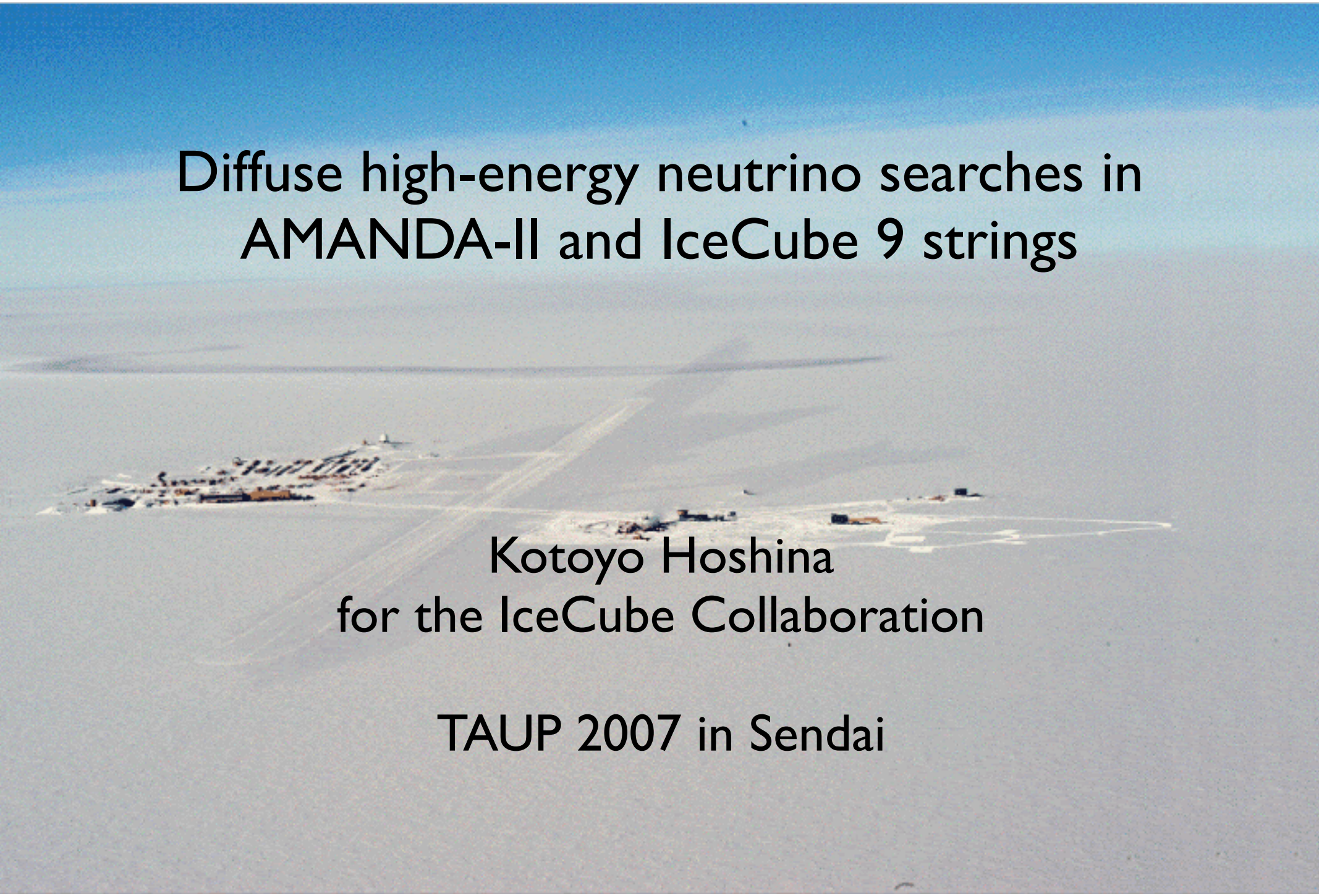
Diffuse high-energy neutrino searches in AMANDA-II and IceCube 9 strings



Kotoyo Hoshina
for the IceCube Collaboration

TAUP 2007 in Sendai

Event Detection Strategy

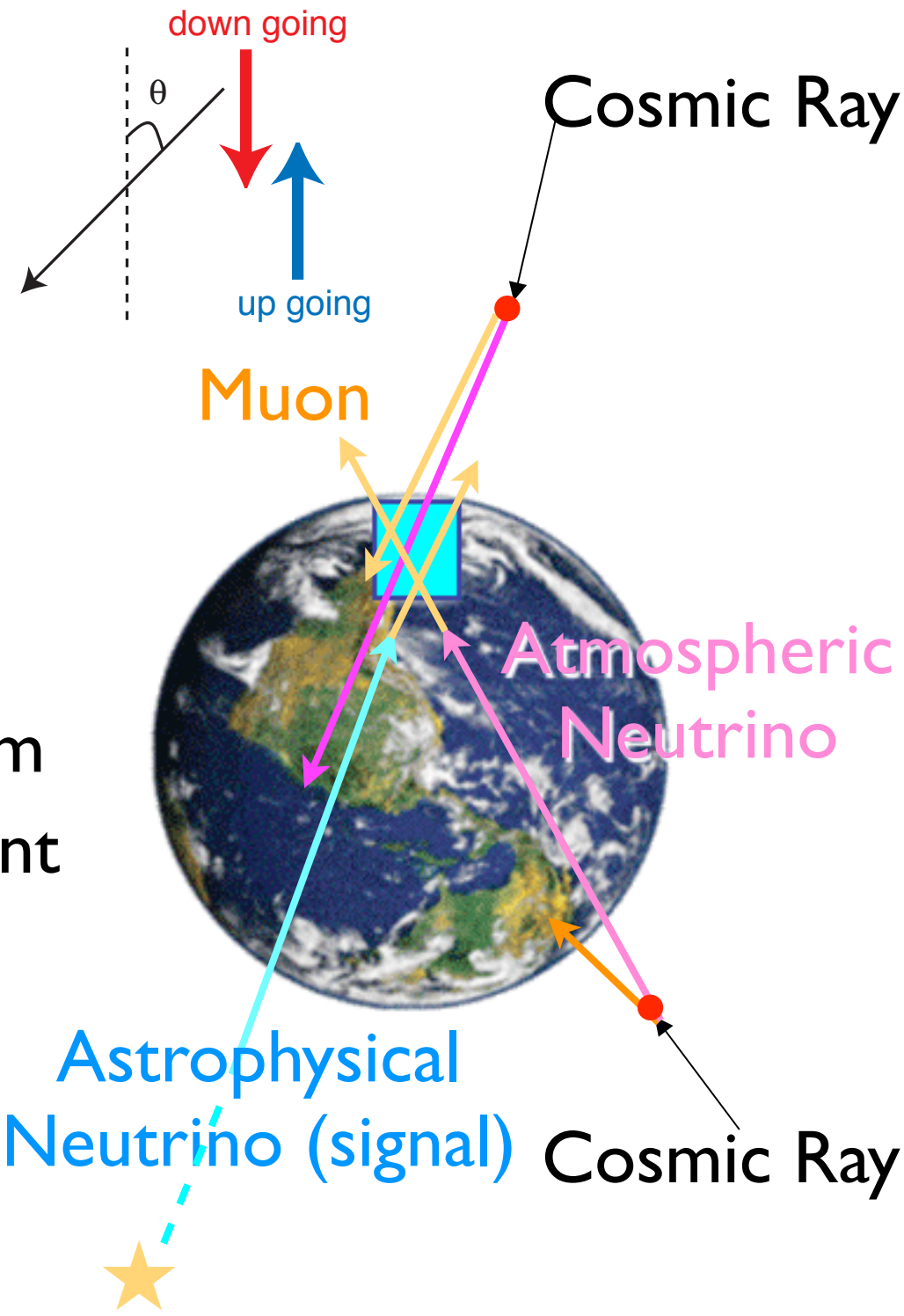
- Target neutrinos :

$$\pi^+ \rightarrow \mu^+ + \nu_\mu$$
$$\hookrightarrow e^+ + \nu_e + \bar{\nu}_\mu$$

(similar for $\pi^-, K^\pm$)

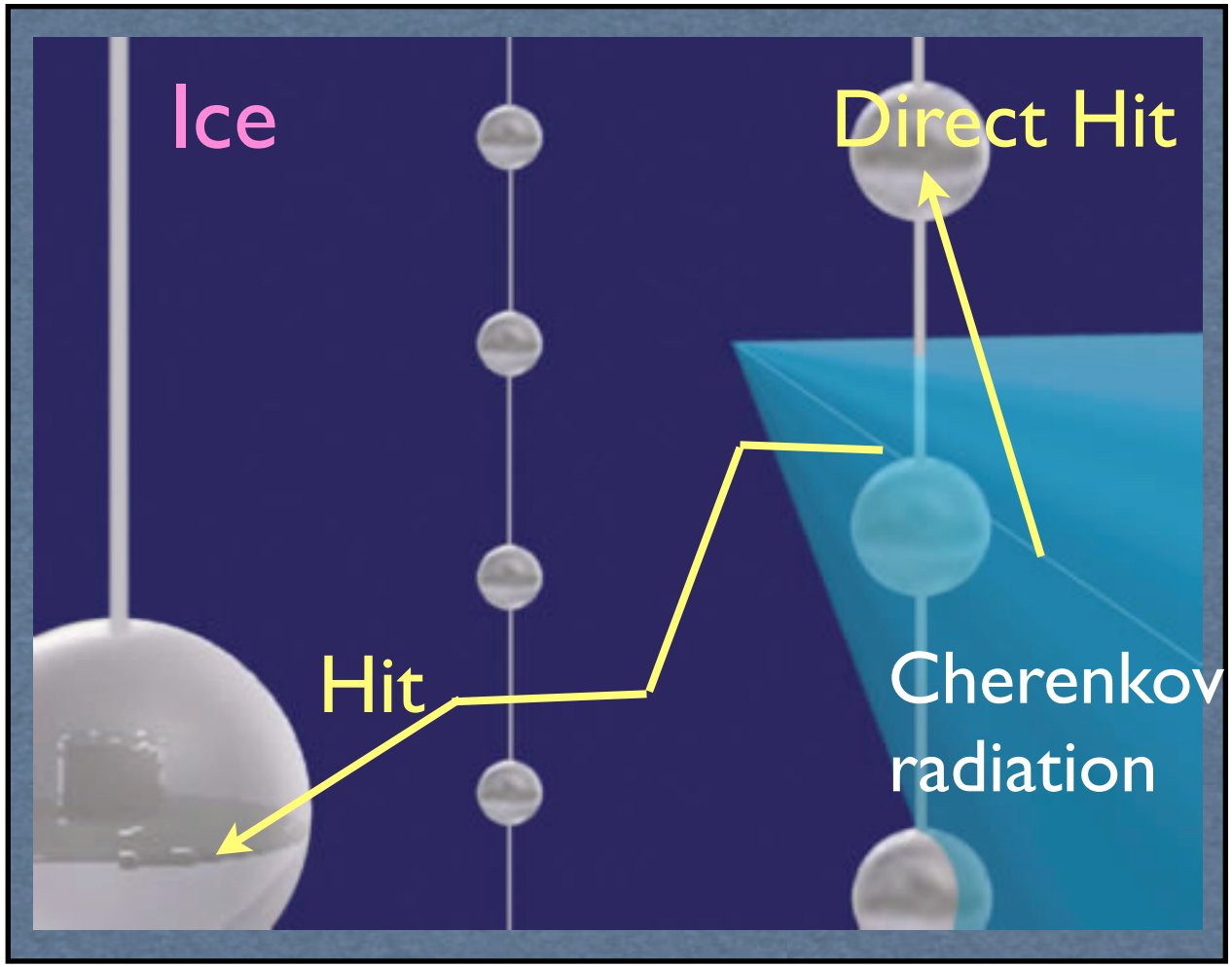
- Detect muons generated from neutrinos via Charged Current interaction

