

Activities in high-energy astroparticle physics in Bavaria



WELCOME

- Part 1 in a series of two workshops between FAPESP and BAYLAT. Central theme: multi-messenger astrophysics with the focus areas:
 - Multi-instrument analyses of complex regions
 - Fundamental physics from high-energy astrophysics
- Potential goals
 - Joint publication in the focus areas in the light of the upcoming CTA and SWGO
 - Training in state-of-the art analysis skills
 - Joint funding applications
 - Networking opportunities

FAPESP/BAYLAT – Call for Proposals for Workshops 2021 – State of São Paulo, Brazil and Free State of Bavaria, Germany

Brazilian coordinator: Prof. Luiz Vitor de Souza Filho, Universidade de São Paulo
German coordinator: Prof. Stefan Funk, FAU Erlangen-Nürnberg



Astroparticle physics in the era of CTA and SWGO

Jointly submitted to

Bavarian Academic Center for Latin America (BAYLAT)

and to the

São Paulo Research Foundation (FAPESP)

February 11, 2022

A FEW ORGANISATIONAL REMARKS

- Speed collaborating
 - Would like to encourage a joint scientific project. Will award travel budget for selected proposal
- Social events
 - Tonight (Monday): get together here at ECAP (in the lobby)
 - Tomorrow (Tuesday) 7.30pm workshop dinner at Mein Lieber Schwan
 - Wednesday: excursion to Bamberg (whole day). We will meet at the station at 9am, train leaves at 9.14am.

High-energy astrophysics in the multi-messenger era

Main topics:

High-energy astroparticle physics – Open questions – Instruments – Data analysis – Possible near future discoveries

Target participants:

Postdocs and final year PhD students

First workshop:

Erlangen – Germany, 8th - 12th May 2023

Second workshop:

São Carlos - Brazil, TBD 2024

Application deadline: Jan 13th 2023

Open for applications:

For registration and more information:
<https://indico.ecap.work/event/44/>



Coordination group:

Stefan Funk, Vitor de Souza, Aion Viana, Edivaldo Moura Santos, Christopher van Eldik, Alison Mitchell, David Berge, Jim Hinton, Karl Mannheim, Carola Dobrigkeit, Chinellato, Farinaldo da Silva Queiroz, and Manuela Vecchi.

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WHERE ARE YOU?

- Smallest of 8 large cities in Bavaria (117.000 inhabitants). Franconia (!)
- Dominated by university (FAU) and by Siemens and Adidas/Puma
- FAU (Friedrich-Alexander Universität)
Erlangen-Nürnberg: 3rd largest university in Bavaria, 12th largest in Germany
- 40,000 students, can study all major subjects
- Physics department particularly strong in optics, condensed matter physics and astroparticle physics





THE ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS – ECAP – A UNIQUE CENTER

- 5 experimental faculty (Kopper, van Eldik, Funk, Katz, Nelles jointly w. DESY Zeuthen), 1 Emmy-Noether group (Mitchell)
- 4 theoretical faculty (Giesel, Mecke, Sahlmann, Thiemann)
- 3 professors at Remeis-Observatory in Bamberg (Heber, Sasaki, Wilms)



THE ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS – ECAP – A UNIQUE CENTER

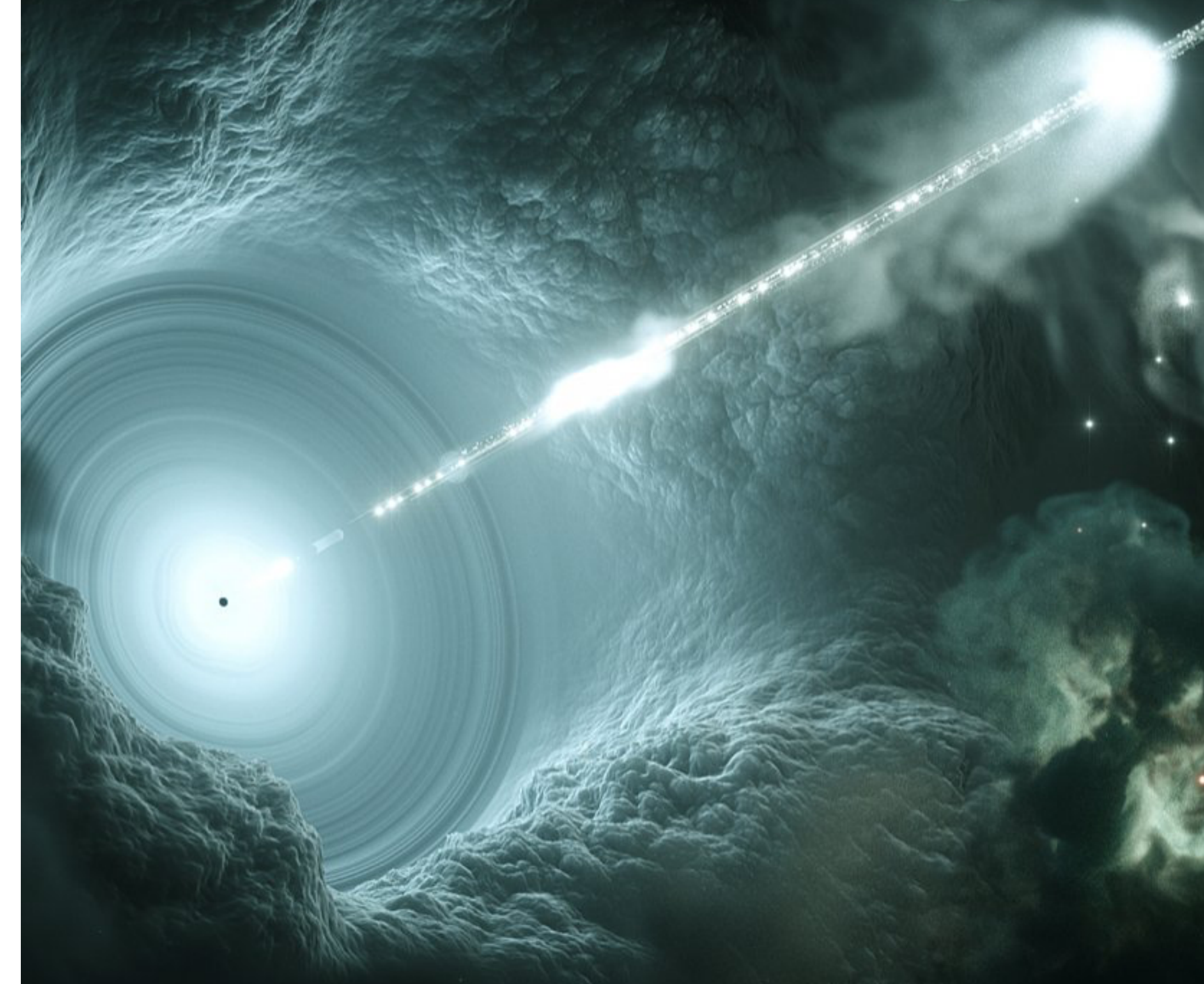
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THE MAIN SCIENCE TOPICS IN ECAP

- High-energy Astroparticle physics
 - The origin of cosmic rays
 - Black holes, neutron stars, supernova explosions
 - Multi-messenger astronomy with light, neutrinos (and gravitational waves)
- Fundamental theory connecting gravity and quantum mechanics and the early Universe
- Big data science, detector development, and technology transfer to medical applications

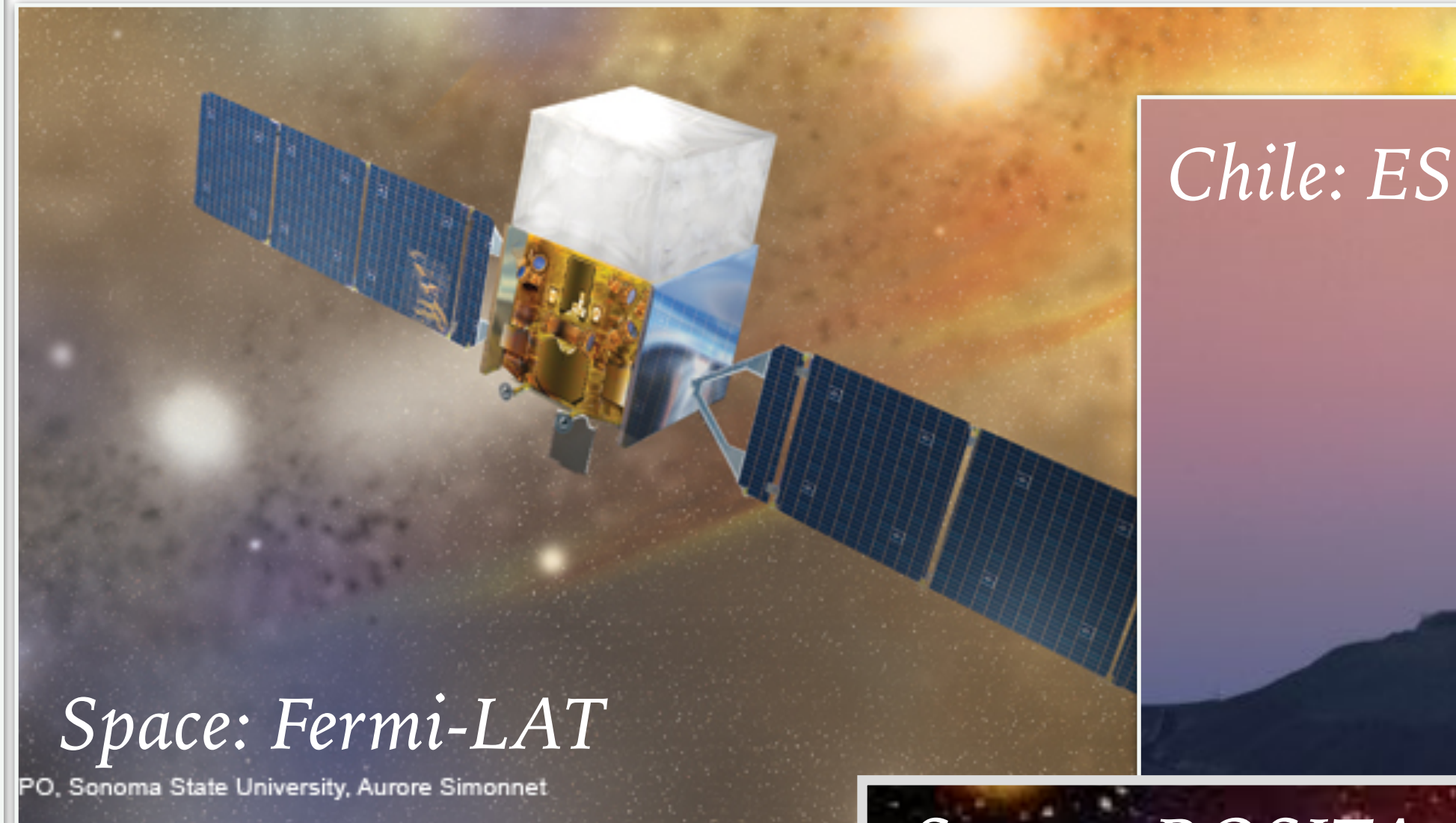
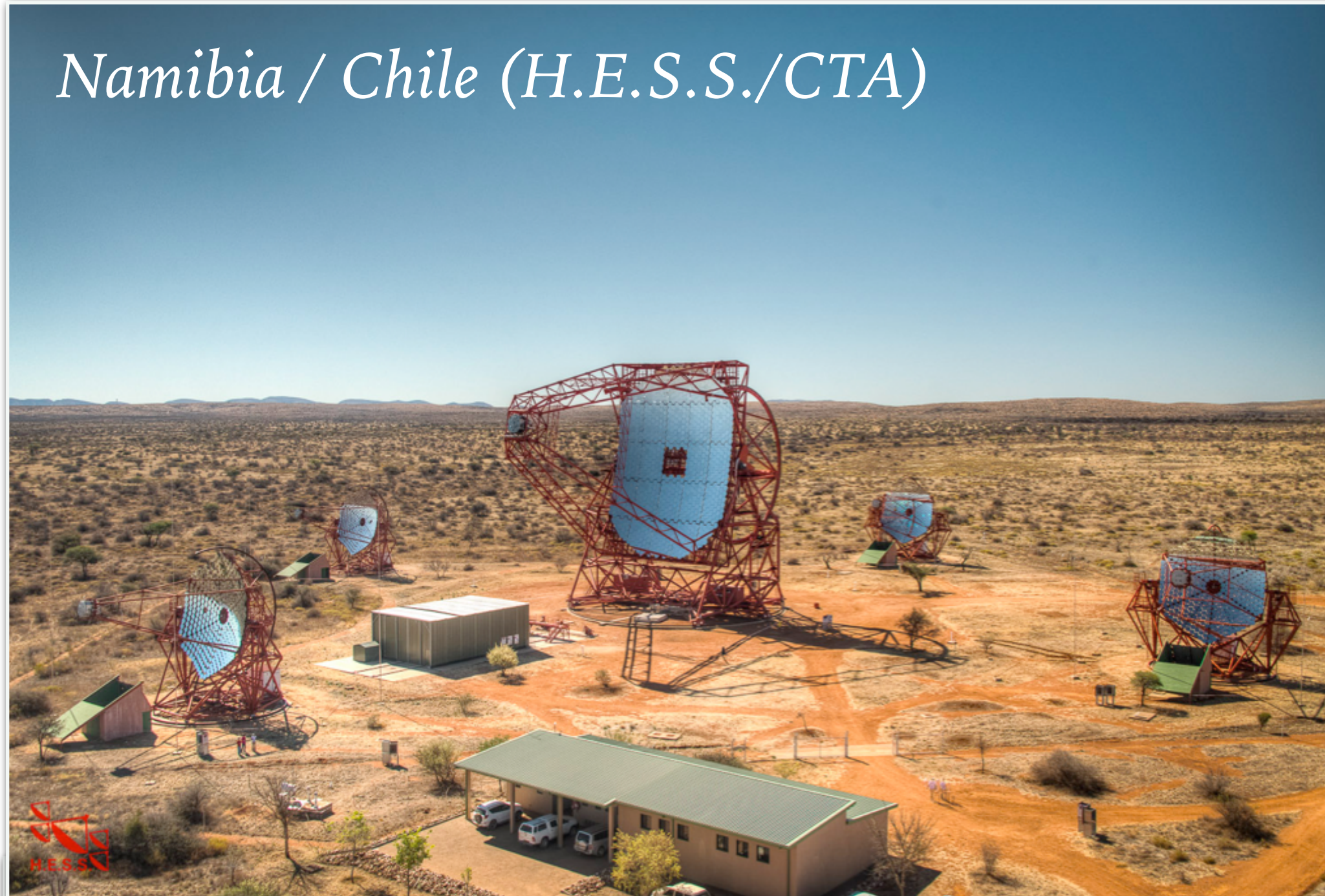
nature
astronomy



Neutrinos from a blazar flare

WE BUILD, COMMISSION, TEST AND CALIBRATE TELESCOPES OURSELVES

Namibia / Chile (H.E.S.S./CTA)



