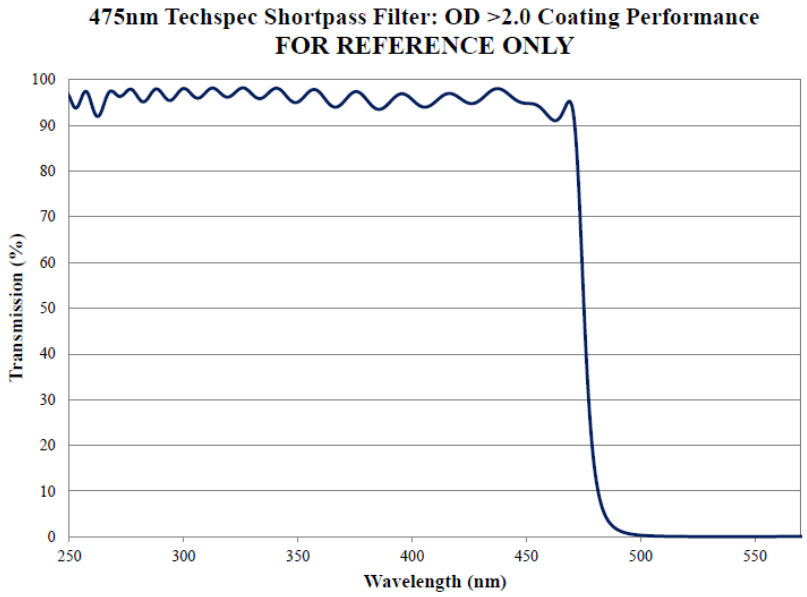
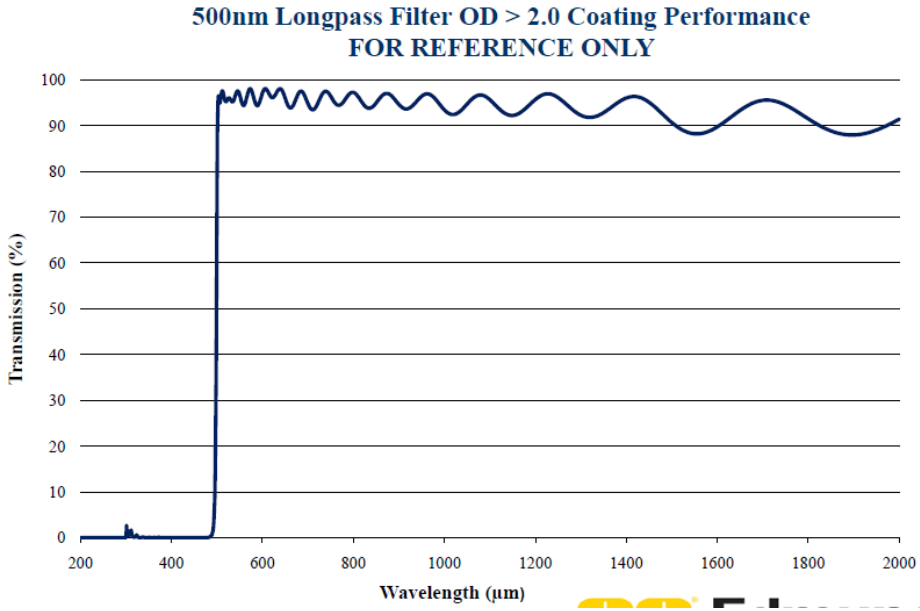
DNA Setup:
Further Progress
16^{th} to 20^{th} of June

