

# Diagnostic tools for X-Ray 3D-CT & Dynamic AngioThermography (DATG)

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- Giuseppe Baldazzi, Department of Physics and Astronomy, University of Bologna
- Marco Bontempi, Istituto Ortopedico Rizzoli, Bologna, Italy

**Place of Work:**

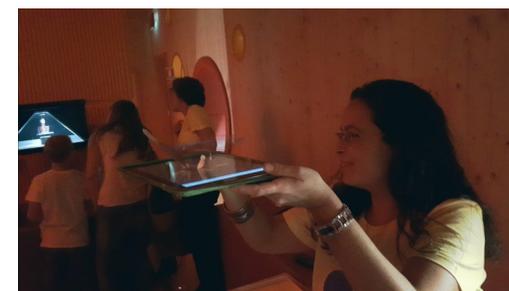
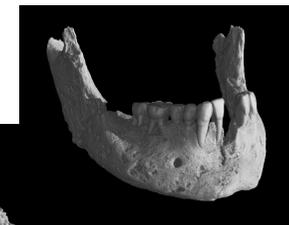
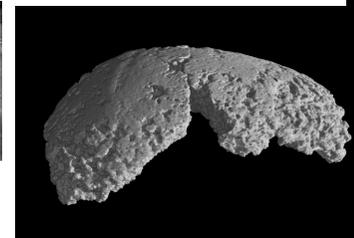
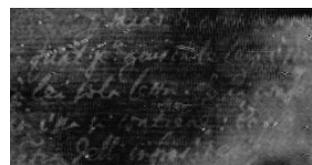
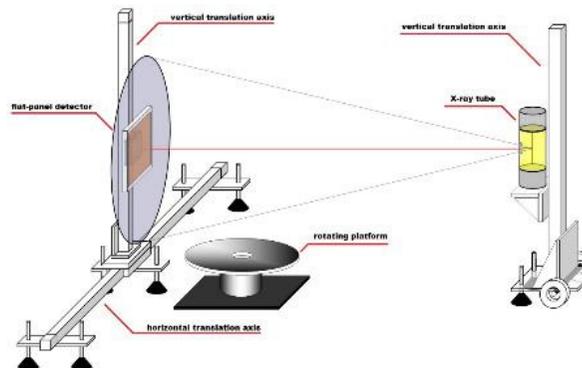
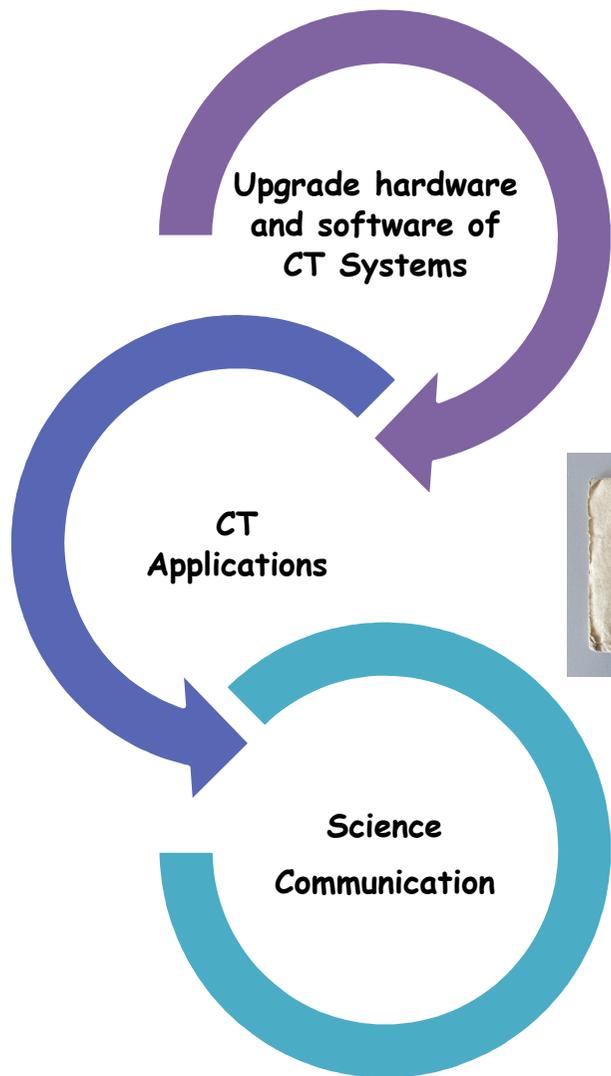
**Department of Physics and Astronomy, University of Bologna**

**Collaborations:**

- **INFN TT\_CHNet**
- **INFN CNAF & INFN\_TTLab**
- **Sistema Museale di Ateneo, Università di Bologna**
- **Istituto Ortopedico Rizzoli, Bologna**
- **ION+, Roma**
- **ENEA, Frascati**
- **Max Planck Institute for Evolutionary Antropology, Leipzig, Germany**
- **École Polytechnique Fédérale de Lausanne (EPFL), Switzerland**

# Diagnostic tools for X-Ray 3D-CT

## Project main goal and results so far achieved

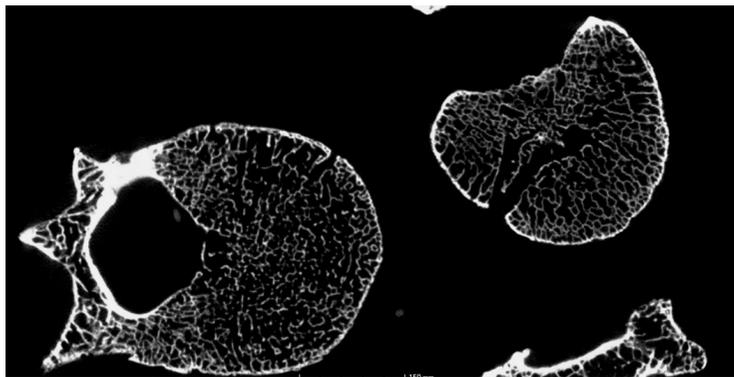


Roma, March 2017 - PTA

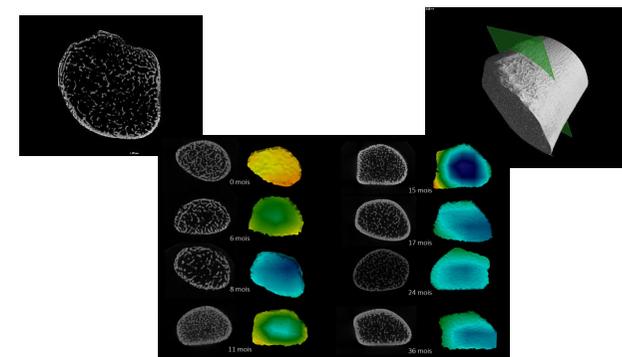
# Diagnostic tools for X-Ray 3D-CT

Collaboration with *Department of Biological, Geological, and Environmental Sciences, University of Bologna*

