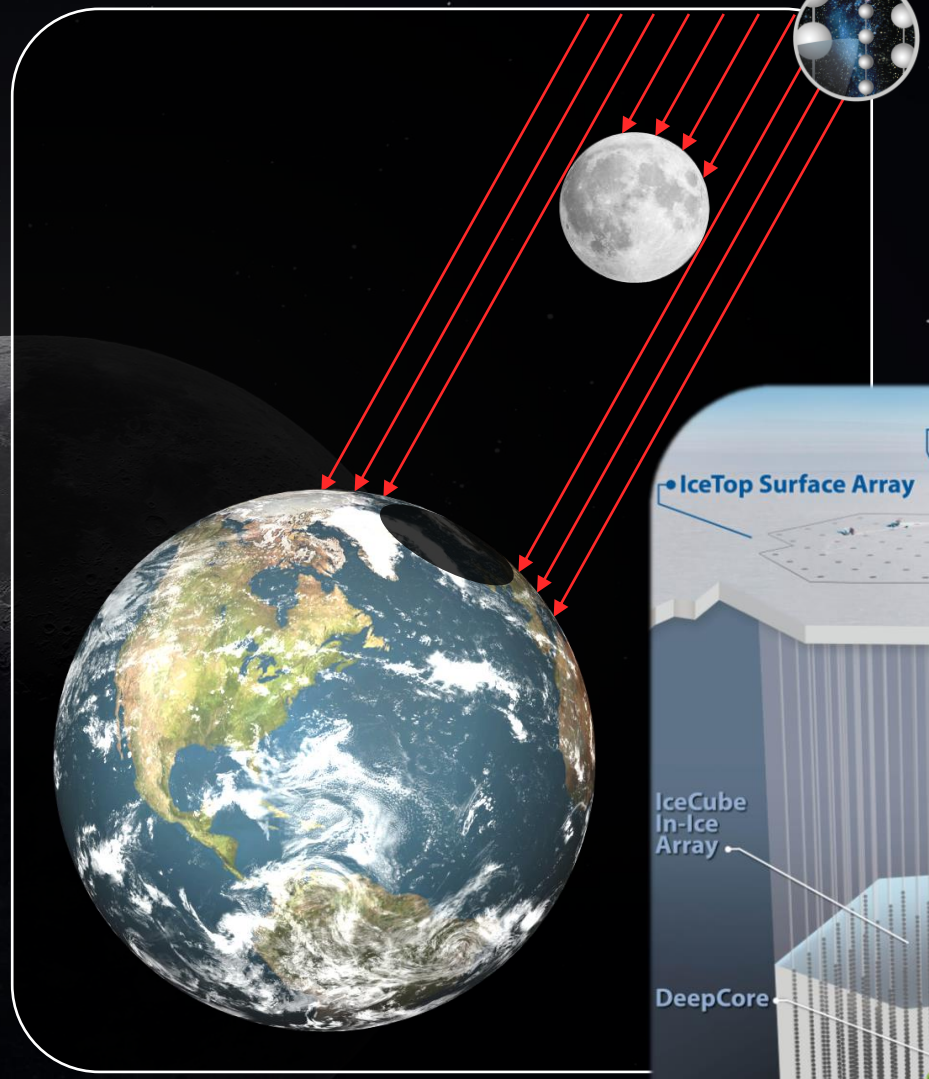
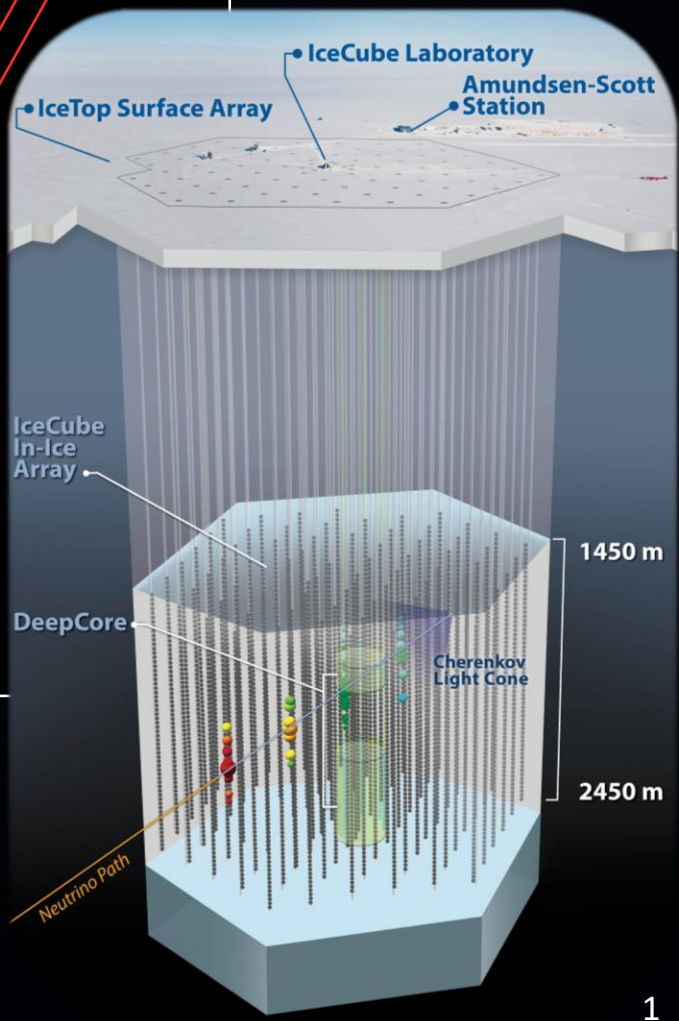
Motivation

