Testbeam, Flex Tapes and Serial Powering

*William Barter, **Emma Buchanan**, Abhishek Bohare, Stephan Eisenhardt, Yanyan Gao, Pratik Gheewalla, Matthew Needham, Ryunosuke O'Neil, Fuat Üstüner, Gediminas Sarpis, Mary Slipper*
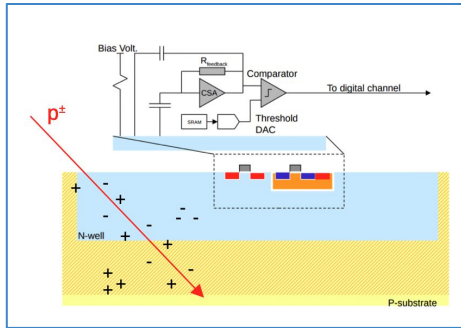
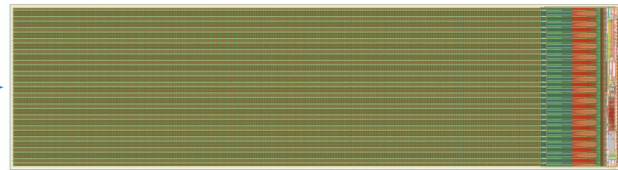*LHCb UK Upgrade II Meeting - 10/07/2024*

The MightyPix

- Efficiency: 99.9 %

- Time resolution < 3 ns

- Radiation tolerance: 40 MRAD (TID) & $3x10^{14}$ 1 MeV n_{eq} cm^{-2}

- Power consumption: < 150 W/cm^2

- Hit rate ~ 70kHz/mm^2

Tested in the lab or at testbeam

*pixel schematic*

MightyPix1 Prototype

Lab Tests

- Liverpool, RAL, Cambridge and Edinburgh are performing lab based tests

  - Liverpool and Edinburgh using GECCO

  - RAL and Cambridge using MARS

- The GECCO setup developed for the ATLASpix project

  - Easy to use to test MightyPix in the lab

  - Will be used for serial powering testing and development

- MARS system developed by the Bonn group

  - A little more user friendly

  - Will hopefully be used at future testbeams

  - Edinburgh and Liverpool will have MARS setups in the future

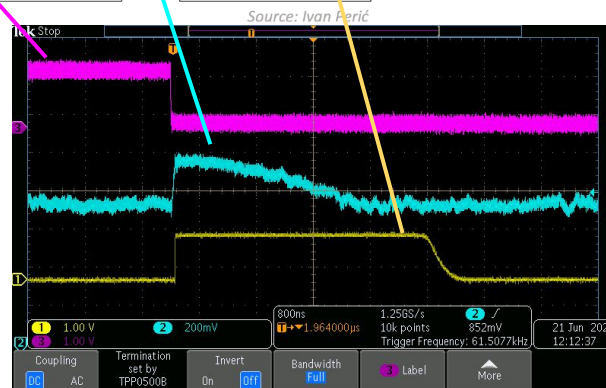- Lab tests include: IV, injection scans and source scans etc

