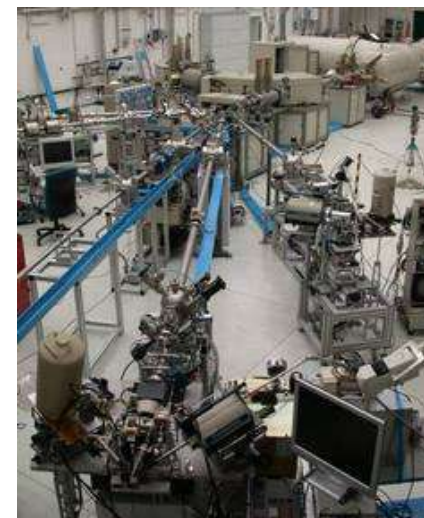
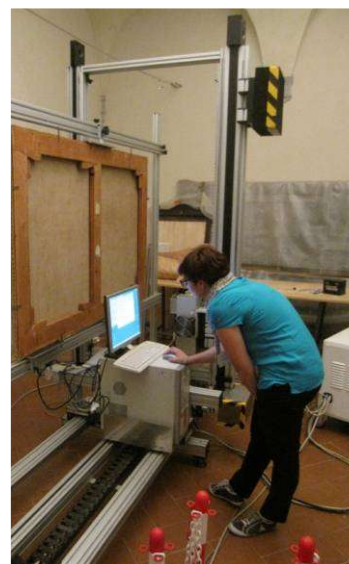
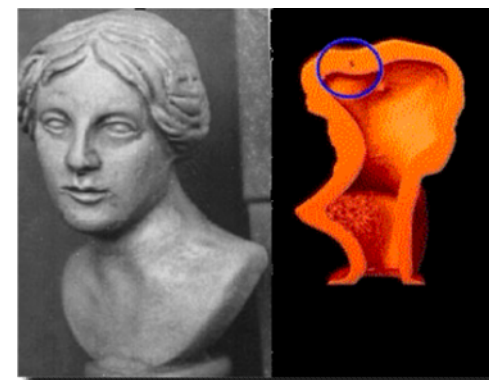


Workshop on basic research and interdisciplinary applications with small accelerators



Istituto Nazionale di Fisica Nucleare
Cultural Heritage Network



Francesco Taccetti

INFN-CHNet

Napoli 17/01/2018

- **INFN-CHNet: Origini e Missione**
- **Attività**
- **Struttura in nodi**
- **Attività con acceleratori**
 - **Misure in ambito bbcc *dirette***
 - **Misure in ambito bbcc *indirette***
 - **Altre misure collegate ai bbcc**
- **Il nodo Campano, CHNet ed E-RIHS**

Delibera CD 14886 21/Luglio/2017

CNTT 12/Settembre/2017



INFN-CHNet è una rete INFN distribuita monitorata dal CNTT

- **Interoperabilità di strumentazione e personale**

Strumentazione: definire linee guida per sviluppo di strumentazione di rete

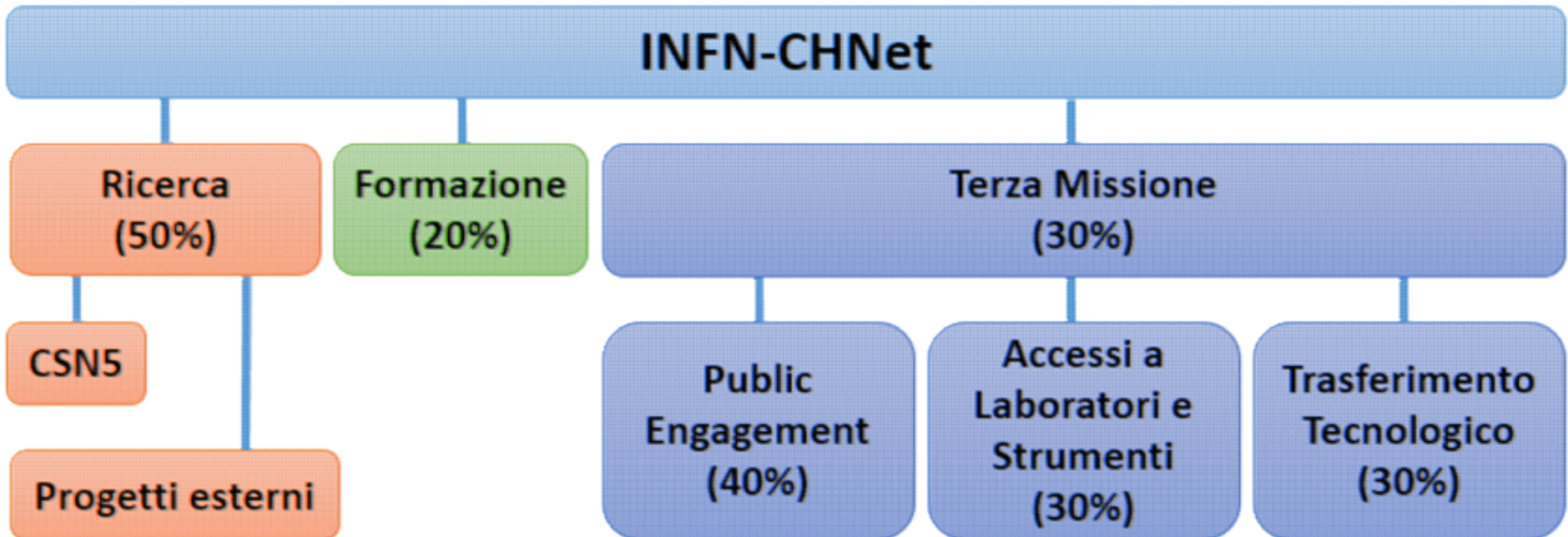
Competenze: mobilità delle conoscenze e/o dei ricercatori all'interno della rete

- **Partecipazione congiunta a bandi** o iniziative su scala internazionale, nazionale o locale.

- **Interazione con gli altri attori del panorama italiano** dello studio e diagnostica sui beni culturali, in particolare nell'ambito del nodo italiano dell'infrastruttura europea E-RIHS, entrata nella sua preparatory phase nel 2016, a cui INFN partecipa proprio attraverso CHNet.

- **Diffusione e valorizzazione dei risultati** delle attività della rete attraverso sito web, social networks, eventi divulgativi e piattaforme digitali per la fruizione dei dati.

- **Internazionalizzazione** della rete per creare una struttura che possa integrarsi facilmente in un'eventuale infrastruttura globale GRI

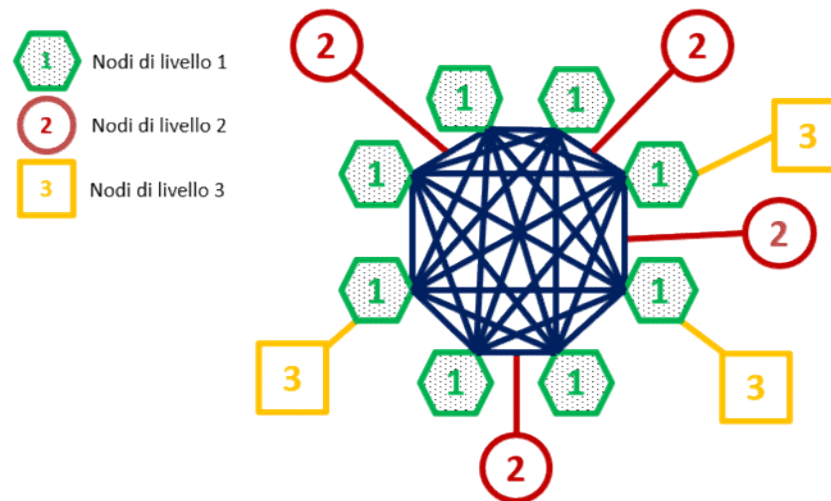


CHNet è allo stesso tempo una rete di ricerca e un'infrastruttura di servizio

Allargamento della rete a università, centri di restauro e centri di ricerca scientifica all'estero (fuori dall'Europa)

 **Rete multidisciplinare e internazionale**

Oggi la struttura della rete viene così a essere composta da tre livelli, caratterizzati da vincoli diversi nei confronti dell'INFN



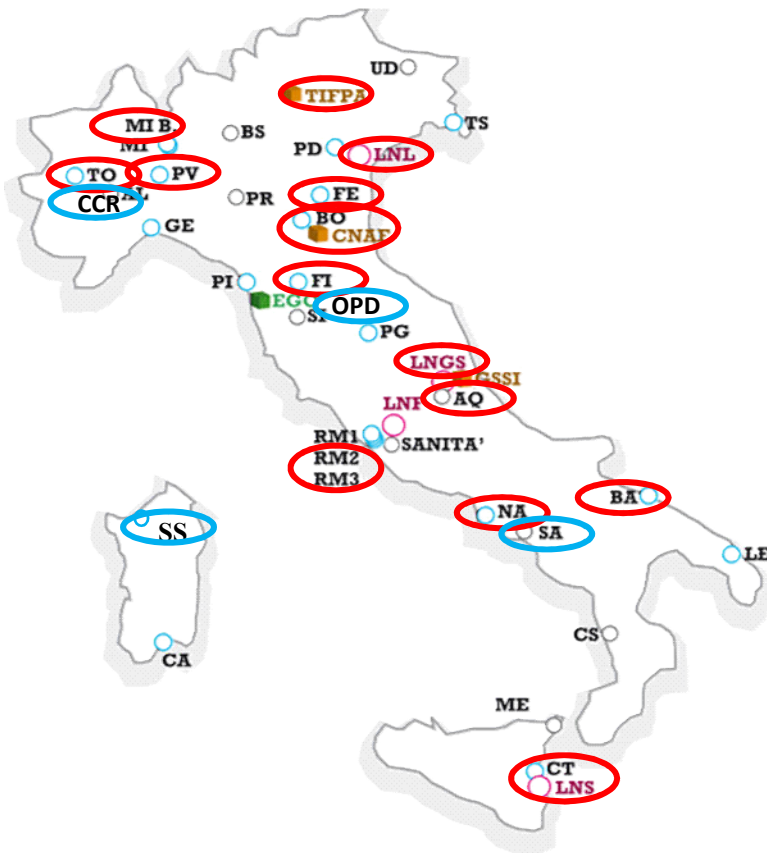
La rete nazionale

Nodi di livello 1:

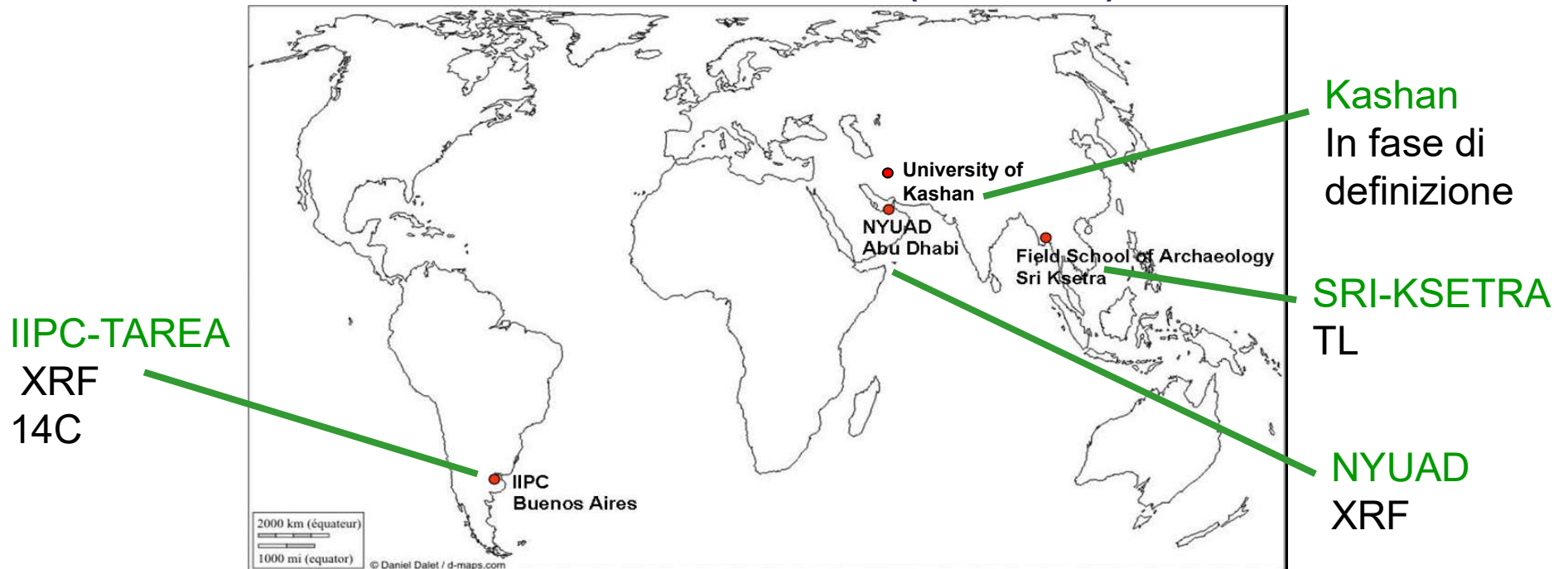
Nodi della rete interna, basati su personale dipendente o associato e strumentazione operante in Strutture INFN.

Nodi di livello 2:

Università, centri di restauro, associazioni, etc. Soggetti non direttamente afferenti a Strutture INFN che vogliono partecipare ad attività comuni, afferendo alla rete attraverso specifiche convenzioni. Possono essere anche soggetti con competenze esclusivamente nel campo umanistico, della conservazione e del restauro.



La rete internazionale (nodi attivi)



Nodi di livello 3:

Soggetti esteri (esclusivamente università e centri di ricerca) che vogliono partecipare ad attività comuni e aderiscono alla rete attraverso convenzioni. Ogni nodo di livello 3 è agganciato ad una struttura di livello 1.