Space: Fermi-LAT

PO, Sonoma State University, Aurore Simonnet

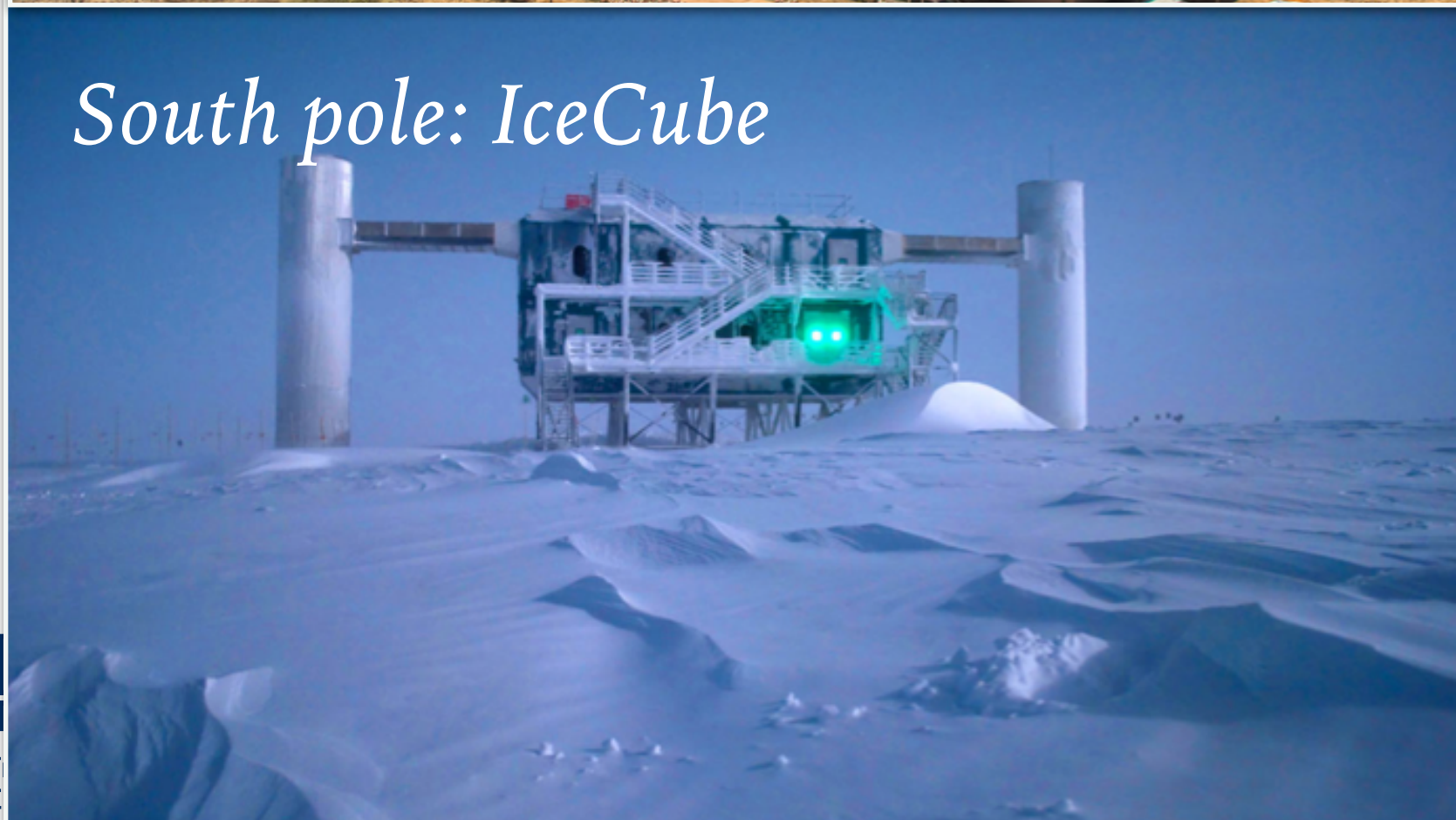
Chile: ESO VLT



Space: eROSITA



South pole: IceCube

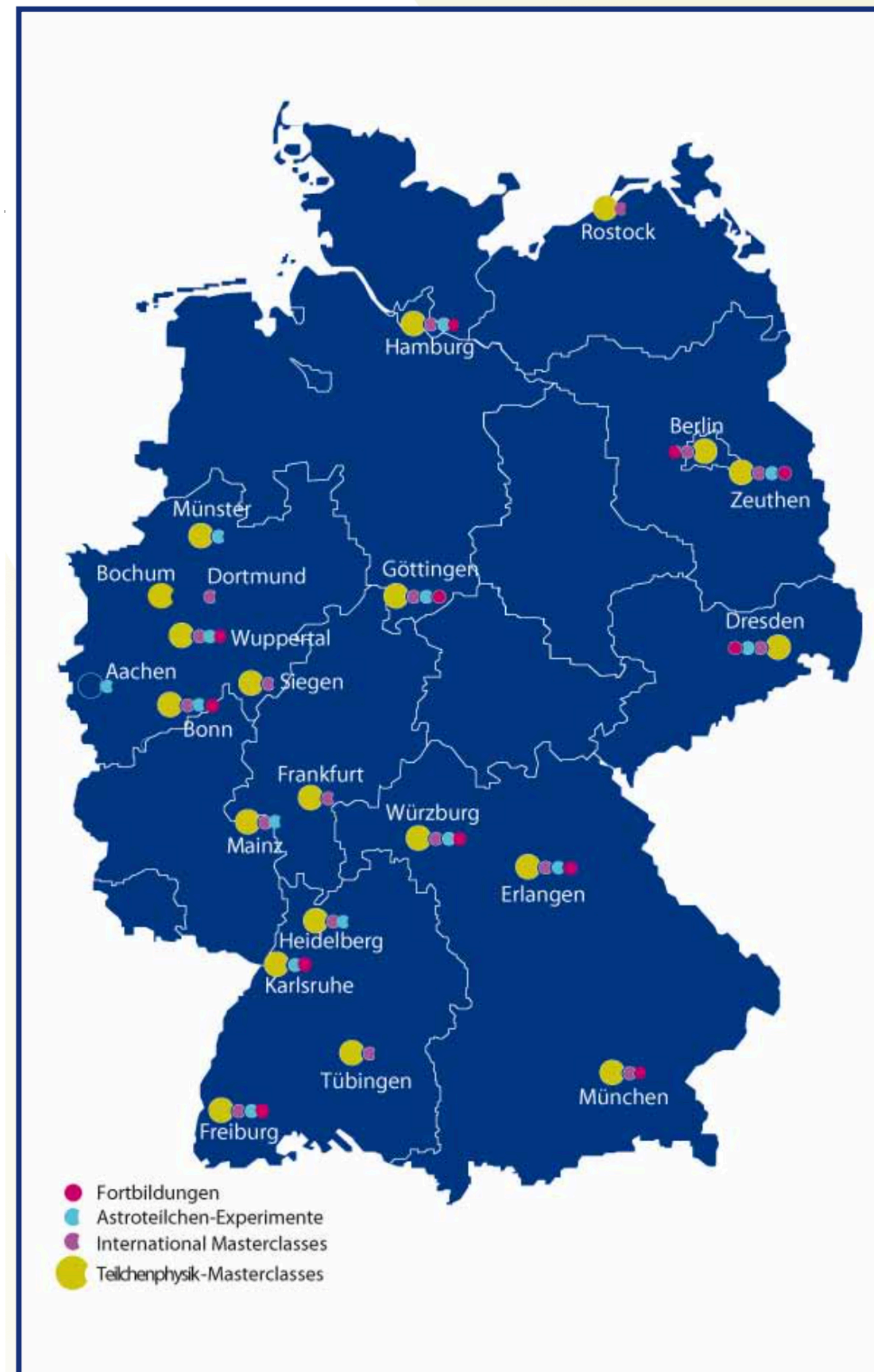


*Mediterranean sea:
ANTARES/KM3NeT*

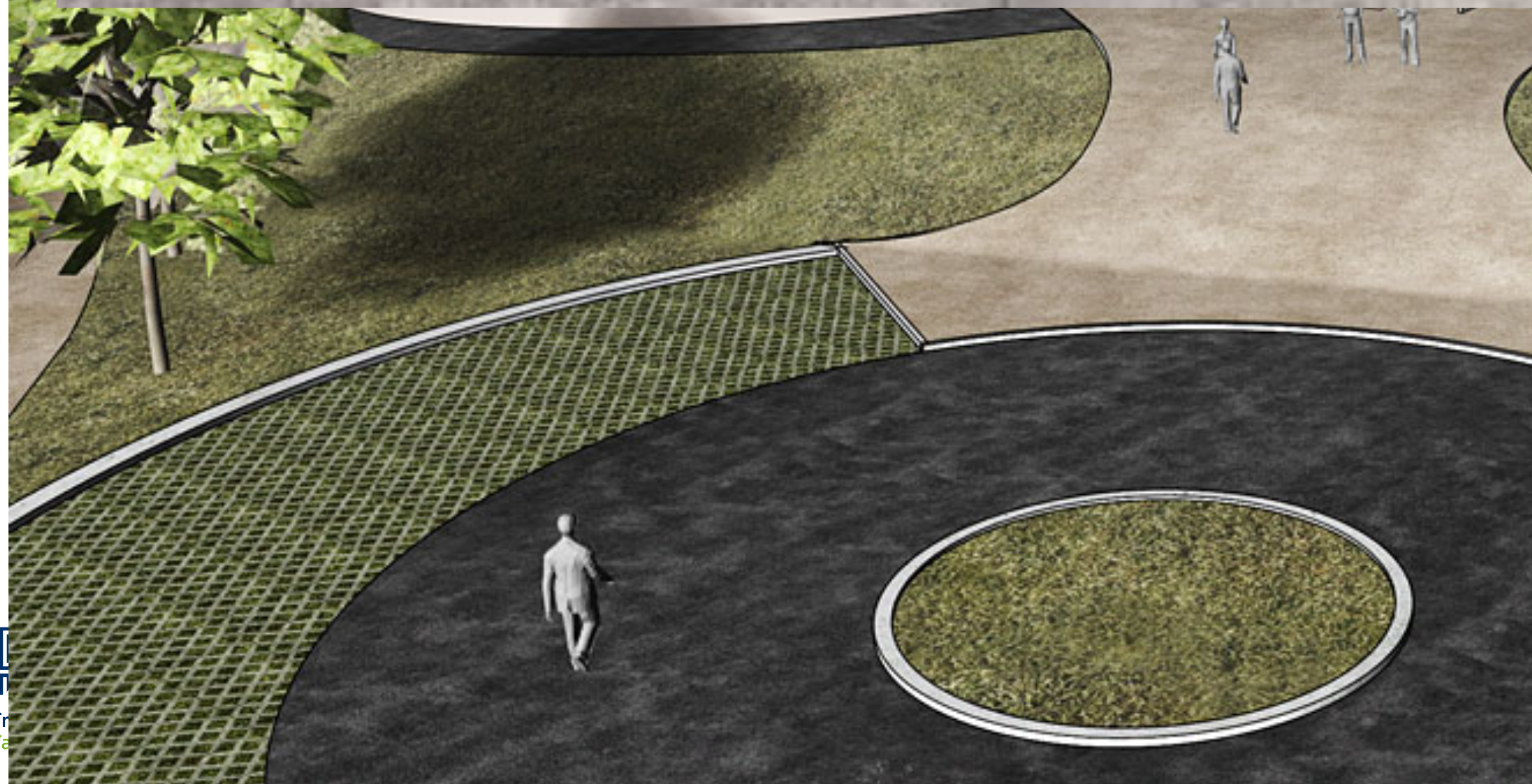


ACTIVITIES IN BAVARIA

- In Bavaria the active centres in astroparticle physics clearly are Würzburg (in particular Karl Mannheim's group), ECAP and the whole Munich area
- We actively collaborate on many topics
- Nearly all of the funding beyond the groups' base funding comes from the federal or European level

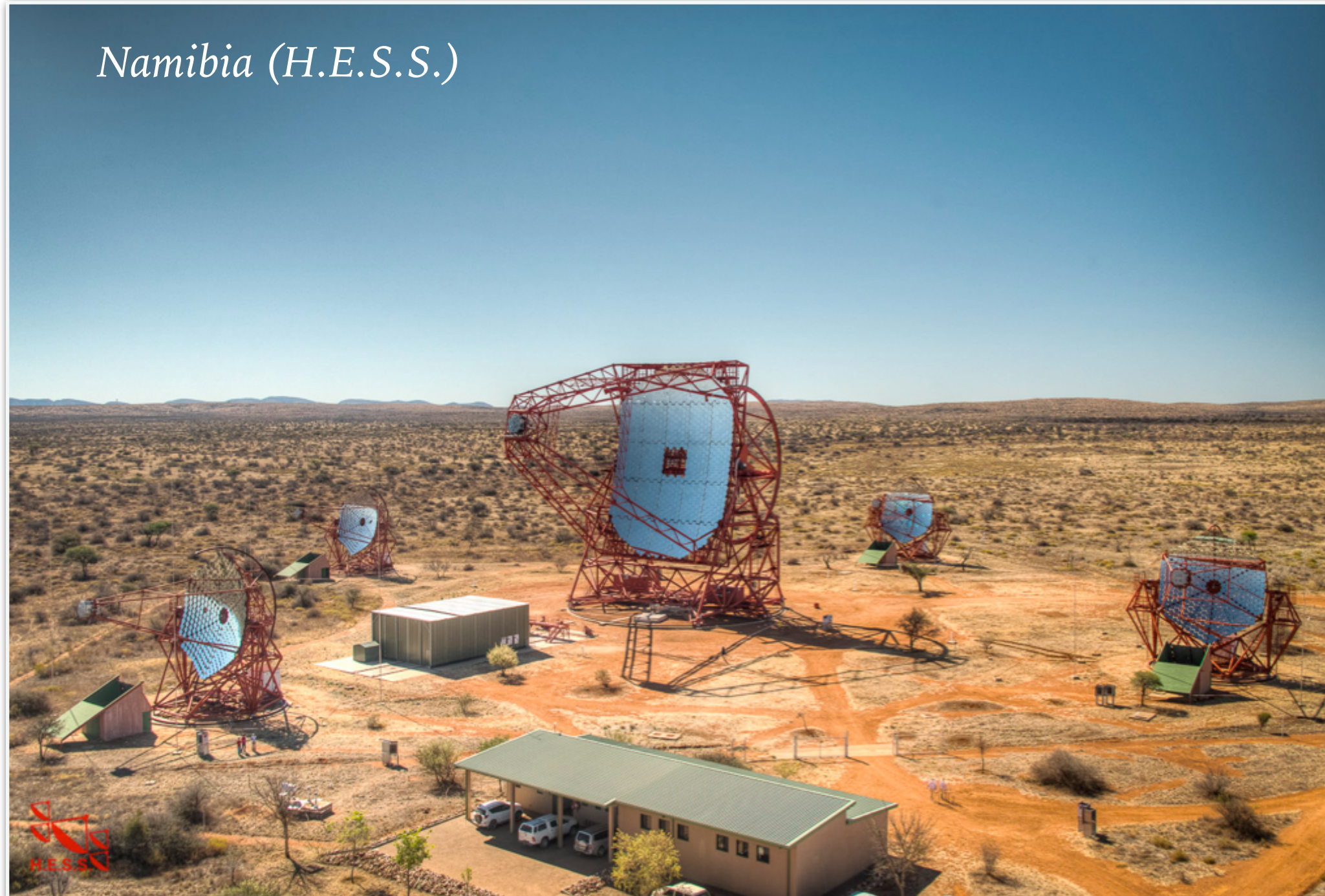




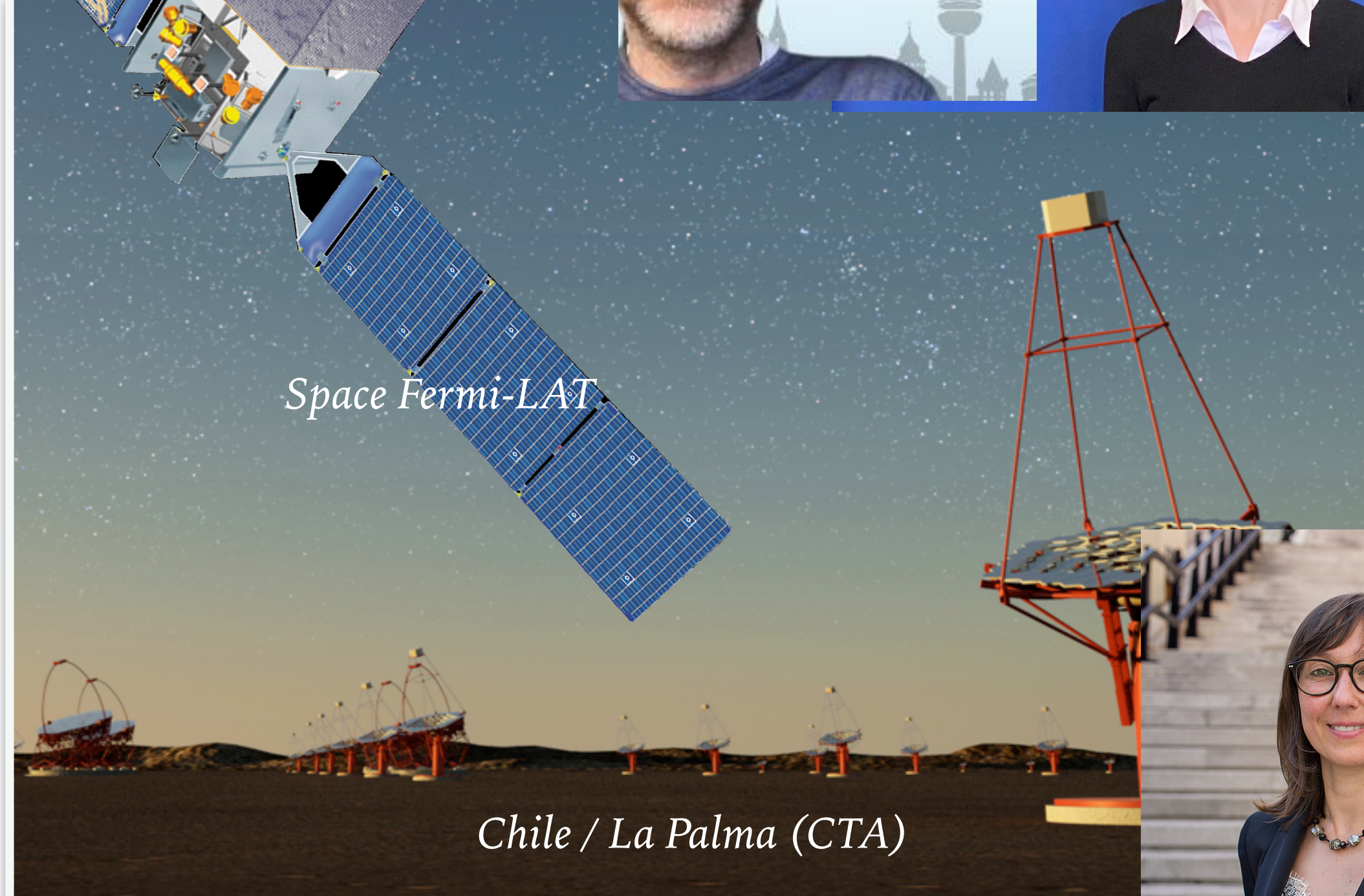


GAMMA-RAY ASTRONOMY

Namibia (H.E.S.S.)



