The European research landscape in optics and photonics

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Achievements

- Creation of a database
- **Academic research laboratories** and institutions related to **optics and photonics**
- 27 EU member states plus Israel, Norway, Switzerland and Turkey
- Connection with Industry and common use of the information through Dynamo database (TNO)

Method

- Informations collected
  - Name of the laboratory
  - Contact info (address, and phone number)
  - Email
  - Website
  - Head of the institution
  - Description of the research areas
- Common database with Industry
- Accessible to all on **www.opera2015.org**

Data collection

- Sources
  - Governmental sources
  - National optical societies directories or other type of equivalent information
  - Optics and photonics conferences lists, such as SPIE, OSA, EOS
  - Internal databases

- Verification of the collected information
  - Verification by each partner of the data concerning national labs

Examples of sources

- WLT - Wissenschaftliche Gesellschaft für Lasertechnik, www.wlt.de (Scientifical Society for Laser technology)
- University Worldwide internet site http://univ.cc
- University and engineering schools associations websites: http://www.amue.fr/Universites; http://www.cge.asso.fr/
- Slovenian Research Agency website - http://www.arrs.gov.si/en/povezave.asp)
- Pan-European Researcher's Mobility Portal - http://www.eracareers.sk/version_eng/
- Paris region – **Optics**valley's internal database

Classification of Research areas

6 main thematics divided into 65 sub thematics

General optics

- Coherent optics
- Colorimetry
- Diffractive optics
- Holography
- Lasers
- Lasers applications
- Light-matter interaction
- Nonlinear optics
- Optical engineering
- Optical scientific computation and modelling
- Optical solitons
- Photodynamic processes and research
- Photo-induced processes
- Photoionisation
- Photoluminescence and fluorescence
- Photorefractive effects, devices and research
- Plasma research and applications
- Plasmonics
- Polarization related optical devices and research
- Quantum optics, devices and research
- Short-pulses generation and characterization
- Theoretical optics and photonics
- Ultrafast optics

Instrumentation

- Optical instrumentation
- Optical measurement systems and sensors
- Signal and image processing
- Spectroscopy
- Terahertz spectroscopy

Optical devices

- Active optical devices
- Adaptive optics
- Optical components and devices
- Optical design
- Optical diagnostic and control
- Optical diodes
- Optical fibre devices and research
- Optical imaging
- Optical interconnects
- Optical microscopy
- Optical parametric processes and devices
- Optical sensors
- Passive optical components
- Photonic crystals
- Photonic hybrid architectures
- Photonic integration
- Photonic lightwave circuits
- Rare earth-based devices and research
- Semiconductors materials, processes, devices

Optical materials

- III-V and II-VI materials
- Liquid crystals
- Other materials for optics and photonics
- Polymers and organic materials
- Thin films and thin layers

Optical technologies

- Optical sources in infrared, visible, UV, X optical spectrum
- Optoelectronics
- Packaging of optical components
- Sol-gel optics and technologies
- Sources of X-radiation by plasmas

