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THE FIRST
ELECTROTECHNICAL
UNIVERSITY



LASER TECHNIQUES IN CULTURAL HERITAGE PRESERVATION

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Measuring & Navigation Systems

St.Petersburg Electrotechnical University “LETI”

One of leading technical universities of Russia

9,700

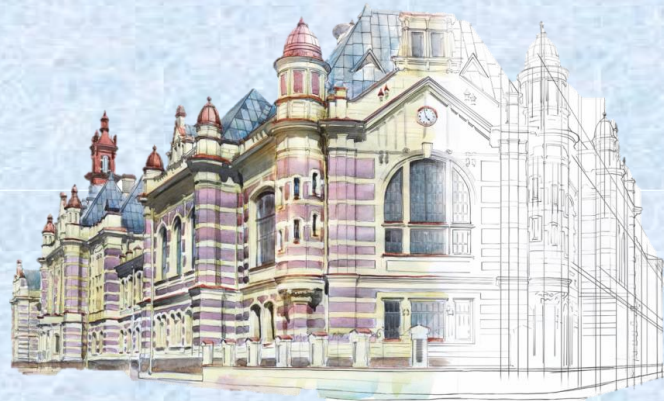
Students in total

20,7%

Of international students



Inventor of Radio Communication
Prof. Alexander S. Popov



One of ETU`s graduates of the ETU -
Nobel Prize Laureate in Physics (2000)
Prof. Zhores I. Alferov

ETU “LETI” was established in **1886**

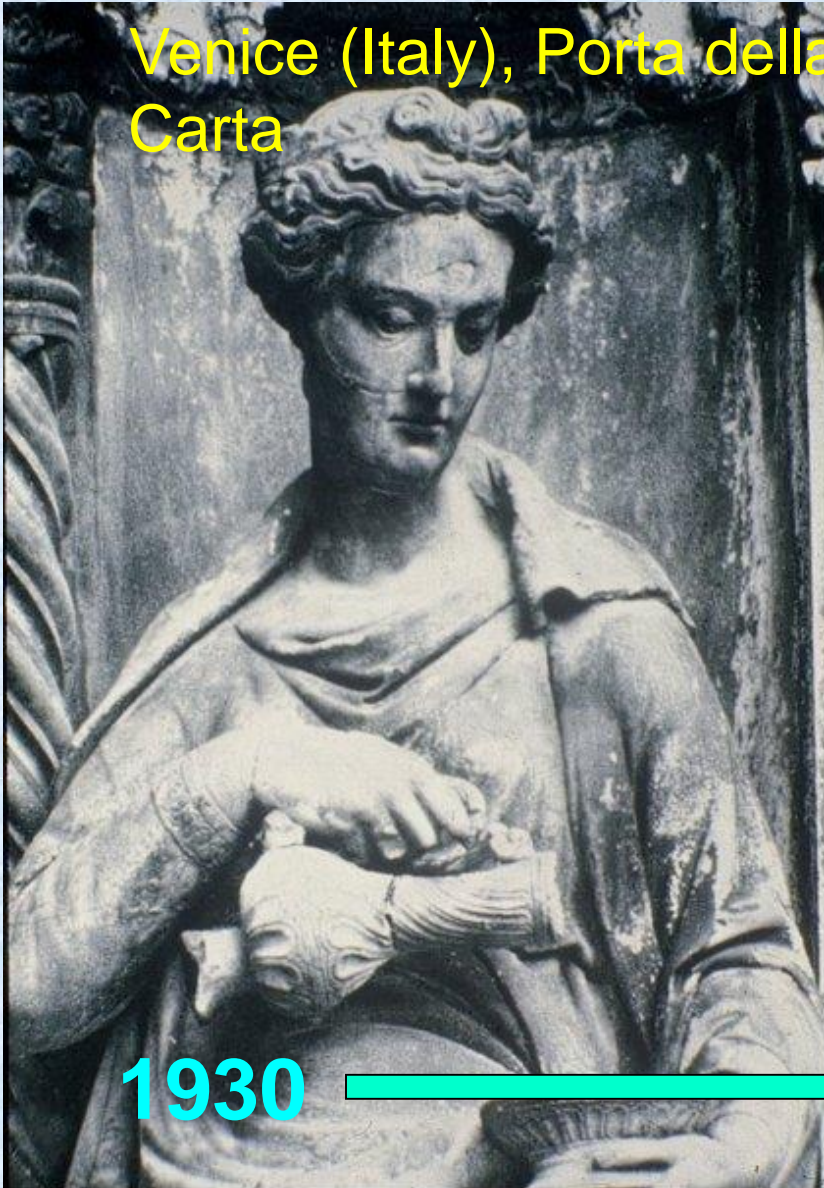
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1. INTRODUCTION

