AC-LGAD Feb2021 Testbeam

Si Xie

California Institute of Technology & FNAL
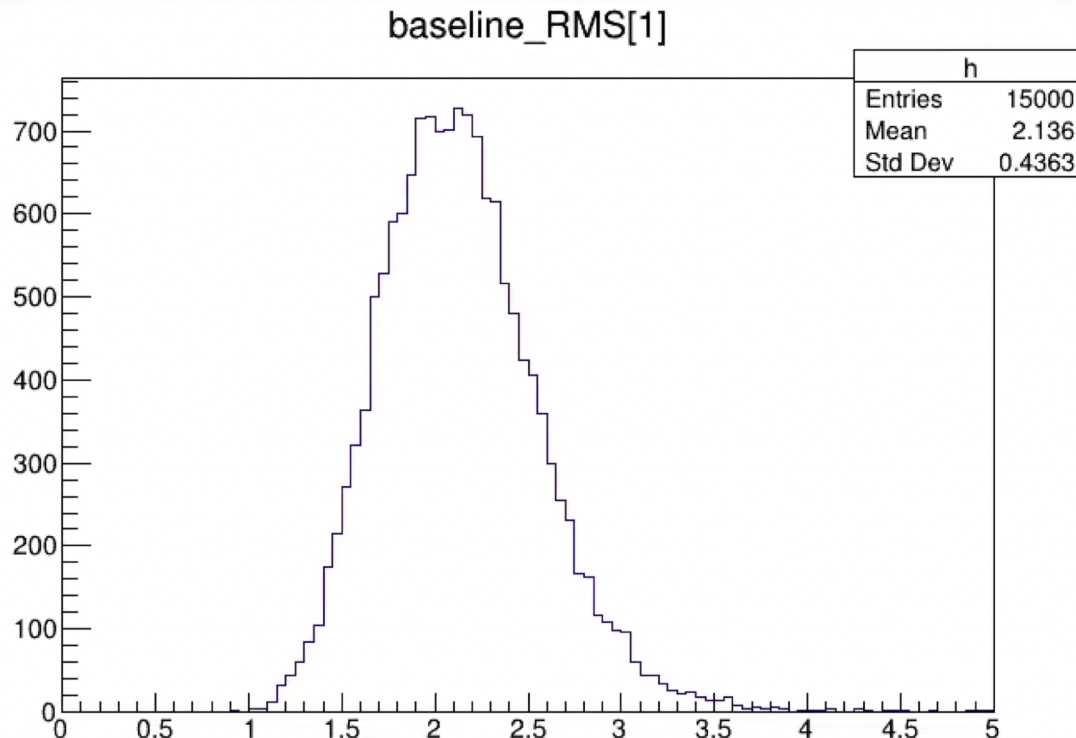
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???

03/30/2021

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Noise

Baseline RMS peaked at 2mV – checked that each channel (1-6 for BNL2020 sensor) all have the same baseline RMS

- The DC guard ring (ch0) had baseline RMS = 2.6mV

Let's try to go to 3x baseline RMS = 6mV threshold
If it's too low, then we go to 5x baseline RMS = 10mV threshold
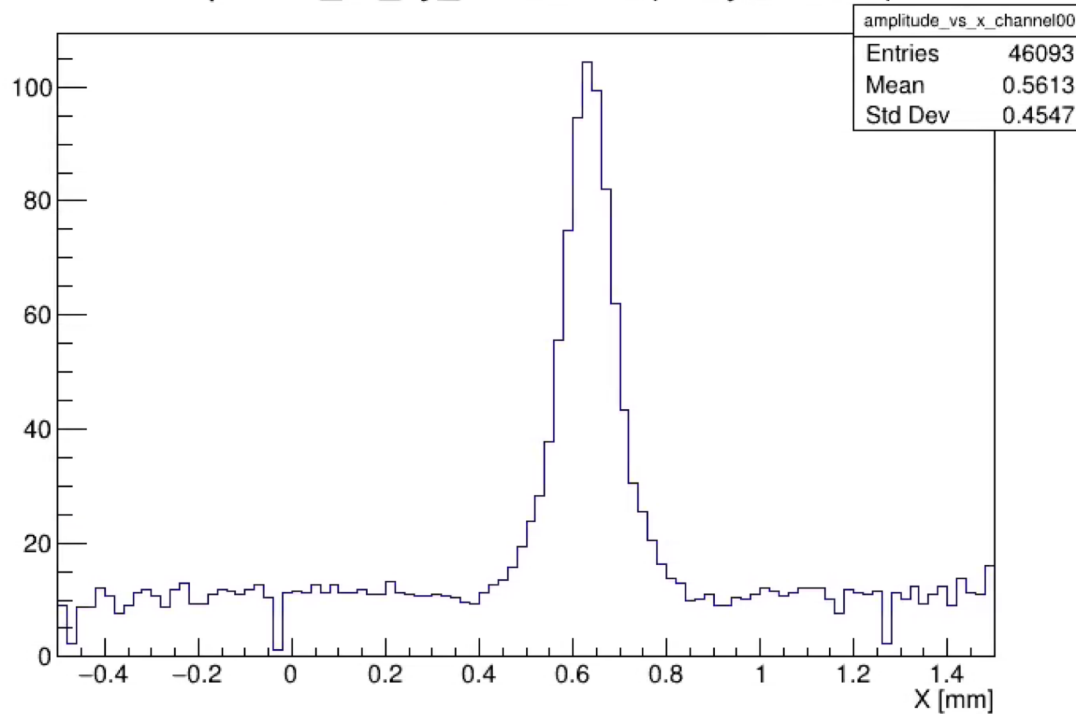
Langaus fits

To make amplitude vs X plots, we take the 3D histogram (amp/X/Y), project to 2D (amp/X), and then take slices in X. Then we fit the amp histogram in each slice with a langaus, in the range (histMean – histRMS , histMean + 3*histRMS)

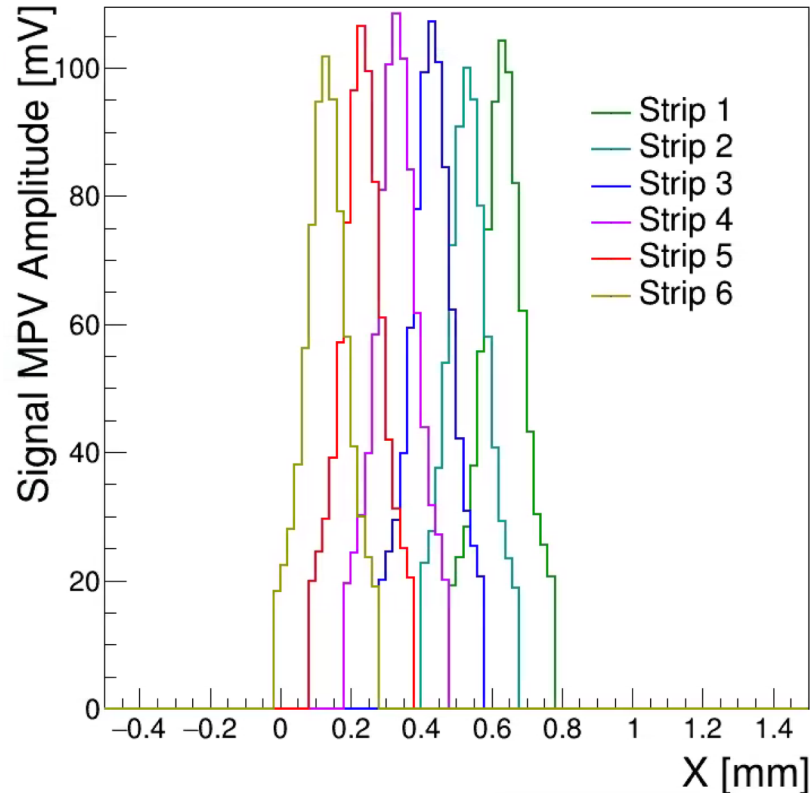- Seems to work pretty well in majority of cases

