

Gamma Irradiation: a Tool for Remedial Conservation of Cultural Heritage



- *Biocide Treatment of Organic Materials and Consolidation of Wooden Degraded Artifacts by Radiation Curing Resins* -



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Nuclear New Horizons: Fueling our Future

October 21-25, 2019 - Santos, SP, Brazil

Short Presentation of ARC-Nucléart and Introduction •

*Gamma Rays for Biocidal Treatments
of Cultural Heritage Artefacts •*

*Radiocurable Resin for Consolidation of
Porous Degraded Material •*

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ARC-Nucléart : An Unique Structure for Cultural Heritage Conservation

*born in the 70's from the idea of using "nuclear"
techniques for heritage conservation*



*Located in Grenoble / France,
on the site of the French Commission for
Atomic Energy (CEA) research center*



ARC-Nucléart : An Unique Structure for Cultural Heritage Conservation

French Special Status: Groupement d'Intérêt Public (GIP)
Public Interest Grouping : a consortium of public organisms



8 persons (provided staff)
Building and facilities
Subvention



Atelier de Recherche
et de Conservation

7 persons
(employees of the
grouping)



2 persons (provided staff)
Subvention

2 persons
(provided staff)



ProNucléart



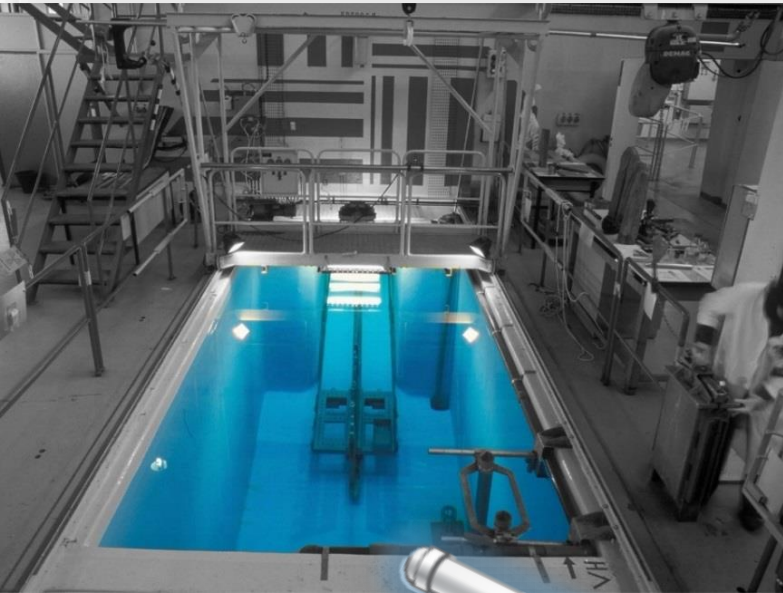
3000 m² facilities : irradiation facility, large scale freeze dryers,
impregnation tanks (large scale, up to 14 meter long),
restoration workshops, storage rooms, chemical and biological
analysis laboratories

A multidisciplinary team of 19 people: biologist,
chemists, physician, technicians,
mechanic, photographer,
conservators, curator, administrative.



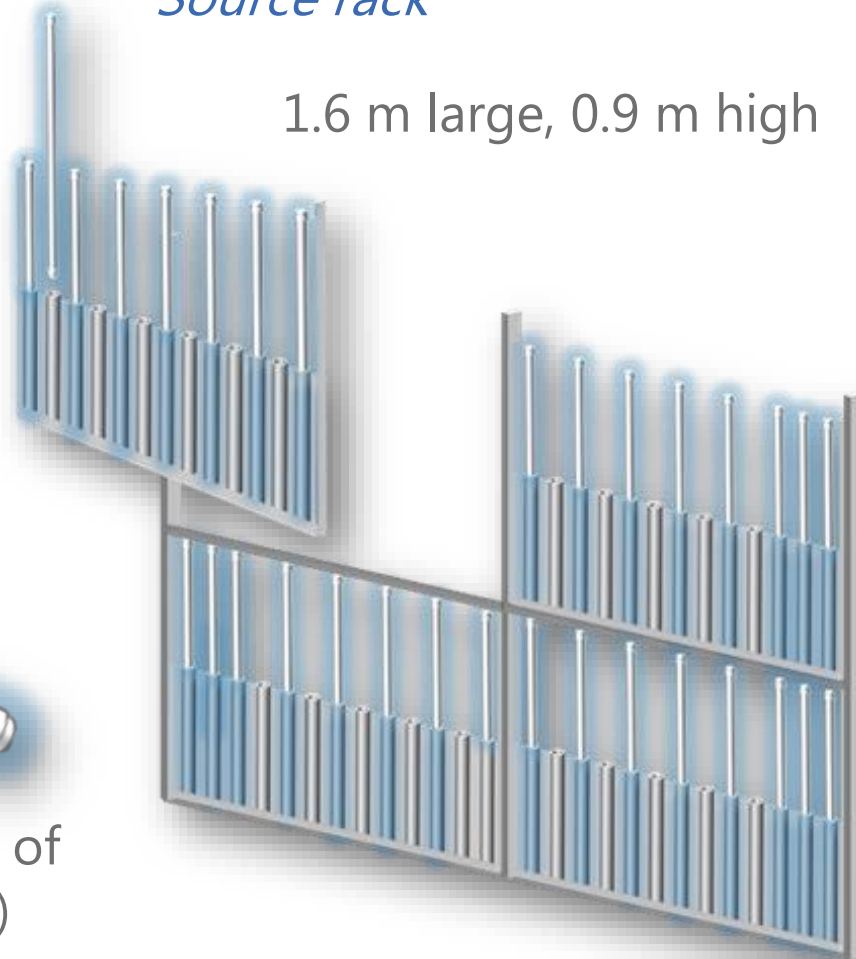
Dedicated Irradiator of ARC-Nucléart

Pool irradiator 2000 TBq ^{60}Co (max 3700 TBq)



