Ferrara map

center for science and technology

Center for Science and Technology

"Channeling 2010"4th International Charged and Neutral Particles Channeling Phenomena October 3 - 8, 2010 Ferrara (FE), Italy

Research at the Physics Department of Ferrara University

M. Gambaccini

Physics Department Staff

July 2010

Total	108
Full Professor	11
Associated Professor	9
Researcher	20
PhD student	35
Post Doc	16
Contract Researcher	6
Technical staff	7
Administrative staff	4

In additction to the INFN research
the Physics Department also include:

Research line
Archaeometry
Astrophysics
Physics of Magnetic Materials
Physics of sensors and semiconductors
Plasma Physics
Physics of the Atmosphere
Nuclear technologies for health and environment

Archaeometry

Application of physics and technology science to the study and preservation of cultural heritage.
It is essentially oriented toward the imaging of paintings, the research involves the use of electronic image acquisition techniques in various bands of the electromagnetic spectrum and the subsequent image and data analyses.

Pinting Image Spectroscopy

610 nm

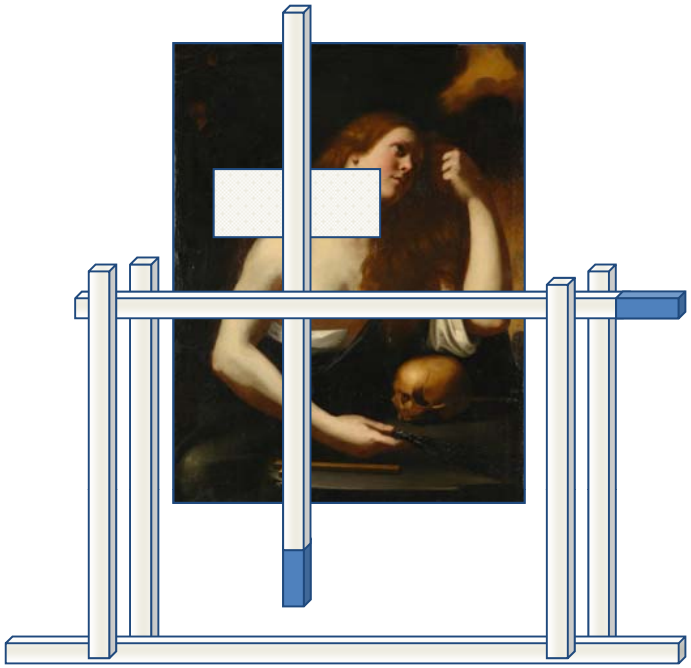
690 nm

730 nm

790 nm

(FE), Italy

Paining Infrared Riflectography



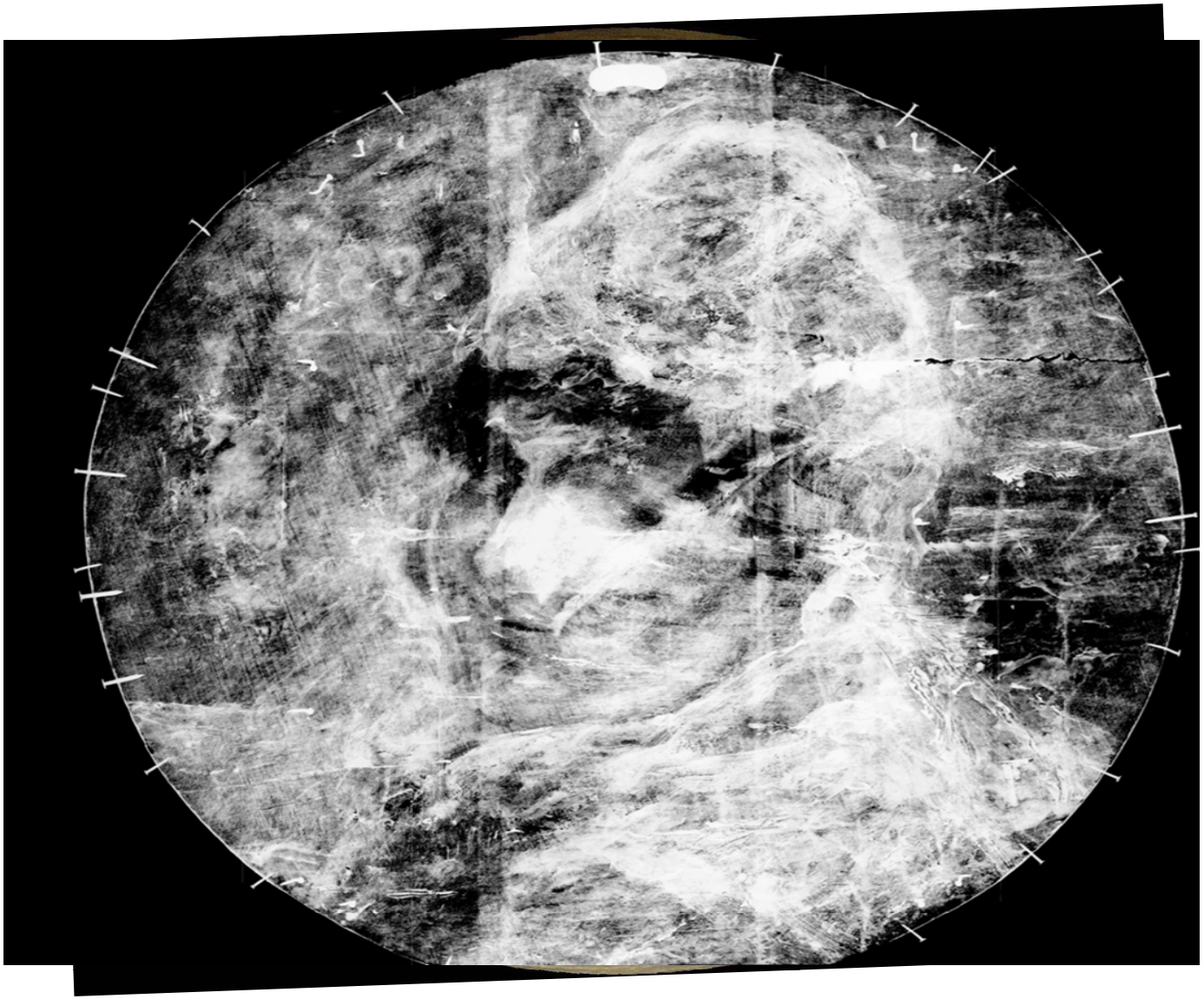
Visible Light

Traditional Si detector:
850-1000 nm IR with Si

InGaS detector:
1000-2300 nm IR with InGaS

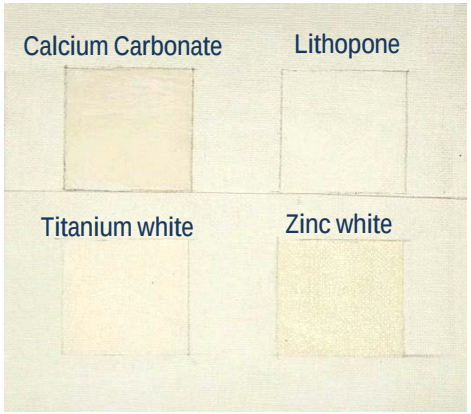
"Landscape"
Oil on wood, XXsec.

X-rays in Art

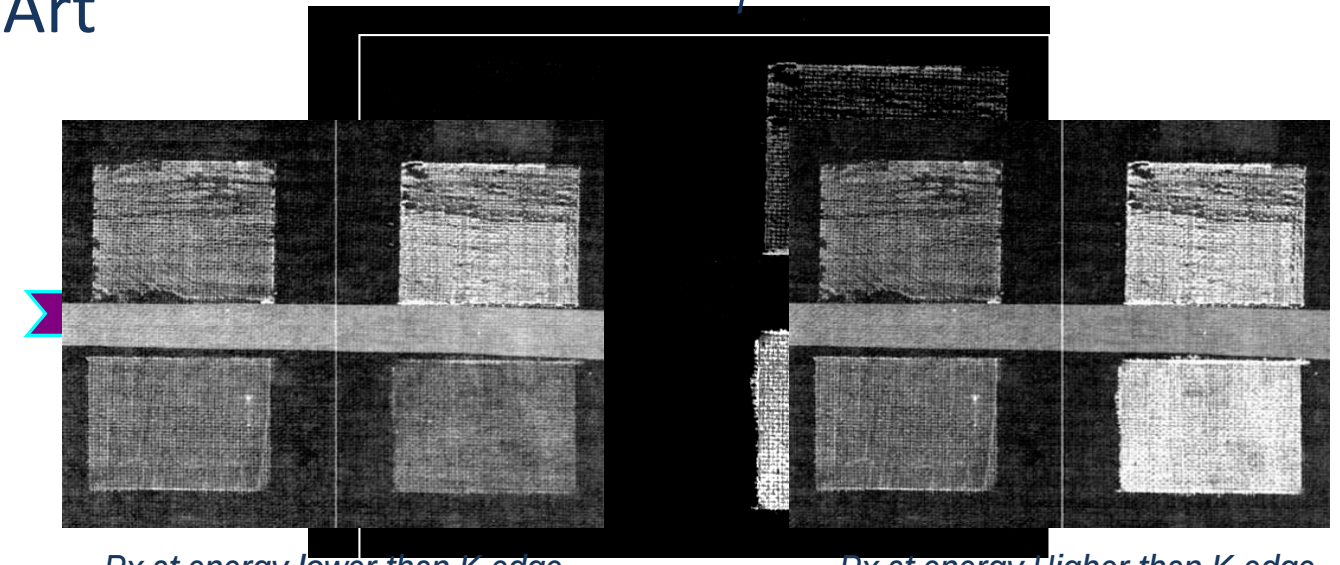


"Landscape"
Oil on wood, XXsec.

