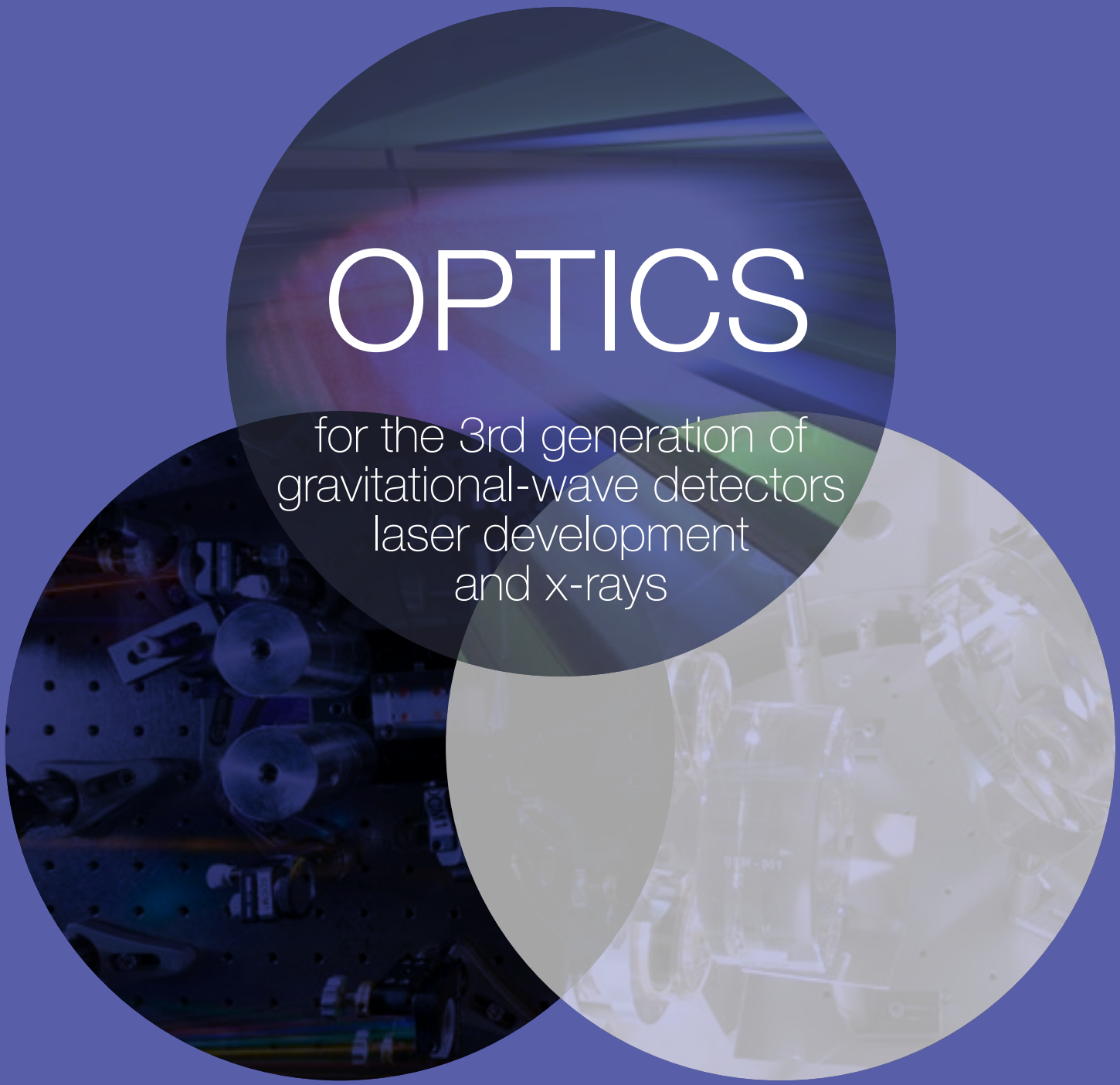
# APPEC Technology Forum 2017

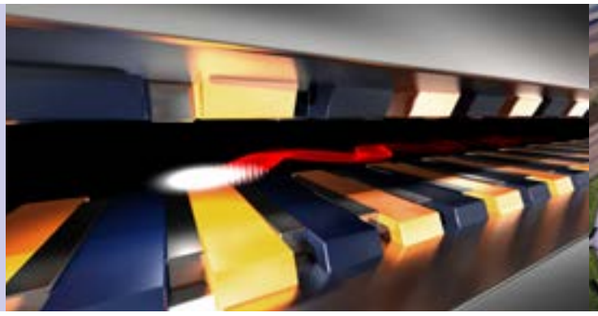


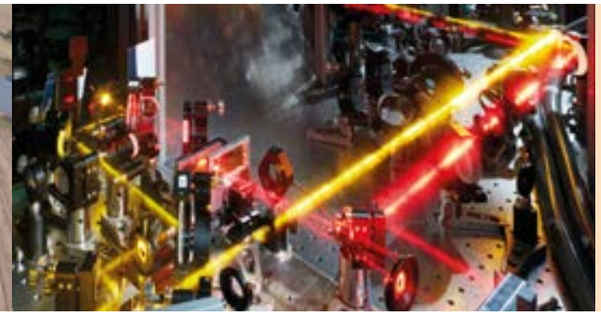
# OPTICS

for the 3rd generation of
gravitational-wave detectors
laser development
and x-rays

www.appec.org

3 - 4 May 2017 | Hannover Leibnizhaus





# Introduction





The Astroparticle Physics European Consortium - APPEC - invites to the APPEC Technology Forum (ATF) 2017.
This event is addressed to optics experts aiming to discuss the present challanges in the development of coatings, substrates, optoelectronics and optomechanics.

