# McGill update

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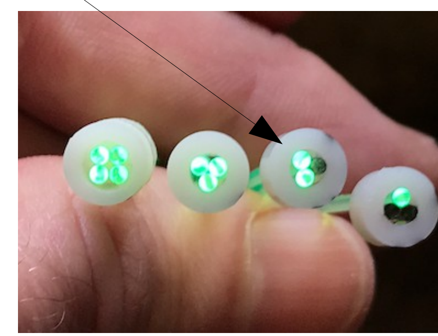
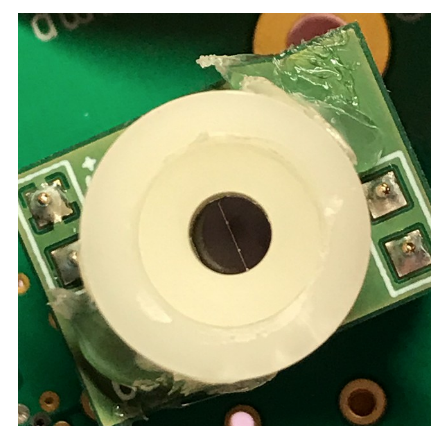
# Scintillator test configuration

- Externally triggered cosmics, ~5cm long sensitive region
- FNAL scintillator samples (5cm wide). 1 and 2 cm thickness, and two different hole configurations
- 1.5mm Y-11 fibre, 2 strands in single 50cm pigtail with nylon connector. Both fibres routed to a single SiPM
- Polished on SiPM end, cut on far end (same pigtail used previously in polished vs cut test)



- 3 x 3 mm Broadcom SiPM AFBR-S4N33C013 via Broadcom evaluation board
- 31.9 V operating point
- Signals from “normal” output



# Broadcom SiPMs

AFBR-S4N33C013

- Active area 3.0mm x 3.0mm;   9815 pixels
- 30µm pixel pitch, 76% fill factor
- Breakdown voltage:  26.9V
- I'm working at 31.9V,    i.e. OV=5V