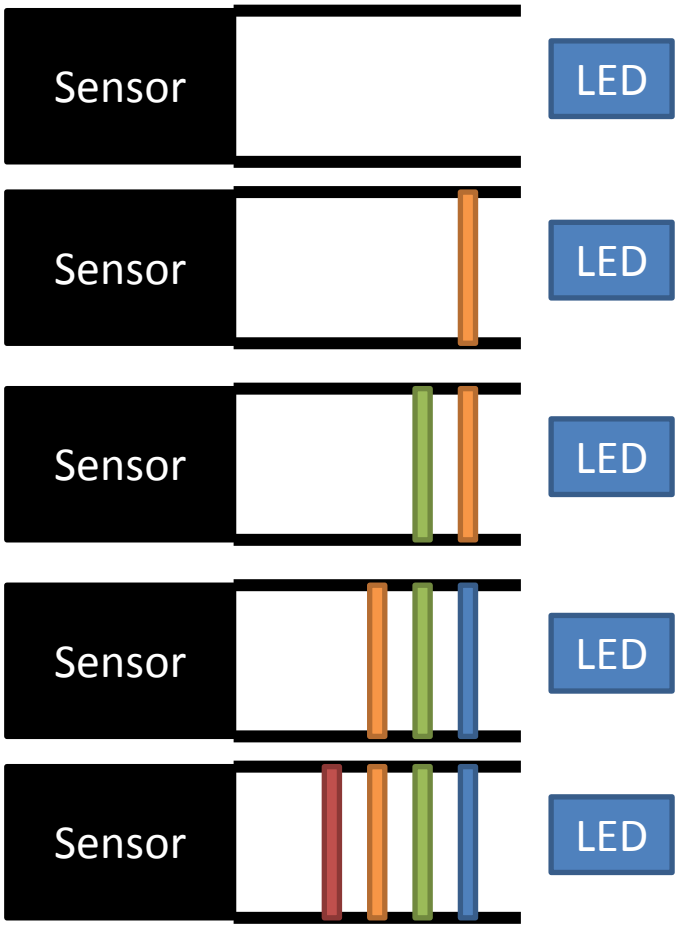
Testing the Filters

- Open question: Why we have a direct signal from the LED with short- (SP) and longpass (LP) filter between LED and PMT?
- Naively a shortpass filter of 475 nm combined with longpass filter of 500 nm should block “all” light



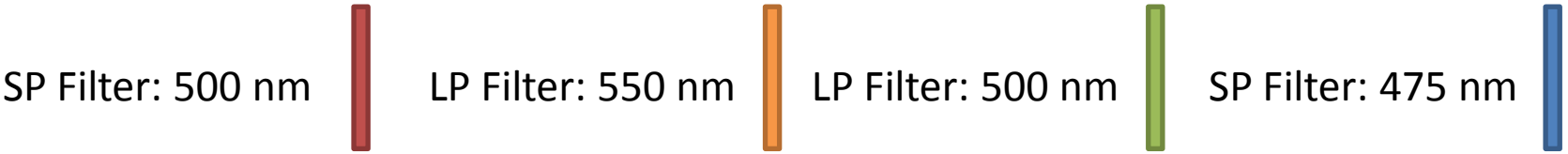


Test Setups



- Direct: 800 uW
- SP 475 nm: 536 uW
- SP 475 nm + LP 500 nm: 0.14 uW
- SP 475 nm + LP 500 nm + LP 550 nm: 0.22 uW
- SP 475 nm + LP 500 nm + LP 550 nm + SP 500 nm: 0.04 uW

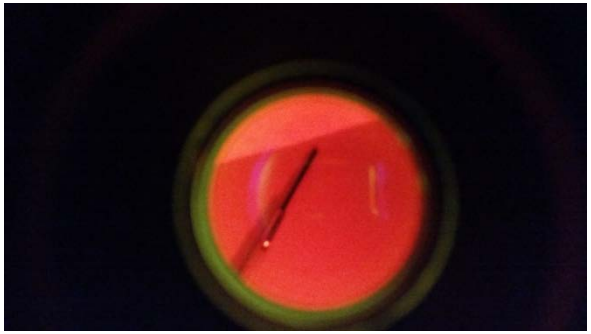
=> Filter reduce light by factor 4000-20000



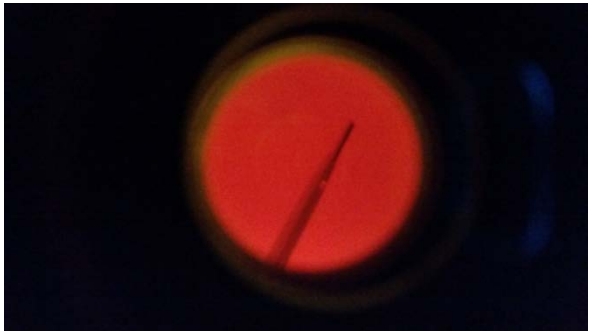
Results

- Which wavelength has the light which passes?
- Answer by eye: probably red! (=> > 600 nm)

