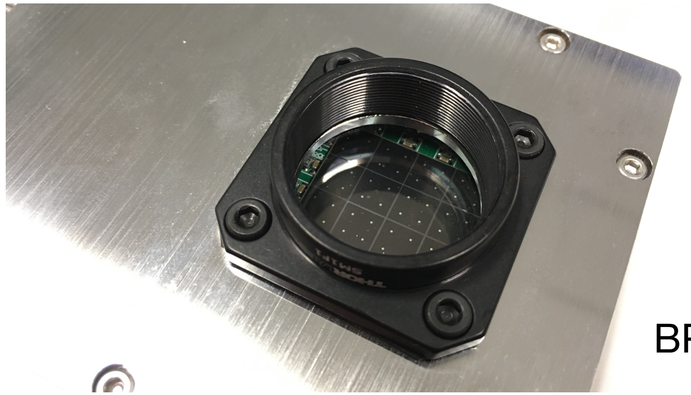
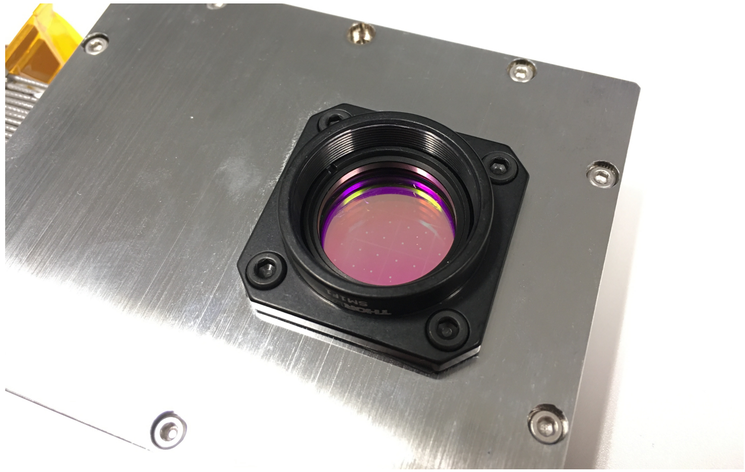
Optical crosstalk suppression

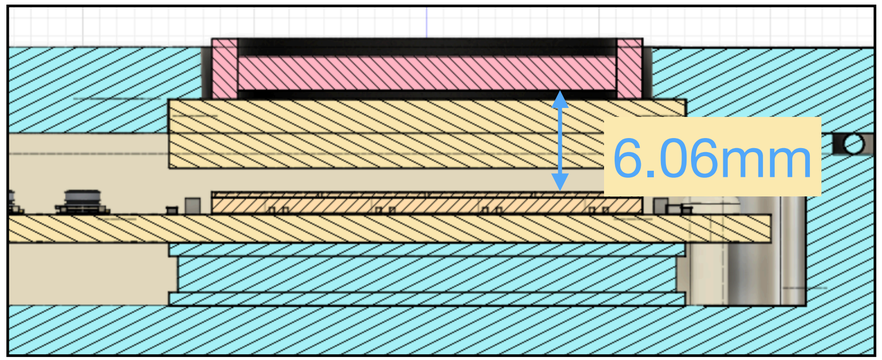
11. Jun. 2020. T. MASUDA

OCT w/ BPF (presented on 4/18)

