AMANDA-II
Status of Data Analysis for 2000

Report to DESY-PRC

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- Overview
- Data Sample & Calibration
- MC Simulation
- Data: B10-subdetector/2000 compared to 1997
- First atmospheric neutrino results
- Summary

AMANDA-B10 Analysis

Analysis of 1997 data lasted from 1998-2001: first high statistics atmospheric ν-sample from an underwater/ice detector.

- Calibration (iterated)
  - Geometry and relative timing
  - Vertical ice properties
  - Optical Module(OM) sensitivties (local bubbles?)
  - Absolute rate & flux calibration (HE-Muon flux)
- Detector performance: X-talk, transient noise
- Unresolved: *COGz*-structure, ...
- Highest level neutrino cuts: tuning by MC or data ?

AMANDA History

1995/1996	deployment of first 4 strings (86 OMs) AMANDA-B4: 4 strings, 86 OMs
1996/1997	deployment of 6 strings strings (216 OMs) AMANDA-B10: 10 strings, 302 OMs
1997/1998	deployment of 3 strings strings (126 OMs) AMANDA-B13: 13 strings, 428 OMs
1999/2000	deployment of 5 strings strings (252 OMs) AMANDA-II: 19 strings, 680 OMs

New in 2000:

375 OMs of new technology (Fiber-OMs, dAOMs, DOM)

AMANDA-II Analysis

- Will also be an iterative procedure
- Can largely profit from neutrino selection experience from B10
- Basic calibration procedures are stable (Geometry, “T0”)

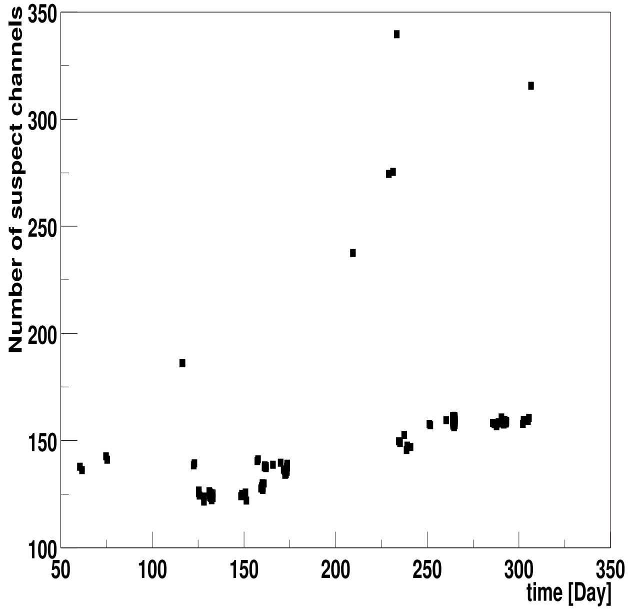
Analysis Steps

- Step 1: Select atmospheric ν_μ events
- Step 2: Tune for HE/EHE-physics ν_μ events, for ν_e shower, ...

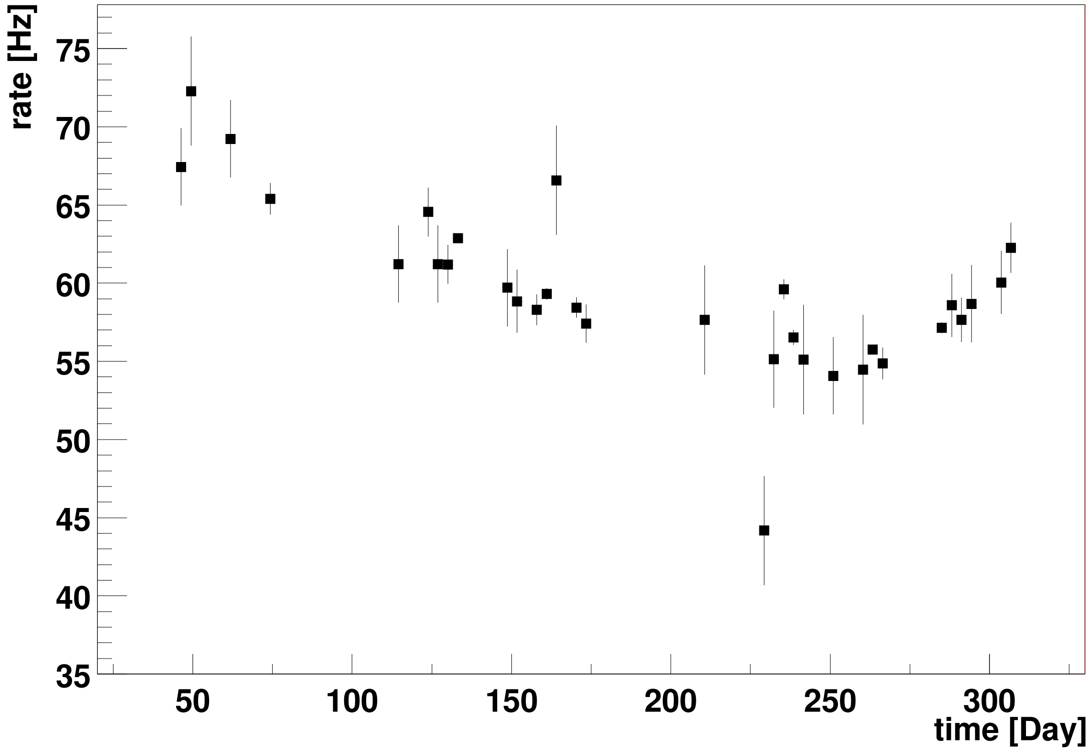
- Main Muon Trigger: 24 fired OMs within a 2.5μs time window
- 5 GB/day raw data, stored on DLTs, Shipped out of South Pole only at season end (December 2000)
- Uploading of the 100 DLT-Tapes for 2000 to Tape-Robot is in progress at DESY-Zeuthen
- Analysis at Zeuthen started March 2001

	Muon Trigger	Total Rate	Livetime	Volume	Location	Analysis
1997	$\geq$16	75 Hz	130 d	0.56 TB	LBNL,DESY	Yes
1998	$\geq$12	110 Hz	?	1.5 TB	LBNL,DESY	(No)
1999	$\geq$18	60 Hz	?	0.9 TB	LBNL	No
2000	$\geq$24	70 Hz	[$\leq$195 d]	1.2 TB	(LBNL,DESY)	Started

First scan of detector performance



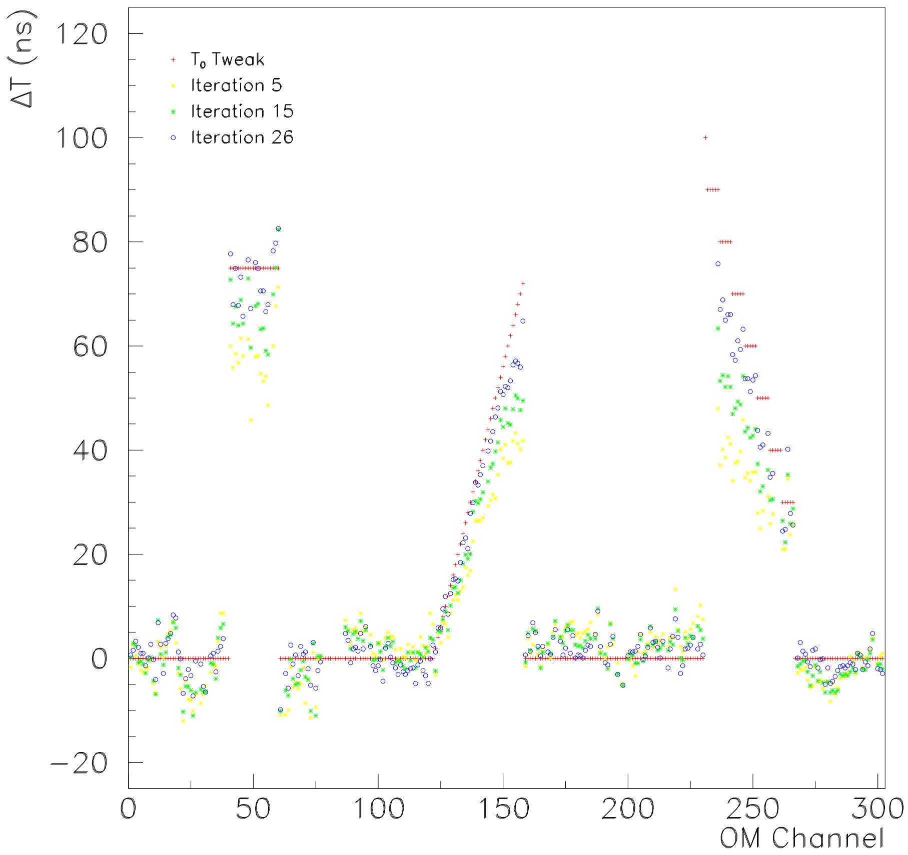
“Suspect” Data Channels.



