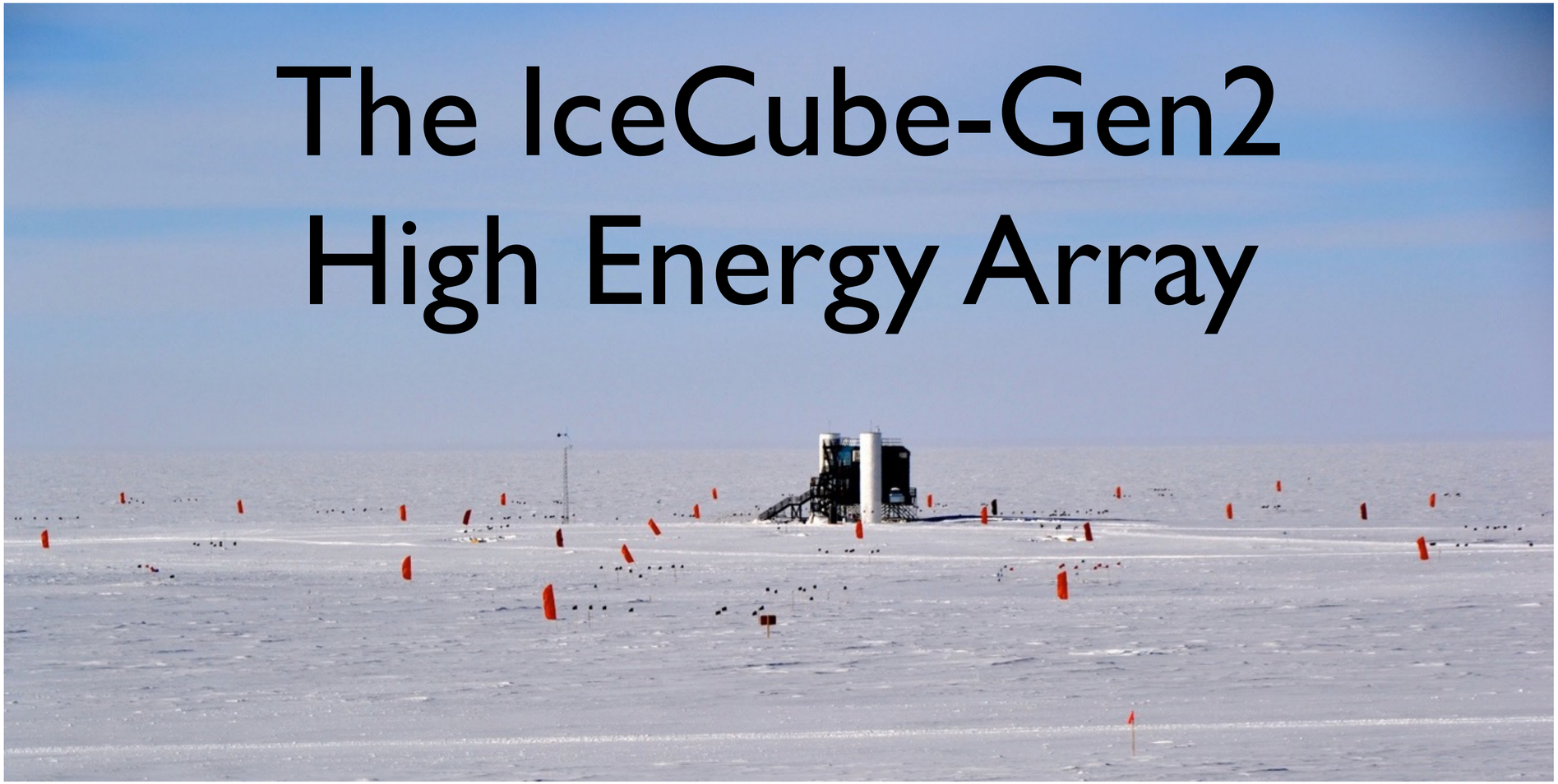
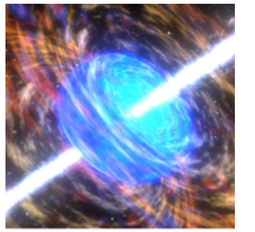
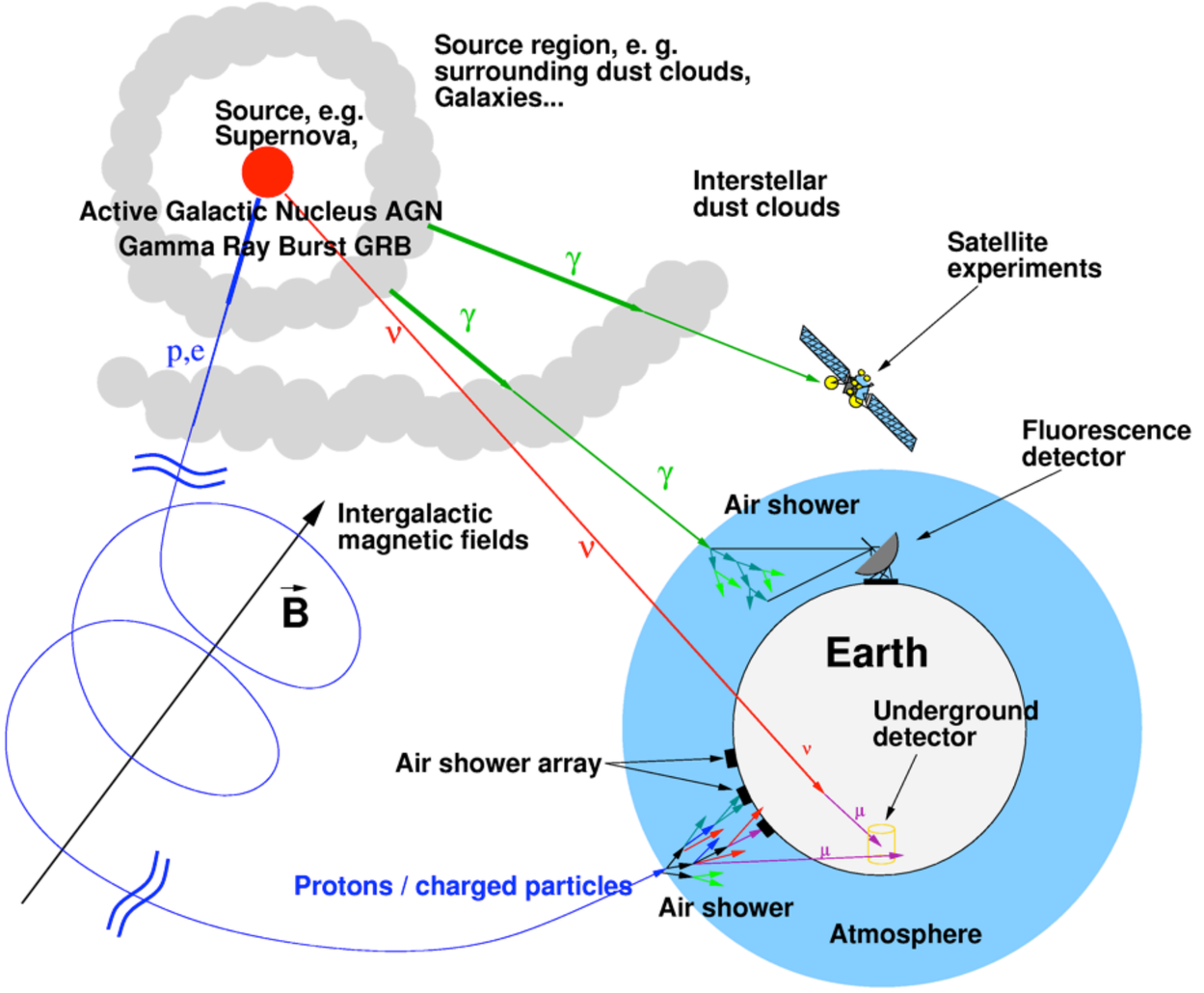
The IceCube-Gen2 High Energy Array

