
ITALIAN EMBASSY
HUNGARIAN NATIONAL MUSEUM

PREFACE

The Italian Embassy in Budapest, within its promotional activity for scientific and technological co-operation between Italy and Hungary, has initiated a series of scientific and cultural events illustrating the role which Hungary played in Europe, not least by a celebration of the nation’s archaelogical and architectural heritage.

On this topic, Italy has a consolidated and long since partnership with Central-East Countries, mainly with Hungary, for their common cultural roots and unique Cultural Heritage which must be preserved for future generations. Italy and Hungary, in fact, more than other Countries, have the need and duty to preserve this unique Cultural Heritage which belongs to the entire humanity.

The integral connection between science and culture is something strongly felt by the scientists and scholars of both countries; and this has nourished closed and detailed cooperation, including cooperation among archaeologists, art historians and architects as it is documented by the many common projects which are already on way between the two countries.

The experts and scientists gathered together in this magnificent ceremonial room of the pretigious Hungarian National Museum will surely pave the way to policy makers in undertaking the best strategies of interventions for preserving masterpieces of arts and artefacts of our ancestors.

In offering my heartfelt thanks to the Hungarian and Italian scholars and researchers who made this major cultural encounter possible, I must also record my satisfaction at the support given by our Embassy in Budapest to an event which clearly illustrates how deeply-rooted are the relations, at this moment in history, between the Italian and Hungarian cultures, not least in the conservation of the artistic and architectural heritage in Budapest.

On remarking again the high cultural and scientific value of this symposium, I wish you an enjoyable stay and profitable work.

Paolo Guido Spinelli
Ambassador of the Republic of Italy

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PROGRAM
OF THE HUNGARIAN-ITALIAN SYMPOSIUM ON *NEW TECHNOLOGIES AND THEIR APPLICATION TO CULTURE HERITAGE PRESERVATION AND ENHANCEMENT*

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9:30 *Opening*

Benito Righetti, S&T Attaché – Italian Embassy

Welcome addresses

H.E. the Ambassador of Italy, Paolo Guido Spinelli
Erika Koncz, State Secretary, Ministry of Cultural Heritage
Tibor Kovács, Director General – Hungarian National Museum

Session 1

Moderator: Elisabetta Starnini (University of Genova, DARFICLET – Archaeology section)

10:00-10:30 **Prof. Marco Martini**
President of AIAR – Italian Association for Archaeometry, University of Milano-Bicocca
"Luminescence dating for the Cultural Heritage"

10:30-11:00 **Dr. Zsolt Kasztovszky**
Department of Nuclear Research, Institute of Isotopes Chemical Research Centre of HAS
"Non-destructive investigations with guided cold neutrons in Cultural Heritage research"

11:00-11:30 **Dr. Franco Zanini**
ELETTRA and University of Trieste
"Large Research Infrastructures for Cultural Heritage"

11:30-12:00 *Coffee break*

Session 2

Moderator: Katalin T. Biró (Hungarian National Museum)

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Director of LABEC (INFN) and Department of Physics - University of Florence
"Ion Beam Analysis and Radiocarbon dating"

12:30-13:00 **Dr. Zoltán Szőkefalvi-Nagy**
Research Institute for Particle and Nuclear Physics of the HAS
"Energy dispersive X-ray spectroscopy of art and archaeological objects"

13:00-13:30 **Prof. Franco Casali**
University of Bologna – Department of Physics
"X-ray digital radiography and computed tomography for cultural heritage"

Dr. Gianfranco Cicognani
S&T Expert of the CEI (Central European Initiative)
"Advanced technologies focused to the evaluation of the state of preservation and related restoration actions of the monumental historical heritage"

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Session 3

Moderator: Marco Martini President of AIAR - Italian Association for Archeometry, University of Milano-Bicocca

14:30-15:00 **Dr. Mende Balázs Gusztáv**
Institute of Archaeology of the HAS
"Possibilities and limits of the archaeogenetical analysis on the ancient human remains"

15:00-15:30 **Dr. Renzo Salimbeni**
IFAC – CNR; Institute of Applied Physics "Nello Carrara" Florence
"Laser Technologies in Culture Heritage Conservation"