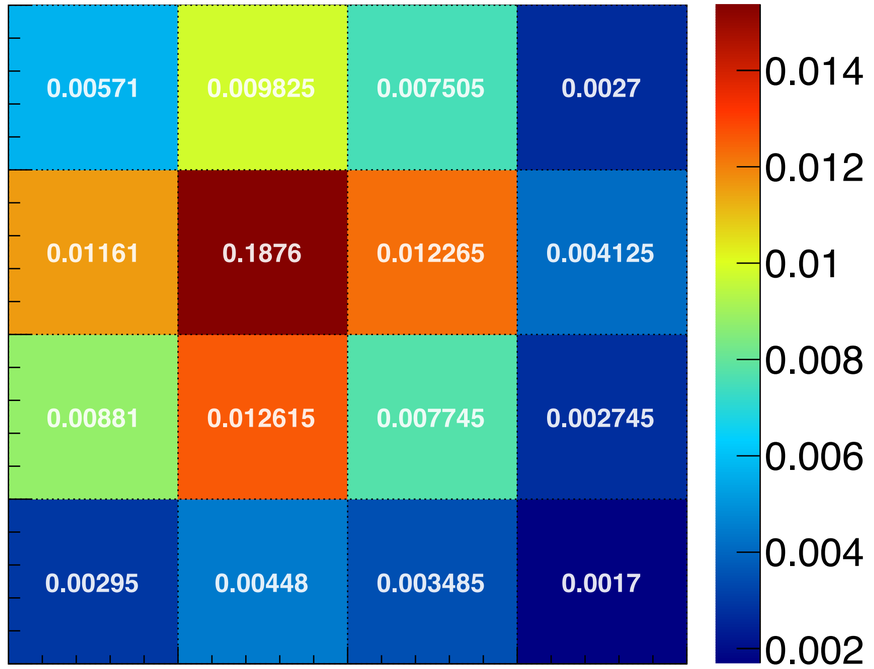


BPF F01-520/70-25





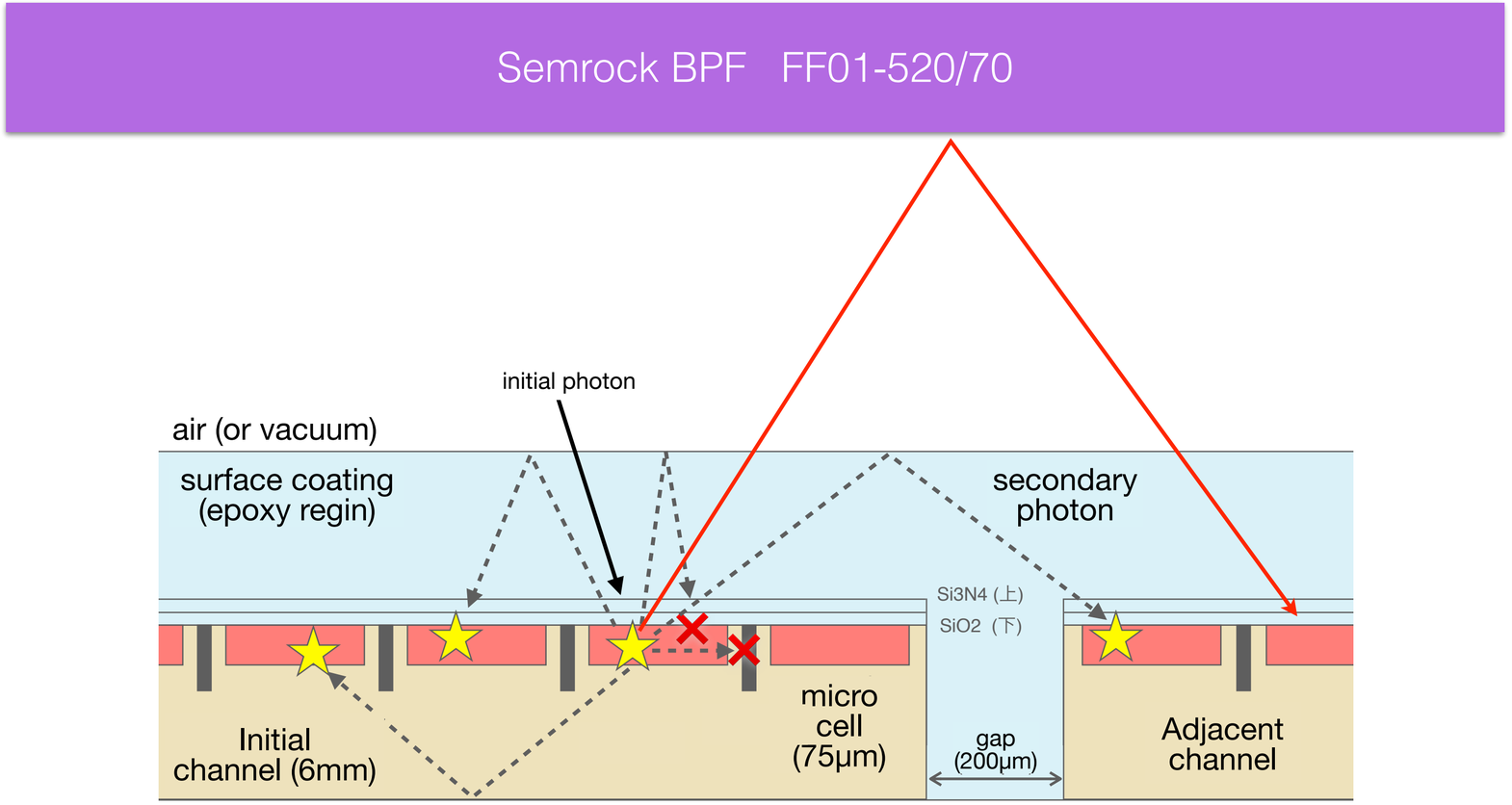
Optical crosstalk w/ BPF



- OCT probability is increased due to the BPF.
  - Total OCT probability : 17% → 28.6%
  - Factor 1.7 increased.

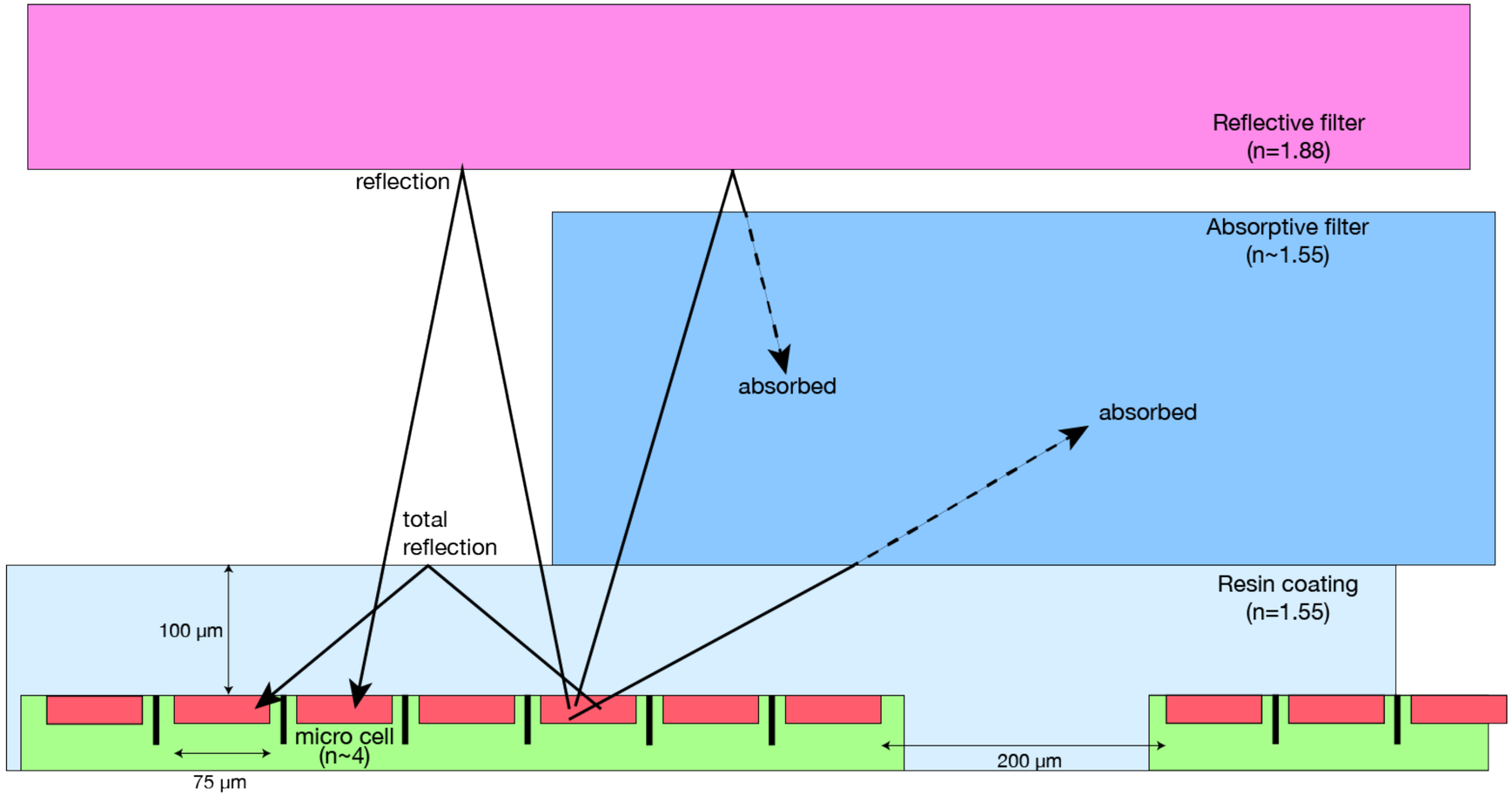
mechanism (presented on 4/18)

- The BPF reflects some of secondary photons from the fired cell and the reflected photons can fire another cell with a certain probability.



