First signals

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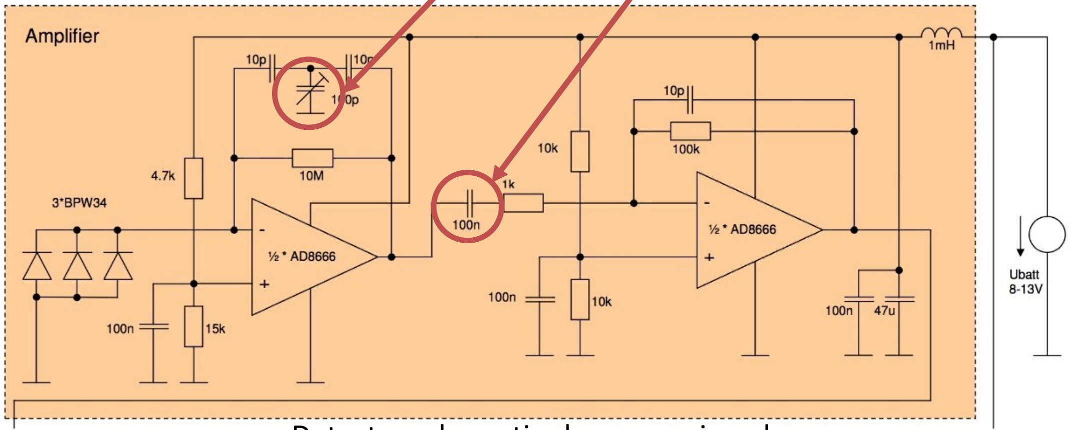
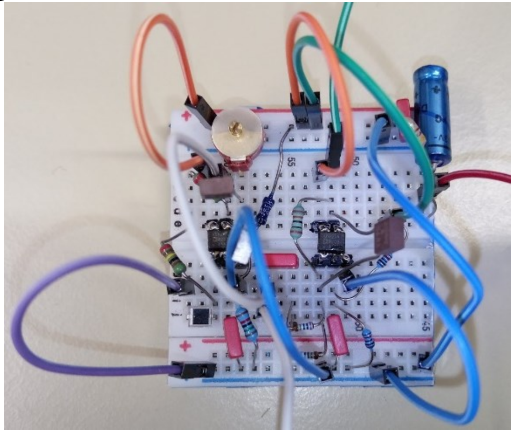
Better understanding the opengeiger circuit

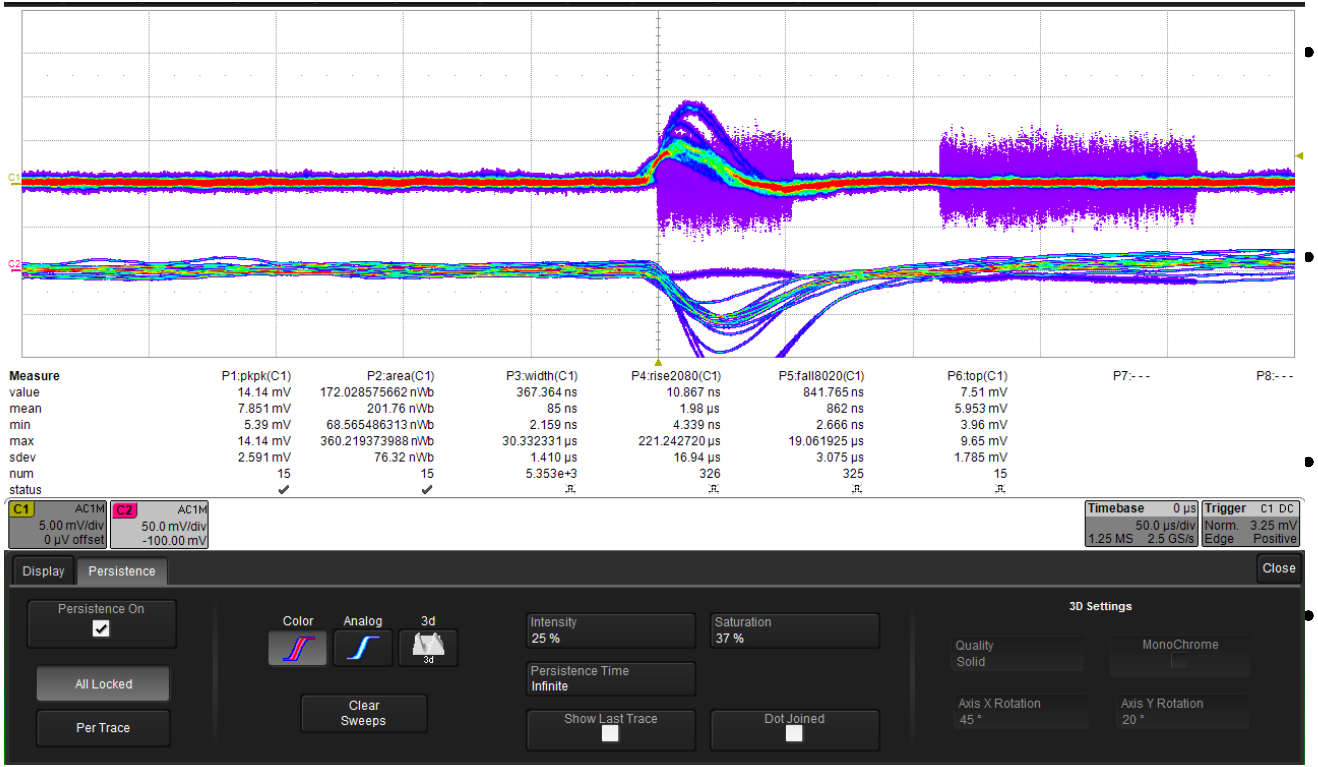
- Trimming capacitor
  - Smooths the amplification towards ground
  - Recommendation by Texas Instruments
- Capacitor between op-amps
  - Cuts the DC component of the signal and differentiates the signal



