

RU Astroparticle Physics

Experimental and theoretical Astroparticle Physics at DESY

Helmholtz Program: Matter and the Universe (MU)

PoF III Topic: Matter and Radiation from the Universe

DESY Research Unit: Astroparticle Physics

Marek Kowalski

Center Evaluation DESY, 5 – 9 February 2018

HELMHOLTZ RESEARCH FOR
GRAND CHALLENGES

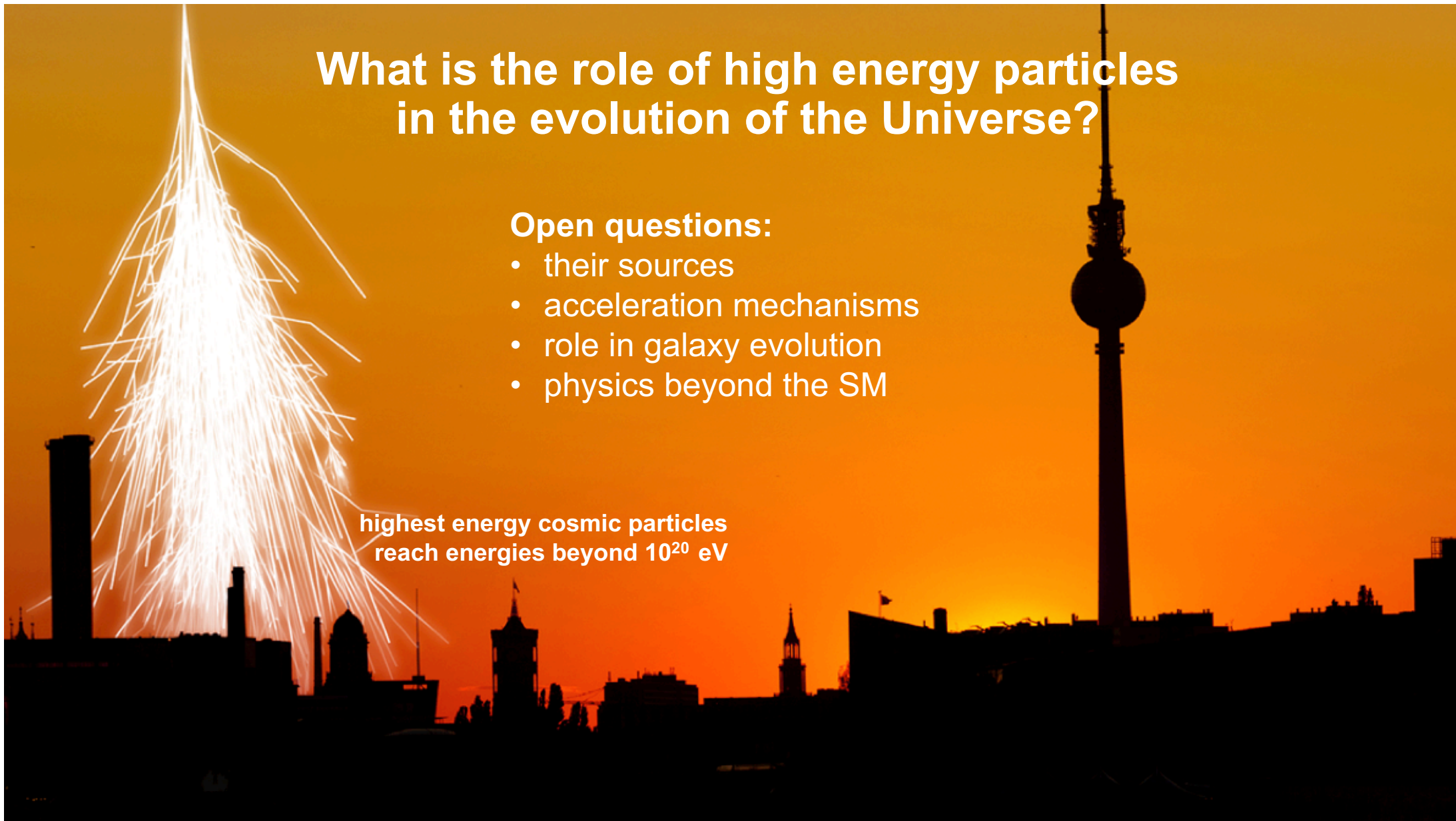


What is the role of high energy particles in the evolution of the Universe?

Open questions:

