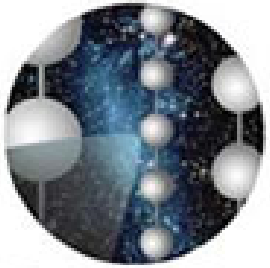


The IceCube experiment

K. Mase, Chiba univ.

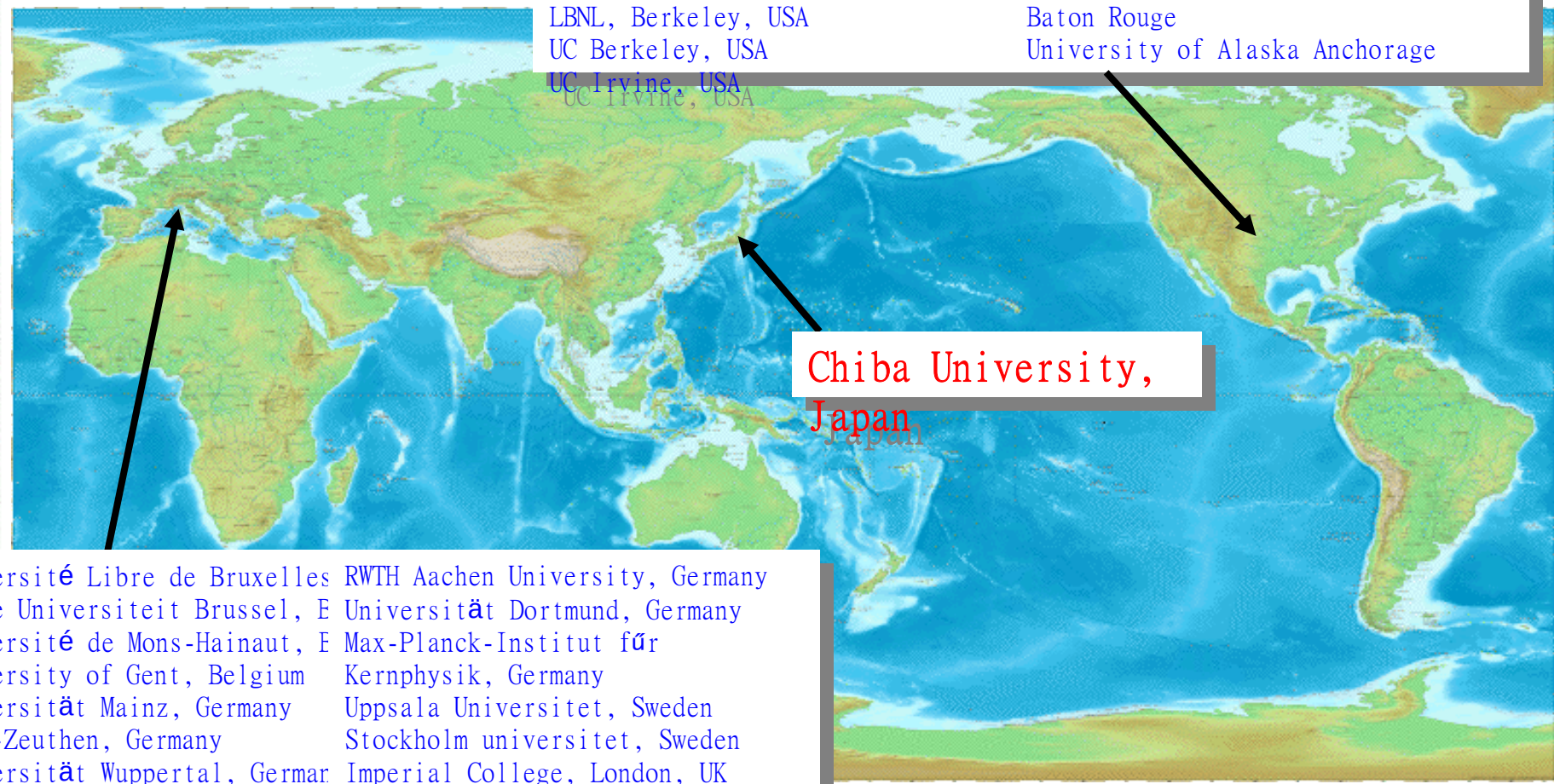
千葉大学
Chiba University

The IceCube Collaboration

~30 institutes and ~200 physisits

Bartol Research Inst, Univ of Dela
USA
Pennsylvania State University, USA
University of Wisconsin-Madison, U
University of Wisconsin-River Fall
LBNL, Berkeley, USA
UC Berkeley, USA
UC Irvine, USA

Clark-Atlanta University, USA
Univ. of Maryland, USA
University of Kansas, USA
Institute for Advanced Study, USA
Southern Univ. and A&M College,
Baton Rouge
University of Alaska Anchorage



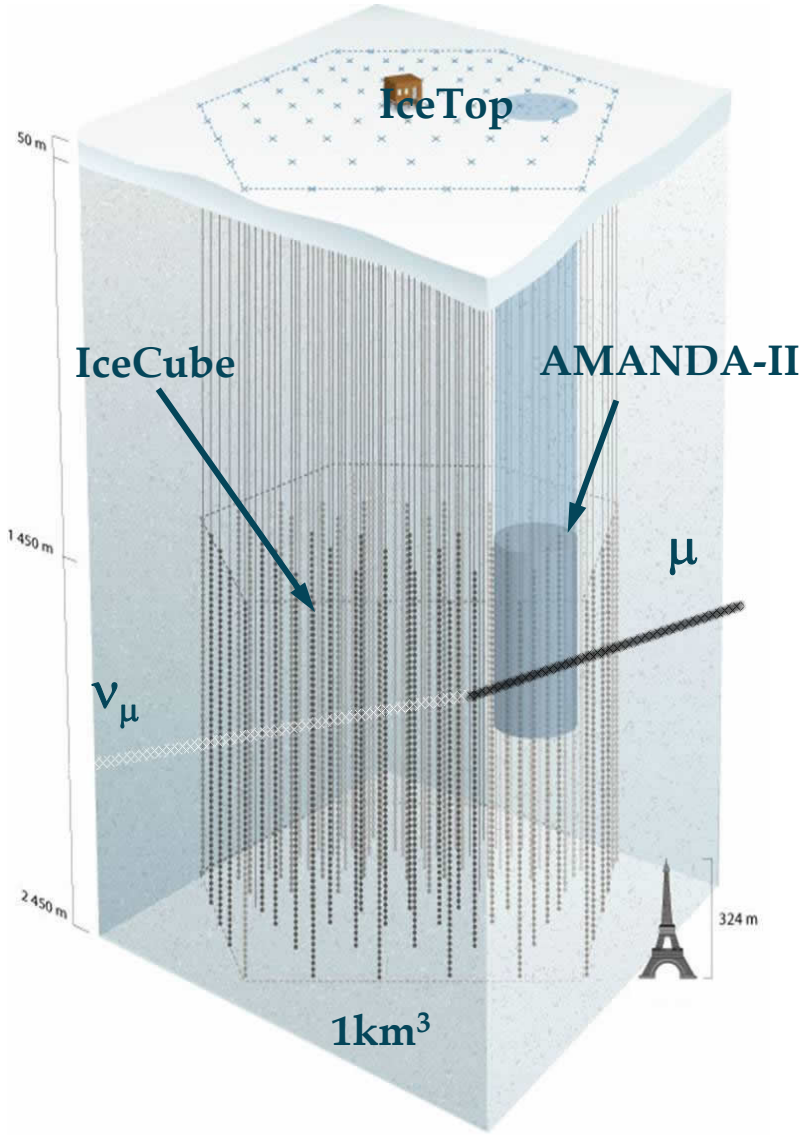
Chiba University,
Japan

Université Libre de Bruxelles
Vrije Universiteit Brussel, E
Université de Mons-Hainaut, E
Unibersity of Gent, Belgium
Universität Mainz, Germany
DESY-Zeuthen, Germany
Universität Wuppertal, Germar
Humboldt Universität, Germany

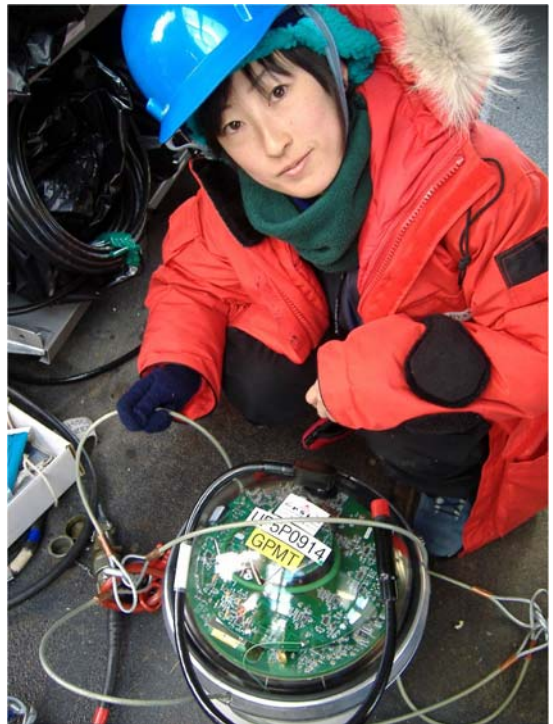
RWTH Aachen University, Germany
Universität Dortmund, Germany
Max-Planck-Institut für
Kernphysik, Germany
Uppsala Universitet, Sweden
Stockholm universitet, Sweden
Imperial College, London, UK
University of Oxford, UK
Utrecht University, Utrecht, NL

