

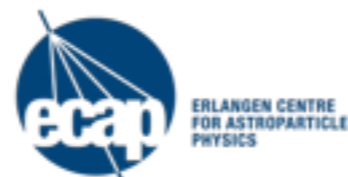
IceCube – Exploring the Universe with Neutrinos at the South Pole

ERLANGEN CENTRE
FOR ASTROPARTICLE
PHYSICS

Alexander Kappes

Inauguration of Research Training Group GRK 2149

Telgte, 24–26 November 2015





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MÜNSTER

IceCube – Exploring the Universe with Neutrinos at the South Pole

Inauguration of Research Training Group GRK 2149
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The group



Alexander Kappes



Lew Classen
(Postdoc)



Raffaella Busse
(Master student)

Located at *Institut für Kernphysik*
(currently in setup phase; start in Januar)

Fields of activity

- Neutrino astronomy
- Neutrino oscillations
- Photon sensor development

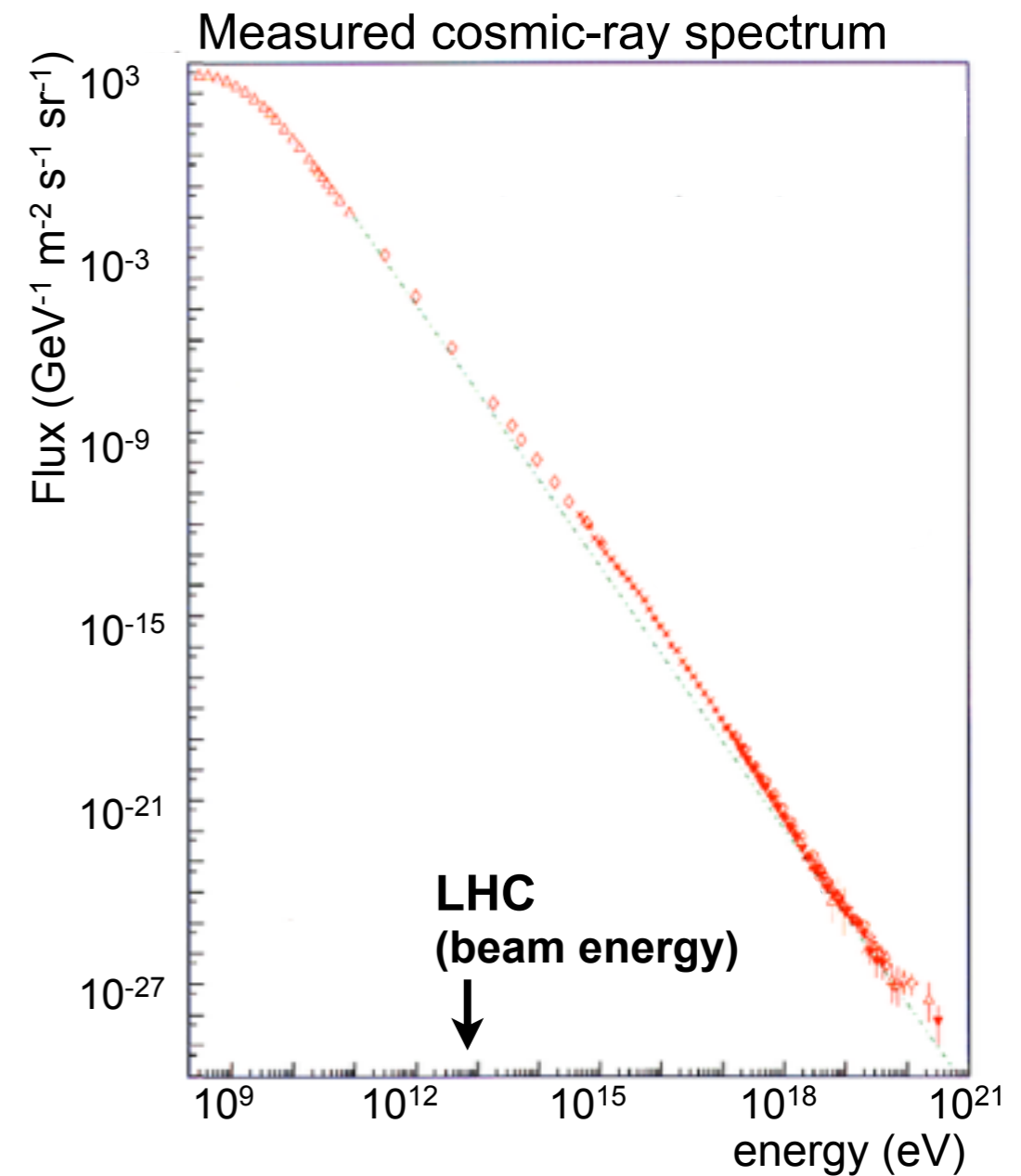
Neutrino astronomy, what's that?

- Explore high-energy universe with neutrinos
- Central question: locate / understand sources of cosmic rays

Supernova remnants
(SN1006, optical, radio, X-rays)



Aktive Galactic nuclei
(artist's view)