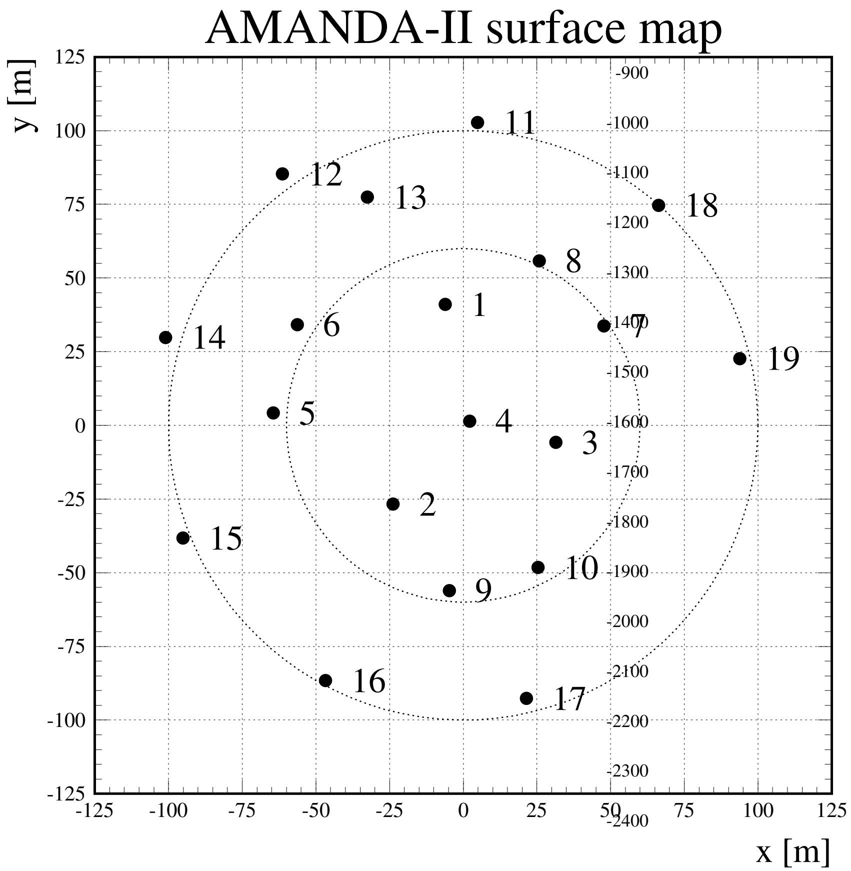
Raw muon rate vs. day (seasonal variation).

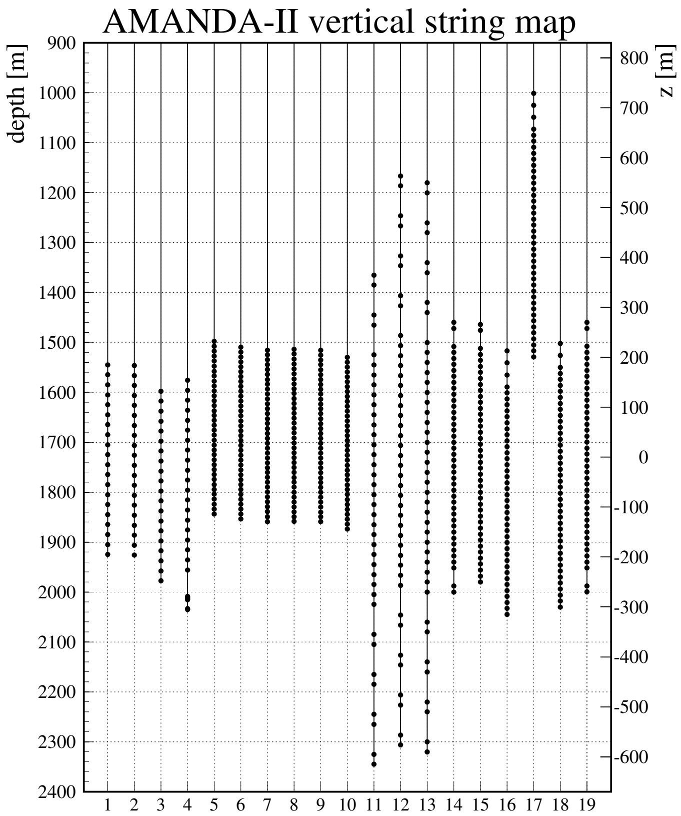
Time Offset Calibration with Muons

- 0th time offsets by in-situ laser
- Fit "good" muon tracks
- Get OM fit residuals shifts
- Correct OM time offsets
- Iterate until residuals converge



