SVD Software

CoG reconstruction

Giulia Casarosa &

Michael De Nuccio

Face2Face Tracking Meeting ~ Pisa December, 5th 2017

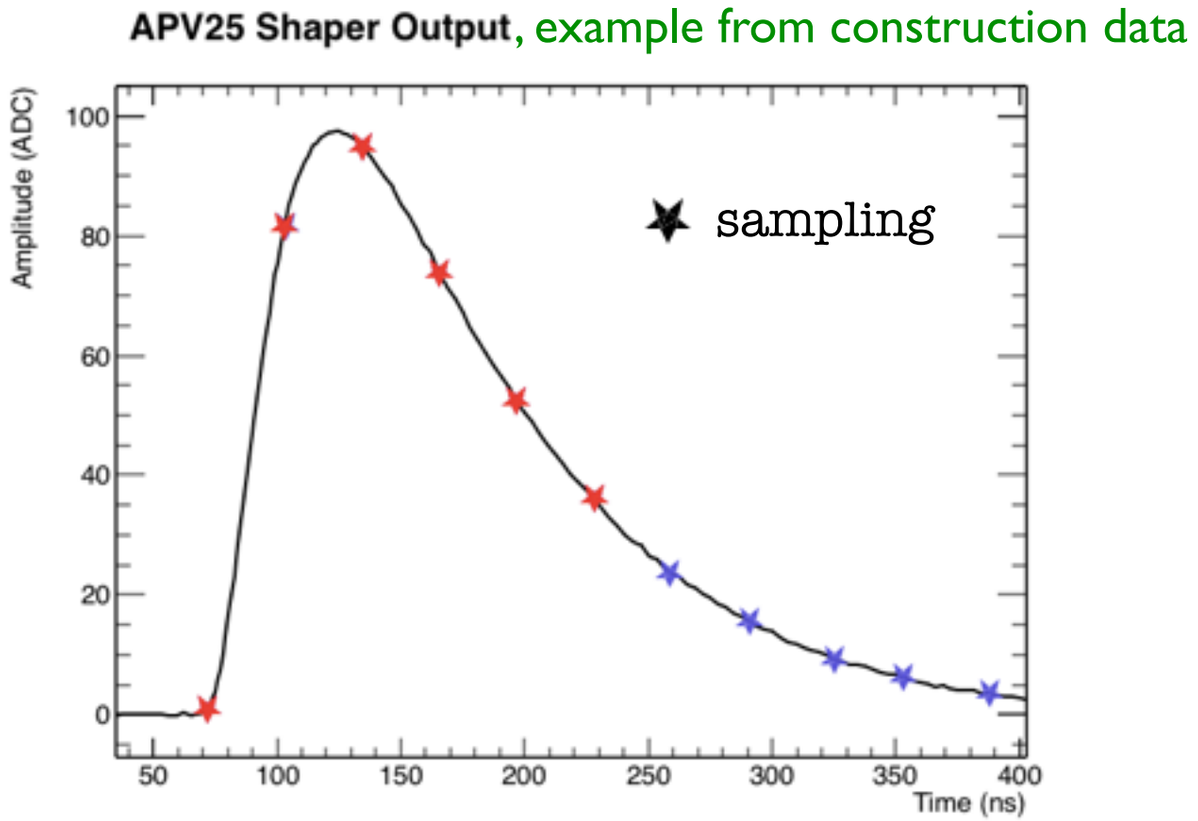
Overview

- ☑ *The Center of Gravity Reconstruction*
- ☑ *Performances on Simulation*
- ☑ *Performances on 2017 TestBeam data*

CoG Reconstruction

Strip Reconstruction

THE RESULTS SHOWN IN THE FOLLOWING ARE OBTAINED IN ABSENCE OF TRIGGER JITTER



- From the 6 samples provided by the SVD DAQ we should reconstruct:
  1. the strip charge
  2. the strip hit time

- The charge of the strip is the largest among the 6 samples

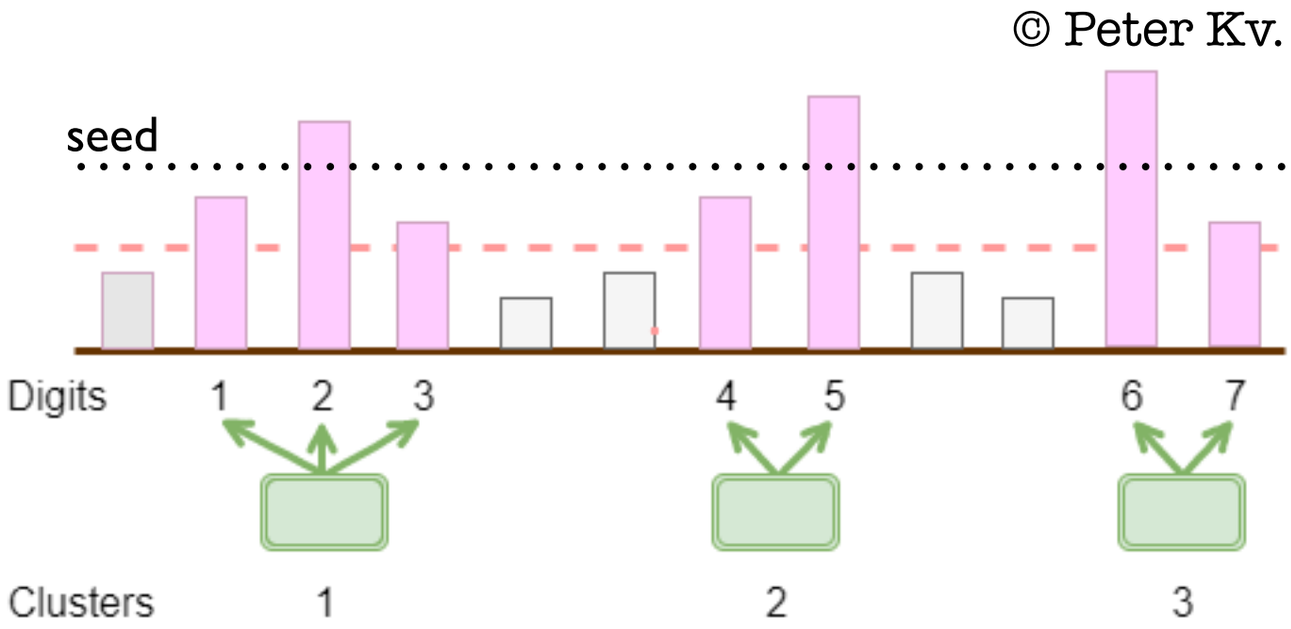
- The hit time reconstruction is entrusted to the Center-of-Gravity (CoG) algorithm
  - the CoG is the simple average of the time of the sample weighted with its amplitude
  - correction are applied, details are reported later

NOTE: *the CoG reconstruction is the current default reconstruction, but we are studying more powerful algorithms, in particular a reconstruction based on Neural Network that will be discussed in the next talk.*

Simple Clustering

➡ Clustering steps:

1. look for adjacent strips if S/N > 3 until no strip to be added is found
2. if the cluster candidate contains a *seed strip* with S/N > 5, the cluster is finalised and provided to the SVDSpacePointCreator



➡ Cluster time and position determination:

- the position is computed as the center of gravity/head-to-tail
- the time is computed as average of the strip time weighted with the strip charge

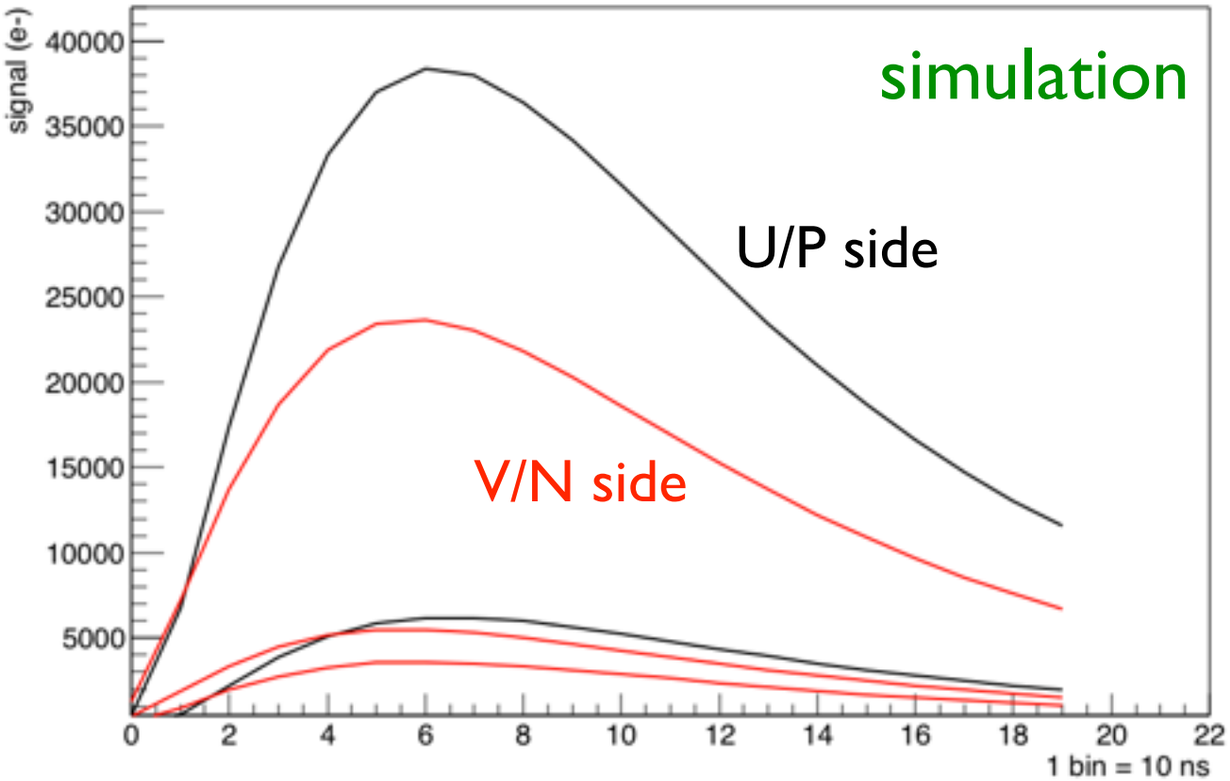
NOTES:

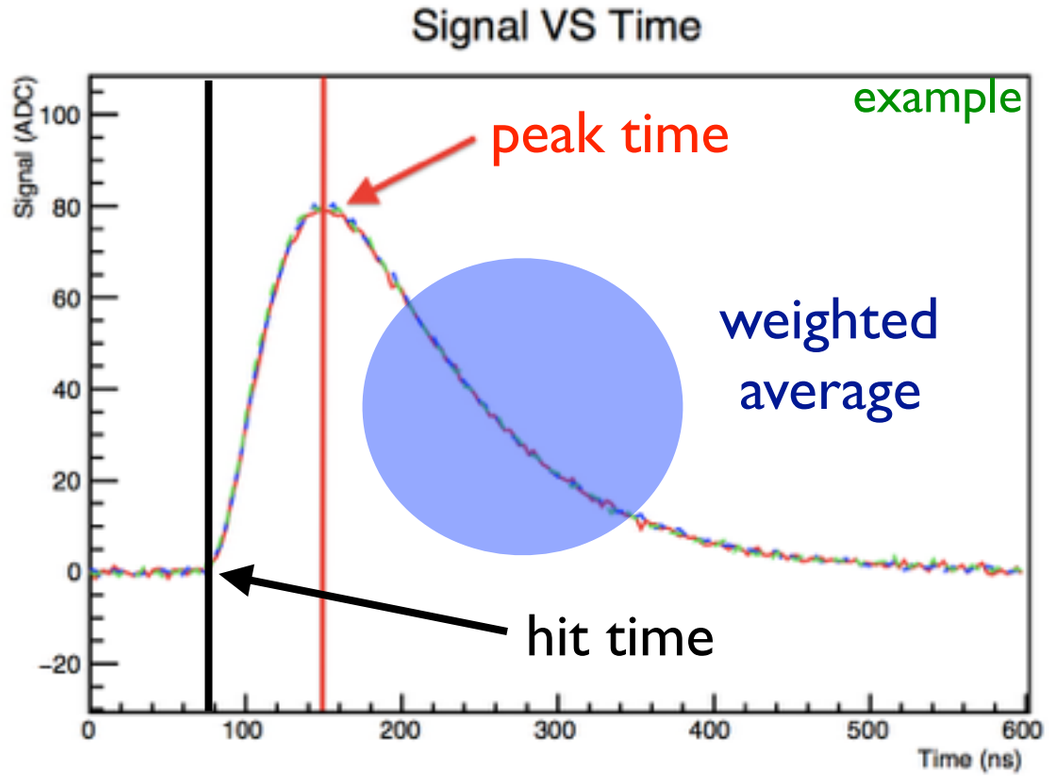
- *not* using the hit time information (to reject off-time strips adjacent to signal strips) ok for Phase2
- *not* using the defect map, (e.g. opens will break cluster) ok for Phase2

