Attenuation correction for SN events

DUNE Photon Detector Simulation Meeting

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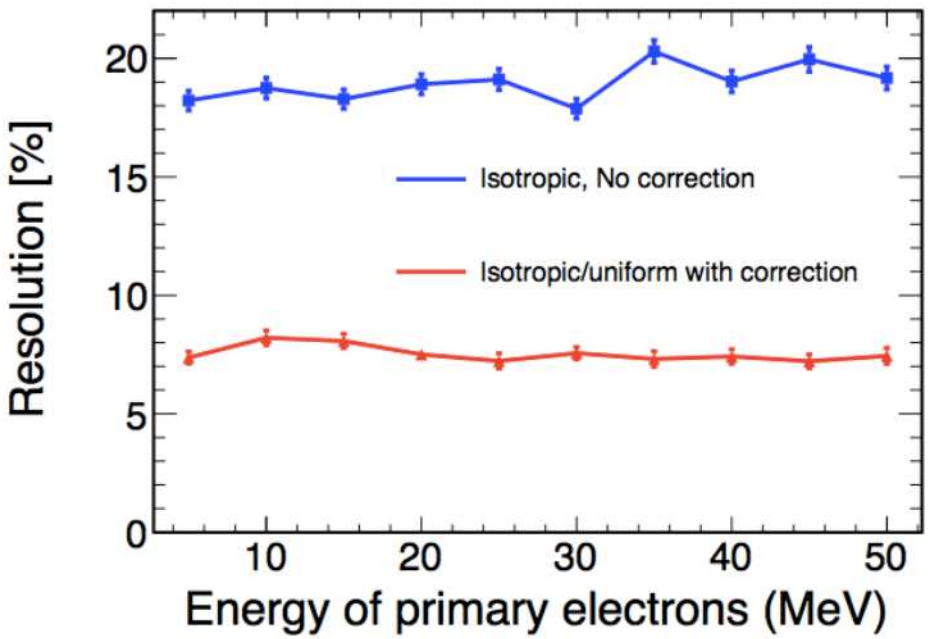
Prior art

LArSoft single-electron TPC resolution studies by Z. Li

- MicroBooNE geometry (max 2.5 m drift)
- 3 ms electron lifetime
- Note: electrons, not neutrinos; we don't yet have a handle on deex γ's
- Note: might get some improvement from induction planes (and/or better recon)



~20% resolution (slightly worse w/ new LArSoft) without drift correction (i.e. without photon detectors)... is this good enough?

Refs: docdb 8297, 8448, 9742

Improve speed of OPDet digitization

- Huge number of samples (575,011) in each trace
- Don't analyze stretches with no photon signals or dark noise
- Drawback is line noise can never create a trace in this period
- Checked into feature branch `cb_fastopdigi`
- Not heavily tested, but seems relatively sane in this talk

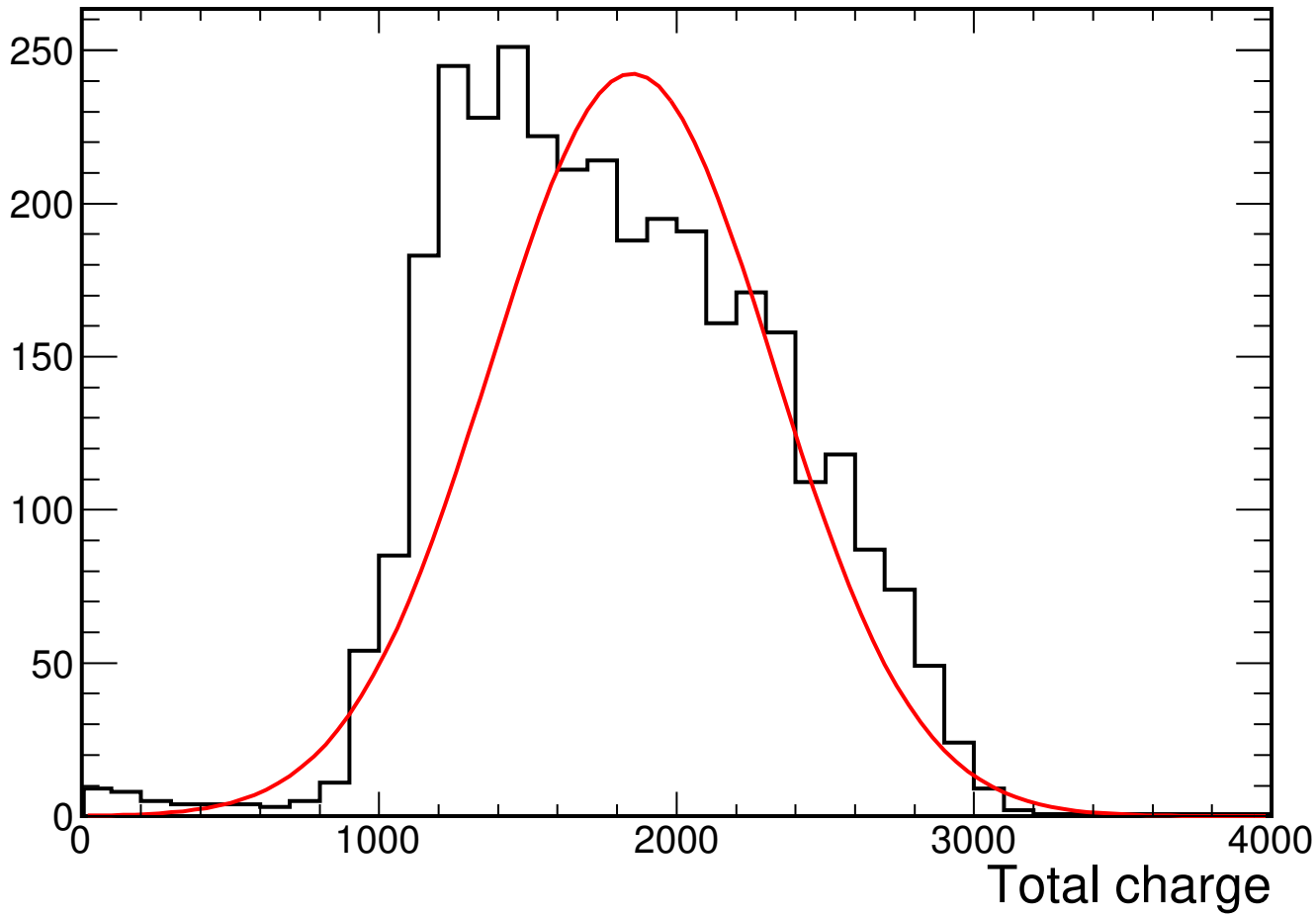
(s)	Min	Mean	Median	Max
Before	0.0005	22.6	25.8	35.4
After	0.0004	0.38	0.21	1.00
Ratio	-	59.5	122.9	35.4

