TMAGIC

Terahertz iMAGIng for Clinics

Sezione Proponente: Roma 1 (Stefano Lupi)

Sezioni componenti: LNF

Collaborazioni: Università Sacro Cuore, Sapienza Univ., Campus Biomedico

FTE

Roma1 (1.2 FTE)

Responsabile Nazionale: Stefano Lupi

Massimo Petrarca

Stefano Sarti

LNF (1.5 FTE)

Coord: M. Cestelli Guidi (Tecn)

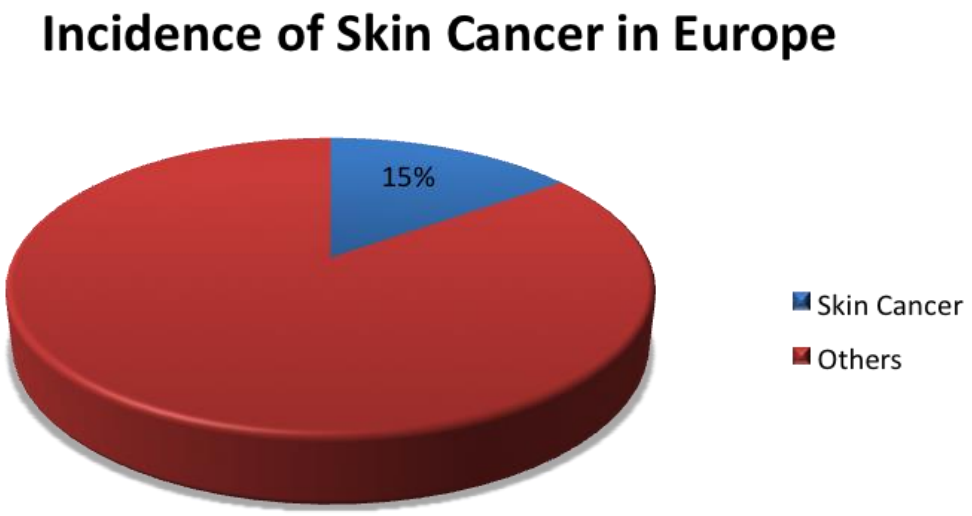
Enrica Chiadroni (Ric)

Claudio Marcelli (I Ric)

Maddalena Daniele (PhD)

Scientific case

Skin Cancer in various forms represents 15 % of Total Incidence in Europe
Among them, Melanoma is the most aggressive

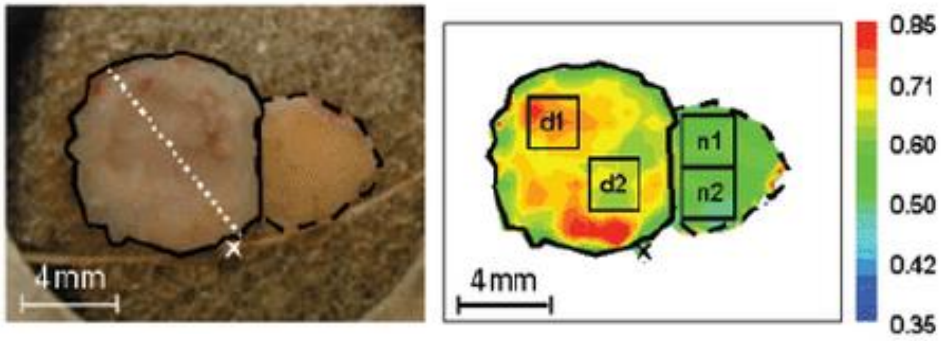


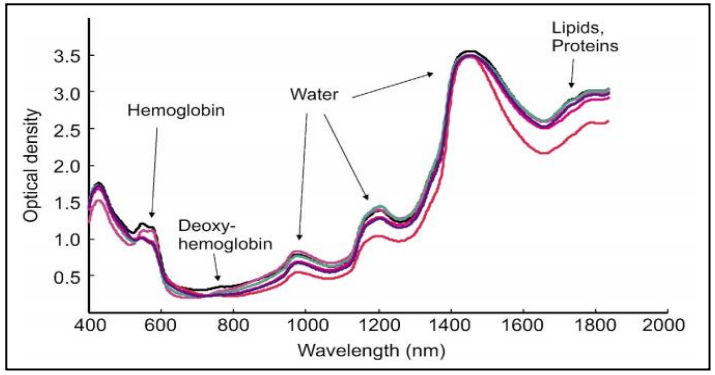
Standard diagnostic optical techniques (Epiluminescence and Fluorescence) are based on VIS/UV radiation having a scarce penetration in tissues and non chemical recognizing.

