Applications of Digital Signal Processing for Energy Dispersive X-Rays Detectors

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Agenda

1. Introduction
2. Digital Signal Processing
3. Hardware
4. Market Analysis
5. Conclusion

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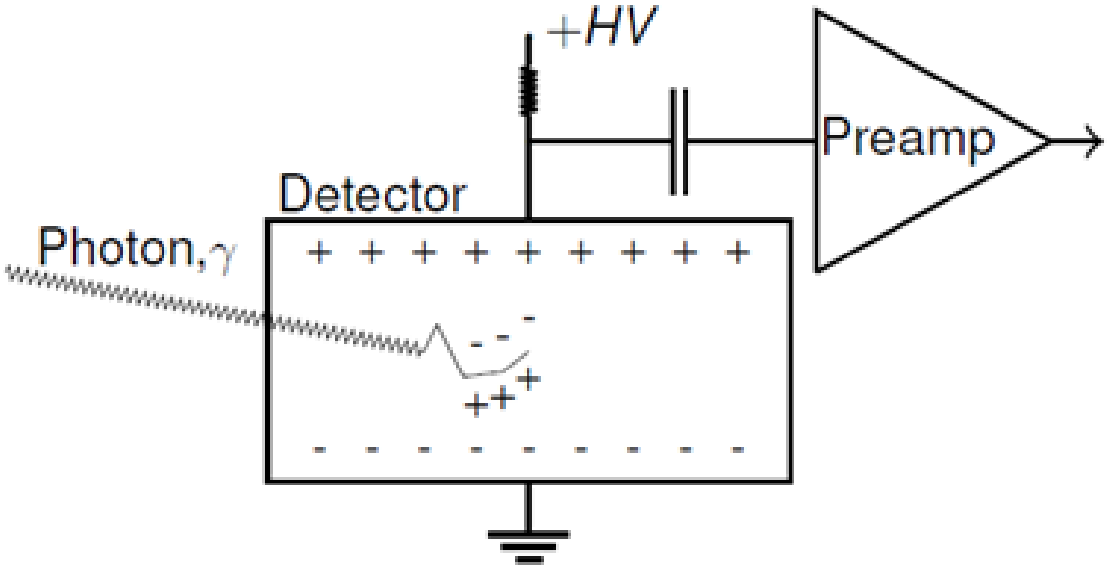
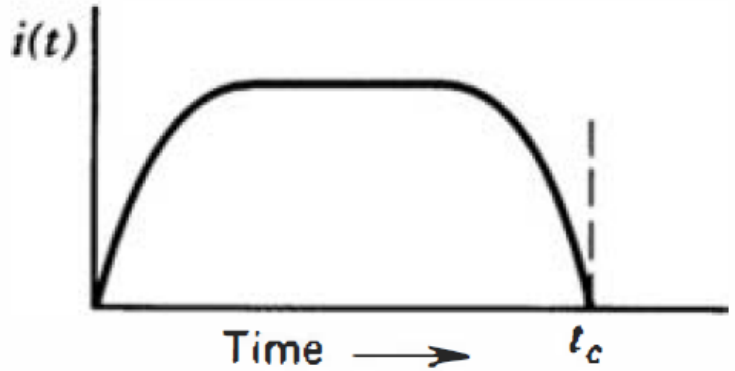
1 Introduction

Introduction





- Detector

  Solid State detectors
  (Semiconductor)