Files

- Simulate $\sim$ 9000 events (overnight on one core) of 20MeV e^-
- Workspace geom
- Leave out Ar^{39} (descoping for complexity and runtime)

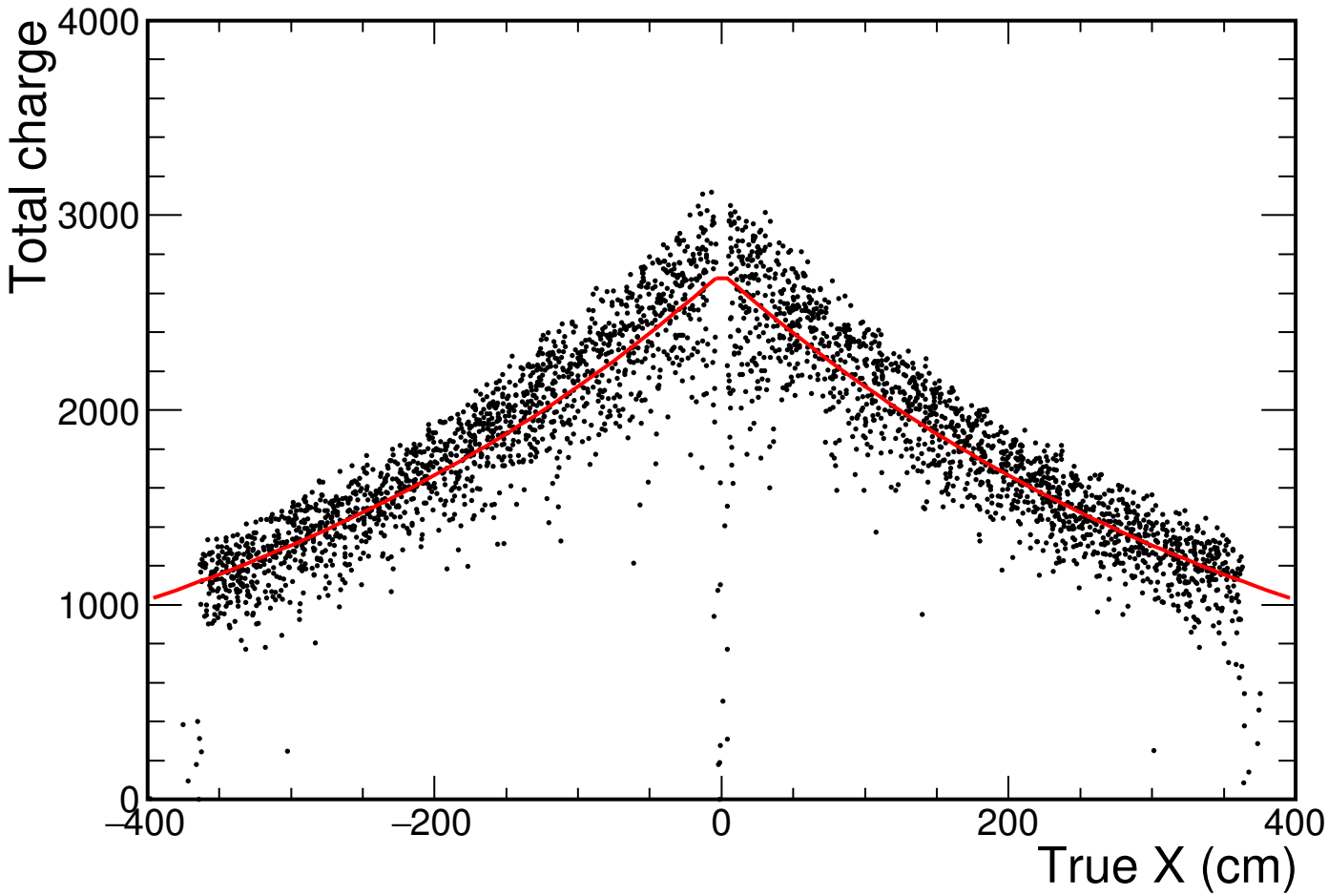
- Reco all events (10 processes $\times \sim$ 1 hr)
  - `ophit`, `opflash`, `calwire`, `gaushit`, `hitfd`, `linecluster`, `trajcluster`, `blurredcluster`
- `calwire` dominates runtime. Using `trajcluster` throughout