In particular, the focus will be on three main applications of optics:
- development of the 3rd-generation gravitational-wave detectors
- laser development and related optoelectronics
- X-ray optics

## The ATF 2017 shall:

- allow scientists to present the status of their projects, the challenges and requirements concerning optics and optoelectronics
- allow experts from companies to show their products and latest development
- support active discussions about specific challenges, which at present are hindering a progress in different scientific and technological fields
- favor interdisciplinary communication and collaborations for the application of efficient strategies also in neighbor fields
- be inspired by the experience gained with the past Technology Forums and in particular with the one in 2011, concerning optics and lasers in astroparticle physics
- focus on the most promising solutions of any field-related problem and draft a vision for the R&D of the upcoming years
- attract young researchers and specialists to be involved in the crucial steps of the future top-notch technologic development

Starting in 2010, a series of dedicated academia and industry events have been organized in the frame of ASPERA, the EU-funded network of national funding agencies active in the domain of astroparticle physics. Since 2015, this work is continued by APPEC.

Developments in optics are a key feature in many fields internal and external to astroparticle physics. For this reason, they were already object of a past Technology Forum - the ATF 2011[1] focused mostly on astroparticle physics, namely on gravitational-waves (GW) detection and on Gamma-Ray astronomy. Companies working in the field of laser development and optics have been invited to discuss their latest progresses in the frame of collaborations of existing and future experiments in astroparticle physics.
This year, the aim is to support extra-field synergies beside astroparticle physics and different topics concerning laser development, X-ray optics and particle physics will be also addressed.

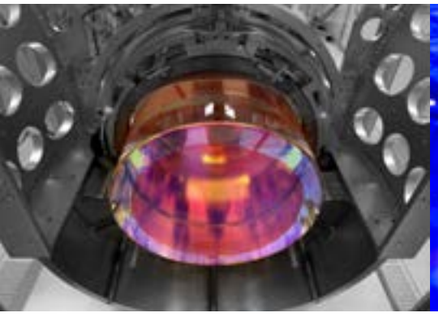
In science, a new generation of experiments is typically sustained by a consistent advancement in the technology which characterizes the experimental setup. From the particle- and astroparticle-physics perspective, there are many examples where, in order to move forward to the following generation of experiments, breakthroughs in optics, optomechanics and laser development have to take place simultaneously.

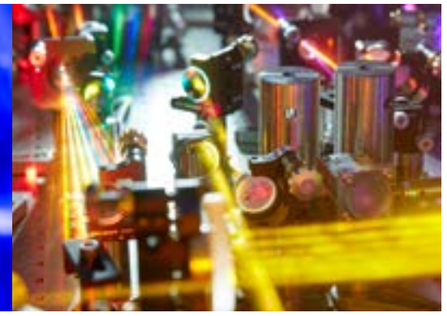
One of the major aims of an ATF is to foster the cooperation and exchange between academia and industry. In the format of a Technology Forum it is forseen that companies have the opportunity to discuss their products and to establish new collaborations with scientists, which may lead to future innovative developments.
Often the requirements of research are particularly challenging for a company, meaning a positive push towards a technological breakthrough, but also an extensive work-load, which not always pays off immediately.
In this ATF edition we would like to point out positive examples of cooperations between research and industry described as „good practice“. Furthermore, to emphasize how in the last years always more often scientists decided to undertake the way of entrepreneurship, attention will be payed on those development experiences which led to the foundation of spin-off companies out of medium- and large-size scientific institutions.

At the ATF 2017 the new challenges for the development of the third generation of GW-detectors will be presented and discussed. Speakers from USW (University of the West of Scotland), EGO (European Gravitational Observatory), LMA (Laboratoire Matériaux Avancés), AEI (Albert Einstein Institute), INFN (Istituto Nazionale die Fisica Nucleare) and LZH (Laser Zentrum Hannover) will focus on all the different technological aspects, which have to be improved to reach the next necessary increase of sensitivity in the detection. Cutting-edge technology development is important also for the second phase of the Any Light Particle Search (ALPS II) project, which will be as well introduced and examined during the Forum. If the focus moves more specifically to photon science, different fronts challenge optics development, e.g. broad ranges of pulse duration (typically from the nanosecond to the attosecond) and of wavelength (from X-ray to Terahertz). At the ATF 2017 examples of superior technology progress taking place at DESY (Deutsches Elektronen-Synchrotron) and European XFEL (X-ray free electron laser) in the fields of laser development and X-ray optics will be shown and opened to discussion for interdisciplinary comparison.

A broad spectrum of industrial participants, from well-established enterprises to freshly founded spin-off companies, will present its expertise in specific development areas inspiring new possible collaborations.