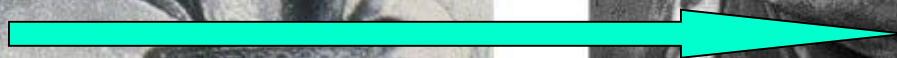
PROBLEM: catastrophic conditions of many out-door monuments around the world due to ecological problems

Venice (Italy), Porta della Carta



1930

1980



**So, advanced techniques
for restoration, analysis and
and documentation of
artworks are needed !**

**Use of laser techniques is one
of most effective solutions**

MOST ESTABLISHED APPLICATIONS OF LASER TECHNIQUES IN CULTURAL HERITAGE PRESERVATION

- 1. Restoration (laser cleaning and micro-welding);**
- 2. Analysis and documentation of artworks;**
- 3. Environmental monitoring and monitoring of out-door monuments**

Historical note

The first trials on use of lasers in documentation, analysis and restoration of artworks have been carried out by an American physicist **John Asmus** in **1972** on marble surfaces of historical buildings in Venice (Ca' d'Oro and S. Marco Cathedral).



In **1989** a laser was for the first time employed for carrying out the **practical works** on CH conservation (Cremona Cathedral, Italy)



There are many amazing case studies concerned with restoration of most valuable objects of World CH





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Research and educational
Laboratory for laser technologies
of analysis and restoration of artworks
(on the base of Department of Photonics)