- Choose up going events to reject atmospheric muons (apply quality cuts)



Detection Mechanism

Digital Optical Module (DOM) for IceCube



Observables

- Hit timing (Direct Hit, Hit) ⬅

Used for track reconstruction, Number of Direct Hit (Ndir) indicates reconstruction quality

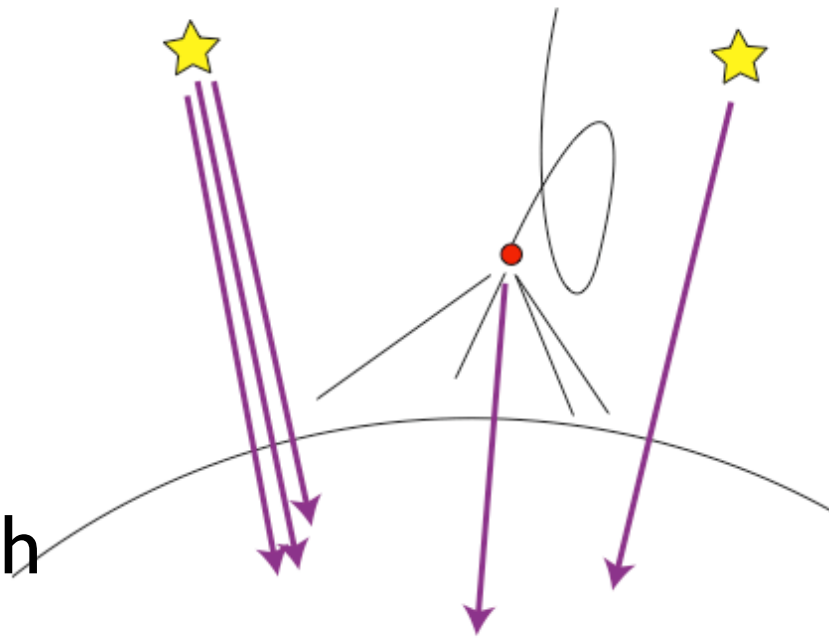
- Number of Hit OMs (Nch) ⬅
- Charge / waveform

Used as energy estimator waveform can be used for track reconstruction (not this analysis)

What is Diffuse Neutrino Search ?

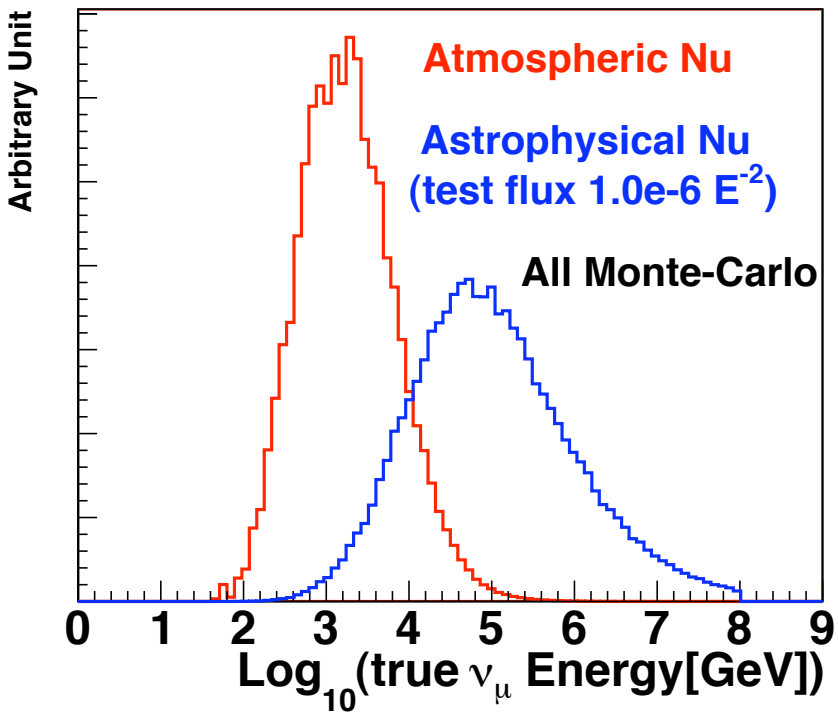
- Astrophysical point source search
  (See T.Montaruli's talk in this session)
  - Observe multiple events from same source
  - Needs good angle resolution
- Atmospheric Neutrino study
  (see P.Desiati's talk on Thursday)
  - Uses low energy sample
  - Need statistics
- Diffuse high-energy source search
  - Uses energy-related parameter to investigate excess from Atmospheric Neutrino events
  - Event selection : optimized to extract high-energy sample

    ⇨ fewer Atmospheric Neutrino event in final sample



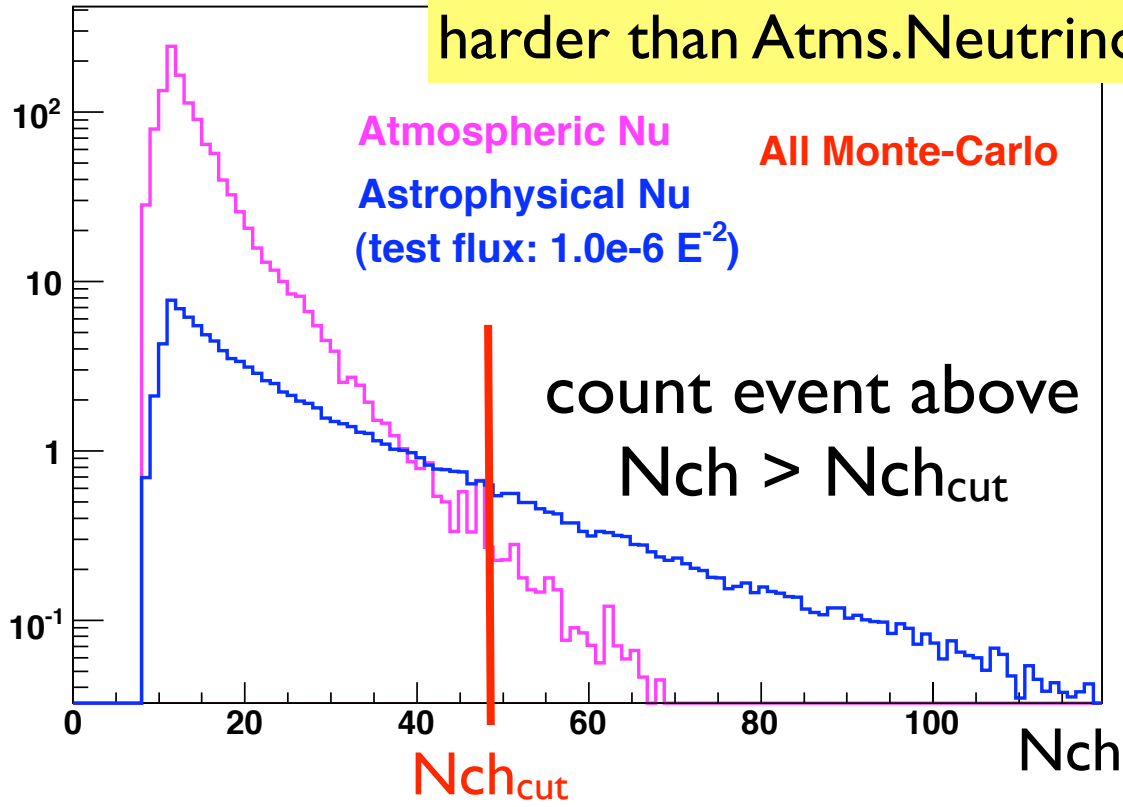
Analysis Strategy

True Neutrino Energy Distribution (not observable)



Number of Hit OMs (Nch) (observable)

Signal spectrum is harder than Atms.Neutrino

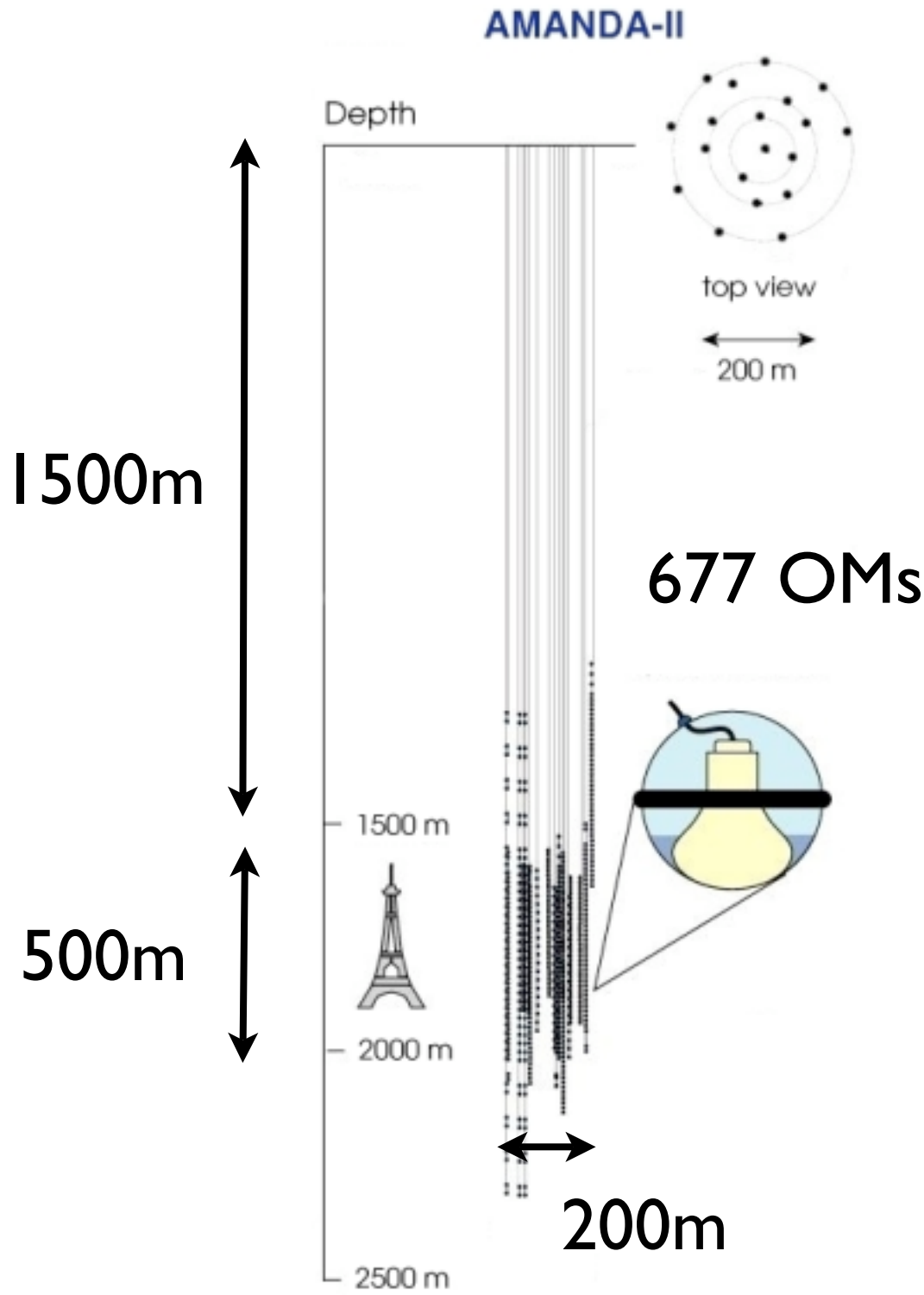


i. Reject all background muons then Search best Nch$_{cut}$

ii. Apply Nch cut (Nch>Nch$_{cut}$) then
compare number of survived events with Monte-Carlo prediction

