Irradiation Method for the Protection of Croatian Cultural Heritage Objects

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IRRADIATION METHODS IN THE PROTECTION OF CULTURAL HERITAGE
Zadar, October 6, 2011

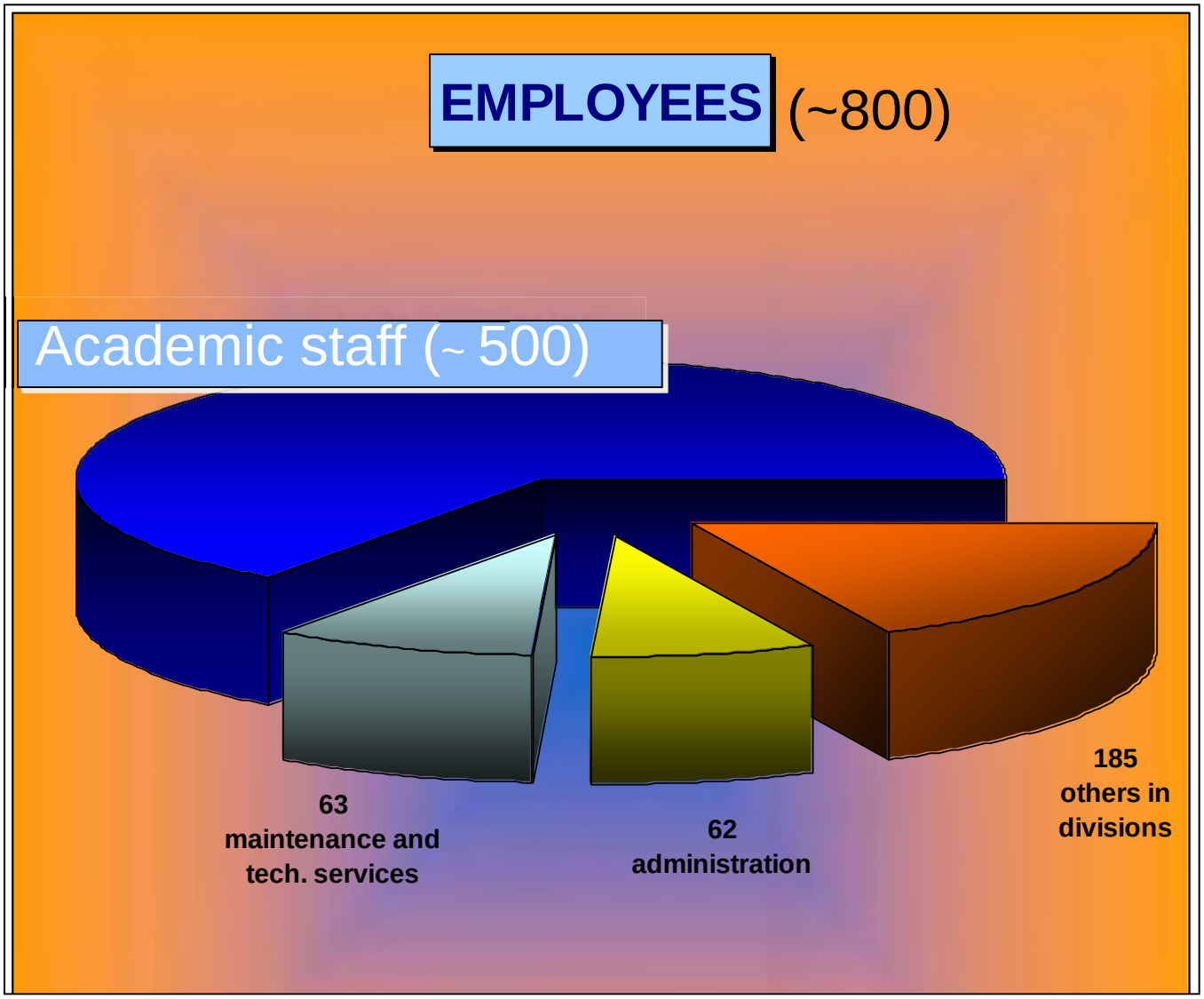
IAEA Project RER/8/015
"Using Nuclear Techniques for the Characterisation and Preservation of Cultural Heritage Artefacts in the Europe Region"

Ruđer Bošković Institute (RBI), Zagreb

The largest research Institute in Croatia covering all fields of natural sciences

- Scientific sector structured into 11 divisions

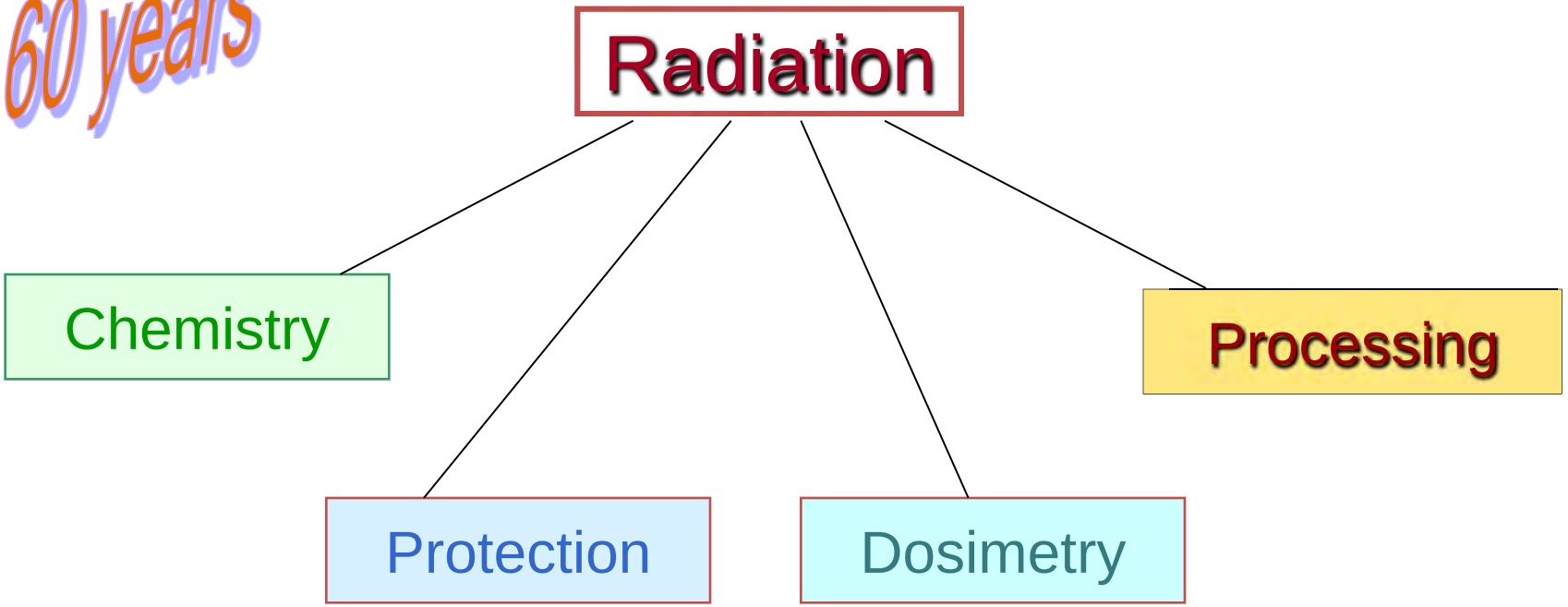
Ruđer Bošković Institute (cont.)



Radiation Chemistry and Dosimetry Laboratory (RCDL)
Materials Chemistry Division

A combination of basic and applied research

60 years



2 national projects: Ministry of Science, Education and Sports
4 international projects: IAEA, EU,
6 bilateral projects: Germany, Hungary, Japan, Slovenia, USA

Gamma irradiation facility, RCDL

Panoramic batch-type dry storage ^{60}Co irradiator (constructed in 1963)

- ^{60}Co total activity 4416 TBq (1 July, 2000)
- source assembly: 96 source pencils arranged in 24 source rods, arranged as a cilinder, 32 cm dia 32 cm high