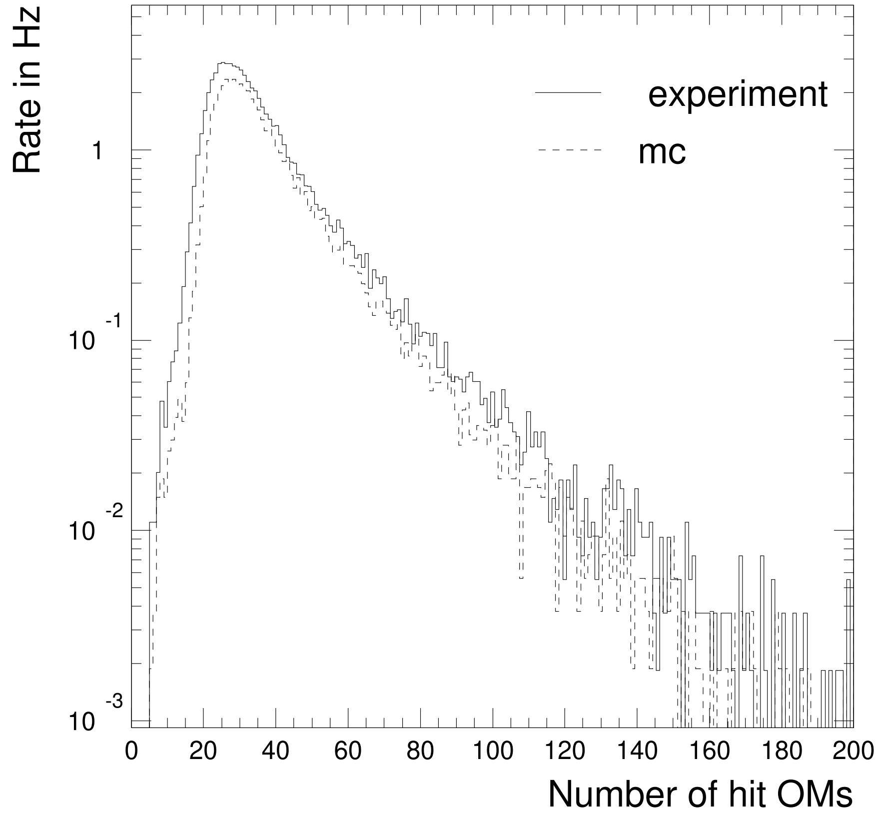
Geometry Calibration





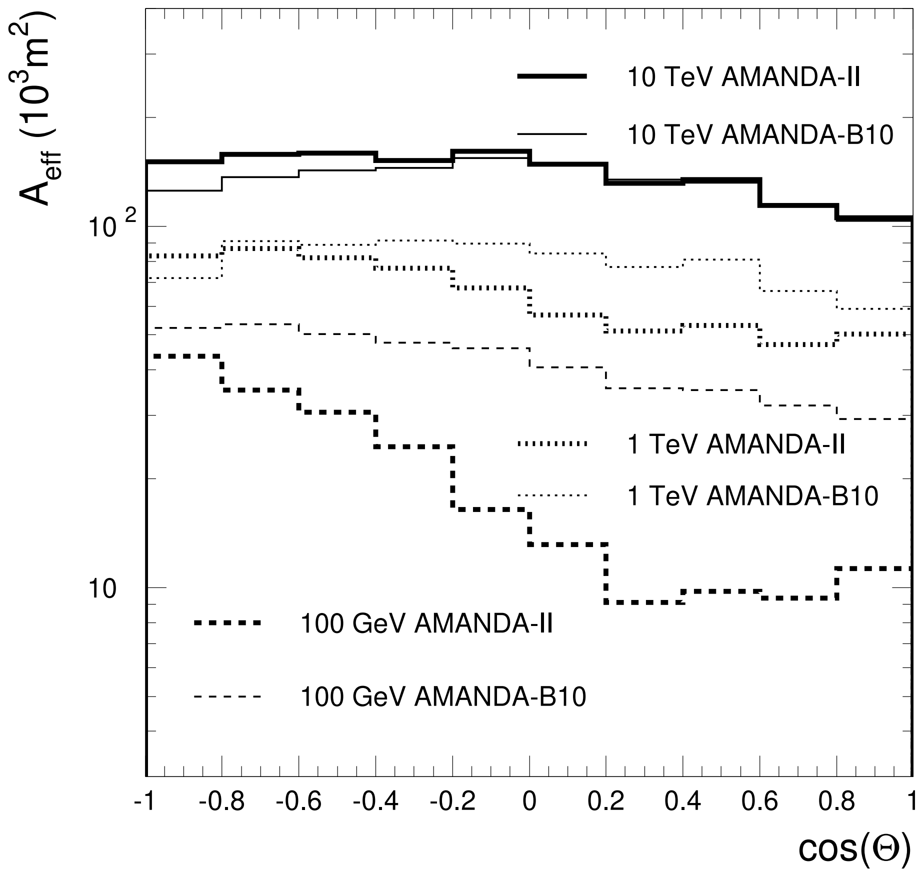
Trigger rate and OM-multiplicity

exp	atmosph. μ MC	atmosph. ν_μ MC
75 Hz	53 Hz	3.5$\cdot 10^{-4}$ Hz

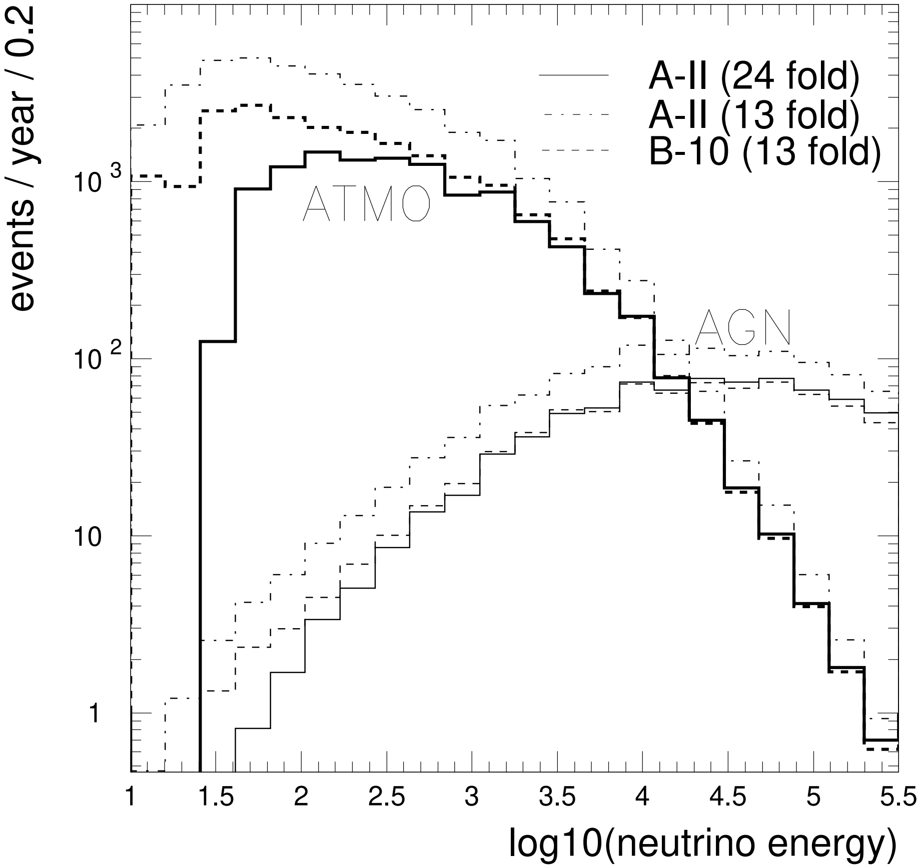


$\Rightarrow$ Absolute trigger rates differ by $\sim$30% (prelim.)

Effective area for fixed energy at trigger level



Event Rates at trigger level: Atmospheric ν and AGN-ν



Atmospheric ν

A-II: 11000

B-10: 21000

A-II/13: 40000

AGN ν

A-II: 740

B-10: 760

(triggered events/year)

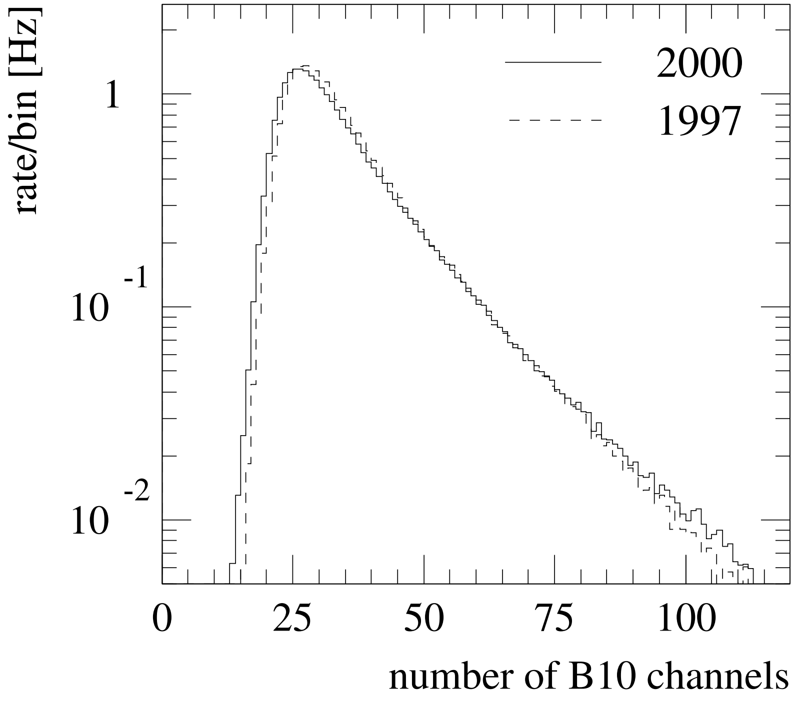
Compare 10 strings from 1997 with 2000 performance

3 years of detector upgrade (new DAQ, FE-electronics, calibrations)

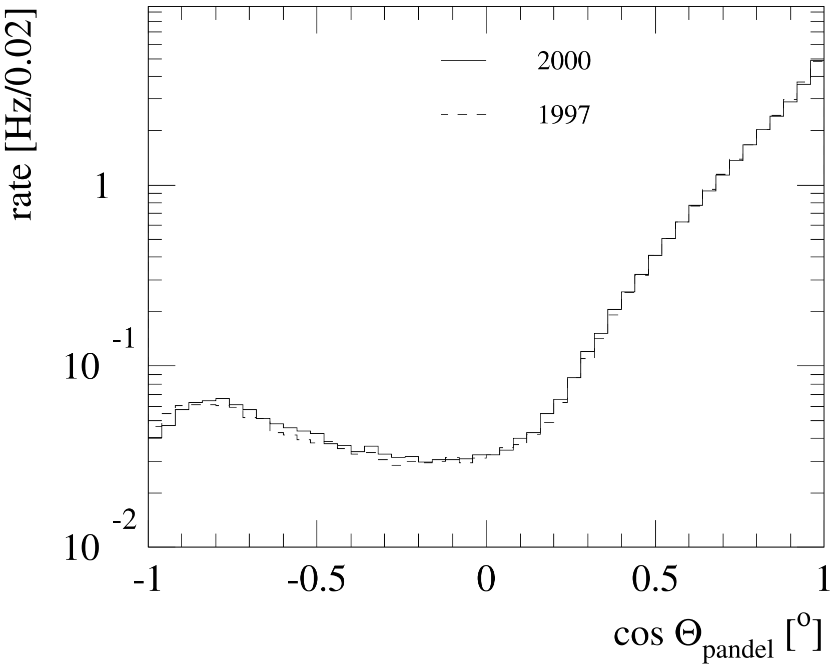
1. Direct observables:
   Rates, OM-Multiplicities, ...

