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Technology

# XH Germanium Microstrip Detector for EDAS.

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STFC Daresbury Laboratory

- Brief History of EDXAS detectors at STFC
  - Photodiode array (PDA)
  - Prototype Si microstrip
  - XCHIP
  - XSTRIP
- XH
  - Technical details
  - Experimental results
- Developements

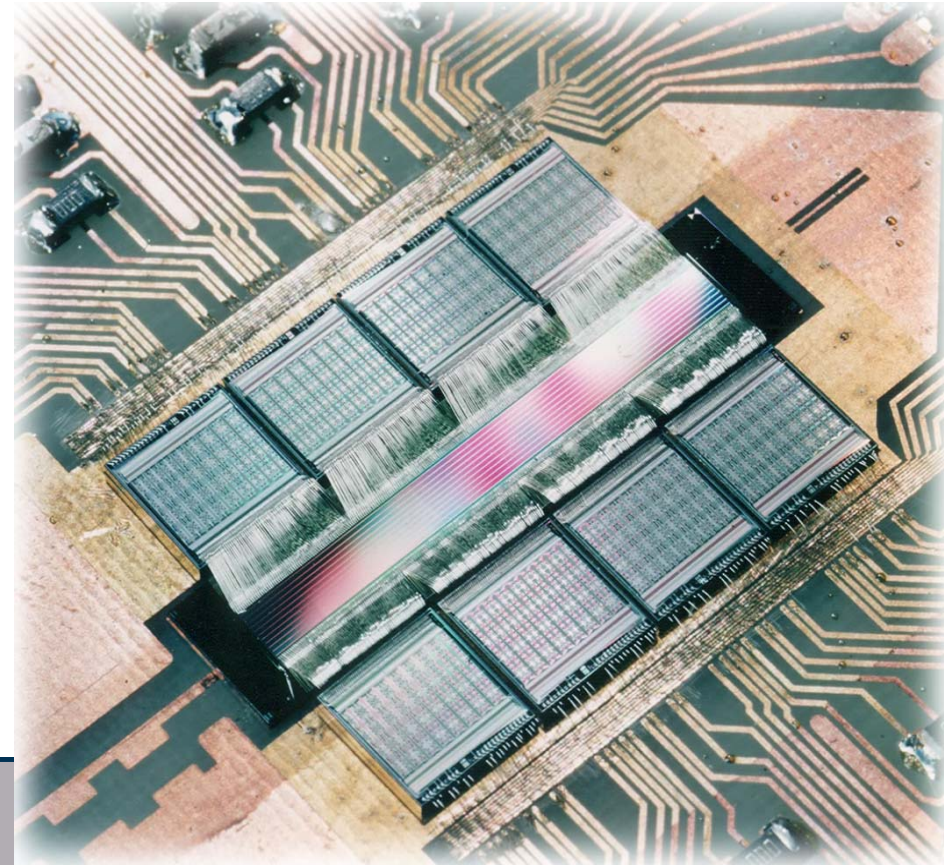
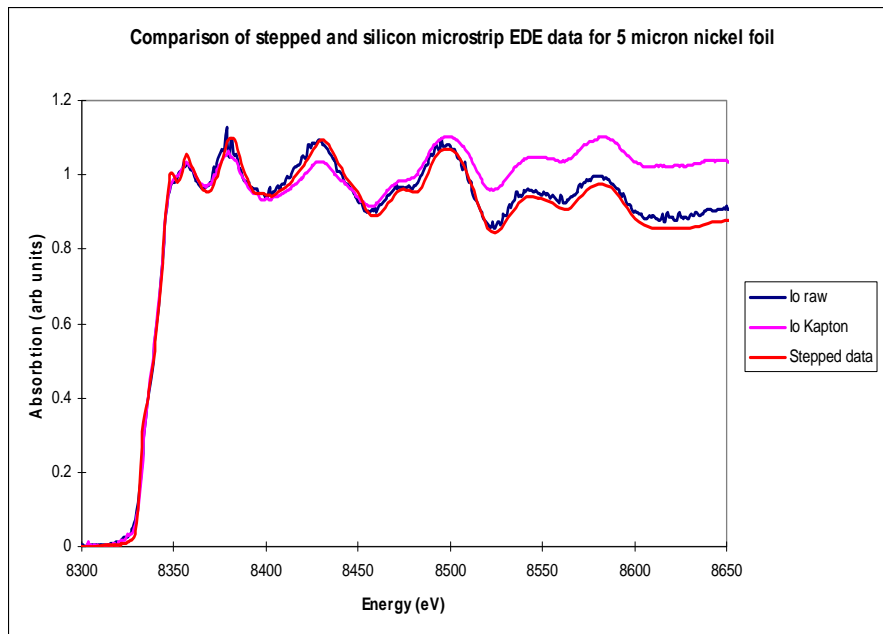


- 512/1024 strips
  - Hamamatsu and Reticon devices
- 1ms frame rates
- Efficiency poor
- Radiation damage

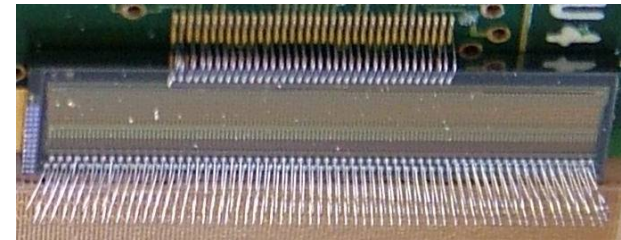


# Prototype Si microstrip

- Building on the Si microstrip technology and the MX4 readout ASICs implemented in particle physics detectors
- Prove that a system could be developed.



*High frame rates and high linearity for the XH and XSTRIP detectors are accomplished by using custom designed ASIC frontend the **XCHIP***



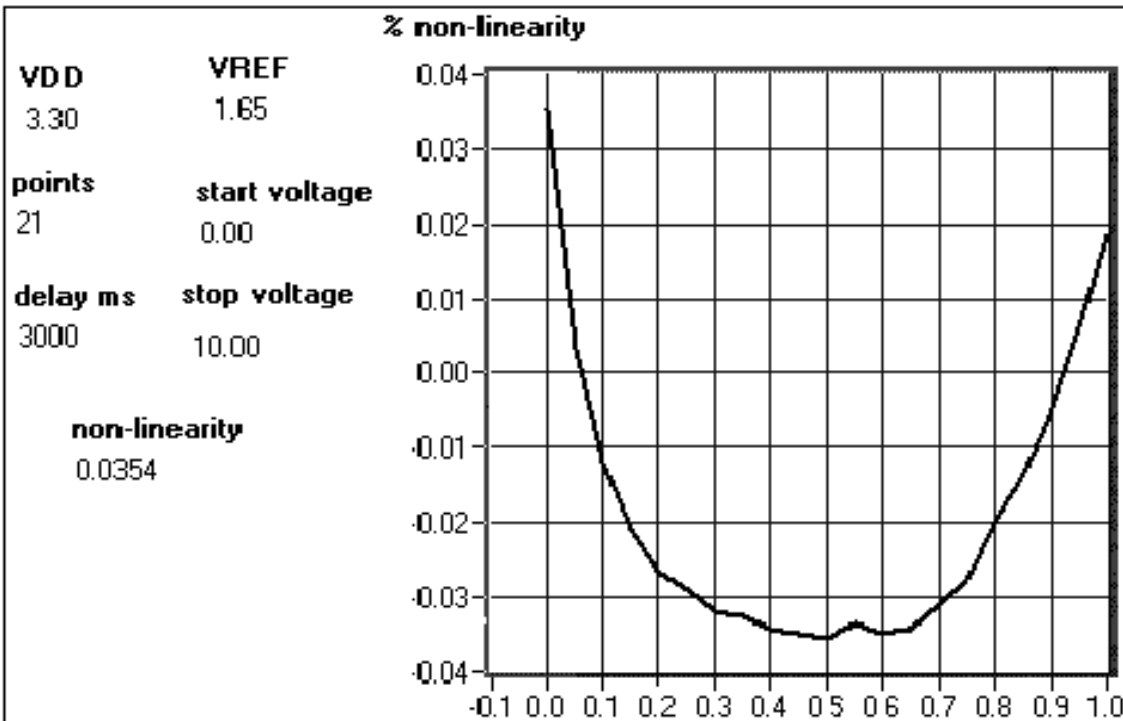
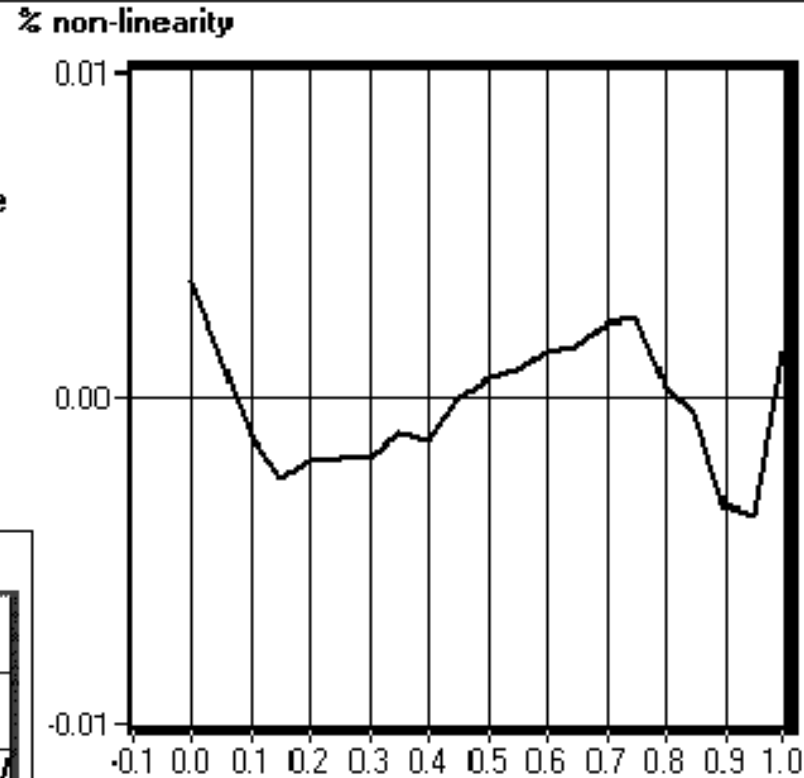
## **The XCHIP is: 128-channel integration amplifier array with data storage and multiplexed outputs**

