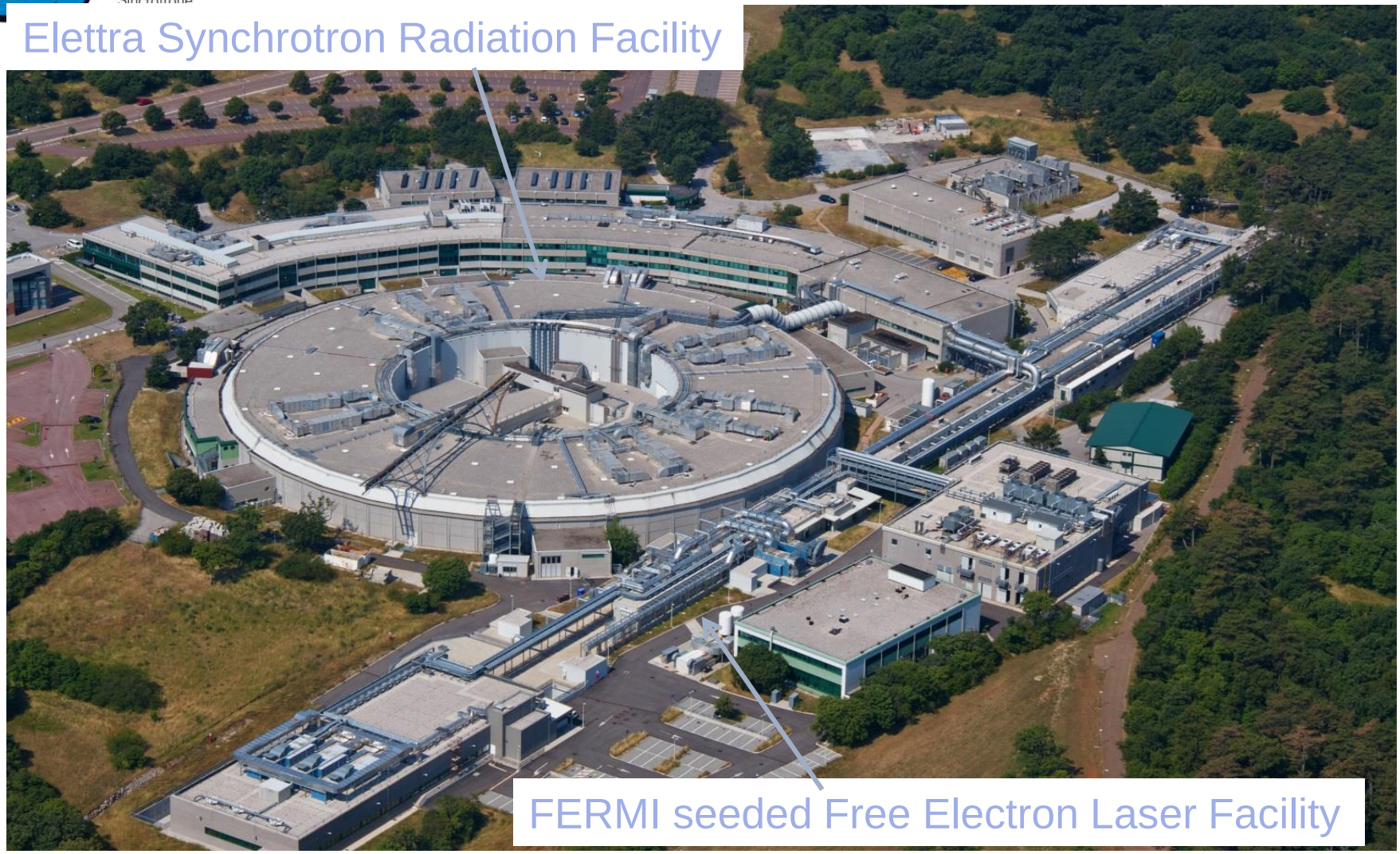
InCIMa
Elettra presentation

Dr. Barbara Rossi
Elettra Sincrotrone Trieste

InCIMa Kick-off meeting, 16th-17th March 2017, Trieste, Italy

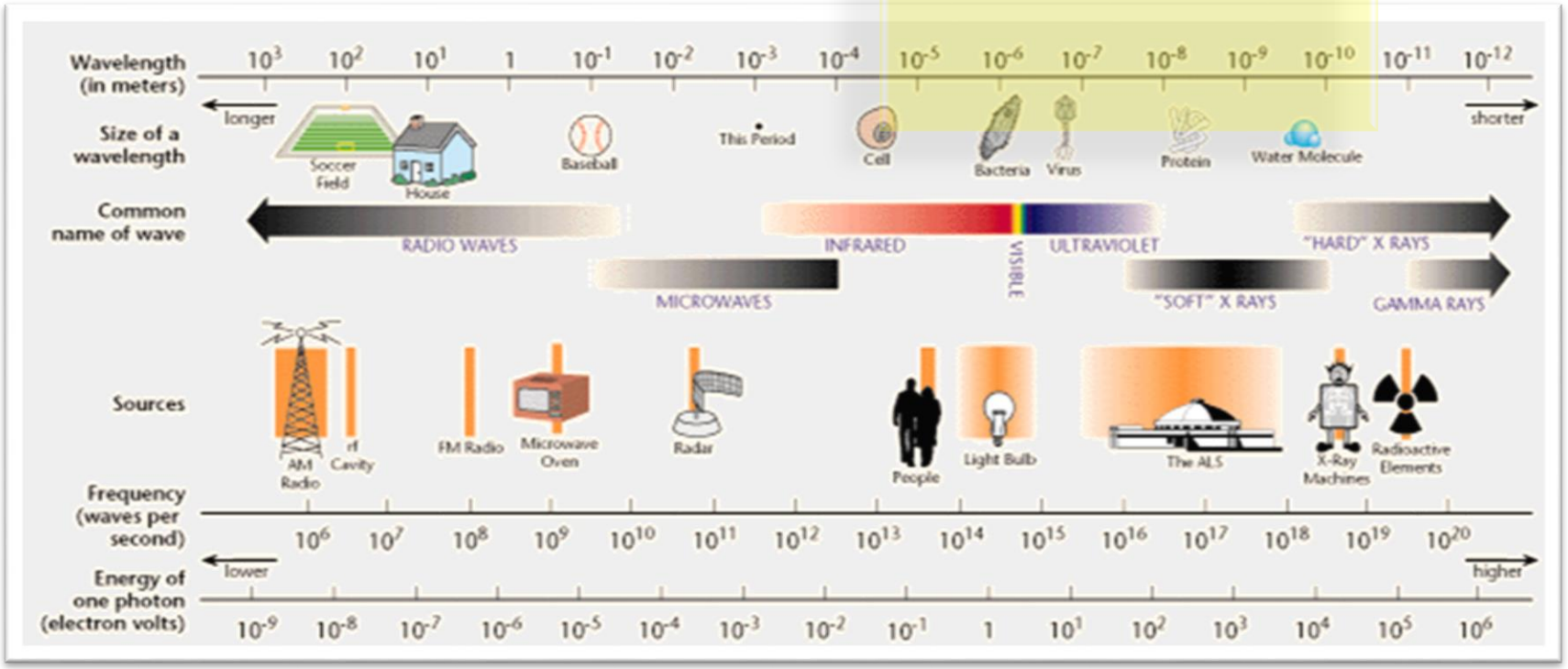
Elettra and FERMI lightsources



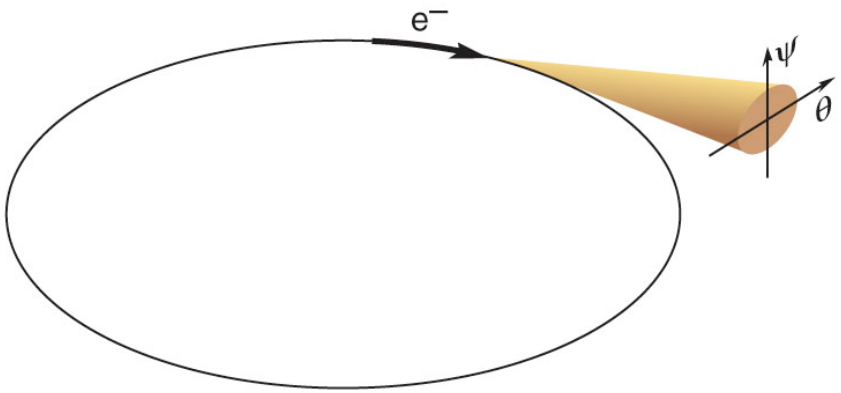
Elettra Sincrotrone Trieste

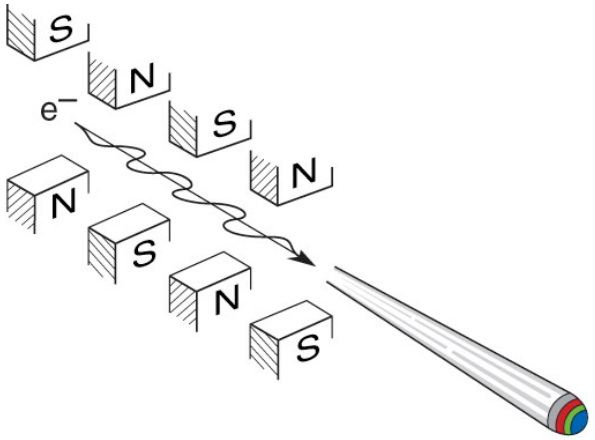
Elettra is the third generation storage ring (2 and 2.4 GeV) in operation since October 1993

It has been optimised to provide the scientific community with **photons in the energy range from a few to several tens of KeV** and is continuously upgraded in order to be competitive with the most recent sources.



