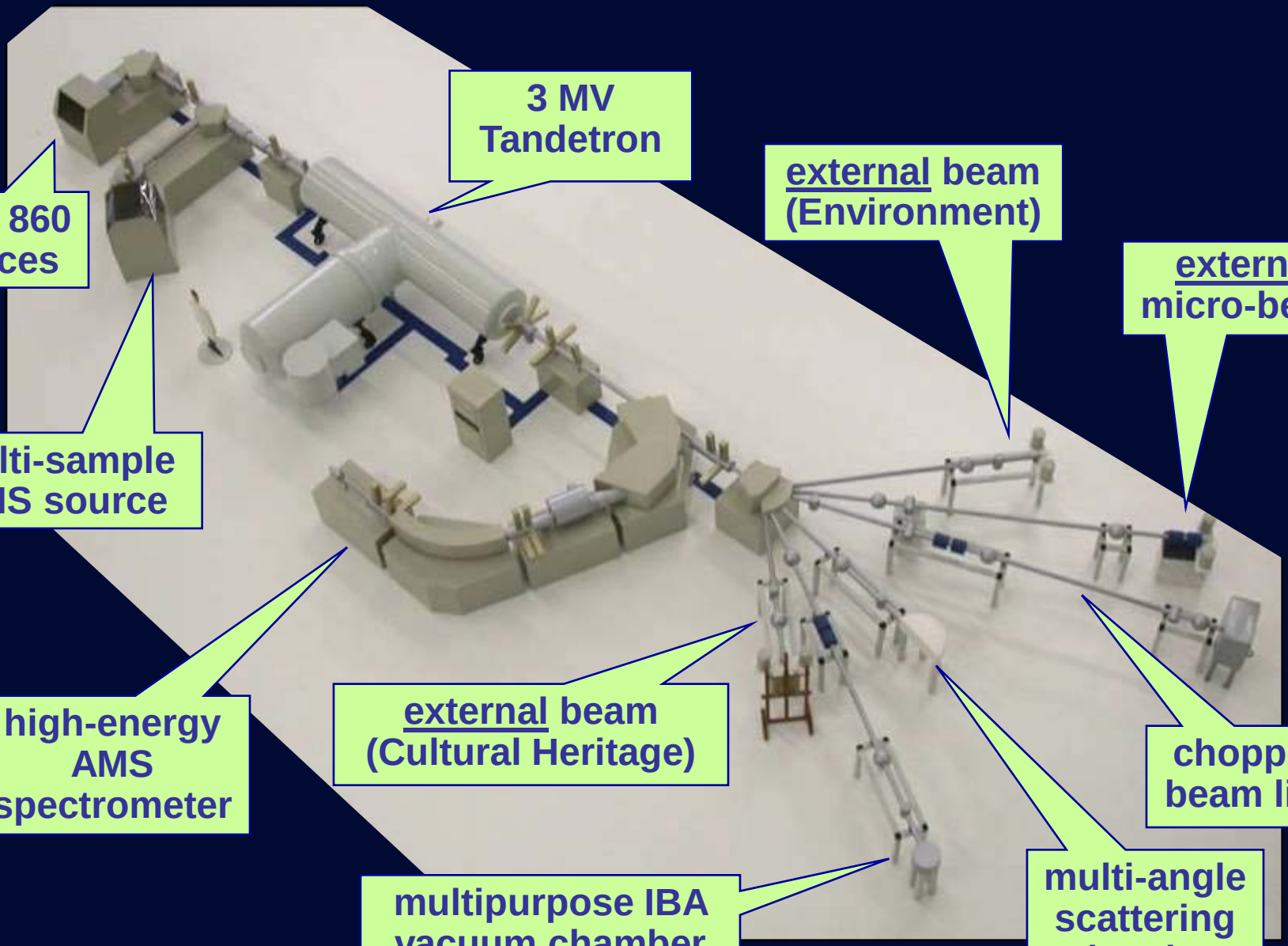
LABEC

Laboratory of Nuclear Techniques for Environment and Cultural Heritage

L. Giuntini, F. Taccetti

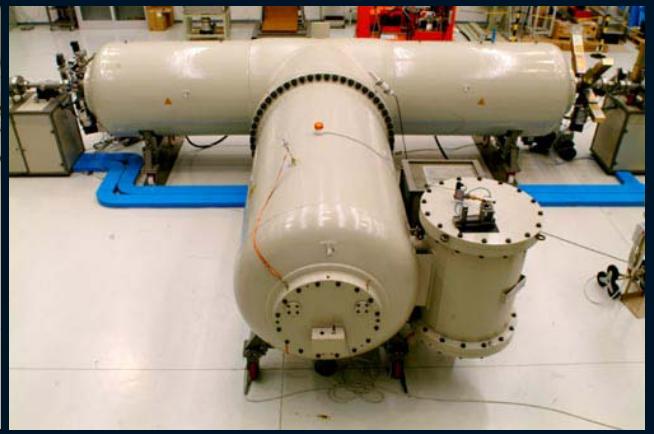
Department of Physics of the University and INFN of Firenze, Italy

The LABEC accelerator hall

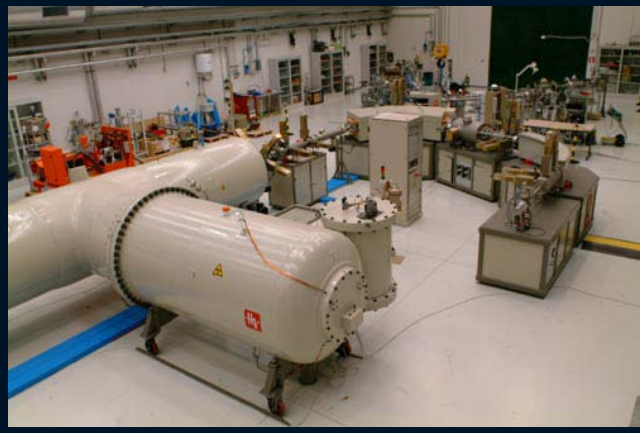


Accelerator hall: AMS beam line

AMS 846
•multi sample sputter source
•low energy filters
•injection magnet

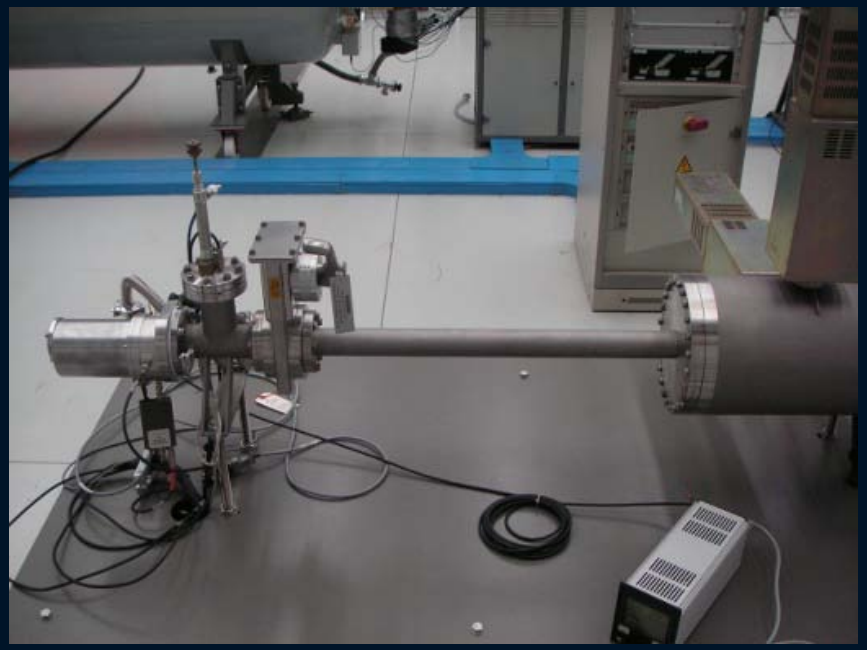


3 MV tandem accelerator

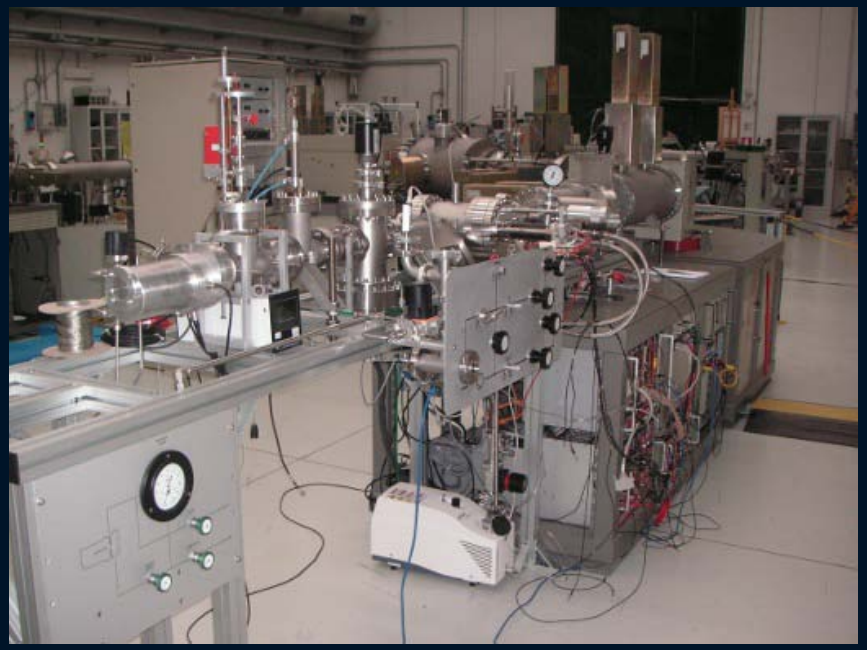


AMS high energy filters and detectors

The AMS beamline: the old and the new



The AMS beamline (final part) as delivered by HVEE



The AMS beamline (final part) ***now***

Activities at LABEC

- technological developments (electronics and process automation, data acquisition systems, detection setups...)
- methodological developments
- interdisciplinary research projects:

  in collaboration with other Institutions (CNR, CH safeguard Institutions, Environmental Protection Agencies) and University
- collaborations with physics groups:

  detector tests, material science, radiation damage,...

Beam time

~ 30 % AMS

~ 30 % IBA for aerosol

~ 30 % IBA for CH, material and earth science,...

~ 10% tandem setup, transport optimisation, different measurements,...

