

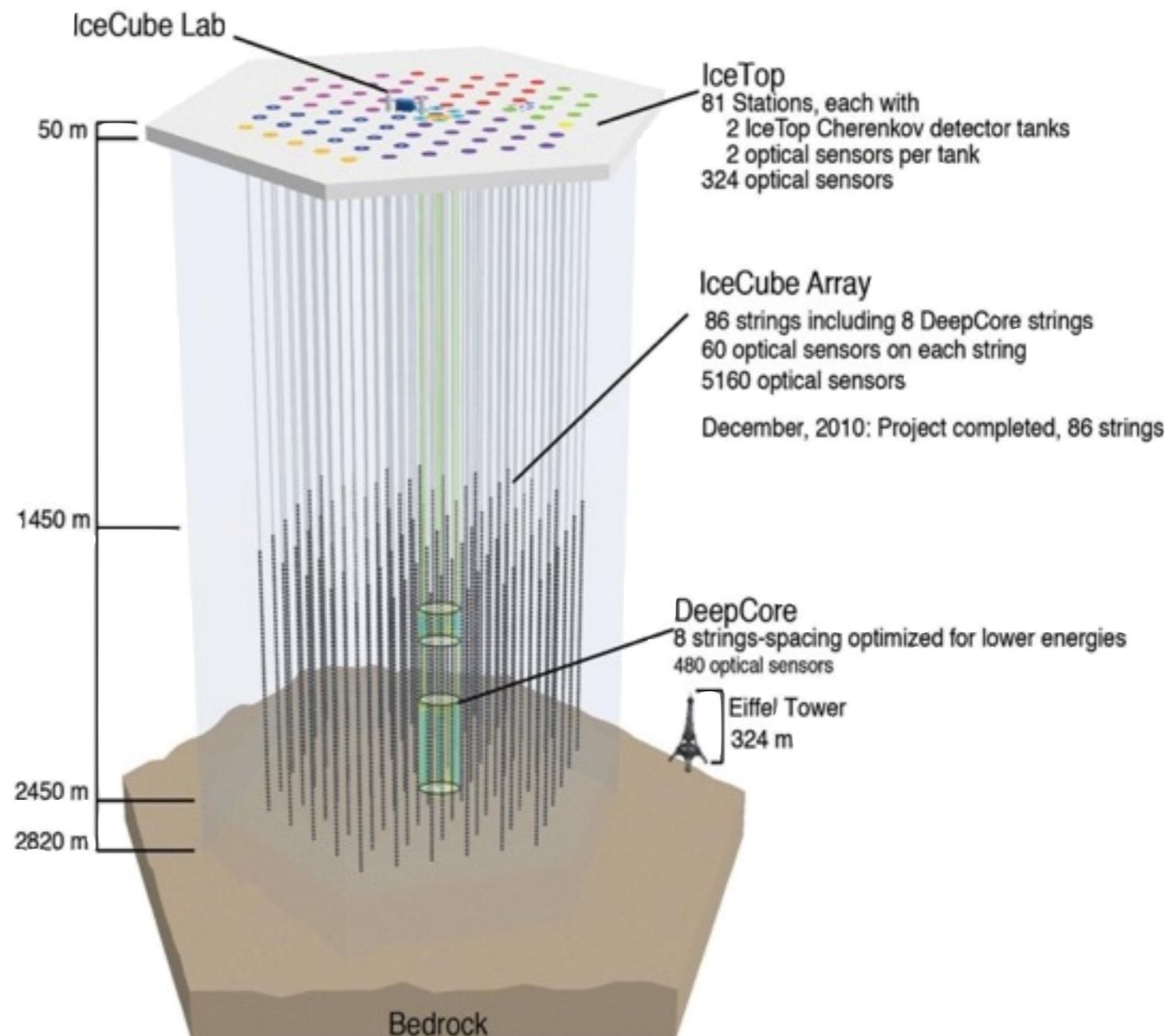
Neutrino physics and astrophysics with IceCube In-fills

Carsten Rott

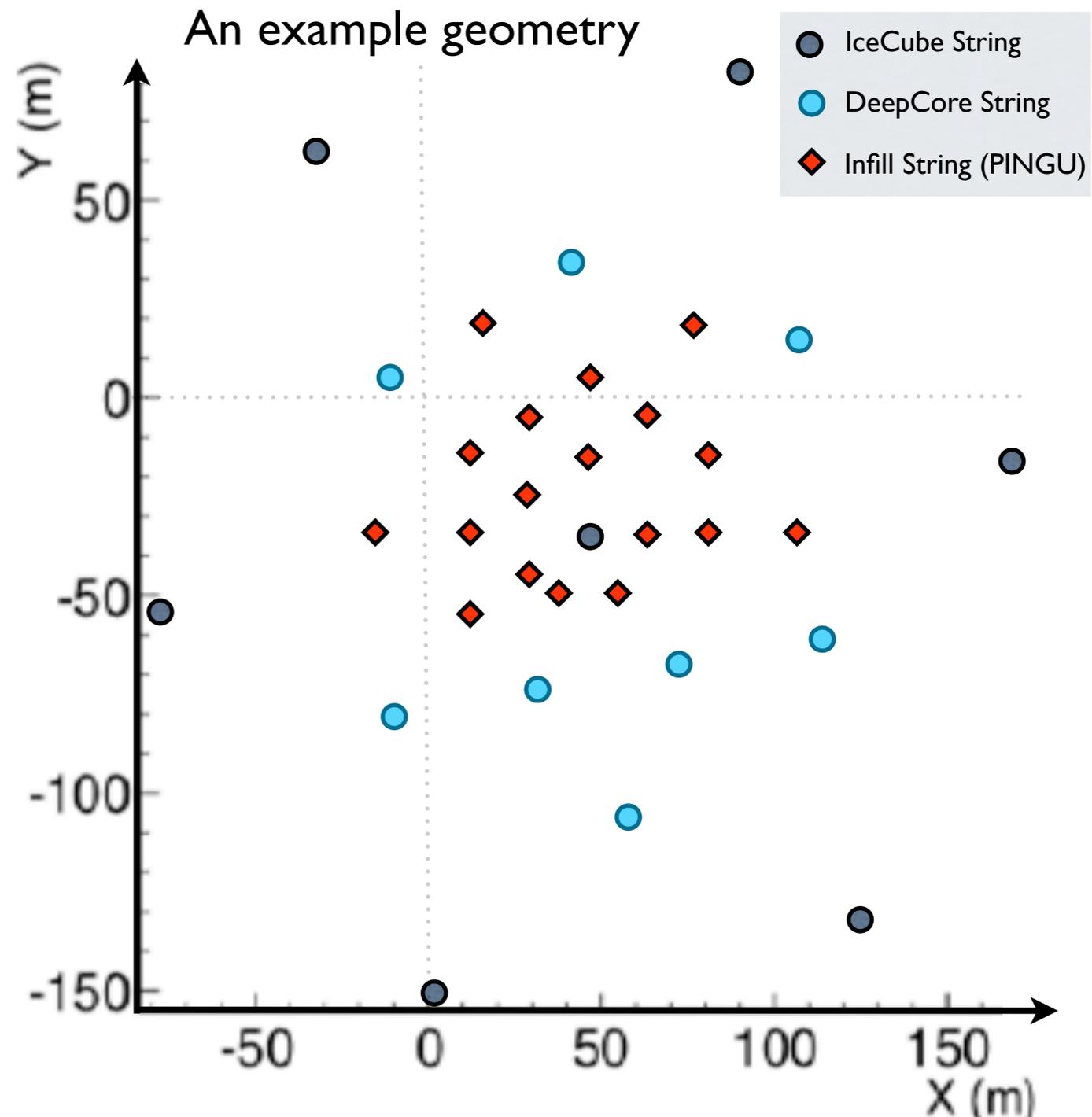
Center for Cosmology and AstroParticle Physics (CCAPP),
The Ohio State University

