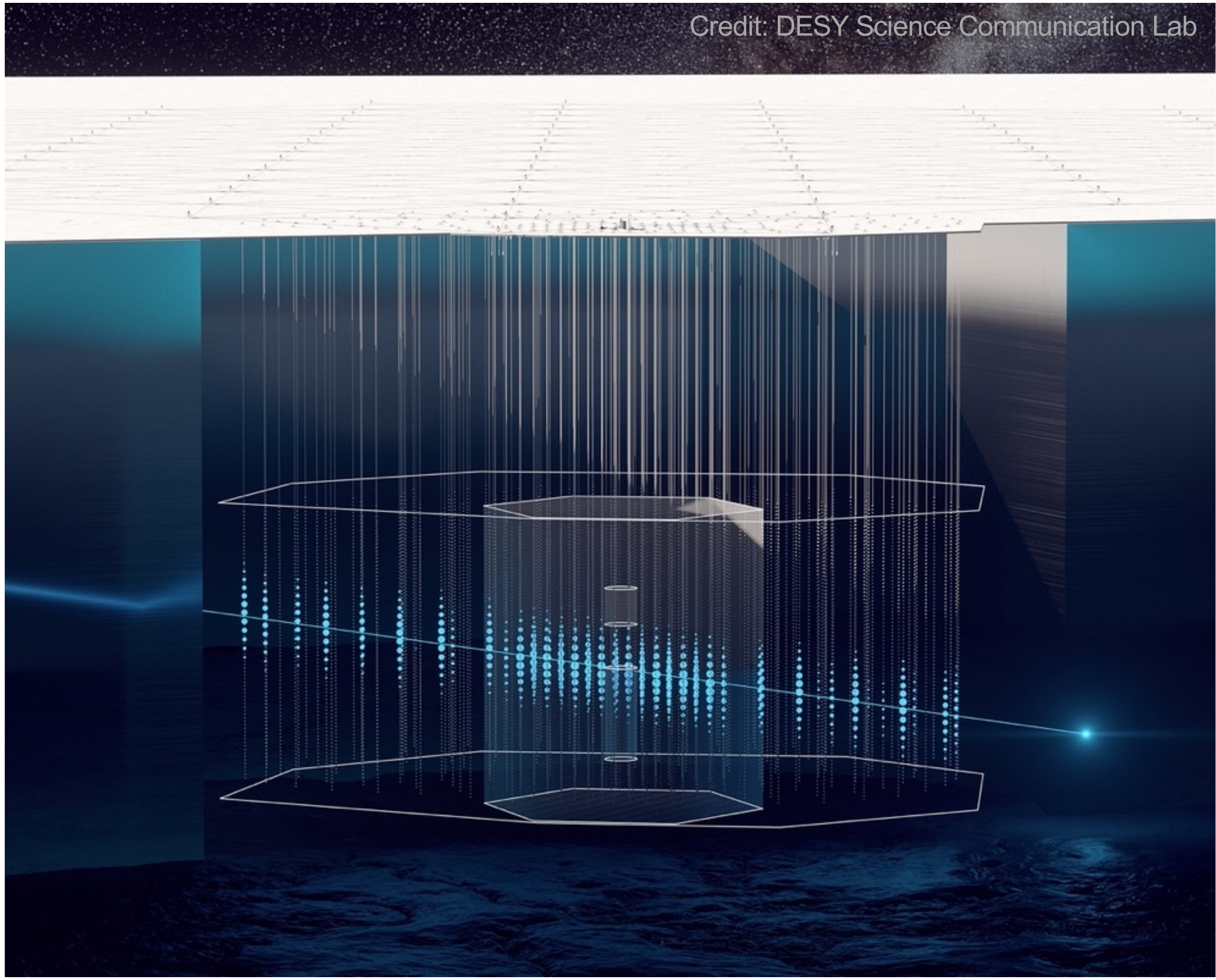
Simulation and sensitivities for a phased IceCube-Gen2 deployment



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ICRC 2021
"Berlin"

