

# ASTROPARTICLE PHYSICS DETECTORS.

Current projects and plans

Timo Karg

DESY Detector Retreat, 16 June 2025

HELMHOLTZ

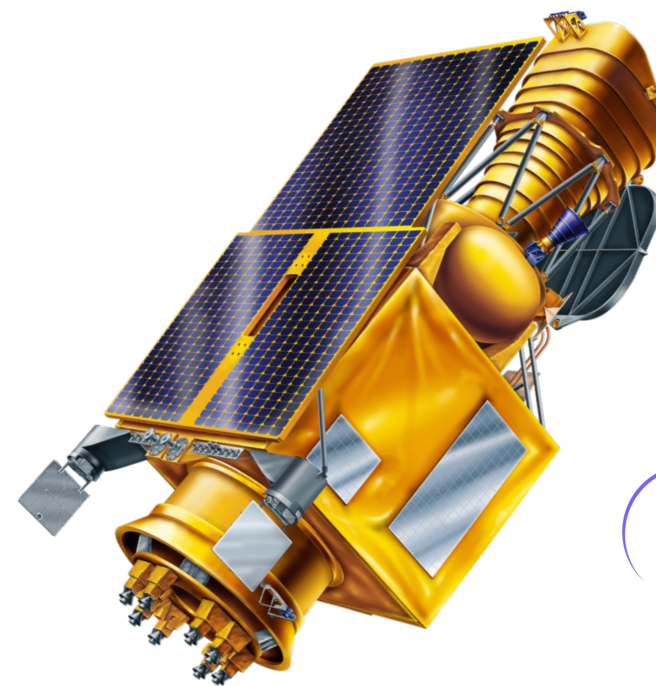
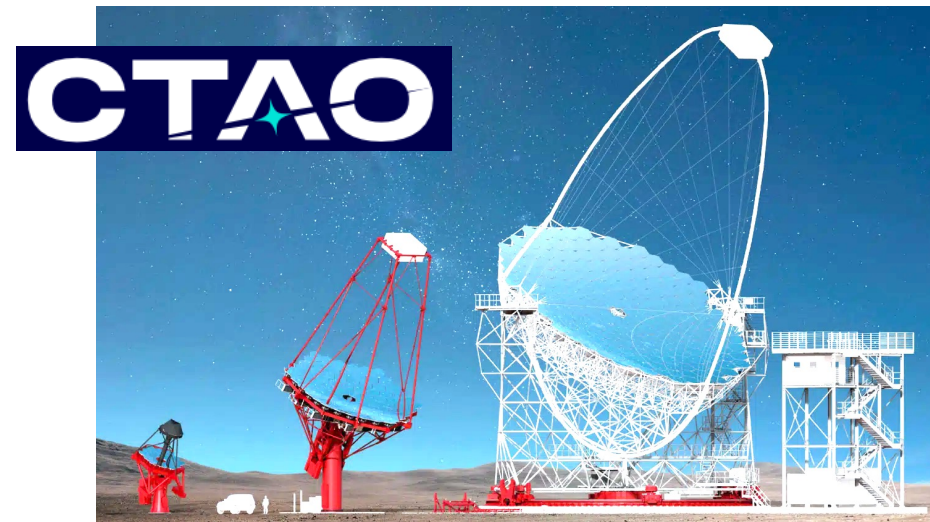
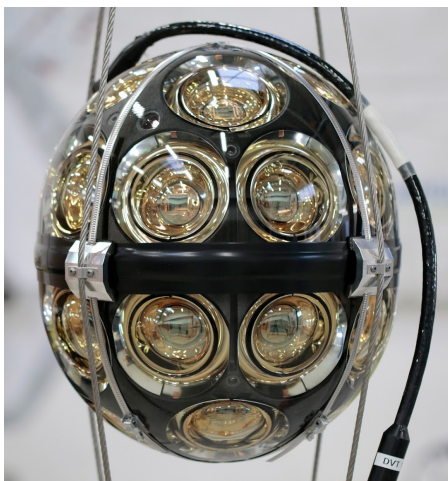




RNO-G  
Radio Neutrino Observatory - Greenland



ICECUBE  
GEN2



# CTAO – Cherenkov Telescope Array Observatory

Observatory with two sites with instrumentation (Alpha Configuration)

- North array (La Palma): 9 MST, 4 LST
- South array (Paranal): 37 SST, 14 MST

CTAO is our flagship project

We are involved on all levels and spearhead many activities

- Co-host of CTAO with the SDMC
- Council member
- Key member of the user consortium
- Largest individual In-Kind provider
- Lead Medium-Sized Telescopes and computing contributions