Bright and Powerful X-Rays from Relativistic Electrons





Synchrotron radiation

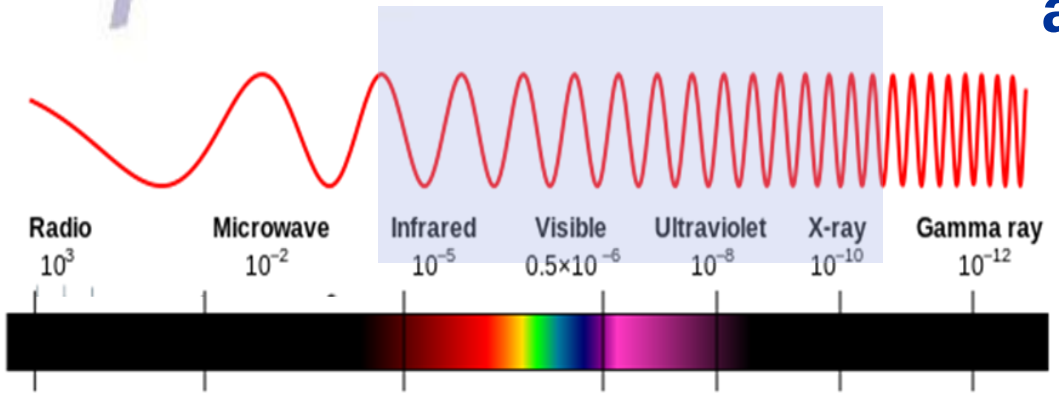
- 10^{10} brighter than the most powerful (compact) laboratory source
- An x-ray "light bulb" in that it radiates all "colors" (wavelengths, photons energies)

Undulator radiation

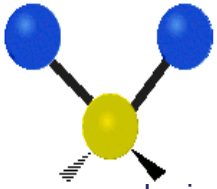
- Lasers exist for the IR, visible, UV, VUV, and EUV
- Undulator radiation is quasi-monochromatic and highly directional, approximating many of the desired properties of an x-ray laser

BrightPowrfulXRs.ai

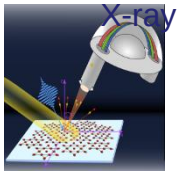
Multidisciplinary research center for materials and life science