MightyPix1

GECCO

FPGA
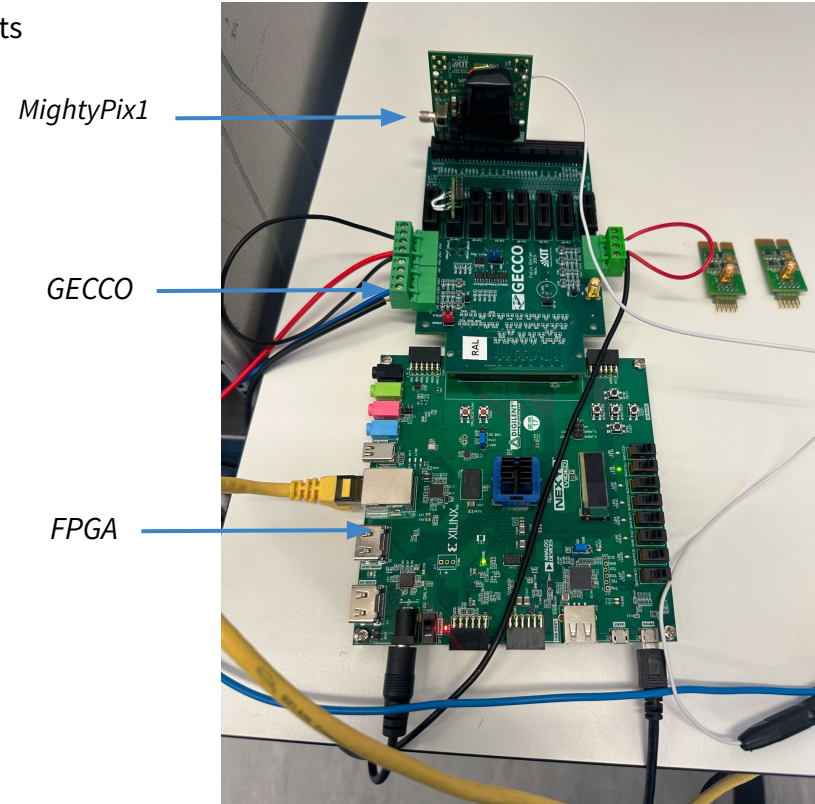
MightyPix1 and GECCO setup at Edinburgh
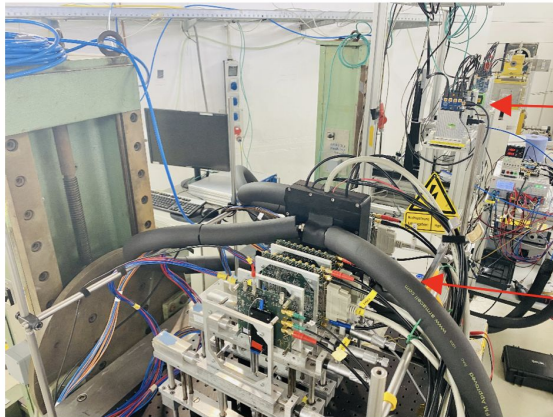
Lab Tests
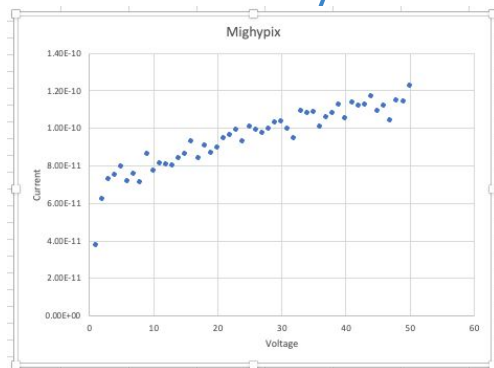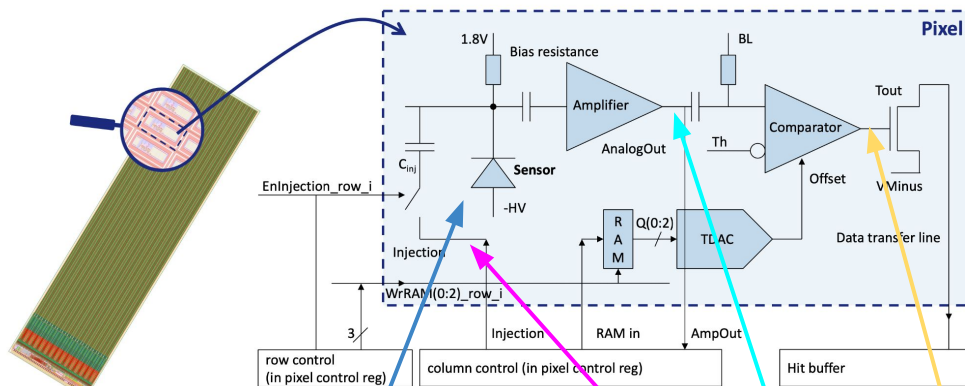
Source: Ivan Perić

IV

Injection charge

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Emma Buchanan

Testbeam at DESY

- TelePix, a similar chip (amp) to MightyPix, was tested at DESY in March and May

  - Problems with MightyPix1 means we only have a few FIB'd and they are difficult to configure.