We have a lead role in the strong German community





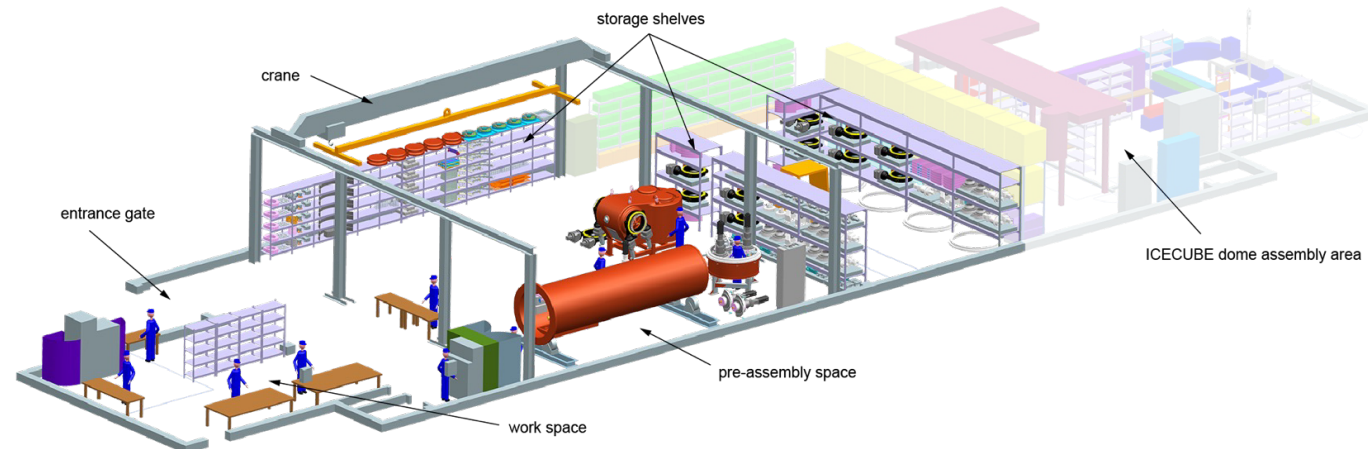
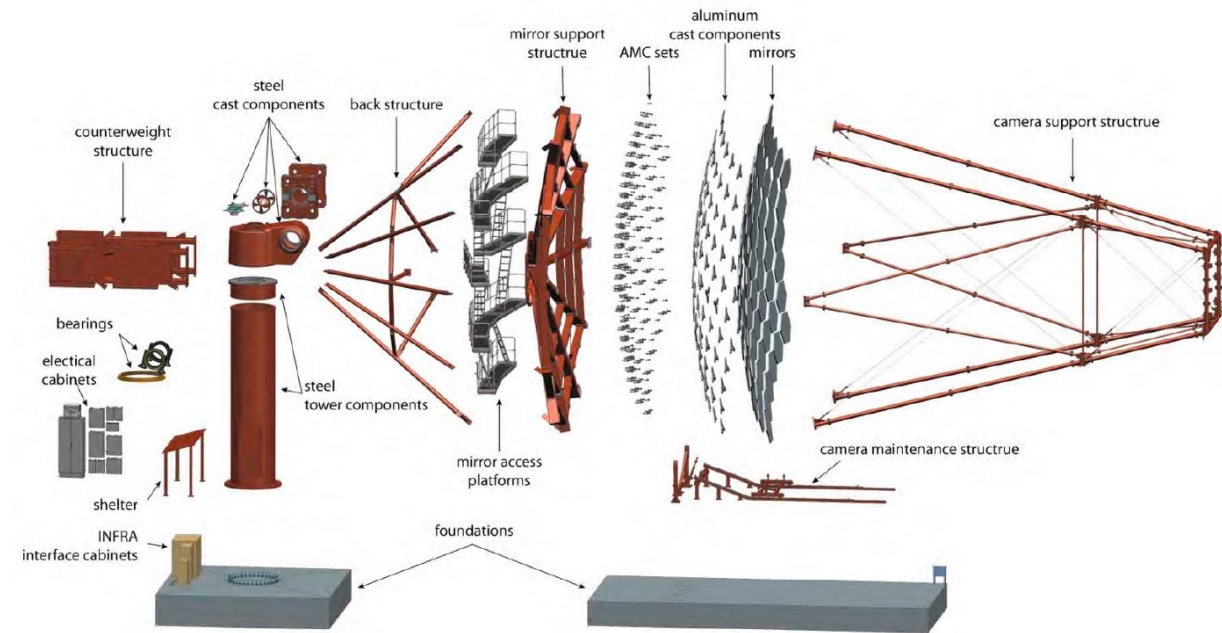
# Medium-Sized Telescopes (MSTs)

## Achievements 2021-2024

- Formed coherent collaboration led by DESY, agreed on construction plan (2 sites, 23 MSTs)
- Critical Design Review telescope structure passed
- Logistics plan with pre-assembly in Zeuthen exists
- Procurement MST pathfinders kicked off
- On-site assembly of 3 MST pathfinders by 2026



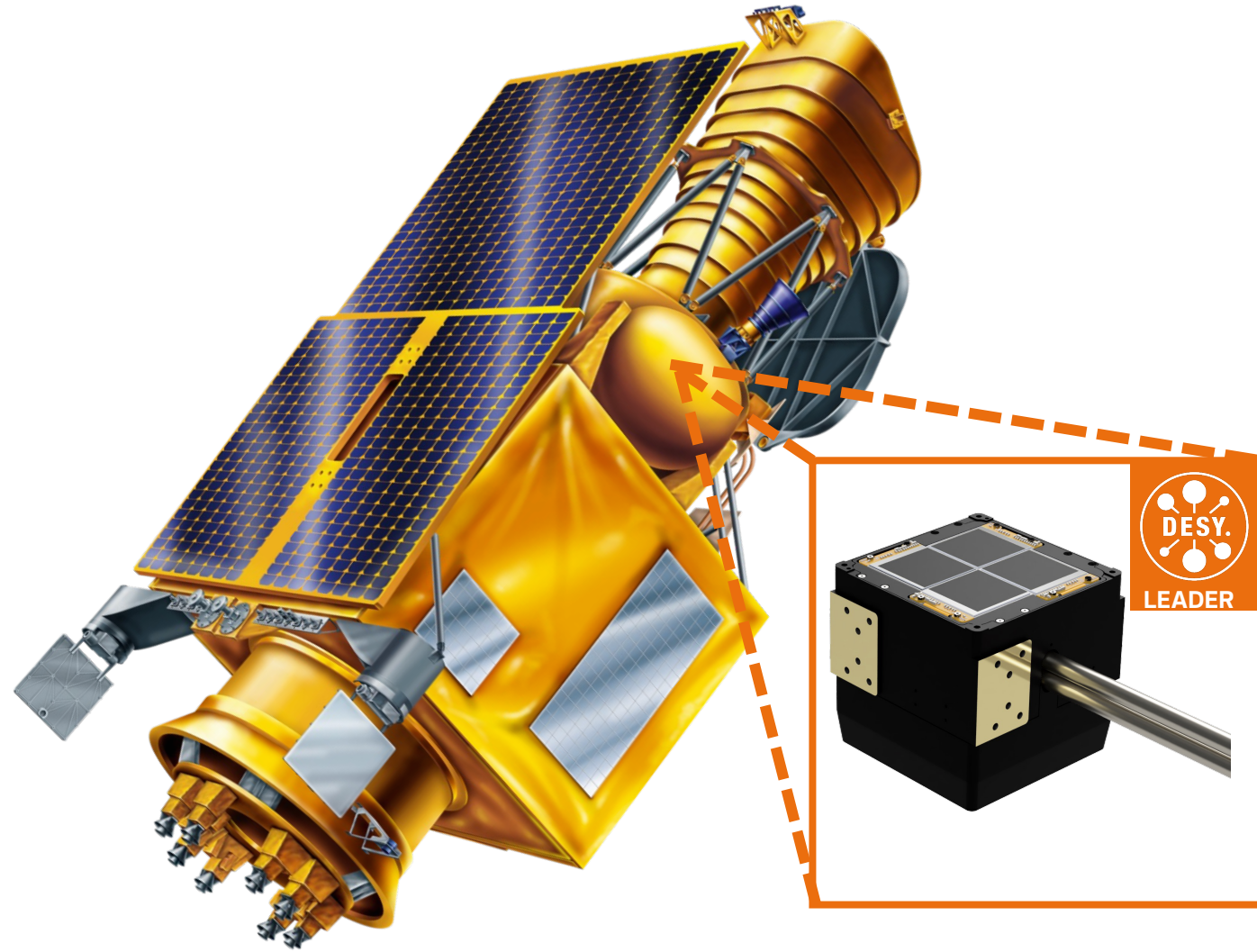
We coordinate the MST collaboration of In-Kind Contributors





