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7th International Forum on Advances in Radiation Physics

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Book of Abstracts

Jorge E. Fernández and Francesco Teodori, eds.

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Foreword

The seventh International Forum on Advances in Radiation Physics (IFARP-7) takes place in Buenos Aires on March 12–13, 2026, under the auspices of the International Radiation Physics Society (IRPS) and the Embassy of Italy in Buenos Aires. The event is hosted at the Italian Cultural Institute of Buenos Aires and the Centro de Altos Estudios of the University of Bologna in Buenos Aires.

The forum provides an important platform for discussion and exchange among researchers working in the field of radiation physics. It brings together scientists to present recent results, foster international collaborations, and strengthen active scientific networks. The opening session takes place at the Benedetto Croce Auditorium of the Italian Cultural Institute, reflecting the strong ties between our nations in promoting scientific excellence.

IFARP-7 is preceded by the "Summer School on Applications of Radiation Physics on Cultural Heritage" (SARP-CH), held from March 9 to 11, 2026. This intensive three-day program is designed for advanced university students, PhD candidates, young researchers, and technical staff from Argentine partner institutions — UNC, UBA, UNSAM, and CONICET — as well as from other institutions interested in the field. The school takes place at the Centro de Altos Estudios of the University of Bologna (Representation in the Argentine Republic) and offers specialized training focused on the most advanced techniques for the investigation and conservation of cultural heritage through the use of radiation.

We sincerely hope that your participation in IFARP-7 will be both scientifically rewarding and personally enriching.

Welcome to Buenos Aires.

Jorge E. Fernandez and Francesco Teodori
On behalf of the Organizing Committee

Thursday 12

	Auditorium Benedetto Croce (Italian Cultural Institute)	
	S01: Special Focus on Applications to Cultural Heritage and Art 1	
09:30	Non-invasive analysis of the palette of Antonio Berni in four paintings from 1931 to 1944 by portable X-ray fluorescence spectroscopy (pXRF)	Marta Maier, Astrid Blanco Guerrero, Eugenia Tomasini and Gabriela Tomasini
09:50	A door to the past: X-Ray µCT scan of an Egyptian animal mummy	Nahuel Vega, Peter Zabala Medina and Faramarz Sahra Gard
10:10	Complementary application of radiative analytical techniques for the conservation of archaeological metal objects from North Patagonia: an interdisciplinary methodological proposal	Josefina María Schweickardt, Marcia Bianchi Villelli and Pablo Daniel Pérez
10:30	Analytical Contributions in Restoration of "Los Capuchinos" Church´s frieze, Córdoba, Argentina	Marcela Mammana, Marcelo Rustán, Cazón Sofía, Verónica Shoijet and Alejandro Germanier
10:50		

Non-invasive analysis of the palette of Antonio Berni in four paintings from 1931 to 1944 by portable X-ray fluorescence spectroscopy (pXRF)

Astrid C. Blanco Guerrero(1,2), Marta S. Maier(1,2,3), Eugenia Tomasini(3) and Gabriela Siracusano(3)

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X-ray fluorescence spectroscopy using portable equipment is a non-invasive analytical technique that can be used *in situ* for the analysis of the elemental composition of materials in cultural heritage objects. It is a fast and green procedure that may be applied both as a prospective approach and to select areas for the extraction of micro-samples to carry out further studies, such as stratigraphic analysis and the characterization of organic materials.

Within the framework of an interdisciplinary project on the materiality and painting technique of the renowned Argentinian painter Antonio Berni (1905-1981), we have recently reported the identification of zinc oxide, together with traditional inorganic pigments, in two oil paintings, *Toledo* (ca. 1928) and *Figure* (1941) [1]. Analysis by Attenuated Total Reflection-Infrared Spectroscopy (ATR-FTIR) of micro-samples extracted from both artworks revealed the formation of zinc carboxylates, also known as "zinc soaps".

These results prompted us to investigate the materials in four artworks that are representative of his production during the first half of the 20th century. The oil paintings "Susan and the old man" (1931), "The nap and its sleep" (1932), "The woman in the red sweater" (1935), and "Portrait of Mujica Lainez" (ca. 1944) were analyzed *in situ* by portable X-ray fluorescence spectroscopy (pXRF). The results indicated Berni´s predilection for historic red, blue and green inorganic pigments, such as vermillion, red cadmium sulfoselenide, Prussian blue, cobalt blue, and green chrome, together with lead, zinc, barium and titanium whites.

The extensive use of zinc white in the manufacture of the artworks of this period is an important issue, since it is highly probable that zinc soaps may have developed in the paintings studied posing a risk for their integrity and stability due to the potential development of efflorescence and delamination processes on their surfaces [2].

[1] A.C. Blanco Guerrero, I. Alcántara Millán, V.P. Careaga, G. Siracusano, M.S. Maier, Minerals 13(7), 2023, 919.
[2] P. Noble. *Metal Soaps in Art Conservation and Research*; Casadio, F.; Keune, K.; Noble, P., Van Loon, A.; Hendriks, E.; Centeno, S.; Osmond, G., Eds.; Springer Nature Switzerland AG: Cham, Switzerland, 2019; pp. 1-22.

A door to the past: X-Ray µCT scan of an Egyptian animal mummy

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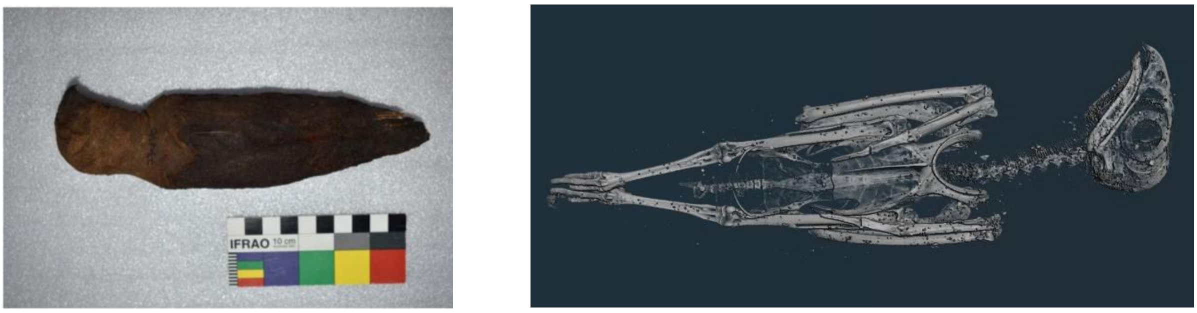
Animal mummification was a widespread religious practice in ancient Egypt, particularly during the Late Period and Ptolemaic era. Millions of animals were preserved as part of temple rituals, serving as sacred embodiments of deities or as votive offerings presented by worshippers. This study uses non-invasive X-ray computed tomography (CT) to examine an animal mummy (Fig. 1A) and investigate its biological identity, method of preparation, and cultural significance. CT imaging reveals the remains of a small bird contained within a carefully shaped mummy bundle. The skeleton is largely intact and articulated, with wings folded tightly along the body and legs extended downward in a deliberate, compact posture. Cranial morphology, especially the long, slender beak, suggests the bird is an ibis or ibis-like species (Fig. 1B). Ibises were strongly associated with Thoth, the god of wisdom, writing, and knowledge, making them one of the most commonly mummified birds in ancient Egypt.



(A) (B)

Fig. 1: (A) External view of the avian mummy, (B) CT-based 3D reconstruction of the avian mummy

The internal structure indicates intentional preparation consistent with standardized votive mummification. The body appears to have been positioned to achieve a recognizable external form, possibly supported by packing materials. This suggests that symbolic appearance was as important as anatomical preservation. Such features are typical of animals bred, prepared, and sold to pilgrims as offerings at temple sites.

Animal mummification served multiple religious and social functions. Most commonly, these mummies acted as votive offerings, functioning as physical messages or prayers to specific gods. They also reflect the broader belief that animals could embody divine qualities. In addition, large-scale animal mummy production supported an organized temple economy, linking religious devotion with animal breeding, embalming, and trade. Mummification transformed the animal into an eternal sacred form, ensuring its continued presence in the divine realm. This CT study demonstrates how non-destructive imaging can reveal both biological and cultural information from wrapped specimens. The mummy represents a deliberately prepared avian votive offering, illustrating the intersection of ritual practice, religious belief, and economic activity in ancient Egyptian society.

Complementary application of radiative analytical techniques for the conservation of archaeological metal objects from North Patagonia: an interdisciplinary methodological proposal

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This work presents an interdisciplinary methodology that integrates complementary analytical techniques involving different radiation types in order to characterize archaeological objects and their degradation products. This approach builds on conservation frameworks that emphasize analytically informed diagnostics as the basis for sustainable intervention strategies [1]. The methodology is presented through a case study and the discussion of analytical results obtained from multiple techniques.

The case study focuses on archaeological metal body ornaments from funerary contexts, manufactured by indigenous groups inhabiting the northern Patagonian Andes during the colonial period. The objects belong to the "Andrés Giai" Collection, housed at the Museo de la Patagonia (Nahuel Huapi National Park, Argentina). The lack of contextual information and the complex conservation condition, involving both material and symbolic dimensions, motivated the development of an interdisciplinary methodology aimed at guaranteeing the integral conservation of the objects through analytically supported treatments.

Five non-destructive analytical techniques were applied in a complementary way: Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy (SEM–EDS), Particle Induced X-ray Emission (PIXE), X-ray Diffraction (XRD), and X-ray and Neutron Tomography (X-ray and Neutron TRX) [3]. Their combined application enabled a comprehensive characterization of the composition and microstructure of the objects and their degradation products, while providing key information for conservation assessment and decision-making.

[1] Baca, L. F. G., (...), Ruigz Gomez, A. J. (2019). Conservación de bienes culturales: acciones y reflexiones. Instituto Nacional de Antropología e Historia; D.F. México.
[2] Joint ICTP-IAEA Advanced Workshop on Portable X-Ray Spectrometry Techniques for Characterization of Valuable Archaeological/Art Objects | (smr 3298) (03-14 June 2019)
[3] Schweickardt, J. M., Pérez, P. D., Morán, M., Villelli, M. B., & Cantargi, F. (2024). Interdisciplinary methodology for the characterisation of archaeological metal grave goods from the Museum of Patagonia by PIXE, DRX, and SEM/EDS. Archaeometry, 1-17. https://doi.org/10.1111/arcm.12966

Analytical Contributions in Restoration of "Los Capuchinos" Church´s frieze, Córdoba, Argentina

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"Los Capuchinos" Church, located in Córdoba, Argentina, is an important catholic temple built between 1926 and 1933. It was the first Argentine church made with a reinforced concrete structure. Architect Augusto Ferrari designed it in an eclectic Neo-Gothic/Neo-Romanesque style. Ferrari also created the 14-meter-high interior frieze, which comprises 30 murals depicting the life of Saint Francis of Asis. Each mural measures approximately 8 square meters. The artist used gold leaf mosaics to represent sky, while paint was used for the rest of the scene [1]. An expert assessment carried out in 2025 determined that at least eight of these murals require extensive restoration. Artistic technique used in the murals was identified as "*fresco secco*". Restoration work began with the most deteriorated mural, "*Los mártires de Gerusalen*", from which samples were taken. The analytical techniques used to study inorganic materials present were: X-ray fluorescence spectroscopy, X-ray diffraction, and scanning electron microscopy with energy-dispersive X-ray spectroscopy. Analyses were performed on both the substrate and the paint layer, determining the chemical elements present and, for those with higher concentrations, the associated compounds.

In the sample identified as CM-4, the principal substrate was gypsum ($CaSO_4$:$2H_2O$) with a minor phase of anhydrite ($CaSO_4$). The paint layer also contained, in smaller proportions, Ca corresponding to calcite ($CaCO_3$), Pb corresponding to both cerussite ($PbCO_3$) and hydrocerussite ($Pb3(CO_3)_2(HO)_2$), while silicon corresponding to quartz (SiO_2). Last, we also detected traces of Fe, P, Al, K, Cl, Ti, Sr, Zn, Mg, and Na. In the sample identified as CM-10, the principal substrate was gypsum ($CaSO_4$:$2H_2O$) with a minor brushite phase ($CaPO_3(OH)\cdot 2H_2O$). In the paint layer, following minerals were found in smaller proportions: Ca corresponding to calcite ($CaCO_3$), Ba corresponding to both barite ($BaSO_4$) and barium succinate ($C4H_4$-BaO_4), and Pb corresponding to lead oxide sulfate ($PbSO_4\cdot 4PbO$). Finally, were also present traces of Ti, Zn, Fe, Sr, Si, K, Cl, P, Al, and Mg.

"*Los mártires de Gerusalen*" mural showed generalized degradation due to the advance of moisture originating on the external surface of the wall. Some compounds may have originated of unrecorded interventions, as indicated by the presence of barium succinate and titanium in some areas of the samples. It would be important to continue these studies to further the restoration of the remaining 29 murals and ensure their future preservation.