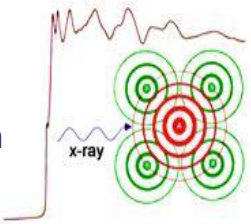
Small angle X-ray Scattering



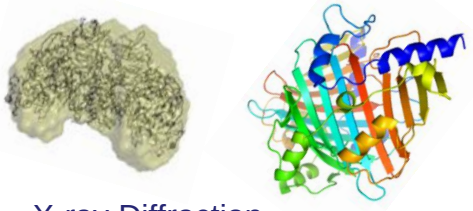
UV Spectroscopy and microscopy



X-ray Absorption Spectroscopy



X-ray and UV Photoemission

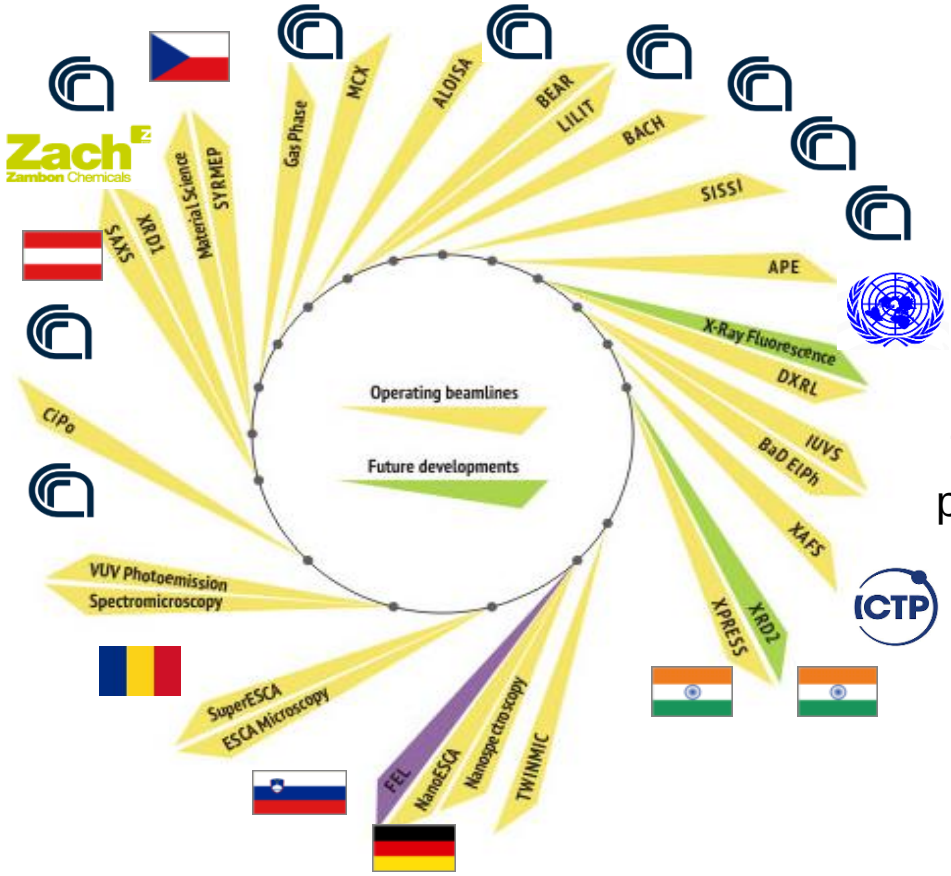


X-ray Diffraction

Elettra Sincrotrone Trieste is a multidisciplinary international research center of excellence, specialized in generating high quality synchrotron and free-electron laser light and applying it in materials and life sciences. Its mission is to promote cultural, social and economic growth through:

- Basic and applied research
- Technology and know-how transfer
- Technical, scientific and management education
- Role of reference in the national and international scientific networks

Elettra: users facility



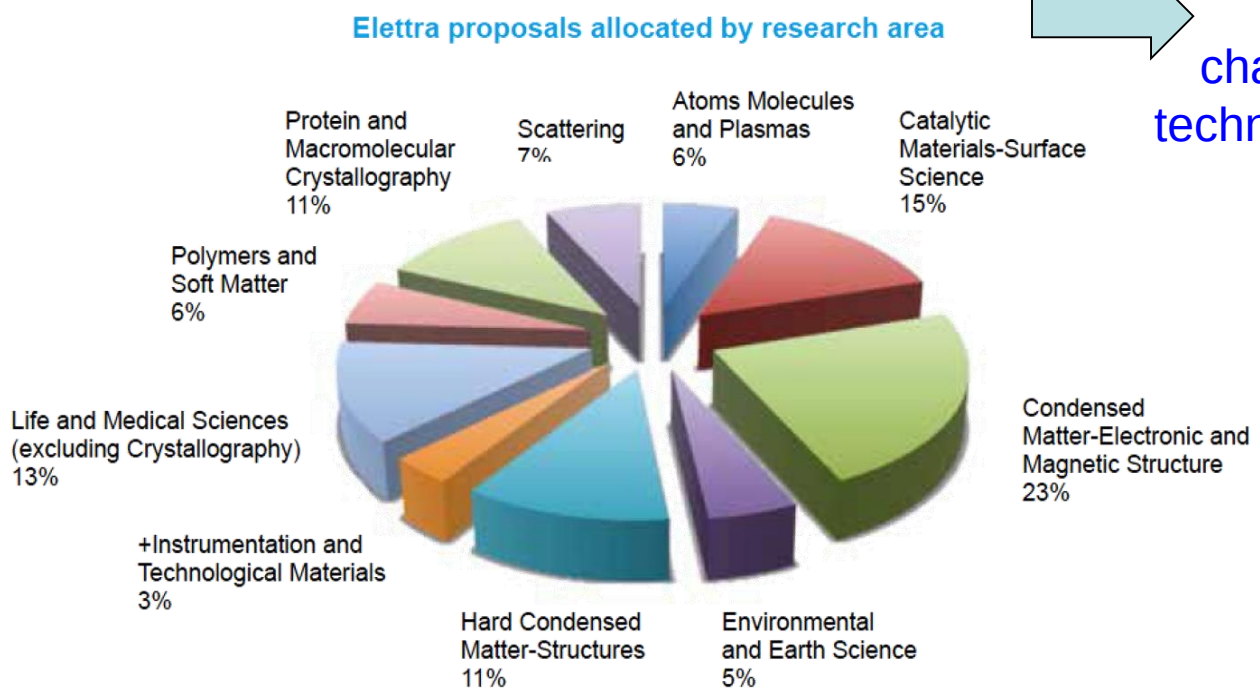
28 beamlines in operation

Elettra is a facility open to users

The access to the beamlines is free of charge and granted through proposal merit.

Twice per year, worldwide researchers submit proposal for experiments, that are evaluated by international Peer-Review-Committees (accordingly to the research area)

Proposals and scientific disciplines



Novel materials, novel characterization and processing techniques, nano- and life sciences

934 Proposals received in 2016

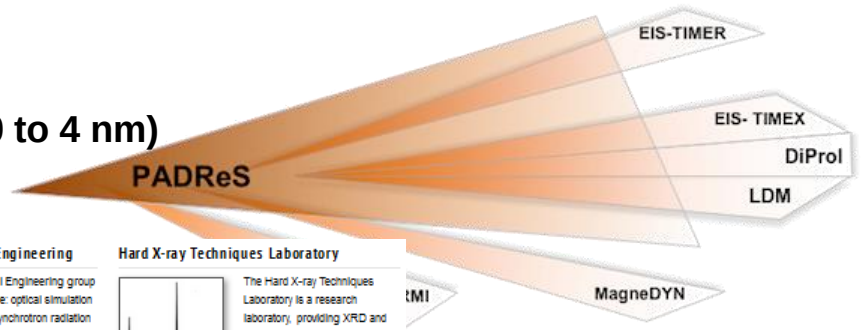
- from > 50 countries
- Italy 41%: truly international centre

438 ISI publications

FERMI beamlines and support labs

FEL-1 and FEL-2 lines (100 to 4 nm)

6 beamlines in operation



- Photon Diagnostics (PADReS)
- Elastic and Inelastic Scattering (EIS-TIMEX,EIS-TIMER)
- Diffraction and Projection Imaging (DiProI)
- Low Density Matter (LDM)
- TeraFERMI
- MagneDYN
- Laser beam for Pump-Probe (SLU)

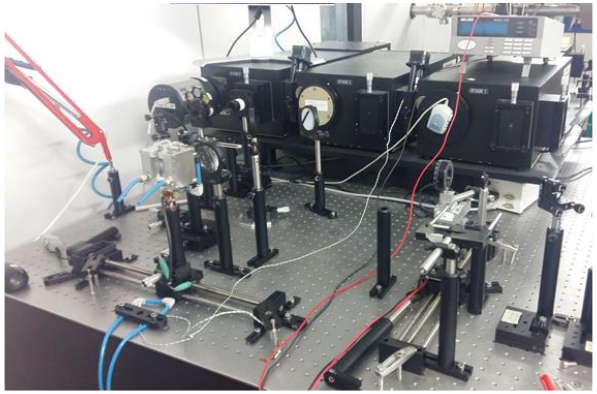
12 supporting laboratories

- Protein production
- Sample preparation
- Scientific computing
- NanoLab
- Tomolab
- T-ReX
- …

