

Coordinator: Roberto Senesi, Università degli Studi di Roma Tor Vergata, Centro NAST

Participants:

Università Tor Vergata – C. Andreani, R. Senesi, C. M. Labarga, O. Rickards (Centro NAST).

Centro Fermi – G. Festa, L. Arcidiacono (October 2017- September 2018)

Università di Firenze - P. Baglioni; Università di Milano-Bicocca – G. Gorini; Università di Teramo – C. Piperno

University College London (UK) Science and Engineering in Art, Heritage and Archaeology (SEAHA) Centre for Doctoral Training - Marcos Martinon-Torres

Place of work & Collaborations:

Place of Work

- ❖ Centro Fermi - **Research and Heritage Institution**
- ❖ ISIS Spallation Neutron Source (Harwell, UK) – **Research Institution**
- ❖ University College London (UK) – SEAHA, <http://www.seaha-cdt.ac.uk> - **Research Institution**
- ❖ Università degli Studi di Roma Tor Vergata - **Research Institution**

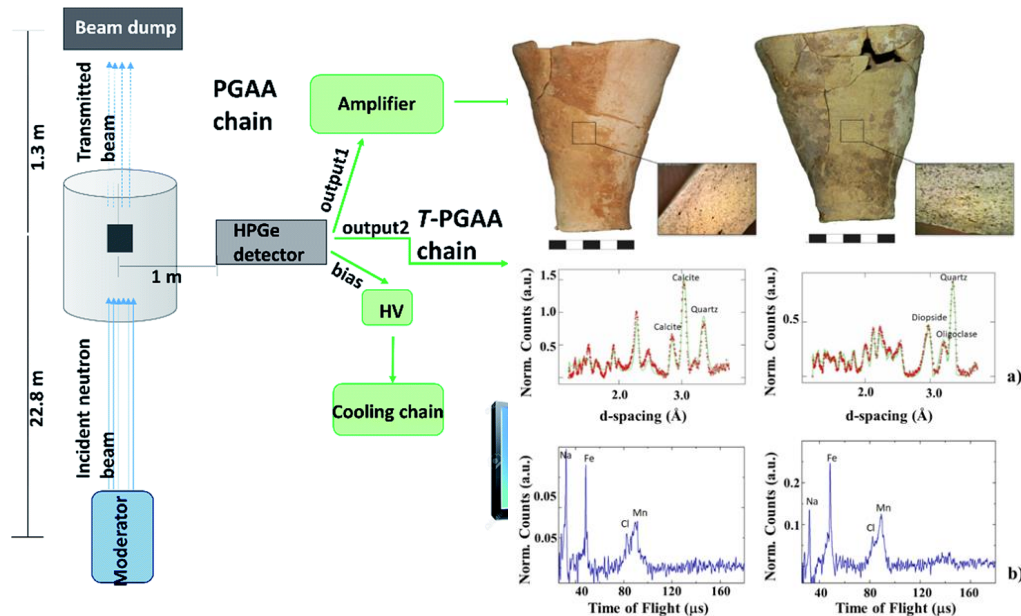
Collaborations

- ❖ **Research Institutions:** Consiglio Nazionale delle Ricerche (CNR-IBAM Catania and CNR-IPCF Messina) ; MOLAB (I), Oak Ridge National Laboratory (USA), Helmholtz-Zentrum Berlin (G), Argonne National Laboratory (USA); Sapienza Università di Roma (I); Università di Milano Bicocca (I) ; Scuola Normale Superiore (I); Università di Palermo (I); University of Coimbra (PT); Università degli Studi di Firenze (I).
- ❖ **Heritage Institutions:** Anthropological Service, Soprintendenza Archeologia del Lazio e dell'Etruria Meridionale - (MIBACT, I) Museo Egizio, Torino (I) ; Tarisio – Fine Instrumentations & Bows (UK), Fondazione Pro Canale (I); University of Coimbra (PT); Scuola Normale Superiore (I).