ONLINE ICRC 2021
THE ASTROPARTICLE PHYSICS CONFERENCE
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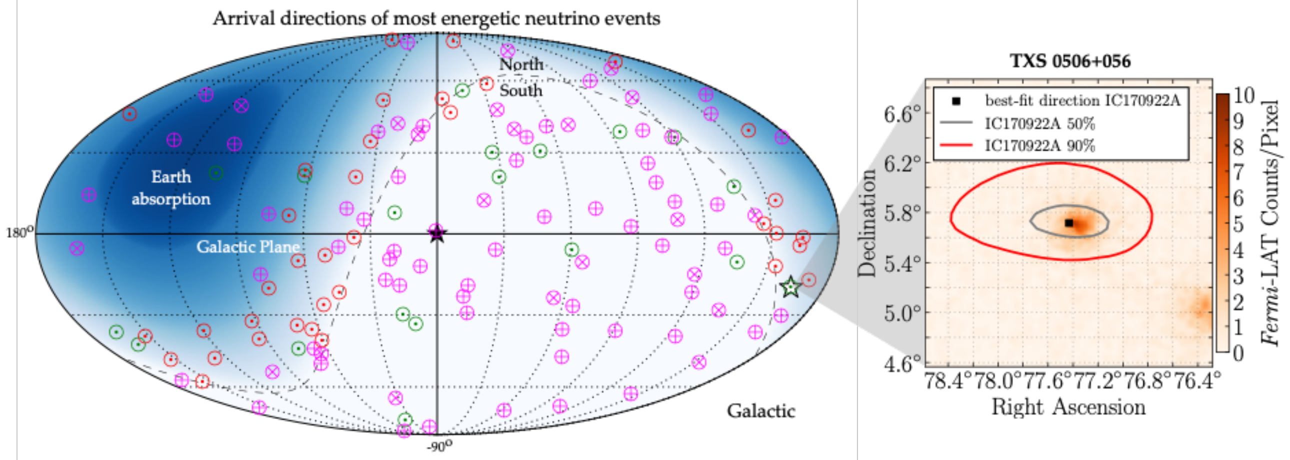
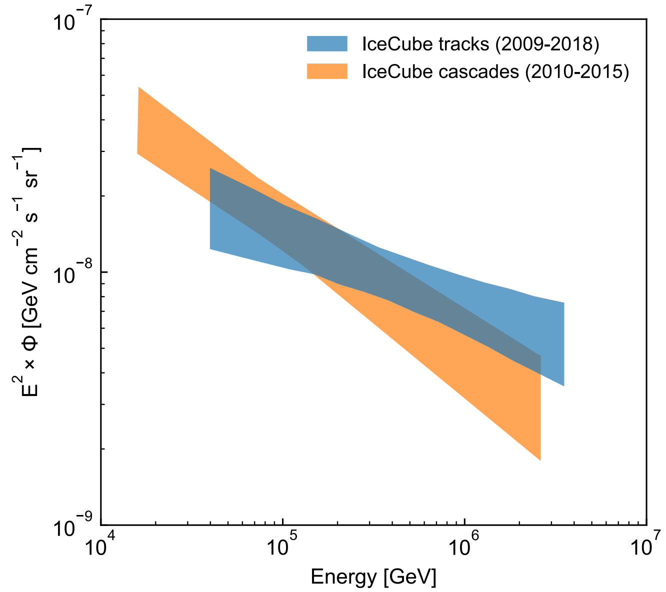
Questions

- What we know about the flux of high-energy neutrinos
  - Roughly power law in shape
  - Seemingly flavor democratic
  - Consistent with isotropic arrival direction
- But…
  - No definitive sources (some tantalizing evidence!)
  - No UHE neutrinos
- Goals for a next generation instrument:
  - Better pointing for point source localization and multi-messenger observations ⟶ improved angular resolution
  - Statistically significant observations over a broad energy range





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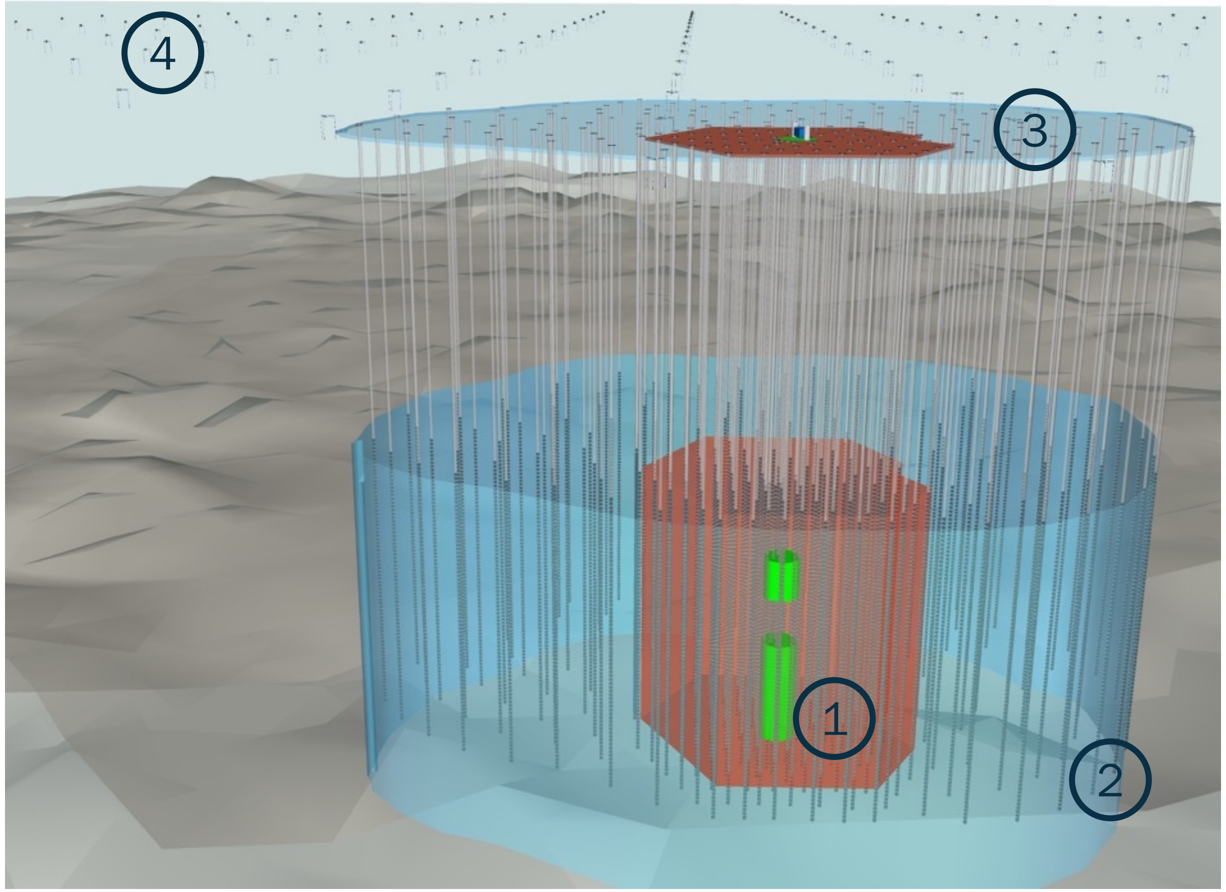
IceCube GEN2

