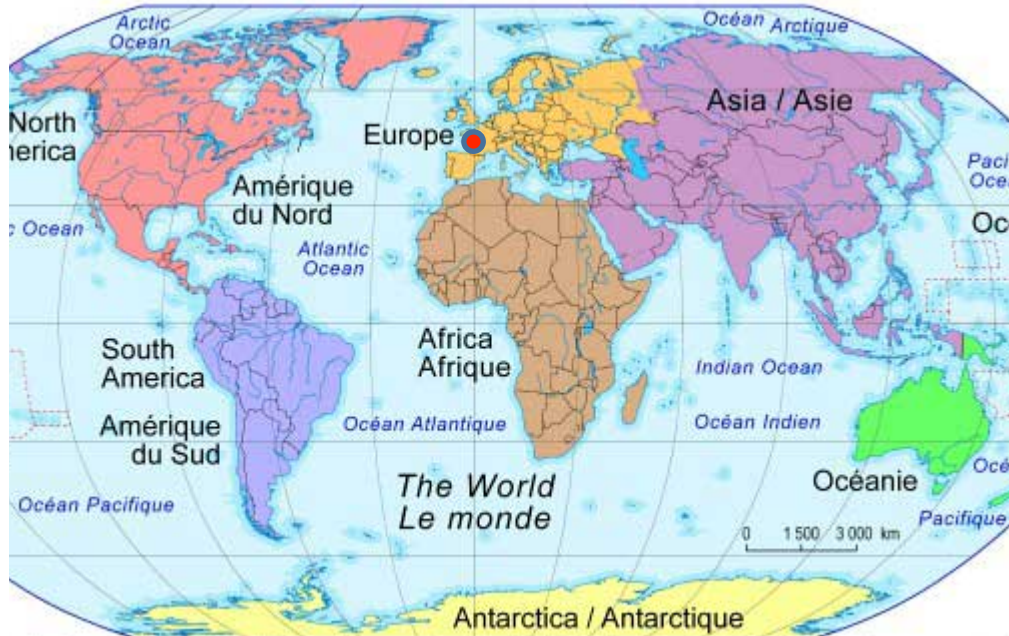


TeraBook

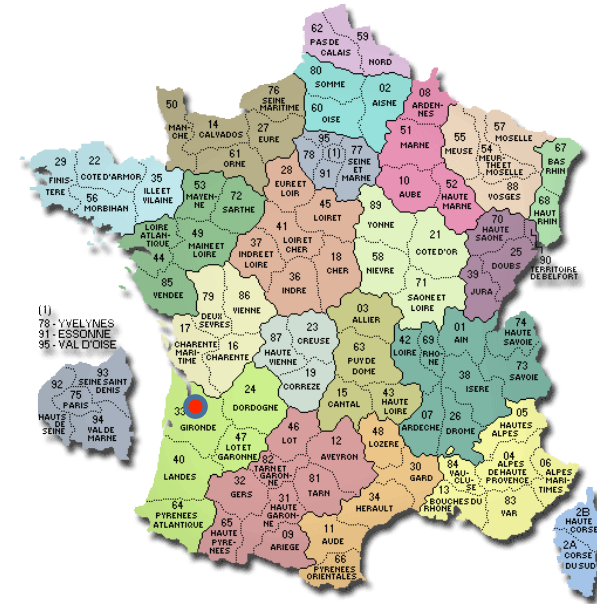
E. Abraham, LOMA (UMR 5798)

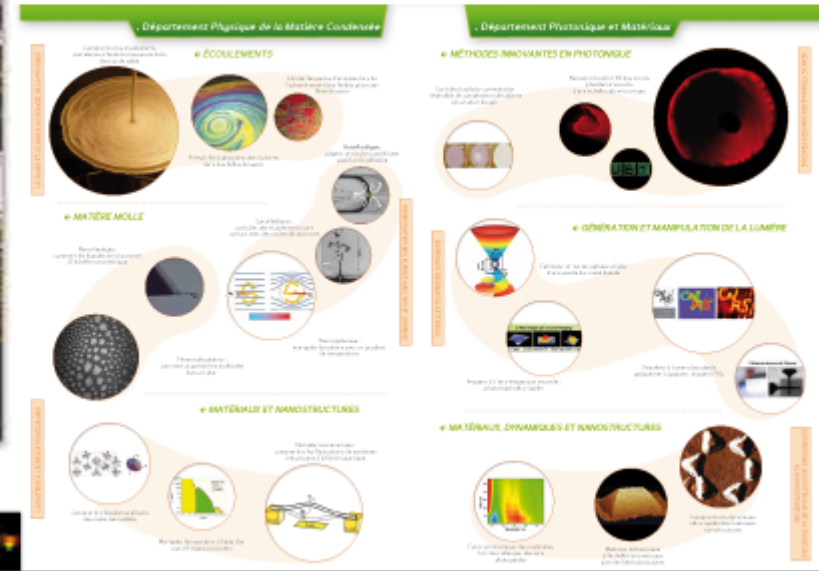


LOMA – Bordeaux University



by the Queen in Right of Canada, Natural Resources Canada. / Sa Majesté la Reine du chef du Canada, Ressources naturelles