Space Fermi-LAT

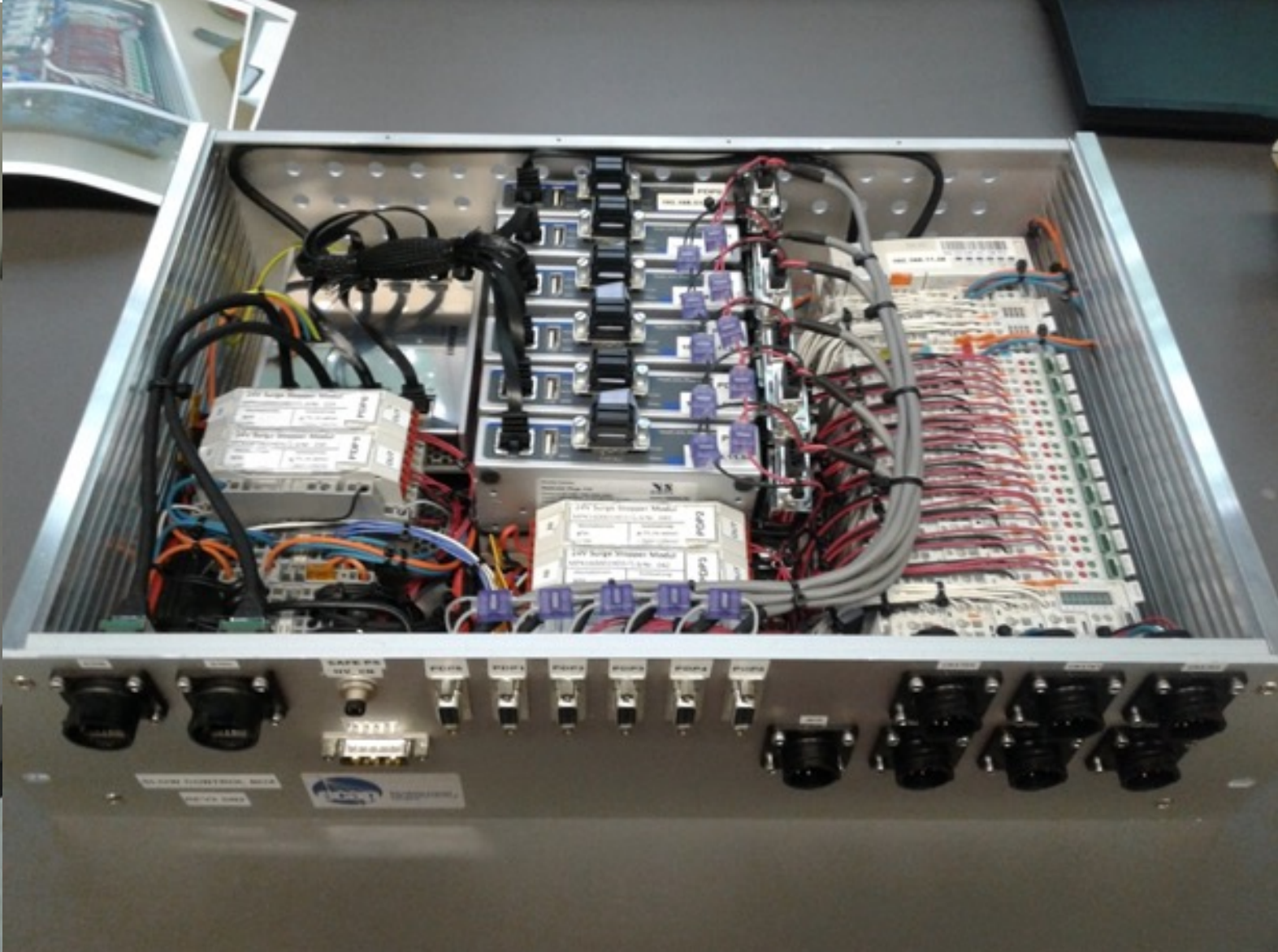
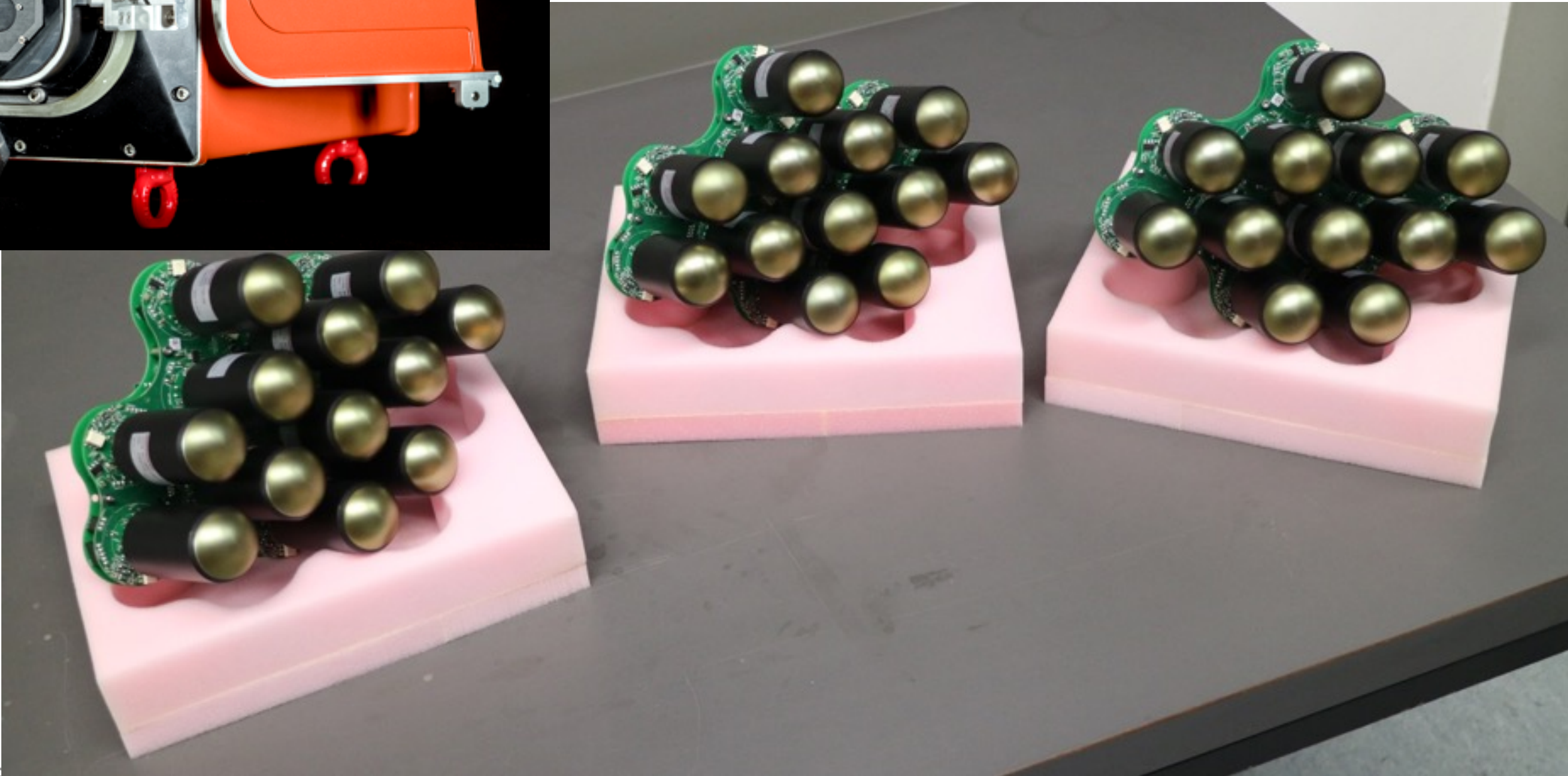
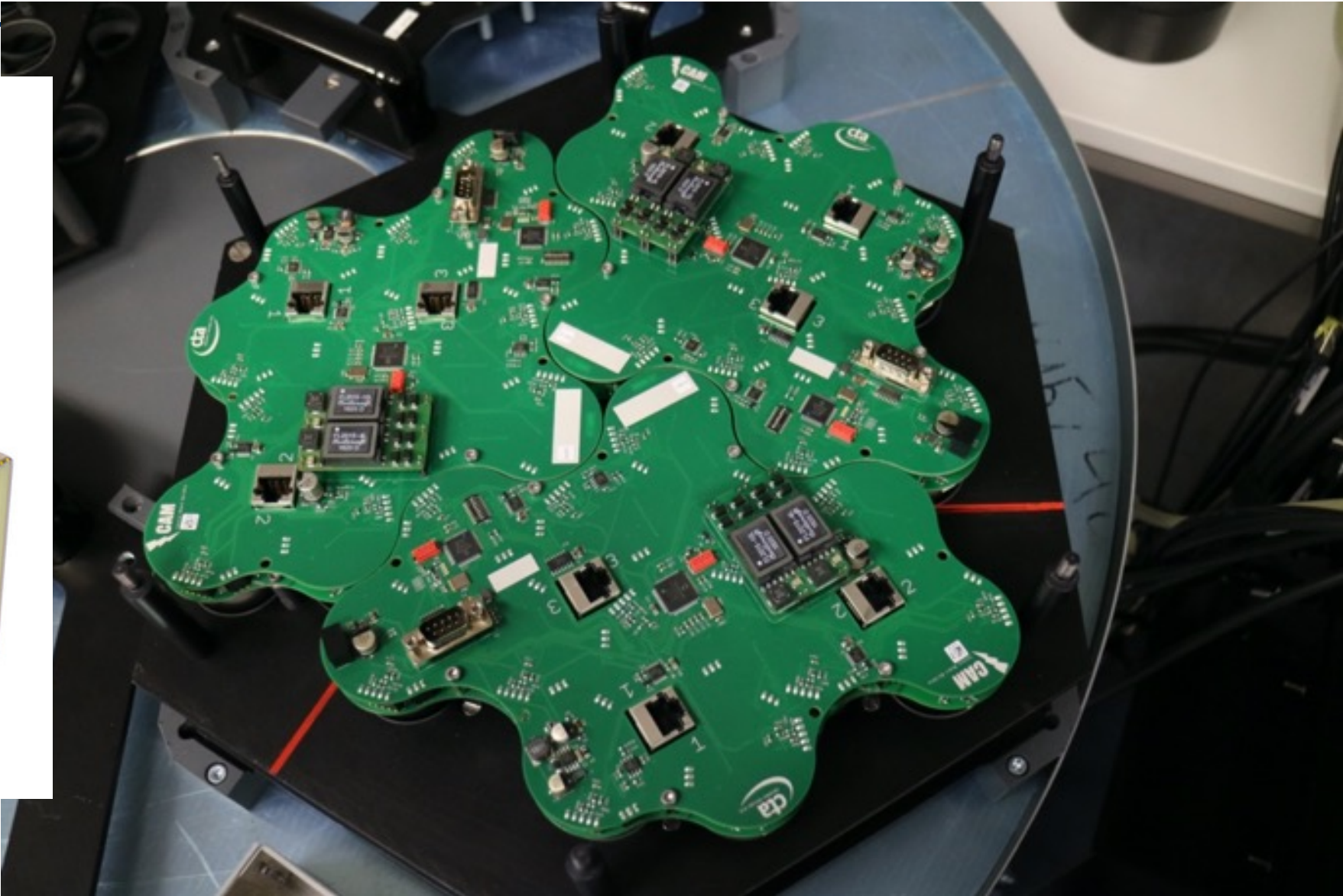
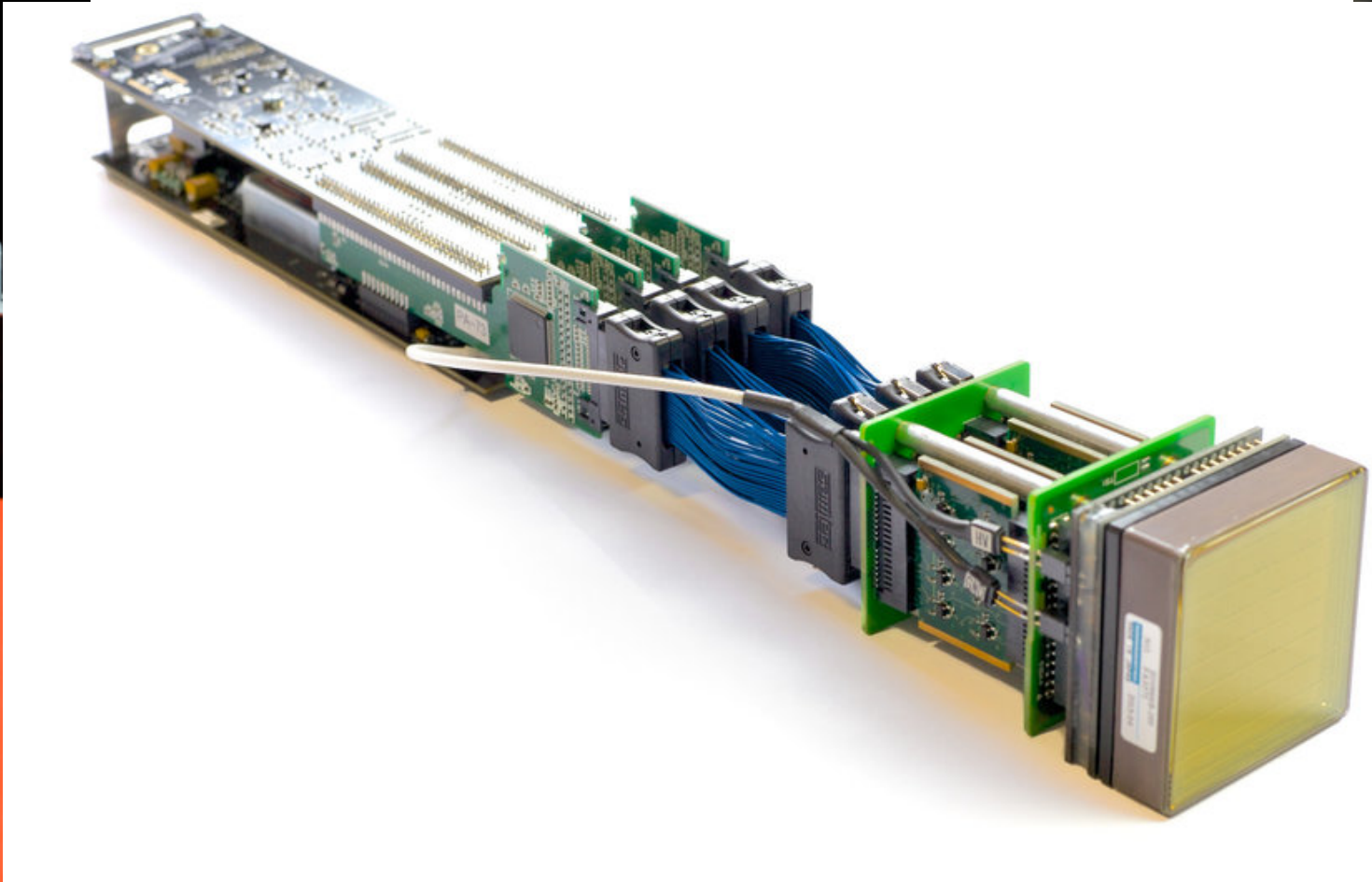


Chile / La Palma (CTA)

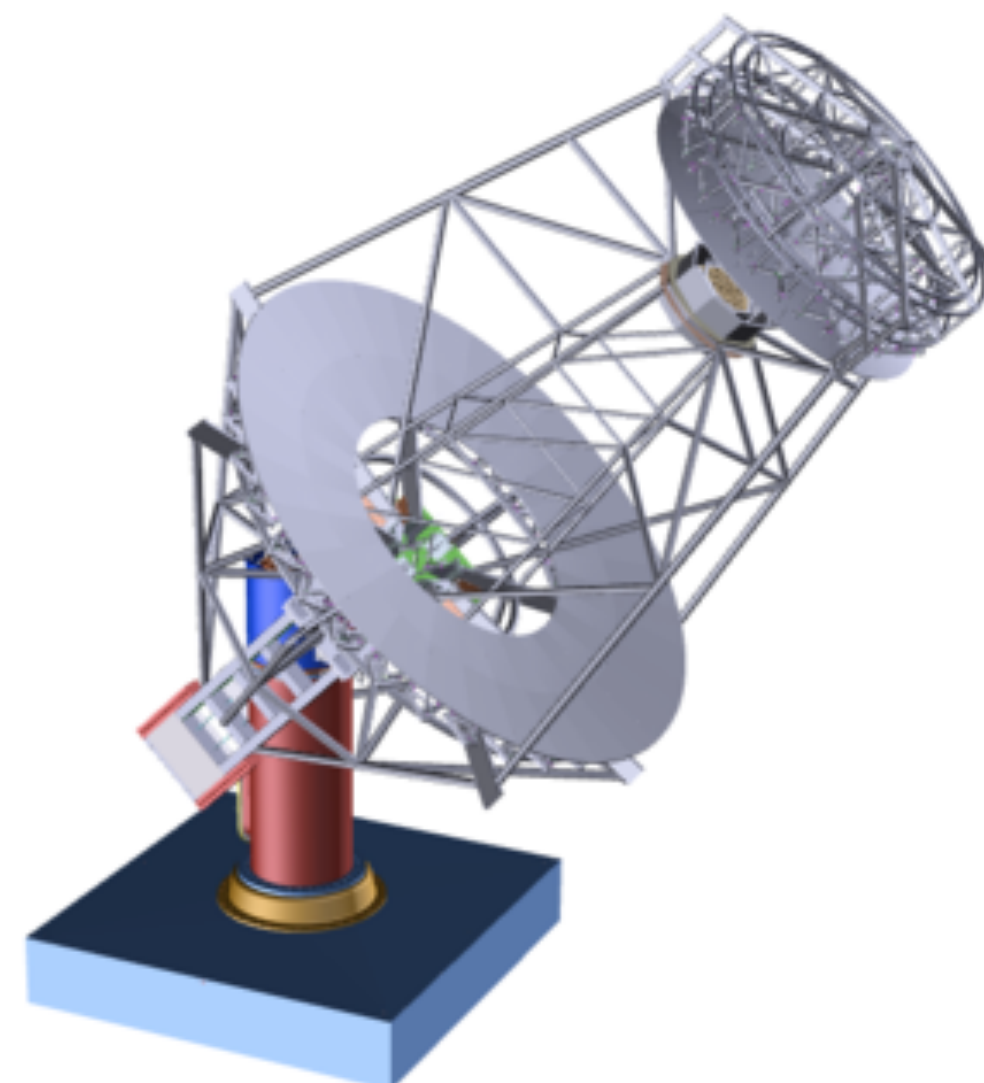
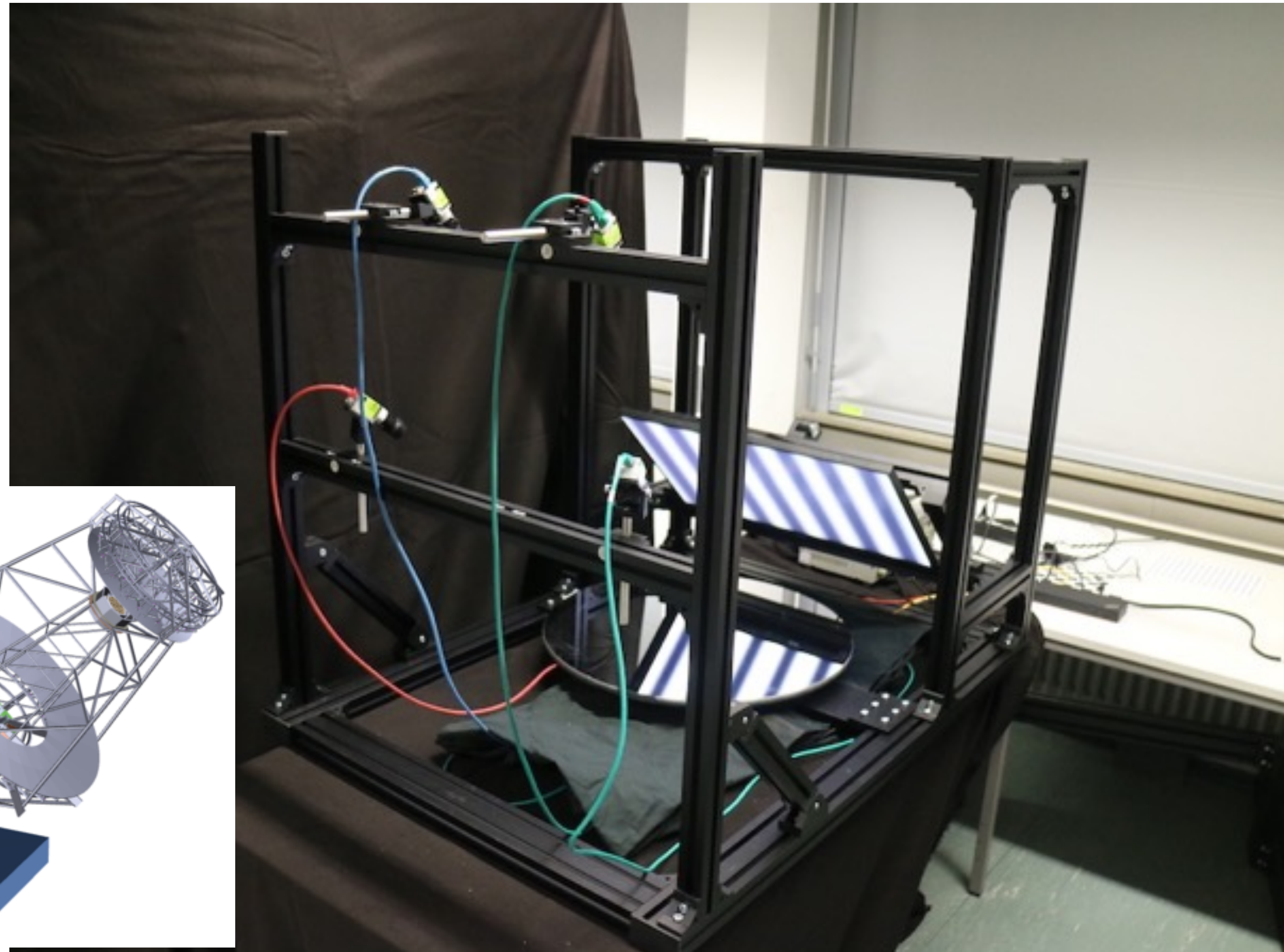
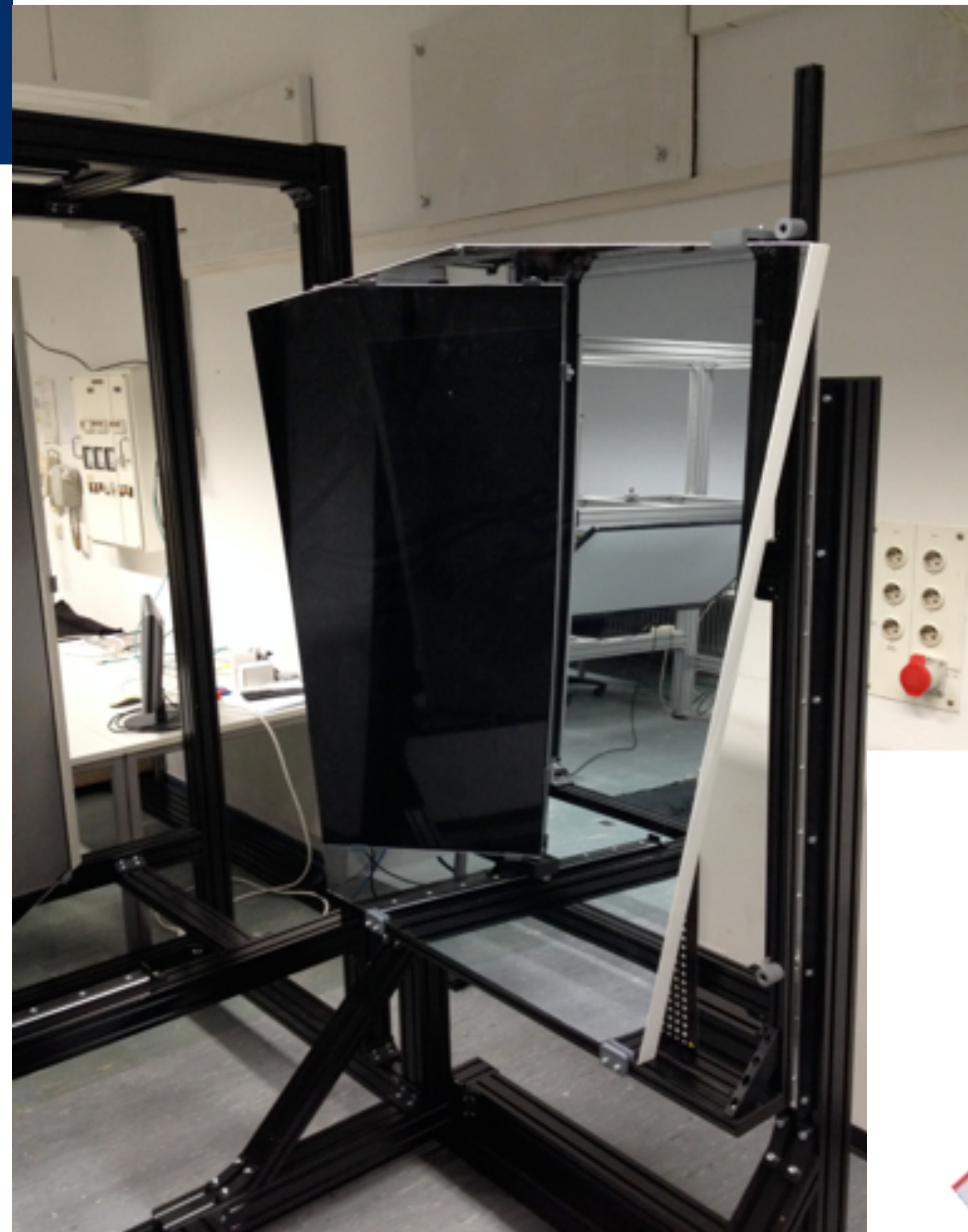


- Substantial efforts in H.E.S.S. (Erlangen), MAGIC (Munich, Wuerzburg), Fermi-LAT, CTA and SWGO
- Hardware development (e.g. camera electronics), software development (multi-instrument high-level science tools for CTA) and data analysis and interpretation (for Fermi-LAT, H.E.S.S.)