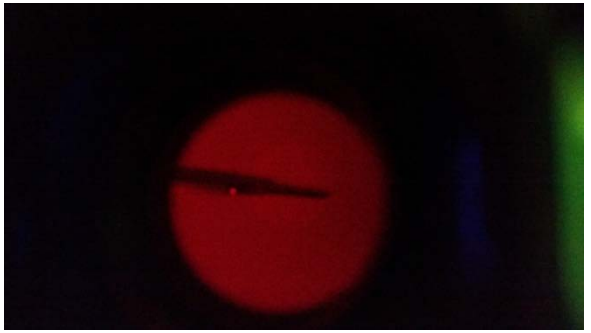
SP 475 + LP 500



SP 475 + LP 500 + LP 550



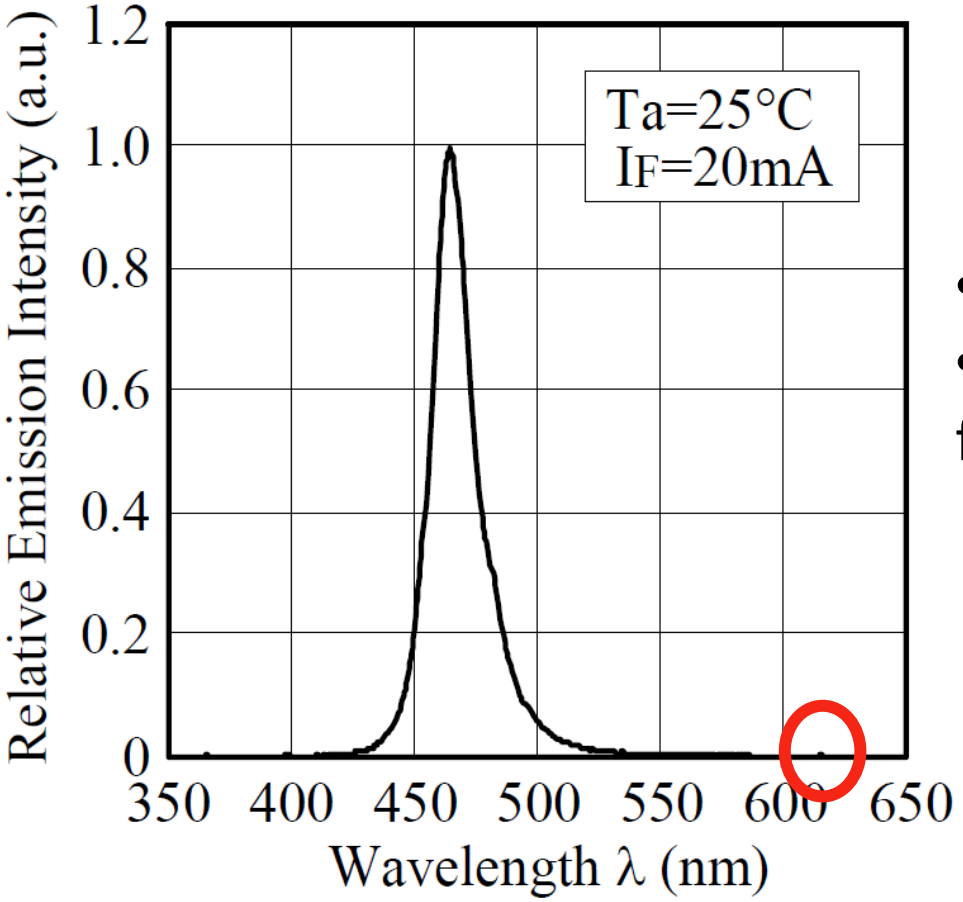
SP 475 + LP 500 + LP 550 + SP 500



2 questions now:

1. What is the source of the red light when we use a blue LED?
2. Why is the red light not filtered out?

Source of the red light



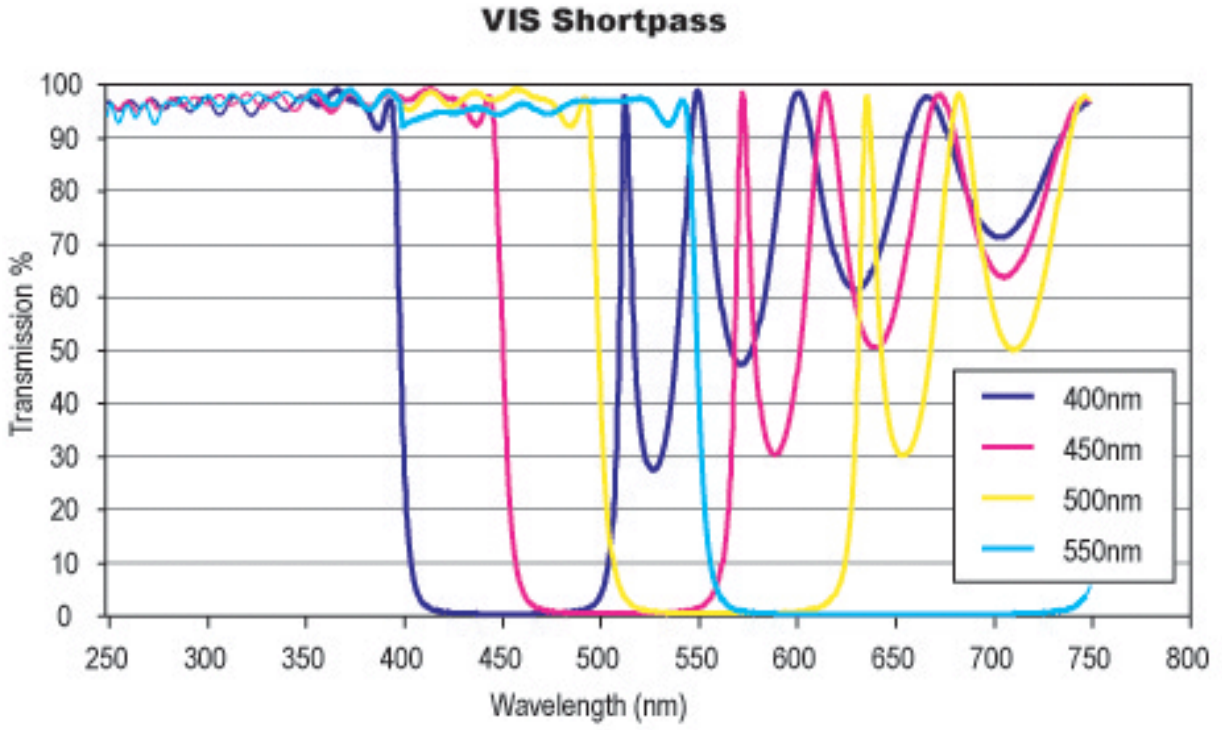
- Emission spectrum of LED
- tiny emission at about 625 nm

following official data sheet

Why is the red light not filtered out?

- Curve from slide 16 misleading since ends at 570 nm
- Plot below: SP filter works only from edge wavelength + 100 nm
- Transpartent for higher wavelength

$\Rightarrow$ SP 475 nm (and even SP 500) highly transparent to 625 nm



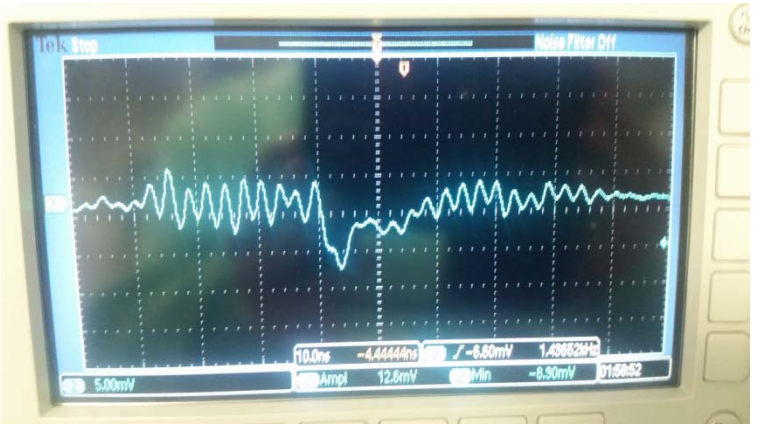
Signal-to-Noise Improvements

- Problem during previous measurements:
  - Noise ripple has amplitude of some 10s of mV
  - Single photon amplitude about 1 meV
- Tried Solutions:
  - Using in addition another PMT: more gain => single photon amplitude about 7 mV
  - Understanding better origin of noise ripple and reduce it to minimum => successfully done: 1) old PMT now: +/-4 mV 2) new PMT: +/-2 mV
- Noise ripple reduced to 2 mV (amplitude)

