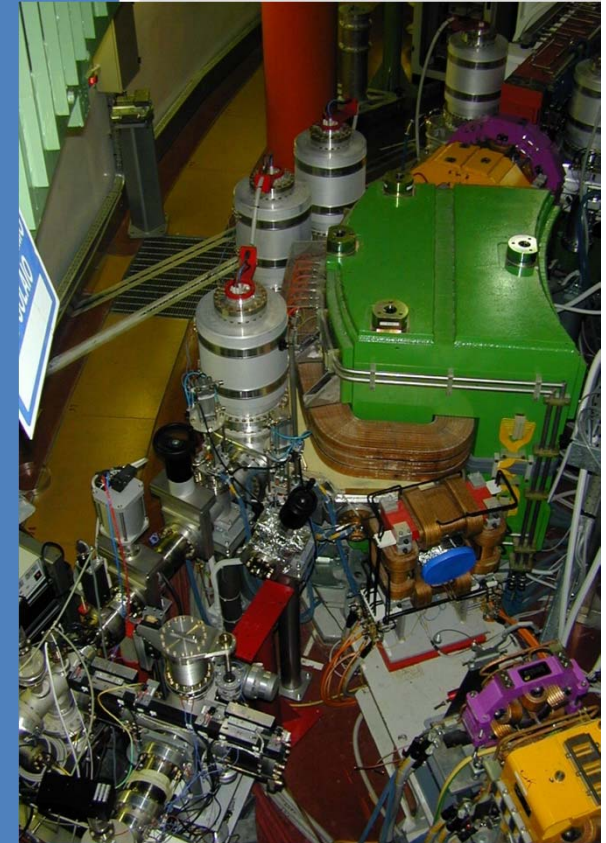


# Il canale di Luce di Sincrotrone infrarosso SINBAD: opportunità per la radiazione THz

*Mariangela Cestelli Guidi-LNF*



La tecnologia Terahertz (THz) ha diversi vantaggi che la rendono uno strumento per indagini non distruttive e contactless di molti materiali non conduttivi (ad esempio plastica, carta / cartone, ceramica, prodotti chimici, prodotti farmaceutici):

- ❖ Profondità di penetrazione elevate, ad es. Per materie plastiche nell'intervallo di cm (vantaggio rispetto a IR)
- ❖ Migliore risoluzione spaziale (da mm a sub-mm) rispetto alle microonde
- ❖ Non ionizzante (vantaggio rispetto ai raggi X)

# Sorgenti artificiali di radiazione THz



$$P(\lambda) = 4.4 \cdot 10^{14} \times I \times \Theta_H \times \text{bw} \times (\rho/\lambda)^{1/3} \text{ photons s}^{-1}$$

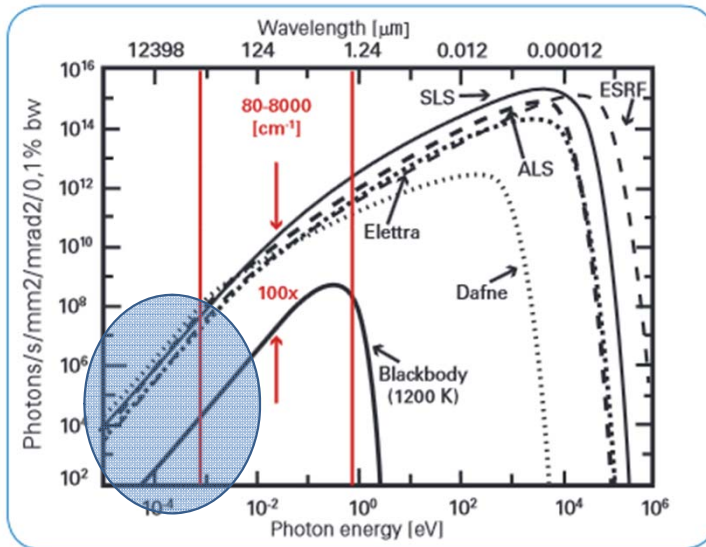


Fig. 1: Advantages of the e-Synchrotron radiation source

Il flusso e la brillantezza della radiazione THz dipendono unicamente da:

- corrente  $I$  del fascio di elettroni
- emittanza/dimensioni della sorgente
- angolo di estrazione  $\Theta_H$
- ottiche di trasporto

