



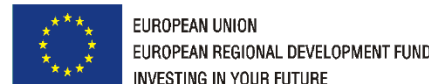
**REGIONAL CENTRE
OF ADVANCED TECHNOLOGIES
AND MATERIALS**

Regionální centrum pokročilých technologií a materiálů



Regional Centre of Advanced Technologies and Materials (RCPTM)

Optical and Photonic Technologies



www.rcptm.com

Olomouc, Czech Republic



Joint Laboratory of Optics



Palacký University

Faculty of Science

Regional Centre
of Advanced Technologies
and Materials



Institute of Physics AS CR

Division of Optics



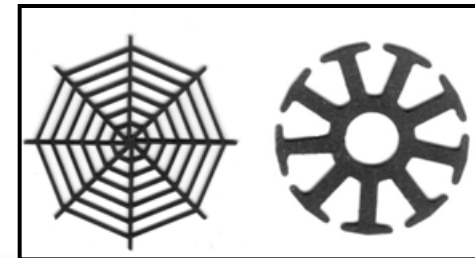
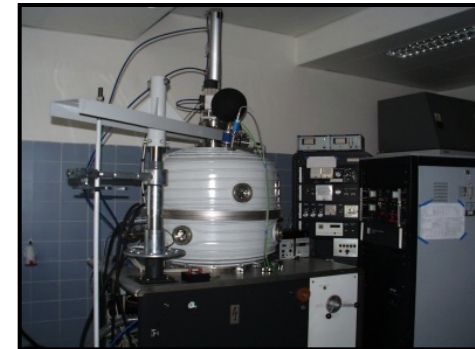
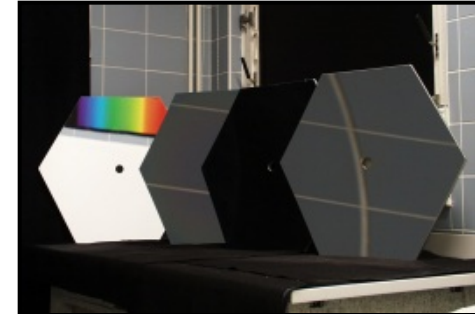
Joint Laboratory of Optics



Division of Optical and photonic technologies

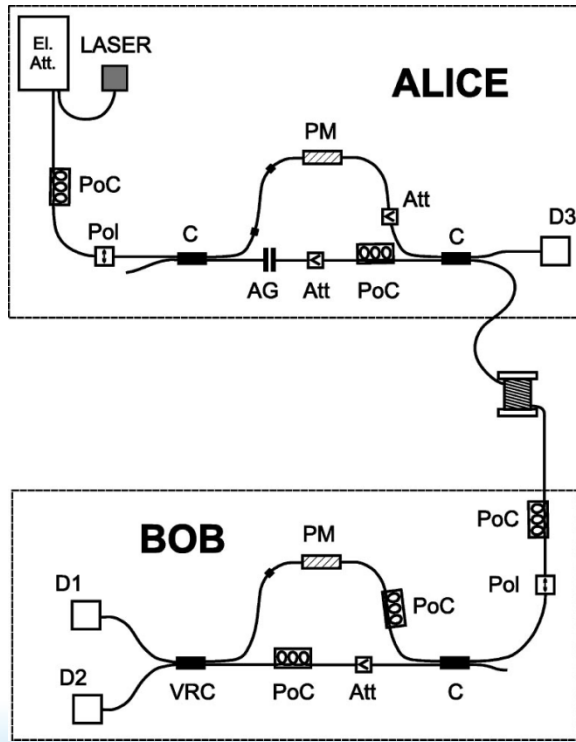


- Design, construction and quality-control of **specialized optical components** for applications in the industry and large scientific collaborations (e.g., The Pierre Auger Observatory) and development of related **optical technologies**
- Development of methods and devices for the production, detection, and characterization of **weak photon fields** and for the transmission and processing of quantum information
- Development of methods for deposition and characterization of **thin layers** using methods of plasma deposition and vacuum steaming
- Optical non-contact **measurement methods** based on speckle-field and white-light interferometry, or moiré topography
- **Laser welding, cutting and surface treatment**
- Simulation of **optical detection processes** for the CERN-ATLAS experiment

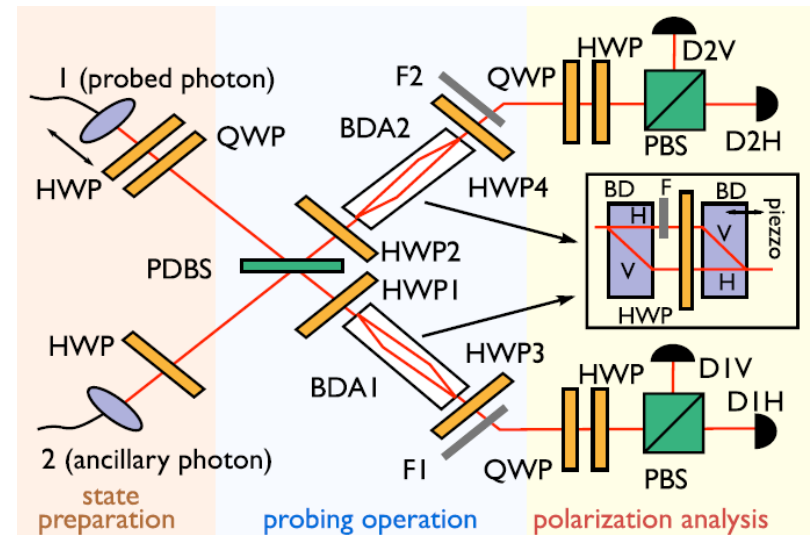


Quantum communications

- Quantum cryptography
- Quantum cloning
- Quantum identification
- Quantum eavesdropping



Phys. Rev. A 60, 149-156 (1999)



Phys. Rev. Lett. 110, 173601 (2013)



Quantum internet (?)



Classical information (bits):



0; 1

Quantum information (qubits):

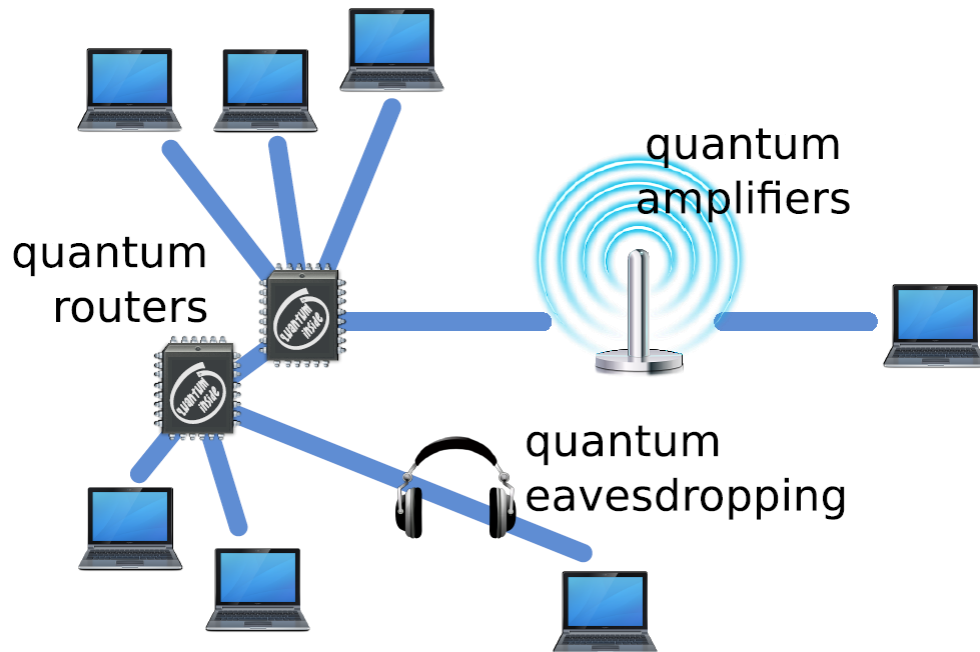


$|0\rangle + |1\rangle$

Quantum effects:



**superposition,
entanglement**



Phys. Rev. A **85**, 050307(R) (2012)