The IceCube experiment

- deployed in the Antarctica glacier
- ~70 strings
- ~4200 photo-multiplier tubes (PMTs)
- Detector volume: $1km^3$
- ATWD 300MHz effectively 14 bits
- 3 different gains (x15, x3, x0.5)
- 10 bits FADC for long duration pulse
- Neutrino energy of 10^7(SNs)-10^{20}eV is detectable.
- 9 strings are deployed. The

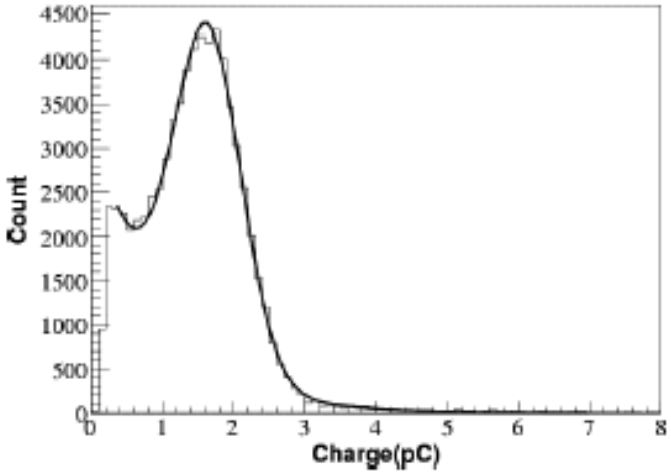


The IceCube

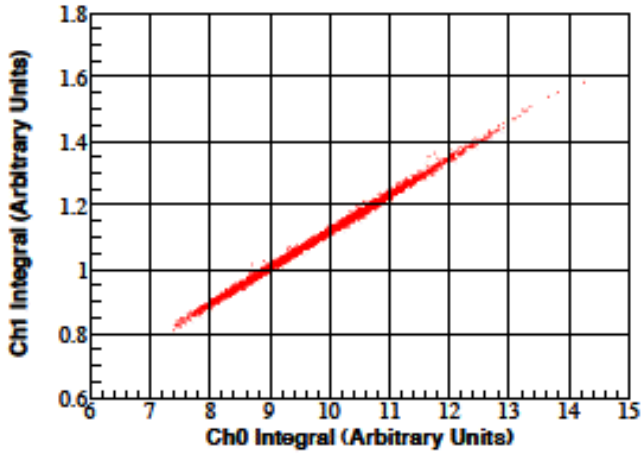


The system check

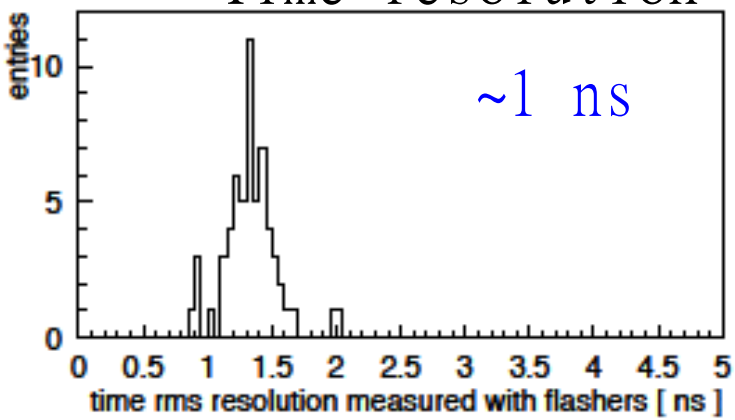
1 p.e. distribution



Gain check

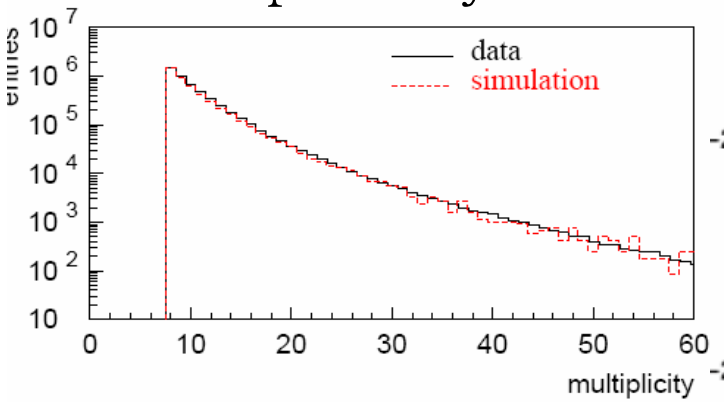


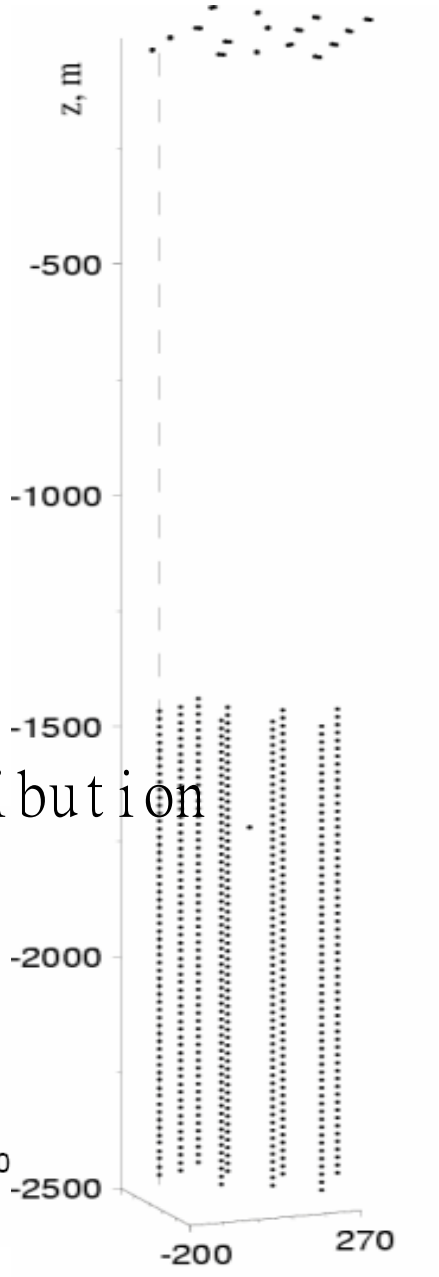
Time resolution



~1 ns

Multiplicity distribution

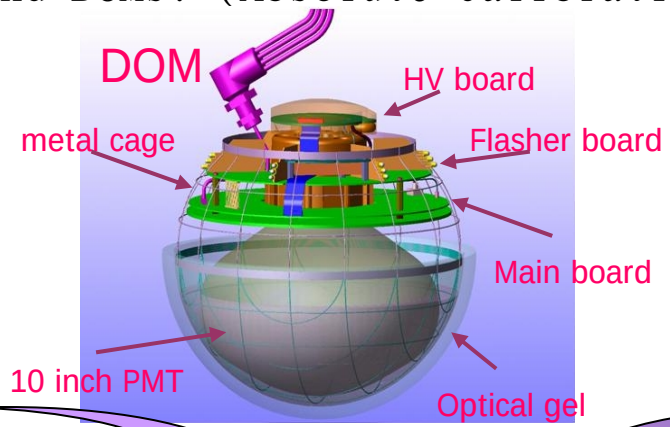


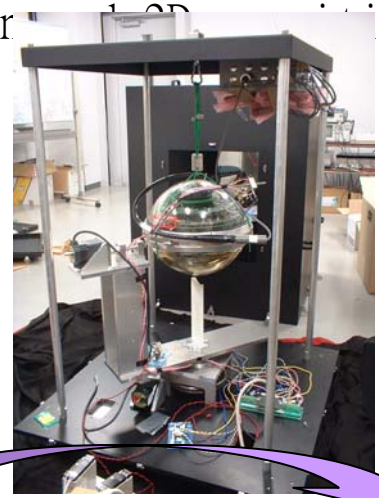


A. Achterberg et al., Astropart. Phys., 26, 3, 155-173 (2006)

Calibration of PMTs and Digital Optical Modules (DOMs)

- Calibration of IceCube detector is difficult once installed. (flusher and atom. neutrino)
  → Calibration of detectors before the installation is important.
- We calibrate PMTs and DOMs. (Absolute calibration and 2D sensitivity scan.)

