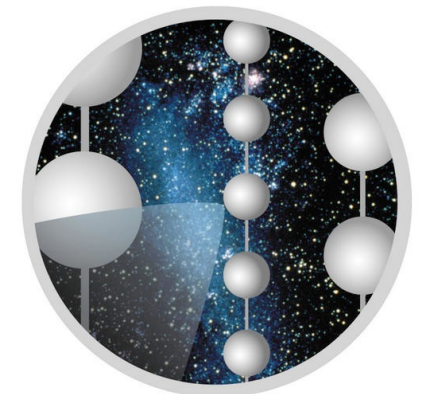




IceCube/Gen2 Software/R&D Status and Plans

Tyce DeYoung
Department of Physics and Astronomy
Michigan State University



ICECUBE

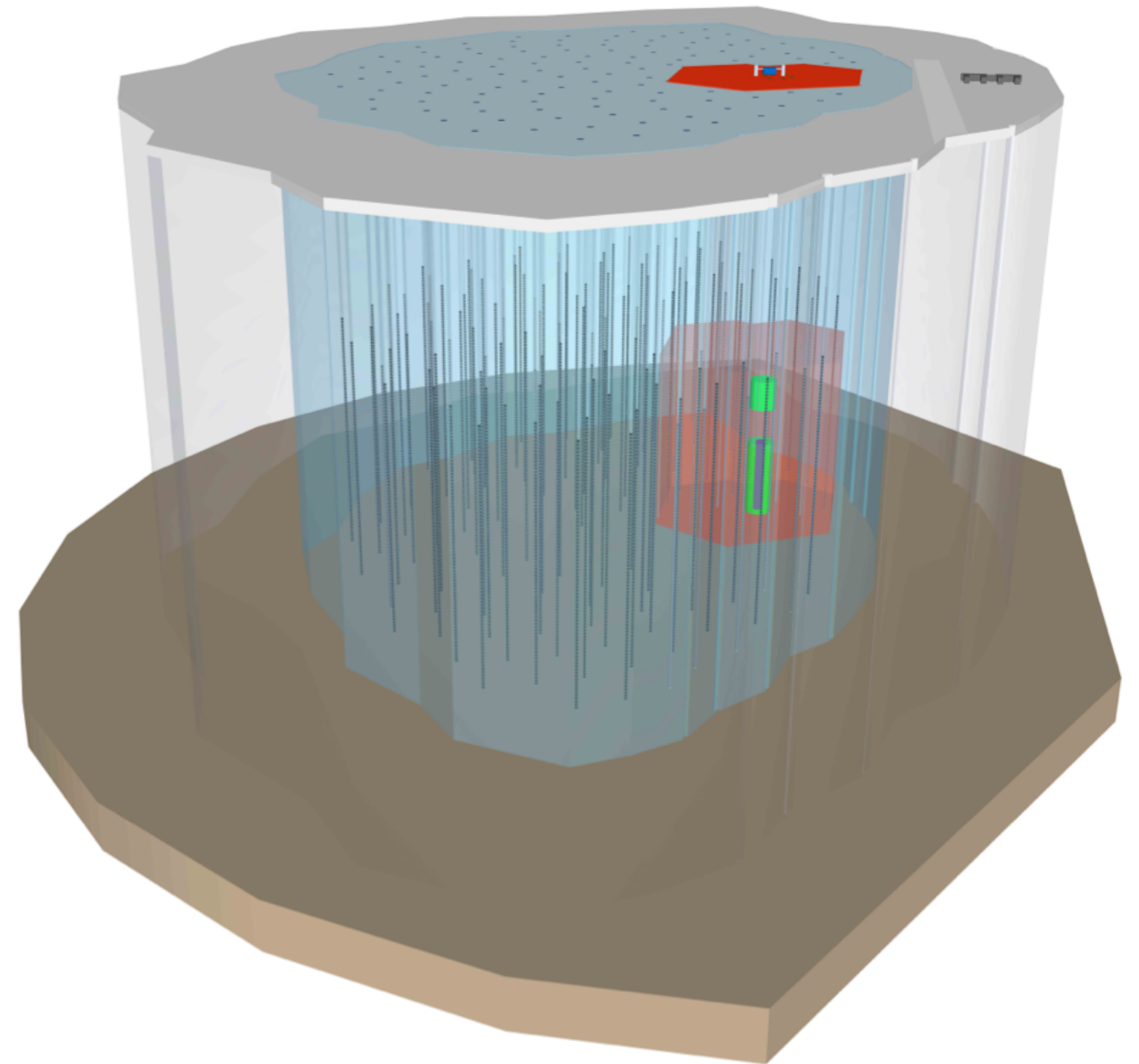
NNN Water Detector Satellite Meeting
Stony Brook University
October 27, 2015

