

# LABEC

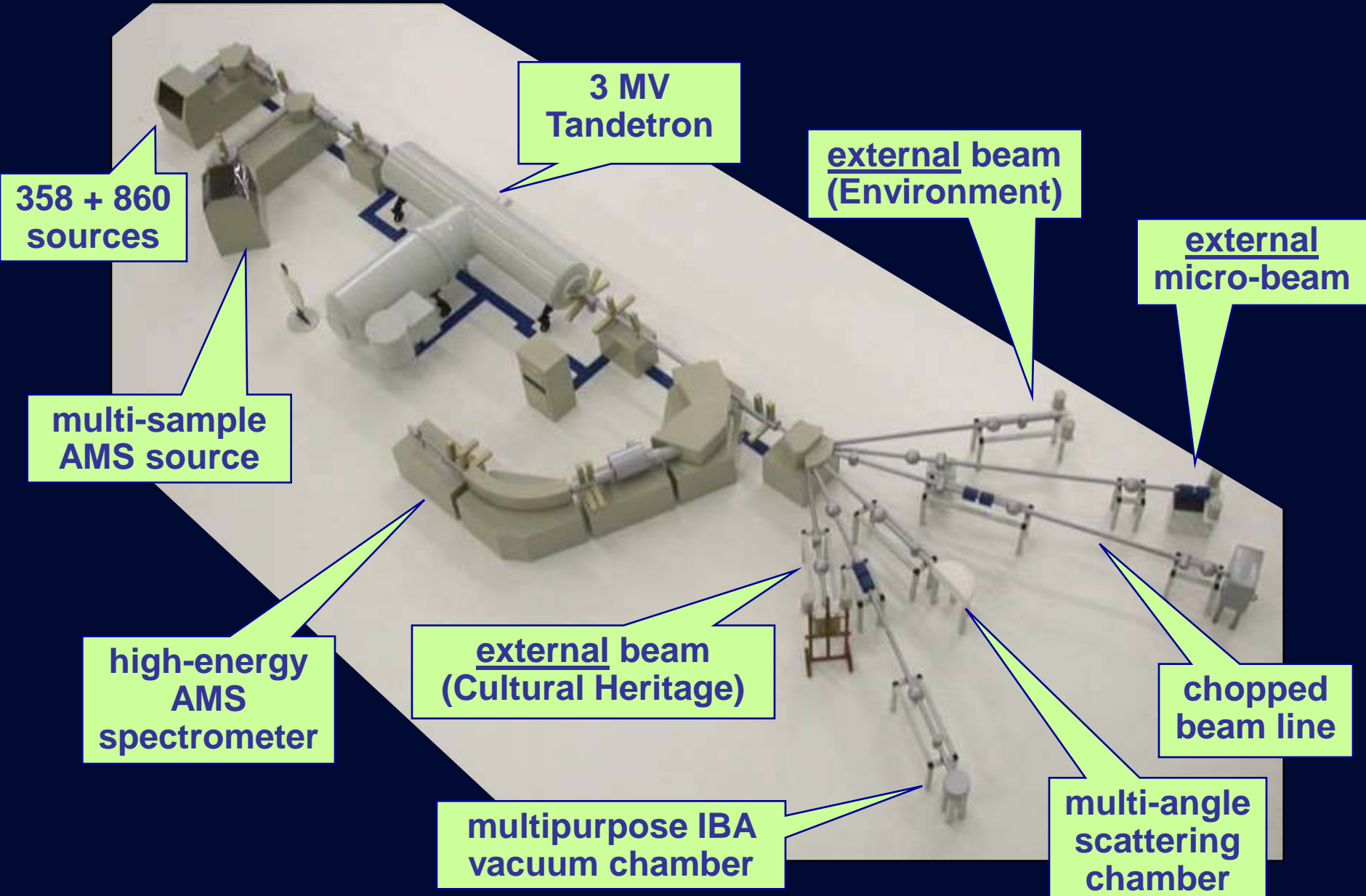
## *Laboratory of Nuclear Techniques for Environment and Cultural Heritage*

L. Giuntini, F. Taccetti

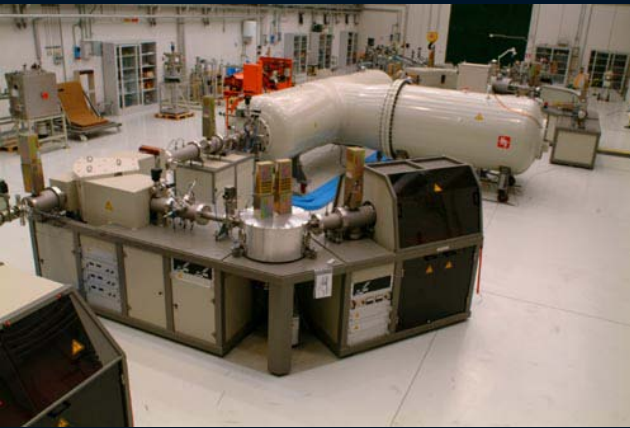
*Department of Physics of the University and INFN of Firenze, Italy*



# *The LABEC accelerator hall*

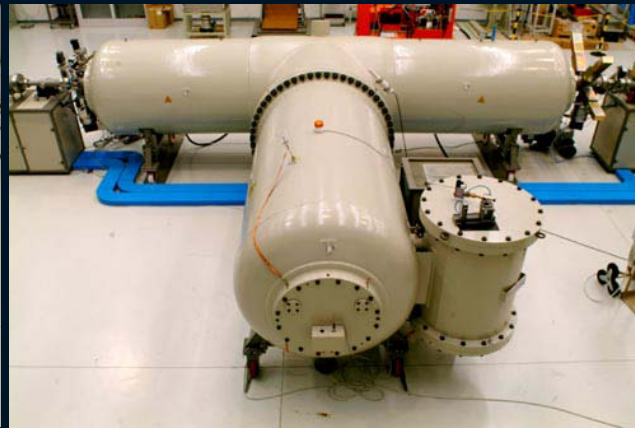


# *Accelerator hall: AMS beam line*

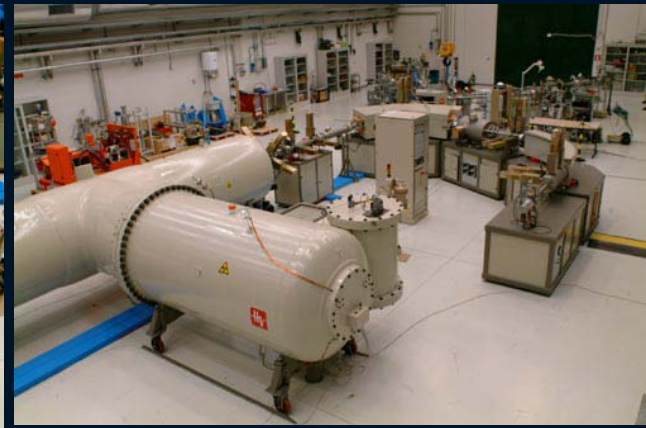


AMS 846

- multi sample sputter source
- low energy filters
- injection magnet

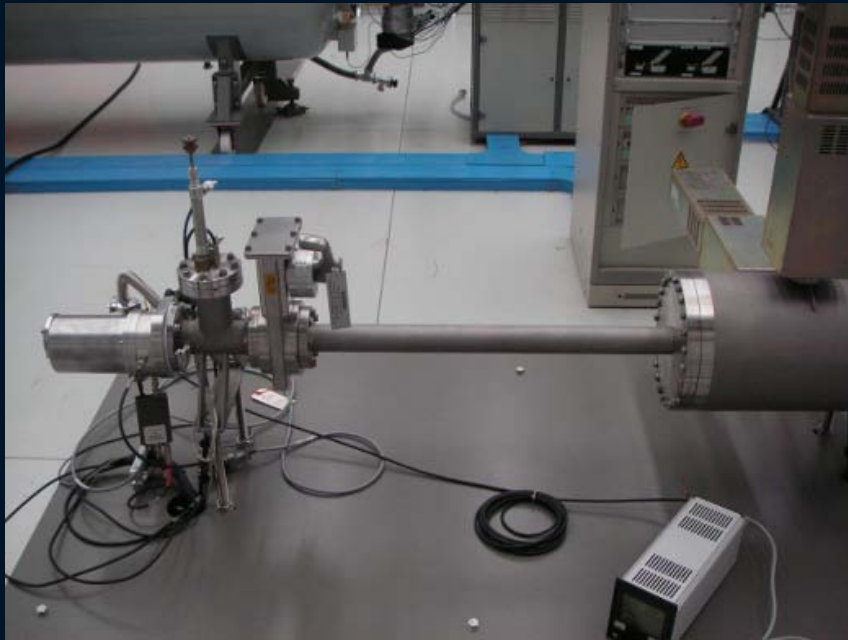


3 MV tandem  
accelerator

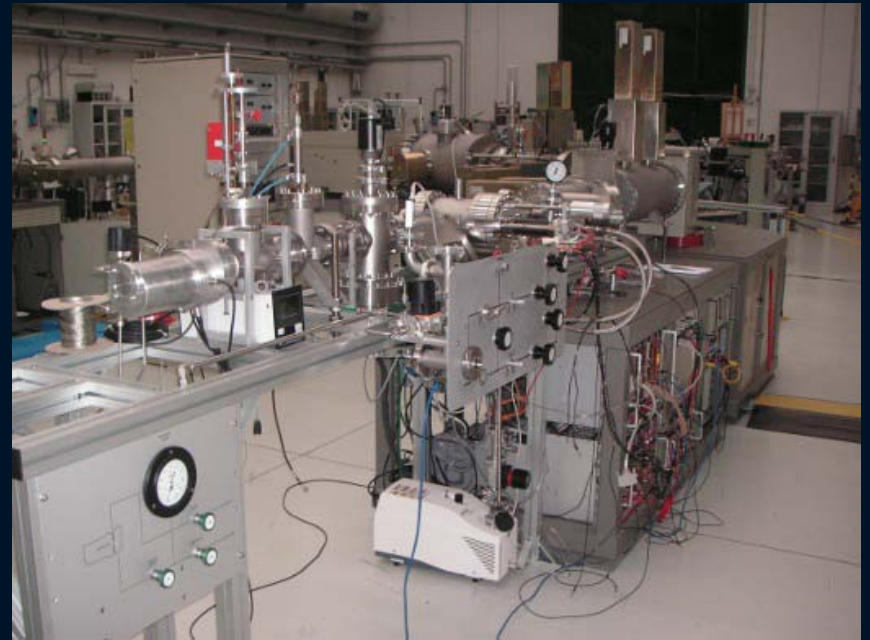


AMS  
high energy  
filters  
and detectors

# *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:

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

Until now:

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



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- **bone-alloy**  
- **coastal-plasma**  
- **on-her-herb**

SEARCH

September 10, 2007

September 10, 2007

## Carbon dating casts doubt on age of St. Francis robe

By Stephen Zhou

**ROME (Reuters)** - Carbon dating has cast doubt on the authenticity of one of four robes kept by Italian churches as relics of the medieval saint Francis of Assisi. Though another robe, a hat and a cushion were found to be the right vintage.

