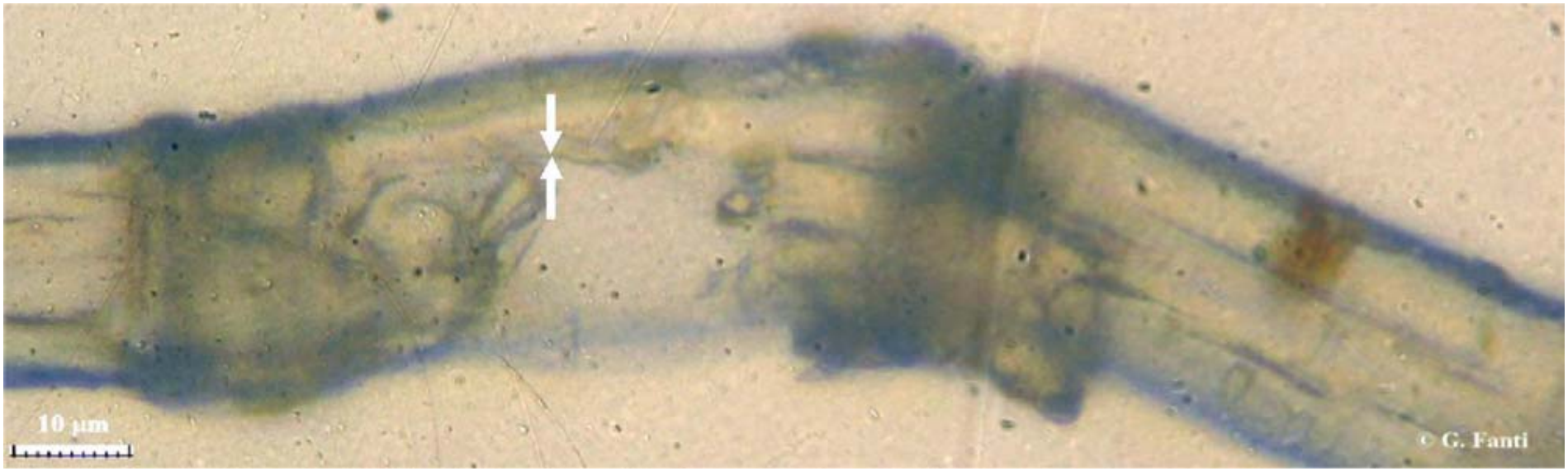
Despite the Shroud was not in full contact with the whole body, images are complete, i.e. include regions that could not stay in direct contact with the cloth

The image was NOT formed by contact with the body



from *J. Imag. Sci. Techn.* ***54*** *050503 (2010)*

Coloration depth



Lacuna of primary cell wall in TS image fiber obtained after mechanical stress. In that area only the colorless secondary cell wall is visible. The continuous blurred border at the bottom is the fiber edge that is below the focal plane. The brighter area below and at the right of the two arrows is the inner cellulosic material of the secondary cell wall that is not colored. The arrows indicate the area where the thickness of primary cell wall can be measured as 0.2±0.2 micrometers.

from *J. Imag. Sci. Techn.* ***54*** *040201 (2010)*

Consequences of STURP results

The images on the Shroud

- ✓ are very superficial,
- ✓ are not formed by contact with the body,
- ✓ are not produced by gases of putrefaction,
- ✓ are formed after the deposition of the corpse

i.e. formed by an “acting-at-distance” mechanism.

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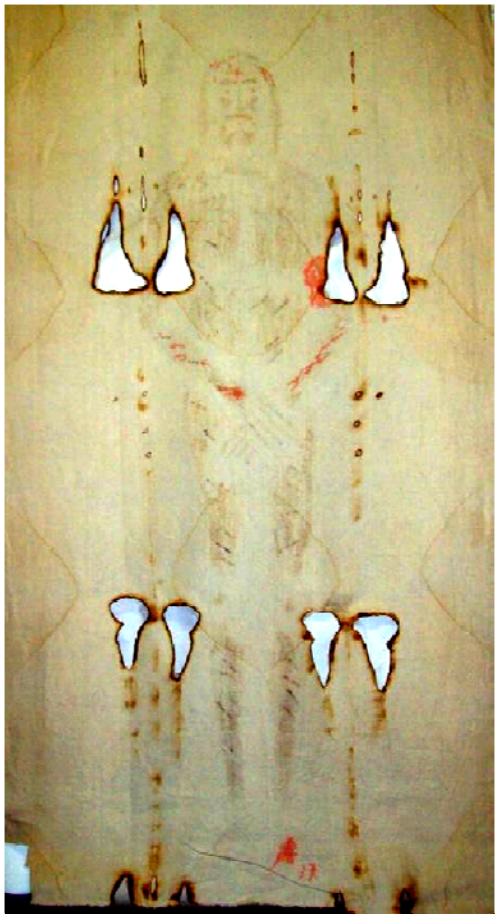
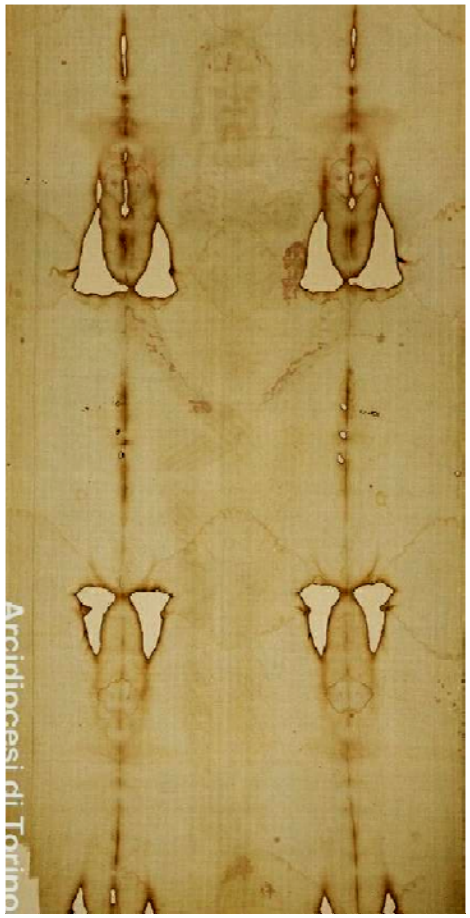
Chemistry approach: results of Garlaschelli



