Progress towards a 256 channel multi-anode microchannel plate photomultiplier system with picosecond timing

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University of Leicester
Space Research Centre

Outline

- Concept
- Applications
- Prototype development
- 256 channel detector system (IRPICS)
  - Detector design
  - Integrated electronics
  - System design
- Future work

System concept

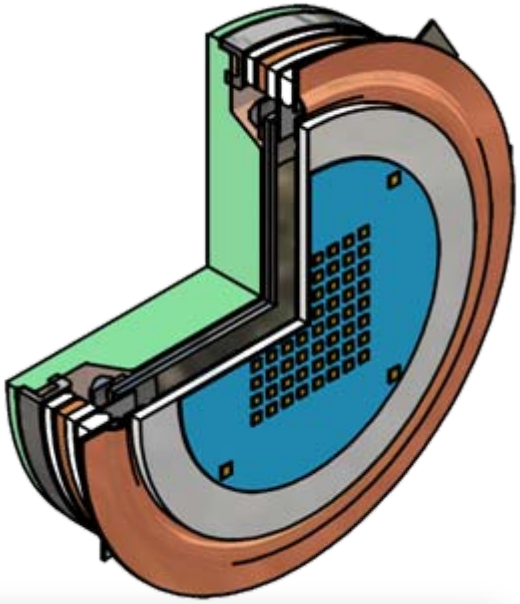
A High Content detector for life-science applications

- Imaging or simultaneous event detection
- High density multi-anode readout
- True single photon counting
- Picosecond timing for time resolved spectroscopy
- Parallel multichannel readout for high throughput
- Integrated detector and electronics
- Adaptable, multi-purpose digital processing

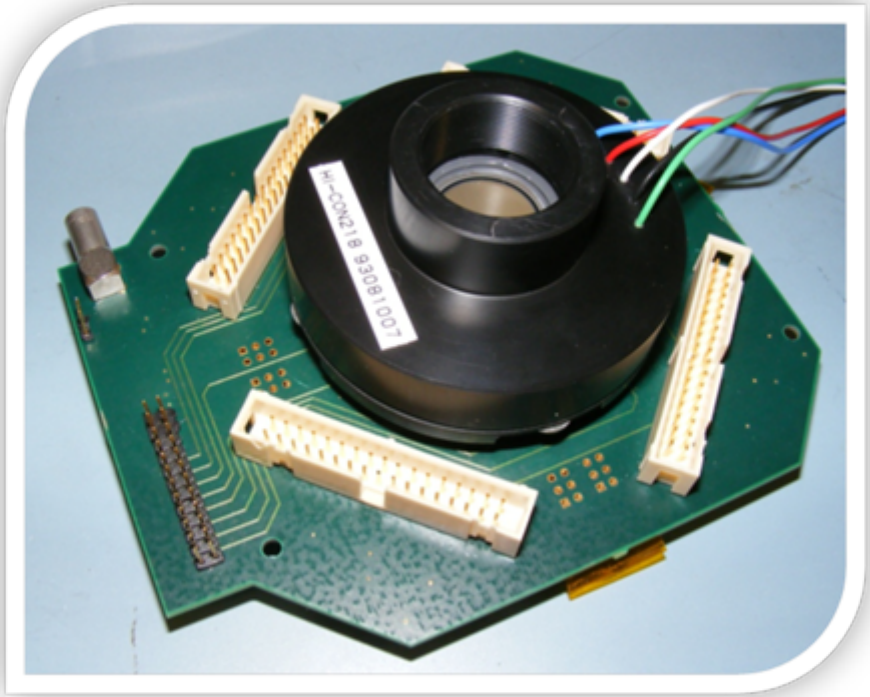
Applications

- Proteomics – study of protein interactions *in vivo*
  - E.g. High throughput bioassay for drug discovery
- Purposefully adaptable for
  - Fluorescence lifetime imaging
  - Fluorescence correlation spectrsocopy
  - Optical tomography
  - Confocal microscopy

The prototype design

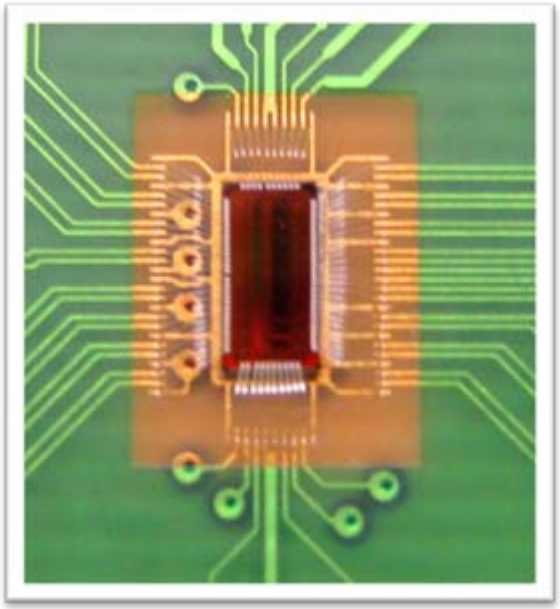


- 8 x 8 multi-anode readout
  - Multilayer ceramic construction
- Two chevron stacked 3 µm pore microchannel plates
  - <100 ps pulse rise time
  - Chevron MCP stack with >10^6 gain
- Integrated multi-channel electronics
  - CERN NINO 8 channel preamplifier ASICs
  - CERN HPTDC (Caen V1290A VME module)