Study of tuberculosis evidence in trabecular structure of ancient human bones

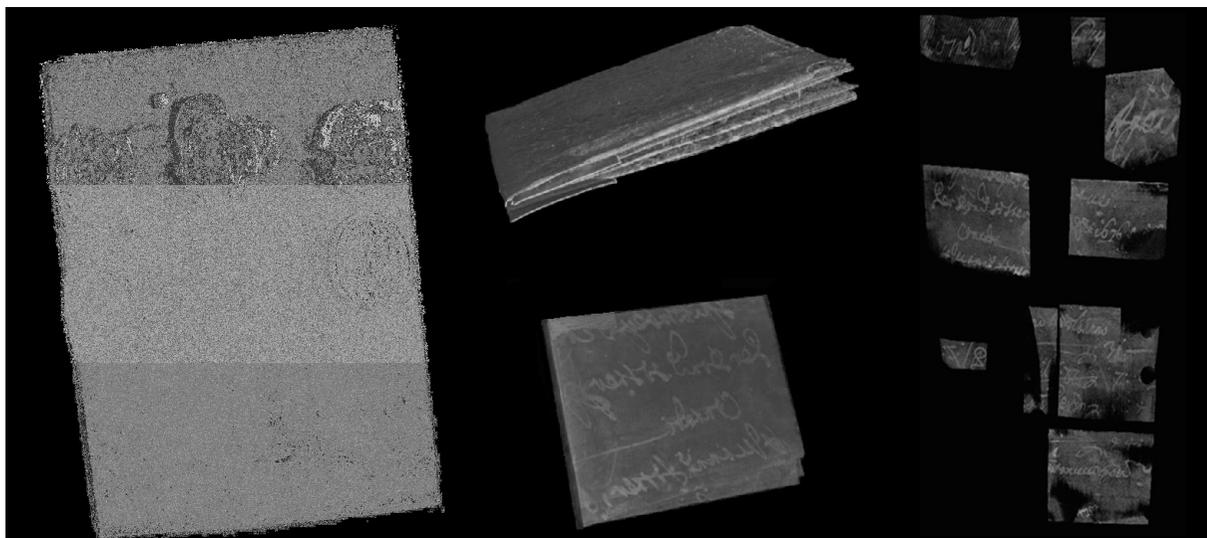


Study of motor development in infant bones



Collaboration with Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany

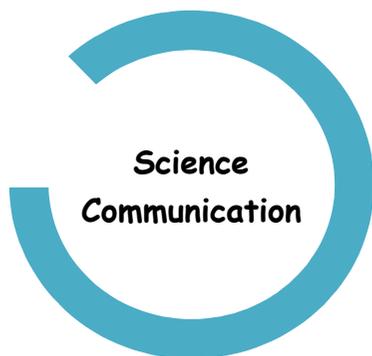
Collaboration with *École Polytechnique Fédérale de Lausanne*



CT investigation of ancient manuscripts kept at the Archives of Venice

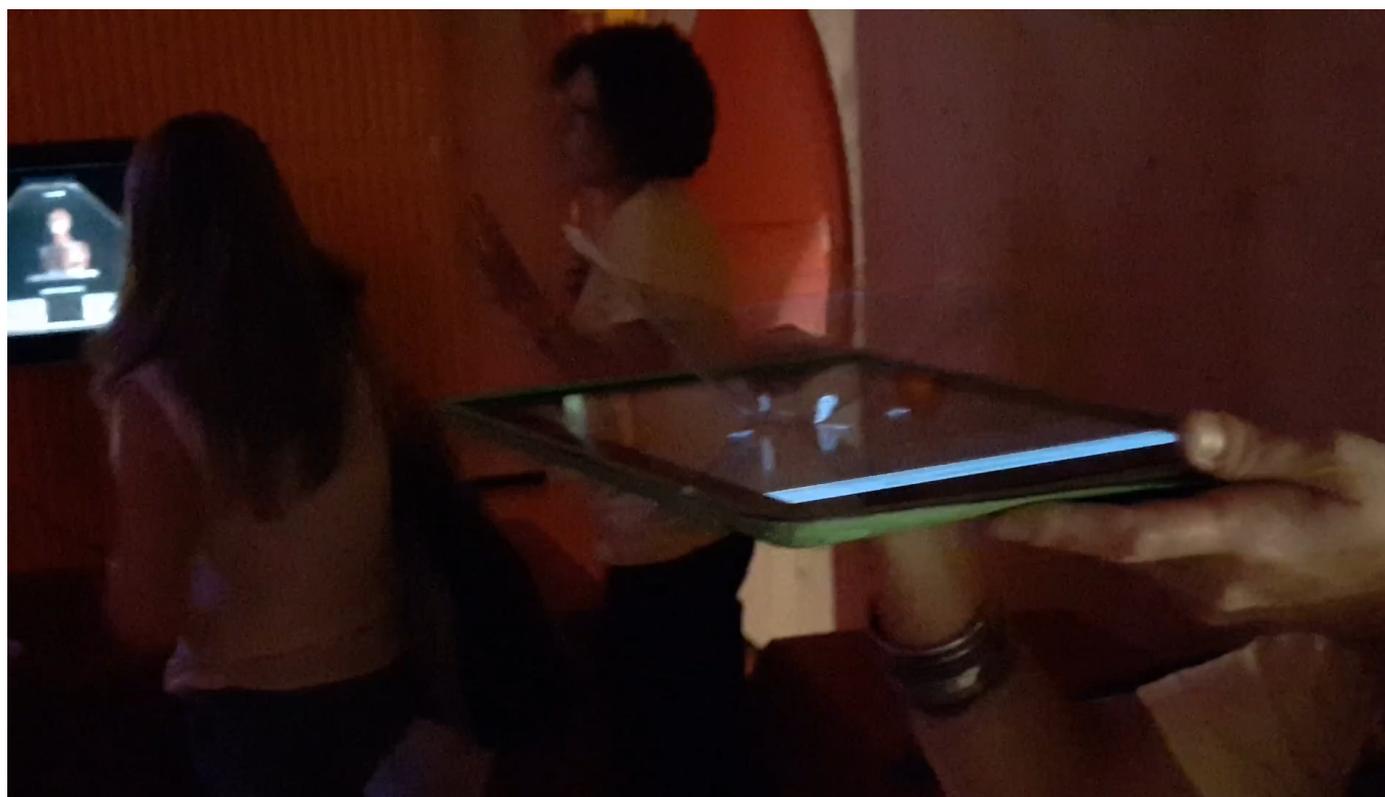


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## European Researchers' Night 2016

- Holographic box to show CT results
- Development of an app for smartphone and tablet