Reconstruct event energy



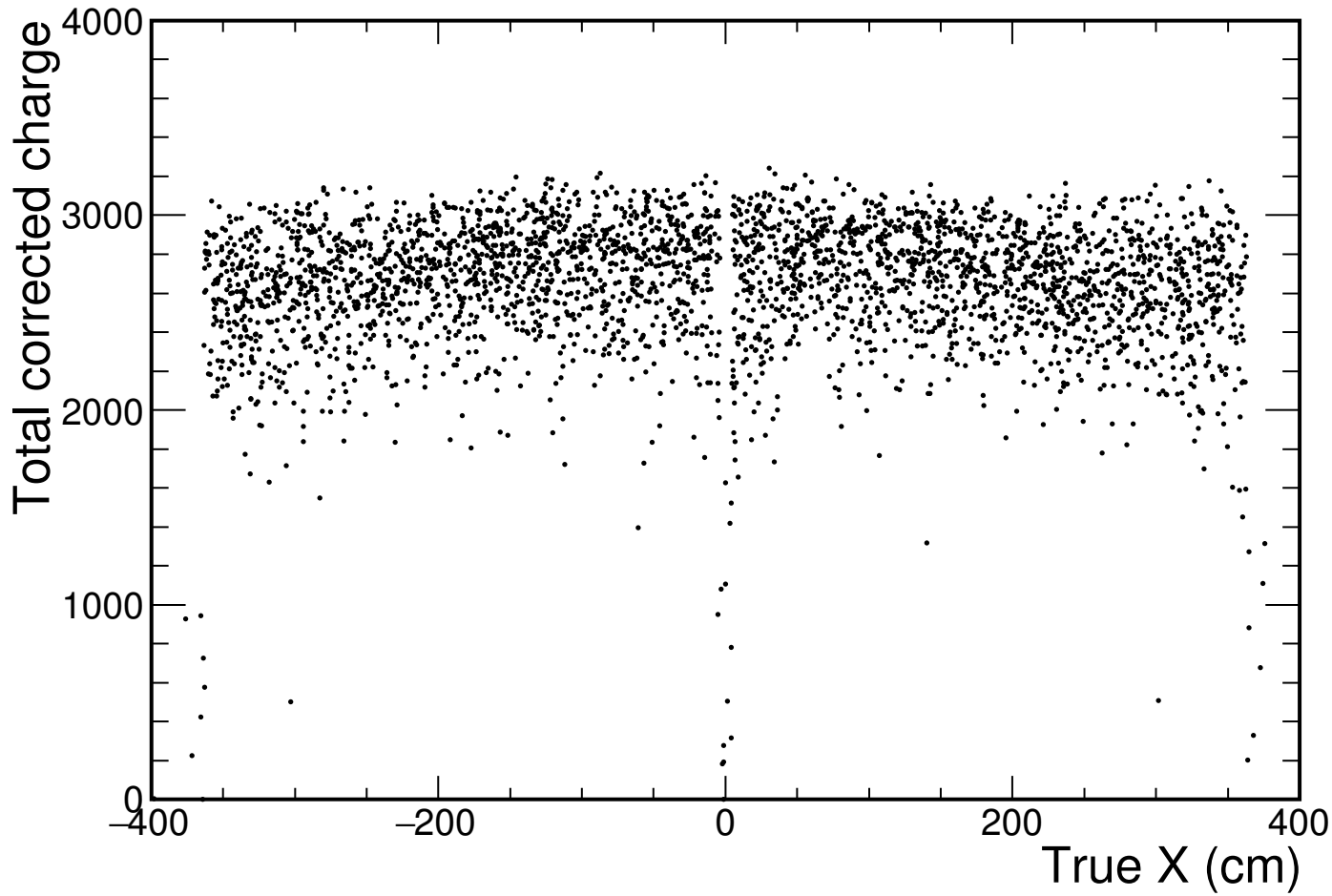
- totq is sum of `clust.Charge(cmFit)` if `clust.View() == geo::kZ`
- Width = 26% (fit), 29% (RMS)

Position dependence



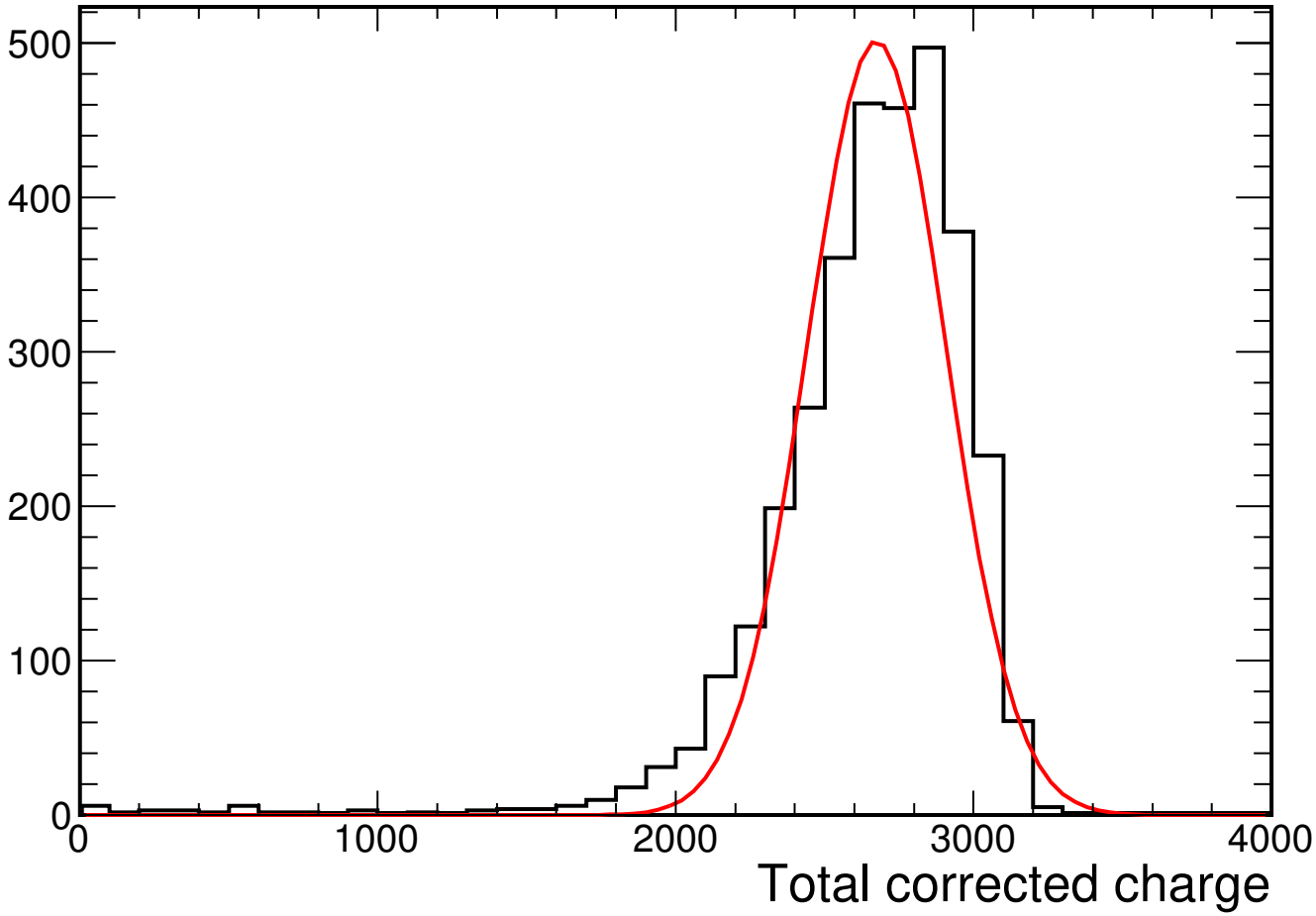
- Charge attenuation length seems to be 429cm