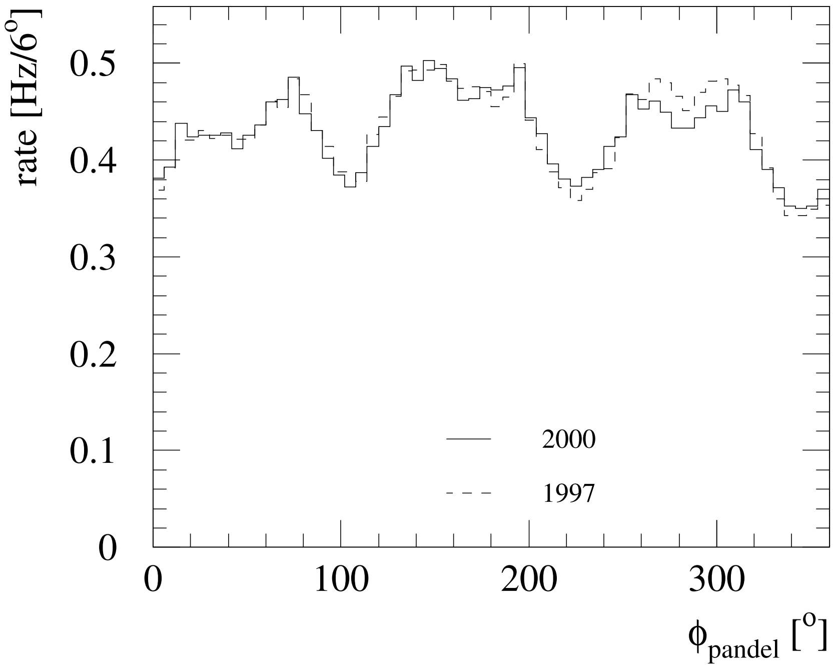
	1997	2000
R^{24} [Hz]	25.9	26.0
R^{L2} [Hz]	0.035	0.038
t_{dead} [%]	24.0	17.6