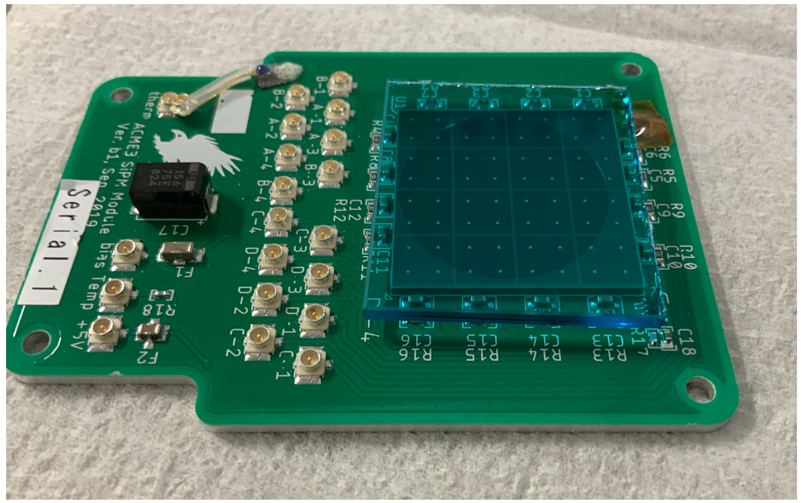
Plan of the OCT suppression

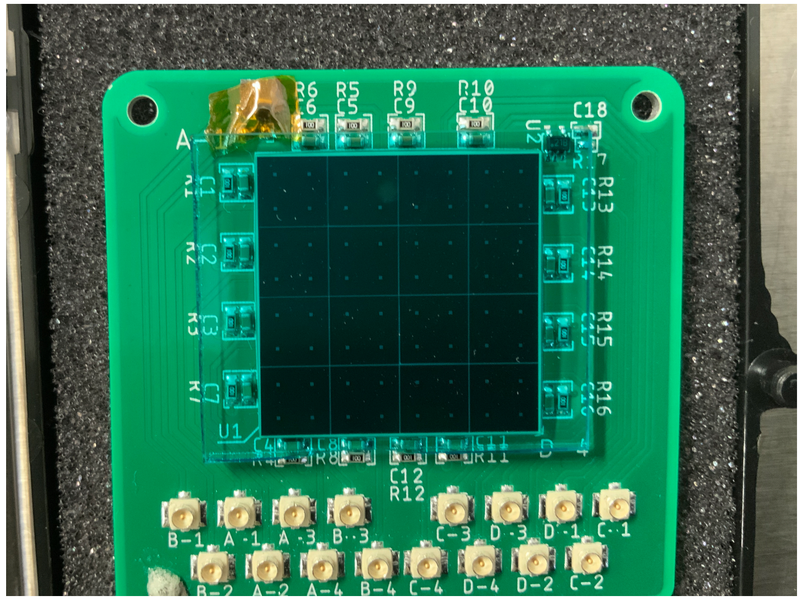
- Glueing an absorptive filter on the SiPM surface may be able to reduce the OCT due to the reflection both at the reflective filter surface and the SiPM surface.



Absorptive filters

- I glued 3 absorptive filters on the SiPM by using transparent silicone rubber (Momentive material TSE3032)

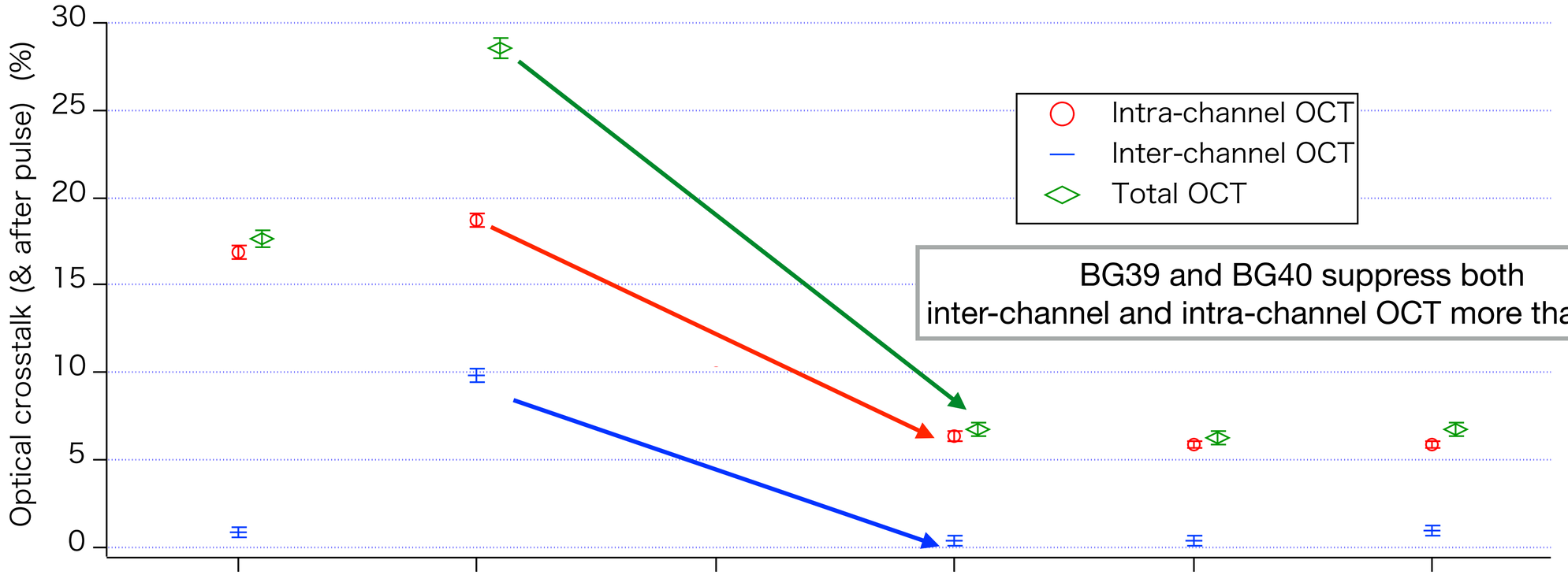




	Edmund Parts #	Measured transmittance @ 515 nm	Data sheet transmittance @ 510 nm	Guaranteed transmittance @ 510 nm
BG39 t=1mm	14-418	85.7% (94.5%)	87.7% (97.0%)	84% (93%)
BG39 t=2mm	14-419	84.6% (93.3%)	85.3% (94.6%)	78% (86%)
BG40 t=1mm	14-421	89.8% (99.0%)	89.0% (98.1%)	88% (97%)

Upper line : surface reflection is included (9.3% assumed)
(Lower line) : internal transmittance only

Absorptive filter effect



Vacuum window (BK7)

SiPM

FF01-520/70

Vacuum window (BK7)

