2nd ASPERA Technology Forum

ASPERA

20-21 October 2011 - EGO/Virgo Site (Cascina), Pisa

Mirrors and Lasers in Astroparticle Physics Infrastructures

Academia meets industry!

Publication: March 2012

SEVENTH FRAMEWORK PROGRAMME

2nd ASPERA Technology Forum

«Mirrors and Lasers in Astroparticle Physics Infrastructures *Academia meets industry*»

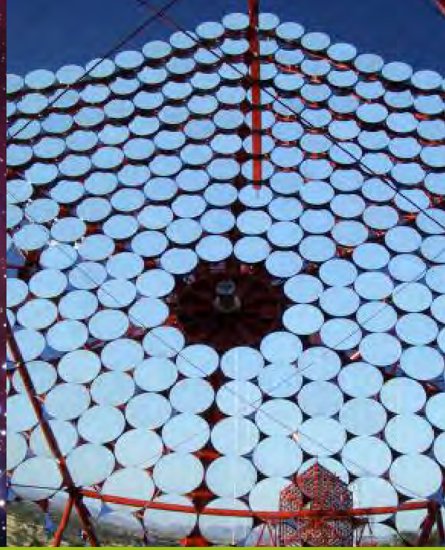
Images & Graphics

Coverage page:
- ET at night (with content from Hubble website. Credit: R. Williams (STScI), the Hubble Deep Field Team and NASA).
- VERITAS Telescopes, VERITAS collaboration.

Publisher

Astroparticle Physics ERA-Net
ASPERA-2 Contract N°: 235489
Coordinator: Thomas Berghoefer – PT-DESY, Germany
www.aspera-eu.org





Content

Forward

To some extent, Astroparticle Physics (ApP) can be considered as the science of rare events, arising in some cases from the most violent phenomena in the Universe, happening fortunately far away! Nonetheless, detecting such weak signals and understanding their nature / origin are of paramount importance in our understanding of the fundamental laws governing the Universe.

Identifying rare and weak signals requires imagining appropriate experiments and then going from conceptual design to the realisation of sophisticated and large size facilities with technical performances often beyond the exciting technological abilities. Accordingly, to constitute the indispensable large spectrum of expertise, close collaboration / cooperation between academia and industry is a must.
ASPERA, a European ERA-Net project started within FP6 (2006 – 2009) and being continued in FP7 (2009 – 2012), has been developing an ambitious approach for i) facilitating the creation of large enough collaborations in ApP in Europe, ii) strengthening / creating bridges between public research institutions and companies, especially via the organisation of Technological Forums.

The present event is focused on lasers and mirrors.

Actually, new generation of facilities for the detection of Gravitational Waves (GW) and (very) high energy gamma rays (HEGR) are in R&D phases.

The first topic deals with one of the most fascinating predictions of the General Relativity, going back to 1916 and still undiscovered! Detectable signals are expected resulting from merging / collision between black holes, binary neutron stars… The third generation interferometic detectors is planned to be constructed underground and use cryogenics technology, with unprecedented requirements on the characteristics and performances of lasers and mirrors.

The realm covered by the second topic spans phenomena due to supernovae, pulsars, merging galaxies… Hunting rare events requires a very high selectivity and hence minimised background. The Cherenkov Telescope Array project anticipates various sized telescopes in order to pin down the sources of the HEGR and uncover the mysteries of underlying mechanisms. Here also, the required characteristics and performances go far beyond the state-of-the-art in the ground-based telescopes.

In summary, the ApP community needs to impulse highly challenging R&D in optics, lasers and mirrors. Innovations in all those areas will certainly also allow companies to apply the gained expertise in other fields at the heart of social needs and concerns: energy, environment, health…

Next generation observatories and the Einstein gravitational wave Telescope project

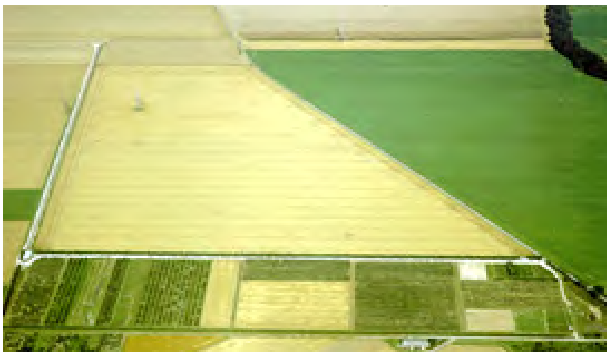
An important prediction of the General Relativity Theory of Albert Einstein is the existence of the gravitational waves, a small perturbation of the space-time generated by accelerated stellar bodies, propagating at the speed of light. Although the existence of this kind of radiation has been indirectly confirmed by the observation of the orbital period decrease in the Pulsar Binary system PSR1913+16, measure that has been worth the prize Nobel in 1993 to R. A. Hulse and J. M. Taylor, its direct detection is still missing. In the last two decades giant size interferometric detectors have been studied, designed, realized, commissioned and operated in the World, aiming to the detection of such as elusive radiation. In Europe two of these facilities are currently operating: the Virgo and the GEO600 detectors. The challenging requirements of these machines pushed the development of new technologies in the optics and laser fields. Low absorption and dissipation coatings, new polishing technologies, low noise continuous wave and high power lasers, injection of squeezed states of light are some of the technological progresses induced by this kind of fundamental research. A new generation of advanced detectors is currently under installation in the sites hosting the initial detectors; the sensitivity of these new machines will finally allow the detection of the gravitational waves.

Furthermore, a 3rd generation of gravitational wave observatories is currently under study; the aimed sensitivity will finally open the era of the Gravitational Wave precision Astronomy, complementing the observation of the Universe currently performed by radio, optical and gamma observatories in a multi-messenger approach. A pioneer project, addressed to the design of a 3rd generation GW observatory has recently been supported by the European Commission under the Framework Programme 7 (FP7): The Einstein Telescope (ET) Gravitational Wave Observatory. New optical materials, new laser wavelengths, new coating technologies need to be developed to realize ET and a long R&D programme is requested.

Submitted by: **Michele Punturo, INFN Perugia & EGO**

Introduction

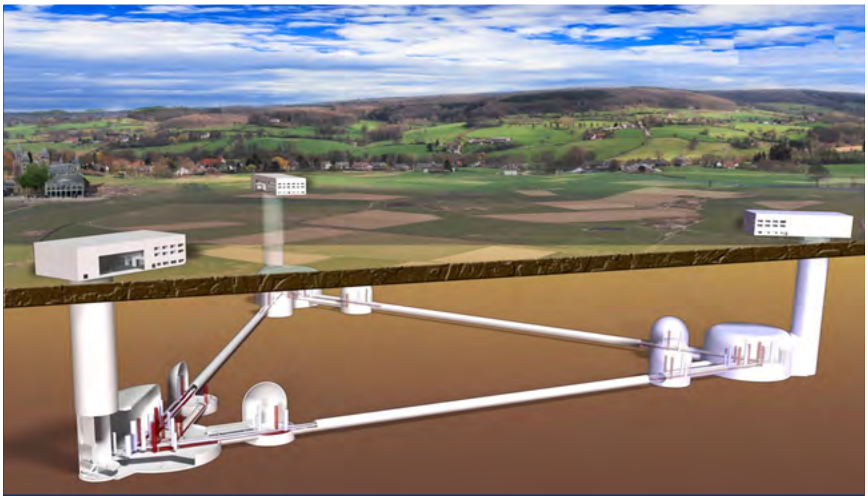
Some three hundred years after Galileo observed the first Jovian satellites, the twentieth century heralded a new era in observational astronomy with radio and microwave antennas and gamma- and X-ray detectors, which revolutionized astronomy and opened the entire electromagnetic spectrum for observing and understanding the Universe. Each new spectral window has unveiled a new source or phenomenon that could not have been discovered in any other way. A remarkable revelation coming from these observations is that, through the electromagnetic telescopes we are able to investigate a small fraction (~4%) of the Universe and that gravitational interaction powers the most luminous and spectacular objects and phenomena such as quasars, gamma-ray bursts, ultra luminous X-ray sources, pulsars, and the evolution of the early Universe.



Aerial view of the GEO600 detector (Hannover, Germany).
Interferometer arms are 600 m long.

Aerial View of the Virgo detector (Cascina, Pisa, Italy).
Arms of 3 km long are well visible.