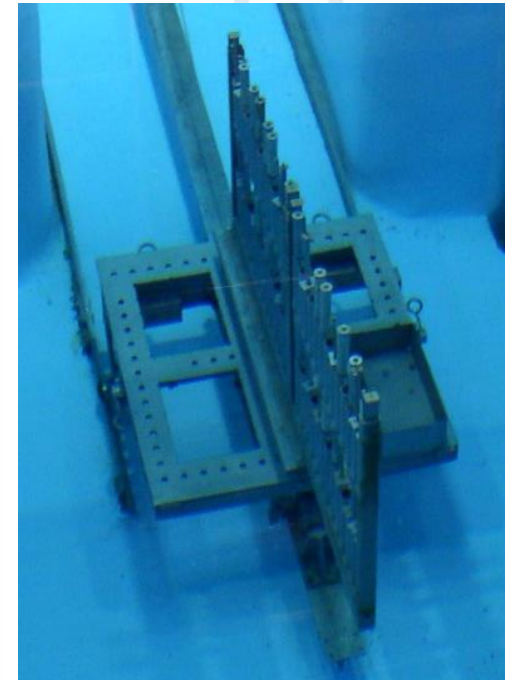
Source rack

1.6 m large, 0.9 m high

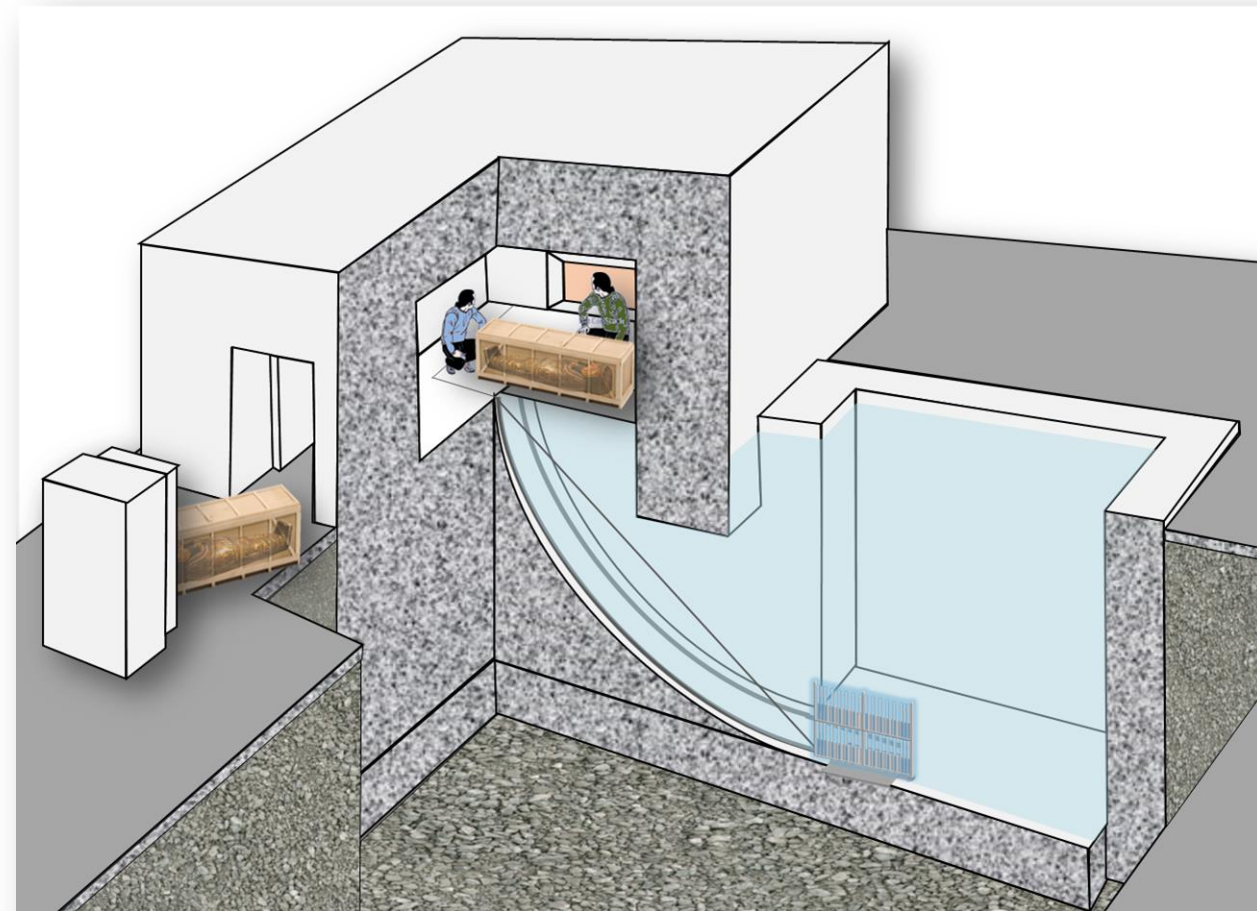


Industrial sealed sources

double enclosed capsule of stainless steel (inox 316L)

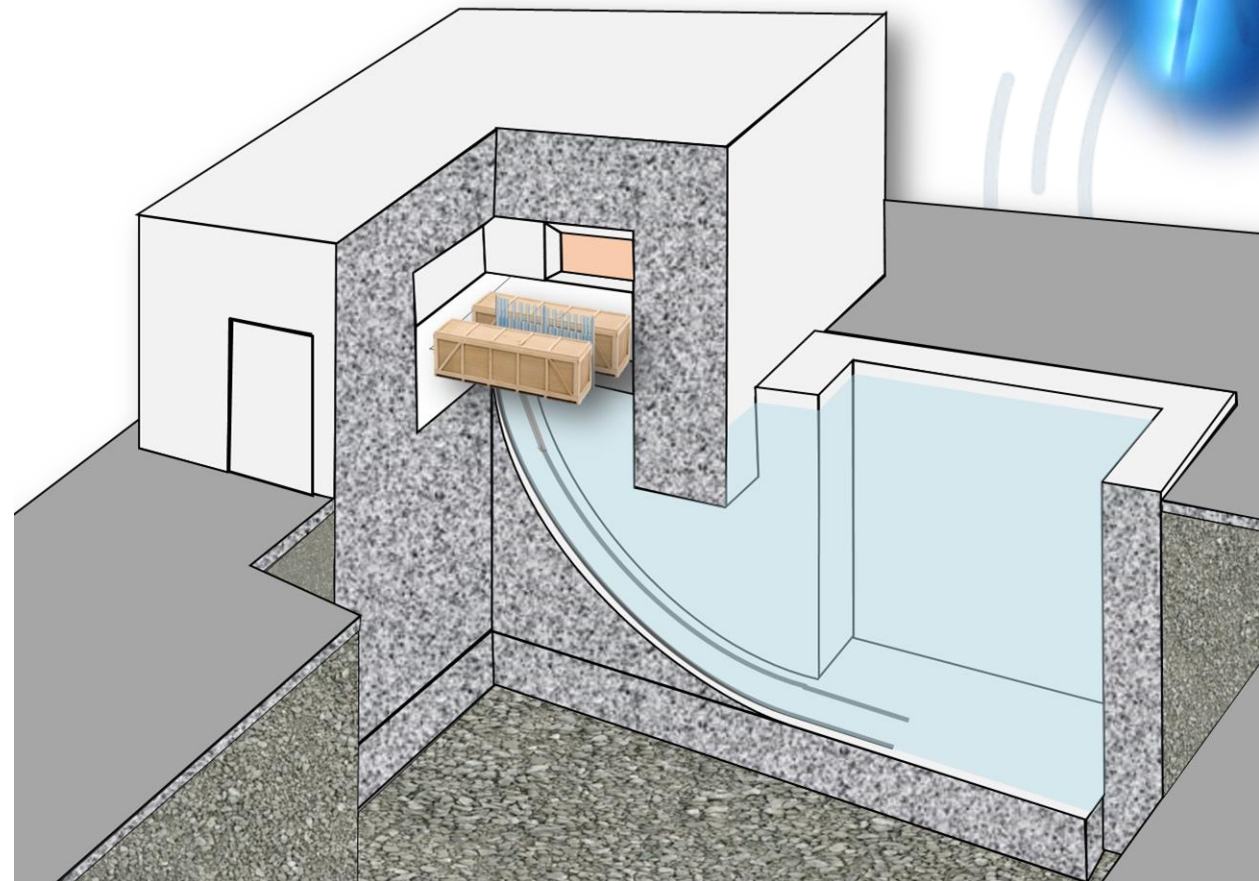


Dedicated Irradiator of ARC-Nucléart



*Dose rate ranging from
hundreds of Gy/h*

to few kGy/h

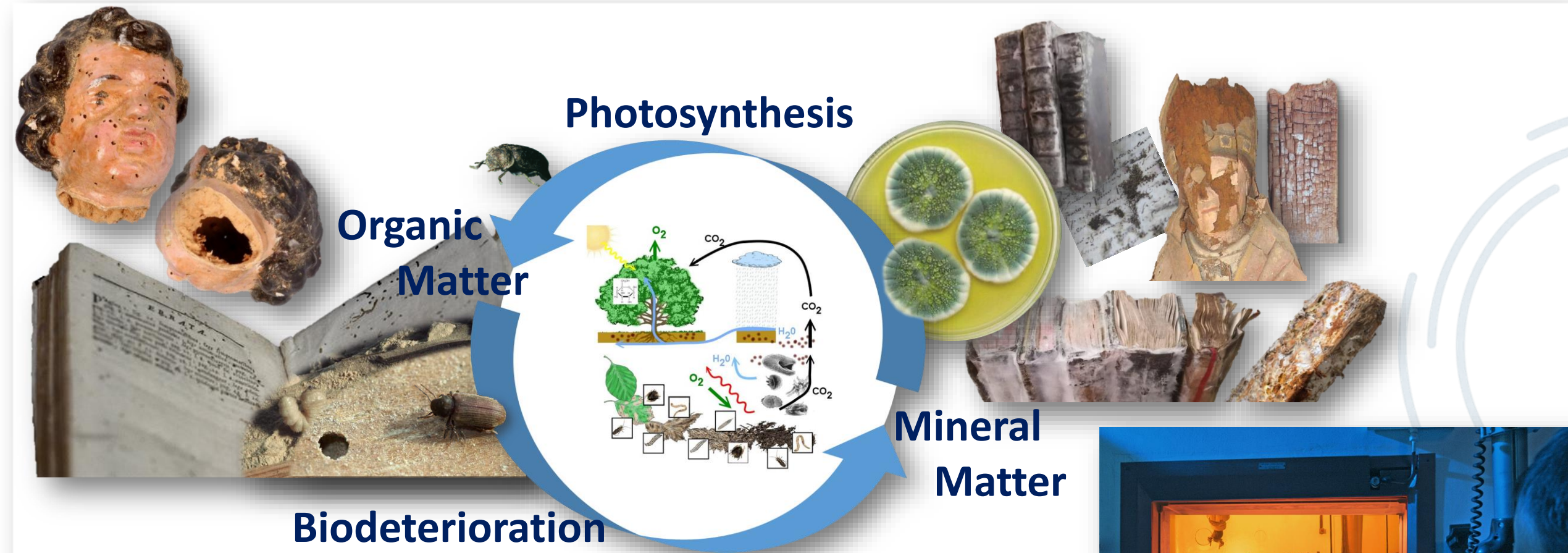


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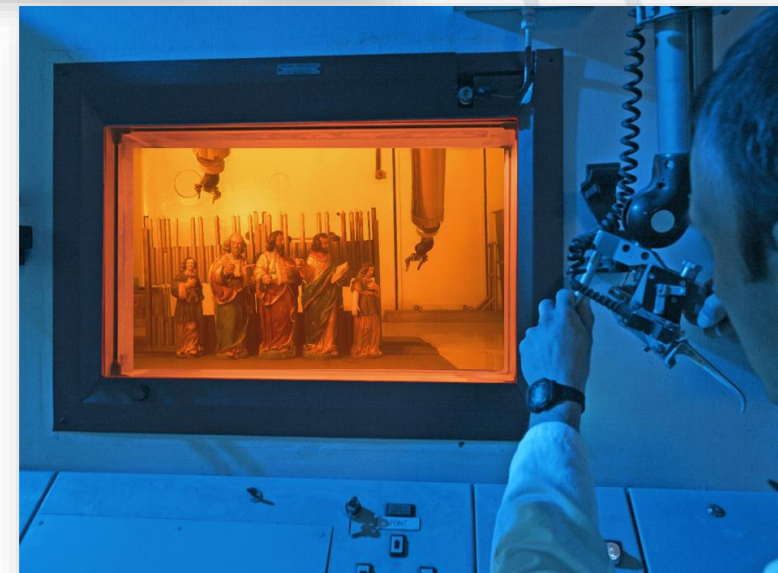
*Radiocurable Resin for Consolidation of
Porous Degraded Material •*