The IceCube/PINGU Collaboration*

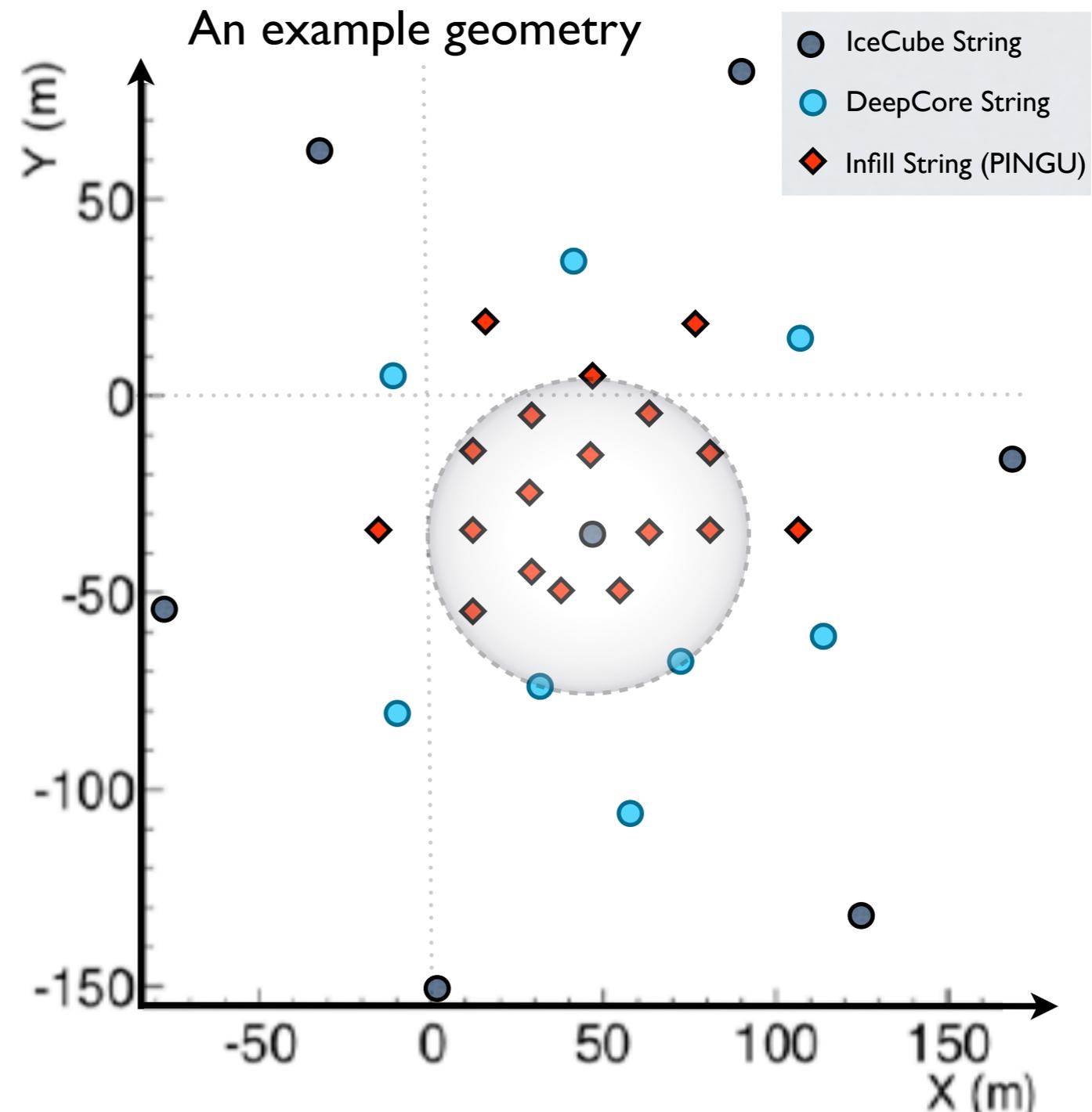
- IceCube Detector performing extremely well
 - uptime ~99%
 - modules failed ~1%
- DeepCore offers ideal environment for neutrino detection
 - favorable ice properties
 - 3 layers of IceCube “veto strings” reduce atm. μ background
 - $O(\text{atm } \mu) \approx O(\text{atm } \nu)$