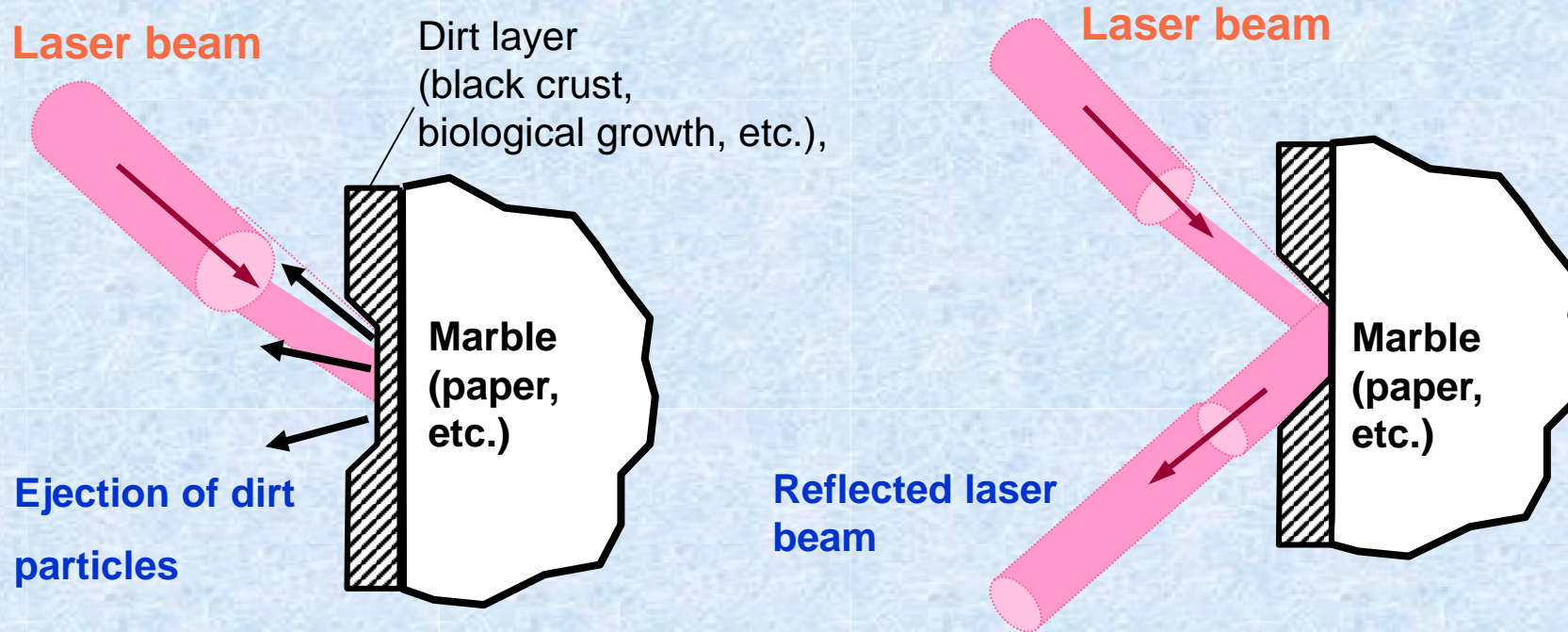


Main fields of the ETU “LETI” research activity and practical works

- **Laser cleaning of stone, paper and other organic materials;**
- **Analysis of paintings by means of laser spectroscopic techniques;**
- **Laser removal of biological growth from the surface of CH objects;**
- **Study of accuracy of creation of 3D models and accuracy of replication of artworks by means of 3D laser and optical scanning.**

1. LASER CLEANING OF ARTWORKS

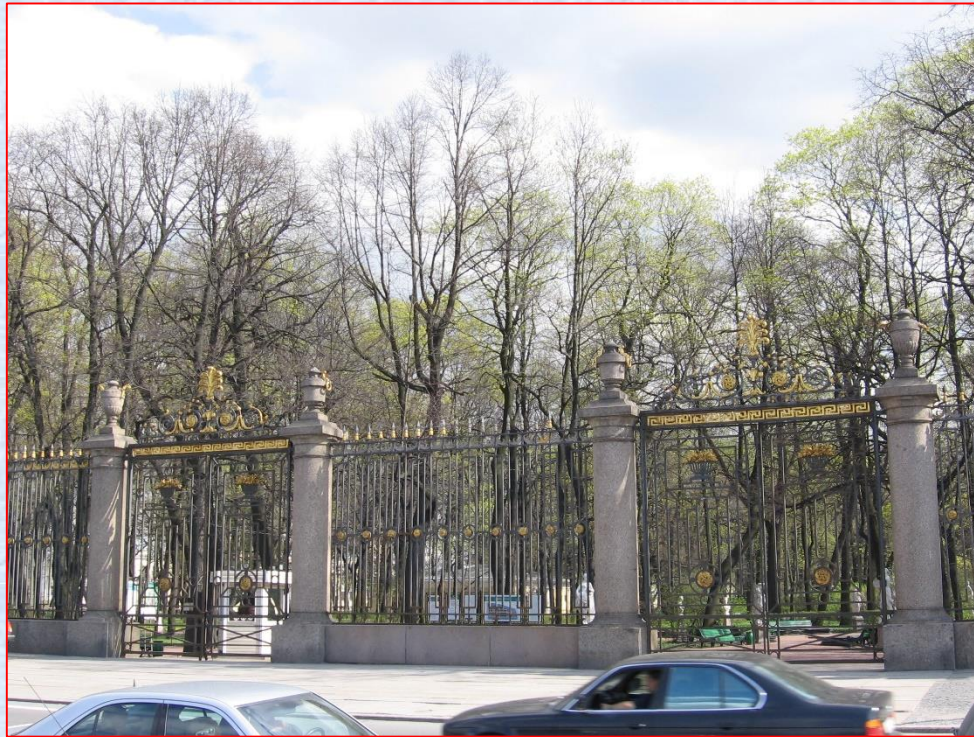
Physical principle of laser cleaning



1. Absorption of laser radiation and ejection of dirt particles due to vaporization and inducing mechanical stresses

2. Reflectance of laser beam

Cleaning of Italian marble sculptures of XVIII century with **The Summer Garden**