Corrected charge vs true position



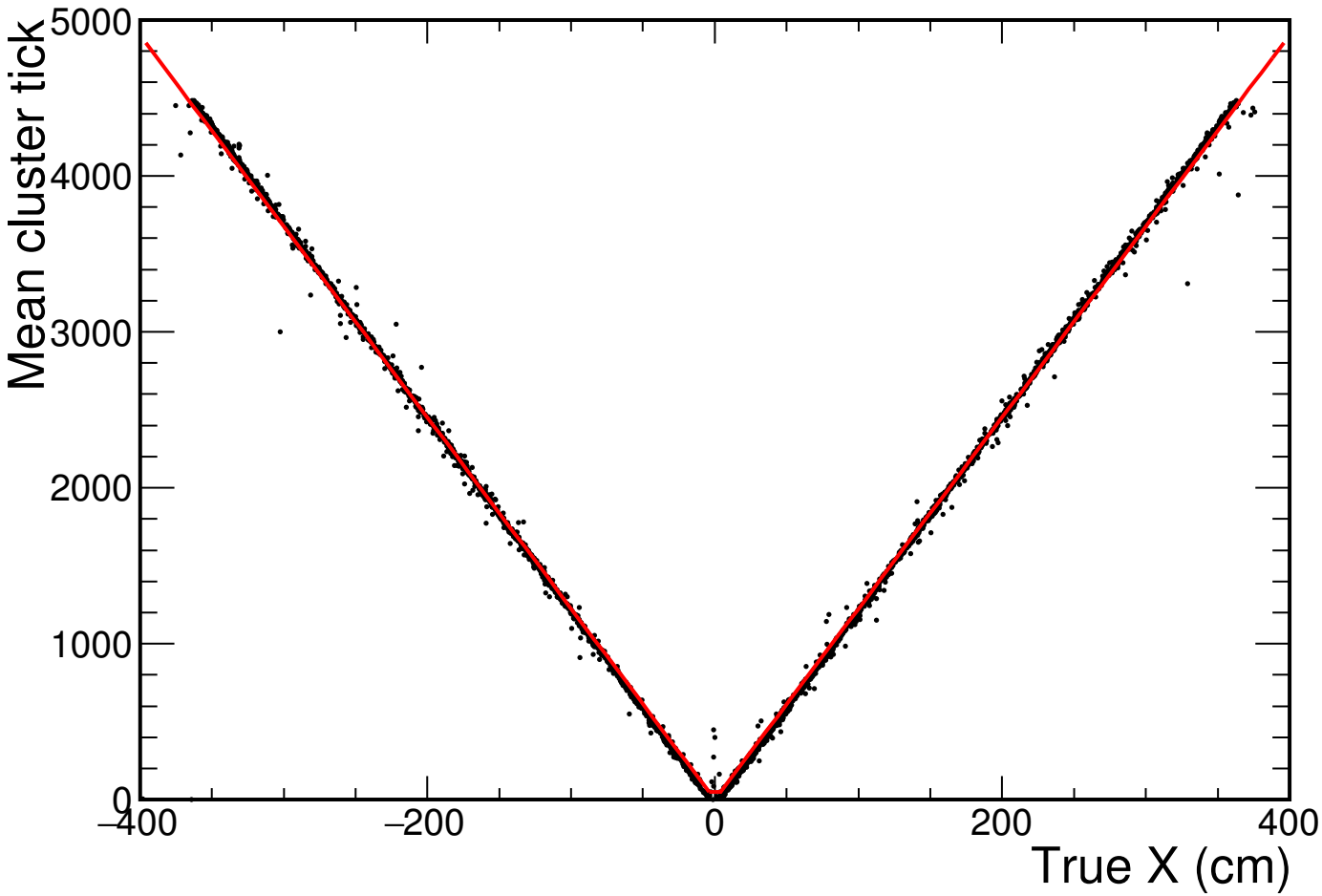
- totq $\rightarrow$ totq $\times \exp(|X_{\text{true}}|/429)$