15:30-16:00 **Dr. Belényesy Károly-Virágos Gábor**
Archeosztráda Ltd.
"The use of 3D technologies to survey and document archeological buildings and sites"

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Session 4

Moderator: Jankovich Dénes (Director of the National Office of Cultural Heritage - Documentary Directorate)

16:30-17:00 **Dr. Paula Zsidi - Orsolya T. Láng**
Aquincum Museum
"Fast Archaeology - Applying New Technologies in the Archaeological Research of the Civil Town of Aquincum"

17:00-17:30 **Dr. Mauro Bacci**
CNR – IFAC (Institute of Applied Physics "Nello Carrara")
"Non invasive instrumentation for diagnostic and color control"

17:30-18:00 **Dr. Attila J. Tóth**
National Office of Cultural Heritage
"River archaeology – a new field of research"

LUMINESCENCE DATING FOR THE CULTURAL HERITAGE

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In the field of Archaeological Science, Thermoluminescence (TL) is being applied since 1970 and its validity and reliability has been widely demonstrated. The various TL techniques are specifically applied to ceramic material and even to other materials containing quartz or feldspar minerals and that have been submitted to heating to a temperature up to some hundreds degree centigrade.

In principle, many historical and archaeological materials and artifacts can be dated: potteries and bricks, but also porcelain, furnaces, hearths, clay cores. In normal conditions, accuracies as good as 5-10% of the age can be obtained in the range between 50 and 60,000 years.

High precision has been reached when applying this technique to building dating. In these cases a real “stratigraphy” can be obtained, giving as a result the various phases of building, reconstruction and restoration.

Recently the reasearch moved also toward the study of the so called Optically Stimulated Luminescence (OSL), which uses visible or infrared light, instead of heat, to empy the electronic traps, filled by environmental irradiation. OSL dating is giving results more and more interesting, even if the understanding of the basical physics mechanisms is still under study.

The basis of TL and OSL will be presented, together with their applications and some examples of dating in the field of Archaeology and the History of Art.

NON-DESTRUCTIVE INVESTIGATIONS WITH GUIDED COLD NEUTRONS IN CULTURAL HERITAGE RESEARCH

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Prompt Gamma Activation Analysis (PGAA) is a powerful multielement method, suitable for non-destructive archaeometric studies. It is based on the detection of prompt- and delayed γ-photons, produced in (n,γ) nuclear reaction. In principle, PGAA is suitable to detect all the chemical elements, but with very different sensitivities. In practice, we are able to determine most major and some trace elements quantitatively in various materials. The PGAA laboratory in Budapest is planted on an external horizontal cold neutron beam of the Budapest Research Reactor. Since 1997, we have investigated successfully most types of archaeological materials, including metals (bronze, iron, silver), stones (chipped and polished tools and raw materials), glass and pottery.

Determination of chemical composition can help the archaeologists to identify the provenance of the objects, the possible raw material sources, workshops, etc. In this paper we describe the basic principles of the method and show examples of the archaeological problems which can be investigated. Since in regular conditions PGAA only provides information about the "bulk" composition, it could be necessary to apply other complementary methods. One possible way of improvement is to develop a 3D elemental mapping/imaging method to investigate inhomogeneous archaeological objects.

A new EU project is about to start from 2006 in this research field. The members of this consortium (ANCIENT CHARM) are the following institutions: Università degli Studi di Milano-Bicocca; Università degli Studi di Roma Tor Vergata; Hungarian National Museum; Institute of Isotopes Chemical Research Centre Hungarian Academy of Sciences; Rheinische Friedrich-Wilhelms Universität Bonn; Universität zu Köln; European Commission – Joint Research Centre Institute for Reference Materials and Measurements; Faculty of Archaeology, Leiden University; Technical University Delft and Central Laboratory of the Research Councils.

LARGE RESEARCH INFRASTRUCTURES FOR CULTURAL HERITAGE

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Research Infrastructures (RI) are multi-disciplinary institutions by nature, and provide an array of techniques and instrumentation suitable to tackle a variety of problems in material science. In most cases, these methods complement more conventional, lab-based techniques, and represent but one, albeit very prominent, weapon among many available to research groups in each field.