I also have AFBR-S4N44C013

- 3.72mm x 3.72mm sensor, but otherwise identical

Figure 4:  Spectral Sensitivity

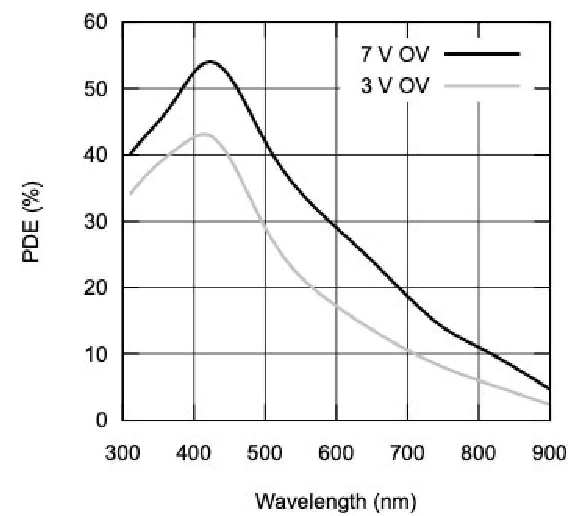



Figure 5:  PDE at Peak λ vs. OV

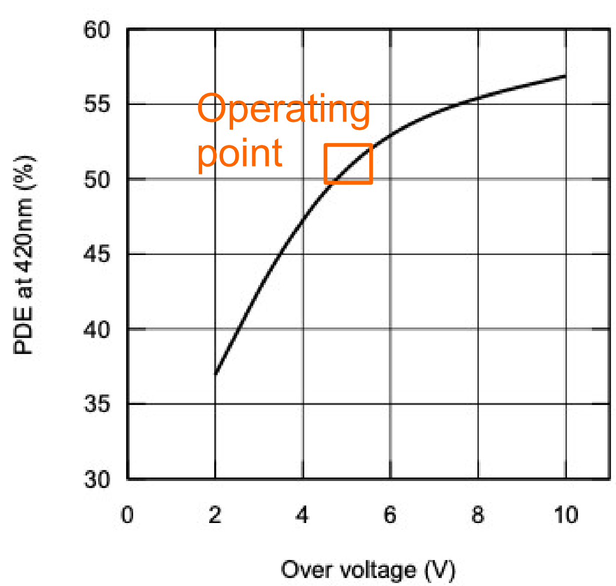
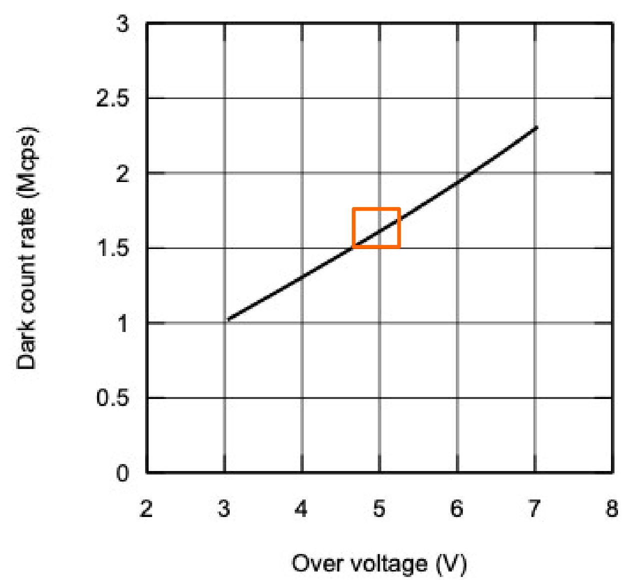
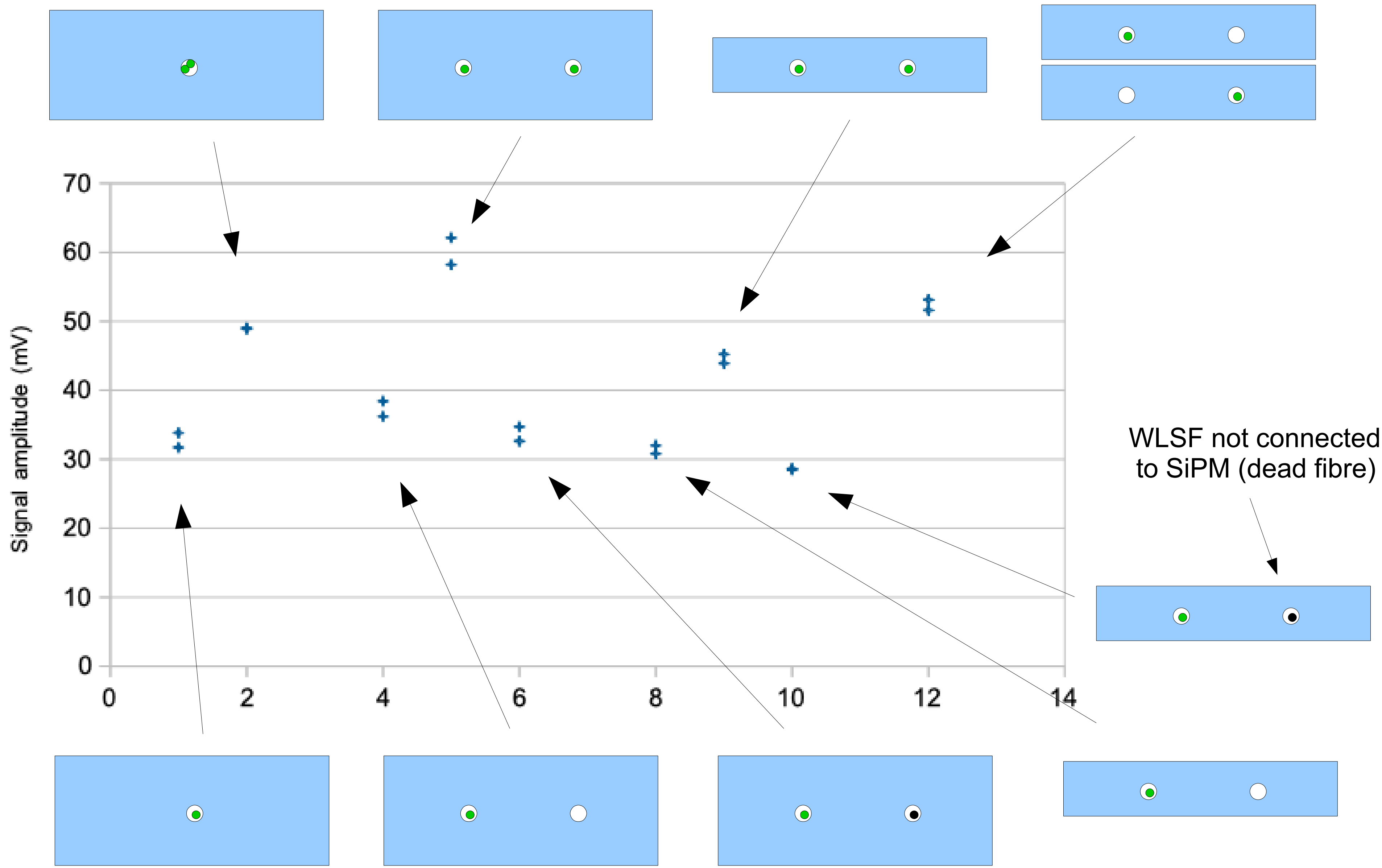



Figure 7:  Dark Count Rate vs. OV



# Results



Signal amplitude (mV)
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
WLSF not connected to SiPM (dead fibre)

# Next: Long fibre test

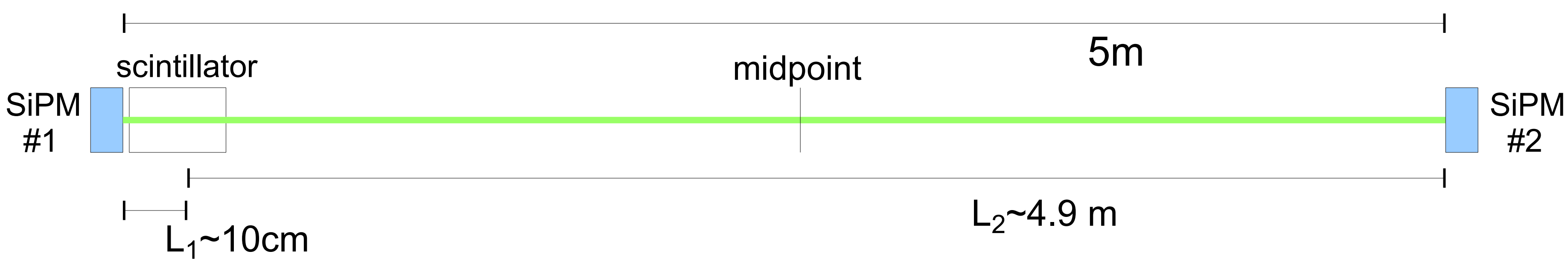
(from last week)

Will use my long fibre timing test setup to perform an attenuation measurement using a configuration similar what I did for the cut/polish study

- Can simply measure the average signal amplitudes from the two fibre ends as a function of scintillator position
- In principle, can cancel out some of the Landau fluctuations by measuring the relative amplitudes from the two ends on an event-by-event basis, but have not yet convinced my scope to let me do this...

