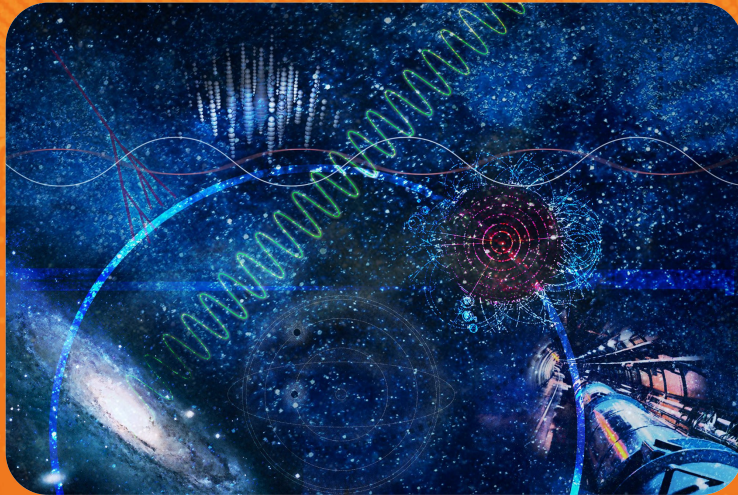


## MU Topic 3: Matter and Radiation from the Universe



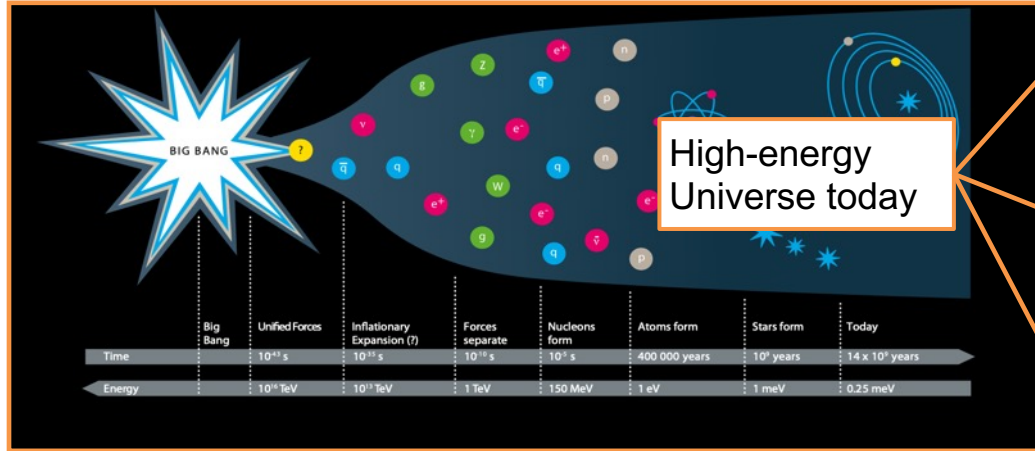
Strategy | MU Days 2023

*Kathrin Valerius & Christian Stegmann*

# Topic 3 – Matter and Radiation from the Universe (MRU)

Understanding the high-energy Universe and its constituents

A broad but coordinated research program with observatories and in laboratories – a growing field of science



Strong interplay between experiments and theory

Multi-messenger view of the cosmos

Gamma-ray astronomy

Neutrino astronomy

Cosmic rays

Gravitational waves

Understand the role of **neutrinos** in the Universe

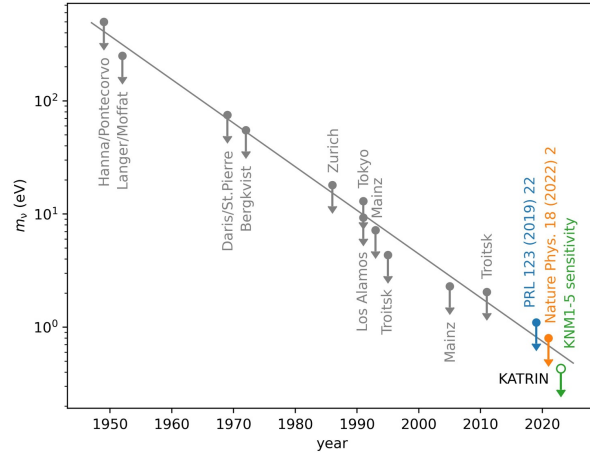
Search for new physics and **Dark Matter**