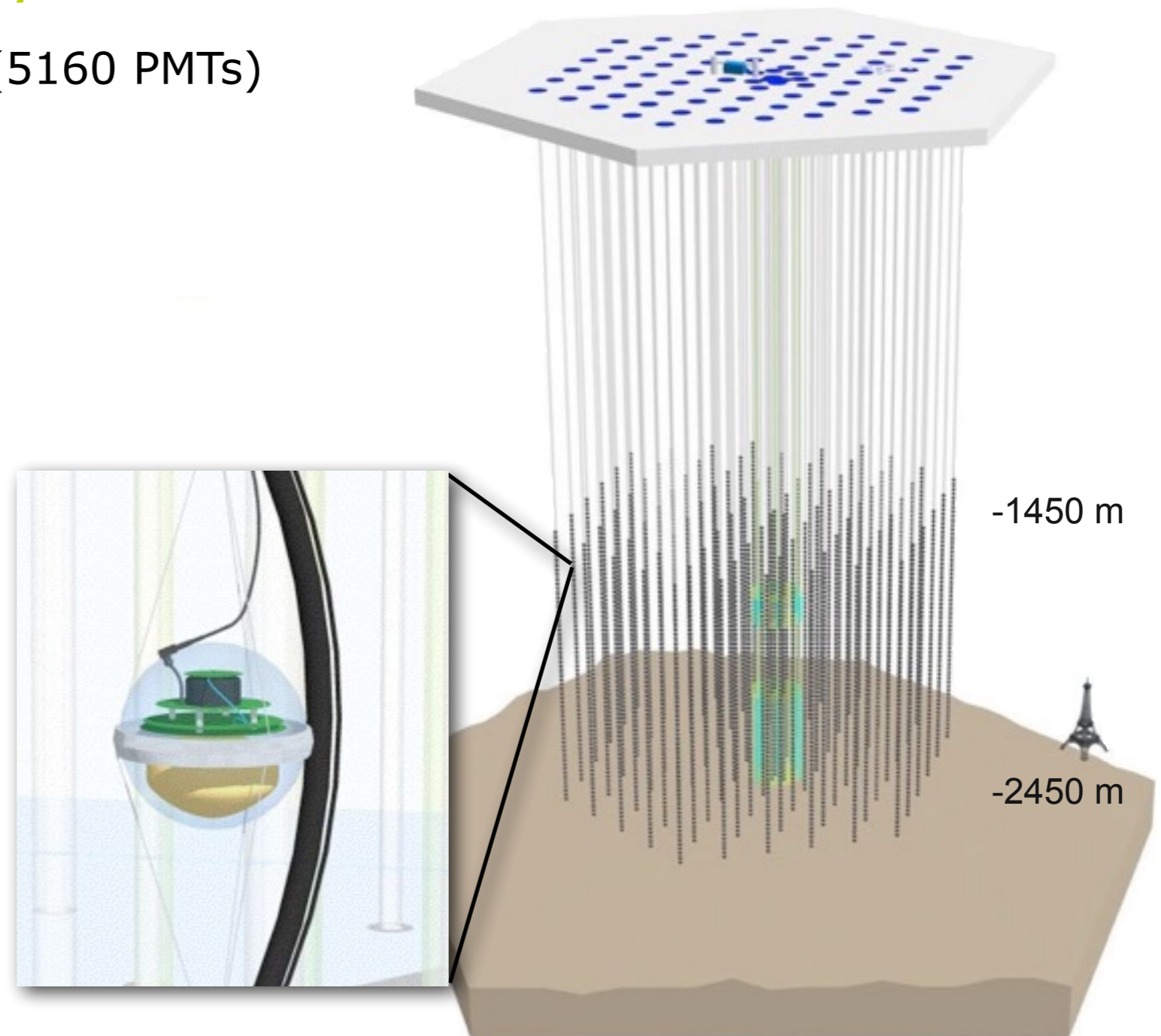






The IceCube Observatory

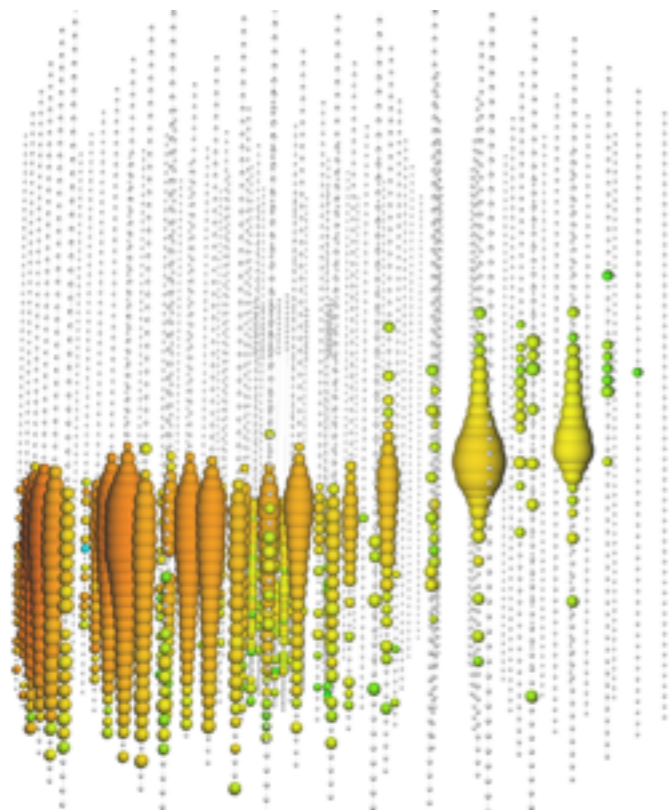
- Neutrino telescope: 86 strings (5160 PMTs)
instrumented volume: 1 km³
- Completed since Dec 2010
(data taking since 2005)



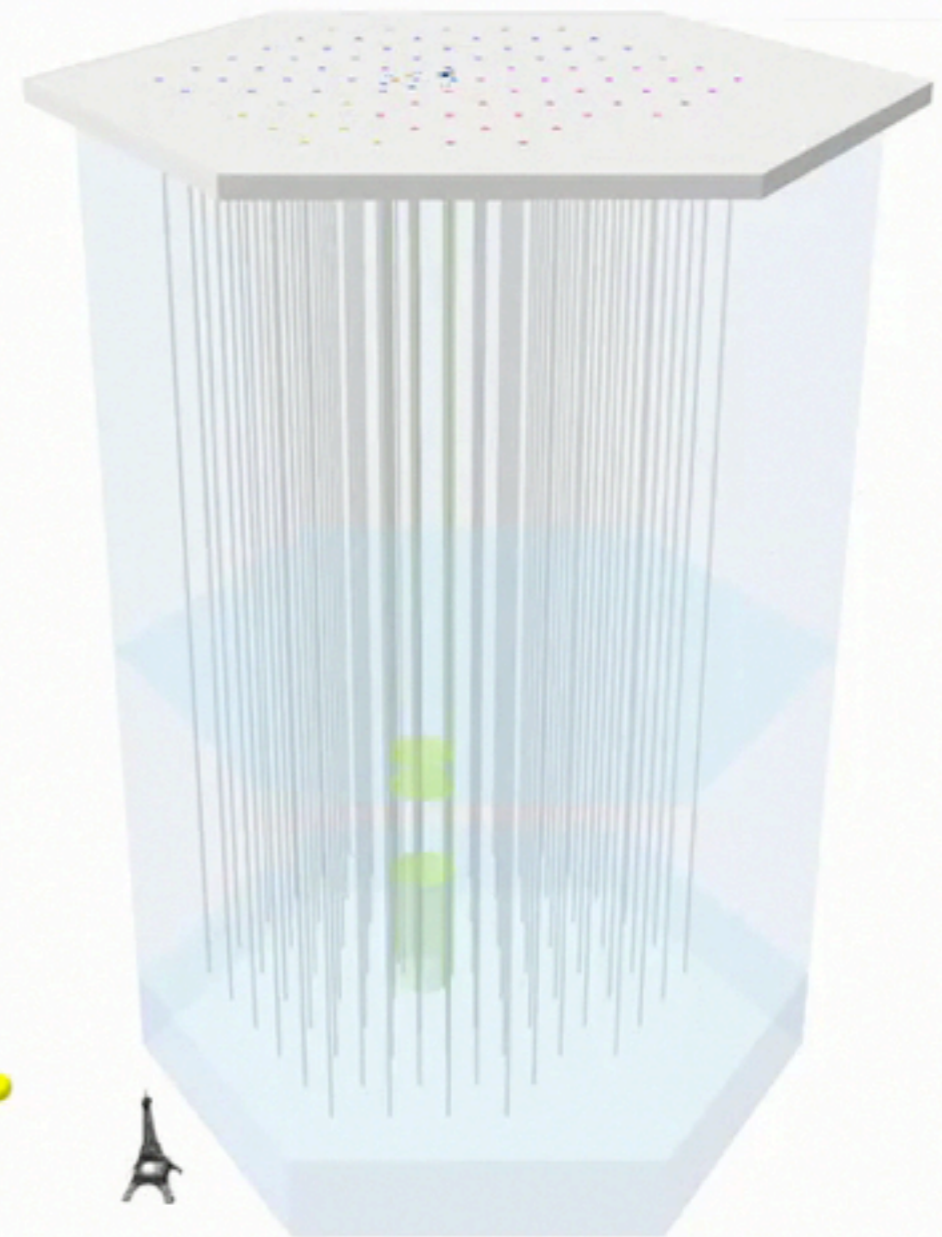


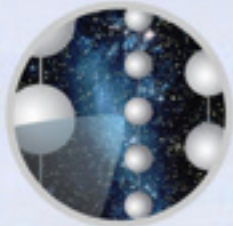
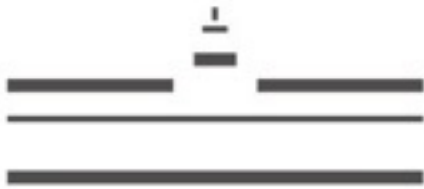
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$E_\nu > 3 \text{ PeV}$





