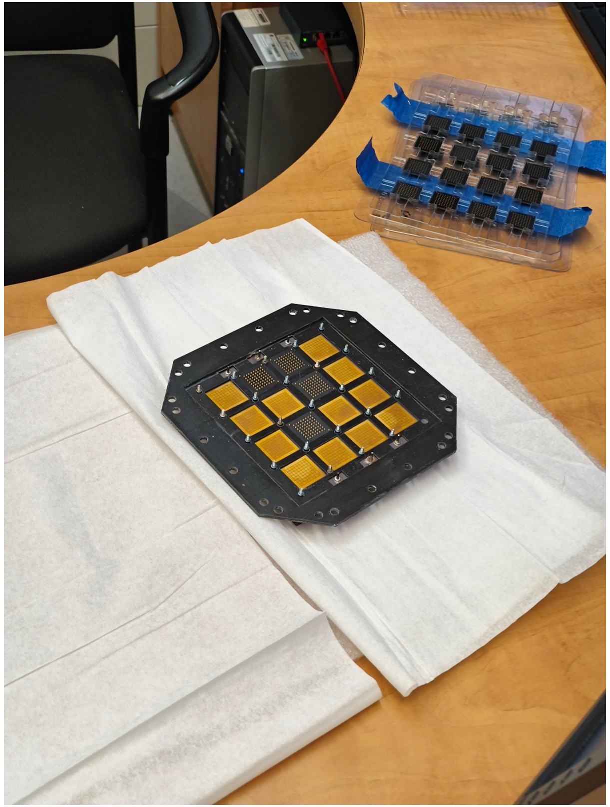
HRPPD test @BNL

AGC - notes

Measurement program

From Alexander's *HRPPD evaluation for ePIC hpDIRC*

The details of the measurement program (instrumented HRPPD pad area, combination of light sources and their intensity, neutral density filter settings, etc) will depend on the available resources and time, and will be further clarified as the studies are progressing. Conceptually, we want to mimic hpDIRC running conditions in ePIC, to the extent possible, and quantify HRPPD photosensor performance under these conditions, when a single HRPPD is expected to record up to ~200 photoelectrons within 20-30 nanoseconds. These occupancies correspond to the most demanding hpDIRC events observed in ePIC GEANT4 simulations. Quantities of interest are a possible efficiency, gain and timing resolution degradation, as well as an onset of a capacitive crosstalk, ringing and fake hits seen earlier in MCP-PMTs produced by other manufacturers (see [1], section 4.6). A starting point of the measurement program, resembling to a large extent the setup and methodology described in [2] (section 5), as well as possible extensions are outlined in the following subsections.



Motivation

To quantify HRPPD photosensor performance under these conditions, when a single HRPPD is expected to record up to ~200 photoelectrons within 20-30 nanoseconds

Investigate possible efficiency, gain and timing resolution degradation, as well as an onset of a capacitive crosstalk, ringing from high occupancy measurements.

Example possible readouts

Can implement these configurations.

Left is easiest to get started. Other’s can be done, but need labour time to modify housing.

