

The IceCube-Gen2 Project

IceCube 15 year symposium

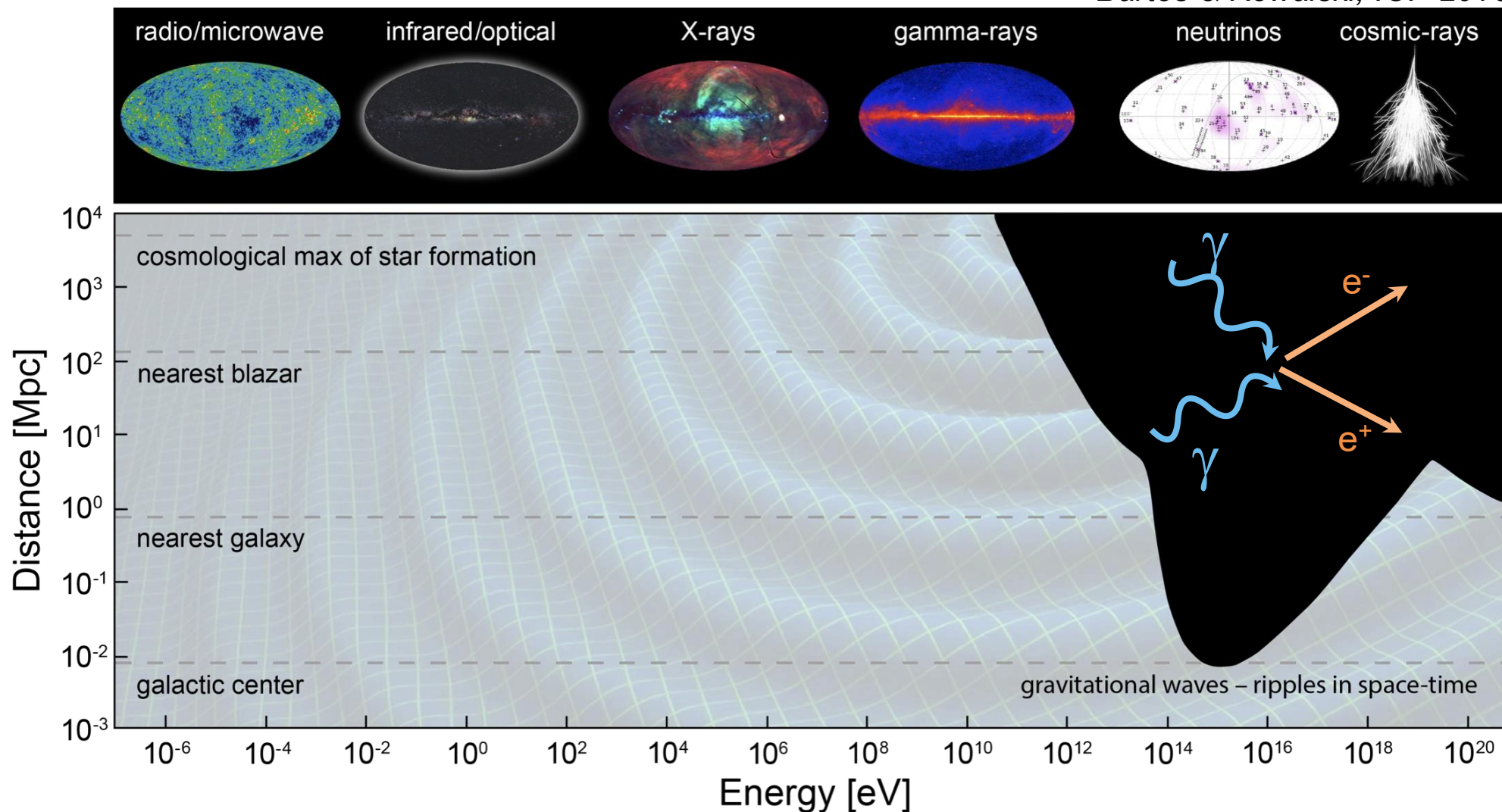
Chiba, 9.9.2026

Marek Kowalski
DESY & Humboldt-University of Berlin



High energy neutrino astronomy in a nutshell

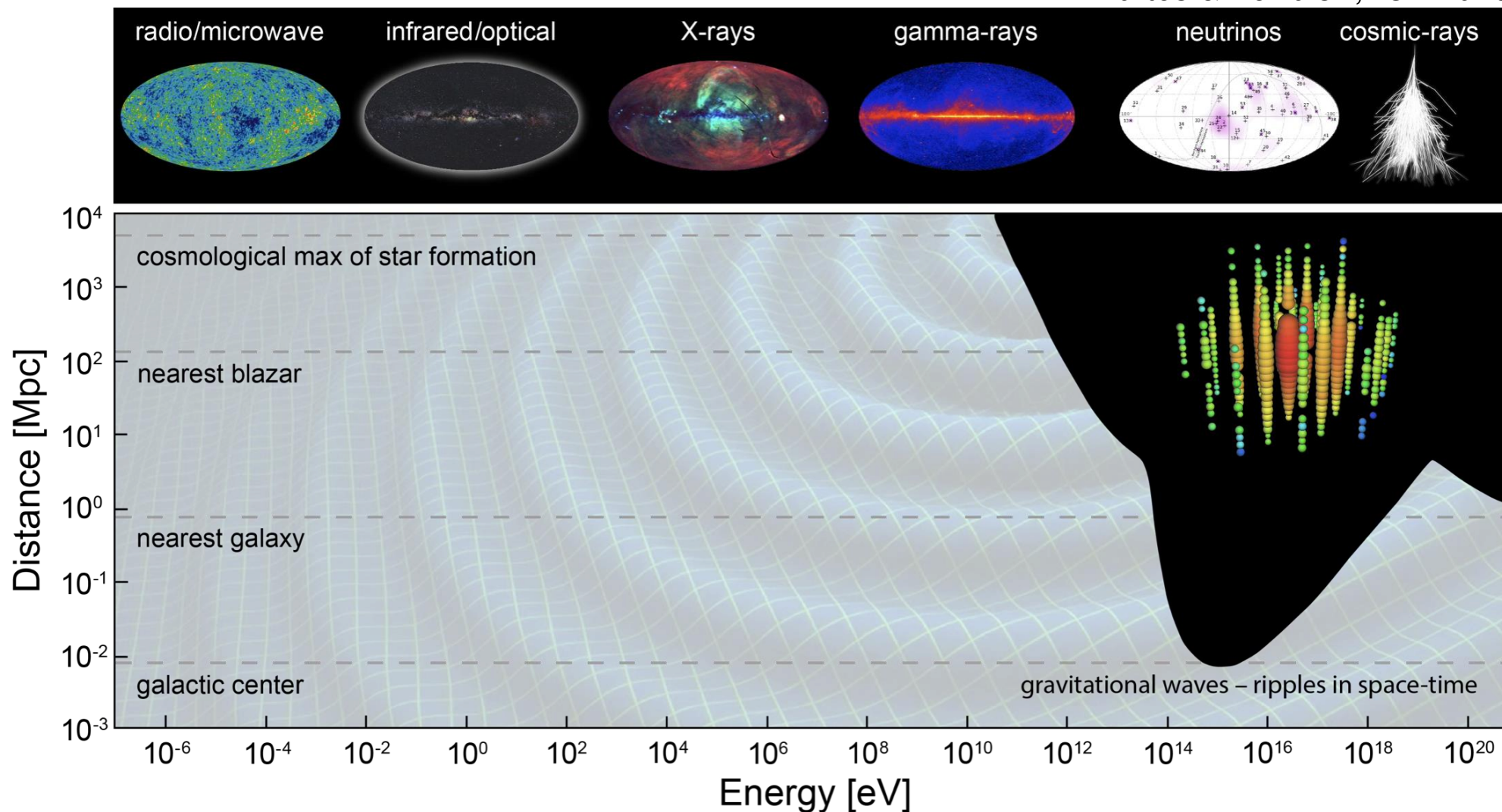
Bartos & Kowalski, IOP 2018



The Universe is opaque to photons for $\frac{1}{4}$ of the spectrum

High energy neutrino astronomy in a nutshell

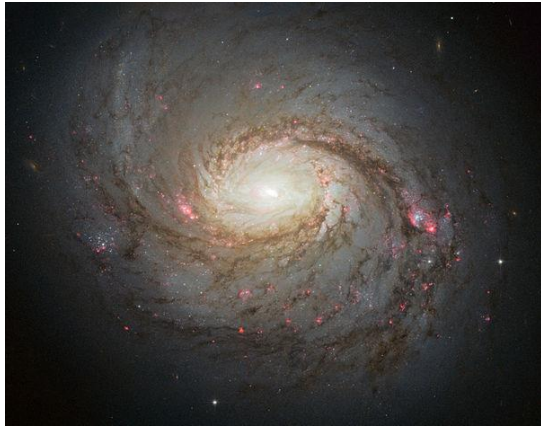
Bartos & Kowalski, IOP 2018



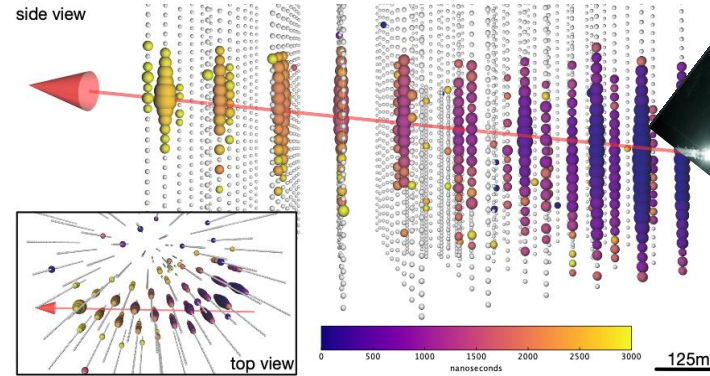
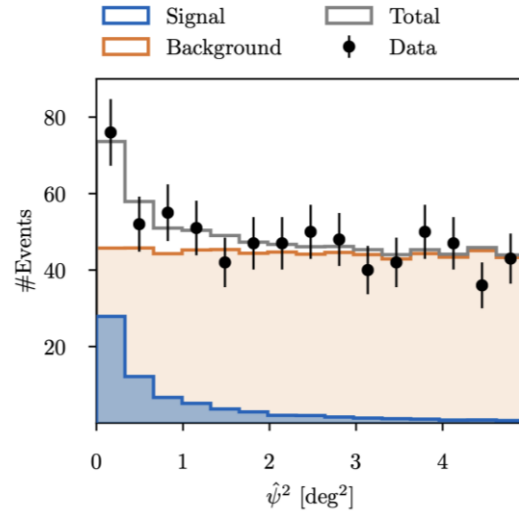
The Universe is opaque to photons for $\frac{1}{4}$ of the spectrum