[1] Marcela Mammana. "Survey and Enhancement of 30 Murals, Heritage of the Capuchin Church (work of Architect Augusto Ferrari). 2nd Prize, Competition for the Artistic Appraisal of Cemeteries, Temples and Sacred Spaces. *Fondo Nacional de las Artes, Argentina. 2024.*

Thursday 12

	Auditorium Benedetto Croce (Italian Cultural Institute)	
	S02: Applications to space, earth and enviromental sciences	
11:20	Neutron production using the nuclear reaction 45Sc(p,n)45Ti driven by the 1.7 MV Tandem accelerator located at the Atomic Center Bariloche	Pablo Daniel Pérez, Gustavo Ruano, Martín Pérez, Nestor Haberkorn, Sergio Suárez and Jerónimo Blostein
11:40	Radiation-enabled 3D visualisation of diagenetic processes in Permian silicified wood from the Carapacha Basin, Argentina	Enrique Baez, Alejandro Germanier and Alexandra Crisafulli
12:00	Atomic Signatures of the Cosmos: XPS Study of Meteorite Surfaces	Faramarz Sahra Gard, Yamil Paz and Rogelio Daniel Acevedo
12:20	Preliminary Results of Erythrocytes Aggregation Parameters Under Gamma Radiation Exposure in Transfusion Medicine	Sabrina Lorena Porini, Mariel Elisa Galassi and Horacio Castellini
12:40		

Neutron production using the nuclear reaction $^{45}Sc(p,n)^{45}Ti$ driven by the 1.7 MV Tandem accelerator located at the Atomic Center Bariloche

Pablo Daniel Pérez(1)(2), Gustavo Ruano(1)(2), Martín Pérez(1)(2), Nestor Haberkorn(1), Sergio Suárez(2) and Jerónimo Blostein(1)(2)

(1) Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), CCT Patagonia Norte, San Carlos de Bariloche, Argentina.
(2) Comisión Nacional de Energía Atómica (CNEA), Centro Atómico Bariloche (CAB), San Carlos de Bariloche, Argentina.

In this presentation, the progress made in the study of the nuclear reaction $^{45}Sc(p,n)^{45}Ti$ conducted at the 1.7 MV Tandem Ion Accelerator Laboratory located at the Bariloche Atomic Center will be discussed. This nuclear reaction presents absorption resonances at well-defined incident proton energies. Each resonance produces monoenergetic neutrons of a different energy that increases as the incident proton energy increases. By appropriately tuning the incident proton energy, it is possible to produce neutrons with discrete and well-defined energies between 8.12 keV and 51.62 keV [1]. These neutrons can be used for the characterization of neutron detectors and dosimeters.

For the study of the nuclear reaction, an ion tandem accelerator was used for proton production, and a detector bank based on ^{3}He proportional counters was used for neutron detection. The target consisted of a thin film of Sc deposited on Si (characterized by RBS using the same accelerator). After calibrating the high-voltage terminal, an energy scan was performed to obtain the number of neutrons emitted as a function of the proton energy. Results were comparable to those existing in the literature.

[1] V. Lamirand, PhD thesis, Université de Grenoble, 2011.

Radiation-enabled 3D visualisation of diagenetic processes in Permian silicified wood from the Carapacha Basin, Argentina

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(2) CEPROCOR, Ministry of Production, Science and Innovation of Córdoba, Ceprocor Pavilion, CP 5064, Santa María de Punilla, Córdoba Province, Argentina.

Silicified fossil woods represent high-fidelity archives of sedimentary fluid circulation and diagenetic transformation in continental basins, yet their internal three-dimensional organisation and coupling with basin-scale processes remain poorly constrained [1]. A radiation-based multiscale investigation was conducted on an Early Permian silicified wood specimen assigned to *Scleromedulloxylon aveyronense* (33 × 23 × 13 mm) from the fluvio-lacustrine Carapacha Formation, near Puelches, La Pampa, Argentina. The material belongs to the Dr Rafael Herbst Palaeontological Collection of the Universidad Nacional del Nordeste (CTES-PB) and is curated at CECOAL–CONICET–UNNE. The study links basin evolution, depositional setting, burial history and fluid pulses with microscale mineral architecture preserved within the fossil tissue. High-resolution X-ray micro-computed tomography (micro-CT) was employed as a non-destructive structural and densitometric framework that exploits differential X-ray attenuation driven by local variations in density and elemental composition. This contrast mechanism resolves coherent three-dimensional greyscale domains that map successive diagenetic overprints and preserve the internal wood anatomy with high spatial fidelity. Volumetric datasets were quantitatively integrated with element-specific information obtained by X-ray fluorescence, X-ray photoelectron spectroscopy and SEM–EDS, while confocal Raman spectroscopy constrained the crystalline phases associated with radiologically distinct regions. The combined radiation-based workflow demonstrates that silicification was neither instantaneous nor homogeneous, but progressed through a resolvable multistage pathway. Mineralogically, an early quartz-dominated matrix records pervasive primary replacement of the original tissue [1]. This stage is overprinted by an intermediate diagenetic phase expressed by Fe–V-enriched domains, which coincide with internal density stratification in micro-CT volumes and are interpreted as redox-sensitive mineral redistribution during progressive burial and compaction. A late-stage overprint is marked by Br–Sr–K-enriched infiltrations, together with minor Te, reflecting saline fluid pulses linked to basin-scale hydrological reorganisation during transgressive–regressive cycles and preferential flow through pre-existing porous networks and microfractures. Radiation-based 3D imaging reconstructs basin-scale fluid dynamics from fossil wood mineralisation, linking sedimentary processes with micron-scale diagenetic signatures. The non-destructive integration of micro-CT, spectroscopy and quantitative imaging advances radiation instrumentation while establishing transferable analytical protocols. This framework positions radiation physics as a core tool for decoding complex geological archives and enabling scalable palaeoenvironmental studies.

[1] E. Baez, A. M. C. Crisafulli, A. E. Kanbour, P. Zuliani, Estudio mineralógico de maderas petrificadas de la Formación Carapacha (Pérmico), La Pampa, Argentina, **FACENA** 34(1) (2024) 127–151.

Atomic Signatures of the Cosmos: XPS Study of Meteorite Surfaces

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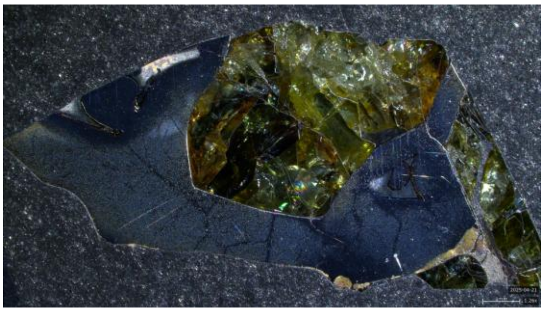
Meteorites preserve critical information about early Solar System processes while also recording chemical modification during their residence in space and after arrival on Earth. In this study, X-ray Photoelectron Spectroscopy (XPS) was applied to investigate the surface chemistry of a diverse suite of meteorites recovered in Argentina, including chondritic, iron, and plessitic specimens [1]. Figure 1 shows a selection of the meteorites analyzed in this work. The focus was placed on determining oxidation states, characterizing weathering products, and identifying surface mineral phases.

The surface-sensitive nature of XPS enabled detailed analysis of elemental composition and chemical states of major and minor constituents such as Fe, Ni, Mg, Si, S, O, and C. The measurements revealed variations in iron oxidation states across samples, reflecting differences in primary mineralogy as well as the extent of terrestrial alteration. Iron metal, sulfides, and silicate phases were distinguished from secondary oxides, hydroxides, and oxyhydroxides formed through weathering processes. In iron and plessitic meteorites, the coexistence of metallic Fe–Ni phases with oxidized surface layers highlighted progressive oxidation under terrestrial conditions.



(A)

(B)

Figure 1: (A) Esquel meteorite, (B) Cerro mesa meteorite

Comparative evaluation of the different meteorite classes demonstrated that surface alteration features are strongly linked to both original mineral assemblages and environmental exposure after fall. The results underscore the effectiveness of XPS for differentiating extraterrestrial mineral signatures from secondary weathering products and for assessing the chemical stability of meteoritic materials at Earth's surface. This work demonstrates the value of surface analytical techniques in advancing the understanding of planetary materials and their post-arrival evolution.

[1]: Gard, F. S., Acevedo, R. D., Gaztañaga, P., Alderete, P. N., Solis, L. M., Pierangeli, G., Zbihlei, G., Vega, N., & Halac, E. B. (2026). Esquel Meteorite, a Forgotten Argentine Peridot: A Multi Analytical Study. *Spectroscopy Journal*, *4*(1), 3. https://doi.org/10.3390/spectroscj4010003

Preliminary Results of Erythrocytes Aggregation Parameters Under Gamma Radiation Exposure in Transfusion Medicine

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(3) Física Biomédica, IFIR (CONICET-UNR) – Blvr. 27 de febrero 210 Bis, (S2000EKF) Rosario, Argentina
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Irradiation of transfusion units is a common technique in blood banks to inactivate donor T lymphocytes and prevent graft-versus-host disease. Ionizing radiation can potentially break double strands of DNA of nucleated blood cells, but in the case of erythrocytes (enucleated cells), other changes occur that shorten their lifespan from 42 to 20 days. Studies indicate that the biochemical parameters most affected are mean corpuscular volume and free sodium and potassium content [1,2], but the damage to red blood cells has not yet been fully elucidated. In this study, transfusion units in two different preservation media, were irradiated with different doses of gamma radiation and erythrocytes aggregation parameters (Half Time, Aggregation Index and Amp_{60}), were analyzed.

Red blood cell concentrate units preserved in CPDA and CPD-Optisol® were used. Each unit was divided into 4 satellite bags, 3 of which were irradiated at different doses (2, 10 and 25 Gy), and the remaining one was used as a control (0 Gy). Aliquots from each bag were analysed weekly for 28 days of storage (4 °C). Red blood cell aggregation parameters were determined, and biochemical tests were performed for the main indicators of cellular homeostasis.

Significant variations were observed for some aggregation and biochemical parameters depending on the storage time and dose, and for each preservation media used. The data obtained provide information on the damage to red blood cells caused by radiation dose and storage, which is related to the different characteristics of the two preservation media used.

[1] F Adams, GRM Bellairs, AR Bird, OO Oguntibeju. Afr J Lab Med. 7(1), 2018, a606.
[2] AI Alet, SL Porini, G Detarsio, A Aresi, L Di Tullio, N Manzelli, A Acosta, ME Galassi, BD Riquelme. Anales AFA 35, 2024, 21–24.

Thursday 12

	Auditorium Benedetto Croce (Italian Cultural Institute)	
	S03: Processes in Radiation Physics	
13:40	An Extended-Range Approach to Energy-Dispersive Inelastic X-ray Scattering Spectroscopy: Fundamentals and First Results of EDIXS+	Francisco Romero Carena, Héctor Jorge Sánchez and Juan José Leani
14:00	Experimental setup for the formation of an intense positronium beam for gravitation experiments	Alberto Galanti, Matias Nicolas Bayo, Rafael Omar Ferragut, Giuseppe Vinelli, Giuseppe Vinelli and Gabriele Rosi
14:20	Towards a Precision Measurement of the Antihydrogen Ground-State Hyperfine Constant at the ASACUSA Experiment	Matias Bayo, Alberto Galanti, Rafael Ferragut and Marco Giammarchi
14:40	Positron annihilation lifetime spectroscopy applied to perovskite photovoltaic materials	Abigail Williner, Silvia Tinte, Sergio Dalosto, Sandy Sánchez-Alonso, Rafael Ferragut and Javier Alejandro Schmidt
15:00		

An Extended-Range Approach to Energy-Dispersive Inelastic X-ray Scattering Spectroscopy: Fundamentals and First Results of EDIXS+

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Energy-Dispersive Inelastic X-ray Scattering spectroscopy (EDIXS) is a powerful technique for probing local atomic environments and oxidation states, particularly in systems where conventional X-ray absorption methods are strongly affected by self-absorption and/or geometric constraints [1]. In this work, we present the foundations and first experimental results of an extended-range implementation of this technique, referred to as EDIXS+, demonstrating its potential through the study of titanium-based dental implants.

While standard EDIXS is typically restricted to a limited region of interest located in the low-energy tail of the RIXS-K_α peak, EDIXS+ broadens the analyzed spectral window to include the full RIXS-K_α and RIXS-K_β features, as well as elastic (Rayleigh) and inelastic (Compton) scattering contributions. By incorporating these additional processes, EDIXS+ provides access to complementary physical information, enabling sensitivity not only to oxidation state but also to changes in electronic structure and material density. In this work, the conceptual basis of EDIXS+ and its differences with respect to standard EDIXS are outlined, highlighting the advantages of using an extended energy range combined with multivariate analysis.