Fighting Against Biodeterioration

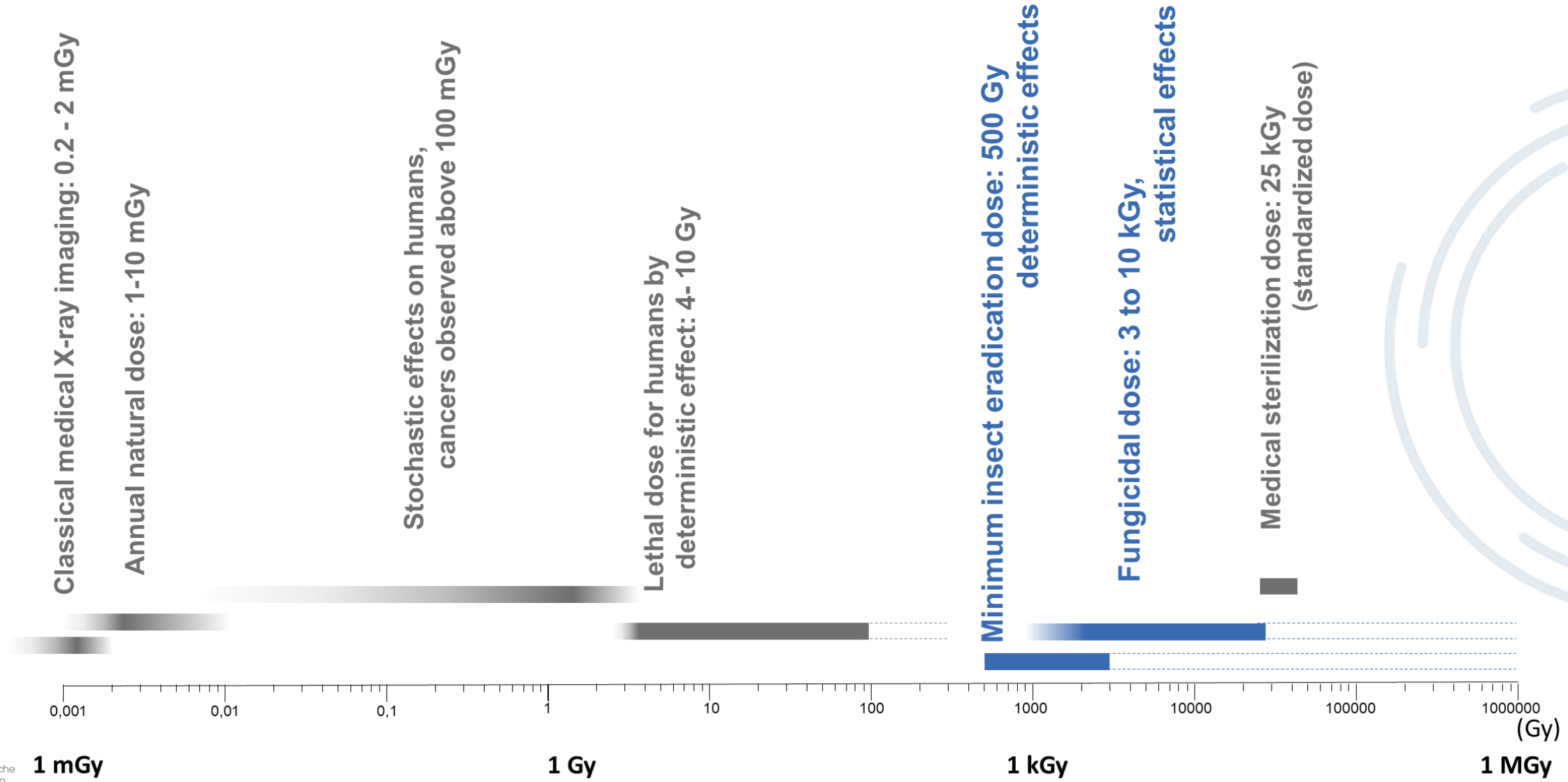


Main pests are insects and fungi (rot, mold)

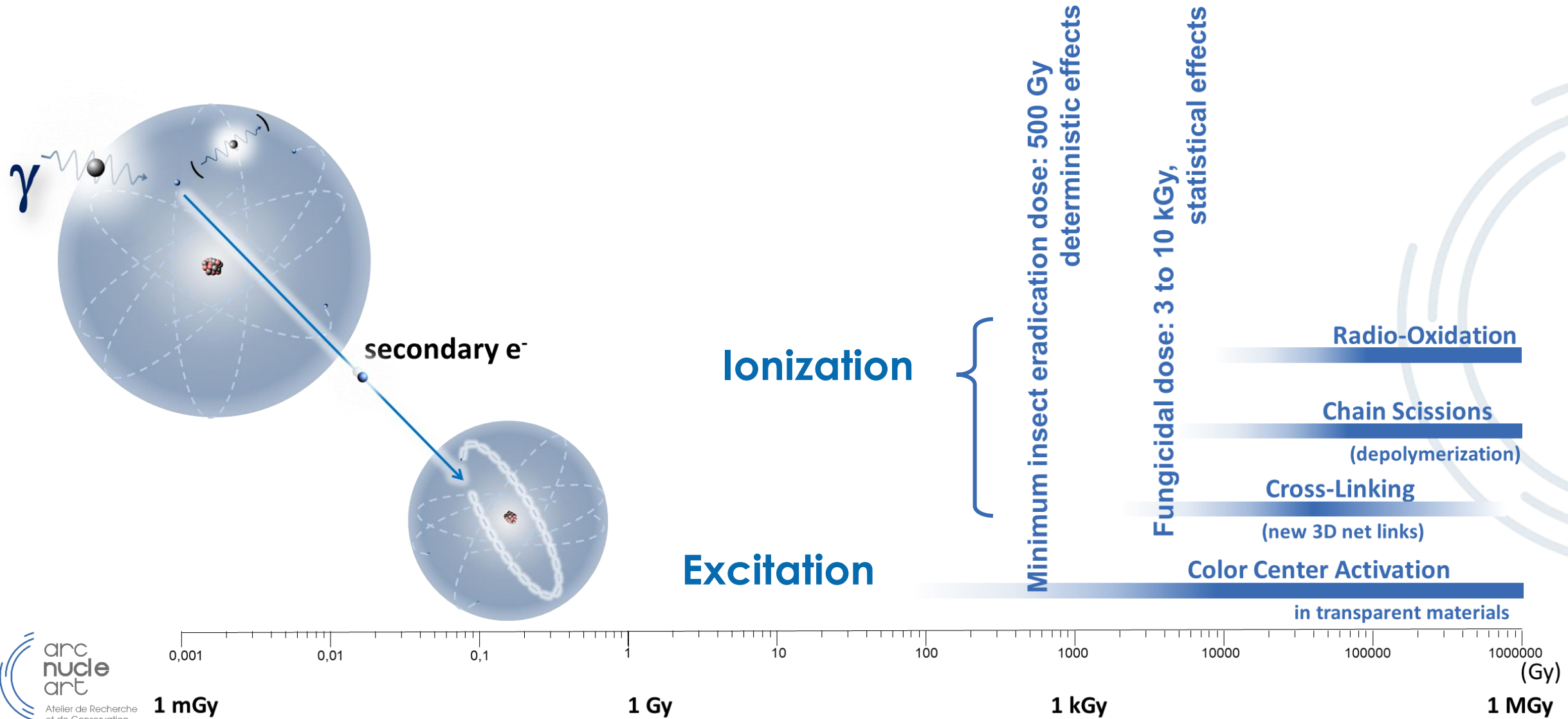
**Biocidal treatment
by simple exposure to gamma rays**



