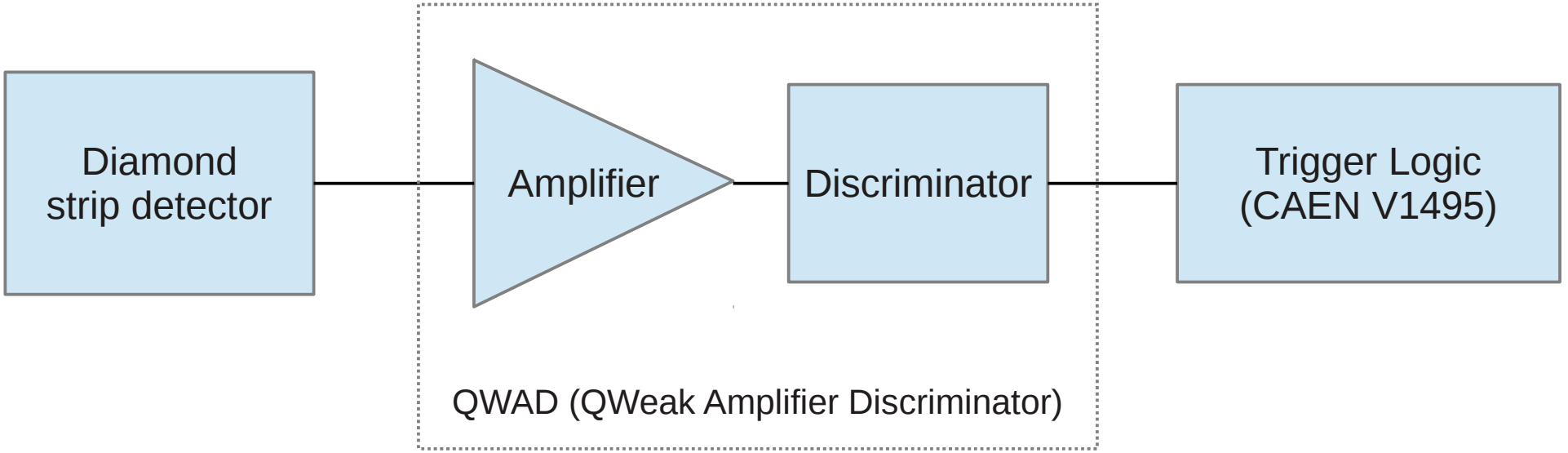
Electron Detector Frontend Electronics of Qweak Compton Polarimeter



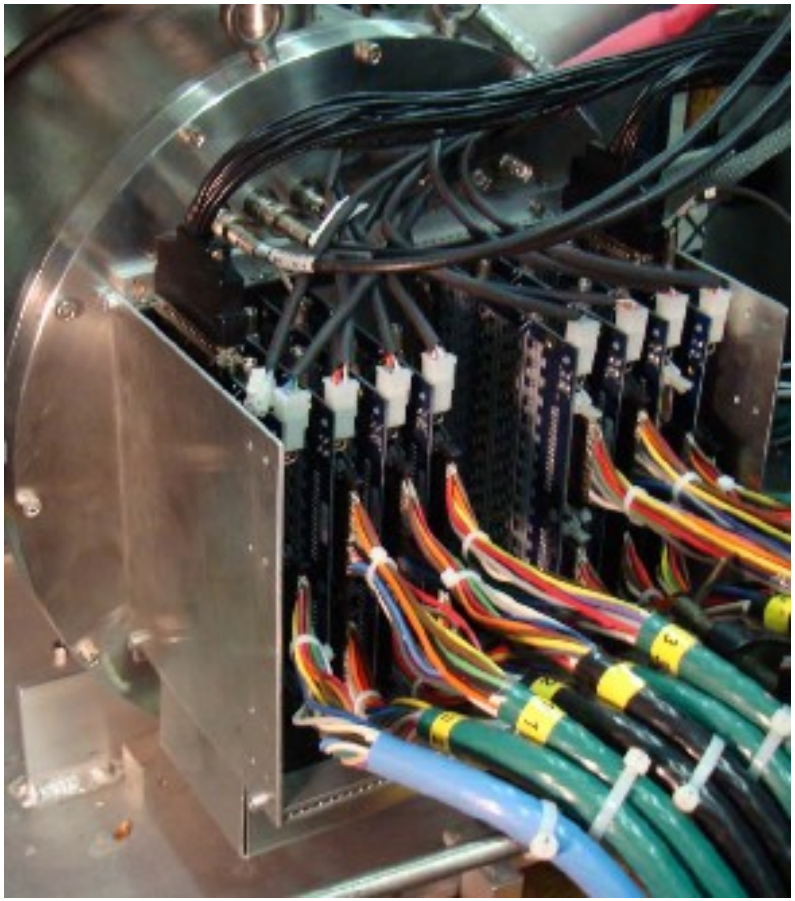
- R&D: since 2008
- Amplifier: modified AGAM board (preamplifier of TRIUMF LiXe TPC)
- Discriminator: LVDS comparator
- V1 & V2: noise pickup & crosstalk issues
- V3: PCB layout with EMC control, production version for Qweak

