

Overview of AstroPix Performance

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4th BIC Workshop, Argonne National Lab

Overview

2020 AstroPix_v1	2021 AstroPix_v2	2023 AstroPix_v3	2024 AstroPix_v4	2025 AstroPix_v5
				
1st prototype: incremental design changes from ATLASPix	2nd prototype: Power reduction, Radiation testing '22	Flight prototype: Beam tests '23, '24 Sounding Rocket '26	4th prototype: individual pixel readout, Power reduction	5th prototype: AMS Foundry Energy range, Power reduction, Balloon '28(?)

Discussion Topics:

- AstroPix Version 3
- AstroPix Version 4
- SW/FW Development

AstroPix Version 3 : Overview

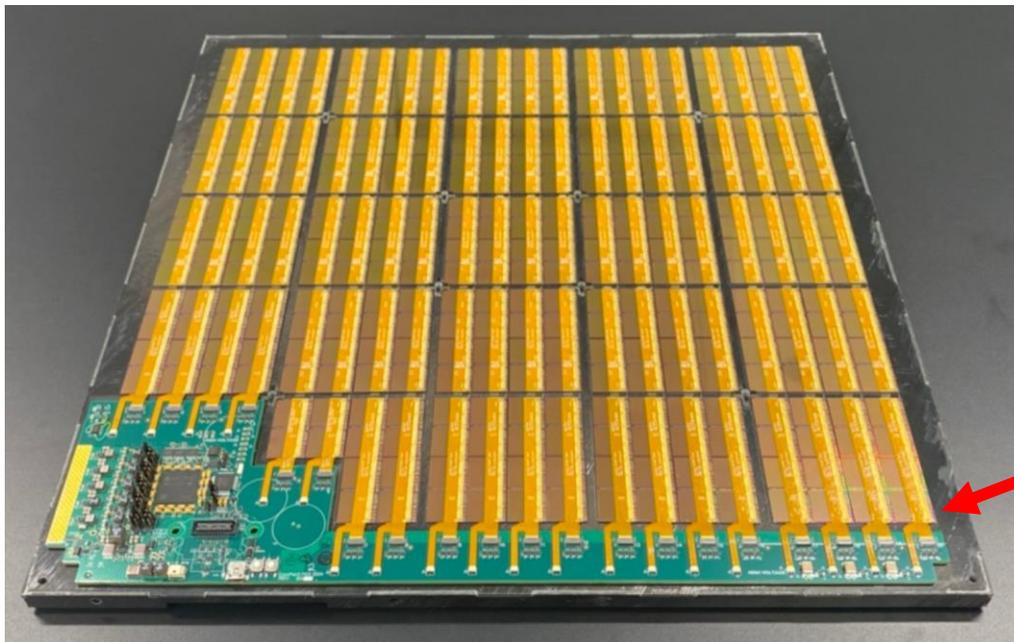
- **AstroPix v3** is the first 2x2 cm² chip implemented.
- Last version with OR'd Row/Column Hit Buffers
- First version of AstroPix tested in “quad-chip” design.
- Testing with AstroPix v3 is still providing lots of important feedback on how to operate the AstroPix daisy-chain readout.



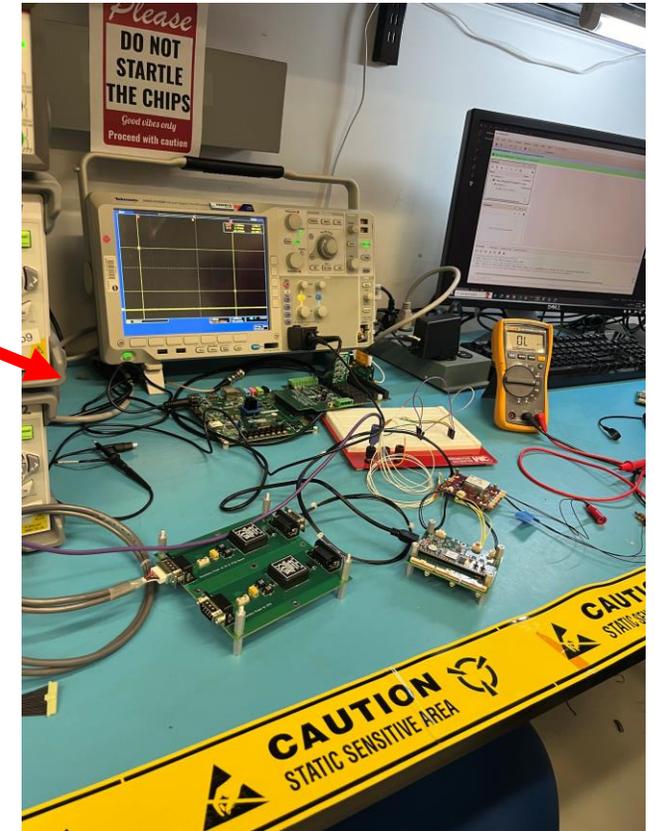
AstroPix v3 Quad Chip Test Board

AstroPix Version 3 : Overview

New hardware has been developed to interface with AstroPix v3, moving away from the Nexys Video + GECCO board readout.



AstroPix Sounding Rocket
Technology Demonstration
Payload (A-STEP)



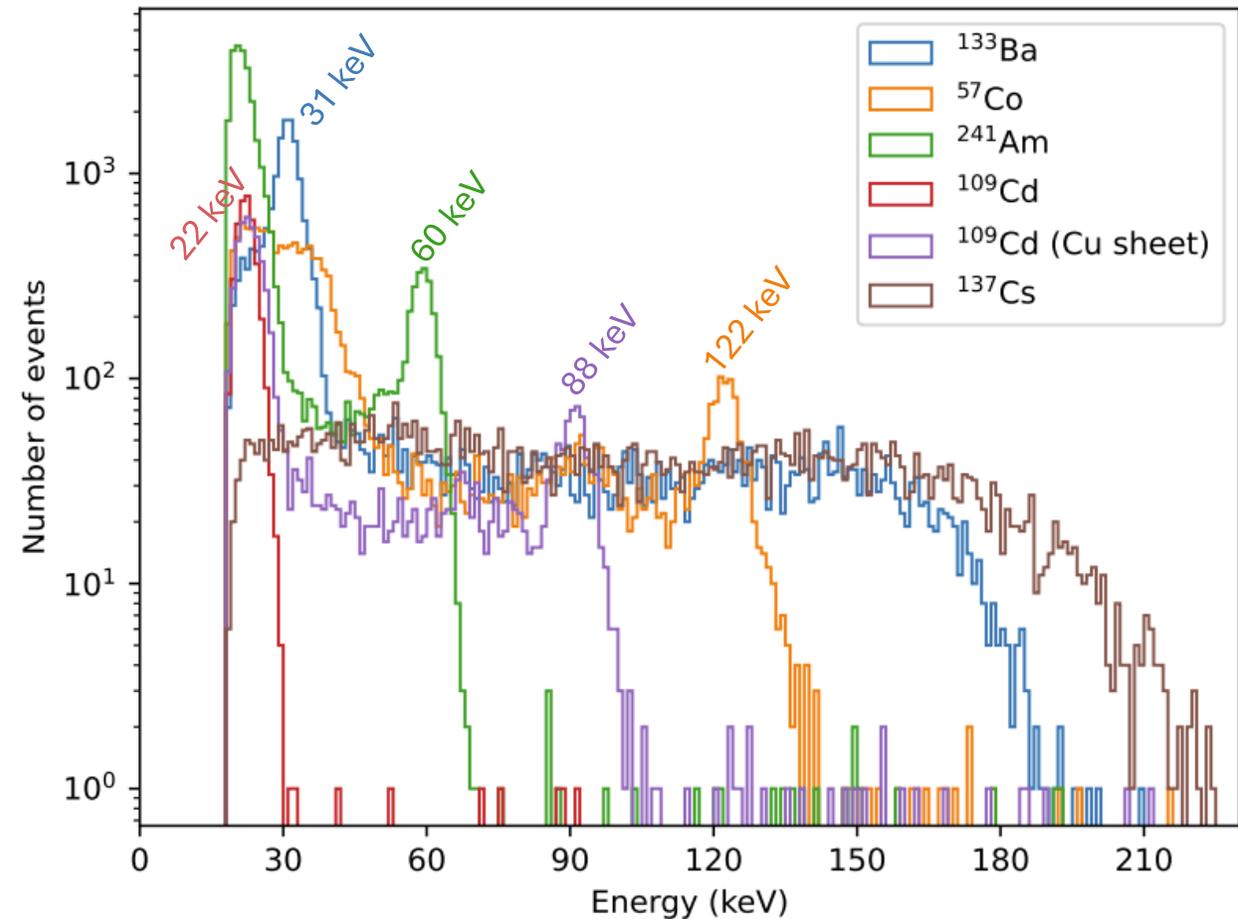
Compton-Pair (ComPair-2)
Segment

AstroPix Version 3 : Single Chip Performance

- AstroPix v3 detector testing: mean 6.4 keV FWHM at 59.5 keV.
- 44% of pixel meet target (<10% FWHM at 60 keV)



