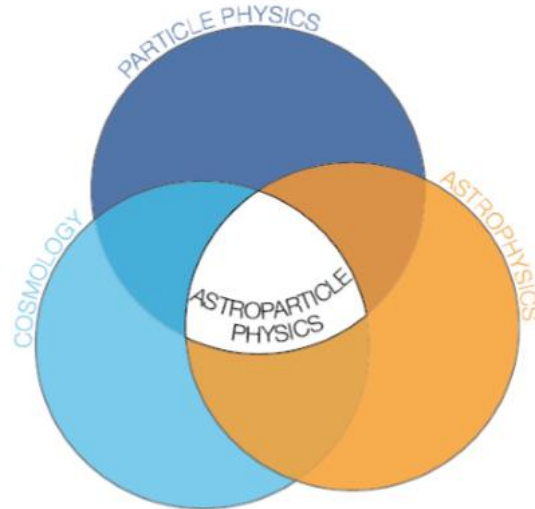


Astroparticle physics



Petr Trávníček

FZÚ - Institute of Physics,
Czech Academy of Sciences

Activities / Institutes

- **Astronomical Institute CAS:** Black hole astrophysics Cosmic jets, particle acceleration in shocks Plasma physics, magnetic reconnection
- **Czech Technical University in Prague:** Baikal-GVD - neutrino point sources, diffuse neutrino flux, transient sources; Indirect search for dark matter and other exotic particles; Neutrino oscillation parameters Picasso/PICO - Direct detection of dark matter (neutralino) in Sudbury Pixel detectors in space CZELTA (outreach)
- **Institute of Physics CAS:** Pierre Auger Observatory (Auger), Cherenkov Telescope Array (CTA), Large Synoptic Survey Telescope (LSST)
- **Silesian University in Opava:** astrophysical processes near compact objects (neutron stars, black holes), cosmology
- **Charles University:** Auger – science topics, data analysis CTA – calibration, atmospheric studies neutrino experiments (Daya Bay, NovA, JUNO, ...)
- **Palacky University in Olomouc:** Auger, CTA - mirror design and manufacturing, maintenance and calibration
- **Nuclear physics institute CAS:** ANC – Asymptotic normalization coefficients THM – Trojan Horse Method Direct study of resonance
- ...

Outline

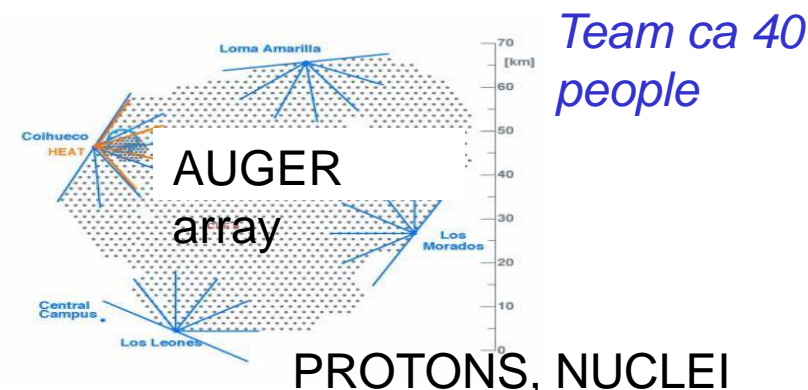
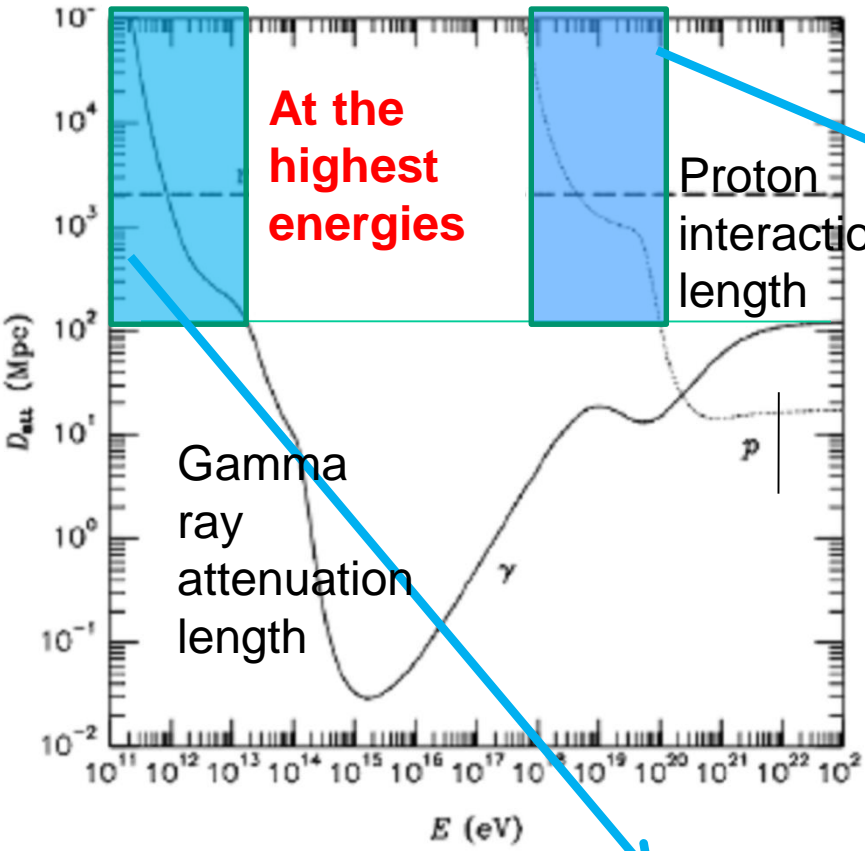
Reminder of the Czech participation in (some) astroparticle physics projects (Charles University - CUNI, Czech Technical University - CTU, Palacky University - UP, Institute of Physics, CAS – FZU, Astronomical Institute, CAS - ASU)

