

# Electron Lifetime Measurement

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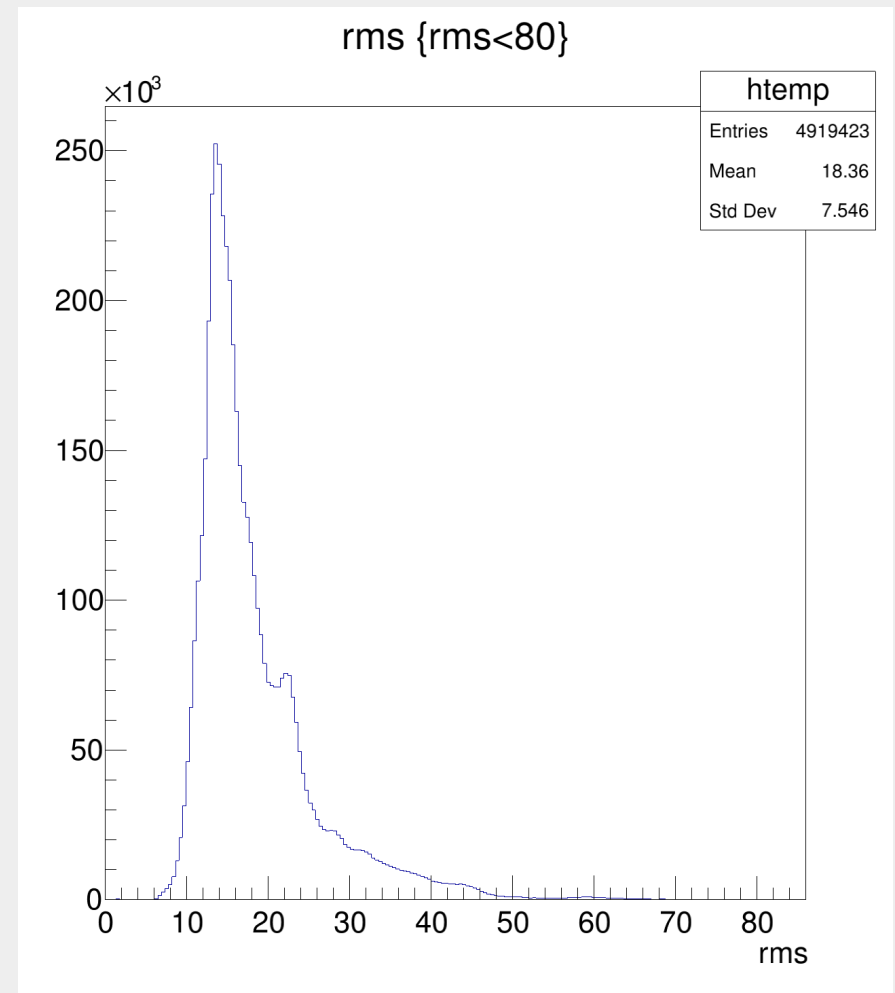
35-ton Sim/Reco/Ana Meeting

# Topics

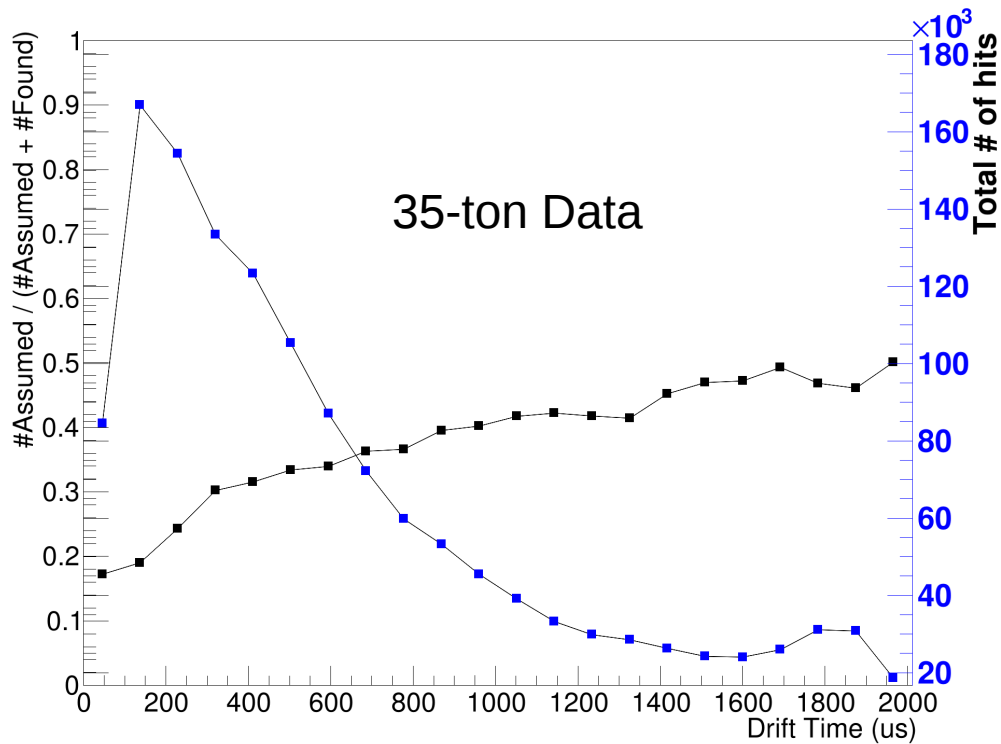
- Bad Channel Cuts
- Found / Assumed Hits
- Landau (x) Gauss fits
- MC study of efficiency & purity of reconstruction
- Uncertainty & Efficiency Propagation

# Bad Channel Cuts

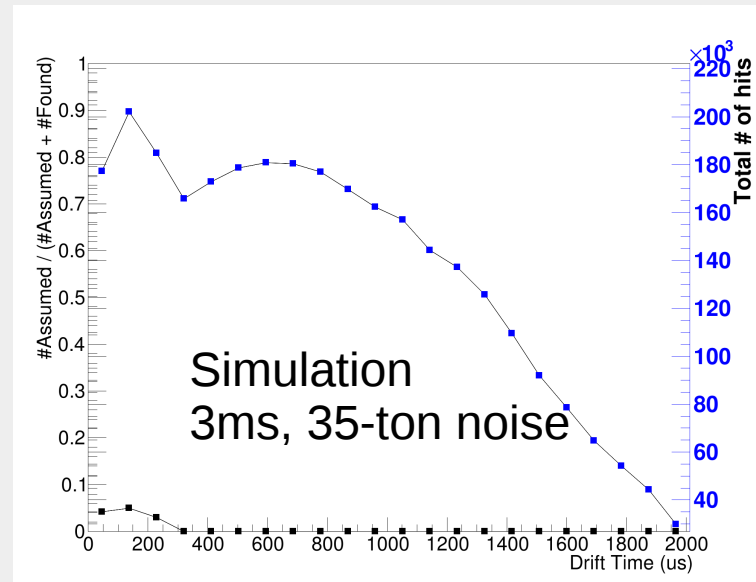
- My channel selection:
  - Collection wires only
  - Ignore wires next to an APA gap or TPC edge
  - Baseline-subtracted RMS of wire noise between 10-40 ADC
  - Calculated (event-by-event) baseline < 20 ADC from pedestal
  - Ignore channels in channelstatus\_dune.fcl
  - Ignore channels 566, 885, 1547 (I found to have very high noise RMS in some events)
  - > 50 hits per event (i.e. 50 channels with low enough noise for a hit to be found)
- Intended cuts (which require re-processing all of my data...)
  - Stuck ADC % between hit start/end



# Found / Assumed Hits

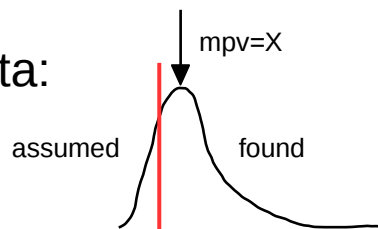


- ~20-40% of all reconstructed hits are “assumed”
- “Assumed” hit start /end calculated based on neighbouring “found” hits start/end
- All other parameters calculated in same way, e.g. integral of ADCs
- Interesting: simulation (same noise level as data) has practically no assumed hits...

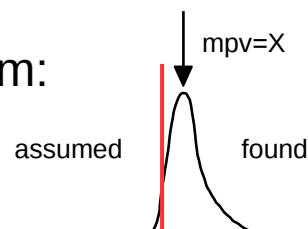


Maybe this is what's happening?