As a first application of the technique, EDIXS+ was employed to investigate cross-sections of titanium dental implants using monochromatic synchrotron radiation under resonant excitation conditions. Both brand-new implants, presumed to be in optimal condition, and failed implants, retrieved after unsuccessful osseointegration, were analyzed. The spectra were interpreted using Principal Component Analysis (PCA), which plays a central role in the methodology by allowing an objective extraction of subtle spectral differences distributed over the extended energy range.

The results reveal a clear and systematic distinction between brand-new and failed implants. In detail, a progressive modification of the titanium state is observed in new implants, from the surface toward the bulk, exhibiting oxide-like characteristics in terms of electronic structure and density, although not necessarily corresponding to stoichiometric TiO_2. In contrast, failed implants show a spectral behavior dominated by metallic titanium, with little evidence of surface modification. These findings underline the critical role of surface treatment in implant performance and osseointegration.

Beyond this specific case study, the results presented here constitute a proof of concept and first experimental validation of EDIXS+, demonstrating that the key discriminating information resides in spectral regions that are not accessible in conventional EDIXS analyses. The technique thus emerges as a sensitive and versatile tool for the characterization of surfaces and interfaces at the micrometric scale. In addition, the results of EDIXS+ presented in this work highlight its strong potential for applications in materials physics, surface science, biomedical research, cultural heritage studies and the investigation of radiation-sensitive samples, opening new perspectives for advanced X-ray spectroscopic analysis.

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Experimental setup for the formation of an intense positronium beam for gravitation experiments

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QUPLAS (Quantum interferometry and gravitation with Positrons and LASers) is an experiment aimed at measuring the gravity acceleration of positronium (Ps), a bound state of an electron and a positron. This would represent the first gravitational measurement performed on a matter-antimatter system composed of elementary particles, providing a crucial test of the CPT symmetry and the Einstein Equivalence Principle, whose violation would indicate new physics beyond the current framework [1]. The gravitational acceleration of Ps will be measured using a Mach-Zehnder interferometer by detecting the phase shift between two spatially separated paths [1]. This technique requires a continuous-wave, low-divergence Ps beam; therefore, a suitable setup capable of fulfilling these conditions is essential. QUPLAS proposes to achieve this in two stages: the production of a positronium negative ion (Ps^-) high-intensity beam followed by the photodetachment, i.e. the de-ionization, to obtain neutral Ps.

The Ps^- ions are produced by means of a converter in which a positron beam is implanted close to the surface of a polycrystalline tungsten disk coated with a sub-monolayer of sodium, a configuration that yields the highest production efficiency reported so far [2] and at the same time maximizes the photoelectric emission. The ions are then rapidly accelerated and focused to minimize annihilation losses and preserve beam intensity. The photodetachment stage requires a high-power optical cavity (200 kW), where a 1560 nm laser beam crosses the Ps^- beam, removing one electron via single-photon absorption [1].

In this work the QUPLAS gravitation experiment is presented, together with the photoelectric characterization, of the Na/W sample, a description of the photodetachment stage and an overview about the Mach-Zehnder interferometer.

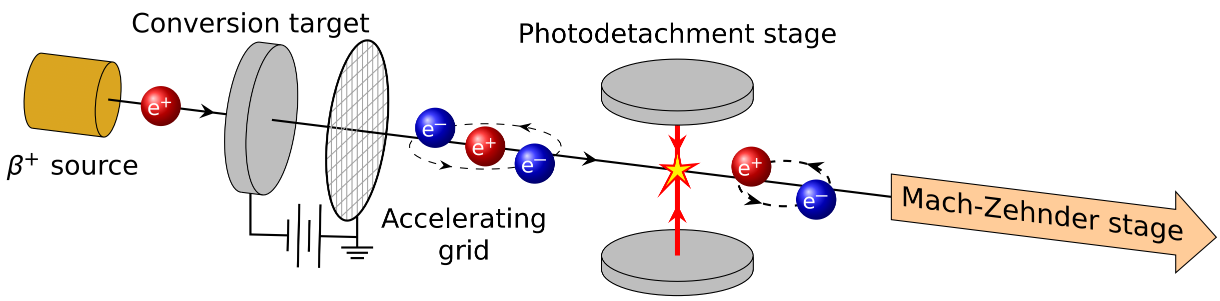

Figure 1: Scheme of the QUPLAS stages to produce the Ps beam as input for the Mach-Zehnder interferometer

[1] G. Vinelli et al., Class. Quantum Gravity 40 (2023) 205024.
[2] Y. Nagashima, Phys. Rep. 545 (2014) 95–123.

*QUPLAS Collaboration: https://www.positron.fisi.polimi.it/

Towards a Precision Measurement of the Antihydrogen Ground-State Hyperfine Constant at the ASACUSA Experiment

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on behalf of ASACUSA Collaboration**

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Antihydrogen, the bound state of an antiproton and a positron (produced using a β^+ radiation source) is routinely formed at the CERN Antiproton Decelerator, provides a unique system for precision tests of fundamental symmetries. The ground-state hyperfine splitting of hydrogen is one of the most precisely measured quantities in physics, reaching a relative precision of 10^{-12}. In the context of CPT symmetry, hydrogen and antihydrogen are expected to share identical spectral characteristics. However, a measurement of this transition in antihydrogen has remained elusive, representing a significant gap in our testing of fundamental symmetries. While recent years have seen breakthroughs in measuring the 1S-2S transition, the hyperfine structure offers a complementary and sensitive probe for New Physics.

The ASACUSA collaboration at CERN, proposes a distinct approach to overcome this challenge. Unlike magnetic trap experiments, ASACUSA relies on a Rabi-type atomic beam spectroscopy method. This setup allows for transitions to be driven in a region of low and homogeneous magnetic field, thereby avoiding the strong field gradients that typically limit the precision in trapping experiments.

In this contribution, we present the status of the ASACUSA antihydrogen beamline. The experimental scheme utilizes a CUSP trap to produce a polarized antihydrogen beam, a radiofrequency cavity for spin-flipping, and a sextupole magnet for spin analysis. We will discuss the recent upgrades to the beam apparatus described in the latest technical reports [1], focusing on the optimization of the antihydrogen yield and the characterization of the background rejection. Furthermore, we report on the latest beam characterization measurements [2] which are critical for the upcoming precision runs.

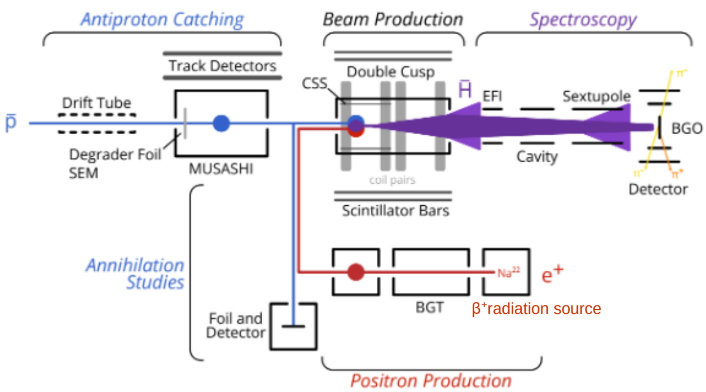

Figure 1. Overview of the ASACUSA hyperfine spectroscopy beamline.

[1] Optimizing Antihydrogen Production via Slow Plasma Merging, ASACUSA Collaboration, 2025, arXiv:2511.06883
[2] Measured Properties of an Antihydrogen Beam, ASACUSA Collaboration, 2025, arXiv:2509.02583

** http://asacusa.web.cern.ch/

Positron annihilation lifetime spectroscopy applied to perovskite photovoltaic materials

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Perovskite solar cells have emerged as one of the most promising photovoltaic technologies of the past decade, owing to their remarkable power conversion efficiencies, low-cost fabrication, and tunable optoelectronic properties [1]. Among the various perovskite compositions, formamidinium lead iodide ($FAPbI_3$) has attracted particular attention due to its optimal bandgap for single-junction solar cells and good thermal stability [2]. On the other hand, methylammonium lead bromine ($MAPbBr_3$) is well suited for tandem solar cells due to its direct band gap of circa 2.2 eV, which combines well with the established silicon technology [3].

Defects usually limit the optoelectronic properties of semiconductors. One of the few methods that can directly identify the charge of the defects and partially their chemical origin is positron annihilation lifetime spectroscopy (PALS). Analyzing the PALS spectrum, one can extract the lifetime and estimate the quantity of defects that trap and provide annihilation centers for the positron [4].

First-principles calculations provide insight into the possible point defects present in perovskite materials. Moreover, they provide a method to identify the measured lifetime components of PALS to a given defect state.

In this work, we apply PALS measurements to $FAPbI_3$ and $MAPbBr_3$ samples. We compare the effects of the different cations and the different anions. Using density functional theory (DFT) as implemented in the ABINIT software package, we perform self-consistent calculations of positron and electron densities, including atomic relaxation effects. This approach allows us to directly compare experimental lifetimes with theoretical predictions, thereby providing deeper insight into the nature of point defects in perovskites and their role in device performance.

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[3] R. Sheng, A. Ho-Baillie, S. Huang, S. Chen, X. Wen, X. Hao, M. A. Green, Journal of Physical Chemistry C 119, 2015, 3545.
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Thursday 12

	Auditorium Benedetto Croce (Italian Cultural Institute)	
	S04: Simulation of Radiation Transport and Detection	
15:30	Carbon-ions irradiation: mean kinetic energy of the emitted electrons through H2O	Nicolás Esponda, Roberto Rivarola, Michele Quinto and Juan Monti
15:50	Identification of Calcification Composition Using Conical Slits in X-ray Scattering Imaging (CS-XSI): A Simulation and Experimental Study	Carolina Moravec de Viana Borges, Renata Olmedo Benedet, Marcelo Goncalves Honnicke and Martin Eduardo Poletti
16:10	X-ray imaging with a phase sensitive detector	Marcelo Honnicke
16:30	Innovative ion-based radiotherapies: from interaction cross-sections to clinical applications	Mario Alcócer-Ávila and Mariel Elisa Galassi
16:50	Proton Stopping Power in Air: Inelastic Atomic Processes and Implications for Hadrontherapy Dosimetry	Camila Strubbia Mangiarelli, Veronica Belen Tessaro, Michael Beuve and Mariel Elisa Galassi
17:10	Monte Carlo-based simulations in a computational thyroid model: towards the implementation of dosimetric calculations	Venecia Magalí Calandrón, Luis Héctor Illanes and Cecilia Yamil Chain
17:30		

Carbon-ions irradiation: mean kinetic energy of the emitted electrons through H_2O

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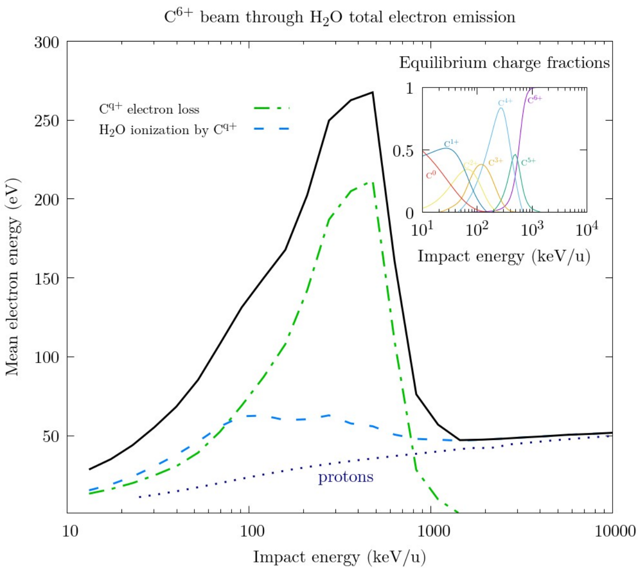
Hadrontherapy is the name given to the radiation treatments involving charged hadrons, like protons, alpha particles and carbon ions. Its main characteristic in dose delivering is the well known Bragg peak, that is, all the biological damage is produced in the spot where the ion stops. Comparing to conventional X-ray irradiation, the hadrontherapy showed to have less toxicity in the patient, a higher biological effectiveness as well as more accurate dose delivering [1].



Theoretical studies on energy deposition of an ion beam in biological media are usually performed with Monte Carlo simulations. These codes can represent the stochastic nature of the physical processes which may take place within the main particle path. Nonetheless, the reliability of Monte Carlo track structure codes strongly depends on the accuracy of the input magnitudes used in the simulations. For example, the capture, excitation and ionization cross sections [1,2].

With a recent revised Continuum Distorted Wave model [3], we calculated double, single and total cross sections for single ionization of water molecules by impact of all charge states of carbon. Then, we calculated the average kinetic energy of the emitted electrons in water vapour as a function of the carbon beam energy. This is an interesting quantity for track simulations codes and it may also encourage experimental tests over C^{q+} systems [2].