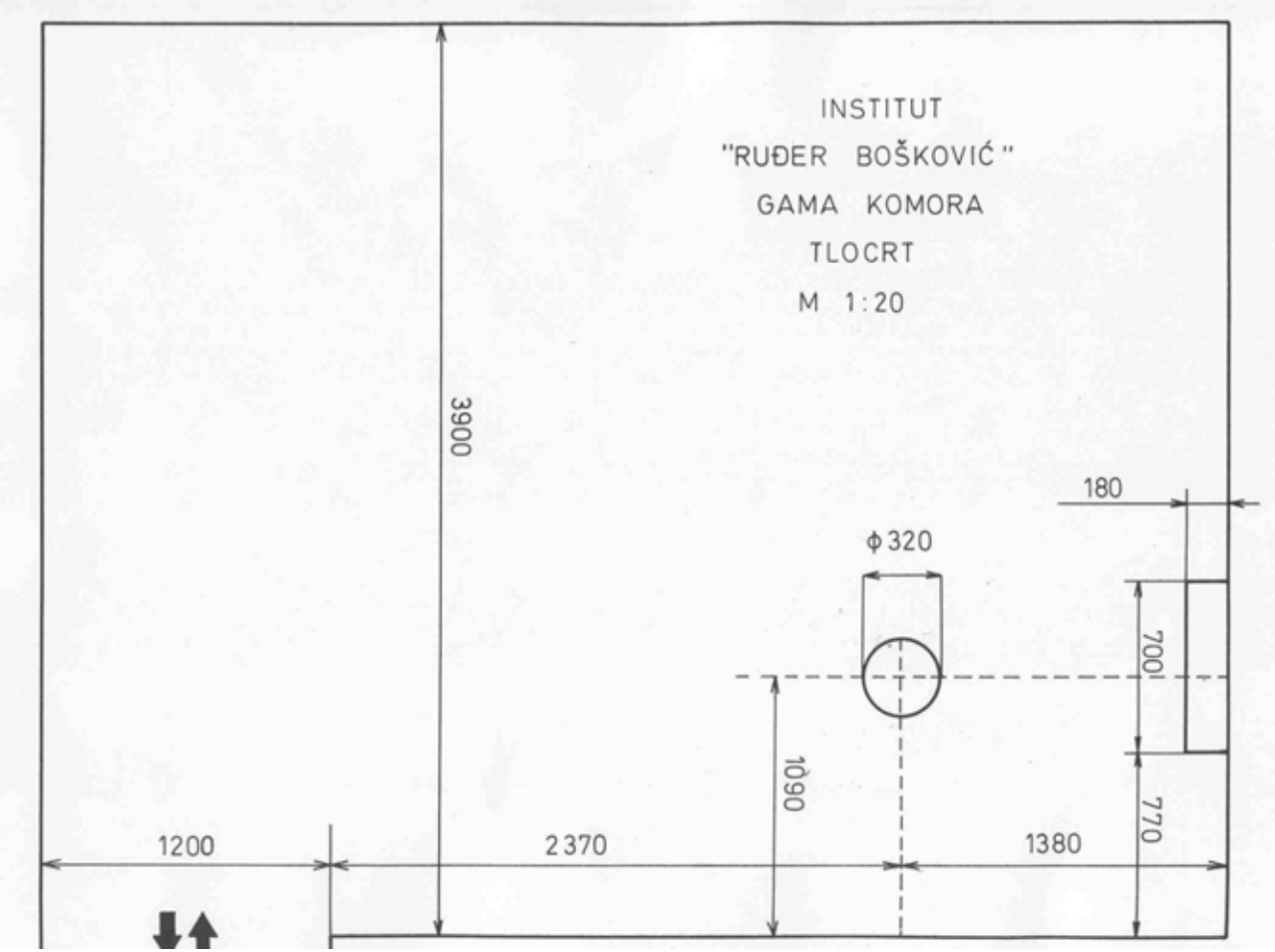
Irradiation chamber:

- rectangular room:
  4.9 m 3.9 m, 3.5 m high
- capacity 4 - 6 m^3 of material
- in the irradiation position the center of the source assembly is 0.7 m above the floor

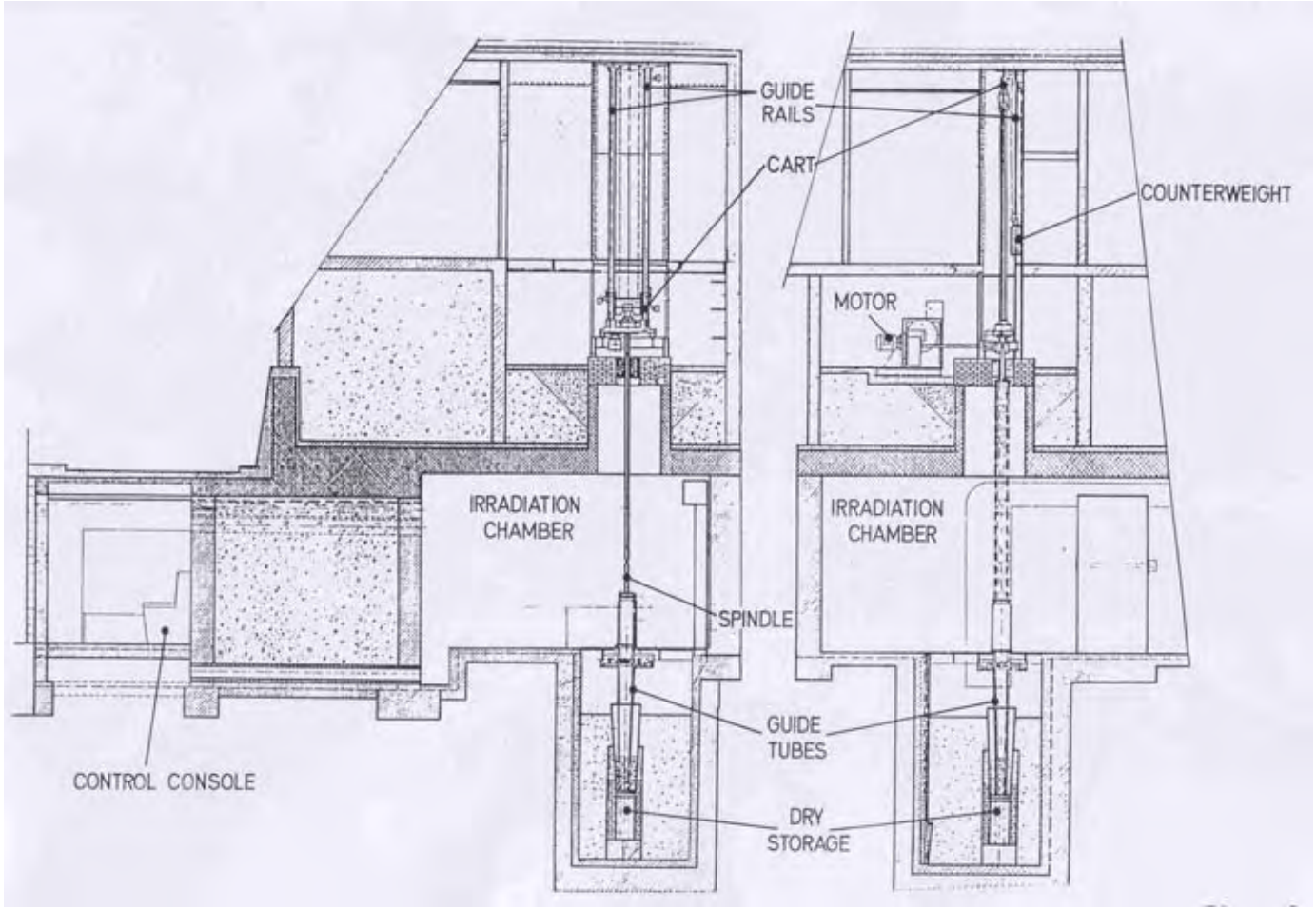
Radiation field mapping:

- ethanol-chlorobenzene (ECB) dosimetry system (ISO/ASTM 51538)

