Mighty Tracker

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Performance Studies of the MightyPix for LHCb

13th International "Hiroshima" Symposium on the Development & Application of Semiconductor Tracking Detectors

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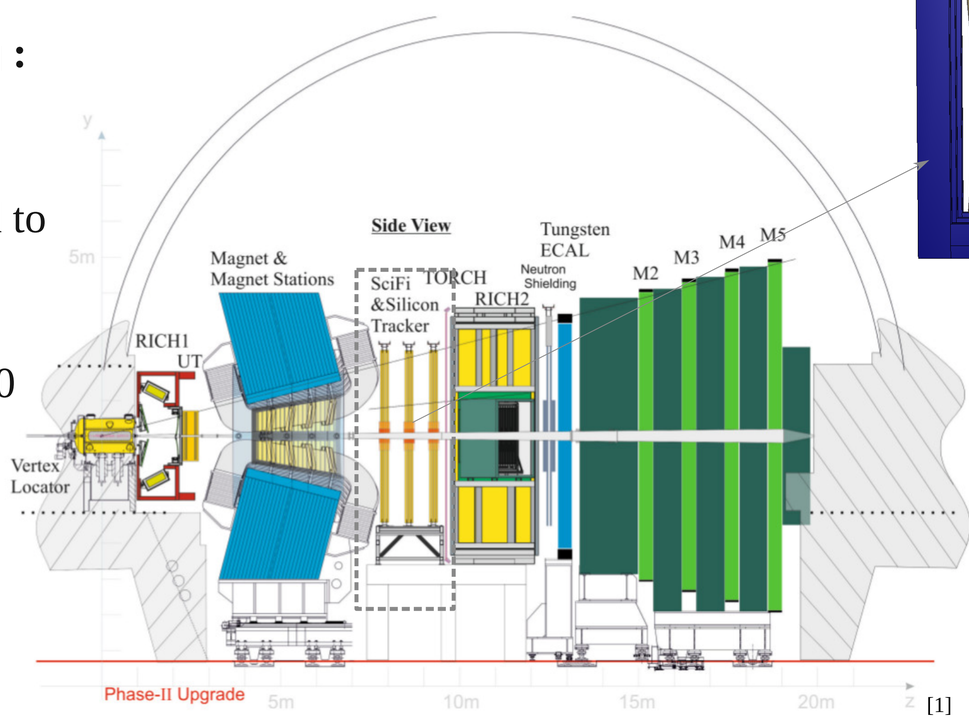
LHCb Upgrade Ⅱ Detector

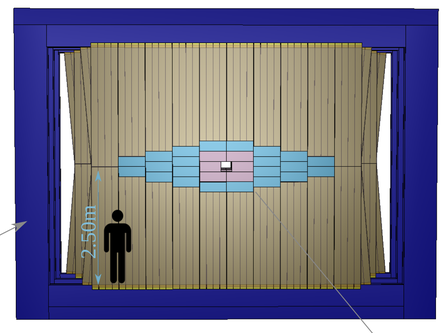
Planned Upgrade Ⅱ specifications [1] **:**

- 40 MHz triggerless DAQ
- $L_{inst} = 1.5 \cdot 10^{34}\ cm^{-2}s^{-1}$
- 6x higher occupancy/fibre compared to Upgrade 1 for SciFi only
- $6 \cdot 10^{14}$ MeV n_{eq}/cm^2 after Run 6
- Interactions/bunch crossing $<\mu> = 40$

→ Upgrade during LS4 to ensure efficient tracking & particle identification

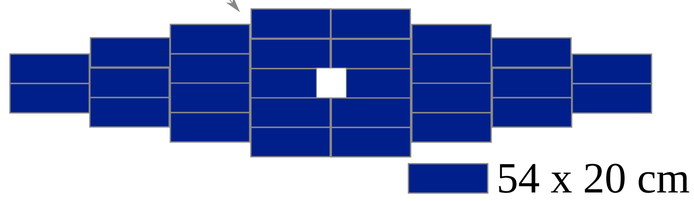


[1]



- 6 layers silicon in total
- 28 submodules/layer
- 35 pixel/submodule
- 18 m^2 pixel area

[1]

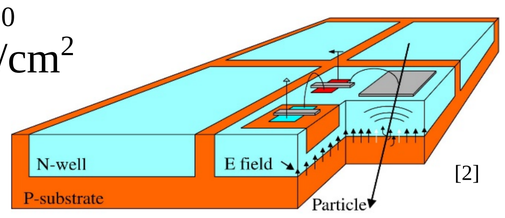


- Pixel size of 55 x 165 μm^2
- 29 columns x 320 rows
- CMOS amplifier & comparator
- V1 chip size: 5 x 20 mm

MightyPix Specifications [1][2][3]

