Validation checks for CR track reconstruction in 3x1x1

V. Galymov

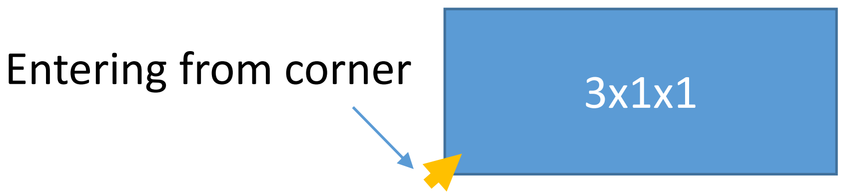
SB Meeting 06.07.2016

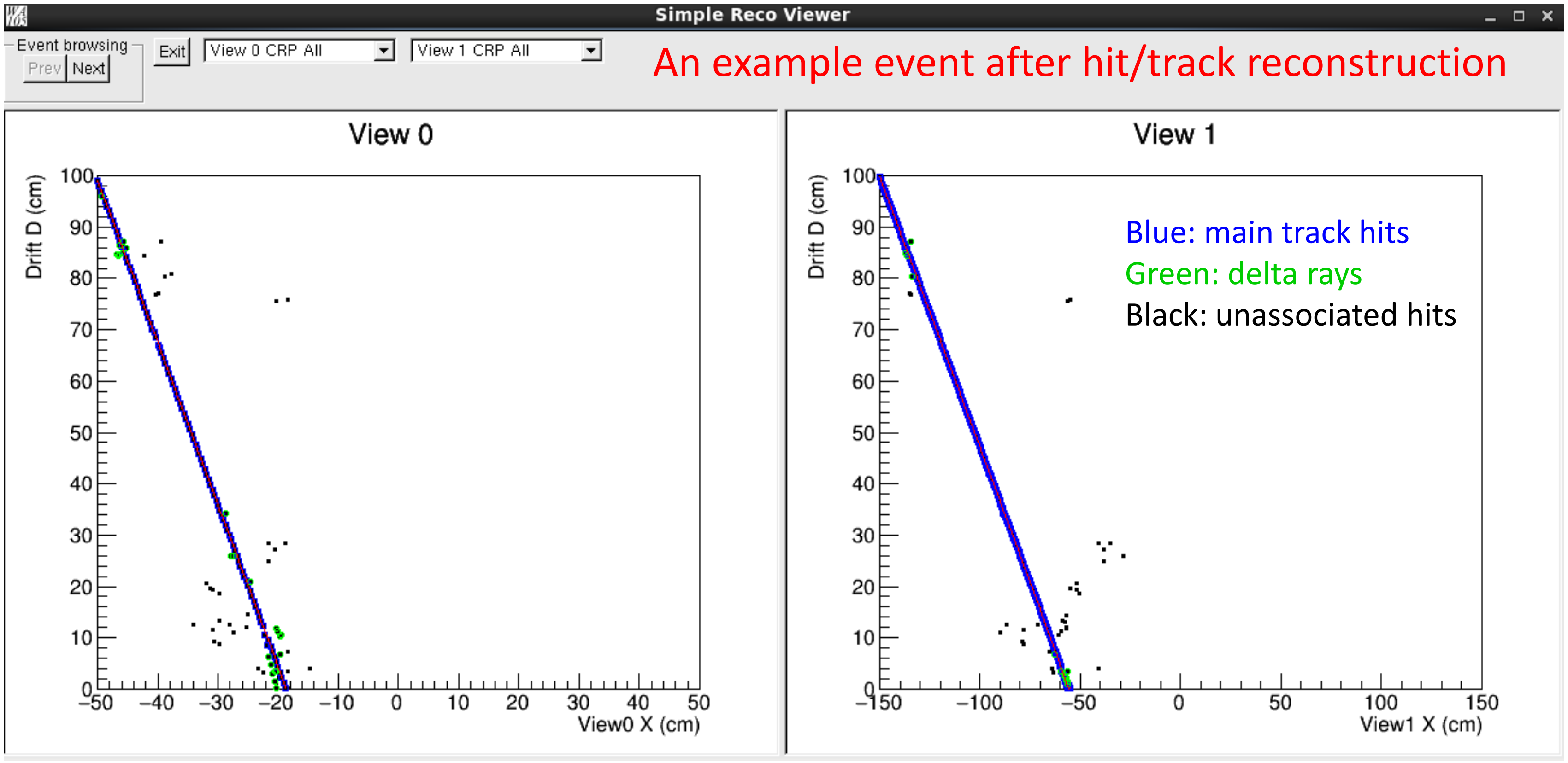
Introduction

- Initial studies on gain calibration with CR flux in 3x1x1 has been shown in the past SB
- Now look in detail at the reconstruction performance
- Use sample of muons with well defined input direction / momenta to look for systematic effects in track reconstruction
- Will also show some results produced with a basic online analysis program for looking at dQ/dx

Muon samples

Events: 1000
Momenum: 4, 40 GeV/c
Polar angle: 45 deg
Azimuthal angle: 72 deg
Gain per view: 10

