# ProtoDUNE-SP Electron Drift Simulation Update
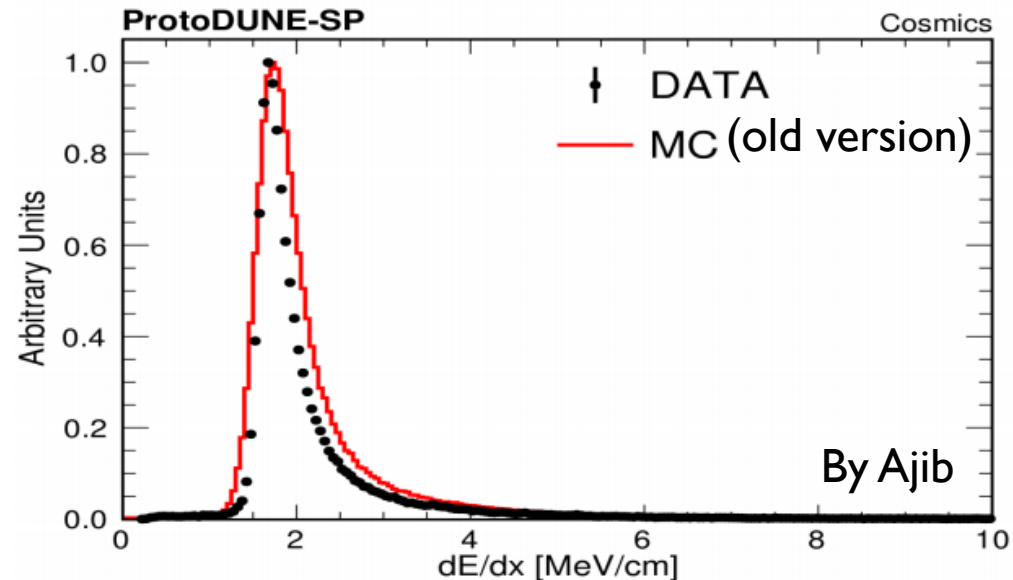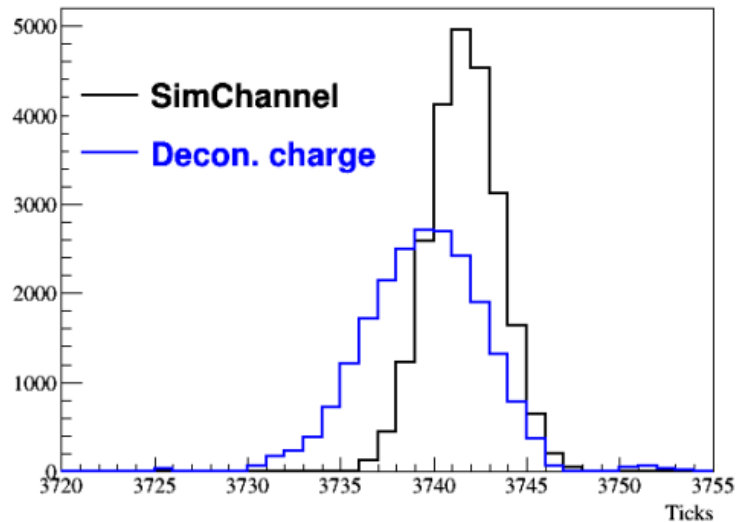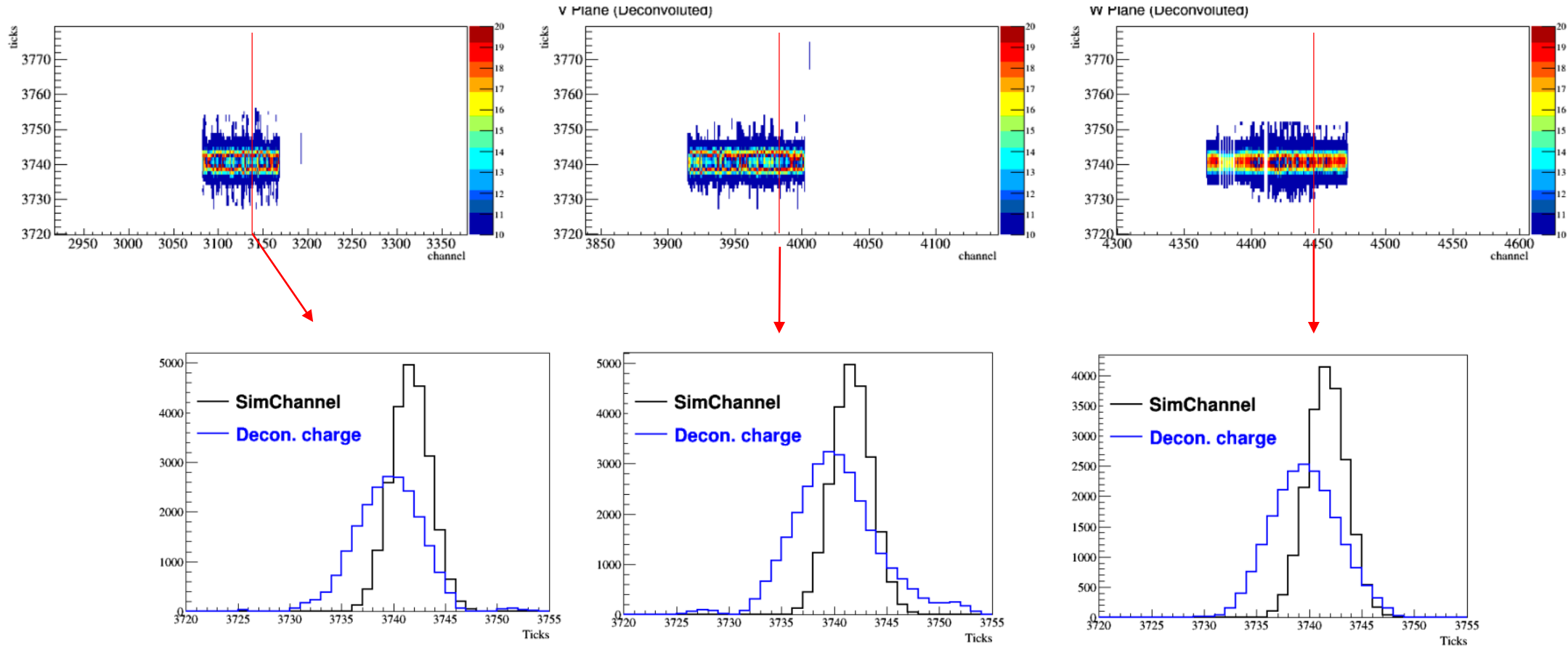
Wenqiang Gu