- Power consumption < 150 mW/cm^2
- Low material budget < 1 % of X_0
- Radiation hard: $6 \cdot 10^{14}$ MeV neq/cm^2
- Time resolution < 3 ns
- Hit rate: 17 MHz/cm^{-2}

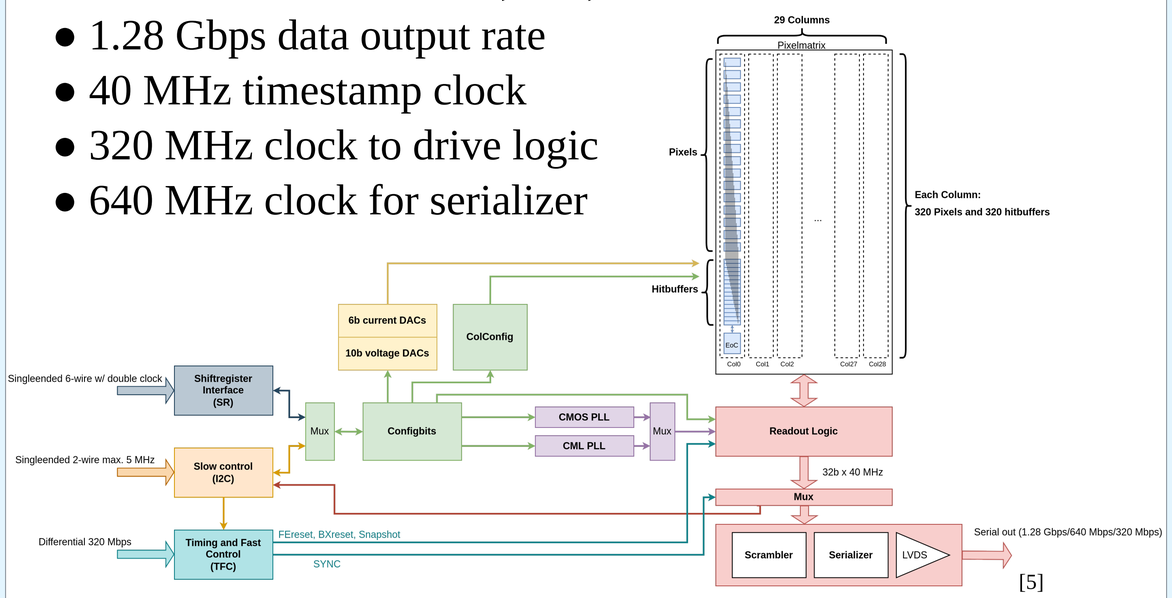
→ **HV-CMOS MAPS**



[2]

MightyPix Design [1][2][3][5]

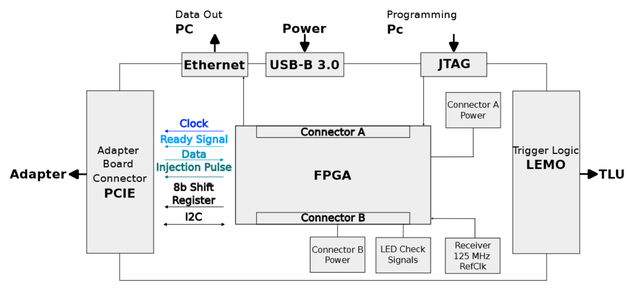
- Commercial 180 nm production
- Control interfaces: TFC, I2C, SR
- 1.28 Gbps data output rate
- 40 MHz timestamp clock
- 320 MHz clock to drive logic
- 640 MHz clock for serializer

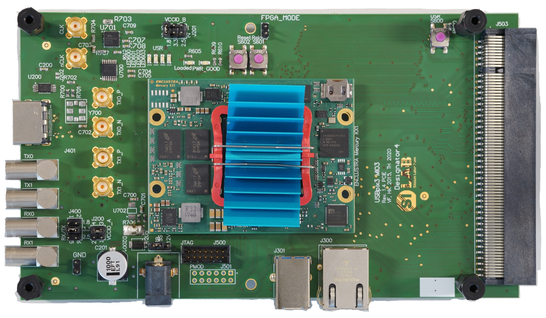


[5]