Test setup:

- Extreme case (worst case for fibre attenuation):




$\Delta L = L_1 - L_2$ ~4.8m   For N = 1.59 (Y-11 spec sheet), $\Delta t$ ~ 25.5ns

- **1ns differential timing corresponds to ~10cm position resolution**

# Long fibre test (progress)

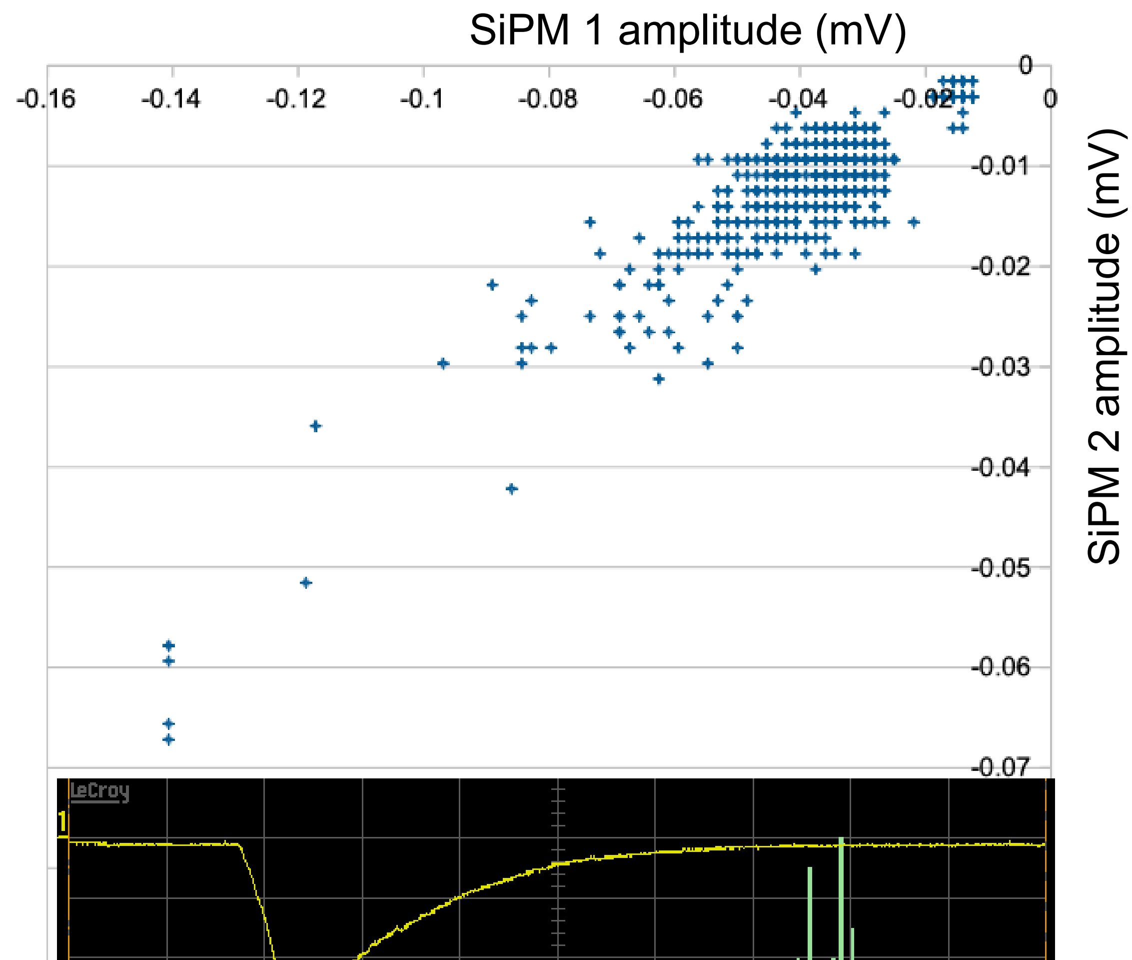
Want to measure light yield as function of position of signal along fibre