1 brochure: https://www.appec.de/doku.php?id=technology





# Scientific topics



## Astroparticle and particle physics

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for GW-detection

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for X-ray free electron lasers

# Coating and thin-layer development

for GW-detection



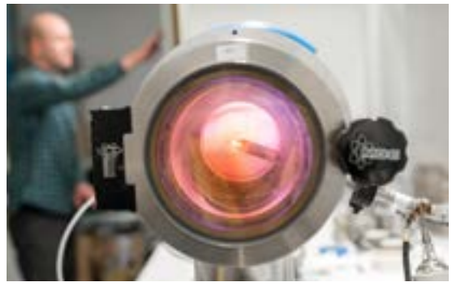
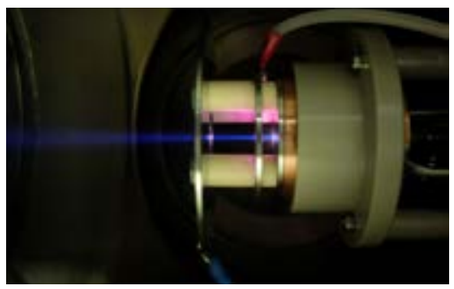
### General

For future gravitational wave detectors to remain quantum noise limited instruments, further reductions in Brownian thermal noise will be required. The dominant source of Brownian thermal noise within the optical cavities of current detectors, such as Advanced LIGO (Laser Interferometer Gravitational-Wave Observaatory), is associated with the dielectric mirror coatings, required for high reflectivity. The optical coatings currently comprise of ion beam deposited (IBD) multilayers of $SiO_2$ and $Ta_2O_5$ (with some fraction of $TiO_2$ mixed in the $Ta_2O_5$ layers) for the low-/high-index layers. Significant reductions in thermal noise will likely require a move towards cryogenics, selecting suitable substrate and coating materials with appropriate properties at these temperatures. The most attractive route, e.g. as detailed within the Einstein Telescope design study in Europe, is the use of silicon optics, and implementing laser wavelengths of 1.5 µm (or possibly longer).

During his talk, **Ross Birney** will provide an overview of the status on amorphous coating materials suitable for use at 1550nm, with a particular focus on the use amorphous silicon coatings. An overview on crystalline coatings will also be provided, including the status of AlGaP thin film growth capabilities being developed in Scotland for the gravitational wave community

### Requirements:

- reduction of Brownian thermal noise associated with the dielectric mirror coatings required for high reflectivity
- cryogenics (possibly)
- silicon optics


http://www.uws.ac.uk/staff-profiles/engineering/ross-birney

University of Glasgow

UNIVERSITY OF THE WEST of SCOTLAND
UWS

# Fiber-optic development



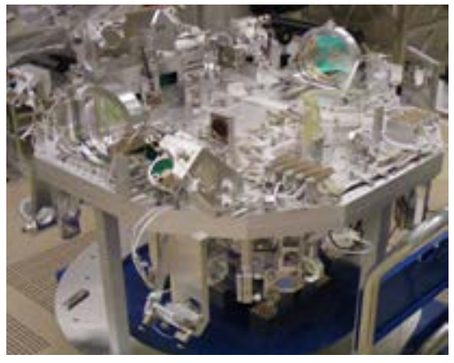
## General

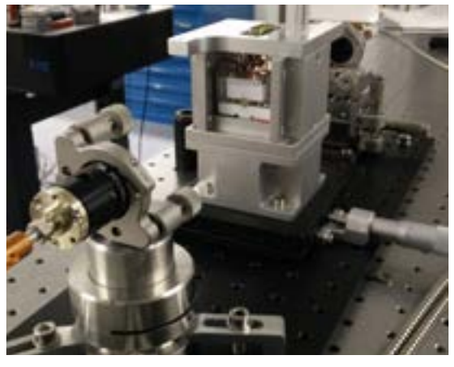
In 2007, LIGO and Virgo, the interferometric gravitational-wave detector of EGO, agreed to join in a collaborative search for GW from sources in and far beyond our galaxy. This means that since then the three LIGO detectors in USA and its German partner GEO600 are linked with the Virgo detector to increase the lieklihood of detecting GW. Nine years later, after the implemantation of different fundamental upgrades in any key stage of the setup, the collaboration gave an outstanding result with the first detection of GW.
Nowadays, in the multiple different laboratories supporting the upgrades in the three main facilities, the R&D teams are coordinated tow apply and further improve cutting-edge technology in order to significantly increase the sensititivity in the GW-detection.
In the specific, at EGO they are investigating the use of optic fibers for the injection part of gravitational waves detectors (optics located between the main laser and the interferometer). The idea is to have components, electro-optics modulators and Faraday isolators, that are fully fibered in order to ease the whole injection subsystem, from the laser (eventually fibered as well) to the Input Mode Cleaner. This would especially be useful for the propagation of the beam between the different benches.

During his talk, **Matthieu Gosselin** will describe the results, challenges and perspectives of the experiments he is carrying out at EGO.

