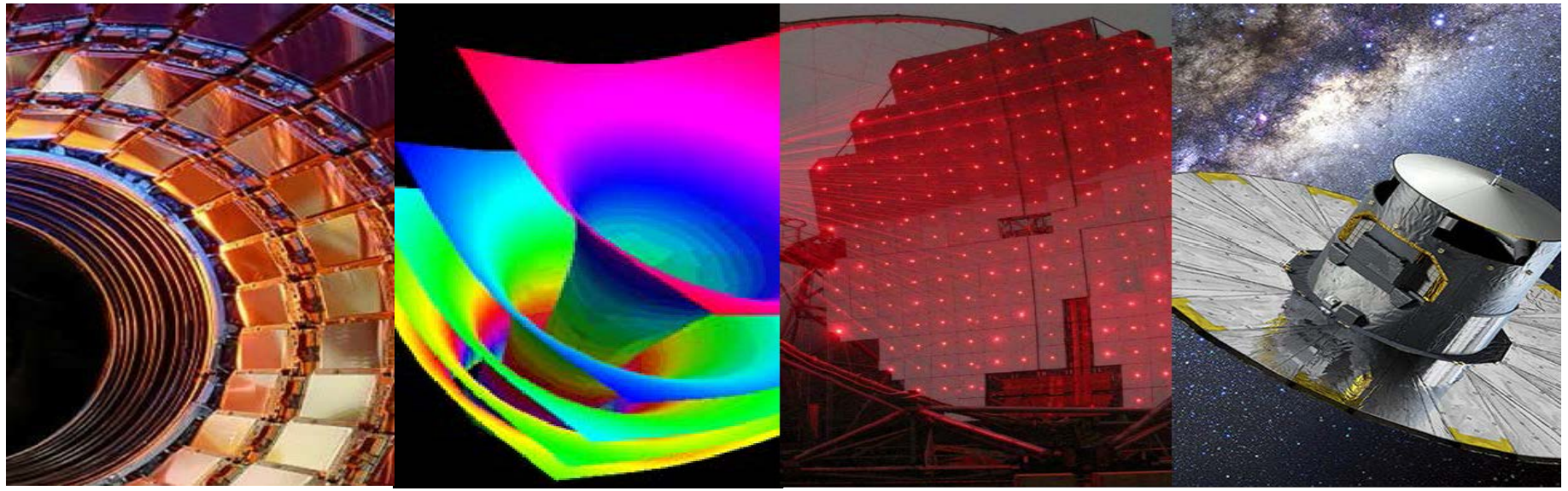
Institute of Cosmos Sciences



Fiber Tracker Readout BETA ASIC for the High Energy Cosmic Radiation Detection (HERD) facility

A.Sanmukh[1] , D. Gascon[1], S. Gomez[1], A.Comerma[1], J. Mauricio[1] , R. Manera[1], A. Sanuy[1].

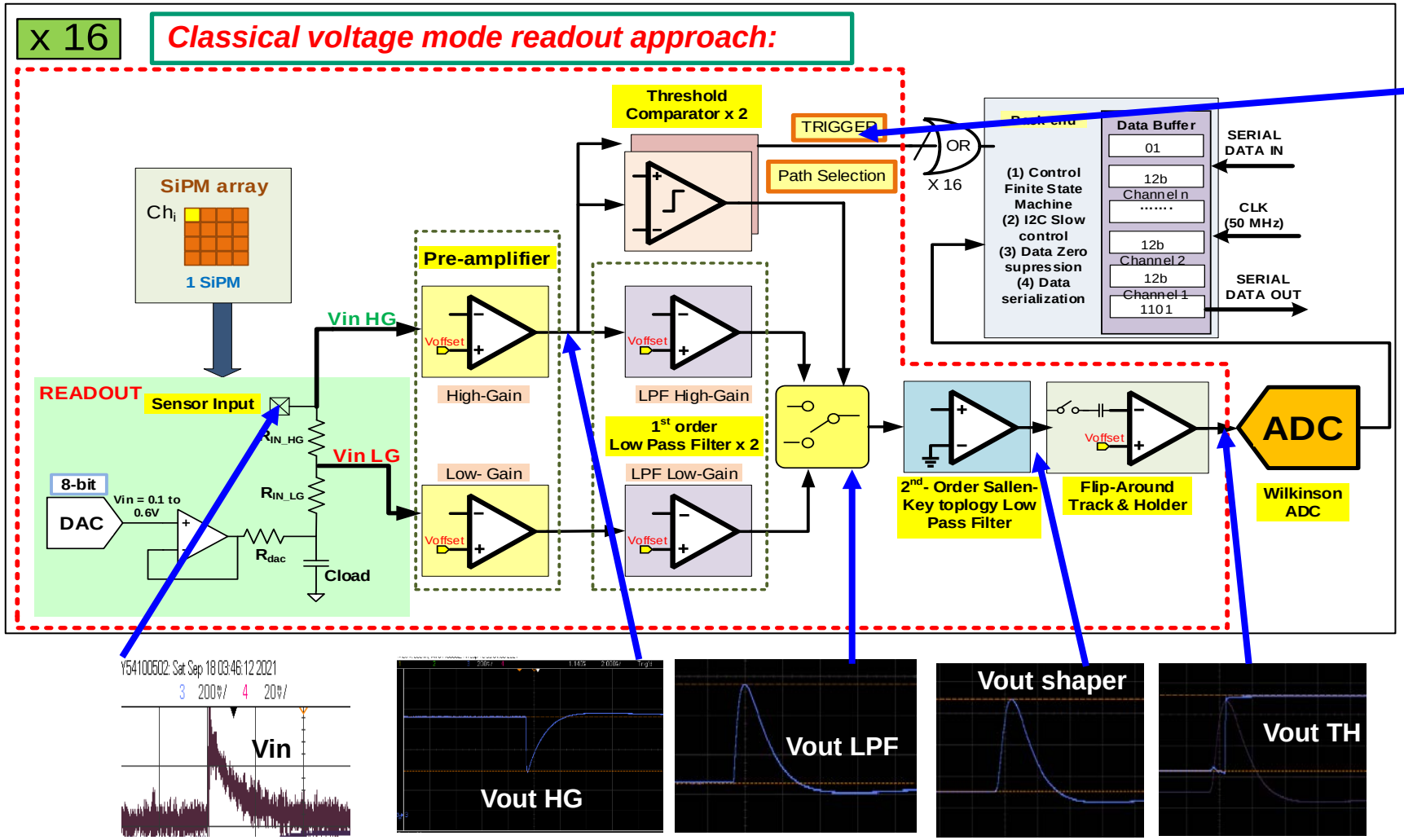
ICCUB – Universitat de Barcelona (1)