**Slightly dependent on the machine energy:  $\sim (\lambda c/\lambda)^{1/3}$**

DaΦne Energy = 0.51 GeV

DaΦne  $e^-$  beam current  $\sim 1.5$  A

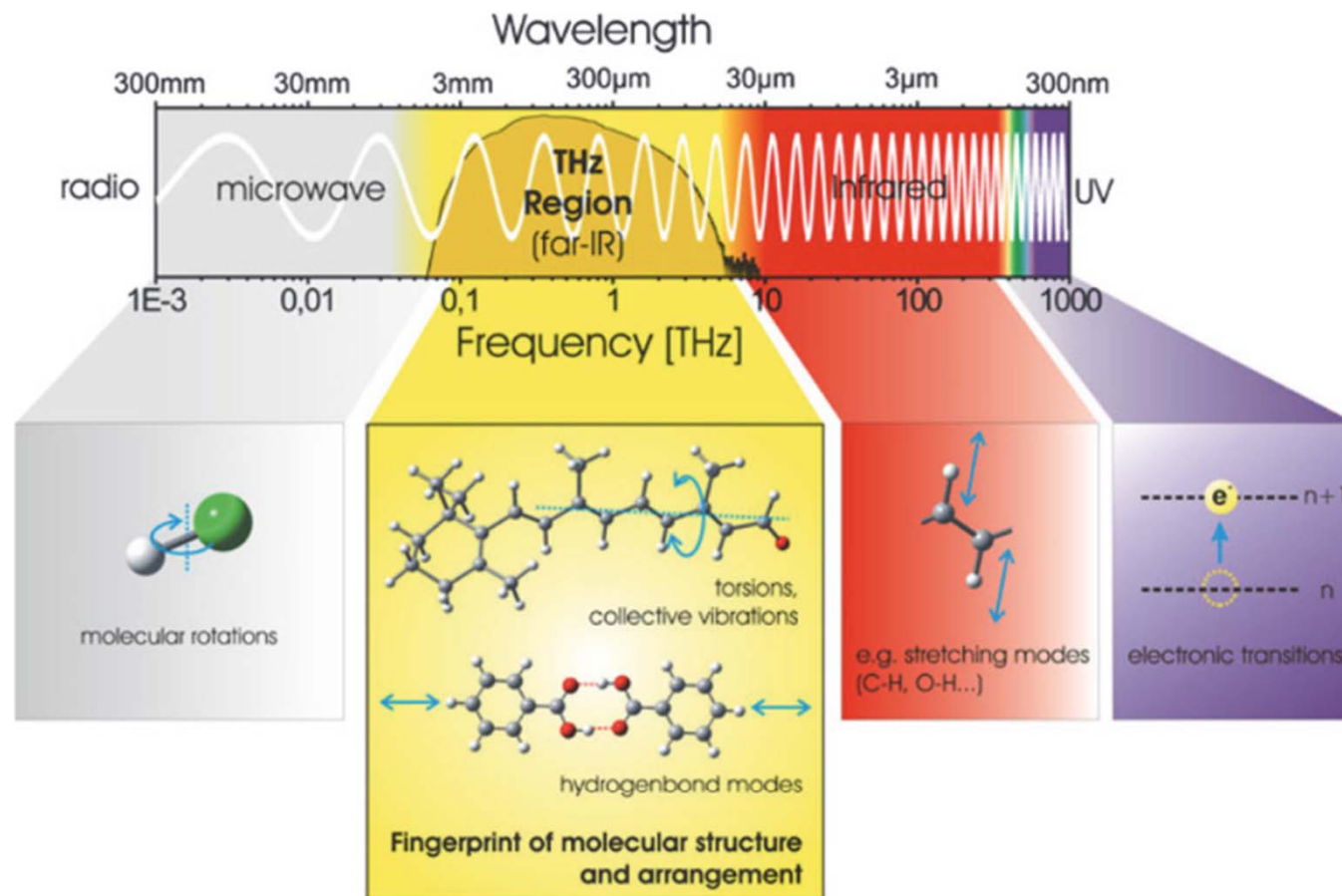
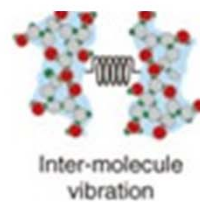


Figure 1. Terahertz waves in the electromagnetic spectrum (adapted from Walther et al., 2010).



# Industrial applications of THz radiation



## Security

Terahertz homeland security and screening



## Pharma

Pharmaceutical and cosmetics industries



## Food

Terahertz food inspection and quality control



## Ceramics

Terahertz applications in ceramic industry



## Wood

NDT inspection for wood processing



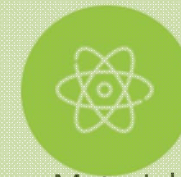
## Automotive

Automotive industry



## Medicine

Medical diagnostics



## Material Science

Sensibilità e specificità della spettroscopia terahertz alle vibrazioni sia intermolecolari che intramolecolari consente di identificare diverse forme cristalline dei farmaci (Polimorfismo)

Differente solubilità, stabilità e biodisponibilità → fattore importante per l'efficacia terapeutica di un farmaco