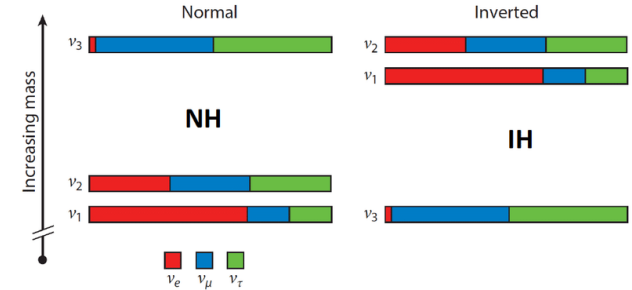
KATRIN



## A world-leading platform for the direct measurement of neutrino mass



**Aim:** next generation experiment with mass sensitivity to probe inverted mass scale



**Needed:** Atomic Tritium source and improved quantum detector

PoF V

2019 - 2025

Phase 1 (integral)  
neutrino mass

2026 – 2027

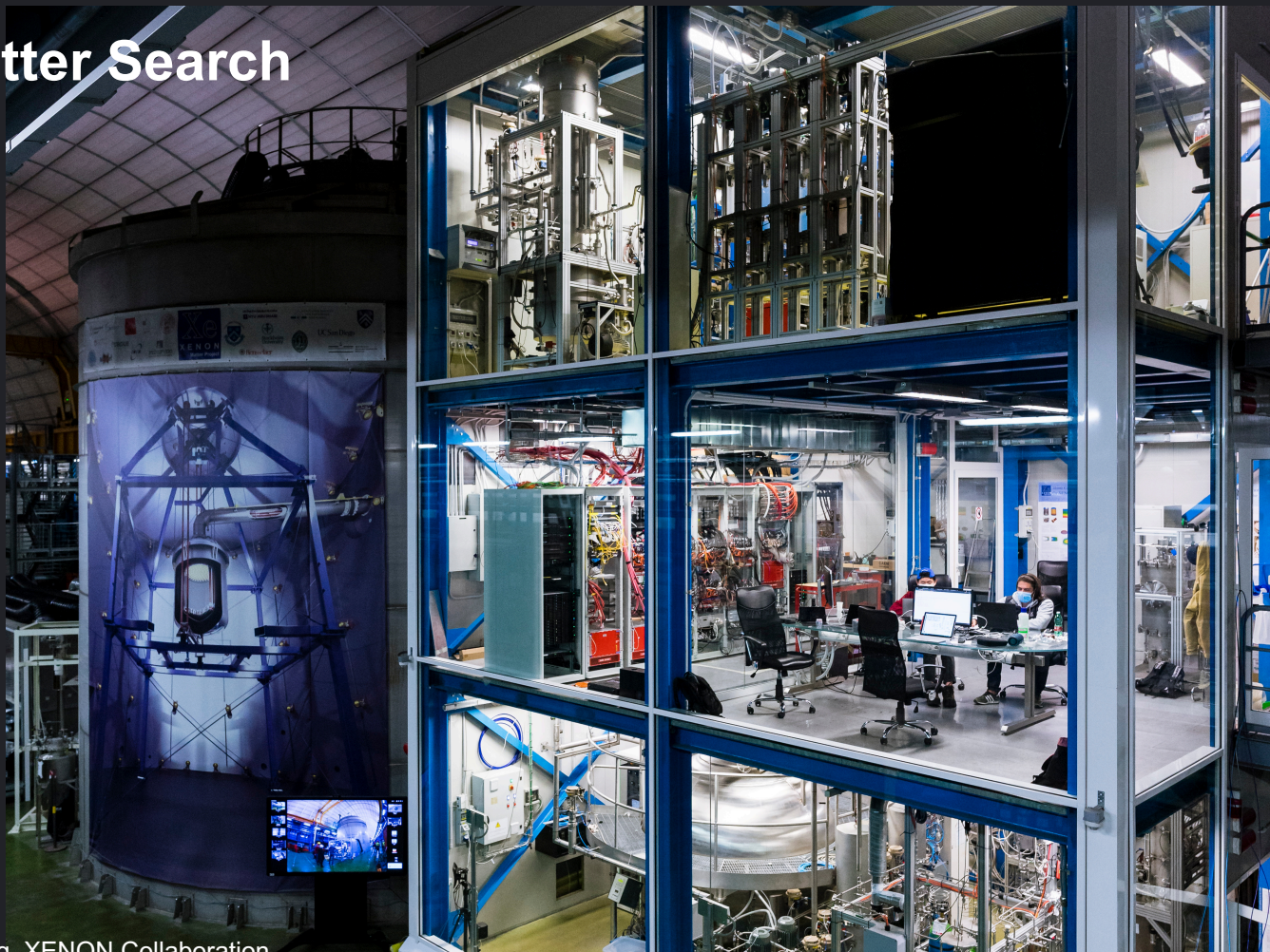
Phase 2 (differential)  
keV sterile  $\nu$

2028 – 2034

R&D for future experiments  
Atomic T demonstrator  
Quant. detector demonstrator



# Dark Matter Search



© H. Schulze-Eiβing, XENON Collaboration

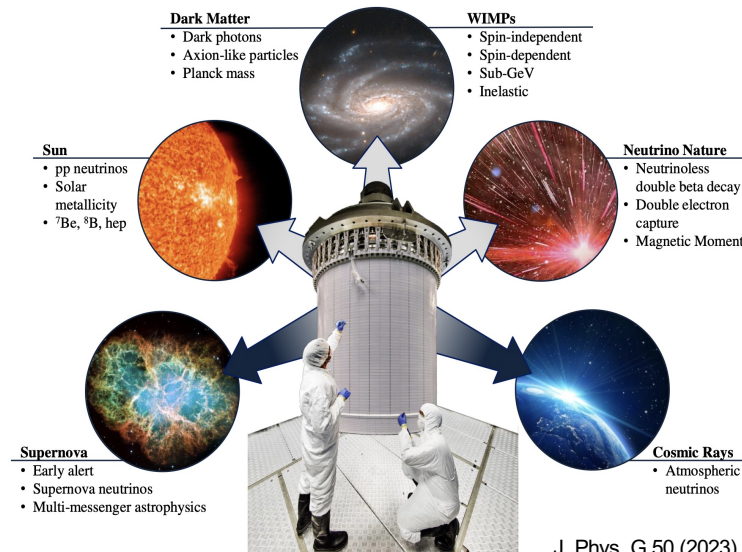
# DARWIN and XLZD

From XENONnT (8.6 t Xe) to 50+ t Xe

**Announcement:** Marc Schumann  
Dark matter (and more) with DARWIN/XLZD



**Aim:** the ultimate liquid Xenon experiment  
**Needed:** Joint forces



## PoF V

2020 - 2025

Design & planning

“Design Book” in prep. (fall 2023)

