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

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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

Photek LPG-650

Pulsed Laser

HiContent Detector

8×NINO ASICS

VME HPTDC

CAEN V1290A

Laser Trigger

TDC Trigger

BNC 565 Delay Generator

40MHz Ref Clock

NDIP 2011 7/18
Prototype – first results

Ratio of detected flux to input flux

Output rate / input rate

Counts/cm^2/s

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Time over threshold vs T-rise

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

Laser reflection

25 ps per div
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

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

<table>
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<th>IRPICS 250 nm CMOS technology</th>
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<td>Power consumption</td>
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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

Pulse Width as Function of Input Charge

Input Charge (fC):
0 200 400 600 800 1000 1200 1400 1600 1800

Pulse Width (ns):
16.5 17.0 17.5 18.0 18.5 19.0 19.5

- Chan 1
- Chan 2
- Chan 3
- Chan 4
- Chan 5
- Chan 6
- Chan 7
- Chan 8
NINO – Amplitude walk

![Graph showing NINO Timewalk Calibration Data with delays from trigger vs pulse width for different channels.](image-url)