IceCube-Gen2

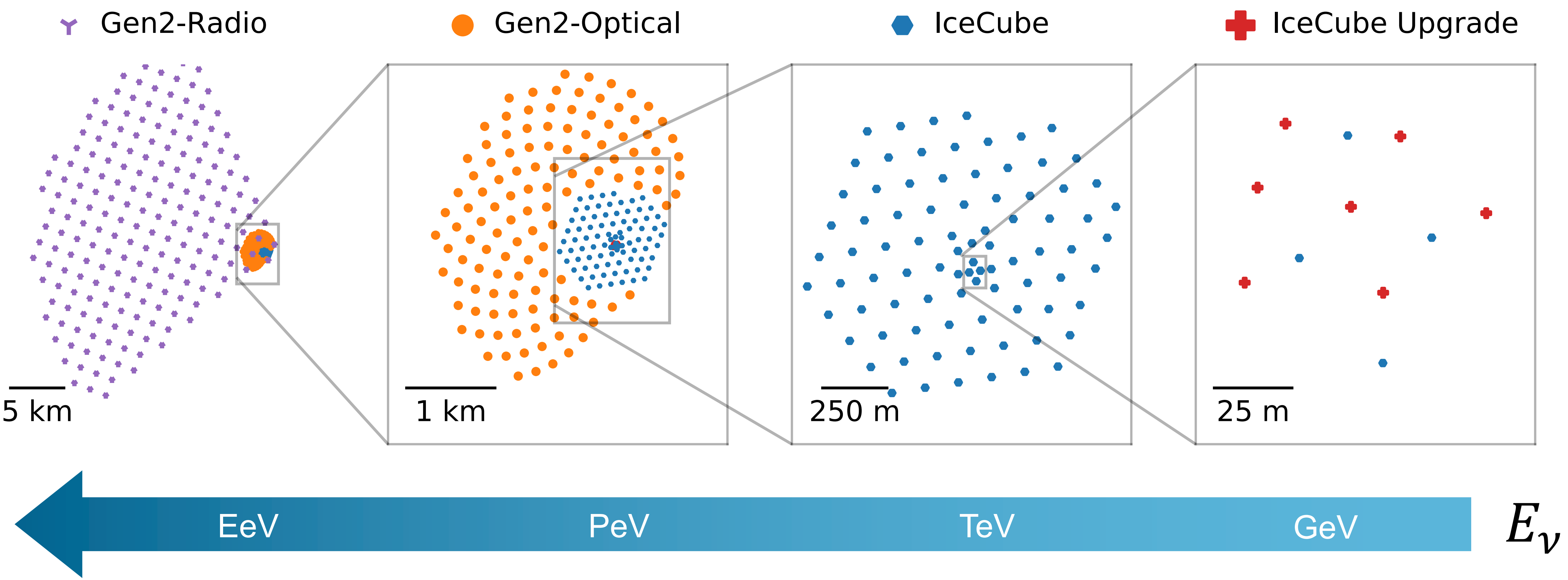
A broadband neutrino observatory

Four new elements, leveraging complimentary technologies, to achieve sensitivity to MeV-EeV neutrinos