Siting decision expected 2025

2026 – 2029

Construction and commissioning I & II

Construction and xenon procurement starting ~2026 (option: phases I & II)

> 2030

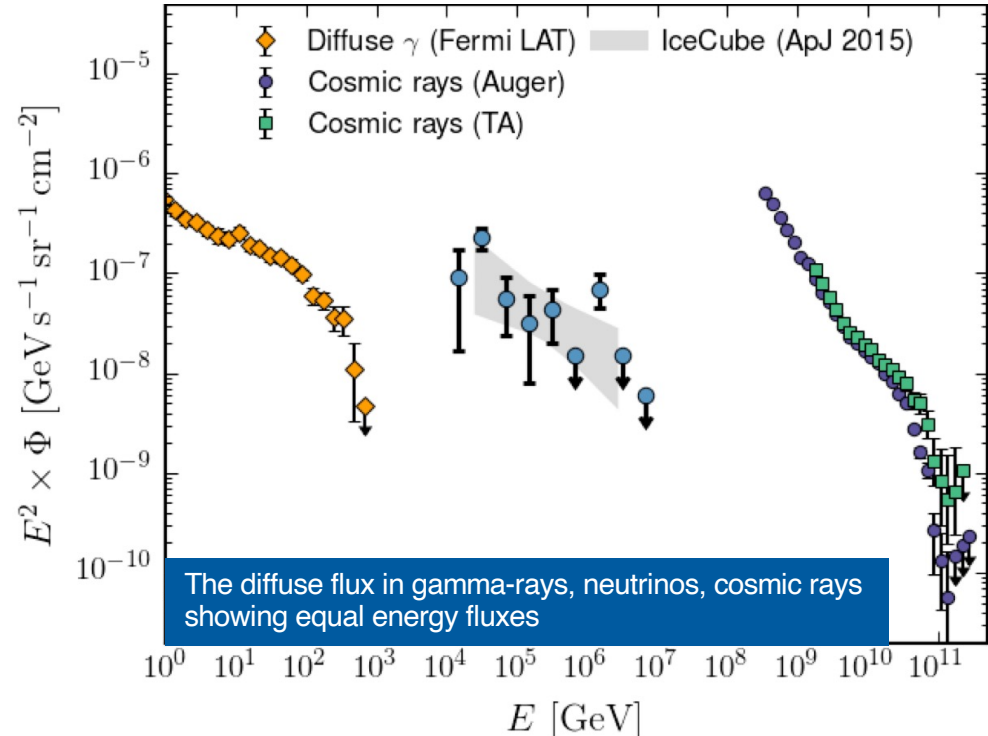
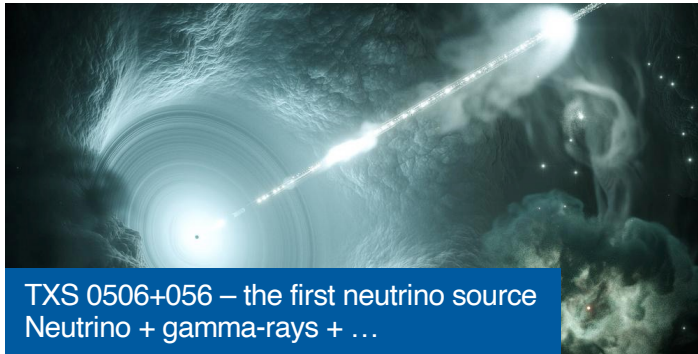
Long term data taking





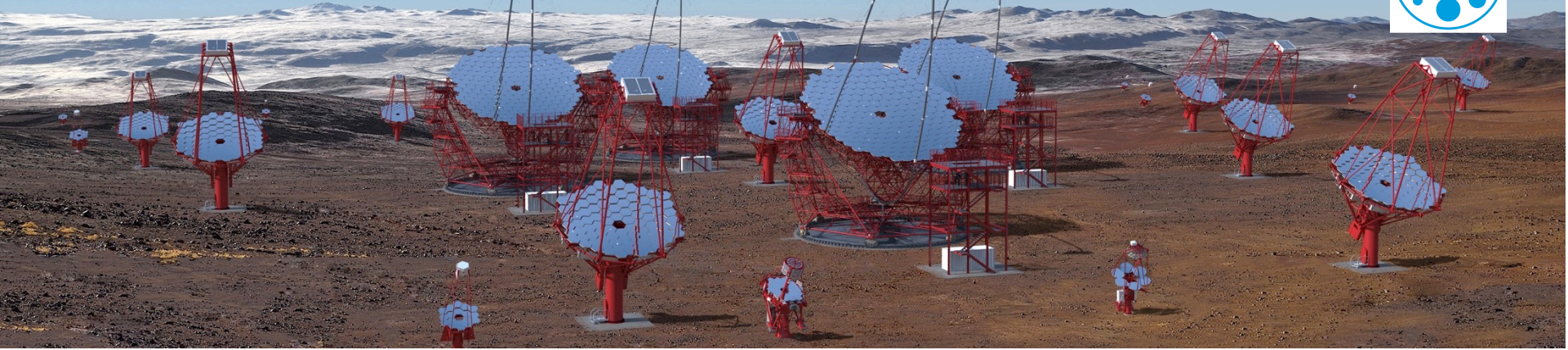
# Multimessenger Astronomy

Everything has to fit together





# CTA



## An open observatory for gamma-ray astronomy

PoF V

2023 - 2028

Construction alpha configuration

> 2028

Operation

# CTA construction has started

in Zeuthen, on La Palma, ...