## Requirements:

- management of high power density (hundreds of Watts over hundreds of squared micrometers):
  - non linear effects inside the fibers
  - damaging of the fibers
- design improvements of the components





https://www.ego-gw.it/

# Amorphous-coating development



## General

Thermal noise in optical coatings is the main fundamental limitation to the detection of GW in the frequency band around 100 Hz where the detectors are more sensitive.
The technology used for the Advanced Detectors (i.e. 2nd generation) is based on the amorphous coatings adapted for the 1064nm wavelength.
In the next generation the challenges are given by a reduction of the thermal noise level, the cryogenic temperature operation as well as the room temperature one and the size that should grow from the 350 mm of today to the 600 mm in the future.
An extensive research of all these challenges has already started at LMA in collaboration with several local and Virgo laboratories. Amorphous coatings have the potentiality to fulfil the requirements for the 3rd generation detectors.

During his controbution, **Gianpietro Cagnoli** will give a general introduction on the problem of mirror thermal noise in GW detectors; the requirements for the 3rd generation detectors; a short introduction of LMA and its collaborations on coating thermal noise research; a description of the technological challenges.

## Requirements:

- reduction of thermal noise in optical coatings, especially at 100 Hz
- increasement of the size of the coated surfaces
- room-temperature and cryogenic operation

http://lma.in2p3.fr/Lmagb.htm

# ALPS II



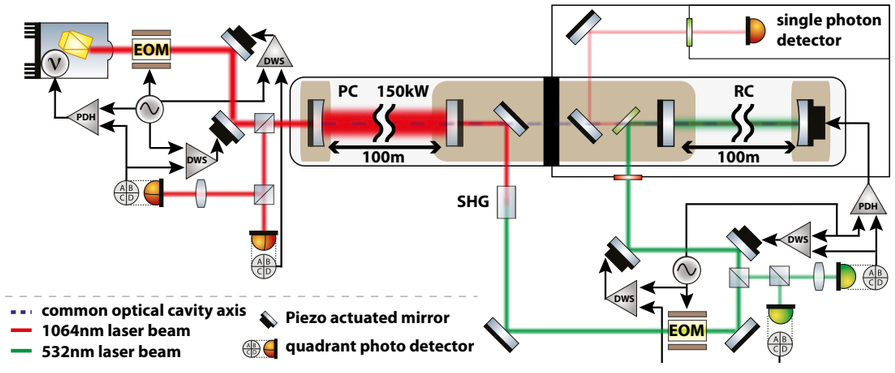
## General

The ALPS Collaboration started in 2007 its first *light-shining-thorugh-a-wall* experiment (ALPS I) searching for photon oscillations into weakly interacting sub-eV particles (WISPs). DESY could show the best laboratory limits for WISPs in 2010, improving previous results by a factor of 10.
After this success, the ALPS Collaboration decided to persue further the search of WISPs and designed the ALPS II experiment. In this phase, the driving observations are of astroparticle-physics nature (e.g. stellar evolution and the TeV-transparency). The Standard Model is not able to explain such phenomena and ALPS II aims to probe into their characteristics regions.

During his talk, **Jan Hendrik Pôld** will describe the concept of the ALPS II experiment and outline the challenges focussing on the precision optics required.

## Requirements:

- ultra stable laser sources,
- resonant optical enhancement techniques,
- string of dipole magnets
- special photosensors with e.g. low dark count and background rates and high efficiency for infrared photons.




https://alps.desy.de/e191931/

# Development of ultrafast optical lasers



## General

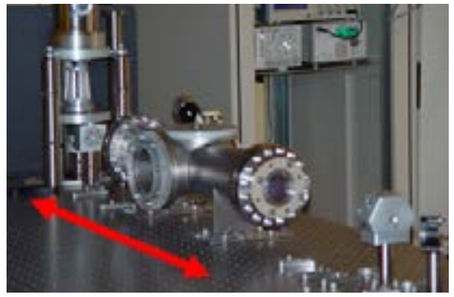
For scientific applications in the study of ultrafast dynamical processes in matter, the Ultrafast Optics and X-Rays Group at DESY is developing ultrafast laser drivers to serve as the primary power in a compact, laboratory sized Inverse Compton Scattering (ICS) X-ray source.
Liquid-nitrogen cooled DPSSLs (diode-pumped solid-state lasers) based on $Yb^{3+}$ offer a clear advantage with regards to all the requirements (on the right). Engineering leverage is gained by an intrinsic several-fold improvements in thermo-optic and thermo-mechanical properties as well as ~decade higher gain-coefficients, which enable simple, passively switched multipass architectures to be implemented. Our progress in scaling chirped-pulse amplifiers has produced 250-Watt at 100-kHz and 160-mJ at 250-Hz based on liquid-nitrogen cooled Yb:YAG in rod and composite thin disk geometries.

In his talk, **Luis E. Zapata** will present operational parameters for these systems as they are presently using them and review the design of the power amplifier stage, now in the building stage, in scaling with a 20-mm diameter cryogenic composite thin-disk towards one-Joule pulse energy at 1 kHz.

