TST 2016 - 5th EOS Topical Meeting on Terahertz Science & Technology

Multispectral multiple-technologies approach to paintings analysis

THz - NIR - Visible - UV - X-Ray

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Pecs - Hungary
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The Actors

Ausonio Tanda
Sassari, Italy 1926 – Roma, Italy 1998

„After Fishing“ mid '60

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Profilocolore Srl Roma	Georgia Institute of Technology, School of Electrical and Computer Engineering, Metz, France	University of Reading, School of Systems Engineering, Reading, United Kingdom	Laboratoire de Recherche des Monuments Historique, Champs-sur-Marne, France

Purpose of this study

Test the Terahertz technology as a tool for the Cultural Heritage

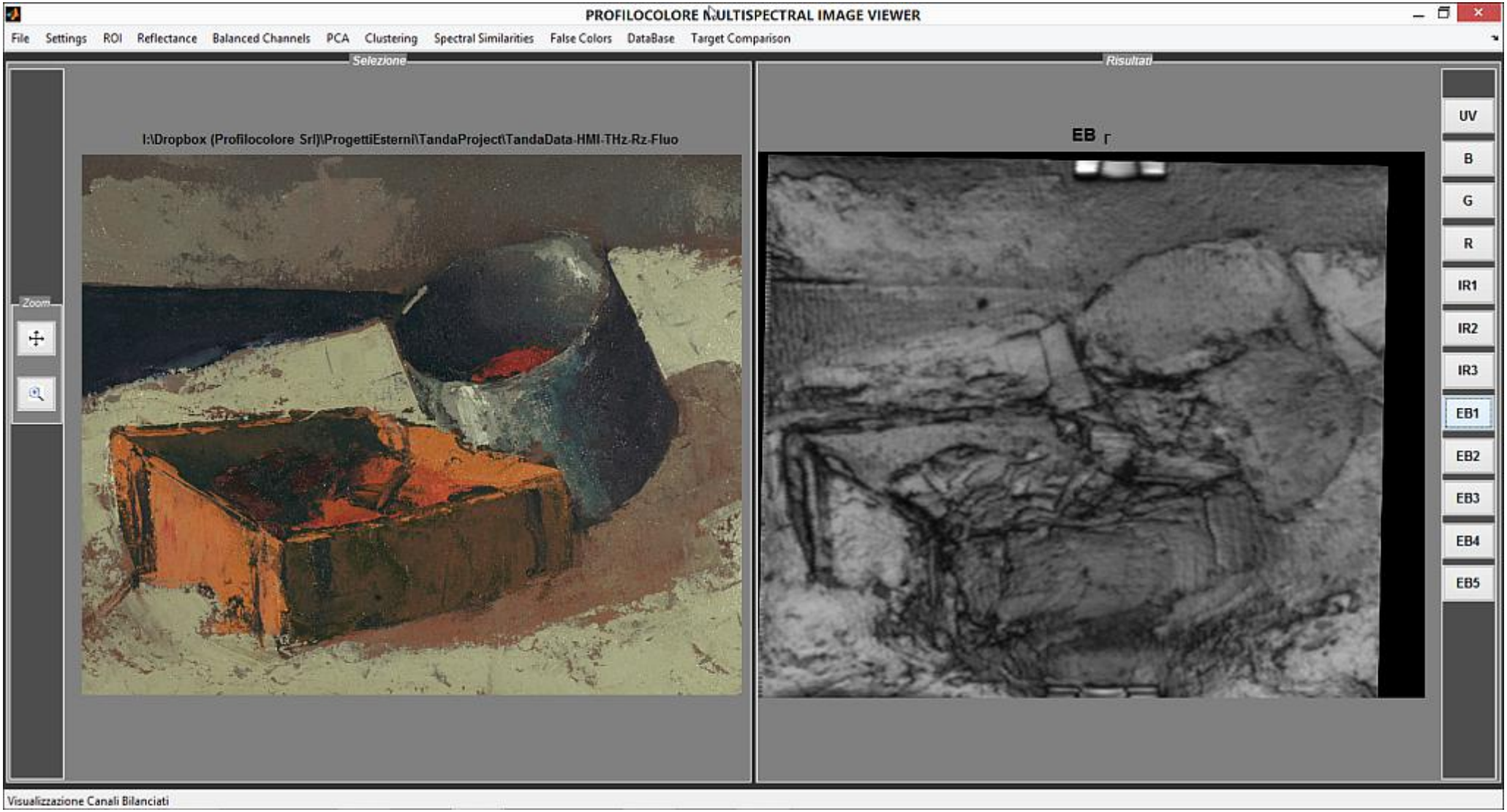
Evaluate the achieved findings and compare to other already consolidated techniques

Understand the added value of THz in this application field

Methods

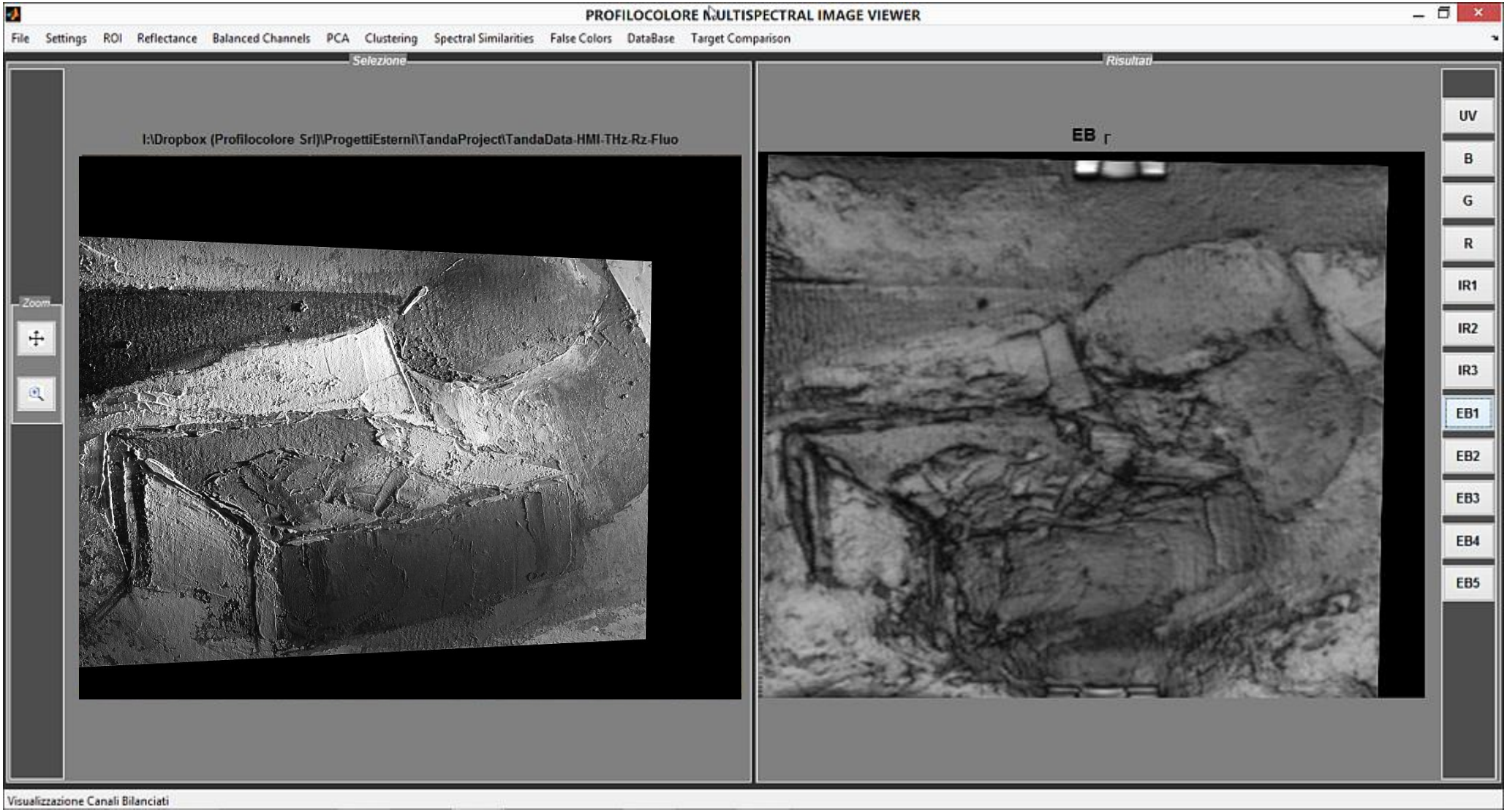
- Time Domain Spectroscopy (TDS) System (Teraview TPS 3000)
- Roughly single-cycle THz pulse 60 GHz to 3 THz
- Focus spot of about 300um @ 1THz
- Normal incidence reflection
- THz reference signal recorded on metal plate at sample position
- Motorized X,Y stage for raster scan @ 1mm step 28x25 cm (280x250 points)
- 4096 data point per THz waveform, 10 shots average
- THz frequency-wavelet domain deconvolution (symlet wavelet, a modified form of Daubechies wavelet)
- Weighted spectral reflectance 0°/45° on 7 partially overlapping bands centered at 350, 450, 550, 650, 750, 850 and 950 nm (95% radiometric precision) image
- Xray (transmission) image
- 360 nm to visibe (400-700nm) fluorescence image
- Colorimetrically calibrated AdobeRGB image (max error deltaE2000 = 2)