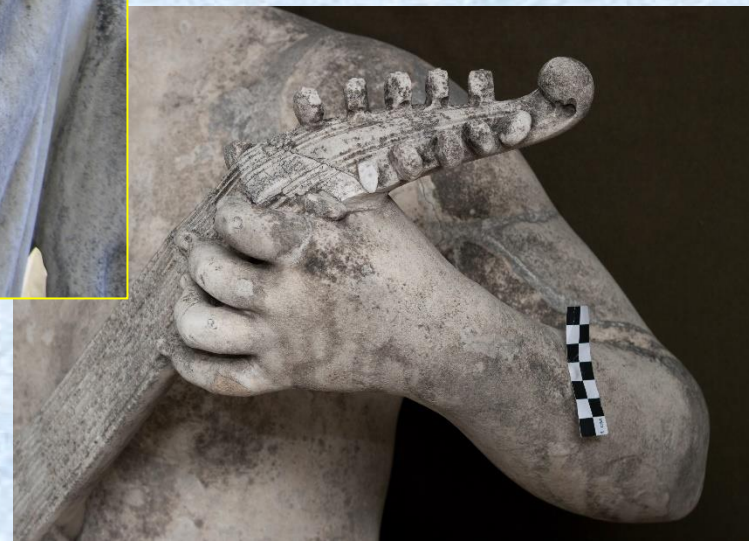
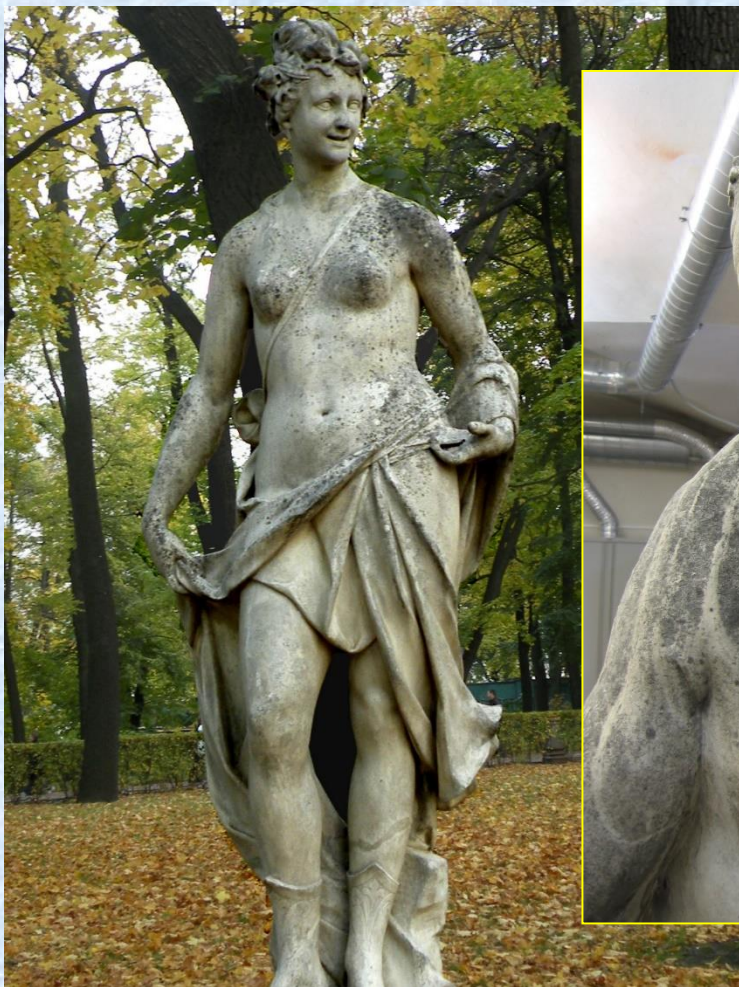


Summer Garden was created in
1704 by tzar Peter the Great



Summer Garden is open-door
part of The State Russian museum,
which owns one of the best in the
world collection of marble sculptures
of XVIII-XIX centuries (92 items)

Typical conservation problems of marble sculptures of the Summer Garden



Gypsum black crust, biological films, etc.