AMS at LABEC

We can measure the concentration of rare radio-isotopes:

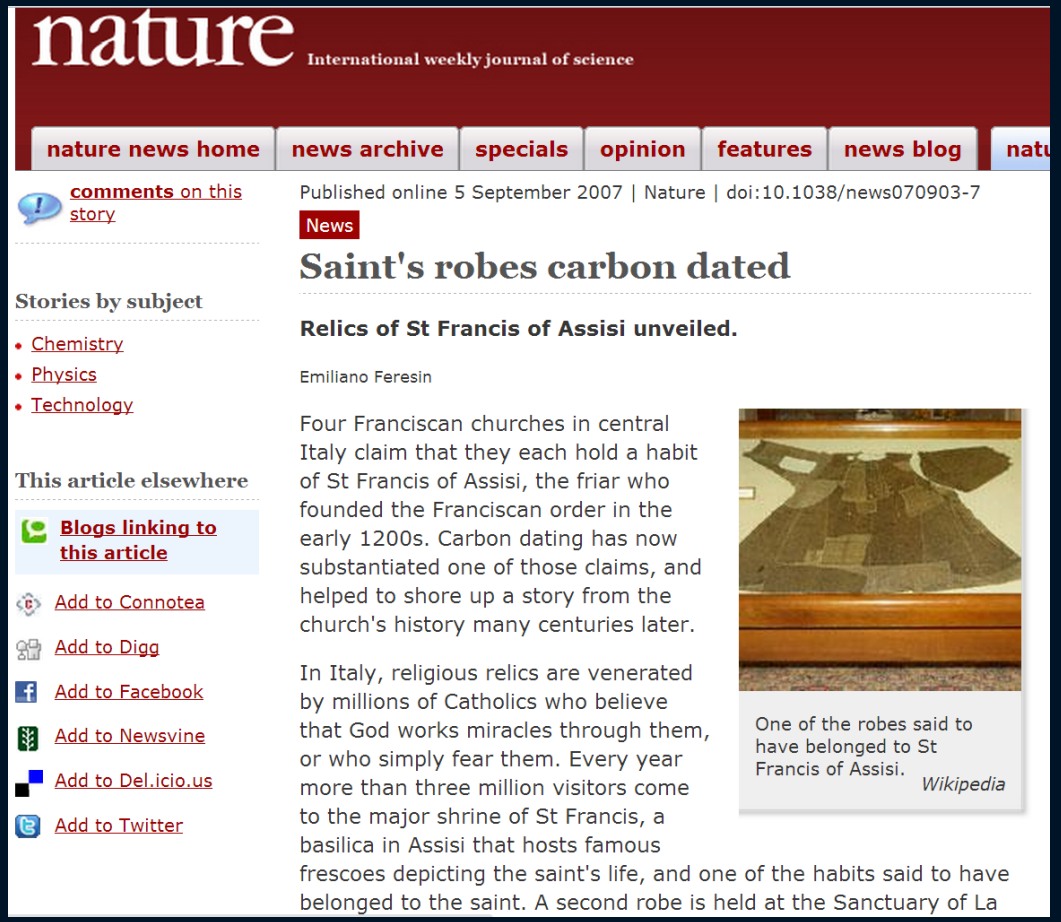
- ^{10}Be
- ^{14}C
- ^{26}Al
- ^{129}I

Until now:

- routine ^{14}C measurements
  - *around 400 samples per year: 50% carbon, 13% wood,…*
  - *uncertainty < 0.5% (< 0.3% if required)*
  - *around 400 samples per year*
- succesfull ^{129}I tests

Scientific American online

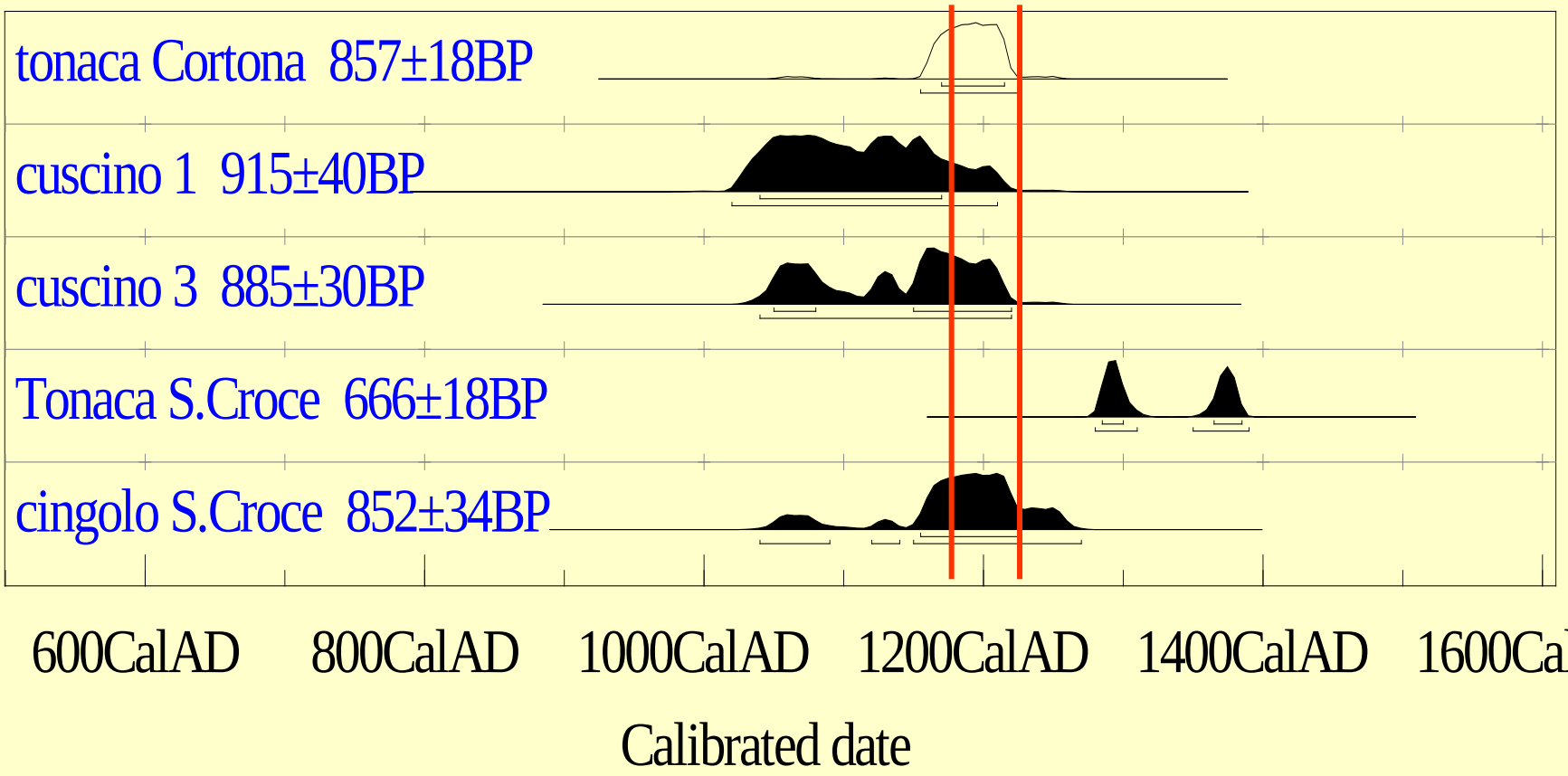
6 settembre 2007



NEWS @ Nature.com

5 settembre 2007

Atmospheric data from Reimer et al (2004);OxCal v3.10 Bronk Ramsey (2005); cub r:5 sd:12 prob usp[chron]



Atmospheric aerosols

Solid or liquid particles with a diameter from 10^{-3} to 10^{2} µm

- natural or anthropogenic sources
- primary or secondary origin

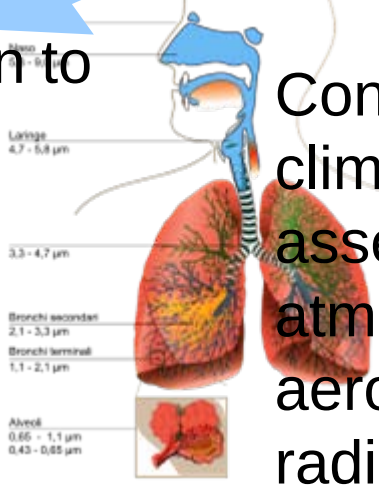
Identification and quantification of sources

OUTPUT

Impact on the environment

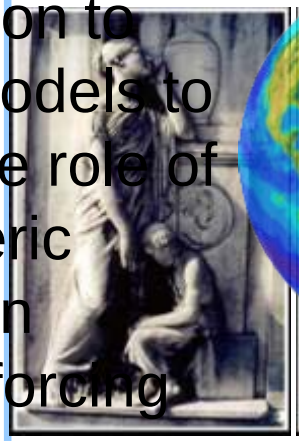
Contribution to pollution abatement policies to improve air quality

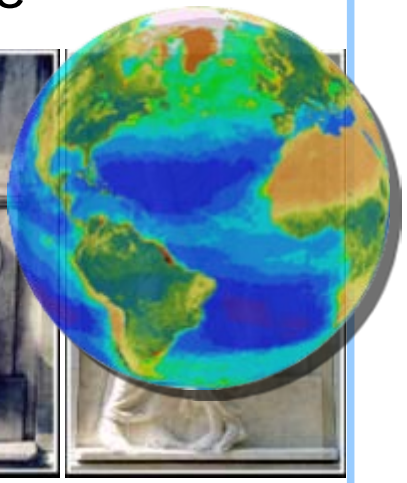
Impact on human health



Contribution to climate models to assess the role of atmospheric aerosols in radiative forcing

