

# Activities of the Karlsruhe Center Elementary Particle and Astroparticle Physics (KCETA)

Marc Weber

KIT Center Elementary Particle and Astroparticle Physics - KCETA



**The UNKNOWN**

**symmetries**

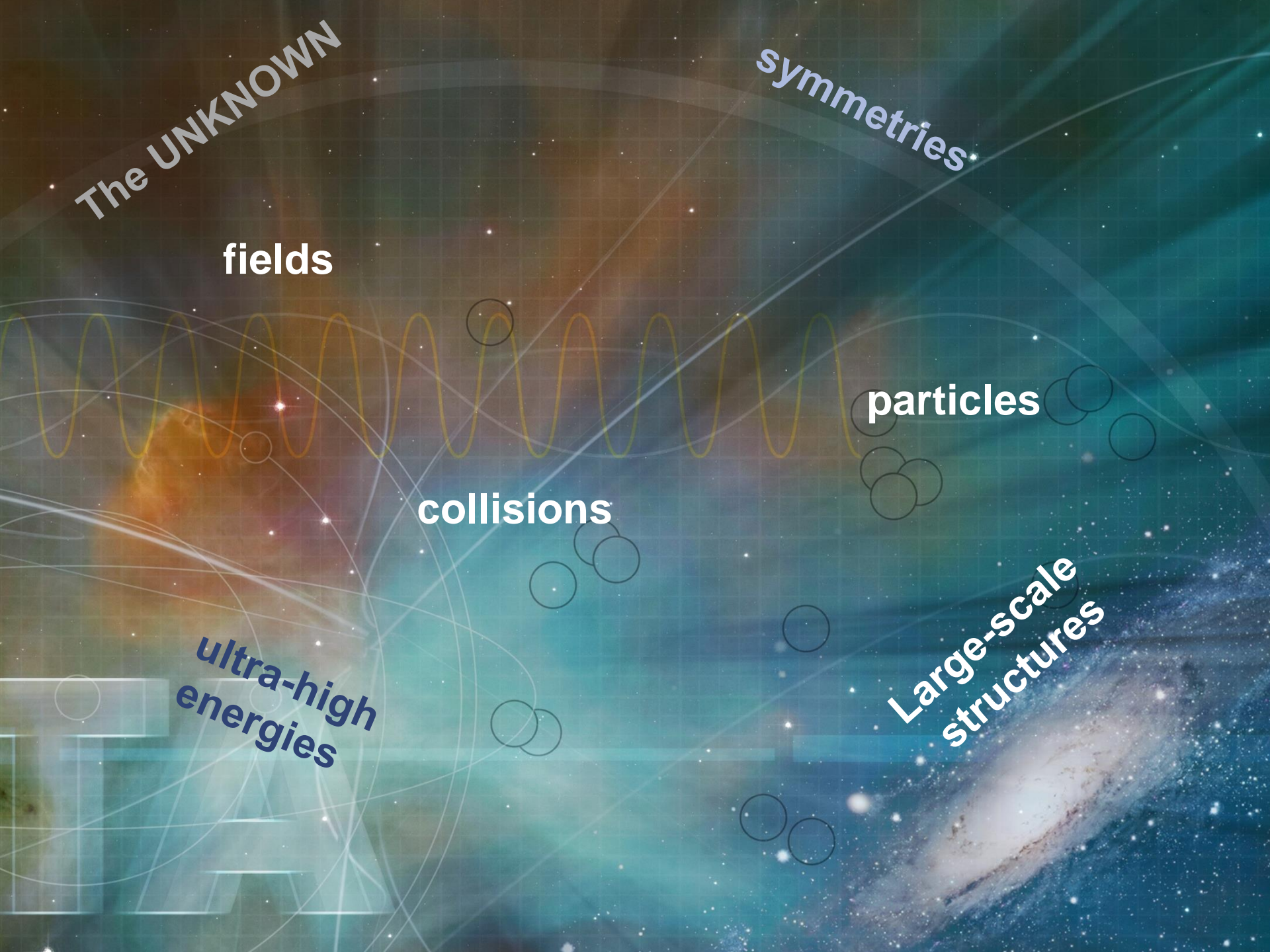
**fields**

**particles**

**collisions**

**ultra-high  
energies**

**Large-scale  
structures**





# Tradition

## Stronghold of astroparticle and particle physics

- KIT is one of the leading German institutions in astroparticle and particle physics
- Strong links between Karlsruhe University and Research Center Karlsruhe since the 1960ies
- ~ 60 years of history of institutes IEKP and IKP
- Renown personalities include Prof. Herwig Schopper, Prof. Anselm Citron and Prof. Julius Wess



Herwig Schopper



Anselm Citron



Julius Wess



December 14<sup>th</sup>, 2010  
50th Anniversary of experimental and theoretical  
particle and astroparticle physics at KIT