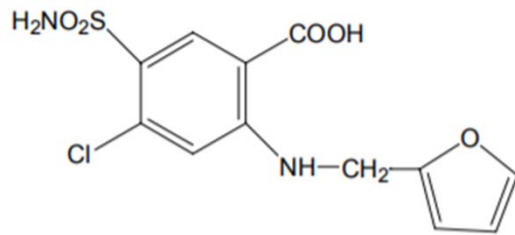
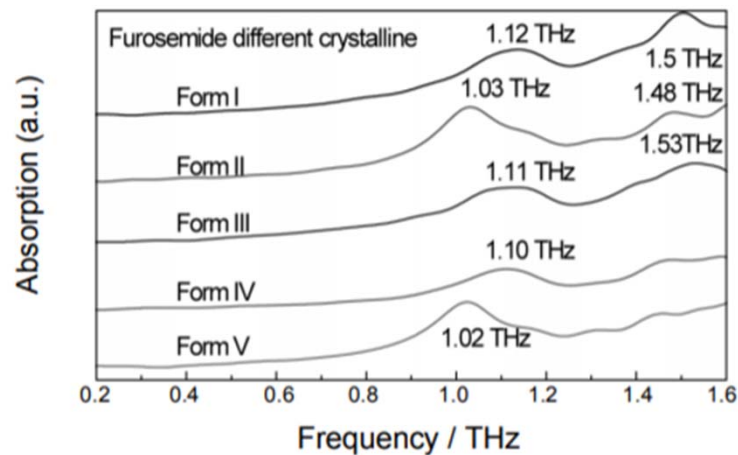
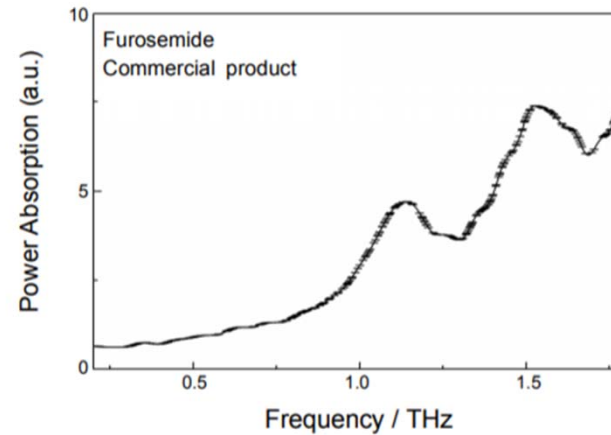
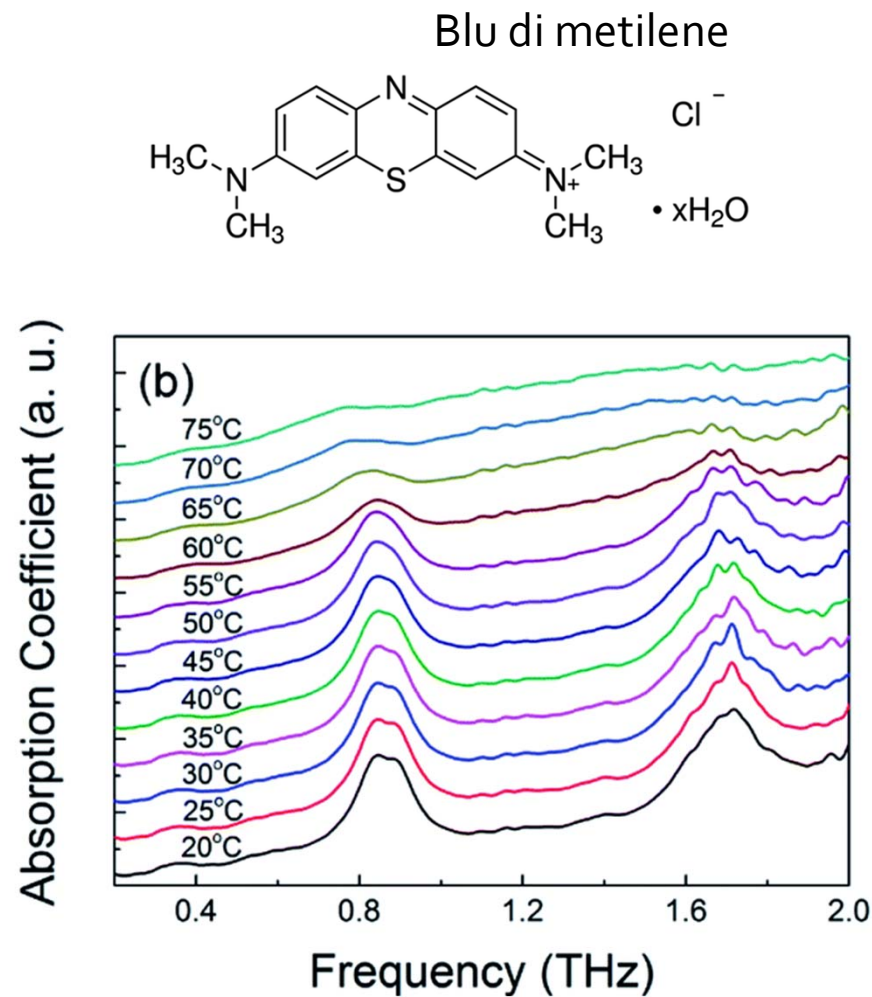
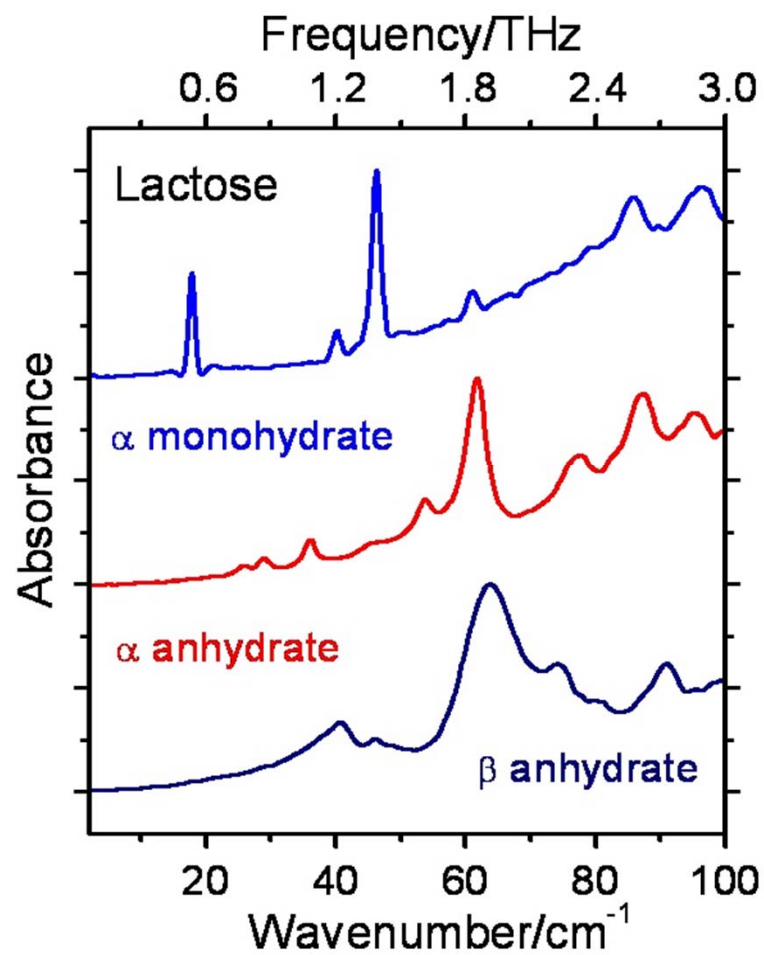


Figure 1. Chemical structure of furosemide.



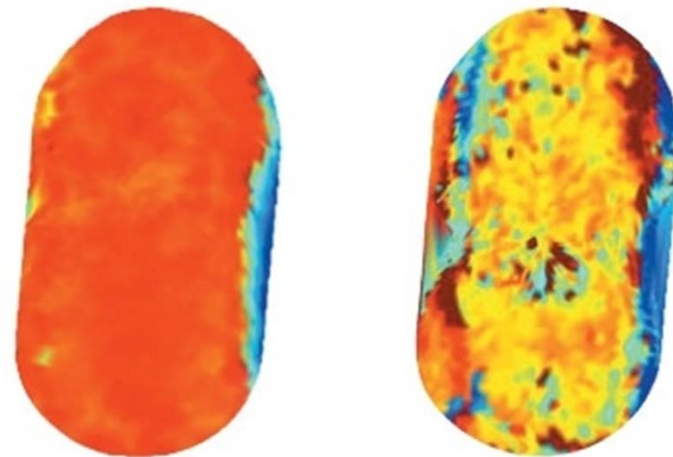
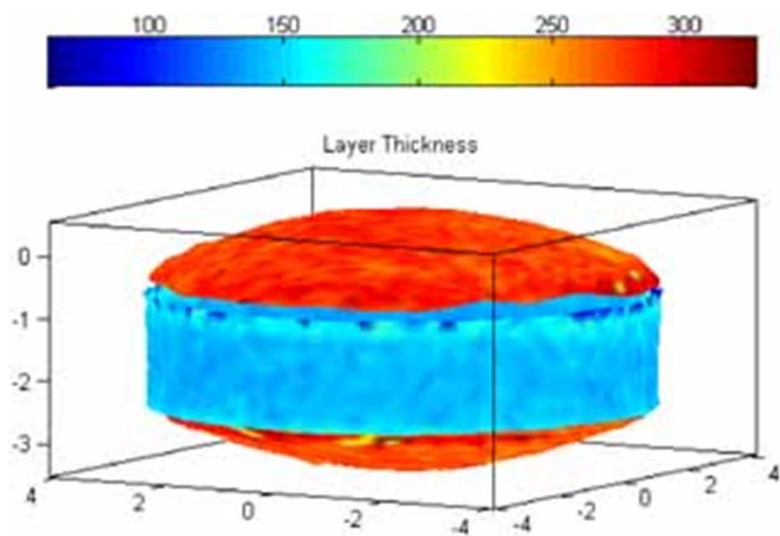