Despite its fundamental contribution to all the phenomena of the Universe, gravity is not playing an important role as investigation tool. But this is about to change. Einstein's General Theory of Relativity is among the most successful physical theories of the 20th century. It has passed, until now, with flying colors all laboratory-based experiments and solar system tests. It predicts that dynamical systems in strong gravitational fields will release vast amounts of energy in the form of gravitational radiation. This radiation has the potential to open a new observational window to the Universe, complementing the electromagnetic window. Furthermore, a gravitational wave interacts weakly with matter; this is a major difficulty for the detection of this kind of radiation, but it is this property that makes it a powerful investigation tool for the core processes of the astronomical events and for the farthest cosmological events, otherwise undetectable because of the shielding effect of the surrounding matter.



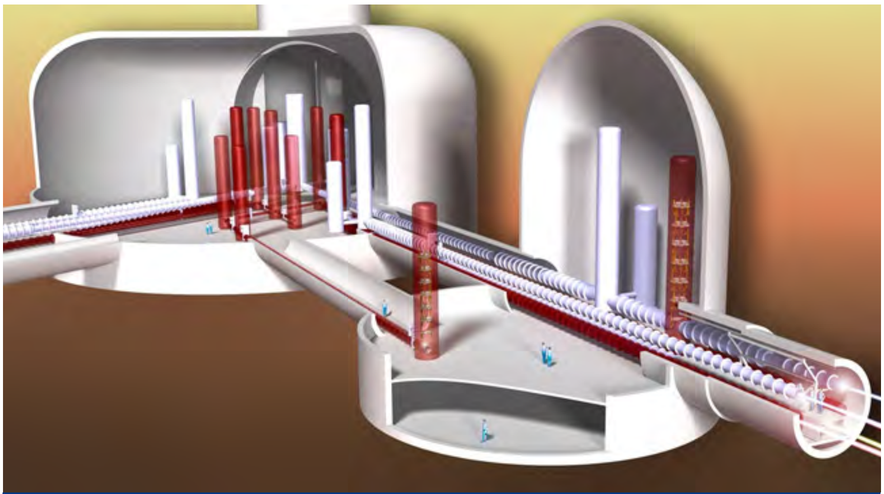
Artistic view (not in scale!) of the Einstein Telescope (ET) Gravitational Wave Observatory.
Arms of 10 km long and corner stations are expected to be about 100-200 m underground.

A gravitational wave can be described as a small perturbation of the flat space-time and the detectors are designed to reveal this small ripple. Initial interferometric detectors have just concluded their data taking and are currently being upgraded to the advanced (or 2nd generation) phase to be completed in few years; this will be the first steps in establishing the field of gravitational astronomy. Advanced Virgo and Advanced LIGO are expected to observe several tens of inspiralling and merging binaries of neutron stars (NSs) and black holes (BHs) each year. They could also detect occasional Galactic sources such as transients associated with supernovae, glitching pulsars, or soft gamma-ray bursts. This phase of observation will, for the first time, test Einstein's theory in the dissipative regime beyond the basic quadrupole approximation, verify the existence of binary black holes (BBHs), measure the speed of gravitational radiation relative to the speed of light and map the expansion rate of the Universe on scales of hundreds of megaparsec[1] (Mpc), providing a completely independent determination of the Hubble parameter, which allows estimating the expansion rate of the observable Universe. Advanced Virgo and Advanced LIGO will be sensitive to binary neutron stars (BNSs) at a distance of 200 Mpc and to stellar mass BBHs at a redshift[2] of z = 0.5. The lower frequency cut-off of a detector places an upper limit on the total mass of binary systems they can detect. A lower frequency cut-off of 20 Hz in the case of Virgo and LIGO limits the total mass to be less than about 200 solar masses.

[1] Mpc = Mega-parsec =10^6 parsec. The parsec is a unit of length used in astronomy corresponding to 3.26 year or 3.1 x 10^{13} kilometers.

[2] An observer detects the radiation emitted by a moving source with a different wavelength with respect to the emitted one. This is the so-called Doppler Effect. If the observer-source relative velocity increases, the detected wavelength (λ) is larger and it is usually indicated as "redshift". In cosmology, the redshift is essentially due to the expansion of the Universe, and the redshift of a source indicates, through the cosmological model relating recessional velocity to the expansion of the universe, its distance from the Earth. In astronomy, it is customary to refer to this change using a dimensionless quantity called z, defined by $z = (\lambda_{observed} - \lambda_{emitted}) / \lambda_{emitted}$, or $1+z = \lambda_{observed} / \lambda_{emitted}$.

To open the era of the precision gravitational astronomy and cosmology it is needed to improve the amplitude sensitivity by an order of magnitude beyond the design sensitivity of the advanced detectors and extend the frequency sensitivity down to 1 Hz. This will allow astronomers to explore, for example, binaries at cosmological distances and unveil new sources. To reach these sensitivity targets a new research infrastructure, implementing novel optical-, laser-, and mechanical-technologies is needed: the Einstein gravitational wave Telescope (ET). ET would observe BNSs up to a redshift of z~2; the stellar-mass BBH population out to the edge of the Universe (z~15) and intermediate-mass (10^2-10^4 solar masses) BBH out to a typical redshift limit of z~5. ET will be sensitive to supernovae out to a distance of 15 million light years within which one can expect to observe an event every year. An observatory with the capability of ET will produce tremendous scientific payoffs. ET will make it possible to observe a greater variety of phenomena and provide a new tool for expanding our knowledge of fundamental physics, cosmology and relativistic astrophysics.



Artistic view of the underground halls of the ET observatory.

The main purpose of the ET project is the realization, in the 2020s, of an infrastructure (an “observatory») capable of hosting more than one GW detector. This infrastructure will be usable for many decades, while the implemented detectors will undergo successive upgrades or replacements according to the current state of the art of interferometer technologies. To reduce the effect of the residual seismic motion, hence allowing a better sensitivity at low frequencies (between 3 and 100 Hz), ET will be located underground at a depth of about 100 m to 200 m and, in the complete configuration, it will consist of three nested detectors, each in turn composed of two interferometers (xylophone configuration). The topology of each interferometer will be the dual-recycled Michelson layout with Fabry-Perot arm cavities, with a length of about 10 km. The xylophone configuration of each detector devotes one interferometer to the detection of the low-frequency components of the GW signal (2-40 Hz) while the other is dedicated to the high-frequency components, each interferometer adopting different, optimal technologies. In the former (ET-LF), operating at cryogenic temperature, the thermal, seismic and radiation pressure noise sources will be particularly suppressed; in the latter (ET-HF) the sensitivity at high frequencies will be improved through extremely high laser light power circulating in the Fabry-Perot cavities.

Instruments

The limitations of the current technologies in the gravitational wave detector optics can be partially summarized in the following list:

Quality of the optical surfaces: to reduce the optical losses in the gravitational wave detectors the surfaces of the optical components must be as close as possible to an "ideal" sphere; for this reason **polishing technologies**, able to arrive to a sub-Angstrom micro-roughness and sub-nanometer flatness, must be further developed especially for large optics; in fact, in the Einstein Telescope the diameter of the main optics will almost double with respect to the advanced detectors. In parallel, to achieve these requirements, the **metrology procedures and technologies** must be further improved, for verifying the quality of the optical component during the production procedure.

Thermo-optical-mechanical properties of the optics: absorption, uniformity, expansion coefficient, and mechanical dissipation of the materials composing the optics (substrates and coatings) are the origin of the main limitations of the performances of gravitational detectors. The development of new materials for the substrates, having less than 0.1 ppm/cm of optical absorption, able to operate also at cryogenic temperature and with new laser wavelength (for example 1 550 nm instead of 1 064 nm), new formulae for the chemical composition of the dielectric coatings, new geometries for the multilayer structure of the coatings, in order to reduce the absorption to less than few tenths of ppm and the dissipation by at least a factor ten with respect to the current values, are needed to realize the Einstein Telescope.

Monitoring and compensation: the capability of measuring the status of the optics in the gravitational wave detectors on line, monitoring, for example, the thermal deformation induced by minimal absorption of laser light, and to actuate accordingly, in order to recover the ideal conditions is crucial in future (and present) gravitational wave detectors. A wide range of optical sensors is used for control and monitoring of HeNe, Nd:YAG and CO2 lasers: photodiodes, quadrant photodiodes, PSDs, cameras, wave front sensors, etc... Very high quantum efficiency photo-diodes on large area or off-axis Hartmann sensors with accuracy better than λ/1 000 require further research and development. Radiative heating and radiative cooling techniques allow correcting the wavefront aberrations by homogenizing the temperature distribution inside the substrates. Additional R&D is required to improve, for instance, CO2 scanning systems or other kinds of adaptive optics systems in the infrared (IR).