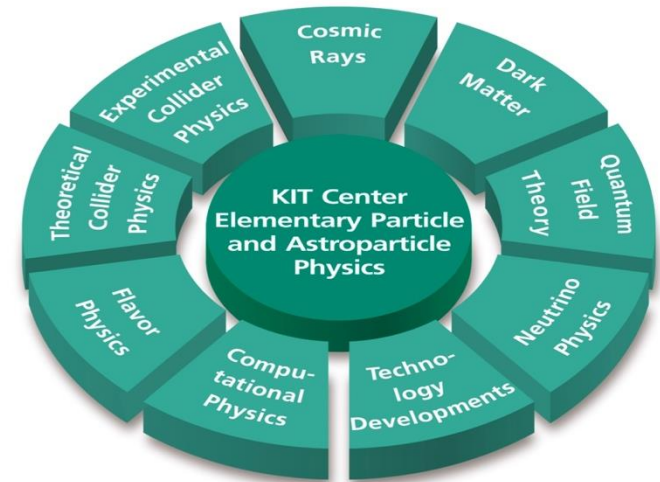


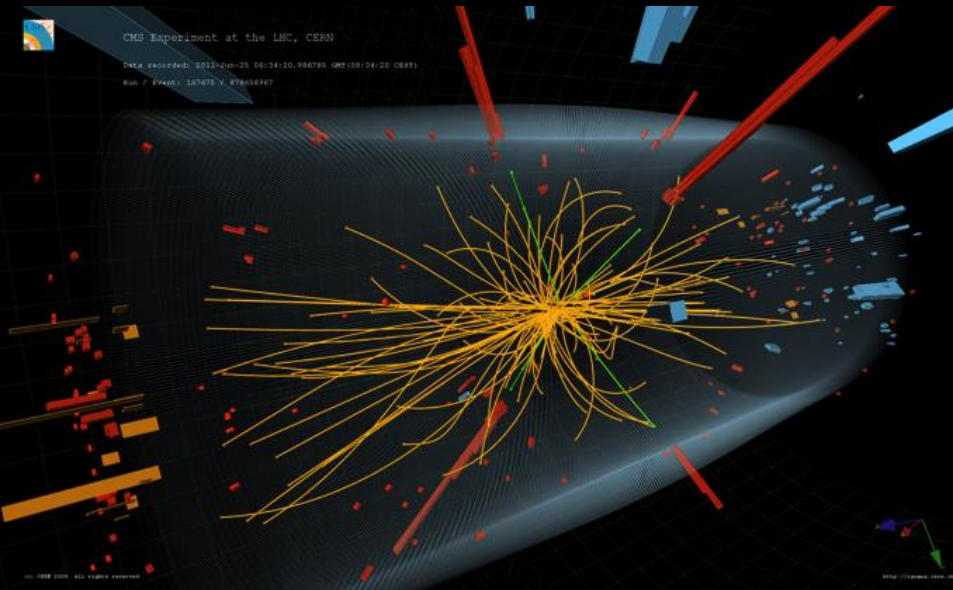
# KCETA Institutes

Institute of Experimental Particle Physics  
Institute for Theoretical Physics  
Institute for Theoretical Particle Physics  
Institute of Micro- und Nanoelectronic Systems  
Institute for Information Processing Technologies  
Institute for Technical Thermodynamics and Refrigeration  
Laboratory for Applications of Synchrotron Radiation

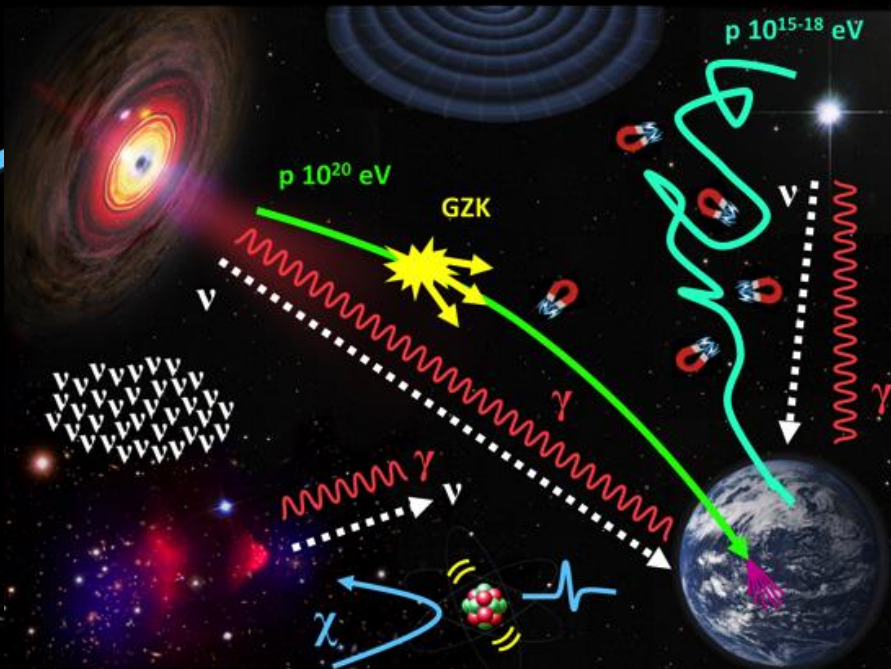
Institute for Nuclear Physics  
Institute for Data Processing and Electronics  
Institute for Technical Physics  
Steinbuch Centre for Computing  
Institute for Beam Physics and Technology