# ULTRASAT

- First scientific satellite mission led by Israel
- Unprecedentedly large field of view ( $204 \text{ deg}^2$ )
- First wide-field survey of transient UV sources
- Kick-off in 2019, launch planned for  $\geq 2027$



# ULTRASAT at DESY

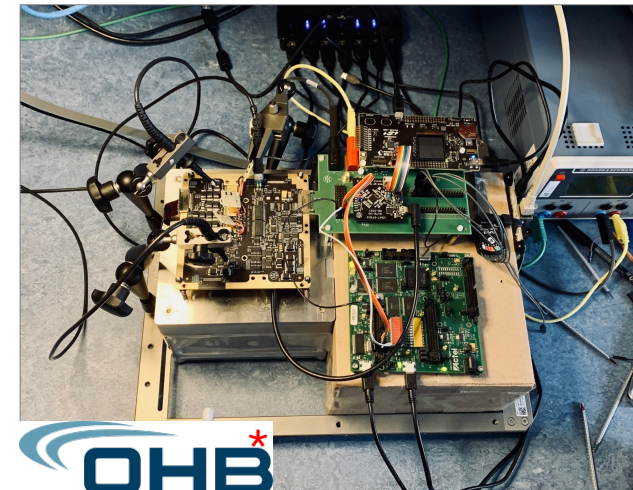
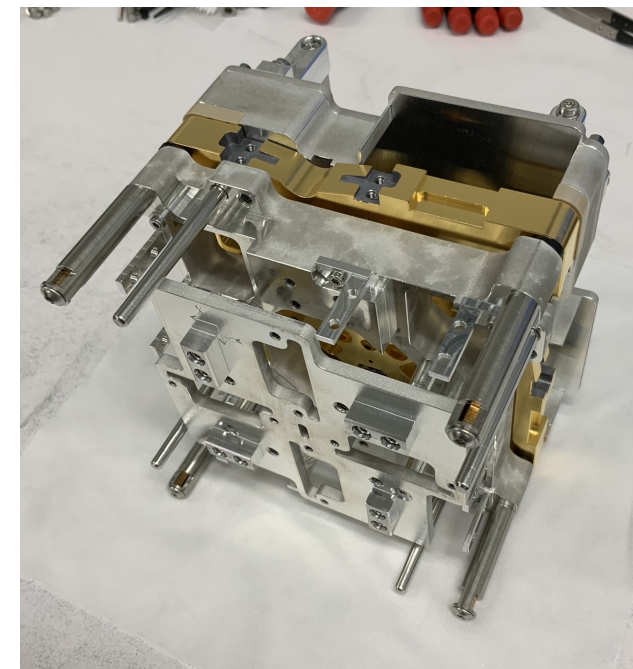
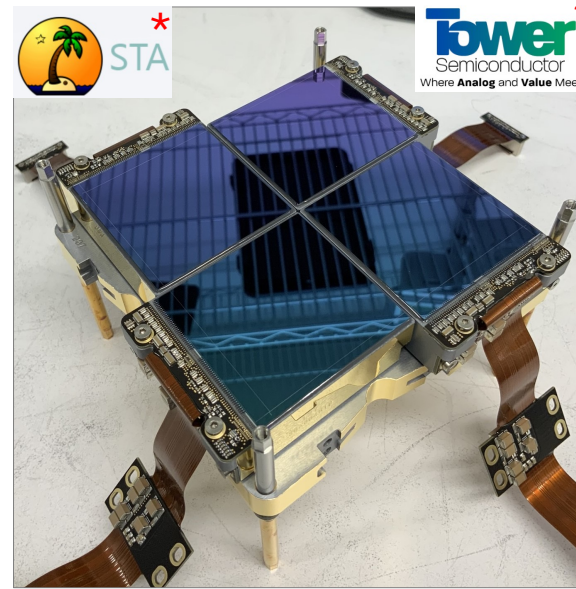
## Achievements 2021-2024