Phys. Rev. A **87**, 062333 (2013)

Opt. Commun. **300**, 282–285 (2013)

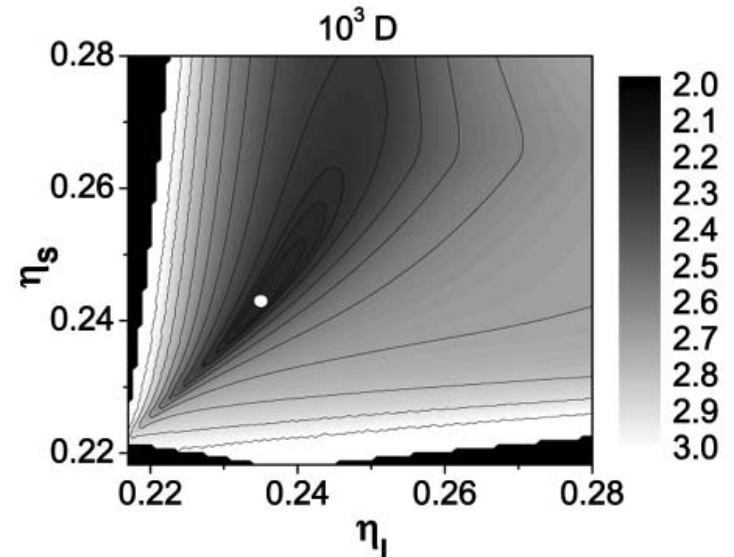
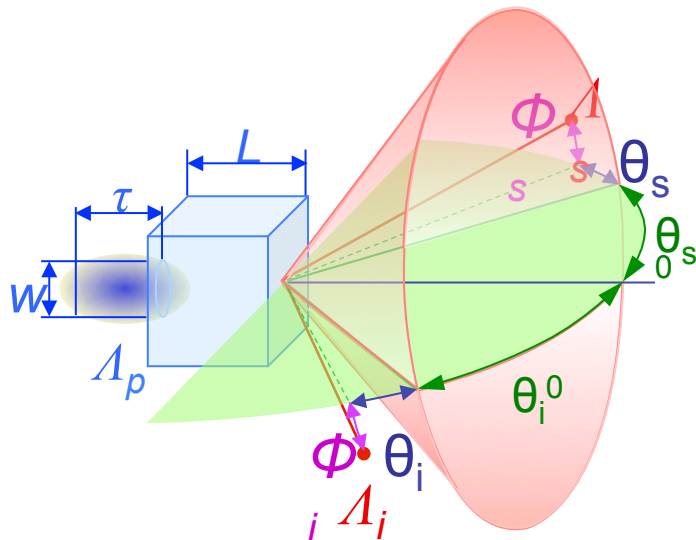
Phys. Rev. A **87**, 033826 (2013)

Phys. Rev. A **88**, 012327 (2013)

Phys. Rev. Lett. **114**, 153602 (2015)



Photon pairs

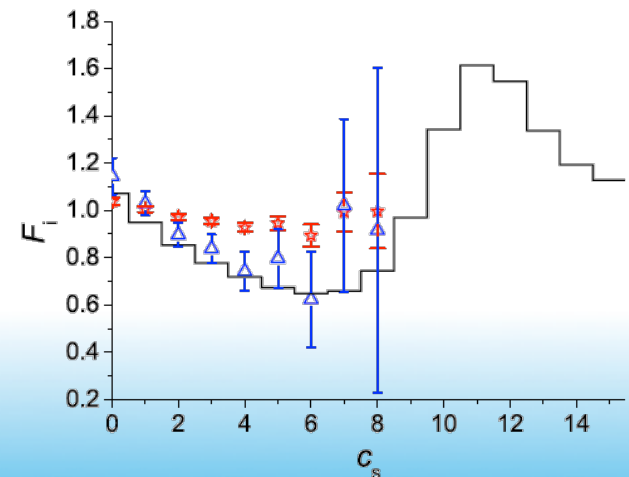


- Quantum metrology
- Calibration of detectors
- Generation of sub-Poissonian states
- Nonclassical correlations

Opt. Lett. **37**, 2475 (2012)

Opt. Express **21**, 19387 (2013)

Opt. Express **22**, 13374 (2014)





Single-photon detection



- Silicon avalanche detectors
- iCCD and EMCCD cameras

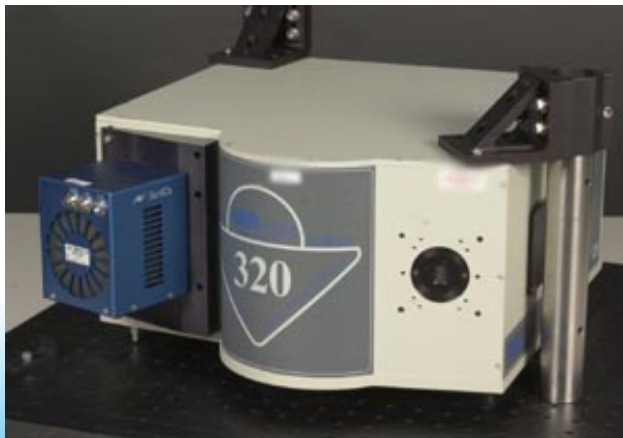




Spectrophotometry



- Deep UV
- Visible
- Near IR
- Time-resolved
- *Single-dot cryo*



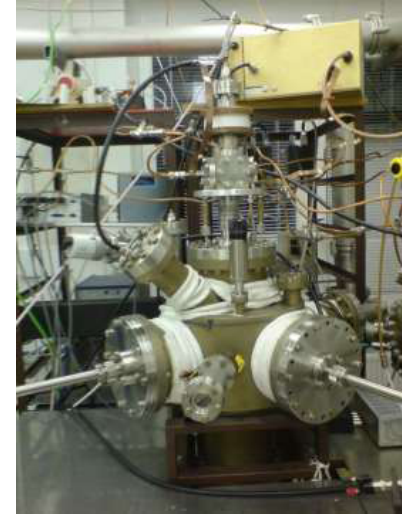
Plasma deposition and analysis

- High Power Impulse Magnetron Sputtering (HiPIMS)
- “cold plasma” ($<150^{\circ}\text{C}$)
- well-defined crystal structure, spatially uniform
- Glow-discharge optical emission spectrometer (GD-OES)
- Elemental analysis (low concentrations, down to monolayers)
- Promising for high-performance dye-sensitized solar cells

Opt. Lett. **38**, 2428 (2013)

Catal. Today **230**, 8 (2014)

Appl. Catal. B Env. **165**, 344 (2015)



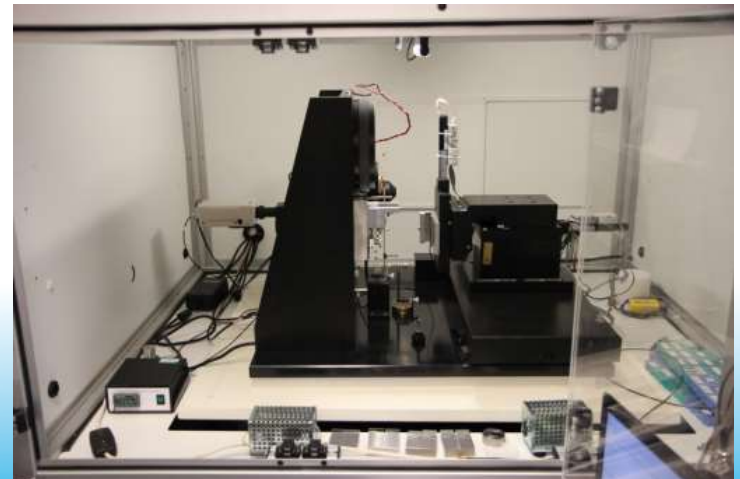
Mechanical properties of surfaces and layers

- NanoTest – static, quasi-static and dynamic tests (hardness, elasticity, resilience, adhesion, cohesion, profilometry and degradation) combined with acoustic emission detector
- Local mechanical and tribological properties (thin layers, multilayer structures, bulk, composites, ceramics, polymers, biological samples)
- Room-temperature testing (up to 500°C)