1. IceCube Upgrade
2. Enlarged deep optical array
3. Surface Array
4. Shallow radio array



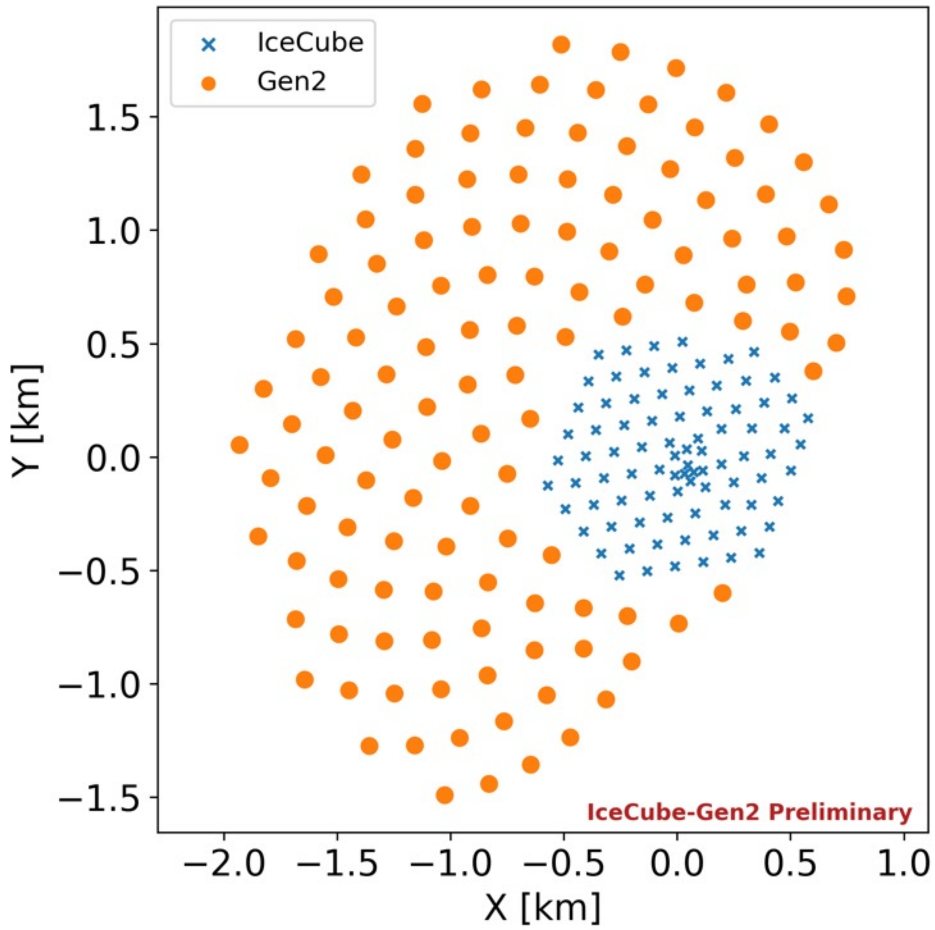
IceCube-Gen2



Gen2-Optical

TeV-EeV neutrinos

- 8 km^3 optical array: ~10x volume of IceCube
- Laid out in a "Sunflower" pattern
  - 120 strings, 240m lateral spacing
  - 80 OMs/string, 17m vertical spacing
- Larger depth range than IceCube
  - Gen2: 1340-2700 m
  - IceCube: 1446-2451 m
- Deployment expected to take ~7 seasons, with ~21 holes drilled per season
  - Drill rate ramps up in first two seasons



Gen2-Optical

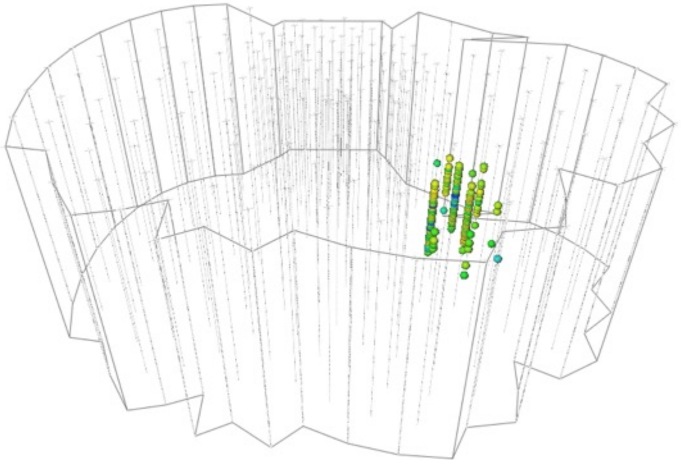
Event Topologies

- Like IceCube (and many other telescopes!) two primary detection channels: cascades and tracks
- Focus on *throughgoing* tracks
  - $\nu_\mu/\bar{\nu}_\mu$ charged-current interactions
  - Vertex *outside* of the contained volume
- This class of events provides the longest lever arm for reconstruction of neutrino direction
- Provides best sensitivity in search for sources of neutrinos