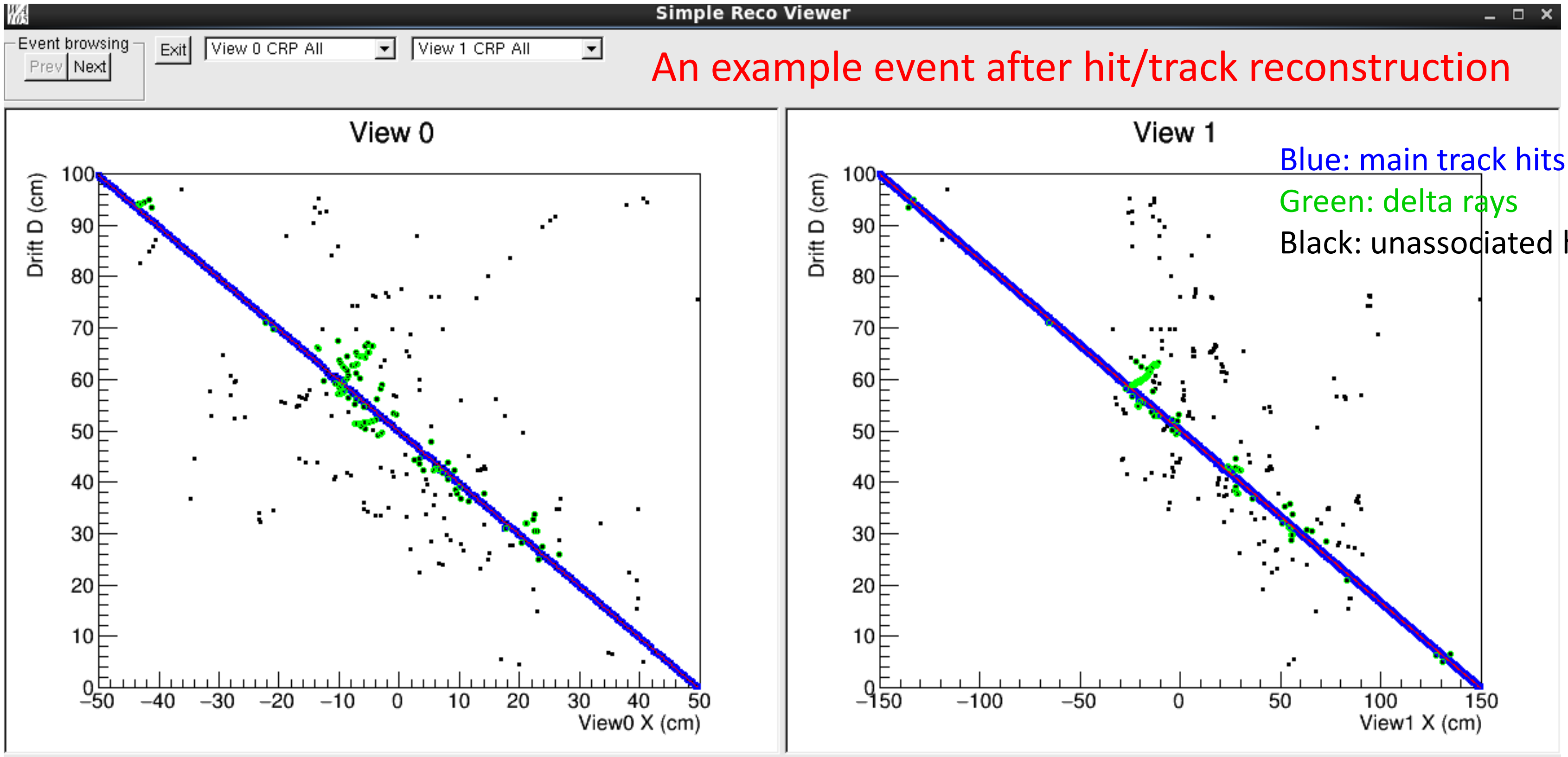




Muon samples: across diagonal

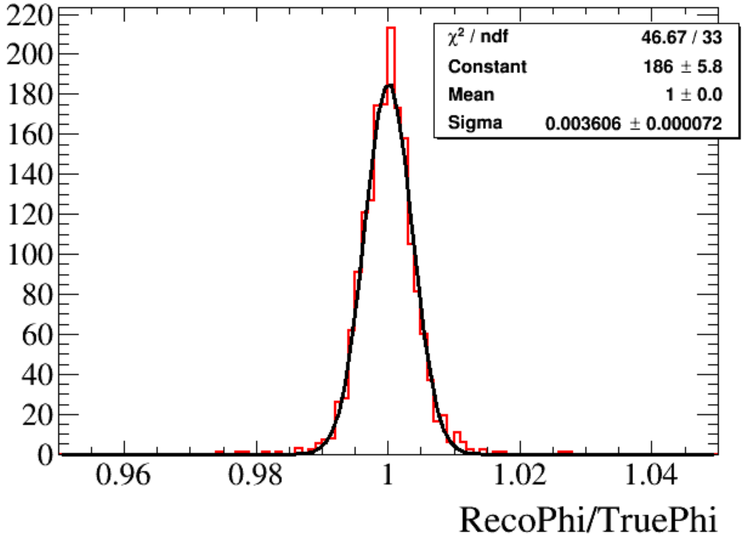
Events: 1000
Momenum: 4, 40 GeV/c
Polar angle: 72 deg
Azimuthal angle: 72 deg
Gain per view: 10

Entering from corner

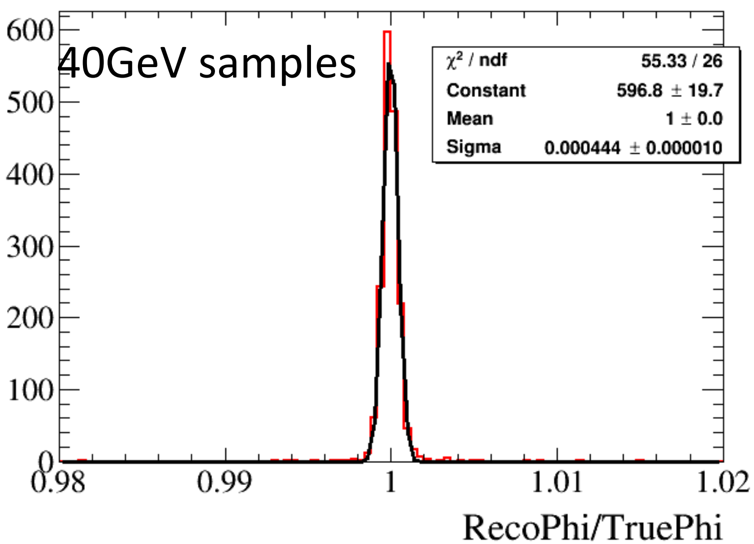


Azimuthal angle (angle in CRP plane)

4GeV samples



40GeV samples



The azimuthal angle is reconstructed from the fitted tangent in each view (S_x & S_y) at the beginning of each track

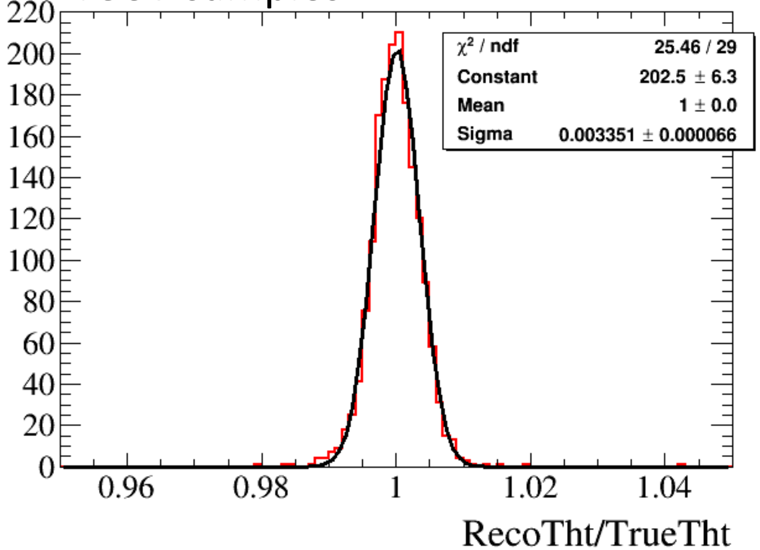
The tangents are calculated from the first ~20 points of the track ~10-20cm depending on the direction / views

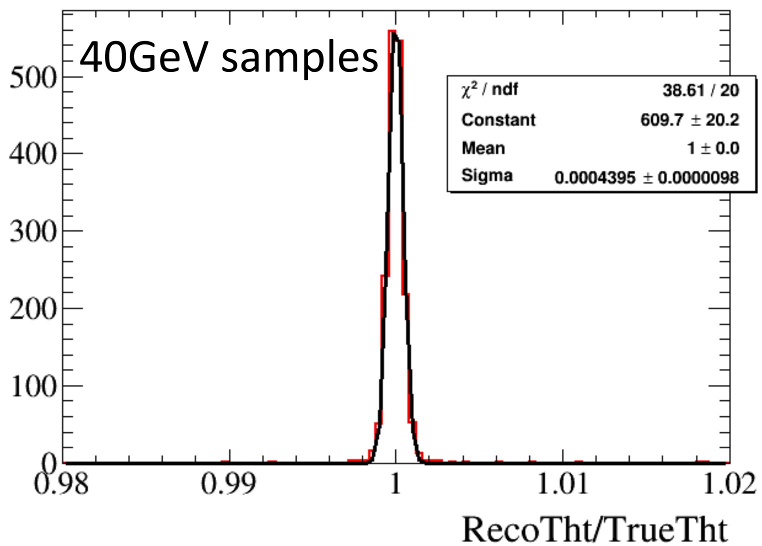
➔ Not negligible compared to X_0 (~14cm)

Since MS goes as 1/p expect sigma ~10 smaller for 40GeV samples compared to 4GeV

Polar angle (angle wrt z[drift] axis)