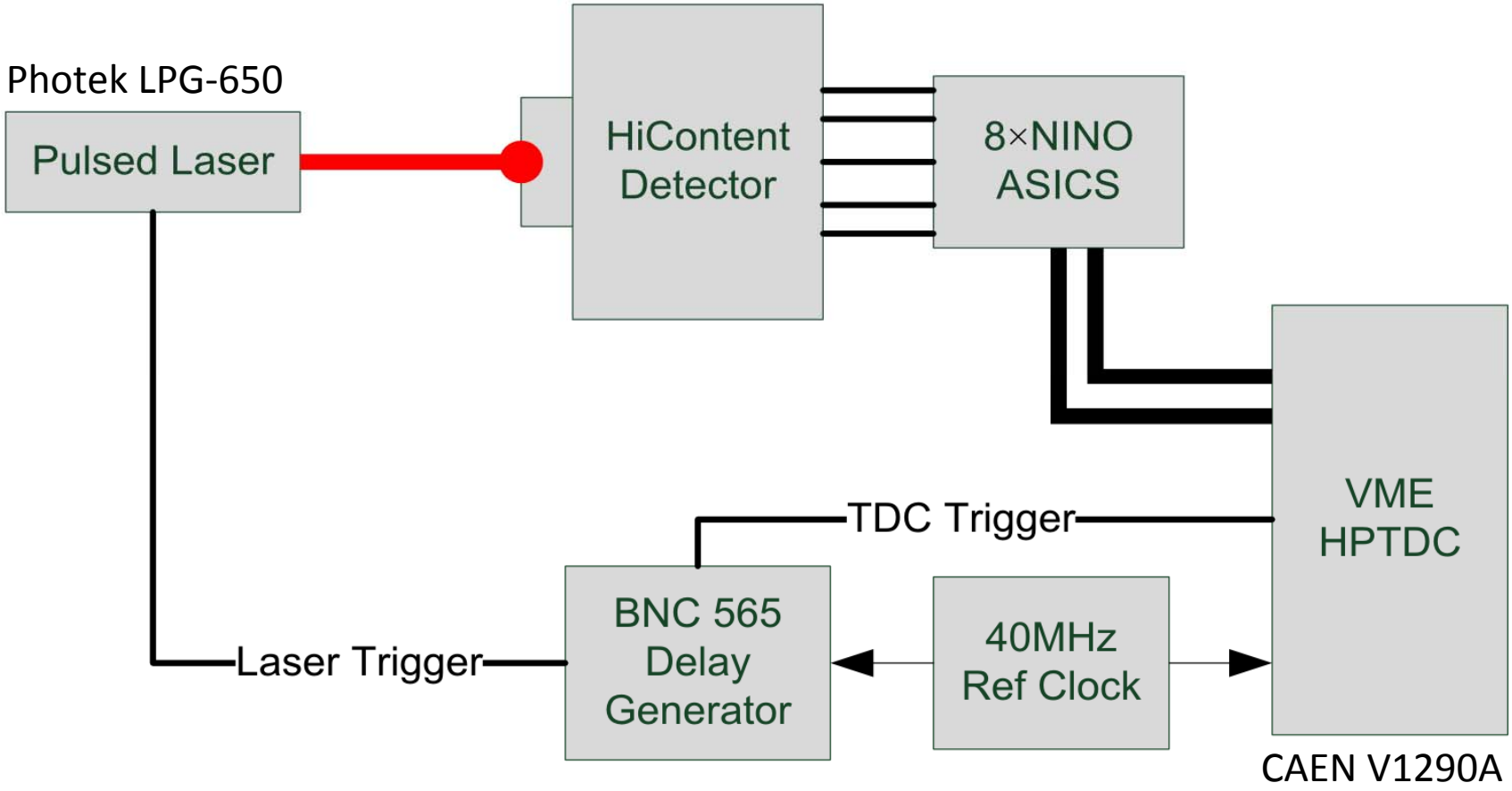


Electronics – NINO Amplifier/Discriminator

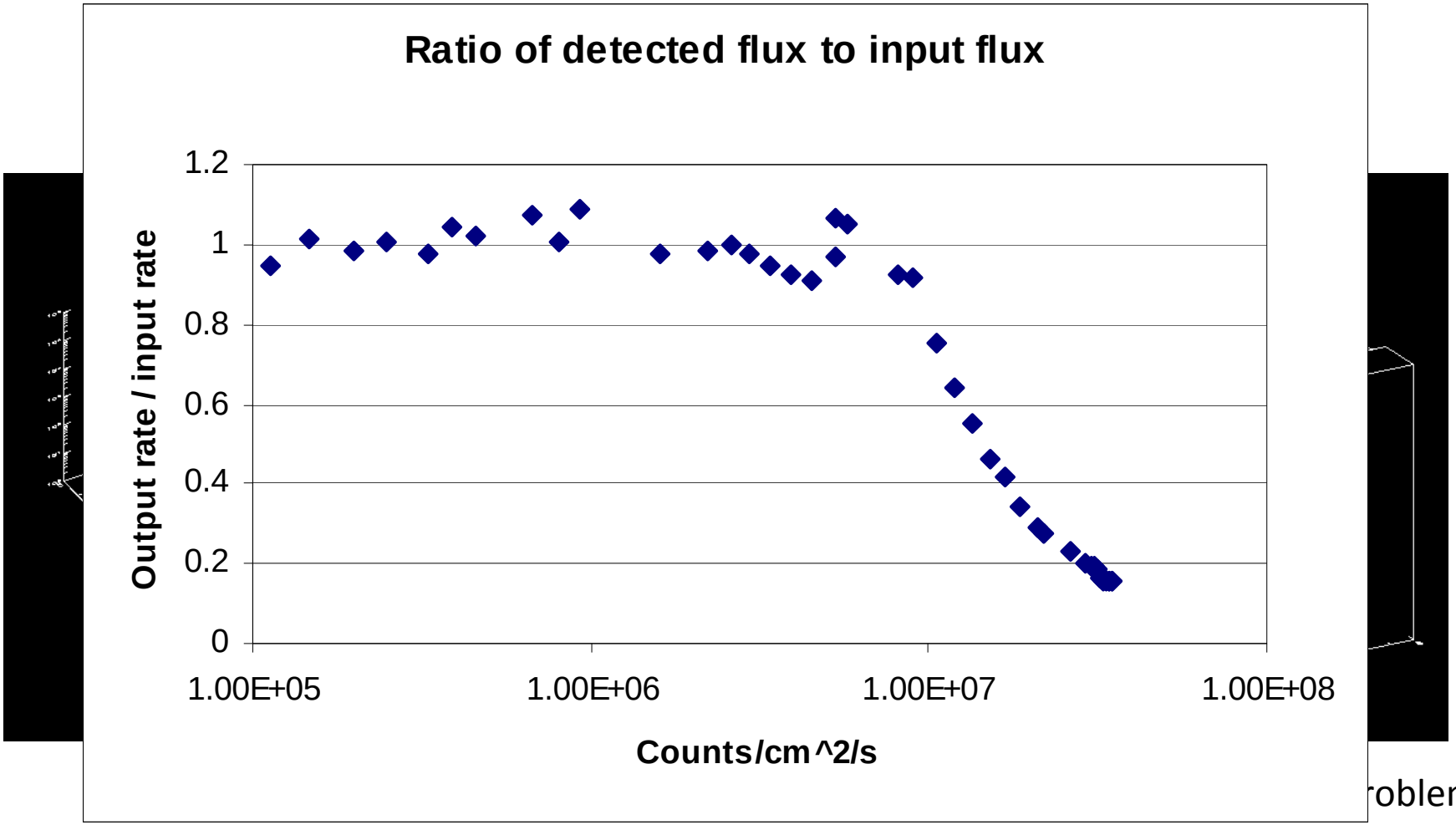
- Originally an 8 channel differential amplifier/discriminator, using a Time-over-Threshold technique
- 32 channel version developed for IRPICS detector
- Excellent time resolution <10 ps RMS jitter on the leading edge
- Differential LVDS outputs for common-mode noise rejection
- High Dynamic Range, 30 fC to 2 pC



