CONFERENCE BOOK

International Conference on Astronomical X-Ray Optics

11 - 15 November 2024,
Vila Lanna, Prague, Czech Republic

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https://github.com/maximelucas/AMCOS_booklet

Prepared by Martin Urban for AXRO conference.
https://www.axro.cz

Contents

About

International Conference on Astronomical X-Ray Optics

AXRO is an international conference on Astronomical X-Ray Optics focused on the presentation and discussion of recent and future technologies for future X-ray astronomy missions. One session is focused on astrophysical aspects of X-ray telescopes/satellites, where some review talks are typically given by leading scientists in this field, plus some presentations of relevant Czech scientists. Sessions focusing on all aspects of astronomical X-ray optics, X-ray detectors and test facilities are an essential part of the AXRO conference as well. Last but not least, recent and future X-ray space missions are also presented and discussed.

The goal of the conference is to present and discuss recent and future technologies for X-ray astronomy missions. These missions require the development of the most innovative technologies, and we would like to discuss in detail the possibilities, the results obtained so far, and new ideas. It is obvious that the requirements of future large space X-ray astronomy missions are so demanding that they need a truly interdisciplinary approach in a broad international collaboration. These technologies will include X-ray optics based on Si wafers, advanced glass forming for precise X-ray optics, but also other possible technologies and alternatives, as well as related advanced metrology, measurements and tests.

Albeit the conference is focused on astronomical X-ray optics, we also invite participants from X-ray communities outside astronomy, as many aspects, such as designing, manufacturing, and testing X-ray optics, are similar for both communities, so sharing experience can be beneficial for all.

This year's held the 15th International Conference on Astronomical X-Ray Optics.

Organising committee

Veronika Maršíková	Rigaku Innovative Technologies Europe s.r.o.
Martin Urban	Czech Technical University in Prague
Ondřej Nentvich	Czech Technical University in Prague
René Hudec	Astronomical Institute of the Czech Academy of Sciences & Czech Technical University in Prague

Scientific committee

René Hudec	Astronomical Institute of the Czech Academy of Sciences & Czech Technical University in Prague
John Nousek	The Pennsylvania State University
Peter Predehl	Max Planck Institute for Extraterrestrial Physics
Vadim Burwitz	Max Planck Institute for Extraterrestrial Physics
William Zhang	NASA Goddard Space Flight Center
Ladislav Pina	Rigaku Innovative Technologies Europe s.r.o.
Randall McEntaffer	The Pennsylvania State University
Thorsten Döhring	Technische Hochschule Aschaffenburg
Dan Schwartz	Smithsonian Astrophysical Observatory

Partner Institutions and Sponsors

Topics

AST X-ray Astrophysics

This session is focused on the astrophysical aspects of X-ray telescopes/satellites. Contributions from all fields of X-ray astronomy and astrophysics are invited here, both experimental as well as theoretical, especially those with relation and/or impact on space X-ray telescopes. The main focus of this section is on potential X-ray sources for use in X-ray astronomy using telescopes and satellites.

OPT X-ray Optics

Presentations discussing technologies for future space X-ray astronomy missions are encouraged. These missions require the development of most innovative technologies; the possibilities, the results obtained so far and details of new ideas are suitable topics for discussion. The recent situation in the field strongly demonstrates the urgent need for novel, cost-effective approaches and solutions.

MIS X-ray Missions

This session will include presentations of recent as well as new and future space missions and related scientific payloads with the focus for X-ray domain. Contributions from all categories of satellites and space missions are welcome (like L-class, M-class as well as S/F-class). Presentations of current, new results as well as proposals for new missions are very welcome.

DTF X-ray Detectors & Test Facilities

Contributions regarding detectors and facilities suitable for use in X-ray are very welcome. New methods and principles of detection can be presented as well as existing solutions and their improvements. Facilities their testing method and measurement options, along with exciting results, can be presented in this section as well.

Icons

 **Talk**  **Poster**

Time schedule

Monday, 11 November

13:00–13:20	**Registration**		

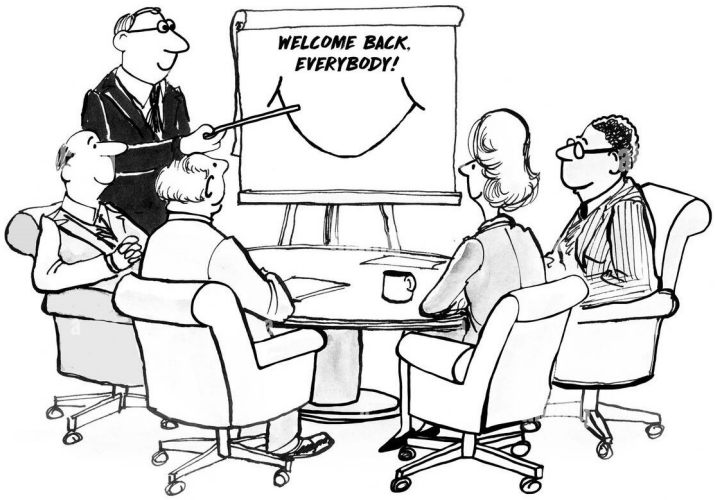
13:25–13:30	**Rene Hudec**	Opening workshop

Session chair: Vadim Burwitz

13:30–14:00	**OPT**	**William Zhang**	Next generation x-ray optics for astrophysics: high resolution, light weight, and low cost
14:00–14:30	**OPT**	**Nicolas Barrière**	The X-ray Optics for the NewAthena observatory
14:30–15:00	**OPT**	**Chen Zhang**	The MPO optics onboard Einstein Probe mission
15:00–15:30	**OPT**	**Yanji Yang**	Development of X-ray Focusing Mirrors onborad the eXTP Mission

15:30–16:00	**Open discussion over coffee**

18:00–23:00	**Welcome reception**



Tuesday, 12 November

09:00–09:20	**Registration**		

Session chair: Rene Hudec

09:30–09:30	**Welcome notes**		
09:30–09:40		**Zbyněk Škvor**	Vice-Rector of the Czech Technical University in Prague
09:40–09:50		**Karel Dobeš**	Government commissioner for EUSPA
09:50–10:15		**Václav Kobera**	Ministry of Transport: Space Activities in the Czech Republic
10:15–10:35		**Richard Pavlica**	Czech Space Industry last projects
10:35–10:50		**Rene Hudec**	AXRO introduction and historical background
10:50–11:10	**Coffee break**		

Session chair: Nicolas Barrière

11:10–11:40	**AST**	**Konrad Dennerl**	Spectral studies of the heliospheric X-ray emission with SRG/eROSITA
11:40–12:00	**AST**	**Martin Jelinek**	Evolution of Robotic Observatory Control: Advantaced Scheduling Automated Photometry at Ondřejov Observatory
12:00–12:30	**AST**	**Vojtech Simon**	Observing the activity of X-ray sources by a combination of monitors
12:30–14:00	**Lunch**		

Session chair: Zhang William

14:00–14:30	**AST**	**Lorenzo Natalucci**	The AHEAD2020 program: an update
14:30–15:00	**OPT**	**Vadim Burwitz**	Final status of X-ray optics AHEAD2020 joint research activity
15:00–15:20	**OPT**	**Rene Hudec**	Czech Contribution to AHEAD2020: A Summary
15:20–15:40	**Coffee break**		