Ogni nodo di livello 3 può creare una rete locale, aggregando nel proprio Paese organismi con competenze scientifiche e umanistiche nel settore → GRI

Sansepolcro 2014, L'Aquila 2015, Siracusa 2016, Alghero 2017



- Corsi di circa una settimana
- 20/30 partecipanti fra scienziati/umanisti/restauratori
- Laboratori pratici in gruppi multidisciplinari di 5-6 persone
- Strumentazione e docenti da CNR, INFN, ENEA, OPD

Qualche numero sui partecipanti di Siracusa:



7
Restauratori



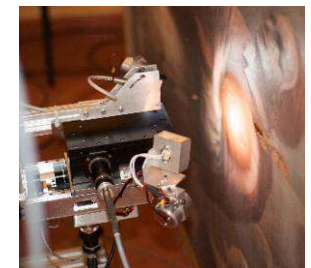
5
Storici dell'arte
Archeologi



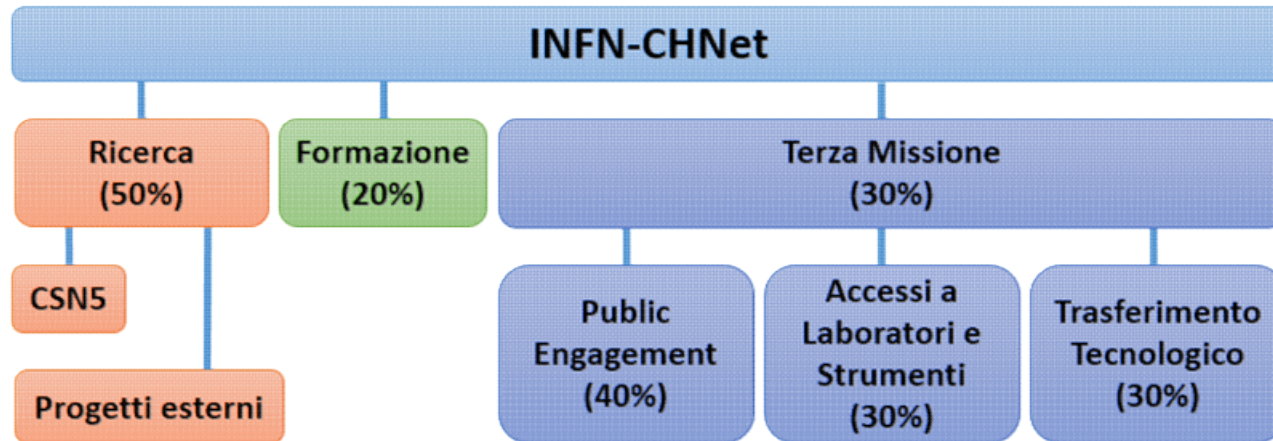
5
Chimici, Fisici,
Scienziati dei Materiali



7
Scienziati per la
conservazione
dei Beni Culturali



**4 gruppi
MULTIDISCIPLINARI**



- Accesso ad enti pubblici attraverso accordi



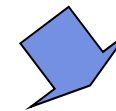
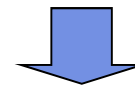
VERSO L'ACCORDO CON LA FONDAZIONE VULCI

- Call di E-RIHS.it

Accesso a soggetti pubblici o privati attraverso la partecipazione a un bando finanziato dal MIUR



Il Trittico Fiammingo della Chiesa Madre di Polizzi Generosa (PA)

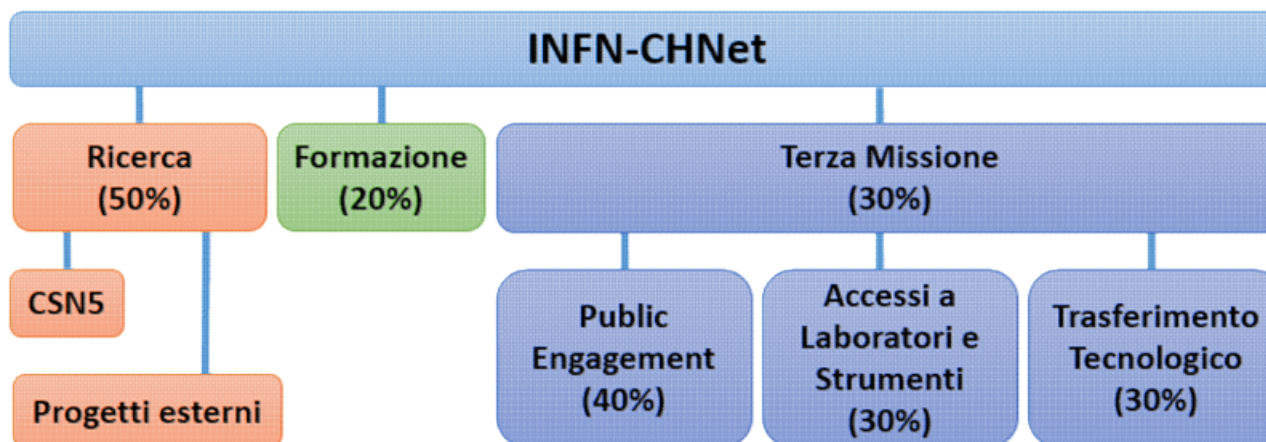


- Ricerca collaborativa commissionata
- Conto terzi

Verso un tariffario unico di servizi da parte dei laboratori di rete...



Il Mosaico di Alessandro nel Museo Archeologico di Napoli



- Eventi, mostre, apertura di laboratori



IL PROSSIMO FINE SETTIMANA È ARTE E()
SCIENZA 2016



CHI HA DETTO CHE SCIENZA E BIRRA NON VANNO D'ACCORDO?

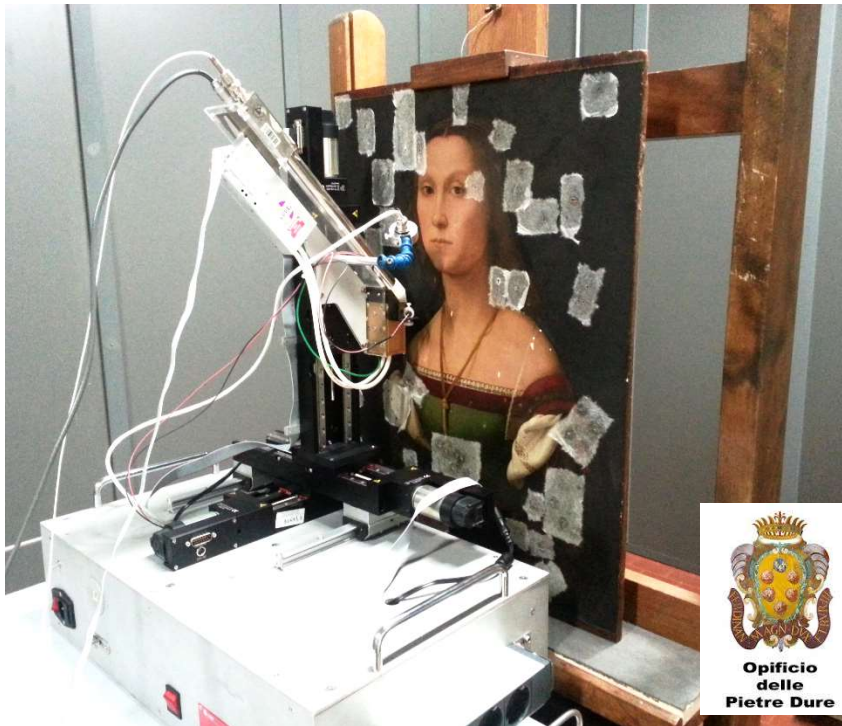
rechnet / maggio 8, 2017 / Leave a comment / Divulgazione

CHNet partecipa all'evento internazionale "Pint of Science", l'iniziativa che porta nei bar alcuni dei più brillanti ricercatori per discutere le loro ultime ricerche e scoperte direttamente con il pubblico. In Italia il festival avrà luogo il 15-16-17 Maggio 2017 per raccontare, sorseggiando una buona birra, le novità della ricerca a chiunque ne sia interessato.

Quando possibile
organizzazione
congiunta da parte
di più nodi della
rete

La strumentazione sviluppata dalla rete è testata presso i centri di restauro della rete

Opificio delle Pietre Dure, Fi



XRF scanner



CCR La Venaria reale, To



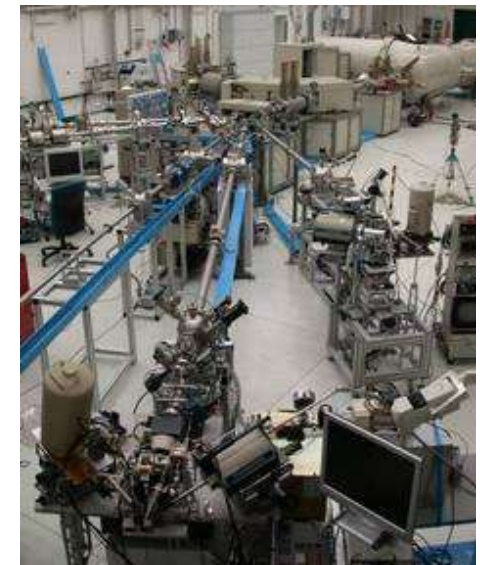
Tomografia

La Venaria Reale



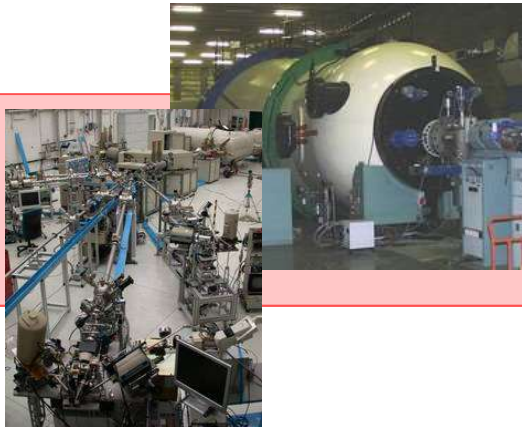
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Cultural Heritage Network

Le piattaforme e le competenze



FIXLAB

Medium-large scale facilities (IBA, ^{14}C , ...)



TL dating



X-ray imaging



Mass Spectrometry



X-ray imaging



MOLAB

Thermography



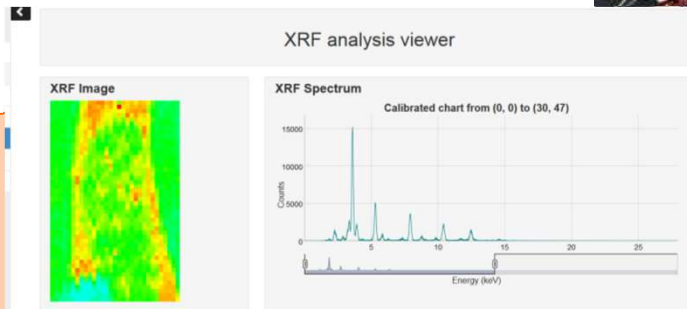
XRD

XRF



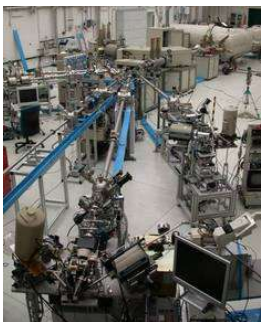
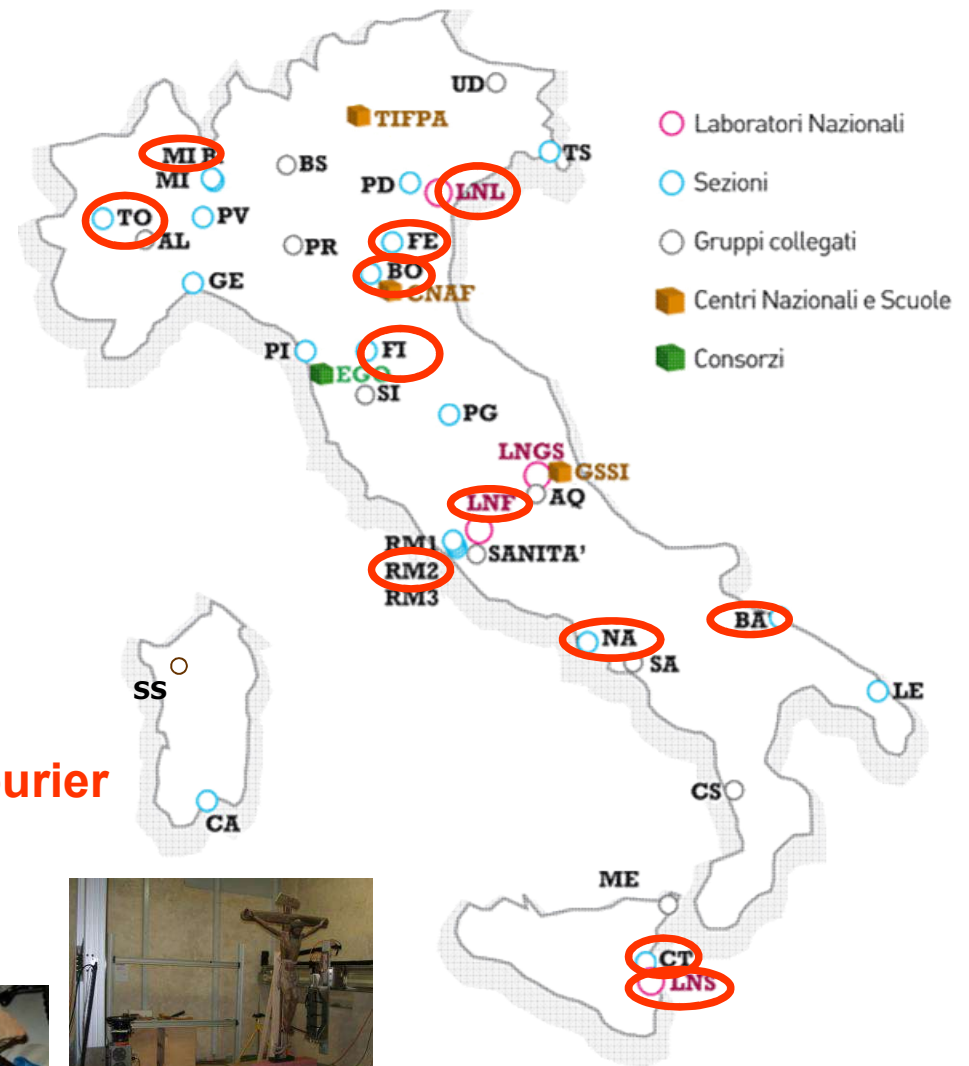
DIGILAB

Web tool for data fruition

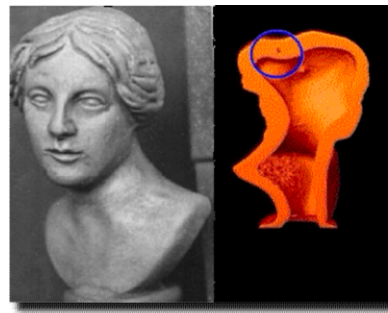
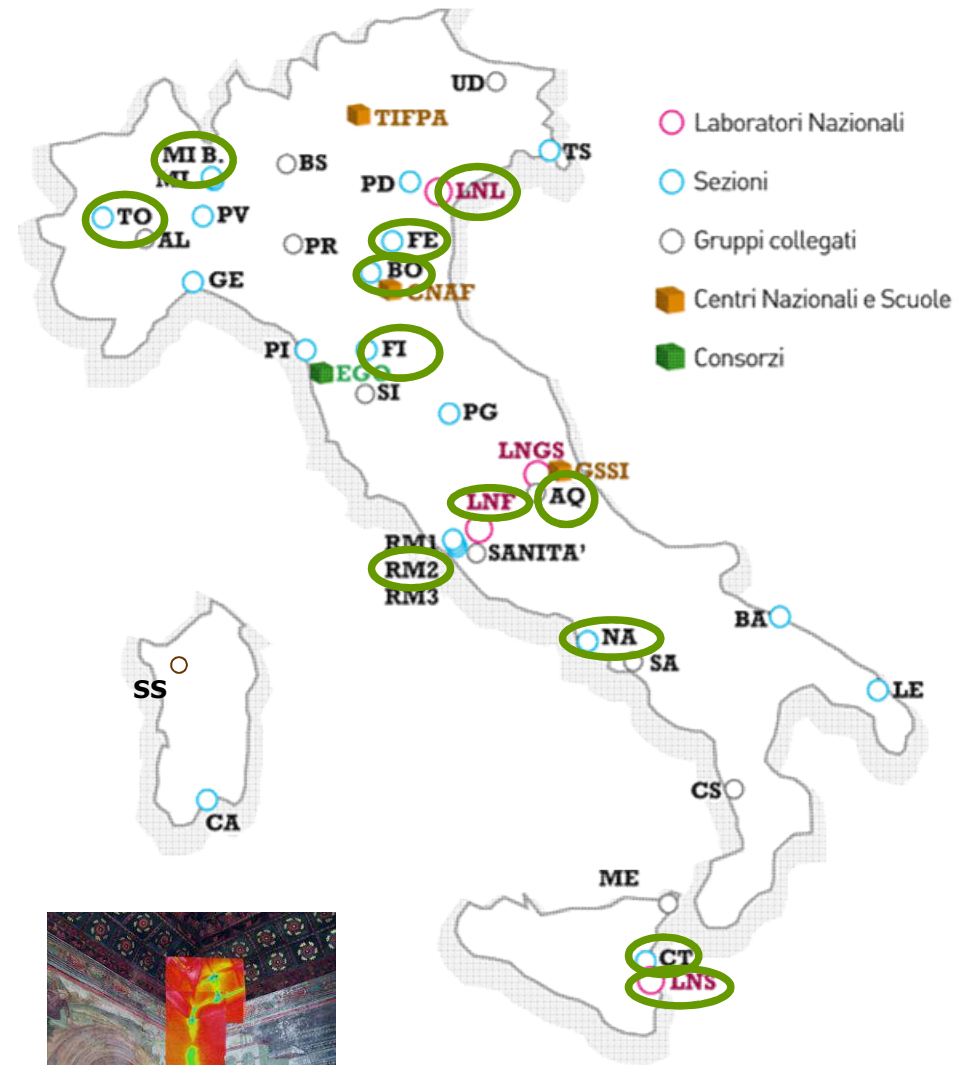