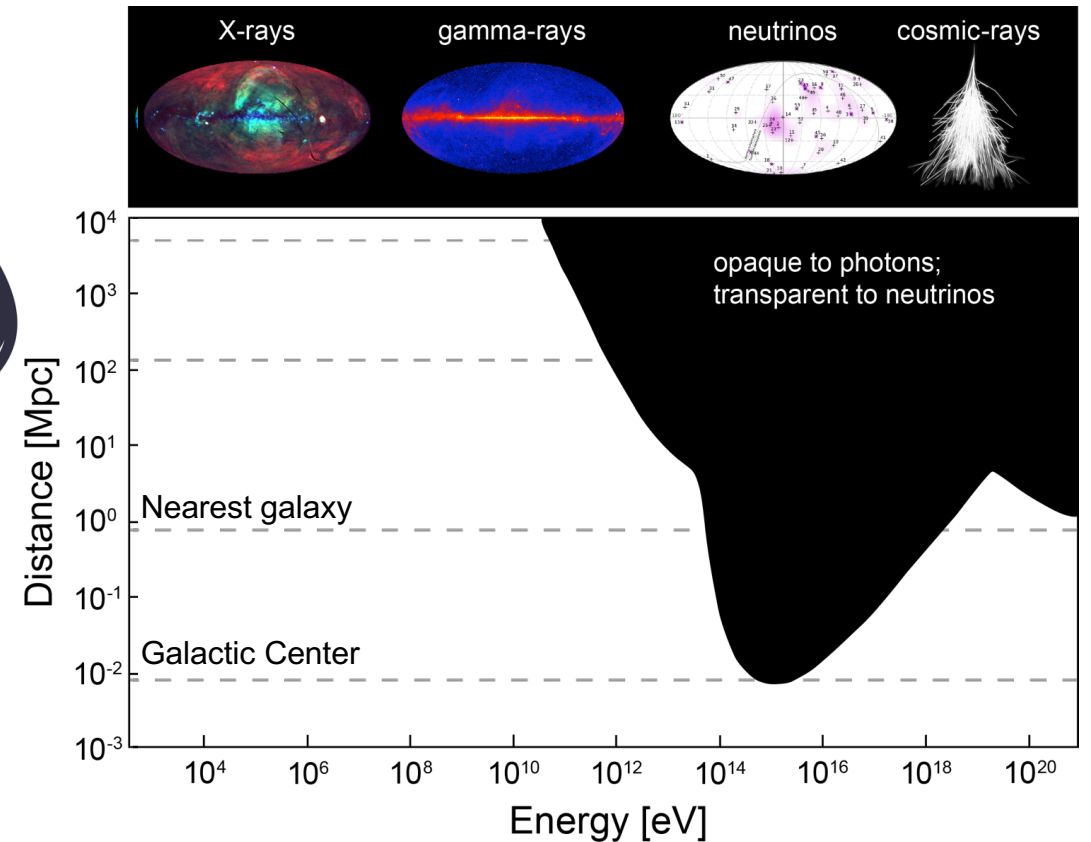
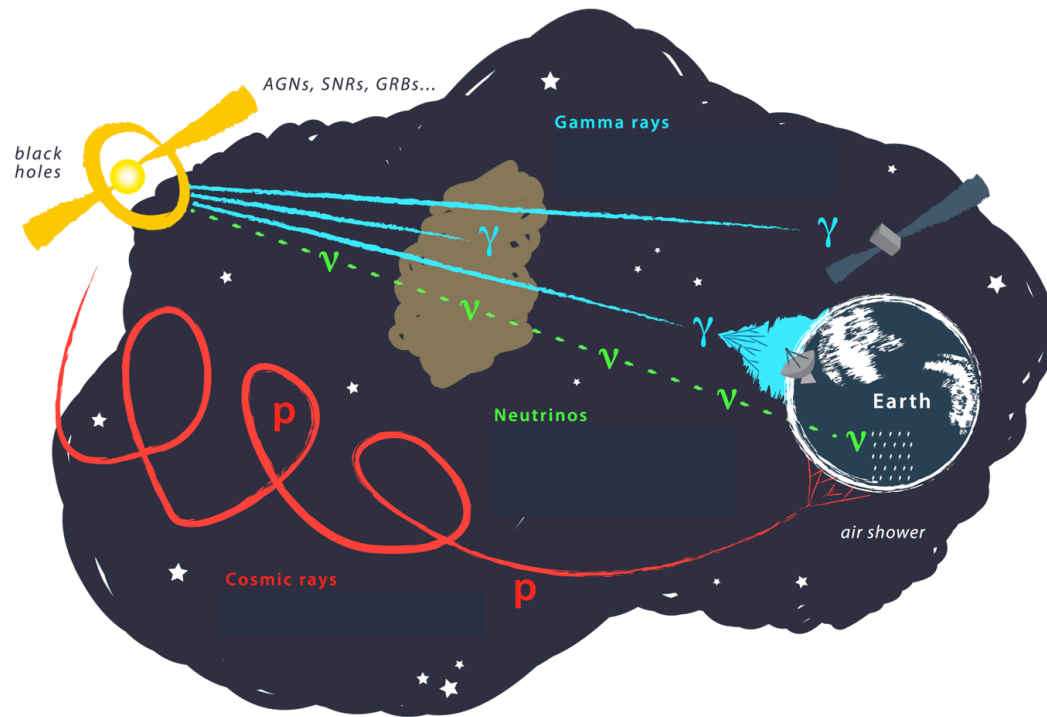
- their sources
- acceleration mechanisms
- role in galaxy evolution
- physics beyond the SM

highest energy cosmic particles
reach energies beyond 10^{20} eV



Understanding the high-energy Universe

Multi-messenger Astronomy at DESY



Understanding the high-energy Universe

Multi-messenger Astronomy at DESY

Focused research program at DESY based on four pillars:

1. Gamma-ray astronomy
2. Neutrino astronomy
3. Multi-messenger astronomy
4. Theoretical astroparticle physics



FERMI



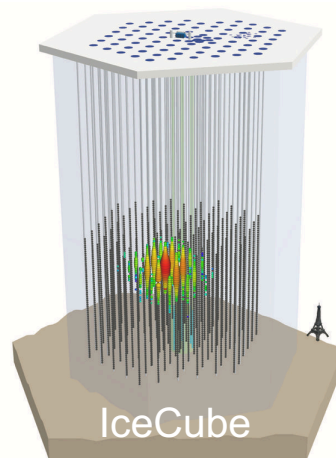
H.E.S.S.