Scientific case

The goal is to develop a combined spectroscopic and imaging terahertz and near-Infrared radiation portable system to detect not only **morphological** but also **biochemical** markers.

THz Imaging + NIR Spectroscopy



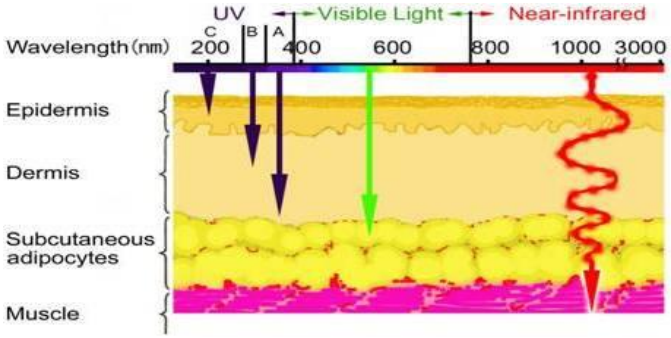


THz radiation evaluates cutaneous regions (nevi and lesion), their *depths* and their *shape* through *phase and amplitude constrast* → Tomographic reconstruction;

Near-IR radiation evaluates their chemical composition

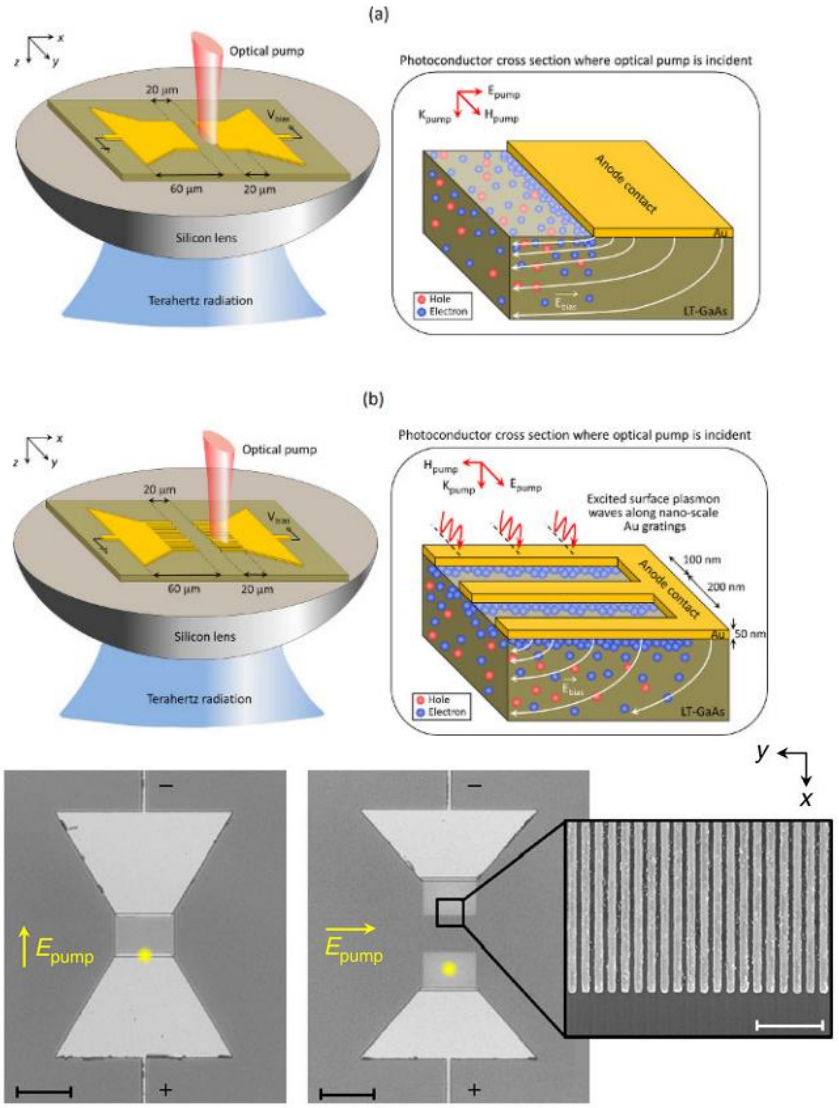
λ=1000-50 μm (50 GHz a 5 THz)