Surf. Coat. Technol. **205**, 4052 (2011)

Surf. Coat. Technol. **206**, 3580 (2012)

J. Mat. Sci. **50**, 1553 (2015)

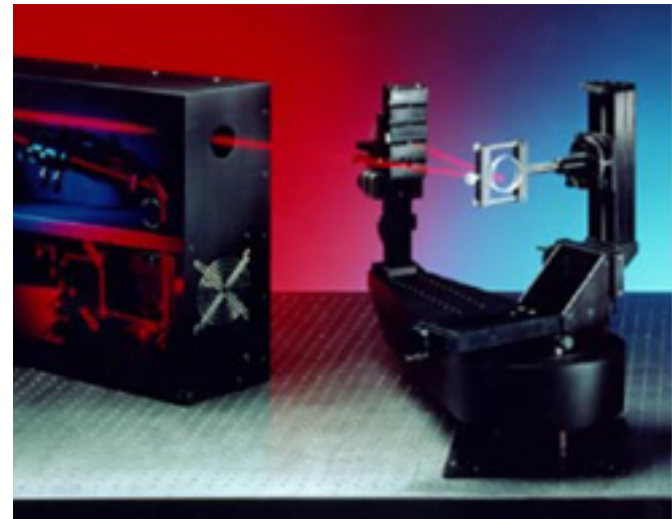




Scatterometry, confocal microscopy



- Measurement of surface roughness down to 1 nm
- 325 nm and 635 nm
- Full-angle



- Lateral resolution 120 nm
- Vertical resolution 40 nm

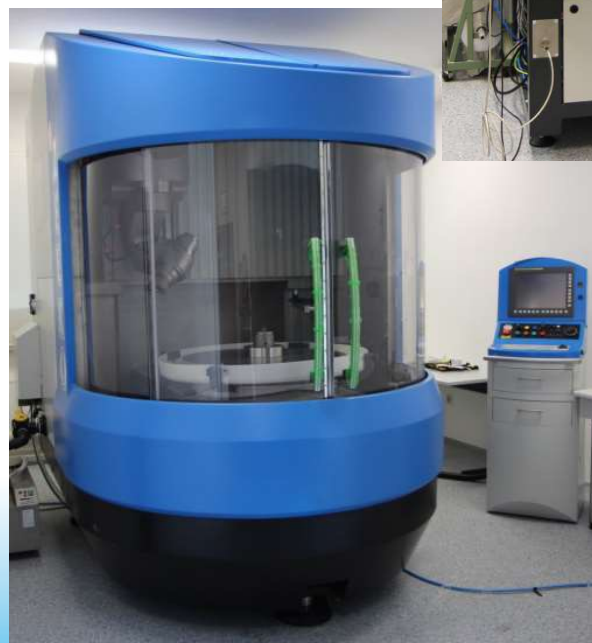


Optical components, layers, surfaces (up to 1 m diameter)



- Vacuum steaming
- Optical surfaces

SPHERE			Rotationally Symmetric Error	λ	$\lambda / 10$
SPHERE			Non-Rotationally Symmetric Error	λ	$\lambda / 10$
CIRCULAR ASPHERE			Rotationally Symmetric Error	λ	$\lambda / 10$
CIRCULAR ASPHERE			Non-Rotationally Symmetric Error	λ	$\lambda / 10$
COMPLEX ASPHERE			Complex Error	3λ	$\lambda / 8$
OFF-AXIS ASPHERE			Off-Axis Error	3λ	$\lambda / 4$
FREE-FORM			Free-form Error	3λ	λ

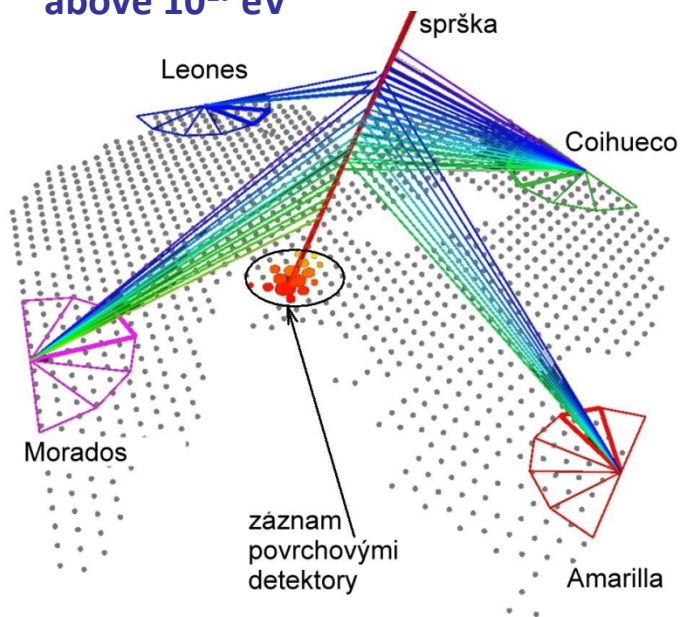




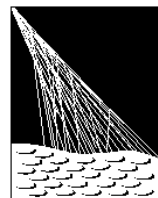
Pierre Auger Observatory



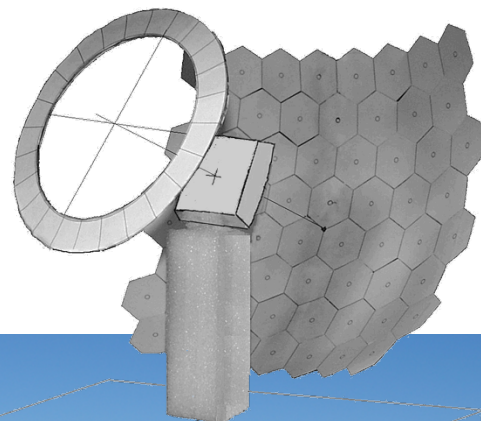
Detection of primary particles with energies above 10^{17} eV



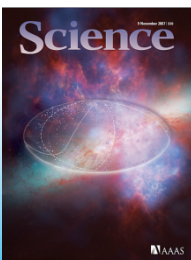
24 fluorescence telescopes
1600 ground detectors (cca 3000 km²)



PIERRE
AUGER
OBSERVATORY



1600 segmented mirrors for fluorescence telescopes
analysis of properties of other optical components



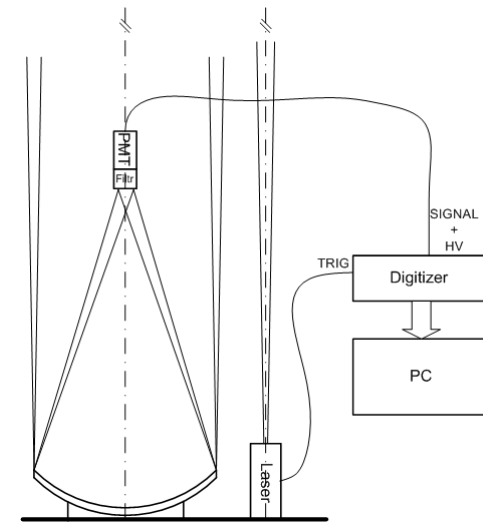
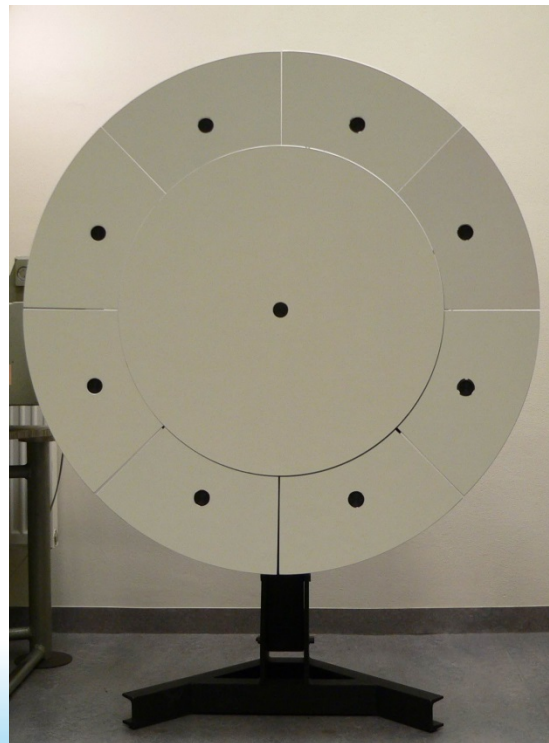
since 2011 RCPTM is a member of the Pierre Auger Collaboration