# CTA construction has started

in Chile, Bohnsdorf, and many other places



CTA access road in Chile



CTA containers in Chile



Medium Size Telescope Pathfinder Site



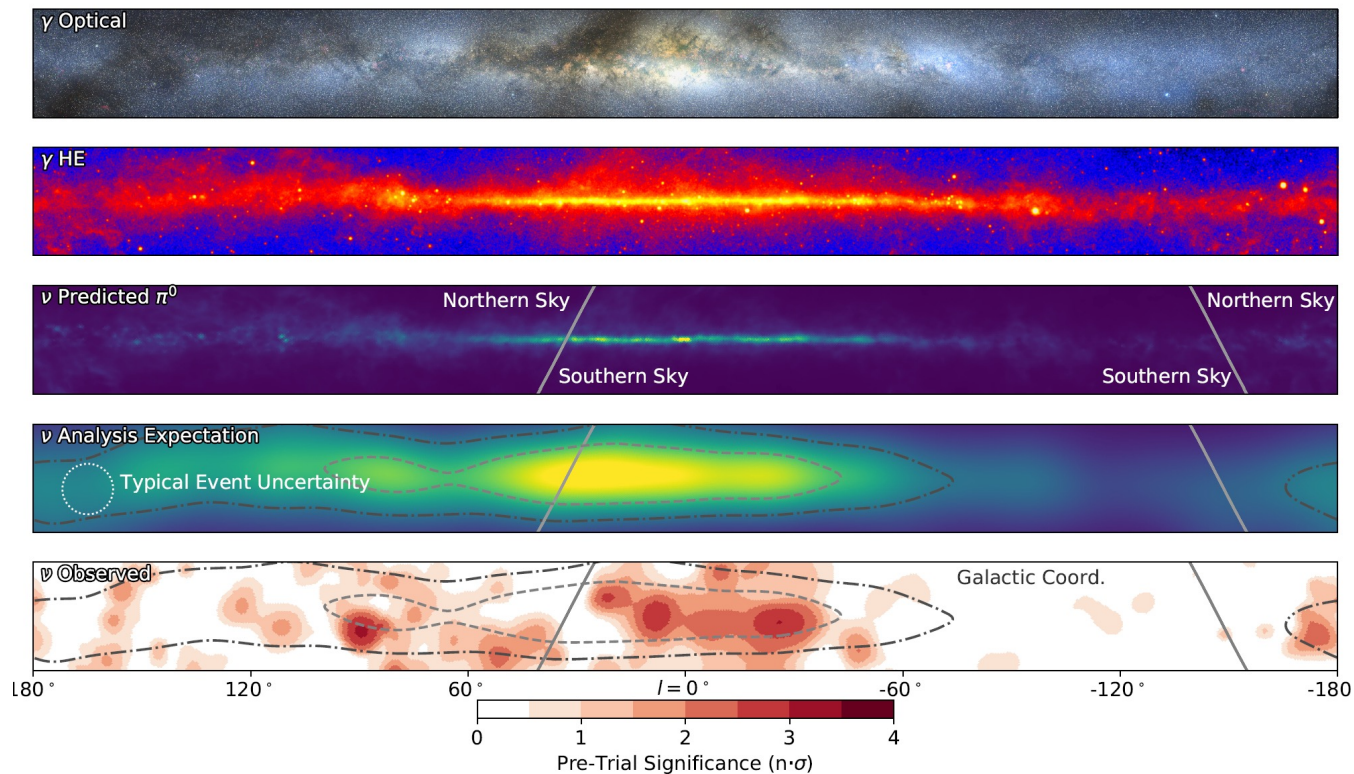
Medium Size Telescope Production Hall in Bohnsdorf



# Neutrino Astronomy

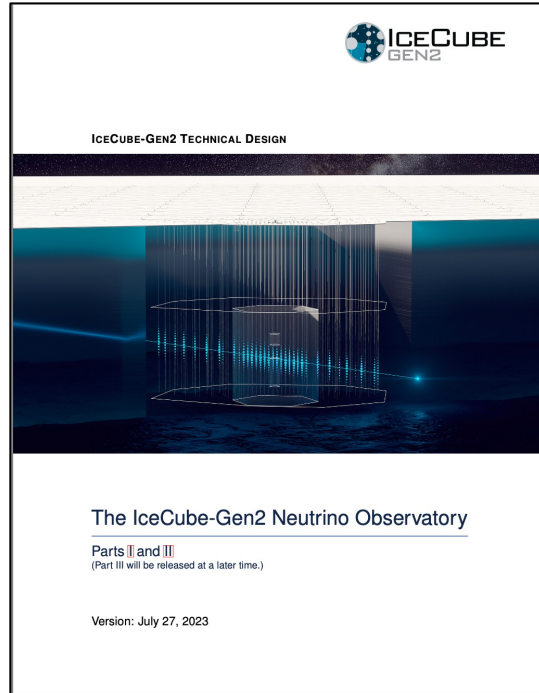
The window is open

The IceCube Collaboration *Science* 380, 6652 (2023)