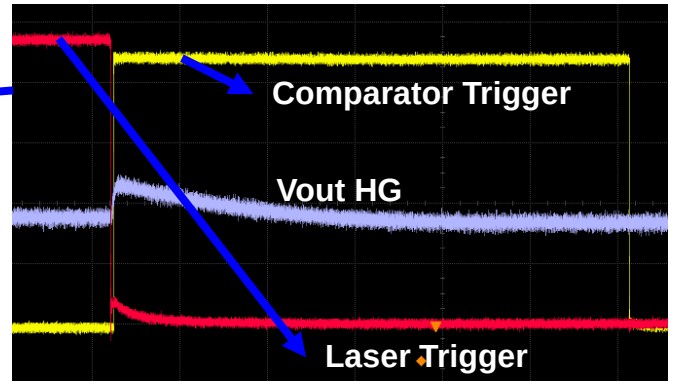
HERD Status Report

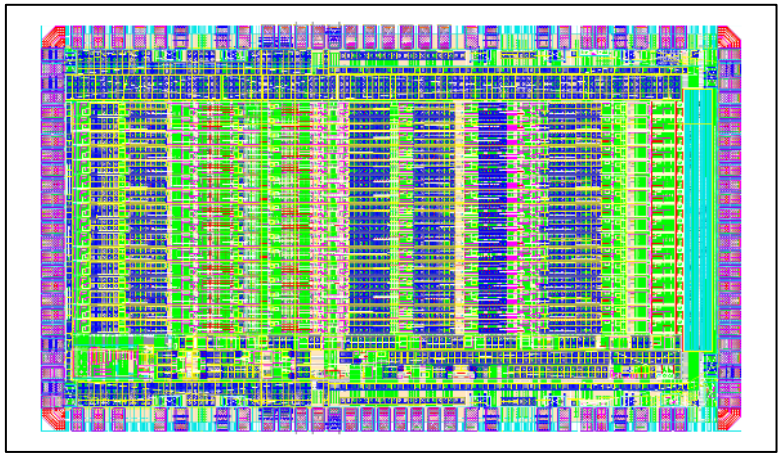
16th Feb 2022

I. Table of contents

HERD BETA - Architecture





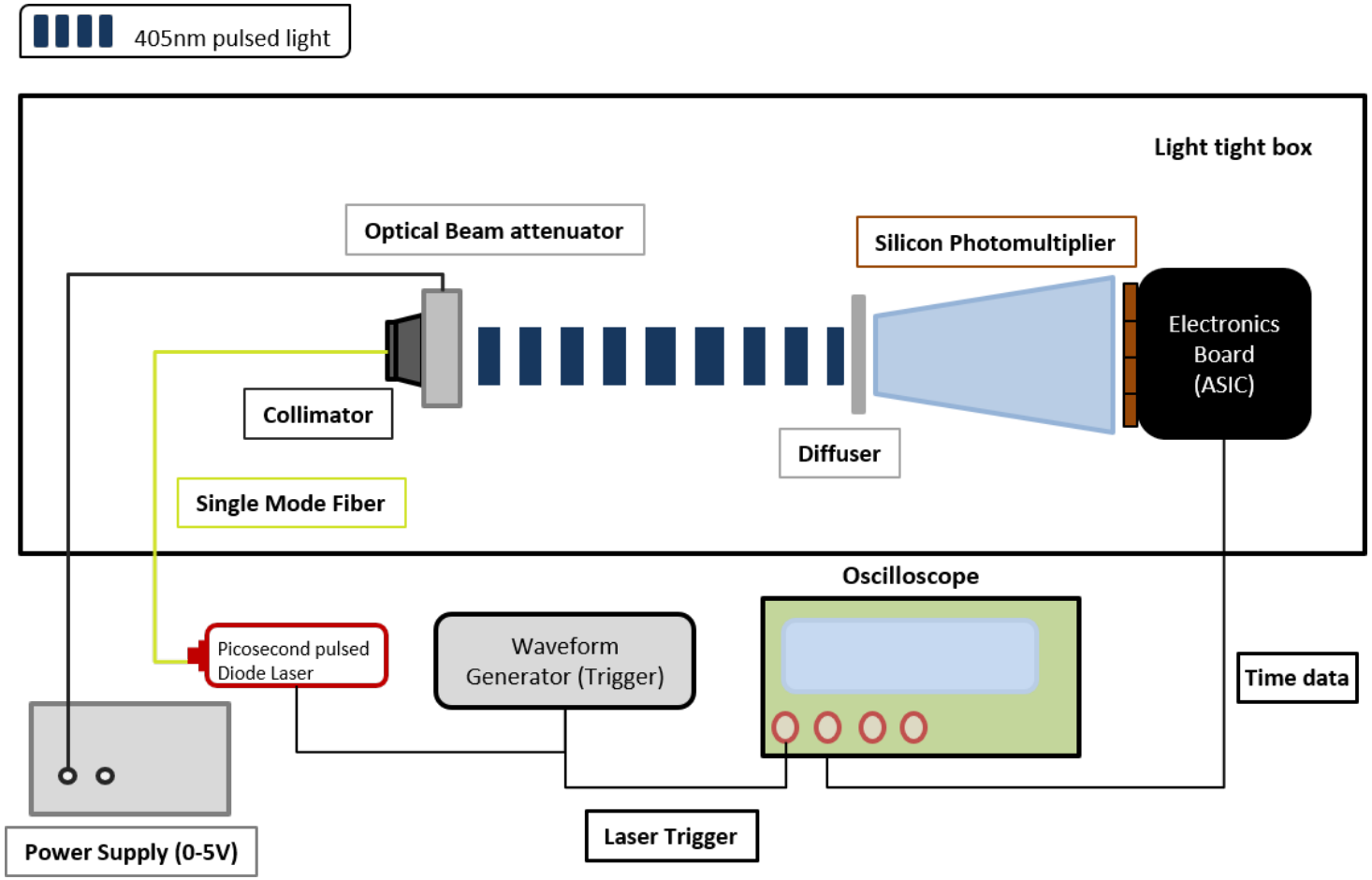


130 nm – 3.38 x1.96 mm²

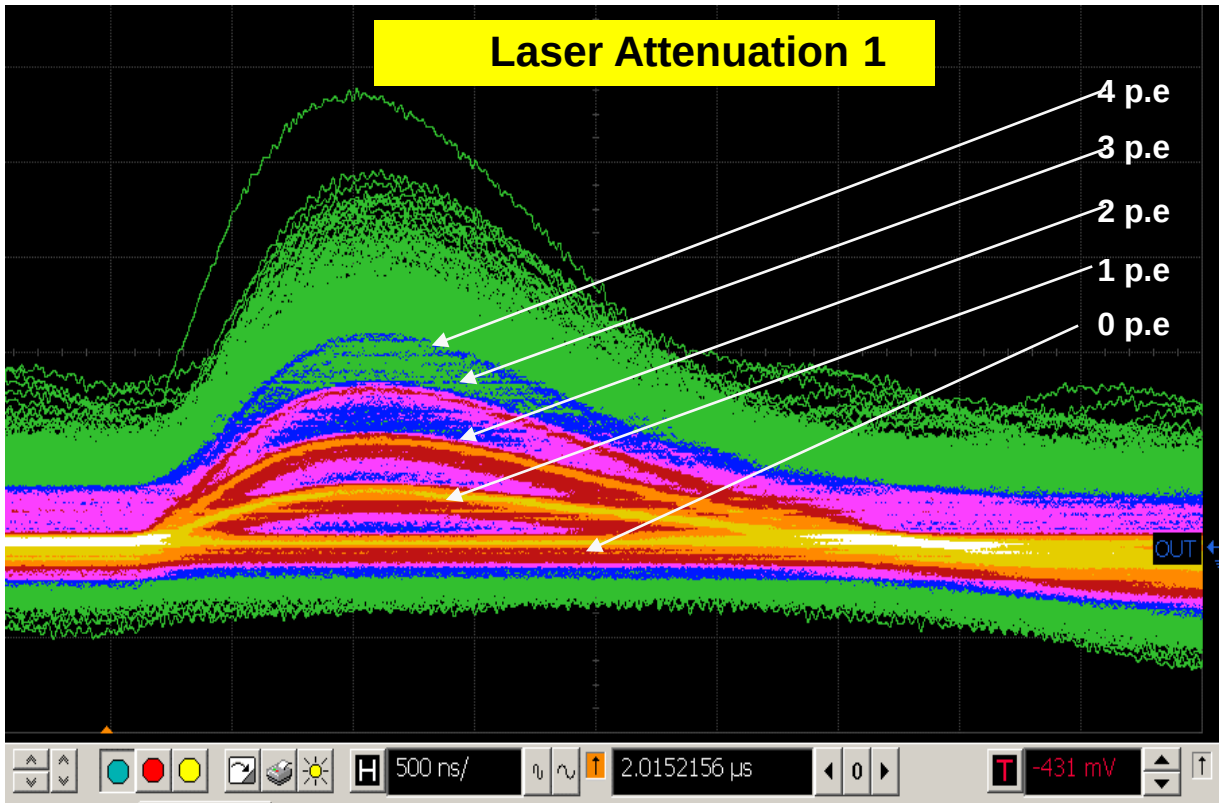
Fig 2: HERD BETA - Architecture Oscilloscope measurements

II. HERD performance: SPTR measurements with SiPM and blue light

- The setup is as follows:
  - Advanced Laser Diode Systems A.L.S. GmbH (PiL040X) at 405 nm and a tuned intensity level of 50%, jitter < 3 ps and < 45 ps pulse width .
  - **Sensor:** S13360-1350CS (Hamamatsu)
  - Agilent MSO 9404A 4 GHz oscilloscope (20 GS/s).
  - Several measurements are performed to identify the optimal threshold.