Lattosio principale eccipiente si presenta in diverse forme idrate



(S.Yan [RSC Adv.](#), 2017, 7, 41667-41674)

## Uniformità dei rivestimenti delle compresse



(Image courtesy: Azo OPTics)



# Biomedical

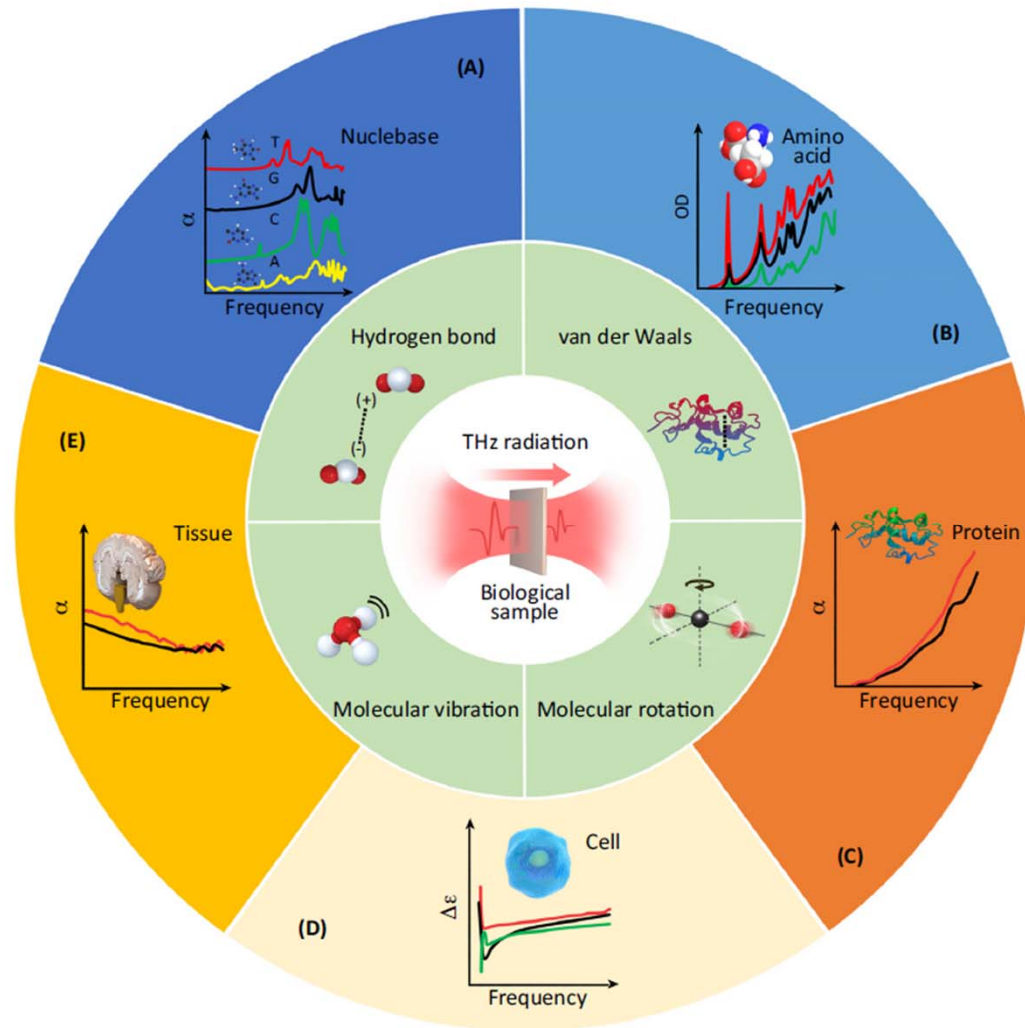