- First DESY satellite mission
- Unique multimessenger science synergies, contribution to space project as part of our strategy
- We started the camera project in 2019 and plan to deliver it by 2026
- New CMOS sensor design verified and being tested
- Electronics, mechanics, thermal system fully developed and being tested at DESY
- New infrastructure (clean room, thermal vacuum chamber) constructed and commissioned for tests
- First radiation campaigns performed



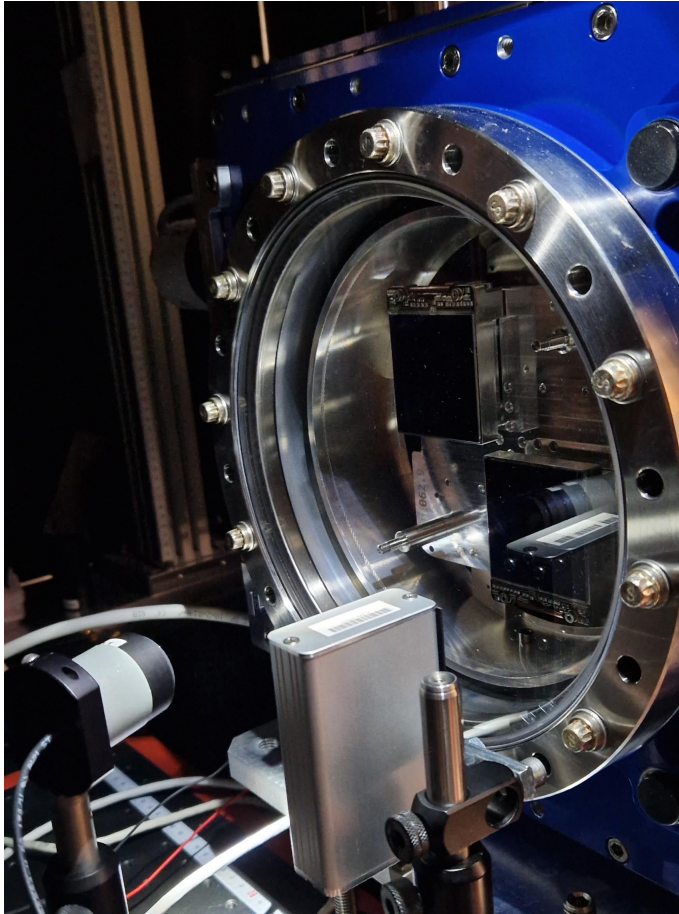
We provide the end-to-end ULTRASAT camera

\* companies we work with





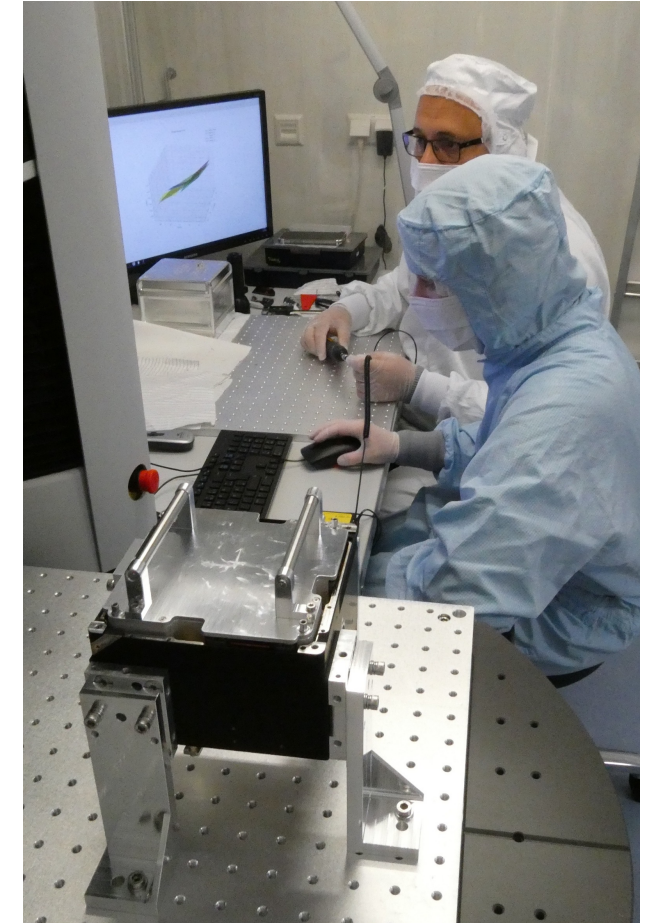
# ULTRASAT camera assembly, characterisation, testing



Optical calibration setup at DESY has unique precision capacities, also used by NASA and NIST!



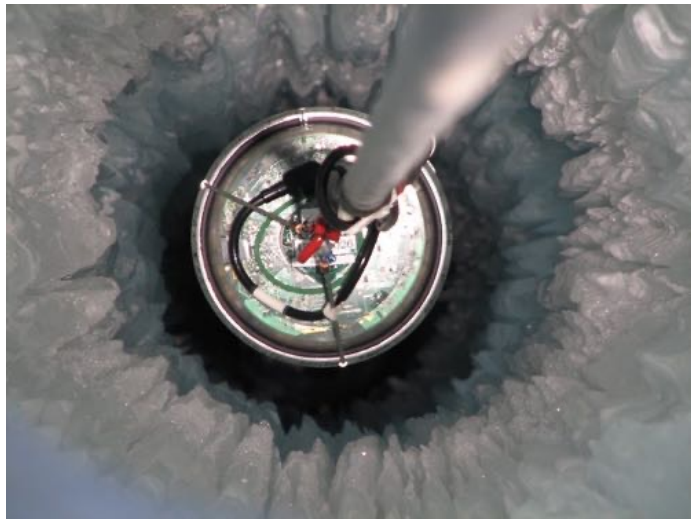
Dedicated cleanroom built and commissioned, integration tests ongoing





