

**ICECUBE**  
NEUTRINO OBSERVATORY

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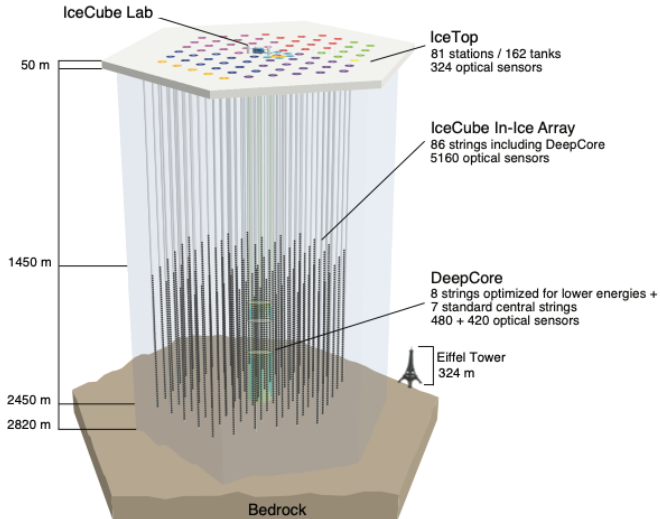
## Observing the Prompt Component of the Atmospheric Muon Flux Using IceCube

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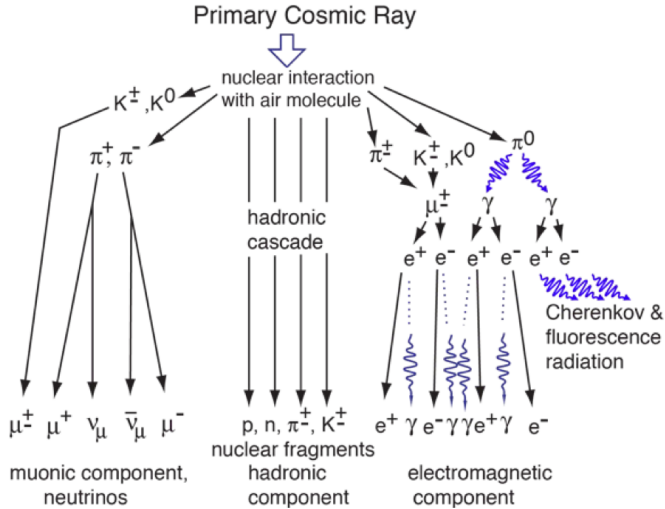
18. März 2025

## IceCube Neutrino Observatory



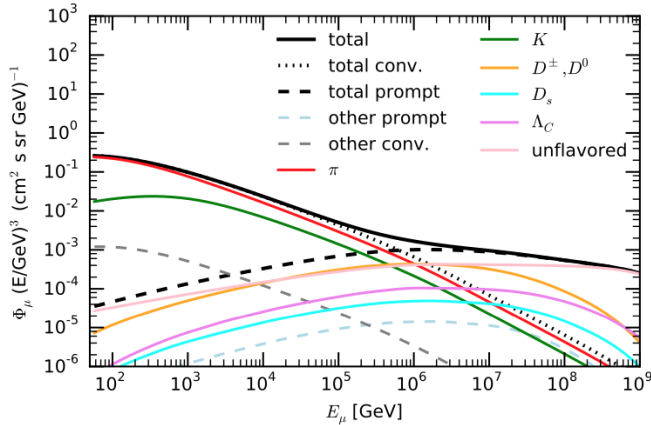
- Cubic kilometer scale cherenkov detector
- 5160 DOMs on 86 strings
- 270 measured neutrino Events per day
- $\approx 3$  kHz muon event rate

## Atmospheric Air Showers



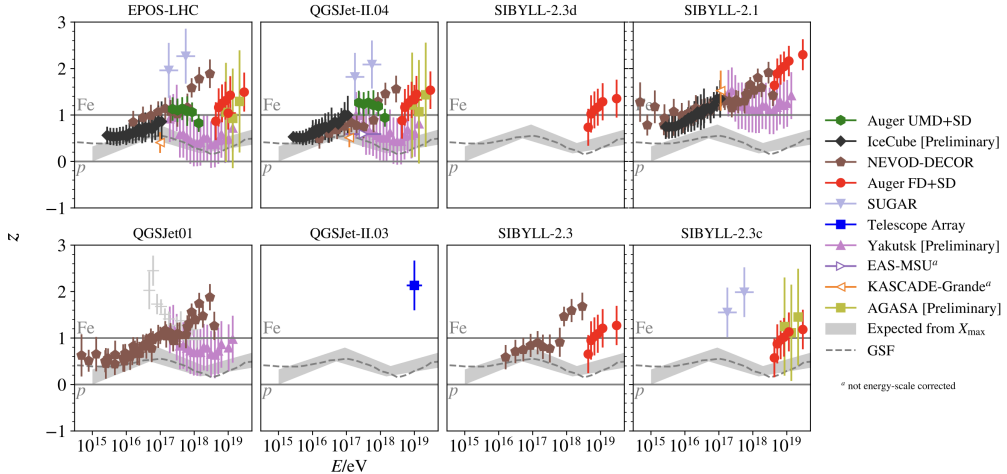
- Cosmic ray interactions produce secondary particles
- Major decay product:  $\mu$