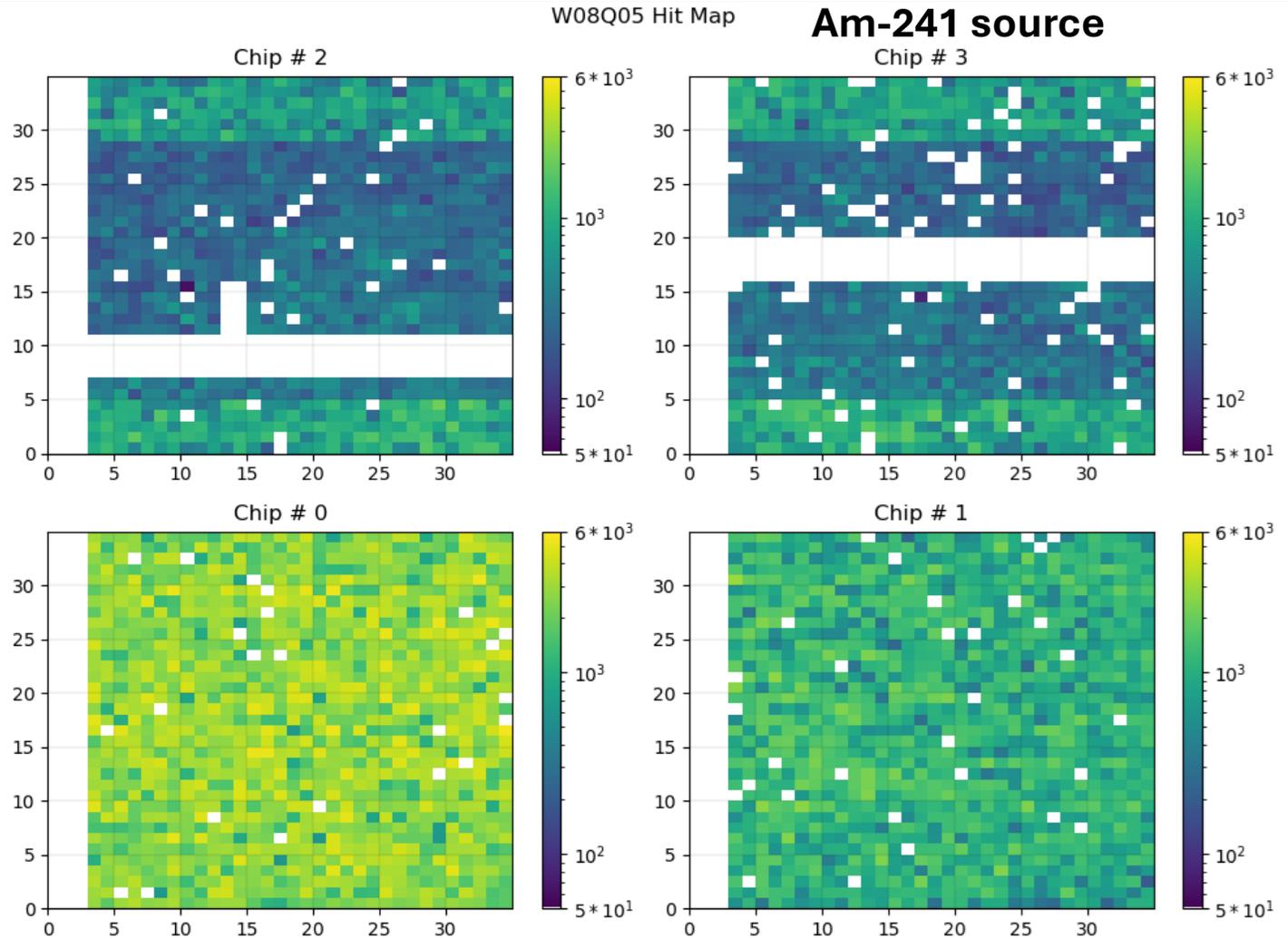
Single Pixel Source Spectra



AstroPix Version 3 : Quad Chip Performance

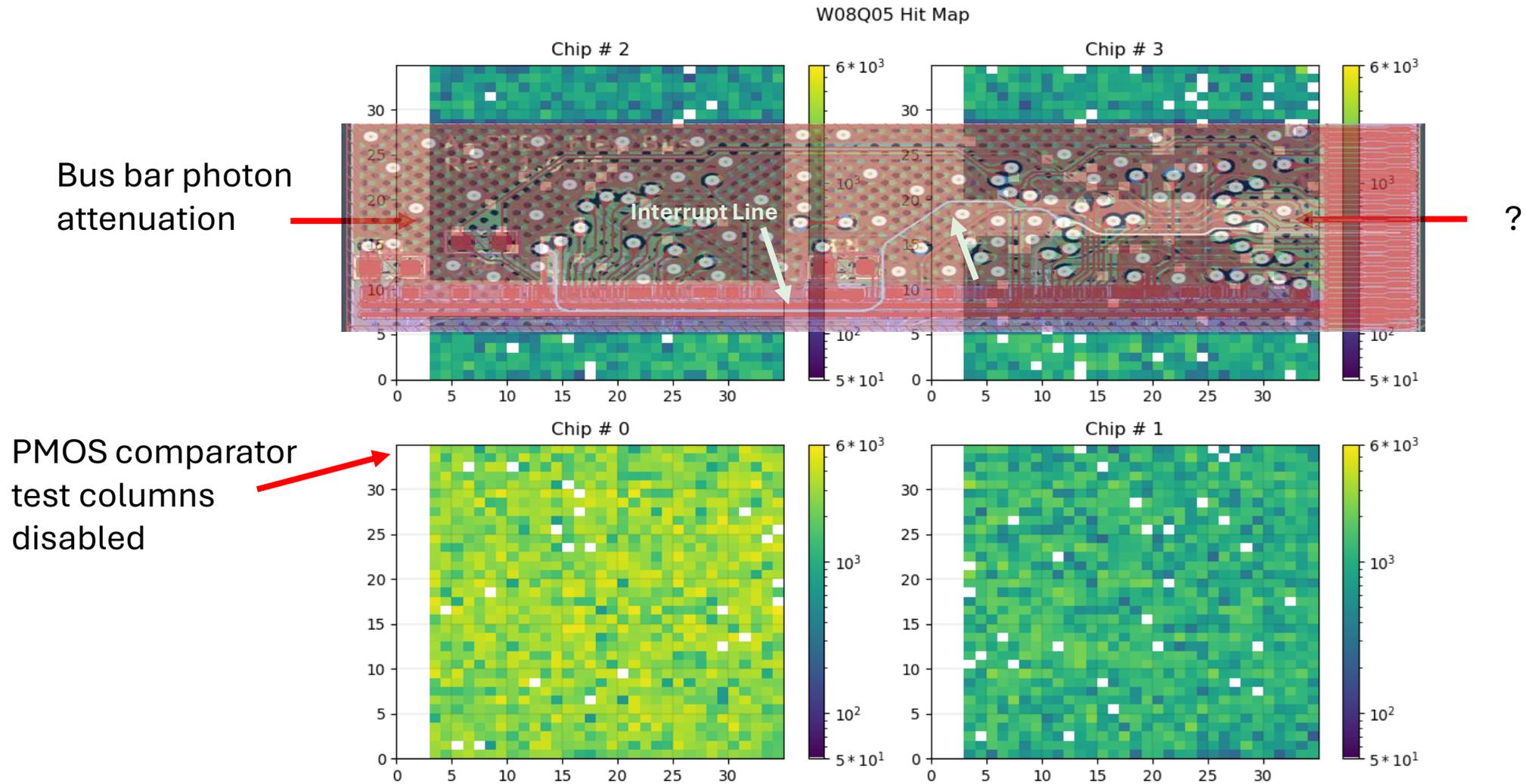


- Hit-map of four AstroPix chips on one SPI bus
- Recorded 580 events/s after row/col hit matching