HiContent – Timing Jitter



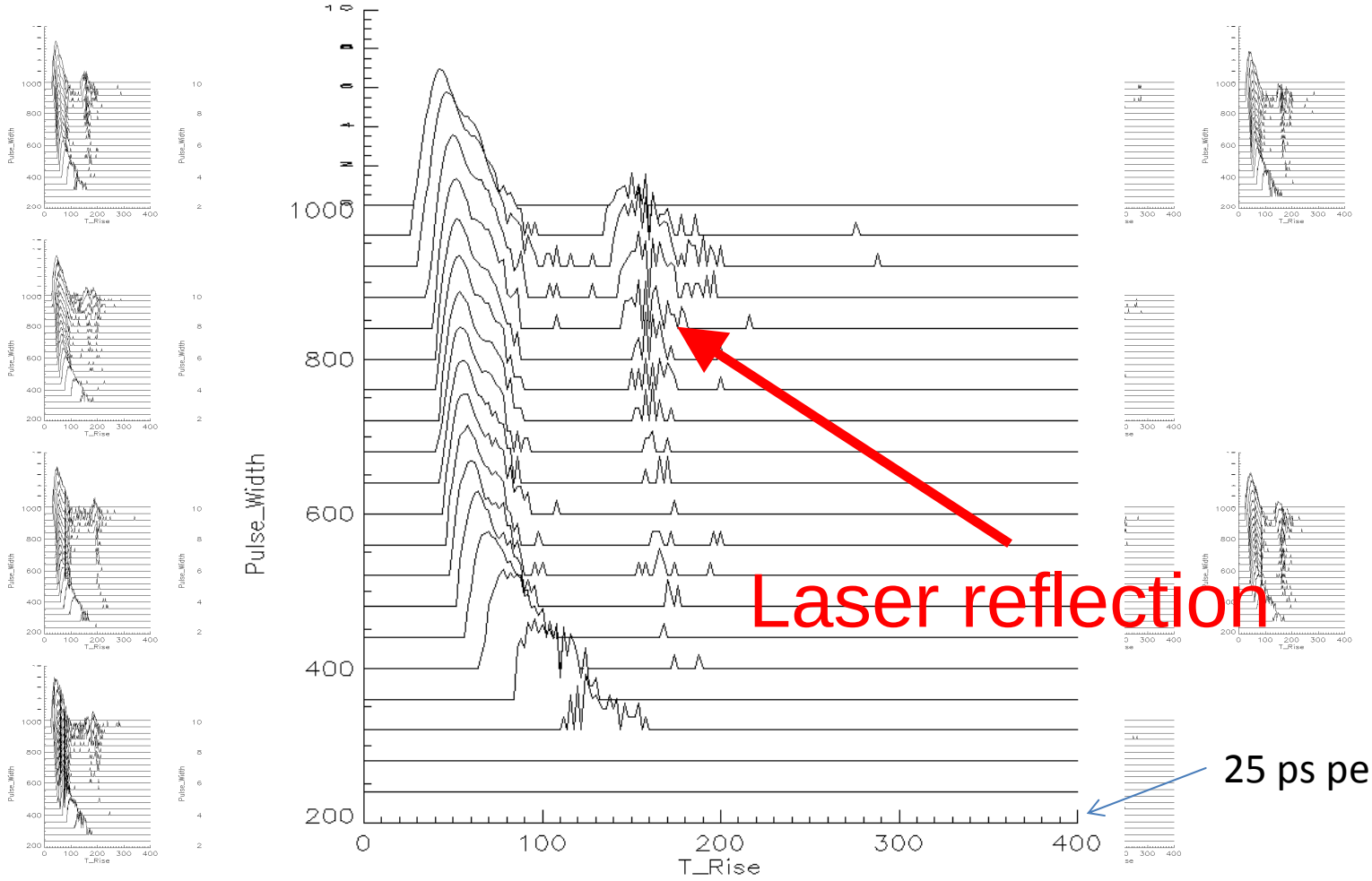
Prototype – first results



roblem

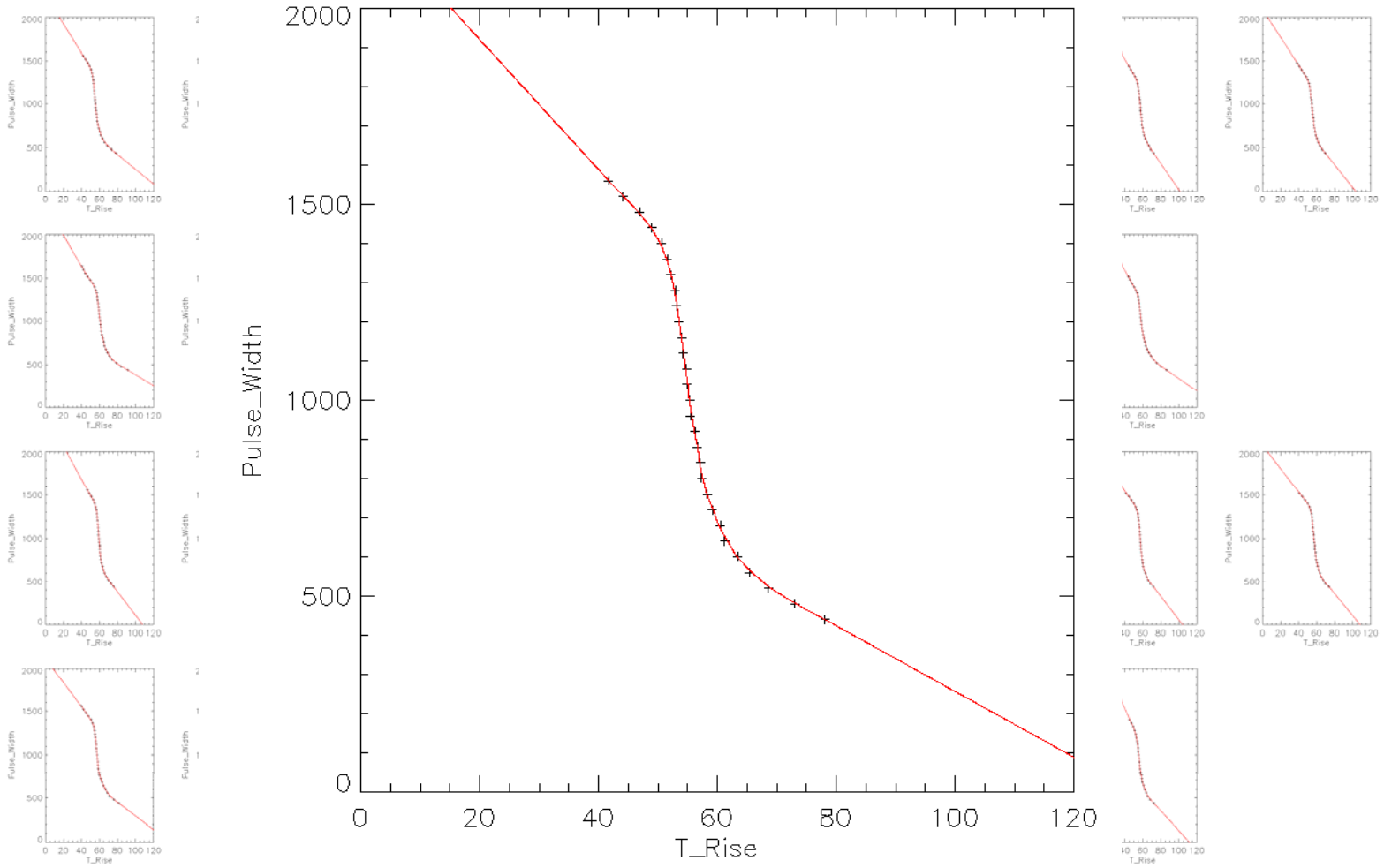
Time over threshold vs T-rise

