The LHCb Verification Framework for the MightyPix

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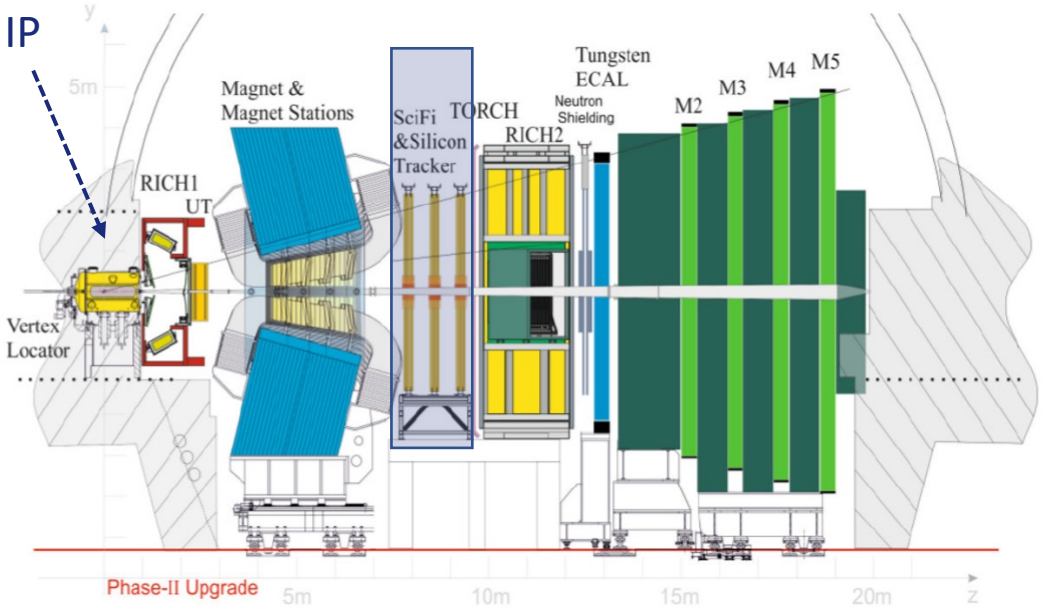
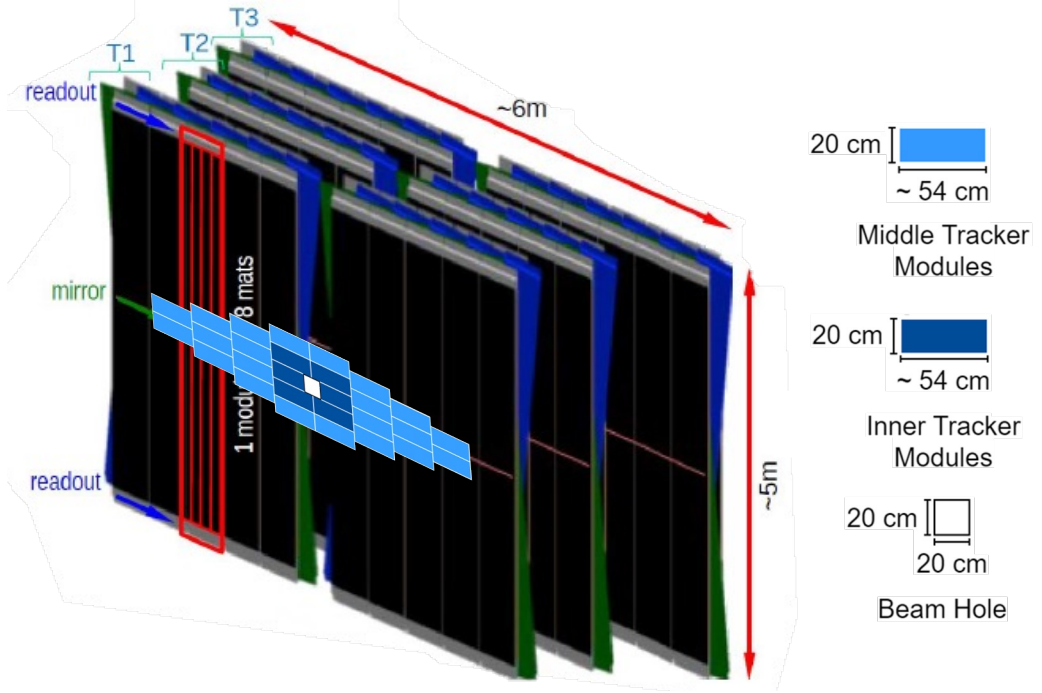
The Mighty Tracker at LHCb