Credit: Kavic Kumar, UMD College Park, Adrien Laviron NASA\GSFC

AstroPix Version 3 : Quad Chip Performance



AstroPix Version 3 : Thermal Testing

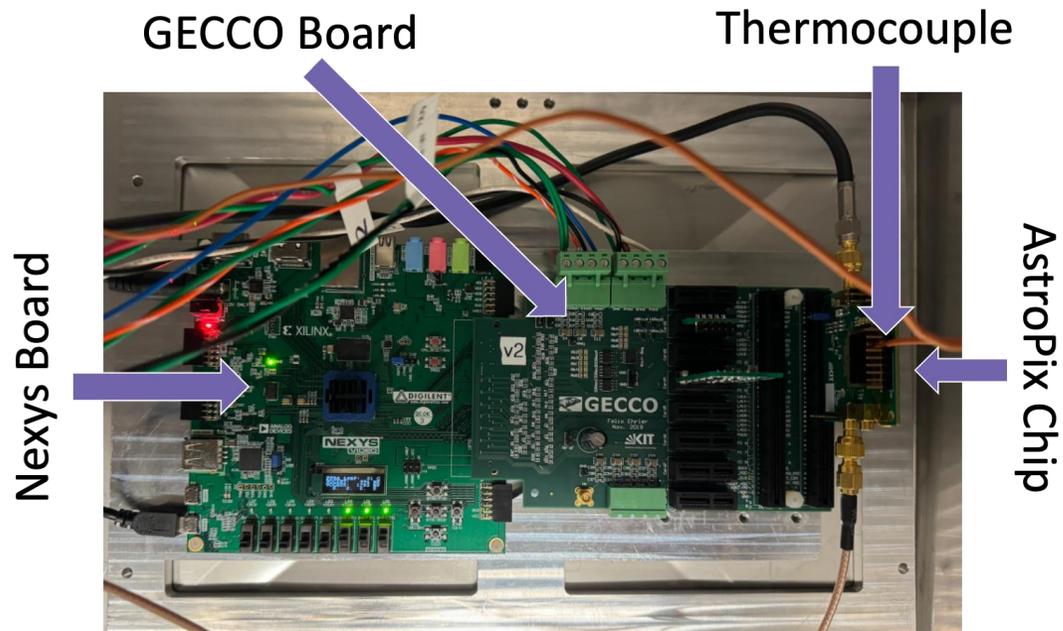
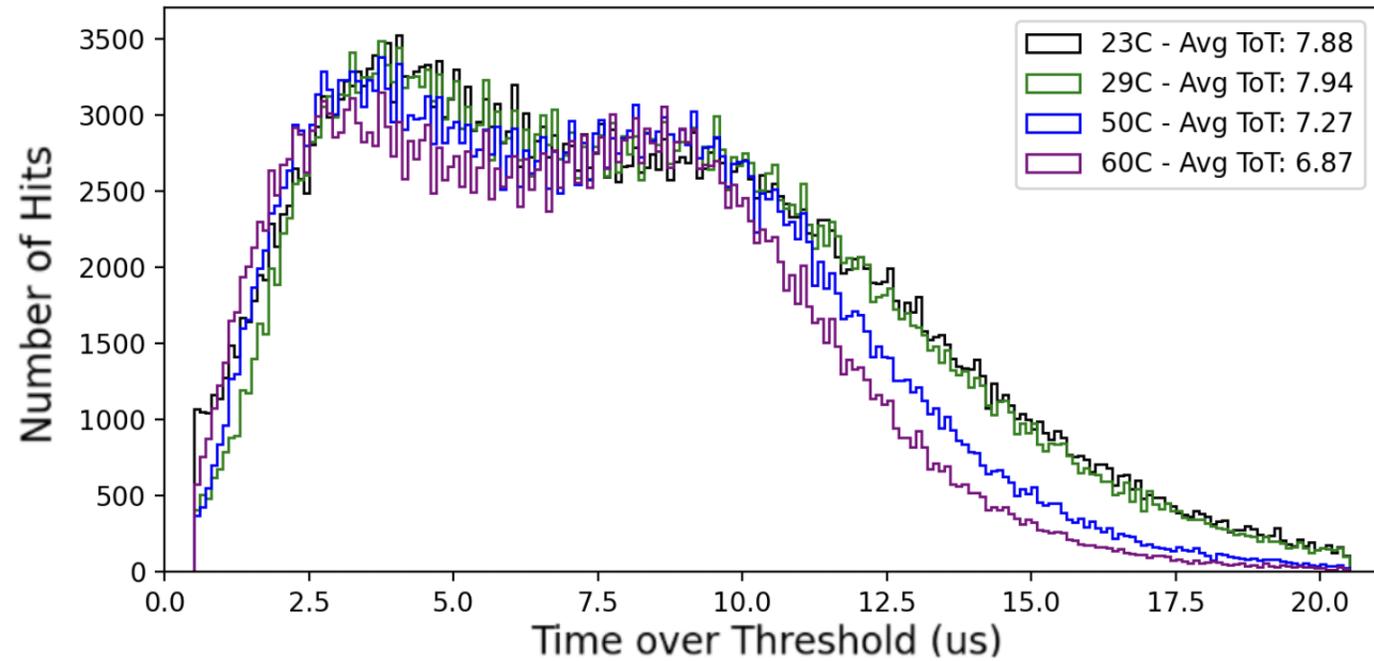


