



Istituto Nazionale di Fisica Nucleare
Cultural Heritage Network

Meeting CHNet: nodo di Milano Bicocca

M. Cataldo, **M. Clemenza**, D. Di Martino, G. Marcucci, F. Saliu

Attività principali del nodo

- Esperimenti di CSN5:

CHNet_MAXI	2023-2025	<i>(MiB, PV, CA (UniSS))</i>
CHNet_BRONZE	2023-2025	<i>(MiB, TO, Fi)</i>
CHNet_NICHE	2020-2021	<i>(FI, PV, MiB, BO)</i>
CHNet_TANDEM	2017-2019	<i>(MiB, PV, LNS (UniSS), Roma3)</i>

- Collaborazioni internazionali e accesso a «large facilities»:

ISIS Muon and Neutron Source (RAL UK)
ANSTON (Australia)

- Collaborazioni con Università, Musei e altri gruppi INFN :

UNIPV, LENA (PV), UNIMI,
INFN-LNGS, CA-UniSS,
Museo archeologico di Firenze, Sito archeologico Sant’Imbenia, AGLAE
(Museo del Louvre, Parigi, FR), MOLAB-ERIHS.it, Museo Archeologico
Nazionale di Aquileia

Staff

M. Clemenza (tecnologo INFN)

D. Di Martino (PA UNIMIB-FIS)

F. Saliu (RTDB UNIMIB-DISAT)

Tempo determinato: *assegni post-doc*

M. Cataldo (INFN)

Assegno attuale termina il 31/03/26

G. Marcucci (UNIMIB-FIS)

Assegno attuale termina il 31/01/25, rinnovato fino al 31/01/27

Gruppi di lavoro a cui eventualmente partecipare

Gruppo di lavoro:

GL1 ricerca CSN5

M. Clemenza

GL2 Formazione comunicazione e disseminazione

D. Di Martino, G. Marcucci

GL3 3M, accessi, TT e **GL4** sostenibilità

Tutti

Esperienza con la rete CHNet: punti di forza, criticità, suggerimenti

Punti di forza

- Condivisione di esperienze ed expertise diverse all'interno dell'INFN
- Maggiore visibilità e peso delle singole attività/laboratori

Criticità

- Mancanza di fondi di trasferta (anche pochi) per sostenere più efficacemente le attività della rete
- Poca presenza in CSN5 di coordinatori con attività sui beni culturali (ci sono solo io...)
- Poca consapevolezza delle iniziative svolte e promosse dagli altri nodi, ancora poca interazione fra i nodi

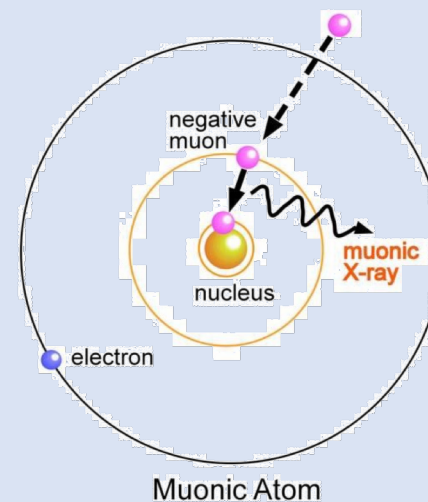
Suggerimenti

- Creazione gruppo whatsapp (se non c'è già) dove poter comunicare immediatamente eventuali iniziative da «rilanciare» poi con i canali meno immediati, mail, teams, social etc...

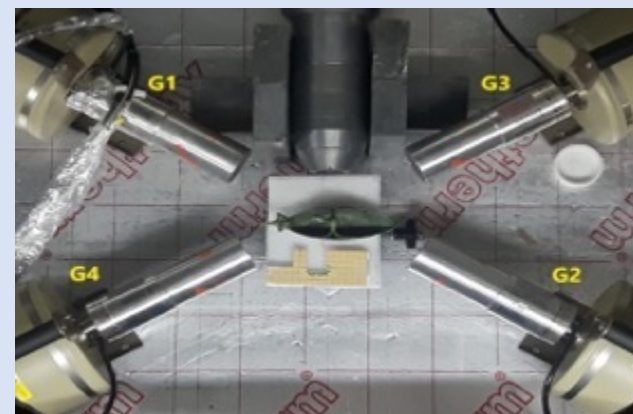
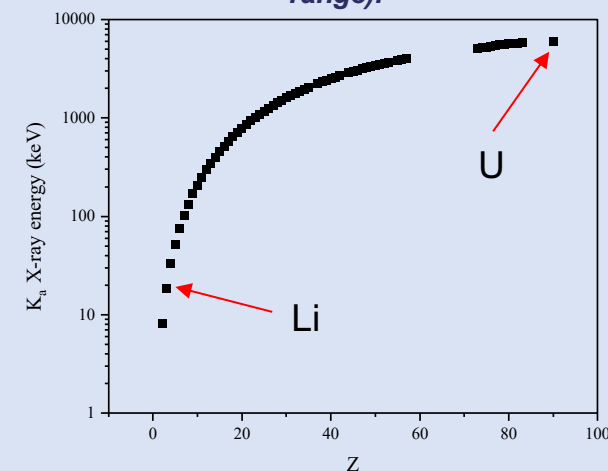


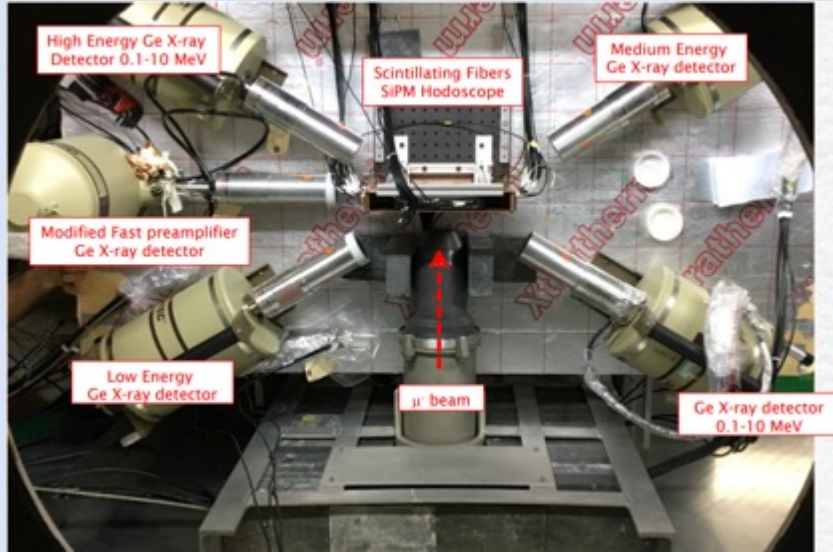
Muonic Atom X-ray and prompt gamma spectroscopy for non-destructive Isotopic analysis for cultural heritage

Development and implementation of a non-destructive analysis technique based on negative muons at the ISIS neutron and muon source (UK)