Friars from two churches of the Franciscan order reacted by the suit and a laboratory specializing in dating artifacts to examine two simple brown-brown robes to which have been worn by the champion of the poor, as well as a hat and a cushion.

Francis who gave up the life of a playboy and soldier and all his worldly goods to dedicate himself to the poor and preach the word of peace, died in 1226. His followers, Assisi, attracts millions of Christian pilgrims every year.

**Carbon dating casts doubt on age of St. Francis robe**

The relic of Saint Francis of Assisi is seen during a exhibition in Assisi on Sept. 10, 2006. The photo, Carbon dating has cast doubt on the authenticity of one of four robes kept by Italian churches as relics of the medieval saint Francis of Assisi. Though another robe, a hat and a cushion were found to be the right vintage. PHOTOGRAPHED BY AP/WIDEWORLD

ADVERTISMENT (article continues below)

*Scientific American online*  
*6 settembre 2007*



**nature**  
International weekly journal of science

**nature news home** **news archive** **specials** **opinion** **features** **news blog** **nature**

**comments on this story**

Published online 5 September 2007 | Nature | doi:10.1038/news070903-7

**News**

## Saint's robes carbon dated

### Relics of St Francis of Assisi unveiled.

Emiliano Feresin

Four Franciscan churches in central Italy claim that they each hold a habit of St Francis of Assisi, the friar who founded the Franciscan order in the early 1200s. Carbon dating has now substantiated one of those claims, and helped to shore up a story from the church's history many centuries later.

In Italy, religious relics are venerated by millions of Catholics who believe that God works miracles through them, or who simply fear them. Every year more than three million visitors come to the major shrine of St Francis, a basilica in Assisi that hosts famous frescoes depicting the saint's life, and one of the habits said to have belonged to the saint. A second robe is held at the Sanctuary of La



One of the robes said to have belonged to St Francis of Assisi. *Wikipedia*

**Stories by subject**

- Chemistry
- Physics
- Technology

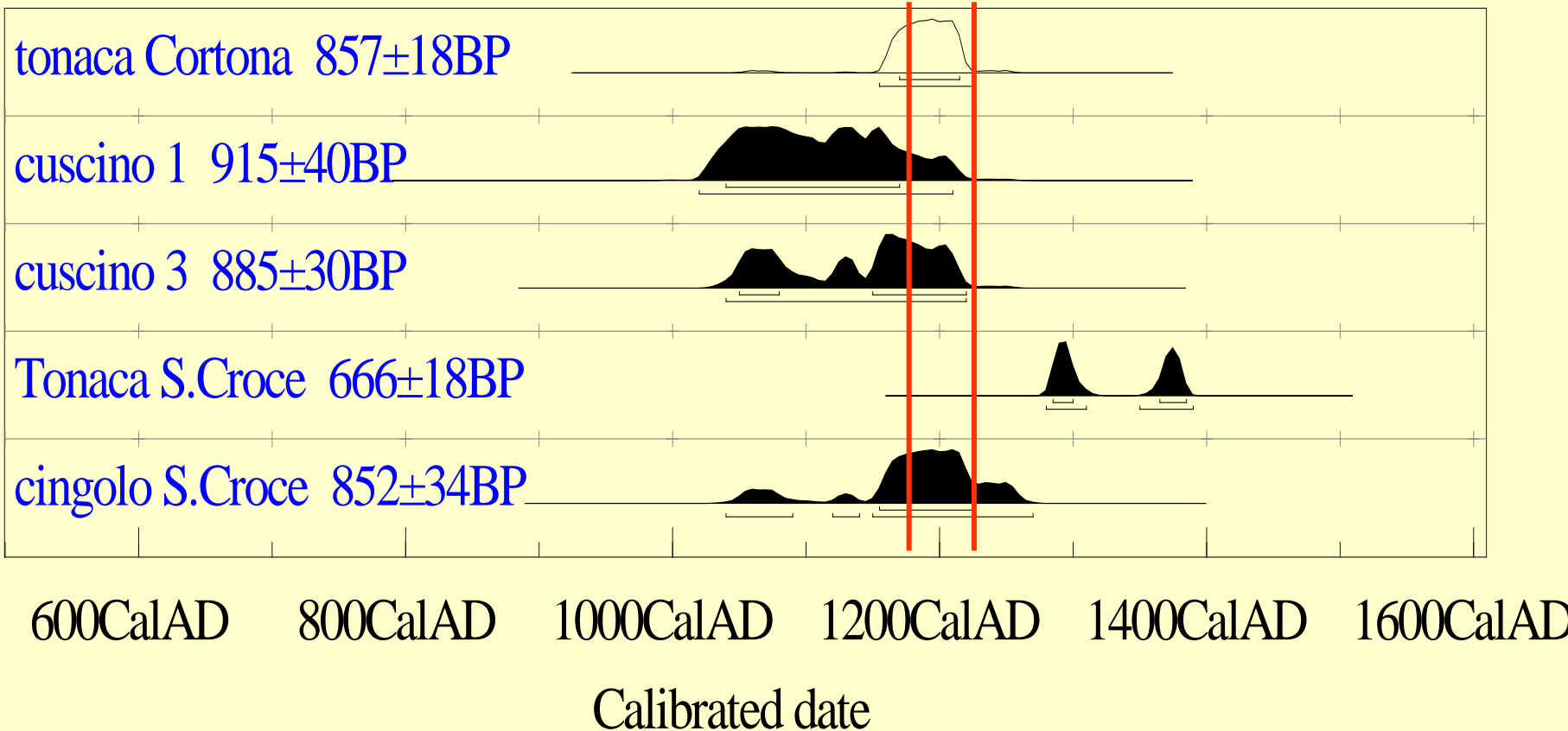
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*NEWS @ Nature.com*  
*5 settembre 2007*



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  $10^2 \mu\text{m}$

- natural or anthropogenic sources
- primary or secondary origin

Identification and quantification of sources

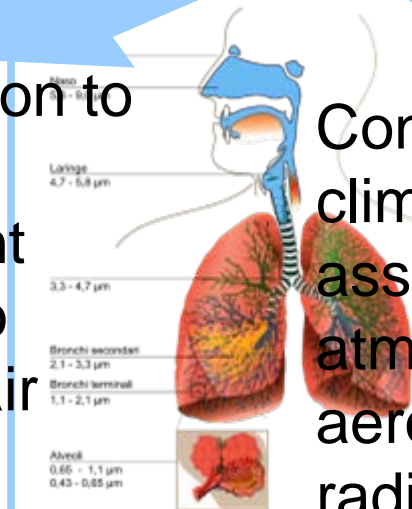
Impact on the environment



Contribution to pollution abatement policies to improve air quality

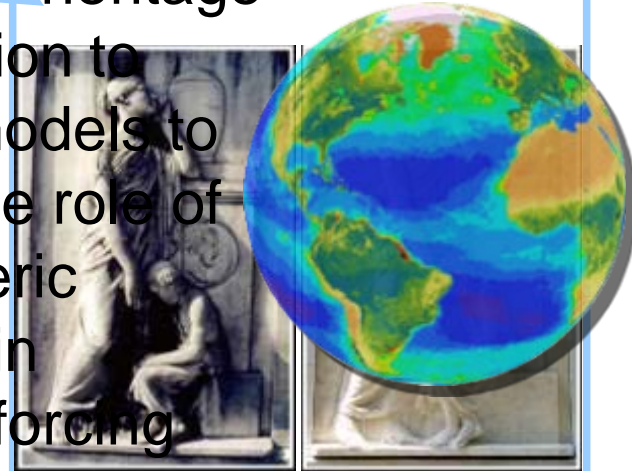
Impact on human health

**OUTPUT**



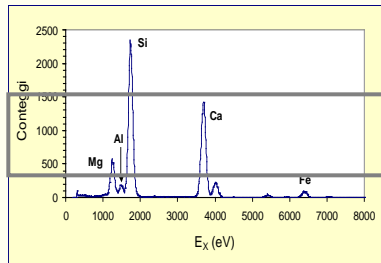
Contribution to climate models to assess the role of atmospheric aerosols in radiative forcing

Impact on cultural heritage

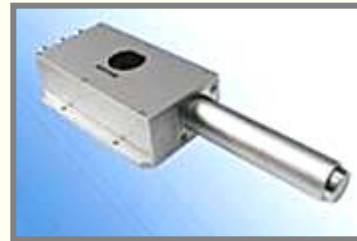


# *Ion Beam Analysis (IBA) for Aerosols*

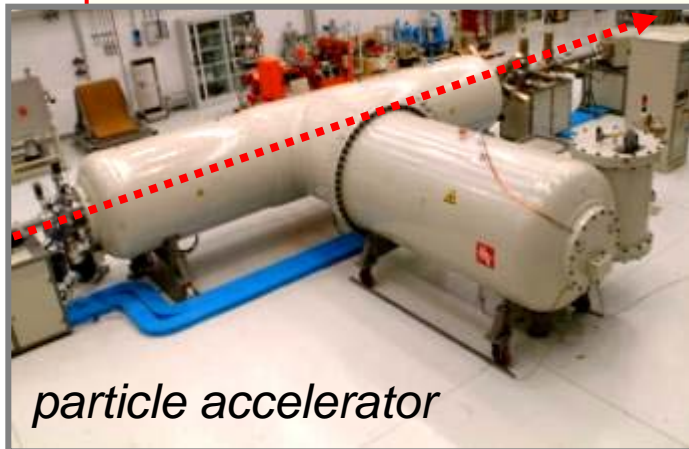
- Material composition analysis through beam particle bombardment typically proton or alpha beams at some MeV energy