Cascades

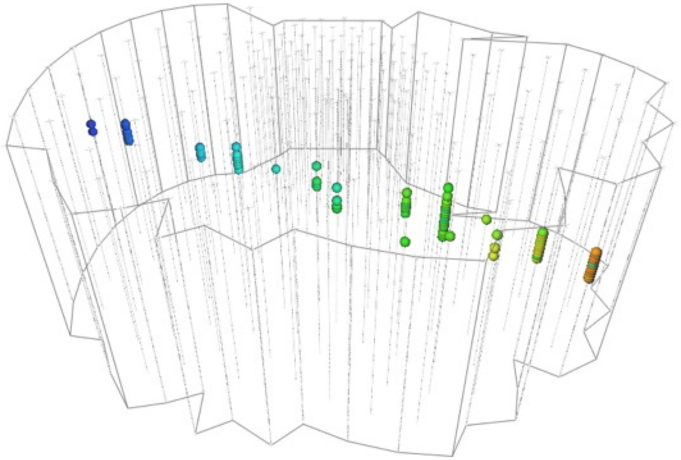
$\nu_e/\bar{\nu}_e$, $\nu_\tau/\bar{\nu}_\tau$ charged current

All flavors neutral current



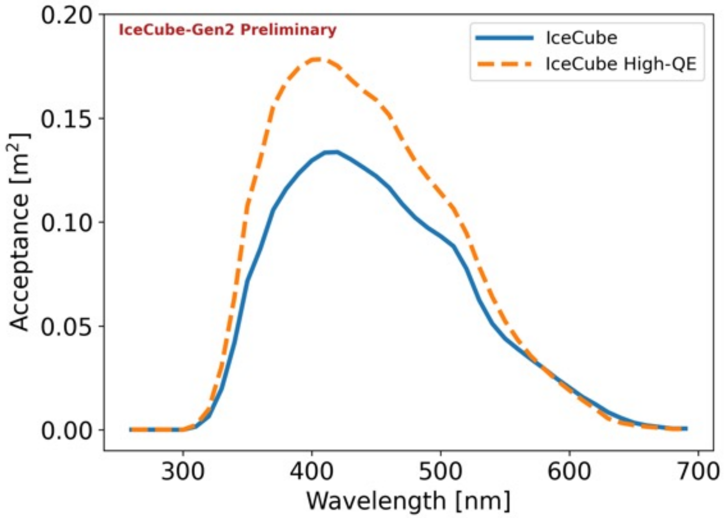
Tracks

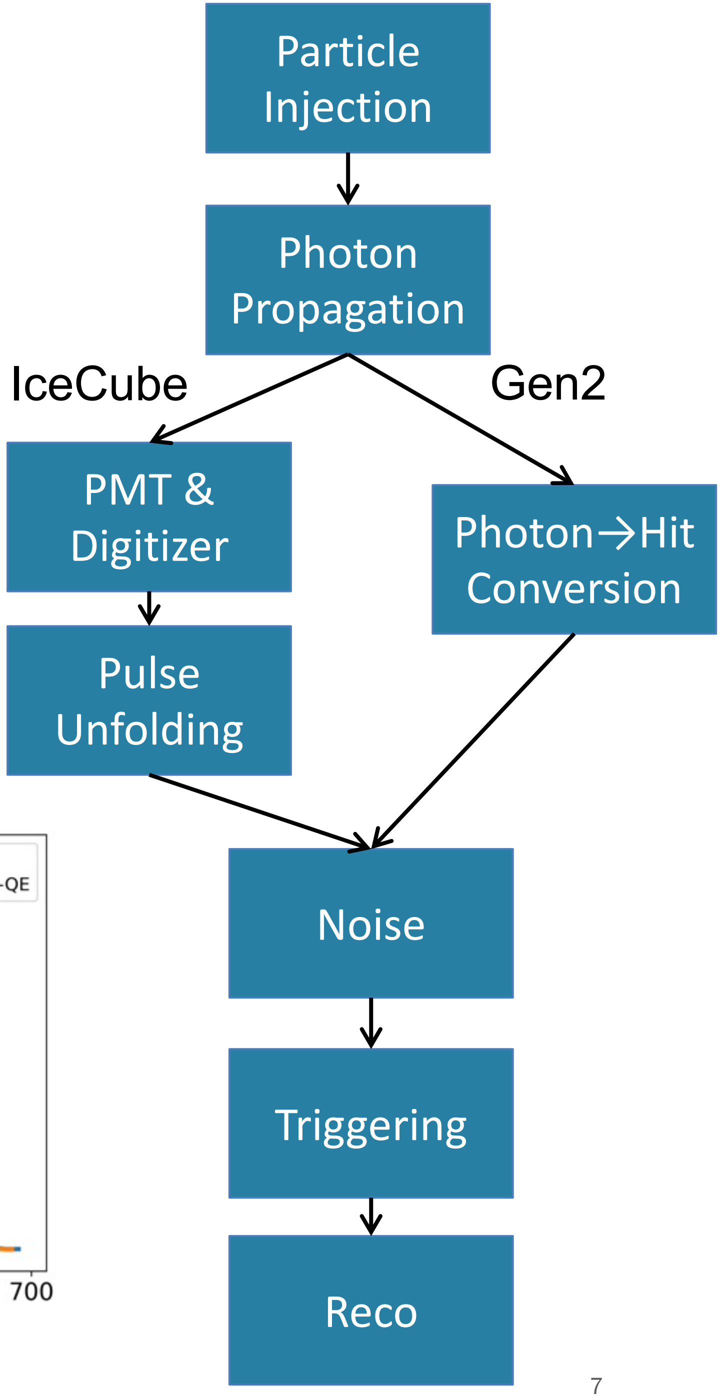
Mostly $\nu_\mu/\bar{\nu}_\mu$ charged current