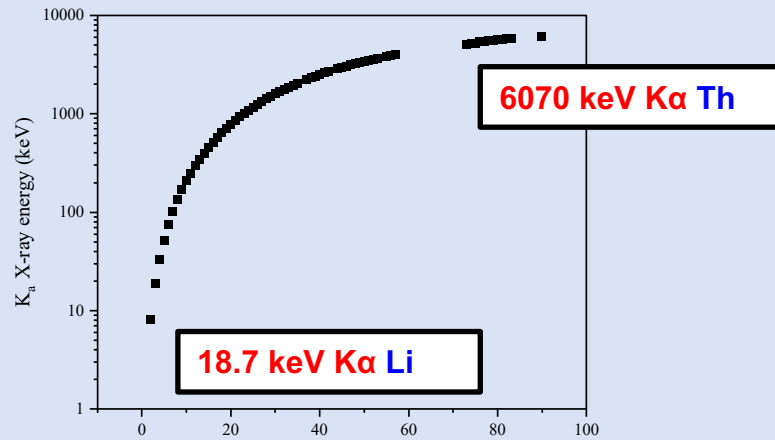
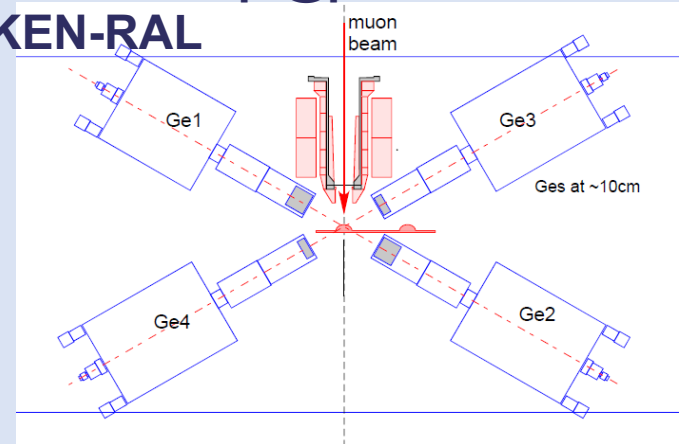


μ -XES is based on the detection of the **characteristic radiation of the emitting atom**, that can be used for material characterization (**0.01 – 6 MeV range**).





Current set up @port4 for uXES RIKEN-RAL



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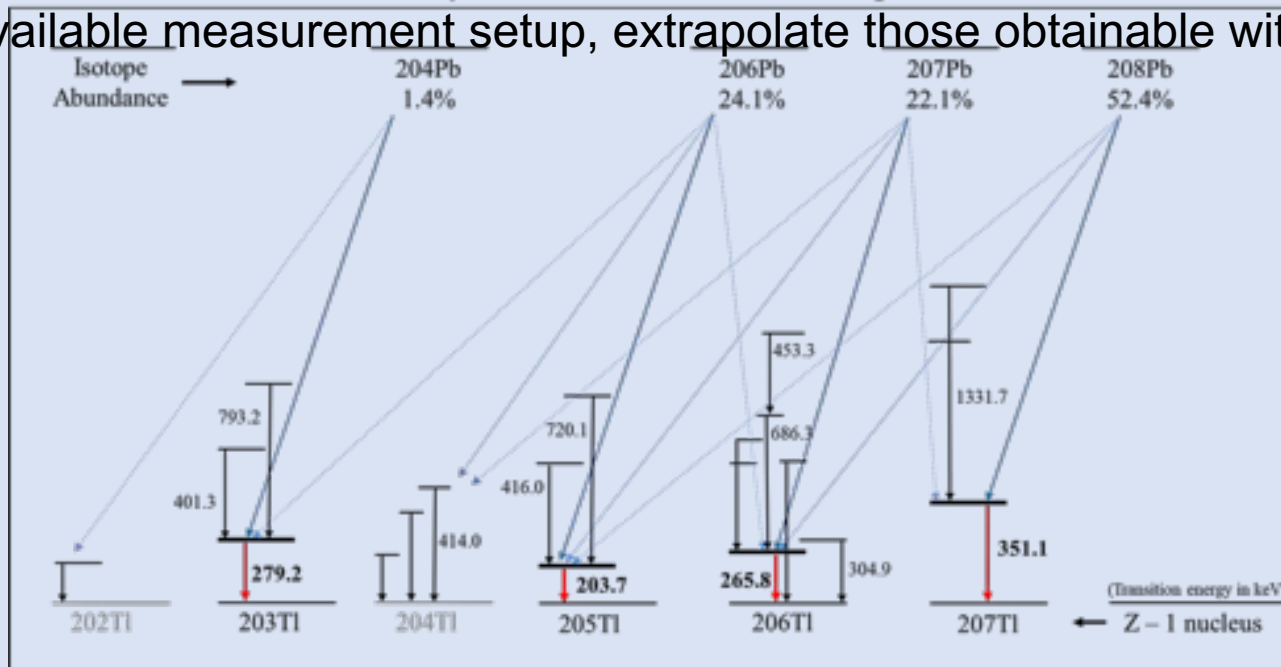
@port4	Dimensions
GMX20P4 Upstream High energy	54.8x49.8 mm
GEM-S5020P4-B Upstream Low energy	49.5x22.3 mm
GEM20P4-70-PL Downstream High energy	56.7x39.7 mm
GEM-S5020P4-B Downstream Low energy	49.6x22.8 mm
Total active volume	300 cm³

CHNET-MAXI Experiment level up: methodology

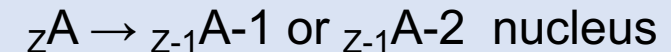
By irradiation of isotopically enriched material in lead isotopes 204-206-207-208, study all the possible "figures of merit»:

- isomeric "shift" of muon X-rays (about 15 keV energy shift for Lead Ka X-rays)
- **prompt gamma reactions following simple muon capture or with neutron emission**
- *activated radionuclides having characteristic half-lives and gamma emissions.*

By Monte Carlo simulations, sensitivity study of all possible "figures of merit" (from the results obtained with the available measurement setup, extrapolate those obtainable with a high efficiency HPGe array)



With 1 or 2 neutron emission

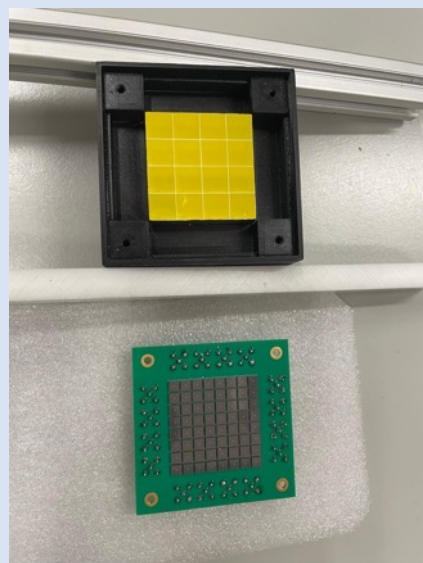


MAXRS: Detectors development

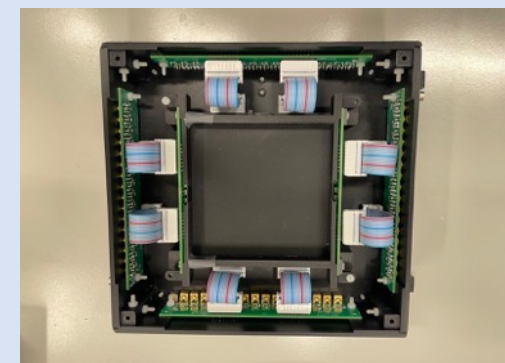
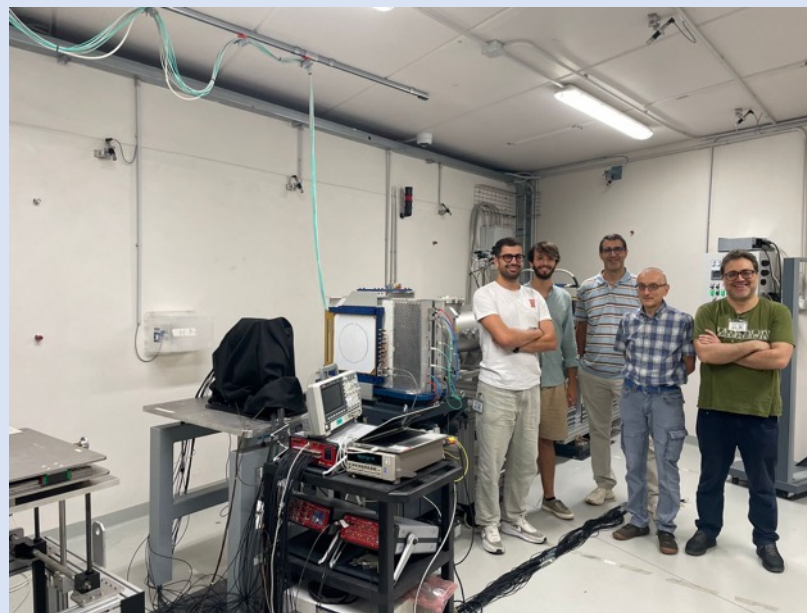
DAQ openFPGA con SciCompiler