AGAM board:

- Signals: ~20K electrons
- ENC: ~600 electrons
- Gain: >10 mV/fC
- Shaping time: ~300 ns
- Linearity: no requirement

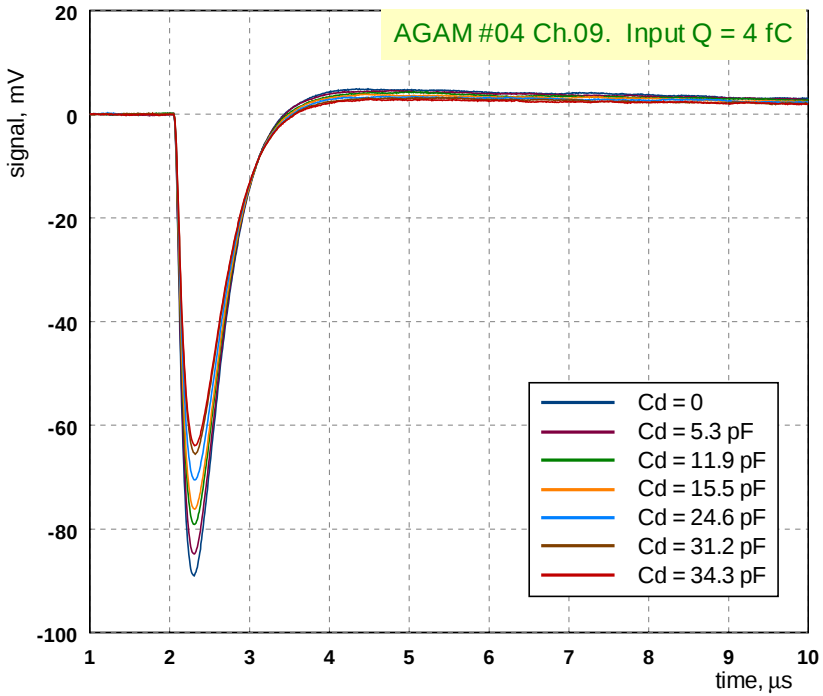
Qweak requirements:

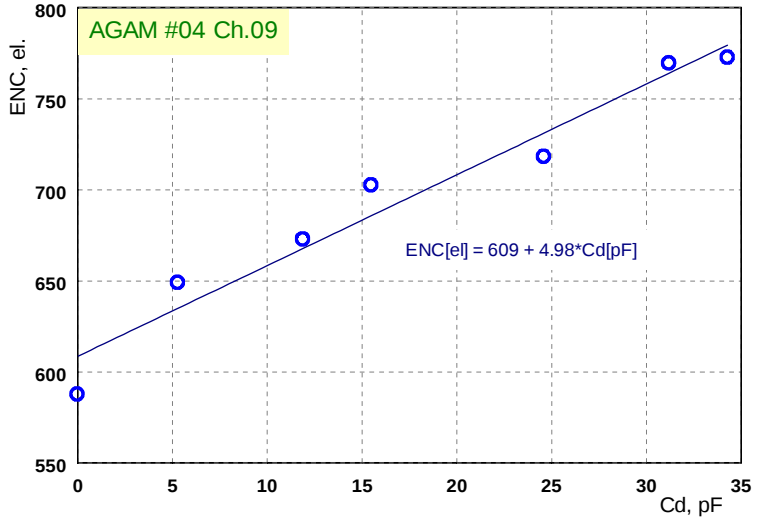
- Signals: ~6K electrons
- ENC: ~1-2K electrons
- Higher gain (>40 mV/fc)
- Shaping time: < 1 μs
- Other = AGAM's

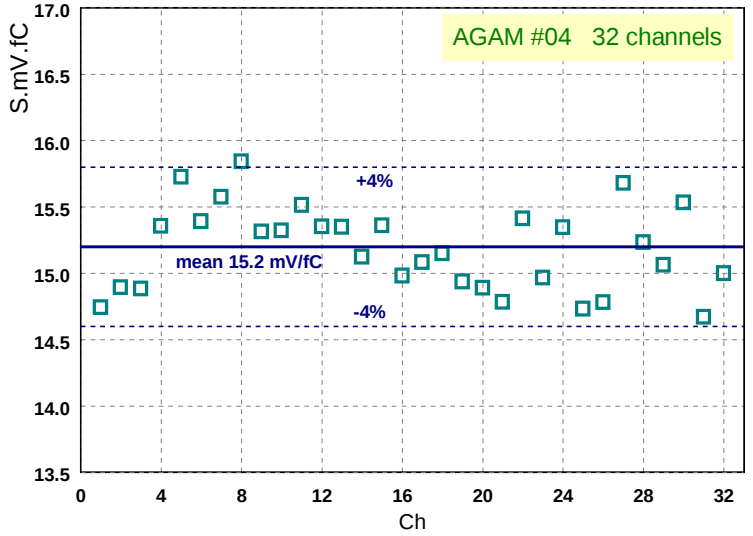


Pre-amp of LiXe TPC
(L.Kurchaninov, TRIUMF)

Characteristics of AGAM Board:







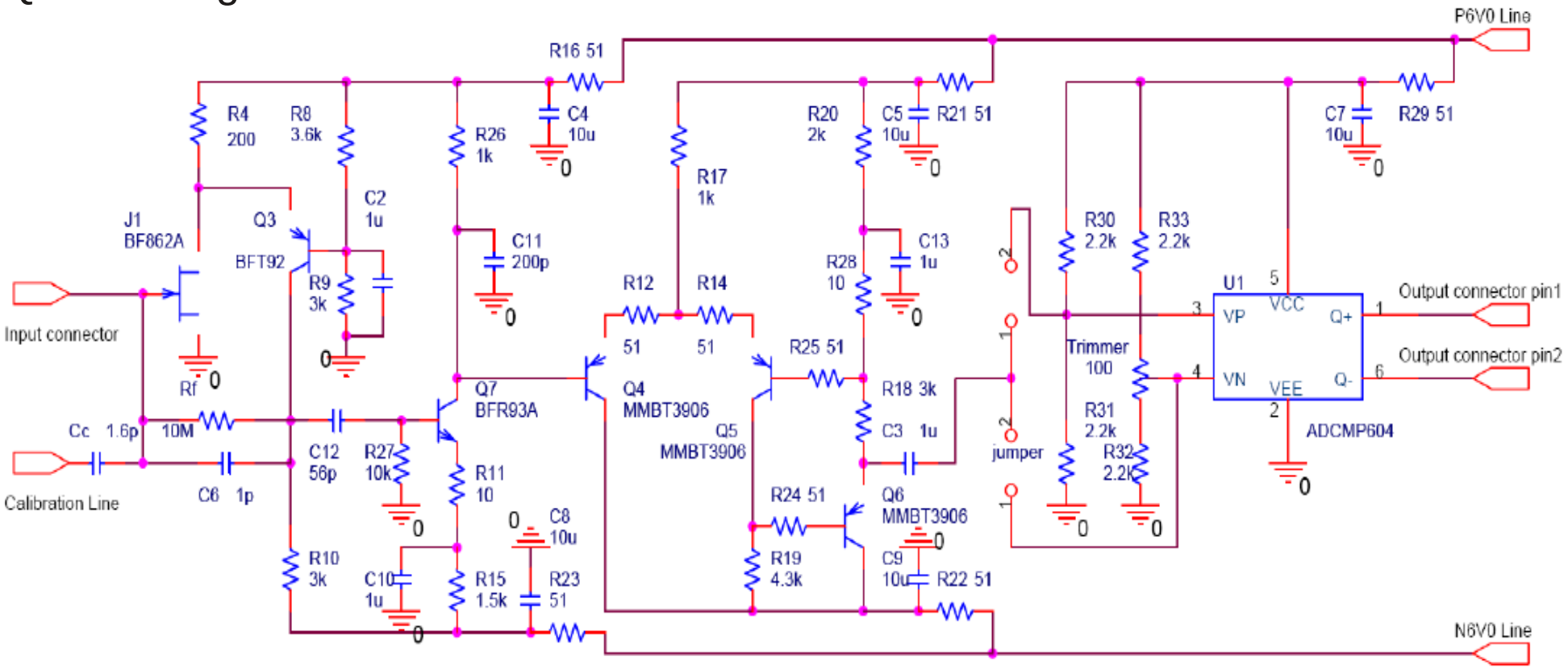
- Transfer gain: ~15 mV/fC
- Gain & ENC vary with input capacitance
- Gain uniformity: <8% channel-to-channel

Qweak modifications to AGAM board:

- Removed input protection to reduce ENC
- Increased gain from 15 mV/fc to >40 mV/fc
- Added in digital section (discriminator with adjustable threshold)