Cultural Heritage (CH) involvement with RI is relatively recent, if compared to that of other communities in physics, chemistry and biology. Over the years, the latter have undergone a process of reciprocal adaptation with the RIs, whereby the needs of the communities in terms of instrumentation, information and access have been identified and catered for, and new techniques are now gradually been incorporated in the portfolio to meet the evolving research requirements. It is fair to say that a very significant fraction of the research community in the physical and biological sciences is associated with RI, either directly or indirectly through collaborative projects or simply by using RI results in their research.

In recent years, RIs have seen a significant growth of the demand in the field of CH research, mainly coming from experts in specific RI techniques who have developed interests and connections in CH. This research has at times produced high-profile results, and is always well received by access panels, to the point that management of several RIs is envisaging a broader, mainstream role for their facilities in CH research. However, the number of CH operators that are active at RIs is still small, and probably not fully representative of the broader CH community. This creates an obstacle for RIs to assess their potential "markets" and direct their effort towards the most promising ones, and for the CH community to become collectively aware and focus on the best "products" that RIs can offer.

In assessing the potential of RIs in CH research, one should not be limited to look at individual techniques, as powerful as they are, but must consider the synergies between different RI-based as well as more conventional tools. More and more frequently, large-scale facilities are co-located in clusters within what are becoming true "cities of science" (such as the Polygone Scientifique in Grenoble, France, the RAL site in Chilton, UK and the AREA Science Park in Trieste), increasingly endowed with "research complexes" to support RI research with more conventional lab techniques. In other cases, RIs have formed form regional networks with universities or other research institutions. These entities are being fully exploited by other communities (once again, the biological sciences are an excellent example), and have the potential to be future "hubs" to coordinate and support a variety of CH research activities.

ION BEAM ANALYSIS AND RADIOCARBON DATING

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Ion Beam Analysis (IBA) and radiocarbon dating are probably the best known and most extensively used nuclear techniques for diagnostics in the field of Cultural Heritage.

As to IBA techniques, they are a very powerful tool to measure the composition of any material in a fully non destructive way. On the other hand, knowing e.g. which kind of pigments were used for a painting, or which metal alloy in a coin, in a jewel or in a statue, or measuring the composition of the inks used in a manuscript, and so on, can provide a huge amount of precious information to the humanists. For example, it can give them hints about the period of production of the work (or even about authenticity or not of the work), or concerning the availability or not of certain raw materials in the place of production, or finally on the technological skills already developed in ancient times. This kind of information can be easily obtained using a beam of particles produced by an accelerator to "bombard" the material under investigation (i.e., the pigment, or metal, or ink, etc.) and detecting the energies of the induced X rays, gamma rays, secondary or backscattered primary particles, which are characteristic of the atomic elements present in the "target". The physics of the beam-target interactions leading to the emission of the characteristic radiation is such that these analyses can be performed without procuring any damage to the investigated material, and this is a basic requirement when dealing with precious objects such as the works of art!

As far as radiocarbon (i.e. ^{14}C) dating is concerned, this technique is very well known even to the general public. In the past two decades or so, a huge development of the analytical capabilities has been achieved in this field, thanks to the use of Accelerator Mass Spectrometry (AMS) to measure the ^{14}C concentration in the material to be dated. With AMS, dating of finds as old as 50000 years is possible, "sacrificing" only tiny quantities of the sample (order of the milligram). This datable time lapse covers all the historical and pre-historical period of relevance to the human kind, so that ^{14}C dating (together with thermo-luminescence dating) is a basic tool for the archaeologists.

n Florence, our group has been performing IBA for the Cultural Heritage for over twenty years now, working until two years ago with a single-ended Van de Graaff accelerator, re-used for this purpose after a previous period of use in basic nuclear physics problems. A lot of relevant results were obtained in problems concerning the Cultural Heritage.

Since 2004, a new Tandem accelerator has been installed by INFN in a new laboratory, dedicated just to applications to the Cultural Heritage (LABEC = LAboratorio di tecniche nucleari per i BEni Culturali). With a Tandem, AMS is now also possible; in addition, thanks to the characteristics of the new accelerator the potential of IBA is greatly increased. Our laboratory is thus currently operating with both IBA and AMS techniques; switching from one to the other is a matter of hours or even less, if needed, so that the use of our facility is very flexible.