Charge corrected by true position



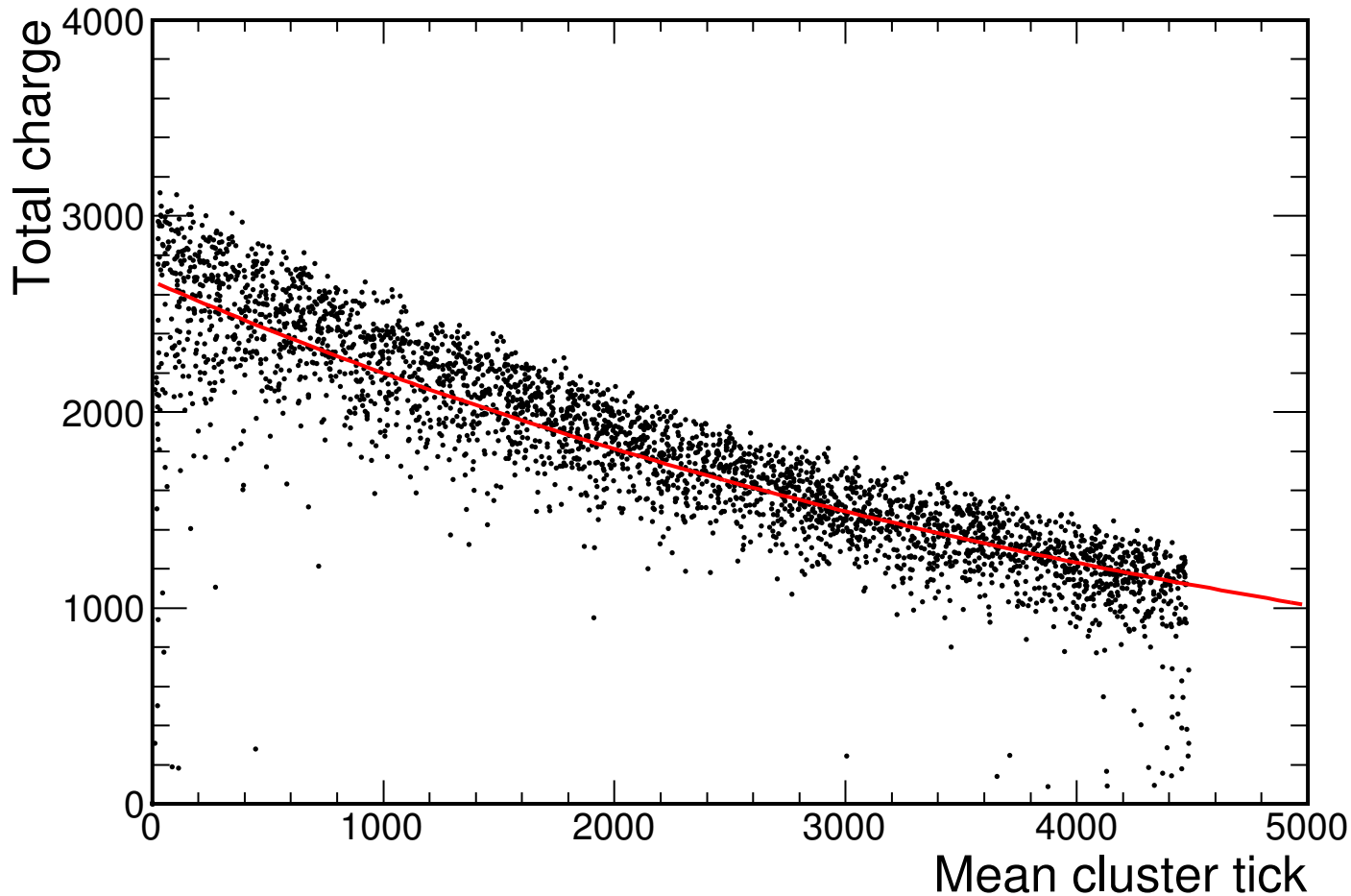
- totq $\rightarrow$ totq $\times \exp(|X_{\text{true}}|/429)$
- Width = 8.7% (fit), 13.5% (RMS)

We can measure position from time



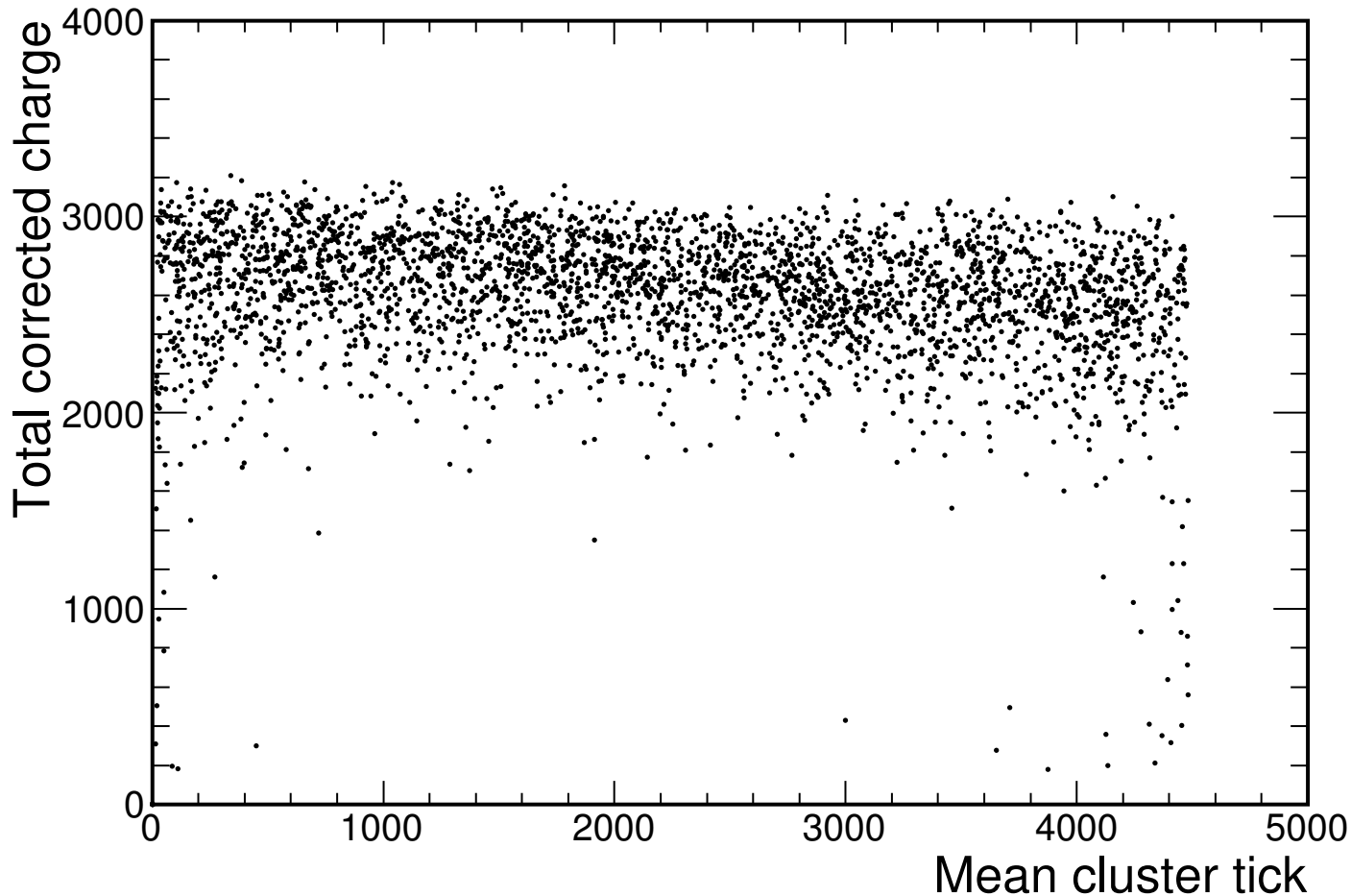
- Weighted average of all cluster first and last times
- Conversion 0.081 cm/tick. Tick = 500ns $\rightarrow$ drift velocity 1.6m/ms