$\Rightarrow$ Single photons can be detected

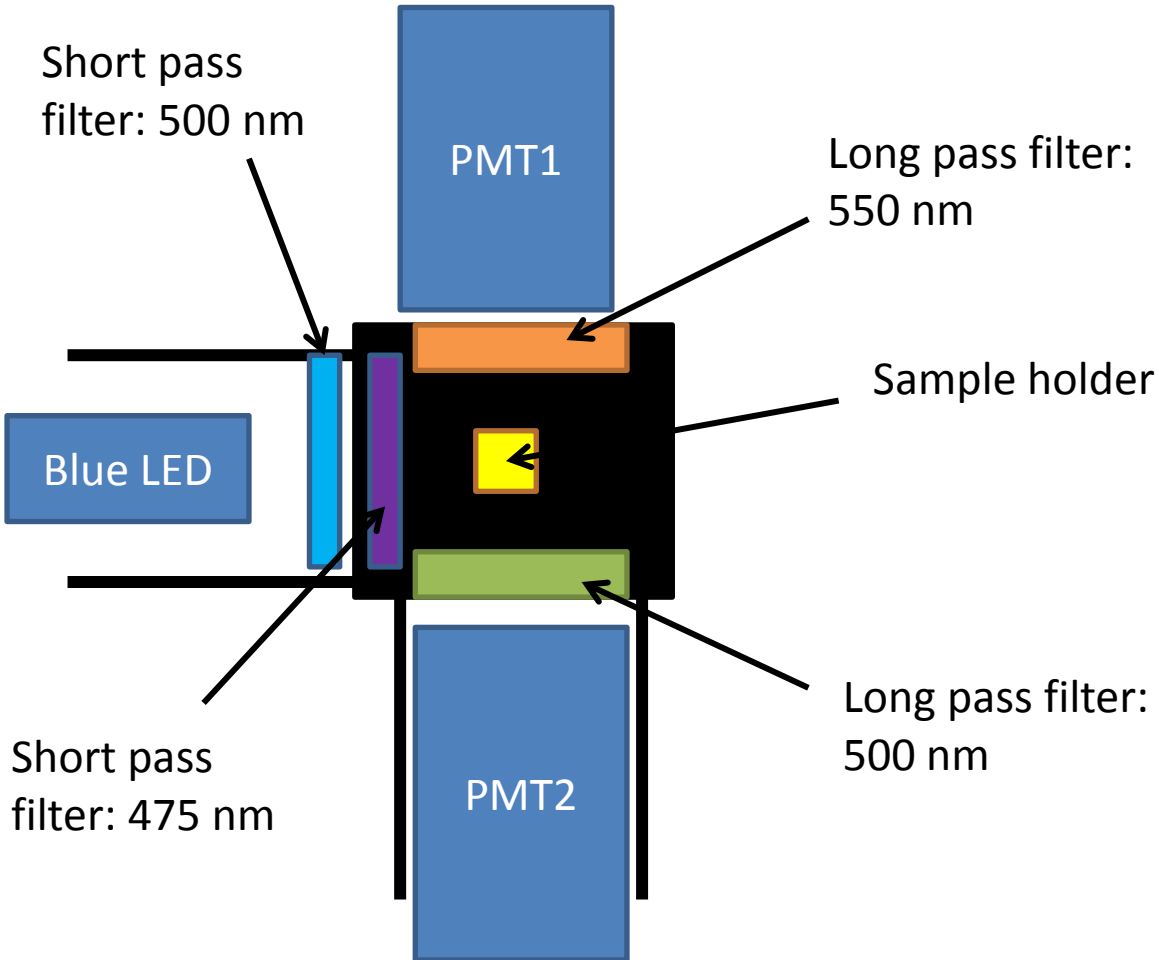
Dark count signal (== single photon)

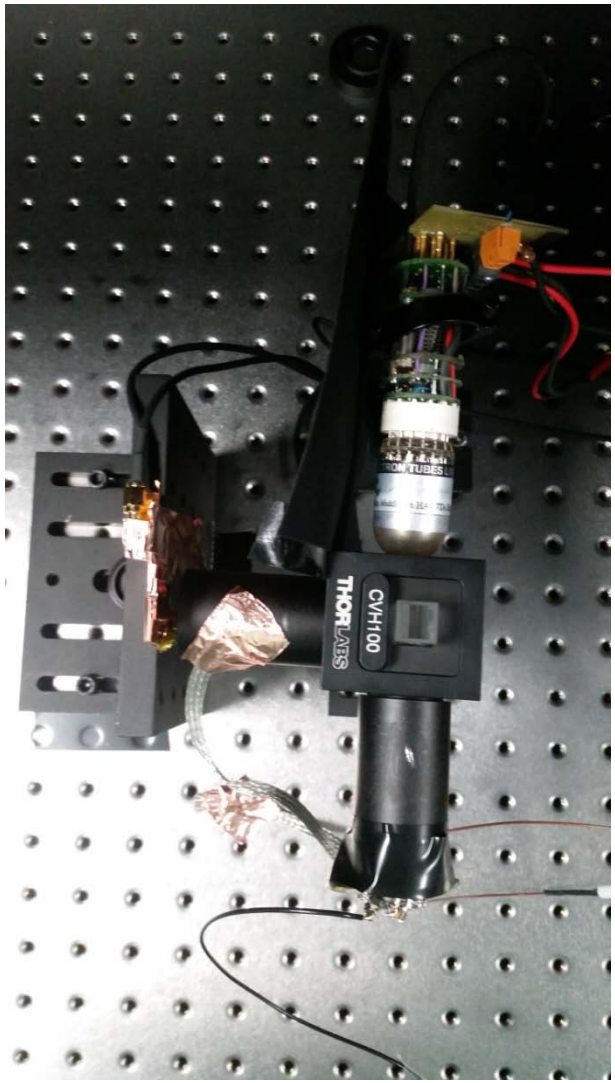
Kaputschinsky induced single photon (same amplitude as DC signal but overlaid by noise ripple)