- Data storage – allows simultaneous readout and integration
- Multiplexing allows reduction of 128 channels to 4 (or 1) output node
- Integration time  $\sim 1\mu\text{s}$  to  $\sim 1\text{s}$
- Feedback capacitor 2pF or 10pF
- Maximum charge 15pC positive, 10pC negative (for 10pF feedback)
- Gain -500mV/pC (2pF) or -100 mV/pC (10pF)
- Noise at output  $< 50\text{ mV rms}$
- Non-linearity  $< 0.1\%$  over +10pC dynamic range
- Output settling 200ns (to within 0.1mV of final value)

# XCHIP linearity

For EDXAS the linearity is everything

<b>VDD</b>	<b>VREF</b>
4.00	1.80
<b>points</b>	<b>start voltage</b>
21	0.00
<b>delay ms</b>	<b>stop voltage</b>
3000	10.00
<b>non-linearity</b>	
0.0036	







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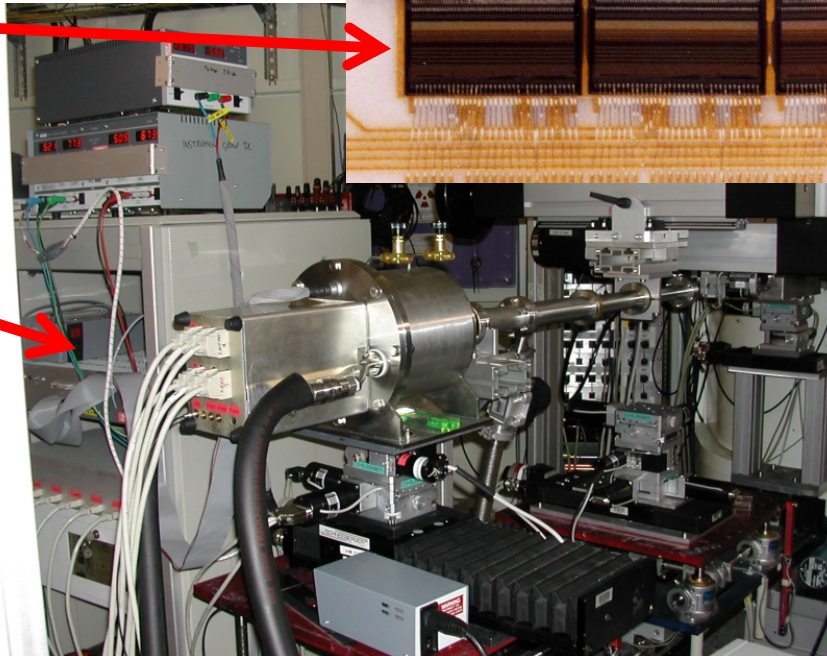
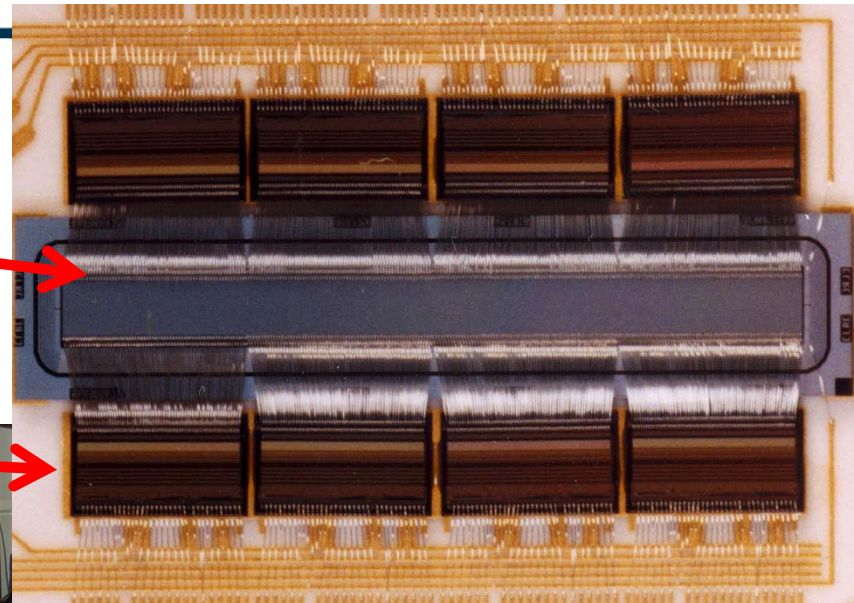
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# XSTRIP

*500 $\mu$ m thick Si detector 1024 strips, 25 $\mu$ m pitch*

*8 XCHIPs providing the parallel readout*

*32 channel DAQ system*



XSTRIP on ID24



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XH

## Worlds first 1024 strip 50um pitch Ge detector

Designed to address-:

- Detection Efficiency.
- Radiation Damage.



XH on ID24

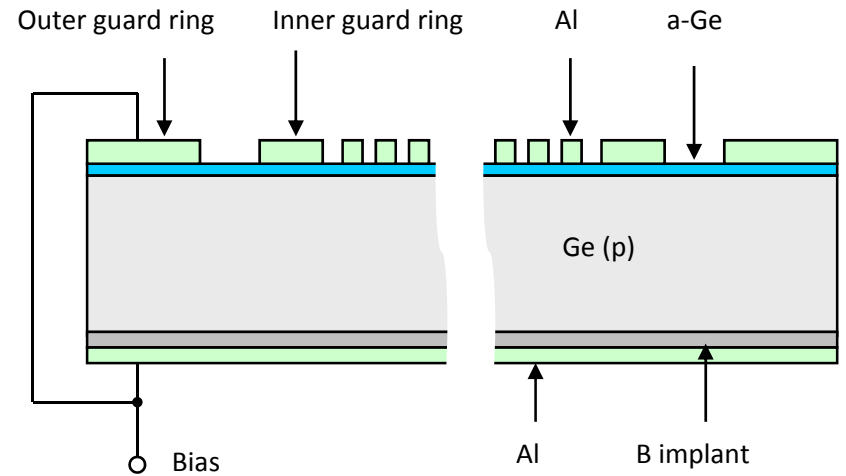
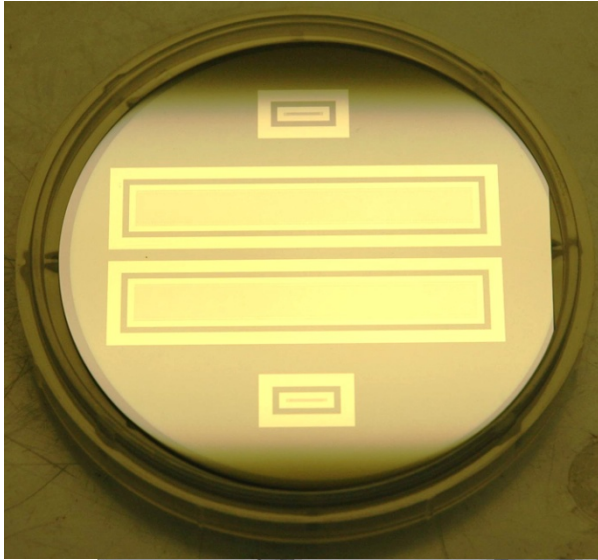