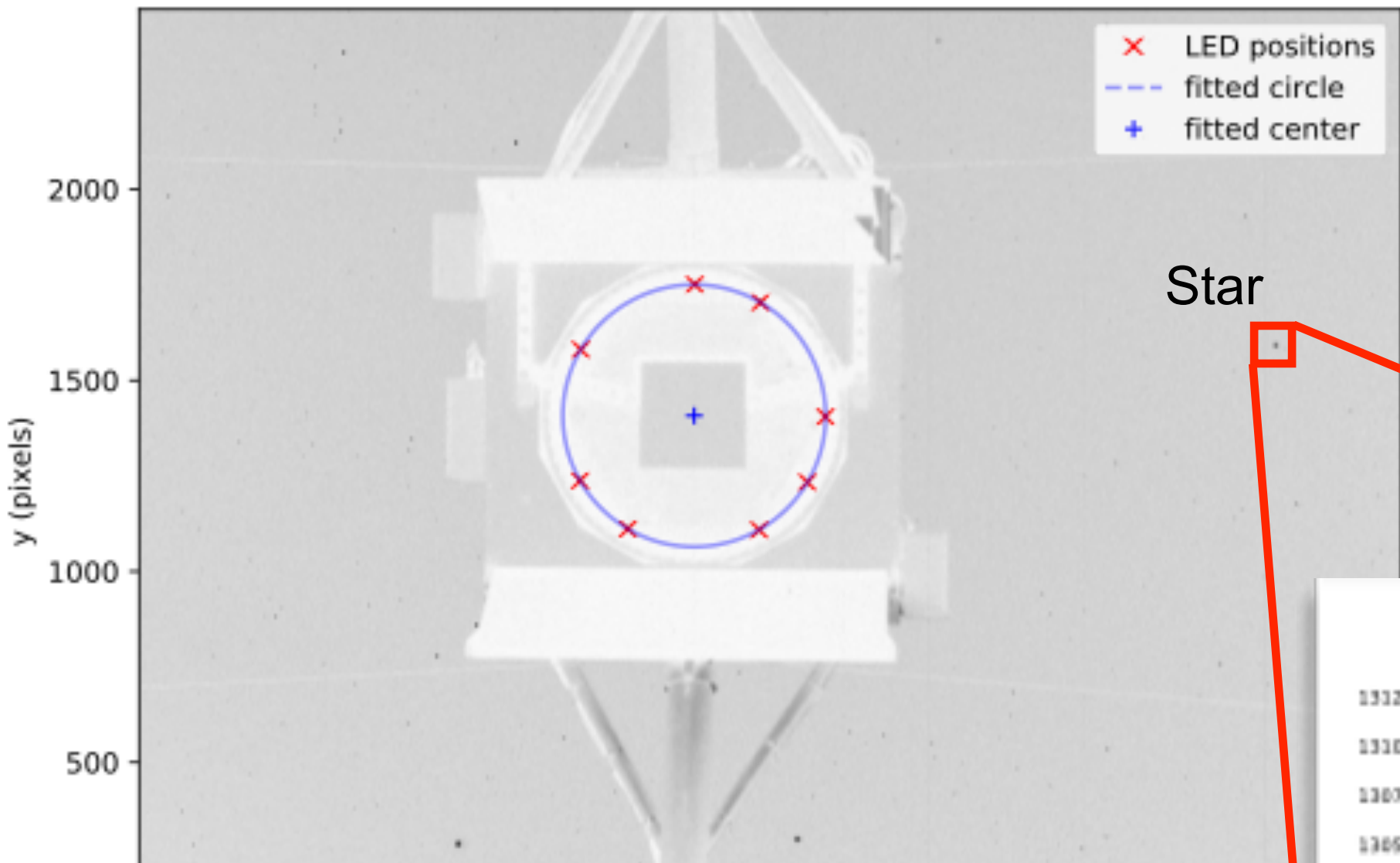
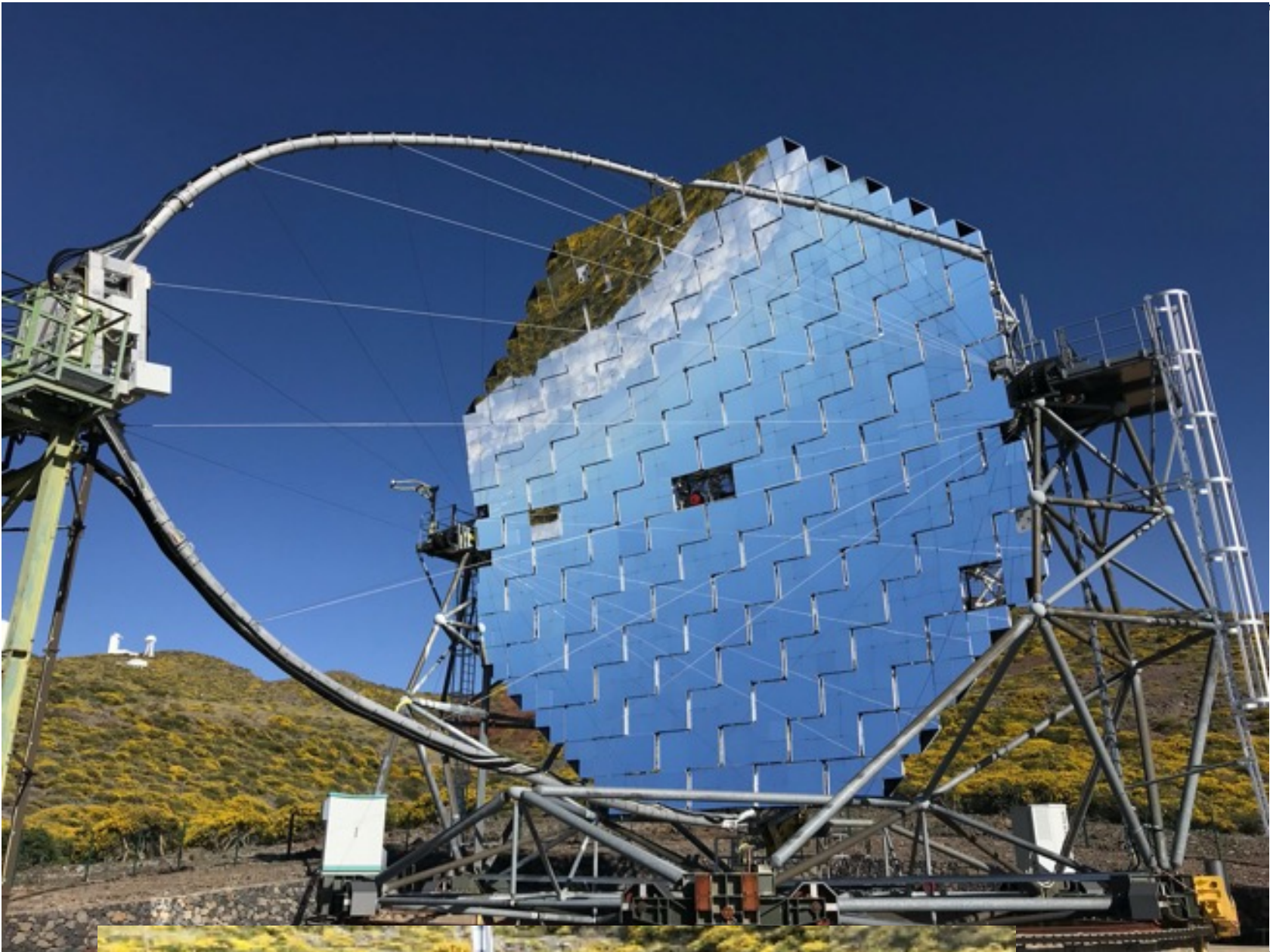
CTA CAMERA DEVELOPMENT FOR MSTs AND SSTs



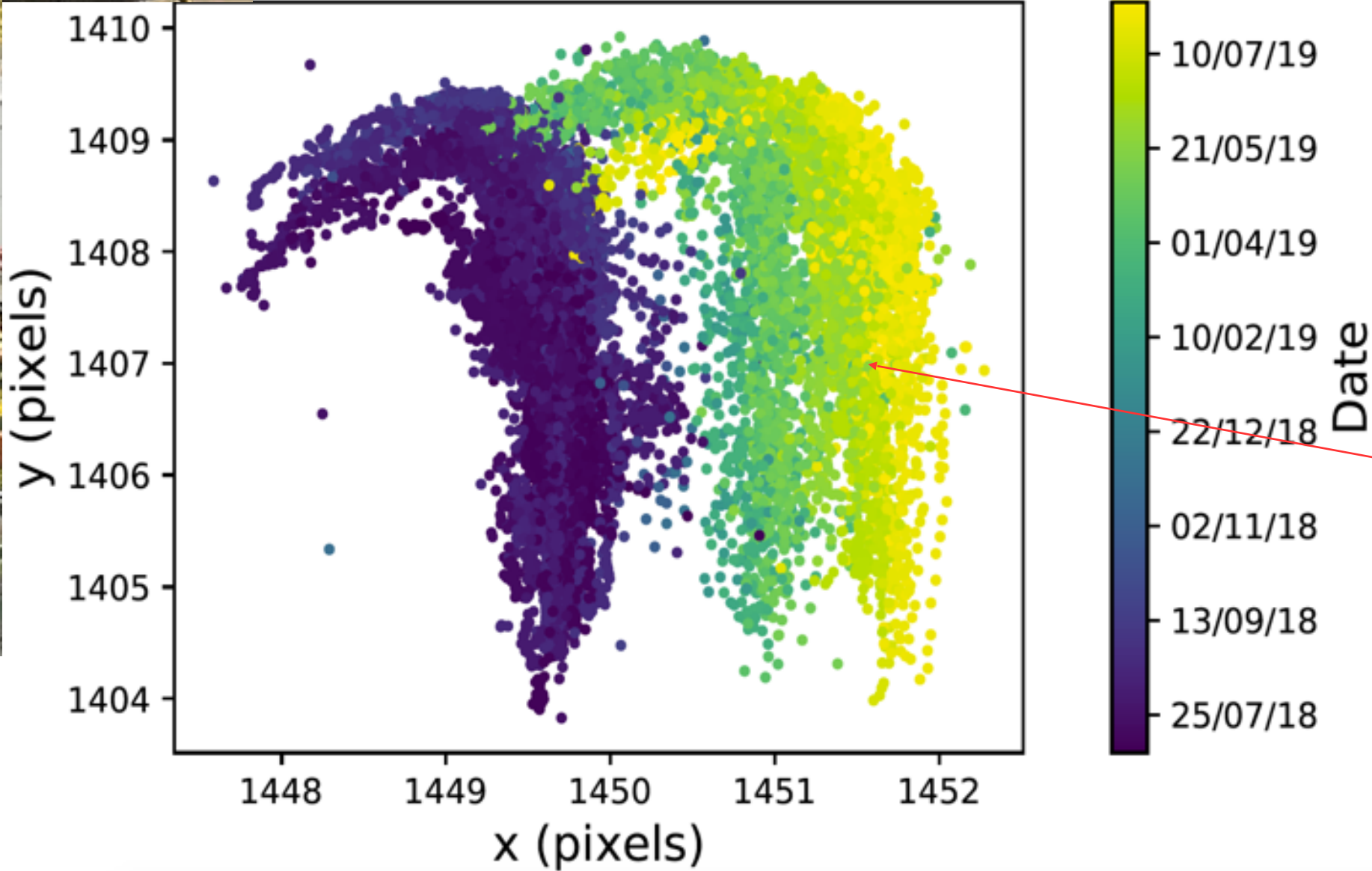
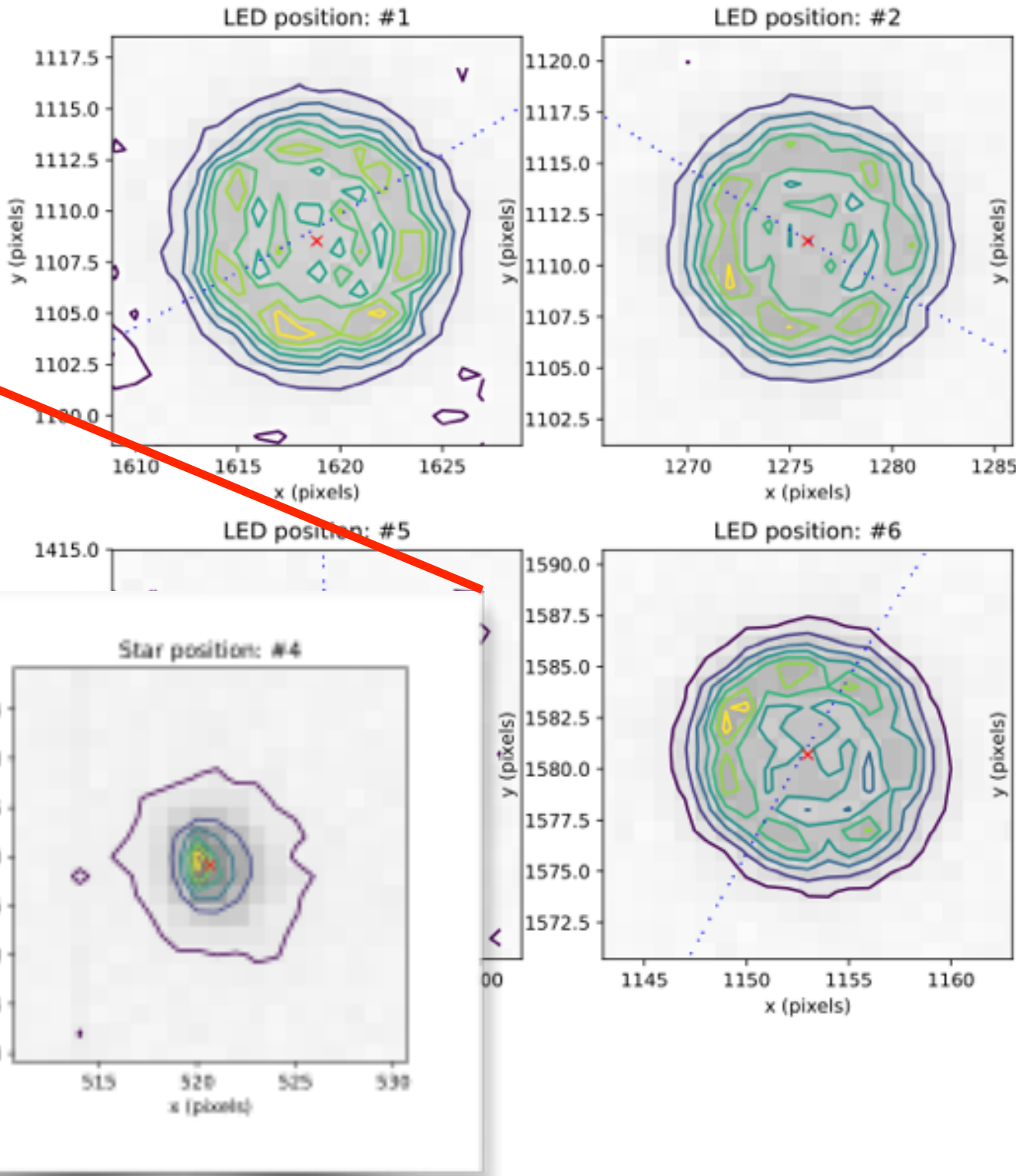
CTA MIRROR QUALITY



CTA TELESCOPE POINTING PRECISION



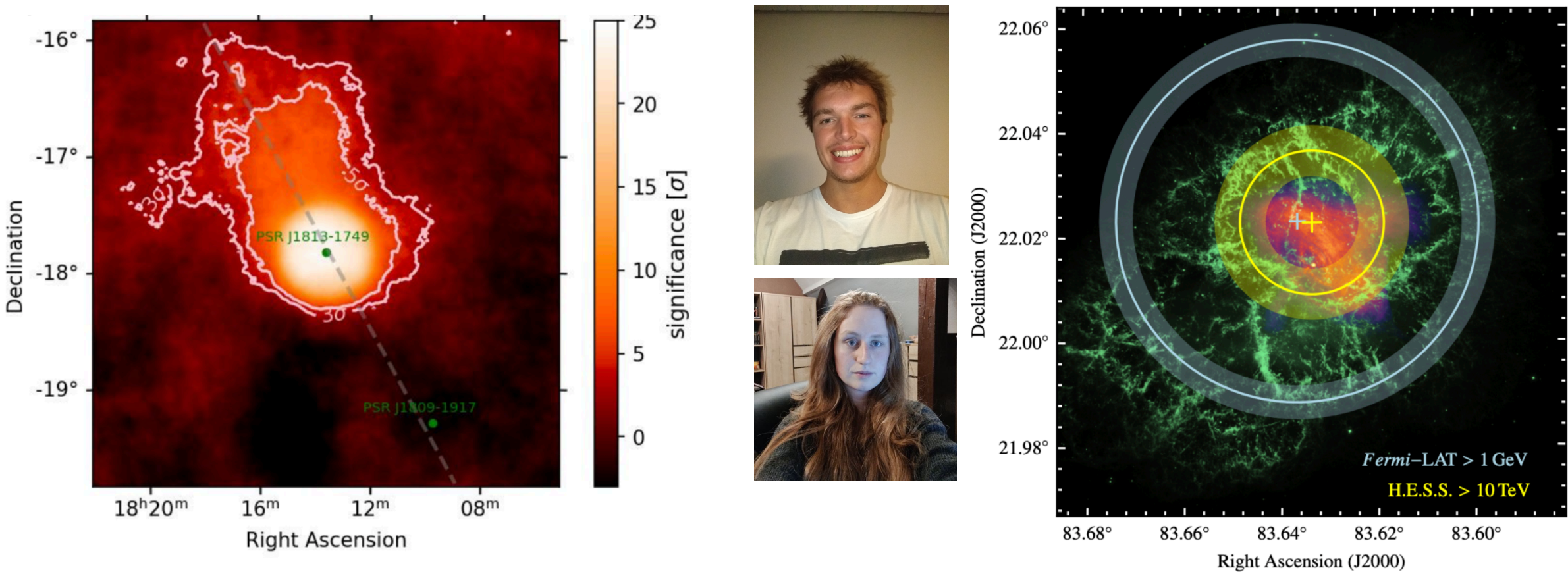
Star



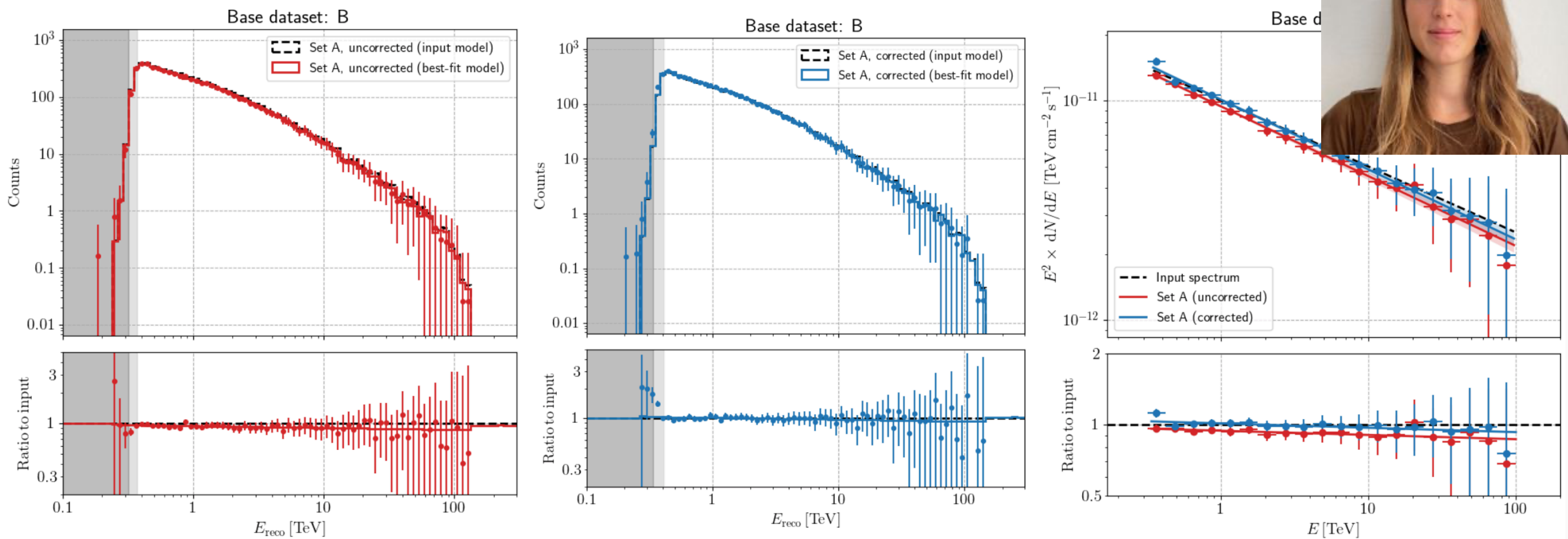
Determine reconstructed LED positions to measure bending of structures

CTA-RELEVANT ANALYSIS TECHNIQUES IN H.E.S.S.