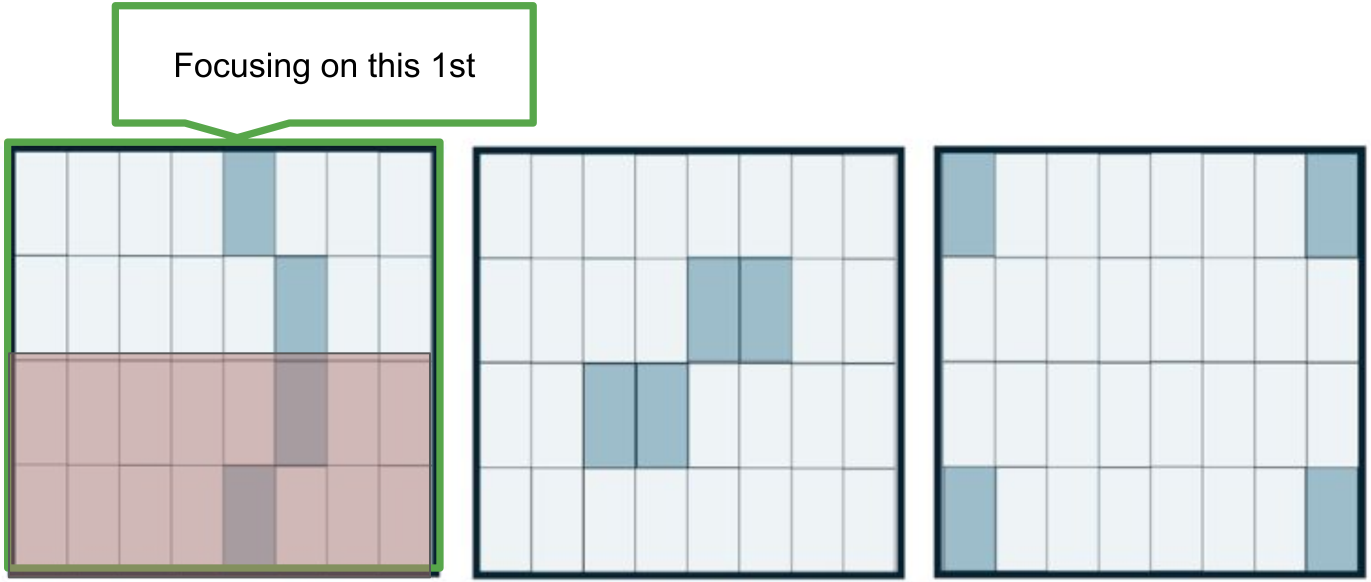


Figure 2 Three possible readout configurations. Each of the three panels represents a full HRPPD active area of 104 mm x 104 mm (32x32 pads), with only four highlighted 4x8 pad areas instrumented.

Example possible readouts

Focusing on this 1st

Can implement these configurations.

Left is easiest to get started. Other's can be done, but need labour time to modify housing.

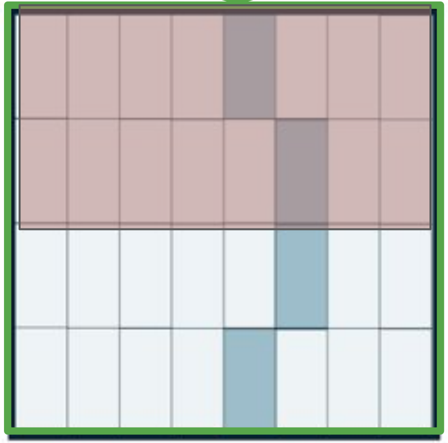
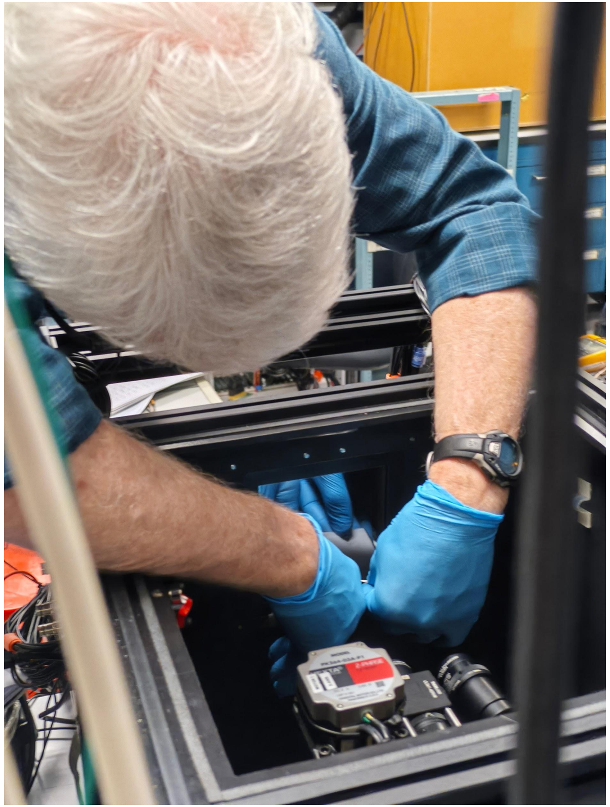


Figure 2 Three possible readout co
area of 104 mm x 104 mm (32x32 p



Current status 03/08/2026 - i.e. things done so far

- HRPPD #23 in the box (specific for this test)
- LED with diffuser inplace and seeing signals across the instrumented HRPPD area
- Laser in place adjacent to LED with larger focal length lens in place to allow room
- Seeing coincident signals, with evidence of ringing at LED pulse
- **Currently, the delay induced from the fast photodiode -> nim -> trigger LED too long**
- Need to recover ~ 48 ns between laser and LED
- DAQ is working, analysis scripts to plot 8x8 grid working
- Working on improving the scripts as needed