Beamlines involved in InCIMa

FTIR Microscopy, Imaging and Tomography @SISSI

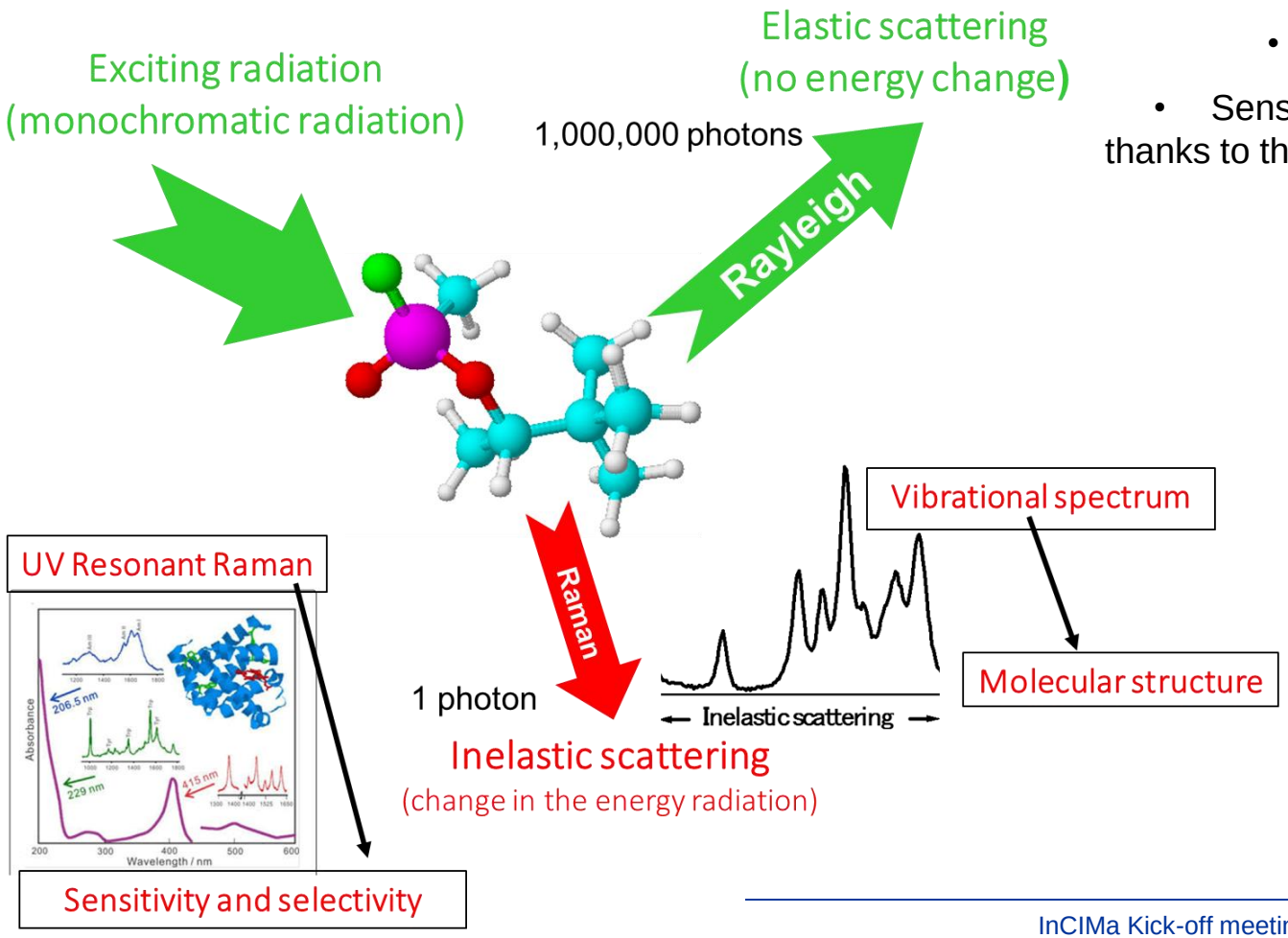
X-ray Imaging and Tomography @SYRMEP



UV-resonant Raman Spectroscopy and Microscopy @IUVS

IUVS: UV Resonant Raman Scattering

- Inelastic scattering technique for measuring the molecular vibrations in solid, liquid, gels, solutions,…
- Sensitive to type of atoms and bonds but also to intra- and inter-molecular interactions

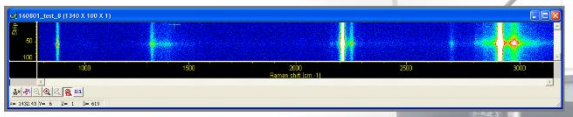


- Non-destructive technique
- Sensitive and selective technique thanks to the UV resonant Raman effect

IUVS: UV Resonant Raman Scattering

Back thinned
Peltier cooled
CCD
(1340x100 pixels)

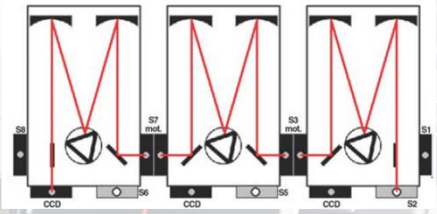
Spectral acquisition



Analyzer: Triple stage Czerny-Turner spectrometer
(Trivista 557)

We can work in many configurations:
Single spectrometer
3 turrets additive mode
3 turrets subtractive mode

3 gratings x turret:
HVIS **1800 lines/mm**
HUV **1800 lines/mm**
HUV **3600 lines/mm**



Resolution performances:
0.3 cm^{-1} @ 633 nm
1 cm^{-1} @ 266 nm

Excitation sources

Synchrotron radiation 200-270 nm

Ancillary lasers:
266 nm
532 nm
633 nm

Sample holder:

- Controlled sample temperature in the range 273-400 K
- **Horizontal oscillation** of the sample to avoid photodegradation

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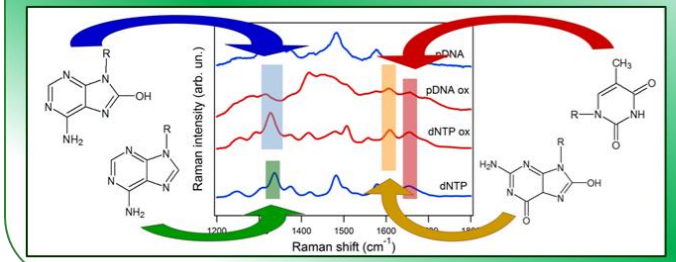
Sincrotrone
Trieste