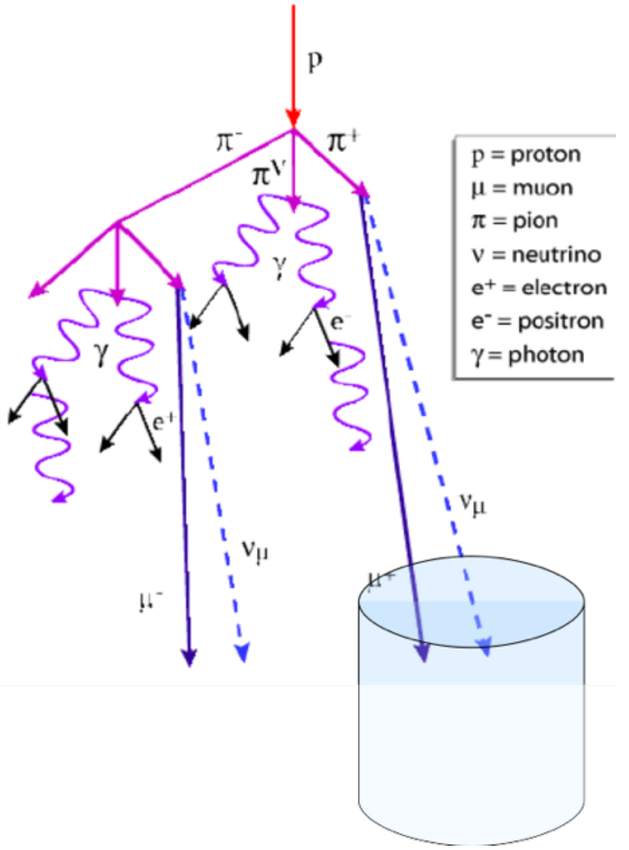


E. Blaufuss, C. Haack, C. Kopper
for the IceCube-Gen2 collaboration

Neutrinos as astrophysical messengers







Neutrino from atmospheric air showers often accompanied by muons

Astrophysical neutrinos

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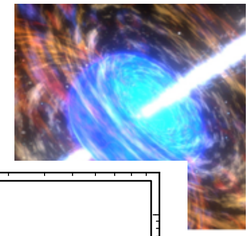
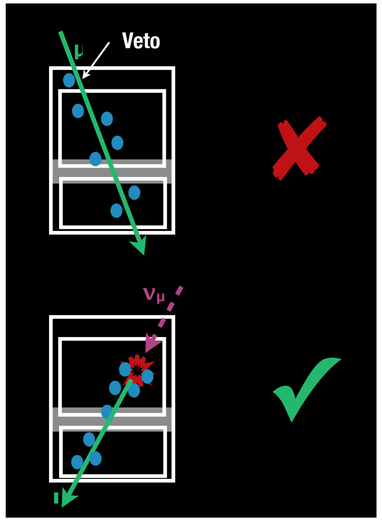
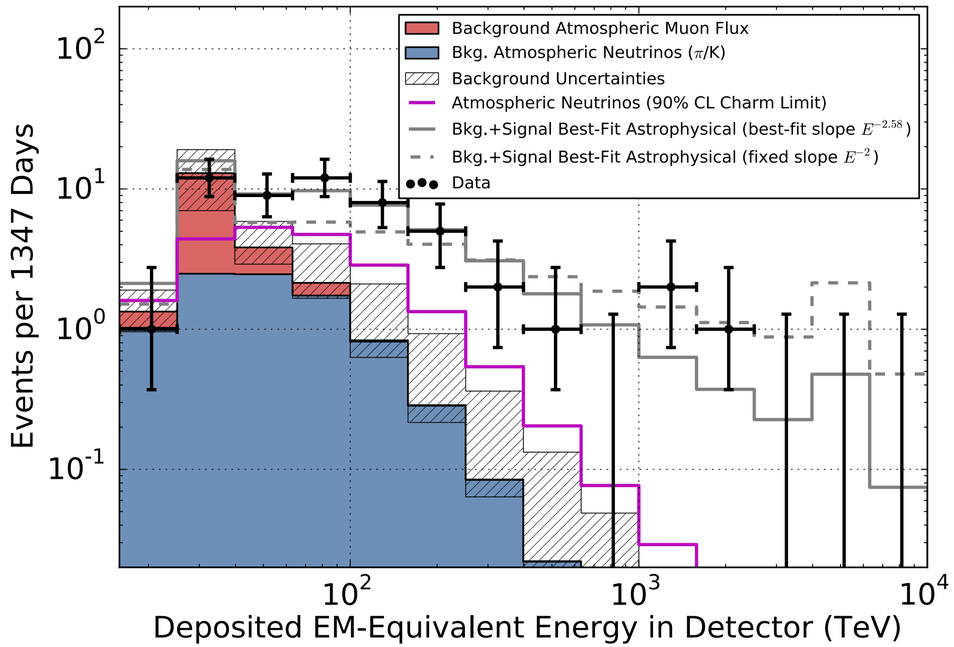
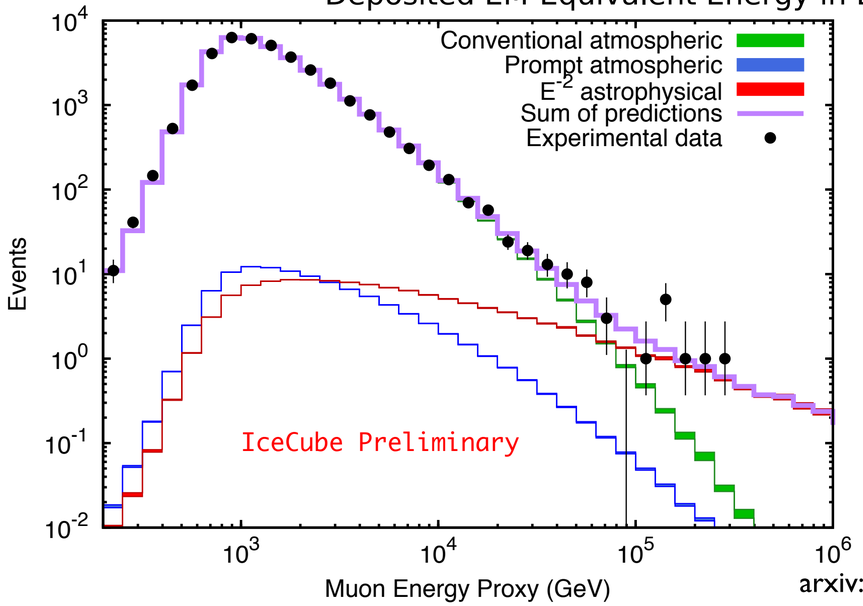


- IceCube
  - 1 km^3 neutrino detector located at South Pole
  - In full operation since 2011
- Observed astrophysical neutrinos
  - Several independent analyses
- First light in field of neutrino astronomy