K-edge X-rays in Art



Zinc map



Rx at energy lower than K-edge

Rx at energy Higher than K-edge

"Harvest in Montfoucault" Copy of Pissarro, Oil on canvas, 1980

Analized detail in Visible Light

Zinc map

Astrophysics

Research and Technolgy Development on various topics of optical telescopes for focusing hard X-ray and gamma-ray by means of Laue lenses.

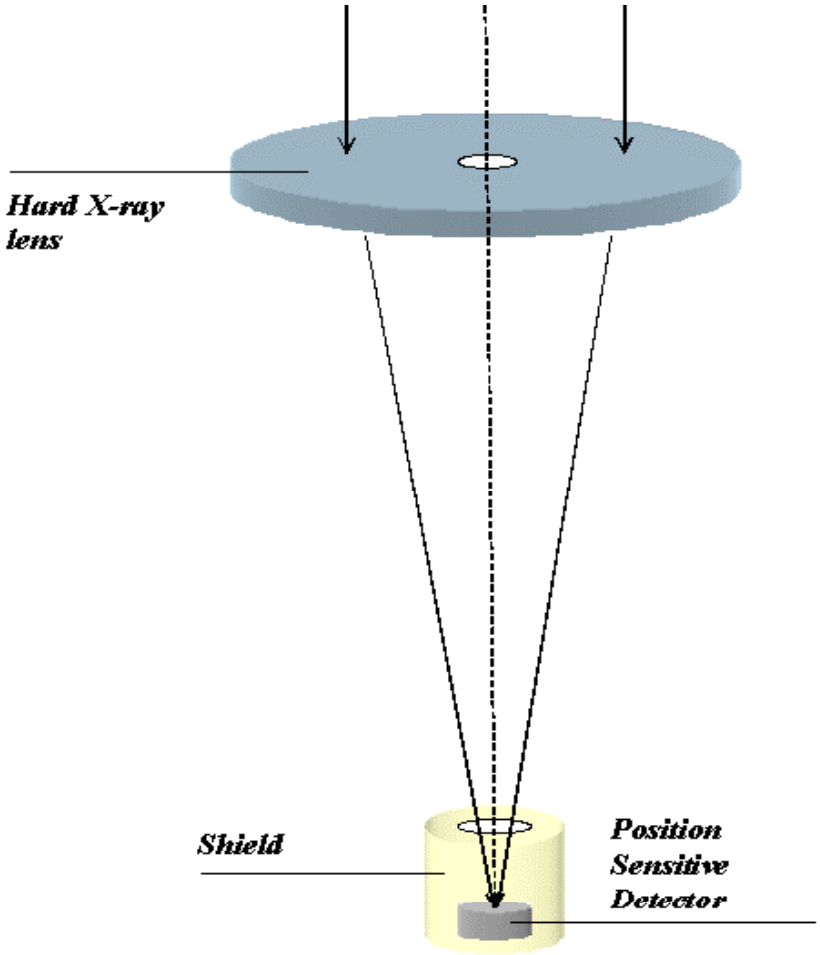
Studies and designe of future missions for X and gamma ray observation.

Data analysis and interpretation of observations of celestial sources of X-ray and Gamma-Ray Bursts (GRBs) obtained by previous missions and / or astrophysics missions still operating in the visible and / or X-rays and gamma.

Theoretical studies for the interpretation of observations of X-ray binaries contaning a compact object (neutron star or black hole).

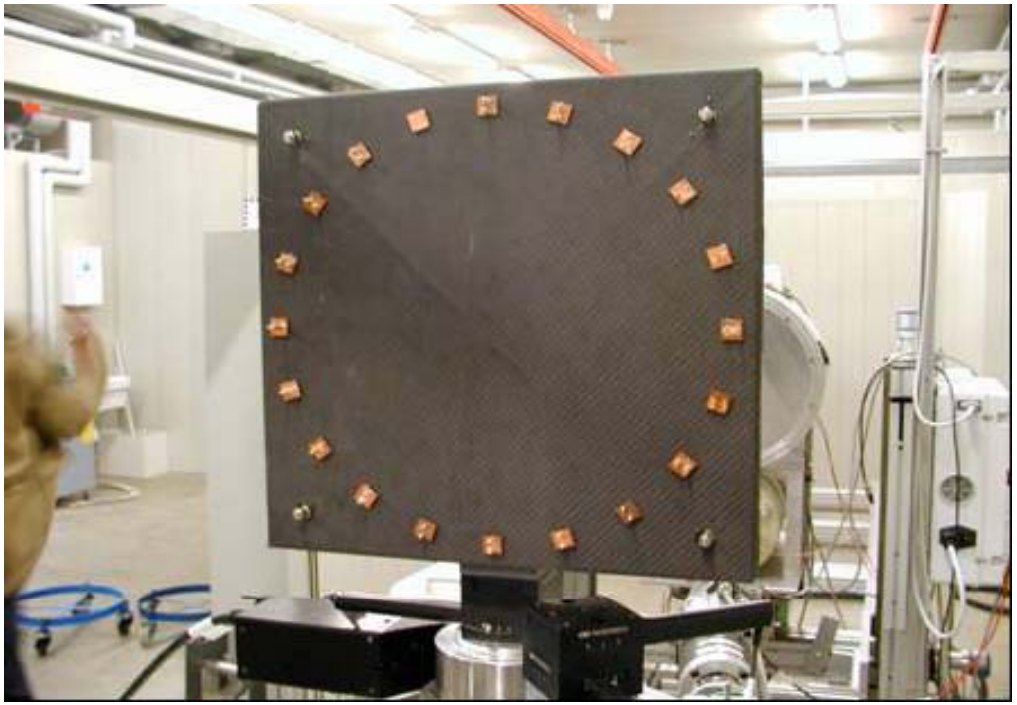
Theoretical studies for the interpretation of X and gamma emission from isolated neutron stars with strong magnetic fields (10^{14} - 10^{15} G) known as magnetars.

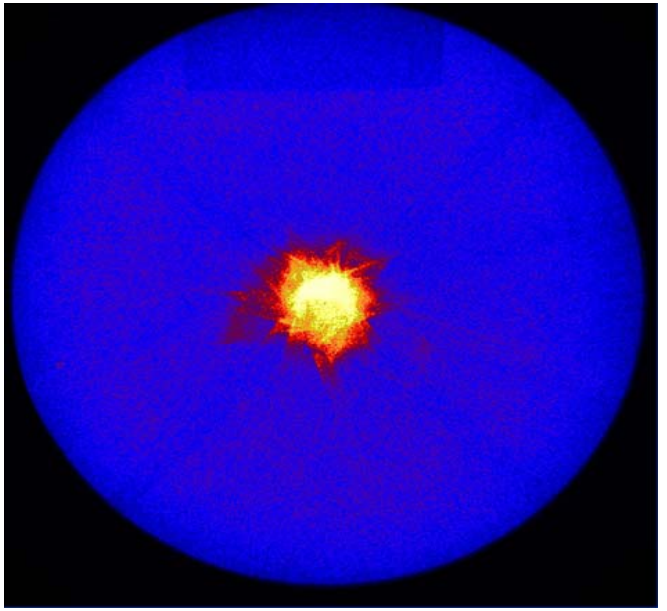
Main experimental activity : Laue lens development for space astronomy(>60 keV)