Multi-instrument fitting with gammapy

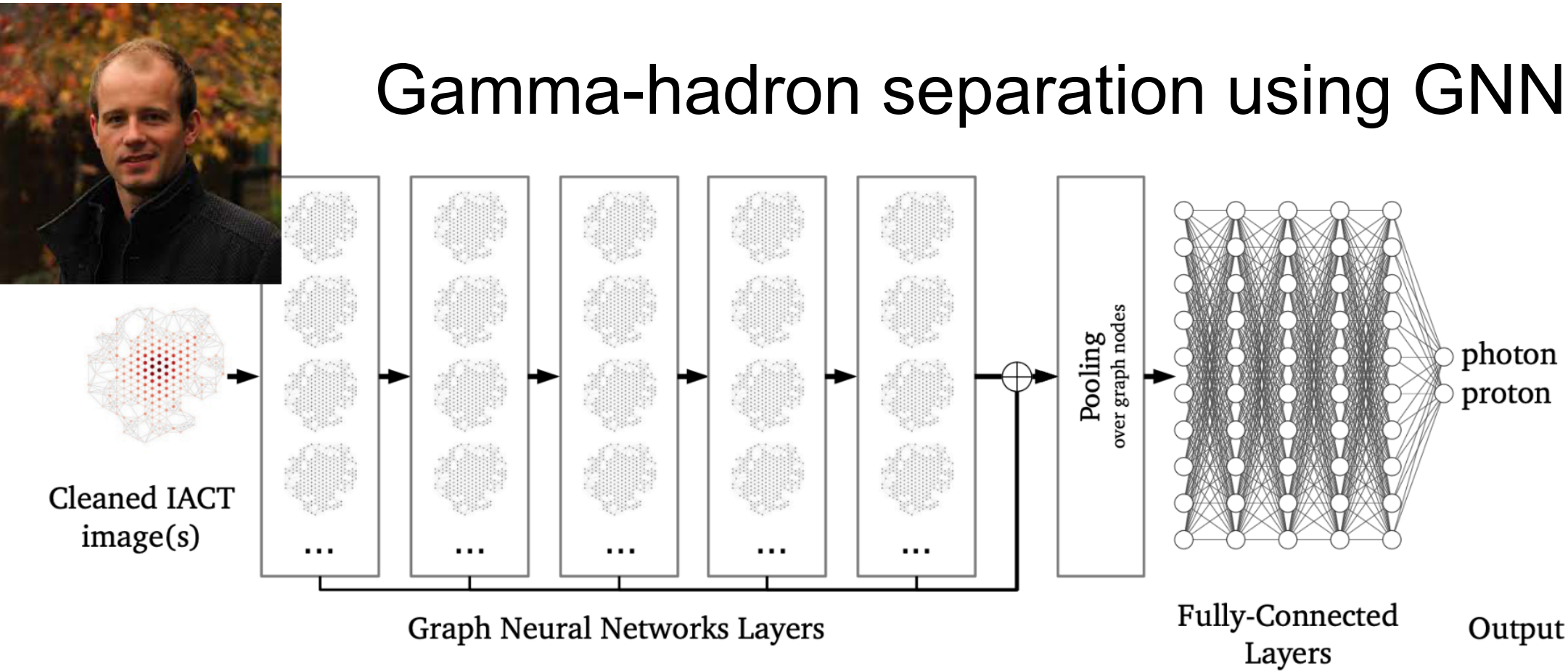


Atmospheric correction scheme

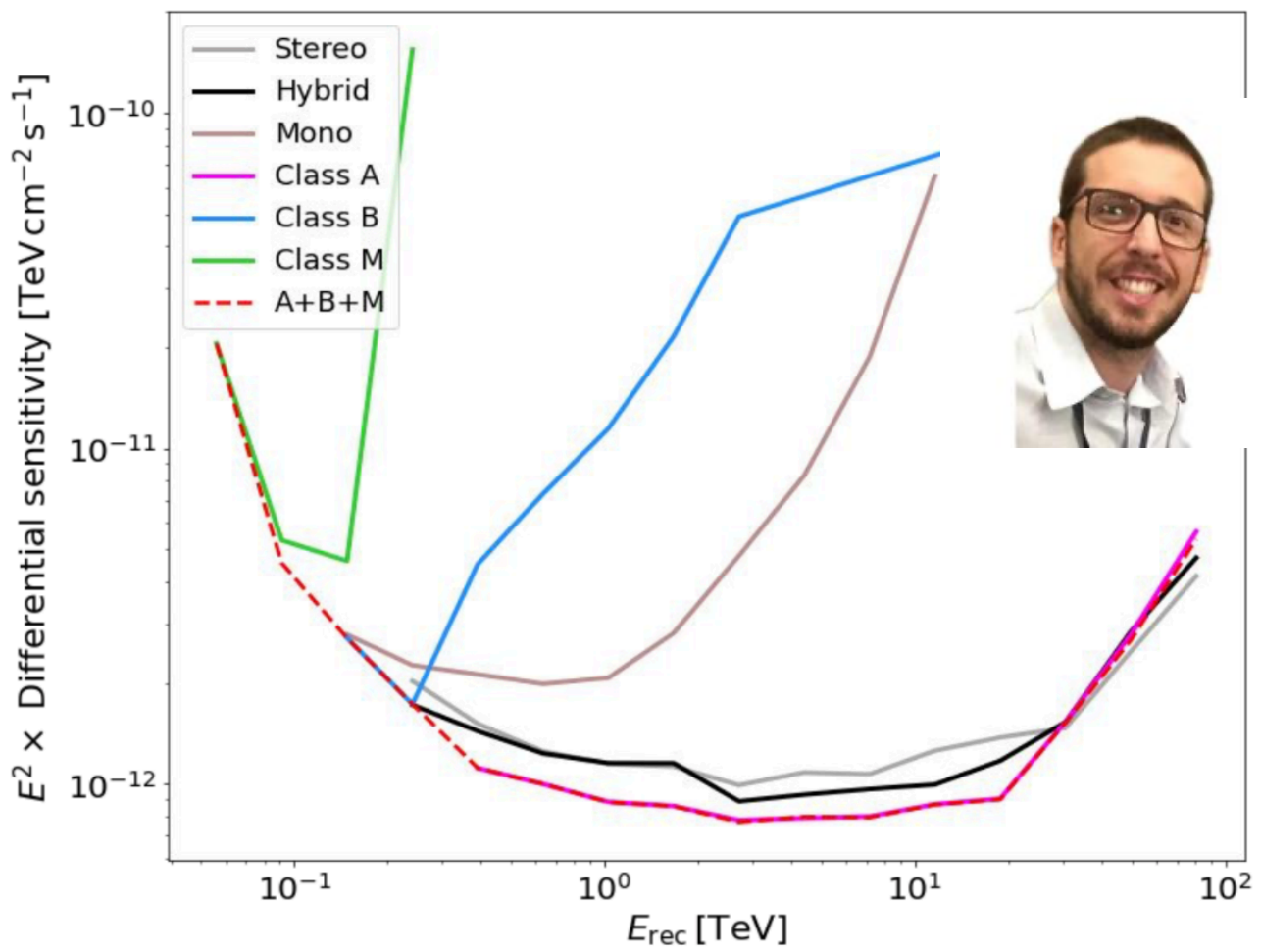


Time-based image cleaning

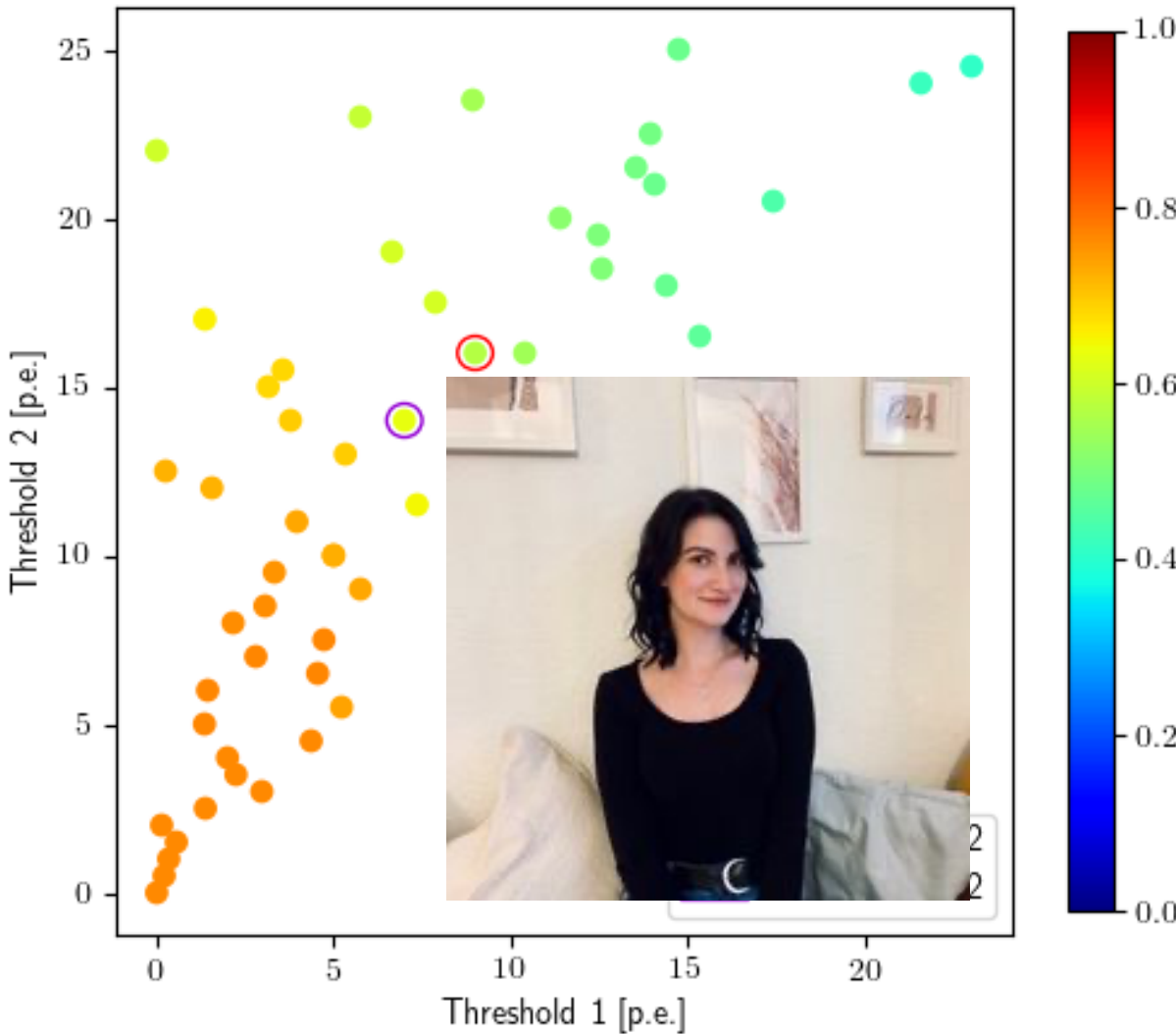
Gamma-hadron separation using GNNs

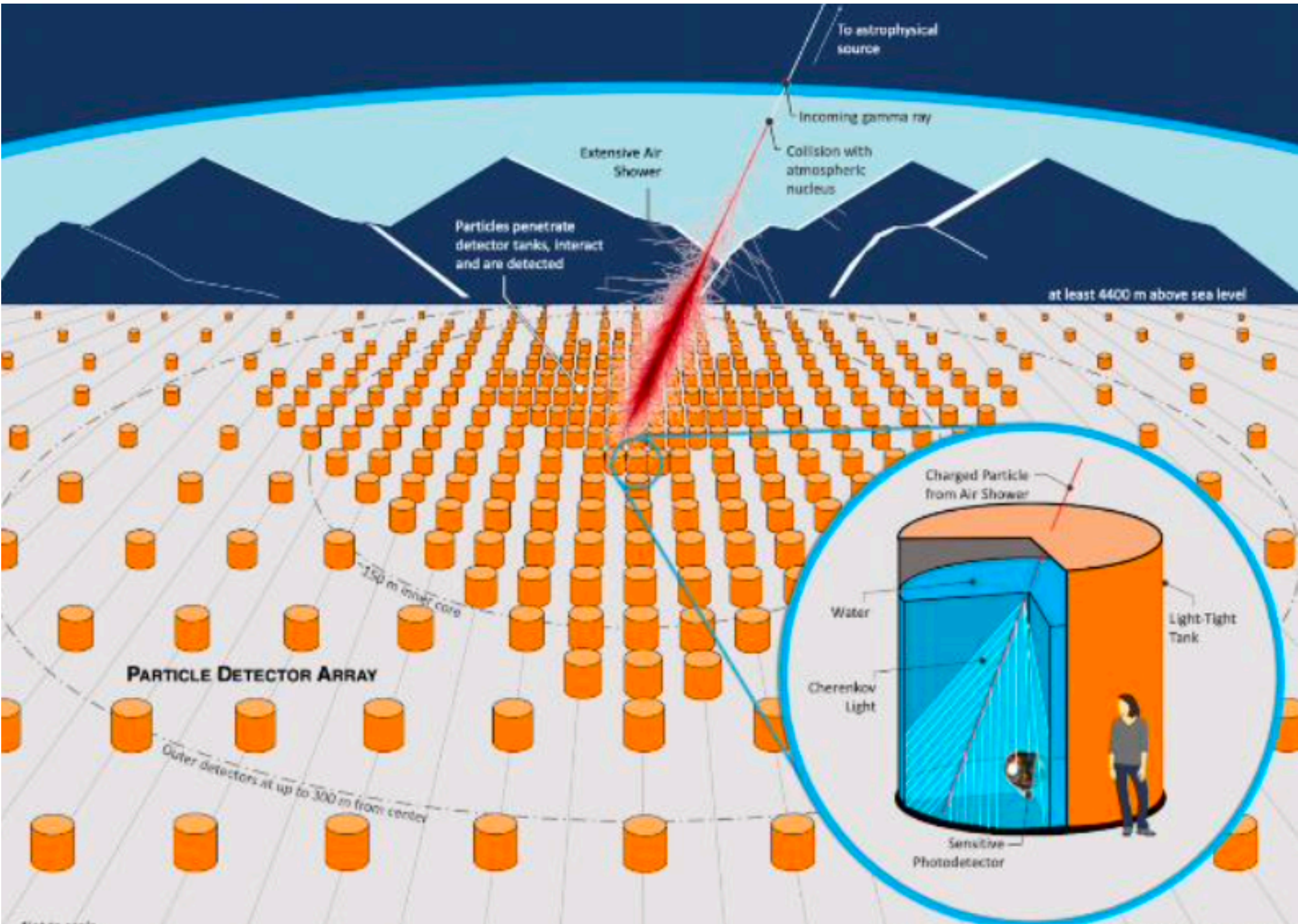


Event classes

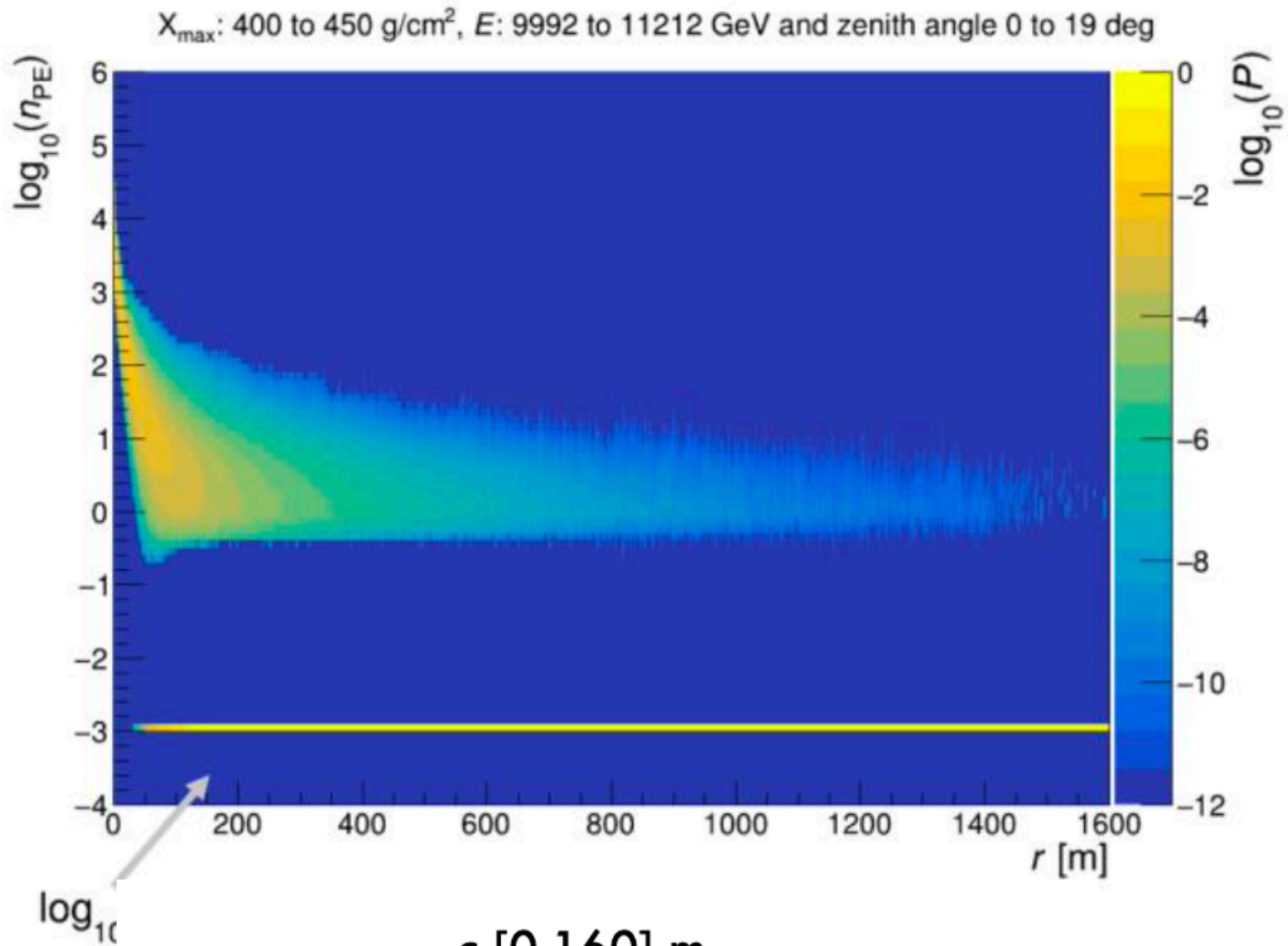