Data Storage and fruition

- Analisi con fasci ionici (IBA)
- Datazioni con radiocarbonio
- Datazioni con Termoluminescenza o Luminescenza Otticamente Stimolata
- Radiografia
- Tomografia
- Misura di rapporti isotopici
- Tof-SIMS
- Fluorescenza indotta da Laser (LIF) risolta in tempo
- Raman
- Spettroscopia IR in trasformata di Fourier



- Fluorescenza a raggi X (XRF)
- Diffrazione a raggi X (XRD)
- PIXE-alfa
- Radiografia
- Tomografia
- Termografia
- Raman
- Colorimetria
- Imaging multispettrale




Soluzioni per la fruizione dei dati

Creazione di una repository per i dati provenienti da misure eseguite presso i centri di restauro e dalle call

Server-side tools per la parte di analisi dati

Autenticazione per l'accesso attraverso IDEM



INFN
CHNet
Istituto Nazionale di Fisica Nucleare
Cultural Heritage Network

Welcome to **chnet**

Username

Password

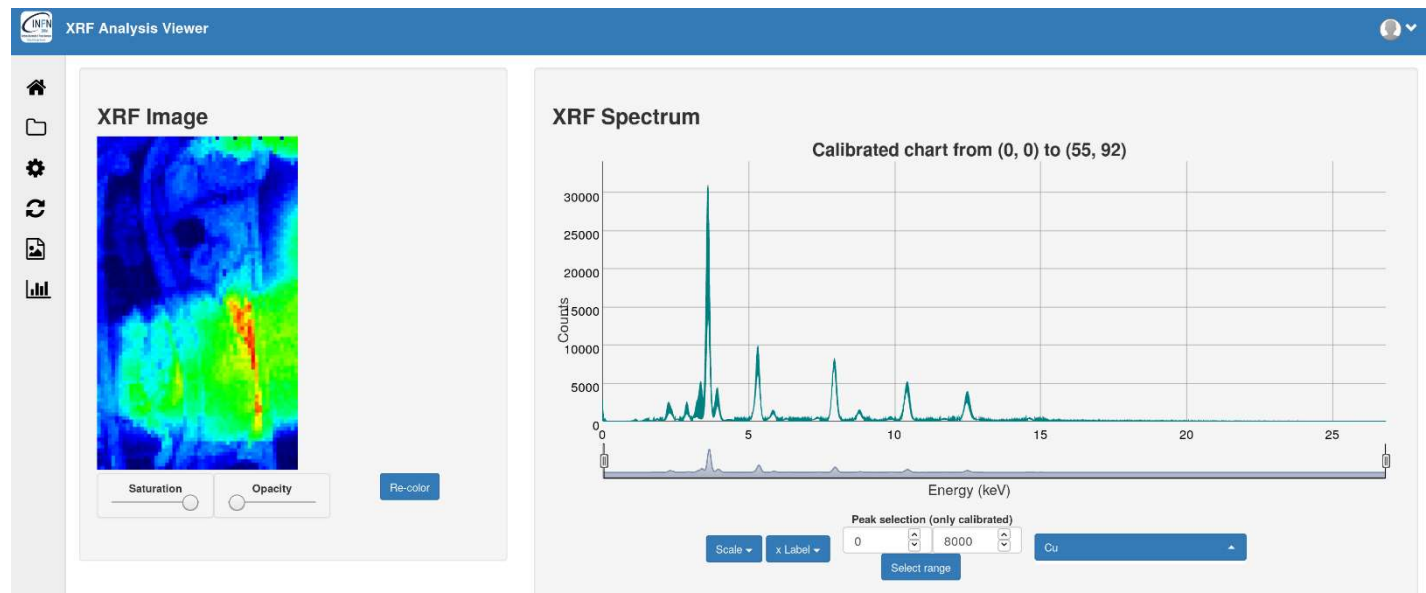
Sign in

[Forgot your password?](#)

[Sign in with IDEM](#)

[Register a new account](#)

[Privacy policy](#)



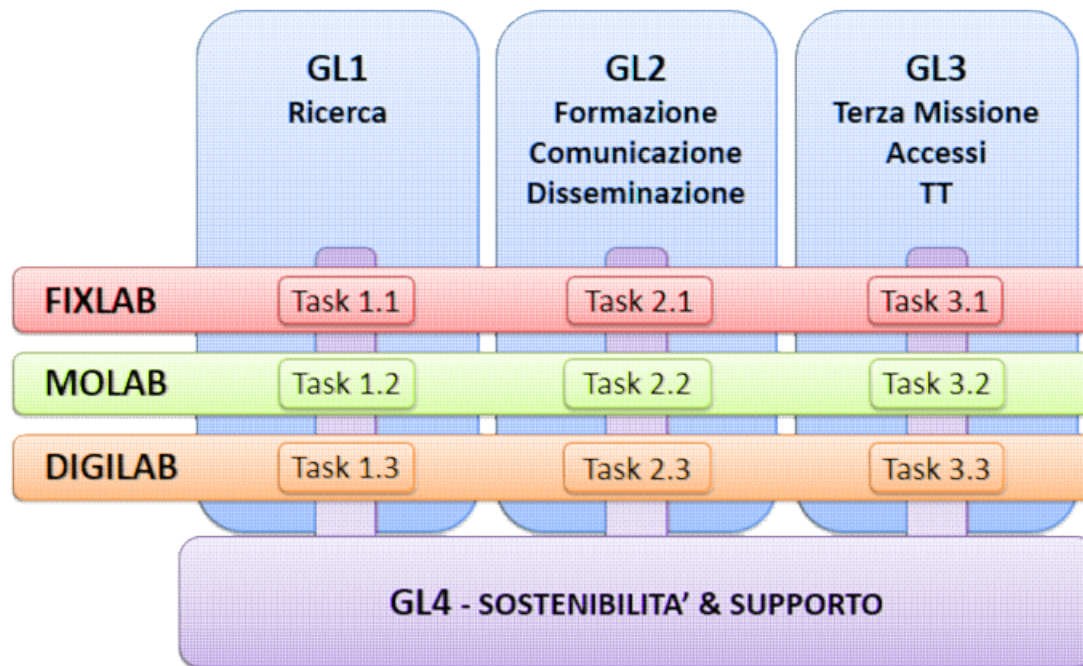
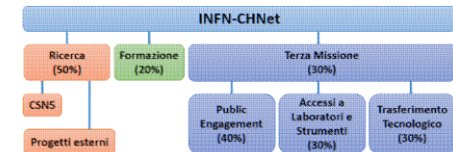


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Cultural Heritage Network

Struttura interna della rete

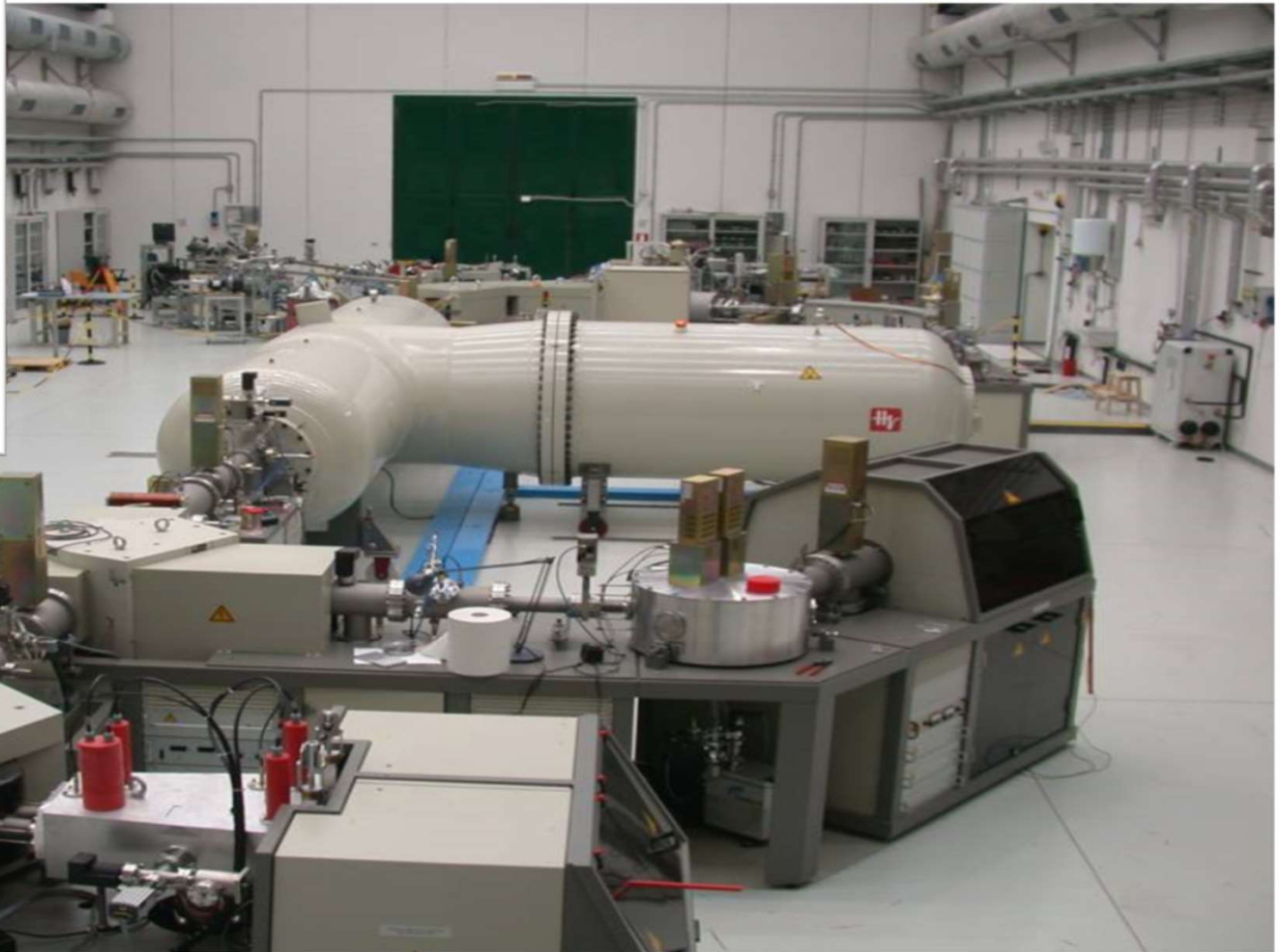


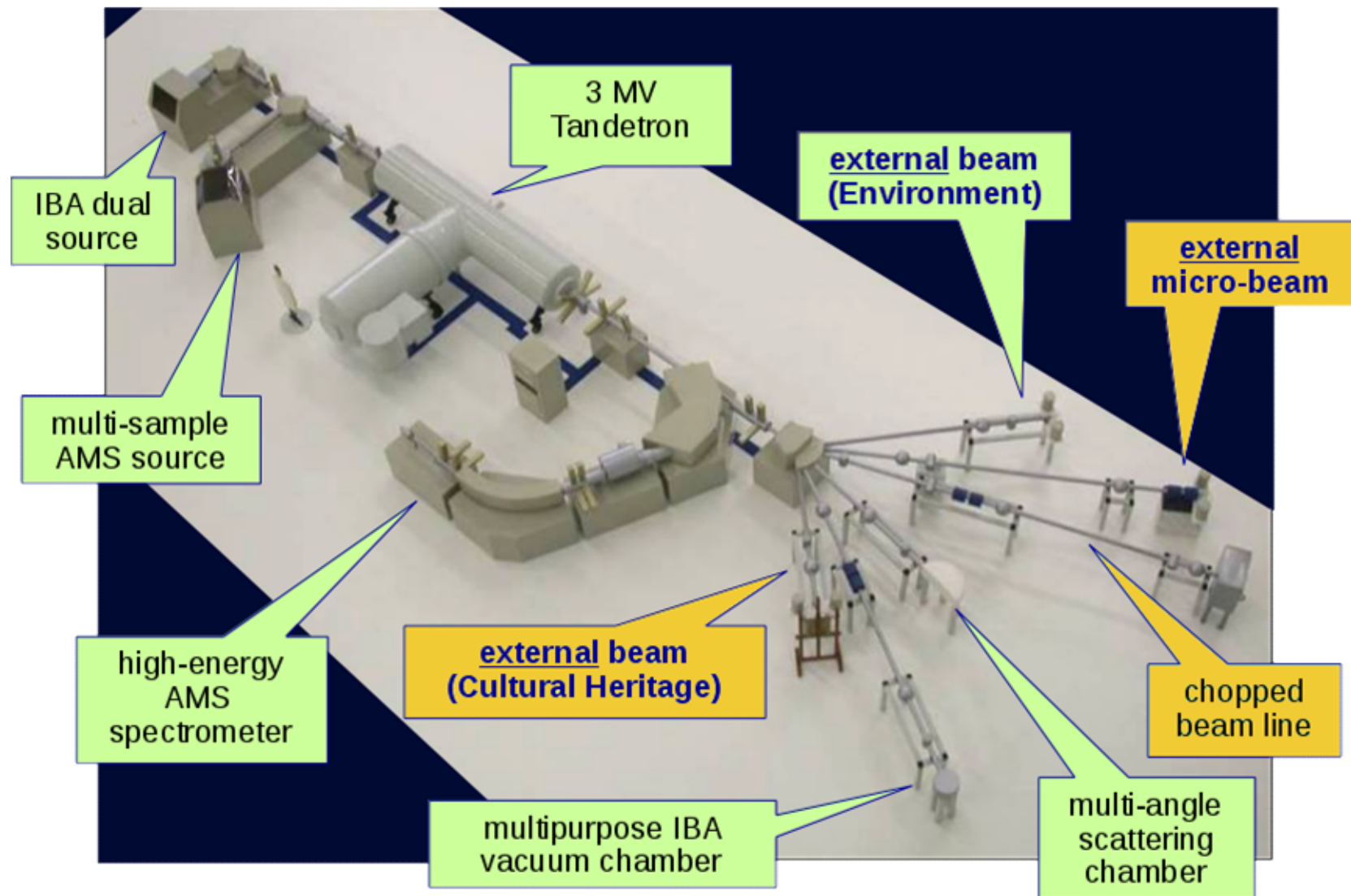
Tre Gruppi di Lavoro che seguono le diverse attività della rete



Infrastruttura di ricerca
→ Suddivisione in
laboratori fissi, mobili e
digitali

Un Gruppo di Lavoro che offre supporto amministrativo e suggerisce possibili fonti di finanziamento per le attività dei Gruppi di Lavoro