HERD performance: Analog Shaper output for HG path selection



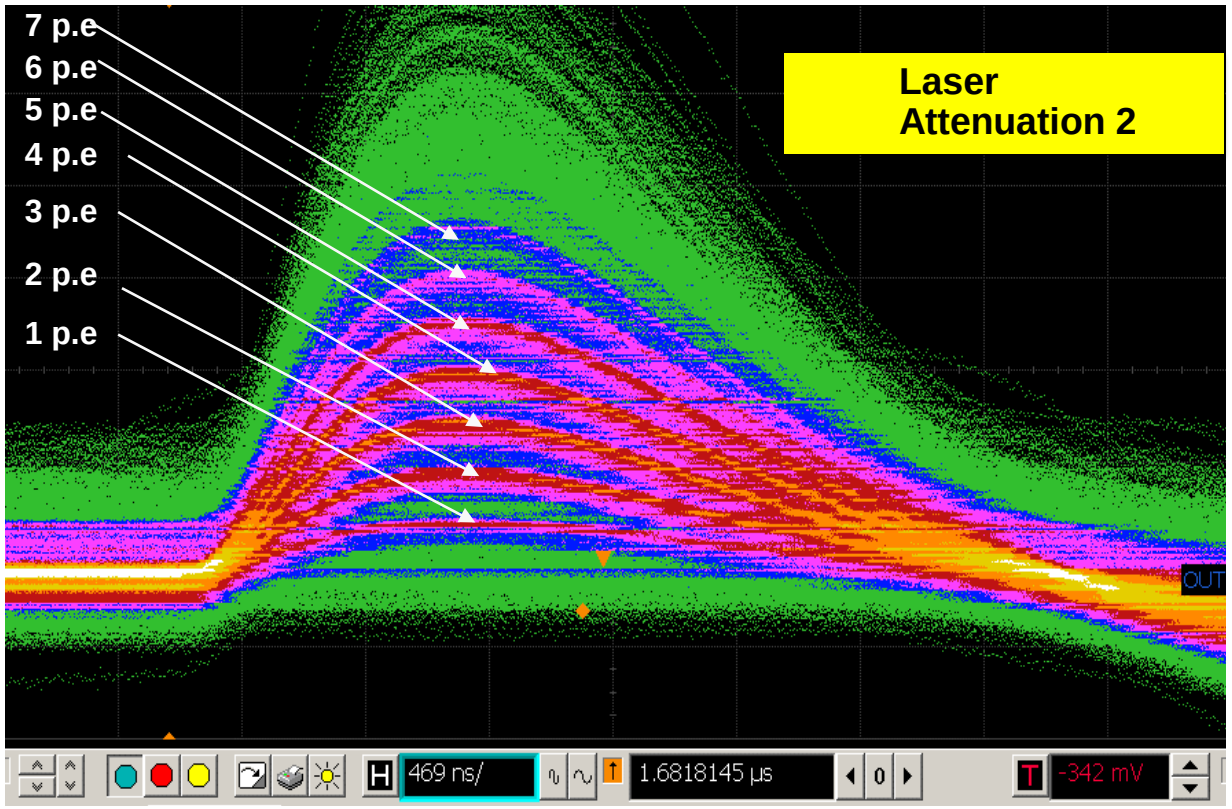
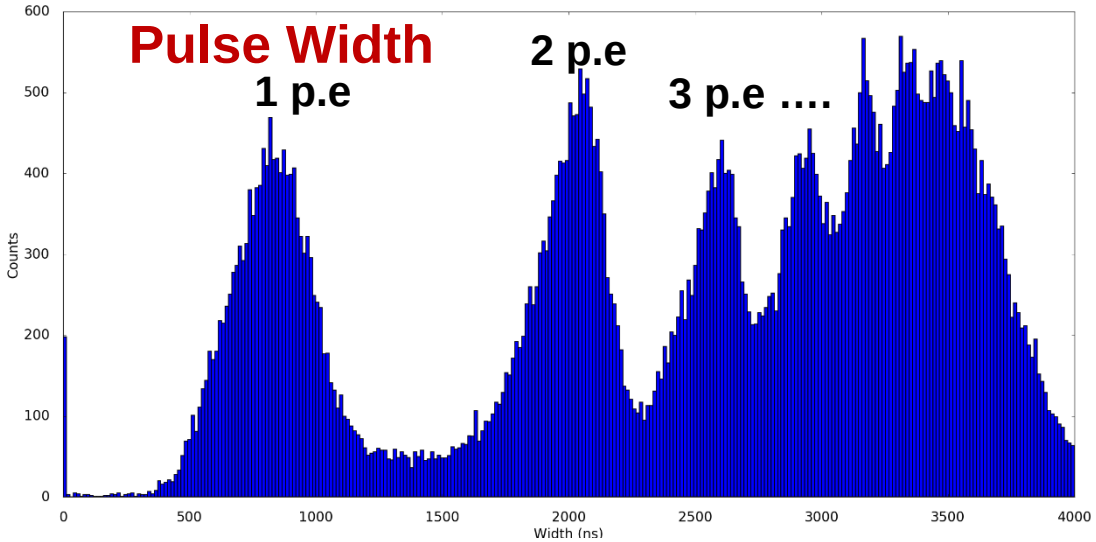
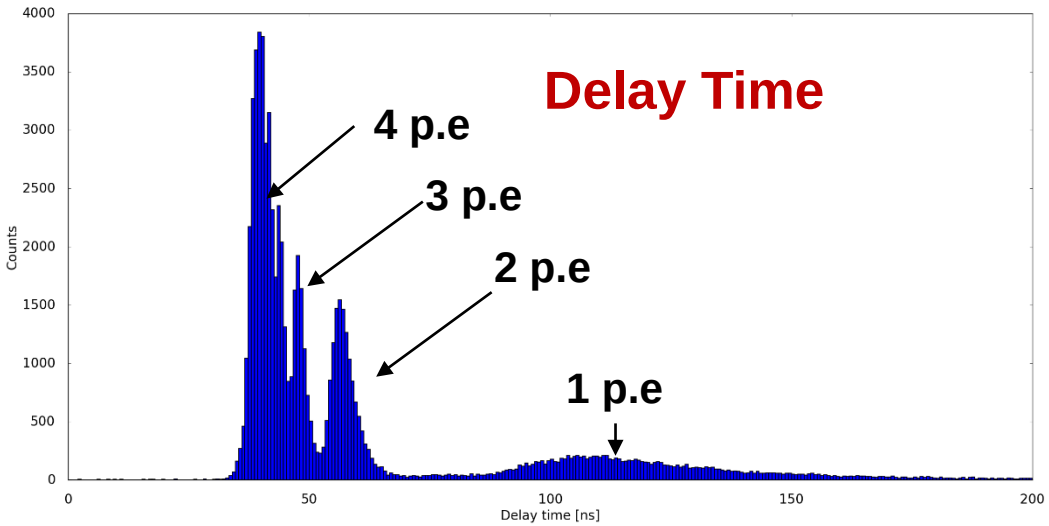


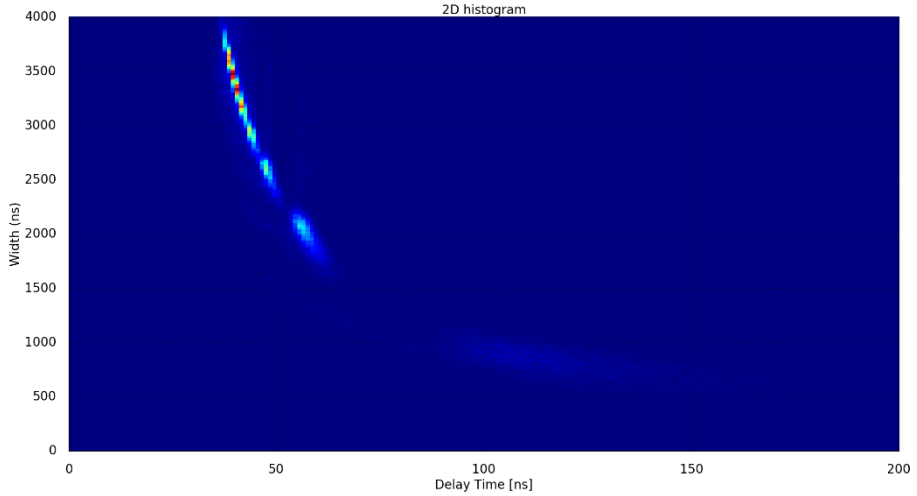
Fig. Oscilloscope colour grade capture for various number of photons showing the Shaper Output for HG path selection