Tailcuts Cleaning with fixed NN=2 True size range 200pe - 1000pe

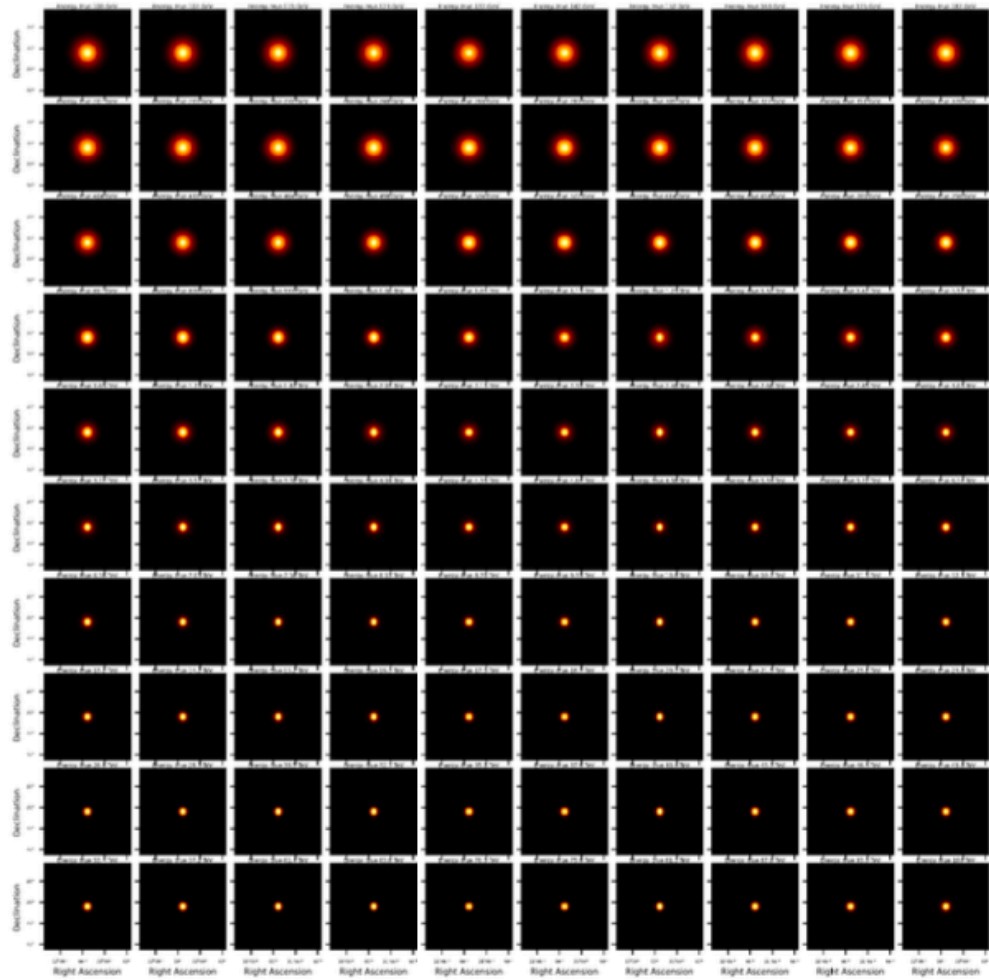




Template-based event reconstruction



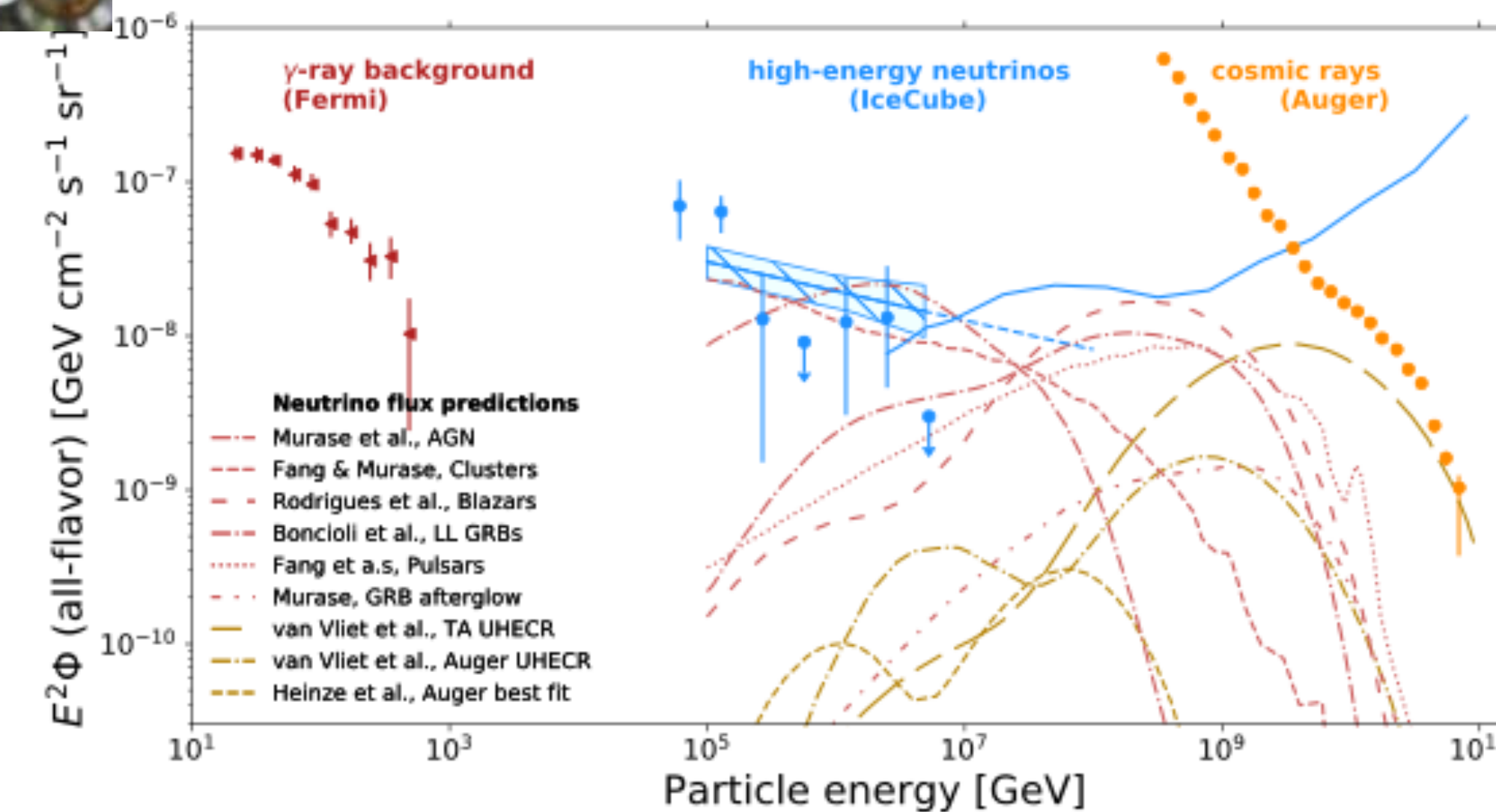
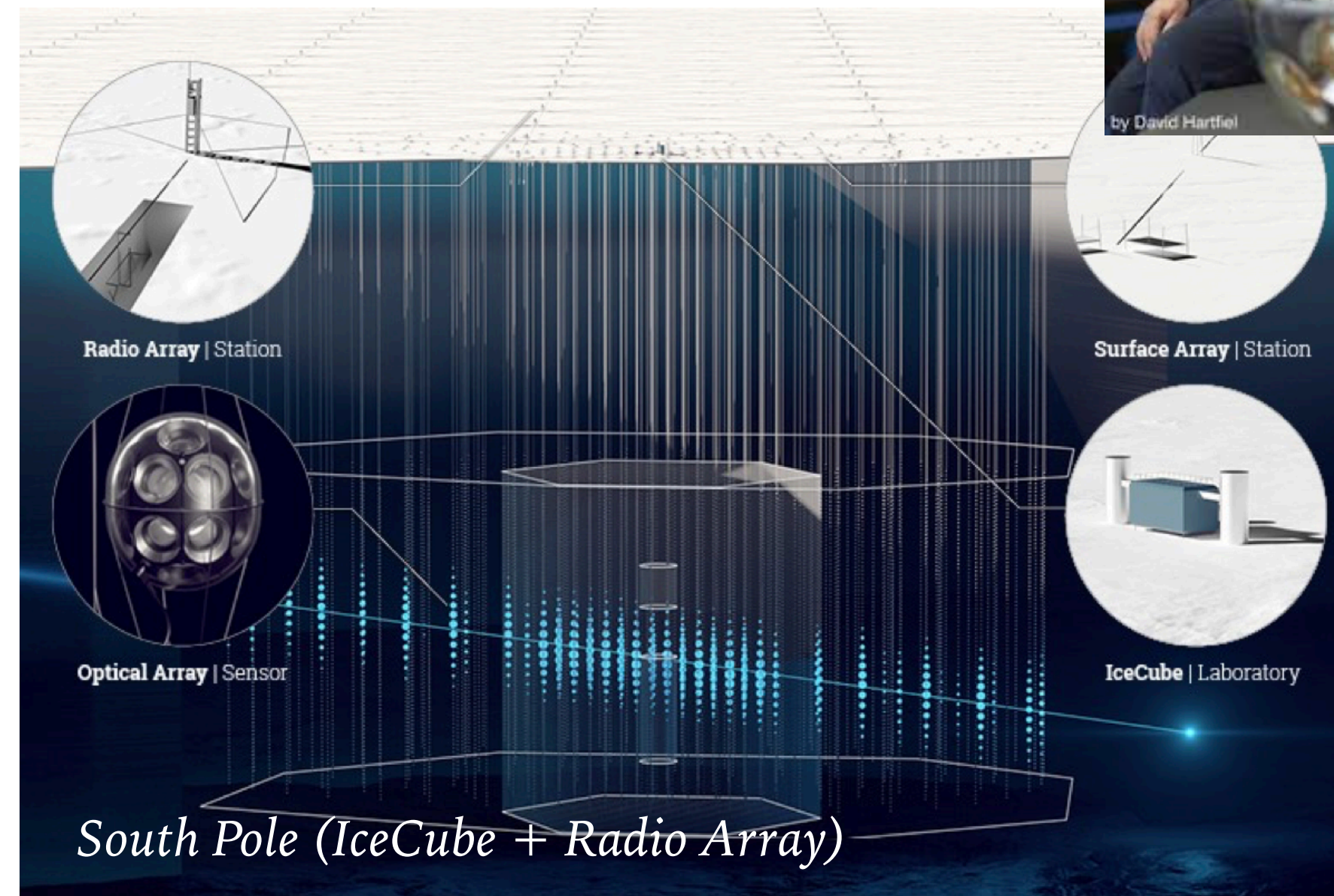
c [0,160] m
z [0,30] deg



Martin Schneider

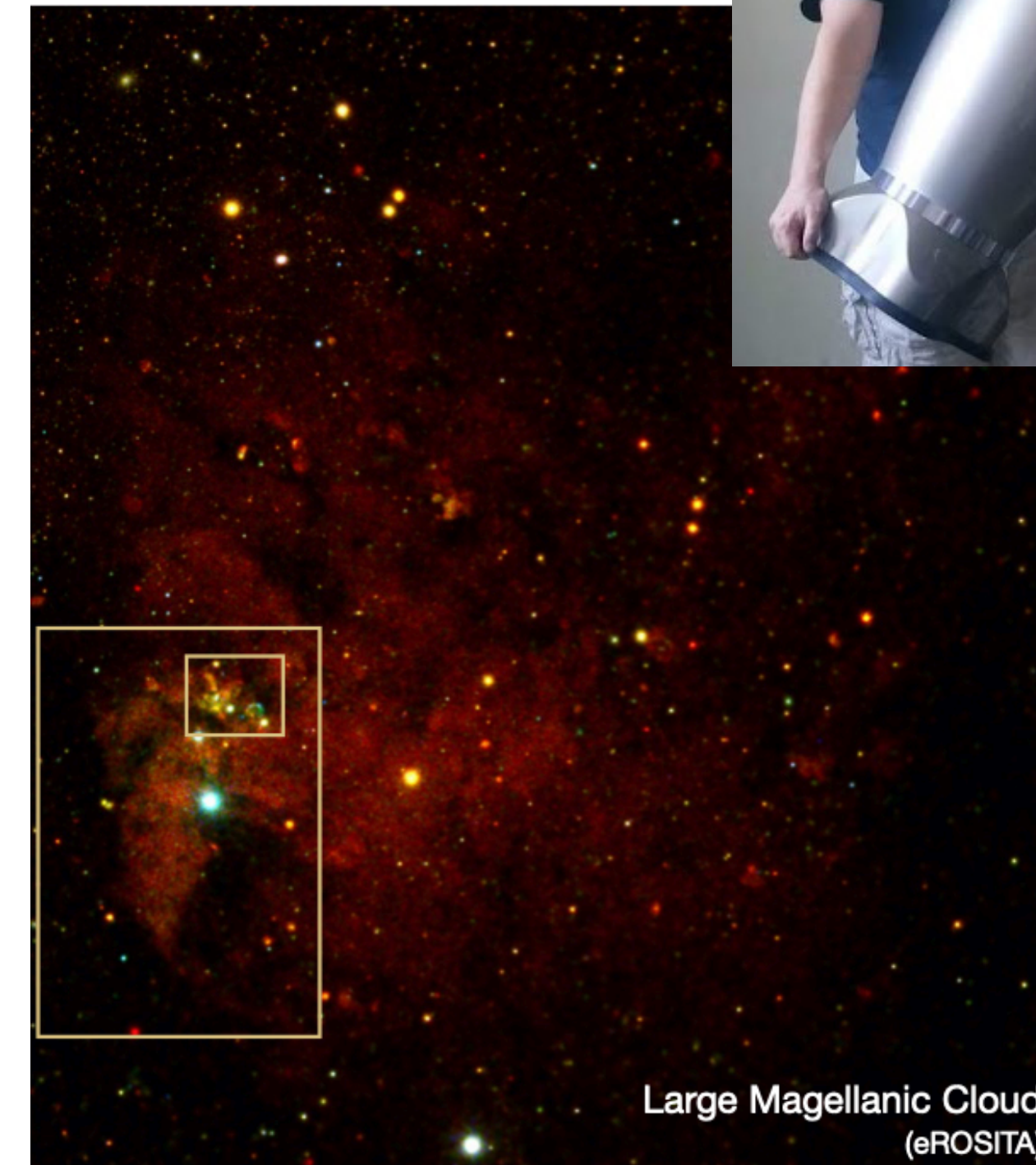
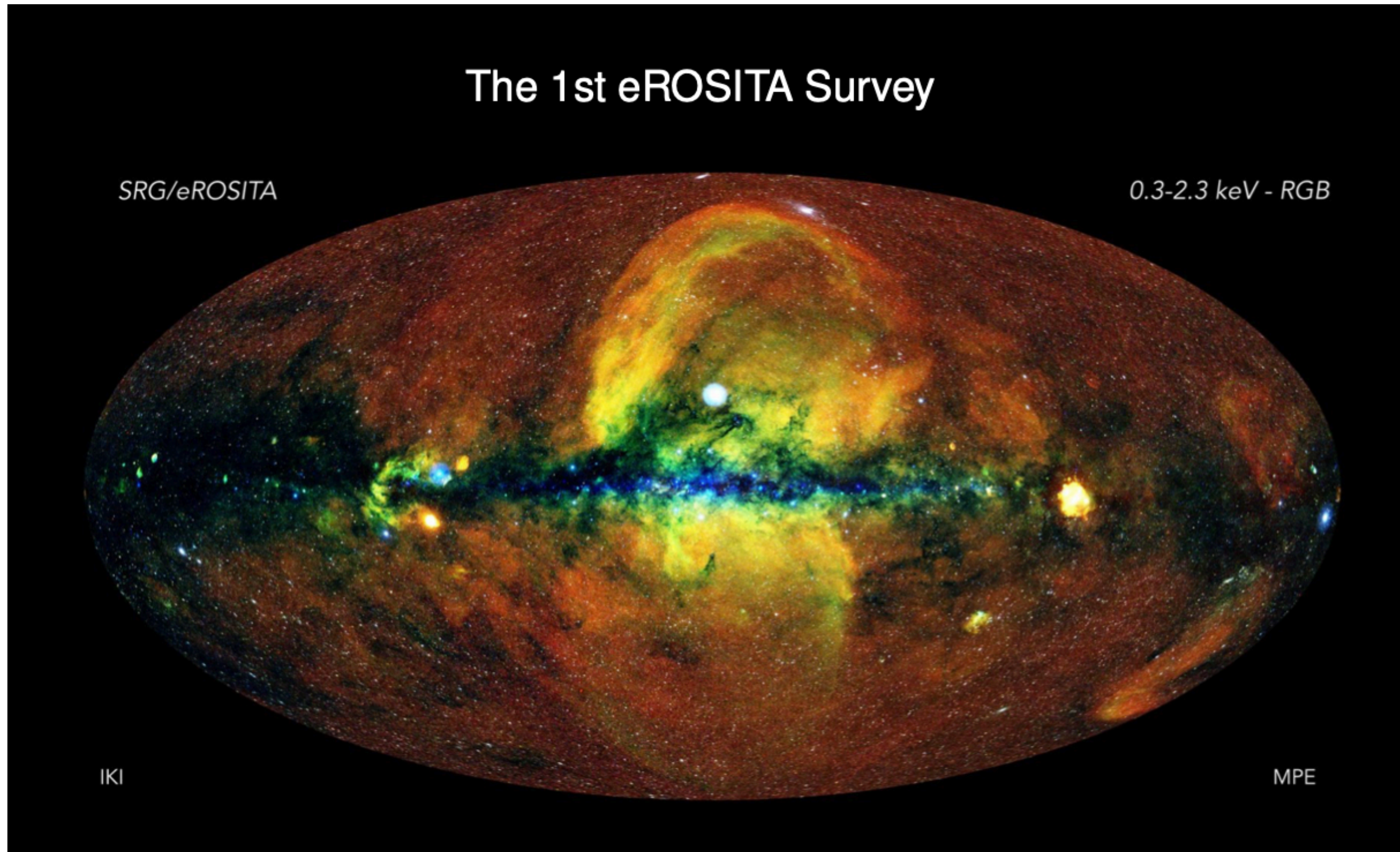
IRF production