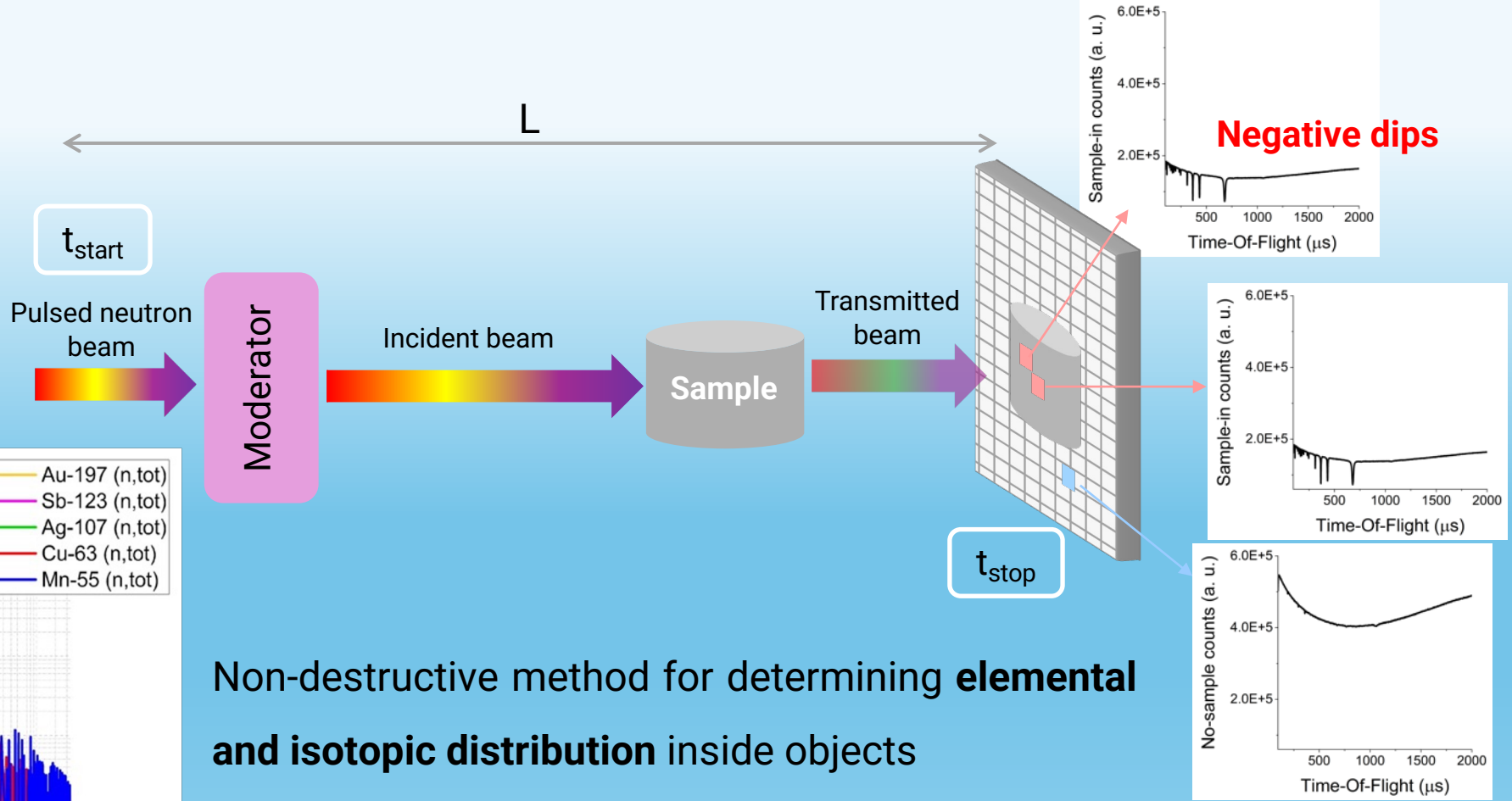
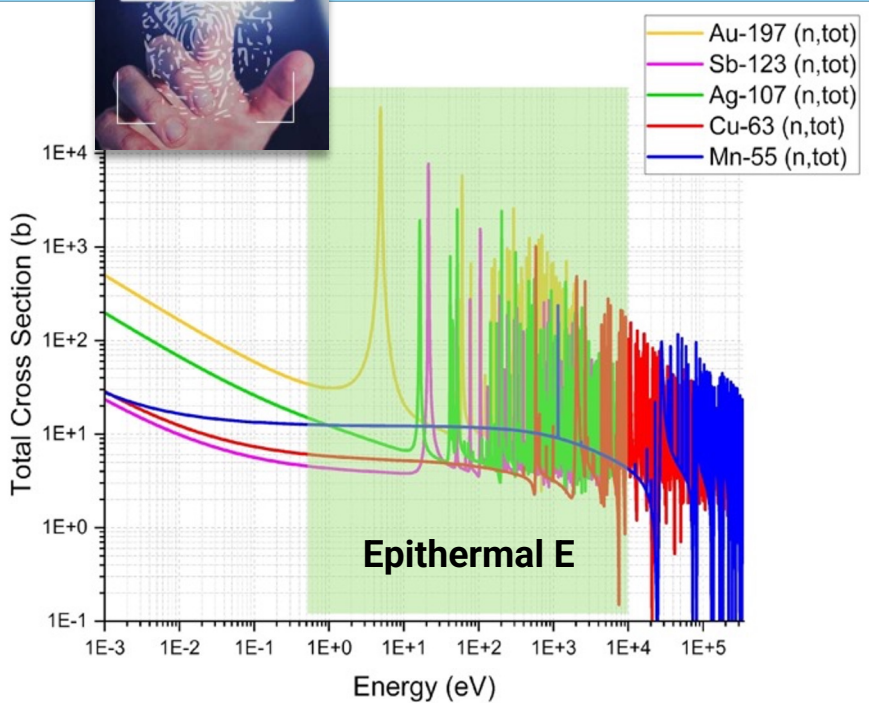
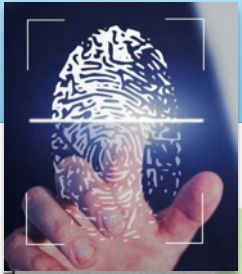
CLLB neutron/gamma PSD Day 16 canali GAGG-HR