CoG Hit Time Reconstruction

- the time estimator uses amplitude (A_n) and time (T_n) of the n^{th} sample

$$T_{raw} = \frac{\sum_{n=0}^{5} A_n \cdot T_n}{\sum_{n=0}^{5} A_n}$$

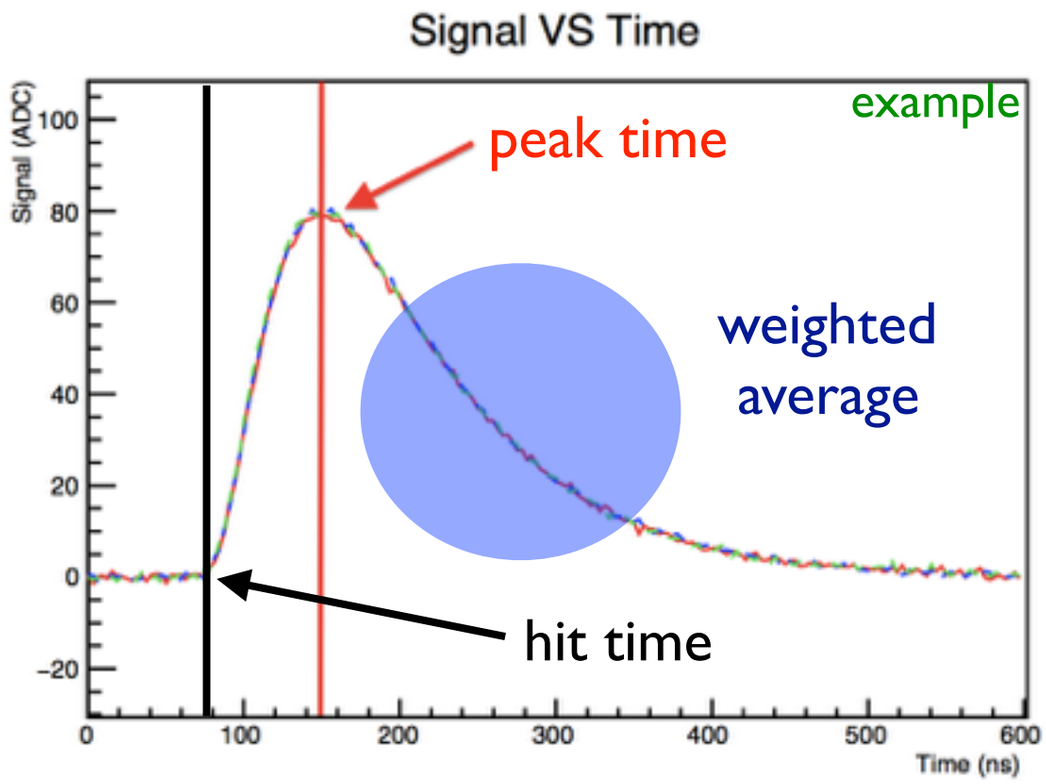


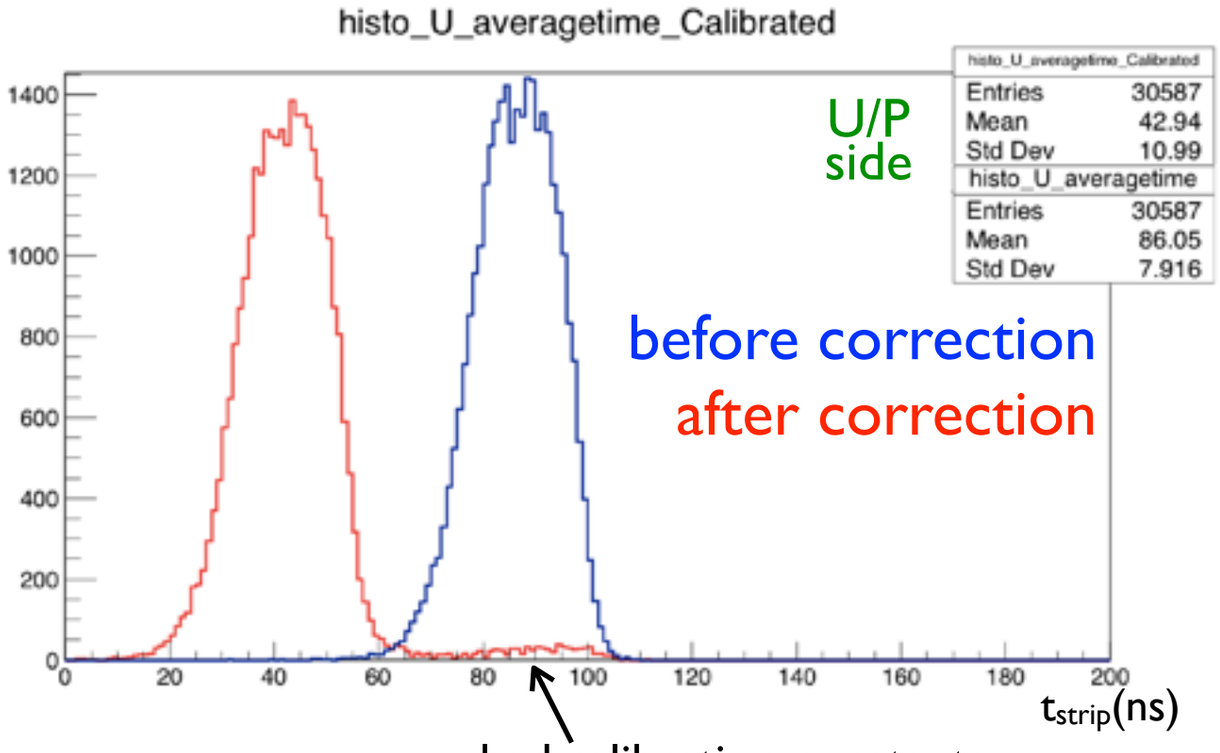


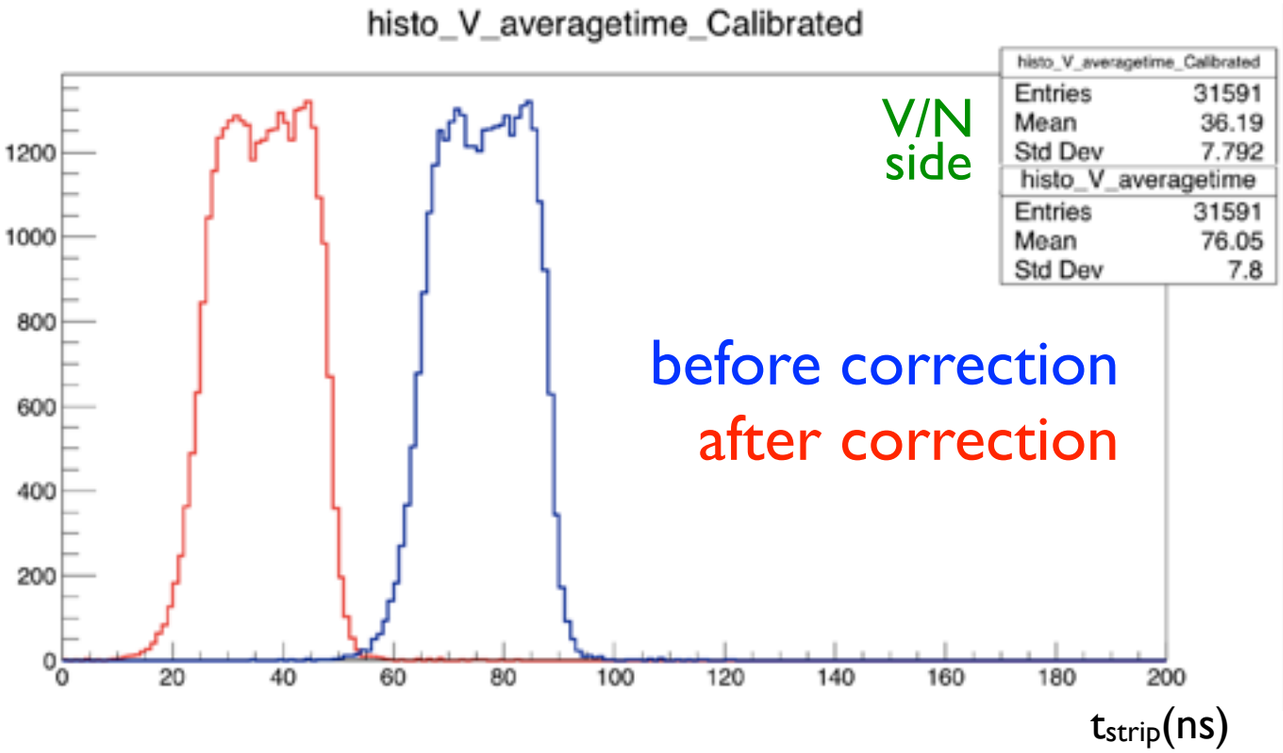
- The raw average does not represent the hit time, we need to calibrate it.
- V/N and U/P strips show a different waveform: the signal induced by electrons is faster (x3) than the one induced by holes. [the different height of the waveforms is due to 1-strip (N side) vs 2-strip (P side) clusters]

Peaking Time Correction

- We want the *hit time* = the time at which the APV25 pulse starts rising
- From the raw time we can correct for the rising time of the pulse using the a strip-dependent calibration constant
  - the correction depends on the capacitance seen by the APV25



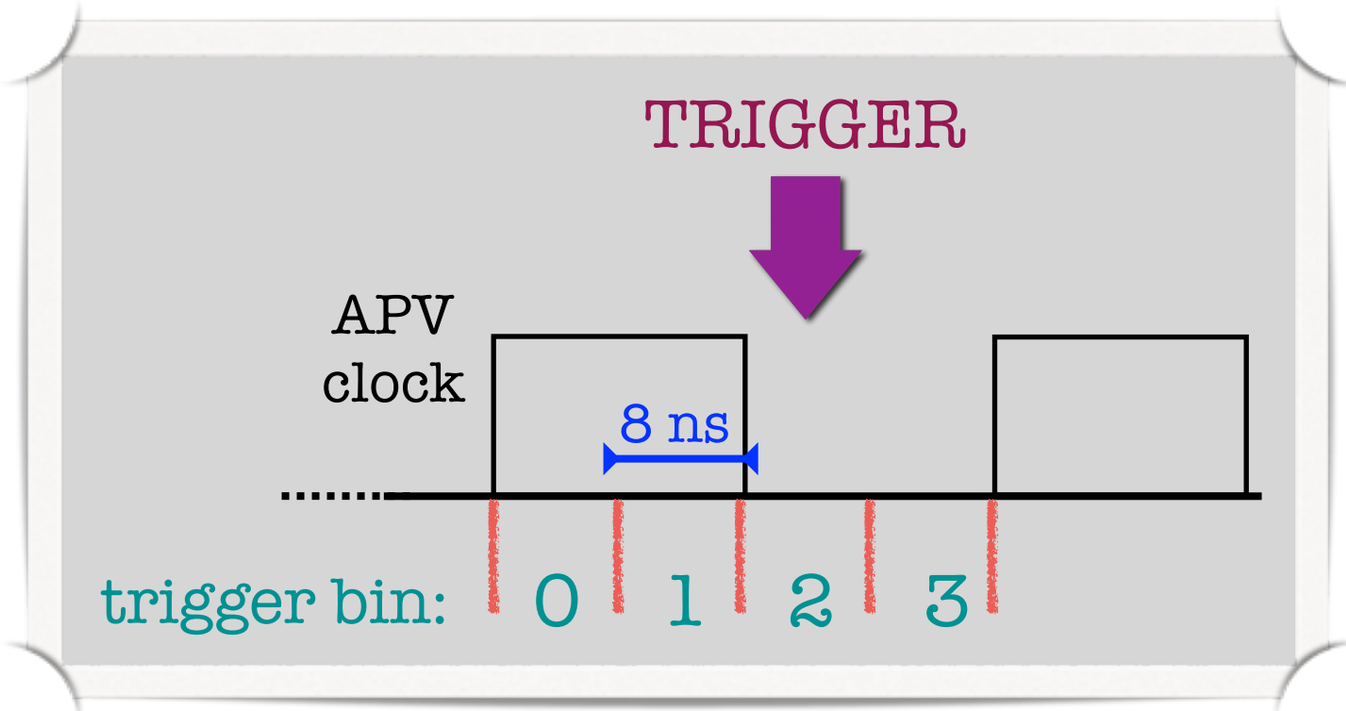


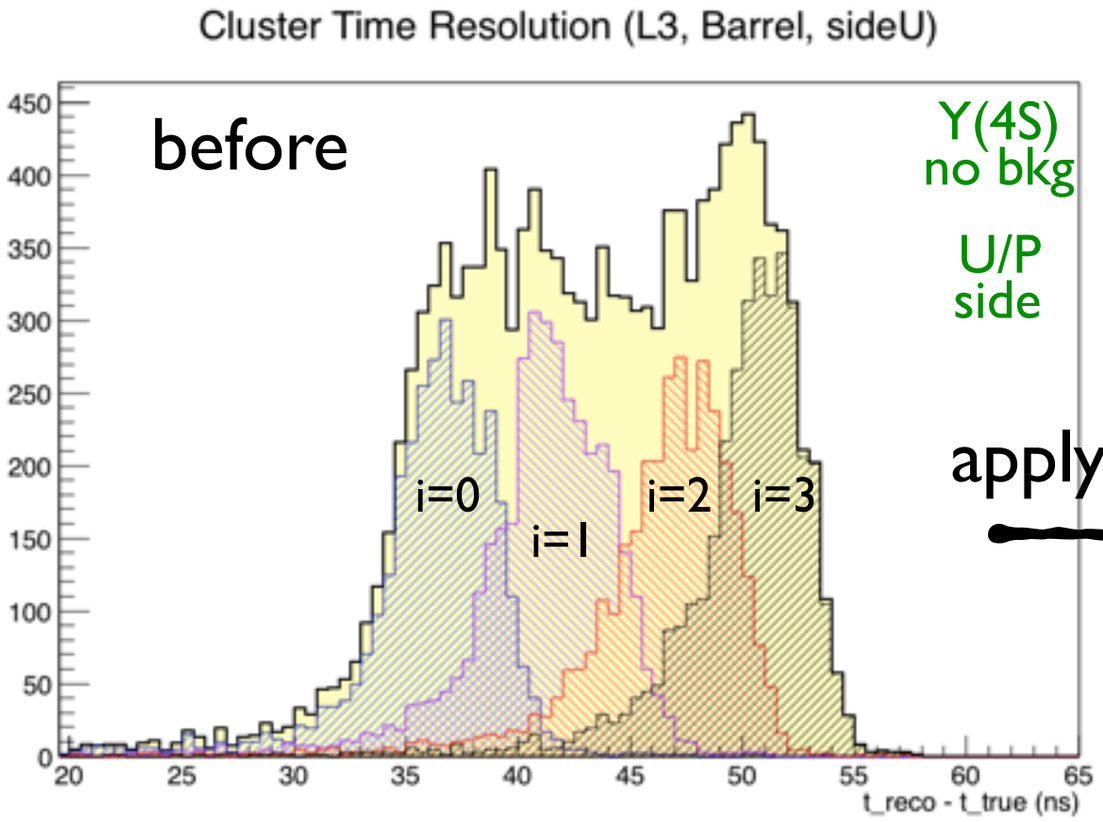


The Trigger Bin (U side)

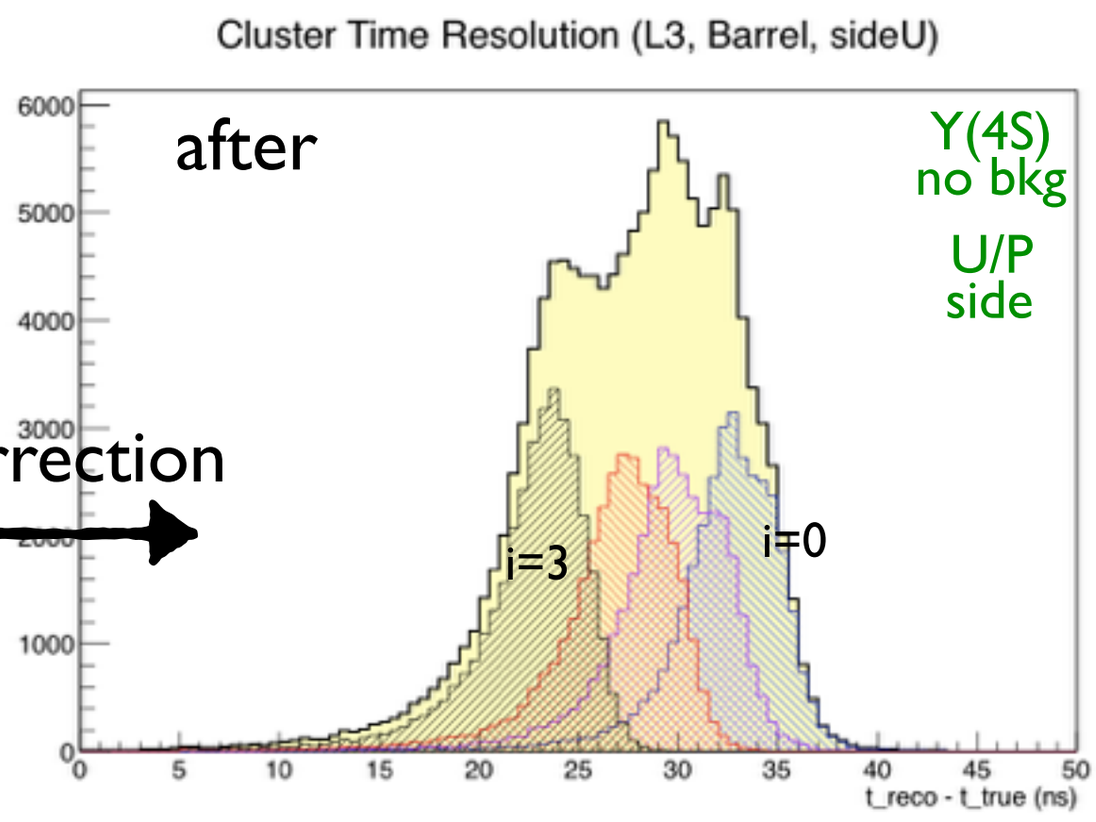
- We know the trigger arrival with a better precision than the APV clock period (31.44 ns)
- The trigger bin (*i*) contains the following informations: in which of the 8 ns wide time window the trigger signal has arrived:

$$T_{CoG} = T_{\text{raw}} - (4 + 8 \cdot i)$$



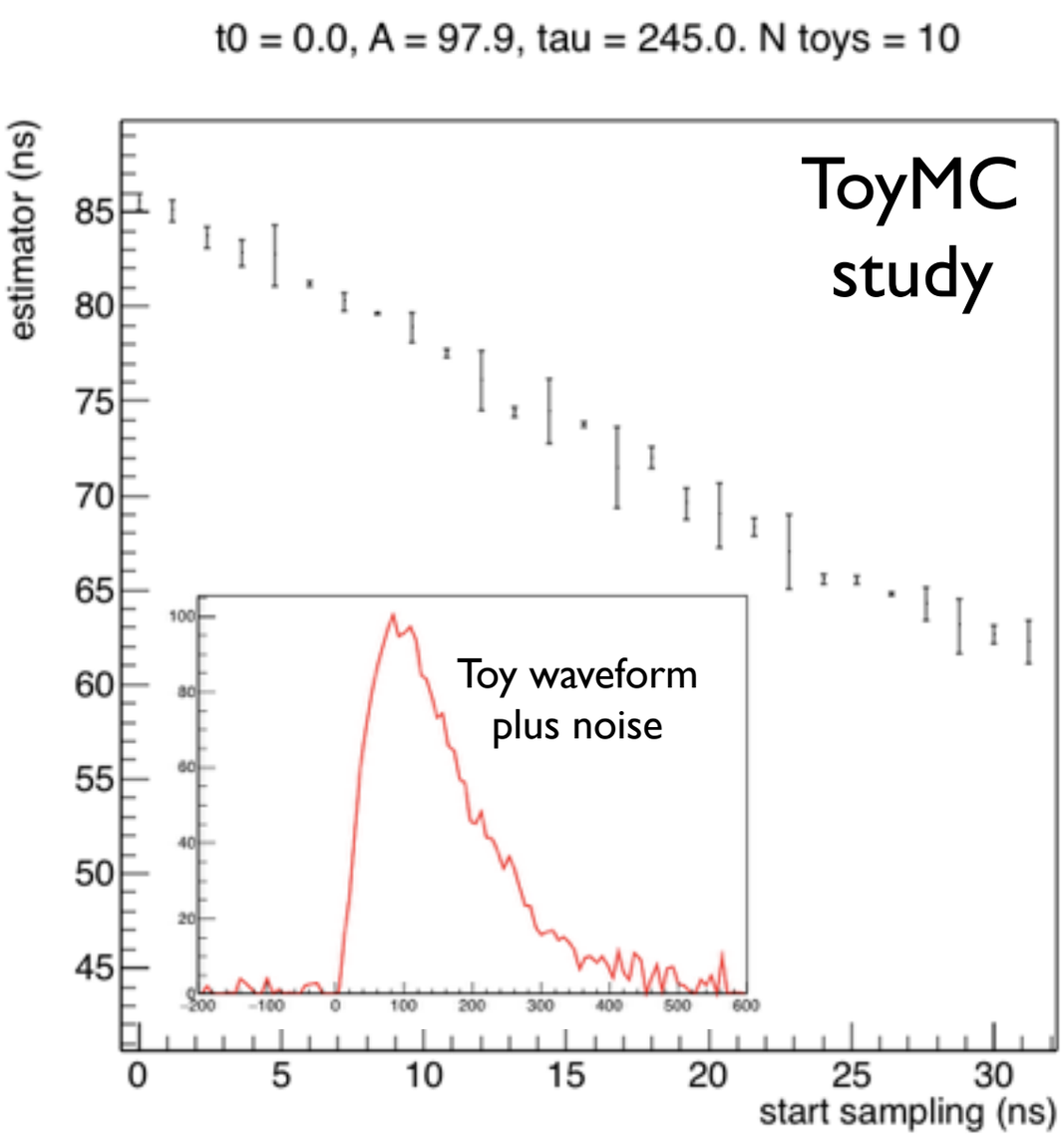


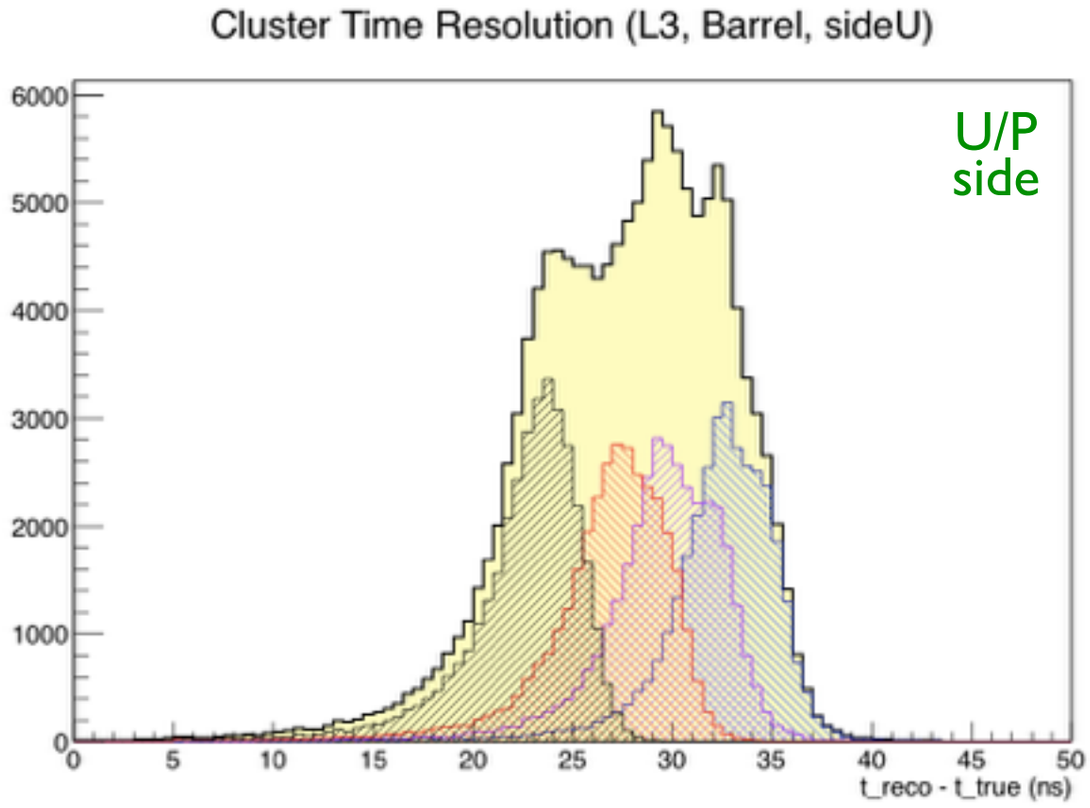
apply correction



Investigation on the Residual Shift

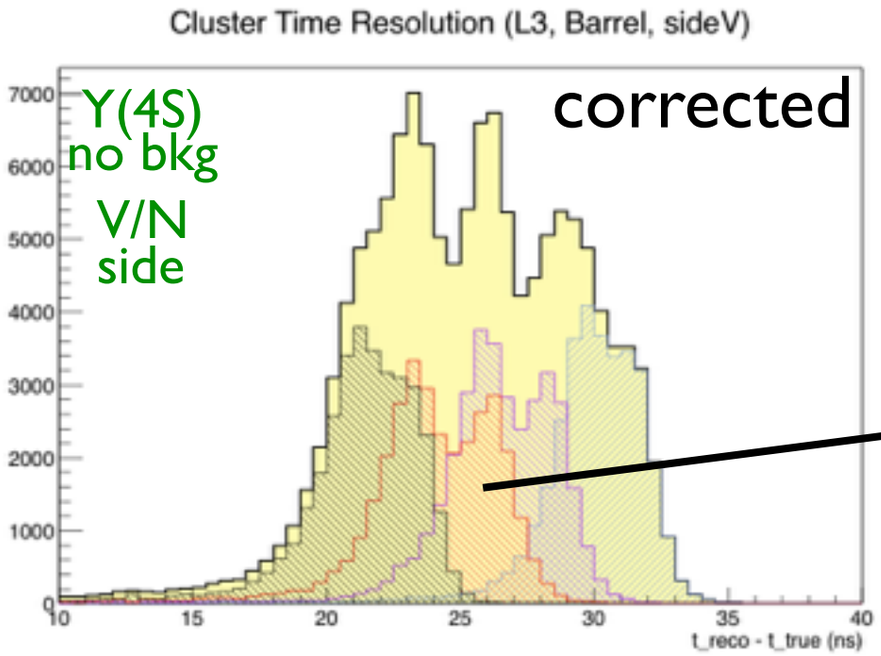
- The distributions related to the four trigger bins are shifted by ~5 ns
- The CoG value depends on the beginning of the sampling window:

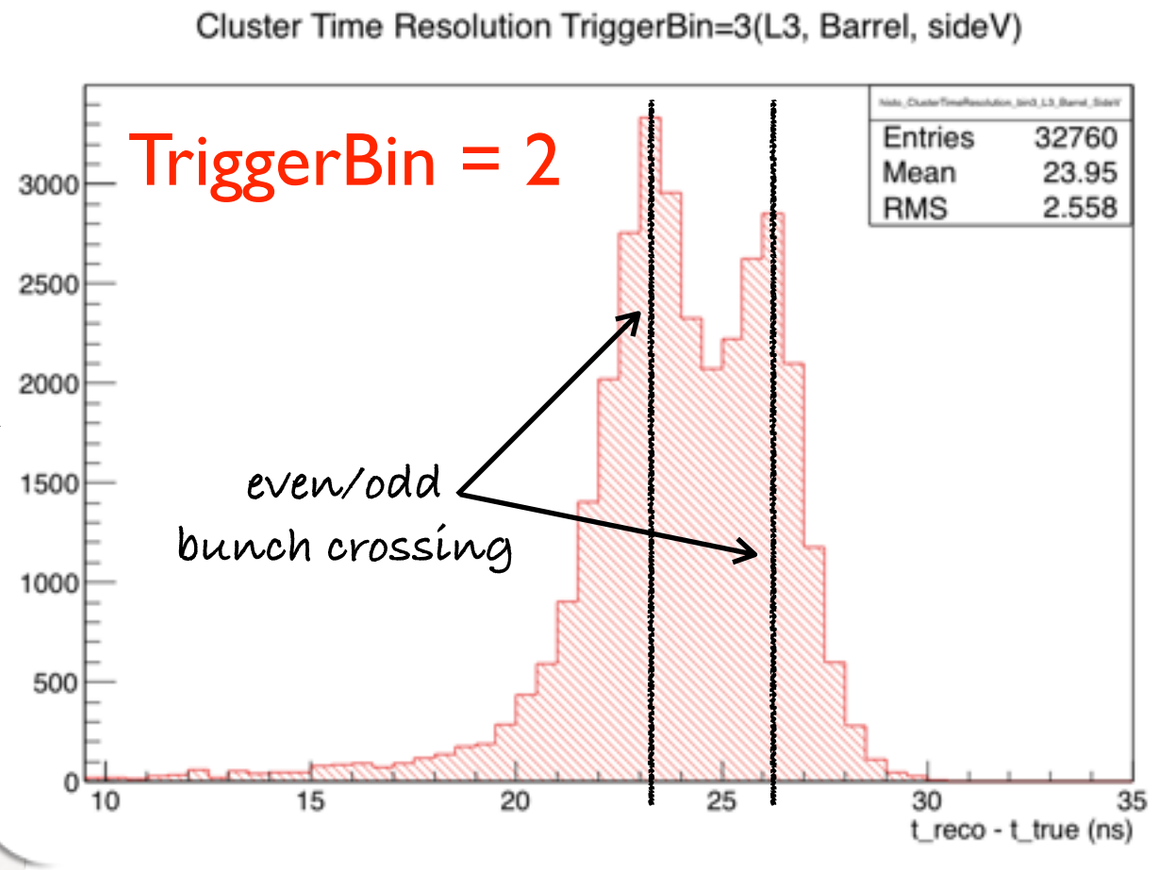


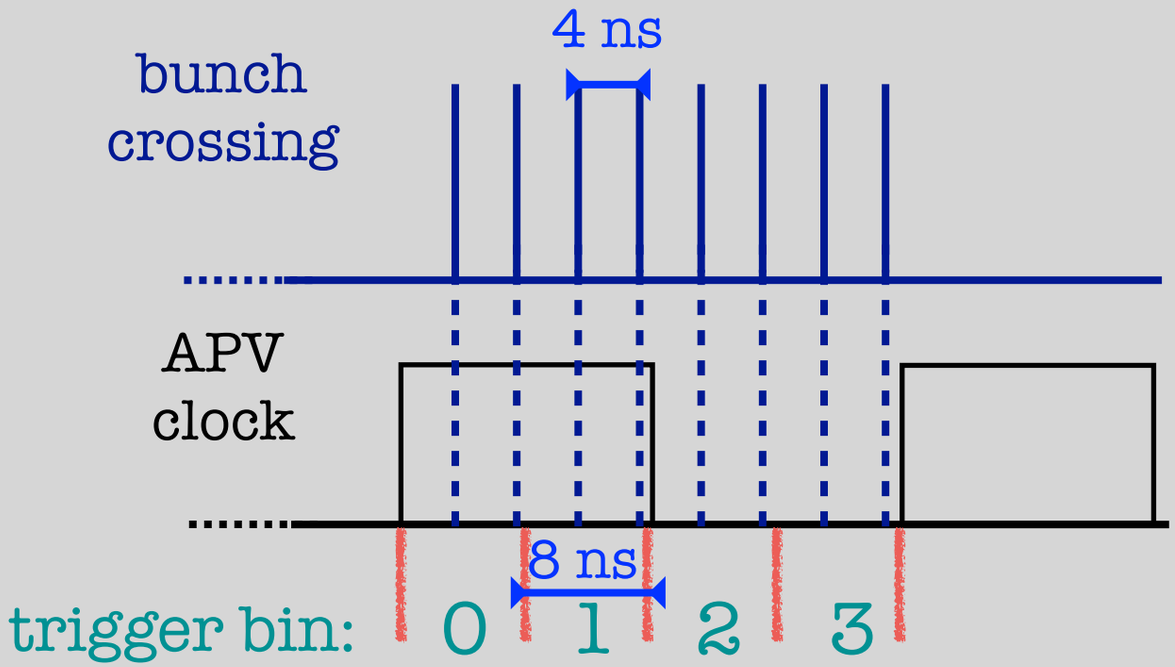


- Different trigger bins correspond to different waveform position in time with respect to the beginning of the sampling window
- The bias is robust against amplitude and width of the waveform → relative times are much less sensitive to this bias

The Trigger Bin Correction (V side)