Data:



Sim:



# L(x)g Fits

COVARIANCE MATRIX CALCULATED SUCCESSFULLY

FCN=347459 FROM HESSE STATUS=OK 16 CALLS 101 TOTAL  
 EDM=5.86036e-05 STRATEGY= 1 ERROR MATRIX ACCURATE

EXT	PARAMETER	INTERNAL	INTERNAL
NO.	NAME	STEP SIZE	VALUE
1	GaussWidth	9.58137e-05	-1.25906e+00
2	LandMPV	6.18884e-05	3.91635e-02
3	LandWidth	3.78669e-05	-1.23757e+00

ERR DEF= 0.5

EXTERNAL ERROR MATRIX. NDIM= 25 NPAR= 3 ERR DEF=0.5

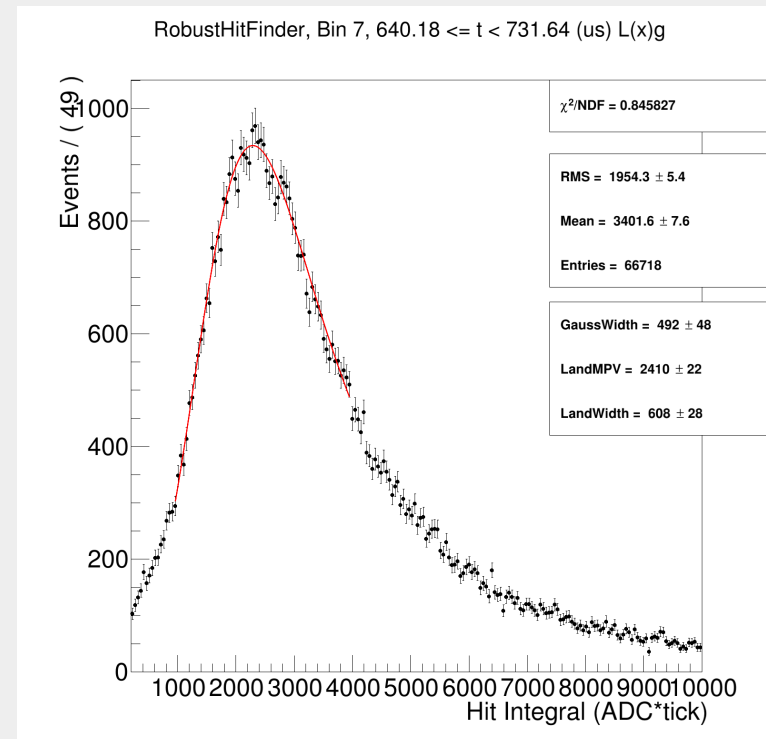
2.301e+03	-9.075e+02	-1.231e+03
-9.075e+02	4.682e+02	5.615e+02
-1.231e+03	5.615e+02	7.682e+02

PARAMETER CORRELATION COEFFICIENTS

NO.	GLOBAL	1	2	3
1	0.92618	1.000	-0.874	-0.926
2	0.93644	-0.874	1.000	0.936
3	0.96206	-0.926	0.936	1.000

No surprise why Landau width and Gauss width didn't behave as expected.

Plan of action: Fix Landau width and vary Gauss width.



# L(x)g Fits

COVARIANCE MATRIX CALCULATED SUCCESSFULLY

FCN=347461 FROM HESSE STATUS=OK 10 CALLS 45 TOTAL  
 EDM=3.29188e-07 STRATEGY= 1 ERROR MATRIX ACCURATE

EXT PARAMETER				INTERNAL	INTERNAL
NO.	NAME	VALUE	ERROR	STEP SIZE	VALUE
1	GaussWidth	5.79606e+02	1.60919e+01	7.86941e-05	-1.23157e+00
2	LandMPV	2.37089e+03	7.66497e+00	6.23339e-05	1.96982e-02

ERR DEF= 0.5

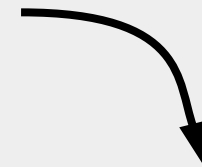
EXTERNAL ERROR MATRIX. NDIM= 25 NPAR= 2 ERR DEF=0.5  
 2.590e+02 -5.235e+00  
 -5.235e+00 5.875e+01