360 Scientists in 12 Institutes  
22 Professors  
3 Young Investigator Groups

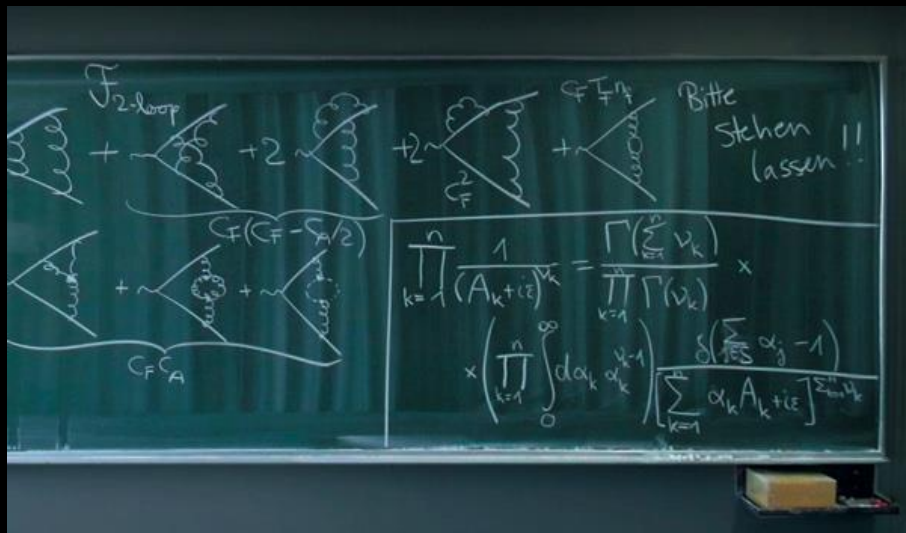




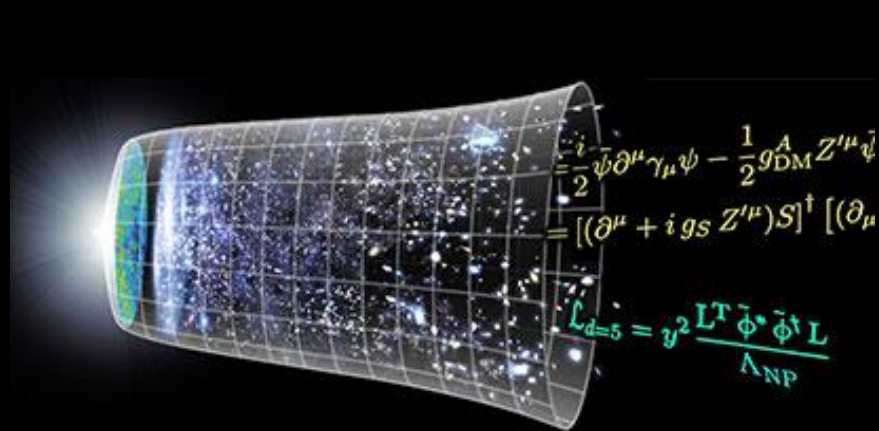
Experimental Particle Physics



Experimental Astroparticle Physics



Theoretical Particle Physics



Theoretical Astroparticle Physics



# Elementary particle physics

- **Collider physics**

Theory: ultra-high precision calculations, phenomenology

Experiment: CMS at CERN (Geneva)

Search for new physics beyond the SM, Higgs boson, top quark, QCD jets

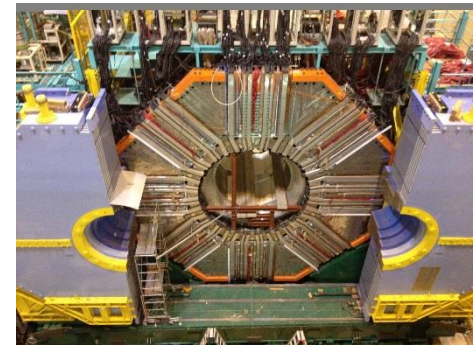


- **Flavour physics**

Theory: calculation of flavor-changing transitions in the SM, theories of new physics

Experiment: Belle II (Japan)

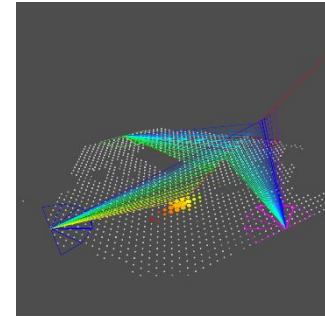
Spectroscopy of hadrons with c and b quarks, measurements of CP violation and oscillations in B-meson decays



# Astroparticle physics

- **Cosmic rays**

messenger particles from the Universe  
 Pierre Auger Observatory (Argentina) – most energetic cosmic rays



Event 200716104390 (11.6.2007)

- **Neutrino physics**

neutrino mass important for particle physics and cosmology  
 KATRIN – model-independent measurement of the mass electron neutrino



- **Dark Matter**

fundamental puzzle in particle physics and cosmology  
 AMS space detector – annihilation signatures  
 EDELWEISS – direct scattering of Dark Matter