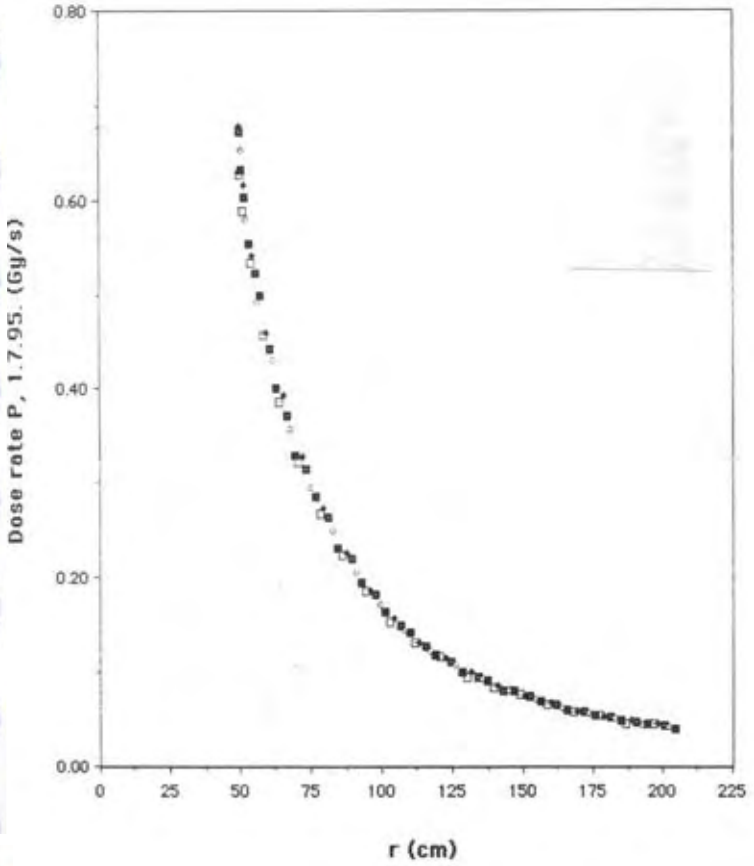
Floor plan of the irradiation chamber

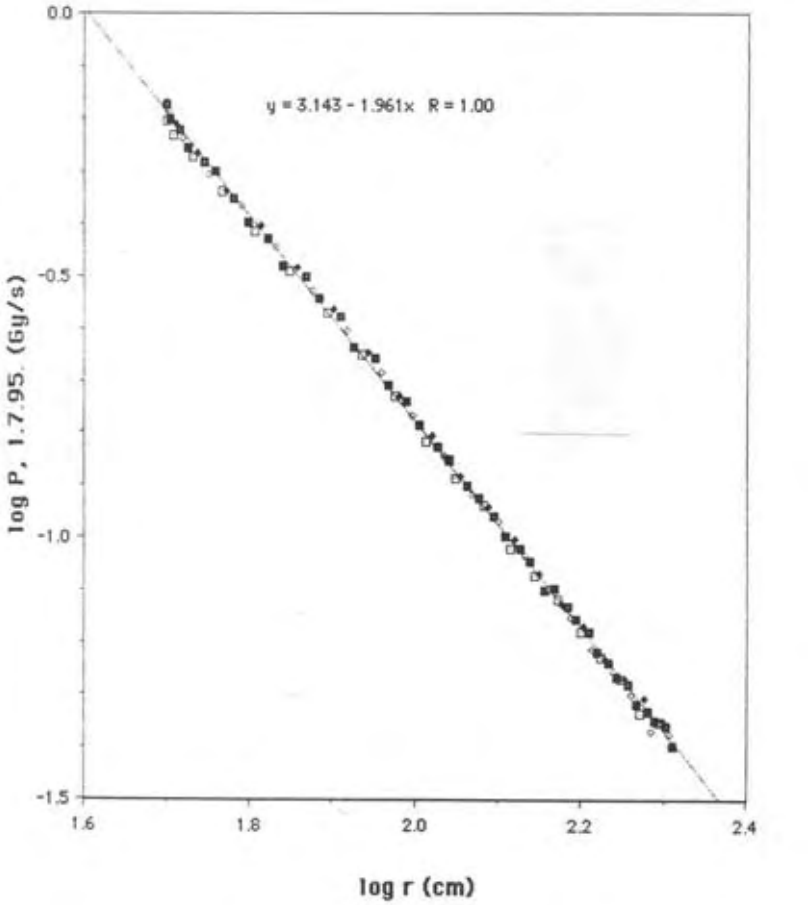


Side views of the irradiation chamber



Dose rate as function of distance





Gamma irradiation facility; RCDL

only of the kind in Croatia

applications:

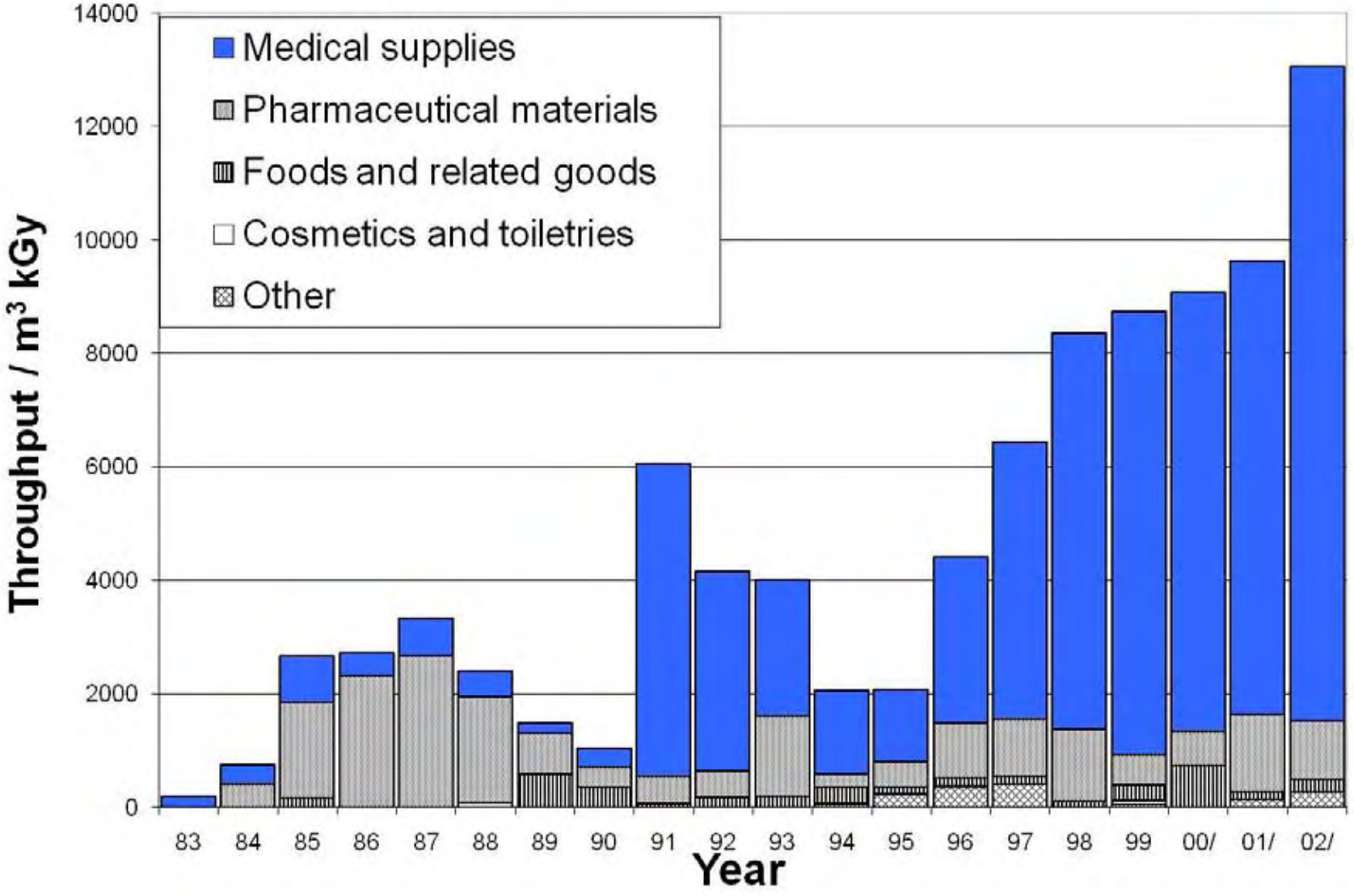
- suitable for a variety of applications
from medium dose range used in radiobiology to the high doses pertaining to radiation processing and radiation chemistry

irradiation services:

- for research and radiation processing

D. Ražem: Twenty years of radiation sterilization in Croatia, *Radiation Physics and Chemistry* 71 (1-2), pp. 595-600 (2004)

Twenty years of radiation processing in RBI

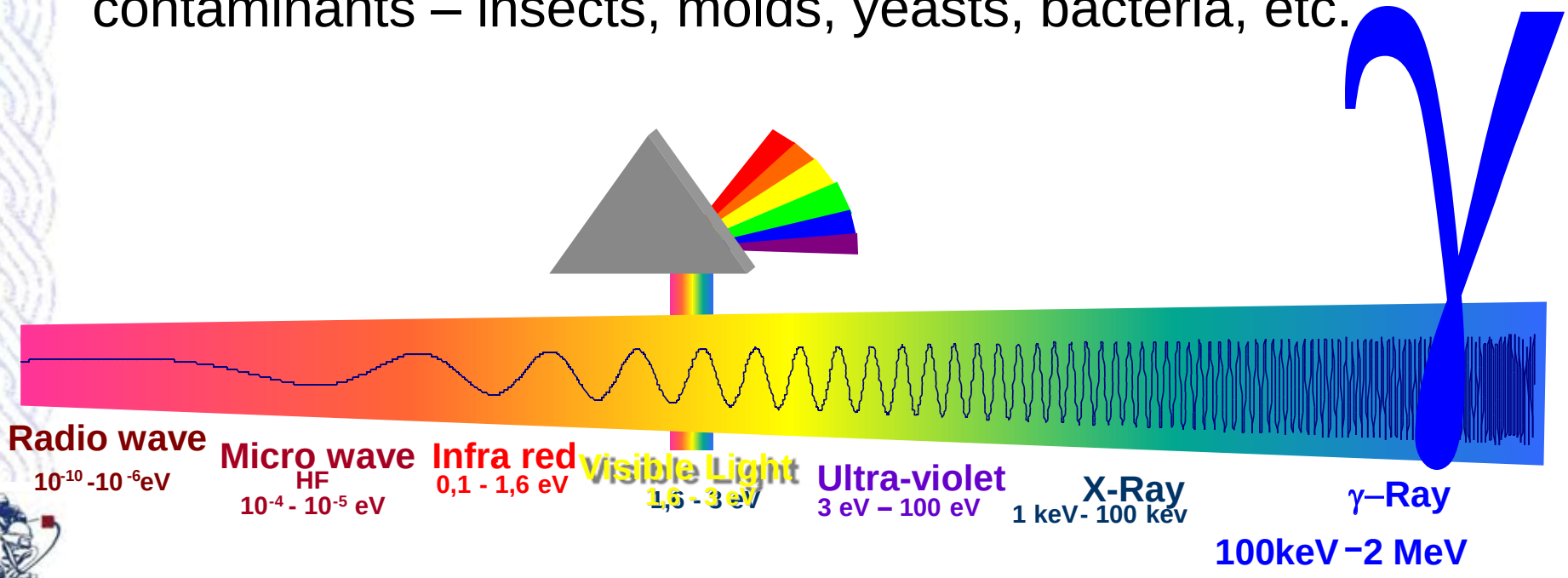


Radiation method for desinsection and disinfestation

Physical method, based on the ability of

high energy photons (electromagnetic radiation) from radioactive ^{60}Co

to induce chemical damage of DNA of all biological contaminants – insects, molds, yeasts, bacteria, etc.