Key scientific questions for IceCube-Gen2

Exploring the new window to the extreme Universe

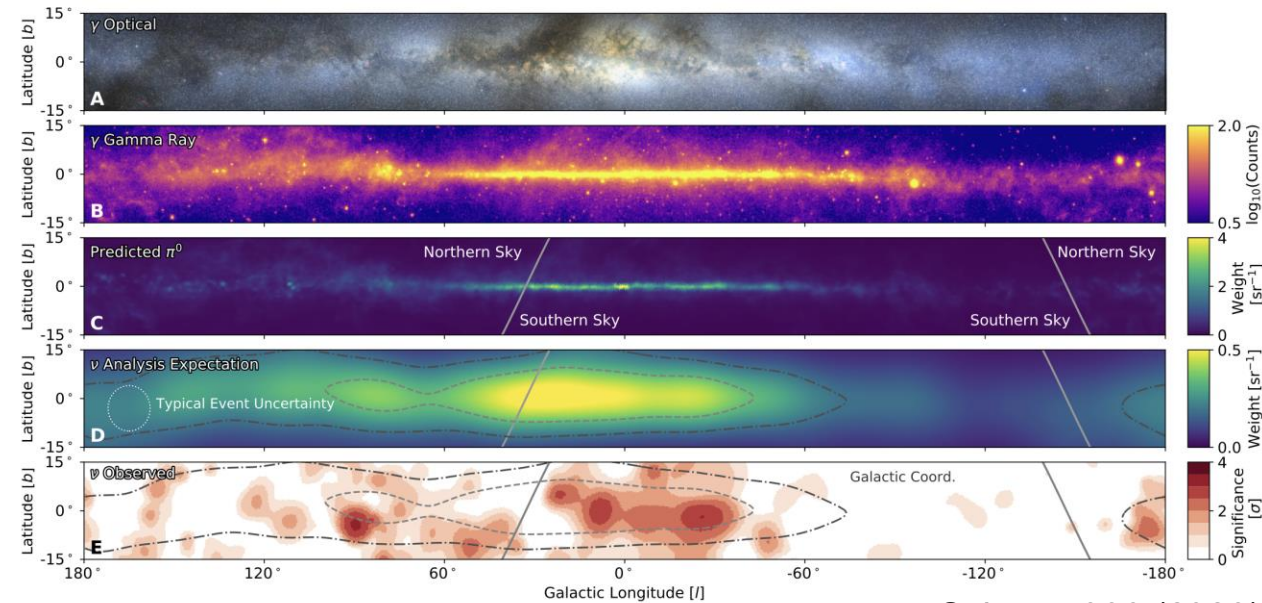


Science 378 (2022)



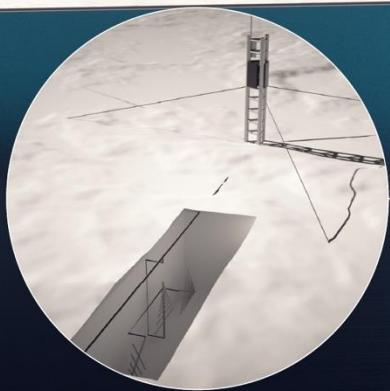
Science 361 (2018)

- Resolving the high-energy sky from TeV to EeV energies
- Understanding cosmic particle acceleration through multi-messenger observations
- Revealing the sources and propagation of the highest energy particles in the universe
- Probing fundamental physics with high-energy neutrinos



Science 380 (2023)