Noise only

Small signal
Near edge of strip

big signal
Near center of strip

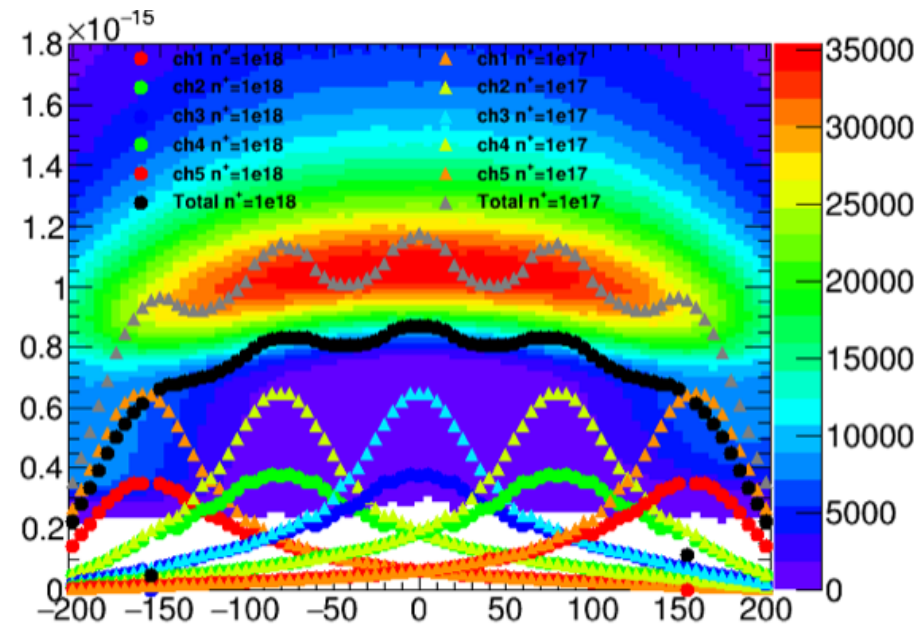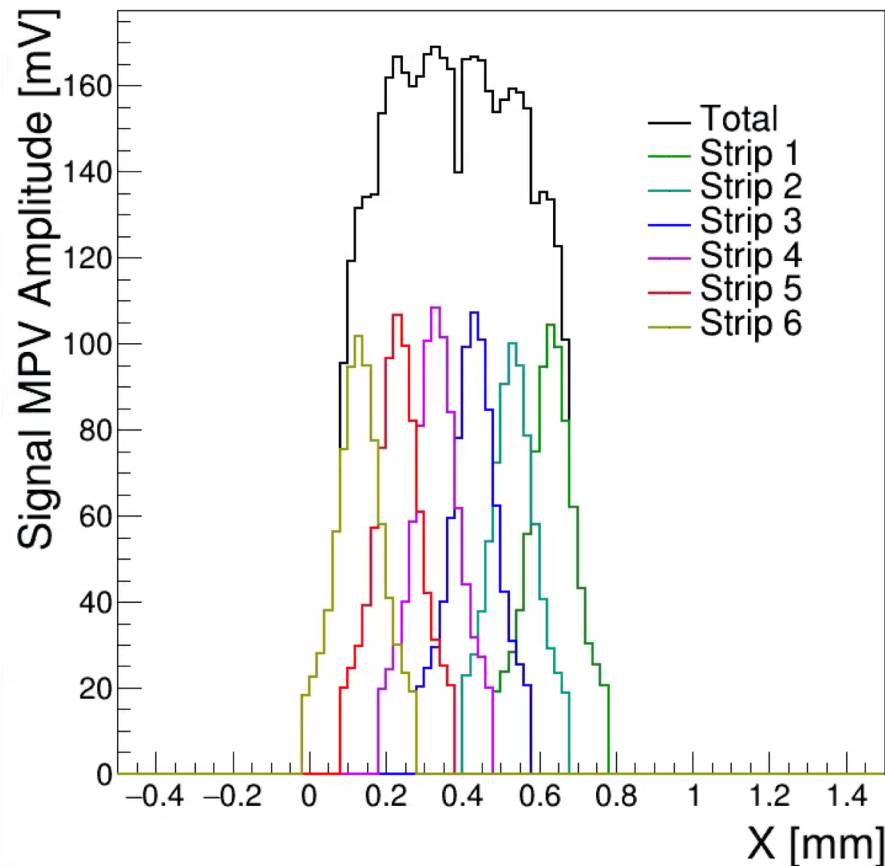Caltech
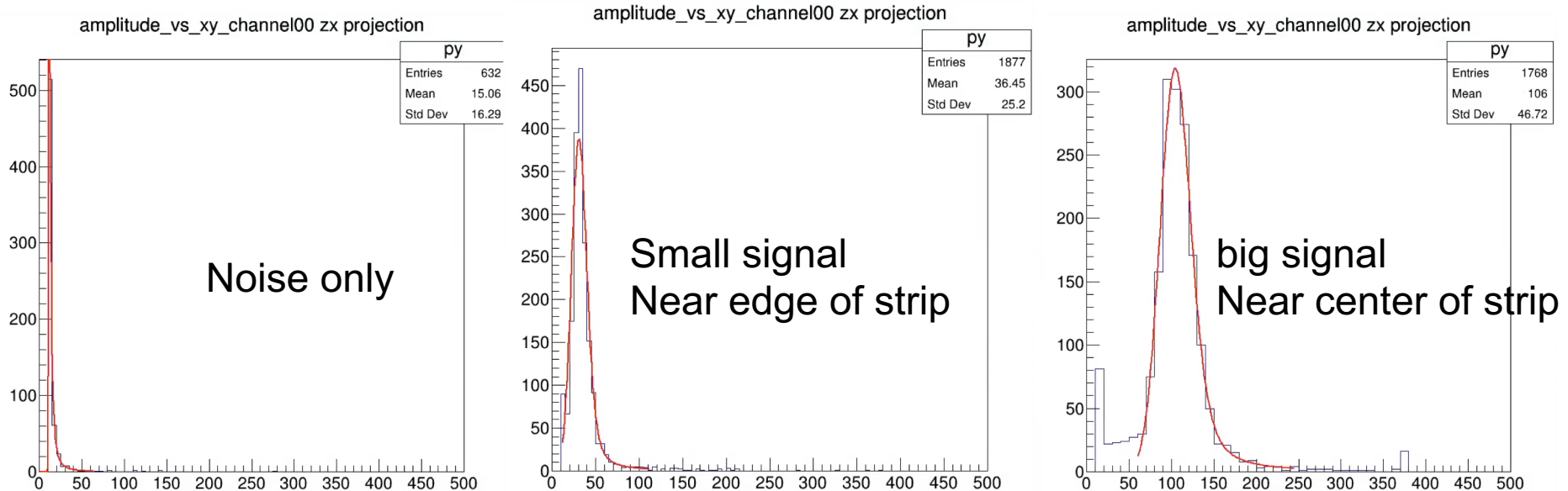
Amplitude vs X

Looks pretty good, but the noise presents a baseline at around the 10mV threshold

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Amplitude vs X

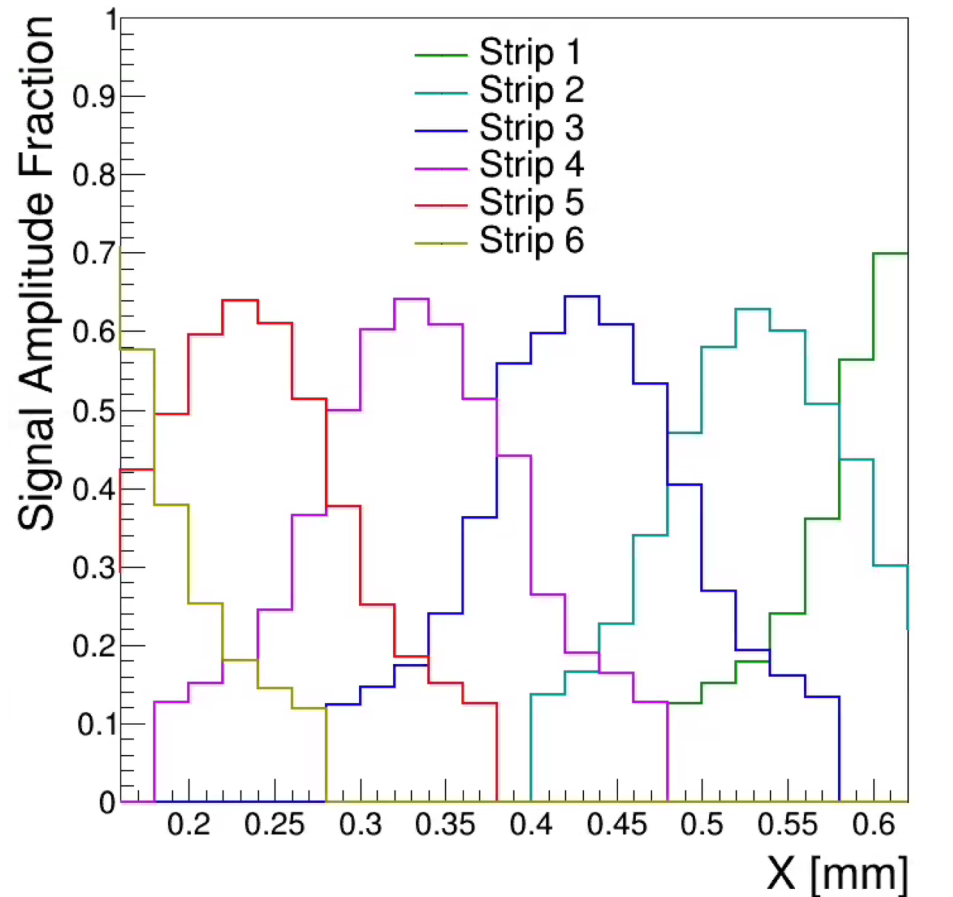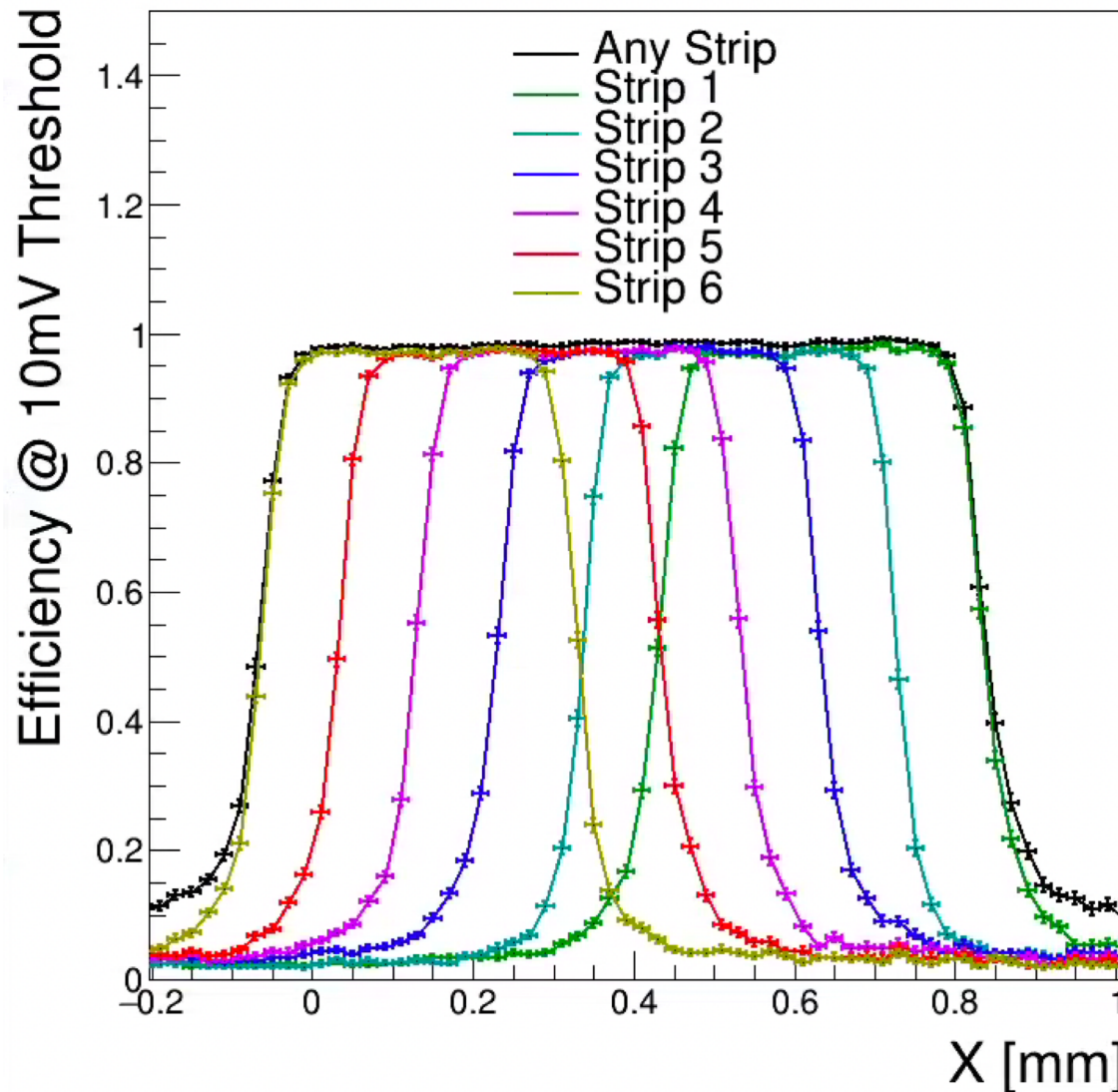We're zero-suppressing the noise floor at about 18mV