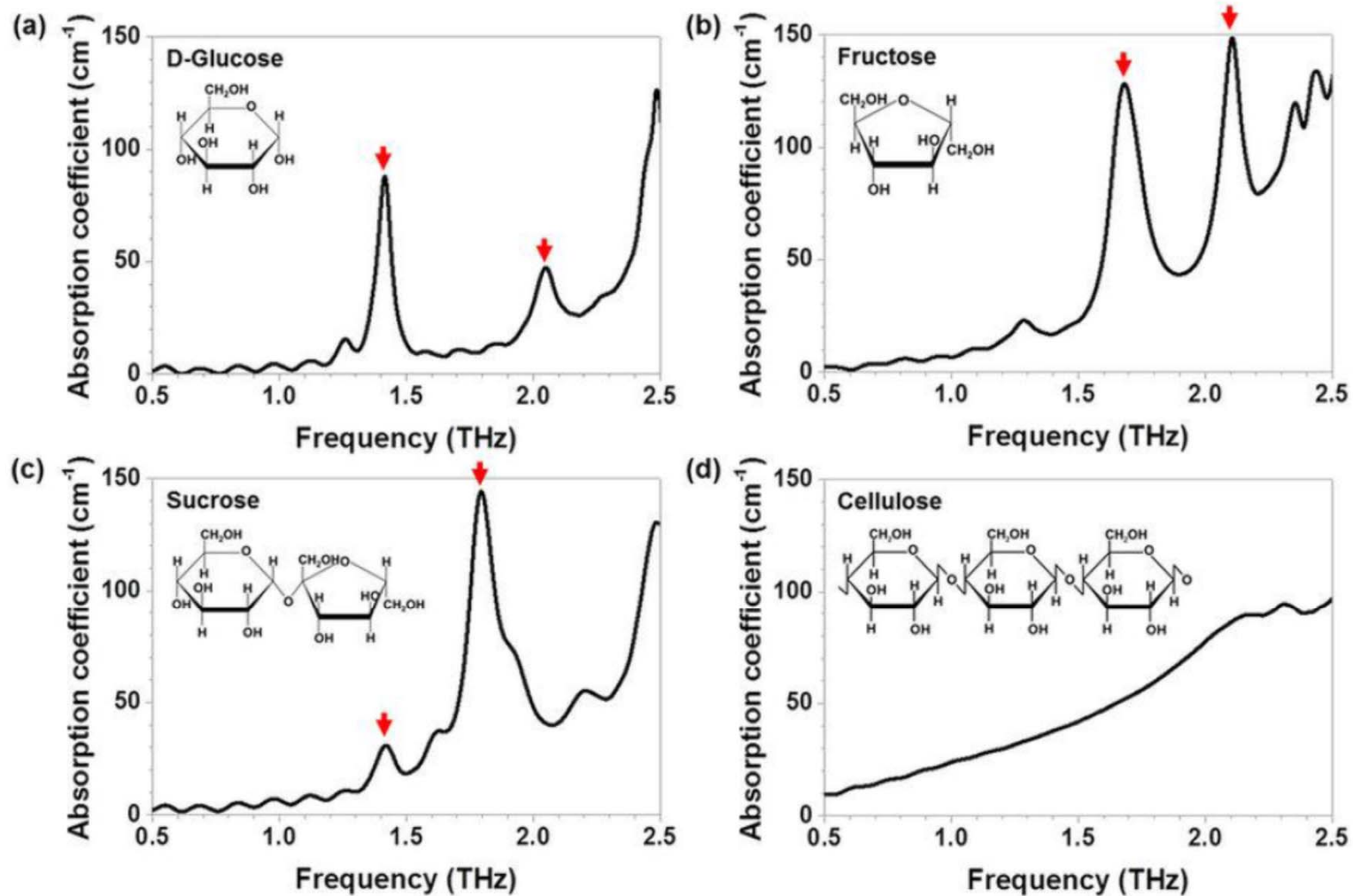
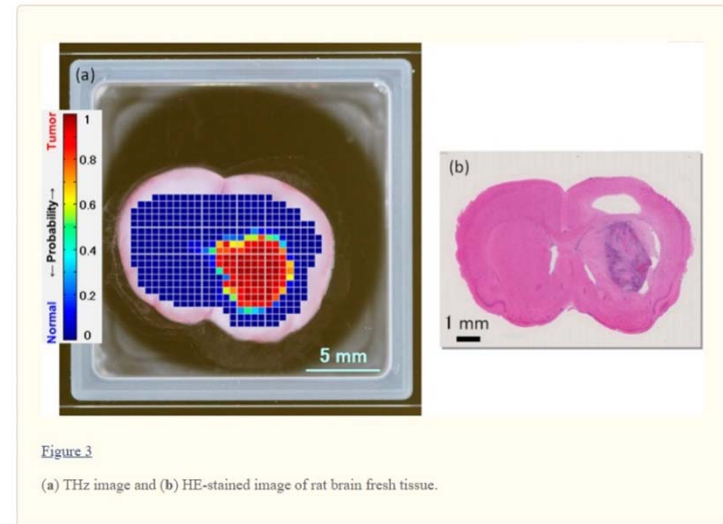
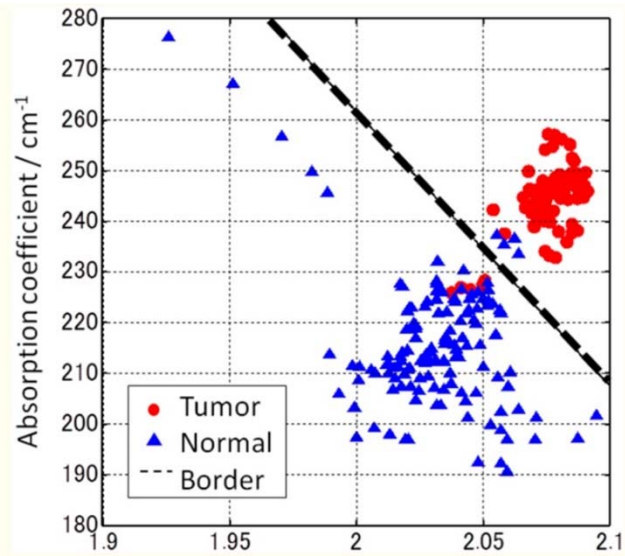
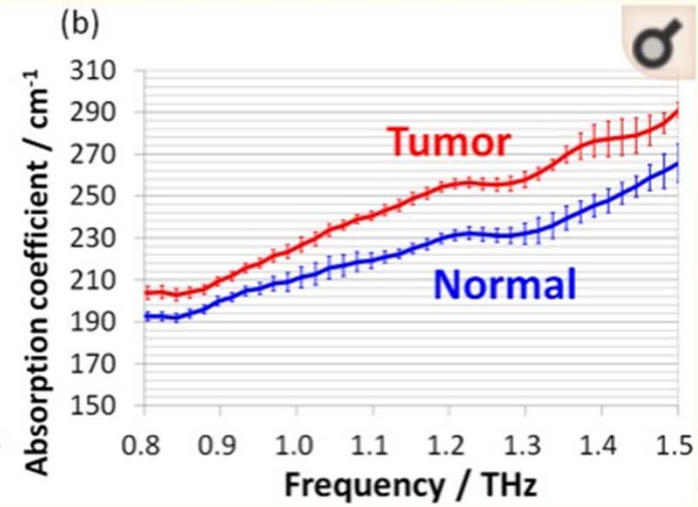
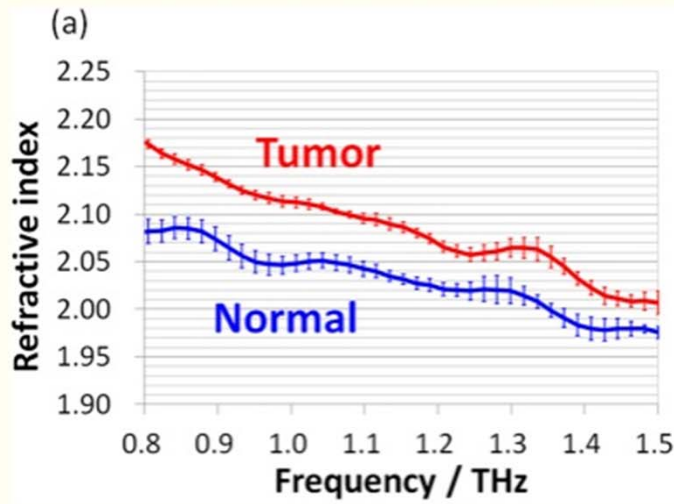


