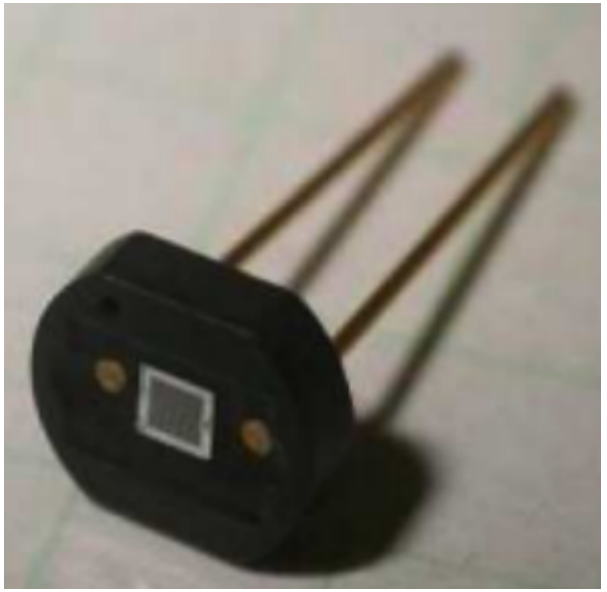
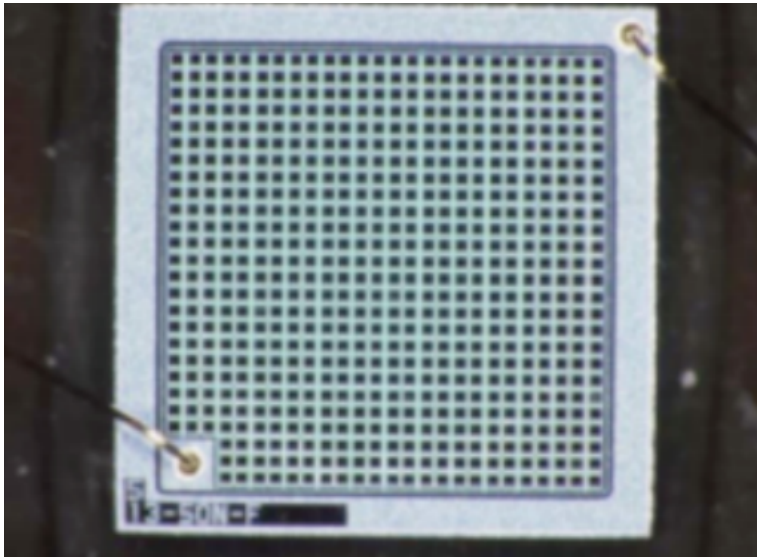
Hamamatsu S10362-013-050C Testing





Chris Ketter

University of Hawaii at Manoa
High Energy Physics
Instrumentation Development Lab

Improved Fitting Algorithm

- Following suggestions from Dmitri and dissertations by Chen Xu (Study of SiPMs) and Oskar Hartbrich (Scintillator Calorimeters), the Single Photon Spectra (SPS) fit function has been improved
  - Dark count rate for n^{th} photo-electron give by power law:

$$f(n) = f_0 \cdot \eta^n \quad , \quad \eta \in [0, 1]$$

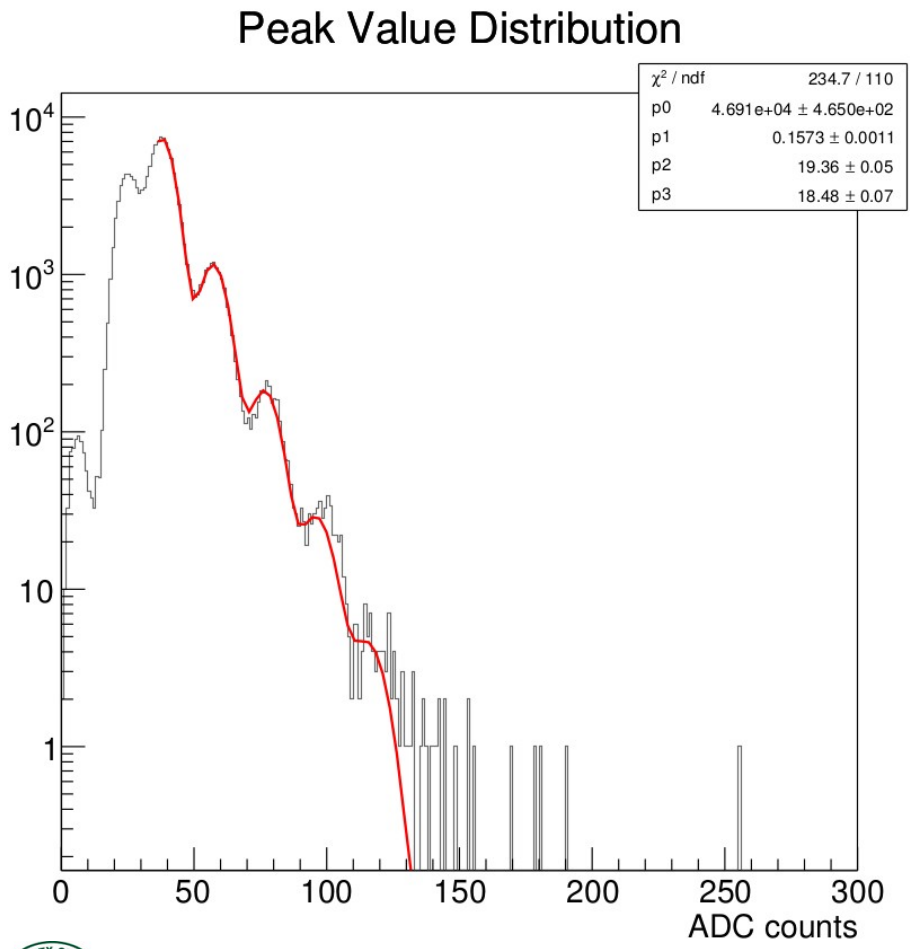
  - New fit is sum of 5 Gaussians w/ descending amplitudes according to the above power law:

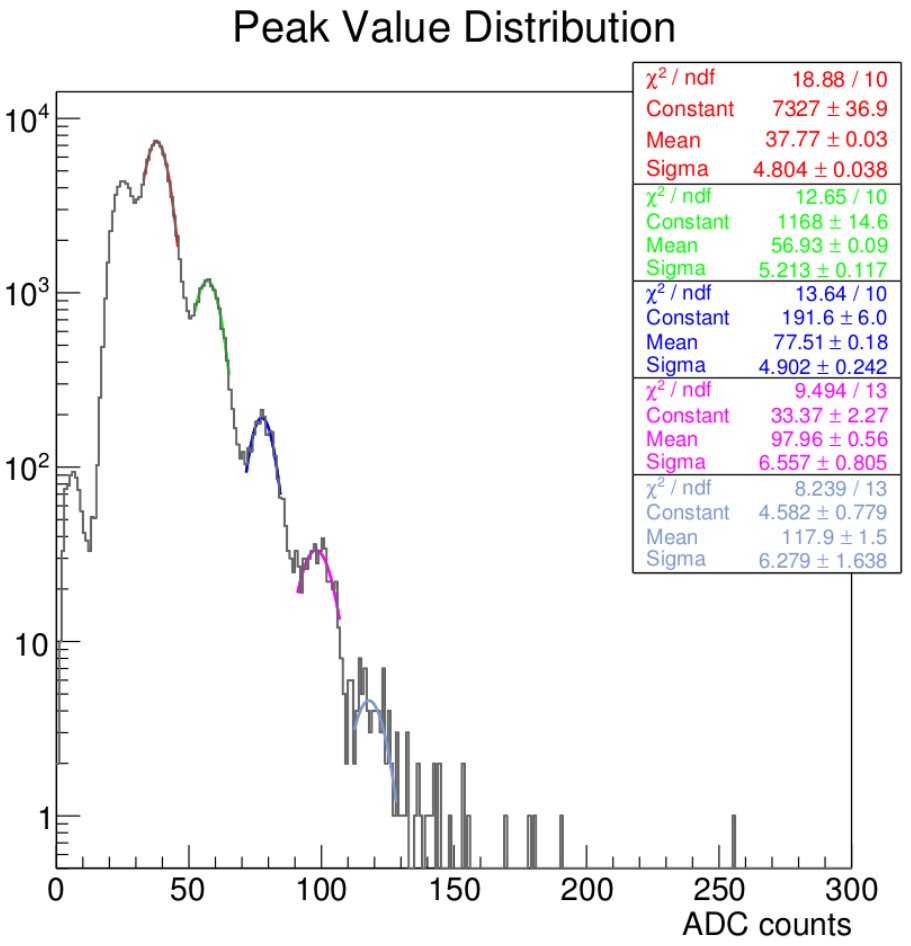
$$g(x) = A\left(\eta e^{-\frac{(x-(a+b))^2}{2\sigma_1^2}} + \eta^2 e^{-\frac{(x-(2a+b))^2}{2\sigma_2^2}} + \ldots + \eta^5 e^{-\frac{(x-(5a+b))^2}{2\sigma_5^2}}\right)$$

  - Only 4 fit parameters
    - Amplitude (A), optical cross-talk probability (η), one PE (a), and pedestal offset (b)