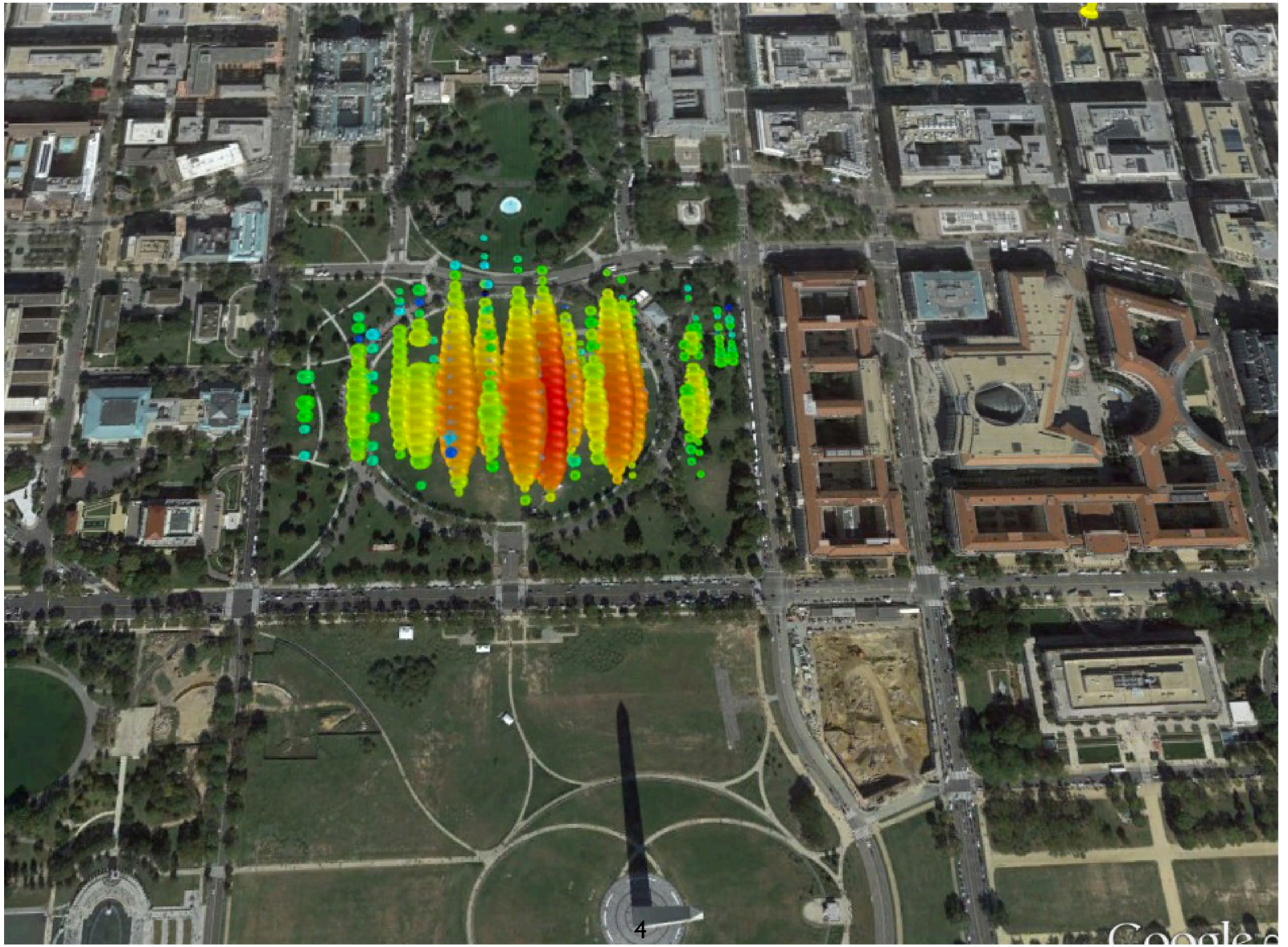






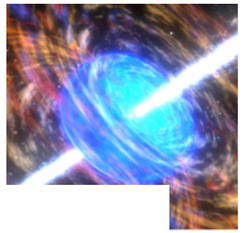
arxiv:1507.04005

The PeV Scale



Many questions

- So far, observed astrophysical flux is consistent with a isotropic flux of equal amounts of all neutrino flavors
  - No evidence for a point source in several analyses
- Where are the point sources?
- What is the spectrum? Cutoff?
- What is the flavor composition?
- Multi-messenger physics?
- GZK neutrinos?



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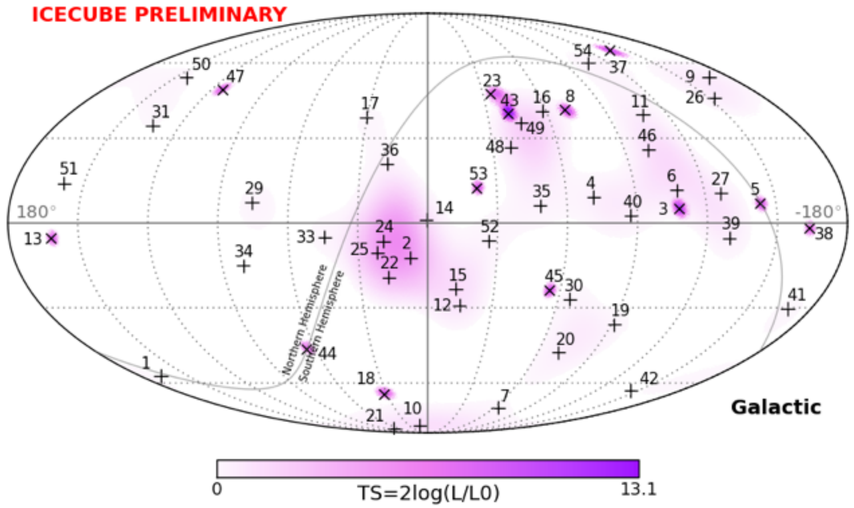
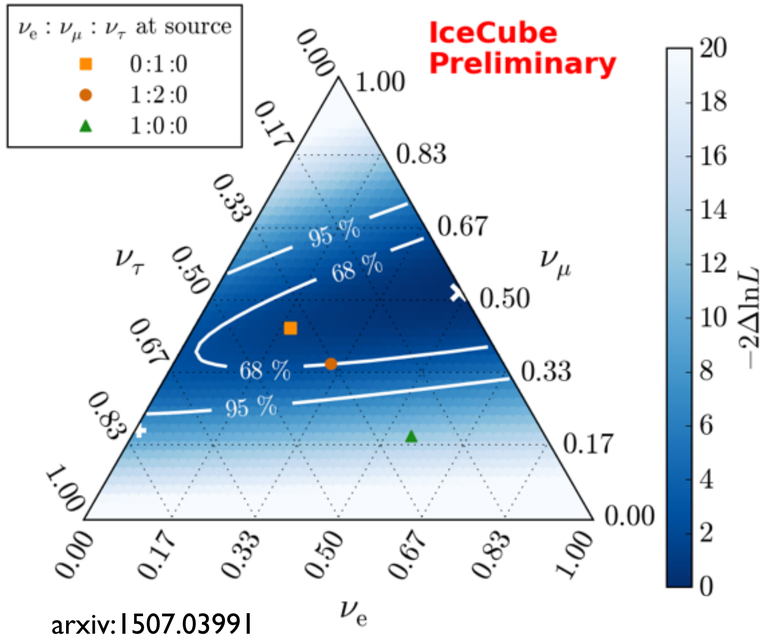
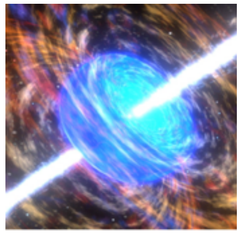




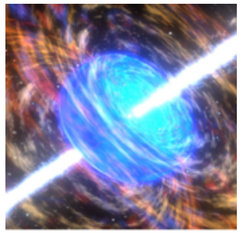
arxiv:1507.03991



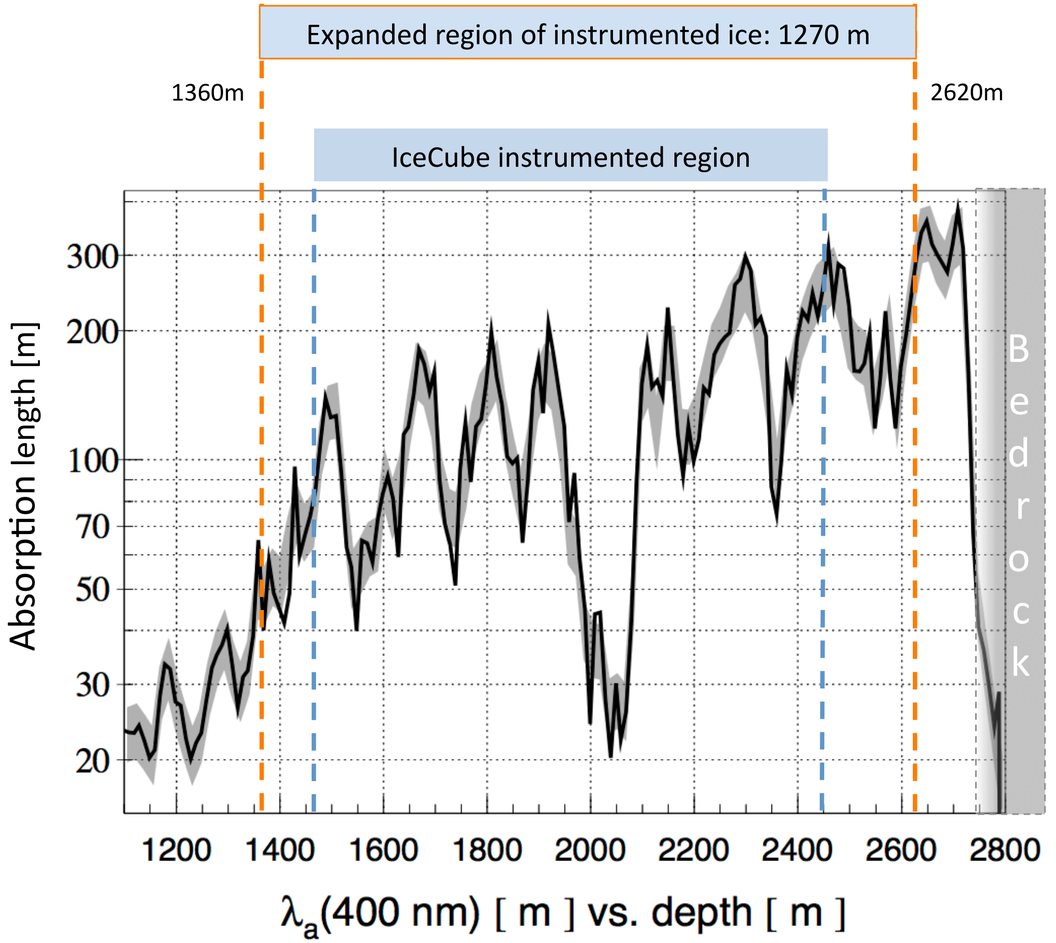
IceCube: Gen2

- While able to deliver amazing discoveries, IceCube is limited by the small numbers of astrophysical neutrinos
  - ~few 10's of astrophysical neutrinos per year
- The IceCube-Gen2 High Energy Array will instrument a significantly larger volume (~10 km^3)
  - Deliver significantly larger samples of astrophysical neutrinos
- Gains in sensitivity can grow rapidly, especially for transient events.
  - Detection of multiple events more likely
  - Sensitive to wider classes of transient phenomena