Examples of both IBA applications and ^{14}C dating with AMS will be given.

ENERGY DISPERSIVE X-RAY SPECTROSCOPY OF ART AND ARCHAEOLOGICAL OBJECTS

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The preservation and conservation of our cultural heritage has become one of the main concerns today all over the world. In particular there is an increasing need for non-destructive investigations, as sampling from the unique and precious objects of art and archaeology. In addition to the conventional analytical procedures, techniques utilising nuclear instruments and methods play increasing role in this field. The small, portable X-ray fluorescence (XRF) spectrometers using radioisotope excitation allow in situ analysis in museum, galleries, on even on field.

Utilising this elemental analytical technique selected areas of the object are exposed to the primary X-rays emitted by the radioactive excitation source. As the consequences of the interaction of these X-rays with the material of the object so called characteristic X-rays are induced. By accurate measurement of the energy of these secondary X-rays the chemical element composing the sample can be identified, while careful analysis of the X-ray intensities can provide quantitative data about their concentrations. Due to the very small energy given to the irradiated volume, not any deterioration, damage or destruction of the analysed surface can be observed. This non-destructiveness together with its multi-elemental character, that is numerous elements can be detected simultaneously, makes this method so promising.

In this talk the main features and performance of our portable XRF spectrometer is described and illustrative applications are presented with special attention to the study of paintings. Taking the elemental map of regions of different colour conclusions on the composition and kind of the paints used by the artists can be drawn. The detailed knowledge of the "palette" of a painter could certainly be very important and useful for artists and art historians, but the most frequent question of the public that is whether a particular painting is a forgery, or an authentic one, can not be answered in general on the basis of the elemental compositions. There are, however, a few special cases, when the presence of a particular paint provides unanimous evidence for the age of the painted spot. One of the most known example is the identification of the presence of titanium at white coloured spots. Taking into account, for instance, that titanium white (TiO2) is available since about 1920, only, its presence provides an indisputable indication for either forging or later repainting. The decision, however, is not always easy even is this "simple" case. The difficulties caused by the simultaneous presence of Ti and Ba (a very frequent component white paints) are also discussed.

Reference

Z. Szőkefalvi-Nagy, I. Demeter, A.Kocsonya, I. Kovács: Non-destructive XRF analysis of paintings, Nuclear Instruments and Methods B 226 (2004) 53-59.

X-RAY DIGITAL RADIOGRAPHY AND COMPUTED TOMOGRAPHY FOR CULTURAL HERITAGE

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X-ray detection systems for high resolution Digital Radiography (DR) and Computed Tomography (CT) have been developed at the Physics Department of the University of Bologna. The research target is the development of systems to be applied in cultural heritage conservation and industrial radiology.

In the field of cultural heritage, different kind of objects (ancient necklaces, paintings, bronze or marble statues) have to be inspected in order to acquire significant information as the method used to assemble, the manufacturing techniques or the presence of defects. These features could be very useful, for example, for dating works of art or determining appropriate maintenance and restoration procedures. Among the advanced methods available, 3D CT can be successfully used for the investigation of ancient works of art because it preserves their integrity and provides images of inner parts, otherwise not visible.

