Analysis of atmospheric muons in AMANDA

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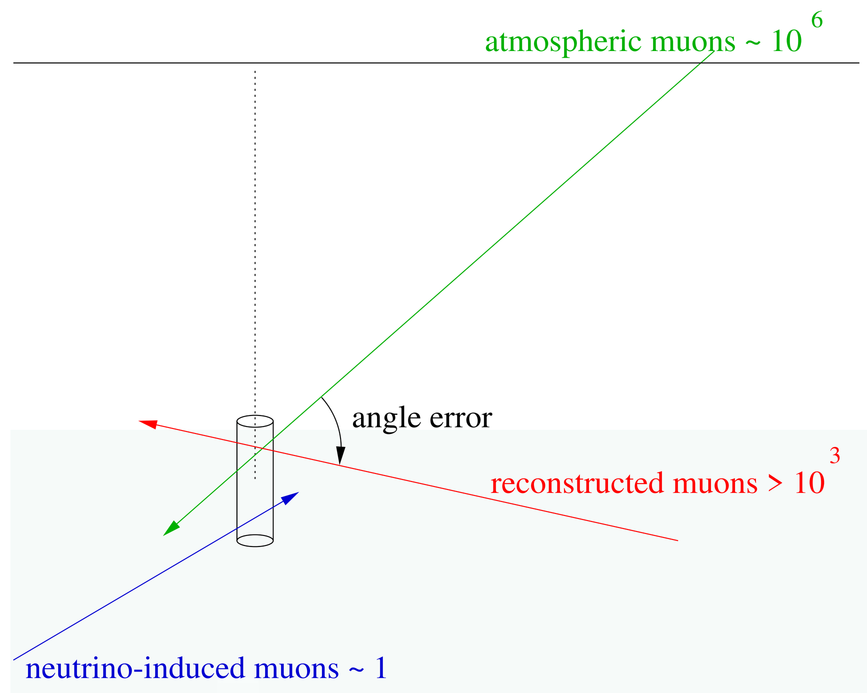
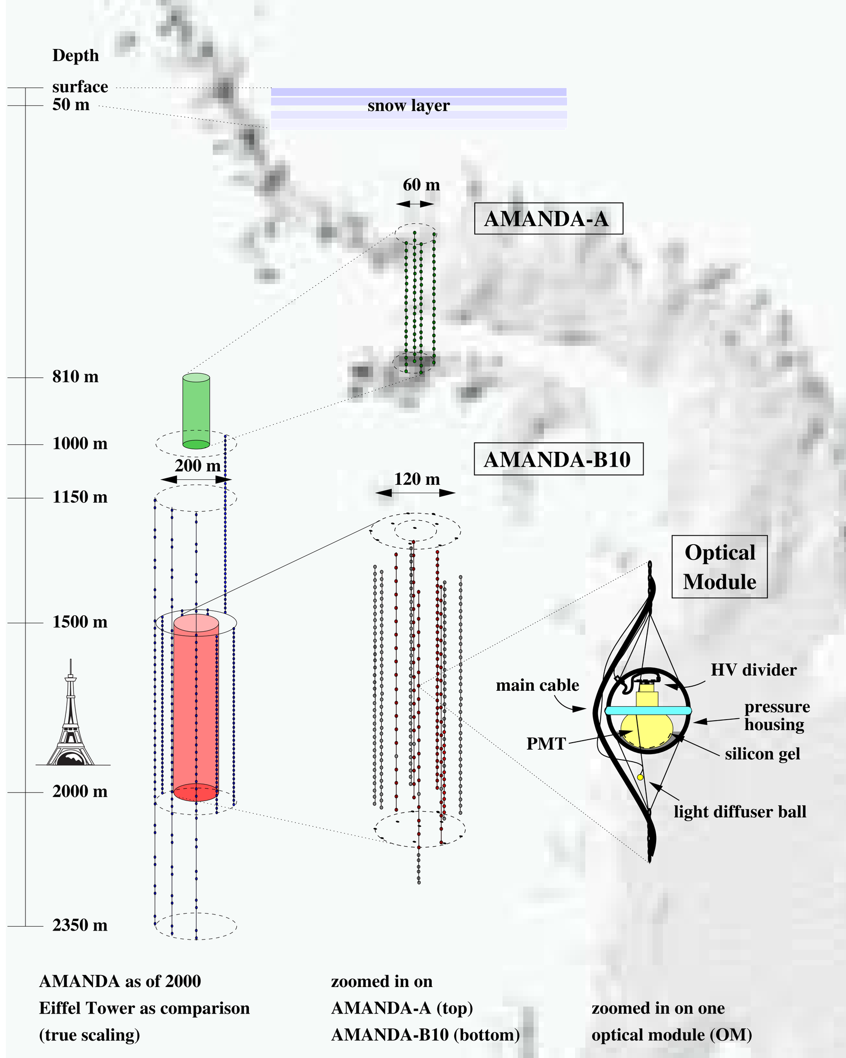
Introduction