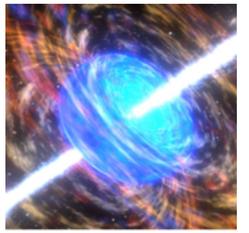
Antarctic Ice



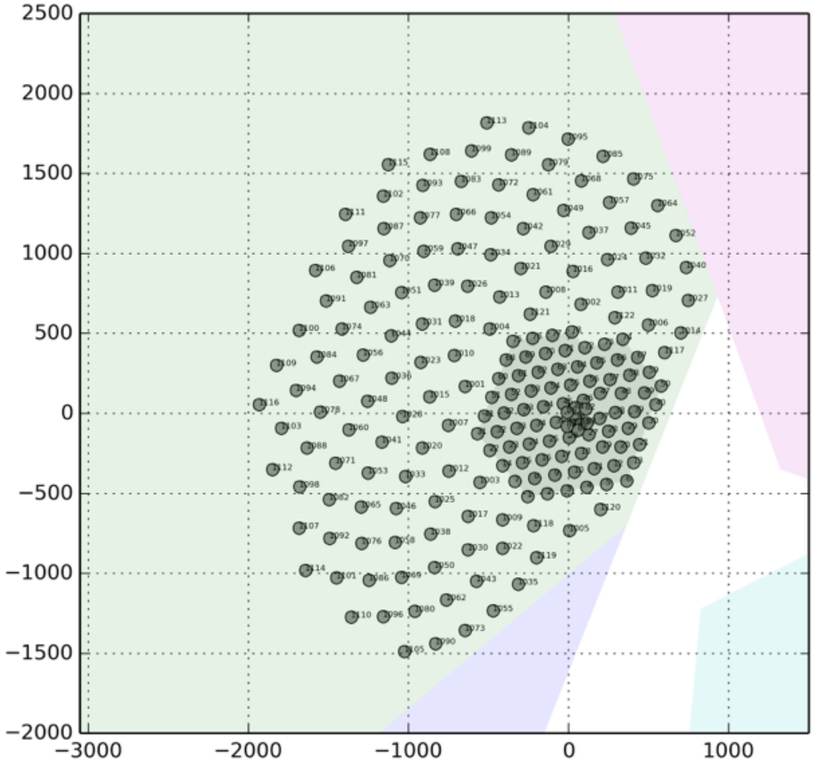
- Construction of IceCube has yielded a wealth of data on the optical properties of glacial ice.
  - Absorption length for Cherenkov light is large
- We can extend instrumented length above and below current instrumented volume
  - 25% gain in instrumented volume



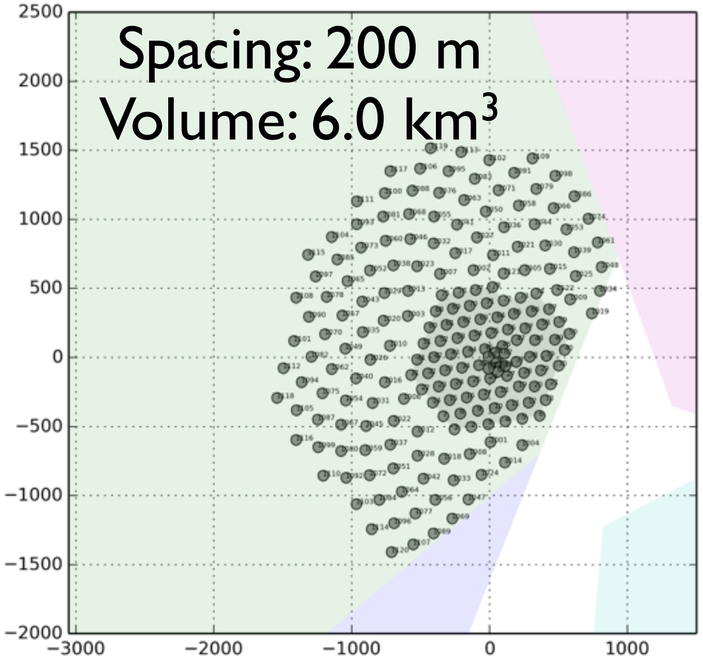
Gen2 High Energy Array: Realization

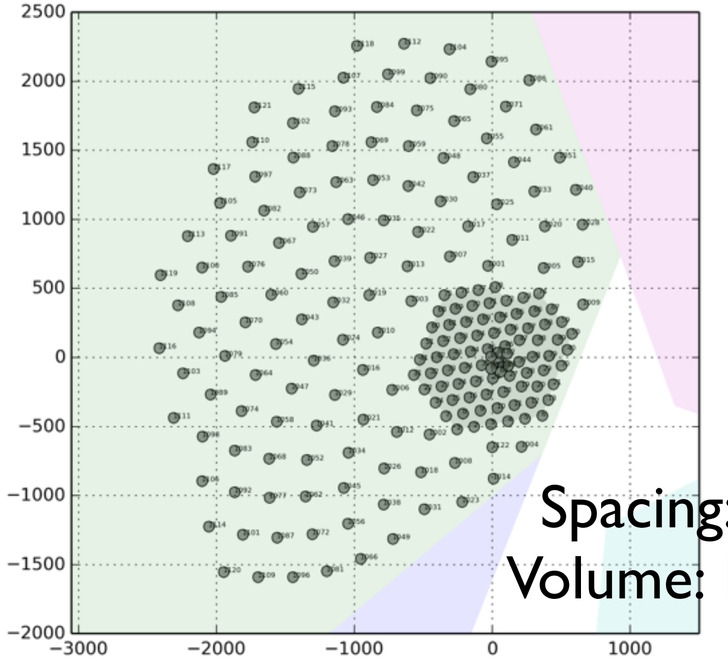


- Benchmark detector designs have been simulated that:
  - Add strings around the IceCube instrumented volume
  - Add ~120 strings
    - Vary string spacing uniformly (200m, 240m and 300m)
    - Edge-weighted geometry to evaluate the impact on veto techniques