Optical applications

- Astronomy
- Biophotonics
- Industrial processing
- Nanophotonics
- Optical communications and networks
- Optical computing
- Optical data storage and processing
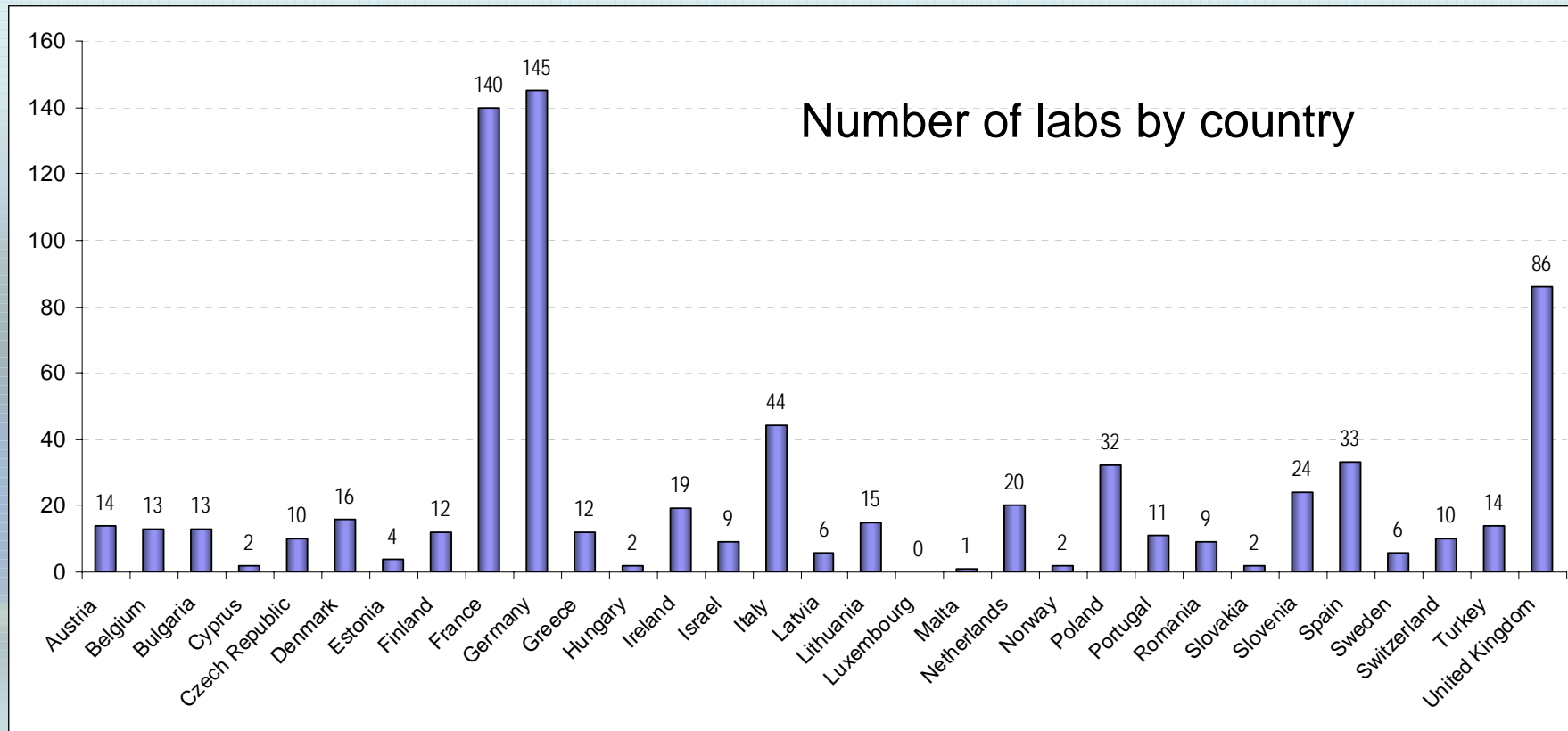- Photovoltaics