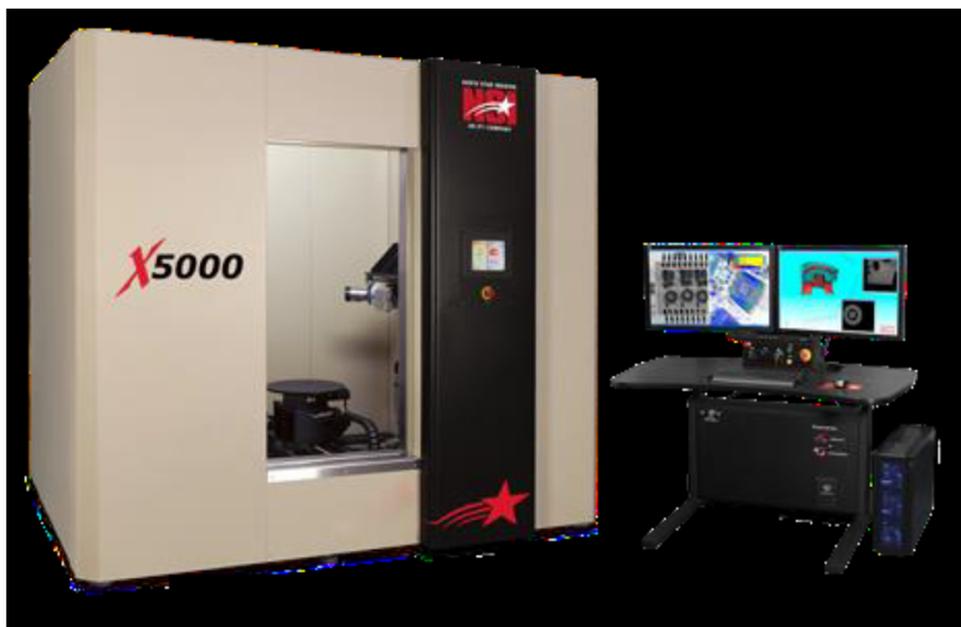


# Diagnostic tools for X-Ray 3D-CT

## Plan of activities 2017 - 2019

### At Centro Fermi

**Realization of a laboratory for diagnostics on Cultural Heritage  
using X-ray techniques**



# Diagnostic tools for X-Ray 3D-CT

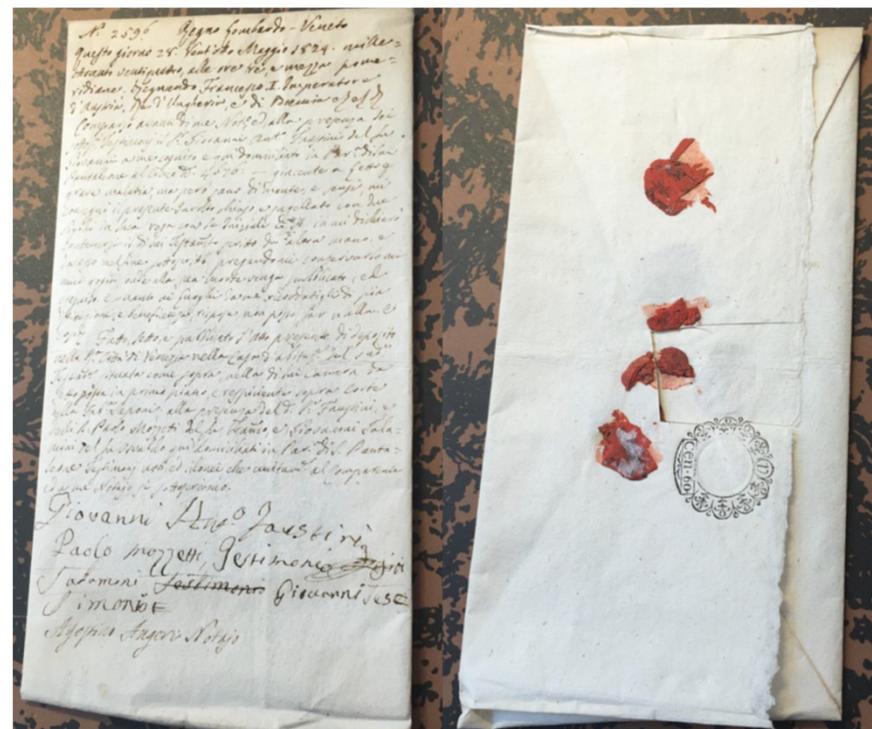
## Plan of activities 2017 - 2019

### At Bologna

Study of Syphilis evidence in trabecular structure of ancient human bones



CT investigation of ancient manuscripts with iron-gall ink



# Diagnostic tools for X-Ray 3D-CT

## Plan of activities 2017 - 2019

### Measurements on-site: at Palazzo Vecchio, Florence



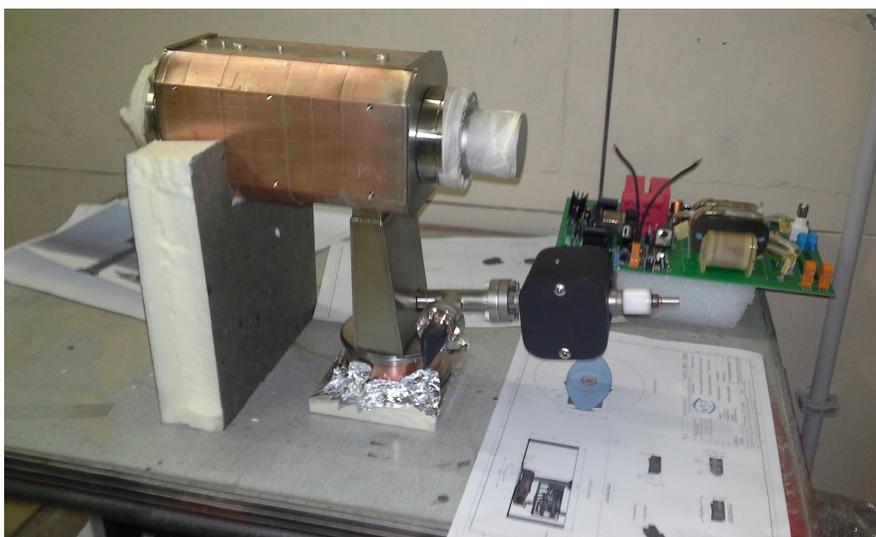
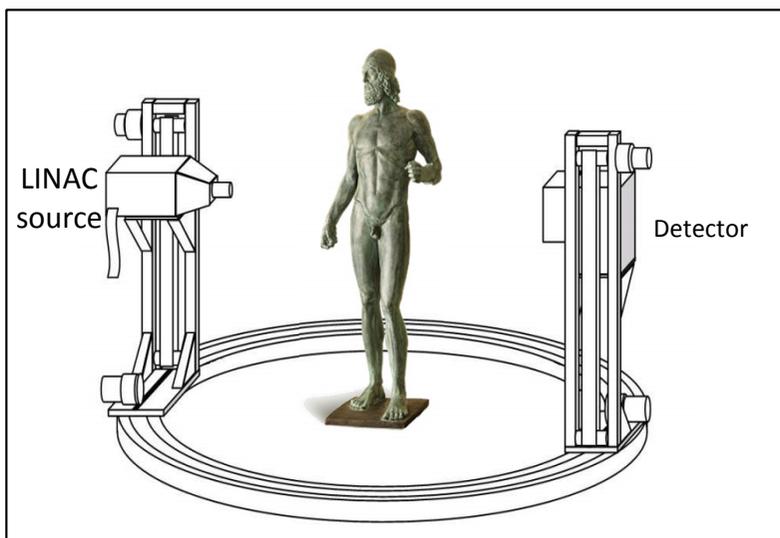
X-ray analysis of the famous panels painted by Pontormo for the processional wagon of St John the Baptist. Shaped like a tower, this was the most monumental of all the wagons representing Florentine corporations that paraded in *Piazza della Signoria* during the festivities for the city's patron saint.



