SVD CoG (Centre of Gravity) Updates
Jitter Effects and Calibration

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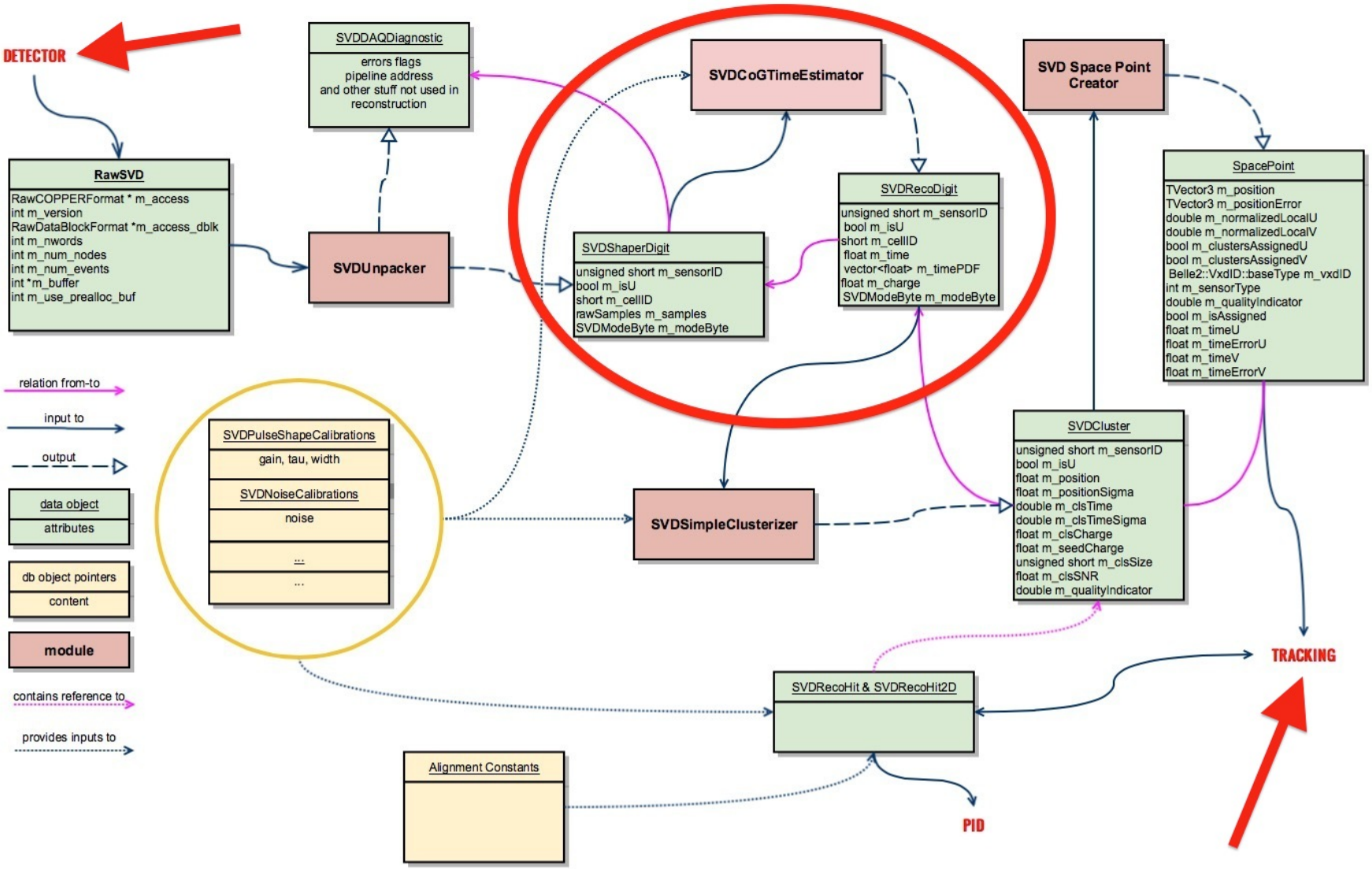
Talk Summary

In this talk we will see:

- Recap of CoG (definition and corrections);
- Effect of the Trigger Jitter on the CoG time distribution;
- Calibration procedure for phase 2.

SVD Reconstruction Software Organization



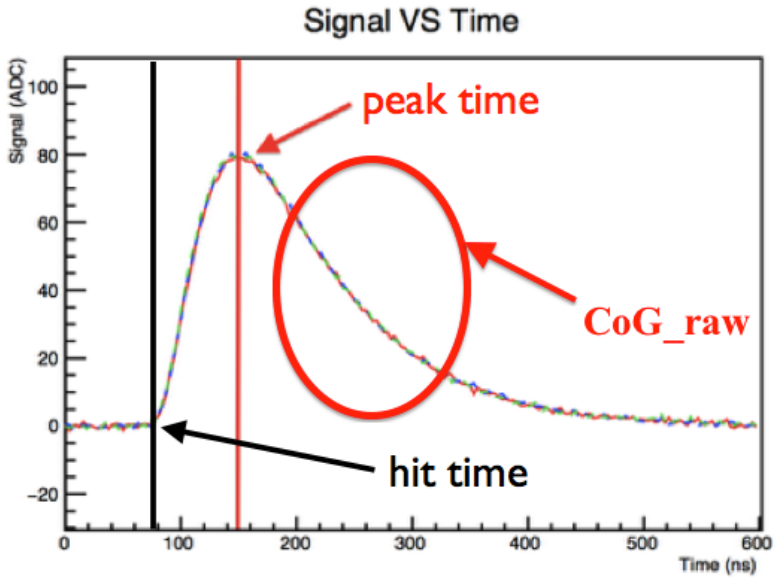
CoG - Centre of Gravity

Definition

CoG is the current default option to perform time estimation (from the 6 samples of the waveform).

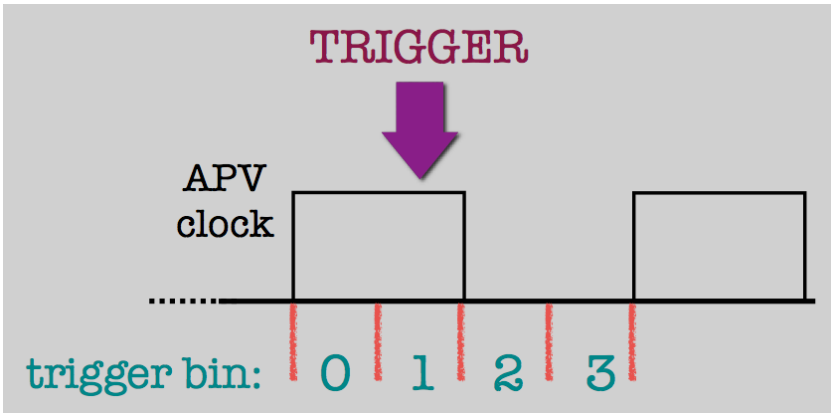
$$T_{CoG_{raw}} = \frac{\sum_{n=0}^{5} A_n \cdot T_n}{\sum_{n=0}^{5} A_n} \tag{1}$$

A_n: amplitude; T_n: time, of the nth sample.
It doesn't directly provide the hit time $\Rightarrow$ needs some corrections.



1. **Peak-Time correction**: $T_{CoG} \sim T_{peak} \neq$ hit time ($T = 0$): subtract rising time (from calibration);
2. **Trigger-Bin correction**: $f_{\text{clock trigger}} = 4 \times f_{\text{clock sampling}}$.
   We save the info on the arrival time of the trigger $\Rightarrow$ we can improve distribution resolution subtracting the following quantity:

$$T_{TriggerBin} \simeq 4 + 8 \times \text{TriggerBin}_{\text{Index}} \text{ [ns]} \quad (2)$$



3. **Shift-to-Zero correction**: Residual shift to move the mean of the distribution to 0.

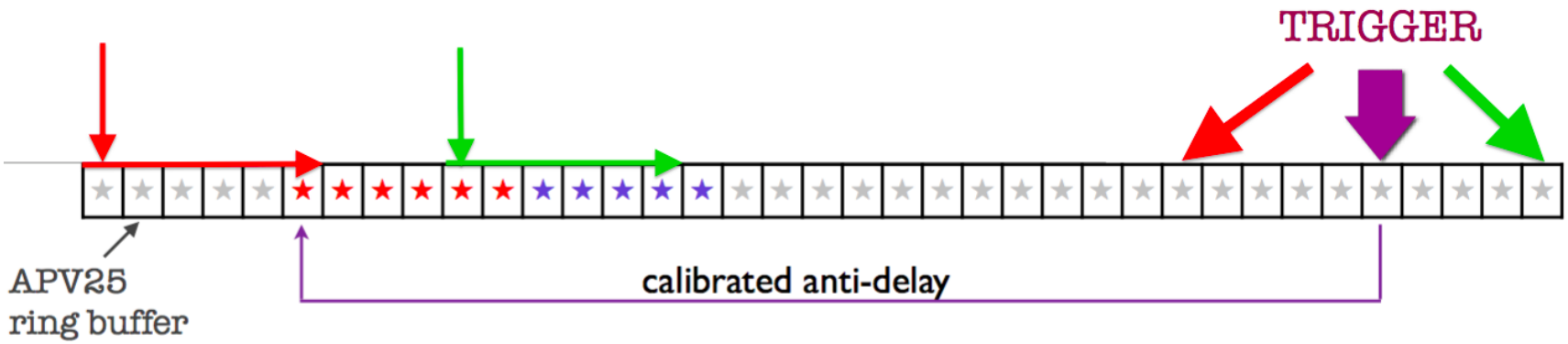
The last correction must be **calibrated**!

Trigger Jitter

The **Trigger** tells us when the event has happened.
This information has an uncertainty: **Trigger Jitter** (TJ).
If TJ is large:

- Bad starting time of the sampling $\Rightarrow$ we could lose meaningful bins (the ones containing the peak of the waveform);
- Trigger Bin (TB) information could be meaningless $\Rightarrow$ TB-correction would be useless.

Expected TJ in Phase 2: ~ 40 ns.



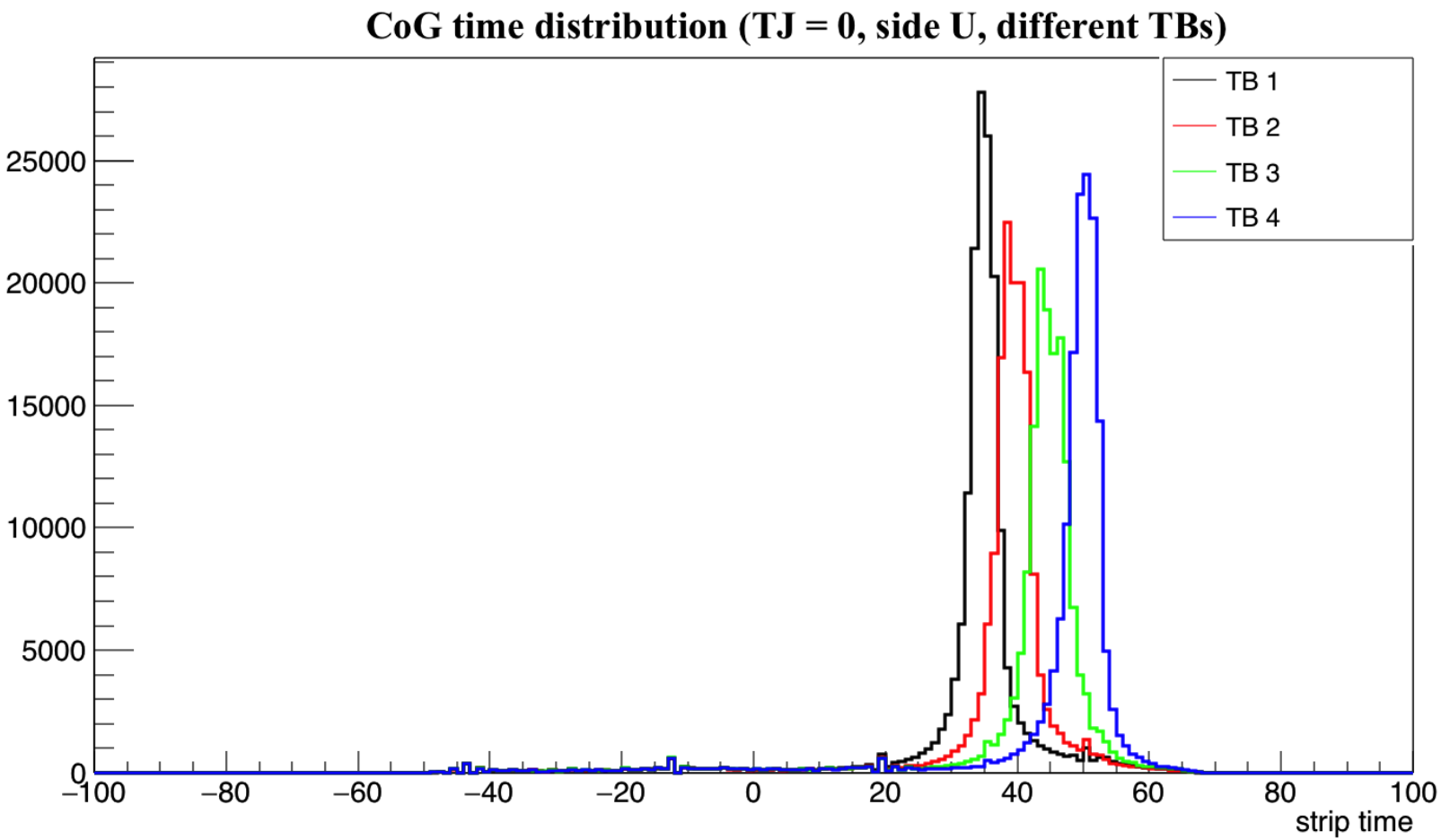
TJ Studies

Is it worth to include the TB-correction if TJ is "too" large?
Problem studied with 5000 $\Upsilon(4S)$ events, no bkg, phase 3 simulation, release 1.00, using Trigger module.
We will see the CoG time distribution for:

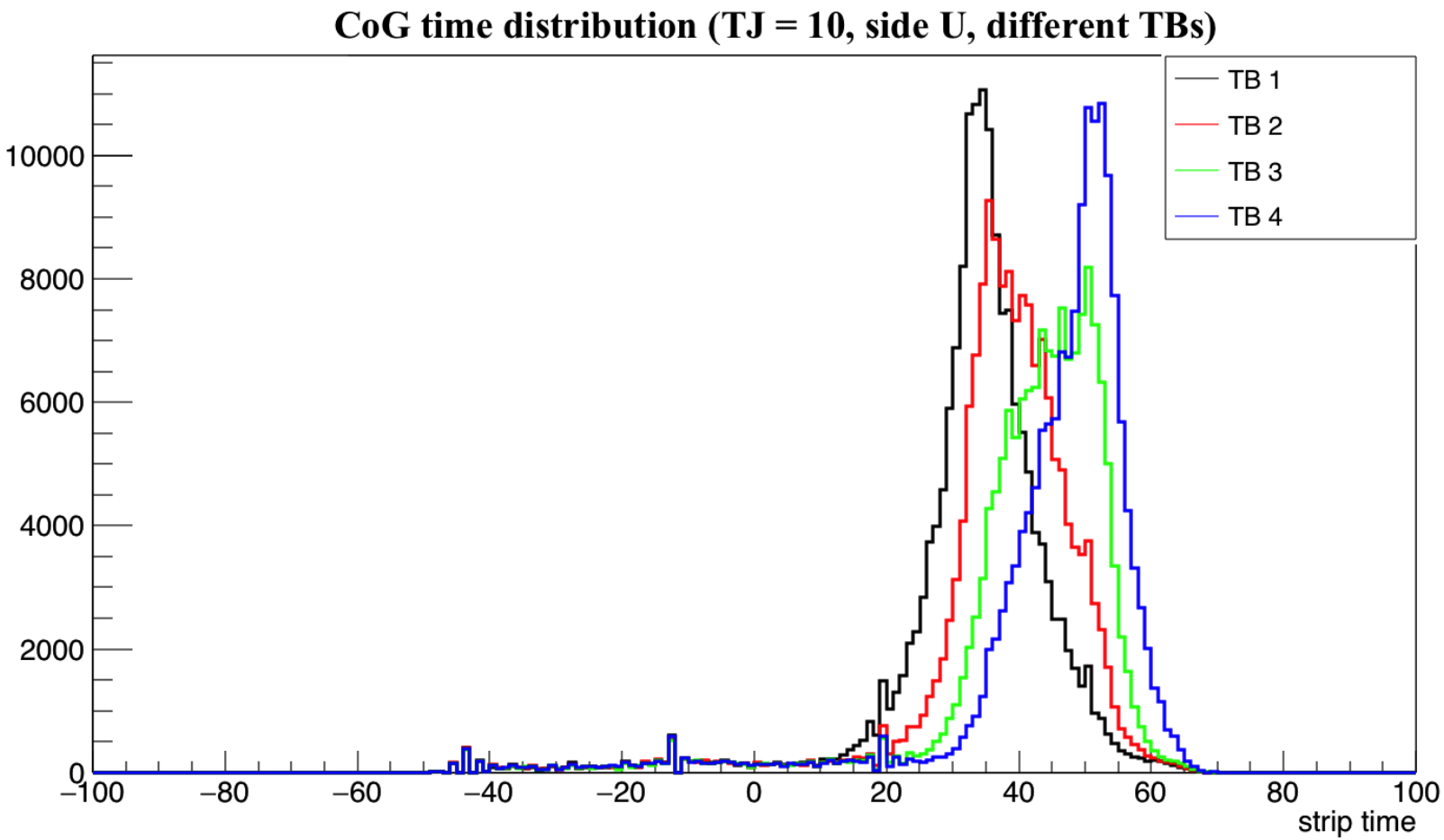
- Different TJs (0, 5, 10, 20, 40, 60 ns);
- Different TBs (1, 2, 3, 4);
- Only Peak-Time correction and both Peak-Time and TB corrections applied.