Project main goals and results achieved in 2018

Project goals: **Element/isotope analysis, microstructure and spectroscopy on samples of archaeological and forensic relevance.**

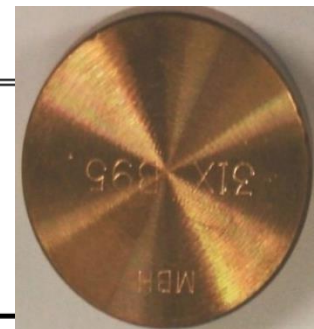
- 1) Instrumentation development: Time-Resolved Prompt Gamma Activation Analysis (T-PGAA) apparatus not yet available at Spallation Neutron Sources → broaden the scope of chemical/isotope analysis for Cultural Heritage and forensic studies.
- 2) To create an outpost in UK of the Centro Fermi - TNAAF team (under the CNR-STFC Agreement) for interdisciplinary research activities and projects: Harwell, London.
- 3) To integrate advanced neutron techniques with molecular and atomic spectroscopy techniques for the study of cultural heritage artefacts, materials and forensic samples.



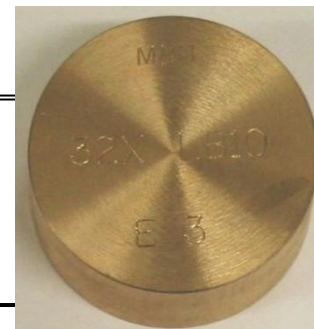
Project results achieved in 2018

1) Comparative tests for quantitative analysis: Prompt Gamma Activation Analysis vs X-Ray Fluorescence (bulk vs surface sensitivities)

BRONZE	⁶³ Cu	⁶⁵ Cu	⁶⁴ Zn	¹¹⁷ Sn	⁵⁶ Fe	¹⁰⁹ Ag	¹⁰⁷ Ag	⁵⁵ Mn	⁵⁸ Ni
wt% T-PGAA	94.8		0.01	0.086	0.023		0.0063	0.67 d	0.031
wt% certificate	94.81		4.92	0.062	0.036		0.0065	0.0006	0.038
wt% XRF	94.34		5.19	0.45	0.013		<LOD	<LOD	<LOD



