



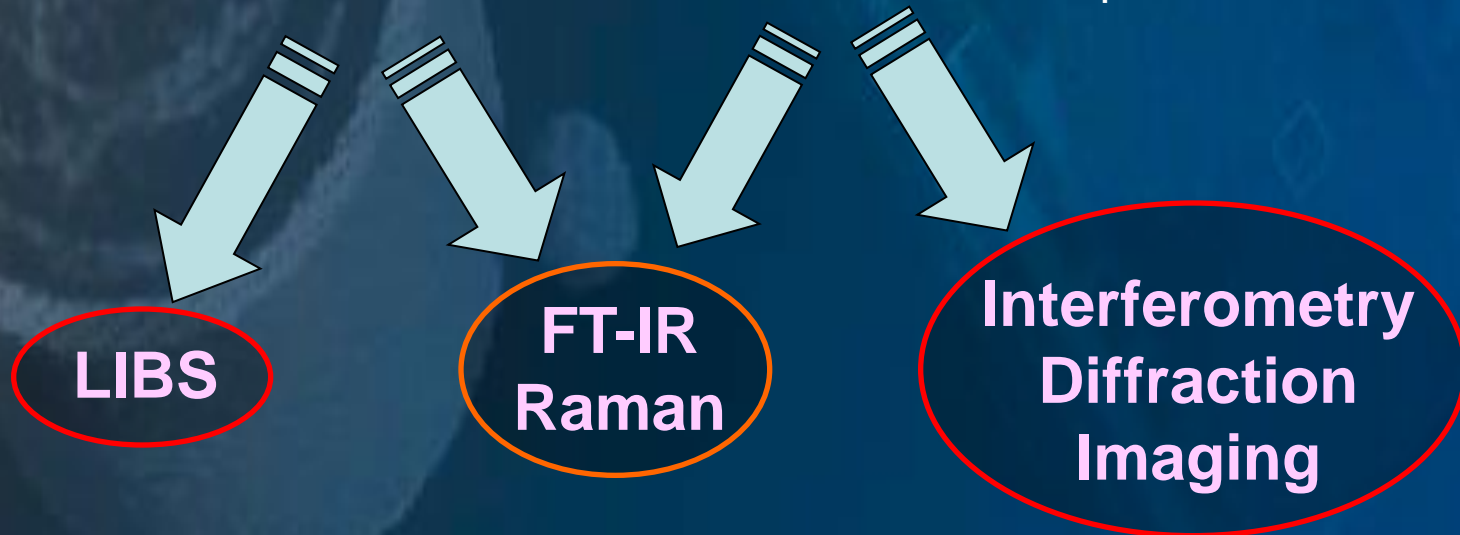
IMAGING IN ARCHAEOMETRY AND ENGINEERING NEUTRON TOMOGRAPHY AT ISIS

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IMAGING IN ARCHAEOOMETRY AND ENGINEERING

Museum objects and handcrafts considered as cultural heritage are often unique, aged and degraded. Their interior composition, very often unknown, can deliver information about their period of origin, the manufacturing process and their use.

Requirement: micro-invasive or non-destructive techniques



IMAGING IN ARCHAEOOMETRY AND ENGINEERING

Some engineering tasks requires non-invasive techniques too:

- Study of stress and deformation of mechanical components
- Real time visualization of operational structures
- Study of chemical or physical attack of critical components under working condition

Imaging allows the direct visualization of the property of interest.

Reverse engineering problems:
 Images can be obtained by different probes:

- etc.....

• Light (UV, Visible, IR)

furnishes only surface information (at least from opaque objects)