Figure 4: Experimental setup with AstroPix in a thermal chamber

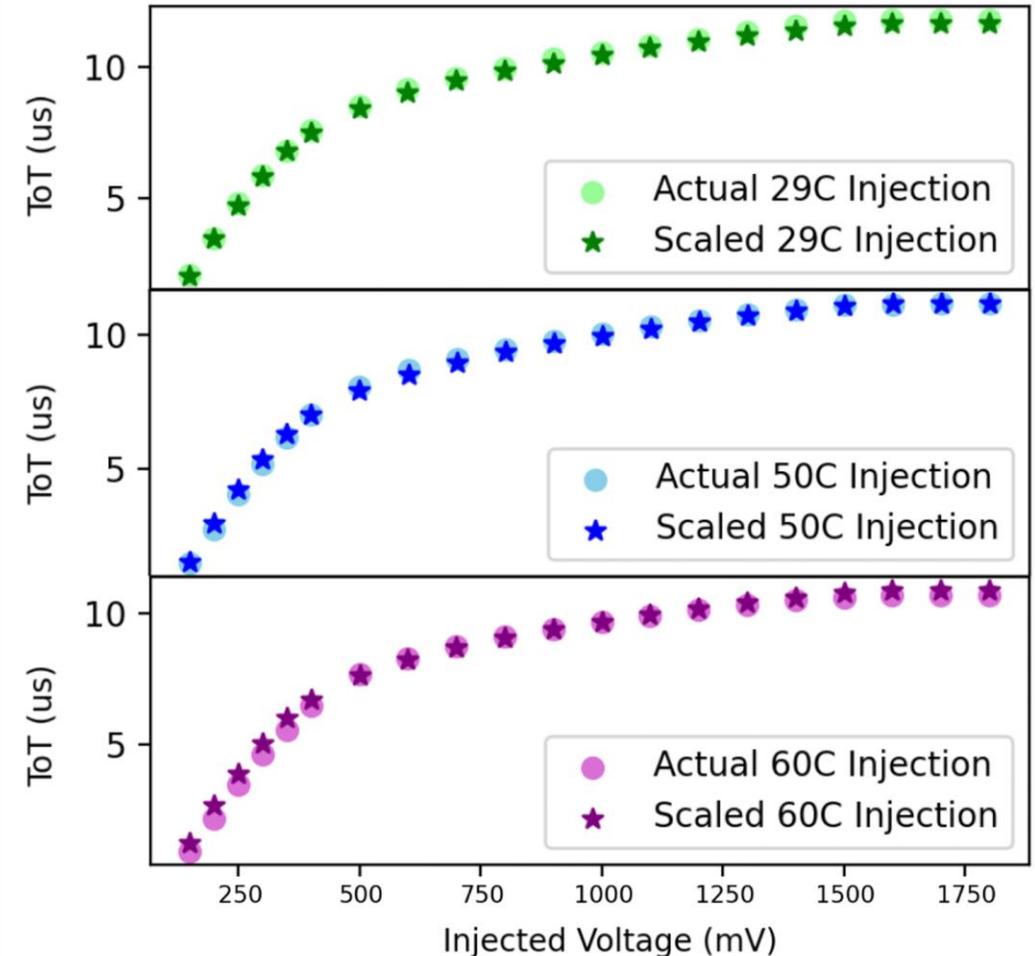
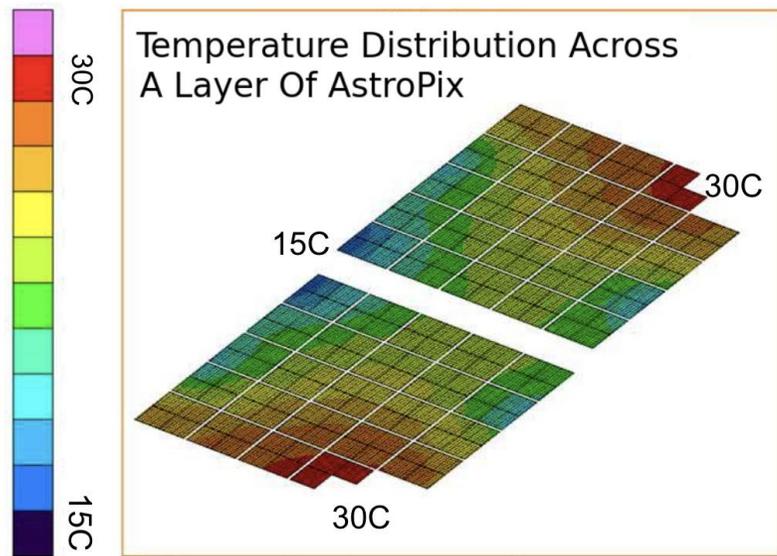
Barium-133 Spectra At Different Temperatures



Credit: Carolyn Chinatti, Carleton College

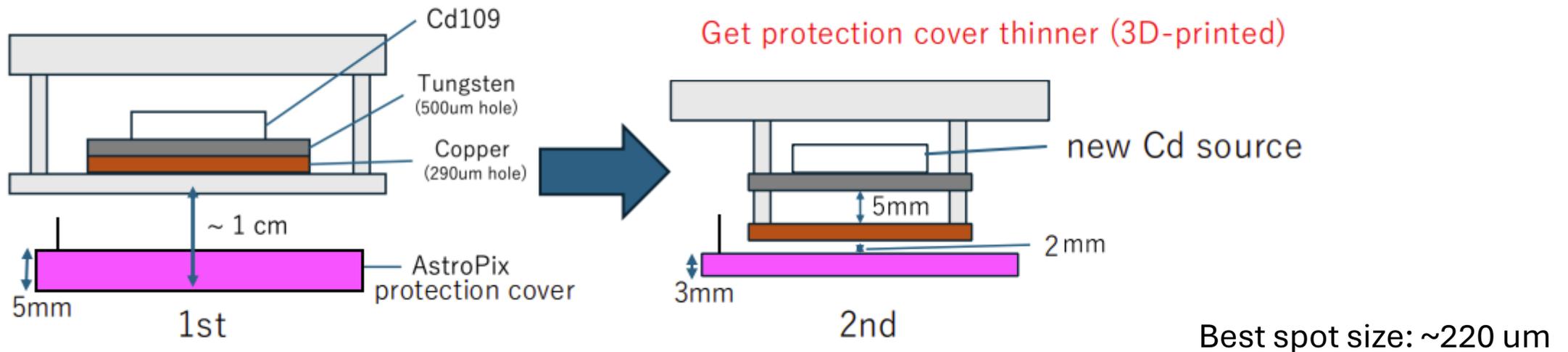
AstroPix Version 3 : Thermal Testing

- Attempted a linear scaling of the shifted ToT spectrum as a function of temperature.
- Some noted energy dependent shifts remain, bimodality of the amplifier, other effects?



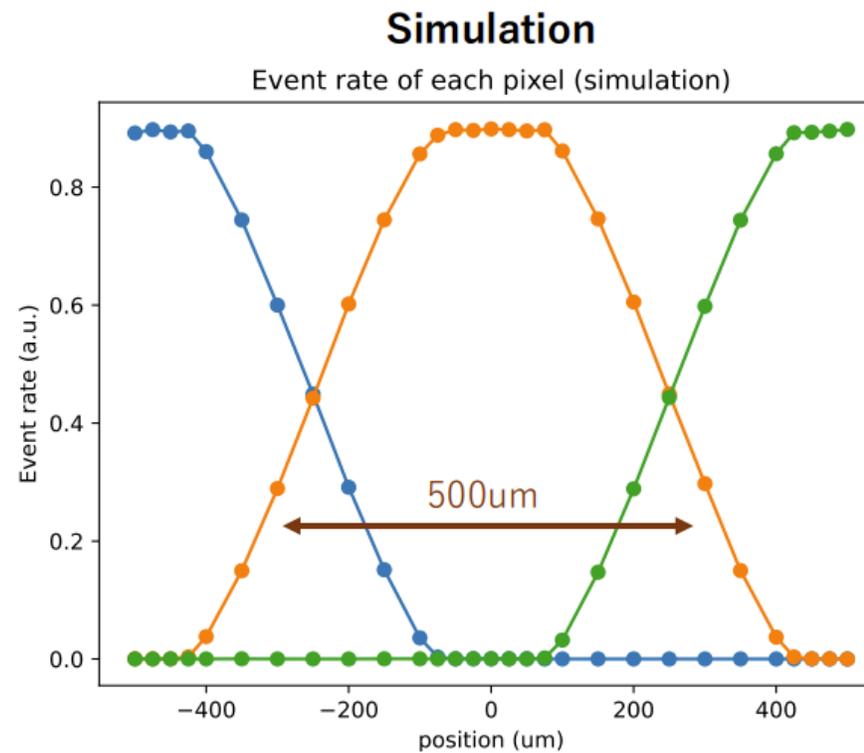
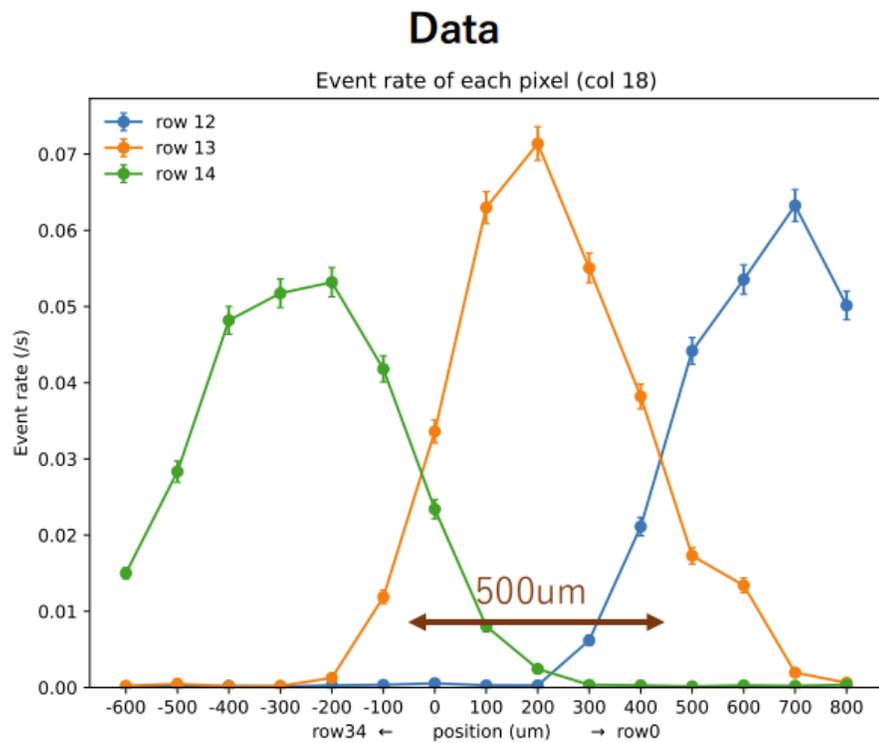
AstroPix Version 3 : Sub-Pixel Scans