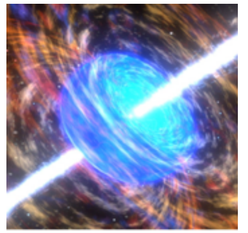


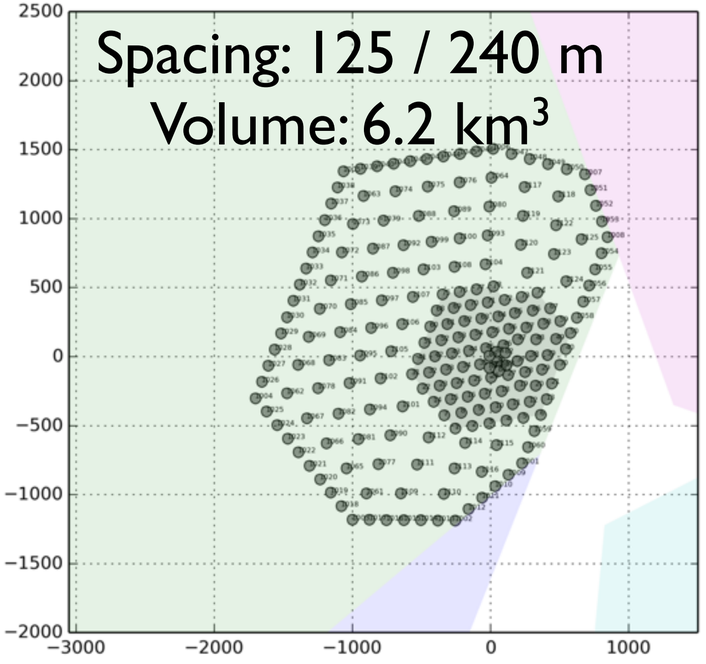
Spacing: 240 m
Volume: 8.0 km^3

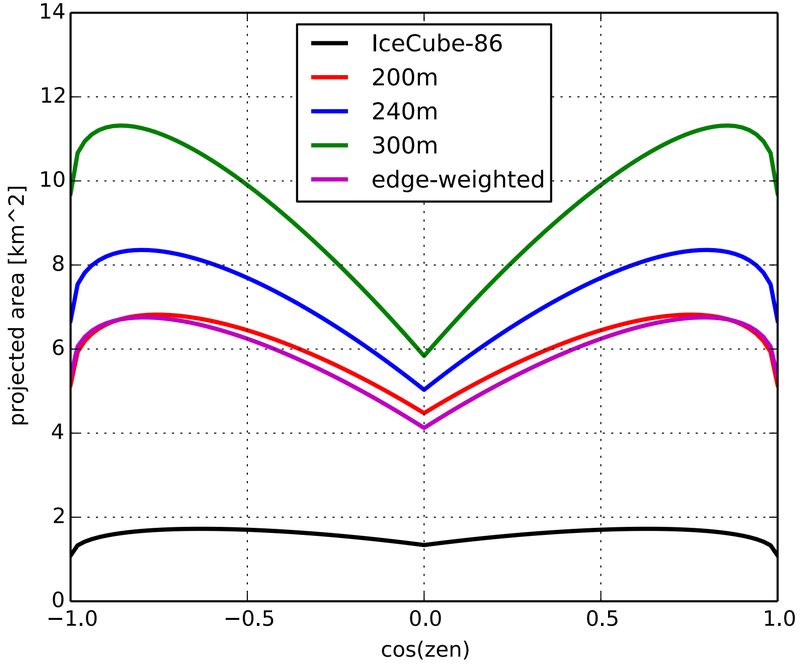


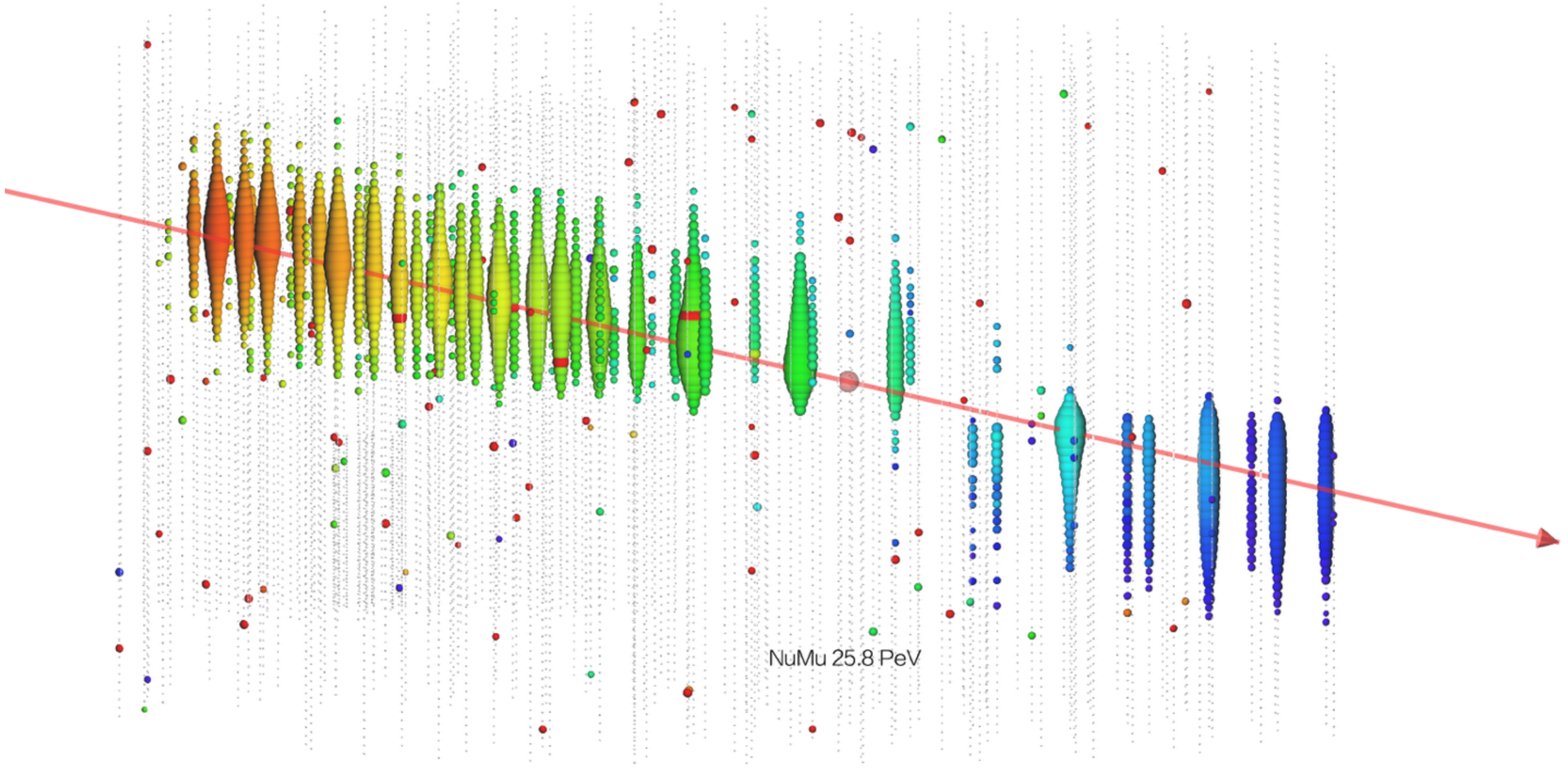


Spacing: 300 m
Volume: 11.9 km³

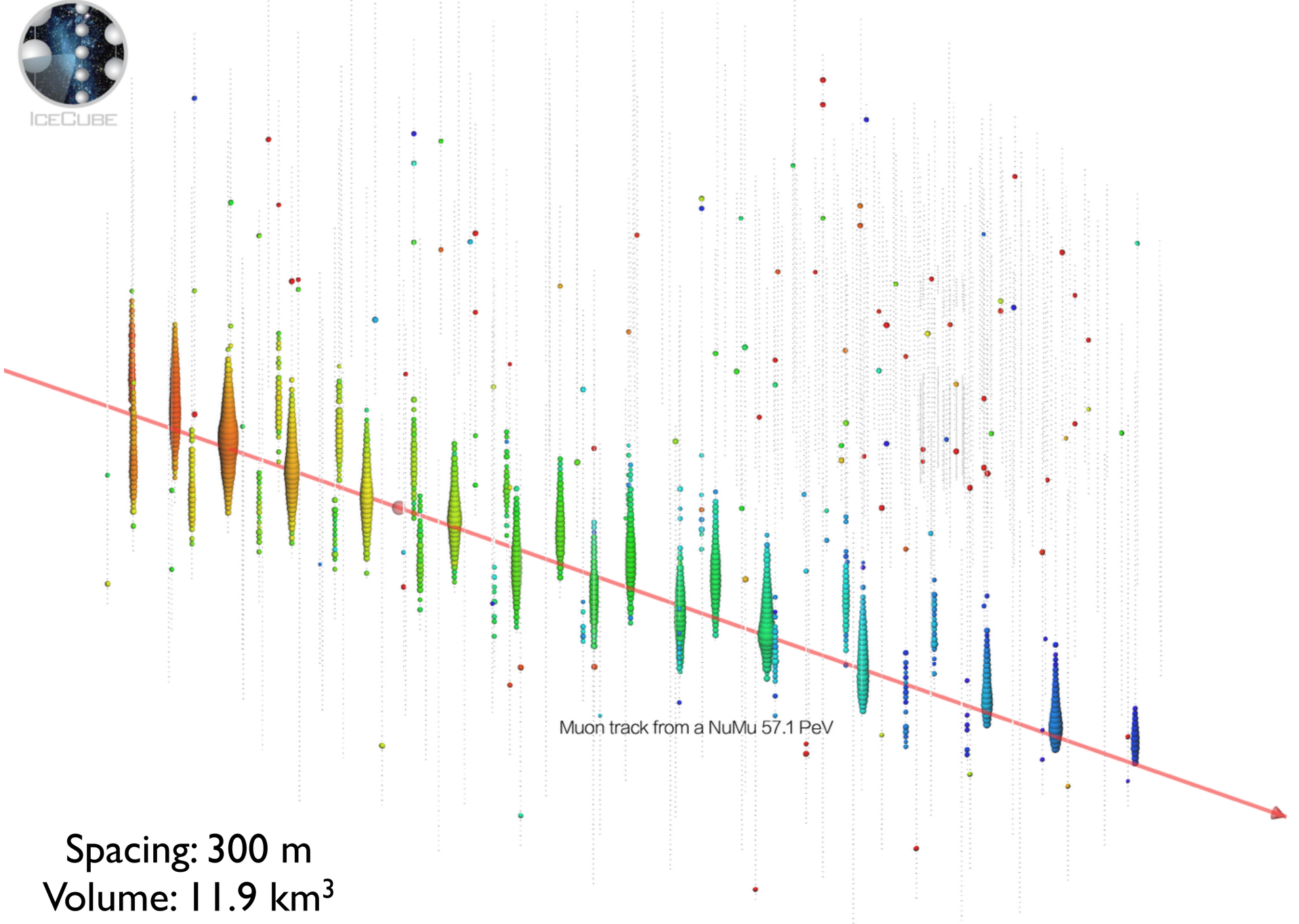




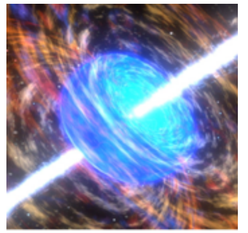




Spacing: 240 m
Volume: 8.0 km^3

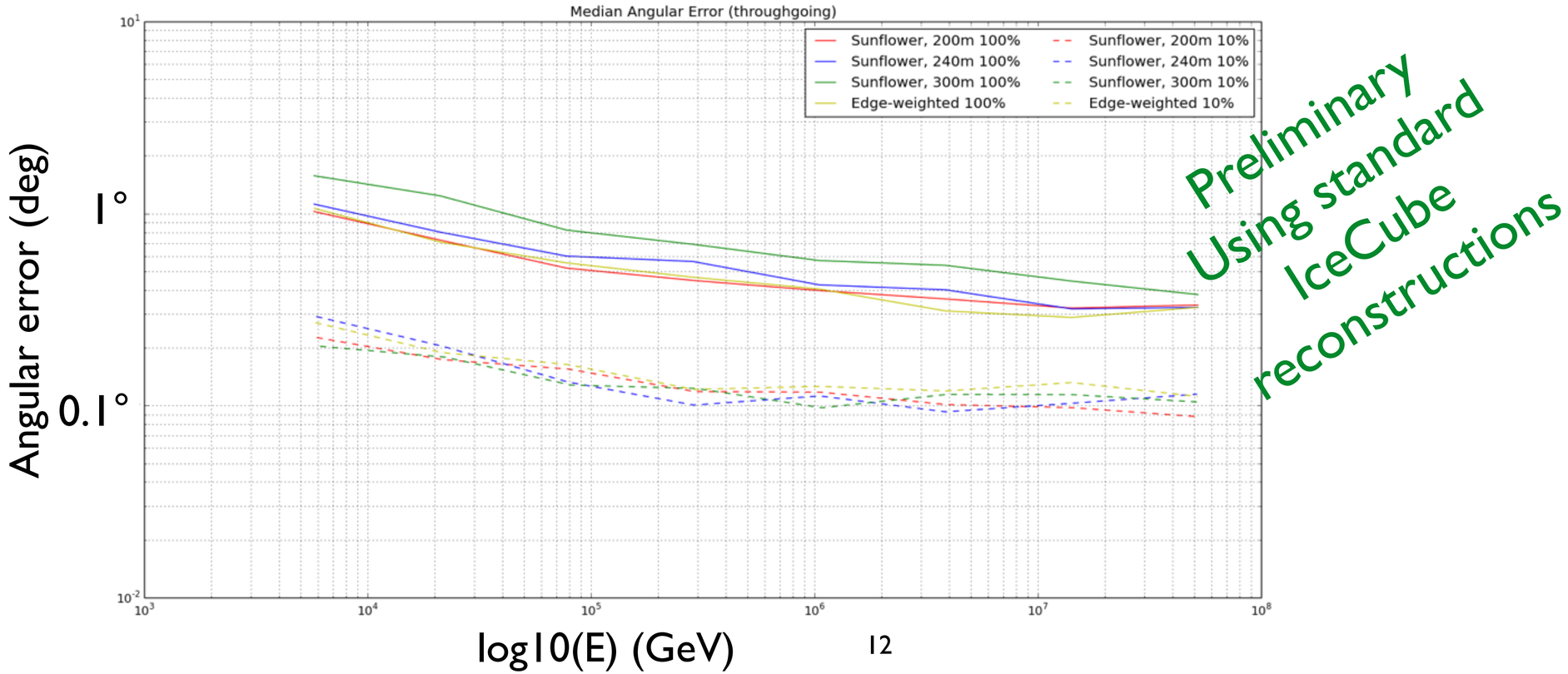


Spacing: 300 m
Volume: 11.9 km^3



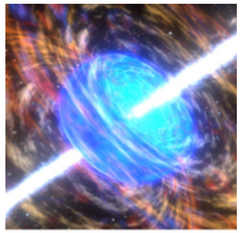
Angular resolutions

- Gen2 geometries show promising angular resolutions
  - Using IceCube reconstructions: 0.3-0.5 degree