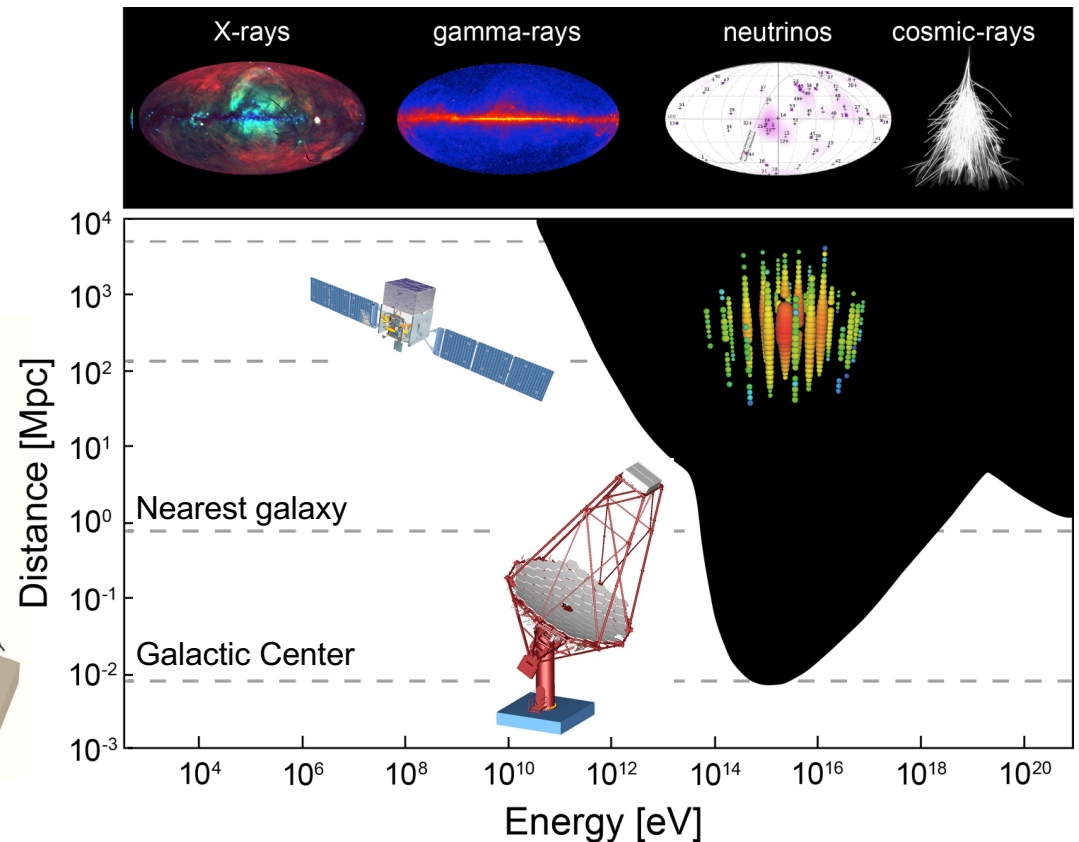
VERITAS



MAGIC



IceCube



RU Astroparticle Physics

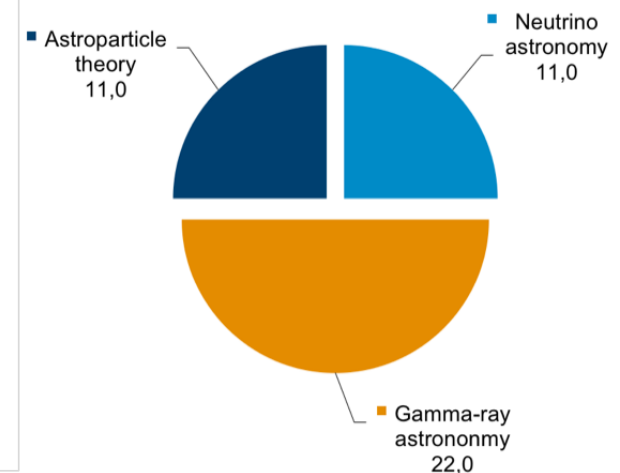
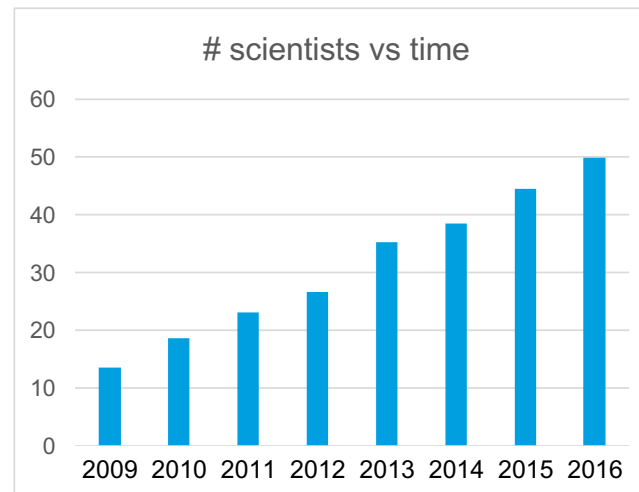
A team of ambitious people



Core-financed costs (2016): 12.5 MEUR

Significant increase in personal:

- From 2 to 5 leading scientists / joined professorships since 2013, corresponding increase on all levels
- External funding: 2 full professorships and 3 young investigator/ERC groups