Session chair: Lorenzo Natalucci

15:40–16:00	**OPT**	**Vladimír Tichý**	Calculation of effective collecting are of lobster eye wtih respect to full point spread function
16:00–16:20	**OPT**	**Vincenzo Cotroneo**	Enhancing Soft X-ray Optics with Dopamine Overcoatings

16:30	**End of day**

Wednesday, 13 November

08:45–08:55	**Registration**		

Session chair: Peter Friedrich

09:00–09:20	**OPT**	**John Rankin**	X-ray optics for accurate transient localization
09:20–09:40	**OPT**	**Lizhi Sheng**	Investigation on optical design of eXTP X-Ray focusing telescope
09:40–10:10	**OPT**	**Randall McEntaffer**	The status and future of X-ray reflection gratings in the context of upcoming UV opportunities

10:10–11:25	**Poster session + Coffee break**

Session chair: Randall McEntaffer

11:25–11:45	**OPT**	**Grisé Fabien**	Electron-beam lithography-driven development of optics for astronomical missions
11:45–12:05	**OPT**	**Vladimír Tichý**	Optical Tests of Lobster Eye X-Ray Optics Prototype for Nano-Satellite Missions Based on New Technology
12:05–12:25	**OPT**	**Pengfei Qiang**	Development of the X-ray baffle for the FXT flight spare of the EP Satellite
12:25–13:40	**Lunch**		

Session chair: Carlos Granja

13:40–14:05	**DTF**	**Jaroslav Nejdl**	Laser-driven X-ray Sources at ELI Beamlines: Development and Application
14:05–14:25	**DTF**	**Weiwei Cui**	The electronic design of the focal plane detector
14:25–14:45	**DTF**	**Patrizia Barria**	Calibration and data analysis of the GRASS detector module for gamma-ray emission spectroscopy

15:15–22:00	**Social Event**

Thursday, 14 November

Session chair: John Rankin

09:30–10:00	DTF	**Stefano Basso**	BEaTriX: current status and future prospective
10:00–10:30	DTF	**Kristin Madsen**	Athena mirror performance characteristics at XRCF
10:30–10:50	**Coffee break**		

Session chair: Lorenzo Amati

10:50–11:20	MIS	**Lucia Kriváneková**	First flight of the stratospheric balloon experiment ASTRABAX
11:20–11:40	MIS	**Jakub Řípa**	GRB-detecting nanosatellites GRBAlpha and VZLUSAT-2
11:40–12:10	MIS	**Carlos Granja**	X-ray field in LEO by miniaturized payload MiniPIX-Timepix3 Space onboard One Web JoeySat satellite
12:10–13:25	**Lunch**		

Session chair: Petre Robert

13:25–13:45	MIS	**Vladimír Dániel**	X-ray optics trade-off for small spacecraft
13:45–14:15	MIS	**Lorenzo Amati**	The Transient High-Energy Sky and Early Universe Surveyor (THESEUS)
14:15–14:45	MIS	**Stephane Schanne**	Status of the recently launched Gamma-Ray Burst mission SVOM

15:15–22:00	**Social Event**

Friday, 15 November

Session chair: Kristin Madsen

09:30–10:00	**MIS**	**Yong Chen**	In-orbit performance verification of EP-FXT
10:00–10:30	**MIS**	**Chen Zhang**	The status the Einstein Probe mission
10:30–11:00	**MIS**	**Robert Petre**	XRISM Performance and First Results

11:00–11:20	**Open discussion over coffee**

11:20–11:40	**Vadim Burwitz**	Concluding Remarks
11:40–12:00	**Rene Hudec**	Concluding Address

12:00	**Lunch**

12:00	**End of workshop**

The X-ray Optics for the NewAthena observatory

OPT

Nicolas Barrière
cosine Measurement Systems, Netherlands

NewAthena, the New Advanced Telescope for High Energy Astrophysics, was endorsed by the European Space Agency as one of its L-class mission, aiming to be launched in 2037. For the past 20 years the European Space Agency, cosine and partners have been developing Silicon Pore Optics (SPO) as a means to enable large space borne X-ray observatories like NewAthena. NewAthenaś SPO-based mirror will be a 2.5 m diameter structure with an aperture segmented in up to 600 separate mirror modules following a Wolter-Schwarzschild configuration with a focal length of 12 m. Targeting an angular resolution better than 9änd more than 1m^2 effective area at 1 keV, the mirror is designed to provide significant response up to 10 keV thanks to its coated reflecting surfaces. Building hundreds of mirror modules with high yield, in time, within budget, and up to the scientific specifications, is a task that requires bringing together scientific and technical developments with a high degree of automation, at facilities across a number of European countries. In this presentation we describe the work being done to make this possible, zoom in on some of the most interesting aspects of the production and characterization processes, and report on the latest performance results. A benefit of the development of NewAthenaś optics is the advent of a new versatile technology to manufacture optics for the X-ray, hard X-ray, and even soft gamma-ray domains. We conclude this talk with examples of optical designs that can be realized with SPO.

Final status of X-ray optics AHEAD2020 joint research activity

OPT

Vadim Burwitz
Max-Planck-Institut for Extraterrestrial Physics, Germany

The end-of-project status for the X-ray optics AHEAD2020 joint research activity will presented. This activity is part of the AHEAD2020 project, funded by the European Union Horizon 2020 research and innovation program that is ending on December 1st, 2024. Many tests have been done at the PANTER X-ray test facility of the Max Planck Institute for Extraterrestrial Physics as part of this activity. These encompass the testing and calibrating optics for new missions such as Einstein Probe and SVOM which have both been successfully launched and are now in operation, supporting the development through testing of many new X-ray optics such as Silicon Pore Optics and Next Generation polished silicon X-ray Optics for future missions such as NewATHENA and AXIS, as well novel optics designs such as large K-B optics modules. This activity has also enabled the completion of the new X-ray test facilities, BEaTriX in Merate, Italy, and the VTF in Leicester, UK.

OPT

Enhancing Soft X-ray Optics with Dopamine Overcoatings

Vincenzo Cotroneo
INAF - Brera Astronomical Observatory, Italy

X-ray optics typically rely on grazing-incidence reflections from metallic coatings to focus radiation below 10 keV. Enhancing reflectivity in the soft X-ray band is crucial for detecting faint cosmic sources, but traditional deposition methods face technical challenges, especially on complex geometries. We developed a liquid-phase deposition process using dopamine for thin overcoatings that increases soft X-ray reflectivity without degrading high-energy performance. This scalable dip-coating technique enables straightforward application even on assembled optical modules, overcoming the limitations of vacuum-based methods. Our tests demonstrated that dopamine coatings on substrates representative of space missions significantly improved reflectivity in the soft X-ray band, with controllable growth characteristics. Our ongoing research aims to optimize these coatings for space applications, potentially transforming X-ray telescope capabilities for missions like ATHENA and eXTP by offering a cost-effective and high-performance solution to enhance instrument sensitivity in a critical spectral region.