• Ultrasounds

furnish low resolution details of inner particulars

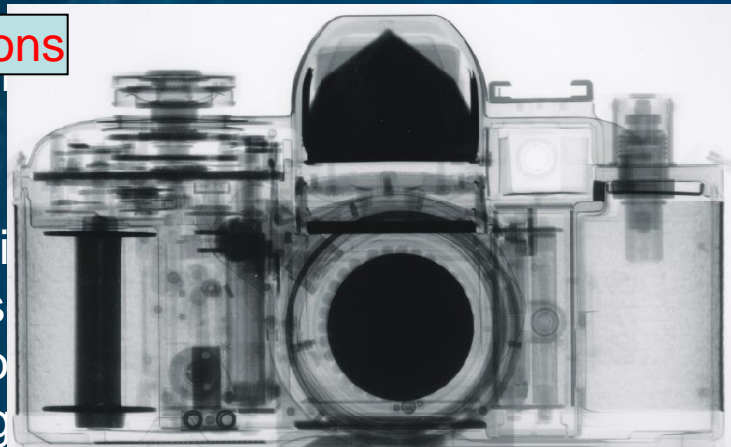
• X-rays & neutron

are able to produce high resolution images of the inner details

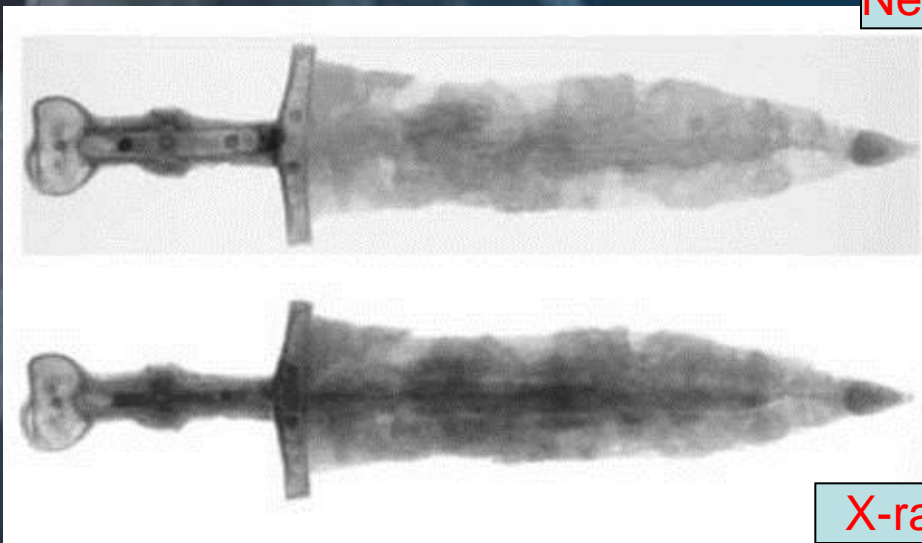
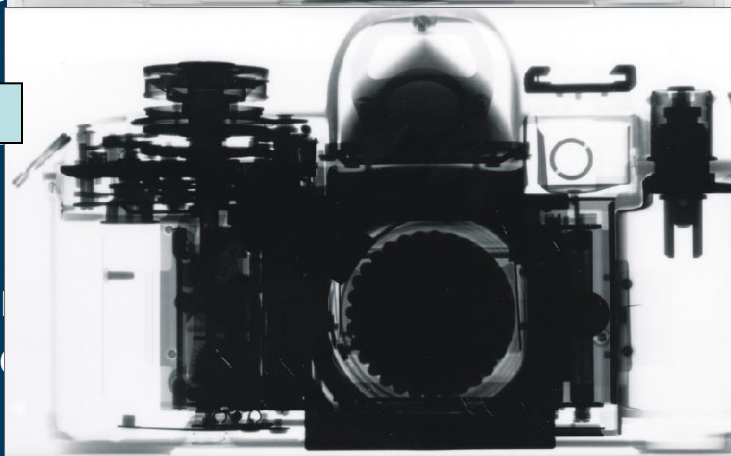
Interferometry
Diffraction
Imaging

RADIOGRAPHY, CHAEOOMETRY AND ENGINEERING

Neutrons



X-rays



more difficult by heavy metals.

E. Deschler-Erb, E. H. Lehmann, L. Pernet, P. Vontobel, S. Hartmann

Archaeometry 46, 4 (2004) 647-661

Neutron transmission varies randomly and
 aluminium are transparent while hydrogen and

NEUTRA-PSI, Switzerland

www.ati.ac.at/~neutropt/esperiment/Radiography/radiography.html

ATI-Austria at Station-2

X-rays and neutrons provide complementary information.

RADIOGRAPHY

A neutron radiography system consists of:

1. a neutron source
2. a scintillator screen
3. an imaging device (typically a CCD)

TOMOGRAPHY

Resolution:

Steps:

1. several radiographies (projections) are acquired at different view angle around a rotation axis
high L/D ratio (L=length of collimator; D=diameter of the aperture)
short sample-scintillator distance
2. corrections of each 2-D image (normalization, correction for noise signal, white spot filter, etc.)
Safety of the imaging device:
shielding against neutrons and off-axis geometry
3. filtered back-projection of the 2-D images (or other reconstruction algorithm)
shielding against γ -rays from scintillator

Result: 3-D image of the object, that can be sliced in different views by a suitable visualization software.

