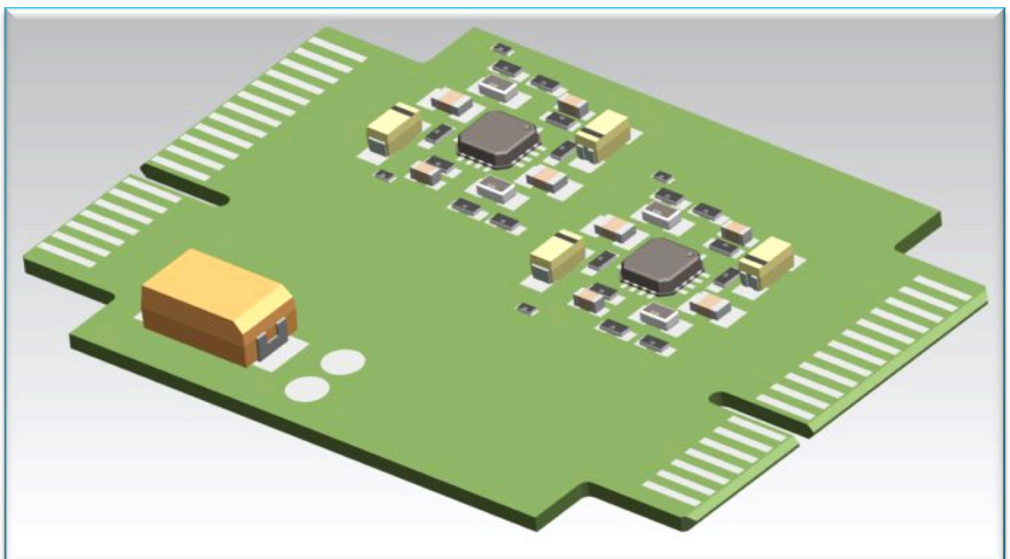
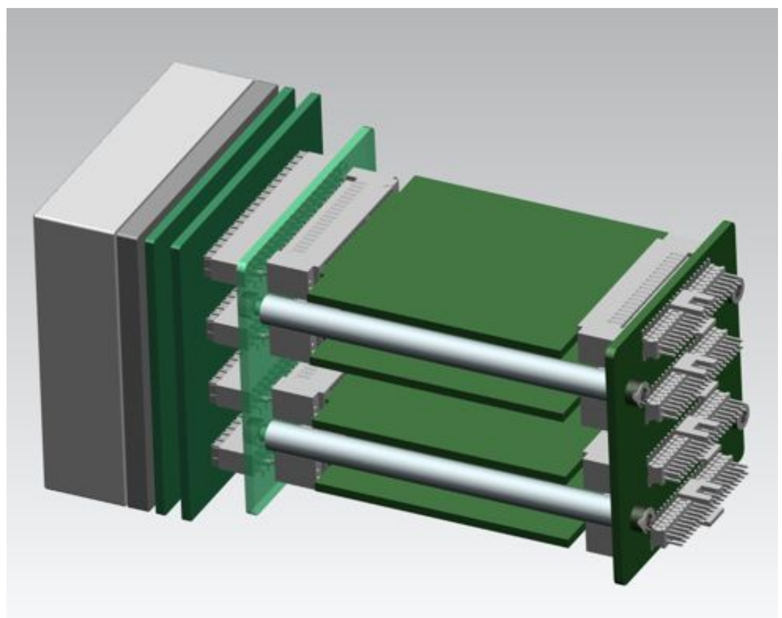
CHEC Detector Pre-amplifiers



D.Ross, R.White. University of Leicester

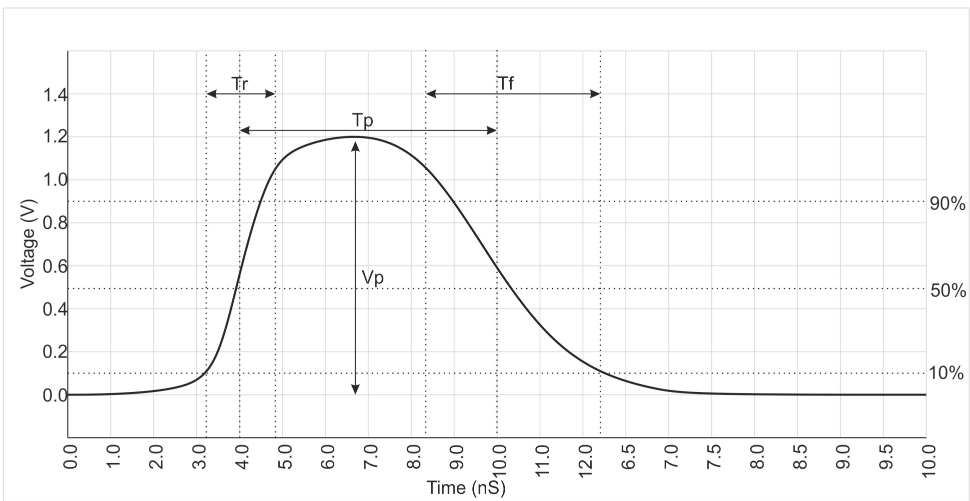
Mechanical Concept

- Amplifiers with edge fingers
- Minimises connector numbers and costs
- 4 boards with 16 amps each (64 channels per detector)
- Modular (with end boards) for detector and flex interfaces.
- If real estate is needed (not currently envisaged), mezzanine boards will be added between



Interface Specification

- Draft Target Module interface specification written and circulated (SLAC)
- Basic input pulse parameters agreed:-
  - 70 Ohm system (Max SLAC can achieve, reduces power consumption, increases available peak pulse voltage)
  - Peak pulse into Target, 1.0V, positive going, capacitively coupled
  - 1.2V under consideration to improve Target signal-noise function
  - Nominal FWHM pulse width 4-9nS
  - Supply nominally 5.0V single ended, and probably <10mA per channel (3.2W per MAPMT) – Amplifier dependant
  - 5.2V under consideration if 1.2V peak pulse required (common mode and rail consideration)
  - Power supply noise immunity tests for SLAC PSU design, still to be done on recently built candidate amplifiers



Nominal Pulse Specification (From Monte Carlo)

Candidate amplifiers

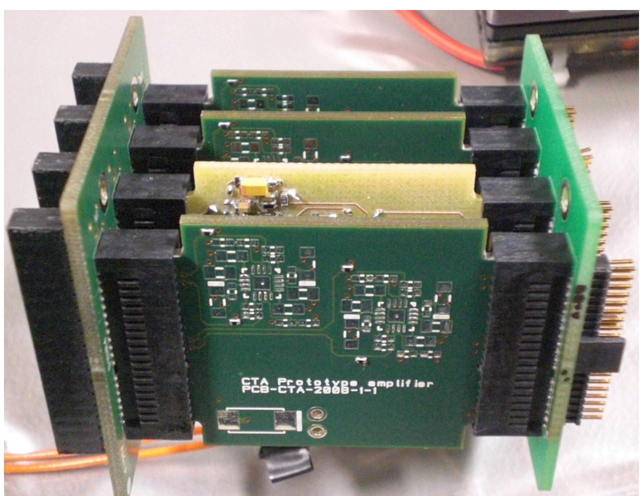
- Majority of candidates are current feedback (CFB) types, which is our preferred topology,
  - Currently testing AD8014, OPA2683 and AD8004
- Also looking at quad-core (also known as H-Bridge core) voltage-feedback (VFB) types as these may also have an adequate gain vs bandwidth suitable for this application.
  - Currently AD8038
- Current Feedback has constraints compared to voltage feedback
  - higher offset voltages
  - Higher bias currents,
  - Differing impedances on the inverting and non-inverting inputs,
  - Restricted feedback arrangements,
  - Instability due to stray capacitances.
- However we favour the low inverting input impedance and if we utilise the trans-impedance route (i.e. current to voltage conversion):-
  - lower input voltage noise per given bandwidth,
  - faster slew rates
  - lower distortion.
- We are particularly attracted by extra fast complimentary bipolar (XFCB) devices at this stage
  - e.g ADA4817-2 (first candidate being tested, but has high quiescent current which SLAC were not keen on for PSU design) .