# Motivation

- To understand the time offset between deconvolved charge and SimChannel

- To add extra smearing from software filter into SimChannel

- To understand the different width of cosmic dE/dx in data and MC

# Alignment: SimChannel v.s. Decon. Charge



- A global 1us time offset
  - Geometry mistake or signal processing effect?

# 1us offset from signal processing

- An 1us offset in SP to align with the collection raw waveform

- SimChannel should be shifted accordingly



-1 us offset for SimChannel

// sp.jsonnet

```
27      ftoffset: 0.0,  // default 0.0
28      ctoffset: -7.0,  // default -8.0
```

// OmnibusSigProc.cxx

```
843      //do the shift in time
844      int time_shift = (m_coarse_time_offset + m_intrinsic_time_offset)/m_period;
845      if (time_shift > 0){
846          Array::array_xxf arr1(nrows,ncols - time_shift);
847          arr1 = m_r_data[plane].block(0,0,nrows,ncols - time_shift);
848          Array::array_xxf arr2(nrows,time_shift);
849          arr2 = m_r_data[plane].block(0,ncols-time_shift,nrows,time_shift);
850          m_r_data[plane].block(0,0,nrows,time_shift) = arr2;
851          m_r_data[plane].block(0,time_shift,nrows,ncols-time_shift) = arr1;
852      }
853      m_c_data[plane] = Array::dft_rc(m_r_data[plane],0);
854  }
```
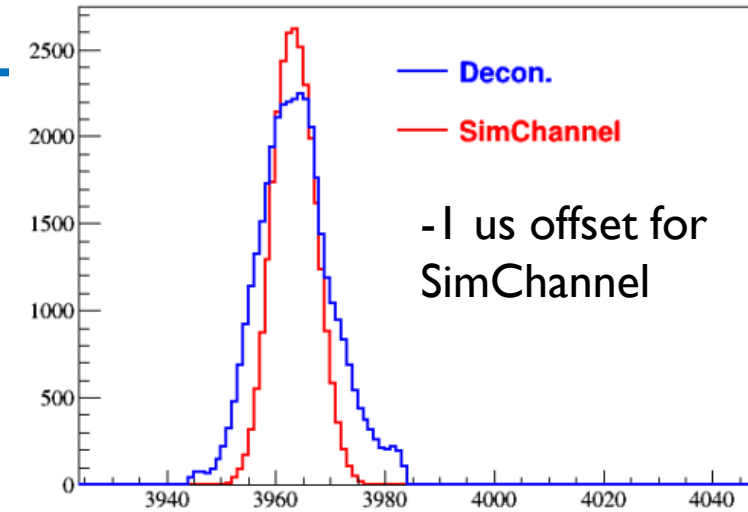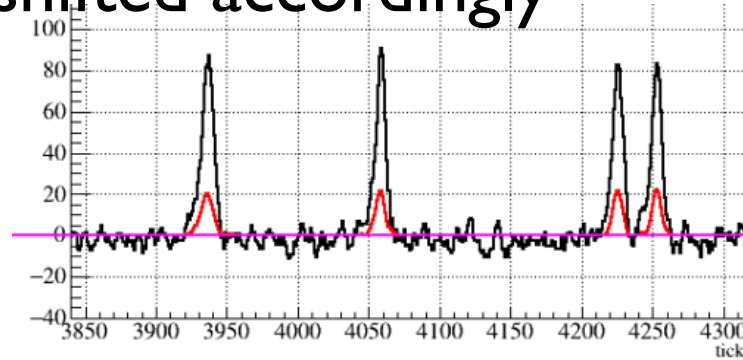
// sim-drift-simchannel.jsonnet
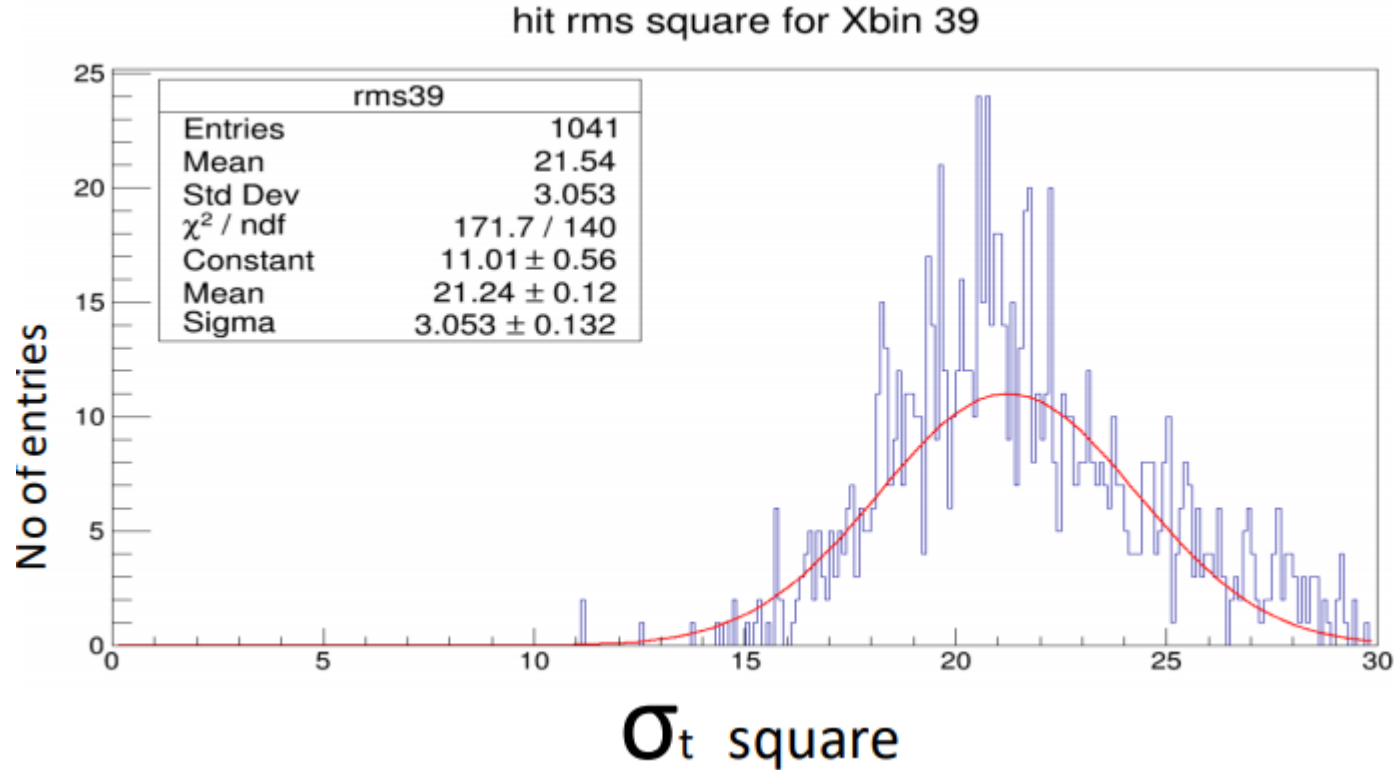
```
120  local wcls_simchannel_sink = g.pnode({
121      type: 'wclsSimChannelSink',
122      name: 'postdrift',
123      data: {
124          artlabel: 'simpleSC',  // where to save in art::Event
125          anodes_tn: [wc.tn(anode) for anode in tools.anodes],
126          rng: wc.tn(rng),
127          tick: 0.5 * wc.us,
128          start_time: -0.25 * wc.ms,
129          readout_time: self.tick * 6000,
130          nsigma: 3.0,
131          drift_speed: params.lar.drift_speed,
132          u_to_rp: 100 * wc.mm,  // 90.58 * wc.mm,
133          v_to_rp: 100 * wc.mm,  // 95.29 * wc.mm,
134          y_to_rp: 100 * wc.mm,
135          u_time_offset: -1.0 * wc.us,
136          v_time_offset: -1.0 * wc.us,
137          y_time_offset: -1.0 * wc.us,
138          use_energy: true,
139      },
140  }, nin=1, nout=1, uses=tools.anodes);
141
```