The previous list of required improvements in the optical technologies for gravitational detectors is strongly linked to the requested progresses in the laser technologies. In fact future GW detectors will need high power continuous wave lasers, operating both at 1 064 and 1 550 nm, having low noise profiles (RIN < 10^{-9} $Hz^{-½}$, frequency noise < 10^{-3} Hz/$Hz^{-½}$); probably new fiber technology will replace the current solid state lasers, if the requirements in terms of noise, disturbances immunity, reliability will be achieved. In particular, reliable laser diode long term (> 2 years) performance is mandatory. CO2 lasers are used to correct for thermal effects induced by absorption of the laser light. High power, better reliability, excellent power stabilization (RIN < 10^{-7} $Hz^{-1/2}$) and high quality beam shape (TEM00 content > 99%) are the key points for such systems.

Finally, the simulation technologies are crucial to understand, design, test and commission all the optical components of the GW detectors. New optical simulation software, based on FFT propagation, frequency domain codes and higher order Gauss modes, have been developed in the gravitational wave community to design and characterize the optics, as well as the controls of the multiple coupled optical cavities. These simulations are used to translate control requirements into optical requirements, in particular mirrors flatness and roughness. Some effects as radiation pressure are not yet fully implemented into these codes. Various independent codes ensure across-validation of the results, but vary in user friendliness and versatility and computational efficiency. Developments in the usage of GPUs for the optical simulations are needed.

R&D

The R&D activities are performed by the laboratories of the institutions participating in the Virgo, GEO600 and ET projects. An incomplete list is described hereafter. Laser technologies are mainly investigated.

- In Germany, by the Max Planck Institut für Gravitationsphysik (MPG) in Hannover, in collaboration with the Laser Zentrum Hannover (LZH) and neoLASE, a local SME;
- In France, by the Virgo group in the l'Observatoire de la Côte d'Azur, Nice, in collaboration with a French company, EOLITE.
- The European Gravitational Observatory (EGO) in Italy, is engaged in the development of many optical components for the Virgo detector; in particular the development of the optical components of the laser injection system (Faraday optical isolators, mode matching telescopes) and in the optical shields ("baffles" and light dumps) needed for the suppression of the diffused light; new materials (Silicon, Silicon Carbide) for these components are investigated in collaboration with Boostec, a French company. Dielectric coating R&D is led by the CNRS Laboratoire des Matériaux Avancés (LMA) in Lyon, having a crucial role also in the metrology for the Virgo optics and collaborating with the fused silica substrate producers (Heraeus Quarzglas GmbH) and polishers (Coastline Optics, Inc.) for the characterization of the optics.
- The INFN laboratory in the Università di Roma "Tor Vergata", Italy, is developing the thermal deformation monitoring and compensation system for the Virgo main optics.
- The Glasgow University group, member of the GEO600 collaboration, is leading the research on the minimization of thermal noise in GW detectors through the reduction of the mechanical dissipations in the main optics; a particular chemical bonding technique of optical components is investigated in collaboration with Gooch & Housego (UK) Ltd.
- The Birmingham University GEO600 group is one of the developers of the simulation tools for the GW interferometers.

Optical components and technologies suppliers for the GW detectors, in addition to the previously cited companies, are CVI MellesGriot, Gestione SILO srl, II-VI ITALIA S.R.L. and ZygoLOT GmbH.

E.T. Project

A design study project in the European Framework Programme FP7.

An European Consortium:

- 8 European research institutes leader in the gravitational wave experimental research.
- Almost 200 scientists involved from the 8 members states
- Open to the community of gravitational waves; around 30 scientists from other countries.
- The project will be run as observatory.

Construction phase (tentative)
Partial start in 2016.

Links

Virgo experiment -- https://wwwcascina.virgo.infn.it

GEO600 Experiment -- http://www.geo600.org

The ET project -- http://www.et-gw.eu

A glance at the future with the Cherenkov Telescope Array observatory

Gamma-rays provide a powerful insight into the non-thermal universe and perhaps a unique probe for new physics beyond the standard model. Current experiments are already giving results in the physics of acceleration of cosmic rays in supernova remnants, pulsar and active galactic nuclei with a hundred sources detected at very-high-energies so far. Despite its relatively recent identification, very high-energy gamma-ray astronomy has proven to have reached a mature technology with fast assembling, relatively cheap and reliable telescopes.

The goal of future installation is to increase the sensitivity by a factor of ten compared to current installations, and enlarge the energy domain from few tens of GeV to a hundred TeV. Gamma-ray spectra of astrophysical origin are rather soft thus hardly one single size telescope can cover more than 1.5 decades in energy. Therefore an array of telescopes of 2-3 different sizes is required. Hereafter, we present design considerations for a Cherenkov Telescope Array (CTA), a project for a new generation of highly automated telescopes for gamma-ray astronomy.

Submitted by: **Michele Doro, Universitat Autònoma de Barcelona**

Introduction

Gamma-ray astronomy as a probe for cosmic rays

Despite its origin goes back to only few decades ago, ground-based gamma-ray astronomy has already demonstrated to be a mature scientific technique to probe non-thermal phenomena in the universe, where cosmic-ray (CR) particles are accelerated to extremely high-energies. CRs of non-thermal origin can be accelerated either directly at the place of origin, for example nearby the surface of a fast rotating pulsar, or may gain energy in cosmological times through interaction with irregular cosmic magnetic fields or shock wave fronts.

CRs cover a vast range of energies, from 10^9 to 1 0^{21} eV. Below 100 GeV the CR interaction with the solar wind is efficient and they are absorbed. Their flux covers more than 32 orders of magnitude, and they are distributed roughly according to a power-law of spectral index -3.

There are many publications about CRs, but still conclusive evidence about how and where they are accelerated, is missing. CRs are mainly composed of protons and helium, with smaller percentages of heavier elements and electrons. Due to the rapidly falling fluxes of CRs, it is experimentally difficult to cover an energy band larger than few decades in energy by a single experiment. Therefore different experimental techniques are needed for different energy ranges. They are typically investigated with balloon-borne calorimeters and ground-based detectors. Late in the second half of last century, it was recognized that gamma-rays (GRs) could provide a useful tool to investigate the origin of CRs. First of all, GRs are neutral, thus they travel undeflected by inter-stellar or inter-galactic magnetic fields and therefore trace back their origin, and second, they interact with local radiation/dust fields thus providing useful information on the morphology of the emission region.

Scientific case

As in the case of CRs, it is not possible to construct a single observatory which could cover the entire GR spectrum because of the rapidly falling flux with GR energies. From an experimental point of view, two sub-ranges are defined at high energy (HE; MeV-GeV) and very-high energy (VHE; GeV-TeV). For many sources the combined power emitted at these energies overcome the total power emitted at other wavelengths, and therefore HE and VHE astrophysics has attained large attention over the last years.

The goals of GR astronomy could be divided in three categories: the galactic targets, like pulsar and pulsar-wind nebulae (PWN), supernova remnants (SNR) and star-active region like OB-associations or binary systems. Another fundamental target in this family is the galaxy center (GC). Among the extragalactic targets, stand the active galactic nuclei (AGN), particularly blazars and radio-galaxies. Galaxy clusters, starburst and merging galaxies are also interesting targets. Finally, gamma-ray bursts (GRBs) are also among this category.

There is a third family of observation about fundamental physics, which can be studied within GR astronomy. At first place is the study of dark matter (DM) annihilation or decays, which could have very clear GR signatures. The extragalactic background light (EBL) can be studies through the GR absorption from distant targets to understand the universe transparency.

The Imaging Atmospheric Cherenkov Telescope technique

Very-high energy GRs impinging on the earth, interact with atmospheric nuclei and generate an electromagnetic shower. The showers extend over several kilometers in length and few tens to hundreds of meters in width, and their maximum is located at 8-12 km altitude, in case of vertical incidence. For gammas roughly below 100 TeV, the shower particles stop high up in the atmosphere, and cannot be directly detected at ground. However, a sizeable fraction of the charged secondary shower particles, mostly electrons and positrons in the shower core, move with ultra-relativistic speed and emit Cherenkov light. This radiation is mainly concentrated in the near UV and optical band and therefore passes mostly non-attenuated to the ground. Imaging Atmospheric Cherenkov Telescopes (IACTs) reflect the Cherenkov light at the focal plane where a multi- pixel camera records the shower image. The technique was pioneered by the Whipple experiment, which first detected the Crab Nebula at VHE, in 1989.

Current IACTs Technology and experiments

Currently, the world largest ground-based IACTs are HESS, MAGIC and VERITAS (see Figures below).

HESS is an array of 4 clone telescopes, each of 12 m diameters, located in the Gamsberg Mountain in Namibia and is operating since 2003 with a very high scientific impact. A fifth telescope, dubbed HESS-II, of 28 m diameter, is under construction at the center of the array.

MAGIC has operated since 2004 with a single dish of 17 m diameter and parabolic profile in the Canary island La Palma.