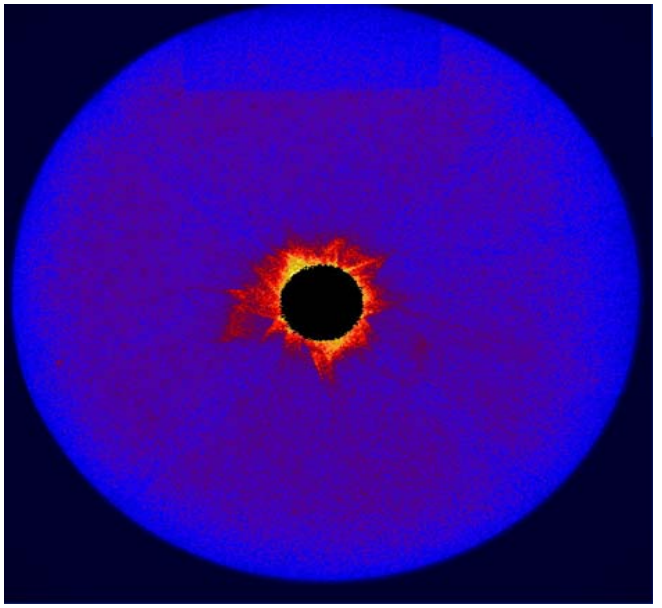


First Laue Lens prototype

- Mosaic crystals of Cu[111]
- Tile size: 15x15x2 mm^3
- Mosaic spread: 3-4 arcmin
- Lens support: carbon fiber







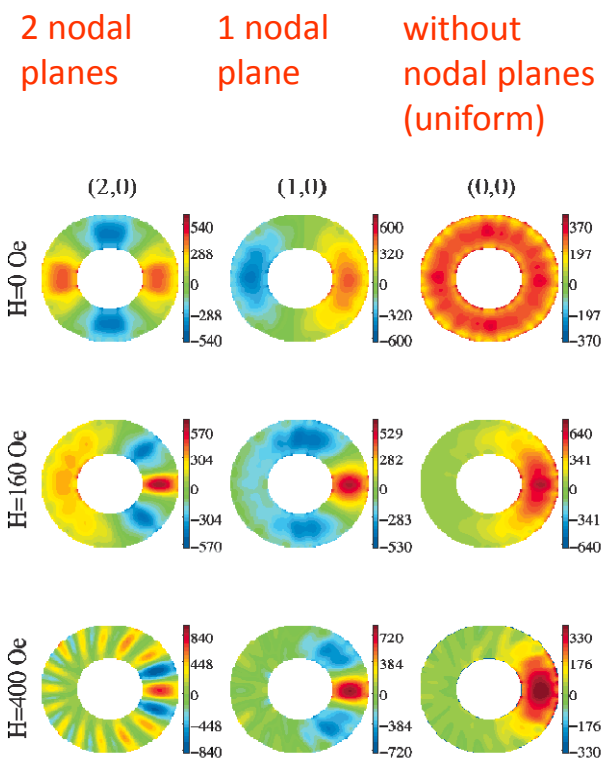
Physics of Magnetic Materials

Study of magnetic interactions in low dimensional systems and development of magnetoelectronics devices to increase the volumetric density of information recorded on storage media.
This led to design systems with magnetic and electronic properties in the areas of innovative nano-composite materials and magnetic materials.
The research in this field concerns in theoretical studies on spin waves detected by laser light scattering, using both experimental techniques of growth and characterization of new nanostructured materials.
In particular the object of study are the materials having great importance in magnetic recording, sensors and spintronics.

It has been devised an original method to calculate frequencies and magnetization of spin standing waves in nanometric dots of any shape (**Dynamic Matrix Method**)

Example: amplitude of spin waves (magnetic modes) in circular rings of outer radius 355 nm and thickness 20 nm, calculated vs. the applied magnetic field H (0-160-400 Oe)

The rings are in vortex state. Three magnetic modes are shown.



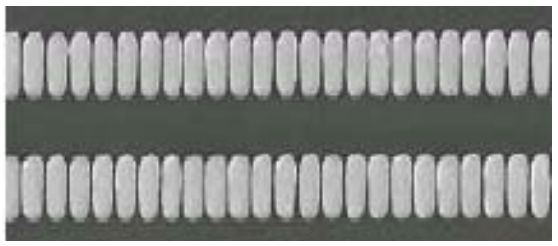
Applications:

-Knowledge of the magnetic modes in thermal equilibrium that favour or disturb the magnetization reversal (essential in magnetic recording)

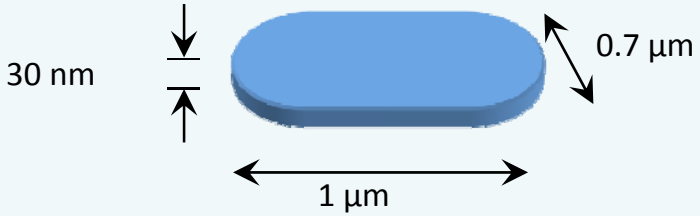
-Search for nanometric dots (shape, size) that could form ultra-high density arrays where information may be stored.

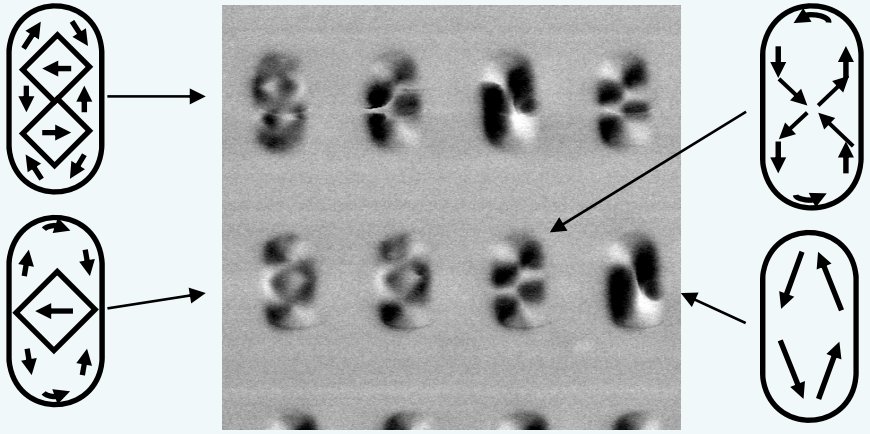
-Search for 1D, 2D, 3D periodic arrays of dots (anti-dots) which could behave as Magnonics Meta-Materials [artificial systems of unusual properties that propagate spin waves (Magnons) only in given directions and for given frequencies (spintronics)]

Example of chains of ultra-dense nanometric dots, which strongly interact and may transmit spin waves

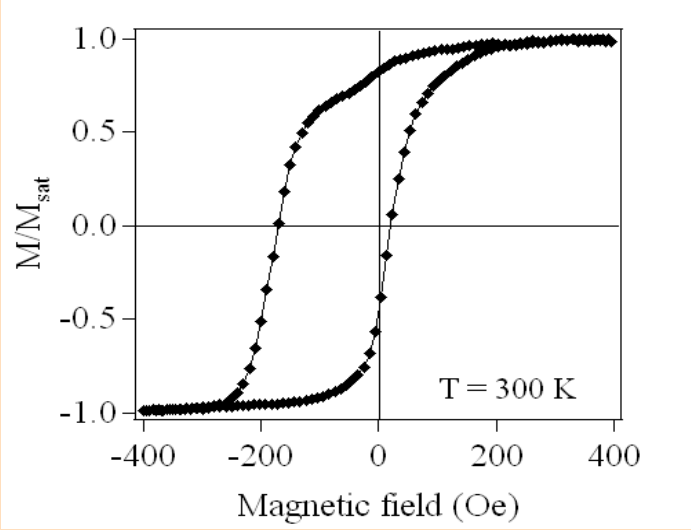


Analysis of the magnetic configuration of nanosized magnetic particles arranged in a regular pattern

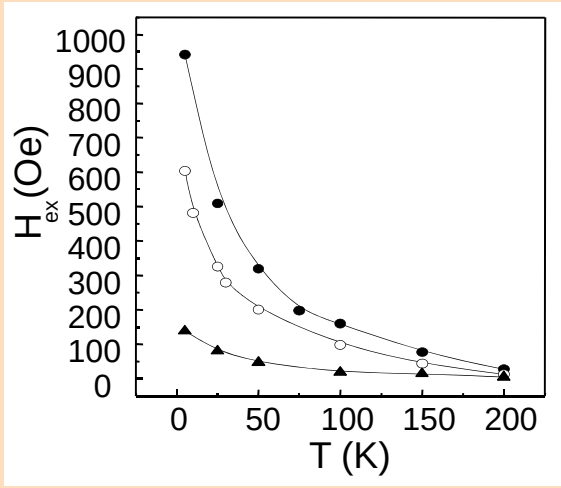




Exchange-bias investigation in nanostructured samples: FeMn/FeCo – Ni/NiO



Shifted loop in a FeMn/FeCo sample



Exchange field measured in ball-milled nanogranular Ni/NiO samples as a function of temperature.
[JMMM 321 (2009) 3071]