Ranking of research areas

- Main research areas
  - Lasers and their applications
  - Spectroscopy and Measurement systems
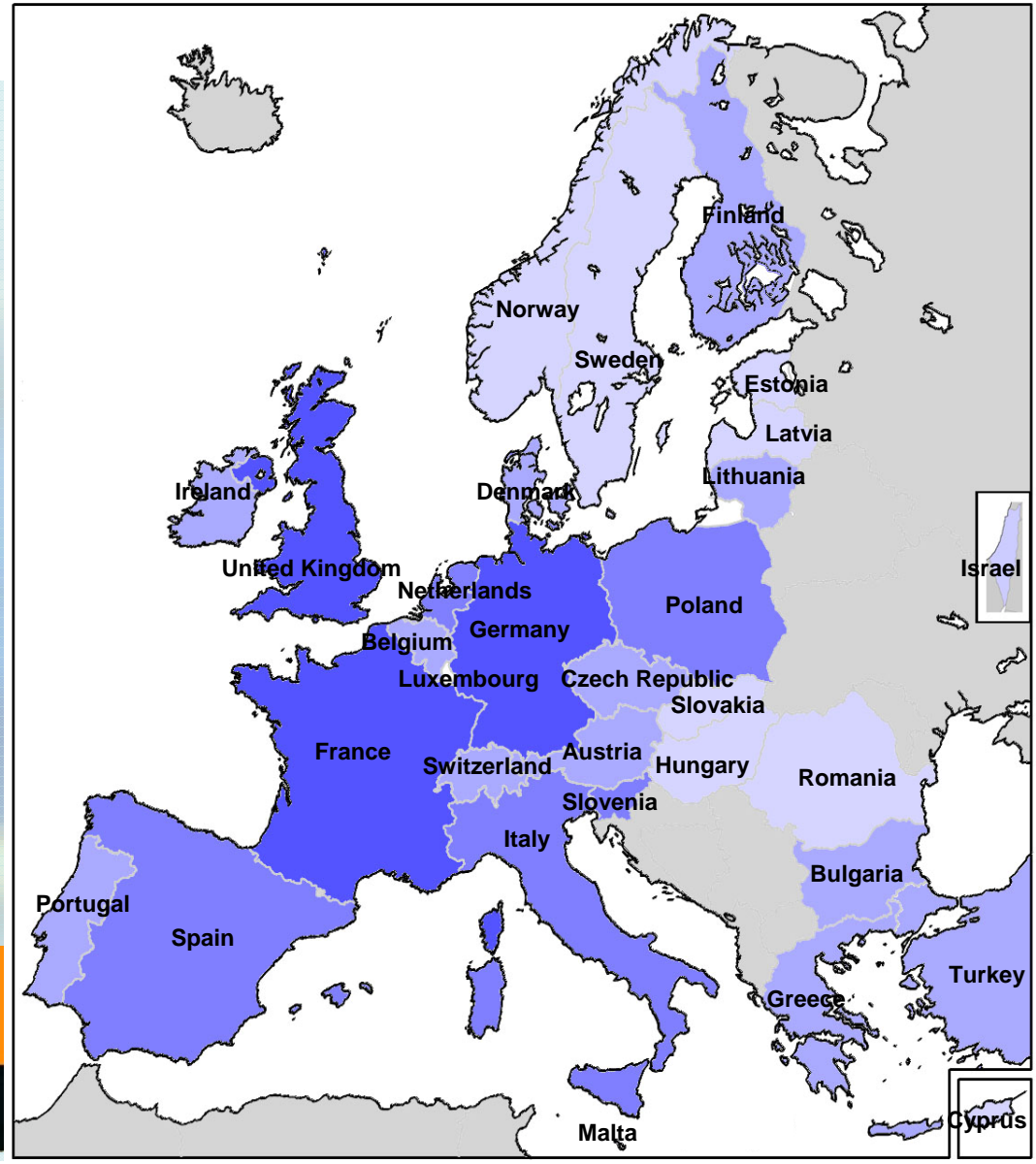