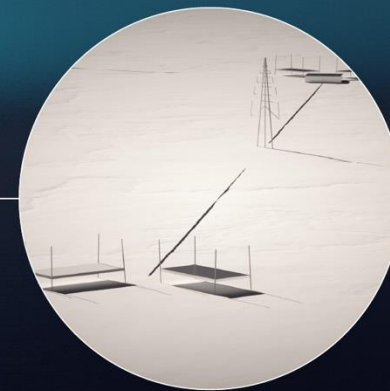
ICECUBE GEN2



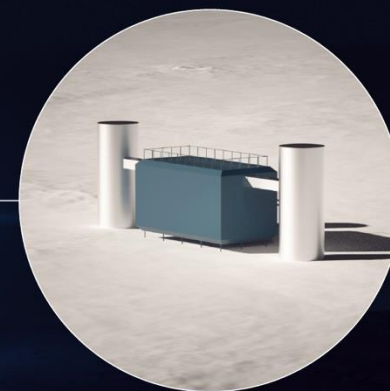
Radio Array | Station



Optical Array | Sensor



Surface Array | Station



IceCube | Laboratory

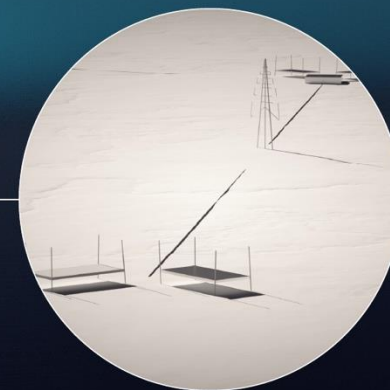
ICECUBE GEN2



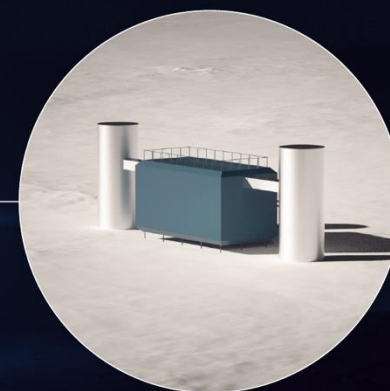
Radio Array | Station



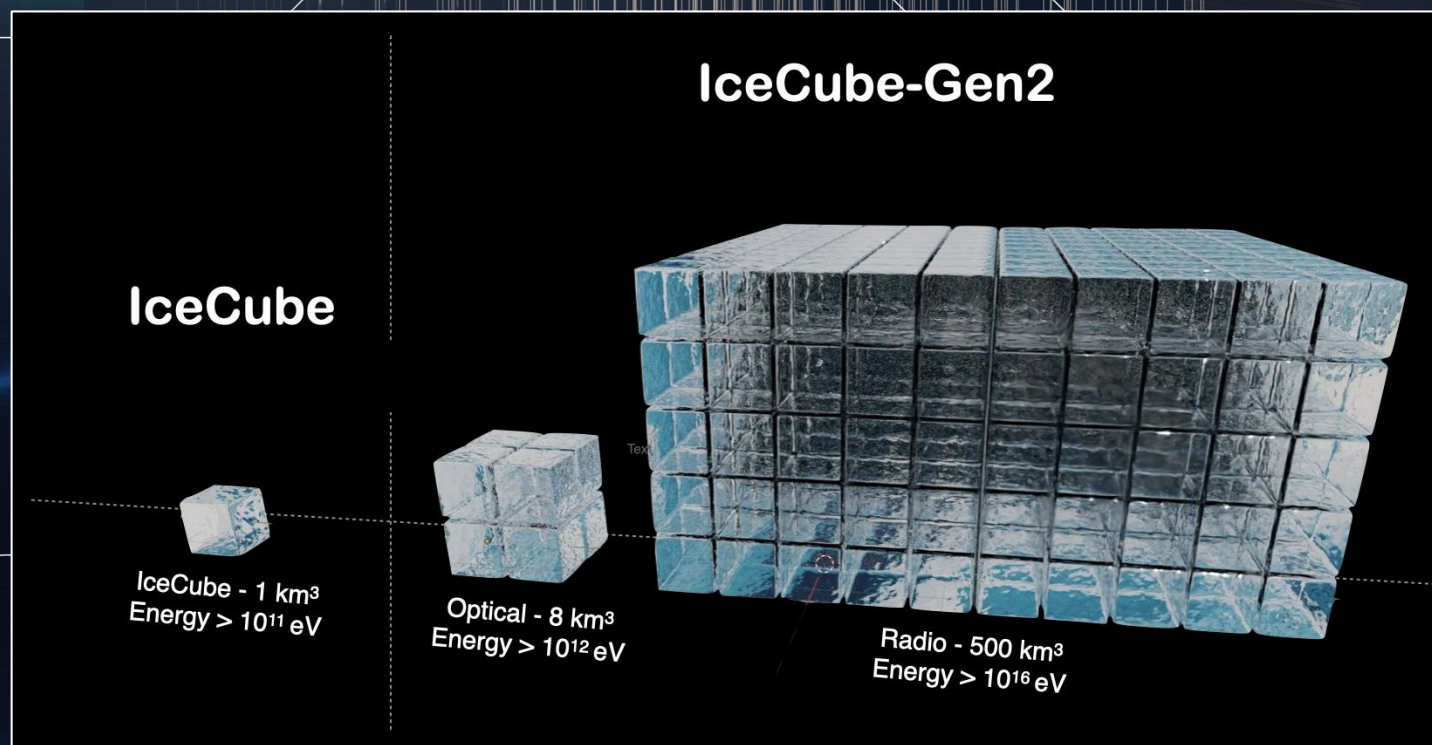
Optical Array | Sensor



Surface Array | Station

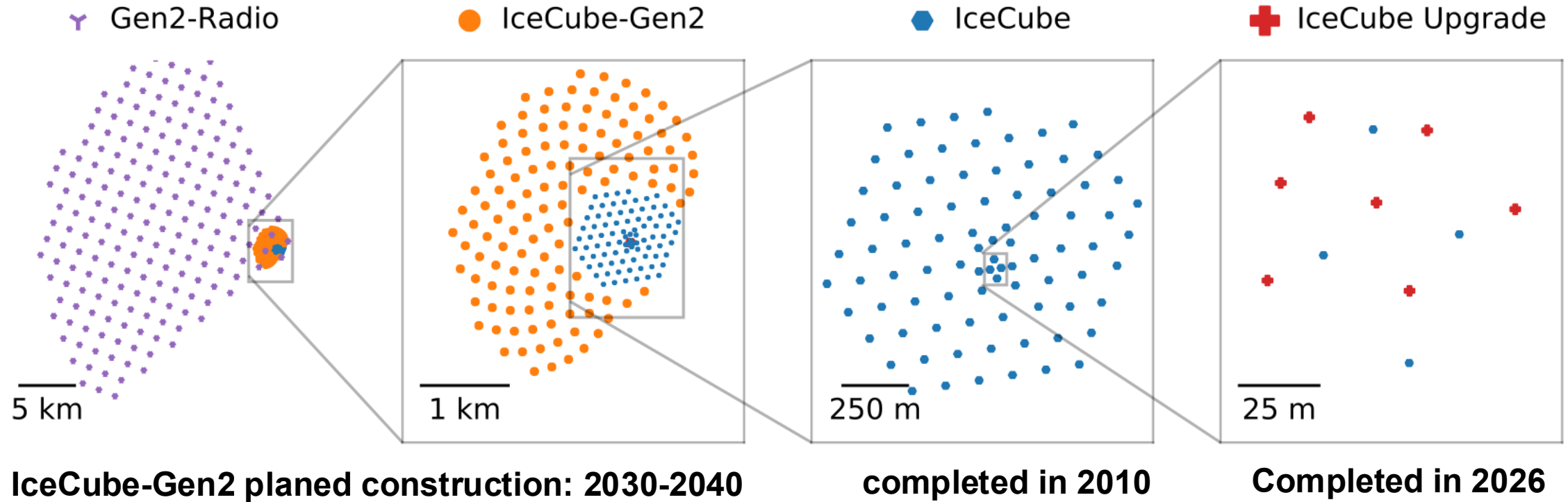


IceCube | Laboratory

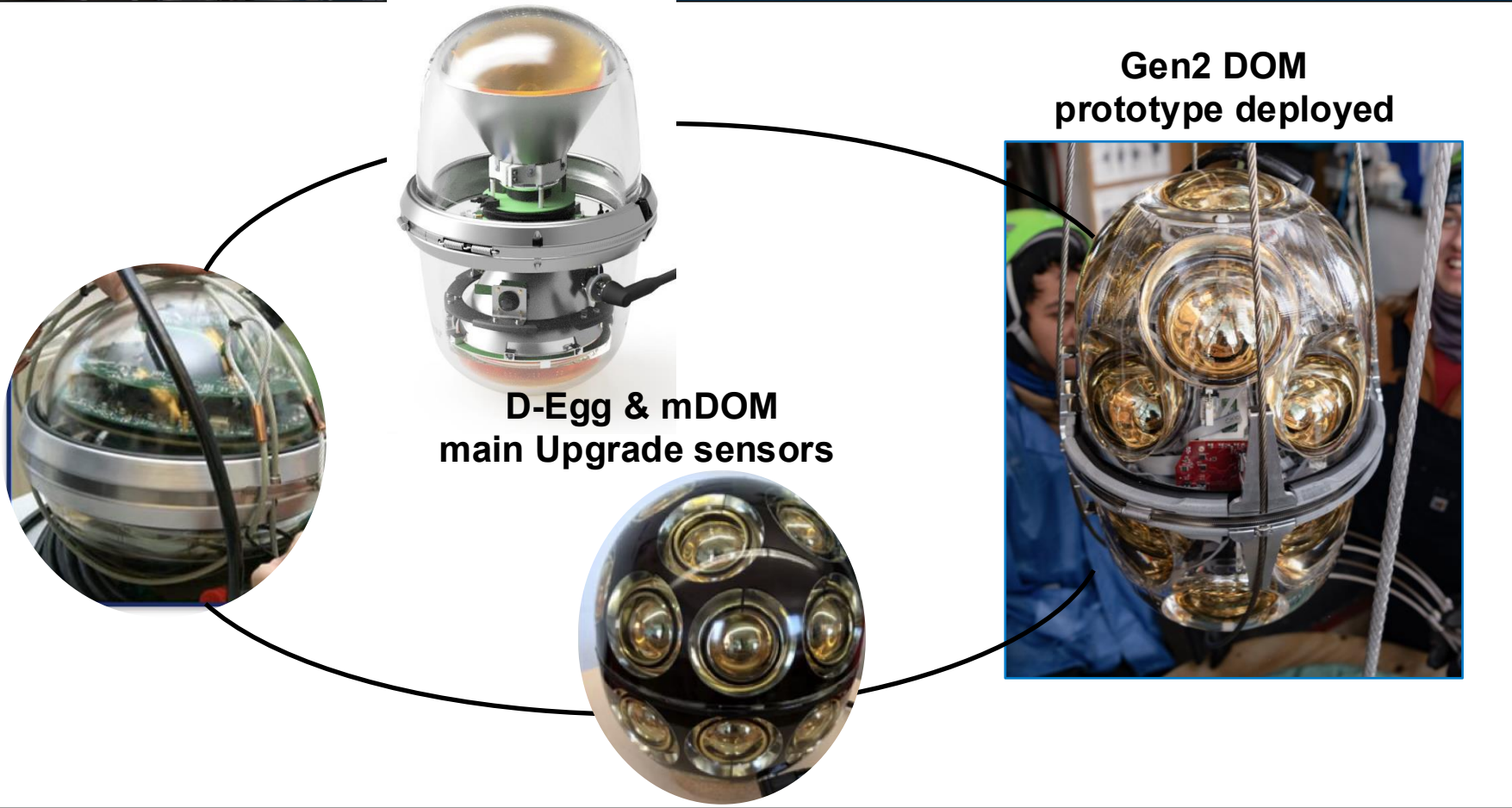
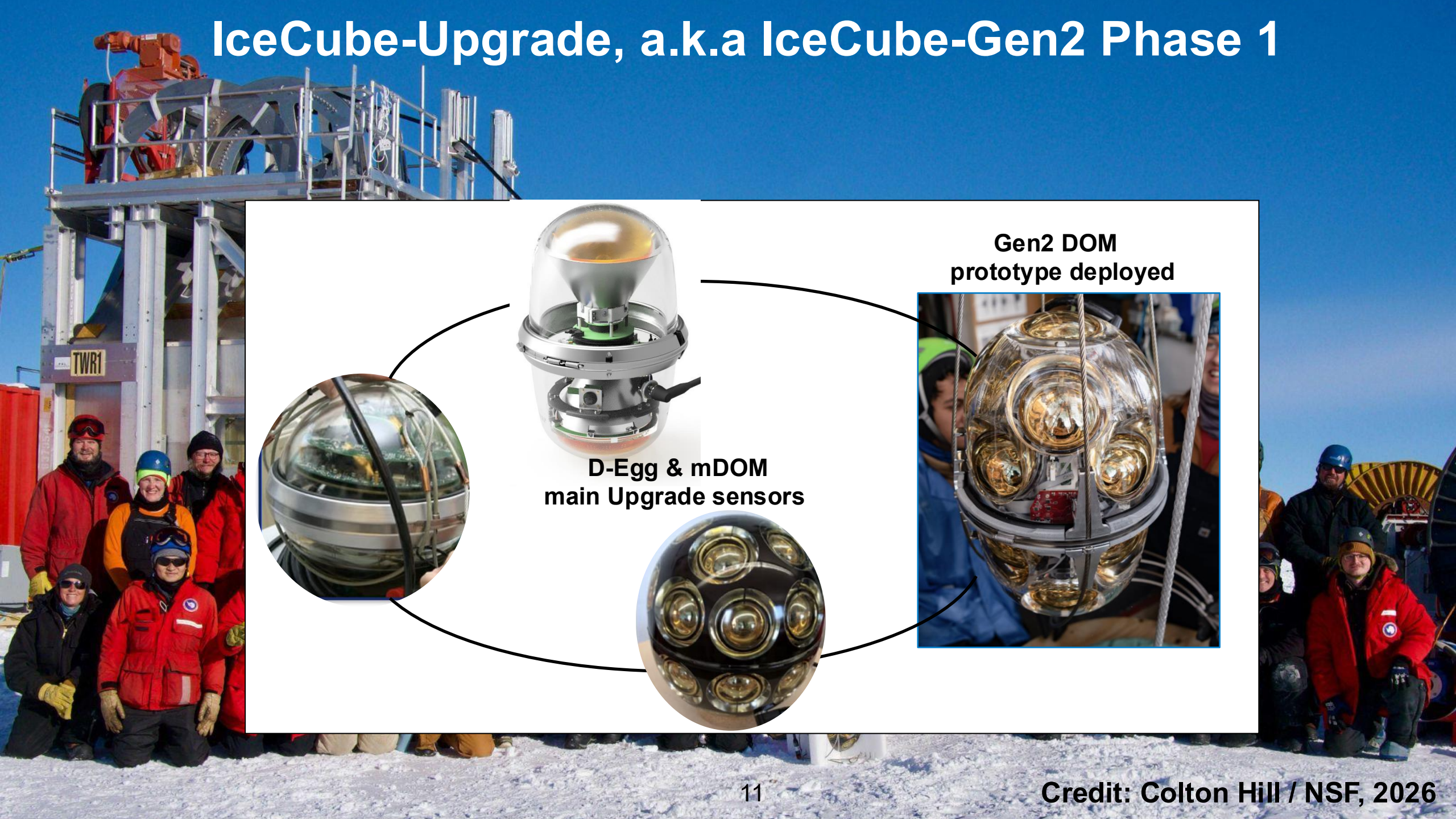


The IceCube Gen2 facility at the South Pole

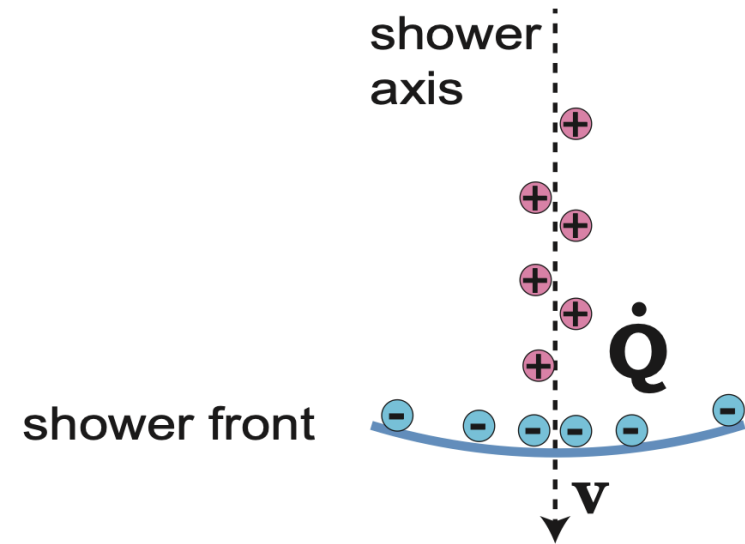
Wide-band observatory: Optimizing scales for leading sensitivity from 10^9 to 10^{20} eV