Amplitude vs X

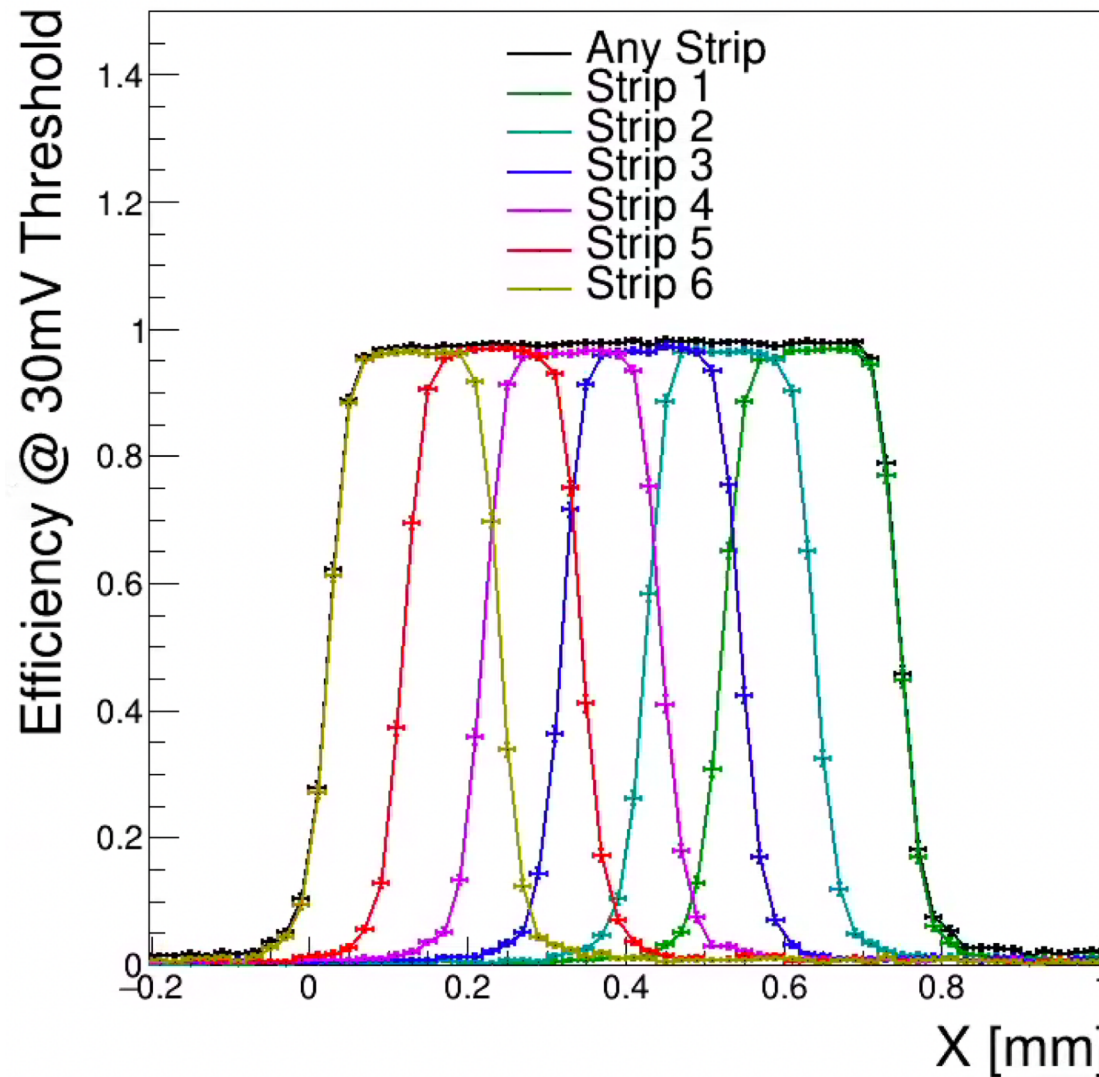We do see indication of the wiggles in between the strips
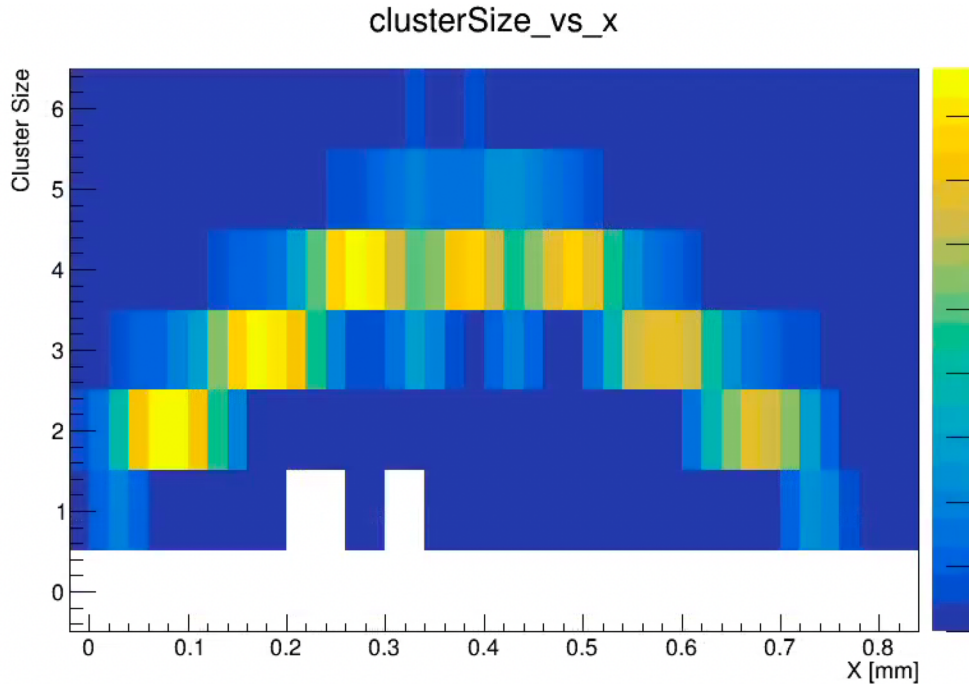
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Amplitude Fraction

Looks pretty good

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Efficiency (10mV Threshold)

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Efficiency (30mV Threshold)

