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# The directionality reconstruction and particle identification for atmospheric neutrino events in JUNO

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The Jiangmen Underground Neutrino Observatory (JUNO) aims to determine the neutrino mass ordering. To enhance its sensitivity, JUNO will combine the measurements of low energy reactor anti-neutrinos and atmospheric neutrinos in the GeV region. Directionality reconstruction and neutrino flavor identification are crucial for achieving precise measurements of atmospheric neutrino oscillations, but these topics have not yet been explored by any large liquid scintillator detectors. This talk will present the first demonstration of directionality reconstruction and the high-efficiency, high-purity particle identification for atmospheric neutrinos in such detectors like JUNO. Based on machine learning methods, our approach utilizes the topological properties of atmospheric neutrinos characterized by PMT waveform features and event-level information such as Michel electrons and captured neutrons. Preliminary results show that this approach has great potential for utilizing atmospheric neutrinos to unearth JUNO's capabilities.
江门中微子实验（JUNO）的首要科学目标是测量中微子质量顺序这一前沿热点问题。为了提高测量中微子质量顺序的灵敏度，JUNO 实验除了需要精确测量低能区反应堆中微子能谱，还需要联合对 GeV 能区大气中微子的精确测量。大气中微子精确测量的关键在于对大气中微子事例的方向重建和粒子鉴别。在超大型液体闪烁体探测器实验中，这项研究还处于空白。本研究基于机器学习算法，利用从数万个光电倍增管的波形信息中提取到的事例拓扑特征，以及中微子事例整体层面的例如米歇尔电子和俘获中子的特征信息，在国际上第一次基于超大型液体闪烁体探测器实现了对大气中微子事例的方向重建，并且实现了对中微子味道的高效率高纯度鉴别。初期的研究结果表明，这个方法对实现大气中微事例的精确测量、帮助 JUNO 实验实现测量灵敏度的物理目标具有巨大潜力。

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