C-scan imaging in time domain (RAW data)
max peak amplitude in reflected signal



Bright: high global reflectance. Flatness and density
Dark: absorption or scattering. Roughness and lower interface discontinuity

C-scan imaging in time domain (RAW data)
max peak amplitude in reflected signal



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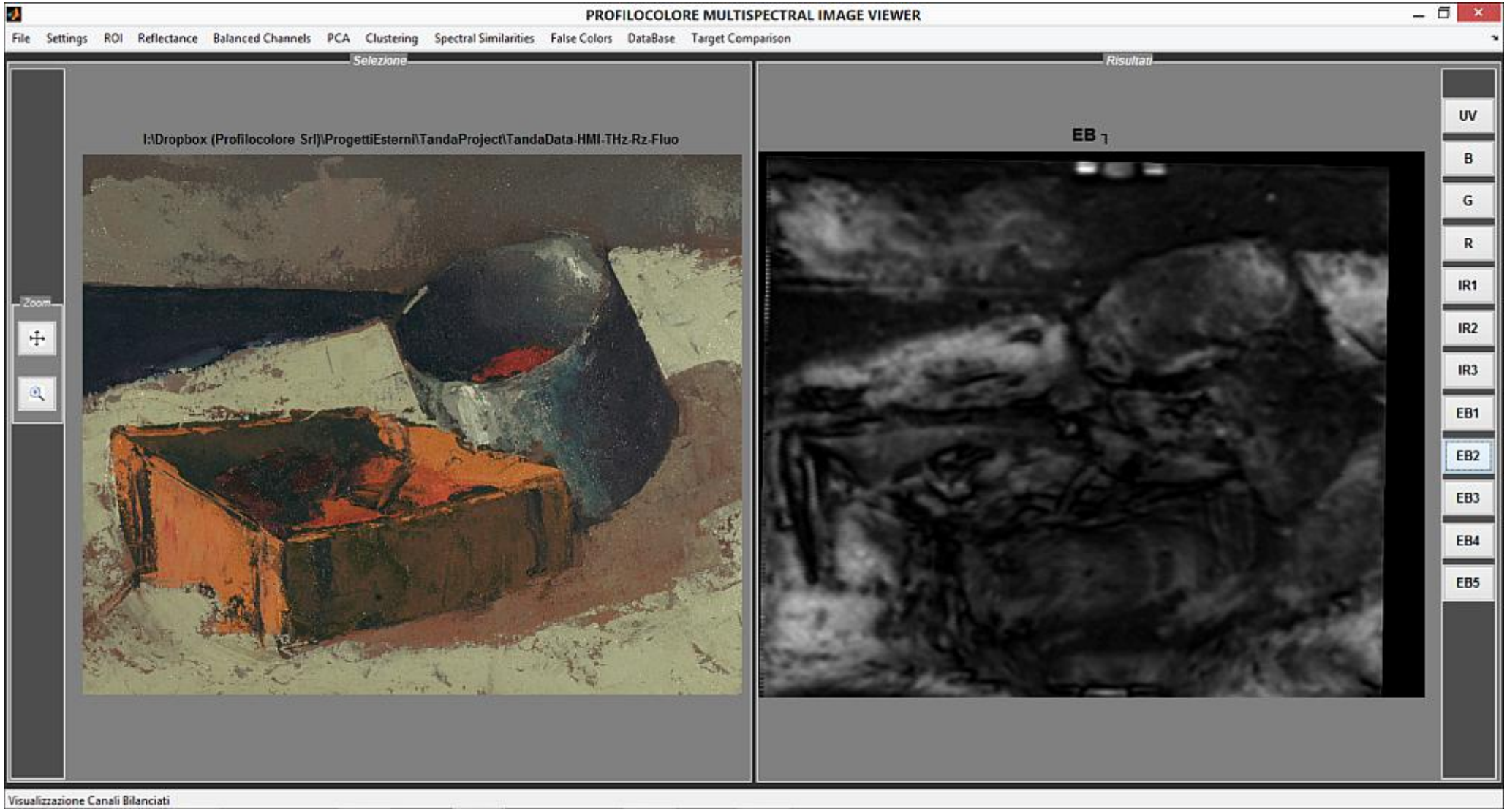
C-scan imaging in time domain (RAW data)

max peak amplitude in reflected signal

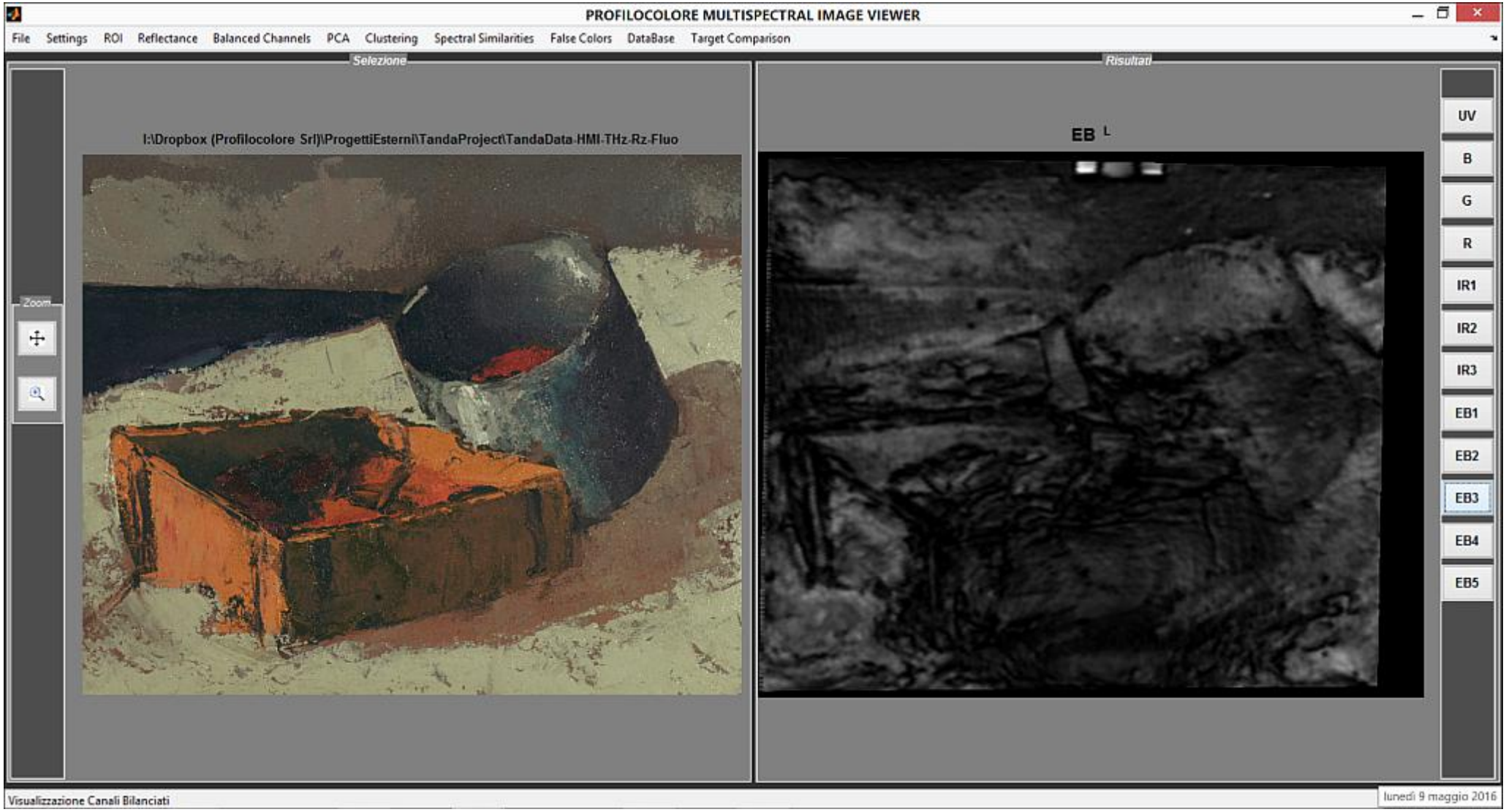
Bright: high global reflectance. Flatness and density