Image courtesy: Yang, Trends in Biotechnology

# THz spectra of small organic molecules



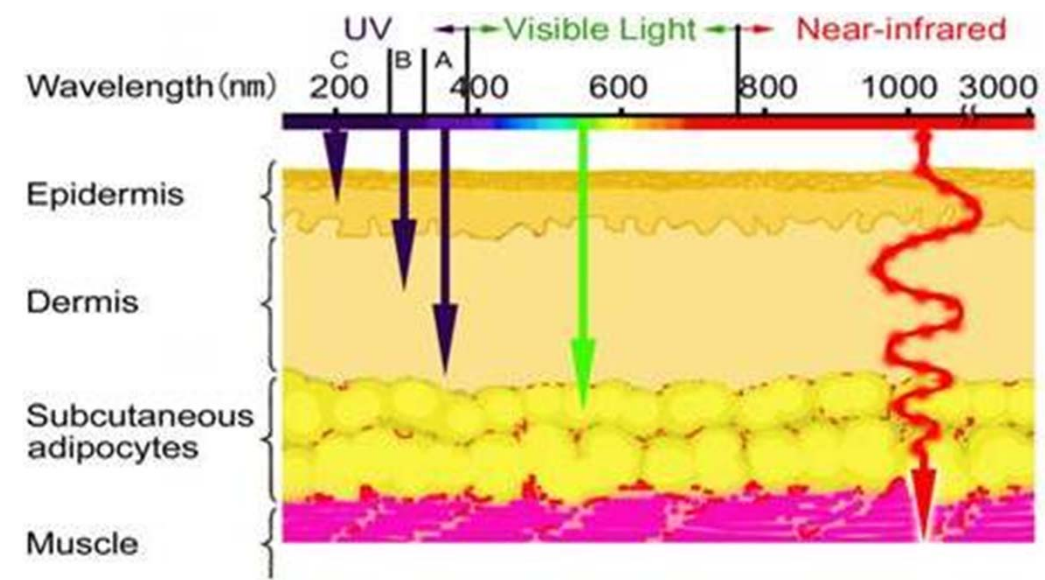
Lee, Dong-Kyu, "Highly sensitive and selective sugar detection by THz nanoantennas" *Scientific reports* 5 (2015).



(S.Yamaguchi, [Sci Rep.](#) 2016; 6: 30124).

## Terahertz iMAGIng for Clinics (CSN5)

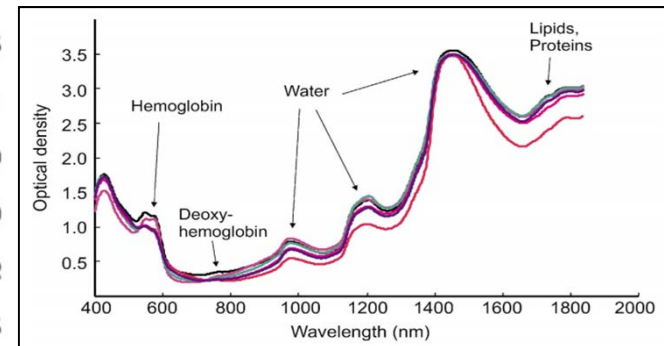
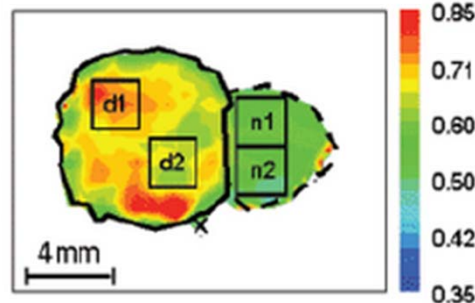
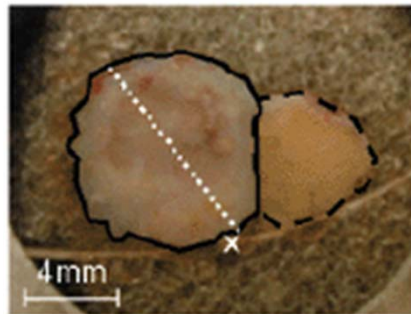
Combined spectroscopic and imaging THz and Near Infrared (NIR) radiation portable system to detect morphological and biochemical markers.



## THz Imaging

+

## NIR Spectroscopy



THz radiation evaluates cutaneous regions (nevi and lesion), their *depths* and their *shape* through *phase and amplitude contrast* → Tomographic reconstruction;

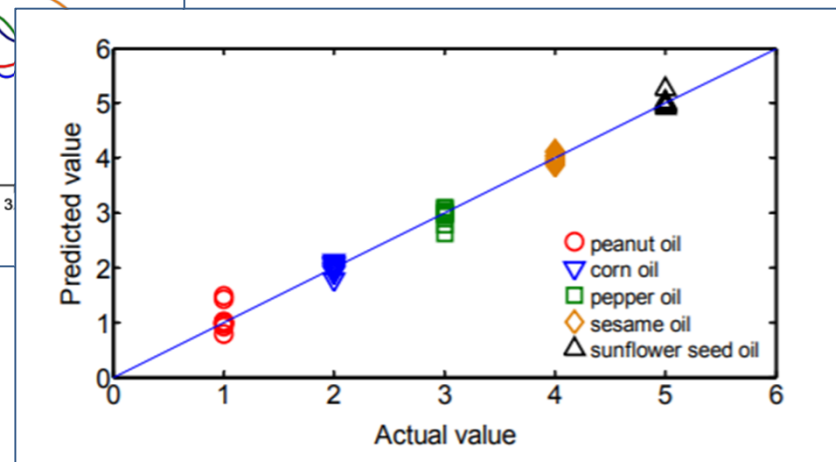
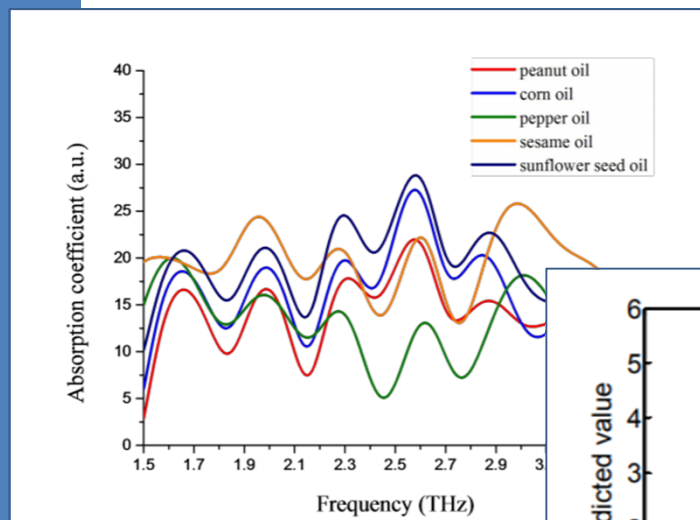
Near-IR radiation evaluates the chemical composition