(N.B.: all the times are in ns)

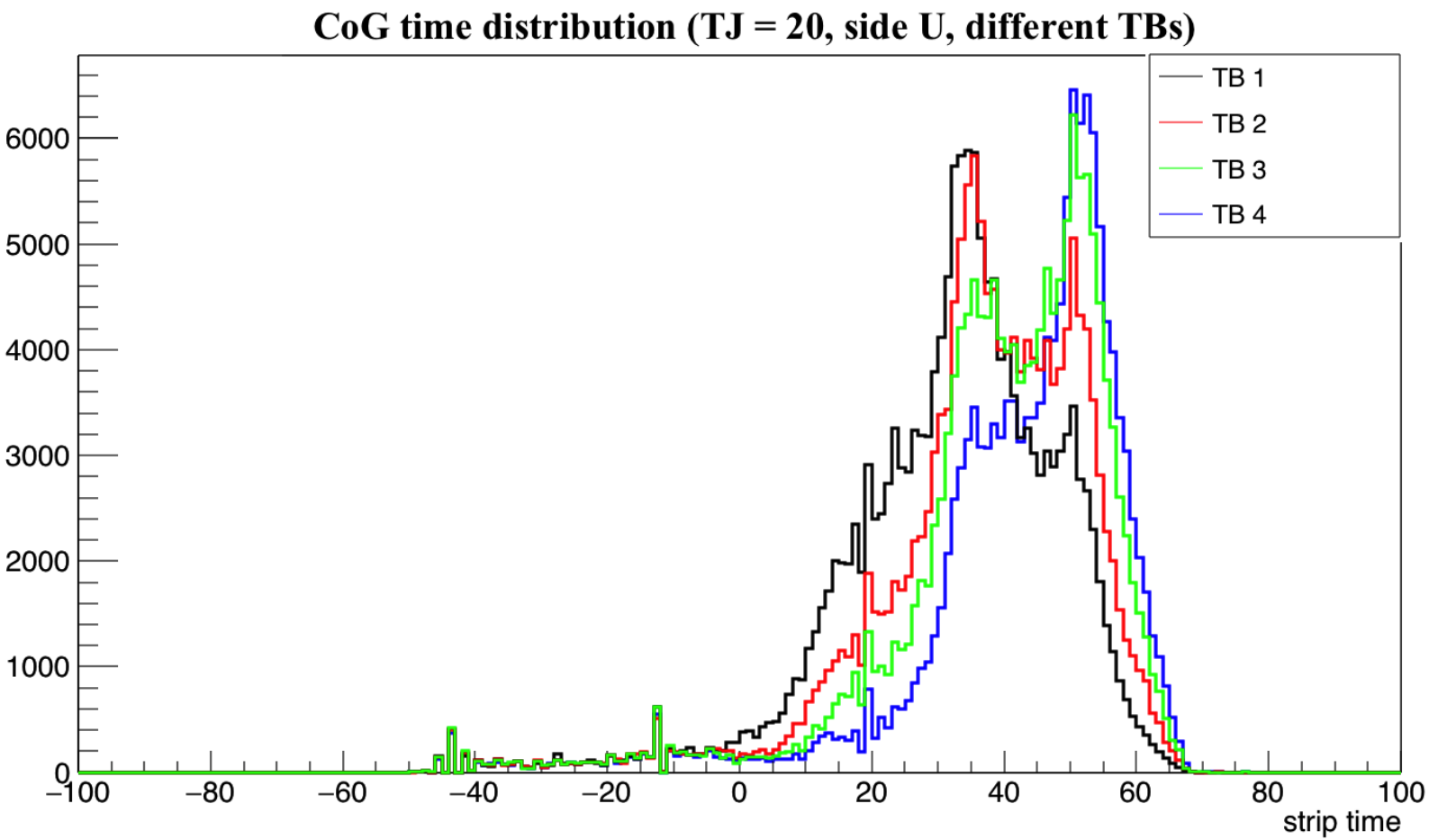
Peak-Time Correction Applied
TJ = 0



Peak-Time Correction Applied
TJ = 10

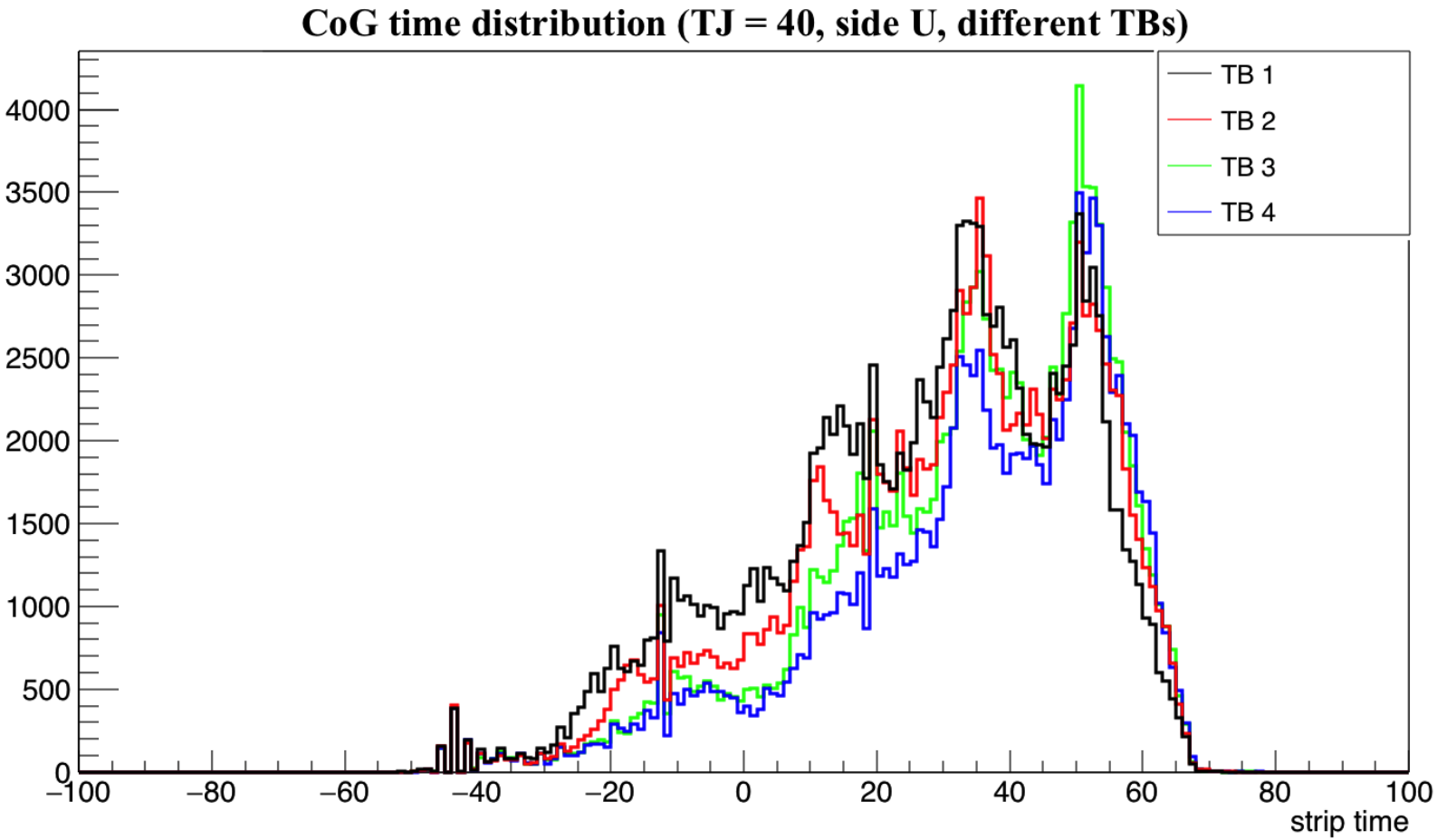


Peak-Time Correction Applied
TJ = 20

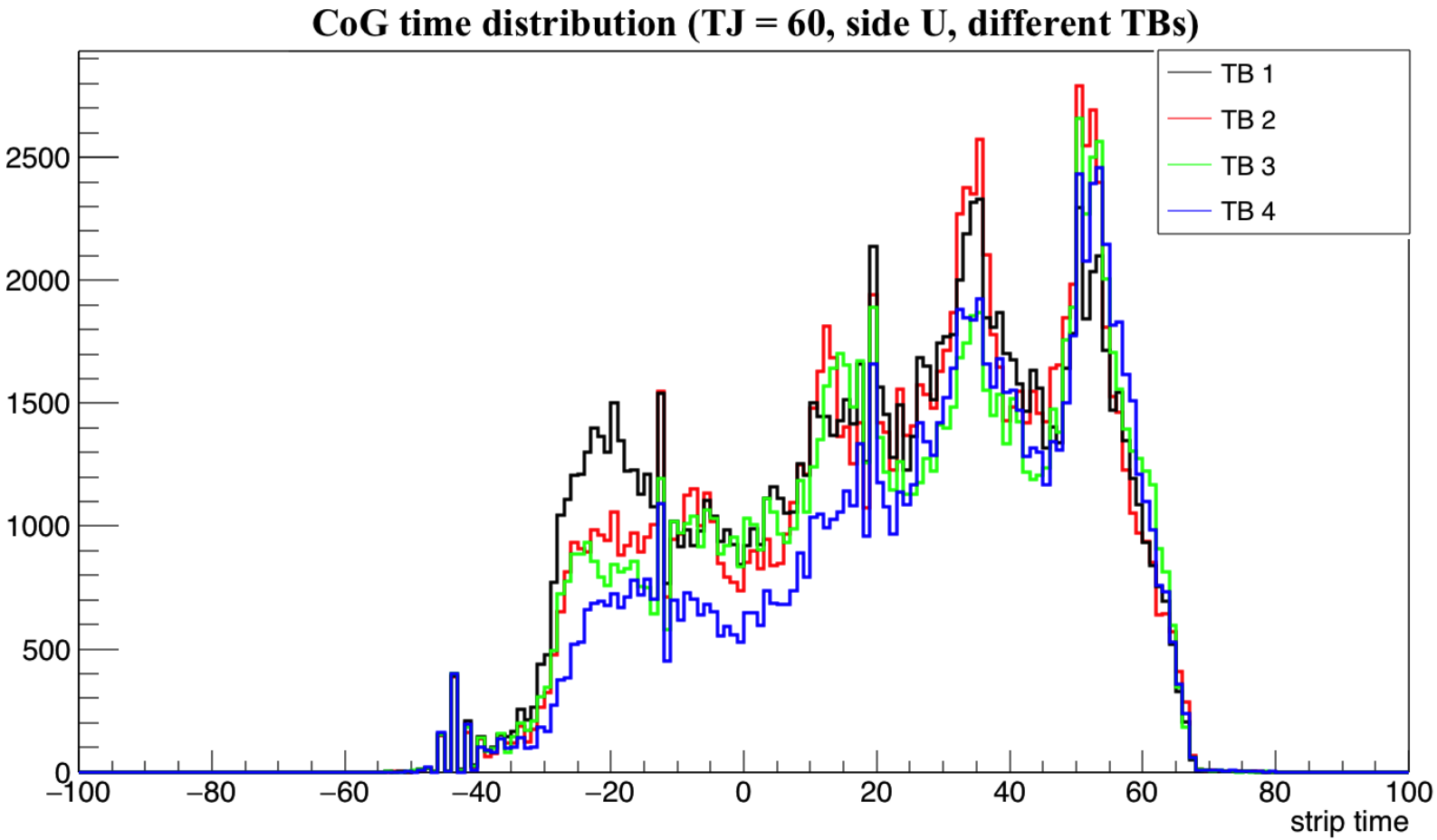


Peak-Time Correction Applied

TJ = 40



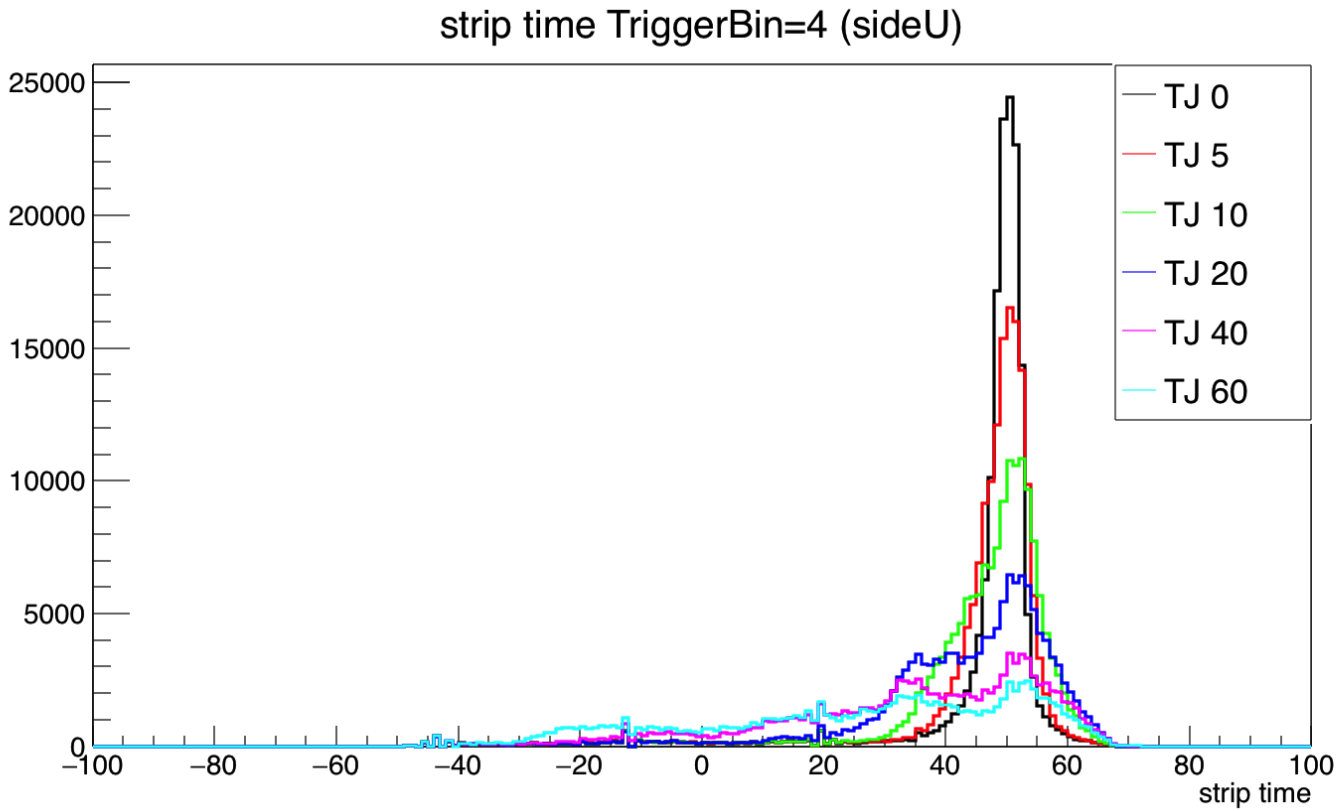
Peak-Time Correction Applied
TJ = 60



Peak-Time Correction Applied

Summary

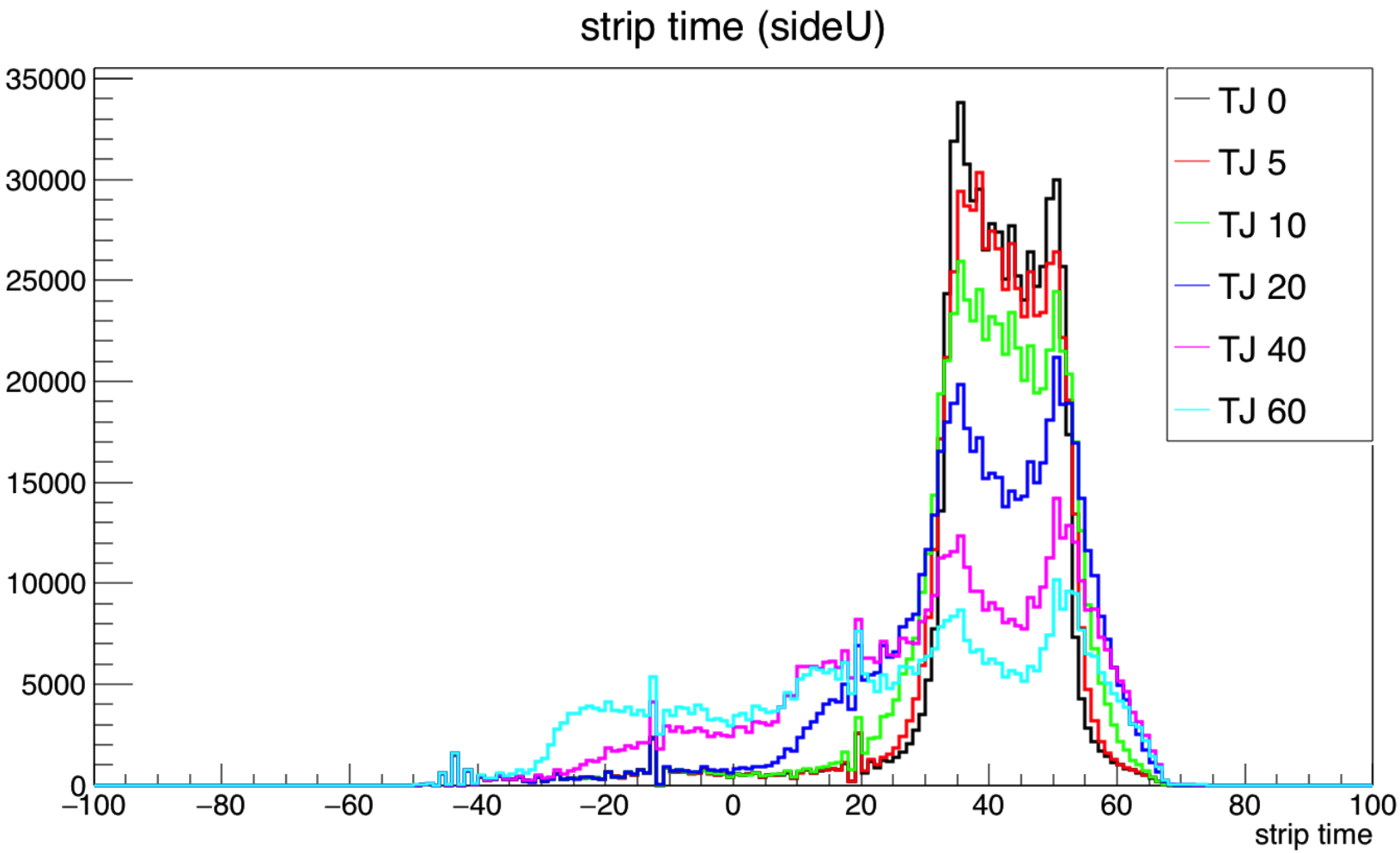
As we can see, the distributions for different TBs tend to become very similar, and largely overlap, for TJ $\gtrsim$ 20 ns.
The situation for the V side is basically the same.
Here an example for one particular TB, showing the differences for the various TJs.



Peak-Time Correction Applied