Simulation

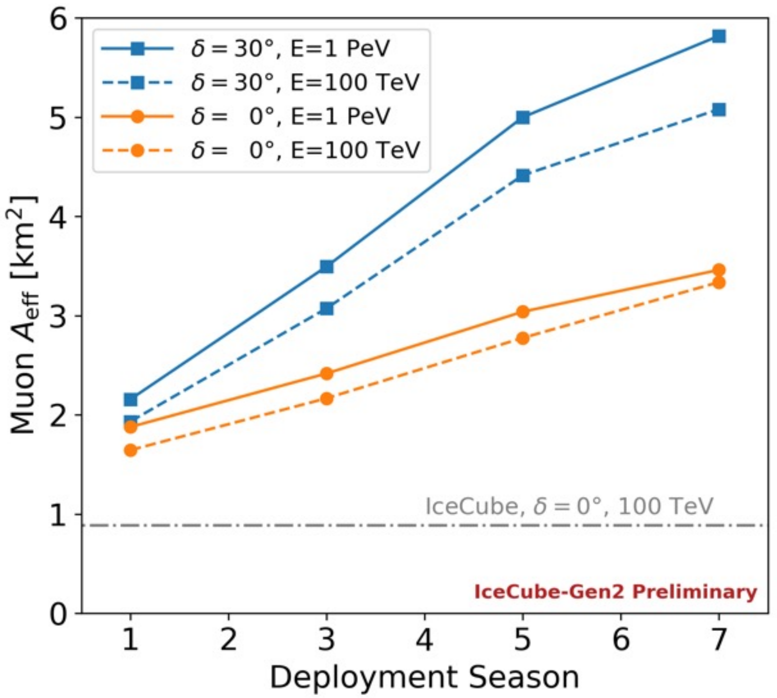
- Hard, isotropic flux of single high energy muons (3 TeV-100 PeV, $E^{-1.4}$)
- Photons are propagated in ice (*CLsim* code)
    - Photons weighted by module wavelength acceptance for efficiency
- Received photons are processed into recorded hits
- Models of noise and triggers are applied
- Finally, apply likelihood based reconstruction

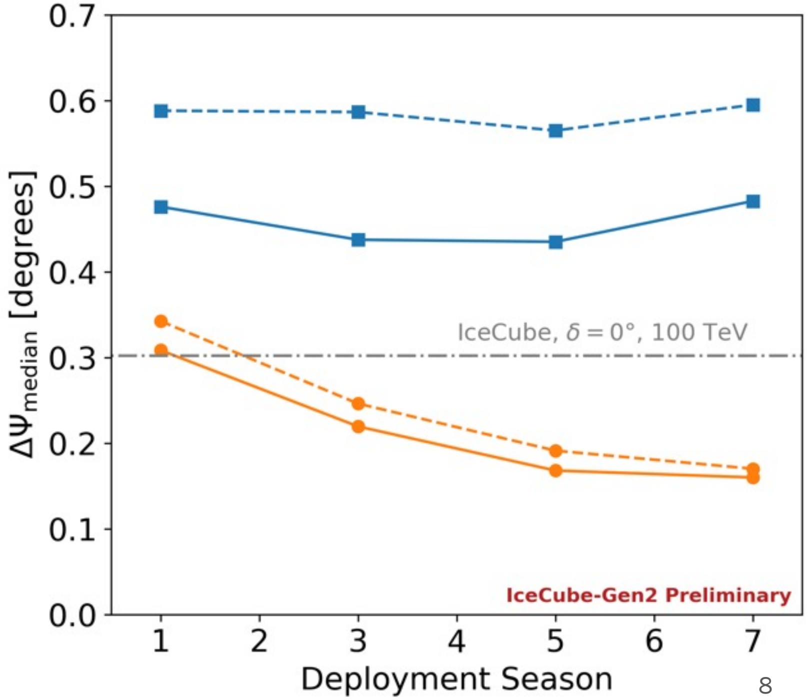




Performance

- Apply quality cuts to isolate well-reco'd tracks
  - Minimum number of hit OMs
  - Minimum reco track length, etc.
- Two key figures of merit
  - Muon effective area
  - Median angular error ("angular resolution")
- Halfway through construction, IceCube-Gen2 will already have:
  - 2x the aperture for horizontal events
  - 50% better angular resolution