- 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
    → HV-CMOS pixel chip **MightyPix**

T. Ackernley et al. CERN-LHCb-INT-2019-007.

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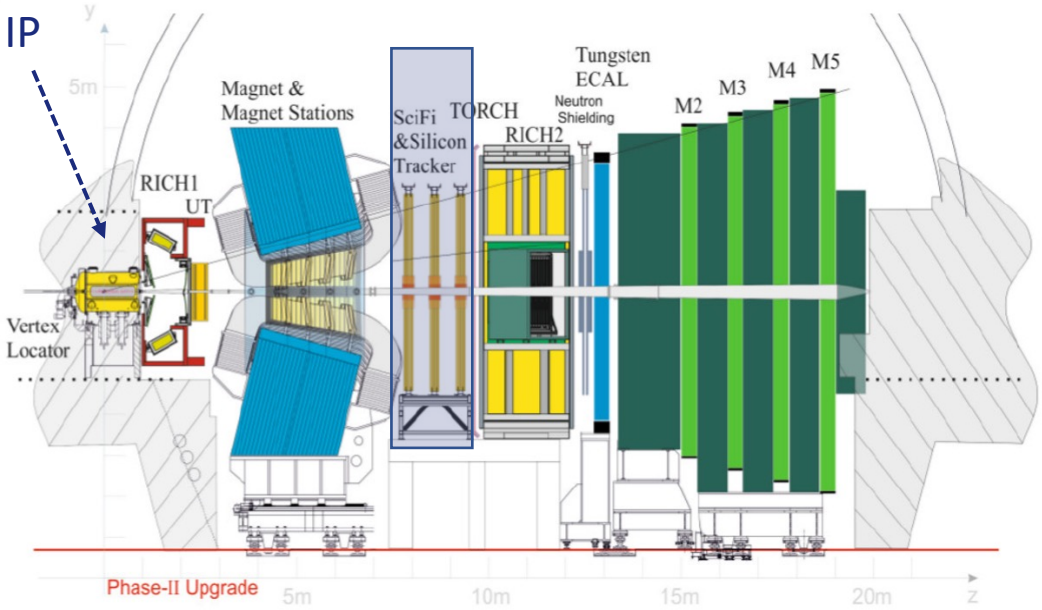
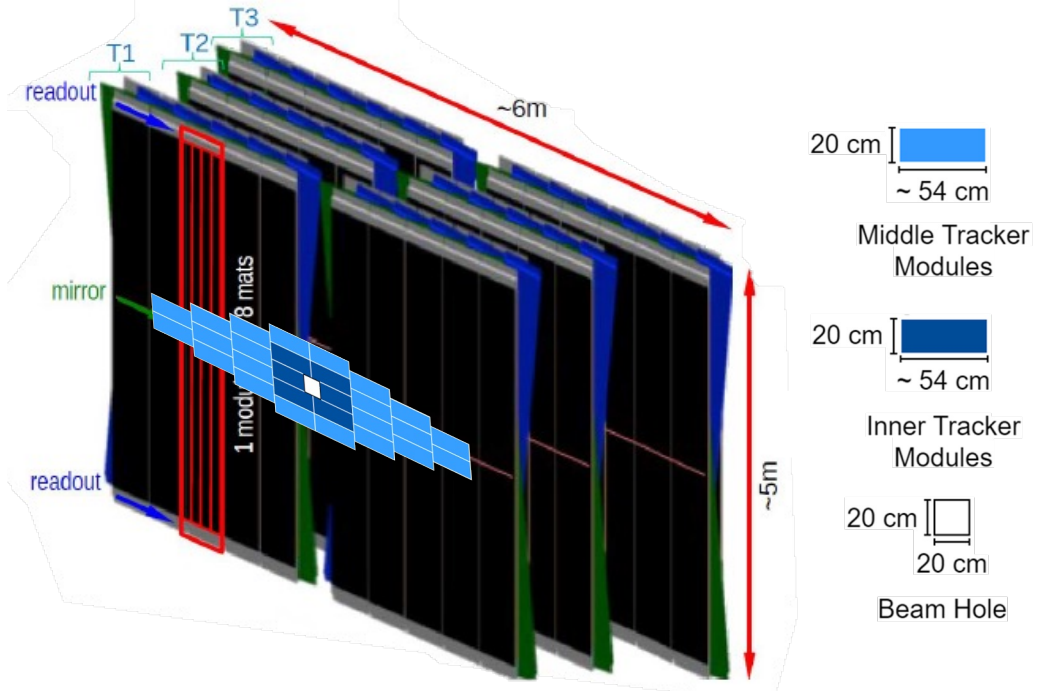