Efficiency (Biological Effect): A Matter of Dose

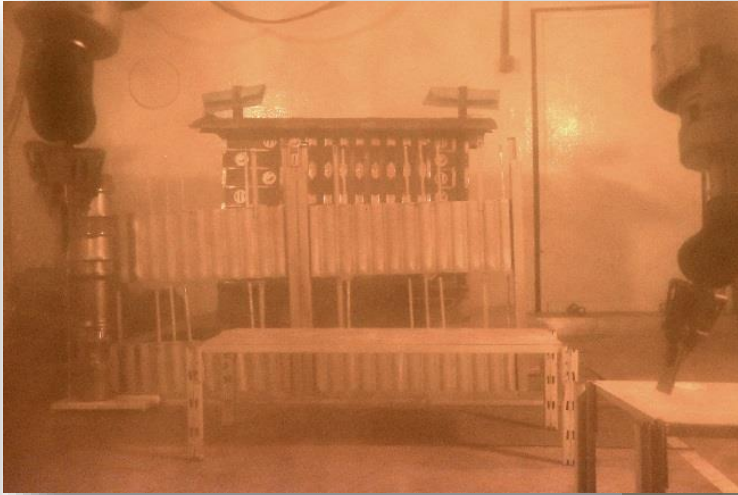


Harmlessness: A Matter of Dose



Example of an Insect Eradication Treatment

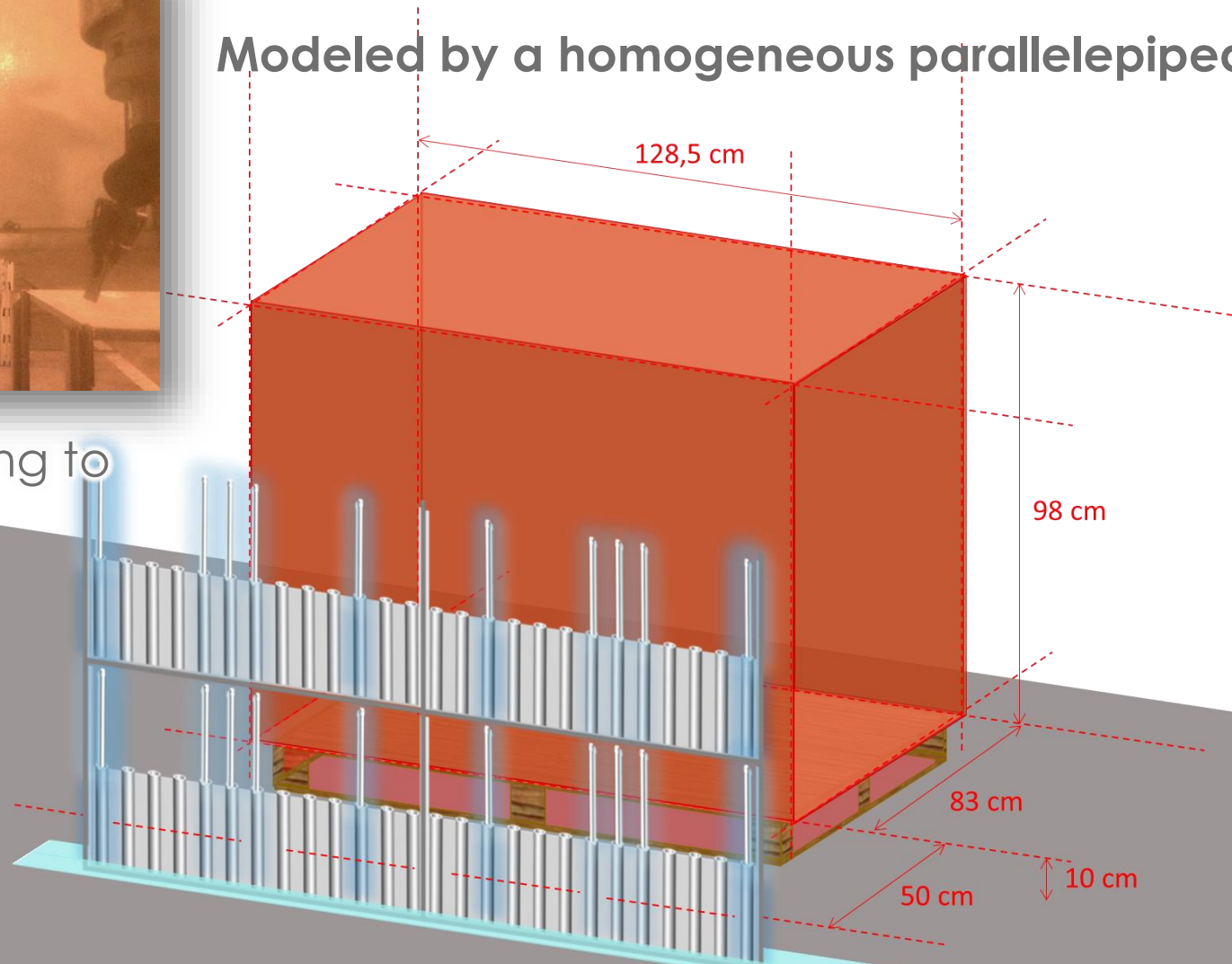
Japanese palanquin
in lacquered wood
with metal
decorations,
19th c.,
Saint-Rémi Museum,
Reims, France.



Example of an Insect Eradication Treatment

Japanese palanquin
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Modeled by a homogeneous parallelepiped

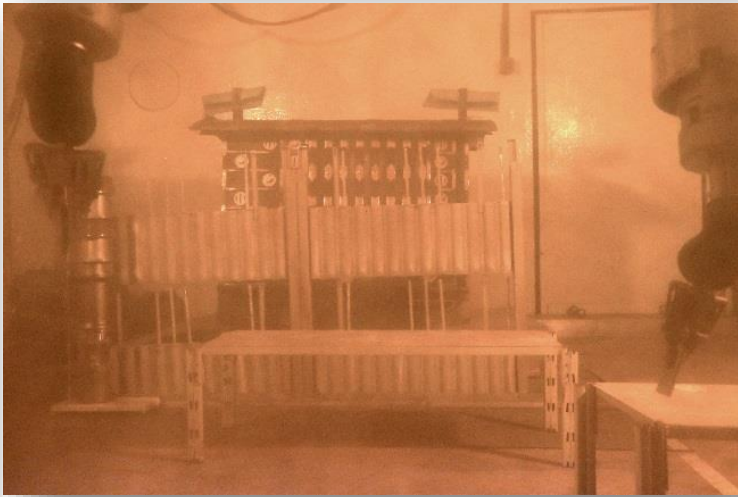


Attenuation according to
the average density



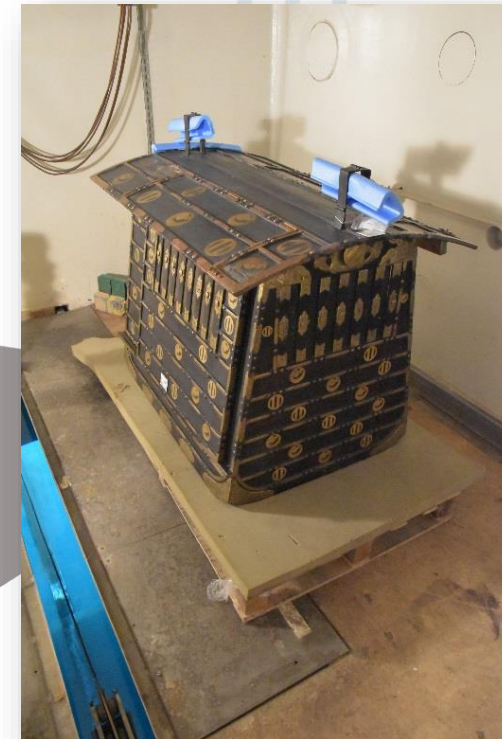
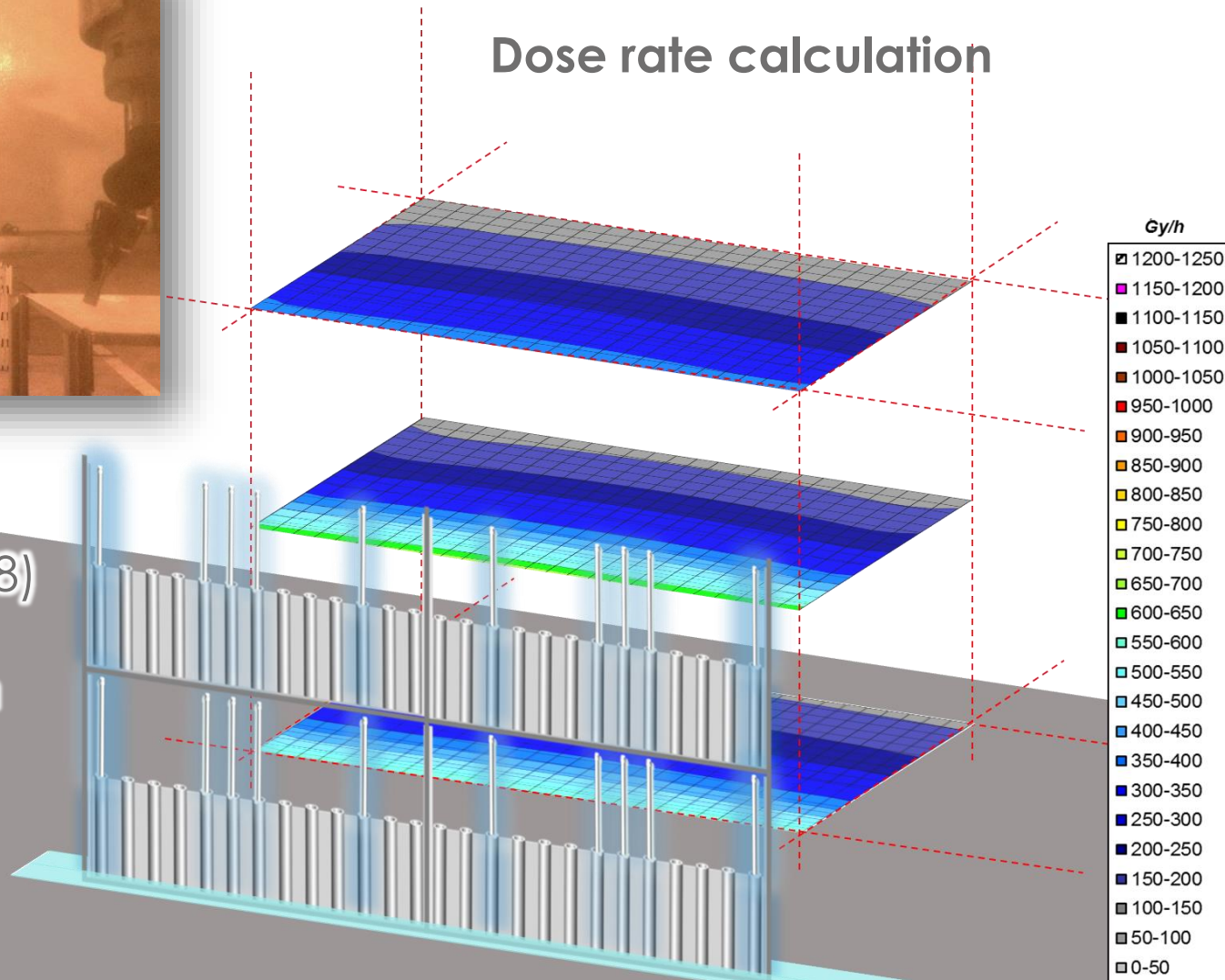
Example of an Insect Eradication Treatment

Japanese palanquin
in lacquered wood
with metal
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19th c.,
Saint-Rémi Museum,
Reims, France.