DESY's Role in Astroparticle Physics

A player on all scales in research, coordination, education and outreach

Clear and focussed research profile

Central role in **coordination of astroparticle physics** in Germany and Europe

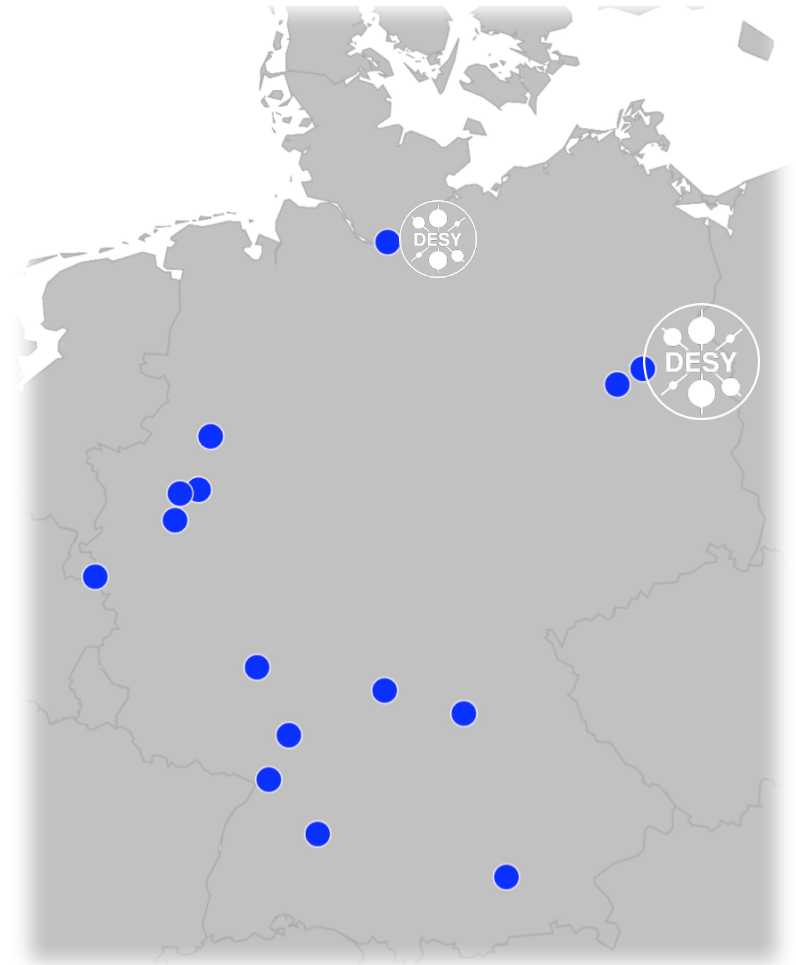
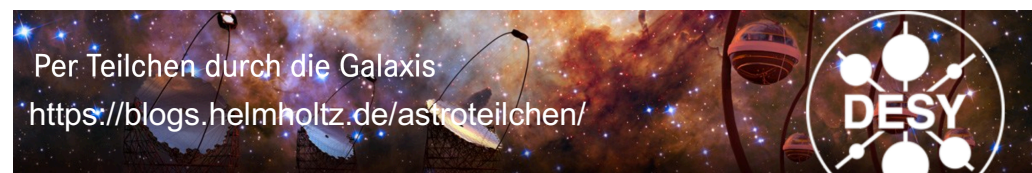
- National coordination of IceCube and large parts of CTA activities
- Ex-officio representation in KAT (Germany), APPEC (EU)
- Host of an APPEC centre

Education and Outreach

- 5 joint professorships with U. Potsdam and Humboldt University
- Cooperate with local partners in the Astrophysics Network Potsdam
- Cosmic lab and masterclasses for schools, APP blog

HELMHOLTZ BLOGS

Webseite durchsuchen...



Gamma-Ray Astronomy

H.E.S.S., MAGIC, VERITAS, FERMI, CTA

Complete coverage of all aspects of ground-based gamma-ray astronomy

- Telescope construction and operation
 - H.E.S.S. camera upgrade (4/12 worldwide operating cameras built by DESY)
 - CTA prototype of a Medium Size Telescope (MST) in Berlin-Adlershof
 - DAQ system for H.E.S.S. and the control system for CTA
- Reconstruction and analysis
 - advanced reconstruction pipelines/algorithms
 - advanced analyses (Galactic PeVatron, Eta Car, Vela pulsar,...)
- Leadership roles, e.g. H.E.S.S. spokesperson, CTA convenerships,...



H.E.S.S. camera upgrade & first light



CTA-MST prototype in Berlin-Adlershof

Gamma-Ray Astronomy

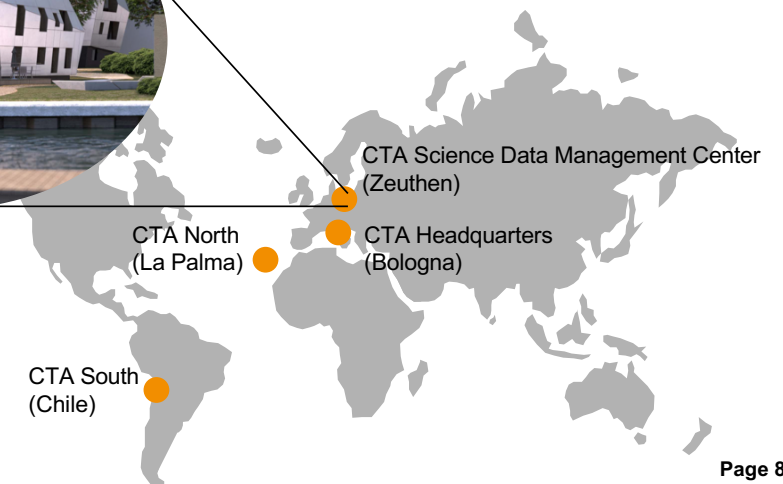
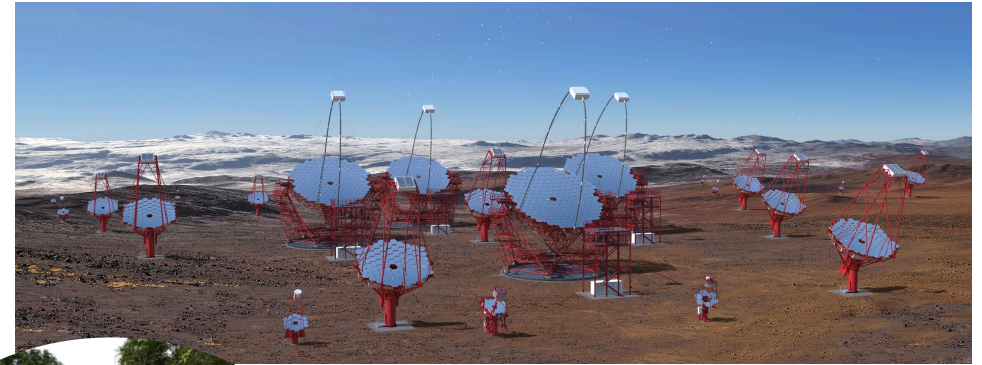
CTA – Cherenkov Telescope Array