4GeV samples

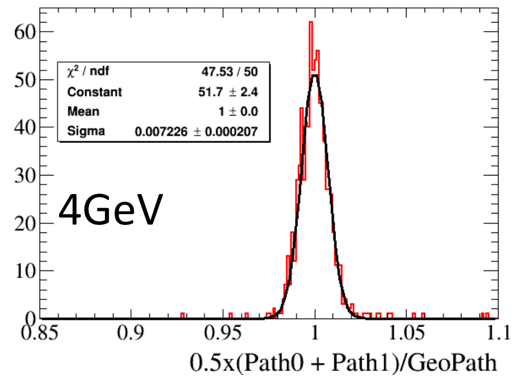


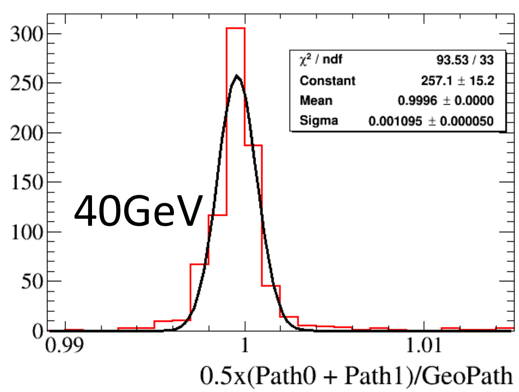


The polar angle is reconstructed from the fitted direction in each view (S_x & S_y) at the beginning of each track and the corresponding reconstructed azimuthal angle

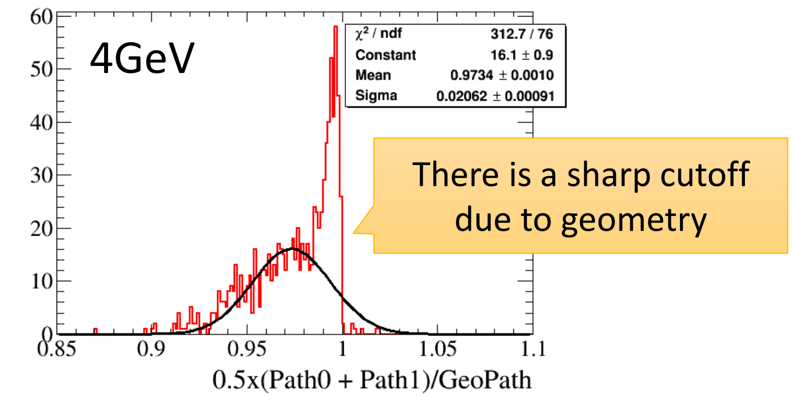
3D path lengths

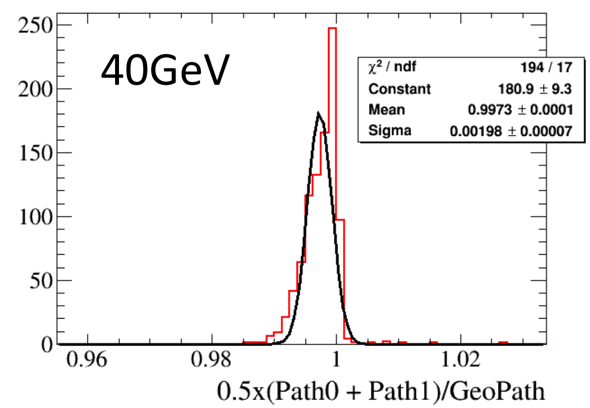
Polar angle: 45 deg
Azimuthal angle: 72 deg
Geo path length = 1414.2 mm



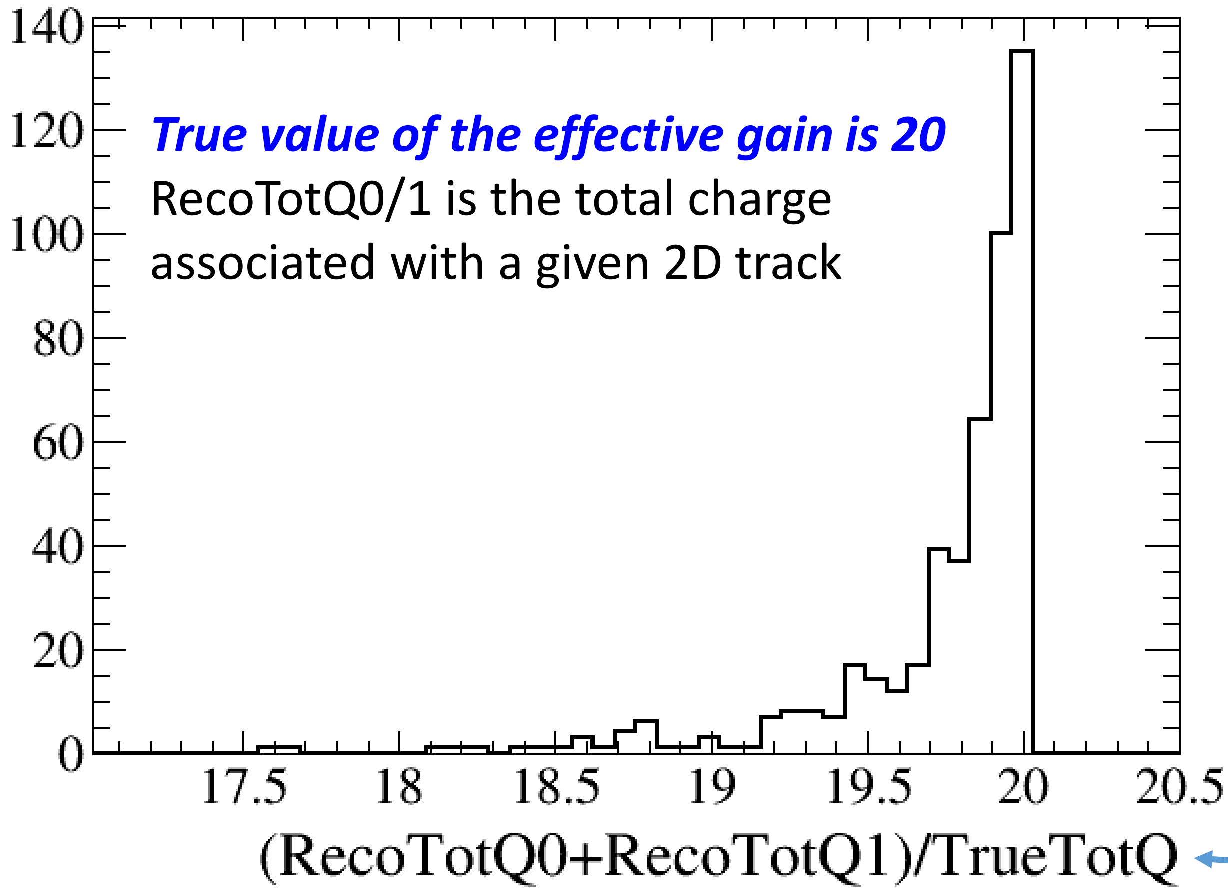


Polar angle: 72 deg
Azimuthal angle: 72 deg
Geo path length = 3316.6 mm
$(= \sqrt{3^2 + 1 + 1}\text{m})$