NEUTRINO ASTRONOMY



- ECAP the only institute in Germany with involvement in all major current (ANTARES, IceCube) and upcoming neutrino observatories (KM3NeT, IceCube-Gen2, RNO-G)
- Covering huge range in neutrino energies
- Also large presence of IceCube activities in Munich and multi-messenger observations in Würzburg

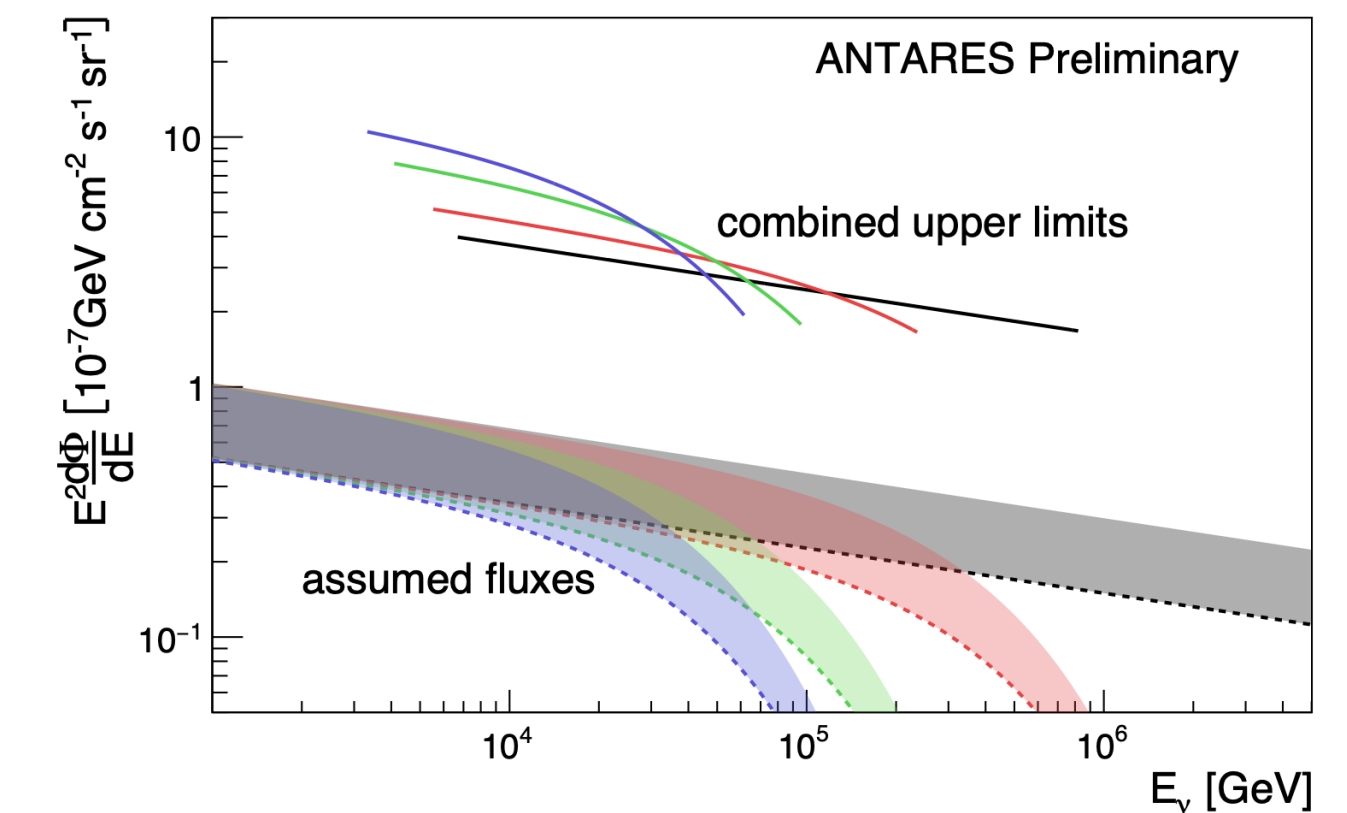
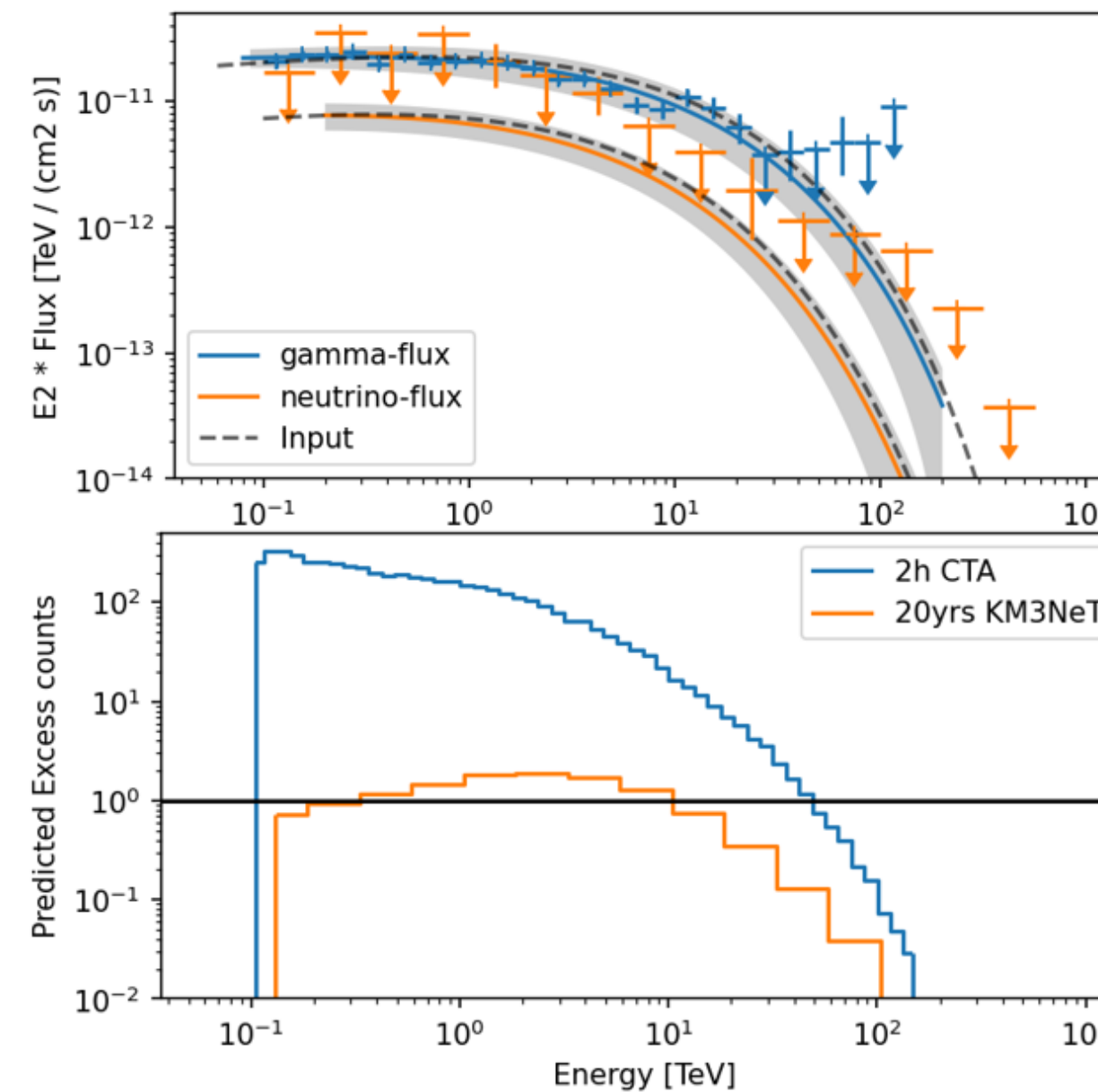
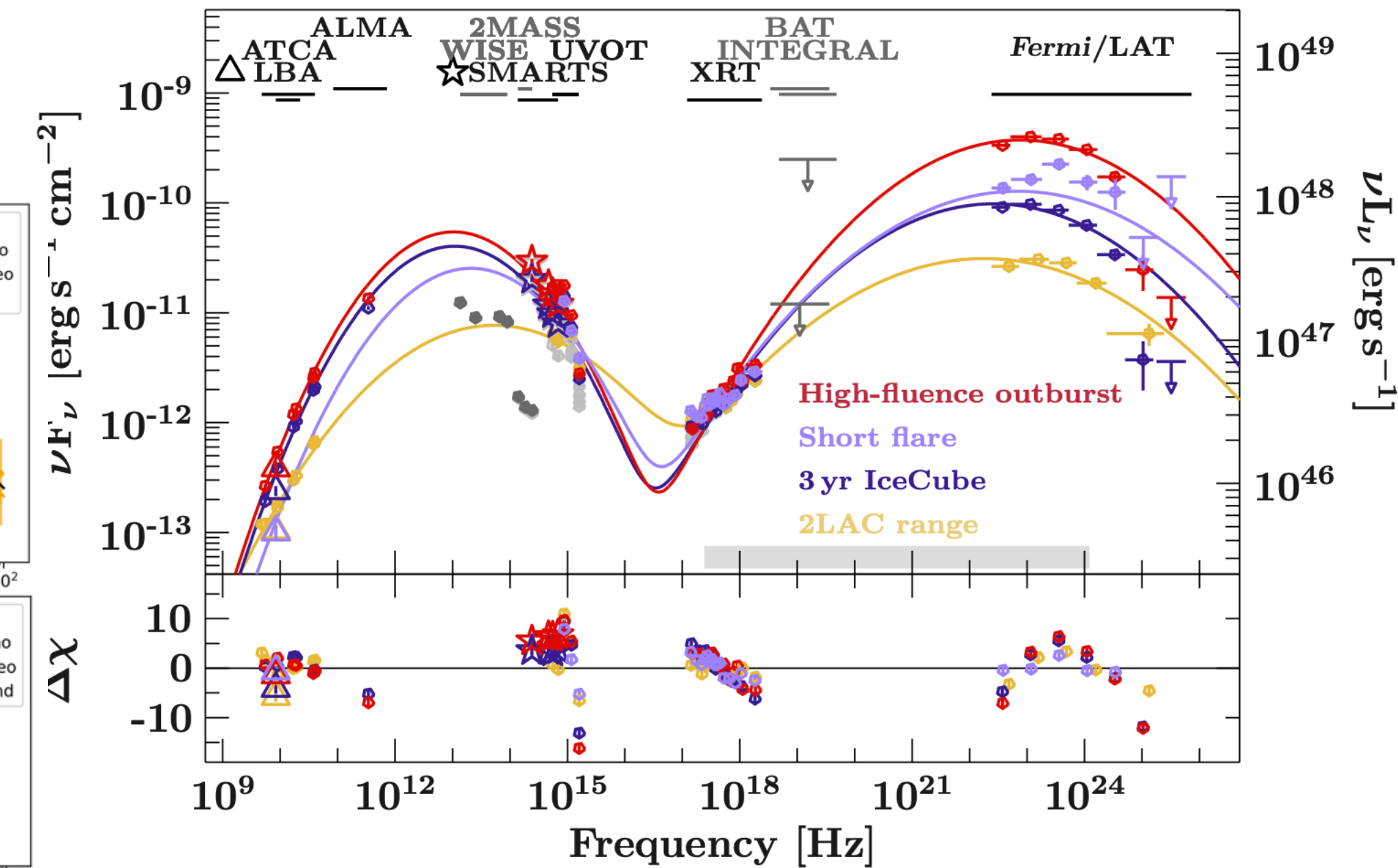
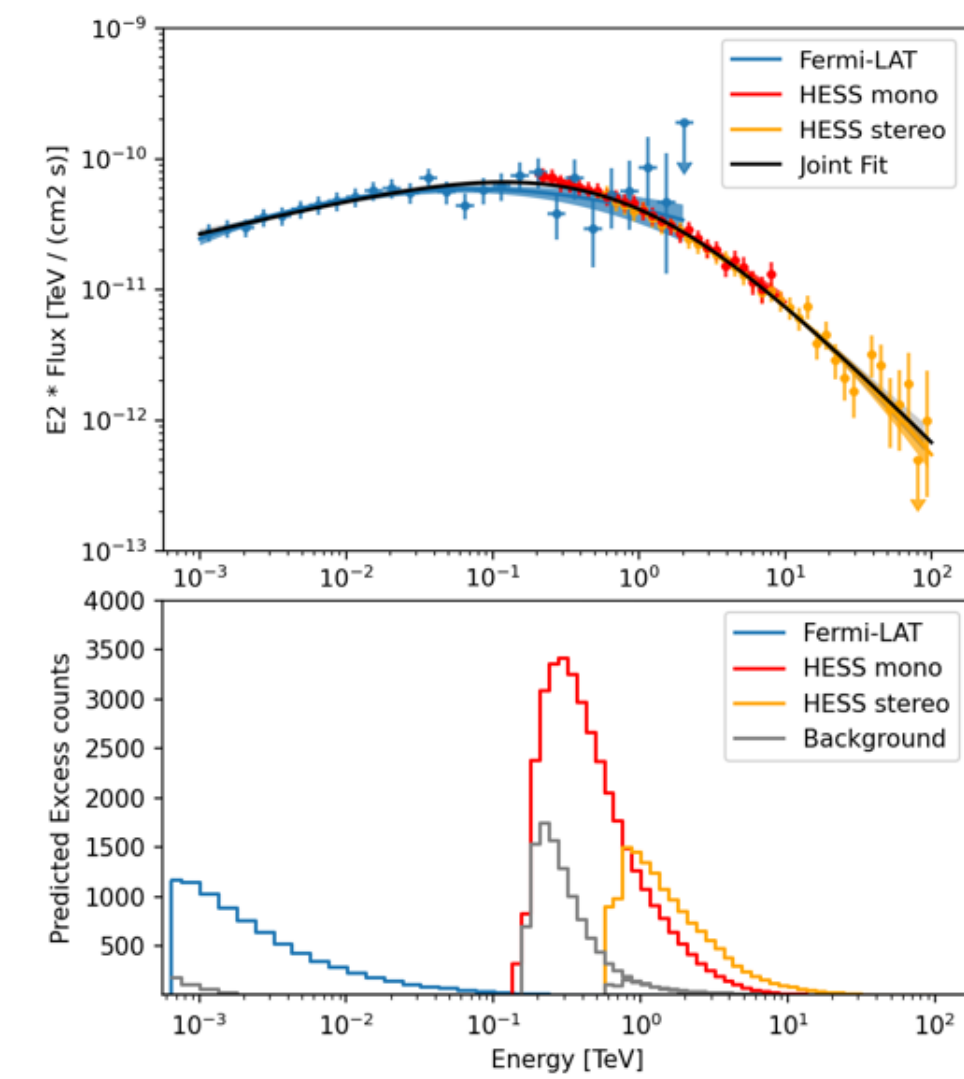
X-RAY ASTRONOMY



- Landessternwarte Bamberg part of ECAP (will visit on Wednesday). Expertise in current X-ray missions (XMM, Chandra, eROSITA, ...), participation in many future missions. Large center for X-ray activities: MPE Munich.
- Strong ties between X-ray and Gamma-ray astronomers within ECAP

MULTI-MESSENGER ASTRONOMY EXAMPLES

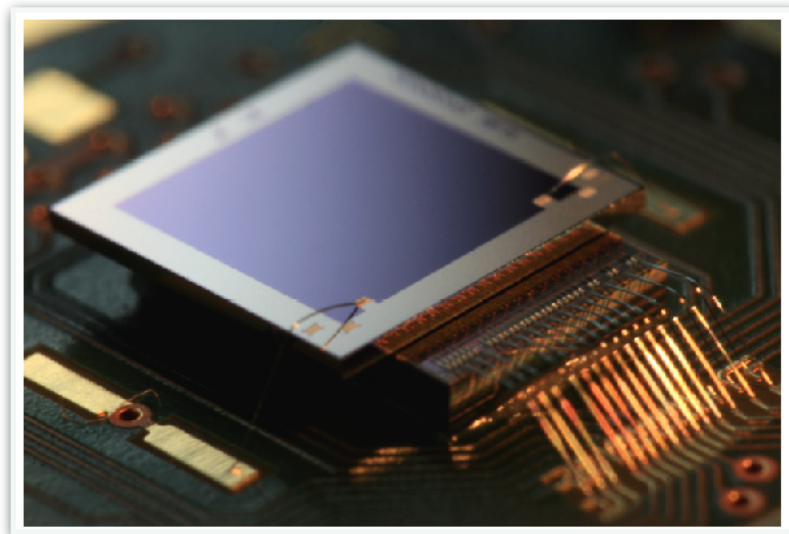
- e.g. Radio (TANAMI) and Fermi-LAT observation of candidate AGNs for IceCube events
- e.g. joint fitting of gamma-ray and neutrino data for Galactic supernova remnants
- e.g. event-wise multi-instrument fitting of Crab Nebula



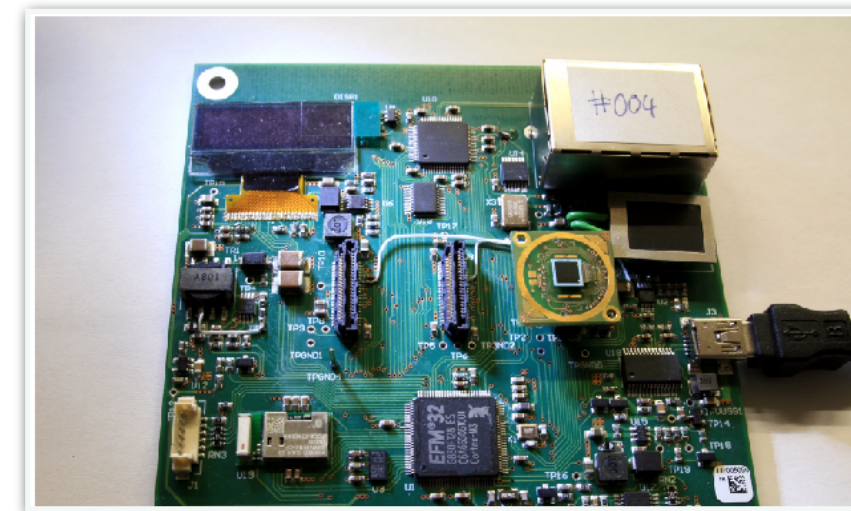
TECHNOLOGY TRANSFER AND MEDICAL APPLICATIONS AT ECAP