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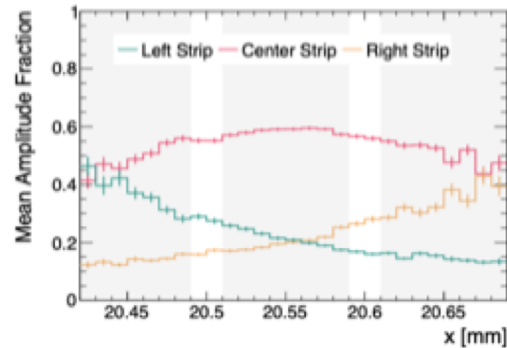
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Cluster Size

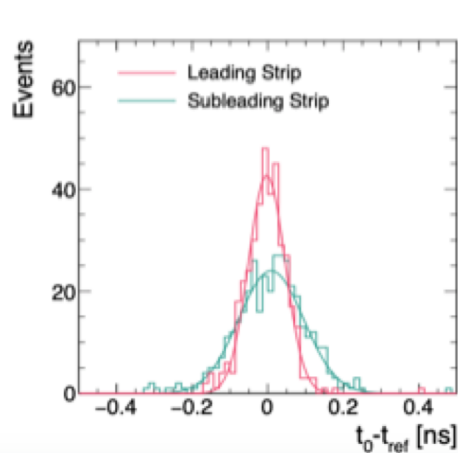clusterSize_vs_x

clusterSize_vs_x

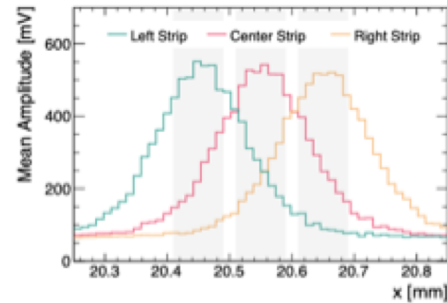30mV threshold on primary strip,
10mV signal on secondary strips
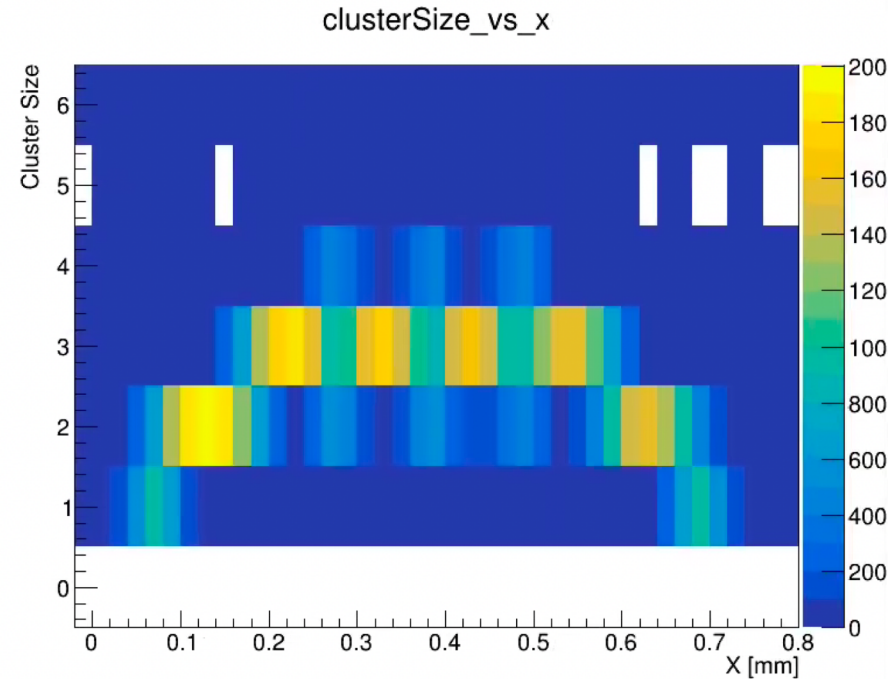
50mV threshold on primary strip,
20mV signal on secondary strips

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These are plots we need

We need Efficiency for primary threshold (max channel), and efficiency for secondary threshold (all the other channels)

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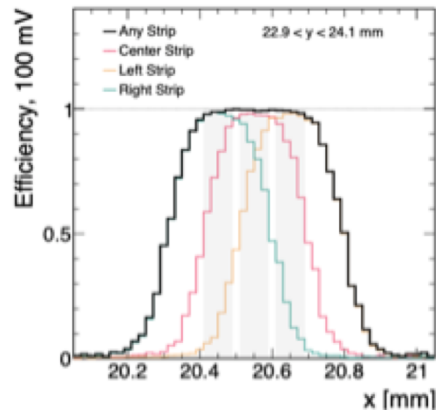
These are plots we need

Total amplitude (of channels passing threshold) vs position
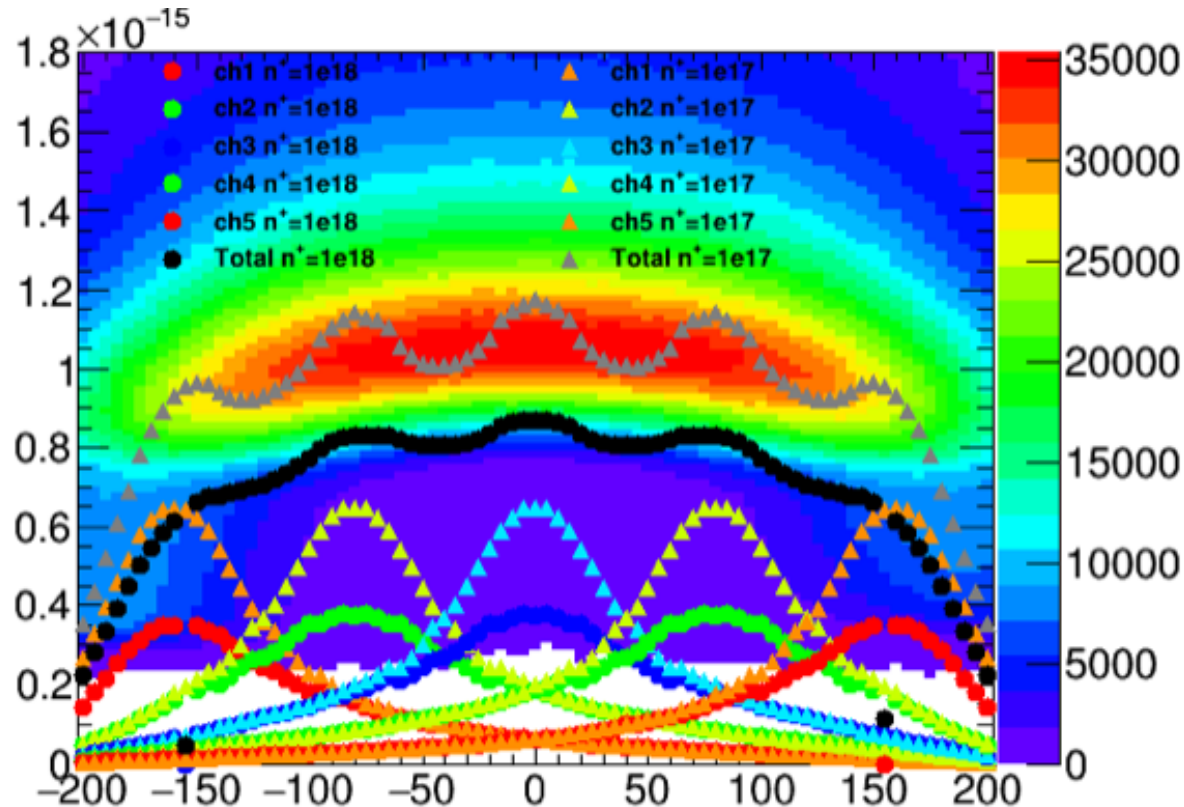
Should this be done with the landau peak at each X position, or should this be done event-by-event?