→ **Part of next big upgrade to LHCb!**



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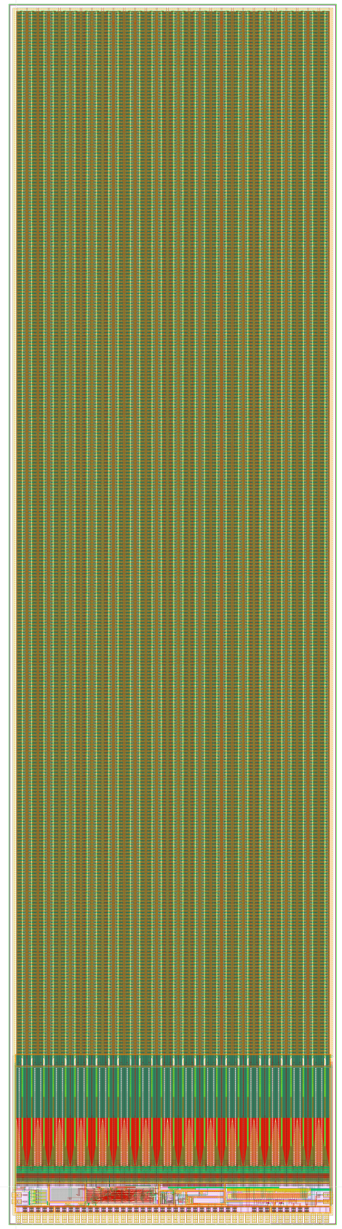
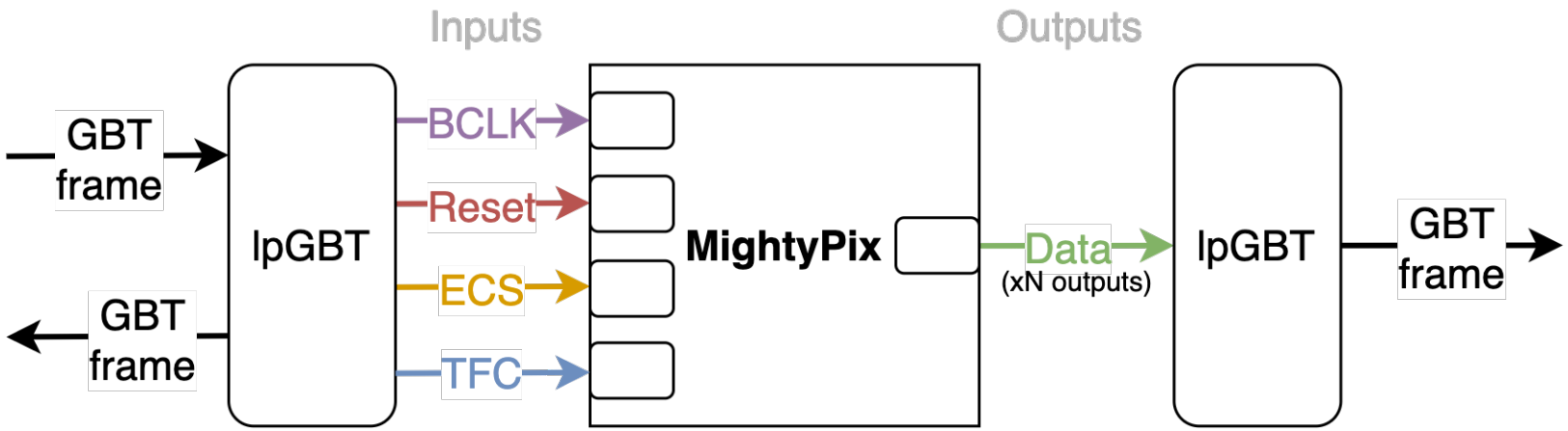
The MightyPix