Outline

- Gen2 status
- Detector R&D
- General software
- Simulation software
- Event reconstruction software
- Global Neutrino Network
- Water Cross Section Measurements

IceCube-Gen2 Status

- Vision: a facility for neutrino physics and astrophysics at energies ranging from a few GeV to many PeV
 - Extended high energy array – all-flavor neutrino astrophysics, sterile neutrino searches
 - Surface veto – enhanced muon neutrino sensitivity (astronomy)
 - PINGU – neutrino physics
 - Radio array – enhanced sensitivity for $>PeV$ astronomy and GZK/BZ neutrinos
- Plan to release Gen2 LOI and update to PINGU science document soon

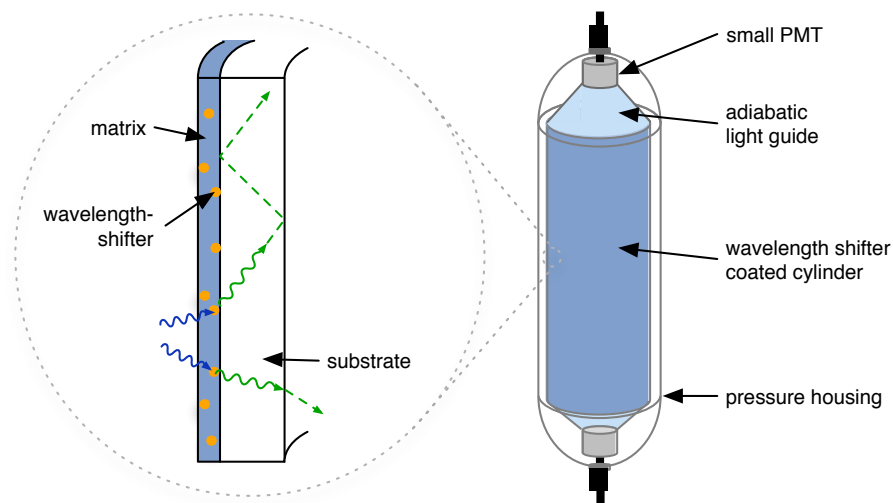


Detector R&D

- Baseline design for IceCube-Gen2/PINGU is closely based on IceCube DOMs – simplified/updated electronics
- Several R&D projects underway for better/cheaper photodetectors
 - LAPPD? Don't need ps...



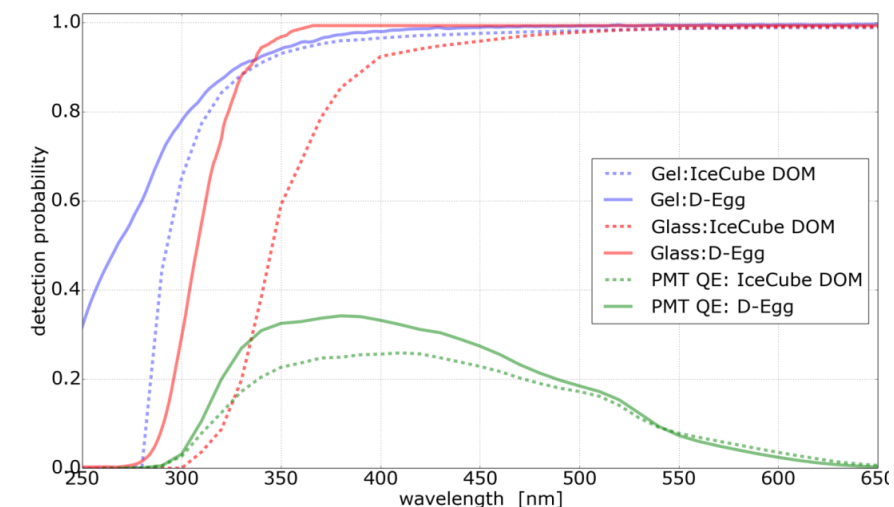
Multi-PMT DOM (mDOM)
24x3" PMTs, new glass similar to D-Egg



Wavelength-shifting Optical Module (WOM)
low cost, narrow, poor timing resolution



D-Egg: 2x8" PMTs, new glass



General Software

- Online DAQ Java-based, python online monitoring package (I3Live)
- IceCube (offline) software is primarily C++ with python wrappers
 - Analysis/processing framework called IceTray (adopted by KM3NeT)
 - Designed to prioritize flexibility of data structures/algorithms
- Highly flexible distributed computing framework (IceProd), rewritten version coming soon
 - Jobs broken across clusters to best match resources, parallel re-processing (e.g. simulate this event in DeepCore and PINGU), etc.
- Two relatively mature oscillation analysis packages tuned for atmospheric analysis (multiple baselines, etc.)