- During March two different telescopes were used:

MARS +
Adenium telescope

MUDAQ
telescope

- Debugging was done with the MARS system to get it working with the ADENIUM Telescope

- The cooling was not sufficient enough to perform tests with irradiated TelePix using the MUDAQ telescope
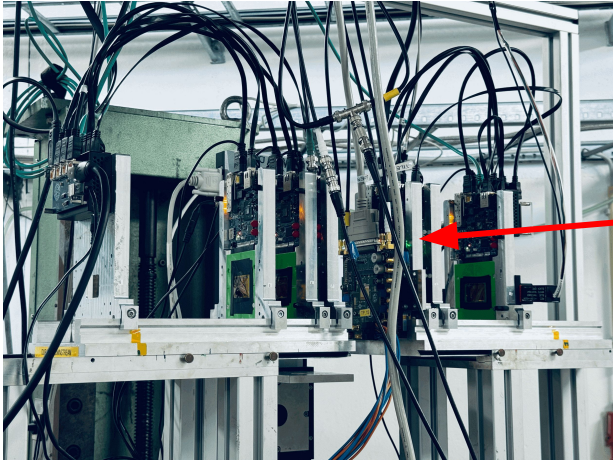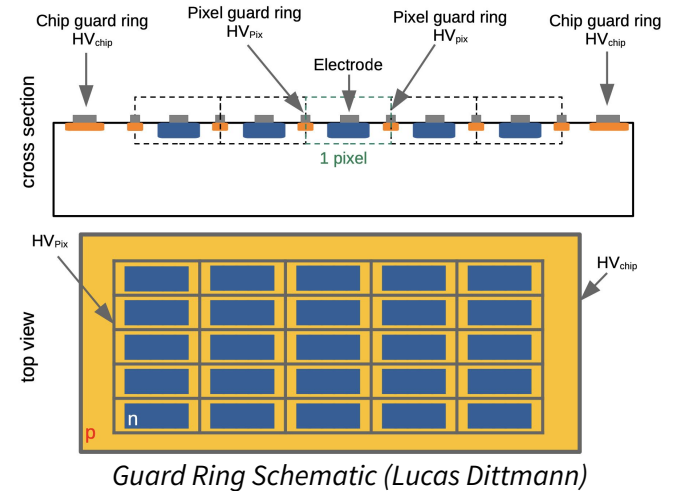

DESY Testbeam March Week 1

Testbeams were attended by Atanu and Lucas from RAL, Tian-Qi from Cambridge, Ayushi from Liverpool and Mary, Abhishek and Emma from Edinburgh

Testbeam at DESY

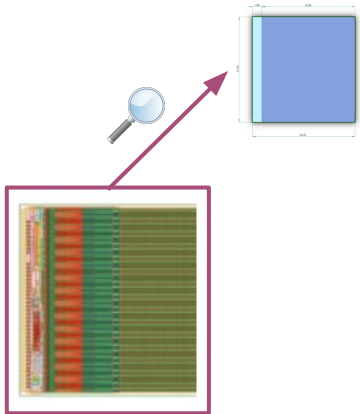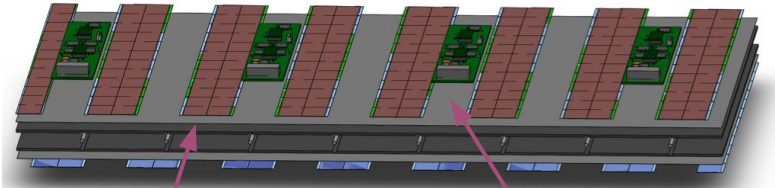- During May only one telescope was used:

MUDAQ + Adenium
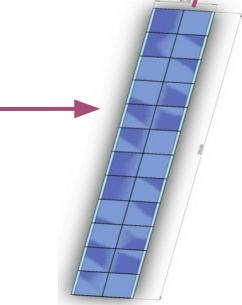

Guard Ring Schematic (Lucas Dittmann)

- An un-irradiated TelePix was installed to test the different bias options: chip bias vs pixel bias

- Analysis still ongoing but some results have already been presented at mightypix workshops/meetings

  - https://indico.cern.ch/event/1402868/contributions/5923703/attachments/2844991/4974080/20240425_Telepix2TB.pdf

  - https://indico.cern.ch/event/1403159/contributions/6017687/attachments/2889261/5064619/Dittmann_Schmitz_TelePix.pdf

Mighty Tracker Module

Array of 24 chips made up of
2x12 flex assemblies
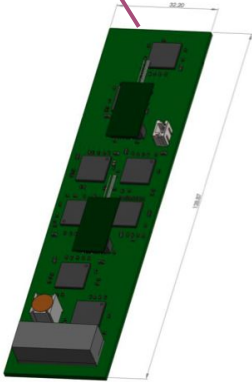
HIgh Density Interconnect (HDI) PCB

HDI - facilitates power, slow control and signal

*MightyPix Readout is at the
bottom of the chip*

Alex Bitadze: https://indico.cern.ch/event/1426621/contributions/6000441/attachments/2876396/5037438/LHCb_MT_Mechanics_and_Modules_2024-06-13.pdf

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Mighty Tracker Flex Tape

Flex Tape attached to the top of the chips

High Density Interconnect (HDI) PCB

Connection Cable

Wire bonds connect the MightyPix to the flex tape
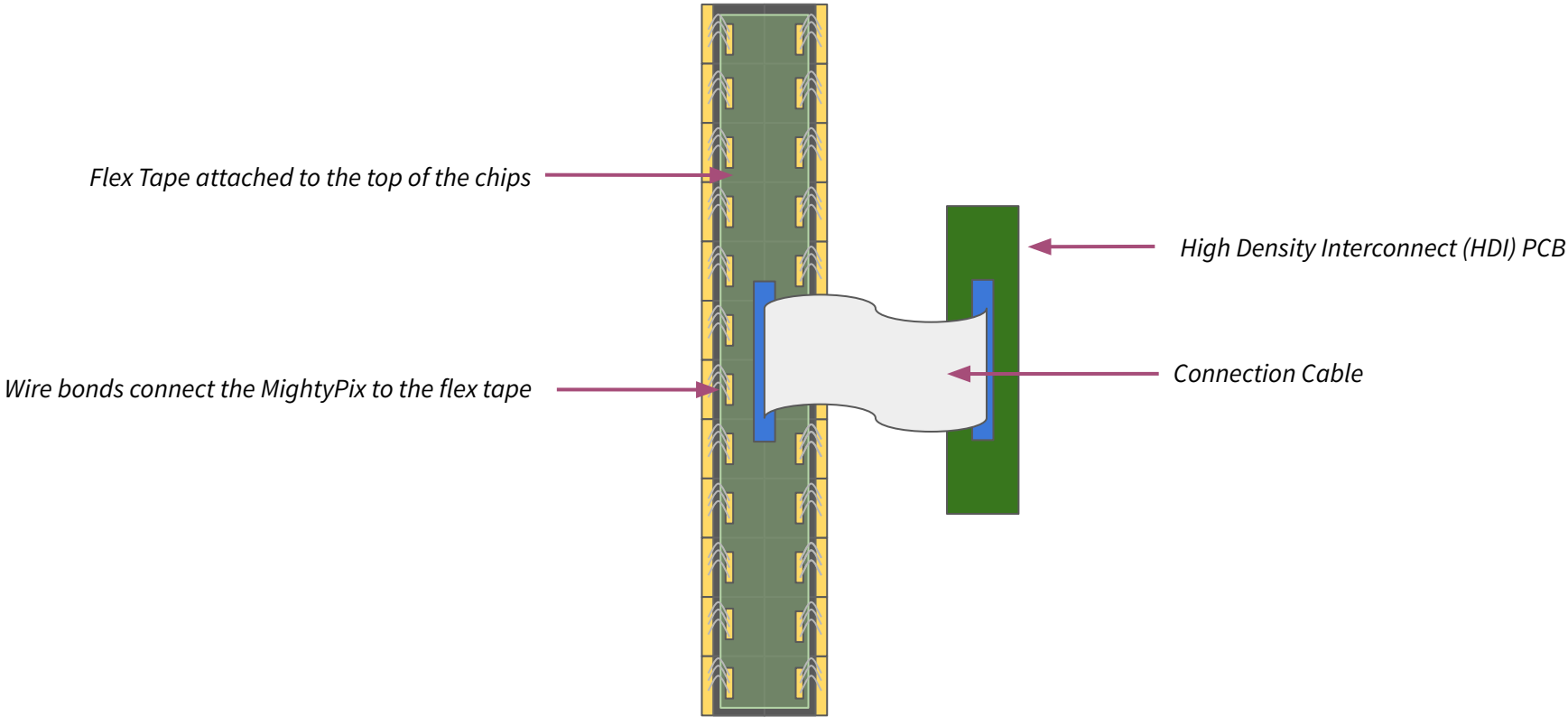
Mighty Tracker Flex Tape