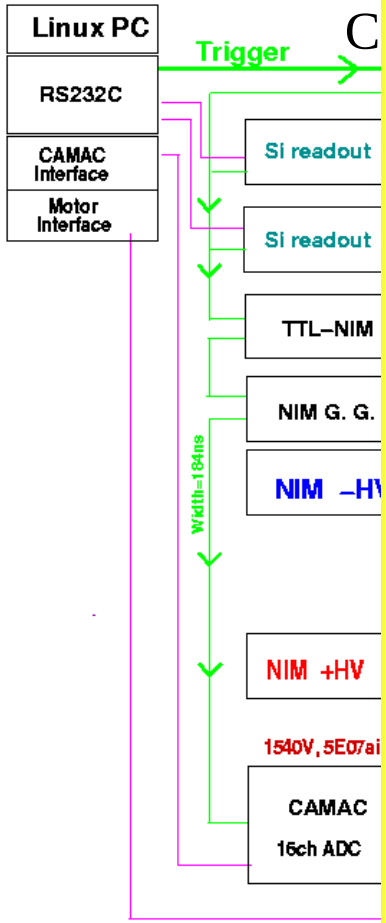


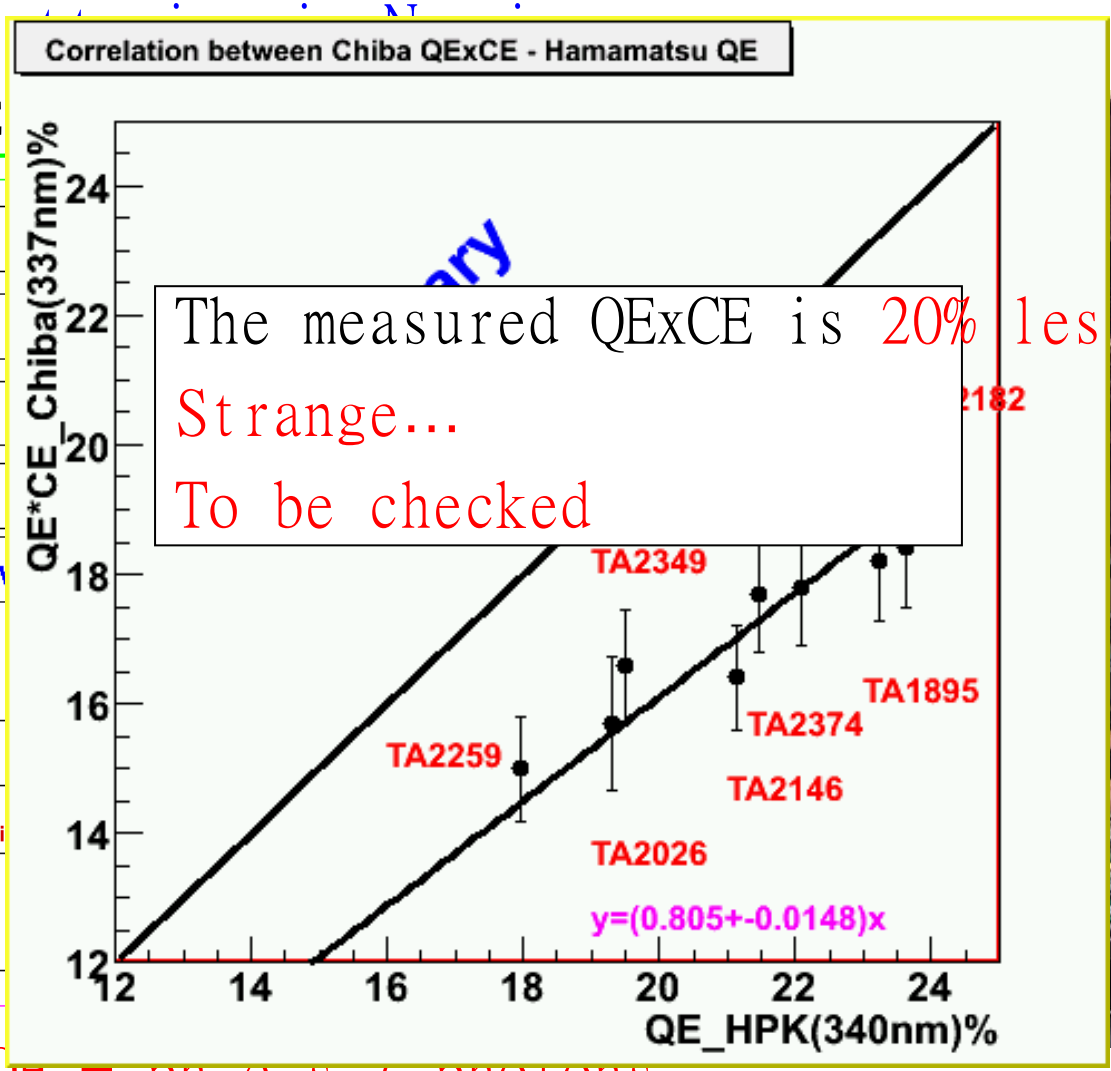


Hamamatsu → **Chiba Univ.** → **Wisconsin Univ.** → **Chiba Univ.** → **South Pole**

- makes all PMTs
- **Normal check**: (1/10)
  - Linearity of the PMT gain
  - dark noise rate
  - charge resolution
- **Golden PMTs**: (1/60)
  normal check +
  - 2D sensitivity scan
  - Absolute calibration
- assembles DOMs
- check all DOMs
  (under low temperature)
  - Linearity of the DOM gain
  - dark noise rate
  - component check
  - cold reboot
  - communication test
- **Golden DOMs**: (1/80)
  - 2D sensitivity scan
  - Absolute calibration

The absolute calibration of PMTs and DOMs using Rayleigh sc

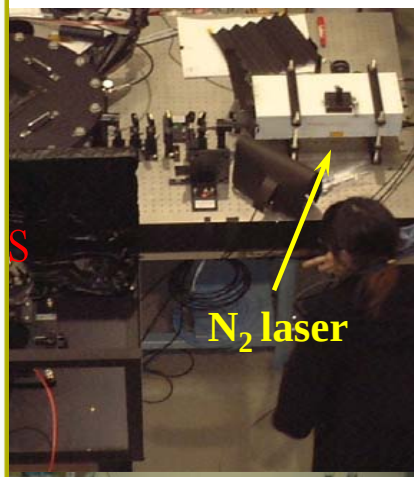




The measured QExCE is 20% less

Strange...