A more recent experiment was started in the Arizona desert in USA, following the successful experience of the Whipple experiment. VERITAS has rapidly reached the expected performance, with sensitivity comparable to HESS and has already collected important scientific results.

HESS array of four telescopes, Namibia.

MAGIC array of two 17 m diameter telescopes, La Palma.

Recently completed four IACT array VERITAS at Mt Hopkins, Arizona.

IACT, a well proven technology

Given that its origin traces back to the late 70's, IACTs has reached a mature technological development. In the following, the basic features will be discussed.

Mounting: HESS, MAGIC and VERITAS have an alt-azimuth mount, but while the former two have structures rotating on wheels, VERITAS has a sole central mast and therefore an easier design. HESS is built from stainless steel while MAGIC is made of lighter carbon-fiber reinforced-plastic (CFRP) tubes.

Mirrors: The demands for the quality of mirror facets for IACTs are quite less challenging than for optical telescopes, because IACTs focus on the intrinsic-aberrated Cherenkov light from atmospheric showers. On the other hand, the facets are exposed to the environment and must be robust. A classical solution is the use of quartz-coated aluminized glass substrate. An innovative solution was used by MAGIC, based on all-aluminum diamond-milled sandwiches with hex-cell honeycomb interspaced. This technique has proven to produce mirrors with reflectivity loss more than 5 times smaller compared to standard techniques. MAGIC II is also featuring novel glass-aluminum sandwich mirror facets.

Focal-plane instrumentation: HESS, MAGIC and VERITAS have a focal-plane instrumentation composed of a multi-pixel camera of photo-multiplier tube (PMTs; 960, 576, 1038, 499 for HESS, MAGIC-I, MAGIC-II and VERITAS respectively). PMTs are an optimal solution due to their high gain and fast read-out. A drawback is their limited photon conversion efficiency for Cherenkov photons, currently about 20-25%. More performing devices are under research, as will be discussed later.

Read-out electronics: The short duration of Cherenkov signals demands at least a MHz sampling capacity and a signal forming, whereas GHz sampling is already in use in MAGIC and HESS. Such technology is continuously evolving and research is ongoing.

Trigger system: The trigger system is multifold: the basic discrimination is at the photoelectrons level to adjust to different illumination conditions (moon, galactic or extragalactic targets); a second-level trigger is typically topological when a cluster of PMTs are activated. This allows rejecting spurious events from the light of the night sky. Other triggers are used to synchronize telescopes in the array or make more advance logical trigger.

Towards a precision gamma-ray astronomy; physics motivation for CTA

Despite the promising achievements from the current generation of IACTs, there are a number of limitations that the future generation will have to overcome:

a. IACTs of current generation are sensitive in a limited energy range, from 100 GeV to 50 TeV. At the lower end, IACTs are limited by the background from atmospheric hadronic showers. At the high end, the limit is posed by insufficient statistics;

b. Due to the lack of a calibrated cosmic GR source, IACT spectral reconstruction is limited by systematic bias and statistical uncertainties on the energy reconstruction;

c. They have a limited aperture, with typical field of view (FOV) of the order of 3-5 deg diameter;

d. They have a limited angular resolution which currently states around few arcmin; `

e. They have limited collection area;

f. They are rather poorly automatized. To overcome this limitation, a new generation of IACT is under design now with expected performance well above the current generation. We believe that with CTA we are heading toward a new era of precision GR astronomy.

General technical ideas on CTA

To comply with the physical requirements specified in the previous section and to maintain an overall high technical performance, the CTA concept is based on few general ideas:

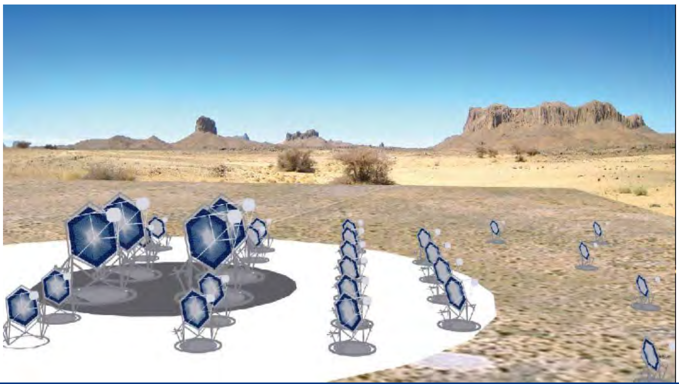
1. Increase the array from 4 to around 100 telescopes;
2. Distribute them over a large area (1-10 km^2);
3. Make use of telescopes of 2-3 different sizes;
4. Take advantage of well-proven technology of current IACTs;
5. Achieve high automatization and remote operation;
6. Run array as observatory and open to astronomers community.

Few Large-sized Telescopes (LSTs) should catch the sub-100 GeV photons thanks to their large reflective area. To maintain the time stamp of the showers, they will have probably a parabolic shape. To avoid the intrinsic optical aberrations due to this profile, LSTs will probably have limited size FOV (3 - 4°) while large telescope f /D > 1.2 ratio presents the technical challenge of displacing the camera at more than 28 m from the reflector. Technologically, the LST will be the most challenging telescope. A design is currently under development. Several tens of Medium-sized Telescopes (MSTs) will perform the bulk TeV search. Those telescopes will come from the well-proven experience of HESS, MAGIC and VERITAS collaborations. The main goal is to reduce the costs and maintenance activities.

The MSTs will constitute the core of the array, and will perform the fundamental task of vetoing the LST triggers to reduce the hadronic background. Several different designs are currently taken into account and the construction of the first prototypes is expected in few years from now. Finally, several tens of Small-sized Telescopes (SSTs) will complete the array to perform the super-TeV search. They will be very simple in construction, contributing to a small percentage of costs of the full array, and distributed in between and around the core array of MSTs.

Basic array design

The design of the array is artistically depicted in the following figure. The CTA project is being designed both to provide an extension of the energy range down to a few tens of GeV and up to about 100 TeV and with at least 10 times improvement in sensitivity compared to current installations. This can only be achieved by combining: **A)** Large enough numbers of telescopes distributed over at least 1 km^2 and **B)** Using telescopes of different sizes. CTA is planned to comprise about a hundred telescopes of 2-3 different sizes: several Small-sized Telescopes of 6 m diameter, several Medium-sized Telescopes of 12 m and few Large-sized Telescopes of 23 m diameter. However, the number of the telescopes, their size, their configuration and the overall performance are still under investigation and the final layout will come out after Monte Carlo optimization.



Artistic view of the compound different size telescopes CTA system.
The area coverage is of 1 - 10 km^2.

Subsystems development

From the technological point of view, the major effort is currently concentrated on the working packages responsible for telescope design, mirror facets development, electronic and focal-plane instrumentation. Different projects for SSTs, MSTs and LSTs are under design at several institutes to stimulate competition and technological development. Mirrors constitute an important challenge because they contribute to a sizeable part of the costs. A major effort is ongoing to build fast assembling, reliable mirrors with reduced optical degradation with time.The focal-plane instrumentation also represents a challenge in technology and cost. The current baseline design envisages the use of high conversion efficiency PMTs. Studies are ongoing also on GaAsP hybrid photon detectors (HPD) and Geiger avalanche photon detectors (GAPD).

CTA Project

A European FP7 project

A world-wide Consortium:

- Partnership between the HESS, MAGIC and VERITAS collaborations plus several world-wide institutions.
- 500 scientists involved from more than 50 institutes of 14 countries.
- The project will be run as observatory.

Operation phase (tentative)

Partial start in 2016.

Links

CTA: www.cta-observatory.org

MAGIC: magic.mppmu.mpg.de

HESS: http://www.mpi-hd.mpg.de/hfm/HESS/

VERITAS: veritas.sao.arizona.edu

3D-SHAPE

3D-Shape GmbH provides a wide range of optical 3D-sensors and software for fast and precise 3D-measurements – white light – Interferometry (KORAD^{3D}-products), fringe projection (FaceSCAN^{3D}, BodySCAN^{3D}) and phase measuring deflectometry (SpecGAGE^{3D}).

3D-Shape GmbH has at the moment 10 employees.

Submitted by: Dr. Klaus Veit

Field of activity

- Quality assurance for industrial applications, particularly, automotive and electronics industries.
- 3D-measurements of reflecting surfaces., e.g. eye glass lenses, windshields, lacquered objects.
- 3D-measurements of parts of the human body for medical applications.

KORAD3D sensor

Current state-of-the-art technologies

- **KORAD^{3D}** – Measurement fields up to a diameter of 70mm and measurement times of 1 second.
- **BodySCAN^{3D}**/F**aceSCAN^{3D}** – Measurement times <0.3 seconds and photo-realistic texture.
- **SpecGAGE^{3D}** – Measurement uncertainty of 0.01 dioptres.