- We want to understand AstroPix's subpixel detection efficiency.
- Is depletion uniform? What does charge collection look like at pixel boundaries?
- Norito Nakano designed experiment to collimate x-rays for a 2-D scan using Cd-109.



AstroPix Version 3 : Sub-Pixel Scans

- Showed change-over in count rate from one pixel row to the next while scanning across a column. Compared simulations.

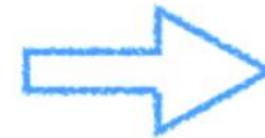
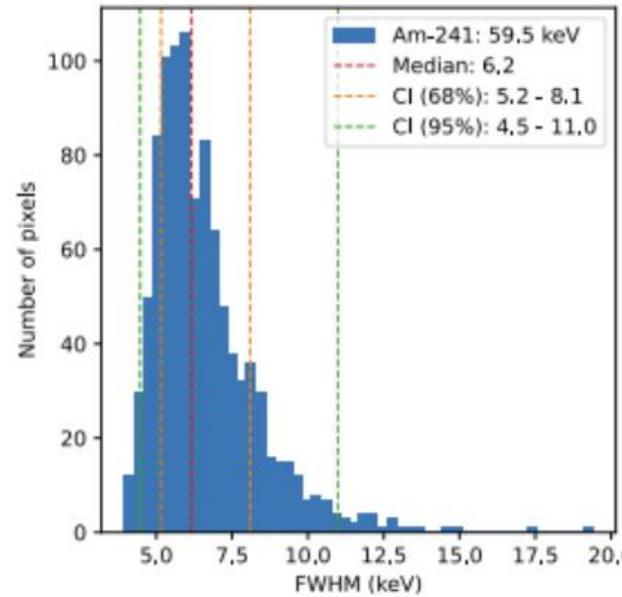


AstroPix Version 4

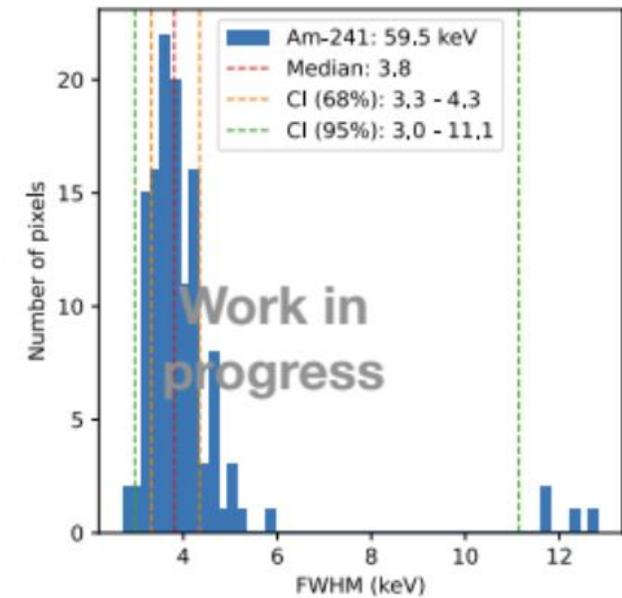


Reduction in pixel capacitance!