*radiation detection and  
spectral analysis*

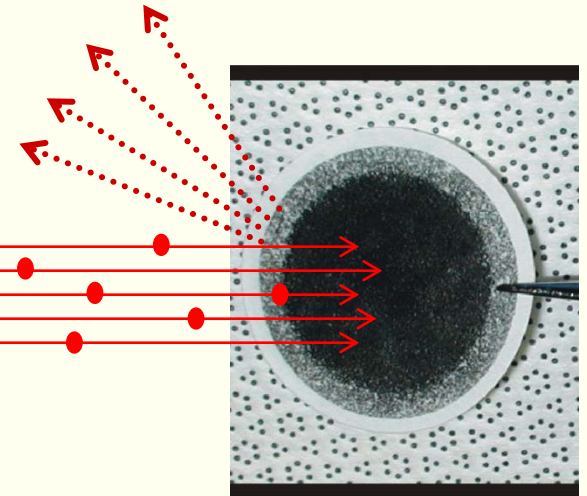
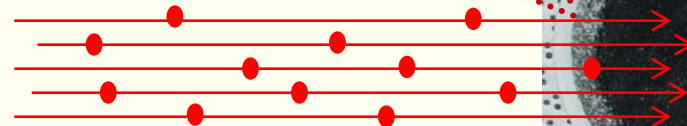


*emission of radiation of  
characteristic energies  
(X-rays,  $\gamma$ -rays,  
particles...)*



*particle accelerator*

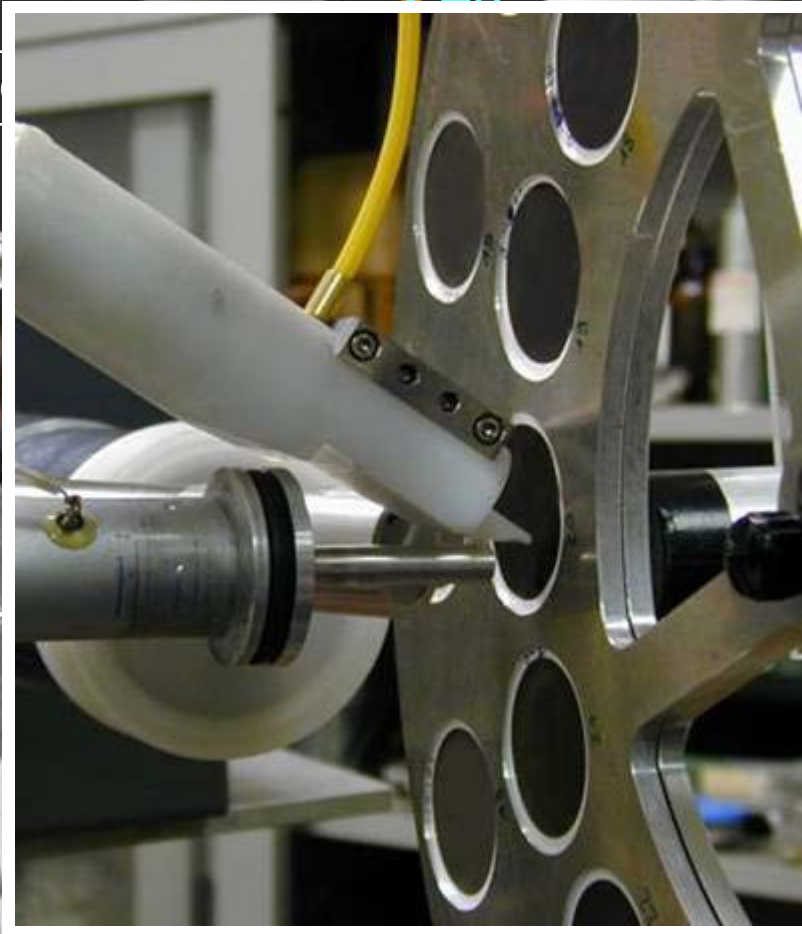
*particle beam*



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

Gamma ray det. HP

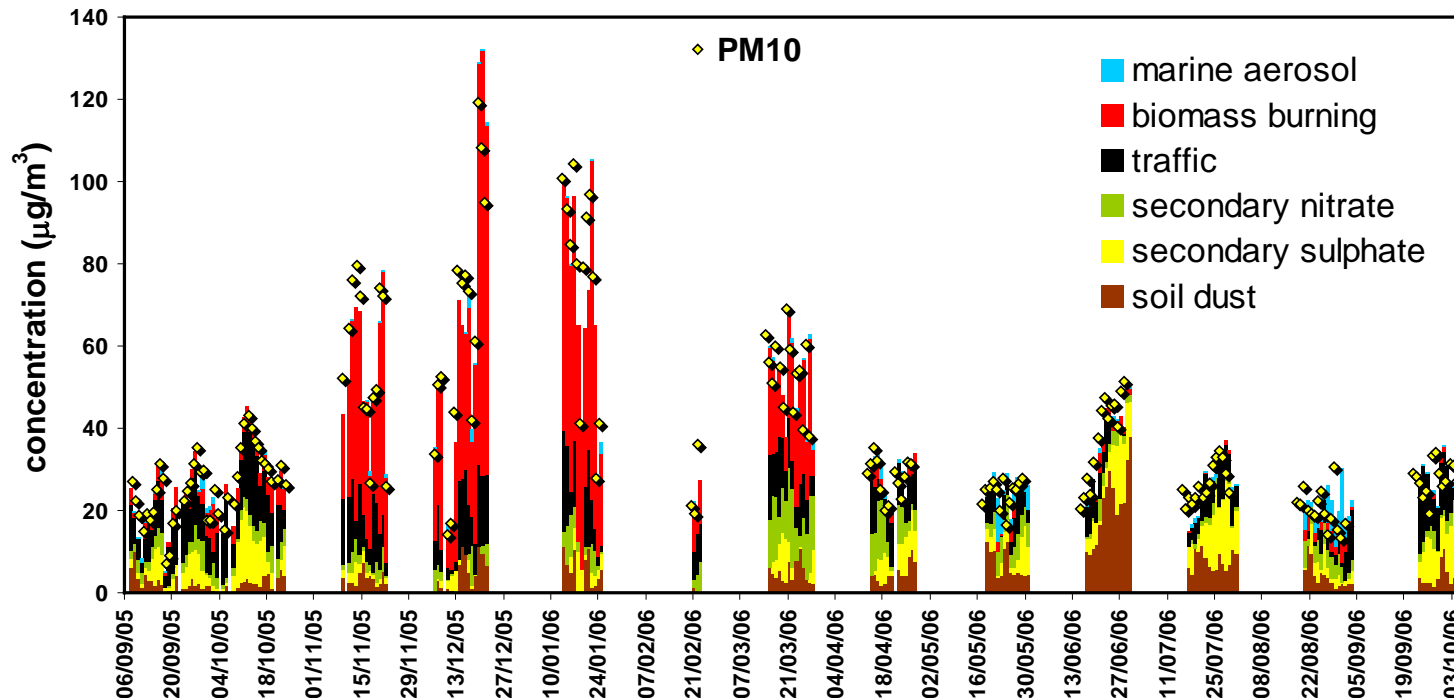
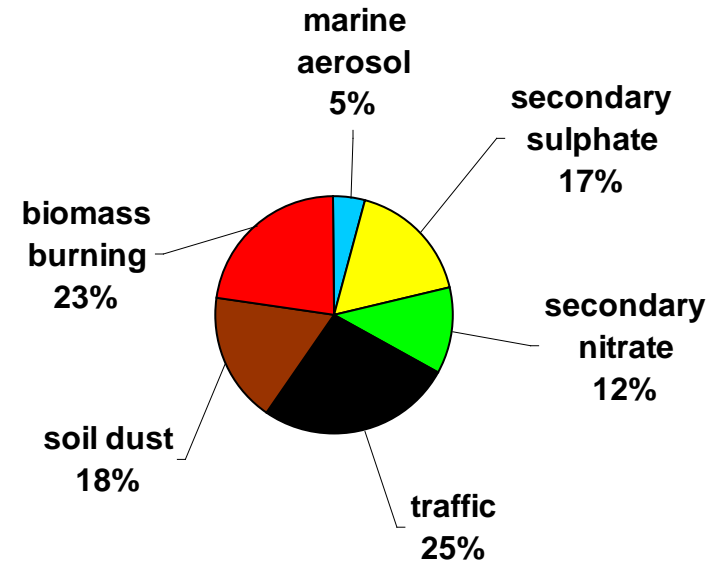
Faraday cup



Light elements X ray detector (SDD)

Higher-Z elements X ray detector (Si(Li))