Impact on cultural heritage

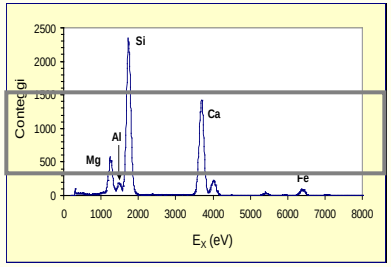




Ion Beam Analysis (IBA) for Aerosols

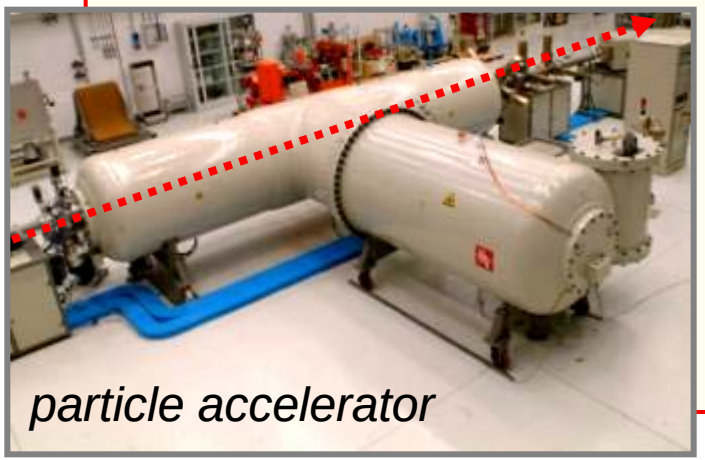
- Material composition analysis through beam particle bombardment

typically proton or alpha beams at some MeV energy

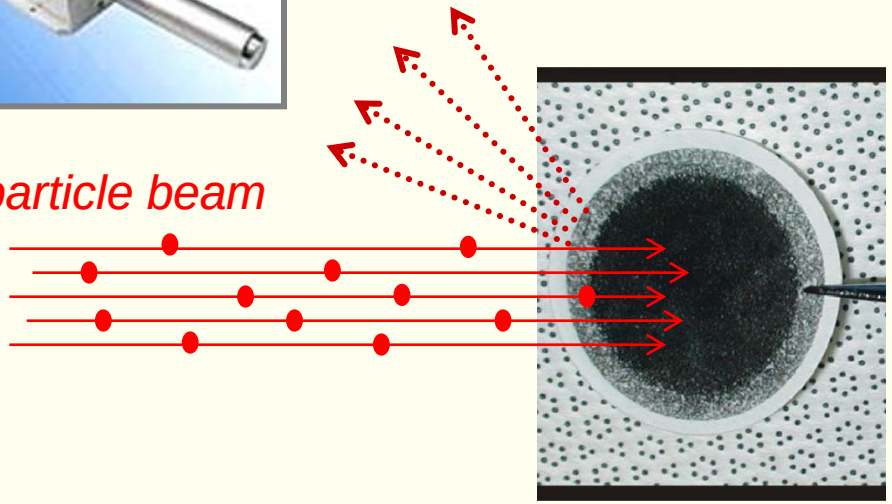


radiation detection and spectral analysis

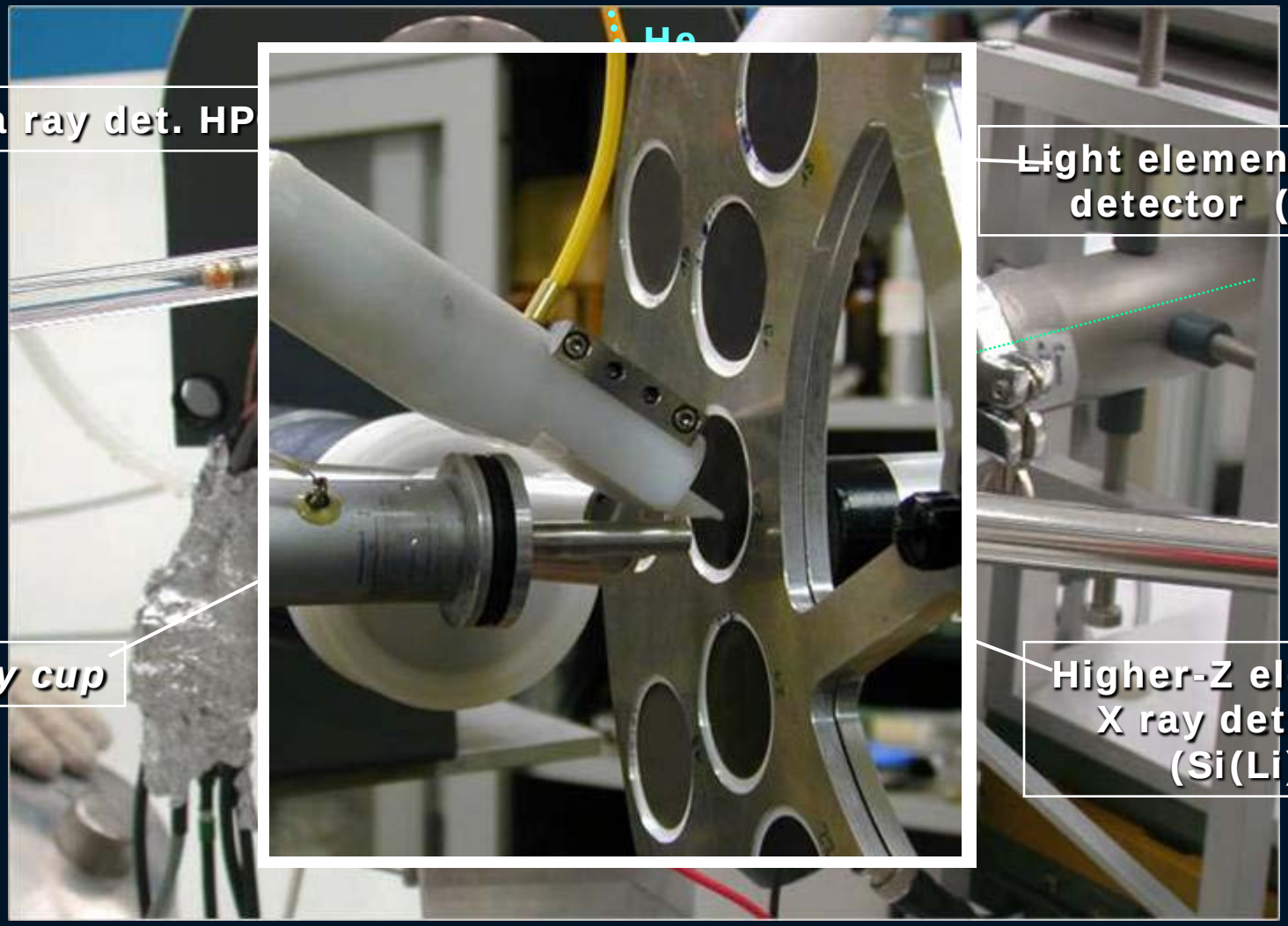
emission of radiation of characteristic energies (X-rays, γ-rays, particles…)