## Requirements

For ICS X-ray sources:

- laser-driven THz sources producing tens of millijoules of single-cycle and multi-cycle THz pulses efficiently to accelerate electrons to 15 MeV
- a high energy infrared laser pulse colliding with the electron beam provides the optical undulator to generate the X-rays
- operation at high repetition rates i.e., high average power lasers) to shorten the time necessary in the collection of scientific data
- size, weight and reliability, which are strongly tied on their complexity, have to be suitable



https://ufox.cfel.de/

# Fiber-laser Development



for GW-detection

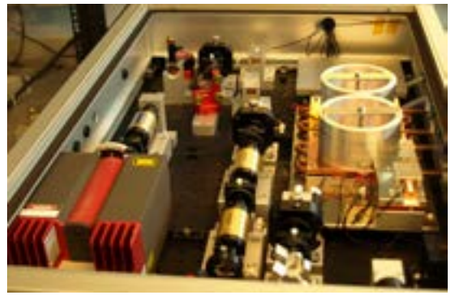
## General

For the first generation of km-scale GW-detectors, solid-state laser technology turned out to be very promising, in particular in the form of non-planar ring oscillators (NPROs) at 1064, because of their linewidth and intrinsic stability.
LZH together with the Albert-Einstein Institute (AEI) and the LZH spin-off neoLase have been responsible for the development of several generations and upgrades of the detectors of LIGO, Virgo and GEO600. The goal has been reached when the LIGO detectors were equipped with the optimized laser systems and in 2016, as part of the advanced LIGO (aLIGO) upgrade, they were involved in the first detection of gravitational waves.
The GW-detectors community is already making plans for the next generation of detectors that will allow for a new era of astronomy.

In his talk, **Michael Steinke** will present the latest challenges and laser developments, which address the new frontiers of reliability and sensitivity in detection. In particular, the new laser systems are based on fiber technology, which allows for high single-pass gain levels and does not require complicated injection-locking schemes. Furthermore, due to a parallel detector development, longer wavelengths in the range of 1.5-2.0 µm are required, where fiber systems have shown good aspects for power-scaling. As result of a collaboration between LZH and AEI, a single-frequency fiber amplifier at 1064 nm has been developed, long-termed tested and will be further upgraded. In addition, a comparable fiber amplifier prototype at 1550 nm will be developed, after the successfull tests of a monolithic system with more than 100 W of output power in the $TEM_{00}$ mode and an investigation of 2-µm single frequency fiber systems is already planned.

## Requirements:

- so far solid-state lasers with:
  - diffraction-limited high output-power levels
  - narrow bandwidths
  - outstanding stability
- for the new generation of GW-detectors, lasers have to provide:
  - even higher output-power levels
  - longer wavelengths
  - enhanced reliability by simple and user-friendly optical concepts all-fiber technology



http://www.lzh.de/en/departments/laserdevelopment/fiberoptics

LZH
LASER ZENTRUM HANNOVER e.V.

# Development of ultrafast optical lasers



for X-ray free electron lasers

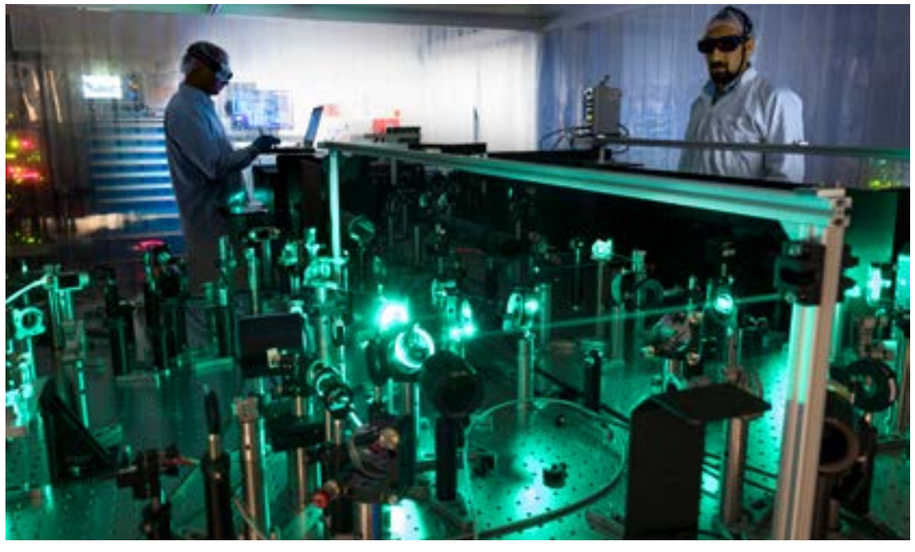
## General

The European XFEL will start its operation in 2017, enabling innovative atomic-scale measurements at high repetition rates and with femtosecond time resolution. Helping to facilitate such experiments are highly specific, synchronized, ultrafast optical lasers, which can be used, for instance, to excite specimens before they are probed with x-rays. At the European XFEL a development of such a laser source aimed at the MHz / millijoule / femtosecond performance level, hence substantially outside the realm of commercial lasers.

In his talk, **Maximilian J. Lederer** will present the main results of the laser development taking place in his group and also highlight some of their long term collaborations with industry in the process.