New Tests

- Setup:



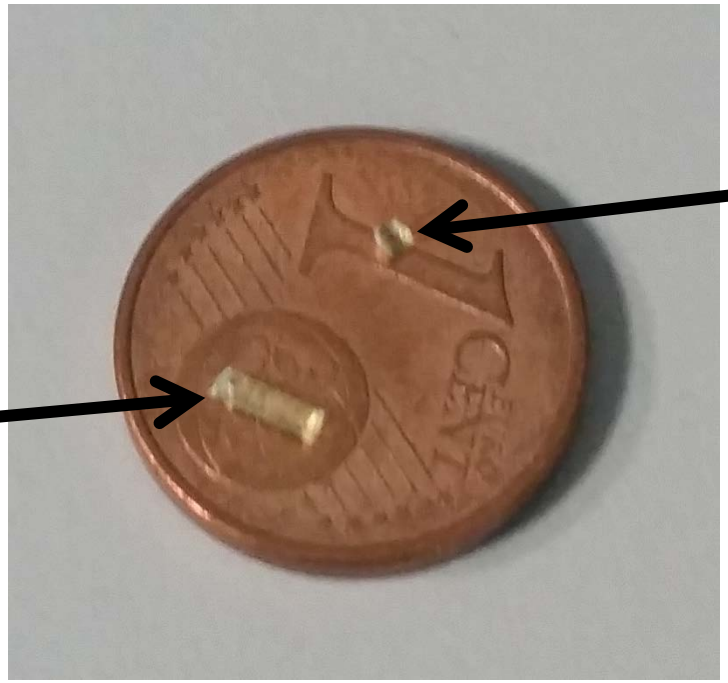


Setup Motivation

- 2 short pass filter behind each other to reduce light around 625 nm
- Testing old and new PMT in parallel
- 500 nm long pass filter provides probably more signal but also possibly more background
- 550 nm long pass filter better signal to background separation
- Seeing spectrum of Mitori Green probably 525 nm long pass filter would have the best choice but not available at IFAE

Measurements

- 3 different modes:
  - Completely empty, not even the sample holder
  - The sample holder but no sample
  - With small sample