Overall CoG distribution

Finally the effect of TJ on the overall distribution (regardless TB):



Peak-Time and TB Corrections Applied

Applying TB correction $\Rightarrow$ every TB-related time distribution is shifted accordingly to:

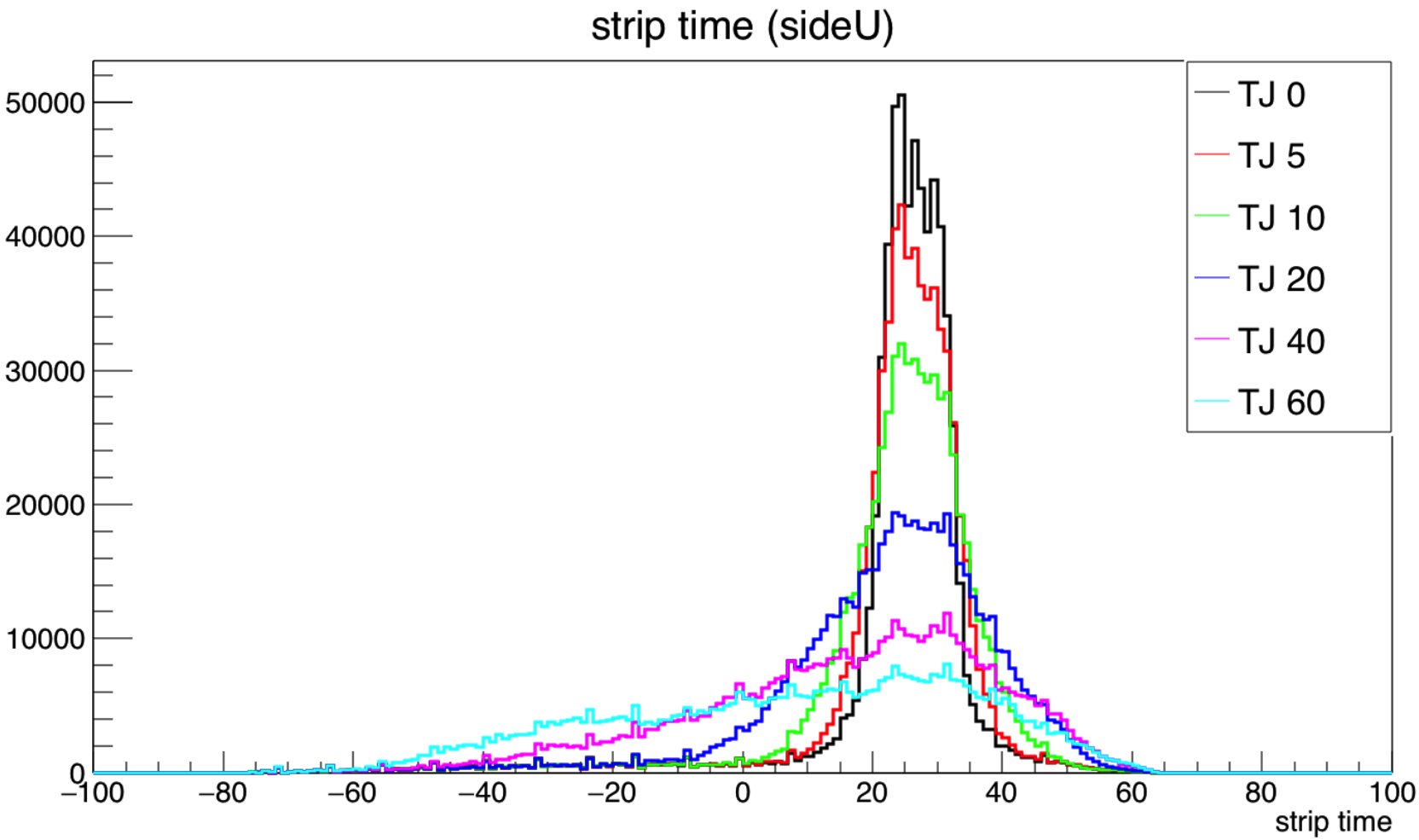
$$T_{TriggerBin} \simeq 4 + 8 \times \text{TriggerBin}_{\text{Index}} \text{ [ns]} \quad (3)$$

So we will not go into the details for each of them (plots in the Backup).
We want instead to perform a comparison between the two possibilities: applying **or not** applying also the TB correction.

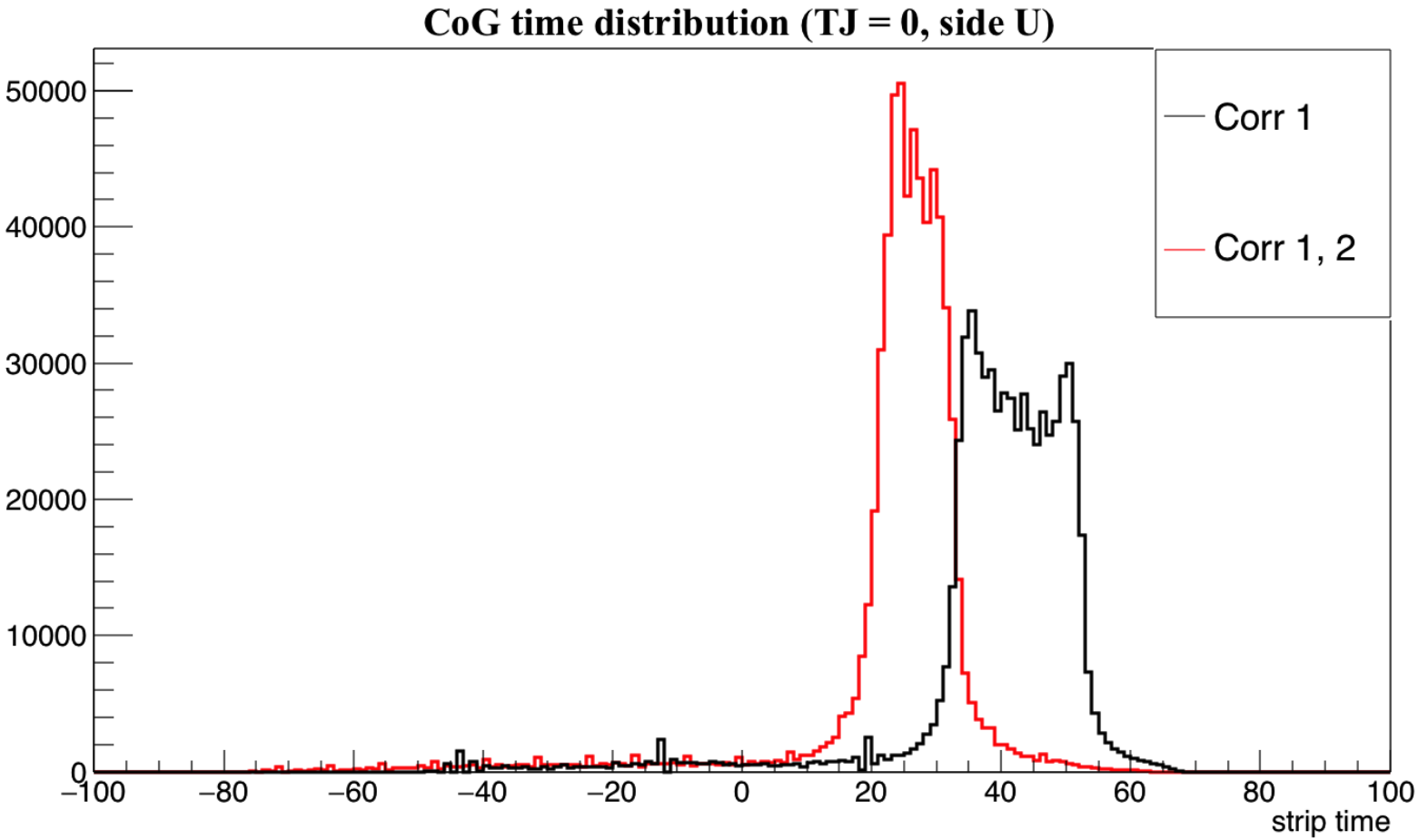
Peak-Time and TB Corrections Applied

Overall CoG distribution

The effect of TJ on the overall distribution (regardless TB):