λ=500 nm - 2 μm

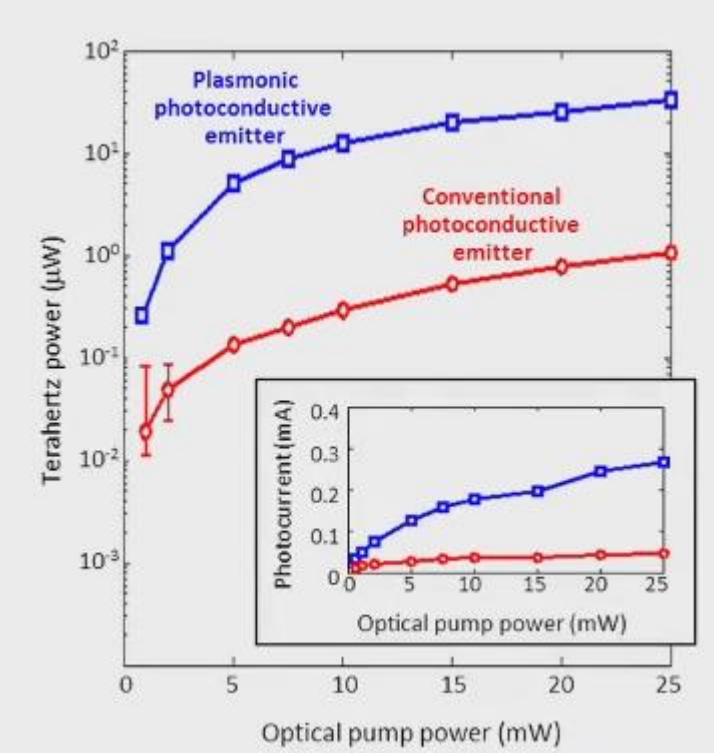


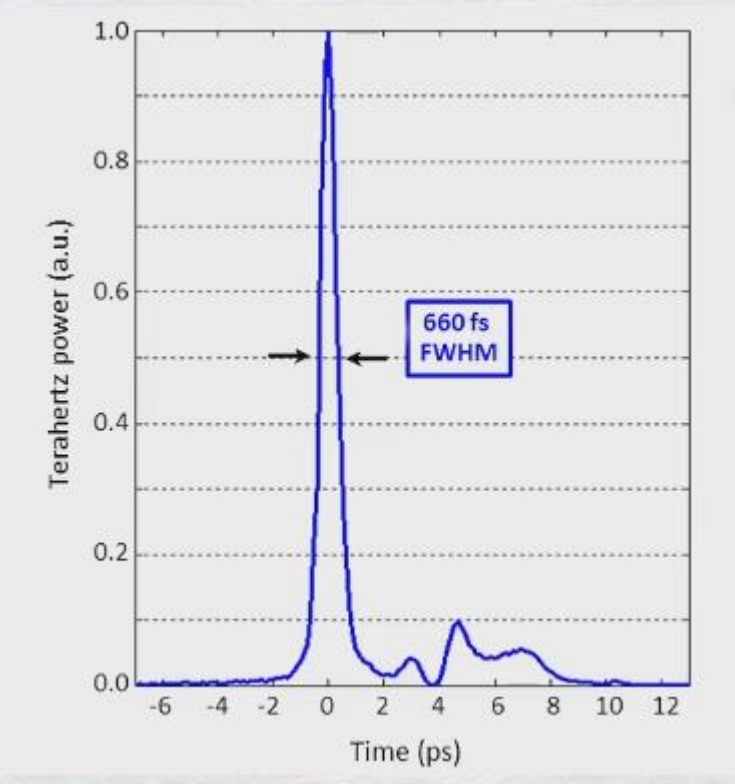
THz radiation generation

- Transduction of ps laser pulse via photo-conductive antenna based on plasmon grids on GaAs/GaP wafers
- The laser pulse produces e-h pairs that are accelerated by 10-50 KHz ddp applied to the plasmonic antenna producing THz pulses at the same laser pulse scale.
- THz radiation is coherent (phase/amplitude) → phase contrast, tomography.
- R&D on material research for antenna (Collaboration with Pavia University).
- R&D on miniaturization of antenna for THz sub-wavelength imaging.