NEUTRON TOMOGRAPHY IN EUROPE

Reactors

- | | |
|-------------------|--|
| 1. FRM-II | Garching, GERMANY (fast neutrons, $8 \cdot 10^{14} \text{ n}\cdot\text{cm}^{-2}\cdot\text{s}^{-1}$) |
| 2. BENSC (CONRAD) | Berlin, GERMANY (cold neutrons, $10^9 \text{ n}\cdot\text{cm}^{-2}\cdot\text{s}^{-1}$) |
| 3. CASACCIA | Rome, ITALY (thermal neutrons, $2 \cdot 10^6 \text{ n}\cdot\text{cm}^{-2}\cdot\text{s}^{-1}$) |
| 4. CEA | Saclay, FRANCE (thermal neutrons, $3.4 \cdot 10^6 \text{ n}\cdot\text{cm}^{-2}\cdot\text{s}^{-1}$) |
| 5. ATOMINSTITUT | Wien, AUSTRIA (thermal neutrons, $1.3 \cdot 10^5 \text{ n}\cdot\text{cm}^{-2}\cdot\text{s}^{-1}$) |
| 6. KFKI | Budapest, HUNGARY (thermal neutrons, $10^8 \text{ n}\cdot\text{cm}^{-2}\cdot\text{s}^{-1}$) |

Neutron Spallation Sources

- | | |
|-----------------------|--|
| 1. SINQ (NEUTRA, PGA) | Villigen, Switzerland
(thermal and cold neutrons, $10^{14} \text{ n}\cdot\text{cm}^{-2}\cdot\text{s}^{-1}$, <u>ontinuous</u>) |
| 2. LPI | Moscow, Russia
(thermal and fast neutrons, $10^9 \text{ n}\cdot\text{cm}^{-2}\cdot\text{s}^{-1}$, <u>pulsed</u>) |

Why tomography at ISIS?



With the project TS2, in July 2008 we pulled neutron chrofuors comd target station at ISIS. On 3 August 2008, the source (with a flux of 10^{14} n/cm²·s). The target station of the neutron pulse at the beginning of its path toward the sample is $\sim 20 \mu\text{s}$ and the pulse repetition rate is 60Hz. The time width of the pulse on the sample depends on the length of the path to the sample. The pulse width



In 2008 a new agreement for collaboration between CNR and STCF has been performed supporting the access of Italian researchers to the neutron source. Within this agreement a new project, **PANAREA**, will be developed, that will be co-financed by CNR and STCF. **Final Agreement for the utilization of neutron source in the Rutherford** (2008-2016).

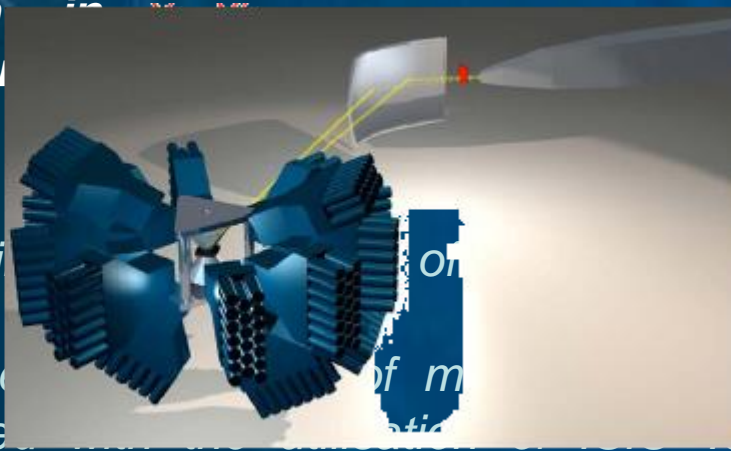
Appleton Laboratory.

PANAREA

Progetto per l'**A**pplicazione dei **N**eutroni **A**lla
Ricerca in **E**lettronica e **A**rcheometria
 CHIP IR radiation

IMAT
IMage and **MAT**erials
 science and engineering

Agreement concerning collaboration in scientific source



[...] CNR
 contribu
 Aiming
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on making
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 target

Station 1 and especially its new Target Station 2.