V3

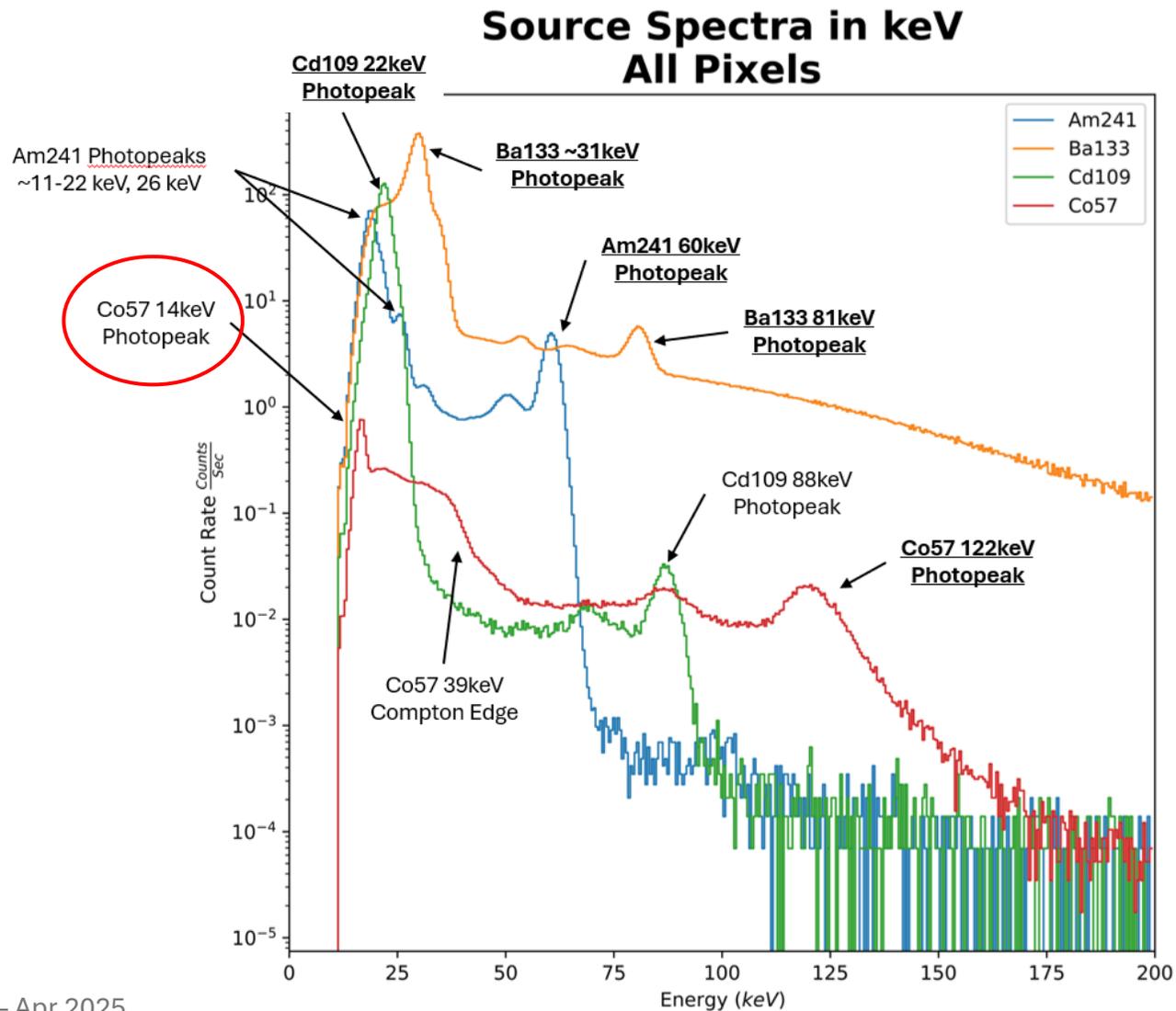


V4



Credit: Yusuke Suda, Hiroshima U

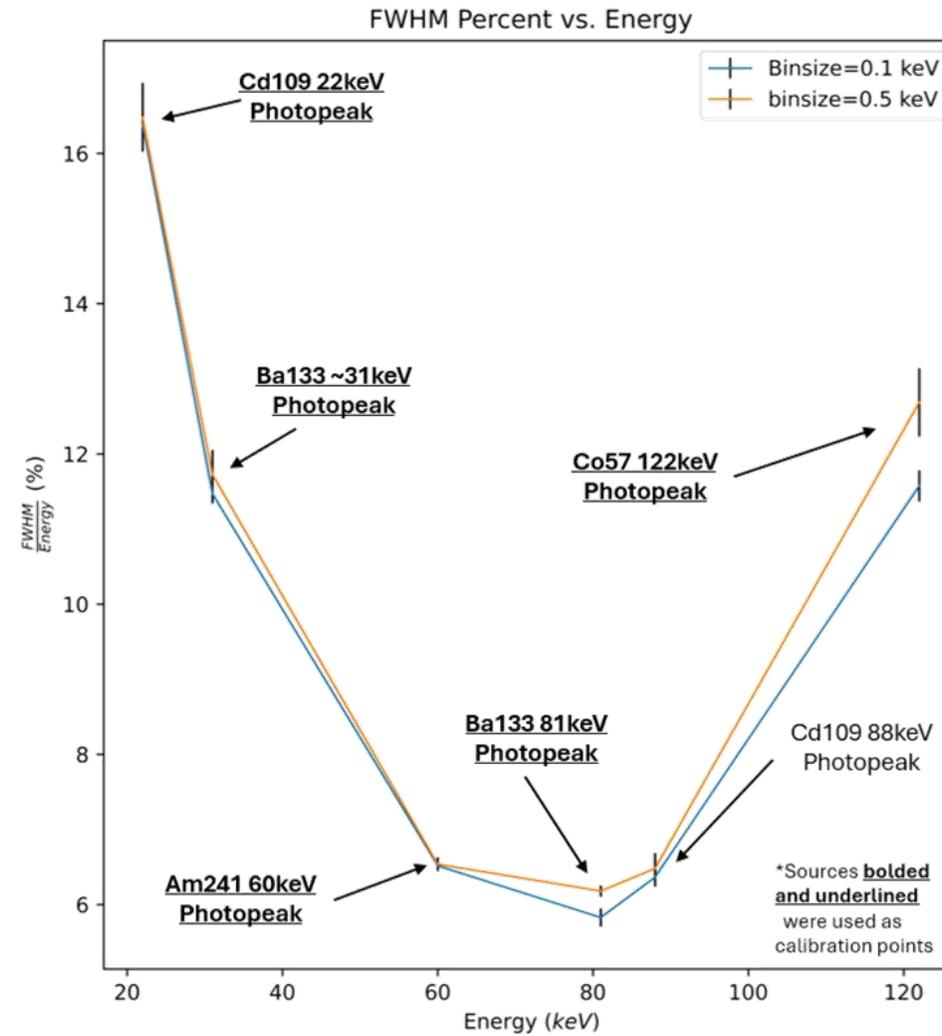
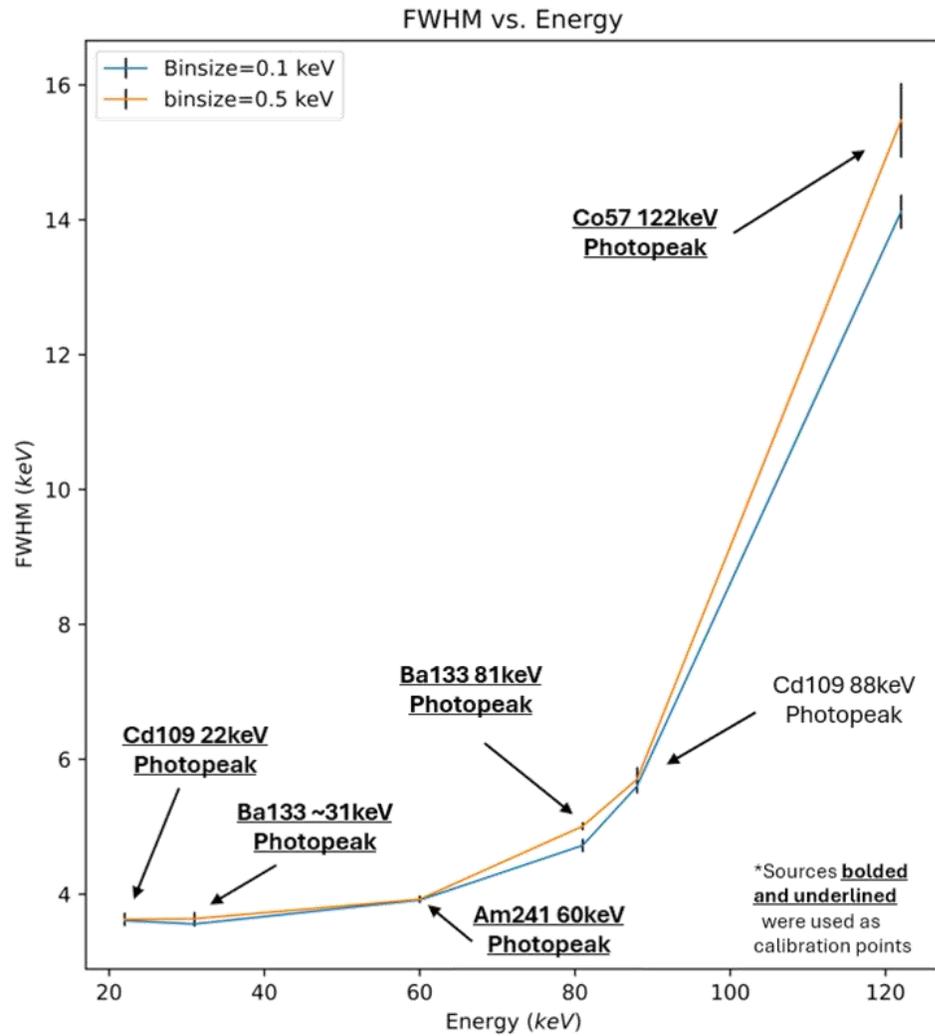
AstroPix Version 4: Performance



Credit: Grant Sommer, GW University.

*Sources **bolded and underlined** were used as calibration points

AstroPix Version 4: Performance

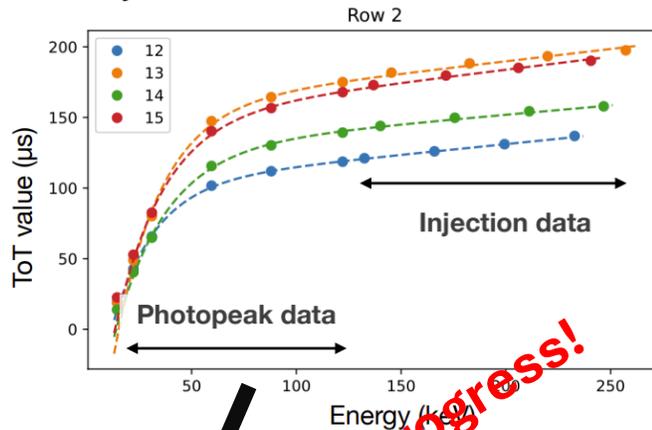


Slightly above goal 10% FWHM at 122 keV!

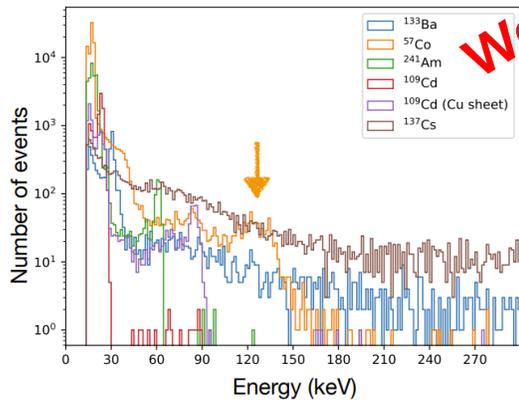
Credit: Grant Sommer, GW University.