  - Selecting highest quality track events(~10%): 0.1 degree
- Expect improvements as reconstructions improve for Gen2 geometries

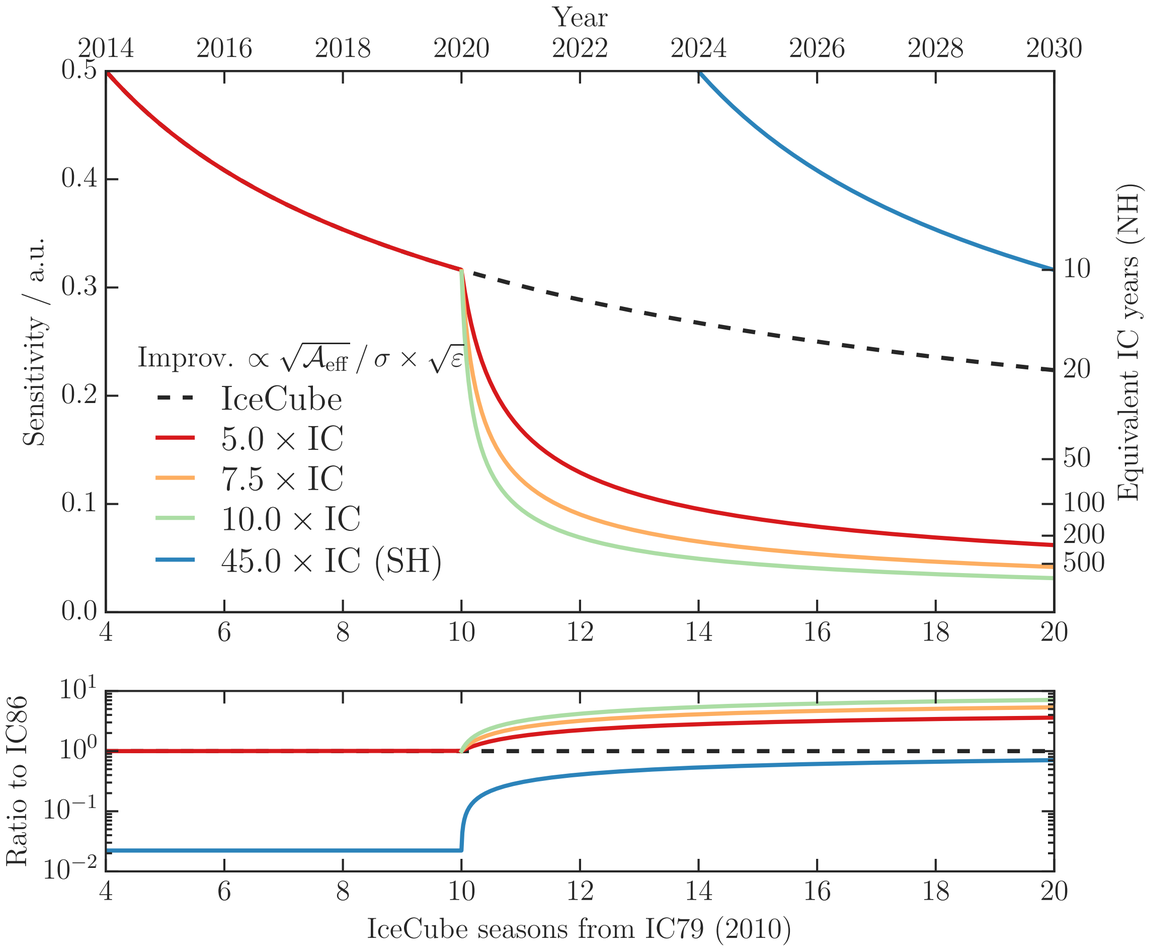


Preliminary
Using standard IceCube reconstructions

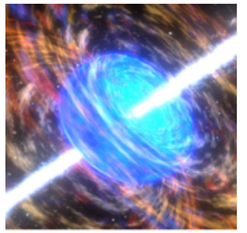
Point source sensitivity



- Evaluation of point source sensitivity is a work in progress for Gen2
- Improved Gen2 specific event selections, reconstructions and methods will increase sensitivity.
- 10 years of observation with Gen2 HEA is equivalent to >200 yrs of IC86
  - Gains in southern hemisphere are strong.



