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The Pandora multi-algorithm approach to automated pattern recognition of cosmic-ray muon and test beam events in the ProtoDUNE-SP detector

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Abstract Insert your abstract here. Include keywords, PACS and mathematical subject classification numbers as needed.

Keywords First keyword · Second keyword · More

1 Introduction

Your text comes here. Separate text sections with

-Abstract and introduction, covering Pandora background, its use across LArTPC programme, ProtoDUNE and aspects of the pattern recognition problem specific to ProtoDUNE. -ProtoDUNE details. -Pattern recognition. We?d reference the MicroBooNE algorithm description, give an executive summary of PandoraCosmic and explain how PandoraTestBeam differs from PandoraNu. In the MicroBooNE paper, we used a two-pass reconstruction, but explicitly said that this would become more sophisticated soon. This then allows us to explain the consolidated reconstruction properly, making this a major communication goal of the paper. Includes stitching, more on slicing, beam particle id. -Performance assessment, using MC and metrics consistent with MicroBooNE paper to assess quality of pattern recognition, understand contributions to efficiency, etc., but then moving into real data plots. Inclusion of all of the latest and greatest plots, with (ideally!) explanation of the key features. -Concluding comments (short).

2 ProtoDUNE-SP

Text with citations [2] and [1].

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2.1 Subsection title

as required. Don't forget to give each section and subsection a unique label (see Sect. 2).

Paragraph headings Use paragraph headings as needed.

$$a^2 + b^2 = c^2 \tag{1}$$

3 Pattern Recognition

3.1 Algorithm Chains

3.1.1 Pandora Test Beam

Reference the basis as Pandora Neutrino. Highlight test beam particle creation algorithm. Add lots of pictures of both tracks and shower events.

3.1.2 Pandora Cosmic

Mention stitching here.

Reference the MicroBooNE paper.

3.2 Consolidated Reconstruction

The consolidated reconstruction is a framework designed to reconstruct test beam particles in the presence of cosmic ray backgrounds. The process utilises both the Pandora Teat Beam and Cosmic algorithm chains in order to apply the optimal pattern recognition logic to any given scenario.

The consolidated reconstruction begins by running the Pandora Cosmic algorithm chain that reconstructs all particles under the cosmic ray particle hypothesis. The reconstructed particles are then examined in order to determine if they are clear cosmic rays. Two distinct methods are used for identifying clear cosmic rays:

- If the hits for the reconstructed particle fall outside the expected read out time window for the target test beam particle.
- If it the reconstructed particle enters the detector through the top face and exists the lower face.