Detector schematics by opengeiger.de

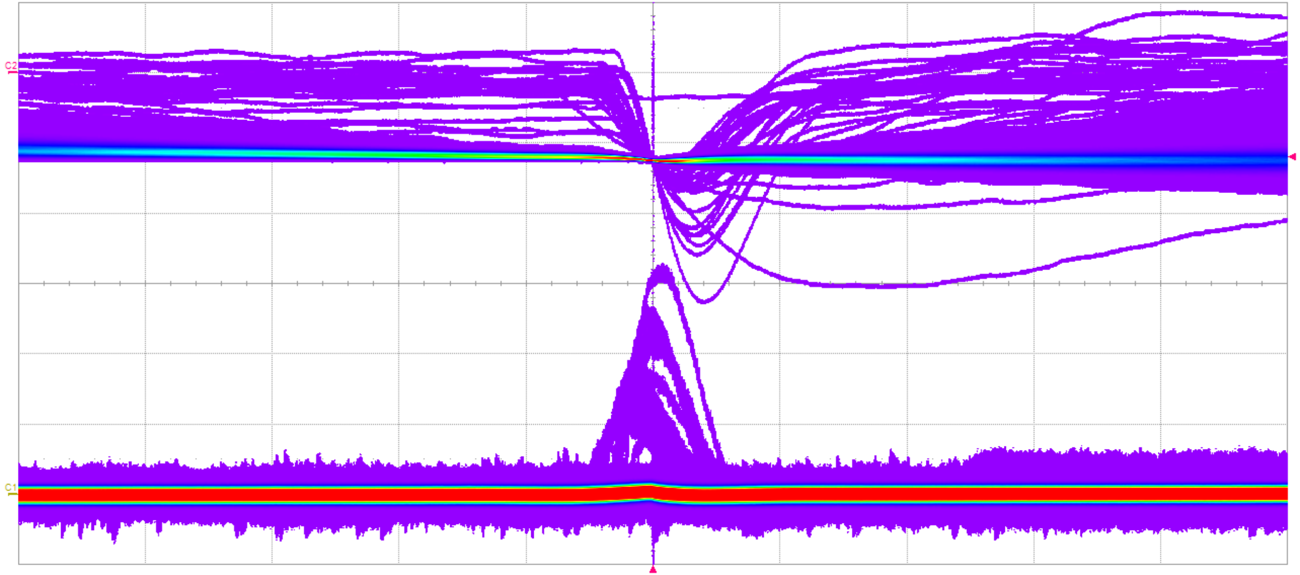

Breadboard circuit

Results with the opengeiger circuit



- Signals
  - C1: First op-amp
  - C2: Second op-amp
- Pulse characteristics
  - Height: 50~100 mV
  - Length: ~50 µs
- Second op-amp filters HF noise
- Shows coincidences with the CosMo detector