## Requirements:

- customization on demanding requirements of the accelarator facility and the users
- synchronization to X-ray beam
- support of industry
- versatile system in terms of:
  - energy scaling through a broad frequency change
  - generation of nearly transform-limited pulses in the femtosecond-range
  - generation of multiple wavelengths



http://www.xfel.eu

European XFEL

# Development of diffractive X-ray optics



## General

Multilayers are artificially layered structures that can be used to create optics and optical elements for a broad range of wavelengths. Among other applications, they are enabling technology for extreme ultraviolet lithography (EUVL).
High-brightness X-ray sources, such as next generation synchrotrons and free electron lasers (FELs), pose unique challenges but also great opportunities for the development of X-ray optics. The peak intensities of X-ray pulsed sources, such as FLASH in Hamburg, LCLS at Stanford or upcoming European XFEL in Hamburg, are high enough to convert any material placed in the focused beam into a plasma. Hence, the optics do not only have to meet extremely demanding specifications in figure and finish but also in damage threshold and lifetime, as well as high efficiency and high numerical aperture.

## Requirements:

Optics for high-brightness X-ray sources have to be characterized by:

- demanding specifications in figure and finish
- high damage threshold
- long lifetime
- high efficiency
- high numerical aperture

In her talk, **Saša Bajt** will present how she and her group address these challenges and take advantage of the opportunities given by the work experience with FELs. In particular, she will introduce us the multilayer Laue lenses - novel diffractive X-ray optics with high-aspect-ratio structures, based on thick multilayers.

https://cid.cfel.de/team/multilayer_x_ray_optics/

# Development and implementation of X-ray optics

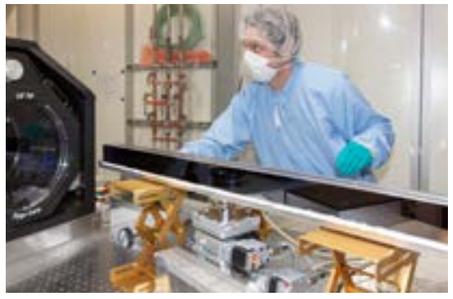


## General

The European XFEL will be comprised of a linear accelarator and three FEL beamlines (SASE1, SASE2 and SASE3) covering the energy range from 250 eV to 24 keV.
For the filtering and the transport of the X-ray pulses to every experimental station, different kind of special optical elements of unprecedent precision have been developed.
**Maurizio Vannoni** will introduce us the different challanges that he and his colleagues in the frame of different collaborations had to face for te realization and installations of such opticl elements.
Reaching high quality polishing is very difficult. To ensure that a mirror is really as flat as needed or that it has a particular and precise shape is challenging. Furthermore, during installation the mechanics could be affected and therefore a perfect optics could change its shape in an unpredictable way. Piezo-actuated silicon optics have been experimented and even commercially produced, but it is questionable if they could be controlled on a single nanometer of reproducibility. In FELs- setups is also very important to have a low vibration level of the optics. Improvements in active or passive dumping of the vibrations by allignment and control optics-holders need to be performed. In addition, there are still unsolved technological issues characterizing the soft-X-ray wavelegth range, e.g. how to produce large Variable Line Spacing (VLS) gratings up to 500 mm long.
A strategy which would optimize the efforts made by different teams is the organization of a platform, at least at European level, where different methods and results are routinely compared between each other. Such opportunity will be also discussed at the forum.

## Requirements:

- single-nanometer reproducibility of adaptive optics.
- vibration-insensitive holders
- large gratings for soft X-rays
- periodic comparisons of methods and results at least within Europe



http://www.xfel.eu

# Companies







# AXILON

AXILON serves the worldwide synchrotron, accelerator and photon science community with state-of-the-art instrumentation and engineering servicecs

Free electron lasers as well as the newest synchrotron light sources demand X-ray optics with extremely low surface errors and highest pointing stability, which results in very challenging requirements for the optic mounts and its adjustment units.

AXILON designs and builds mirrors systems, monochromators and all sorts of other beamline components as well as complete solutions serving those demands.

Based on their competencies and long-term experience of their experts, they can deliver excellent and efficient solutions to the worldwide synchrotron, accelerator & photon science community.

AXILON is interested to build up partnerships to apply the knowledge and experience, e.g. with high-precision mechanics in vacuum, in other fields. At the Forum, **Timm Waterstradt** will introduce the company to the audience.

http://www.axilon.de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# Bernhard Halle Nachfolger

Bernhard Halle Nachfolger provides the design and the production of a great variety of precision optical elements. Their workshop produces optical components of the highest quality made from crystals and optical glasses. With a teamof scientists, they also provide optical design services as well as support in identifying the optimized solution for customers' tasks



## Range of services

Bernhard Halle Nachfoger offers quick delivery for many components from their catalogue containing more than 500 products. Furthermore, they have in-house capabilities for design and production of custom optics. A special focus is put on:

- polarizers
- wave plates (retarders)
- lens systems (UV to IR)
- reflective optics
- prisms and beam splitters
- design od polarization optical systems
- design of lens systems

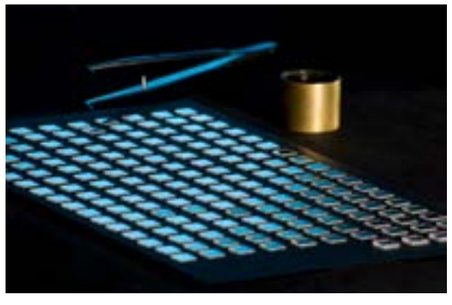
## Special equipment

The combination of traditional production techniques with modern measurement equipment enables us to manufacture small series with reasonable effort. This opportunity can give our partners a key advantage in research projects as well as in meeting the increasing demand for customized products.