IUVS: UV Resonant Raman Scattering

Oxidative damage in DNA bases

F. D'Amico, et al. Analyst
2015 140 1477-1485

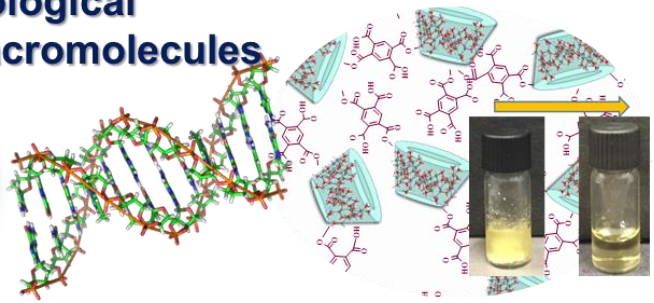


Spectroscopic investigation of Roman decorated plasters by combining FT-IR, micro-Raman and UV-Raman analyses

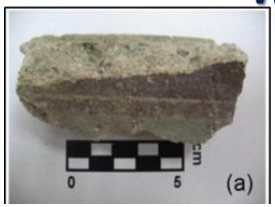
V. Crupi et al. / Vib. Spectrosc. 83 (2016) 78-84

Polymers and gels

Biological macromolecules



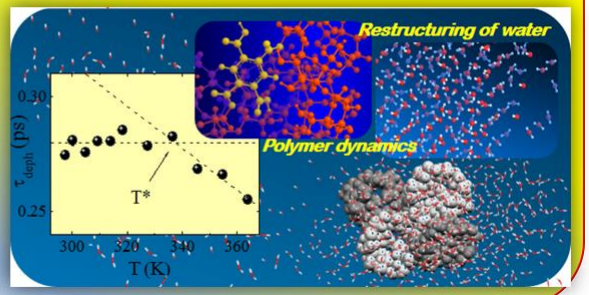
Materials



Water and liquids

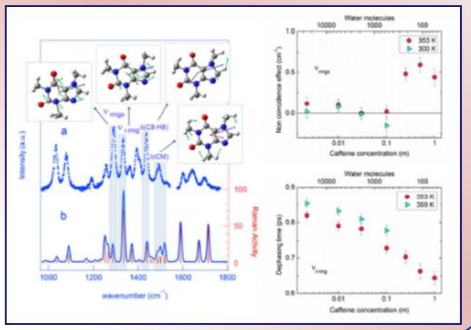
Toward an understanding of the thermosensitive behaviour of pH-responsive hydrogels based on cyclodextrins

B. Rossi et al., Soft Matter
2015 11 5862-5871



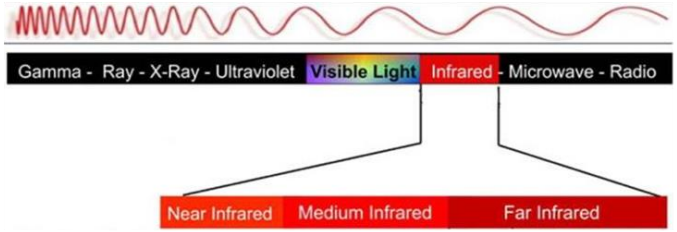
Stacking of purines in water: the role of dipolar interactions in caffeine

L. Tavagnacco et al., Phys. Chem. Chem. Phys. 2016, 18, 13478-13486



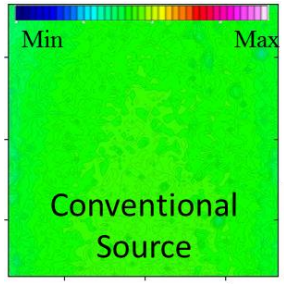
SISSI: FTIR microscopy, imaging and tomography

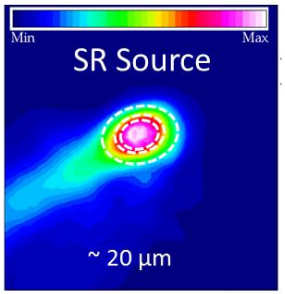
- Absorption spectroscopy that studies the vibrational modes of covalently bonded molecules
- Label free technique
- No radiation damaging
- Compositional and structural information
- Correlation of morphological and vibrational-biochemical information at the micrometer scale

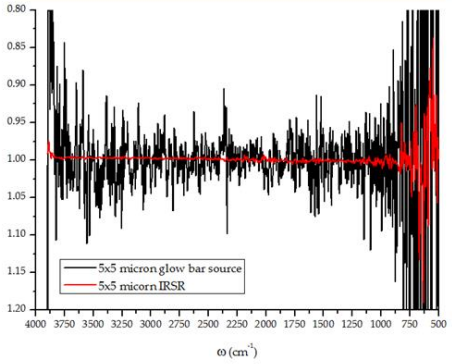


$$\delta \approx \lambda$$

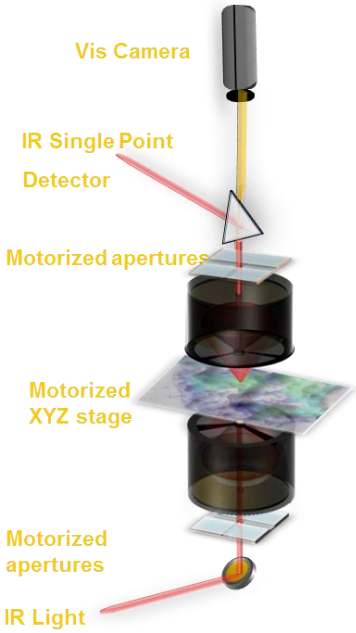
Wavelength	δ (NA=0.65)
10 mm (1 cm^{-1})	~ 1 mm
100 µm (100 cm^{-1})	~ 100 µm
10 µm (1000 cm^{-1})	~ 10 µm
2.5 µm (4000 cm^{-1})	~ 2.5 µm







	NIR	MIR		FIR
λ (µm)	0.74	3	30	300
ν (THz)	400	100	10	1
ν (cm^{-1})	~13000	~3333	~333	~33
E (eV)	1.65	0.413	0.041	0.004
E (Kcal/mol)	37	10	1	0.1



SISSI: FTIR microscopy, imaging and tomography

Hyperion 3000

Vertex 70v

Alternate
Operatio

Open to use

1st Branch – S

Material Scienc

Optimized for s

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European Regional Development Fund

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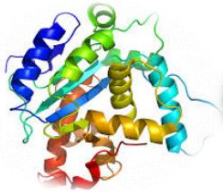
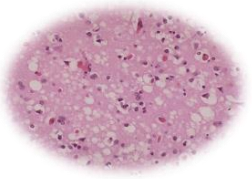
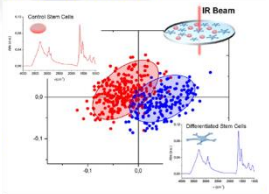