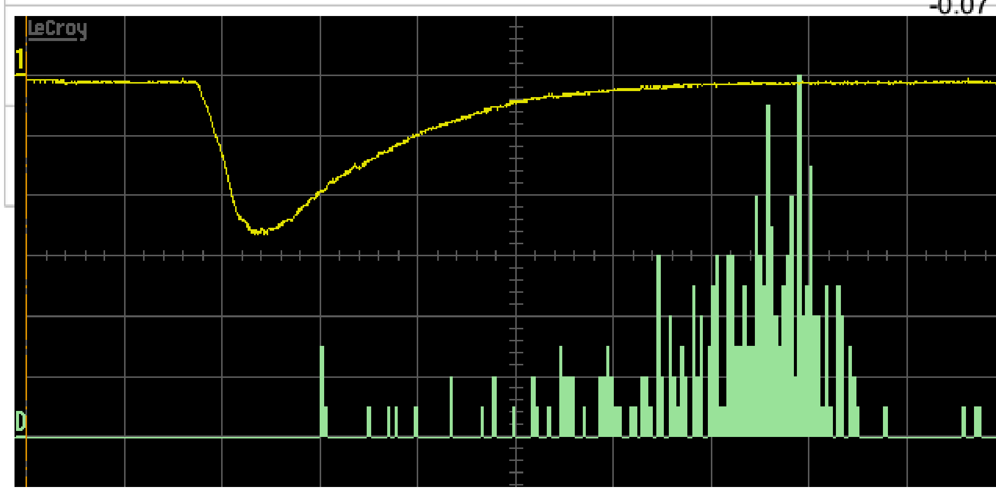
Two possibilities:

- Measure mean light yield vs position
- Read WLSF simultaneously from both ends on event-by-event basis and measure RATIO as function of position

Figured out how to get event-by-event parameter measurements from scope

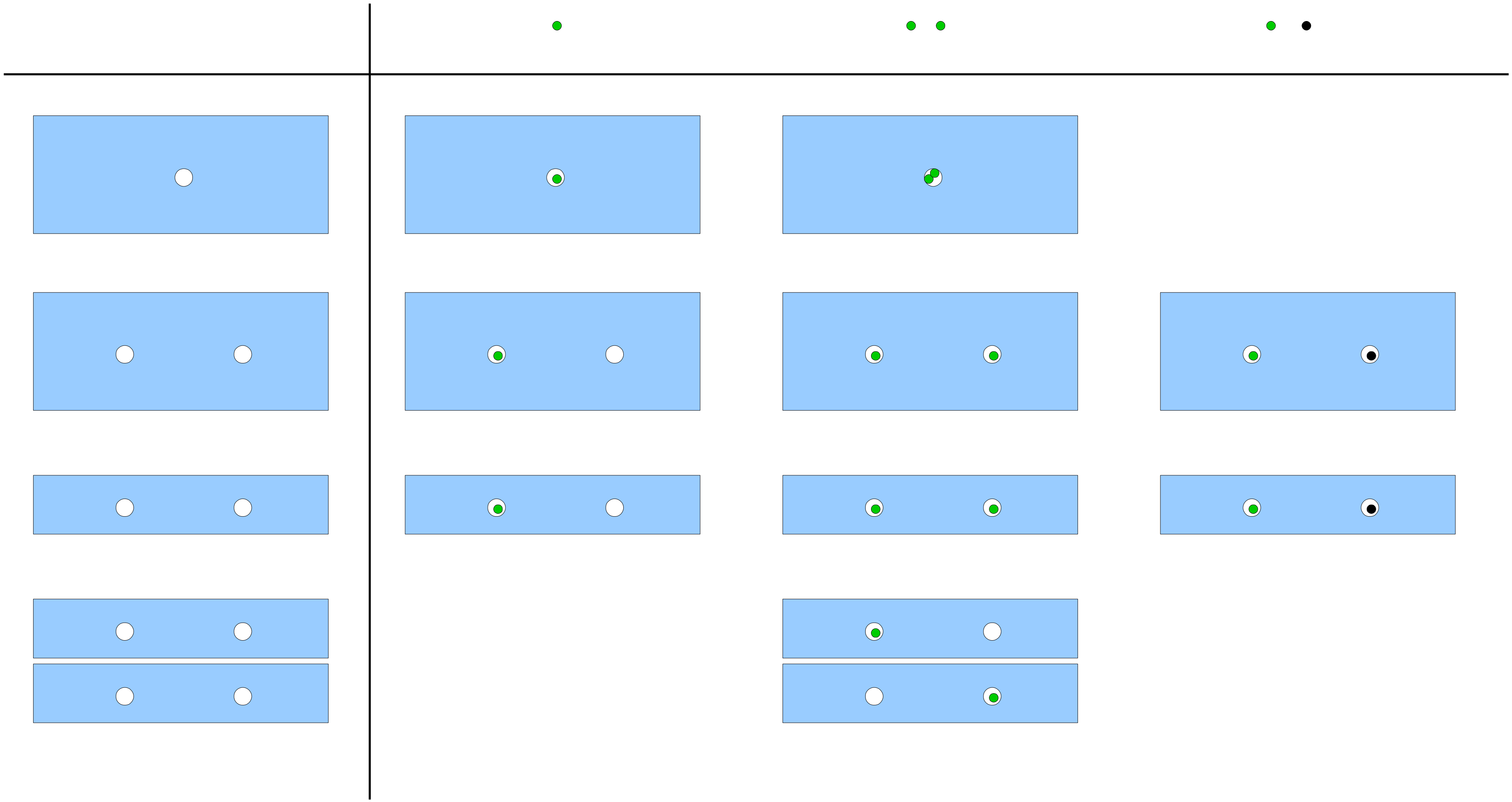
- Looks like ratio method will work; correlations in SiPM signals will allow cancellation of large Landau tails in SiPM signals