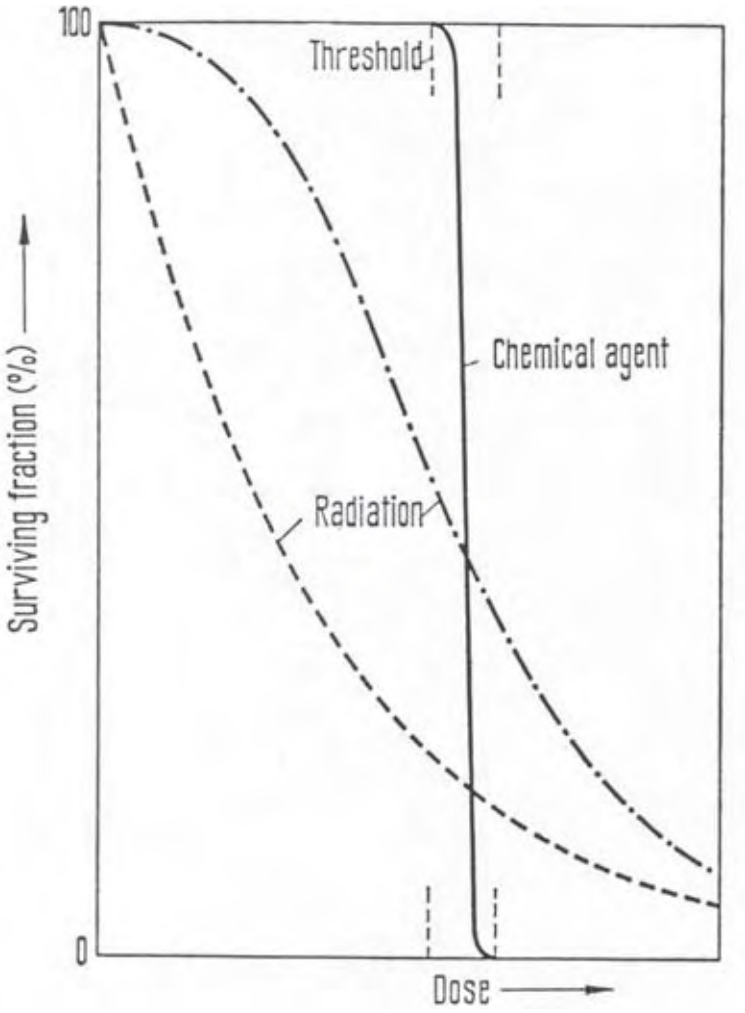
Radiation method for desinsection and disinfestation

Radiation dose - the most important parametar of the treatment

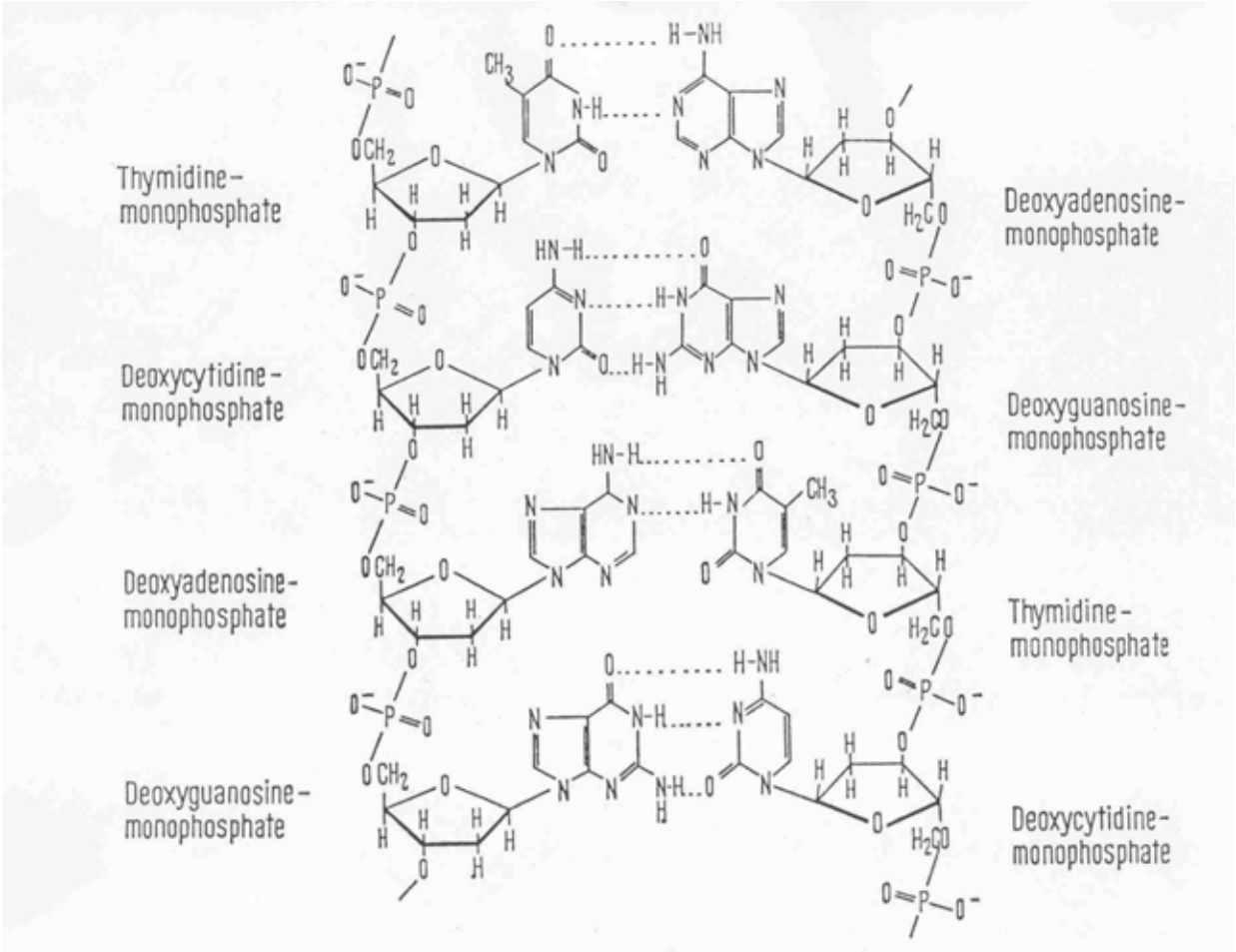
Dose setting should take into acount:

- initial level of contaminats
- radiosensitivity of contaminatig agents
- desirable factor of reduction
- minimal damage to irradiated material

The comparison between radiation and toxic chemical as biocidal agents



Structure of DNA



Inactivation Equation

- $N = N_0 10^{-D/D_{10}}$

- N – final number of microorganisms
- N_0 – initial number of microorganisms
- D – dose
- D_{10} –decimal reduction dose

- $D = D_{10}(\log N_0 - \log N)$

Biocidal action of radiation

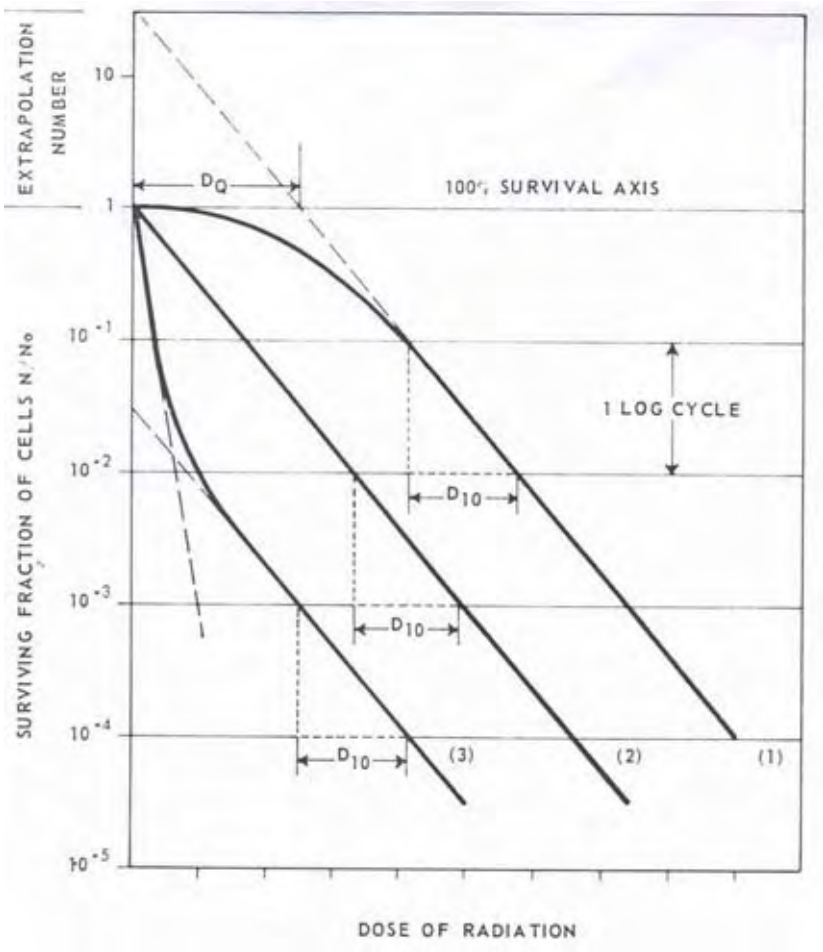


Table 1

Radiation sensitivity of bacteria associated with cellulosic textiles

Bacterium	**D_{10}/kGy**	**Substrate**	**Reference**
Cytophaga	3.45 5.05	buffer soln. pork mince	Collins & al., 2000
Cellulomonas	3 – 5		present estimate
Cellvibrio	3 – 5		present estimate
Cellfalcicula	3 – 5		present estimate
Sporocytophaga myxococcoides	3 – 5		present estimate; Dumova & Kruglov, 2009
Acynetobacter radioresistens	1.25 – 2.20	cotton	Nishimura et al., 1988
Micrococus sodonensis	3.0; n = 400		Watts et al., 1975
Bacillus pumilus	1.5; n = 10		Parisi and Antoine, 1974
Bacillus anthracis spores	5.5		Horne et al., 1959
Sulphite reducing Clostridia	3.45	dry leek	Katušin – Ražem et al., 1992