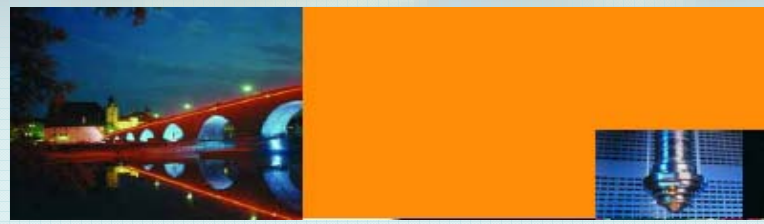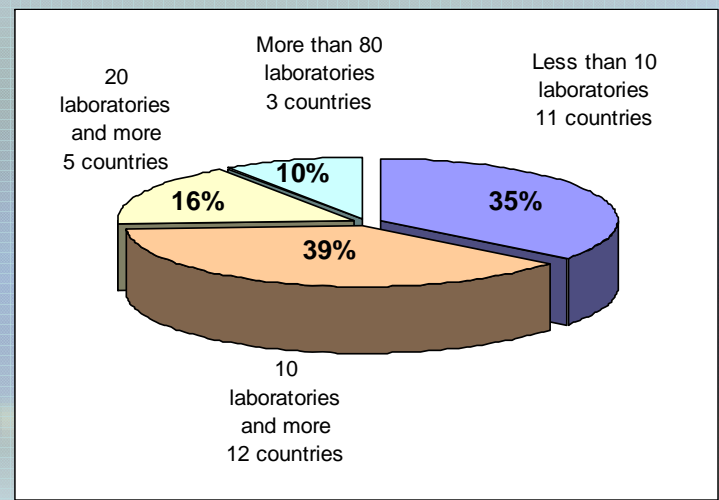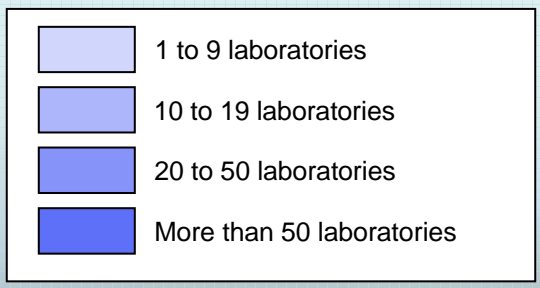 - Nanophotonics and Quantum optics
  - Biophotonics