SiPM

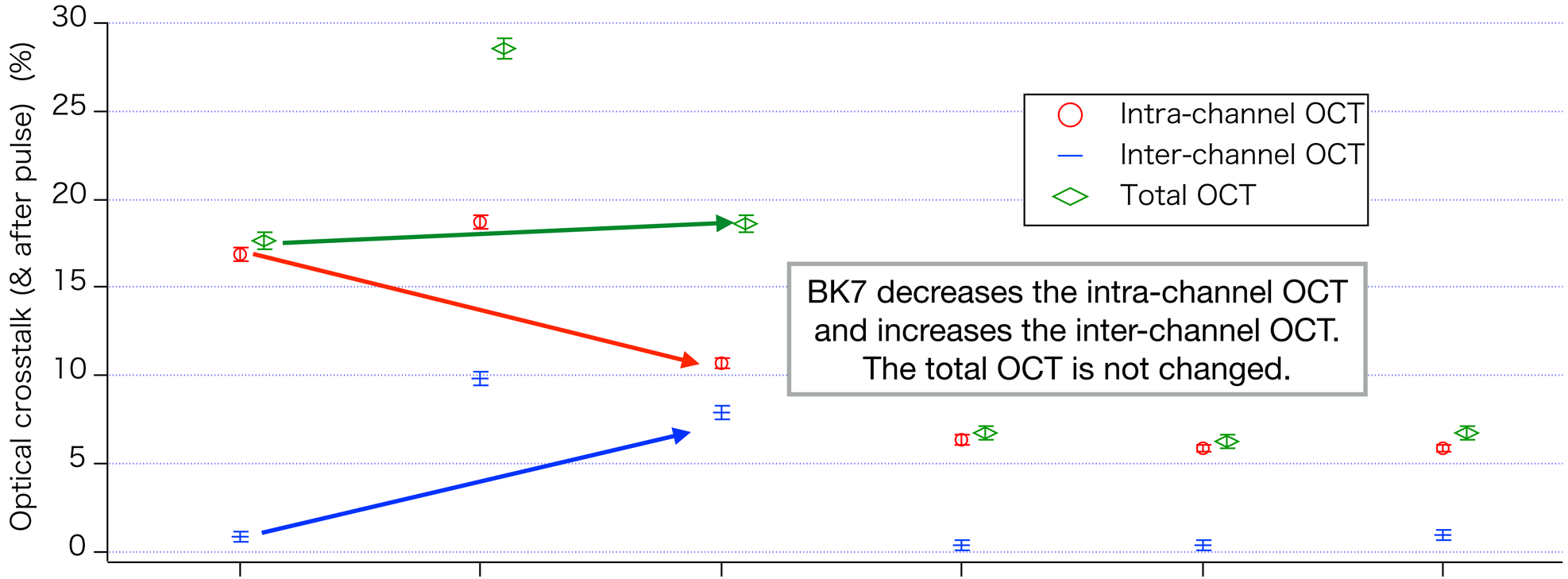
FF01-520/70

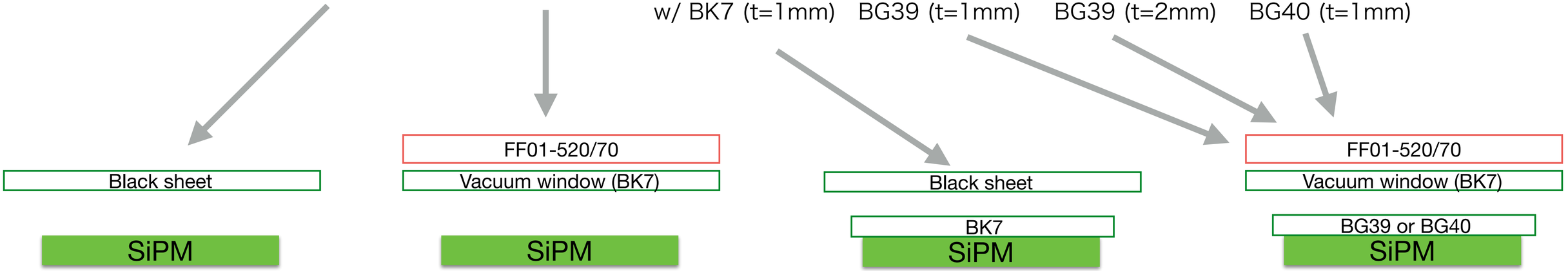
Vacuum window (BK7)

BG39 or BG40

SiPM

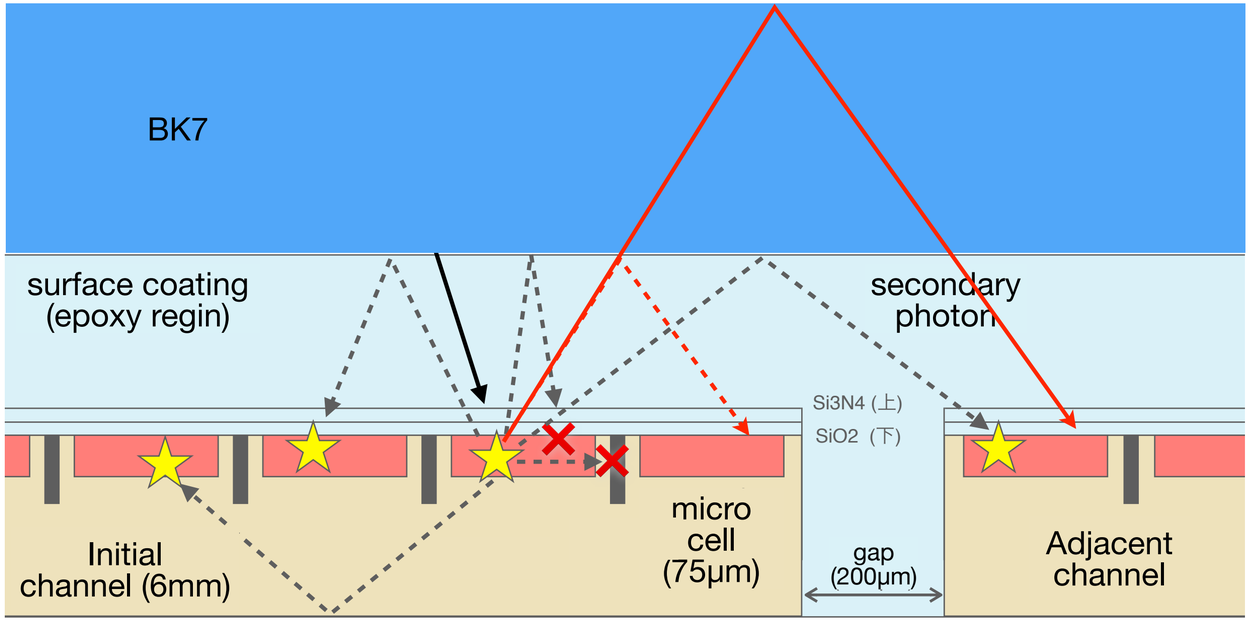
BK7 case


Optical crosstalk (& after pulse) (%)
30
25
20
15
10
5
0
Intra-channel OCT
Inter-channel OCT
Total OCT
BK7 decreases the intra-channel OCT
and increases the inter-channel OCT.
The total OCT is not changed.
w/o BPF
w/ BPF
w/o BPF
w/ BK7 (t=1mm)
w/ BPF &
BG39 (t=1mm)
w/ BPF &
BG39 (t=2mm)
w/ BPF &
BG40 (t=1mm)

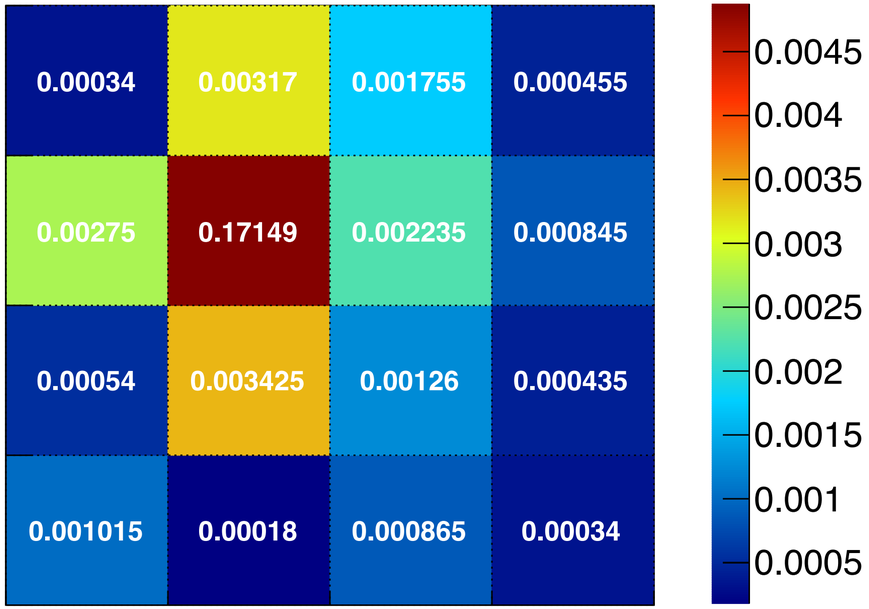

Black sheet
SiPM
FF01-520/70
Vacuum window (BK7)
SiPM
Black sheet
BK7
SiPM
FF01-520/70
Vacuum window (BK7)
BG39 or BG40
SiPM