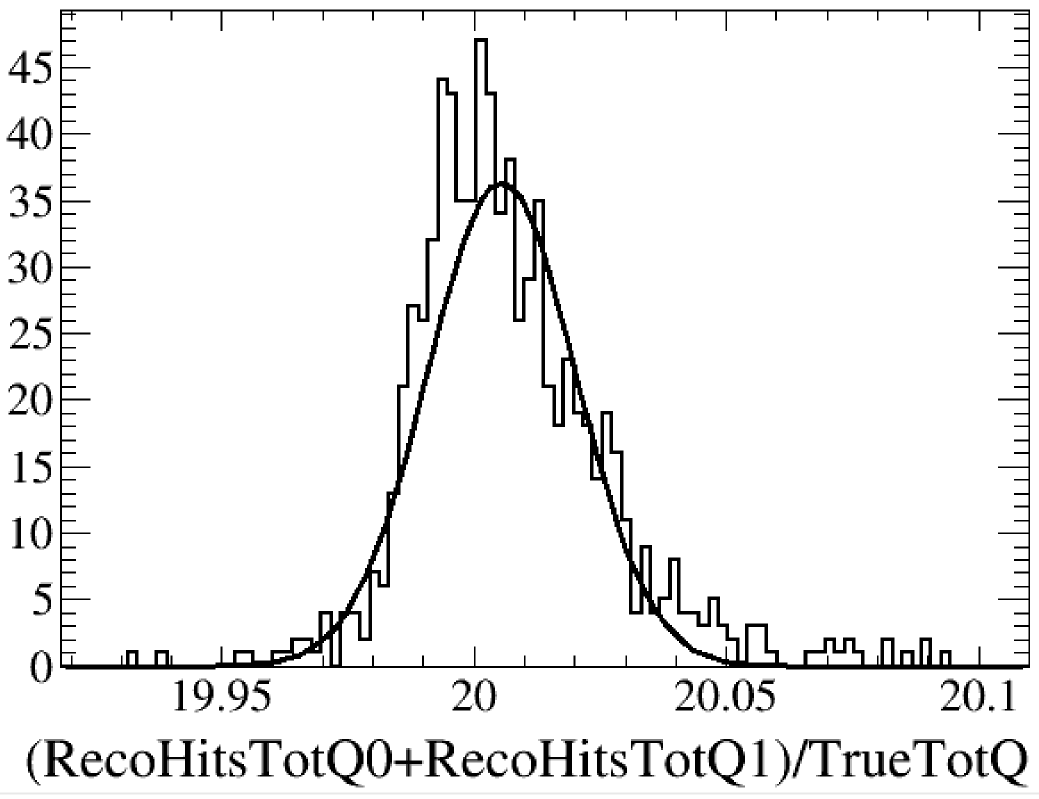
Total charge budget



From total deposited E after quenching

Where do we loose charge?

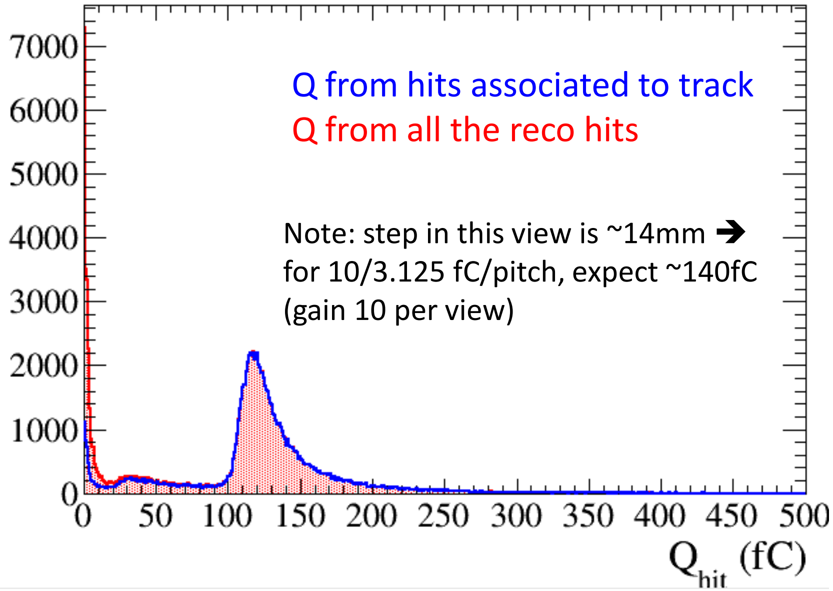
Sum of charge from all reconstructed hits gives a correct answer, i.e., 20 (= true effective gain)

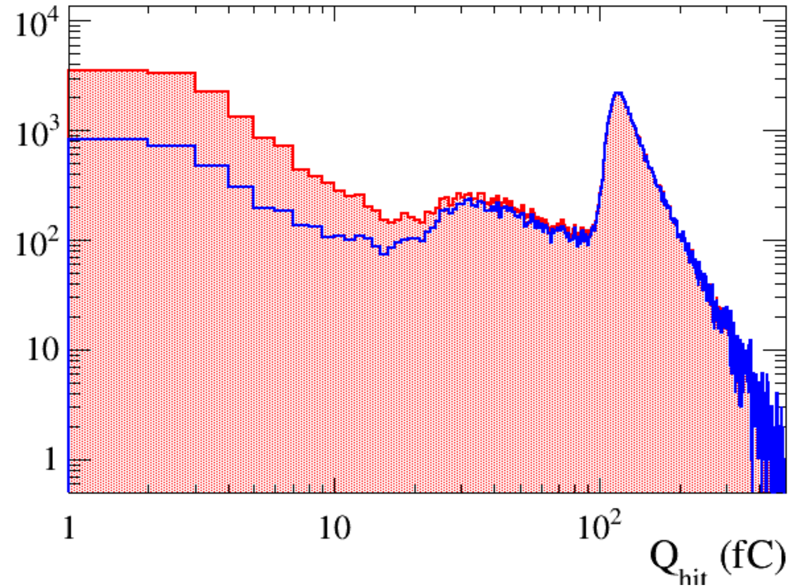


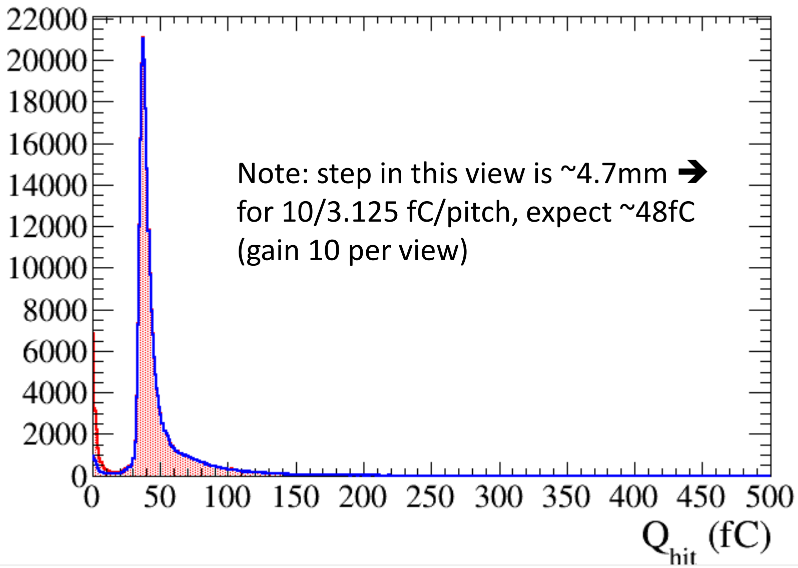
The total charge seen from the hits matches the true deposited energy

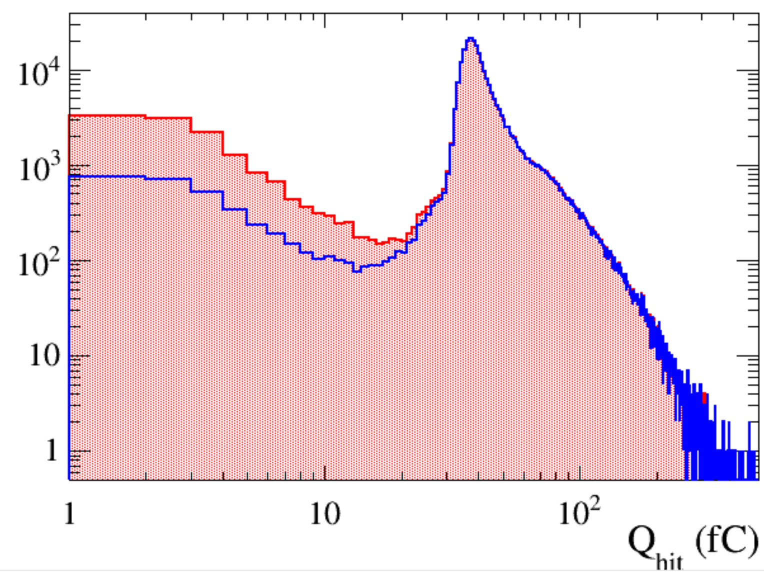
Where do we loose charge?