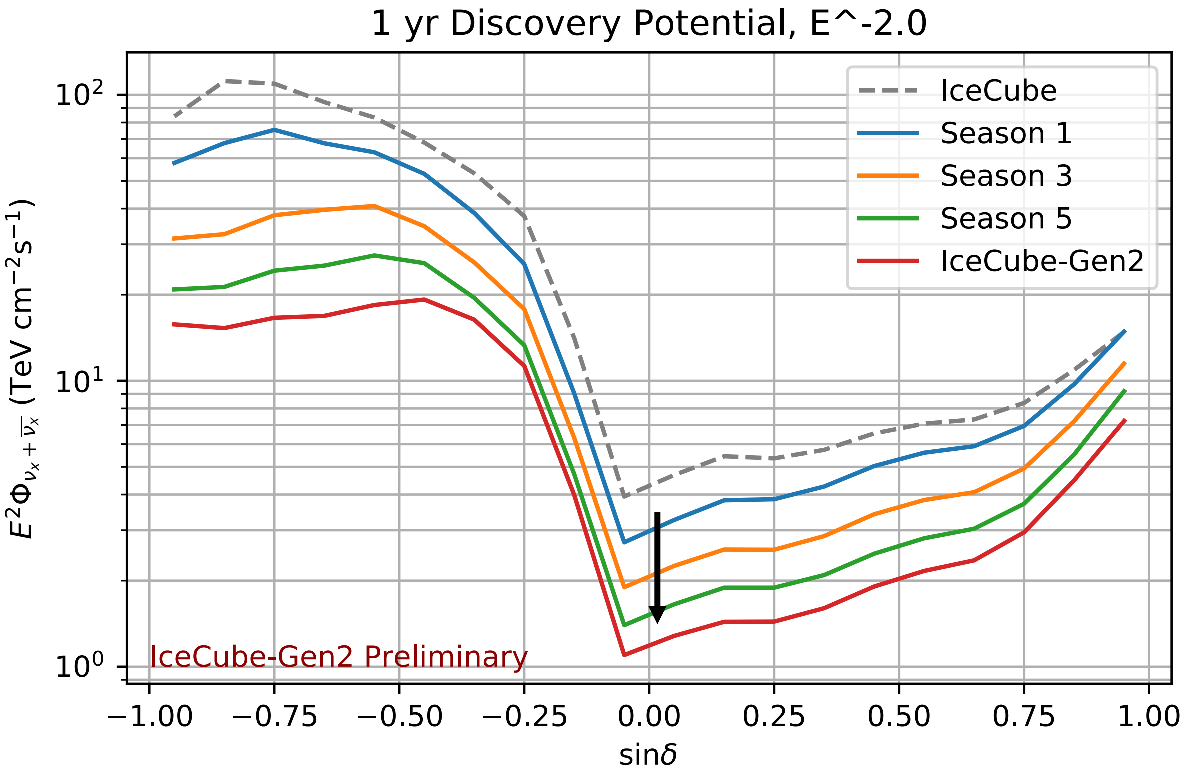




Sensitivity

Steady Sources

- Estimated 1-year discovery potential for E^{-2} spectrum
- Background assumed to be conventional + prompt atmospheric neutrino flux (Honda, Enberg, + Gaisser H3a)
- Flattening at $\sin\delta < -0.5$ due to growing surface veto