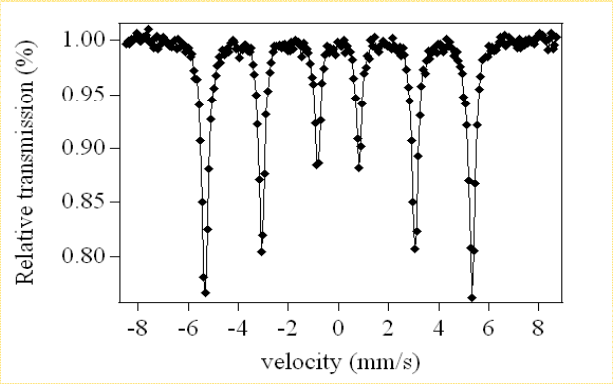
dc-magnetron sputtering apparatus for thin films growth

magnetoresistive, magnetic (SQUID, VSM) and magneto-optical (Magneto-Optic Kerr Effect) characterization

magnetic and morphologic surface analysis (atomic/magnetic force microscope)

Differential scanning calorimeter and in-field ThermoGravimeter Analyzer

Mössbauer spectrometer



Physics of sensors and semiconductors

Professor Giuliano Martinelli

Physics of sensors and semiconductors

Application of semiconductor technology in several field of science and technology: renewable energy, environmental and air pollution control.
The research offers sophisticated instrumentations that allow the design and production of semiconductor devices, starting from the synthesis of the active material to the construction of the final device.
Manufacturing of semiconductor oxides (such as SnO_2, TiO_2, and WO_3 solid solutions) made from the synthesis, control and deposition of nano-structured film with embedded electronic control devices.
The RTD activity for the photovoltaic devices includes technology for cutting the wafer, doping, contact patterning as well the growth of virtual substrates of Si-Ge on Si wafer.
The theoretical study of the properties of nanostructures and the interface phenomena of gas-semiconductor is an integral part of this research activity.

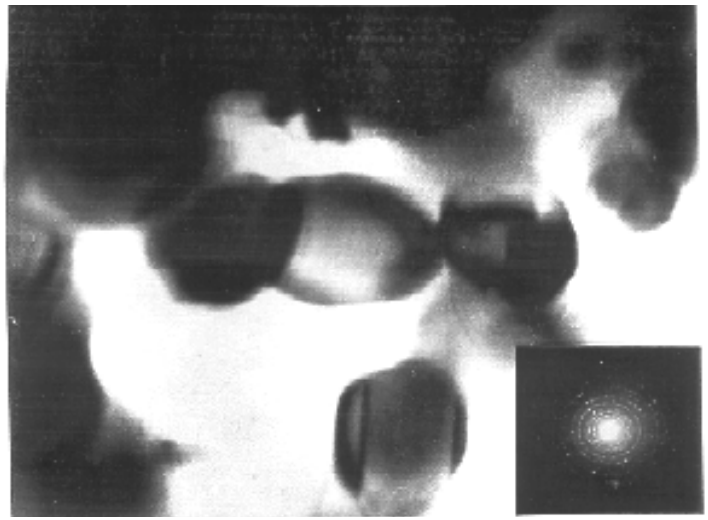
Sensors and Semiconductors

Fundamental and applied research on nanostructured materials

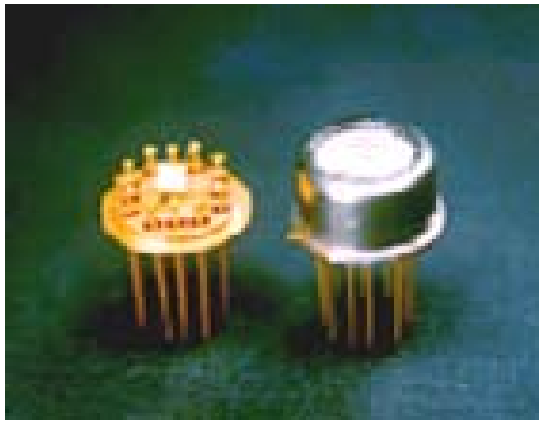
- Gas sensing
- Photovoltaics
- Micromachining and microdevices
- Coherent effects in crystals

Sensor and Semiconductor Laboratory

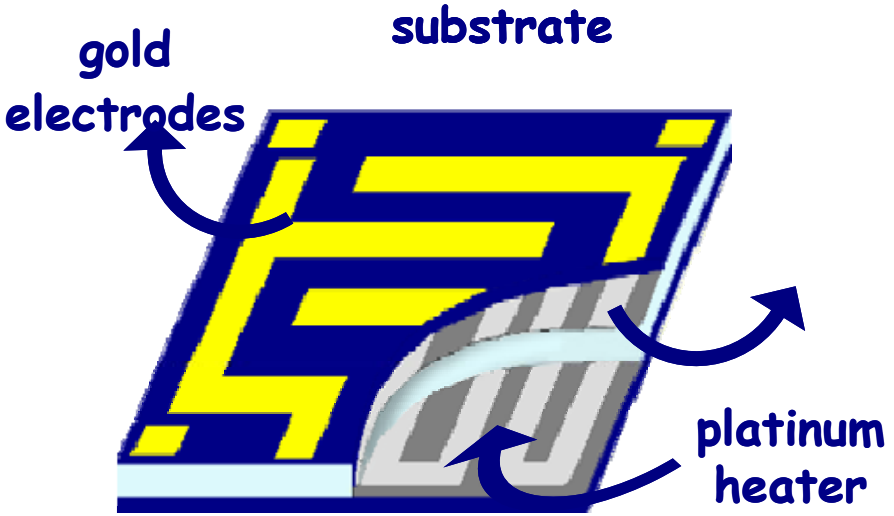
Gas sensing



TEM image of TiO2 nanograins

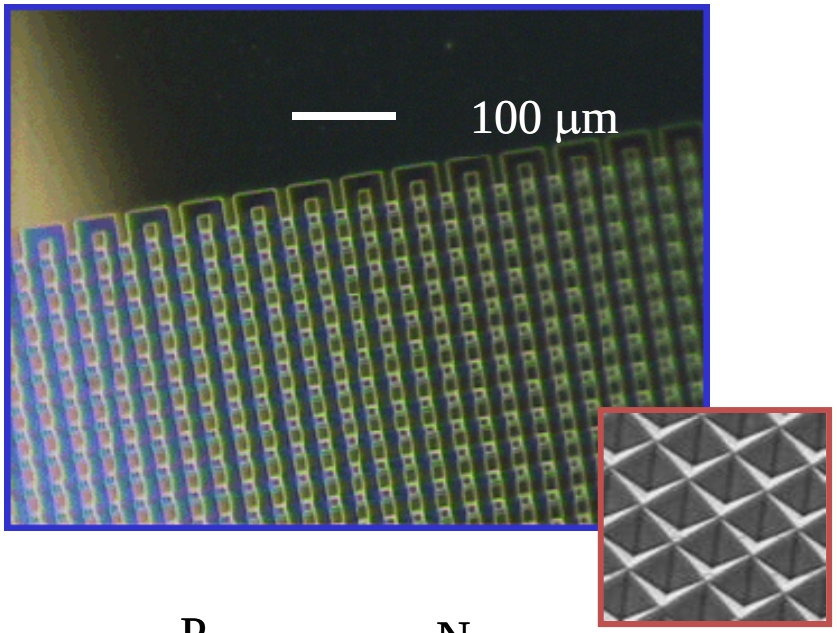


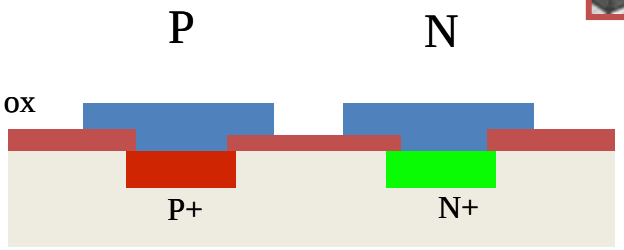
Research on chemoresistive chemical sensors based on metal-oxide nanostructures for detection of environmental gas pollutants