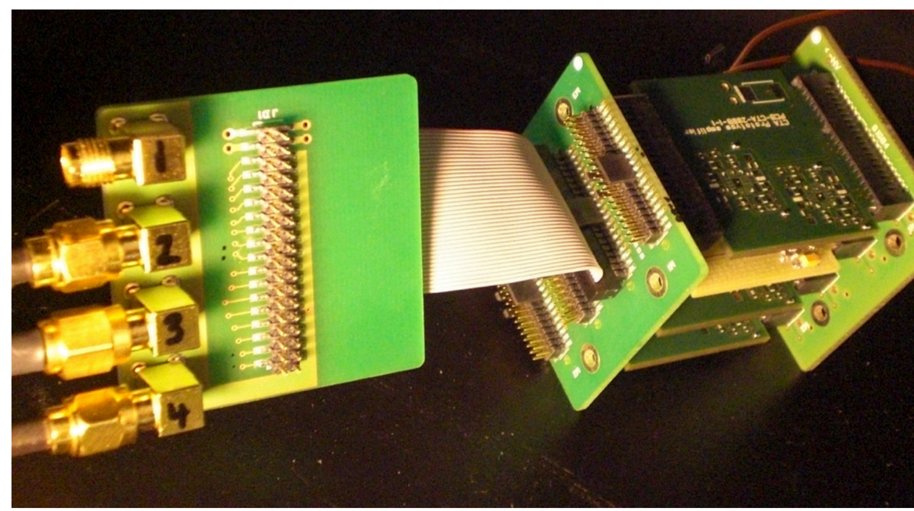
Testing

- Two amplifier systems recently built, being tested, results are promising
- Looking closely at common mode voltage restrictions to ensure batches of amplifiers / PCB build will all behave correctly
- Designs need minor modifications based on results
- Noise immunity needs urgent attention for SLAC PSU design

Initial Test Setup

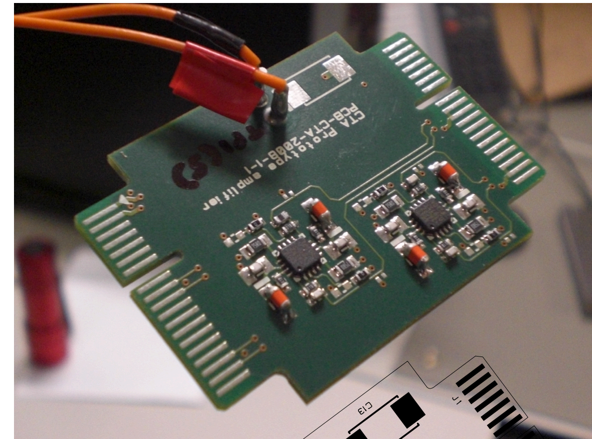
- Aim: examine the pulse shape and output range.
- Prototype preamplifier boards connected into MAPM prototype module.
- All channels other MAPM channels terminated with 1K Ohm.
- 4 preamp channels terminated after amplification with 75 Ohm and input with high-Z to the scope.
- MAPM illuminated as described in Mark's talk tomorrow.

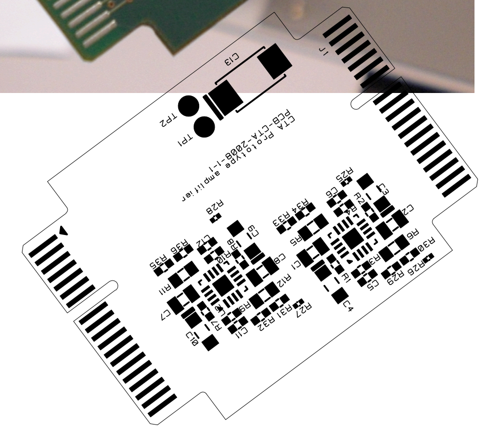


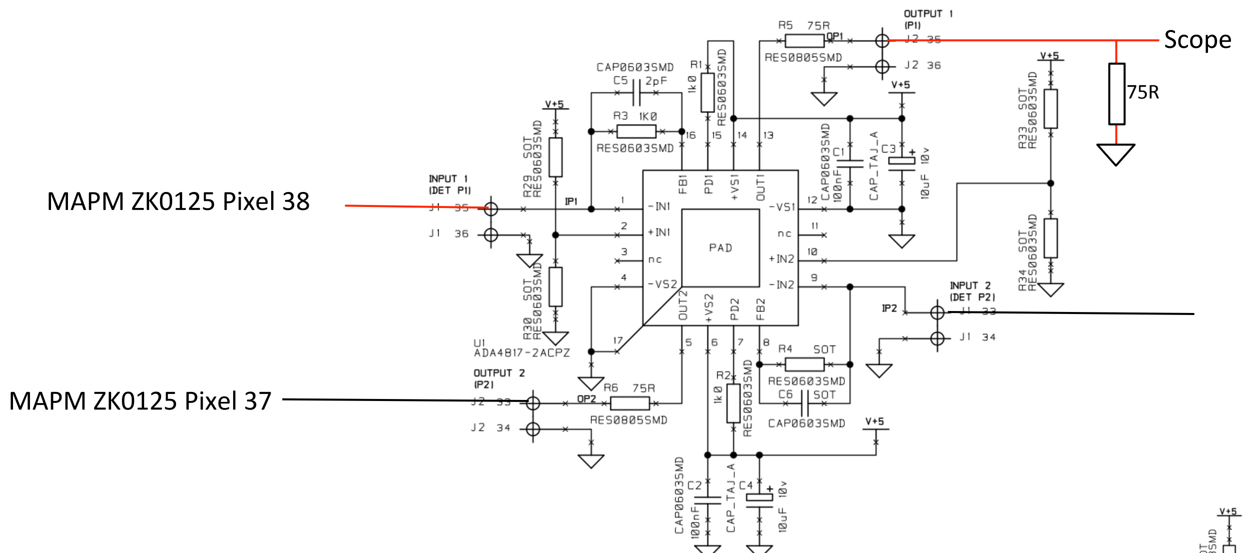


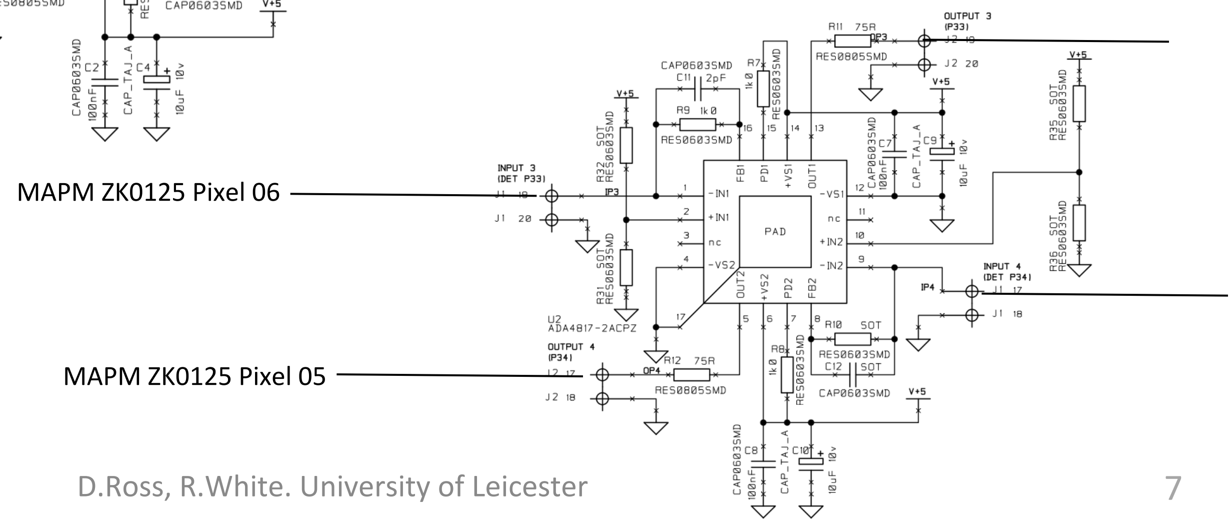
Circuit A

- 2 x ADA4817 dual channel
- Pixel 37 investigated in more detail
- ~50 mA @ 5V consumption for all 4 channels