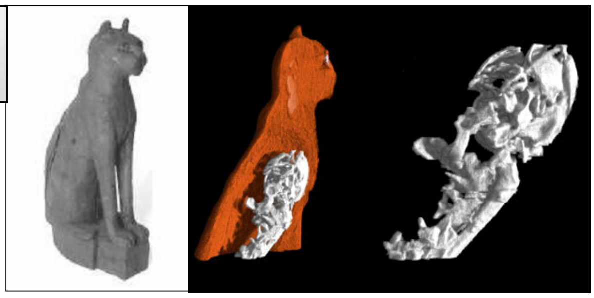
Several high-resolution CT systems to investigate objects of different sizes (from micro to macro) have been developed. For example, we have carried out the micro CT reconstruction of Roman human tooth with carie (found in the "Isola Sacra" necropolis); as well as the cone beam CT analysis on an Egyptian cat-shaped coffin exhibiting the inner mummy; until to the CT study of an ancient large globe (2 m of diameter). This globe was created by a Dominican monk, Egnazio Danti, around 1567 and is located in Palazzo Vecchio, at Florence. The 3D CT reconstruction of the globe clearly shows the entire inner structure, consisting of a central pole, 8 bars as 2 tetrahedrons and 30 meridians. All the inner structure is made of iron, with a total weight of about 350 kg, estimated from the segmented 3D reconstruction. The very high resolution reached investigating small objects is an important result other than tomography on a big object, like the globe, is an absolute innovation. A 3D CT investigation is being in project to determine how much deterioration has occurred on the ankles of David, the towering marble figure sculpted by Michelangelo, a very exciting purpose that we will achieve in collaboration with Lawrence Livermore National Laboratory.

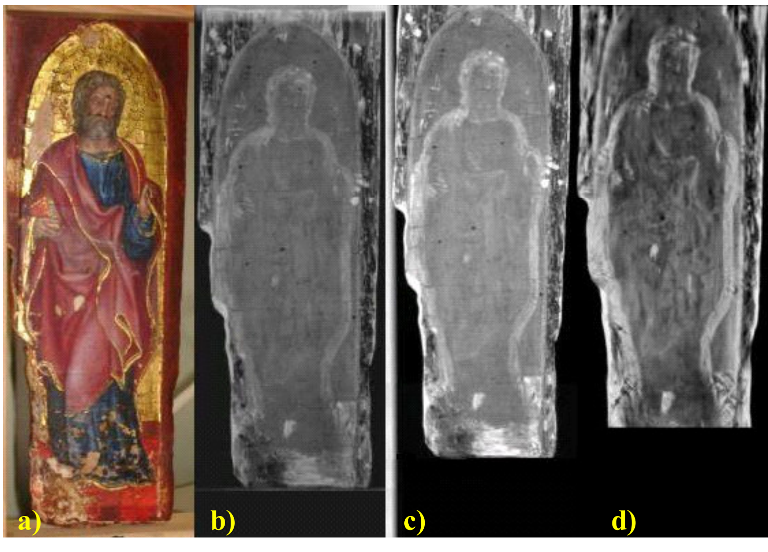
A new linear array detector for high resolutions and low dose digital radiography for painting was realized. This new instrument is able to acquire radiological image with an amount of dose one hundred times reduced. The system was tested on a benchmark panel with a number of classified original pigments provided by the "Opificio delle Pietre Dure" Institute in Florence. The resolution and the image contrast reached by the scanning system were superior to that of the common film systems used at the Institute.

Moreover, in collaboration with the National Gallery of Bologna and the "Opificio dele Pietre Dure" restoration center in Florence, was performed an X-ray investigation of the inner structure of two small (20 cm × 7 cm) painted "tablets", made of wood, and recognized as an artwork of Gentile da Fabriano, an important painter of the XIII century. Different techniques were used: conventional film radiography, digital radiography and computed tomography, the latter two with innovative equipment of the Department of Physics in Bologna. An important result was achieved with the intensified fiber optics scanner. A quality close to that of a conventional film was obtained with estimated two orders of magnitude less dose. The x-ray scanner developed at Department of Physics demonstrated to be a very useful and vanguard tool for direct digital radiography of paintings.

We also have been performed experiments with multispectral imaging equipments. These techniques are powerful to investigate ancient book in order to support the study of library materials, the mechanisms involved in deterioration, to discover hidden information and to assist book conservation and restoration.