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Position Reconstruction

- Parameterize distance to center of max strip vs A1/(A1+A2)
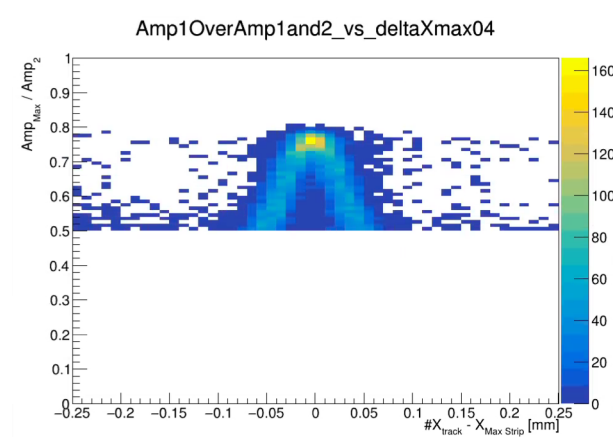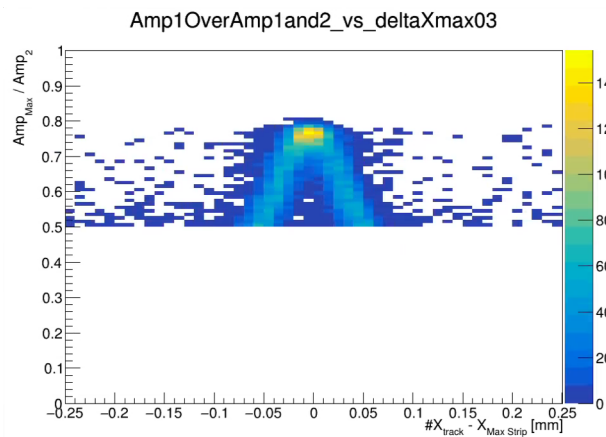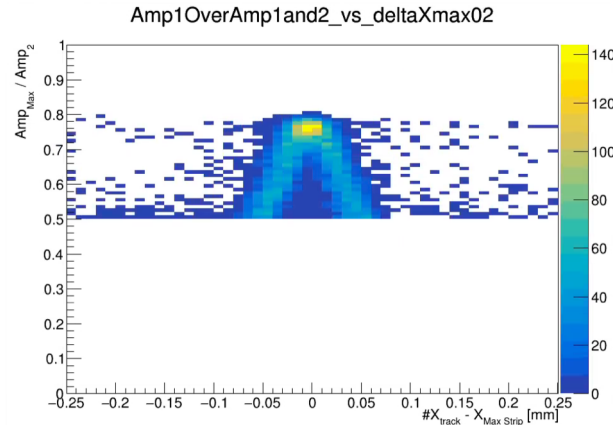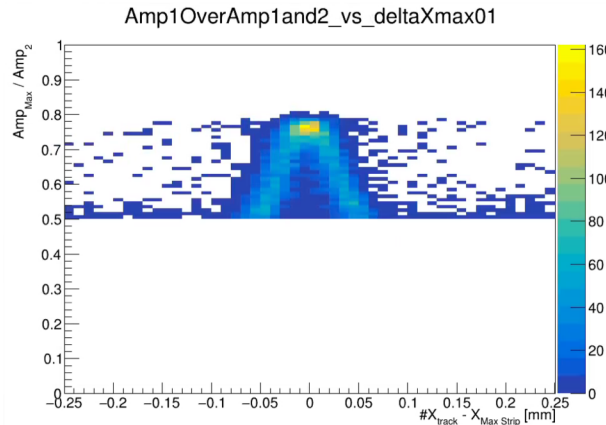
- Distance to center of strip vs A1/(A1+A2) looks identical for the 4 central strips

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Position Reconstruction

Left and Right edges look different as expected

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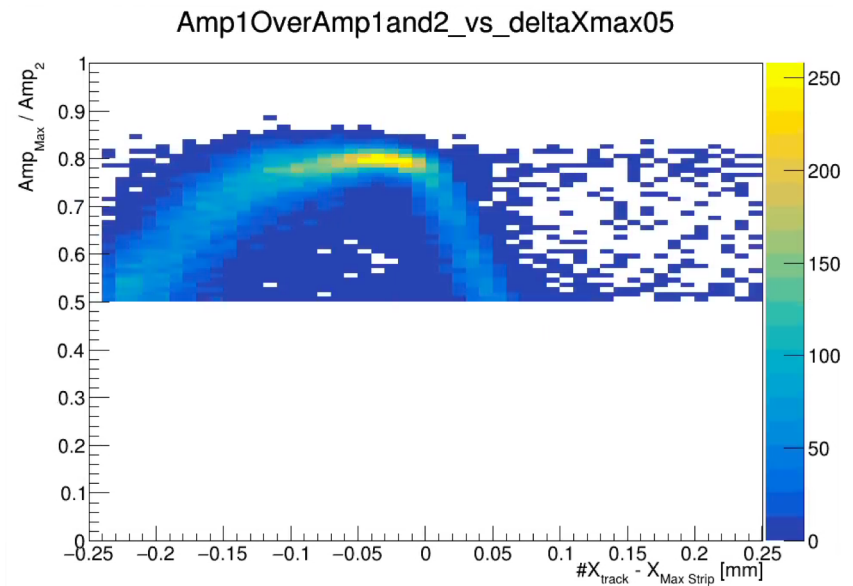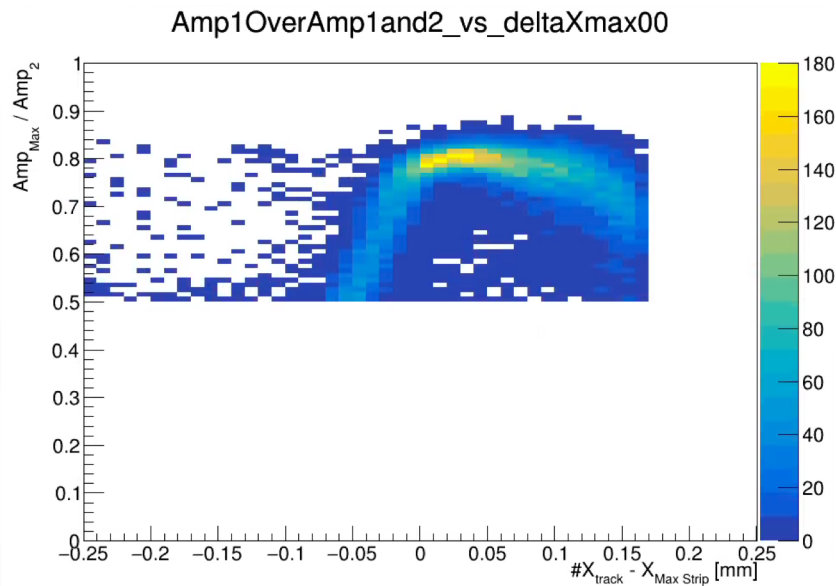
Position Reconstruction

Focus on the 4 middle strips and combine all events to derive parameterization of position vs A1/(A1+A2)

Amp1OverAmp1and2_vs_deltaXmax

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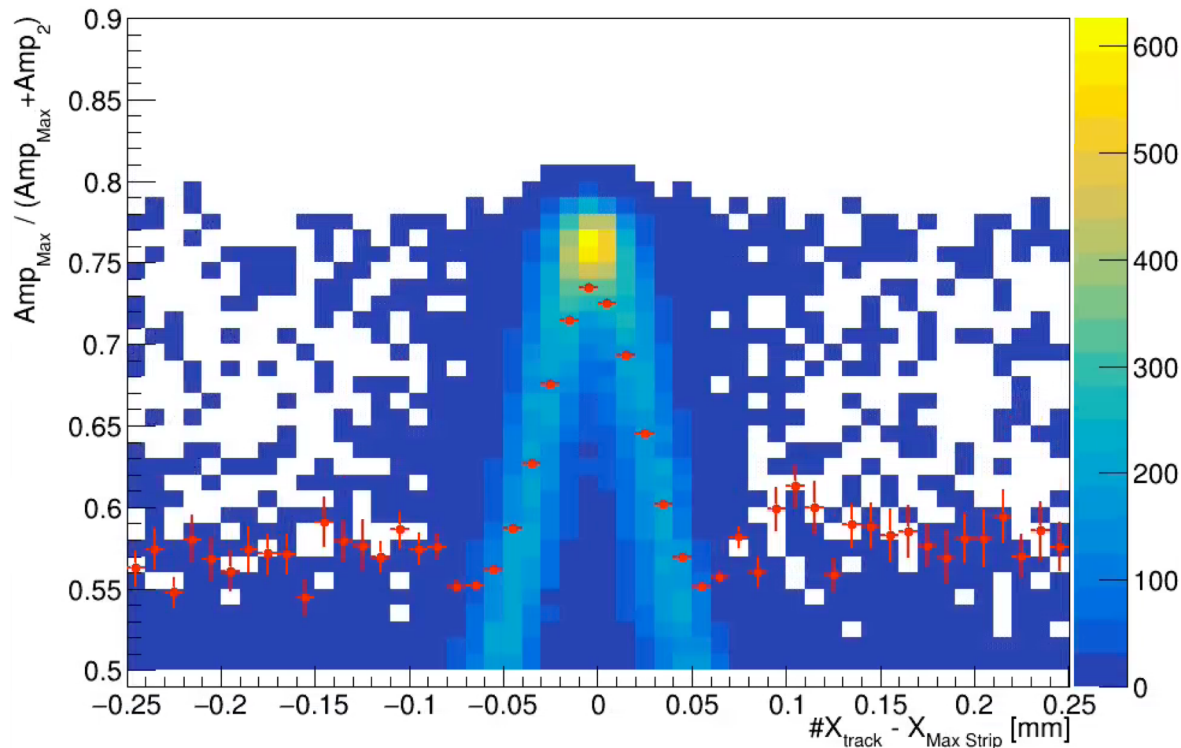
Position Reconstruction