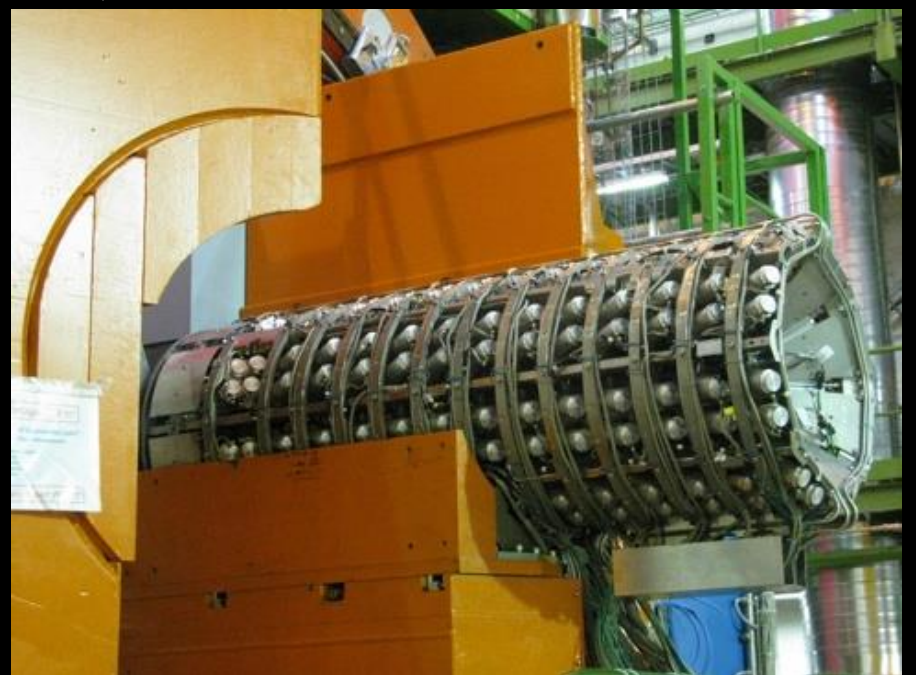
**AMS**, Space



**CMS**, Switzerland



**EDELWEISS**, France



**CASTOR**, Switzerland

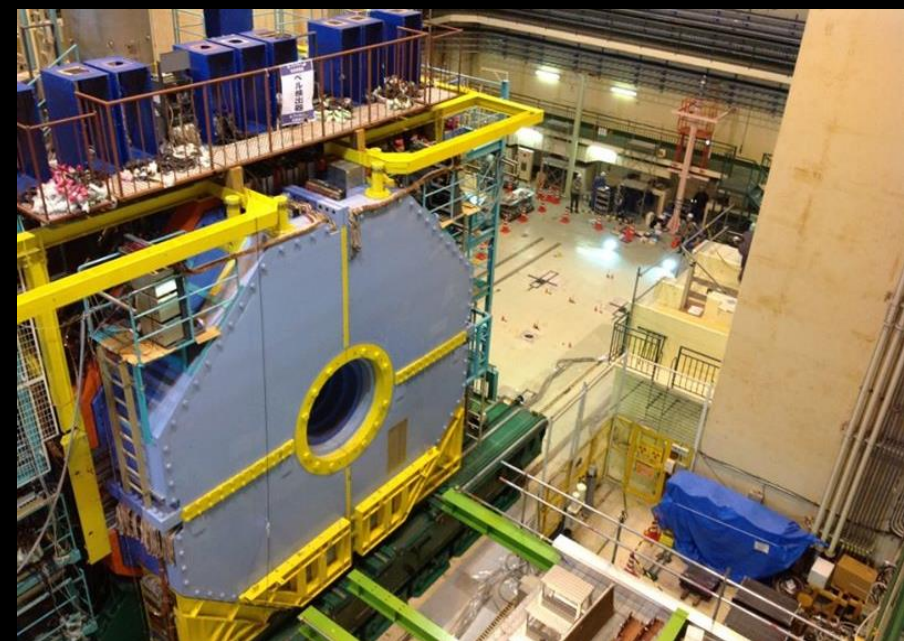




**Auger, Argentina**



**KATRIN, Germany**



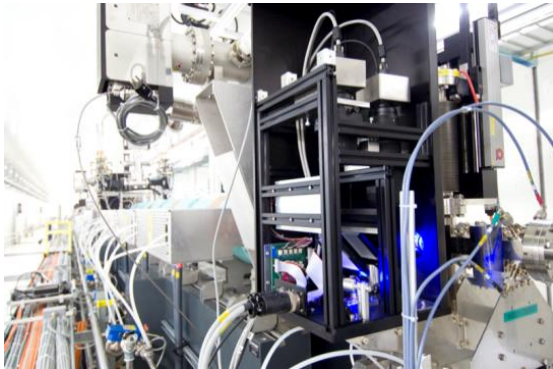
**Belle II, Japan**



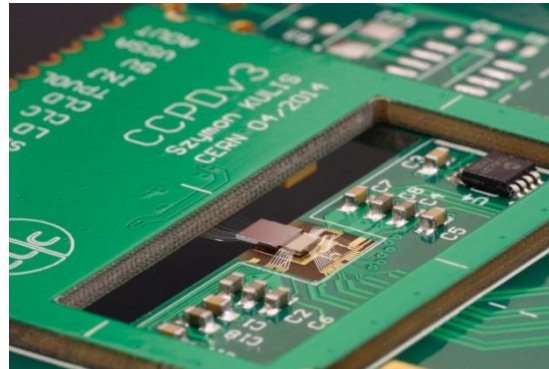
**TUNKA, Russia**



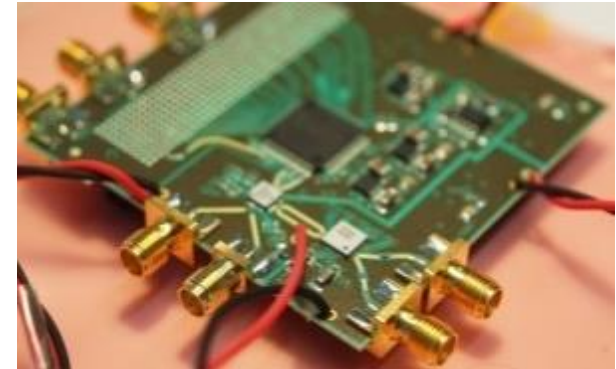
# Technologies



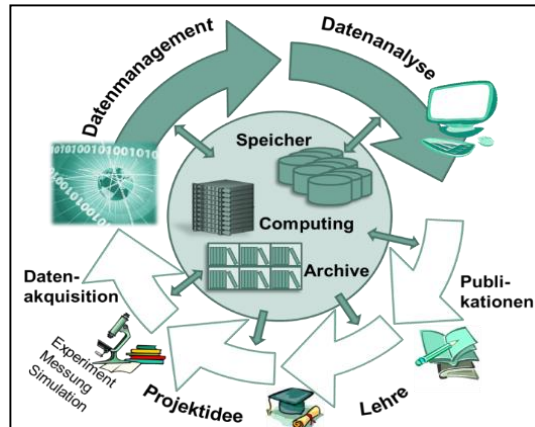
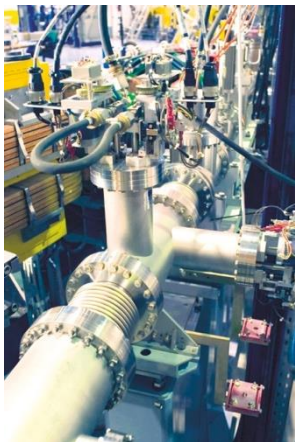
**Accelerator physics and technology**



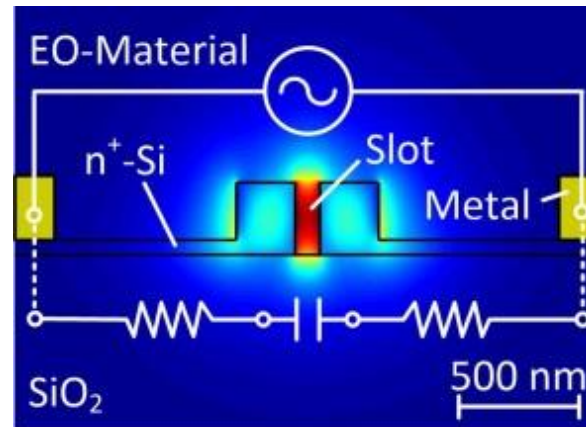
**Sensor and microchip design**



**Analog and digital electronics**



**Computing and Big Data**



**Information technology/  
silicon photonics**



**Medical technology**



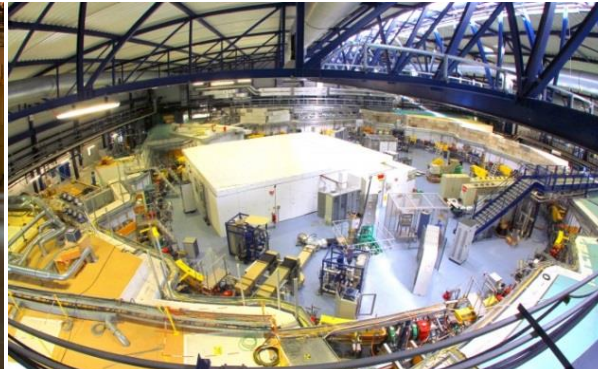
# Infrastructures



**Grid Computing Center  
Karlsruhe (GridKa)**



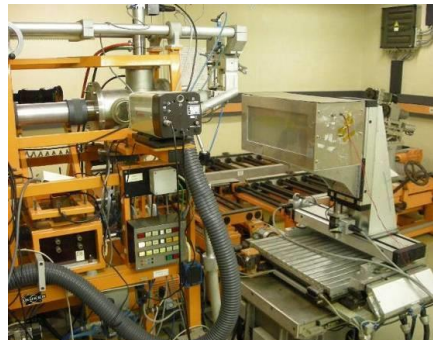
**Tritium Laboratory  
Karlsruhe (TLK)**