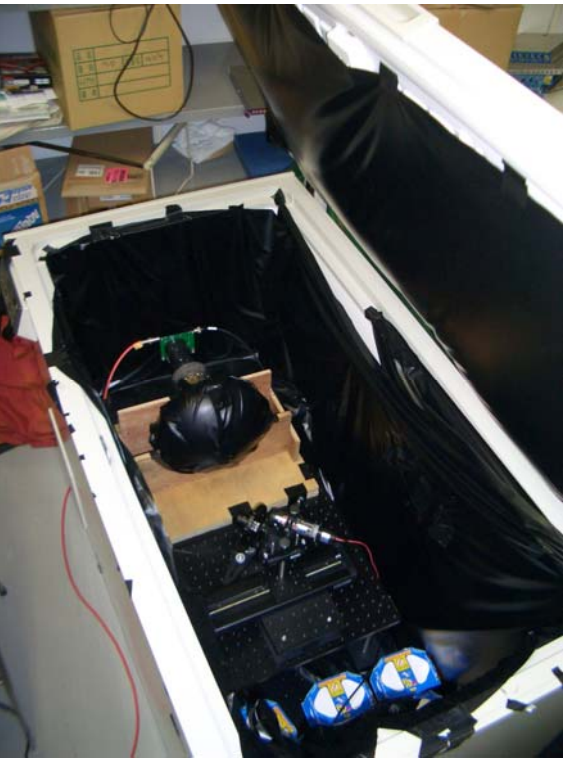
To be checked

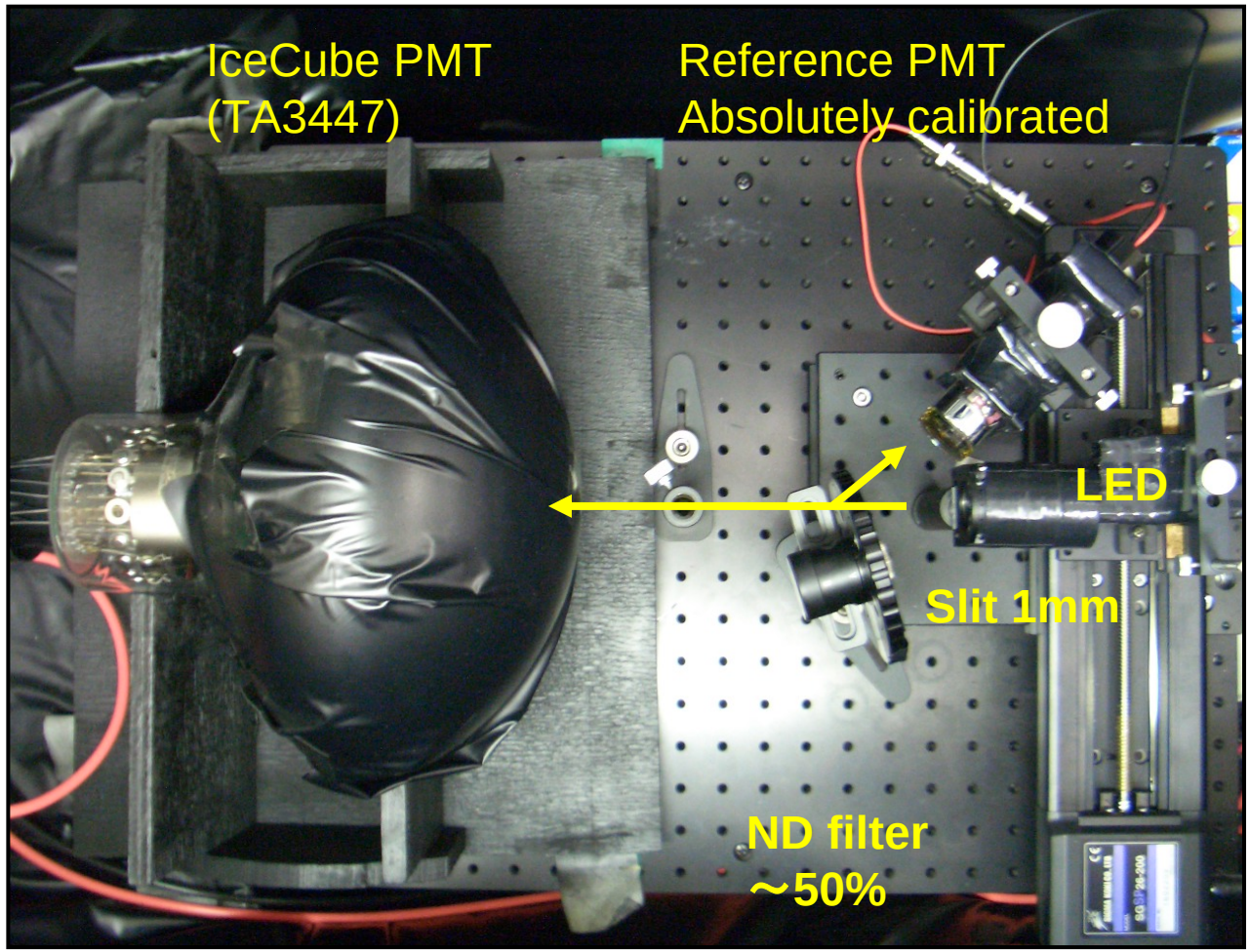


QE = ph.e.s / photons

The Rayleigh scattering is well understood!