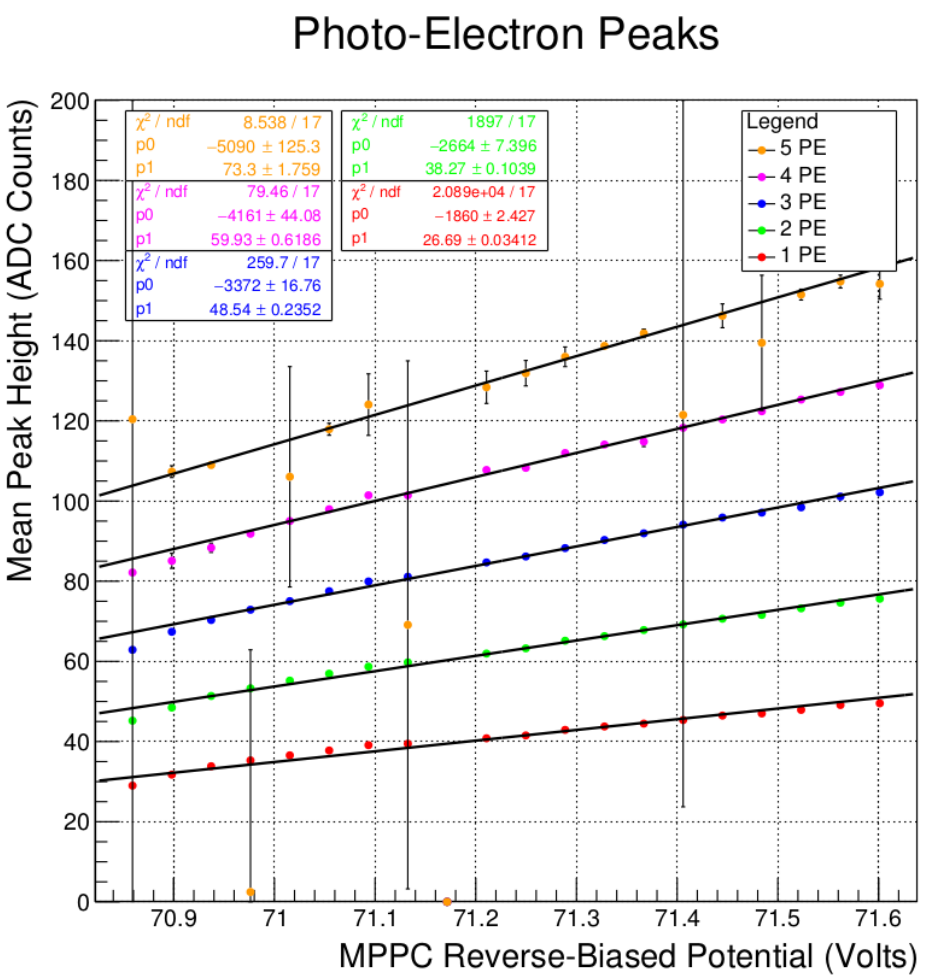
Sample Result

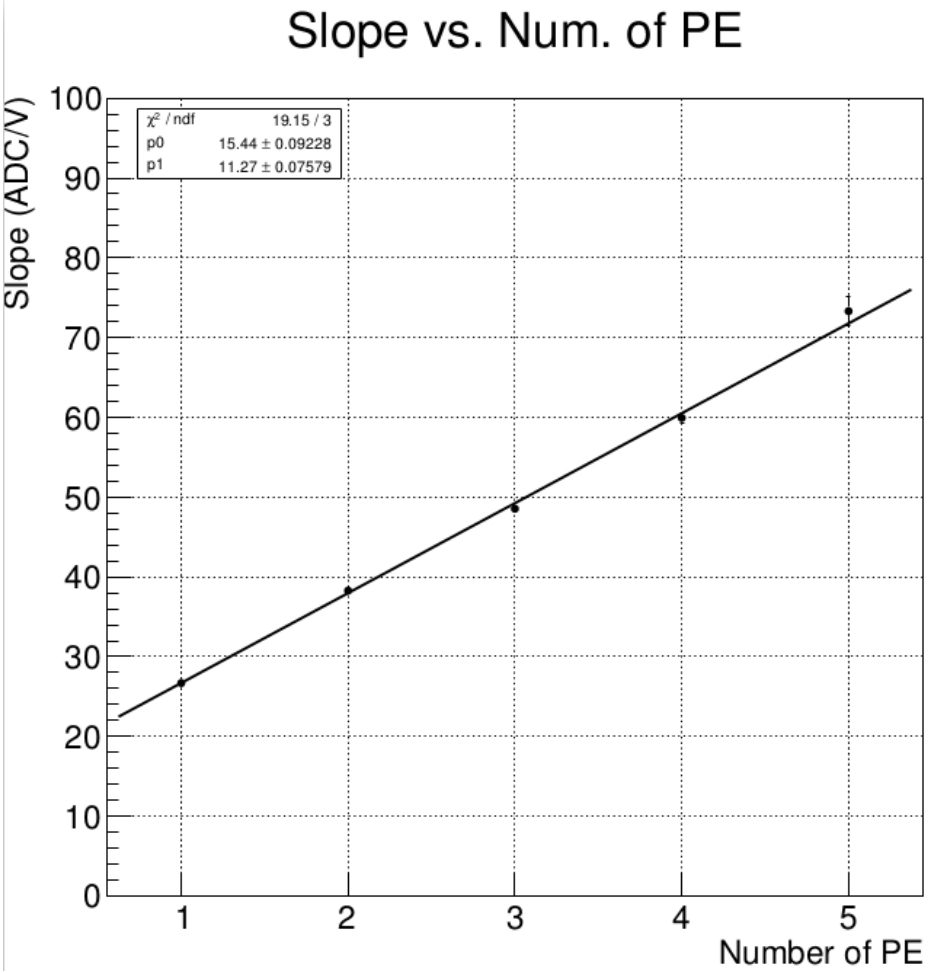
- Fit SPS to multi-gauss function g(x), then fit each peak individually, using the former to define the fit ranges on the latter