C. Berry et al, Nature Communications 4, Article number: 1622 doi:10.1038/ncomms2638





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NIR radiation generation

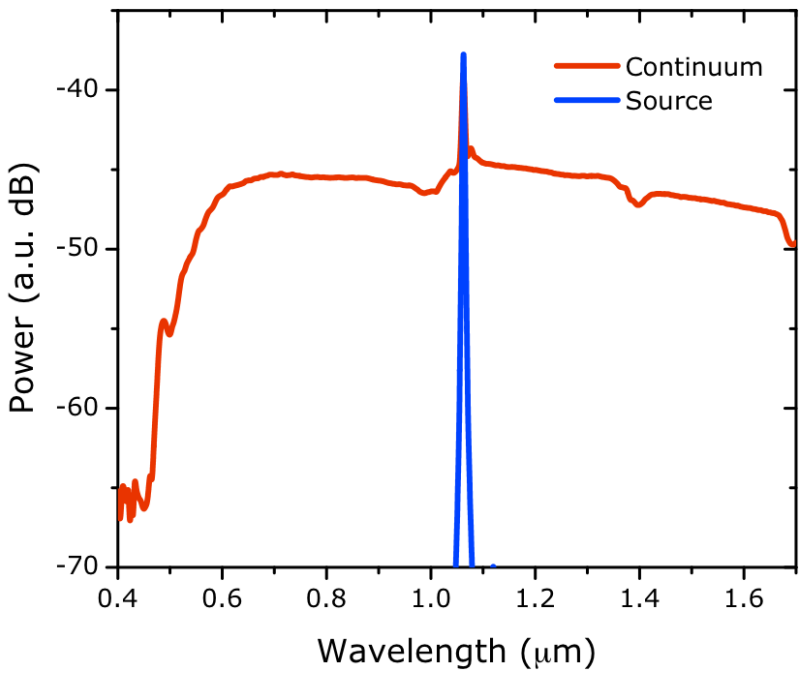
- The NIR radiation (500 nm- 2 μm) will be produced from the same laser use for the THz radiation. The production mechanism is based on the supercontinuum effect which is determined by a combination of non linear optical effects which broades a monochromatic pulse (at 800 nm) in a non linear quartz fiber.

http://www.nktphotonics.com/technology/supercontinuum/

- At the first stage we will produce radiation down to 1 μm. A R&D collaboration with Politecnico Milano will provide NIR radiation down to 2 μm through the use of **new photonic fibers** having a high conversion efficiency.

- NIR radiation will be finally focalized on tissues (spatial resolution on the order of 1 microns) and measured by an InGaAs spectrometer.