News from 2018

- Ultra High Energy Cosmic Rays - Pierre Auger Observatory (CUNI, UP, FZU)
- High Energy Photons - Cherenkov Telescope Array (CUNI, UP, FZU, ASU)
- Cosmological Survey Telescope – LSST (CUNI, UP, FZU)
- Direct detection of dark matter (CTU)
- Cosmic neutrinos – Baikal (CTU)
- Pixel detectors in space (CTU)
- Other activities

News from APPEC

Pierre Auger Observatory and Cherenkov Telescope Array

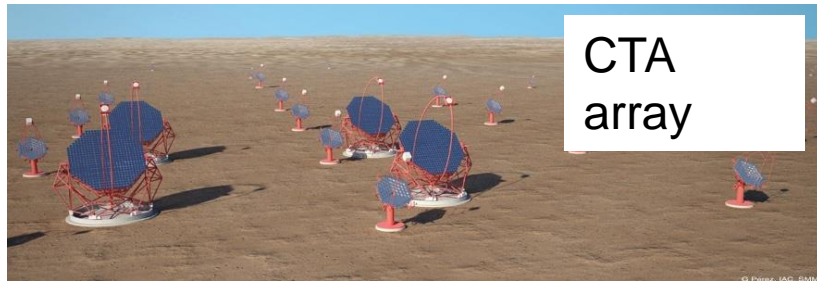


PROTONS, NUCLEI
FZU, CUNI and UP

AUGER upgrade - AugerPrime operation 2020-2025

CTA - construction, ready for operation in 2024

cosmic particles with the highest energies !!!



PHOTONS

Pierre Auger Observatory (FZU, CUNI, UP):

Team ca 30 people

students also from Czech Technical University (CTU)

charged particles of the highest energies - world largest **cosmic ray observatory, Argentina**

- Construction, operation and maintenance of fluorescence telescopes (FZU-Prague, FZU-Olomouc, UP, CUNI)
- Atmospheric monitoring (FZU-Prague, FZU-Olomouc, UP)
- Grid computing (FZU-Prague)
- Auger Upgrade, testing of electronics (FZU-Prague)
- Science – test of hadronic interactions (FZU-Prague), hybrid and FD low energy spectrum (FZU-Prague, CUNI, CTU), composition of cosmic rays (FZU-Prague, CUNI, CTU)

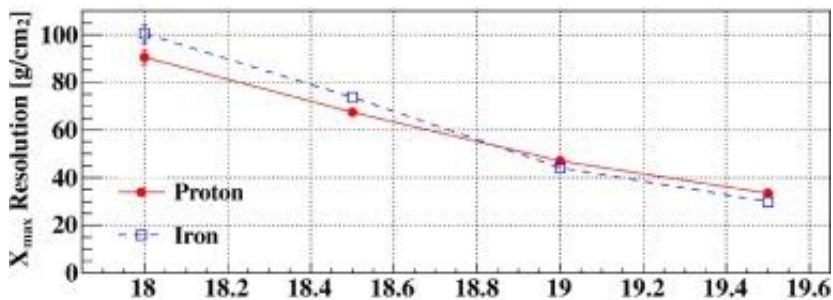
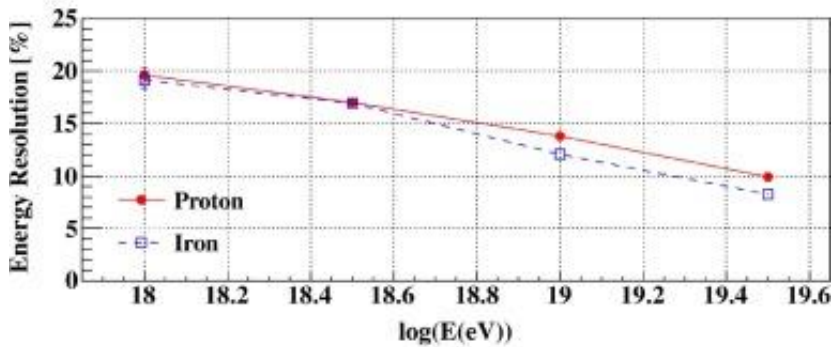
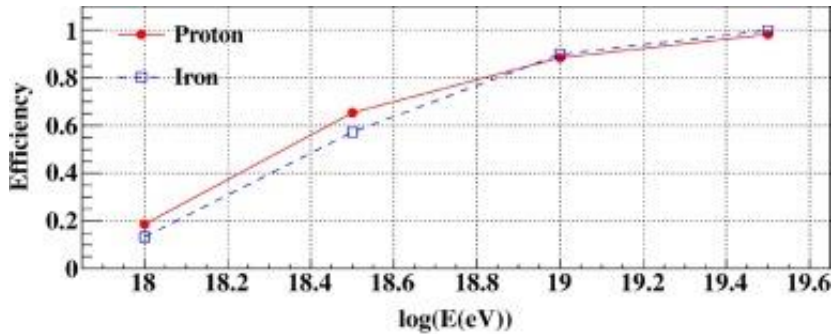
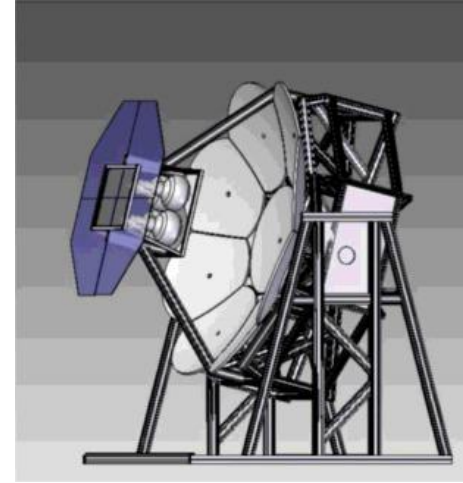