PARAMETER	CORRELATION COEFFICIENTS		
NO.	GLOBAL	1	2
1	0.04244	1.000	-0.042
2	0.04244	-0.042	1.000

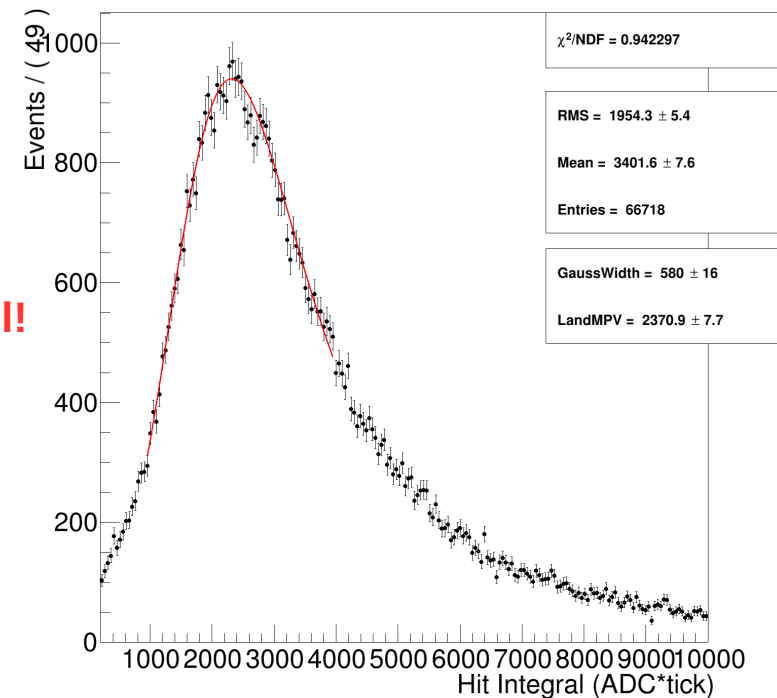
**Fixed LandWidth = 550**

**All 22 fits are successful  
(according to RooFit)**

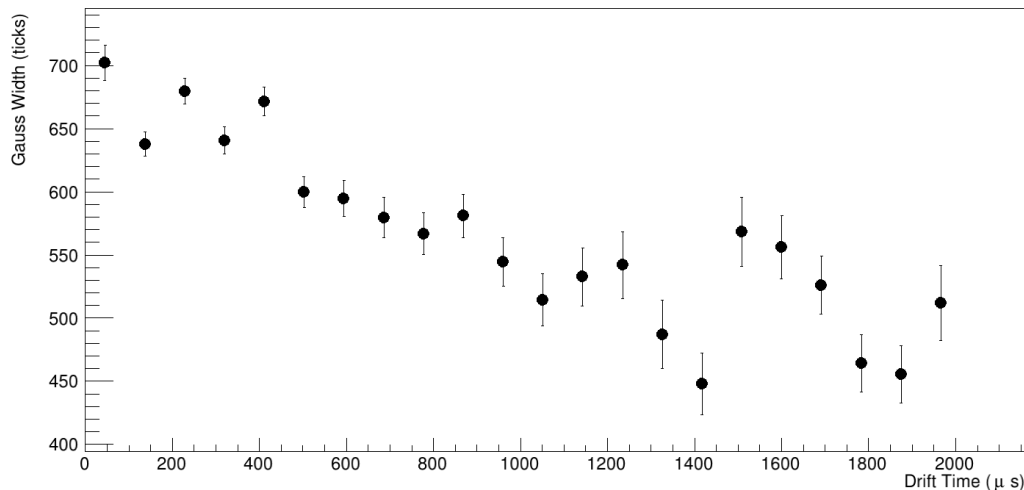
**Gauss Width decreases still!**



RobustHitFinder, Bin 7, 640.18 <= t < 731.64 (us) L(x)g

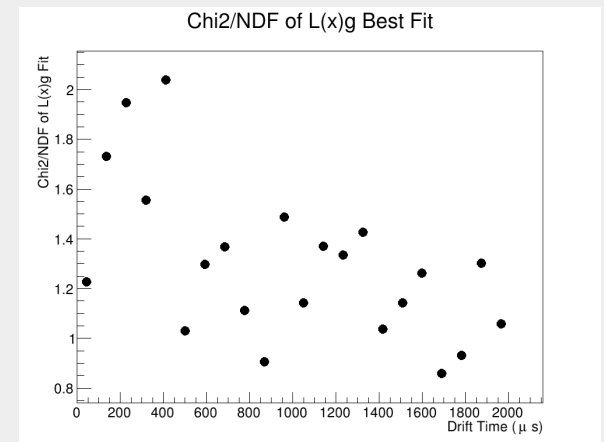
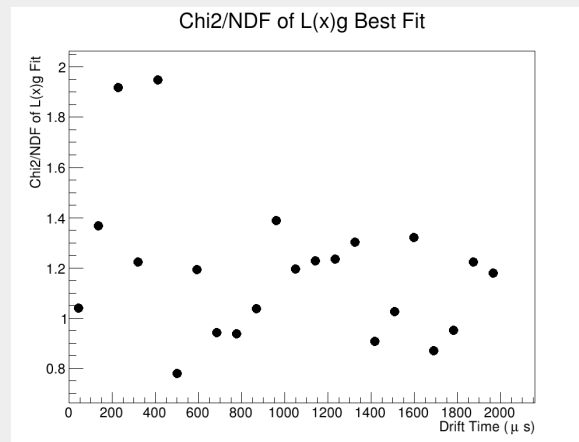
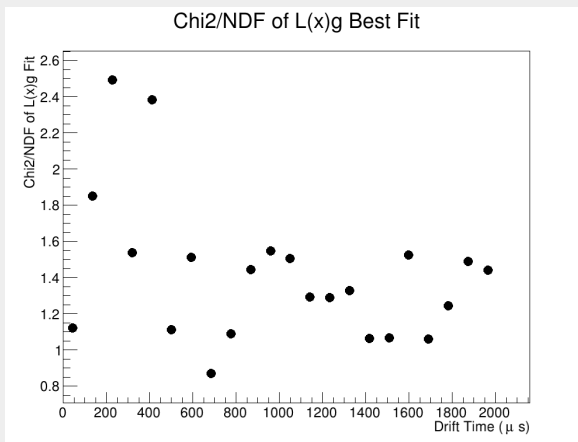
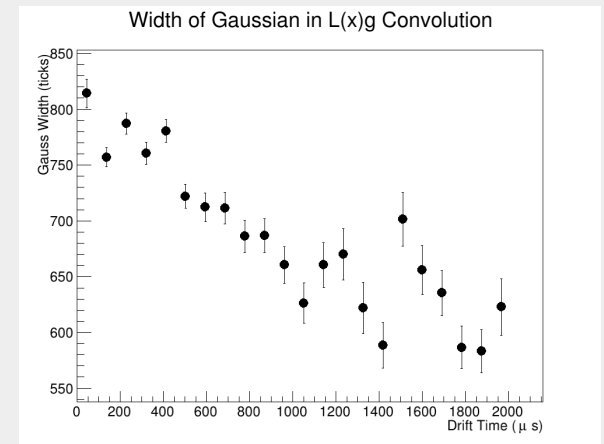
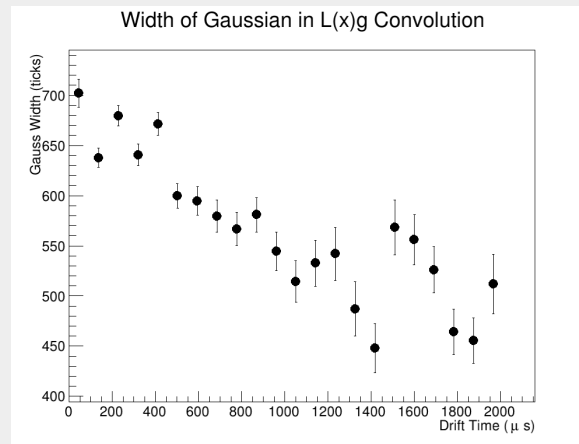
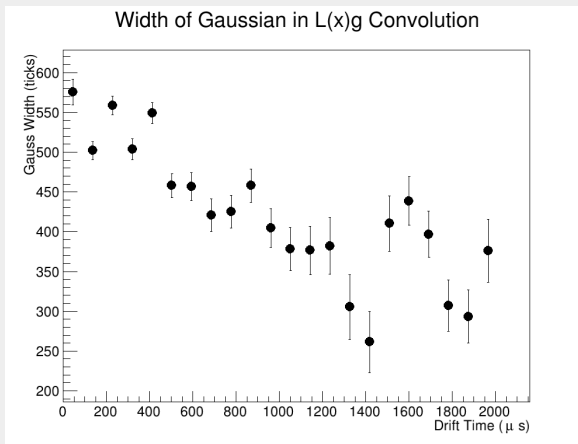


Width of Gaussian in L(x)g Convolution



Hit-finding threshold  
effect is to blame

# One step further



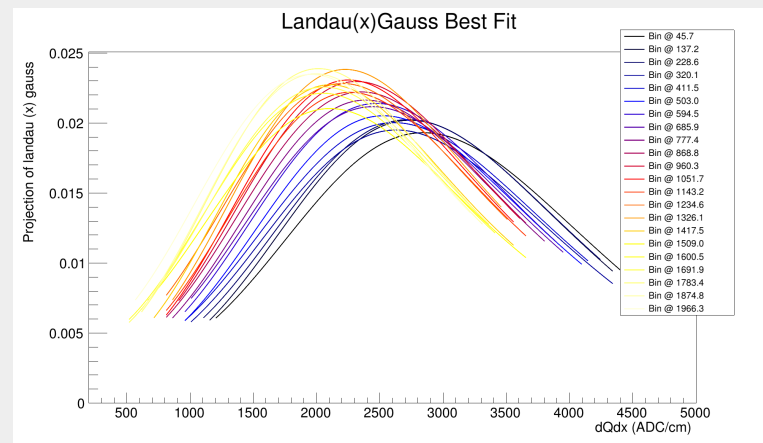
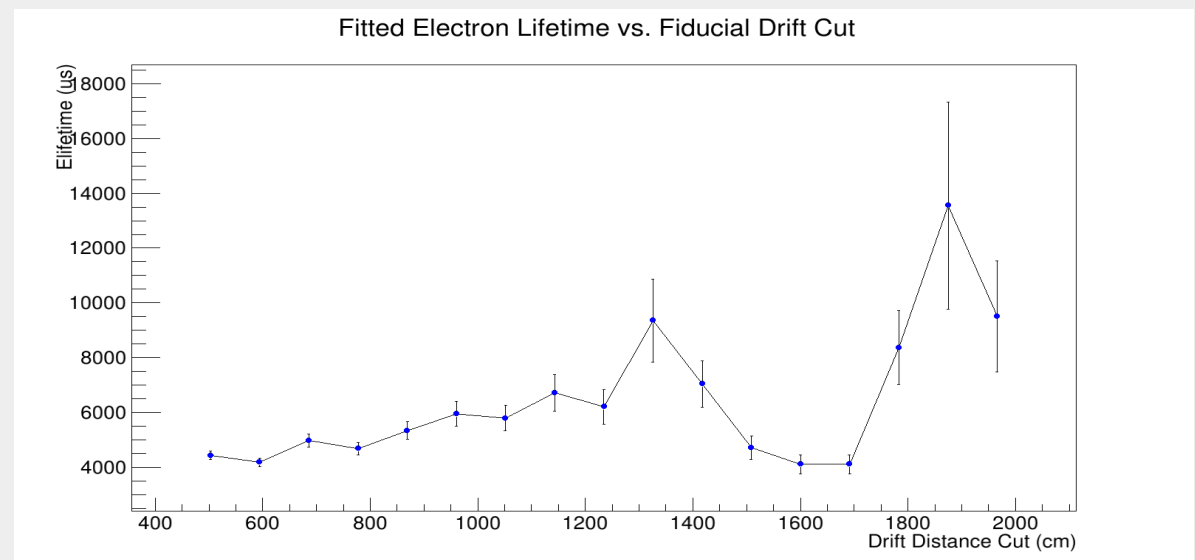
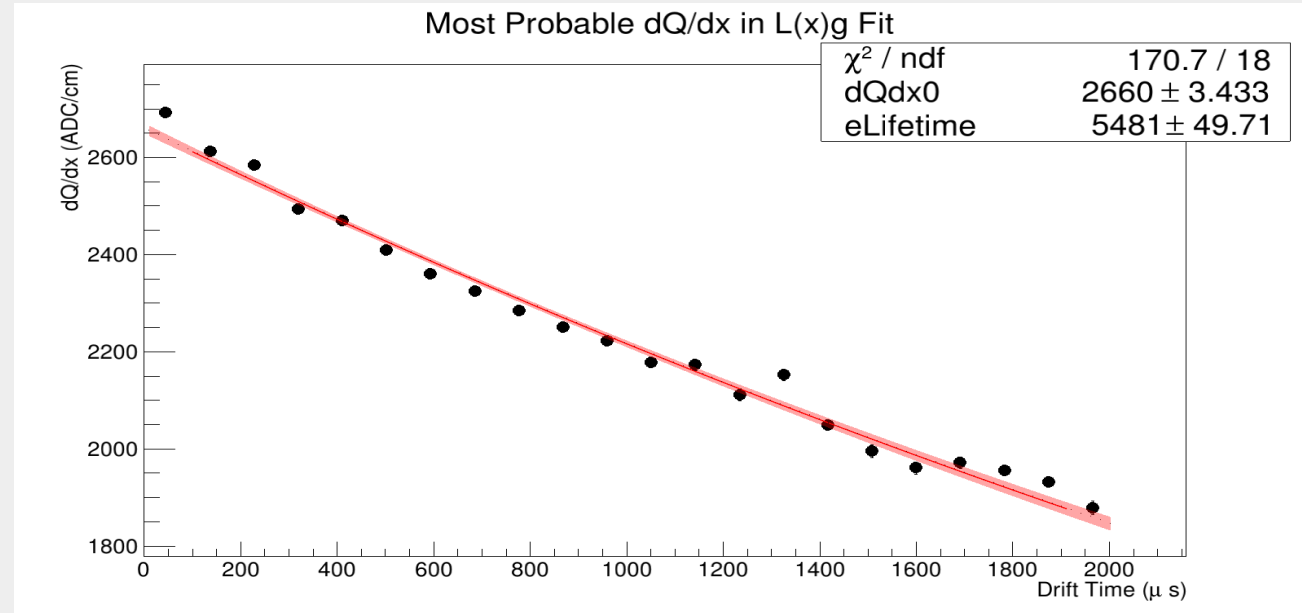
LandWidth = 650