Dark: absorption or scattering. Roughness and lower interface discontinuity

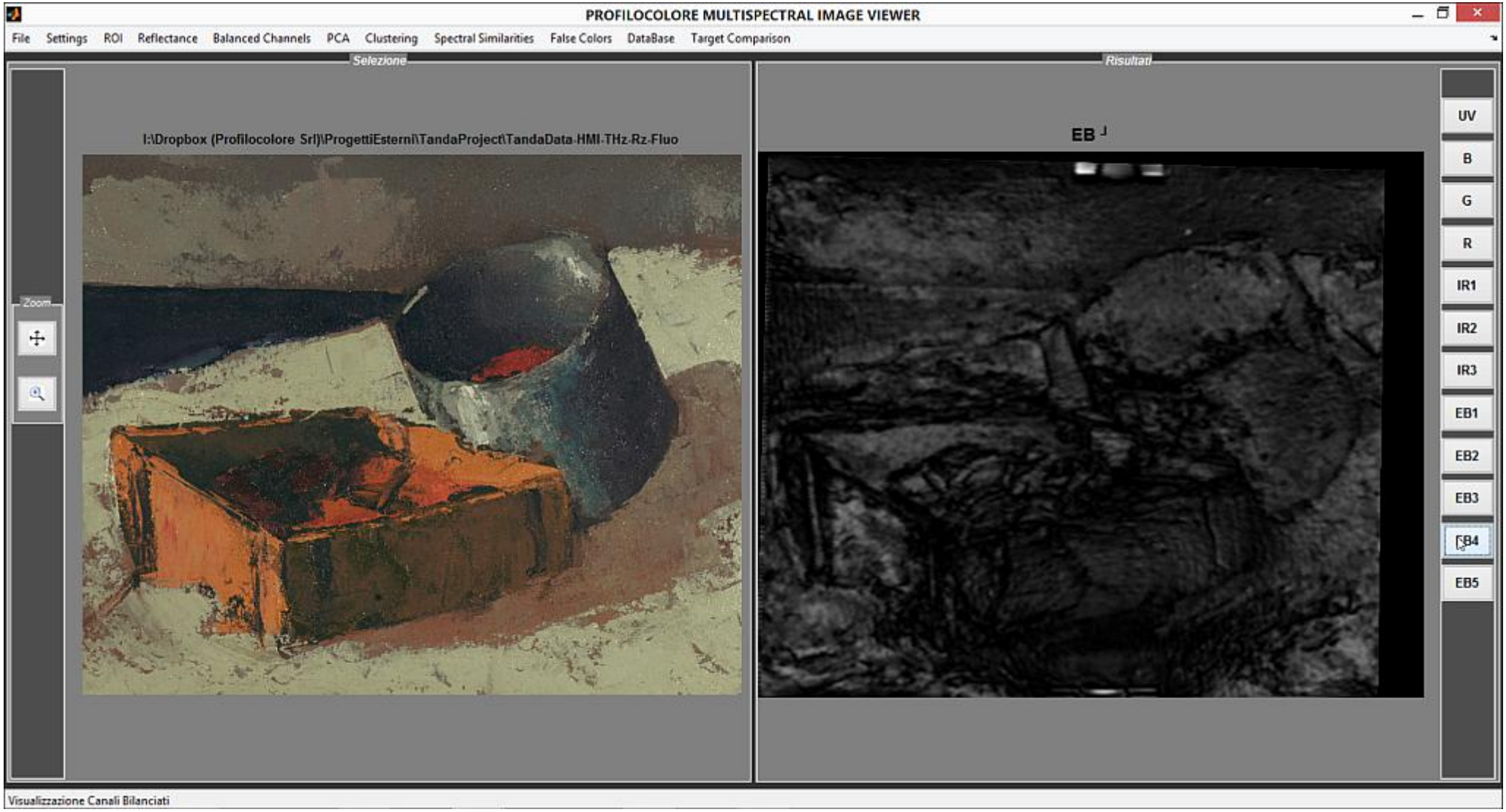
C-scan imaging in frequency domain (RAW data)
spectral power density @ 0.4THz



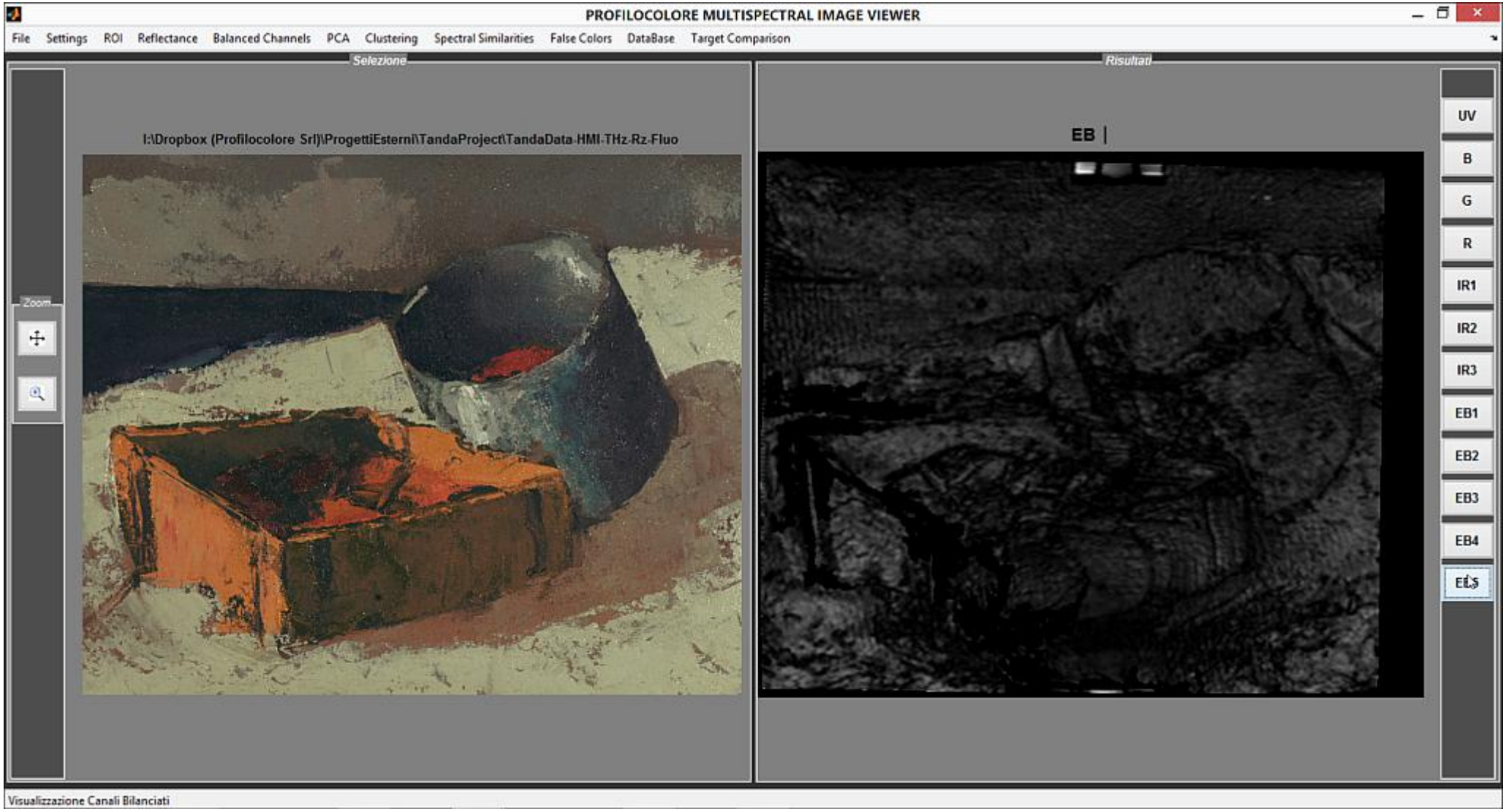
C-scan imaging in frequency domain (RAW data)
spectral power density @ 0.6THz