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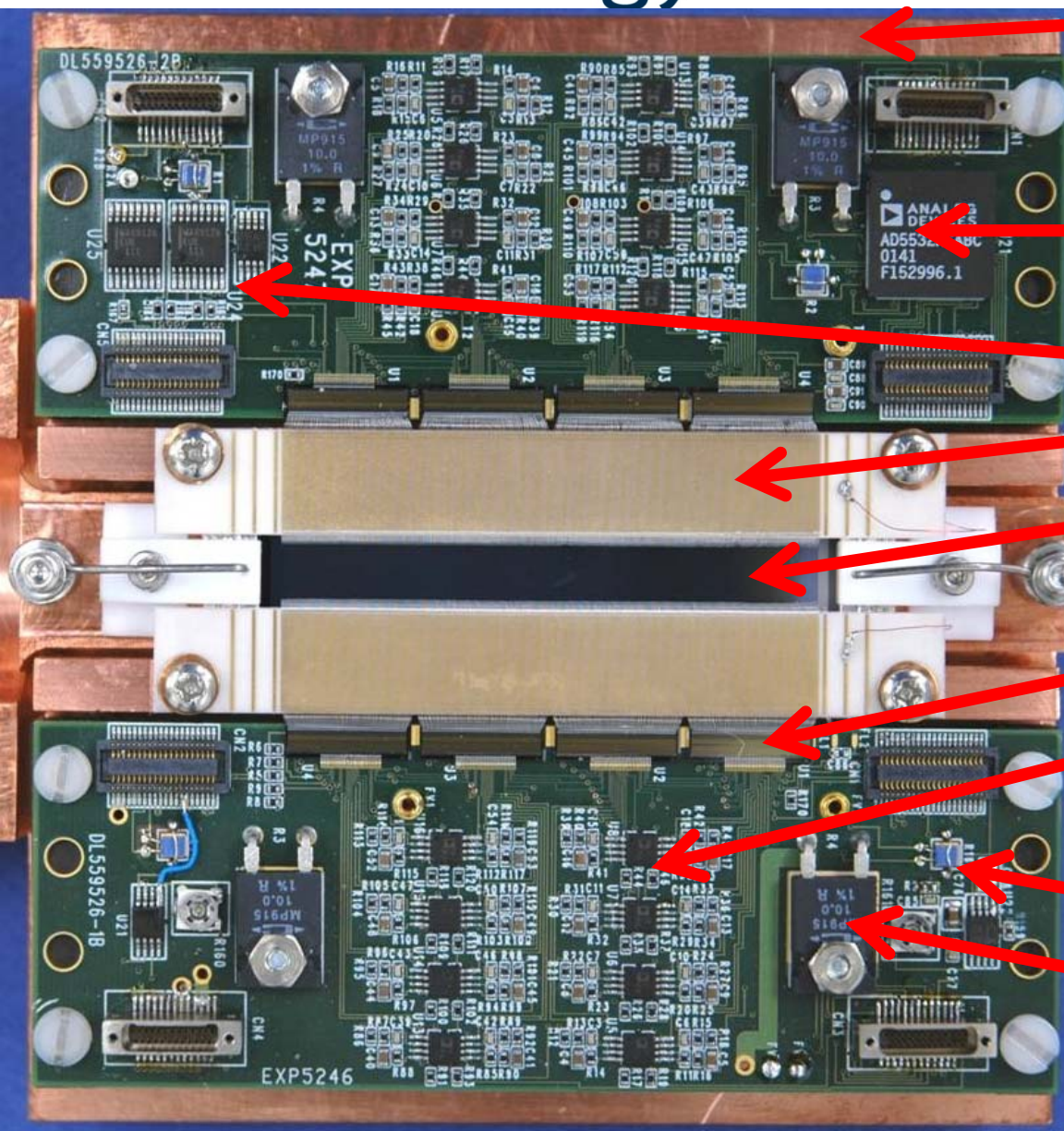
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## Ge Sensor





## XH detector head



Cold plate

Thermally isolated readout circuit (230k)

32 channel DAC (offset control)

LVDS control signal inputs

Ceramic thermal break

Ge sensor (105k)

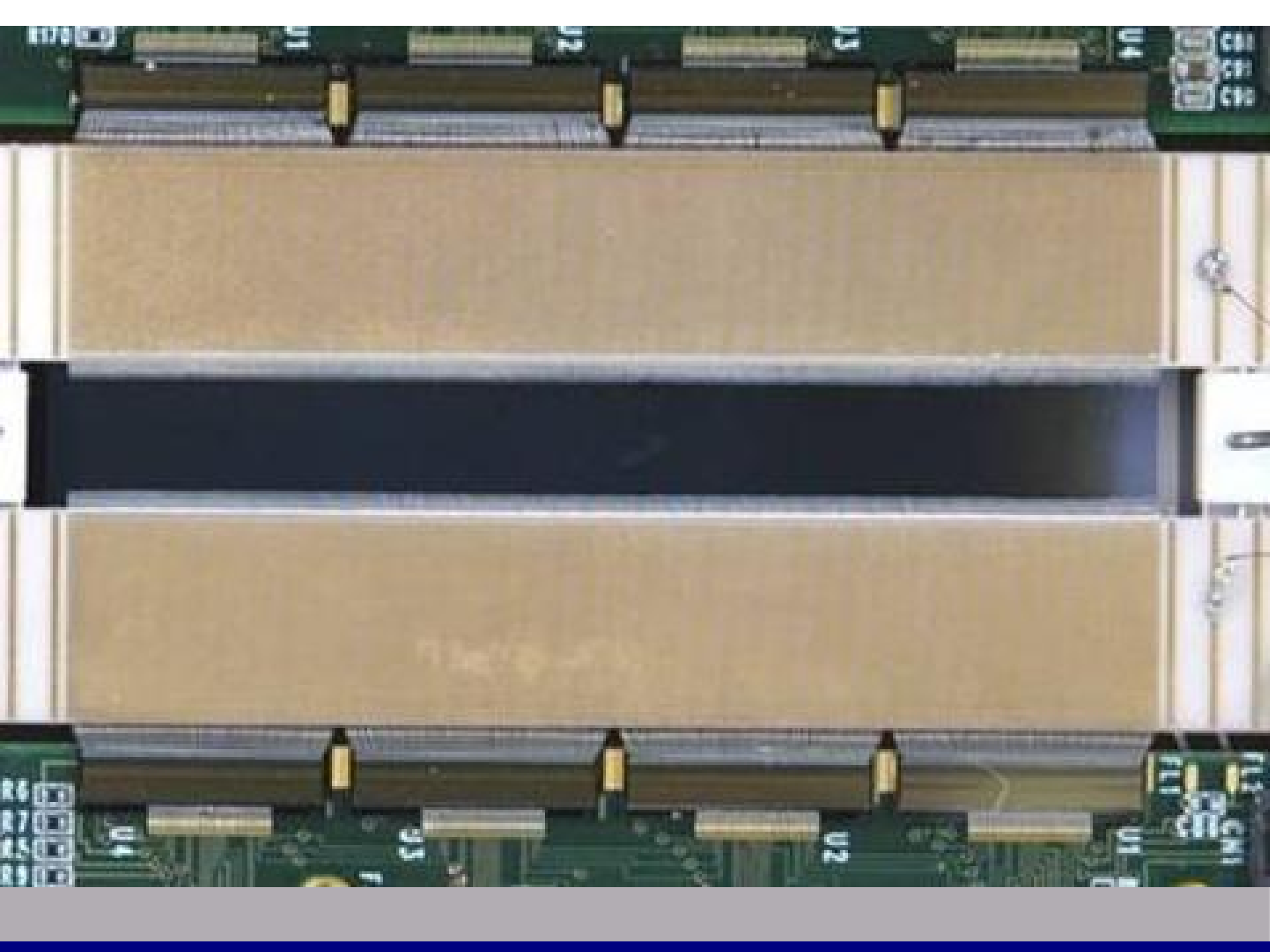
X2CHIP readout ASICs (x8)