LandWidth = 550

LandWidth = 450

# e<sup>-</sup> Lifetime with fixed LandWidth

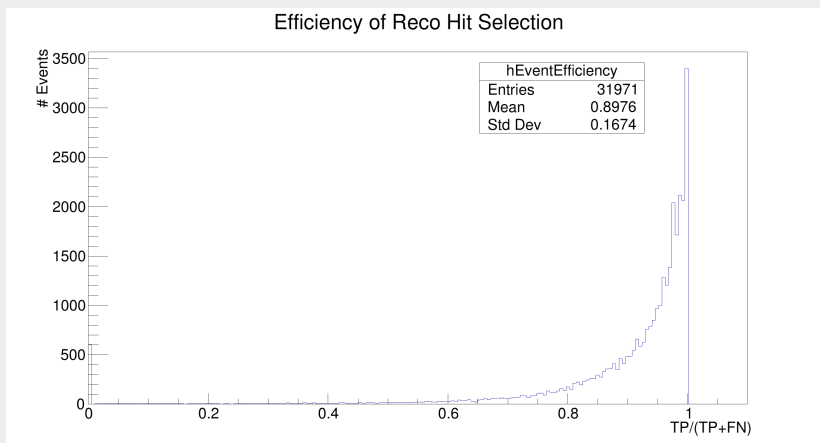
- (Before fixing LandWidth, eLifetime=5300us)
- After fixing LandWidth, eLifetime measurement is not improved
- Still a factor of ~2 above the purity monitor measurement



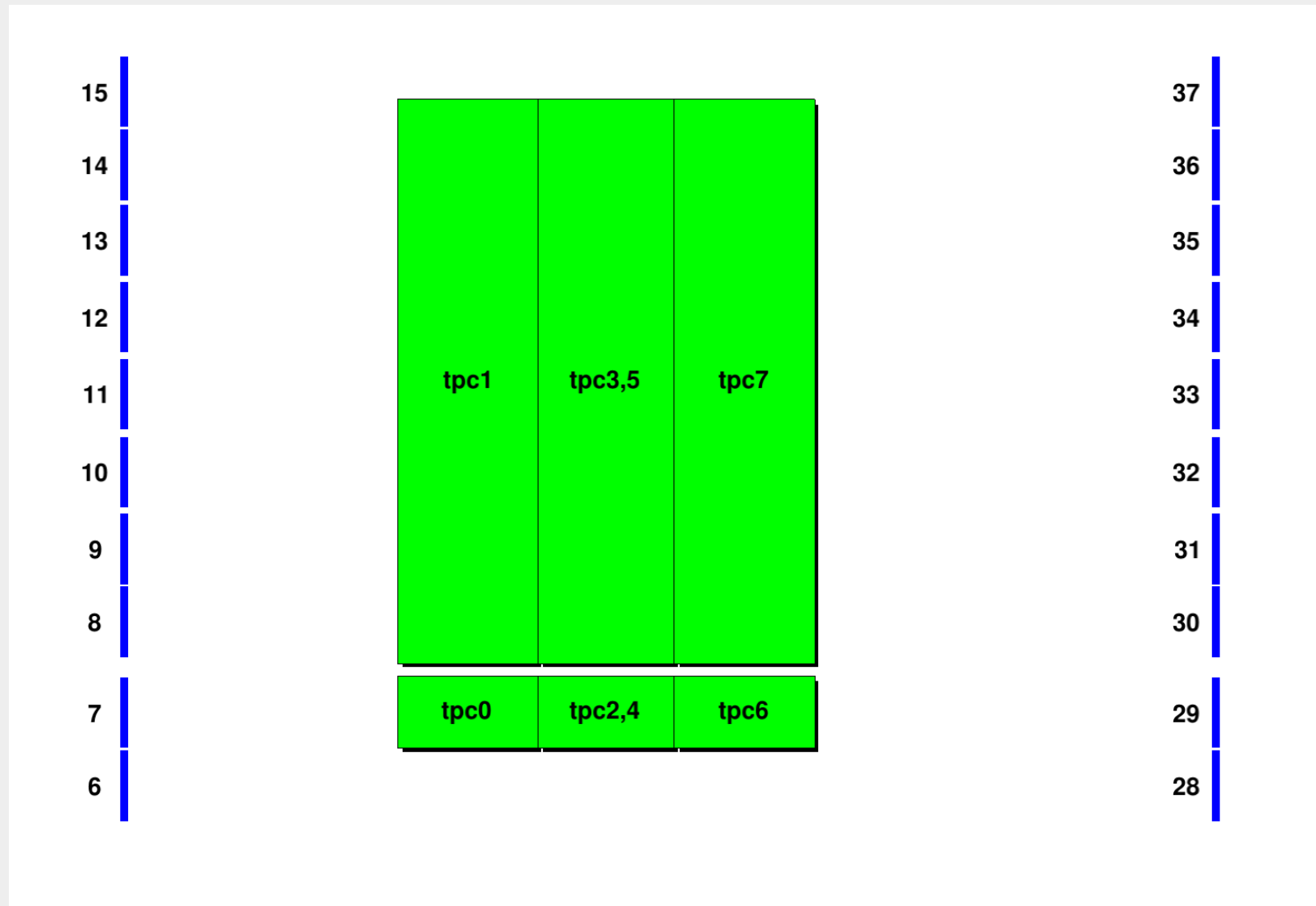


# Simulated Hit Efficiency

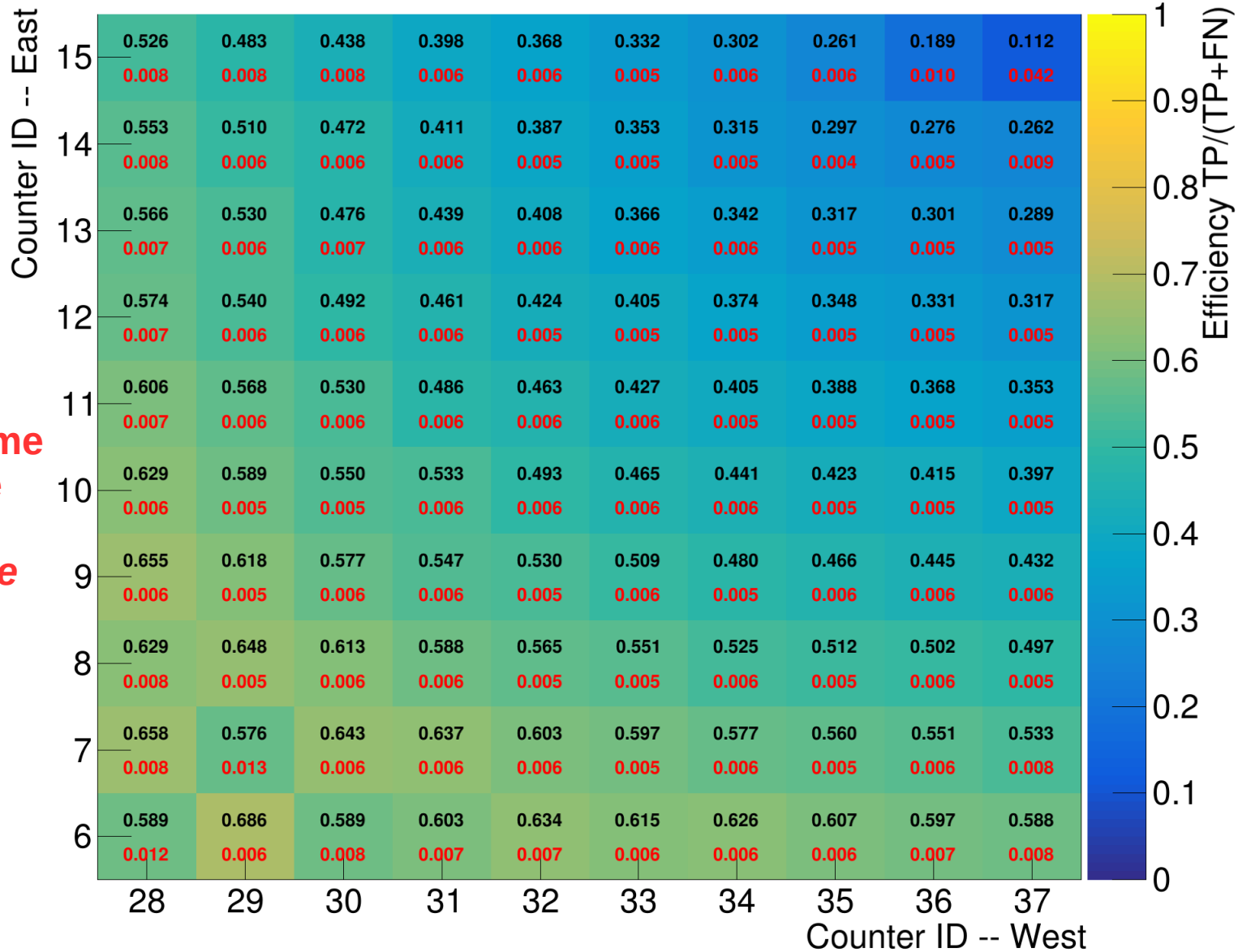
- Last time, I showed efficiency and purity of hit reconstruction
- Efficiency had a bug, which is now fixed
  - While doing DataOverlay, channels which were off during data run, do not have RawDigits created, and are correctly ignored in reconstruction. However, `sim::SimChannels` still exist for that channel in the event record...
- Unnatural binning over drift distance (bins of ~10cm) caused weird effects in first and last bins
- Have changed this to use counter coincidences to define drift distance bins
- Can now get Hit efficiency/purity (and charge efficiency / charge purity) of *any* EW trigger coincidence
  - And, with a bit of extra work, can get tracking efficiency by trigger