Characterization of Muon Beam Monitor at CNAO



Neutron Resonance Transmission Imaging

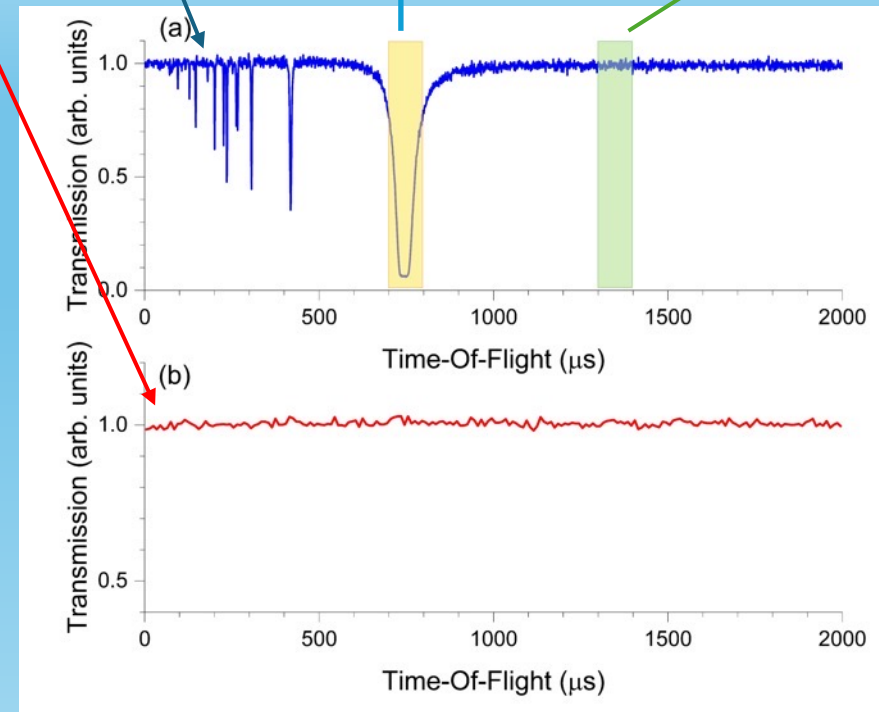
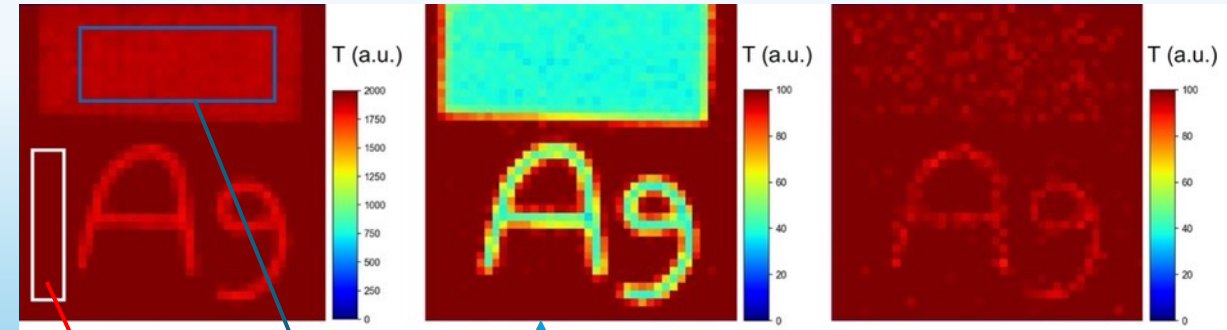


Non-destructive method for determining **elemental and isotopic distribution** inside objects

Based on the **resonance structures** in neutron induced reaction cross-sections

Neutron Resonance Transmission Imaging

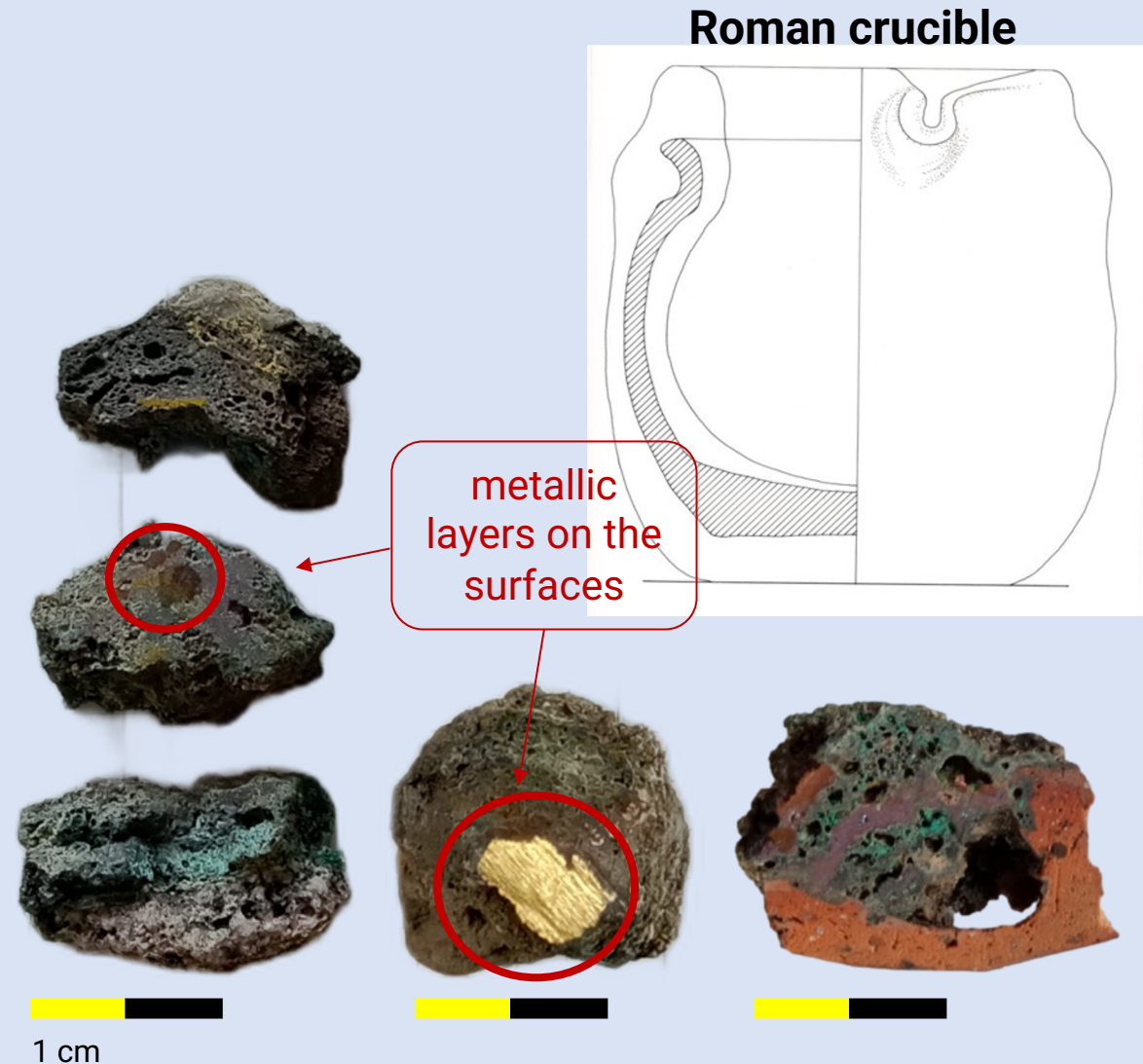
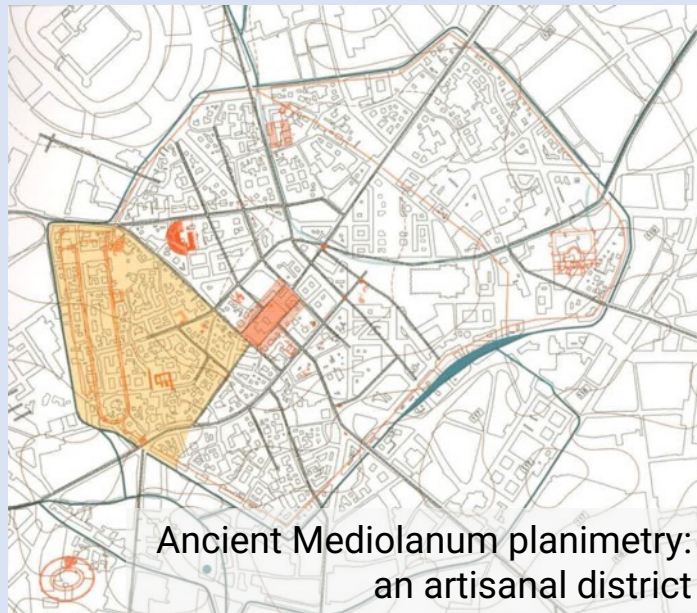
- Sviluppo di tecnica di imaging neutronico presso la sorgente neutronica ISIS (UK) basato su assorbimento risonante di neutroni epitermici per lo studio della composizione elementare ed isotopica di materiali disomogenei.