Sensor and Semiconductor Laboratory

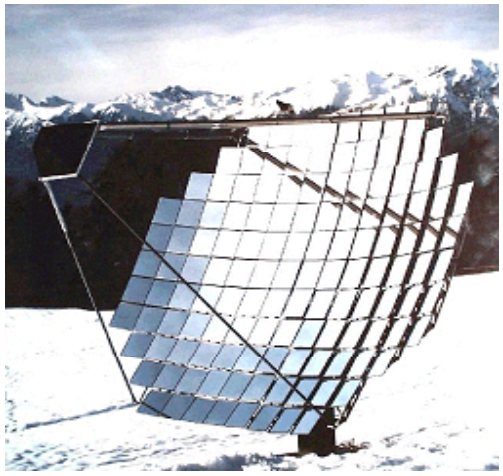
Concentrated photovoltaics





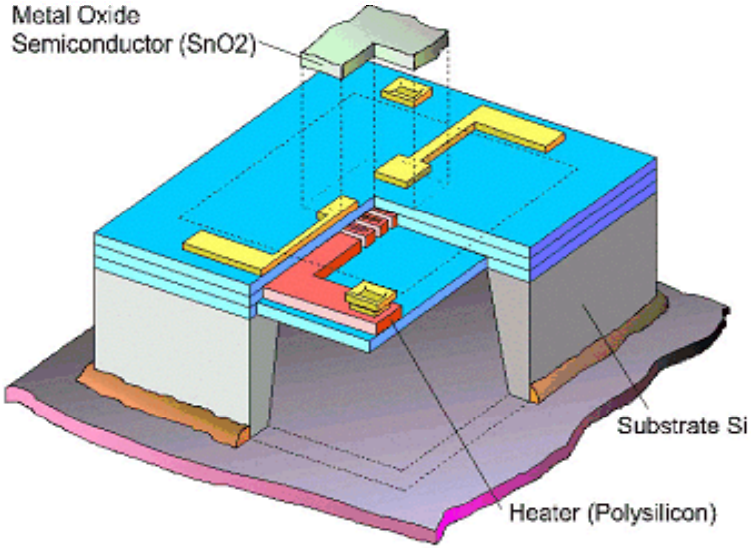
Concentrated photovoltaics: mirrors are used to concentrate the radiation of the Sun on high-efficiency PV cells.

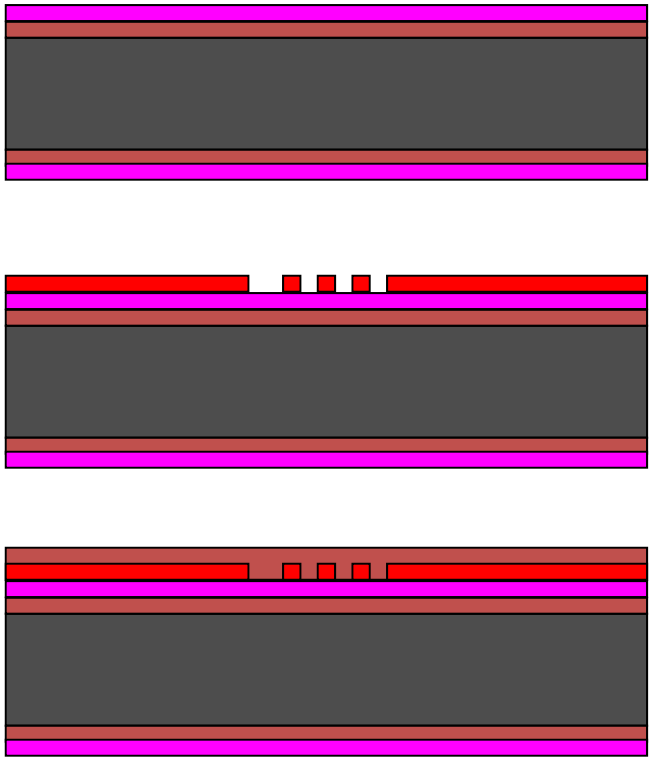
PV cells are fabricated through microlithography



Sensor and Semiconductor Laboratory

Micromachining

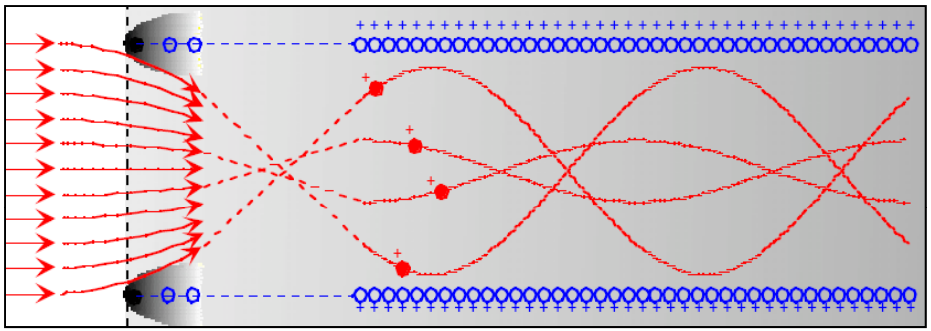




Micro hotplates on a membrane to heat up sensing units

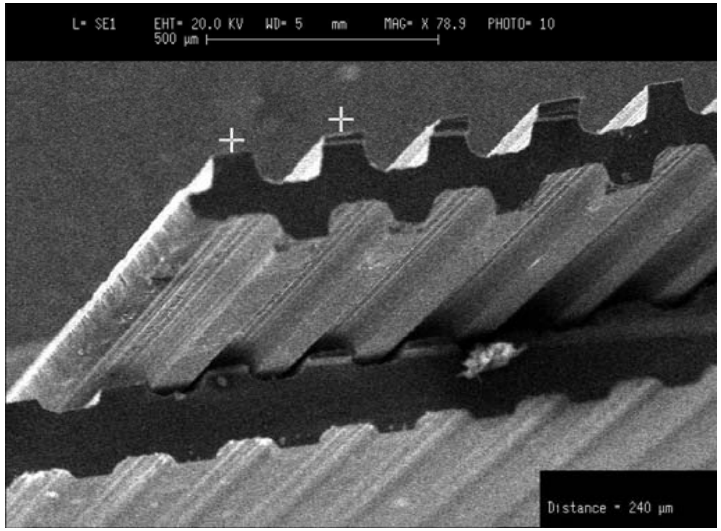
Sensor and Semiconductor Laboratory

Coherent effect in crystals



Channeling is the confinement of charged particles traveling through a crystal within atomic planes (planar or axial modes)

Particles can be channeled and steered in a bent crystal

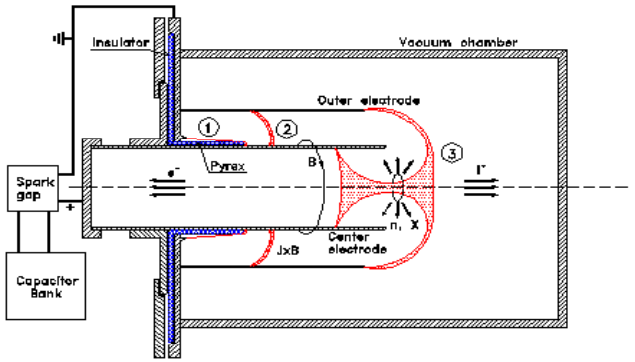


Deflection
Collimation
Focusing
Undulation
Microbeam generation
...

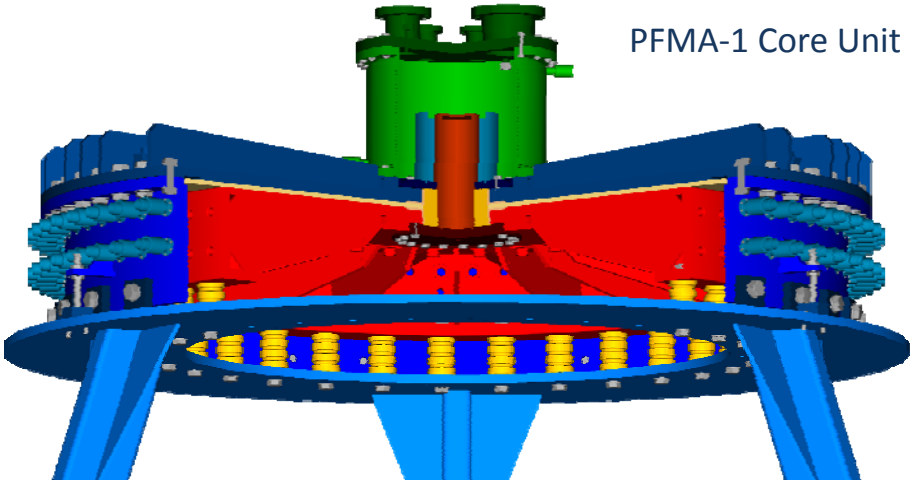
Plasma Physics

This research takes place in the Plasma Physics Laboratory, is focused on the production and use of particle beams produced by high temperature plasma by means of a Plasma Focus machine.
The plasma is accelerated and confinated in a so small volume so as to allow thermonuclear reactions whose products (elecron beams and ions beams) are applied in the field of biomedical diagnostics and therapy.