## Current state-of-the-art technologies

- polarizers with extinction ratio down to $10^{-8}$
- superachromatic wave plates for the range 310-1100 nm
- apochromatic lens systems for the range 190-1100 nm

In his talk, **Jakob Silbermann** will give a short introduction to the history of the company Bernhard Halle Nachfolger and the range of products it provides. Furthermore, it will be focused on broadband achromatic waveplates and an example how they can be customized. The talk will be summarized by the description of an experimental setup that includes such a customized broadband achromatic waveplate to generate circular polarized light in the EUV.



https://www.b-halle.de

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# CMS - Crystalline Mirror Solutions

Crystalline Mirror Solutions manufactures low-noise refelctive optics using a proprietary coating technology



Ultrastable optical interferometers require mirrors that simultaneously exhibit excellent optical and mechanical quality. The current bounds of stability and sensitivity in these systems are dictated by the mechanical dissipation and thus the corresponding Brownian noise level of the high-reflectivity interference coatings that comprise the cavity end mirrors.

A spin-off of fundamental quantum optics research from the University of Vienna, Crystalline Mirror Solutions has developed a novel microfabrication technique that enables the transfer of low-loss single-crystal semiconductor heterostructures onto arbitrary optical surfaces. These "crystalline coatings" simultaneously exhibit minimal mechanical and optical losses, with mechanical loss angles an order of magnitude below that of ion-beam sputtered dielectric coatings at room temperature and over a factor of one hundred lower at cryogenic temperatures, coupled with sub-ppm levels of optical absorption and scatter losses at the few ppm level for relevant wavelengths spanning 1000 to 2000 nm. The excellent optical quality in these crystalline mirrors has enabled cavity finesse values in excess of 300,000 in the near infrared for coatings on fused silica, sapphire, and silicon substrates, with coating sizes from the single centimeter-level up to diameters of 10 cm, with a clear path to manufacture 20-cm transferred coatings. The remaining technical hurdle lies in the further scaling of these optics to diameters of 30+ cm.

In his presentation, **Garrett D. Cole** will outline the development steps required for the successful implementation of their crystalline coatings in future generations of laser-interferometer-based gravitational-wave detectors.

http://www.crystallinemirrors.com

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# Coherent

Coherent is one of the world's leading suppliers of laser solutions.
Their portfolio of laser tools and optical components are used in scientific, industrial and medical applications



Considering the broad market of products that Coherent can offer, at the ATF 2017 the focus will be pointed on the Mephisto product line - ultimate low-noise laser performance.

Mephisto single frequency ultra-narrow linewidth lasers were successfully integrated in Coherent's scientific products portfolio in recent years while continuing to serve most demanding low noise applications.

In his talk, **Volker Leonhardt** will review the current status of Mephisto product line with the focus on GW applications. The potential methods of power and wavelength scaling will be discussed.

https://www.coherent.com

COHERENT.

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Scotland, UK

# Cycle

The mission of Cycle is to commercialize femtosecond laser technology and related developments of the Ultrafast Optics and X-rays group at DESY



Cycle GmbH is a spin-off company from DESY founded in 2015 by Franz X. Kärtner and co-workers from his research group at DESY.

A first series of products solves the timing and synchronization problems of customers that need to time and synchronize multiple laser and microwave sources with femtosecond or even sub-femtosecond accuracy.

Potential customers are ultrafast laser laboratories in general that may only need to tightly synchronize two femtosecond lasers up to km-scale X-ray Free-Electron Laser facilities such as the European XFEL.

In his talk, **Franz X. Kärtner** will explain the principles of operation of such timing distribution systems and will discuss the specifications reached today.



http://www.cyclelasers.com

Cycle

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# FiberBridge Photonics

FiberBridge Photonics offers customized fiber components (e.g. splitter, coupler) and fiber assemblies (e.g. amplifier modules, beam delivery systems) for a wide range of fiber types in the wavelength range between 350 and 2200 nm



FiberBridge Photonics is a spin-off company of the Laser Zentrum Hannover e.V. - founded based on 10 years of experience in fiber component manufacturing and fiber-based laser development.
FiberBridge Photonics - your partner for fiber-based light guiding solutions.

Challenging scientific projects often need cutting edge technology. For the laser development of the 3rd-generation GW detectors fiber laser systems seems to be a very promising solution. Key advantages are power scalability, high optical-to-optical efficiency, modularity and the possibility for a monolithic all-fiber structure accompanied by low frequency- and power noise as well as extreme low laser beam pointing. For the realization of monolithic all-fiber structures FiberBridge Photonics provides precisely manufactured customized fiber components, such as fiber couplers or splitters and highly integrated fiber assemblies, such as fiber amplifier modules.