AMANDA-II

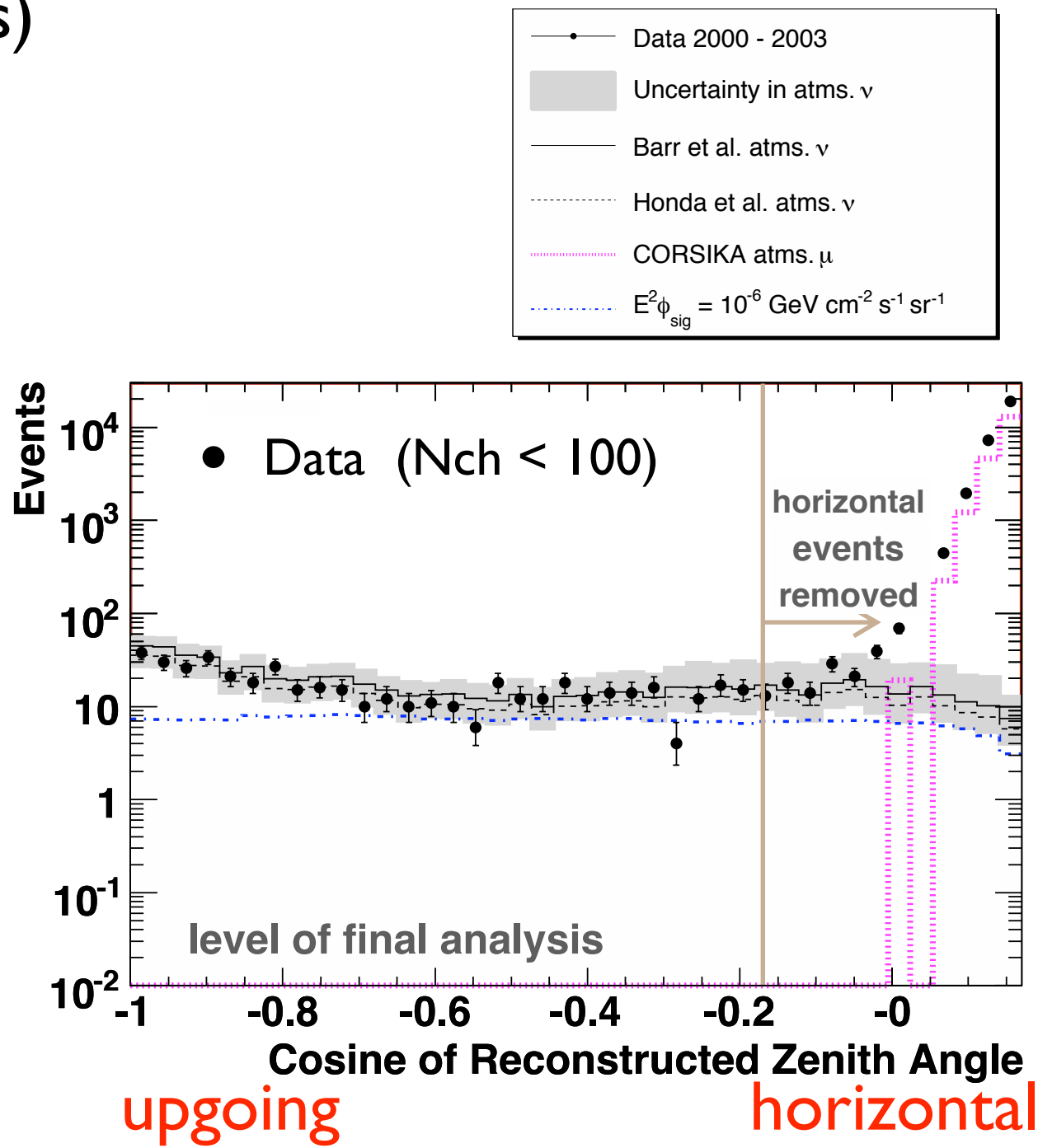
807days multi-year analysis



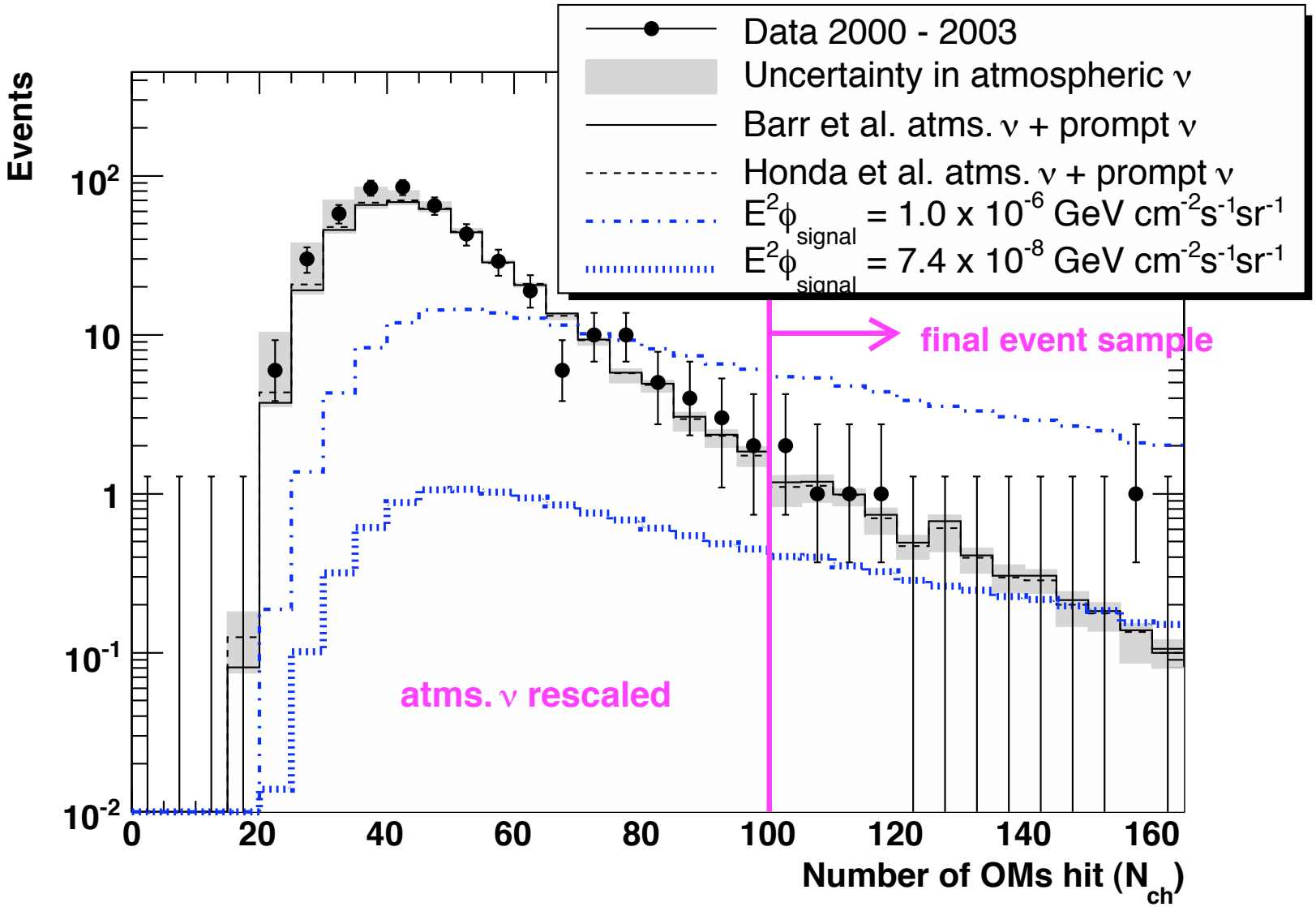
Event selection : Preparing neutrino induced events

Quality cuts (examples)

- Require enough number of Direct Hit which close to the expected hit time for the reconstructed track (Ndir cut)
- Hits should distribute smoothly along with the reconstructed track
- Require long enough track
- Remove horizontal events