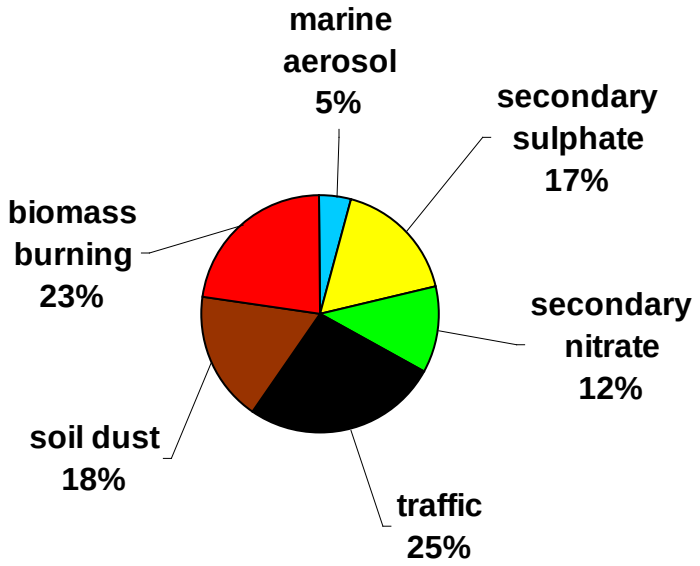
particle beam

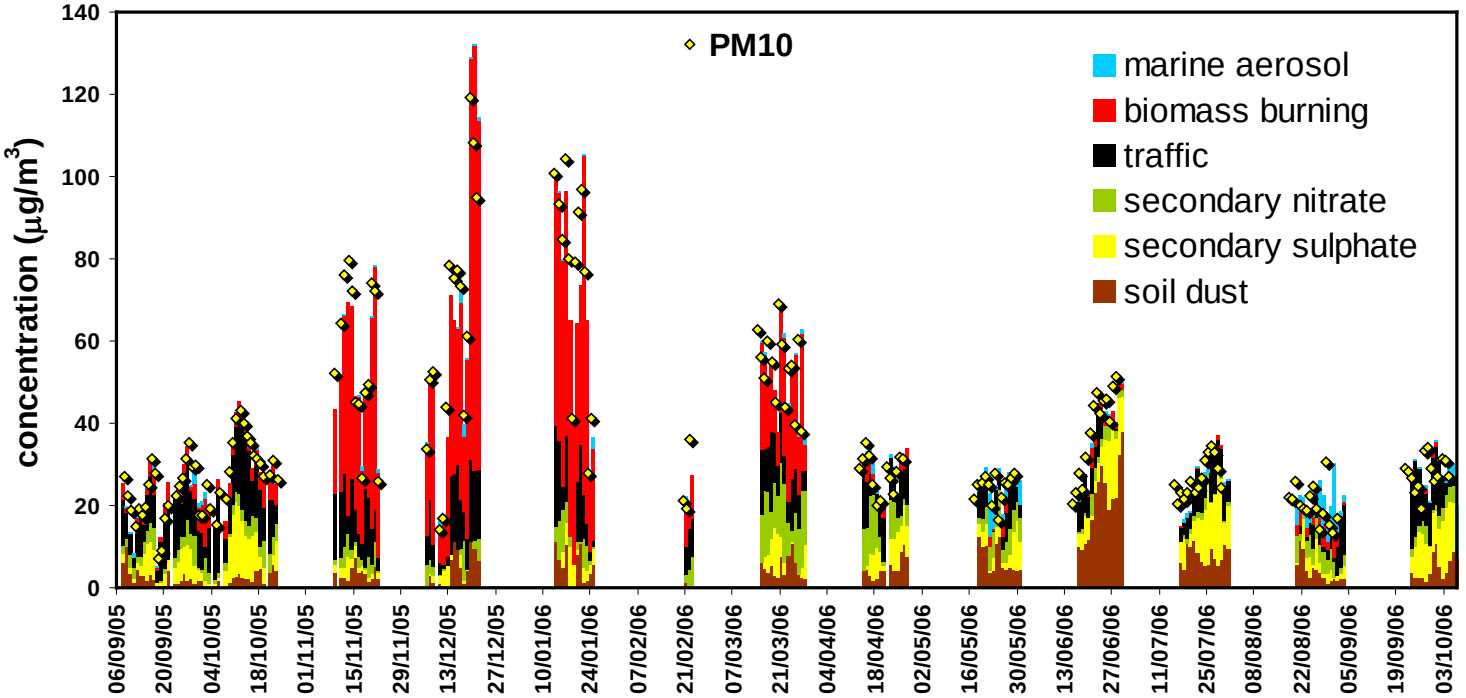


PIXE-PIGE external set-up at LABEC for aerosol composition measurements



Average source apportionment





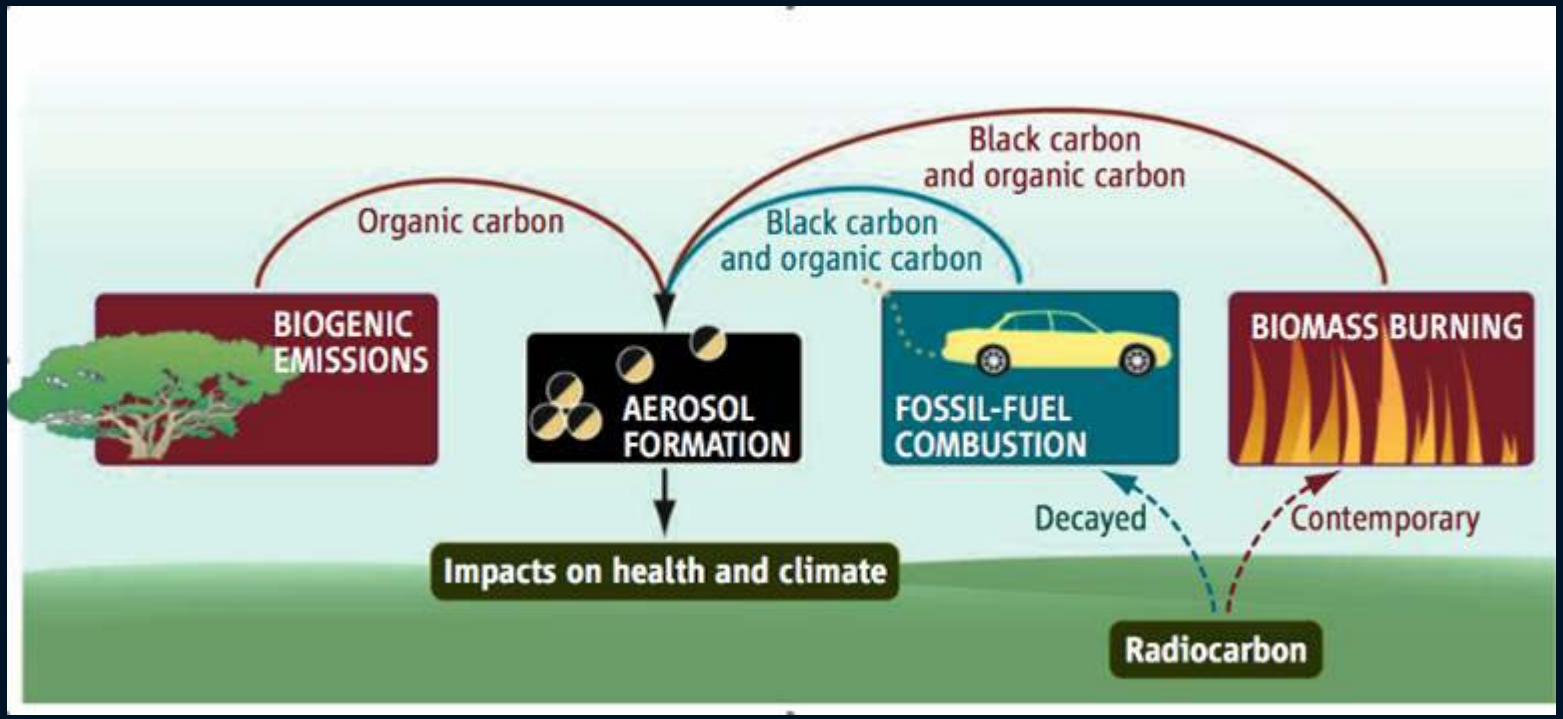
AMS ^{14}C measurements in aerosols

$(^{14}C/^{12}C)_{SAMPLE}$ ^{14}C fraction with respect to modern carbon:

~ 0 in the aerosols produced by fossil fuels

~ 10^{-12} in aerosol of biogenic origin or from biomass burning

$(^{14}C/^{12}C)_{SAMPLE}$ is a marker of pollution from fossil fuels



S. Szidat, Science 323 (2009), 470

LABEC aerosol group research projects

Local impact:

- Study of PM10, PM2.5 and PM1 in Tuscany (**PATOS**, **PATOS 2**)
  and in major Italian towns, Barcelona, Sevilla, Elche, Alicante, London, Japan

Global impact:

- **EPICA -** *European Project for Ice Coring in Antarctica*
- **TALDICE -** *TALos Dome Ice CorE*
- **ANDRILL -** *Antarctic Geological Drilling*
- **AMMA -** *African Monsoon Multidisciplinary Analysis*
- **MAIL -** *Marine Aerosol in the Island of Lampedusa*
- **DIRIGIBILE ITALIA** (multidisciplinary study of climate change in Arctic region)

Environmental monitoring of cultural heritage sites

Indoor pollution/Personal exposure:

- **HEARTS -** *Health Effects And Risks of Transport Systems*

IBA for Cultural Heritage

- can Ion Beam Analyses techniques help in the Cultural Heritage field?
- let’s see….

Two external beamlines dedicated to CH

beam size defined by collimation
(Ø 0.2 1 mm)

strong focusing system
from 8 μm up to hundreds of microns

Study of ancient glass,

External PIXE-PIGE analysis of the glass tesserae from Villa Adriana

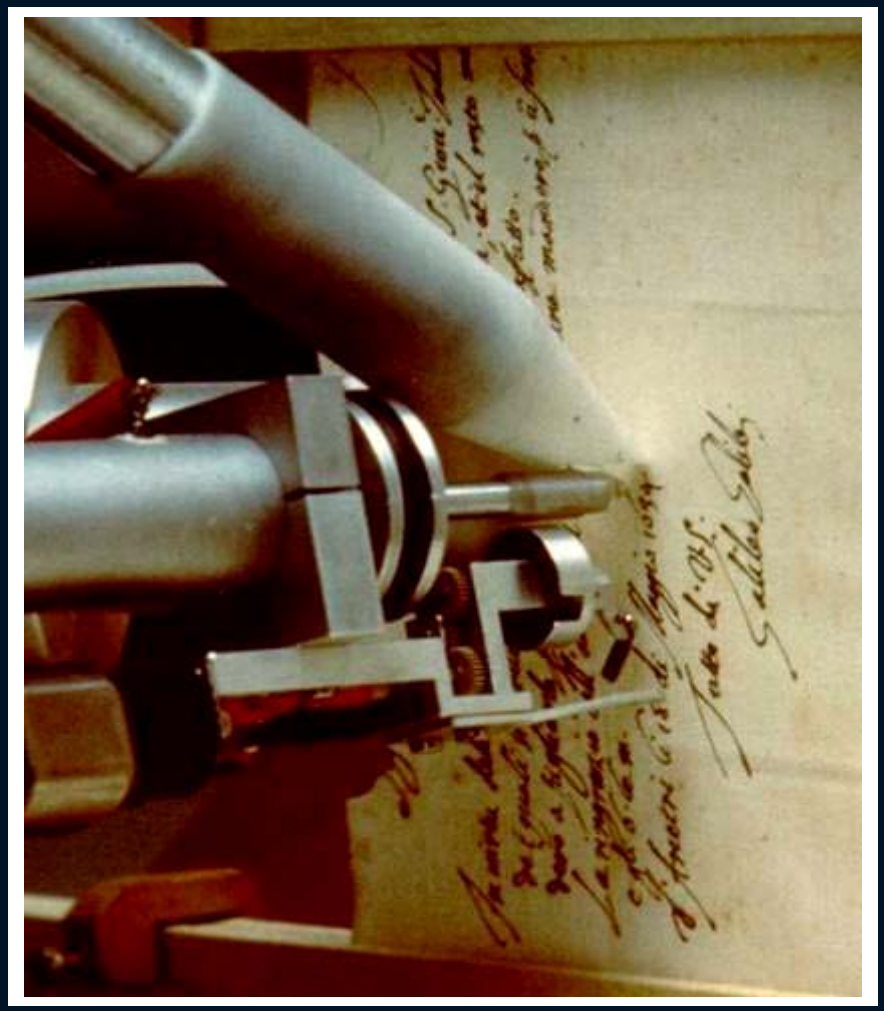
...glazed terracottas,

External PIXE analysis of the "Ritratto di fanciullo" by Luca Della Robbia – before restoration at the Opificio delle Pietre Dure in Florence

...ancient illuminated manuscripts,

External-beam PIXE analysis of the frontispiece of Pl.16,22 (XV century, Biblioteca Laurenziana in Florence)

...historical documents,



Inks in Galileo's manuscripts (Florence National Library) analysed by external PIXE

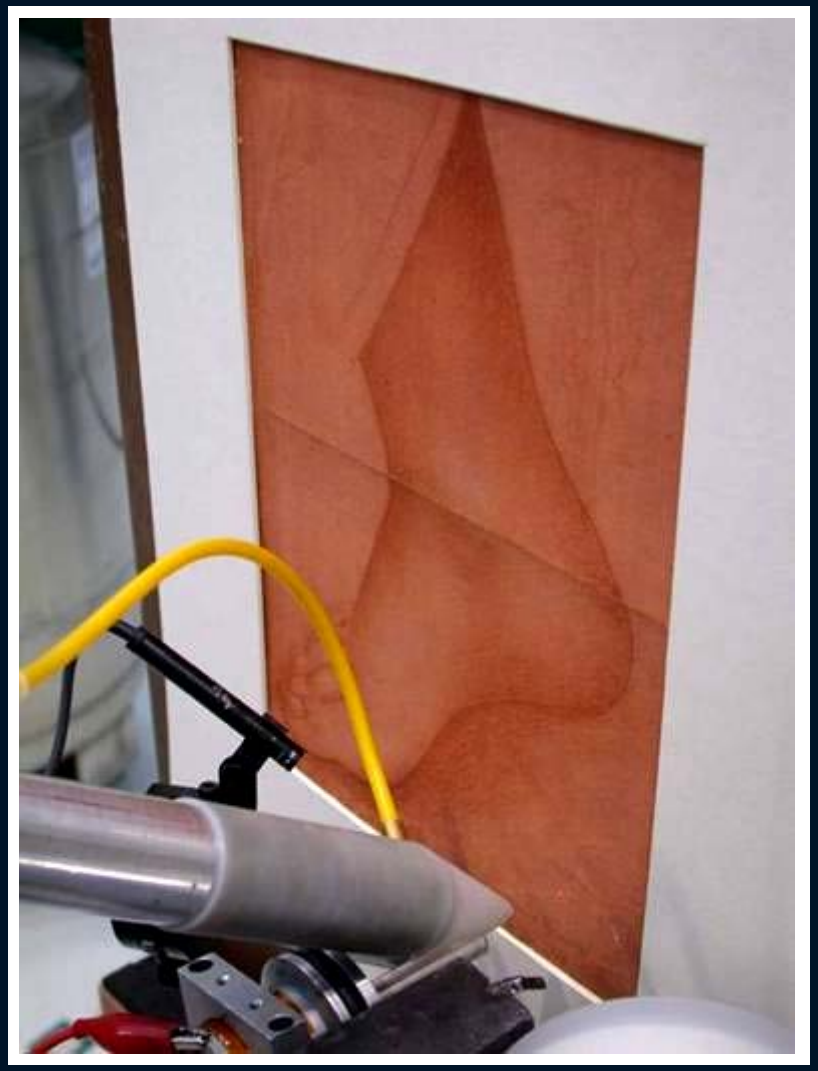
…ancient embroideries,

Micro-PIXE and –PIGE analysis of gold threads of a Renaissance embroidery based on a cartoon by Raffaellino del Garbo