Current status 03/08/2026 - i.e. things done so far

- Extended laser fibre to try to recover ~ 48 ns between laser and LED
- Taking sets of data at various cable additions
- Brian taken scope data - will quantify delay + attenuation from each
- Possible 10m cable ordered for fast delivery*

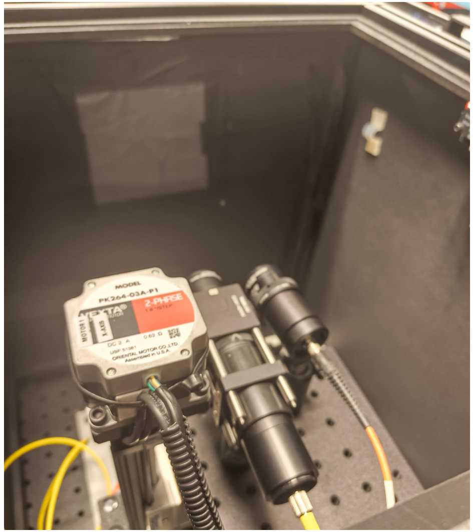
New image from scope here

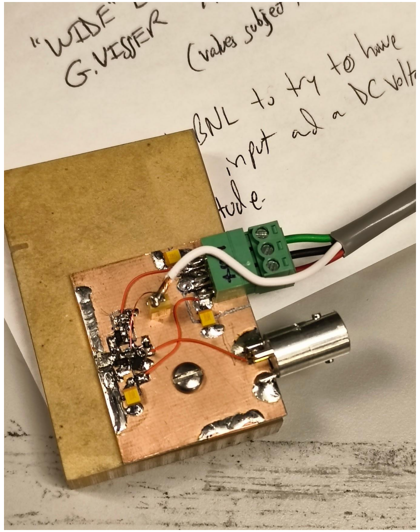
Plan 04/08

- Finish delay study:
  - Quantify delay/attenuation
- Look at Waveform with LED separated in time or laser not in.
- Scan in LED intensity
- Scan in HRPPD gain

Update 05/08

- Gerard, Mark, Ray arrived
- Gerard working on modifying his LED to accept TTL and on delay (waiting for the 10m fibre)
- Took a set of scope data with flood-field
  - Fixed HRPPD gain, LED intensity
  - Shifted LED delay across a range before and after laser signal
- Created mask from Tedlar and checked on DRS4 with whole detector masked