# Average source apportionment





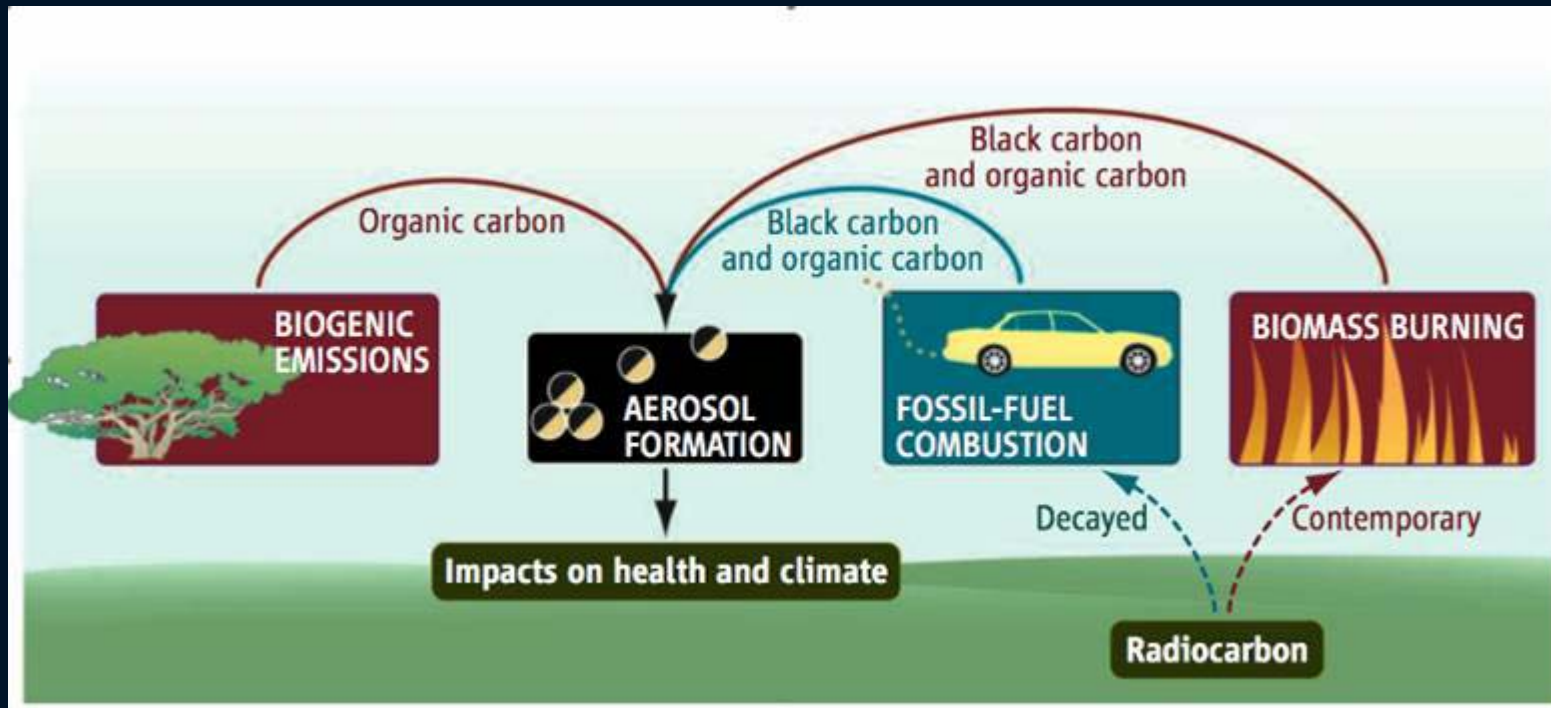
# AMS $^{14}\text{C}$ measurements in aerosols

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

$\sim 0$  in the aerosols produced by fossil fuels

$\sim 10^{-12}$  in aerosol of biogenic origin or from biomass burning

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





# *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  
( $\varnothing$  0.2 – 1 mm)

strong focusing system  
from 8  $\mu\text{m}$  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*

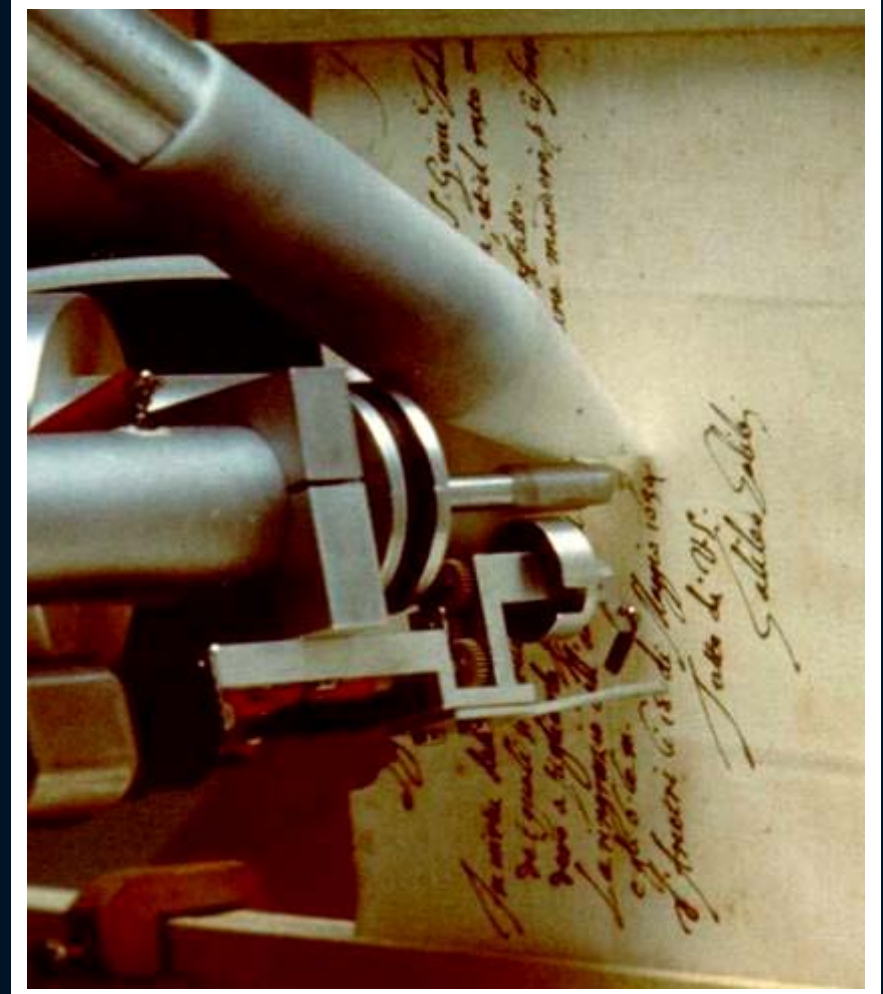


*...ancient illuminated manuscripts,*



*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*

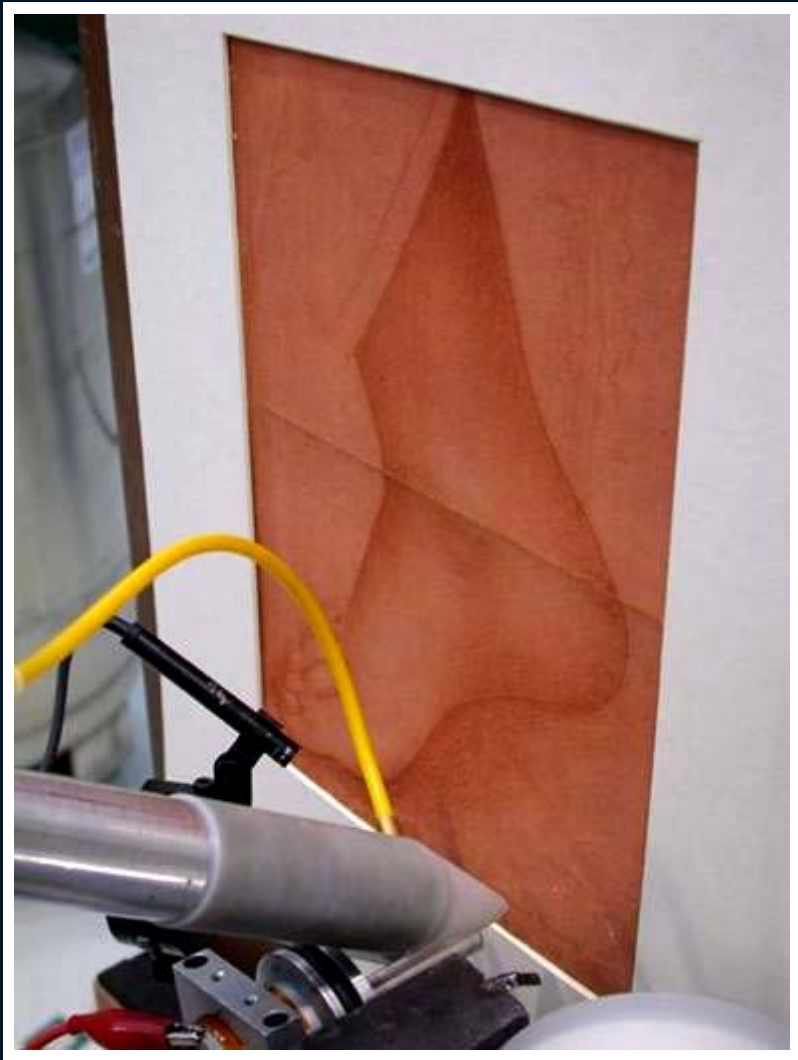
*...early photographs,*



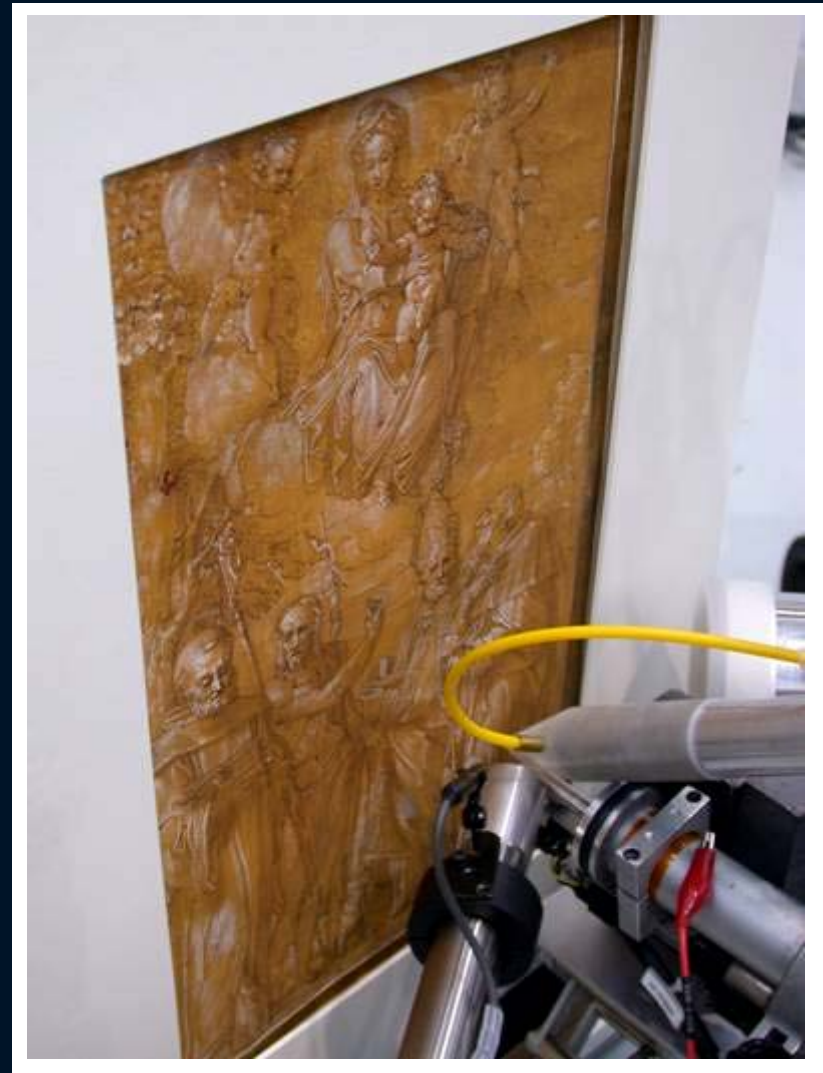
*PIXE-PIGE analysis of a print on  
metal plate of the XIX century*