Research infrastructure and Inter-Excellence program of Ministry of Education



R&D and Pierre Auger Observatory 2018

- FAST – simplified FD R&D
- 3rd telescope in Utah since Oct. 2018
- Fast telescope to Pierre Auger Observatory in 2019



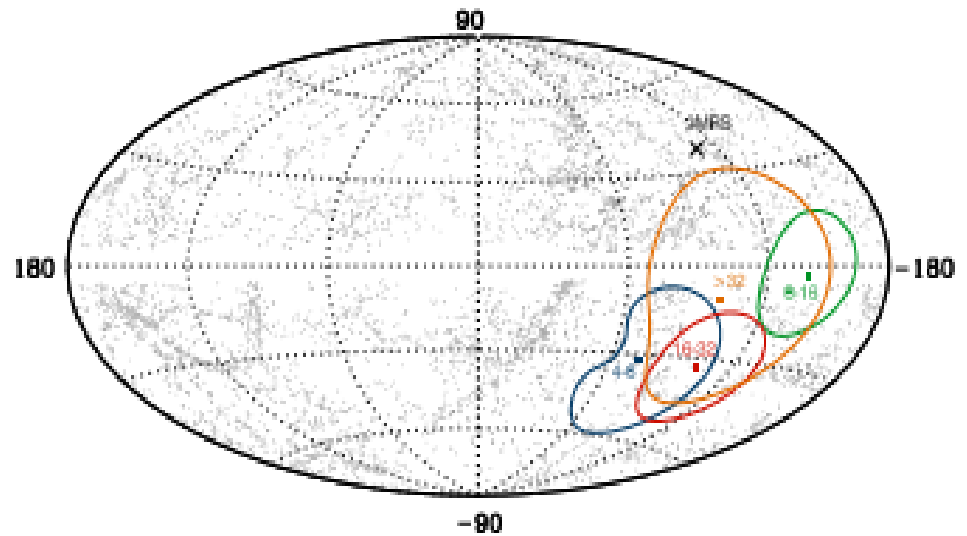
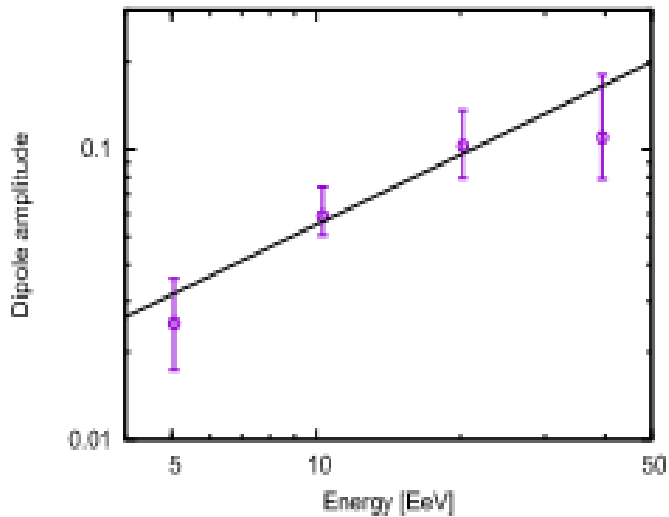
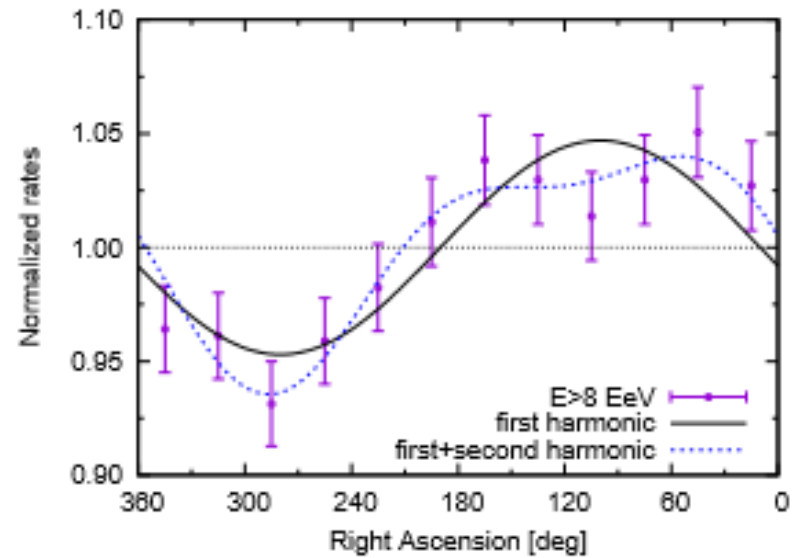
Pierre Auger Observatory 2018