Pulsed laser illuminating whole detector (data from 32 ch only)

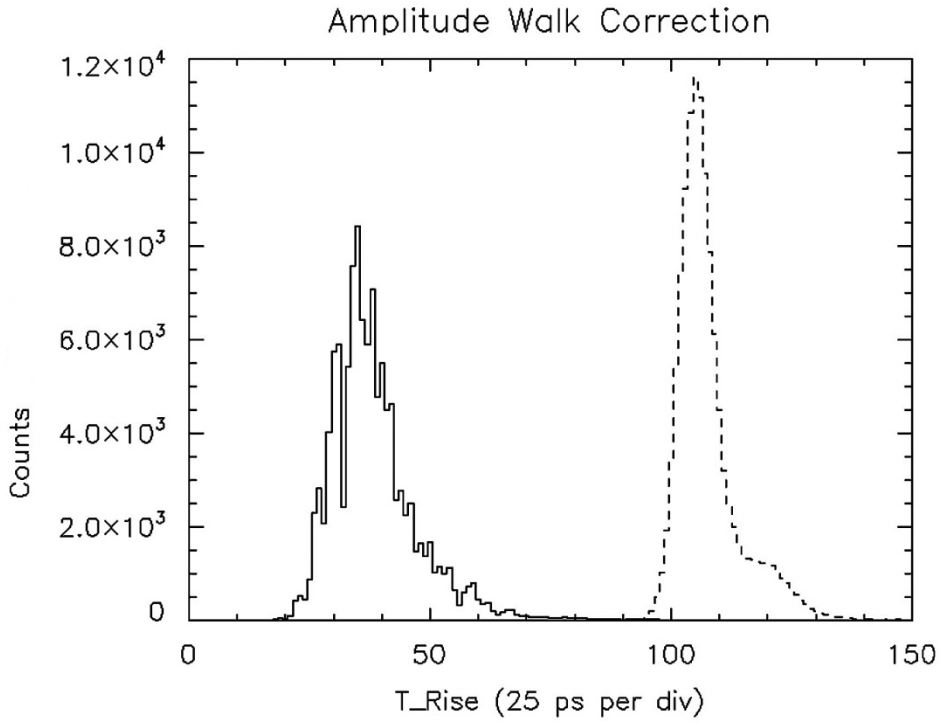


Amplitude walk correction

Simultaneous correction for amplitude walk and time offsets between channels – using LUT