[1] T. Liamsuwan, H. Nikjoo, Physics in Medicine and Biology (58), 2013, 673.
[2] V. Conte, P. Colautti, B. Grosswendt, D. Moro, L De Nardo, New Journal of Physics (14), 2012, 093010.
[3] N. Esponda, M. Quinto, R. Rivarola, J. Monti, Atoms (13), 2025, 88.

Identification of Calcification Composition Using Conical Slits in X-ray Scattering Imaging (CS-XSI): A Simulation and Experimental Study

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(2) Federal University of Latin American Integration (UNILA)

X-ray scattering imaging (XSI) complements mammography by relating scattering profiles to molecular structure [1], with conical slits (CS) being investigated to selectively enhance profiles associated with microcalcifications [2]. This work assesses, through deterministic simulations [3], the effectiveness of CS-XSI in identifying di-hydrated calcium oxalate (DHCO) microcalcifications. The algorithm was validated by comparing experimental and simulated images of adipose tissue acquired under identical conditions, confirming the correspondence of the characteristic scattering peak (Fig. 1a-c). Subsequently, images of a mixture of adipose tissue and DHCO were simulated, with and without a CS designed to select the characteristic DHCO scattering peaks ($\chi = 1.5$ and $2.0\ nm^{-1}$) [2]. A molybdenum (Mo) target X-ray source operated at 40 kV, together with a zirconium (Zr) filter of 15 µm, was considered to ensure that the radiation incident on the samples was predominantly monoenergetic, closely matching the MoKα emission. In the absence of CS, the intrinsic blurring of the XSI technique [3] hindered proper identification of the DHCO peaks (Fig. 1d,e). By contrast, the inclusion of CS allowed clear visualization of the DHCO peaks (Fig. 1f,g). These findings confirm the potential of CS-XSI for identifying microcalcifications, with further studies on other microcalcification compositions currently underway.

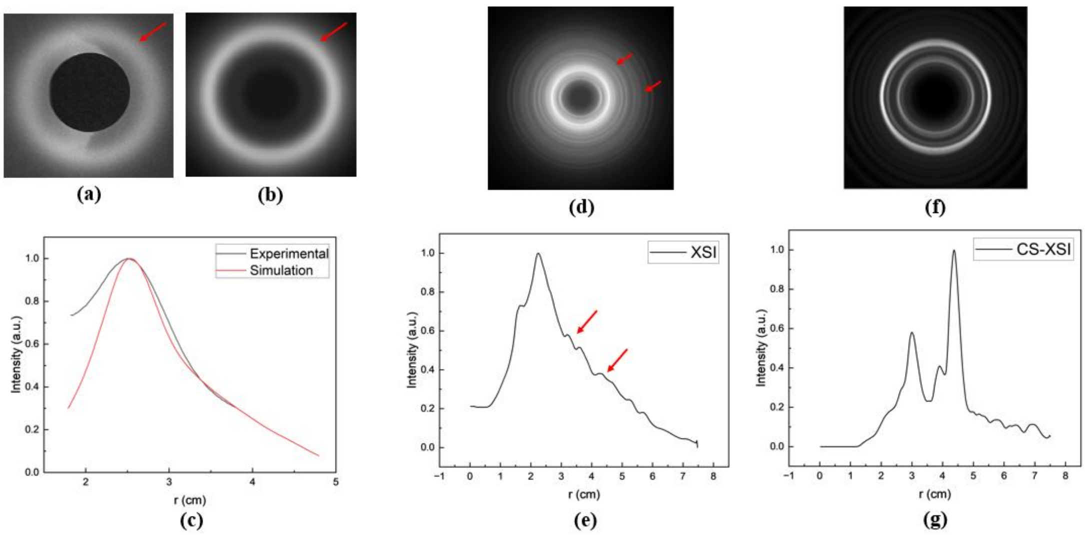

Figure 1 - (a) Experimental and (b) simulated images of adipose tissue, with (c) their radial profiles (arrows: adipose peak). Simulated images of the adipose/DHCO mixture (d) without and (f) with the CS, with their (e, g) radial profiles (arrows: DHCO peaks).

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[2] R. O. Benedet, P. R. dos Santos, C. Cusatis, et al., X-Ray Spectrom. 54(6), 2025, 765-772.
[3] C. M. V. Borges, B. Tomazi, M. E. Poletti, X-Ray Spectrom. 54(6), 2025, 693-702.

X-ray imaging with a phase sensitive detector

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Self-detection of X-ray diffraction can be achieved by measuring a decrease in photocurrent or photon count when a single-crystal detector is positioned in the diffraction condition [1]. This effect was initially used in few applications [2-3]. For imaging, the self-detection of the standing wavefield intensity in a single-crystal CCD detector was reported [4]. Using this effect [4], it is proposed here a novel type of phase-contrast X-ray imaging technique. If a sample is placed in front of a CCD detector and the detector is set in the diffraction condition, at angles close to 90º (back-diffraction), the phase shifts in the X-ray beam, after passing through the sample, can be associated with different diffraction angles (within the total reflection region) of the CCD detector. These angles can be associated with different phases of the X-ray standing wavefield [from 0 rad (maximum standing wave intensity between atomic planes) to π/2 rad (maximum standing wave intensity on atomic planes)] (Fig. 1). Thus, for different detected intensities, a different standing wavefield phase can be associated. The theory developed, including simulated, as well as, the acquired experimental images (Fig. 1), will be presented in this talk. Further studies with more complex samples and with CCD detector with low crystal lattice stress [5] is envisaged.

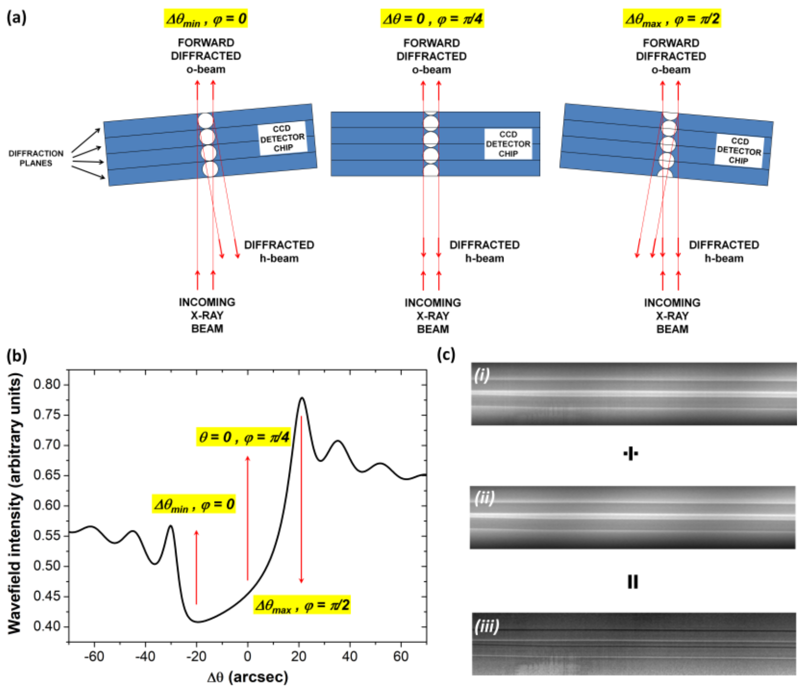

Fig. 1: (a) Schematic representation of the standing wavefield within the diffraction condition (total reflection region) of a single-crystal media (CCD detector chip), where the standing wavefield goes from its maximum between the atomic planes (lower angles) to the maximum on the atomic planes (higher angles). (b) Standing wavefield intensity within the diffraction condition, showing the different wavefield phases (φ) at different angles (Δθ). (c) Measured X-ray images of two parallel 350 μm thick polyamide wires taken with a direct conversion CCD detector (Si 800): *(i)* image taken with the CCD in diffraction condition; *(ii)* image taken with the CCD out of diffraction condition and *(iii)* resulted phase contrast image.

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[3] M. G. Hönnicke, E. M. Kakuno, C. Cusatis, I. Mazzaro, J. Appl. Cryst. 37, 2004, 451.
[4] M. G. Hönnicke, C. Cusatis, J. Appl. Cryst. 42, 2009, 999.
[5] C. Gollwitzer, M. Krumrey, J. Appl. Cryst. 47, 2014, 378.

Innovative ion-based radiotherapies: from interaction cross-sections to clinical applications

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(4) Facultad de Ciencias Exactas, Ingeniería y Agrimensura, Universidad Nacional de Rosario (UNR), Argentina
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(6) Laboratoire de Physique de Clermont, CNRS/IN2P3, Université Clermont Auvergne, France
(7) Laboratoire d'Informatique en Image et Systèmes d'Information, CNRS, Université Lyon 1, France
(8) Laboratoire de Radiobiologie Cellulaire et Moléculaire, CNRS/IP2I, Faculté de Médecine Lyon-Sud, Université Lyon 1, Oullins, y Service de Biochimie et Biologie Moléculaire, Hôpital Lyon-Sud, France
(9) Centre de Recherche en Acquisition et Traitement de l'Image pour la Santé (CREATIS) y CNRS/Inserm, Institut National des Sciences Appliquées (INSA) de Lyon, Université Lyon 1, Lyon, France

Ion-based radiotherapies offer the potential to effectively treat tumors resistant to conventional radiotherapy while minimizing radiation exposure to healthy tissues. These innovative modalities include Hadrontherapy, Targeted Alpha Therapy (TAT), and Boron Neutron Capture Therapy (BNCT). Optimizing these treatments requires the development of tools capable of integrating all stages of ionizing radiation interaction with living matter—ranging from atomic-level physical cross-sections to the resulting biological effects in patients. This work presents a multiscale approach to modeling ion-based radiotherapies and predicting their biological effectiveness to achieve high-precision dosimetry. The proposed framework combines Monte Carlo (MC) simulations of ion transport in water, experimental cell survival data, and biophysical models to estimate the biological impact of irradiation.

The LPCHEM and GEANT4-DNA MC codes were employed to describe the physical, physico-chemical, and chemical stages of radiation-matter interaction at nanometric resolution. The simulation outputs were processed using the NanOx biophysical model to derive radiobiological coefficients. These coefficients were subsequently integrated into the GATE code to generate biological dose maps within a patient geometry. For targeted therapies (TAT, BNCT), various intracellular and intratumoral distributions of the therapeutic agents were investigated. The results of our multiscale approach are promising, demonstrating the capability to bridge the gap between microscopic physics and clinical outcomes. Current efforts are focused on refining models at all scales, particularly in the low-energy regime [1]. The acquisition of further experimental data will facilitate exhaustive validation at the preclinical level.

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Proton Stopping Power in Air: Inelastic Atomic Processes and Implications for Hadrontherapy Dosimetry

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Mariel E. Galassi(1,2)

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Hadrontherapy is an advanced cancer treatment modality based on high-energy proton and heavy-ion beams. It provides superior ballistic accuracy compared to conventional photon radiotherapy and enables the treatment of radioresistant tumors or tumors located near critical organs. Accurate dose determination relies on reference dosimetry, typically performed using water phantoms and air ionization chambers. In this context, detector readings are related to absorbed dose through fundamental physical quantities such as the stopping power in air and the W-value, defined as the mean energy to produce an ion-electron pair, whose accurate determination is essential for reference dosimetry.

The aim of this work is to investigate the proton stopping power in air over a wide incident energy range, from 1 keV to 100 MeV, with particular emphasis on the role of inelastic atomic processes relevant for hadrontherapy dosimetry. Stopping power calculations were performed using the Monte Carlo code MDM-Ion, extended to this medium and ion projectile [1], as well as an analytical method based on the Continuous Slowing Down Approximation (CSDA) [2]. These calculations require inelastic cross sections described by semi-empirical models derived from experimental data [3,4,5].

The stopping power results show good agreement with recommended reference data for proton energies above 50 keV [6]. Below this energy, discrepancies exceeding 20% are observed, mainly due to limitations in semi-empirical parametrizations resulting from the scarcity of experimental data for specific inelastic channels. Since experimental determination of the inelastic cross sections in this energy range is challenging, accurate theoretical modeling becomes essential. This is especially important for the determination of differential W-values in small sensitive volumes, which are highly sensitive to the underlying inelastic cross sections and therefore require improved modeling of these processes [1,7].

Despite these limitations, the use of semi-empirical models significantly reduces computational time, enabling fast and efficient determination of stopping power values. Ongoing work focuses on improving the modeling of poorly constrained inelastic processes in the low and intermediate energy regimes. This study contributes to the physical basis required for accurate reference dosimetry and supports the development and optimization of proton therapy in emerging clinical centers, including the Argentine Proton Therapy Center.

