Results from Testing the Neutrino Mass Ordering with Three Years of IceCube DeepCore data

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Neutrino Mass Ordering …
... via matter effects in atmospheric ν-oscillations

- **NMO describes ordering of ν mass eigenstates**
  - two options: Normal (NO) & Inverted Ordering (IO)

- **NMO modulate vacuum ν-oscillations via matter effects**
  - MSW effect, parametric enhancement during ν-propagation

- **Matter effects (ME) in ν or \( \bar{\nu} \) depend on NMO:**

- **Atmospheric ν an \( \bar{\nu} \) generated in atmosphere by Cosmic Ray interactions**
  - propagate through Earth, seeing matter effects

- **Net signature as:** \( \phi_\nu > \phi_\bar{\nu} \) and \( \sigma_{N\nu} > \sigma_{N\bar{\nu}} \)

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<table>
<thead>
<tr>
<th>Normal (NO)</th>
<th>Inverted (IO)</th>
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<tbody>
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<td>( \nu_e,\mu \rightarrow \nu_e,\mu,\tau )</td>
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**Signature:** more ME less ME
Results on Testing NMO…
… with 3 years of IceCube DeepCore data

- IceCube DeepCore detector measures atmospheric $\nu$ above $E_\nu \sim 5$ GeV
- Developed 2 independent log-likelihood analyses to test the NMO
  - binned likelihood in: 1. energy, 2. zenith-angle, 3. flavor-separating variable
  - High statistics of 40’000 events, simultaneous fit of systematic parameters
  - Use LLH difference between NO and IO hypothesis as test statistic
- Results from fitting three years of data (to be published soon):
  - In more sensitive analysis observe preference for NO in left octant:
    \[ p(\mathcal{H}_{NO}) = 71\% \quad p(\mathcal{H}_{IO}) = 15\% \quad CL_s(\mathcal{H}_{NO}) = 83\% \quad CL_s(\mathcal{H}_{IO}) = 53\% \]