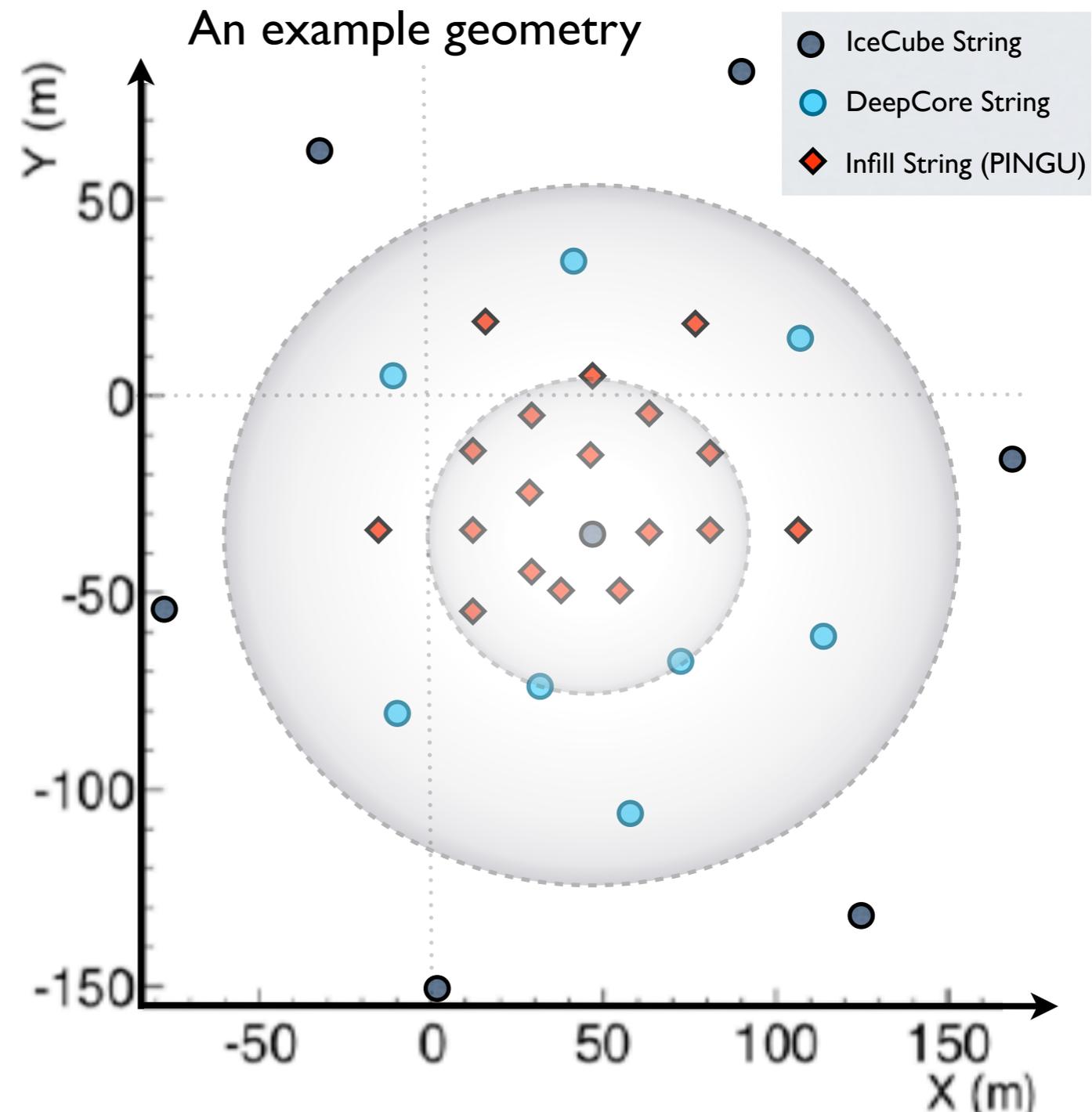
- Test low mass WIMPs and precision measurements of neutrino oscillations
 - needs energy threshold of $\sim 1\text{ GeV}$
- Developing a proposal to further in-fill DeepCore, called PINGU
 - Instrument a volume of about 10MT with 18-20 strings each containing 50-60 optical module
 - Rely on well established drilling technology
 - Create platform for calibration program and test technologies for future detectors
- Expected cost around \$25M - \$30M