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[2] M. Inokuti, Rad. Res. 64(1), 1975, 6-22.
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Monte Carlo-based simulations in a computational thyroid model: towards the implementation of dosimetric calculations

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Radioiodine therapy is the gold standard radiopharmaceutical therapy (RPT) for the management of hyperthyroidism. In clinical practice, the therapy is based on administering the same ^{131}I activity to all patients, with the potential risk of being effective in some cases. The therapy can be optimized by performing dosimetric calculations, which require accurately quantifying the activity taken up by the thyroid gland, using nuclear medicine imaging [1].

The aim of this work is to use Monte Carlo simulations to model the acquisition of ^{131}I planar images in the thyroid under different operating conditions. The SIMIND MC code was configured with the technical specifications of a Picker Prism 2000 XP clinical gamma camera, and the simulator was validated through quality control tests. The results of these tests were compared with the manufacturer's expected values. An anthropomorphic Zubal computational phantom was used as the patient model, configured to reflect the ^{131}I distribution pattern observed in three real clinical cases of patients with hyperthyroidism. The accuracy in the quantification of ^{131}I and in the subsequent dosimetric calculation was evaluated in different scenarios and the usefulness of the obtained value in the clinical context was analyzed.

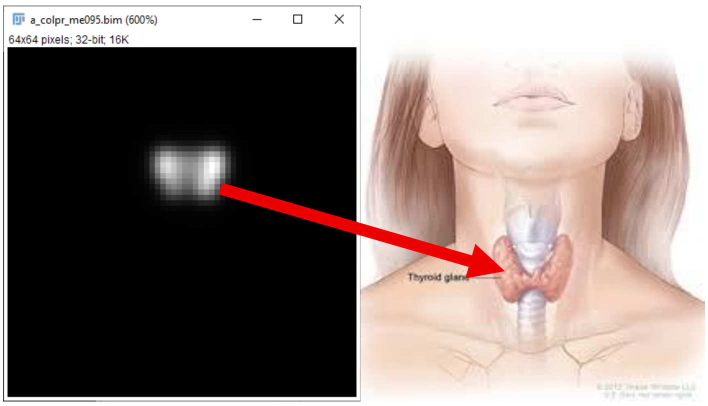

Figure: Simulated planar image of the thyroid gland and scheme of its localization and anatomical shape

[1] Hänscheid, Heribert, et al. "EANM Dosimetry Committee series on standard operational procedures for pre-therapeutic dosimetry II. Dosimetry prior to radioiodine therapy of benign thyroid diseases." *European journal of nuclear medicine and molecular imaging* 40.7 (2013): 1126-1134.

Friday 13

	Aula Magna (Centro de Altos Estudios)	
	S05: Special Focus on Applications to Cultural Heritage and Art 2	
9:00	Dual Energy Computed Tomography (DECT) for the characterization of heritage objects	Maria Pia Morigi, Nayyab Amjad, Matteo Bettuzzi, Patricia Guilló Vigo, Cecilia Riccardizi, Antonin Zajicek and Michal Vopálenský
9:20	Multianalytical identification of an atypical green pigment in late pre-Hispanic rock art from Inca Cueva, Northwestern Argentina	Matias Landino, Eugenia Ahets Etcheberry, Lucas Gheco, Marcos Tascon, Diego G. Lamas and Fernando Marte
9:40	Archaeometric study of ceramic production at the Ventarrón–Collud Archaeological Complex, Peru	Cheila Sumenssi de Araujo Desanti, Carlos R. Appoloni, Renato Ikeoka, Arcuri, Fagundes, Silva, Lopes, Silva and Samulewski
10:00	Multianalytical characterization of an Ary Brizzi easel painting	Carolina Sanchez Barberena, Astrid Blanco Guerrero, Pino Monkes, Alejandra Fazio and Marta Maier
10:20	Fluorescence-based and multitechnique spectroscopy for the non-invasive analysis of small-format printed objects	Cecilia Angulo Valdivia, María Gabriela Lagorio and Eugenia Tomasini
10:40	Accessible strategies for optimizing X-ray fluorescence measurements on paper-based heritage objects	Fermina Valeria Ziaurriz and Eugenia Paula Tomasini
11:00		

Dual-Energy Computed Tomography (DECT) for the characterization of heritage objects

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X-ray Computed Tomography (CT) is a fast-evolving and highly versatile technique that has become a reference tool for non-destructive analysis across a wide range of research fields, including Cultural Heritage studies. In recent years, the demand for on-site CT investigations by museums and conservation institutions has increased significantly, reflecting the growing importance of this technique in both artwork restoration and heritage research [1]. Nevertheless, a well-known limitation of single-energy CT is its limited capability to distinguish materials exhibiting similar X-ray attenuation properties. Dual-Energy Computed Tomography (DECT) addresses this issue by acquiring two datasets of the same object using distinct X-ray spectra, which are reconstructed into low- and high-energy images [2]. A material decomposition algorithm is then applied to generate quantitative maps of two selected basis materials, allowing both material differentiation and estimation of their relative concentrations. Although DECT is well established in clinical practice, its application in heritage science remains limited and is still under development [3]. Building on our extensive experience with conventional CT, we investigated the potential of DECT for the characterization of pigments in painted artifacts. For this purpose, a set of mock-up samples was prepared using a variety of historically relevant pigments, including cinnabar, lead white, Herculaneum red, and cadmium red. CT scans were performed over a wide range of tube voltages (40–200 kV) with different filtration conditions. After identifying the most effective energy pair, custom Python-based decomposition algorithms were applied to selected Regions Of Interest (ROIs). This approach yielded color-coded maps capable of distinguishing coexisting pigments within the same paint layer (see Fig. 1).

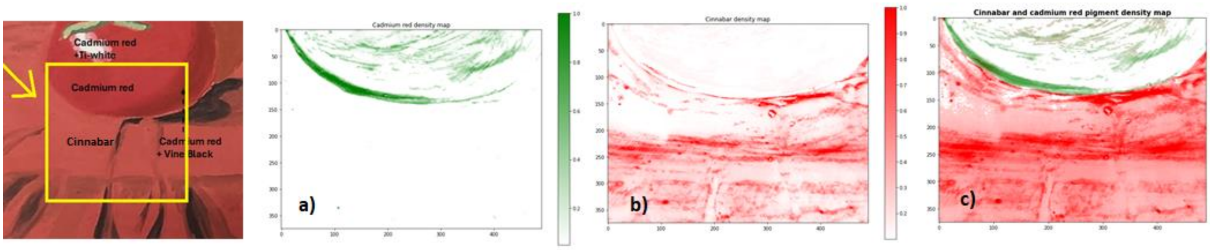

Fig. 1. Material decomposition applied to differentiate cinnabar and cadmium red in one of the mock-up samples: a) map of cadmium red; b) map of cinnabar; c) composite image.

The application of DECT-based material decomposition to painted mock-up samples produced encouraging results, demonstrating its potential for pigment identification while also revealing certain limitations. Further experimental investigations are required to refine the methos and to validate its applicability to real historical artworks.

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Multianalytical identification of an atypical green pigment in late pre-Hispanic rock art from Inca Cueva, Northwestern Argentina

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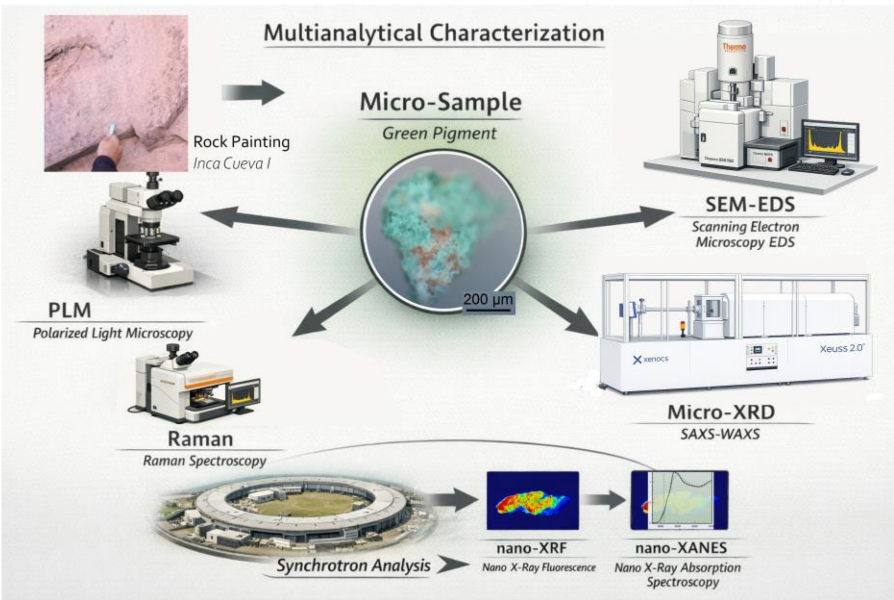
Green pigments are rarely documented in pre-Hispanic rock art from Northwestern Argentina, where red, black, and white palettes predominate. The presence of a green anthropomorphic motif at Inca Cueva 1, one of the most important rock art sites in the region, raises questions regarding pigment selection, technological knowledge, and raw material procurement. This study presents a preliminary multianalytical characterization of this pigment to determine its mineralogical composition and painting technology.

A painting's micro-sample was analyzed using polarized light microscopy (PLM), SEM-EDS, Raman spectroscopy, and micro-X-ray diffraction (µXRD, SAXS-WAXS configuration). Synchrotron-based nanoXRF mapping and nano-XANES spectroscopy were further employed to investigate elemental distribution and copper speciation. This integrated, multiscale approach enabled the correlation of mineralogical and chemical data at micro- and sub microscale resolution.

Preliminary results indicate the presence of a copper-based pigment consistent with the atacamite mineral group (atacamite and/or its polymorphs). The evidence supports the deliberate selection and preparation of a copper-bearing mineral rather than secondary alteration. These findings provide new insights into pigment technology in late pre-Hispanic rock art from Northwestern Argentina and demonstrate the value of combining synchrotron radiation techniques with laboratory-based analyses for complex pigment identification.



Archaeometric study of ceramic production at the Ventarrón–Collud Archaeological Complex, Peru

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This study investigates ceramic production technologies at the Ventarrón–Collud Archaeological Complex, on the northern coast of Peru, a region with more than 4,000 years of occupation [1, 2]. A total of 193 ceramic fragments from the sites of Huaca Ventarrón, Huaca Collud, Huaca Zarpán, and Arenal were analyzed. Elemental and mineralogical analyses were carried out using Energy Dispersive X-ray Fluorescence (EDXRF), X-ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), and gamma spectrometry, supported by exploratory multivariate analysis and digital microscopy. The results show strong similarity in the elemental composition of the ceramic pastes, indicating long-term use of carbonate-rich clay sources, even with stylistic differences and different archaeological contexts. Mineralogical differences between the assemblages are mainly related to firing conditions, such as temperature, atmosphere, and cooling. Differences in weathering patterns between the Ventarrón–Arenal and Collud–Zarpán groups suggest the influence of local depositional environments. The analysis of surface treatments shows little variation in red pigments, mainly composed of iron oxides. Black pigments are also mostly iron-based, with possible use of manganese-rich material in one fragment. White pigments show greater variation, suggesting the use of different raw materials and mixtures. These results help clarify technological choices and production practices in ancient ceramic traditions [3].

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Multianalytical characterization of an Ary Brizzi easel painting

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The 1950s and'60s were pivotal decades in Argentina's art scene, as alternative representations and non-traditional materials emerged in artworks of several artistic movements. The pictorial work *Pintura* (1964), by the local renowned contemporary artist Ary Brizzi, serves as a testimony of this period.

Catalogued as oil and pyroxylin on aluminium, *Pintura*'s colour palette consists of four colours: a plain white/beige base, and black, green and orange stripes. The painting showed early fungal colonization patterns over the black surface, which prompted us to characterize the pictorial materials in an attempt to explain the fungal presence. Micro-samples (~1 mg) of the pictorial layer were taken from the periphery of the painting and analysed by a combination of spectroscopic and radiation techniques such as XRF, ATR-FTIR, and Raman microscopy, in order to characterise pigments and binders.

XRF analysis of sample BR01 (black layer) showed the presence of Zn as the major element, together with Ca, Ti, Cr, Fe, and Co. ATR-FTIR spectroscopy allowed the characterization of the binder as an alkyd resin due to bands of C-H stretching at 2920 and 2852 cm^{-1}, C=O at 1728 cm^{-1} and C-O at 1276 and 1120 cm^{-1} [1][2]. Common mineral extenders used in industrial paint formulations, such as talc ($Mg_3Si_4O_{10}(OH)_2$) and calcite ($CaCO_3$) [3], were also identified by bands at 376, 951 and 667 cm^{-1}, and 876 cm^{-1} respectively. A broad band in the range 580-400 cm^{-1} confirmed the presence of zinc oxide as white pigment. Raman spectroscopic analysis of the black layer of the sample identified a carbon-based black pigment (1350 and 1550 cm^{-1}) [4] together with chrome green (Cr_2O_3) (546 cm^{-1}) and titanium white (TiO_2) in its rutile phase (142, 231, 444, and 608 cm^{-1}). The presence of a carbon-based black pigment may have promoted fungal proliferation in this area of the painting [5].