- Sensor used is Hamamstu S13360-1350CS 1.3 mm X 1.3 mm 50µm pixel pitch.
- Pulsed blue laser light at 405 nm and acquisition was synchronous with the laser light

II. HERD performance: SPTR measurements with SiPM





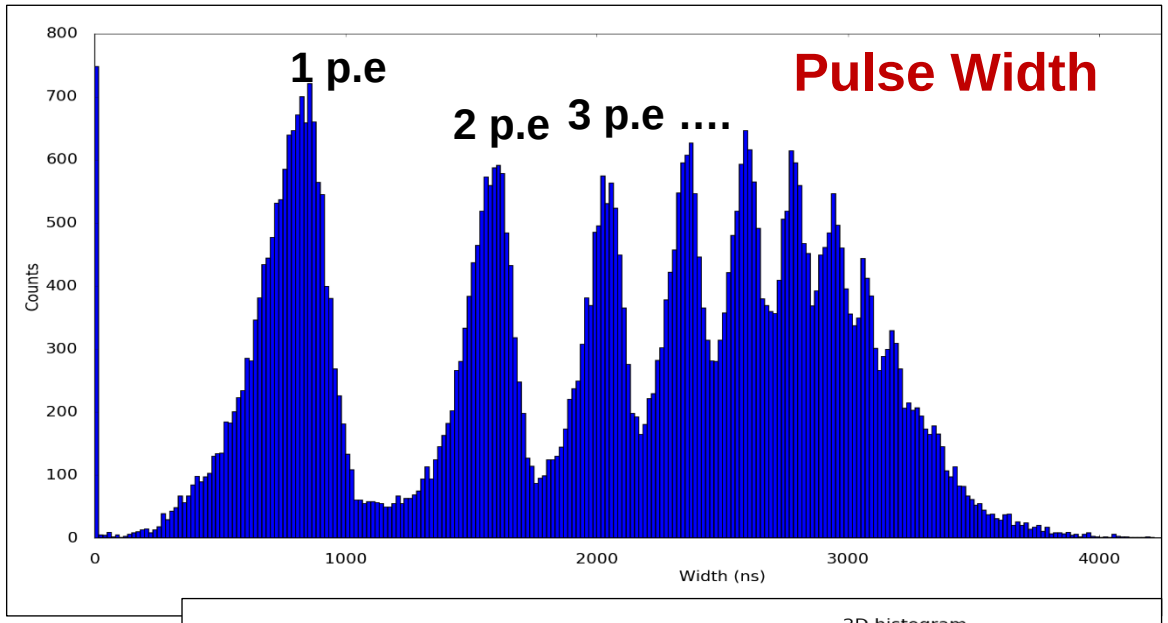


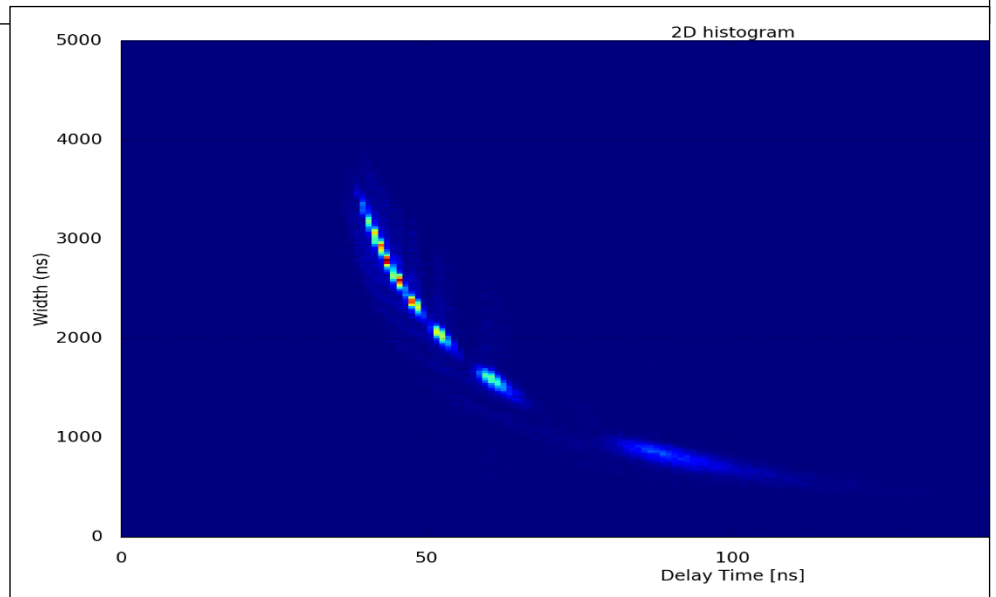
Bias voltage 54V (2V of Over-voltage)

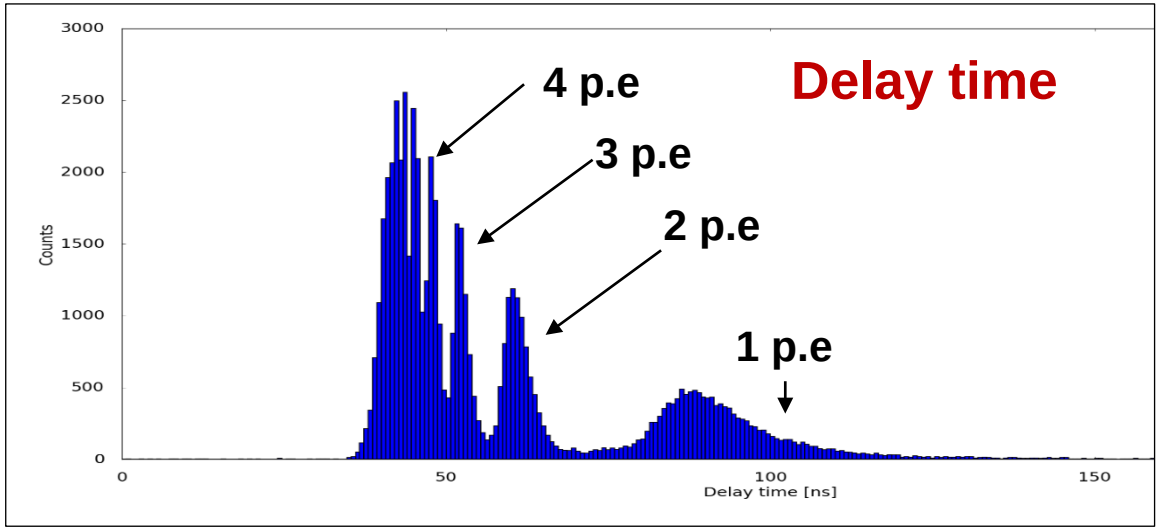
Comparator Threshold selection: 48

- Sensor: **HPK S13360-1350CS**
- **Delay Time** is the delay between the leading edge of the laser trigger signal and the rising edge of HERD discriminated output.
- **Pulse width** is the time width of the discriminated output signal.