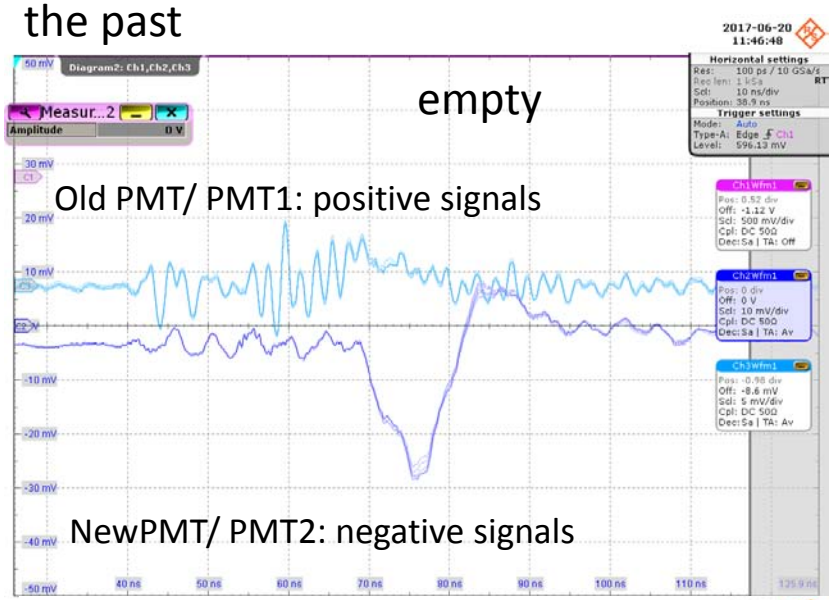


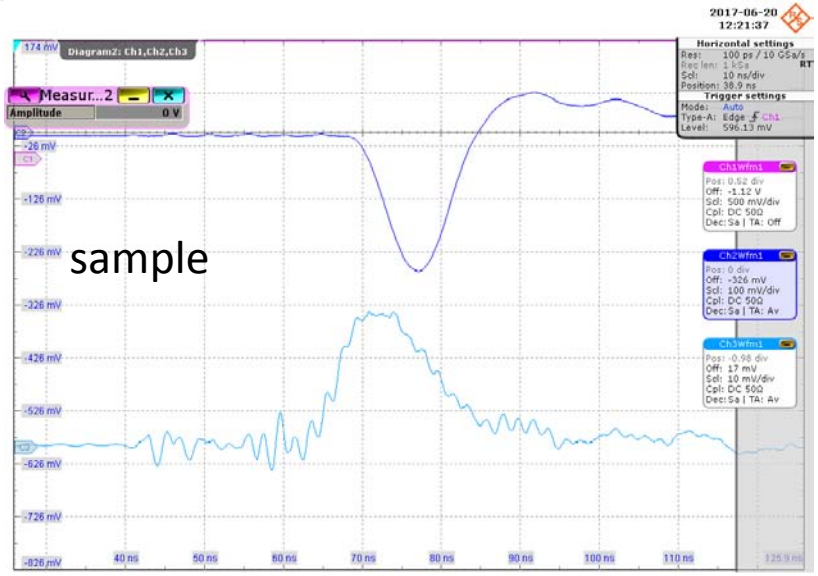
Sample used for the current tests

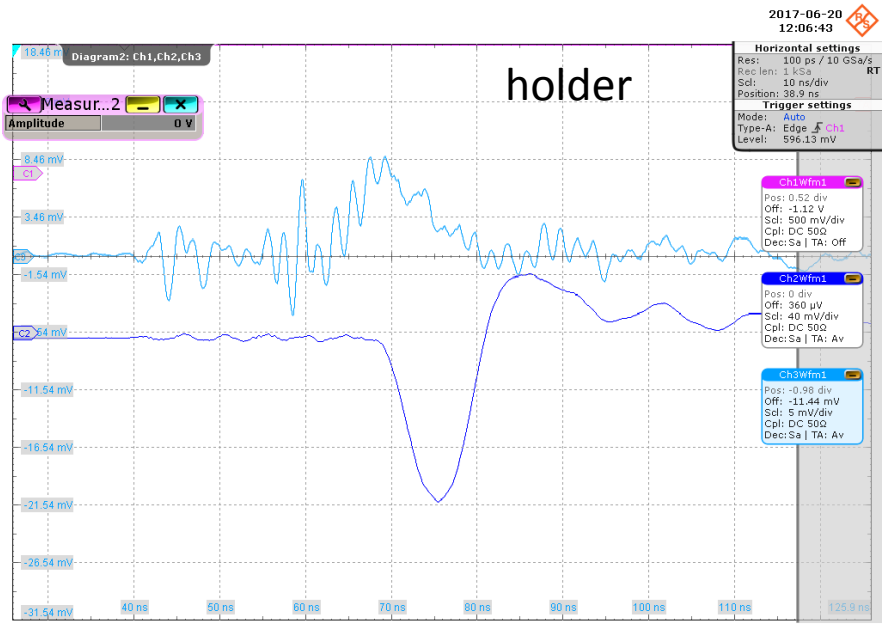
Roughly such a sample was used in the previous tests from slide 10

Results

LED voltage: 19.5 V like in the past







- S/N ratio from amplitude: ~2 (LP 500 nm), 2.5-3 (LP 550 nm)
- In previous tests was ~3
- BUT: sample now much smaller