# Counter Locations (for reference)



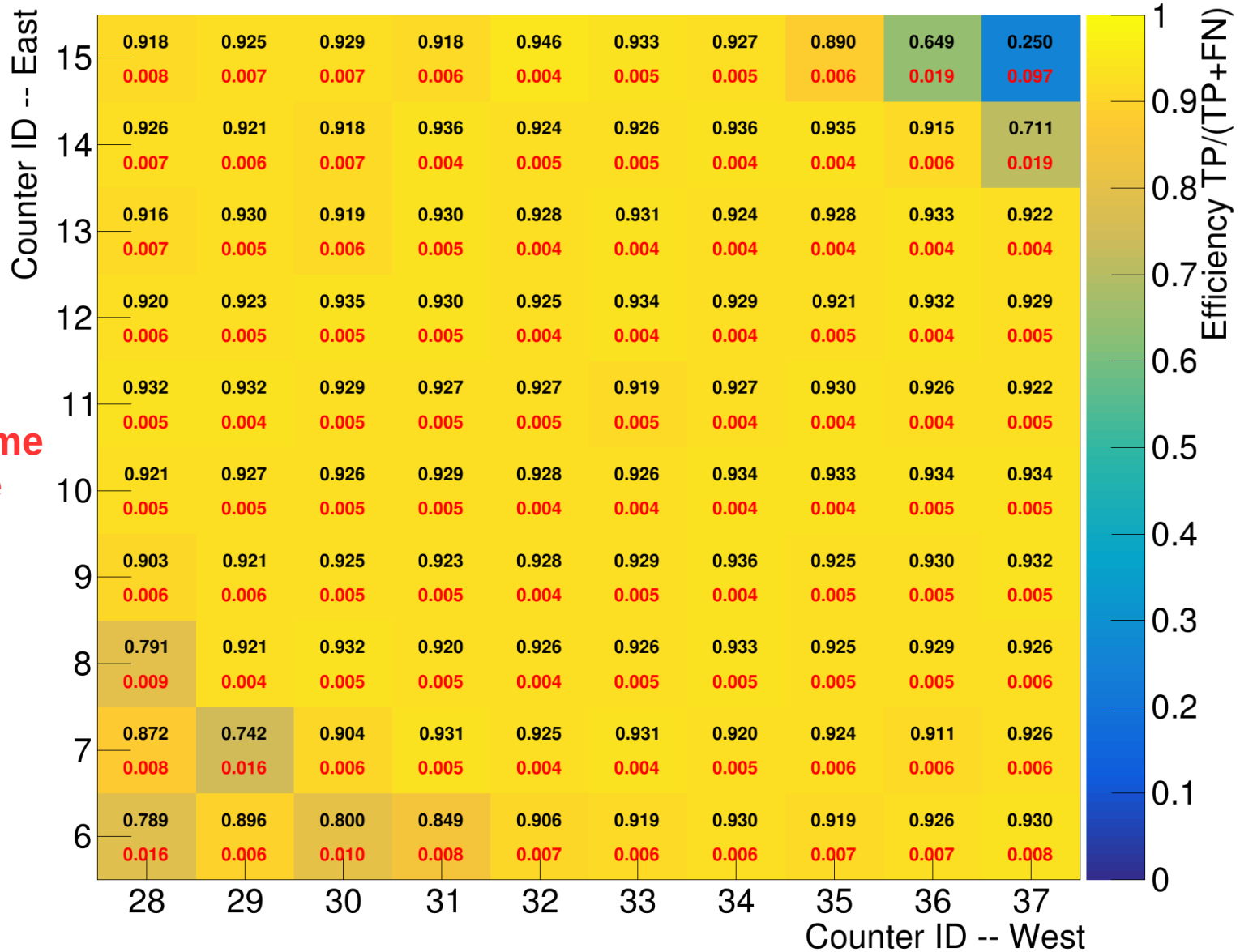
# Hit Finding Efficiency



3ms eLifetime  
1.0 mc scale

35-ton Noise

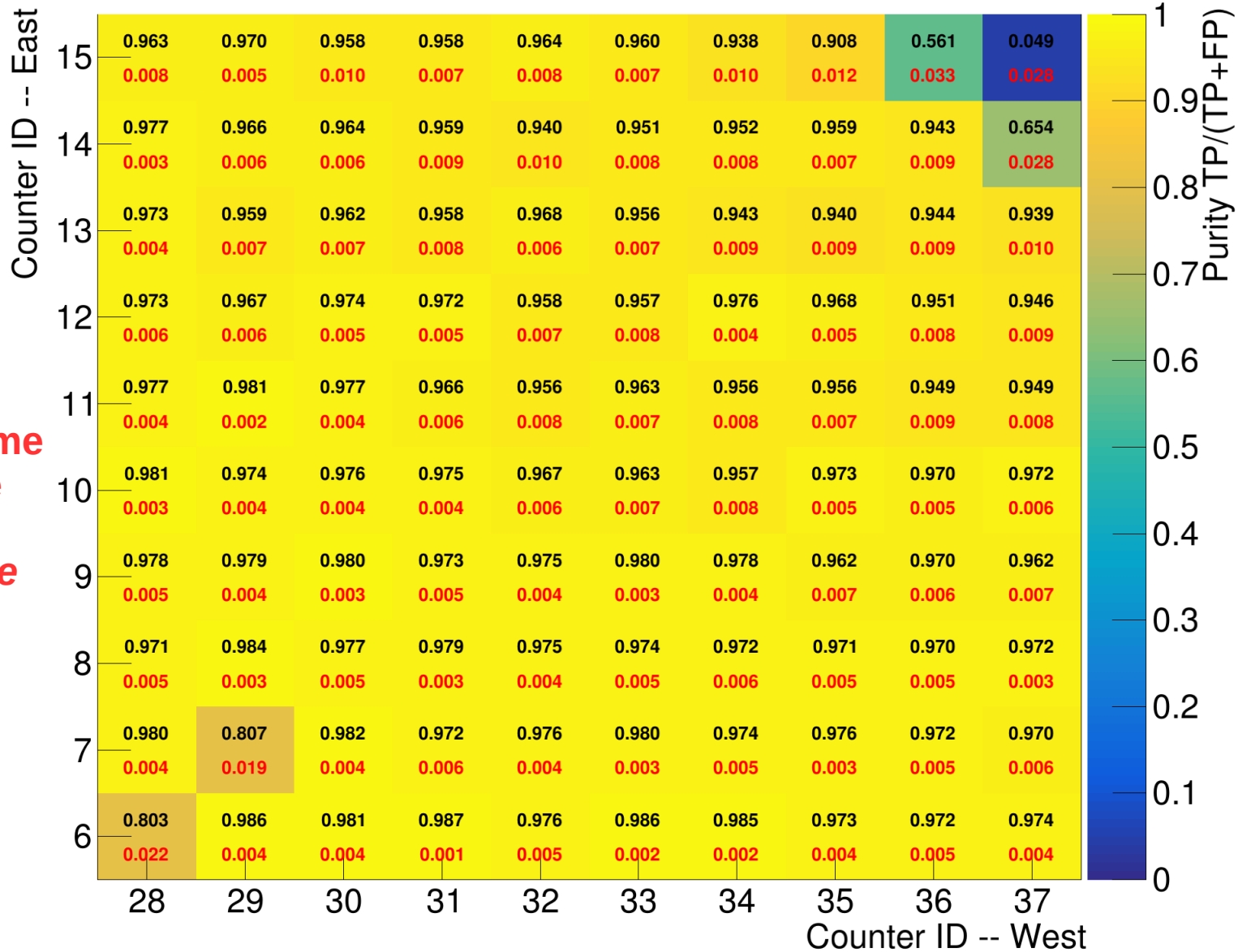
# Hit Finding Efficiency



3ms eLifetime  
8.0 mc scale

8x 35-ton  
S-N ratio