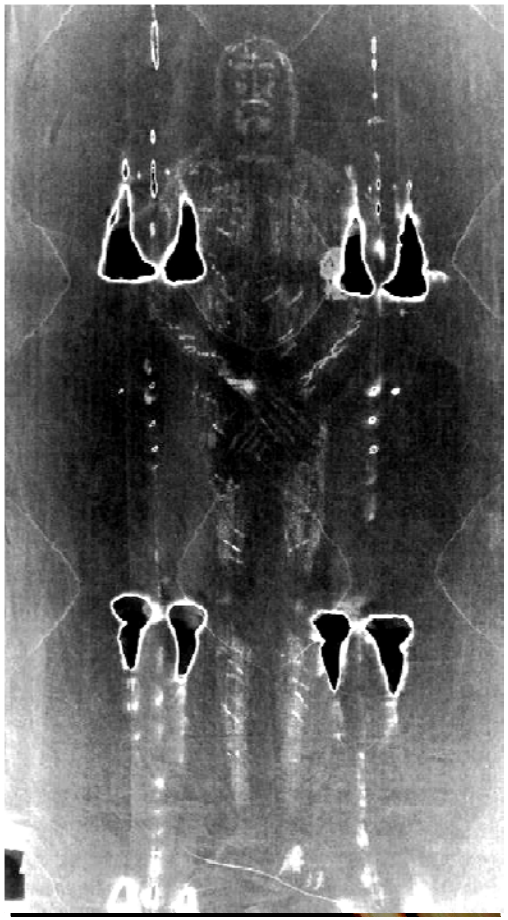
Garlaschelli copy



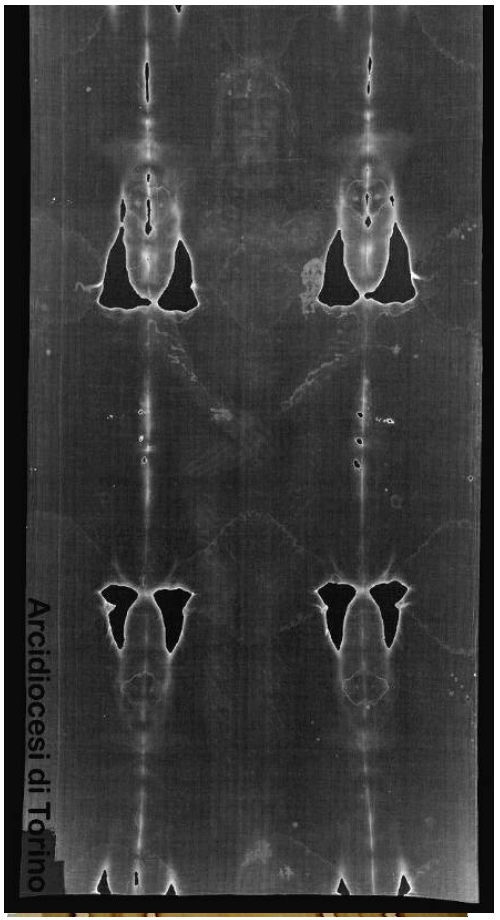
Shroud

from Proc. IWSAI (ENEA 2010) pp 19-28

Chemistry approach: results of Garlaschelli



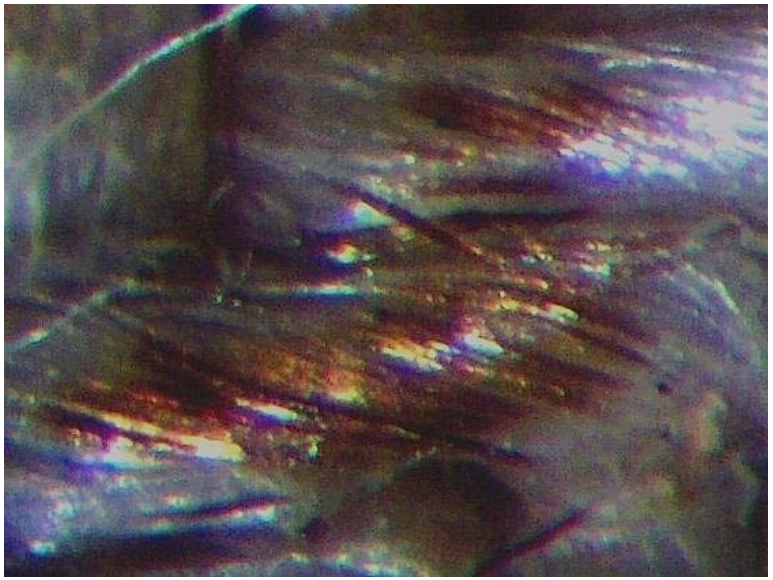
Garlaschelli copy



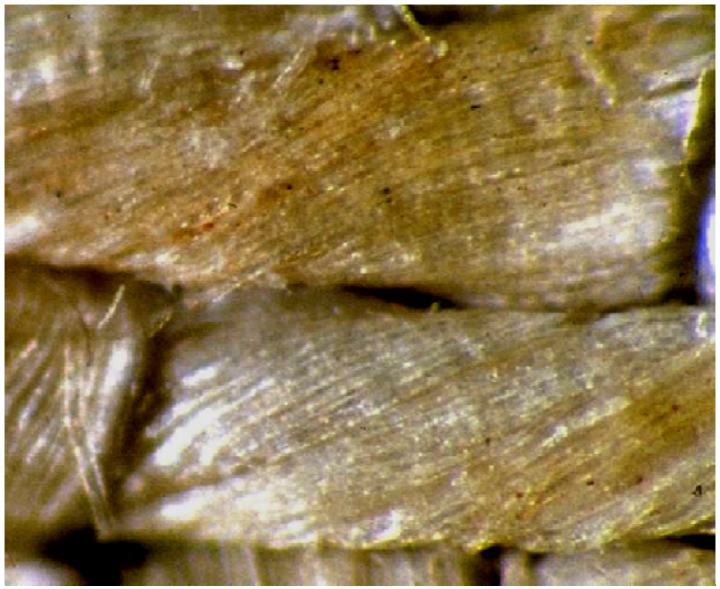
Shroud

from Proc. IWSAI (ENEA 2010) pp 19-28

Chemistry approach: results of Garlaschelli



Garlaschelli copy

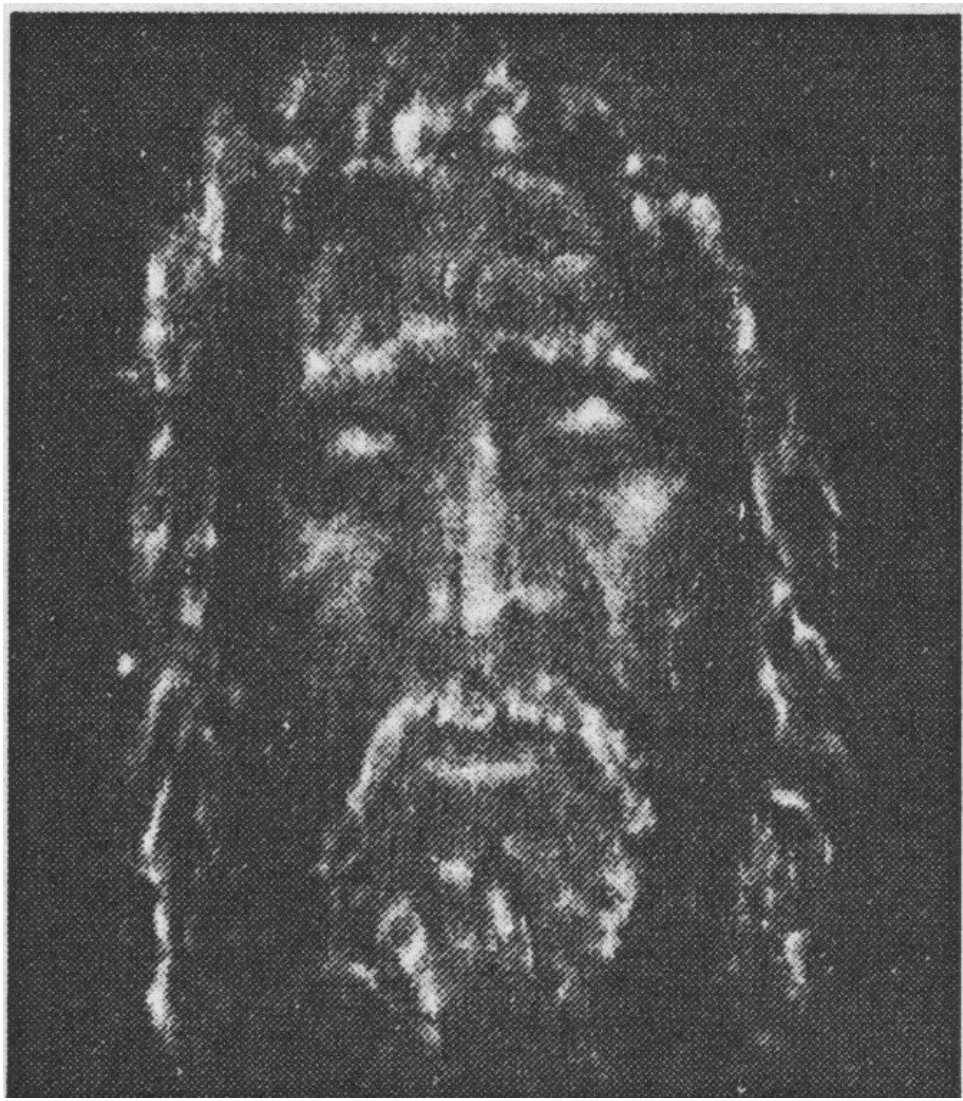


Shroud

from Proc. IWSAI (ENEA 2010) pp 19-28

Chemistry approach: results of Nickell

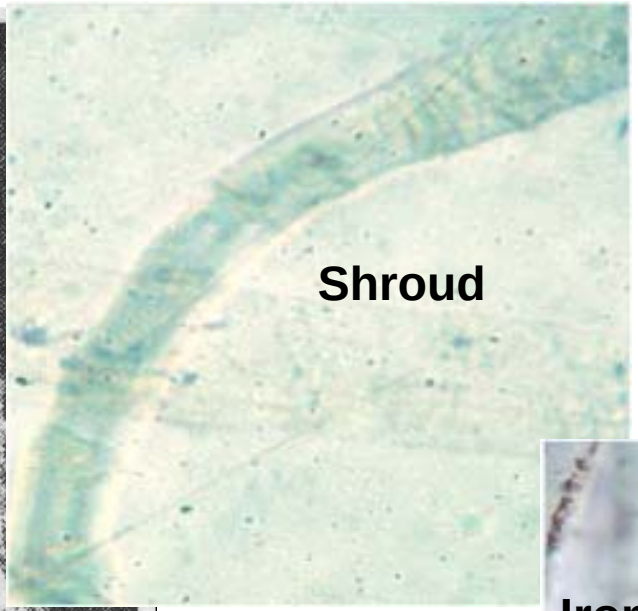
Iron oxide and vitriol



Iron oxide

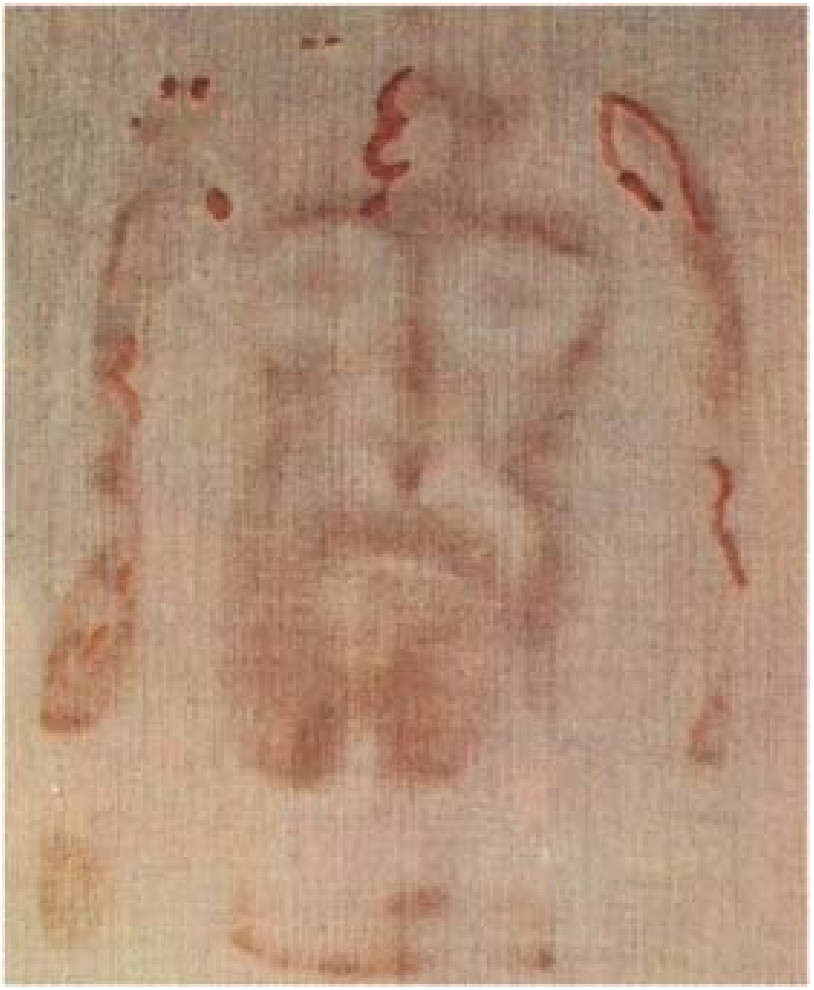
Chemistry approach: results of Nickell

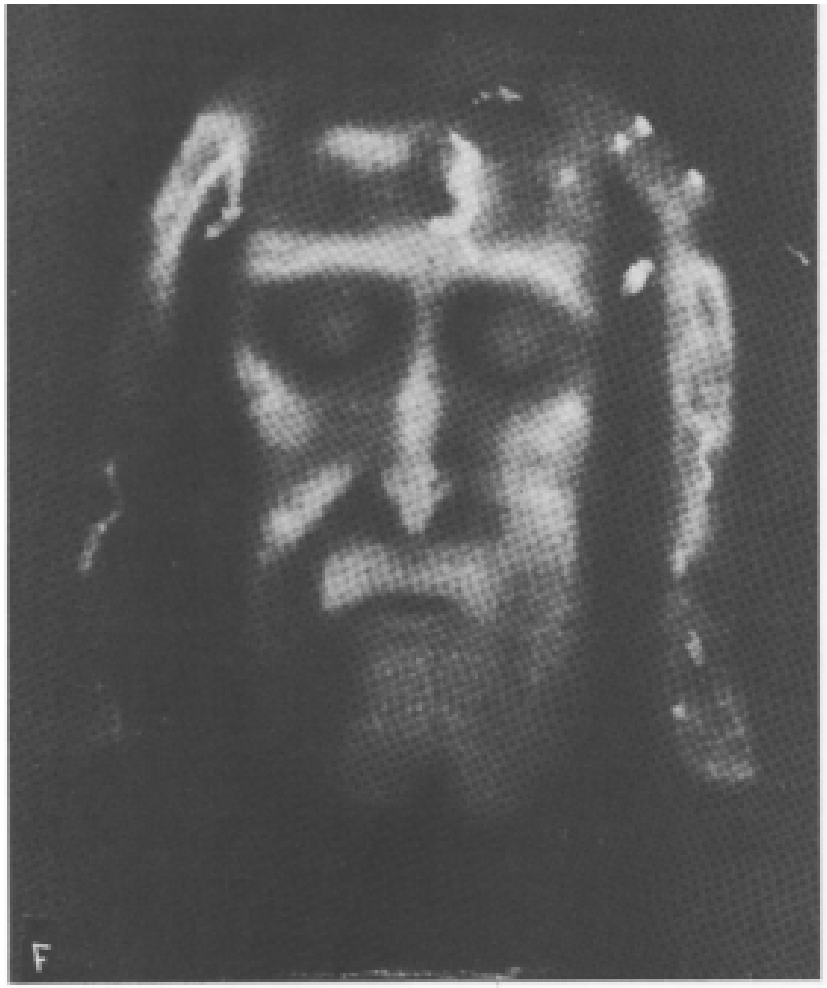
Iron oxide and vitriol



Iron oxide

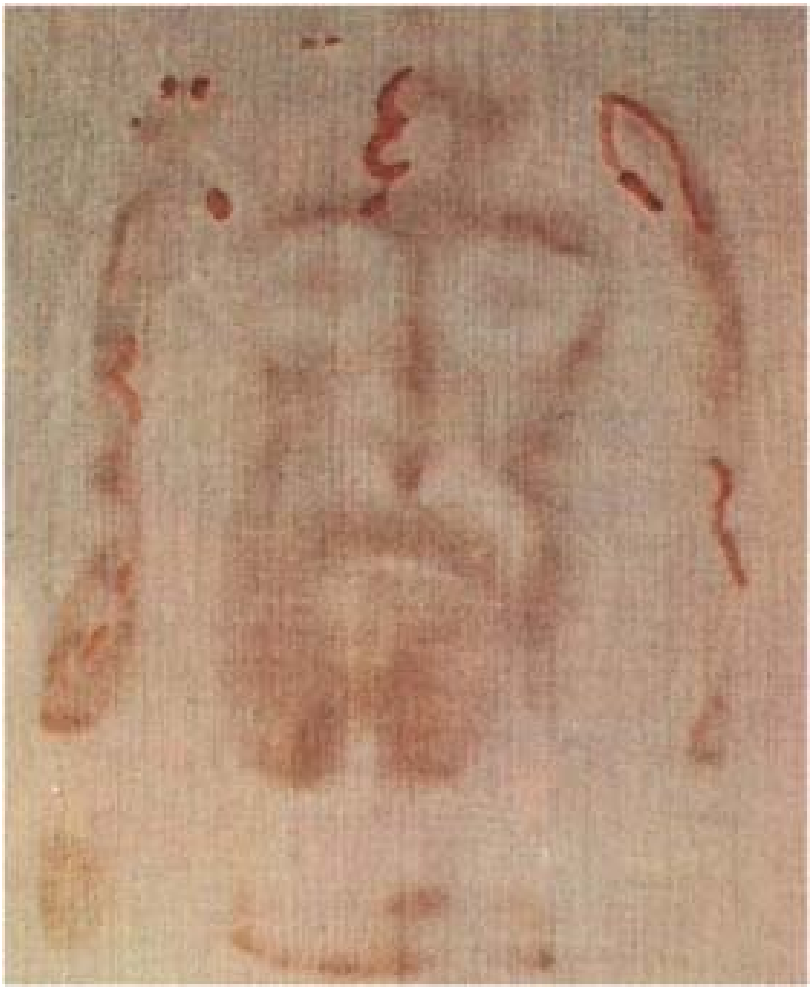
Heat by contact and infrared radiation: results of Pesce Delfino

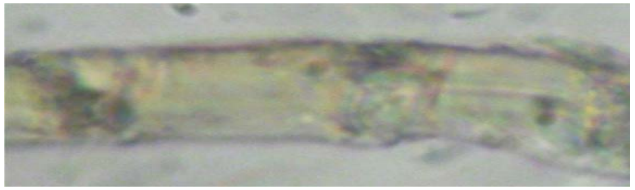




Bas relief, heated

Heat by contact and infrared radiation: results of Pesce Delfino





Shroud

heated

Bas relief, heated

Chemistry approach: results of Rogers

Cadaveric gases of ammine interact with polysaccharides and surface impurities thus generating a coloration of linen treated with Saponaria (Maillard reaction). **Problem: cadaveric gases are emitted mainly by orifices, and cannot generate a homogeneous coloration of the whole body.**

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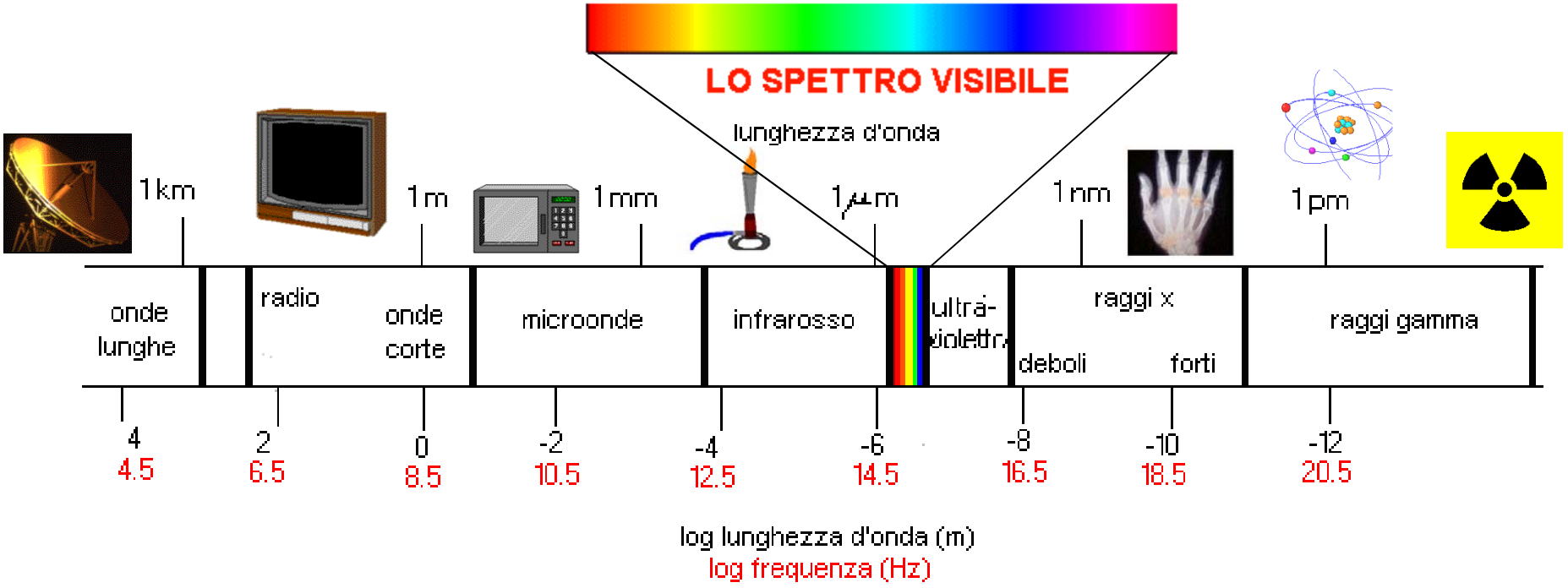
What “radiation” does mean?

“**Electromagnetic radiation**”, is a form of energy that can be transferred at distance without needing an interposing medium. Visible light is a small fraction of the whole electromagnetic radiation, corresponding to the “colors” our eyes can see.