AMANDA-II 807days Diffuse Analysis
Nch distribution after final selection



at Nch ≥ 100, 6 events observed

no significant excess from background

AMANDA-II 807days Diffuse Analysis Upper Limit

$E^{-2} < 7.4 \times 10^{-8}$ GeV cm^{-2} s^{-1} sr^{-1}

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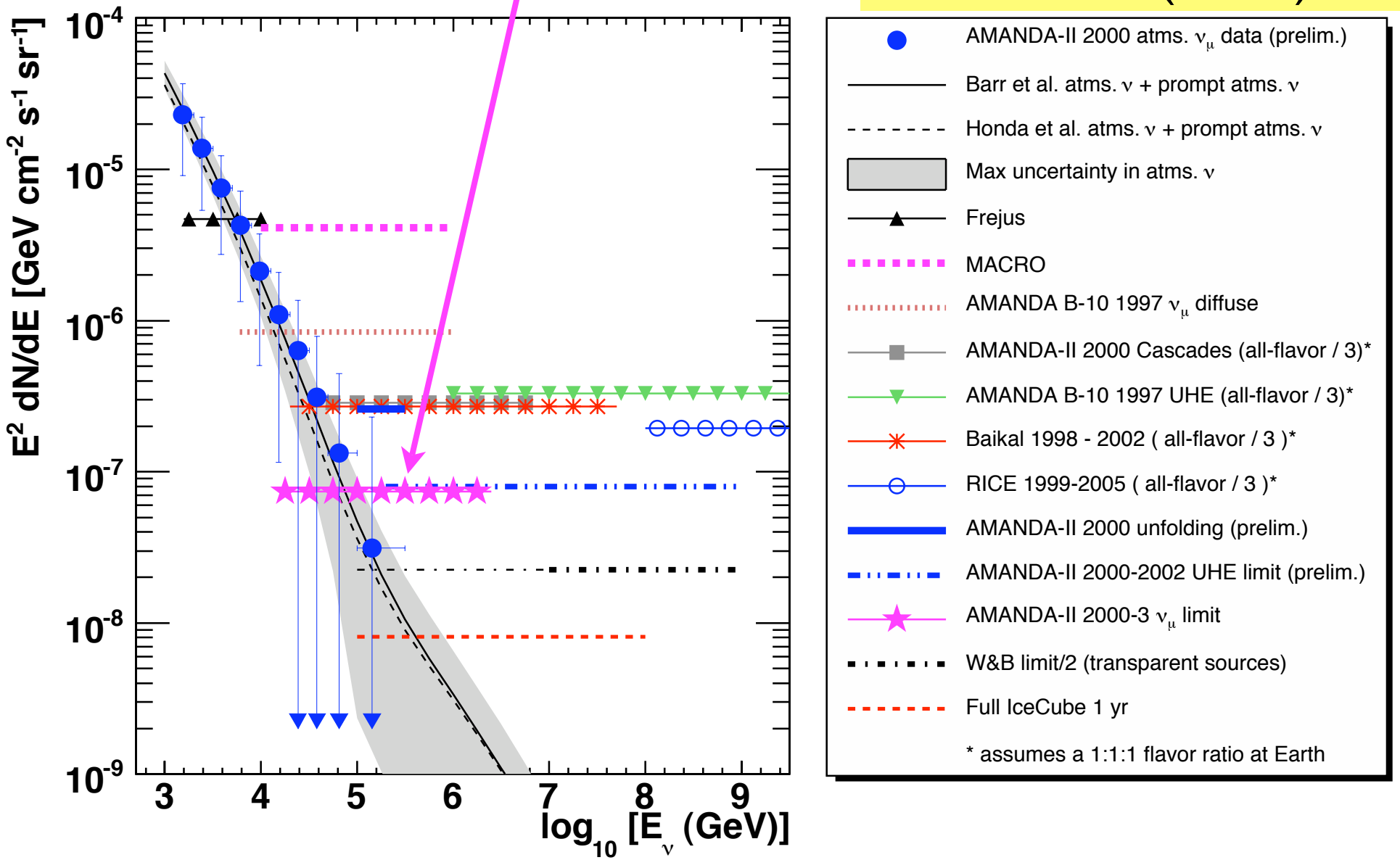
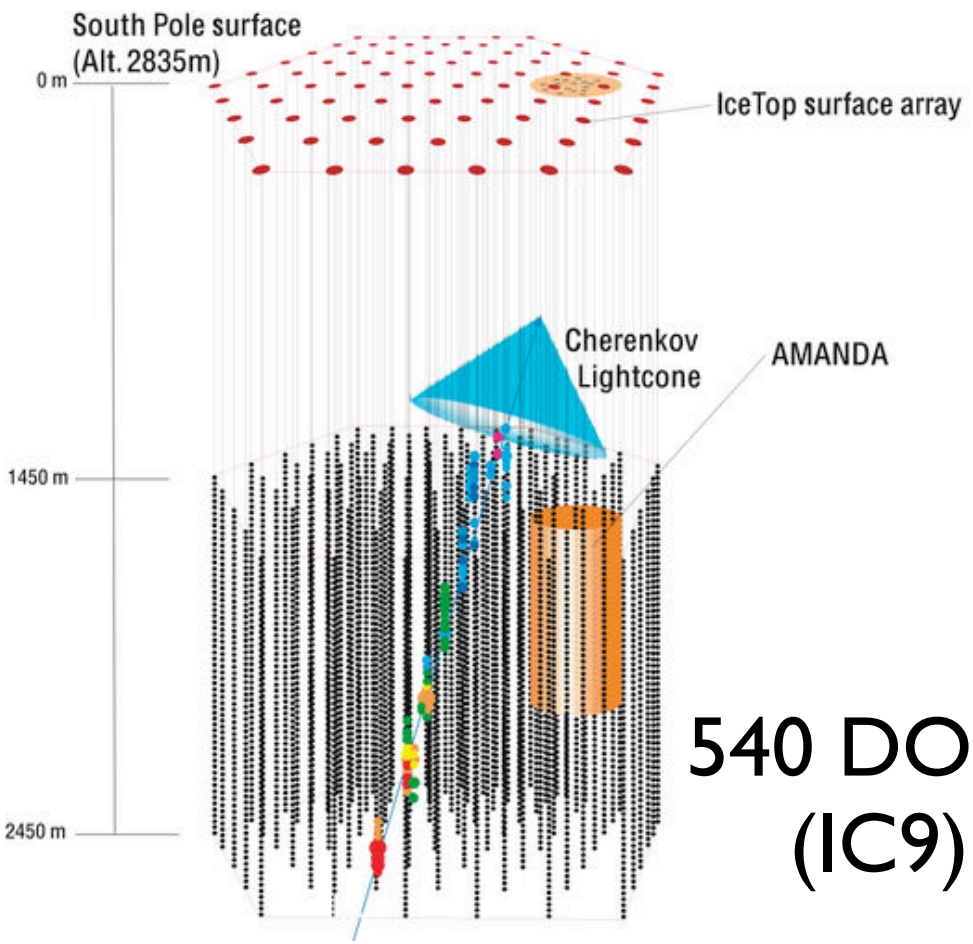
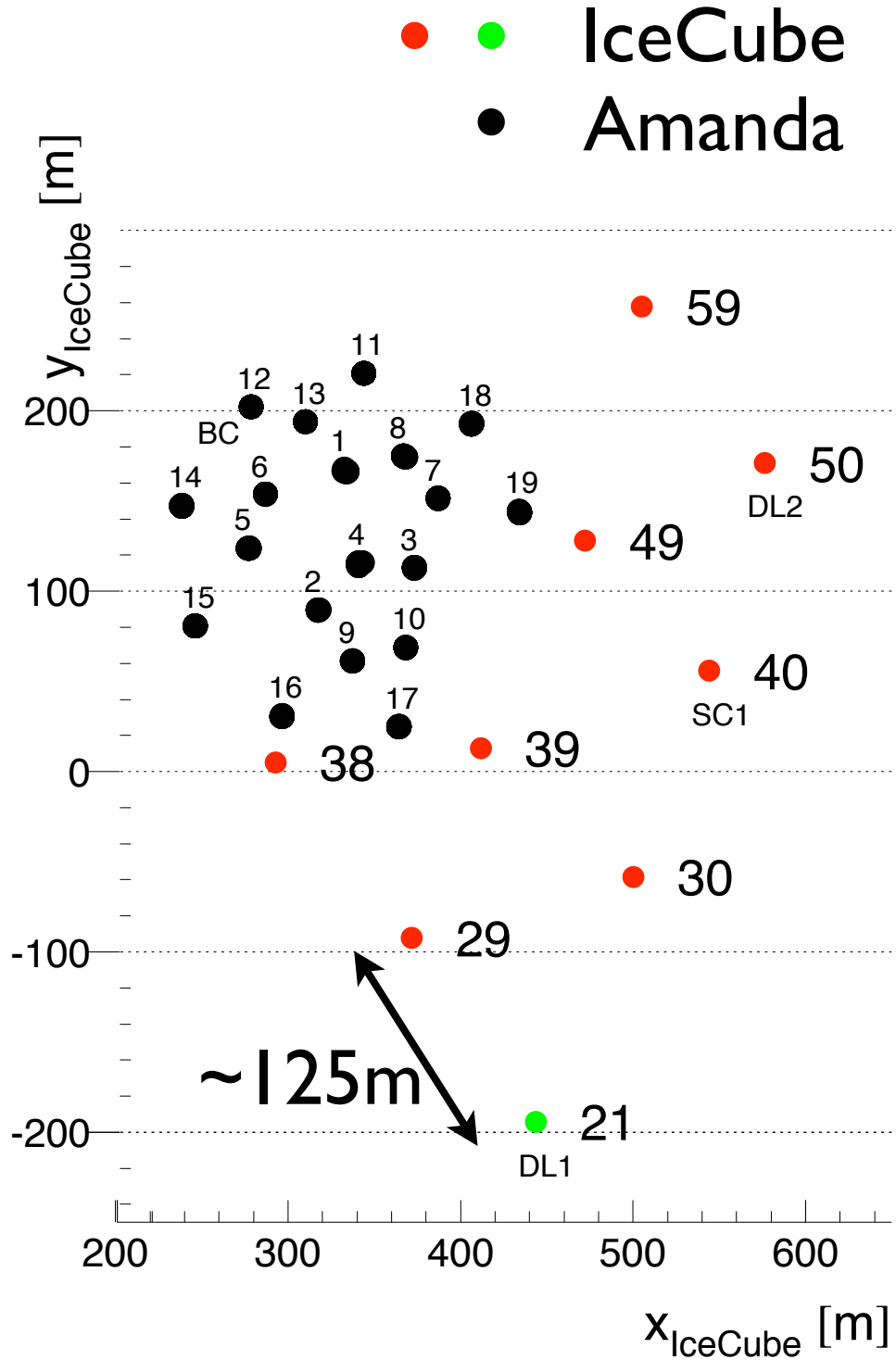