Cultural Heritage applications

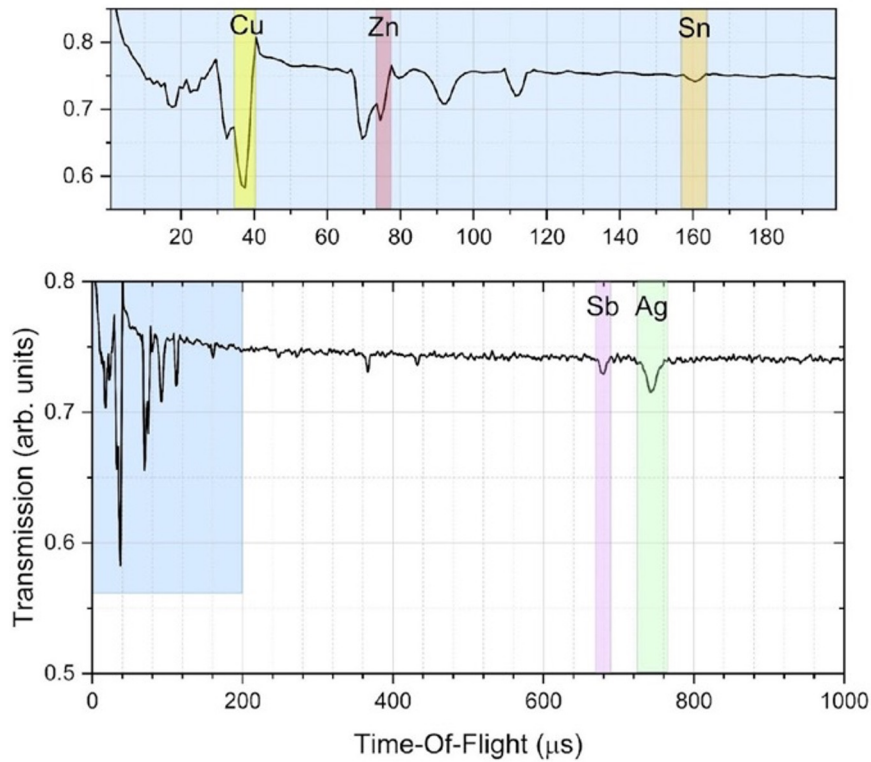
Brass production in Italy in Roman times:

- Excavation of Corso di Porta Romana in Milan (Italy)
- Crucible fragments connected to **bronze and brass production**, datable between the end of I and the beginning of II century AD.
- Activity of at least one **workshop** in the Roman city of *Mediolanum*.

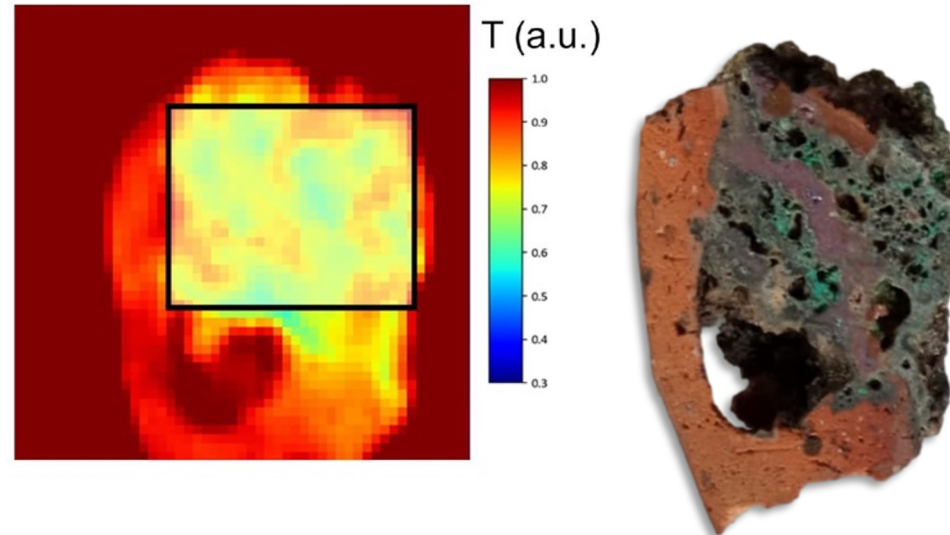


Bulk composition of the fragment?

NRTI: bulk composition

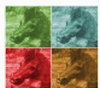


Fragment with no metallic deposition on the surface



PIXE: below detection limit

Sample	Description	Mg	Al	Si	P	Cl	K	Ca	Fe	Ni	Cu	Zn	Ga	As	Ag	Sn	Sb	Pb #La
OT20_small	metallic 'drop' #1	3870	17170	36070	1100	3340	1090	1120	845	<i>u.d.</i>	1E+06	<i>u.d.</i>	<i>u.d.</i>	<i>u.d.</i>	0	0	0	3300
OT20_small	metallic 'drop' #2	3430	17250	36840	1030	3940	1040	1040	846	586	1E+06	0	0	<i>u.d.</i>	<i>u.d.</i>	<i>u.d.</i>	<i>u.d.</i>	3600
OT20_small	metallic 'drop' #3	<i>u.d.</i>	6730	20280	965	873	471	440	319	<i>u.d.</i>	1E+06	<i>u.d.</i>	0	<i>u.d.</i>	<i>u.d.</i>	0	<i>u.d.</i>	2430
OT20_small	metallic 'drop' #4	<i>u.d.</i>	6050	19890	<i>u.d.</i>	948	395	533	332	<i>u.d.</i>	1E+06	<i>u.d.</i>	<i>u.d.</i>	<i>u.d.</i>	<i>u.d.</i>	0	<i>u.d.</i>	2500



IPERION HS

Progetto GEMMAE

*Glass-gems Exploration by
Multidisciplinary Methods, Analyses
and Experiments*

In collaborazione col Museo Archeologico Nazionale di Aquileia e con le Università di Pavia e La Statale di Milano.

Sono stati ottenuti accessi presso le grandi infrastrutture di ricerca: AGLAE (Museo del Louvre, Parigi, FR), e MOLAB-ERIHS.it per misure *in situ*.