OPT

Electron-beam lithography-driven development of optics for astronomical missions

Fabien Grisé
The Pennsylvania State University, United States

Spectroscopy is a core component of most astronomical missions, from flagships to sounding rockets. The variety of science cases and instrument geometries usually dictate the requirements associated with diffraction gratings. This leads to a large range in design but with commonalities such as maximizing efficiency, and minimizing aberrations and stray light. To meet imposed requirements, grating patterns benefit from a high level of customization: from coarse parallel grooves with a laminar profile onto flat substrates to high-density non-parallel blazed grooves on curved substrates. Their design leads to strong constraints on the fabrication methods involved, or in some cases precludes it. We have been developing various processes to fabricate gratings and other optics relying on electron-beam lithography patterning and etching on both flat and curved substrates. We will summarize our efforts to date and will expand on their applicability to future missions while outlining the technological challenges and possible solutions.

Czech Contribution to AHEAD2020: A Summary

OPT

Rene Hudec
Czech Technical University in Prague, Czech Republic

R. Hudec, V. Marsikova, M. Urban, O. Nentvich, V. Stieglitz.We present a summary of the Czech contribution to the EU H2020 Project AHEAD2020 with emphasis on the X-RAY OPTICS work package where innovative Lobster Eye (LE) and Kirpatrick Baez (KB) modules based on Multi Foil Optics technology (MFO) were studied. The LE X- ray optics is a wide field of view (FOV) optics type Lobster Eye (LE) with short focal length (suitable for cubesat application) based on Schmidt design. The 2D LE optics consists of two orthogonal sub-modules of flat smooth reflective foils and each sub-modules focuses in one direction. The advantage of MFO LE is that for off-axis points the angular resolution is preserved throughout the FOV, as demonstrated by simulations and measurements. In addition, two major events were organized, namely a workshop in December 2023 and a summer school in May 2024.

The status and future of X-ray reflection gratings in the context of upcoming UV opportunities

OPT

Randall McEntaffer
the Pennsylvania State University, United States

X-ray spectroscopy for tender X-rays, is not a key component of missions currently being developed for flight. The <2 keV energy range requires dispersive spectroscopy using diffraction gratings to accomplish high resolving power concurrently with high diffraction efficiency. These energies host the majority of electronic transitions expected for $\sim 10^6$ K plasma; yet no X-ray missions are actively developing such instruments. Meanwhile, there is a rich suite of investigations occurring in the UV, including in the far and extreme UV, very close to tender X-rays. This talk will discuss work that is being done on X-ray and UV reflection grating spectrographs, the missions that are currently being studied, and future opportunities.

Development of the X-ray baffle for the FXT flight spare of the EP Satellite

OPT

Pengfei Qiang
Xián Institute of Optics and Precision Mechanics, CAS, China

In this paper, based on the parameters of FXTś mirror module and the detector, the design parameters of the X-ray baffle are optimized through preliminary design and detailed ray tracing simulation. Fabrication involved precision laser cutting, roll forming, laser welding, and integration processes. Thermal stability was verified through thermal cycle testing. Finally, the X-ray baffle was mounted onto the mirror module with alignment precisely controlled using telecentric optical system.The results proved that X-ray baffle has a high thermo-mechanical reliability. The angular resolution (HPD) of the mirror module remained unchanged on-axis with/without X-ray baffle. The introduction of X-ray baffle is expected to be highly significantly reduce stray light.

OPT

X-ray optics for accurate transient localization

John Rankin
INAF - OAB Merate, Italy

Current X-ray telescopes have a combination of field of view and angular resolution unsuitable to accurately localize the electromagnetic counterparts of gravitational wave events – which will become increasingly important when the LIGO and Virgo experiments will work at full sensitivity, or when the Einstein Telescope observatory will come online in the next decade. We study how appropriately built Lobster eyes optics could be capable of localizing sources to tens of arcsec over a ∼10 square degrees field of view, together with hundreds of cm^2 effective area. We also compare how Kirkpatrick-Baez and Wolter-I optics perform for the same objective.

OPT

Investigation on optical design of eXTP X-Ray focusing telescope

Lizhi Sheng
Xián Institute of Optics and Precision Mechanics, CAS, China

X-Ray focusing observatory is one of the most important equipment for X-Ray space observation, which is designed based on grazing incidence principle. In this article, Multi-layers telescope has been designed for the demand of enhanced X-Ray Timing and Polarimetry Mission (eXTP). Monte Carlo method and power spectral density had been used when the relationship between mirror profile and roughness with angular resolution are investigating, We have analysis the relationship between different angular resolution and different mirror profile, The relationship between effective area with film structure and layers number are also investigated. Finally, the X-Ray focusing telescope with 5.25 m focal length, 45 layers is obtained.

OPT

Calculation of effective collecting are of lobster eye wtih respect to full point spread function

Vladimír Tichý
Czech Technical University in Prague, Faculty of Electrical Engineering, Czech Republic

The lobster eye shows a specific point-spread function (PSF). The PSF consists of a cross and spots around the cross. The cross consists of focal spot and four arms. The analysis how much radiation is collected to each of these parts is presented. The analysis is done for lobster eye with reflecting surfaces of ideal reflectivity and few reflectivity models. Results are demonstrated on ray-tracing simulations. The results have an important consequence: If a smart image processing algorithm (e.g. deconvolution) that utilizes not only the focal spot but all the focal cross is used then the utilized collecting area of the optics is increased.

Optical Tests of Lobster Eye X-Ray Optics Prototype for Nano-Satellite Missions Based on New Technology

OPT

Vladimír Tichý
Czech Technical University in Prague, Faculty of Electrical Engineering, Czech Republic

Results of optical tests of Schmidt lobster eye prototype module based on a new technology are presented. The prototype is designed for X-ray energies about 1keV. Dimensions and focal length of the prototype are chosen to allow boarding on CubeSat class Satellite. The module was tested using visible light, which is possible because glass plates coated with gold are used as mirrors. Focal image is taken at various angle positions. FWHM is evaluated. The results show good accordance with simulations. It means that the technological concept offers precise assembly of optical mirrors, which is the key aspect to obtain sharp focal image.

Development of X-ray Focusing Mirrors onborad the eXTP Mission

OPT

Yanji Yang
Institute of High Energy Physics, Chinese Academy of Sciences, China

In the Phase B study of the eXTP mission, three phototypes of mirror module have been developed. After that, the configuration of the satellite has been modified to fit the long march 3 rocket, which decreases the quantity of the mirror module down to 9, including 6 SFA and 3 PFA mirror modules. In the optical design, we add 5 addition mirror shells inside to increase the margin of the requirement of the effective area. We also improves the manufacturing process of the mirror shells, which angular resolution can reach 15 arcsecs. In the next year, the STM of the eXTP mirror will be manufactured with a few X-ray shells and other e-forming shells without the X-ray reflectivity, and the qualification model of SFA MM is planned after.

The MPO optics onboard Einstein Probe mission

OPT

Chen Zhang
NAOC, China

The Einstein Probe (EP) dedicated to time-domain astronomy to monitor the sky in the soft X-ray band, was launched in Jan 2024. It is in normal operation led by the Chinese Academy of Sciences with international collaboration. Its wide-field imaging capability is achieved by using established technology of the micro-pore lobster-eye X-ray focusing optics. In this talk, we will briefly present the developments of Micro-Pore optics, a Lobster-eye telescope, covering a FOV of about 3830 square degrees. The performances of MPO chips for flight, the automatic mounting facility as well as the performance of all the optics assemblies will be presented. A nova way to achieve the 1 arcmin MPO optics will also be proposed.