- AUGERPrime – upgrade of the Observatory
- 30 SSDs in the field



Pierre Auger Observatory 2018

Large-scale cosmic-ray anisotropies above
4 EeV measured by the Pierre Auger
Observatory
ApJ 868 (2018) 4

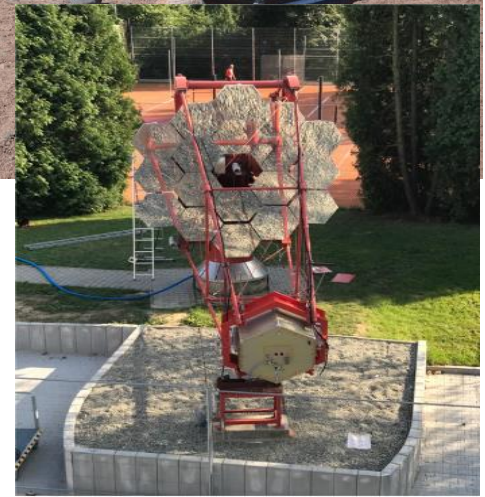
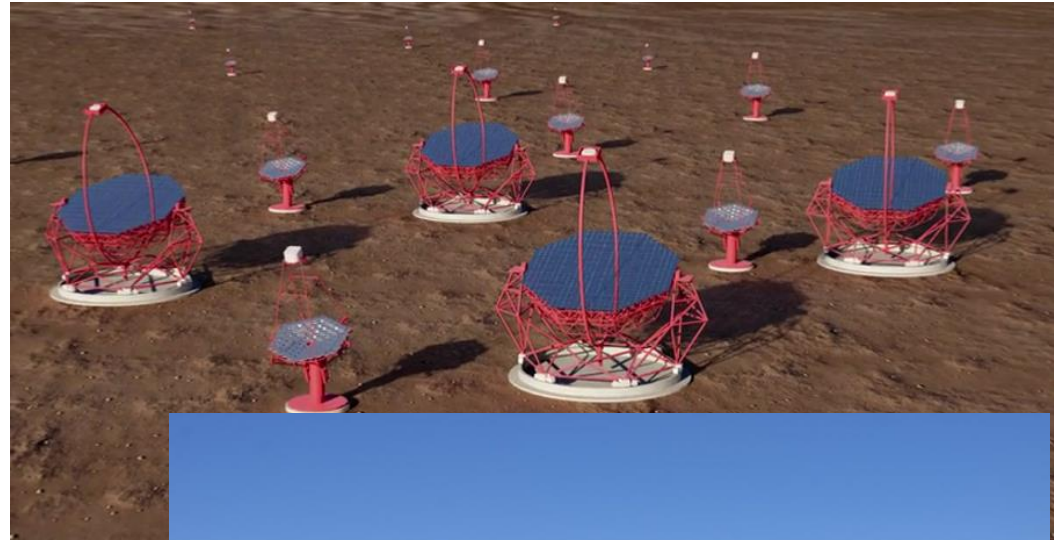


Cherenkov Telescope Array (FZU, CUNI, UP, ASU)

Team ca 30 people

CTA – photons of the highest energies - world largest gamma ray observatory under construction, Chile, Canary Islands

- Site search (FZU-Olomouc, FZU-Prague)
- SST telescope design (FZU-Olomouc, UP)
- mirror construction and testing (FZU-Olomouc, CUNI)
- Atmospheric program, calibration (FZU-Prague, FZU-Olomouc, UP, CUNI)
- Grid computing (FZU-Prague, CUNI)