- Cosmic rays are blocked by the moon
  - No cosmic-ray-induced muons from lunar direction
  - A deficit in muons is measured with high statistics

- Moon is used as a standard candle for several calibration purposes for the IceCube Neutrino Observatory:
  - Presented on this poster:
    - Verification of improved analysis methods
    - Benchmarking of new directional reconstruction algorithms
  - Further planned applications:
    - Regular testing of detector performance
    - Testing of new detector calibration (DOM positions)
    - Test on the impact of Earth's magnetic field

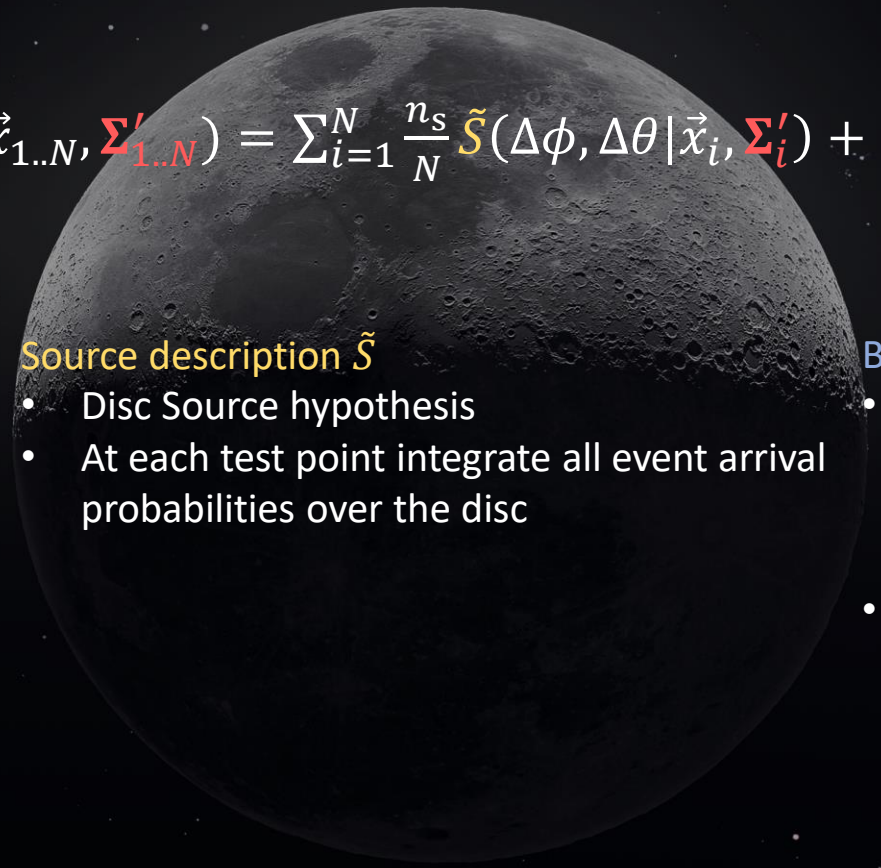




Analysis Method

- Maximum-Likelihood method:
  number of blocked events n_s is fitted with regards to the total number of events N

$$\log \mathcal{L}(n_s, \Delta\phi, \Delta\theta | \vec{x}_{1..N}, \boldsymbol{\Sigma}'_{1..N}) = \sum_{i=1}^{N} \frac{n_s}{N} \tilde{S}(\Delta\phi, \Delta\theta | \vec{x}_i, \boldsymbol{\Sigma}'_i) + \left(1 - \frac{n_s}{N}\right) \tilde{B}(\vec{x}_i, \boldsymbol{\Sigma}'_i)$$



Uncertainty estimation $\boldsymbol{\Sigma}'_i$

- Asymmetric Gaussian event reconstruction uncertainties
- Asymmetric scaling of the uncertainties based on the detector geometry to achieve correct statistical coverage