$\lambda=1000\text{-}50\ \mu\text{m}$  (50 GHz a 5 THz)

$\lambda=500\ \text{nm} - 2\ \mu\text{m}$



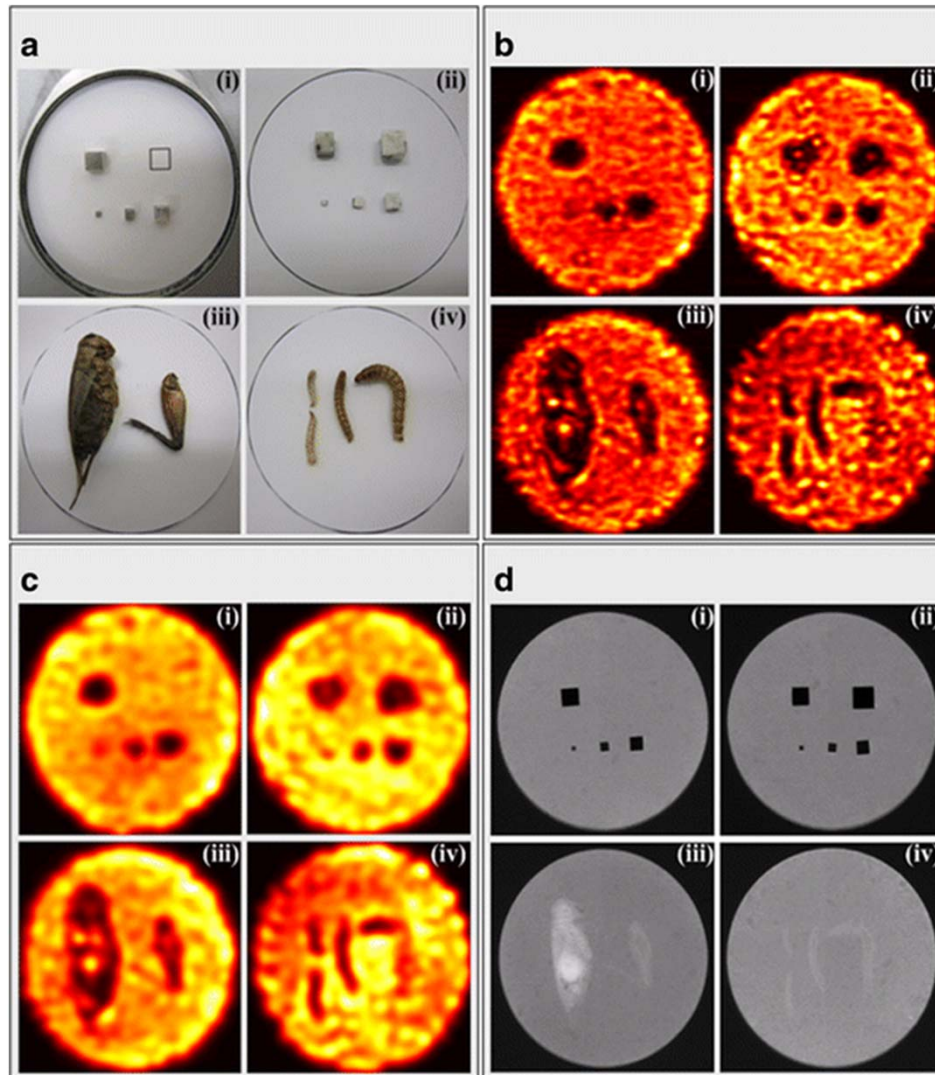
# Agrifood



(PRIN 2017)

Yin, Analytical Methods (2016)

# Food inspection

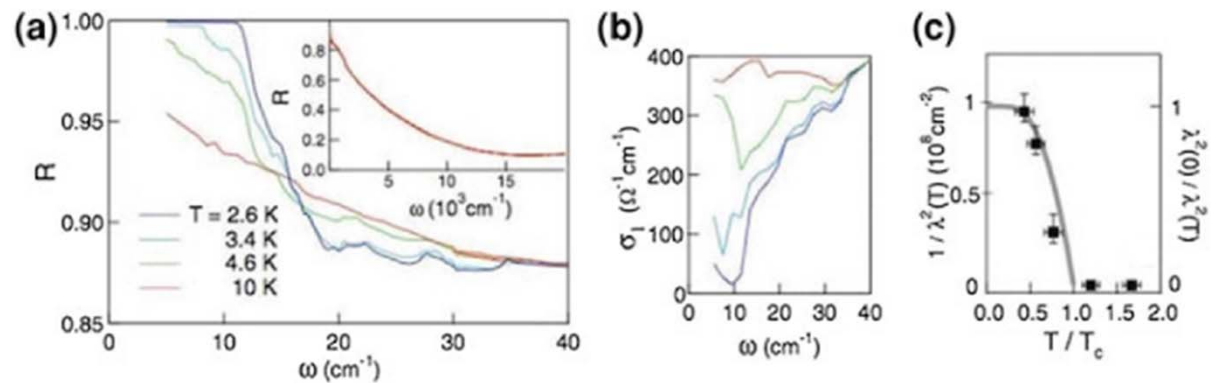
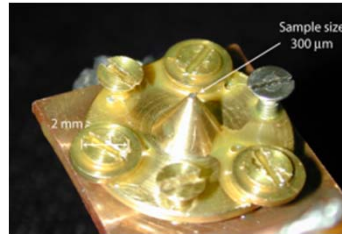