Molecule **Cell** **Tissue**

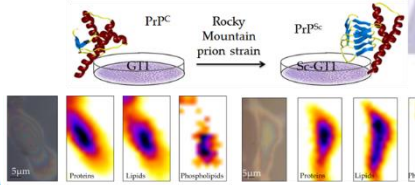
Cell differentiation
Prof. Alessandro Vindigni

Fourier transform infrared microspectroscopy reveals biochemical changes associated with glioma stem cell differentiation



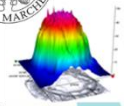
S. Kenig, et al., *Biophysical Chemistry*, (2015); **207**:90-96

Prion Disorders
Prof. Giuseppe Legname



Didonna A, et al., *ACS Chemical Neuroscience*, (2014); **2(3)**: 160-174

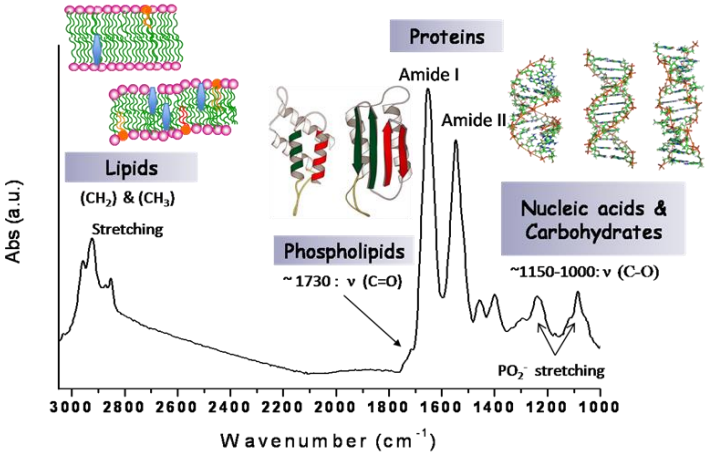
Fertility and sterility
Prof. Oliana Carnevali



Vibrational characterization of female gametes

IR Microspectroscopy on GCs: a new non-invasive oocyte assessment

Giorgini E. et al., *Anal Bional Chem* **2010**, 398, 3063–72
Gioacchini G. et al., *Biology of Reproduction* **2012**, *86(3)*:65, 1–11
Giorgini E. et al., *Vibrational Spectroscopy* **2012**,62, 279–285
Gioacchini G et al., *Fertility and Sterility*, **2014**, 101(1): 120–127
Giorgini E et al, *Analyst*, **2014**, 139(20):5049-60



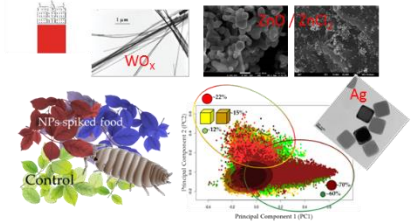
Nanotoxicology
Prof. Damjana Drobne — Dr. Lorella Pascolo

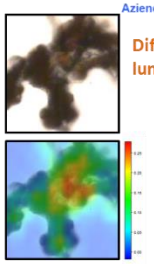
University of Ljubljana

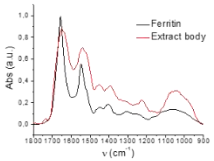
Azienda per l'Assistenza Sanitaria n.2 Bassa Friulana-Isontina

BURLO

Differential protein folding and chemical changes in lung tissues exposed to asbestos or particulates







T. Romih et al., *Nanotoxicology*, **2016**, *10(4):462-70*
S. Novak et al., *Environmental Science and Technology*, **2013**, *57: 11284-11292*
S. Novak et al., *Nanotoxicology*, submitted 2017

L. Pascolo et al. *Scientific Reports* **2015**, *5, Article number 12129*

Radiation Damage

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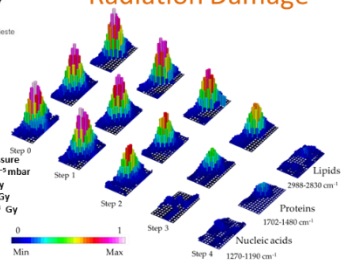
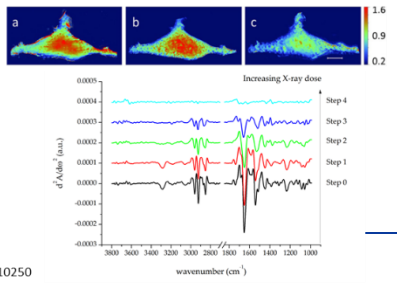
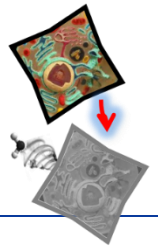


Density maps at the 3 dose levels

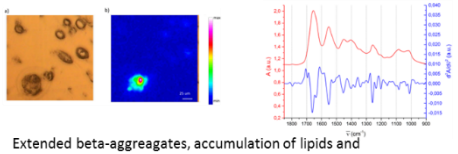




A. Gianoncelli, L. Vaccri et al, *Scientific Reports* (2015); **5**:article number 10250

Rare disease
Prof. Annalisa Santucci

A synchrotron light on Alkaptonuria: a comparative XRF and FTIR study on a rare disease



Extended beta-aggreagates, accumulation of lipids and proteoglycans, accumulation of bio-calcite

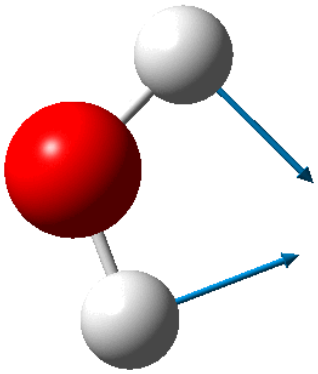
Mitri E. et al., *BBA Genral Subjects* **2016**, doi.org/10.1016/j.bbagen.2017.02.008

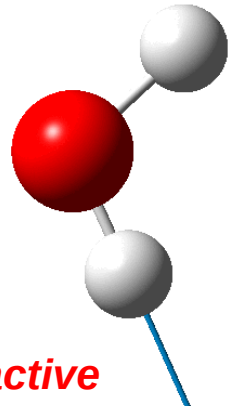
Complementarity UV Resonant Raman / FTIR

Region	Wavelength [μm]	Energy [meV]	Wavenumber [cm^{-1}]	Type of excitation
Far IR	1000 - 50	1.2 - 25	10 - 200	Lattice Vibrations
Mid IR	50 - 2.5	25 - 496	200 - 4000	Molecular Vibrations
Near IR	2.5 - 1	496 - 1240	4000 - 10000	Overtones

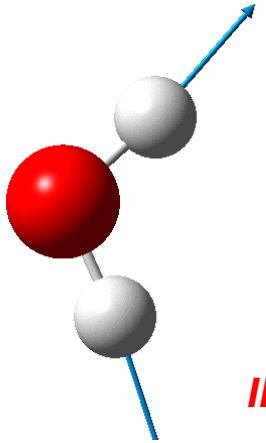
Raman spectroscopy

Bending mode (1620 cm^{-1}) **Symmetric stretching (3600 cm^{-1})** **Asymmetric stretching (3700 cm^{-1})**