# Where do we want to go in neutrino astronomy?

Our strategy



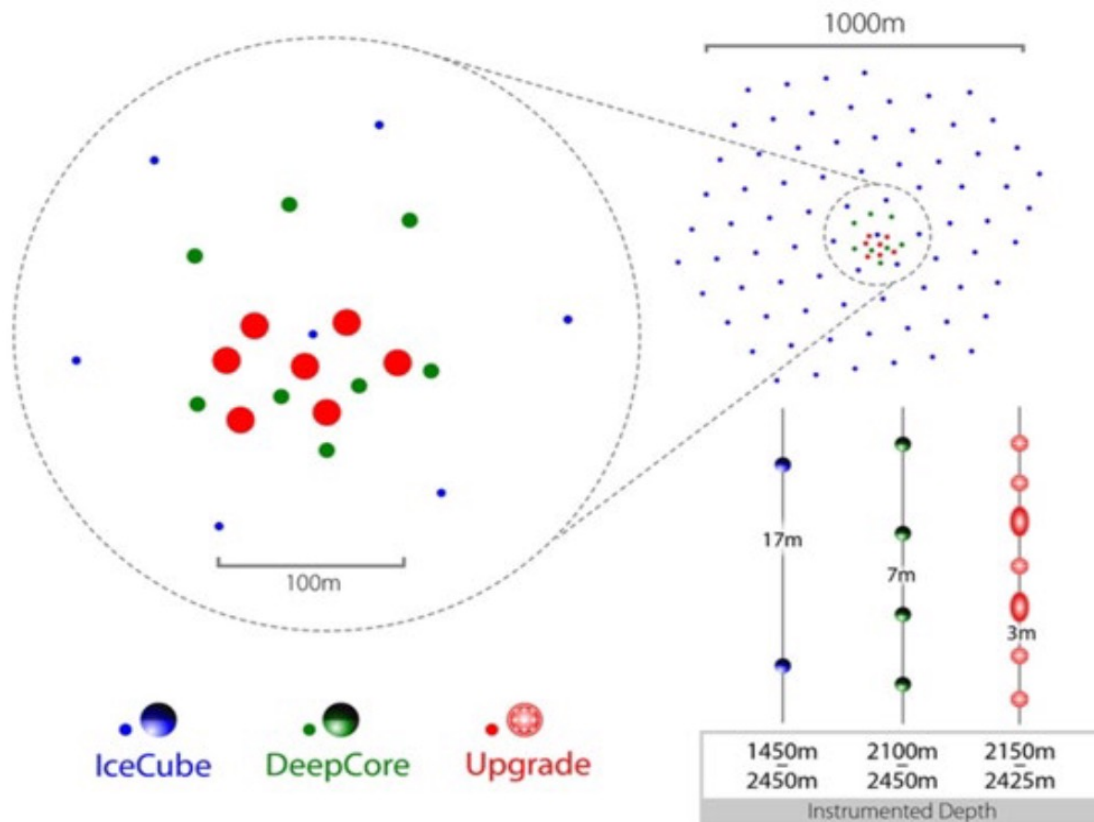
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# IceCube Upgrade

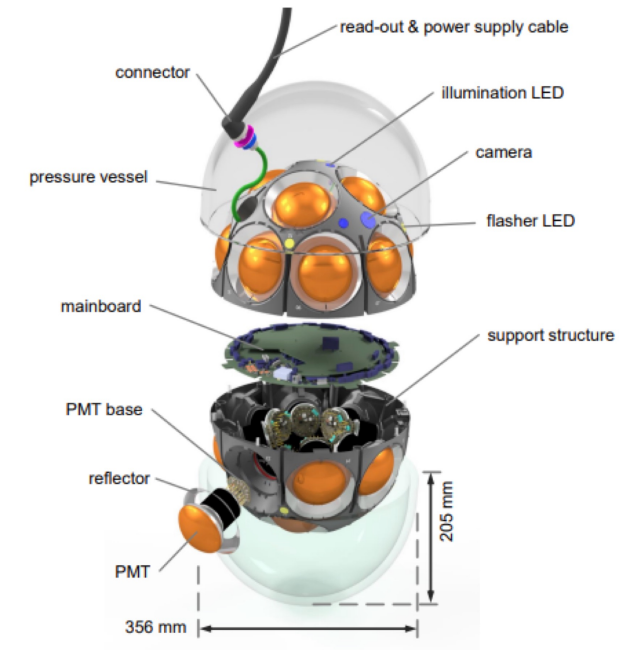
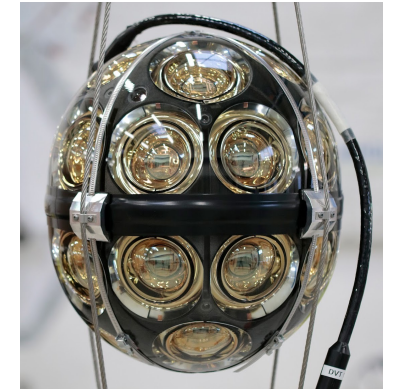
Towards the low energies with the mDOM

To be installed in the 2025/26 field season



## The mDOM, a German design:

- 24 small PMTs instead of one large one
- Enhances photocathode area by factor 2.5 and multi-faceted approach allows for better reconstruction