Proposal of John Jackson (1990)

J.P. Jackson, "***Is the Image on the Shroud Due to a Process Heretofore Unknown to Modern Science?***", Shroud Spectrum International, No. 34, March 1990 pp. 3-29.

UV radiation is suitable to obtain a Shroud-like coloration (shallowness, shade embedding 3-D information, image in linen regions not in contact with the body).

R. Rogers, "***Testing the Jackson 'Theory' of Image Formation***", www.shroud.com/pdfs/rogers6.pdf

"Intense radiation exerts pressure as in a nuclear weapon. Radiation pressure coupled with ablation (the sudden appearance of hot gas, which gives the same propulsive effect as rocket exhaust) of the cloth by intense radiation should have thrown the cloth a considerable distance and probably would have torn it to shreds. **Experiments we did with pulsed ultraviolet lasers on linen resulted in ablation and destructive shock waves. Samples often were converted into a little amorphous powder and gas. (…) The surface of the Shroud does not show the effects of radiation.**

Two opposite views. Where is the synthesis?

J.P. Jackson, K.E. Propp, ***Comments on Rogers' "Testing the Jackson 'Theory' of Image Formation"*** , www.shroud.com/pdfs/jacksonpropp.pdf

"**Radiation represents a large category of phenomena that can be described by (1) intensity, (2) wavelength, and (3) event duration. Each of these variables can change by orders of magnitude. The laser experiment cited above represents but one point in this vast three-dimensional parameter space. Clearly, the entire category of radiation cannot be discarded on the basis of one, overly intense, laser experiment that corresponds to a single point in that radiation parameter space"**

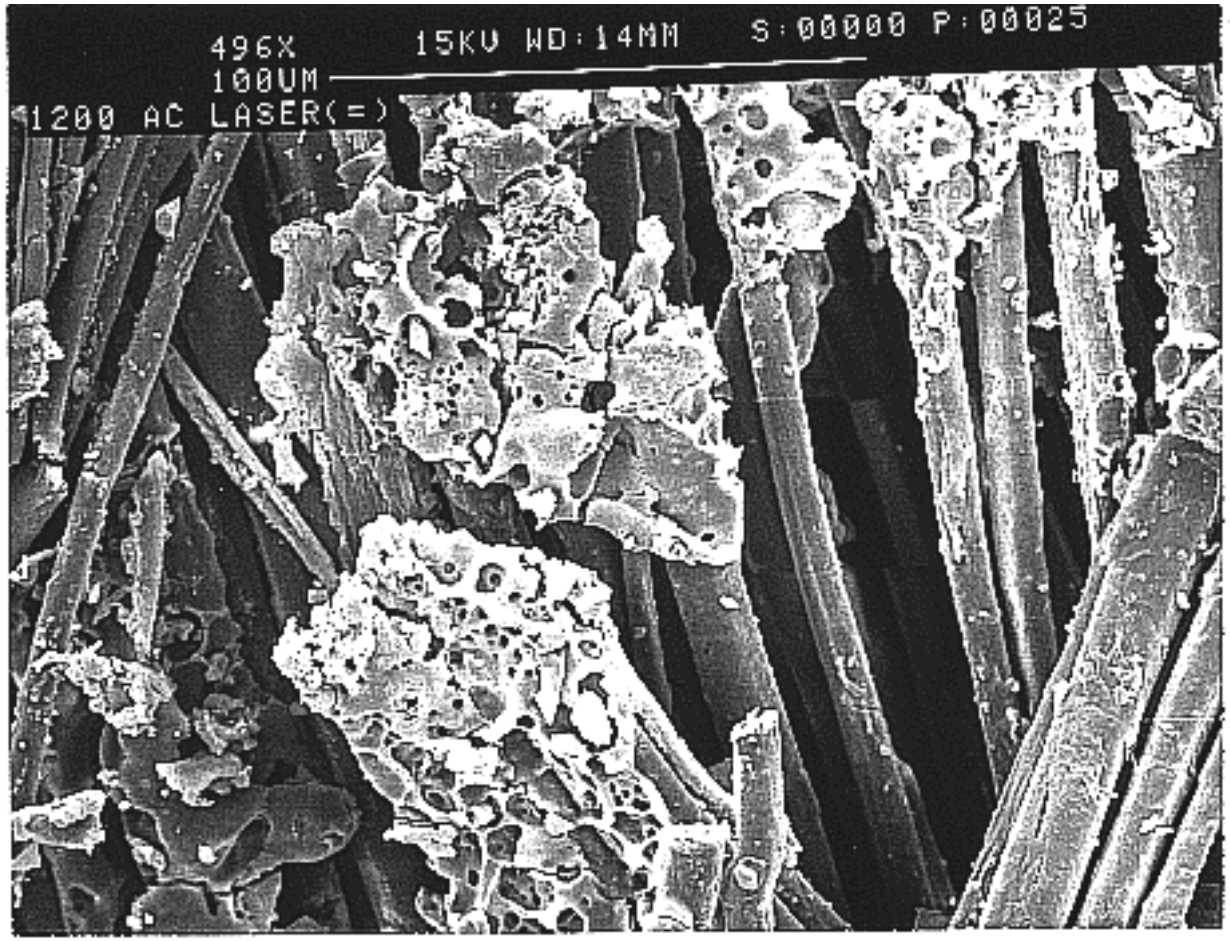
Attempt of Testore et al.

From AUTEX Research Journal, Vol. 2, September 2002

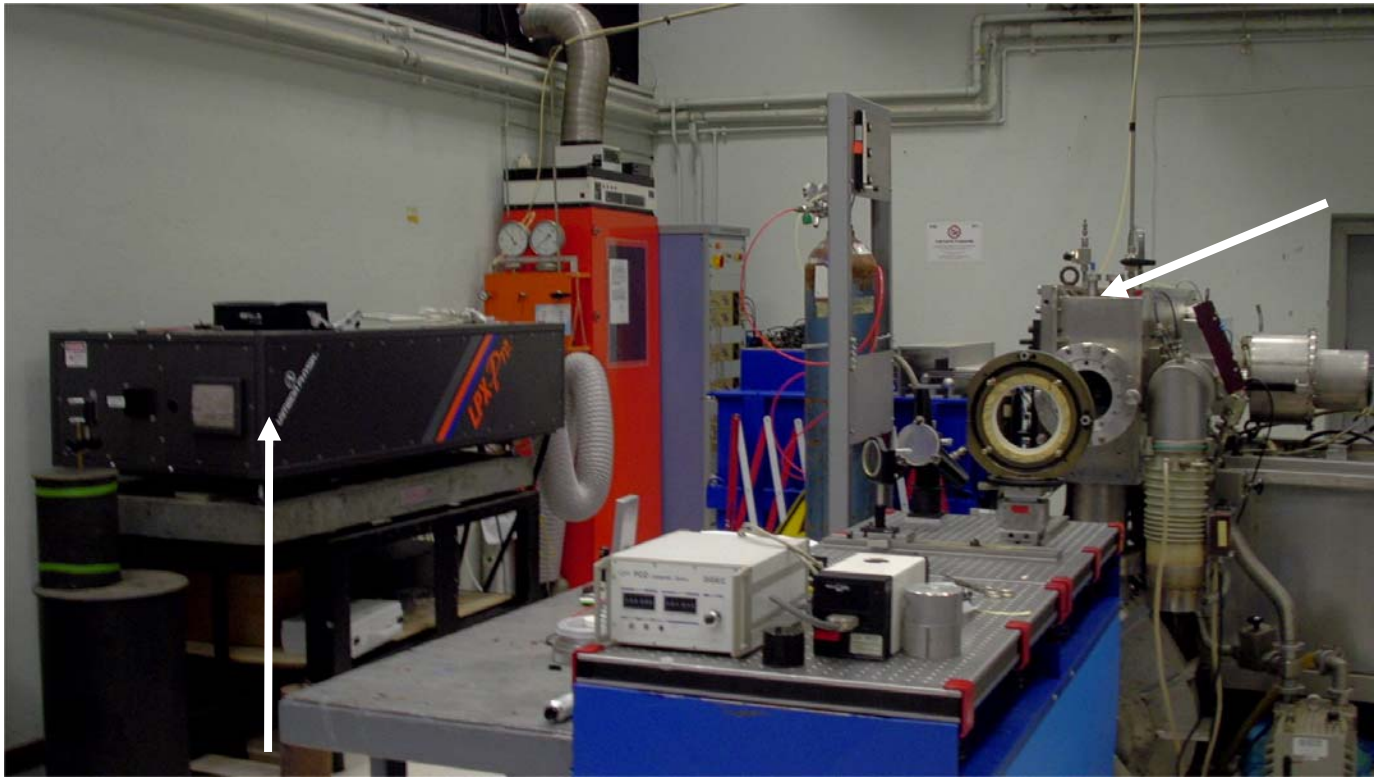
- Laser CO_2 (far infrared) and electron beams.
- **Macroscopic results**: brown coloration.
- **Microscopic results**: Fibers are damaged, burnt, vaporized.

Attempt of Testore et al.

From AUTEX Research Journal, Vol. 2, September 2002



Experimental apparatus at ENEA Frascati



Hercules ENEA PBUR

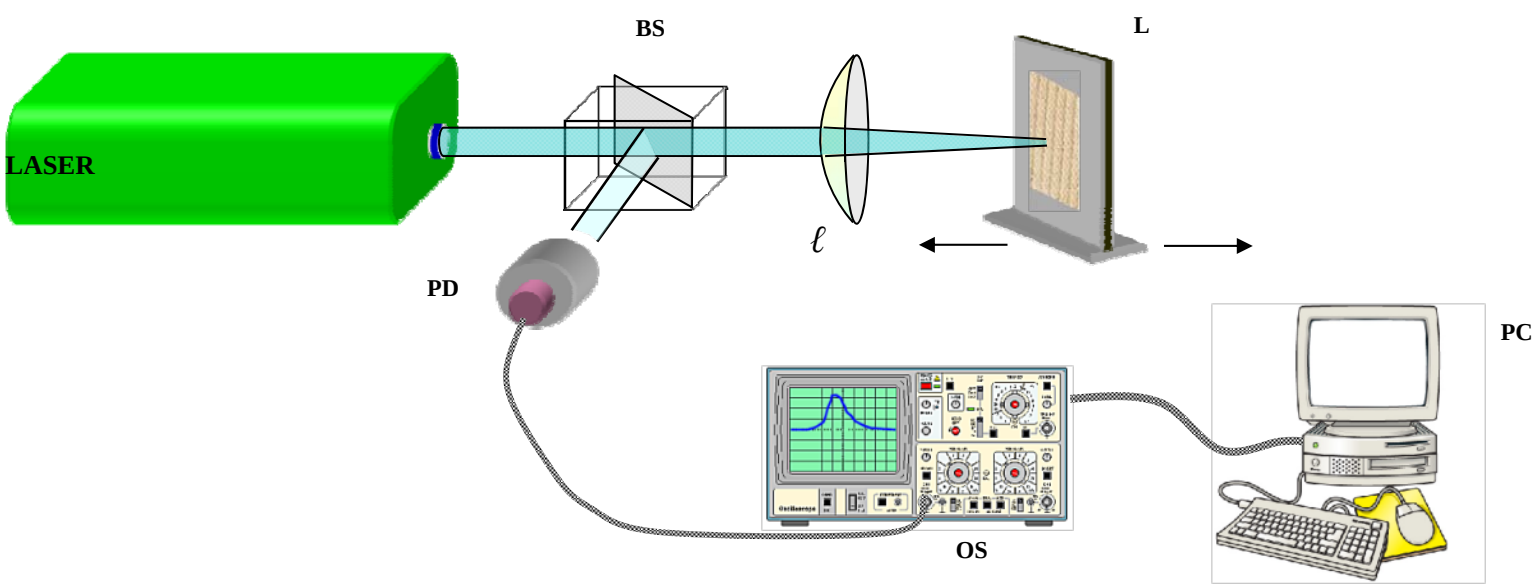
6 J, 120 ns, 5 Hz

308 nm

LPX-305, PBUR

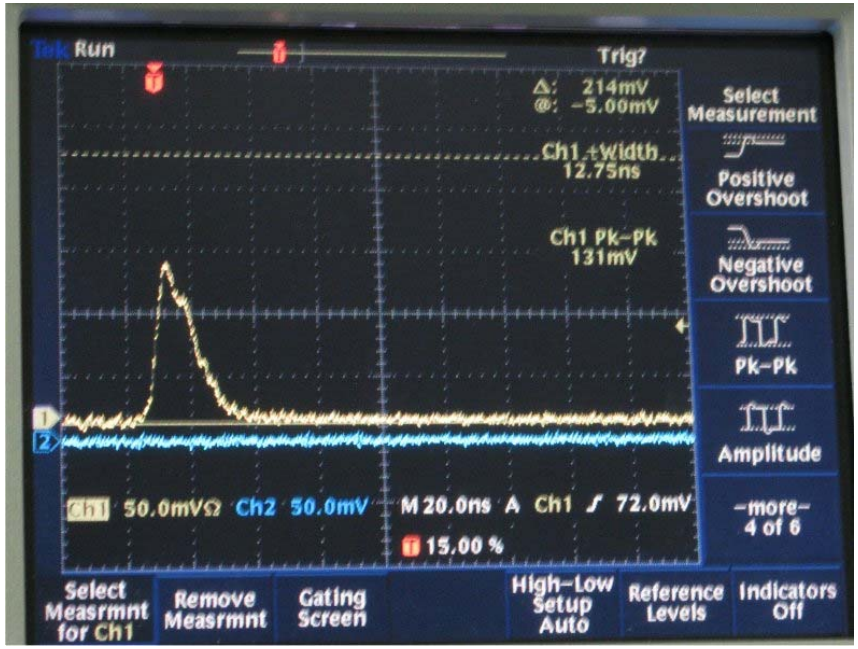
0.5 J, 10 ns, 50 Hz. 308 nm or 193 nm

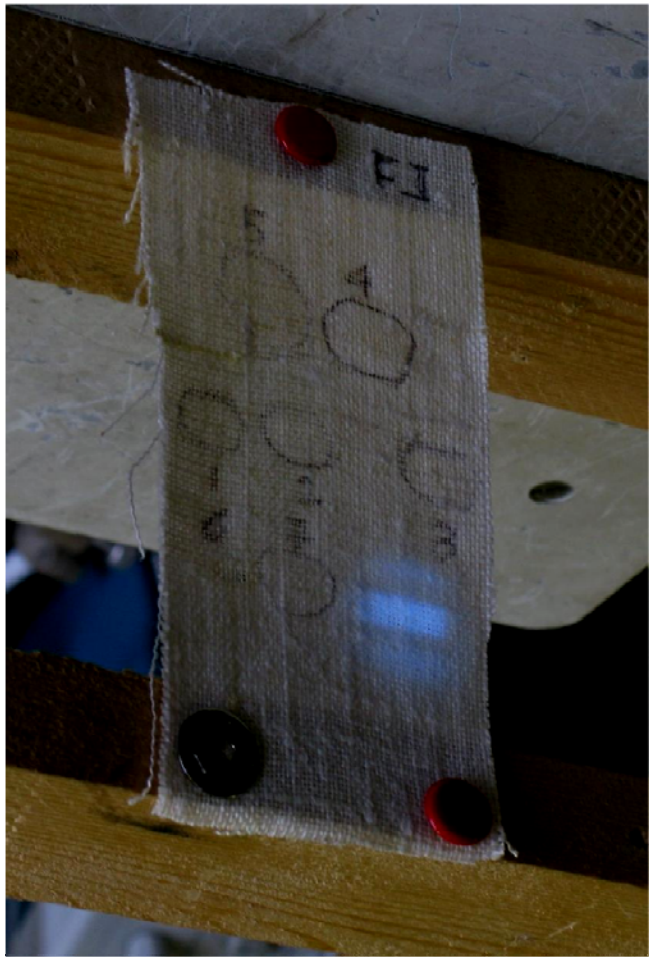
Schematic of the irradiation experiments