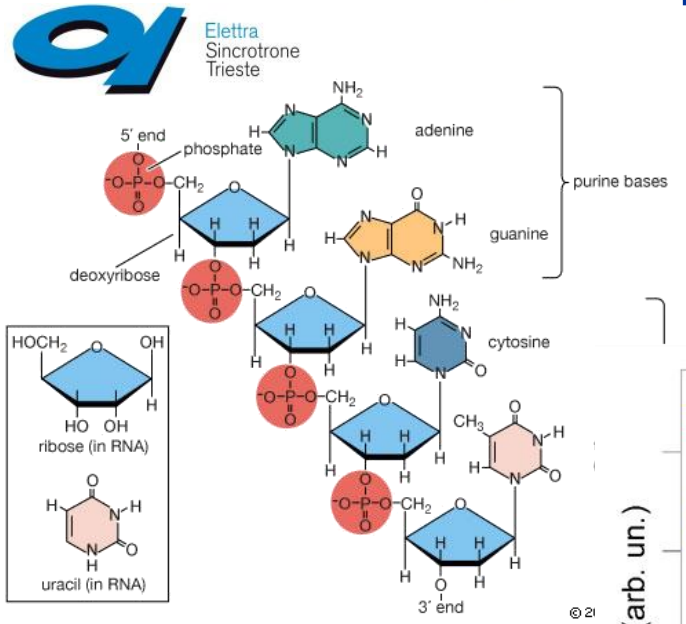


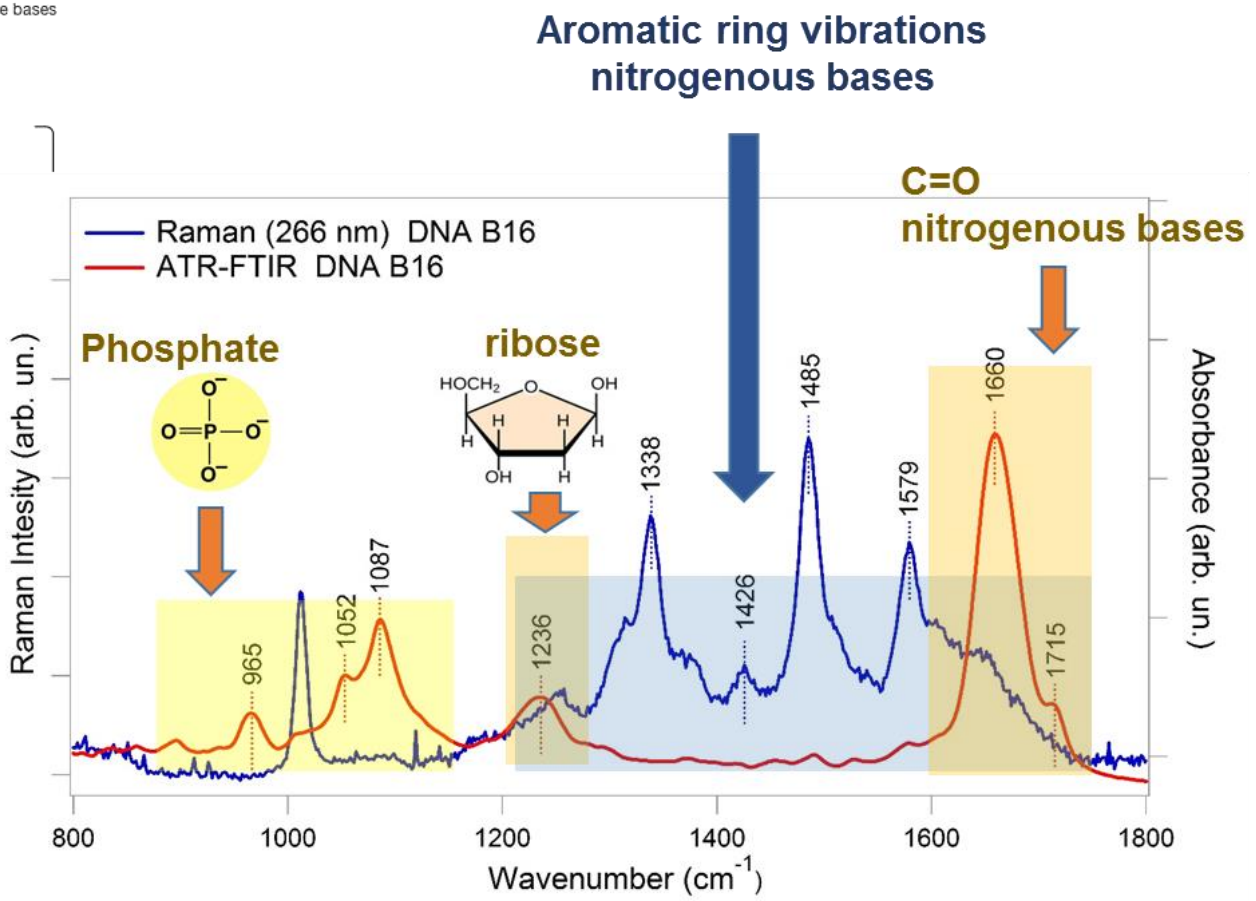
Raman active



IR active

Complementarity UV Resonant Raman/FTIR



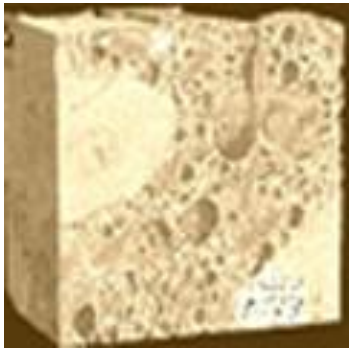


SYRMEP: X-Ray Imaging and Tomography

- Absorption/Phase Contrast Imaging (free propagation)
- Dual energy imaging (K-edge subtraction)
- Analyzer Based Imaging (ABI)

Modalities:

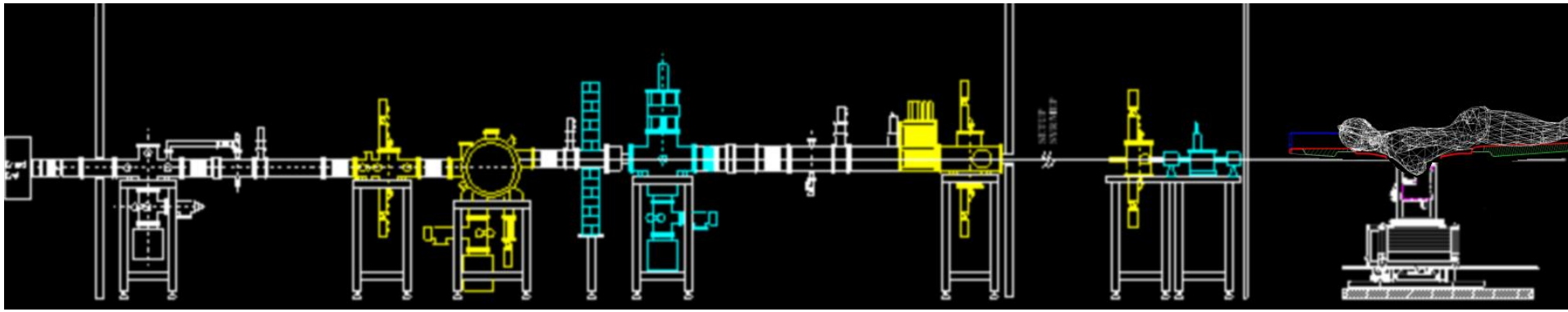
- *Planar*
- *Computed micro-tomography (micro-CT)*