*...drawings,*



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

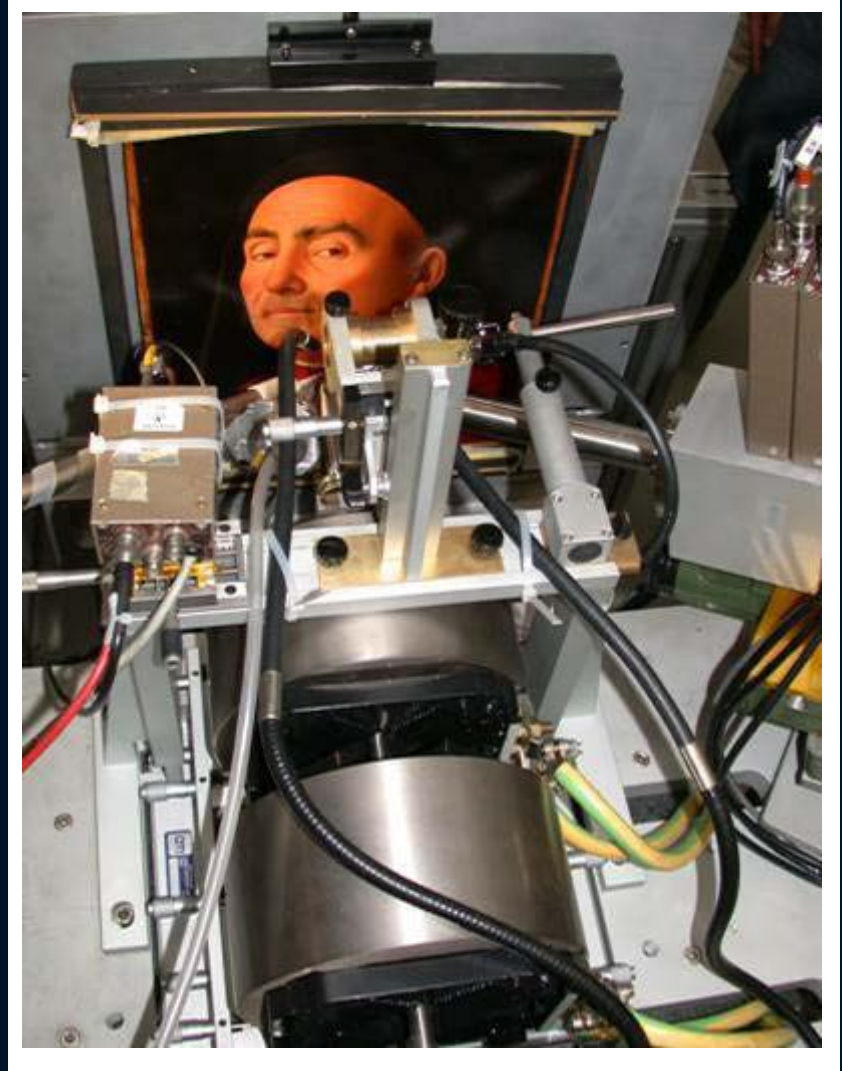


*PIXE-PIGE analysis of a drawing on prepared paper, school of Verona, XVI cent.*

*...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*



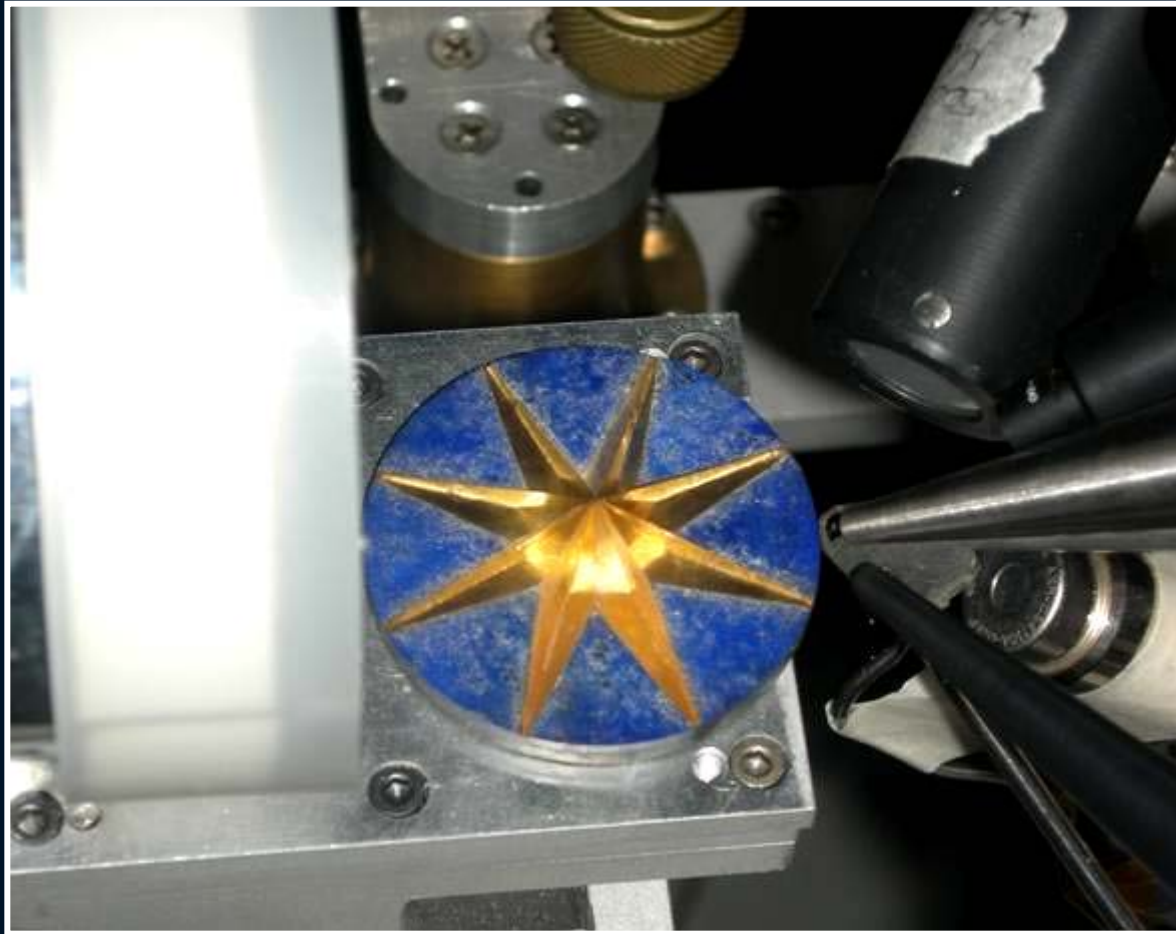


*Giorgio Vasari*  
*Tavoletta with S.Lucia, from*  
*Pala Albergotti, Arezzo*



*Andrea Mantegna*  
*Madonna col Bambino, oil on canvas,*  
*Accademia Carrara di Bergamo*

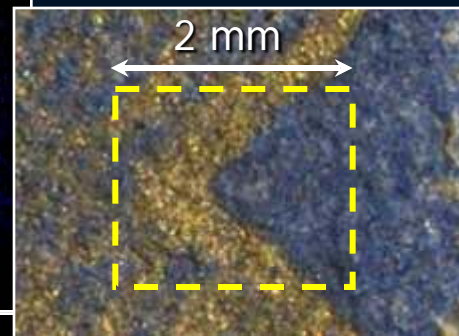
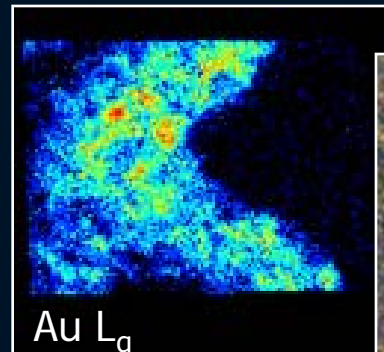
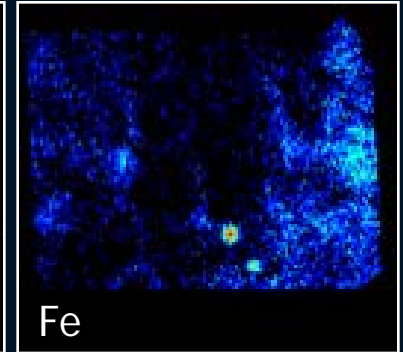
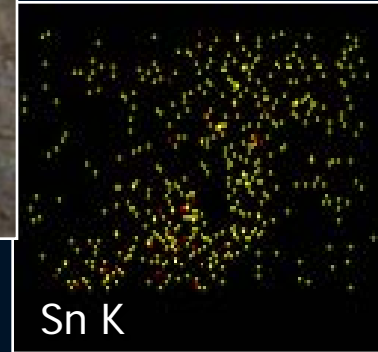
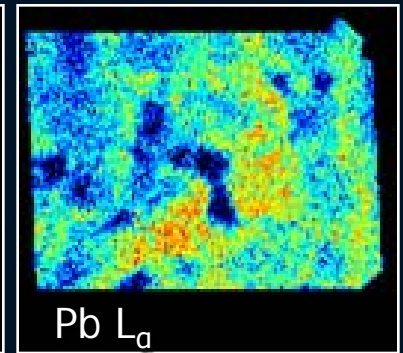
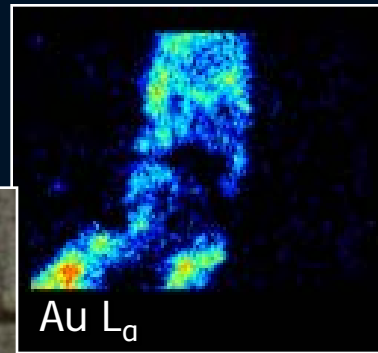
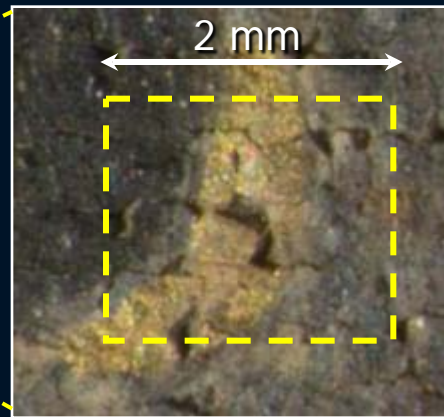
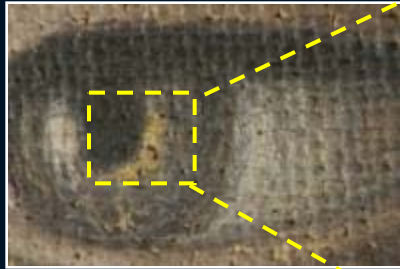
*...artworks in semi-precious stones,*