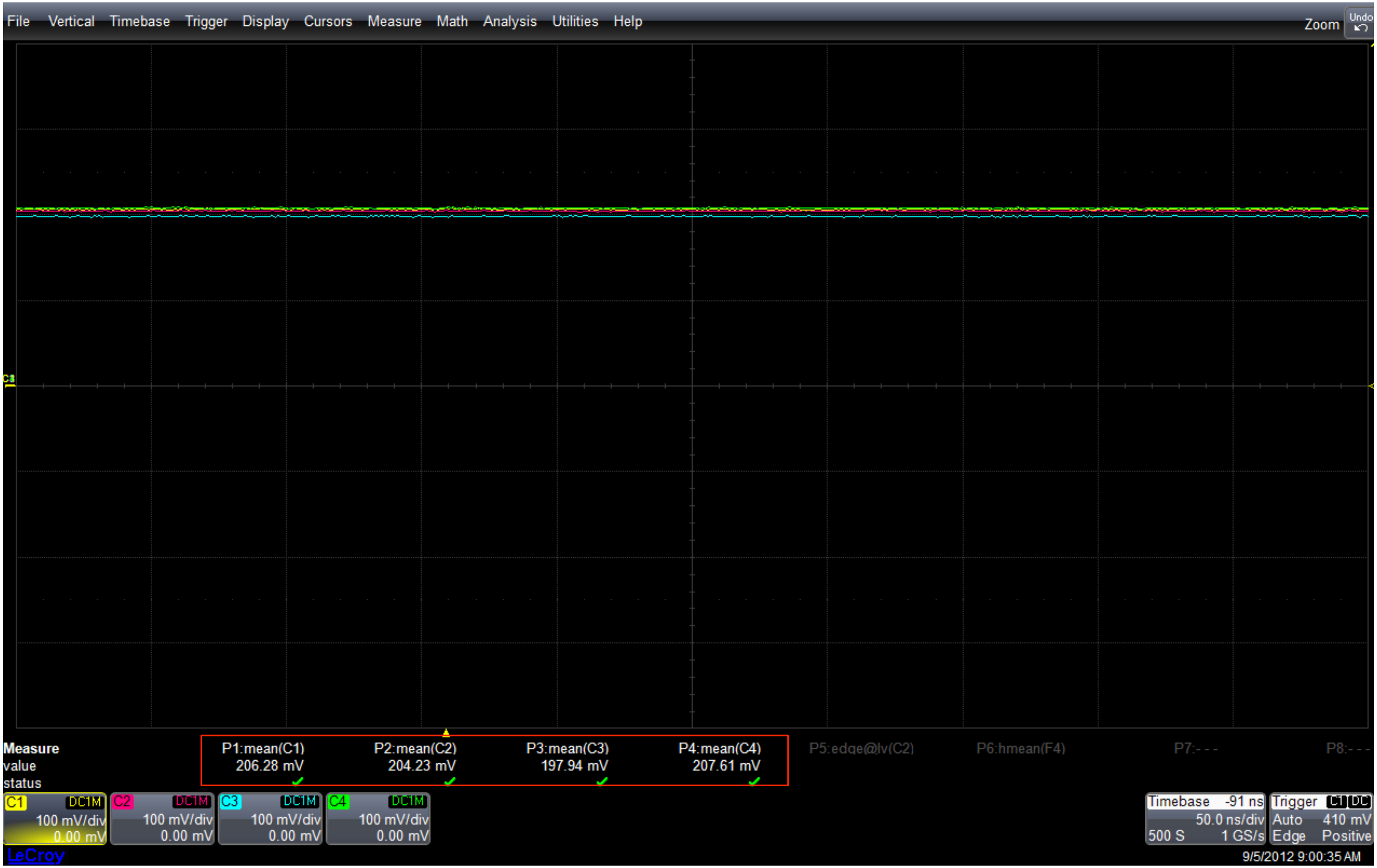






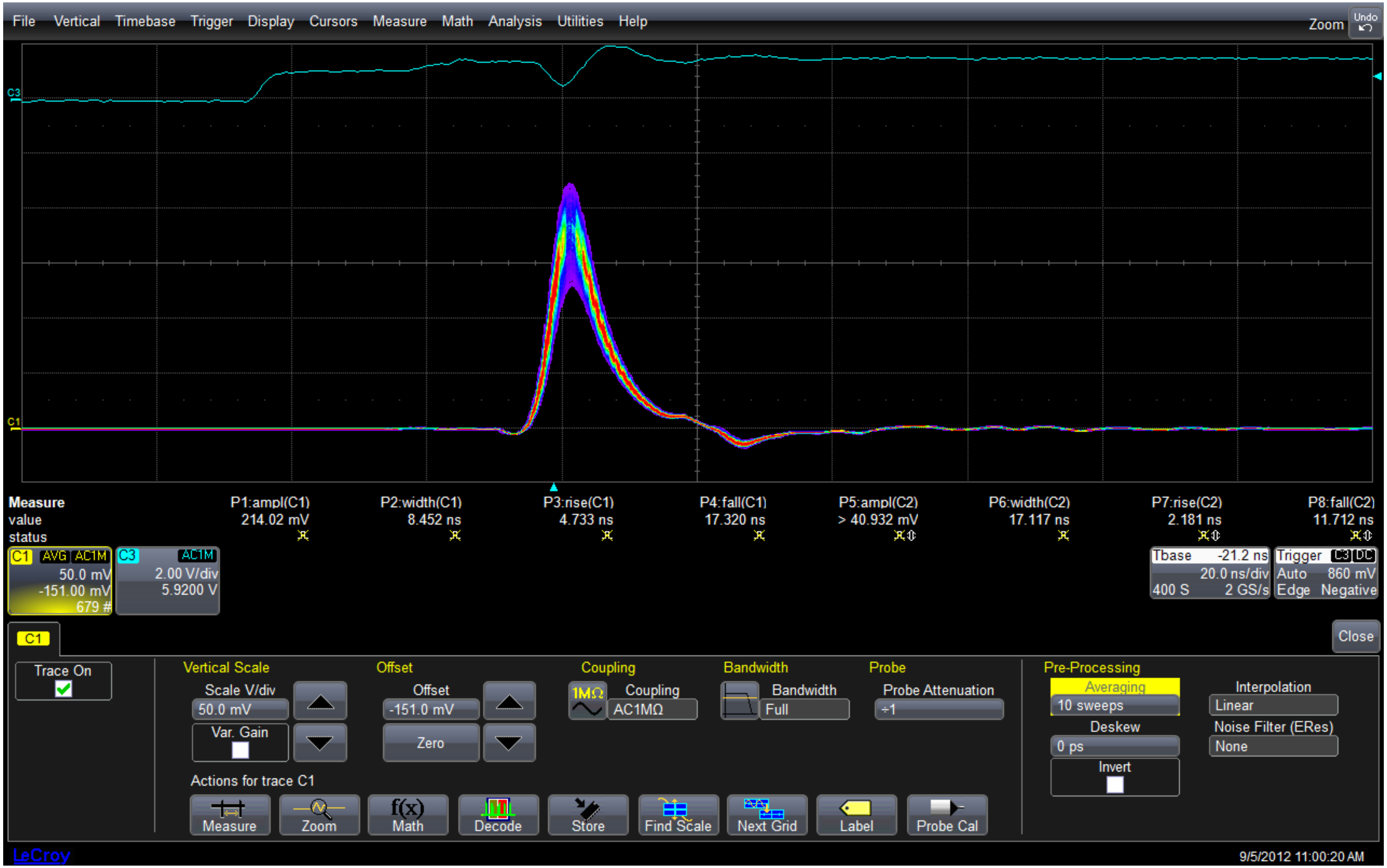
Circuit A: DC Offsets

- ~200 mV



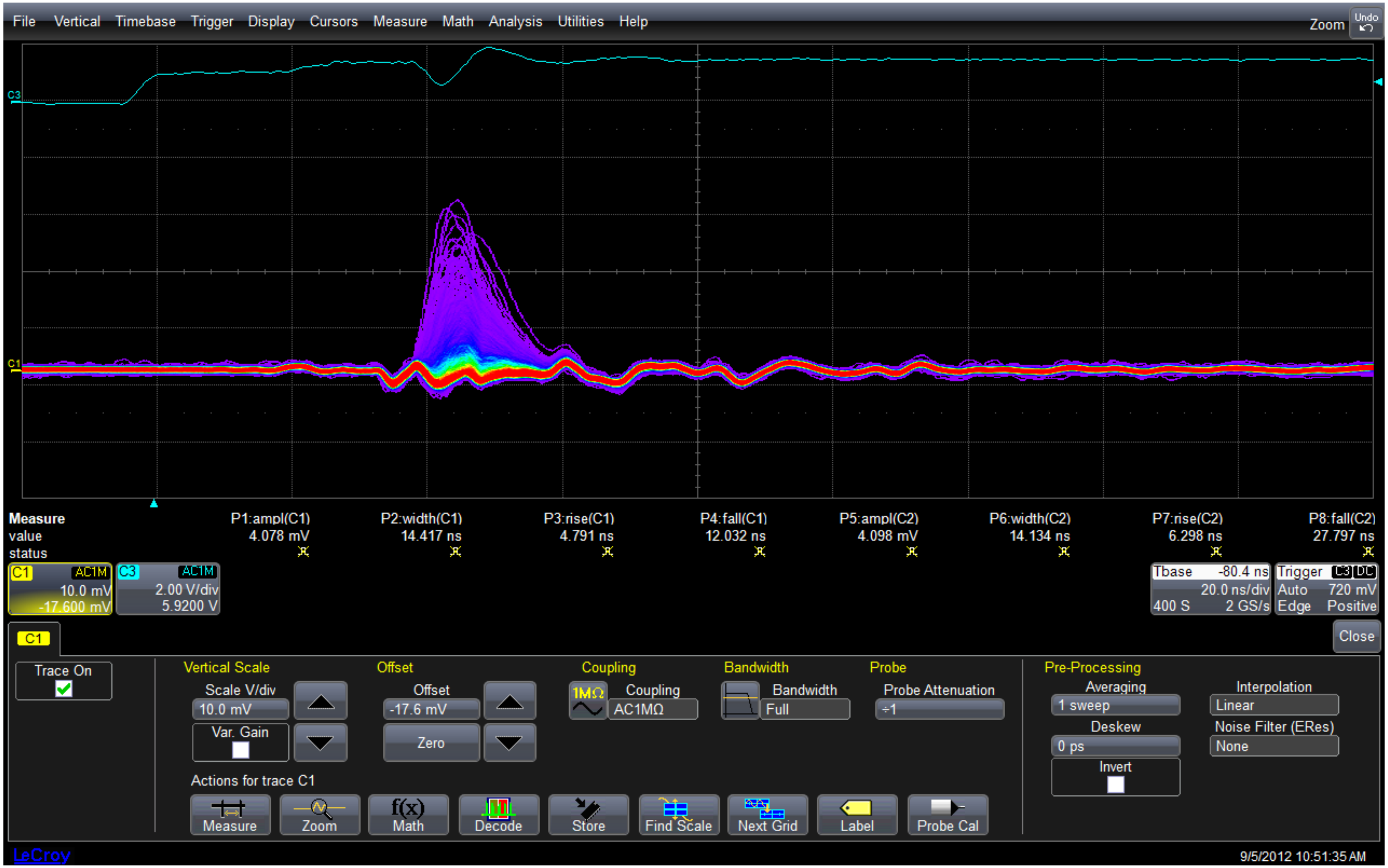
Circuit A: Pulse Shape

Rise Time: ~5 ns   Fall Time: ~ 17 ns   FWMH: 8.5 ns



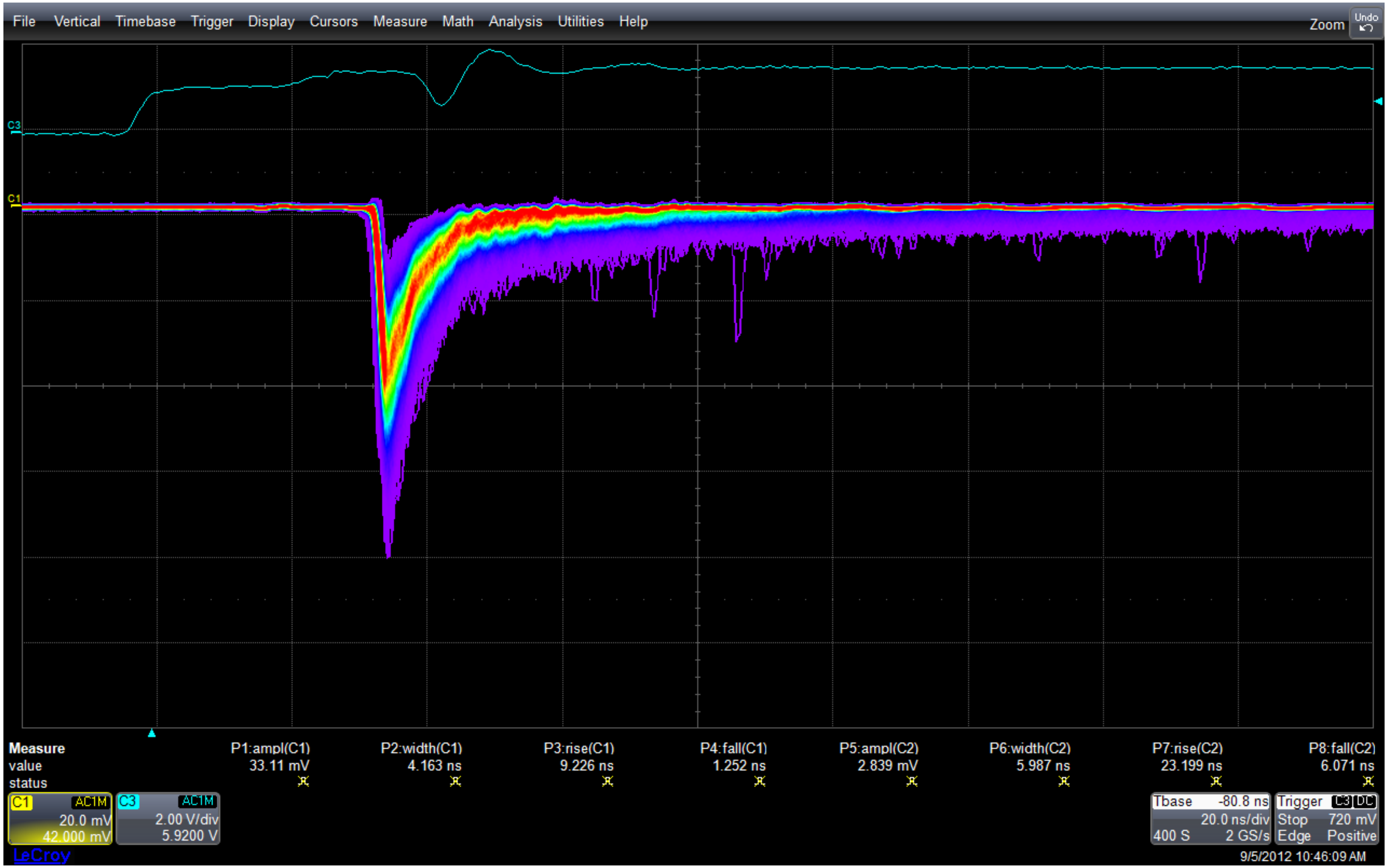