Results with the opengeiger circuit



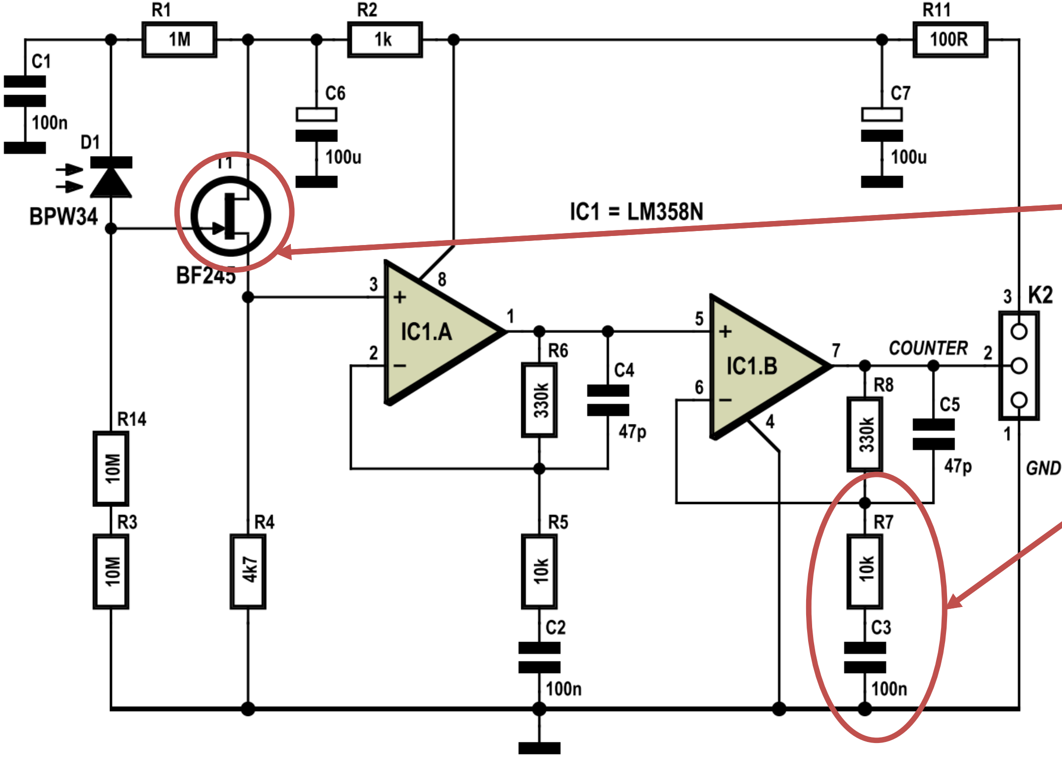
Measure	P1:pkpk(C1)	P2:area(C1)	P3:width(C1)	P4:rise2080(C1)	P5:fall8020(C1)	P6:top(C1)	P7:- - -	P8:- - -
value	2.55 mV	-39.032634985 nWb	8.033979 µs	21.783927 µs	13.014382 µs	1.27 mV		
mean	> 2.5111 mV	12.27 nWb	772 ns	< 8.14 µs	< 7.61 µs	> 1.2920 mV		
min	> 2.09 mV	-481.955037129 nWb	274 ps	< 296 ps	< 318 ps	> 280 µV		
max	> 40.95 mV	469.976279593 nWb	344.349826 µs	< 440.943474 µs	< 454.184740 µs	> 35.47 mV		
sdev	> 552.5 µV	80.93 nWb	3.321 µs	< 12.11 µs	< 10.95 µs	> 472.0 µV		
num	15.975e+3	15.975e+3	4.889682e+6	487.593e+3	483.811e+3	15.975e+3		
status	✓	✓	⎍	⎍	⎍	⎍		

C1 AC1M 5.00 mV/div -15.000 mV | C2 AC1M 50.0 mV/div 150.00 mV

Timebase 0 µs 50.0 µs/div 1.25 MS 2.5 GS/s | Trigger C2 DC Stop -60.0 mV Edge Negative

- Signals
  - C1: First op-amp
  - C2: Second op-amp
- Second channel shows significant low-frequency noise
- Noise improvements should be possible with the trimming capacitor
- Osram and Vishay diodes show similar characteristics