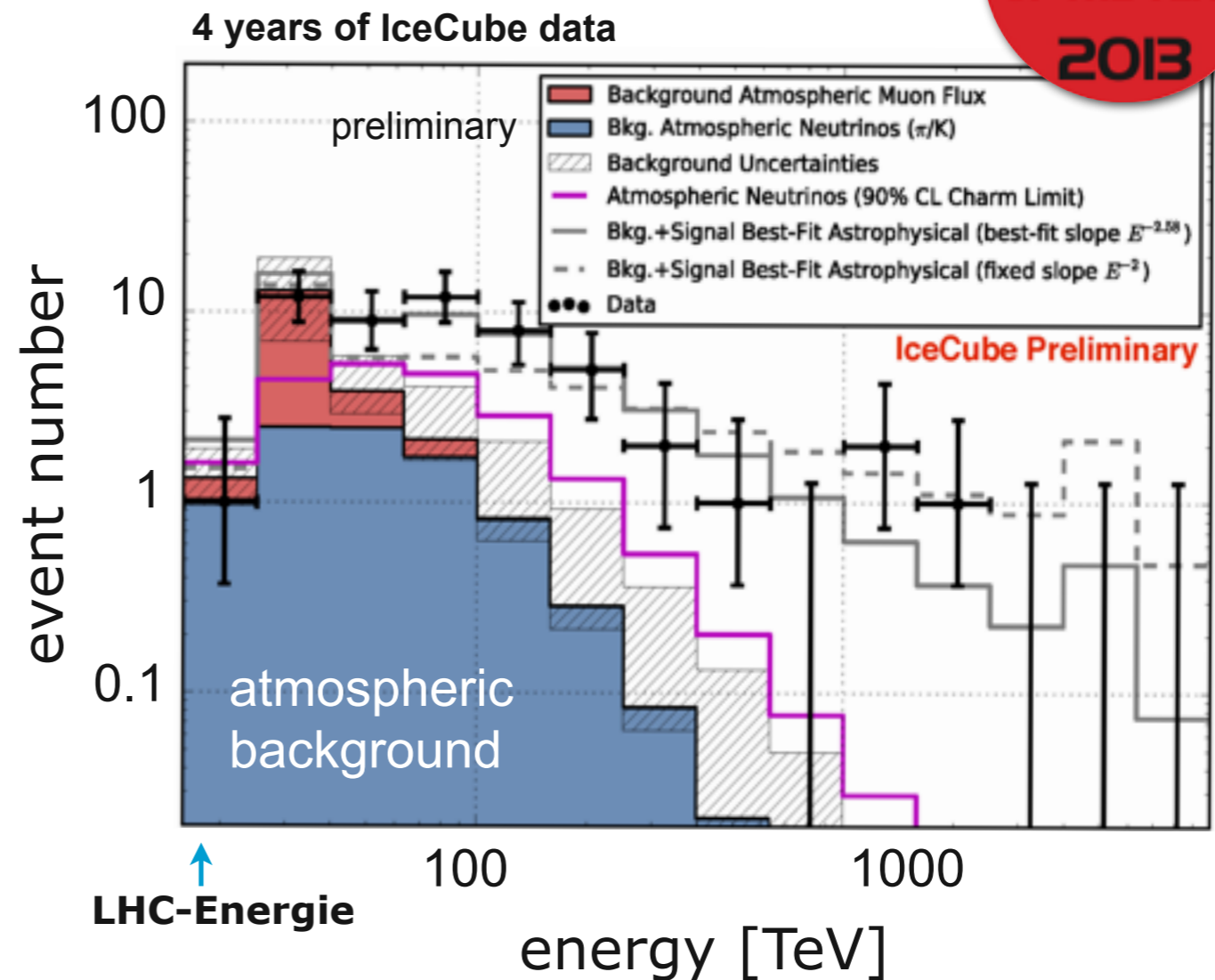
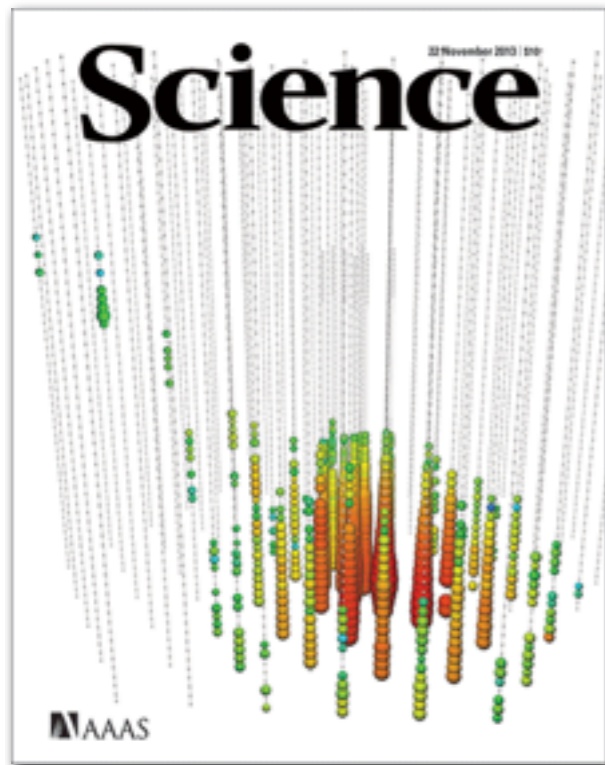
The IceCube Collaboration