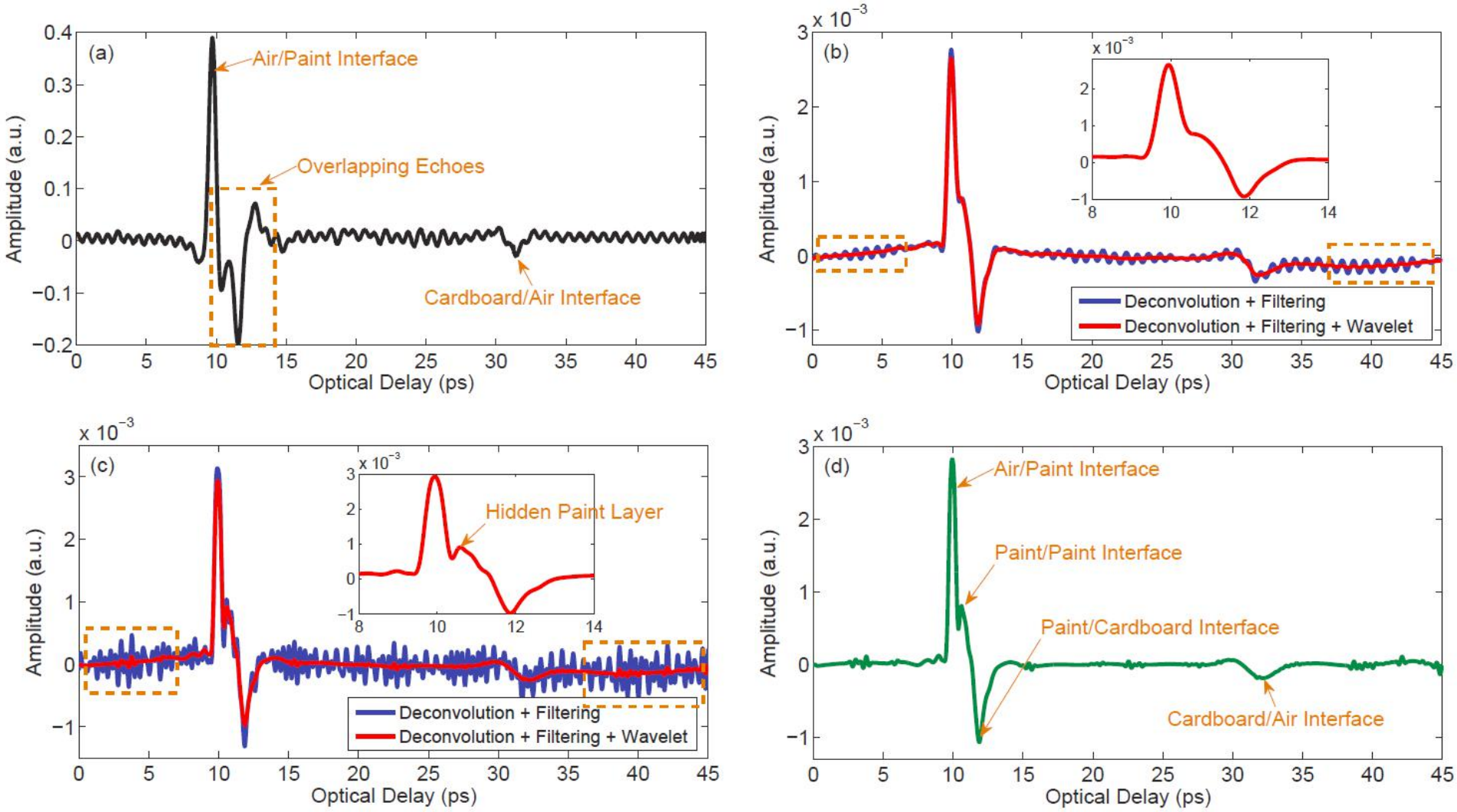
C-scan imaging in frequency domain (RAW data)
spectral power density @ 0.8THz



C-scan imaging in frequency domain (RAW data)
spectral power density @ 1.0THz

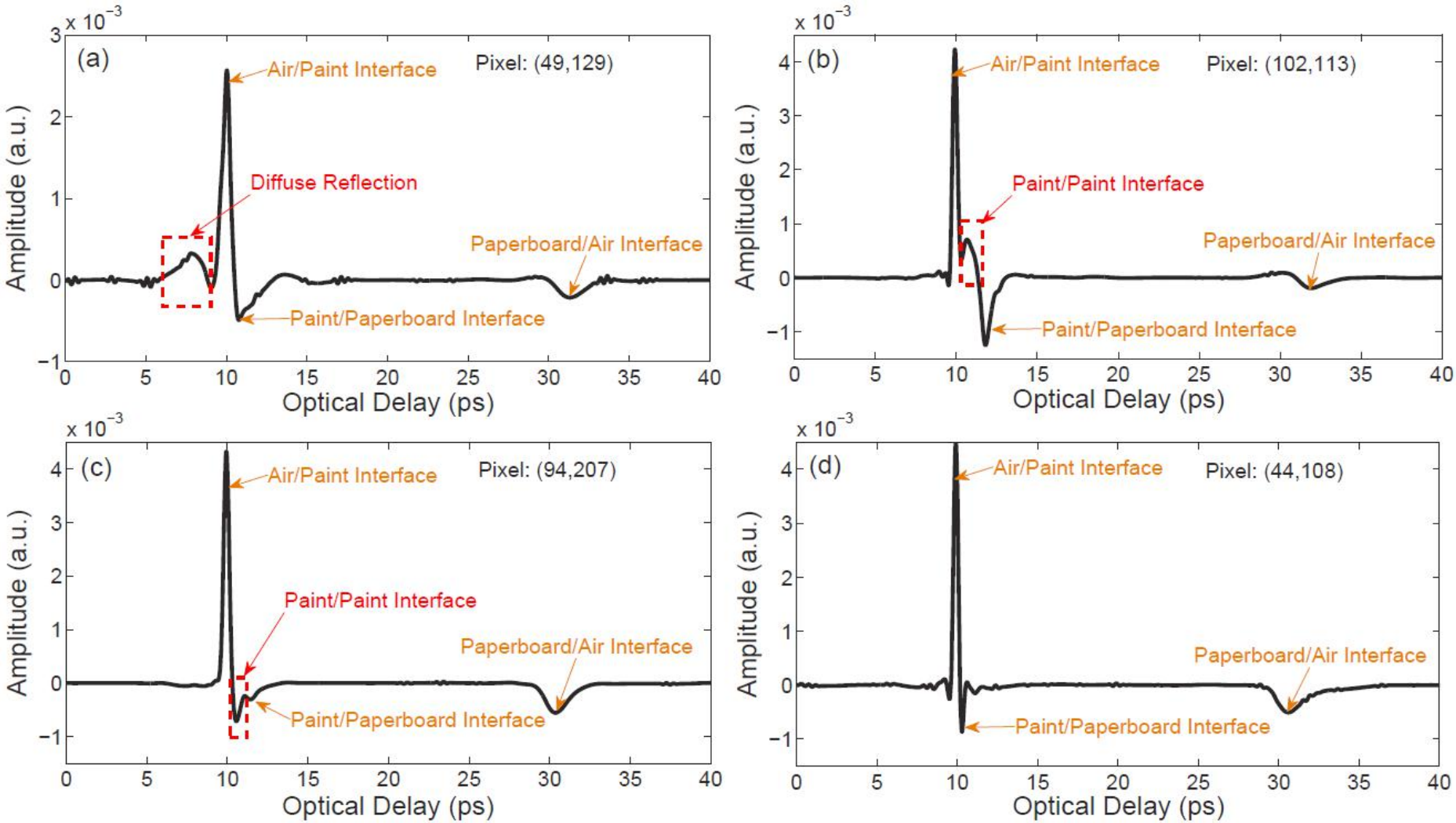


Internal painting structure investigation: Imaging from deconvolved signals



a) original THz reflected signal;
b) deconvolution with cutoff frequency 1.0THz
c) deconvolution with cutoff frequency 1.5THz;
d) final deconvolution result revealing the stratigraphy