from *Applied Optics* ***47*** *1278 (2008)*

Irradiations





unpublished

30-ns, λ = 308 nm macroscopic results

Linen and cotton

Linen

After **100** laser shots at 308 nm

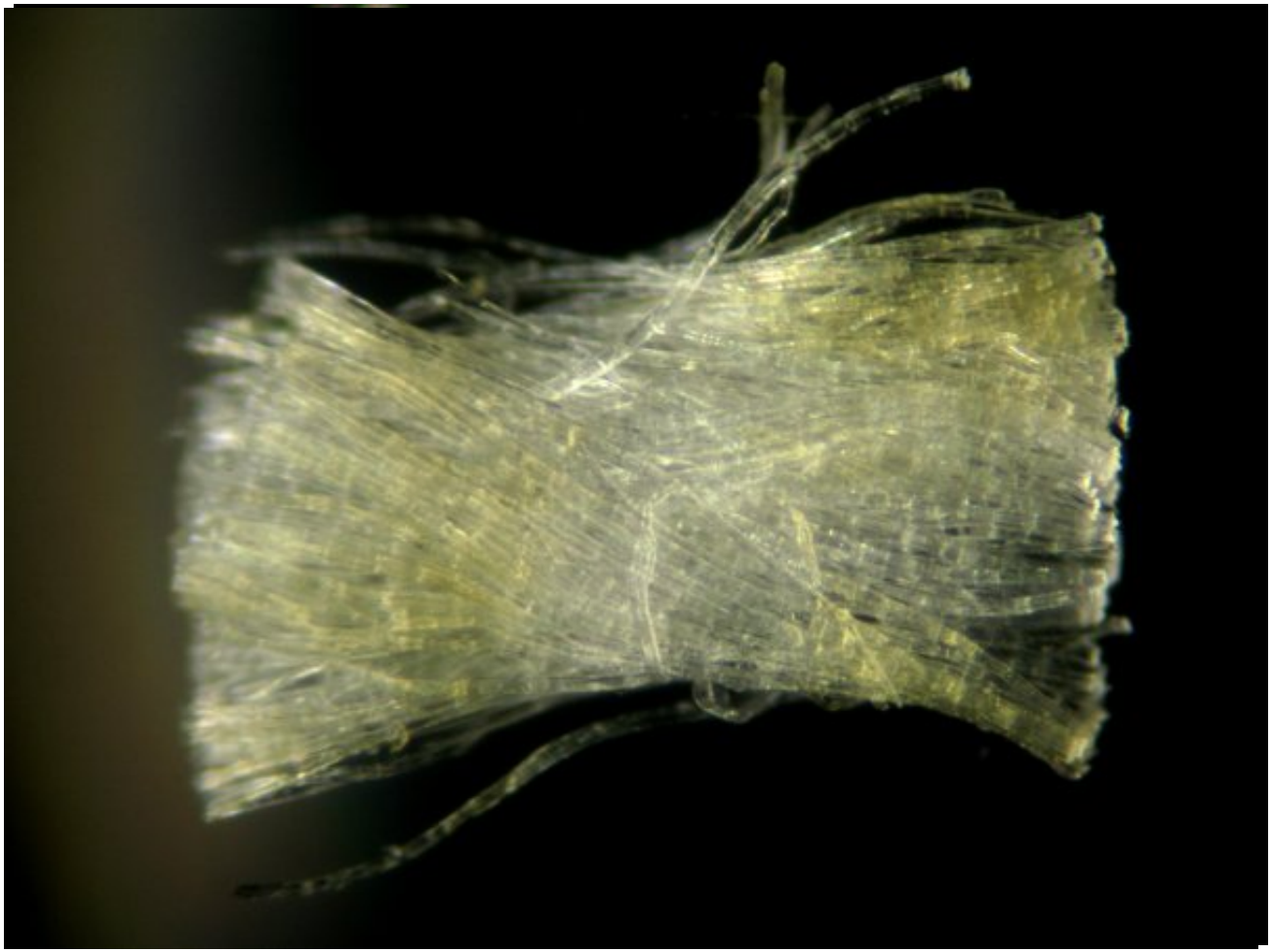
Fluence = 0,4 J/cm^2/pulse

Intensity = 16 MW/cm^2/pulse

Repetition rate = 9 Hz.

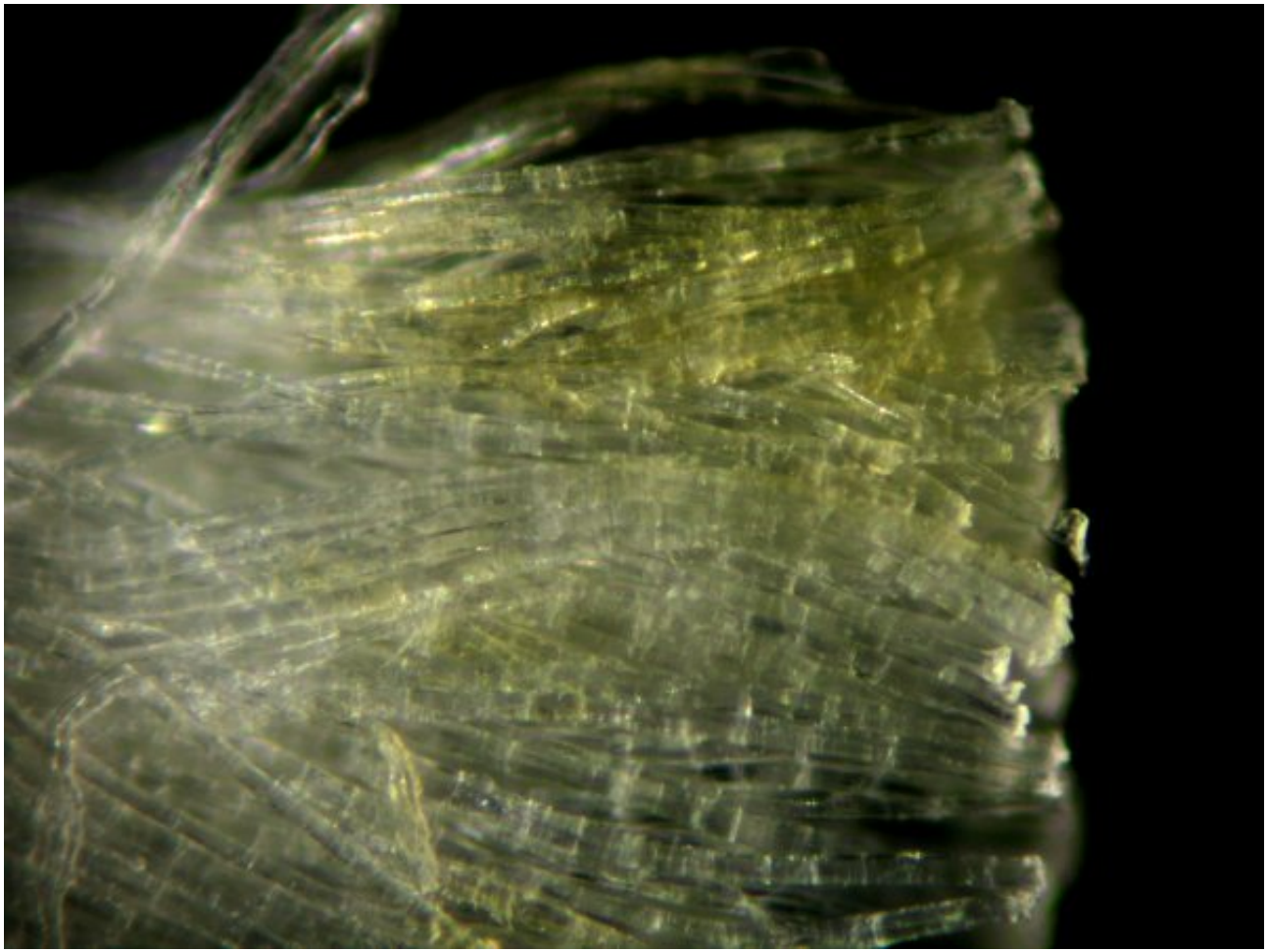
unpublished

10-ns, λ = 193 nm macroscopic results



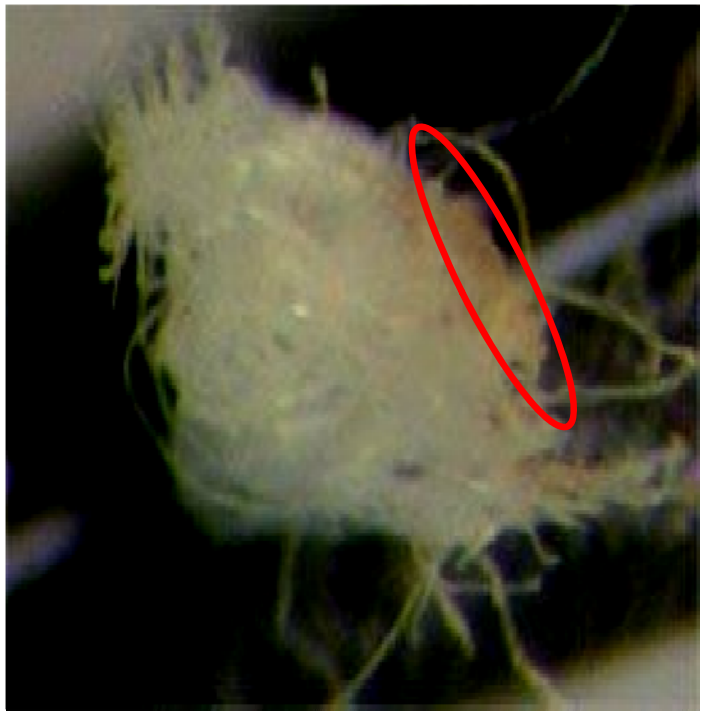
from *J. Imag. Science Techn.* ***54*** *040201(2010)*