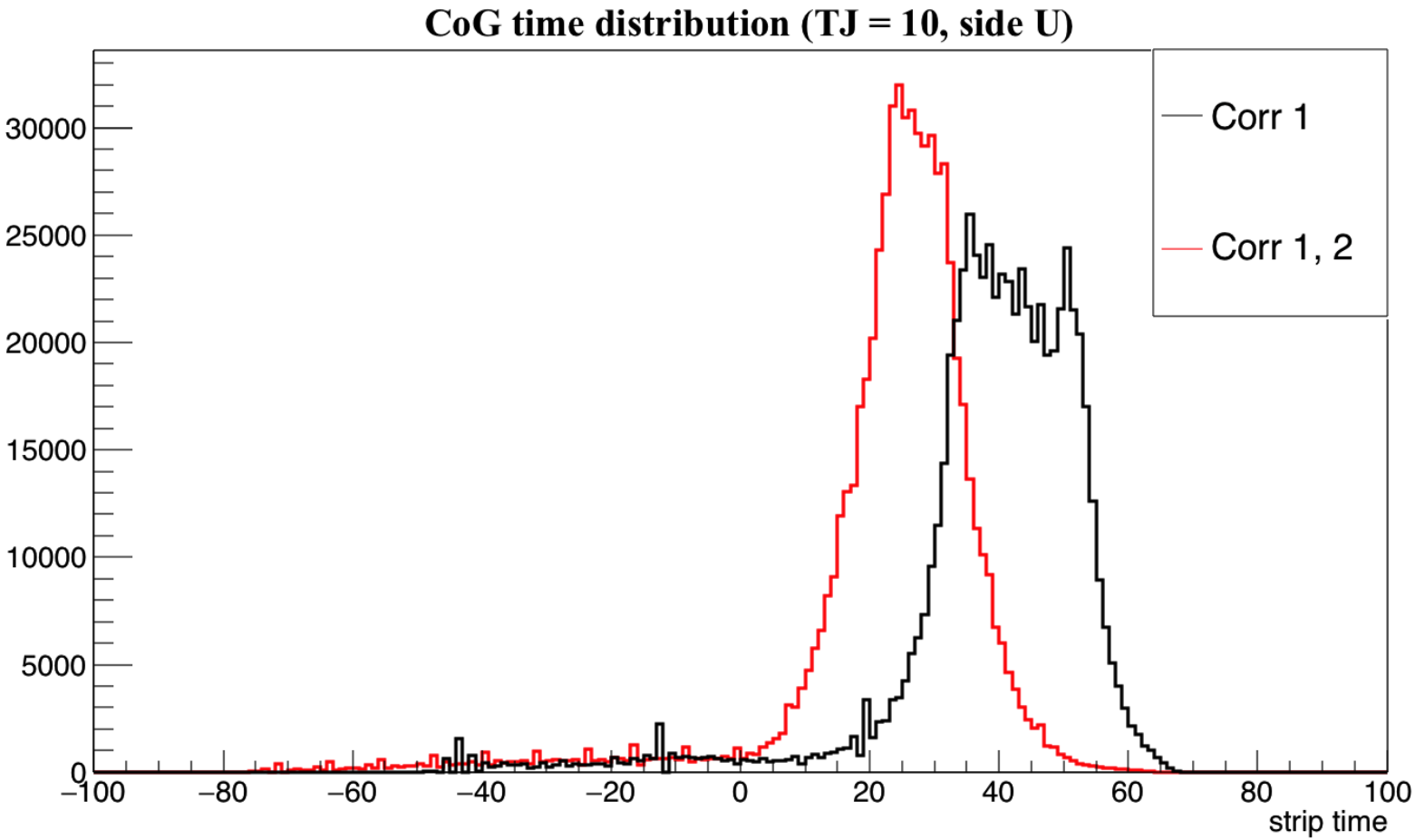


Peak-Time Correction vs Peak-Time & TB Corrections
TJ = 0



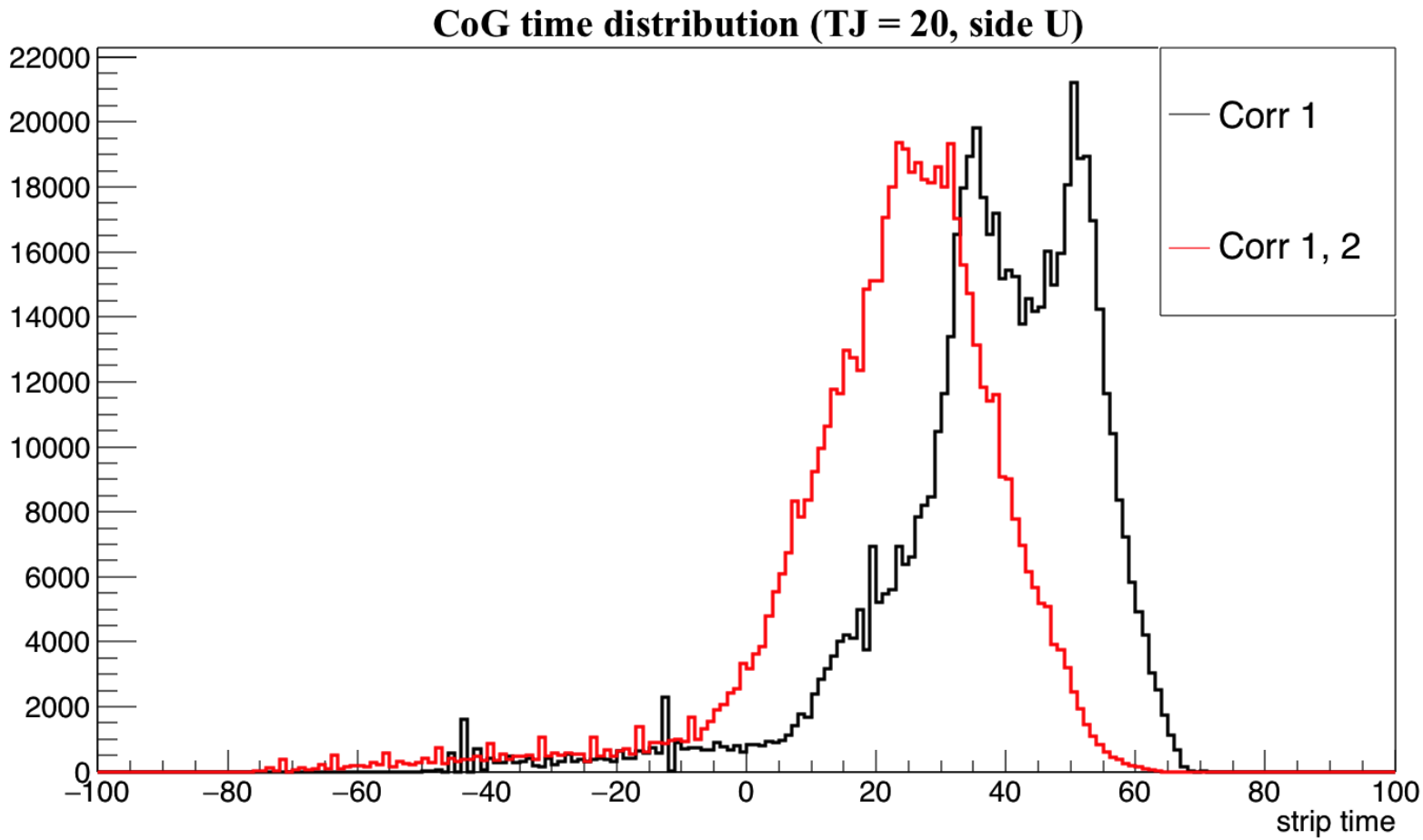
Peak-Time Correction vs Peak-Time & TB Corrections

TJ = 10



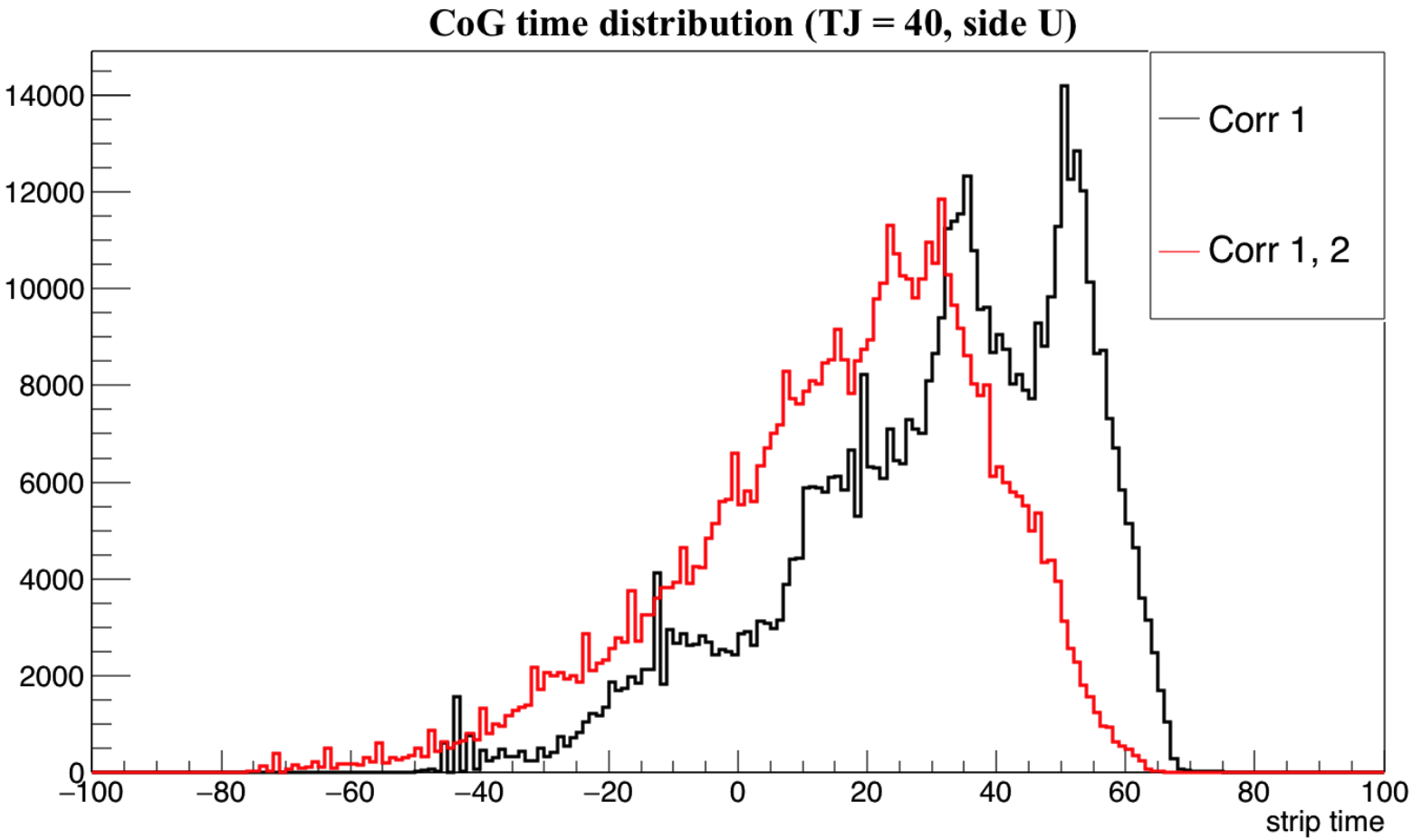
Peak-Time Correction vs Peak-Time & TB Corrections

TJ = 20



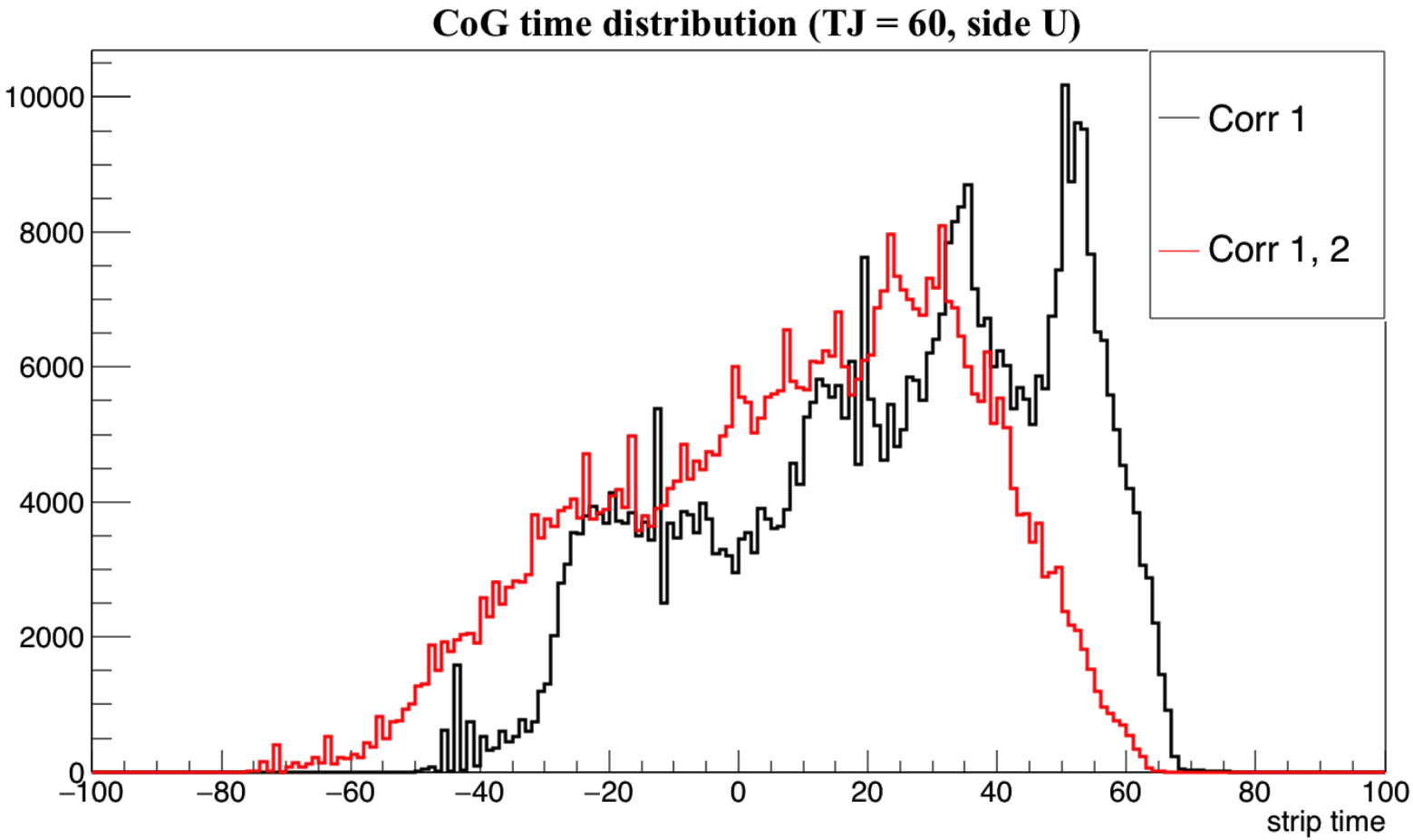
Peak-Time Correction vs Peak-Time & TB Corrections

TJ = 40



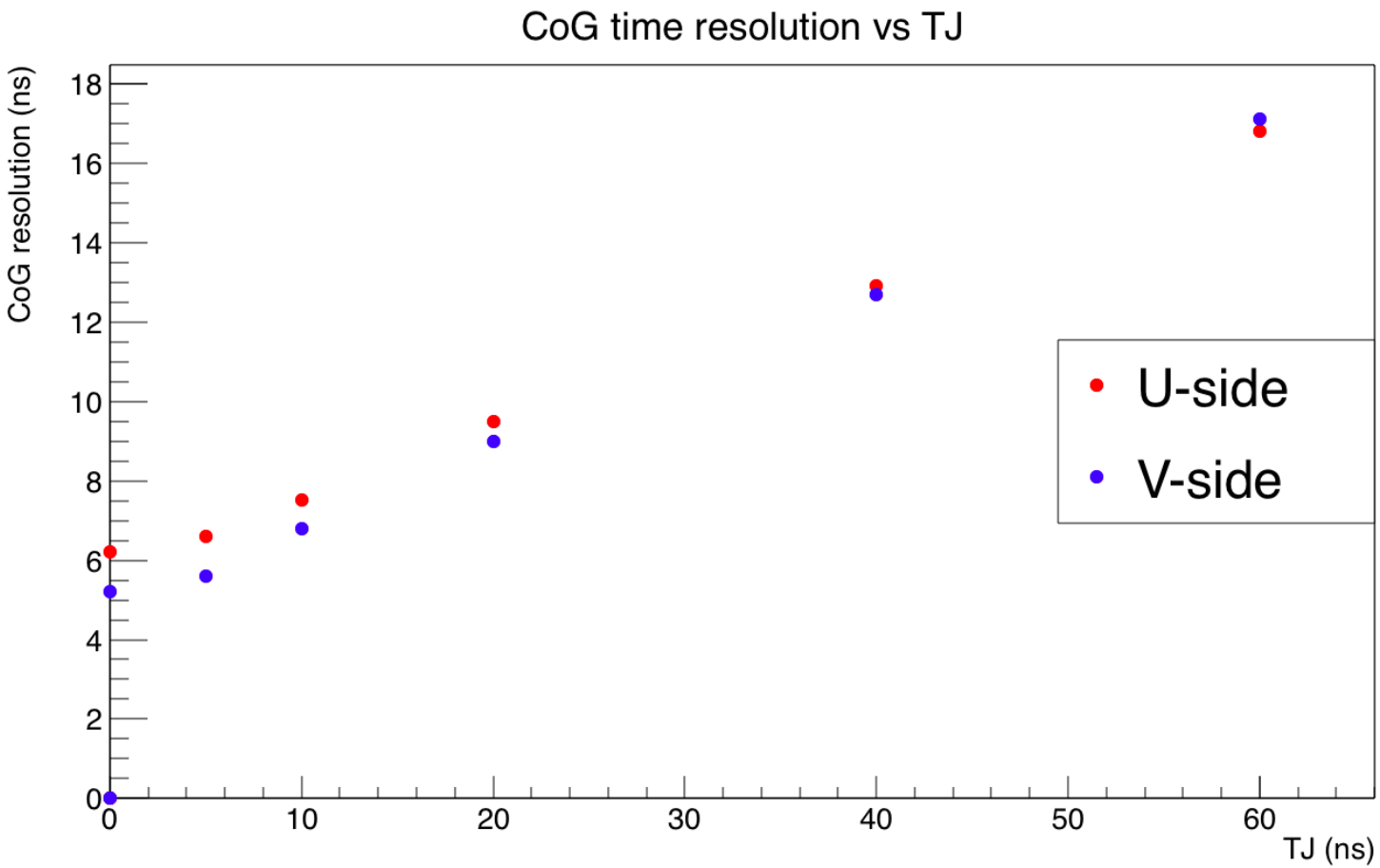
Peak-Time Correction vs Peak-Time & TB Corrections

TJ = 60



Peak-Time & TB Corrections - Resolution

Resolution (width of the distribution of $T_{CoG} - T_{true}$) for different TJ, both Peak-Time and TB corrections applied.



Calibration procedure for Shift-to-Zero correction

First of all, it is necessary to decide if we want to include:

- Only Peak-Time correction (more straightforward);
- Also TB correction (better precision for at least low TJ values, smoother structure even at higher TJ).

This decision reflects on a **parameter** of the module appointed to perform the CoG calibration.
After that, it is mainly a **3-steps procedure**.

Step 1

Process data and create root file and local database.

- Choose if you want to use only Peak-Time correction or TB correction too;
- Set the corresponding parameter in the calibrator module;
- Run it over the selected dataset (it is possible to run also on simulation);
- A root file (containing CoG time distribution for different subset of sensors) and a local database are created.

Step 2

Check if everything is fine.