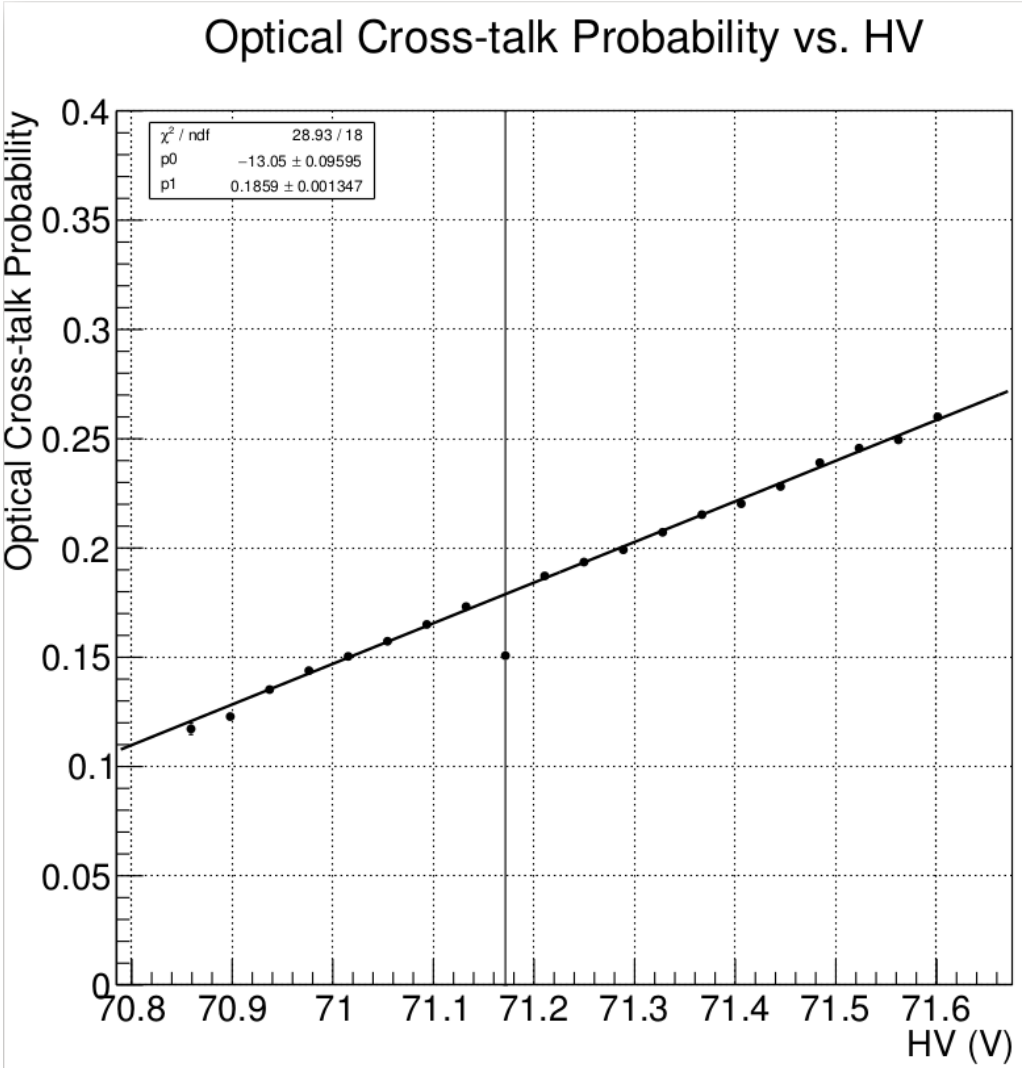


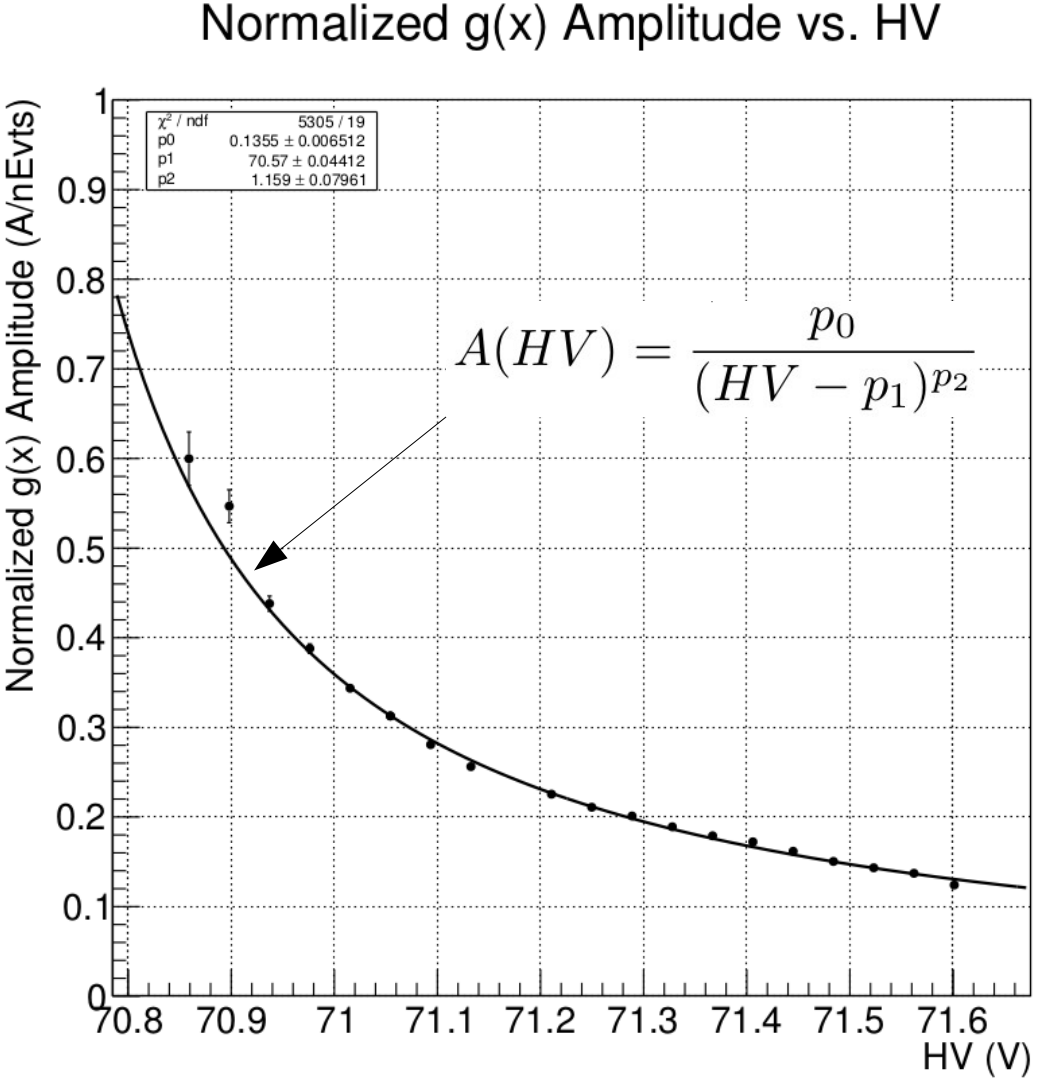
Automated Fit of 20 SPS





Evolution of New Parameters (η and A)