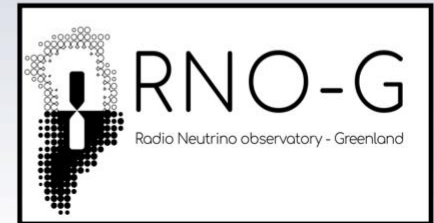
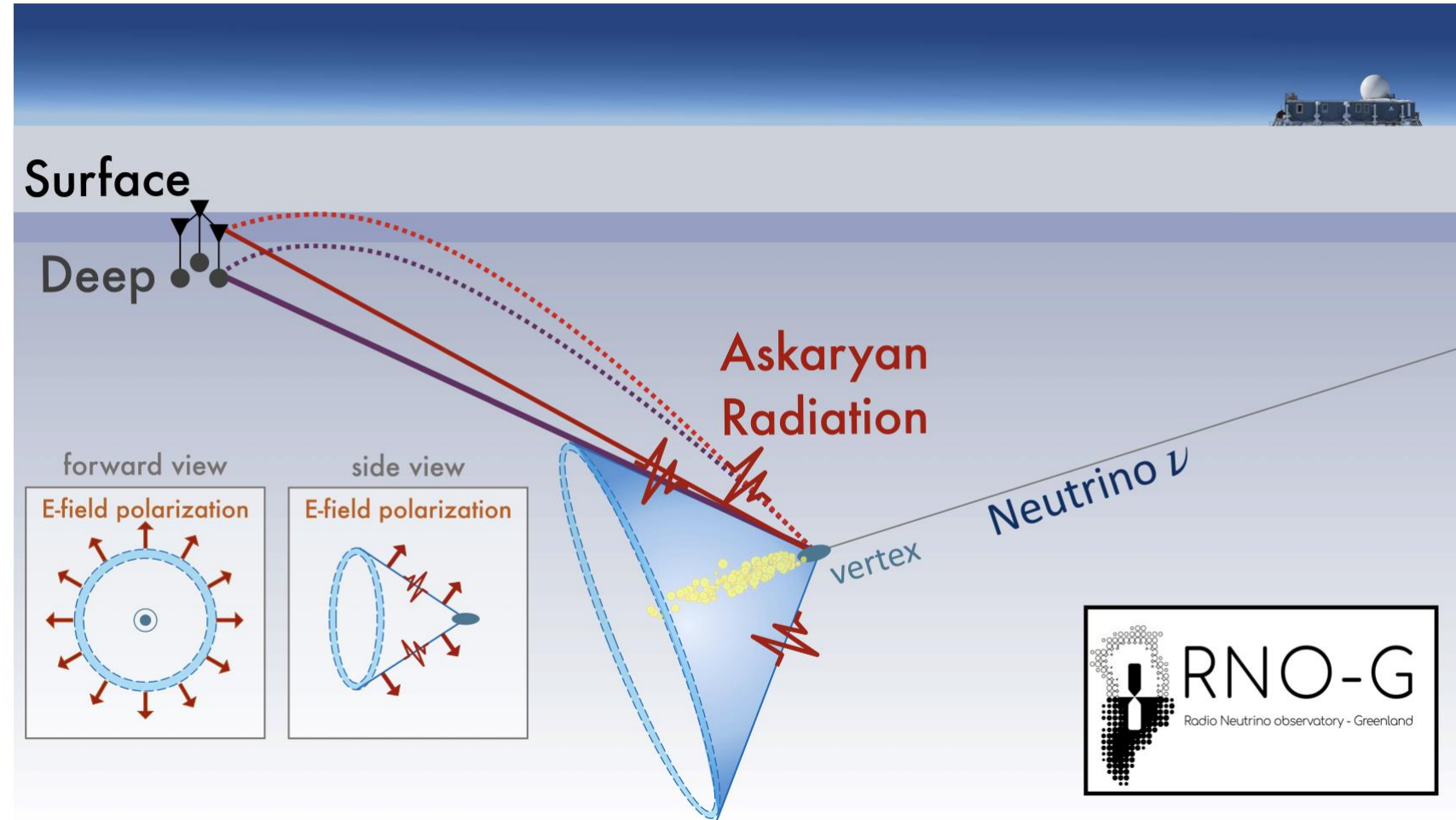
IceCube-Upgrade, a.k.a IceCube-Gen2 Phase 1



Radio detection of neutrinos



Askaryan emission from
particle showers in ice,
dominant @MHz-GHz
Attenuation length >1km!



Technical Readiness

New technologies verified within IceCube-Upgrade and RNO-G in Greenland.

optical sensors



Prototype Gen2
sensors part of
Upgrade

hot-water drilling



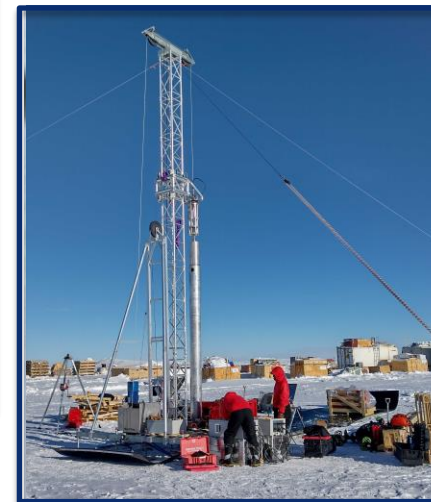
Installation of 6 strings
at South Pole in 2026

surface-stations



Next generation surf.
stations at South Pole

radio-stations



RNO-G pathfinder
installation in Greenland

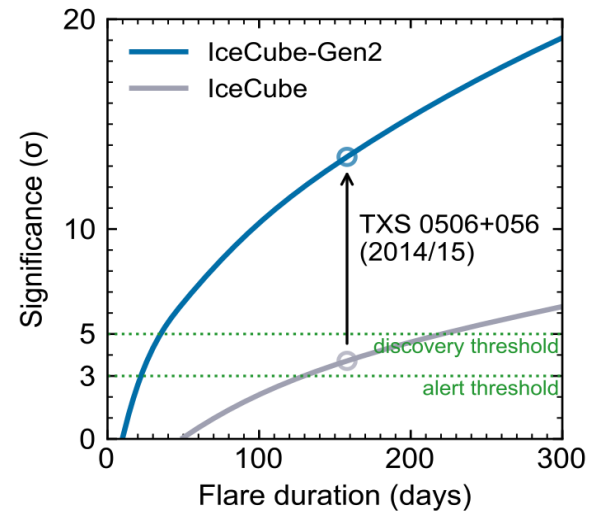
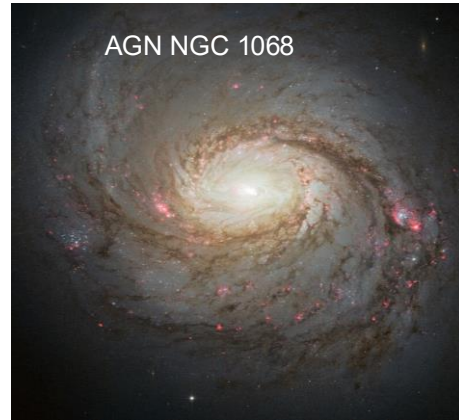
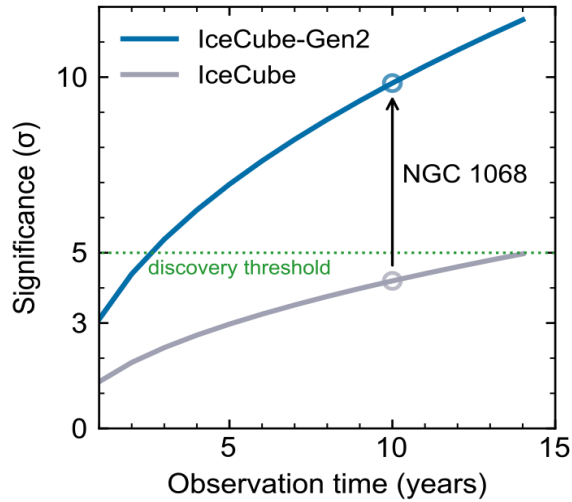


ICECUBE
GEN2

Scientific objectives for IceCube-Gen2

Resolving the high-energy sky from TeV to EeV energies

Sensitivity to point sources, *Technical Design Report 2024*



IceCube-Gen2 vs IceCube:

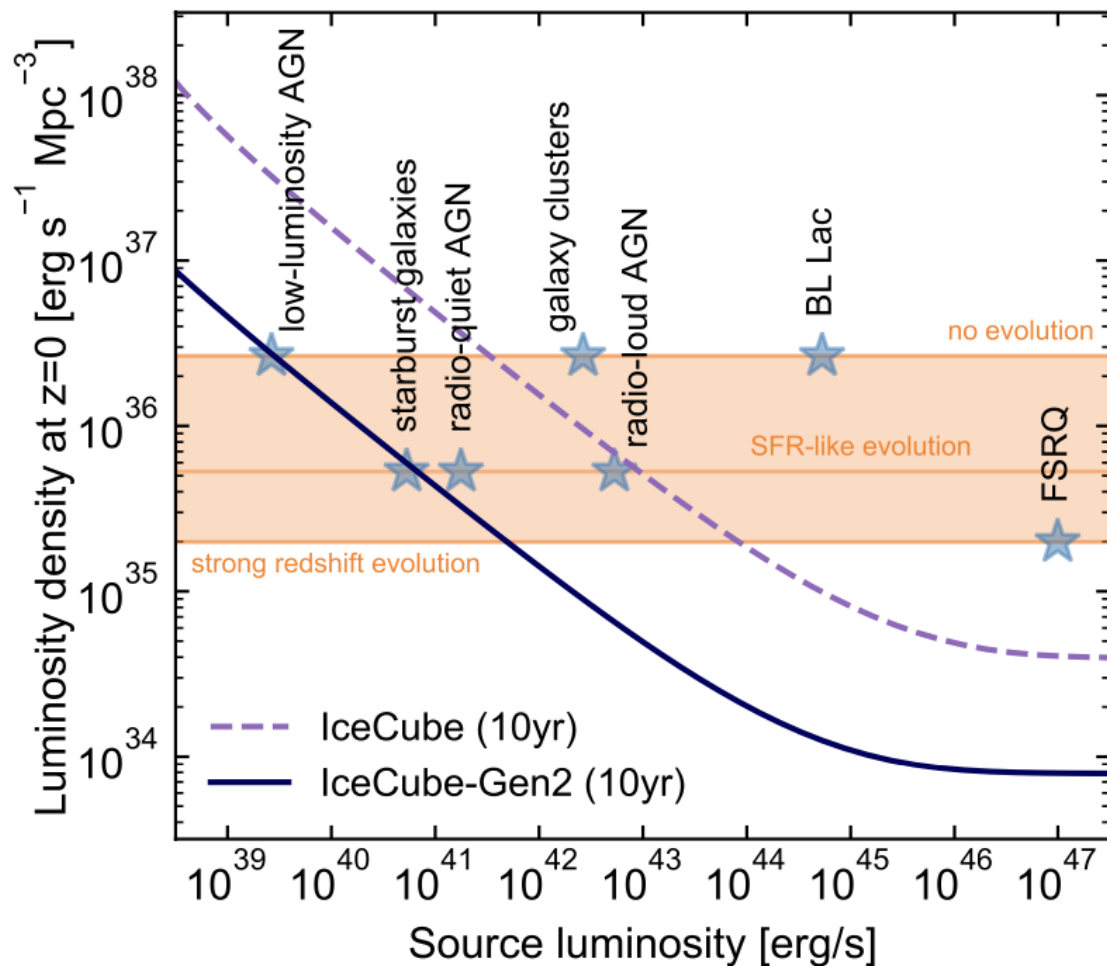
- 5 x point source sensitivity
- 10 x number of sources

IceCube-Gen2 will probe the leading source classes to produce the diffuse neutrino flux

Scientific objectives for IceCube-Gen2

Resolving the high-energy sky from TeV to EeV energies

Sensitivity to point sources. *Technical Design Report 2024*



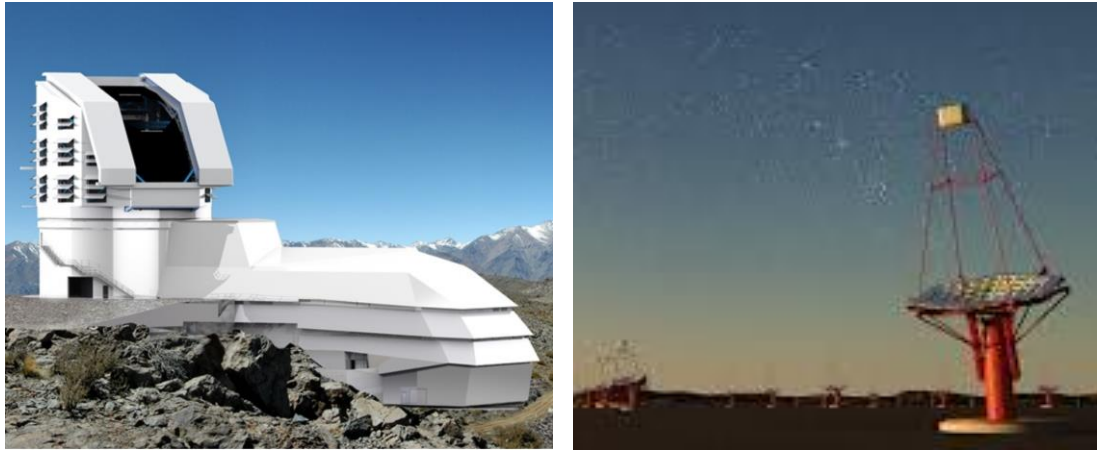
IceCube-Gen2 vs IceCube:

- 5 x point source sensitivity
- 10 x number of sources

IceCube-Gen2 will probe the leading source classes to produce the diffuse neutrino flux

Scientific objectives for IceCube-Gen2

Understanding cosmic particle acceleration through multimessenger observations

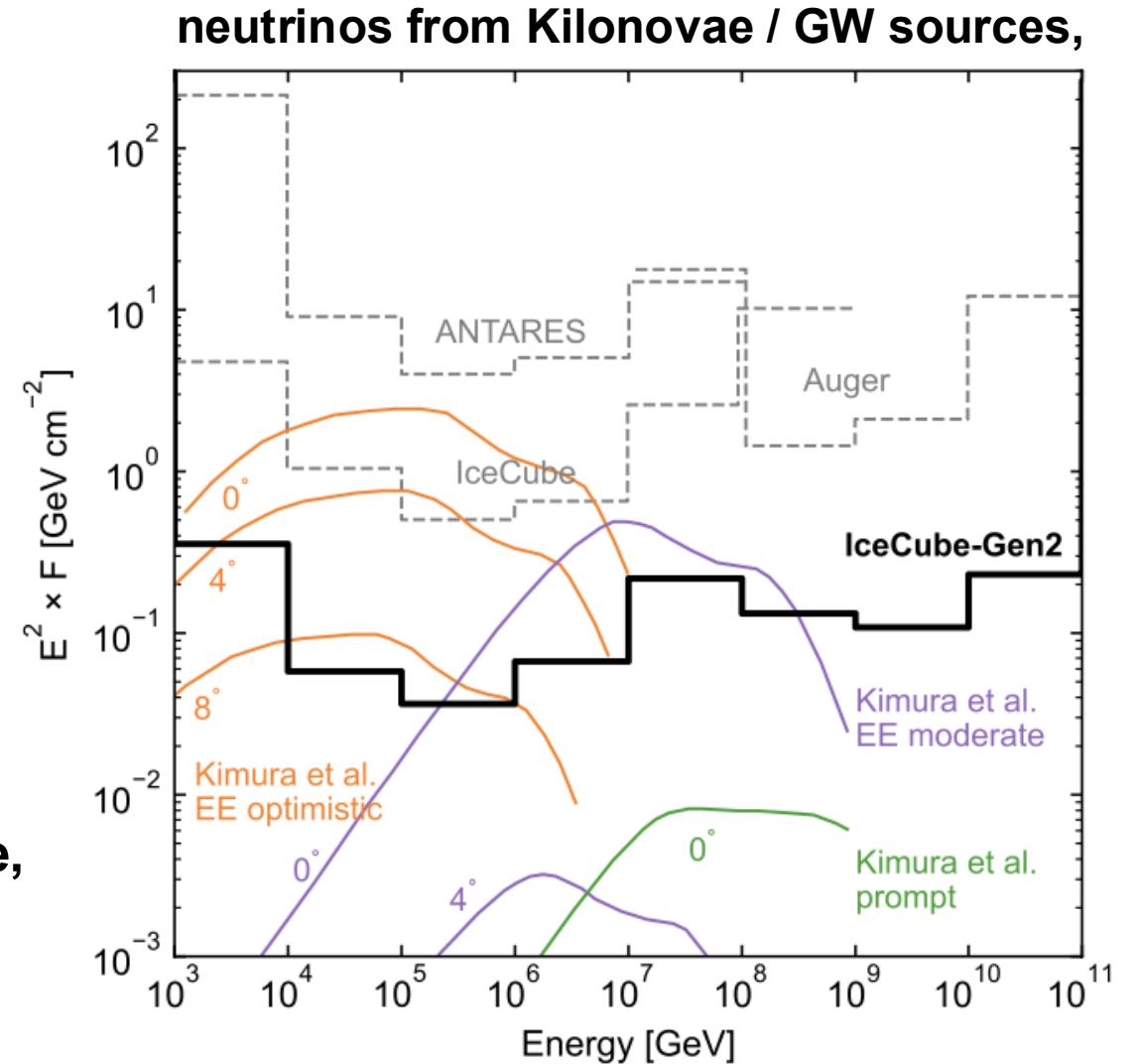


Significant synergies with LSST / Rubin,
CTA, SKA, Gravitational Wave detectors,,