Zoom in

Amp1OverAmp1and2_vs_deltaXmax
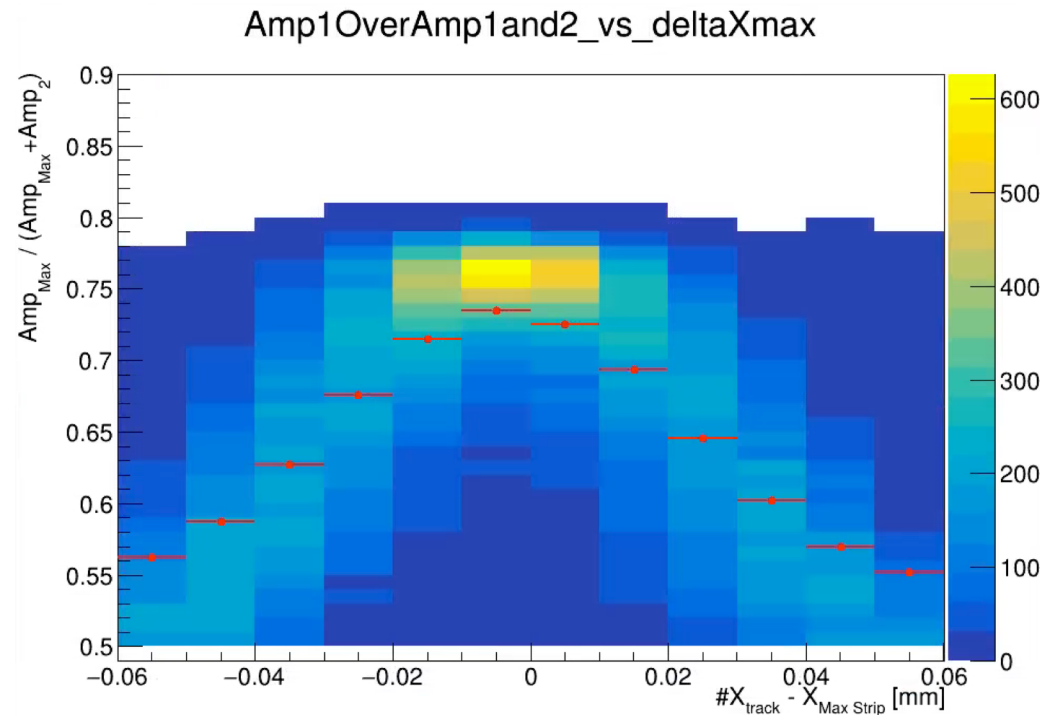
Left and Right side not perfectly symmetric. Not sure if this is important or not. Maybe ignore this for now and just use abs(X_track – X_maxStrip)

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Position Reconstruction

Make Profile plot and fit to polynomial
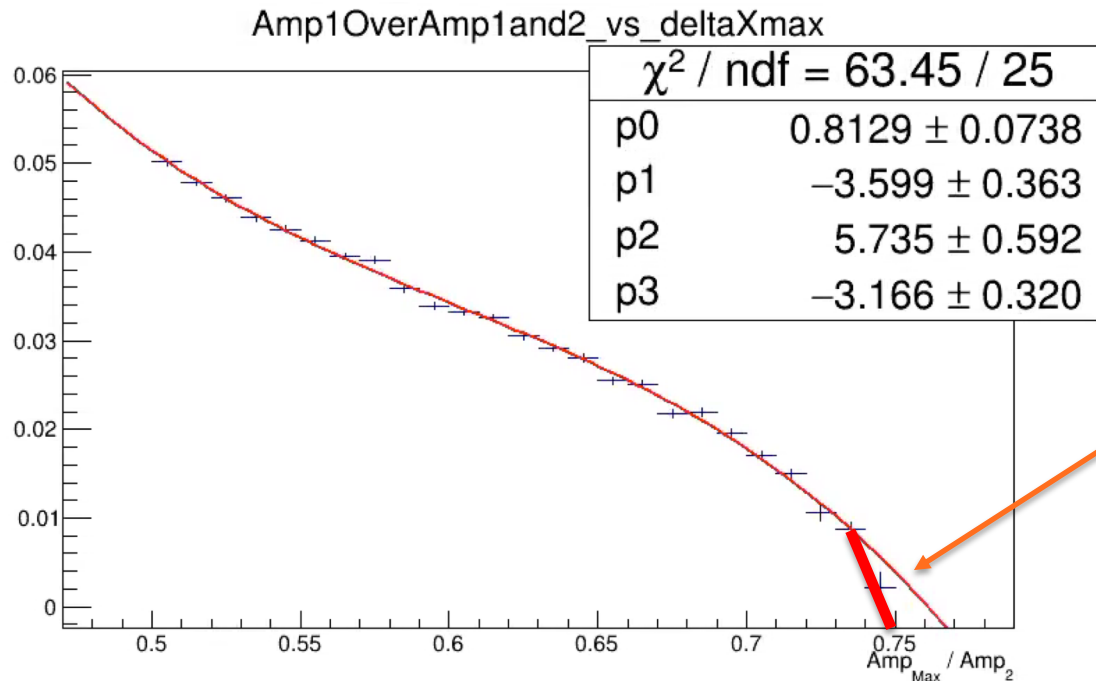
Fix the last part by using linear interpolation from (0.735,…) to (0.75,0)

- Fit looks good.
- Set physical limits at dX between 0.0 and 0.5

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Position Reconstruction

```
if (pass)
{
  if (maxAmpIndex >= 1 && maxAmpIndex <= 4) {
    assert(Amp1OverAmp1and2 >= 0); //make sure a1/(a1+a2) is a sensible number
    assert(Amp1OverAmp1and2 <= 1);
    x1 = stripCenterXPositionLGAD[0][maxAmpIndex];
    x2 = stripCenterXPositionLGAD[0][Amp2Index];

    //use the poly fit function
    double dX = positionRecoPar0 + positionRecoPar1*Amp1OverAmp1and2 + positionRecoPar2*pow(Amp1OverAmp1and2,2
) + positionRecoPar3*pow(Amp1OverAmp1and2,3);

    //After the "cut-off" point of the fit, then linearly
    //interpolate to (Amp1OverAmp1and2=0.75,dX=0.0) point
    if (Amp1OverAmp1and2 > 0.75) {
      dX = 0.0;
    } else if (Amp1OverAmp1and2 > positionRecoCutFitCutOffPoint) {
      double dX_atCutOffPoint = positionRecoPar0 + positionRecoPar1*positionRecoCutFitCutOffPoint + positionRe
coPar2*pow(positionRecoCutFitCutOffPoint,2) + positionRecoPar3*pow(positionRecoCutFitCutOffPoint,3);
      dX = dX_atCutOffPoint + ((0.0 - dX_atCutOffPoint)/(0.75 - positionRecoCutFitCutOffPoint))*(Amp1OverAmp1a
nd2-0.75);
    }

    //if dX is larger than 0.5, then just use the midpoint between the strips
    //not sure why the profile wants to "over-shoot"
    //if (dX >= 0.5) dX = 0.5;

    if (x2>x1) {
      x_reco = x1 + dX;
    } else {
      x_reco = x1 - dX;
    }
```
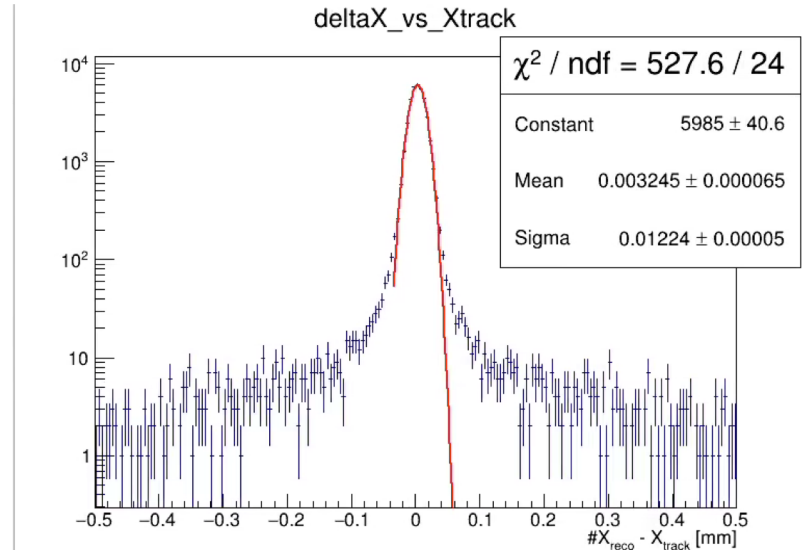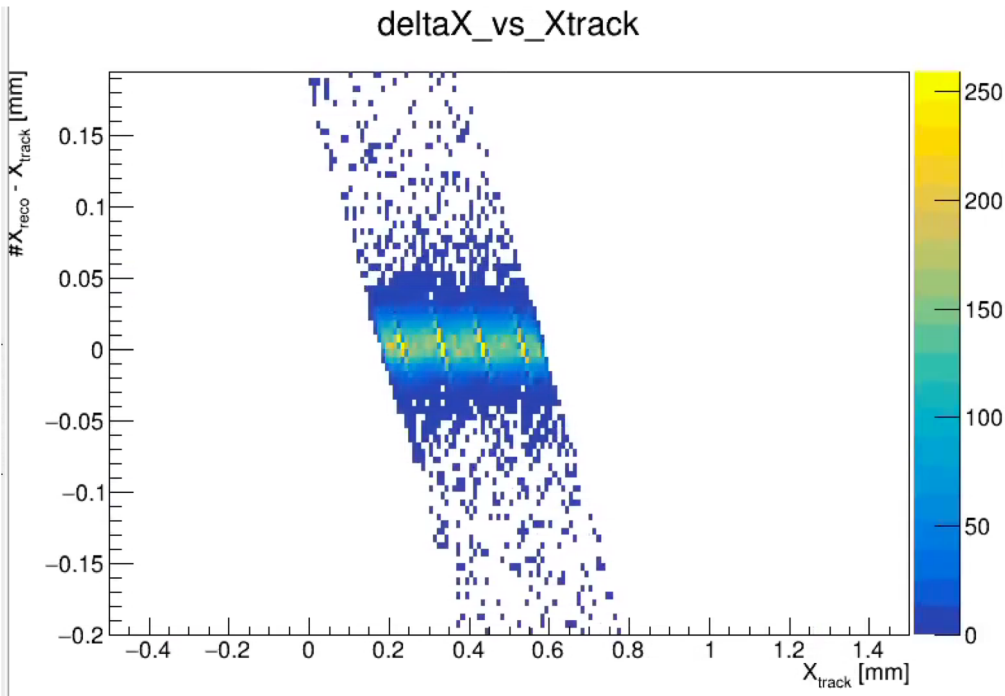
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Position Reco Performance

deltaX_vs_Xtrack

- Use only events with max-strip amplitude > 30 mV
- Core sigma is ~12.2micron – consistent with telescope resolution ONLY
- There are non-gaussian tails beyond dX > 30 micron
- The shape is independent of which strip is the max – they all look identical

