electronic response for PDVD

Xuyang Ning, Karla Tellez Giron Flores

Brookhaven National Laboratory

electronic calibration data:

Run-VD	DAC	charge (fC)
41573	1	2.65
41574	2	5.30
41577	5	13.26
41582	10	26.51
41587	15	39.77
41593	21	55.67
41597	25	66.28
41602	30	79.53
41603	31	82.18

RUN-HD	DAC	charge_fC
30367	5	13.26
30376	10	26.51
30385	15	39.77
30394	20	53.02
30404	25	66.28
30413	30	79.53
30421	35	92.79
30430	40	106.04

$$1\ \mathrm{mV} = \frac{2^{\mathrm{resolution}}}{(\mathrm{fullscale}_{hi} - \mathrm{fullscale}_{lo})} = \frac{2^{14}}{(1.6 - 0.2)\ \mathrm{V} \times 1000\ \frac{\mathrm{mV}}{\mathrm{V}}} = \frac{16384}{1400} = 11.703\ \mathrm{ADC}$$

$$Q_{\mathrm{fC}}\,(\mathrm{fC}) = \mathrm{pulse\_dac}\,(\mathrm{bit}) \times \frac{CC\,(\mathrm{F}) \times \mathrm{dac\_du}\,(\mathrm{mV/bit})}{1000\,(\mathrm{mV/V})} \times 10^{15}\,(\mathrm{fC/C})$$

$$= \mathrm{pulse\_dac}\,(\mathrm{bit}) \times \frac{1.85 \times 10^{-13}\,(\mathrm{F}) \times 14.33\,(\mathrm{mV/bit})}{1000\,(\mathrm{mV/V})} \times 10^{15}\,(\mathrm{fC/C}) = \mathrm{pulse\_dac} \times 2.65105\,(\mathrm{fC})$$

Electronic response

- Calibrate the ch-by-ch electronics response function with dedicated pulser data
- The non-uniform electronics response is then replaced by an ideal response function during signal processing

Imperfect Pole-Zero cancellation

- $T(s) = \frac{(s+k3)(s+k5)}{(s+k4)(s+k6)} \times \frac{A}{(s+p_0)(p_{1i}^2+(p_{1r}+s)^2)(p_{2i}^2+(p_{2r}+s)^2)}$
- In the case of k3 = k4 and k5=k6, transfer function recovers to the ideal function form
- K3 ~ k4 ~ 10 kHz
- K5~k6 ~ 30 kHz
- Mismatch between k3 (k5) and k4 (k6) is essentially the **imperfect pole-zero cancellation**

Ideal Electronics Response

$$T(s) = \frac{A_0 \cdot C_A}{(p_0+s)\cdot(p_{i1}^2+(p_{r1}+s)^2)\cdot(p_{i2}^2+(p_{r2}+s)^2)}, \tag{3.1}$$

with s being a complex frequency variable. The parameters in equation 3.1 are obtained from a detailed simulation of the network design and are determined to be:

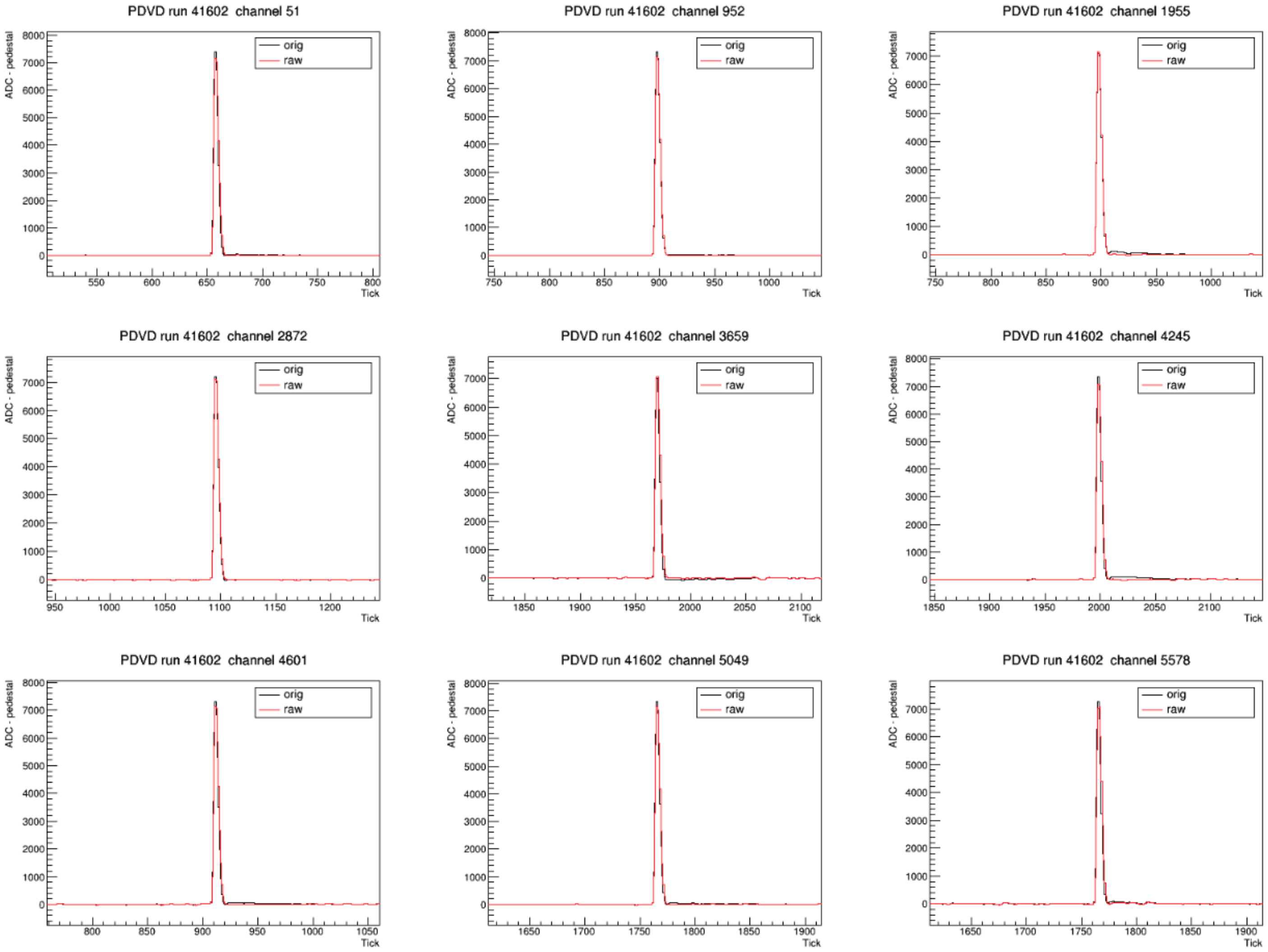
$$\begin{aligned} p_{r1} &= \frac{1.417}{t_p \cdot C_T}, & p_{r2} &= \frac{1.204}{t_p \cdot C_T}, \\ p_{i1} &= \frac{0.598}{t_p \cdot C_T}, & p_{i2} &= \frac{1.299}{t_p \cdot C_T}, \\ p_0 &= \frac{1.477}{t_p \cdot C_T}, & C_A &= \frac{2.7433}{(t_p \cdot C_T)^4}, \\ C_T &= \frac{1}{1.996}; \end{aligned} \tag{3.2}$$

where A_0 is the gain parameter and t_p is the peaking time constant. $T(s)$ has units of $\frac{\mathrm{V}}{\mathrm{C}}\,(\mathrm{Hz})^{-1}$.

- placed at then end of one channel noise filter
- source code: perChannelShaper
  - https://github.com/WireCell/wire-cell-toolkit/blob/master/sigproc/src/ResponseShaper.cxx