# Extra diffusion from software filter
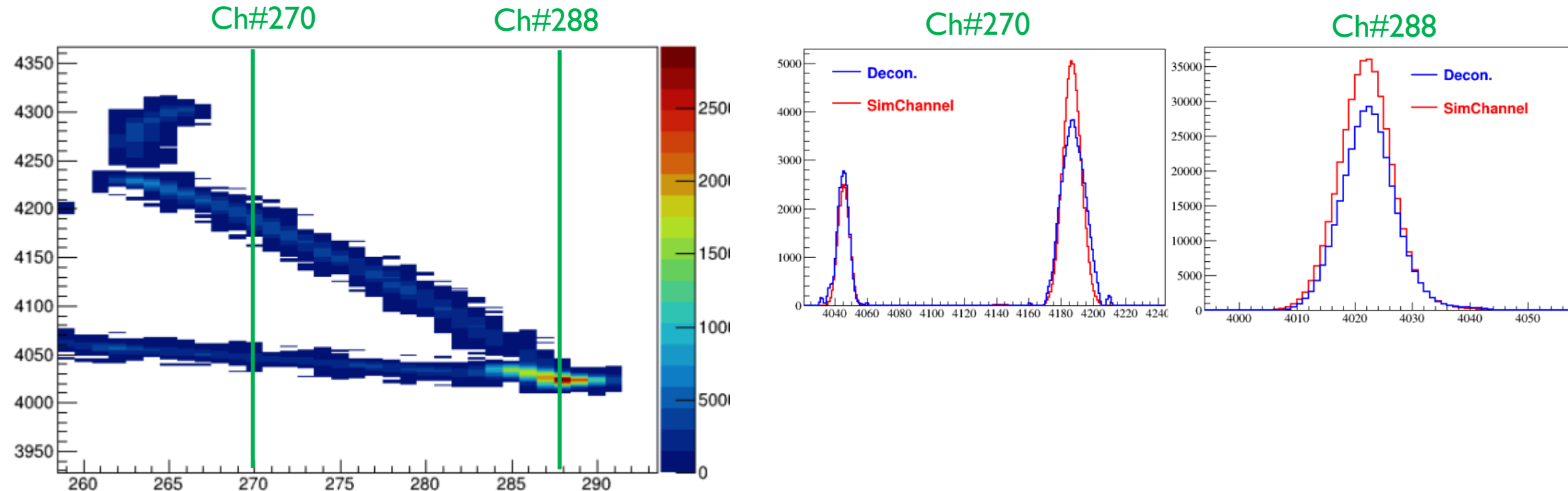


- Addin extra smearing from software filter in the uboone tuning (Xin)
- Range of decon charge properly tagged by the SimChannel distribution
- Sufficient for charge backtracking