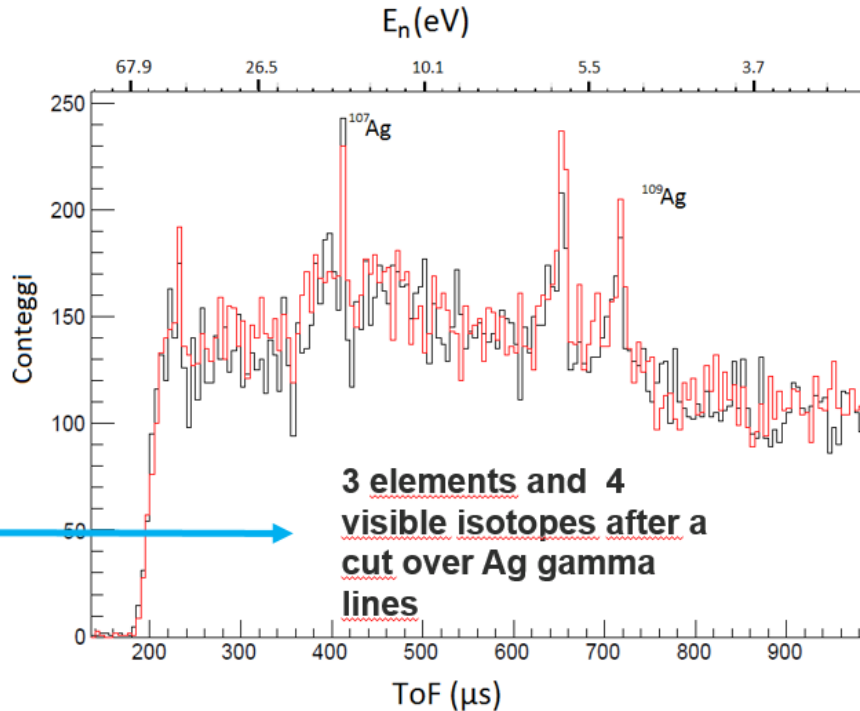
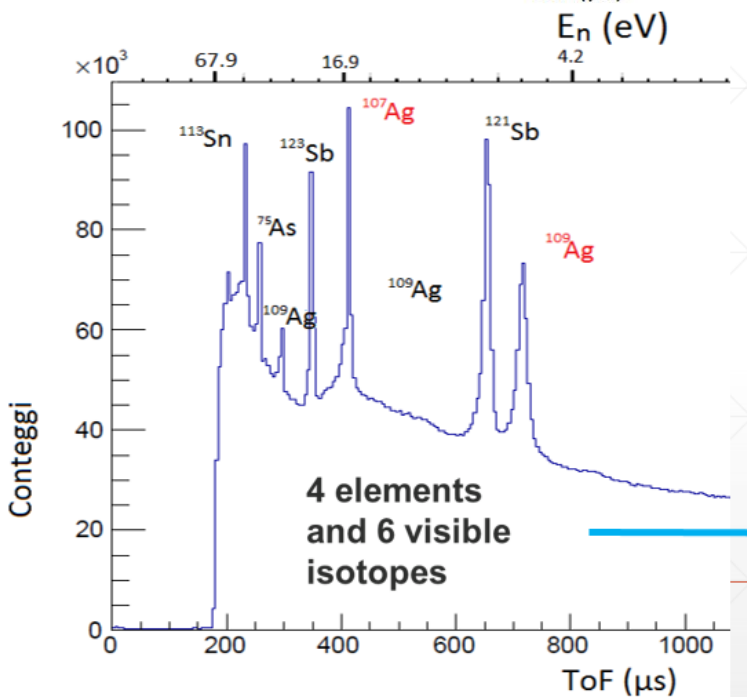
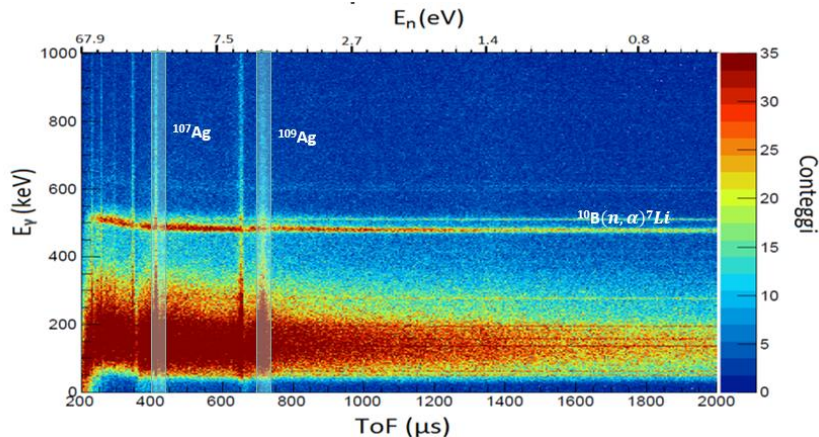
BRASS	⁶³ Cu	⁶⁵ Cu	¹¹⁵ Sn	¹¹⁷ Sn	¹¹⁹ Sn	¹²⁰ Sn	¹⁰⁹ Ag	⁵⁵ Mn	⁵⁸ Ni
wt% T-PGAA	77.23			7.31			0.012	4.67 d	0.53
wt% certificate	77.23			8.26			0.046		0.69
wt% XRF	78.96			6.8			<LOD	<LOD	0.71



L. Arcidiacono, Assegnista C. Fermi, 2- nd year [PhD Thesis](#) at UCL

Project results achieved in 2018

**2) Isotopic sensitivity enhancements:
 ^{107}Ag vs ^{109}Ag in multicomponent metallic objects (S.Sait Aid- BSci thesis)**



TNAAF - Neutron techniques for Archaeology and Forensic Science

Project results achieved in 2018

3) Neutron resonance capture analysis of recently discovered sites in Iraq (Abu Tbeirah-3000 a. C.)

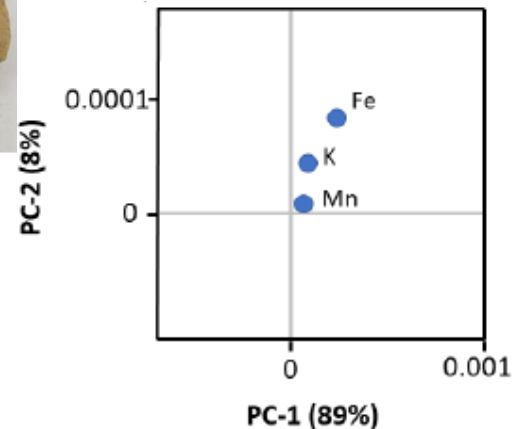
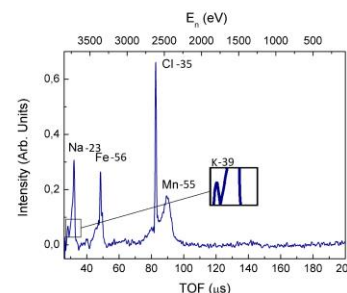
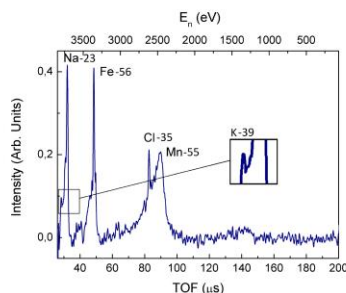
Chemometric tools (PCA)
 (M. Nardini- MSci Thesis)