BK7 case

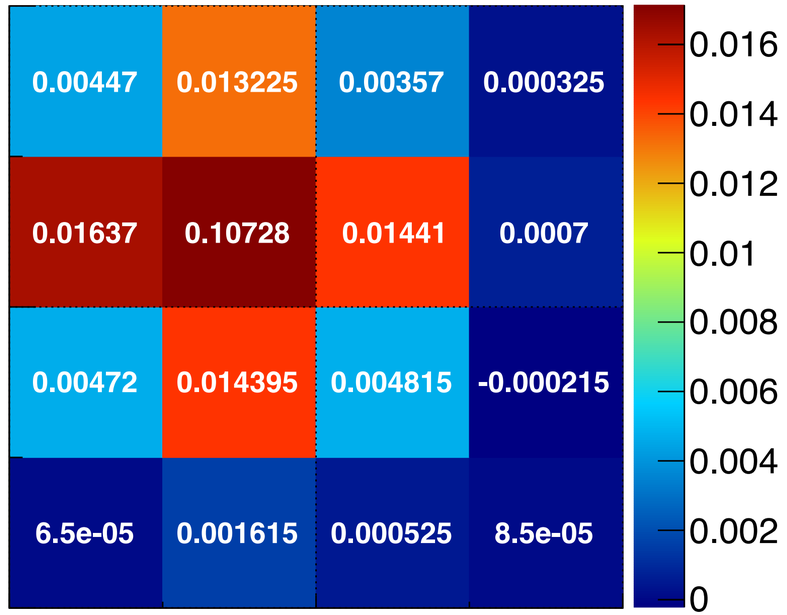
- Some portion of the secondary photons can escape to the adjacent cells through the glued BK7 window and cause the inter-channel OCT; therefore, the total OCT does not change.



Optical crosstalk w/o BK7

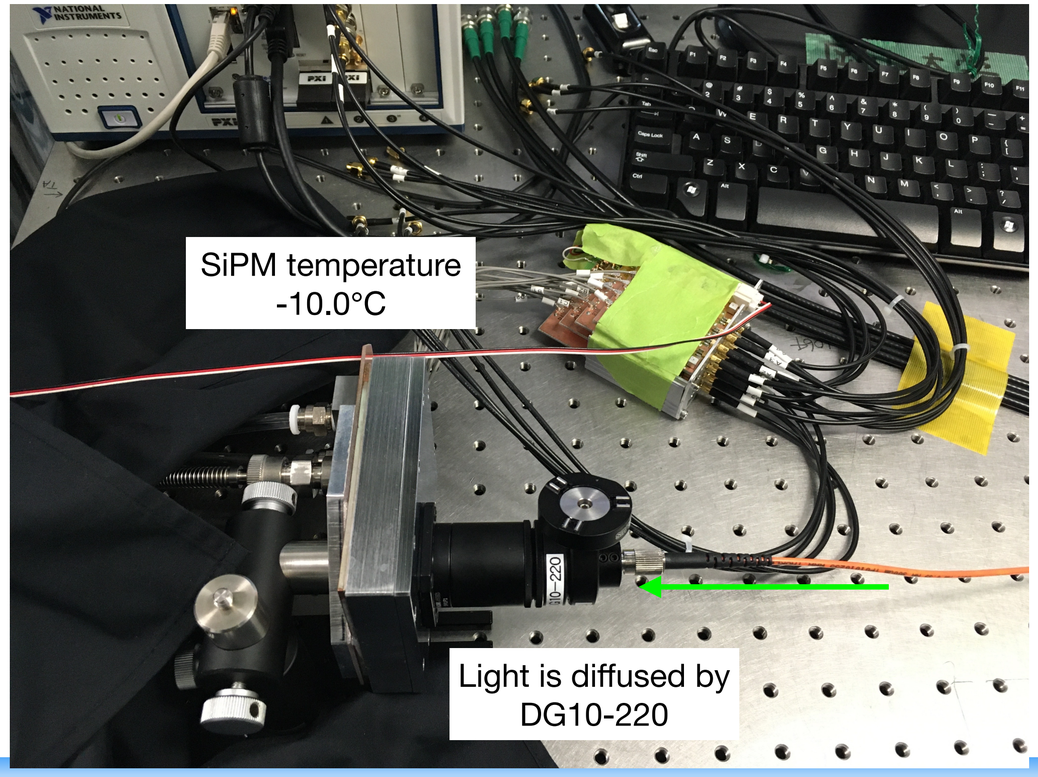


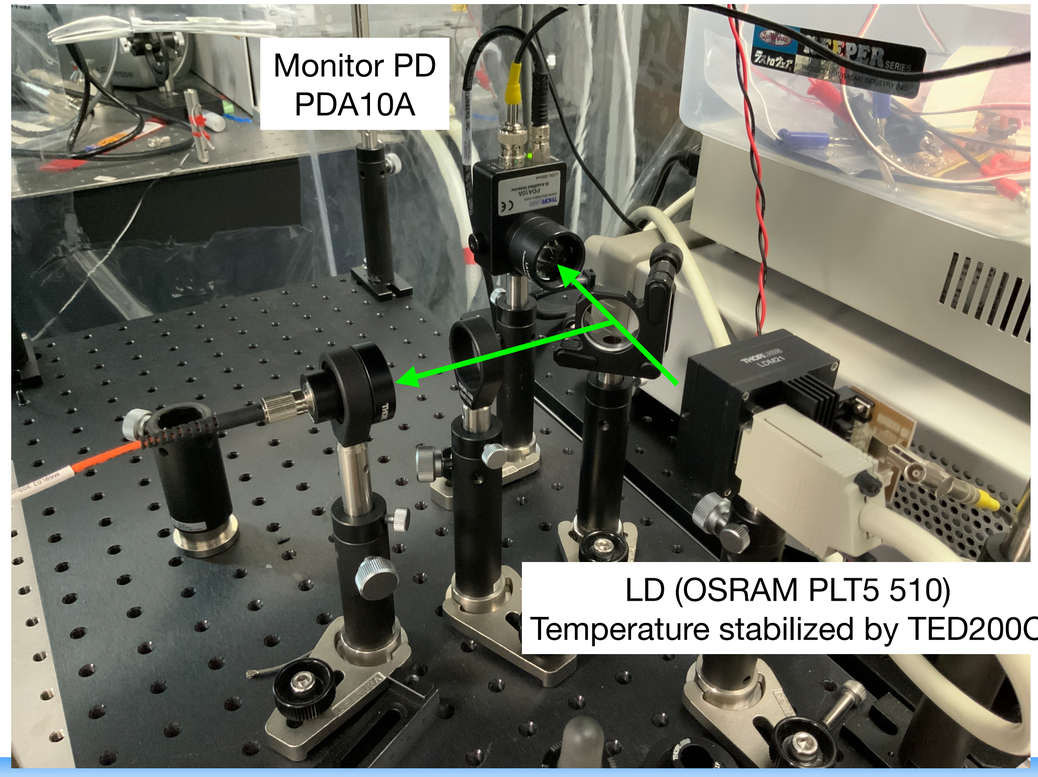
Optical crosstalk w/ BK7 (t=1mm)



Transmittance check w/ SiPM

- I compared the received light yield of SiPM w/ and w/o the glued absorptive filters to confirm that there is not unexpected problems.
  - BG39 (t=1mm) : 89%
  - BG40 (t=1mm) : 95%
- These are a little bit lower than expected (TSE3032?) but there is no unexpected problem.
- If we use an AR-coated filter, it will increase by ~5%.