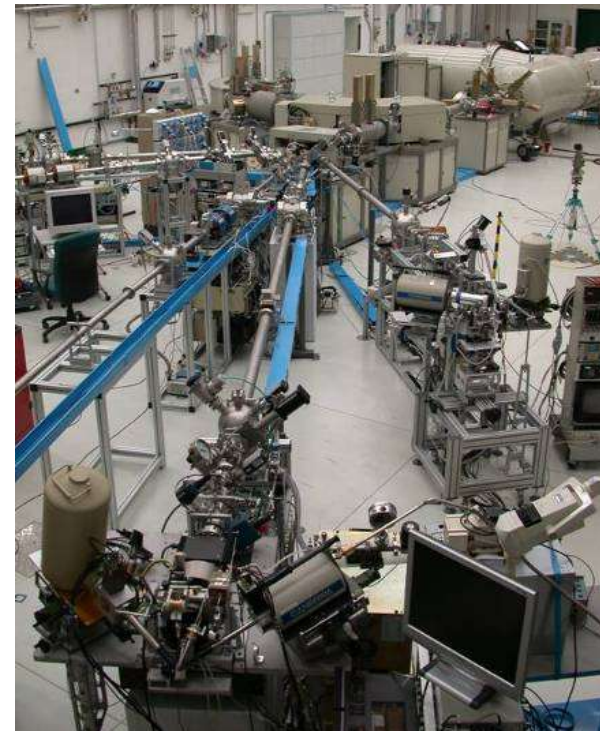


Ion Beam Analysis

beam size defined by collimation
(\varnothing 0.2 ÷ 1 mm)



strong focusing system, quadrupole
doublet (\varnothing 8÷10)



Typical working conditions for Cultural Heritage studies

External beam

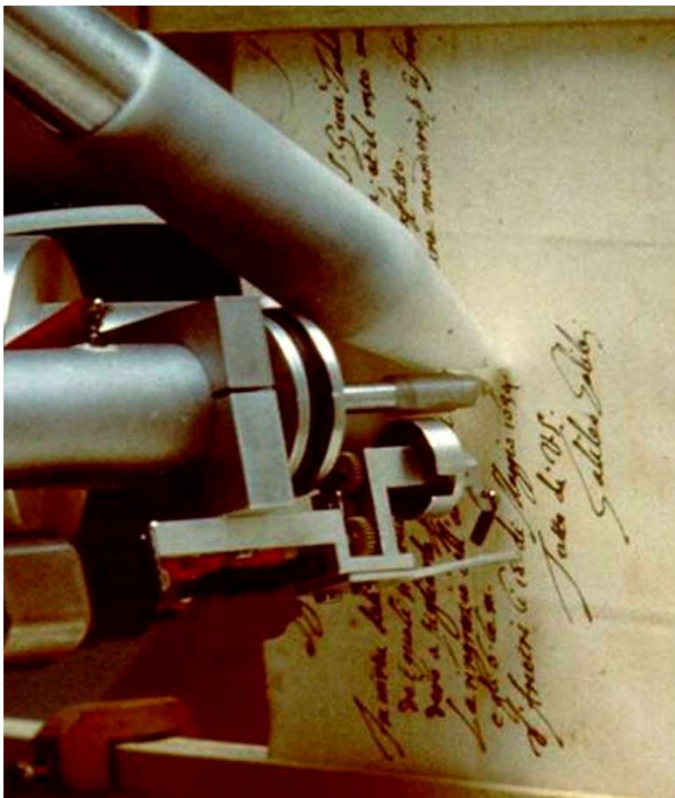
Beam size 10 μ m to 1 mm

Protons 0.7 ÷ 5.5 MeV

Beam currents from a few pA to 100-200 pA

Ion Beam Analysis

Analysis of documents of historical interest



PIXE measurements to quantitatively determine ancient inks composition

Important contribution to the chronological reconstruction of Galileo's hand-written notes about motion

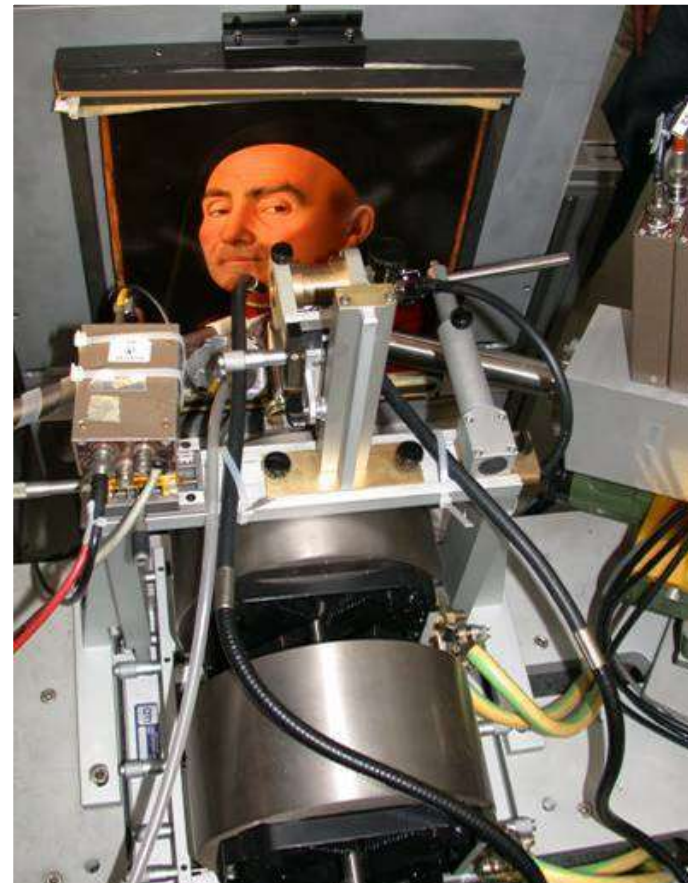
Comparison of ink composition in the notes (which are not dated) with that in dated documents (letters, etc.)

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

Ion Beam Analysis ...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*

Blue areas (I)

- Paint layer

- Co → cobalt blue (cobalt aluminate, $\text{CoO} \cdot \text{Al}_2\text{O}_3$)
- Zn → zinc white (ZnO)

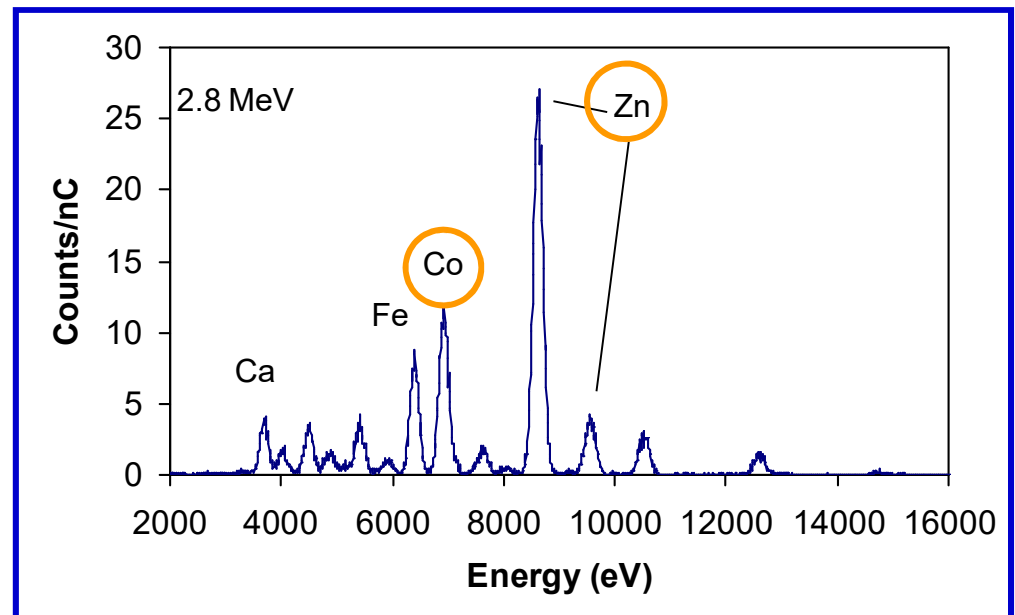
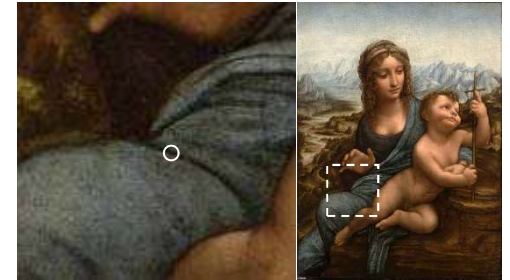


Pigments used only since the beginning of XIX century



RESTORED AREAS

(mainly in the mantle of the Virgin)

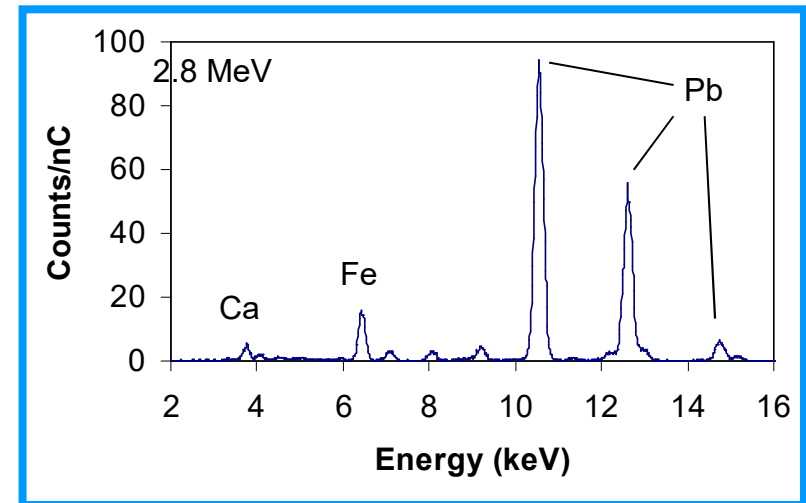


– *Ca and Fe from the varnish*

Blue areas (II)



- In other blue areas the **PIXE** analysis revealed:
 - large amount of **Pb** → lead white
 - no elements characterizing a blue pigment (such as Cu for azurite)



- Identification of lapis-lazuli through **PIGE** by detecting **Na** 440 keV **γ -rays** on the $^{23}\text{Na}(p,p'\gamma)$ reaction

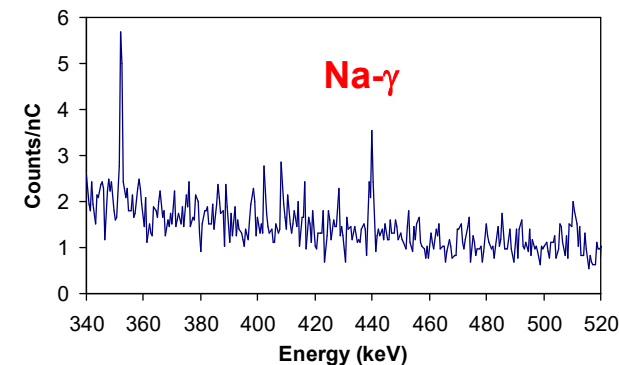
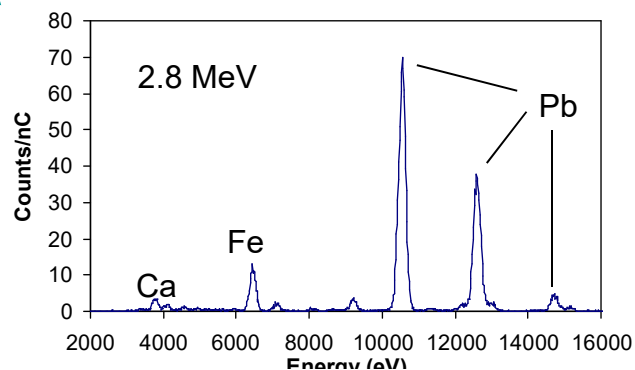
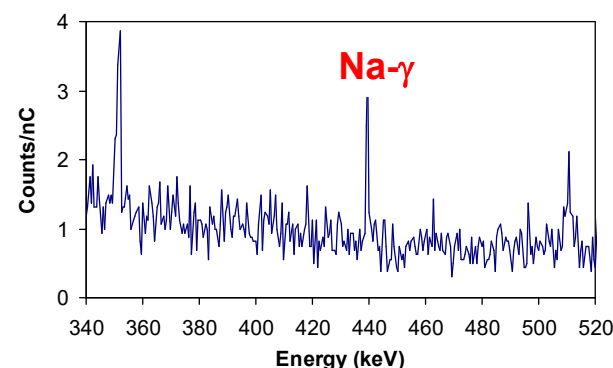
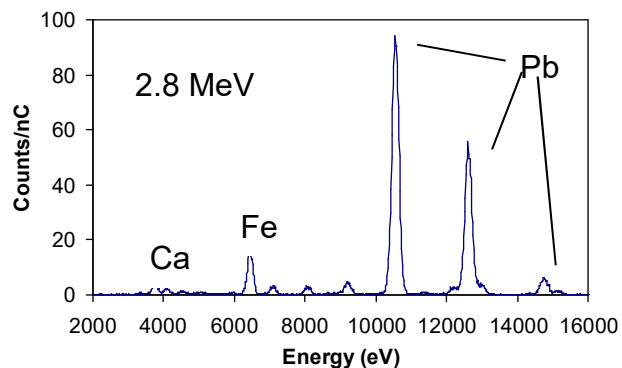
Lapis-lazuli → blue pigment produced with a semi-precious stone, main mineral lazurite, $3\text{Na}_2\text{O} \cdot 3\text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2 \cdot 2\text{Na}_2\text{S}$

- Na X-rays (~1 keV) completely absorbed by the varnish, as well as X-rays from the other light elements in lapis-lazuli

Original
blue area

*lapis-lazuli +
lead white*

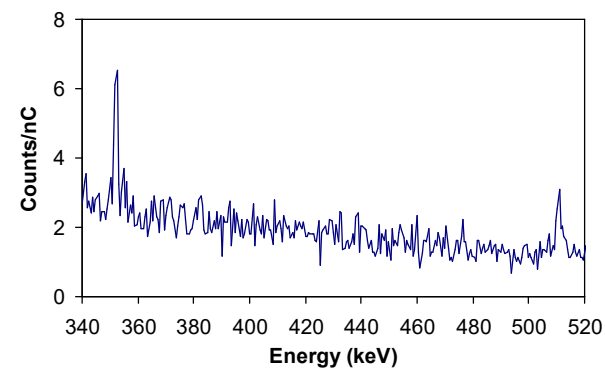
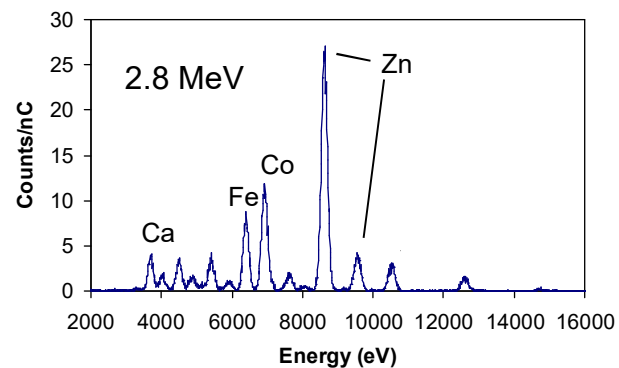
P
I
X
E