300 members from 45 institutes in 12 countries

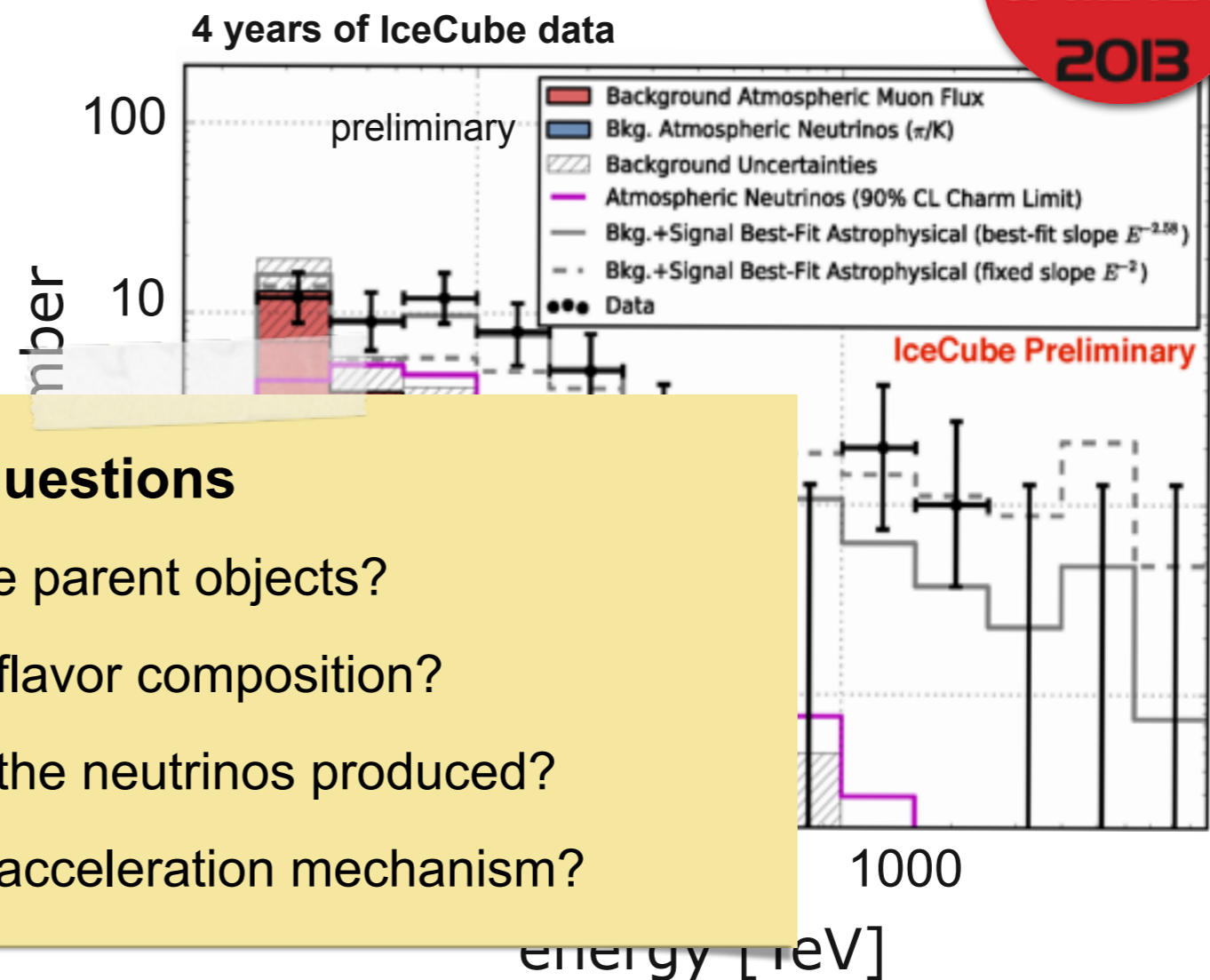
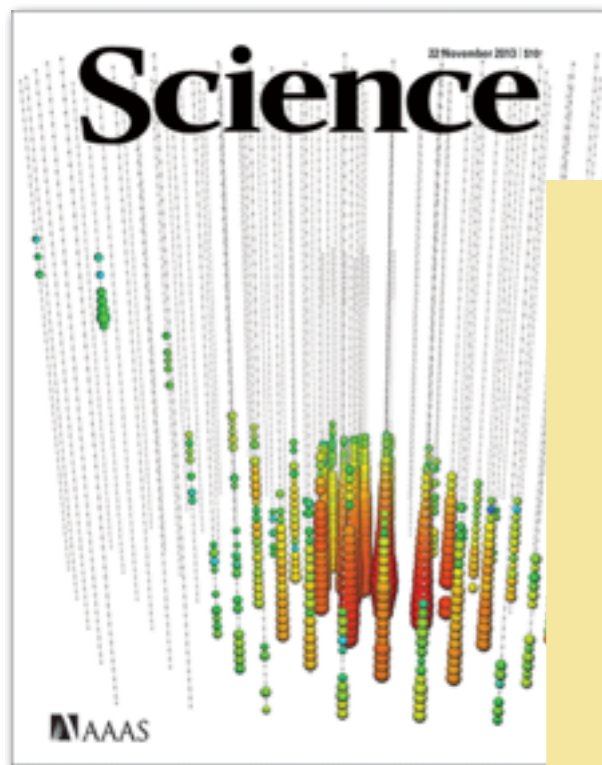
The very first (high-energy) cosmic neutrinos

- Observation of excess at high energies
- By now 4 neutrinos with $\approx 500\times$ LHC energy



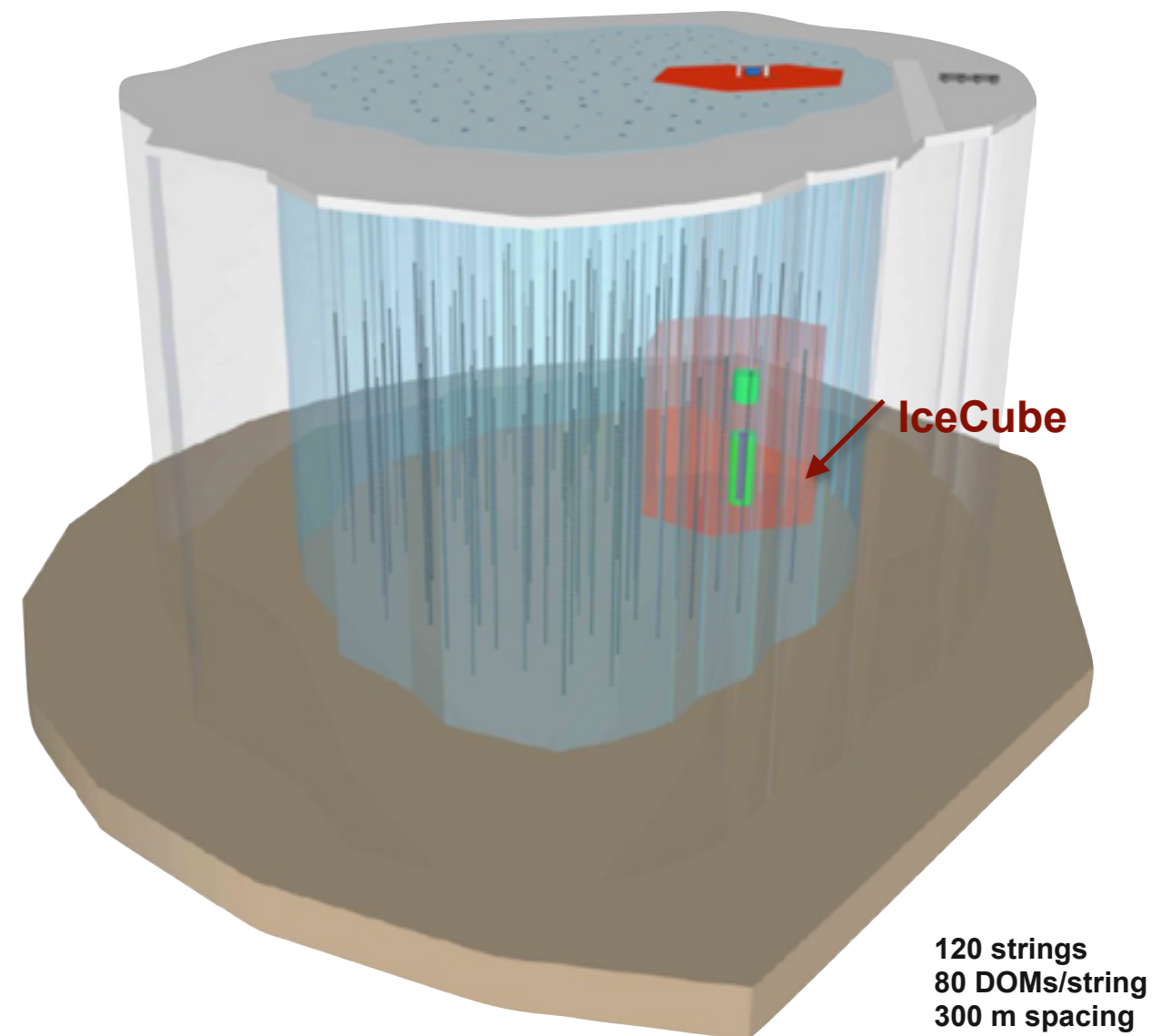
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The next generation – IceCube-Gen2

