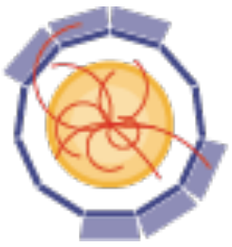


Advanced Particle Flow

- **Development of advanced particle flow and pattern recognition algorithms in PandoraPFA**
- **Application to LHC, LC and neutrino experiments**

J.S. Marshall, S. Green, 25 September 2017

Cambridge: MicroBooNE

High Energy Physics - Experiment

The Pandora multi-algorithm approach to automated pattern recognition of cosmic-ray muon and neutrino events in the MicroBooNE detector

MicroBooNE collaboration: R. Acciarri, C. Adams, R. An, J. Anthony, J. Asaadi, M. Auger, L. Bagby, S. Balasubramanian, B. Baller, C. Barnes, G. Barr, M. Bass, F. Bay, M. Bishai, A. Blake, T. Bolton, L. Camilleri, D. Caratelli, B. Carls, R. Castillo Fernandez, F. Cavanna, H. Chen, E. Church, D. Cianci, E. Cohen, G.H. Collin, J.M. Conrad, M. Convery, J.I. Crespo-Anadon, M. Del Tutto, D. Devitt, S. Dytman, B. Eberly, A. Ereditato, L. Escudero Sanchez, J. Esquivel, A.A. Fadeeva, B.T. Fleming, W. Foreman, A.P. Furmanski, D. Garcia-Gomez, G.T. Garvey, V. Genty, D. Goeldi, S. Gollapinni, N. Graf, E. Gramellini, H. Greenlee, R. Grosso, R. Guenette, A. Hackenburg, P. Hamilton, O. Hen, J. Hewes, C. Hill, J. Ho, G. Horton-Smith, A. Hourlier, E.-C. Huang, C. James, J. Jan de Vries, C.-M. Jen, L. Jiang, et al. (84 additional authors not shown)

(Submitted on 10 Aug 2017)

The development and operation of Liquid-Argon Time-Projection Chambers for neutrino physics has created a need for new approaches to pattern recognition in order to fully exploit the imaging capabilities offered by this technology. Whereas the human brain can excel at identifying features in the recorded events, it is a significant challenge to develop an automated, algorithmic solution. The Pandora Software Development Kit provides functionality to aid the design and implementation of pattern-recognition algorithms. It promotes the use of a multi-algorithm approach to pattern recognition, in which individual algorithms each address a specific task in a particular topology. Many tens of algorithms then carefully build up a picture of the event and, together, provide a robust automated pattern-recognition solution. This paper describes details of the chain of over one hundred Pandora algorithms and tools used to reconstruct cosmic-ray muon and neutrino events in the MicroBooNE detector. Metrics that assess the current pattern-recognition performance are presented for simulated MicroBooNE events, using a selection of final-state event topologies.