Attenuation vs reco position



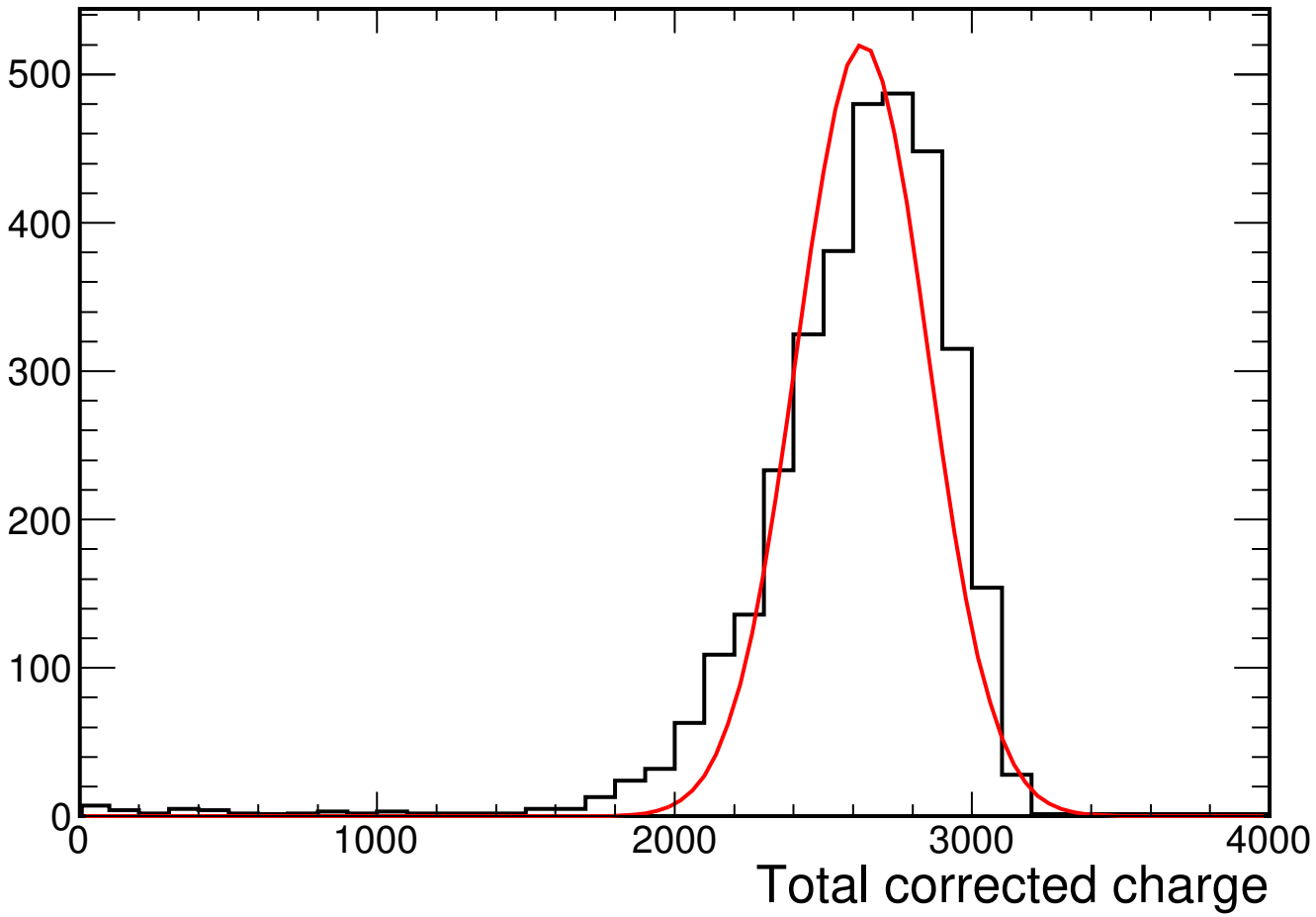
- Attenuation 5451 ticks
- Converts to 436cm, consistent with truth