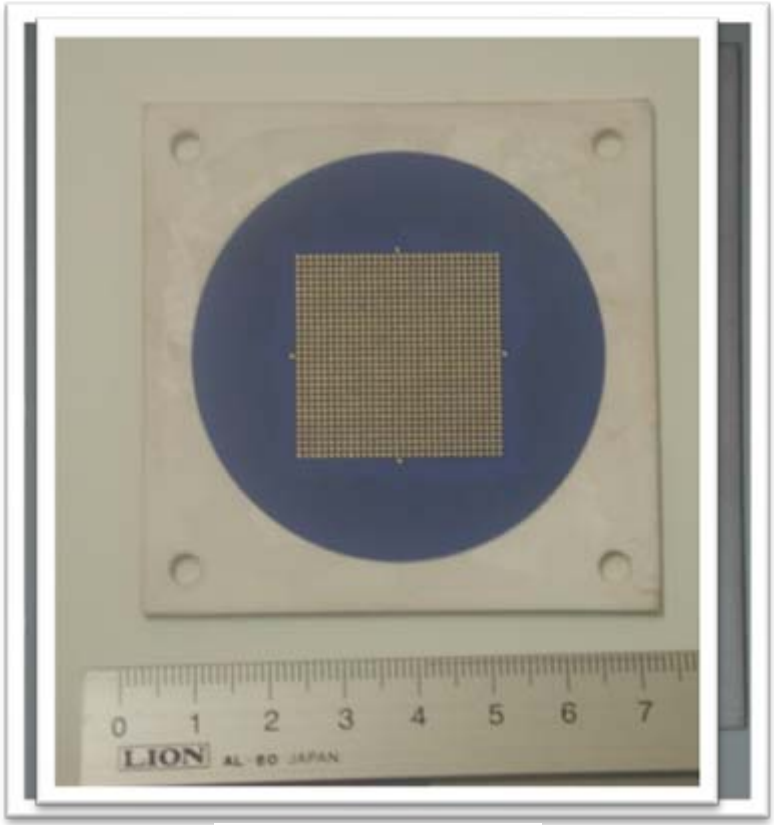
Hi-Content – Timing Jitter Results



- Time correlated single photon counting from the laser illuminated detector
- The solid line shows the uncorrected data
- The “time walk” corrected histogram is shown as a dashed line
- Corrected histogram has 78 ps RMS
- Subtracting the trigger jitter of 65 ps in quadrature leaves 43 ps for the detector, electronics and laser pulse width
- Laser pulse is approximately 40 – 45 ps!

IRPICS Detector

- IRPICS is a follow up to Hi-Content
- Detector size has increased to a 40 mm diameter
- Multi-anode density has increased to 32×32
- 0.83 mm wide square anode pads on a 0.88 mm pitch
- Modular readout electronics using the HPTDC and a 32 channel version of the NINO have been developed
- Currently provide 256 readout channels with 100 ps LSB resolution, enough to have a 16×16 multi-anode detector
- 1024 channel interconnect using anisotropic conductive film with solder bumps – 100% success at 0.2 ohm
- The detector is currently in production at Photek

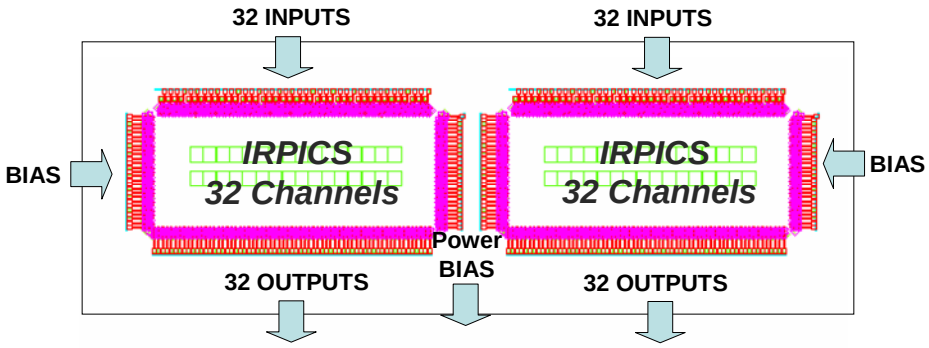


External

Manufactured by Rui D'Oliveira, CERN

NINO32 ASIC specification

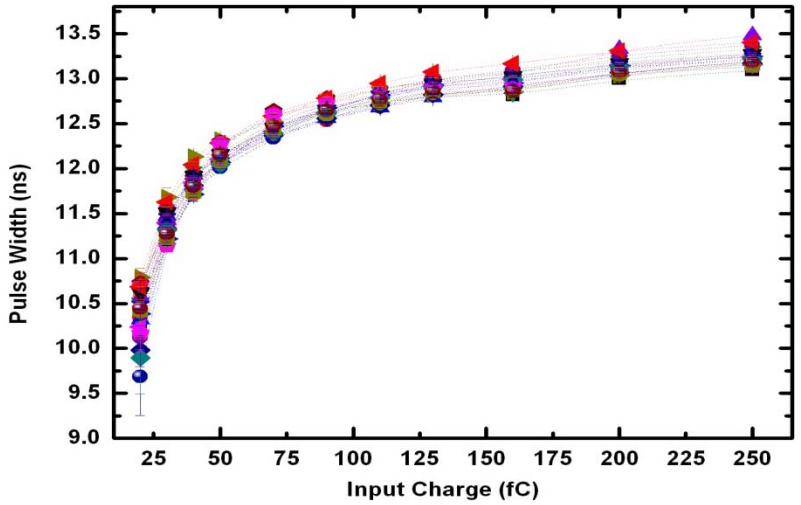
- 32 channel version of * channel NINO originally ASIC designed for ALICE-TOF
- Lower power consumption - 10 mW/ch
- 2 designs – one with inbuilt LVDS biasing, one without