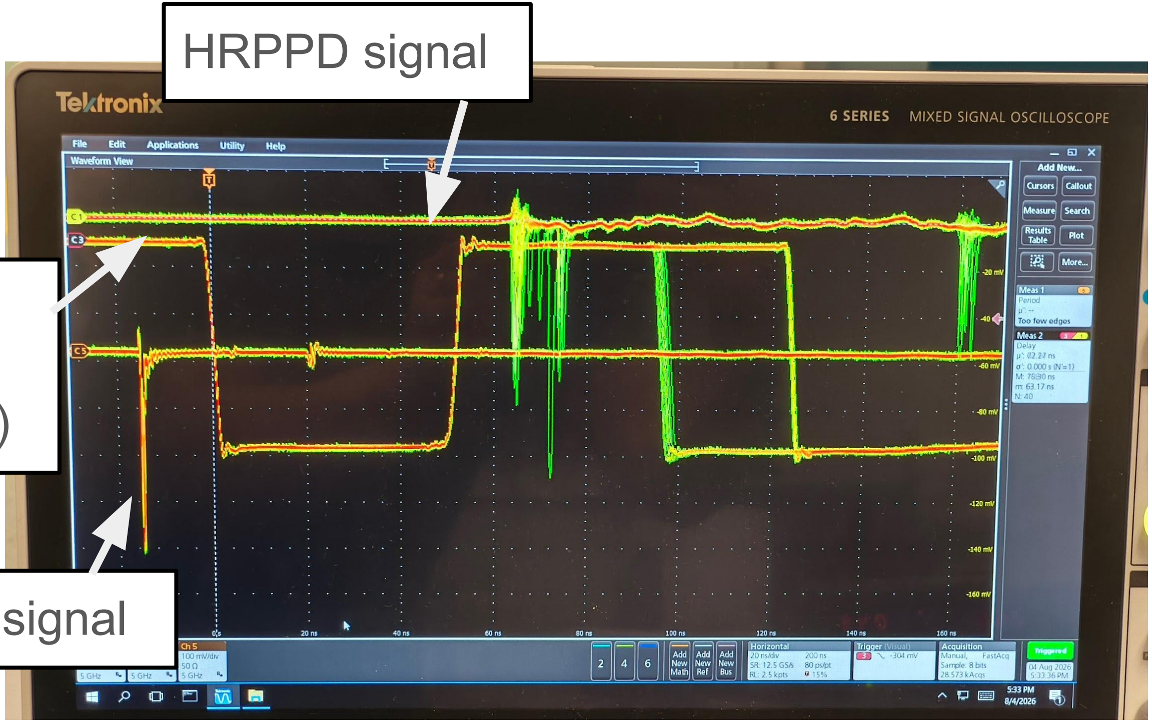




Run log:
https://docs.google.com/spreadsheets/d/1pgvYQGpIAH8gfV17sJNrhIDyHJLJcCgXNzFf0n6LbW4/edit?usp=sharing