IceCube
9 strings
137days analysis

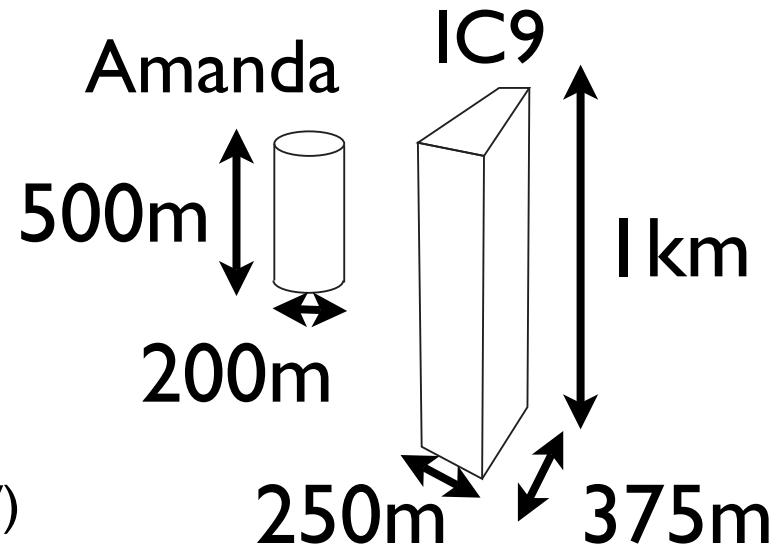


540 DOMs
(IC9)

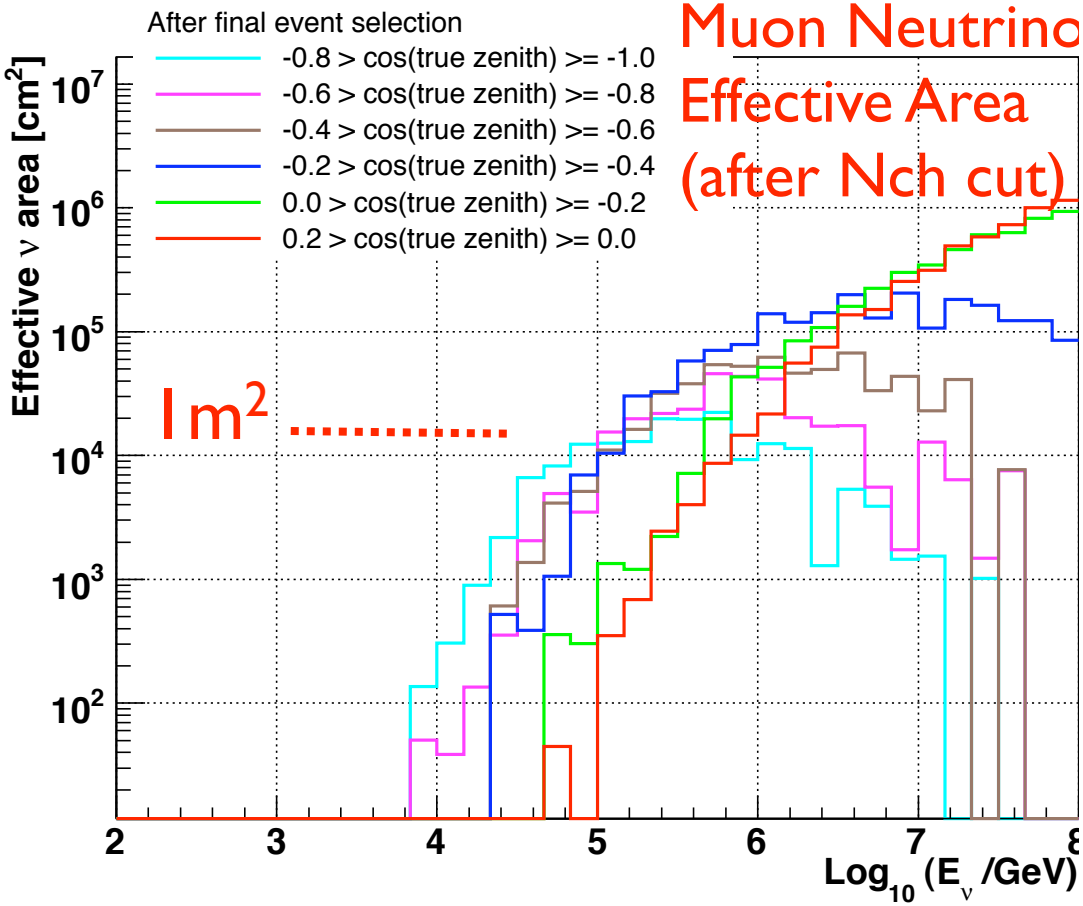


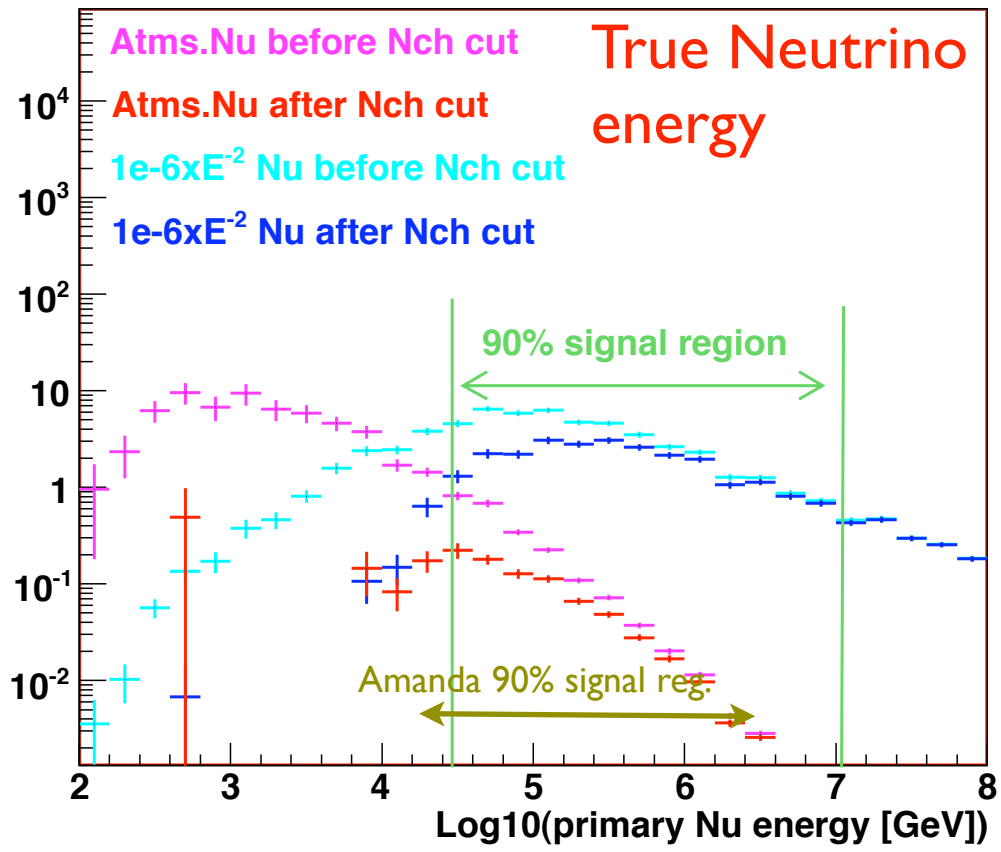
IceCube 9 (IC9) vs AMANDA

- 3~4 times larger detector volume
- 3~4 times wider string intervals
- Similar number of Optical Sensors



2~4 times larger effective area (10^5 ~ 10^6GeV)
90% energy range shifts to higher energy





Event selection : Preparing neutrino induced events

Data Nch < 46 is already unblinded for Atms.Nu study

Low Nch data sample is compared with MC

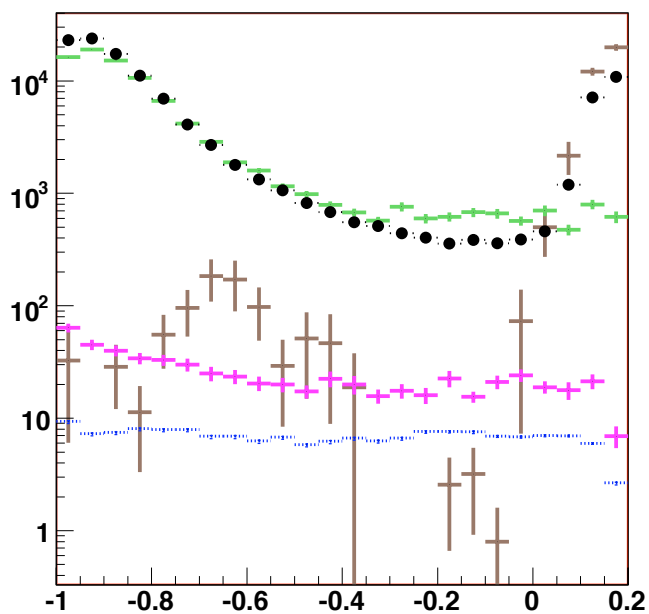
- Data + Atms. Mu
  + Double Mu
  + Atms. Nu
  + 1e-6 E^{-2} Nu

Number of event after final cut (Nch<46)

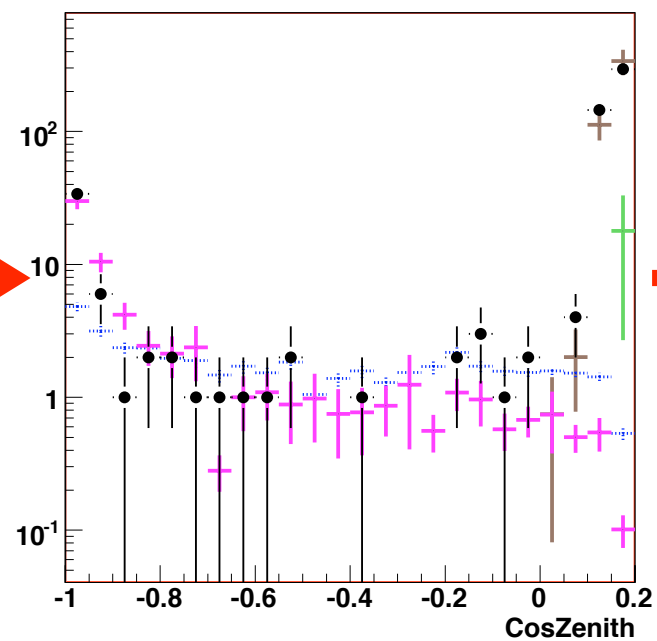
Data : 52 event

Background MC : 60 ± 5 (Bartol)

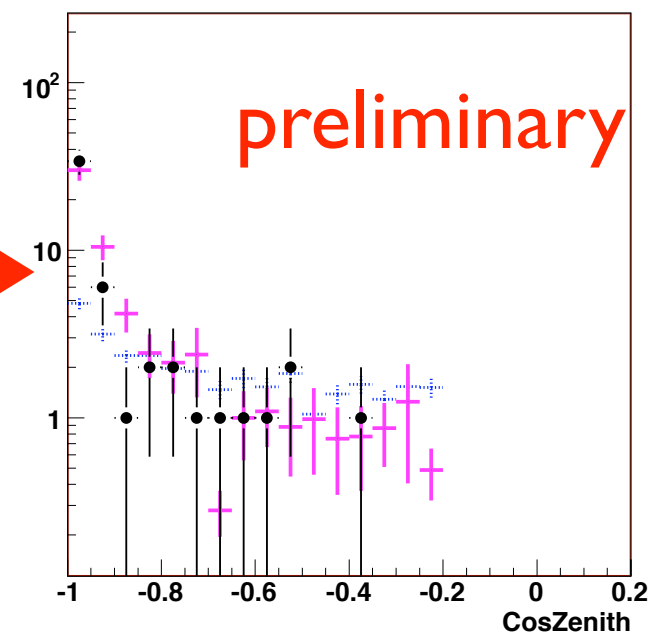
(54 ± 4 : Honda 2006)