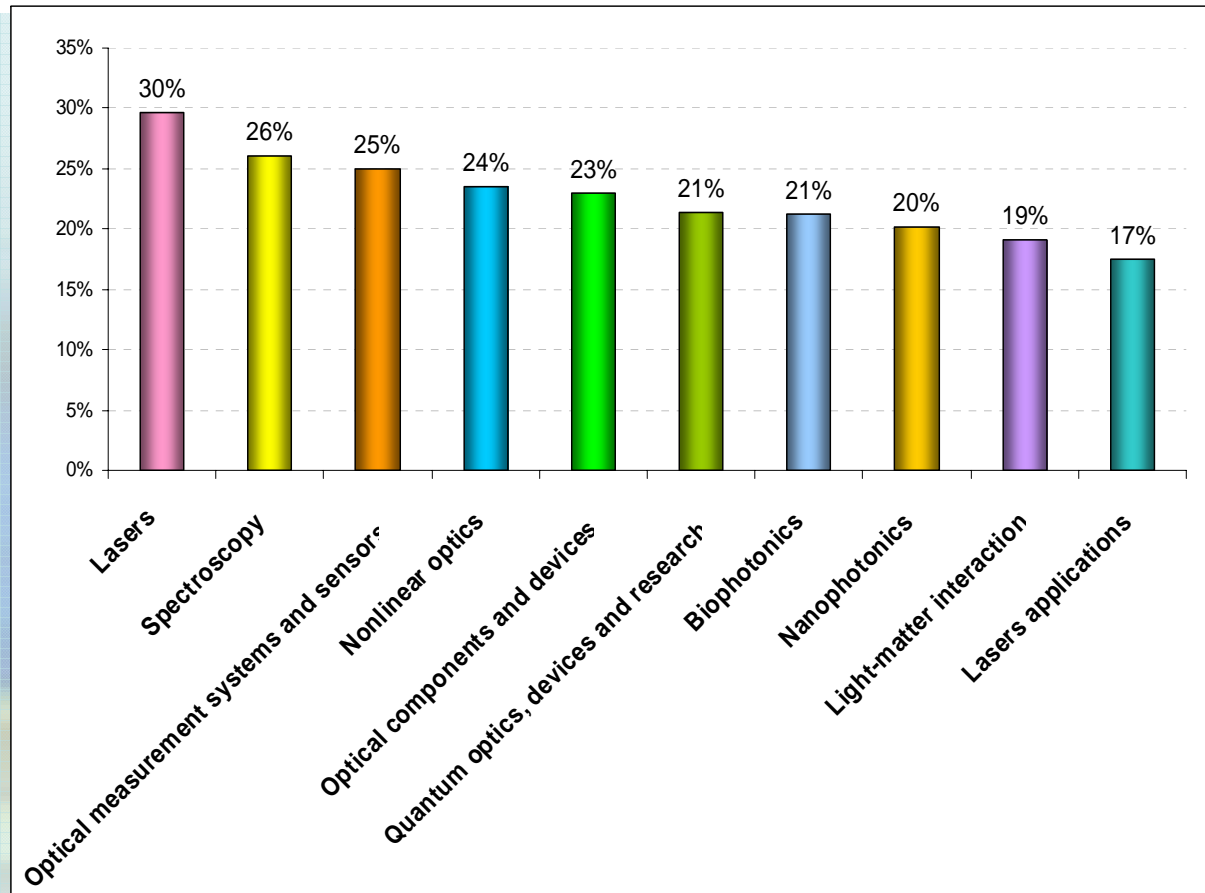
Repartition of labs by country
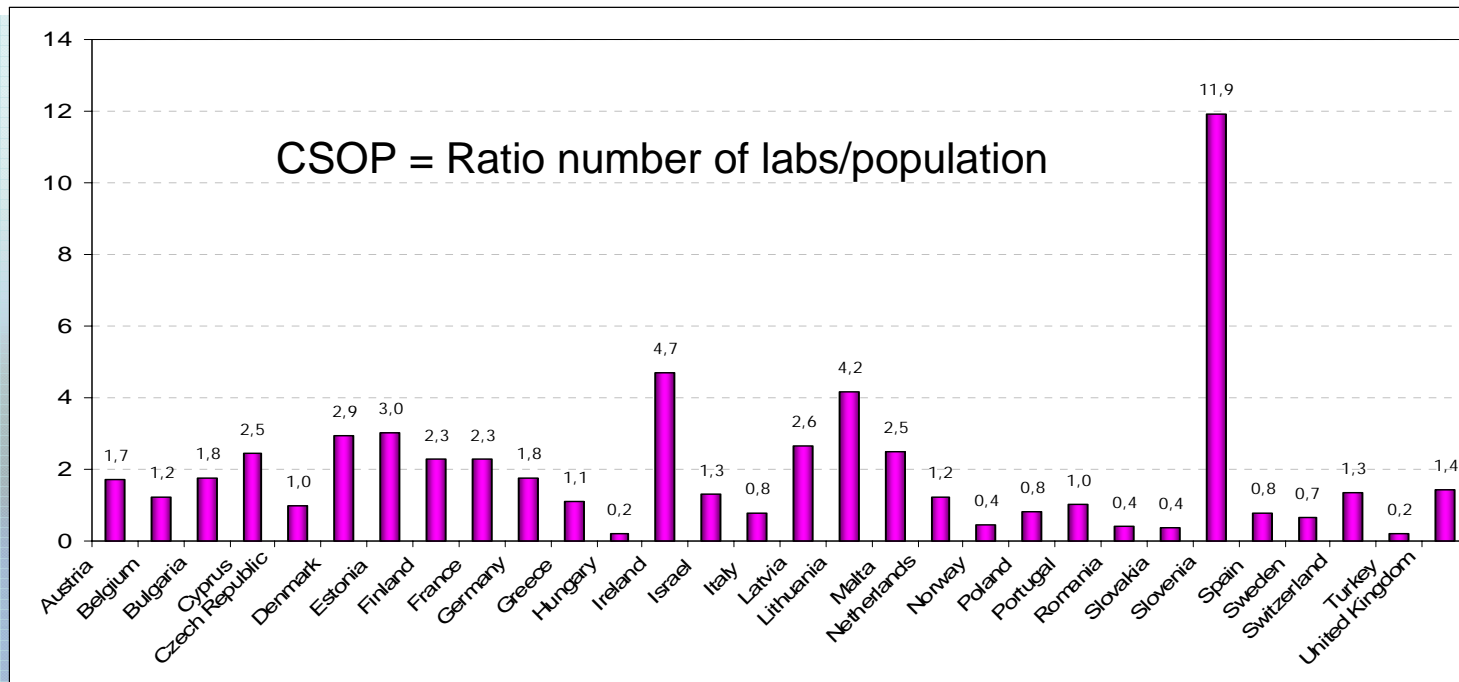
About 700 research laboratories registered