20 sources,
1398 TBq (27/06/2018)

Numeric model with
Dispersion and
attenuation



Example of an Insect Eradication Treatment

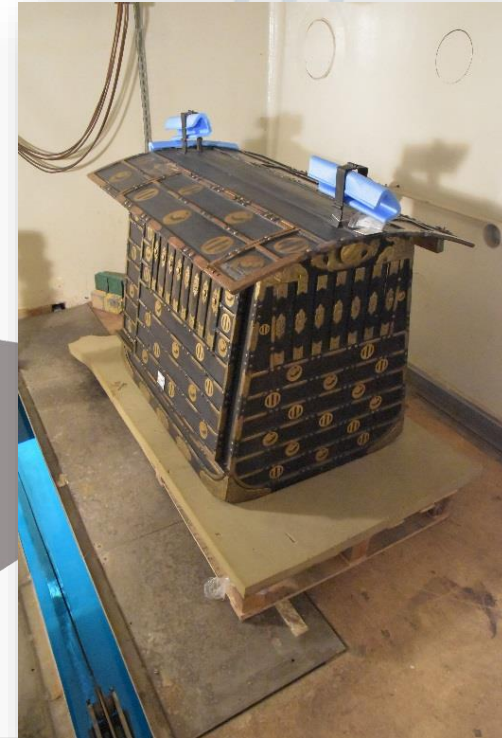
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Mid-irradiation Reversal

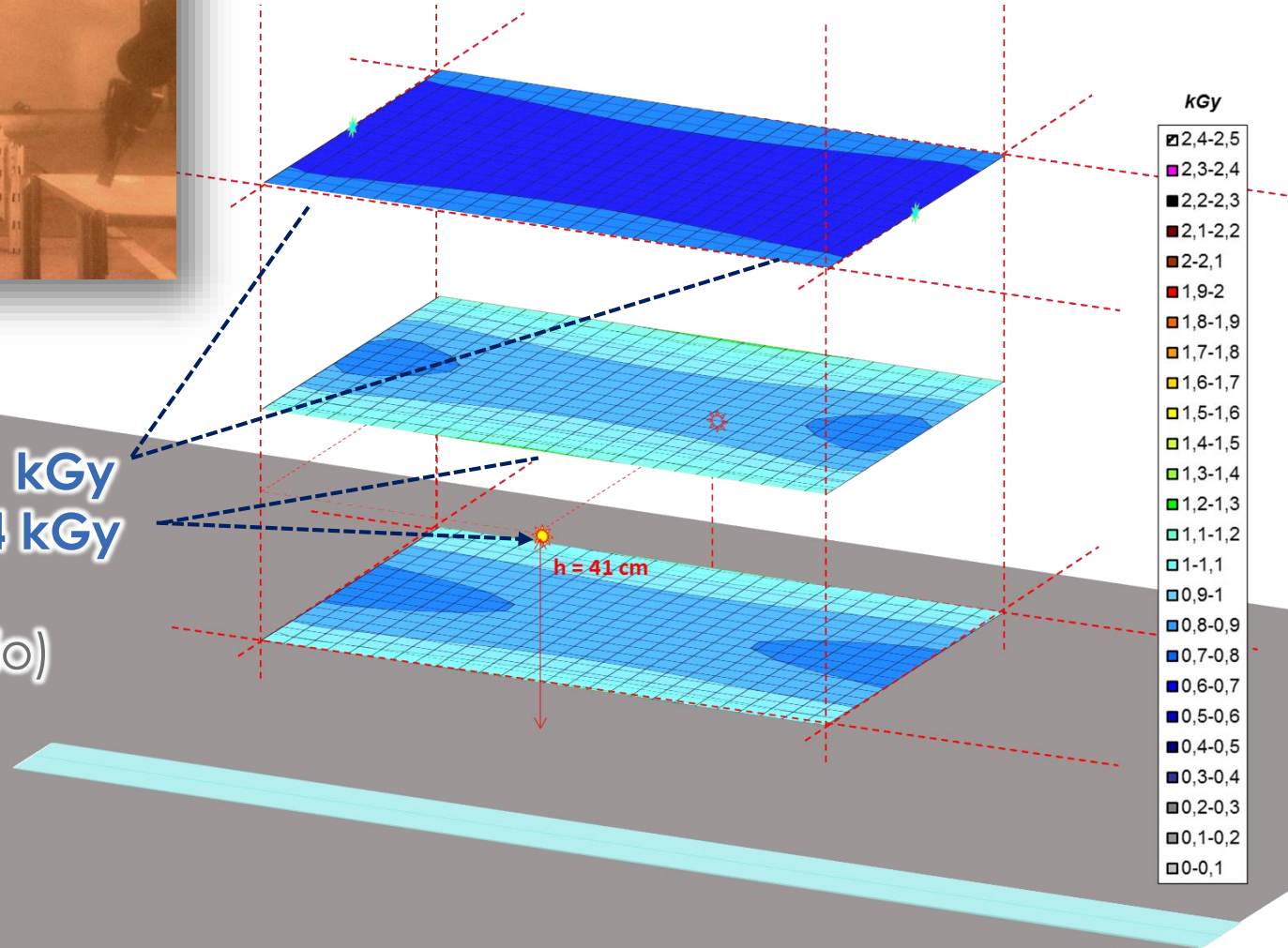


Example of an Insect Eradication Treatment

Japanese palanquin
in lacquered wood
with metal
decorations,
19th c.,
Saint-Rémi Museum,
Reims, France.



Cumulated dose is given by integration
of dose rate on the exposure time
with half-irradiation turnaround



Twice 1 h 30 min
of irradiation

Minimum Dose: 0,61 kGy

Maximum Dose: 1,14 kGy

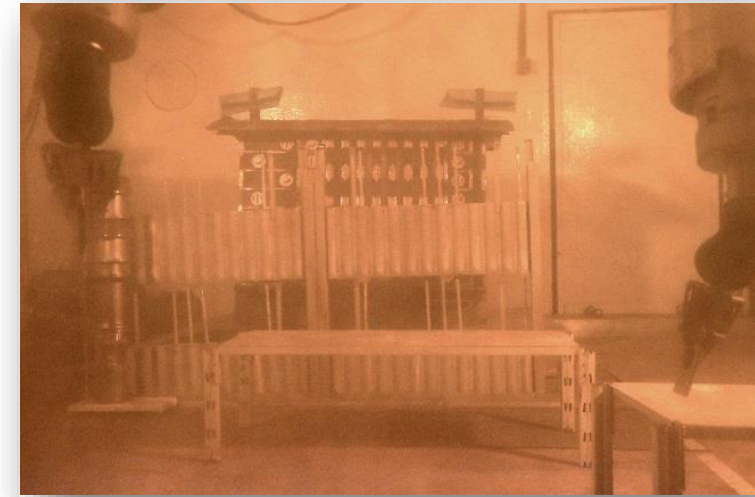
DUR = 1,83

(Dose Uniformity Ratio)

Example of an Insect Eradication Treatment

Control with optical dosimeter

Japanese palanquin
in lacquered wood
with metal
decorations,
19th c.,
Saint-Rémi Museum,
Reims, France.