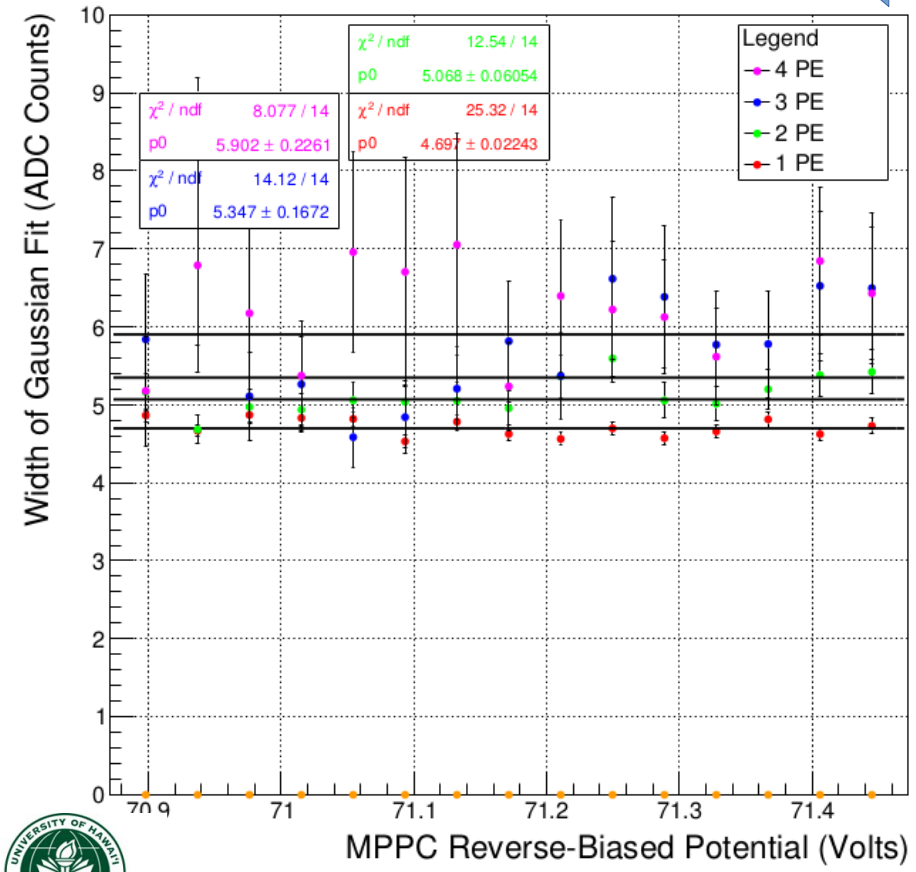


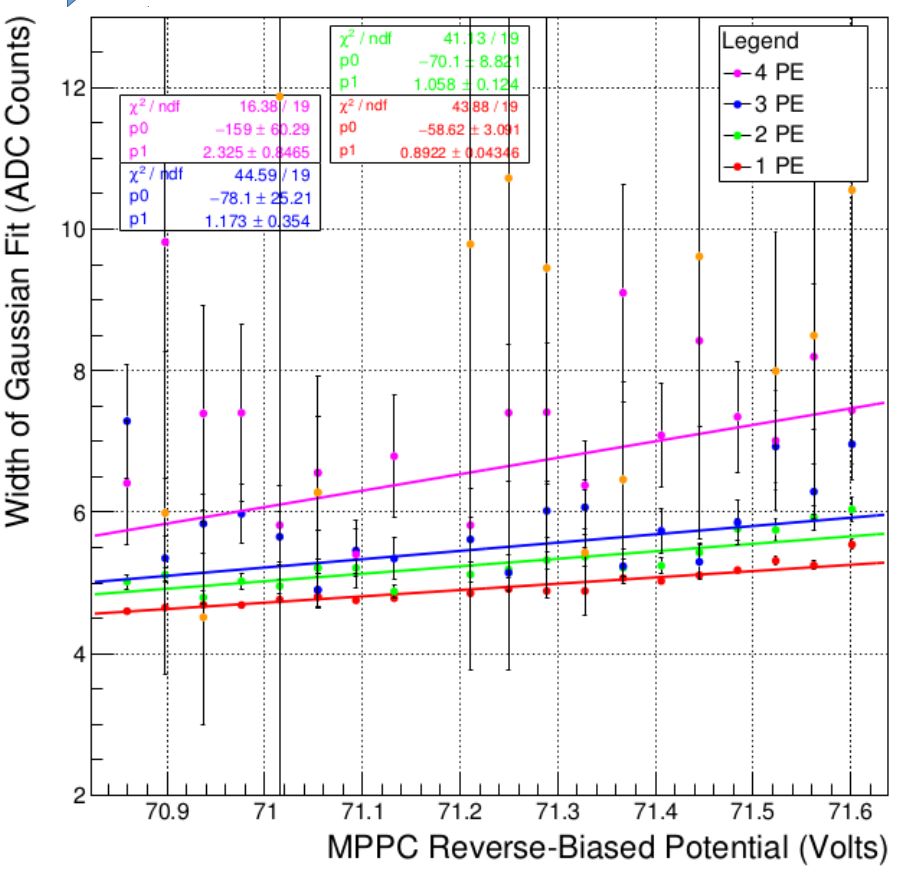


Peak Widths

- Now beginning to resolve peak-width