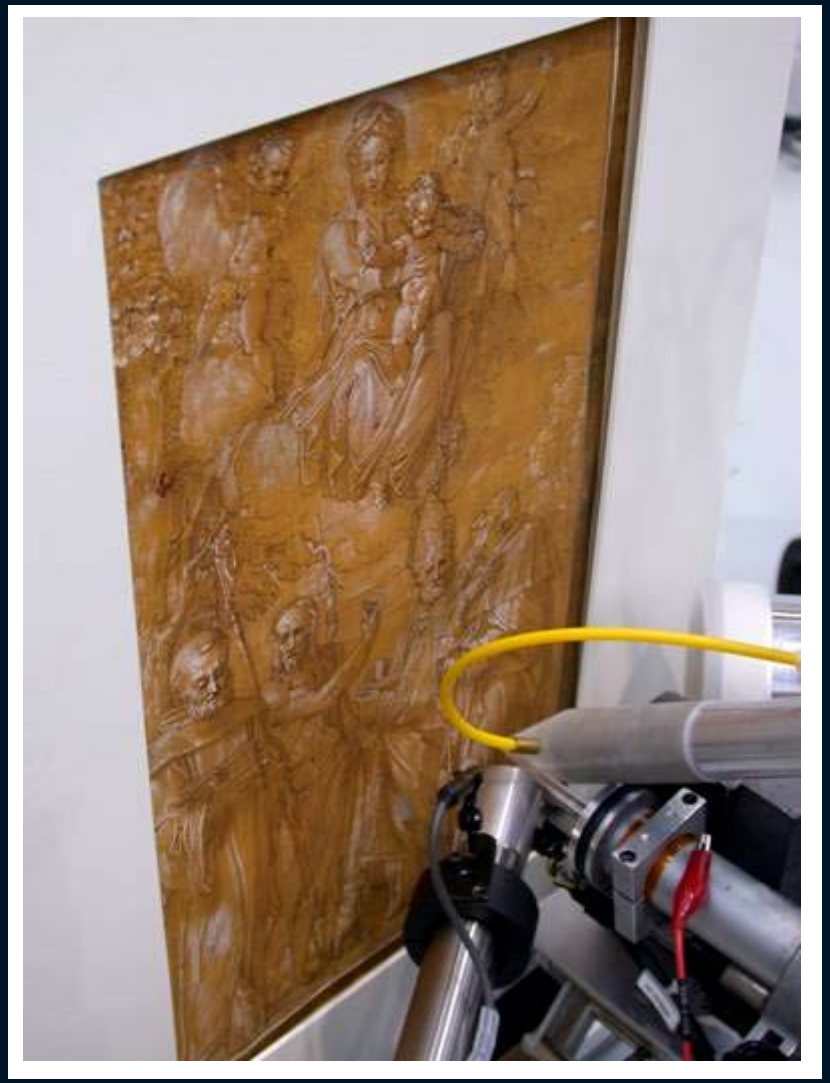
…early photographs,

PIXE-PIGE analysis of a print on metal plate of the XIX century

...drawings,



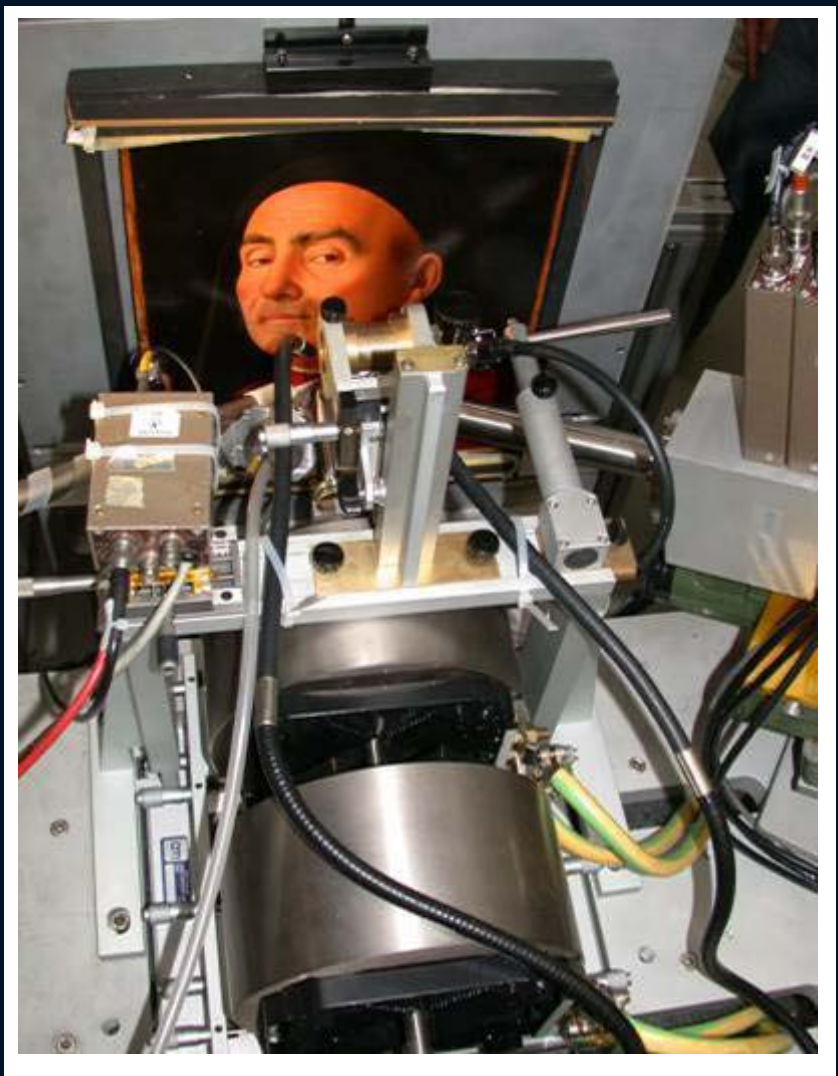
PIXE-PIGE analysis of a drawing on prepared paper, by Leonardo or his school



PIXE-PIGE analysis of a drawing on prepared paper, school of Verona, XVI cent.

...paintings on wood or canvas

Differential PIXE and PIGE analysis of the Madonna dei Fusi by Leonardo



Micro-PIXE and -PIGE analysis of the "Ritratto Trivulzio" by Antonello da Messina

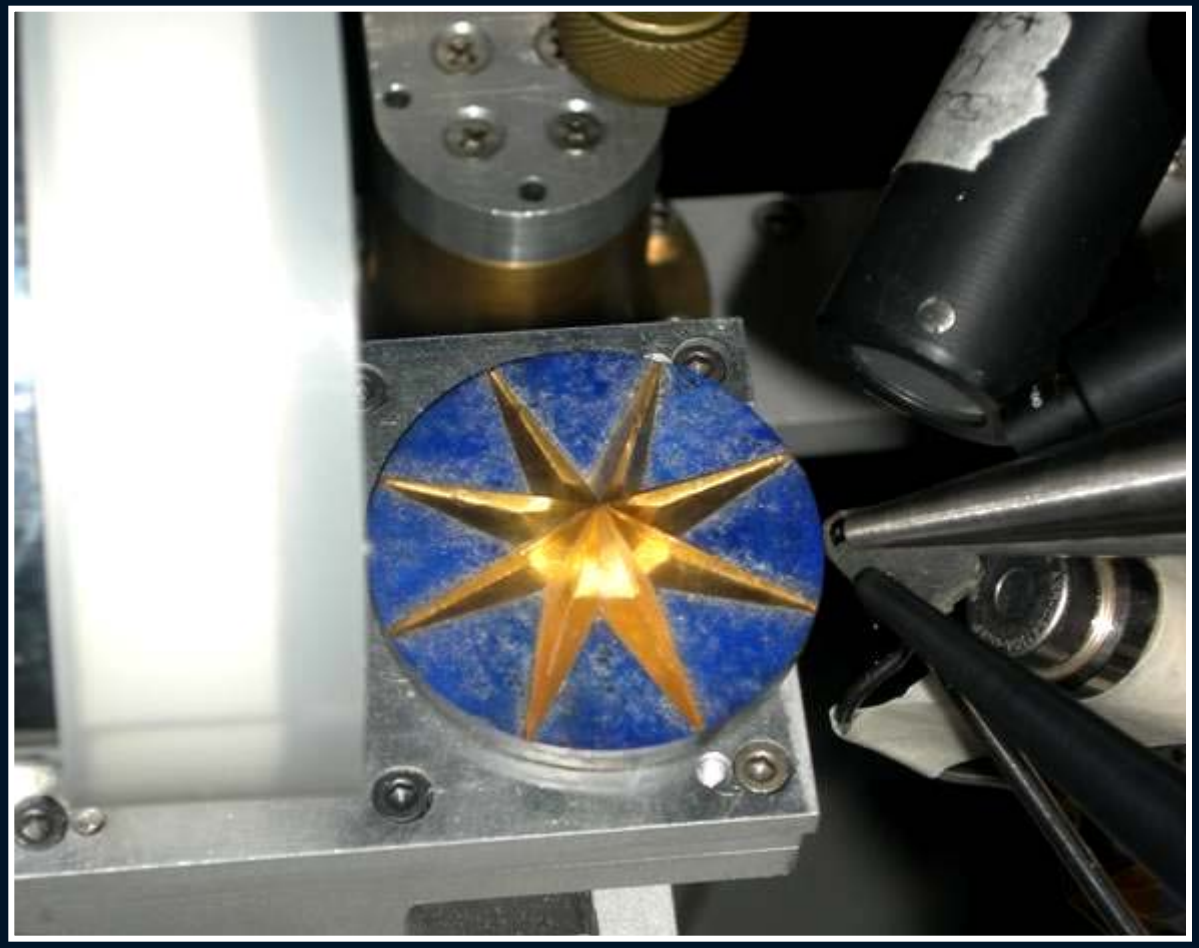
Giorgio Vasari

Tavoletta with S.Lucia, from Pala Albergotti, Arezzo

Andrea Mantegna

Madonna col Bambino, oil on canvas, Accademia Carrara di Bergamo

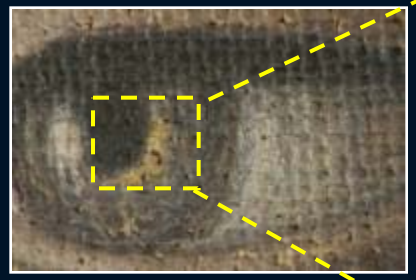
…artworks in semi-precious stones,

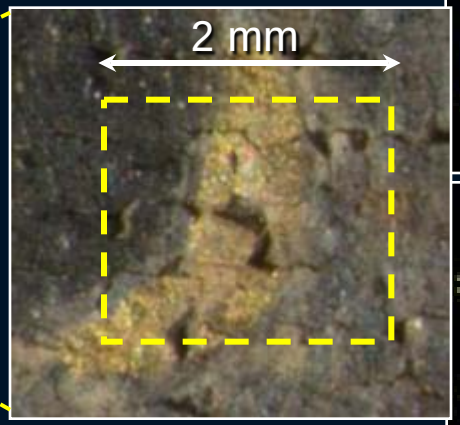


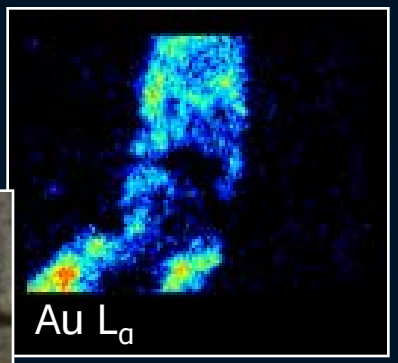
“Disc with star” from the “Collezione Medicea di Pietre Ornamentali” of the Natural History Museum in Florence (mineralogy and lithology division)