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Position Reco Performance
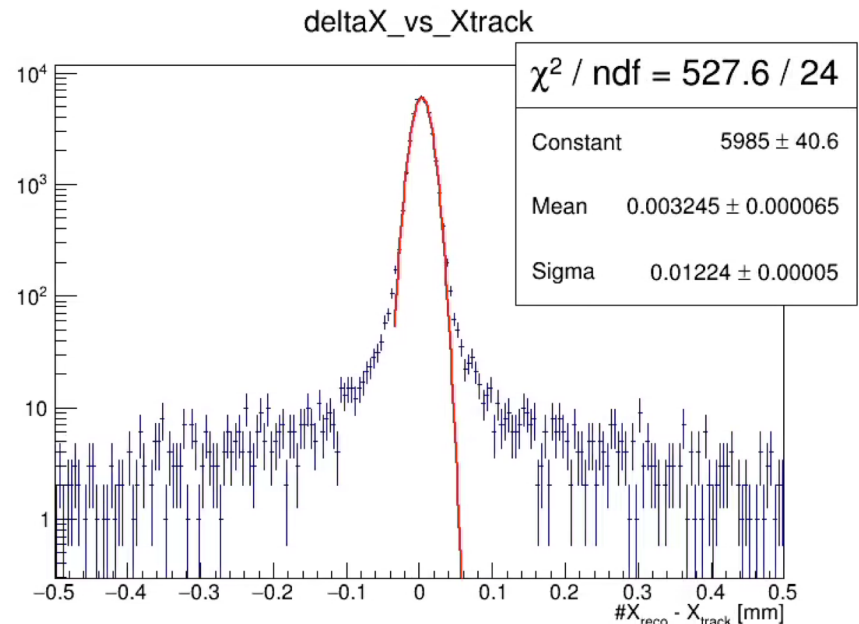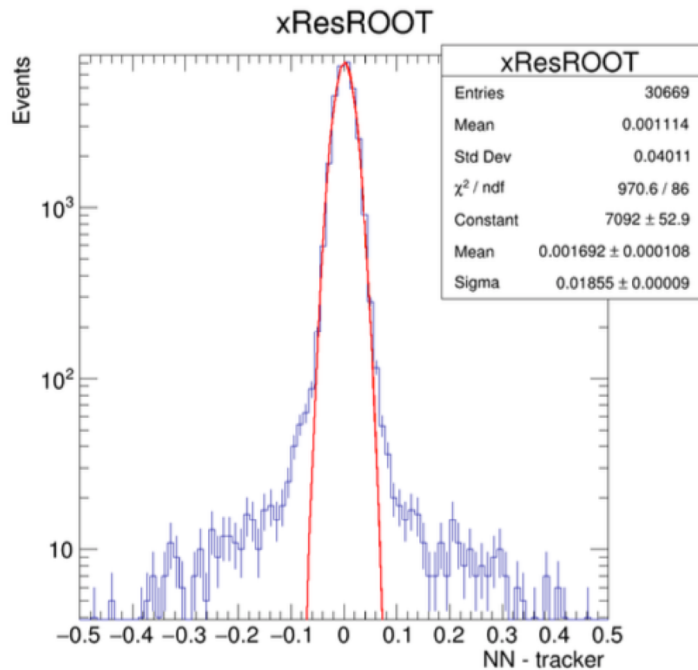
- Compared to NN result, the core resolution is better

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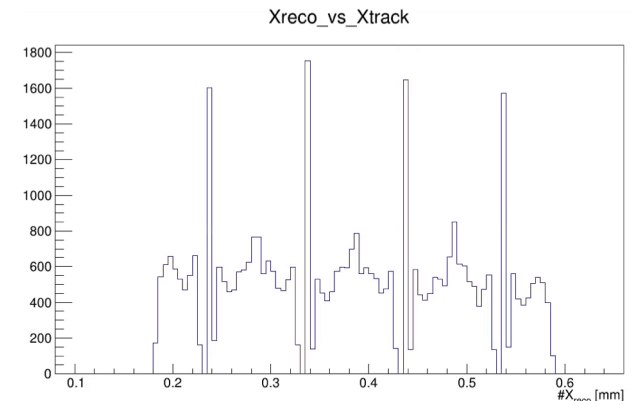# Position Reco Performance
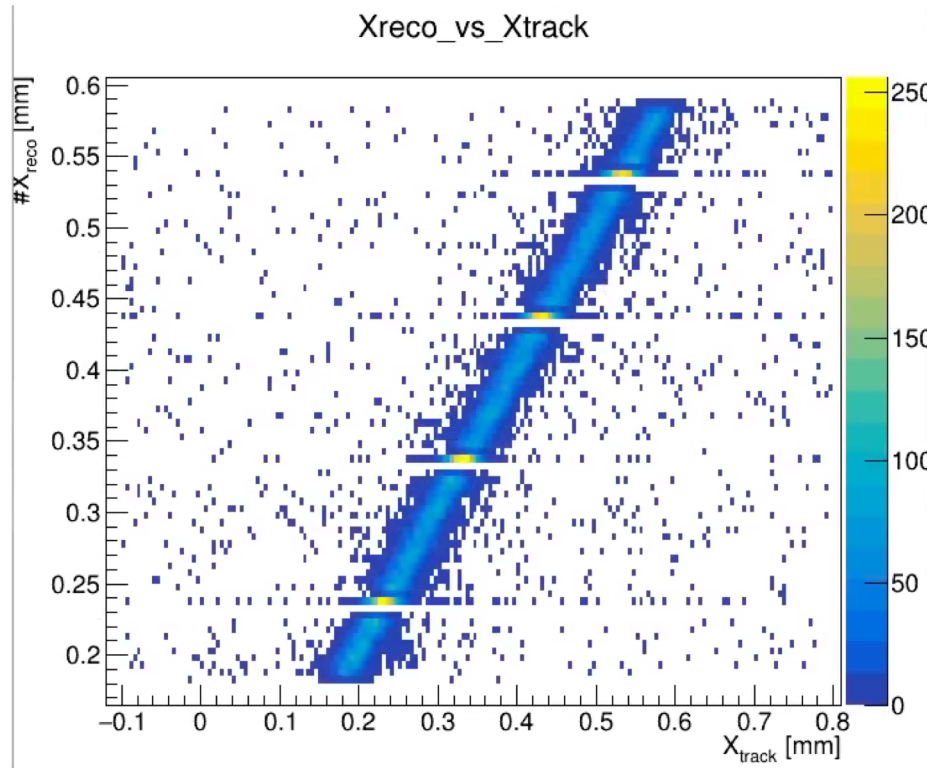
- There are clearly spikes at the location of the strips when a1/(a1+a2) is too large to distinguish between locations near the strip.
- Maybe for those, we need to use a2/(a2+a3)