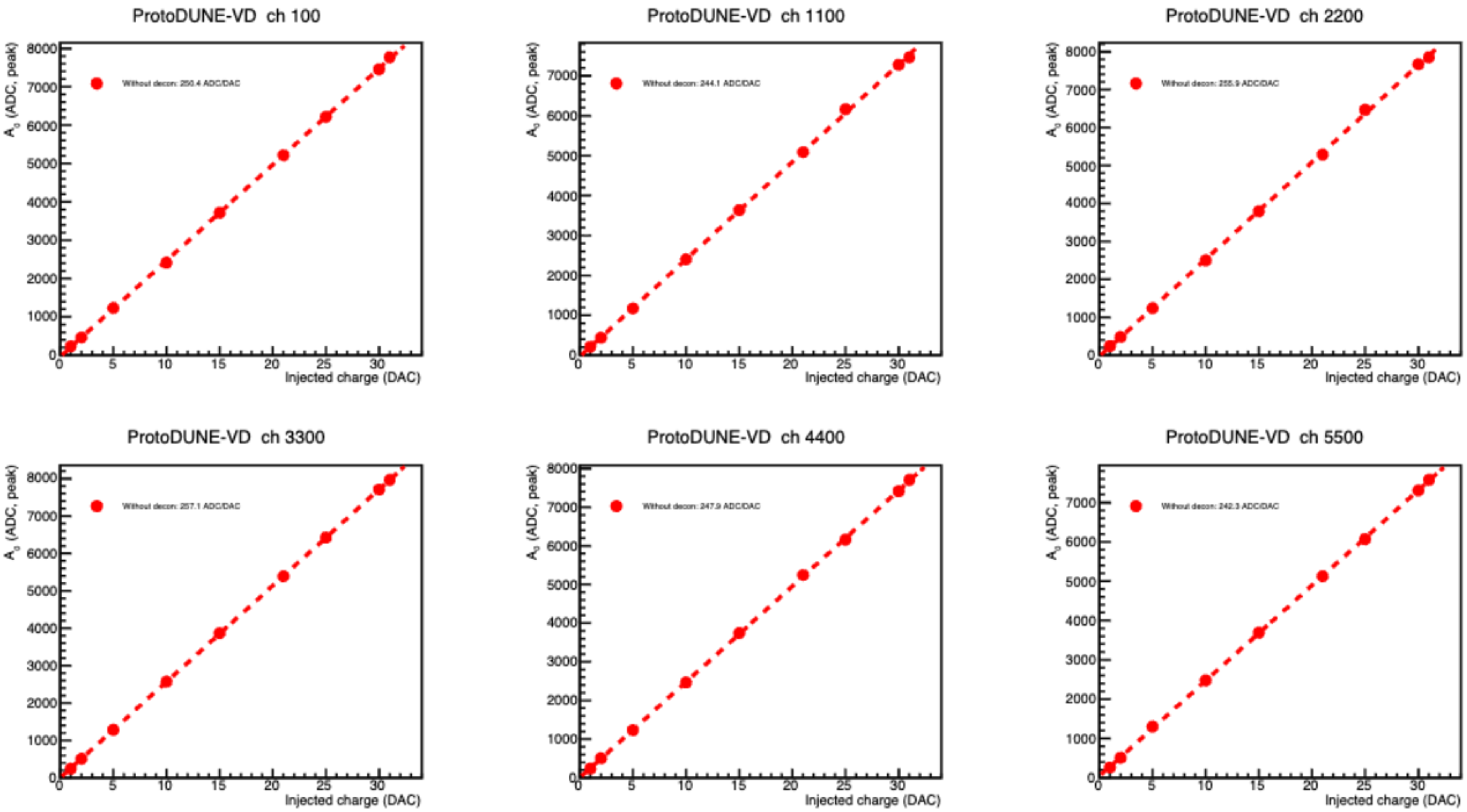
Response result check for PDVD

- Karla already has all the fitting result for all the calibration pulse
- With this fitted result, **for pulse calibration data**, I disable all the noise filter, only apply *perChannelShaper*