dependence on bias voltage

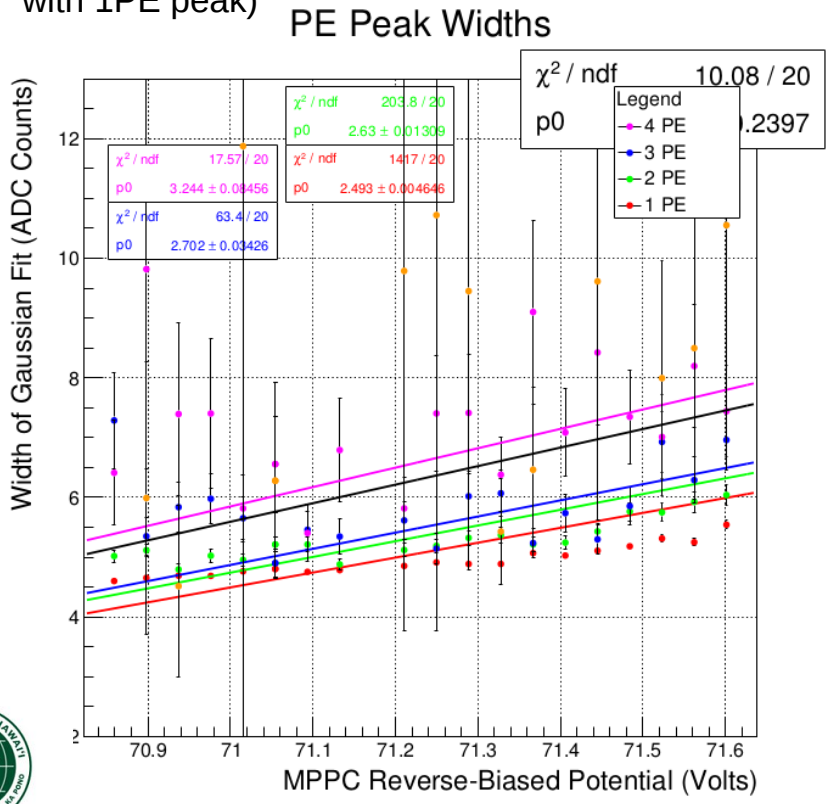
Before / After

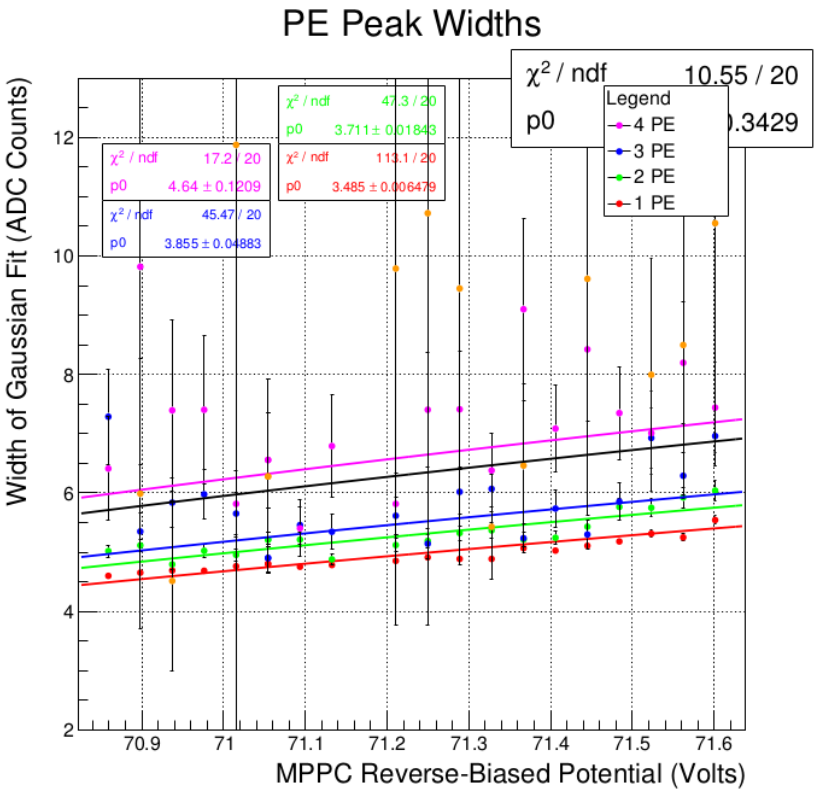




Peak Widths (2)