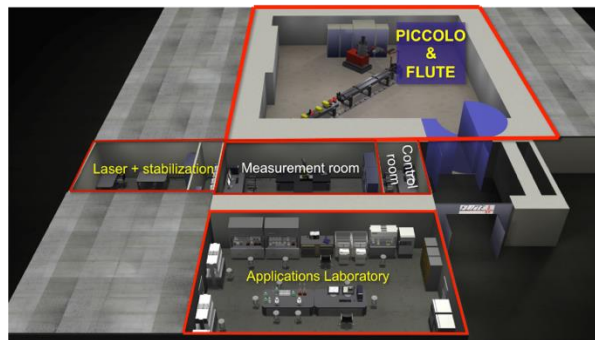
**Accelerator technology platform  
(ATP)**



**ASIC- and Detector Laboratory**



**Irradiation center/ cyclotron**



**Far infrared Linac- and test  
experiment (FLUTE)**



**Clean room for production of  
superconductive sensors**

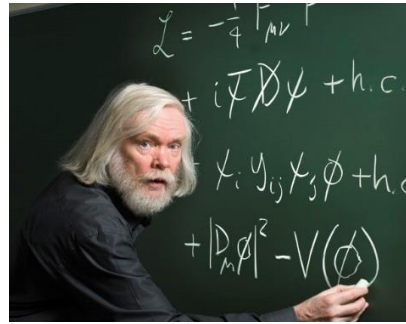


**Test facility for  
superconductive  
magnets  
(TOSKA)**

# Julius Wess Award



**Frank Wilczek**  
2008



**Jonathan Ellis**  
2009



**Valery Rubakov**  
2010



**Guido Altarelli**  
2011



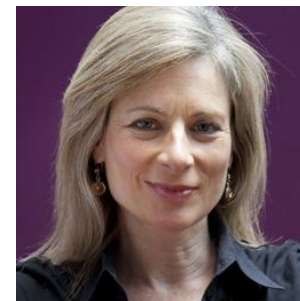
**Peter Jenni und Michel Della Negra**  
2012



**Takaaki Kajita**  
2013



**Arkady Vainshtein**  
2014



**Lisa Randall**  
2015

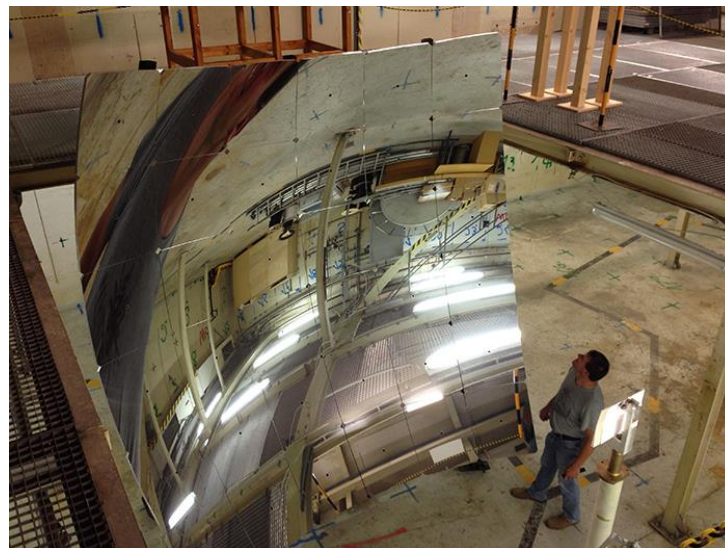


**Robert Klanner**  
2016



**TRISTAN**, sterile neutrinos

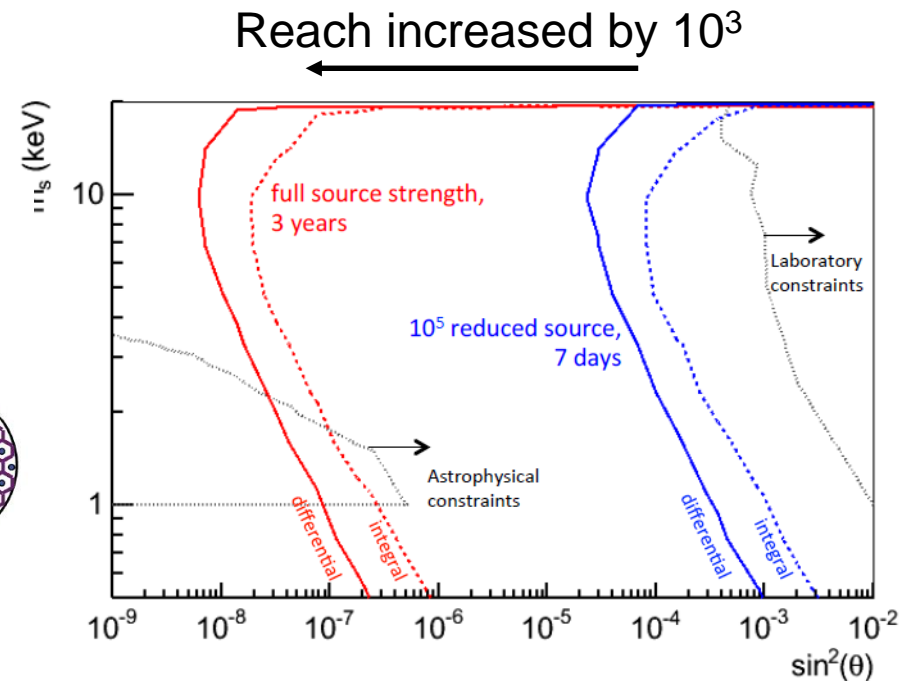
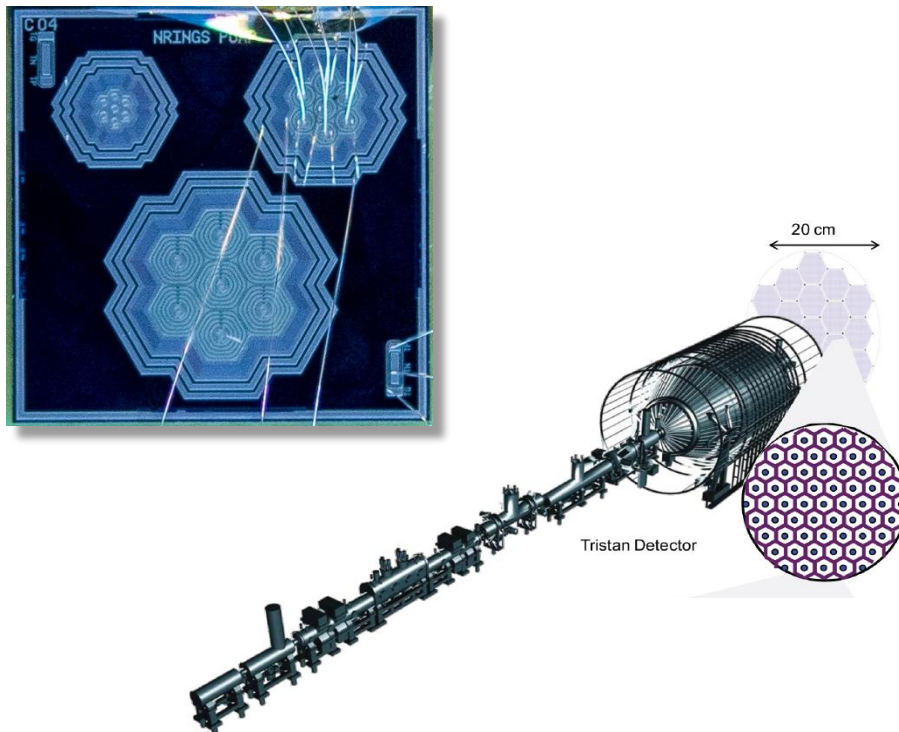
**MATRIX**, sterile neutrinos