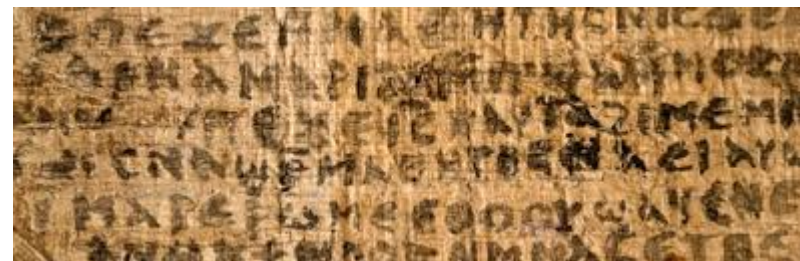
LOMA: 50 researchers, 25 technical staff, 30 students

Two departments:

- Condensed matter (fluidics, soft matter, nanomaterials)
- Photonics (laser technology, time-resolved spectroscopy, materials)

TERABOOK

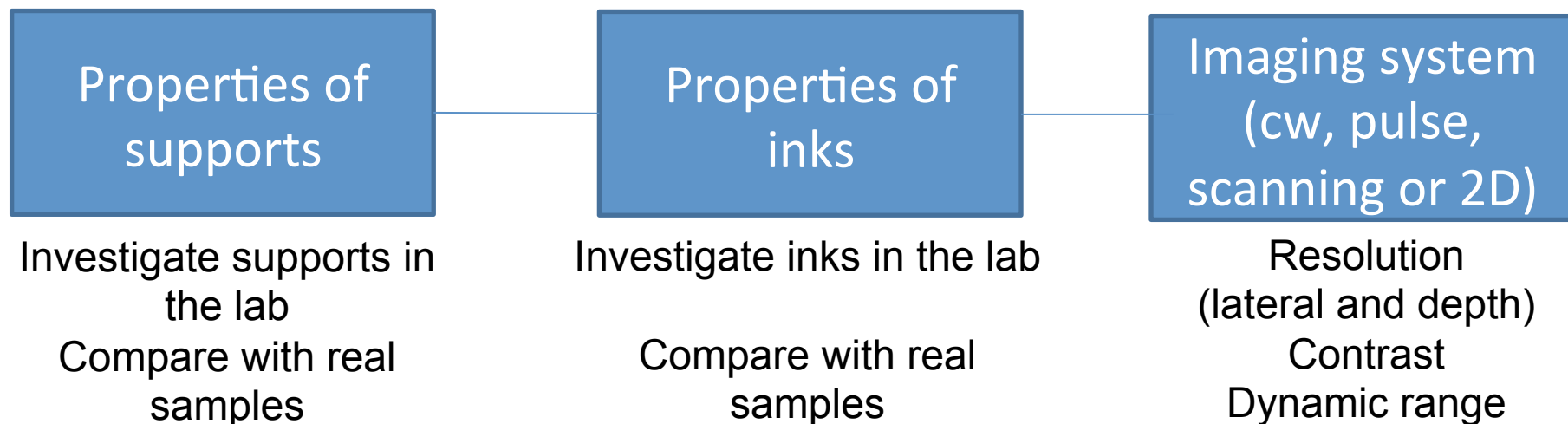
Is it possible to read a document without opening/touching it?