## The Prompt Component



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

## The Muon-Puzzle



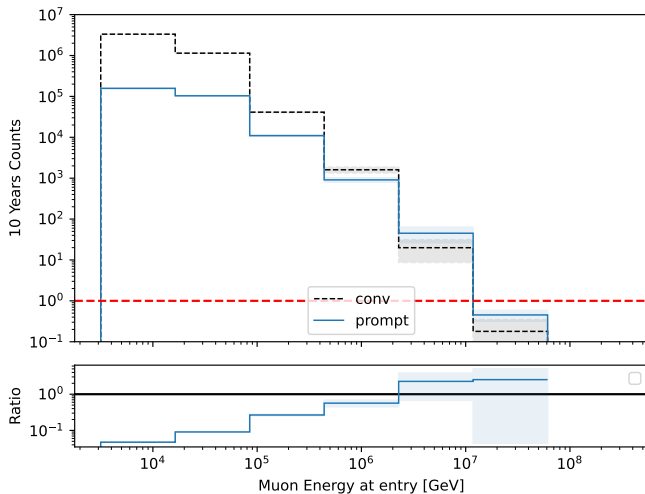
## Simulations and tagging

- 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

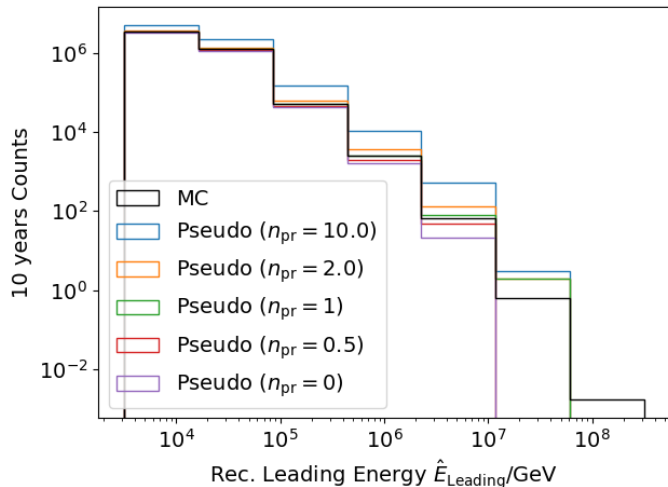
## Forward Folding



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

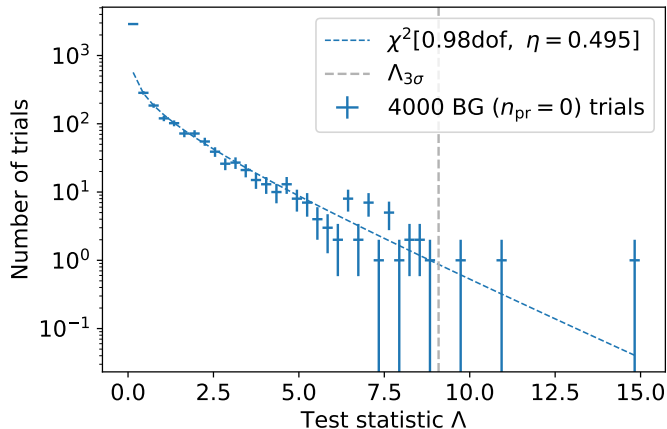


## Pseudoexperiments



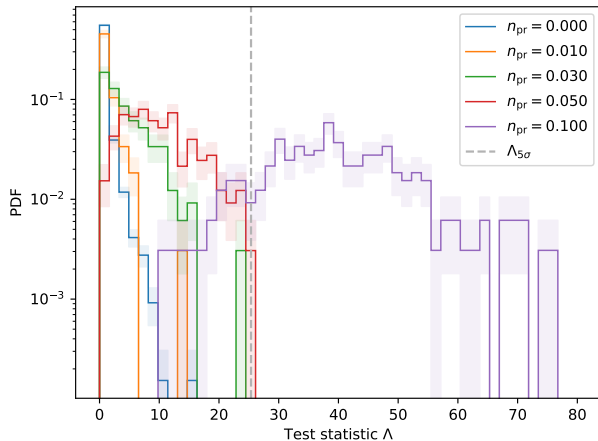
- Testing methods based on simulations
- Events drawn based on primary model and normalizations
- Inject normalization

## Background Estimation



- Likelihood ratio test
- Draw background samples with  $n_p = 0$
- Wilks' theorem: fit  $\chi^2$ -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  $5\sigma$  significance in the likelihood ratio test
- Sensitive to input parameters, binning etc