II. HERD performance: SPTR measurements with SiPM





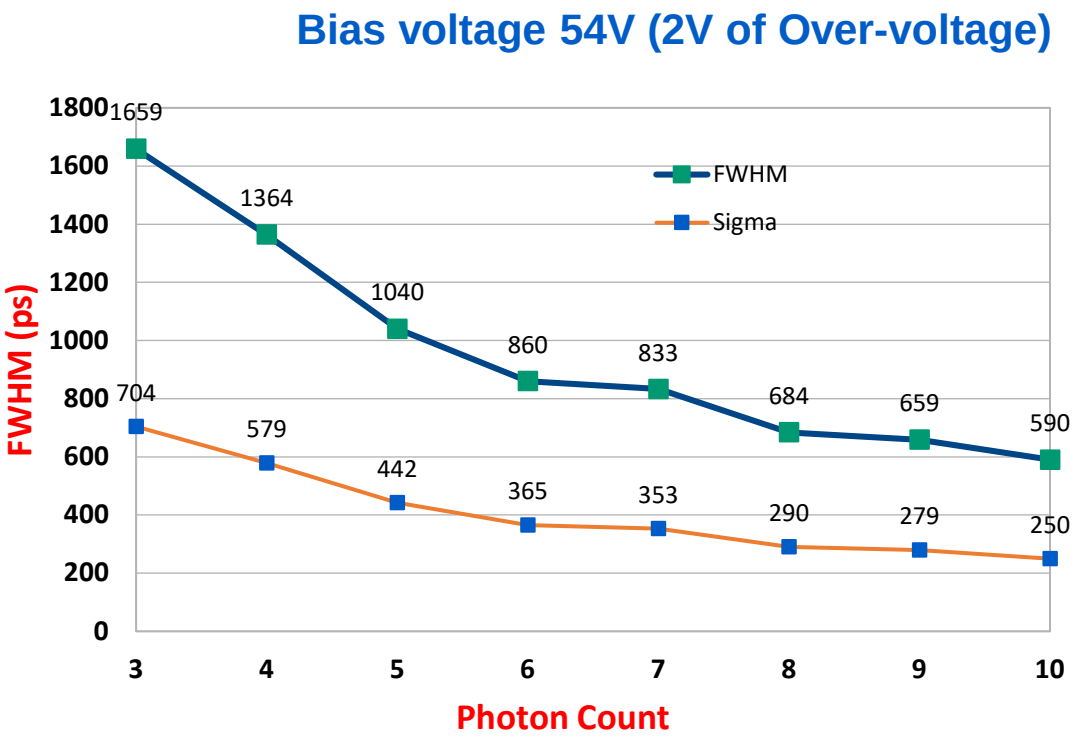


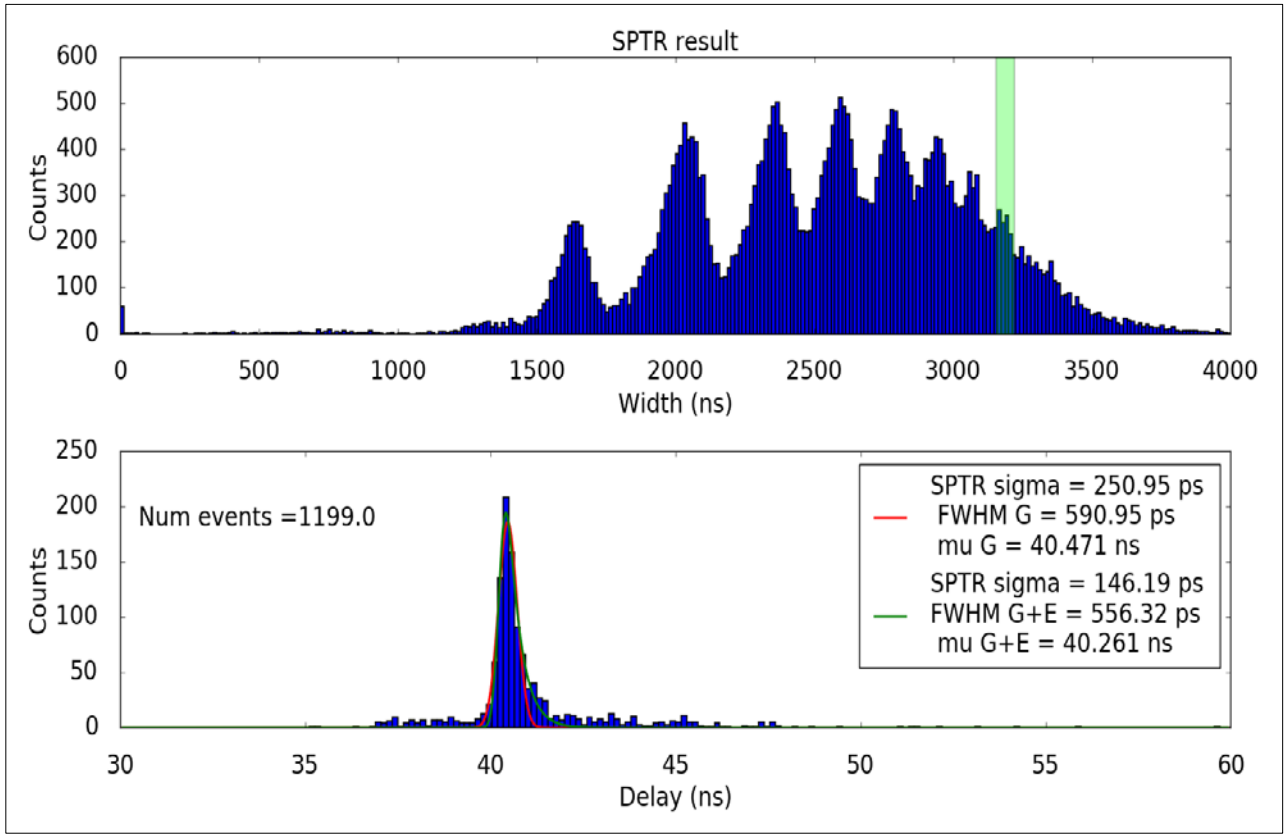
Bias voltage 54V (2V of Over-voltage)

Comparator Threshold selection: 56

Sensor: **HPK S13360-1350CS**

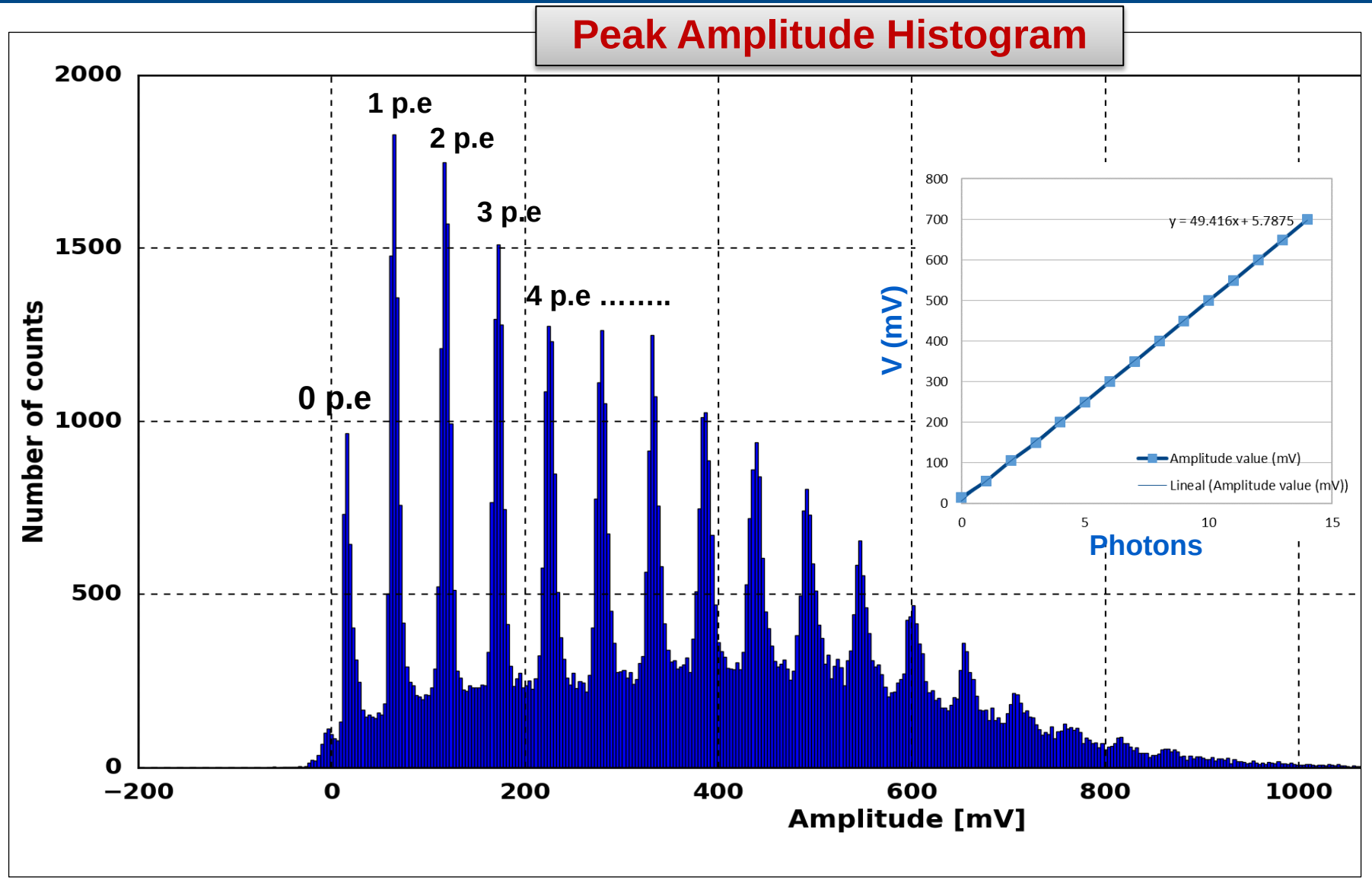
II. HERD performance: SPTR measurements with SiPM