B-10 event rates for trigger and Level-1 filter

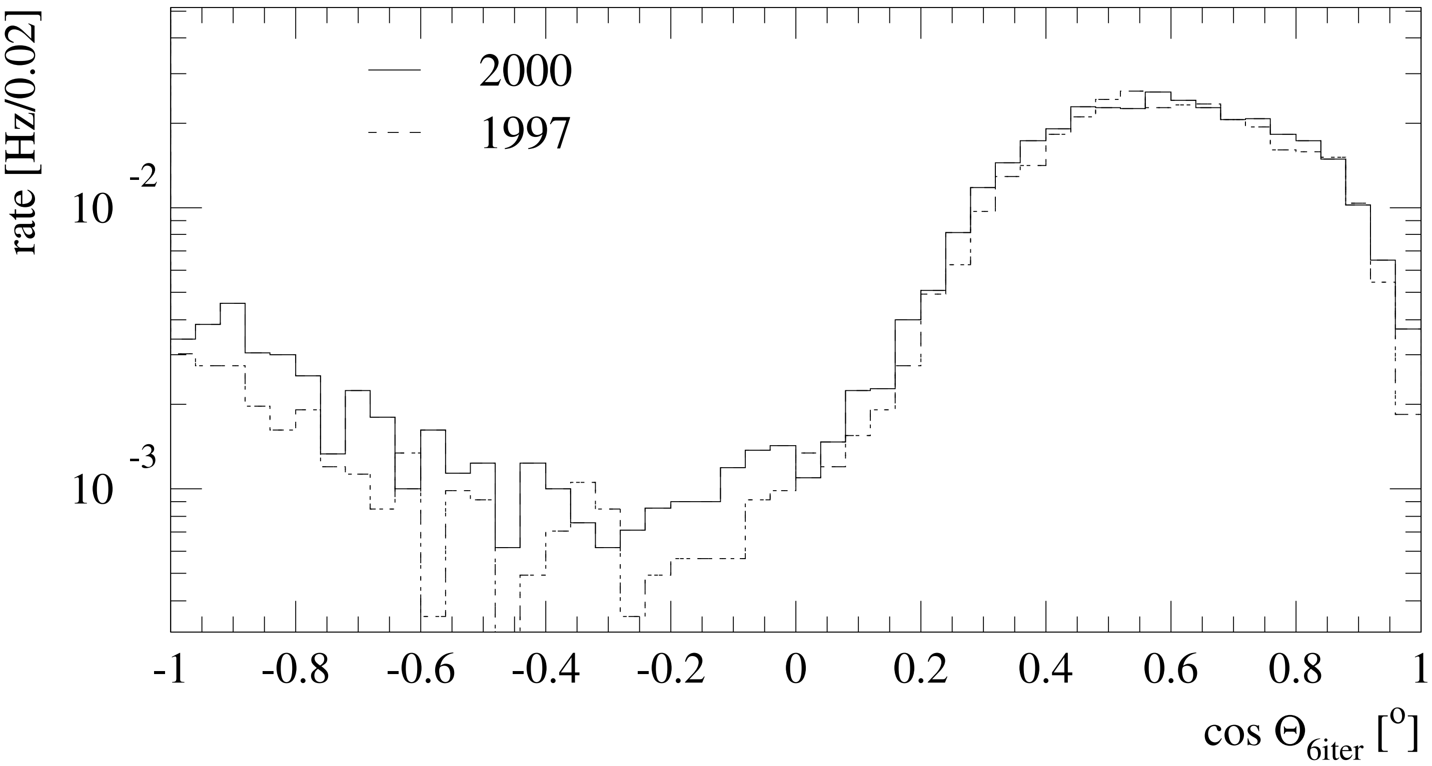


2. After reconstruction/filtering: Zenith and Azimuth

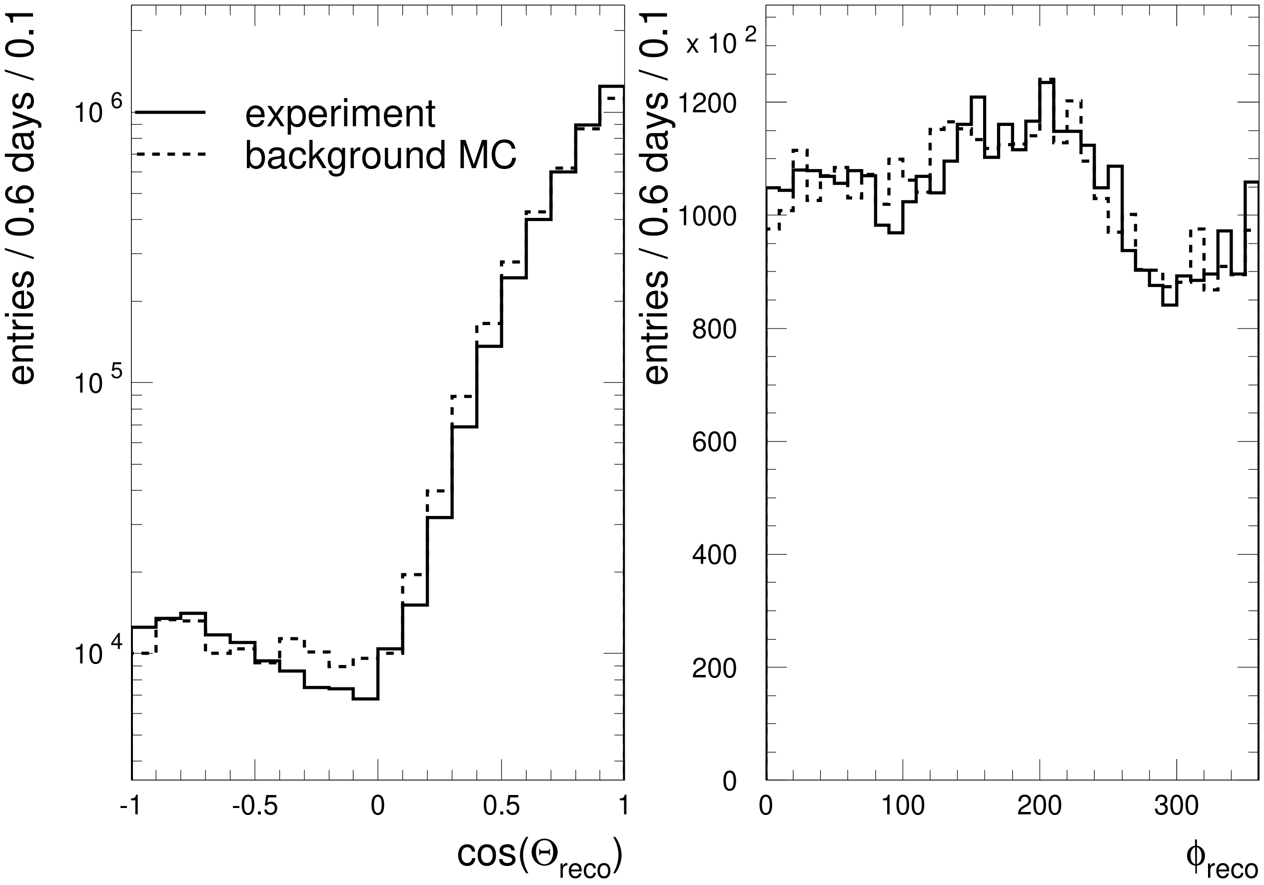




3. After Level-2 filter: Zenith



Minimum Bias check for AMANDA-II - Zenith & Azimuth at Level-1



Filtering to Level-1 and Level-2

- Level 0 (Trigger): Atmos.Muon / Atm.ν = BG/Signal $\approx$ 2$\cdot 10^5$
- Level 2 (TimeLikelihood, angular Cut): BG/Signal $\approx$ 900

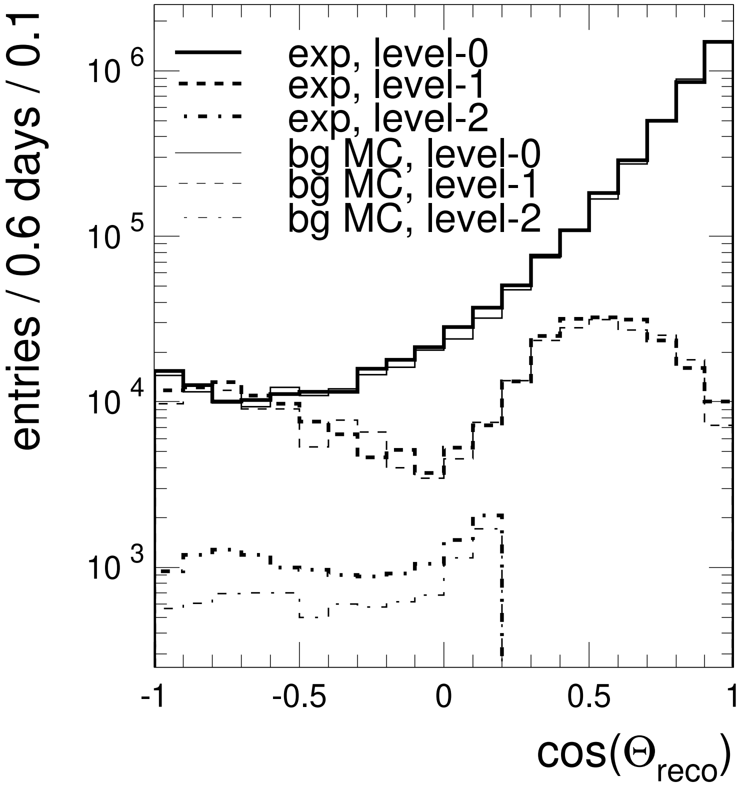
	exp data	atmospheric μ MC	atmospheric ν_μ MC
Level-0	$6.3 \cdot 10^6$ (events/day)	4.4$\cdot 10^6$ (events/day)	31 (events/day)
Level-0	1.0	1.0	1.0
Level-1	$7.5 \cdot 10^{-2}$	$7.0 \cdot 10^{-2}$	0.89
Level-2	$3.3 \cdot 10^{-3}$	$2.4 \cdot 10^{-3}$	0.75

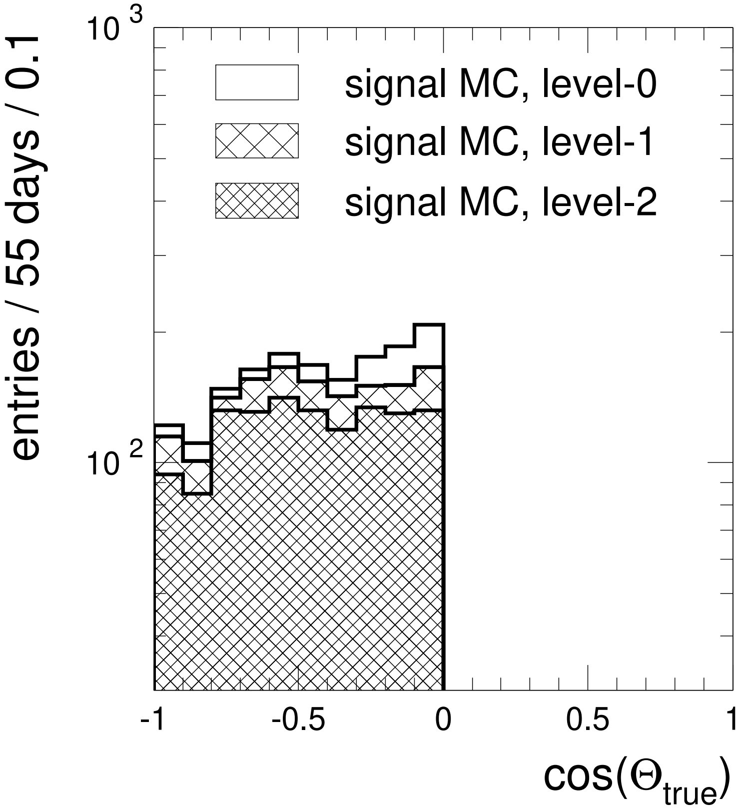
Reconstruction and cuts for Level-1 and Level-2

Id		Name	Remarks
Level-1			
Reco 1		Line-fit	
	Cut 1	$\theta(1) > 70^\circ$ $[\theta(1) < 90^\circ]$	Zenith L ine-fit
Reco 2		U-Pandel likelihood	Single photon arrival time probabilities
Reco 3		Dipole approximation	
Reco 4		Tensor of Inertia	
Level-2			
	Cut 2	$\theta(2) > 80^\circ$	Zenith, Reco 2
	Cut 3	$N_{direct}^{-25..75}(2) > 3$	Number of direct hits, Reco 2
Reco 5		Iterative U-Pandel	16 iterations
	Cut 4	$\theta(3) > 80^\circ$	Zenith, Reco 3
Reco 6		Energy reconstruction	$P_{hit} * P_{nohit}$, using Reco 5

Reconstruction and cuts for Level-1 and Level-2

First data set (0.6 days livetime): Cuts from Level 0 ⇒ Level-2.



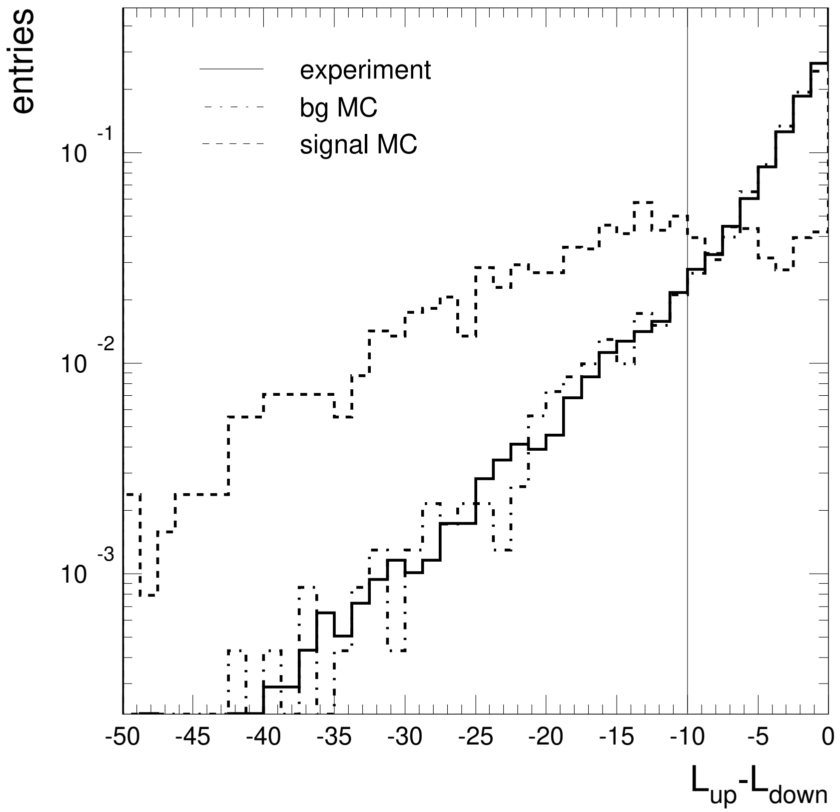


Beyond Level-2 - Atmospheric Neutrinos

Use a subset of variables from B10-Analysis. Not yet optimized.