# IceCube Upgrade

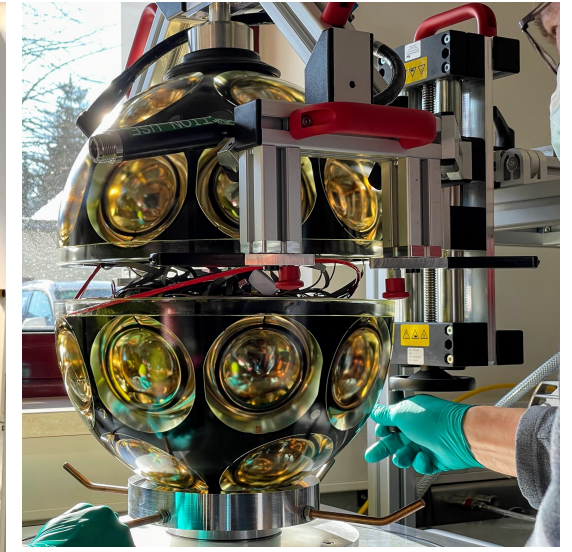
## Producing the mDOM

- DESY one of two production centers for the IceCube Upgrade mDOM
- Production line as developed at DESY has been exported to second production line in the US
- 225 of 430 novel optical modules have been produced and tested at DESY



L2 Manager Sensor production  
coordinator of German  
contribution

- On-time delivery of the first two strings to South Pole for installation in 2025/26





# IceCube Upgrade

This winter at South Pole

Readout electronics installed



Drill refurbished



DOMs and calibration devices arrived

Cabling for the seven strings ready

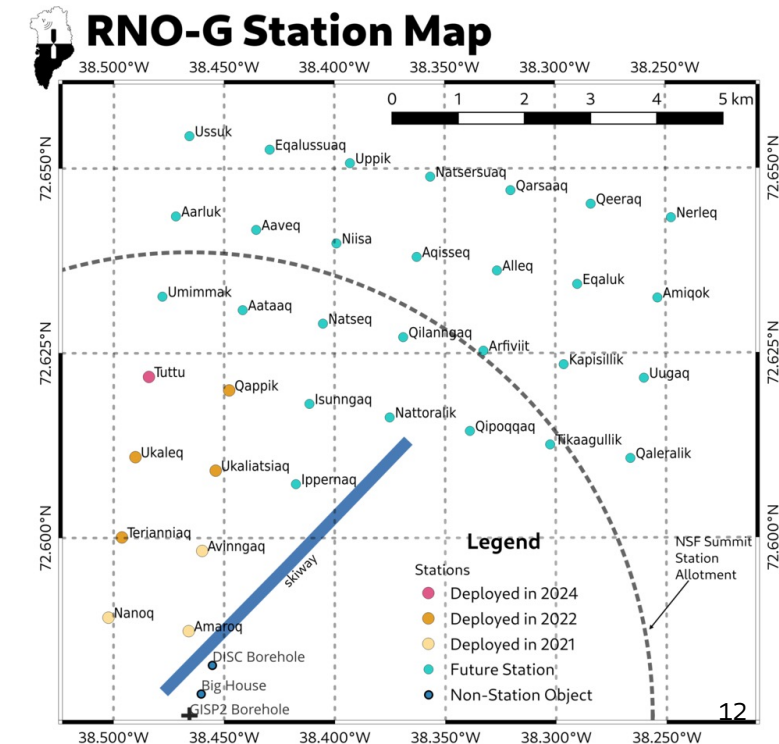
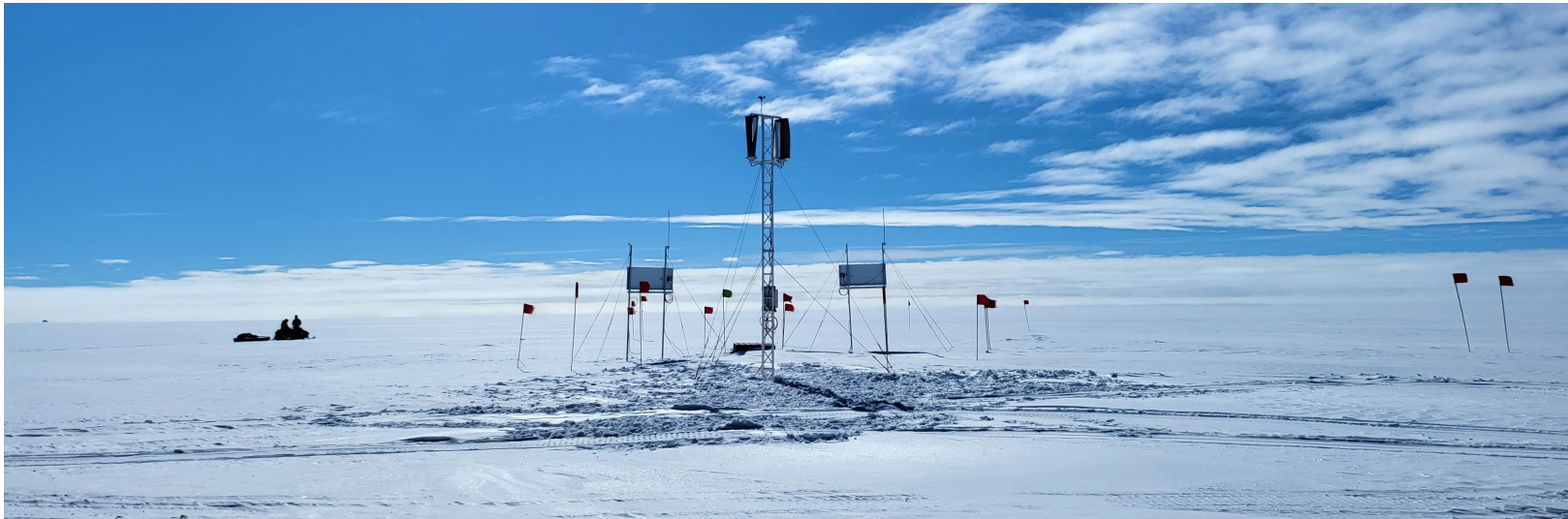
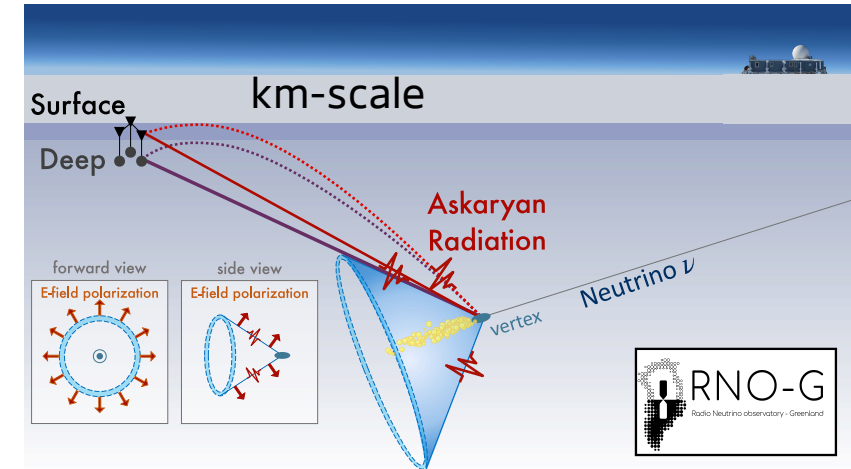