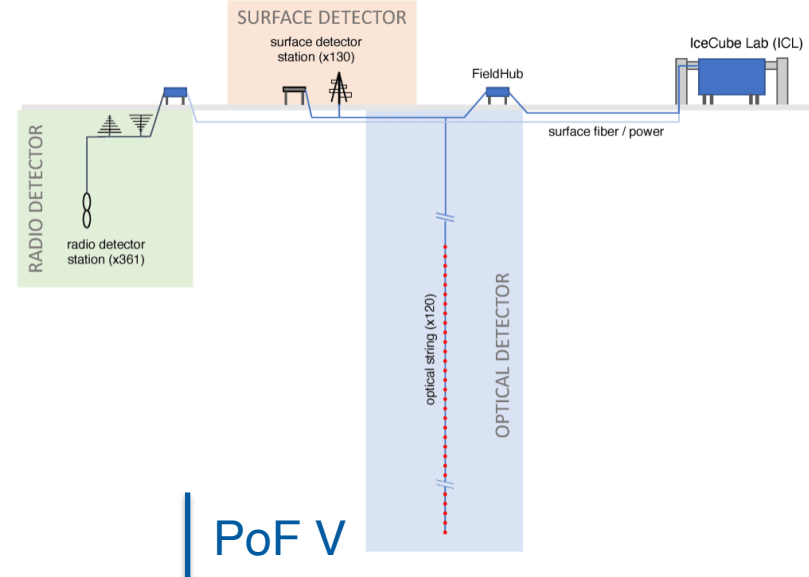


# The IceCube-Gen2 Neutrino Observatory

A neutrino physics and neutrino astronomy infrastructure at the South Pole



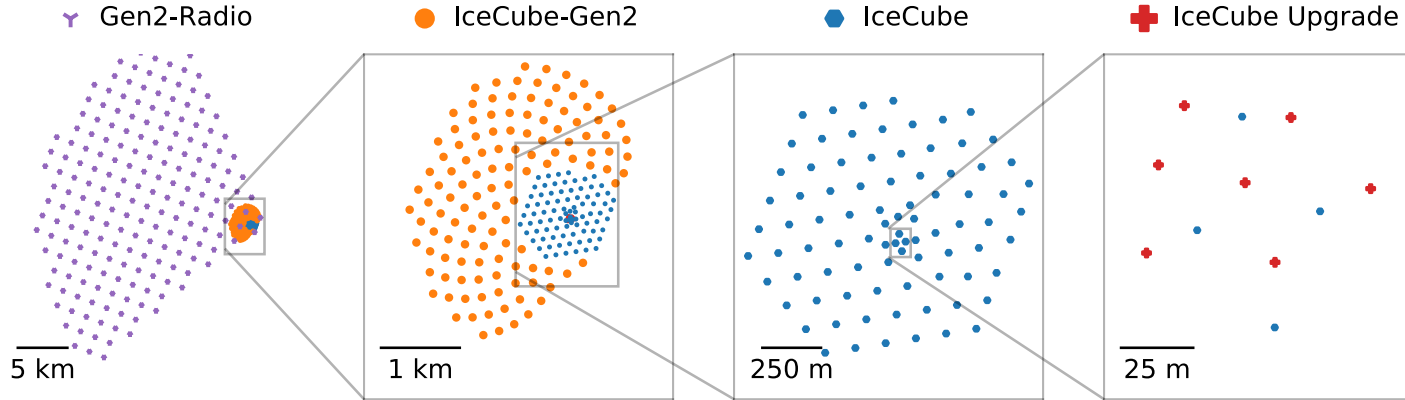
<https://icecube-gen2.wisc.edu/science/publications/tdr/>



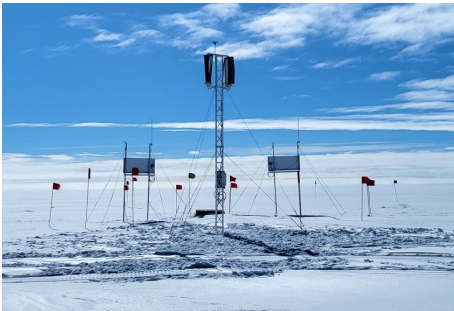
Time schedule under discussion with NSF and partners

# The IceCube-Gen2 Neutrino Observatory

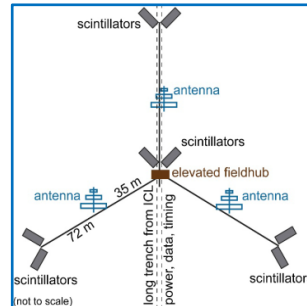
A neutrino physics and neutrino astronomy infrastructure at the South Pole