Example for 4 GeV muon sample with $\theta = 45°$



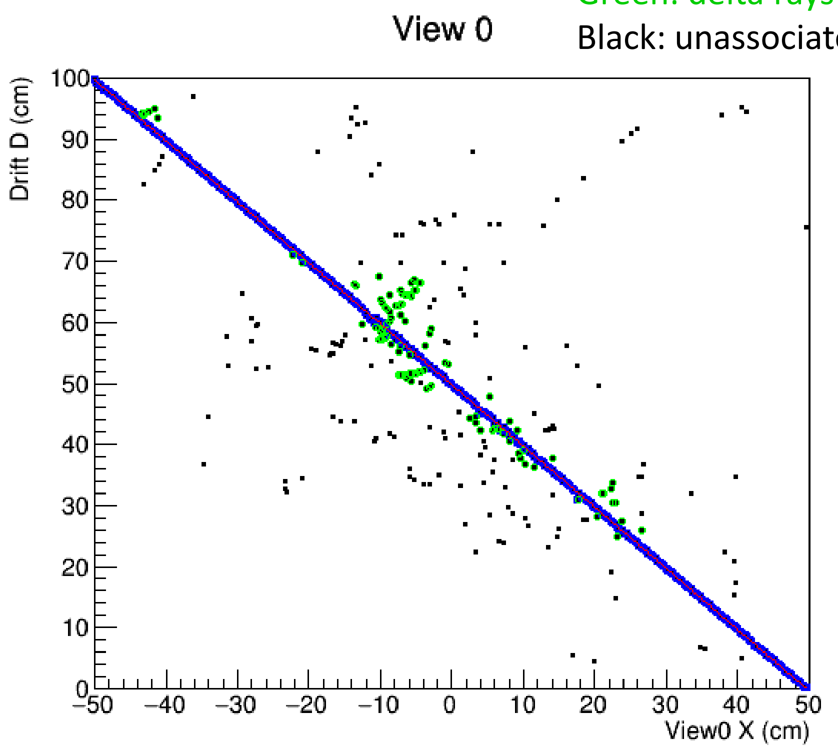


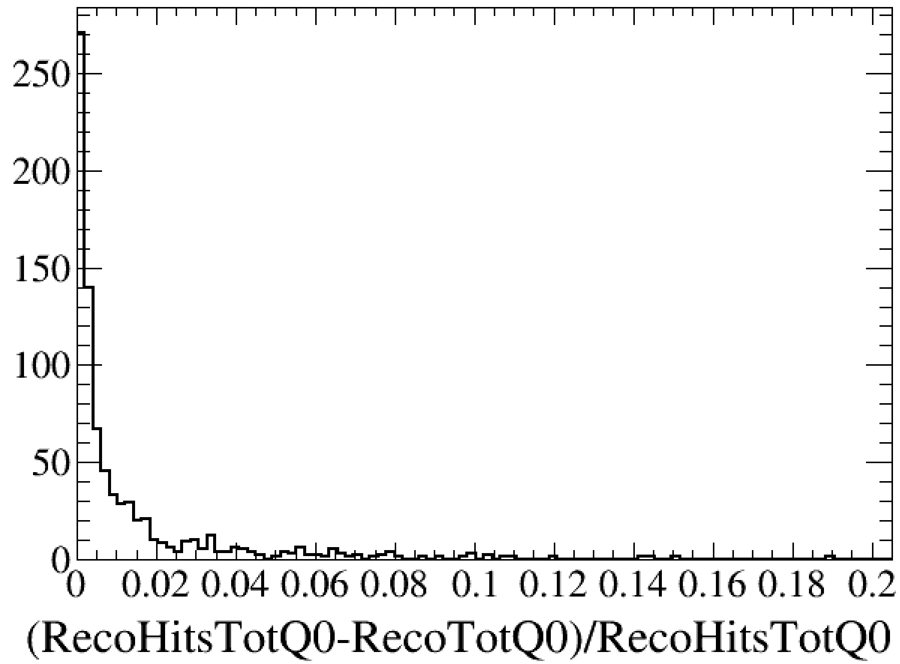




Where do we loose charge

Blue: main track hits
Green: delta rays
Black: unassociated hits



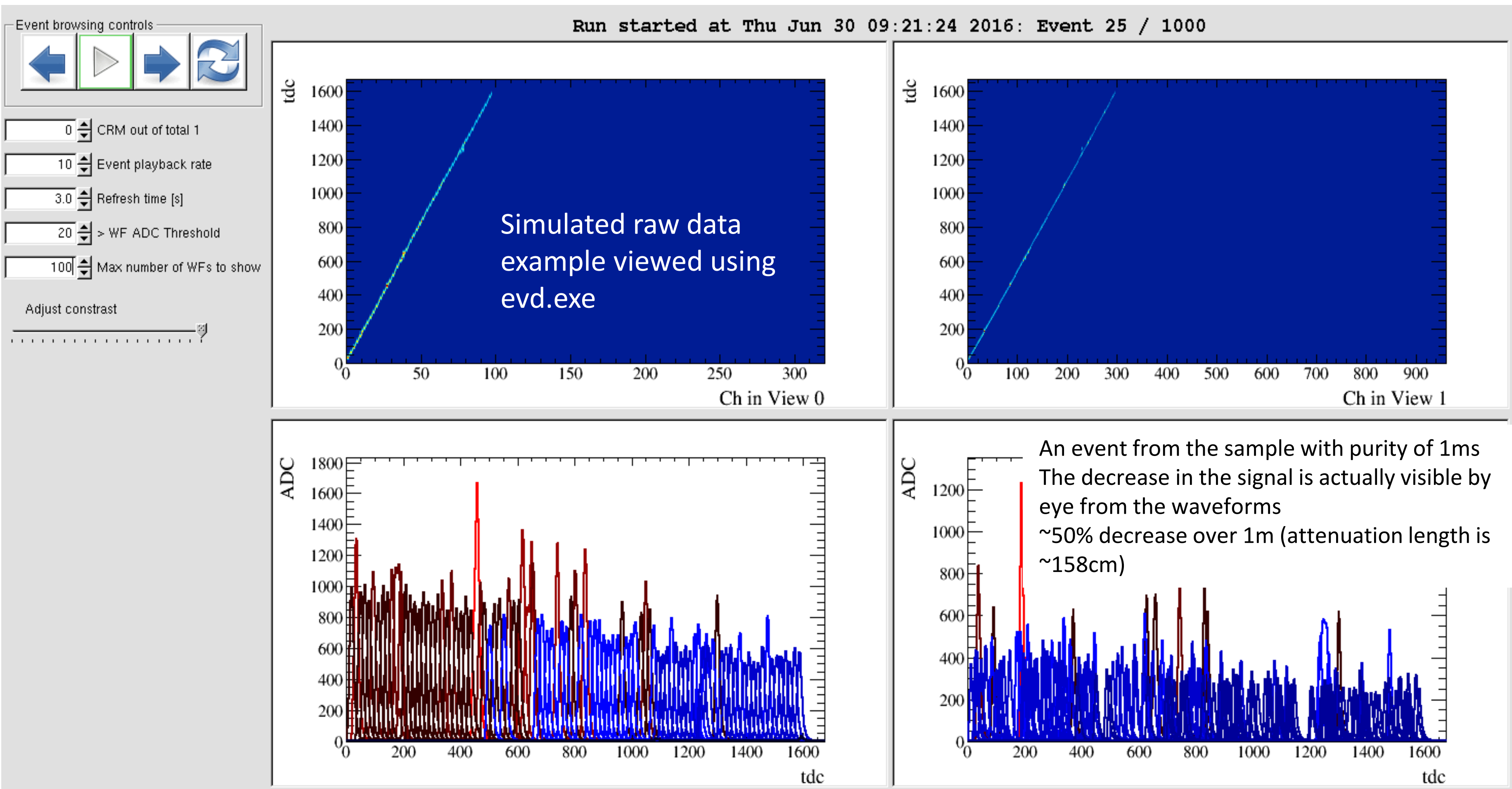


The track reconstruction is not picking up hits from isolated charge depositions or disconnected small or few hit clusters (brem photons)
This is about 1-2% of total charge which is missing from track on average