Next generation x-ray optics for astrophysics: high resolution, light weight, and low cost

OPT

William Zhang
NASA GSFC, United States

We report on the status of an X-ray optics development effort at Goddard Space Flight Center. The development effort is designed to enable future flagship missions like Lynx in the long term and to support Probe missions and Explorer missions like AXIS, HEX-P, and LEM, in the near term. It takes into consideration the three major work areas of building an X-ray mirror assembly, i.e., technology, engineering, and production, while focusing its resources on developing and maturing a technology based single crystal silicon. Boiled down to the most essentials, the development tackles four major technical areas: fabrication, coating, alignment, and bonding of thin, lightweight mirror segments. The technology is based on single crystal silicon, whose lack of internal stress makes it possible to use many polishing techniques to make the best possible thin, lightweight mirror segments. We will report results achieved with repeated building and testing mirror modules, as well as knowledge and lessons learned in each of the four technical areas.

KB Silicon Pore Optics for high-angular-resolution hard X-ray telescope

OPT

Nicolas Barrière
cosine Measurement Systems, Netherlands

We present a concept of hard X-ray telescope that could reach angular resolution of arc-second level. The optics is based on Kirkpatrick-Baez (KB) configuration realized with Silicon Pore Optics (SPO) technology. SPO has been developed for 20 years at cosine (The Netherlands) together with the European Space Agency and partners as a means to enable large space borne X-ray observatories like NewAthena. It is a versatile technology that can be employed to realise other optical designs, such as the KBSPO presented in this presentation.

In this configuration, the plates require only a slight meridional curvature and remain flat in the sagittal direction, significantly reducing the stress they experience and, consequently, minimizing the formation of slope errors. SPO is well suited for the KB configuration as the ribs running along the plates block efficiently stray light. Without sagittal curvature, the KB mirror modules can be designed for the very small grazing incidence required for reflectivity at high energies. This type of telescope could be well suited for solar physics or astrophysics as a complement to NewAthena. We have developed a ray-trace model based on the XRT package to study the optical performance of this peculiar, yet promising, optical system.

A visitor experiment on astronomical X-ray optics for the "Deutsches Röntgenmuseum"

OPT

Thorsten Döhring
TH Aschaffenburg, Germany

The "Deutsches Röntgenmuseum" in Remscheid is the unique institution worldwide that researches and documents the life and work of the first Nobel Prize winner, Wilhelm Conrad Röntgen, and the effects of his discovery of X-rays. As an integral part of the museum, the RöLab laboratory offers visitors the opportunity to gain practical experience in X-rays, optics and technology through own experiments. As part of a joint development project, students from Aschaffenburg University of Applied Sciences are currently designing a visitor experiment on astronomical X-ray optics for the museum laboratory. An optical set-up with visible light illustrate the focusing principle of X-ray telescopes, e.g. for wide-angle optics based on the lobster-eye principle. Display boards explain the optics of various types of telescopes with accompanying text and corresponding illustrations. Modern X-ray observatories such as CHANDRA, XMM-Newton and eROSITA are presented clearly. Once implemented, the new visitor experiment inside the "Deutsches Röntgenmuseum" intend to inspire young researchers for the fascinating world of X-ray optics and X-ray astronomy.

Investigations of the XMM-Newton X-ray baffle alignment

OPT

Peter Friedrich
Max-Planck-Institut für extraterrestrische Physik, Germany

Peter Friedrich, Michael Freyberg

An unwanted side effect of nested Wolter telescopes is the occurrence of so-called single reflections in the image field. These are caused by beam paths with only one reflection either at the parabolic or hyperbolic part of the mirror. Some of these beam paths, especially with reflection at the hyperbolic part, reach the camera field of view. As the rays in question come from a certain off-axis angle range, they can be suppressed - at least in part - by shielding in front of the Wolter mirror module. With XMM-Newton, this shielding, also known as an X-ray baffle, is realised in the form of two sieve plates, which are aligned with the 58 mirror shells of the mirror modules. Detailed studies of the remaining single reflections in the observations, which manifest themselves in arcuate patterns near real X-ray sources, reveal an asymmetry of these arcs. They are particularly pronounced in one direction, while they are considerably weaker on the opposite side. It is likely that this effect is due to a slight misalignment of the X-ray baffle with respect to the mirror module. Ray-tracing simulations were able to confirm this assumption and show that a lateral shift of the baffle in the order of 100 micrometres can in principle explain the observations. Such a shift would also be associated with a slight reduction in the effective collection area, which is interesting in terms of improving the calibration.

OPT

AHEAD2020 at CTU in PRAGUE. Selected Achievments.

Rene Hudec
Czech Technical University in Prague, Czech Republic

R. Hudec, V. Marsikova, M. Urban, O. Nentvich, V. Stieglitz.
We present examples of selected results obtained at the CTU FEE team in Prague within the EU H2020 Project AHEAD2020 with emphasis on WP8 and WP2. These examples include calculations, simulations, optics design, parameter optimization and related measurements and data analyses along with astrophysical considerations and justifications. We will also briefly describe the AHEAD2020 related events that were organized by CTU, namely a workshop in December 2023 in Prague and a summer school in May 2024 in Cheb. The event in Cheb is accompanied by PROCEEDING VOLUME in Acta Polytechnica, a CTU-referred journal indexed in Web of Science and SCOPUS.

OPT

Poly-dopamine – an organic material for X-ray mirror coatings and other technical applications

Diana Khropost
TH Aschaffenburg, Germany

Although the organic molecule dopamine (3,4-dihydroxyphenethylamine) is commonly known as the “hormone of happiness”, thin polymer films of poly-dopamine also have interesting technical properties. When produced by dip coating, these self-organizing layers grow in a reproducible thickness of single or multiple molecule monolayers of a few nanometre thickness only. One application is the use of thin poly-dopamine overcoatings to increase the soft X-ray reflectivity of astronomical X-ray mirrors. We thereby introduce a method of determining the layer thickness of poly-dopamine, which is based on spectroscopic ellipsometry measurements and applies an optical model for the poly-dopamine layers including their dielectric function. Furthermore, we give an outlook to other technical applications for this promising material, presenting this bio-inspired organic polymer as an innovative technical solution for the future.

OPT

Lobster eye optics with combined reflective layers

Veronika Stieglitz
Czech Technical University in Prague, Czech Republic

This poster describes test setup, test campaign course and obtained results of an X-ray test campaign at PANTER facility, Neuried. The campaigns aim was to verify the reflectivity of a series of mirror samples, coated with iridium and chromium. The coatings use iridium as main reflective layer, on which is applied a nanolayer of chromium, which is supposed to improve reflectivity in the energy range where it drops due to the M-absorption lines of iridium. Performed test verified the simulated results and served as a basis for further application of designed layer combination. Another applicable materials available for performance tests are briefly discussed as well.

LOPSIMUL: High Computing Rate Numerical Simulator of Multi-Foil Reflective Optical System

Vladimír Tichý
Czech Technical University in Prague, Faculty of Electrical Engineering, Czech Republic

The poster presents description of LOPSIMUL ray-tracing simulation software that offers extremely high computational rate. LOPSIMUL has not a specific requirements for computer hardware and the computing time is less than one second or few seconds on a common personal computer. The software is optimized for lobster eye reflective optics (Angel as well as Schmidt variants) and various types of multi-foil optics. These systems are commonly used for X-rays. As the optimization supposes a specific optics design, the software cannot be used for a generic optics. Lopsimul draws focal image and $\times$ and y profiles. LOPSIMUL calculates FWHM, effective collecting area and other principal results.