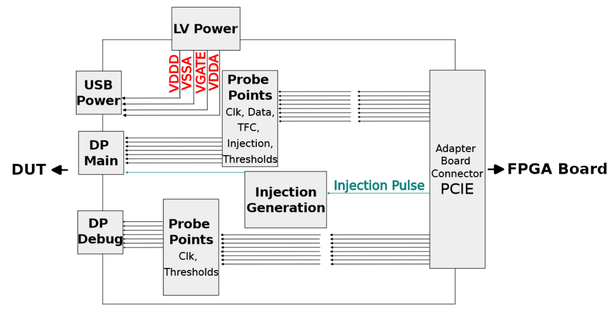
MightyPix Readout - MARS

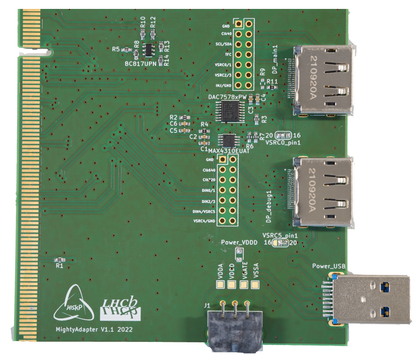
FPGA Board



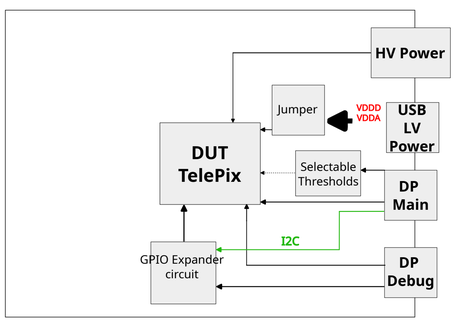


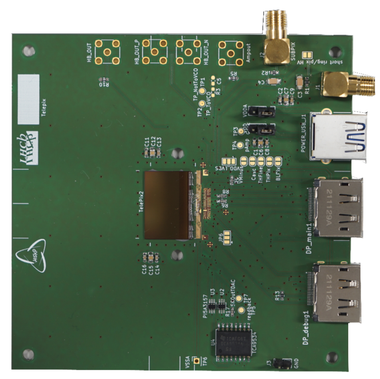
Adapter Board

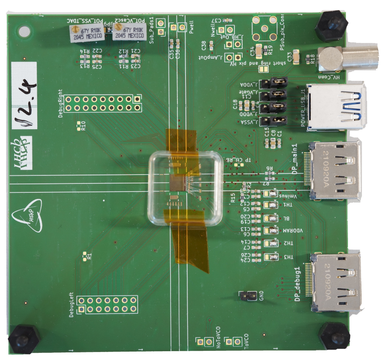




DUT Board



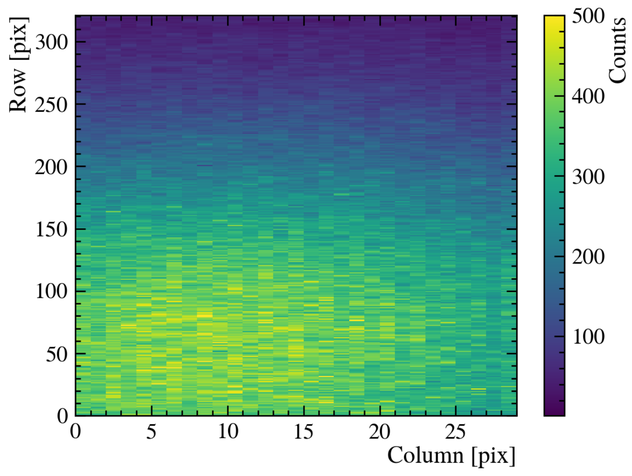




MightyPix - First Performance Studies [7]

- Simulation confirmed hit rate [8]
- Lab tests started 2023
- Functionality tests:
  - CMOS PLL
  - Slow control
  - TFC interface
  - SR interface
- Breakdown ~ 200V
- Time resolution studies started

Sr90 measurement [7]



MARS - Specifications

- Modular & flexible hardware design
- Usable at testbeam facilities
- Adapter to use Chip carrier boards from other readout systems
- Multiple DUTBoards: Run2020, Run2021, TelePixV2, MightyPixV1
- High readout speed possible: 1.6 GBps
- Firmware: Modular design with switchable receiver (fast/slow)
- Slow control: Python interface with common functions for all DUTs
- DUT specification defined in configuration file
- Functionality validated for Run202x and TelePix sensors
- Characterization of TelePix ongoing

[1] *Framework TDR for the LHCb Upgrade II - Opportunities in flavour physics, and beyond, in the HL-LHC era*, LHCb Collaboration, CERN-LHCC-2021-012, LHCB-TDR-023
[2] *A novel monolithic pixelated particle detector implemented in high-voltage CMOS technology*, I. Peric, NIM A 2
[3] *TSI engineering run HVMAPS*, I. Peric, https://adl.ipe.kit.edu/downloads/TSI engineering run v2.pdf
[4] https://github.com/SiLab-Bonn/basil, 06.09.2022
[5] MightyPix Documentation, N. Striebig & T. Frei, 21.11.2023
[6] https://gitlab.cern.ch/mightypix/MightyPixdaq, 21.11.2023
[7] L. Dittmann, Heidelberg University, Internal Communication 22.11.2023
[8] MightyPix at the LHCb Mighty Tracker, S.Scherl, TWEPP 2023