10-ns, λ = 193 nm macroscopic results



from *J. Imag. Science Techn.* ***54*** *040201(2010)*

Coloration depth: comparison

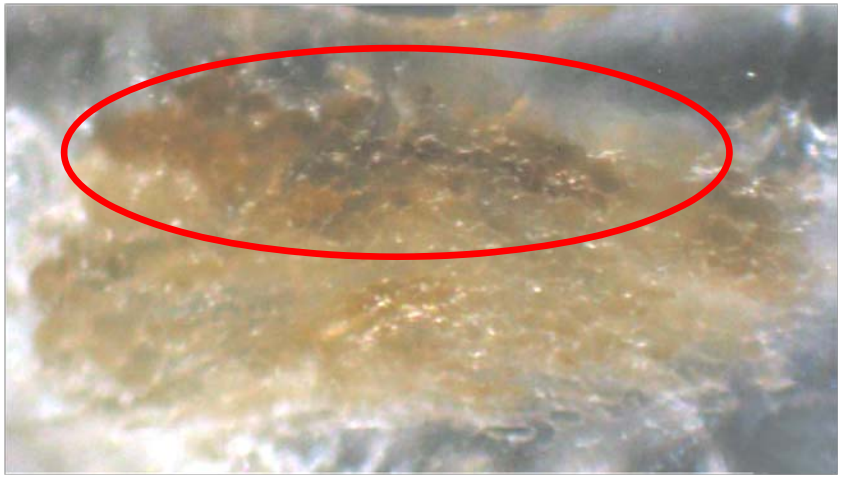


λ = 193 nm

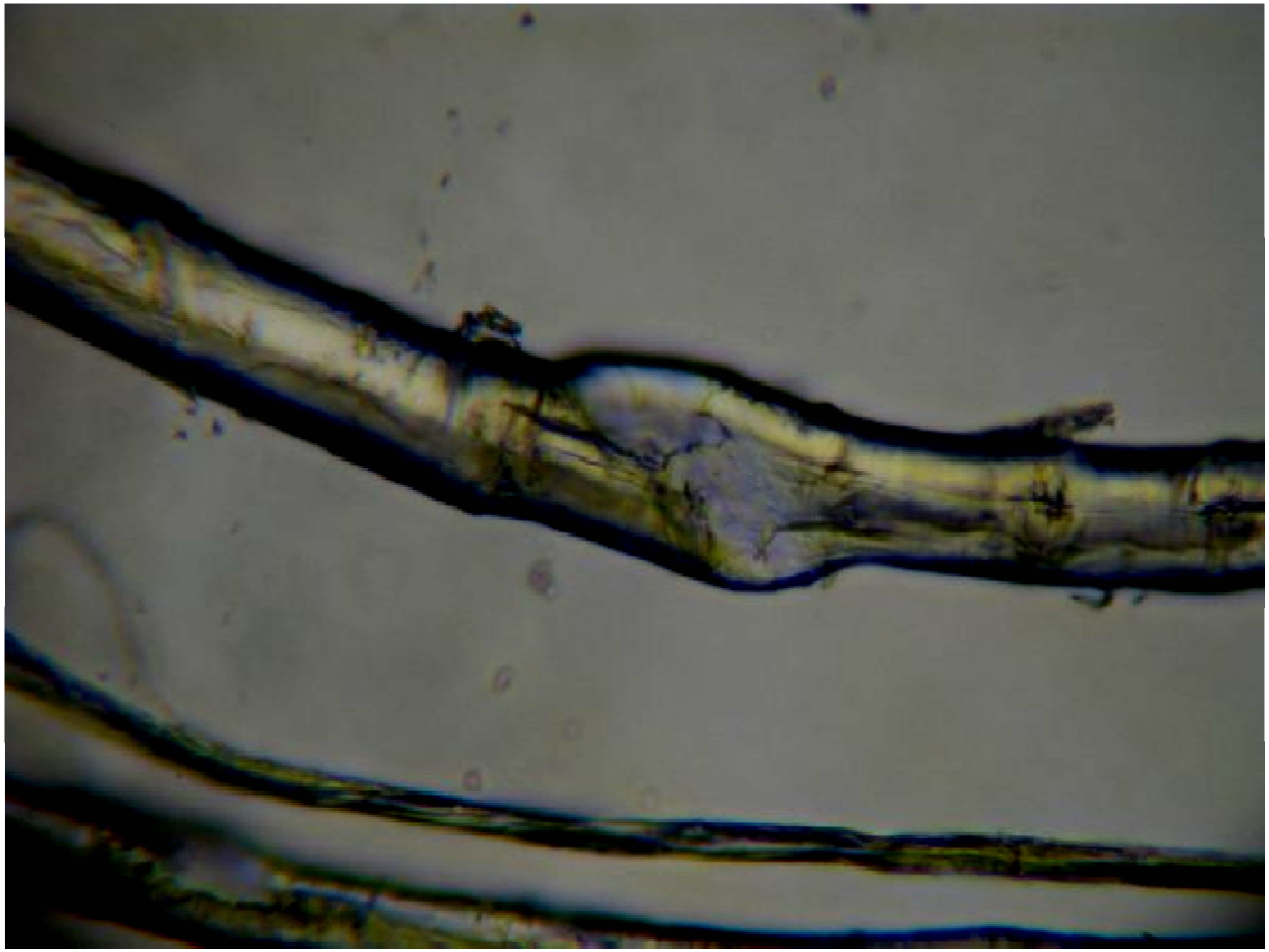
Linen yarn

unpublished

λ = 308 nm

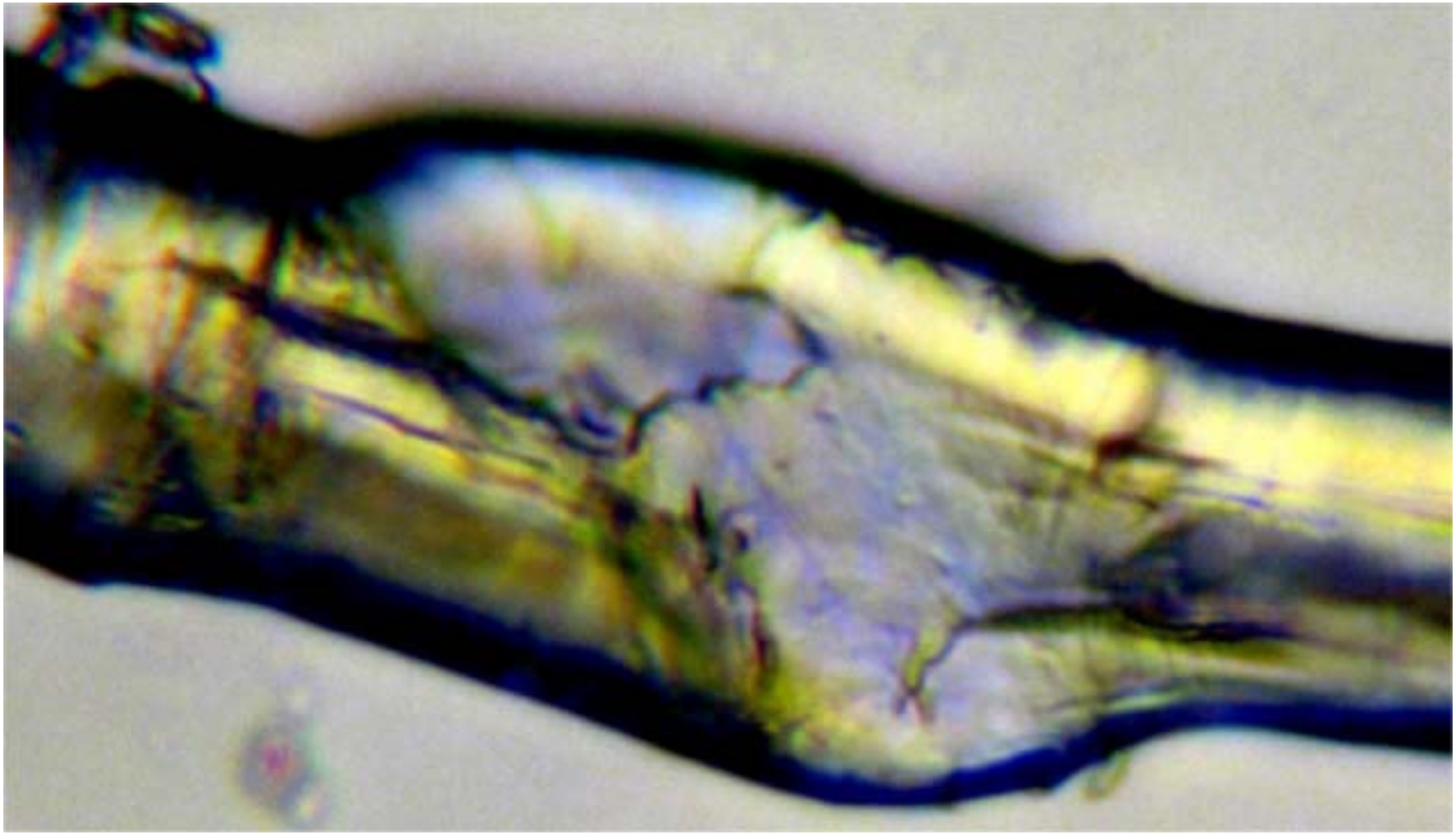


Inside the fiber, medulla is not colored!



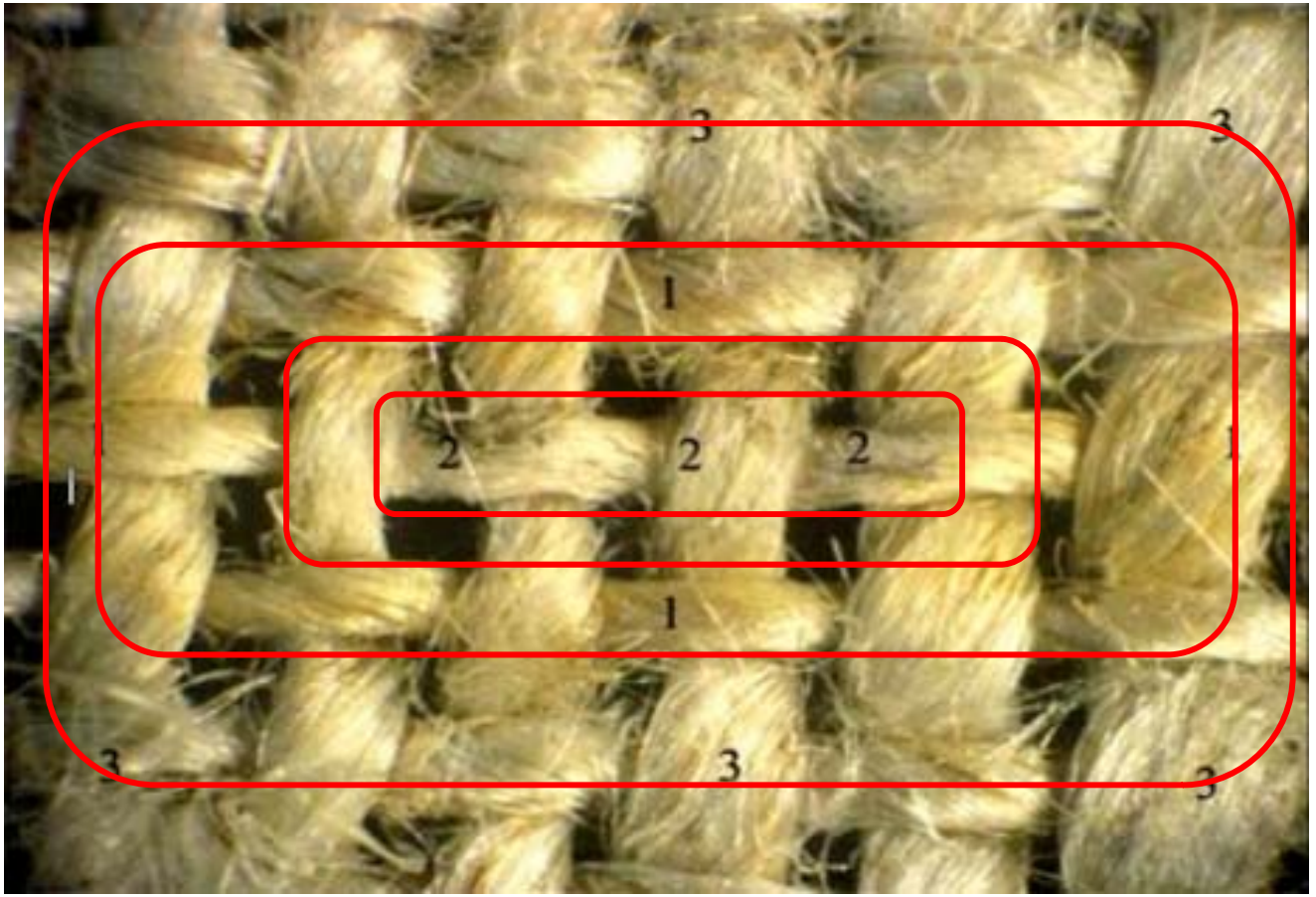
from J. Imag. Science Techn. ***54*** *4302 (2010)*

Inside the fiber, medulla is not colored!



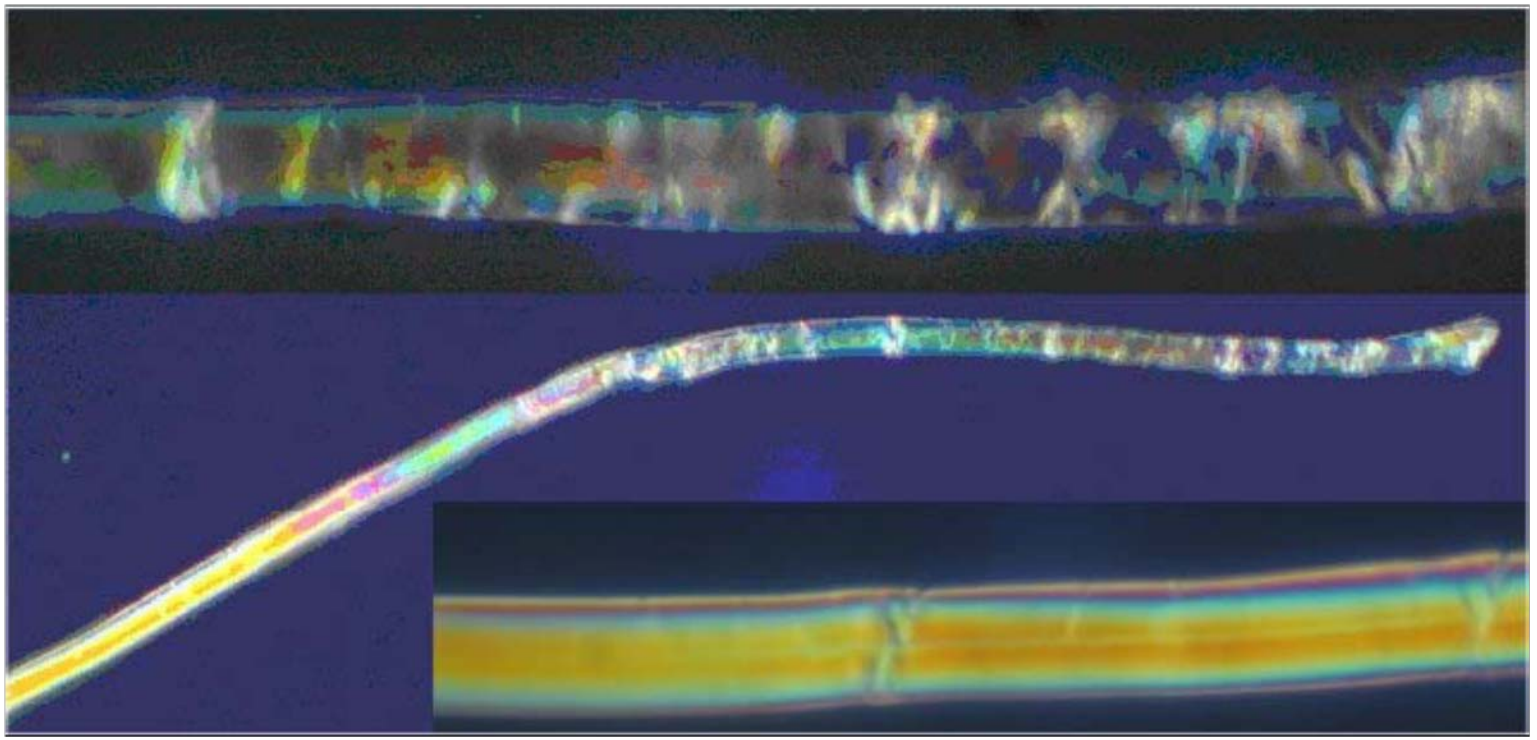
*from J. Imag. Science Techn. **54** 4302 (2010)*

All the effects in a spot at λ = 193 nm



from Proc. IWSAI (ENEA 2010) pp 3-10

Stress of fibers: loss of birefringence

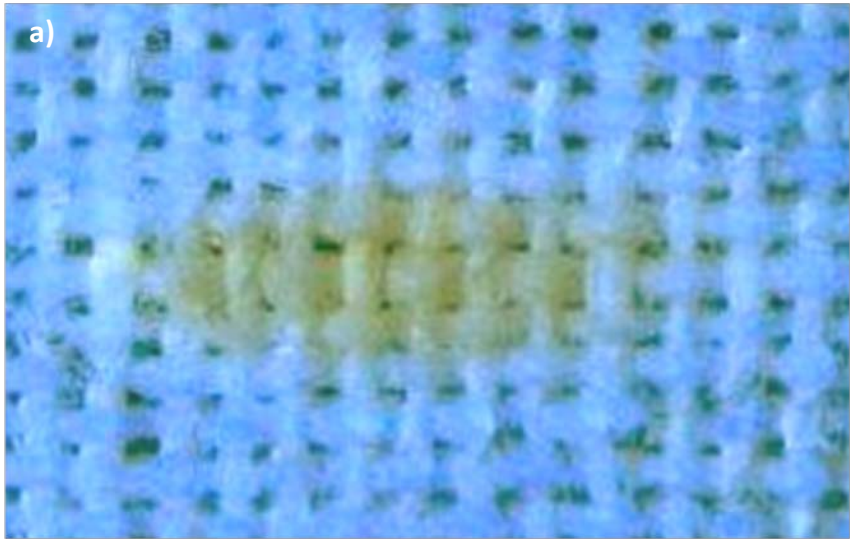


Partially irradiated fiber, observed in crossed polarization.