# Cosmic track's "gaus hit" (Ajib)



hit rms square for Xbin 39

| rms39 | |
|---|---|
| Entries | 1041 |
| Mean | 21.54 |
| Std Dev | 3.053 |
| $\chi^2$ / ndf | 171.7 / 140 |
| Constant | 11.01 ± 0.56 |
| Mean | 21.24 ± 0.12 |
| Sigma | 3.053 ± 0.132 |

No of entries

$\sigma_t$ square

- MC sample, SCE on

- RMS of the "Gaus hit" at a drift x=30-40cm

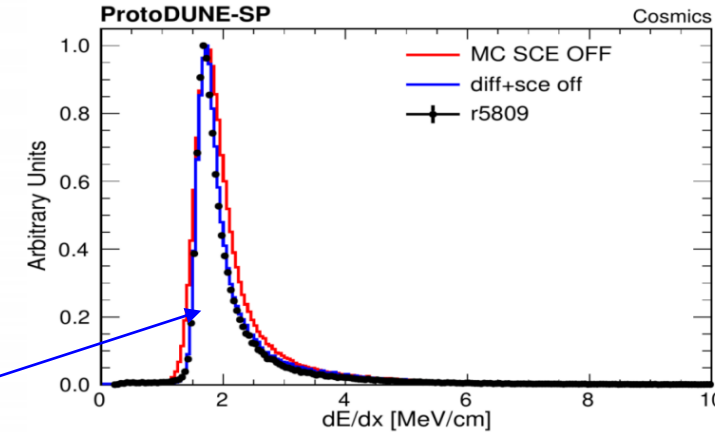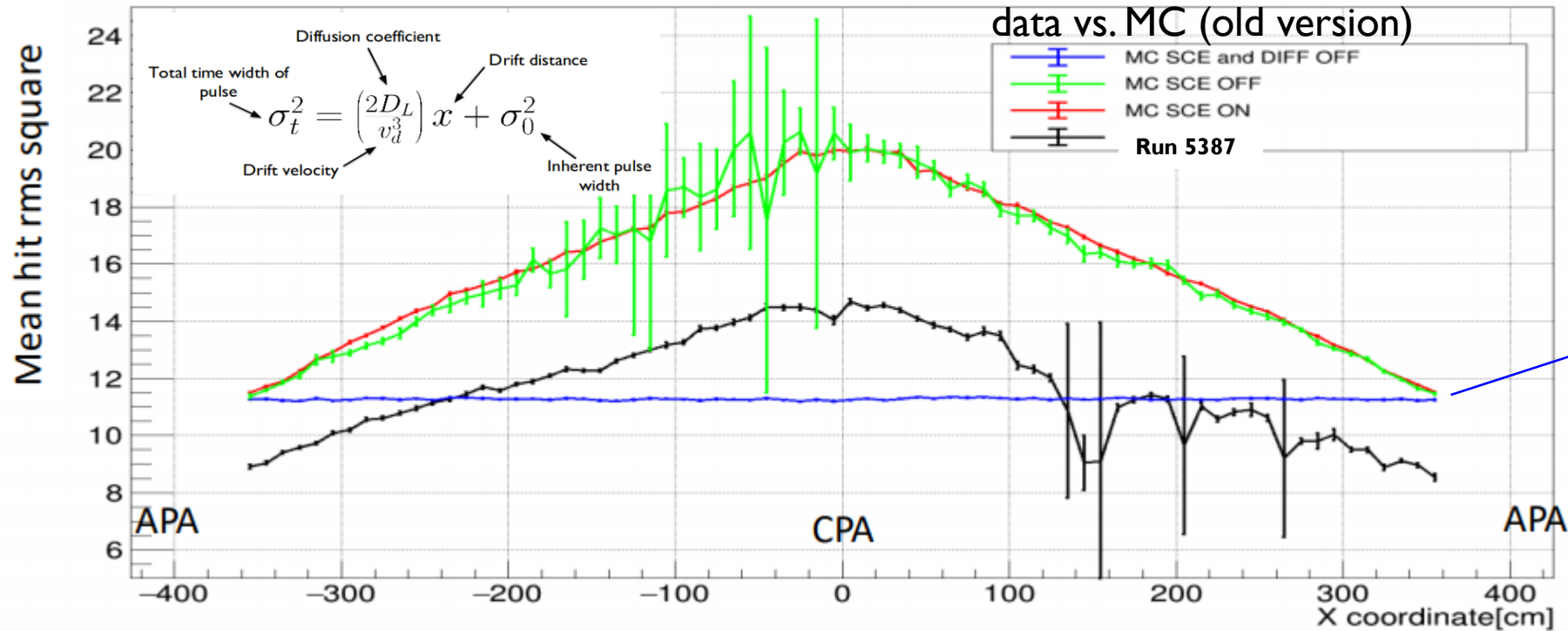- Want to investigate the diffusion at different drift distance
- And the effect to dE/dx