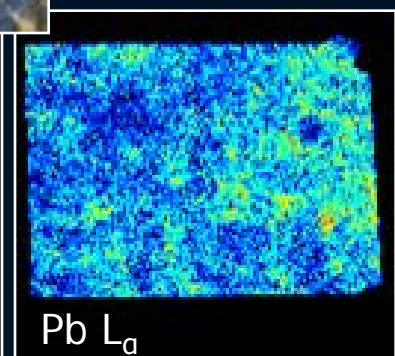
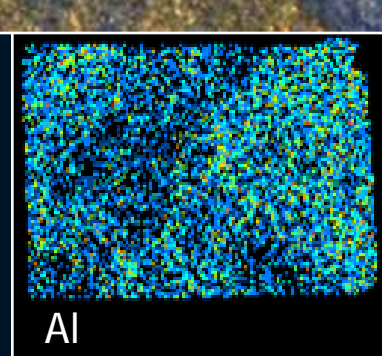
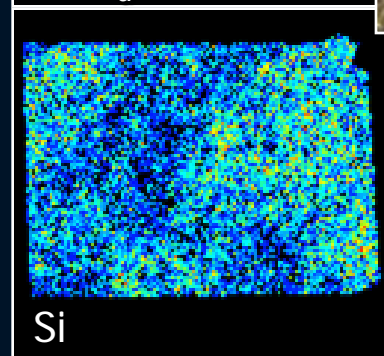
*“Disc with star” from the “Collezione Medicea di Pietre Ornamentali” of the Natural History Museum in Florence ( mineralogy and lithology division)*

# 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**

S. Lagomarsino\*

*Department of Energetics University of Firenze and INFN, Via S.Marta 3, 50136 Italy*

P. Olivero and F. Bosia

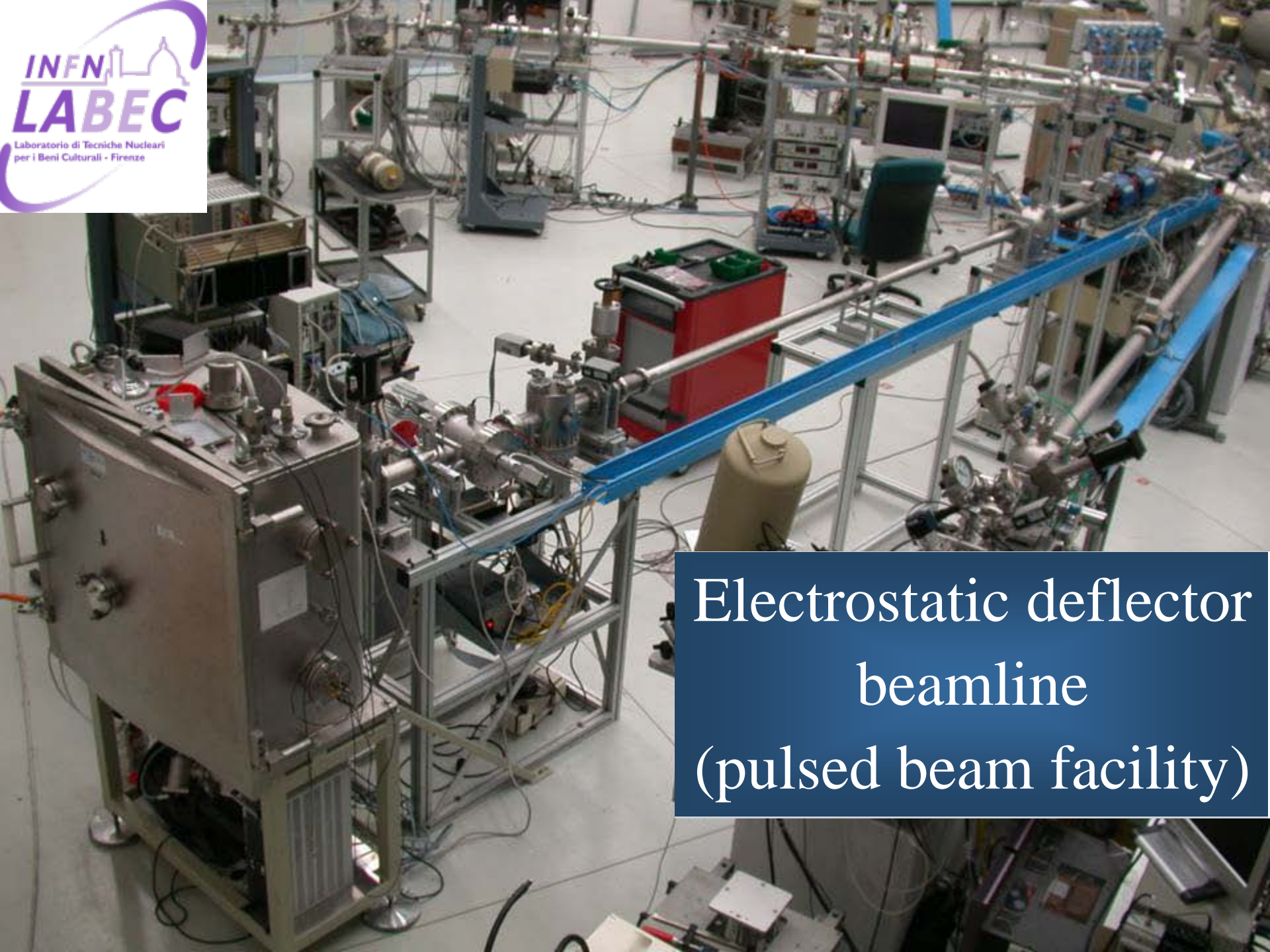
*Experimental Physics Department and Nanostructured Interfaces and Surfaces Centre of Excellence,  
University of Torino and INFN, via P. Giuria 1, 10125 Torino, Italy*

M. Vannoni

*CNR, Istituto Nazionale di Ottica (INO), Largo E. Fermi 6, 50125 Arcetri, Firenze, Italy*

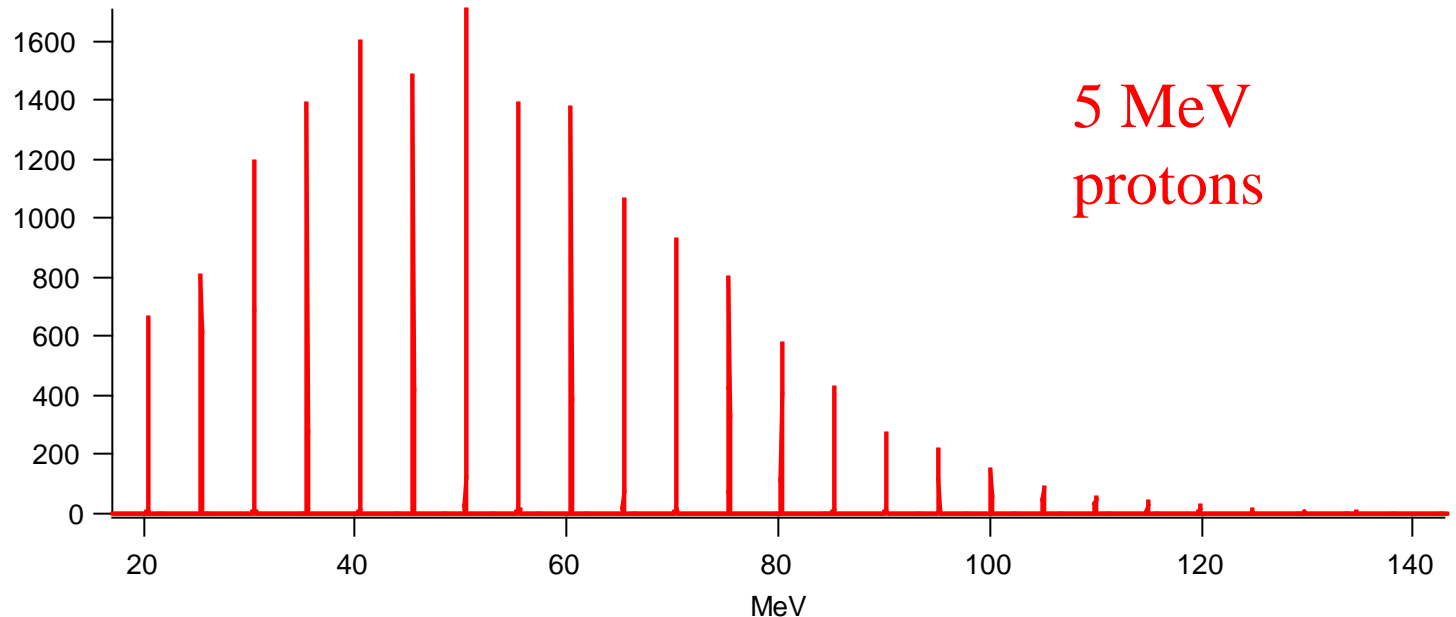
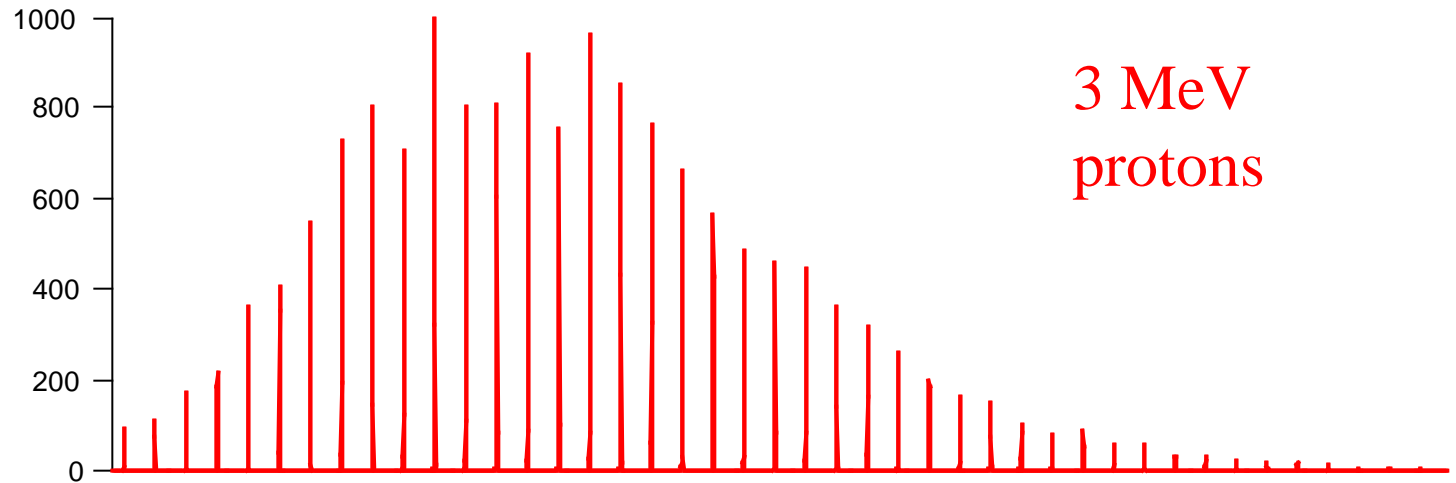
S. Calusi, L. Giuntini, and M. Massi