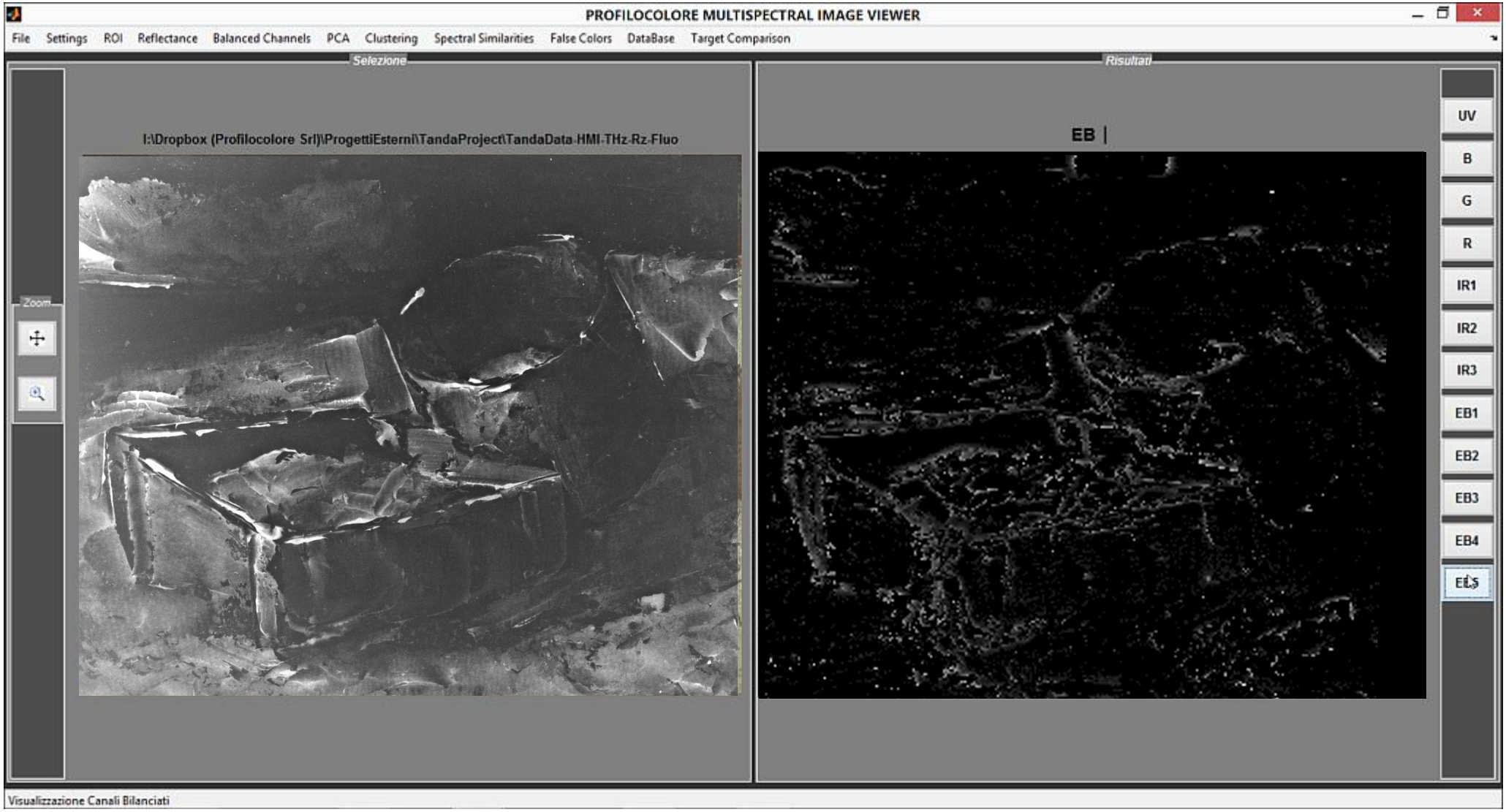
Internal painting structure investigation: four types of deconvovled signals



a) Type I: small peak before main peak: diffuse early reflection;
b) Type II: additional n1<n2 pigment layer interface peak;
c) Type III: additional n1>n2 pigment layer interface peak;
d) Type IV: no additional peak;

Air/paint-paint/paperboard thickness vs Xray:
Good correlation but Xray peaks are missing

Type I (diffused early echo) vs Xray:
most of missing Xray peaks are here



Negative MaxPeak vs Xray: *Good Correlation with high scattering, thick area missing*