**FUNK**, dark photons

# Search for KeV sterile neutrinos: TRISTAN

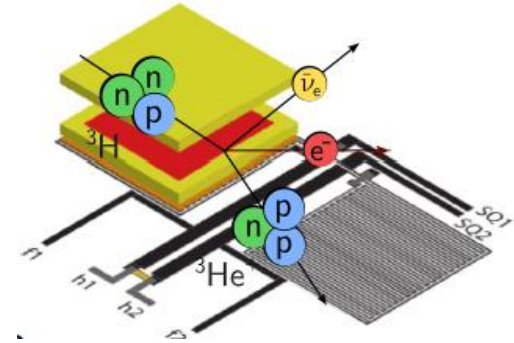
- Explore the full beta spectrum rather than its end-point only (as in KATRIN)
- Data rates of  $10^9$  counts/s and required energy resolution make this a challenging project of  $< 300$  eV



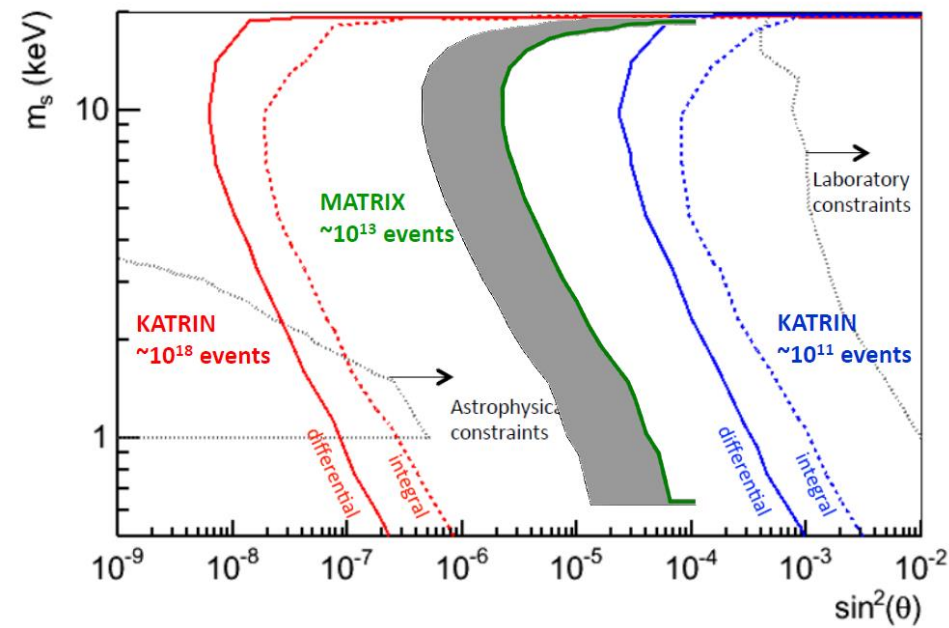


# Search for KeV sterile neutrinos: MATRIX

- Implement tritium atoms into magnetic microcalorimeter (MMCs) absorbers and exploit unique energy resolution

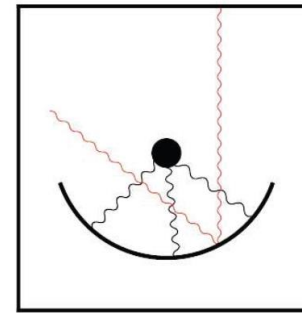


- MATRIX does not require KATRIN to run longer, but R&D is challenging
- Complementary technology to TRISTAN but similar reach