Minimum dose: 0,62 kGy
Maximum dose: 1,24 kGy

DUR = 2
(Dose Uniformity Ratio)



Dosimètre	Dose (kGy)
Face 1 (milieu)	1,11
Face 2 (milieu)	1,24
Coté gauche (haut-centre)	0,64
Coté droit (haut-centre)	0,62

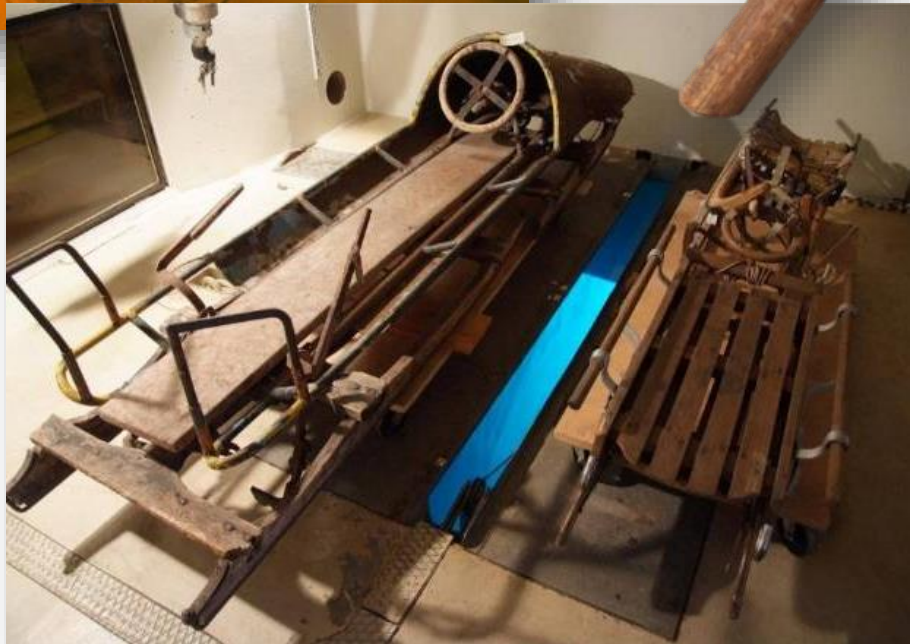
Tens of Thousand Cubic Meters Treated Since the 70's in ARC-Nucléart:



- Furniture
- Wooden Sculptures
- Ethnological Objects
- Musical Instruments
- Taxidermy
- ...
- Modern Art



Insect Eradication in Ethnological Artefacts



Objets ethnographiques, Collection
Lacroix, XXe s., Musée de Fessey



Bobsleigh, milieu du XXe s.,
Villard-de-Lans

Church Sculptures: Chambors, Christ en croix, XVI^e s.



Church Sculpture: Yenne, Pietà, XV^e – XVI^e s.



Archive Decontamination

- New application in France (“Archives Nationales”, 2016-2017)

- Ongoing studies on “non standard” archival materials

- Widely used in many countries despite a slight depolymerization of cellulose at high doses

“Paper deterioration by mold is more severe than by gamma irradiation”

John Havermanns (†), TNO, Netherlands



Some “exotic” customers

- Frozen baby mammoth



- Mummies



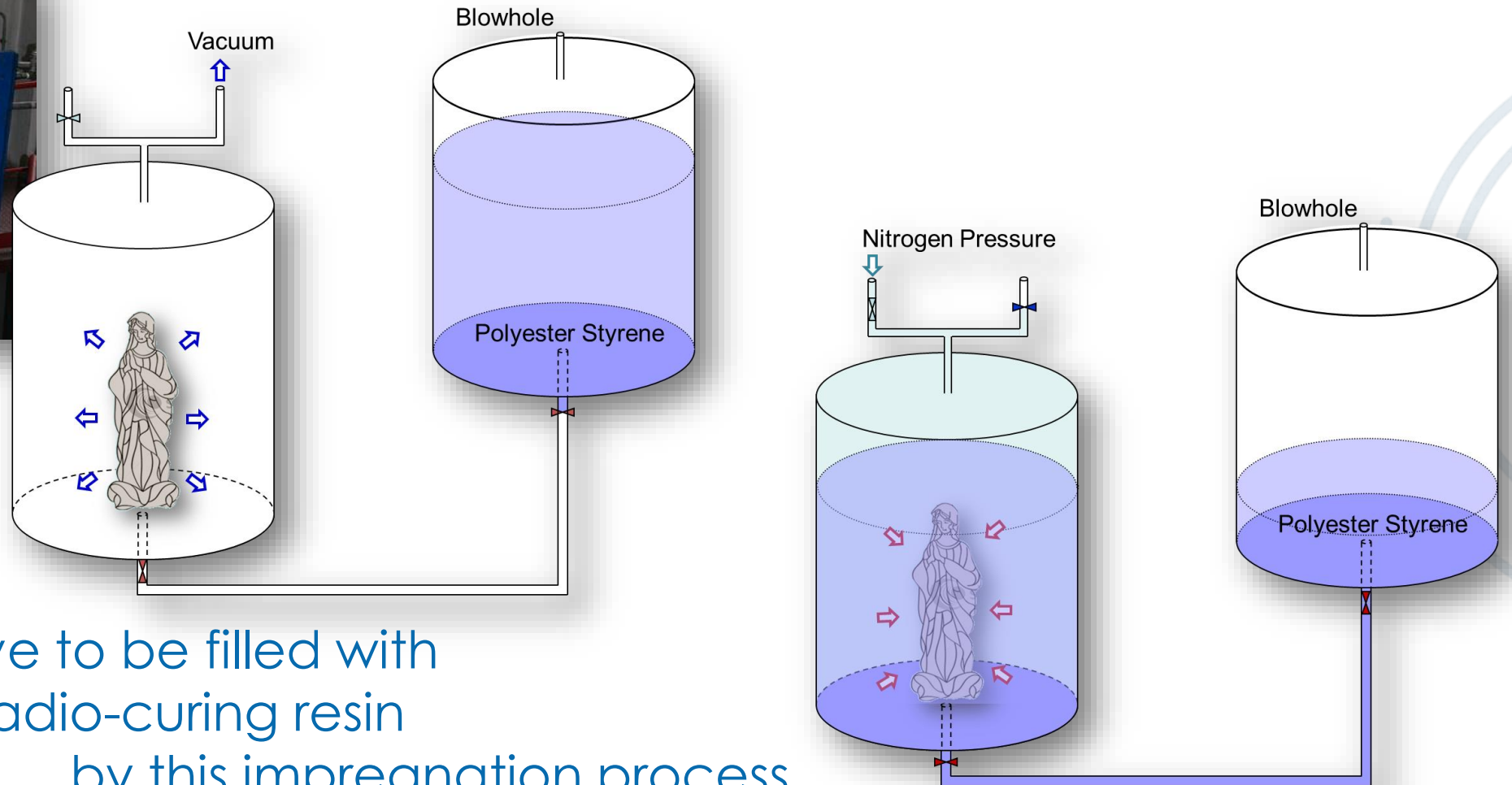
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**Radiocurable Resin for Consolidation of
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“Nucléart” method: Consolidation by densification in two steps

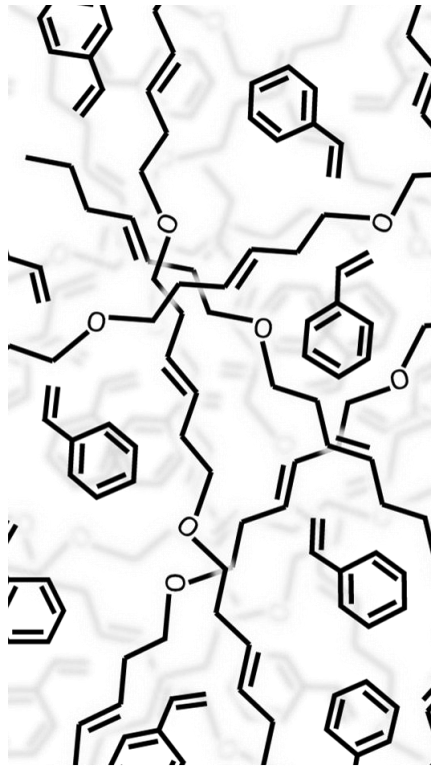
First Step: Vacuum / Pressure Impregnation



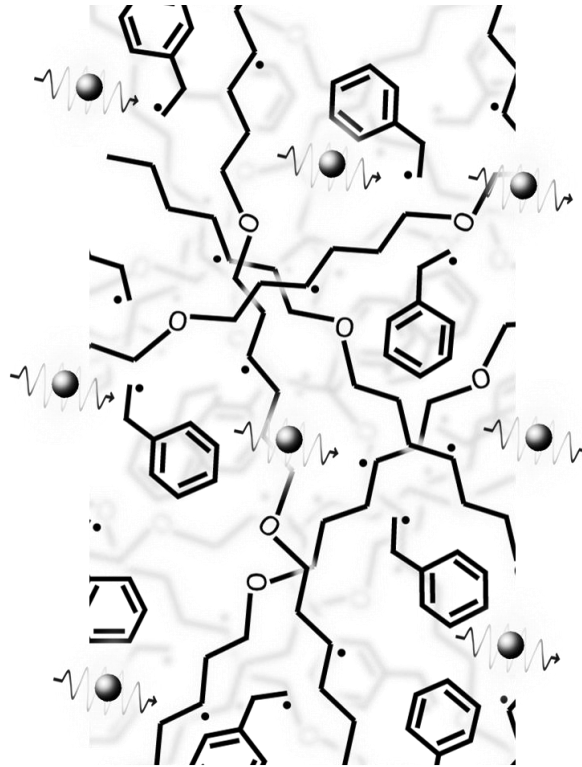
Microporosity have to be filled with
radio-curing resin
by this impregnation process.