Number of labs by country

Geographical repartition

Specialization of countries

« Coefficient of specialization » in Optics-Photonics (CSOP)

CSOP = Ratio number of labs/population

Austria 1,7; Belgium 1,2; Bulgaria 1,8; Cyprus 2,5; Czech Republic 1,0; Denmark 2,9; Estonia 3,0; Finland 2,3; France 2,3; Germany 1,8; Greece 1,1; Hungary 0,2; Ireland 4,7; Israel 1,3; Italy 0,8; Latvia 2,6; Lithuania 4,2; Malta 2,5; Netherlands 1,2; Norway 0,4; Poland 0,8; Portugal 1,0; Romania 0,4; Slovakia 0,4; Slovenia 11,9; Spain 0,8; Sweden 0,7; Switzerland 1,3; Turkey 0,2; United Kingdom 1,4

– Group 1: more than 50 million inhabitants
– Group 2: between 10 and 50 million inhabitants
– Group 3: less than 10 million inhabitants

Specialisation of countries
Group 1 - 3 main countries

- **France**
  - 30% to 40% : **Nanophotonics, Lasers, Non linear optics** and **Optical measurement and sensors**
  - 25% : Optical components and devices and Spectroscopy
  - 20% : Biophotonics, Light-matter interaction, Optical instrumentation and Optical communications

- **Germany**
  - 30% to 40% : **Lasers and Quantum optics**
  - 25% : Spectroscopy, Non linear optics and Laser applications
  - 20% : Biophotonics, Optical measurement and sensors, Light matter interaction and Nanophotonics

- **United Kingdom**
  - 30% to 40% : **Optical components and devices**
  - 25 % : Lasers, Biophotonics, Spectroscopy, Quantum optics, Optical measurement systems, Nanophotonics, Theoretical optics

Specialisation of countries
Group 2 - 3 main countries

➤ Analysis of the laboratories distribution in this group might not be relevant in case of small numbers

- **Belgium**
  - 30% : **Active optical devices, Nonlinear optics, Optical sources, and Quantum optics**

- **Netherlands**
  - 40% : **Signal and image processing**

- **Poland**
  - 30% to 40% : **Theoretical optics**, **Spectroscopy**, **Light-matter interaction** and **Optical measurements**
  - 20% to 25% : Lasers, Non-linear optics, Biophotonics, Quantum optics, Photo-induced process and Laser applications

Specialisation of countries
Group 3 - 3 main countries

➢ Analysis of the laboratories distribution in this group might not be relevant in case of small numbers

- **Ireland**
  - 30% to 40% : **Optical components and devices** and **Lasers**
- **Lithuania**
  - 60% to 70% : **Photonic crystals** and in **Linear optics**
- **Slovenia**
  - Mainly applicative
 - 35% : **Optical measurement and sensors**

Comparison with industry (Data from WP3)