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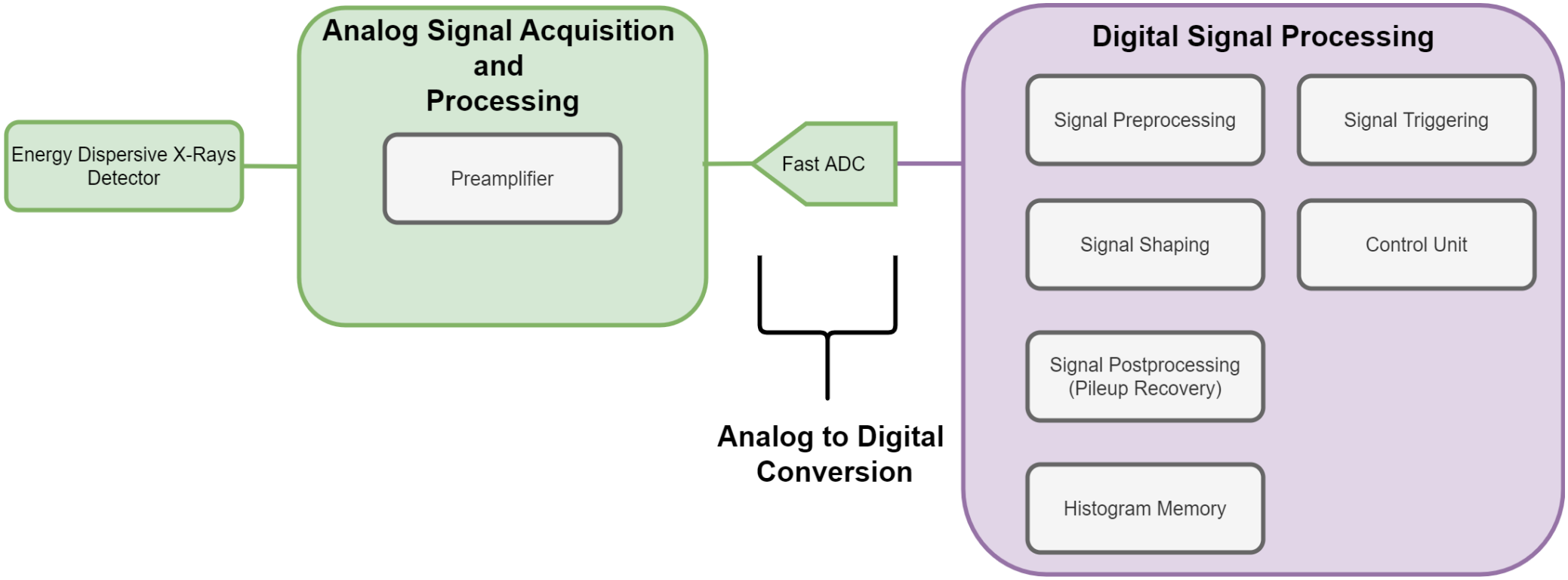
2 Digital Signal Processing

Block Diagram



Digital Signal Processing Algorithms

- Signal Preprocessing
- Signal Shaping
- PileUp Recovery and Rejection

- **Signal Preprocessing Methods**

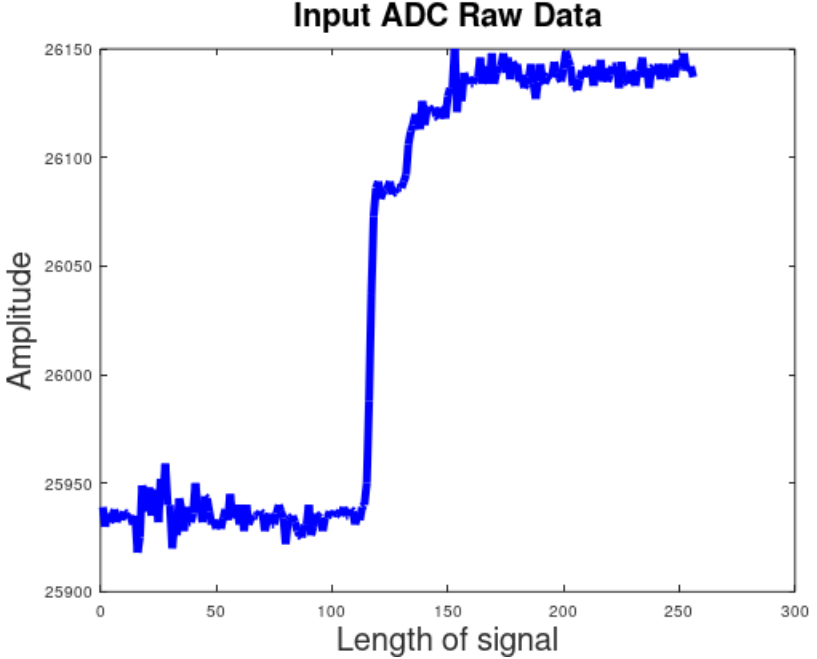
1) Moving Average Filter
2) Savitzky-Golay Filter
3) Gaussian Smoothing Filter
4) Independent Component Analysis (ICA)
5) Discrete Wavelet Transform (DWT)