- 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

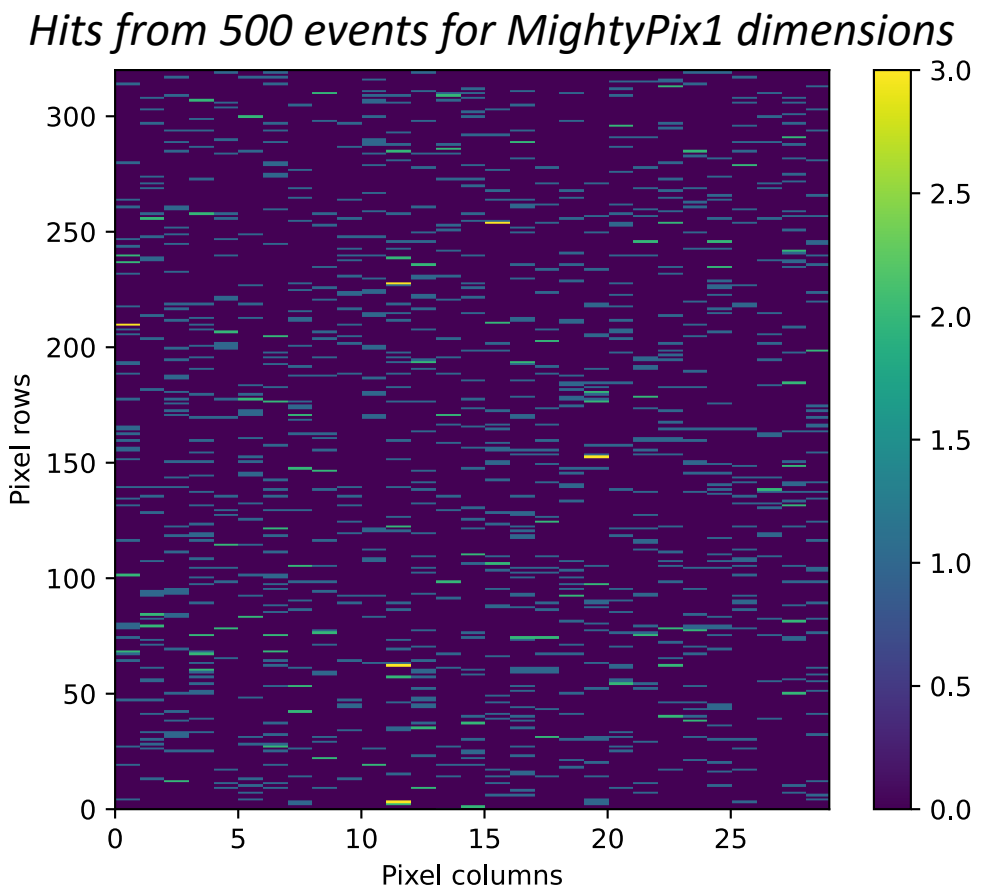
- Chip designers test general features, but new to LHCb
- Verification Framework to test **MightyPix within LHCb environment**