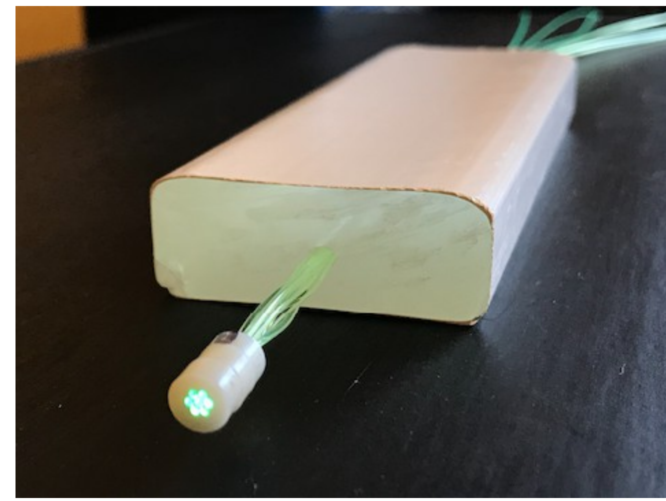

(this is just an example)

# Backup

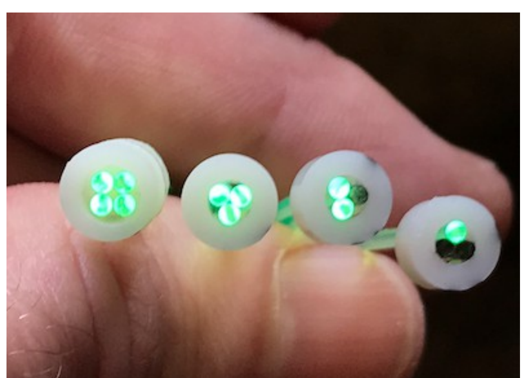


# Fibre configuration measurements

- Use a combination of 50cm long pigtails, prepared with one or multiple fibres per bundle
- Fibres are glued in nylon sleeve, which press-fits to a matching sleeve on SiPM adaptor board
- All, or a subset of fibres can be threaded through a FNAL scintillator block
- Cosmic ray muons are externally triggered using a pair of scintillators above and below (active region ~7cm long)



These configurations will all fit a 3mm x 3mm SiPM

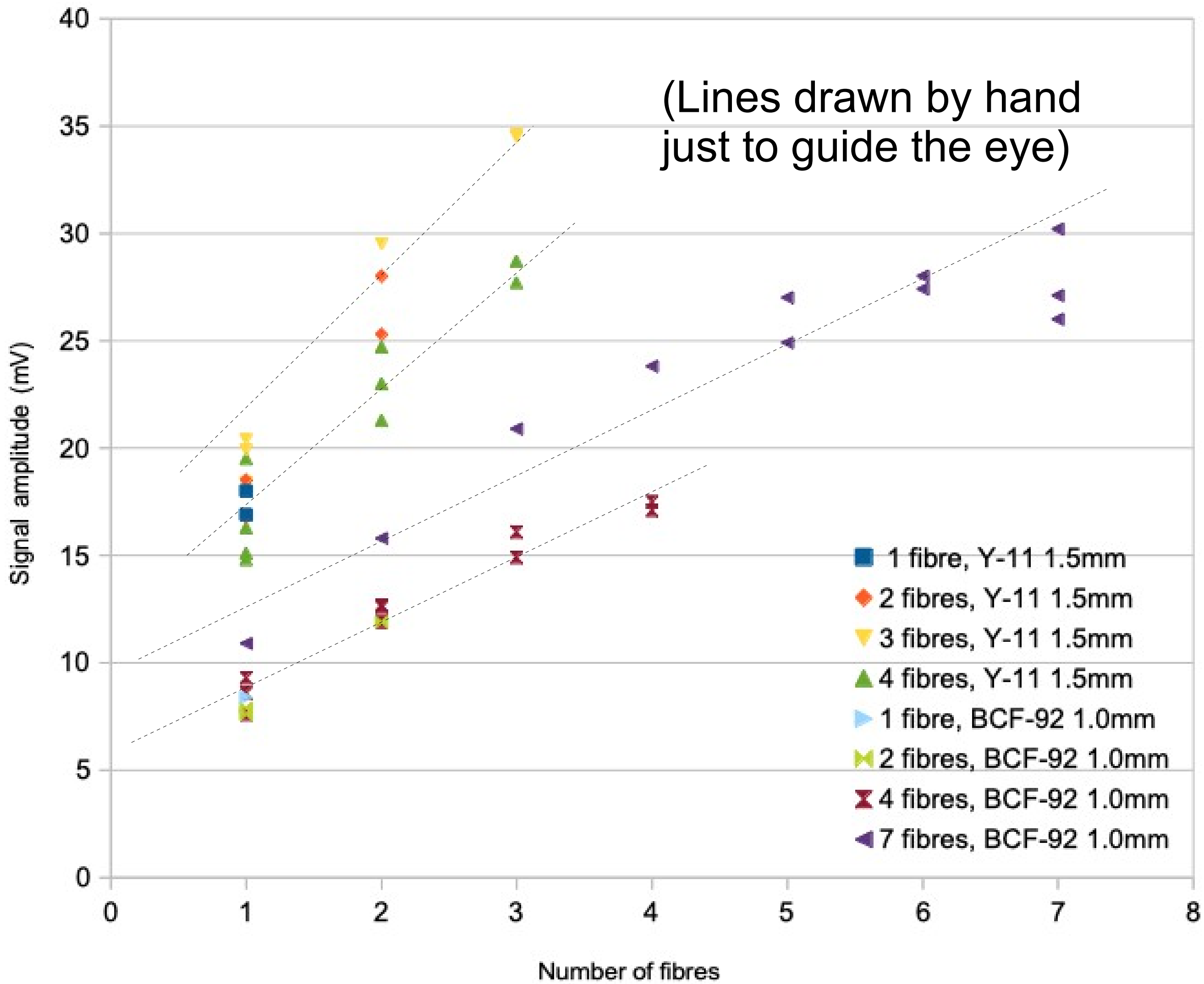


1.5mm fibres

1.0mm fibres

# WLSF test results

- More fibre = larger SiPM signals
- Larger diameter fibre gives larger SiPM signals (?) Caveat: different fibre type
- ~6-7  1mm fibres give signal amplitudes similar to 3 1.5mm fibres
- ~10-20% variation in amplitude due to “systematics”, i.e. optical coupling between fibre and SiPM etc.