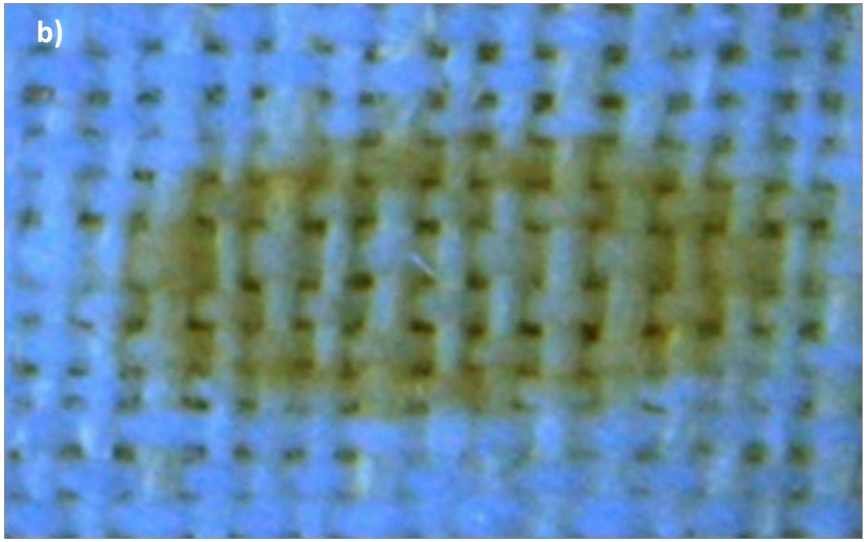
The irradiated part is associated with stress and fractures, pointed out by loss of birefringence.

from *Applied Optics* ***47*** *1278 (2008)*

Ultraviolet fluorescence



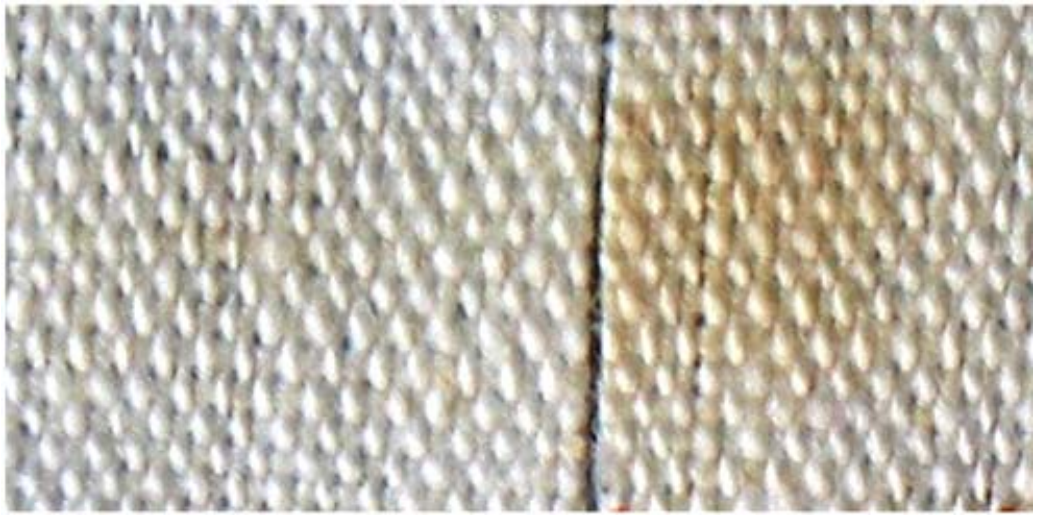
1800 MW/cm^2
(light yellow)



3600 MW/cm^2
(yellow sepia)

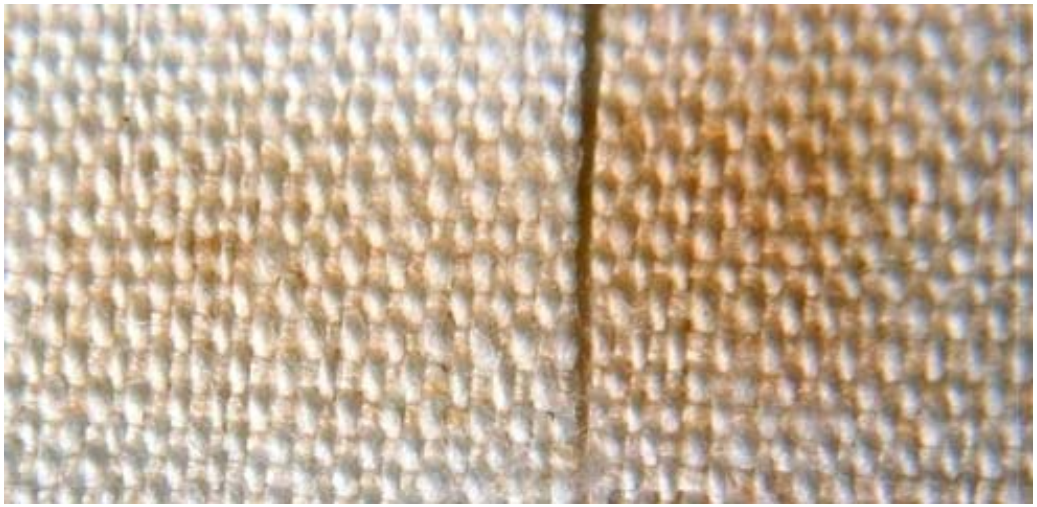
From Proc. IWSAI (ENEA 2010) pp 3-10

Aging and latent images, λ = 308nm



Linen irradiated below threshold (5 bursts × 10 shots) cut in 2 parts.

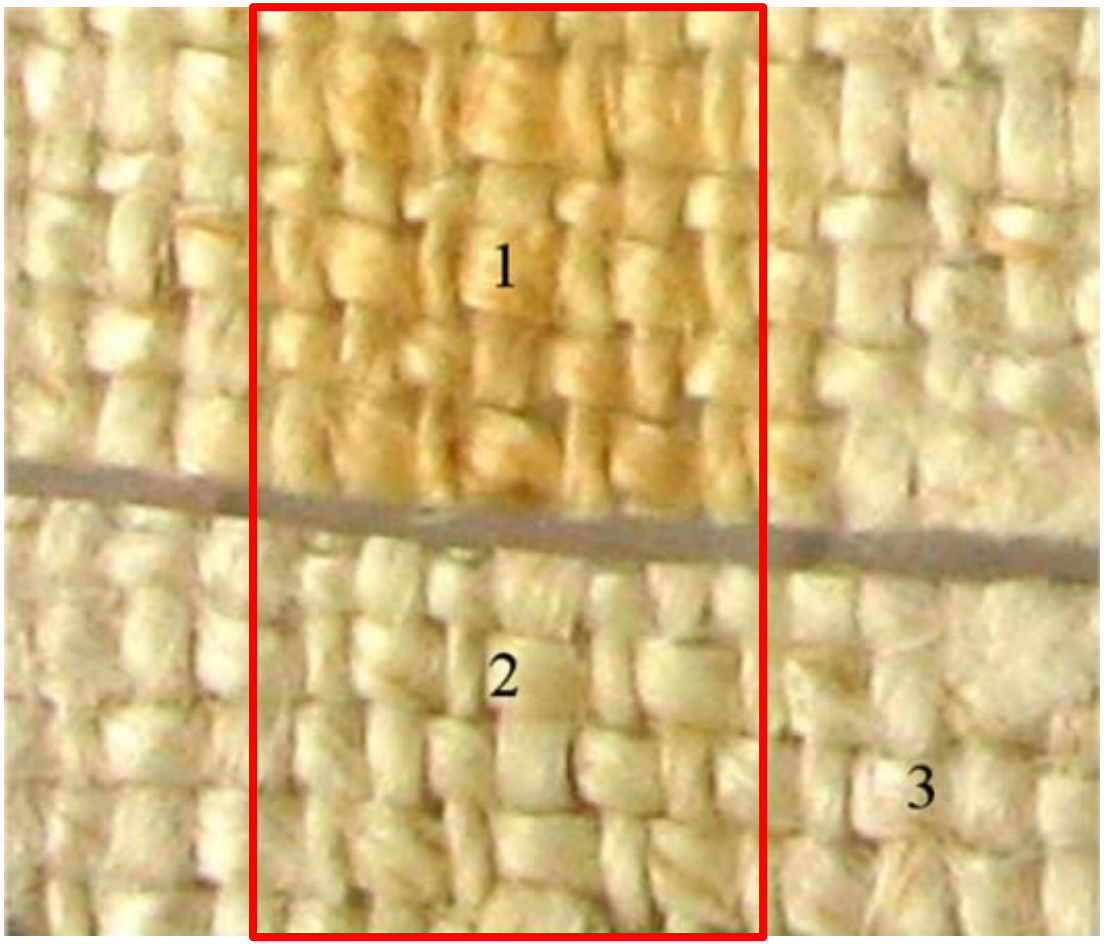
The right one was heated 15 seconds at 190 °C: a coloration appears



The same sample, 18 months later

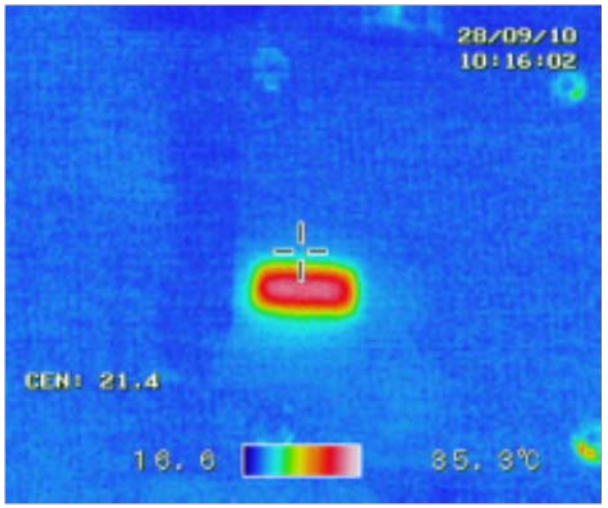
*from Applied Optics **47** 1278 (2008)*

Latent images generated at λ = 193 nm

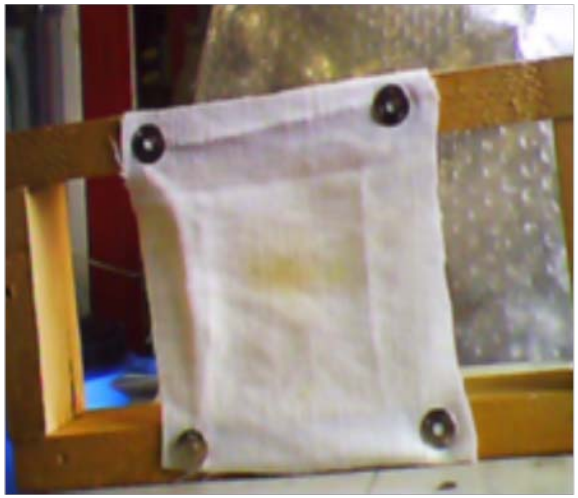


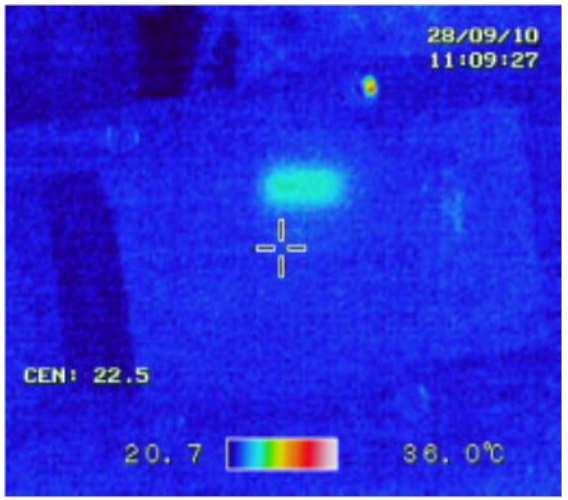
*from J. Imag. Science Techn. **54** 040201(2010)*

Thermal or photochemical coloration?