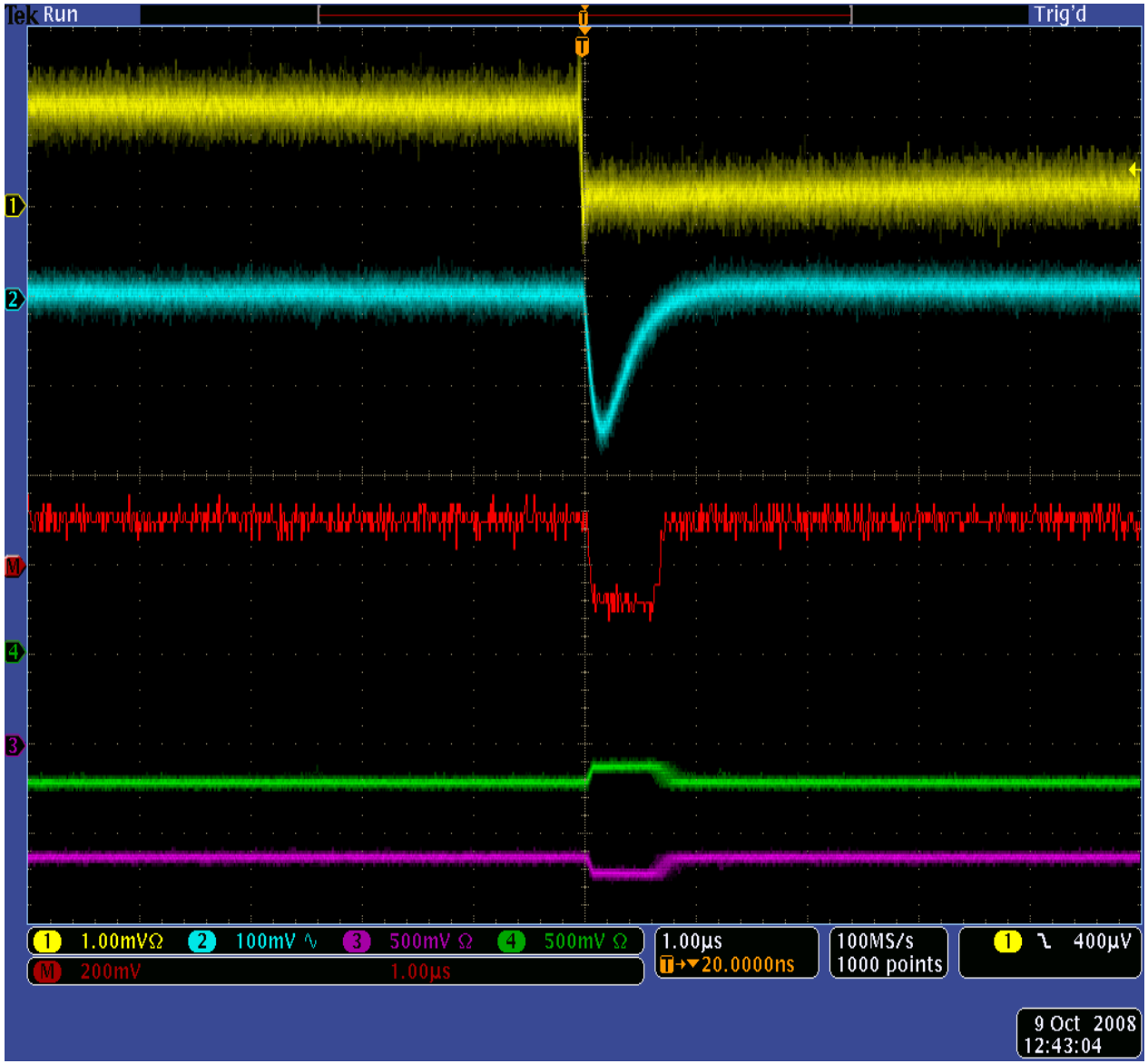
AGAM → QWAD

QWAD: single channel schematics



Charge-sensitive stage · RC-CR shaper · Driver/amplifier (Single-ended) · Comparator (LVDS output)

Test of QWAD prototype (modified AGAM board):