# Material Science

Optical properties  
of solids

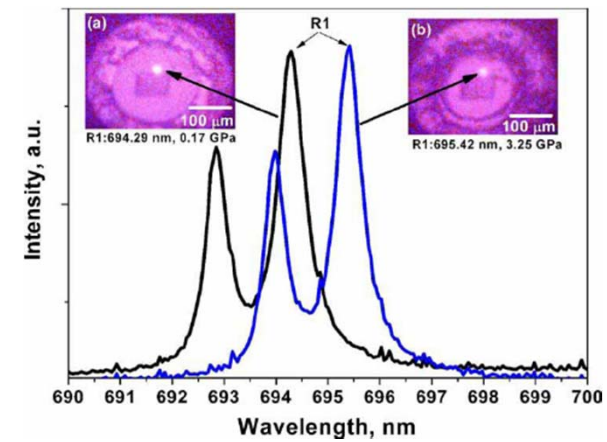
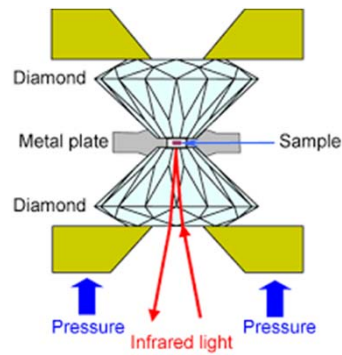
Superconducting  
gap

Phonon spectra



**Fig.** Optical response of superconducting diamond: **a** absolute reactivity in the THz range, at various temperatures.  $R(\omega)$  at 10 K in the full infrared range is shown in the *inset*; **b** real part of the optical conductivity; **c** inverse square of the penetration depth (*black squares*), compared with its behavior for a dirty BCS superconductor (*gray line*).

# High pressure experiments



## Challenges and limitations

Elevato costo di detector e sorgenti

→ R&D

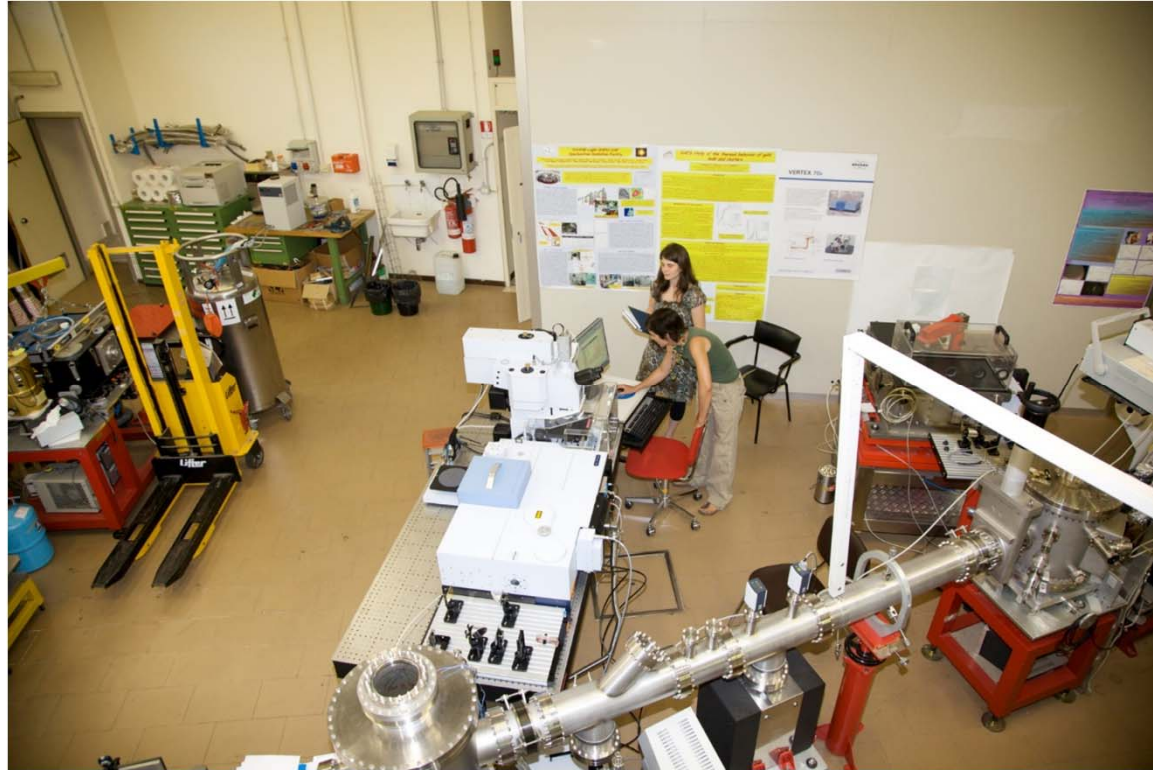
Velocità di rivelazione

Non adatto per campioni con elevato livello di idratazione e spessori > 1mm

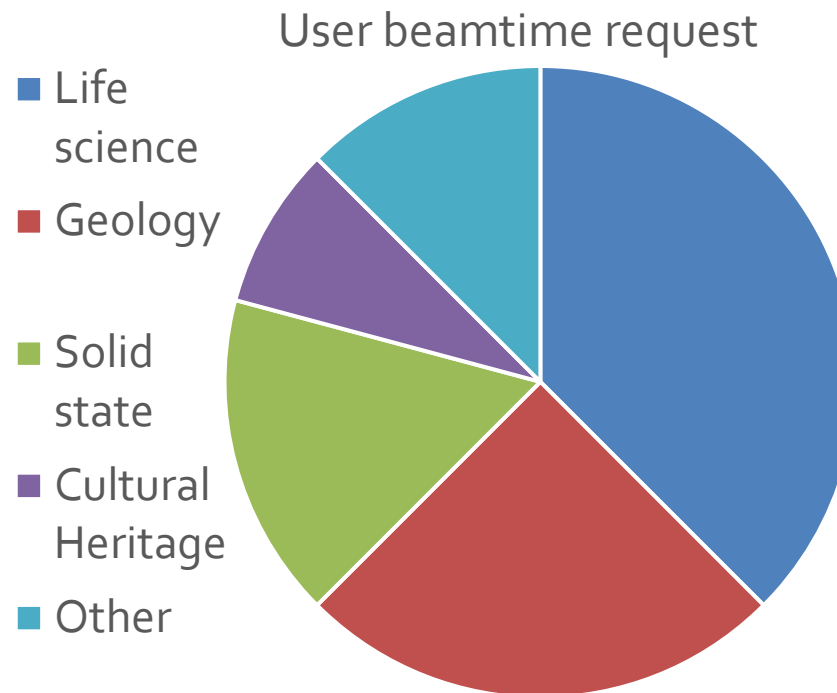
→ Spettroscopia in riflessione (image artefacts)



# The Sinbad beamline



# USERS of the Sinbad beamline



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<http://dafne-light.Inf.infn.it>