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Fluorescence-based and multitechnique spectroscopy for the non-invasive analysis of small-format printed objects

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The non-invasive characterization of cultural heritage materials requires approaches capable of addressing their intrinsic chemical and optical complexity. In this context, small-format printed artifacts provide a valuable opportunity for *in situ* spectroscopic analysis, as their dimensions allow the use of versatile bench-top instrumentation to investigate entire objects without sampling.

Heritage objects and printed materials constitute optically complex systems, largely due to their light-scattering properties and the presence of multiple interacting compounds, which pose significant challenges for fluorescence analysis and require adapted spectroscopic approaches. Accordingly, Argentine postage stamps were employed as models for small-format heterogeneous matrices and as a methodological starting point to explore spectroscopic responses from inks, additives, and substrates in philatelic materials. The main approach integrates reflectance- and fluorescence spectroscopy-based models commonly applied to opaque materials [1], here adapted to the analysis of complete printed objects.

This study addresses key photophysical challenges and supports the development of non-invasive analytical methodologies for small-format printed materials, while highlighting the importance of appropriate data analysis and the complementarity of different techniques, such as Raman and FTIR-ATR, for the non-invasive study of cultural heritage objects beyond philatelic collections.

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Keywords: Non-invasive analysis, Fluorescence spectroscopy, Multitechnique analysis, Heritage science

Accessible strategies for optimizing X-ray fluorescence measurements on paper-based heritage objects

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Portable X-ray fluorescence spectroscopy (pXRF) is widely used for the non-invasive elemental characterization of cultural heritage materials. In paper-based objects, which are thin and of low-density, penetration of the incident beam can generate spectral contributions from the underlying support during *in situ* measurements on uncontrolled surfaces. Elements present in furniture or base supports may produce dominant signals that increase the spectral background and mask elemental information of interest [1]. From a paper-conservation-oriented perspective, this study addresses the optimization of pXRF measurement conditions through the evaluation of support materials identified in specialized literature for the analysis of paper-based objects.

A range of materials proposed as supporting surfaces for pXRF analysis on paper was examined, including acrylic sheets of various thicknesses, polycarbonate, high-density polyethylene, and expanded polystyrene. Their influence on the spectral background and on the suppression of signals originating from an underlying metallic base was evaluated. The results show that thicker acrylic sheets (> 10 mm) effectively reduce support-related interference. On this basis, a modular system using stacked thin acrylic layers (4–5 mm) was assessed, with the aim of reusing materials commonly available within institutions. Experimental comparisons demonstrated the functional equivalence between stacked layers and thick acrylic sheets. The system was subsequently applied to an *in situ* analysis of a collection of hand-colored entomological drawings on paper from the Bonpland Archive, housed at the Museo de Farmacobotánica of the University of Buenos Aires, thereby improving the quality and interpretability of the pXRF spectra without compromising the physical integrity of the objects [2].

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Friday 13

	Aula Magna (Centro de Altos Estudios)	
	S06: Quantitative X-ray and Particle Analytical Techniques	
11:30	Full theoretical modeling of inner-shell ionization, applications in cultural heritage and material technology	Claudia Montanari, Darío Mitnik and Jorge Miraglia
11:50	Operando chemical analysis of batteries by quantitative x-ray spectrometry	B. Beckhoff, K. Frenzel, G. Greco and S. Brutti
12:10	Multi-elemental X-ray fluorescence computed tomography: sub-millimetric mapping of samples containing Ag and Gd	Nicolás Eugenio Martín, Carolina Salinas Domjan, Miguel Sofo Haro and Mauro Valente
12:30	Integrating sub-millimetric morphological data as a framework for attenuation compensation in XFCT	Nicolás Eugenio Martín, Carolina Salinas Domján, Miguel Sofo Haro and Mauro Valente
12:50	Analysis of Metals in Biological Fluids Deposited on Paper Filters by X-Ray Fluorescence	Martina Brué, Juan José Leani, Héctor Jorge Sánchez and Roberto Daniel Perez
13:10		

Full theoretical modeling of inner-shell ionization, applications in cultural heritage and material technology

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Particle-induced X-ray emission (PIXE) is one of the most widely used techniques in art and cultural heritage studies [1-3] and material analysis of technological applications, such as the characterization of new steels [4,5], owing to its non-destructive nature, the quantitative analysis of composition, and the precision in resolving overlapping peaks, for elements heavier than sodium. The accuracy and high performance of PIXE studies depend on the K-, L-, and M- ionization cross sections. These values are mainly derived from experimental measurements or from semiempirical models such as ECPSSR [6-7]. In this work, we present *ab initio* results for the continuous distorted-wave eikonal initial-state (CDWEIS) [8-9] for inner-shell ionization cross sections. We systematized proton impact values for all group 3 and 4 atoms in the periodic table (from Na to Kr). These specific groups contain some of the main components of paints (Ti, Co, Mn, Fe, Zn) [10] and of new steels (Fe, Cr, V, Ni) [4,5] for technological applications such as nuclear reactor walls and equipment.

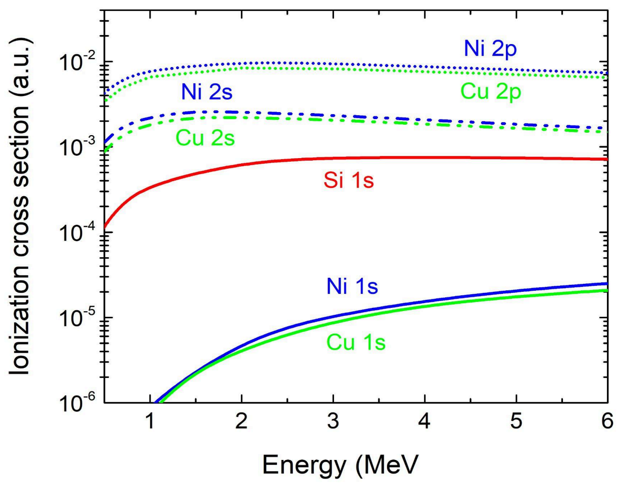

Figure 1: Present CDWEIS results for Si, Ni, and Cu.

The objective of the present systematization is to provide the user community with accurate, full theoretical values relevant to art and technology. In Figure 1, we display the present results for ionization of Si, Ni, and Cu by proton impact in the energy range of PIXE interest, 1-4 MeV. It can be noted that for Ni and Cu, the K-shell cross sections are 2 orders of magnitude smaller than those of Si. The L-shell is suggested as a better option for identifying the 4-group targets.

We aim to make the CDWEIS tables available online and to introduce a machine-learning model [11] based on these cross sections to extend existing values and better meet users' needs.

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Operando chemical analysis of batteries by quantitative x-ray spectrometry

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Quantitative characterization methods allow for the reliable correlation of the functionality of energy materials with the underlaying chemical or physical properties. These correlations are required for the directed development of advanced materials to reach target functionalities such as specific battery capacities. The traceability of analytical methods revealing quantitative information on chemical properties often relies on calibration samples, the spatial elemental distributions of which must be very similar to the sample of interest. To establish traceability to the SI, an alternative approach lays in the physical calibration of the analytical instrument's response behavior and efficiency as well as in the use of good atomic fundamental data. This approach has been established by Germany's metrology institute PTB for x-ray spectrometry (XRS). In different operational configurations the information depth, discrimination capability and sensitivity of XRS can be tuned, especially when using synchrotron radiation. Time-resolved and hybrid, i.e. multimodal approaches, provide access to complementary analytical information of different kind of batteries (NMC, LiS and SIB) under ex-situ to operando conditions while using calibrated instrumentation. The latter is a prerequisite to real quantitative conversion and transport rates.

The improved understanding of degradation mechanisms is essential to developing next-generation batteries. Quantitative operando NEXAFS in fluorescence detection mode has been used during multiple charge–discharge cycles on both electrodes of lithium–sulfur (Li/S) cells.

This enables the absolute quantification of dissolved polysulfides (PS) with respect to both the local polysulfides concentration and the average chain length. Using novel self-standing 80% C/S composite electrodes long-term hybrid operando XRS investigations (XRF and NEXAFS) were performed allowing to determine quantitative and time-resolved information on relevant sulfur species over 90 cycles of this LiS battery.

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Multi-elemental X-ray fluorescence computed tomography: sub-millimetric mapping of samples containing Ag and Gd

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The development of benchtop X-ray fluorescence computed tomography (XFCT) systems offers a versatile tool for high-sensitivity imaging of multiple high-Z contrast agents in laboratory settings [1,2]. This work presents the design, integration, and experimental characterization of a custom-built XFCT system. The instrumentation consists of an X-ray source and a Amptek XR100 CdTe detector, selected for its superior efficiency at the characteristic emission energies of high-Z elements [3]. Additionally, a centralized control system was implemented in order to synchronize a high-precision positioning stage with the multichannel analyzer acquisition. To demonstrate the system's capabilities for element discrimination, a specific application case was considered based on scanning a physical phantom containing silver (Ag, Z=47) and gadolinium (Gd, Z=64) at different concentrations. The acquisition followed a first-generation CT protocol with submillimeter translation steps. Data processing focused on spectral analysis for the extraction of the Ag K_α and Gd K_α fluorescence peaks. Correction techniques such as background subtraction were applied to estimate the X-ray fluorescence peak intensity [4]. The results demonstrate the generation of submillimeter elemental maps, showing a strong spatial correlation with the actual phantom. The use of the CdTe proved to be suitable for the detection of the Gd and Ag signals, while the overall performance of the proposed system demonstrated promising reliability for further developments.

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Integrating sub-millimetric morphological data as a framework for attenuation compensation in XFCT

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While benchtop X-ray fluorescence computed tomography (XFCT) allows for the detection of specific contrast agents, the quantitative accuracy of reconstructed images is often compromised by the inherent attenuation of fluorescence photons produced within the sample [1], thus affecting the probability of emerging from the sample according to the specific location in the sample where the X-ray is generated. This physical phenomenon leads to significant image artifacts and a loss of linearity in elemental mapping, which remains a major issue for XFCT systems [2]. This work presents an integrated system that addresses these limitations by implementing a data fusion strategy based on integrating submillimeter morphological information from transmission computed tomography (CT) into the XFCT reconstruction process. A dedicated experimental setup was developed consisting of a benchtop system equipped with an X-ray source, a digital flat panel detector [3], and an Amptek XR100 CdTe detector [4]. A dual-mode acquisition protocol was implemented: firstly, a transmission CT scan was performed to characterize the sample's morphology and attenuation map; secondly, an XFCT scan was executed to capture the distribution of high-Z elements (Ag and Gd). A home-built main control system ensured precise spatial alignment between both modes. The implemented attenuation compensation model uses the CT-derived density map to calculate the optical path of the X-ray beam and the subsequent escape path of the fluorescent photons for each voxel. This morphological framework allows for a voxel-by-voxel correction of the sinogram before final reconstruction. Results demonstrate that integrating morphological data significantly reduces cupping artifacts and restores the linearity between the effective fluorescent signal and the actual concentration of Ag and Gd. The sub-millimetric precision of the CT framework ensures that structural boundaries are properly respected during the compensation process. Therefore, the implemented synergistic approach enhances the potential of benchtop XFCT for quantitative imaging in complex heterogeneous samples.

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Analysis of Metals in Biological Fluids Deposited on Paper Filters by X-Ray Fluorescence

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Reliable determination of metals in biological fluids is essential for environmental, occupational, and nutritional monitoring studies. In this work, methodologies based on energy-dispersive X-ray fluorescence, implemented using a secondary target geometry , are developed and evaluated for the non-destructive multielemental analysis of biological fluids deposited on porous membranes under the dried spot sampling approach using filter paper (DBS and analogous samples) [1,2].

The proposed methodology addresses common limitations associated with this type of sampling, such as variability in the deposited volume, spatial heterogeneity of the spot, and the influence of hematocrit in blood samples. The developed quantification procedure relies on Monte Carlo simulations to model matrix effects and non-uniform mass distributions, improving analytical robustness while reducing both processing time and dependence on operator expertise [3].

As an application example, the methodology was employed for metal analysis in blood samples, demonstrating its feasibility for studies of heavy metal exposure in human populations. The results highlight the potential of modern XRF as a rapid, non-destructive, and adaptable tool for multielemental analysis in biomedical research and field sampling campaigns..