- $|S^{van}|$: Smoothness - homogeneity of the hit distribution along the track
- $|S^{phit}|/(\theta - 75^{\circ})$: Hit probability weigthed Smoothness, and zenith angle cut
- $(N_{dir}(-15:75) - 2) \cdot L_{dir}(-15:75)$: Number of OMs hit by un-scattered photons $\times$ largest distance between any two of these OMs
- $\log(\mathcal{L}_{up}/\mathcal{L}_{down})$: Ratio of likelihoods for best upward and downward track fits
- $\Psi(16iter, LF)$: Space angle between iterative likelihood reconstruction and the line fit
- *COGz*: the z-coordinate of "center of gravity" of all hit OMs
- $\theta_{reco} > 95^{\circ}$: Zenith angle of the iterative likelihood reconstruction

Example for a cut variable: Likelihood ratio



Normalized distribution of $\mathcal{L}_{up} - \mathcal{L}_{down}$, for the experiment, atmospheric μ MC and atmospheric ν_μ MC, after level-2 cuts.

First Neutrino samples

Very first

- 0.6 days livetime (See Report to PRC)

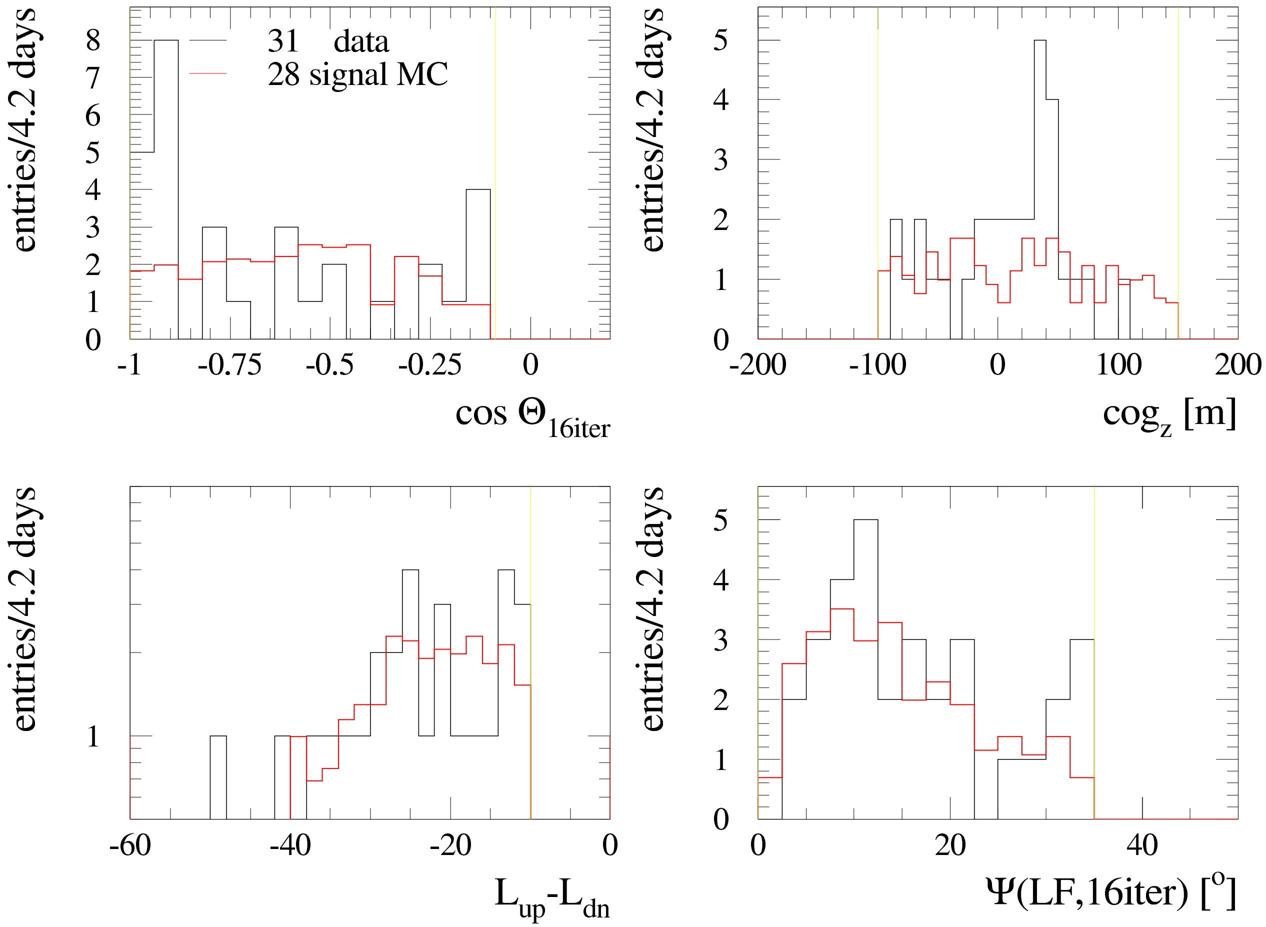
$\Longrightarrow$ 6 upward ν candidates

Current sample

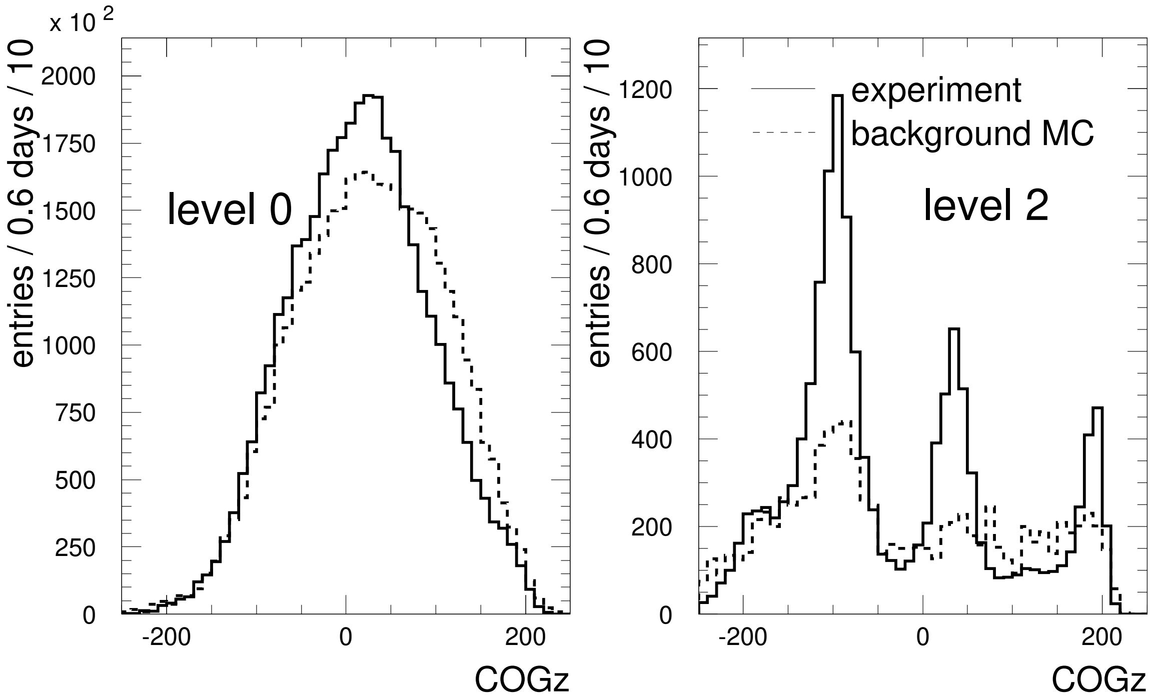
- 4.2 days of livetime
- $\sim$5 hr of atmopsheric μ MC
- $>$50 days of atmospheric signal MC

$\Longrightarrow$ 31 upward ν candidates (with $<$30% BG contamination)