https://indico.fnal.gov/event/22125/contribution/2/material/slides/0.pdf
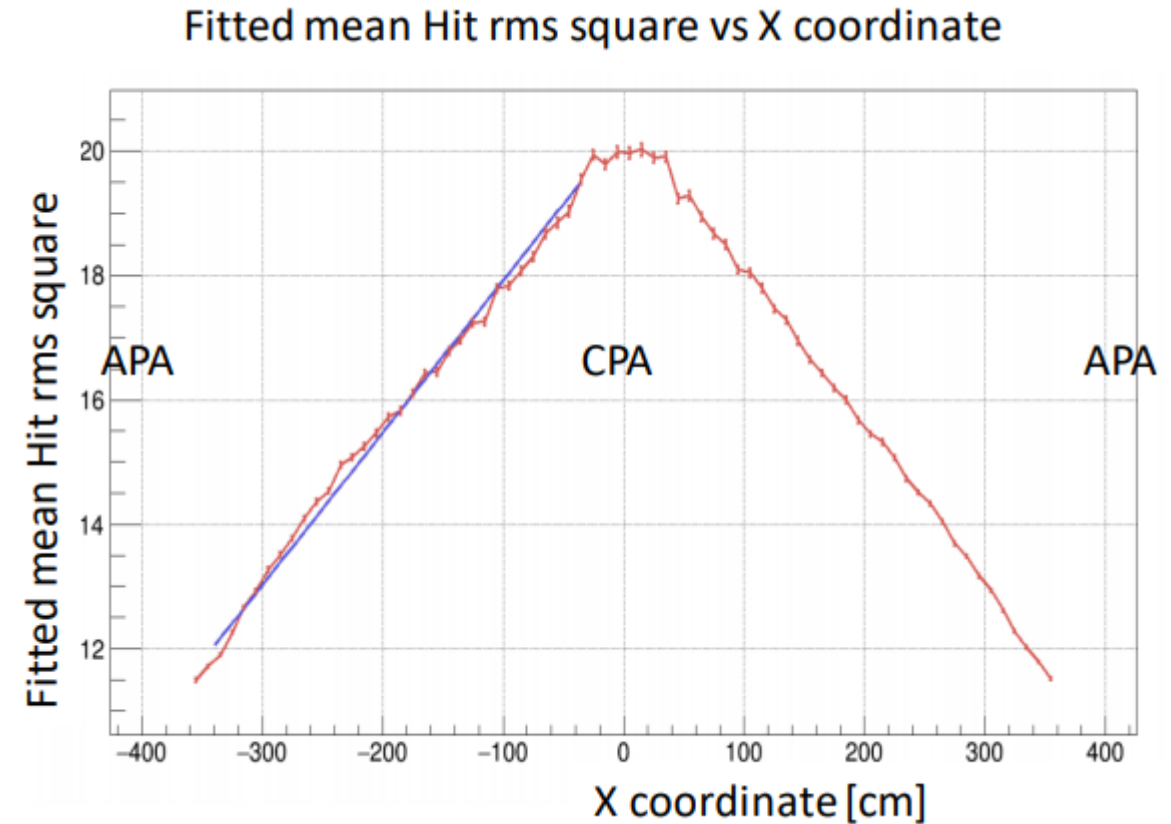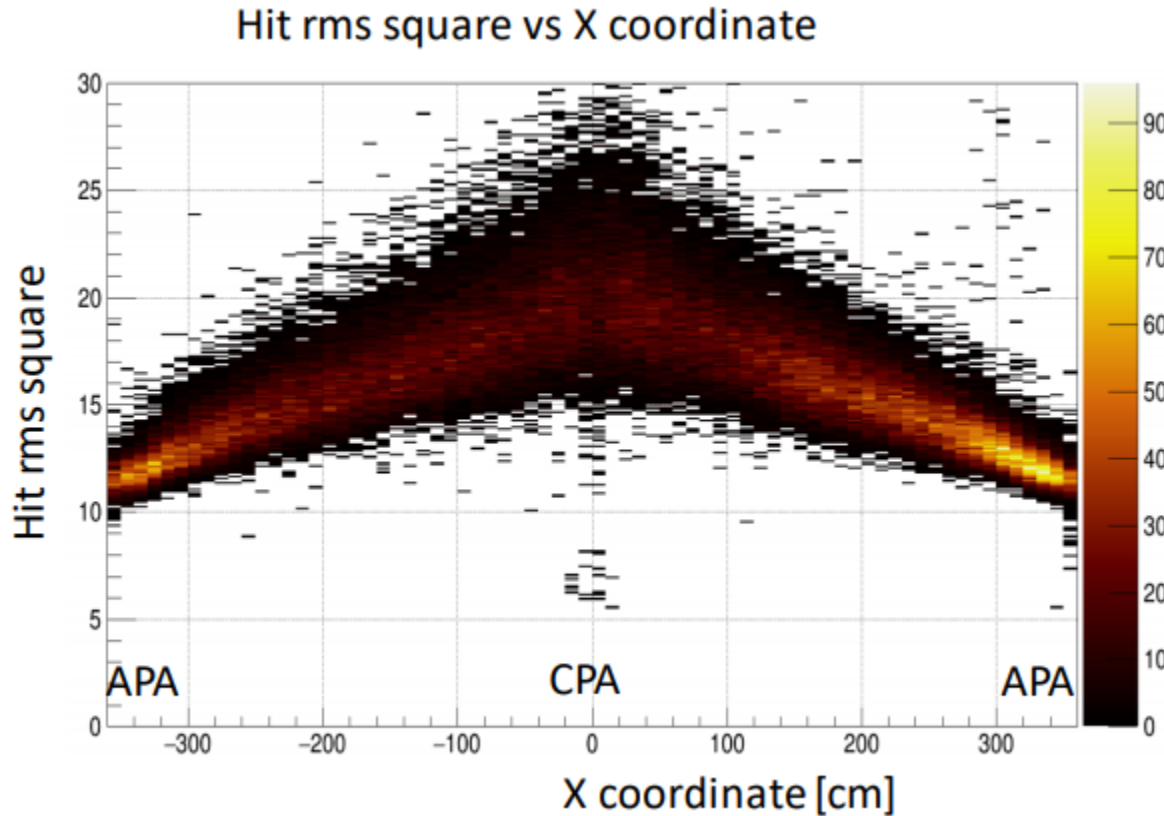
# "Gaus hit" RMS (Ajib)

# "Gaus hit" RMS (Ajib)



Fitted mean Hit::RMS square vs X coordinate

data vs. MC (old version)

$$\sigma_t^2 = \left(\frac{2D_L}{v_d^3}\right) x + \sigma_0^2$$

Diffusion coefficient
Total time width of pulse
Drift distance
Drift velocity
Inherent pulse width

- MC SCE and DIFF OFF
- MC SCE OFF
- MC SCE ON
- **Run 5387**

- Need to redo the MC sample with the wire cell electron drift simulation

- Slope is similar between data and MC → diffusion should be similar
- Intrinsic smearing in the old version MC is much higher
  - ▶ Could be due to the different software filter in "1D" deconvolution

# Summary

- The new simulation work (wirecell + PD + larg4) has been submitted to feature branches
  - ‣ Will be released next week

- SimChannel is aligned with decon charge

- Range of SimChannel is similar to decon charge now

- The different width of dE/dx in data/MC could be due to some intrinsic smearing from signal processing
  - ‣ We are regenerating MC sample with the new simulation and 2D deconvolution