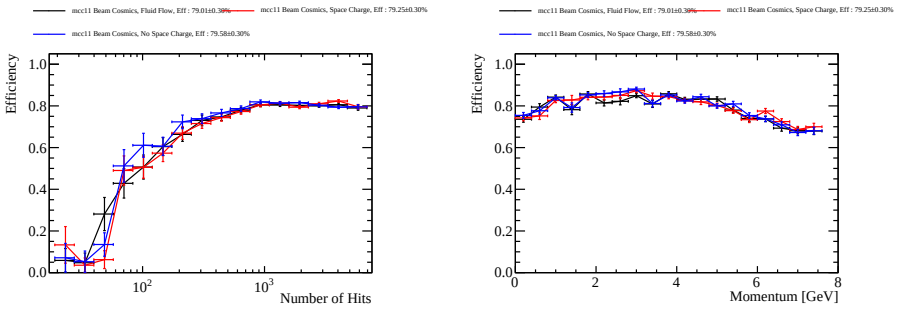

Fig. 1 Please write your figure caption here

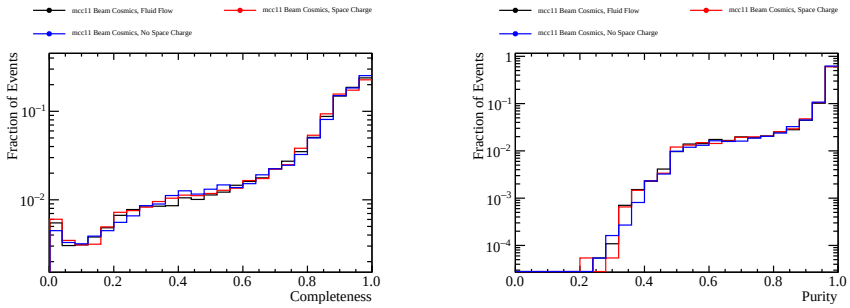

Fig. 2 Please write your figure caption here

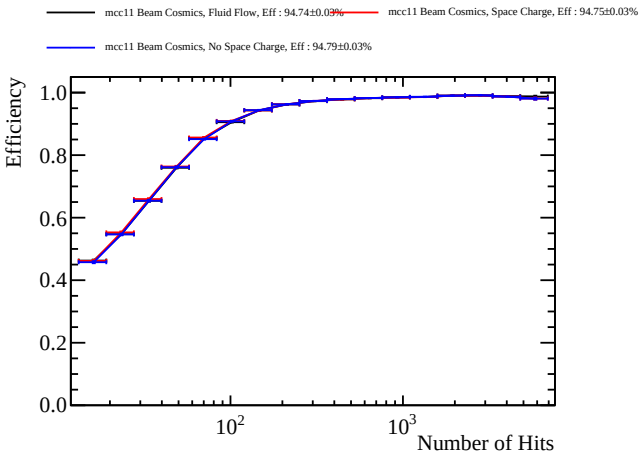

Fig. 3 Please write your figure caption here

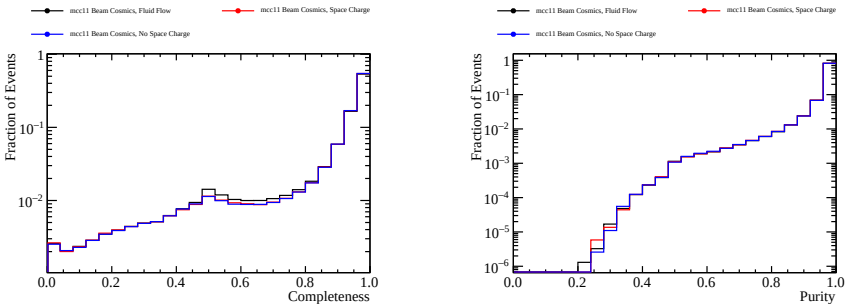

Fig. 4 Please write your figure caption here

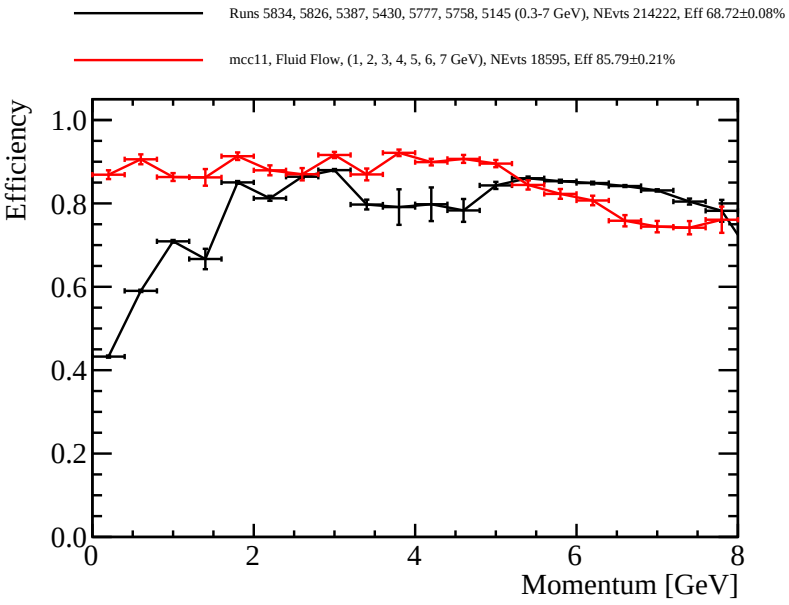

Fig. 5 Please write your figure caption here

4 Assessment of Pattern Recognition

4.1 Monte-Carlo

4.1.1 Test Beam Metrics

4.1.2 Cosmic Ray Metrics

4.2 Data

4.2.1 Test Beam Metrics

4.2.2 Cosmic Ray Metrics