Inactivation by irradiation as function of cell size

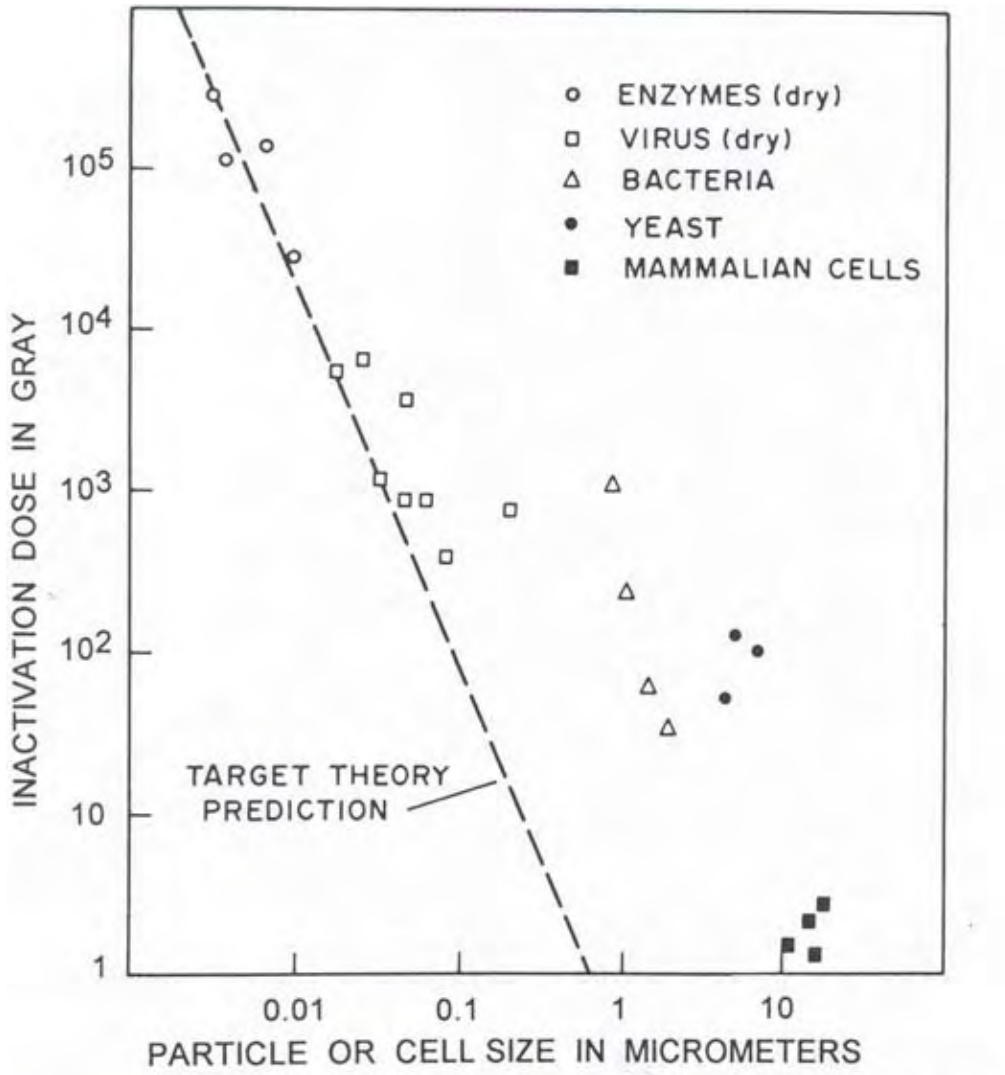
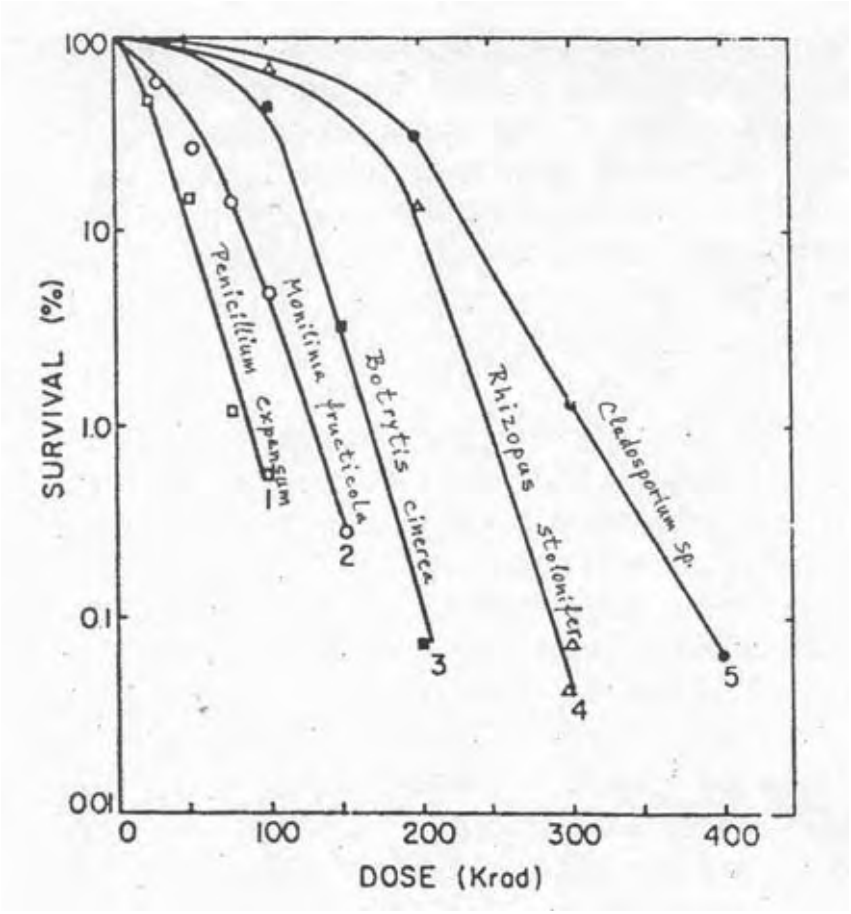
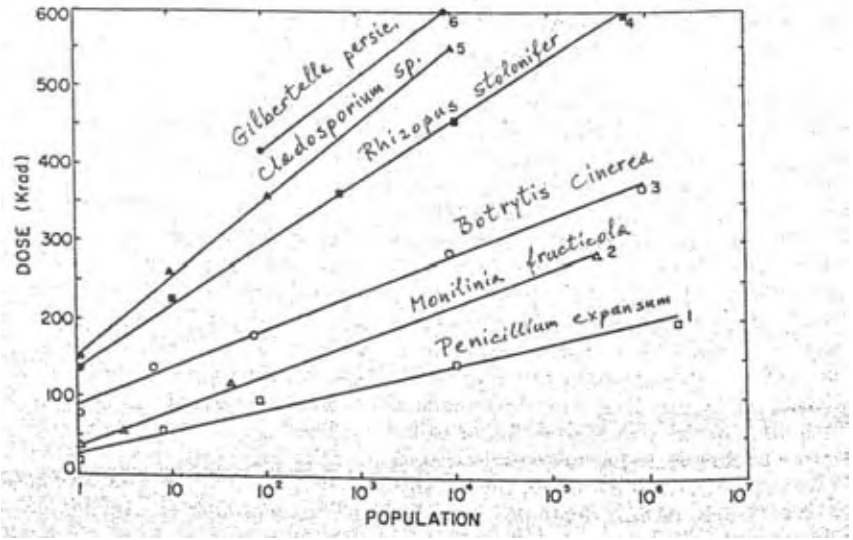


FIG. 18.2. Inactivation doses for cells and particles of different sizes.