“Nucléart” method: Consolidation by densification in two steps

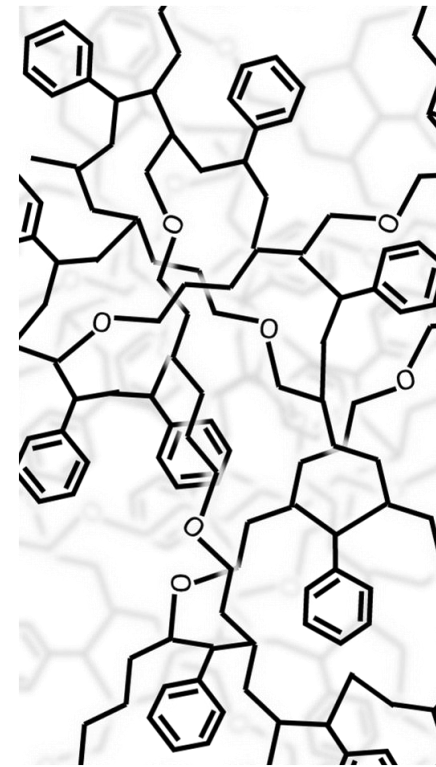
Second Step: Radio-induced cross-linking by gamma irradiation



Styrene / unsaturated
polyester resin

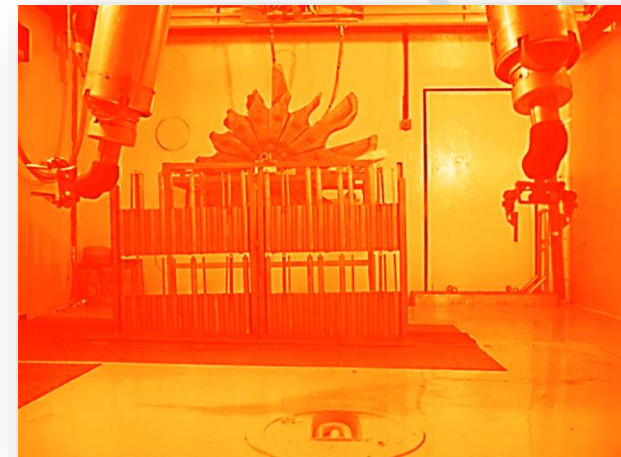


gamma irradiation



Thermoset plastic

Solidification of the impregnated resin
staying in microporosity

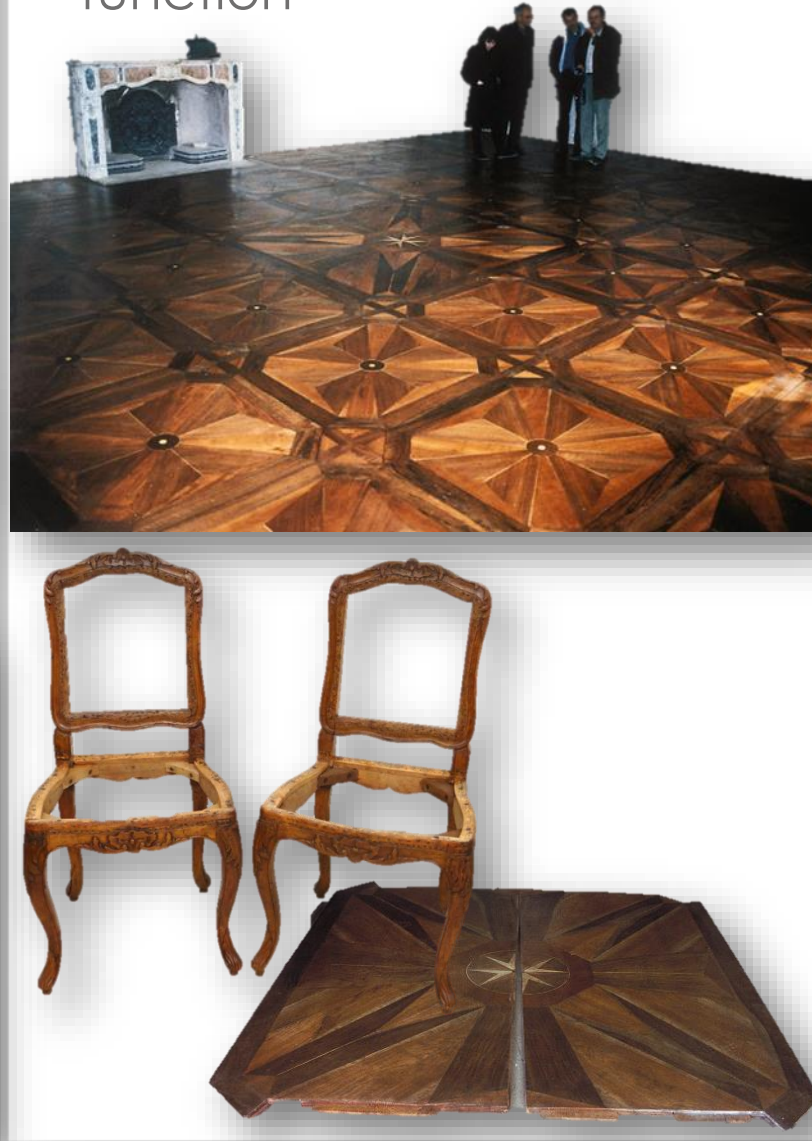


An Irreversible Method that Must Be Justified

- Last chance technic



- Conservation of the function



- Treatment of archaeological waterlogged wood



Suzannecourt, saint Vincent, 18th c.

Extremely severe xylophagous attack



First intervention before consolidation

Suzannecourt, saint Vincent, 18th c.

“Nucléart” consolidation



Suzannecourt, saint Vincent, 18th c.