5 Conclusions

References

1. Author, Article title, Journal, Volume, page numbers (year)

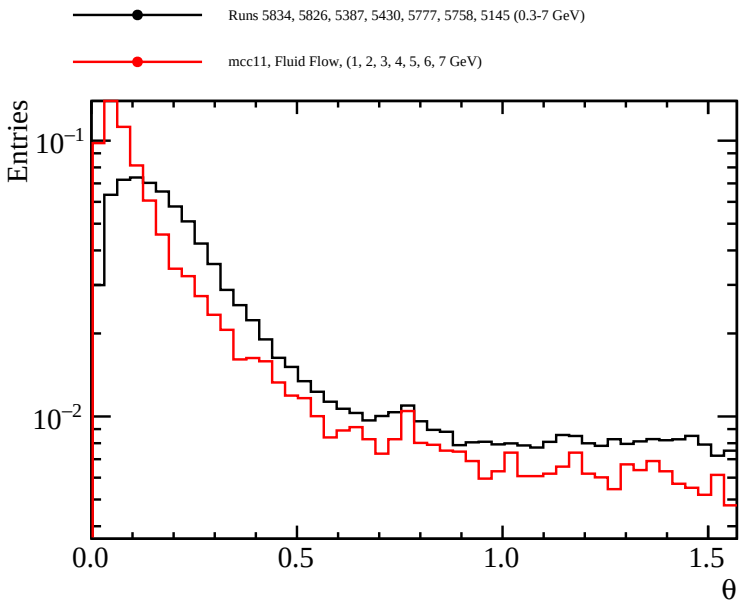

Fig. 6 Please write your figure caption here

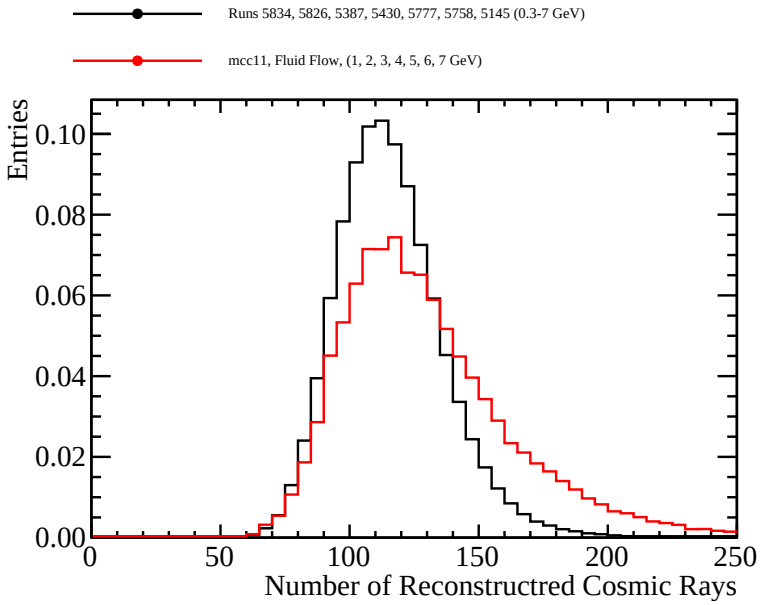

Fig. 7 Please write your figure caption here

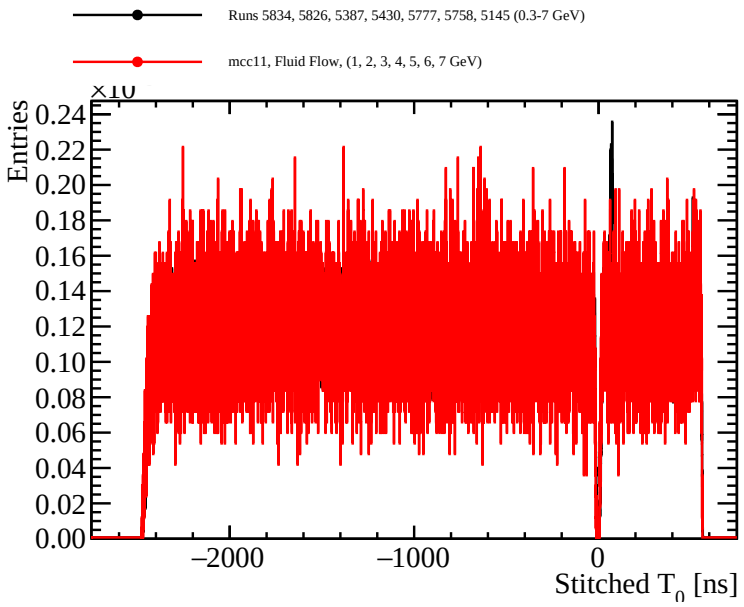

Fig. 8 Please write your figure caption here

Table 1 Please write your table caption here

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number	number	number
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2. Author, Book title, page numbers. Publisher, place (year)