Source description $\tilde{S}$

- Disc Source hypothesis
- At each test point integrate all event arrival probabilities over the disc

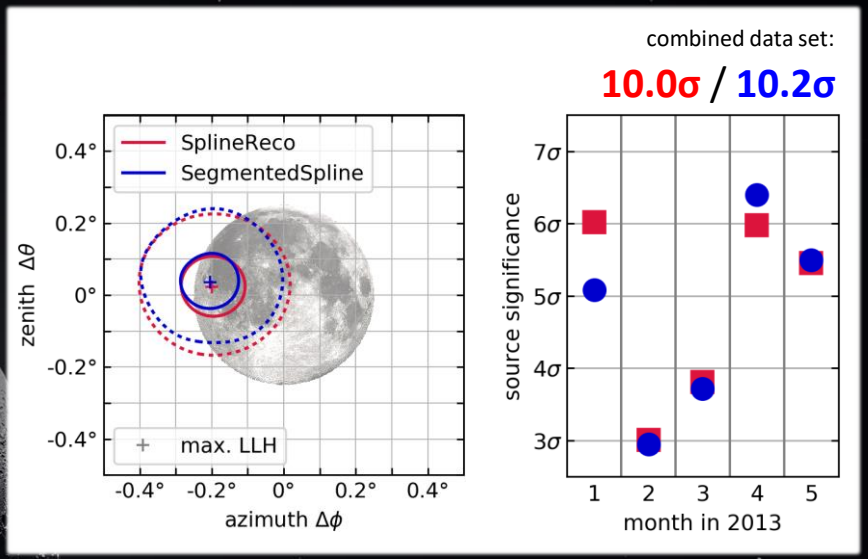
Background description $\tilde{B}$

- Determine the true background distribution by summing up the Gaussian distributions of each event in the off-source region at each point
- Evaluate the background distribution for events in the on-source region by integrating over their uncertainty estimations

Test of Reconstruction Methods

Two new reconstruction methods were tested against the current standard SplineMPE (based on multiple photo electrons using spline tables):

- SegmentedSplineReco (based on SplineMPE with improved energy-loss estimation):
  - Performs as good as SplineMPE
  - Improvements are expected on higher energies than used here



- CRNN-Reco (neural network using convolutional and recurrent elements):
  - Performs worse than the current standard,
    but is not trained on cosmic-ray-induced muons bundles yet
    → better performance should be achievable
  - Completely new type of single-step event reconstruction,
    passed this first valuable test on non-simulated data successfully