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Friday 13

	Aula Magna (Centro de Altos Estudios)	
	S07: Medical Radiation Protection and Dosimetry	
14:30	Radiation Protection and Dosimetry Topics in the Novel Applications of Radiopharmaceuticals in Medicine	Pedro Vaz
14:50	Neutron thermalization and gamma spectrometry for neutron activation with Am-Be sources: A FLUKA Monte Carlo approach	Carolina Salinas Domján, Alejandro Ferreira, Miguel Sofo Haro and Mauro Valente
15:10	Exploring the potential use of steelworks waste as radiation shielding	Laura Damonte, Ma. del Carmen Menendez, Ma.Victoria Gallegos and Ma. Agustina Corti
15:30	Establishment of Diagnostic Reference Levels for Pediatric Interventional Cardiology Procedures Based on Procedural Complexity	Hugo Schelin, Akemi Yagui, Gabriel Martins, Eloisa Carneiro, Sergei Paschuk, Valeriy Denyak, Edney Milhoretto, Paula Vosiak, Adriano Legnani and Carlos Ubeda
15:50	Optimization of Image Quality and Radiation Dose in Flat Panel Digital Radiography	Hugo Schelin, Akemi Yagui, Rosiane Mello, Laura Ruckel, Priscila Castilho, Sergei Paschuk, Valeriy Denyak, Paula Vosiak and Adriano Legnani
16:10	Development and Clinical Dosimetric Validation of a MATLAB-Based Tool for Total Body Irradiation	Clara Lucia Latour, Victor Palacios and Ramiro Cufre
16:30		

Radiation Protection and Dosimetry Topics in the Novel Applications of Radiopharmaceuticals in Medicine

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In recent years, novel applications of radionuclides and radiopharmaceuticals, for diagnostic and therapy applications in Medicine have emerged, posing challenges from the Radiation Protection and Dosimetry point of view. In addition to scientific, technological and technical issues, they also raise regulatory, policy, socioeconomic and financial concerns.

In this review, promising β-emitters, α-emitters (Targeted Alpha Therapy) and Auger electron emitters are identified. Production mechanisms, physical, biological and clinical characteristics and effectiveness are succinctly described. Supply and demand needs, routes and mechanisms are addressed.

Radiation Protection and Dosimetry scientific, technological, technical, clinical, economic, financial and regulatory needs and issues to address the widespread clinical use of these radiopharmaceticals are identified. Prospective views, informed by European and other international technical reports and data and peer reviewed scientific articles are provided. Potential hurdles and implementation issues are identified. The way to personalized and precision medicine and to the widespread implementation of theranostics in Nuclear Medicine Therapy[1] are discussed.

It can be anticipated that in the coming years, the dissemination of the use of β-emitters and α-emitters in Nuclear Medicine Therapy will reach its mature phase, with significant and impactful clinical outcomes. However, Radiation Protection and Dosimetry medical, occupational and public exposure issues need to be properly addressed in order to warrant radiation safety of these procedures.

Keywords: Radiation Protection, Dosimetry, Radiopharmaceutical therapy, α-emitters, β-emitters

References: Several international technical reports (EU, IAEA, EANM, others) are referenced and their findings reported. Results from a number of peer reviewed scientific articles published in international jour-nals are referenced.

[1] also referred to in the literature as Molecular Radiotherapy (MRT), Targeted Radionuclide Therapy (TRT) or Radiopharmaceuticals Therapy (RPT)

Neutron thermalization and gamma spectrometry for neutron activation with Am-Be sources: A FLUKA Monte Carlo approach

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Neutron activation analysis represents a highly sensitive technique that quantifies elemental compositions by detecting characteristic gamma radiation emitted after neutron capture for a wide range of radiation physics applications. Thus, accurate determination of the gamma radiation emission spectrum and characterization of neutron interaction are essential in areas such as physics and nuclear medicine, radiological protection, and industry. Neutron thermalization and their interaction with target materials represent critical information that determines rate and type of nuclear reactions, including gamma emission [1]. Furthermore, without precise calibration of the detection system, measurements can be subject to errors that could compromise the quality of data used in areas such as nuclear safety and monitoring of radioactive environments, among others.

In this context, the present work reports a computational study with FLUKA Monte Carlo focused on modeling the energy variation of neutrons emitted by an Am-Be source as they passes through variable thicknesses of different moderator materials [2], such as paraffin, with the aim of evaluating the evolution of the energy spectrum and the optimal thermalization thicknesses. Additionally, the geometric modeling of a thallium-activated sodium iodide detector (NaI(Tl)) and a hyperpure germanium (HPGe) detectors [3], is carried out in order to evaluate the corresponding response of two commonly used gamma spectrometers to different gamma-emitting samples. The results demonstrated that thicknesses larger, than 60 cm of paraffin significantly shift the neutron flux towards thermal energies, acting as an effective moderator, and the effectiveness of the developed FLUKA Monte Carlo method in reproducing its fundamental spectroscopic characteristics of the investigated gamma detectors, while comparisons against experimental data support a promising performance.

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Exploring the potential use of steelworks waste as radiation shielding

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The effective implementation of protective barriers in medical, laboratory, or industrial environments is crucial to minimizing exposure to ionizing radiation. As far as shielding is concerned, radiation shielding materials are required for both, structural or building rooms and personal protection boundaries.

Traditionally, lead (Pb) has been the preferred material for shielding ionizing radiation due to its excellent ability to attenuate X-rays and gamma radiation, since the photons of these radiations are effectively absorbed by dense materials with heavy. However, lead is highly toxic and exhibits low mechanical strength and inflexibility. Long-term exposure to lead can cause poisoning and serious health problems. In addition, their weight can be a limiting factor in some applications. Therefore, its use is declining, and for some time, new radiation attenuation efficient materials have been sought to replace it.

As part of the development of radiation shielding materials, it is essential to include the field of personal protection. In this sense, the study of a material that could replace that of lead aprons was addressed. The search focused on flexible and lightweight substrates, identifying silicones as a promising alternative due to their ability to polymerize at room temperature.

An innovative proposal is to use metallurgical industry waste, generated during steel production, as raw material to manufacture radiation absorbers. These wastes, coming from Electric Furnaces in the south of Santa Fe and the north of Buenos Aires, (Argentine) include slag, particulate matter and various compounds. The solid waste generated is rich in heavy metals such as Pb, Zn, Cd, Ni, and Cr, the most common phases being Fe_2O_3, FeO, metallic iron, ZnO, SiO_2, among others. Since this waste is hazardous due to its leaching potential, finding a new use for it is not only beneficial for the environment but also offers an innovative solution to managing this waste. By converting these byproducts into efficient absorbents, the environmental burden is minimized and the circular economy is promoted, contributing to the reduction of pollution through the recycling of industrial waste.
In this work, different contents of this waste were added to a commercial silicone matrix in order to evaluate its capability for ionizing radiation shielding. The linear attenuation coefficient was evaluated by means of simple gamma spectroscopy and those with the better performance were compared with a 0.5mm thick lead layer.

Establishment of Diagnostic Reference Levels for Pediatric Interventional Cardiology Procedures Based on Procedural Complexity

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The establishment of Diagnostic Reference Levels (DRLs) is a fundamental tool for optimizing radiation doses in medical procedures. In pediatric interventional cardiology, this approach is particularly important, as children are more sensitive to ionizing radiation and healthcare professionals are also directly exposed during these procedures. However, the definition of DRLs in this field requires an analysis that accounts for procedural complexity, as recommended by ICRP Publication 135 [1], considering that procedures may have different diagnostic or therapeutic purposes. The aim of this study was to establish DRLs for pediatric interventional cardiology procedures in a tertiary reference hospital in Brazil. Dose–area product, reference point air kerma, fluoroscopy time, and the number of cine images were evaluated in a total of 215 interventional cardiology procedures, stratified according to their level of complexity. The results showed that procedures classified as having higher complexity did not necessarily result in higher patient radiation doses, indicating that, in addition to procedural complexity, other technical and operational factors significantly influence the delivered doses. These findings highlight the importance of complexity-based stratification in the establishment of DRLs and contribute to more effective dose optimization strategies in pediatric interventional cardiology.

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Optimization of Image Quality and Radiation Dose in Flat Panel Digital Radiography

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(1) Faculdades Pequeno Príncipe, Brazil
(2) Federal University of Technology – Paraná (UTFPR), Brazil

In medical imaging involving ionizing radiation, achieving an optimal balance between image quality and radiation dose is essential to ensure diagnostic accuracy and patient safety. This study investigates the relationship between radiographic image quality and patient radiation dose as a function of three key radiographic parameters: tube potential (kVp), current–time product (mAs), and additional filtration. Image quality assessment was performed using the CDRAD 2.0 contrast–detail phantom in conjunction with the CDRAD Analyser software (Artinis Medical Systems, The Netherlands). Image quality was evaluated at different depths within an acrylic simulator, with tube voltages ranging from 60 to 85 kVp, mAs values between 0.5 and 10 mAs, and copper filtration thicknesses of 0.1 and 0.3 mm. The system configuration and technical parameters were identical to those used in routine clinical examinations. The results demonstrate a clear divergence between the behavior of image quality and radiation dose when varying kVp and mAs. For the detection system evaluated, increasing kVp to improve image quality results in a substantially lower radiation dose compared to increasing mAs. This trend was observed consistently across all object depths within the acrylic simulator. These findings highlight the importance of optimizing radiographic technique parameters, particularly favoring kVp adjustments over mAs increases, to achieve improved image quality while minimizing patient radiation exposure, thereby enhancing both the effectiveness and safety of digital radiography.

Keywords: image quality, digital radiography, CDRAD.

This study was financed in part by CAPES, CNPq, CNEN and Fundação Araucária.

Development and Clinical Dosimetric Validation of a MATLAB-Based Tool for Total Body Irradiation

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Total Body Irradiation (TBI) is a complex radiotherapy technique that requires accurate dose calculation and verification to ensure dose homogeneity while minimizing toxicity to organs at risk, particularly the lungs [1]. In clinical practice, TBI dose calculation is often based on simplified models and manual procedures, which may limit reproducibility and increase uncertainty.

In this work, a computational tool developed in MATLAB was designed to calculate and evaluate delivered dose in TBI treatments using extended source–surface distance. The software calculates absorbed dose at predefined anatomical measurement points corresponding to thermoluminescent dosimeter (TLD) locations, widely used for in vivo dosimetry in radiotherapy [2], allowing the evaluation of lung shielding schemes based on measured doses. The calculation model integrates patient-specific parameters, beam characteristics, tissue-equivalent correction factors, and treatment geometry. Dosimetric validation was performed using a water-equivalent solid phantom and in vivo TLD measurements, complemented by ionization chamber measurements under clinical treatment conditions.

For all evaluated anatomical measurement points, deviations between the calculated delivered dose and the prescribed dose were below 5%, remaining within the ±10% tolerance commonly accepted for TBI dosimetry [3]. In addition, in vivo TLD measurements demonstrated a high level of agreement with the calculated doses, with a maximum difference of approximately 1%, confirming the accuracy of the implemented calculation model. Lung measurements showed a larger difference between calculated and measured doses, with deviations up to 6.46%, consistent with the increased heterogeneity and reduced equivalent thickness of lung tissue.

The proposed approach provides a practical and reproducible framework for TBI dose calculation and dosimetric verification, contributing to improved quality assurance, lung toxicity assessment, and patient safety in clinical radiotherapy.

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Friday 13

	Aula Magna (Centro de Altos Estudios)	
	S08: Applications in Medicine and Biology	
17:00	Low-Energy Antimatter Spectroscopy of Biological Samples: Wet Chamber Design and Dosimetry	Matteo Vicini, Rafael Ferragut, Paola Folegati and Claudio Conci
17:20	Scattered Radiation Intensity in Digital Mammography and Its Reduction Using Anti Scatter Grids	Laura Alcântara Silva Lopes, Bruno Beraldo Oliveira, Renato França Caron, Valdair Francisco Muglia and Martin Eduardo Poletti
17:40	Analysis of Radiation Doses in Conventional Pediatric Radiographs: Correlation between Clinical Justification, Repetitions, and Exposure	Paula Vosiak, Hugo Schelin, Akemi Yagui, Rosiane Mello, Priscila Resmer, Sergei Paschuk, Adriano Legnani and Viviane Asfora
18:00	From Transfusion Units to Radiotherapy: Characterizing Membrane Damage and Pore Formation in Irradiated Red Blood Cells via SEM	Maria Candela Della Rosa, Vanina Tartalini, Analia Ines Alet, Sabrina Porini, Guillermo Moschini, Ariel Aresi, Liliana Di Tullio, Nestor Manzelli, Andrea Acosta, Martina ºAvalos and Mariel Elisa Galassi
18:20	DOSIMETRIC CHARACTERIZATION OF AN ALPHA SOURCE FOR CELLULAR IRRADIATIONS	Maria Candela Della Rosa, Violette Guittet, Gustave Garde, Yannick Zoccarato, Mariel Elisa Galassi, Michael Beuve and Etienne Testa
18:40	**Closing**	
19:00		

Low-Energy Antimatter Spectroscopy of Biological Samples: Wet Chamber Design and Dosimetry

Matteo Vicini(1), Rafael Ferragut(2,3*), Paola Folegati(2), Claudio Conci(1)

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Positron annihilation spectroscopy (PAS) has gained increased attention in recent years for its ability to probe structural and chemical variations in cells and tissues, successfully identifying conditions such as skin cancer or hypoxia in spheroids [1]. However, the vast majority of PAS studies are currently performed with standard ^{22}Na sources directly in contact with tissues, leaving the specific interaction between positrons and living matter at the nanoscale largely unknown. Here, we present a setup enabling the coupling of wet biological matter to a variable energy positron beam, allowing precise control of implantation depth. The prototype consists of a chamber, in atmospheric pressure, with a thin silicon nitride window acting as an interface between the high vacuum chamber, where the beam propagates, and the wet chamber. The system can be loaded with fluids to keep hydrated material within. In this work, we employed murine endothelioma cells, cultured for 14 days and placed in the chamber. We assessed the integrity of the cell layer, prior PAS analysis, by means of Live&Dead assay. Furthermore, we address the critical aspect of dosimetry. PAS uses ionizing radiation, which may induce DNA damage via free radicals. While bulk experiments use sources with broad spectra (0-545 keV), monoenergetic beams work within 1-20 keV, necessitating specific dose rate calculations for future applications. We outline a framework to derive the dose rate from mass stopping power and positron flux for both continuous and pulsed beams. For our experimental apparatus (positron energy 10-20 keV, Fig. 1), the dose rate is estimated at ~10^{-4} Gy s^{-1} [2]. To collect a spectrum with 10^6 – 10^7 counts (from 10 min to hours), the sample absorbs a total dose of a fraction of a gray (Gy). The proposed technology enables us to monitor biological processes non-destructively by implanting positrons at precise locations within living cells, providing nanoscale spectroscopic information.