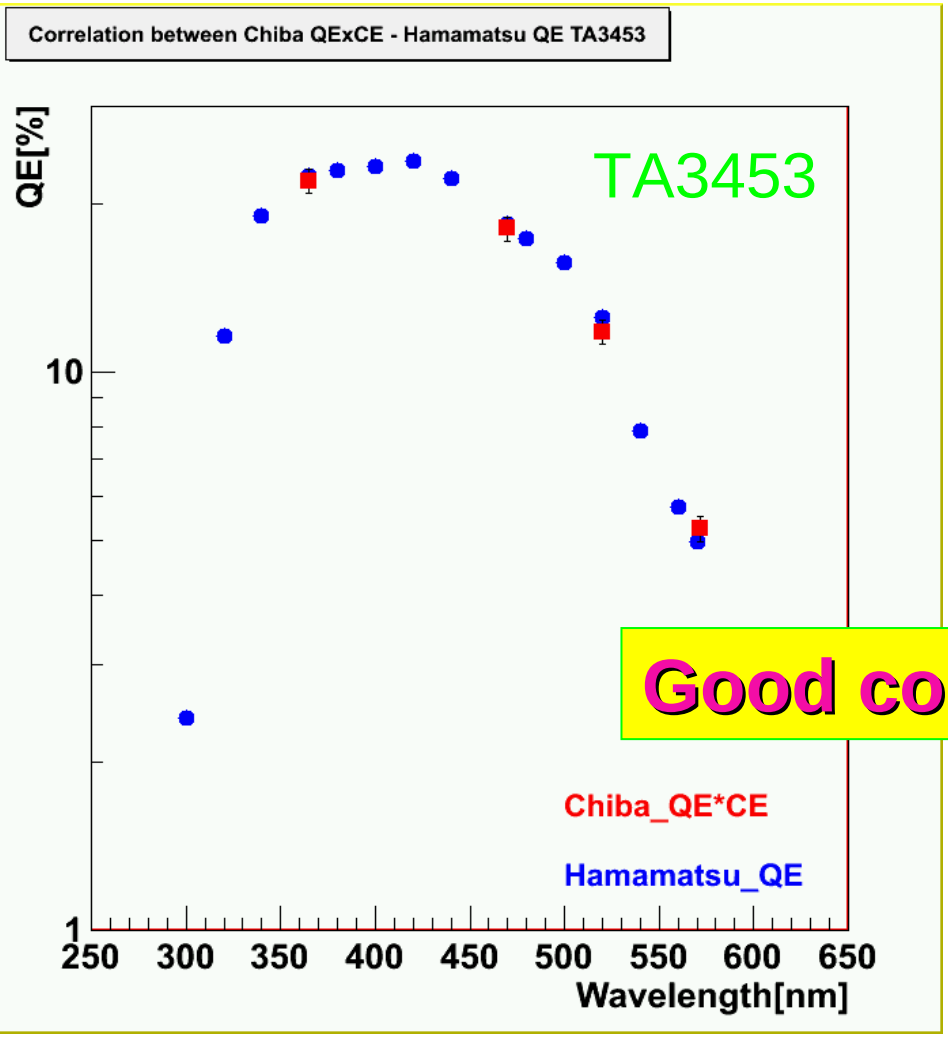
New calibration system in a freezer

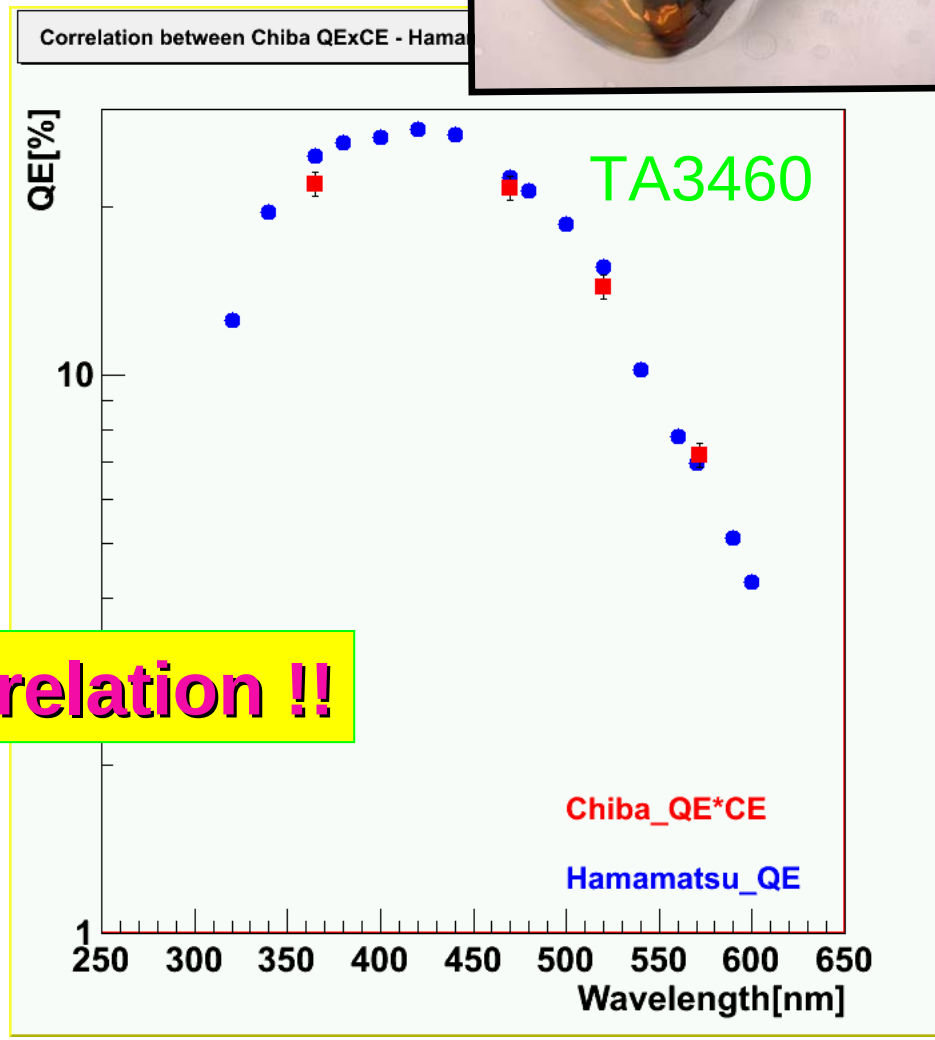




We can calibrate detectors absolutely even at low tem

The QEs of PMTs

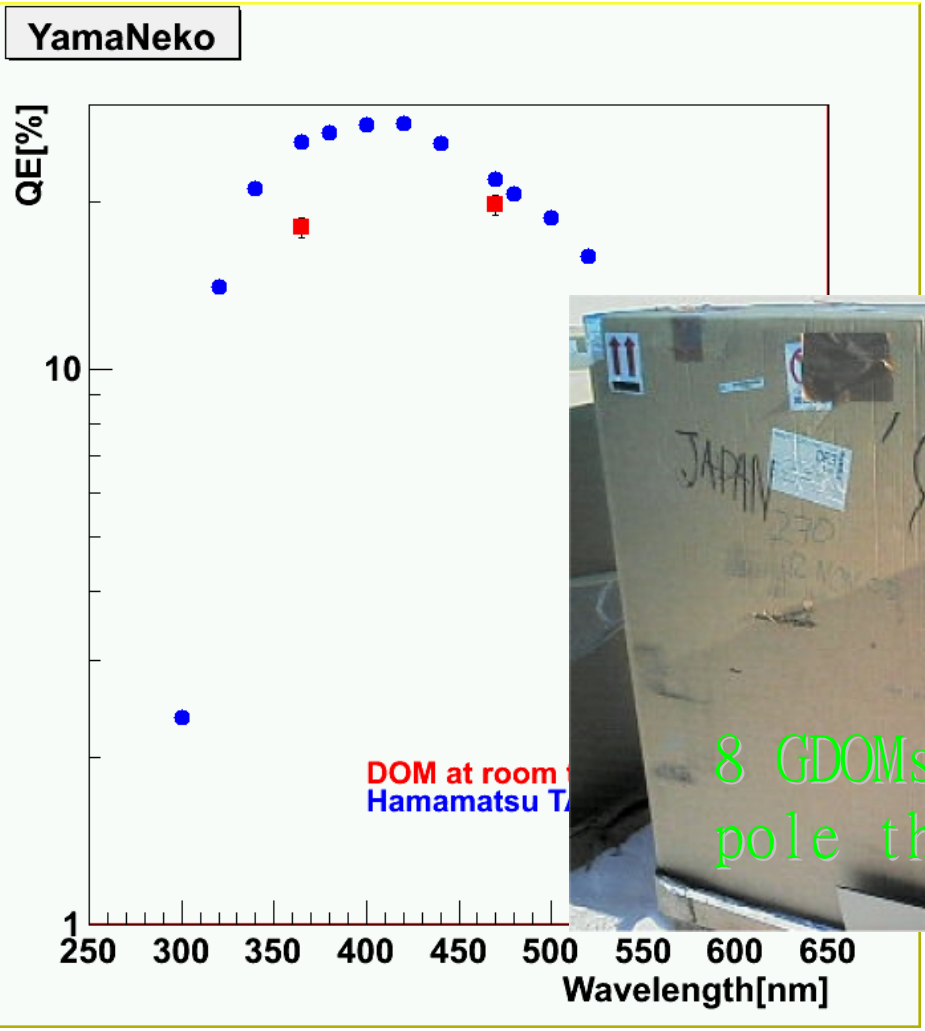


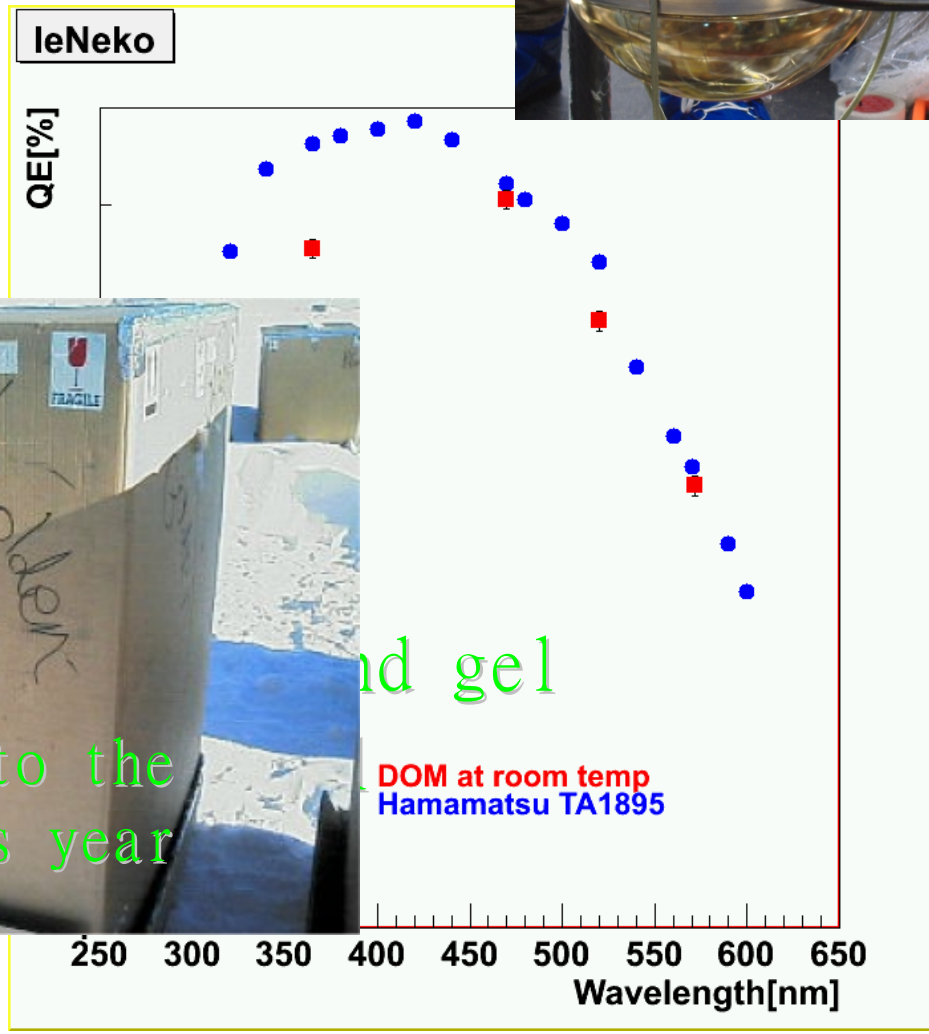


Good correlation !!

(@room temperature)