- High-energy array: neutrino astronomy
 - instrumented ice volume 5–10 km³
 - factor 5–10 gain in sensitivity
- PINGU: neutrino physics
 - ~5 Mton dense array in detector center
 - neutrino oscillations



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2015

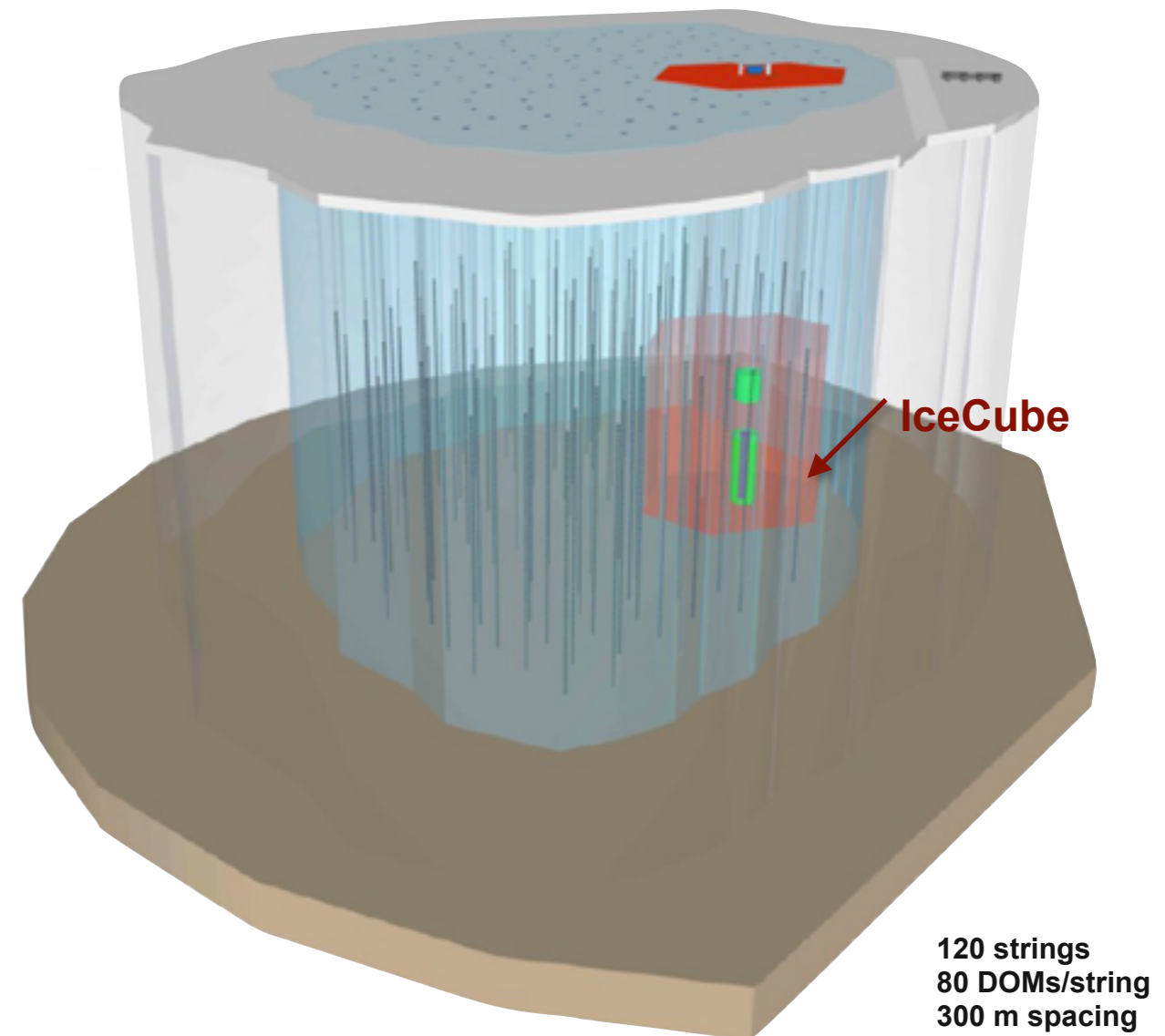


Kajita



McDonald

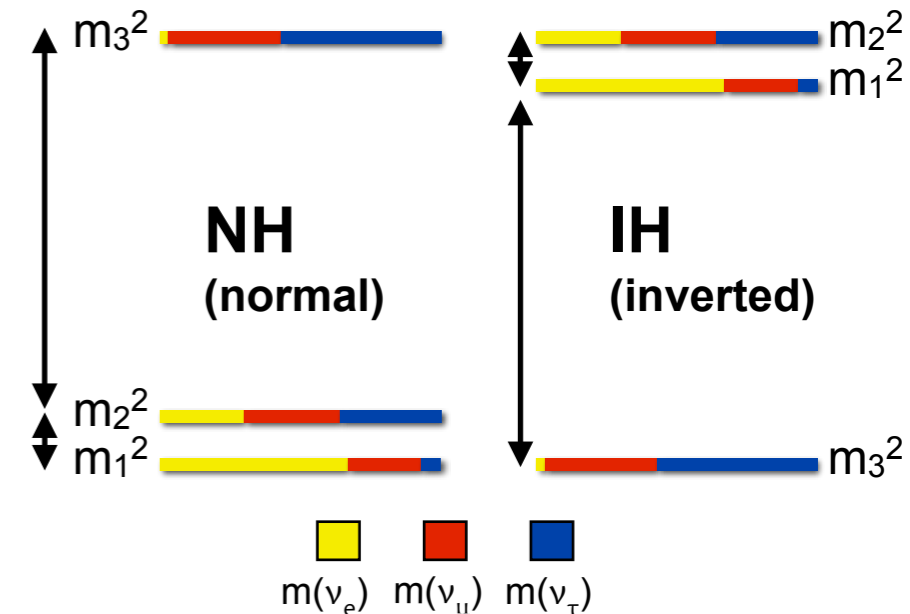
"for the discovery of neutrino oscillations, which shows that neutrinos have mass"