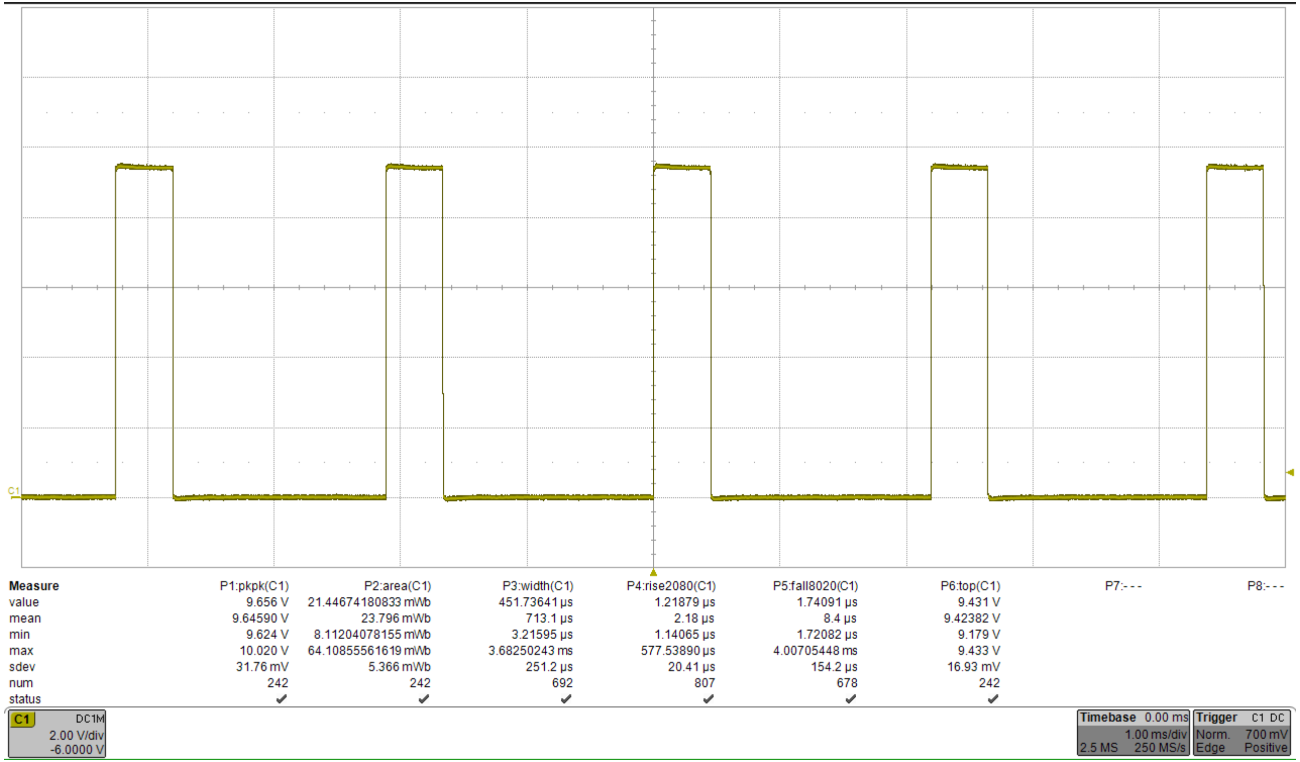
Better understanding Burkhard Kainkas circuit



Detector schematics by Burkhard Kainka

- JFET for pre-amplification
- Low-end op-amps for further amplification
- Coupling towards ground for noise reduction
- No signal inversion
- Same circuit is on the µTelescope
- **Circuit is inherently unstable** (see Michaels calculations)