The action of radiation on fungi and moulds





The action of radiation on insects

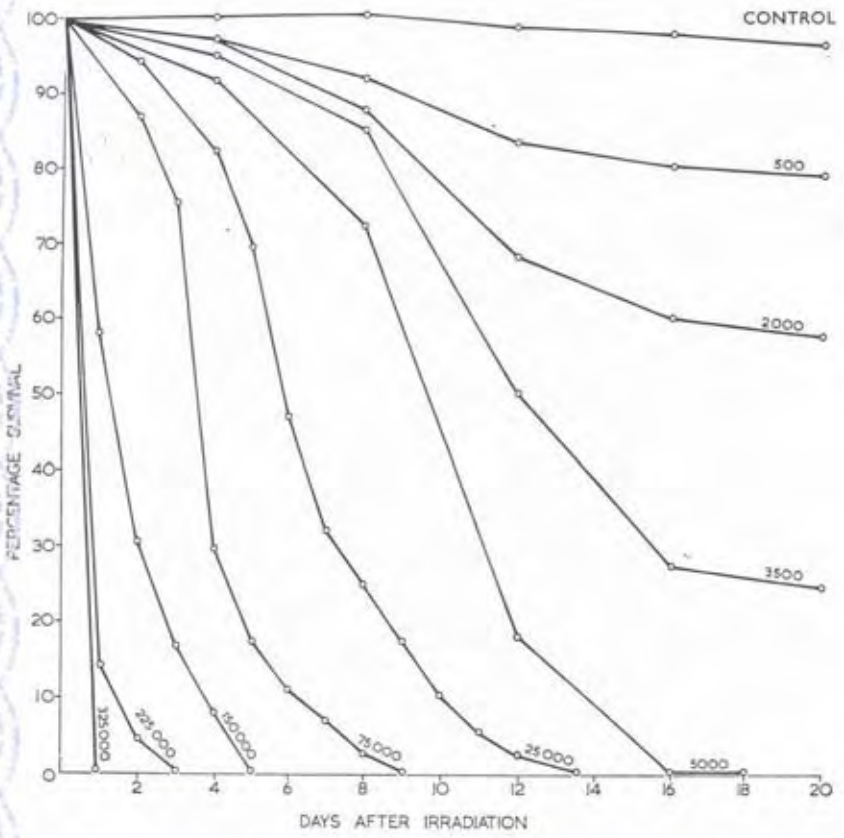


FIG. 30. Response of adult grain weevils (*S. granarius*) to γ-radiation at doses from 500 r to 325,000 r. (After Sumarokov.[94])

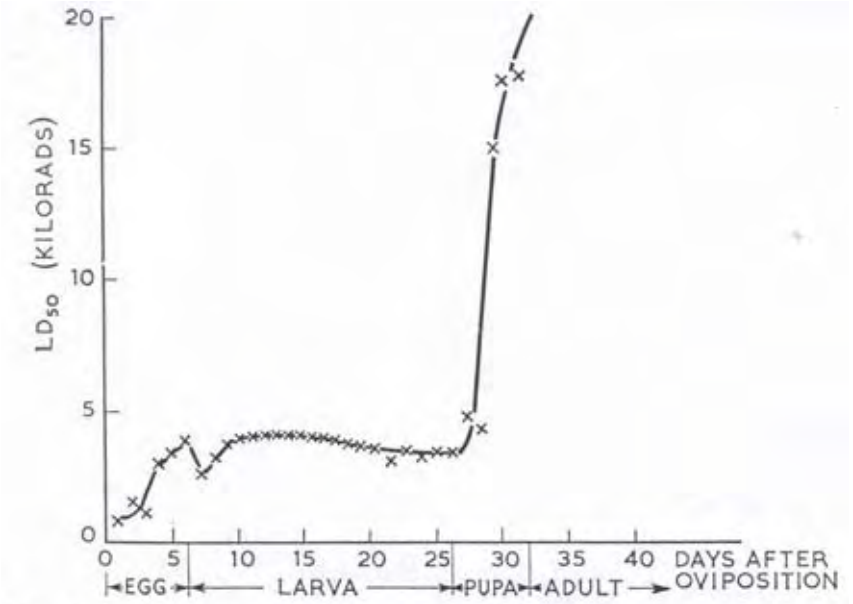
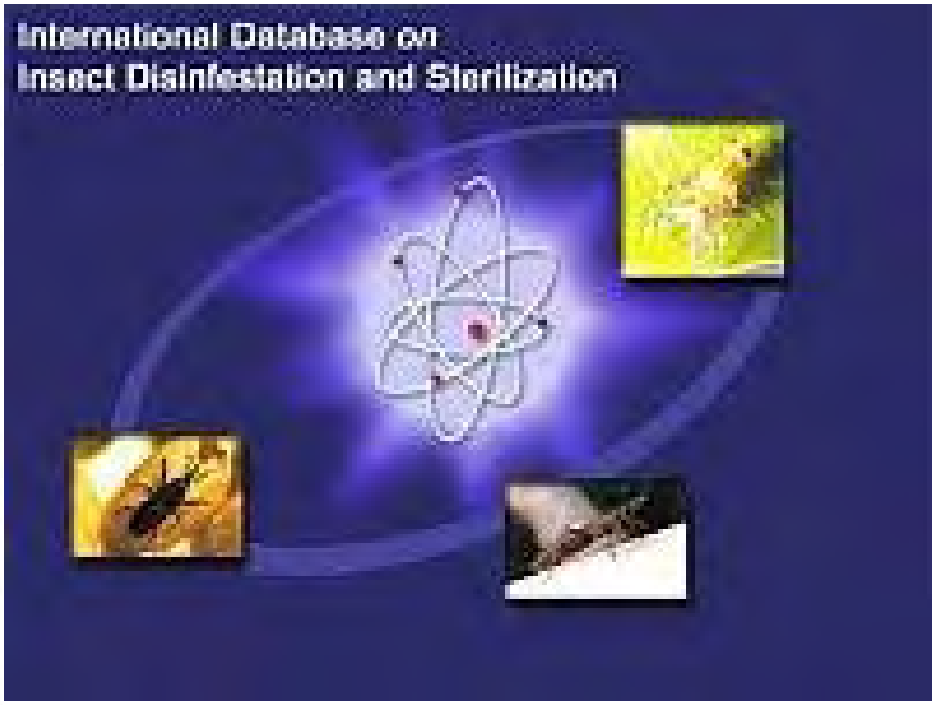
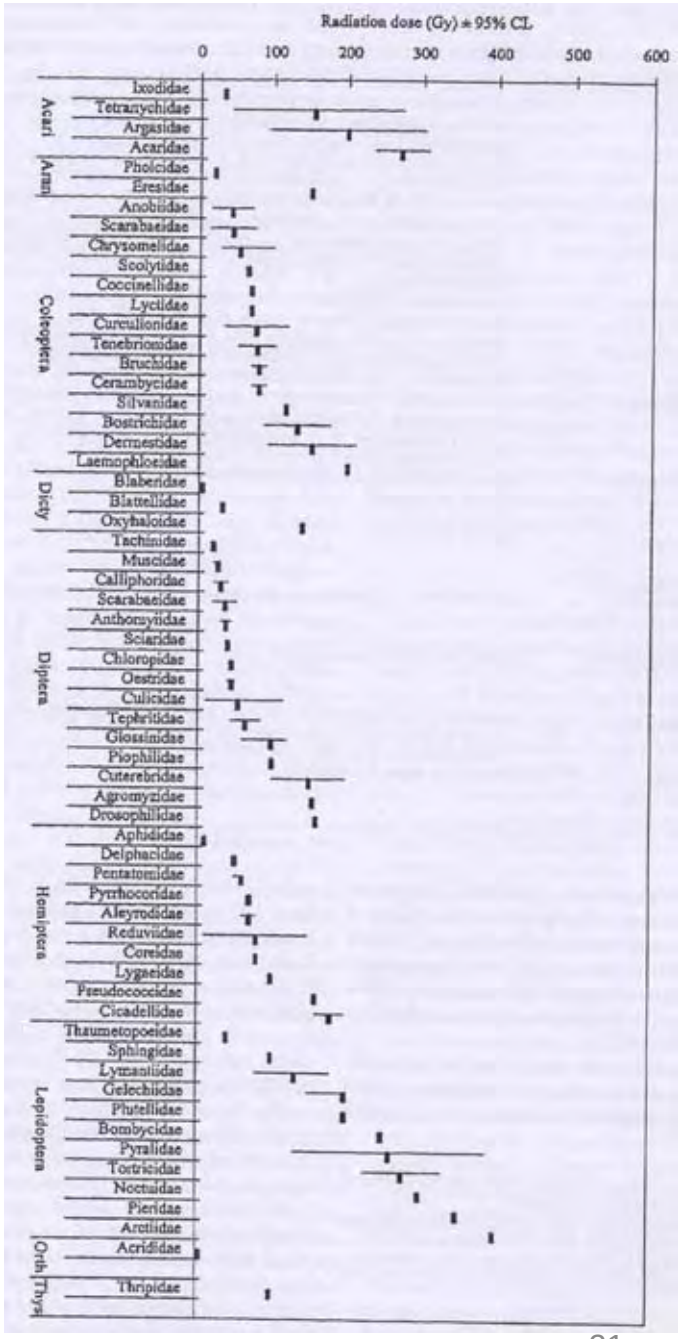


FIG. 14. Dependence of LD_{50} of irradiated *Calandra granaria* on developmental stage. (From Cornwell and Morris.[12])

Inactivation Doses



No insect inactivation dose is larger than 0.5 kGy



Radiation treatment of cultural heritage artefacts

- **1977** breakthrough for the method **radiation disinfestation of Ramses II mummy,** performed by the NucleArt Laboratory, Grenoble; **presented at 5th Triennial Meeting of ICOM, Zagreb, 1978**

For 30 years:

NucleArt Laboratory, Grenoble, and **Radiation Conservation Facility, Museum of Central Bohemia**, Roztoky, Praha, were leading the way in radiation treatment of cultural objects

Radiation treatment of cultural heritage artefacts

- desinsection:

- insect control *0.5 - 2 kGy*

for: wooden objects, textiles, paper, parchment

- disinfestation:

- fungus control *4 - 10kGy*
- decontamination *5 - 20kGy*

for: wooden objects, paper, leather

Treated at the RCDL irradiation facility:

- about 20 m^3 / year, mainly wooden heritage objects

Croatian Conservation Institute (CrCI)

Database of restored cultural heritage objects

BREUH Client 2.7.192 - [BREUH>Unos>Predmeti - SV. MIHAEL ARKANĐEO]