Research Infrastructure and Inter-Excellence program of Ministry of Education

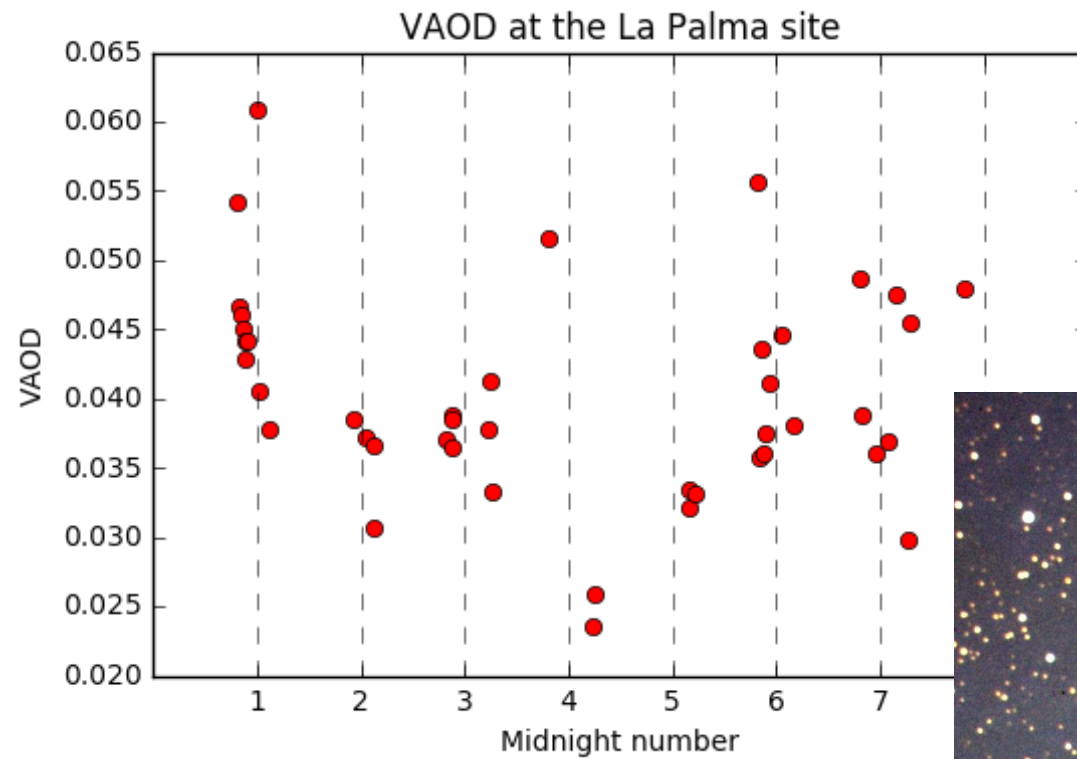
Cherenkov Telescope Array – CZ news 2018

- October 2018 - new FRAM at La Palma
- FRAM at Paranal smooth operation since 2017 – confirms the quality of the site - VAOD typically < 0.05 – supported with photometer measurements
- LST inauguration



Cherenkov Telescope Array news 2018

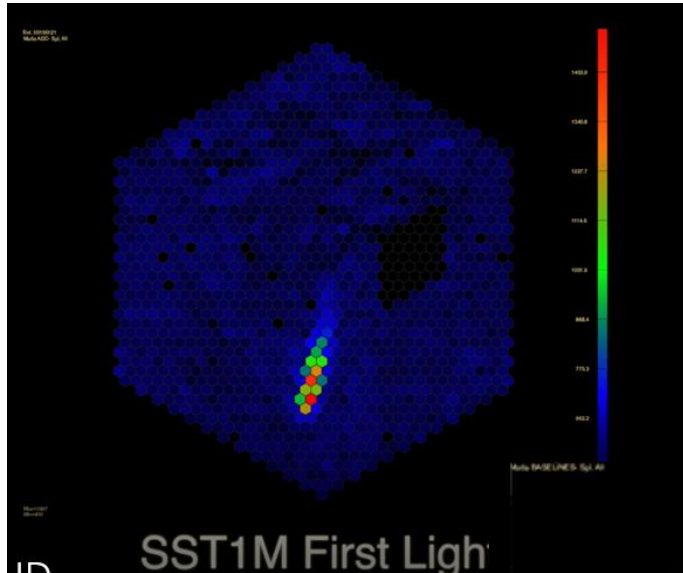
- October 2018 - new FRAM at La Palma



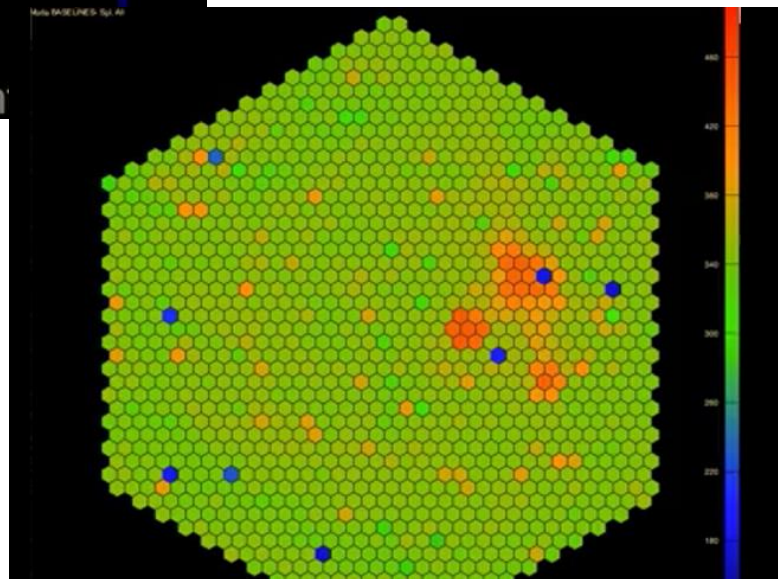
Cherenkov Telescope Array news 2018

SST prototype operation in Krakow

události - spršky



podivné události -
???