# Radio Neutrino Observatory Greenland

Towards the ultra-high energies with RNO-G

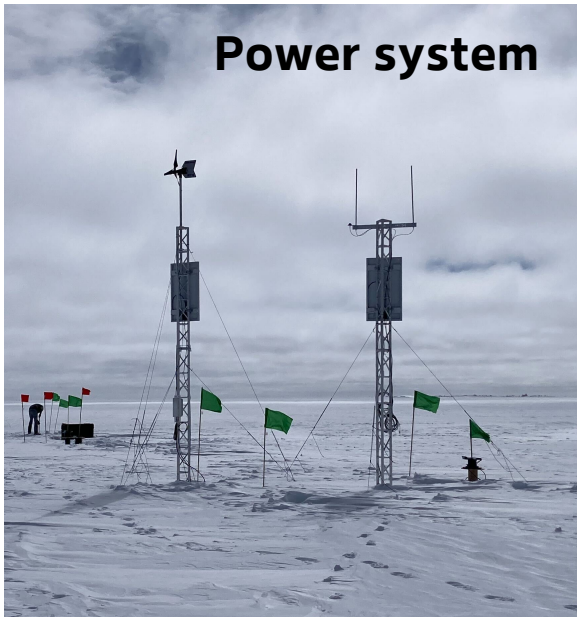
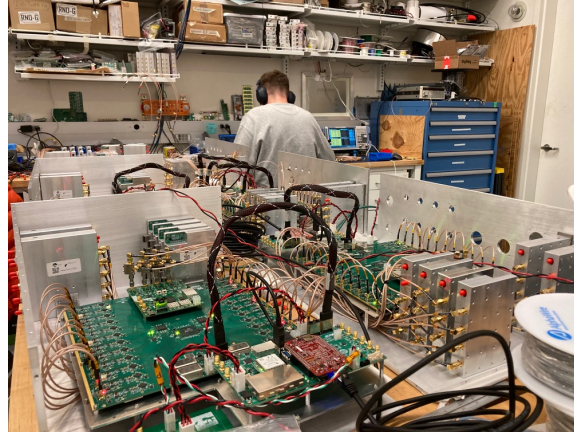
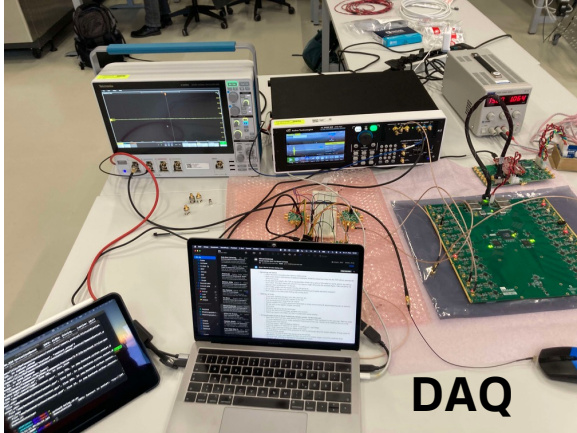
- Improve the sensitivity of IceCube at the highest energies by exploiting the radio emission following a neutrino interaction
- First large-scale implementation of the radio technique to detect neutrinos (Askaryan effect, coherent Cherenkov-like emission)
- Under construction in Greenland since 2021
- Leadership: US (Chicago, Penn State), Brussels and DESY