# Diagnostic tools for X-Ray 3D-CT

## Plan of activities 2017 - 2019

### Development of Tomographic System for Medium-High Energy

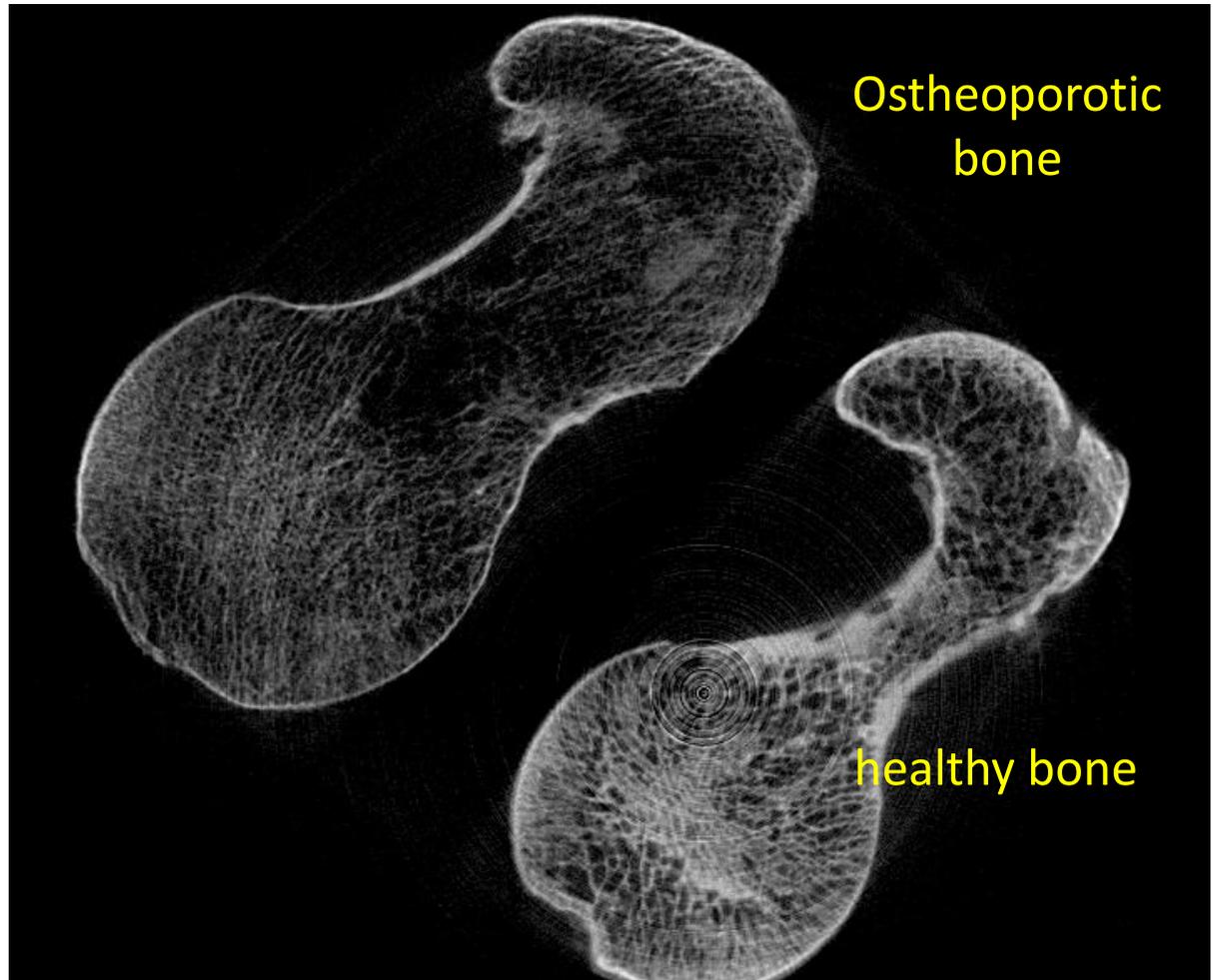
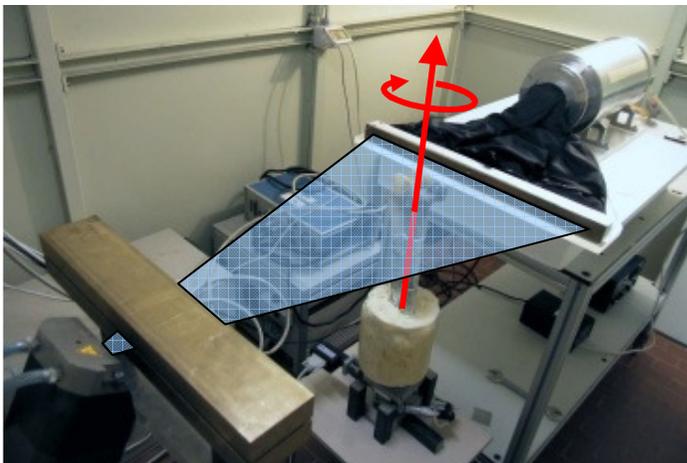
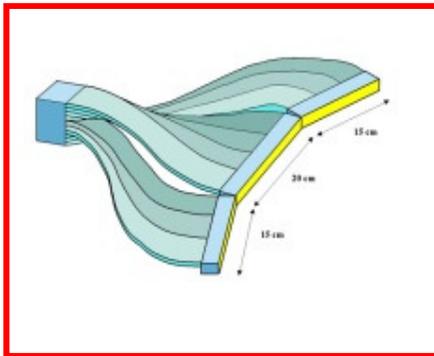


Collaboration with ION+, Roma and ENEA, Frascati

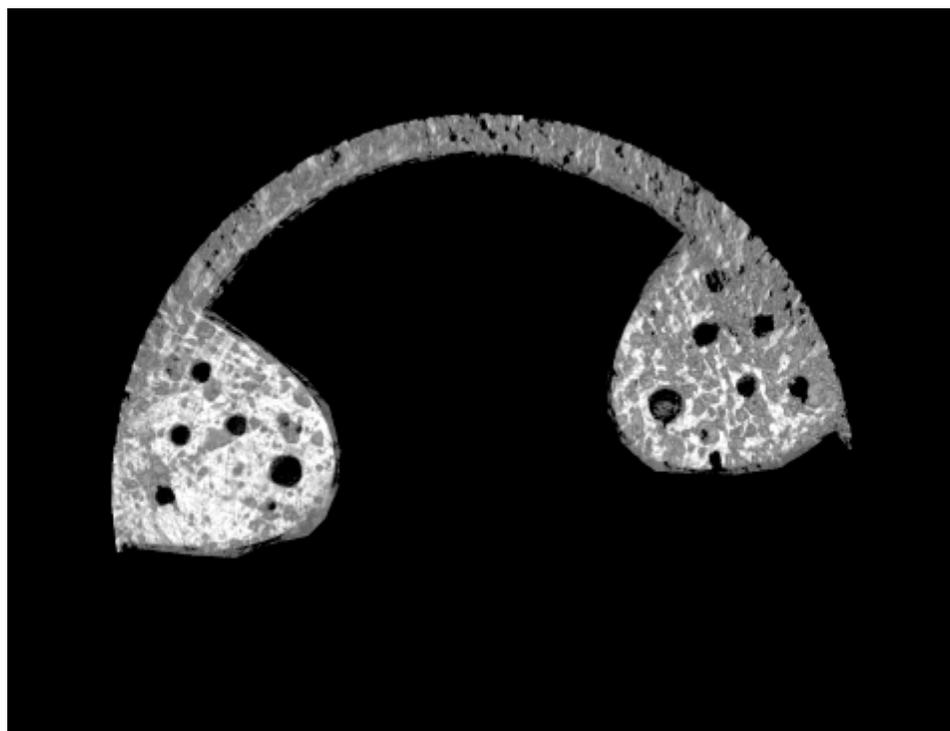
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## Multi-slice CT of human femur bone