The QEs of Golden DOMs

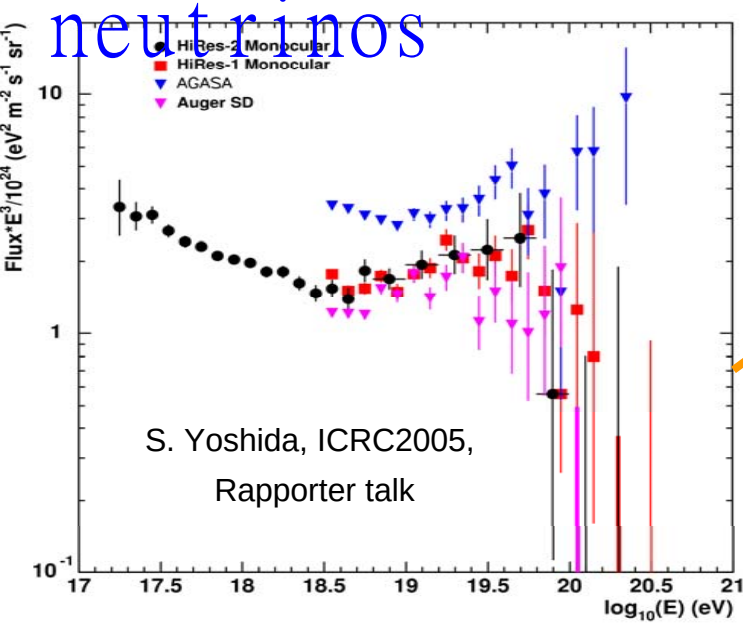




nd gel

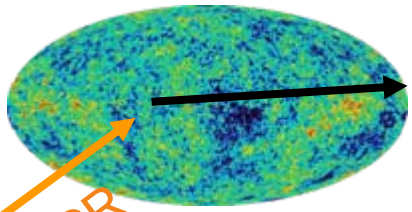
(@room temperature

The extremely high energy neutrinos

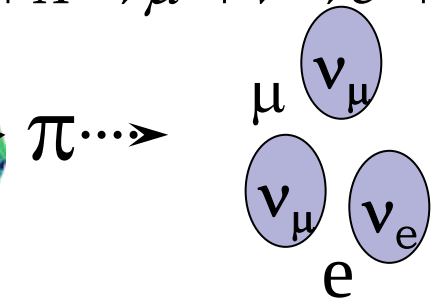


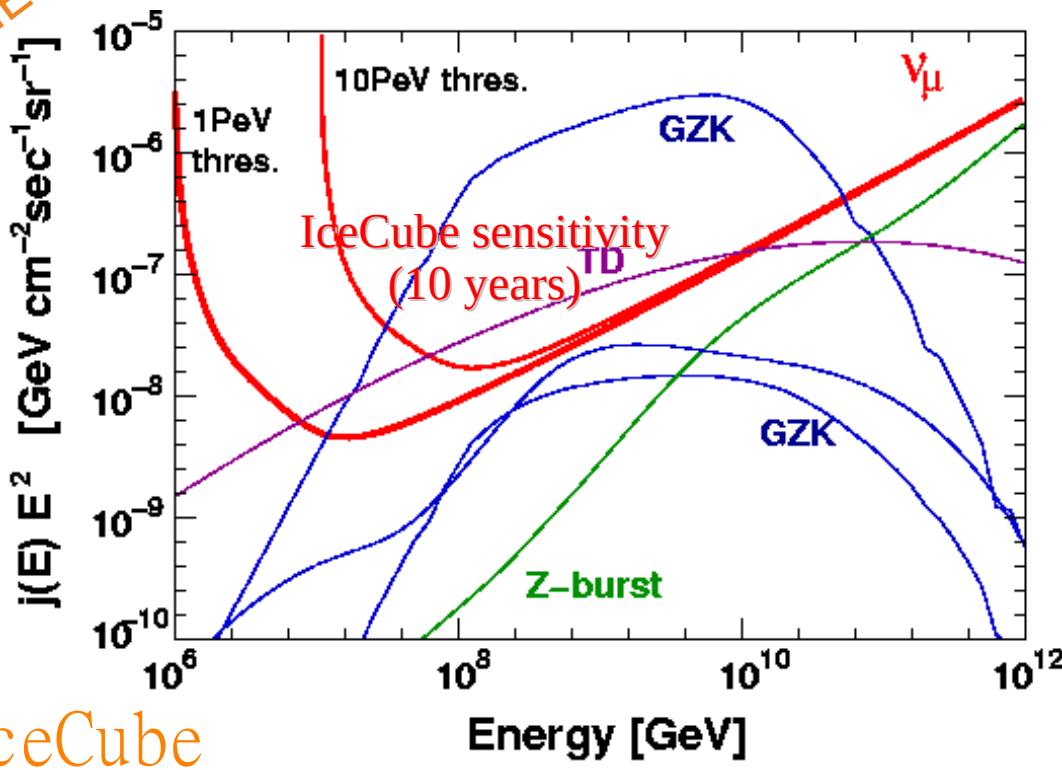
S. Yoshida, ICRC2005,
Rapporter talk

$$p\gamma_{2.7K} \rightarrow \pi^{\pm} + X \rightarrow \mu^{\pm} + \nu \rightarrow e^{\pm} + \nu' s$$



EHE-CR



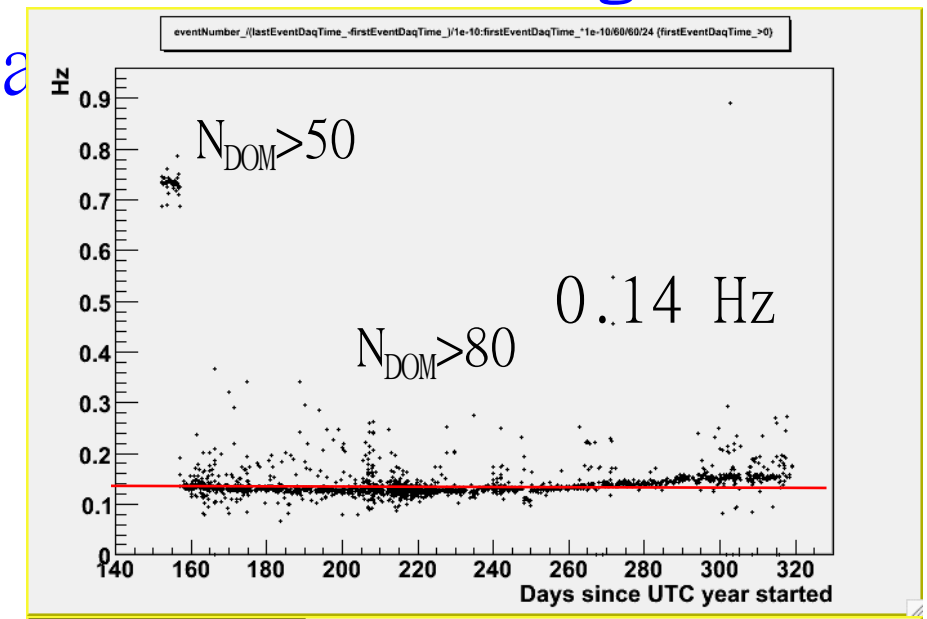


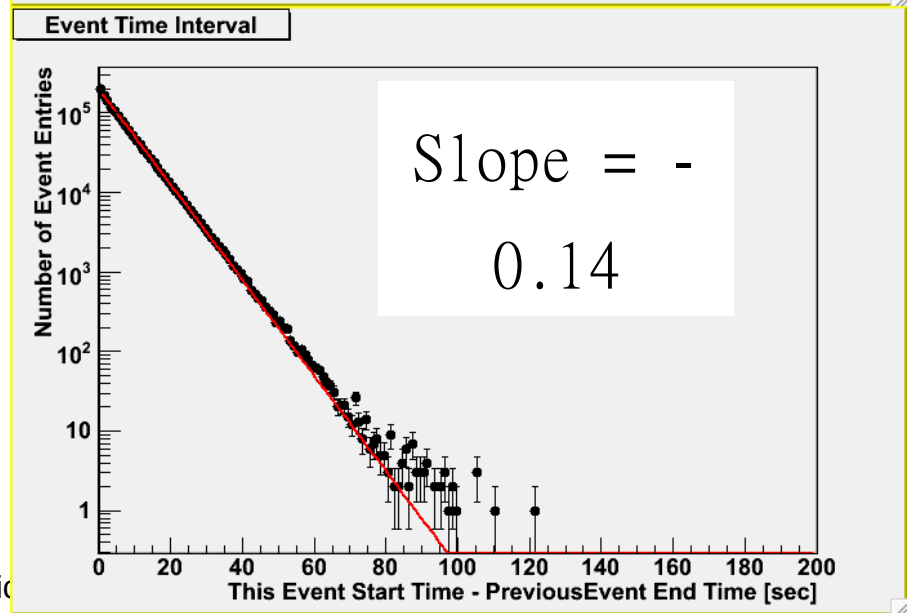
The GZK cut off exist?

Test the GZK model by IceCube

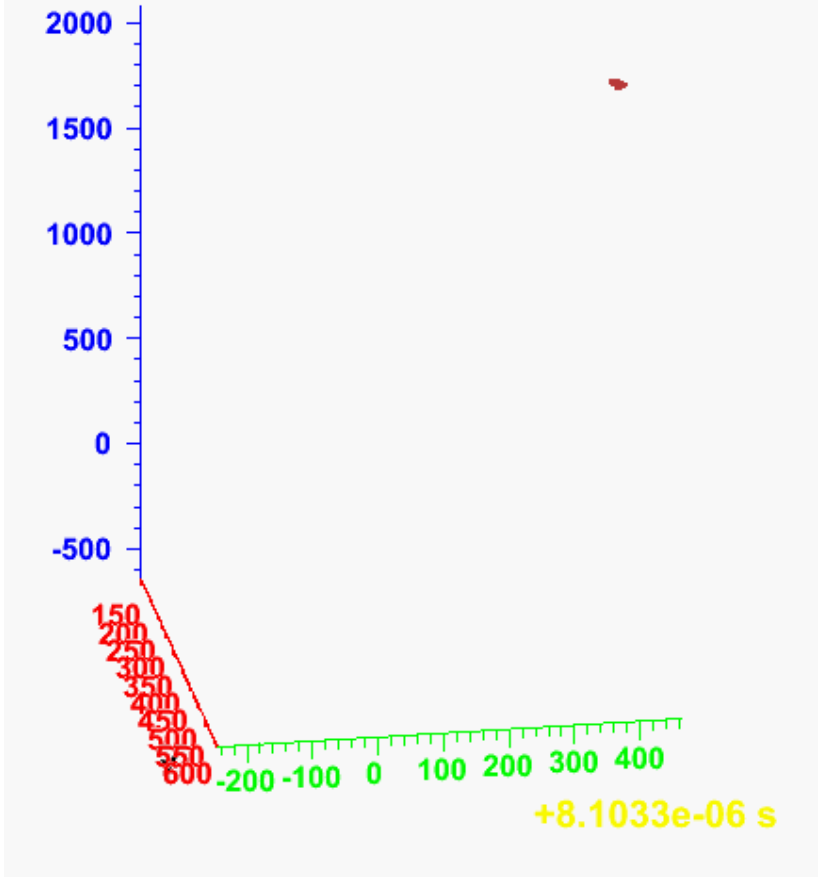
S. Yoshida et. al. (2004) Phys. Rev. D 69 103004