FaceSCAN3D sensor

Range of services

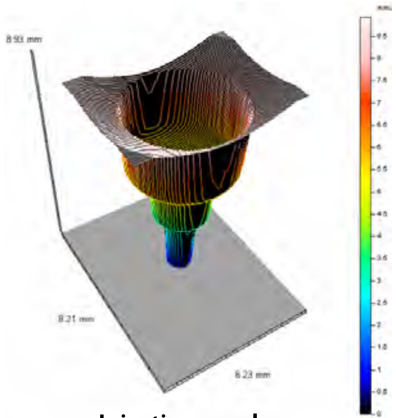
- **KORAD^{3D}** Sensor, based on white light interferometry with measurement uncertainty in the micrometer and submicrometer range for objects from 0.3 mm to 70 mm.
- **BodySCAN^{3D}** and **FaceSCAN^{3D}** sensors based on phase measuring triangulation (fringe projection) for the measurement of human body parts, faces etc.

SpecGAGE3D sensor

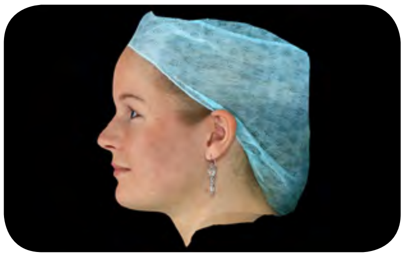
- **SpecGAGE^{3D}** sensor, based on phase measuring deflectometry for the complete area measurement of reflecting surfaces (mirrors, lenses etc.).
- **SLIM^{3D}** software for reverse engineering.
- Feasibility studies, measurement services and customer-specific developments of new sensors.

Research & development activities

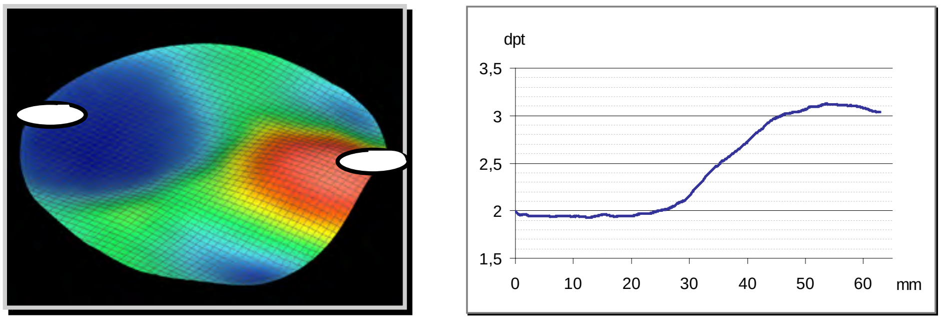
- Optimisation and further development (measurement time, resolution, measurement range, measurement uncertainty ...) in the areas of the white light interferometry, phase measuring deflectometry and phase measuring triangulation.



Injection nozzle



Textured 3d data set



Local refractive power of progressive lens

Technology partners

- Institute for Optics, Information and Photonics from the Universtity of Erlangen-Nürnberg

3D-Shape

Benno Knapp
Managing Director

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www.3d-shape.com

Coastline Optics

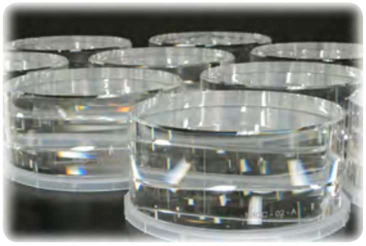
Full Service Optical manufacturing
Shaping, Polishing & thin Film Coatings

Ultra-Smooth Surface finishes ≤ 1 Å
Surface Figures of 1/50 Wave PV or Better!

Submitted by: John Tardif

Field of activity

Custom Optics – Fabrication & Polishing



Coastline Optics specialises in "build to print" manufacturing. From start to finish, we have the unique capability of offering our customers a truly integrated "one-stop" source for all their optical requirements.

In addition to common optical materials such as Fused Silica, BK-7, Pyrex, and others, we have developed highly robust shaping and polishing processes for Sapphire, Silicon, Silicon Carbides, as well as Calcium Fluoride.

Thin Film Coatings – Ion-Beam Sputtering

Low scatter, Low Absorption, Low Loss, our Ion-Beam Sputtered Coatings are second to none. Armed with a large selection of target materials, we have the unique capability of providing our customers with a full range of optical coatings. These dense and durable coatings can be designed to meet a variety of needs. From High Reflector to Anti-Reflector; Polarised to Non-Polarised Beam Splitters or anything in between, our coating team can design a coating to meet your needs.

Test & Metrology – Full Service Inspection

Our metrology department is equipped to measure a number of optical properties.

This includes Surface Figures to 12" Ø, Micro-Roughness to sub-ångström levels, as well as Coating characteristics such as transmission, reflection, and wavelength centering.

John Tardif
Business Development

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Heraeus Quarzglas

Heraeus Quarzglas, headquartered in Hanau, Germany, is the technology leader in manufacturing and processing high-purity quartz materials and advanced quartz components. Having gained know-how and excellence for over a century, Heraeus Quarzglas supplies high-quality fused quartz and fused silica as well as specific solutions for demanding applications. With over 1,400 employees in 8 production facilities worldwide, Heraeus Quarzglas is the world's largest integrated quartz glass producer.

The optics division includes a team of highly qualified and well trained specialists for optics and materials. Heraeus Quarzglas produces custom-tailored or standardized products for your optical application. If the application is operated in the deep UV or in the Near- Infrared or even over the whole spectral range the optics group has the appropriate material for your application.

Submitted by: Mark Altwein

Products & Services

Suprasil® 3001, 3002 and 300 – High-purity synthetic fused silica materials manufactured by flame hydrolysis.

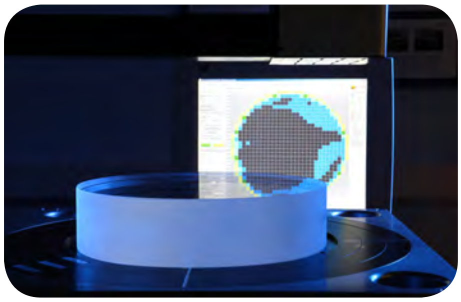
- Combine excellent physical properties with outstanding optical characteristics from the UV to the near IR.
- During the manufacturing process an intermediate drying step reduces the OH content of the Suprasil® 300x to below 1 ppm.
- A chlorine content of 1000 ppm to 3000 ppm is material inherent and results in a slight shift of the UV-absorption edge to the longer wavelength region.
- The Suprasil® 300x family has no absorption bands from the visible to the IR spectral region. This property makes this material family the ideal choice for any low absorption application in the near-IR.

Infrasil® 301 and 302 – Optical quartz glass grades manufactured by fusion of natural quartz crystals in an electrically heated furnace.

- Combination of excellent physical properties with outstanding optical characteristics especially in the IR and the visible wavelength range.
- The index homogeneity is controlled and specified either in one direction (the direction of use or functional direction) or even in all three directions.

Selected quartz glass products

Bubble and inclusion inspection detection limit 10 µm Ø



Inspection for stress-induced birefringence

Performances

Heraeus Quarzglas fused silica material grades for Infrared Applications.

Material	Wavelenght (nm)	Remark	Application	Performance
Suprasil® 3001	200 - 3500	Lowest absorbtion	Highest quality optics	Outstanding
Suprasil® 3002	200 - 3500	Lowest absorbtion	Highest quality 2D optics	Outstanding
Suprasil® 300	200 - 3500	Lowest absorbtion	Windows, lenses with medium need homogeneity	Outstanding
Suprasil® 311	190 - 1100	Very lowest absorbtion @ 1064 nm	3D applications e.g. high grade prisms	Excellent
Suprasil® 312	190 - 1100	Very lowest absorbtion @ 1064 nm	2D applications e.g. lenses, windows	Excellent
Infrasil® 301	270 - 3500	High cost efficiency	3D applications e.g. high grade prisms	Very Good
Infrasil® 302	270 - 3500	High cost efficiency	2D applications e.g. lenses or windows	Very Good

Heraeus

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II-VI INFRARED

II-VI Inc. the global supplier for laser optics

Thanks to decades of innovation in zinc selenide (ZnSe) and zinc sulfide (ZnS) materials processing, thin-film coating, precision diamond-turning, and finished optics fabrication, II-VI Infrared is the world leader in CO2 laser optics, delivering an unbeatable combination of innovation, quality, and experience. II-VI Infrared also delivers the largest vertically integrated CO2 laser optics manufacturing process -- from raw materials to finished coated products -- in the world.