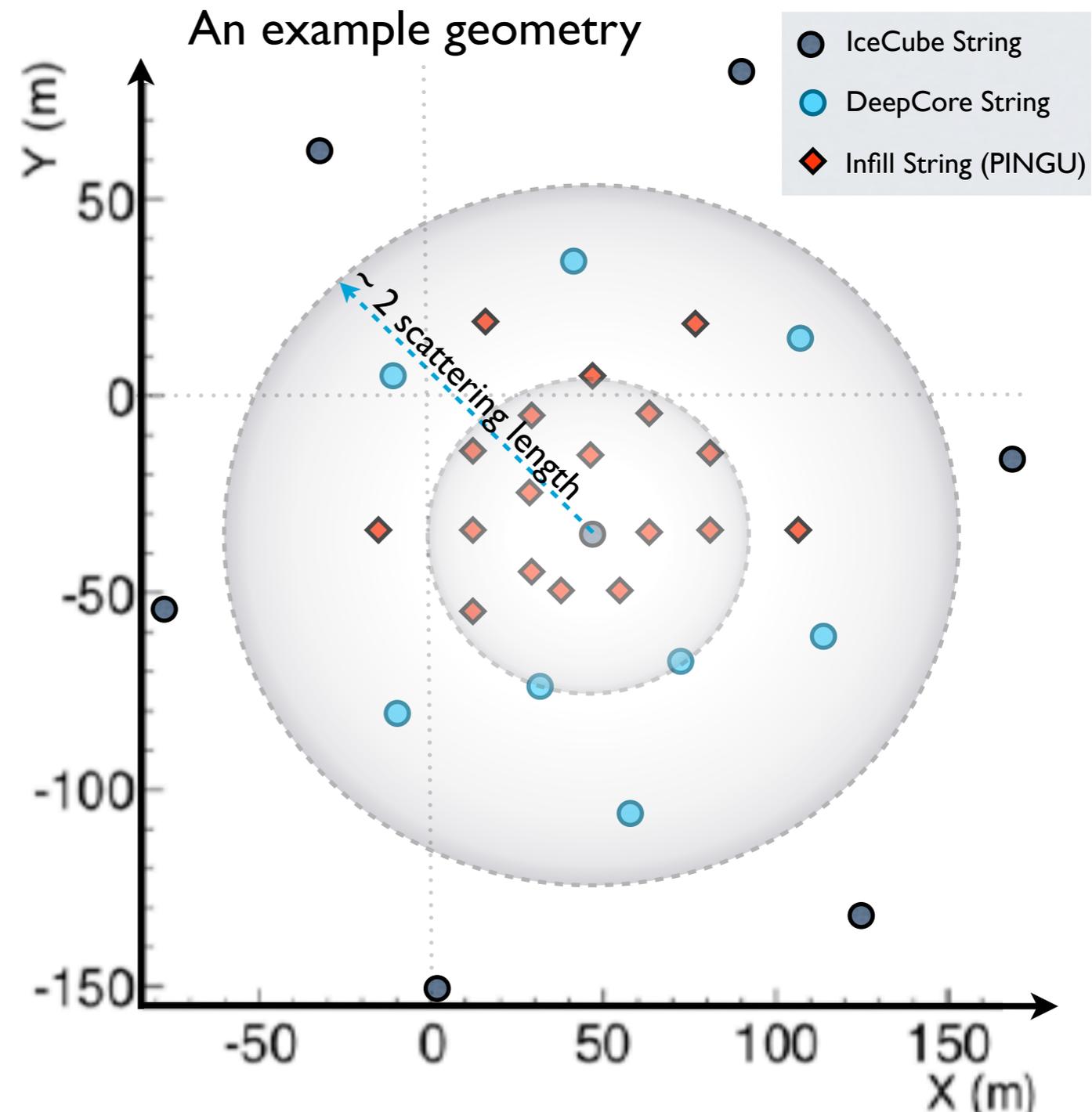
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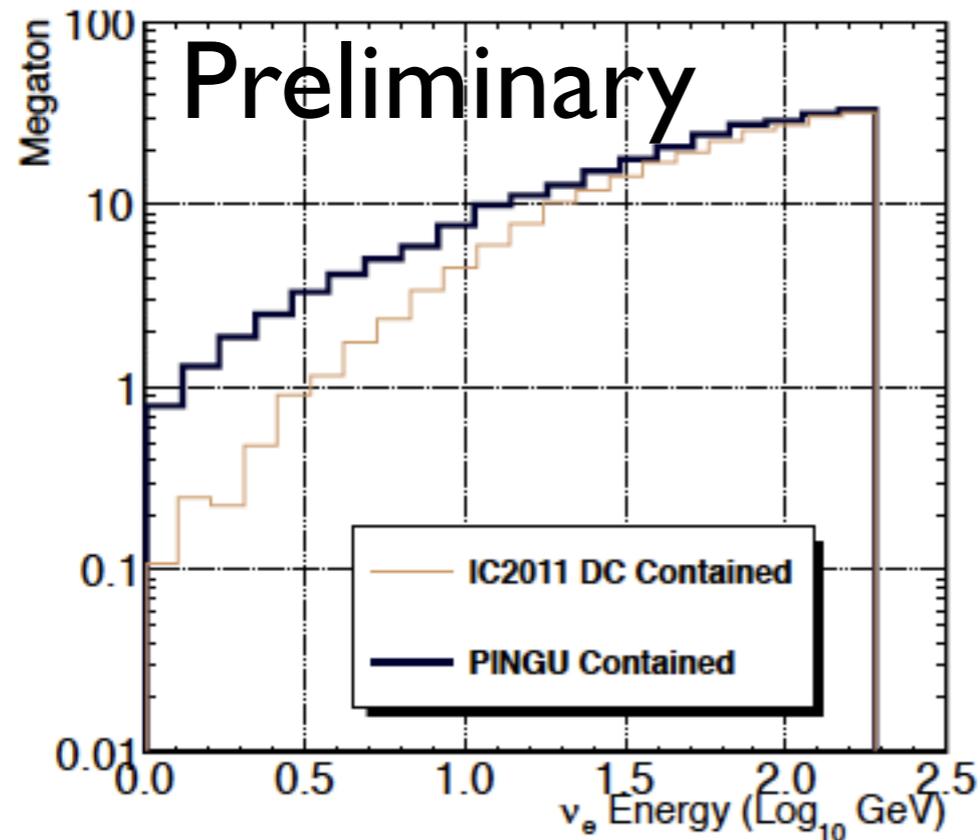