P
I
G
E

Restored
blue area

*cobalt blue +
zinc white*

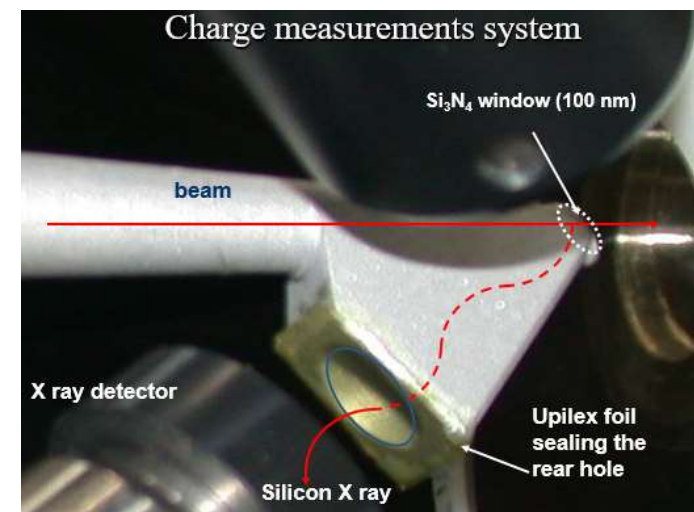
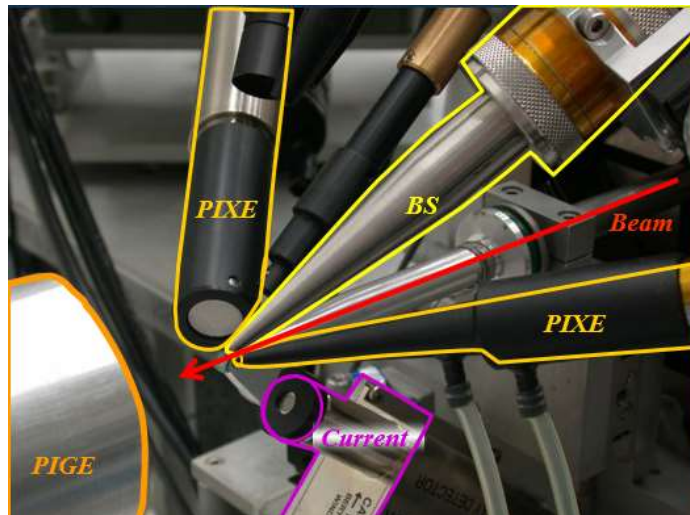
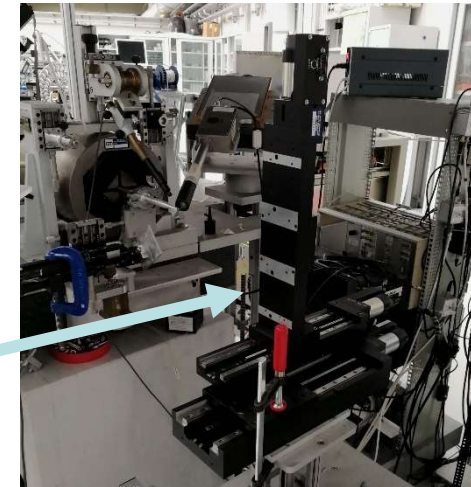


Doppio Sistema di scansione: scansione con fascio o scansione esterna
Setup di misura estremamente flessibili

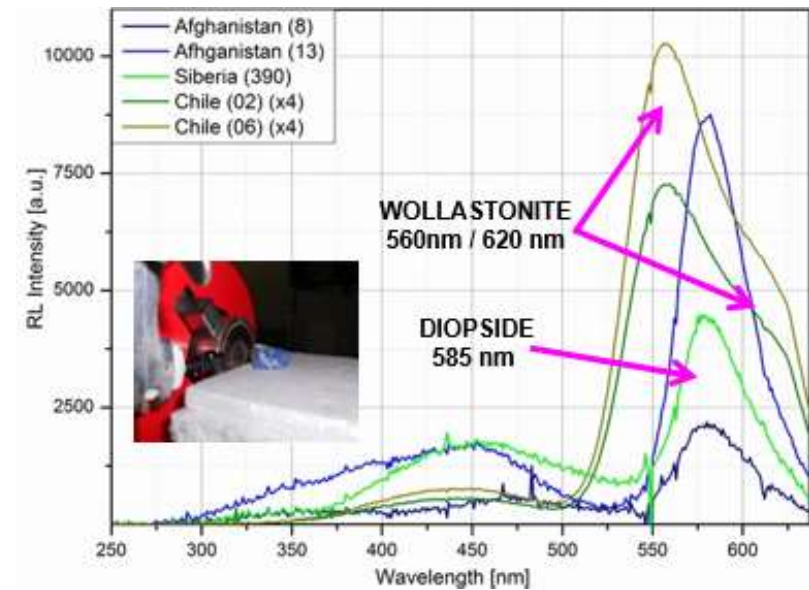
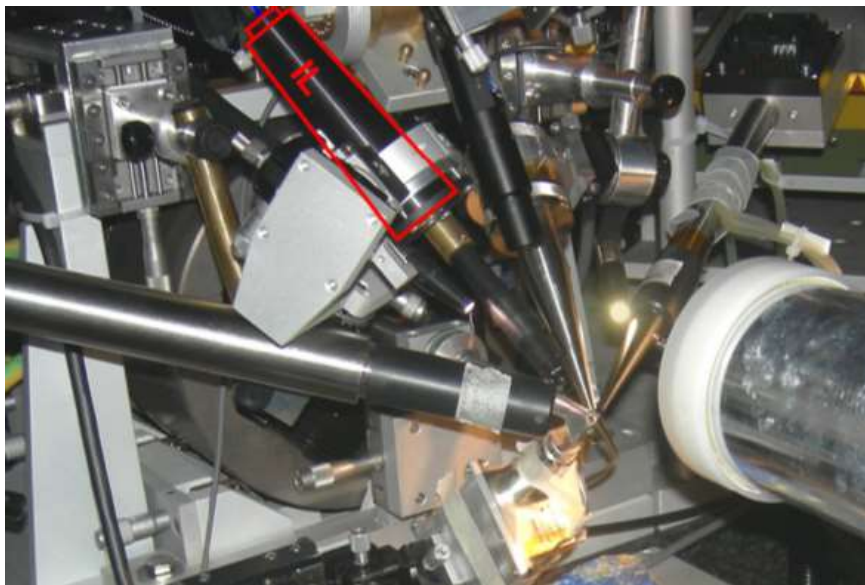
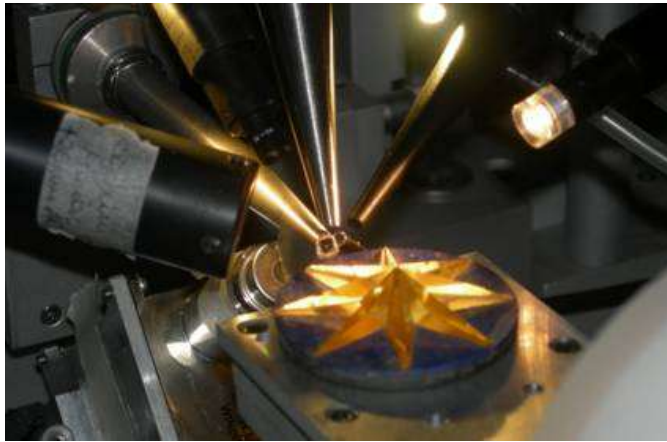
Fasci da 10 fA a uA

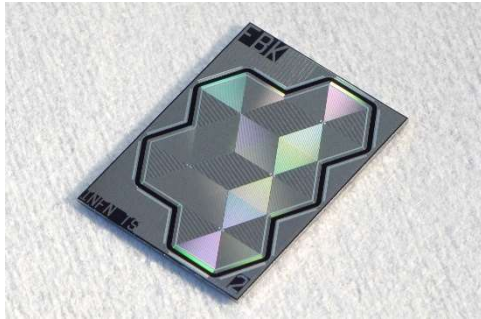
Scansione del fascio → aree di qualche mm²

Scansione del campione → aree fino a 20 cm x 20 cm

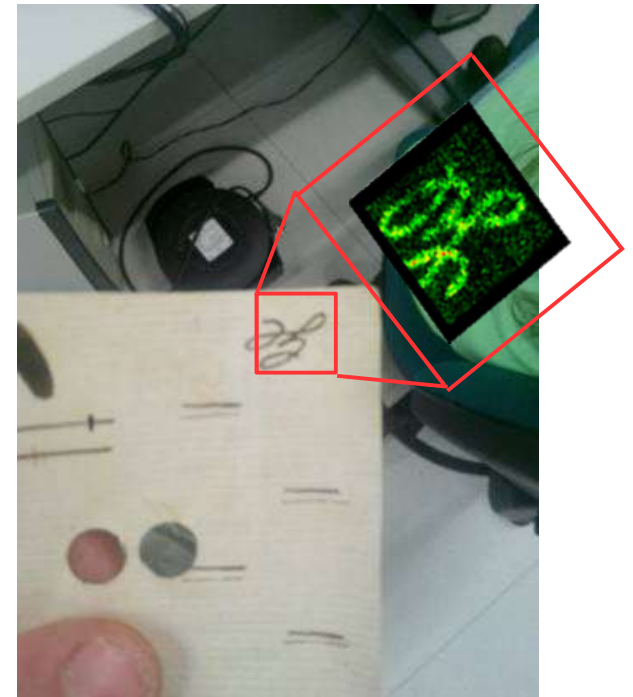
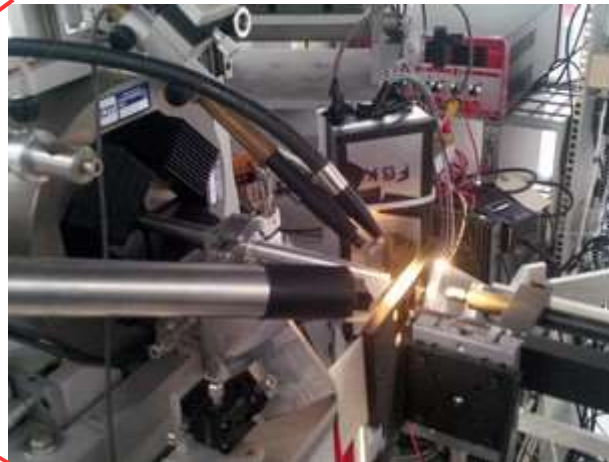
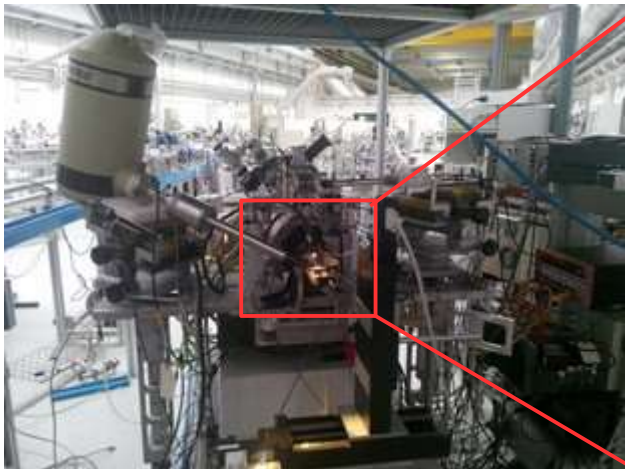


Studio di provenienza dei lapislazzuli





Fe map on a metallogallic ink - FBK detector
PCB INFN-Sidenet Trieste
External 3 MeV proton beam 0.2 mm diameter



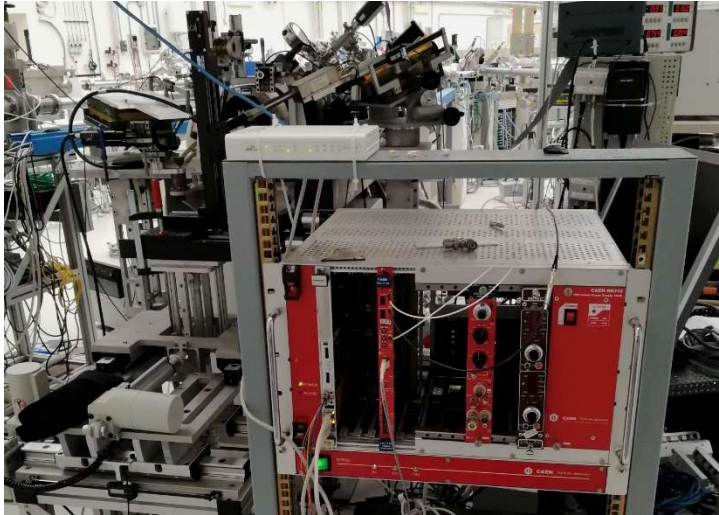
Caen digitizer DTS5780

Detector window: 2 aluminized Mylar layers (2um)

T = 20°

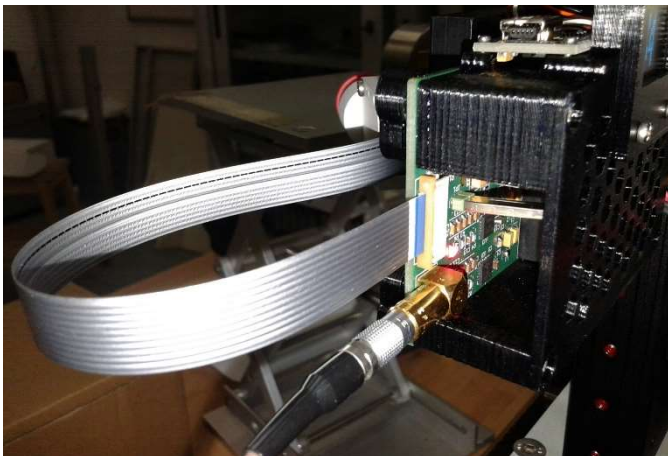
Open software

Canale di microfascio, scansione del campione

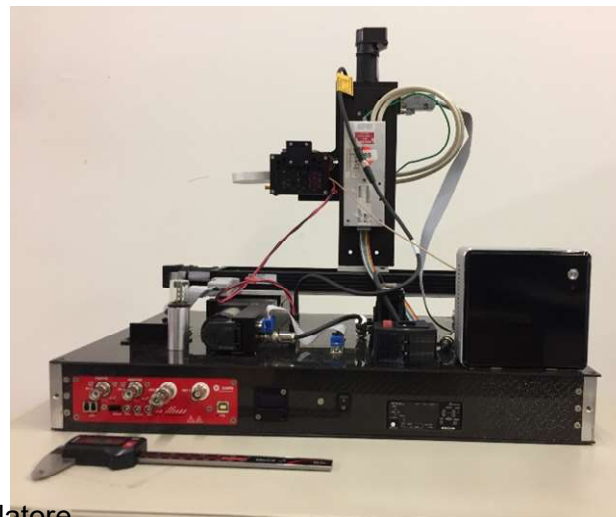


- Motori P. I. gestiti da un programma sviluppato dai nostri laboratori
- Segnale del rivelatore inviato a un digitalizzatore CAEN e gestito dal nostro software di acquisizione