after angle resolution cut

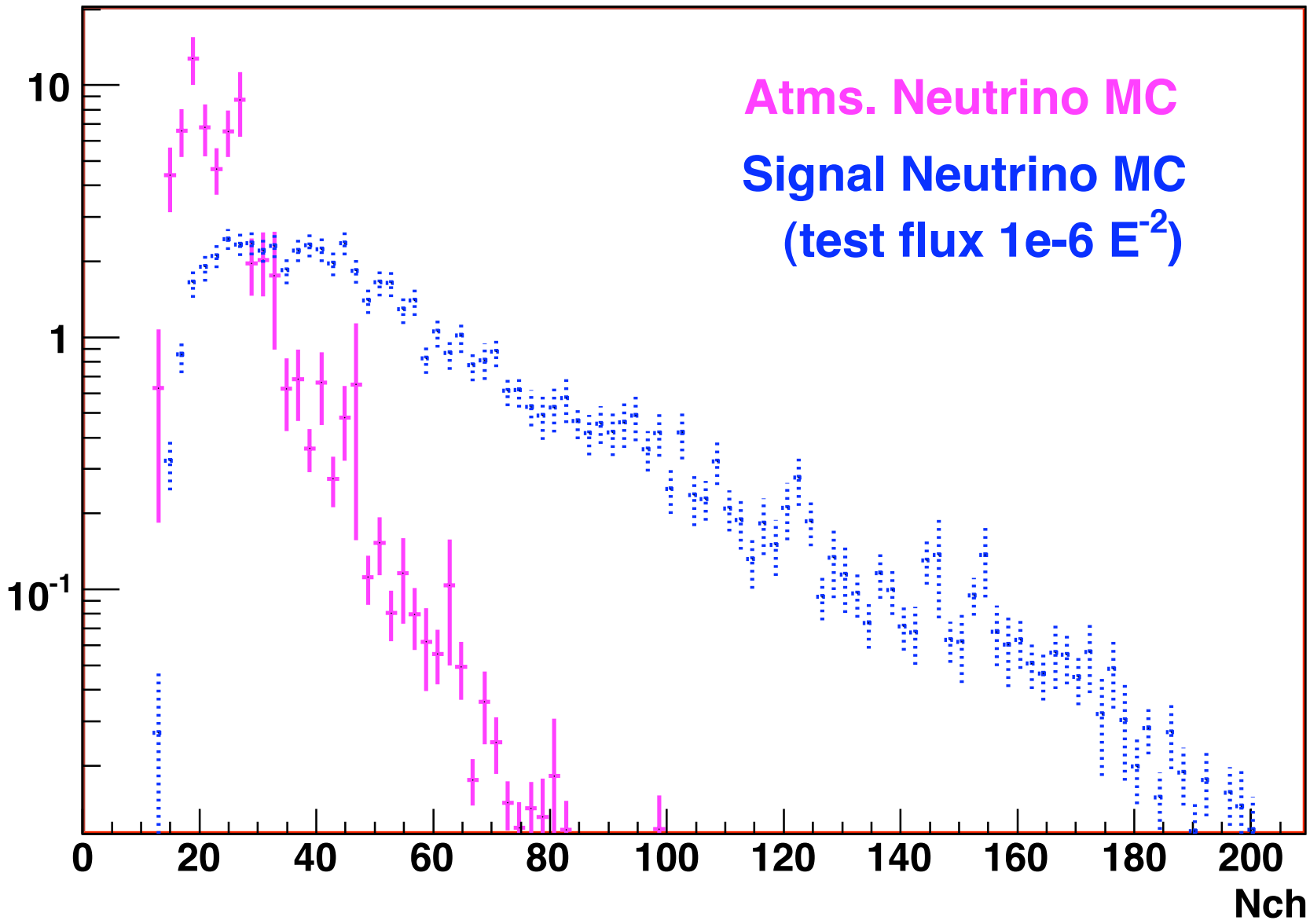


after Ndir cut



after final cut

Nch distribution After final selection

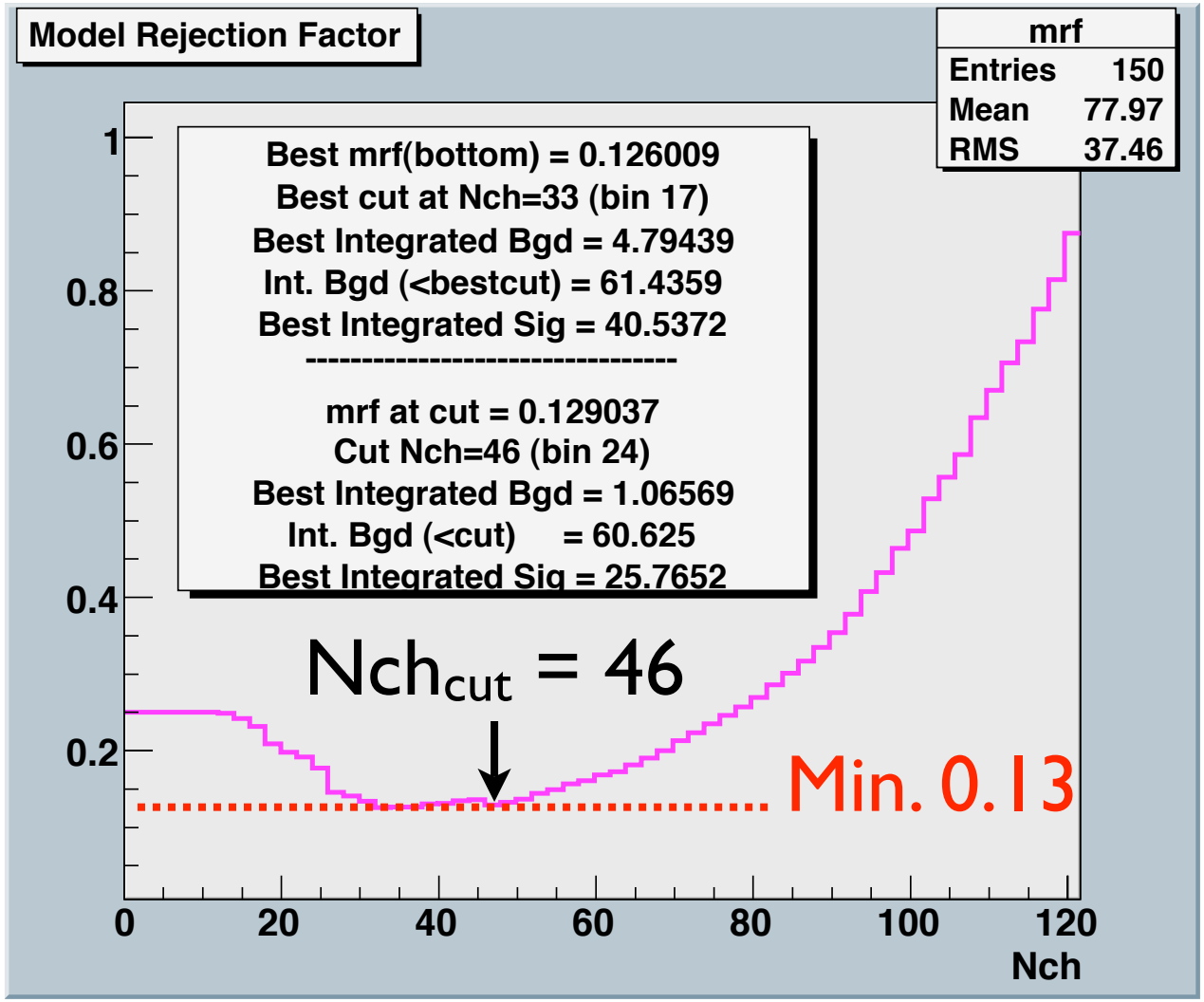


IceCube 9 string ~ 137days
Scale factor of test flux vs Nch cut threshold

- Scale factor is very flat between Nch_{cut} ~30 and 50

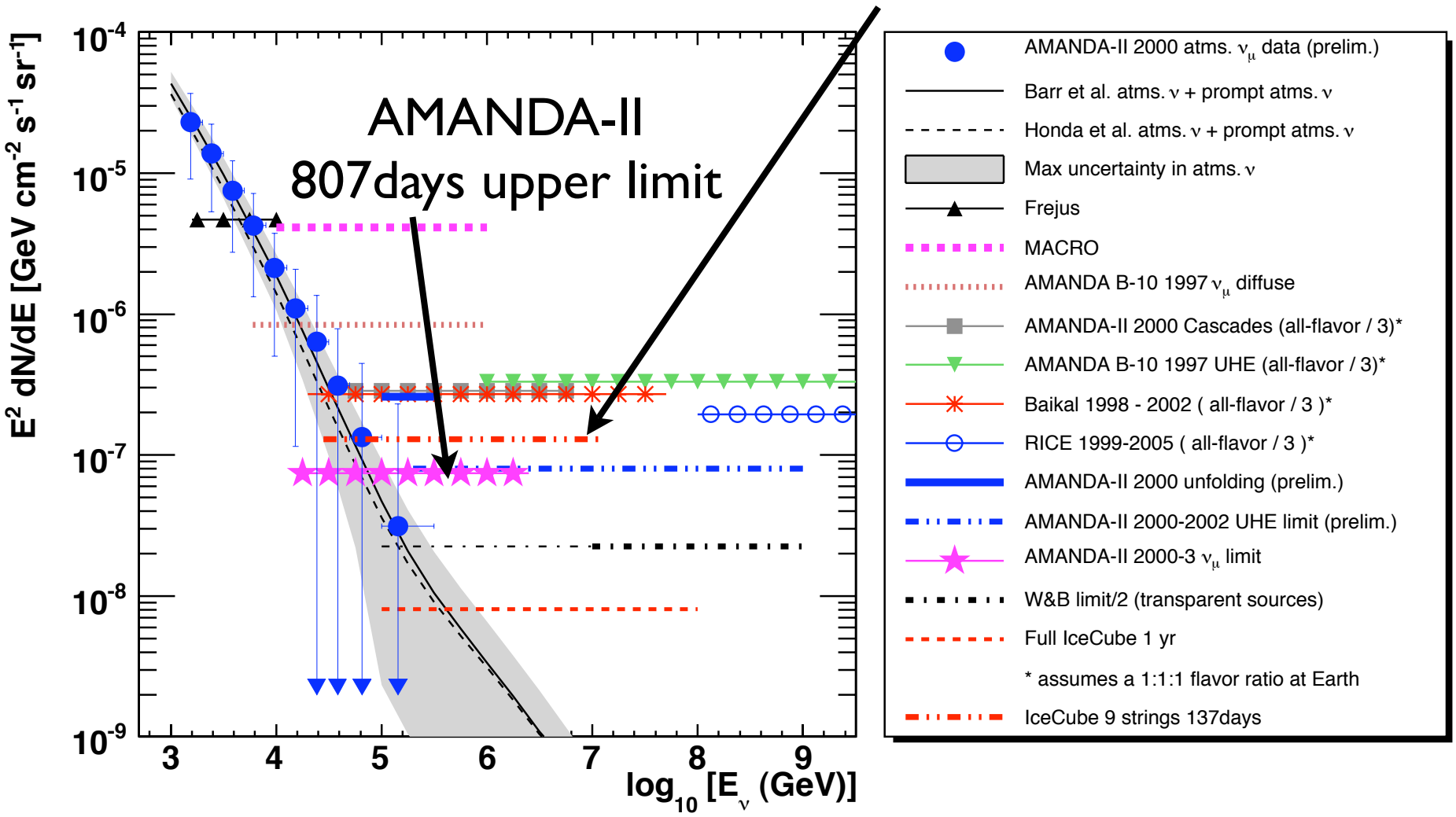
⬇

Choose
Nch_{cut} = 46
to get sensitivity



Diffuse Muon Neutrino Sensitivity of IC9 137 days (2006)

$E^{-2} < 1.3 \times 10^{-7}$ GeV cm^{-2} s^{-1} sr^{-1}



IC9 137days sensitivity is factor 2 above AMANDA-II 807days

in 2007 integrated IceCube exposure exceeds AMANDA-II 4yr

Summary

- AMANDA-II 807days upper limit on the diffuse flux of muon neutrino with a $A_{const}E^{-2}$ spectrum for the energy range 16 TeV to 2.5PeV is

  $E^{-2} < 7.4 \times 10^{-8}$ GeV cm^{-2} s^{-1} sr^{-1}

- Monte-Carlo verification for IceCube 9 string has done with Nch<46 low energy data. MC data shows reasonable agreement with the data sample.