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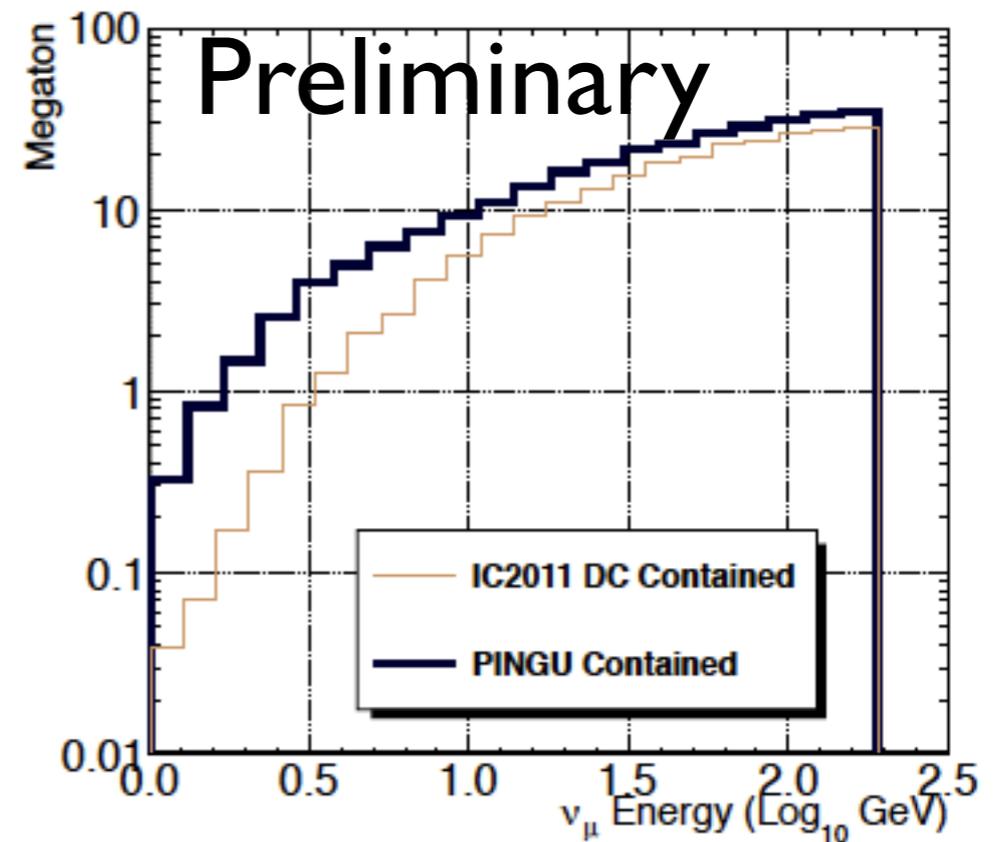
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Effective Volume ν_e