Submitted by: Silvio Brando

An optics foundry to CO2 laser original equipment, manufacturers the world over, consistently building optics to spec with consistent performance and quality, II-VI Infrared's products range from replacement CO2 laser optics and nozzles to lenses, partial reflectors, windows, beamsplitters, mirrors, beam expanders, reflective phase retarders, scanning-laser system optics, diamond-turned custom optics, and more.
Our diamond-turning facility is among the largest and most advanced in the world, offering services such as flycutting and multiple-axis turning, as well as fast and slow tool servos for custom optics. Single-point diamond-turning is used in finishing transmissive optics and mirrors in a variety of metals and IR materials.

Products and services

CO2 Laser Optics

II-VI Infrared produces any kind of laser optics in the IR region and can work them in many different shapes and geometries like plano, spherical, aspheric, parabolic, elliptical, hyperbolic, cylindrical, Fresnel and diffractive, toroidal, axicon/waxicon, multi-facet, non rotationally symmetric.

Near Infrared Optics

Photop USA, another company of the II-VI Inc. group, is specialized in NIR and visible optics such as high reflectors, output couplers, Brewster windows, etalons and lenses. Photop is also the industry leader in the production of crystalline quartz polarization optics, such as waveplates and polarization rotators.

Photop grows a variety of laser gain crystals, including Nd:YAG, Nd:YLF and Ruby.
Photop uses state-of-the-art coating techniques, such as ion assist and ion beam sputtering, which stand up to the rigors of high power laser use on a production basis.

II-VI INFRARED

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ZygoLOT Europe

Zygo Corporation designs, manufactures, and distributes high-end optical systems and components for metrology and end-user applications. Now in its fifth decade, ZYGO leverages its core competencies in metrology and optics to serve a worldwide customer base. Recognized as a valued partner by its customers for its innovation, technology, and responsiveness, the Company assists these customers in becoming leaders in their respective markets.

Headquartered in Middlefield, Connecticut, USA, the Company employs approximately 600 people in offices throughout the world.

ZygoLOT's Darmstadt office supports distribution all over Europe, and maintains demo/application laboratories for doing acceptance tests, providing GR&R data, and conducting software training.

Submitted by: Arno Koehler

Advanced LIGO – The Next Step in Gravitational Wave Astronomy

Gravitational waves offer a remarkable opportunity to see the universe from a new perspective. The Advanced LIGO (Laser Interferometric Gravitational-wave Observatories) project will completely upgrade the U.S. gravitational wave interferometers, bringing these instruments to sensitivities that should make gravitational wave detections a routine occurrence.

- Upgrade provides 10X boost in sensitivity & 15X in detection distance.

ZYGO provided approximately fifty ~340 mm diameter optics of 0.3 nm RMS quality.

EUV Lithographic Projection System

- Mirror - 13.5 nm wavelength, 0.25 NA, 4X reduction, less than 30 nm printing resolution
- Concave off-axis Aspheric Mirror
- Testing of support manufacture; <0.1 nm RMS figure requirement

World's Most Respected Optical Metrology

Since the introduction of our first commercial interferometer over 35 years ago, ZYGO continues to maintain the leadership role in surface form metrology and high precision 3D optical surface profiling; achieving levels of extreme precision in very tight controlled environments.

Thousands of ZYGO systems are installed worldwide and relied upon daily to provide accurate production metrology of optical components and assemblies that affect our daily lives. Applications span across a wide range of industries including consumer electronics, ophthalmic, semiconductor, and defence & aerospace. ZYGO is the one optical metrology company that is trusted across the globe to qualify the world's most critical dimensions.

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Gooch & Housego

Gooch & Housego is a manufacturer of precision optical components and sub-systems, as well as light measurement instrumentation and services, based upon key enabling optical technologies.

World leading design, development and manufacturing expertise across a broad, complementary range of technologies – Optical Polishing, Coatings and Assembly, Crystal Growth, Acousto Optics and RF Drive Electronics, Electro Optics, Fibre Optics, Spectroradiometers, Spectral Imaging & Synthesis - coupled with our long established reputation as an industry leader, makes Gooch & Housego the solution for your optics and photonics needs.

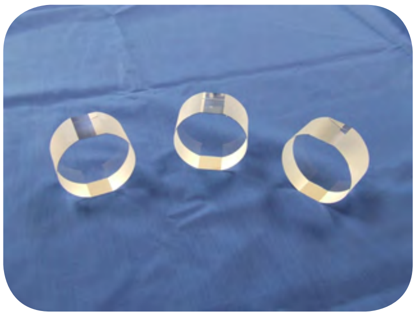
With worldwide sales & marketing and eight manufacturing sites, the clear advantage to the customer is access to proven standard products, as well as the capability to take customers' new visions from design through prototyping to volume production of the future. The various companies have been supplying the highest quality optical components for high vacuum, space and submarine applications for many years.

Submitted by: Dr. Peter Mackay

Products and services

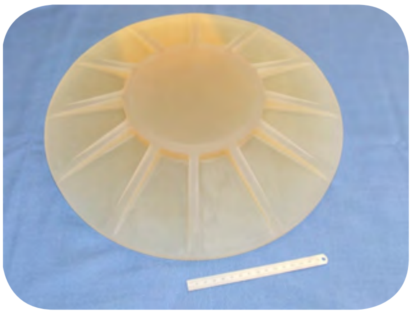
Precision Optics

- Super-polished mirror substrates for low scatter
- Extensive in-house coating capability
  - Low loss mirrors for laser cavities
  - High laser damage threshold coatings
  - E-beam, IBS and Sol-gel technologies
- Prism window and lenses



Glass Engineering

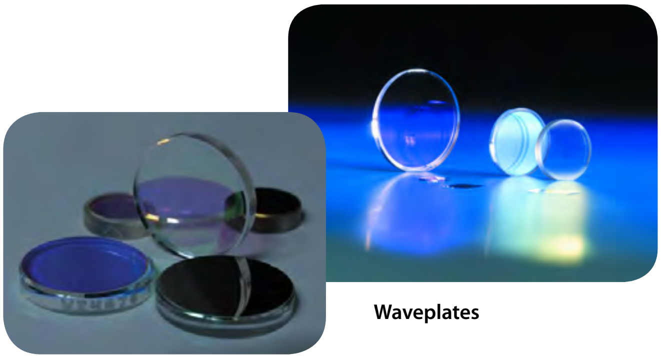
- Fused silica test masses for gravitational wave experiments
- Fused silica substrates and ears for bonding experiments
- Zerodur® base plates and components for e-beam lithography
- Ultra-low expansion glass ceramic cavities for ring laser gyros
- Extensive capability in shaping, polishing and light-weighting zero-expansion glass ceramics



Lightweighted Zerodur® Mirror

Assembly and Bonding Technologies

- Optical contacting
- Cold metal Bonding
- Adhesive free bonding
- Sol gel bonding
- Low outgassing epoxies
- Mechanical assemblies



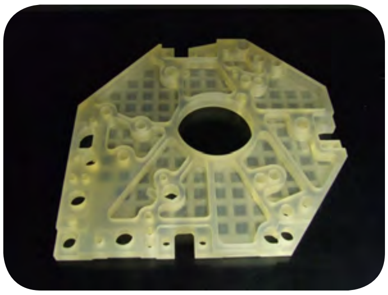
Waveplates

Optical Fibre Components

- Both passive and active components
- Fused fibre couplers for space
- High reliability fused fibre couplers for submarine cables
- MIRAS Optical Harness on the SMOS mission
- Epoxy and organic free DFB's, pump lasers and detector modules
- Hermetic packaging with getters
- Fibre optic gyroscope components – space qualified
- Complete fibre optic assembly capability

Acousto-optics

- Space qualified Acousto optic modulators
- UV Acousto-optic Tunable Filter for Altius payload
- Acousto-optic Frequency shifters for Lisa Pathfinder



Environmental Testing

- Devices deigned to pass:
  - Vibration
  - Thermal vacuum
  - Gamma radiation
  - Vibration
  - Material outgassing
- Tel-cordia, Mil-Std and ISO9001 Quality standards

Gooch & Housego

Dr. Peter Mackay
Principal Technologist

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SELEX Galileo

SELEX Galileo, a Finmeccanica company, provides full security, safety and situation awareness capability for air, land and sea operations.

SELEX Galileo employs 7000 people with operations in the United Kingdom, Italy and the United States.

Headquarters are located, for space activities in Florence and for space operations in Italy and UK. In Italy, there are plants in Florence, Nerviano and Pomezia, where all design, development, manufacturing and testing activities are carried out on an area totalling 18 000 m^2, a large amount of which hosts clean rooms and laboratories equipped with appropriate space simulators for environmental and functional testing.