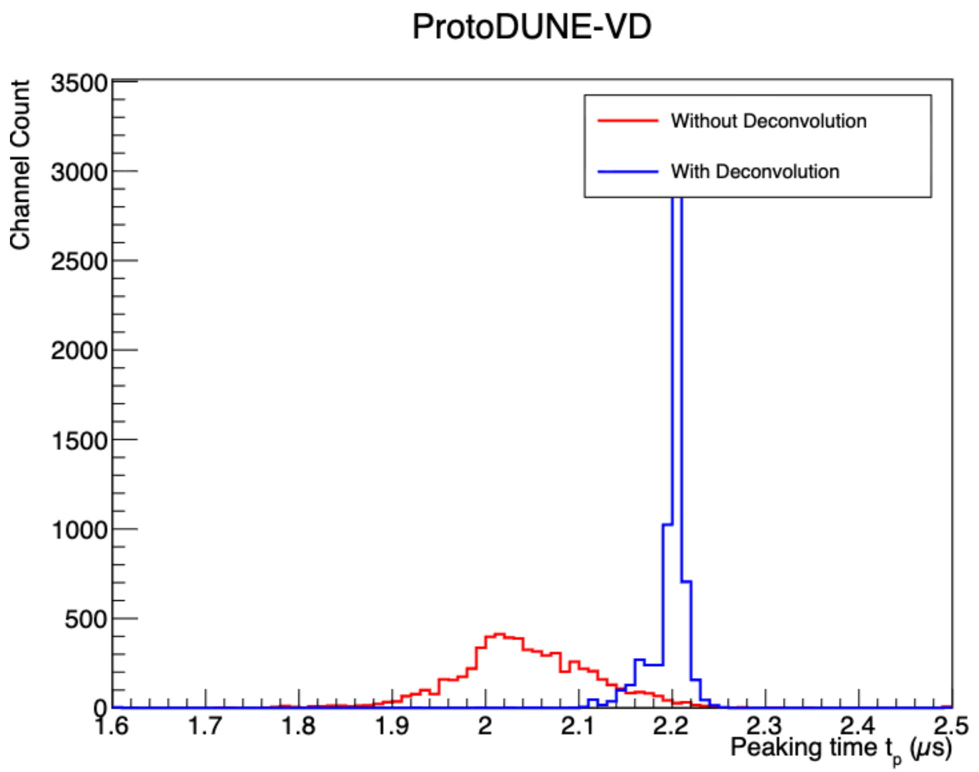


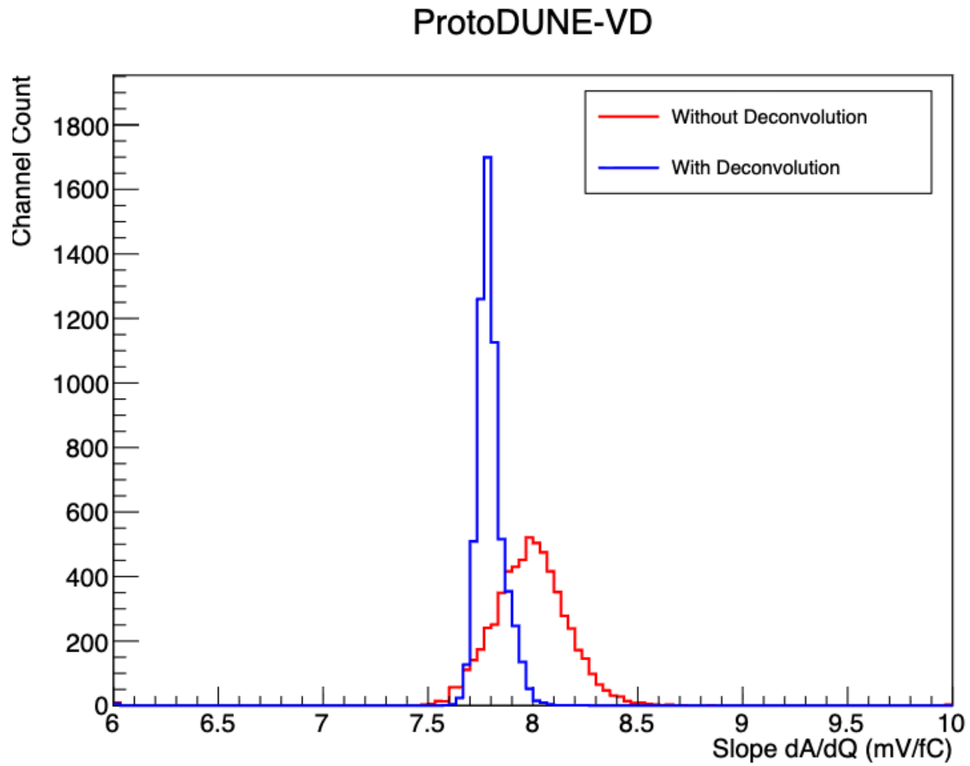
- orig is original data
- raw is after ideal response replaced.

Injected DAC vs A(ADC)



Fitted result for VD before and after response





- jsonnet files:
  - https://github.com/DUNE/dunereco/commit/0b6d6ae6253c3606b4d65ba6766818423bd42b97
- fcl:
  - /exp/dune/data/users/xning/proto-dune-vd/elec_res/run_nf_elec_calib_vd.fcl