*Physics Department and INFN Sezione di Firenze, University of Firenze, via Sansone 1, 50019 Sesto Fiorentino, Firenze, Italy*

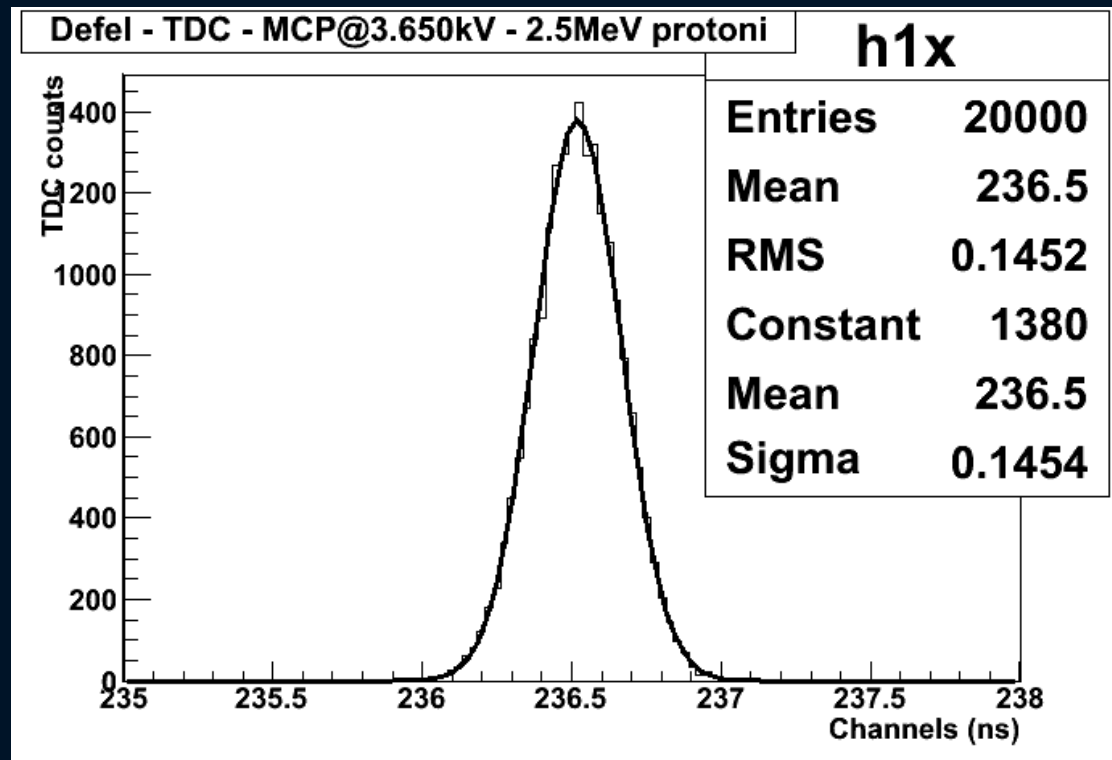


Electrostatic deflector  
beamline  
(pulsed beam facility)

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

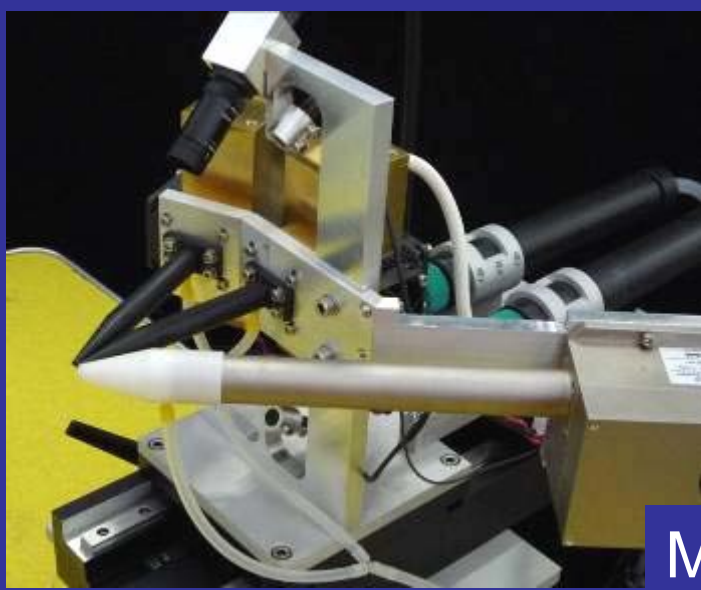


# *Time definition of beam bunches*





# The transportable XRF spectrometer



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

Controller

Measurement head

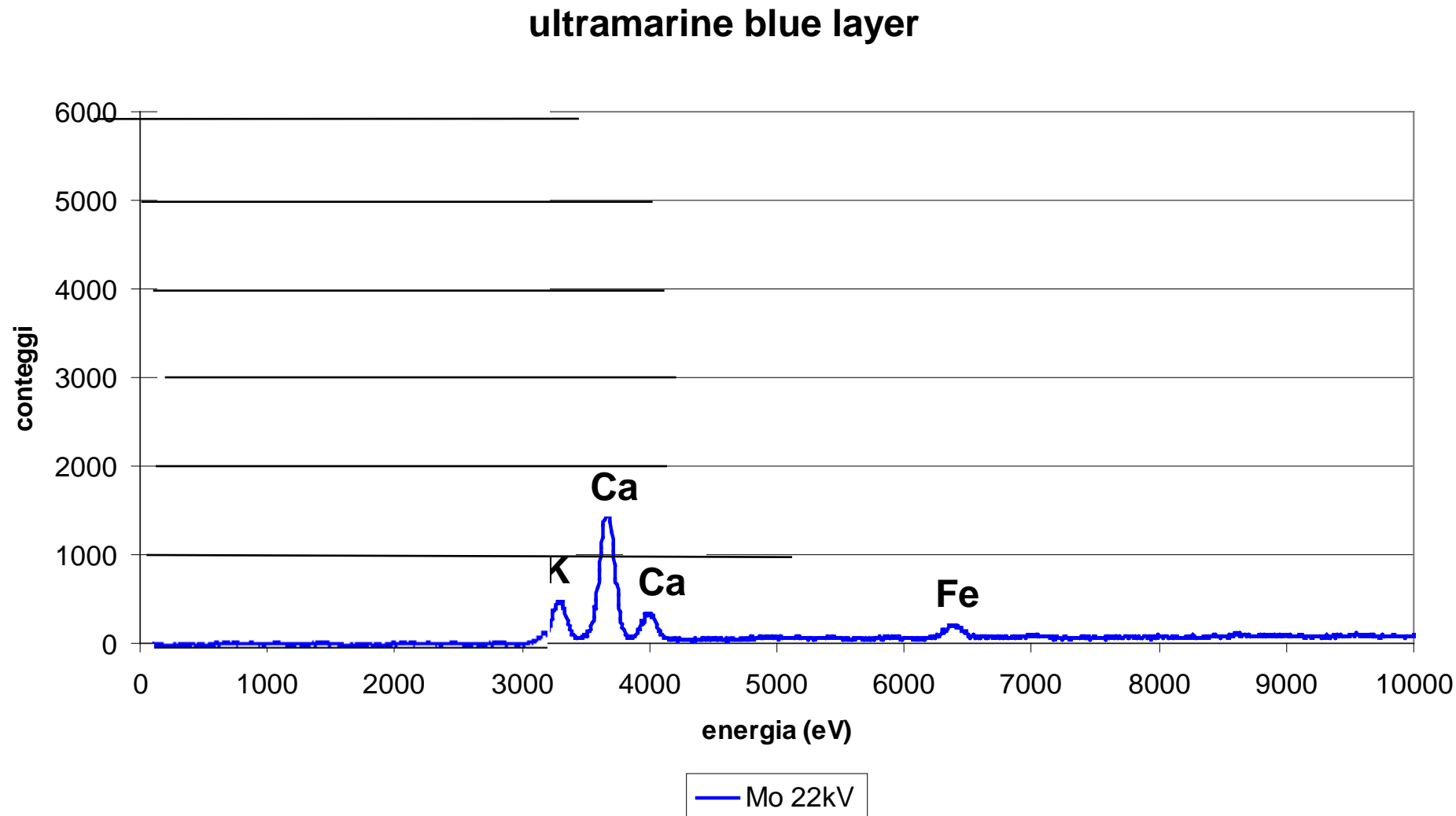
**2 X ray tubes** (30 kV max, 1 mA max) with different anodes: **Mo, Ti and W**