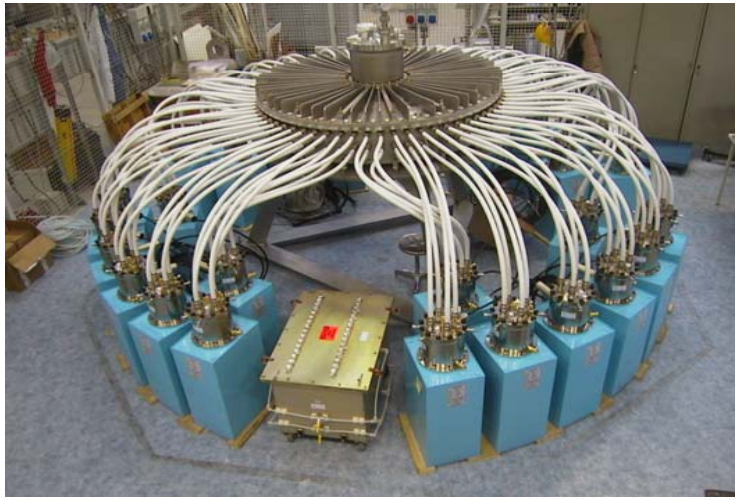
Plasma Focus Technology: PFMA-1, Plasma Focus for Medical Applications, the first prototype of a PF device for 18-F production, a 150 kJ (350 μF @ 30 kV) Mather-type Plasma Focus operated at 1 Hz repetition frequency that could breed ~ 1 Ci of F^{18} in 2 hours.



Mather type PF scheme

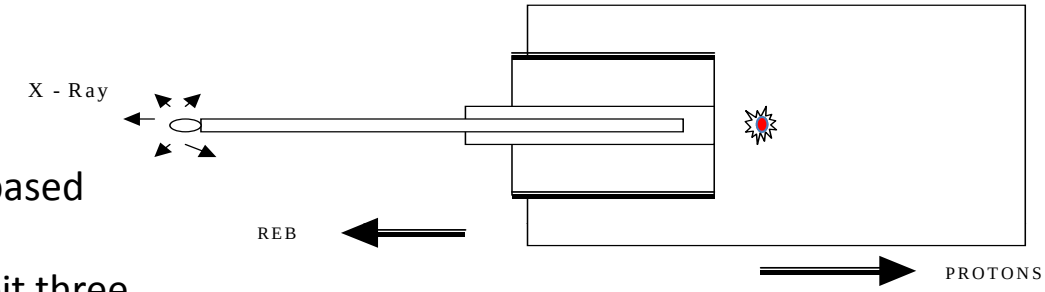


PFMA-1 Core Unit



PFMA-1

I.O.R.T. (Intra Operative Radio-Therapy)
Plasma Focus applications



Interstitial radiosurgery (brachiteraphy) proposal based on PF devices
If H is used as filling gas the pinch region can exploit three main emission:
Soft X-ray (Isotropic incoherent component plus strongly forwarded coherent component from plasma free-electron laser genesis)

Proton beans (forward)

Relativistic electron beams REB (strongly back warded)

THE DOSE IS RELEASED IN SOME TENS OF NANOSECONDS: very high dose rate and fractioning

Prototype at Ferrara

Physics of the Atmosphere

Study of the atmospheric phenomena at different spatial and temporal scales in particular: aerosol physics, physics of ice, satellite meteorology, radar meteorology.

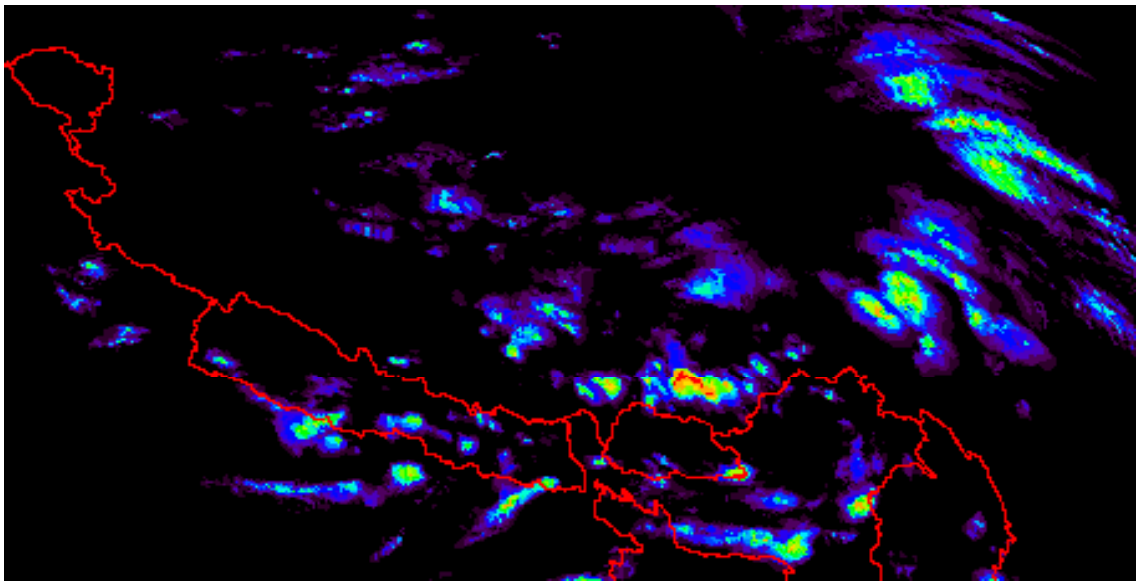
The main activity concerns the study of the impact of aerosols and clouds on Earth's climate system, with field surveys, laboratory experiments and satellite observations.

Very interesting is also the activity for the estimation of precipitation on the Tibetan plateau with ground sensor and satellite obsrevations. The study wont relate the water cycle to the dynamics of the Asian monsoon.

The group is also studying a technique to estimating the intesity of the precipitation from satellite data for the prediction and mitigation of disasters in Italy.

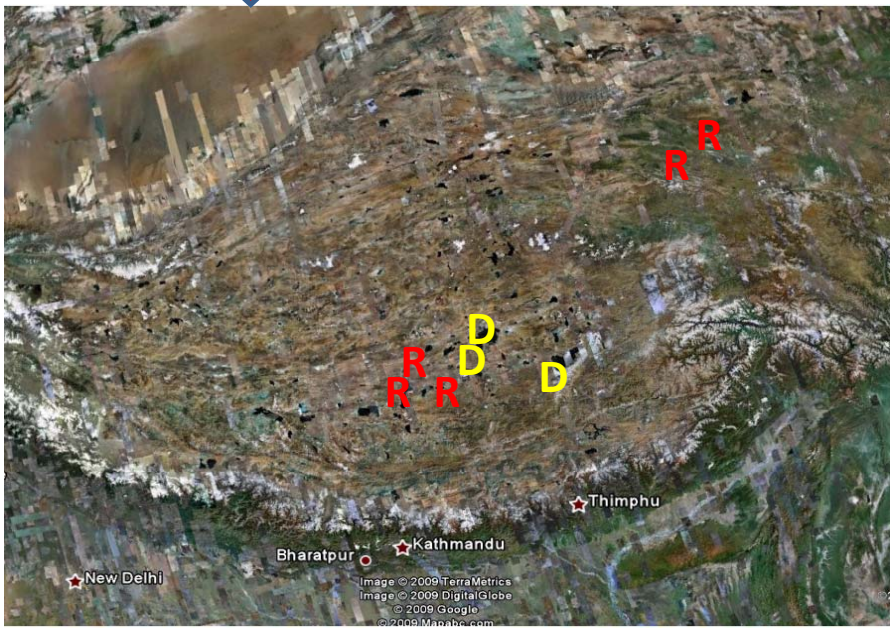
The research activities also include the applications of meteorology to agriculture at European level.

