ICP-MS facility for radio-pure material screening

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IBS – INFN One-day workshop on underground physics

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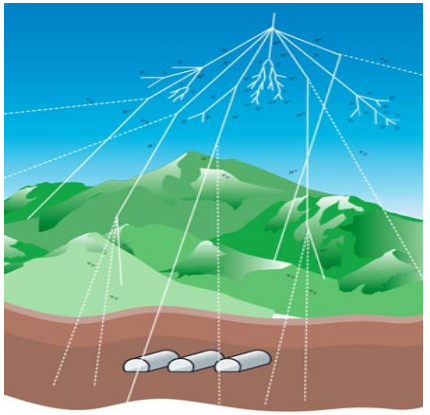
Outline

- ✓Gran Sasso National Laboratory
- ✓Low Radioactive Techniques (LRTs) at LNGS
- ✓ICP-MS: instrumentation and performances
- ✓Interdisciplinary application examples
- ✓Conclusion

Gran Sasso National Laboratory

Detection of extremely weak events

1400 m of rock (3600 mwe)
Cosmic ray flux reduction: 10^6
Neutron flux reduction: 10^4



- The underground facility provides the necessary **low radioactive background**

- Selection of **highly radio-pure materials**

K Pb Th U

Neutron Attivation Analysis, γ-Ray Spectroscopy, ICP-Mass Spectrometry

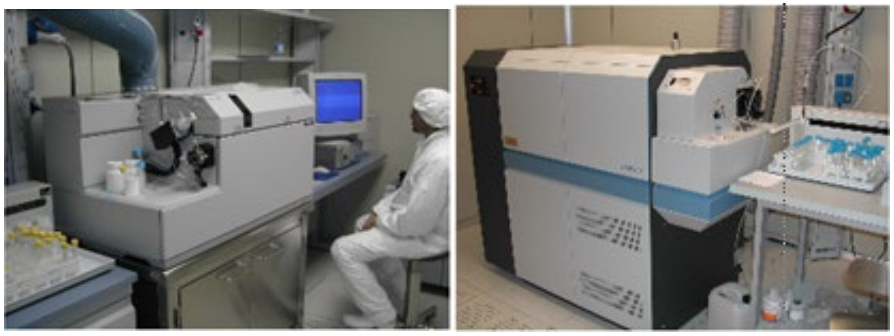
Ultra-low level radioactivity counting facilities

STELLA SubTErranean Low Level Assay

- **ϒ spectrometry High-Purity Ge Detectors (HPGE)**
- α spectrometry Silicon PIPS detectors
- Liquid scintillation counters

\+ Sample treatment free (GRS)
\- Sensitivity depend on the sample mass (Kg)
\- Long measurement time is requested to achieve high sensitivity (weeks)

ICP-Mass Spectrometry



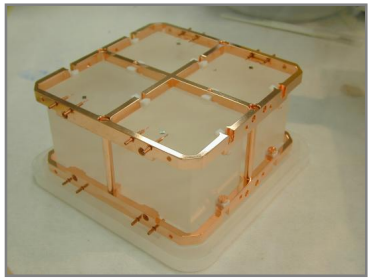
- Quadrupole and double focusing ICPMS
- ISO 6 Clean room
- Reagents purification systems
- Sample treatment device

\+ Small sample (g)
\+ Relatevely quick measurement
\- Sample treament is mandatory and delicate

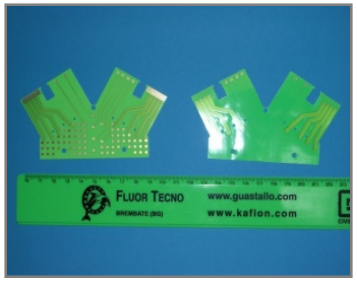
R&MS are often applied both to check for secular equilibrium of decay chain

ICPMS low radioactivity measurements

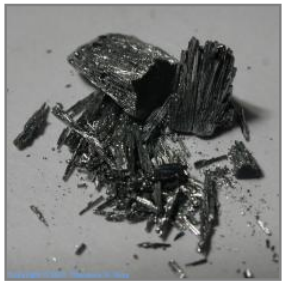
≈ 200 samples/year (complex matrices)
hundreds samples/year (reagents and water)



Cu, TeO2 and reagents
-CUORE-



Printed Circuit Board (PCB)
-GERDA-



Metals and alloys
-GERDA, XENON, DARK SIDE

Al-Mylar insulating foils
-XENON, DARK SIDE-

Our ‘routine’ ICP-MS detection limits:

Sample	Liquid	Metals (solid)		Plastic (solid)
		Dissolution and dilution	Analyte separation	
Element	[pg g^{-1}]	[pg g^{-1}]	[pg g^{-1}]	[pg g^{-1}]
K	50	5×10^4	-	5×10^4
Pb	0.5	500	-	100
Th	0.05	**50**	**1.0**	10
U	0.05	**50**	**0.5**	10