Classical restoration



Assembly



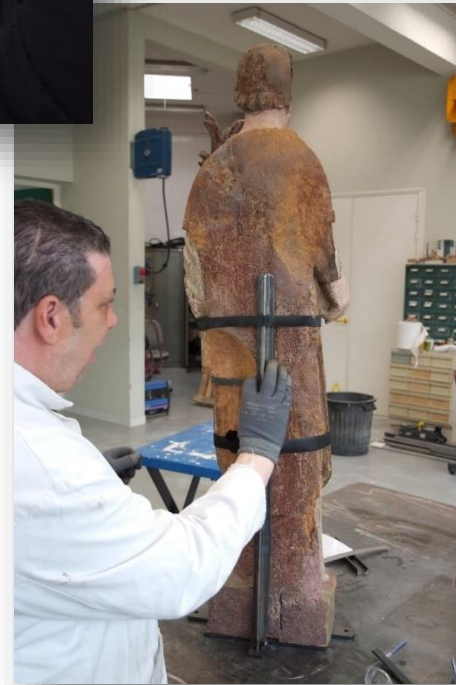
Structural filling



Color retouching



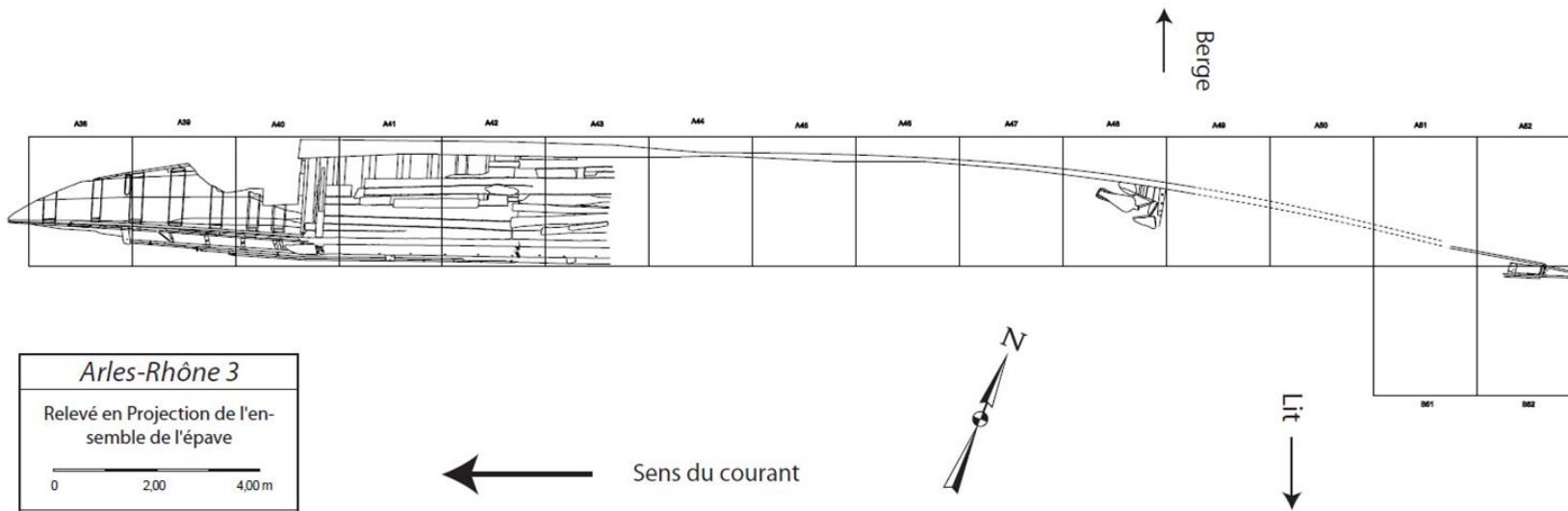
Fine putty



Support



Gallo-Roman Barge, 1st c., Arles, France



Gallo-Roman Barge, 1st c., Arles, France



Gallo-Roman Barge, 1st c., Arles, France



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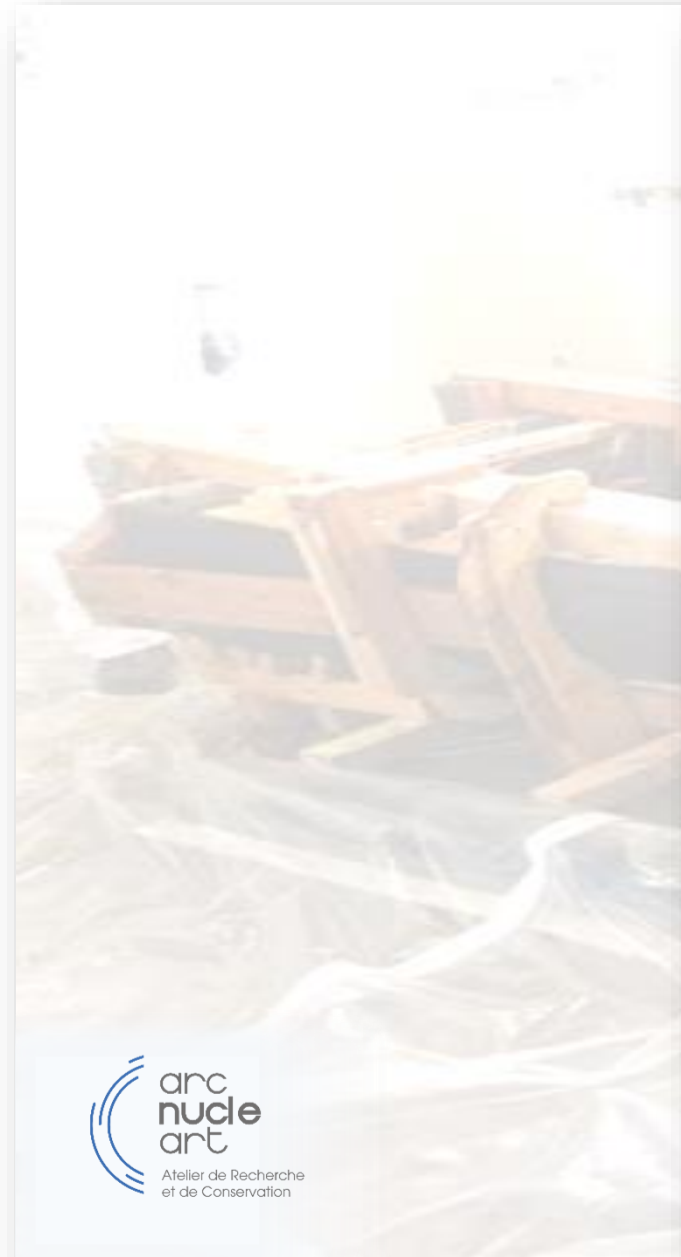
Gallo-Roman Barge, 1st c., Arles, France



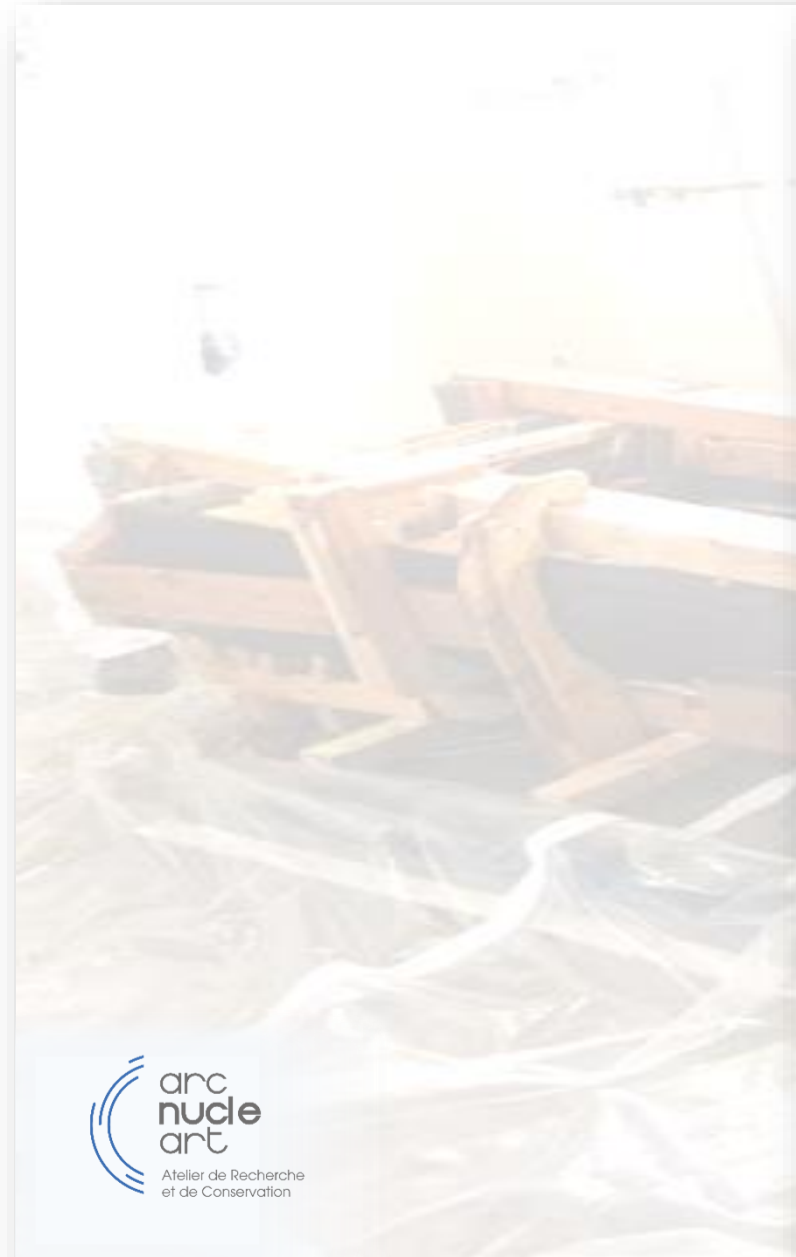
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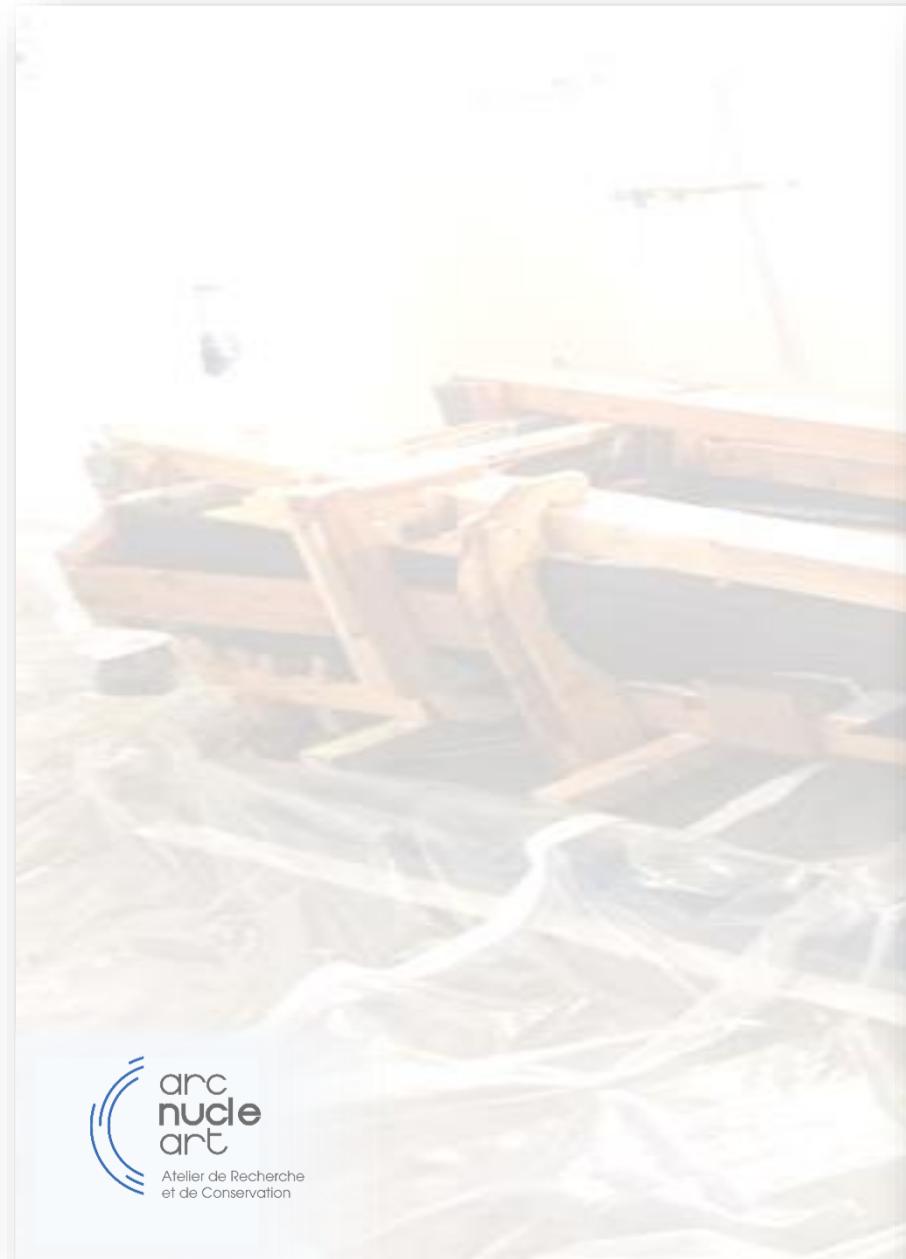
Gallo-Roman Barge, 1st c., Arles, France



Gallo-Roman Barge, 1st c., Arles, France



Gallo-Roman Barge, 1st c., Arles, France



Thank you for your attention