- Sensor: **HPK S13360-1350CS**
- Results are obtained by performing a Gaussian plus an exponential fit of the delay histogram.
  - Best nSPTR HERD: FWHM is 590 ps
  - Best nSPTR HERD : Sigma is 250 ps

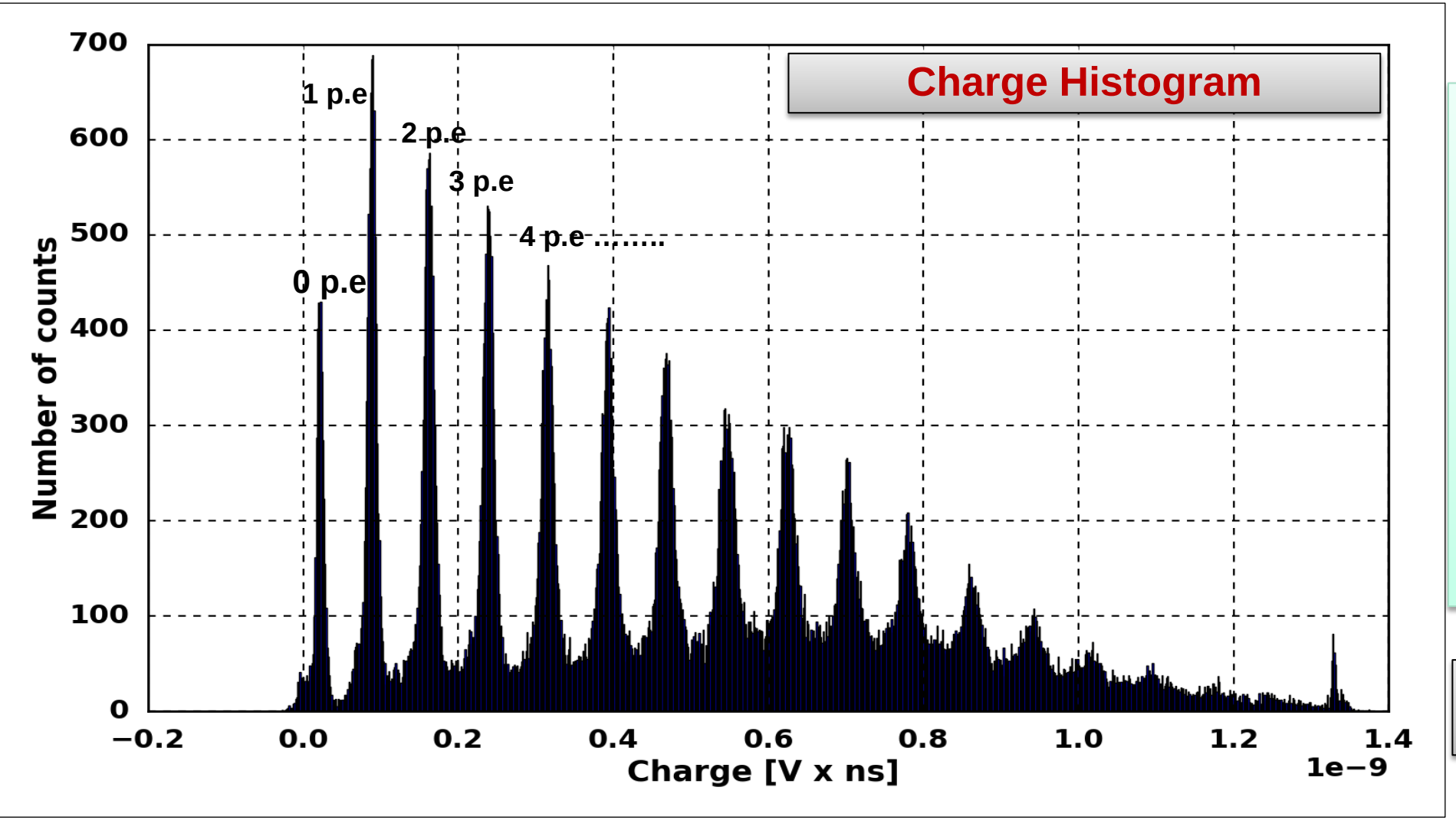
II. HERD performance: HG Output Amplitude Measurements



- Sensor: **HPK S13360-1350CS**
- HG output Amplitude histogram plots acquired for 100k samples
- The individual histogram levels indicates:
  - HG Preamp output amplification depending on number of photons received by SiPM

Bias voltage 55V (3V of Over-voltage)

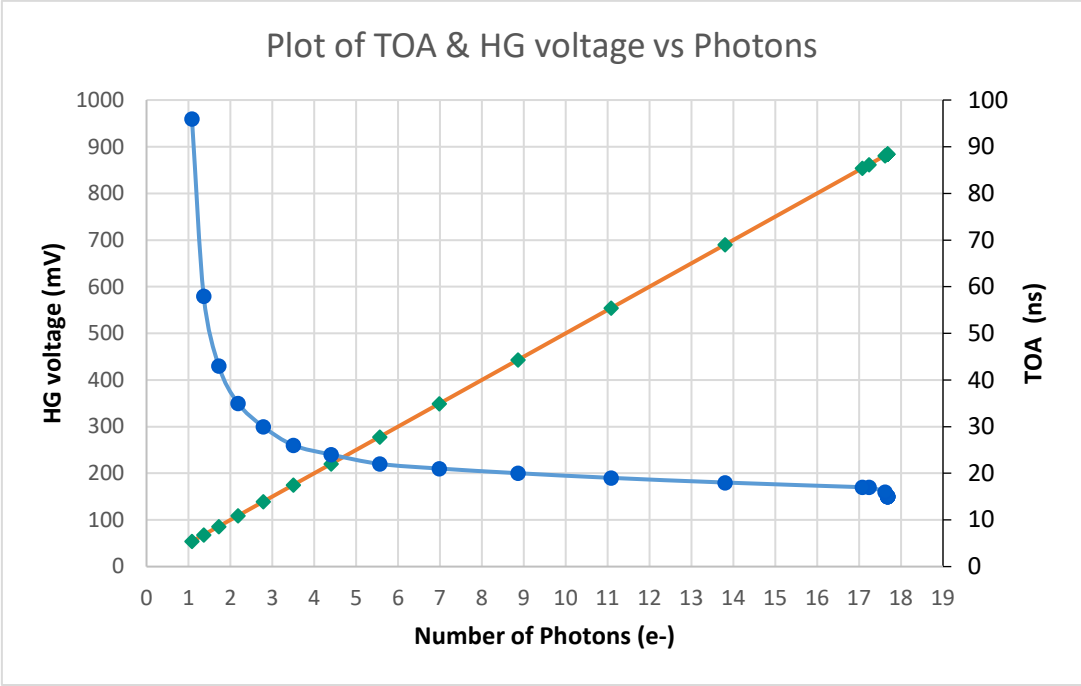
II. HERD performance: HG Output Charge Measurements



- Sensor: **HPK S13360-1350CS**
- HG output charge histogram plots acquired for 100k samples
- The individual histogram levels indicates:
  - HG Preamp output amplification depending on number of photons received by SiPM

Bias voltage 55V (3V of Over-voltage)

Measurement of Electrical setup Latency time



- ✓ **For > 3 photons the delay is < 30 ns**
- ✓ **For > 10 photons the setup delay is ~18 ns and the HG peak amplitude measurement is 500 mV**
- ✓ **The delay added by the laser system is about 20 ns**

The test setup latency is measured with the electrical setup using a waveform generator as an input to the HERD test PCB.

The measurement is performed as:

- ❑ First the delay is measured between the rising edge trigger signal of the waveform generator and the input pulse on the HERD test PCB (t1).
- ❑ Second with the same setup the delay is measured between the rising edge trigger signal of the waveform generator and the HERD comparator trigger output (t2).
- ❑ The difference (t2-t1) between these two delay measurements gives the actual setup delay.