dreamstime.com

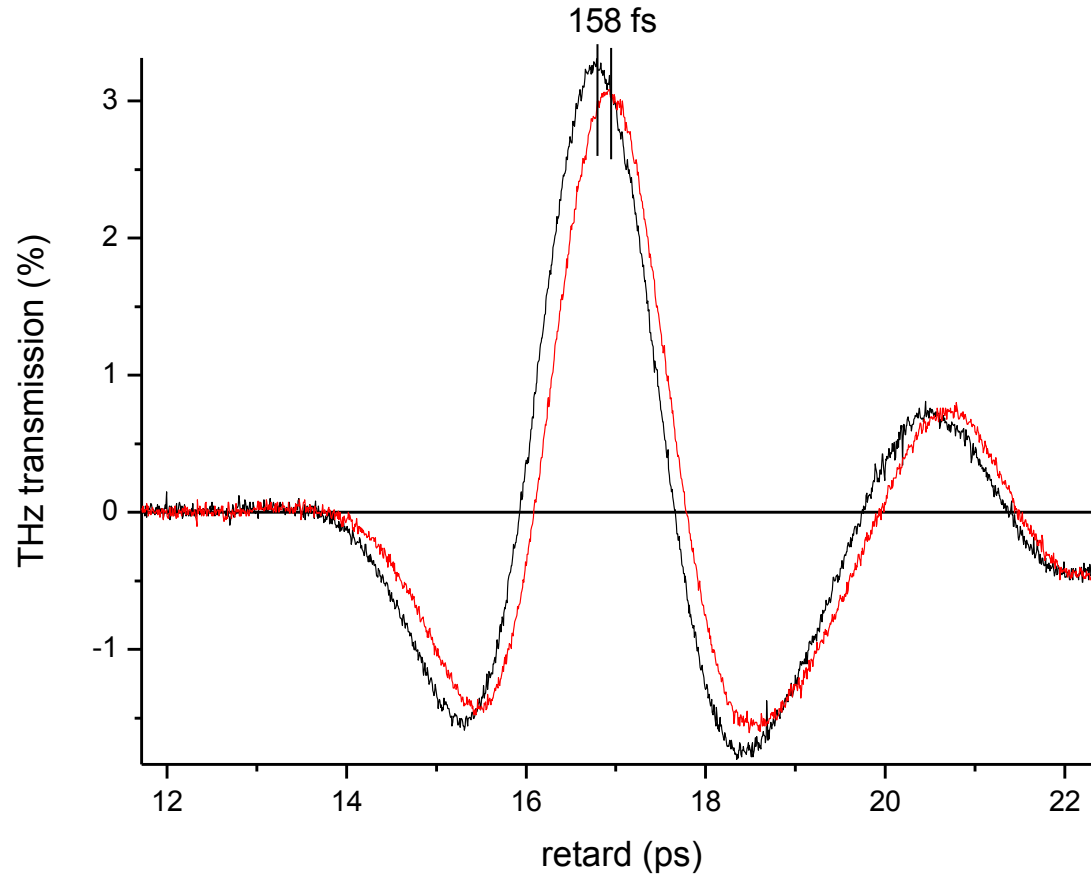
General approach

- Find objects of interest (historic parchment, archives, papyrus)
- Determination of physical properties of the object (support and writing)
- Selection of appropriate imaging / spectroscopic system



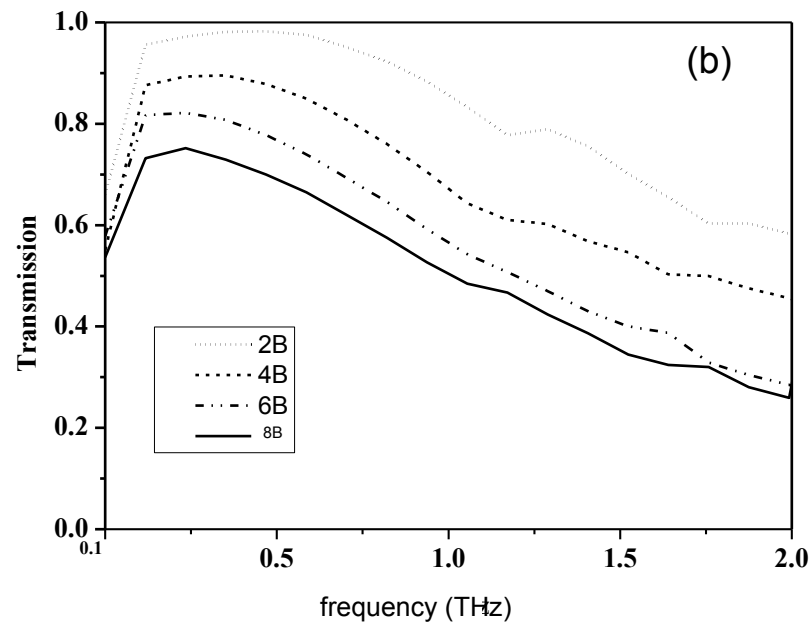
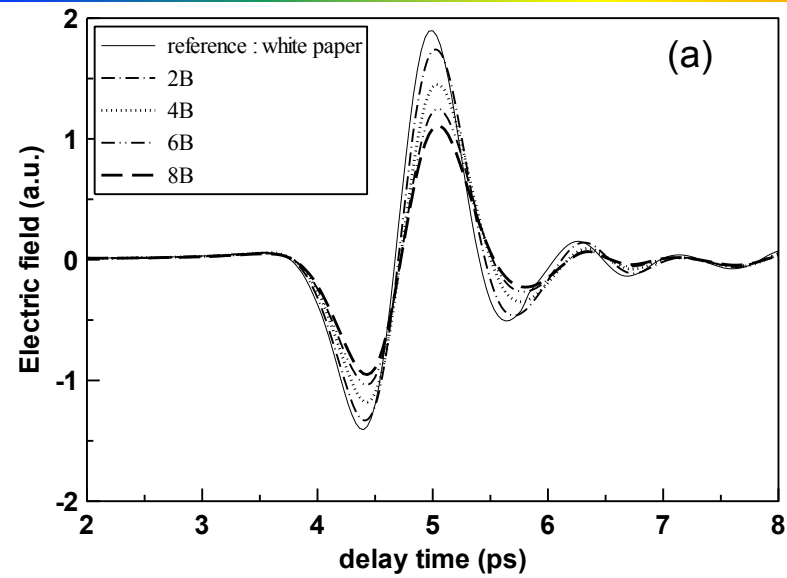
- How many pages can be read? (depends on thickness)