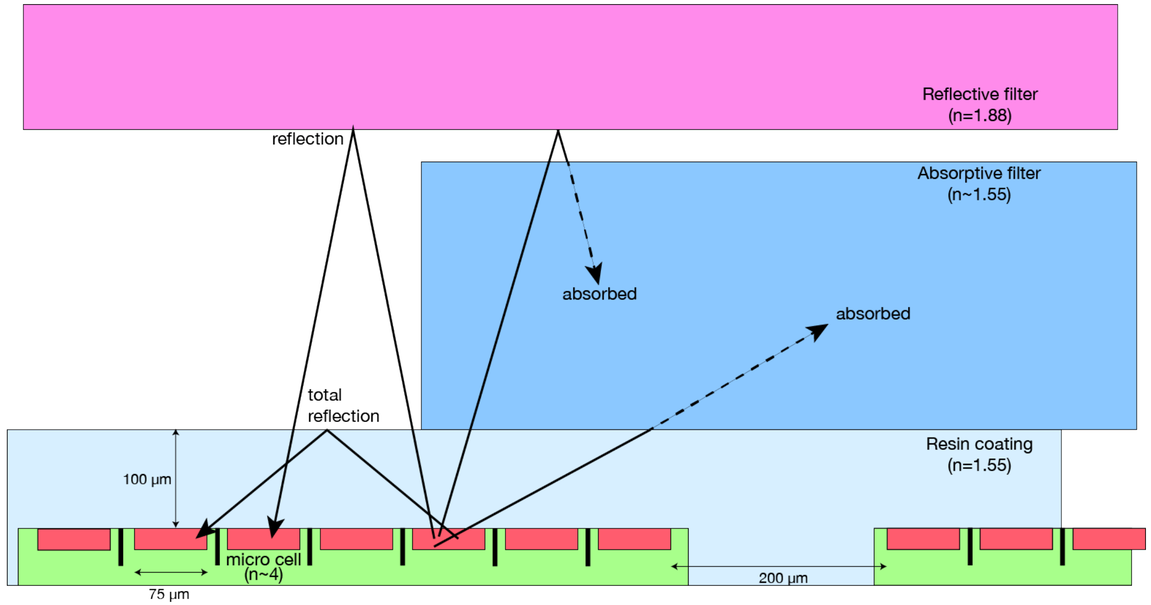




Summary & plan

- The glued absorptive filter can decrease OCT both intra-channel and inter-channel OCT as expected.
- The reduction is almost saturated even with BG40 t=1 mm.

- I plan to use an AR-coated BG40 t=1 mm for the next prototype.
  - OCT (& AP) will be reduced 29 → 7%.
    It reduces the excess noise ~20%.
  - Signal yield will not be decreased.