The international CTA project is our key project for the future

- DESY is involved on all levels:
 - DESY is founding member of CTA Observatory and user consortium
 - DESY is prepared to deliver as in-kind contributions Medium Size Telescopes (MST) and the central control software

Transformational for the DESY campus in Zeuthen

- Decision of CTA to host the CTA Science Data Management Center (SDMC) and the director for science operation in Zeuthen
- Start of operation of the CTA SDMC in 2019



Neutrino Astronomy

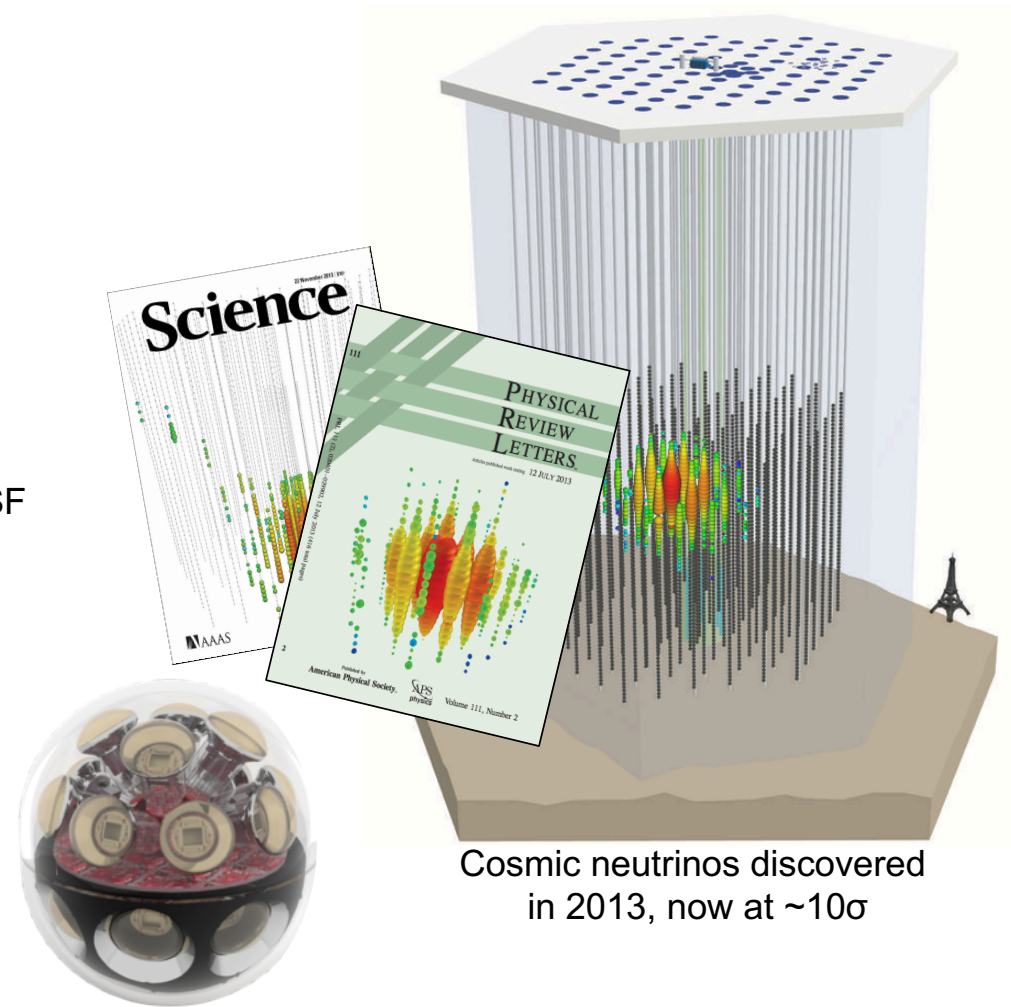
Completing the Multimessenger picture with IceCube

DESY involvement in the IceCube Neutrino Observatory

- ¼ of all optical sensors constructed
- TIER-1 data center
- Lead of German groups (DESY+KIT+8 Universities), various coordination roles
- Key contributions to IceCube upgrade proposal in review @ NSF

... and in IceCube Gen2 (planned construction: 2022-2030)

- Mission: Explore the PeV Universe with 5-10 times of current sensitivity
- DESY is technology driver, e.g. multi-pixel sensors
- DESY coordinates design study (with UW Madison)