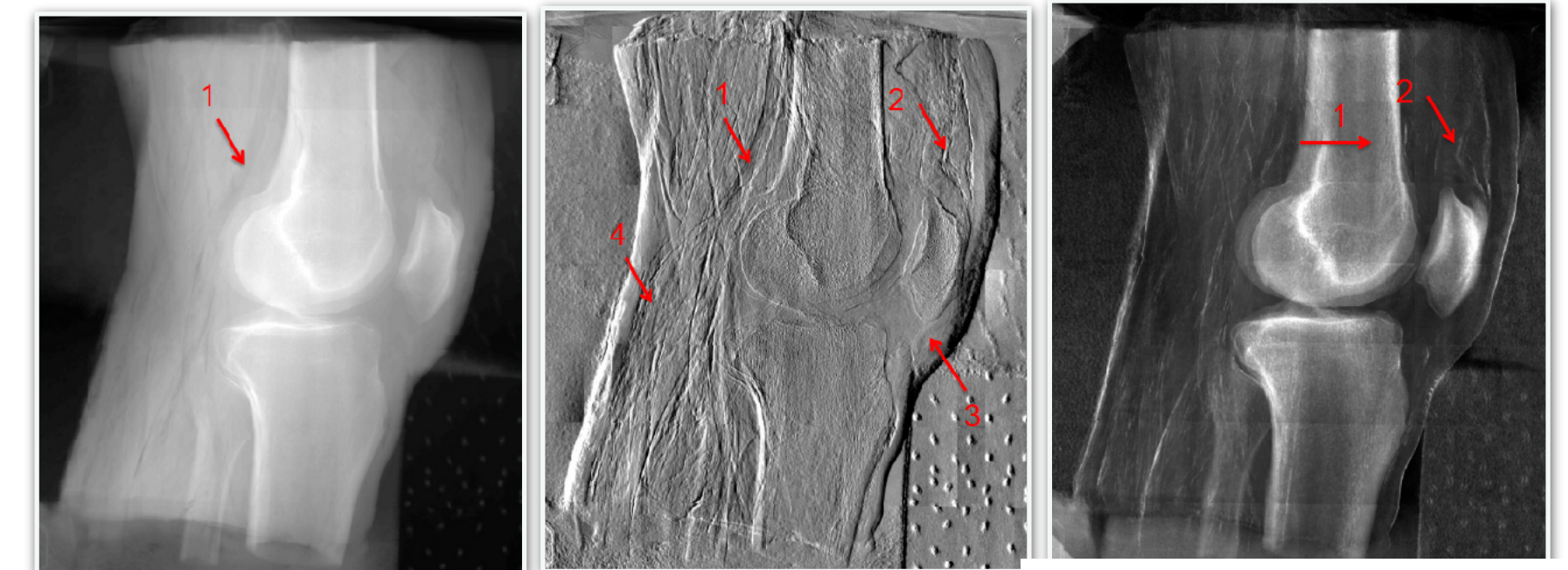
Detector development



Devices and methods for gamma dosimetry



Phase-contrast x-ray imaging for medicine and non-destructive testing



Universitätsklinikum
Erlangen

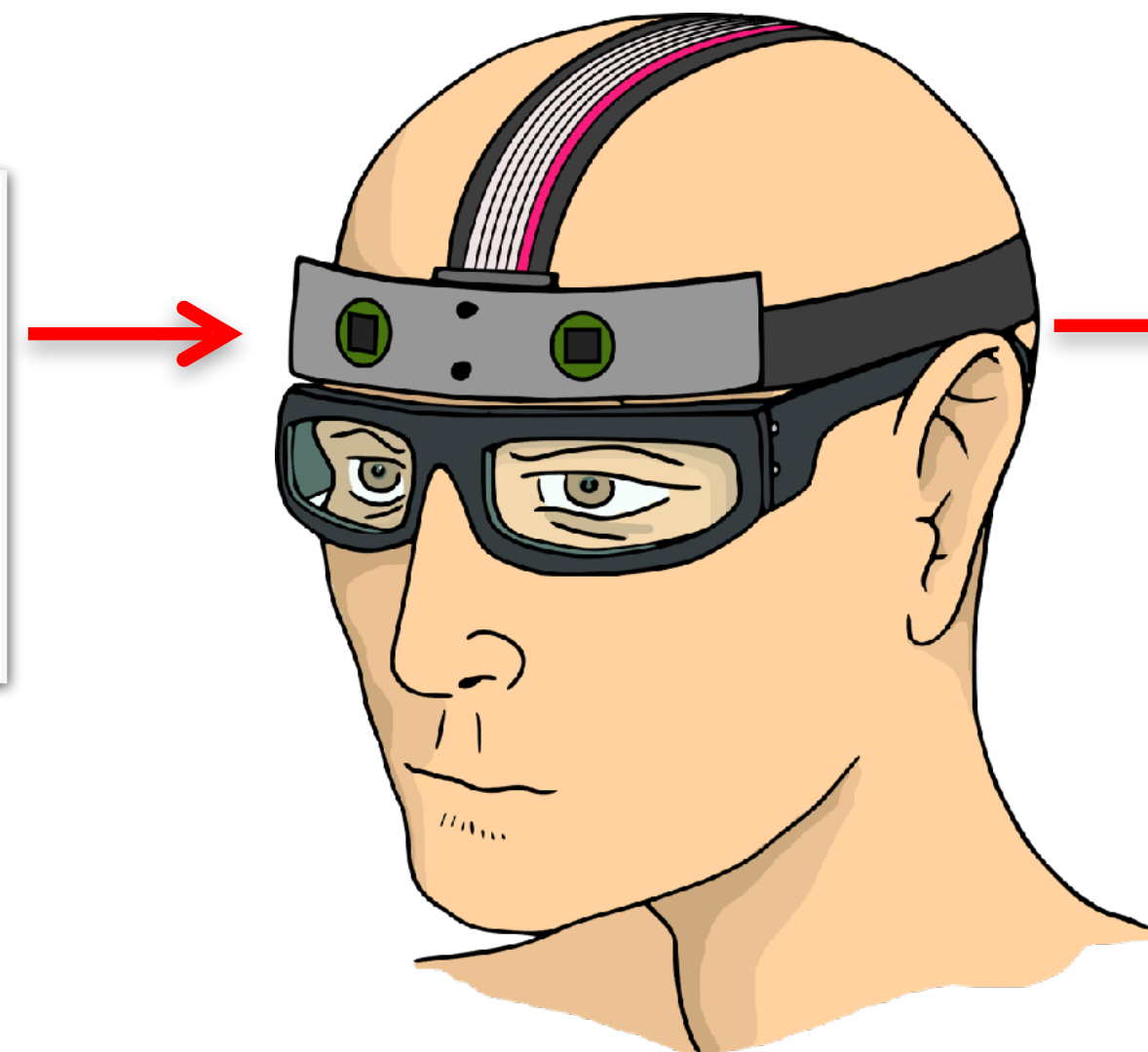
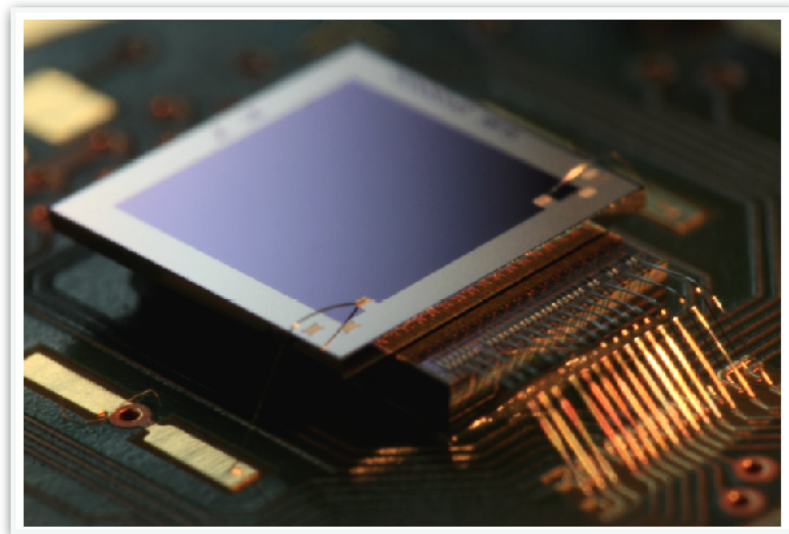
SIEMENS
Healthineers



- Long-standing effort to transfer methods and technologies from our field into medical applications (amongst others), based on our detector development expertise

NOMINATED FOR MEDICAL VALLEY AWARD: EYE LENS DOSIMETRY

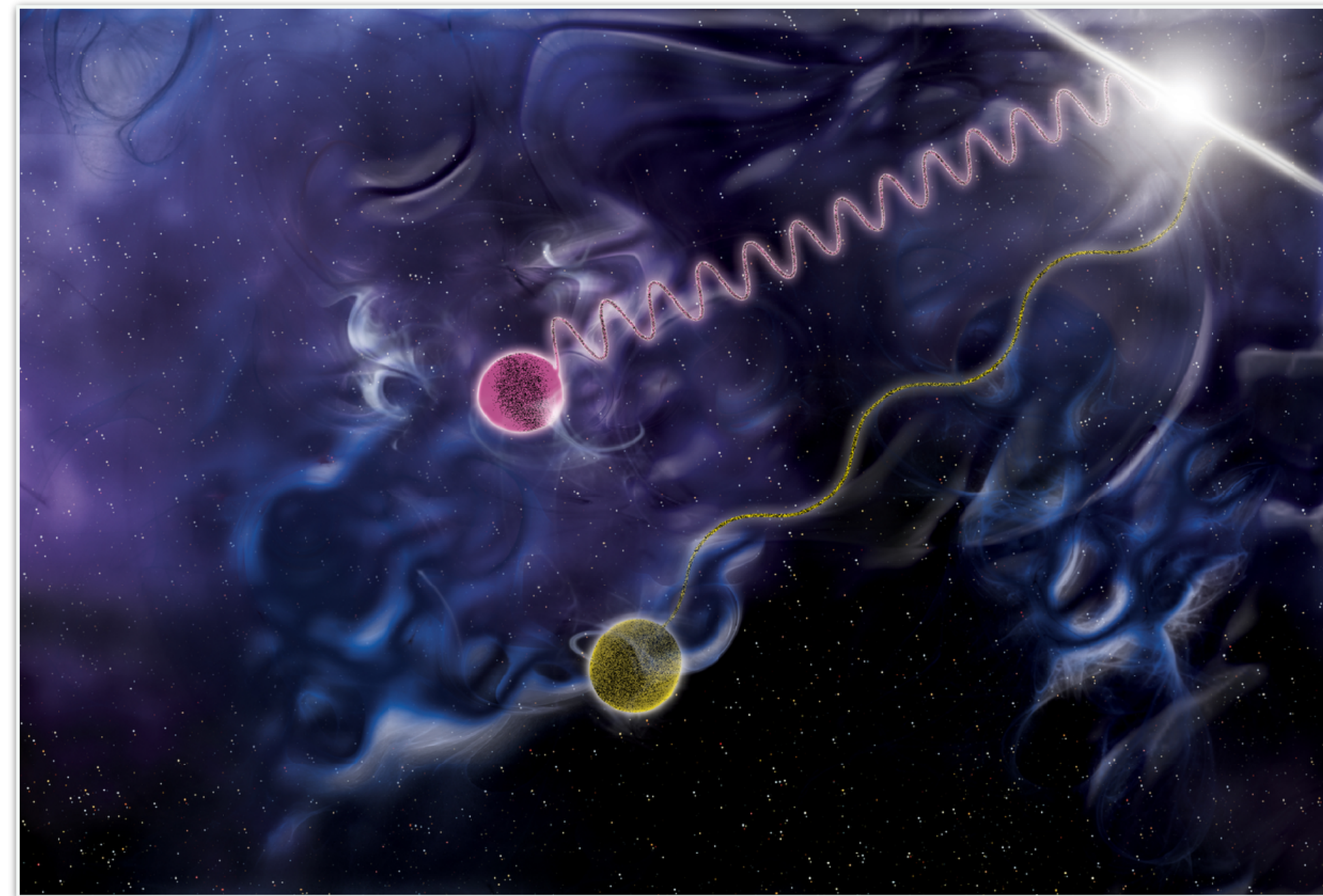
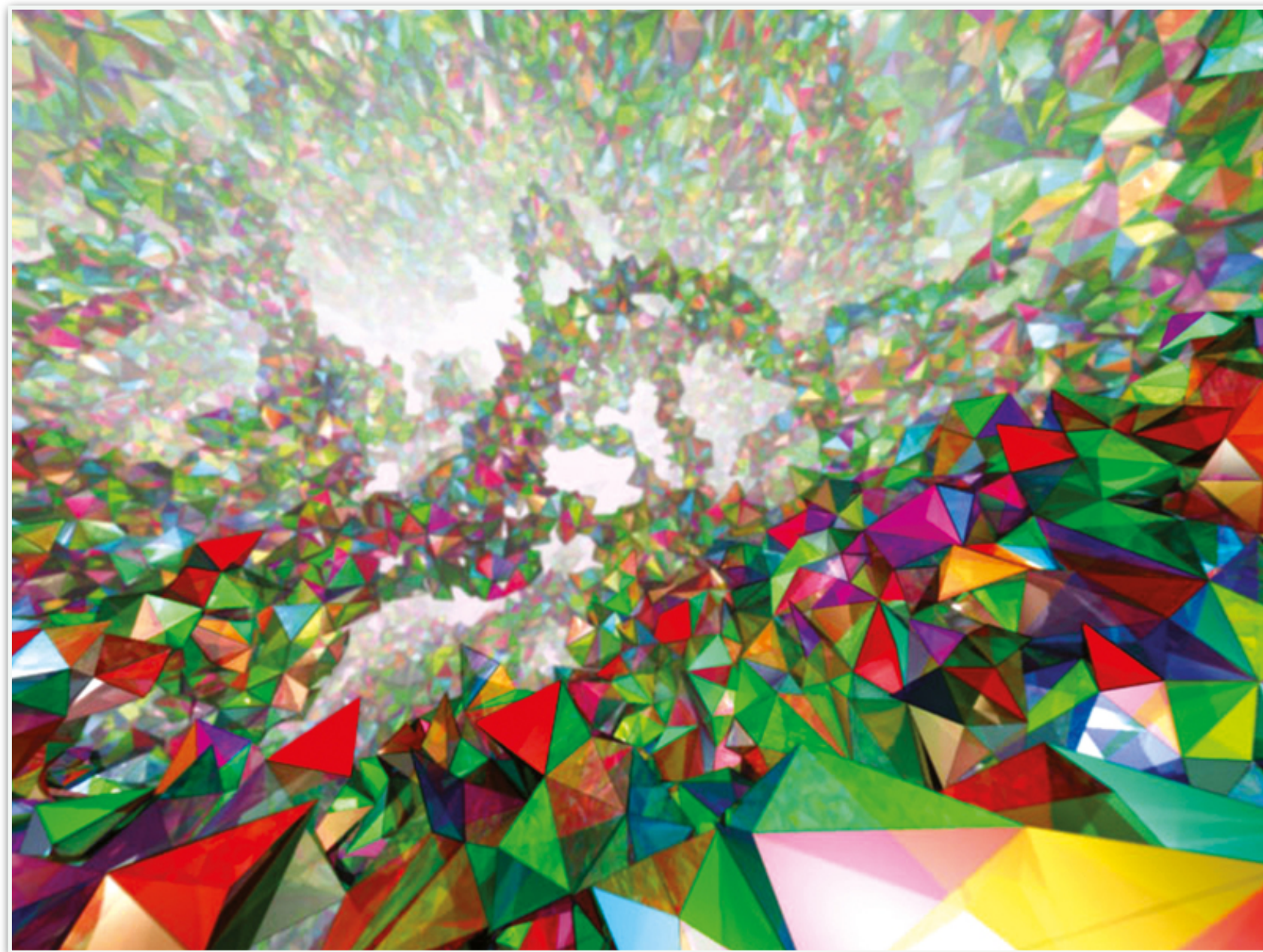
- Development of the first real-time eye-lens-dose dosimeter for medical staff in interventional radiology, head and heart surgery



- Pre-seed-funding to create a spin-off

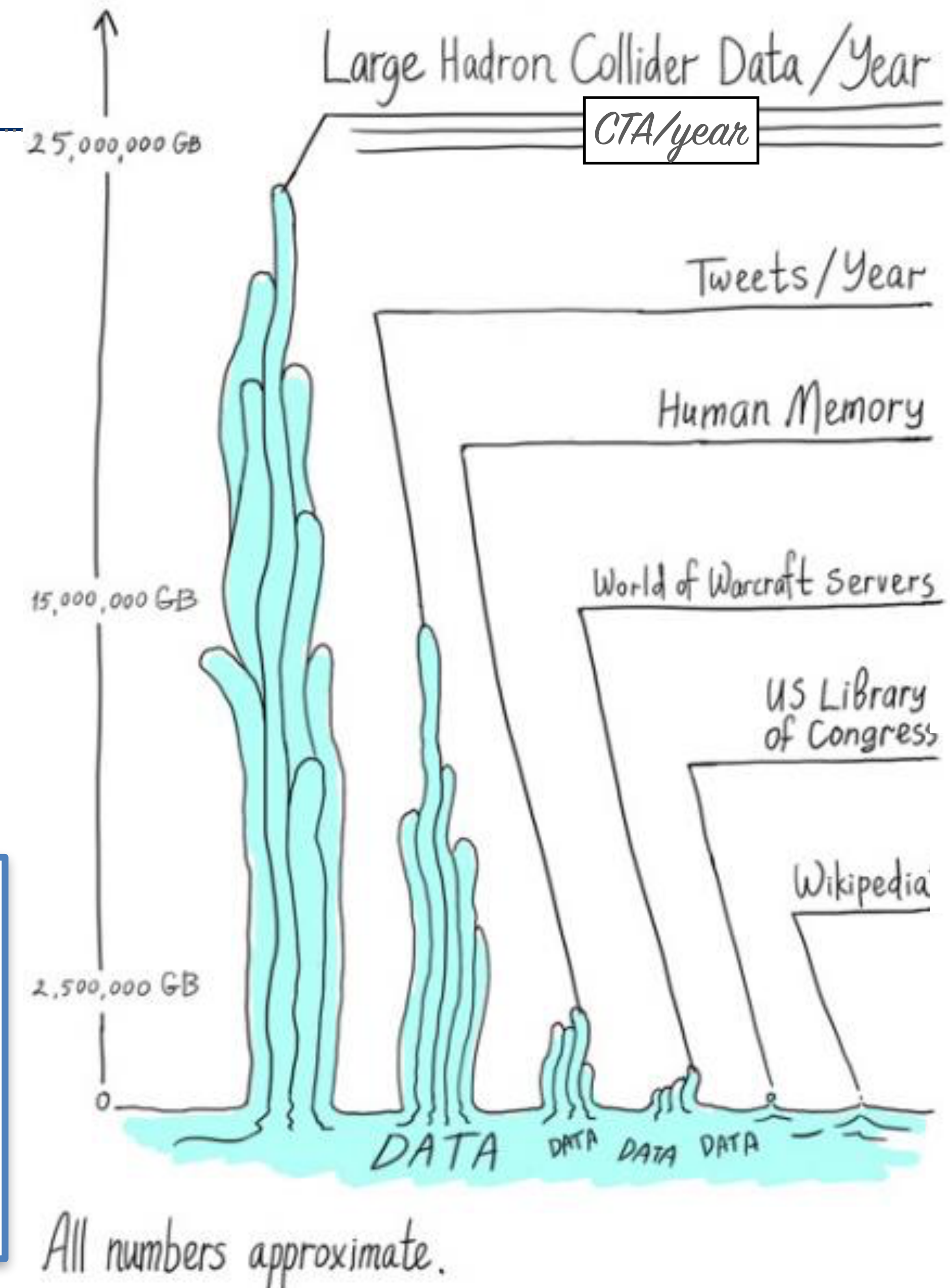
CLOSE COLLABORATION WITH THEORY

- Physics shortly after the big bang (the Planck scale)
- Experimentally measurable effects of physics on the Planck scale (e.g. on cosmic microwave background, on gravitational waves or on the energy-dependence of the speed of light)
- Search for a mathematical consistent theory of space - time - matter



BIG DATA SCIENCE AND MACHINE LEARNING

- *Big data* traditionally key topic (LHC@CERN, ...). E.g: CTA 25 PB/year (public) data.
- Method development and applications in data handling (grid computing) deep learning, pattern recognition, image analysis, open data, NFDI, ErUM-Data



FORSCHUNGSBAU ECAP LABORATORY

- To support developing and building components for telescopes, technology transfer, data monitoring of large experiments
- 3500 sqm of high-tech modern laboratories, offices and an assembly hall
- Moved in August 2022



THIS WEEK

- Areas of joint interest very strong in our field
 - CTA and SWGO the most obvious examples
- I am very much looking forward getting to know you all, meeting you and hearing and discussing about your research
- Lots of exchange in the recent past, let's strengthen our ties here at this workshop and at the next on in São Paulo.
- Let's learn from each other
- Let's have fun