3D CT: Egyptian cat-shaped Coffin with mummy





Painted "tablets", artwork of Gentile da Fabriano

a) Picture, b) Conventional film radiography, c) Digital Radiography with our System, d) Digital Tomography with our System (section)

ADVANCED TECHNOLOGIES FOCUSED TO THE EVALUATION OF THE STATE OF PRESERVATION AND RELATED RESTORATION ACTIONS OF THE MONUMENTAL HISTORICAL HERITAGE

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The main architectonic features - their facades in particular of the monumental palaces, while offering a direct understanding of town centers historical development, are our very first contact with the monuments themselves. More generally they represent a cultural heritage which deserves to be preserved for the benefit of future generations. Ancient residences, however, often show serious conservations problems, thus calling for strictly focused restoration works. Aiming to remedy the degradation of this unique European wealth, comprehensive analytical studies should be identified and properly implemented. The starting point is both the historical-diagnostic evaluation of the monumental building (history related researchers, "layers" analysis, …) and the analytical study of the physical characteristics (micro-invasive and non-destructive analyses, chemical-petrography and mineralogical surveys,…). This will offer the necessary basis for establishing the proper intervention methodology, to be specifically and case-by-case tailored. Highly sophisticated techniques should be considered in the more general frame of the restoration project as a whole, because of the importance of assuring the convergence of different aspects on both the technological and cultural sides. Thus the advanced diagnostic technologies are favoring the development of a new approach to the theory and the best practice of the restoration processes.

This presentation presents the recent technical development in this field and, at the same time, recalls a new initiative within the Emilia-Romagna Region: the establishment of NEREA (NEtwork for Advanced REnewal), a Consortium among Research Centers, Universities and high-tech Companies. NEREA will be committed, from one side, to the implementation of focused R&D activities according to well proved business-related models; from the other, to the promotion of the SMEs which operate in the specific sector. Even if created at the Region level, NEREA is strongly interest to the establishment of broader co-operations at both national and international level, through bilateral-multilateral agreements with parallel, specialized Consortia-Institutions.

POSSIBILITIES AND LIMITS OF THE ARCHEOGENETICAL ANALYSIS ON THE ANCIENT HUMAN REMAINS

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The archaeogenetical investigations – parallel to the wide spread of molecular genetics – have a growing importance in archaeology and population history. This positive change in playing a role in historical research is based partly on the technological development of the last two decades and partly on the recognition of the fundamental conservatism of the DNA.

The field was open for a multi-respect analysis of the DNA of several thousand years old human remains. The polimorphism of the DNA, especially on certain sections of the mitocondrial DNA, offered the possibility of the most thorough examination ever in relation to the spread and genetic variability of human species. Because of the fragmentary character of the survived ancient DNA sections, the morphometric features of the human skeleton and the genetic haplo-groups formed by the DNA-based polimorphism cannot be correlated. In fortunate cases, the archaeogenetic investigations make it possible to study illnesses of genetic origin, or to analyse the kinship in smaller groups of burials. The examination of the patrilinear and the autosomatic inheritance can be a great help in answering the major questions of the population history of the Carpathian basin.

The most recent investigations concentrate on the archaeological and historical preconceptions of the eighth-twelfth centuries, particularly on the problem of population and nation. However, the most distinguished results can be expected in relation to the population problems of the neolithic age. The archaeogenetic laboratory in the Archaeological Institute of the Hungarian Academy of Sciences was established to answer these questions.

The long-range financing of such investigations is, however, not solved properly, not least, because of the time needed and the hardness one has to face when trying to give an interdisciplinary interpretation. In favour of a modern human DNA contamination-free analysis, the recent tendency is to limit the number of research groups in order to focus the limited resources – among them the available grants and funds – in the major archaeogenetic research centres.

LASER TECHNOLOGIES IN CULTURAL HERITAGE CONSERVATION

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The state of the art of laser techniques employed in conservation of cultural heritage is continuously growing in Europe. After more than thirty years since the first experiment in Venice many advancements were achieved and now laser techniques are widely recognised as one of the most important innovation introduced, in the last decades, in conservation of artworks for diagnostics, restoration and monitoring. Many research projects organised at the European level have contributed to this achievement, being complementary to the development carried out at national level.

IFAC-CNR has carried out research projects on these topics, developing new laser instruments dedicated to the cleaning of deteriorated stones and metals. The laser systems have been validated after a vast experimentation, confirming a well controlled ablation of the deteriorated layers, while preserving the historical layers such as patinas or gilding. A number of case studies have validated these instruments on masterpieces of the Florentine renaissance and on archaeological pieces. IFAC is carrying out projects of research, of technology transfer and of international cooperation.