## Radio



## Surface



## Optical





# IceCube-Gen2

A neutrino physics and neutrino astronomy infrastructure at the South Pole

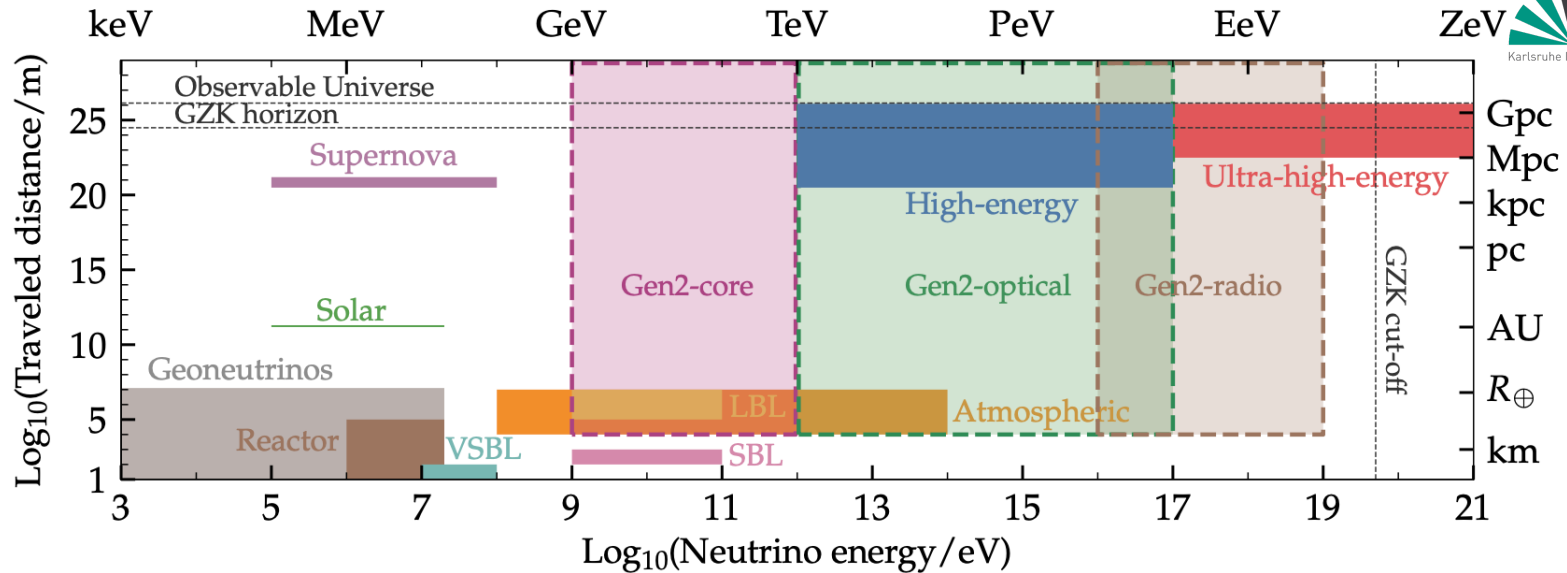


Figure 7: Range of travel distances and energies for neutrinos of different origin that are used for tests of fundamental physics. The IceCube-Gen2 observatory will cover a large range of energies and distances, observing both atmospheric and cosmic neutrinos.

# Auger and Auger Prime

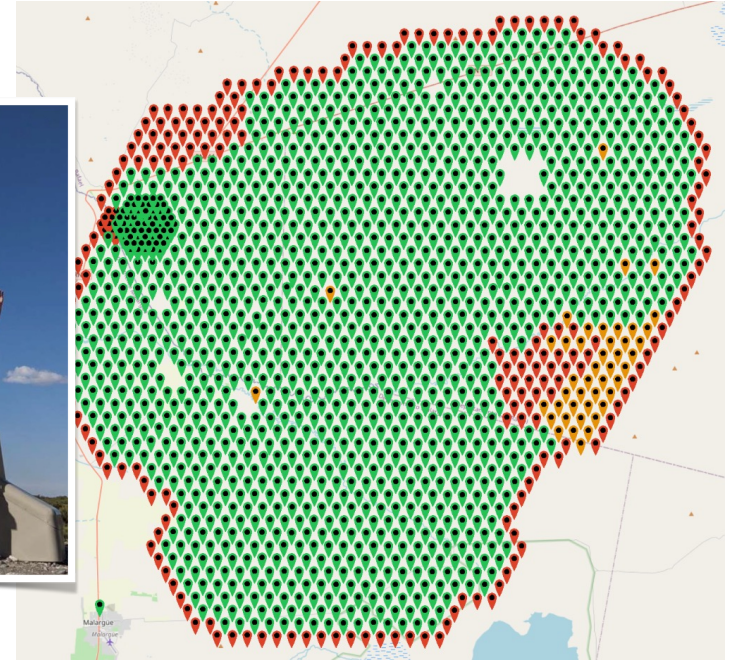
With a rich physics programme up to PoF VI

## Phase II until 2035

- Composition-dependent anisotropy
- Multi-messenger analyses ( $\gamma$ ,  $\nu$ , GW, ...)
- Source regions, astrophysics
- Hadronic interactions, BSM physics