- interchangeable collimators; **typical beam diameter 0.5 mm**
- SDD detector (active area 10 mm<sup>2</sup>, 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



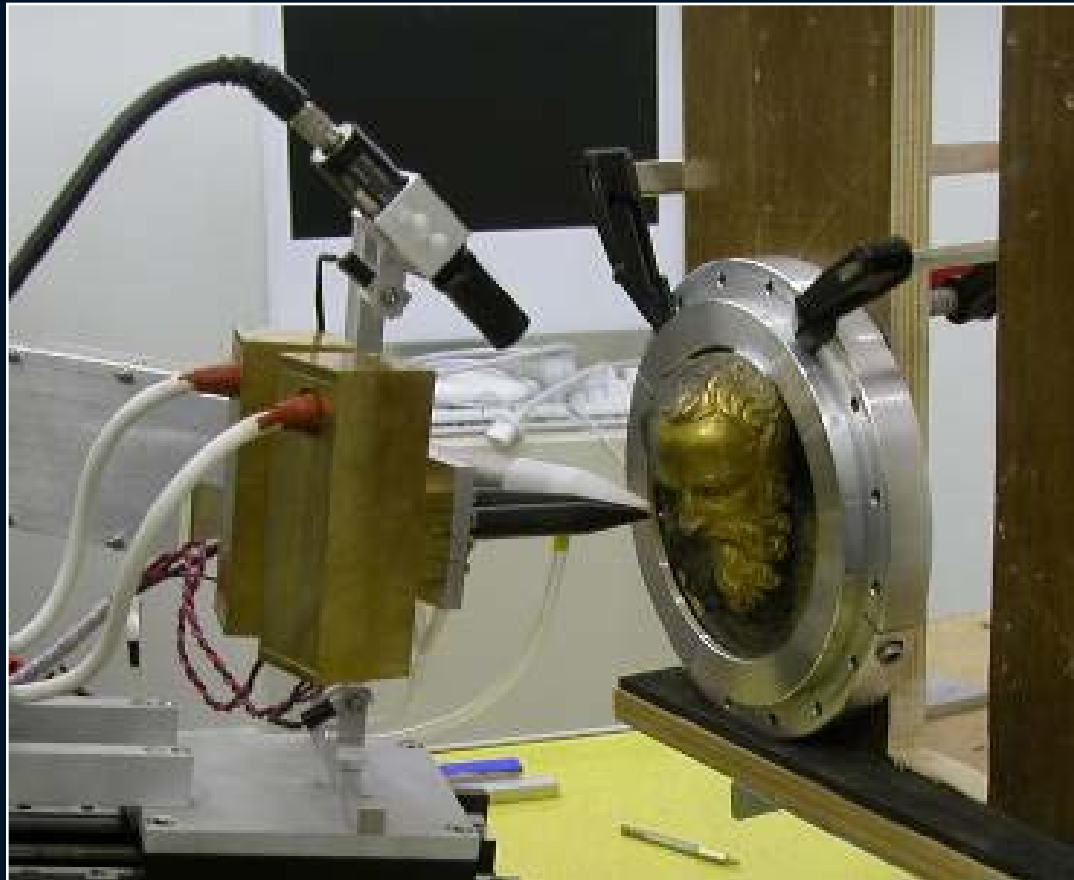
# Ultramarine blue layer on chalk

## 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 :

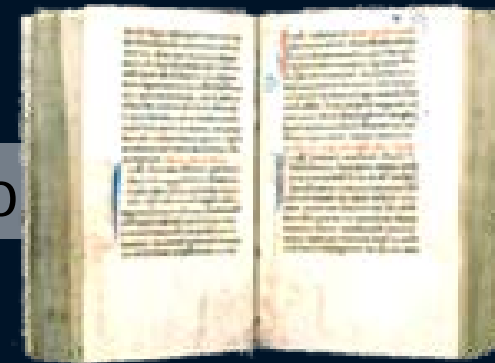


The frok; according to tradition, the one used to cover the Saint's body at the moment of his death.



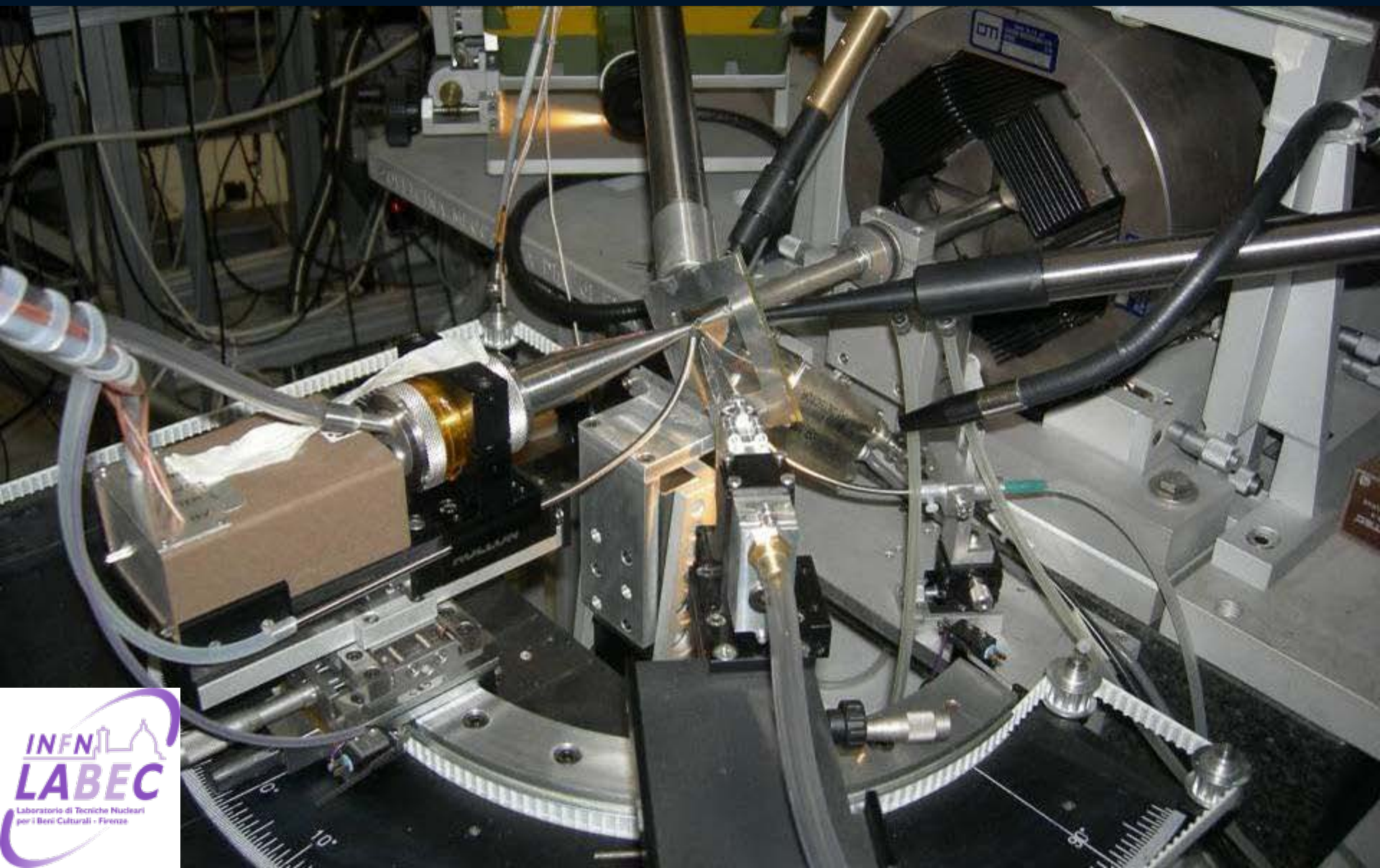
A pillow, *on which tradition tells St. Francis was leaning his head while passing away*

un evangelario

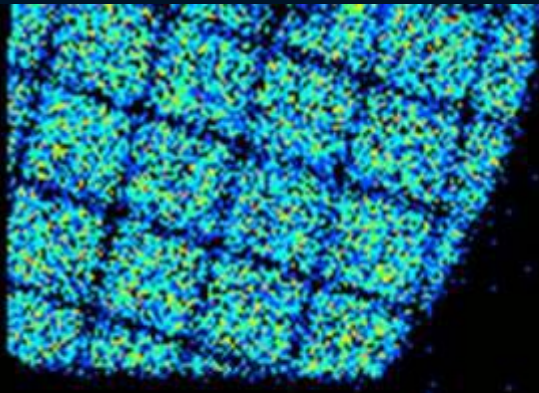




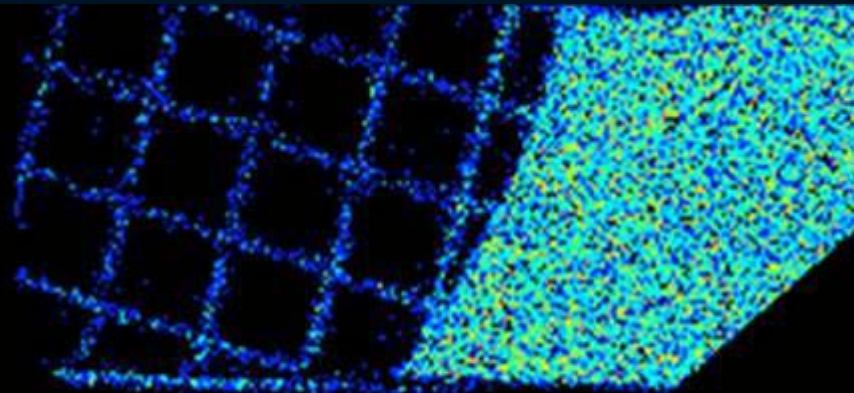
# External STIM set-up



# STIM of a thin copper grid



map of higher-energy  
transmitted protons



map of lower-energy  
transmitted protons