AstroPix Version 4: Injection Calibration + Depletion

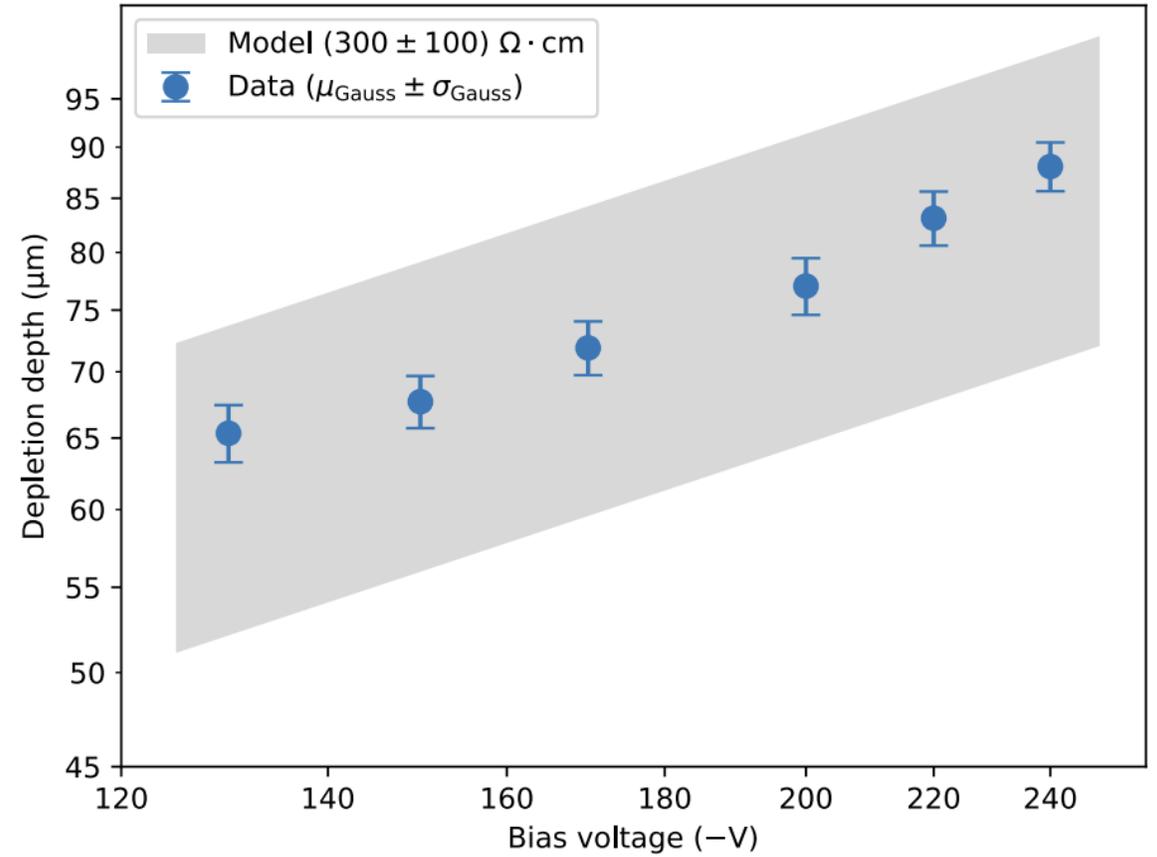
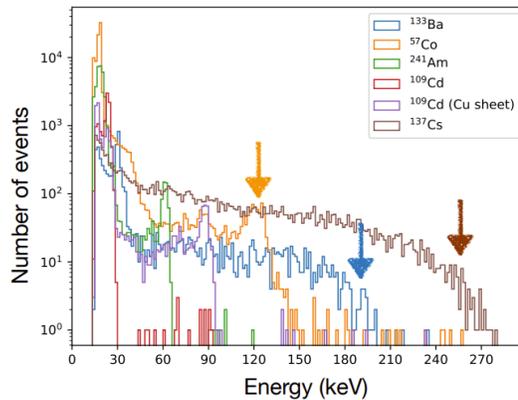
Injection-corrected calibration curves



Work in Progress!



Injection correction



Credit Yusuke Suda, Hiroshima U.

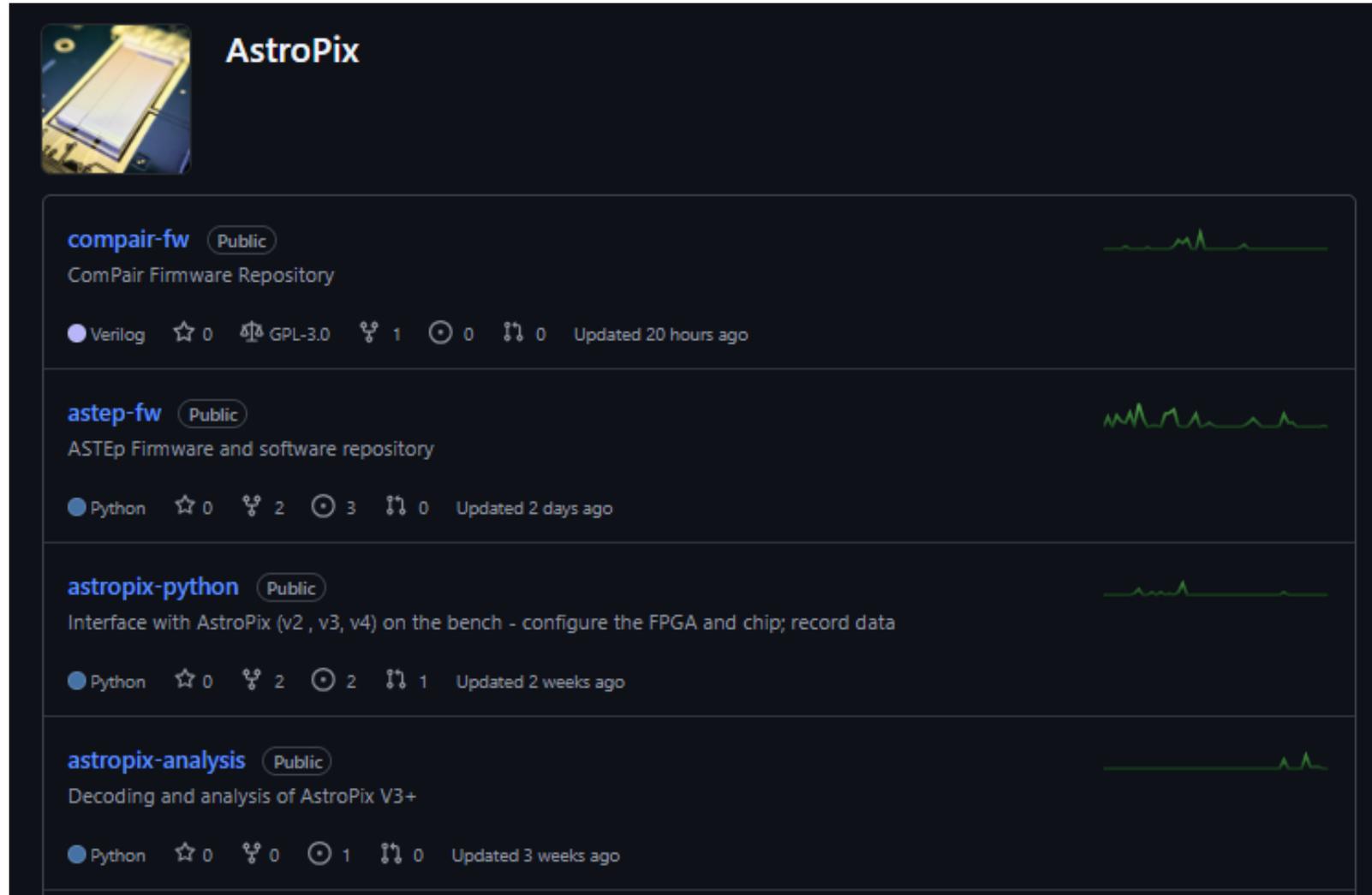
Methods: <https://www.sciencedirect.com/science/article/pii/S0168900224006880?via%3Dihub>

Software Development

- As the AstroPix user group grows we are attempting to adjust from an R&D mindset.
- Looking for feedback!