Study of precipitation structure over the Tibetan Plateau by combining radar, disdrometer and satellite observations

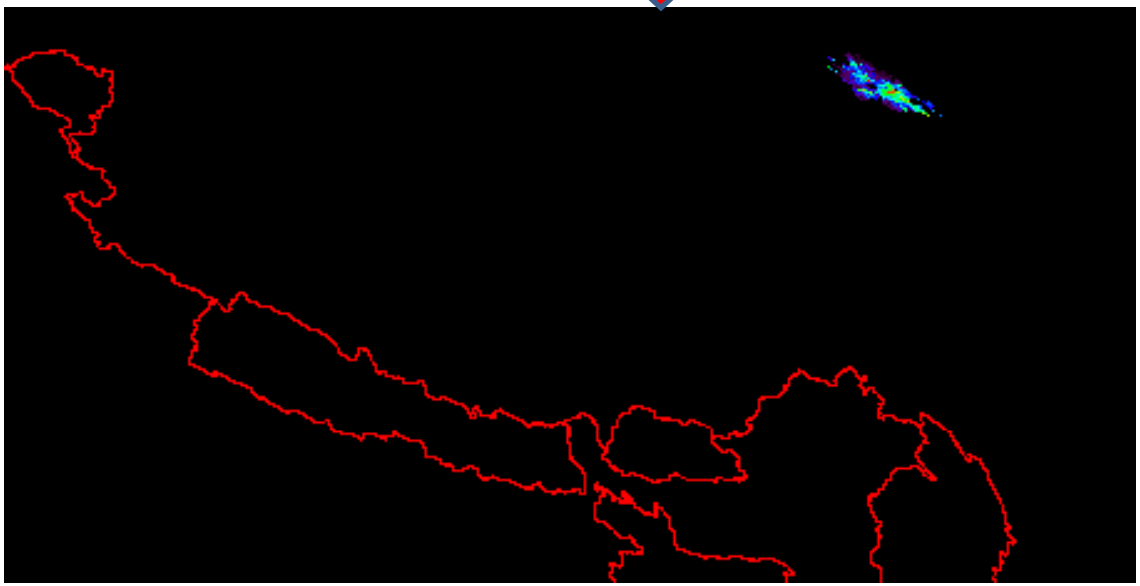


ground instruments: Radar

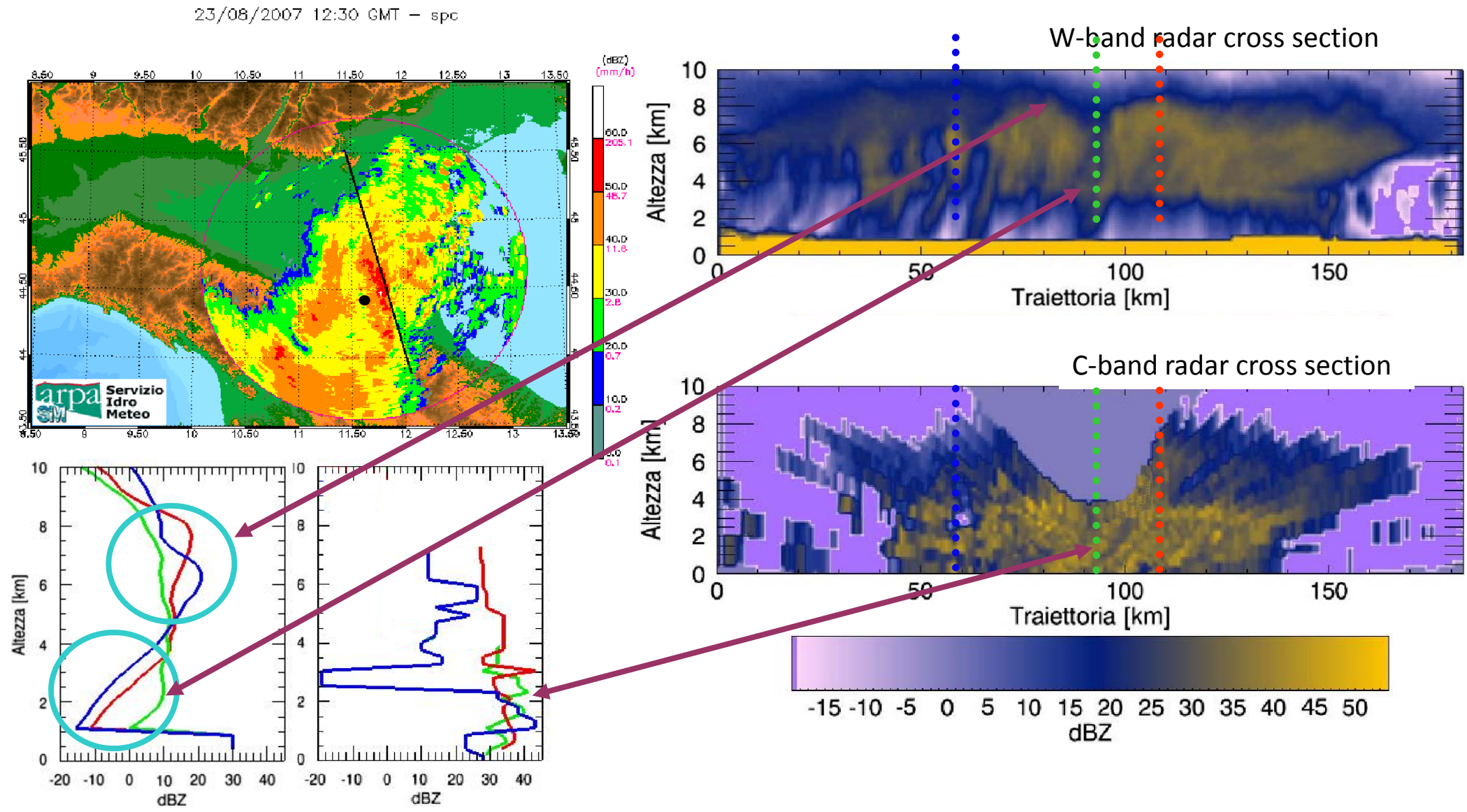
Disdrometers



cumulated rainfall: radar satellite



Study of the 3D cloud microphysical structure by means of ground C-band radar and space-borne W-band radar



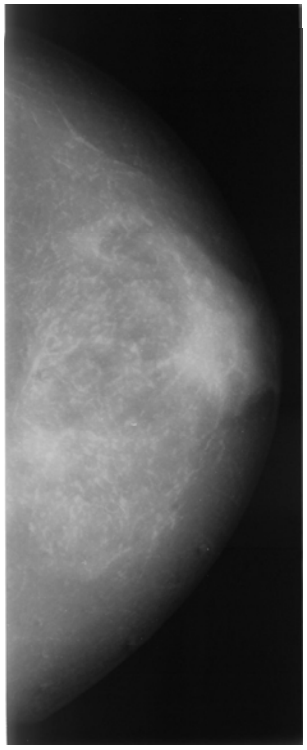
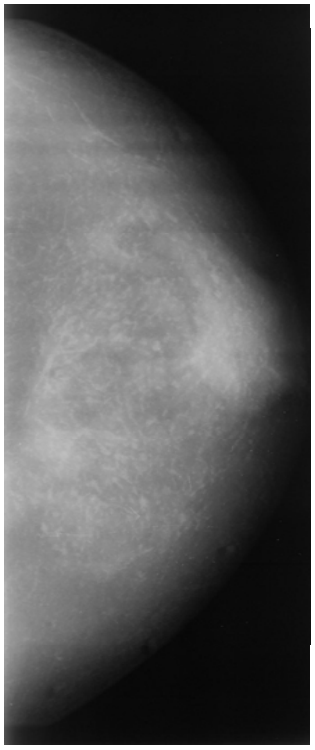
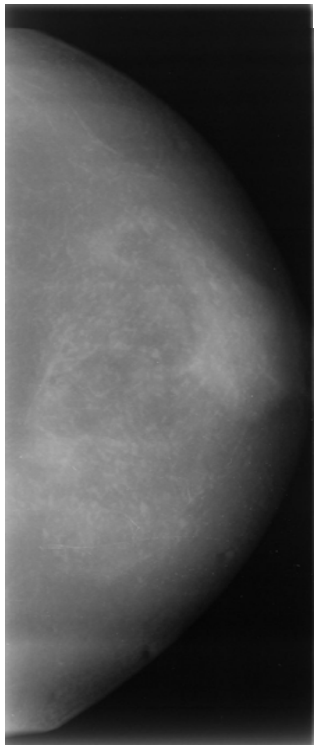
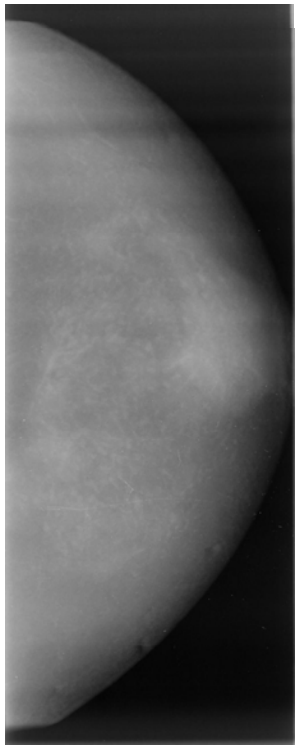
Nuclear technologies for health and environment

Nuclear technologies find more and more applications in the field of public health and environmental monitoring.
Medical Physics research is primarily focused on diagnostic radiology and nuclear medicine with the development of new monochromatic X-ray sources and systems providing high information content and low dose radiographs. The research in the field of nuclear medicine instrumentations concerns the development of novel detection system for small animal scanner (PET and SPECT) with high spatial resolution. With regard to nuclear technologies applied to environmental monitoring, the development of gamma spectrometers for measurements of natural radioactivity and artificial samples is fase of commissioning. Moreover in collaboration with the INFN the group manages the main Italian system dedicated to airborne monitoring of the graund radioactivity.