Update 05/08 - signals

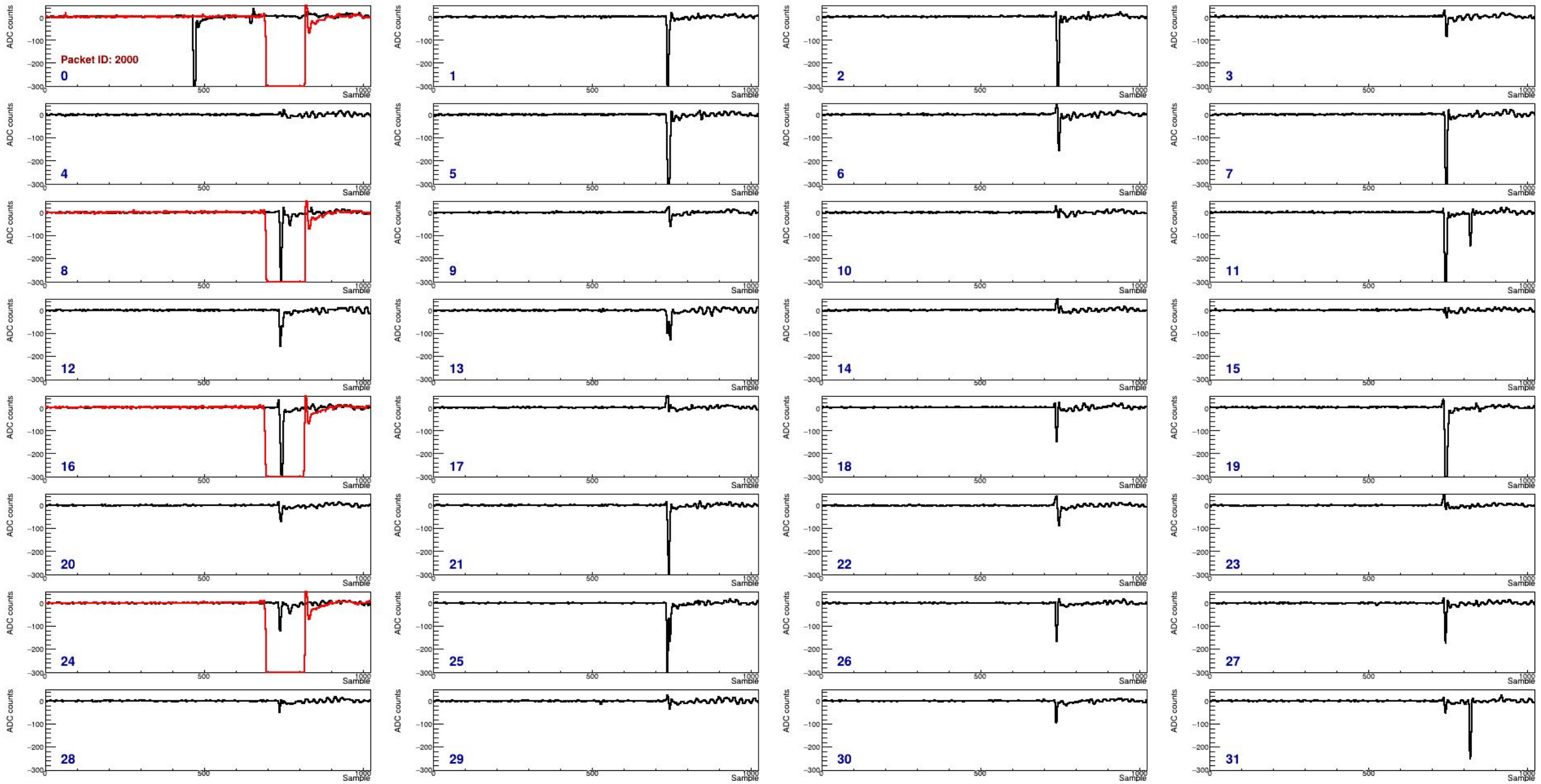
- Example scope
- LED signal



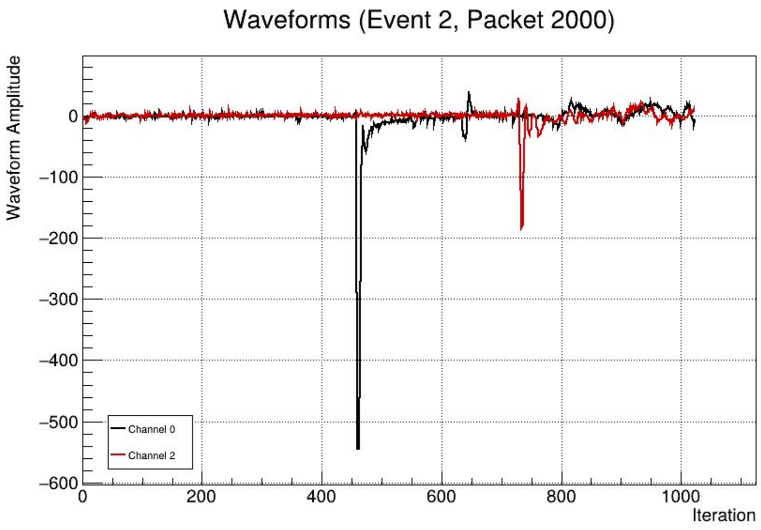
Update 05/08 - DRS4 signals

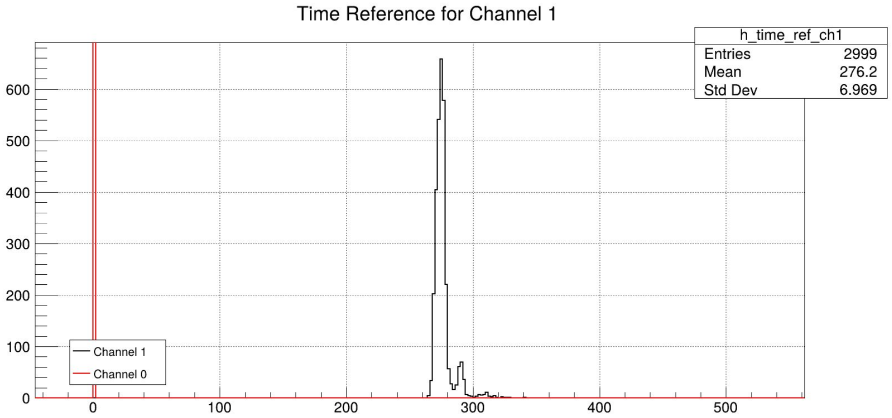
