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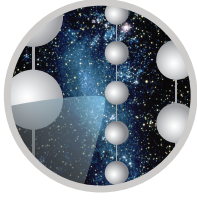


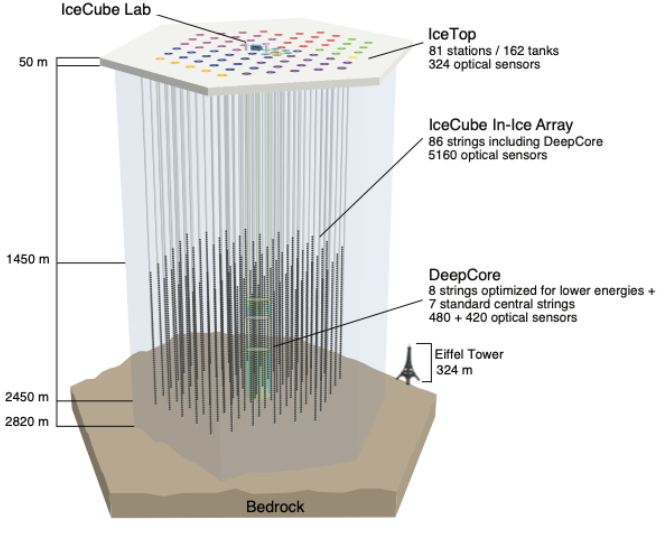
IceCube
Neutrino Observatory

Observing the Prompt Component of the Atmospheric Muon Flux Using IceCube

Leander Flottau

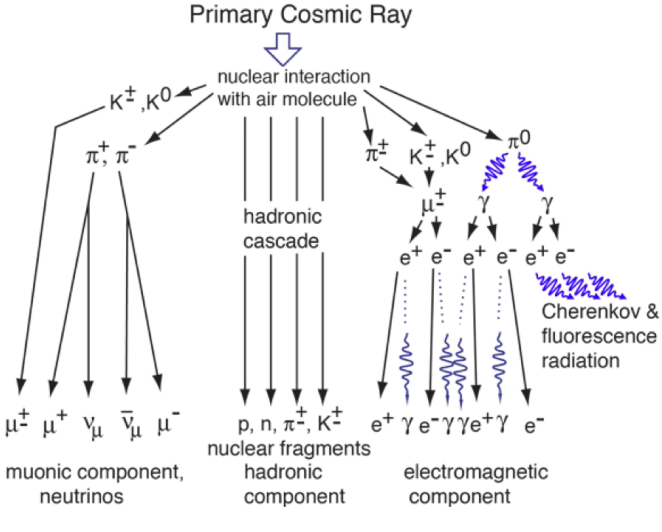
25. März 2025

IceCube Neutrino Observatory



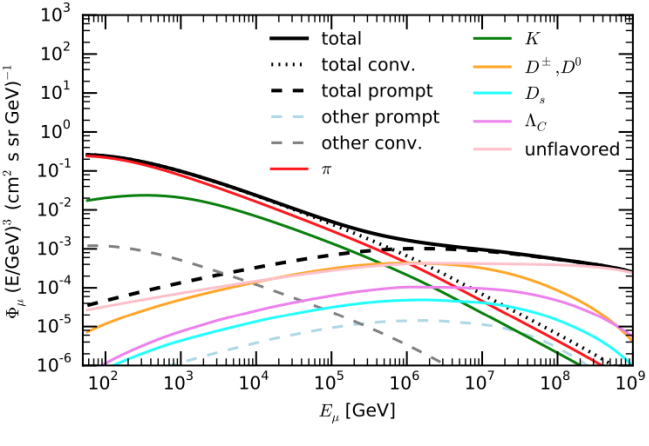
- Cubic kilometer scale cherenkov detector
- 5160 DOMs on 86 strings
- ≈ 3 kHz muon event rate

Atmospheric Air Showers



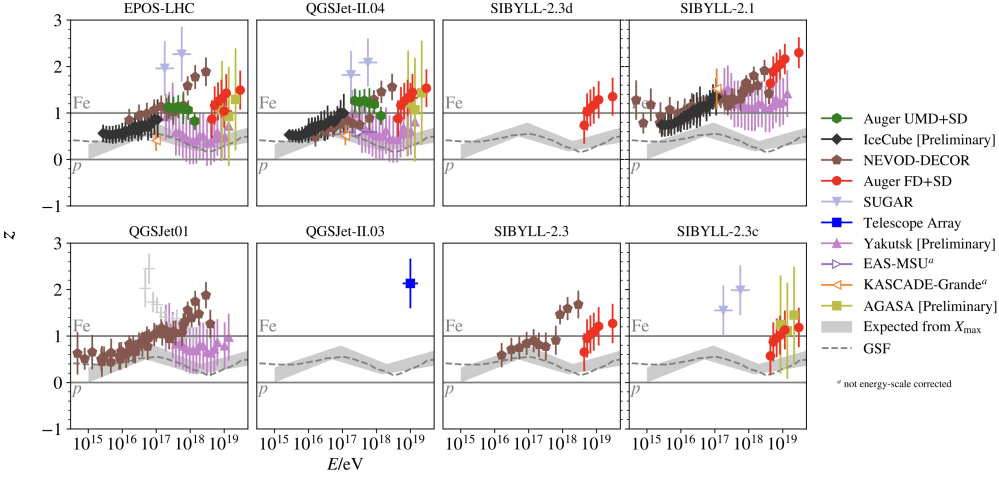
- Cosmic ray interactions produce secondary particles
- Major decay product: μ