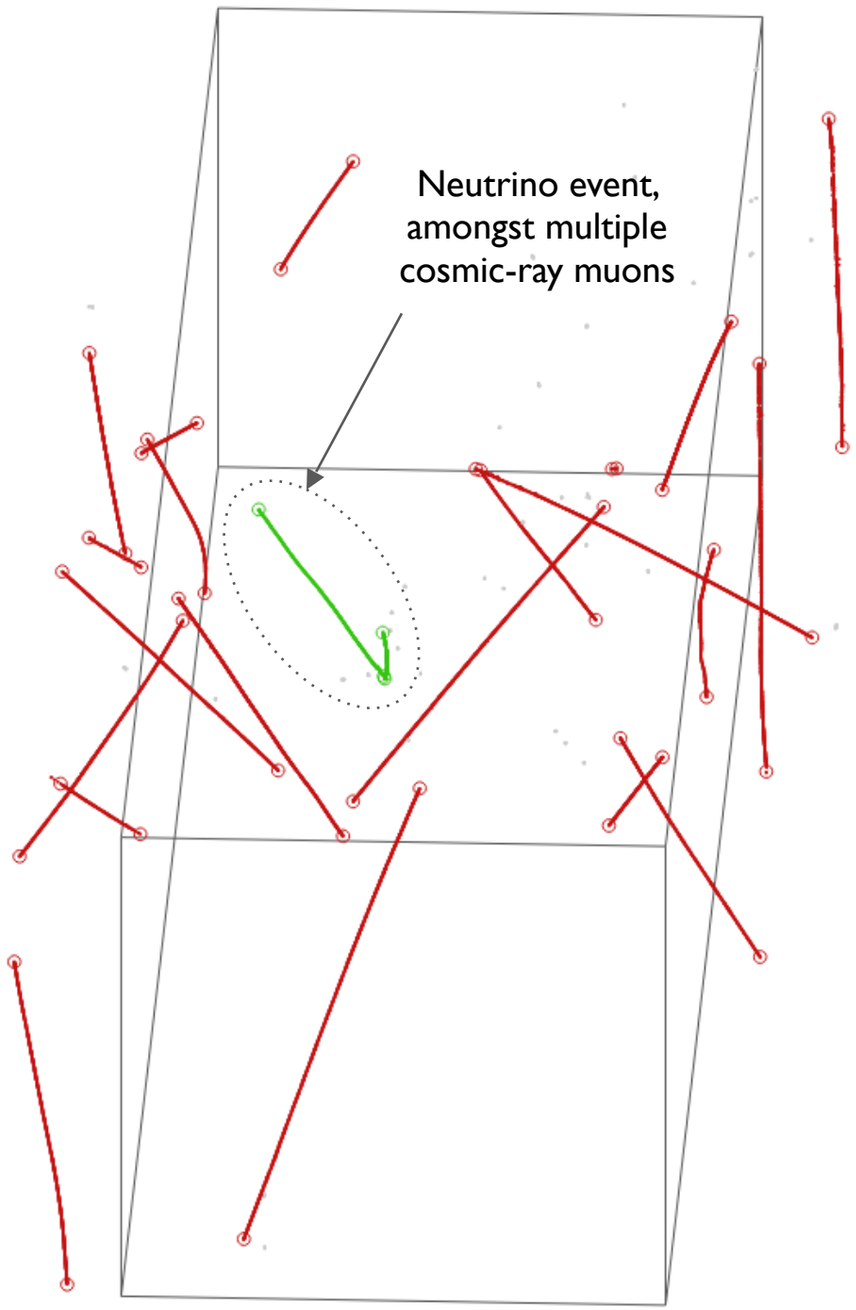
Comments: Preprint to be submitted to The European Physical Journal C
Subjects: **High Energy Physics - Experiment (hep-ex)**; Data Analysis, Statistics and Probability (physics.data-an)
Cite as: **arXiv:1708.03135 [hep-ex]**
(or **arXiv:1708.03135v1 [hep-ex]** for this version)