Edinburgh (Pratik & Stephan) will work on the flex design:
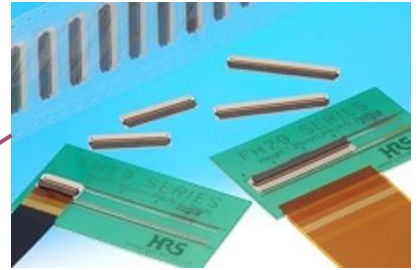- The MightyPix2 wirebond pads need to be finalised before work can start
- wire-bond pad size: 120x80mm to allow for at least two bond attempts
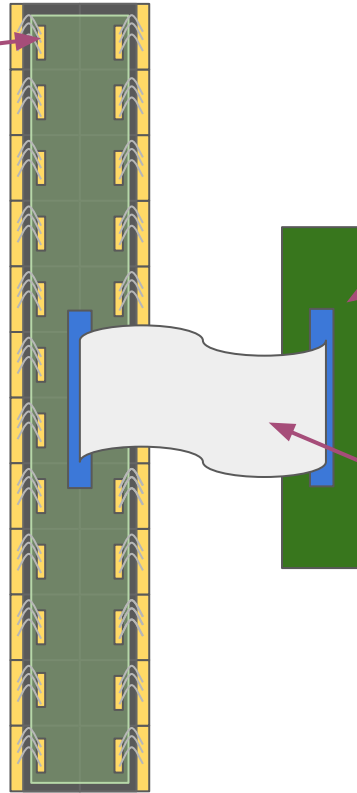
Connector type still needs to be determined:
- Hirose_FH29DJ series of connector
- Mating cycle of 20
- 100 pin vs 2 x 50 pins

The Flex connector needs to be adapted such that it wont interfere with wirebonds
- Pre-form the flex
- Investigate vertical entry connectors

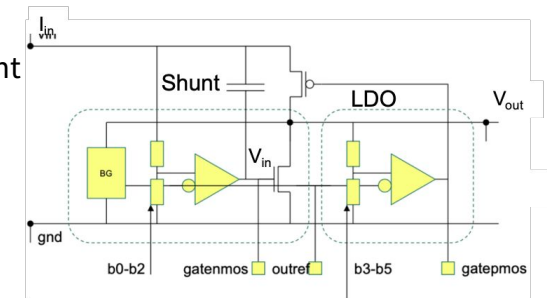# Mighty Tracker Serial Powering

- Serial powering enables the operation of multiple chips in a chain using a single and constant current source