Results with Kainkas circuit

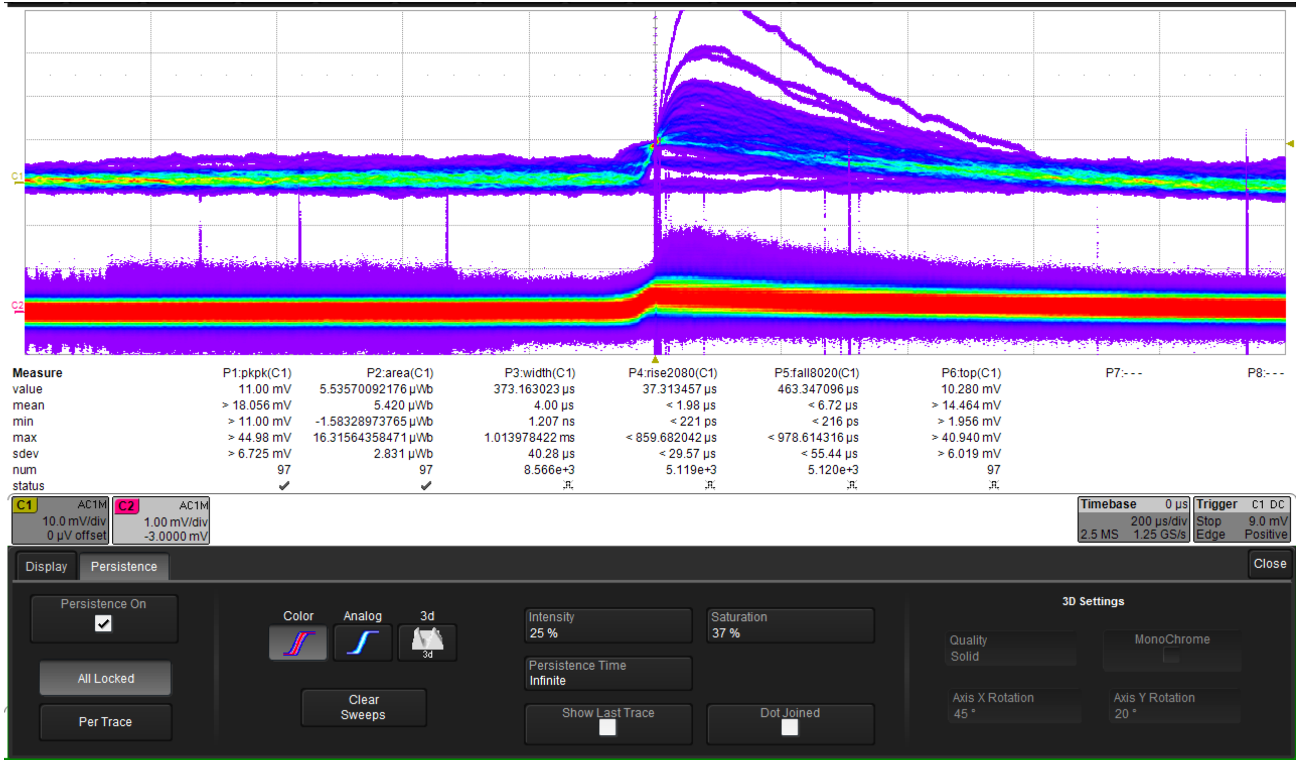


- Signals
  - C1: Second op-amp

- Internal oscillations visible
- Start as soon as light is removed
- Induced via the coupling towards ground and picked up at the gate of the JFET

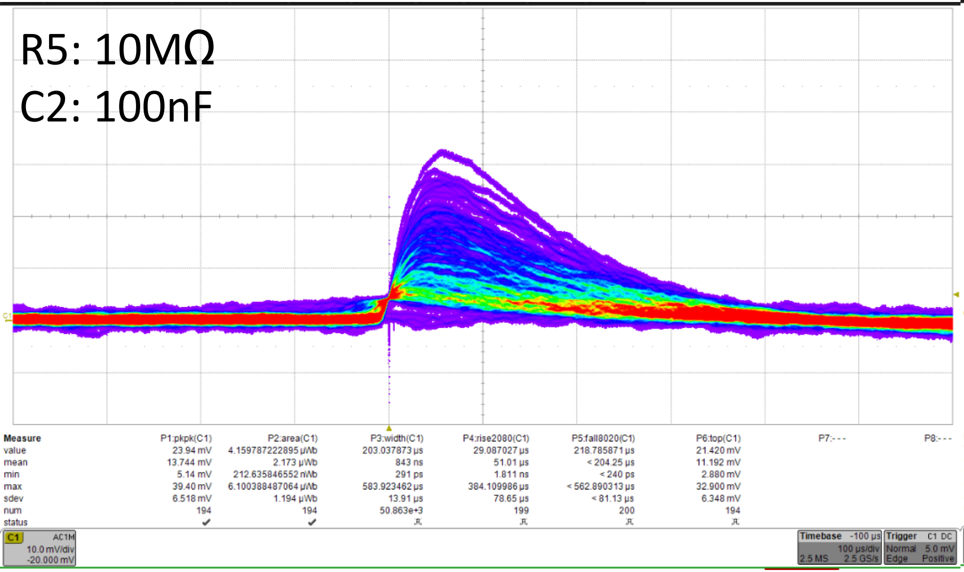
- Can be suppressed by changing capacitor and resistor values at the noise reduction circuits (R5, R7, C2, C3)