## Osteoporosis disease study project of Unibo

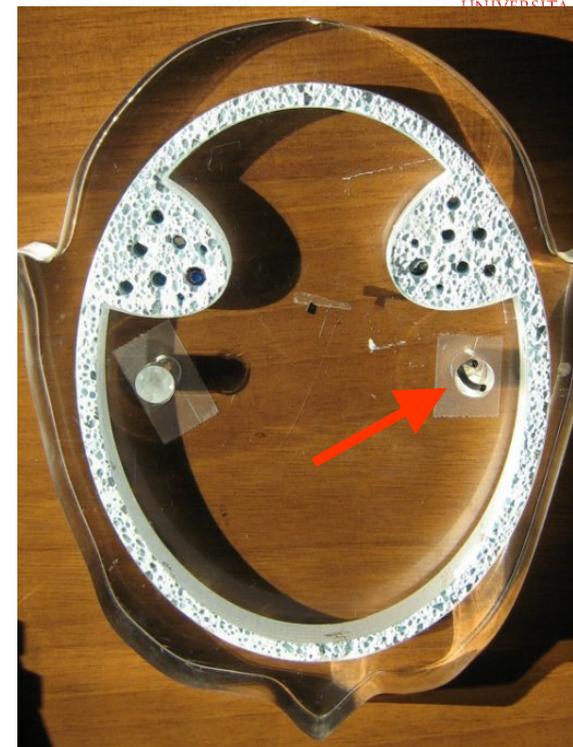


## ESRF: head phantom Synchrotron CT

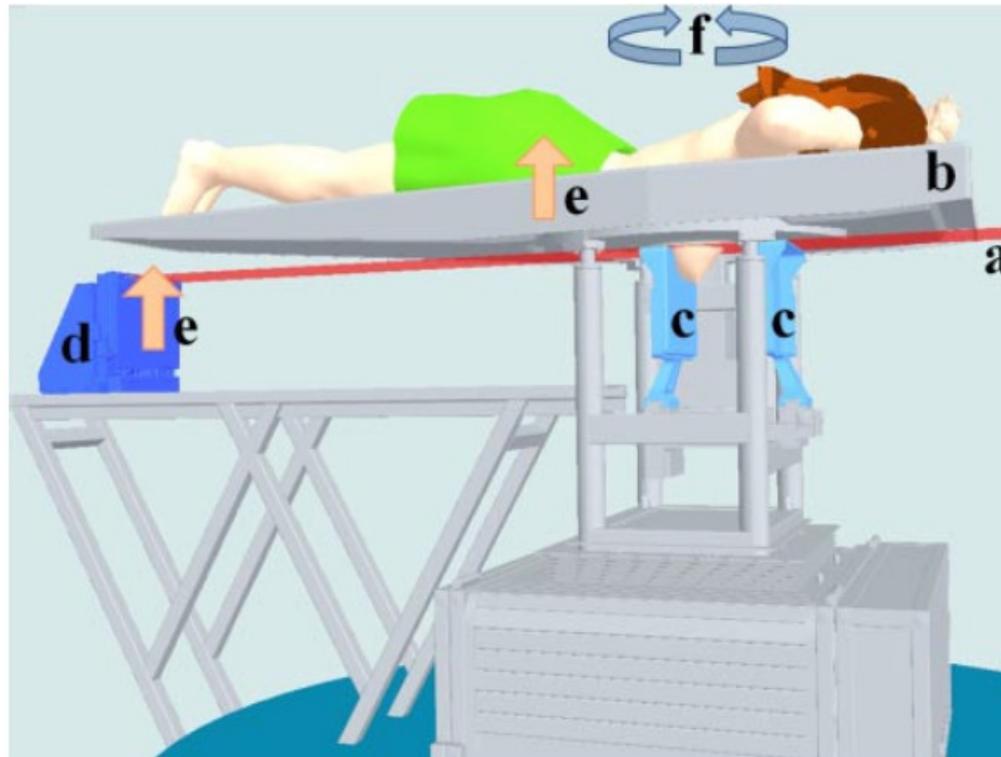


**Preliminary results (69  $\mu\text{m}$  voxel)**

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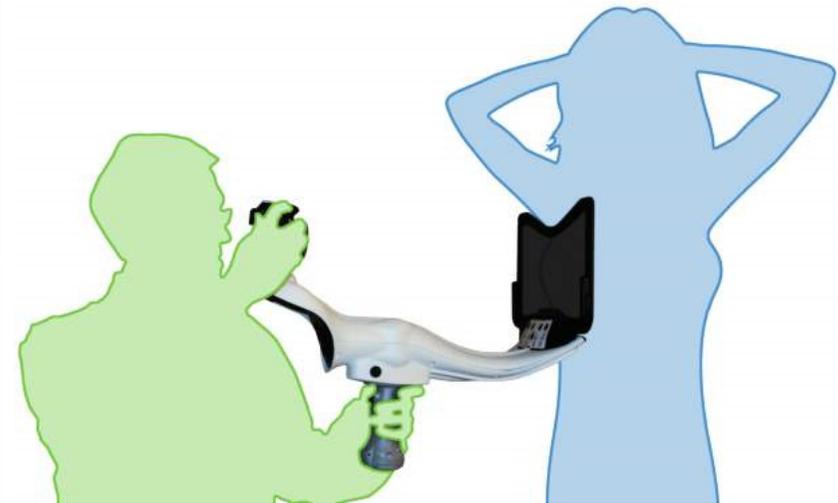
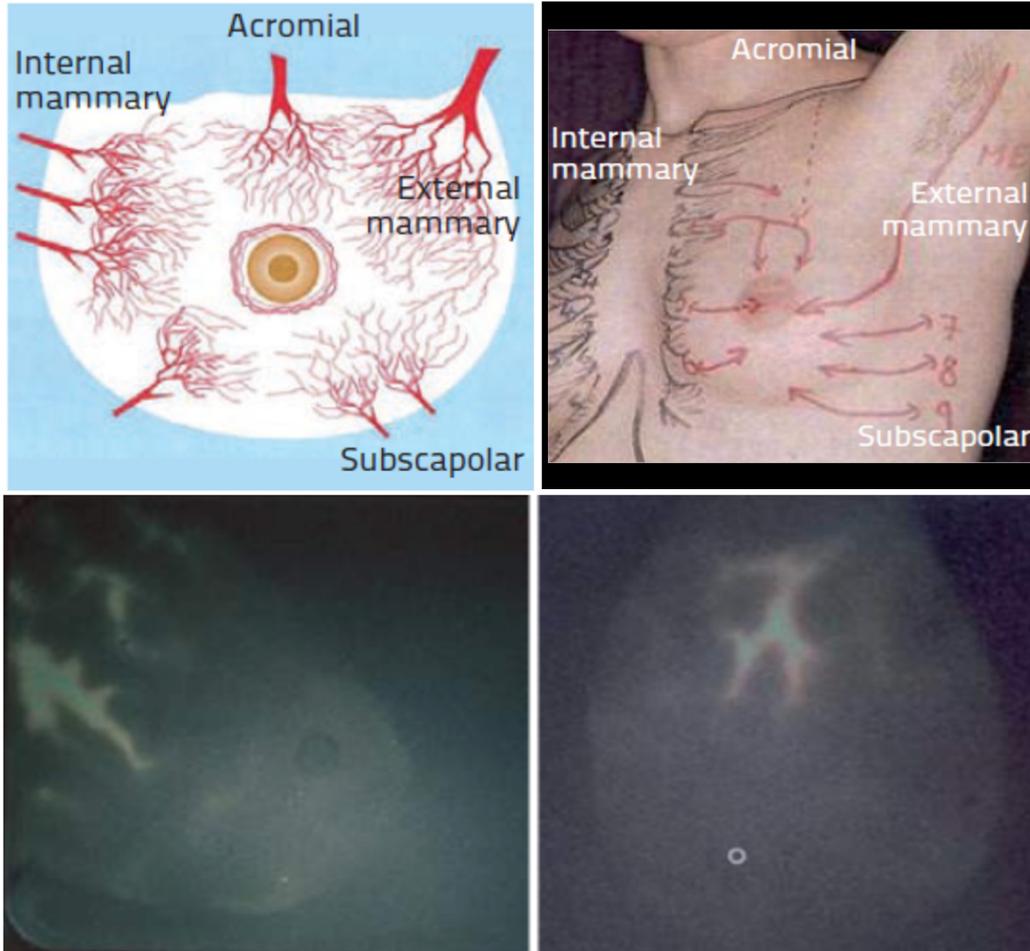


# Advanced CT Systems

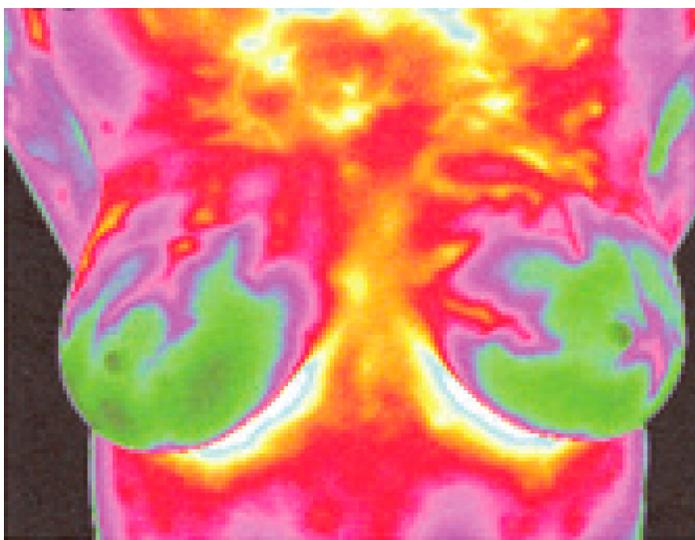


X-ray phase contrast imaging: From synchrotrons to conventional sources,  
A. Olivo and E. Castelli, RIVISTA DEL NUOVO CIMENTO Vol. 37, N. 9 2014