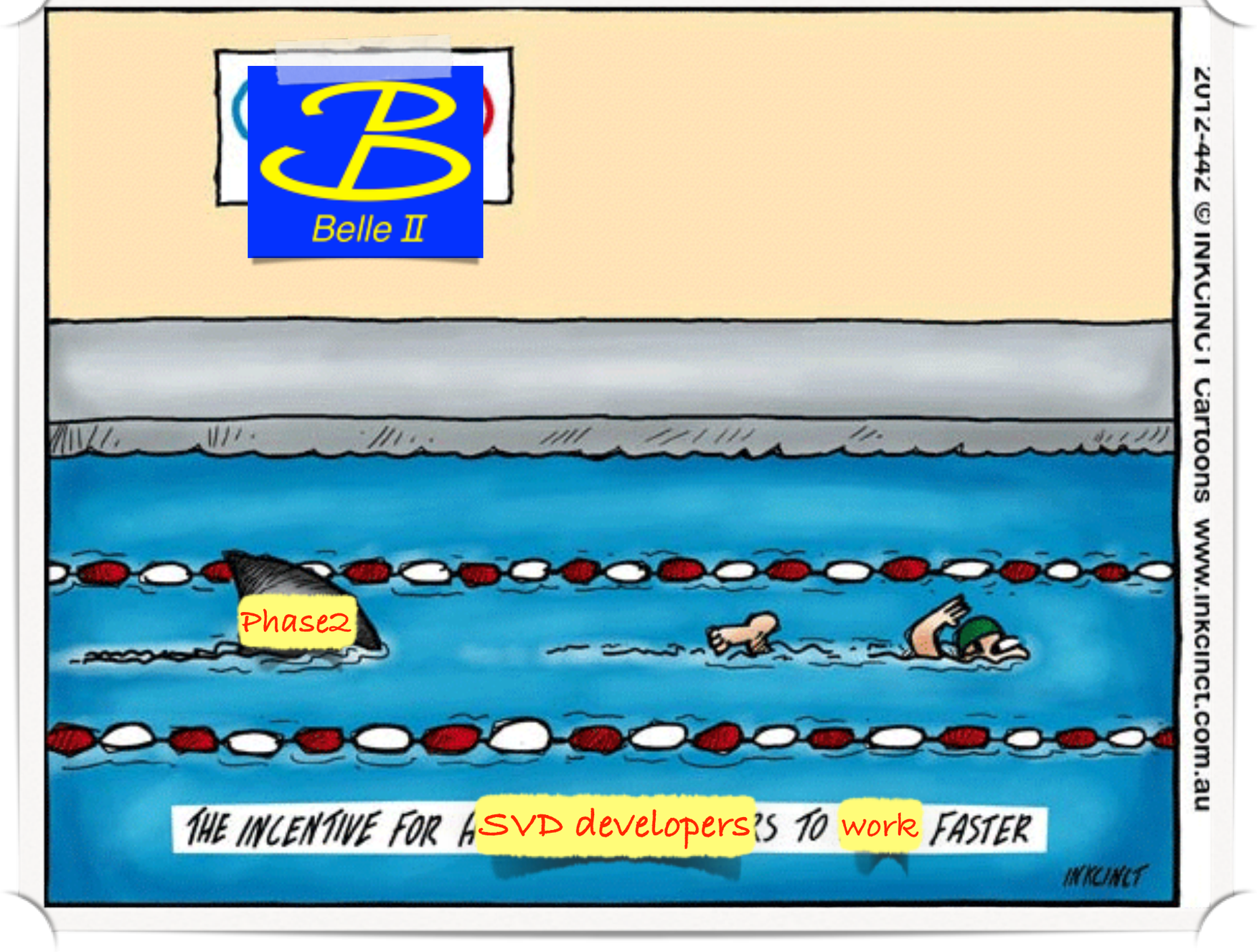
- the double peaks are due to the existence of two possible bunch crossings inside the same trigger bin
- on the U side this effect is not visible because the resolution is worse, not enough to disentangle the two peaks.

Half-Summary

- ➡ The CoG is basically a weighted average of the samples with corrections that depend on:
  - strip-by-strip peaking time (*calibration constant*)
  - trigger bin-related constants (*can be estimated on data*)
  - we apply an additional shift to center the reconstructed time around 0 ns (*can be estimated on data*)

- ➡ The CoG is a robust estimator if used to estimate relative times:
  - all strips in the same event belong to the same trigger bin
  - all APVs in the SVD are synchronized

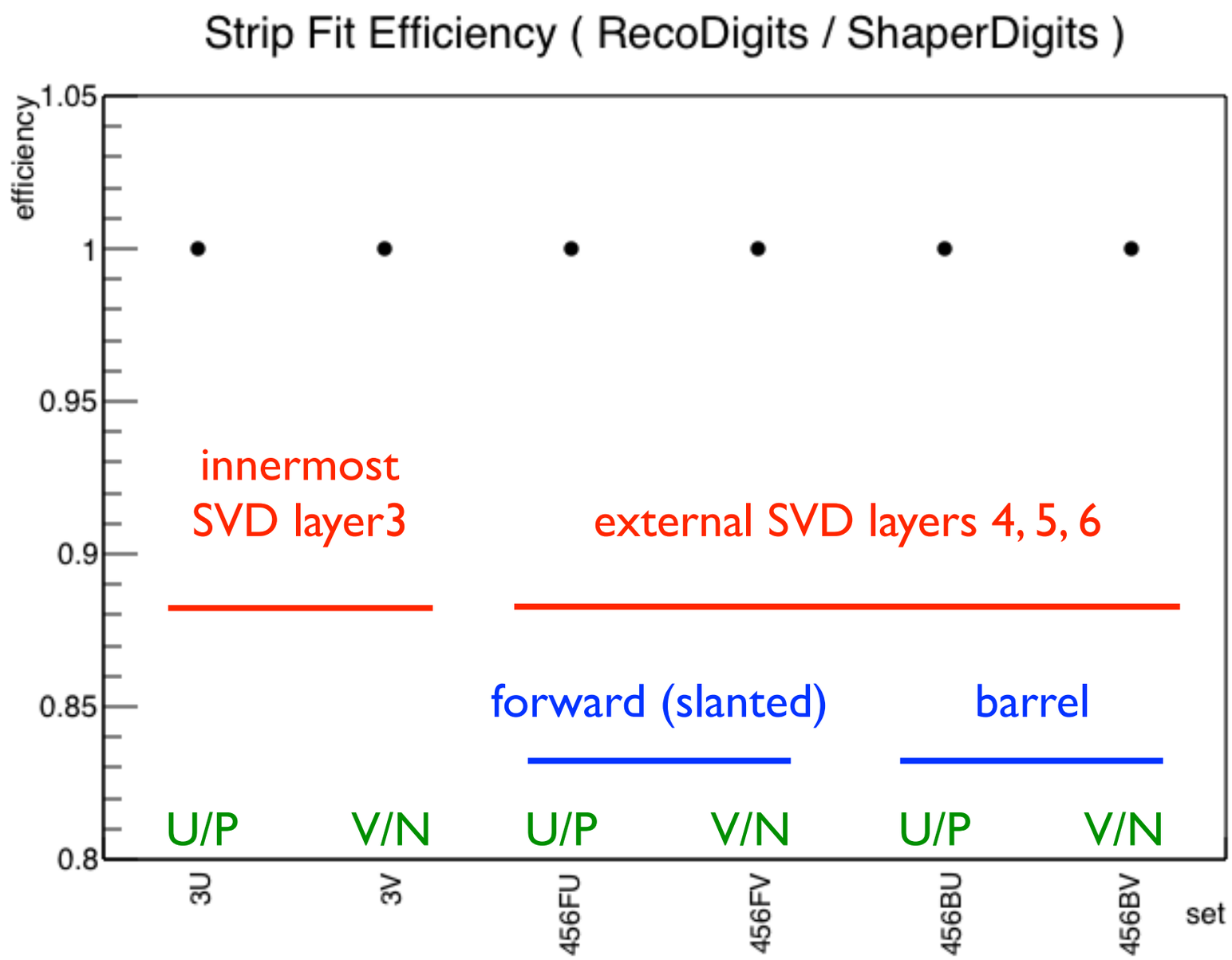
- ➡ The CoG on the N/V side is expected to be more precise because electrons move faster in the silicon, and consequently the signal is faster



Performance

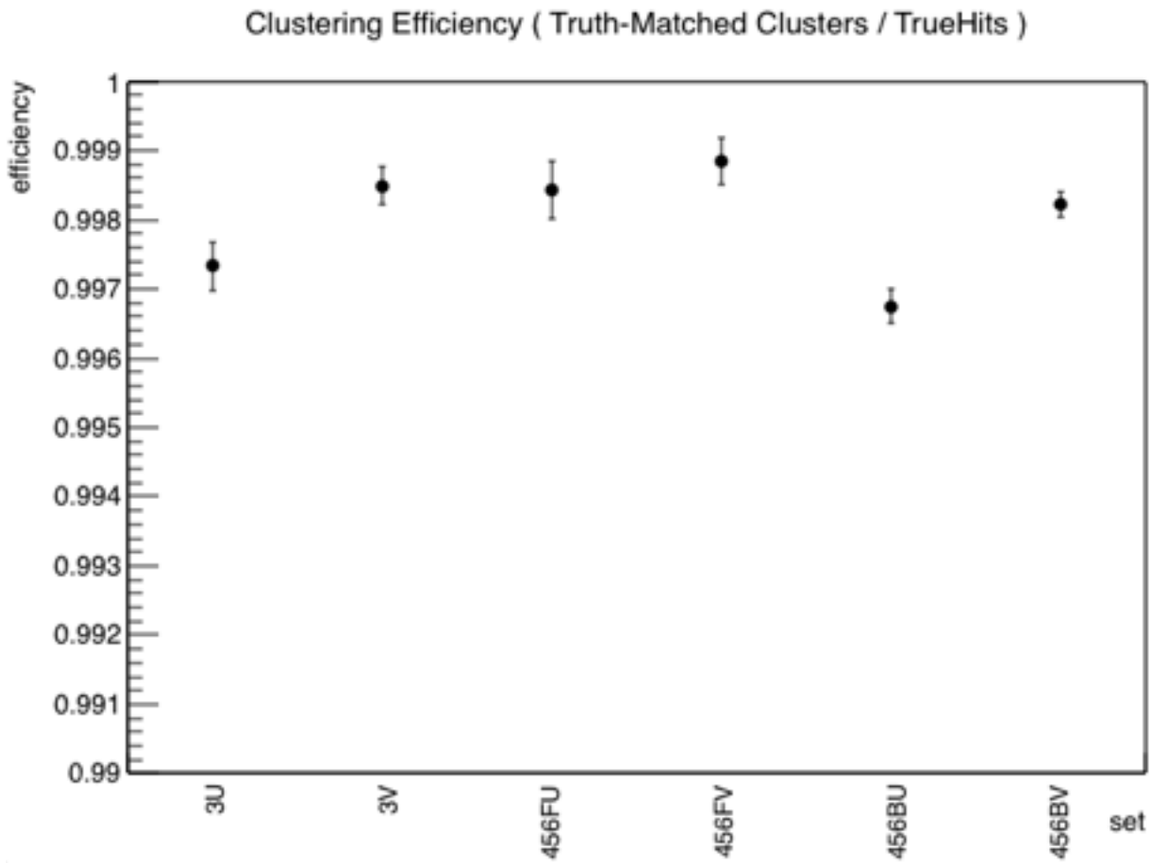
Performance on Simulated data

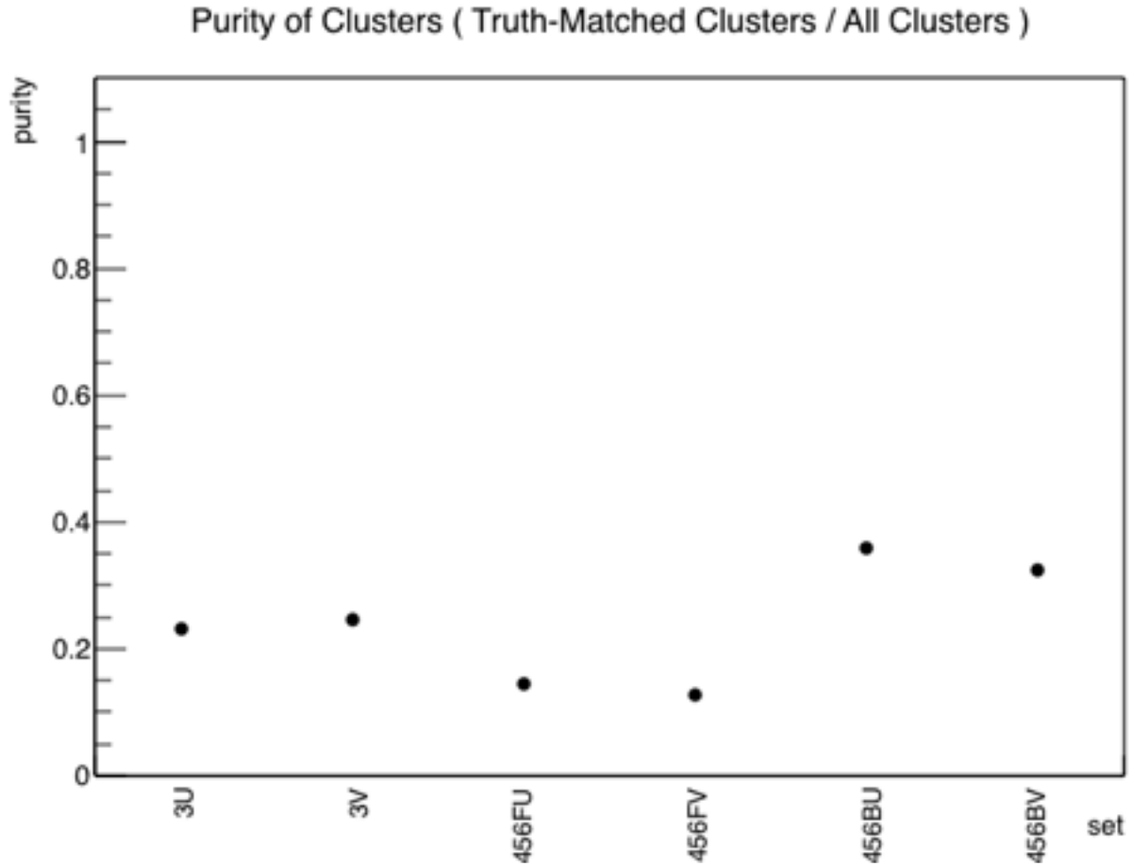
➡ From ShaperDigits to RecoDigits efficiency = 100% by construction