Corrected charge vs reco position



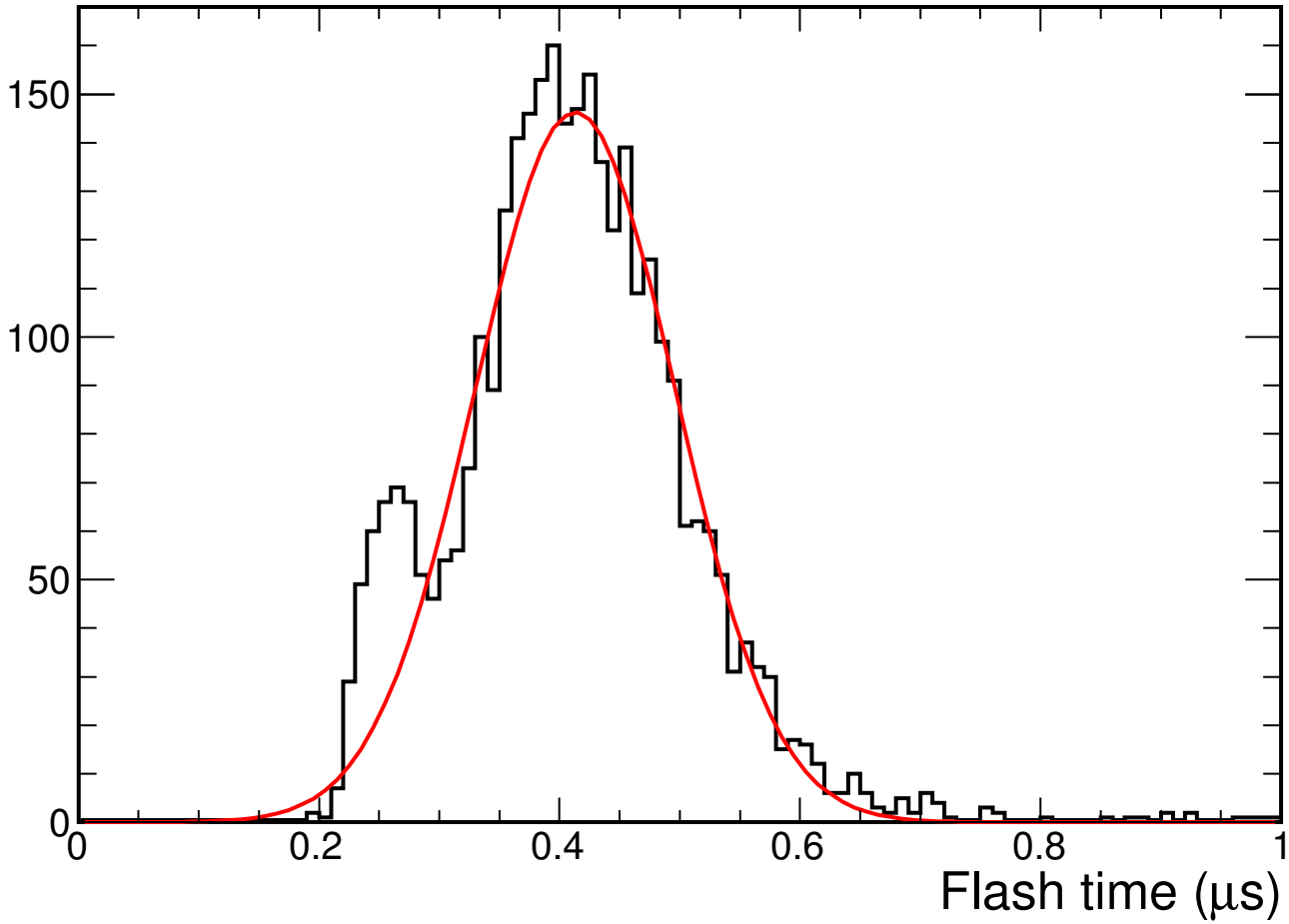
- totq $\rightarrow$ totq $\times$ exp(tick/5451)

Charge corrected by reco position



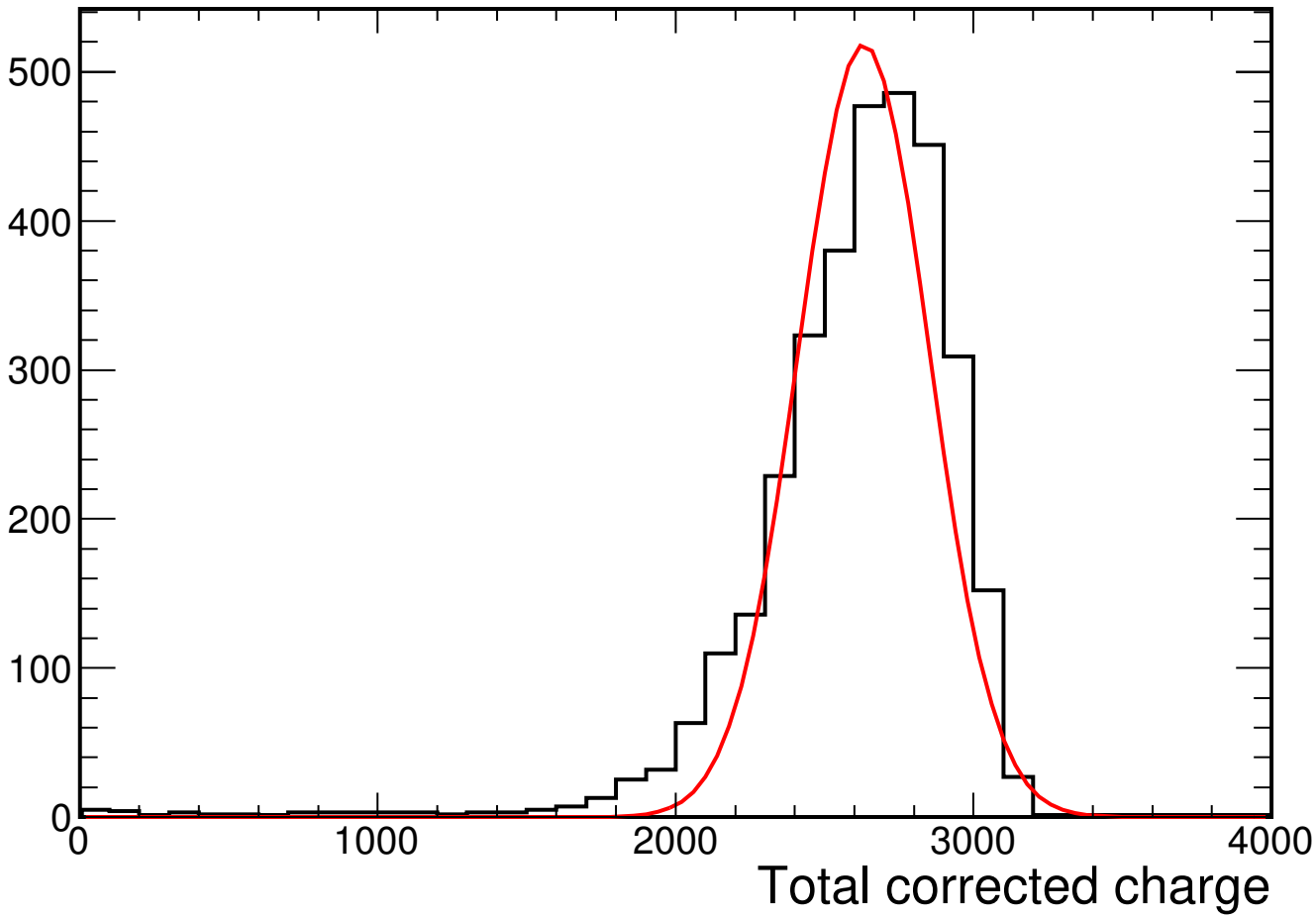
- totq $\rightarrow$ totq $\times$ exp(tick/5451)
- Width = 8.3% (fit), 13.7% (RMS)