Downward muon samples

Events: 1000 per each sub-sample
Momenum: 4 GeV/c
Polar angle: 135 deg
Azimuthal angle: 72 deg

Gain per view: 10
Purity: inf, 1ms (to better see the effect over 1m drift), 3ms



dE/dx comparison

Charge per step after purity correction

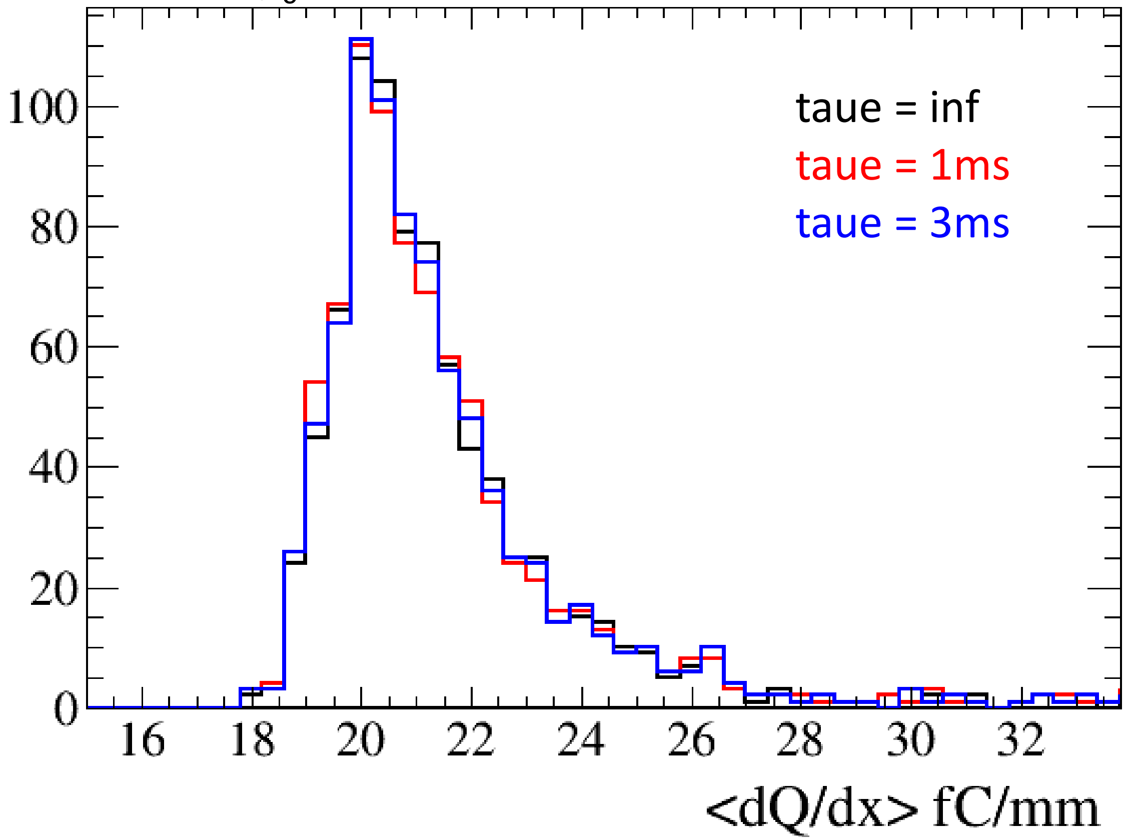
$$< dQ/dx > \equiv < dQ/dx >_0 + < dQ/dx >_1 = \frac{\sum \Delta Q_{0,i}}{\sum \Delta s_{0,i}} + \frac{\sum \Delta Q_{1,i}}{\sum \Delta s_{1,i}}$$

Total Q loss

Total path length

Effective 3D step

Muons, p_0 = 4 GeV/c



CR dEdx basic analysis example

[svn] / WA105Soft / anautils

Index of /WA105Soft/anautils

See CRTrackAnaDEDX for basic analysis

```
int Process( const LArReco::Track2d* trk0,
             const LArReco::Track2d* trk1 );
```

Provide two 2D tracks matched b/w two views

```
std::vector<TVector3> &Get3dPath0(){ return fPath3dTrk0; }
std::vector<double> &GetQloss0(){ return fDqTrk0; }

std::vector<TVector3> &Get3dPath1(){ return fPath3dTrk1; }
std::vector<double> &GetQloss1(){ return fDqTrk1; }

double GetMeanQloss0() const { return fMean_dQdx0; }
double GetMeanQloss1() const { return fMean_dQdx1; }
double GetTotalQloss0() const { return fTotal_Q0; }
double GetTotalQloss1() const { return fTotal_Q1; }
double GetTotalPath0() const { return fPathLen0; }
double GetTotalPath1() const { return fPathLen1; }
```

```
// should be in micro seconds !!!
void SetLifetime( double val )
{
  fLifetime = val;
  fEleAtten = fVdrift * fLifetime;
}
```

Set measured electron lifetime (for MC could also get pick up true value from the run header)

CR dEdx basic analysis example

[svn] / WA105Soft / anautils

Index of /WA105Soft/anautils

See CRTrackAnaDEDX for basic analysis

```
int Process( const LArReco::Track2d* trk0,
             const LArReco::Track2d* trk1 );
```

```
std::vector<TVector3> &Get3dPath0(){ return fPath3dTrk0; }
std::vector<double> &GetQloss0(){ return fDqTrk0; }

std::vector<TVector3> &Get3dPath1(){ return fPath3dTrk1; }
std::vector<double> &GetQloss1(){ return fDqTrk1; }

double GetMeanQloss0() const { return fMean_dQdx0; }
double GetMeanQloss1() const { return fMean_dQdx1; }
double GetTotalQloss0() const { return fTotal_Q0; }
double GetTotalQloss1() const { return fTotal_Q1; }
double GetTotalPath0() const { return fPathLen0; }
double GetTotalPath1() const { return fPathLen1; }
```

```
// should be in micro seconds !!!
void SetLifetime( double val )
{
  fLifetime = val;
  fEleAtten = fVdrift * fLifetime;
}
```

After processing the event can get several relevant quantities

1. $dQ/dx_{0,1}$ and associated 3D path points after purity correction
   - Could book accumulators in a given CRP area or even at the level of each ch (i.e., $3x3mm^2$ area) for gain measurements
2. Total charge reconstructed in each view after purity correction
3. Total reconstructed 3D path length
4. <dQ/dx> = Total reco Q / Total reco path length