- This system reduces overall power consumption and the data and power links

- Less service cables, so lowers material budget

- In this scheme n modules are connected in series, where each of these modules consists of m chips connected in parallel.
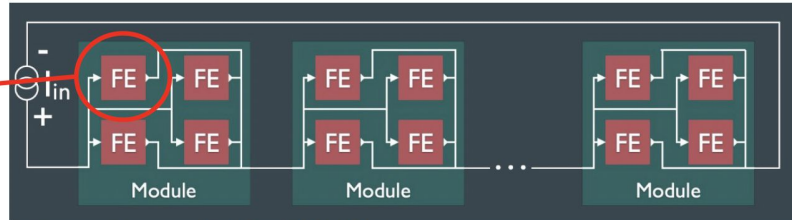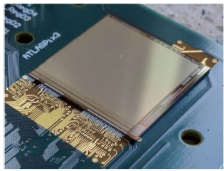
J. Chan, Serial Powering of ATLAS Itk Pixel Modules

*This is being studied for ATLAS where four chips "quads" are connected in parallel, and the quads are powered in series*

- The main building block of a serial powering is a shunt low dropout voltage regulator (Shunt - LDO)

- The shunt generates the local supply voltages for each module from the constant current supply while shunting any excess currently not drawn by the chips

- Each module has its own ground

Mighty Tracker Serial Powering

- Serial powering has never been done for HV-CMOS before but we can gain experience from the ATLASPix project

- At Edinburgh (Fuat & Yanyan), two ATLASPix3.1 Single Chip Carrier (SCC) boards have been connected in series

- There is an issue as the GECCO board does not allow for the different GND of the SCC

- Currently only one SCC can be configured and read out but the voltage output is as expected (see next slide)

- A new adapter card has been designed which provides the connection with GECCO and SCC to separate GNDs of these components

- Once the new adaptor arrives, the serial powering will be tested for 4 ATLASPix3.1 in series, with powering, configuration and readout
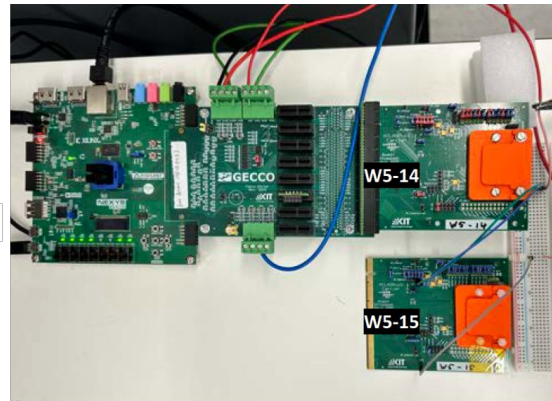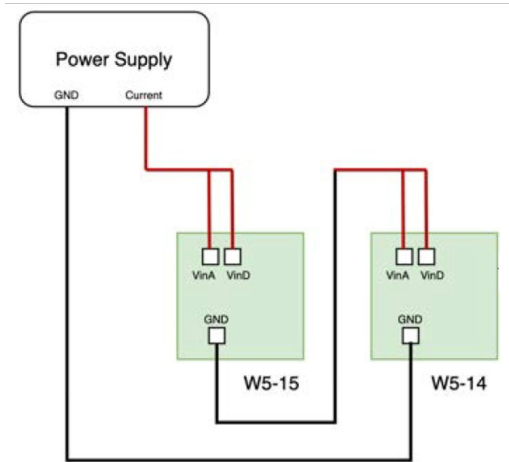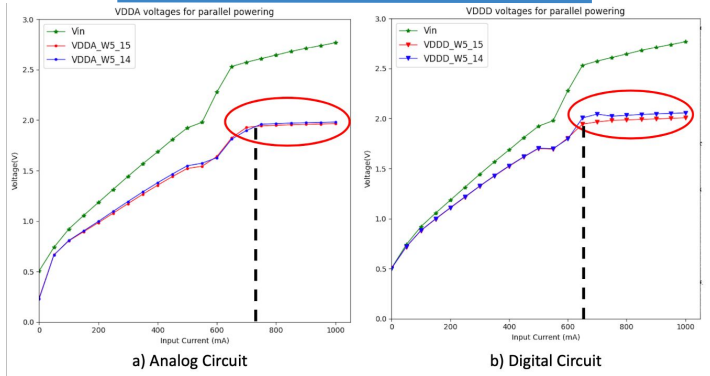