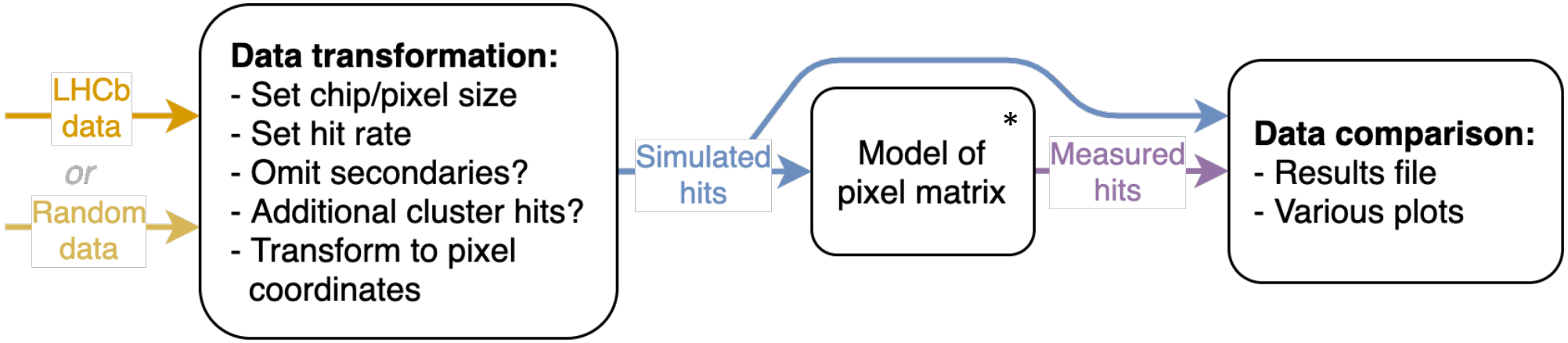
- Current focus: Test MightyPix with LHCb simulation data

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



* Developed by Nicolas Striebig at KIT

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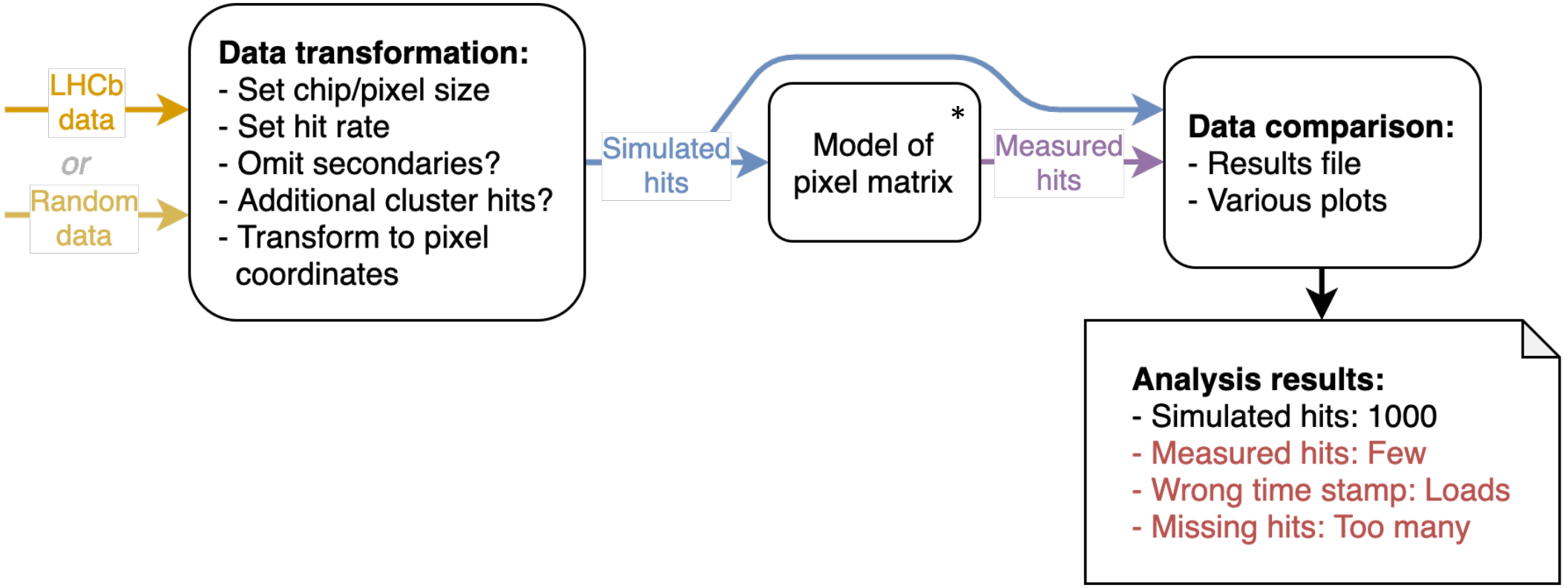