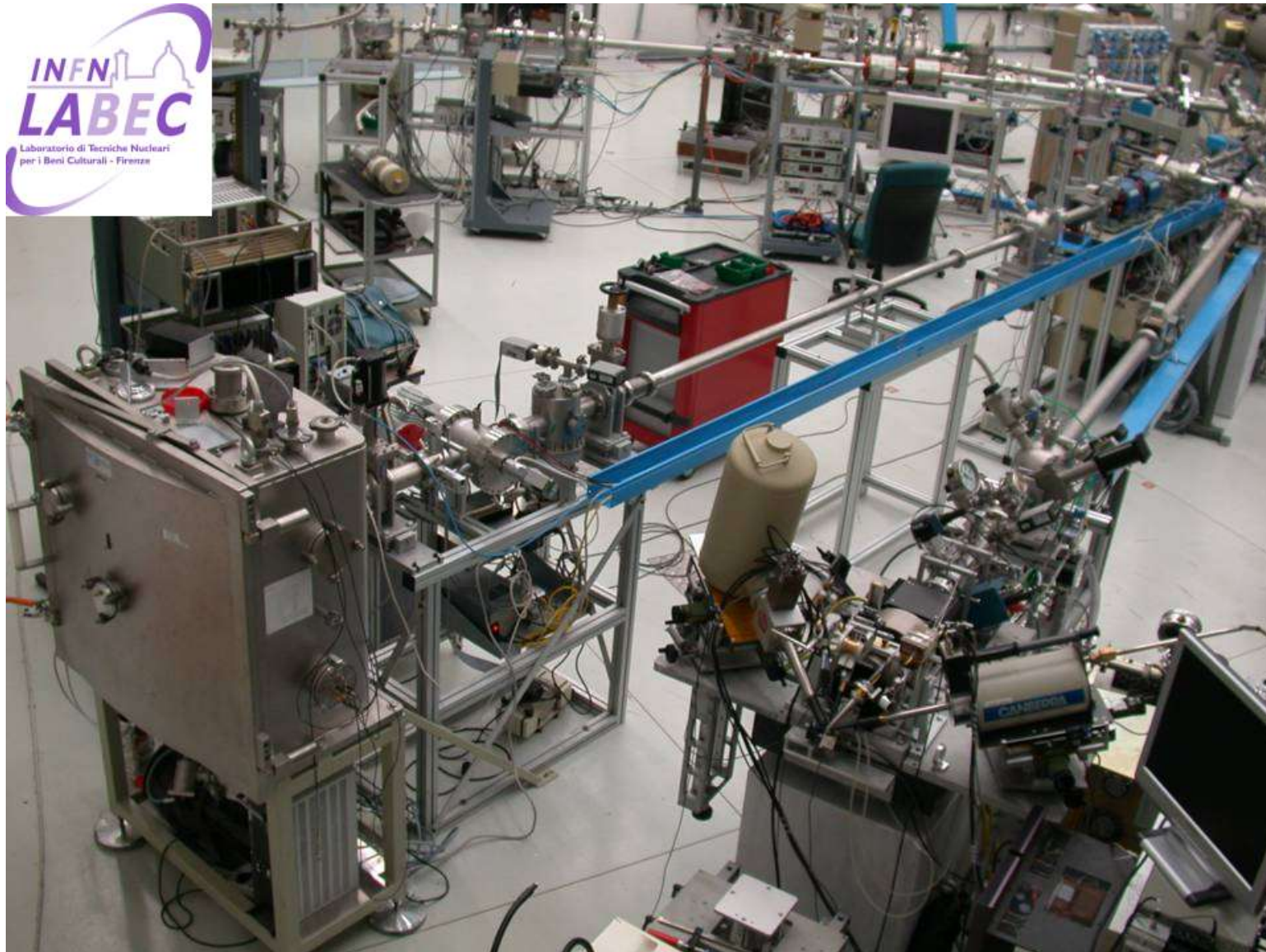
Scanner XRF progettato dai laboratori di CHNet



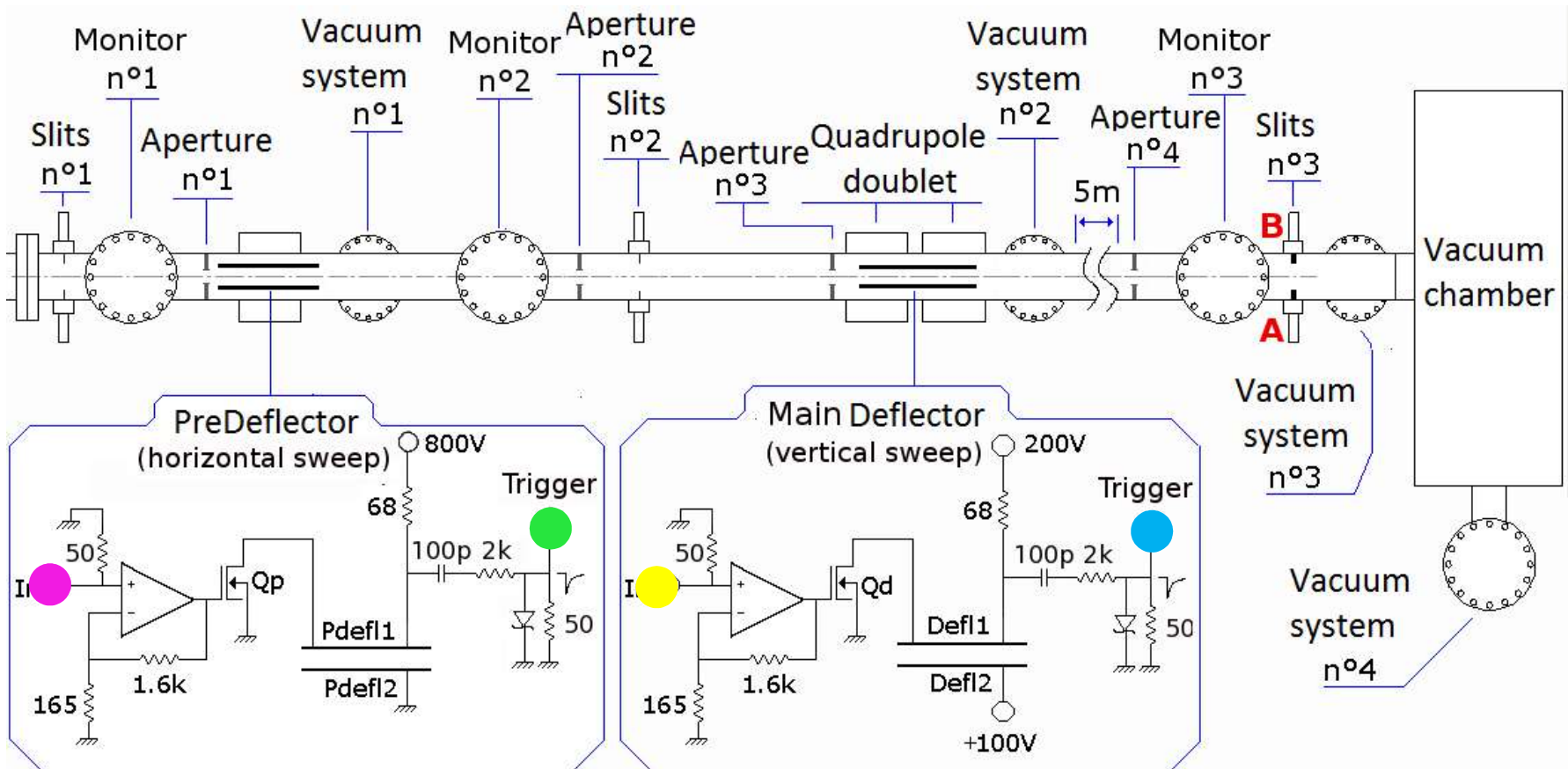
Scheda home made per raffreddamento Peltier del rivelatore



- Stessi motori, analogo digitalizzatore e stesso software usato per la scansione sul canale del fascio

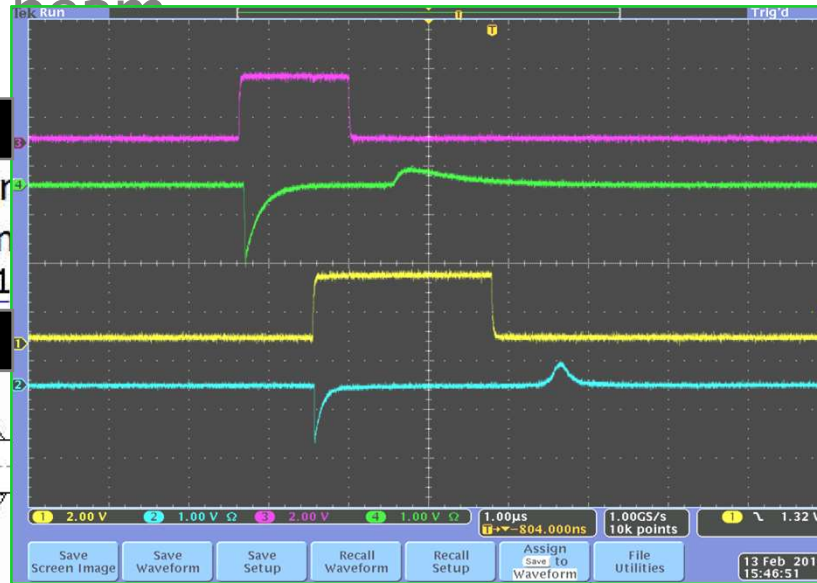
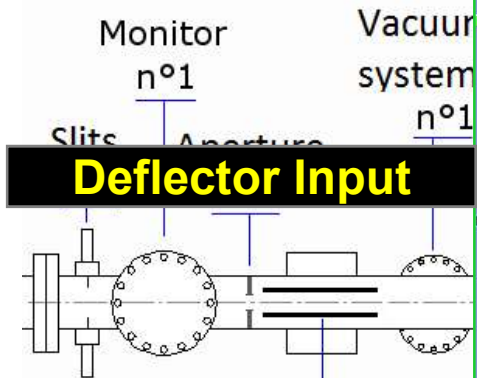


Defel: chopped beam

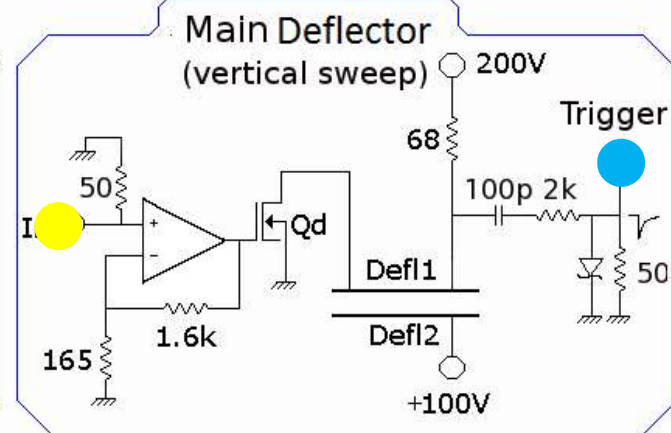
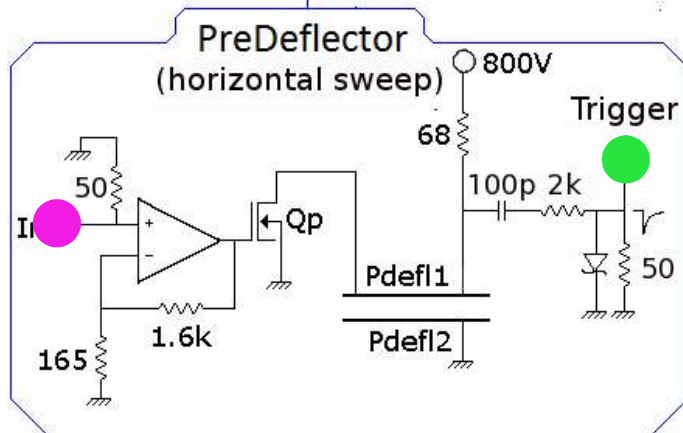
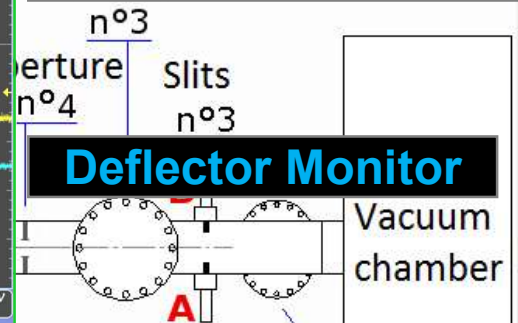


Defel: chopped

PreDeflector Input



PreDeflector Monitor

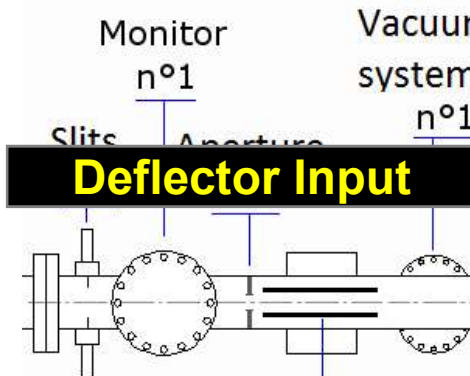


Vacuum system n°3

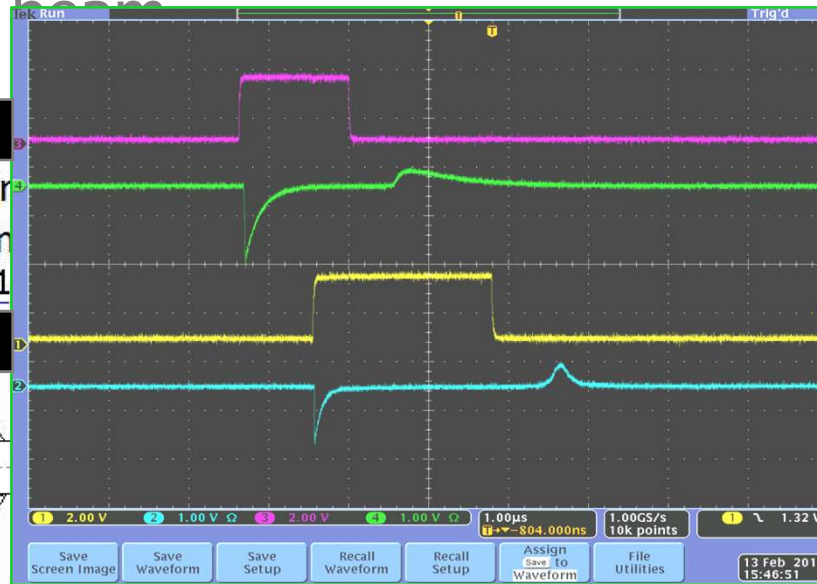
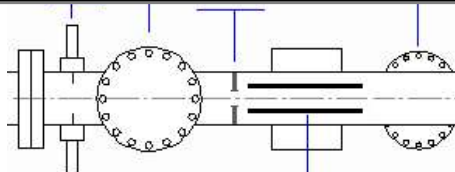
Vacuum system n°4