Counting pages with a THz pulse

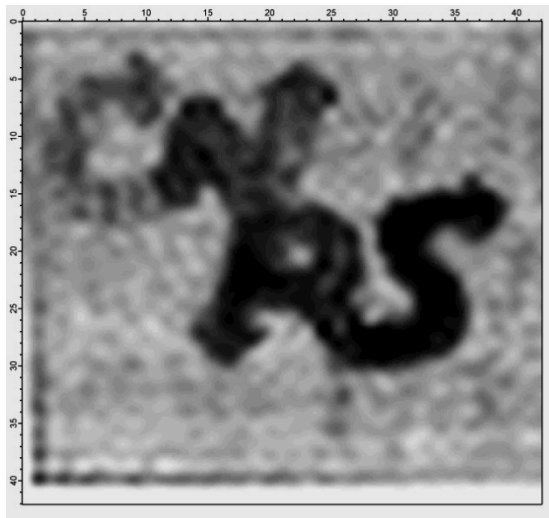
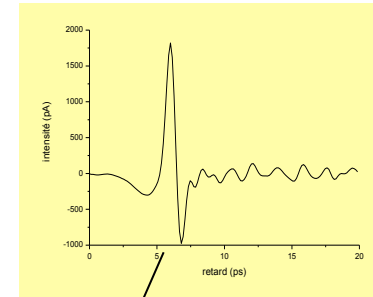
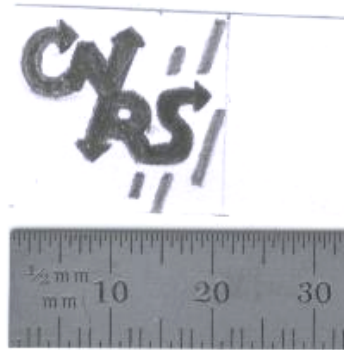


Changes in amplitude and phase will provide information on page number and water content
(Banknotes can also be counted)

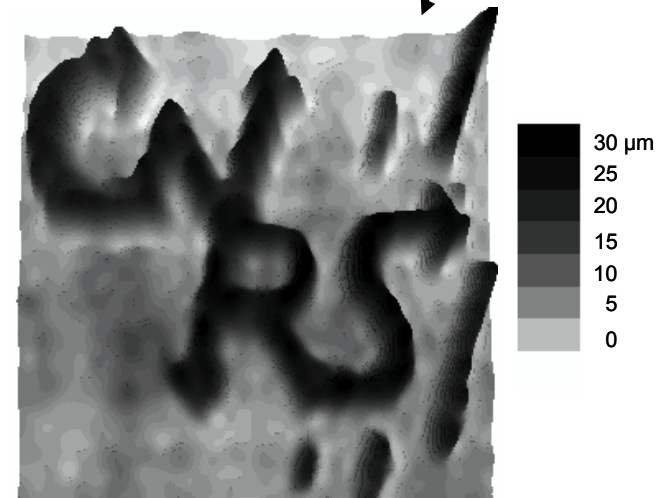
THz spectroscopy of graphite lead pencil



Graphite on paper: grades from HB to 8B (15*15 mm)



high freq



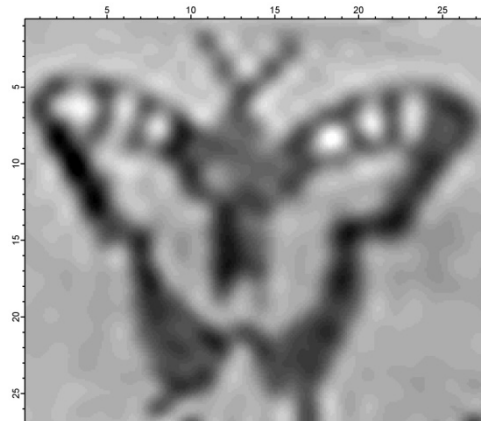
phase

Graphite on paper hidden by black painting

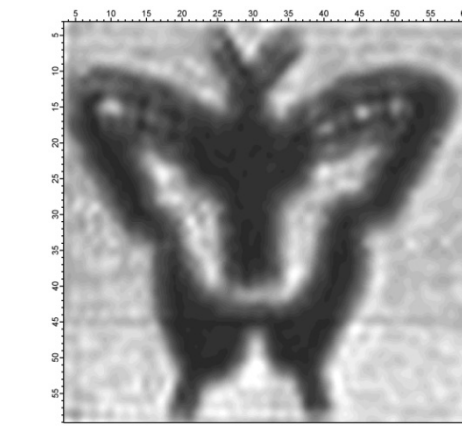
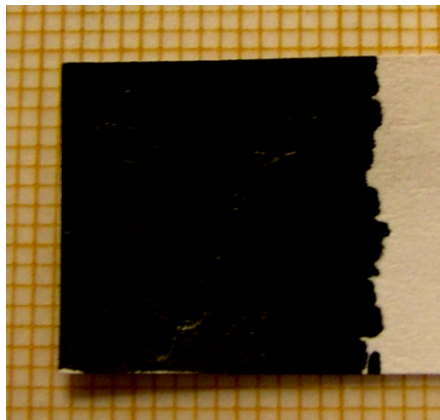
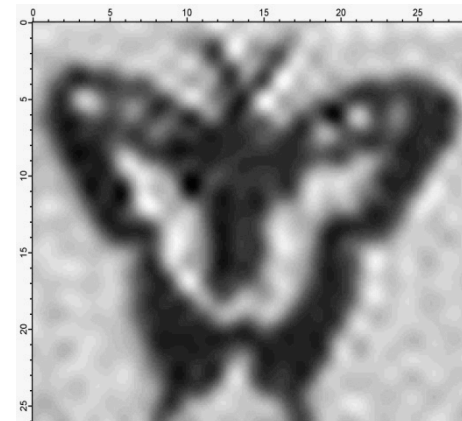
Objet : crayon mine 4B
(15*15 mm)