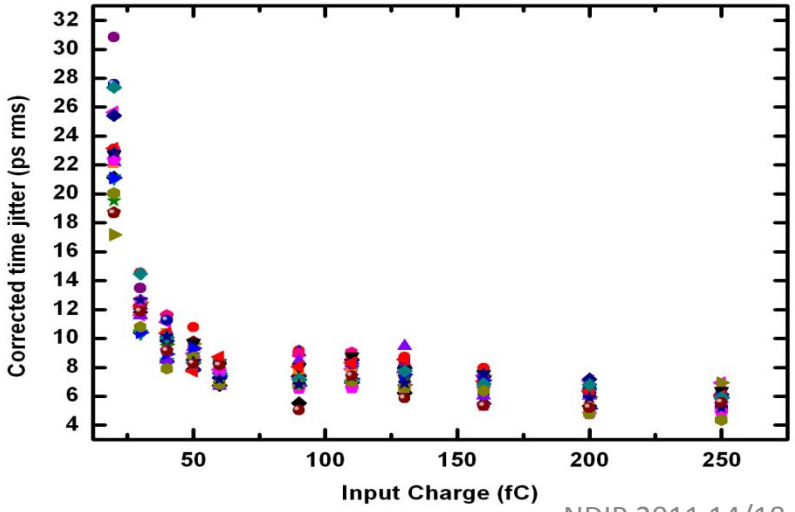
IRPICS 250 nm CMOS technology	
Number of Channels	32 – chip pin out allowing for 64 channels configuration
Power consumption	10 mW / channel
Peaking time	700 ps
Discriminator threshold	20 to 100 fC
Input resistance	30 to 100 Ω
Front edge time jitter	4 to 25 ps rms
Additional features	Calibration circuitry + OR circuits

NINO32 electronic characterization

- Pulse width versus input charge
- All 32 channels shown

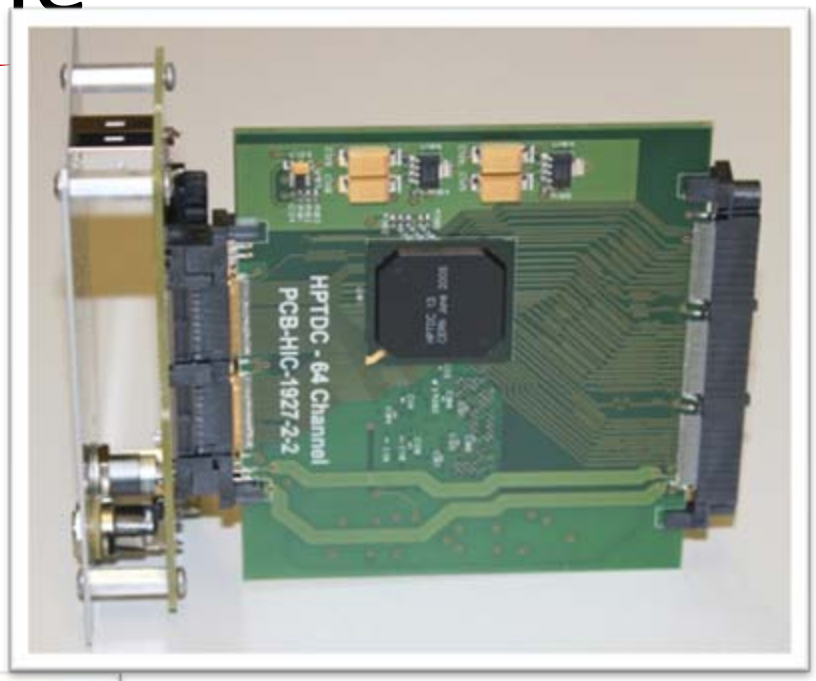


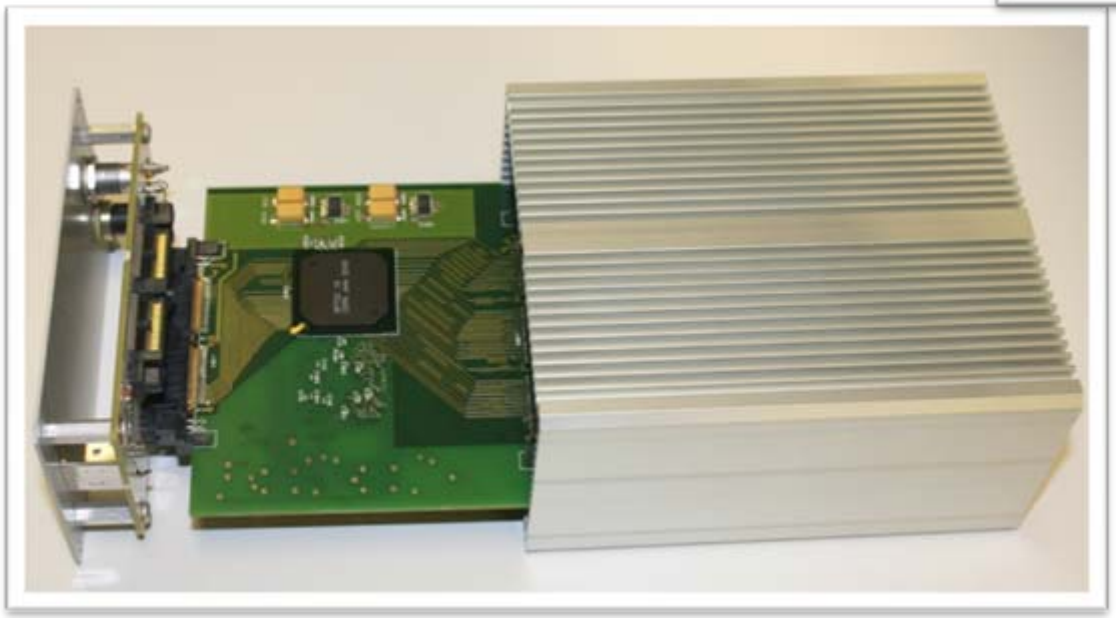
- Corrected Time jitter on the output pulse – all channels
- 1000 pulse measurements at each input charge
- Amplitude walk correction applied