Circuit A: Minimum Signal

- Single p.e. is not resolvable
- Minimum signal is ~10 mV



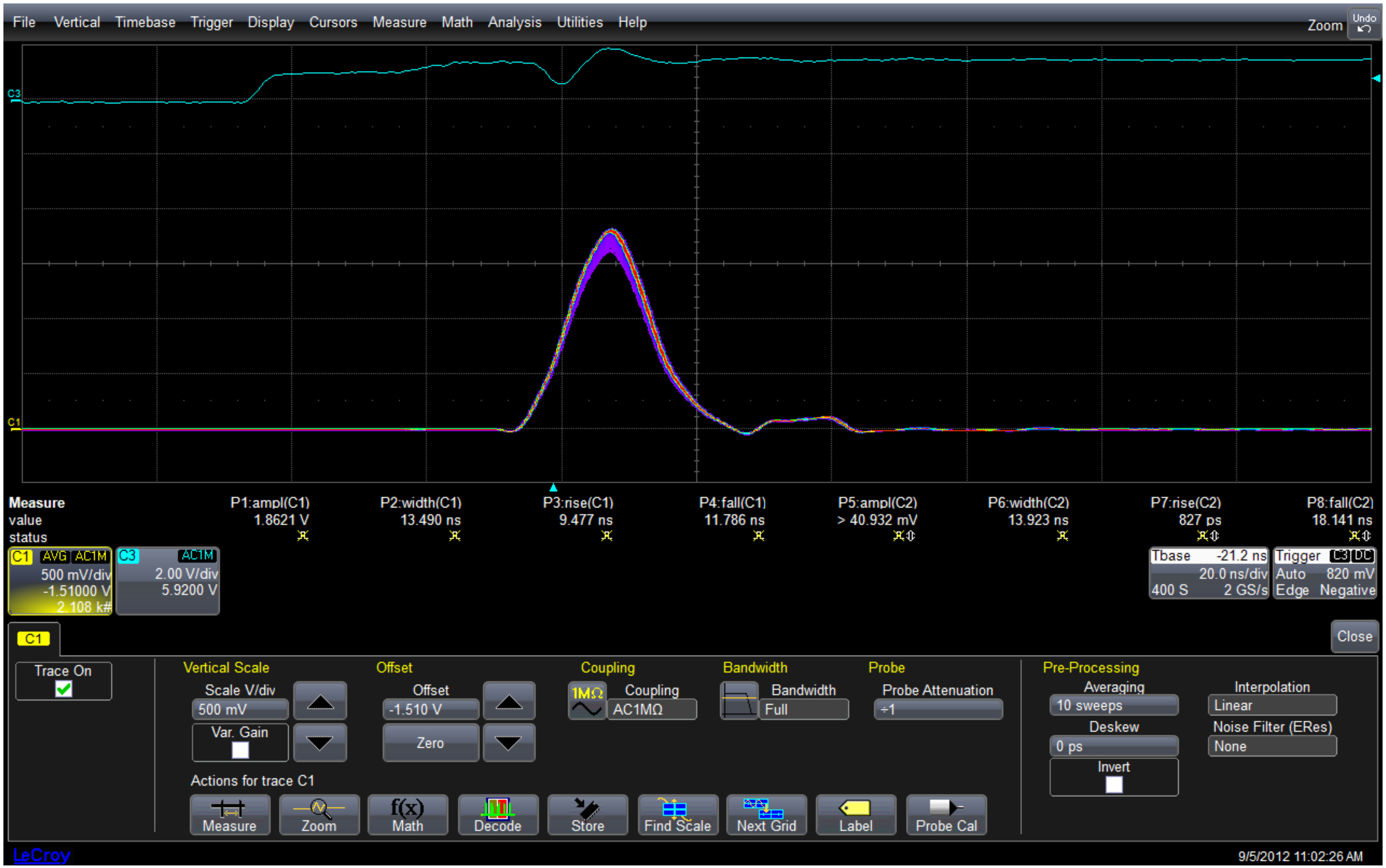
Circuit A: Minimum Signal

- Removing the preamp, this amount of light produces a ~40 mV signal.
- By increasing the filter, fitting the SPE and extrapolating, this is ~45 p.e.