Input

Yellow: long tail calib. pulse

Analog output

Cyan: output of the pre-amp

Digital output

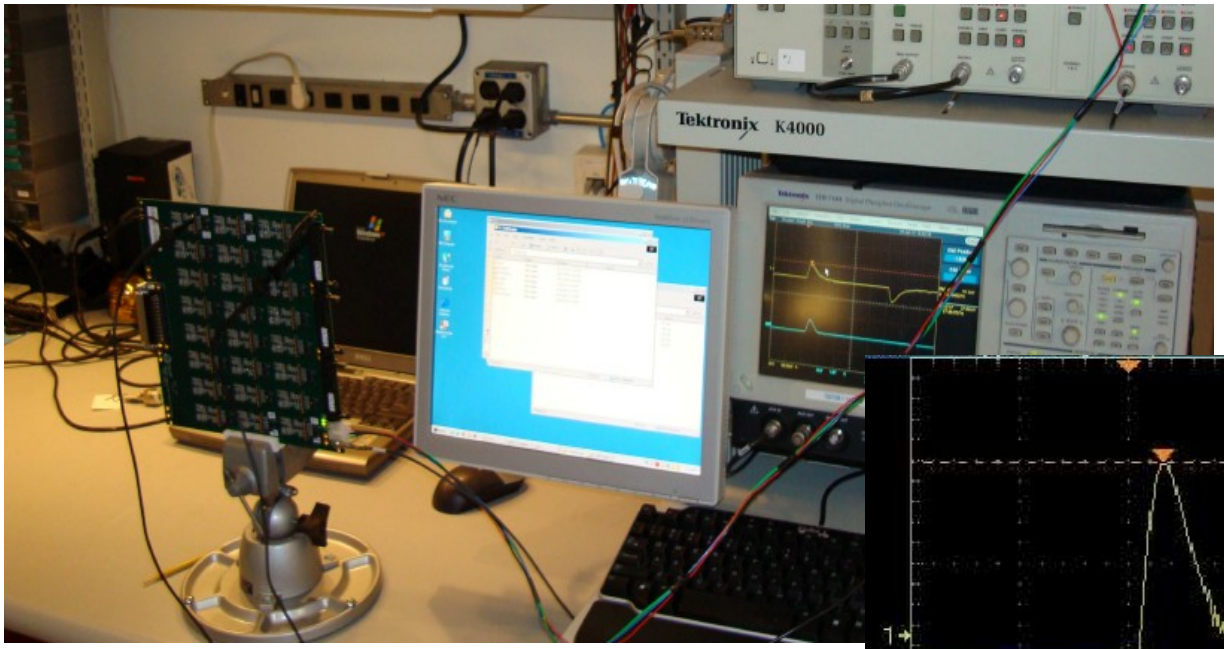
Green & Purple: outputs of the comparator (measured with single-ended probe)

Red: difference between green and purple

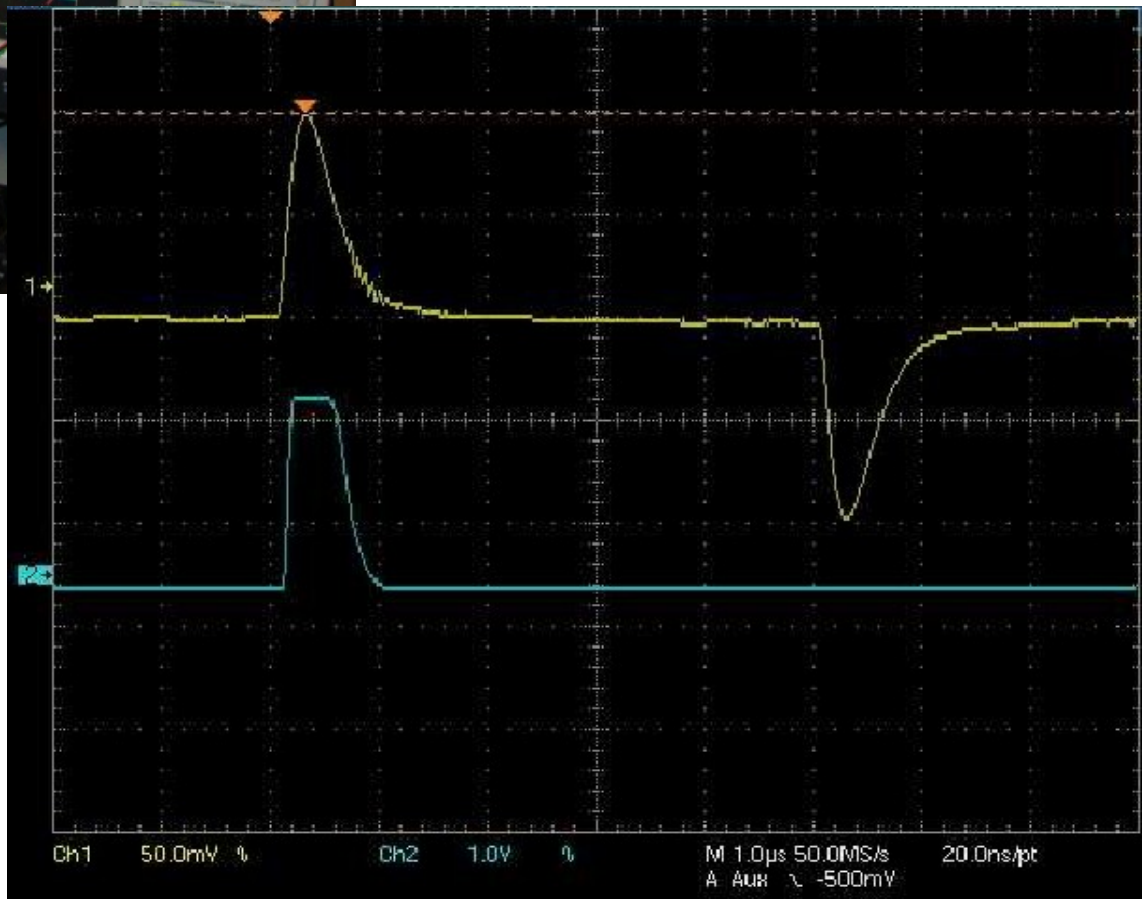
- Pulse width: ~0.6-0.8 us
- Gain: ~100 mV/fc
- No oscillation/instability caused by higher gain