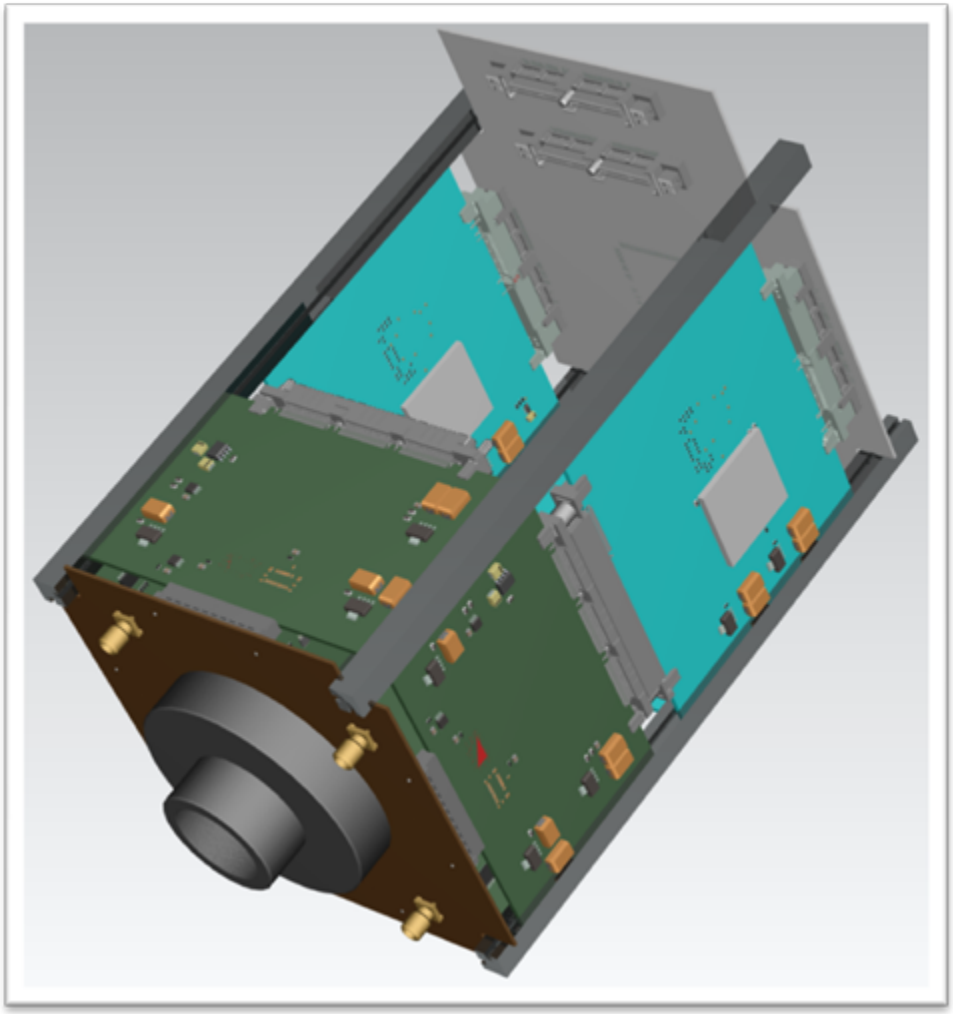
HPTDC Module - Outline

- We are currently developing a HPTDC module
- Common readout for both projects
- A modular architecture allows for multiple HPTDC cards
- On-board FPGA for control and data processing
- USB readout and control
- Will also be available as stand-alone module from Photek LTD.





IRPICS Detector - Assembly



Current status

- 40 mm detector designed, awaiting build
- 32 x 32 multilayer readout manufactured
  - Currently being brazed to detector flange
- Modular electronics
  - 64 channel NINO32 front-end card – being manufactured
  - 64 HPTDC manufactured and under test
  - Digital processing card manufactured and tested
- System testing – 4th quarter 2011

Conclusion

- 8 x 8 Multi-anode MCP detector manufactured, field trials being planned
- Demonstrated better than 50 ps timing resolution
- Modular HPTDC system developed
- 32 x 32 IRPICS detector being manufactured, with integrated readout electronics designed and in production