The Transient High-Energy Sky and Early Universe Surveyor (THESEUS)

MIS

Lorenzo Amati
INAF - OAS Bologna, Italy, Italy

The Transient High-Energy Sky and Early Universe Surveyor (THESEUS) is a mission concept aimed at fully exploiting Gamma-Ray Bursts (GRB) for investigating the early Universe and as key phenomena for multi-messenger astrophysics. Developed by a large European collaboration coordinated by INAF and under study by ESA since 2018, THESEUS is currently one of the three candidate M7 missions for a launch in the mid 30s. By providing an unprecedented combination of X-/gamma-ray monitors, on-board IR telescope and spacecraft autonomous fast slewing capabilities, this mission would be a wonderful machine for the detection, multi-wavelength characterization and redshift measurement of any kind of GRBs and many classes of X-ray transients, including high-redshift GRBs for cosmology (pop-III stars, cosmic reionization, SFR and metallicity evolution up to the "cosmic dawn") and electromagnetic counterparts to sources of gravitational waves (e.g., short GRBs, soft X-ray and KN emission from NS-NS / NS-BH mergers). Through these unprecedented capabilities and a flexible guest observer programme, THESEUS will also have a great impact on general time-domain astrophysics and, in all respects, will provide an ideal synergy with the very large astronomical facilities of the future in the e.m. (e.g., ELT, CTA, SKA, Athena) and multi-messenger (e.g., Einstein Telescope, Cosmic Explorer, km3NET) domains.

MIS

In-orbit performance verification of EP-FXT

Yong Chen
Institute of High Energy Physics, Chinese Academy of Sciences, China

The Einstein Probe (EP) satellite is a Chinese X-ray astronomical satellite for time-domain astronomy research, launched in early 2024. The Follow-up X-ray Telescope (FXT) onboard EP is an international cooperative telescope led by the Institute of High Energy Physics of the Chinese Academy of Sciences, with the participation of ESA, MPE and the Technical Institute of Physics and Chemistry of the Chinese Academy of Sciences. It is mainly used for follow-up observation of transients, and can also be used for images, light curves, and energy spectra of various X-ray sources.
The FXT consists of two Wolter-I type focusing telescopes, each of which contains 54 nested layers of mirror shells, with a focal length of 1.6m and an angular resolution better than 25 arcsec. The focal plane detector adopts pnCCD, which is cooled by a helium pulse tube refrigeration mechanism. The working temperature is controlled below -90 °C, and the temperature stability is better than 0.08 °C in orbit. The detector has three scientific observation modes: full frame, partial window, and timing mode. Both full frame and partial-window modes have the image capability, while the timing mode has the best time resolution and is used for fast timing observation. A filter wheel is installed above the detector, which includes six working positions: thin film, medium film, hole, open, closed, and calibration. The FXT has an energy range of 0.3-10 keV and an effective area of 600 cm^2@1.5 keV. The field of view is $1\,^\circ \times 1\,^\circ$, and the positioning accuracy is better than 10". The low background in orbit gives it a strong ability to discover X-ray celestial sources, including transients.
After operating in orbit for more than half a year, lots of transient sources have been successfully observed, and high redshift gamma ray burst afterglows have been discovered and accurately located by FXT. Additionally, a large number of new X-ray sources have been discovered. In the first light observation, Crab was observed using partial-window and timing modes to obtain image of its pulsar and pulsar nebula, and precise pulse profiles were obtained using the periodic folding method. Compared to XMM-Newton and Chandra, FXT has the advantage of a large field of view. As the Puppis A supernova remnant, which has a scale of over 50 arcmin, can also be seen at a glance, and the neutron star (central compact object) in the remnant is also clearly visible. From energy spectrum analysis, it can be inferred that Puppis A contains various elements such as oxygen, neon, magnesium, silicon, etc. The distribution of these elements within this supernova remnant can be seen in images. The in-orbit performance verification has shown that all performances of FXT have reached or exceeded the design goals, and detailed calibration has just been finished.

MIS

X-ray optics trade-off for small spacecraft

Vladimír Dániel
Výzkumný a zkušební letecký ústav, Czech Republic

Abstract in the lab – it's cooking up something great!

X-ray field in LEO by miniaturized payload MiniPIX-Timepix3 Space onboard One Web JoeySat satellite

Carlos Granja
Advacam, Czech Republic

The space radiation field in LEO orbit is measured and characterized in high-resolution and wide range by the miniaturized (100 g) low-power (2 W) particle tracker detector "MiniPix-Timepix3 Space" deployed as a radiation monitor in LEO orbit (600 km, polar sun synchronous) onboard the JoeySat One Web telecommunications satellite (150 kg) launched in May 2023. Timepix3 provides quantum imaging sensitivity [1], particle-type resolving power [2], high-resolution spectral response (energy loss, linear-energy-transfer LET) [3] and wide field-of-view directional-tracking information [4]. Particle fluxes (total, partial) and dose rates (total, partial) are produced in wide range (over 8 orders of magnitude) together with charged particle (proton, electron) LET spectra (range 0.01 – 500 keV/µm in silicon). The X-ray component is resolved and analyzed with navigation-time stamp into detailed radiation maps along the satellite orbit.

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MIS

First flight of the stratospheric balloon experiment ASTRABAX

Lucia Kriváneková
TH Aschaffenburg - University of Applied Sciences, Germany

The Aschaffenburg Stratospheric Balloon Experiment ("ASTRABAX") is a multimodal platform developed to carry out experiments on material treatments and life sciences under the extreme radiation exposures at high altitude. Stratospheric balloons, as used in ASTRABAX, may replace sounding rockets and even satellites in some cases. The first of three planned flights within the ASTRABAX project was launched in October 2024 in Bad Pyrmont in northern Germany. The focus of the physical measurements was on the observation of the UV-C spectral region using two miniature UV-VIS spectrometers, and radiation dosimetry employing a Geiger counter. A second set of experiments assessed the effect of irradiation on poly-dopamine samples, currently under development for X-ray mirror coatings. The platform also contained samples of biological cells, here exposed to low-dose radiation of high-energy particles, gamma rays and UV radiation simultaneously. After the flight, changes in the cellsśpatial chromatin organization were examined by super-resolution nanoscopy. Experiments under such natural stratospheric conditions are of relevance for high altitude atmospheric flights, human space missions, comparable exposures on other objects of the solar system, as well as for genetic and radiation biology research.

MIS

XRISM Performance and First Results

Robert Petre
NASA GSFC, United States

The X-ray Imaging and Spectroscopy Mission (XRISM), an international JAXA/NASA collaboration including participation from ESA, is an advanced X-ray observatory carrying out a science program that will address some of the most important questions in astrophysics in the 2020s. Resolve, the primary instrument, is a high-resolution, non-dispersive X-ray spectrometer, providing high-resolution (∼5 eV) spectroscopic imaging capabilities in in the ∼2-12 keV band, with a response peaking around the ubiquitous 6.4 keV Fe K-alpha line. A wide-field imager, Xtend, offers simultaneous coverage over nearly a 40śquare field of view, with ∼1ángular resolution. XRISM is observing a wide variety of astrophysical objects, including galaxies and clusters, AGN, X-ray binaries, supernova remnants, and transient phenomena. This talk will highlight the on-orbit performance of XRISM and its instruments and some of the early science results.