- Neutrinos detected via muons produced in CC processes in the Earth below the detector. These up-going muons have the same direction of parent neutrinos
- Atmospheric down-going muon flux is 6 orders of magnitude higher than neutrino induced muon flux
- Even if only 0.1% of muon tracks are reconstructed as up-ward, misreconstructed muons exceed enormously neutrino induced muons

- The knowledge of atmospheric muons aims to
  1. optimize background rejection for neutrino-induced muons
  2. improve detector knowledge
  3. test the physics inputs in generators and propagation codes
- Possibility to determine minor components, such as charm

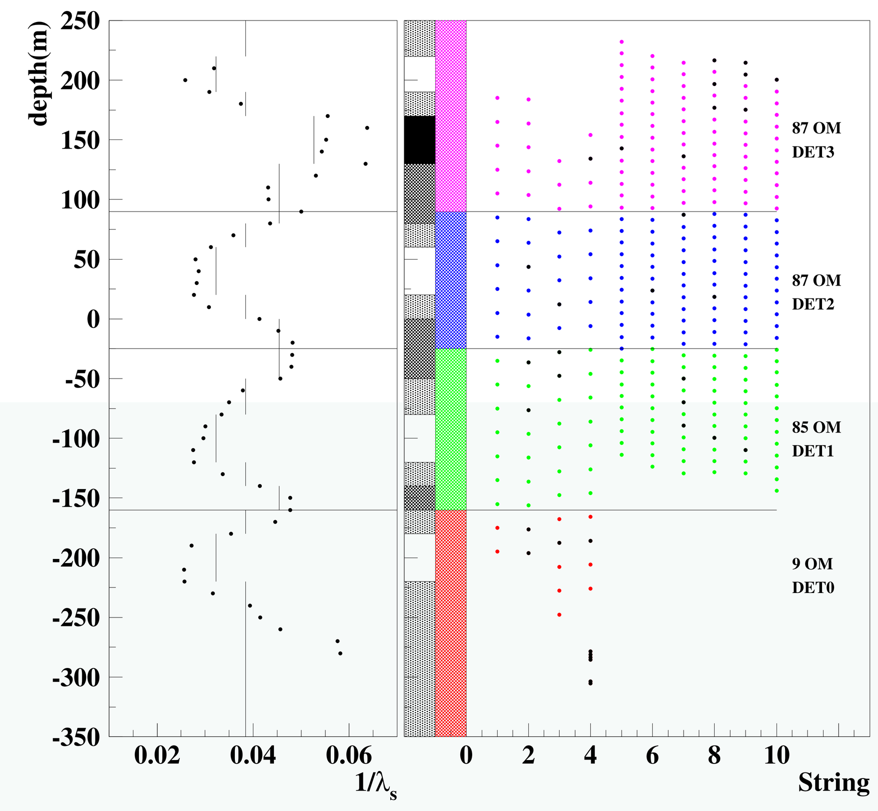
The Detector



- AMANDA-II, situated at the Geographic South Pole, was completed in the antarctic summer 1999/2000
- AMANDA-II contains 677 Optical Modules (OM) deployed in 19 strings, most of them at depths 1500-2000 m
- Charged particles propagating through the ice, emit Cherenkov light which is detected by the OMs. Track reconstruction is based on time recorded by the OMs
- AMANDA-B10 indicates the first 10 strings and contains 302 OMs

The Analysis for AMANDA-B10

- 500 meters AMANDA detector length: $\Phi_\mu(top) \approx 2 \cdot \Phi_\mu(bottom)$
- Optical scattering length λ_s is a function of depth due to glaciological layering
- Detector divided in three parts
- So far data and simulation analysis chain relative to detector parts DET1 and DET2



- OM cleaning purge from random noise
- Time likelihood reconstruction relative to single detector part
- Quality cuts using fit estimators and geometrical criteria
- Sample unfolding of $\cos\Theta$ using Bayes' Theorem
  - Unfolding performed on the reconstructed $\cos\Theta$
  - Experimental data unfolded using different muon propagation codes

The Data Samples

An OM during deployment

- Experimental Data
  - Summer & Winter experimental 1997 samples
  - 5 million triggered events
- Simulated Data
  - Extensive air showers simulated with CORSIKA
    - * Primary flux and composition from Wiebel-Sooth, WUB-DIS 98-9
    - * Curved Earth and antarctic atmosphere properties included
  - Propagation through the ice
    - * Different propagation codes used

The Results

Unfolded atmospheric muon angular and depth-intensity distributions for DET1 part and relative deviation from simulation for the two data samples