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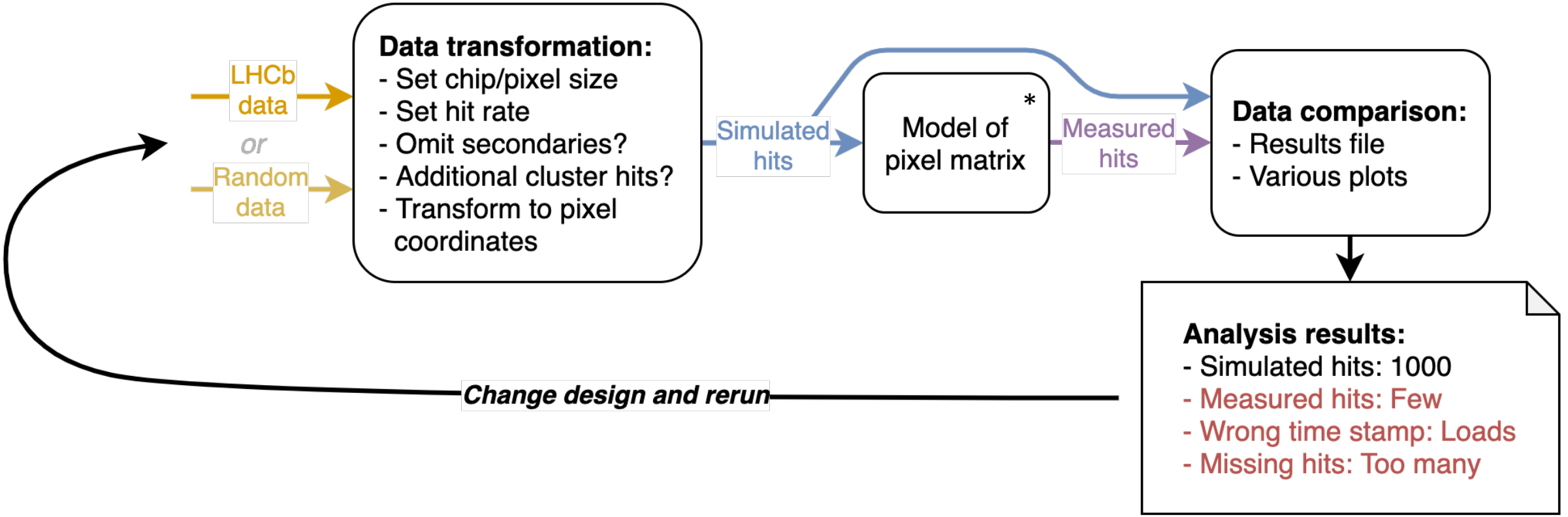