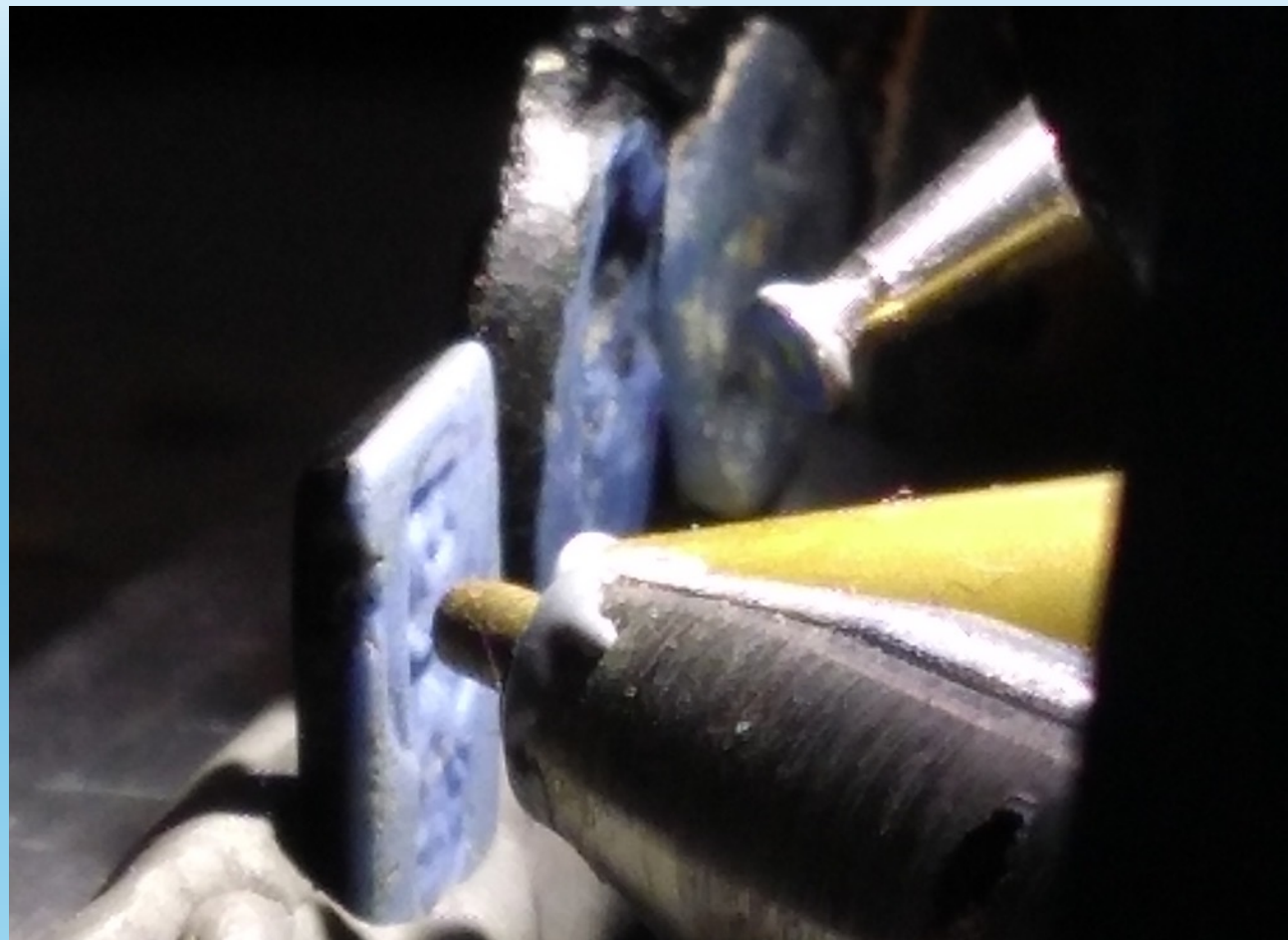


IPERION HS

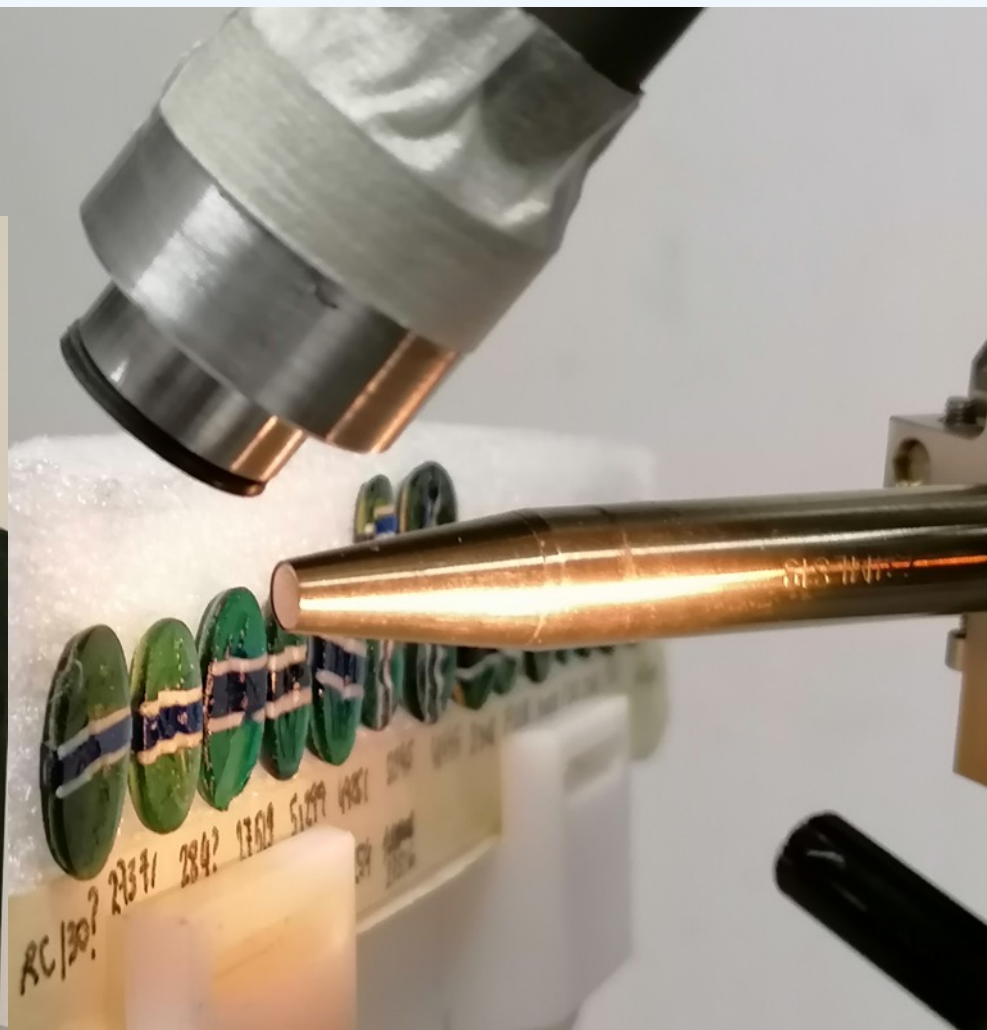
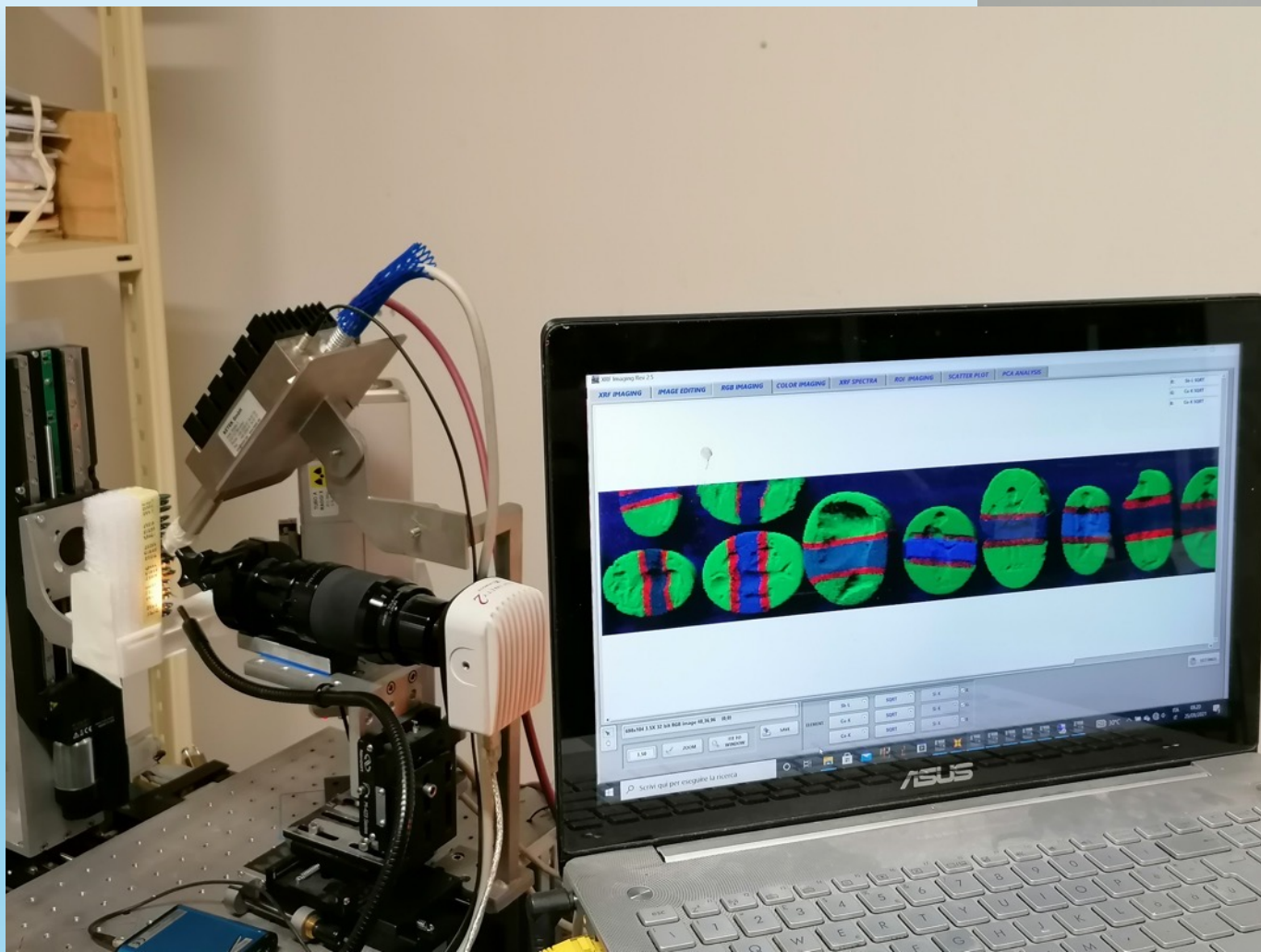