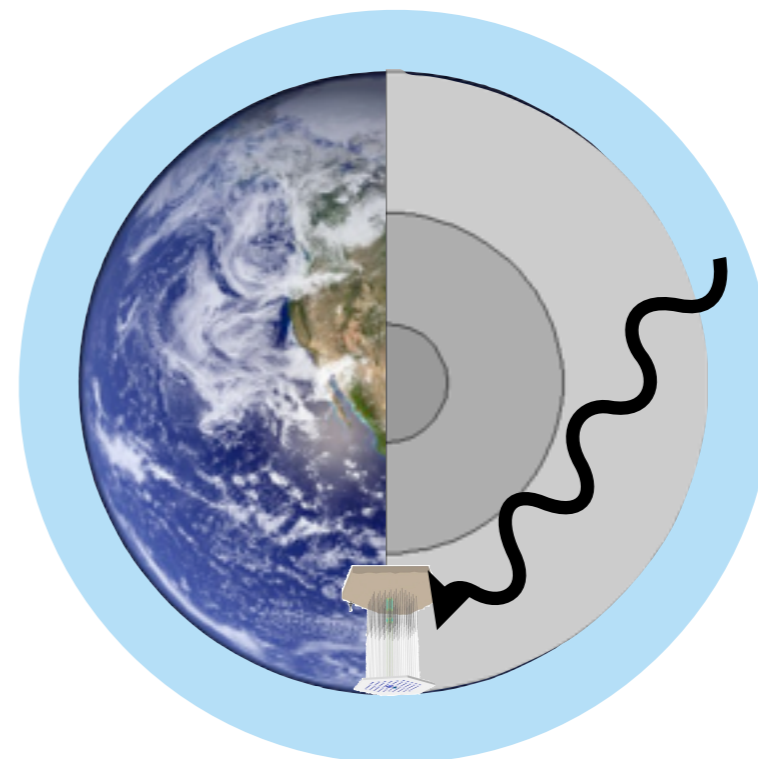
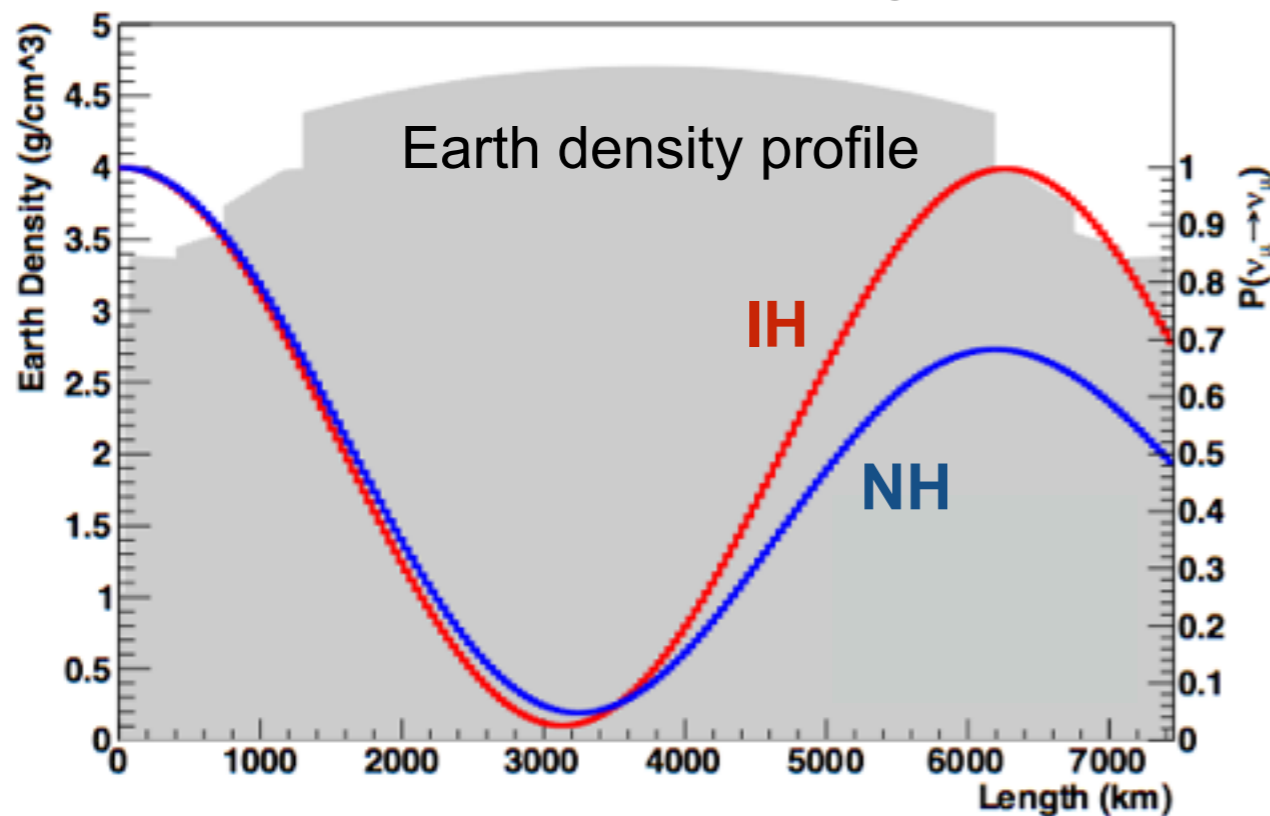


Neutrino physics with neutrino telescopes

- Oscillation physics with atmospheric neutrinos
- Holy grail: neutrino mass ordering
→ in reach with PINGU