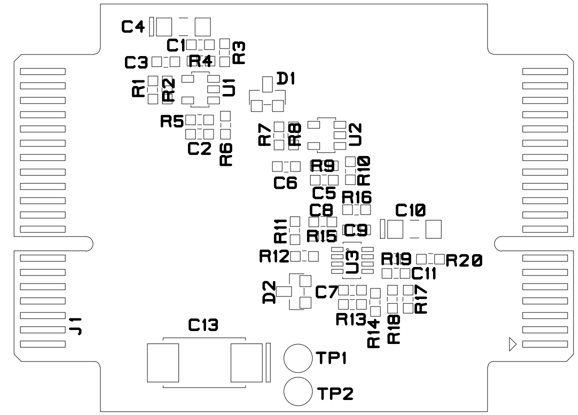
Circuit A: Maximum Signal

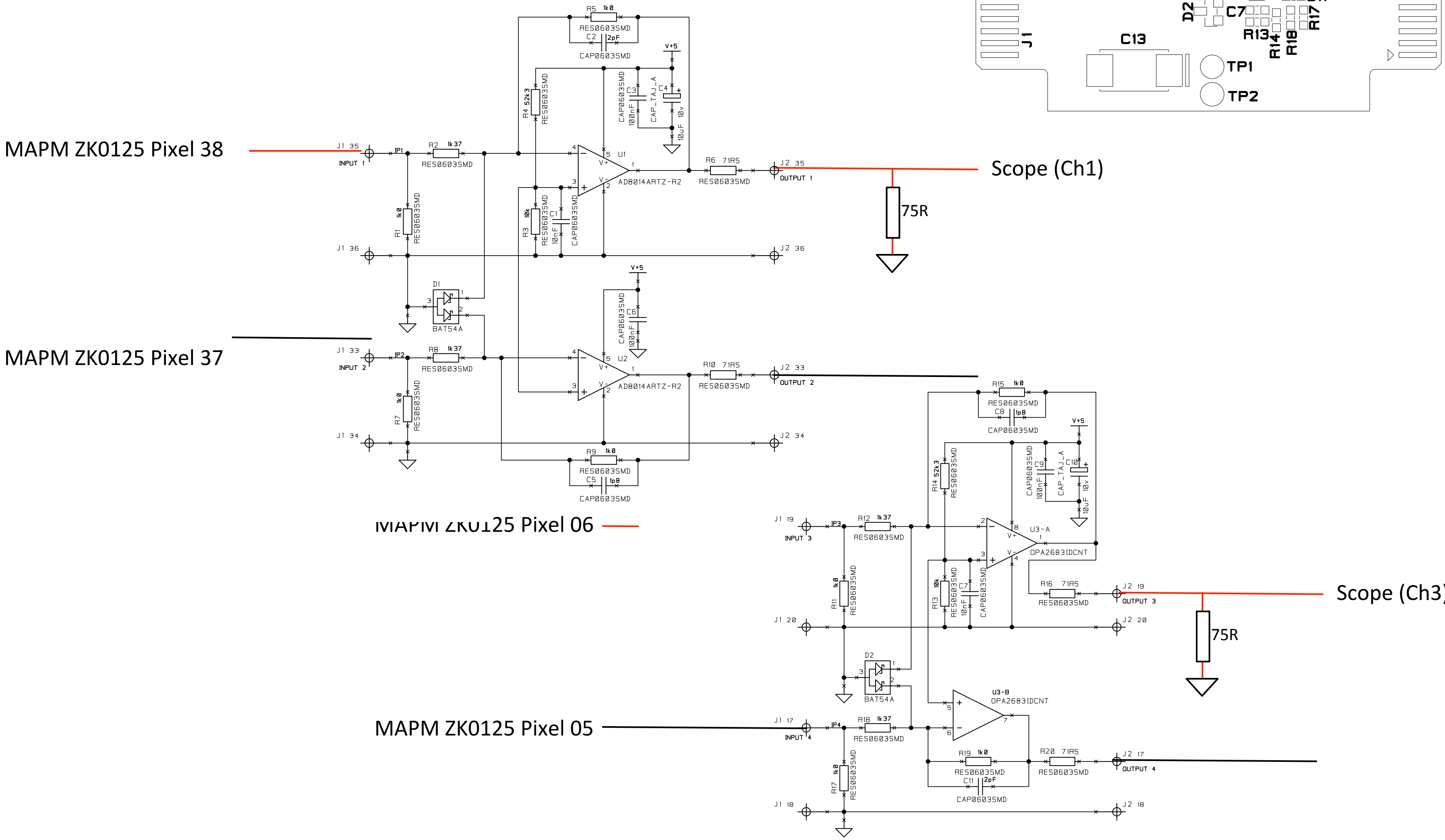
- Maximum signal is ~1.9 V, very roughly this is ~350 p.e.
- Beyond this, the signal saturates.



Circuit B

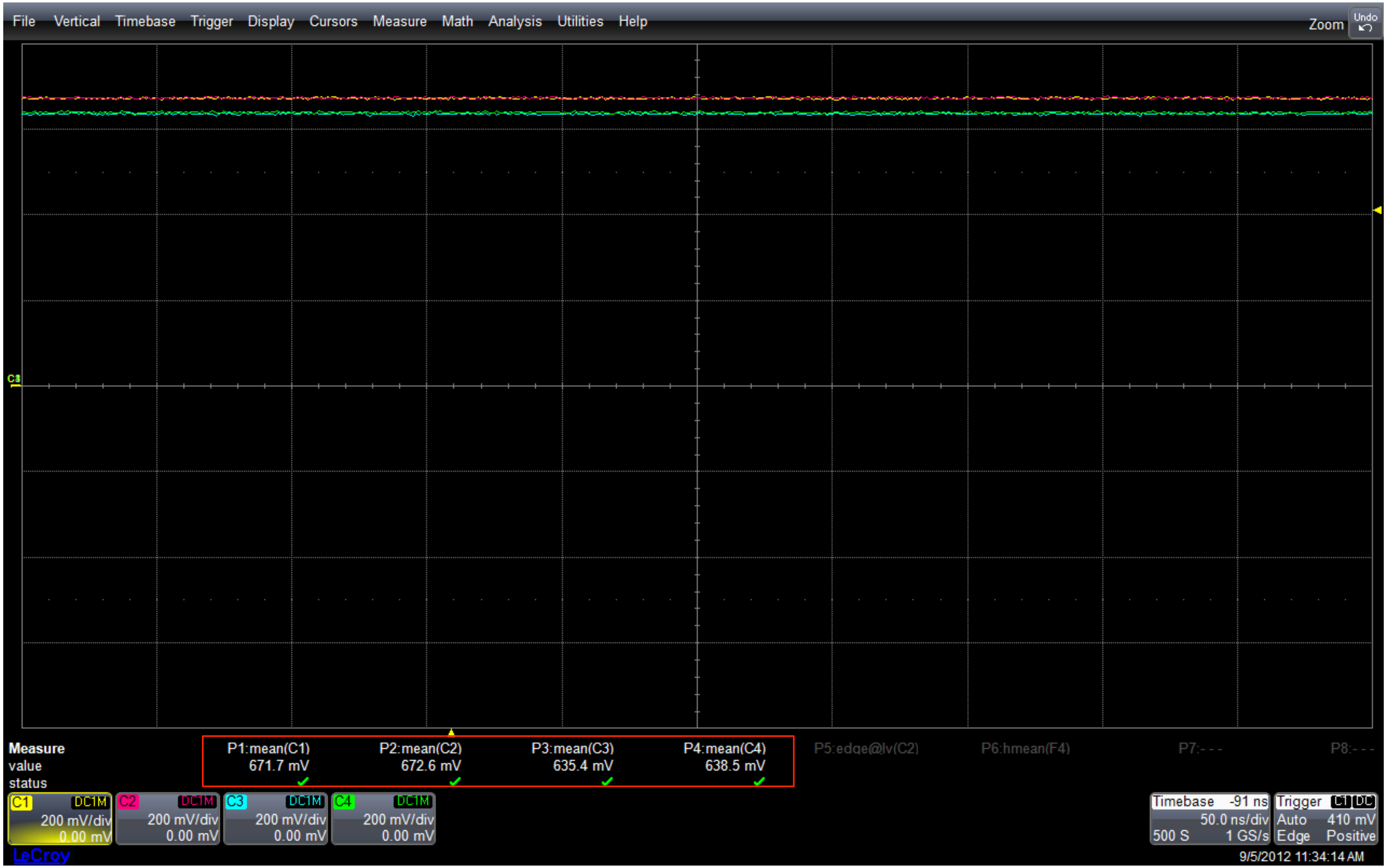
- 4 x individual op-amps
- 2 x AD8014, 2 x OPA2683
- Power consumption too low to measure on PSU (<10 mA)