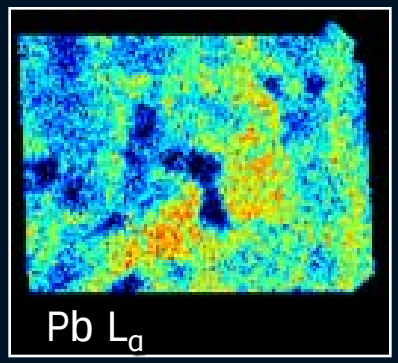
Elemental mapping

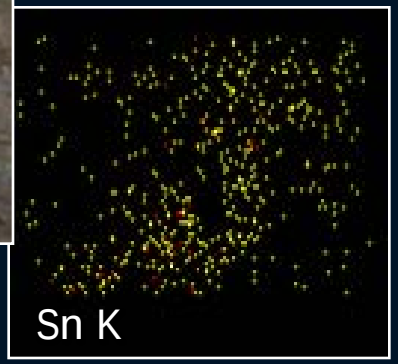
The eye of the Virgin

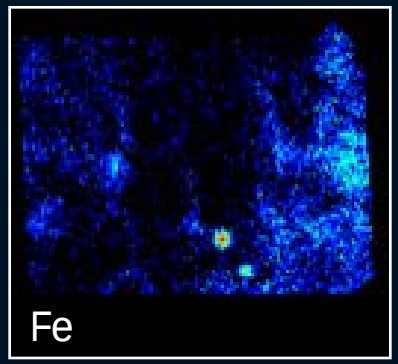




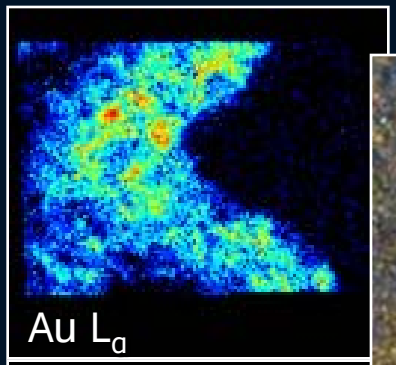


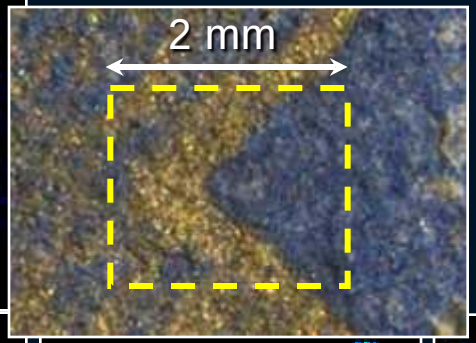


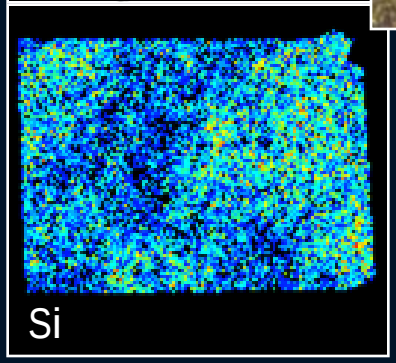


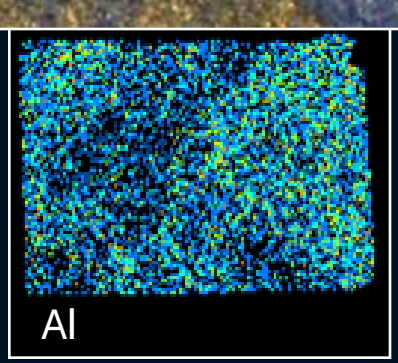


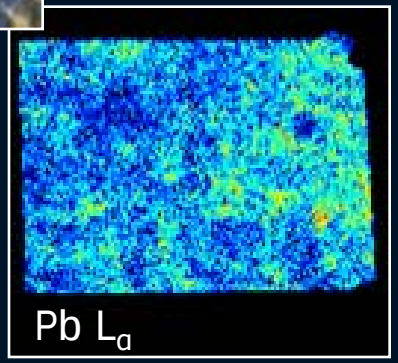
The veil











External microbeam line

full control of beam currents from a few nA down to ultra low intensities (few hundreds of particles/sec)

“high” beam intensities (pA – nA):

standard IBA: PIXE - PIGE - BS maps

low currents (fA):

IBIL (ionoluminescence) studies

rarefied beam (100 10000 particles per second):

STIM (scanning transmission ion microscopy)

IBIC (detector response vs beam position)

Ion Beam Modification of Materials

Ion lithography for beam-induced alteration of material properties (optical, electrical, etc.) on selected zones, “drawn” by the microbeam scan

Example: creating user-defined light guides in diamond exploiting the controlled change of refractive index induced by ion damage