Run 311032

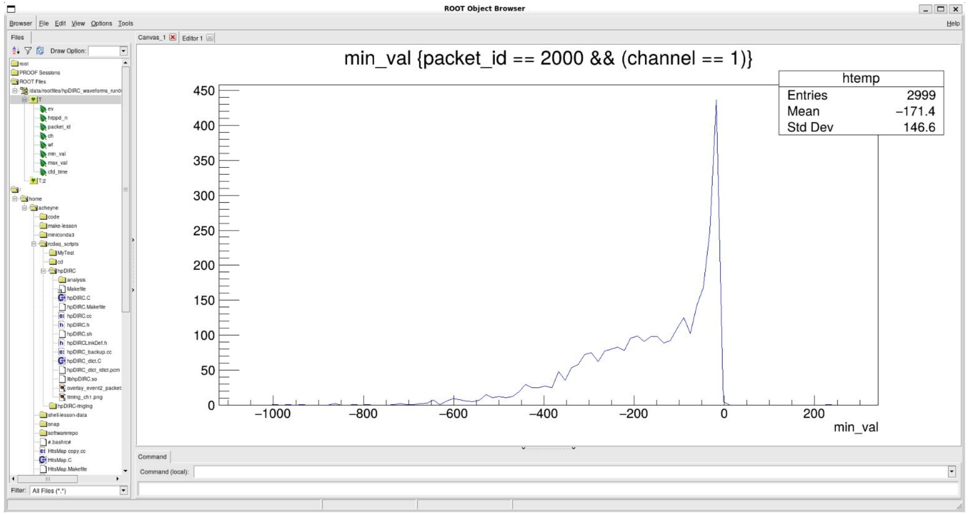
- Plot is 1 DRS4 device (channel order - not mapped)
- All channels + trigger signals in red
- Id2000:ch0 is FPD for timing reference