Current neutrino sample



COGz-Distribution



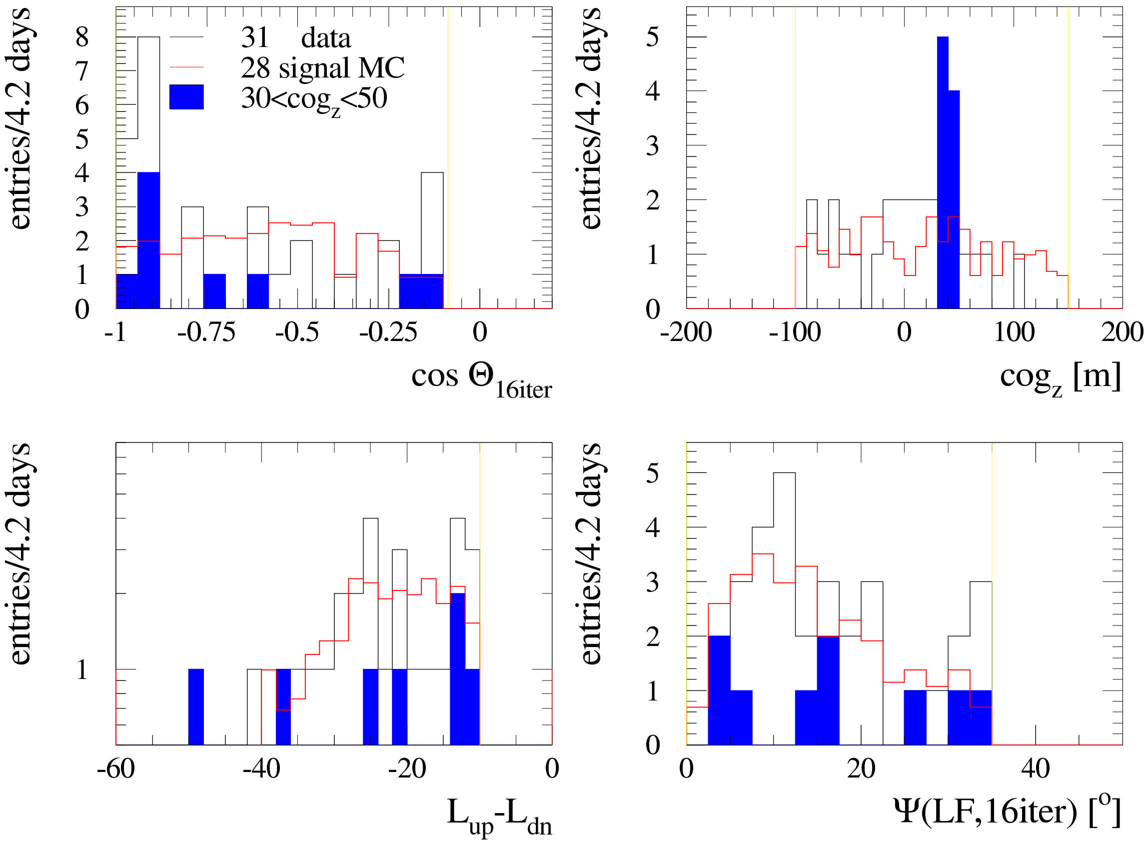
Sharp structures at Level-2 are not reproduced in MC

Already present in B10(1997)

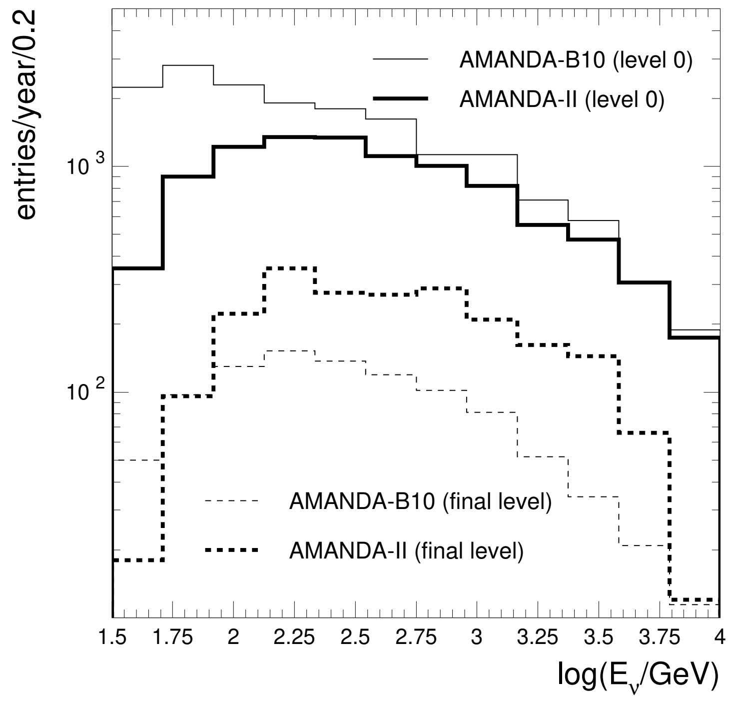
⇒ Not-simulated physics / Electronics artefact / Ice properties . . . ?

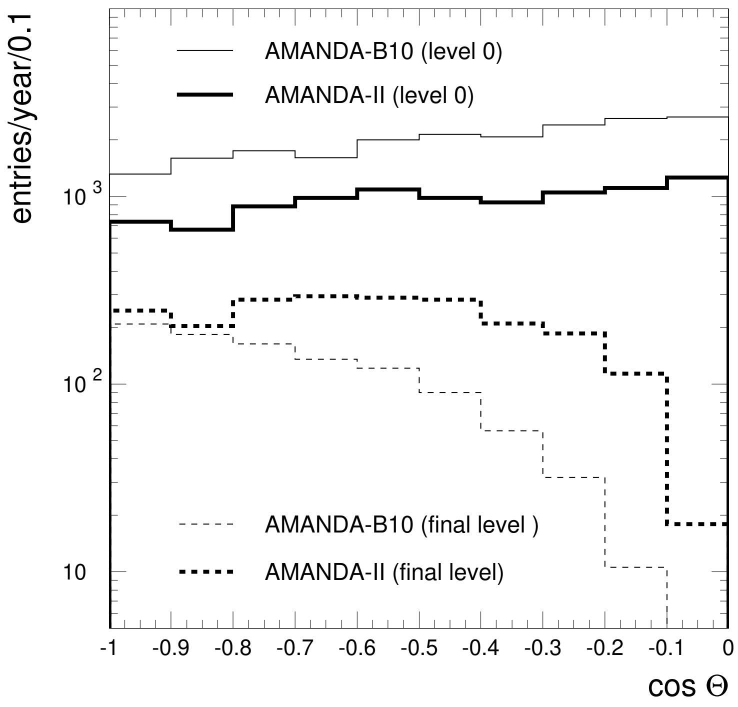
COGz-Distribution

Check correlation of events in *COGz* peak with other cut-variables.



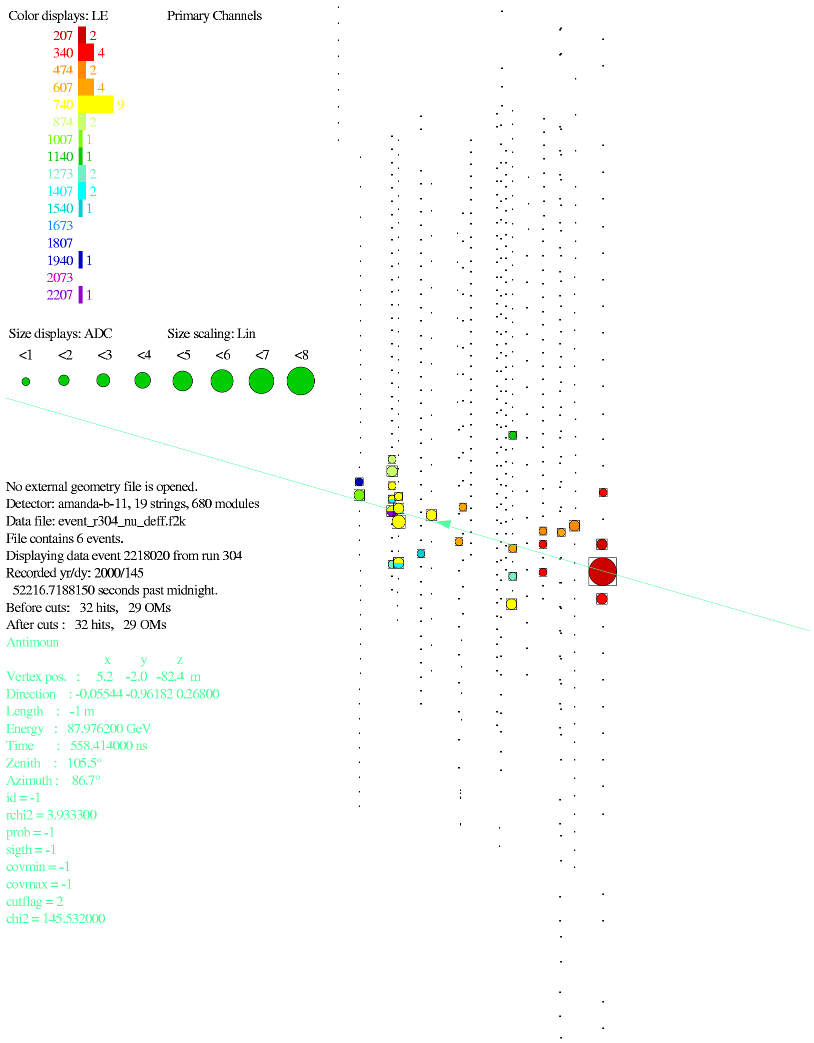
AMANDA-II Energy and Angular spectra (MC, prelim.)