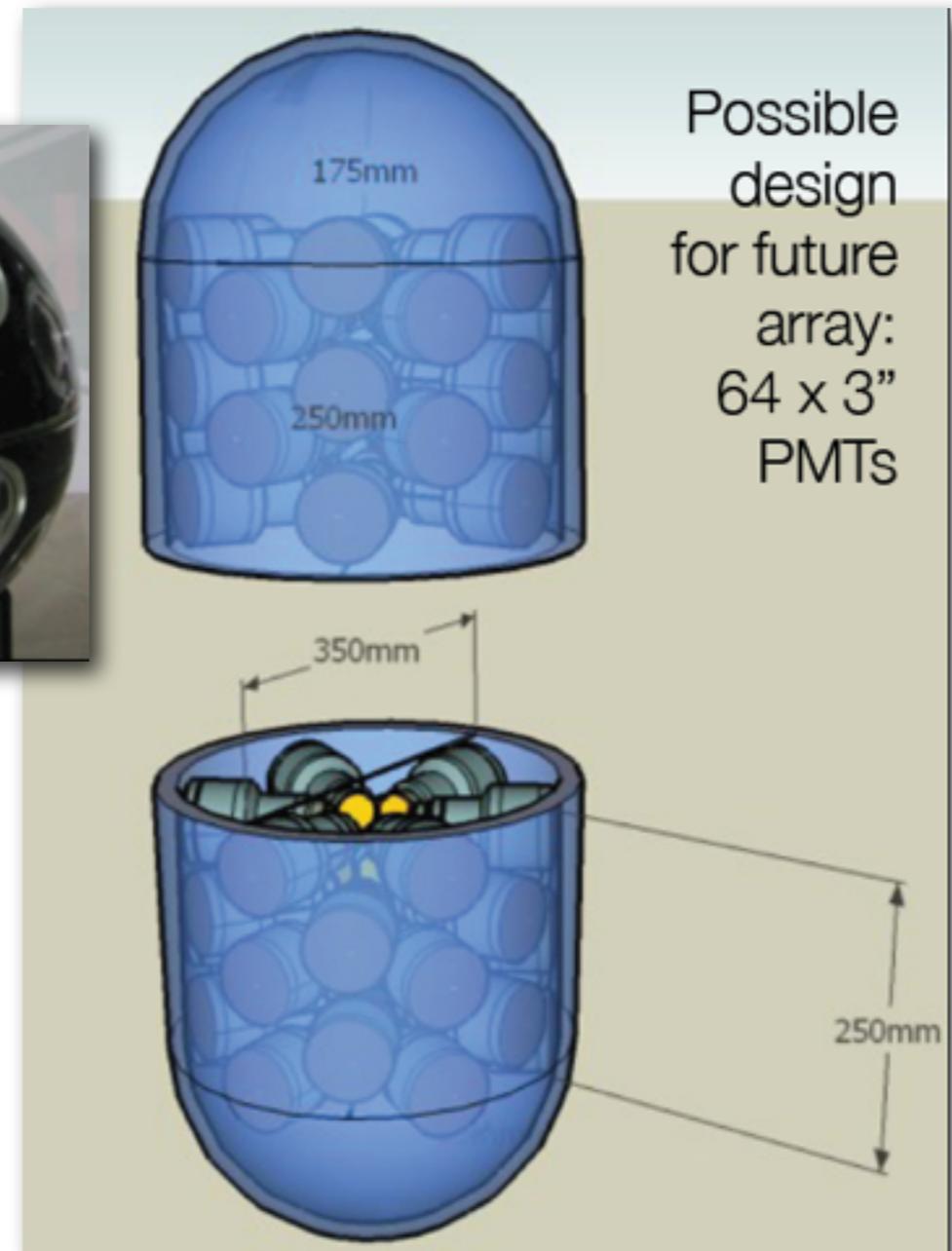


Effective Volume ν_μ



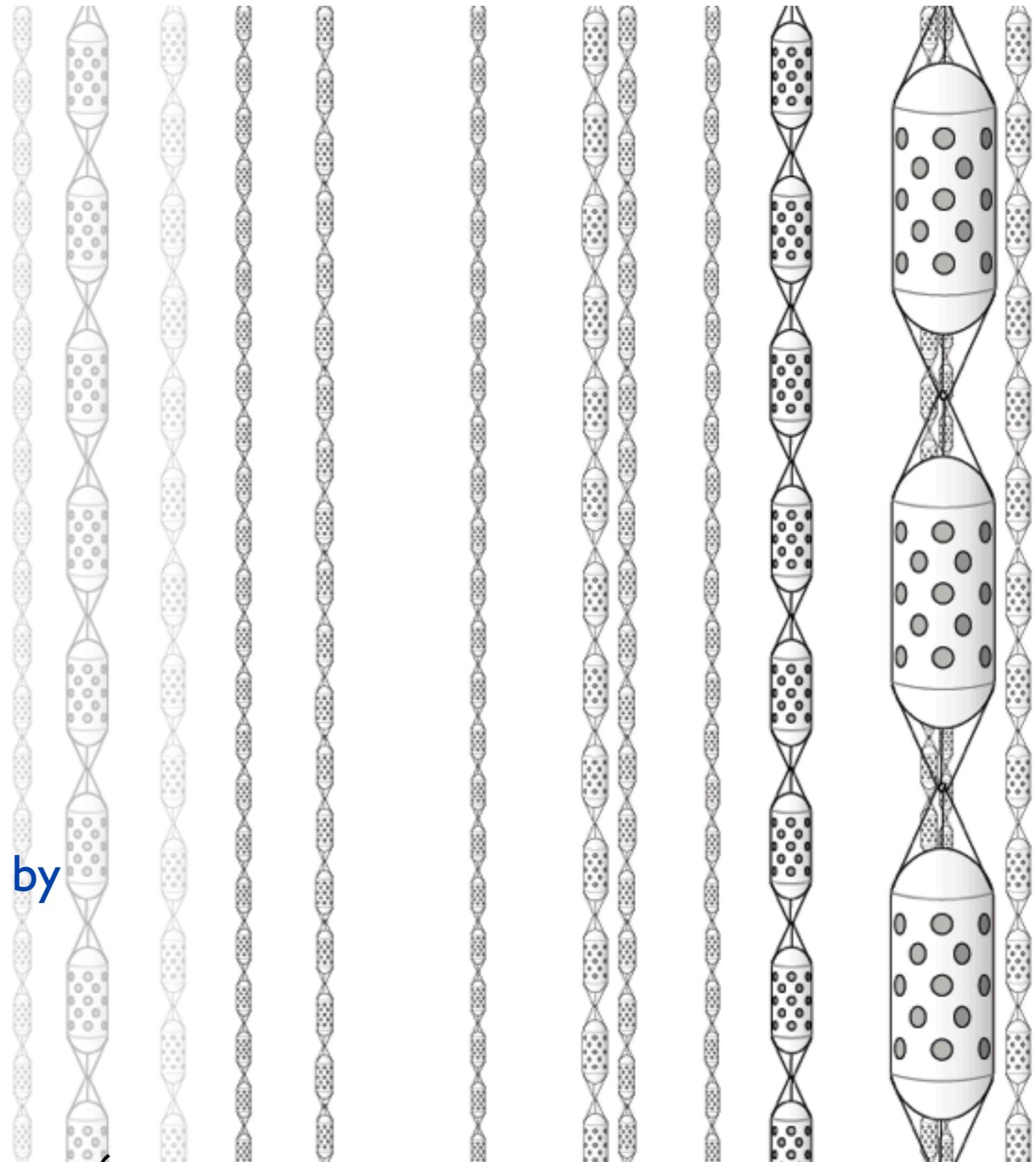
- Significant increase in effective volume below 10 GeV, reach megaton size at few GeV
- Effective volume is at trigger level (analysis efficiencies not included)
 - Absolute scale lower, but improvement with respect to DeepCore expected to be much larger

- Multi-PMT Digital Optical Module (evolved KM3Net design)
- Deployment Vessel
 - diameter similar to IceCube DOM
- Sensors
 - 64 x 3" PMTs
 - Equiv. ~ 2x IceCube HQE DOMs
- Goal
 - pixelization
 - "isotropic" light acceptance
- R&D beginning
 - U. Katz (Erlangen) / P. Kooijman (NIKHEF)