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Potpuni prikaz

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    - Programi/akcije
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    - Evidencija rada
  - Registar
  - Adresar

GRAČANI (308×460)

Predmet N 11616.00 P 005879.000 Fototeka

SV. MIHAEL ARKANĐEO

Objekt ŽUPNA CRKVA SV. MIHAELA/GRAČANI

Određenje cjeline

Cjelina ŽUPNA CRKVA SV. MIHAELA ARKANĐELA

Dio cjeline

Šifre

Stara šifra

Broj ugovora (stari broj ugovora:)

Lokacija

Županija Grad Zagreb Općina GRAD ZAGREB

Mjesto i pt. broj ZAGREB 10000

Adresa

Lokalitet GRAČANI

Nadležna ustanova Gradski zavod za zaštitu i obnovu spomenika kulture i priro

Kartografske reference

Katastar: čestica općina elevacija

Kartografski sustav N E

Smještaj predmeta

Dimenzije

V: 200 Š: 120 D: cm Težina

Opis 200 × 120 cm

Opis

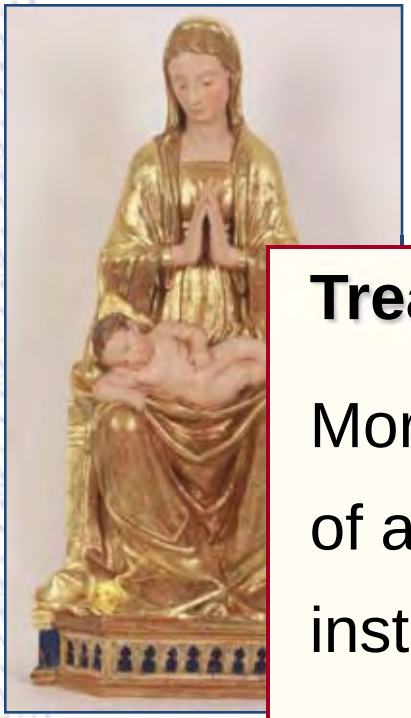
Vrsta umjetnine SLIKA Namjena

Detaljnije određenje

Record: 5744

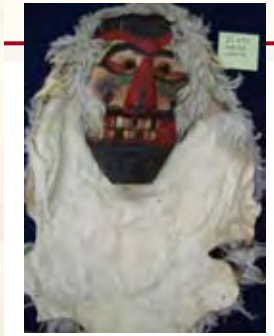
Gračani

Radiation treatment of cultural artefacts in RBI



Treated by irradiation over 20 years:

More than 5,000 wooden sculptures, parts of altars, furniture pieces, tools, musical instruments, other wooden, paper, straw, textile and leather items, etc.



Specially successful cases of the preservation of cultural heritage artefacts by irradiation in Croatia

Preservation of artefacts endangered by the aggression against Croatia (1991-1995)

In anticipation of war ravages the Institute for the Protection of Cultural Monuments of the Croatian Ministry of Education, Culture and Sports initiated a massive action of the preservation of movable objects of cultural heritage from churches, museums and galleries in jeopardized regions. The objects from northern Croatia were sheltered in 15 selected secret depots outside areas affected by the war[1].

To minimize the problem of massive biodeterioration of removed and often inadequately stored objects of cultural heritage it was decided to irradiate them as an interventive and/or preventive treatment[2].

In a joint action of the Croatian Conservation Institute and other concerned groups and individuals about 5,000 objects, mostly polychromic sculptures, altar parts and other wooden objects, comprising about 3,000 complete altars, were evacuated to safety. About one third of them was irradiated at the RBI irradiation facility for desinsection or, if necessary, desinfection before being stored in the CrCI depot in Batthany castle, Ludbreg. The castle was chosen because of its large storage capacity, where the objects could also receive professional attention of Bavarian conservators supported by the Bavarian Government.

1. Ž. Laszlo: *Zaštita i obnova pokretnih spomenika kulture u ratu*, Informatica Museologica br. 1/4 1992.
2. B. Katušin-Ražem, D. Ražem, M. Braun, *Irradiation treatment for the protection and conservation of cultural heritage artefacts in Croatia,* Radiat. Phys. Chem., 78(2009)729-731.

War damages suffered during the Patriotic War 1991-1995 in Croatia

WAR DAMAGES OF MUSEUMS HOLDINGS

Collections	Missing/stolen objects	Destroyed objects	Damaged objects	Total
1. Archaeological	**2.890**	**-**	**342**	**3.232**
2. Numismatic	**17.118**	**-**	**-**	**17.118**
3. Ethnographic	**2.004**	**774**	**201**	**2.979**
4. Cultural History	**3.491**	**818**	**920**	**5.229**
5. Art	**3.256**	**37**	**160**	**3.453**
6. Weapons	**291**	**7**	**80**	**378**
7. Memorial/Documentary	10.758	**7**	**118**	**10.773**
8. Books	**2**	**-**	**125**	**127**
9. Natural History	**75**	**1.534**	**225**	**1.834**
10.Science /Technology	**60**	**1**	**112**	**173**
TOTAL 1999.	**5.038**	**2.374**	**843**	**8.255**
TOTAL 2005.	**46.191**	**3.178**	**2.283**	**51.652**

Museums documentation center, http://www.mdc.hr/RatneStete/hr/

Cooperation RBI-CrCI: *Rescuing artworks in war*

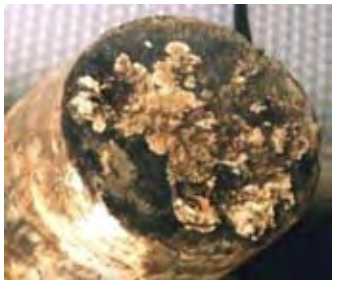
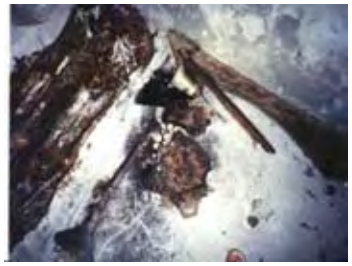
Radiation treated polychromic sculptures

Croatian Conservation Institute, Ludbreg
- storage room (depot) for polychromic sculptures
status: irradiated sculptures prior to restoration

Cooperation RBI-CrCI: *Rescuing artworks in war*

The St. Cross Altar from the Church of Blessed Virgin Mary of the Snow in Kamensko (1685)

In the devastation of the Pauline Monastery Kamensko during the war the altar was burnt down. Four years later the remaining parts of the altar were found covered with moulds. They were disinfected by irradiation with 5 kGy. Some parts which survived in the crypt, where they had been hidden prior to devastation, were found covered with fungi and had to be irradiated with 20 kGy.

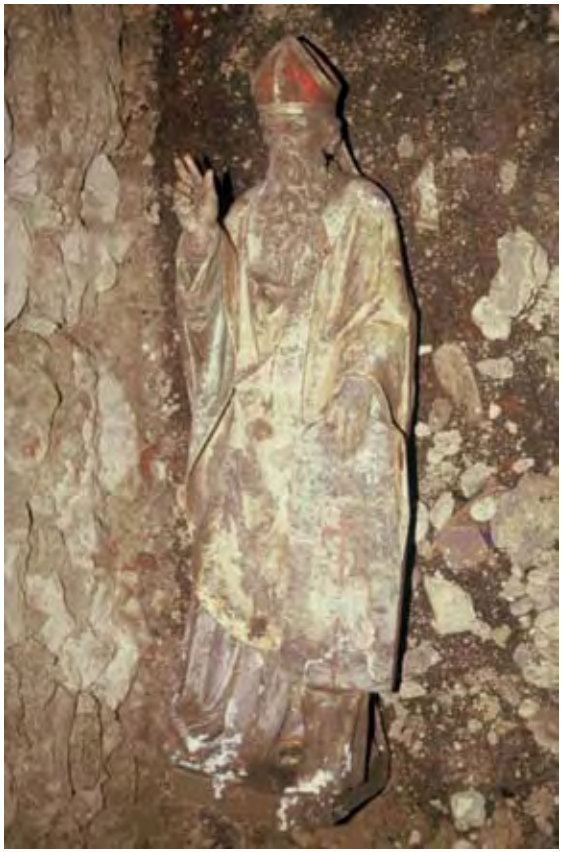




Found elements of all ornaments enabled the reconstruction; after drying, stabilization and restoration, the altar was erected in the church in 2008

Project leader: Romana Jagić, Counselor Conservator-Restorer, Department of wooden polychromic sculpture, Section IV , CrCI

Cooperation RBI-CrCI: *Rescuing artworks in war*
Polychromic sculptures, St. Mary, Gora, Petrinja

- 9 polychromic sculptures were buried for 10 years in the crypt of a church destroyed during the war against Croatia (1991 - 1995)



Destroyed church of the Blessed Virgin Mary in Gora near Petrinja (12th or 13th c.)

Cooperation RBI-CrCI: *Rescuing artworks in war*

Polychromic sculptures, St. Mary, Gora, Petrinja (cont.)

Identification of contaminants

moulds:

Alternaria tenuis

Sordaria timicola

Paecilomyces variotii

Penicilium chrysogenum

bacteria:

genus *Bacillus*

genus *Streptomyces*

Briški F., Krstić D., Jagić R., *Studies in Conservation*. 46(1)14-22, 2001.

Cooperation RBI-CrCI: *Rescuing artworks in war*

Polychromic sculptures, St. Mary, Gora, Petrinja (cont.)