Optics for Astroparticle Physics (Olomouc, FZU and UP)

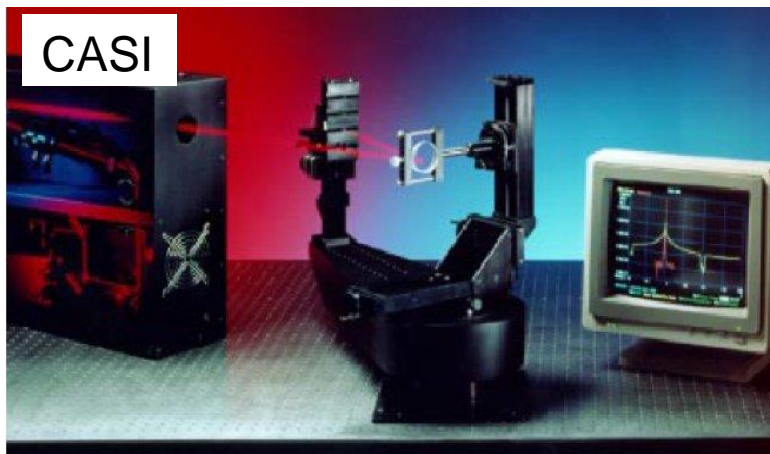


Fluorescence detector building

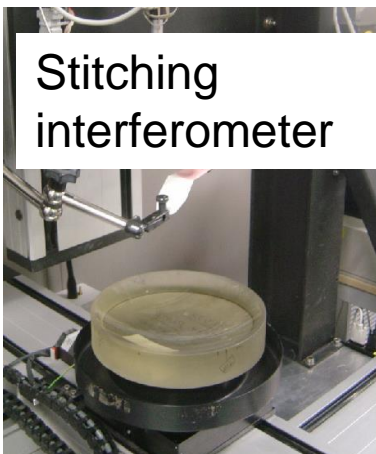


Mirrors and camera

Mirror production up to 1m size



CASI



Stitching interferometer

Battery of devices to study optical properties of components used in astroparticle physics (CASI, nanoindenter, spectrometers, absolute reflectivity setup, ...)



Grinding and polishing machine



Alignment of SST-1M telescope

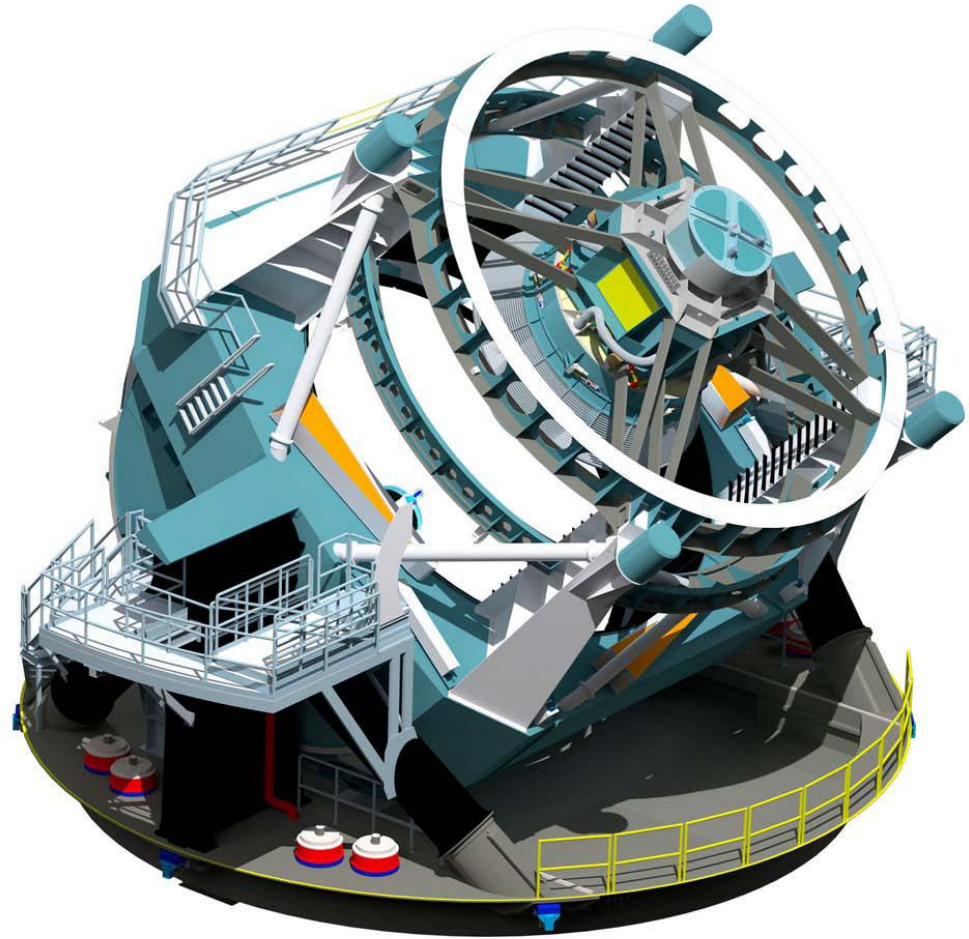
Alignment of fluorescence and gamma ray telescopes