Cosmic neutrinos discovered
in 2013, now at $\sim 10\sigma$

multi-pixel sensor: mDOM

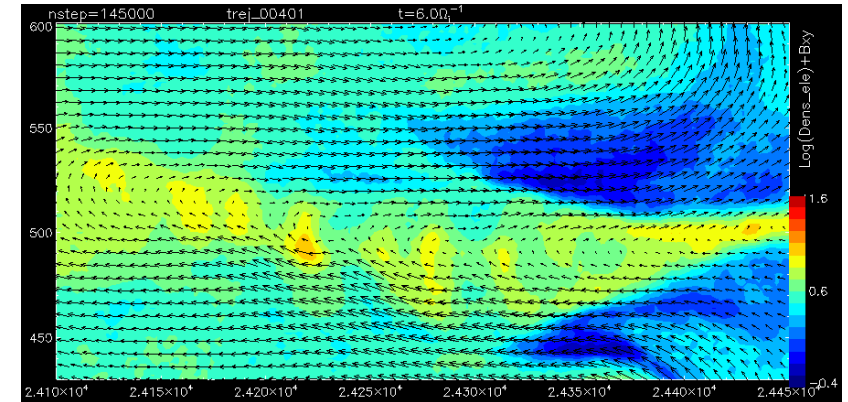
Theoretical Astroparticle Physics

Connecting the pieces

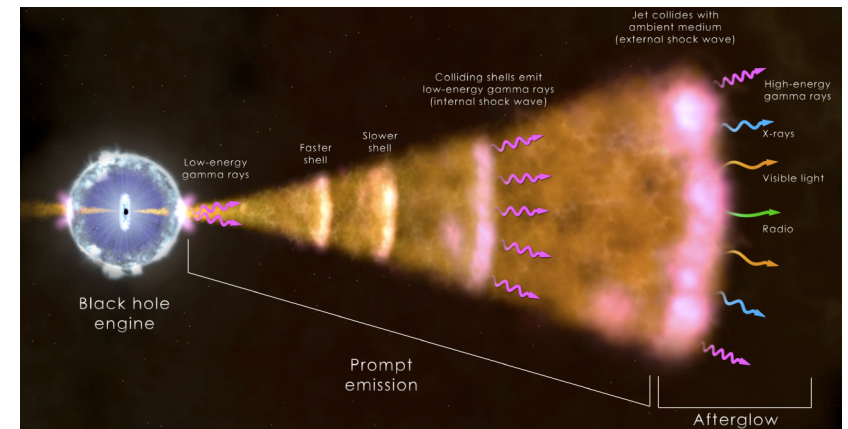
Mission and expertise of APP theory group:

- In-depth studies of particle acceleration and transport processes
- Modeling of sources and their emission.
- Exploit and develop synergies with other fields, e.g. plasma physics, and particle physics

Theory amplifies the scientific return of the RU Astroparticle Physics



acceleration of electrons by magnetic reconnection



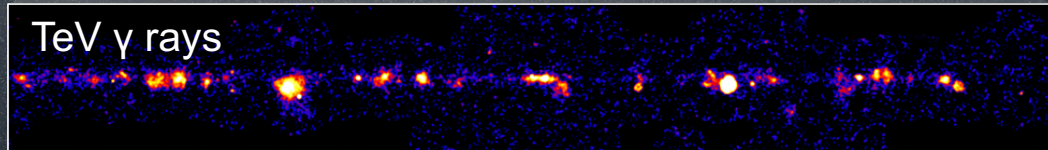
Gamma-Ray Burst caused by a forming black hole