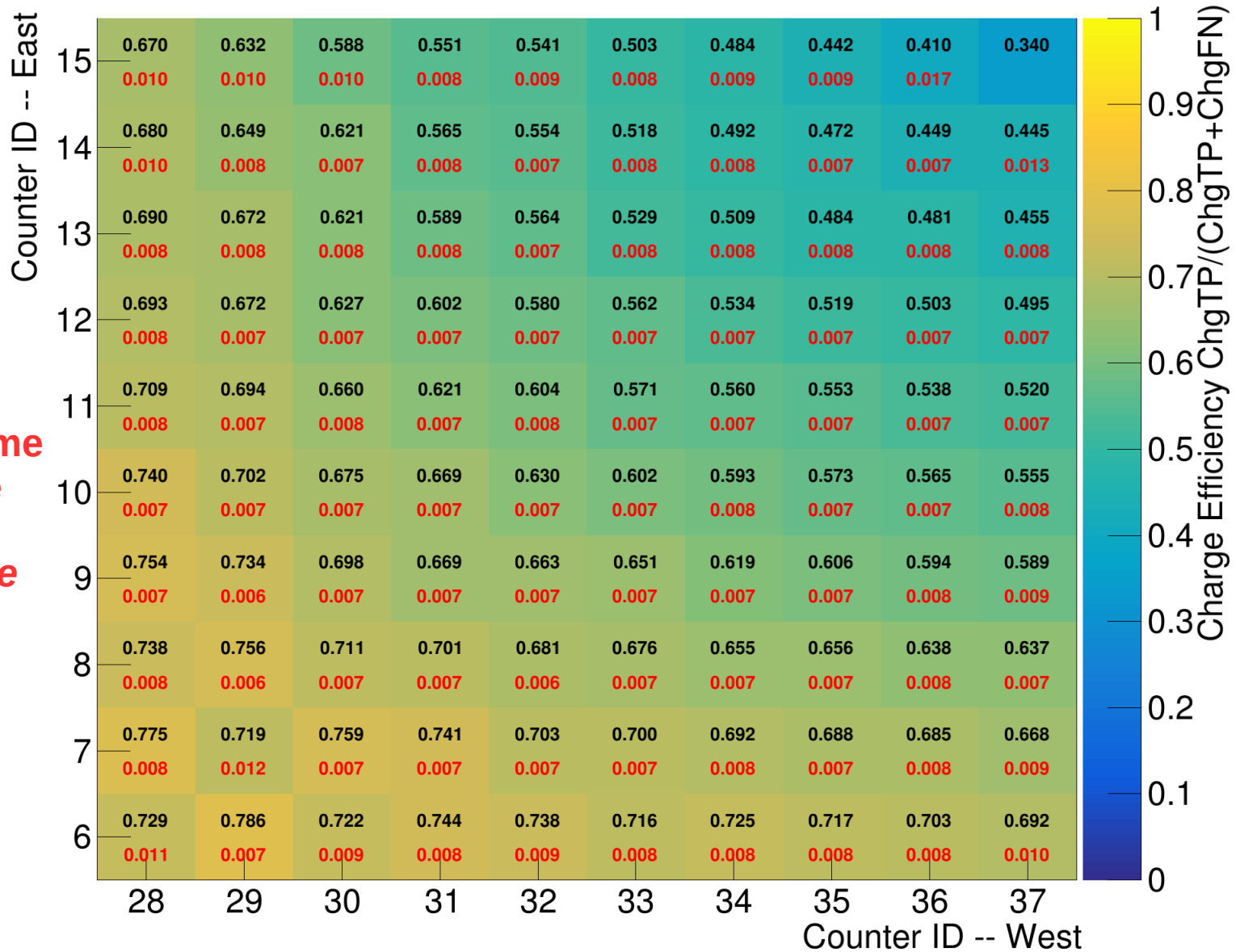
# Hit Finding Purity



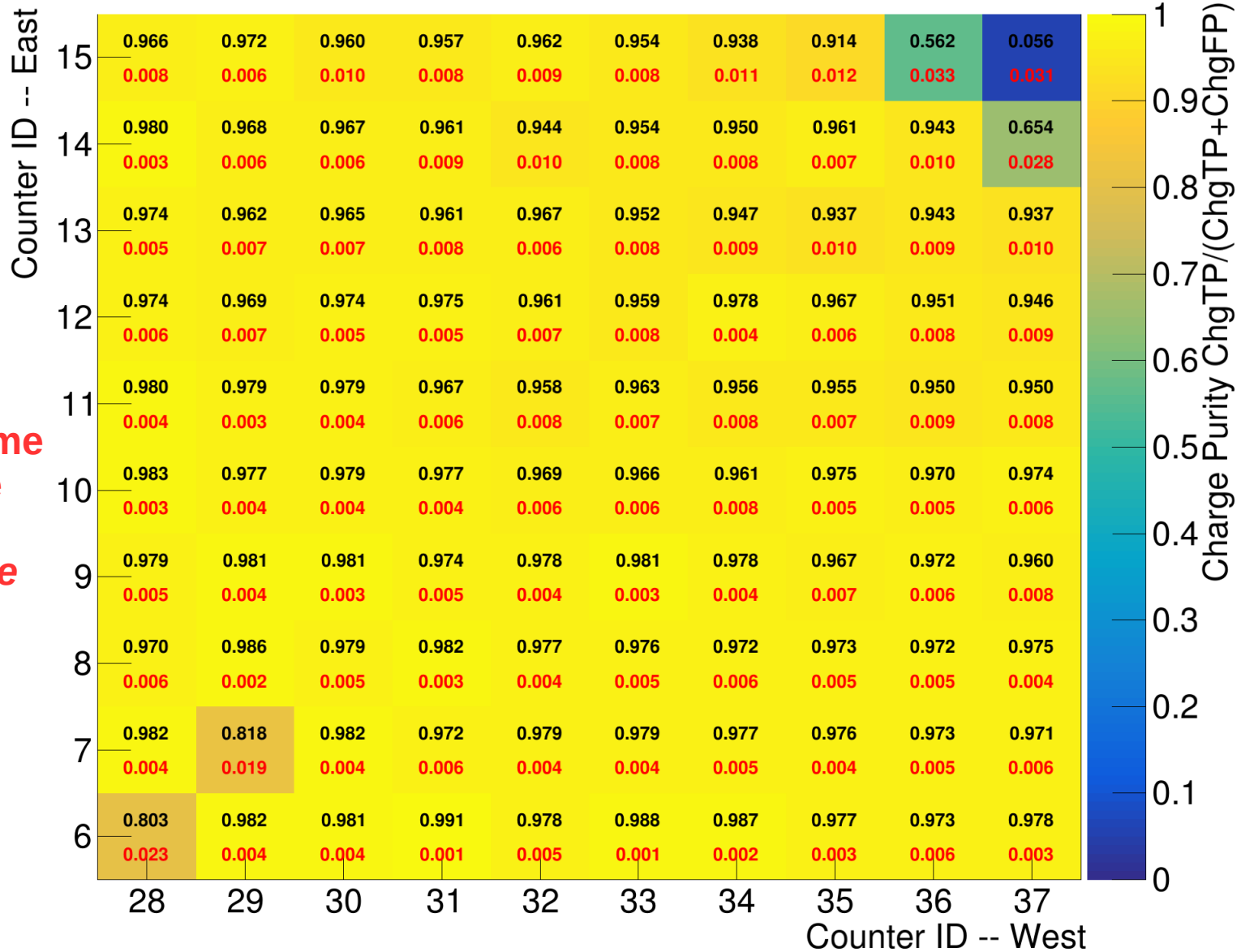
3ms eLifetime  
1.0 mc scale

35-ton Noise

# Charge Reco Efficiency



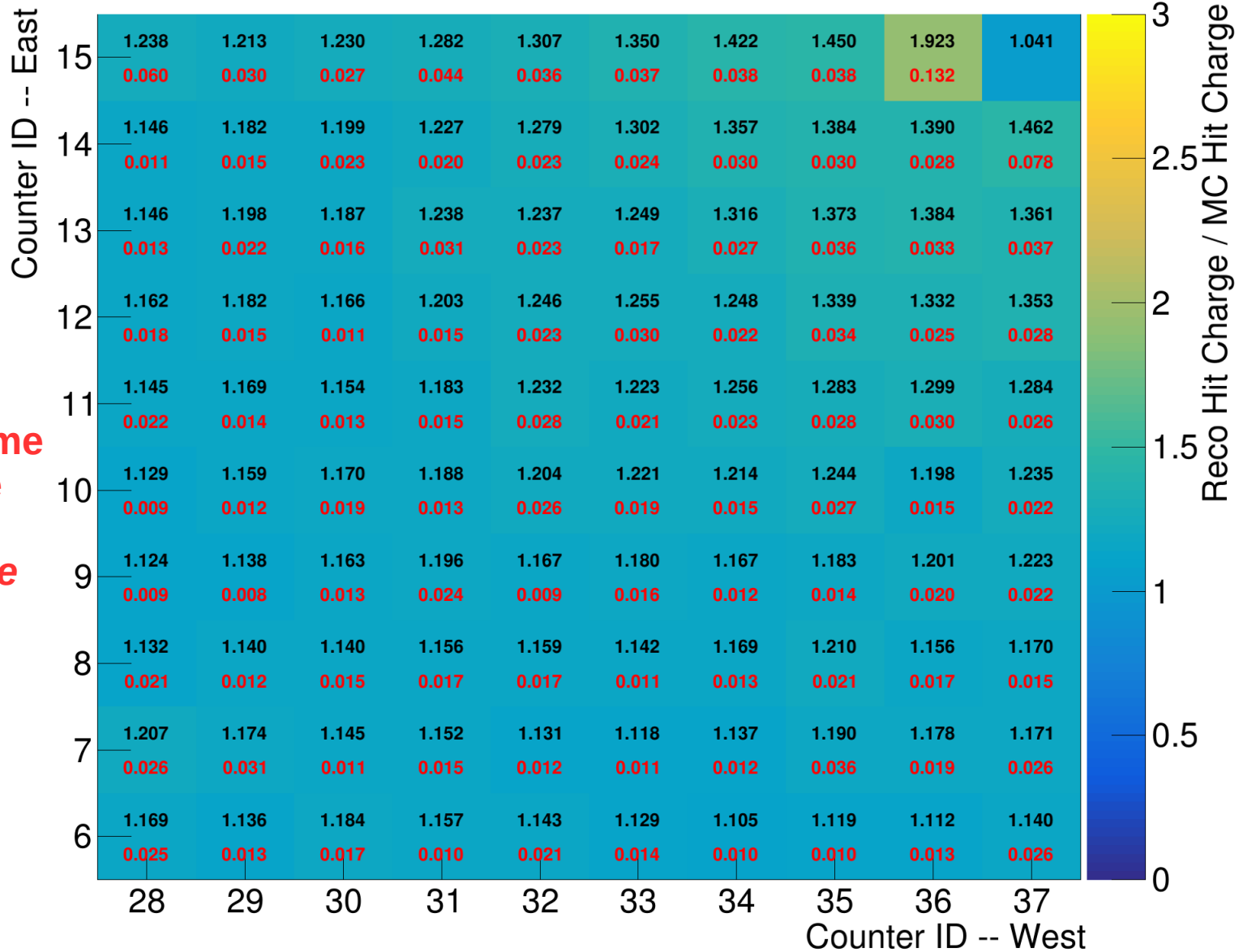
# Charge Reco Purity



3ms eLifetime  
1.0 mc scale