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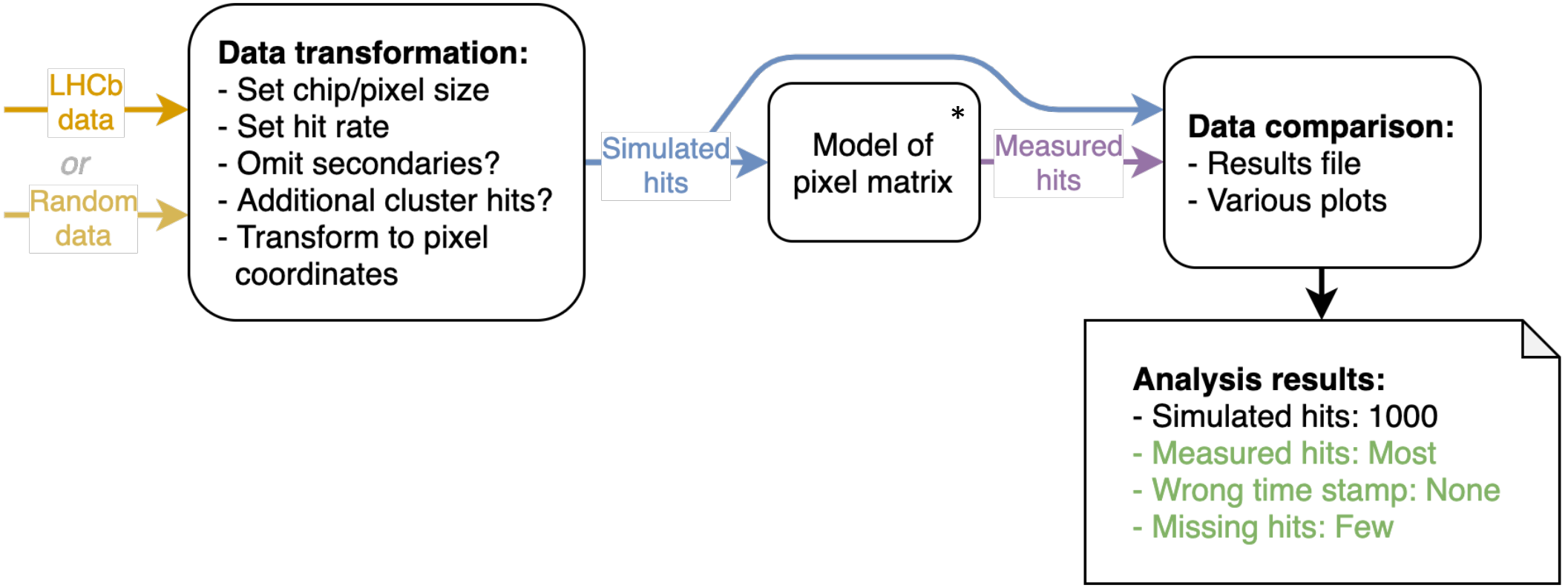

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Simulation Data Studies: Results

Readout Speed	40 MHz	
Clusters	*No*	*No*
Hit Rate	*Single*	*Double*
Simulated Hits	1166 (100%)	2322 (100%)
Missing Hits	9 (0.77%)	105 (4.52%)

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

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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

Readout Speed	40 MHz				160 MHz	
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Hit Rate	*Single*	*Double*	*Single*	*Double*	*Single*	*Double*
Simulated Hits	1166 (100%)	2322 (100%)	1223 (100%)	2437 (100%)	1166 (100%)	2322 (100%)
Missing Hits	9 (0.77%)	105 (4.52%)	9 (0.74%)	122 (5.01%)	7 (0.60%)	16 (0.69%)

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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

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