Defel: chopped beam

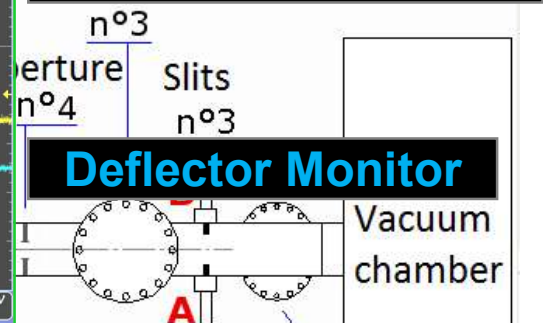
PreDeflector Input



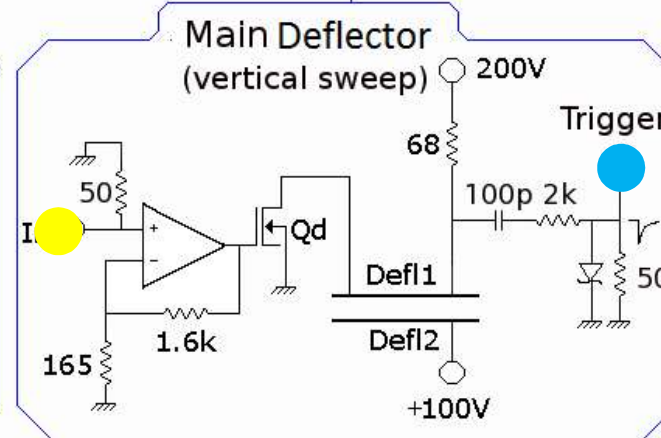
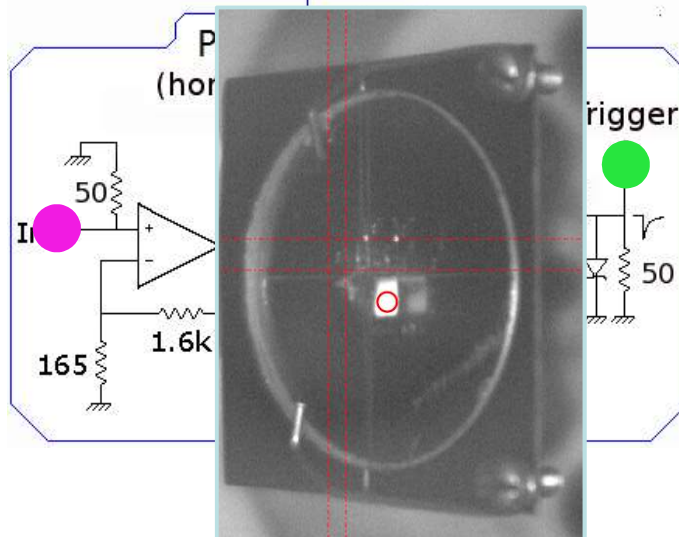
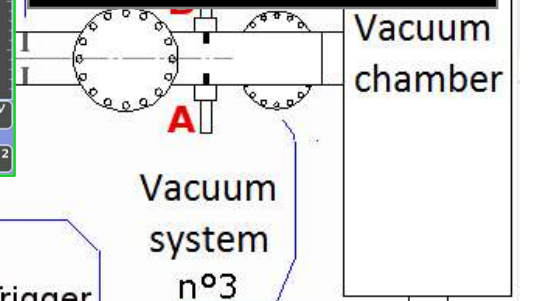
Deflector Input



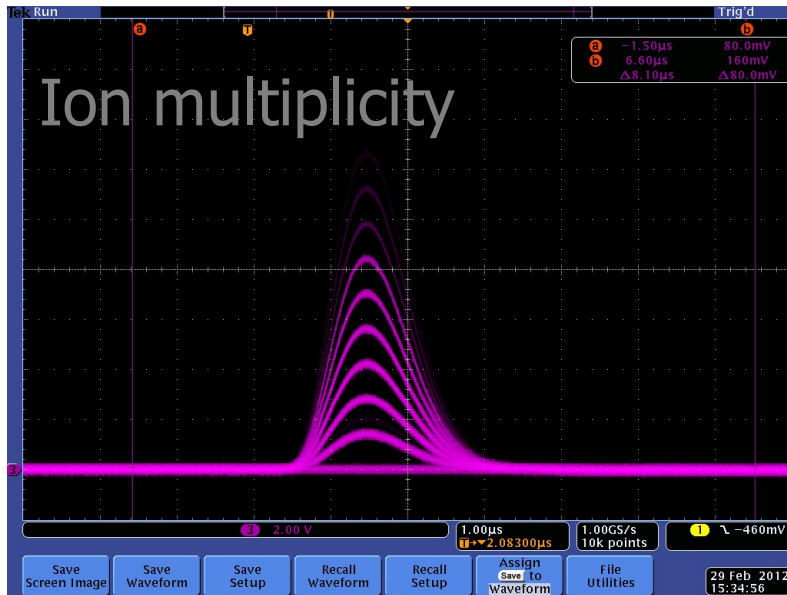
PreDeflector Monitor



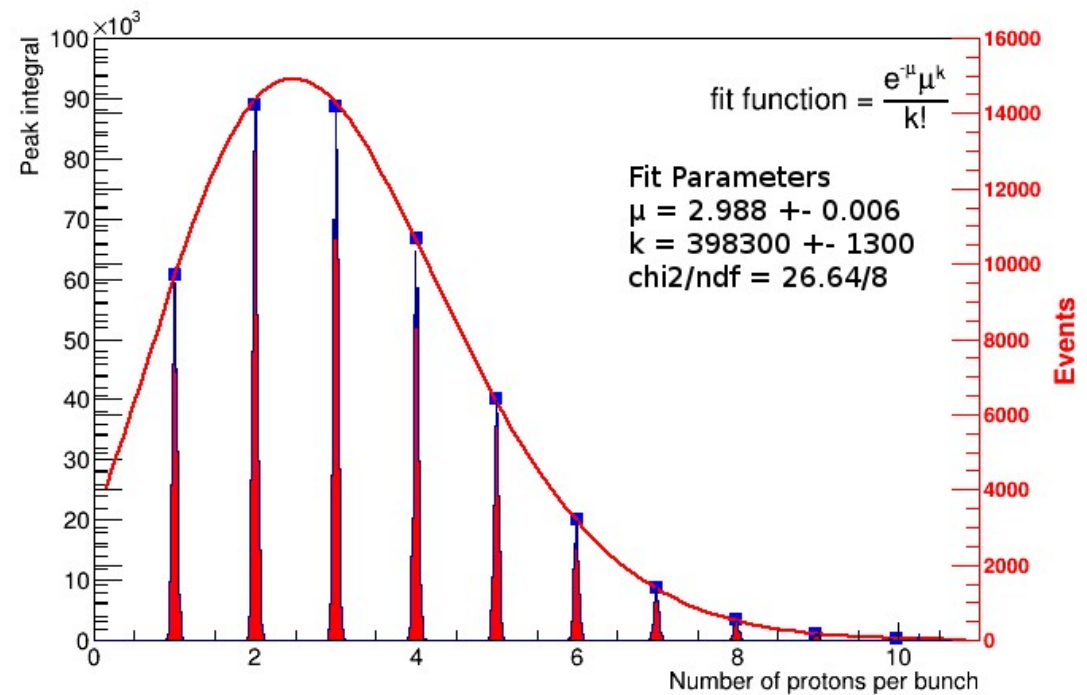
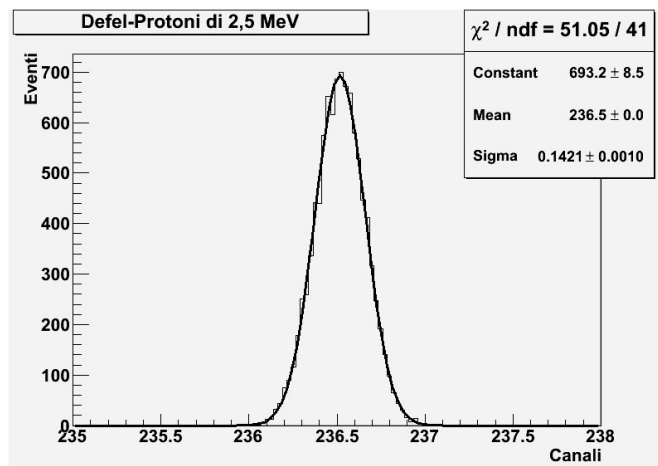
Deflector Monitor



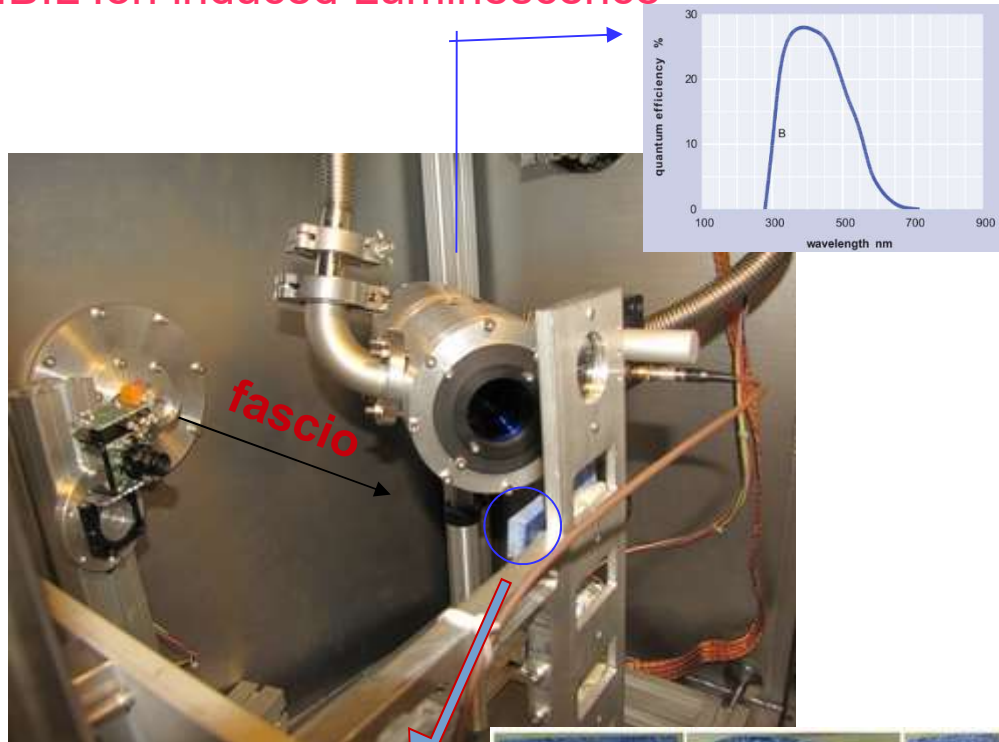
Vacuum system n°4



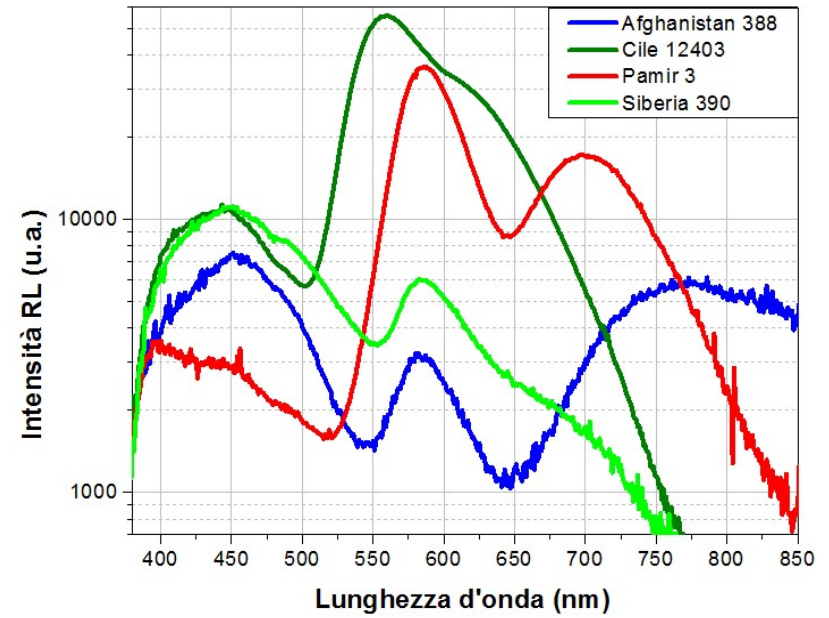
External beam: yes
 Ions: H -> I
 Beam size 100 µm to 2 mm
 Beam currents from single ion..!!!
 Repetition rate up to 10kHz



IBIL Ion induced Luminescence

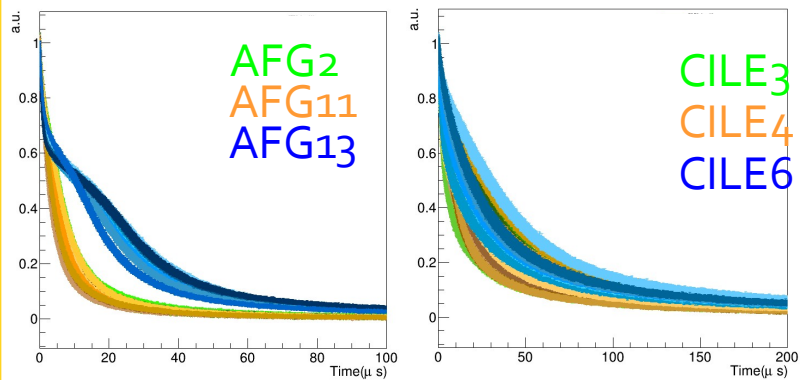


Lapislazuli

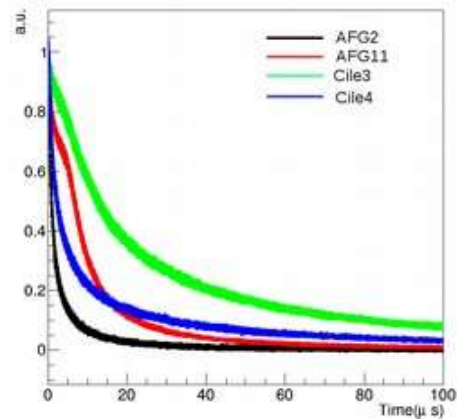


Study of provenances of Lapislazuli

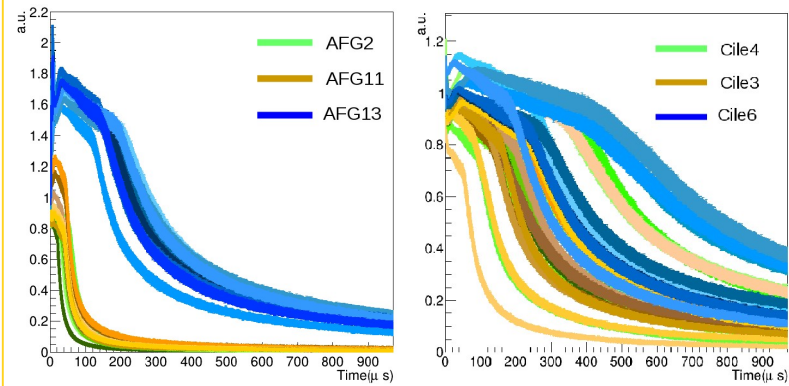
(a), (b) e (c): Campioni irraggiati durante 1 μ s.



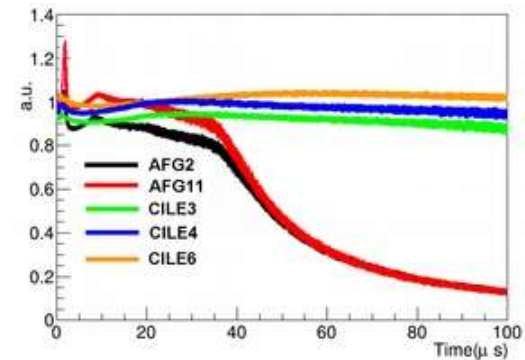
(a) (b)



(d), (e) e (f): Campioni irraggiati durante 2 μ s.