- Run dedicated macro;
- The macro overlays the histograms coming from different sensor to help check if anything wrong is going on;
- If everything is ok, let's go to the next step, otherwise need to revise calibration.

Step 3

Upload database.

- Local database was created at the end of Step 1;
- If nothing wrong appeared from Step 2, it's time to upload the obtained calibration constants to the global DB.

Let's avoid *nan*

Stability of CoG has been augmented purging out possible sources of crashes: implemented check for possible division by 0 (zero).
If a division by 0 is going to happen, the CoG skip that strip *without* stopping.

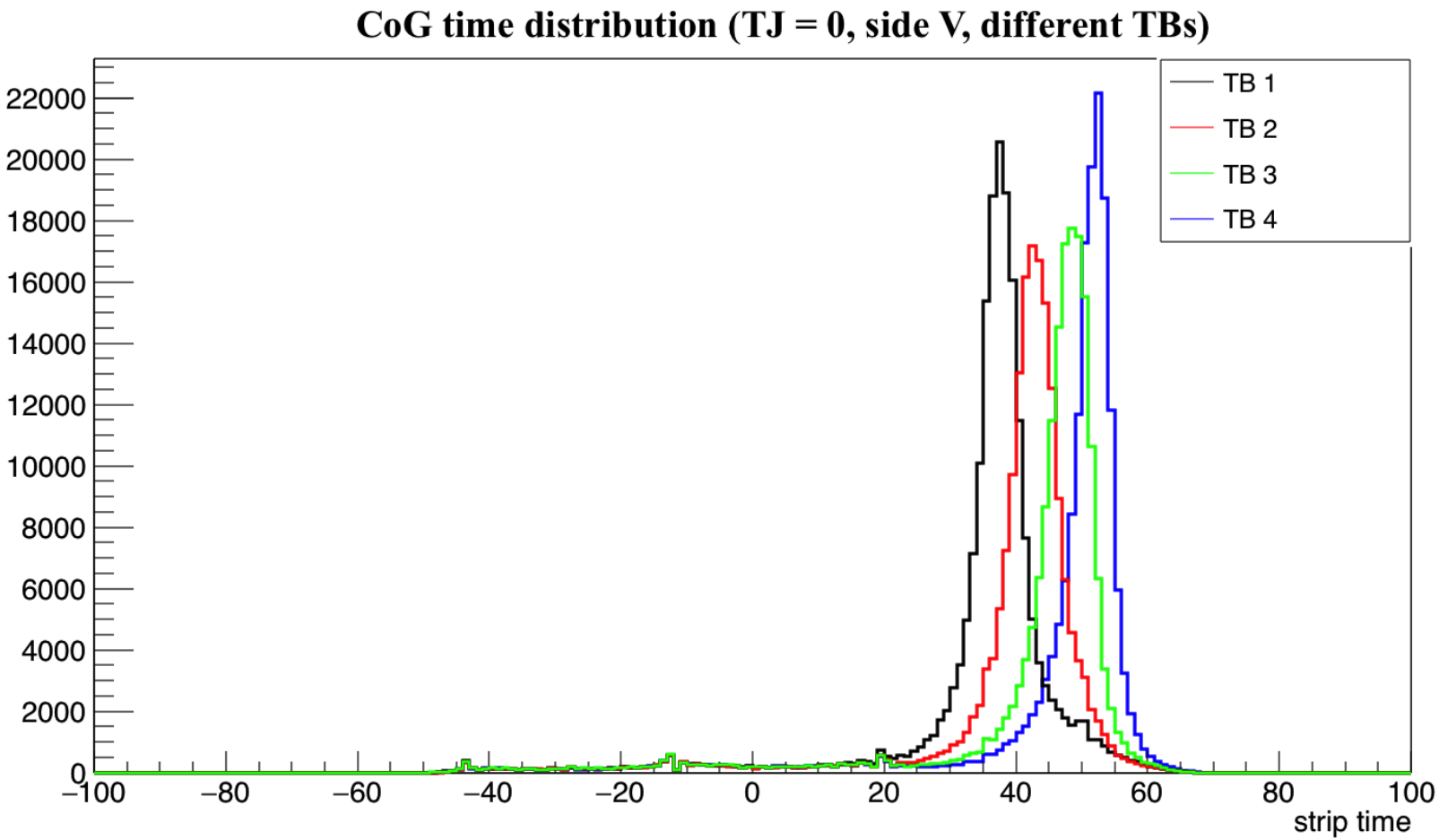
Future Prospects

What is to be decided and done?

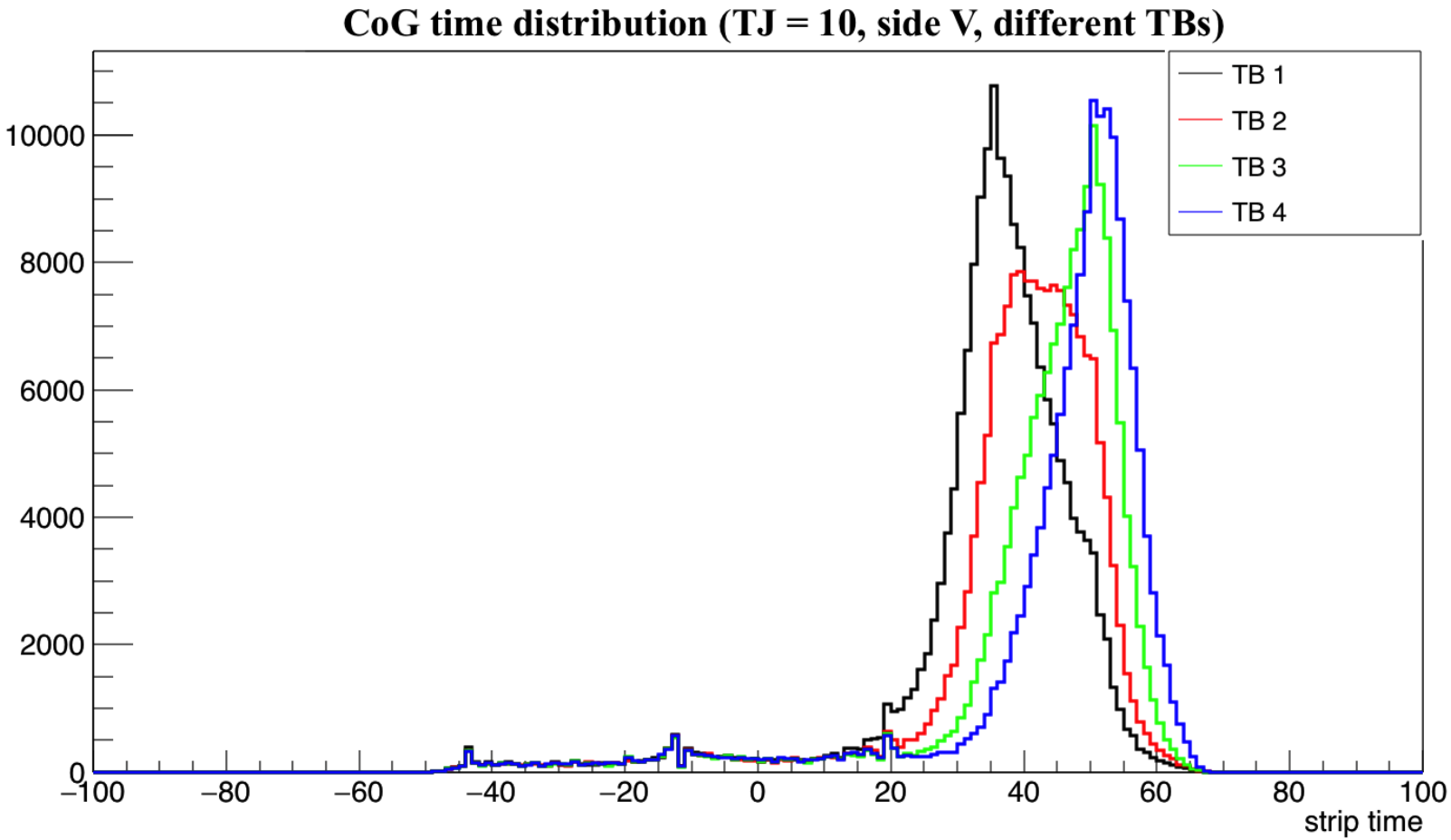
- Decide if using also Trigger-Bin correction or not (maybe now?);
- Study left tail in strip time distribution;
- Study if correlation between amplitude of different samples can be useful;
- These studies can serve both to improve CoG performances and to validate simulation;
- Also, we have seen CoG on Test Beam data; phase 2 data will allow us to check how CoG will actually behave;
- Suggestions?