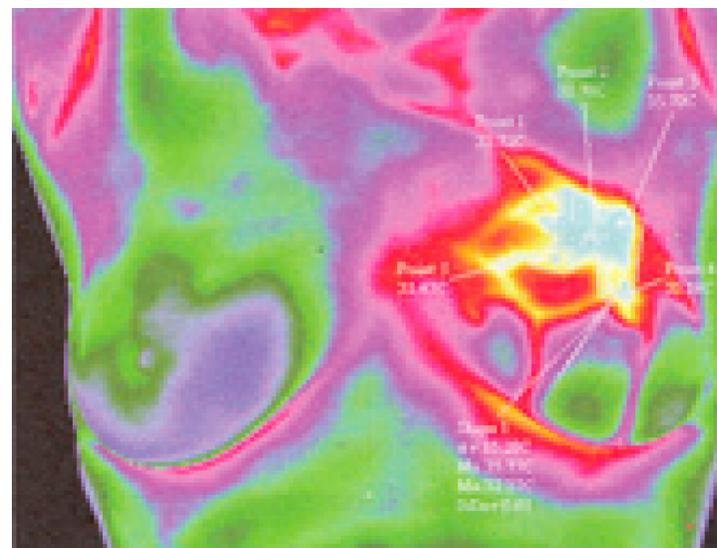
## The DATG and healthy vascularization



## Very often the Dynamic Angiothermography is confused with Mammary Thermography



➤ **Healthy breast**

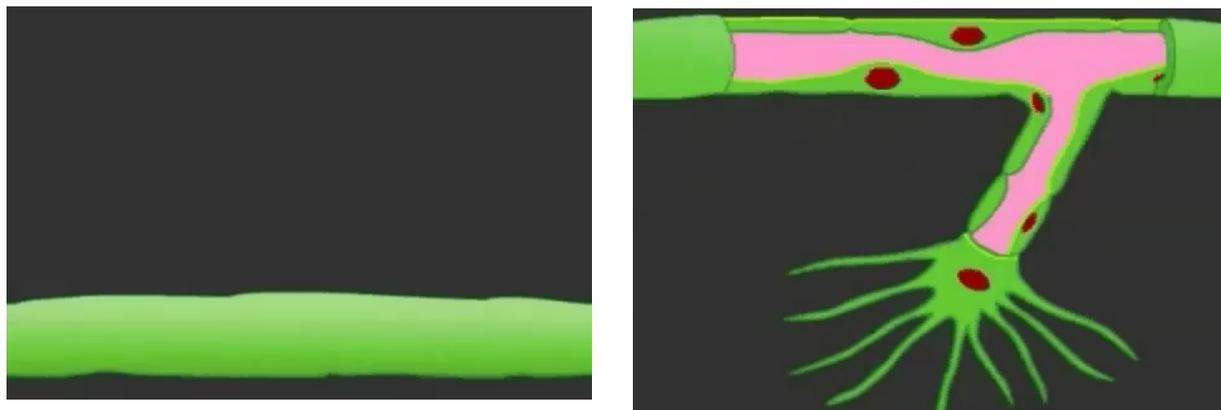


➤ **Left breast with cancer**

Advanced breast thermography utilizes ultra-sensitive IR cameras and advanced computers to detect, interpret, and provide accurate demonstrative images of these temperature and vascular distortions.

## Vascularization and angiogenesis

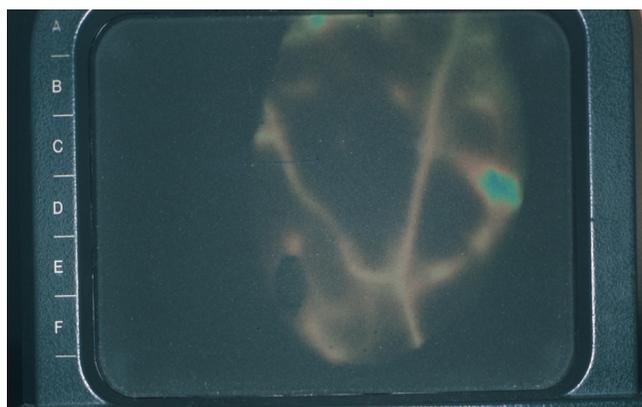
A tumor to be born, develop and grow, has need of new vessels.



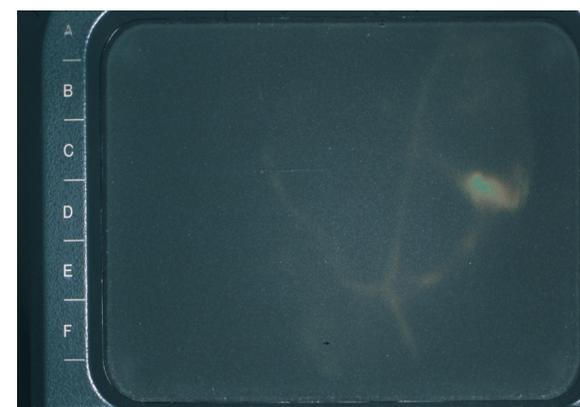
- ➔ Deviations from the normal vascular structure are indicative of pathology (malignancy indicated by red arrows).