... resulting in huge sensitivity to TDEs, SNe,
GRBs. Kilonovae, Blazars



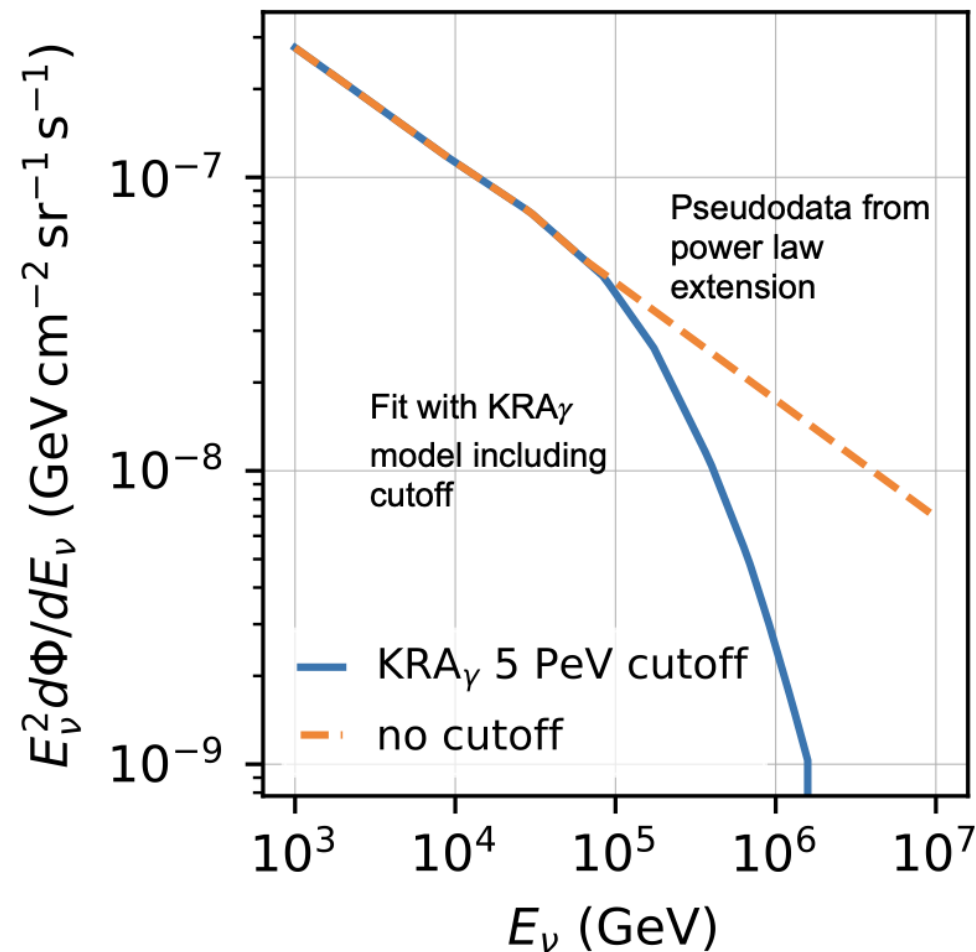
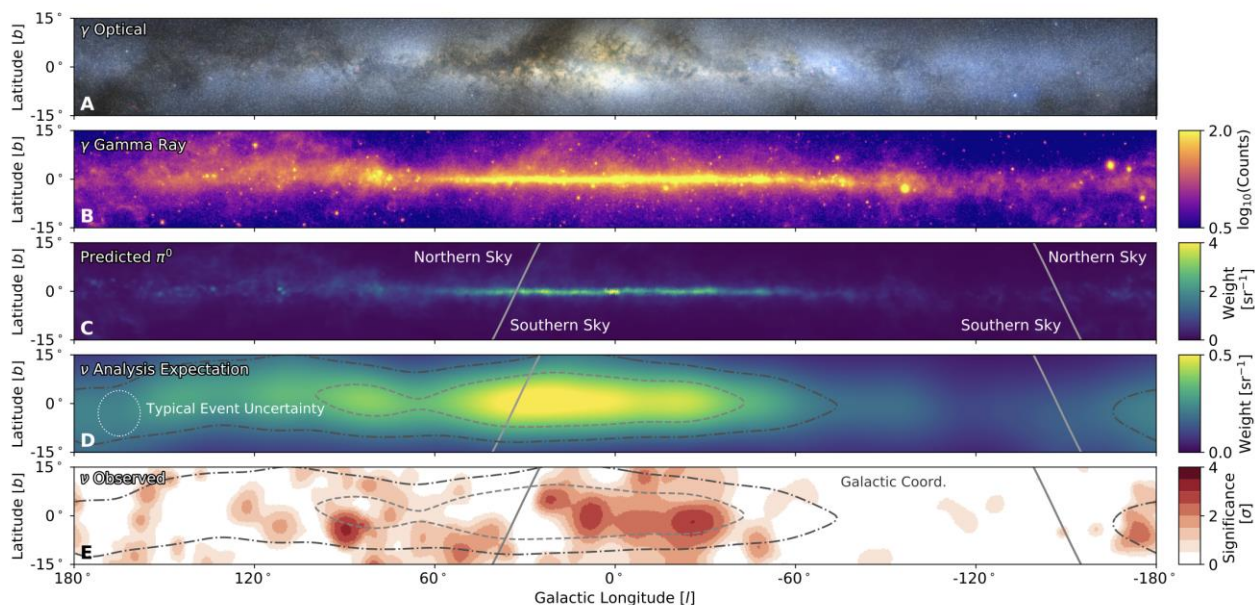
ICECUBE
GEN2



Scientific objectives for IceCube-Gen2

Revealing sources and propagation of highest energy particles in the Milky Way and the universe.

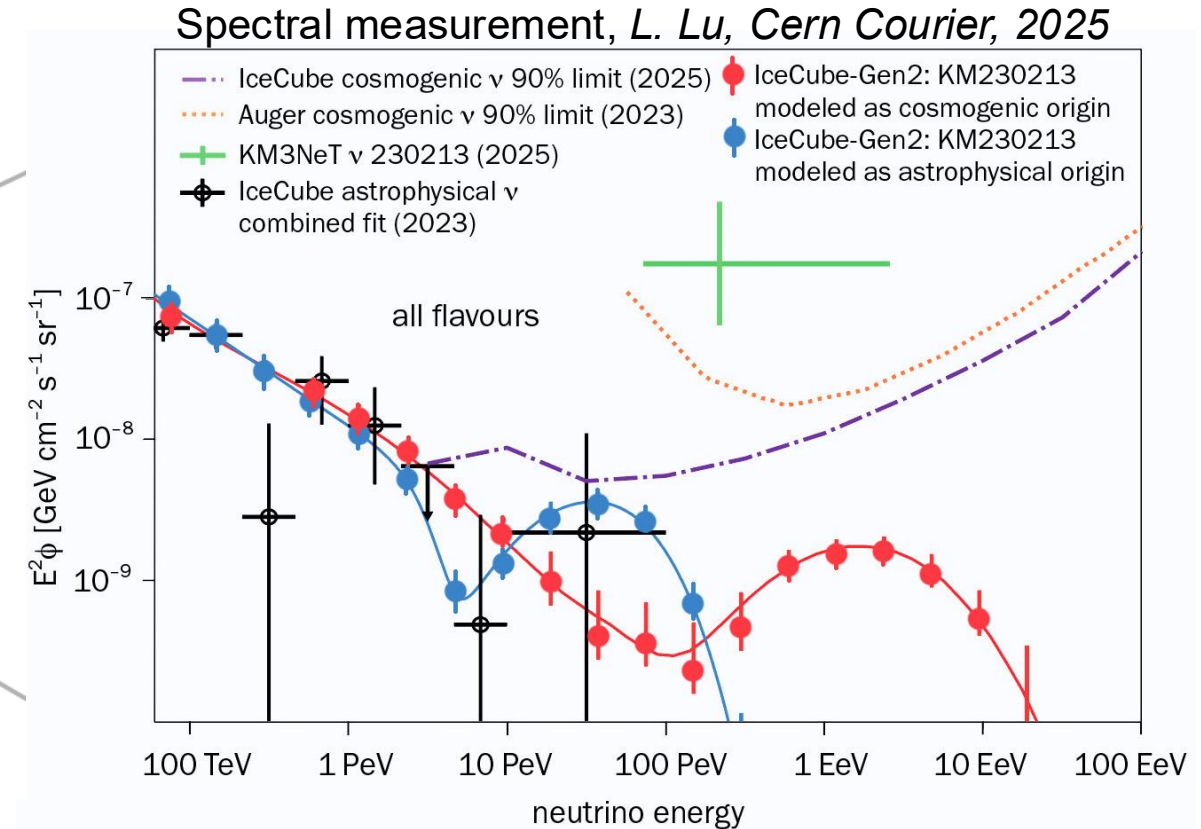
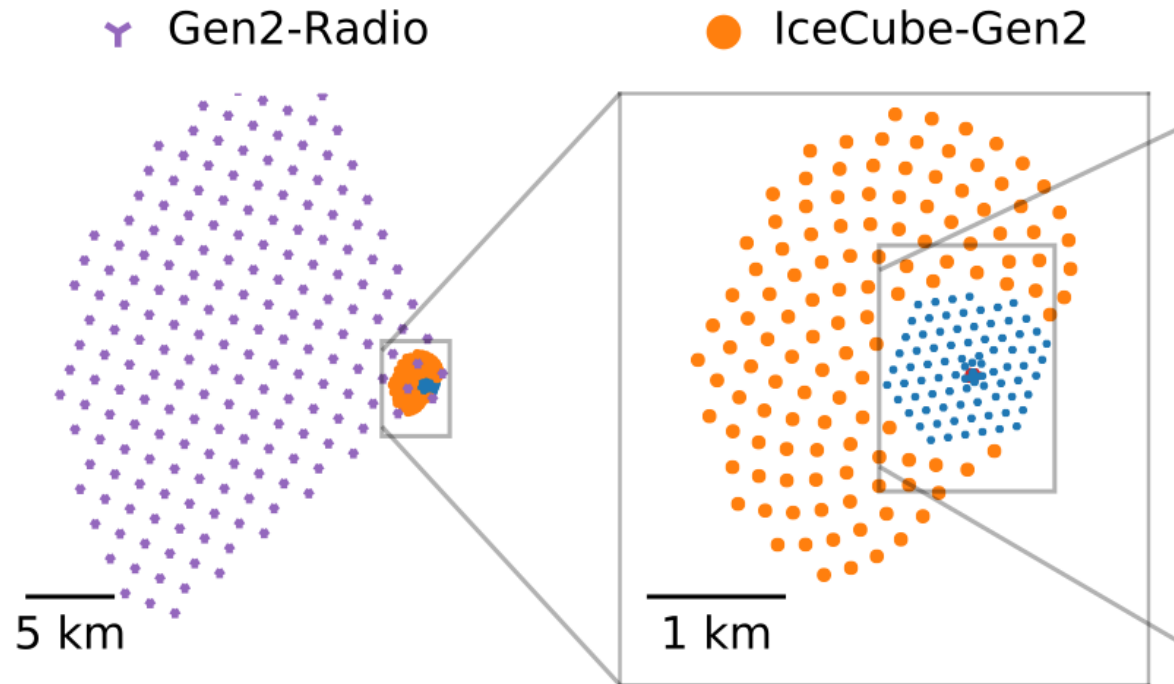
Our Milky Way in Neutrinos



**Gen2 sensitivity to Gal. Plane: 11σ (10 yrs);
Probe cut-off ~ 10 x faster than IceCube**

Scientific objectives for IceCube-Gen2

Revealing sources and propagation of highest energy particles in the Milky Way and the universe.