λ = 308 nm
T = 21 °C - 33 °C

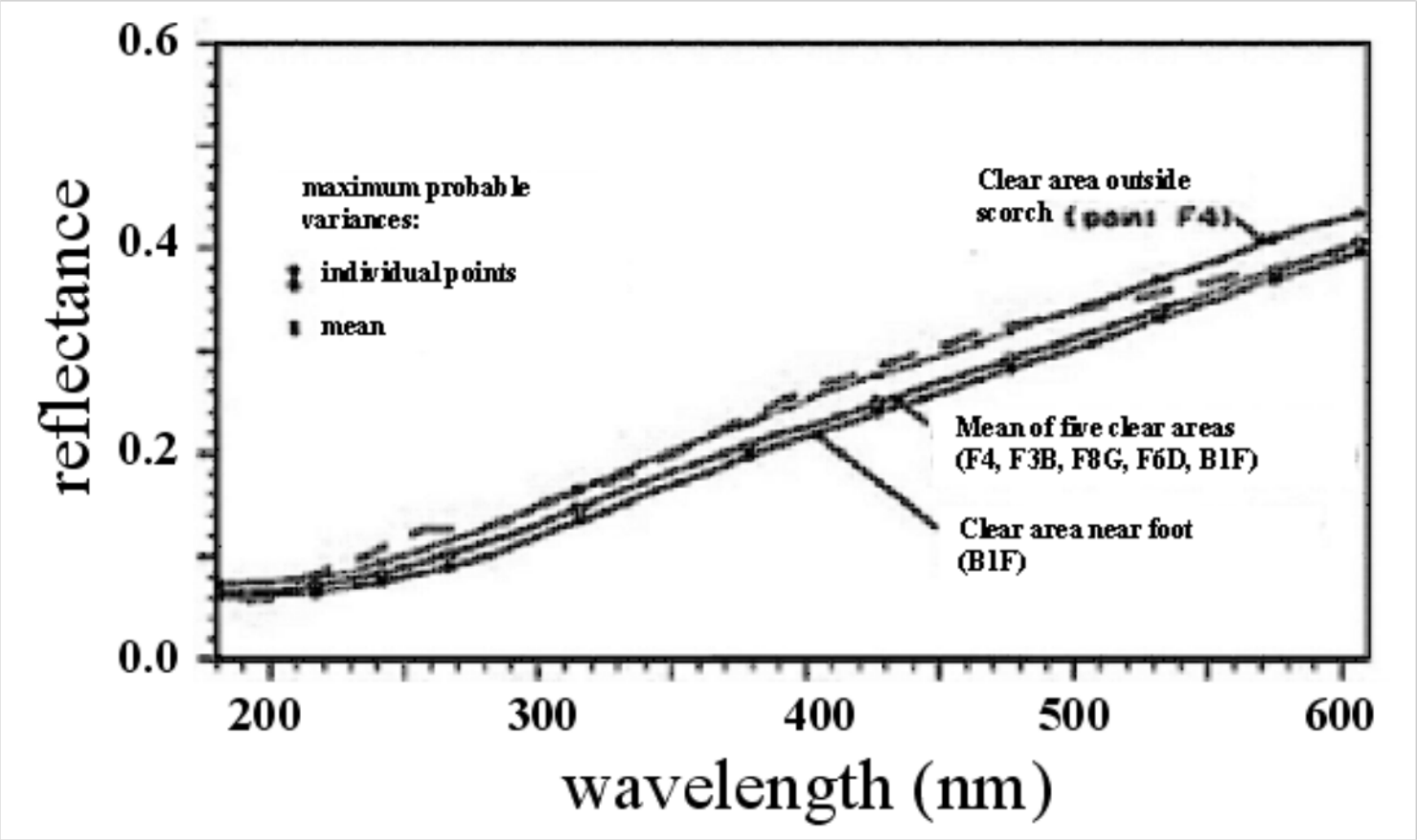




λ = 193 nm
T = 21 °C - 25 °C

from *ENEA Technical Report RT/2011/14/ENEA (2011)*

How much different is our linen from the Shroud?



The solid lines show the absolute reflectance of the linen of the Shroud in areas of no-image as a function of the wavelength. The dashed line shows the absolute reflectance of the linen used in our experiments.

From *J. Imag. Sci. Techn.* ***54*** *4302 (2010)*

Composition of natural textiles

Cotton

cellulose (88 – 94)%
water (7 – 8)%
lignin
proteins

Linen

cellulose (72 – 83)%
pectin (10 – 22)%
lignin 2%
wax 2%
water
proteins

Jute

cellulose (62 – 65)%
hemicellulose (12 – 14)%
lignin (12 – 15)%
water

Hemp

cellulose (68)%
lignin (10 – 15)%
water
proteins

Composition of natural textiles

Cotton

cellulose (88 – 94)%
water (7 – 8)%
lignin
proteins

Linen

cellulose (72 – 83)%
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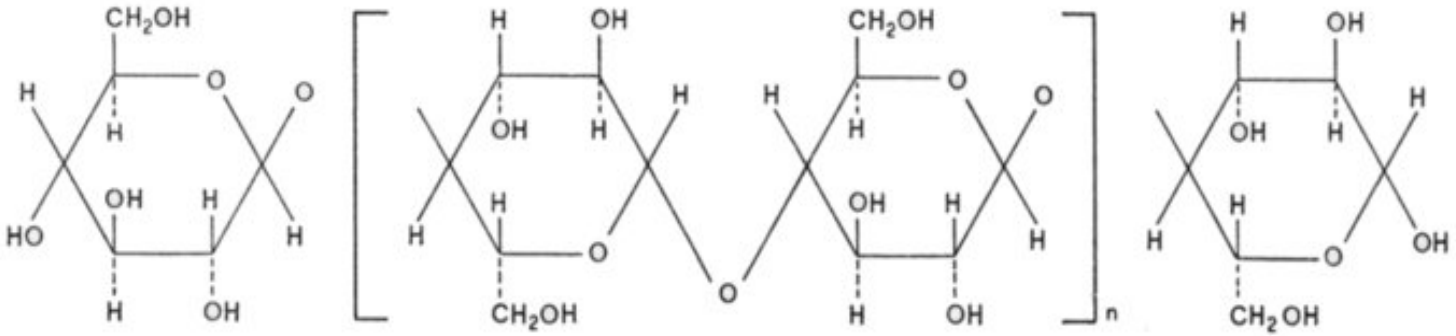
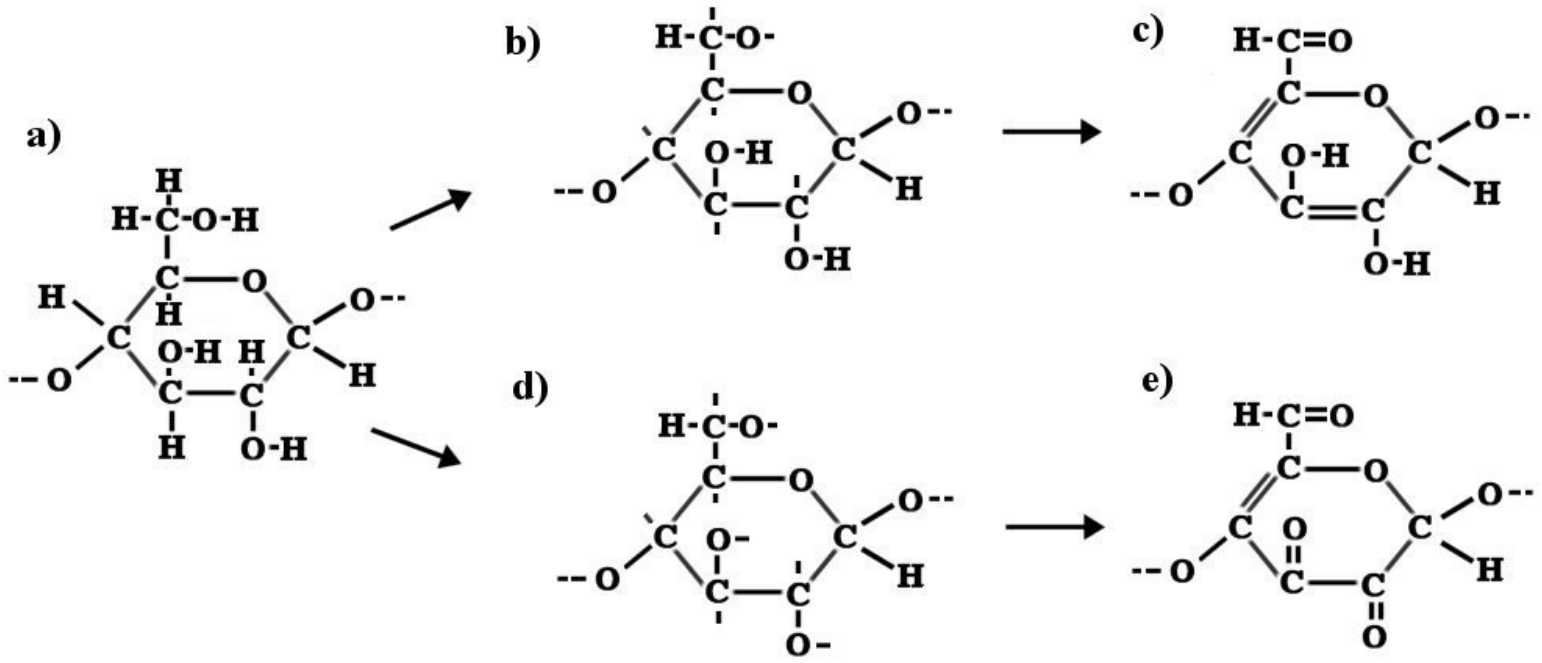
wax 2%
water
proteins



Cellulose and UV radiation: studies of the ’70s

- ✓ Cellulose and hemicellulose (chains of saccharides $C_6H_{10}O_5$) strongly absorbs photons with spectrum > 4 eV (λ < 300 nm, UV and VUV).
- ✓ UV light generates photolysis and photo-oxidation of saccharides.
- ✓ Chemical groups responsible for photolysis: aldehyde ($\lambda \approx 300$ nm) and both alkene and ketonic carbonyl ($\lambda << 260$ nm).
- ✓ Macroscopic effects of UV absorption: cellulose and hemicellulose bleach or become yellowed.

From (hemi)cellulose to cromophore (conjugated carbonyl groups)



Alkene –C=C – and ketonic carbonyls – C=O absorb λ << 260 nm

aldehyde -CHO absorb λ ≈ 300 nm (large bandwidth)

*J. Appl. Polymer Science **16**, 2567-2576 (1972)*

*Cellulose **1**, 205-214 (1994)*

Outline

- The body image on the Shroud
- Chemistry-based attempts
- Radiation-based attempts, our results
- **Conclusion**
- Appendix (Shroud vs. optical illusions)

Ut breviter dicam: ENEA experimental results

- ✓ We obtained linen coloration only in a **narrow range** of laser parameters: in particular, the **temporal duration** of the single laser pulse must be shorter than 50 billionths of a second.
- ✓ The permanent linen coloration is a **threshold** effect, i.e. the color is obtained only if the total laser intensity exceeds a certain value (thousands of megawatts per square centimeter). For intensity values exceeding the "right" range of values the linen is vaporized, while for smaller intensities it is unaffected and does not change color. Even when the total intensity is above threshold, not all the irradiated fibers are colored due to spatial fluctuations of the intensity of the laser pulses.
- ✓ We triggered a **photochemical** coloration process, because the thermal heating associated with UV and VUV radiation is within a few degrees centigrade and therefore irrelevant for the purpose of coloring. This result fits with the requirement of a coloring process at temperatures well below 200 °C according with STURP.

Ut breviter dicam: ENEA experimental results

✓ We observed an irradiated fiber whose coloration was confined in the **primary cell wall**, which is comparable with the thinnest coloration depth observed in the fibers image of the Shroud.

✓ The **hue of color** depends on the wavelength of the radiation and on the number of pulses. Irradiations at 308 nm generate a brownish coloration, while the 193 nm photons generate a yellow color, similar to the color of the Shroud image. In both cases, the contrast of color increases with the number of laser pulses, allowing an **accurate control of the RGB** value by varying the total intensity.

✓ The different colors obtained by UV and VUV radiation is due to different chains of photochemical reactions. In particular, the VUV radiation at 193 nm is absorbed by **alkenes** and **carbonyls**, inducing a **photolytic degradation** of the cellulose of the linen which promotes the **formation of chromophores** having a **double bond C=C**. These chromophores determine the yellow coloration of the fibers.

Ut breviter dicam: ENEA experimental results

✓ After laser irradiations that do not produce a visible coloration of linen, a **latent coloration** appears either by artificial or natural ageing (18 months later) of linen. Latent coloration is interesting for the synergy of UV, oxidation and the dehydrating effect of heat triggering the coloration process, and for historians, attracted by the possibility that, whatever may have caused the Shroud image, the coloration may have "developed" over years.

✓ The **lack of fluorescence** induced by UV and VUV laser radiation is an additional feature of our coloration similar to the Shroud images. The induced fluorescence is also capable to selectively recognize the uniformity of coloration.

✓ We were NOT able to fully obtain the gross shading structure that is determined by the ratio of yellow to uncolored fibers in a given area, the so called "**half-tone effect**".

✓ Absolute reflectance measurements show that when irradiated in the UV and VUV, our linen behaves like the linen of the Shroud.

Indirect consequences of ENEA results

- The UV light coloring linen fits the absence of image under the bloodstains on the Shroud. In fact, even thin layers of blood hemoglobin is opaque to UV light. According to Goldoni, the UV light may be responsible for another special feature of the Shroud, the **red color of bloodstains** after so much time of their deposition.

- Using a petrographic microscope, we have observed some **defects** induced by UV radiation in the structure of the linen fibers irradiated by our lasers, similarly to very old linen fabrics.

- When considering the highly unconventional hypothesis of the Shroud collapsing into a radiating body proposed by Jackson, VUV light is compatible with both shading correlation with cloth-body distance and the absence of side images. This is because VUV photons are strongly absorbed by air.

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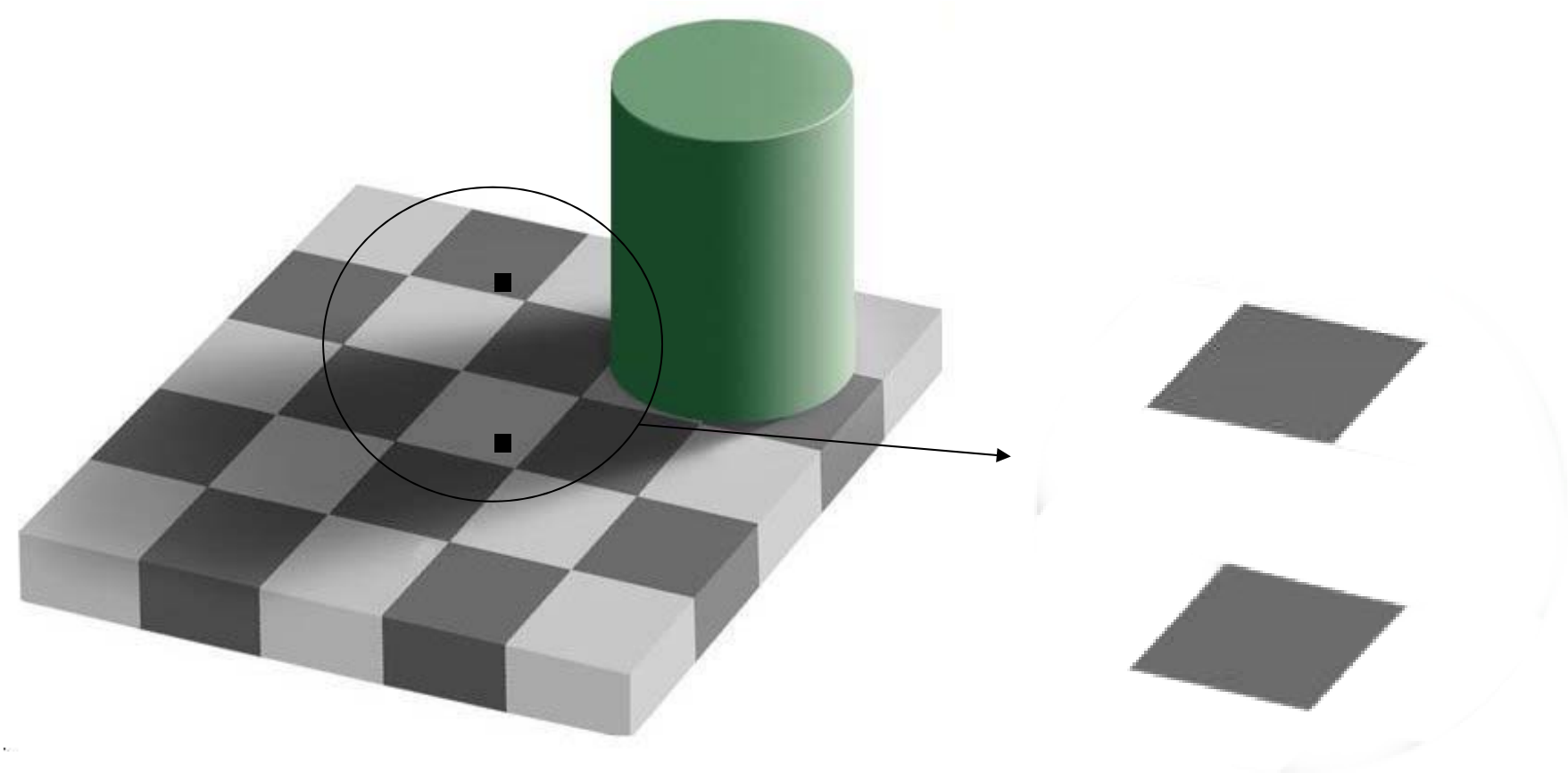
Perception of colours and contrast