Backup slides

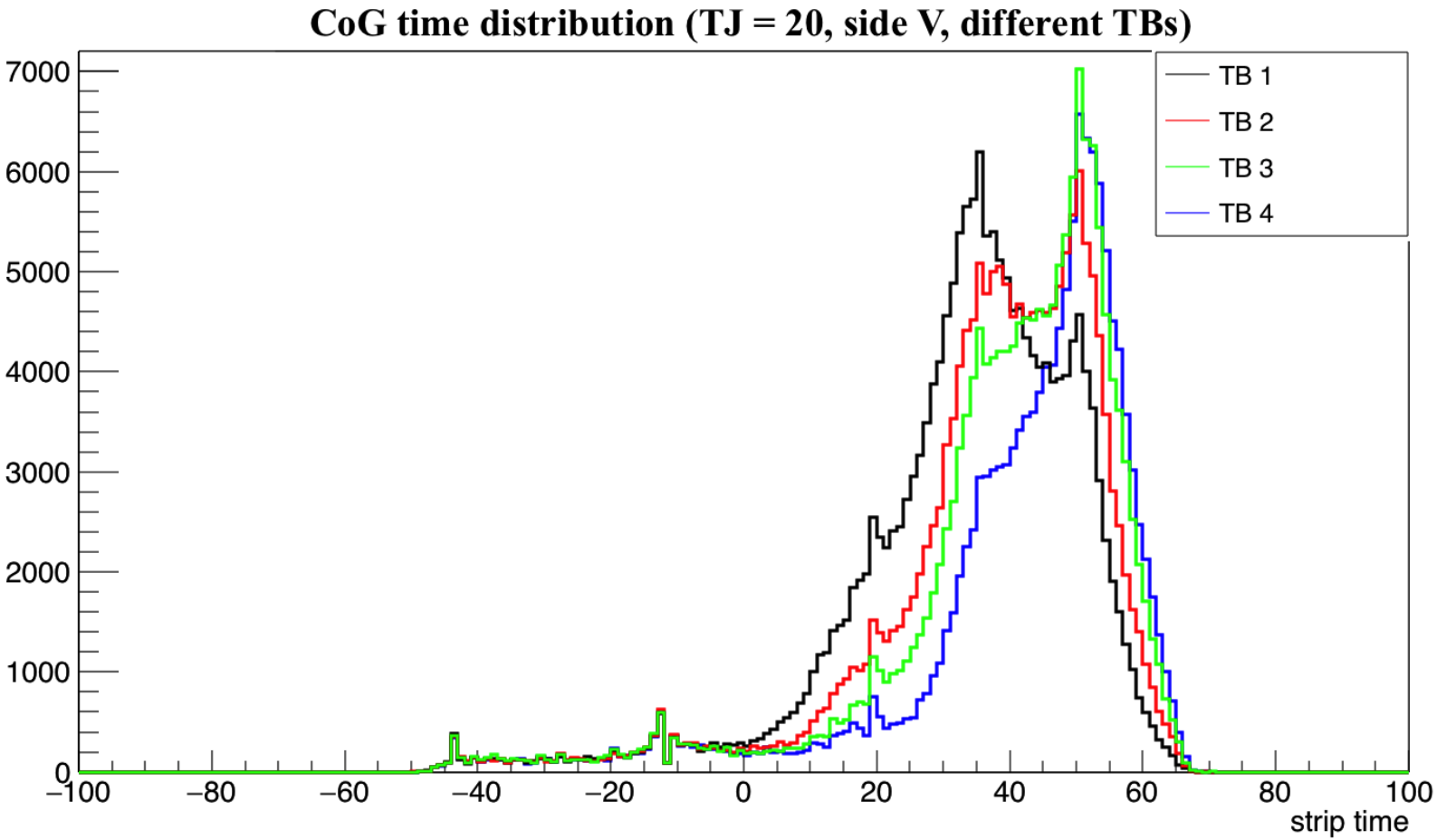
Peak-Time Correction Applied
TJ = 0



Peak-Time Correction Applied
TJ = 10

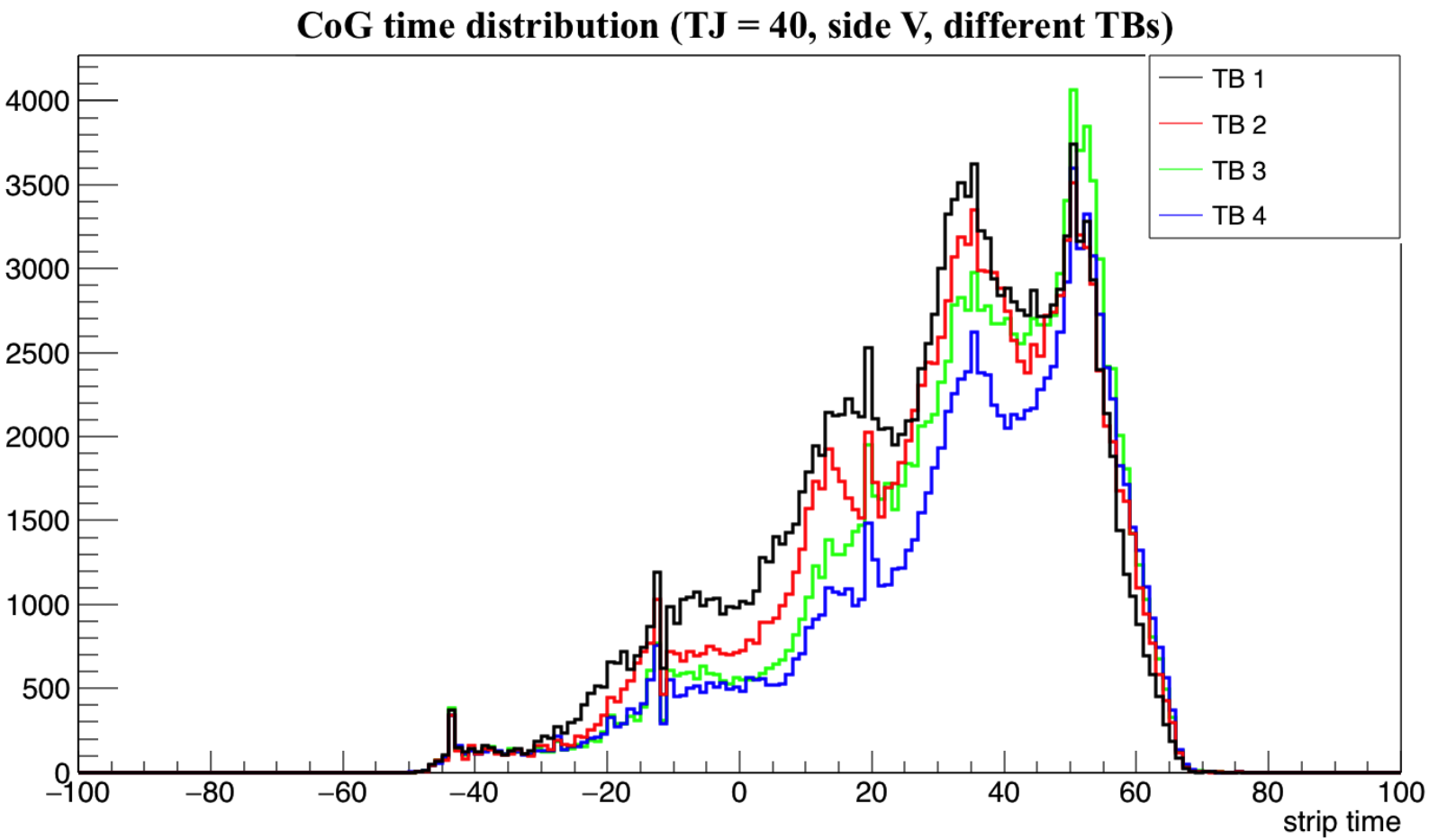


Peak-Time Correction Applied
TJ = 20

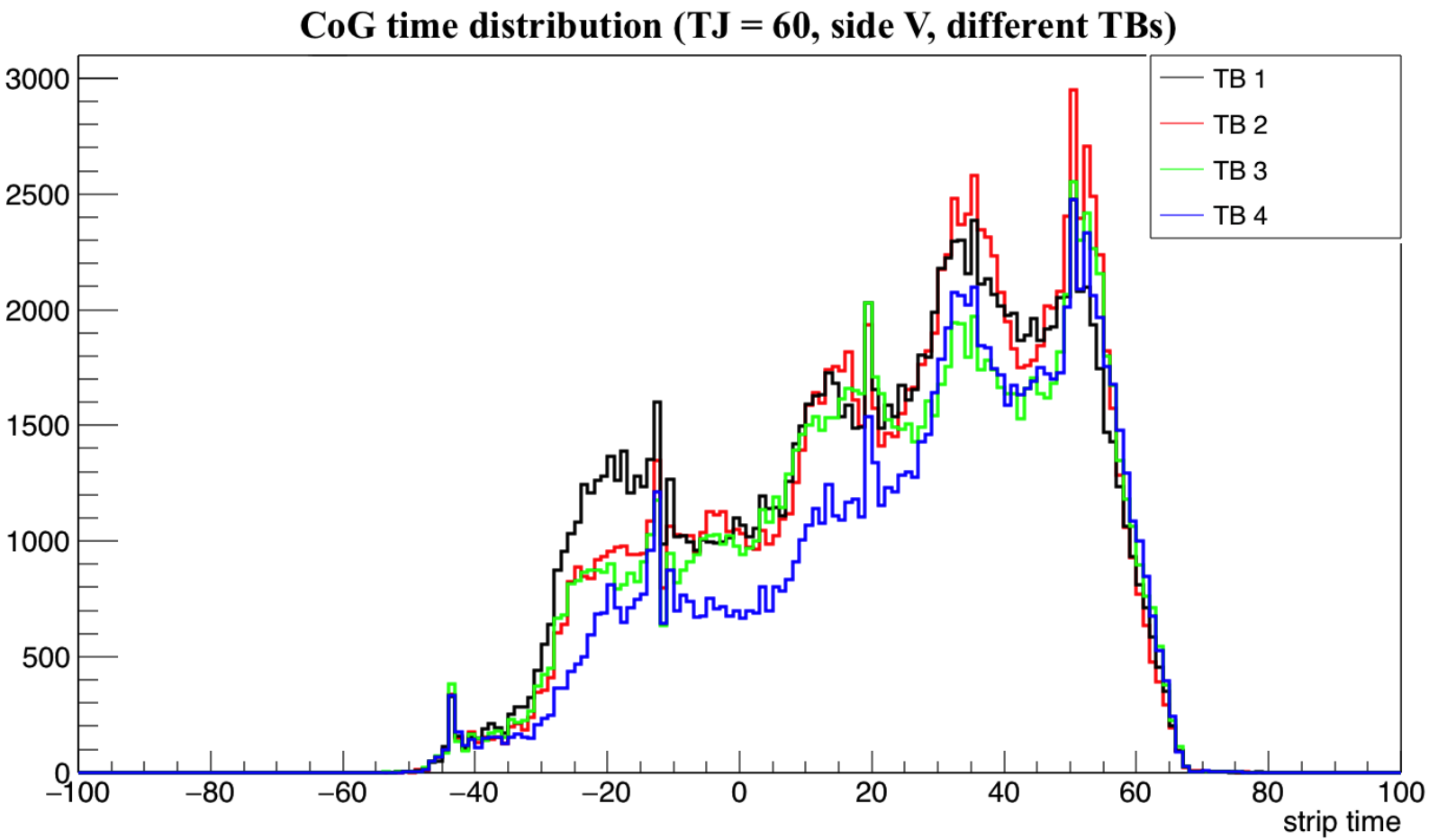


Peak-Time Correction Applied

TJ = 40

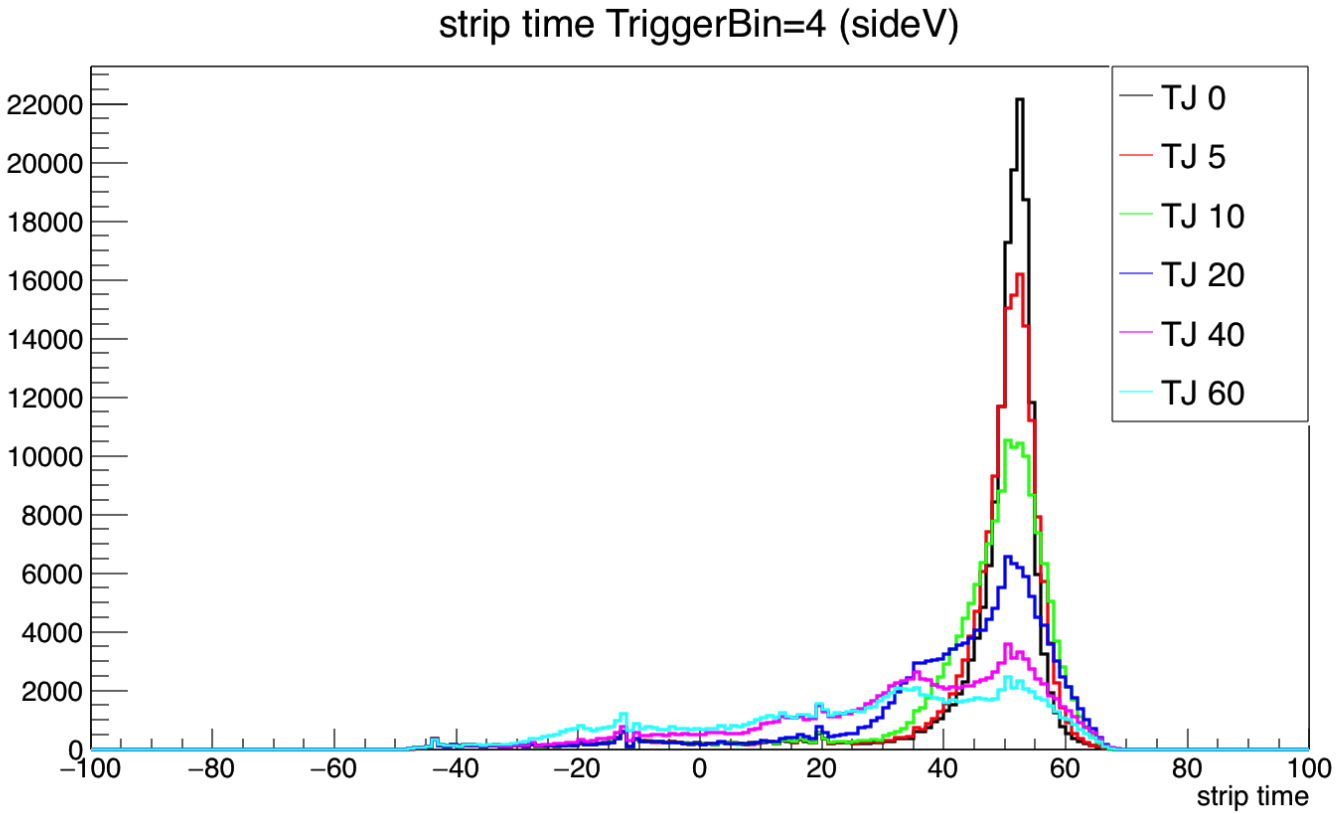


Peak-Time Correction Applied
TJ = 60



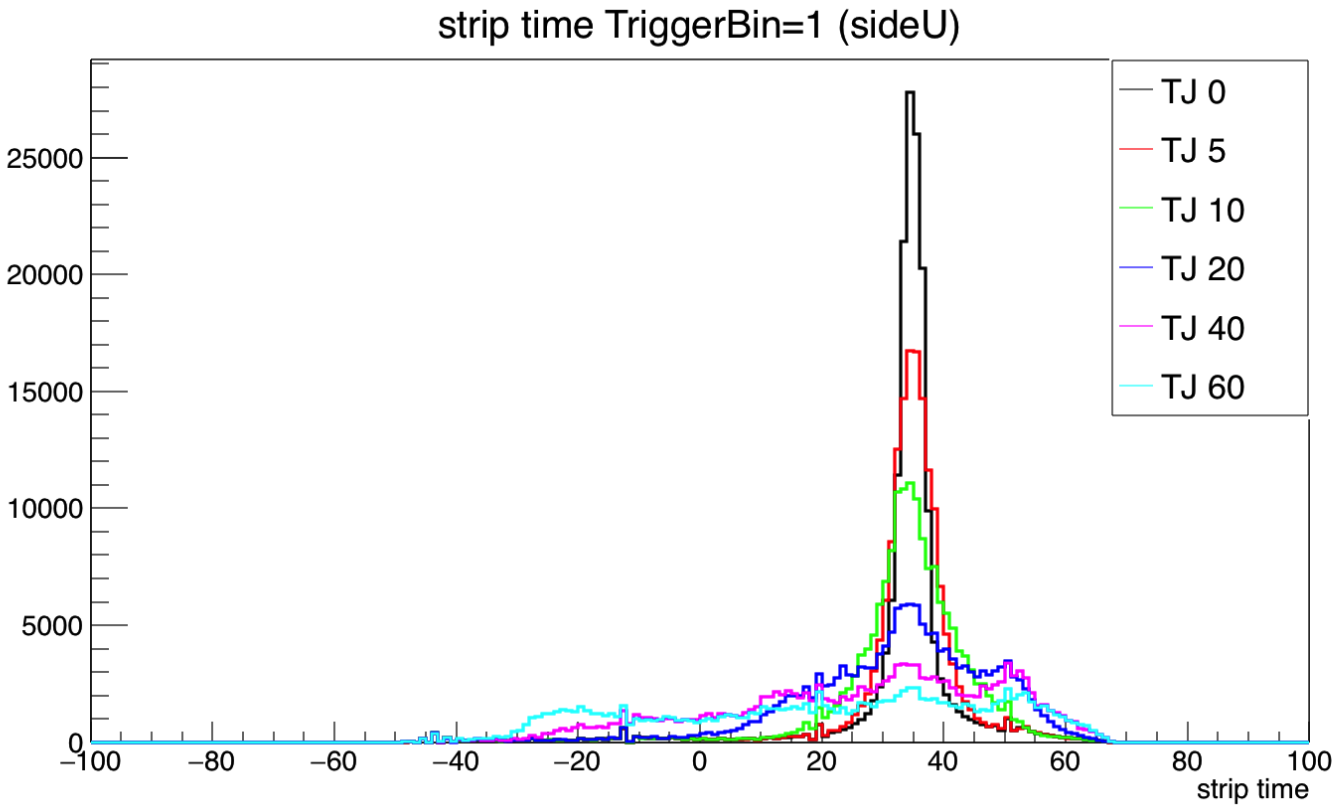
Peak-Time Correction Applied

TB4, all TJs



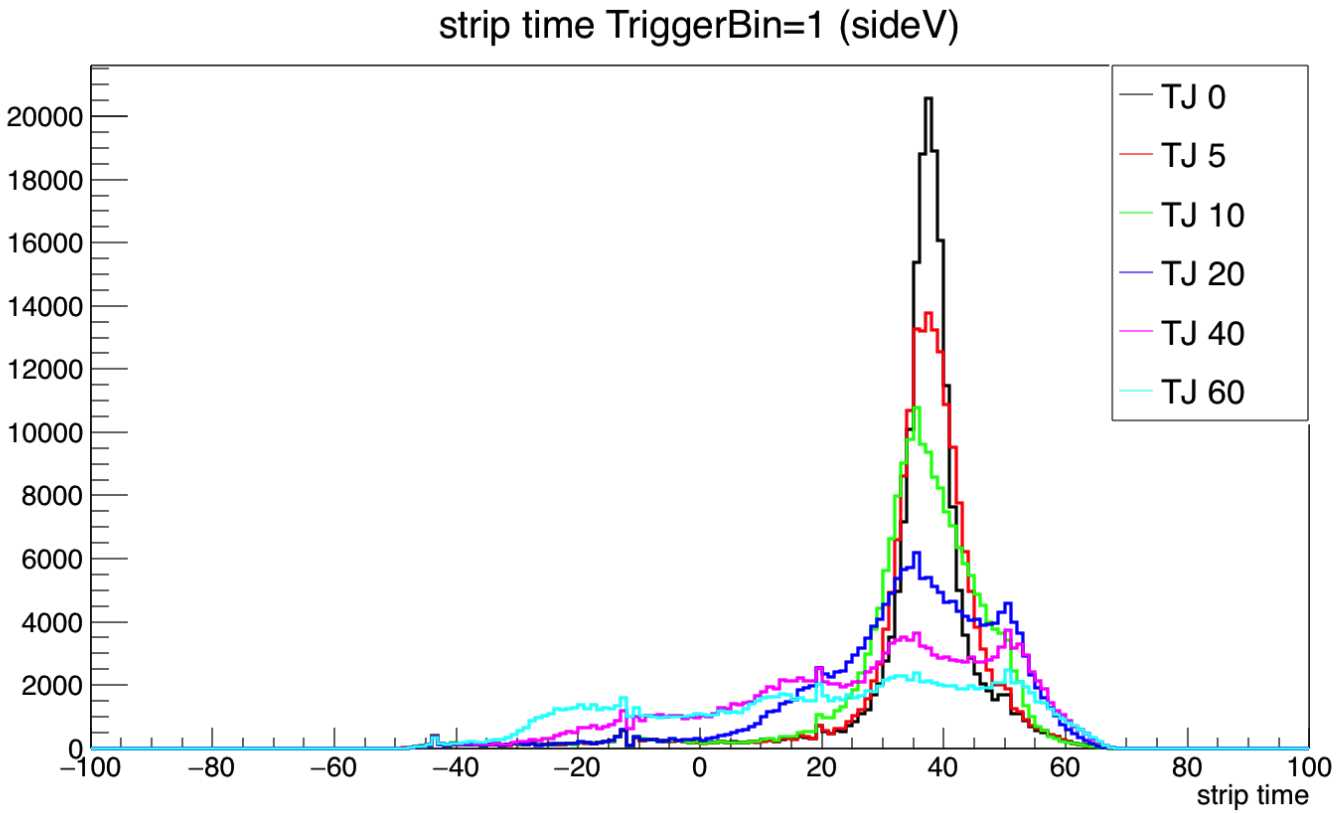