Science Highlights during POF III

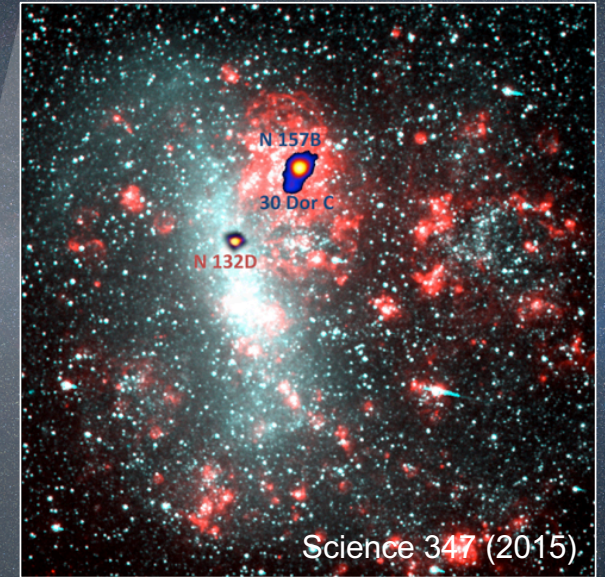
Observing our Milky Way and beyond

Our Milky Way

TeV γ rays



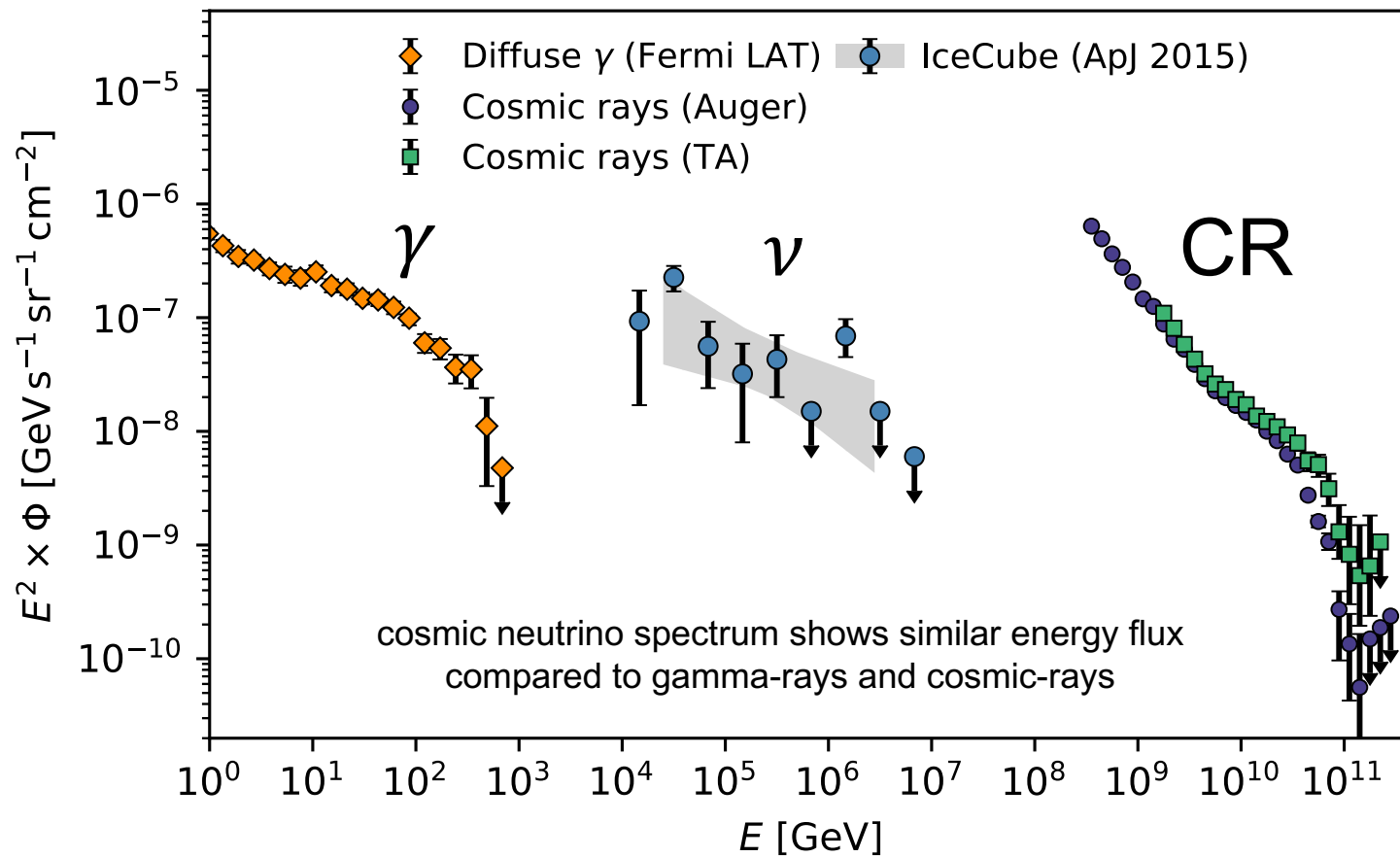
Optical



Large Magellanic Cloud

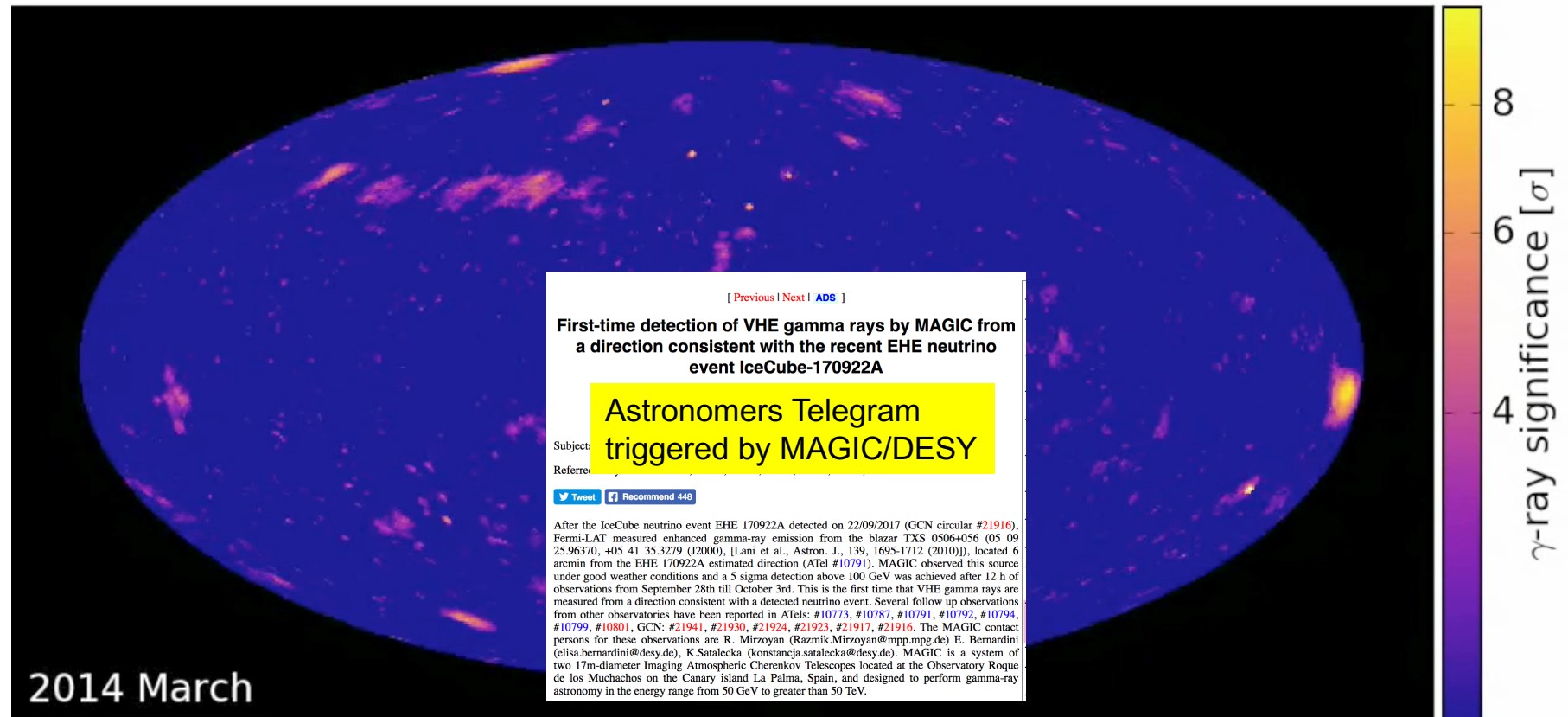
Science Highlights during POF III

The cosmic neutrinos in the context of the topic: Matter and Radiation from the Universe



Science Highlights during POF III

Realtime search for neutrino-gamma-ray coincidences with IceCube, FERMI, MAGIC, VERITAS & H.E.S.S.