- Tried forcing peak widths to 0 at V_breakdown (~69V) and fitting to line (lower left), then repeated with square root function (lower right)
- Note the 5-PE line in black lying between the 3- and 4-PE lines –- **Need more statistics!**
  - Can take SPSs at every DAC step in the range shown (currently incrementing DAC by 2 counts between data runs)
  - Can readjust trigger level for each SPS (currently at 25 DAC counts / 20 ADC counts) so that it falls at say, 1PE – σ/2, thus increasing occupancy of actual PE peaks
  - Can try manually tweaking fit range for every peak in every SPS until reliable peak-width data is obtained
  - Can extend range of scan to maybe 72 volts or higher (but certainly cannot go lower as pedestal noise peak merges with 1PE peak)



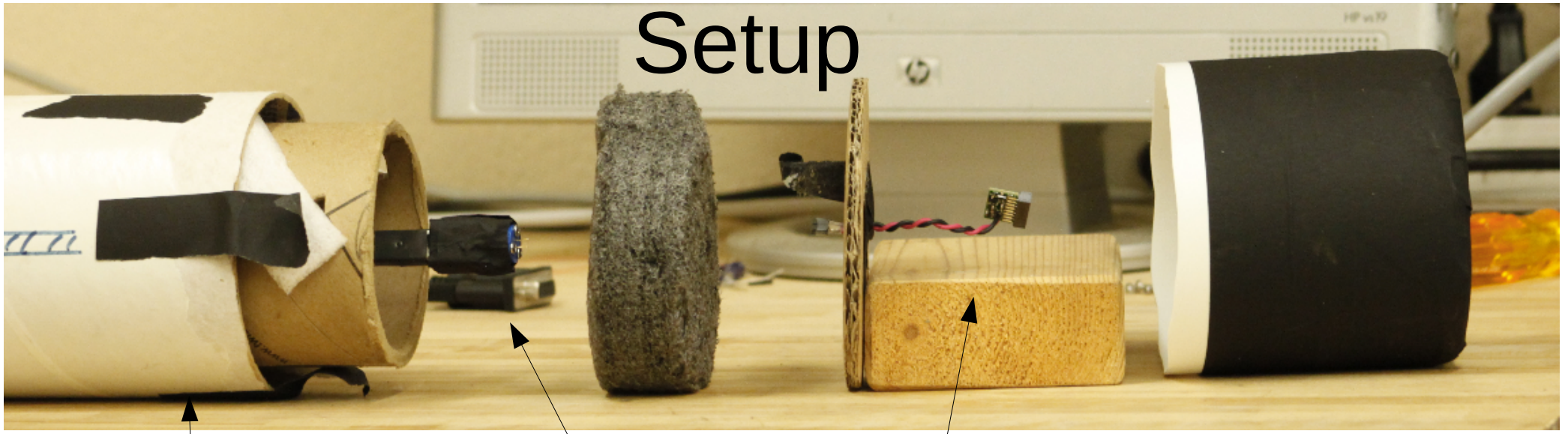


Discussion

- Linearity of optical cross-talk probability is promising
- Functional form of g(x) amplitude vs. HV seems complicated
  - It should be related to number of entries in the SPS, but it omits the noise peak, and the contribution from the noise peak varies with HV
  - Understanding the functional form likely not important as long as I'm able to accurately predict starting values for the fit
- Next step is to seed the fit with smarter predictions for cross-talk probability, g(x) amplitude, and predicted peak widths
- Regarding KEK: what needs to be done to the installed modules in order that we can collect similar data?
  - It seems that being able to do this through the DAQ/FTSW/COPPER network (as opposed to connecting a laptop to each motherboard one by one) would be a valuable feature seeing that there are ~20k installed channels, that this calibration may need to be repeated to account for possible seasonal fluctuations in temperature, and because we need to understand effects of radiation damage on MPPCs after some years of Belle II operation