UV-VIS-NIR 0°/45° Imaging Spectral Reflectance

95% minimum radiometric precision per pixel

350 nm

450 nm

550 nm

650 nm

750 nm

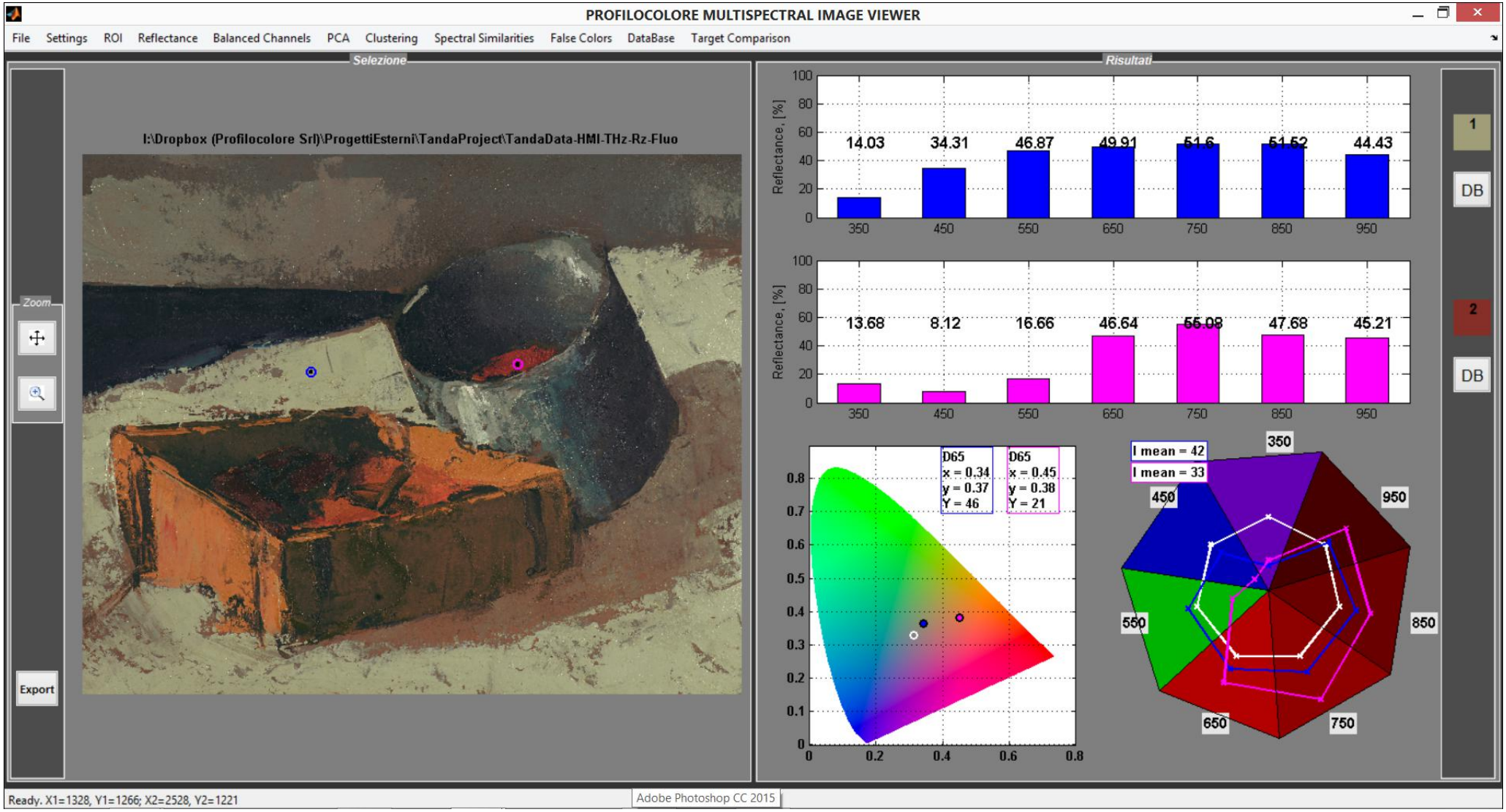
850 nm

950 nm

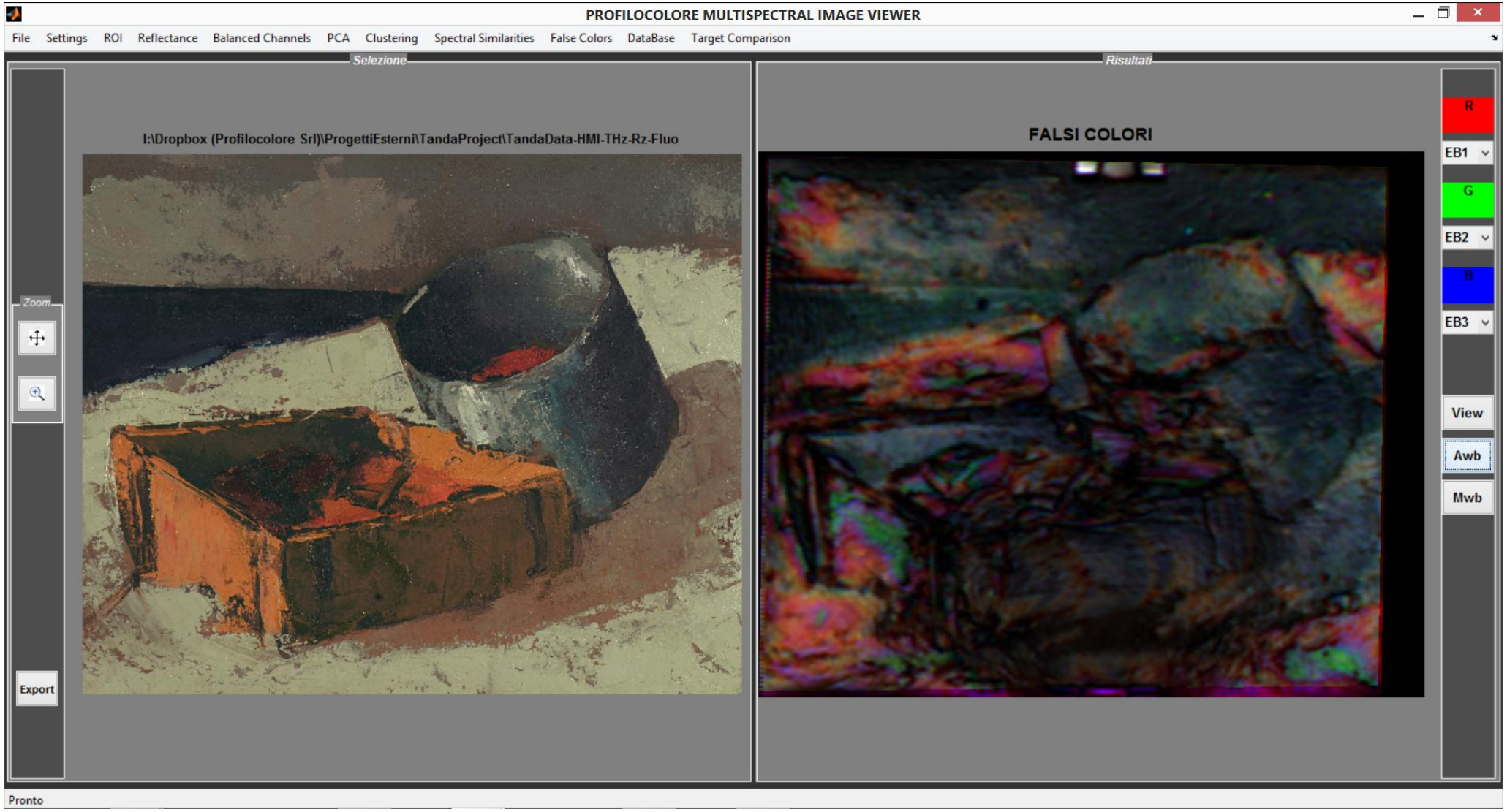
Fluo

Visible, colorimetric, AdobeRGB

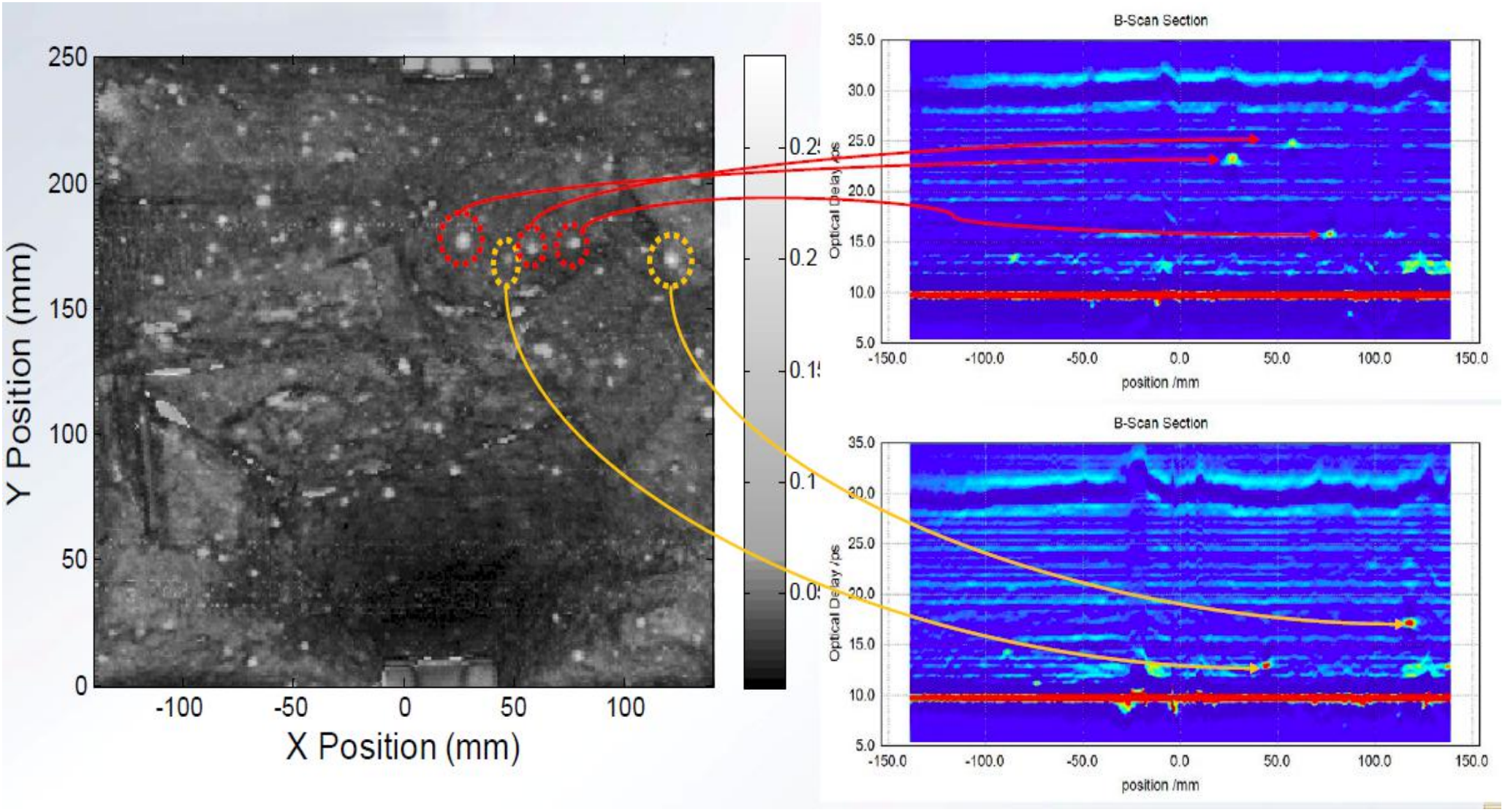
UV-VIS-NIR 0°/45° Spectral Reflectance: pixel reading