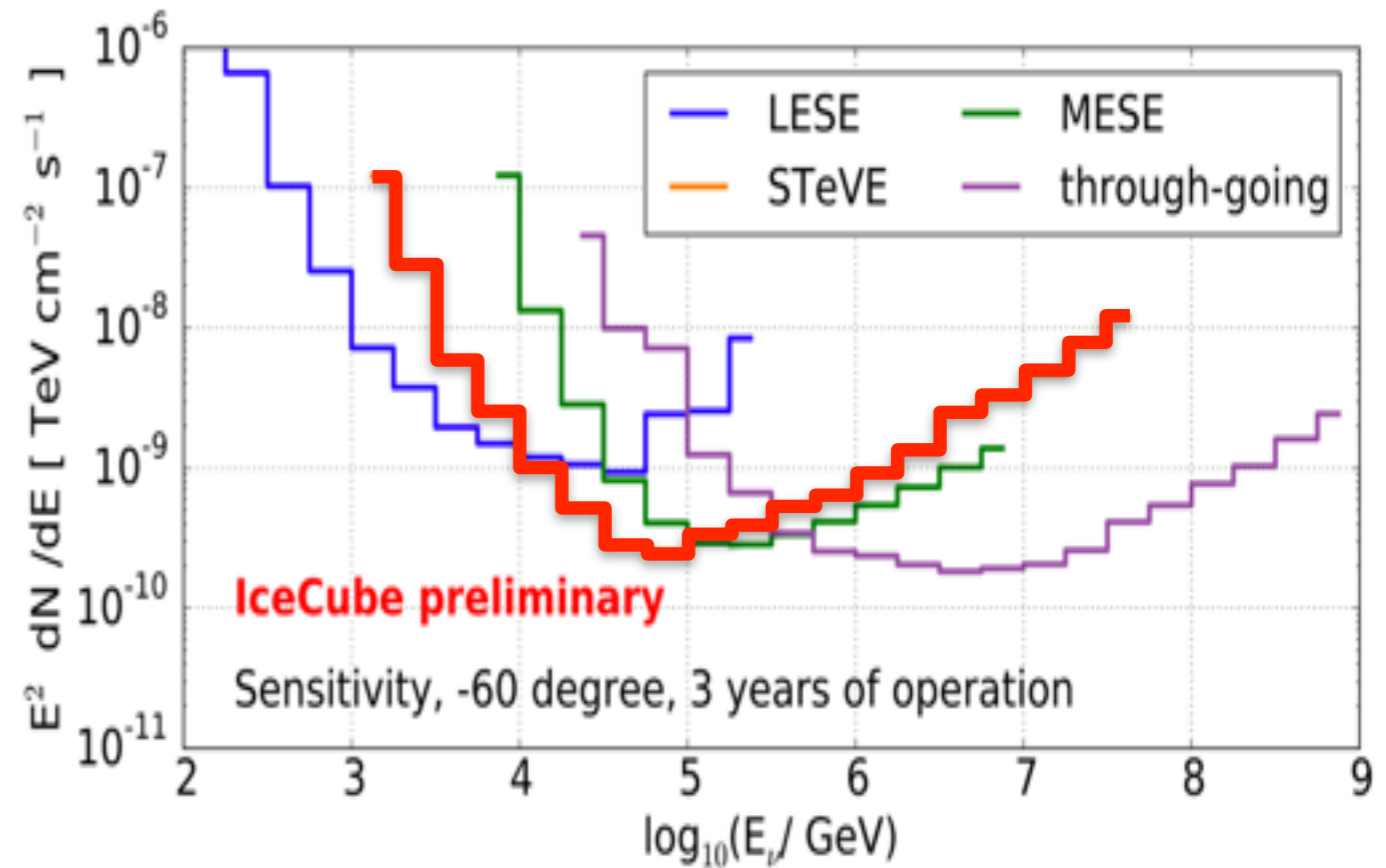
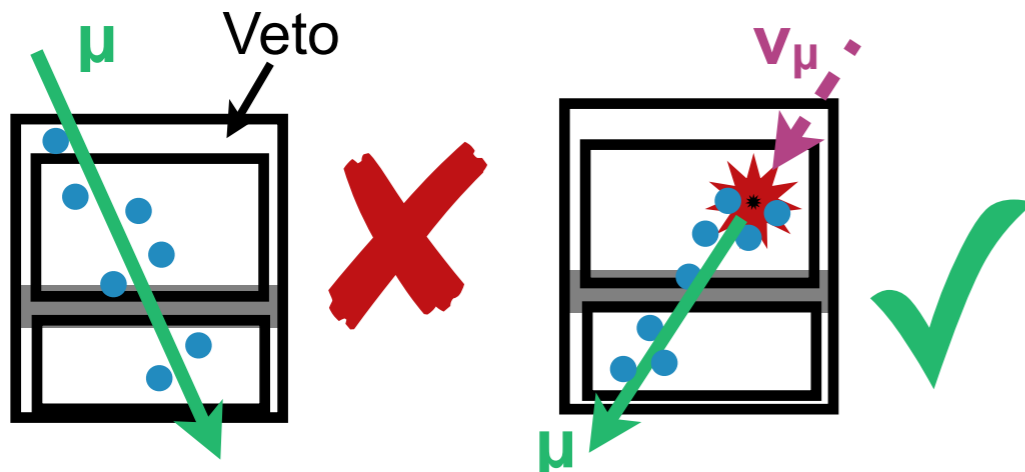
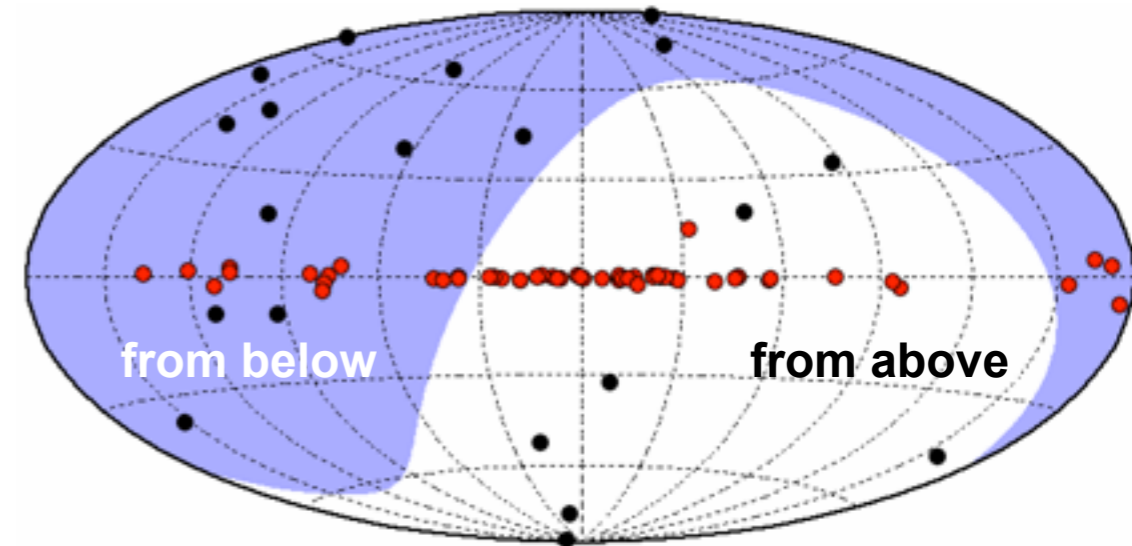
Oscillation probability $P(\nu_\mu \rightarrow \nu_\mu)$ @ 6 GeV, 126°