PRL **105,** 233903 (2010) PHYSICAL REVIEW LETTERS week ending 3 DECEMBER 2010

Evidence of Light Guiding in Ion-Implanted Diamond

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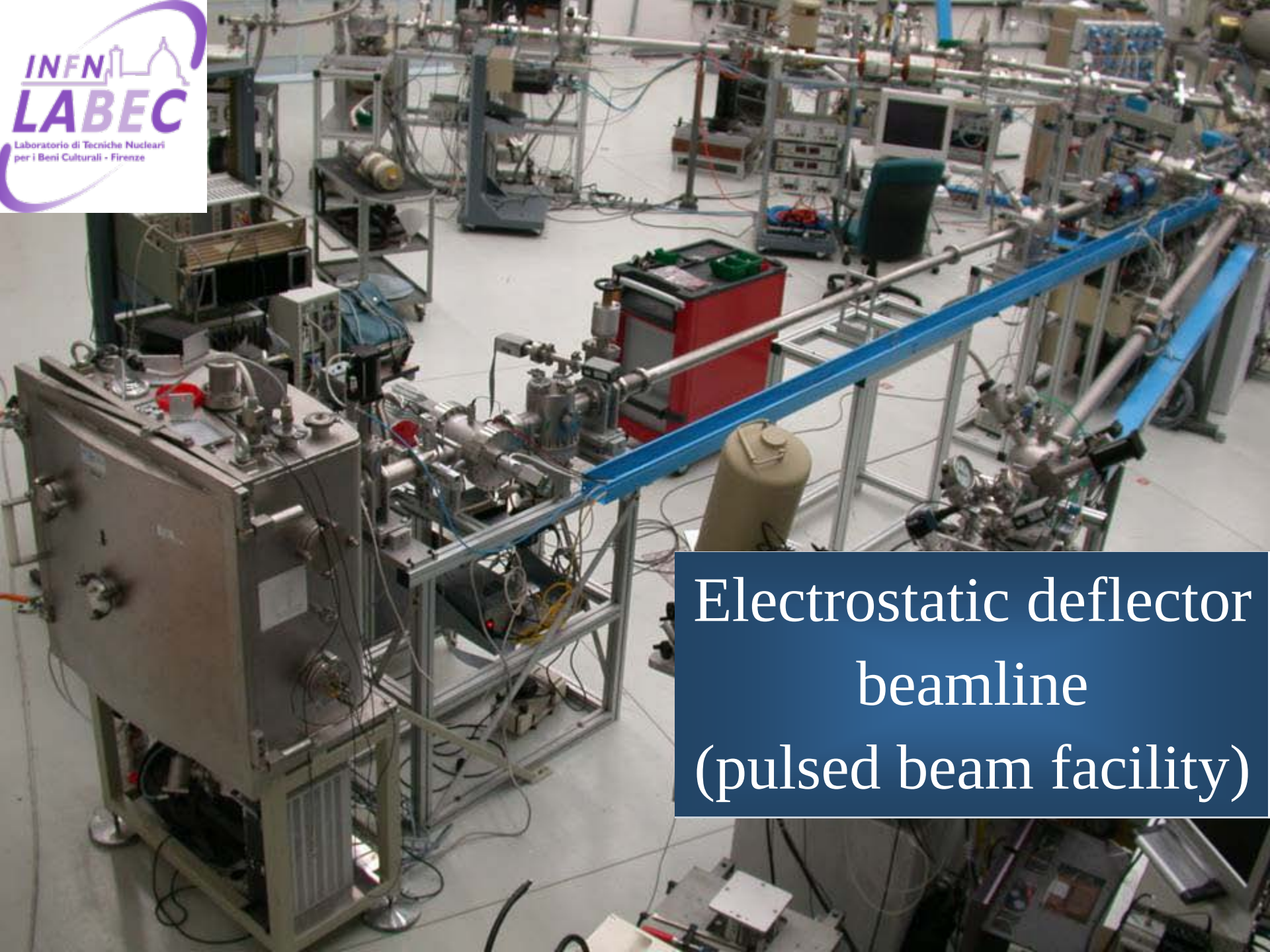
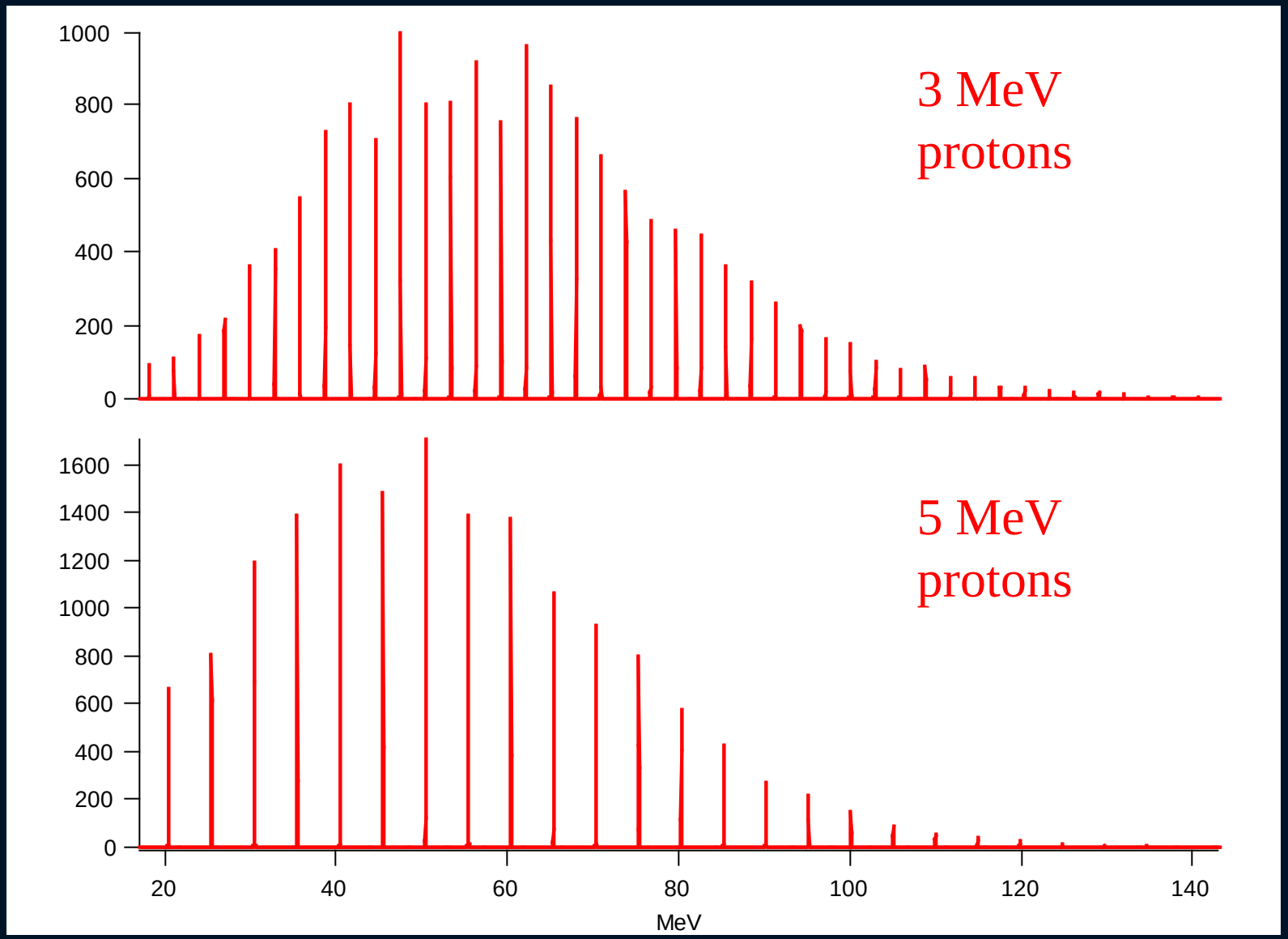
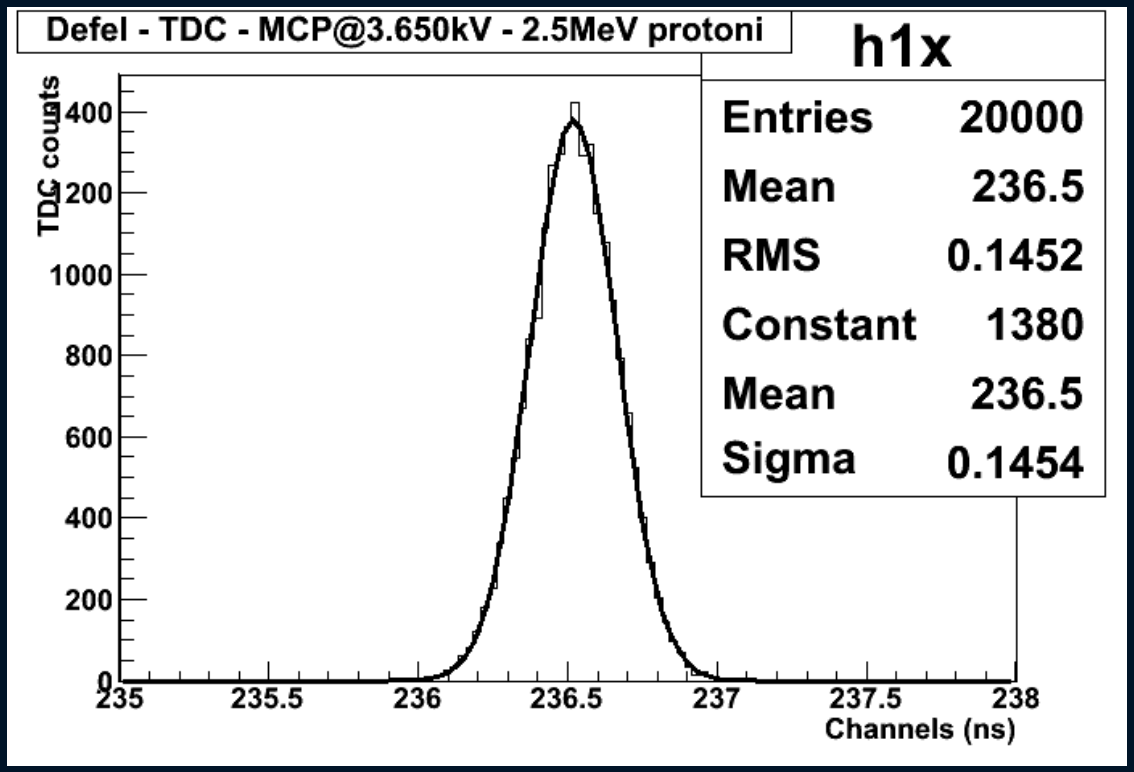

INFN
LABEC
Laboratorio di Tecniche Nucleari
per i Beni Culturali - Firenze
Electrostatic deflector
beamline
(pulsed beam facility)

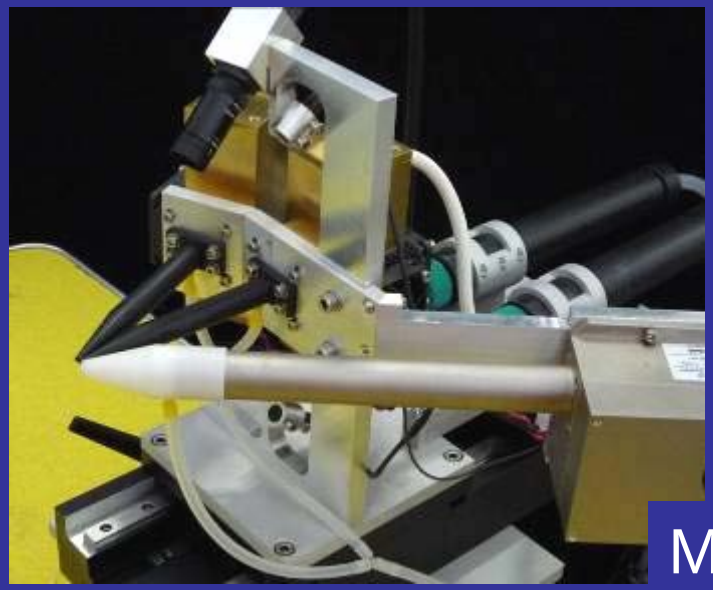
Beam bunches with different particle multiplicity can be delivered directly to a detector for response tests to particles



Time definition of beam bunches



The transportable XRF spectrometer



Measurement head

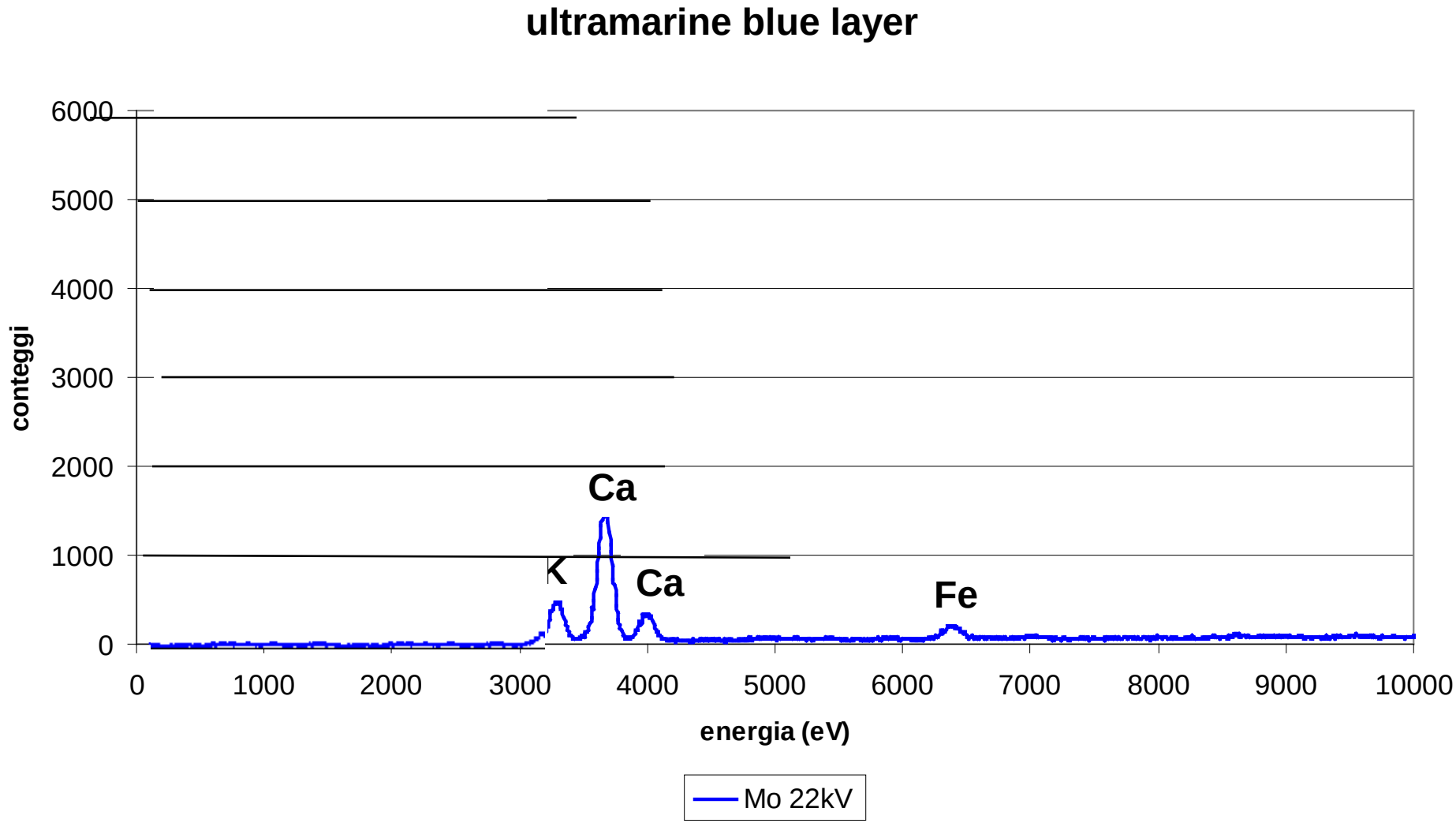
- independent PS for the two tubes
- data acquisition, He flow, X-Y-Z displacement and video camera remotely controlled (Ethernet)