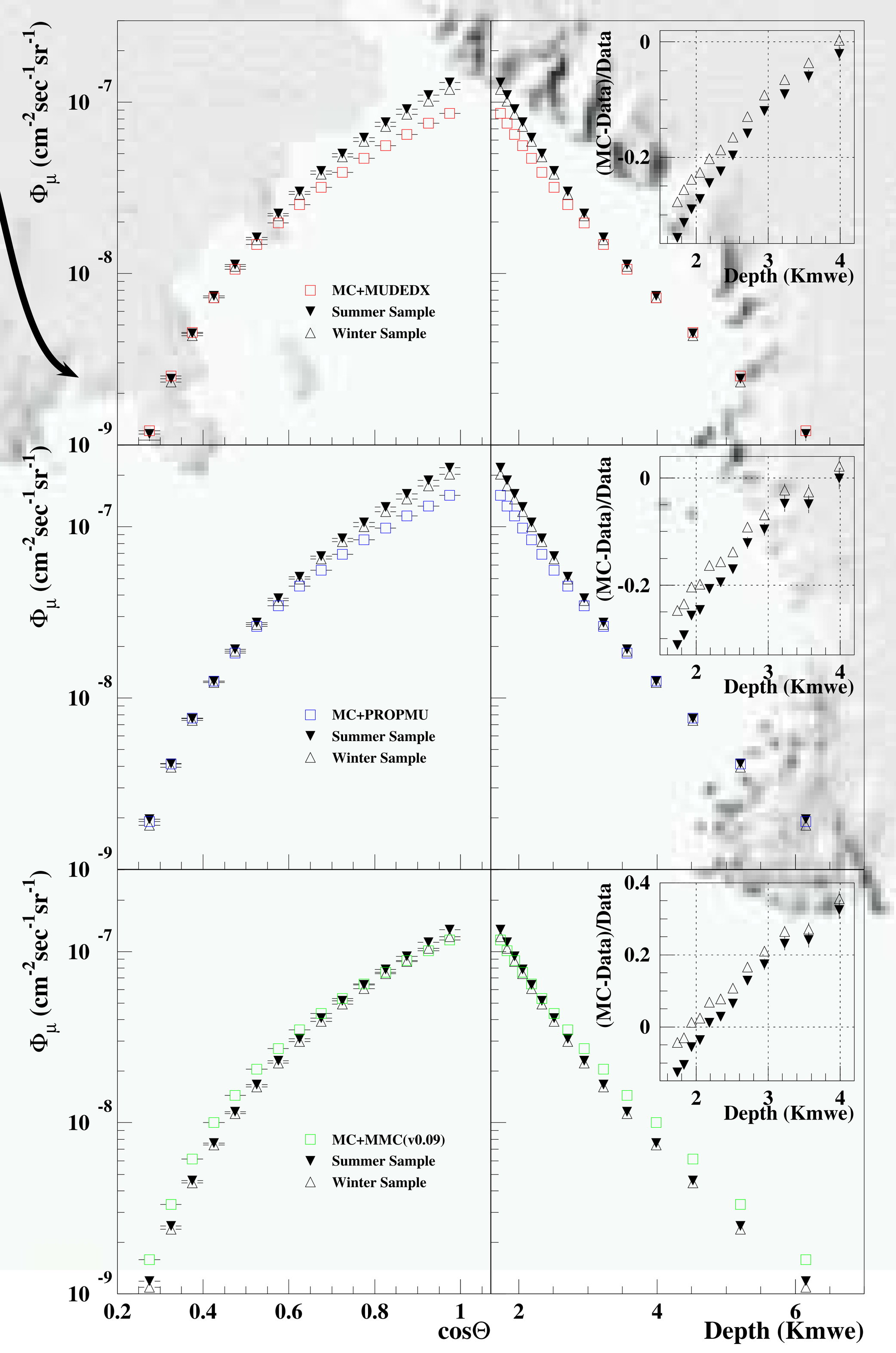
- 10% difference between the two data samples consistent with seasonal variations
- Results confirmed for data unfolded relative to DET2 detector part

MUDEDX: Lohmann, Kopp, Voss, CERN 85-03
Old code designed for fixed target experiments with cross sections evaluated at a given energy

PROPMU: Lipari,Stanev,Phys. Rev. D,Vol.44,3543,1991
Code designed for underground detectors. It underestimates muon energy loss for E<1TeV and is not optimized for secondary shower production

MMC: Chirkin,Rhode,this Conference,HE2.02
Recent code designed for detectors in underground/water/ice locations with the most recent cross section formulæand efficient tracking techniques

MUM: Sokalsky,Bugaev,Klimushin,this Conference,HE2.02
Another recent code designed for detectors in transparent media. Very similar to MMC on cross sections but using different tracking techniques. Results similar to MMC



- ≈30-40% deviation observed
  - absolute and angular/depth-dependent
  - also at trigger level
- Similar deviation from Fréjus Experiment

⇒ see Schröder, Rhode, Meyer, this Conference HE2.02

- Need to improve knowledge on
  1. Primary flux and composition
     - Systematic uncertainties ≈7%
     - New measurement from AMS: 30% lower proton flux for E>20 GeV

     ⇒ AMS Collaboration, Phys. Lett. B 490, pp. 27-35, 2000
  2. Absolute OM sensitivity
     - ≈20% uncertainty
  3. Photon scattering simulation close to OMs
     - ≈15% uncertainty
  4. Environmental properties: ice density profile, South Pole topography
     - ≈10-15% effect
- Muon propagation codes: effective energy loss too small (?)

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