Note: 1 mV input pulse corresponds to ~1.6 fC of charge (calibration cap 1.6 pF).

Test of QWAD V2:



Board was powered by +5.0V (1.53A) and -5.0V (0.36A).



Input:

+/-5 kel signal

Output:

Analog (yellow, gain ~20 mV/kel)
- both positive and negative polarities have the same shape and magnitude

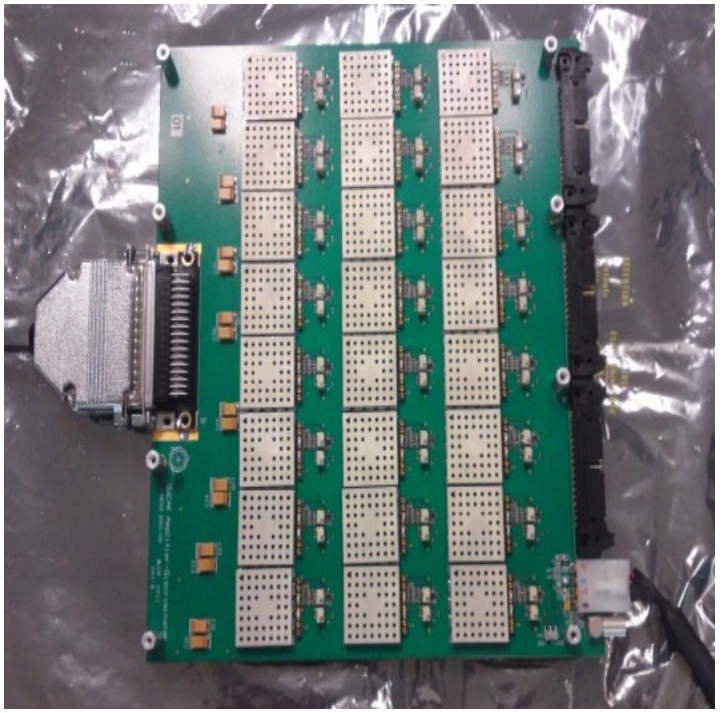
Digital (cyan, LVDS)

Electron Detector Frontend Electronics of Qweak Compton Polarimeter

- QWAD V1: very noisy
- QWAD V2: additional ground plane, less noisy and more stable, but with inter-channel correlation/cross-talk
- QWAD V3: better EMC control in PCB layout, sectional shielding
- There is a variation of channel-to-channel in both gain and ENC, possibly caused by PCB stray capacitances.

  This variation can be reduced by increasing feedback capacitor of input charge sensitive cascade, but it will proportionally reduce the amplifier gain.

  The wide variation of gain requires individual tuning of thresholds.



QWAD-V3

48 Ch./Board (PCB layout by TRIUMF electronics group)

PCB manufacturing: $1000 + 100*PCB

Parts: $300*PCB

PCB assembly: $1000 + 100*PCB