## Testbed

- IceCube scintillators
- GRAND antennas
- GCOS



PoF V

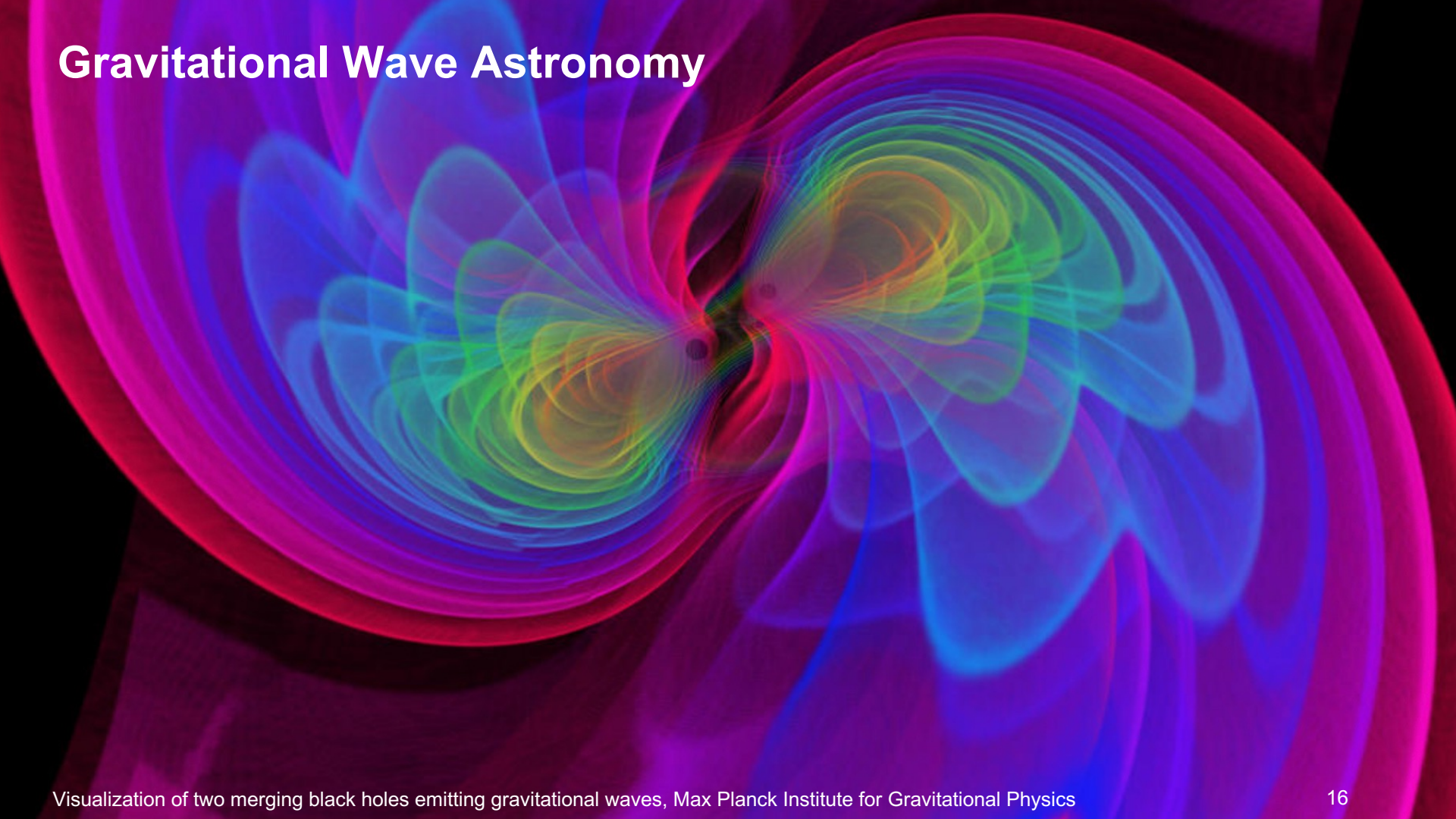
2024

AugerPrime construction

2025 - 2034

Operation

# Gravitational Wave Astronomy



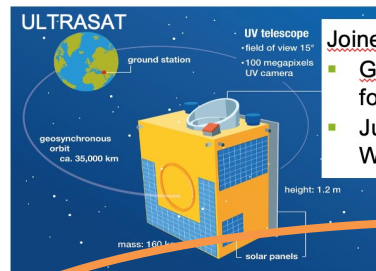


# A short remark triggered an intense discussion ...

## PoF IV evaluation January 2020

### STRATEGIC FOCUS: Transient Event Follow-Ups

Pushing forward time domain high-energy astronomy



#### Joined ULTRASAT:

- Gravitational wave follow-up observations
- Junior partner of the Weizmann Institute

#### Work Program

- Until 2024 build camera for ULTRASAT
- Advance and run multi-messenger realtime analysis center

#### Goals

- Advance multi-messenger astrophysical transients science

#### Strategic opportunity: Gravitational Wave Astronomy with the Einstein Telescope

- Needs national initiative to organize German contribution. We are actively participating.
- We have unique expertise in physics and technology (lasers, vacuum, cryogenics, control, ...).

... resulting in a remarkable recommendation

- “The recent breakthroughs in gravitational wave astronomy offer the potential for observing the universe through a new window requiring large-scale infrastructures such as the proposed Einstein telescope. **Helmholtz is ideally placed to participate in this initiative**, which would complete the missing component of its multi-messenger approach.”
- “**Participate in future global initiatives in gravitational wave observations, e.g. the Einstein Telescope.**”

# The Einstein-Telescope

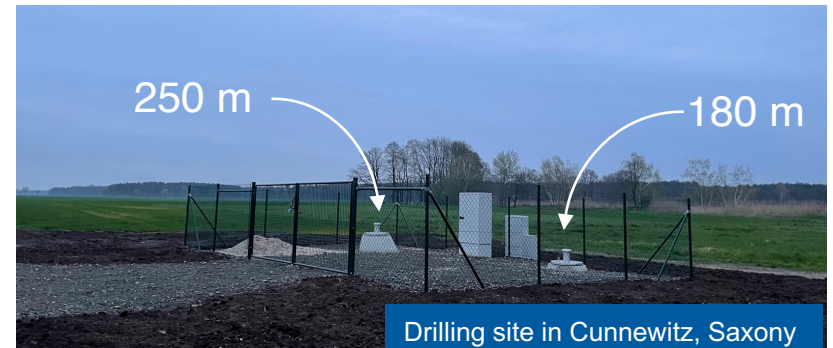
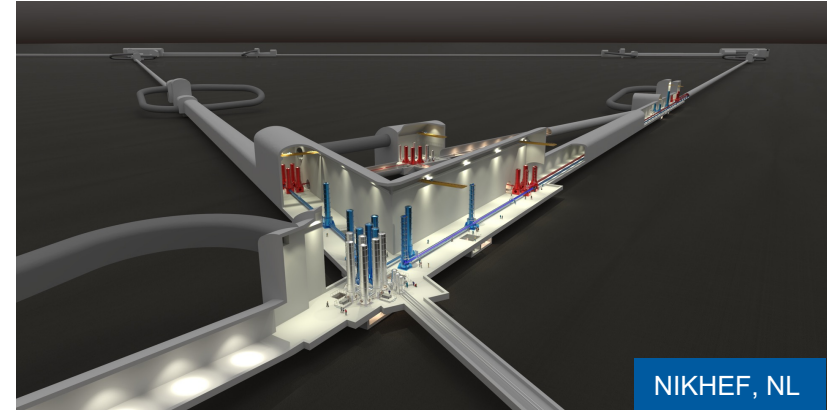
## Where are we?