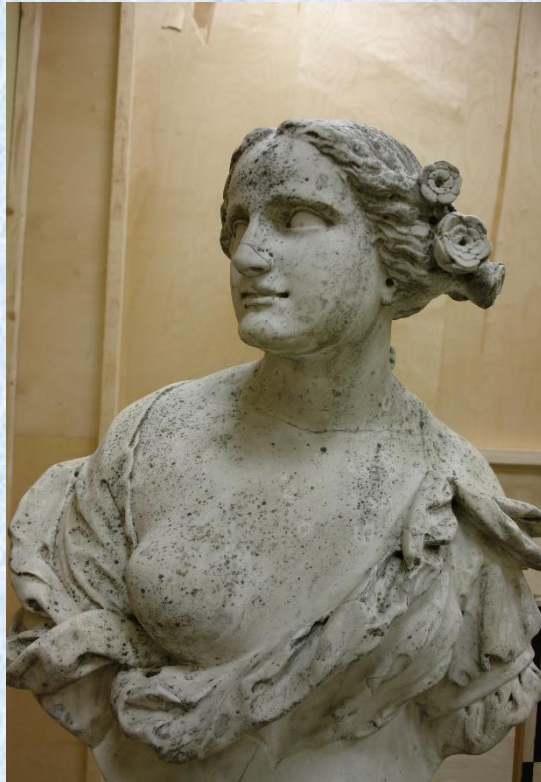
During 2007-2011 **32** sculptures of the Summer Garden have been restored using laser...



Cleaning of Italian marble sculptures with the collection of State museum “Tsarskoye selo” (St.Petersburg)



sculpture *Zefir* (by sculptor V. Brodzky, 1860)



Marble bust *Primavera* (unknown Italian sculptor, XVIII century)

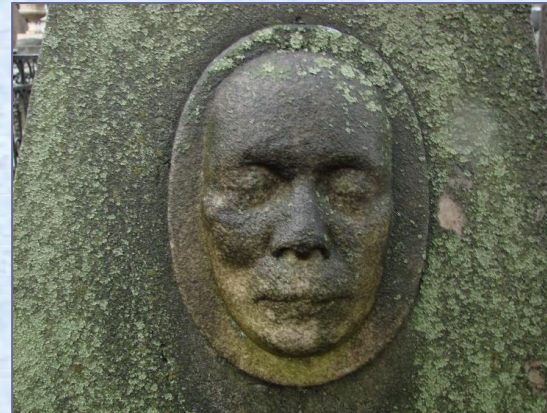
The main goal of research works connected with laser cleaning of artworks is optimization of output parameters of lasers

Optimal parameters for marble cleaning:

- Wavelength – about 1000 nm;
- Energy per pulse - 0.7...1.2 J;
- Pulse duration - 90...110 microsecond;
- Pulse repetition rate - 10 Hz;
- Fluence - 10...15 J/cm²

(water assisted treatment)

Removal and inactivation of micro-organisms – destructors of artworks by means of laser treatment



Objects of our studies

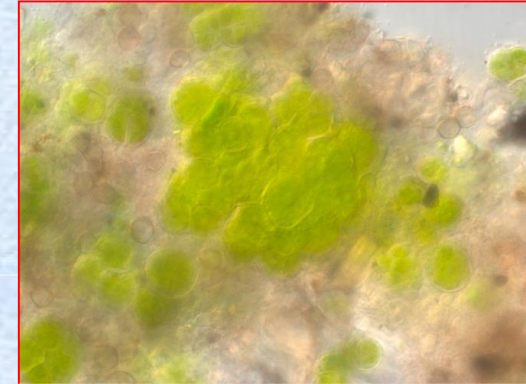
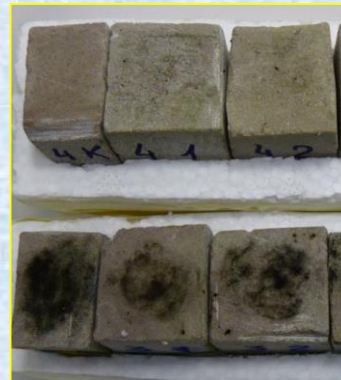
Materials:

- Marble
- Limestone



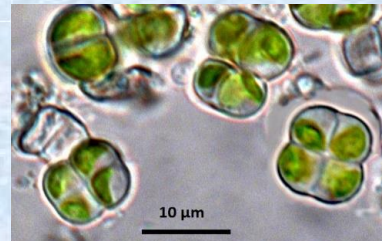
Microscopic fungi:

- Aspergillus flavus*
- Chaetomium globosum*
- Ulocladium consortiale*

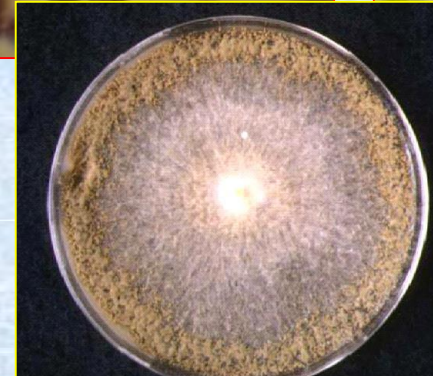


Microscopic algae:

- *Chlamydomonas noctigama*
- *Pseudococcomyxa simplex*
- *Chlorella vulgaris*



Micro-algae



Micro-fungi

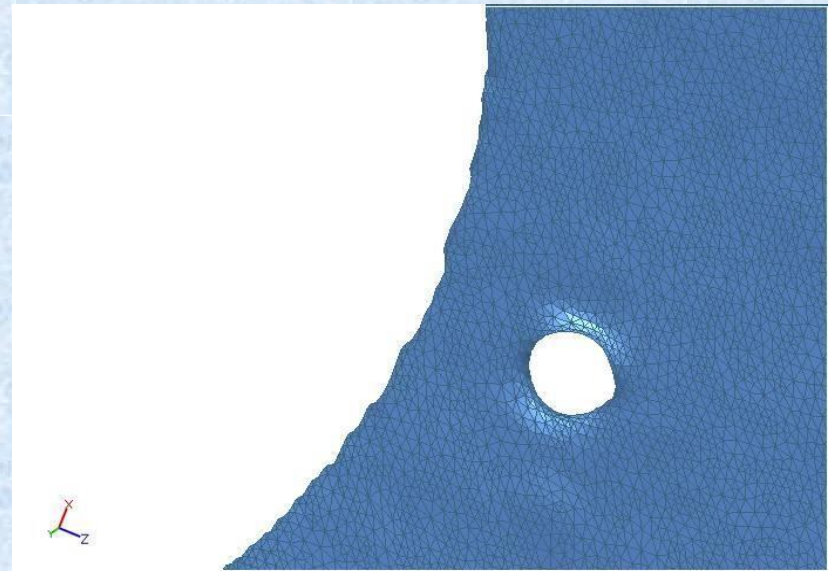
3. 3D LASER SCANNING IN DOCUMENTATION, MONITORING AND REPLICATION OF ARTWORKS

3D laser scanning



3D scanning is the process of analyzing a real-world object or environment to collect data on its shape and possibly its appearance (e.g. colour).

The collected data can then be used to construct digital 3D models.



3D laser scanning ETU`s case studies.



Non-contact replication of CH objects using 3D scanning

The problem statement:

There is a stark choice between removing the deteriorated sculpture to a safer environment or allowing its further destruction.

The obvious solution, which is already used in many countries around the world, is replacement of the original with a **replica**.