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Position Reco Performance

Xreco_vs_Xtrack
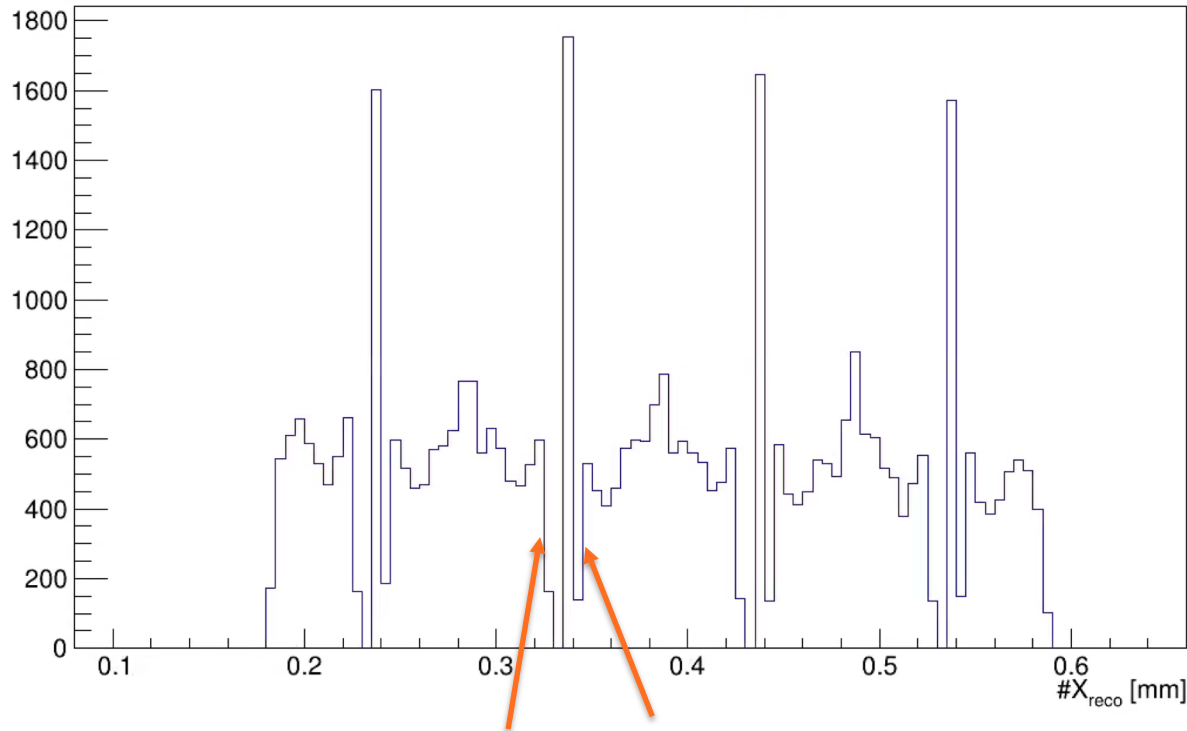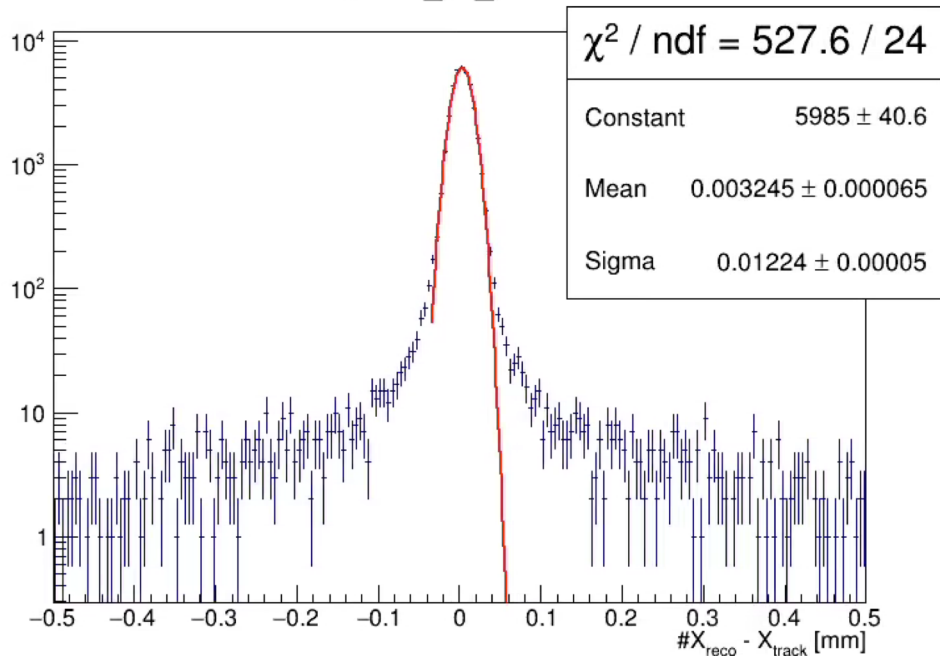
- Between here and here, a1/(a1+a2) is too big.
- So cannot locate to better accuracy.
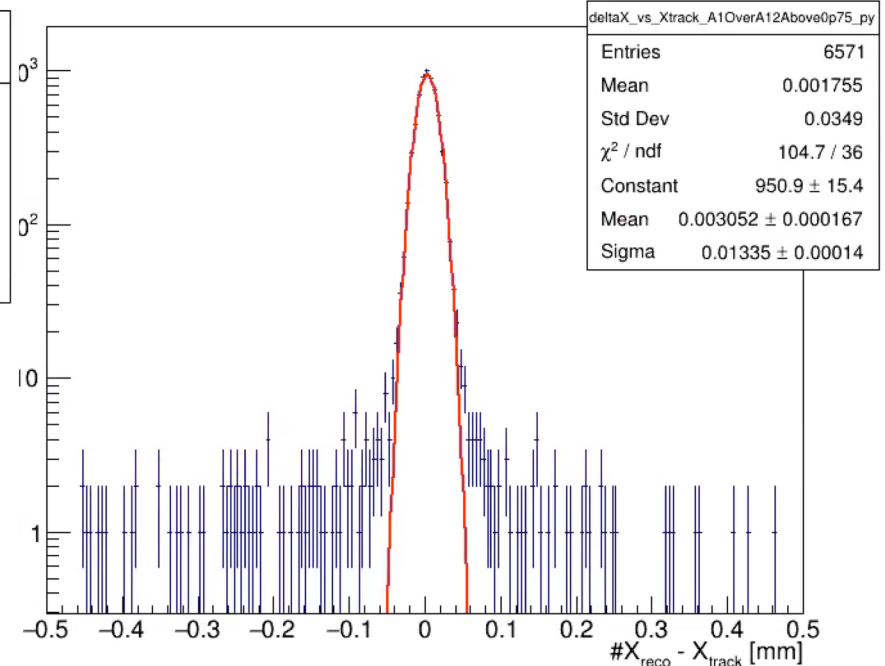- Maybe using a2/(a2+a3) will help in there.

Position Reco Performance

All Events

Events with a1/(a1+a2) > 0.75

deltaX_vs_Xtrack

χ^2 / ndf = 527.6 / 24

Constant	5985 ± 40.6
Mean	0.003245 ± 0.000065
Sigma	0.01224 ± 0.00005

deltaX_vs_Xtrack

deltaX_vs_Xtrack_A1OverA12Above0p75_py	
Entries	6571
Mean	0.001755
Std Dev	0.0349
χ^2 / ndf	104.7 / 36
Constant	950.9 ± 15.4
Mean	0.003052 ± 0.000167
Sigma	0.01335 ± 0.00014

- The events with large a1/(a1+a2) have slightly worse resolution (13.4 vs 12.2) but tails look the same

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Can we do better when $a1/(a1+a2) > 0.75$?
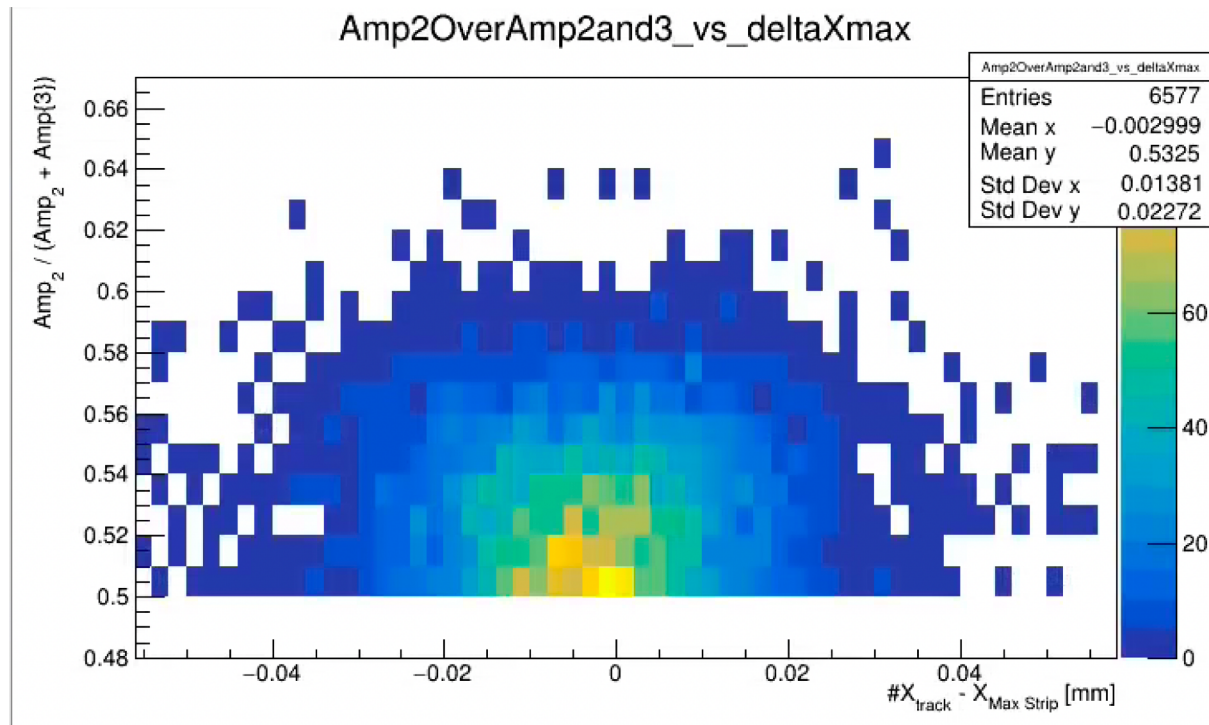
Plot a2/(a2+a3) vs distance to the max strip for the events with $a1/(a1+a2) > 0.75$

- a2/(a2+a3) seems to be not correlated to the track position at all
- So this doesn't work.
- Also tried to use a1/(a1+a2+a3), but it doesn't work better than a1/(a1+a2). Has the same features.

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Is using pulse integral better than pulse amplitude?

- vvv

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Backups

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