Calibration of telescopes

New technologies for simple fluorescence detectors - FAST

LSST – Large Synoptic Survey Telescope

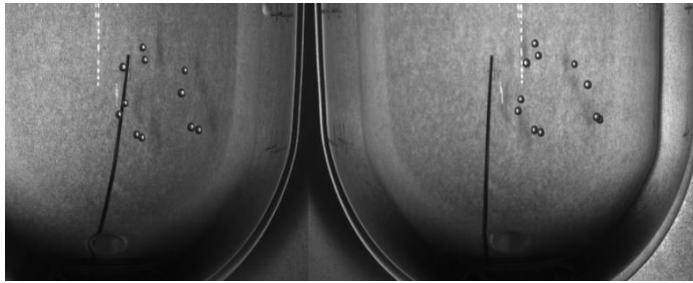
- FZU is one of the three European LSST members
- CCD characterization and measurements automation
- Activities in Dark Energy Science Collaboration (simulations of modified gravity, sensor anomalies and their impact on cosmological observations)



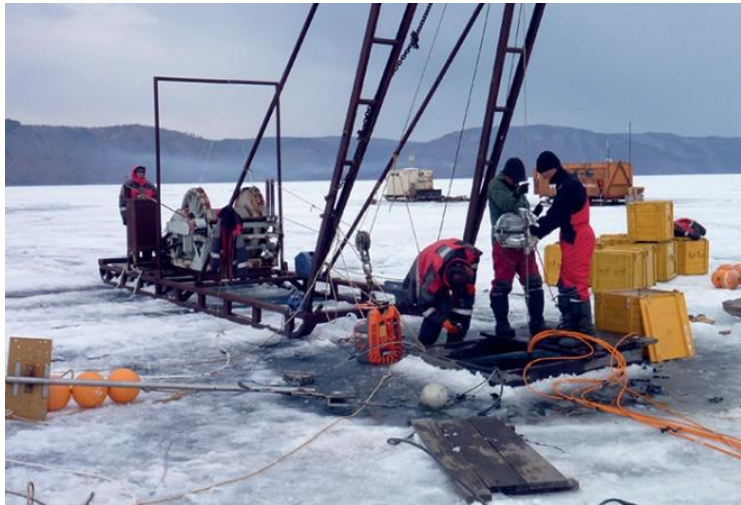
Astroparticle physics at Institute of Theoretical and Experimental Physics, CTU

i) **Direct detection of dark matter (neutralino)**: international collaboration PICO (USA, Canada, Spain, Mexico, India and Czech Republic), location SNOLAB (Canada)

- Detection of neutralinos as dark matter candidates using a bubble detector.
- Robert Filgas will spend 6 months at SNOLAB.

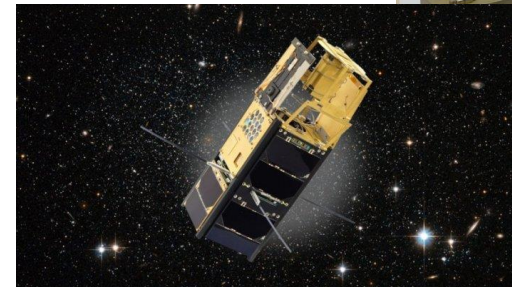
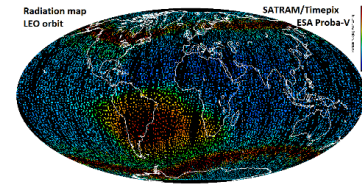


ii) **Baikal-GVD**: cooperation with JINR Dubna, Comenius University in Bratislava...., Galactic and extragalactic neutrino point sources, diffuse neutrino flux, transient sources; Indirect search for dark matter and other exotic particles; Neutrino oscillation parameters; Responsibilities: Time calibrations, Winter expeditions, Double Pulse Detection, Possible future surface extension; Two bachelor students (supervisor L. Fajt)



iii) Measurement of cosmic rays with pixel detectors in space:

- All equipment based on the Medipix/Timepix semiconductor pixel detectors.
- Dosimeters in International Space Station (NASA, Univ. of Houston). In operation since 2012.
- Equipment for the measurement of cosmic rays in outer space in Proba-V satellite (ESA). In operation since 2013.
- VZLUSAT-1 nanosatellite with the novel concept of X-ray telescope (wide-field optical system “Lobster Eye”); launched in 2017
- Rocket REX - X-ray telescope test with ballistic missile, NASA, launched in 2018
- In preparation: RISESAT (Japan Space Agency) – detection of cosmic rays in outer space.
- Project MIRAM – development of new generation of detectors of c. r. for ESA satellites.