THz phase image

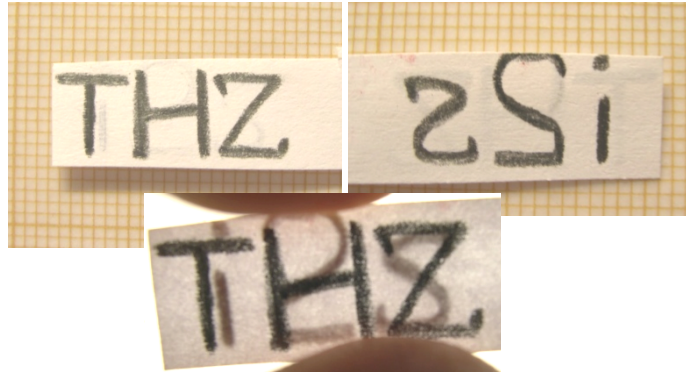


THz high frequency



Graphite on 2 sheets of paper

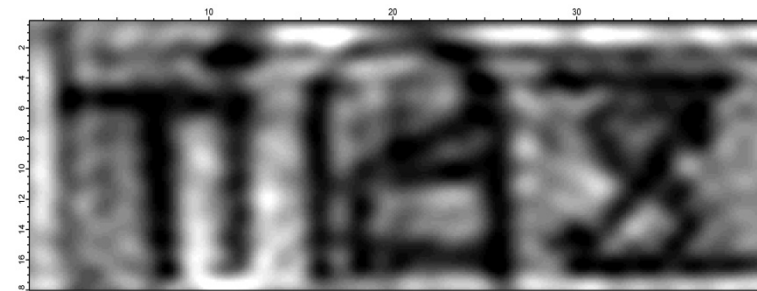
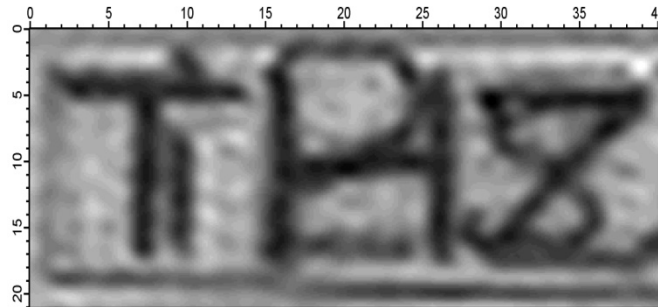
21/03/08
THz recto i2s verso, 8B
20*10 mm
Pas 0.5mm



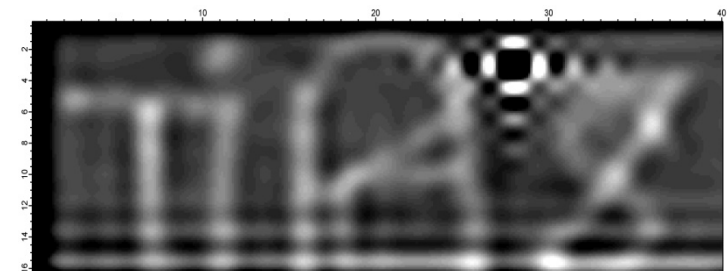
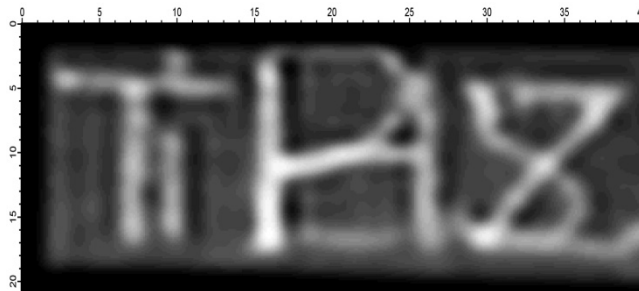
21/03/08
THz page1 i2s page2, 8B
20*10 mm pas 0.5mm



High freq



Phase delay

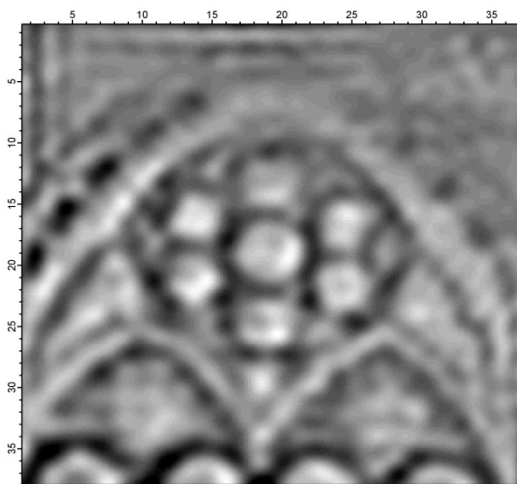
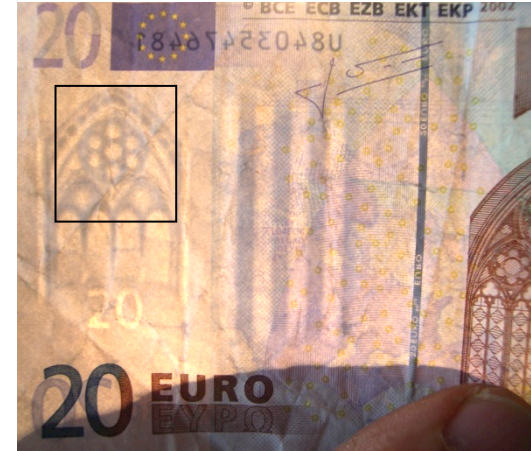