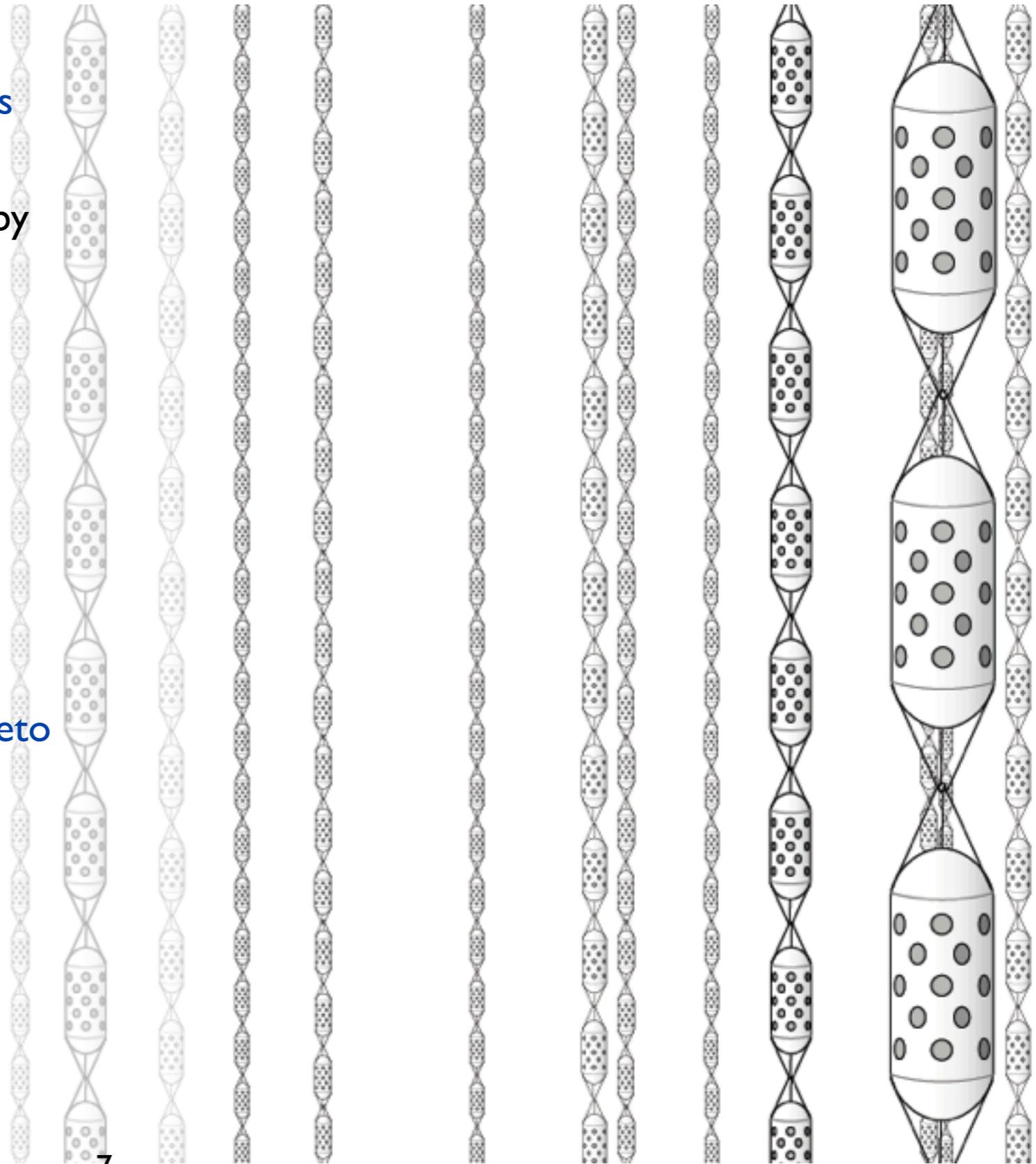


Plan to deploy 3-4 strings of new Multi-PMT DOMs for PINGU

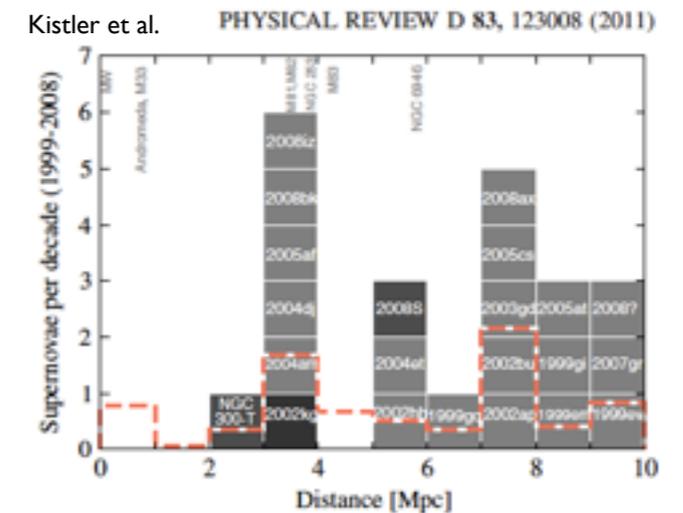
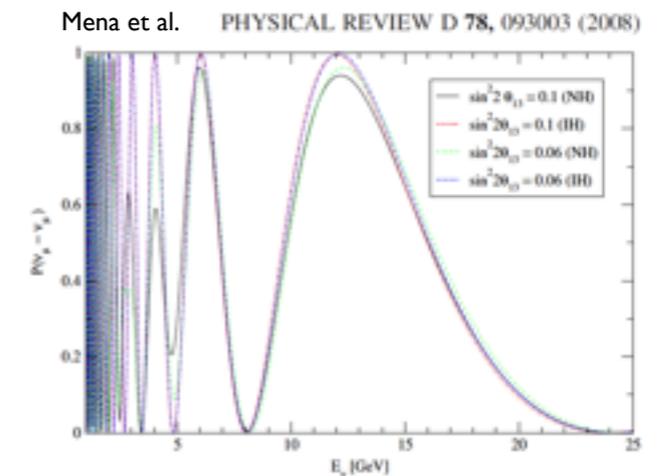
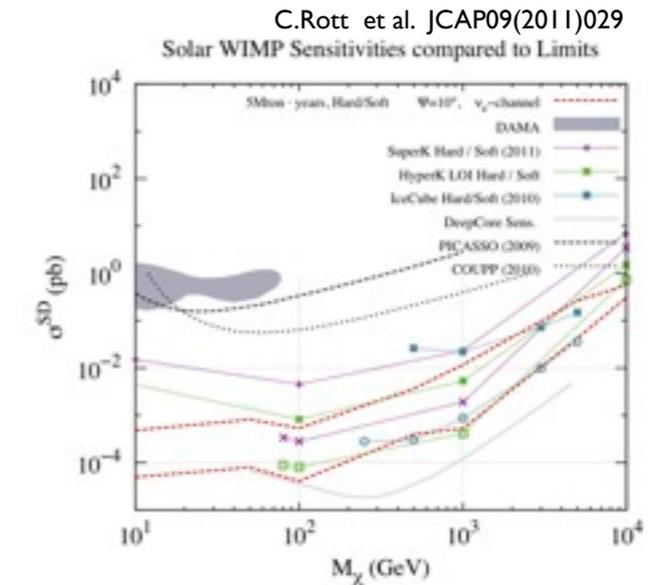
- The medium is the support structure
- Deep ice (< 2100m) has good optical quality, very high radiopurity
 - $\lambda_{\text{abs}} \approx 155\text{m} @ 400\text{nm}$
 - $\lambda_{\text{scat}}^{\text{eff}} \approx 47\text{m}$
- Low installation costs (on the scale of a next-generation detector)
- ... but the maximum density of instrumentation is determined by installation procedure, and the optical properties must be assessed in situ