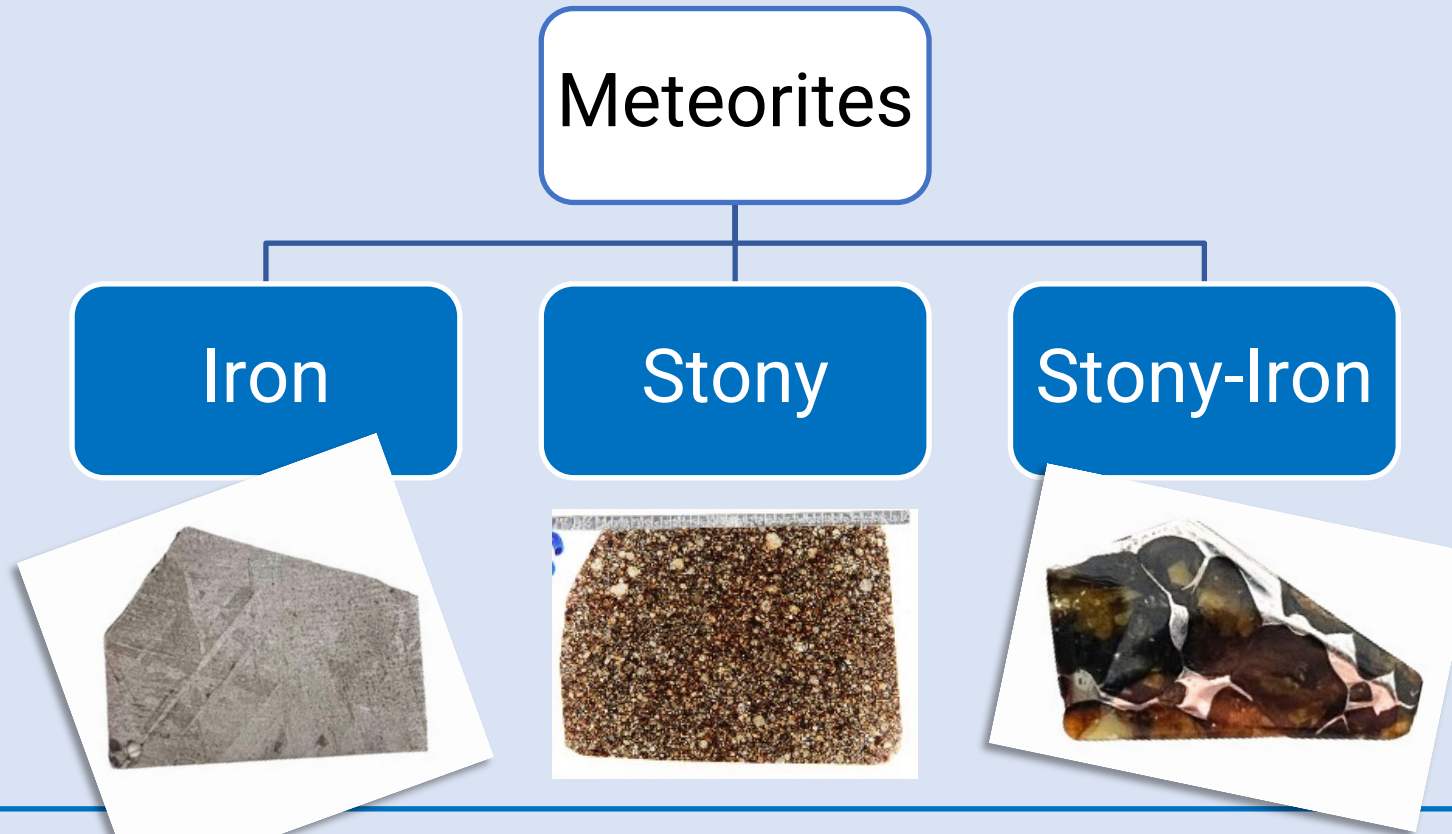
E-RIHS.it

EUROPEAN RESEARCH INFRASTRUCTURE
FOR HERITAGE SCIENCE



Misure in situ, campagna MOLAB





Large olivine crystal inclusions in the ferro-nickel matrix
An 'average' pallasite: 65% olivine (Mg,Fe), 55 wt% total Fe

Composition of a meteorite: classification, original provenance, dating

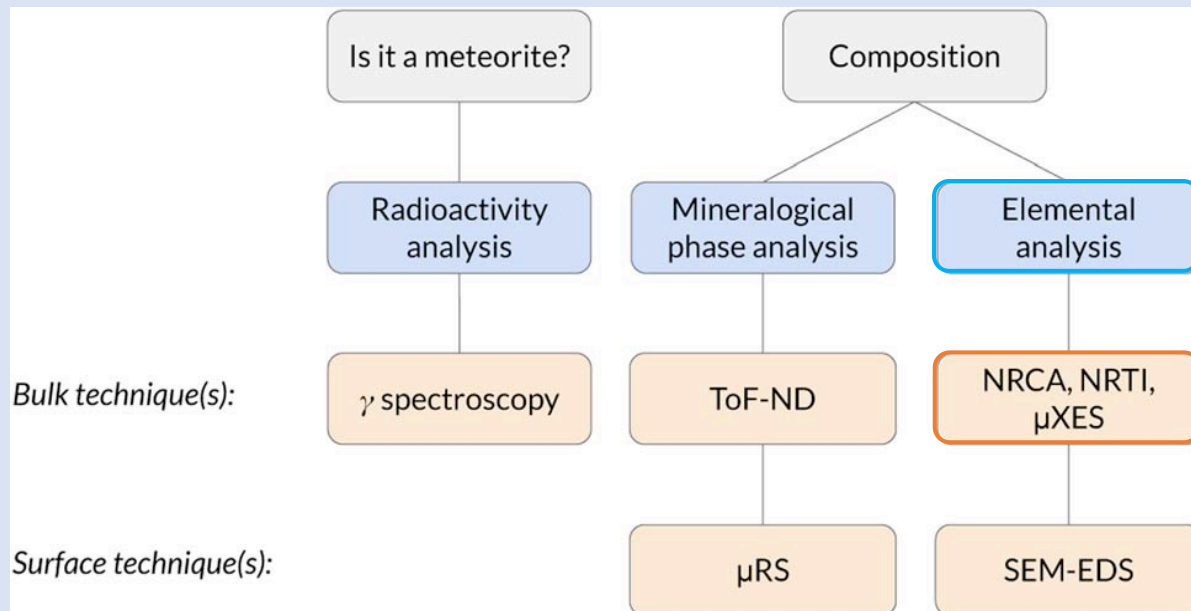
Traditionally achieved through destructive measurements (mass spectrometry or metallographic techniques)