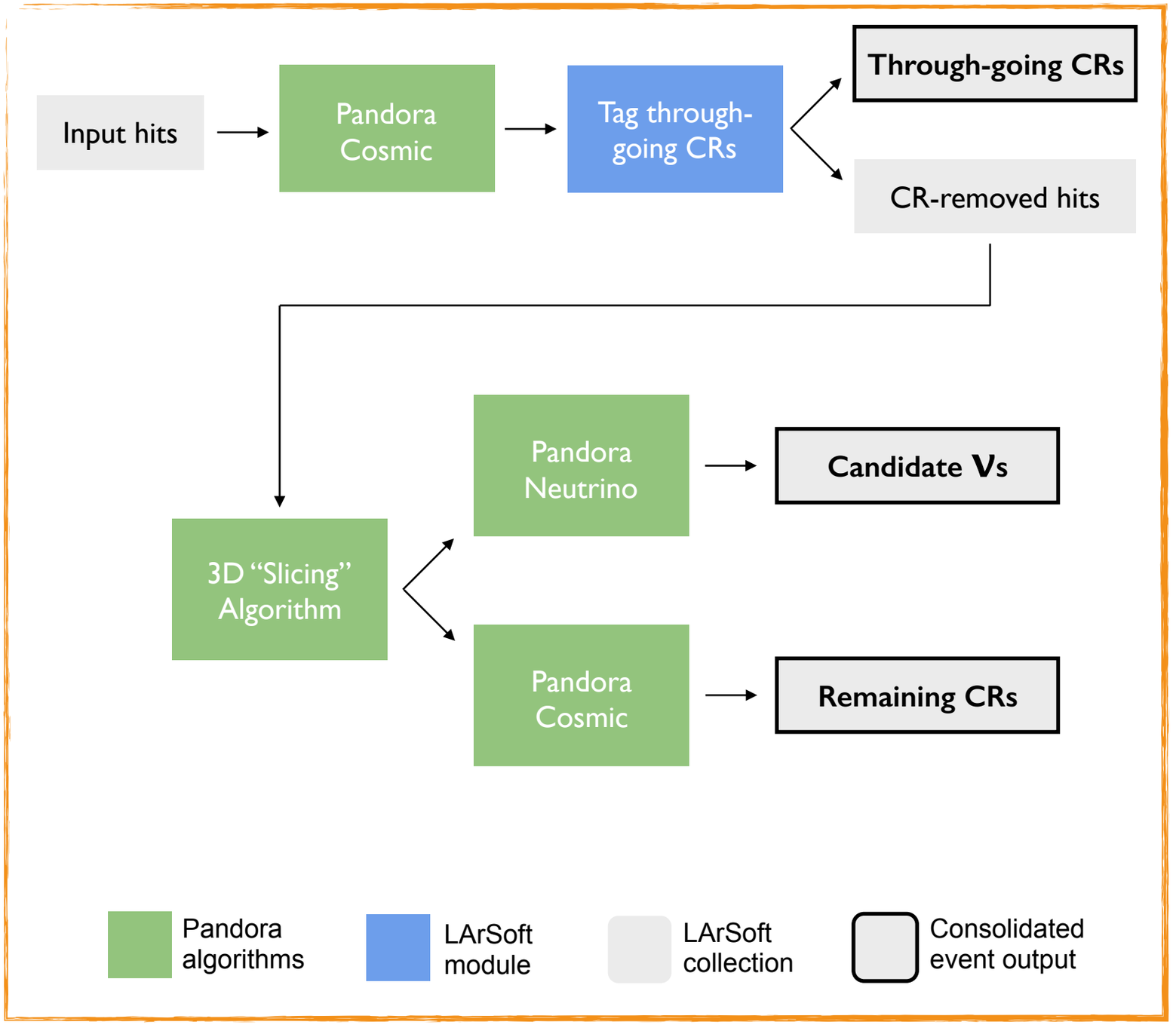
Submission history
From: John Marshall [view email]
[v1] Thu, 10 Aug 2017 09:24:21 GMT (1469kb,D)

The culmination of a lot of work! MicroBooNE pattern-recognition paper has now completed internal collaboration review, posted to arXiv and submitted to EPJC (awaiting feedback).