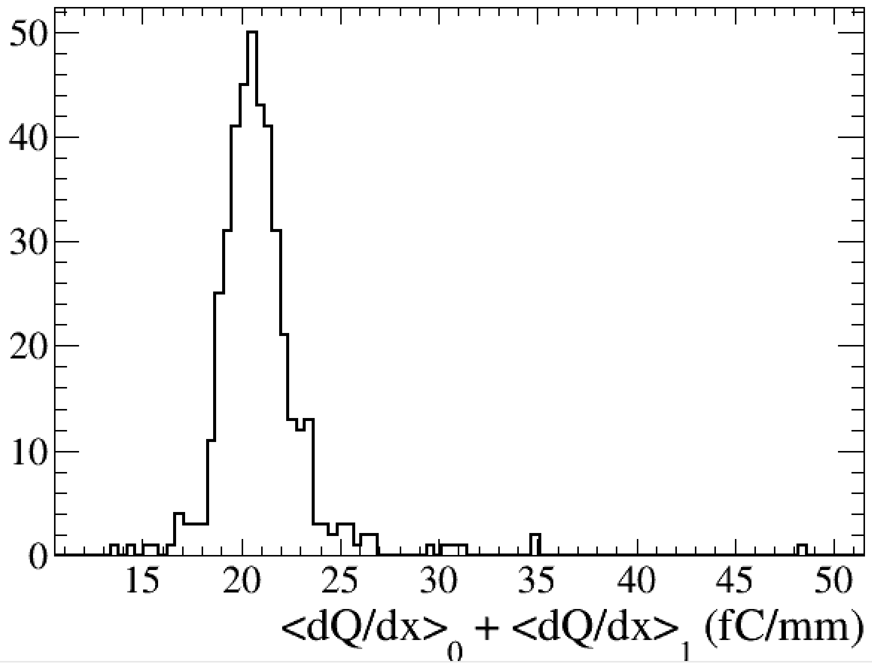
It should be possible using these quantities to build a variety of distribution / plots for online monitoring of CRP gain

Example distributions

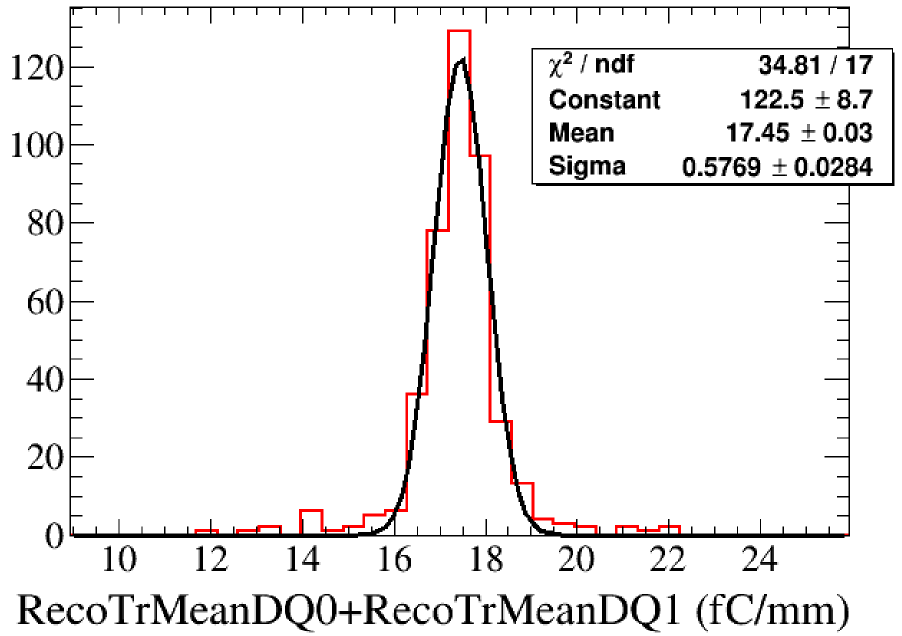
Prepared a small sample of 1000 CR in 3x1x1 detector: no pre-selection on direction or path, i.e., trigger counter planes

The distributions are built from ~500 CR selected for analysis in this study

Sum of mean dQ/dx from each view



Truncated means

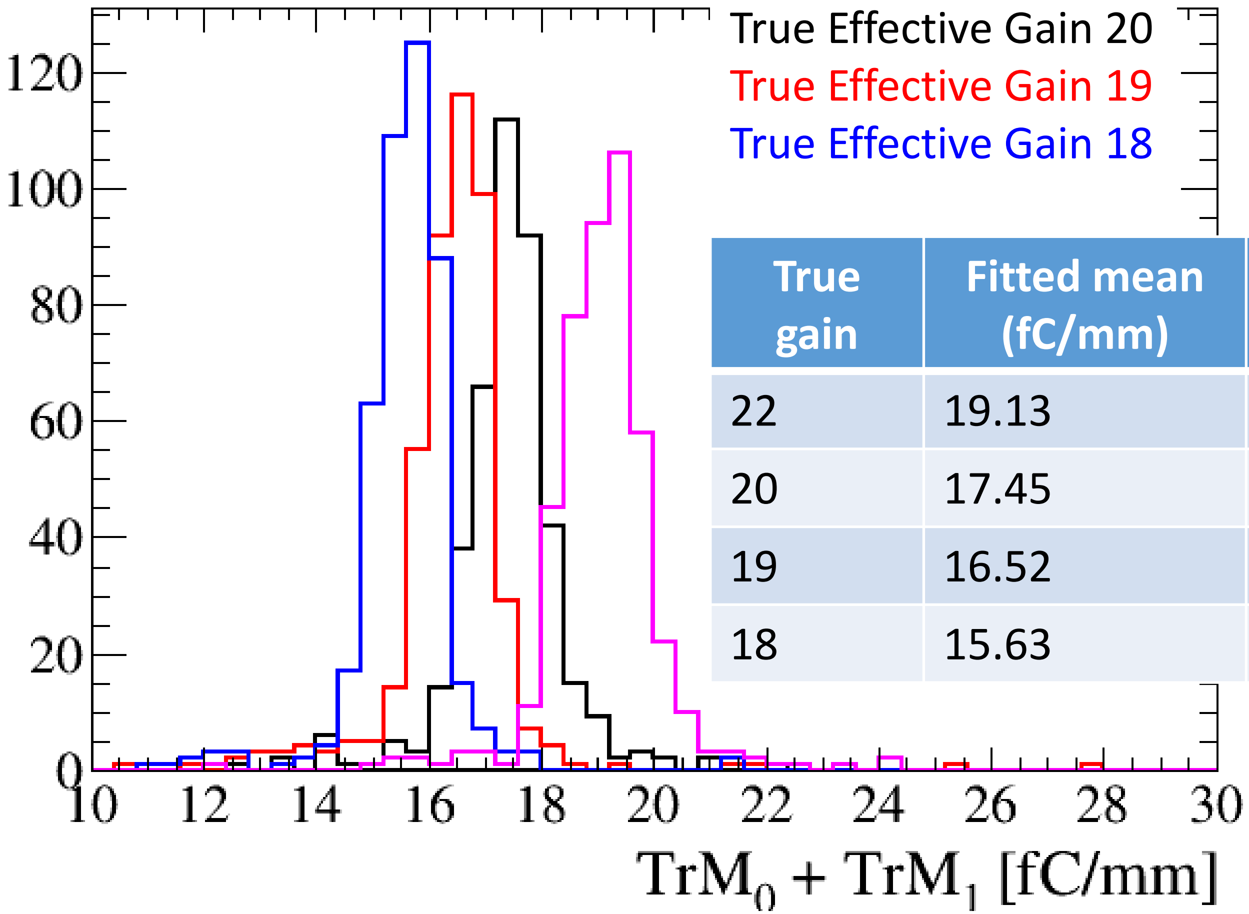


To look at relative gain differences between different CRP segments should try to use truncated mean, since this distribution is much narrower (σ ~ 3% in this example) giving a better sensitivity to possible gain variations from region to region