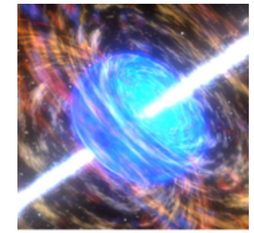
Contained events



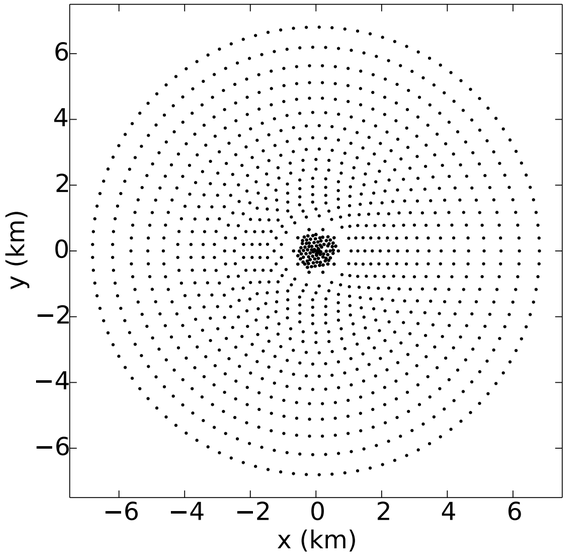
- Contained cascades arise from charge current interactions of e/τ neutrinos and neutral current interactions of all flavors.
- Observation of these events is important
  - Observed energies are directly relatable to neutrino energies
  - Can probe source mechanisms by flavor and neutrino-antineutrino ratios
    - Glashow resonance key tag for anti-ν_e

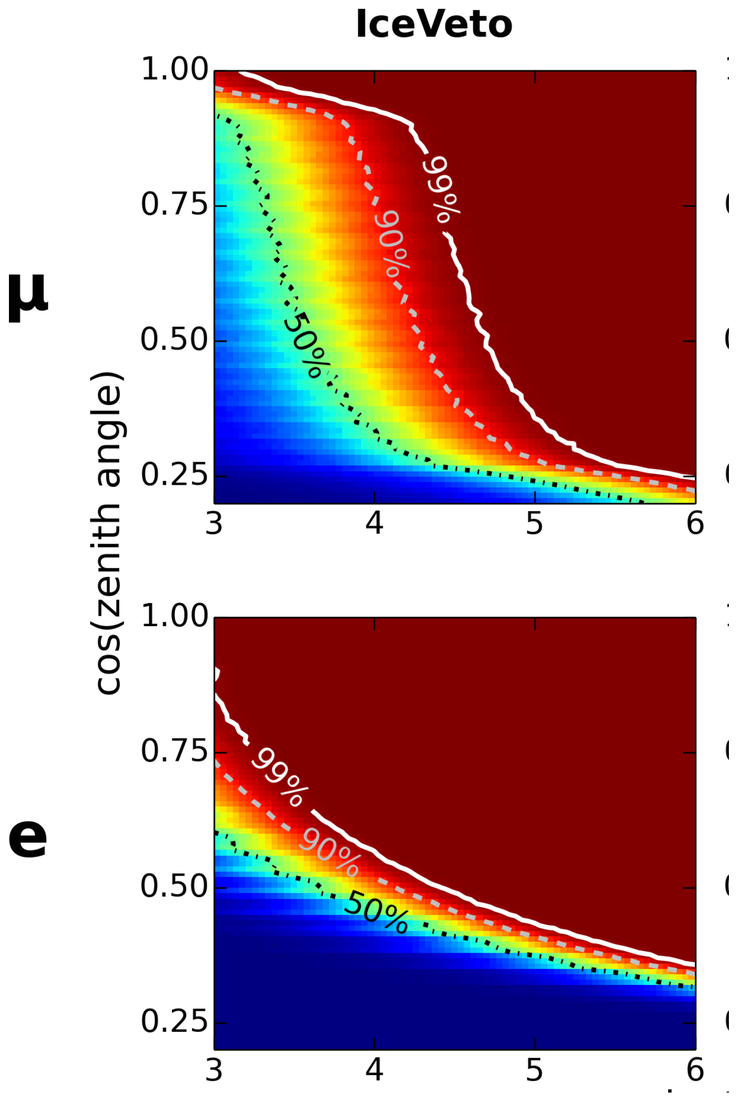
Number of ν_e cascades between 5-7 PeV E_{vis}

Φ_{ν_e} $[\mathrm{GeV}^{-1}\mathrm{cm}^{-2}\mathrm{s}^{-1}\mathrm{sr}^{-1}]$	interaction type	pp source IC-86	pp source 240m
$1.0 \times 10^{-18}(E/100\,\mathrm{TeV})^{-2.0}$	GR	0.88	7.2
	DIS	0.09	0.8
$1.5 \times 10^{-18}(E/100\,\mathrm{TeV})^{-2.3}$	GR	0.38	3.1
	DIS	0.04	0.3
$2.4 \times 10^{-18}(E/100\,\mathrm{TeV})^{-2.7}$	GR	0.12	0.9
	DIS	0.01	0.1



Atmospheric neutrino surface veto





- Down-going atmospheric neutrino backgrounds will be accompanied by particles from parent shower
  - Can be used a veto backgrounds in the Southern sky.
- Studies of detector designs and optimizations are ongoing.

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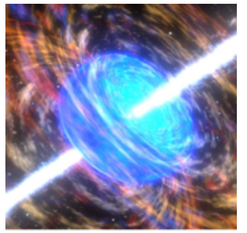
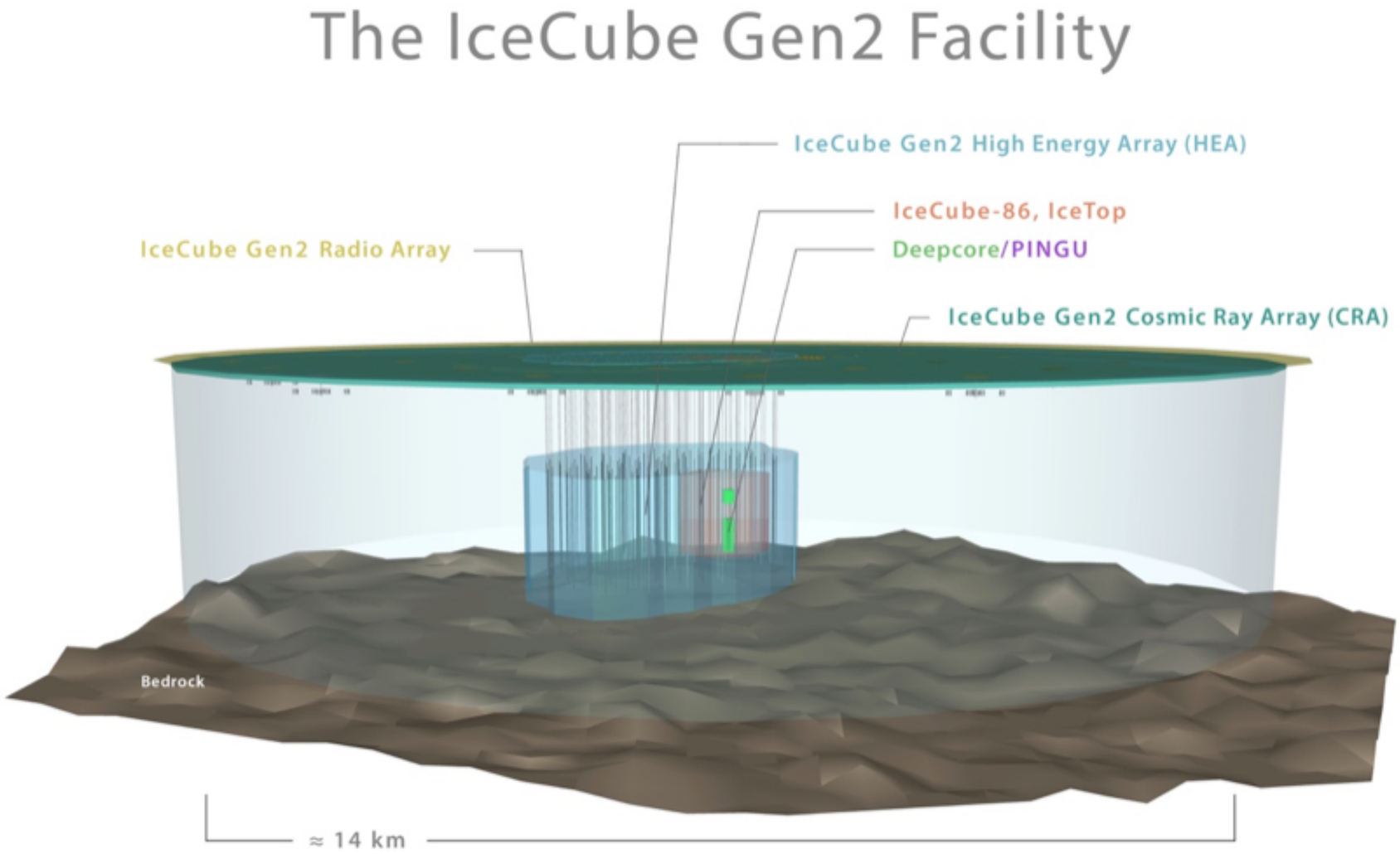
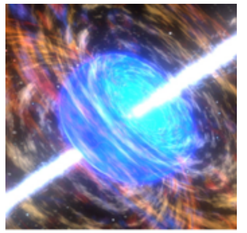
IceCube-Gen2 Facility