In UK space operations are performed in Southampton and in Edinburgh plants.

Submitted by: Andrea Novi

Field of activity

SELEX Galileo combines leading edge technologies to deliver integrated sensor solutions and offers through-life management for defence systems and homeland security applications.
Space activities are carried out within the Space Line of business. SELEX Galileo supplies equipment, subsystems and payloads to European Space Agency (ESA), Italian Space Agency (ASI), NASA and other international customers. Space activities include attitude sensors, electro optic instruments, mission payloads, RF equipment, Passive Hydrogen Maser Clock, photovoltaic assembly, power conditioning and distribution, drilling sample collection systems, robotics arms, motion control software, gyros and IR detectors.

Products and services

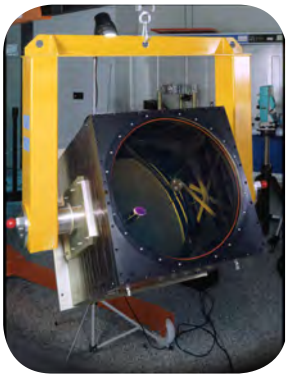
Main Product Lines

- Attitude Sensors
- Mission Payload
- RF Equipment
- Solar Generators
- Electrical Power Systems and Equipment
- Automation & Robotic Systems

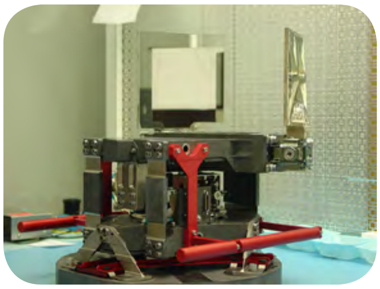
Mirrors & Auxiliary Optics

Polishing and optical figuring:

- Mirrors and lenses in all materials for UV-VIS-NIR-IR wavelength ranges. Ceramics, Silicon Carbide optics.
- Optical technologies (including Diamond Turning, CCP) for flat-spherical-aspherical/off axis mirrors and lenses.
- Design and manufacturing of :
  - Lightweighted mirrors and structures, for space and for ground astronomy.
  - High precision high reliability opto-mechanisms;
  - Optics and optomechanical systems for cryogenic/space environment.



a) **Laser Launching Telescope – for Laser Guide Star Equip. (Adaptive Optics Ground Telescopes)**



b) Refocusing Mechanism for NIRSpec - JWST

Optical metrology.

Coatings:

- Custom optical coatings for military, space and industrial equipment & applications.
- ISO / MIL standards qualified.
- N. 8 Vacuum Chambers up 750 mm dia. in Clean Room of about 300 m2.
- UV-Vis-Nir-Mir ranges.
- Antireflection Coatings.
- HR Dielectric & Metallic Mirrors.
- Dielectric & Metallic Beam Splitters.
- Dichroic Filters
- Diamond Like Carbon A/R on Si & Ge.

Key Data 2010

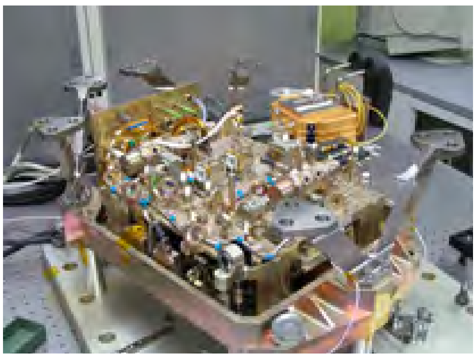
- 1.9 billion euro revenues
- Over 7000 employees
- 14% R&D

Of which for Space:

- About 90 million revenues
- About 360 employees (mostly high grade)

Lasers

SELEX Galileo is responsible for the High Power solid state laser head (TxA) for the ESA missions ADM-Aeolus and Earth-CARE.
The TxA is a high stable, amplified source providing 120 mJ at 355 nm ; it will be the most power laser source ever built operating in the UV band.



Laser TxA

SELEX GALILEO

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Gestione SILO

Tradition and technology in the field of high precision optics

Established in 1950, Gestione SILO is from years the landmark of Italian optics, continuously developing, for its outstanding capacity in the design and production of high precision optical systems.

Having gained experience in a large field of optical applications and constantly following all the innovations of the sector, Gestione SILO has become a qualified supplier for the aerospace industry, the military, telecommunication industry, the scientific and biomedical instruments builders as well as national and European astronomical observatories.

Gestione SILO is one of the major firms able to design, build, coat and assembly high precision optical instruments.

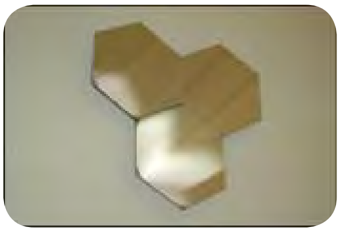
Submitted by: Paolo Sandri

Products and services

Quality optical coating

- Develop of almost every optics design – from the feasibility analysis up to the optimisation of the surface optical treatment;
- Manufacture custom optical designs and systems at the range of 180 nm (UV) to 20μ m (MIR);
- Manufacture antireflection, dichroic, protective and metallic coatings.

Great flexibility



Since 1970 Gestione Silo carries out on its own all the phases of optical designing and manufacturing – blanking, polishing, grinding, coating, cosmetic and functional testing – by using high precision CNC machines.

- Spherical lenses with diameter up to 600 mm
- Cylindrical lenses with diameter up to 250 mm
- Mirrors with diameter up to 1 000 mm
- Prisms of any kind – right angle prism, Amici prims, Dove prisms, Pentaprism, Porro, Pechan, Abbe, Pellin-Broca and Wollastone prisms, retroreflectors, and many others…
- Interferometric flats with planarity of 1/20 Peak to Valley up to 150 mm in diameter,
- Retarders (wave plates and rhombs)
- Super-polished (average roughness 5Å) components for laser applications.
- Aspheric surfaces also are possible.

We are able to do custom workings, on vitreous and metallic materials by using "diamond turning" technology with post-polishing (average roughness <10Å) technique.

- 30 qualified designers
- A well-stocked library, the starting point for new optical projects:
  - 300 own developed optical designs
  - 15 000 optical designs belonging to the international scientific literature.

SILO

Paolo Sandri
Technical Manager

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Bte Bedampfungstechnik

Bte GmbH is a leading company in vacuum thin film coating of optical components. The coating of big size mirrors for array telescopes is one of our main skills. We have 65 employees, 25 coating machines with diameters up to 1 900 mm and are experienced in many markets from natural sciences over medicine, industrial sensorics to automotive components.

We are ISO 9001 certified and supply our products to customers worldwide. Our capabilities have been demonstrated by the coating of the HESS I telescope mirrors under challenging time frame conditions.

Submitted by: Dr. Urban Franz-Josef

Products and services

Mirrors enhanced and selective for array telescopes in the VIS/UV spectrum

The coatings of Bte are very well suited for applications in the astronomy in the spectral range between 200 nm and 2500 nm.

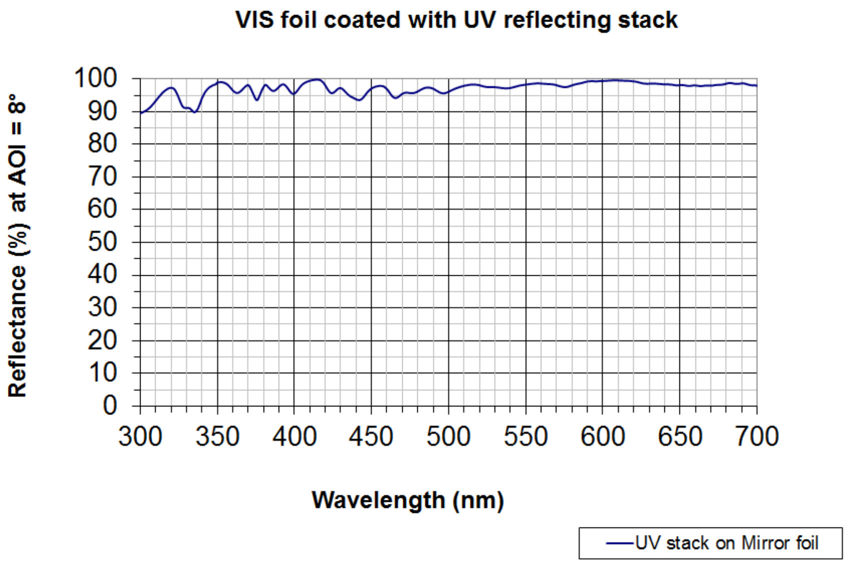
The coating of Cherenkov telescope mirrors in particular requires high reflection between 300 nm and 600 nm.