Controller

2 X ray tubes (30 kV max, 1 mA max) with different anodes: **Mo, Ti and W**

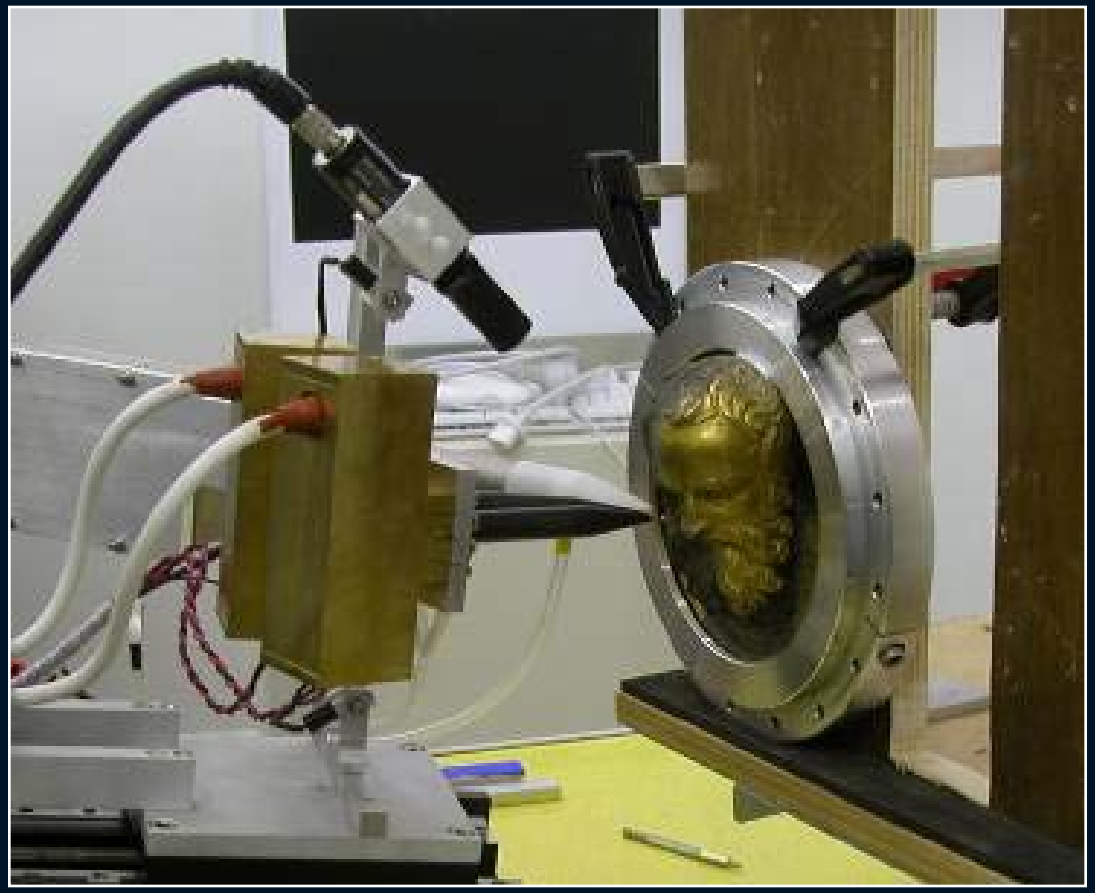
- interchangeable collimators; **typical beam diameter 0.5 mm**
- SDD detector (active area 10 mm^2, 450 μm thickness, FWHM 139 eV @ 5.9 keV)
- **helium flow** in front of tubes and detector
- 2 laser beams for sample positioning
- TV chamber

Ultramarine blue layer on chalk
XRF spectrum with our spectrometre



"Head of a Prophet" by Lorenzo Ghiberti (part of the Paradise Gate of the Florence Baptistery)

Gilded bronze



Affresco della Resurrezione
Piero della Francesca
Sansepolcro,
Museo Civico

Crocefisso, Maestro di Figline

Santa Croce


Madonna del Granduca
Raffaello
Galleria Palatina

Crew

Non-permanent positions

- Mirko Massi
- Novella Grassi
- Alessandro Migliori
- Silvia Calusi
- Elisabetta Colombo
- Elisa Conz
- Maria Albonico
- Antonio Mirto
- Leonardo Bonanni
- Cristina Giancristofaro
- Elisa Maupas
- Pamela Bonanni
- Eva Martelli
- Debora Angelici
- Alessandro Re

Permanent positions

- Luca Carraresi
- Francesco Taccetti
- Franco Lucarelli
- Massimo Chiari
- Silvia Nava
- Marco Manetti
- Nicla Gelli
- Piero Mandò
- Lorenzo Giuntini
- Luca Carraresi

Thank you for your attention

Albrecht Dürer
Study of Hands, 1508
Albertina, Vienna

giuntini@fi.infn.it

Thank you for your attention!

giuntini@fi.infn.it

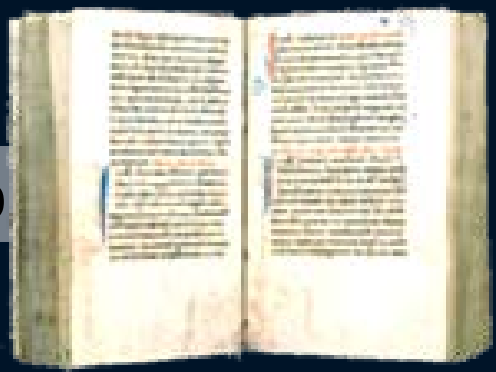
S.Francesco Church at Cortona

It was build by Padre Elia a few years after the death of St- Francesco (1226). Three important relics are kept there :

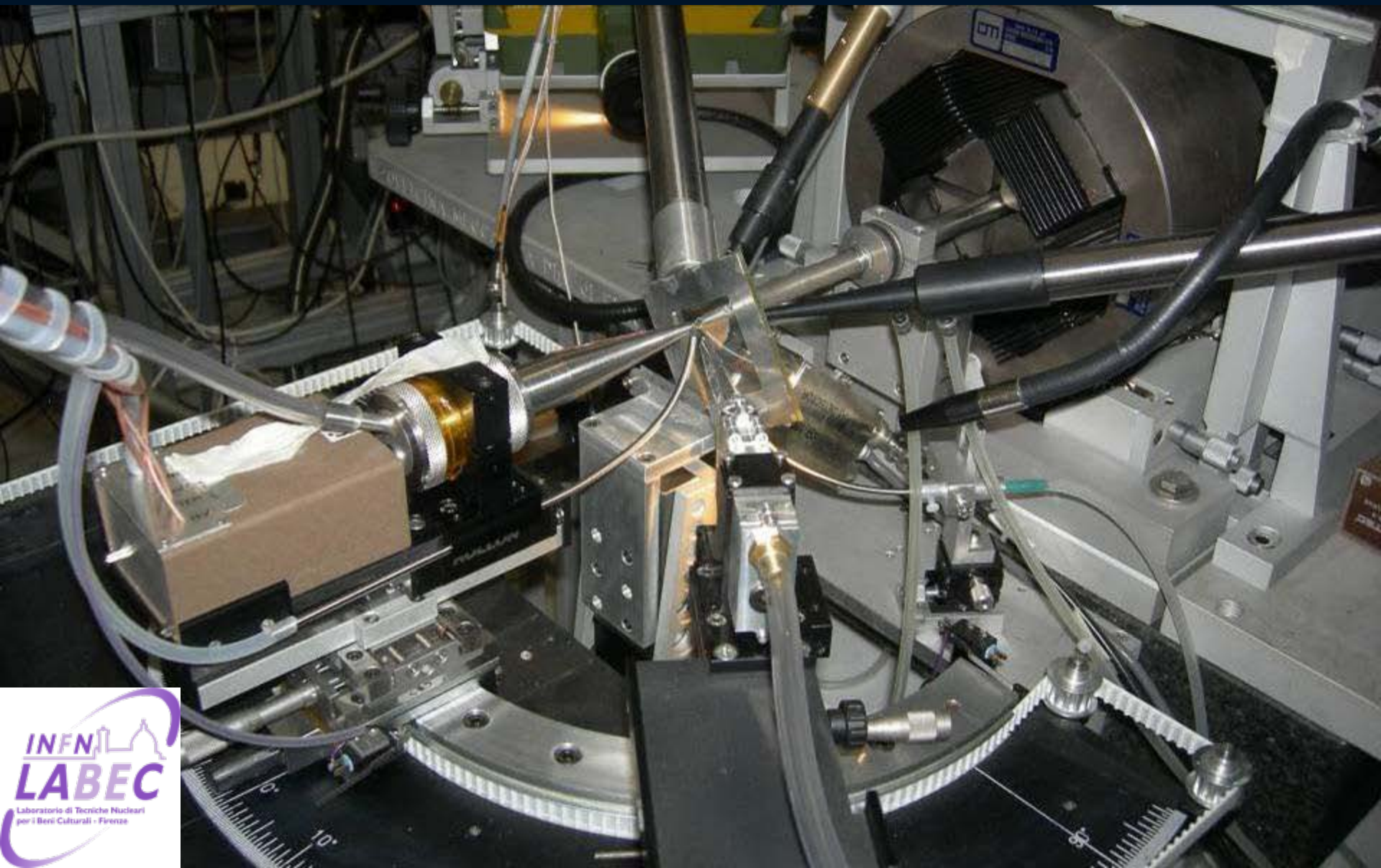
A pillow, *on which tradition tells St. Francis was leaning his head while passing away*

The frok; according to tradition, the one used to cover the Saint's body at the moment of his death.

un evangeliario



External STIM set-up



STIM of a thin copper grid

map of higher-energy transmitted protons

map of lower-energy transmitted protons