Lidar – Monitoring the atmosphere

Investigation of the attenuation of fluorescence radiation by measuring elastic scattering on the particles in the atmosphere



Original lidar with a set of small mirrors



Segmented mirror for the lidar as designed in RCPTM

Diameter: 1000 mm;
 $f' = 1100$ mm

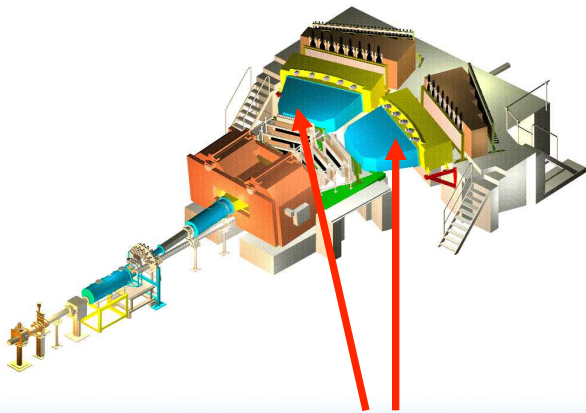


Mirrors for CERN (pion lifetime measurement)

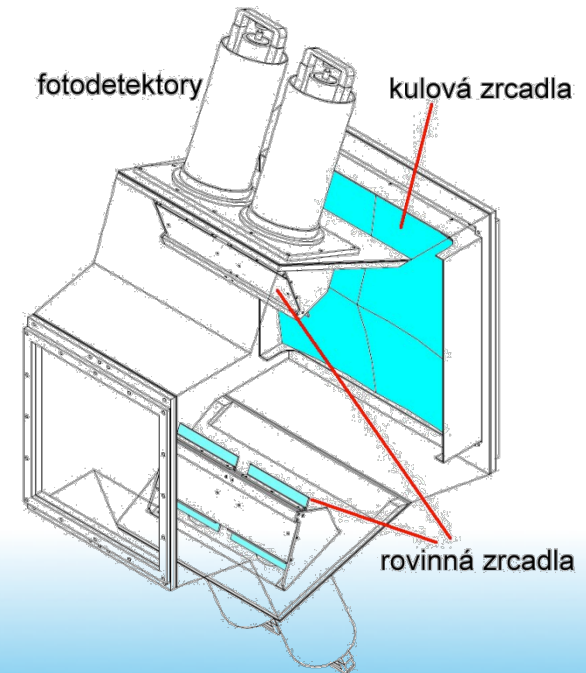
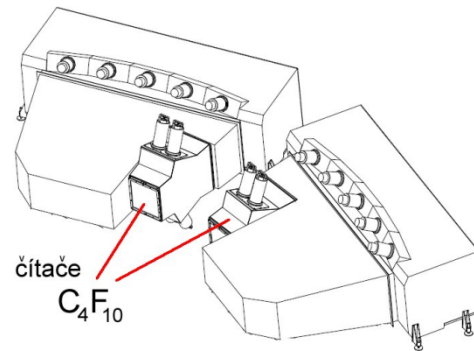


As a part of the DIRAC spectrometer in CERN there are Cherenkov detectors. They include 4-part mirror elements that focus the generated signal to a photodetector.

Mirrors have been designed and fabricated in Olomouc.