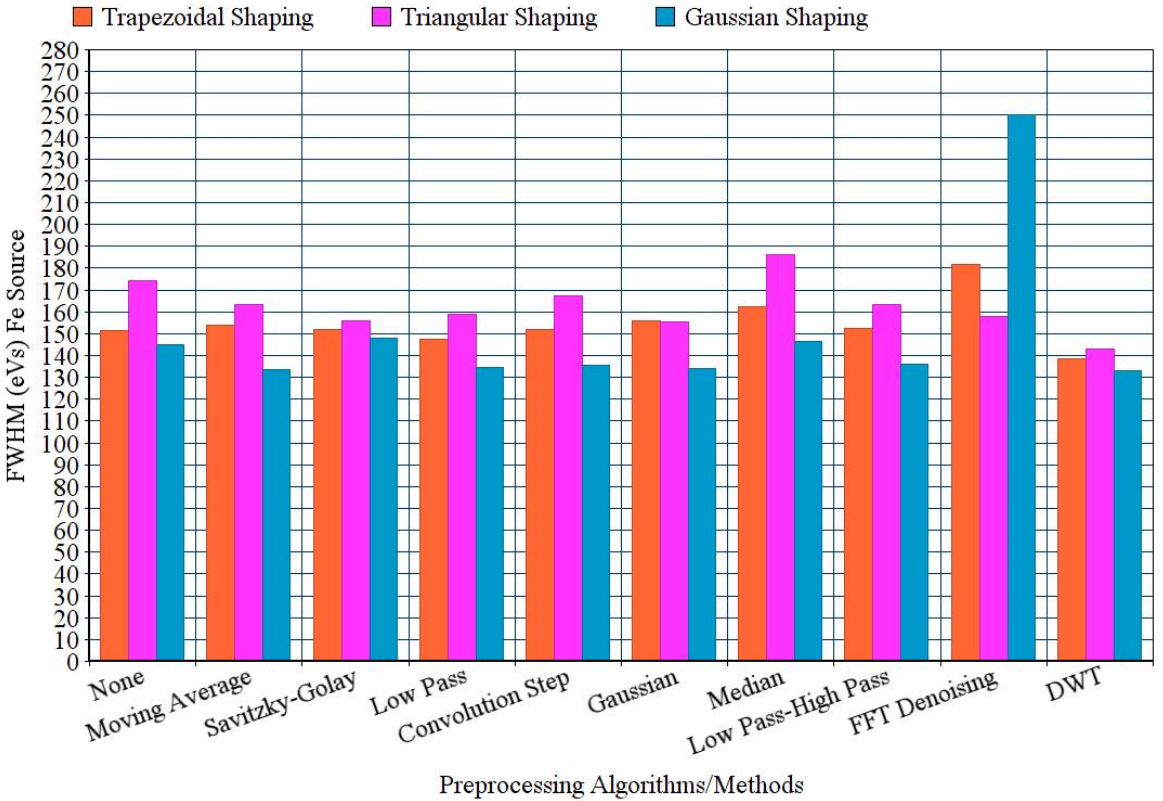
- **Signal Shaping Methods**

1) Trapezoidal Filter
2) Triangular Filter
3) Cusp Filter
4) Flat Top Cusp Filter
5) Gaussian Filter

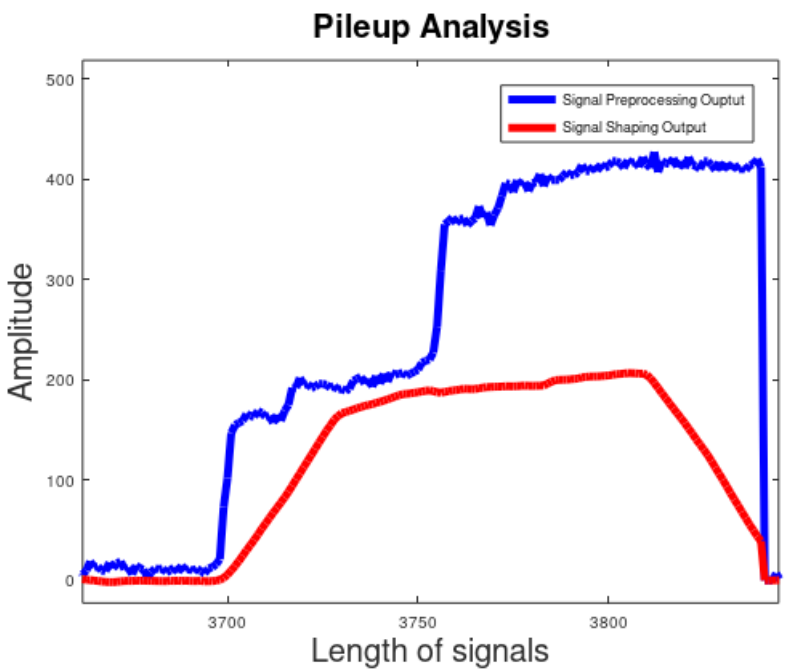
- **PileUp Recovery and Rejection Methods**