U in Cu	AVG 3Meas	SD
ppt	2.36	0.05

→ **30 ± 0,6 µBq/Kg**

Detection limit = $0.2\text{x}10^{-12}$ g/g → **2,4 µBq/Kg**

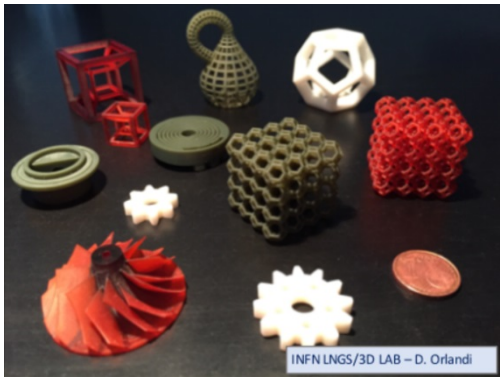
LRTs performances comparison

		ICPMS LNGS	ULL GRS LNGS	ULLGS+NAA Milano-Pavia
		Primordial parents	ϒ emitters	Primordial parents
		Surface/bulk	Bulk	Surface/bulk
Destructive		Yes	No	Yes
DL	[10^{-12}g/g]	Th=0.5 U=0.5	Th= 10-20 U= 10-20	Th(^{233}Pa)= 0.5 U(^{239}Np)= 3-5
Sample size	[g]	0.1-10	1-10000	200
Sample treatment		Contamination **risk not negligible**	Almost free	**Hot sample handling** **Low cont risk**
Analysis Time		Days	Weeks	Days-week

Additive Manufacturing at LNGS

For several years now the Mechanical Workshop is operating 3D printing devices to realize pieces with **photo-polymeric** and MultiJet Hi-performance **thermoplastic resins**

Carbon PEEK 3D printing is coming soon

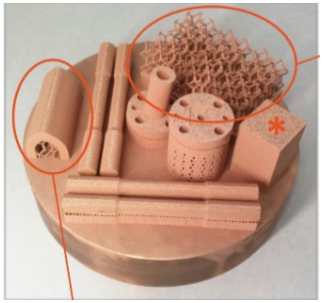


The facility is equipped with a stereoscopic Hi-Res 3D scanning station for quality analysis and reverse engineering

Additive Manufacturing: Future Outlook in Designing Pure Copper Components for LB detectors

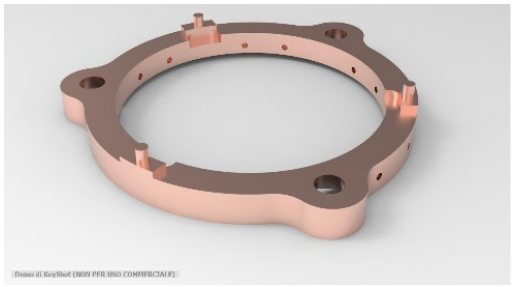
AM allows to produce parts:

- complex geometries
- high Resolution
- hollow components
- w/o final traditional machining
- w/o surface cleaning
- mass savings with a factor ≈ 2-3
- reduction of number of components



LRTs play a fundamental role for production process monitoring

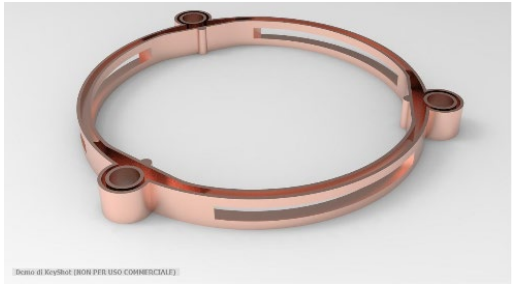
Crystal Holder



Traditional CNC
mass=27g

M/3 !

AM same support
mass=11g



AM new design
mass=9g

Center for Excellence on Aging (CeSi)

Fondazione Università Gabriele d'Annunzio

INFN Istituto Nazionale di Fisica Nucleare

Validation of a method for the quantitative multi-element profiling of brain tissues

Neurodegenerative deseases

Changes in brain levels of some elements, among them:

Li, Al, Cr, Co

Ciavardelli et al, "***Characterization of element profile changes induced by long-term dietary supplementation of zinc in the brain and cerebellum of 3xTg-AD mice by alternated cool and normal plasma ICP MS***", Metallomics, 2012

University of L'Aquila

INFN Istituto Nazionale di Fisica Nucleare

Investigation of the geographical origin of saffron trough elemental finger-print approach

Three set of samples from different production areas :

Crocus sativus

Dried stigmas of Crocus sativus

Medio Campidano

Perugia

L'aquila

Analysis of the mineral composition of Italian saffron by ICP-MS and classification of geographical origin, *Food Chemistry 157 (2014) 485–489*

Angelo Antonio D'Archivio , Andrea Giannitto , Angela Incani , Stefano Nisi

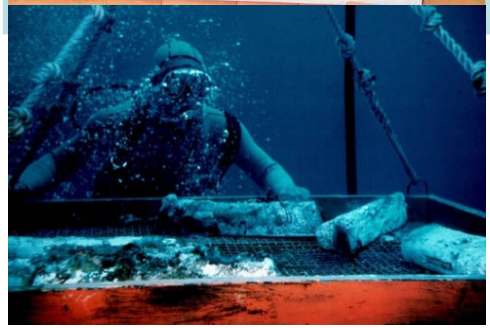
Laboratory of Isotopic Mass Spectrometry (LIMS)

MC Thermal Ionization Mass Spectrometry

- Discrimination between isotopic ratio values: <0.01%
- Internal precision of the measurement>0.005%

Applications (Cultural Heritage Network-INFN)

- Archaeometry (Pb, Sr)
- Human science: mobility ancient population study
- Food traceability (Sr)



Conclusion and perspective

- ICPMS is a fundamental technique for the experiments searching for rare and low energy events
- By the application of both ICPMS and RMs it is possible to have more complete and complementary information
- The R&D about new sample preparation procedures allow the achievement of better and better detection limits and reliable analysis
- The experience and the knowhow developed in ultra-trace measurement often make a significant contribute in interdisciplinary activities
- The purchasing of last generation quadrupole based ICPMS equipped with Laser Ablation System is under evaluating (direct measurement of solid sample)