Backup Slides

Setup



2x cardboard cylinders (different diameters) used for dark box

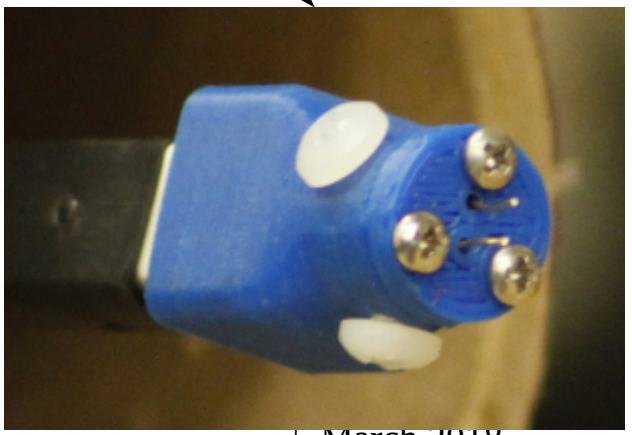
Custom ABS ferrule

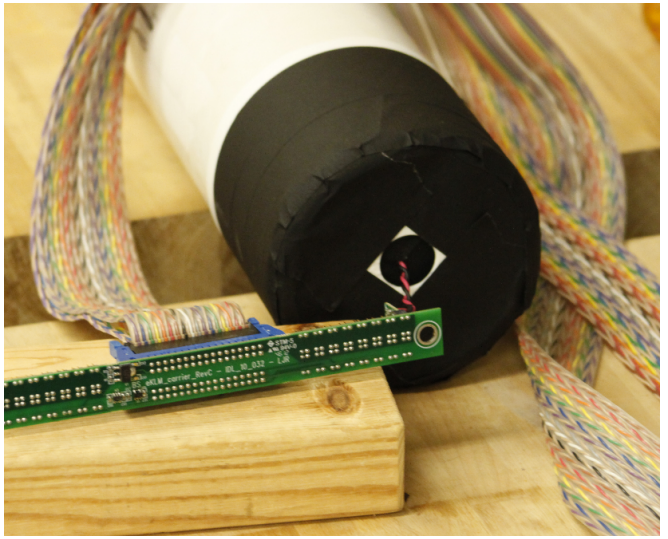
Custom MPPC connector, Twisted pair, and KLM Preamplifier

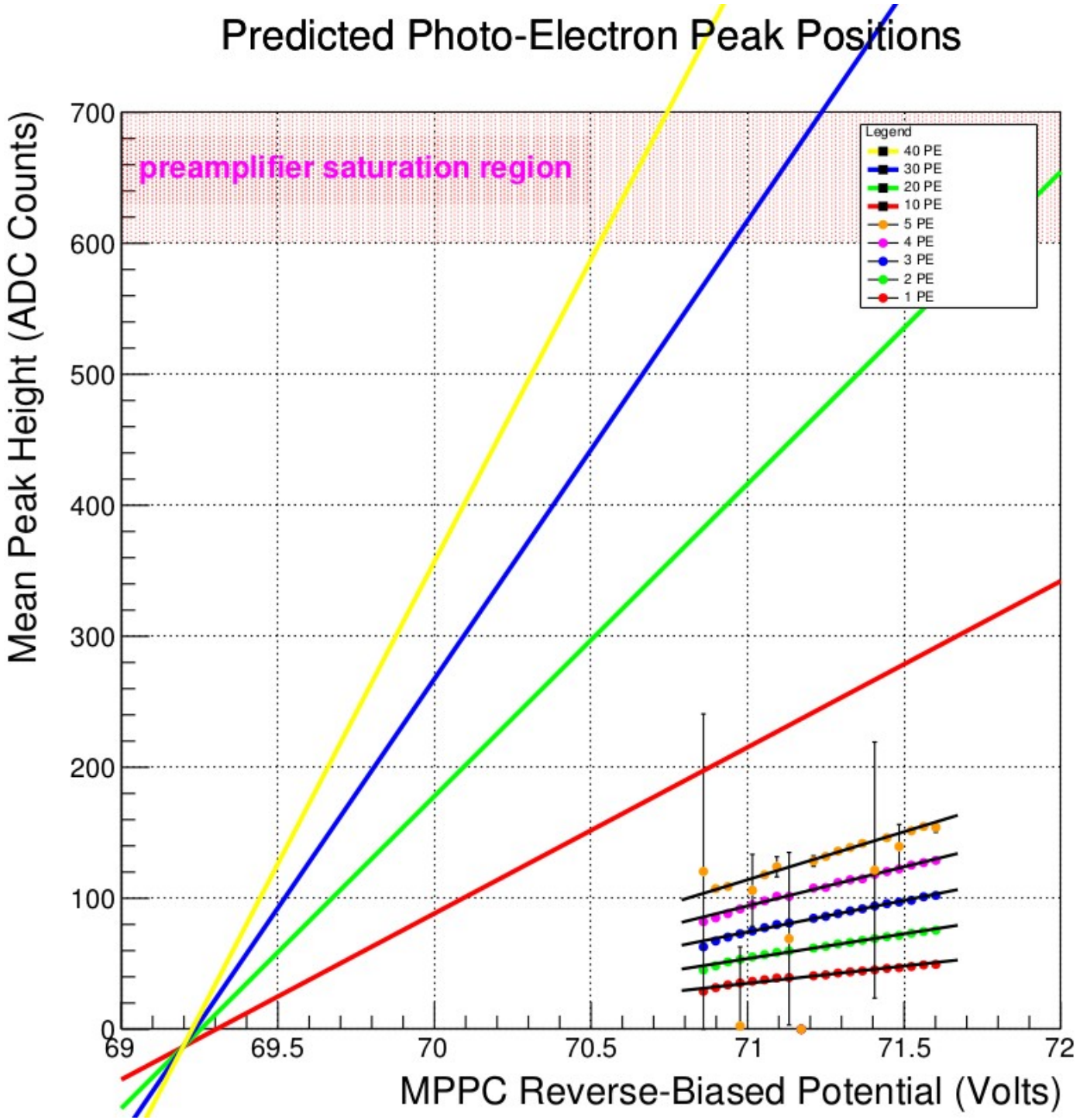
Wet-Wipes container with blackout tape as cap

1cm x 1cm x 100cm PVT coextruded w/TiO2 coating and 3mm hole

St. Elgin wavelength shifting fiber with hand polished end (not by me)







UNIVERSITY of HAWAI'I MĀNOA