Clustering Efficiency & Purity

➡ Simulated and reconstructed 10k Y(4S) events + background overlay

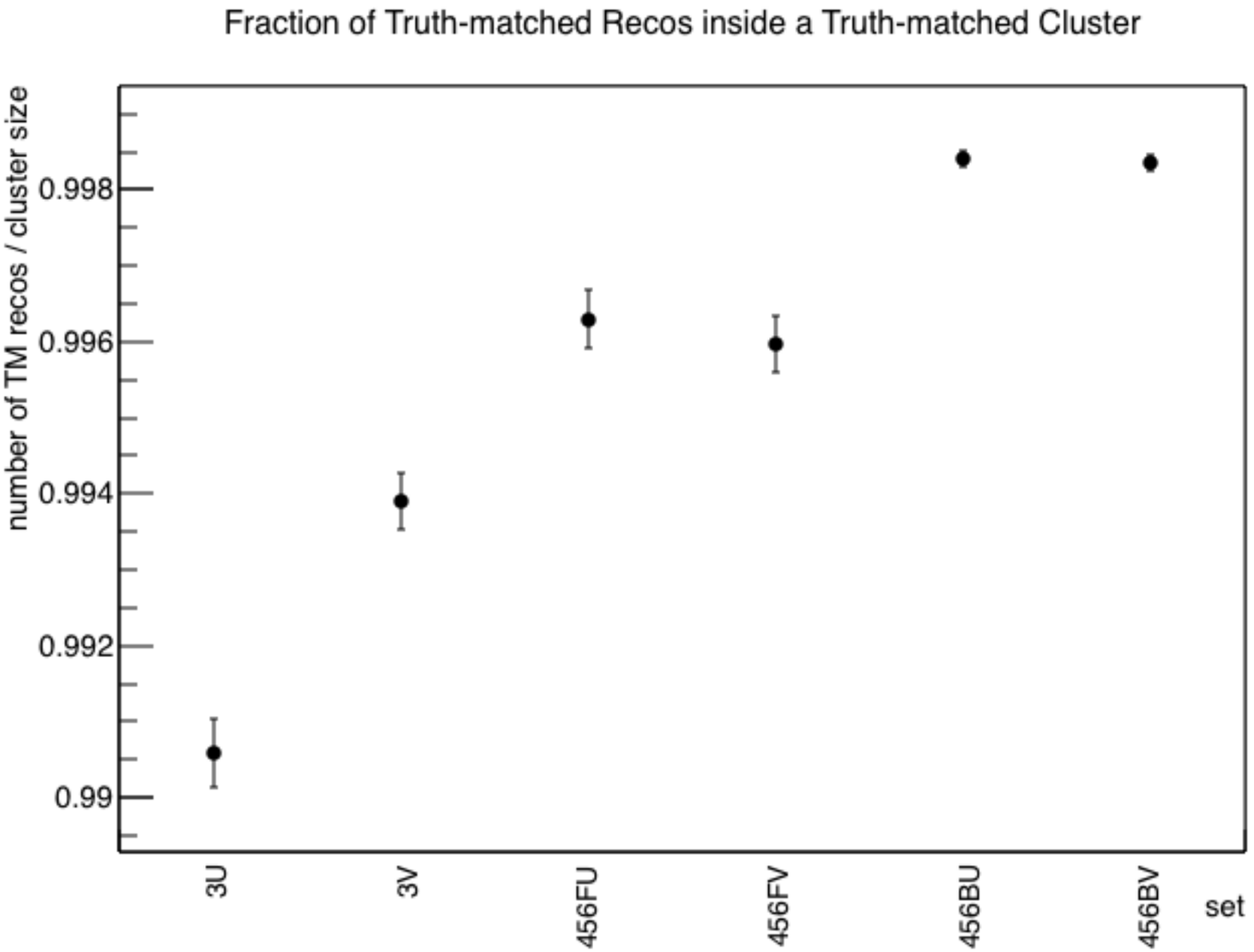




➡ Clustering efficiency higher than 99.5% (considering primary charged particles)

➡ Cluster purity dominated by machine background hits

Cluster Internal Purity

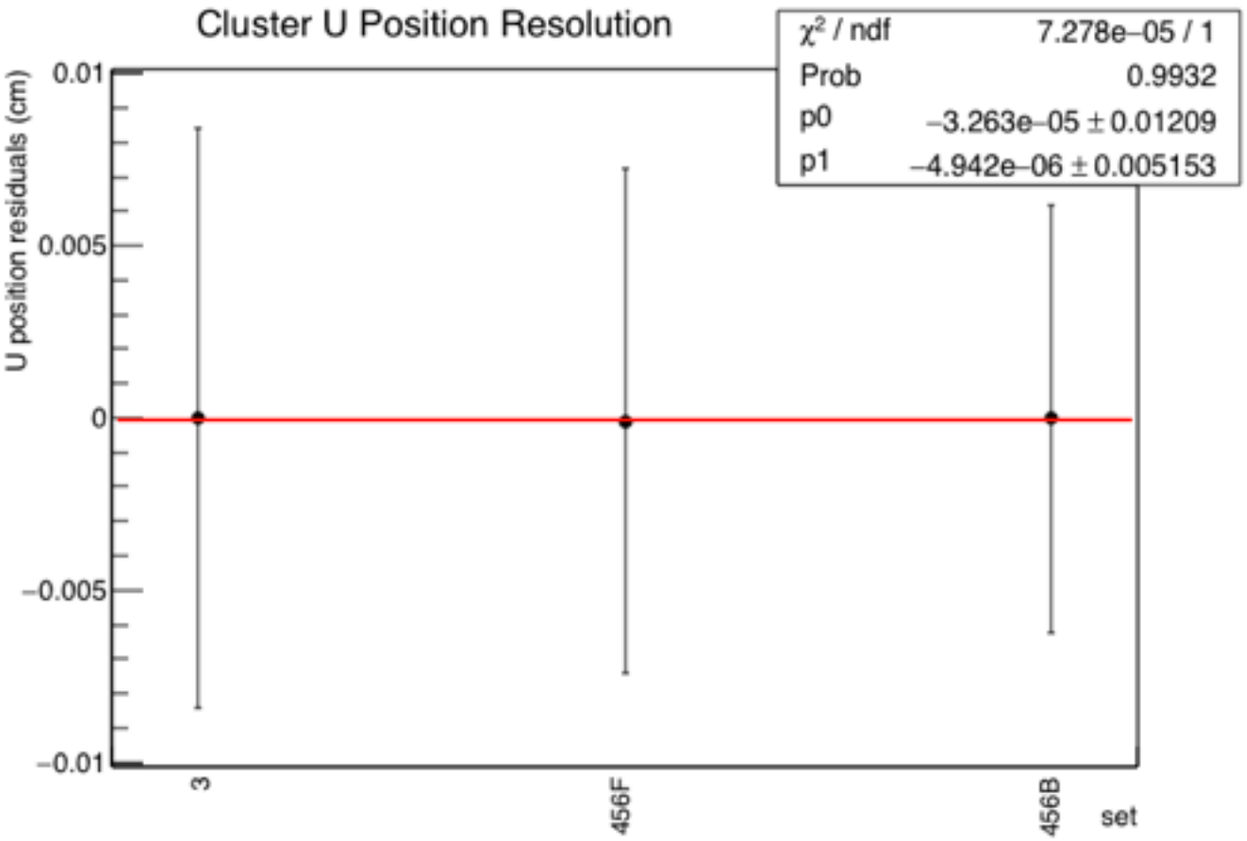


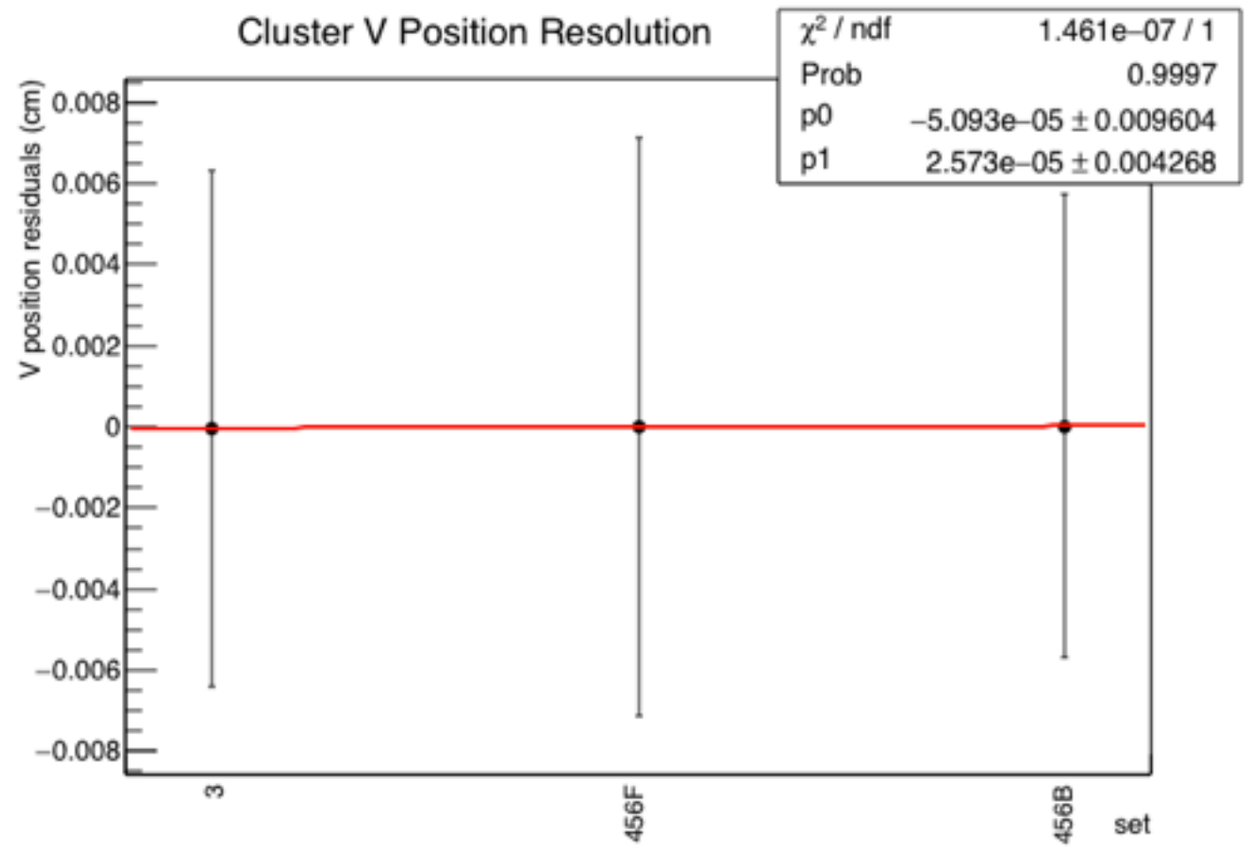
➡ Much less than 1% of the clusters contain a strip that is not related with a true hit

- we do not expect bias in position or time due to the inclusion of a background strip in a signal cluster