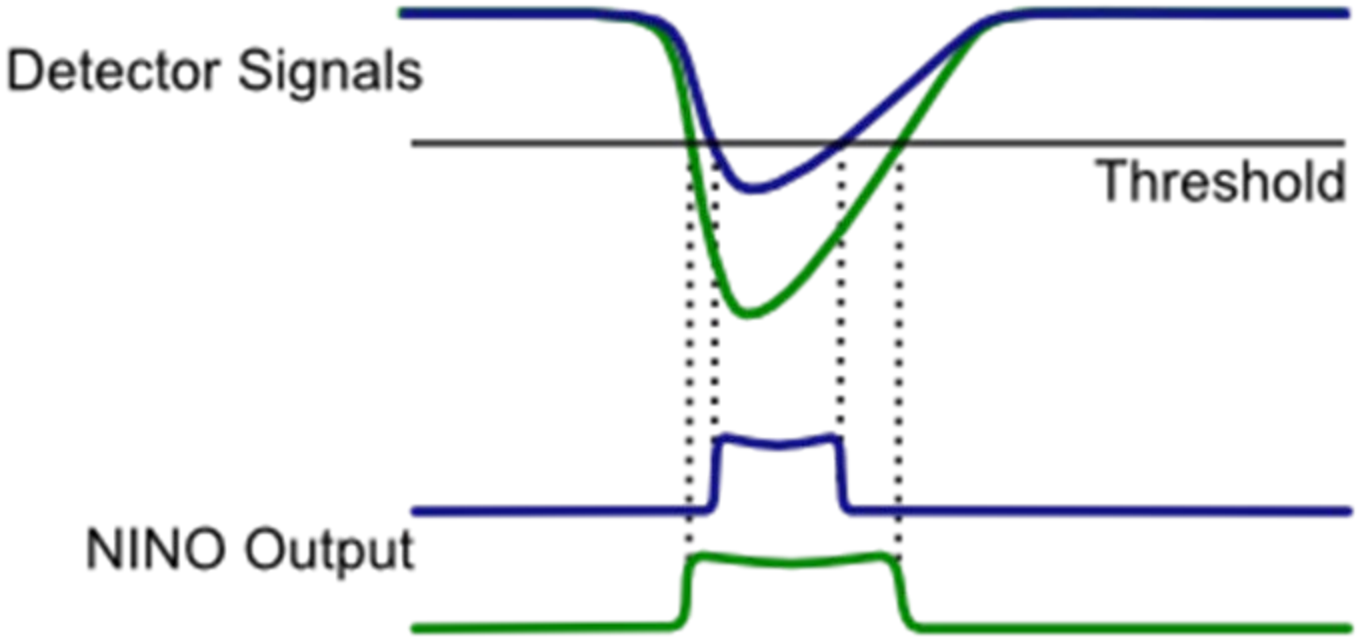
Thank you for listening

With thanks to:

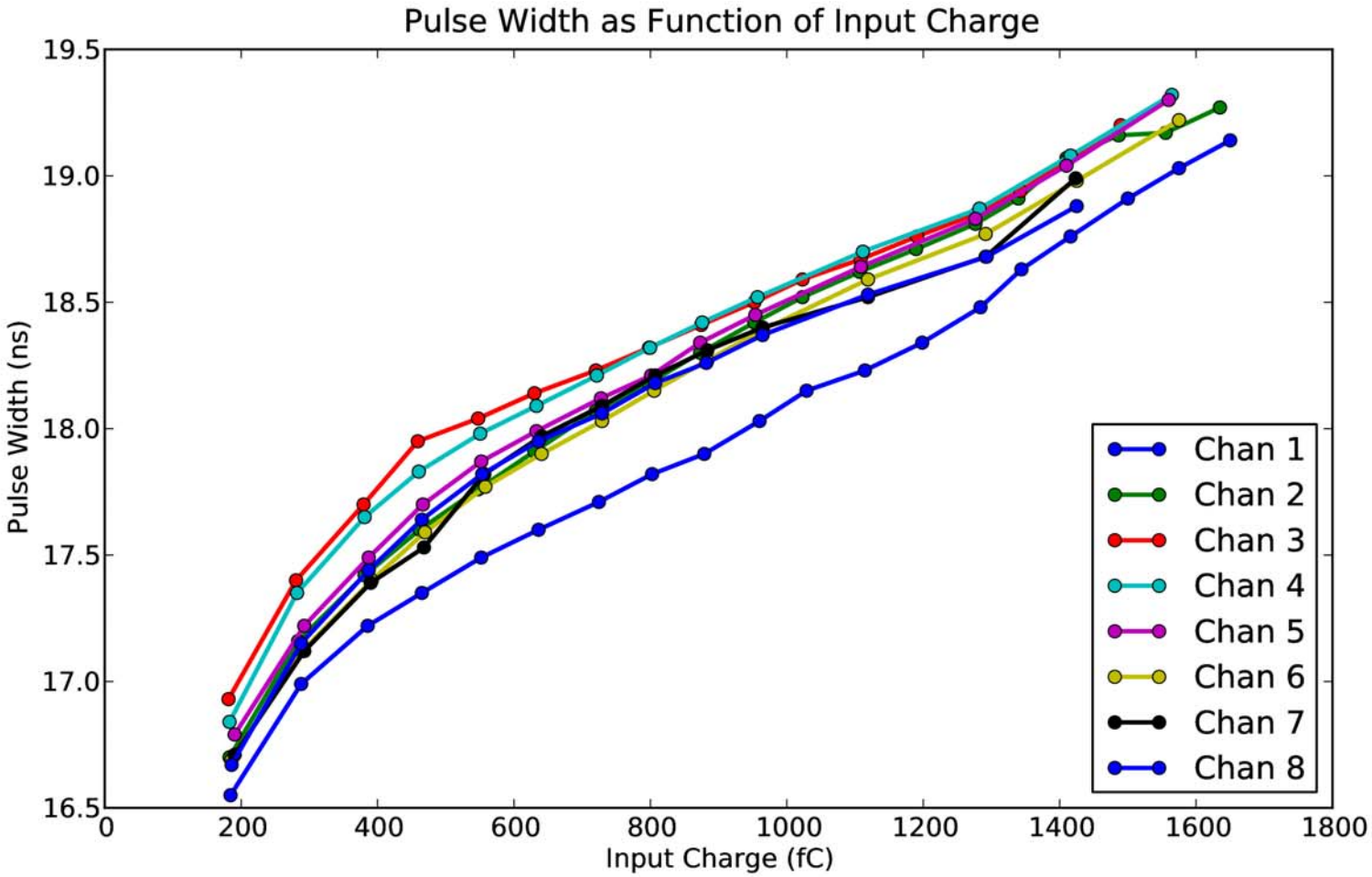
Pierre Jarron

George Fraser

NINO – Time over threshold discriminators



NINO – Charge measurement



NINO – Amplitude walk