Status of the recently launched Gamma-Ray Burst mission SVOM

Stephane Schanne
CEA Paris-Saclay/IRFU, France

The French-Chinese SVOM satellite (Space Variable Objects Monitor) has been launched successfully on June 22, 2024, from the Xichang launch site in China and is currently in its inflight commissioning phase. The objectives of the mission cover the detection and observation of astrophysical transient events, with a prime focus on Gamma-Ray Burst real-time detection and afterglow observation. All instruments are operational and well functioning in flight. The GRB trigger onboard the ECLAIRs instrument has already discovered some very interesting bursts and sent Alerts in real-time over the SVOM VHF net- work to the instrument team, initiating follow-up campaigns involving several space and ground based facilities. This talk gives a status report on the SVOM mission 4 months after launch.

The status the Einstein Probe mission

Chen Zhang
NAOC, China

The Einstein Probe (EP), launched on January 9, 2024, is a space X-ray observatory for time-domain astrophysics. Now EP is in the normal operation after 6 months of commissioning and calibration phases. EP carries two scientific instruments, Wide-field X-ray telescope (WXT) which monitor the soft X-ray sky in 0.5-4keV, and Follow-up X-ray telescope (FXT) which perform deeper observations in 0.3-10keV and precise source locating. The WXT applies lobster-eye micro-pore optics, with a spontaneous field of view of 3830 sq. deg. Transient alerts will be issued quickly to trigger follow-up observations. This talk will introduce the EP mission and present the preliminary observation results. The scientific capability and potential will also be briefly discussed.

MIS

GRB-detecting nanosatellites GRBAlpha and VZLUSAT-2

Jakub Řípa
Masaryk University, Czech Republic

Results from GRBAlpha and VZLUSAT-2 nanosatellites, which carry gamma-ray detectors on board for monitoring transients will be presented. GRBAlpha is a 1U CubeSat launched in March 2021 and it has operated on a 550-460 km altitude sun-synchronous polar orbit (SSO) for more than three years. VZLUSAT-2 is a 3U CubeSat launched in January 2022 and it operates also on SSO at a similar altitude for more than two years. So far both missions have detected ∼300 gamma-ray transients including long and short gamma-ray bursts (GRBs), soft-gamma repeaters and solar flares, including the most intense GRB ever recorded GRB 221009A and exceptionally bright GRB 230307A. The onboard gamma-ray detectors are based on CsI(Tl) scintillator readout by silicon photomultipliers (SiPMs). SiPMs are prone to radiation damage. With the increasing popularity of SiPMs among new spaceborne missions, especially on CubeSats, it is of paramount importance to characterize their performance in the space environment. We will report the in-orbit ageing of SiPMs at SSO over three years, which in duration is unique. We have demonstrated that SiPMs can be used in the low Earth environment on a scientific mission lasting beyond three years. This manifests the great potential of SiPMs being employed in future satellites.

Calibration and data analysis of the GRASS detector module for gamma-ray emission spectroscopy

DTF

Patrizia Barria
INAF (National Institute for Astrophisics) and Centro Nazionale "High Performance Computer, Big Data and Quantum Computing, Italy

The GRASS (Gamma-Ray Astronomical Small Sensor) instrument is a low mass, position sensitive compact detector based on a GAGG (Gadolinium Aluminium Gallium Garnet) scintillator array and a readout system with latest generation solid state sensors (SiPM). It is an advanced prototype conceived as the basic element of a larger area modular detector for time domain soft gamma-ray astronomy. GRASS has been flown two times in 2021 and 2022 on board stratospheric balloons from Kiruna (Sweden) and Timmins (Canada) in 2021 and 2022, respectively.

BEaTriX: current status and future prospective

DTF

Stefano Basso
INAF-OABrera, Italy

BEaTriX is a facility commissioned in 2023 to test the newATHENA optics at the 4.51 keV energy. This compact laboratory is able to test each mirror module with a rate of 3 units per day due to a dedicated chamber with a very short vacuum time to reach 10-4 mbar (about 30 minutes). The unique capability of the beam line is a big collimated beam (170x60 mm, collimated to about 2 arcsec) with a very narrow energy band. Currently some MMs have been tested measuring point spread function and effective area, performing also thermal cycles using a thermal box permitting to reach temperature in the range of -5°/+45°C at the MM level. A second energy (1.49 keV) is under implementation to equip BEaTriX with both energies important for newATHENA; finally, a re-design of the tube between the optic under test and the detector is just started to increase the future flexibility of the facility to measure optics with a focal length in the range of 1.5/12 m.

DTF

The electronic design of the focal plane detector

Weiwei Cui
Institute of High Energy Physics Chinese Academy of Sciences, China

The Einstein Probe (EP) satellite focuses on X-ray time-domain astronomy. The Follow-up X-ray Telescope (FXT) is one of the scientific payloads onboard the EP. FXT consists of two essentially identical units, each employing a Wolter-I type focusing mirror and using a pnCCD as the focal plane detector. The focusing mirror and detector is provided by the European Space Agency (ESA) and the Max Planck Institute for Extraterrestrial Physics (MPE), respectively. FXT designs three scientific operating modes for the pnCCD detector: full-frame mode, partial-window mode, and timing mode. The detector is cooled with a helium pulse tube refrigerator and operates at a temperature of -90 ± 0.5 °C. In the full-frame mode, the energy resolution achieves 88 eV at 1.25 keV (FWHM) in orbit.

DTF

Athena mirror performance characteristics at XRCF

Kristin Madsen
Goddard Space Flight Center, United States

The Xray Cryogenic Facility (XRCF) was the baseline performance verification and calibration facility for the Athena mirror demonstrator (MAMD), the Athena qualification module (QM), and the Athena flight module (FM). The Athena mirror is unique in its size and segmented nature, and there is no facility currently in existence that can fully illuminate the entire mirror. We explored what this meant for the method of testing to obtain the effective area and point spread function with raytracing and simulations. In particular, we investigated the challenge of stitching results together from sub-aperture illumination, which required the design of an elaborate laser metrology system, based on differential interferometric measurements.

DTF

Laser-driven X-ray Sources at ELI Beamlines: Development and Application

Jaroslav Nejdl
ELI Beamlines Facility, Extreme Light Infrastructure ERIC, Czech Republic

The Extreme Light Infrastructure (ELI) Beamlines facility is at the forefront of developing high-flux, coherent X-ray sources driven by advanced laser systems. These sources are pivotal for various scientific applications, including ultrafast spectroscopy, material science, or X-ray metrology. This presentation compiles recent research efforts and advancements with three types of sources: 1) The beamline based on high order harmonic generation in noble gases - a coherent extreme ultraviolet source with femtosecond pulses 2) The laser plasma X-ray source- an incoherent source of hard X-rays with X-ray tube-like spectrum and sub-picosecond pulses 3) The plasma betatron X-ray source employing relativistic electron beams accelerated by laser - an incoherent micron-sized broadband hard X-ray source with femtosecond pulses. Characteristics of those source that are already available to the scientific community as well as their selected applications will be presented.