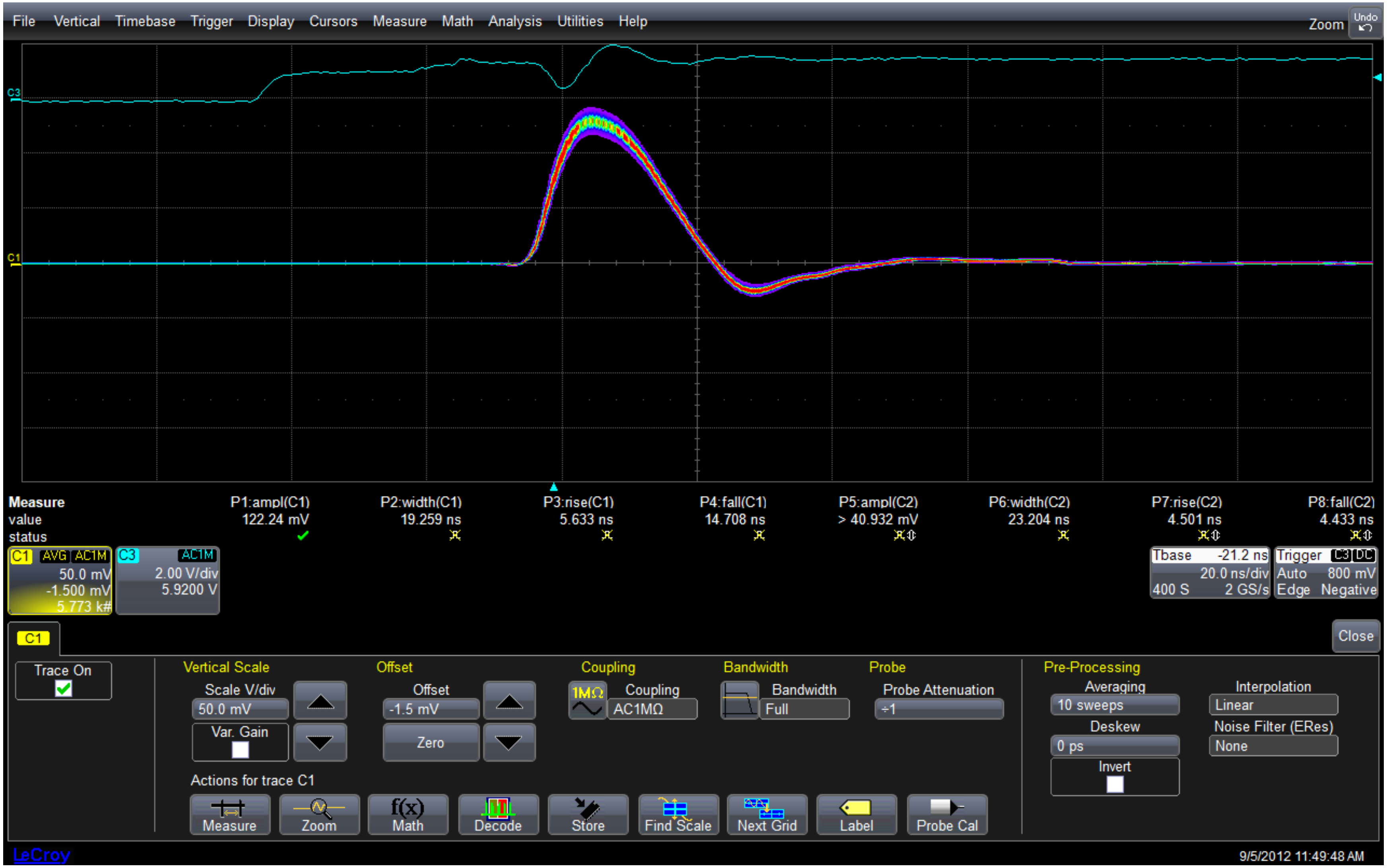
Circuit B: DC Offsets

- AD8014 ~ 670 mV, OPA2683 ~ 635 mV



Circuit B: AD8014 Pulse Shape

Rise Time: ~5.5 ns Fall Time: ~ 14.5 ns FWMH: 19 ns

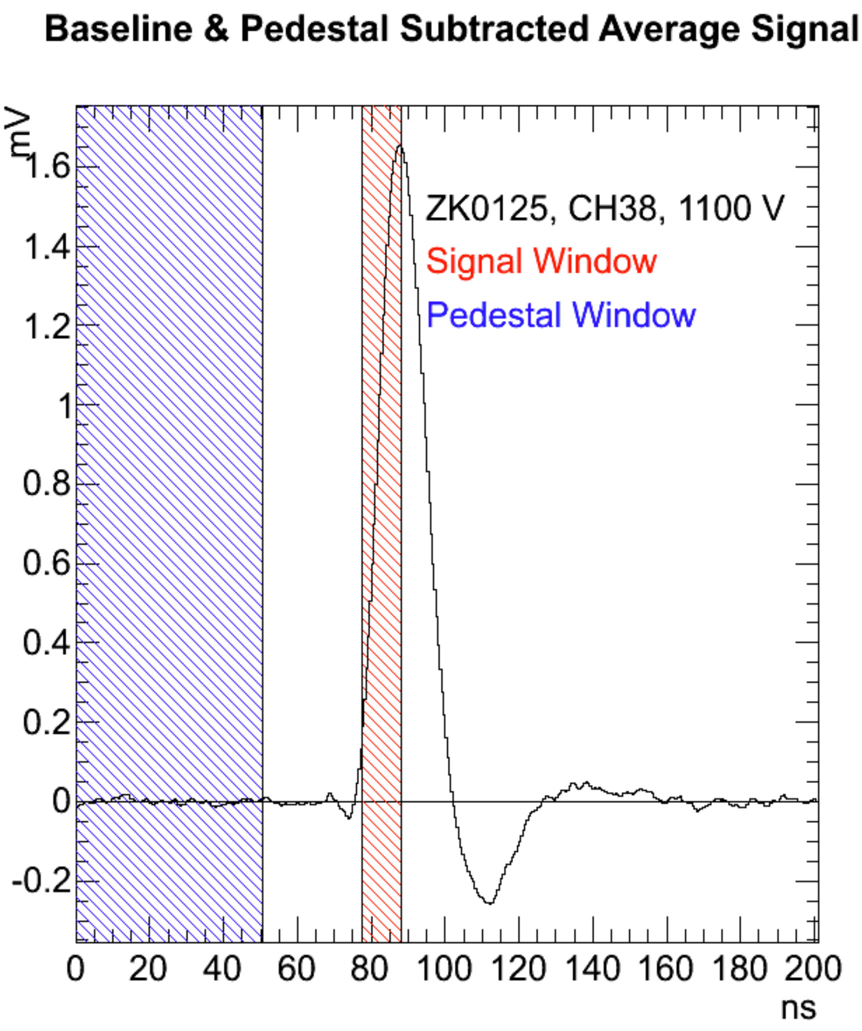


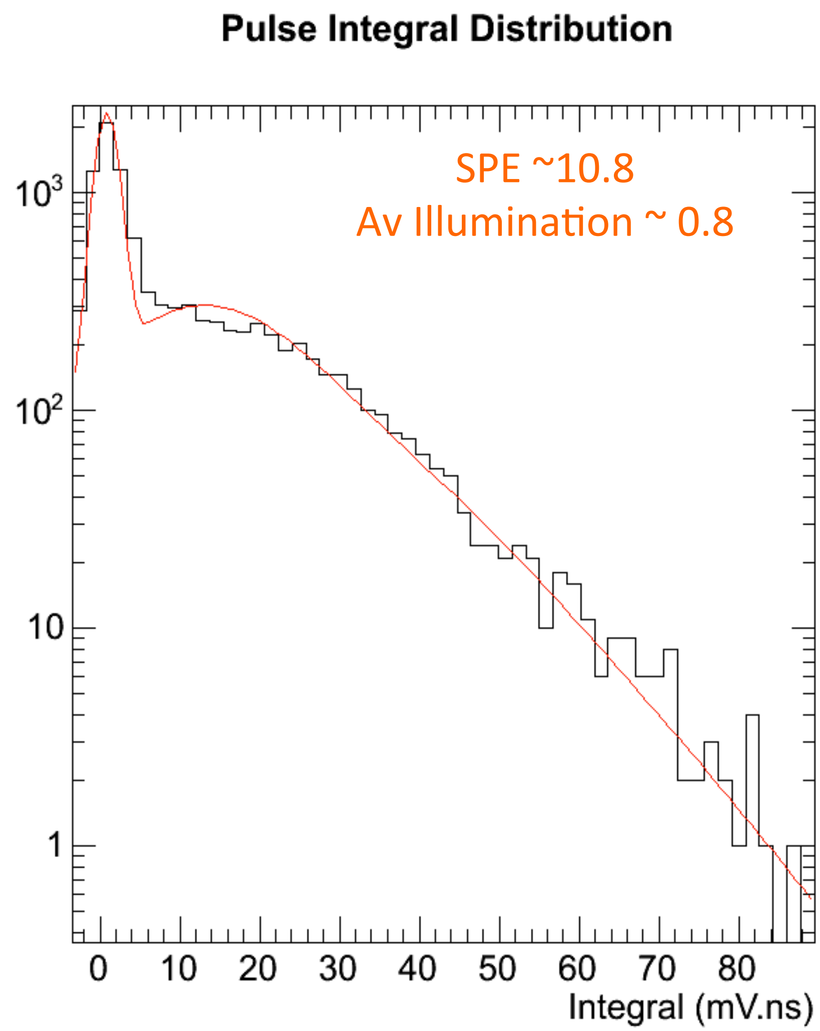
Circuit B: OPA2683 Pulse Shape

Rise Time: ~6.5 ns   Fall Time: ~ 20 ns   FWMH: 13 ns

Circuit B: AD8014 Minimum Signal

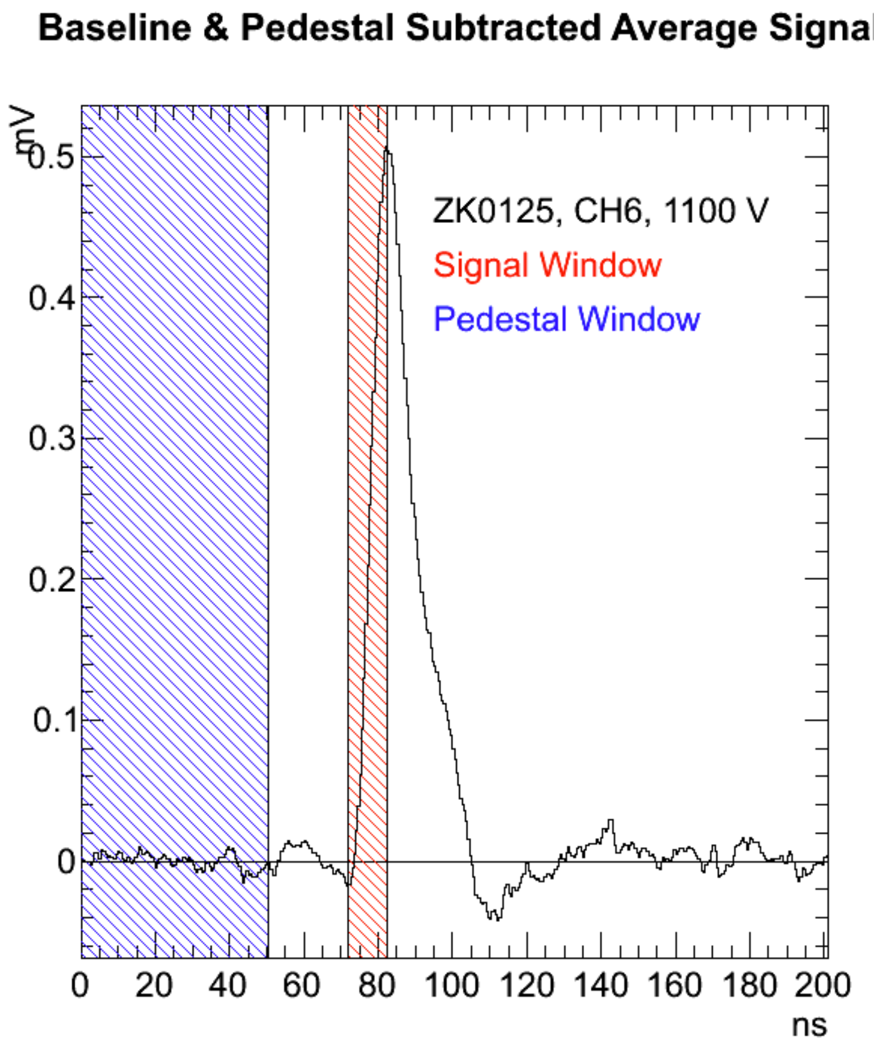
- Single p.e. is resolvable

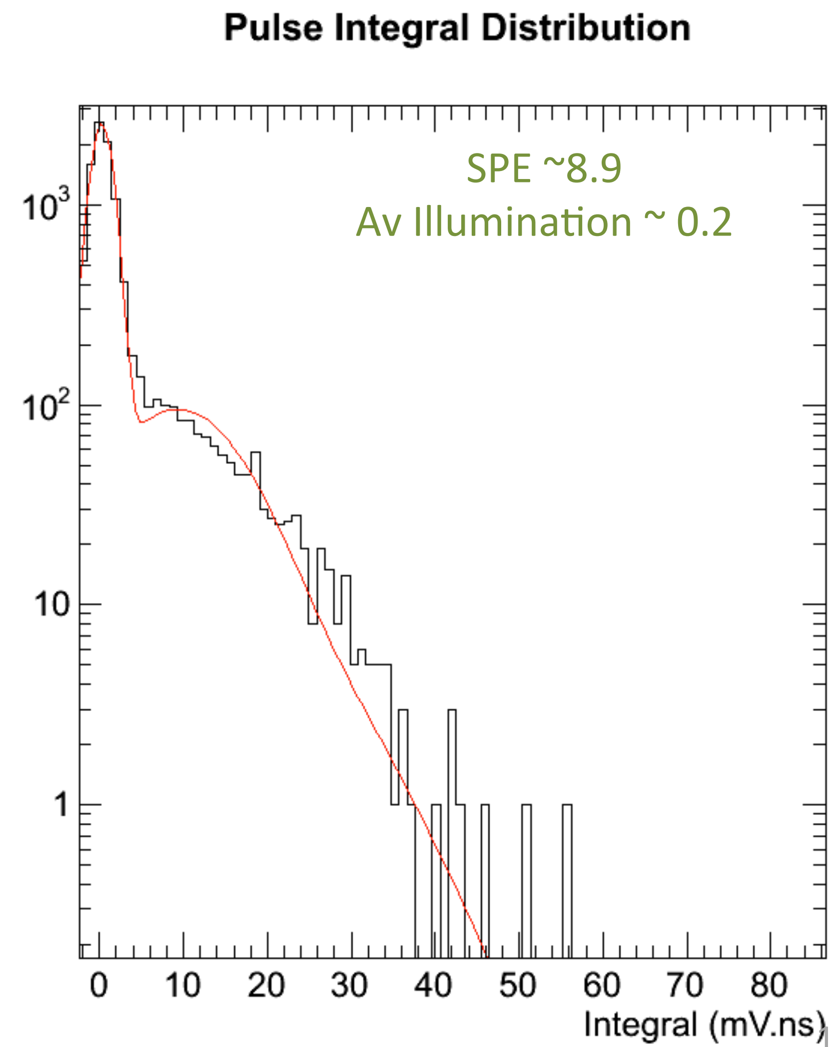