Simulation Software (Low Energy)

- Prob3++ as baseline oscillation code

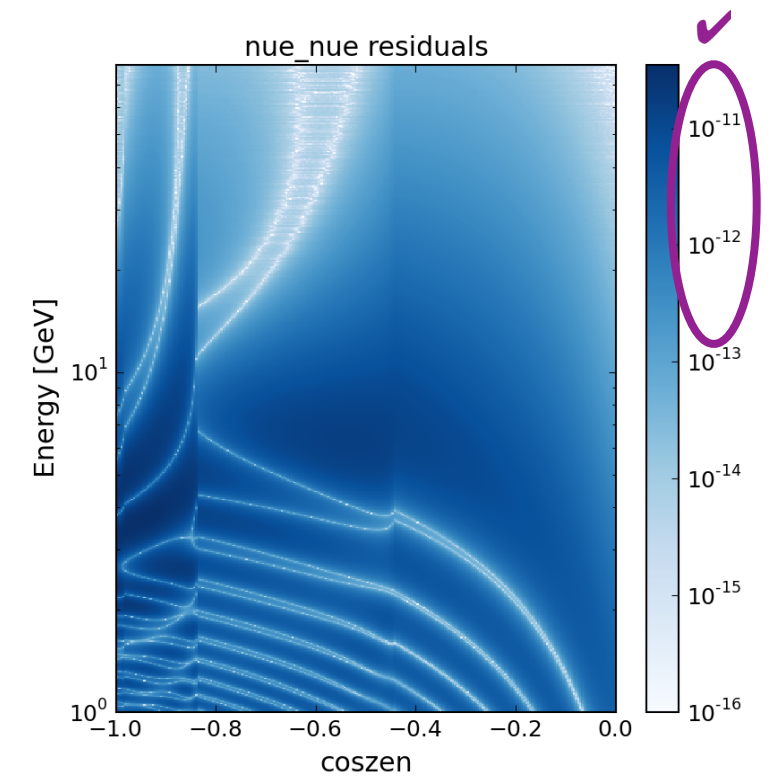
- Ported to GPUs (CUDA) recently, 75x speedup vs CPU (Tesla K20)
- Specialized codes (NuSQuIDS, nuCRAFT) for sterile neutrinos etc.

- GENIE

- Looking into improving DIS modeling – core range for us is ~5-100 GeV

- Background: CORSIKA

- Also use a fast single-muon injector tuned to CORSIKA results
- Other (faster) tools? Limited statistics, use data-driven BGs when possible



Simulation Software (Low Energy)

- Photon tracking through ice is technically challenging
 - Require very detailed treatment of Mie scattering (multiple approximations, etc.), high speed – 100's of millions of photons at high energies
 - Inhomogeneous medium, anisotropic scattering (alignment of dust grains)
- Custom GPU-based photon tracking software
 - Two variants (CUDA, OpenCL), up to 100x faster than CPU-based
 - Interface to tabulated results for high energy showers (bremsstrahlung etc.)
 - Tricks with oversampling, etc.
- Understand GEANT4 is now GPU-enabled – any experience?

Event Reconstruction Software

- Reconstruction is computationally challenging due to spatial inhomogeneity, very long absorption lengths (200+ m)
 - Maximum-likelihood fits based on spline fits to high-dimensional tables describing photon transport through the ice
 - Flexible reconstruction framework, mix-and-match hypotheses (contained/starting/shower-like/etc.), minimizers, PDF calculations
- Also working on a method that calculates likelihoods on the fly by simulating the current hypothesis directly
 - Relatively slow but new detector technologies would be plug-and-play

Global Neutrino Network

- Loose association of very large volume neutrino telescopes
 - IceCube/Gen2, ANTARES/KM3NeT/ORCA, Baikal GVD
 - Originally formed as a way to demonstrate inter-experiment cooperation to (European/Russian) funding agencies
- Supports some information exchange activities
 - Student/postdoc visits, MANTS workshop, VLVNT conference
 - Dissertation award
- Helps organize scientific exchanges controlled by separate MOUs
 - Joint publications (ANTARES/IceCube source search)
 - Software sharing (IceTray/SeaTray)

MINERvA Water Measurements

- Recently approached by MINERvA group about collaborating on water cross section measurement up to ~ 10 GeV
 - Requires validation of target integrity, etc.
- We are very interested in this but having trouble identifying personnel to take responsibility...
- Other relatively high energy measurements? T2K, nuPRISM,...?