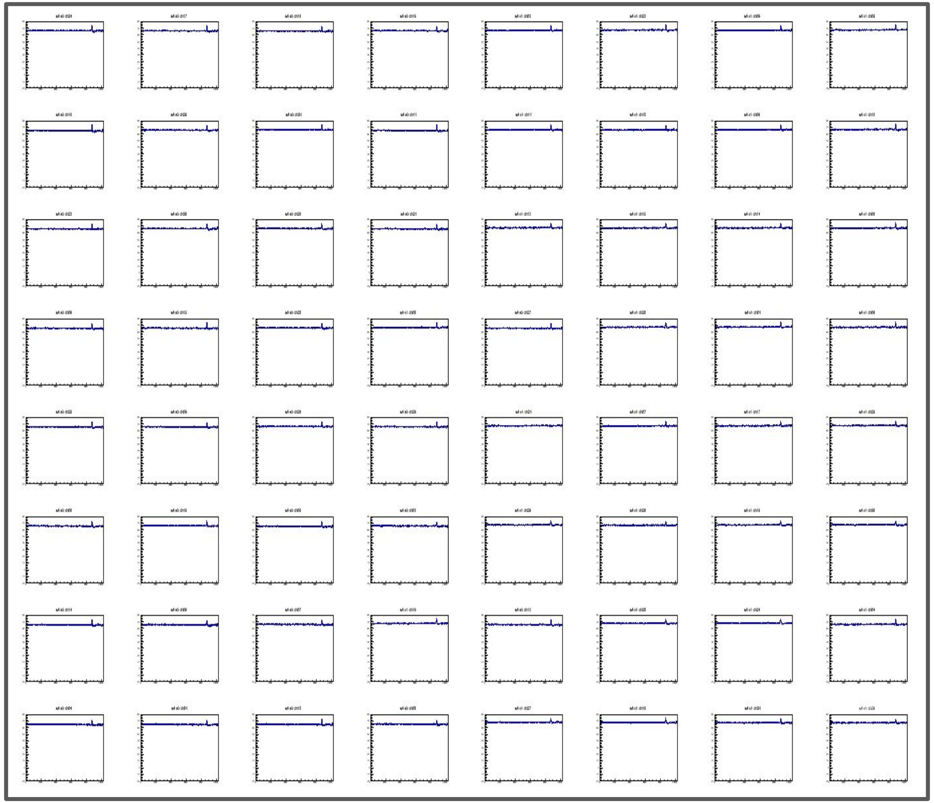
Update 05/08 - DRS4 data

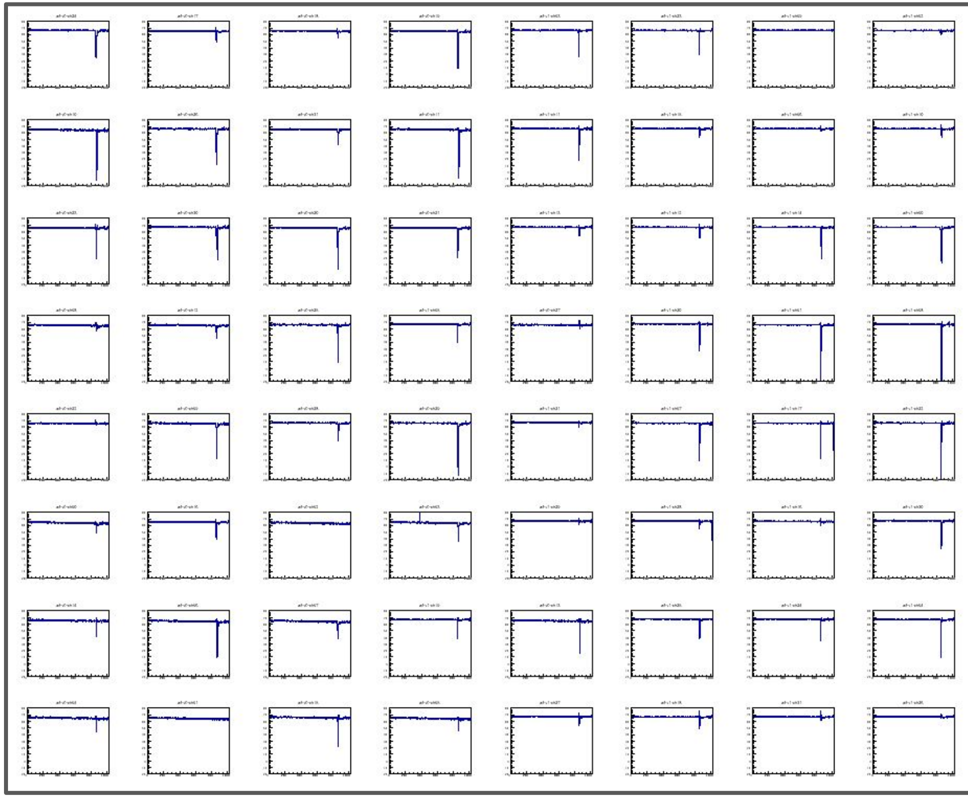






Update 06/08 - DRS4 masked





Up

Questions:

- What else in analysis?
- Pedestal RMS before and after pulse?
-

To do list:

Increase laser delay - source longer fibre (Bob)

- Laser ahead of current LED
- Gerard working on modifying his and checking timing (likely need the new 10m cable)

Modify the readout fixture such that inserts are moveable on backplace (need section cutout/second mount) for other setups.

Summary of planned tests (old):

1. Waveforms in masked region showing oscillations (no laser)
   a. Scope: 1 ch in each pad. Ramp LED intensity
   b. DRS4: Same study but with 4*32 channels.
   c. Repeat but this time varying the gain.
2. Waveforms of a laser only signal on a single pixel
3. Waveforms of LED + laser (once delay is correct)
   a. Any change in laser signal?
   b.

For each test, done at a range:

- 1-20*10^5 gain with the scope and others at
- 5-20*10^5 gain with the DRS4 readout.

Want to compare the signals from pixels that are masked to pixels that are open.

Method

Start with LED pulser (with square diffuser) illuminating the whole tube at very low intensity.

- Expect any pixel ~one in a hundred triggers.
- Take runs, increasing the intensity until 20%-30% per pixel.

Start with the scope at low gain, with mask as shown in red.

Readout 4 channels: Read out one channel from each pad (2 masked, 2 not).

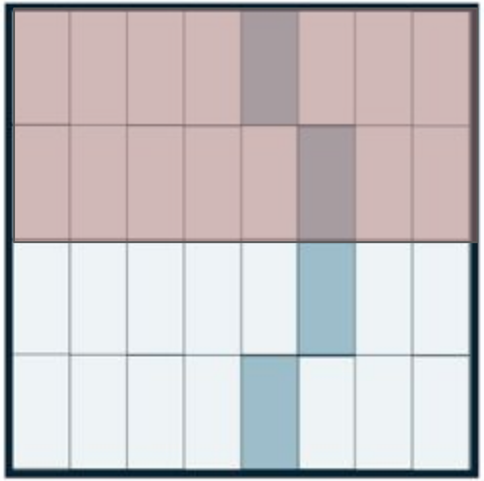


Figure 2 Three possible readout c
area of 104 mm x 104 mm (32x32

Method

Observe traces in masked and open channels, looking for the coherent excitation wiggles. Record the number of hits and timing information too. (Fast photodiode that fires the LED recorded for reference - same as from laser)

Always comparing the masked and open channels as a function of the pulser intensity.

- Repeat this for a couple of larger gain values
- Repeat using DRS4 readout.