Spectral studies of the heliospheric X-ray emission with SRG/eROSITA

AST

Konrad Dennerl
Max-Planck-Institut für extraterrestrische Physik, Germany

SRG/eROSITA has made it possible for the first time to separate the heliospheric foreground emission from the diffuse X-ray sky beyond, on a global scale and on a baseline of more than two years. In this presentation we focus on the observed spectral properties of the heliospheric X-ray emission. This is challenging, because the emission is faint, while the pronounced temporal variability requires to perform the analysis on a high number (about 10^5) of samples. We describe how we have faced this challenge by finding a suitable spectral model with only 3 free parameters and by developing a fitting method which is so efficient that 10^5 spectra can be processed within 30 s. We find that (i) the observed spectral properties can be reproduced by charge exchange interactions between C, N, and O ions in the solar wind and interstellar Helium, that (ii) there is substantial short-term variability in the CNO abundances, that (iii) there is a long-term trend of increasing CNO from solar minimum towards solar maximum, and that (iv) the increase rate raises with atomic number.

Recent Advances in Robotic Observatory Control: Enhanced Scheduling and Photometric Pipeline at Ondřejov Observatory

Martin Jelínek
ASÚ AVČR, Czech Republic

The Ondřejov Observatory operates two robotic telescopes - a 0.5m Newtonian (D50) and a 0.2m Small Binocular Telescope (SBT) - primarily dedicated to time-domain astrophysics, with a focus on Gamma-Ray Burst optical afterglows and other high-energy transients. We present significant improvements to our observatory control system, particularly in two key areas: dynamic scheduling and photometric calibration. The enhanced scheduling system now implements a sophisticated constraint-satisfaction solver using OR-Tools, which optimizes telescope time allocation based on multiple parameters including target visibility, airmass, priority, and timing constraints. The scheduler can now handle meridian flips, maintain execution continuity across observatory restarts, and provides real-time adaptation to changing observing conditions. Our photometric pipeline has been upgraded with robust automated calibration capabilities, featuring multi-filter support and advanced outlier rejection. The system now employs a forward stepwise regression approach for determining optimal photometric solutions, handles color transformations between various photometric systems, and includes automated quality control. The pipeline automatically processes all observations and populates a searchable database, enabling real-time access to calibrated light curves through a cone-search interface. These improvements have significantly enhanced our observatoryś efficiency in both scheduled monitoring and rapid response capabilities, particularly crucial for time-critical observations of transient phenomena.

The AHEAD2020 program: an update

Lorenzo Natalucci
Lorenzo Natalucci, Italy

Since its launch in 2015 as EU infrastructure for high energy astrophysics, AHEAD has constituted a framework to integrate European institutions, facilities and industries working in this highly competitive field. Started in 2020, the AHEAD2020 program has realised an efficient network that was highly successful in keeping the community at the cutting edge of science and technology along the years, at the same time opening to include all aspects of multi-messenger science, such as gravitational wave and neutrino astronomy. AHEAD2020 has offered funding opportunities, also open to participants outside Europe, for transnational visits, workshops and dissemination activities. Much effort has also been devoted to the exploitation of current space missions, also enhancing gamma-ray and multi-messenger science and including the development of different types of optics technology, that are currently used in recently launched observatories and planned for the future open X-ray observatory, newAthena.

Observing the activity of X-ray sources by a combination of monitors

AST

Vojtech Simon
Astronomical Institute, the Czech Academy of Sciences, Czech Republic

We discuss how combining the observations of various X-ray monitors onboard different satellites can be helpful for investigating the long-term activity of a given object using the light curves of the 1-day means. We show how observing the activity of X-ray binaries can contribute and how combining the MAXI/ISS data with those obtained by the monitor BAT onboard Swift can be helpful if the light curves containing the 1-day means are used. Combining observations from MAXI/ISS and BAT/Swift enables the investigation of long-term activity at energies between 2 keV and 50 keV. We show examples of several X-ray sources containing compact objects accreting matter from their companions. We analyzed the typical features of the activity that are distinguishable on the light curves with a 1-day binning. We show the features for which observing with this binning is sufficient. This provides the scientific potential to investigate the role of various physical mechanisms.

AXRO introduction and historical background

OTH

Rene Hudec
Czech Technical University in Prague, Czech Republic

The AXRO history is related to the history of X–ray astronomy in general and to the history of X-ray optics developments in the Czech Republic (and formerly in Czechoslovakia) in particular. The first Czech X-ray mirror was built already in the years 1969/1970, for a solar telescope within the Eastern Europe/Soviet INTERKOSMOS program, There were also essential efforts devoted to the development of novel technologies for satellite projects which were either canceled or interrupted. The two wasted years of development on the technology of high-quality Ni foils for the Danish SODART telescope (Schnopper, 1990), 1986-1988, can serve as an example. The SOviet-DAnish Roentgen Telescope (SODART) was planned for on board the Spectrum Roentgen Gamma (SRG) satellite equipped with three different instruments devoted to X–ray spectroscopy. Each of the two thin foil telescopes had an 8m focal length, a 60 cm diameter, a 1 deg field-of-view (FOV), a half-power width better than 2 arcmin and ca. 1 700 and 1 200 cm^2 collecting area at 2 and 8 keV, respectively. In the last three decades developments of innovative technologies for X-ray optics continued with an emphasis on glass foils and silicon wafers mostly in Multi Foil Optics arrangements and Schmidt Lobster Eye and Kirkpatrick Baez geometries. The late achievements are then related to the AHEAD2020 PROJECT.

Czech Space Industry last projects

OTH

Richard Pavlica
5M s.r.o., Czech Republic

Czech Space Alliance is industrial association of Czech companies involved in Space applications. High number of interesting projects was done in Czech Republic in frame of last 16 years of cooperation with ESA and CSA members were involved in majority of them. The actual most interesting projects of Alliance members will be presented and cooperation between Czech participants will be highlighted.

Concluding Remarks

OTH

Vadim Burwitz
Max-Planck-Institut for Extraterrestrial Physics, Germany

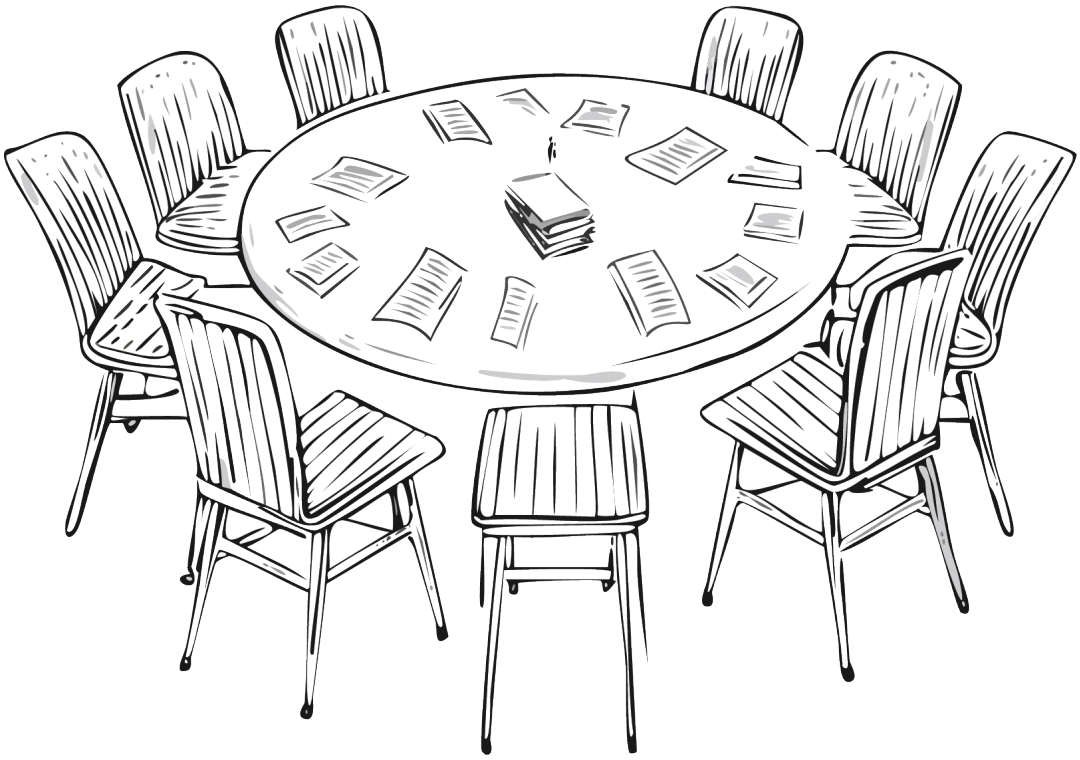
Final thoughts: Did we actually answer anything?