Example distributions

Look for gain variation using reco CR tracks

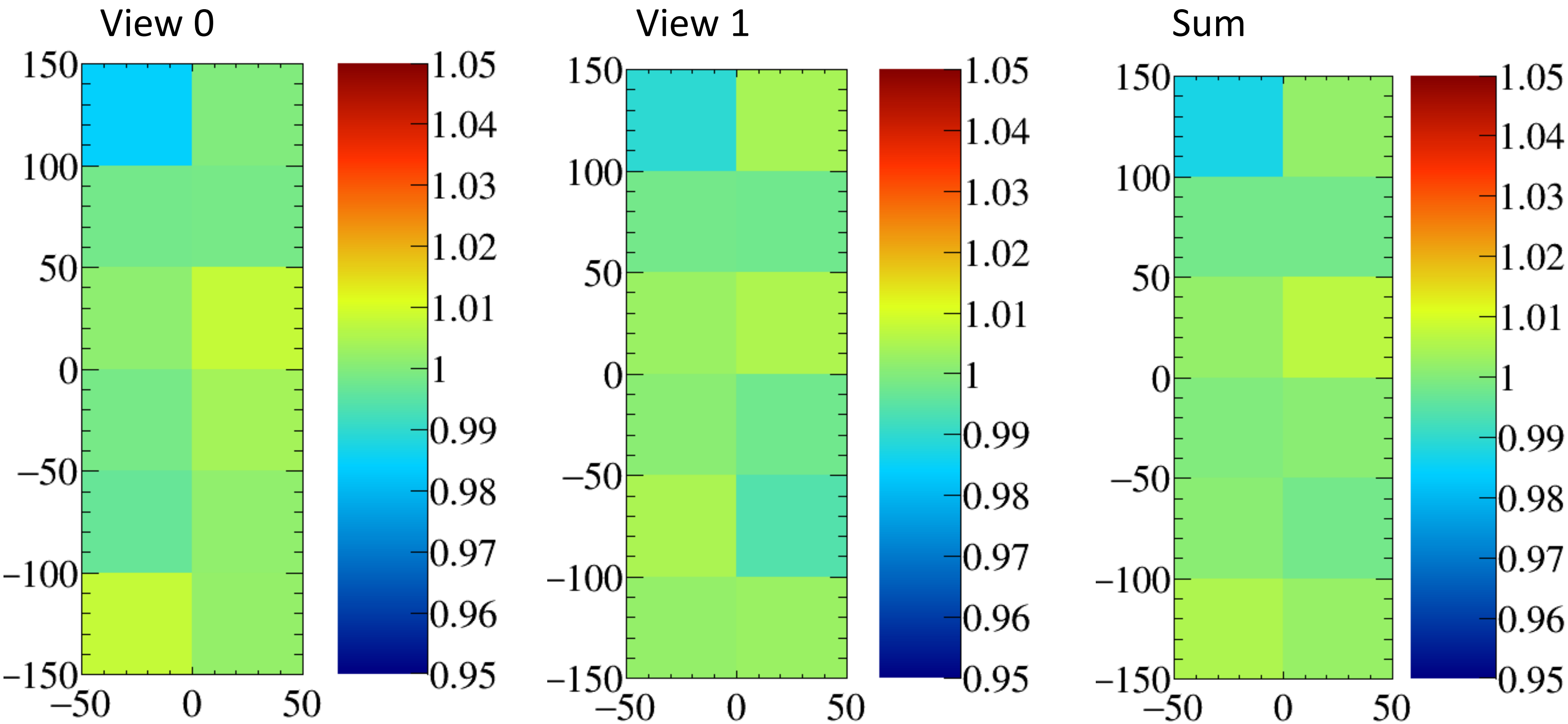
Truncated means



True gain	Fitted mean (fC/mm)	Ratio to nominal	Expected ratio
22	19.13	1.096	1.10
20	17.45	--	--
19	16.52	0.947	0.95
18	15.63	0.896	0.90

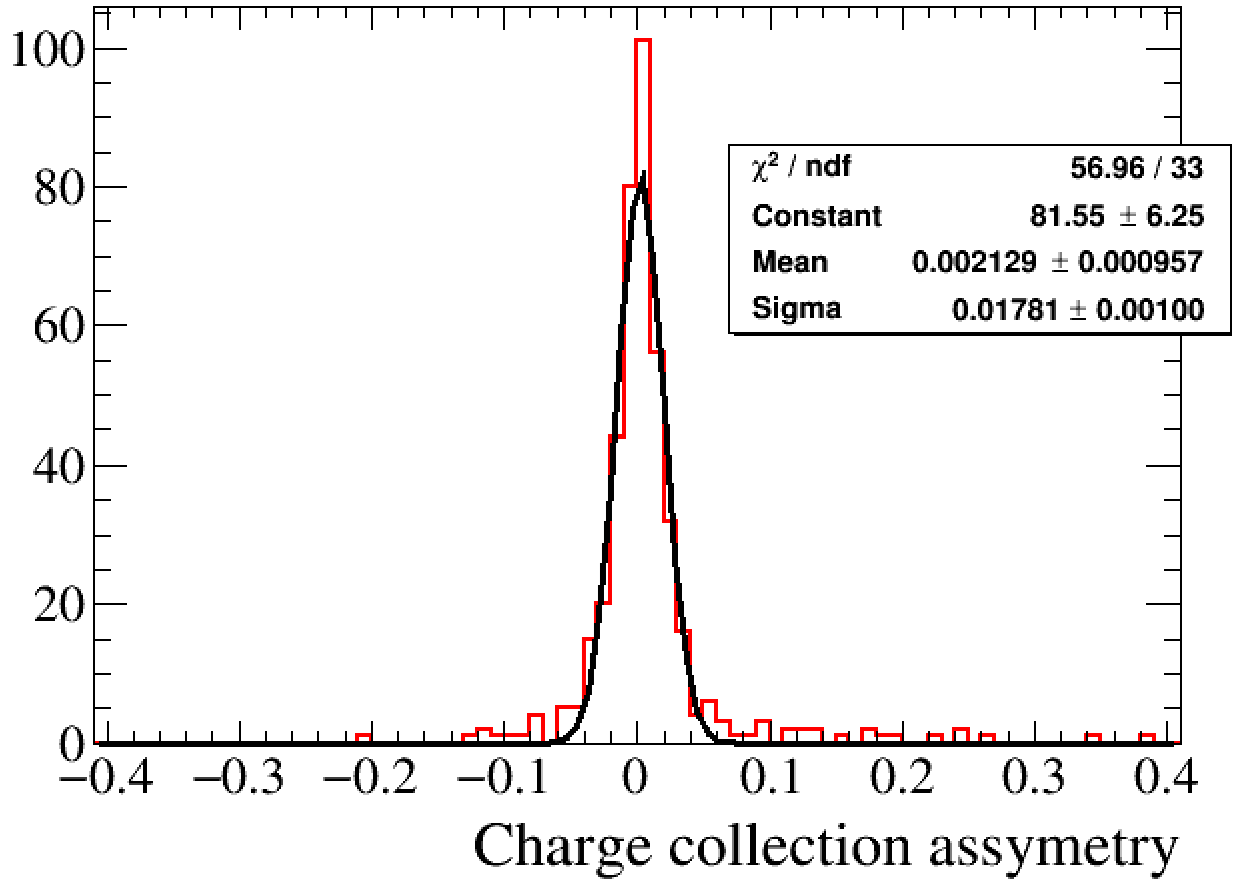
Can reproduce simulated gain change to within a fraction of a percent with ~500 CR tracks

Truncated mean dQ/dx from track points seen by each LEM normalized to Tr<dQ/dx> from all track points ← average over all LEMs (but could also take one of the LEMs as a reference and normalized others wrt it)



The changes seen here from LEM to LEM <2% are due to fluctuations (should be reduced with larger statistics → to check) as all LEMs have equal gain in MC
To give an idea: from ~500 CR one has ~4000 dQ/dx (but 30% of them are then truncated) samples per 50x50cm^2

Charge sharing between collection views



$$F = \frac{< dQ_0/dx > - < dQ_1/dx >}{< dQ_0/dx > + < dQ_1/dx >}$$

➔ Should be 0 for equal charge sharing

The End

- Showed example distributions produced from a basic dQ/dx analysis that could be integrated into online monitoring
  - Of course each quantity of interest should be monitored as function of time as well
- Code is committed

- Format of the raw data files produced by DAQ has been defined
- Need to add the decoder functions to the event manager for reconstruction / event viewing
  - For uncompressed data stream
  - Compressed data stream
- Once finished will run benchmarking to ensure get identical results