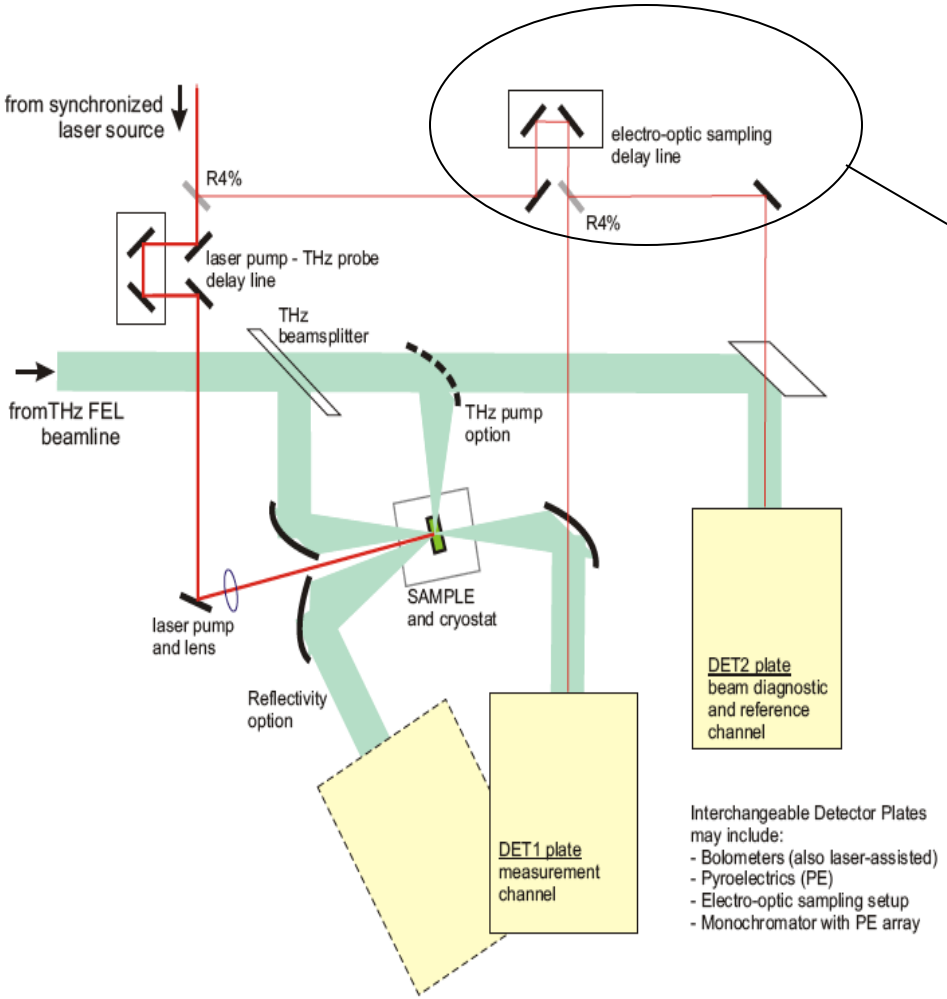
- This radiation will be finally used (together with THz) for a spectroscopic investigation of tissues.

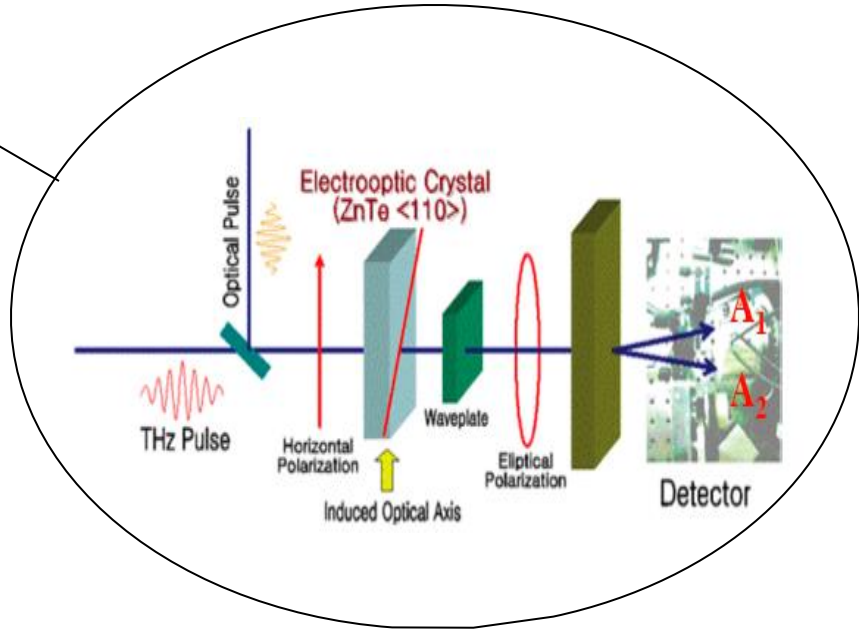


A strong R&D is necessary for going beyond a simple optical imaging diagnostic

- Coherent THz and NIR radiation from the same source;
- Development of THz micro-antenna (for going beyond the diffraction limit in the THz) to achieve a similar spatial resolution in both spectroscopies;
- Development of software for THz and NIR analysis of medical maps;
- R&D on new THz materials and antenna for most performant imaging and spectroscopic systems;