In his presantation, **Thomas Theeg** will show that the availability of sophisticated fiber components - preserving the optical properties and allowing complete fiber integration - is the key for successful laser development for the 3rd-generation of GW-detectors.

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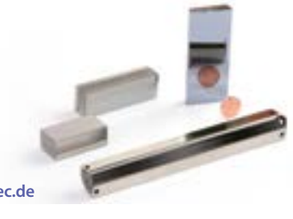
# Incoatec

Incoatec develops and manufactures sophisticated multilayer and total-reflection X-ray optics as well as microfocus X-ray sources for in-house crystallography and synchrotron applications



For synchrotrons Incoatec developed coatings with a length of up to 150 cm for beam conditioning (together with their partners from HZG - Helmholtz-Zentrum Geestacht), multi-stripe multilayer optics for tomography beamlines and 2-dim beamshaping multilayer optics, so called Montel-Optics, for inelastic scattering applications.
In the home-lab multilayer based Montel Optics are widely used as an essential component in modern X-ray diffractometers. These optics consist of bent substrates with shape tolerances below 100 nm, upon which multilayers are deposited with single-layer thicknesses in the nanometer range and up to several hundreds of layer pairs. The multilayers are designed with lateral thickness gradients within ± 1% deviation of the ideal shape. Very low shape tolerances below 100 nm and figure errors below 5 arcsec are required for multilayer mirrors to ensure a superb flux density of more than 4 x $10^{11}$ photons/s/mm$^2$ in combination with very high-brightness microfocus X-ray sources, such as the novel liquid metal jet X-ray source.
Incoatec uses sputtering technology for deposition, optical profilometry in order to characterize the shape and X-ray reflectometry and the multilayer thickness distribution, both laterally and as in-depth. For X-ray analytics the important beam parameters are monochromaticity, flux, brilliance and divergence. They demonstrate the quality of the combination of suitable X-ray sources with selected multilayer optics.

In his contribution, **Jörg Wiesmann** will be giving an overview on current developments of multilayer optics for analytical X-ray applications in the lab as well as for synchrotron applications. He will be explaining the manufacturing process of the optics, summarizing the different types of optics and giving some examples of typical applications which benefit from the new possibilities, especially in combination with modern microfocus X-ray sources.
Furthermore, he will be showing first results of a 50 cm laterally graded multilayer optic, developed for a special mini-synchrotrons and a multi-stripe multilayer optic with an optimized coating for different beam energies in the range of 10 to 45 keV which is used at the tomography beamline at the Swiss Light Source.

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# Laseroptik

LASEROPTIK focuses on the development and production of optical coatings and components for high-power laser applications and precision metrology in industry, medicine and research



LASEROPTIK employs a wide and increasing range of measuring equipment for quality inspection and process optimization to the benefit of their customers.

In his talk, **Robin Bähre** will present an overview of their coating technologies for high-power and low-loss applications, very large optics and other special configurations such as dispersive mirrors, low-stress coatings to meet high flatness requirements and qualification for spaceborne conditions.

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# neoLASE

neoLASE provides Master Oscillator Power Amplifier - MOPA - laser systems by combining innovative seed laser sources with well-established and reliable solid state laser amplifiers



The increasing demands in laser technologies require high flexible and comprehensive laser system designs.

For these areas the neoVAN amplifier family allows power and energy scaling from highly stable and low-noise single-frequency radiation up to high energy picosecond laser pulses. The flexibility of the amplifier modules allow configurations with more than 40 dB gain, output power levels up to 100 W or high energy milijoule class laser pulses with excellent beam quality.

In his presantation, **Maik Frede** will introduce us the new neoVAN amplifier family of products of neoLASE and their potentials in different fields.

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# Zygo Corporation

Zygo Corporation is a worldwide supplier of optical metrology instruments, high precision optical components, and complex electro-optical system design and manufacturing services

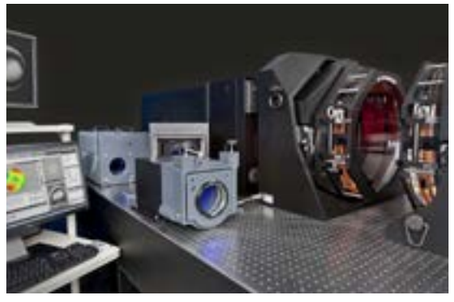


Zygo Corporation is specialised in different business segments.
Zygo's Optics business segment is a world leading manufacturer, featuring innovative and proprietary manufacturing technologies combined with a synergistic relationship with its Metrology business segment.

Zygo's Metrology business segment is a global leader in non-contact interferometric metrology.
Zygo's solutions include production, process control, and R&D tools for semiconductor, optics, display technologies, precision machining, photovoltaic, and research applications.

**Torsten Glaschke**'s talk will be about the fabrication and metrology of demanding optics for scientific applications.
In details, he will introduce:

- optics for Gravity Wave Interferometers
- advanced LIGO
- Beam-line Grating Blank Substrates manufacturing
- Zygo interferometric metrology
- laser interferometers
- scanning coherence interferoemters
- displacement interferometers and interferometric absolute position sensors



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# Your Notes

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