32 Buffer amplifiers

Thermal control via

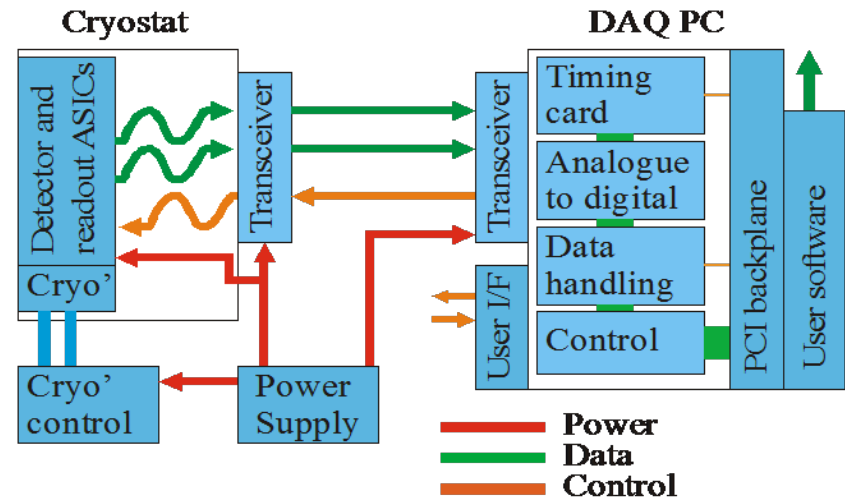
- PT100

- Power Resistors





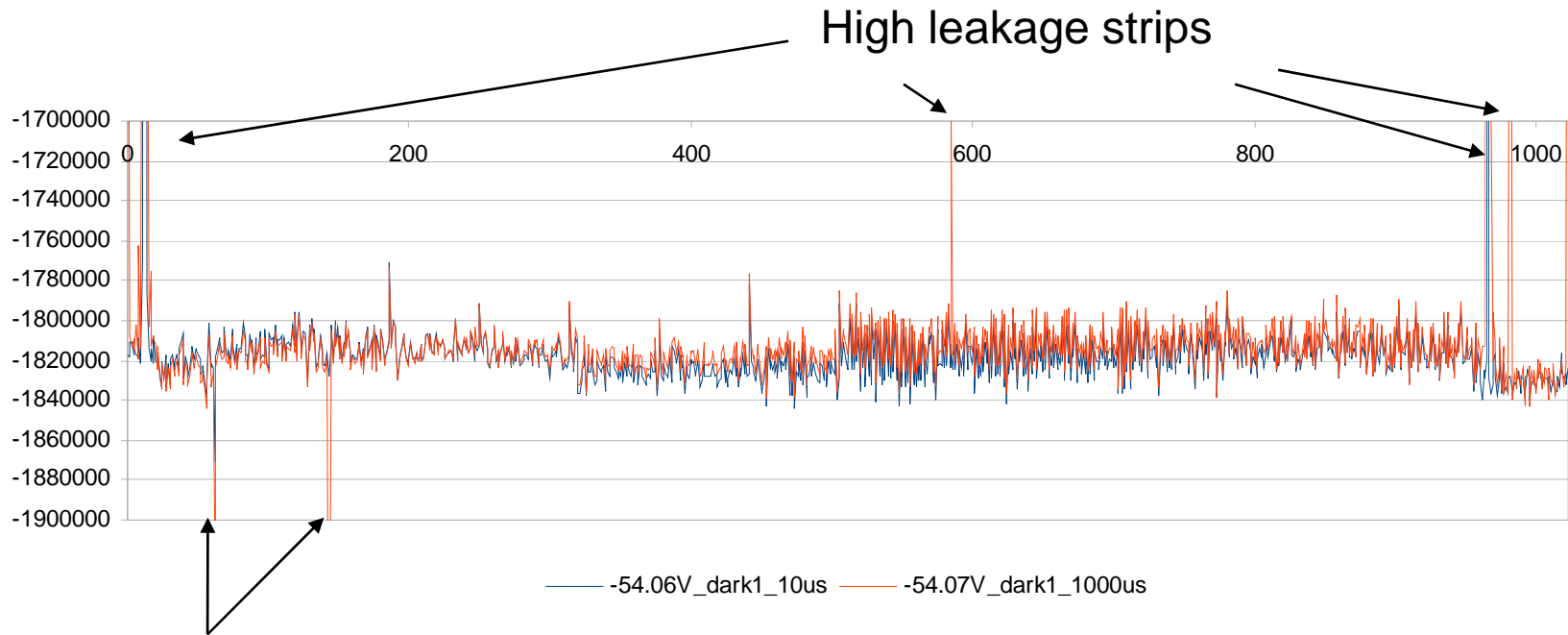
- PC Based
- What we have now:
  - PC running XP, hosting
  - 32 ADC channels, 14 bit 10MHz (running at 4.16MHz)
  - 2 large Xilinx FPGA carrying out data accumulation
  - 2 DSP processors – acting as host interface processors
- DAQ specific
  - Readout in 10us
  - Frame storage 20us
  - 1700 frames







## Radiation tolerance: Dark current baseline



Faulty readout circuit

Data taken prior to start of experimental beamtime on ESRF ID24

**Average dark current ~ 26.6pA**

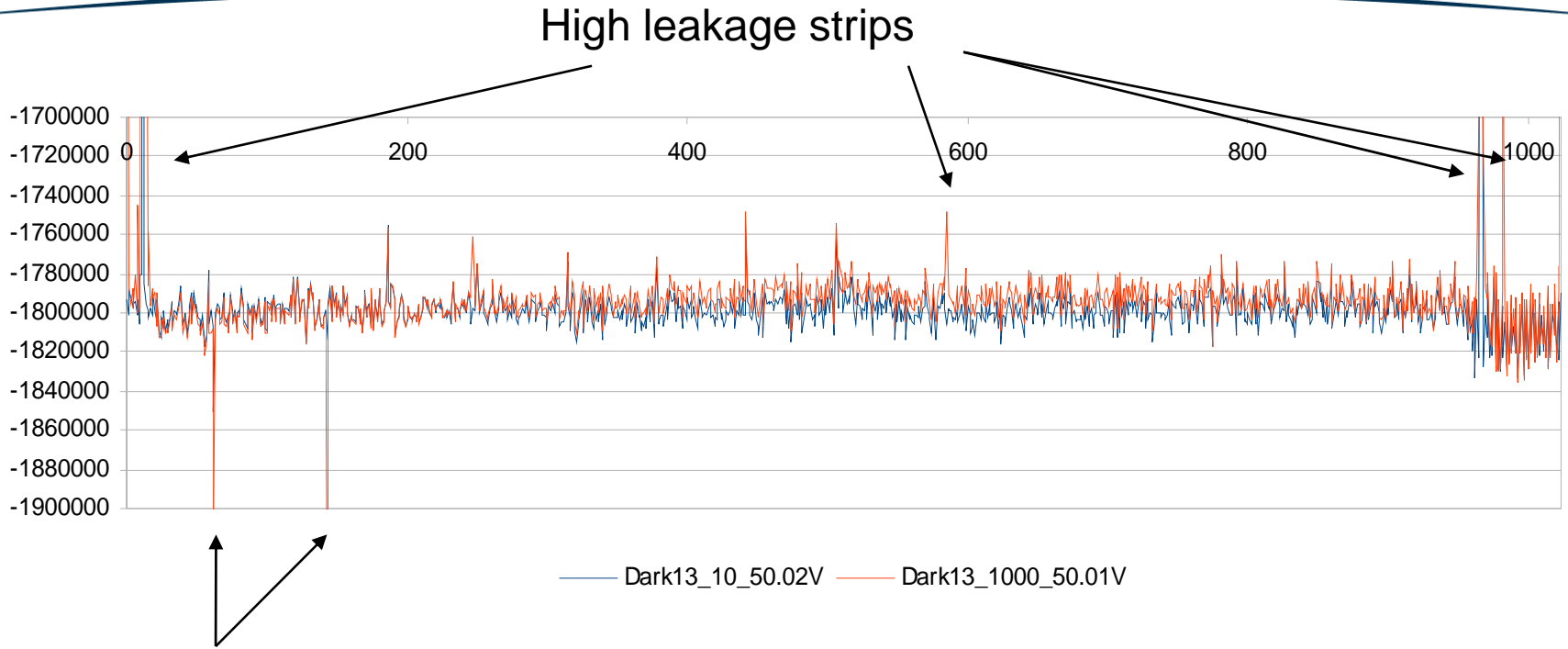




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## Radiation tolerance: 1 week of beamtime