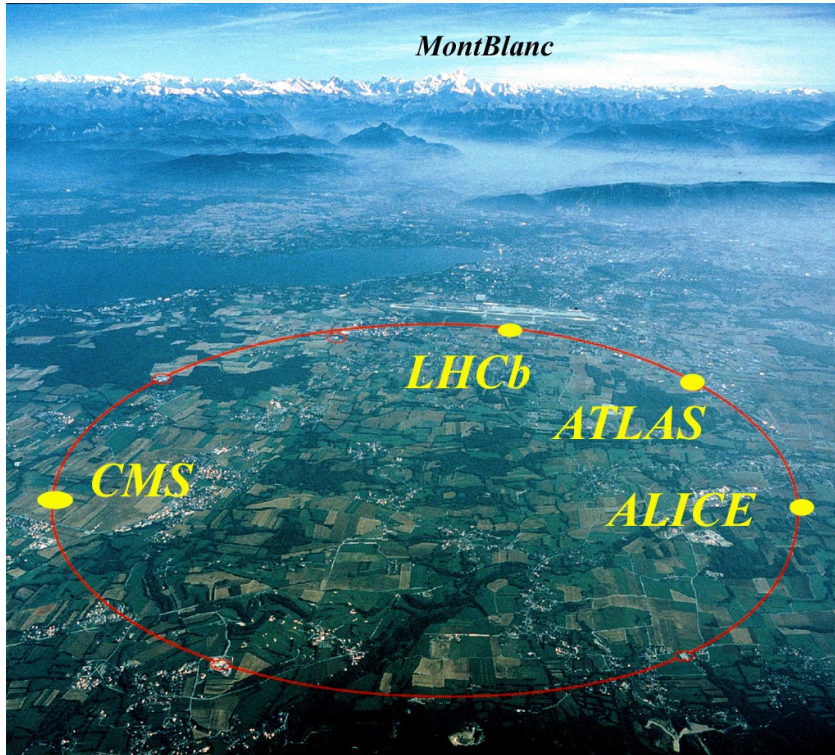


Cherenkov
detectors





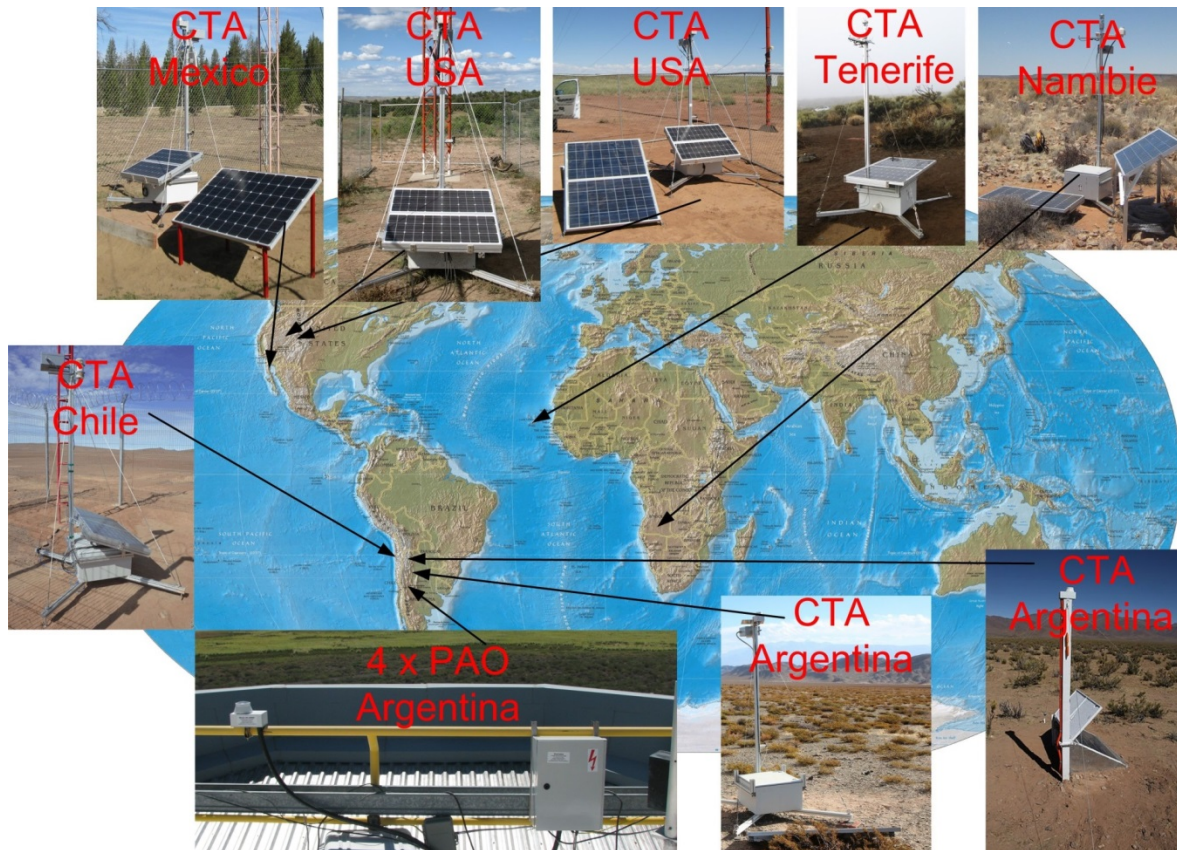
CERN-ATLAS



- Computer simulations of the CERN-ATLAS optical detection process



Autonomous all-sky cameras

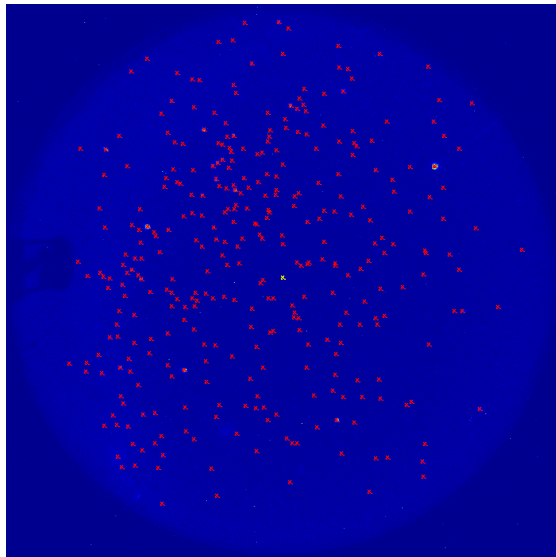


- Monitoring of the sky background
- Extinction of the atmosphere
- Statistics of cloudiness

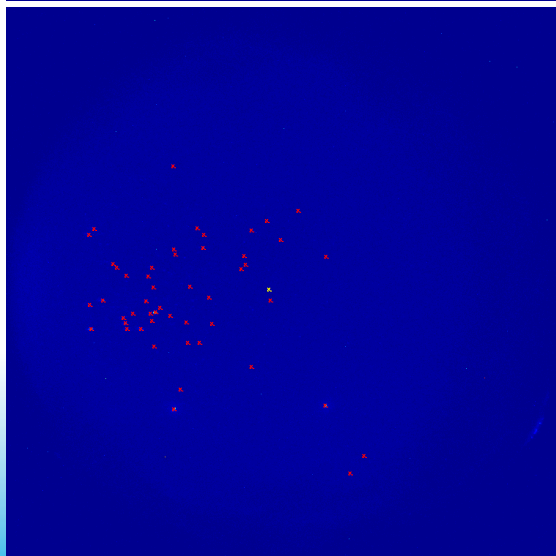
14 installations worldwide



Autonomous all-sky cameras

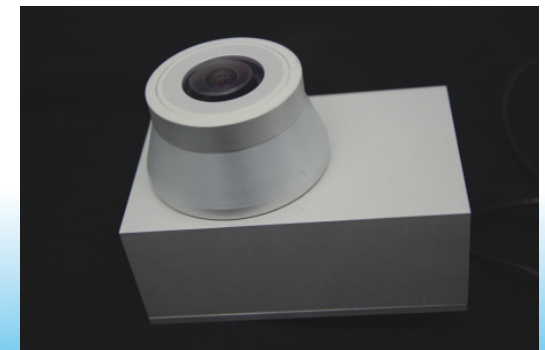
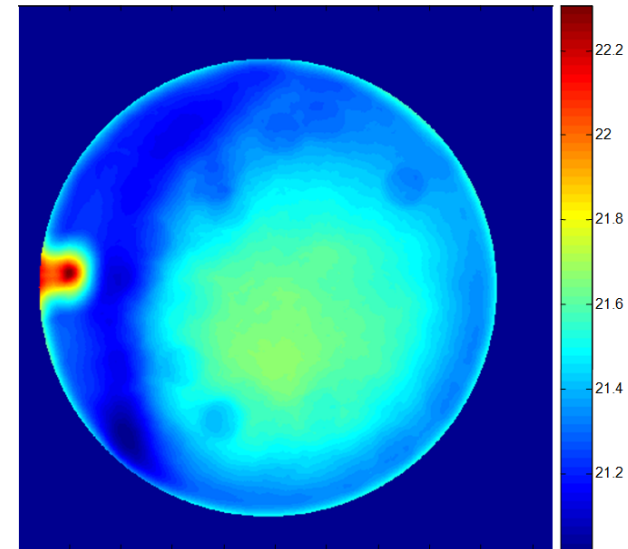


