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MVTX occupancy in pp collisions

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Abstract

This note details the first look at occupancy in the MVTX using magnet-off p+p collisions.

1 Introduction

The MVTX collected data over several runs while the magnet was turned off in early 2024. This data was used to analyse the occupancy of the detector, where occupancy is defined as the number of pixels that are active in an event over the total number of pixels.

There are two occupancy's discussed in this note. The first is the chip occupancy where the pixels are given by the product of the number of rows (512) and the number of columns (1024) in a chip. The second is the layer occupancy which is given from the product of pixels in a chip, the number of chips in a stave (9) and the number of staves in a layer (12, 16 and 20 for layers 0, 1 and 2 respectively).

The definition of an event is the information stored inside one MVTX strobe. An MVTX strobe is a readout period that can be tuned by a detector expert to a specific time, and a pixel is defined as hit if its internal digital circuit is high during the period in which is a strobe is active. The strobe length used for both plots was 89 µs. With a collision frequency of approximately 50 kHz this means there are four to five $p+p$ collisions per event.

All plots are produced from the same run for this study. The run number is 40711 and was taken on the 28^{th} of April, 2024 between 12:05 and 12:09. The magnet was turned off, and $p+p$ collisions were occurring.

2 Occupancy per layer

The occupancy for each layer was obtained from direct analysis of the raw event files and separated by layer to demonstrate any potential radial effect of the occupancy. There are a few contributions to the occupancy in addition to the hits from the collision. There is a geometric effect to the occupancy as the MVTX layers are all the same length in the z-direction (along the beam line) and will cover a different pseudorapidity range for each collision. There are also additional effects to the occupancy arising from noisy pixels that are unmasked although this is a small effect, approximately 1500 noisy pixels occur summed over all three layers but these pixels can be masked from the data recording. A final effect that could impact the occupancy arises from beam backgrounds, which travel parallel to the beam axis but at a radius equivalent to an MVTX layer radius. This results in a large number of pixels being fired. The occupancy for chips in different layers obtained for this run can be seen in Figure 1. The average values in the legend denote the average chip occupancy for a chip belonging to a specific layer.

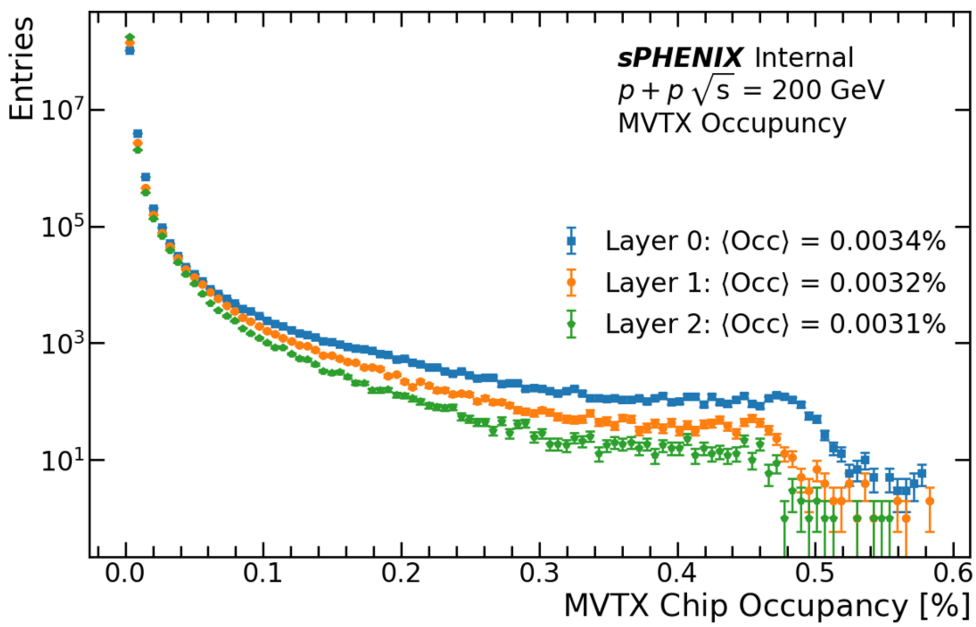

Figure 1: Occupancy recorded chips belonging to each layer of the MVTX over a single run.

3 Unrolled hit maps

To investigate possible beam background effects. It is possible to unroll the hit maps for each layer over a period of time. Background effects will appear as a long collection of fired pixels travelling in the z-direction, the beam axis. This was achieved by decoding and unpacking the raw hits, then applying the ideal Geant geometry to obtain the global 3D position of the fired pixels. The global pixel positions were then plotted in the ϕ-z plane. The unrolled distribution for run 40711, integrated over 890 ms can be seen in Figure 2. The hits are read out on a per-chip basis and only chips that had more than 250 fired pixels per event are shown here. There are readily apparent streaks in the data.

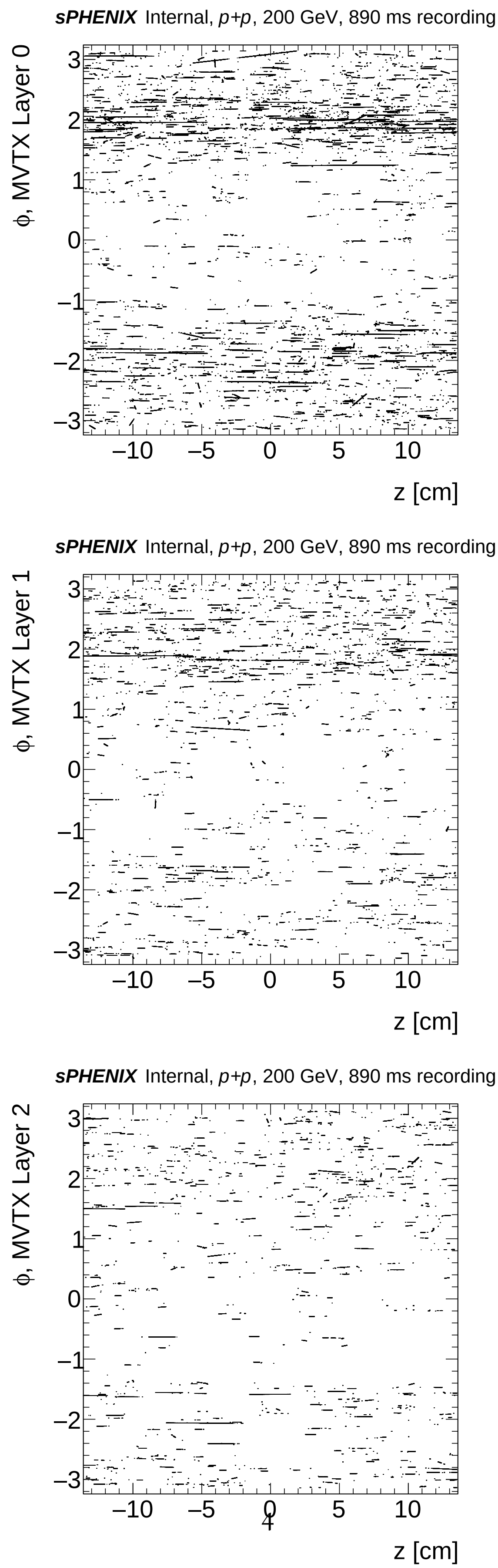

Figure 2: Unrolled hit map from layer 0 (top), layer 1 (middle) and layer 2 (bottom) of the MVTX, recorded over 890 ms of $p+p$ collisions.