The 9 strings EHE data a

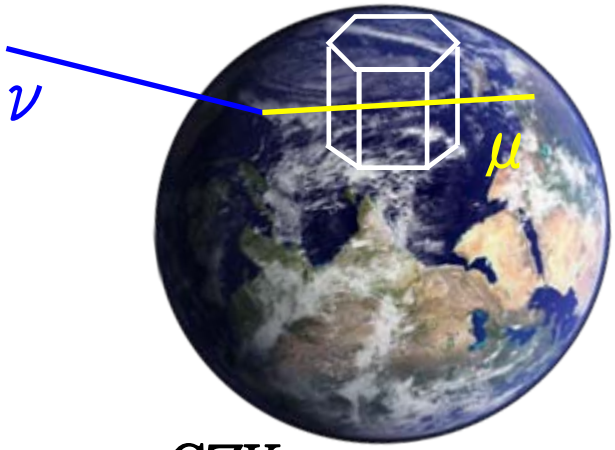




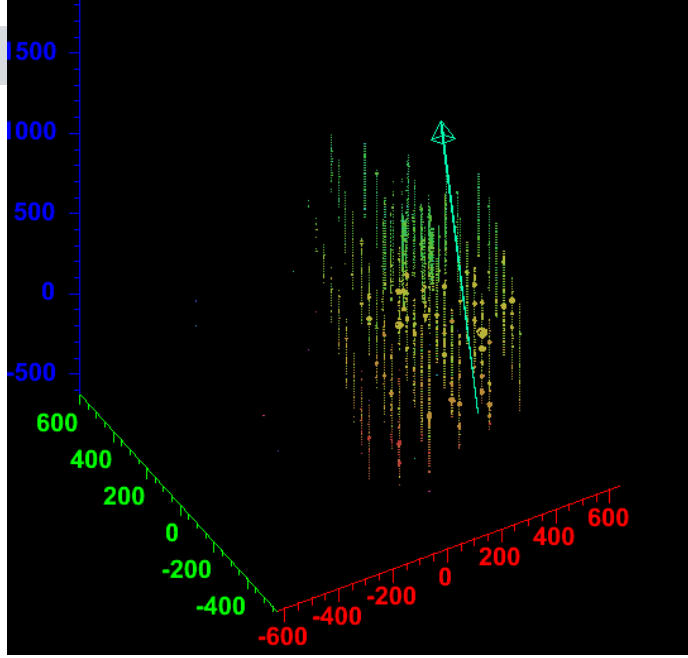
The highest event so far
(4×10^4 p.e.)



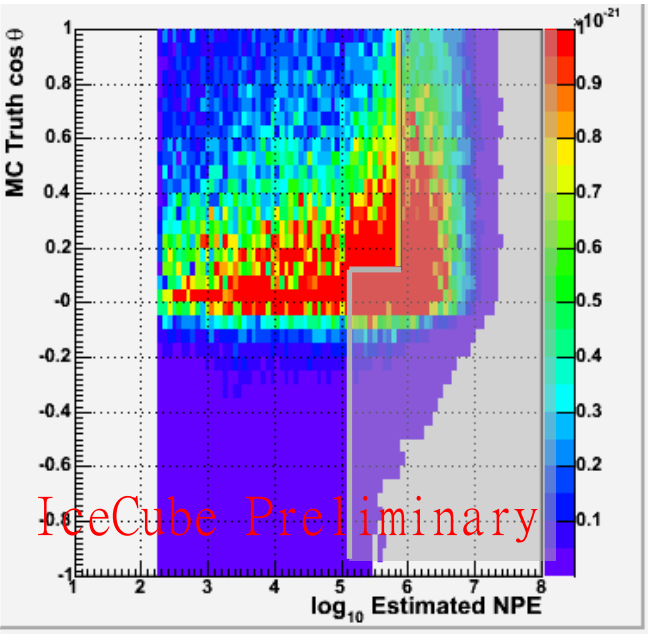
The MC simulation



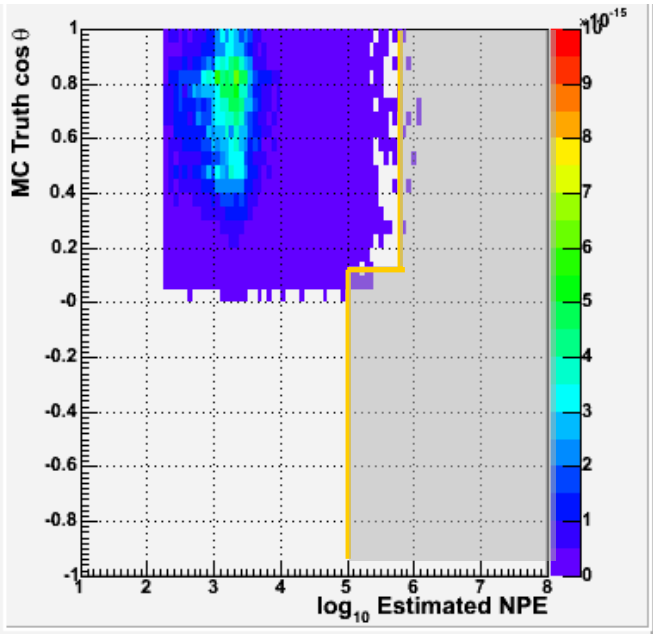
- The GZK and atmospheric flux are taken into account.
- The detector MC included.