Two ATLASPix3.1 SCCs connected in series

https://indico.cern.ch/event/1338643/contributions/5687842/attachments/2762654/4811387/SP_ATLASPIX3_MTWorkshop_30Nov.pdf

Mighty Tracker Serial Powering

Parallel Powering Performance

a) Analog Circuit   b) Digital Circuit

Serial Powering Performance

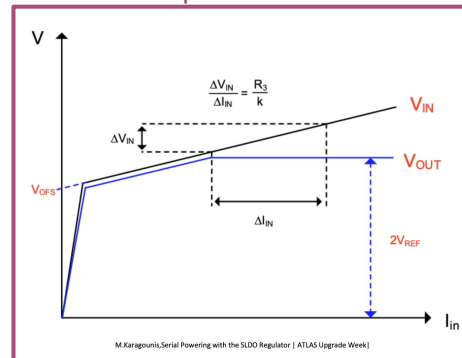a) Analog Circuit   b) Digital Circuit

- Plot of the injection current vs output voltages
  - For the analogue and digital circuits
  - For parallel and serial powering
- Even if we create parallel and serial connection with two single chips, the output voltages are regulated as expected
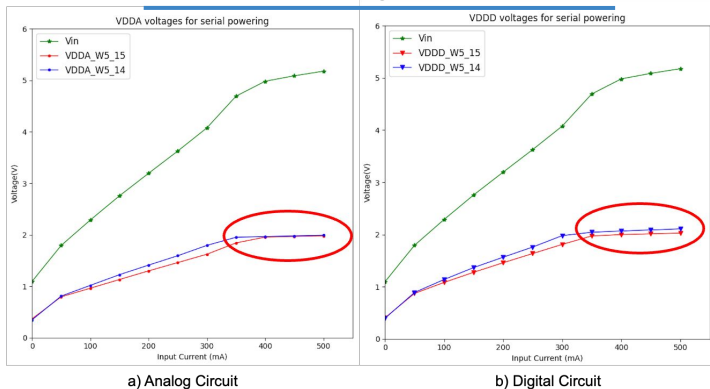
Expectation

Future Plans

- Lab tests will continue in the different UK sites using both the MARS and Gecco readout systems

- For testbeam:

    - The testbeam DUT cooling system needs to be developed before future testbeams with irradiated devices

    - More debugging is needed before the MARS readout will be available for use at testbeam

    - Some data is available for analysis from May testbeam

    - Next testbeam proposed for Decemeber 2024

- A baseline flex design is needed before the TDR, but requires the MightyPix2 design before work can start

- We need to demonstrate that the serial powering works and is a viable route for the Mighty Tracker

    - R&D is ongoing with the ATLASPix3.1, but a new GECCO board adaptor is needed to solve grounding issues

    - Once demonstrated with ATLASPix3.1, we can try with MightyPix2

- Discussions are needed to determine how best to group MightyPix in a serial powering scheme

    - https://indico.cern.ch/event/1403159/contributions/6016944/attachments/2889609/5065336/Readout&Power_Liverpool24.pdf

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Thanks!