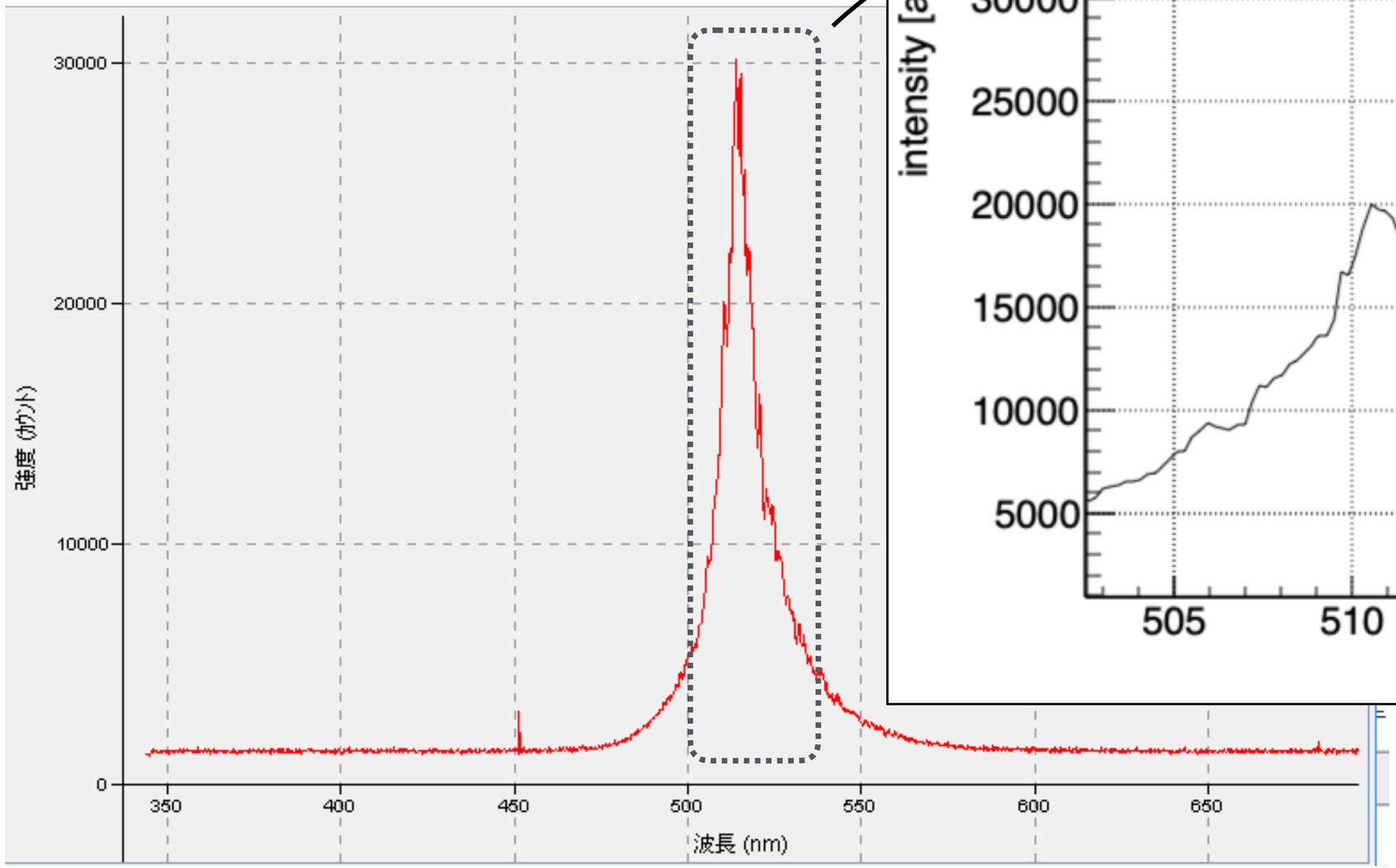


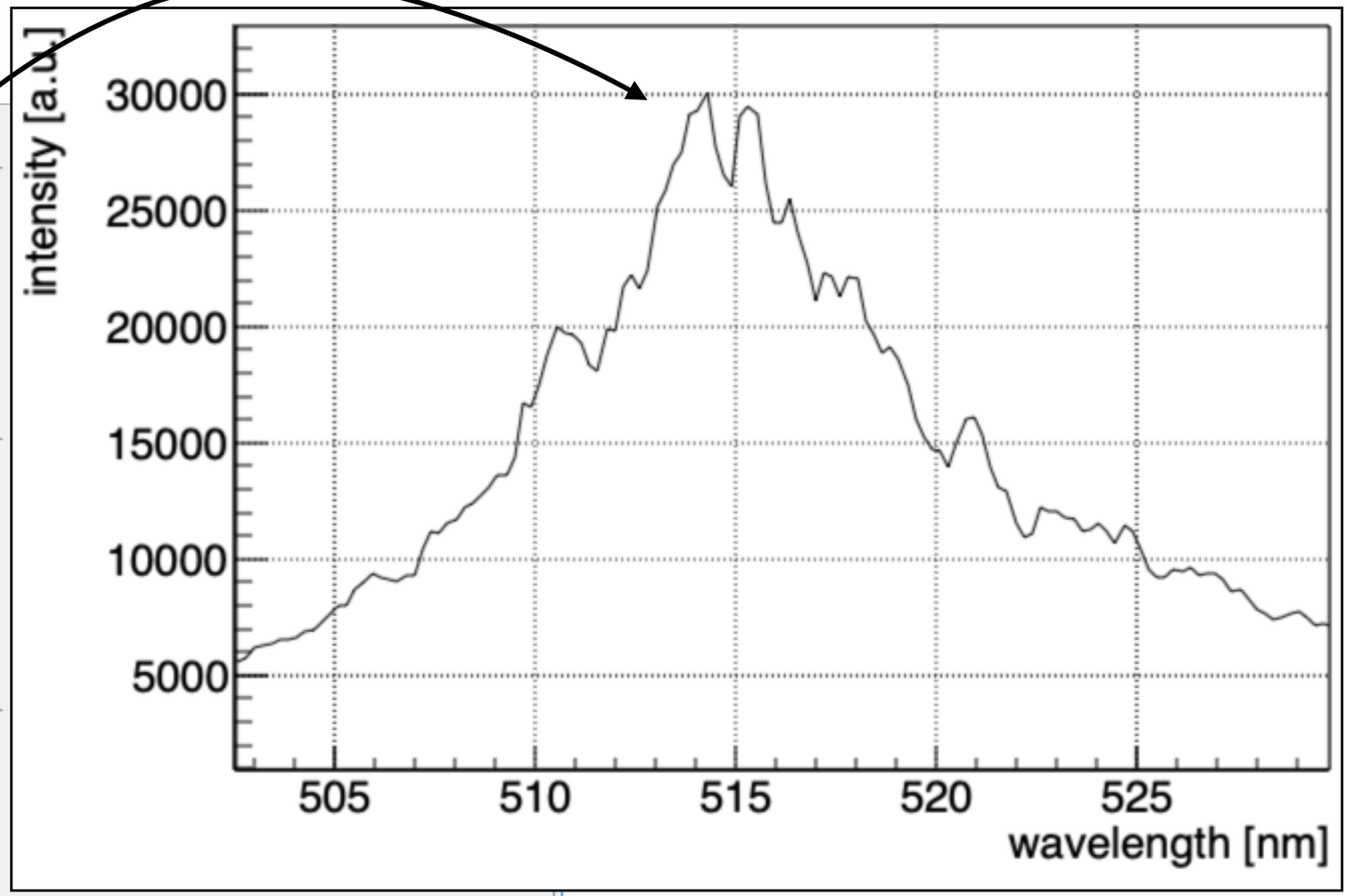
- The OCT suppression by using absorptive filters is probably an interesting topic to SiPM users.
  I would like to report this phenomenon to a dedicated journal (IEEE sensors journal?) with supplementary measurements.
  - checking the OCT suppression with several other color glasses