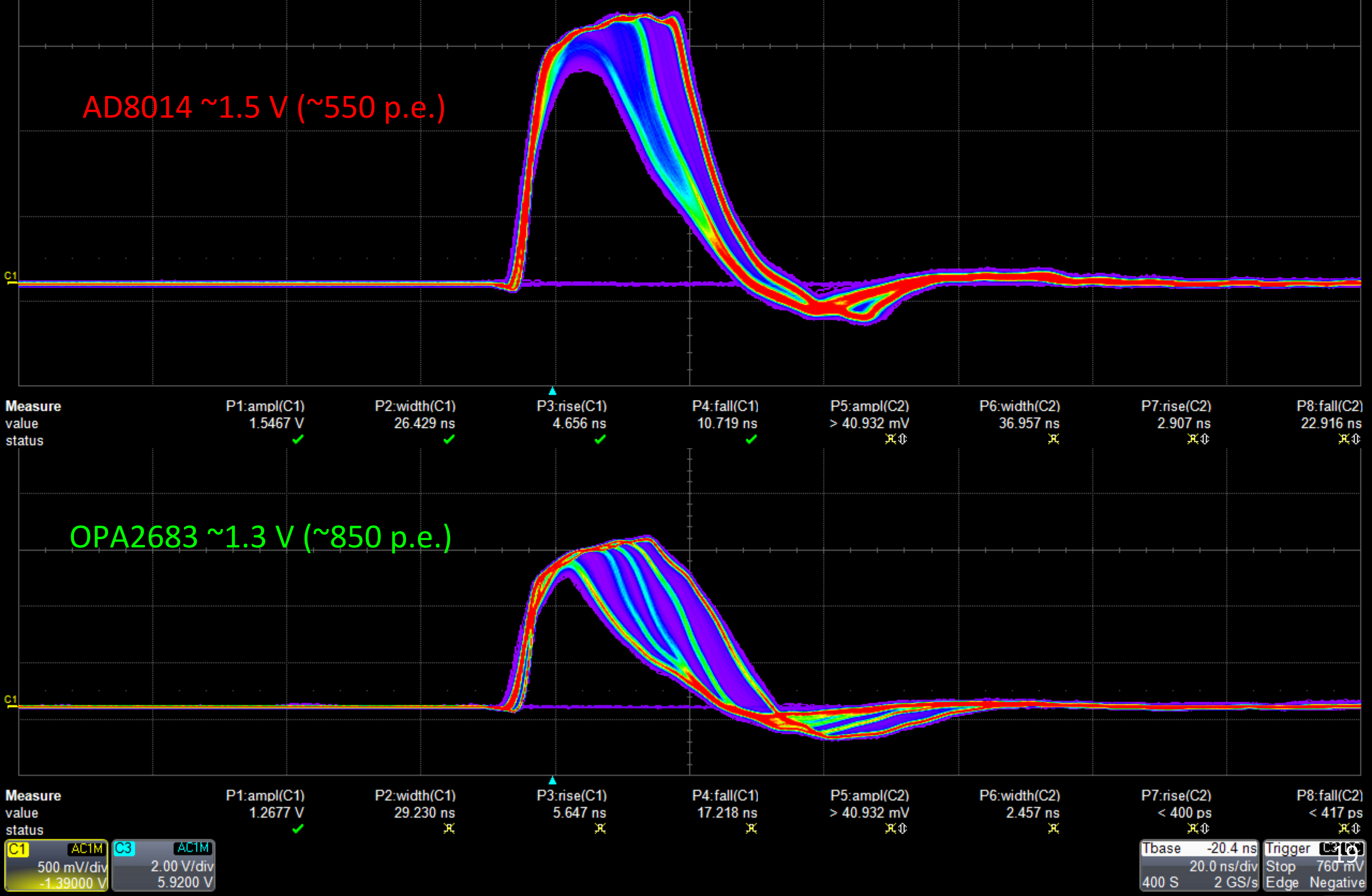
Circuit B: OPA2683 Minimum Signal

- Single p.e. is resolvable





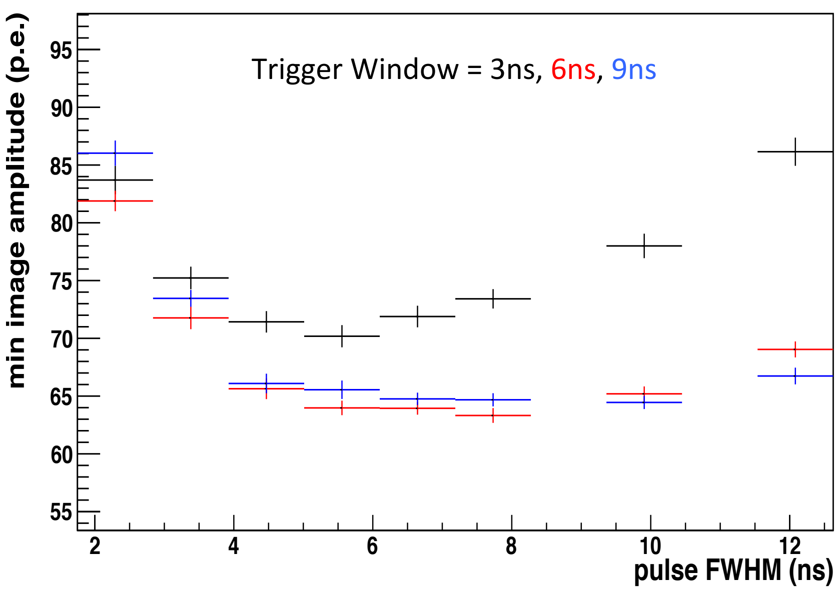
Circuit B: Maximum Signal

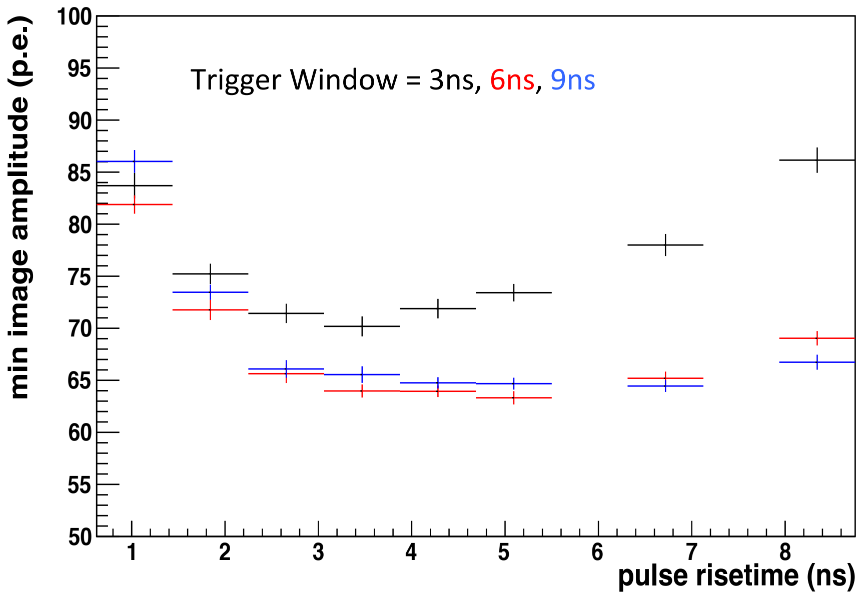


Summary

	T_R (ns)	T_F (ns)	FWHM (ns)	Min (pe) (mV)	Max (pe) (V)
Circuit A: ADA4817	5	17	8.5	45 (10)	350 (1.9)
Circuit B: AD8014	5.5	14.5	19	0.8 (1.6)	550 (1.5)
Circuit B: OPA2683	6.5	20	13	0.2 (0.5)	850 (1.3)

- Initial tests look very good!