The Prompt Component



- Conventional: produced by $K^{\pm}/\pi^{\pm}$
- Prompt: produced by short lived particles
- Prompt dominant at high energies

The Muon-Puzzle



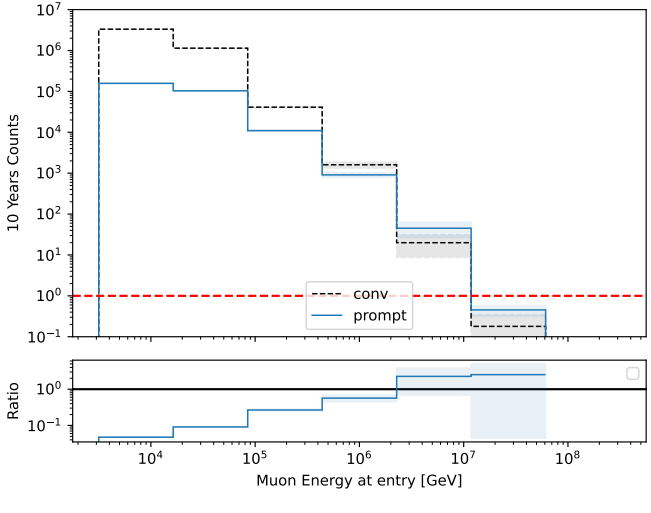
Simulations and tagging

- Tagging of parent particles in CORSIKA simulations
- Prompt definition based on parent of leading muon
- Allows for MC-Sample with prompt/conventional distinction
- Simulation up to extremely high energies > 10 PeV

Reconstructions

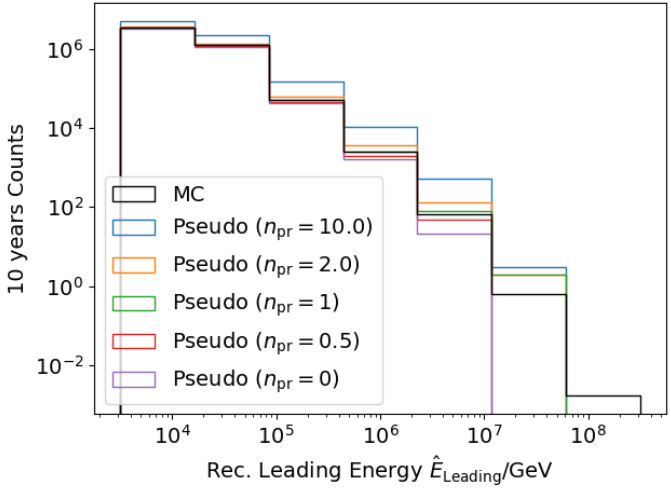
- Neural network based
- Zenith angle, bundle energy and leading muon energy
- Small network for precuts

Forward Folding



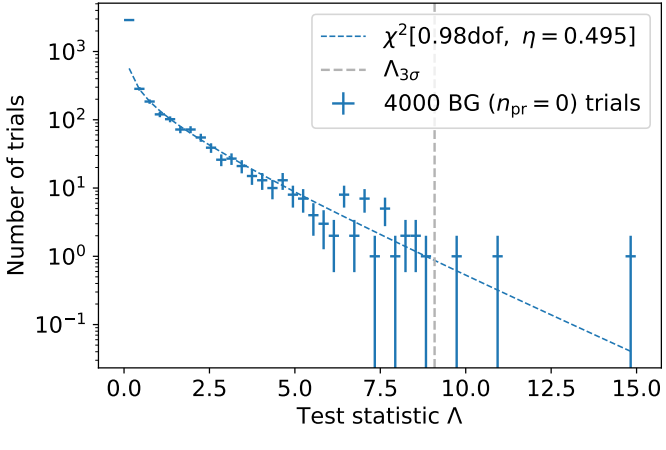
- Prompt normalization: fraction of prompt component relative to current MC-simulation n_p
- Poisson likelihood in each histogram bin
- Rescale with normalization factors
- Strong model dependency

Pseudoexperiments



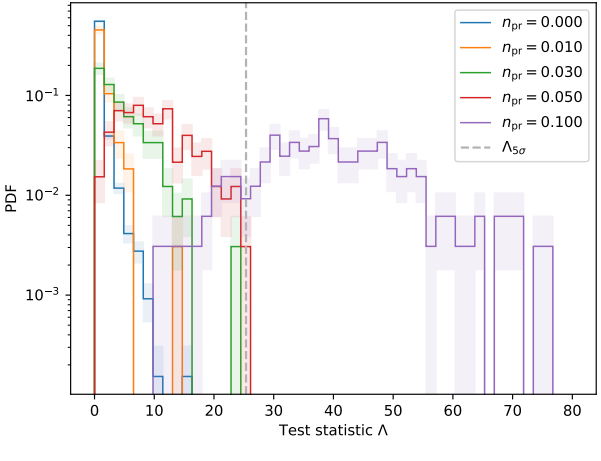
- Testing methods based on simulations
- Events drawn based on primary model and normalizations
- Inject normalization

Background Estimation



- Likelihood ratio test
- Draw background samples with n_p = 0
- Wilks' theorem: fit χ^2-distribution

Discovery Potential



- How high does the prompt norm have to be to detect it with the current method?
- Discovery potential: Norm at which half the generated trials yield 5σ significance in the likelihood ratio test
- Sensitive to input parameters, binning etc

Summary

- Generate prompt tag in simulation
- Simulate up to high energies
- Forward fit of prompt normalization
- Use MC data to estimate significance