*Level of cloudiness:
0%, 350 stars*



*Level of cloudiness:
44% 50 stars*

*Night-sky background
[mag/arcsec²]*

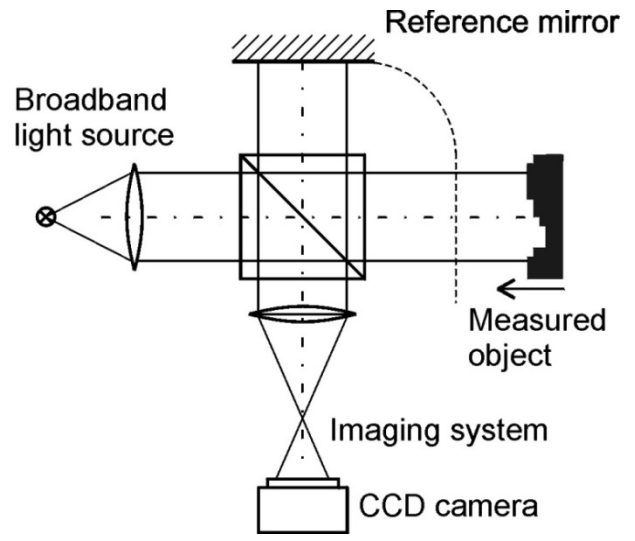




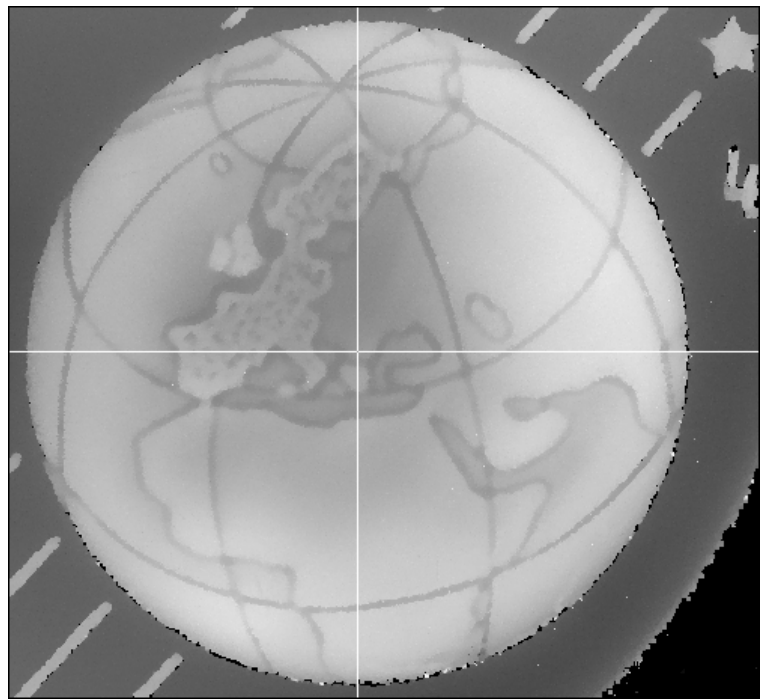
White-light interferometry



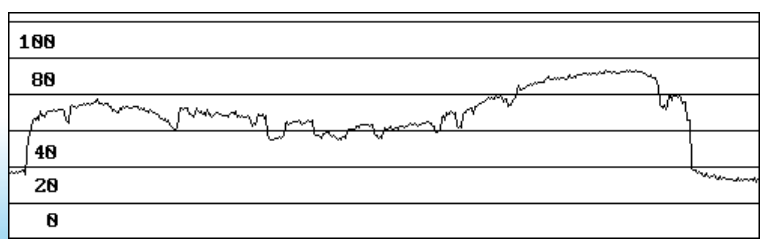
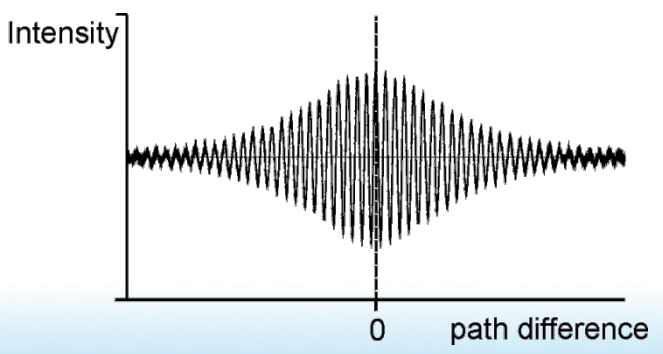
experimental setup



measured height profile



white-light correlogram



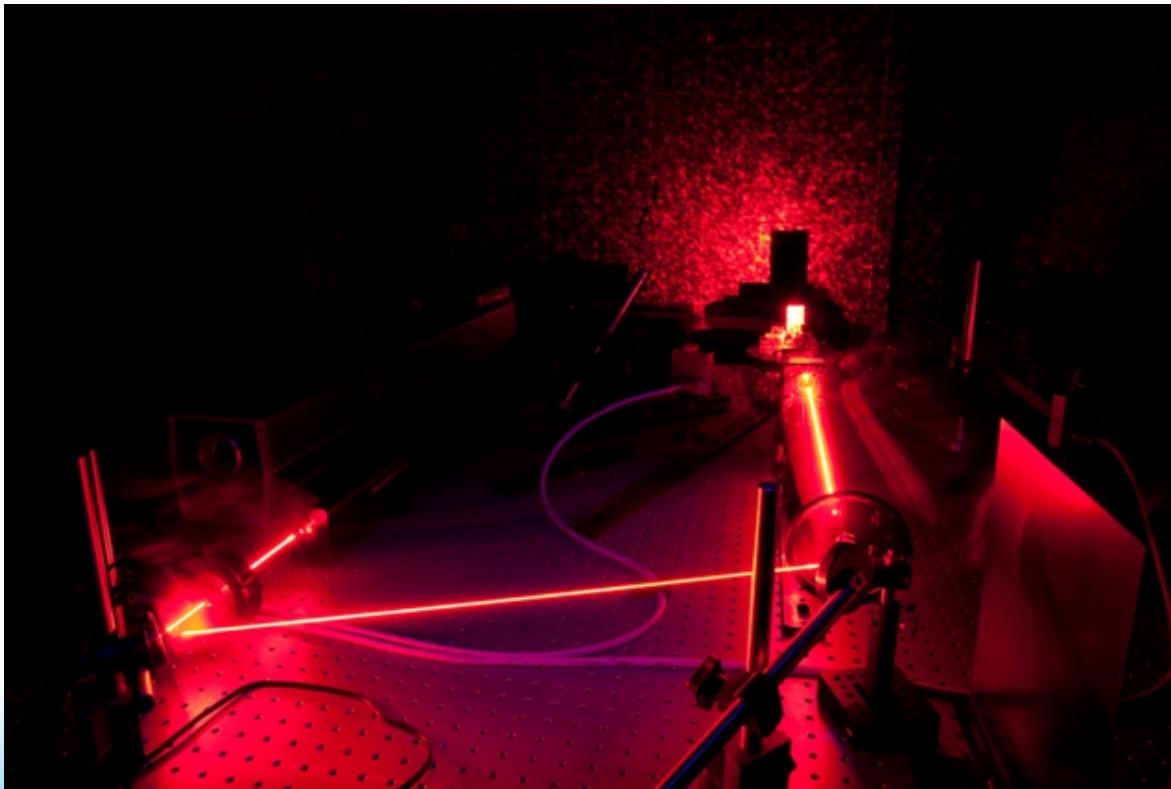
Appl. Opt. **51**, 465 (2012)
Opt. Las. Eng. **50**, 1063 (2012)



Speckle interferometry



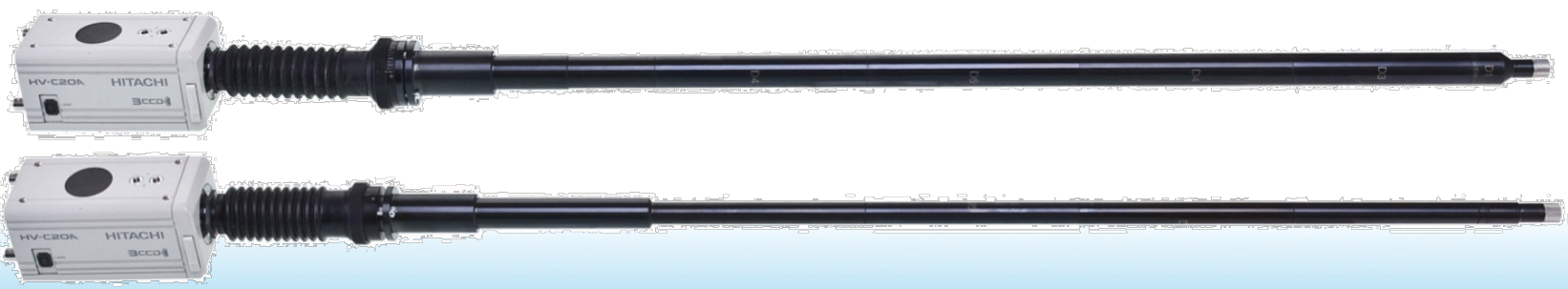
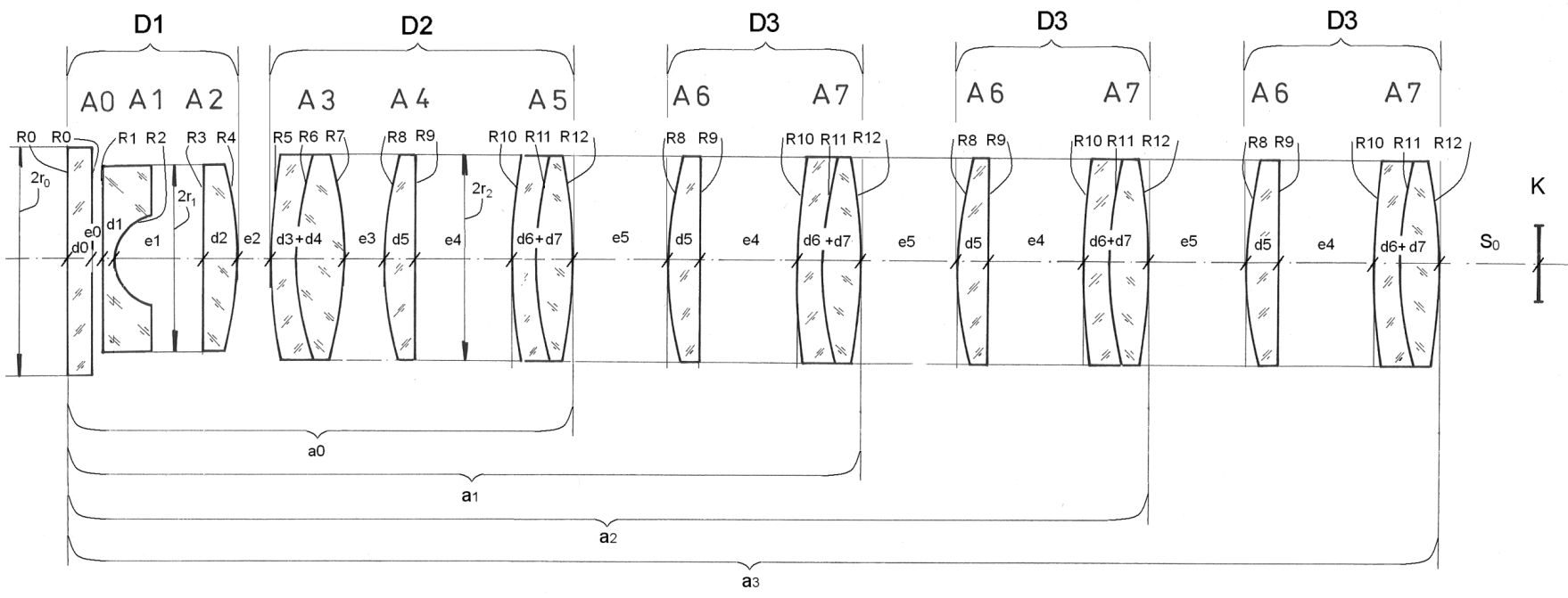
- Non-contact measurement method
- Translation, rotation or deformation of objects