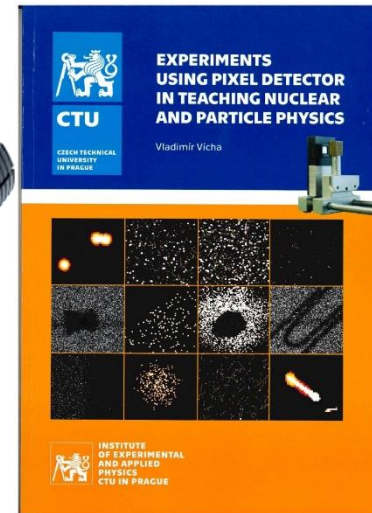
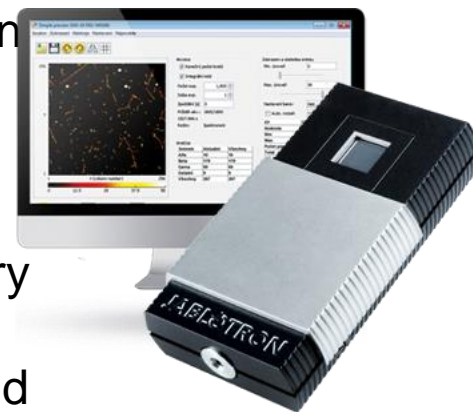


iv) **Theory of neutrinos and dark matter:** development of models of elementary particles beyond the Standard Model to describe origin of neutrino masses and lepton number violation, to predict new particles (majorons, dark matter candidates), to provide input into a leptogenesis, which explains the baryon-antibaryon asymmetry of the Universe.

Conference MEDEX – nuclear matrix elements calculation, every 2 years in IEAP CTU.

v) **Outreach activities:**

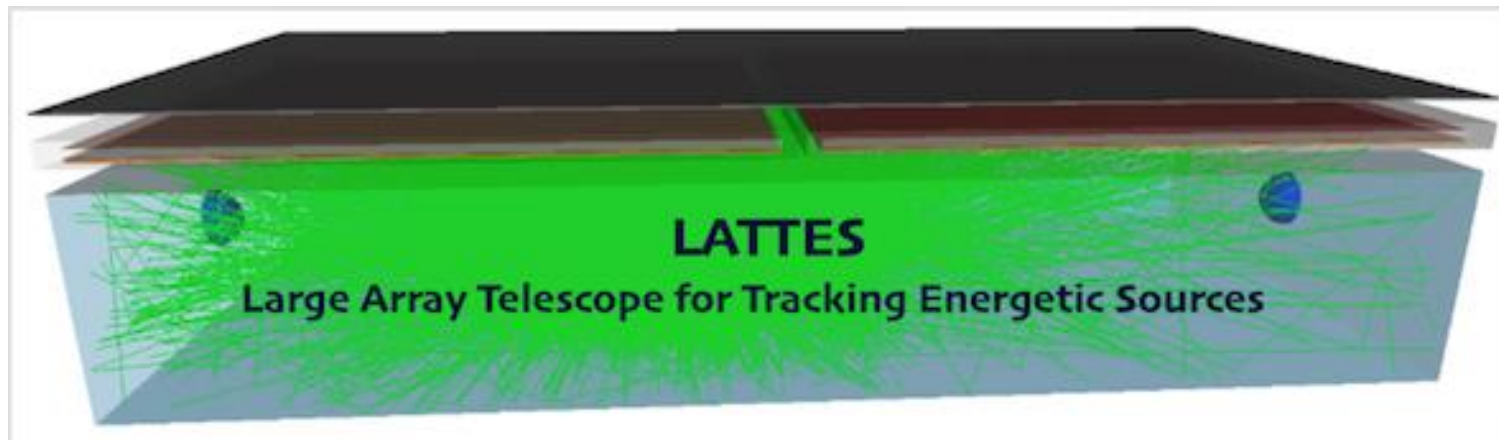
- **CZELTA:** detection of high energy cosmic rays with scintillating detectors, cooperation with secondary schools.
- **MX-10:** equipment developed in cooperation with Jablotron, based on Medipix detectors. Visualization of ionizing particles including cosmic rays.
- Educational program of MEYS for secondary schools teachers, V. Vícha, „Experiments using pixel detectors in teaching nuclear and particle physics“, ISBN 978-80-01-06108-4.



Future program

- **AUGERPrime construction and operation** (till > 2025) – UP, FZU, CUNI
- **CTA construction and operation** (> 2024) - UP, FZU, CUNI, ASU
- Participation in **direct searches for DM, neutrinos** from cosmos - CTU
- **LSST** – first light 2021, science after 2022

- Future ground base observatories for cosmic and gamma rays
 - **LATTES** - FZU
 - **“AUGERNext”** - UP, FZU, CUNI
 - „FAST“ like array ?



APPEC

Astroparticle Physics European Consortium

<http://www.appec.org>



Home

About

Consortium

Roadmap

Implementation

News

Events

European Astroparticle Physics Strategy 2017-2026

(Credit: Christian Reisswig, Luciano Rezzolla, Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut/AEI)/Michael Koppitz, Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut/AEI)/Zuse-Institut Berlin © AEI/TP/ZIB)

Input for the Update of the EU Strategy for Particle Physics –3 areas of recommendation in prefinal text 1) DM; 2) Multi-messenger physics (CTA, TAIGA, KM3Net, IceCube, Baikal-GVD, Pierre Auger Observatory and Telescope Array, Einstein Telescope (ET), ISOLDE, Totem, ALICE and LHCb); 3) CERN neutrino platform.
(I. Štekl)

APPEC - Astroparticle Physics European Consortium

CZ is the member through CTU

CERN is the observer in APPEC

European Astroparticle Physics Strategy 2017-2026 –
launched in January 2018 - <http://www.appec.org/roadmap>

Several links between strategy documents – [European Strategy for Particle Physics](#) and [European Astroparticle Physics Strategy](#)