Banknote identification

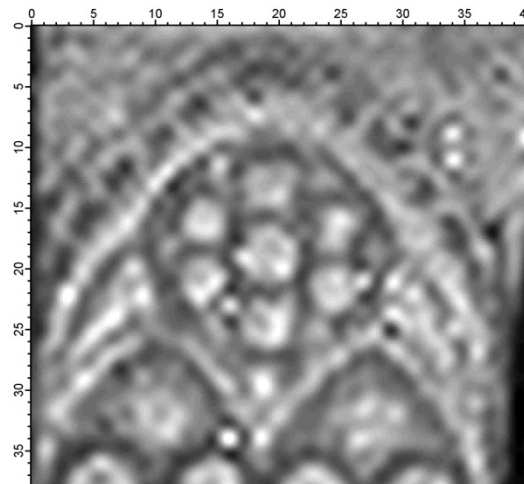
23/04/08

Billet 20 euros cathedrale

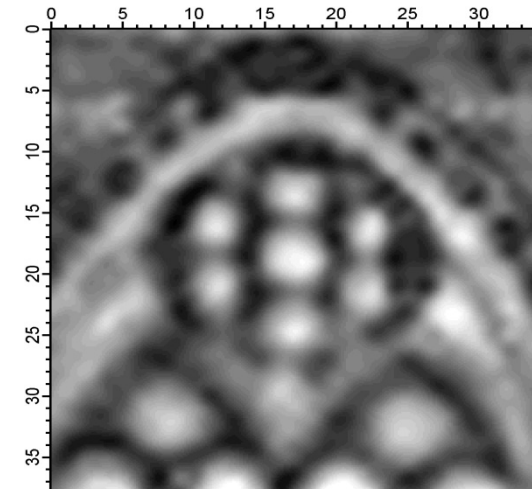
20*19 mm pas 0.5mm



Imax-Imin



Freq 0.17



Phase delay

Reading papyrus (J. Labaune, C2RMF)

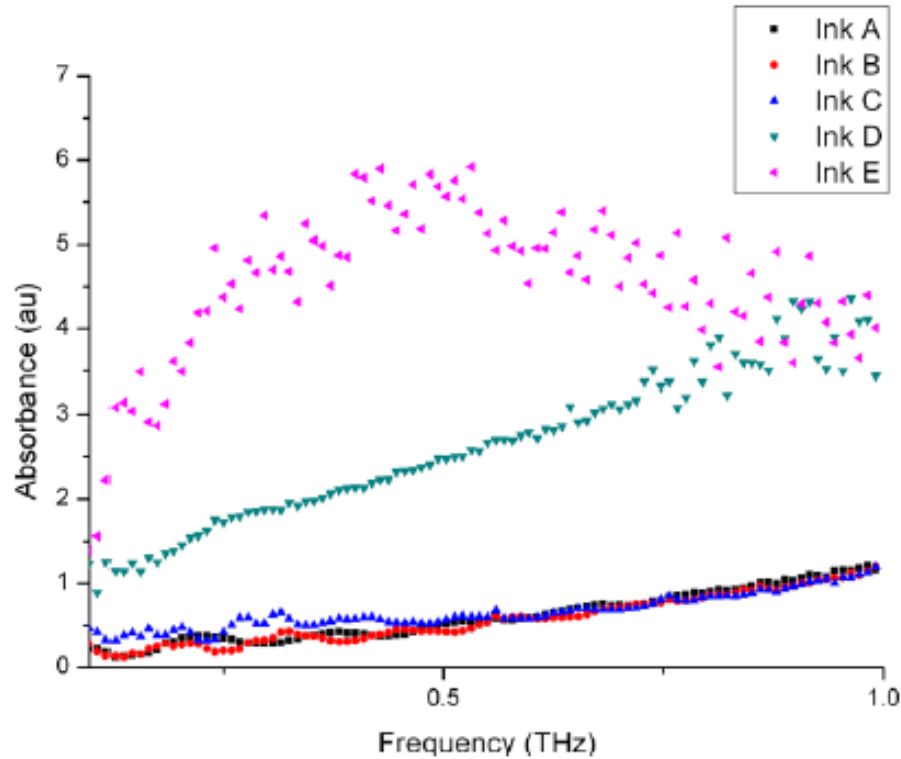


Fig. 2 Absorbance spectra of red ochre and carbon black inks obtained via TDSI transmission measurement in nitrogen