35-ton Noise

# Charge Ratio

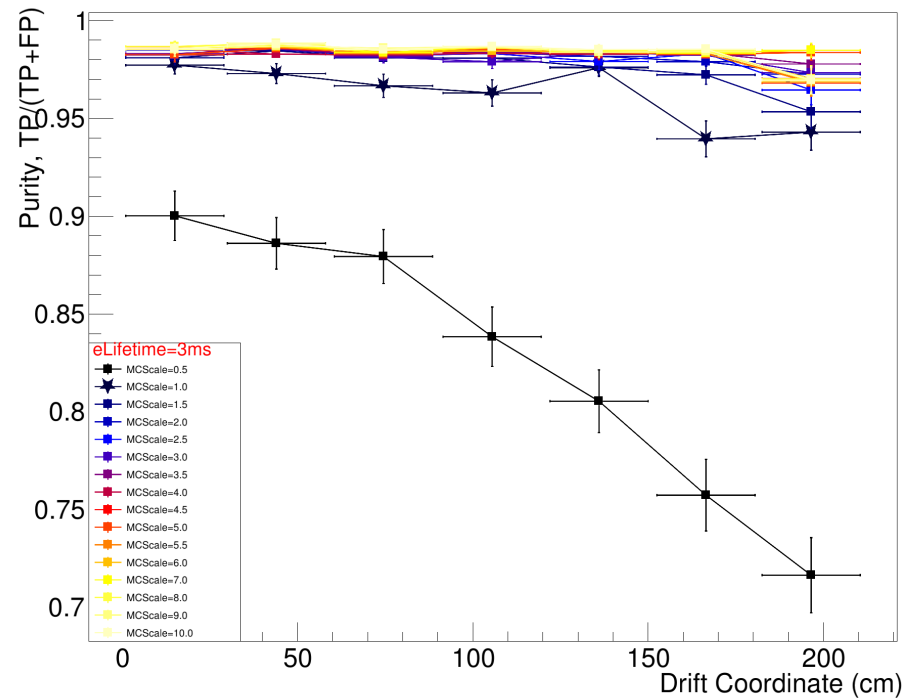
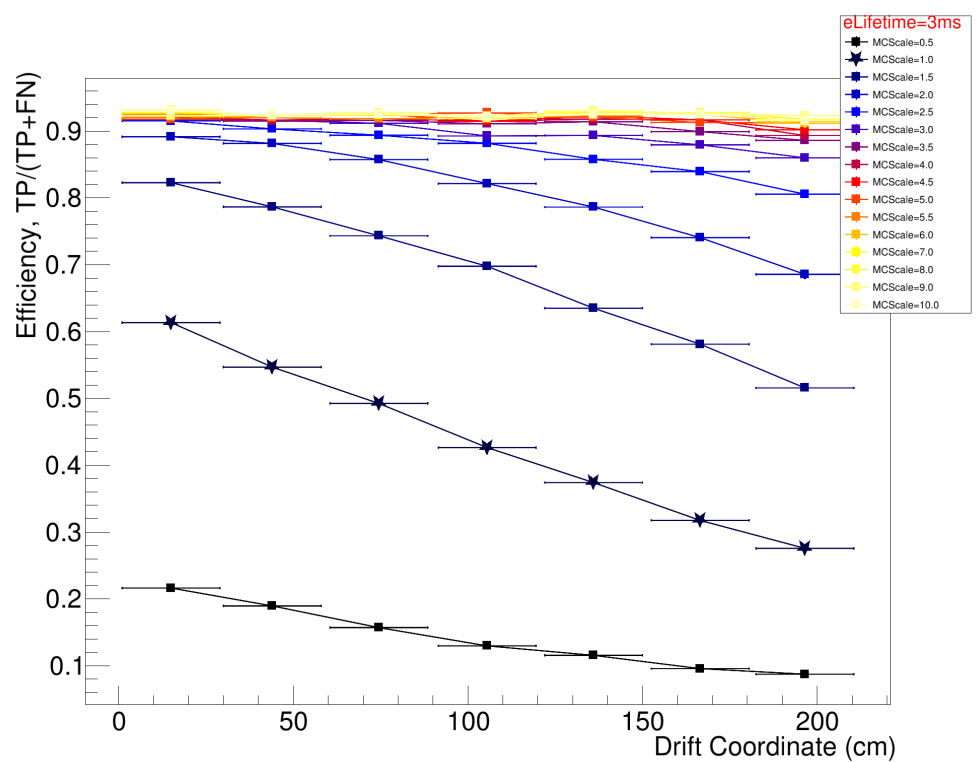


3ms eLifetime  
1.0 mc scale

35-ton Noise



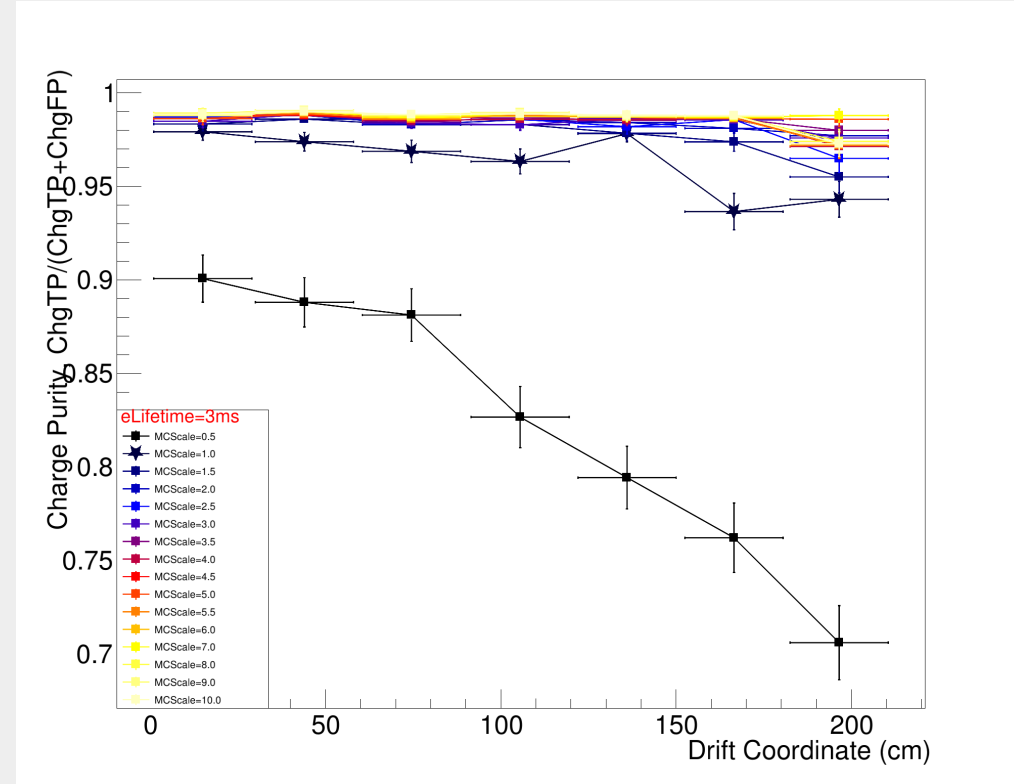
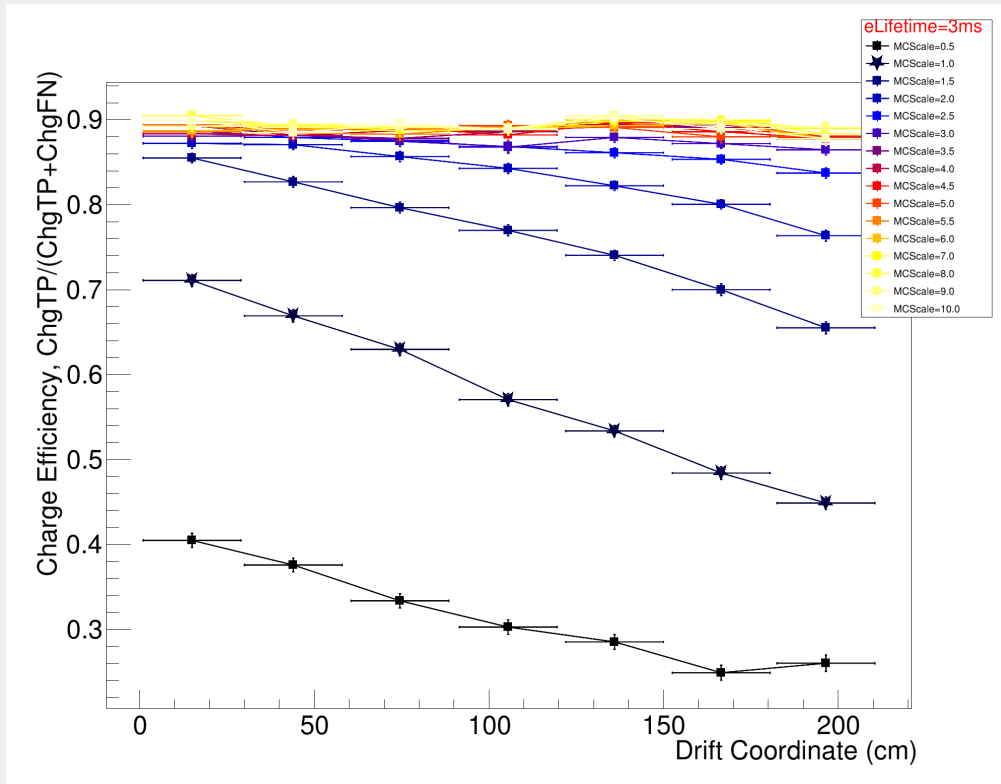
# Hit Reco Performance