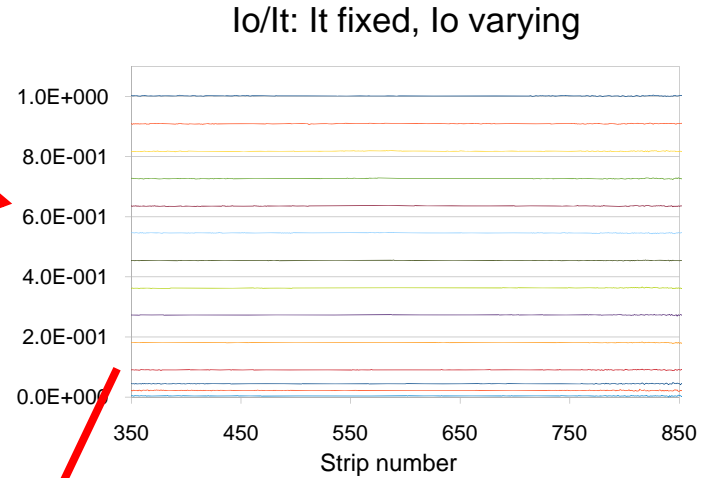
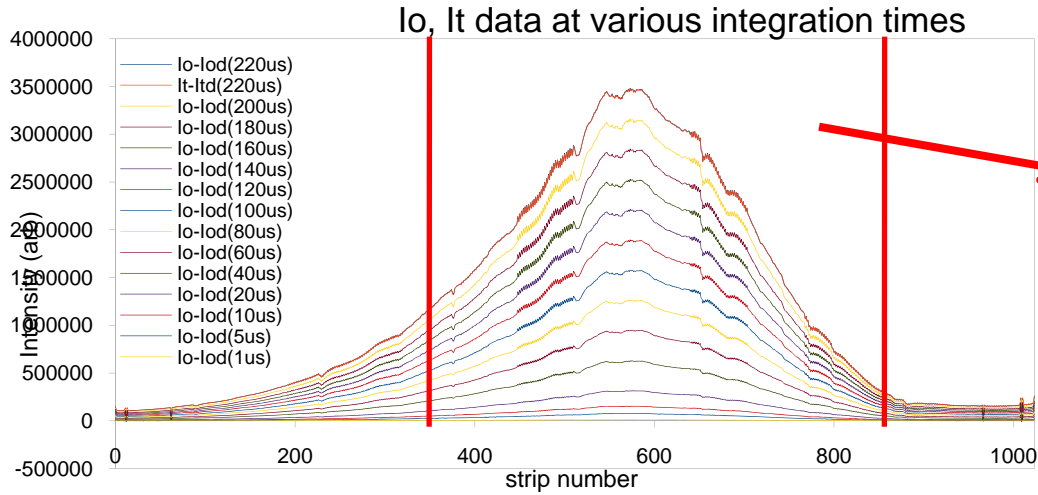
Faulty readout circuit