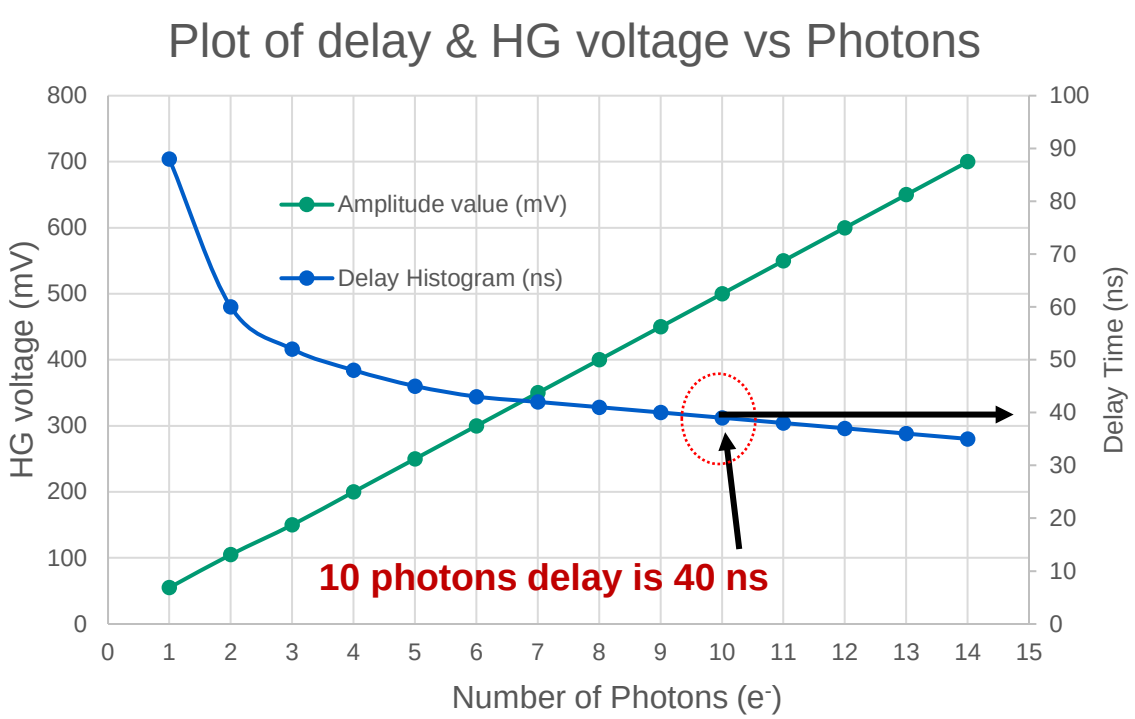
Conclusions and Future works

- The HERD BETA ASIC is functional w.r.t various configurations.
- The delay of the trigger signal is < 30 ns for laser signals with > 3 pe
  - Converging asymptotically to 18 ns for large signals
- Very preliminary results on timing resolution 200-300 ps rms for large signals
  - Limited by present configuration (determined by FIT specification on power: 1 mW/ch)
  - Long time constant of high gain preamp causes baseline fluctuations (dark count pile up)
  - Signal rise time limited by preamp power consumption
  - Potentially both can be tuned, however slow control configuration problem prevents modification
    - Will be solved in next prototype
  - We think that there's room to improve timing resolution but ASIC correction and extensive tests are needed: answer by the end of 2022
- Initial amplitude and charge measurements for HG output various peaks can be differentiated depending on the number of photons.
- Further measurements has to be carried out to characterise the ASIC

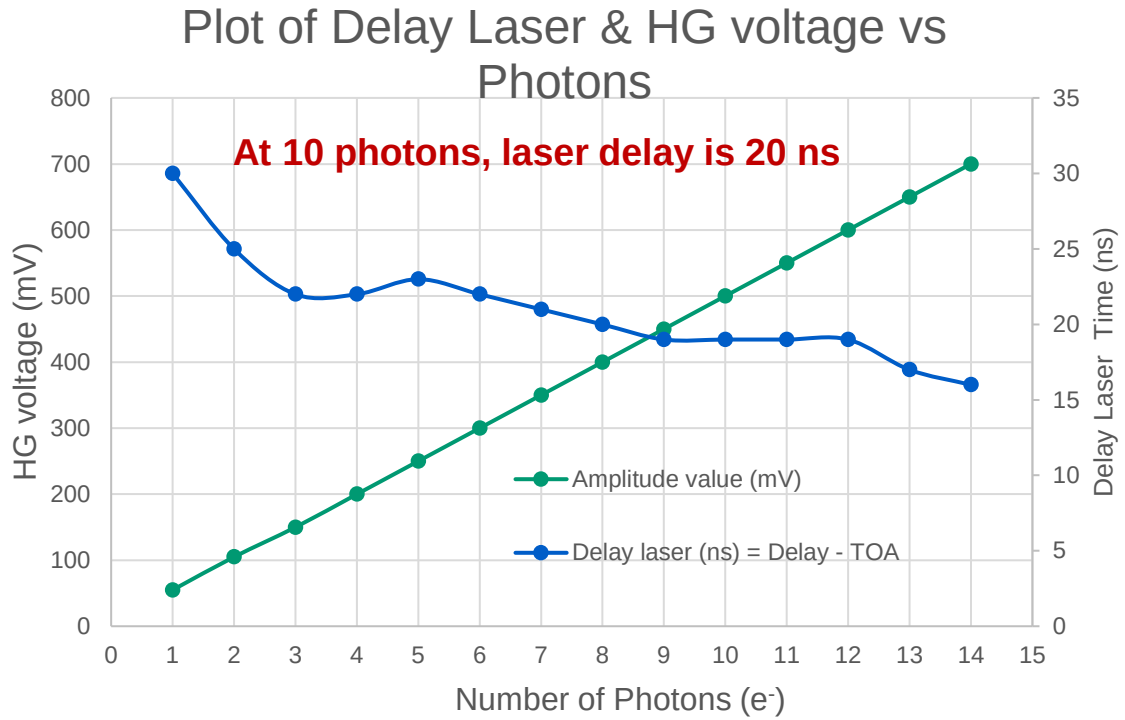
ANY QUESTIONS OR COMMENTS?

Backup Slides

Measurement of Laser set up delay



✓ The plot is the actual measured SiPM delay w.r.t number of photons and the HG output peak voltage.