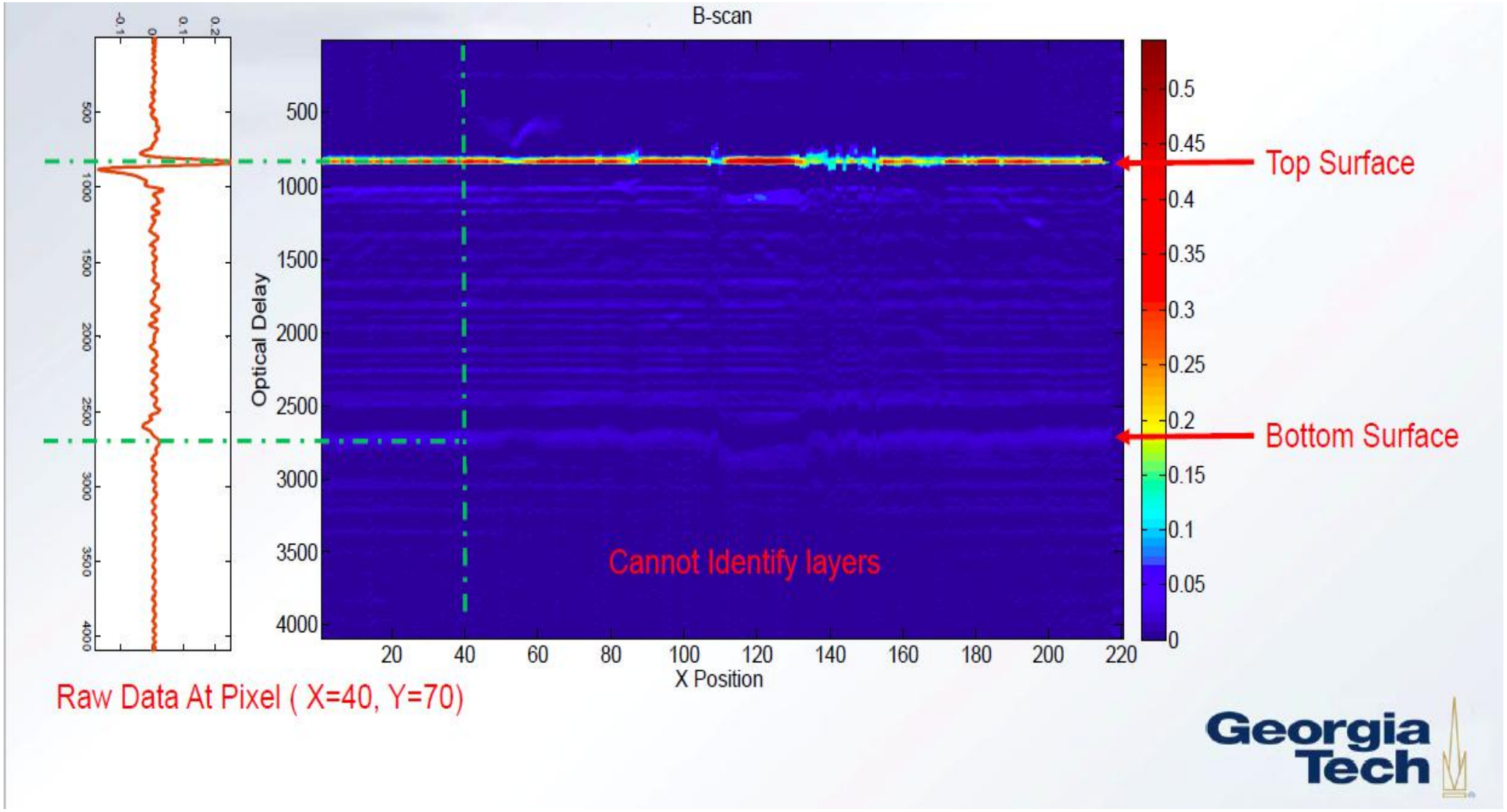
Spectral reflectance (vis) vs Freq. Domain C-scan: *correlation is quite poor (reflectance vs roughness)*