- Shaping can be altered based on these results as can output range.
- Can compare the pulse shape to Stefan's simulations:





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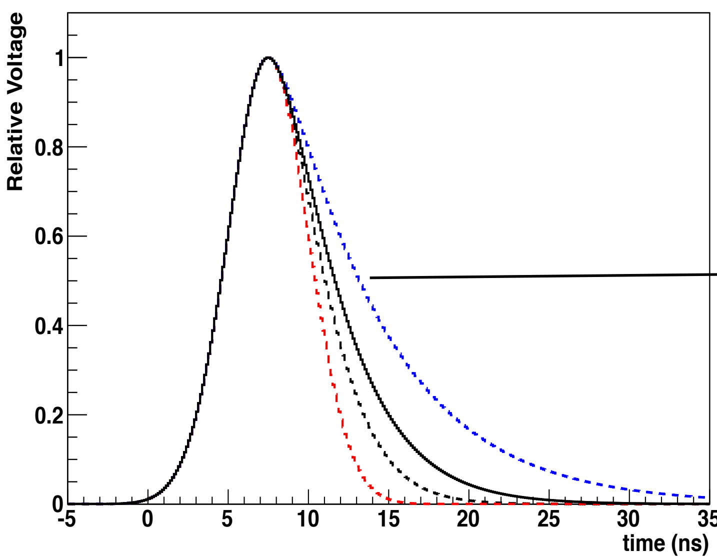

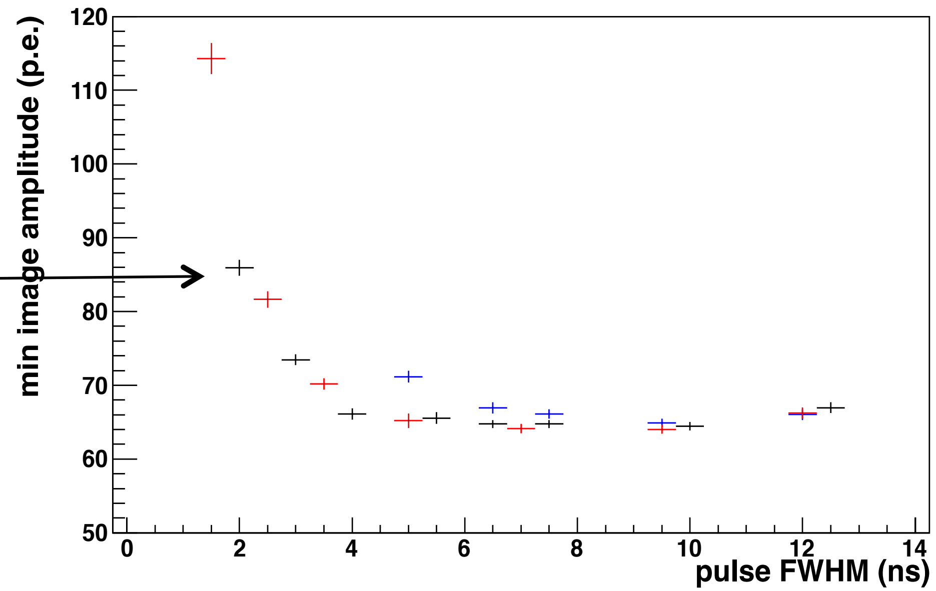

Further Considerations

- MAPMT ot SiPMT ? – different amplifier designs but same principle ?
- CHEC thermal impact of different amplifier power consumptions?
- Different mechanical solutions, dependant on detector configuration ?