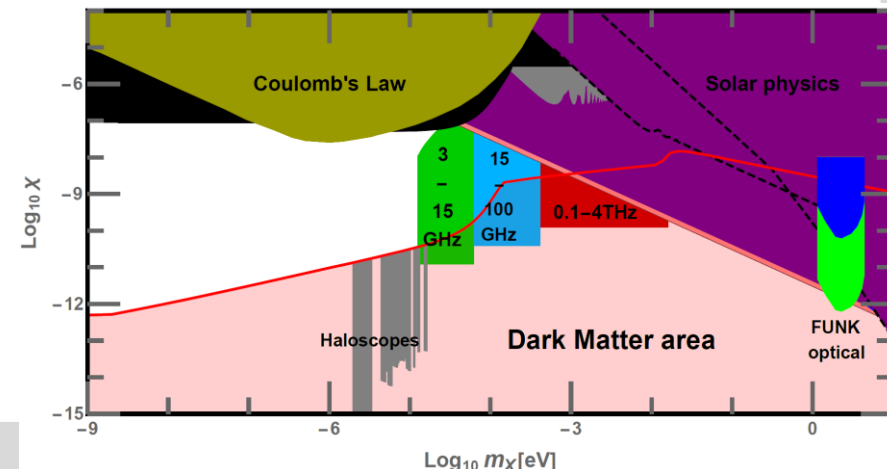
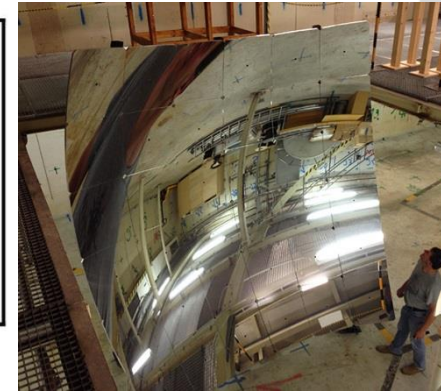


# Hidden photons with FUNK

- FUNK is a joint experiment of KIT and Heidelberg University, already in operation
- Sensitive to hidden photons, axions and axion-like particles (ALPs) at sub-eV mass
- The extension of FUNK would have much increased sensitivity
- Unique competences of KIT include MMCs, GHz/THz technology and superconducting magnets
- FUNK is relatively affordable but there is serious competition



$$P_{\text{centre}} \sim \chi^2 \rho_{\text{CDM}} A_{\text{dish}}$$





# Karlsruhe Graduate School for Elementary Particle Physics and Astroparticle Physics: Science and Technology



## KSETA in brief

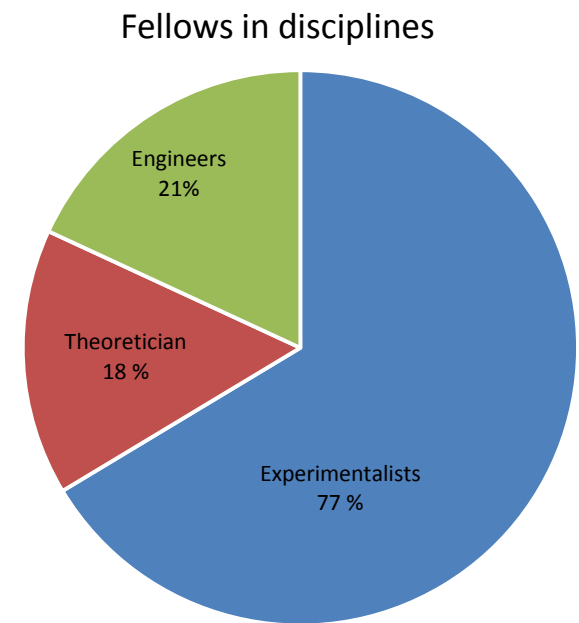
- Proposal submitted 2011 to the Excellence Initiative Germany II
- The only one successful new proposal of KIT
- Important addendum of KSETA : **“Science and Technology”**  
→ joint doctoral research of young physicists,  
engineers and computer scientists
- In October KSETA will celebrate its 5 years of funding





## Statistics KSETA scholars

- About 100 – 120 doctoral researchers per year since 2013
- Students from four departments:
  - Physics
  - Electrical engineering and Information technology,
  - Computer Science
  - Chemical process engineering
- Currently 135 alumni
- Annually “Plenary Workshop” with all doctoral researchers and supervisors



## Selected future activities

- Auger Prime Upgrade  
Ice Cube surface array
- Start of KATRIN data taking  
Preparation of KATRIN upgrades
- Next generation of dark matter experiments
- Laboratory for high-resolution superconducting sensors
- CMS data analysis and upgrades (*silicon tracker and track trigger*)
- Ultra-high precision cross-section calculations
- Analysis and interpretation of neutrino data
- Dark Matter Theory: phenomenology of various DM candidates  
(WIMPs, Axions, sterile neutrinos, ...)



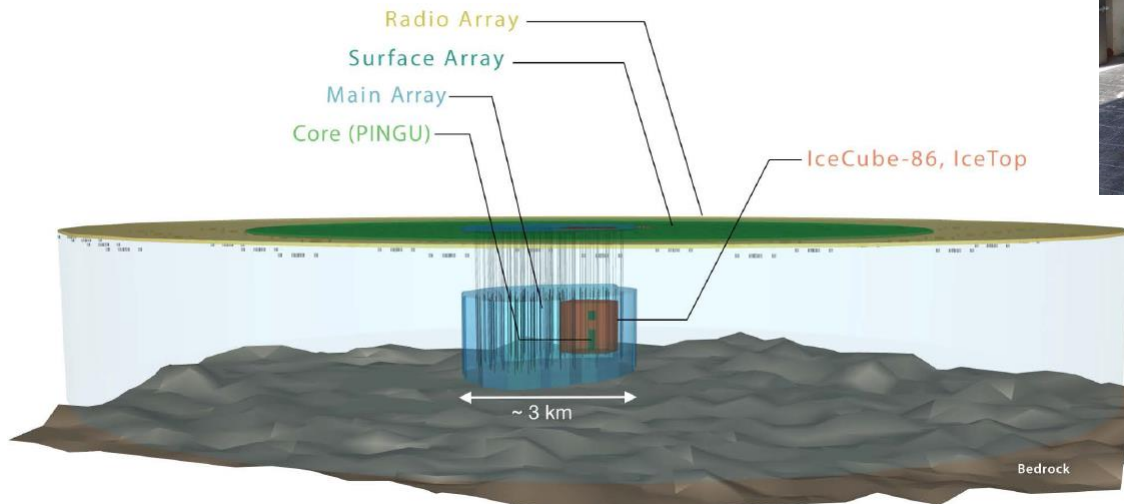
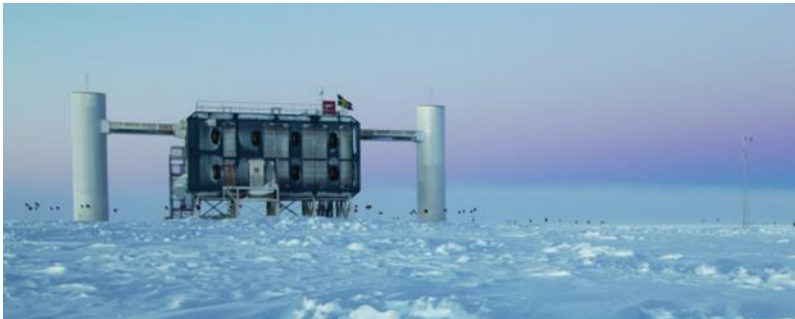
# Auger Prime