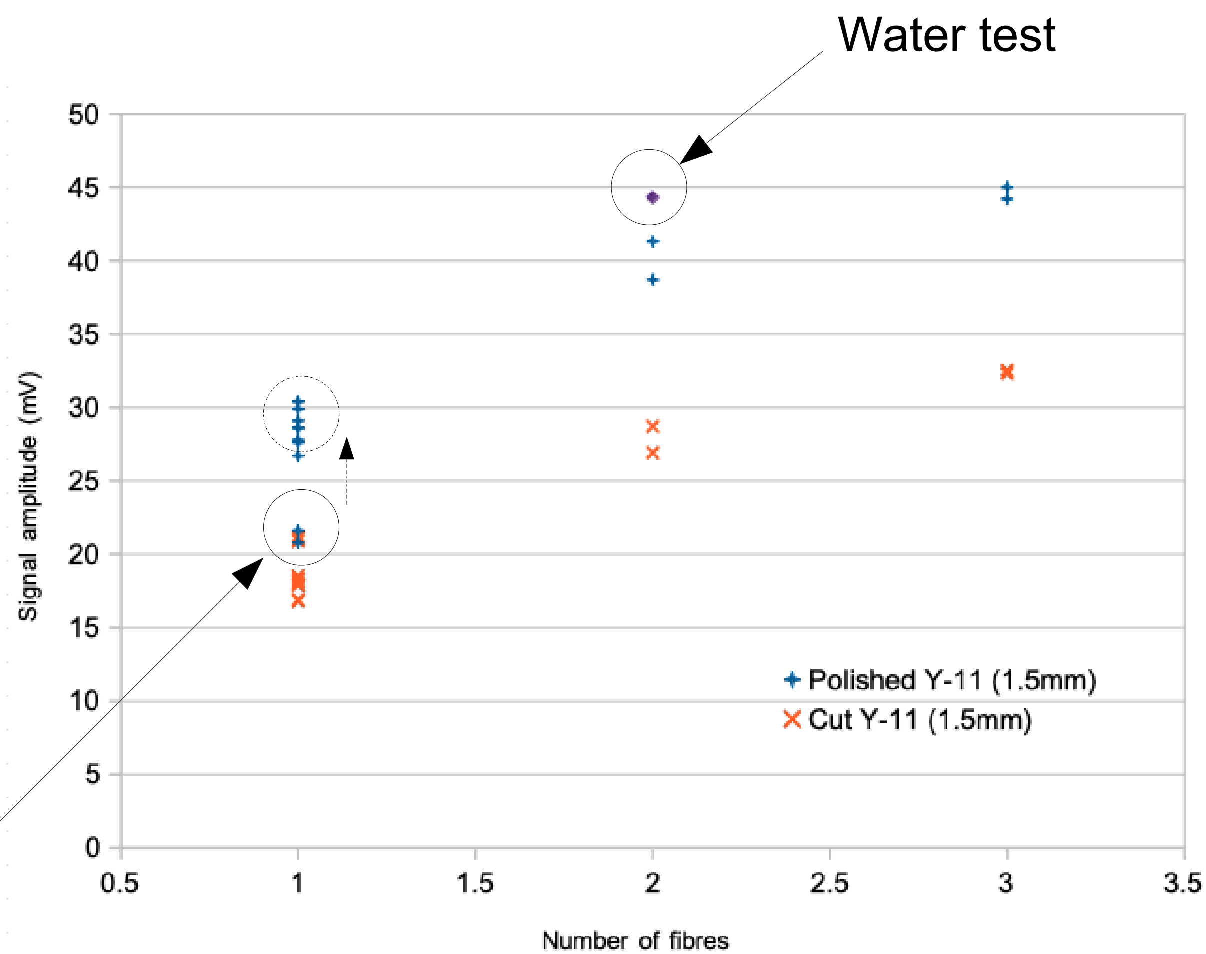


# Polishing vs cutting

1.5 mm Y-11 fibres:

5 polished fibres and 5 cut fibres identically prepared, in bundles of 2 and three fibres

- two trials of each tested fibre configuration; very good reproducibility (i.e. less than fibre-to-fibre variation)
- ~1/3 reduction in signal amplitudes due to surface quality from cutting
- only one fibre was polished on both ends; significantly LOWER amplitude was measured. After cutting the second polished end off, signal increased into "normal" range