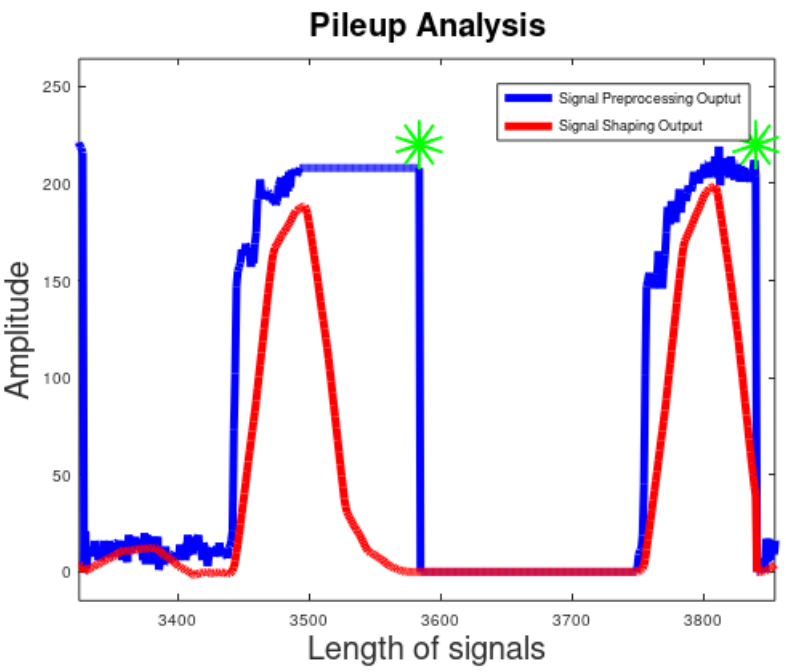
1) Deconvolution
2) Linear Discriminant Anaylsis (LDA)
3) Artifical Neural Network (ANN)
4) Support Vector Machnie (SVM)





- Tested with real ADC data from samples at the beamline (P24).
- Trapezoidal filter gives highest energy resolution but at higher count rates pile up increases due to longer shaping times, while triangular filter gives low energy resolution but pile up decreases for higher count rates due to shorter shaping times.
- Maximum achievable energy resolution is 100-155 eV for Fe source at 5.9 KeV at 0.650 microsecs peaking time.
- Highest flexibility for the User to select between different algorithms/methods for best possible energy resolution.