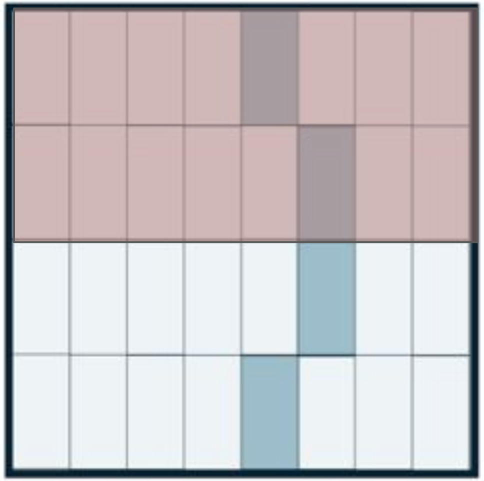


Figure 2 Three possible readout c
area of 104 mm x 104 mm (32x32

Method

Either:

- keep the top half of the HRPPD masked or
- mask only the upper 4x8 pad area (with a generous margin (so no charge sharing or photons from reflections inside the front window) and keep the rest of the tube open.

Then, at 10^6 gain, set the pulser intensity to 1% hit probability, increasing to 20%-30%.

Again, you plot the number of hits in the masked and open area vs the intensity.

This could be repeated at 2*10^6 and maybe 5*10^5.

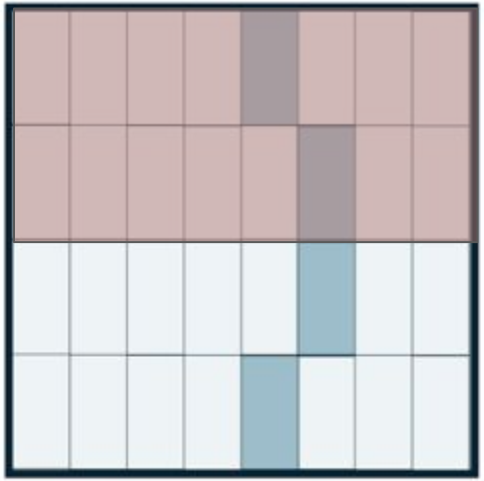


Figure 2 Three possible readout c
area of 104 mm x 104 mm (32x32

Method extension (focused laser spot)

Also use a focused laser on a single pixel.

The Erlangen folks also measured at very high hit probabilities, up to 400% - if we don't see anything at 10-20% (fingers crossed), maybe we should push for these extreme values as well?

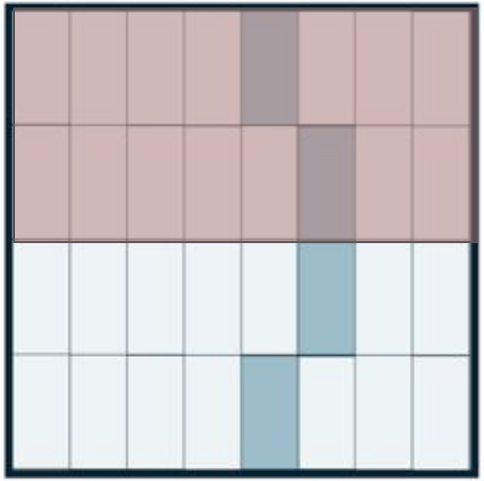


Figure 2 Three possible readout c
area of 104 mm x 104 mm (32x32

Method extension (split pulses)

If you have the 1-4 fiber splitter available, it would be interesting to take another set of runs where you deliver the photons in four bursts per trigger, delayed by some number of ns each, until you reach the equivalent intensity of, so, 50 hits per burst, again look at the same observables.

We do not have access to this method at the moment.

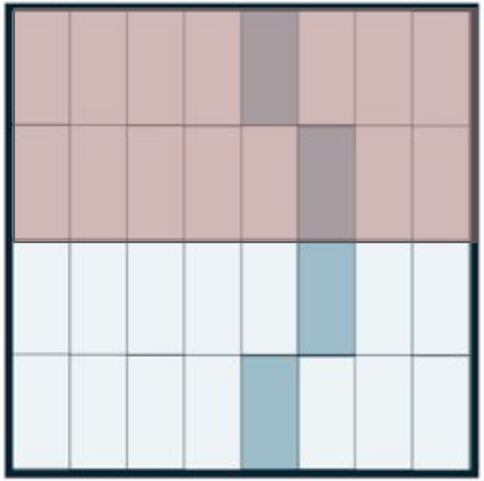


Figure 2 Three possible readout c
area of 104 mm x 104 mm (32x32

For Monday

Summarise what was done this week.

Outlook on conclusion we are converging on - what do we need to add in the next few days.

Success? Consequences?