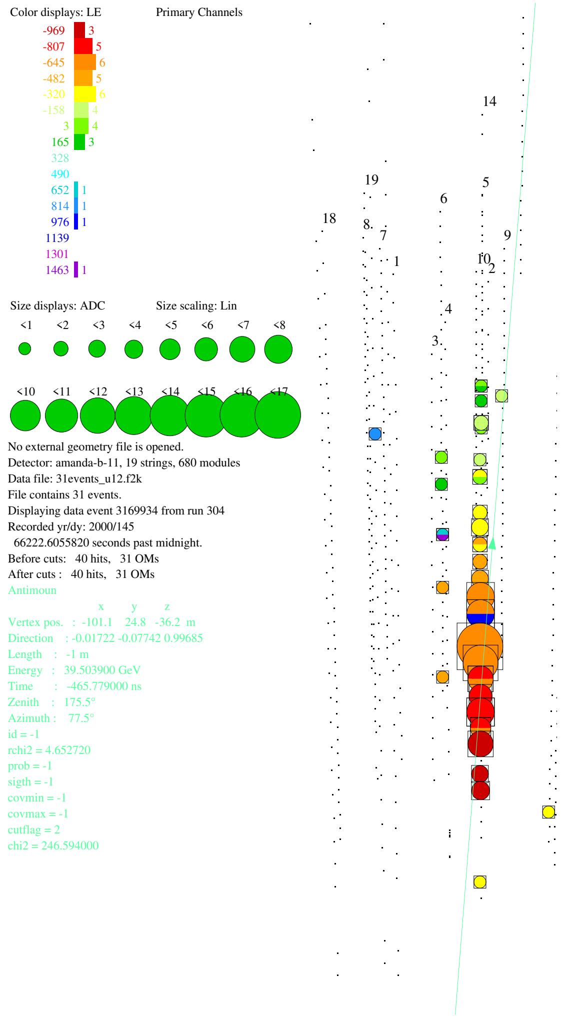


$\Rightarrow$ AMANDA-II has a much improved angular coverage and better acceptance at high energy, compared to B10.

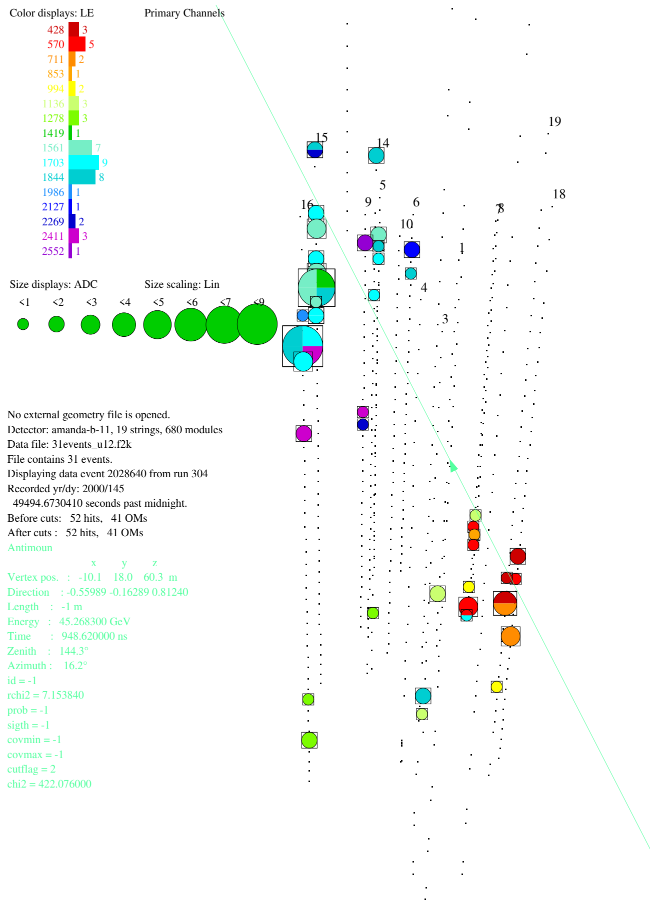
A nearly horizontal AMANDA-II event ($\theta = 105^o$)

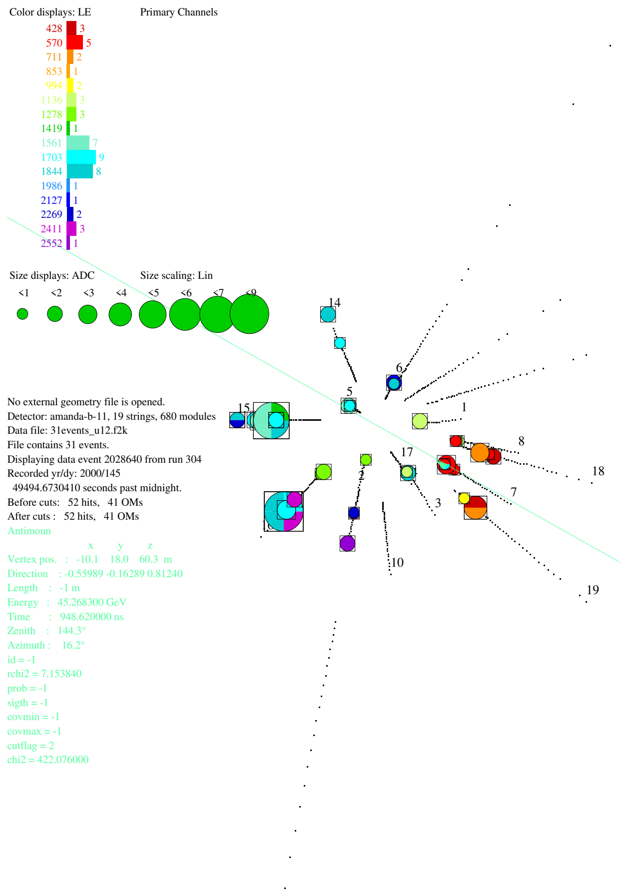


An almost vertical AMANDA-II event ($\theta = 175^o$)



A typical *COGz* event in AMANDA-II





⇒ possible source: coincident muons from uncorrellated showers.

Summary 2000 Analysis

First atmospheric ν analysis (started in March 2001)

- 31 neutrino candidates for 4.2 livetime days
  ($\sim$30% BG-contamination estimated)
- Cuts need proper tuning for BG minimization
- Detector "systematics" t.b.d., New Reconstruction Algorrithms,...

Advantage of AMANDA-II versus B10-Detector

- Angular acceptance improved to horizon
- Larger cut passing rates $\sim$ 6-fold
- Atmospheric ν event rate of 4-5/day feasible (1.5 ev/day for B-10)
  $\Rightarrow$ 800...1000 ν_{at} for 2000 expected (208 ev for B-10)

Summary 2000 Analysis (2)

"Physics analysis" start in parallel to ν_{at} Mass-Production

Optimize filter for different event samples

- Diffuse HE limits
- HE point source search
- ν_e-Cascade search
- EHE energy search (E$>>10^6$GeV)
- Monopoles
- GRB
- WIMP, SN, HE atmospheric muons, Seasonal variations, . . .

First results to ICRC Conference, Hamburg, August 2001

Techncial report on atmospheric neutrinos for October