Mean event hit reconstruction efficiency max value is around 92% for all levels of noise. Efficiency for 35-ton noise is poor, 60% near the anode, and 30% near cathode.

Mean event hit reconstruction purity is very good, even for 35-ton noise level.

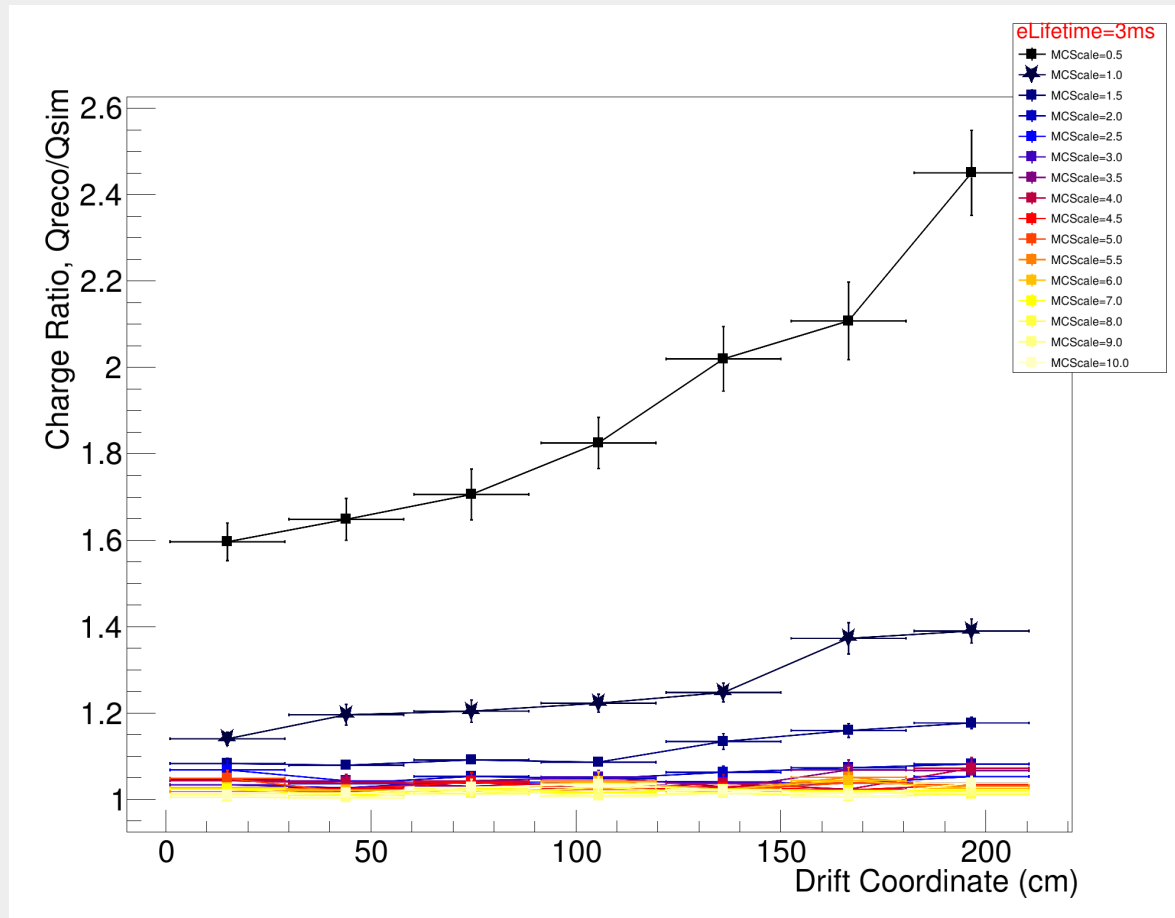
# Charge Reco Performance



Charge reconstruction performance practically mirrors the hit reconstruction performance.

Charge reconstruction accuracy (w.r.t. simulated charge) must be very good.

# Charge Reco Accuracy



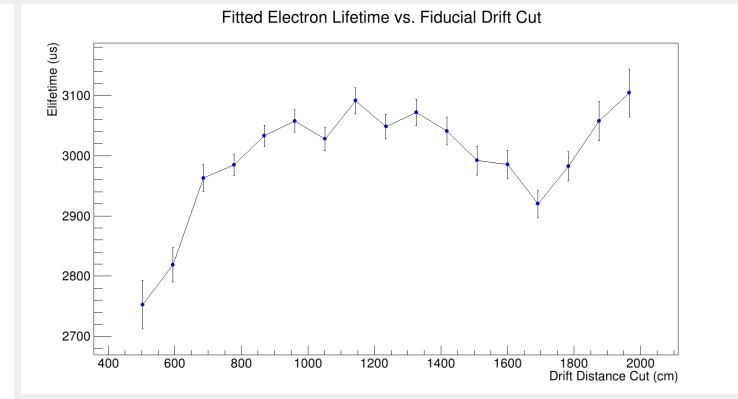
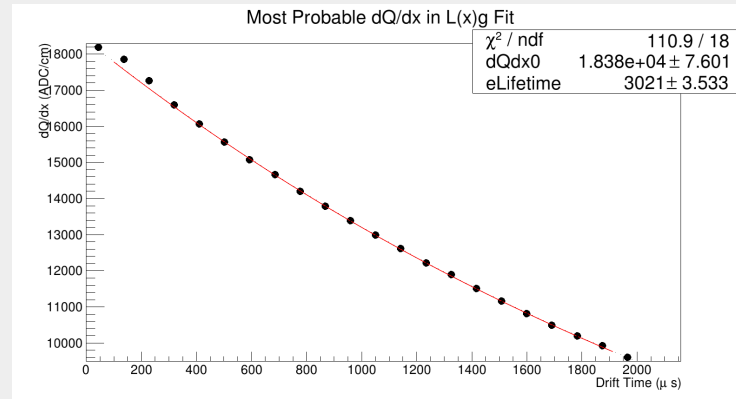
- On average, I reconstruct more charge than is really there
- Because I can quantify this, I can account for it

# Error/Uncertainty Propagation

- Quantifiable errors/uncertainties:
  - Hit integral uncertainty (from data)
    - width of gaussian in  $L(x)g$  fit?
  - Hit time uncertainty (from data)
    - Probably not important here
  - Hit finding efficiency and purity vs. drift distance (from MC study)
    - Or, harmonic mean of efficiency & purity (see *F1 Score*) to combine both
  - Hit charge efficiency and purity vs. drift distance (from MC study)
    - Or, again, harmonic mean of both
  - Hit charge accuracy (comparison of simulated and reconstructed charge)
    - Another gaussian resolution function
  - Statistical
- Unquantifiable errors:
  - Hit finding threshold effect on  $L(x)g$  fits
- Other things which impact eLifetime measurement:
  - Difference in charge resolutions of found/assumed hits
  - Track finding efficiency
- Exactly HOW do these impact the analysis?

# Summary

- Lifetime analysis works for low-noise data →



- For 35-ton noise case, problem lies elsewhere →