How well can we measure flash time?



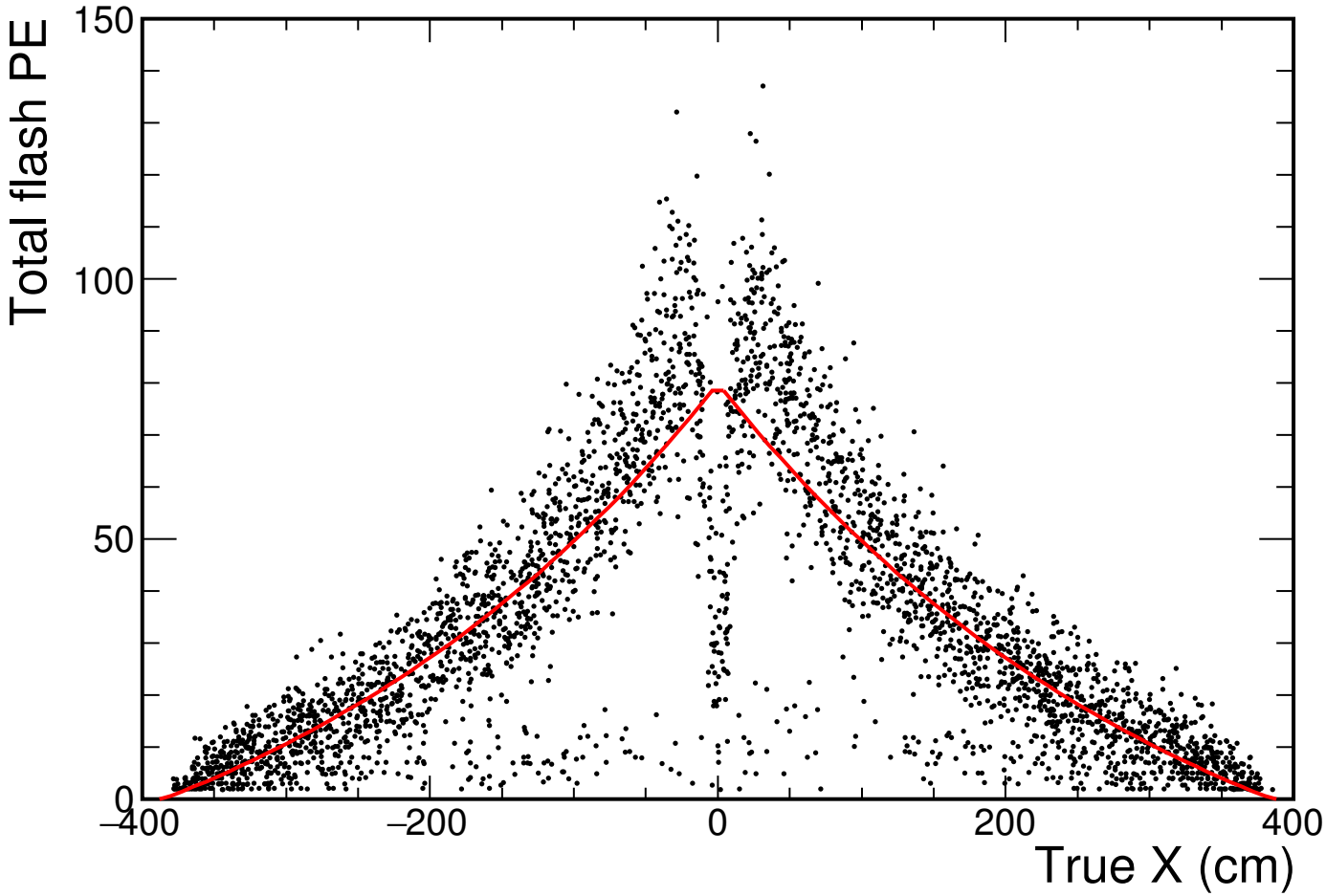
- `flash.Time()` for flash with the largest `flash.PE()`
- Error: 0.084μs $\rightarrow$ only 0.1mm position error

Full correction



- totq $\rightarrow$ totq $\times \exp((\text{tick} - t_{\text{flash}})/5451)$
- Width = 8.3% (fit), 13.4% (RMS)

Light loss



- Light "attenuation length": 330cm

Results summary

	Fit	RMS
Raw	26%	29%
Truth corr	8.7%	13.5%
Tick corr	8.3%	13.7%
"Realistic" corr	8.3%	13.4%

Future work

- Add Ar^{39}
- Check clustering in the realistic case $\rightarrow$ develop slicer?
- Check photon signals in realistic case $\rightarrow$ develop matching alg?