J. Opt. Soc. Am. A **29**,
1071 (2012)
Sci. World J. **2014**,
704368 (2014)



Borescope



Dimensions: diameter 16, 22, 25 mm, length: 550 mm, 830 mm and 1130 mm, viewing angle: 30°, 60°, 90°, CCD camera: 1/2", 1/3", 1/4".



Industrial automation



System for real-time identification of color codes at springs for automotive

PerMon - \DataPermon\20030514_103118_AA

Database Nastaveni Pomoc

Start

Auto start

Pohled

Kopiruj do predlohy & nastavovani

Provoz Nastavovani

Test

Nastaveni etalonu | Tolerance

Oznaceni pruziny: AA

Uloz nový etalon & provoz

1542 / 0 1740 / 225 1828 / 0

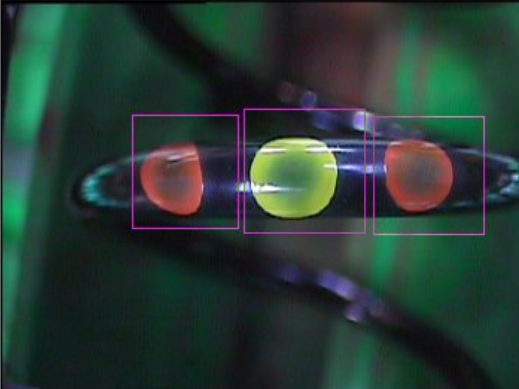
Nastav plochu Nastav plochu Nastav plochu

Nastaveni barev

Zpatky

Vyhazeni

Toler: min=35 max=35 in=T.35
14.05.2003 10:33:54 OK
Etalon: 20030514_103409



C:\data\projekty\pera\pic6\pic1343.bmp

Prehravani

Nahrej Dalsi Auto

Plocha1:	1002 < 1542 < 2082	Diral:	0 < 540
Plocha2:	1277 < 1965 < 2653	Dira2:	225 < 688
Plocha3:	1188 < 1828 < 2468	Dira3:	0 < 640

4036 ms

OK

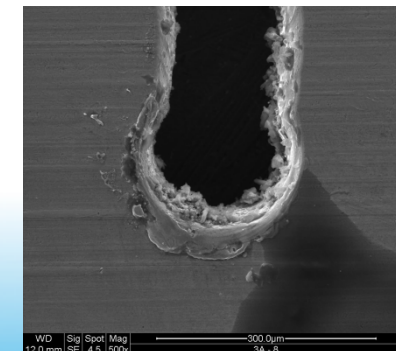
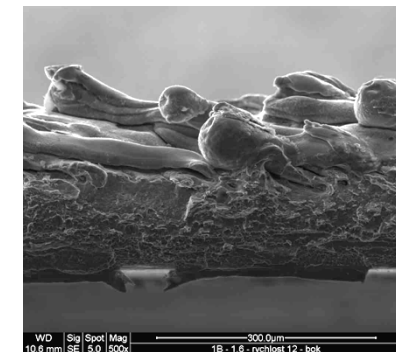
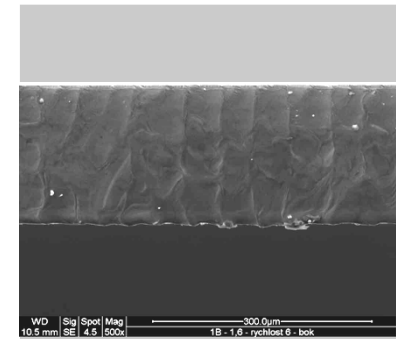
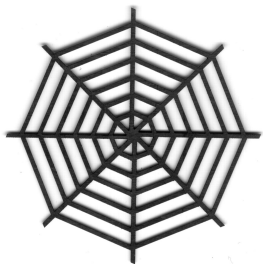
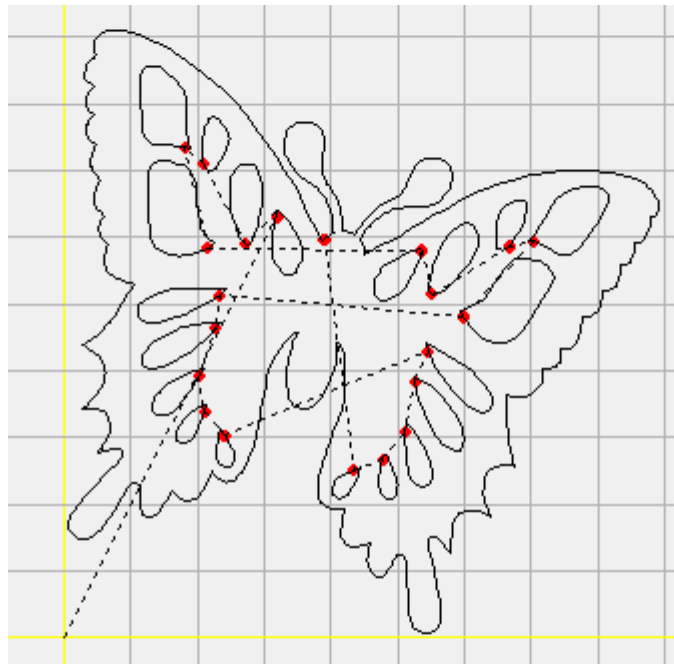
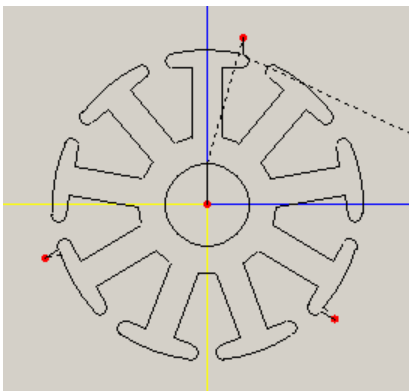




High-power lasers



Optimization of parameters of laser cutting of thin metal sheets



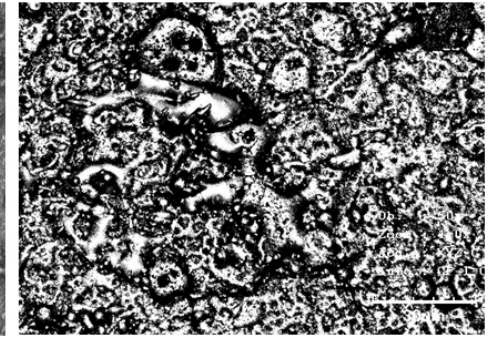
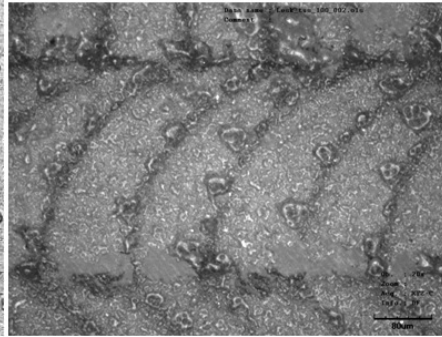
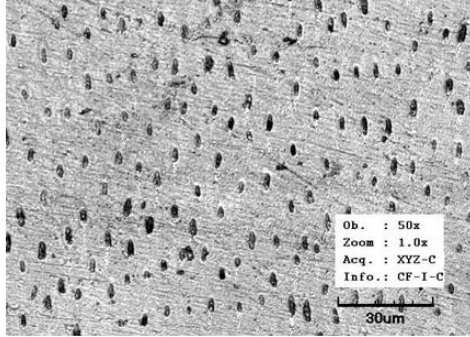
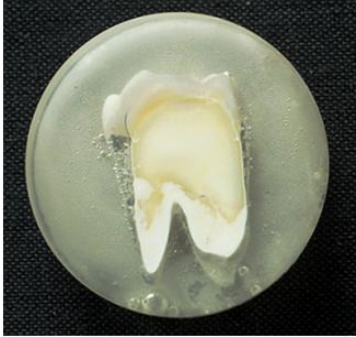
J. Mat. Eng. Perf. **21**, 764 (2012)
J. Mat. Proc. Technol. **212**, 910 (2012)