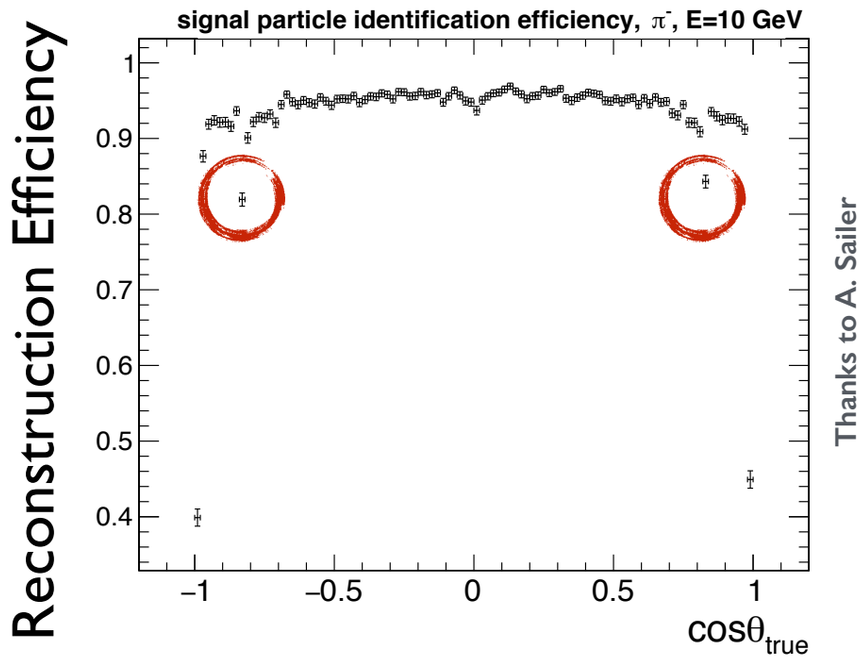
Cambridge: LArTPC

New, more sophisticated approach to reconstructing neutrinos, or test-beam particles, in the presence of significant cosmic-ray muon background:



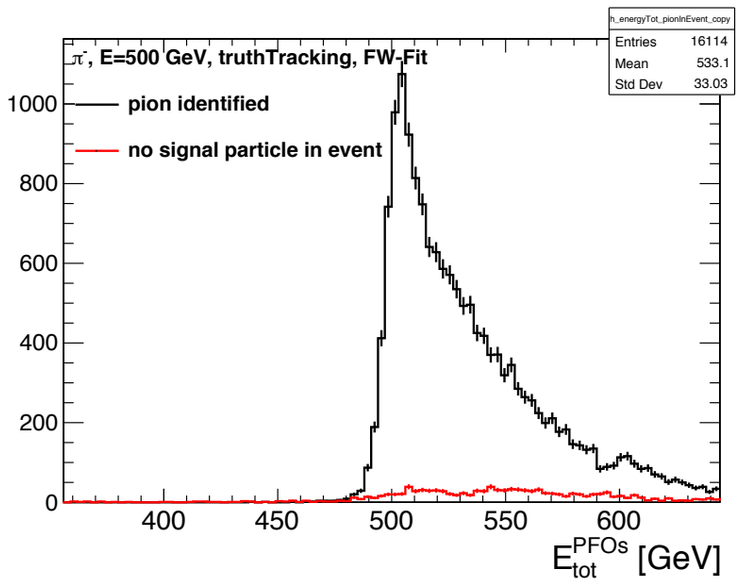


CERN, Cambridge: ILC/CLIC

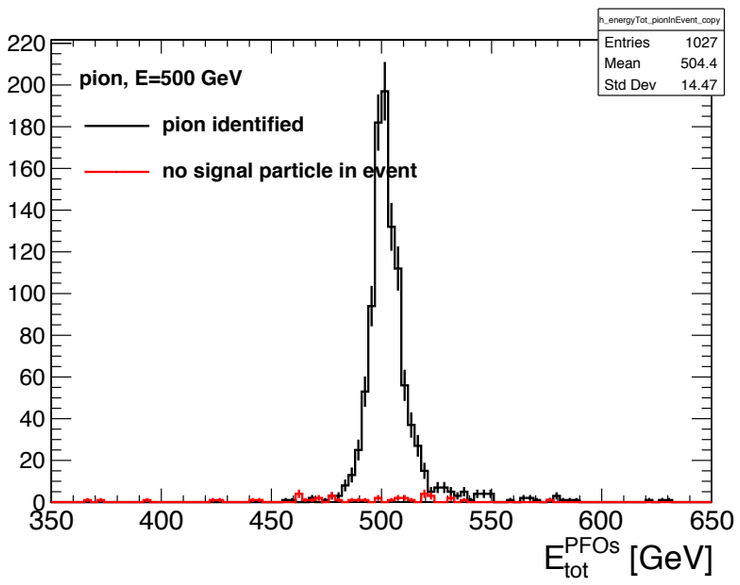


Thanks to A. Sailer

- **Reco/identification efficiency for charged pions in barrel-endcap cross over region improved:**
  - Origin: Use of barrel track state for clusters that start in barrel, but are contained largely in endcap.
  - Solution: Consider list of multiple track-states projections when matching tracks to clusters.



Low-Energy Calibration



High-Energy Calibration

Thanks to M. Weber

- **Removed high-energy tail in reco energy of high-energy $\pi^{\pm}$:**
  - Origin: energy overestimate, (calibration issue), leading to cluster splitting in reclustering.
  - Solution: Recalibration using 500 GeV neutral hadrons.