## The role of the cooling

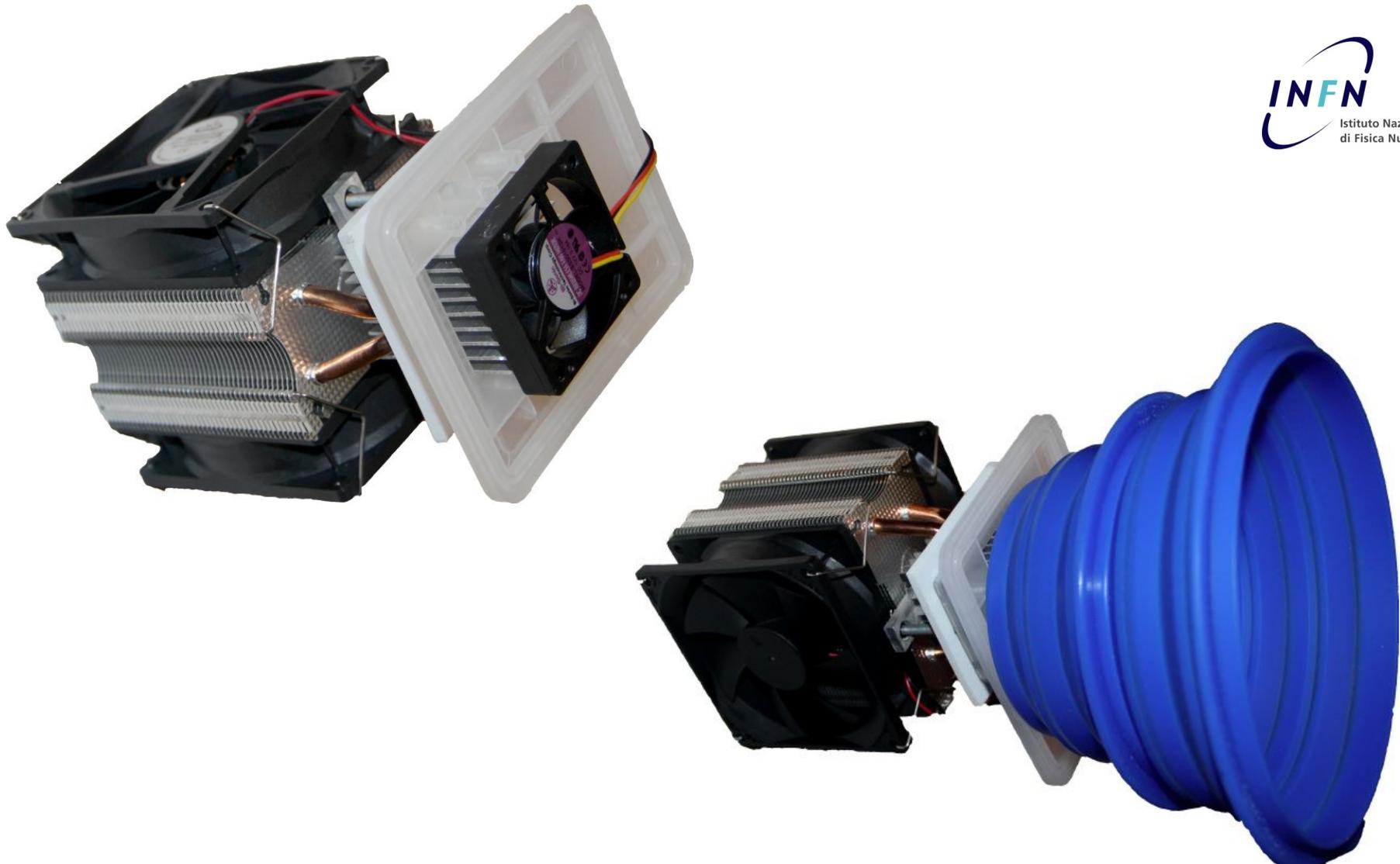


Real picture and DATG  
without having cooled the  
skin



Real picture and  
DATG after having  
cooled the skin

# Dynamic AngioThermography (DATG)



Carlak, H. Feza, and N. G. Gencer. "Electro-Thermal Imaging of Breast Phantom: An Experimental Study." World Academy of Science, Engineering and Technology, International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering 8.8 (2016): 1367-1371.

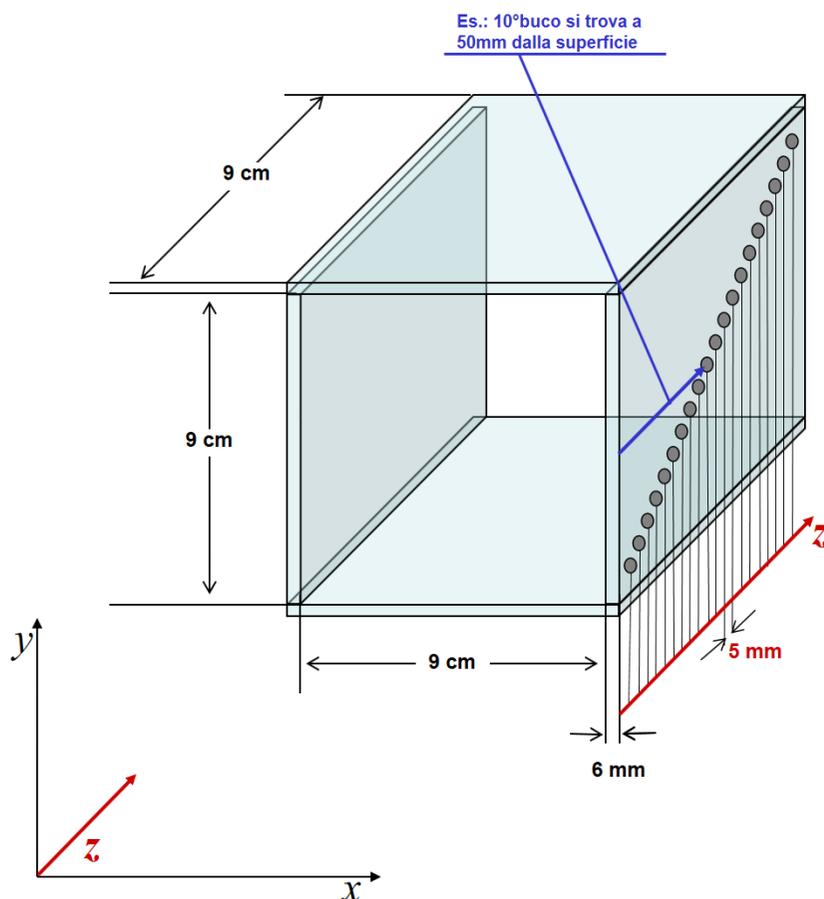
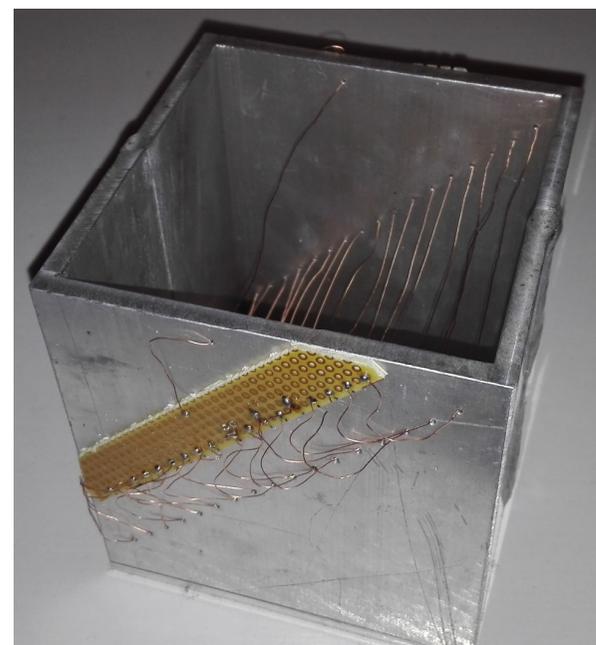


TABLE II  
 PHANTOM INGREDIENTS AND CORRESPONDING CONDUCTIVITY VALUES

Ingredients	Healthy Tissue 1	Healthy Tissue 2	Healthy Tissue 3	Cancerous Tissue
Distilled Water (ml)	100	100	100	100
Agar (gr)	1.5	1	3	1.5
TX-150 (gr)	---	1	---	---
TX-151(gr)	---	---	1	---
Sucrose (gr)	---	---	---	1.5
NaCl (gr)	0.1	0.05	0.05	0.2
Conductivity (S/m)	0.2	0.1	0.16	1



• *Fourier Heat Equation*

$$\nabla^2 T(\vec{r}, t) \alpha = \frac{\partial T}{\partial t}$$

$$\alpha = \frac{k}{\rho c_p}$$

$\alpha$  = diffusivity  
 $k$  = conductivity  
 $\rho$  = density  
 $c_p$  = specific heat