<https://github.com/AstroPix>



AstroPix

compair-fw Public
ComPair Firmware Repository
Verilog 0 stars GPL-3.0 license 1 fork 0 issues 0 pull requests Updated 20 hours ago

astep-fw Public
ASTEpi Firmware and software repository
Python 0 stars 2 forks 3 issues 0 pull requests Updated 2 days ago

astropix-python Public
Interface with AstroPix (v2, v3, v4) on the bench - configure the FPGA and chip; record data
Python 0 stars 2 forks 2 issues 1 pull request Updated 2 weeks ago

astropix-analysis Public
Decoding and analysis of AstroPix V3+
Python 0 stars 0 forks 1 issue 0 pull requests Updated 3 weeks ago

Software Development

How HW agnostic can this be?



ComPair Segment
Running (380 Detectors)!

Quad Chip (v3) Running,
Daisy Chain Readout

Single-Chip (v3,v4) Running

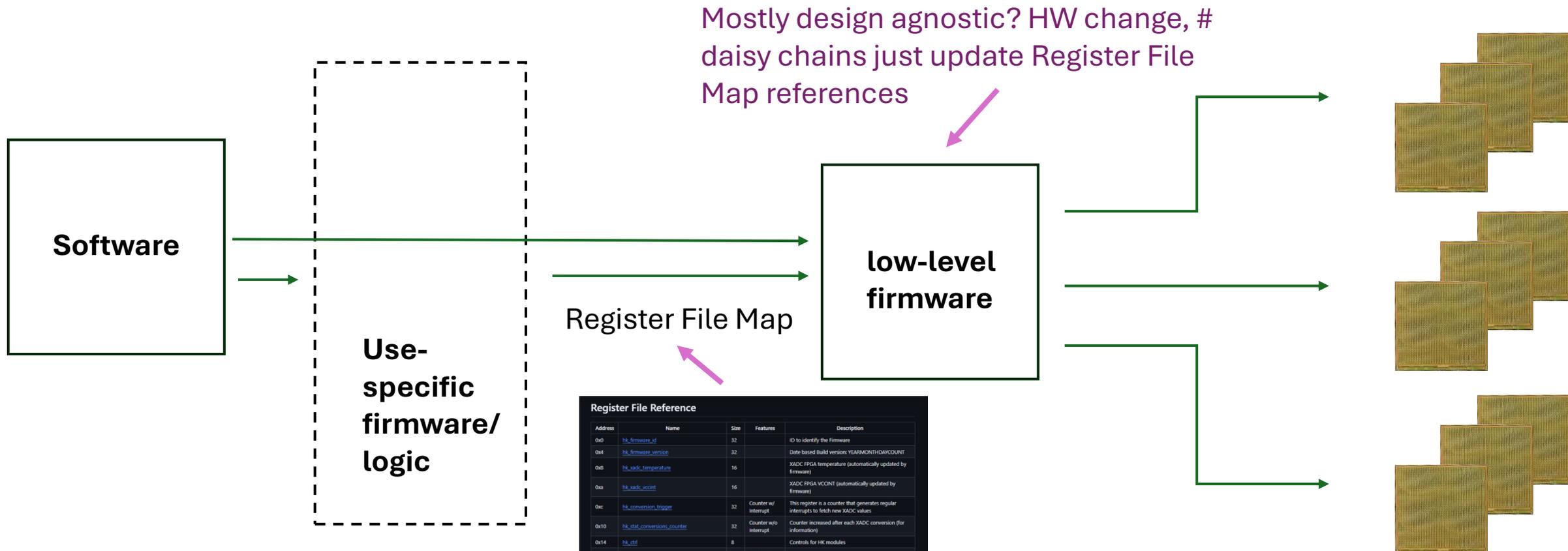
AstroPix v3, Quad-
Chip, v4 Decoding

A screenshot of a GitHub repository page for 'AstroPix'. The page shows four public repositories: 'compair-fw', 'astep-fw', 'astropix-python', and 'astropix-analysis'. Each repository entry includes its name, description, programming language, star count, fork count, commit count, issue count, and update time. Blue arrows point from the text on the left to the first three repositories, and an orange arrow points from the text to the last repository. A green waveform is visible on the right side of each repository card.

AstroPix

- compair-fw** (Public) - ComPair Firmware Repository
Verilog, 0 stars, GPL-3.0 license, 1 fork, 0 commits, 0 issues, Updated 20 hours ago
- astep-fw** (Public) - ASTEp Firmware and software repository
Python, 0 stars, 2 forks, 3 commits, 0 issues, Updated 2 days ago
- astropix-python** (Public) - Interface with AstroPix (v2, v3, v4) on the bench - configure the FPGA and chip; record data
Python, 0 stars, 2 forks, 2 commits, 1 issue, Updated 2 weeks ago
- astropix-analysis** (Public) - Decoding and analysis of AstroPix V3+
Python, 0 stars, 0 forks, 1 commit, 0 issues, Updated 3 weeks ago

Software Development



Mostly design agnostic? HW change, # daisy chains just update Register File Map references

Register File Reference

Address	Name	Size	Features	Description
0x0	hk_firmware_id	32		ID to identify the Firmware
0x4	hk_firmware_version	32		Date based Build version: YEARMONTHDAYCOUNT
0x8	hk_xadc_temperature	16		XADC FPGA temperature (automatically updated by firmware)
0xa	hk_xadc_vccint	16		XADC FPGA VCCINT (automatically updated by firmware)
0xc	hk_conversion_trigger	32	Counter w/ interrupt	This register is a counter that generates regular interrupts to fetch new XADC values
0x10	hk_stat_conversions_counter	32	Counter w/o interrupt	Counter increased after each XADC conversion (for information)
0x14	hk_ctrl	8		Controls for HK modules
0x15	hk_axidac_miso_fifo	8	AXIS FIFO Master (write)	FIFO to send bytes to ADC or DAC
0x16	hk_axd_miso_fifo	8	AXIS FIFO Slave (read)	FIFO with read bytes from ADC
0x17	hk_axd_miso_fifo_read_size	32		Number of entries in hk_axd_miso_fifo
0x1b	spi_layers_clkdivider	8		This clock divider provides the clock for the Layer SPI interfaces
0x1c	spi_hk_clkdivider	8		This clock divider provides the clock for the Housekeeping ADC/DAC SPI interfaces
0x1d	layer_0_cfg_ctrl	8		Layer 0 control bits
0x1e	layer_1_cfg_ctrl	8		Layer 1 control bits
0x1f	layer_2_cfg_ctrl	8		Layer 2 control bits
0x20	layer_0_status	8		Layer 0 status bits
0x21	layer_1_status	8		Layer 1 status bits
0x22	layer_2_status	8		Layer 2 status bits

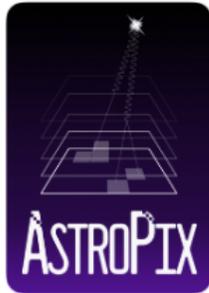
*Adjustable # of AstroPix daisy-chains

Software Development

- Great firmware/software documentation by Richard Leys

ASTEP Firmware documentation

Welcome to the ASTEP Firmware Readout repository



You will find here sources for the Firmware targeting Gecco Nexys Video and CMOD boards, with different configurations based on the type of Astropix Carrier boards (Single Chip V2/V3/V4 , Telescope Chain, Multi-Layer etc..)

The Software part is a python library layer to ease working with the various firmware builds from one API, along with some readout and testing scripts. Experiment's main software sources may be hold in different repositories depending on Team's decision.



<https://astropix.github.io/astep-fw/>

Thank You!