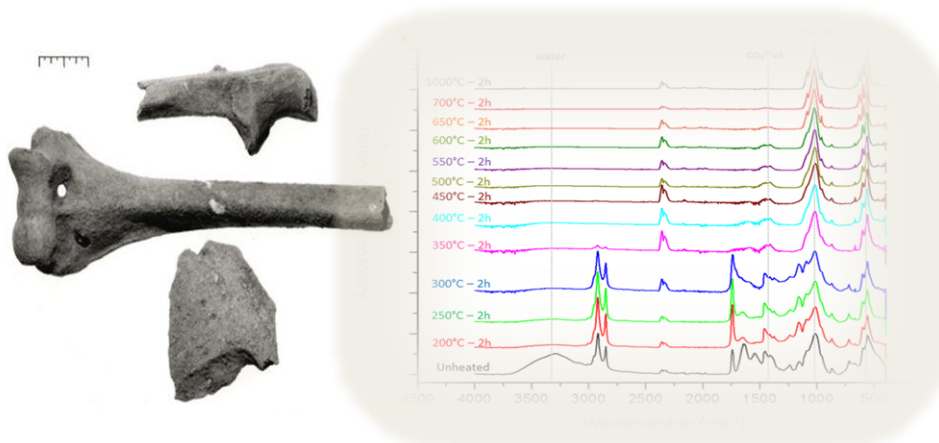
(a) Sample 22.



(b) Sample 23.



4) Introduction of neutron vibrational spectroscopy applied to archaeological skeletal remains



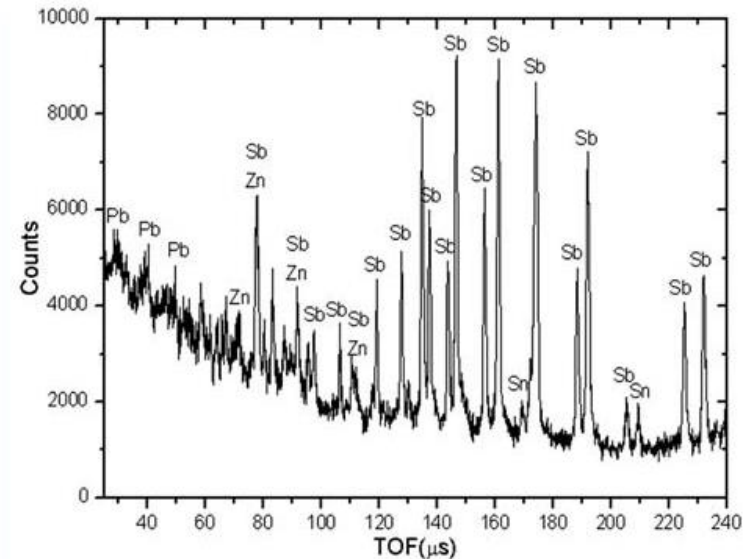
G. Festa et al. ,
 under review
 (2018)

TNAAF - Neutron techniques for Archaeology and Forensic Science

Project results achieved in 2018- two main publications

1) G. Festa, T. Minniti, L. Arcidiacono, M. Borla, D. Di Martino, F. Facchetti, E. Ferraris, V. Turina, W. Kockelmann, J. Kelleher, R. Senesi, C. Greco, C. Andreani,
"Egyptian Grave Goods of Kha and Merit Studied by Neutron and Gamma Techniques", *Angewandte Chemie* 130, 7497 (2018).