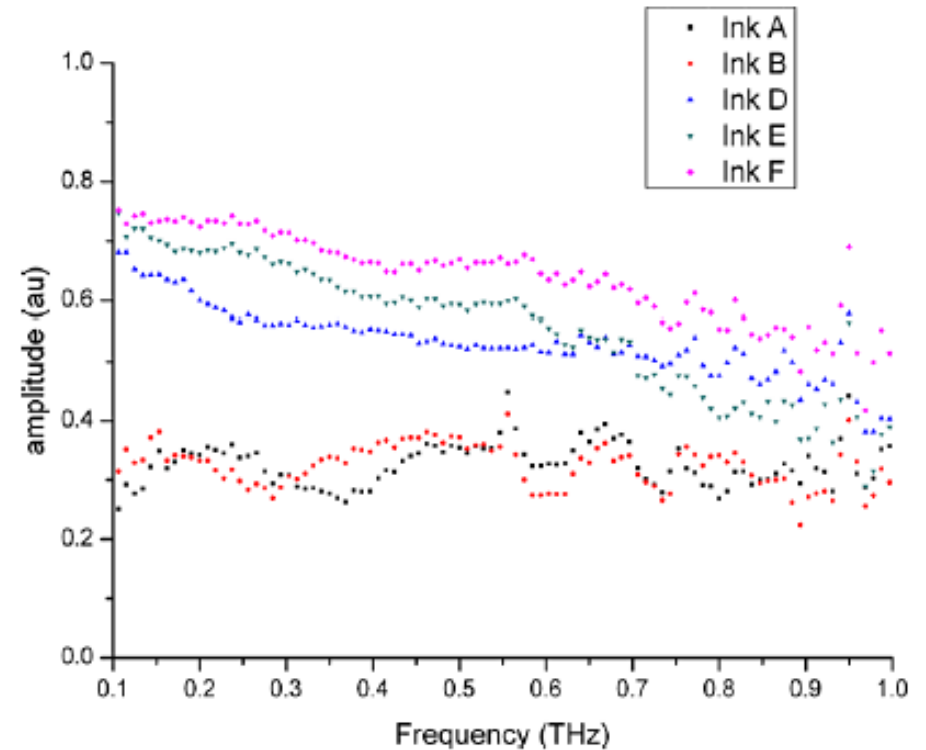


Fig. 3 Reflectance spectra for red ochre and carbon black inks obtained via TDSI reflection measurement

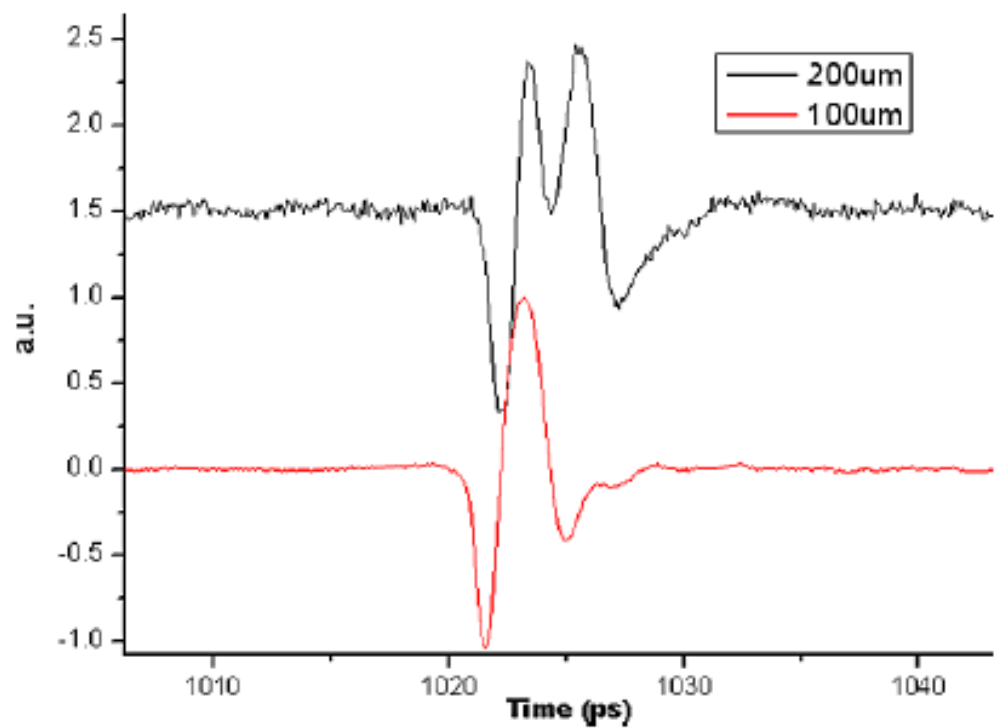


Fig. 4 Temporal evolution of the reflected electric field for normal reflection on two different thicknesses of papyrus sheet