Peak-Time Correction Applied

TB1, all TJs



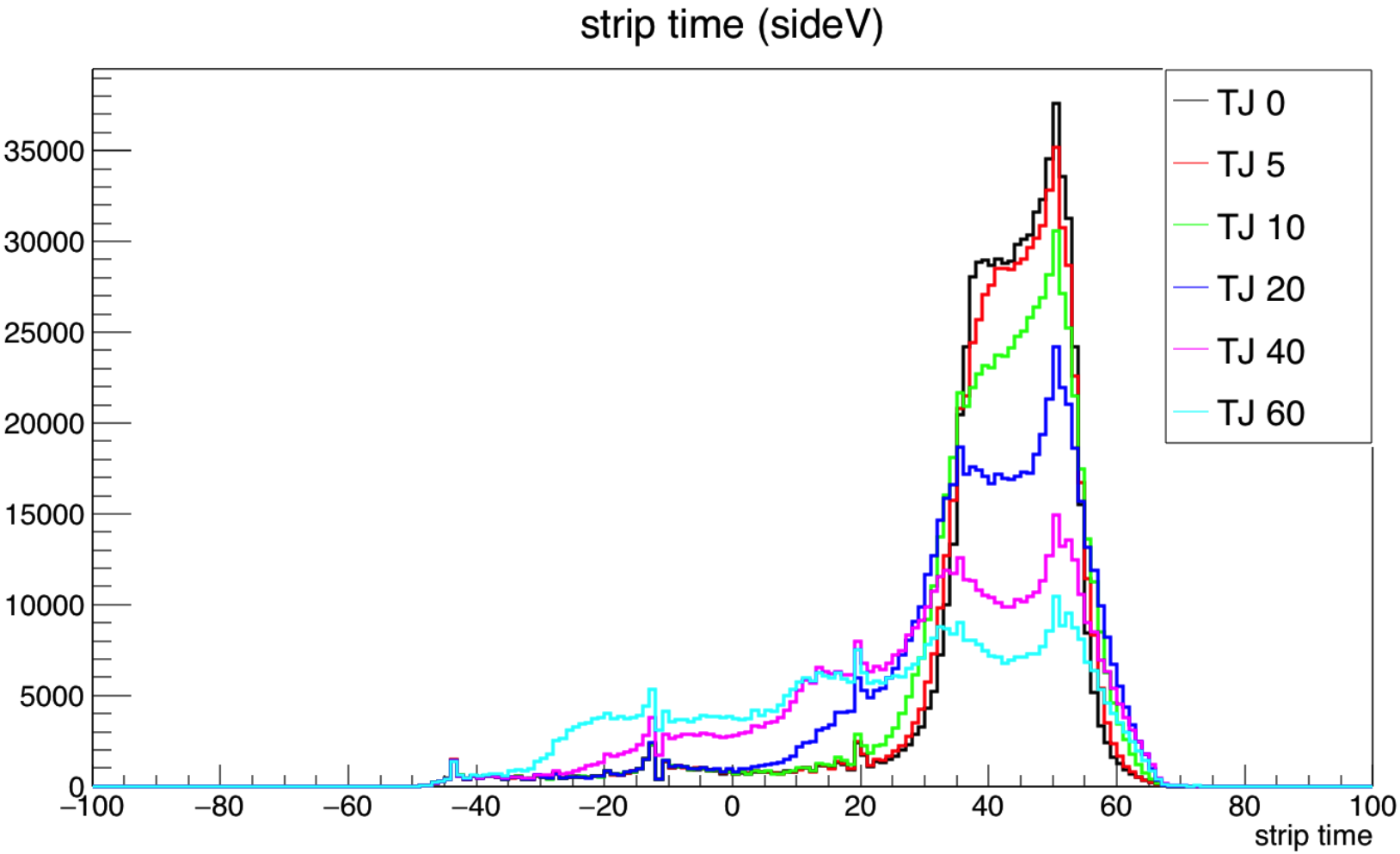
Peak-Time Correction Applied

TB1, all TJs

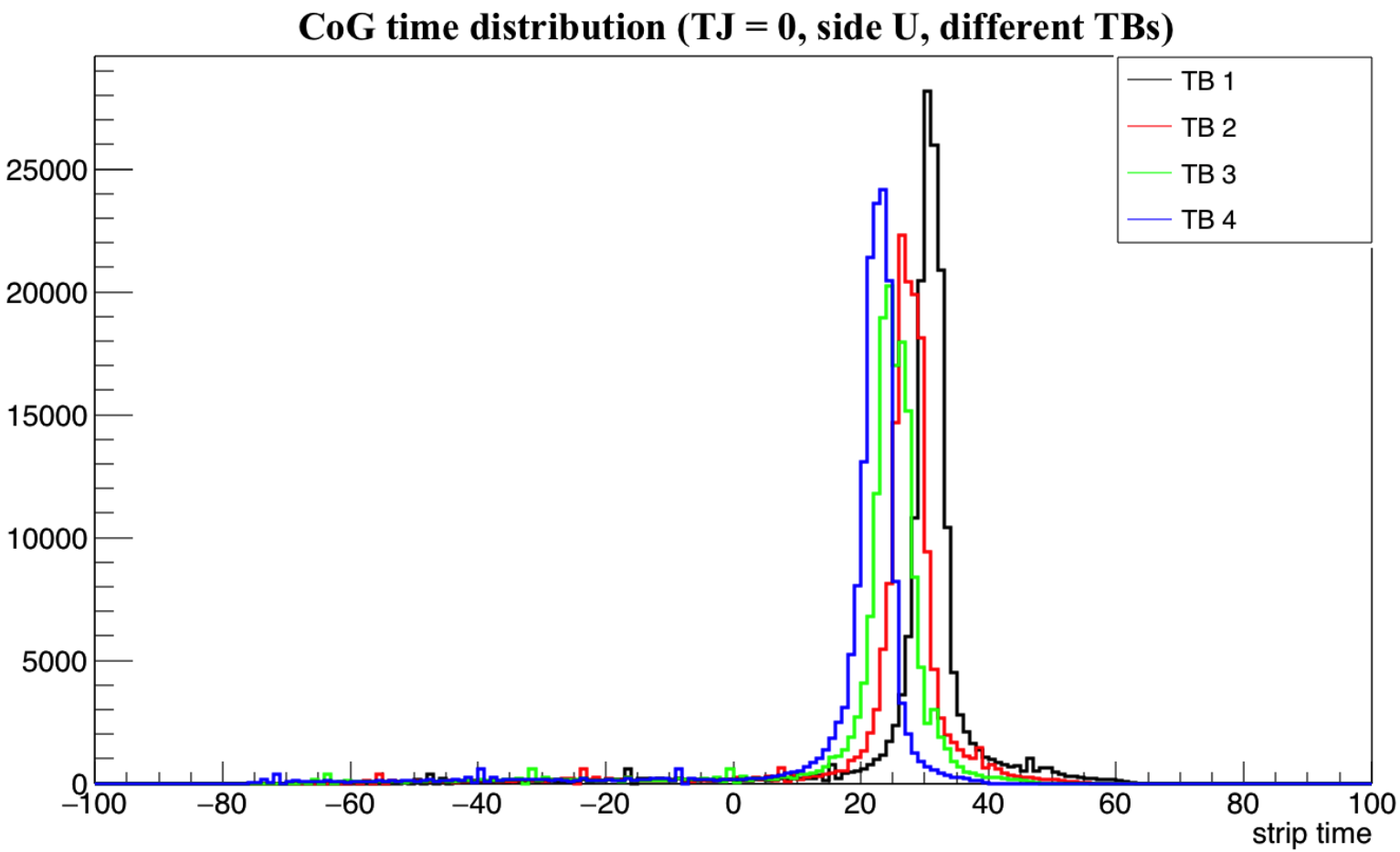


Peak-Time Correction Applied

Overall CoG distribution



Peak-Time & TB Corrections Applied
TJ = 0



Peak-Time & TB Corrections Applied

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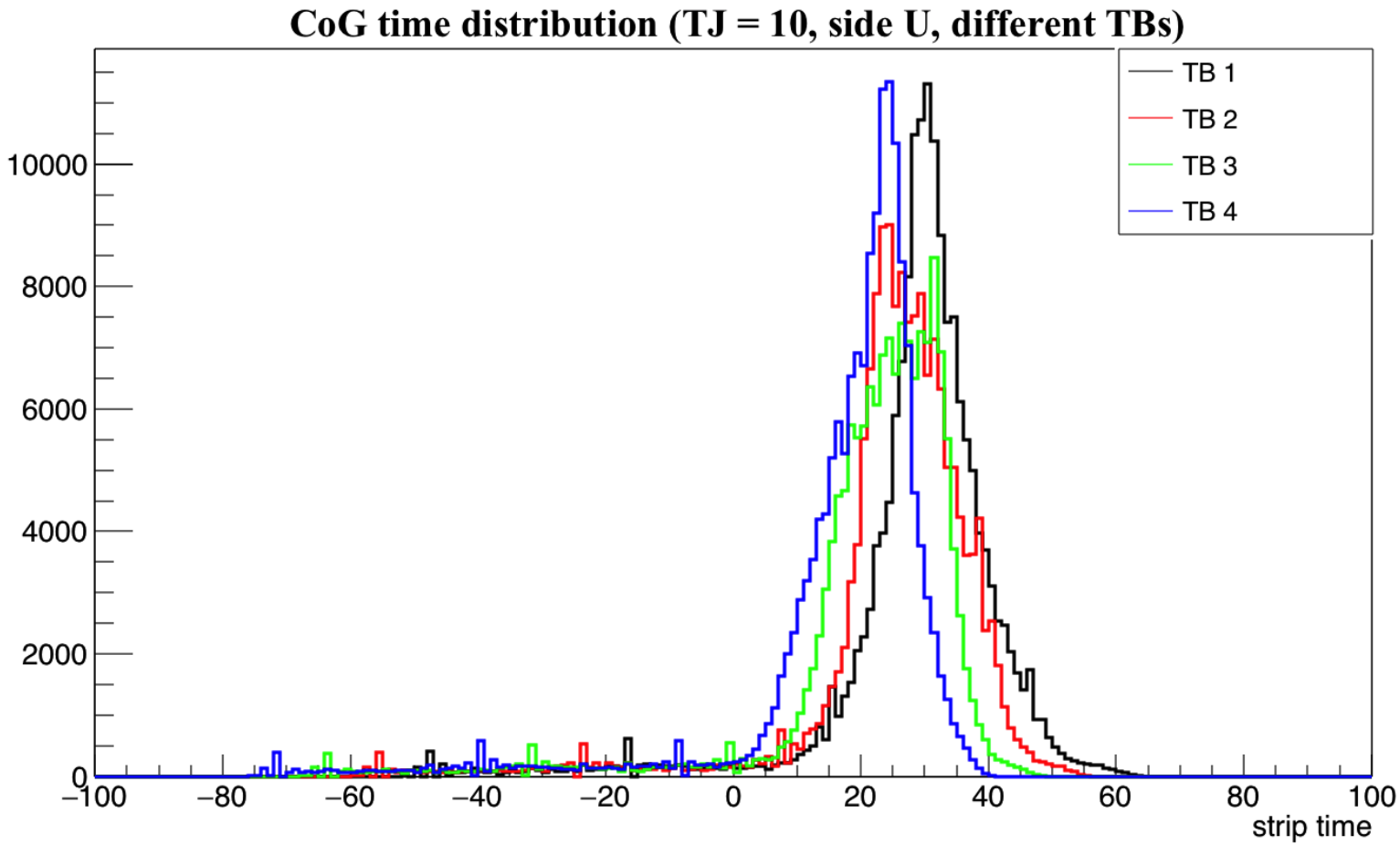
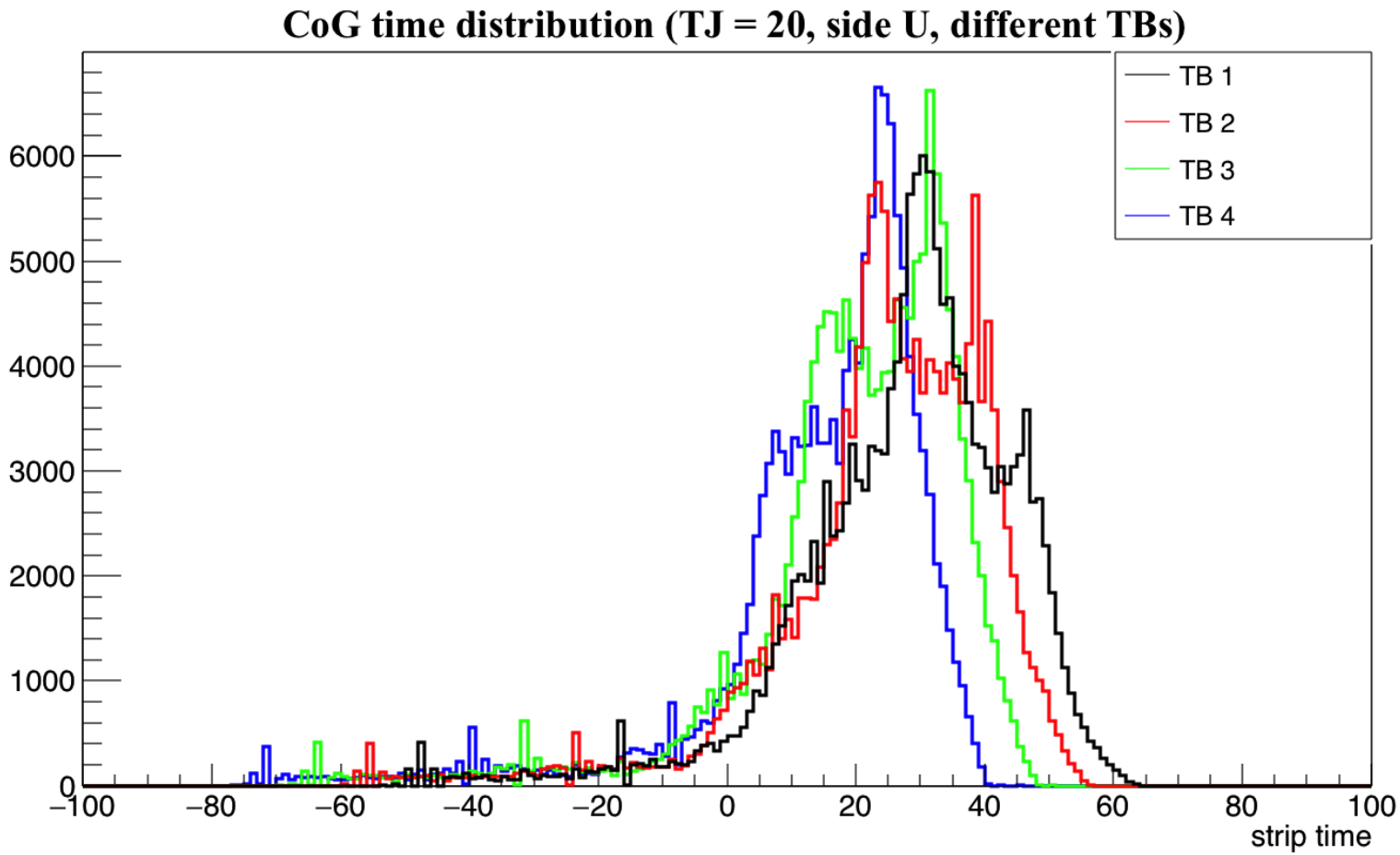
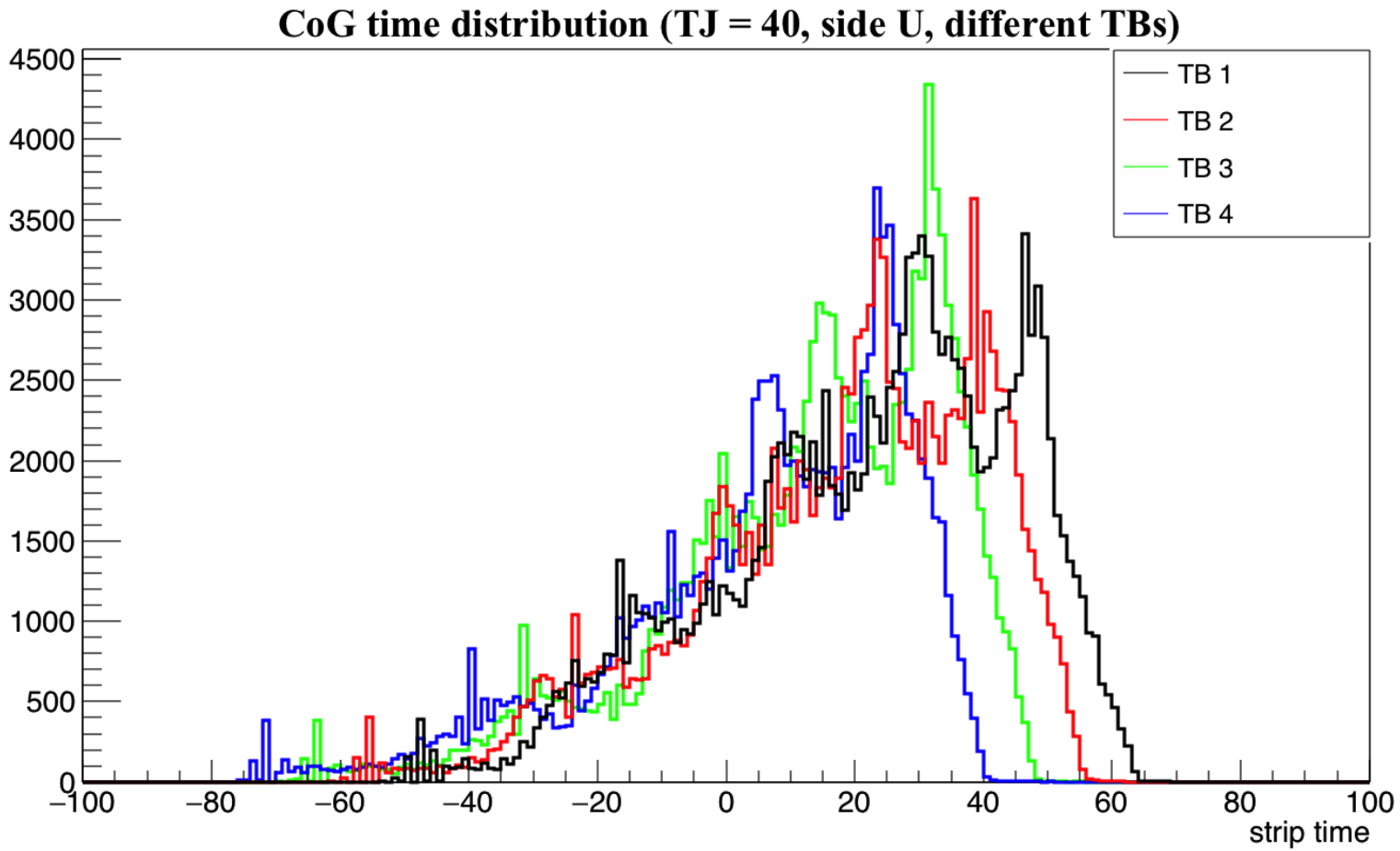