2) G. Festa, C. Andreani, L. Arcidiacono, F. Grazi, R. Senesi,
"Neutron Diffraction and (n, γ)-Based Techniques for Cultural Heritage", in *Nanotechnologies and Nanomaterials for Diagnostic, Conservation and Restoration of Cultural Heritage*, G. Lazzara and R. Fakhrullin, Elsevier, ISBN: 9780128139103 32 (2018)



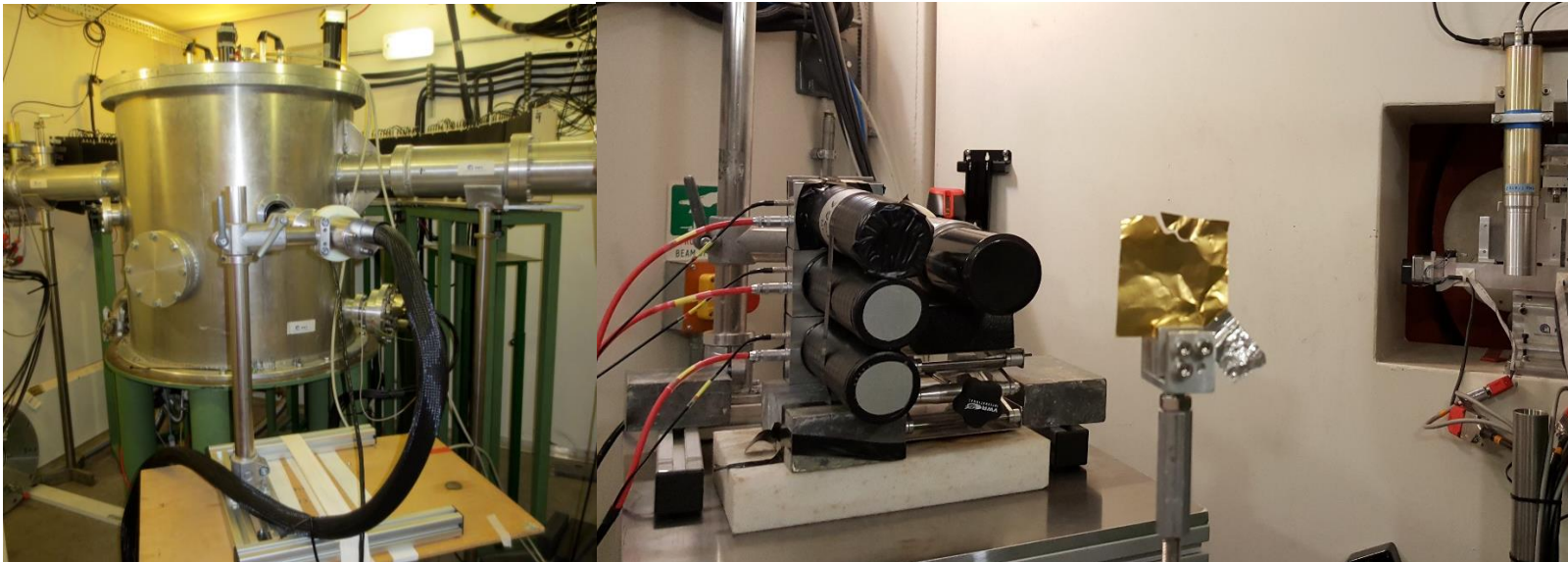
Milestones 2018

- 1) Compton suppression and background optimization systems for T-PGAA (20% completion-Compton suppr. not yet in place)
- 2) Consolidation of experimental plans and data analysis on textile samples from Museo Egizio (90% completion-, one paper published, one under review, one near completion)
- 3) Data analysis on combusted bones (FTIR, neutron, Raman, PCA) (70% completion- one paper under review, one near completion)
- 4) Three (at least) experiment proposals to be submitted to the ISIS Facility Access procedure on archaeometric standards, ancient books, oricalchos. (100% completion- five experiments completed)

Plan of activities 2019 – 2021 (Milestones)

A) *Instrumentation development*

- 1) Compton suppression: HpGe+YAP (LaBr) (Milestone 1)
- 2) Interface for T-PGAA acquisition (Milestone 2)



Plan of activities 2019 - 2021

B) Applications and techniques

integration. Three experiments (Milestone 3) **on:**

- 1) Samples from Museo Archeologico Nazionale di Napoli
- 2) Combusted bones
- 3) Prehistoric axes (British Museum)

**C) Three manuscripts from
project results** (Milestone 4)



Expected funding in the 3-year period: Request of funding by Centro Fermi

Grants: 1 grant for 2019 (assegno di ricerca, 25 keuro); 1
grant for 2020 (assegno di ricerca, 25 keuro); 1 grant for 2021
(assegno di ricerca, 25 keuro)

Travel/missions: 15 keuro/year for the years 2019,2020,2021