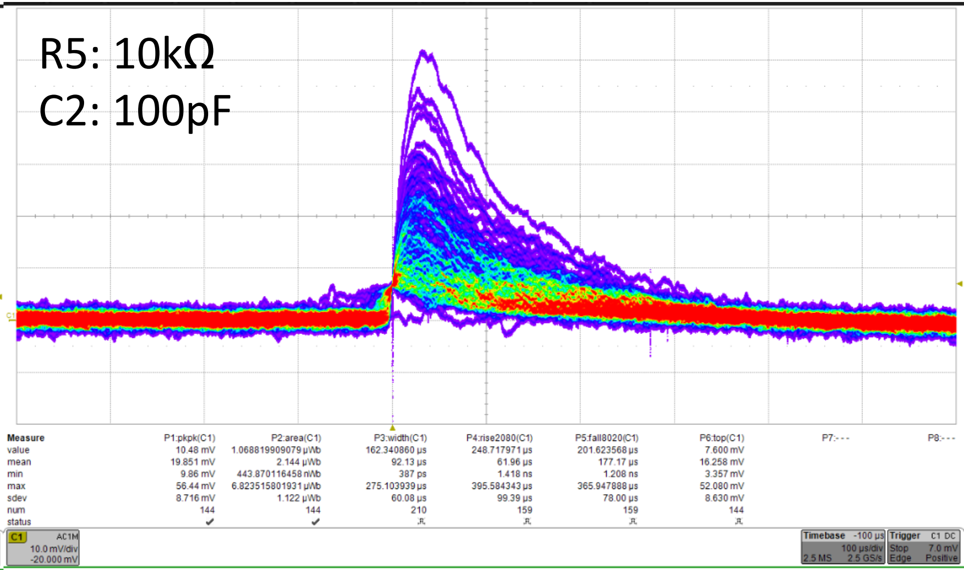
Results with Kainkas circuit



- Signals
  - C1: JFET output
  - C2: Second op-amp
- Stopping the internal oscillation:
  - Change C2: >= 1mF or <= 100pF
  - Change R5: >= 10MΩ
- Pulse characteristics
  - Height: 10~20 mV
  - Length: ~150 µs

Results with Kainkas circuit





- Very high resistance
- Strength of the ground coupling is reduced
- Visible reduction of noise and signal

- Very low capacitance
- Close to no effect from the noise reduction

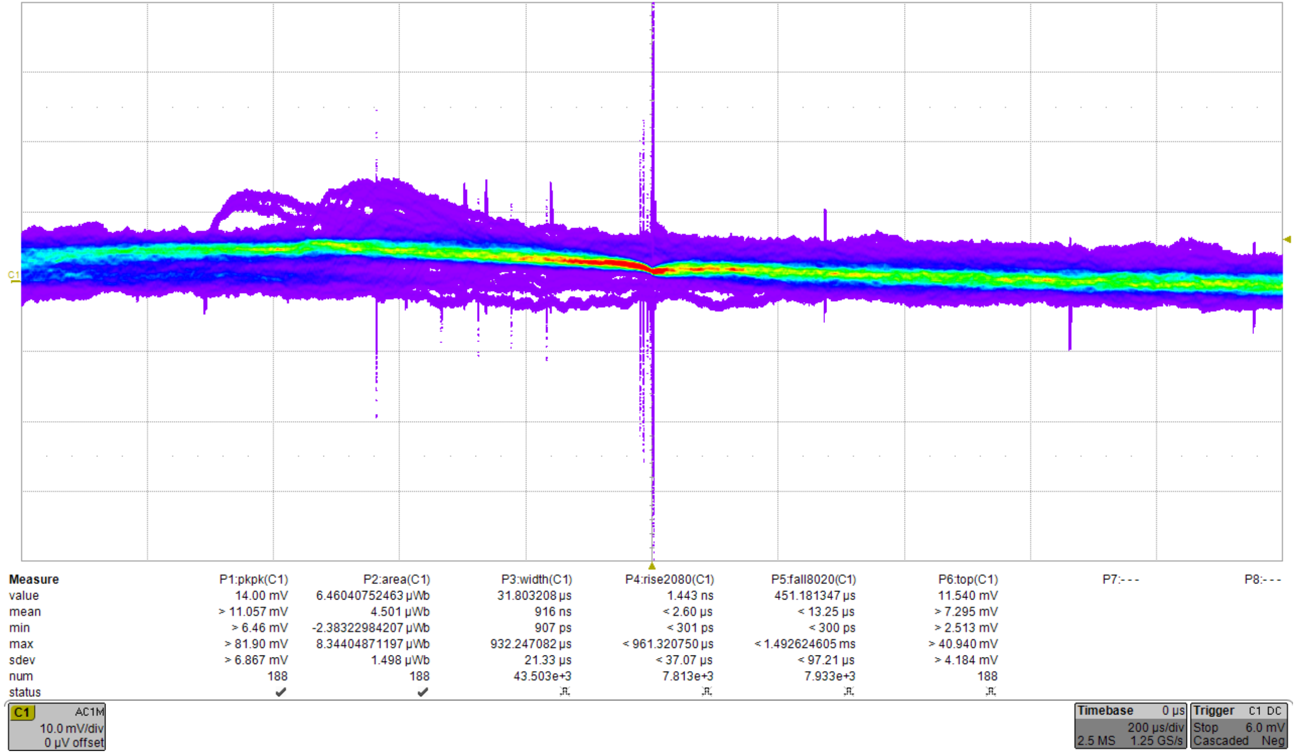
Optimizing Kainkas circuit

- Tuning the oscillation vs signal strength
  - Tunable parameters: R5, R7, C2, C3
  - Resistors are easily tunable via potentiometers