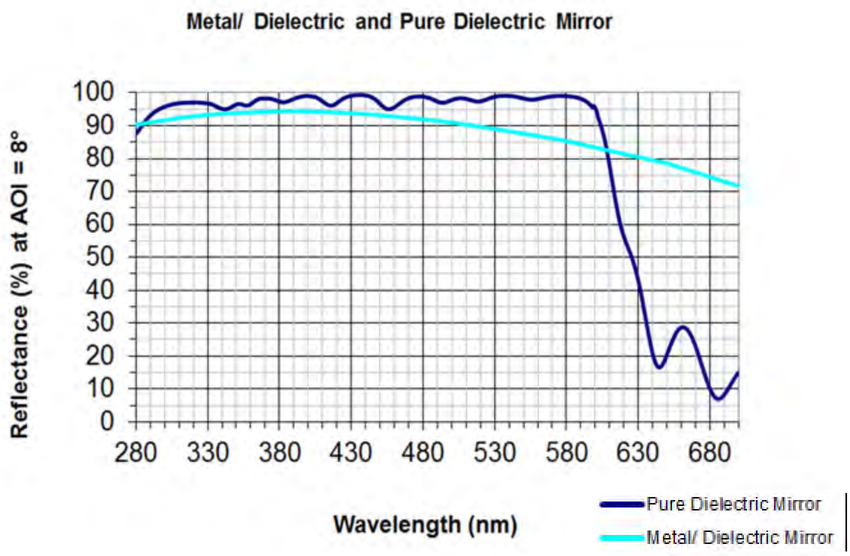
With our dielectrically enhanced aluminium mirrors we achieve a reflectance of > 90% from 300 nm to 600 nm (> 94% in the maximum). The enhancement layers work also as a protection against impact from the environment.

Our dielectric coatings result in reflectance values of even > 95% from 300 nm to 600 nm; suppressing reflection outside the spectral region of interest. In addition the dielectric coatings are unique in environmental durability.

The processes are applied at temperatures < 150°C. Lower temperature processes are under investigation. The existing coating machines can be loaded with hexagons of 1530 mm flat to flat.

Our cost structure and the time frames take advantage from the existence of 6 machines with the necessary size as well as a skilled personnel staff and a process line suited for the coating of a high number of big sized mirrors. Also the coating of a flexible plastic foil has been performed successfully. The reflection band from 300 nm to 400 nm is an ideal addition to the existing reflection band in the visible.





Dr. Franz-Josef Urban

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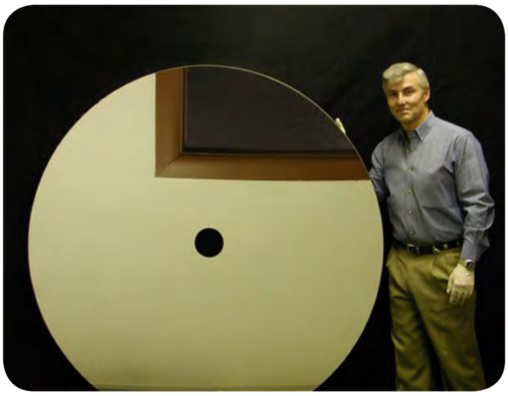
Displays & Optical Technologies

Displays & Optical Technologies (DOTI) is a custom, lightweight optics manufacturer that specializes in thin glass mirrors technologies. Our facilities occupy approximately 1 000 m^2 with current plans to increase to approximately 2 000 m^2 in 2012 and 2013.

Submitted by: Monty Ma Gill

Field of activity

Our capabilities include slumping and annealing of glass sheet materials to reduce the volume of glass necessary to create a rigid and uniform substrate from which to manufacture optics. DOTI employs traditional and modern as well as internally developed processes to grind and polish large aperture optics for a variety of applications, including Gamma Ray Research, UV Lithography, Solar Concentration, Flight Simulation optics, as well as Test and Measurement, etc. We are classified as a small company, with a niche market- large and lightweight optics.



Products & Services

DOTI's area of specialisation is bending, grinding and of lightweight glass substrates for first surface mirrors that are frequently used in telescope, simulation, and display and energy concentration applications.

DOTI has developed a series of techniques and processes that allow us to manufacture very accurate, lightweight mirrors. Due to the abilities that we developed for the VERITAS project, and our willingness to increase our manufacturing capability, DOTI was awarded manufacturing contracts for all of the collecting mirrors for the VERITAS project.
We are able to achieve surface structure that is under 5 Angstroms roughness and scratch and dig specifications as needed by the customer. DOTI's current size limitation is 2.2 meters, with plans to go to 3.5m in late 2012.

In the last 7 years, DOTI has developed a lightweight mirror backing system, utilizing thin aluminium and honeycomb assemblies. These assemblies can be designed such that there is mounting and pointing hardware built into the structure and designs can be customized by the end user to fit their hardware and mounting requirements. These are permanently bonded to the mirror in a stress-free environment to ensure best optical performance.

DISPLAYS & OPTICAL TECHNOLOGIES INC.

Monty Ma Gill
President

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Kerdry Thin Film Technologies

KERDRY Thin Film Technologies develops and implements custom-designed thin films for advanced technologies. The expertise of our engineers enables KERDRY to offer high quality and ultra-precision optical coatings and metal deposition that meet the requirements of the most demanding and diverse applications. Because we are expert in ultra-precision Thin Films Deposition, we can take on new projects from the early stage.

Our custom-designed metal and optical coatings are used in the following industries: Aerospace, Defence, Instrumentation, Medical, Optoelectronics, Telecommunication and Luxury.

Submitted by: Damien Deubel

Field of activity

Metal Layers

They are used for their mechanical and optical properties. A particular application for metallizing is the soldering of components. This ensures a good stability of the component when used in harsh environment and exposed to thermal, pressure or hygrometry constraints; optimized coating for astronomical applications.

Optical Coatings

We offer a wide range of laser resistant optical coatings over the spectral band from 350 nm to 2200 nm and up to 15 microns in Infrared. We perform deposition with dielectric materials that allows us to achieve such a variety of filters as: Antireflection, Mirror, Band pass filters, Dichroic Filters, Laser line Filters, Broadband Filters. In-situ optical monitoring ensures our customers high quality products. Coating performance is measured with spectrophotometers upon completion.

Metal and optical coatings on the same piece

Localised deposit by photolithography: we offer such new Dark Coating with no transmission and low reflection on the spectral band. Ten deposition machines, 500 m^2 clean room facilities, processing of parts from a few milimeters up to 150 cm.

KERDRY
Thin Film Technologies

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France

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🖷 +33 2 964884-78

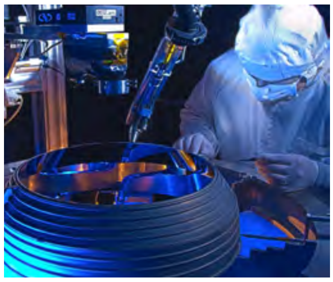
contact@kerdry.com
www.kerdry.com

Media Lario Technologies (MLT)

High precision optics from Microwave and IR through Visible to EUV and X

Media Lario Technologies is a leading supplier of high-precision reflective optical components and systems, serving the desired radiation spectrum from X-ray to millimeter waves.

MLT's track-record spans 15-years in optical systems for applications in Space & Terrestrial Telescopes and since 2004 have successfully spun off the technology into Semiconductor Capital Equipment, and other high growth markets.



Submitted by: Dervis Vernani

Field of activity

MLT's unique technological selling proposition lies in its ability to produce high-precision optical equipments:

- Thermally controlled suitable to extreme thermal environments;
- Based on highly aspherical free-form optics;
- Through a cost-effective replicable process by e-forming or glass cold slumping with a saving >50% in cost & cycle time compared to traditional technologies.

ALMA radio telescope array

Products and services

Optics for ground based telescopes

MLT is the world leader in the production of high precision reflector panels for:

- **Radiotelescopes telescopes:** walkable, high accurate nickel panels with:
  - Surface: up to 2 m^2
  - Surface accuracy < 11µm RSS
  - Coating: Rh
  - Panel weight < 15.5 kg/m^2

Telescopes using MLT high precision reflector panels:

- ALMA radiotelescope array (ESO program)
- GTM/LMT radiotelescope (INAOE program)
- IRAM PdBI (IRAM program)

- **Cherenkov telescopes:** glass slumped panels with
  - Surface ~ 1m^2,
  - Surface accuracy: 80% energy in < 0.5 mrad
  - Reflectivity: > 80% range 300 to 600 nm
  - Coating: Al + SiO_2
  - Panel weight: < 10 kg/m^2

Telescopes using MLT glass slumped panels:

- MAGIC II (MAGIC collaboration)

MAGIC II telescope array

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