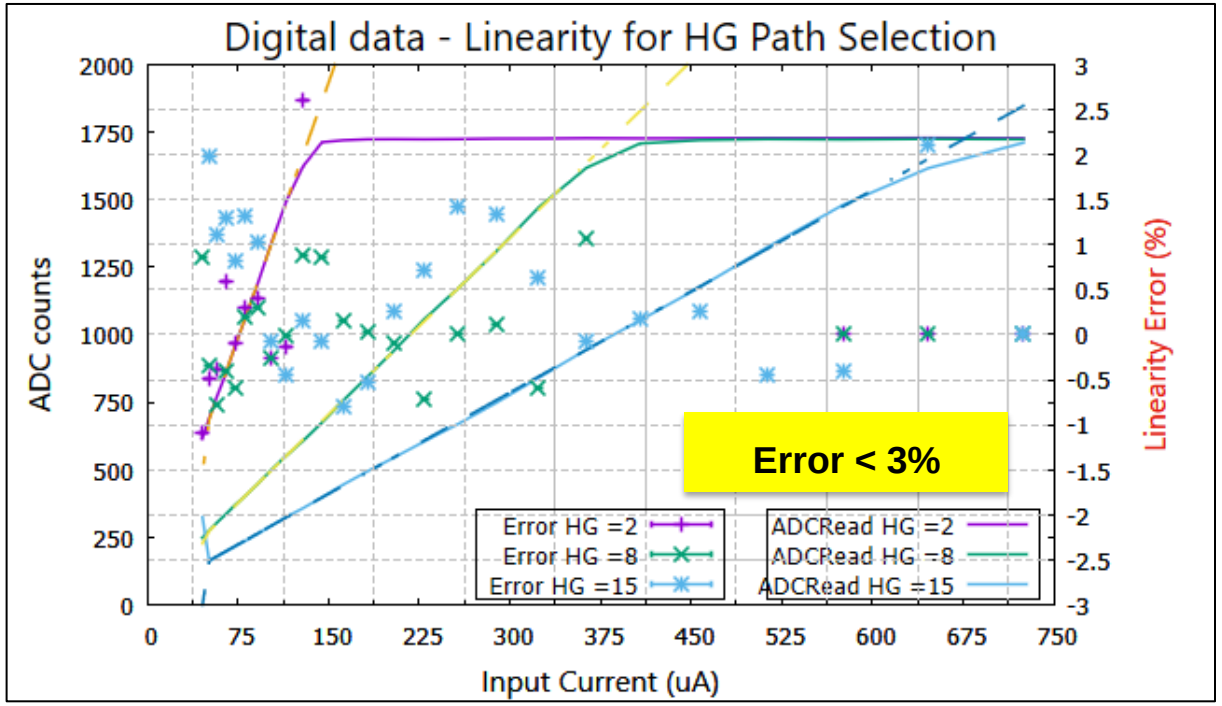


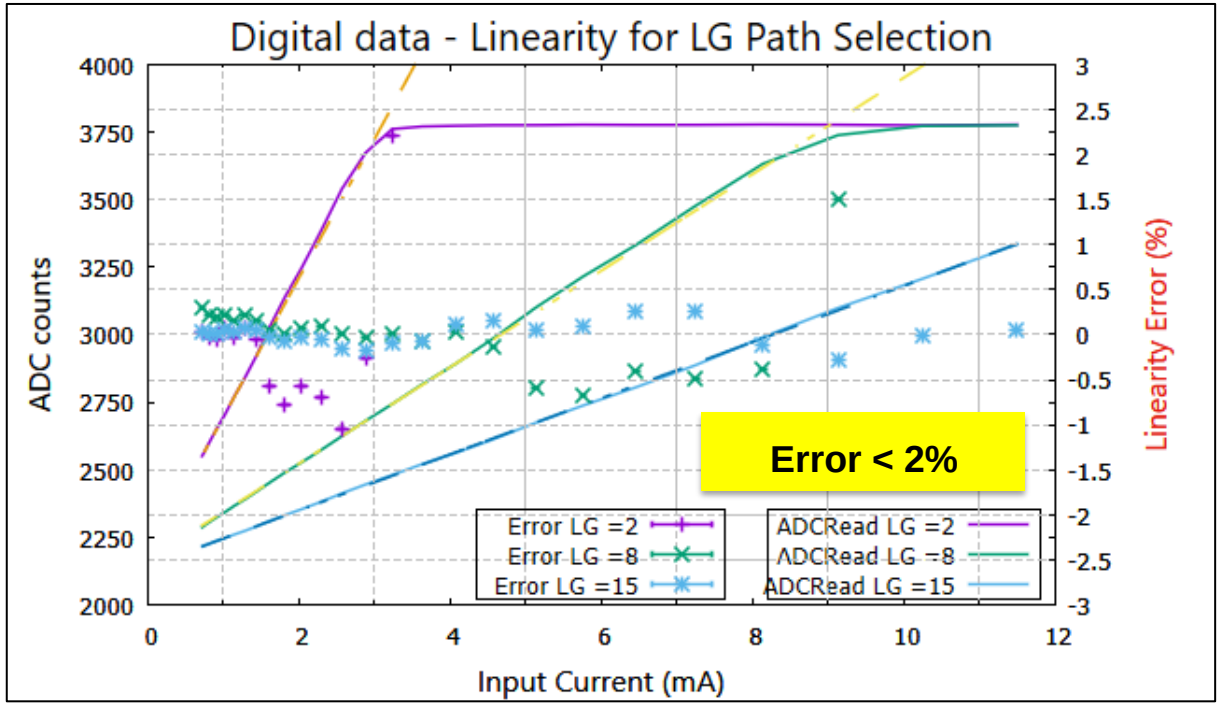
✓ The plot is the final delay after subtracting the laser setup delay.

Laser setup delay = Histogram delay* – measured electrical setup delay

*** The delay time mentioned on slide no. 6,7**

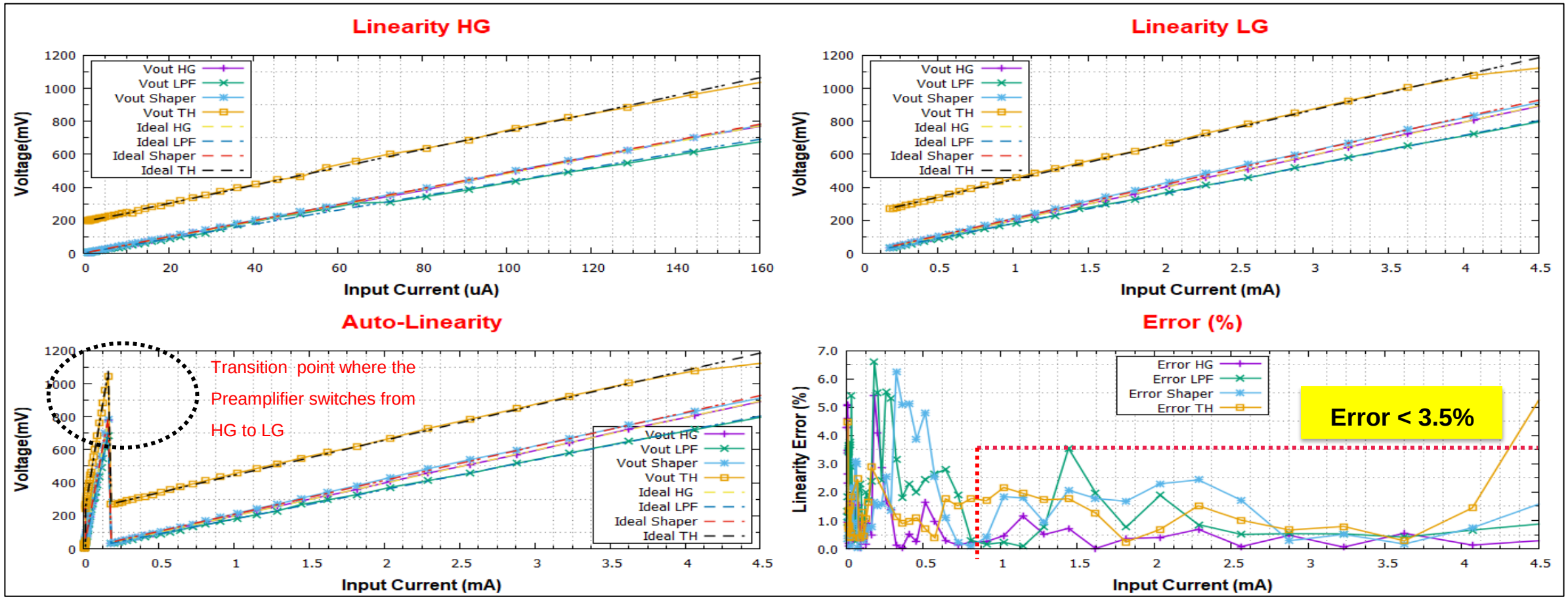
HERD BETA – ADC data readout Linearity & Error





- The linearity error is **below 3%** over the whole dynamic range for HG & LG paths.
- The ASIC provides a large dynamic range from 3800 pe to 0.1 pe (132 pC to 3.5 fC) as large as 15 bits
- The output saturates at 750 uA of input current for HG path selection and 12 mA input current for LG path selection.

HERD BETA – Analog Voltage measurement Linearity & Error



- The above plot shows the linearity error with auto gain path selection
- The linearity error **is below 3.5%** over the whole dynamic range.
- The ASIC provides a large dynamic range from 3800 pe to 0.1 pe (132 pC to 3.5 fC) as large as 15 bits

Conclusions and Future works

- The HERD BETA ASIC is fully functional as expected with various configurable dual gains, tunable peaking time and path selection modes.
- Power per channel is 1.2 mW and this will be scaled down to < 1 mW for final 64 channel ASIC as the common elements (band gap references, common bias) will be the same.
- A total Dynamic range from 4000 pe to 0.1 pe: 1 to 300 for HG path and 200 to 3800 for LG path.
- Rate of operation from 1kHz to 100 kHz with bipolar shaping and baseline restorer(gated baseline) options.
- A linearity error of less than 3% for all operating modes (HG, LG, Auto selection path)

The following studies has to be carried out:

✓**Comparator and single photon regime**	✓**Single photon SNR**
✓**Characterization with SiPMs**	✓**Crosstalk**