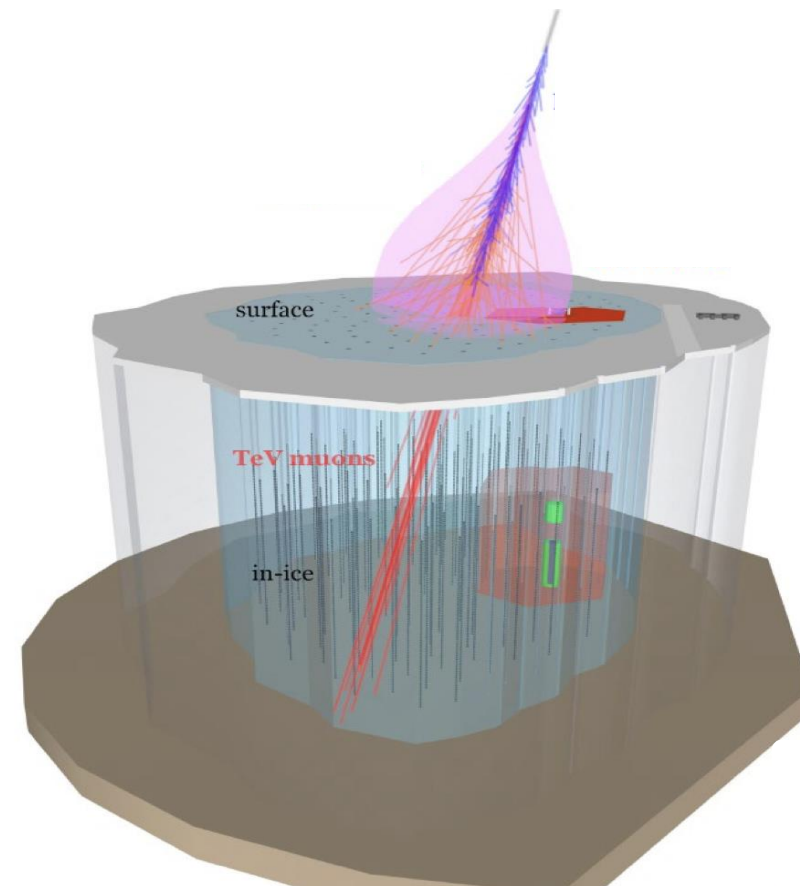
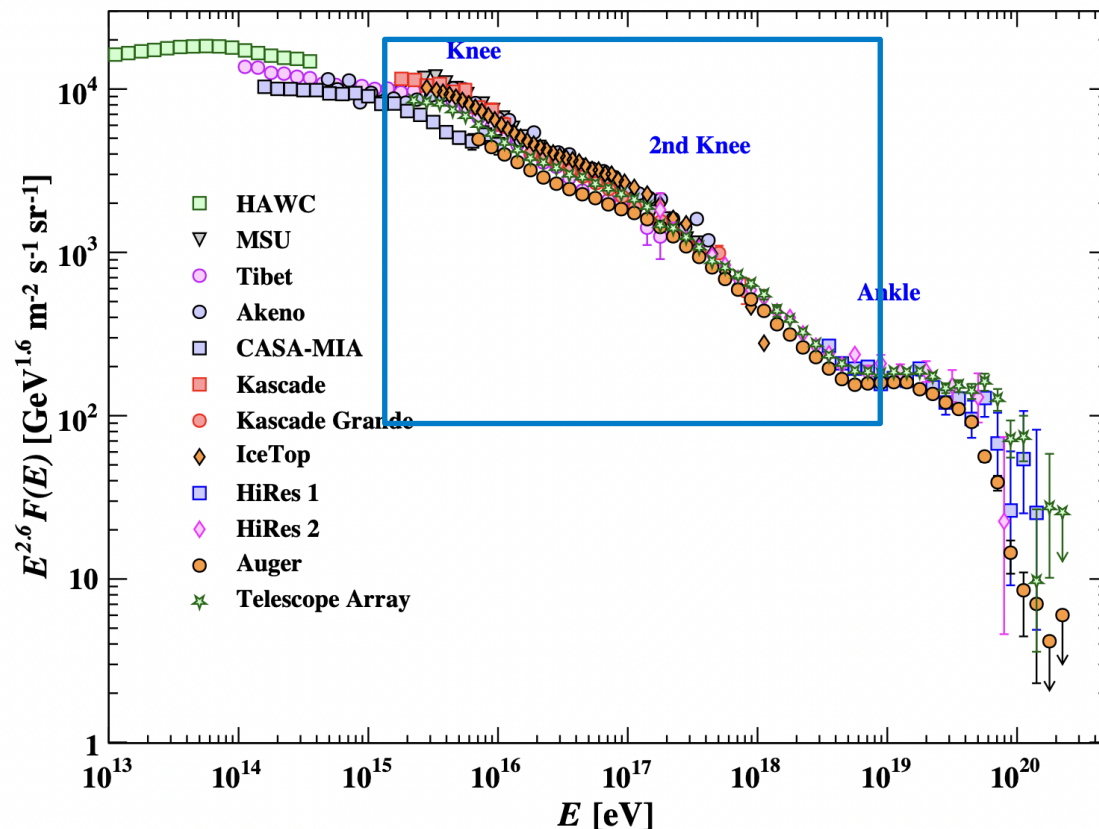
Optical array: **10 x the rate of UHE neutrinos**

Radio array: **100 x the rate of EHE neutrinos**

E.g. Sensitivity to GZK-Neutrinos, if protons make up more than 10% of cosmic rays

Scientific objectives for IceCube-Gen2

Revealing sources and propagation of highest energy particles in the Milky Way and the universe.

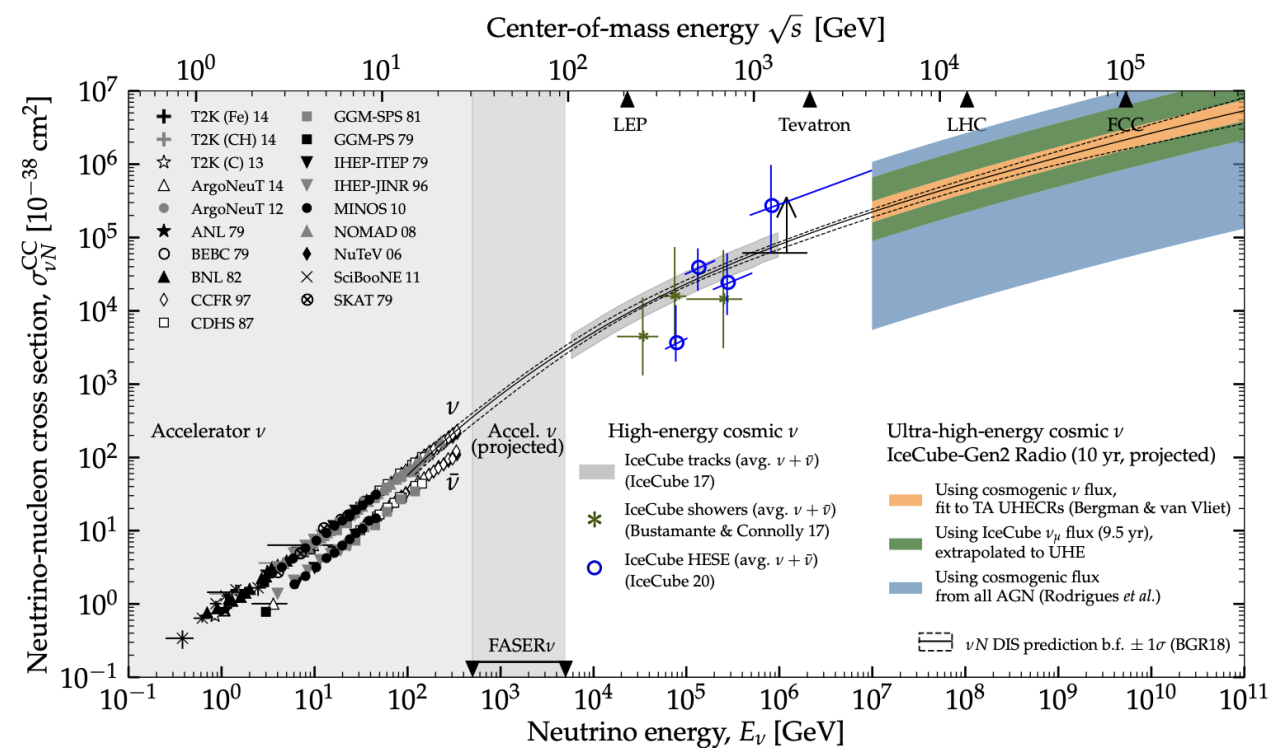


30 x coincident cosmic ray rate!

Uniquely sensitive in the galactic / extragalactic transition region.

Scientific objectives for IceCube-Gen2

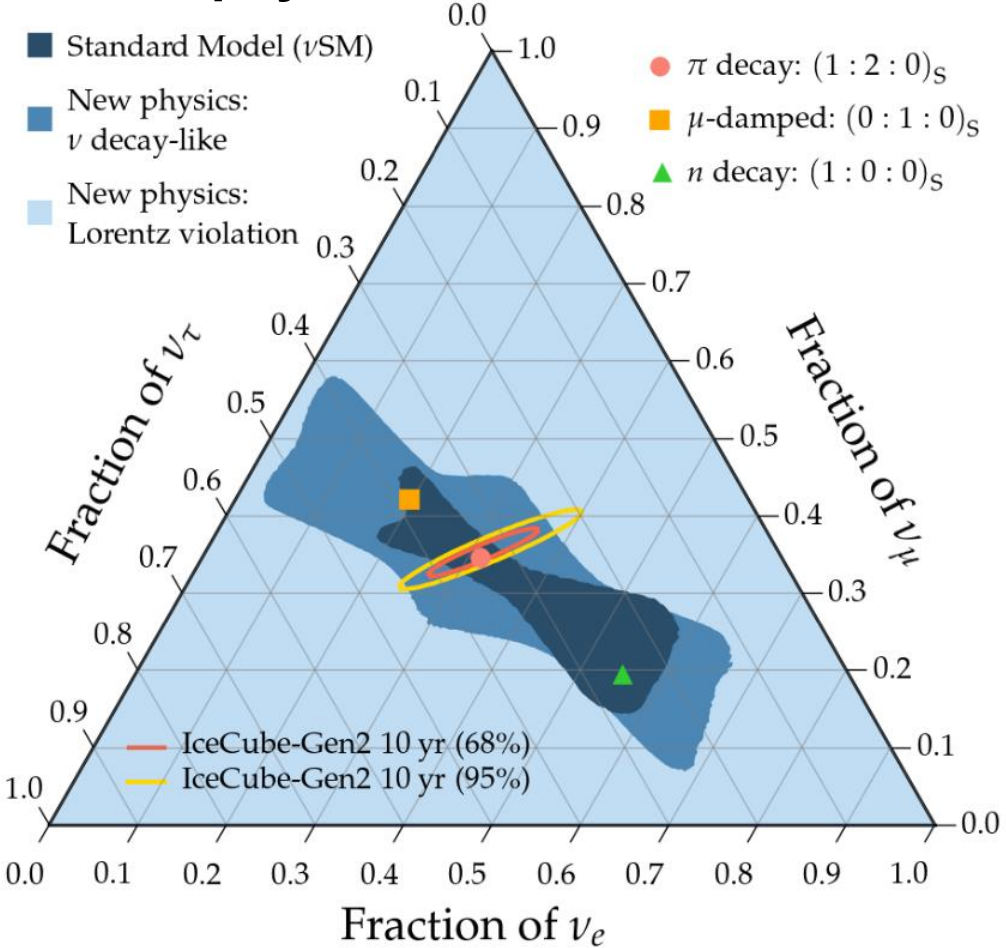
Probing fundamental physics with high-energy neutrinos