OTH

Concluding Address

Rene Hudec
Czech Technical University in Prague, Czech Republic

And that's all, folks! Join us next year for more adventures!



List of Participants

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Nicolas Barrière	Netherlands
Stefano Basso	Italy
Vadim Burwitz	Germany
Yong Chen	China
Vincenzo Cotroneo	Italy
Weiwei Cui	China
Konrad Dennerl	Germany
Vladimír Dániel	Czech Republic
Thorsten Döhring	Germany
Peter Friedrich	Germany
Carlos Granja	Czech Republic
Fabien Grisé	United States
Rene Hudec	Czech Republic
Adolf Inneman	Czech Republic
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Useful Information

Emergencies

There are several important numbers:

112	The Single European Emergency Call Number
158	Police of the Czech Republic
155	Emergency medical services
150	Fire and rescue service of the Czech Republic

In case you are in an emergency situation or witness such a situation and do not know where exactly you are, report your **location** using the **six-digit number** on the nearest street **lighting pole** to the emergency services.

Internet connection

Wi-Fi will be available during the conference.

SSID:
PASS:

There is also access to the **Eduroam network** in the conference venue.

Public transport

The nearest public transport stop to the villa Lanna is Hradčanská (green Metro Line A, Tram: 1, 2, 8, 18, 20, 25, 26, and Bus 131).

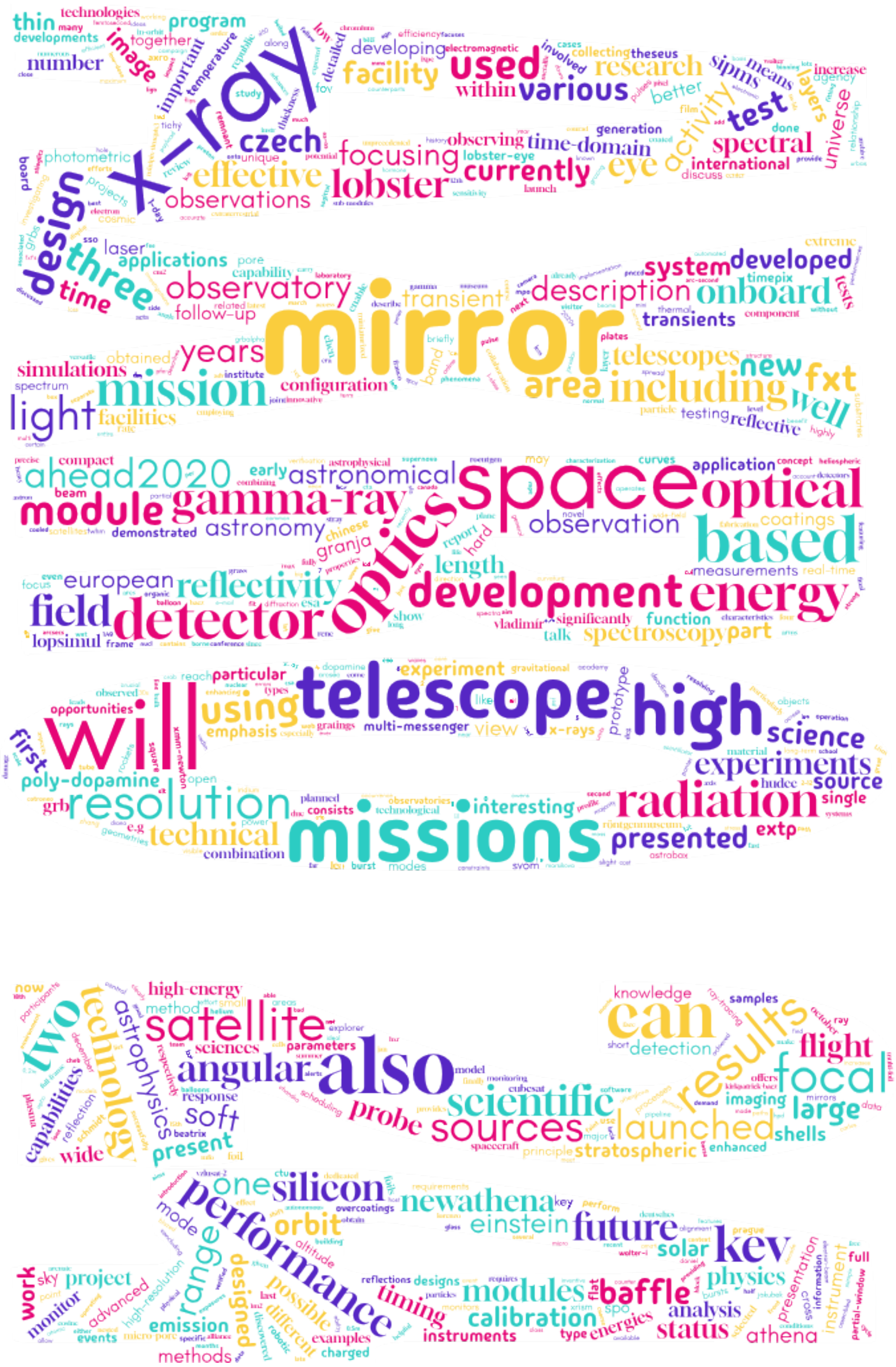
Bus/metro/tram rides do not need to be booked in advance. The passengers must buy a ticket before on-boarding and validate it immediately after boarding the bus/tram or before the entrance to the metro station by a small yellow stamping machine. Validity is limited only by time, number of transfers is not limited.

Participants aged over 65 can verify their right to receive the free age-based fare/tariff through the use of any form of ID card or a passport.

Tickets can also be purchased via SMS (only czech mobile numbers) or the **Lítačka mobile app**, which can also be used to search for the ideal public transport connection. The application is available for Android or iOS.

More information about transportation, prices and connections can be found at `http://www.dpp.cz/en/`

Time	Price
30 minutes	30 CZK
90 minutes	40 CZK
24 hours	120 CZK
72 hours	330 CZK



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