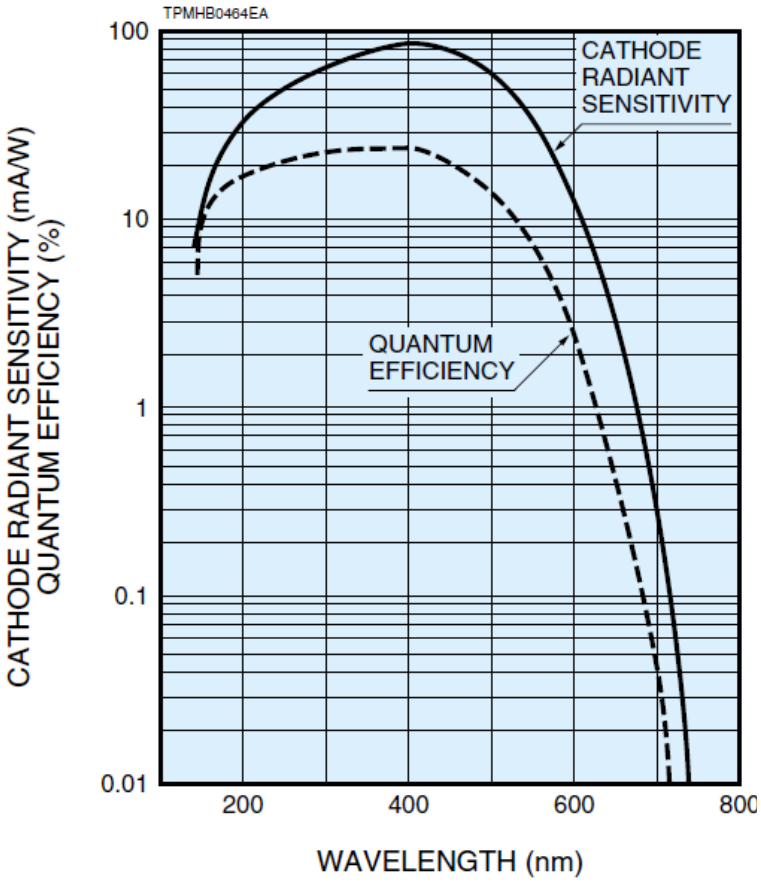
⇒ System much improved and works with less minimum light compared to previous tests

Statistical analysis ongoing

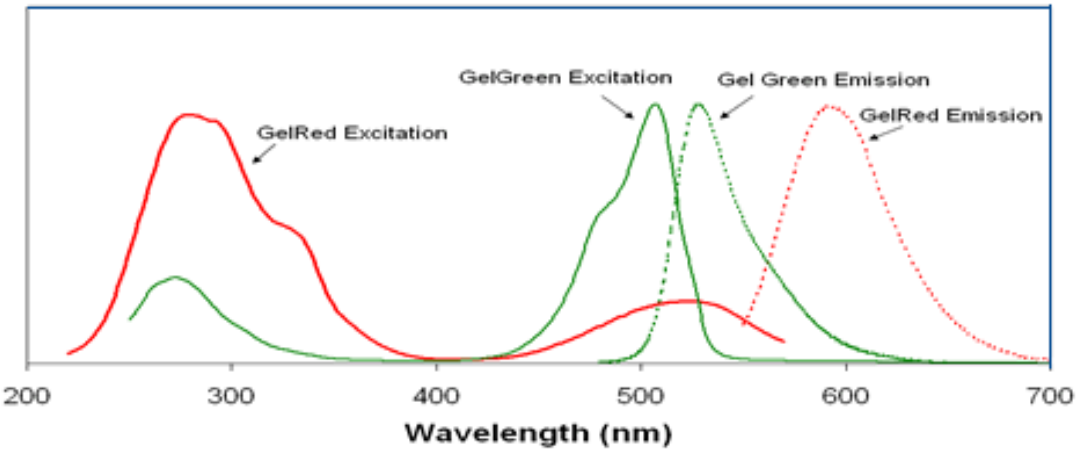
Conclusions

- New PMT detects more background light than old => due to 500 nm versus 550 nm long pass filter? => for systematic study one could swap both to verify this hypothesis
- Impression is that new PMT better in respect of gain but worse from timing (positive overshot after signal)
- In general background light strongly reduced compared to previous tests with single short pass filter at light entrance
- S/N ratio significantly improved accordingly
- Operating PMTs in parallel causes interference
- Asked for new round of measurements

Possible future Improvements



- Optimized light sensor:
  - Midori Gel Green emission peaks at about 540 nm (bottom plot)
  - Currently used PMTs have low quantum efficiency above 500 nm (left plot) => find sensor with high quantum efficiency plateau between 500-600 nm
- Optimized long pass filter: further S/N improvement by using long pass filter between 500 and 550 nm



Noise

• from one to the next day noise in EL PMT disappeared and increased slightly in the old MAGIC PMT (could reduce it again to the previous values)