Meteoriti: Planetary Science e Cultural Heritage

Non-destructive analytical protocol for Meteorites Identification and Characterisation

12 samples from Ca' Del Monte (Italy) Museum Collection

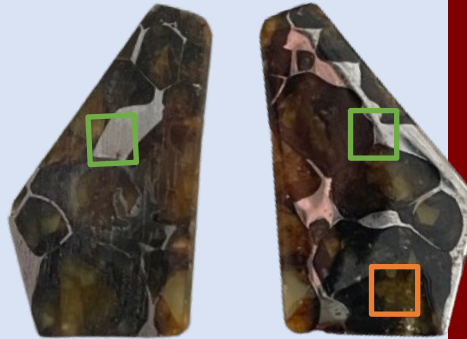
- Pallasite (stony-iron)
- Siderite (iron)
- Chondrite (stony)



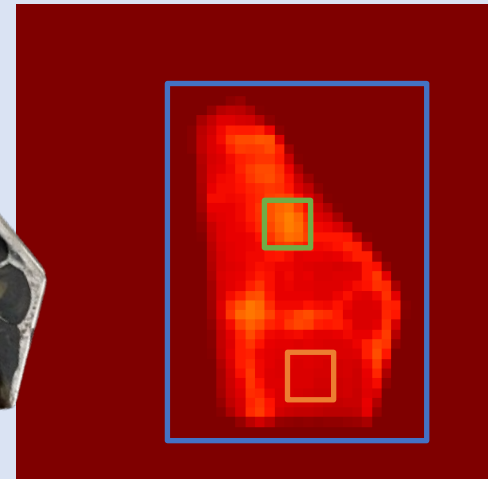
Meteoriti: Planetary Science e Cultural Heritage

Pallasite meteorite

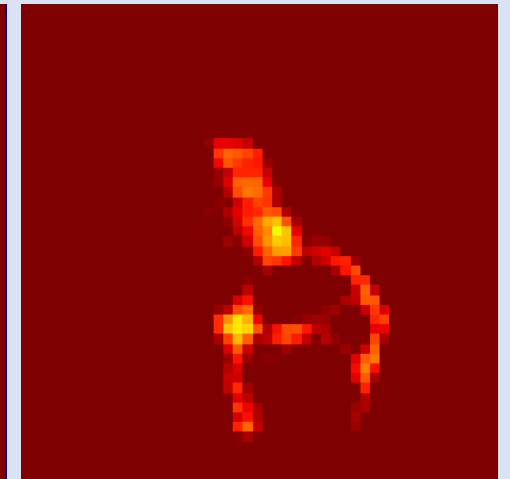
- Acondrite Stony-Iron Meteorite
- Hekandue – Magadan Oblast (Seymchan – Russia)
- Fall: ? - Discovery: June 1967



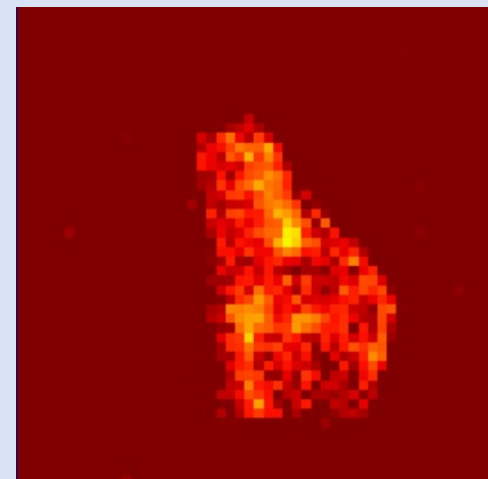
No resonance selection



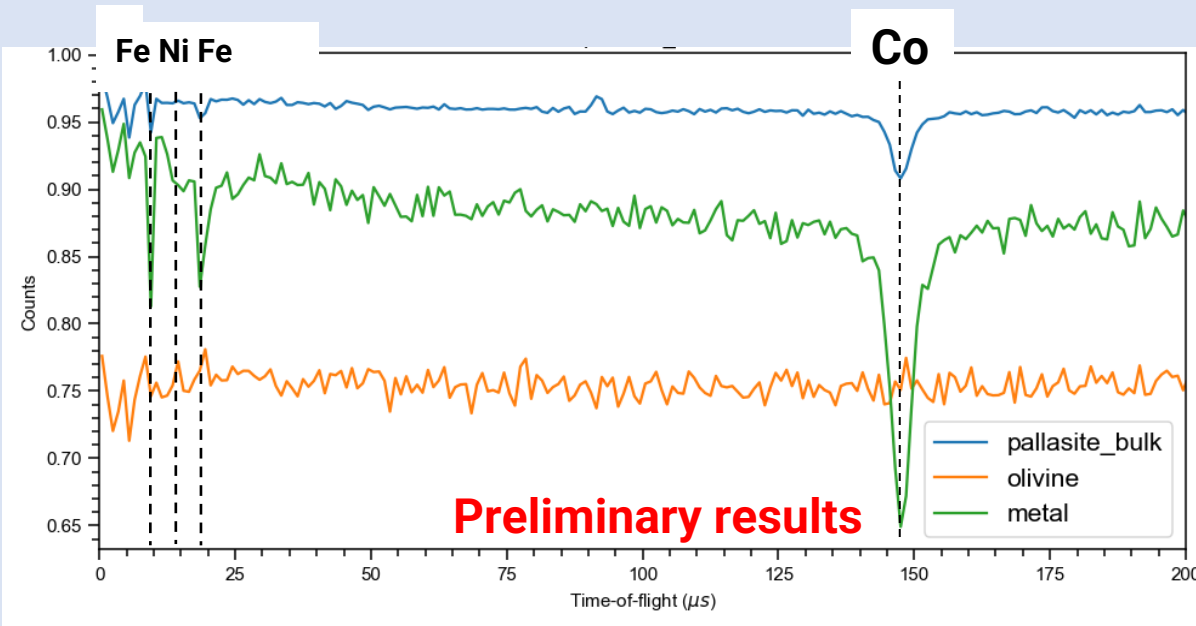
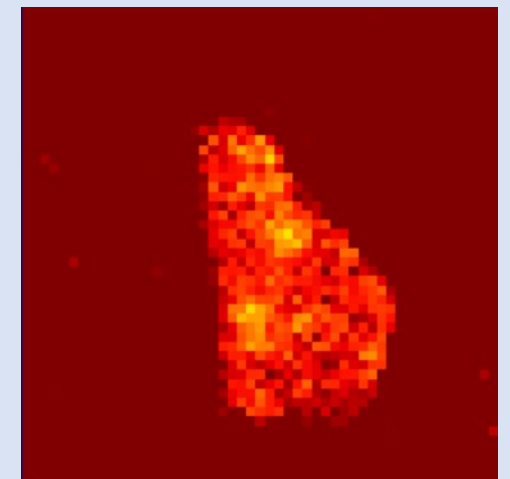
Co selection



Fe selection



Ni selection





Neutron tomography

Floriana Salvemini

Instrument scientist
ANSTO | Australia

3D map and 2D cross sections

	%
matrix	21.77
olivine	78.23

ZWO ASI2600MM Pro (6248*4176) CMOS sensor camera

20 μm thick Gadox scintillation screen

Pixel size: 16 μm

Step angle: 0.37°

Exposure time: 230s

Actual spatial resolution of 50 μm (Siemens star spoke target)

Instrument reference paper: U. Garbe, et al., "A New Neutron Radiography / Tomography / Imaging Station DINGO at OPAL," Physics Procedia, pp. 27-32, 2015.