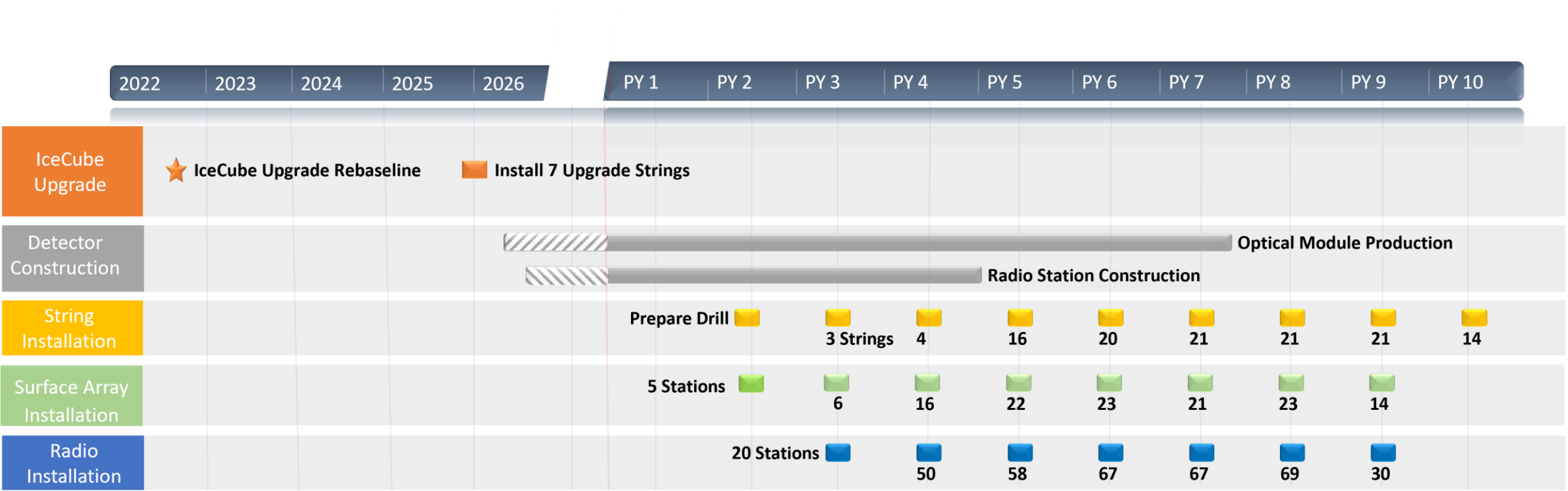
Neutrino cross-sections @ LHC/FCC energies

Plots based on [Valera et al.](#), [Bustamante et al.](#), [Song et al.](#)

Flavor physics over cosmic base lines



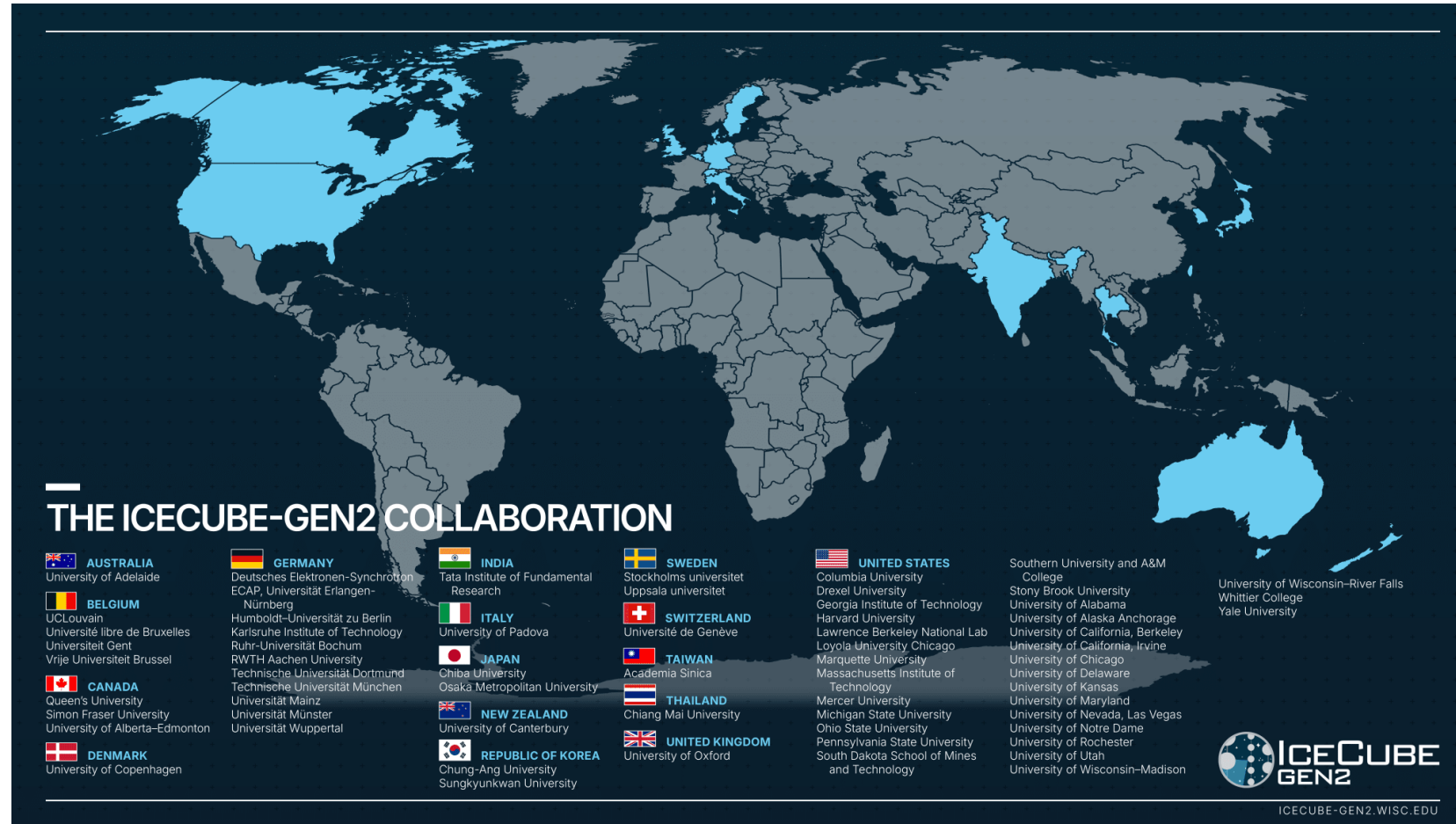
IceCube-Gen2: Schedule



Initial Technical Design Report public, working on preliminary design. Construction will take ten years, initial data from partial configurations already available after five years

IceCube-Gen2: Collaboration

- Internat. collaboration of 400+ scientists from 16 countries
- Endorsements/recommendations from major roadmap processes, e.g. US Decadal Survey on Astronomy and Astrophysics 2020, the Report of the 2023 Particle Physics Project Prioritization Panel (P5 panel), the **Japanese MEXT** roadmap or the European Astroparticle Physics Strategy 2017 - 2026 {APPEC roadmap}, **German BMFTR** roadmap for large scale research infrastructure 2025



IceCube-Gen2 on the German shortlist for large research infrastructure

Forschungsinfrastruktur (FIS) Priorisierungsverfahren

- G** **CREATION**, Medizinische Hochschule Hannover, Universitätsmedizin Göttingen, Universitätsklinikum Leipzig, Fraunhofer-Institut für Zelltherapie und Immunologie (Leipzig/Potsdam-Golm/Halle (Saale)/Rostock/Würzburg)
- D** **DALI**, Helmholtz-Zentrum Dresden-Rossendorf e.V.
- E** **Vorphase für das Einstein-Teleskop**, RWTH Aachen, Universität Münster, Ruhr-Universität Bochum, Technische Universität Dresden
- H** **HBS-I**, Forschungszentrum Jülich, Helmholtz-Zentrum Hereon (Geesthacht)
- I** **IceCube-Gen2**, Deutsches Elektronen-Synchrotron (Hamburg/Zeuthen), Karlsruher Institut für Technologie
- L** **LEGEND-1000**, Max-Planck-Institut für Kernphysik (Heidelberg), Technische Universität München
- P** **PETRA IV**, Deutsches Elektronen-Synchrotron (Hamburg)
- R** **RIDLOP**, GESIS - Leibniz-Institut für Sozialwissenschaften (Köln/Mannheim)
- S** **SLICES-DE**, Technische Universität München



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German proposal: 59 Mio. Euro for construction (~90 % capital costs)
Additional 15,5 Mio. Euro as in-kind

- Deliverables:
3500 optical sensors
A large fraction of the Radio- and surface array

Review Sep 7.-8.: update on project status, funding needs and establish decision points



Japan and Germany, one more time, can make the difference for the IceCube extension to be realized

Summary

Subheading, optional

- IceCube's discovery of cosmic neutrinos and evidence for galactic and extragalactic sources has started a new chapter in high energy astrophysics.
- IceCube-Gen2 needed to address the questions raised by 10+ years of IceCube.
- Mature design for IceCube-Gen2, many details to be found in our [Technical Design Report](#).
- International contributions are coming together, so the chances to realize IceCube-Gen2 are better than ever!