PANAREA

IMAT

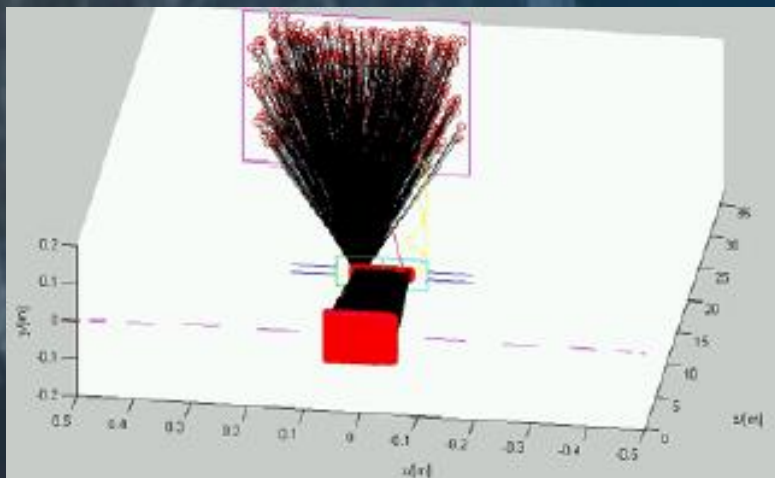
A thermal-cold imaging / materials science beamline for TS-II

CHIPIR

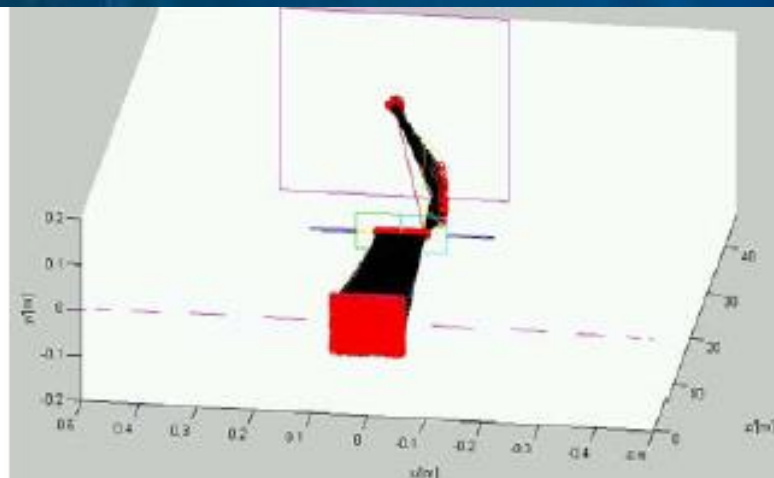
IMAT

CHIP IR radiation

IMage and **MAT**erials science and engineering



Imaging mode



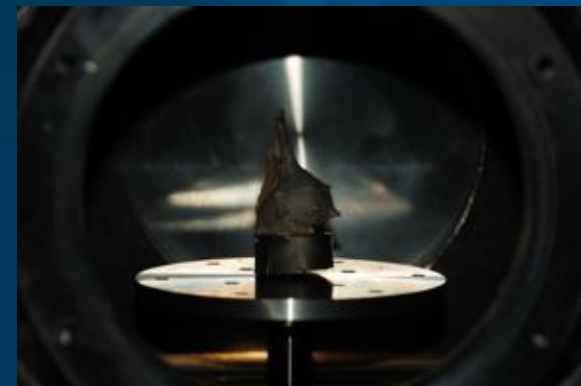
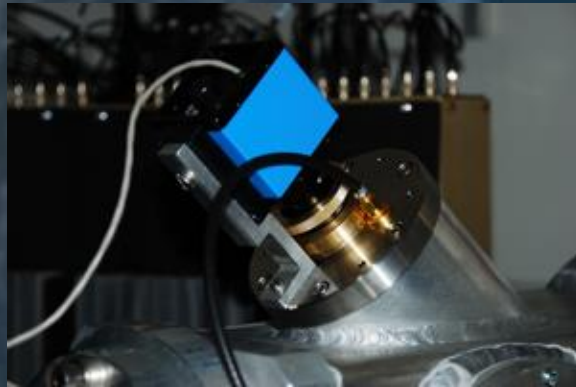
Idiffraction mode

IMAT will be a world-leading pulsed-source cold neutron radiography station and facility for materials science, materials processing and engineering.



INES

The Italian Neutron Experimental Station at ISIS





IMAGING IN ARCHAEOMETRY AND ENGINEERING NEUTRON TOMOGRAPHY AT ISIS

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NEUTRON TOMOGRAPHY AT ISIS