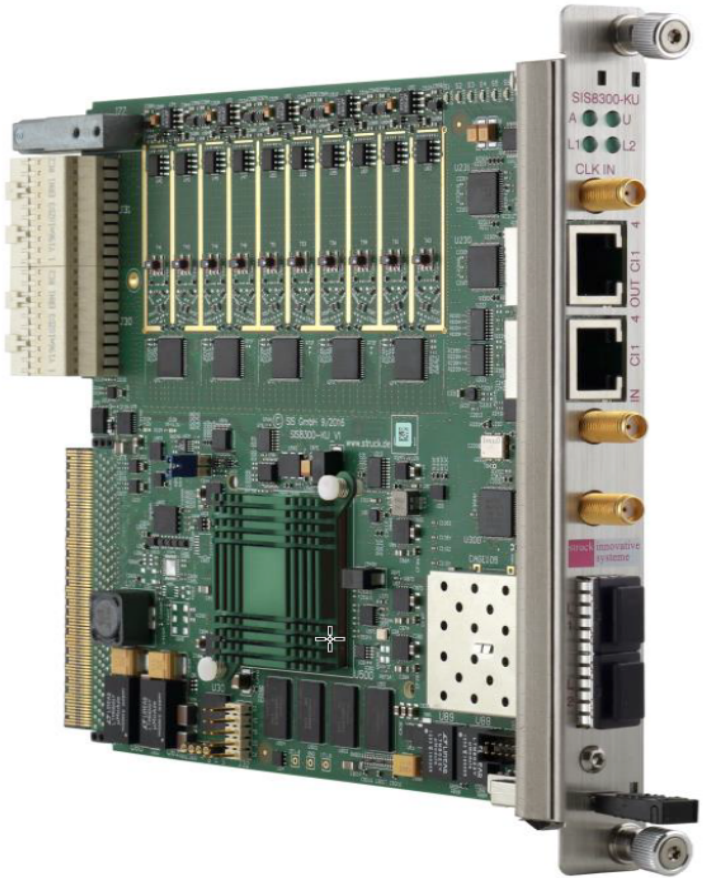


- Signal Postprocessing (Pile Up Recovery Unit) for Higher count rates.
- Multiple algorithms for pile up correction.
- Highest flexibility for the User to select between different algorithms/methods for best possible pileup detection and correction to achieve higher count rates.