**Case study. Replication of marble bust “Primavera”
(XVIII century, with collection of museum “Tsarskoye selo”)**



Process of 3D scanning



3D model on the screen of PC

Manufacturing the replica by CNC-machine milling



FINAL RESULT

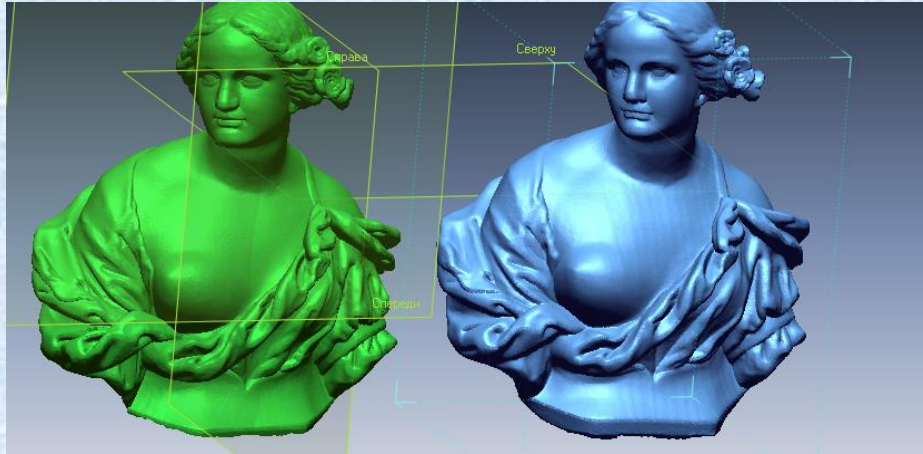


Original

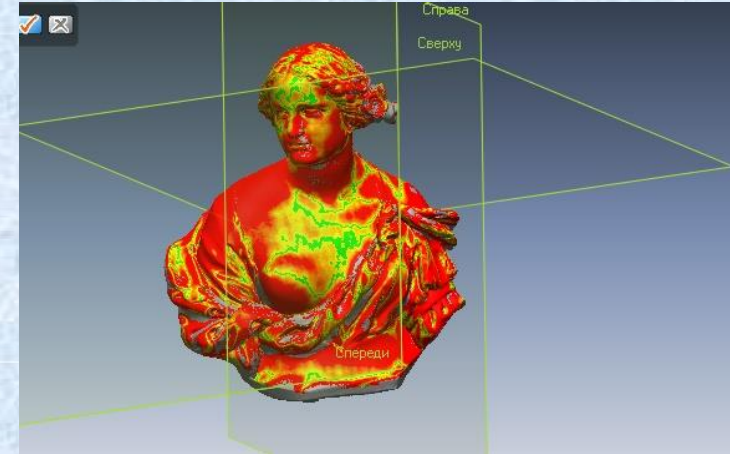


Copy

The main **scientific issue** of replication of artworks is an accuracy of correspondence between surfaces of original sculpture and its replica



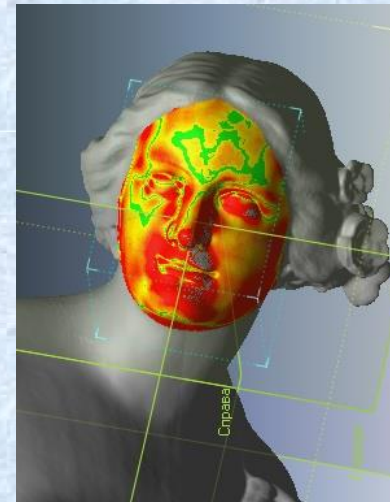
3D models of original sculpture (left) and its copy (right)



Accuracy of matching of 3D models across the entire surface

The results of comparison of the models of the copy and the original "Primavera":

Comparison area for 3D copy models and the original "Primavera"	Deviation value (RMS) of surfaces of 3D models, mm
Entire surface	1.60
Face	1.10
Mouth	1.60
Eyes	0.88
Nose	1.46
Hair	1.43
flowers in hair	1.81



Accuracy of matching of 3D models in the field of faces

4. Perspectives of international collaboration under auspices of the Baltic Science Network

Scientific collaboration ?

1. Joint research projects;
2. Exchange of students, PhD students and research staff.

Fields of possible collaboration:

1. Identification and inactivation of microorganisms-bioconstructors of CH objects by means of lasers
2. Laser cleaning of organic materials.
3. Analysis and restoration of paintings by laser techniques



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Heritage Science

"Heritage Science" is the interdisciplinary **Master of Science** program that combines knowledge in engineering and humanitarian sciences to resolve the most actual tasks of Cultural Heritage preservation.



Possible kinds of academic collaboration:

- internships of students and PhD students;
- the program of "double" diplomas ?

THANK YOU
FOR YOUR ATTENTION !

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