Season	# Deployed Strings
1	19
3	51
5	87

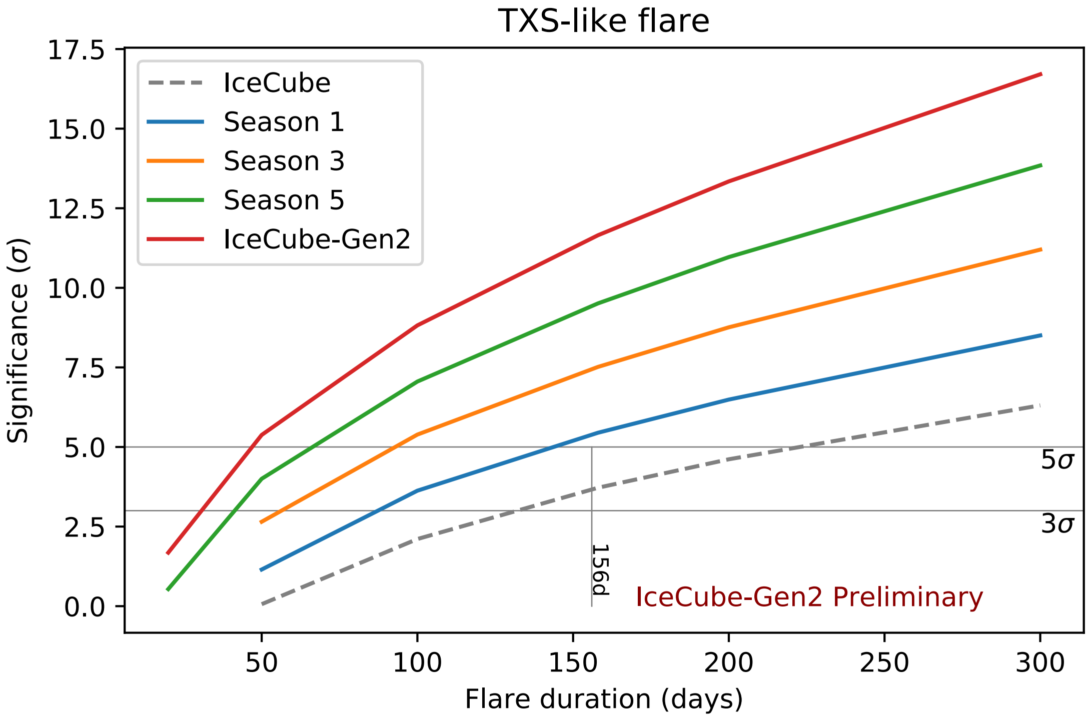
Sensitivity

Flaring Sources

- Estimated significance of detection of a flare as a function of flare duration

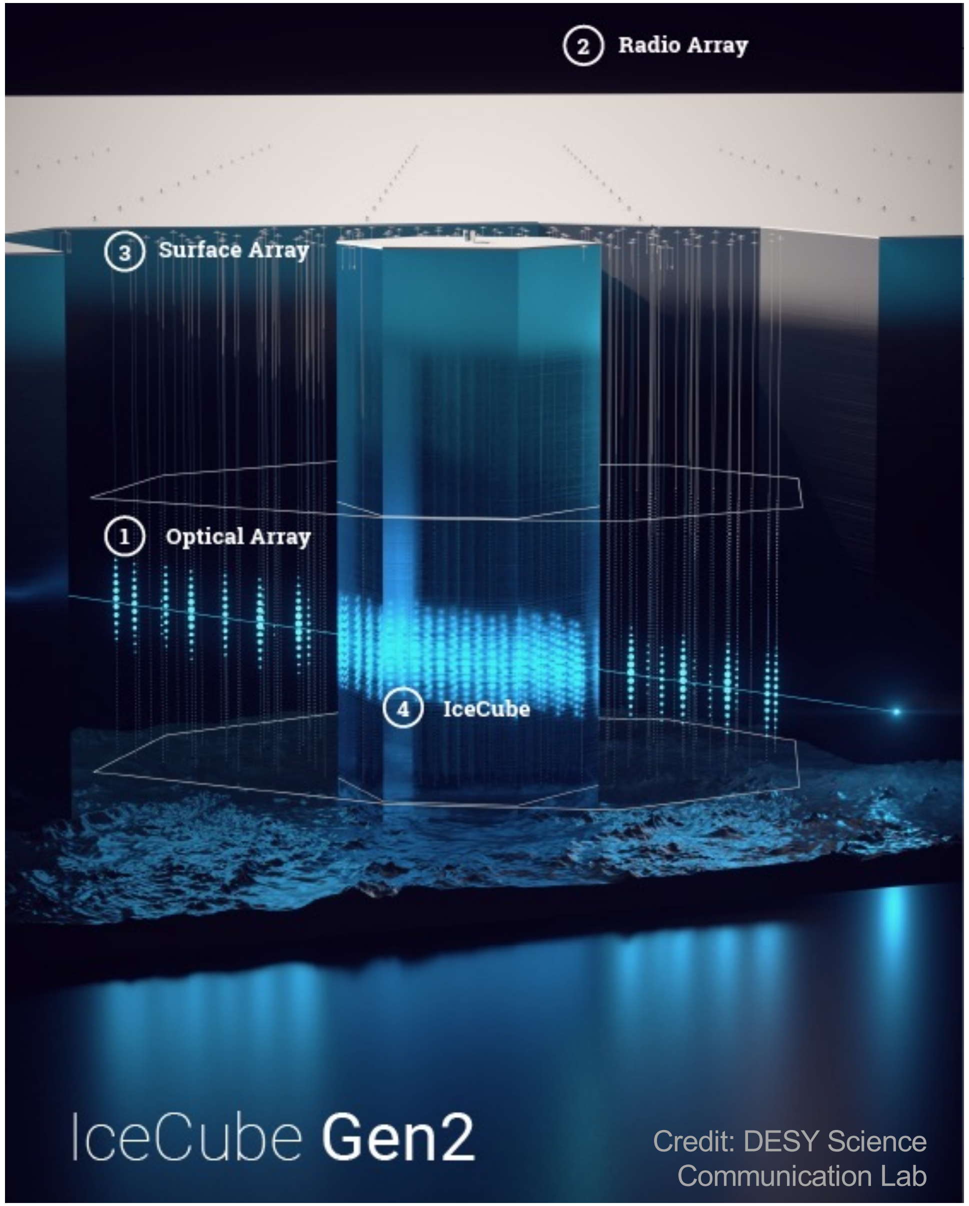
- Flare model: 2014/15 flare of TXS0506+056
  - $E^{-\gamma}$, with $\gamma = 2.2 \pm 0.2$
  - 156 days long in "box shaped" analysis

- 14/15 flare would have been seen in Gen2 at $> 5\ \sigma$ within the first season after deployment



Conclusions

- Gen2 will be a broadband neutrino observatory with unprecedented capabilities
- An enlarged optical array will be built over ~7 Antarctic seasons
- Even during construction, Gen2 will have rapidly increasing discovery potential



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