B-scan: inside the 3D structure:
hidden spots invisible to Xray



B-scan: inside the 3D structure:
counting paint layers



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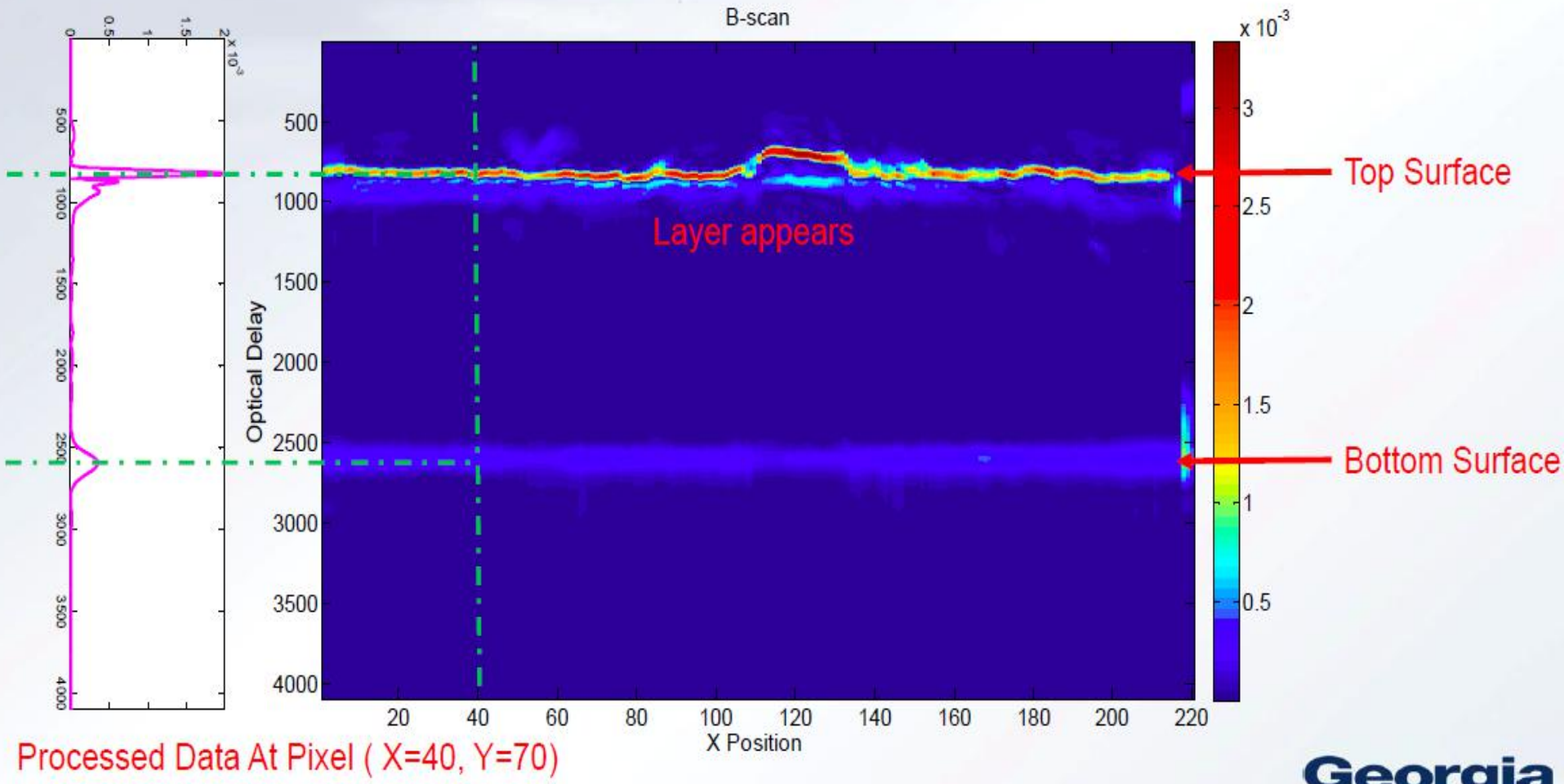
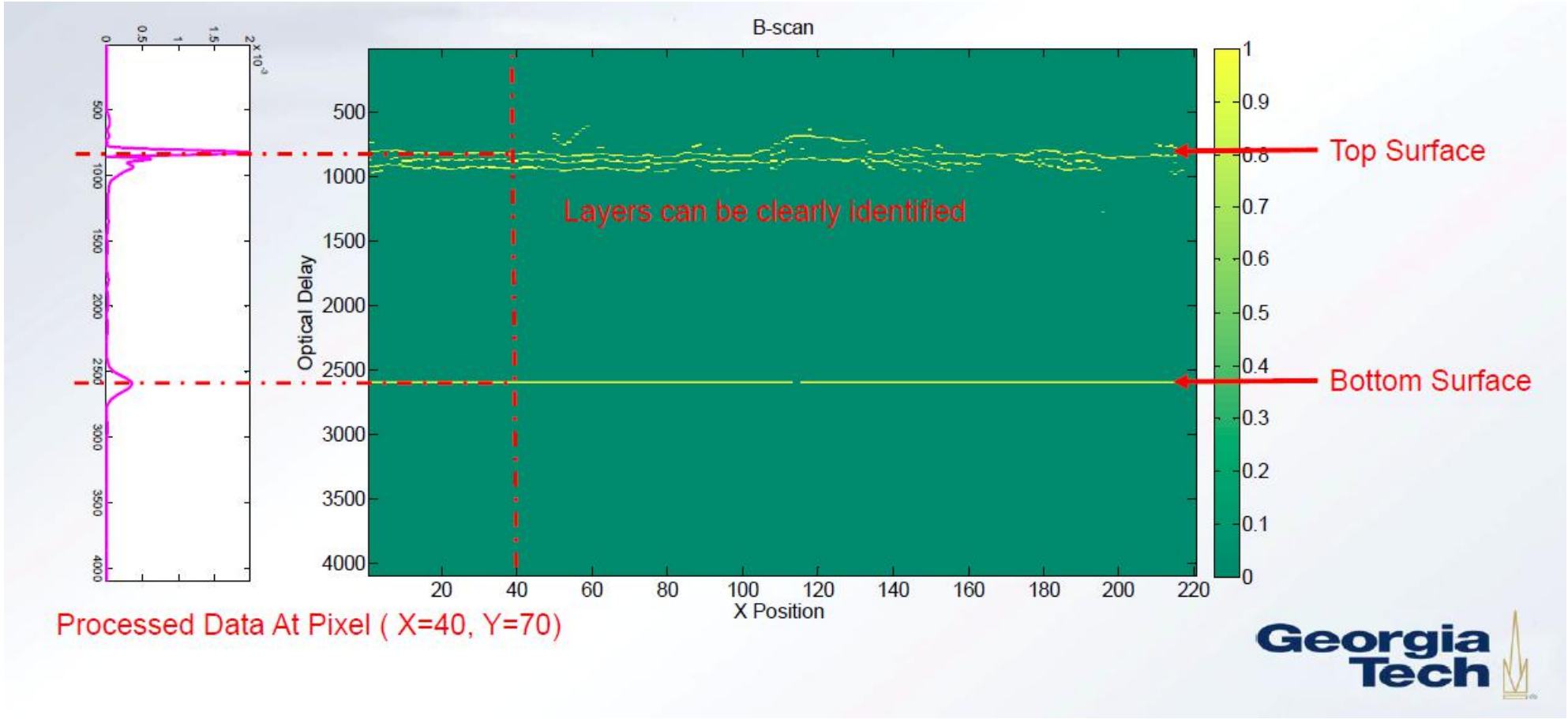


Georgia Tech

B-scan: inside the 3D structure:
counting paint layers



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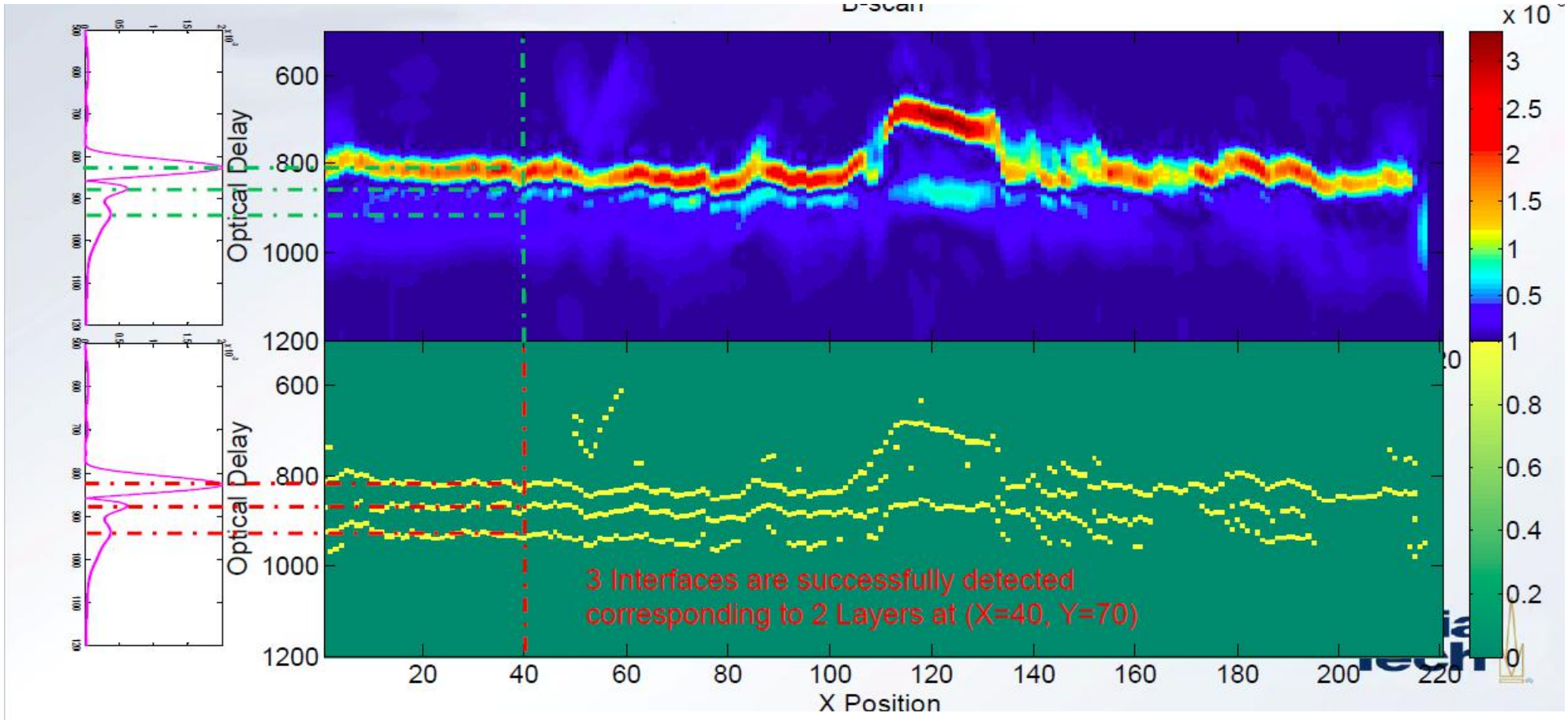

Conclusions

We compared imaging analysis coming from Xray, Spectral Reflectance and THz, to investigate a painting

1. THz can substitute Xray in most cases.
A big benefit because no ionizing radiations and not need to go in transparency (good for frescoes).
THz give more details about the substrate structure

2. THz and Spectral Reflectance give uncorrelated results. This means that together can greatly improve knowledge of the sample under analysis

3. THz can give a very good view of paint layers (provided that layers have different refraction index). This can be combined with spectral reflectance, the Raman analysis and the Kubelka-Munk equations to have a non invasive very accurate knowledge of the paint structure, binding and pigments

4. THz can give similar results as raking light and allowe to measure (with statistical imaging tools) the roughness of the surfaces

5. Need to have specific calibration tools for measurement of refraction index, thickness, roughness

THANK YOU

From our Team

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