- processed by cleaning, drying, irrradiation
- decontamination (20 kGy) & desinsection
- after conservation stored at the CrCI depot in Ludbreg

M. Pavličić i D. Vokić, Skulpture iz kripte Blažene Djevice Marije u Gori: Dezinfekcija i konzerviranje, *Vijesti muzealaca i konzervatora*, 2000, 21- 31

Cooperation RBI-CrCI: *curative treatment*

The Altar of Our Lady of Loretto, Plešivica (1757)

- treated by irradiation (disinfection with 2 kGy) and restored

before conservation, 2003

after conservation, 2005

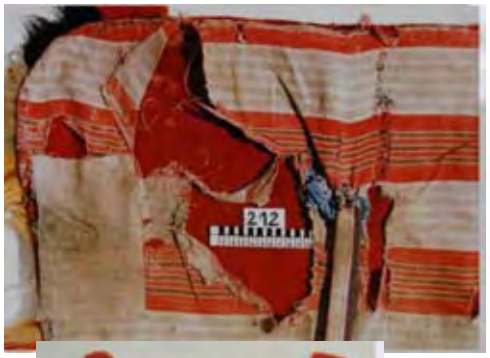
Project leader: Ksenija Škarić, Department of wooden polychromic sculpture, Department of movable heritage objects, CrCI

Cooperation RBI-CrCI

Garments of the Tilters of Sinj

The collection of rich garments belonging to the Society of Tilters comprises 680 original pieces from the 18th and 19th centuries, as well as 1200 replicas. CrCI is in charge of the conservation/restoration works and of manufacture of replicas since 1980.

The garments requiring conservation were treated by irradiation with 1 kGy for desinsection.



Project leader: Bernarda Rundek Franić, Head of Textile Department, Department of movable heritage objects, CrCI

Cooperation RBI-CrCI

Historic furniture

Desk, kidney shape, neo-rococo style, 19th c.
Property of the Wedding Hall in Ludbreg.
The desk was damaged and infested by insects.
Special demands on the conservation – restoration treatment were placed by the requirement to restore the functional role of the object, not just its appearance.

The conservation was started with desinsection by irradiation with 2 kGy in the RBI, followed by consolidation of the structure, fixation of the veneer to the substrate, puttying, cleaning, retouching and polishing. The reonstruction was finished in 2008, the object to be returned to the Wedding Hall after its renovation.

Project leader: Tijana-Annar Trputec Strčić, Department of movable heritage, CrCI
Workshop for the conservation of furniture, CrCI

Cooperation RBI-CrCI

Church textile, Franciscan monastery, Slavonski Brod

A rich collection of sacerdotal attires dating from the late 19th and 20th century, which had not been in use for some time, have been kept in the monastery under inadequate conditions. To improve keeping conditions of attires preventive protection and conservation comprised 27 casulas, 11 stolas, 9 manipulas, 3 velums, 4 dalmaticas, 3 pluvials and 3 antependiums. The first phase of conservation, desinsection by irradiation, was carried out at the RBI with 1 kGy.

After conservation treatments at the Textile Conservation Centre of the CrCI in Ludbreg the attires were placed in special boxes and returned to the owner.

Project leader: Maja Vrtulek, Assistant Senior Restorer-Technician, Ludbreg conservation centre, Section for textiles, CrCI

Cooperation: RBI-Mimara Museum
Ivory triptych, St. Laurence, Trogir

- Italian, first half of the 15thc. (h 42 cm; w 27 cm)
- on loan for the Mimara Museum exibition:The Enigmatic Imagery of Ivory
- revealed by inspection: insects damaged frame - visible holes & larvae
- prior to the exibition the triptych was treated with 1 kGy
  (in consultation with NucleArt, Grenoble)



Cooperation: RBI-private person, musician
Musical instrument

Harp belonging to the renown musician Ms. Rajka Dobronić, appeared to be infected by insects.

On recommendation by conservators the artist addressed RBI seeking for solution of the problem by desinsection.

Harp was treated in the irradiation facility at RBI with desinsection dose of 1 kGy. There were no noticeable changes in the tone quality.

Cooperation: RBI-Ethnographic Museum
Ethnographic objects

The collection of items associated with customs and beliefs

Comprises a large variety of exhibits as objects are made of:
- wood (crucifixes, sculptures, utensils);
- paper (house interior decorations, Christmas and wedding decorations);
- objects made of several different materials such as:
  carnival masks, Christmas creches and wedding decorations

10 carnival masks were treated with desinsection doses up to 2 kGy for preventive and curative purposes.

Cooperation: RBI-Museum of Contemporary Art

Contemporary art objects

Atelier Kožarić: contains more than 6,000 exhibits, sculptures, reliefs, assemblages, objects, installations, paintings, prints, drawings, sketches

Cooperation: RBI-Museum of Contemporary Art

Contemporary art objects

The Kožarić Studio ("the revivification laboratory")
was purchased in 2007 for the Museum for permanent management & maintenance.
Before moving into the new building a large number of objects were treated with 2 kGy for preventive and curative purposes.

Cooperation: RBI-Croatian State Archives

Old book covers:

Central Laboratory for the Conservation and Restoration of Archives (since 1952) works on:

- conservation, restoration & binding of the written heritage.

Old books and covers are often in poor state due to biodegradation
For conservation purposes 4 degraded wooden/leather covers were irradiated with doses up to 2 kGy.

Oriental manuscript on paper

Cooperation: RBI-Croatian State Archives

Coordinated action of RBI & Croatian State Archives:

Identification, characterization and conservation of
The Book of Statutes of the town of Dubrovnik from 1272.

The Book is writen on parchment with wood/leather cover, partially heavily damaged by insects and mechanical stresses

The three RBI laboratories using nuclear methods which are involved in RER/8/015 will join efforts for the first time in the same project

- Laboratory for Ion Beam Interactions
- Laboratory for Measurements of Low Level Radioactivity (C^{14} Dating Laboratory)
- Radiation Chemistry and Dosimetry Laboratory

In the process of conservation of the Statutes book they will cooperate in the confirmation of age by ^{14}C method, characterisation of pigments and metals by PIXE, and in irradiation treatment of book covers for inactivation of insects at the gamma irradiation facility.

Activities in the popularization of radiation treatment

Education and popularization at all levels:

lecturing with a demonstration at the radiation facility for:

Secondary school professional education:

Carpenters School, Zagreb; five years cooperation

Graduate study:

Academy of Fine Arts, University of Zagreb

Department of Restoration - Conservation of Art Objects

Cooperation for more than 10 years since the establishment of the Department

Academy of Arts, Department of Visual Arts, University of Split

Section for Restoration - Conservation

On-line journal ***In Situ***, Sagita Mirjam Sunara, Editor (http://www.e-insitu.com)

University of Dubrovnik, Department of Art and Restauration

Postgraduate study:

- participation in the organization of doctoral studies in restoration at the University of Dubrovnik;

Activities in the popularization of radiation treatment

- organisation of the workshop with CrCI on radiation treatments for conservators & related specialists
  Seminar: *" Irradiation Methods in the Protection of Cultural Heritage",* RBI & CrCI, Zagreb, 2011. (http://www.h-r-z.hr/index_en.asp?news=325)

- participation in seminars organised by CrCI and others, covering the conservation of wooden, textile, leather etc. cultural heritage objects;
  Examples:
  Seminar: *"Destruction of Cultural Monuments by Microbiological Decay"*, CrCI, Zagreb, 2000. (http://www.h-r-z.hr/index.asp?pid=1273&news=178)
  Conference :*"Most Important Procedures in the Preservation and State Enhancement of Historical Textiles"* CrCI, Zagreb, 2008. (http://www.hz.hr/index.asp?pid=1260&news=304)

- including broader scope of specialists from the fields of entomology and microbiology involved in the research of textile, paper & leather;

- expanding the investigation of the use of irradiation for the conservation treatment of sensitive, unconventional materials used in contemporary art (synthetic materials, food items, animals, leather, etc.);

- continuous consulting services to all interested in the irradiation method;

International and national conferences

CHRESP: 8th EC Conference on Sustaining Europe's Cultural Heritage, Ljubljana, Slovenia, 10-12 November, 2008.
Branka Katušin-Ražem, Dušan Ražem, Mario Braun
Protection and conservation of cultural artefacts by irradiation. Croatian experience

IMRP: 15th International Meeting on Radiation Processing, London, UK, 21-25 September, 2008.
Branka Katušin-Ražem, Dušan Ražem, Mario Braun
Irradiation Treatment for the Protection and Conservation of Cultural Artefacts in Croatia

Conference „Most Important Procedures in the Preservation and State Enhancement of Historical Textiles", Zagreb, 24-26 November, 2008.
B. Katušin-Ražem
The conservation of cultural heritage artefacts made of textile by irradiation

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2. D. Ražem, *Twenty years of radiation processing in Croatia*, Radiat. Phys. Chem., 71 (2004) 597-602.
3. B. Katušin-Ražem, D. Ražem, M. Braun, *Irradiation treatment for the protection and conservation of cultural heritage artefacts in Croatia,* Radiat. Phys. Chem., 78 (2009) 729-731.
4. B. Katušin-Ražem, D. Ražem, M. Braun, *Protection and conservation of cultural artefacts by irradiation. Croatian experience,* 8th European Conference on Research for Protection, Conservation and Enhancement of Cultural Heritage, Ljubljana, Slovenia, November 2008.

Thank you!