A very important role was played by the COST Action G7 "Artworks Conservation by Laser" for the decisive acceptance of these techniques. This is a networks of forty organisations, research institutes, conservation institutes, archaeology experts, museums etc. COST G7 has contributed a lot by exchanging experiences, comparing results, selecting best practices. After the COST G7 activity it appears now clear an evolution of the systems, a specialization of the cleaning task, the achievement of side-effect free procedures.

The Prophet Abacuc by Donatello during the laser cleaning at *Opificio delle Pietre Dure*, Florence

The validation of these advanced cleaning techniques has been extensive and diffused in many European countries. Laser-based diagnostics have also specialised their tasks toward material analysis, defects detection and multidimensional documentation. Laser and optical methods successfully monitor deterioration effects. In many European countries interdisciplinary networks are managing the experimentation of these techniques giving them a sound scientific approach, but also a technology transfer to end-users. So doing the appreciation for these techniques is growing in all the conservation institutions involved at national level, disseminating a positive evaluation about the benefits provided by laser in conservation. Nowadays laser cleaning is considered the most precise method available for the restoration intervention, in order to remove in a controlled way the degraded layers. Several laser systems became products for the activity of professional restorers and their increasing sales demonstrate a growing utilisation throughout all Europe.

THE USE OF 3D TECHNOLOGIES TO SURVEY AND DOCUMENT ARCHAEOLOGICAL BUILDINGS AND SITES

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The laser technology doubtless represents the new generation of 3D documentation technologies. We cannot talk about experimental methods any more. Based on the surveys executed on sites – now also in Hungary – it is clear that the fundamental phase of the technical innovation arrived to its end. The research method is fast and provides spectacular results: there are only few specialists in heritage management, who are not convinced by the first insight. Still, the expected growing in the numbers of the surveys is late. Today, both the developers and the users are looking for a market, but they often have to face uninspected difficulties.

The antipathy or aversion, which hinders the wide spread of this new documentation technology, is based on simple, but real reasons. The infrastructure of the traditional manual system is very strong, it obviously tries to withstand any of the new methods, which intend – or at least seems to intend – to change fundamentally the practise, organisation, or system of it. Therefore, accepting the new methodology is not simply a matter of fulfilling a technological prerequisite. The major question is, whether a new attitude will emerge from the side of the heritage people to accept a new approach, a brand new way of thinking: do we want to and will we be able to apply, use, and exploit that surplus value, which is offered by the use of 3D laser technologies.

„FAST ARCHAEOLOGY": APPLYING NEW TECHNOLOGIES IN THE ARCHAEOLOGICAL RESEARCH IN THE CIVILIAN CITY OF AQUINCUM

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The growing number of investments in archaeologically protected areas mean greater challenge for archaeologists all over in Hungary.

It is especially true in the case of Budapest, where building activities bring to light the ruins of Óbuda, Buda and Pest. The primary intention of investors, even if they are interested in archaeology, is to have the excavation done by the Museum as soon and as cheap as possible. The demand is similar when constructing public utilities or in case of public transport. Museums can only adapt themselves to these demands if they apply new techologies in documentation and survey.

The Budapest Historical Musem has long been trying to apply these technologies. Photogrammetry, geophisical survey and laser-scanning were sometimes used as completing traditional documentation.

Testing these new technologies in reality has first been carried out this year. The reconstruction of the railway-line of the Szentendrei HÉV required special attention as it crosses the Civil Town of Aquincum. Comparing the plans of the transport company (BKV Rt.) to our informations of previous excavations, it became clear that the reconstruction could affect roman layers. The strictly built up project only allowed 16 hours for archaeological work to be done.

Taking up the tracks meant that a circa 400 m long and 10 m wide stripe of the roman settlement came more or less to light. The first step was the geophisical survey, which revealed walls of buildings of different orientations. Following the survey, cleaning of the surface was done when remains of buildings of unknown purpose came to light together with traces of terrazzo and heating channels. The documentation of this building together with other wall-fragments was carried out by laser-scanning during the night and also in rain.