- The sensitivity of IceCube 9 string 137days on the diffuse flux of muon neutrino with a $A_{const}E^{-2}$ spectrum for the energy range from 25TeV to 10PeV is

  $E^{-2} < 1.3 \times 10^{-7}$ GeV cm^{-2} s^{-1} sr^{-1}

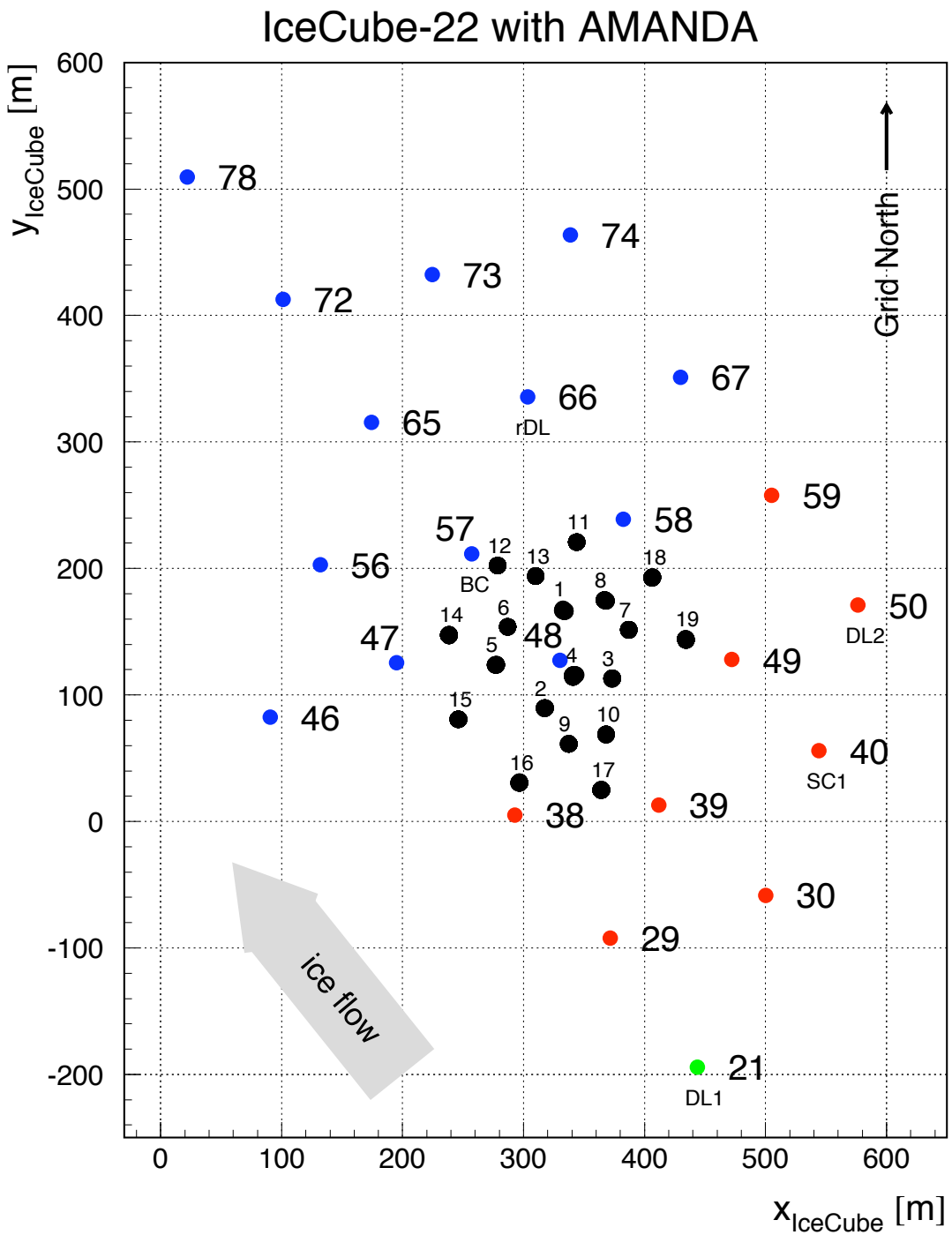
  which is factor 2 above AMANDA-II 807days.

Outlook

Physics run of IceCube 22 started in 5/23

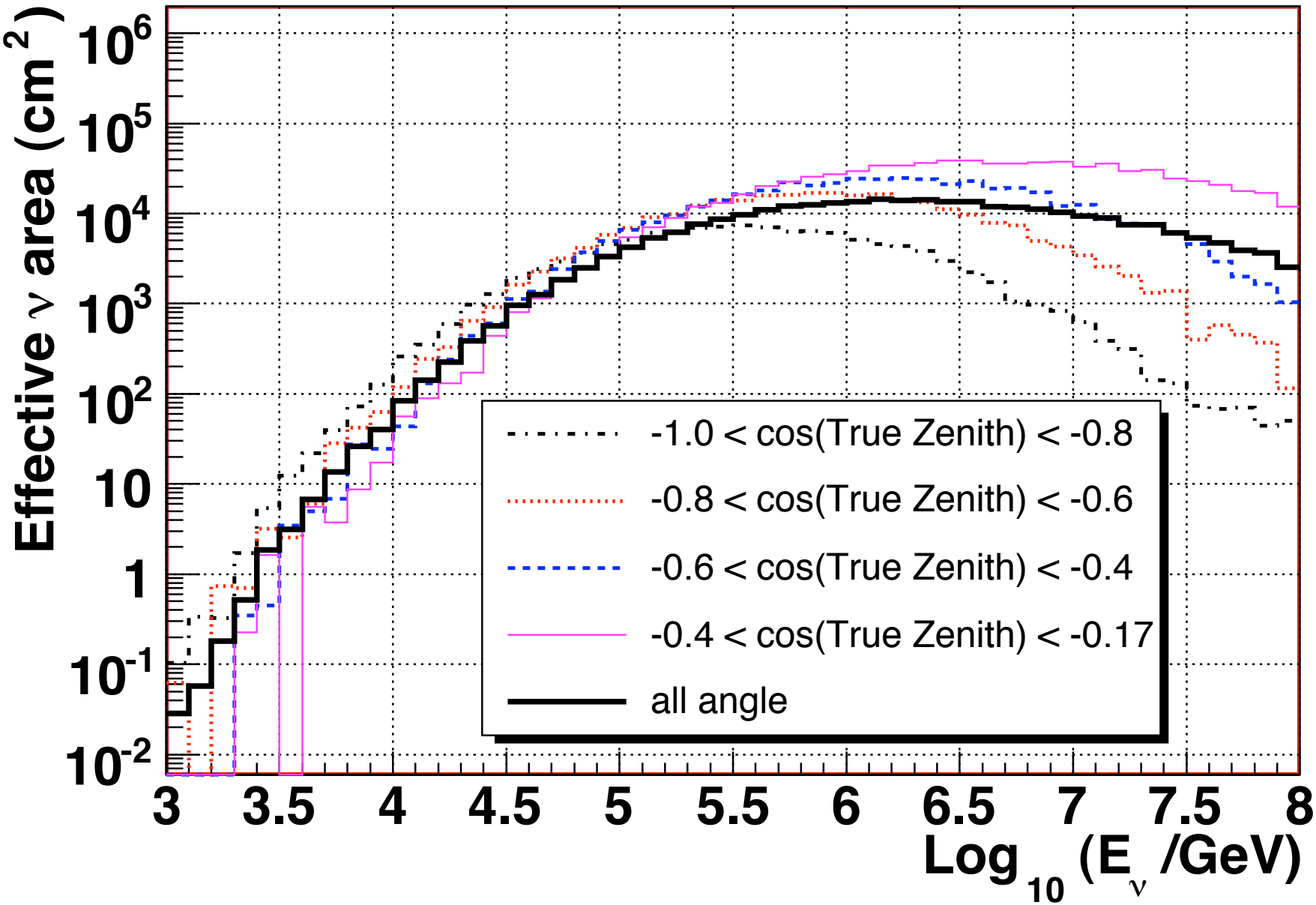
- Detector Volume : x 2~3 of IC9
- Accumulted Livetime : ~3month by now

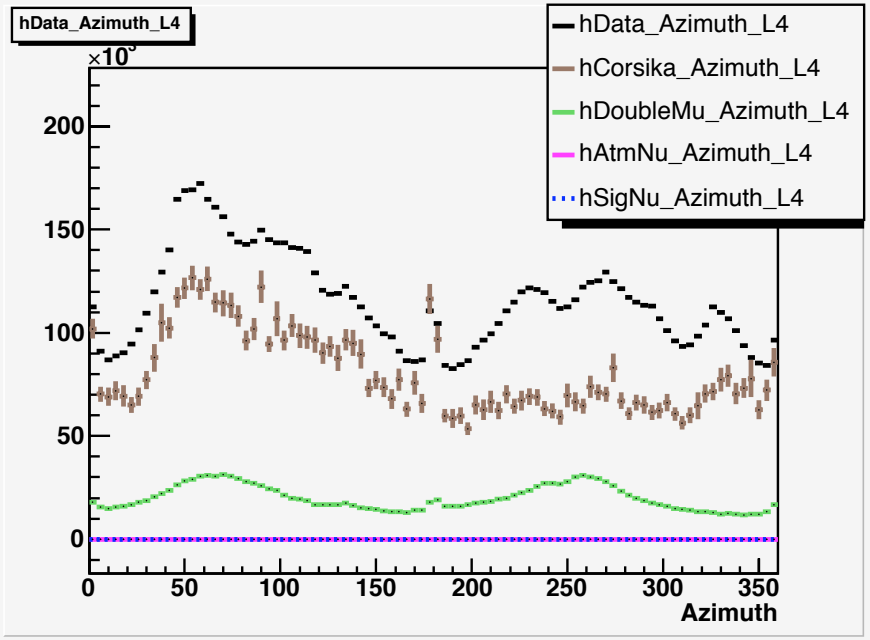
Analyses for 22 string is now in preparation