Cluster Position Resolution

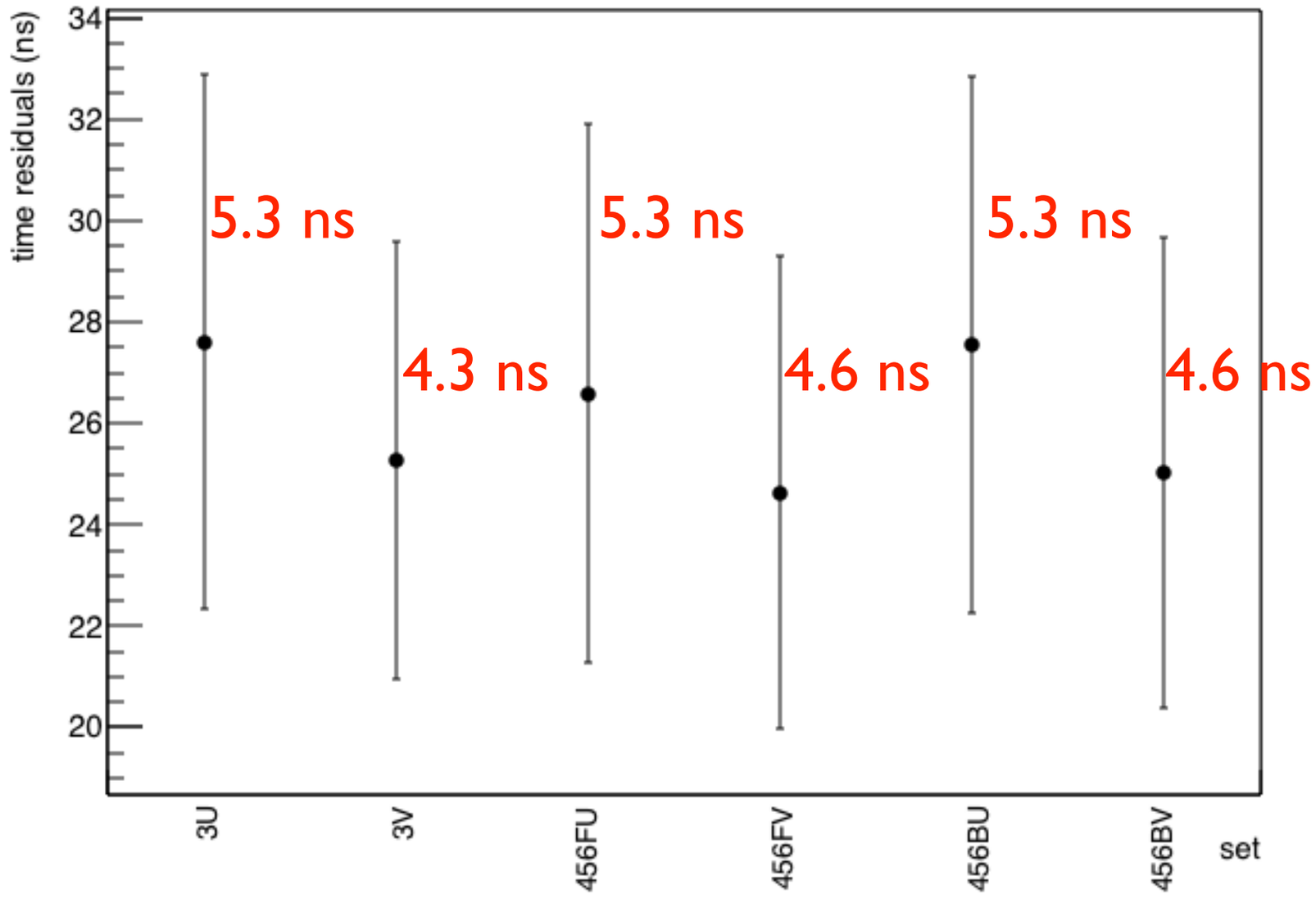
➡ U and V cluster position are unbiased



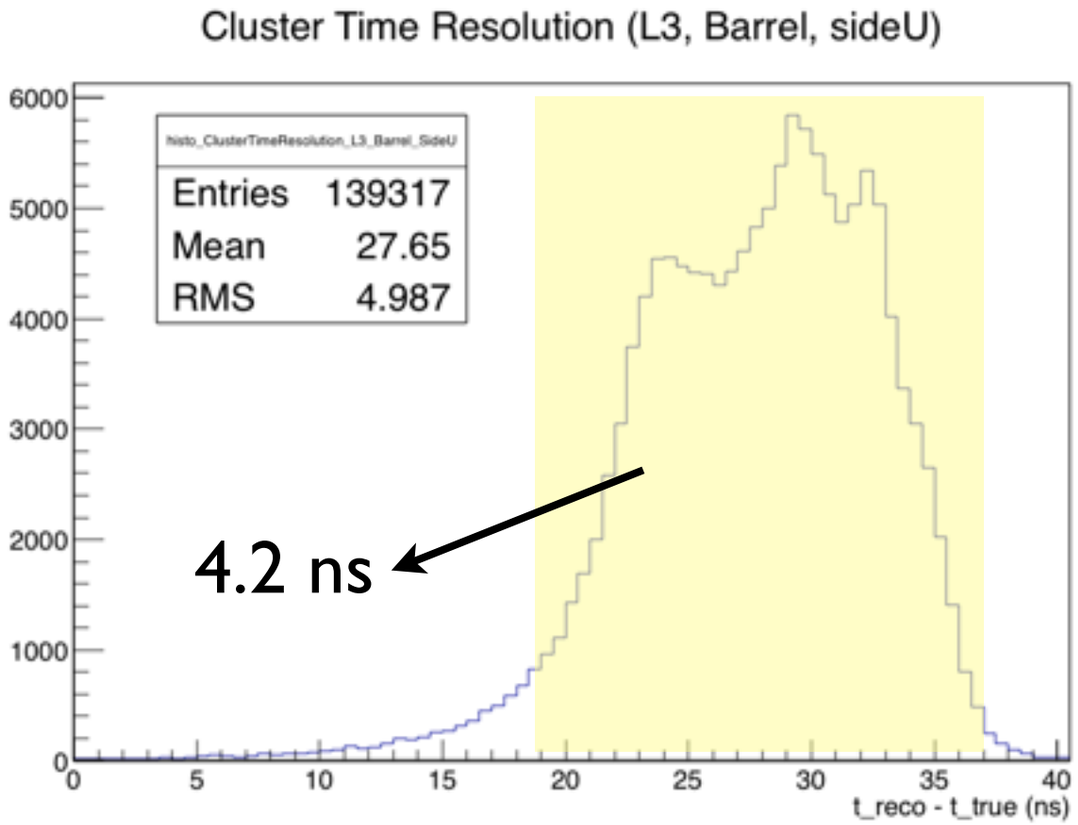


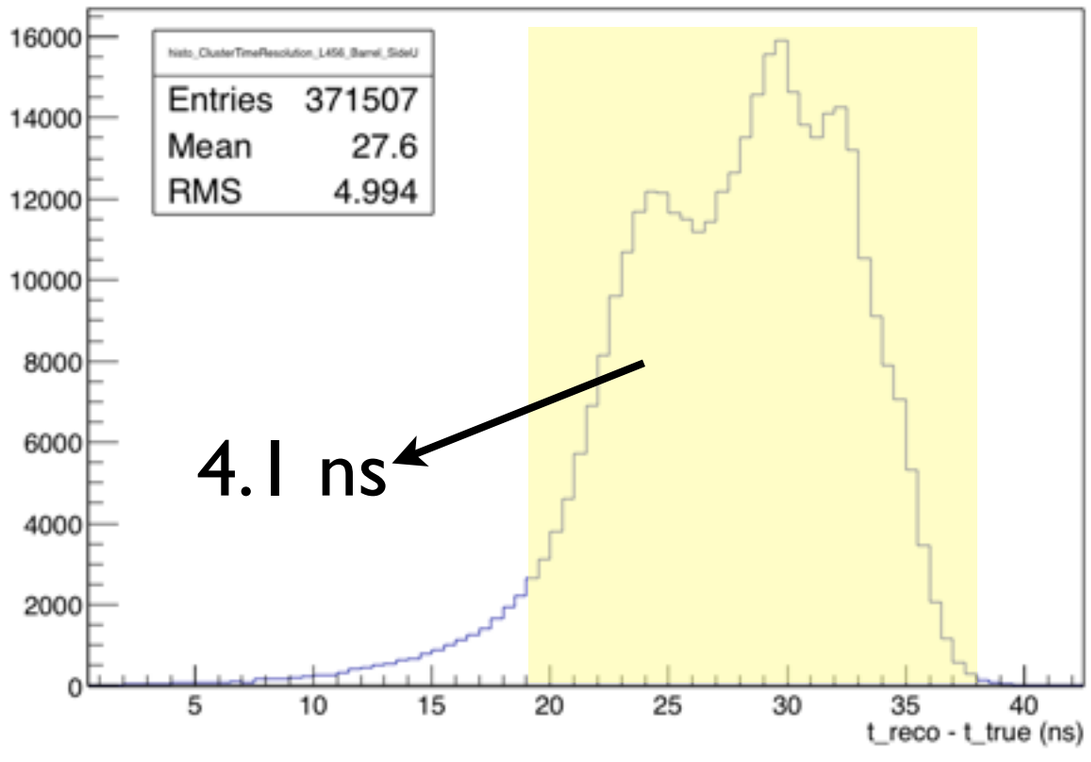
Cluster Time Resolution

➡ V cluster time resolution ~ 4.5 ns, U cluster time resolution is ~1 ns worse:

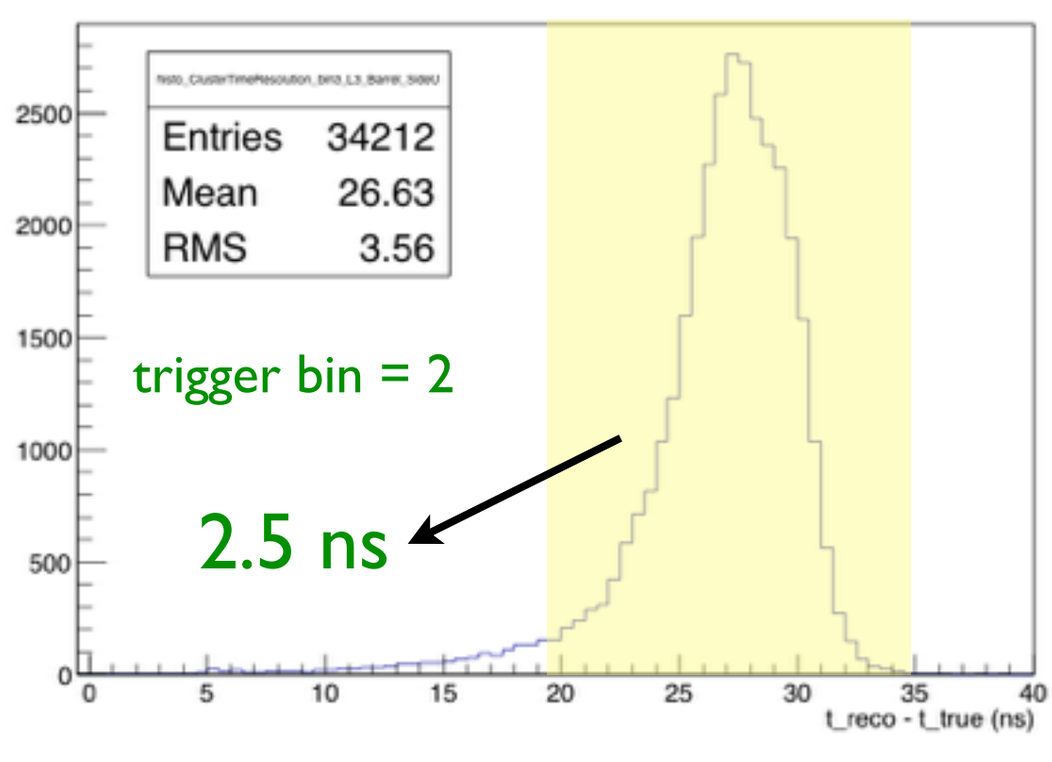


Cluster Time Resolution - U/P side

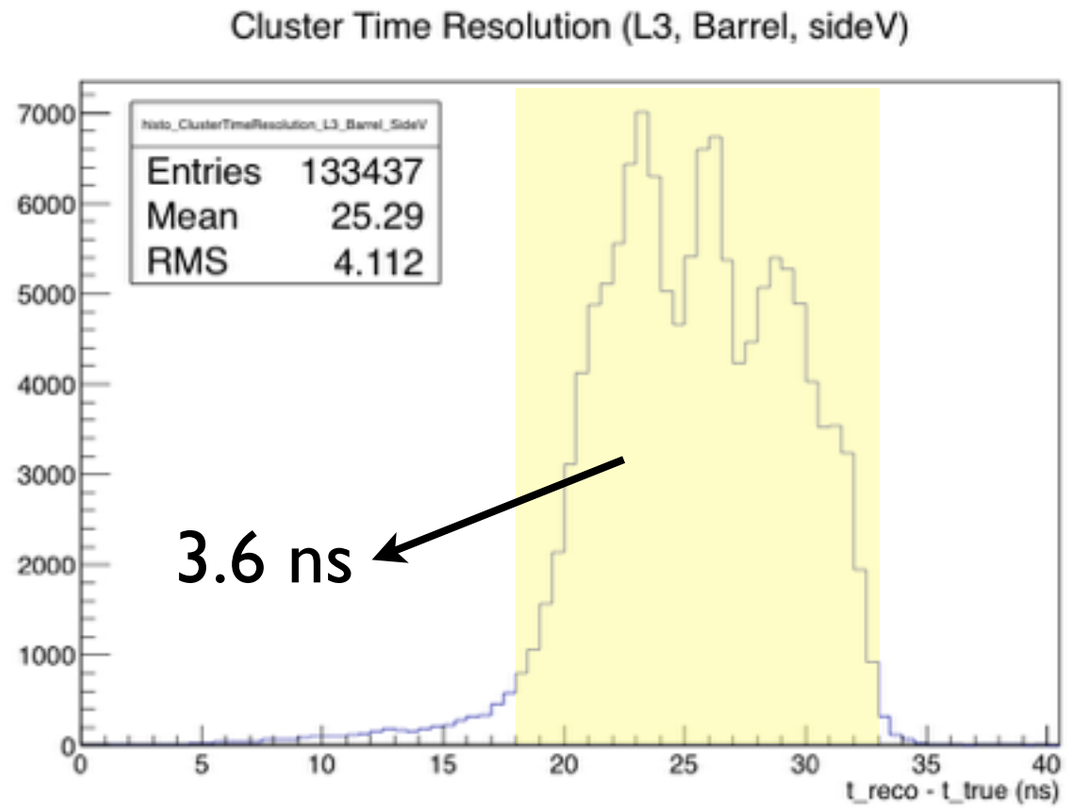


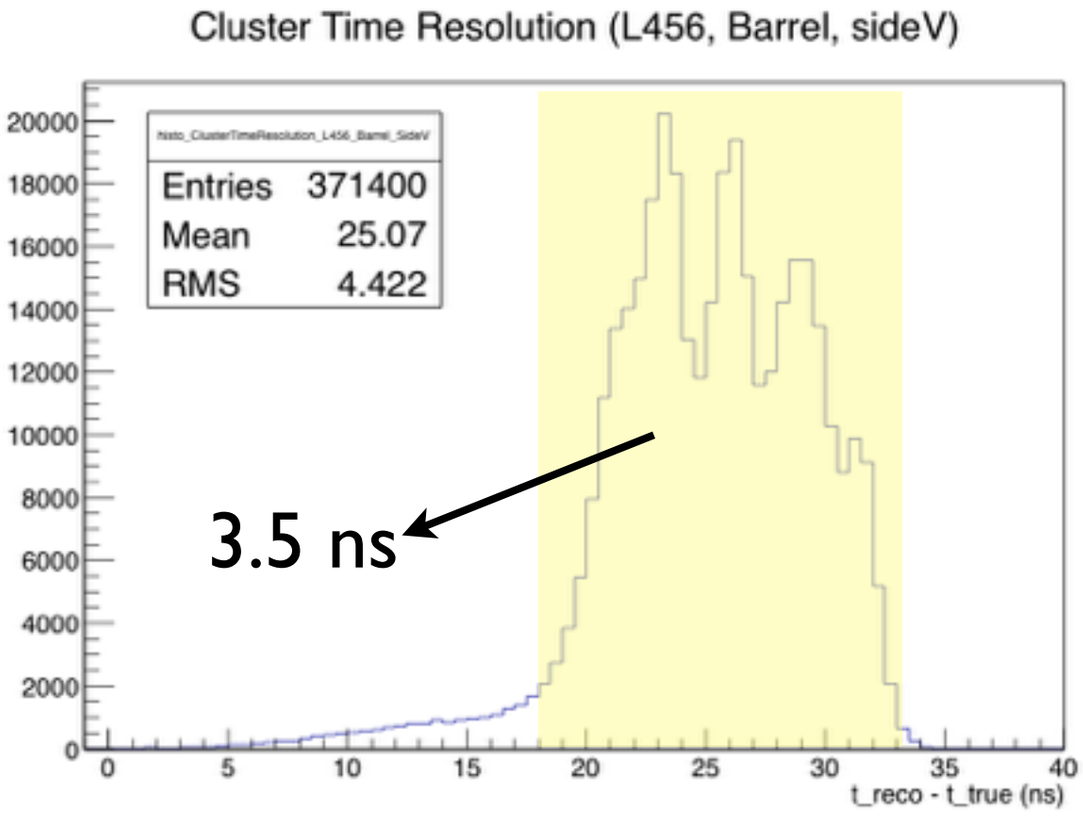


- After eliminating the outliers, there is a visible tail on the left side of the distribution, the resolution arrives to 4.2 ns
- Considering the width in each trigger bin, since all cluster in an event belong to the same trigger bin, the resolution improves significantly to 2.5 ns

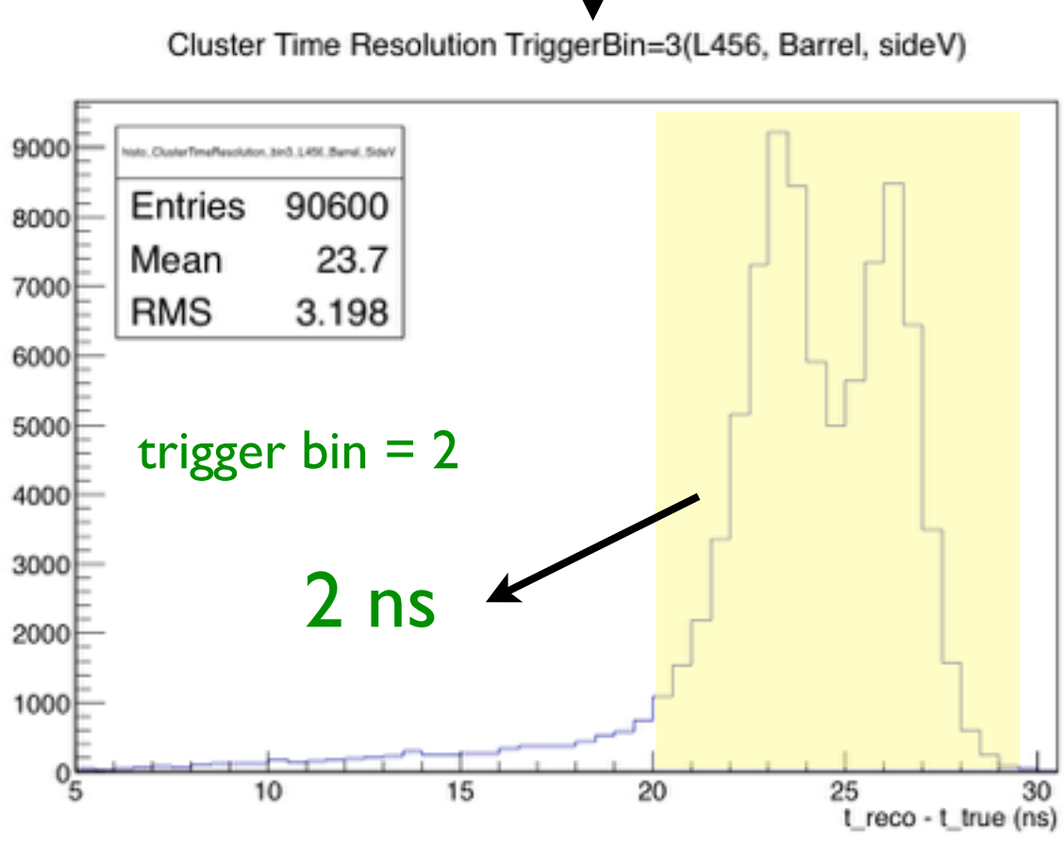


Cluster Time Resolution - V/N side





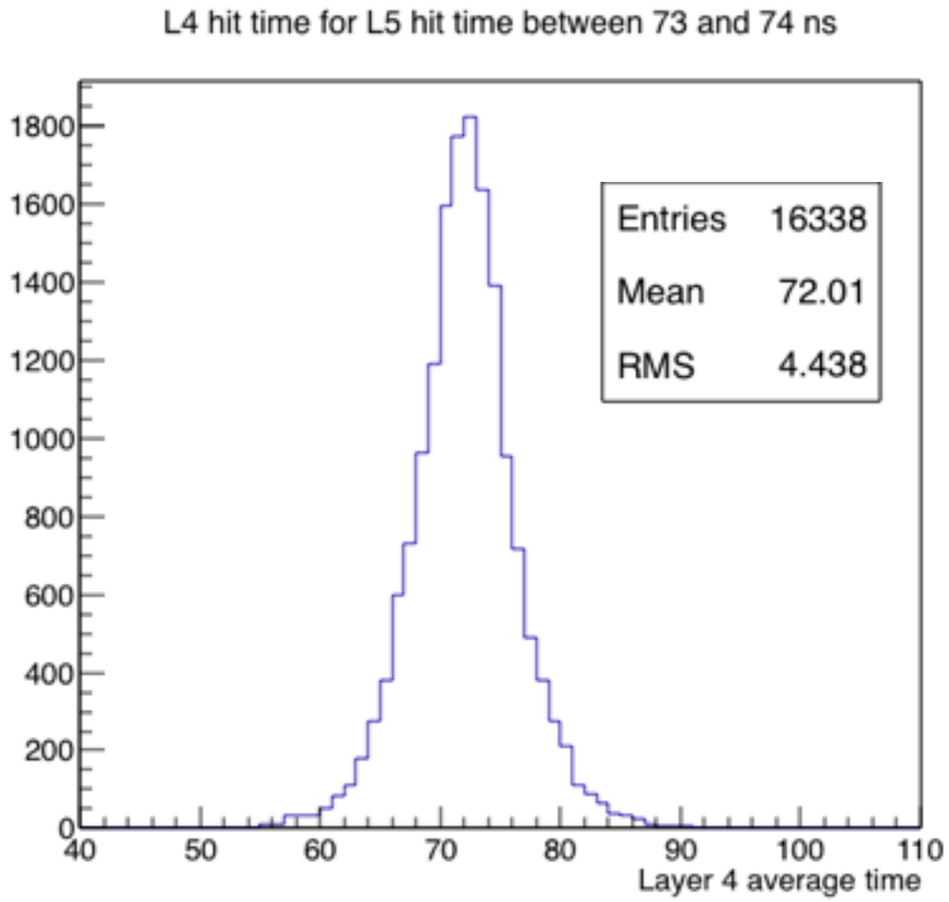
- After eliminating the outliers, there is a visible tail on the left side of the distribution, the resolution arrives to 3.5 ns
- Considering the width in each trigger bin, since all cluster in an event belong to the same trigger bin, the resolution improves significantly to 2 ns