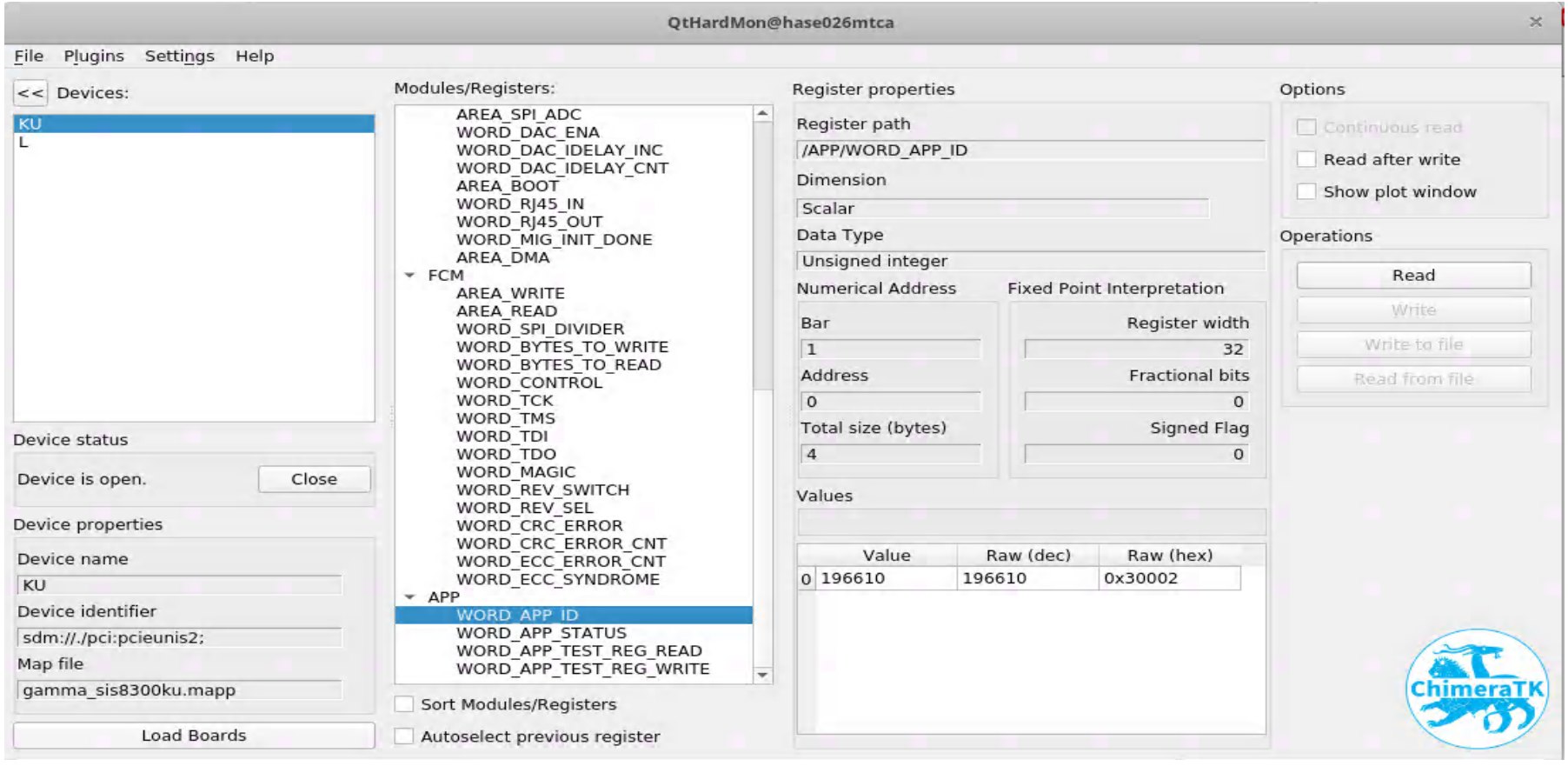
3 Hardware

Hardware

- SIS8300-KU MTCA.4 Digitizer
- 10 channel 125 MS/s digitizer with 16-bit resolution
- FPGA Xilinx Kintex Ultrascale
- AMC .4 µTCA for Physics Board
- 4 Lane PCI Express Gen3 Interface



QT Based GUI


QtHardMon@hase026mtca
File Plugins Settings Help
<< Devices:
KU
L
Device status
Device is open.
Close
Device properties
Device name
KU
Device identifier
sdm://./pci:pcieunis2;
Map file
gamma_sis8300ku.mapp
Load Boards
Modules/Registers:
AREA_SPI_ADC
WORD_DAC_ENA
WORD_DAC_IDELAY_INC
WORD_DAC_IDELAY_CNT
AREA_BOOT
WORD_RJ45_IN
WORD_RJ45_OUT
WORD_MIG_INIT_DONE
AREA_DMA
FCM
AREA_WRITE
AREA_READ
WORD_SPI_DIVIDER
WORD_BYTES_TO_WRITE
WORD_BYTES_TO_READ
WORD_CONTROL
WORD_TCK
WORD_TMS
WORD_TDI
WORD_TDO
WORD_MAGIC
WORD_REV_SWITCH
WORD_REV_SEL
WORD_CRC_ERROR
WORD_CRC_ERROR_CNT
WORD_ECC_ERROR_CNT
WORD_ECC_SYNDROME
APP
WORD_APP_ID
WORD_APP_STATUS
WORD_APP_TEST_REG_READ
WORD_APP_TEST_REG_WRITE
Sort Modules/Registers
Autoselect previous register
Register properties
Register path
/APP/WORD_APP_ID
Dimension
Scalar
Data Type
Unsigned integer
Numerical Address
Bar
1
Address
0
Total size (bytes)
4
Fixed Point Interpretation
Register width
32
Fractional bits
0
Signed Flag
0
Values
Value
Raw (dec)
Raw (hex)
0
196610
196610
0x30002
Options
Continuous read
Read after write
Show plot window
Operations
Read
Write
Write to file
Read from file
ChimeraTK

4 Market Analysis

Market Analysis

Company	FWHM (eV)	Peaking Time (microsecs)
Amptek FASTSDD Detectors	122	4
Vortext ME4 Detectors	145-155	1
Vitus	126	1
Mirion Technologies	145	0.650
This Work	100-155	0.650

5 Conclusion

Conclusion

- Improved Data Anaylsis Algorithms for Energy Dispersive X-Rays Detectors
- Reduced huge amount of data transfer through PCIE as only the spectrum is transferred
- Improved PileUp Events (PileUp Correction)
- Increased Photon Counts
- Improved Energy Resolution (FWHM 100-155 eVs) at shorter shaping times (0.625 microsecs)
- Real Time Data Anaylsis (On-the-Fly Scanning)
- Application firmware was embedded in the MSK board support package
- Qt based GUI for data acquisition, data anaylsis algorithms selection, parameter adjustment and debugging

Source

- Amptek:

  https://www.amptek.com/products/x-ray-detectors/fastsdd-x-ray-detectors-for-xrf-eds/fastsdd-silicon-drift-detector

- Vortex ME4 X-Ray Detector

  https://www.hitachi-hightech.com/hhs-us/product_detail/?pn=ana-vortex-me4

- Vitus

  https://www.ketek.net/sdd/vitus-sdd-modules/

- Quantum Detectors

  https://quantumdetectors.com/

- SXD15M-150-500-TO8 Silicon Drift Detector SDD

  https://www.mirion.com/products/sxd15m-150-500-to8-silicon-drift-detector-sdd

Source

- Struck innovative systeme:

  https://www.struck.de/

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Thanks!

Any questions ?

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