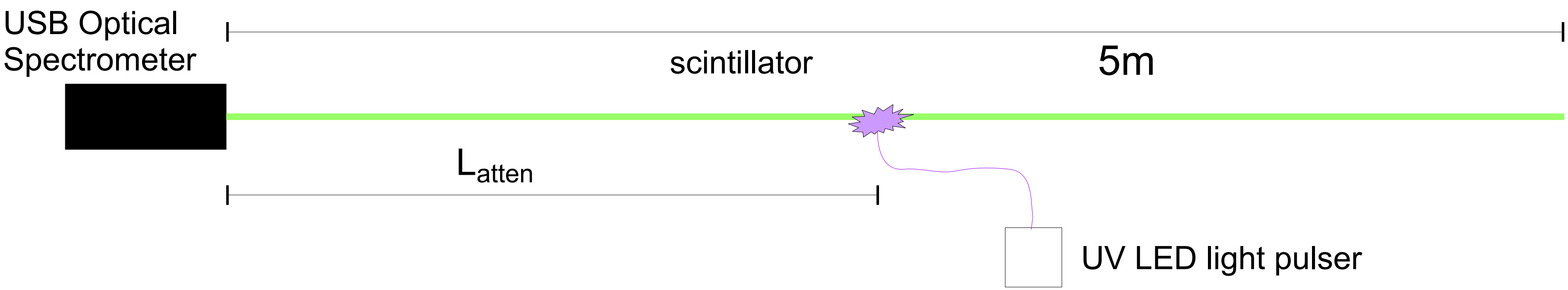

→ Reflections are not negligible!

- will do similar study with Saint Gobain BCF-92 when I have some samples

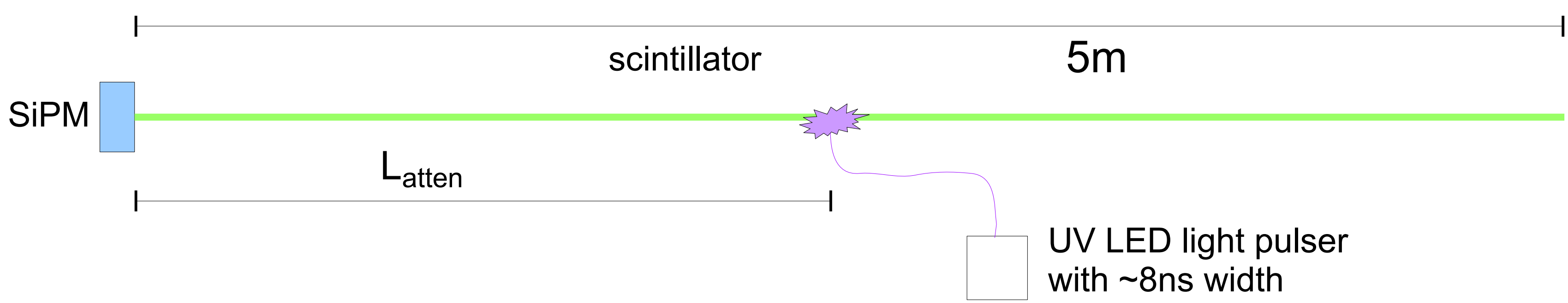
# Attentuation and spectrum

Planning two tests of single-WLSF performance

- Measure attenuation length and spectrum of fibre independently:



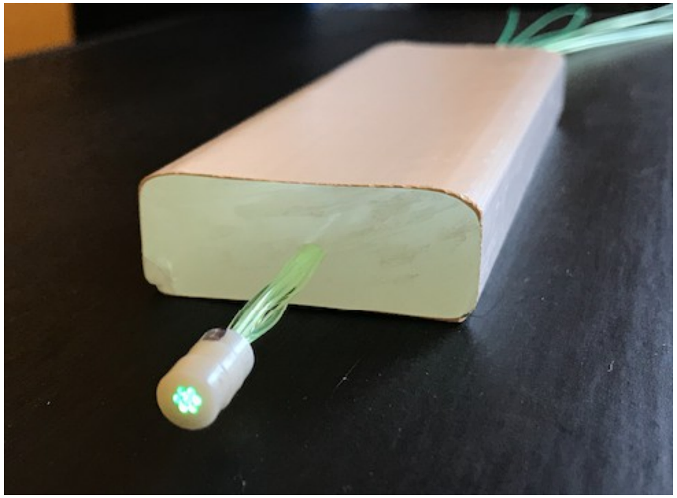

- Measure SiPM signal directly as function of light pulser position:



# To do: Scintillator configurations

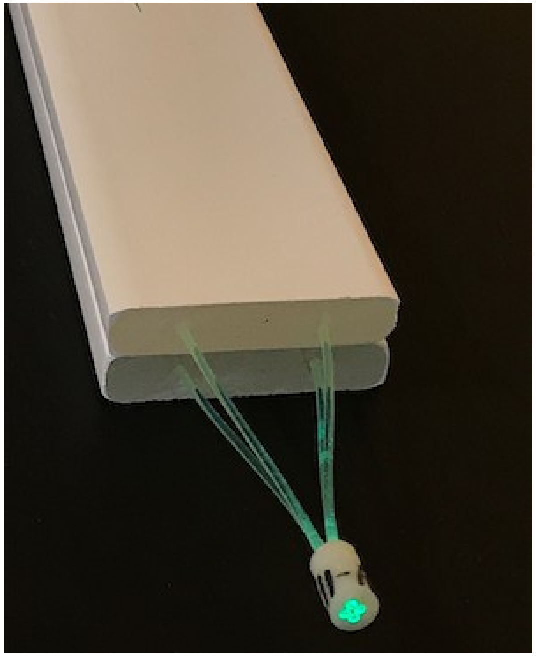
Lots of different configurations that can be tested