Data taken at completion of experimental beamtime on ESRF ID24

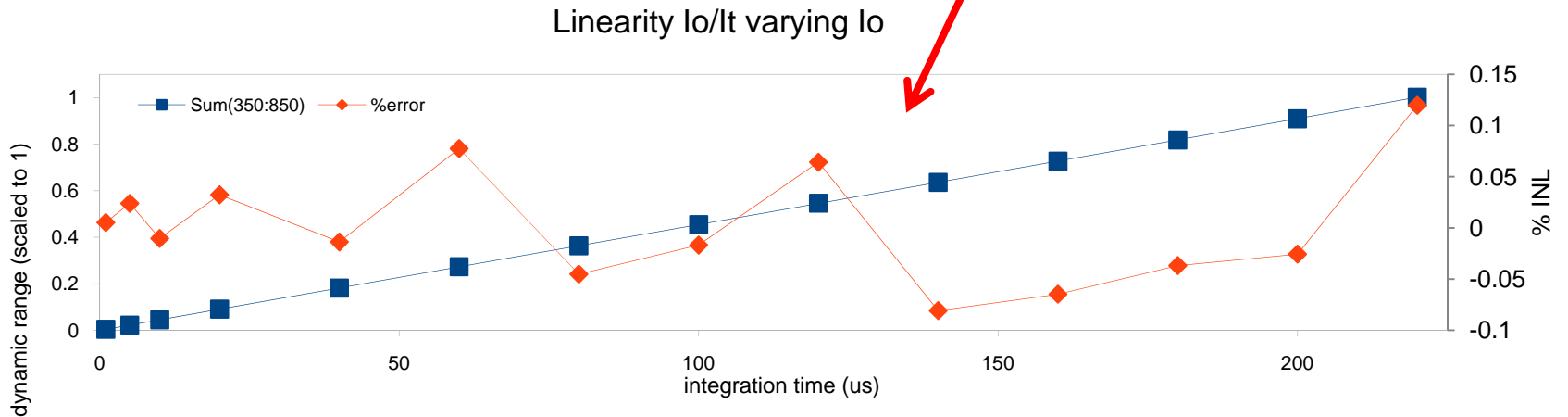
**Average dark current ~ 29.9pA**

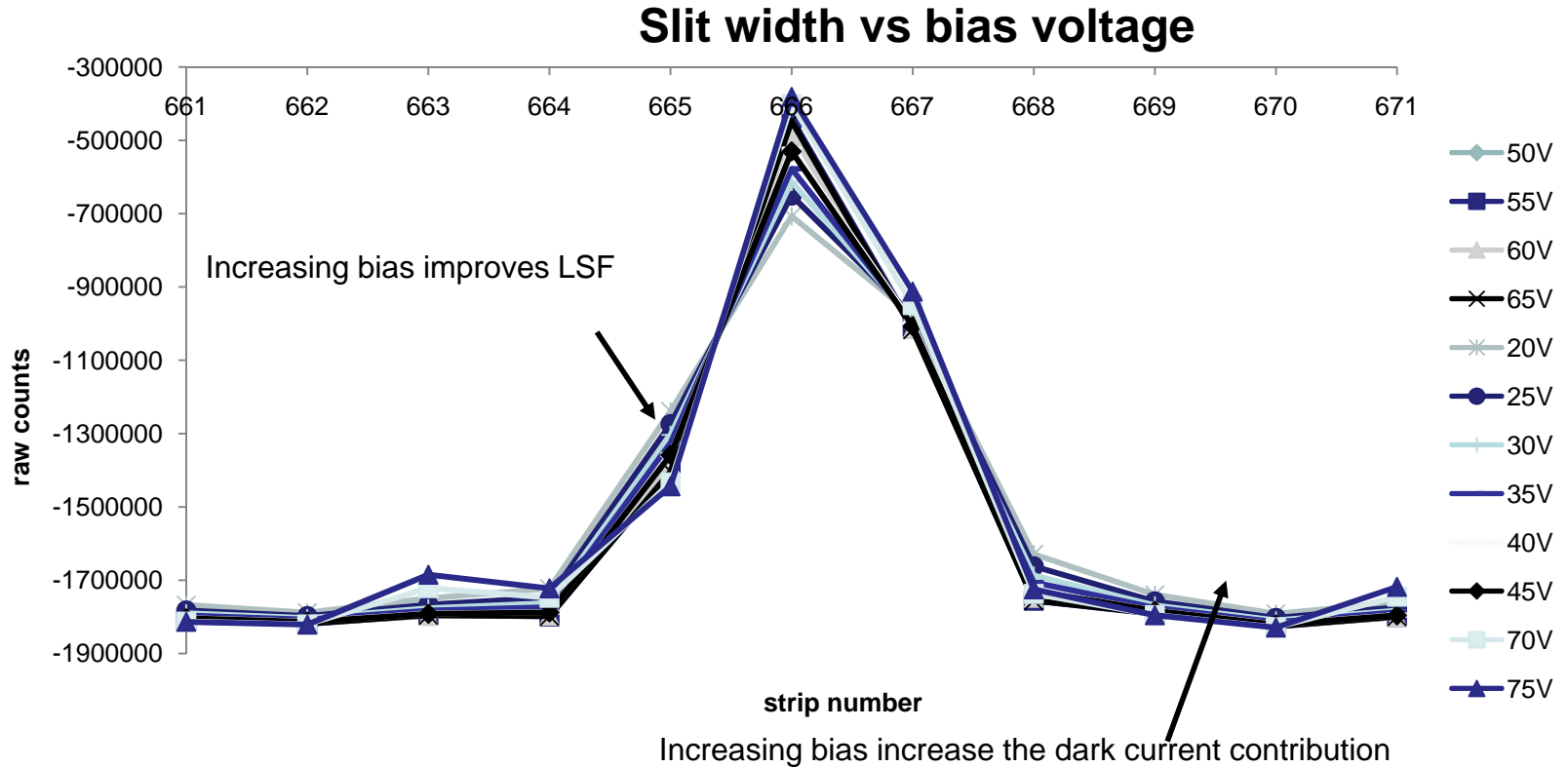


## System Linearity



Linearity data taken from measurement of ESRF-ID24 undulator profile





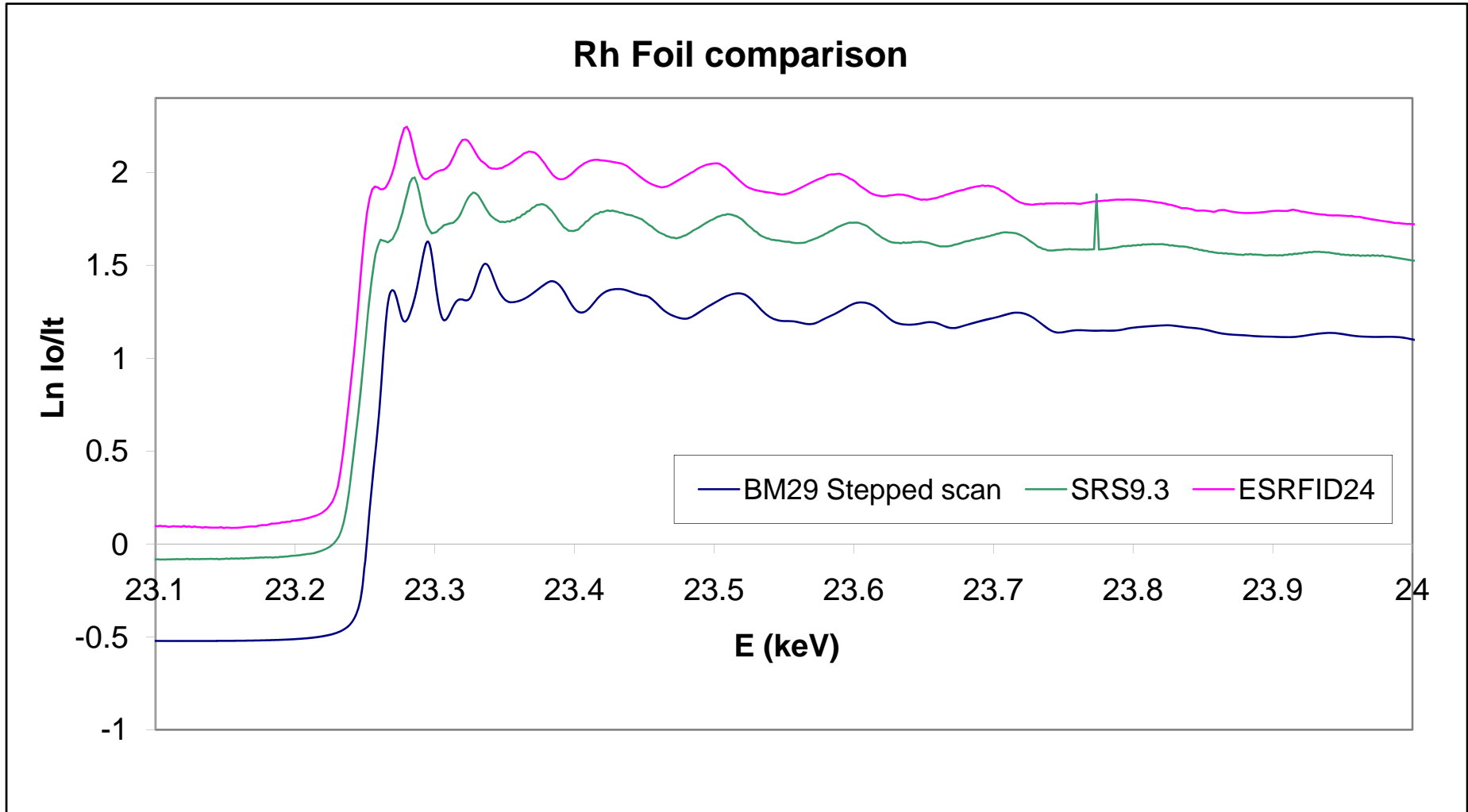
At a bias of  $\geq 50V$

- spatial resolution  $\sim 3$  strips FWHM LSF

At a bias of  $50V$

- minimised dark current noise

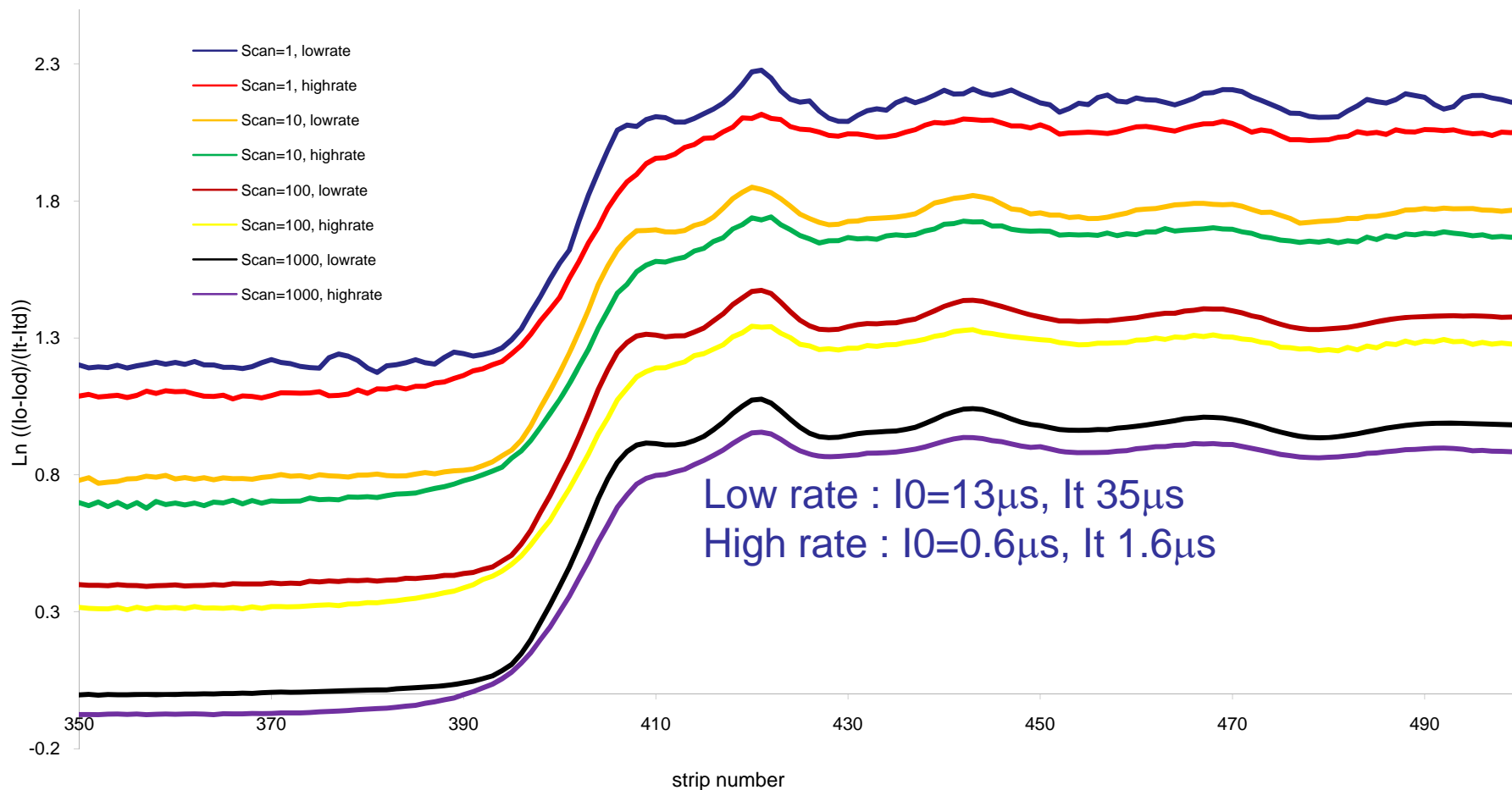
# Spatial resolution - Rh foil





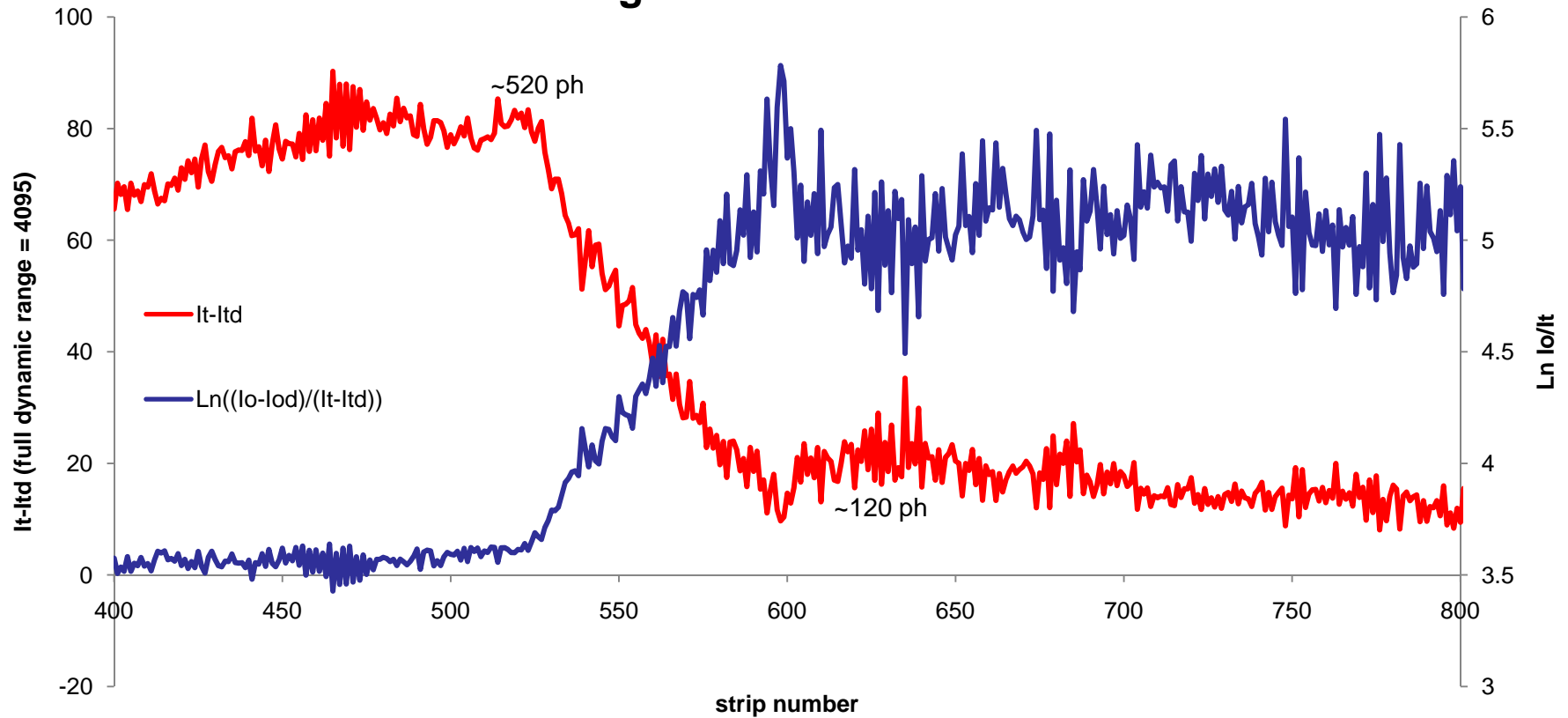
# More Spatial resolution - Rh foil

Rh foil, accumulated readouts at low and high rates



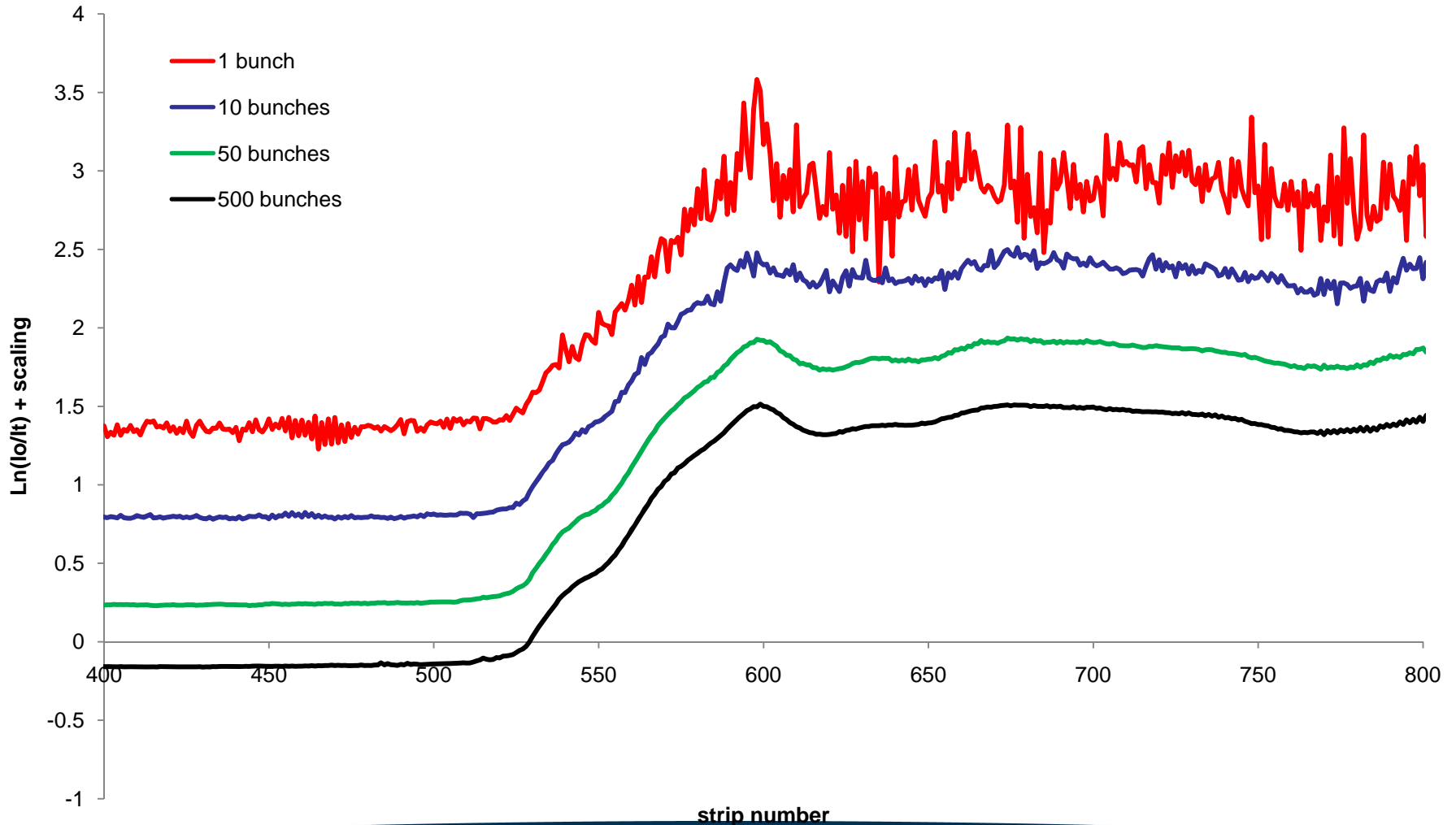


## Single bunch Fe foil



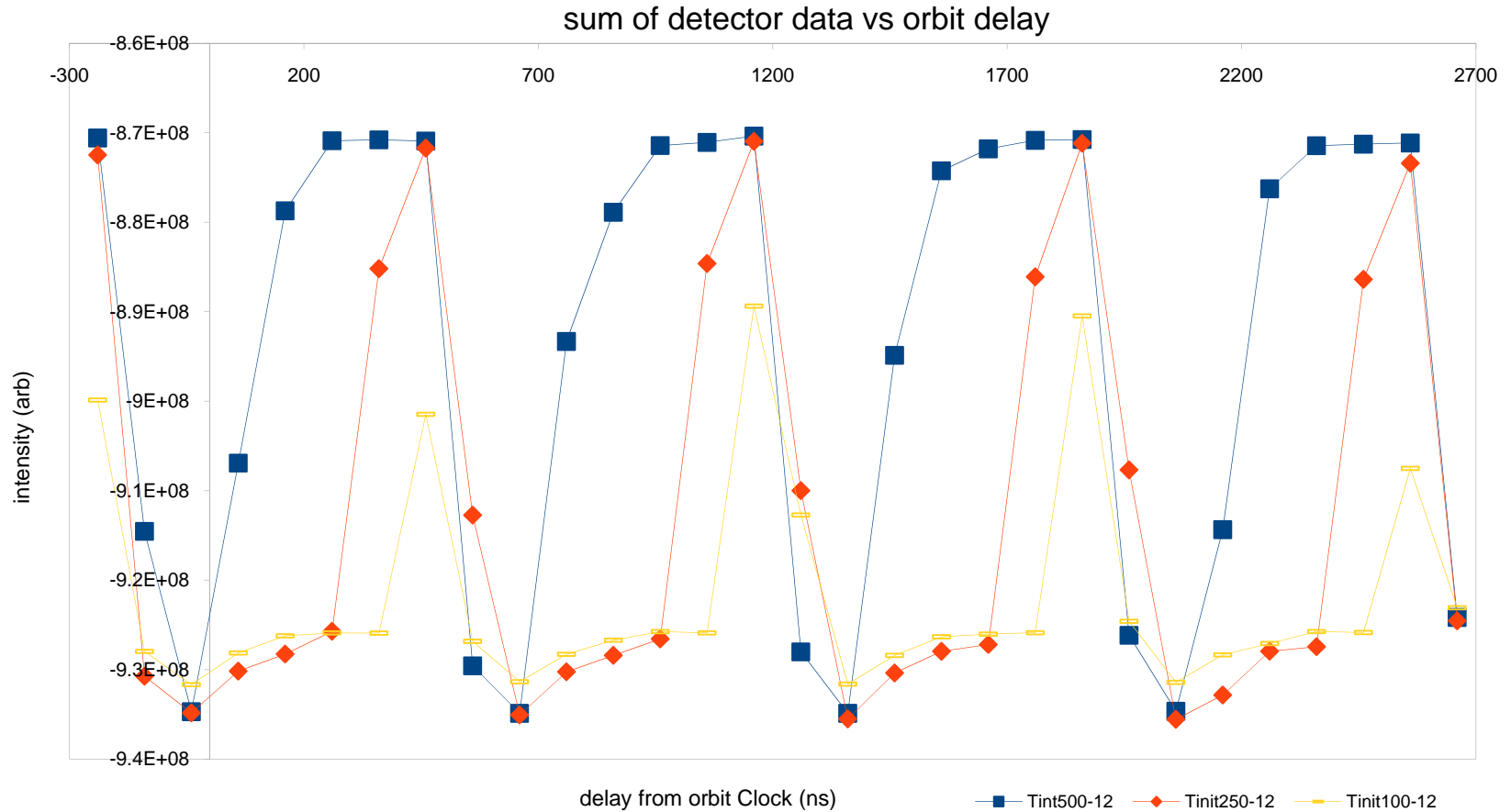
ESRF 4 bunch mode, 700ns gaps, capture a single bunch

## Fe foil for various numbers of bunches





## Recording bunches around orbit





- Development with DLS I20
- New Ge sensor from LBNL