- Few hundred strings of “linear” detectors to be deployed within DeepCore
- String spacings ~ 5 m, sensors spaced by ~ 1 m on a string
- An ambitious vision worth working towards:
 - ~ 5 MTon fiducial volume
 - Photo coverage $\sim 10\%$
 - $O(10$ MeV) threshold for bursts
 - $O(100$ MeV) for single events
- IceCube and DeepCore provide active veto
 - No excavation is necessary, drilling/ deployment has been refined to an industrial process – deployment costs would be well below 10% of total
- Physics extraction from Cherenkov ring imaging in the ice



- Dark Matter
- Test low mass WIMP scenarios
- Neutrino Physics
 - Atmospheric neutrino oscillation physics
 - Accelerator neutrino oscillation physics (see Jian Tang's talk)
- Supernova neutrinos
 - Extend reach beyond Milky Way (?)



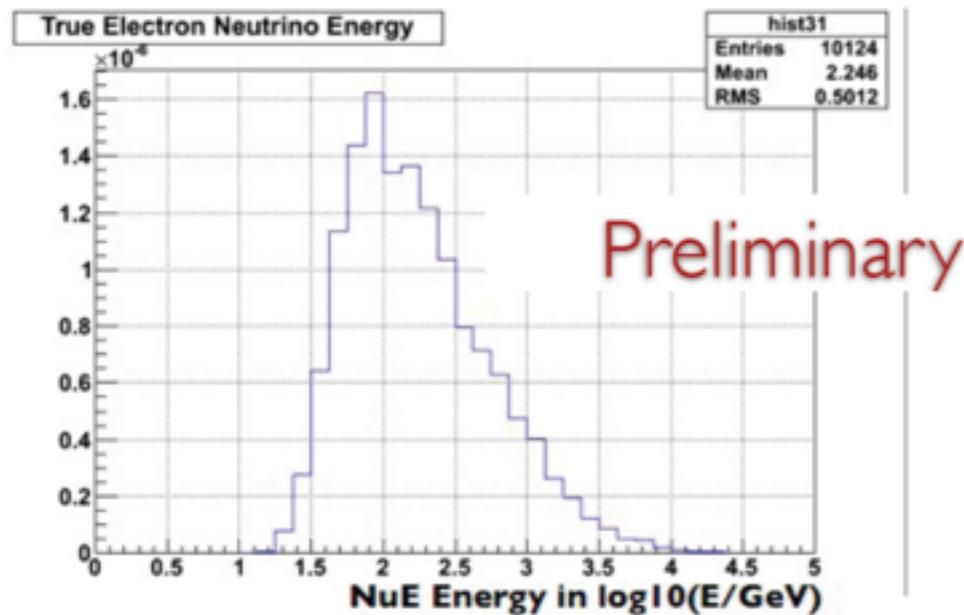
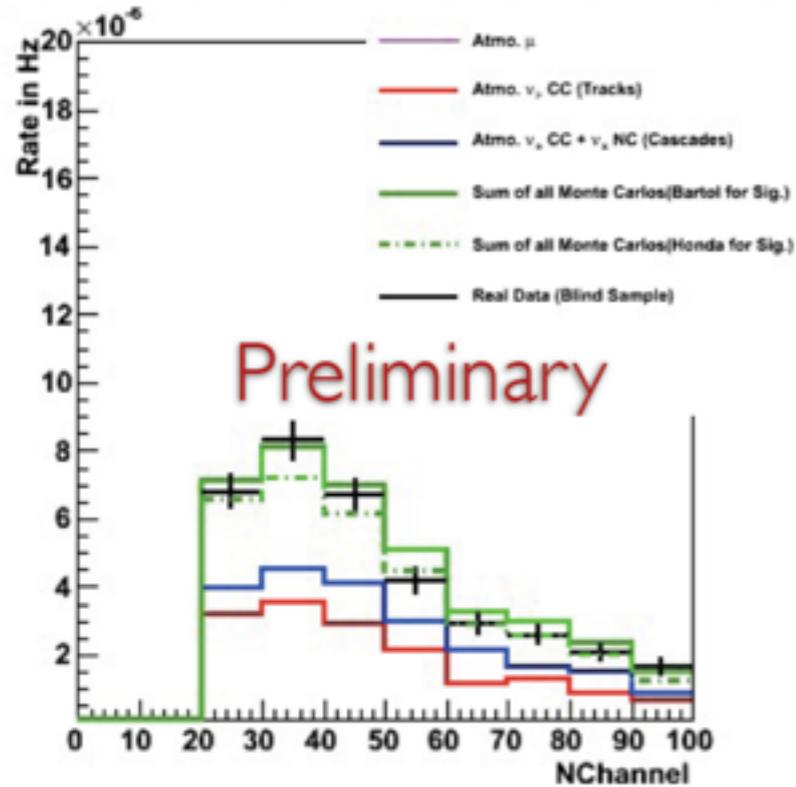
- Aim to construct MT-size detector at the South Pole in two stages
 - Stage 1 (20 string Deep Core upgrade):
 - Improved Dark Matter Sensitivity, Neutrino Oscillations, Improved Supernova Sensitivity
 - Rely on proven IceCube technology and test new technologies
 - Stage 2 (100s of strings):
 - Dark Matter, Neutrino Oscillations, Supernova Detection beyond the Milky Way (?), Extensions reaching proton decay could possibly be contemplated
 - Technology decision based on stage 1 experience
- A document about PINGU is in preparation

Backup Slides

Neutrino Working Group Meeting DeepCore - First Success

Fermilab Oct 24, 2011

Number of Hit Channels



$\langle \text{NuE} \rangle \sim 180 \text{ GeV}$

- DeepCore performing extremely well
- First success: Observing cascade-like event rates consistent with expectations