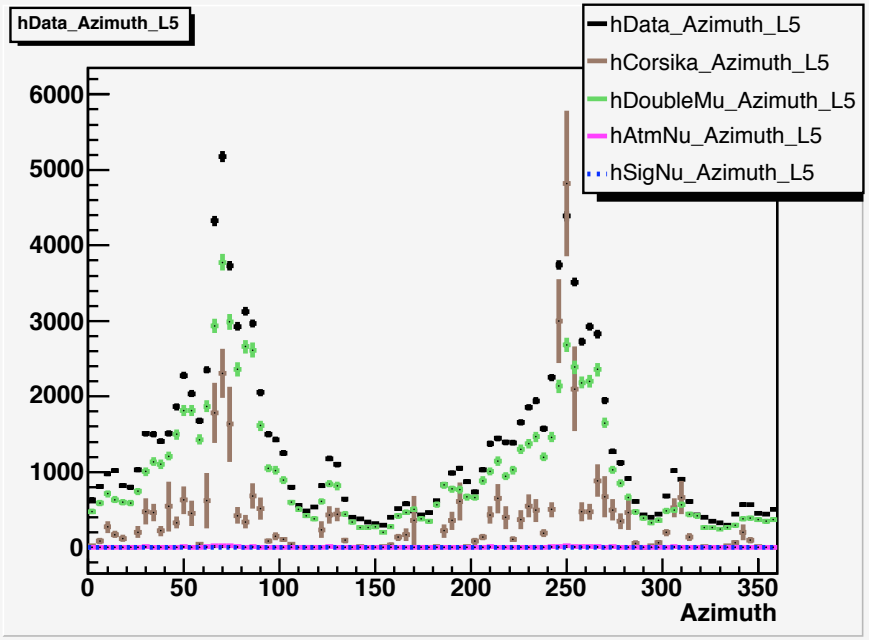


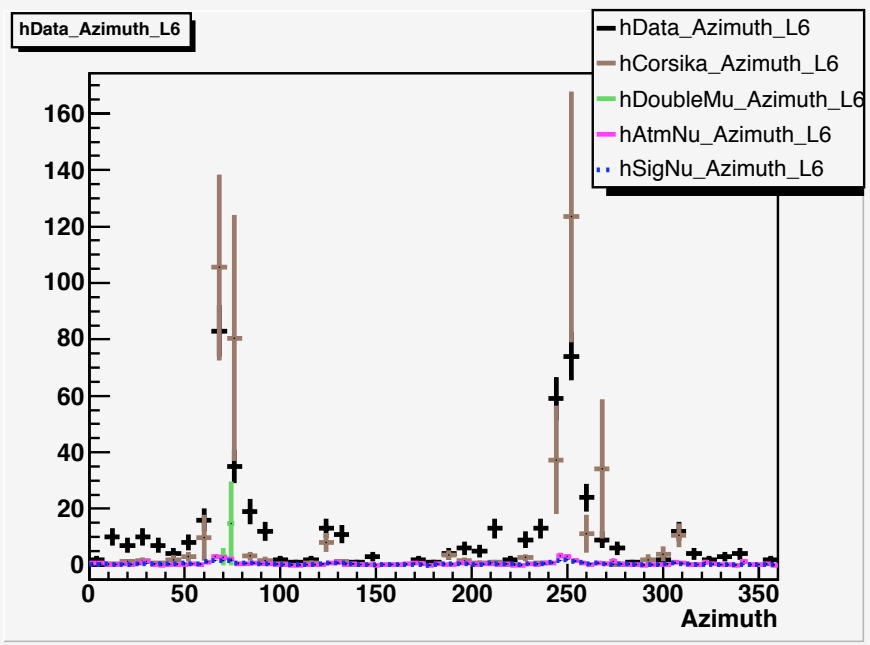
- Backup slides

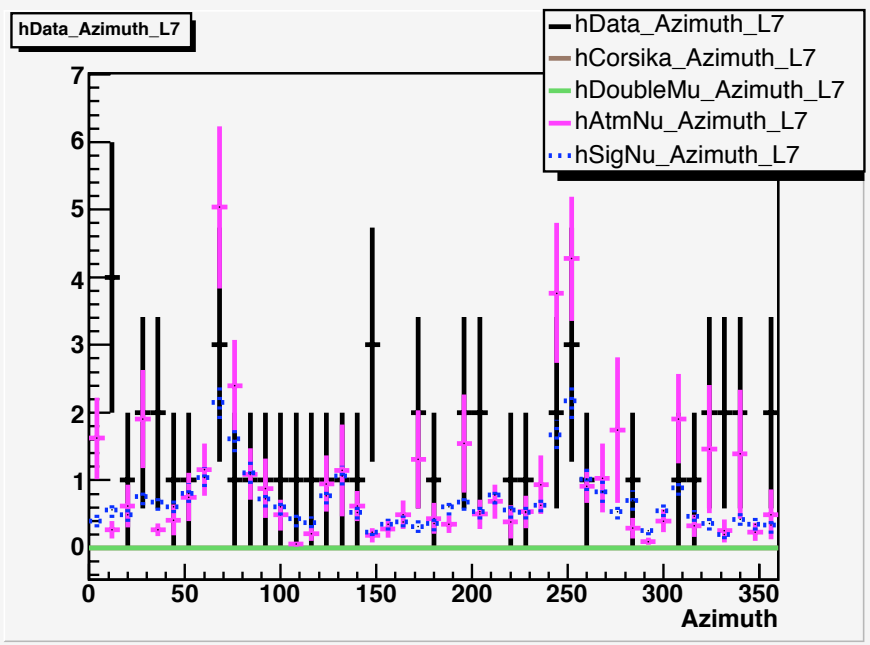
AMANDA effective area







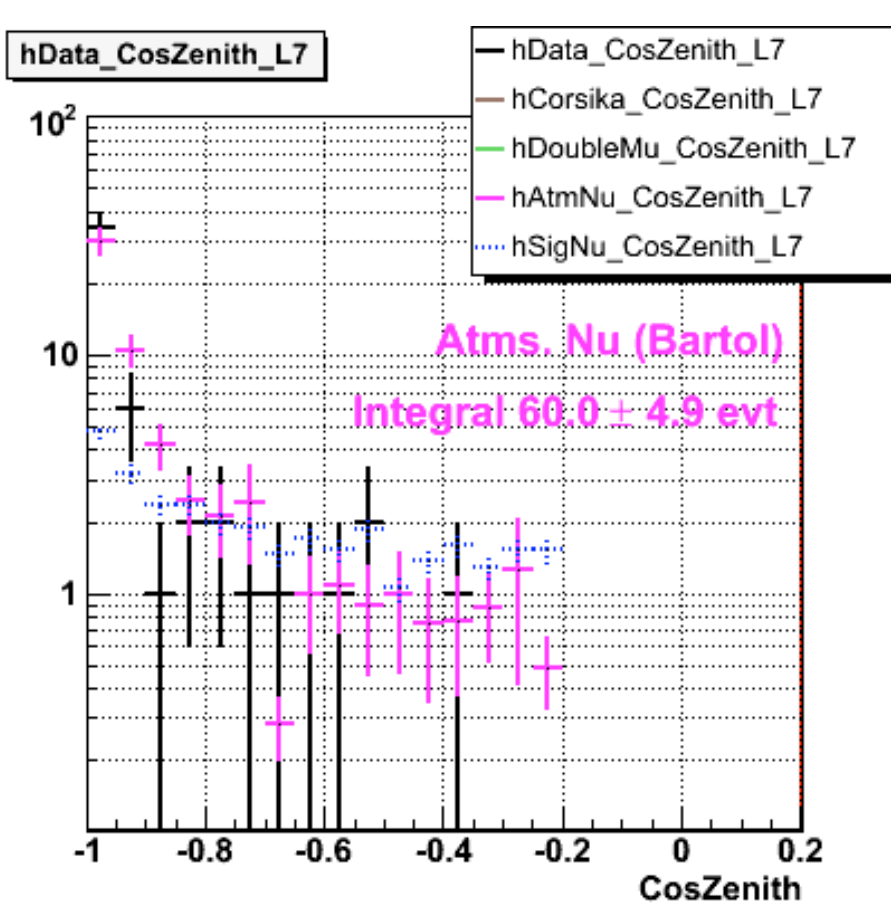




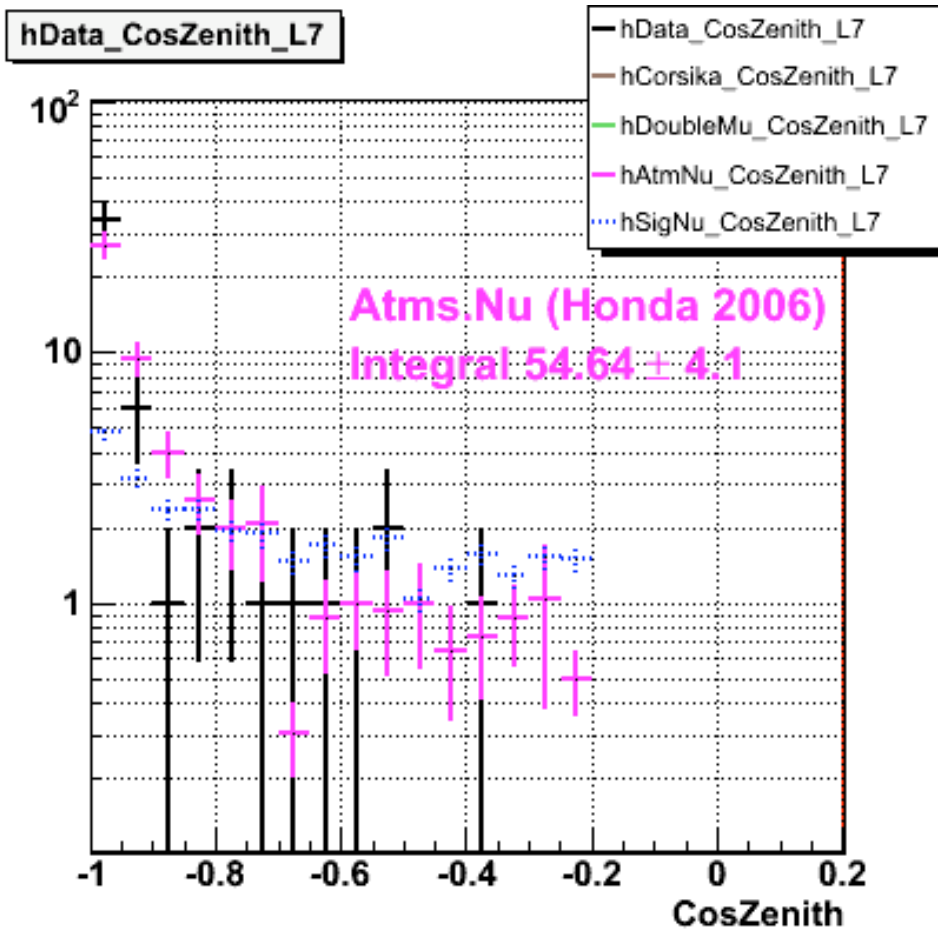
Azimuth distribution

Atms.Nu model difference

Bartol



Honda (2006)



HitDistance vs CosZenith