La beamline THz@SPARC



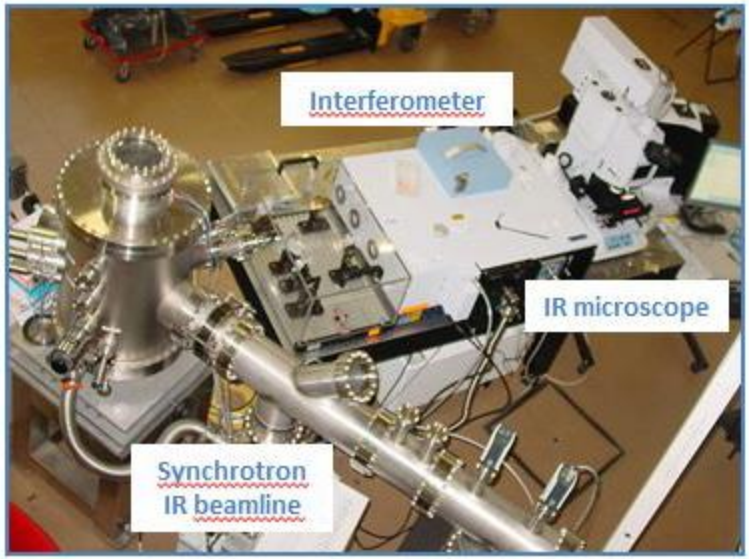


$$\Delta\varphi(t) = (2\pi/\lambda_0)\int_0^L \Delta n[E_{\mathrm{THz}}(t-\beta z)]dz$$

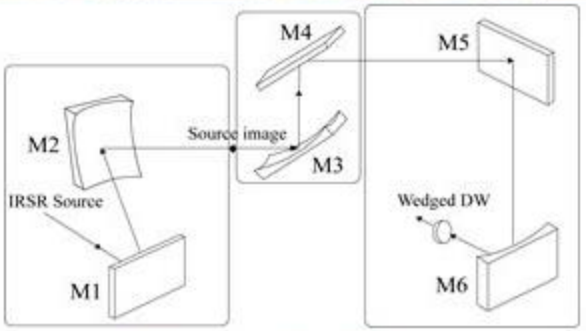
(a)

SINBAD IR beamline

Infrared domain from 10 to 10000 cm^{-1}
(1.24 meV to 1.24 eV)



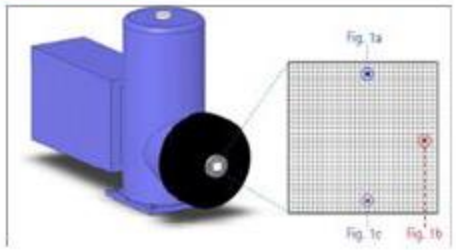
(b)



The optical layout

(c)

Imaging array detector 64x64 pixe



(d)

Clean-room laboratory to support sample preparation and conservation

TMAGIC Goals

1) **R&D on non-conventional radiation sources for clinical imaging and spectroscopy-based diagnostic.**

2) **Early diagnosis based on a combination between THz and Near-IR radiation coherently produced from the same source.**

2) **Development of a portable system for clinical analysis.**

	Working Plan 2017-2019
2017	Progettazione sistema ottico per produzione THz e Near-IR. Acquisizione Laser in fibra e montaggio sistema. Caratterizzazione sorgente.
2018	Sviluppo sistema di imaging e di analisi chimica. Prime analisi ex-situ su tessuti.
2019	Analisi su tessuti. Analisi in situ. Sviluppo del protocollo di analisi.

Financial Plan	
APPARATI	45 k€
INVENTARIO	30 k€
CONSUMO	35 k€
MISSIONI	10 k€
	Totale 120 k€

Servizi richiesti ai LNF

- Elettronica e Automazione (SEA) per realizzazione dei controlli dello strumento portatile (2017) (1 mese/uomo)
- Servizio LDS per la parte di spettroscopia NIR (2017/2018) (2 mesi/uomo)