Science Highlights during POF III

Neutrinos and Gamma Rays from Gamma-Ray Bursts

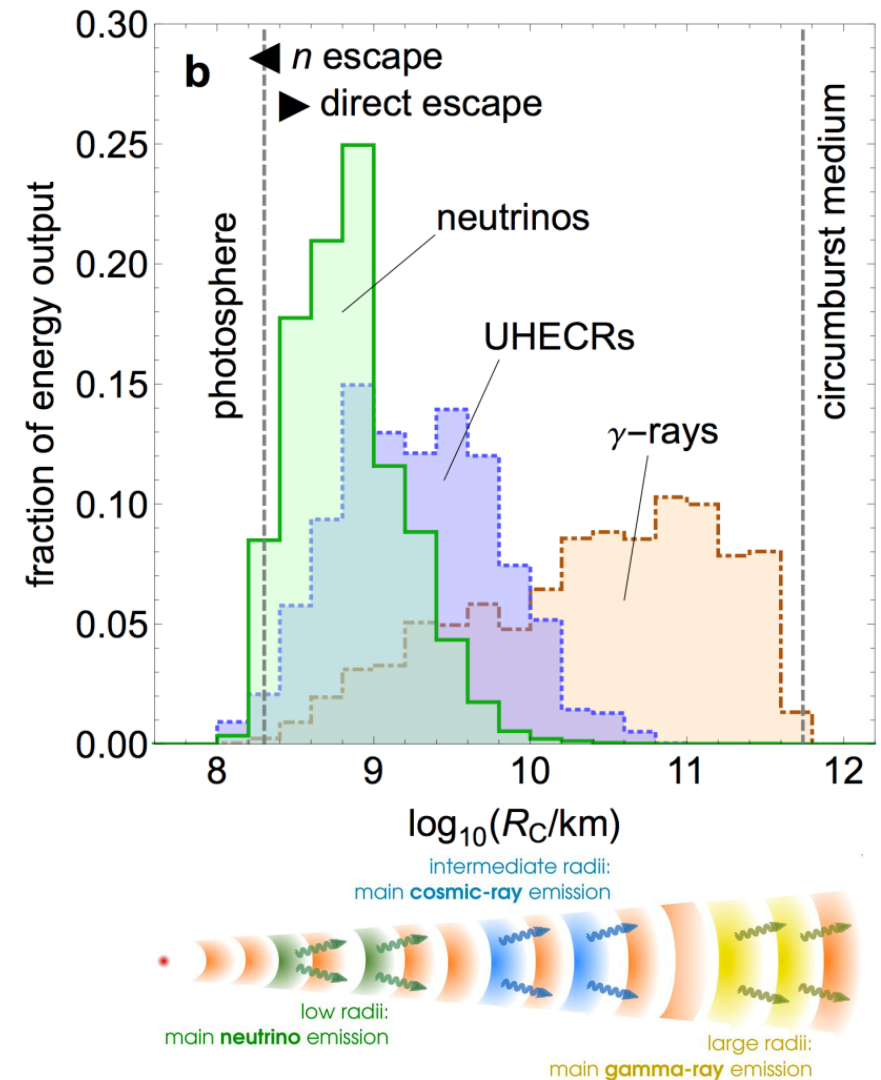
Detailed modelling of Gamma-Ray Bursts

- The three messengers come from different locations
- New and important implications for gamma ray-neutrino connection and expected “minimal” neutrino flux



artistic impression of a GRB - an exploding, massive star

Bustamante et al., Nature Comm. 2015

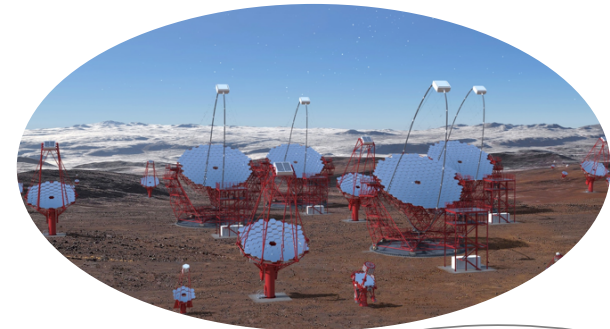


DESY 2030: Strategy for Astroparticle Physics

Building on existing activities while strategically expanding the portfolio

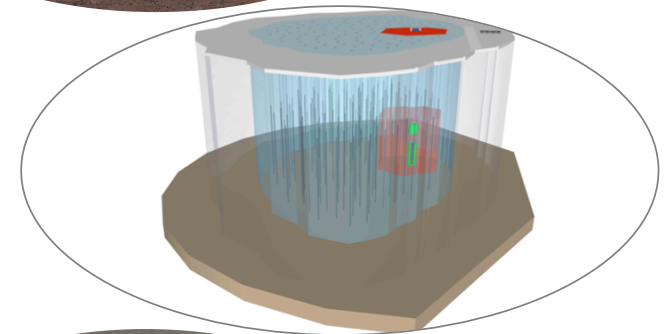
Cherenkov Telescope Array – CTA

- Operation and science exploitation of CTA, key institution in construction
- Camera development and plans for upgrade
- Science focus: Galactic Center and multi-messenger astronomy



Next-generation neutrino astronomy

- IceCube Gen2, a 10 km³ next-generation neutrino observatory
- R&D in photo sensor technology and electronics
- Explore higher energies (10¹⁸ eV) using novel radio techniques



Further pathfinder activities:

- Zwicky Transient Facility,...



Conclusion

- DESY is a key player in high-energy gamma-ray, neutrino astronomy and theoretical astroparticle physics, contributing to several breakthroughs during 2013-2017
- DESY is a driving force behind the emerging field of Multi-Messenger astroparticle physics
- DESY is well on track to become an international key center for astroparticle physics