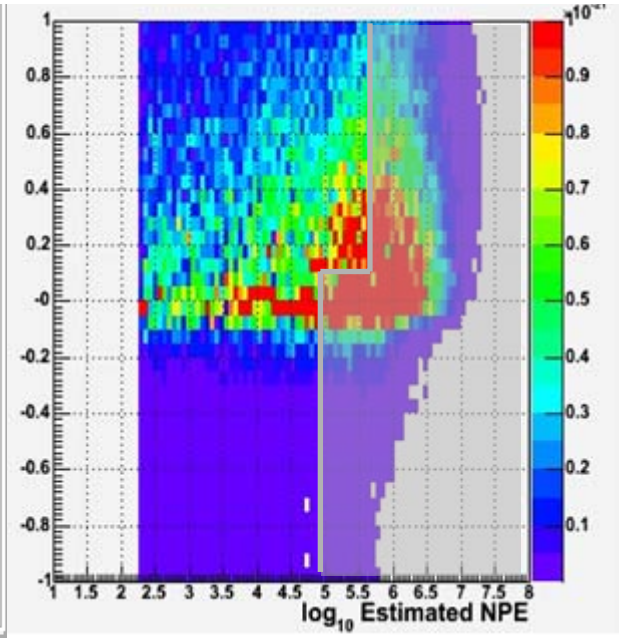
GZK μ



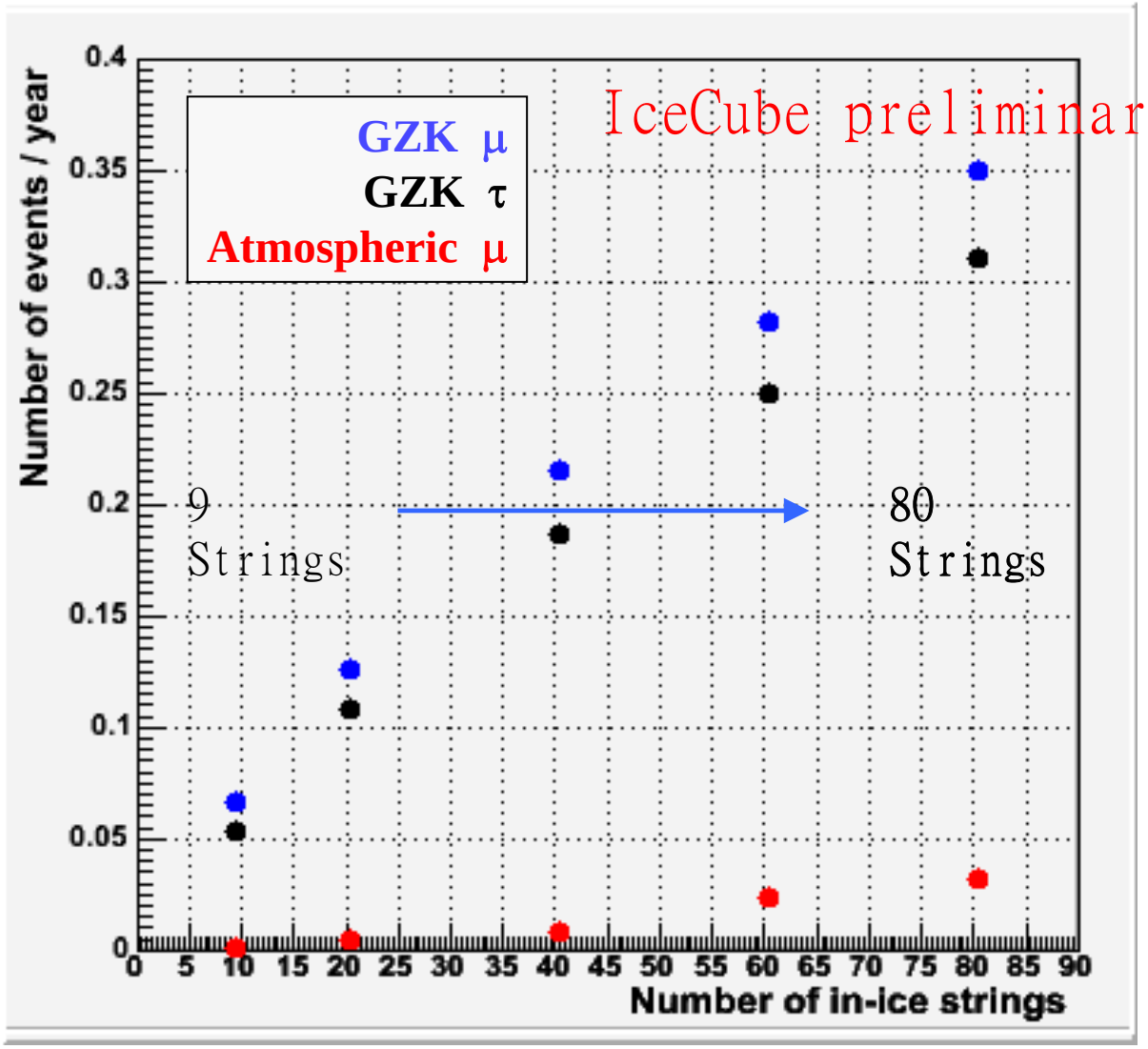
Atmospheric μ



GZK τ



The event rate



9 strings

event rate

0.13 events/year

Atmospheric μ

0.009 events/year

80 strings

event rate

0.66 events/year

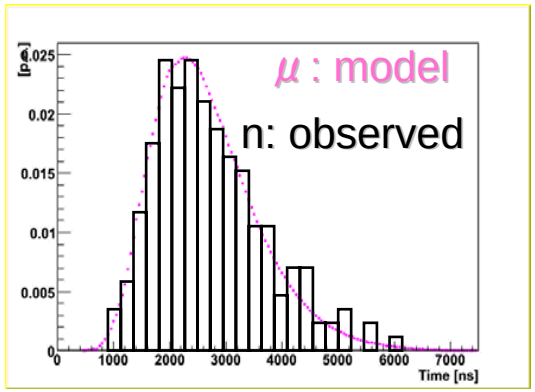
Atmospheric μ

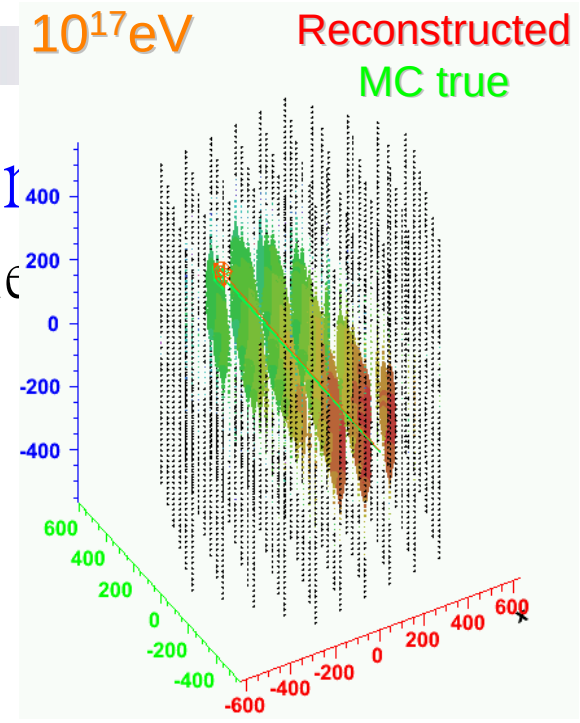
0.033 events/year

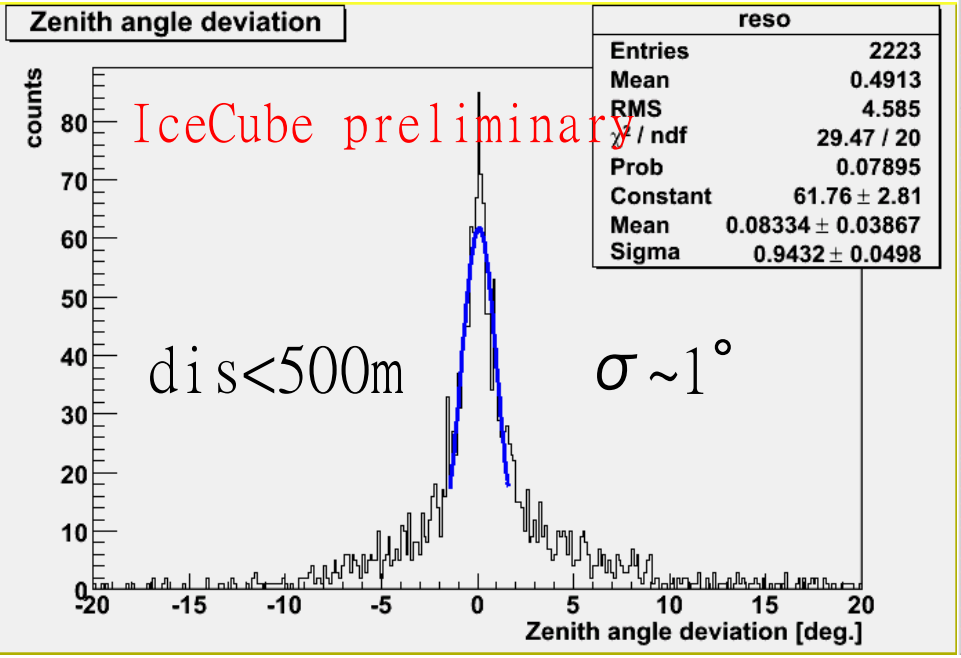
The EHE event reconstructio

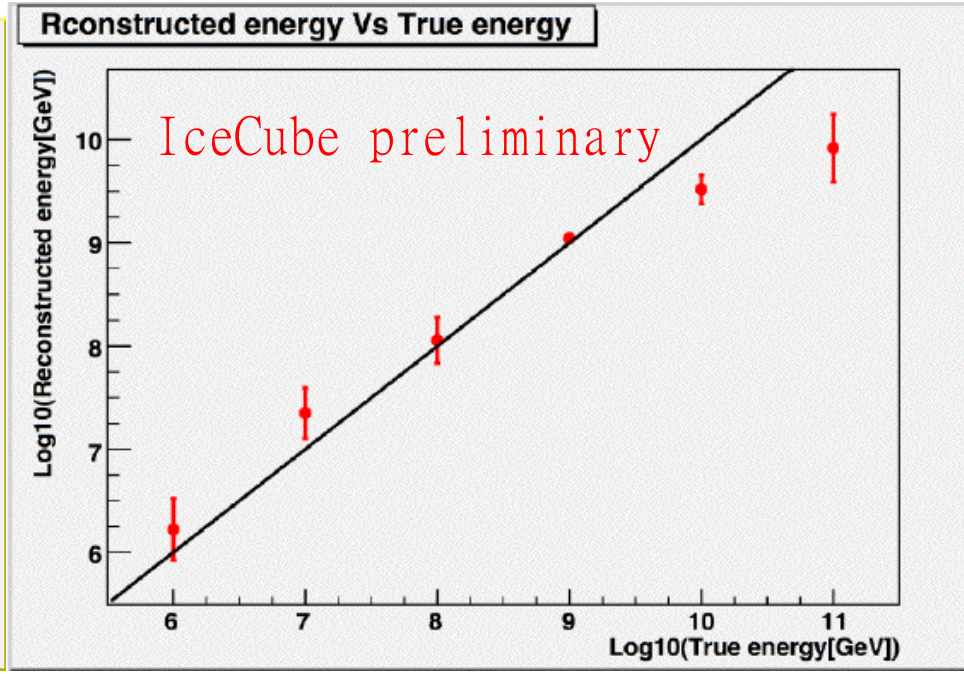
Waveform based reconstruction, using like

$$P(\{n\}|\{\mu\}) = \prod_{i=1}^{k} \frac{\mu_i^{n_i}}{n_i!} e^{-\mu_i}$$









Summary

- IceCube is working with 9 strings.
- We are working both on hardware and software for EHE neutrinos.
- We calibrate PMTs and DOMs (2D absolute). 8 GDOMs to the pole this year.
- We are analyzing 9 strings EHE data with MC data.

The future plan

- In this austral summer, we will (hopefully) deploy 14 more strings. (23 stings in total)
- The disagreement of the QE by N_2 laser has to be investigated well.
- Analyze data more extensively with MC data.
- Need to develop a reconstruction method better.

Physics is coming. Stay tuned!