### Helmholtz

- KIT and DESY members of the **ET collaboration**
- Active participation ranging from vacuum system, site evaluation to theory and software
- ET on the **Helmholtz FIS Roadmap**
- Initiated the **German Center for Astrophysics (DZA)** with GW astronomy as a key research focus

### Europe

- ET on the ESFRI roadmap
- Funding discussed at highest levels in many countries
- Site decision likely postponed by 1-2 years (2027)



# Research program in PoV IV in a nutshell



ULTRASAT



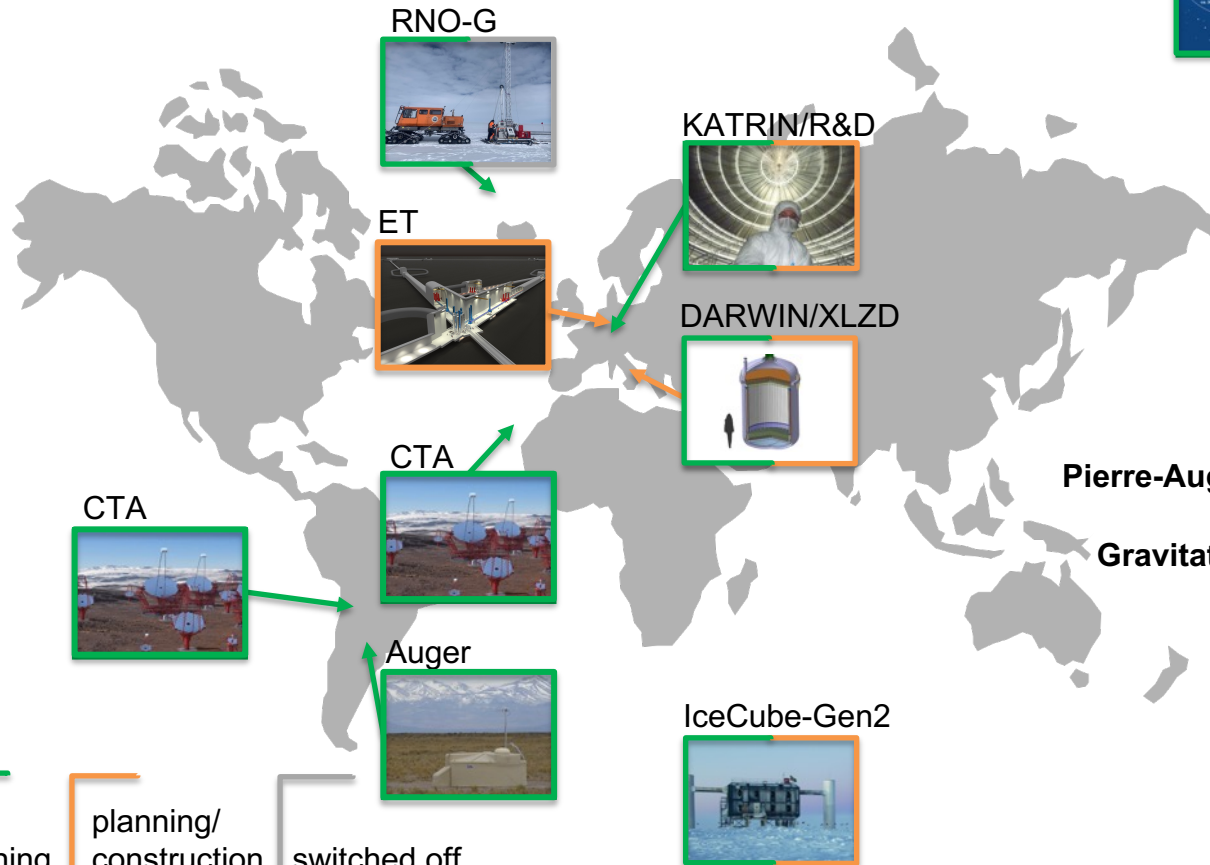
	High-energy Universe	Neutrino properties	Dark Matter
CTA			
IceCube			
Pierre-Auger Observatory			
Gravitational Waves			
KATRIN			
XENON & DARWIN			
Theory			



# Research program in PoF V in a nutshell



ULTRASAT



running
planning/  
construction
switched off

	High-energy Universe	Neutrino properties	Dark Matter
CTA			
IceCube-Gen2			
Pierre-Auger Observatory			
Gravitational Waves/ET			
KATRIN			
DARWIN/XLZD			
Theory			