- ✓ Non-destructive techniques to visualize the internal structures of any kind of samples. Virtual volume renderings
- ✓ Phase contrast imaging: use of phase retrieval algorithms to decouple *phase* from *absorption* signal and increase image contrast
- ✓ Computed micro-CT at different resolution scales (1 - 50 μm) according to sample's size and composition
- ✓ Conventional micro-CT benchtop available for complementary studies
- ✓ Software tool for quantitative analysis of reconstructed data

SYRMEP: X-Ray Imaging and Tomography

Node for '*X-ray phase contrast imaging*'



- Front-end hor. acceptance: **7 mrad**
- Source-to-sample distance ≅ **15** m (white beam station), ≅ **23** m (exp. hutch), ≅ **30** m (patient room)
- Beam hor. size at sample ≅ **10** mm (white beam station), ≅ **160** mm (exp. hutch), ≅ **210** mm (patient room)
- Energy range: **8.5 - 40 keV**, B.W. $\Delta E/E \cong 2 * 10^{-3}$

- Typical resolutions/pixel sizes:
  - 0.9 - 3.5 µm for the white beam modality
  - 4.5 – 50 µm for the monochromatic beam

Interreg

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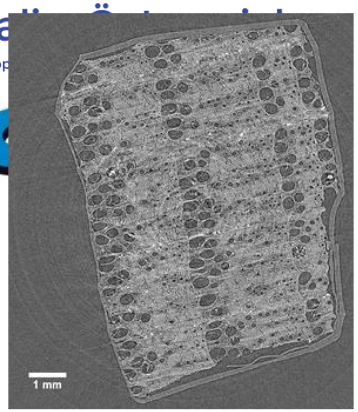
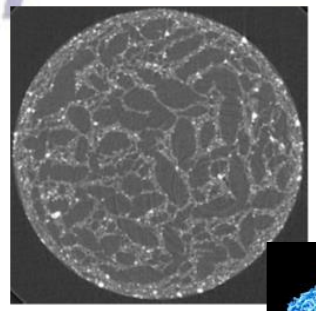


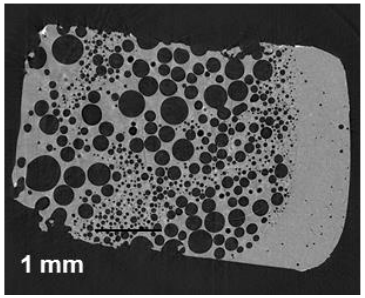
Recent oak sample

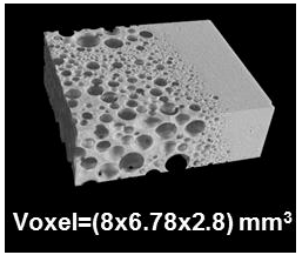
Alginate/Hydroxyapatite scaffolds

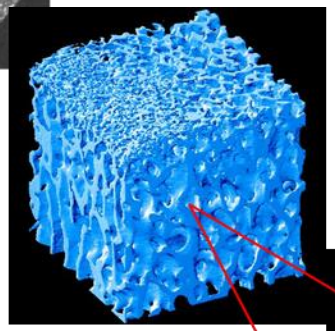


Materials science
Porous materials

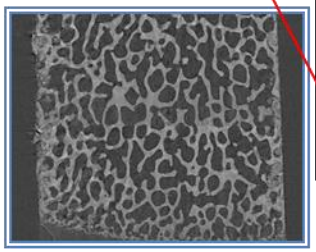
Areated ciocholate

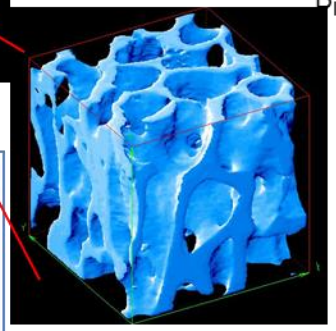






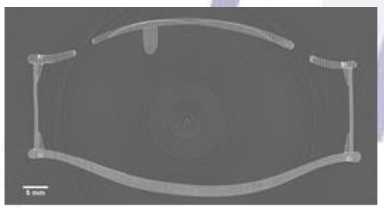
Bone trabecular structure





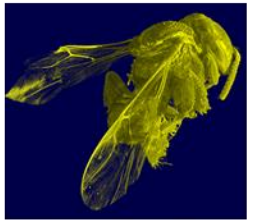
Cultural Heritage

Guadagnini violin (1753)
Pixel size: 50 µm
(whole sample)



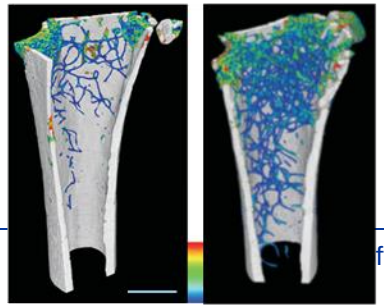
Pixel size: 2 µm (local area)

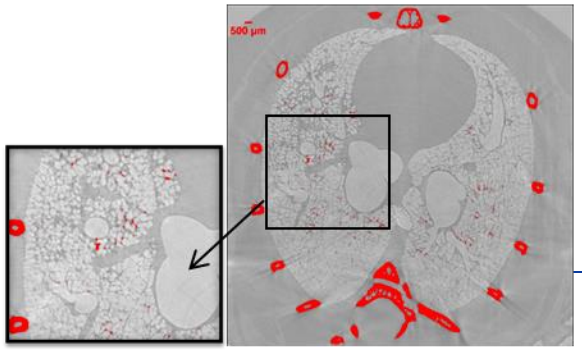
Biomedicine & biology



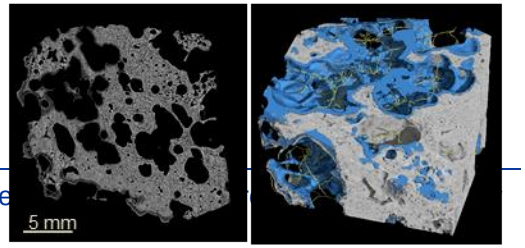
Acient bee in amber

Micrography effects in mice femurs





Scaffold bio-integration/new bone formation



gh resolution morphological
d functional imaging of
thmatic mice lungs

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