- Can additionally do “parasitic” light test of effect of an insensitive fibre in one hole on light yield in other hole



Up to seven 1mm fibres pointed to a single SiPM

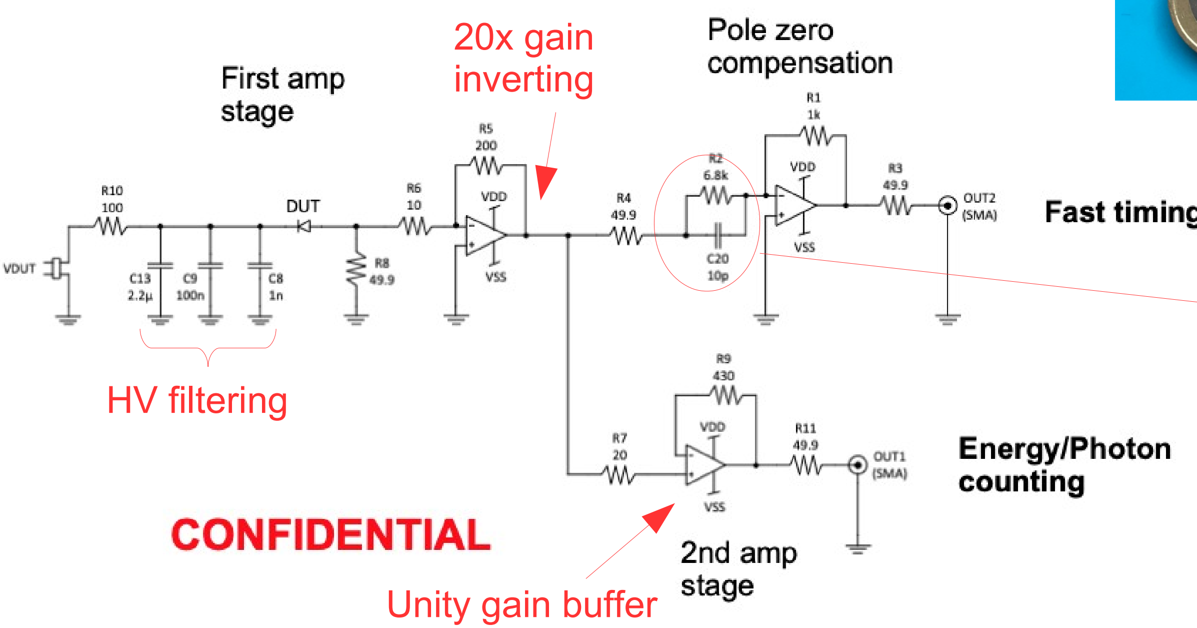
Four 1.5mm fibres pointed to a single SiPM



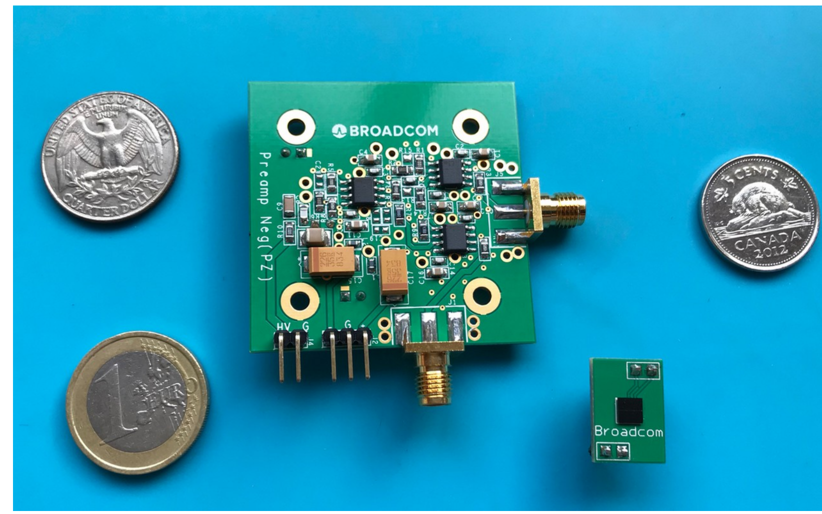
# Broadcom eval board

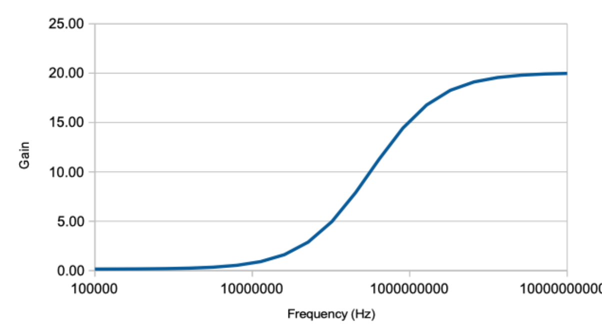
Broadcom test board is pretty nice to work with

- SiPM interposer board mounts (firmly!) on back via header pins; good solid mount points for board itself
- Requires external +/-5VDC and HV (~30V but rated to at least 40V)
- Two 50Ω signal paths via SMA:




Broadcom AFBR-S4E001 Evaluation kit (AFBR-S4N44C013 SiPM)
https://www.broadcom.com/products/optical-sensors/silicon-photomultiplier-sipm




**I note that this is exactly the functionality that we need for MATHUSLA readout**