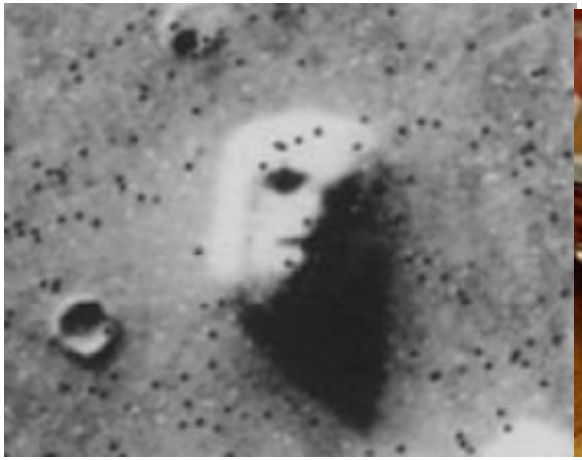
Are we sure of our capability to distinguish if an object is darker than another?



The two elements of the chess signed by a point have the same grey color!

The perception of shapes

We “see” thanks to the system eyes+brain. Sometimes this system is misguided by our experience and our mood.
This is the case when we “see” a well known image in a unusual context: this phenomenon is called *PAREIDOLIA*
from *εἴδωλον*, image, *παρά*, like) is a subconscious illusion involving a vague and random stimulus (often an image or sound) being perceived as significant.



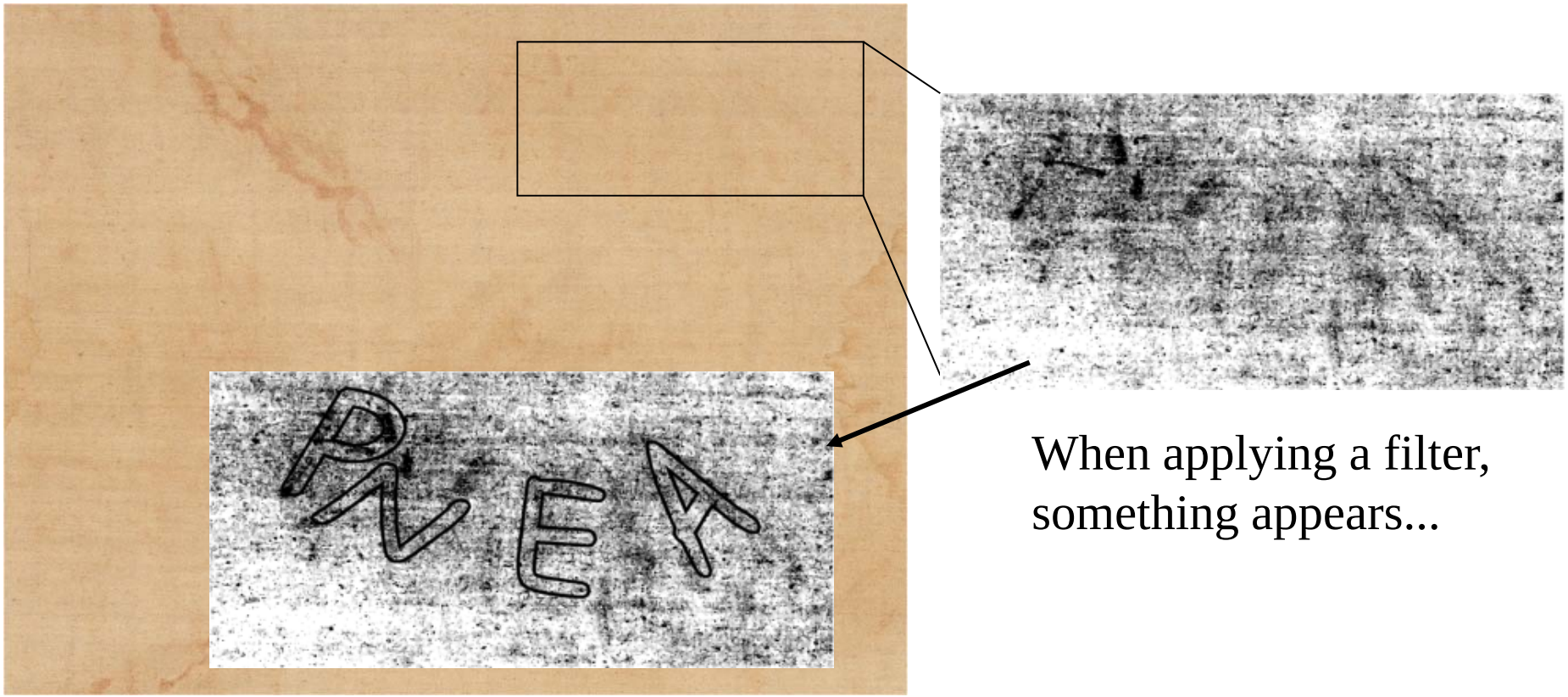
Perception of shapes and colours

A surprising example of *pareidolia*

A deep image elaboration generates inexistent patterns

An improper use of software tools make it possible to “see” patterns where there is nothing. Pareidolia completes the optical illusion…
Let’s make a test:

Detail of the Shroud
(photo by B. Schwortz, 1978)



When applying a filter, something appears...

One example more: a «face» on the reverse side of the Shroud emerges after a deep digital processing of a photograph

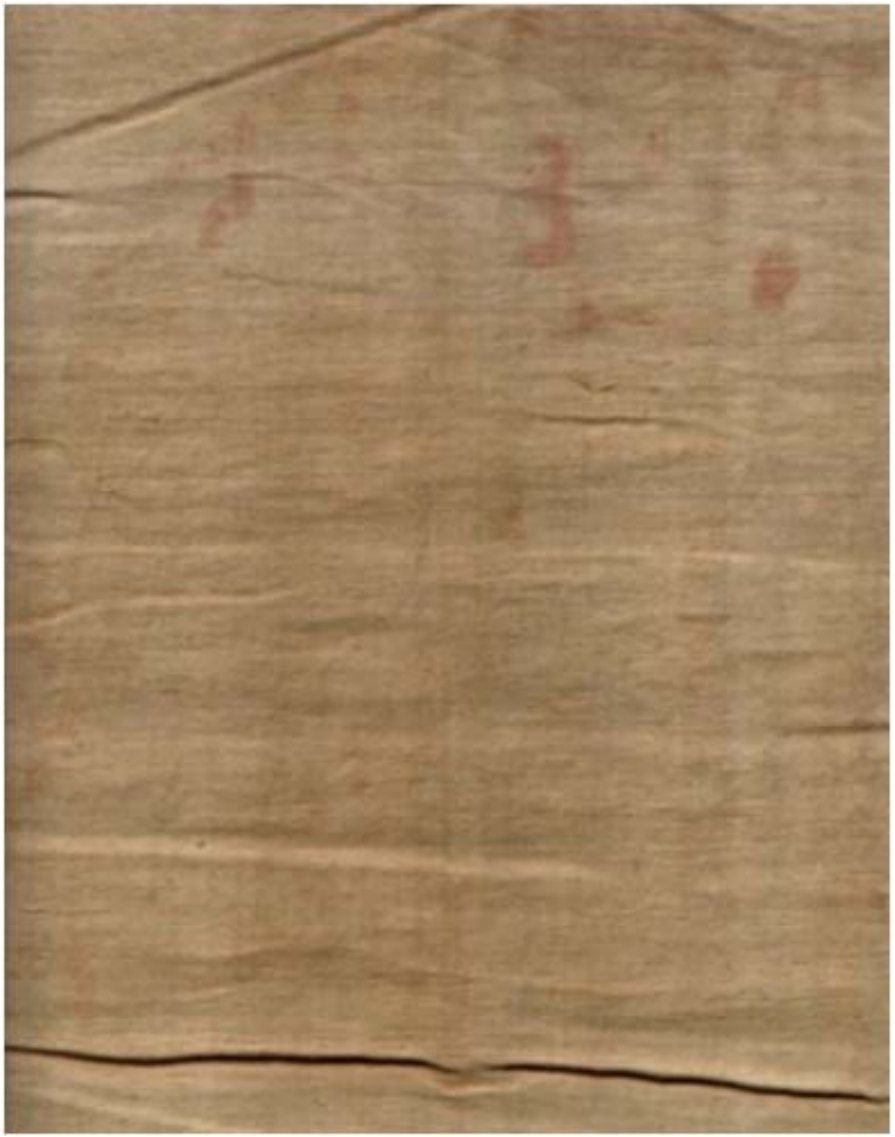
From J. Optics A 6, 491 (2004)

This face is real or it is the result of our innate propensity to interpret stimuli as faces based on minimal cues?

A confirmation of this doubt came from the results of the Fourier transform of a high-resolution image obtained by in-depth scanning of the reverse side of the Shroud, which did not show any face.

However, the problem still remains to understand how the face we perceive comes out.

The photograph of the face on reverse side of the Shroud



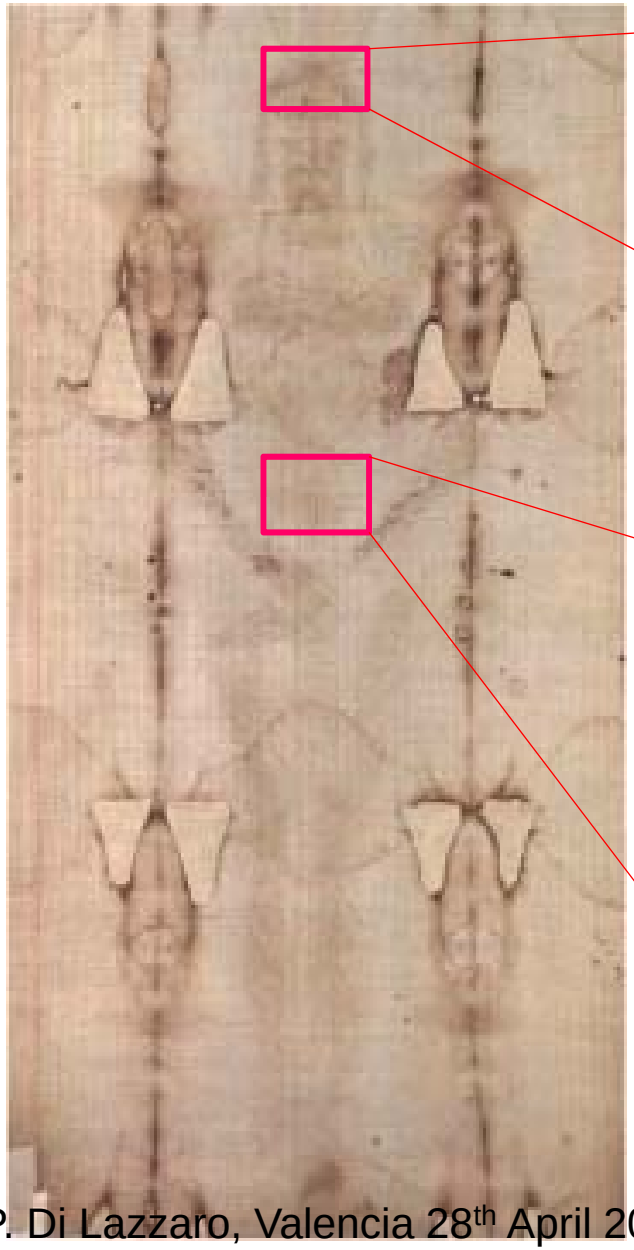
If we look carefully at the photo, within few minutes we will perceive eyebrows, nose, mouth, long hairs: the face of the man of the Shroud.

The typical bloodstains "guide" our brain to select the face of the man of the Shroud as the most similar pattern we find in our memory. Unfortunately, this is an illusion…

The photograph of the face on reverse side of the Shroud

…in fact, a simple rotation of 90° of the photo is sufficient to loose the perception of the "face"!

The unbelievable brain capability to fill the missed information



Below: zooming into a detail of the belly we cannot see any pattern that makes sense. However, simply by adding a detail of the forehead (above) we perceive a Shroud-like face!

The unbelievable brain capability to fill the missed information

Our brain is able to reconstruct and complete the missed information of both images and texts…

- TH15 M3554G3 PR0V35 0UR BR41N C4N R34D 4 L3773R WR1773N W17H NUMB3R5.
- 1MPR3551V3 !
- 4T 7H3 B3G1NN1NG 17 W45 D1FF1CUL7, BU7 1N 7H15 R0W Y0UR M1ND R34D5 4U70M471C4LLY W17H0UT D1FF1CUL7135 !
- C0NGR47UL4T10N5 !

“The Shroud is a challenge to our intelligence.

The Church entrusts to scientists the task of continuing to investigate, so that satisfactory answers may be found to the questions connected with this Sheet.

The Church urges that the Shroud be studied without pre-established positions that take for granted results that are not such. The Church invites them to act with interior freedom and attentive respect for both scientific methodology and the sensibilities of believers”

John Paul II

Torino, May 24, 1998

Coauthors 2005 - 2010

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Daniele Murra	ENEA Frascati
Enrico Nichelatti	ENEA Casaccia
Antonino Santoni	ENEA Frascati

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