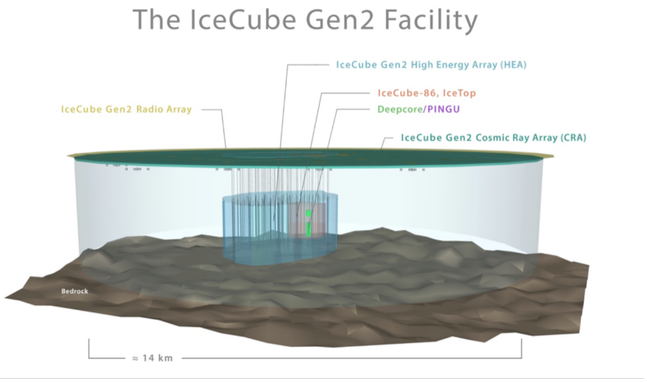




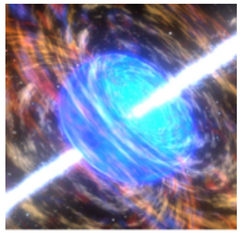
IceCube-Gen2 Facility



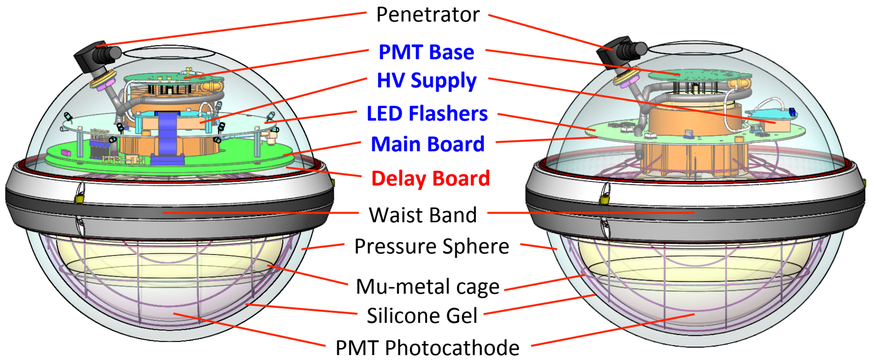
- The IceCube-Gen2 collaboration intends to build an integrated particle-astrophysics science facility at SouthPole
  - IceCube + Gen-2 HighEnergyArray - Neutrino astronomy at the highest energies
  - DeepCore + PINGU - Neutrino oscillations and the mass heirarchy
  - Surface detector - Cosmic ray physics and surface veto for atmospheric backgrounds
  - Radio detector - Search for GZK neutrino signals
  - Wider physics reach - WIMPs, Beyond standard model physics, …



IceCube-Gen2 Facility



- IceCube detector systems designs evolving for use in Gen 2
  - Gen2 DOM
    - New electronics
  - Enhanced hot water drill
    - Modular, efficient system



IceCube DOM

KEY:
Component identical
Component eliminated
Component redesigned

Gen2 DOM

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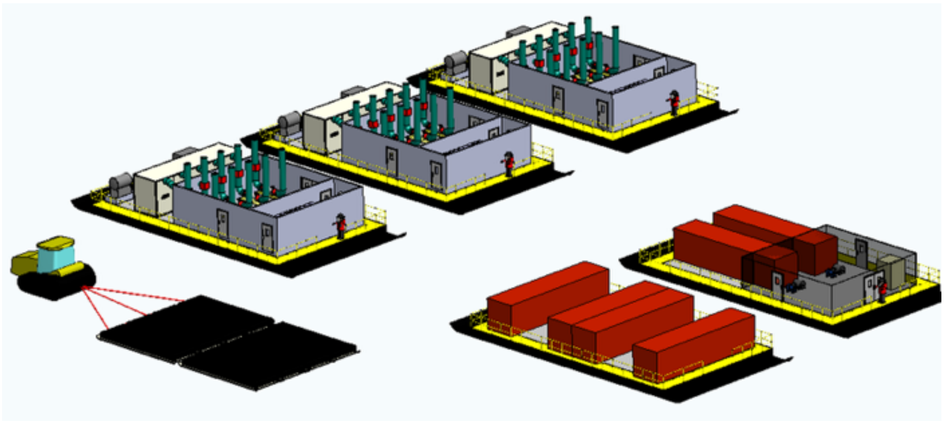
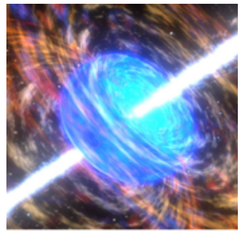
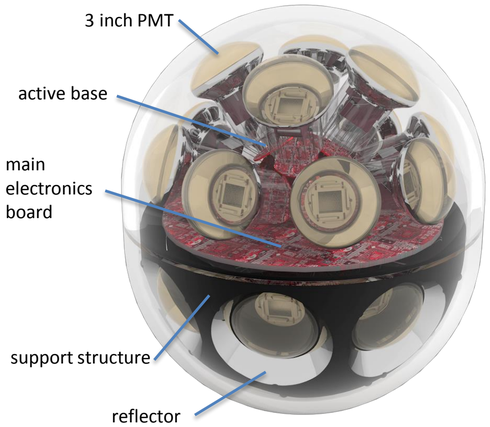


IceCube-Gen2 Facility



- Alternative DOM designs with the aim to increase detector sensitivity
  - Increased light collection
  - Increased directional information
- Currently under study.



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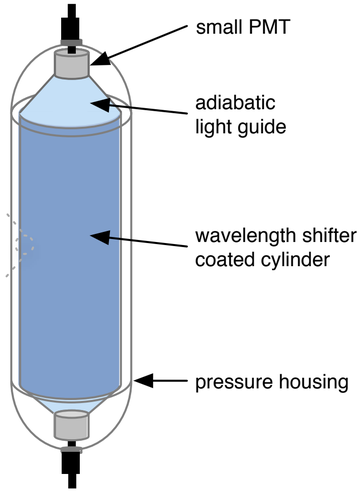
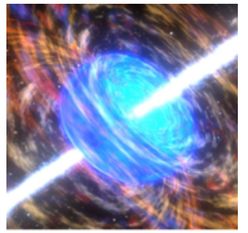
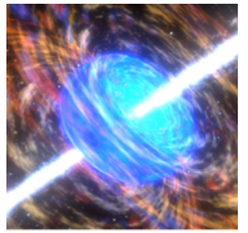




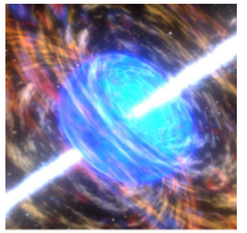
Gen2 at ICRC

- Several IceCube Gen2 specific contributions (talks and posters) here
  - Surface veto design studies: 1070, 1156
  - Calibration devices: 1133, 1145
  - Hardware development: 1137, 1147, 1148
  - PINGU science potential: 1174
  - Cosmic ray science potential from an extended surface detector: 694



Summary

- IceCube-Gen2 High Energy Array will deliver significantly larger samples of astrophysical neutrinos
  - Understand these events and how they connect to the high-energy universe
- IceCube-Gen2 facility will provide samples of neutrinos from a few GeV to EeV energies.
- The IceCube-Gen2 collaboration are developing proposals in the US and worldwide to see this facility constructed.



- Thanks!