- New readout system for detector being developed by P Coleman-Smith for the AIDA nuclear physics programme – currently awaiting final project approval
  - Support up to 2048 strips via 64 ADC channels
  - FPGA data acquisition system running LINUX with Gbit Ethernet connectivity .
  - Increased sampling rate
  - Support 7.5 $\mu$ s readout and frame storage
  - Support 65536 frames
  - Support for integration times <500ns (aiming for 300ns) – readout time will remain at 7.5 $\mu$ s incurring dead time



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## Longer term developments

- New XCHIP is designed for high linearity not high speed - Potentially a new XCHIP design that trades off linearity (and signal to noise) specifically for single bunch experiments
- 1536 element Ge – currently the limit of the wafer diameter
- 2048 element Si device
- IO measurement – concurrent IO would greatly improve data quality. This needs to be addressed.





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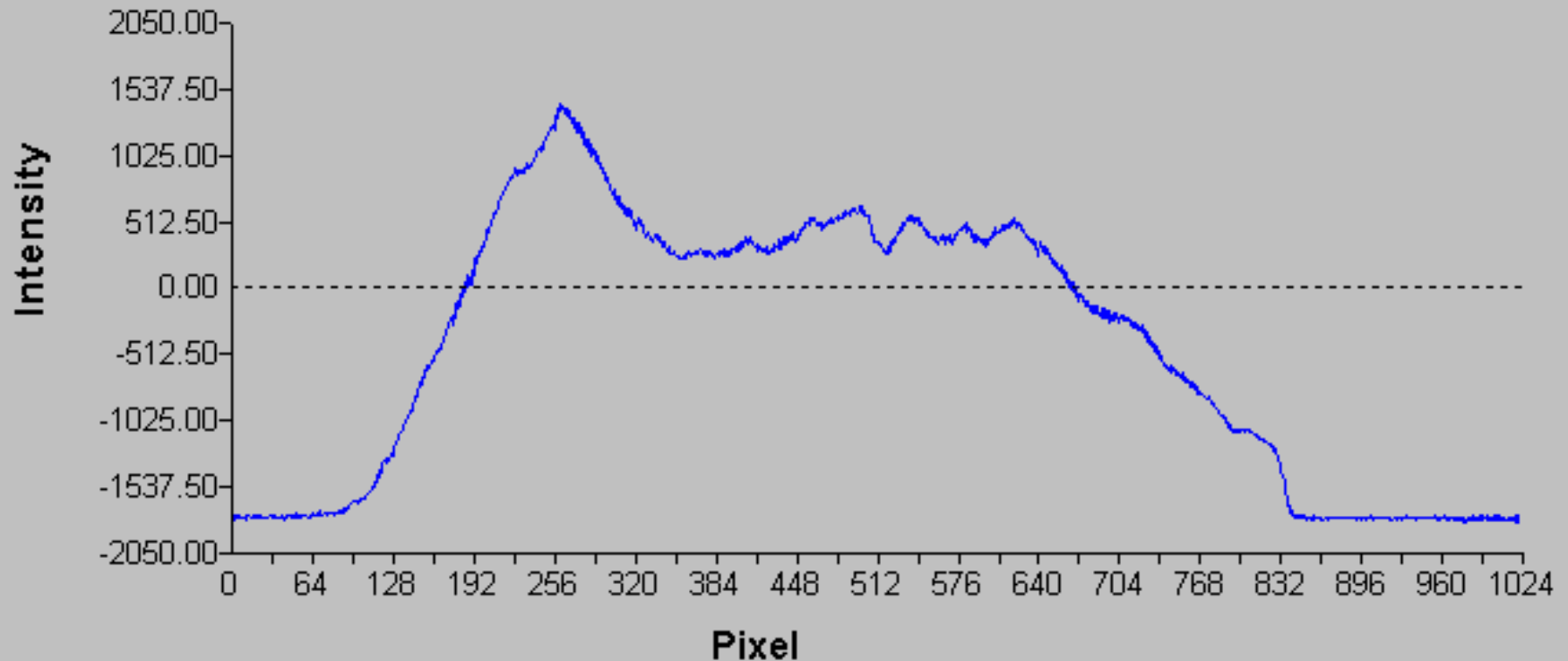
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## Acknowledgements – in no particular order!

- **LBNL**
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- **STFC**
  - G Salvini, M Kogimtzis, S L Thomas, R Farrow,  
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- **Southampton University**
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- **DLS**
  - **A Dent**, **S Diaz-Moreno**, **T Rayment**
- **ESRF**
  - **O Mathon**, C Ponchut, S Pascarelli, Mark Newton

# Scan Showing beam movement on Id24

Absorption frame : 0 Time : 0us



End

End



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Germanium 1024 strips	Silicon 1024 strips
50um pitch	25um pitch
5mm Strip length	2.5mm Strip length
1mm Thick	500um Thick
Leakage current <30pA	Leakage current <10pA
100v bias	70v bias
Energy Range 5-40Kev	Energy Range 5-15Kev



- Detection medium
- Ge
- Number of strips
- 1024
- Strip pitch
- 50mm
- Strip length
- 5mm
- Detector thickness
- 1mm
- Energy range
- 5 - 40keV.
- Efficiency @ 30keV