Current activities

Analysis of IceCube data

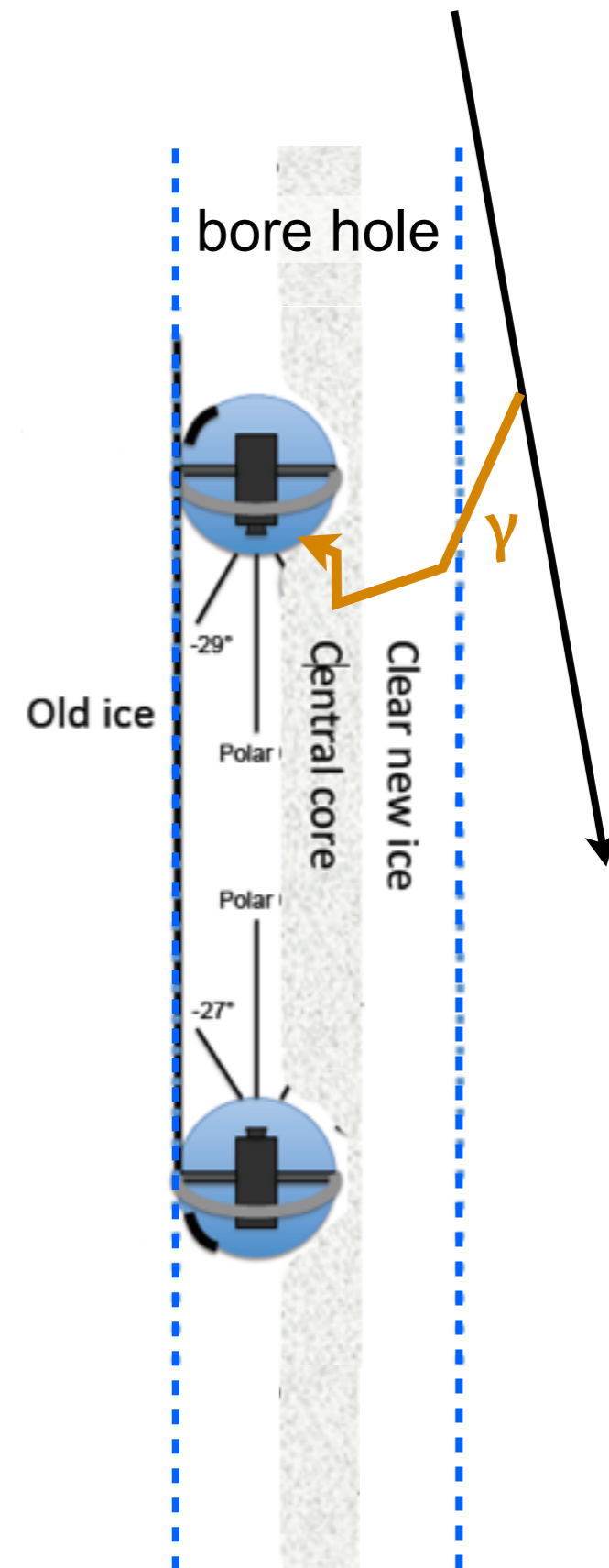
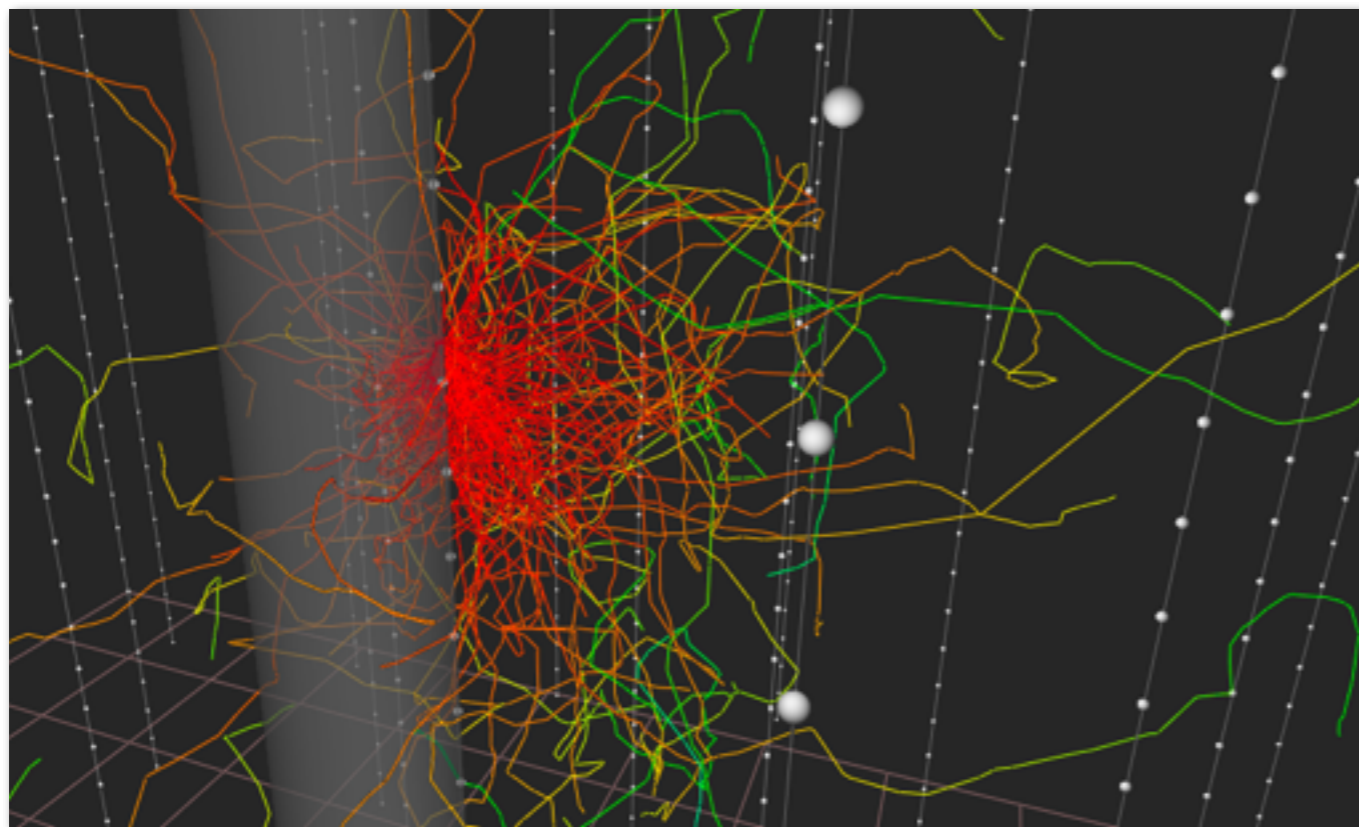
- Point-source search in the southern sky
 - Many interesting galactic TeV γ -ray sources
 - Problem: large atmospheric background



Current activities cont'd

Simulation

- Improvement of photon propagation
 - direct propagation of Cherenkov photons (parallel processing on GPUs)
 - implementation of accurate hole ice simulation



Current activities cont'd

Development of new optical sensor for IceCube-Gen2
(cooperation with DESY/Zeuthen and Alberta/Canada)

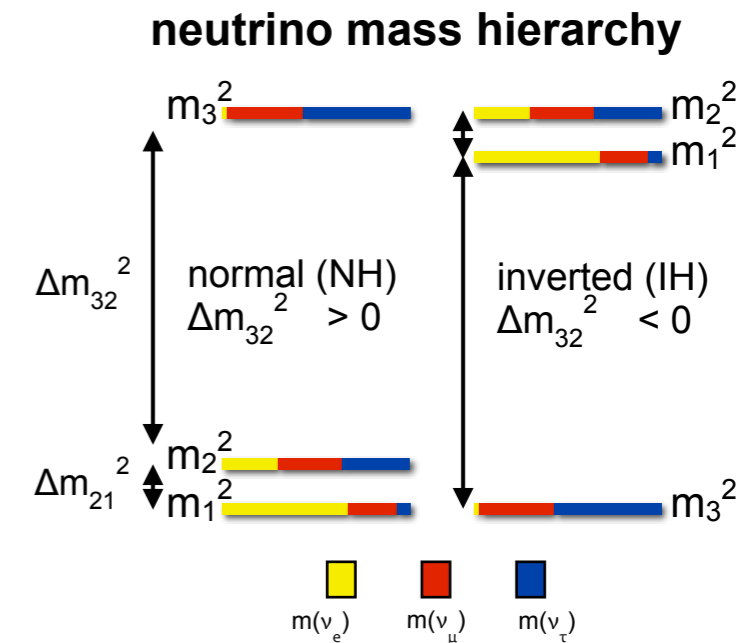
- PMT characterization
- Mechanical setup
- Readout
- Prototype building
- Performance simulations



Prospective activities:

- Multi-Messenger astronomy
- Neutrino oscillations
- Indirect WIMP dark matter
- Sterile neutrinos

GRK 2149: Strong and **Weak Interactions** – from Hadrons to **Dark Matter**



The neutrino sky