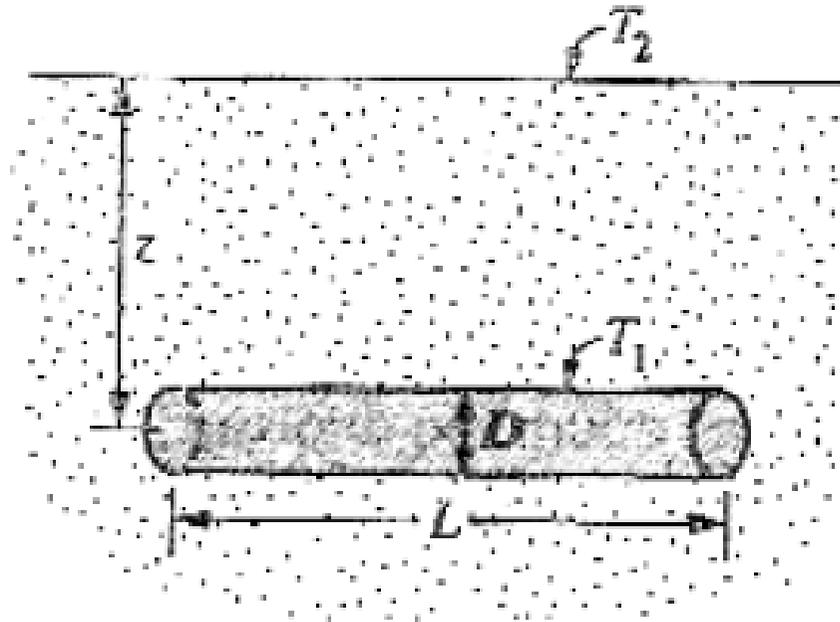
• *Fermi Age Equation*

$$\nabla^2 q(\vec{r}, \tau) = \frac{\partial q}{\partial \tau}$$

• *The shaping factor*

$$W_T = kS(T_1 - T_2)$$

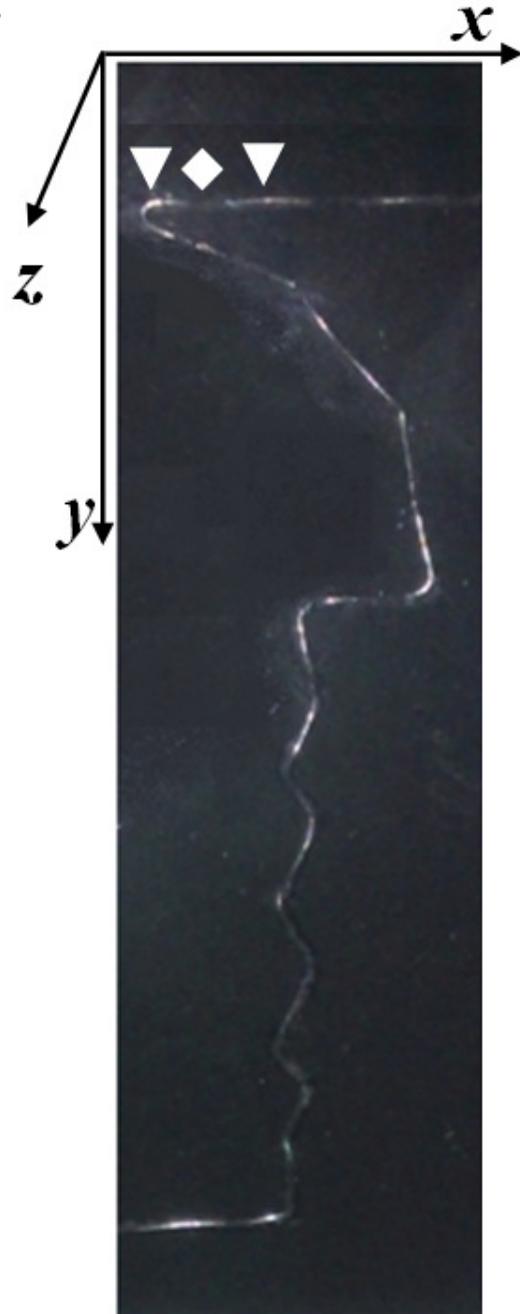
$$\vec{k} = \frac{\vec{q}}{\nabla T} \quad S = \frac{2\pi L}{\ln(4z/D)}$$



• *Hypothesis: Exponential function*

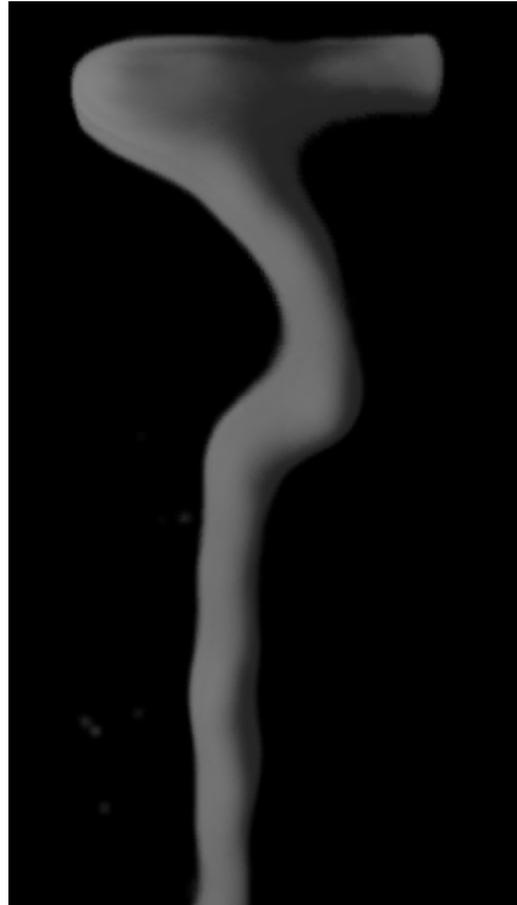
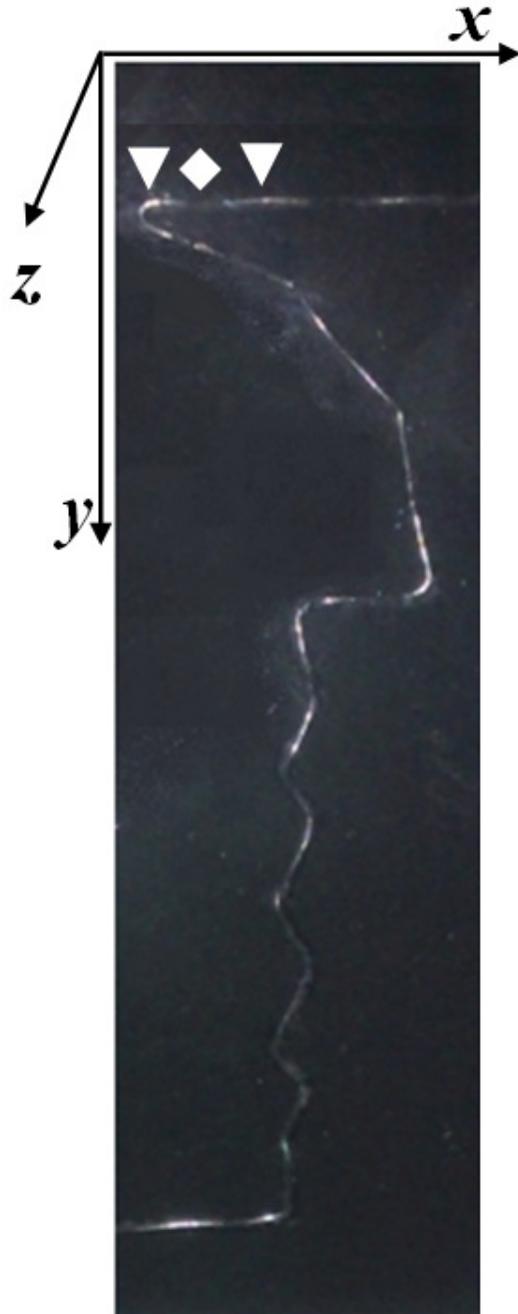
$$z = A + e^{k\Delta t}$$

# Dynamic AngioThermography (DATG)



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# Dynamic AngioThermography (DATG)



## Proposal

Development of breast phantoms to simulate heat diffusion in tridimensional model.

Comparison with thermography and NMR

## Diagnostic tools for X-Ray 3D-CT & Dynamic AngioThermography (DATG)

### Expected funding in the 3-year period:

#### - Request of funding by Centro Fermi

1 Grant for 2017-2019

Consumables: **15 k€** per year

#### Inventory

Contribution for the realization of a high-energy gantry-type tomographic facility: **30 k€**

#### - Potential external funding

INFN TT\_CHNet: 40 K€

**Grazie per l'attenzione!**