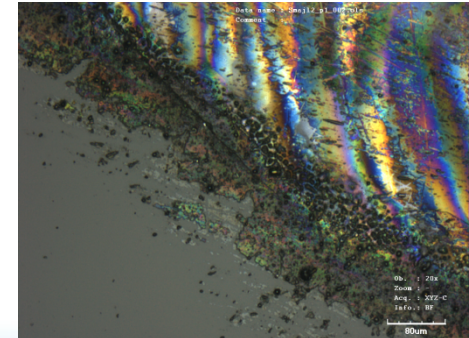
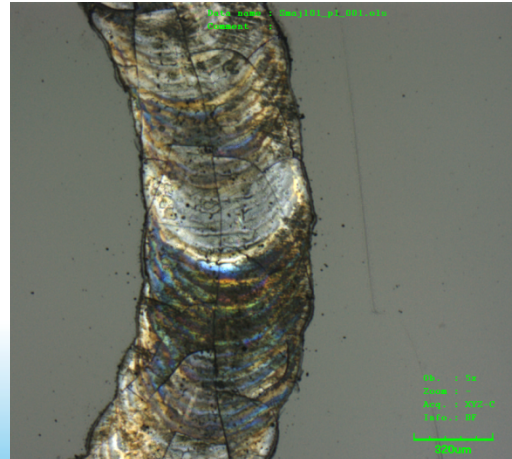
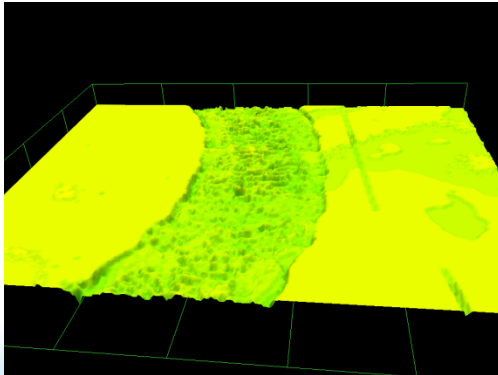
High-power lasers



In medicine: simulation of treatment of teeth using denting melting with a laser



Laser-induced glass-marking

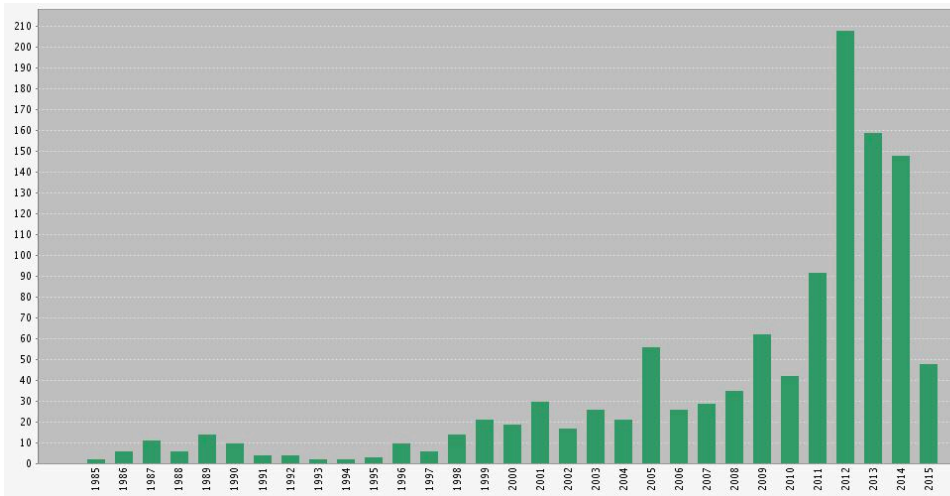




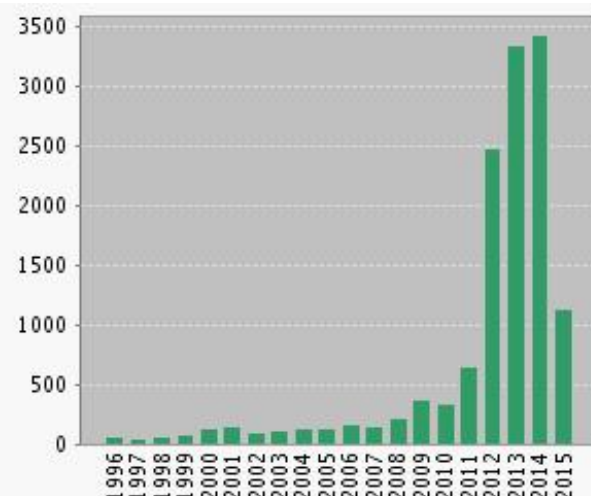
Web of Science



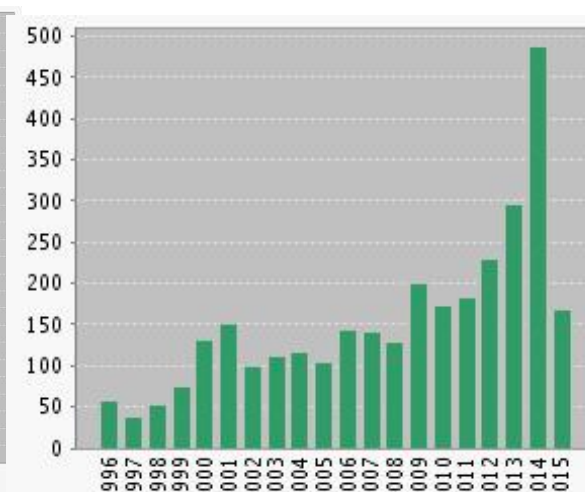
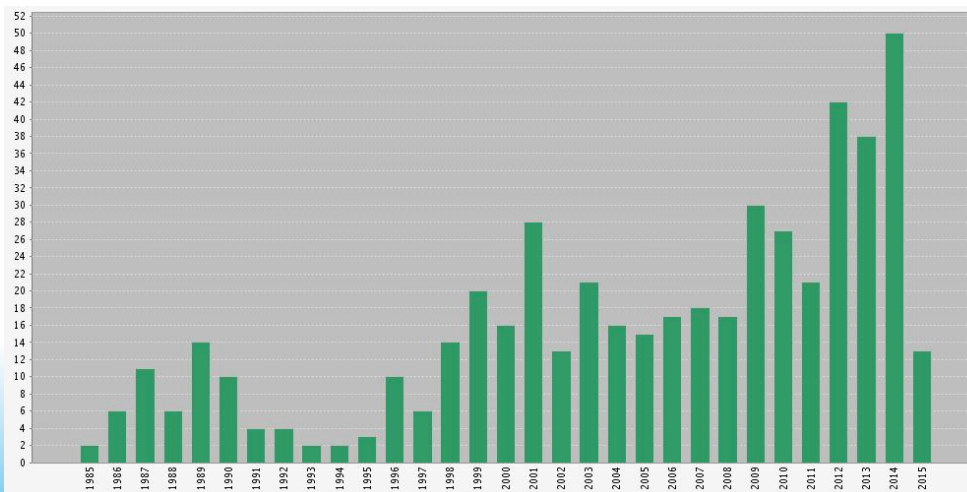
Published Items in Each Year



Citations in Each Year



with PAO and
CERN-ATLAS



without
collaborations