The LHCb Verification Framework for the MightyPix

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19/05/2022
The Mighty Tracker at LHCb

- Proposed hybrid tracker composed of...
- **Scintillating Fibre Tracker (SciFi)**
  - Scintillating fibres with SiPM readout
  - Installed in LS2, replacements in LS3
- **Inner Tracker (IT) and Middle Tracker (MT)**
  - Installation planned for LS3 and LS4
  - Silicon sensors meet requirements of radiation hardness and granularity
    $\Rightarrow$ HV-CMOS pixel chip **MightyPix**
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  - HV-CMOS pixel chip **MightyPix**

→ Part of next big upgrade to LHCb!
The MightyPix

- HV-CMOS pixel chip for the Mighty Tracker
- Current prototype **MightyPix1** submitted this month
  - ¼ size of final MightyPix → full column length, reduced width
  - Chip size: ~2 cm × 0.5 cm
  - Pixel size: 165 µm × 55 µm
  - 29 columns, 320 rows
- First prototype compatible with LHCb readout system
The Verification Framework for MightyPix

• Chip designers test general features, but new to LHCb
• Verification Framework to test MightyPix within LHCb environment

• Current focus: Test MightyPix with LHCb simulation data
Simulation Data Studies: Overview

- Check MightyPix can handle hit rate
- Expected rate:
  - 1.7 hits per event and 2 cm × 2 cm chip in hottest region of Mighty Tracker
  - Add additional 5% of clusters with two pixels
- Simulation data:
  - Old SciFi geometry
  - University of Zürich LHCb Group
Simulation Data Studies: Method

Data transformation:
- Set chip/pixel size
- Set hit rate
- Omit secondaries?
- Additional cluster hits?
- Transform to pixel coordinates

Model of pixel matrix

Data comparison:
- Results file
- Various plots

* Developed by Nicolas Striebig at KIT
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Analysis results:
- Simulated hits: 1000
- Measured hits: Few
- Wrong time stamp: Loads
- Missing hits: Too many

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Analysis results:
- Simulated hits: 1000
- Measured hits: Most
- Wrong time stamp: None
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Simulation Data Studies: Results

<table>
<thead>
<tr>
<th>Readout Speed</th>
<th>40 MHz</th>
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<tbody>
<tr>
<td>Clusters</td>
<td>No</td>
</tr>
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*Single hit rate: 1.7 hits per event and 2 cm × 2 cm chip → what we expect*
*Double hit rate: 3.4 hits per event and 2 cm × 2 cm chip → twice what we expect*
Simulation Data Studies: Results

What about clusters? → Two neighbouring pixels hit at same time

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Missing hits fall into dead time of previous hit → Let’s up the readout speed

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<td>2322 (100%)</td>
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<td>105 (4.52%)</td>
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My further Plans

• **Verification framework** is ongoing project for all future MightyPix prototypes
  → Structure set up, first tests done

• **Test beam analysis**
  → test beam at DESY in June to study related chip ATLASpix3 as preparation for MightyPix
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<th>Simulation Data Studies</th>
<th>Outlook</th>
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Backup
Missing Hits in the Pixel Matrix

- Each pixel has one hit buffer
- Columns scanned left to right and hit info loaded to EoC for each hit buffer
- If readout takes too long and next hit already occurs before readout it will be missed