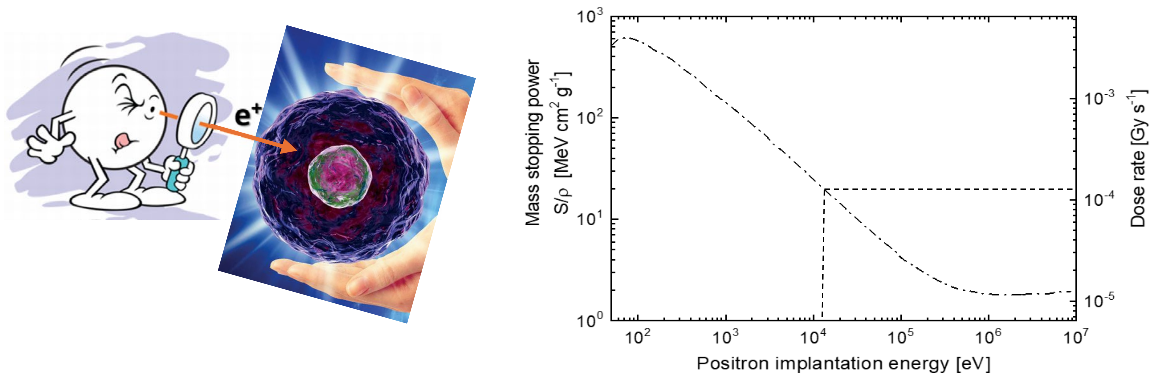

Figure 1. Schematic of positron implantation in living cells (left). Estimation of the dose rate (right).

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Scattered Radiation Intensity in Digital Mammography and Its Reduction Using Anti-Scatter Grids

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Scattered radiation is a major source of signal-to-noise ratio degradation and reduced lesion detectability in digital mammography. Its experimental quantification remains difficult, and available data are limited because scatter metrics depend strongly on system technology [1,2]. This study experimentally determines the scatter-to-primary ratio (SPR) in the absence of an anti-scatter grid for different digital mammography systems and evaluates its reduction when different grids are used, quantified through the grid detective quantum efficiency (DQEg), where values above unity indicate high benefit. Primary, scattered, and total radiation components were measured for PMMA thicknesses of 20–70 mm using the lead disk method [3], with and without anti-scatter grids. Four digital mammography systems were assessed: three with indirect CsI/TFT detectors and linear grids, and one with a direct aSe/TFT detector and a cellular grid. Different anode/filter combinations (Mo/Mo, Mo/Rh, Rh/Ag, Rh/Rh, W/Rh, and W/Ag) were used under AEC-controlled conditions. SPR without a grid increased linearly with PMMA thickness ($R^2 > 0.99$), in agreement with previous studies [1,2], with values of 0.28–0.35 (20 mm), 0.55–0.62 (40 mm), 0.77–0.84 (60 mm), and 0.84–1.00 (70 mm) (Fig. 1.a). Although SPR magnitudes were similar across systems, systematic differences were observed, providing experimental evidence of SPR dependence on detector technology, previously shown mainly through simulations [2]. DQEg analysis (Fig. 1.b) showed that the cellular grid provided the highest scatter rejection for all thicknesses, consistent with earlier findings [2]. Among linear grids, the higher-density design (67 lines/cm) demonstrated the best performance. Overall, the results experimentally demonstrate system-dependent SPR behavior and confirm, using DQEg as a physically meaningful metric [4], the superior scatter-rejection efficiency of cellular and high-density linear anti-scatter grids in digital mammography.

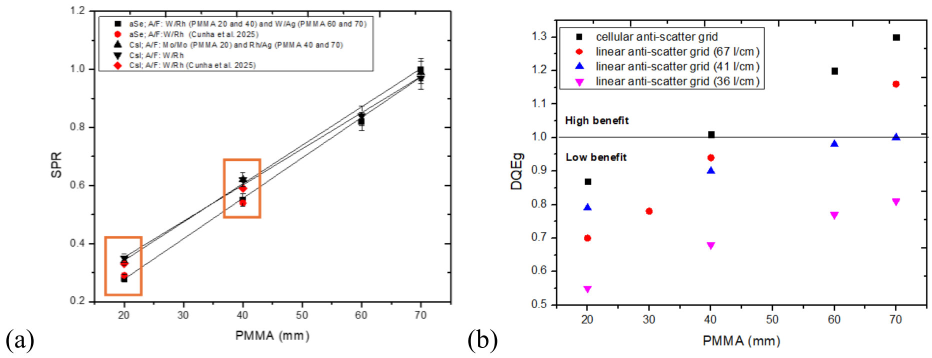

Figure 1 (a) Scatter-to-primary ratio (SPR) without anti-scatter grid as a function of PMMA thickness for a direct-conversion detector (aSe) and an indirect-conversion detector (CsI) (black symbols). The results are compared with simulation data reported [2] (red symbols). (b) Grid detective quantum efficiency (DQEg) as a function of PMMA thickness for different anti-scatter grid designs.

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Analysis of Radiation Doses in Conventional Pediatric Radiographs: Correlation between Clinical Justification, Repetitions, and Exposure

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Conventional radiography is fundamental for pediatric diagnosis of chest, skull, paranasal sinuses, pelvis, and abdomen, but inadequate justification and repetitions increase unnecessary doses in radiosensitive populations [1]. This study correlates clinical indications and repetitions with entrance surface air kerma (Ka,e) in real-service conditions. Prospective study analyzing 736 pediatric radiographic exposures from a structured spreadsheet by anatomical region [Chest: 227; Abdomen: 157; Skull: 125; Pelvis: 116; Paranasal sinuses: 111]. Technical parameters (kVp 60-120; mAs 2-50; FFD 85-130 cm) and clinical indications from INDICATION column were collected in five main groups, calculating repetition rates by category and region using descriptive analysis. Ka,e (mGy) was calculated from X-ray tube output (1.62 to 3.28 mGy/mAs), with descriptive analysis (median, Q1-Q3) stratified by indication and repetition presence. Main justifications were OTHER (65.4% of exams), COUGH/FEVER (16.8%), and CONTROL/PREOP (9.8%). Chest showed COUGH/FEVER as dominant indication (113/227 exams; 49.8% of chest), with Ka,e median of 0.15 mGy in chest PA (Q3=0.42 mGy) and 13.2% presenting repetitions associated with high mAs values. Abdomen exams by NG TUBE (48/157; 30.6%) showed 0.17 mGy median (Q3=0.35 mGy), but with 14.0% repetitions increasing dose 1.6-fold, questioning diagnostic justification. Pelvis by CONTROL/PREOP (33/116; 28.4%) recorded 0.35 mGy median (Q3=0.68 mGy). Facial sinuses Waters achieved 1.1 mGy median (Q3=2.0 mGy) with 0% repetitions. Globally, repetitions (6.5% of exams; 48/736) concentrated in chest (13.2%) and abdomen (11.5%), doubling chest Q3 from 0.25 mGy (with repetition) vs 0.13 mGy (without repetitions). Although COUGH/FEVER adequately justifies 50% of chest exams with doses compatible with national DRLs (Ka,e median 0.15 mGy), the OTHER category (65.4%) reveals urgent need for clinical indication standardization. Abdominal TUBE exams (30.6% of region; 14% repetitions) stand out for high repetition rate and questionable diagnostic justification, suggesting ultrasound substitution in 70-80% of cases. Chest (13.2%) and abdominal (11.5%) repetitions nearly double Q3 dose, representing immediate opportunity for 10-15% total exposure reduction through technical training and adapted ALARA protocols.

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From transfusion units to radiotherapy: characterizing membrane damage and pore formation in irradiated red blood cells via SEM

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Gamma irradiation is a standard procedure in transfusion medicine to prevent transfusion-associated graft-versus-host disease (TA-GVHD) in pediatric and immunocompromised patients [1]. However, ionizing radiation triggers oxidative stress that compromises red blood cell (RBC) membrane integrity, accelerating the storage lesion [2,3]. Also, its impact on RBC integrity reflects the damage sustained during clinical radiotherapy. In some oncology treatments (i.e. hypo-fractionated radiotherapy, Intra Operative Radio Therapy), a part of the circulating blood volume inevitably receives significant doses, yet its role as an Organ at Risk is often overlooked. Characterizing radiation-induced membrane damage is therefore critical not only for transfusion medicine but also for understanding the systemic effects of radiotherapy. This study focuses on characterizing the specific ultrastructural alterations of the erythrocyte membrane induced by ionizing radiation using scanning electron microscopy (SEM).

Blood samples from healthy adult volunteers were collected using CPD-Optisol® as anticoagulant. Red blood cell concentrates were aliquoted, irradiated with 0, 25, and 50 Gy, and stored at 4 °C for 35 days at the Regional Hemotherapy Center (Rosario). Samples were prepared for SEM by fixation with 2% glutaraldehyde, graded ethanol dehydration, and critical point drying, using an EDTA-anticoagulated healthy donor sample as control.

SEM analysis revealed that radiation significantly exacerbates membrane damage. Key findings include a marked transition in spicule morphology, significant changes in cellular morphometry, and a notable increase in pore formation on the lipid bilayer compared to non-irradiated controls.

These findings emphasize that radiation-induced membrane fragility is a key factor in cellular degradation. Crucially, this study serves as a fundamental baseline for future research in radiotherapy, providing insights into how ionizing radiation alters the physical properties of cell membranes. This knowledge is essential for developing novel membrane-stabilizing strategies and optimizing protocols both in hemotherapy and in the protection of healthy tissues during radiation-based treatments.

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Dosimetric characterization of an alpha source for cellular irradiations

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Helium ion beams are increasingly studied in hadrontherapy centers due to their effectiveness in tumor control and reduced damage to surrounding healthy tissue [1], while requiring less costly accelerators than heavier ions such as carbon. As a complementary approach to investigating their health benefits, experimental data can be obtained using radioactive sources, avoiding the high costs and logistical limitations of accelerator-based facilities.

In this context, this work focuses on the characterization of an alpha-emitting source (Am-241, 20 MBq) and on accurately reproducing its irradiation conditions using Monte Carlo simulations with GATE 9, for cell culture irradiation and the study of their biological responses.

The methodology consisted of comparing experimental and simulated data to obtain a reliable dosimetric characterization of the source and conducting robust Monte Carlo simulations to be coupled with biophysical models predicting irradiation effects on cells, e.g., cell survival probabilities [2]. Regarding the measurements, the experimental setup included a three-dimensional source–sample positioning system and a diaphragm under the radioactive source, enabling precise irradiation durations. A collimated PIPS detector was used to measure energy spectra and counting rates as a function of distance from the source. The spatial dose distribution in the irradiation field at a given distance was also obtained by irradiating Gafchromic films.

The absolute count rates from the experiment and the simulation reproduce the behavior as a function of the distance to the source well, with values in agreement within the associated uncertainties. In addition, the simulation describes the mean dose rate as a function of the radial distance from the source center well, particularly within the flat dose region.

The results obtained provide a mostly homogeneous source behavior over a 15 mm diameter area at a 5.5 mm distance from the source, corresponding to the specifications defined for cell irradiation on this platform. The first cell irradiations are planned in the coming months, and the experimental cell survival curves will be preliminarily compared with predictions of the NanOx model [3].

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