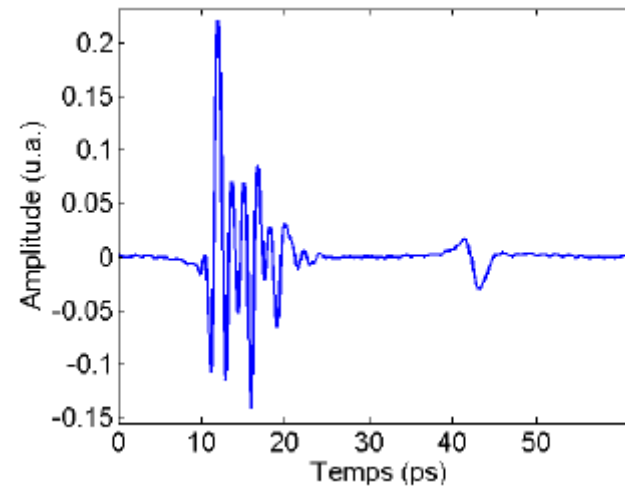
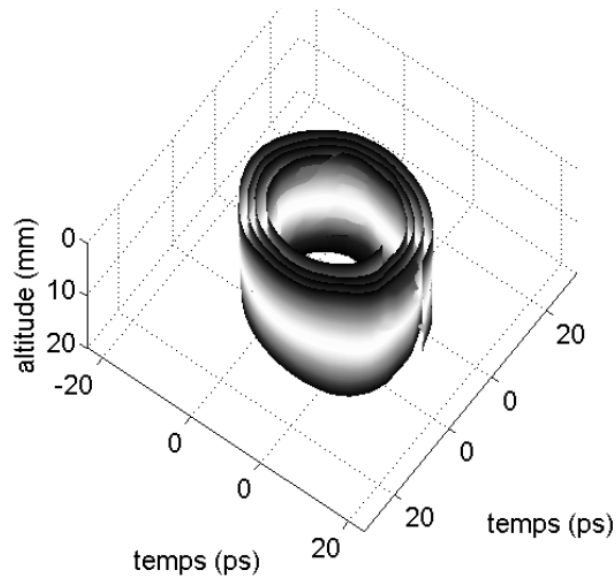
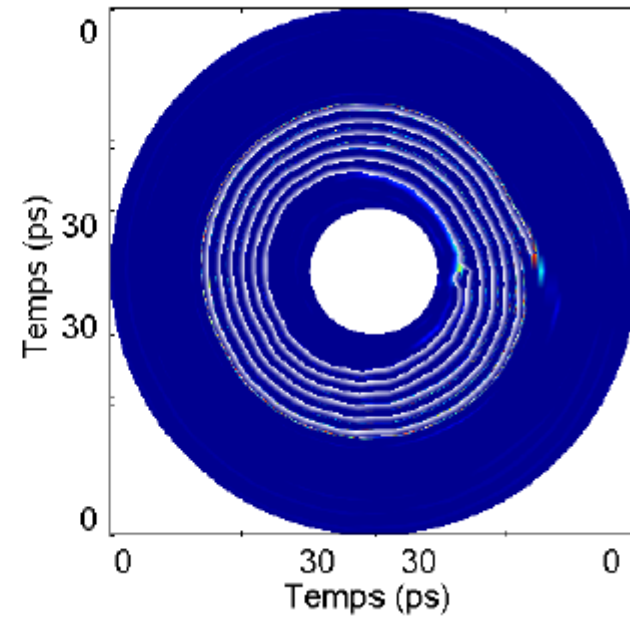
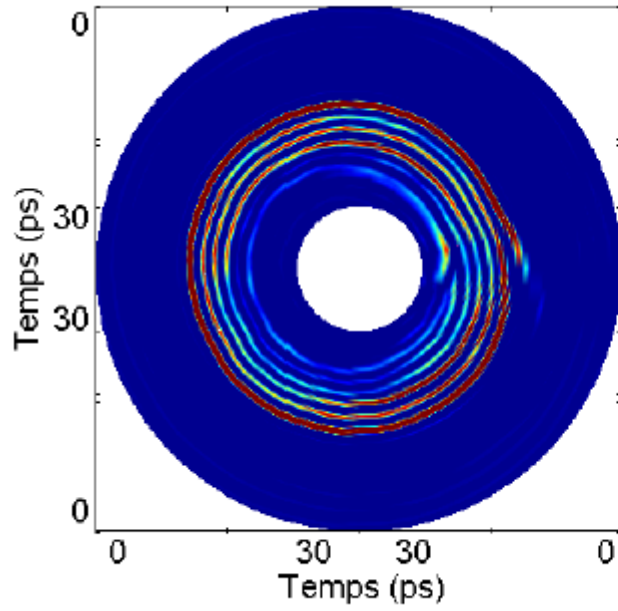
Fig. 5 THz image of one papyrus sheet written with Arabic gum and carbon black ink, in white the ink position



Fig. 7 THz image of second layer of papyrus with a distance of 13 mm between the two layers



Fig. 8 THz image of second layer of papyrus with a distance of 5 mm, in white the ink and in dark the shadow of the top layer



Recent references

Reflectance Spectroscopy Of Pigments In MIR To THz Spectral Range,
Sergey Shilov *Bruker Optics, United States (IRMMW 2014)*

Material Characterization Of Historical Parch-ment Using Terahertz Time-
domain Spectroscopy

Tiphaine Bardon¹; Robert K. May²; Philip F. Taday²; Matija Strlič¹ *1UCL, United Kingdom; 2TeraView Ltd, United Kingdom (IRMMW 2014)*

TeraHertz Time-domain Spectroscopic Imaging of Inks and Manuscripts:
Mrs Dissertation. Auteurs, [Tiphaine Blandine Bardon](#), [Matija Strlič](#),
[Giovanni Verri](#), Éditeur, T. B. Bardon, 2012 Longueur, 58 pages