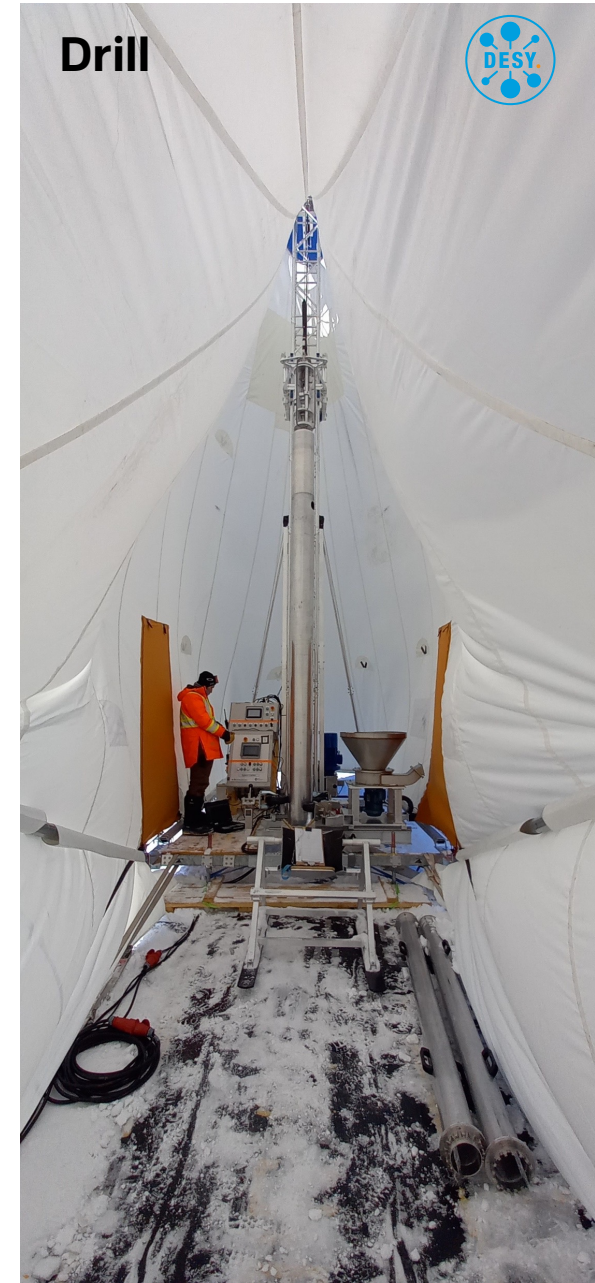


# DESY Hardware expertise for RNO-G

and R&D for IceCube-Gen2



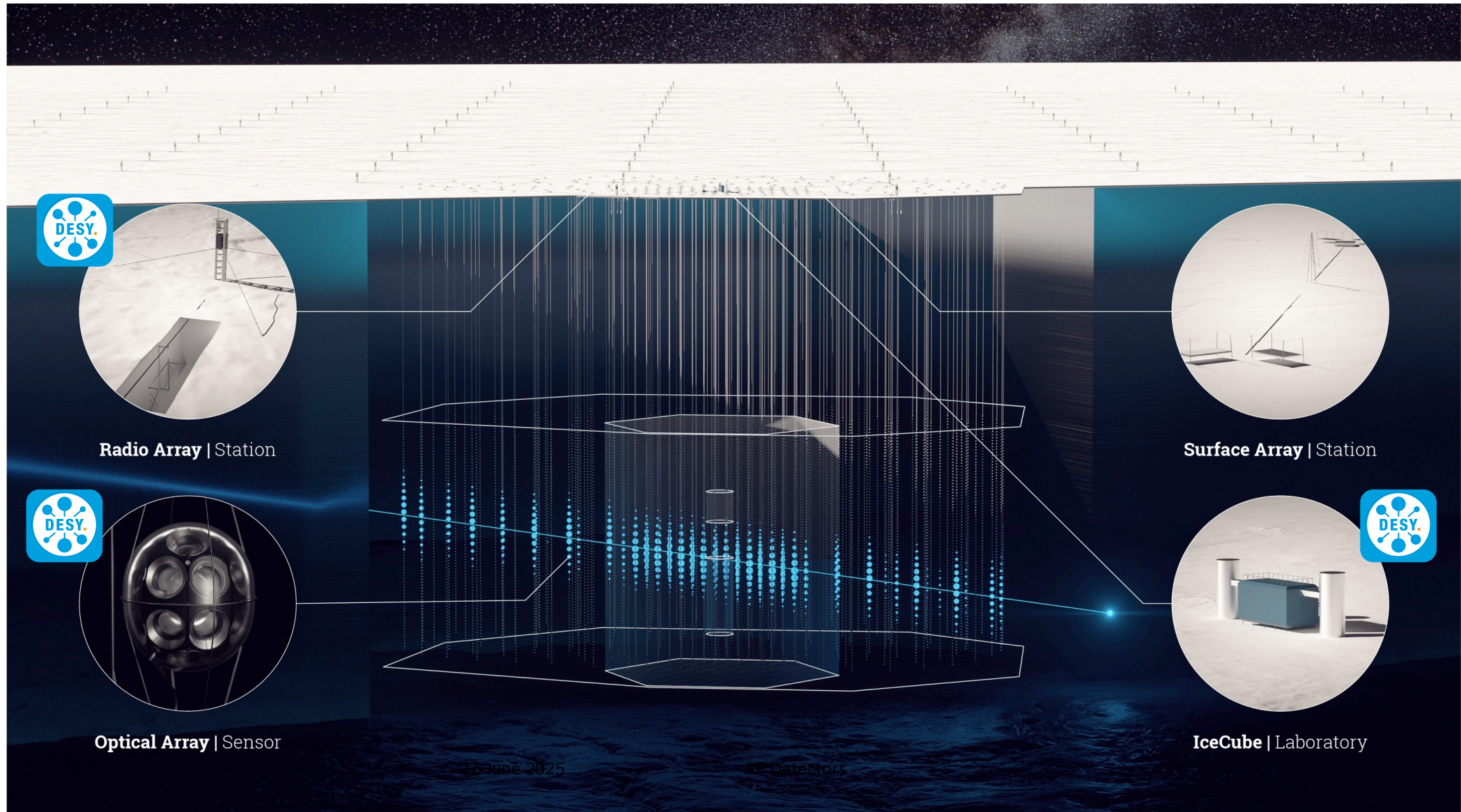
- DAQ component construction and testing
- Drilling and installation support
  - World's largest mechanical ice drill
- Engineering for renewable energy system of wind-turbines and solar power
- Fuel efficient installation tools with small German company





# IceCube-Gen2

Our path ahead



# Plans

## **Experiments in harsh (polar, desert) environments**

- Low power readout, autonomously powered detector stations (wind, solar)
- (Sub-)nanosecond clock distribution over 10s of kilometers

## **CTA**

- R&D for compact, low-power SiPM replacement of current photomultipliers

## **ULTRASAT** plan to develop space-based detectors for MeV gammas

- e.g. double-sided silicon strips → Steve's presentation

## **IceCube, RNO-G** prepare for IceCube Gen2 and/or the next big thing (beyond KM3Net)

- Need to update the DAQ (1) reduce the power consumption (2) allow for triggering, AI, reconfigurability, etc (FPGA)