Back up

PLT5 510 spectrum

Spectrometer:
Ocean optics USB4000-VIS-NIR 350-1000

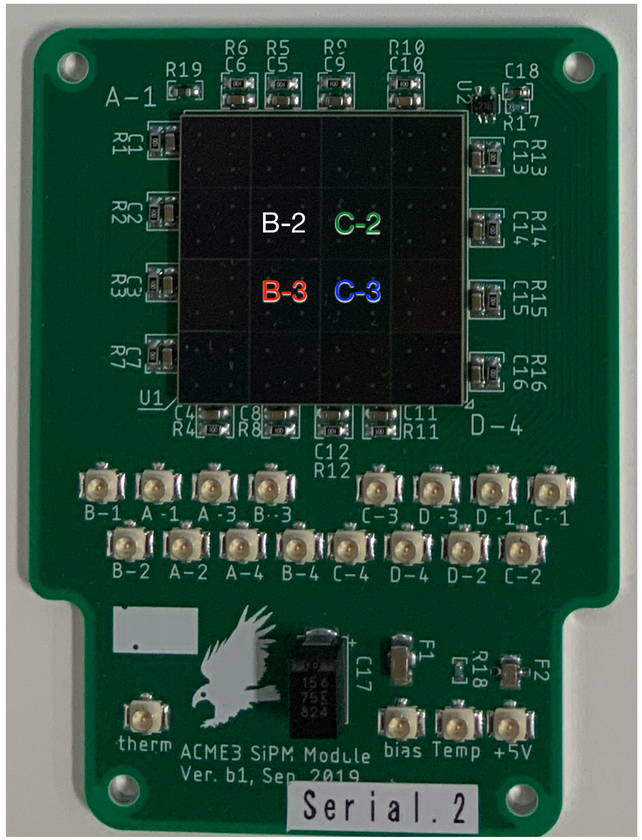


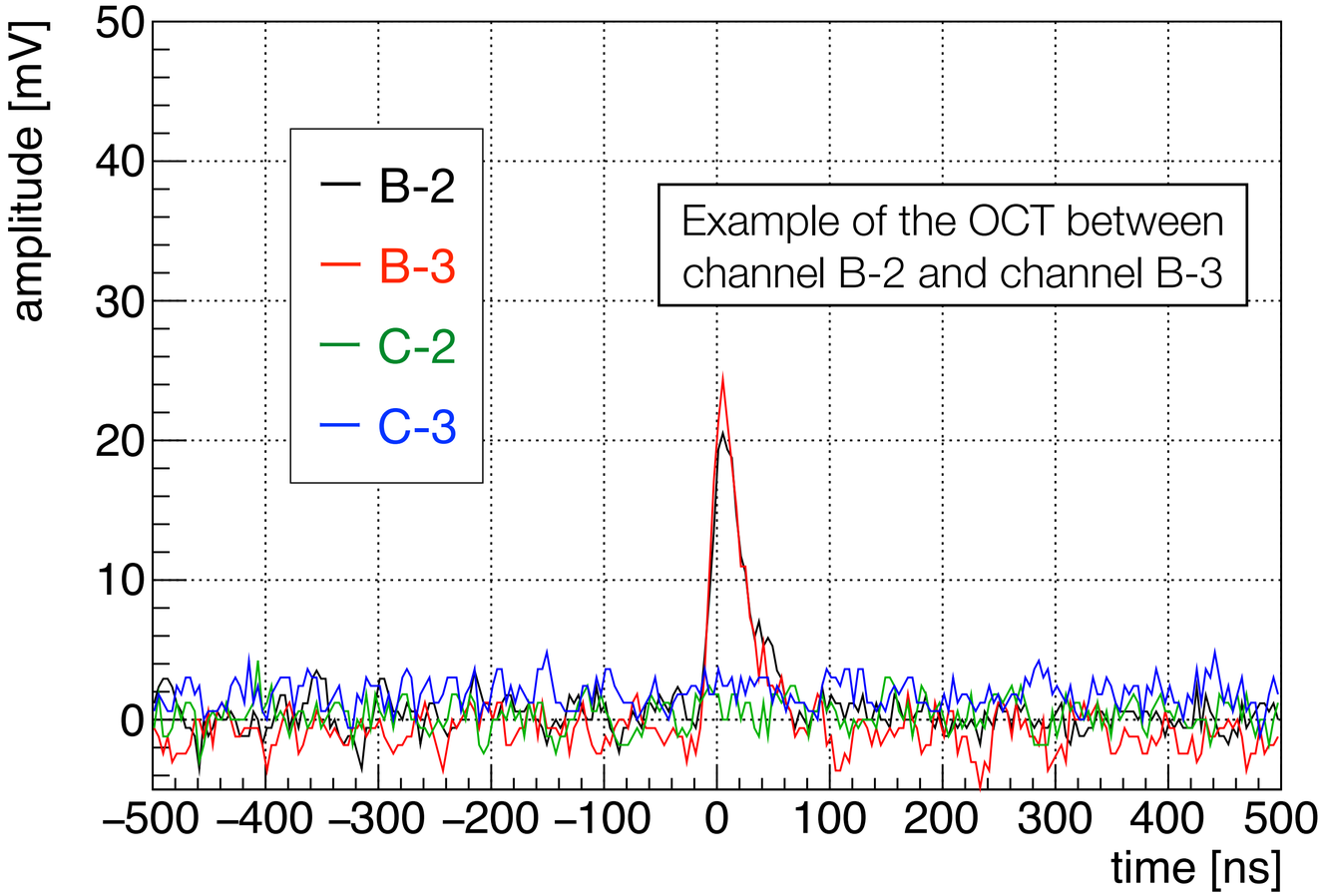


Measurement set up

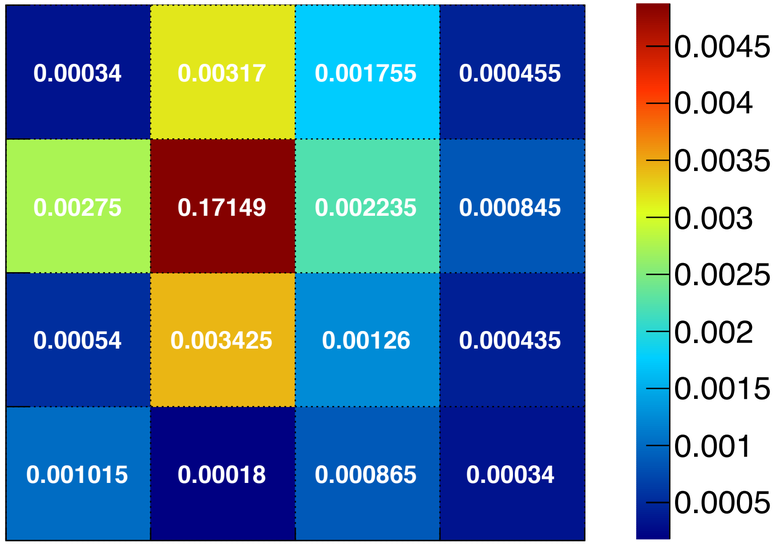
- Setting : -10.2°C, Vov=3.0V
- Oscilloscope trigger is set to channel B-2 (~10mV), then the waveforms of channels B-2, B-3, C-2, C-3 are taken simultaneously
  - 250MS/s, 250S/shot (1us)

24.6mm

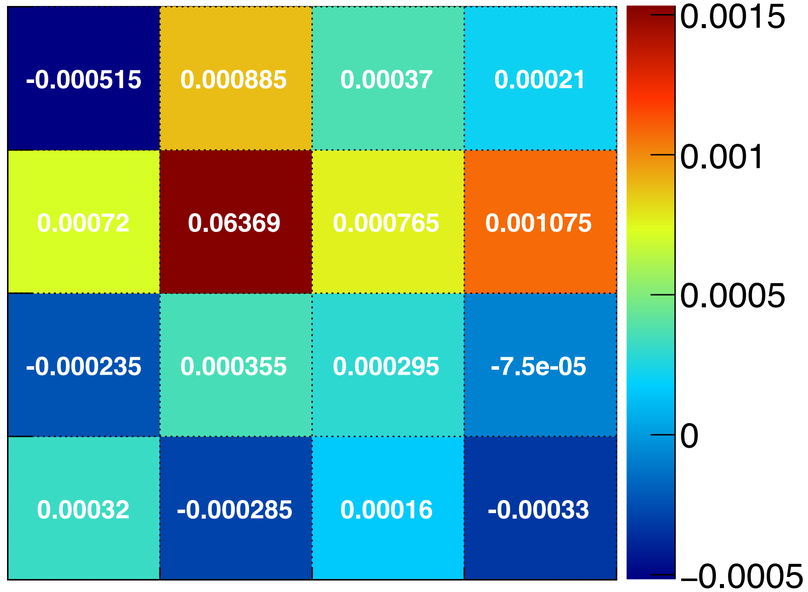




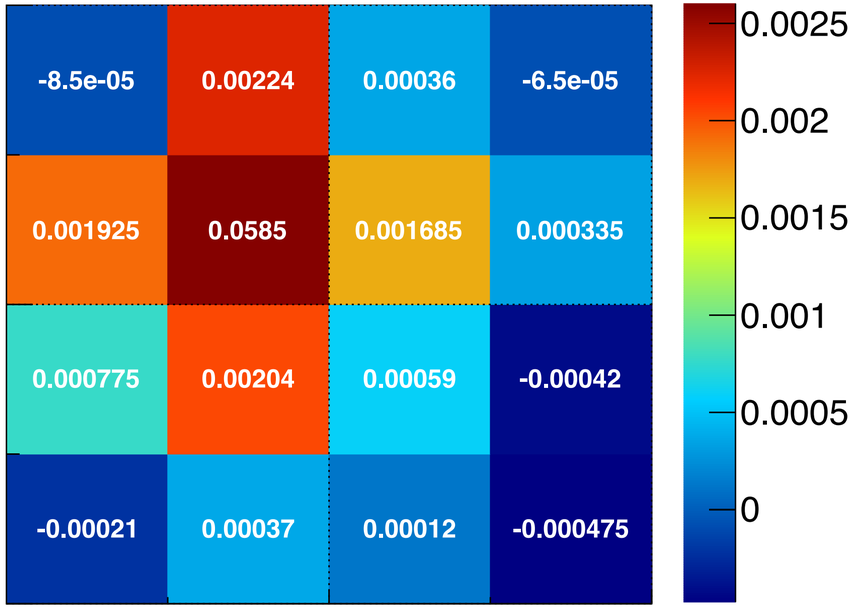
Optical crosstalk



Optical crosstalk w/ BPF & BG39 (t=1mm)



Optical crosstalk w/ BPF & BG40 (t=1mm)



Optical crosstalk w/ BK7 (t=1mm)