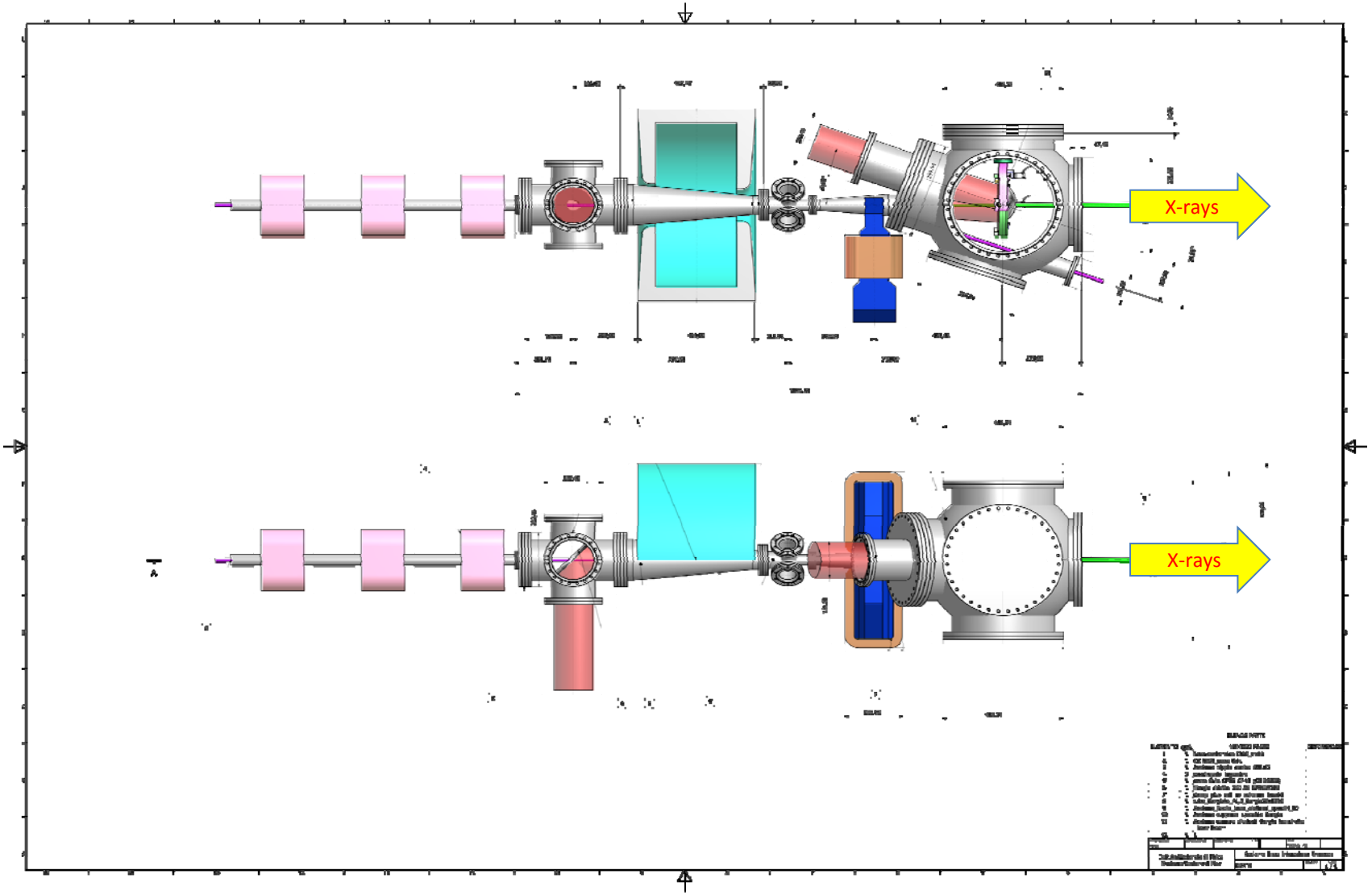
Monochromatic X-ray source with mosaic crystal

Quasi-monochromatic mammography prototype

Mammographyc phantom radiograph

Conventional	18 keV	21 keV	23 keV
			
AGD = 1.3 mGy	AGD = 0.76 mGy	AGD = 0.23 mGy	AGD = 0.12 mGy

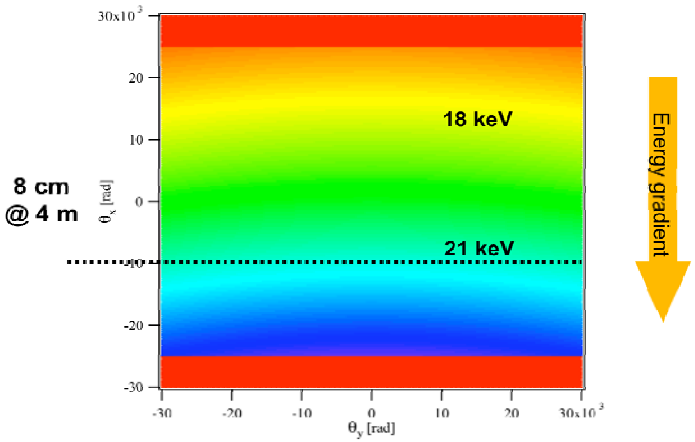
Backscattering Thomson Monochromatic X-ray source



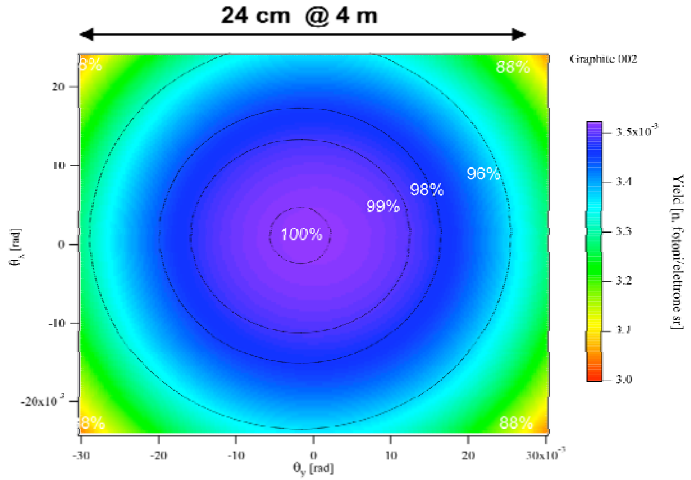
Monochromatic X rays by PXR emission with compact accelerators

X ray field characterization **@ 20 keV**
PXR Graphite 002 Bragg geometry

Field energy gradient



Field uniformity (photon fluence)



Fluence rate @ 4 m from target

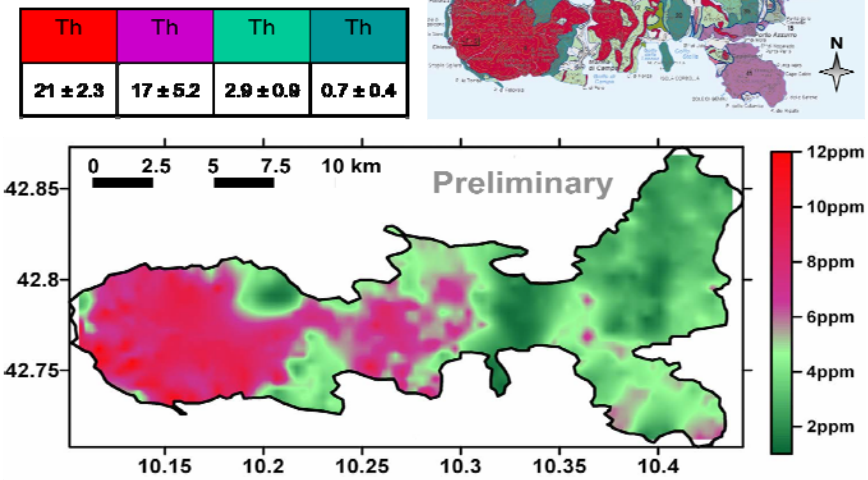
1.4×10^{6} ph mm^{-2} mA^{-1} s^{-1}

Experimental verification of the model is needed

Monitoring enviromental radioactivity.

laboratory | on site | in flight

Thorium distribution of Elba Isle (ppm)



Thank you for your attention
and
enjoy your stay in Ferrara