- Tuning characteristics
  - Non linear signal reaction to changes in R5 or R7
  - Reducing the resistance from R5=10kΩ and R7=10MΩ increases the signal strength, as well as signal undershoot
  - Minimum for R7 = 200kΩ (and R5 at default)
  - Minimum for R5 = 1kΩ (and R7 at default and 500kΩ)

- Good results were found at: R5 = 1kΩ and R7 = 500kΩ
  - Pulse height: ~50 mV

Increasing the detector area

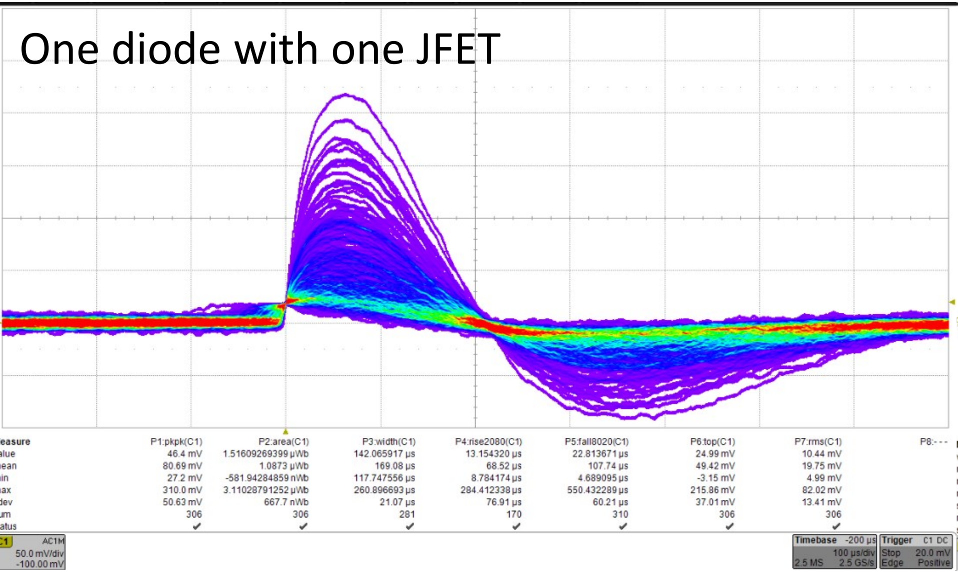


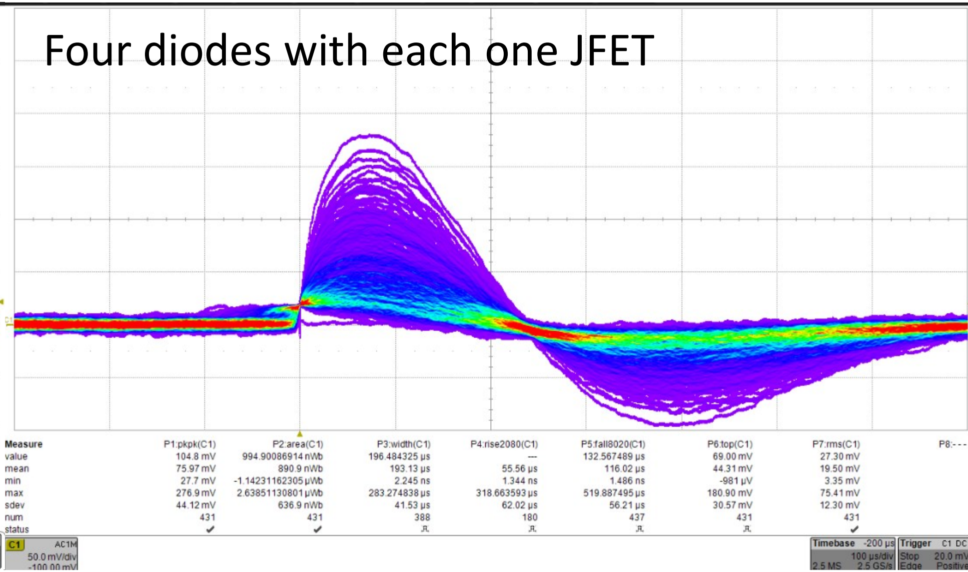
- Signals
  - C1: Second op-amp

- **Two diodes in parallel**
- Almost halved peak height
- Noise stays the same
- Signal close to vanishes in the background

- On µTelescope: Four diodes in parallel are likely to have a very small signal

Increasing the detector area





- Very clear signal
- Strong undershoot
- Noise: +-15 mV
- Events/min: 4.08+- 0.23 (SR90 source)

- Slightly lower signal
- Noise: +-15 mV
- Events/min: 3.91 +- 0.19 (SR90 source)