- Pierre Auger Observatory will run for another 10 years
- Major upgrade is under way
- KIT is delivering 42% of 1.200 scintillator arrays
- Recent Pierre Auger results point to an exciting future

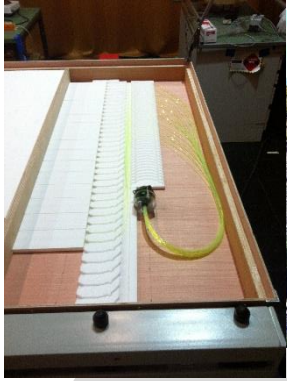


# Ice Cube Generation II

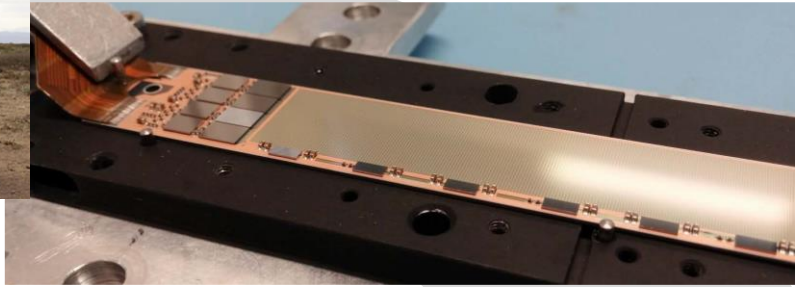
- KIT is taking the leading role in the construction of the Ice Cube surface array
- Key contributions include the world leading radio detection method



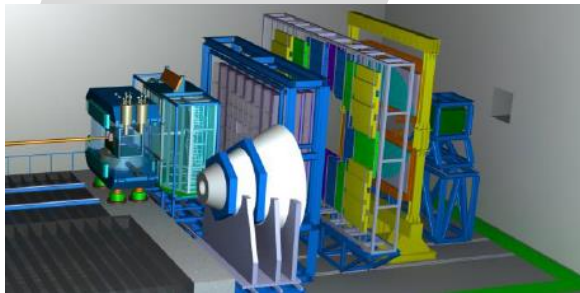




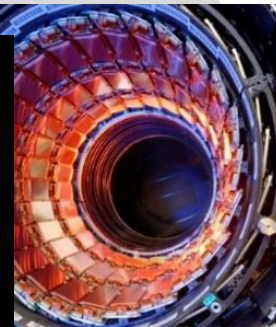
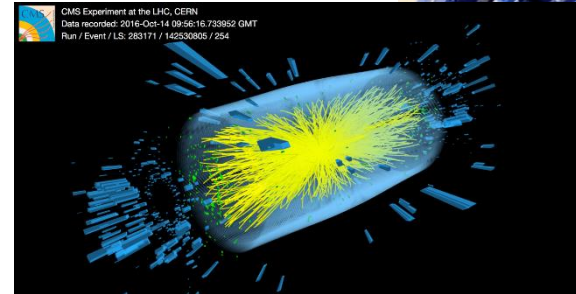
**Pierre Auger Upgrade**



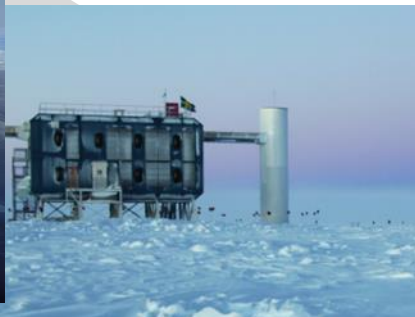
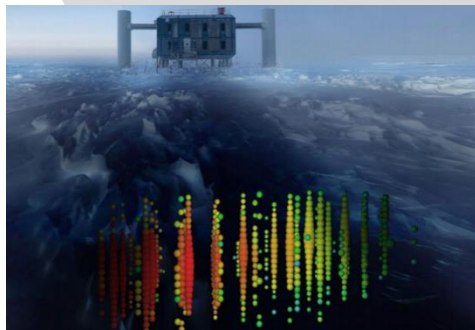
**Belle II Pixeldetector**



**CBM STS Detector**



**CMS Tracker and Track Trigger Upgrade**



**Ice Cube**



**KATRIN First Light**

# Upcoming Events

- Dark Matter Day on October 31, 2017



A communication resource from the world's particle physics laboratories.

## Dark Matter Day Is Approaching ... but Don't Be Afraid of the Dark

A global hunt for the universe's missing matter is underway, and this autumn everyone is invited to join in.

On and around October 31, 2017, events around the world will celebrate the hunt for the universe's unseen "dark matter." Dark Matter Day events will engage the public in discussions about dark matter, and about the many experiments that seek to solve its mysteries.

Universities, laboratories, institutions and individuals are invited to organize a Dark Matter Day event in their area or online. Events could include a public lecture on dark matter, a tour of a science laboratory or experiment connected with the search for dark matter, a dark matter-themed planetarium show or film presentation, Q&A with a scientist live or online, classroom presentation...the sky is the limit.

Just want to attend an event? You don't need a PhD to explore dark matter's mysteries—just curiosity. Anyone who wants to learn about dark matter—adults, kids, non-scientists, scientists, science educators, students—is encouraged to attend local Dark Matter Day events on or leading up to October 31, 2017. Go to [www.darkmatterday.com](http://www.darkmatterday.com) to sign up to be notified of events near you.



### WHAT IS DARK MATTER DAY?

On and around October 31, 2017, the world will celebrate the historic hunt for the unseen—something that scientists refer to as dark matter. Local events planned by institutions and individuals around the planet will engage the public in discussions about what we know about dark matter, and about the many present and planned experiments that seek to solve its mysteries.

October  
31

- HEiKA Dark Matter Symposium in Heidelberg  
June 8, 2018