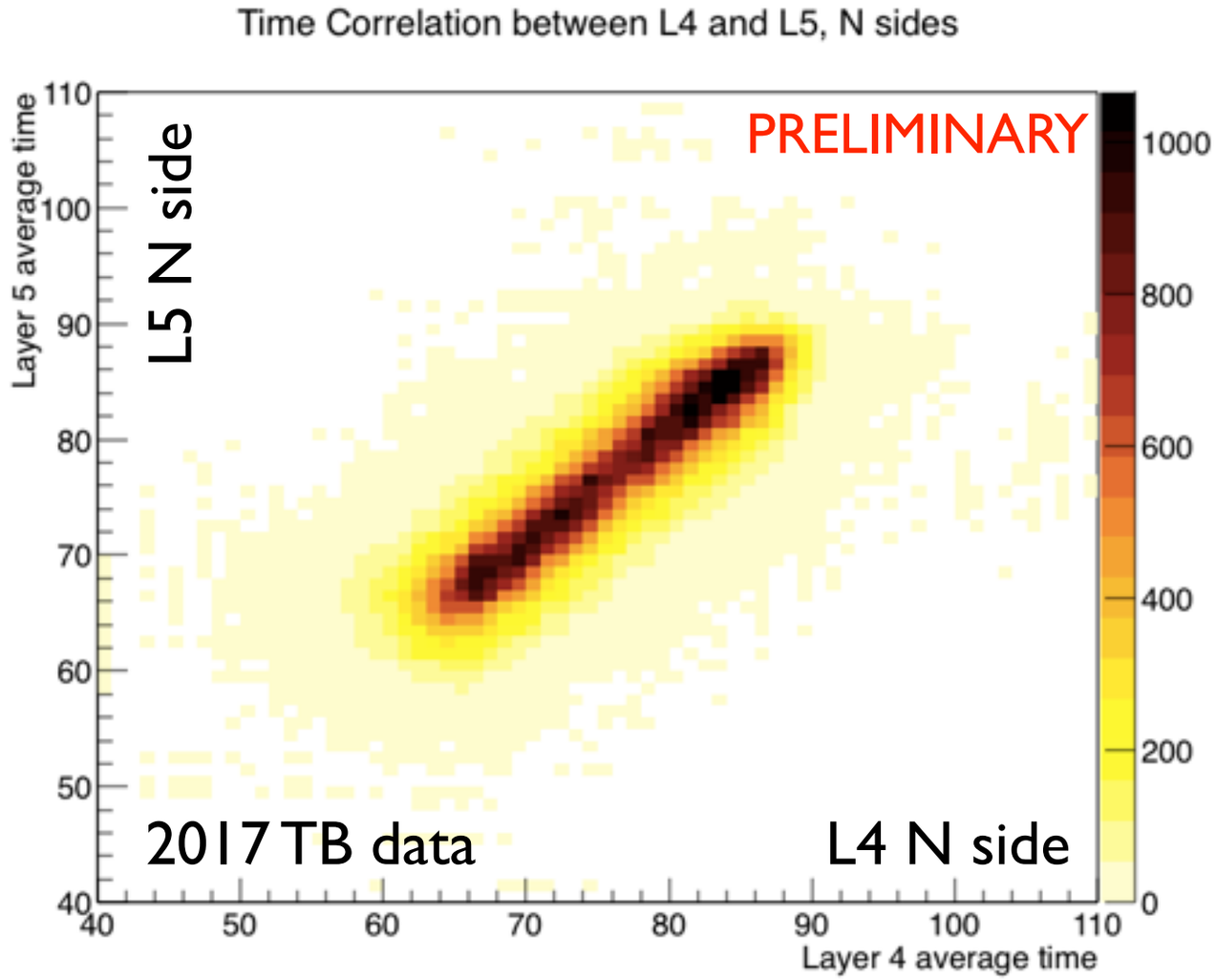


Performance of CoG on TB data

- time estimator uses amplitude (A_n) and time (T_n) of the n^{th} sample

$$T_{raw} = \frac{\sum_{n=0}^{5} A_n \cdot T_n}{\sum_{n=0}^{5} A_n}$$

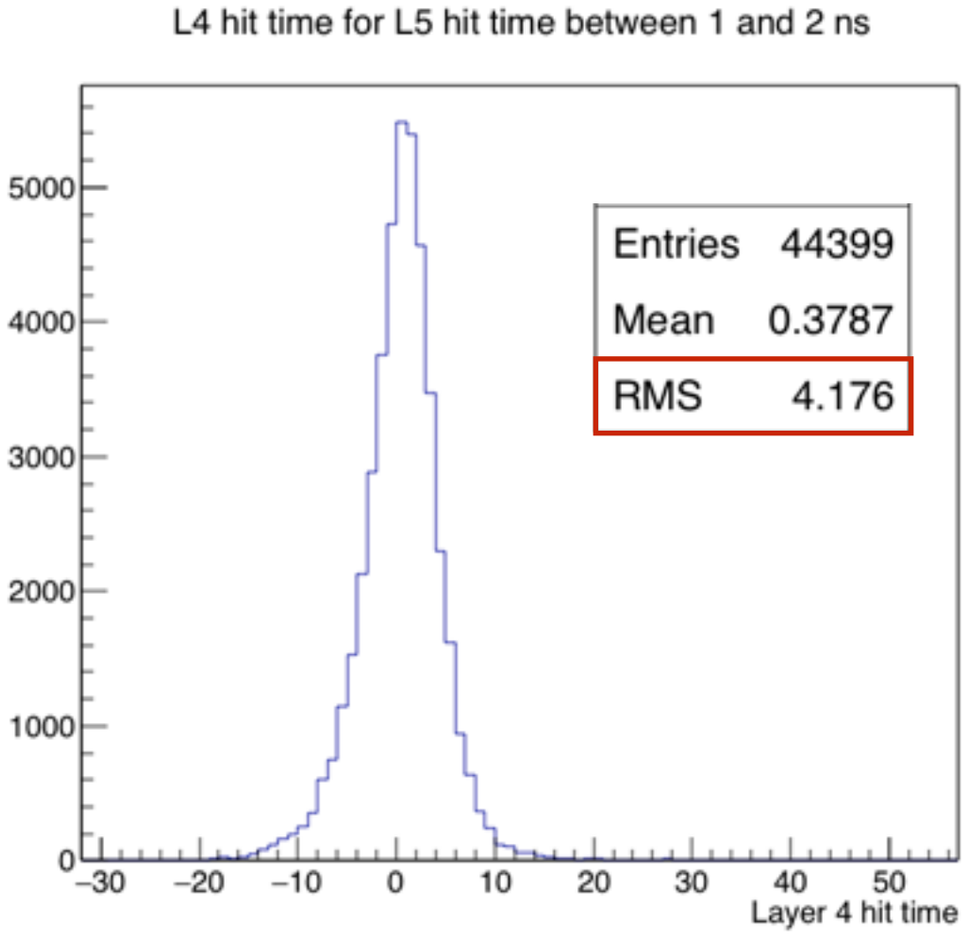


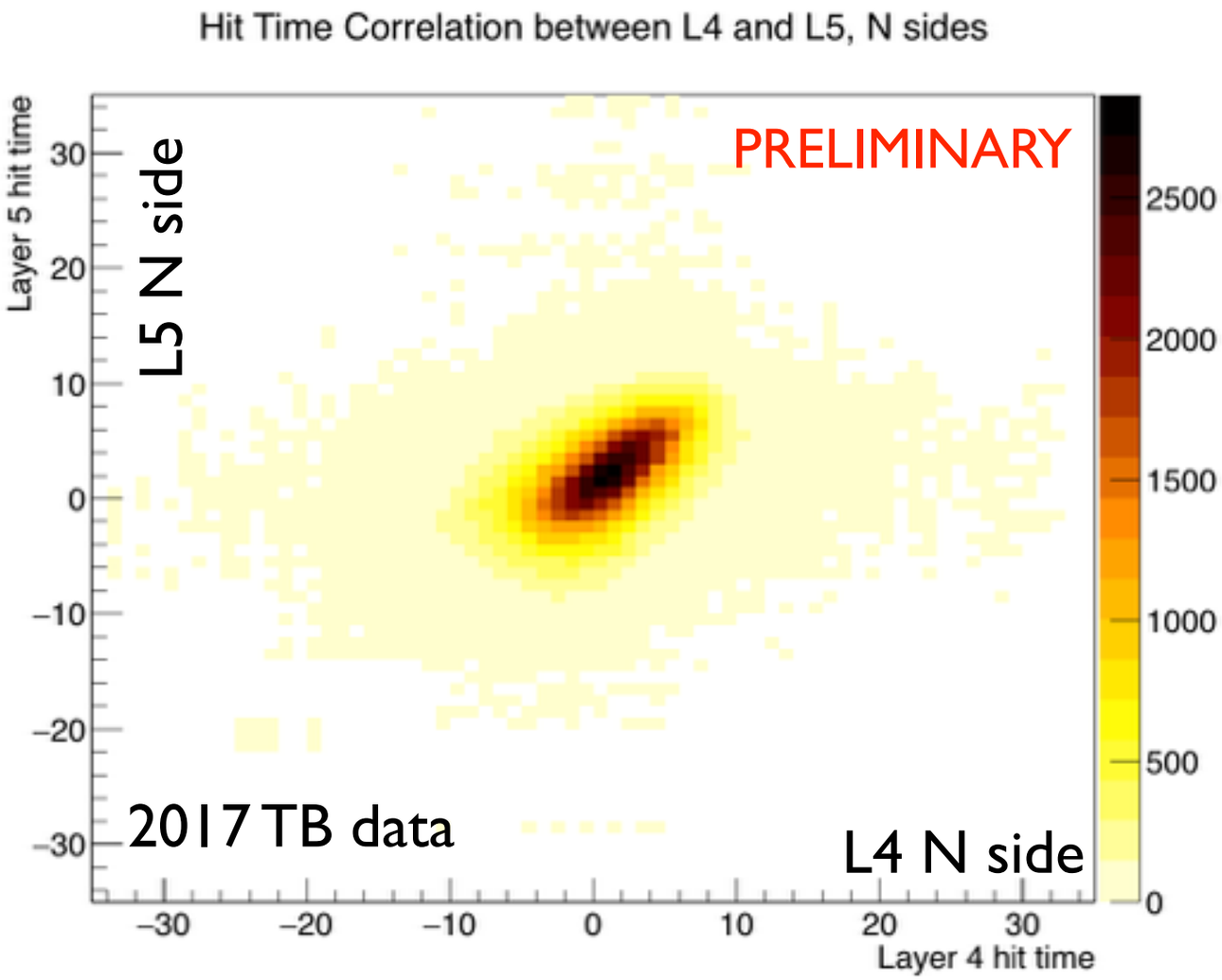


- promising results
  - time resolution around 5 ns for the N side and 7 ns for P side

Corrected Time Determination

- After the application of the previously described correction:
  - expected squeeze around 0 on both layers
  - resolution is not significantly improved