This type of documentation carried out in a few hours, not only helped the archaeological research, but also resulted new informations: so far undefined data, deriving from previous years excavations in the Civil Town of Aquincum, could be explained and we can complete the topographical-chronological picture of the roman town.

NON-INVASIVE INSTRUMENTATION FOR DIAGNOSTICS AND COLOUR CONTROL

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The fact that every work of art is a unique piece emphasises the necessity of working with non-invasive methodologies.

In this communication instruments, which were realized at IFAC-CNR, Florence, and their application to actual cases will be presented. Such instrumentation is based on spectroscopic techniques, namely image spectroscopy (IS) and fibre optic reflectance spectroscopy (FORS). Indeed, the integrated use of both techniques constitutes a powerful tool for obtaining a large amount of spectroscopic information without any sampling, thus overcoming all the limitations and problems involved in sampling operations. Moreover, the availability of lightweight and compact equipment makes it possible to perform measurements *in situ* on objects that cannot be removed from their location.

Furthermore, due to the fact that these techniques are non-invasive and are thus safe for works of art it is possible to re-measure the same object after a given time, to monitor the conservation conditions of the work of art, and also to follow the restoration processes. The methodology also enables the acquisition of a large number of spectra over the entire artefact. This wide sampling operation, the performance of which would be unthinkable with micro-sampling techniques, provides a large amount of data, which can be used for statistical analyses.

As regards the application to actual cases, two case studies will be reported: a) a Leonardo da Vinci's painting, where pigments, binding medium, preparatory layer and previous restoration works were identified; b) the colour evolution of a Luca Signorelli's predella was monitored over the years during the exhibition to the public, during the restoration intervention and after the restoration.

Finally, a brief account of the studies performed at IFAC – CNR about indoor light control will be given and the possible use of a new light dosimeter will be suggested.

RIVER ARCHAEOLOGY – A NEW FIELD OF RESEARCH

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The beginning of underwater archaeology goes back to the turn of the 19^{th}-20^{th} c. With the diffusion of autonomous diving equipment and the work of pioneers (such as J.-Y. Cousteau, G. Bass) underwater archaeology became a real scientific discipline. However these researches concentrated on marine archaeology. Even nowadays underwater archaeology means marine archaeology for most colleagues.

Systematic underwater survey of rivers began in France in the 60's, but only in a small scale (L. Bonnamour in the Saone River). The physical conditions of the rivers are different from the seas: the visibility is close to zero, the current is strong, and the depth is only a few meters. It means that the methods and technologies of marine archaeology are not applicable automatically.

From the 90's the Departement des Recherches Subaquatiques et Sous-marins began the large scale surveys of the French rivers. The National Office of Cultural Heritage of Hungary organised an underwater archaeological research programme in 2002. In 2004 the European Fluvial Heritage programme began with Hungarian, French and Slovenian cooperation. The aim of the programme was to exchange methods, information and experiences. This presentation summarizes the technologies used in underwater archaeological survey, their possibilities and problems.

The use of aerial photos and satellite technologies is diffused in archaeology. In river archaeology they are useful to detect ancient river-beds, roads and bridges/ferries.

Bathymetric survey is a combination of GPS, depth measuring and cartography. The isometric mapping of the river bed could help to find shallows (used often for crossing the river), artificial moles, and dams. This technology is easy and not expensive. Though it is not able to detect shipwrecks or smaller structures.

Sonar systems are often used in marine environment. Marine sonar is not able to make images in shallow water. The new high resolution side-scan sonar (900-1200 MHz) makes good images in rivers. The problem of using this technology is that in the case of underwater vegetation-cover or intense sedimentation (tree-chunks) it is not possible to see the river bottom.

The seismic radar penetrates into the sediments, detecting covered structures. This tool could also create isometric or 3D image of the river-bed. According to our experience this is the most useful technology in instrumental survey. Both of the mentioned technologies require underwater survey to identify sites.

In case of underwater survey and excavation the main problem is the orientation, the positioning of the site and the finds. The modern documentation tools of the archaeological research: GPS, laser technologies are not applicable under water. We can only apply hand measuring, but the scarce visibility makes it very slow and difficult process. The next challenge of underwater archaeology developers is to resolve the problems of underwater documentation.