- Classification of countries in 2 groups
  - Group A : number of companies superior to 100
  - Group B : number of companies inferior to 100
- Group A
  - Number of laboratories and companies **highly correlated** (R2 = 0,9 [1])

- Group B
  - Number of laboratories and companies **markedly correlated** (R2 = 0,7 [1])
  - Belgium, Poland and Slovenia not included because of an important bias in the results (red dots)
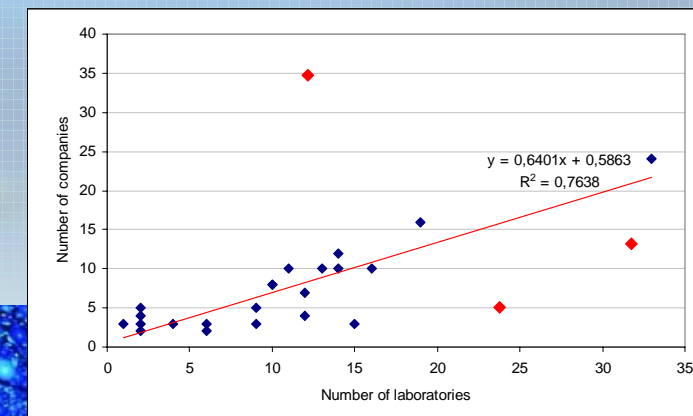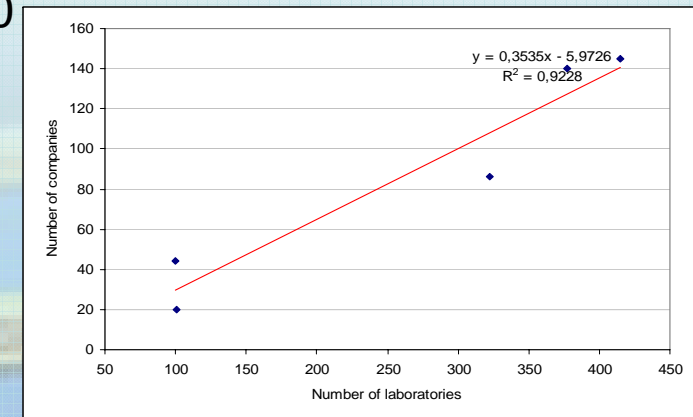
[1] R2 is the square of R, the correlation coefficient, calculated by linear regression.
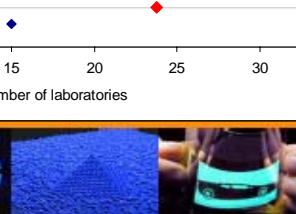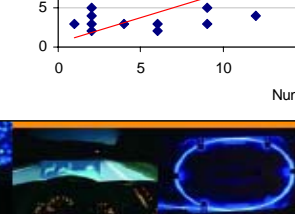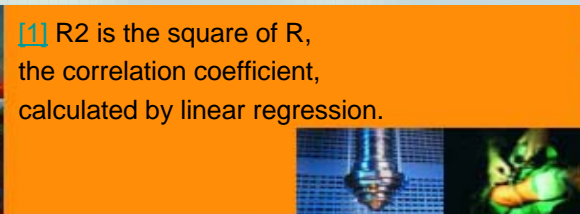
Conclusions (1)

- The OPERA[2015] allowed us to build a **comprehensive database** of **academic research laboratories** in **Optics-Photonics** at European level
  - About 700 research units identified and registered

- The analysis of research topics shows the **strengths of European research** in O/P
  - **Lasers** and **their applications**
  - **Spectroscopy** and **Measurement systems**
  - **Nanophotonics** and **Quantum optics**
  - **Biophotonics**

Conclusions (2)

- These first results should be completed with **more accurate data**, ie. number of researchers in each lab, number of publications etc…

- At this first level of analysis, a **correlation** between the number of **labs** and **companies** in each country has been highlighted

- The collected data is **accessible for all** on the OPERA^{2015} Web site