Conclusions on increasing the detector area

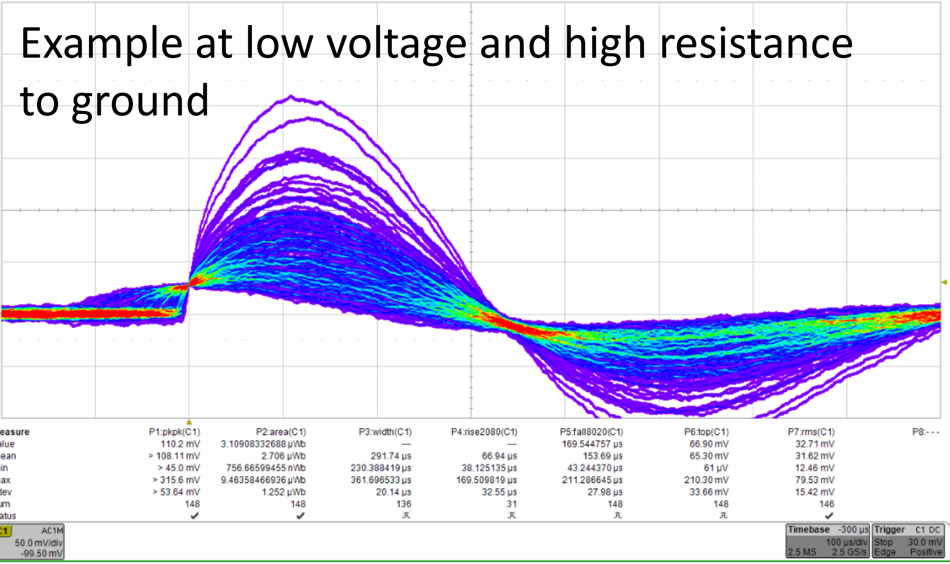
Tested configurations

- Multiple diodes in parallel
  - Heavily degrades the signal
  - Makes decent triggering impossible
- Multiple diodes with each one JFET in parallel
  - Signal doesn't degrade
  - Can't provide the expected count rate
- All used diodes and JFETS were tested for their performance
  - No problems were found and all have similar performance

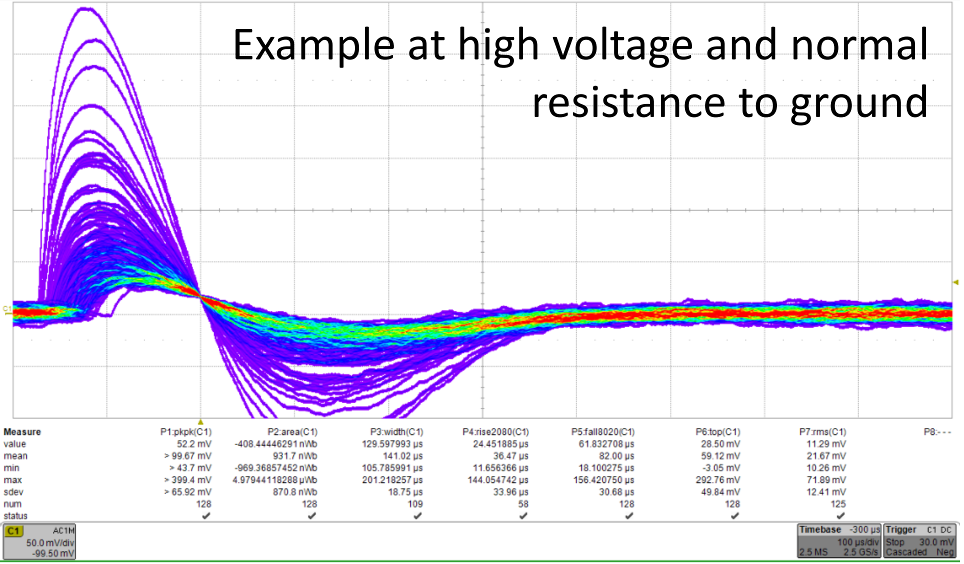
Because the whole circuit is very cheap it would still be possible to have one amplification circuit per diode.

Measuring the capacitance of the PIN-diodes

Example at low voltage and high resistance to ground



Example at high voltage and normal resistance to ground



- Reverse bias = 6.4V
- Resistor to ground R3 = 30MΩ
- Diode capacitance: ~19 pF

- Reverse bias = 26V
- Resistor to ground R3 = 10MΩ
- Diode capacitance: ~14 pF
- Slightly higher signal

Next steps

- Tomorrow 10:30: Partial PCBA (Printed Circuit Board Assembly) of two channels on the µTelescope
    - Channel 1: LM358
    - Channel 2: AD8666
- Test the maximum possible number of diodes on the PCB
- Simulate modifications to the circuit
- Design and build new PCB