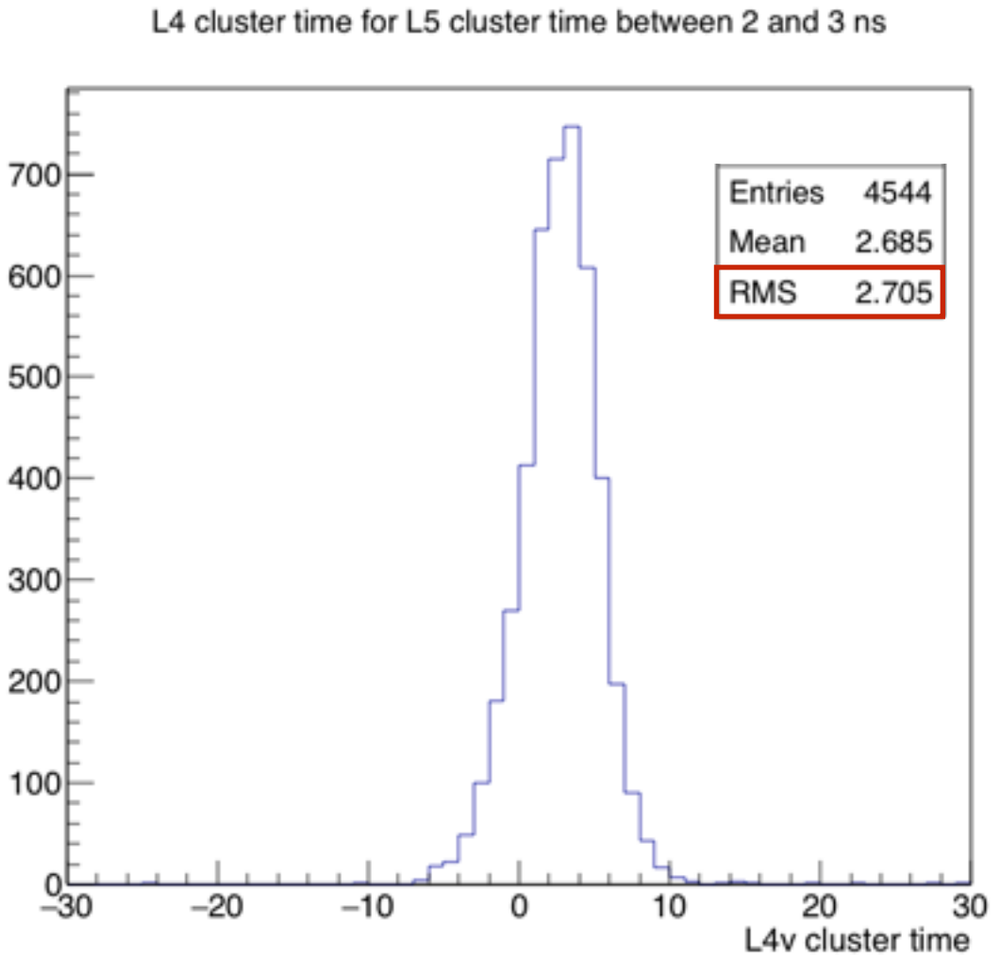


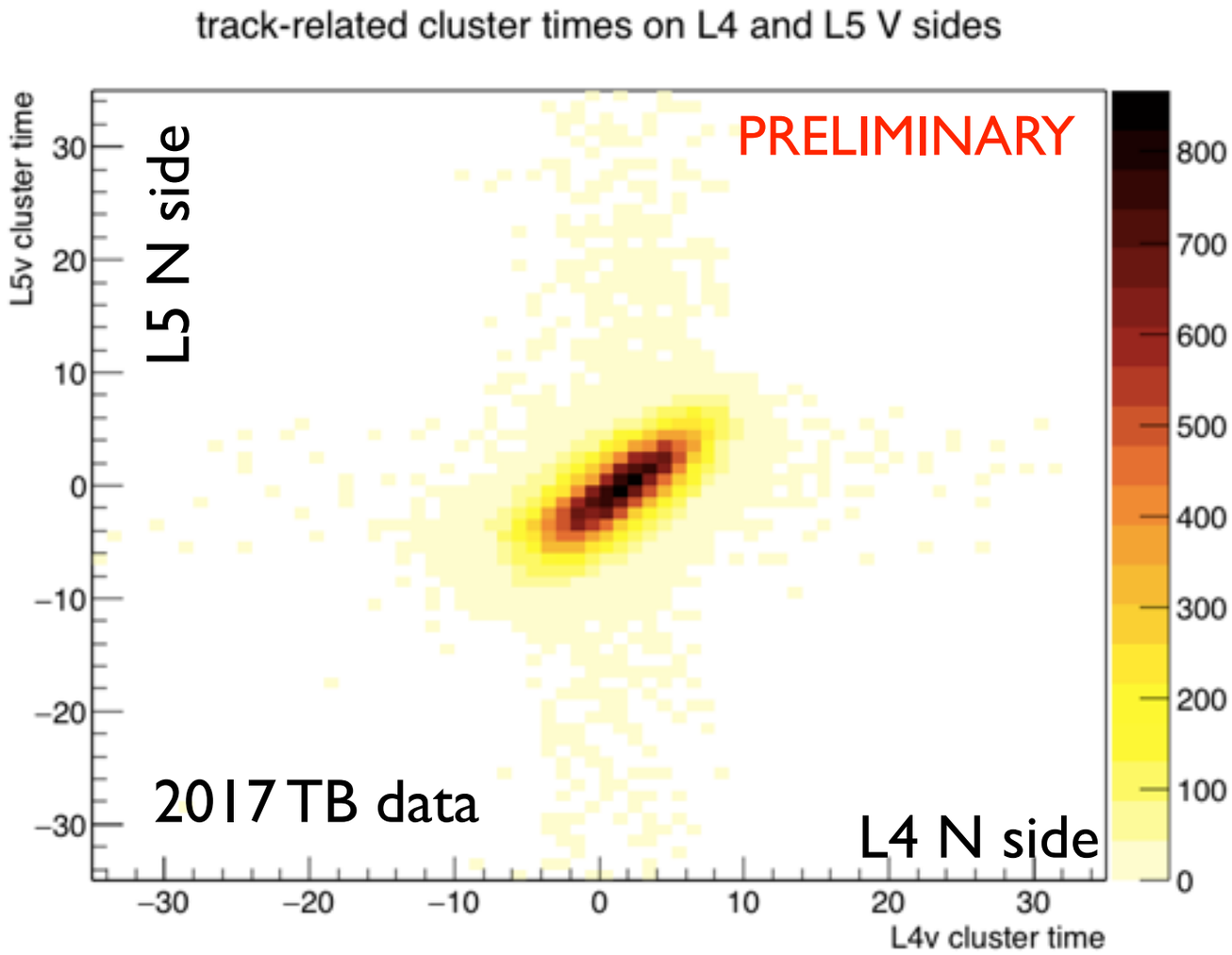


- … but combinatorial background still there, let's use tracking and clusters.

Same-Side Clusters Related to Tracks

- Use *VXDTF1* to find tracks and only use clusters related to the same track
- Significant improvement of the resolution → 2.7 ns

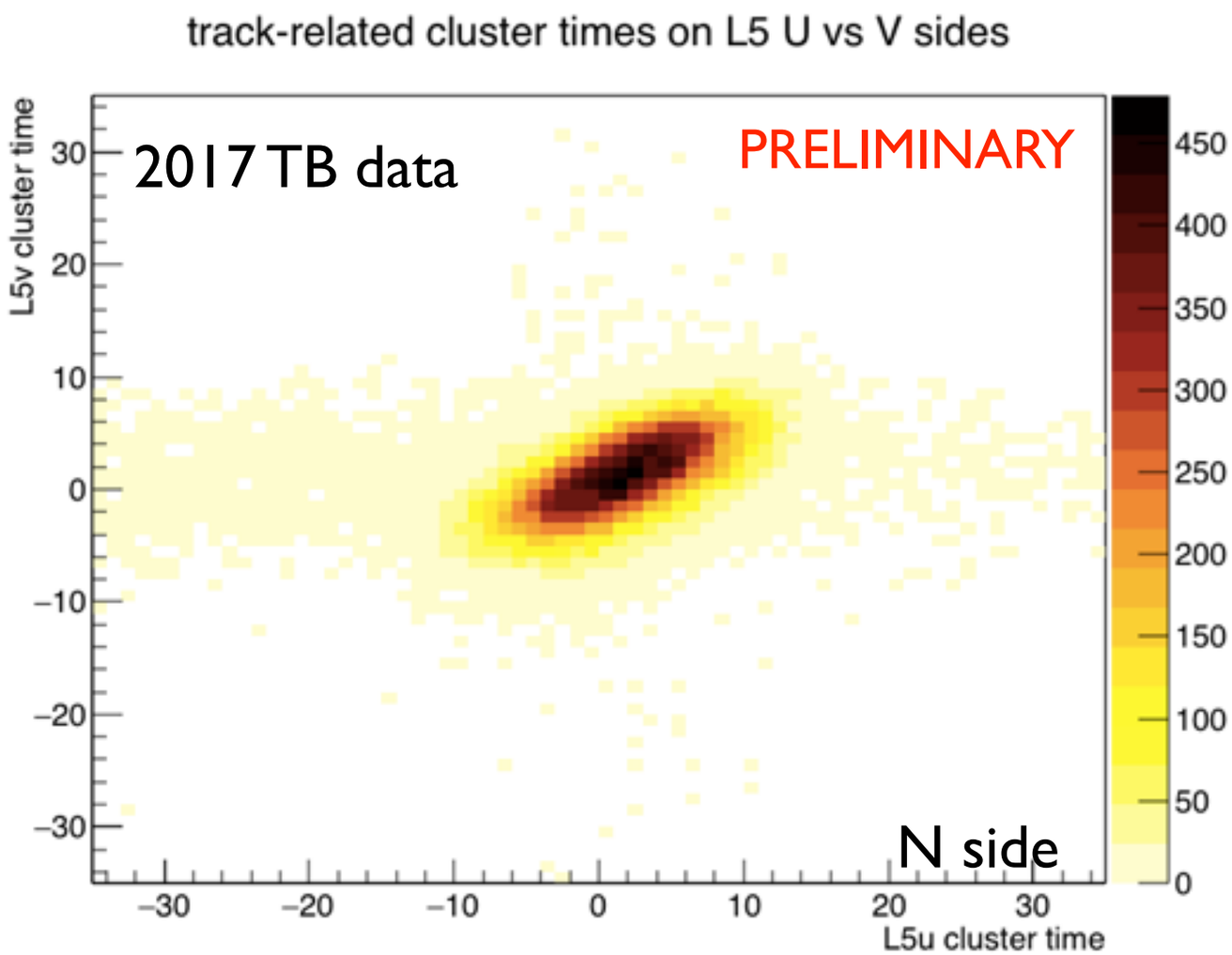




- The L4 V side cluster resolution reported on the left plot is the convolved with the L5 V side resolution
- Agreement with what observed in the simulation, even if it is Phase3 simulation (different kinematics of the tracks)

Opposite-Side Clusters Related to Tracks

- Use *VXDTF1* to find tracks and only use clusters related to the same track
- The CoG on the U side has a worse performance

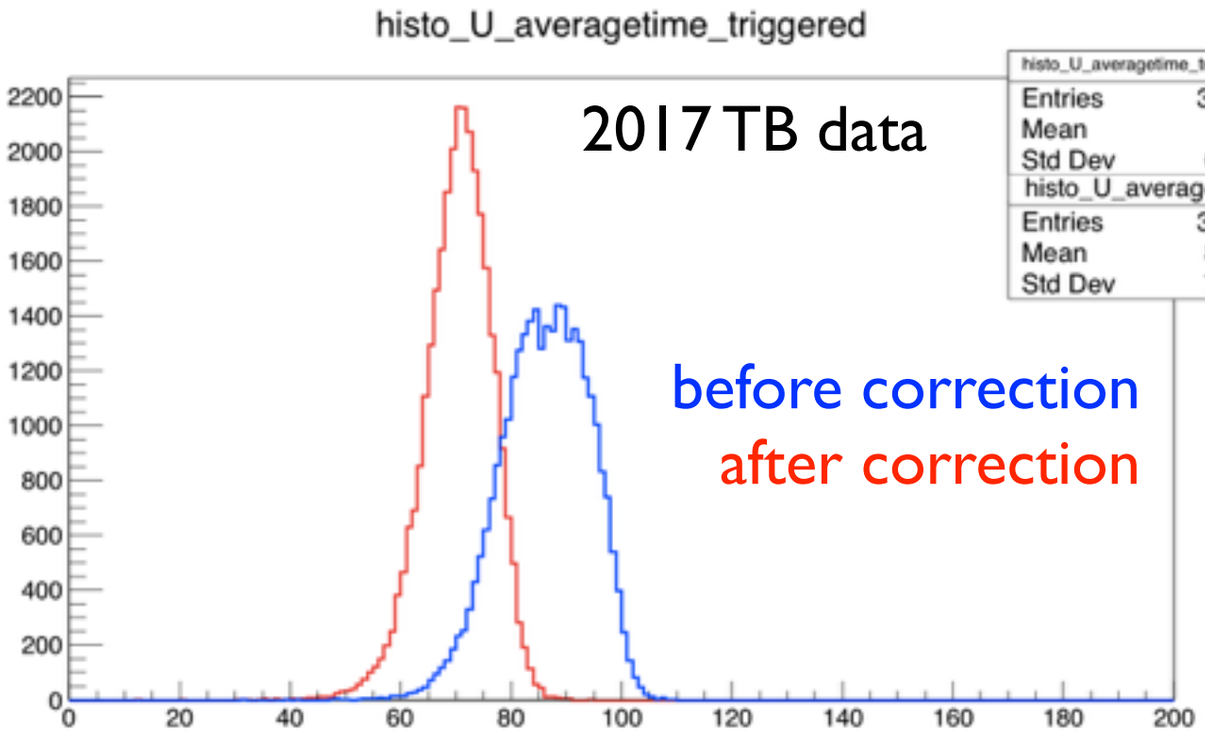


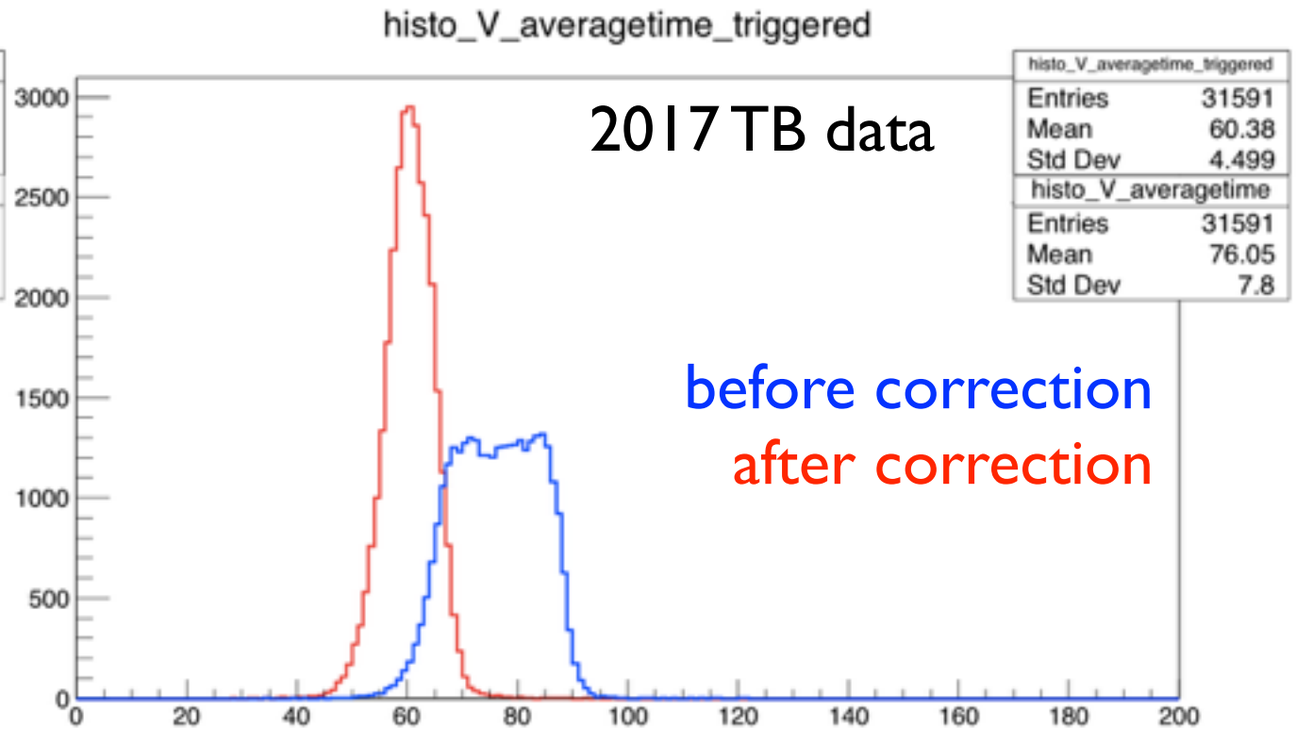
Conclusions

- ➡ The CoG is a corrected weighted average of the samples time with their amplitude
- ➡ It is a robust estimator if used to estimate relative times:
  - all strips in the same event belong to the same trigger bin
  - all APVs in the SVD are synchronized
- ➡ The CoG-based reconstruction has a clustering efficiency greater than 99.6%
- ➡ The cluster time determination can potentially reach precisions of the order of 2-3 ns, assuming no trigger jitter
- ➡ The effect of trigger jitter will be studied in details in the next weeks.

Trigger Arrival Correction

- We know the trigger arrival with a better precision than the APV clock period (31.44ns) → trigger bin
- We can further correct our estimation shifting it by the time between the trigger arrival and the actual action of our DAQ (precision of $31.44/4/\sqrt{12} \simeq 2.3$ ns)





Preview of Performance on Signal Strips