(d) (e)



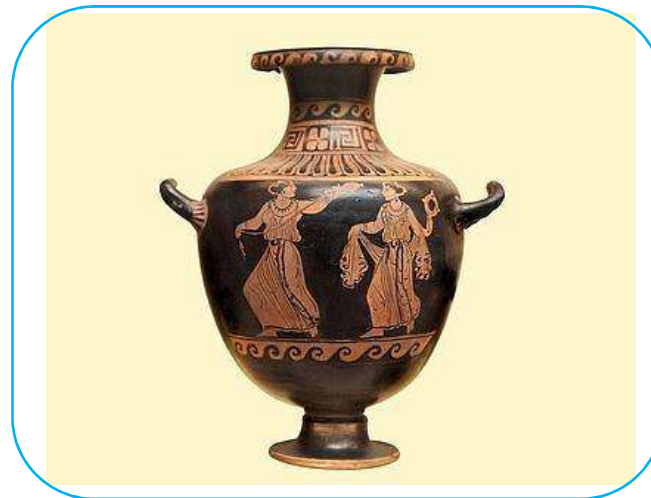
(f)

Application of the fluence control system to cultural heritage: Preliminary irradiations of TL samples

Natural TL materials present in clay and soil: quartz, feldspar

**After calibration TL materials act as dosimeters measuring the amount of
radiation they are exposed to**

Termoluminescence dating (TL)



**Accurate and precise dating requires refined calibrations and deep
studies of the properties of TL materials**

The age calculation

Dating of inorganic materials (ceramics, pottery, sediments, lava, meteorites...)

Authentication of works of art

Dating range: 100-200000 years . Clock is set at time t_0 (when all traps were emptied)

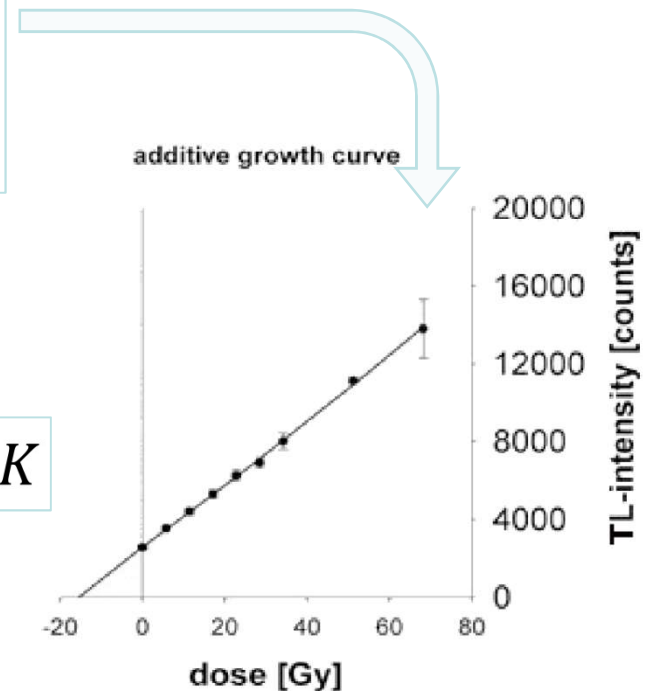
$$A(y) = \frac{D_e (Gy)}{D_r (Gy/y)}$$

Different contributions:

From surrounding soil

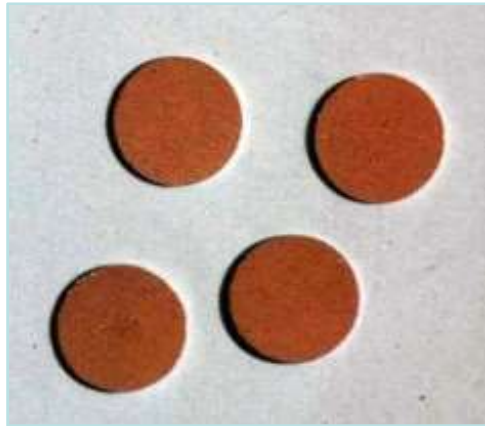
From within the sample

From cosmic rays



Aitken M. J., Thermoluminescence Dating, Academic Press, London,(1985)

“Fine grain” samples → **$D_r \approx 5$ mGy/y mostly from α particles**

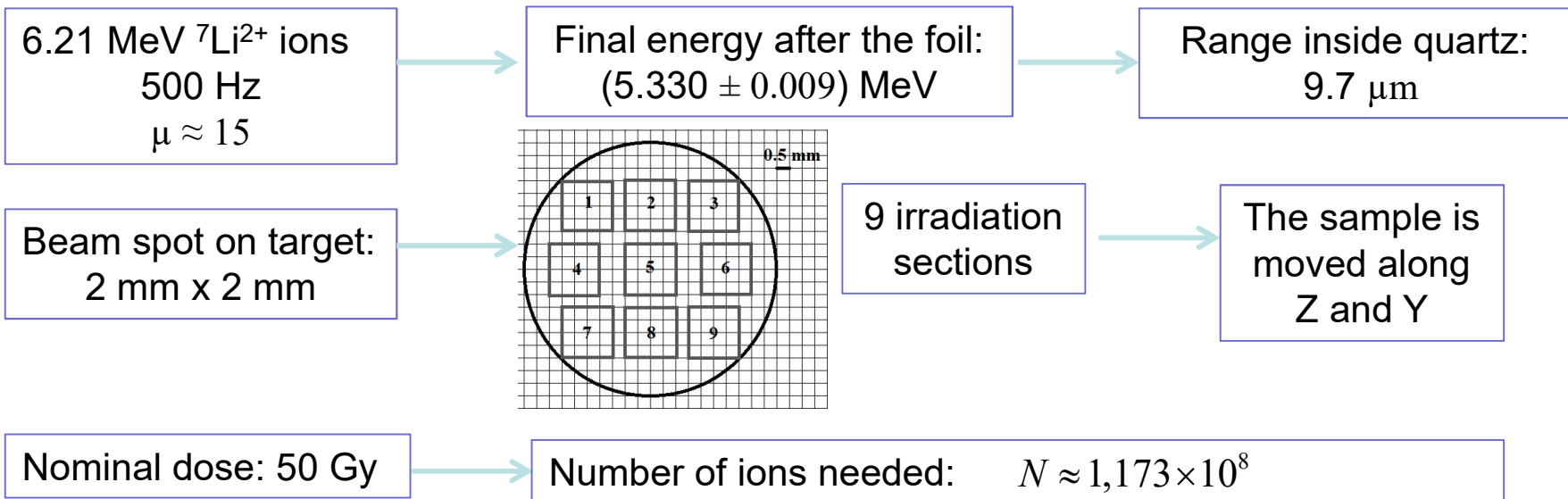


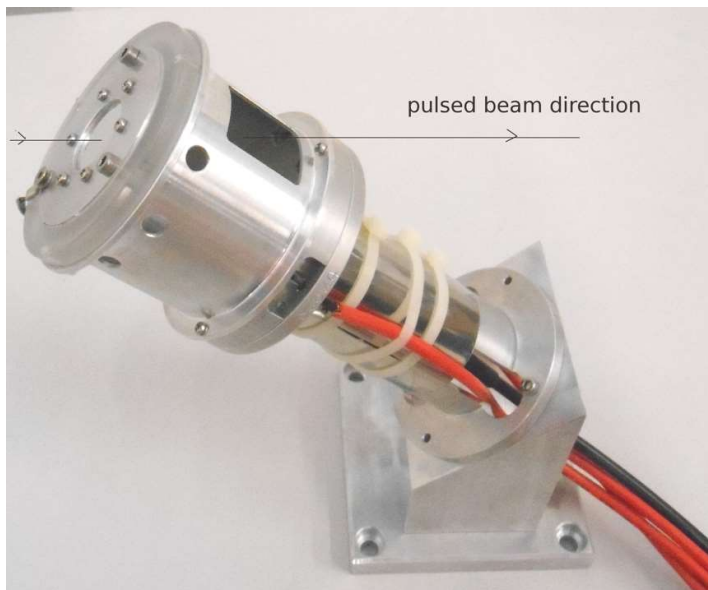
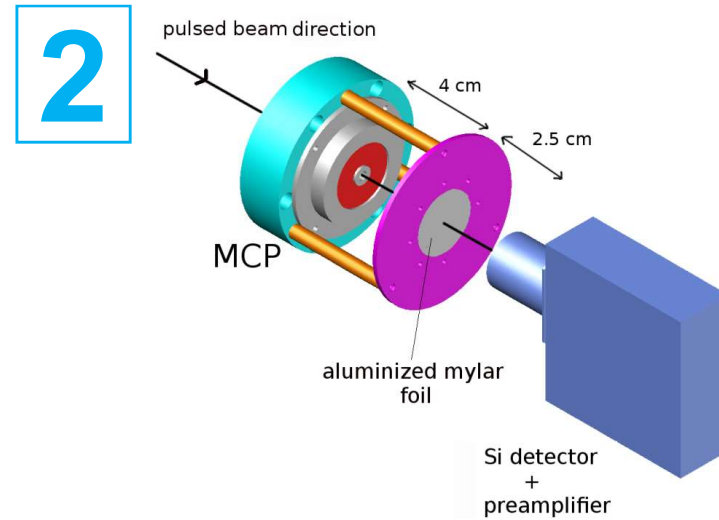
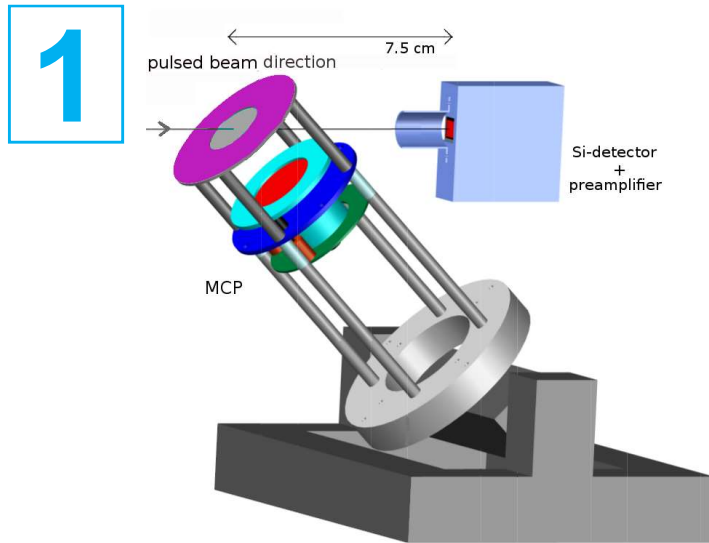
1-10 μm quartz grains diameter
10 μm powder layer deposited on Al discs (1 cm diameter)
2 mg of powder on each disc

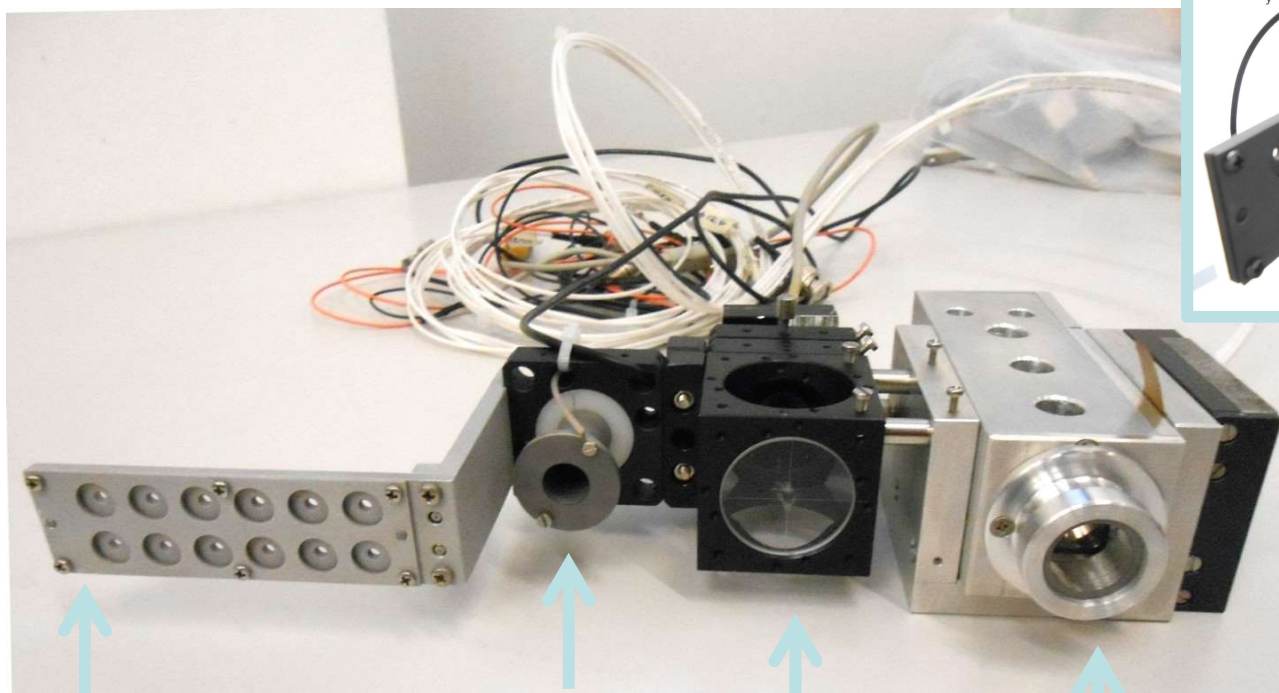
Prepared by the INFN TL laboratory in Turin

Irradiation at LABEC: 2 natural and 2 annealed samples

Irradiation details:





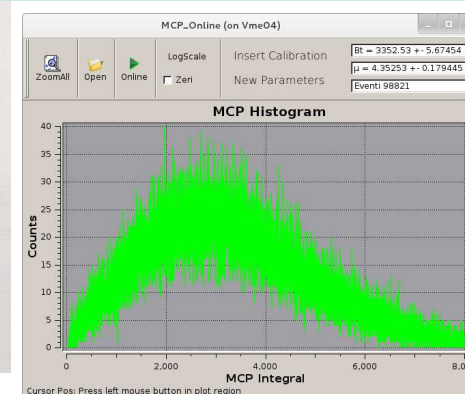
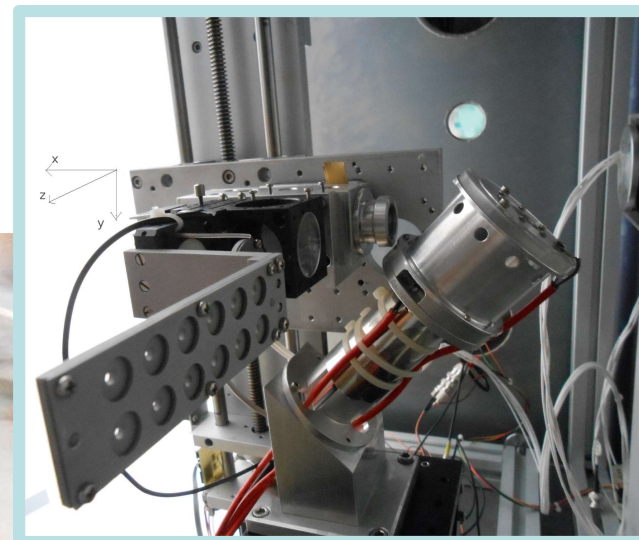


Sample holder

Faraday cup

Quartz

Si detector
+
charge preamplifier



Per quanto riguarda i BBCC con un acceleratore si possono fare:

- Misure nel campo dei BBCC
- Misure/prove in supporto ad attività BBCC
- Sviluppo congiunto con sistemi BBCC Molab
- Sviluppo di macchina.....

INOLTRE:

Un acceleratore è una palestra formidabile per la formazione di future generazione di fisici.... Sia per la parte macchina che per i sistemi ad essa correlati

Infrastrutture:

Italia (JRU)
Europa (E-RIHS)
Globale (GRI)



International dimension of the E-RIHS



....Grazie per l'attenzione...!!!