Peak-Time & TB Corrections Applied

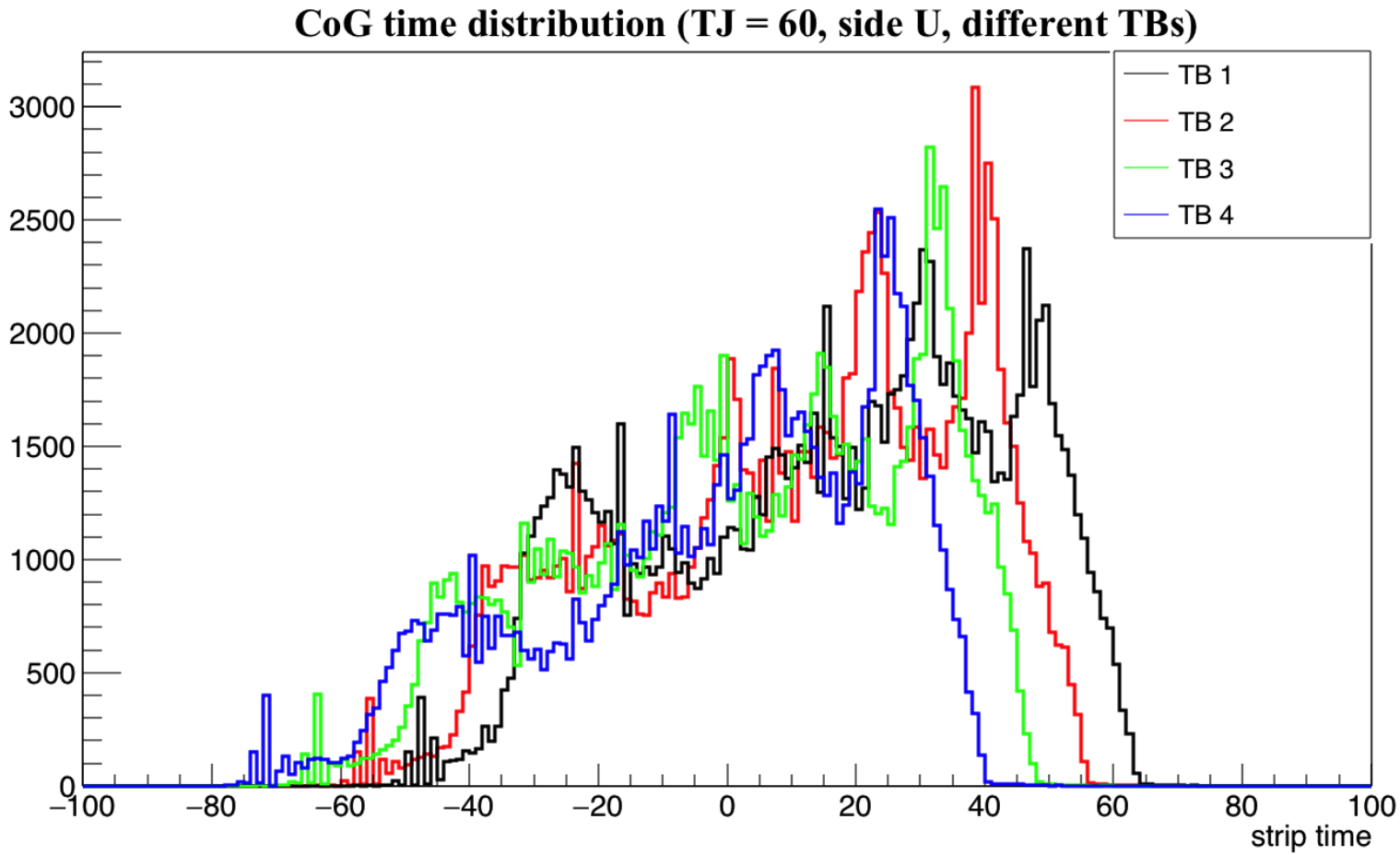
TJ = 20



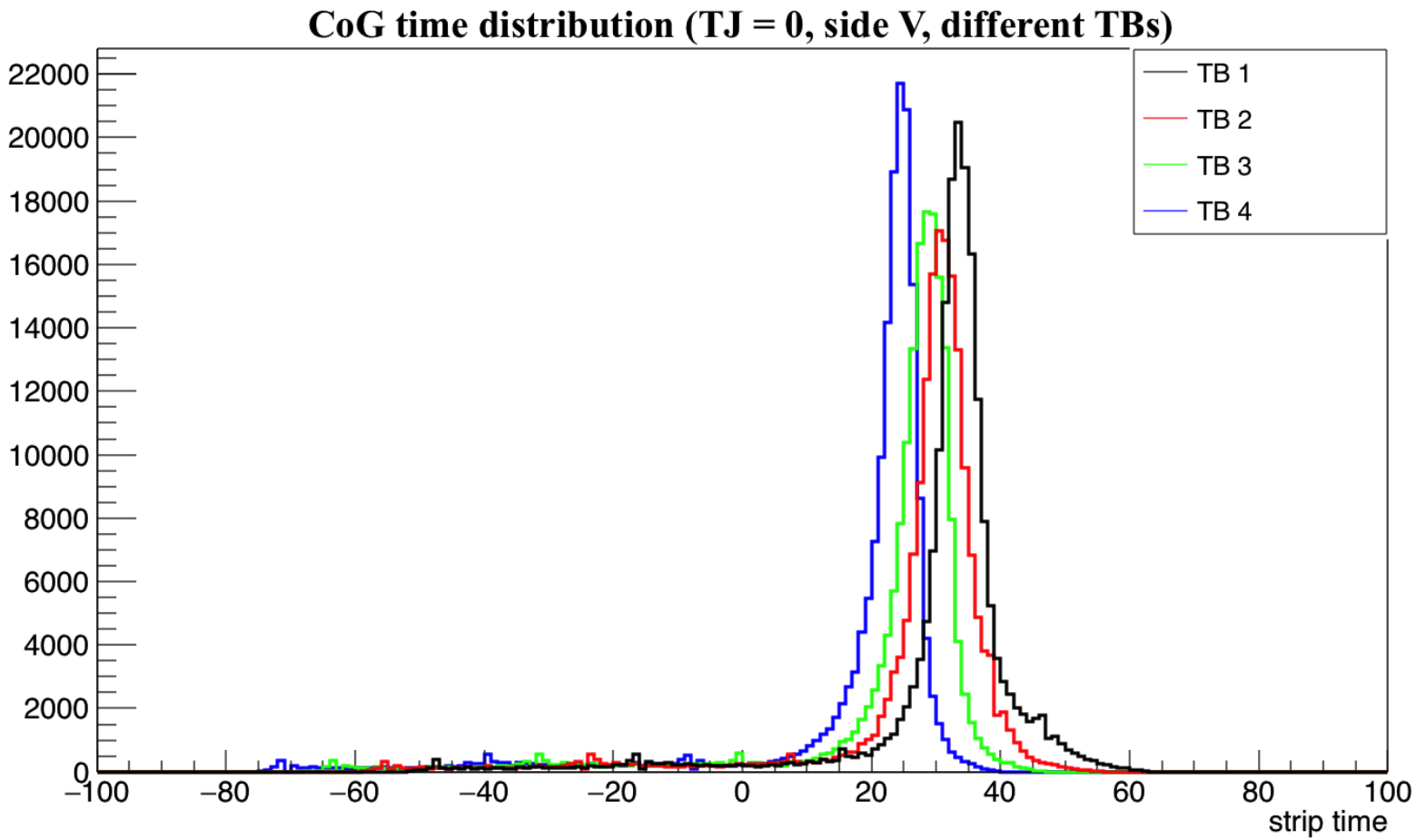
Peak-Time & TB Corrections Applied
TJ = 40



Peak-Time & TB Corrections Applied
TJ = 60

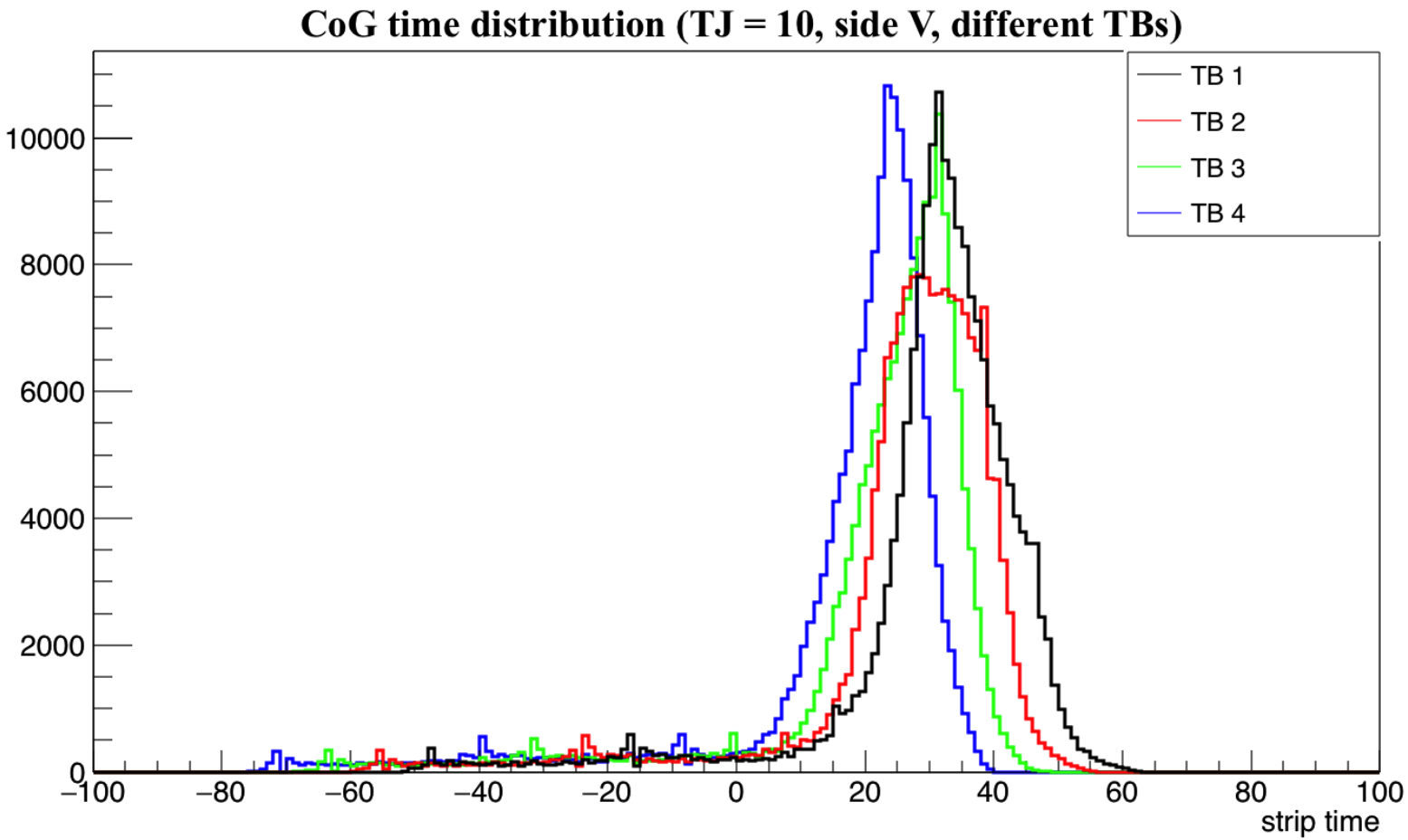


Peak-Time correction&2 Applied
TJ = 0



Peak-Time & TB Corrections Applied

TJ = 10



Peak-Time & TB Corrections Applied
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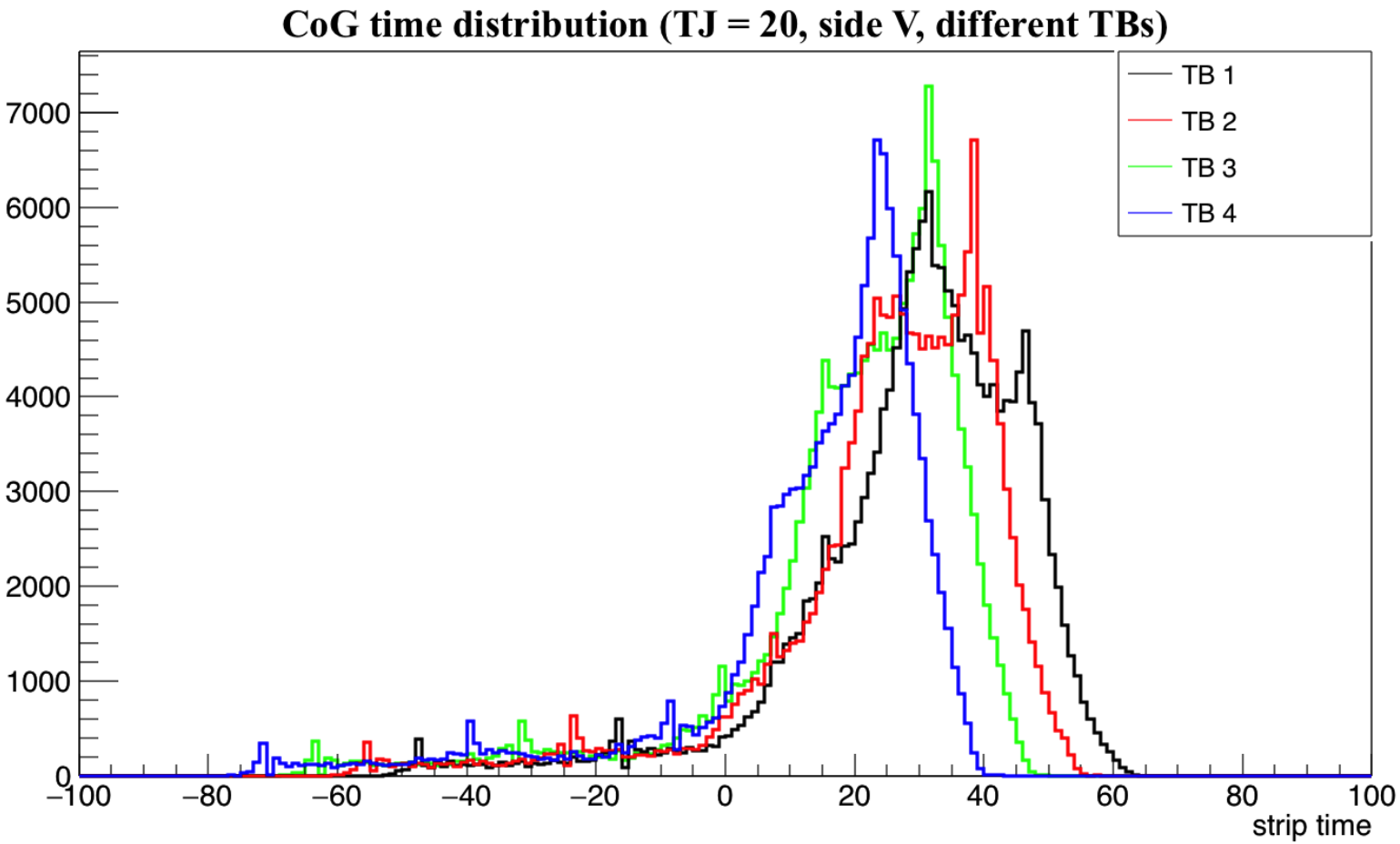

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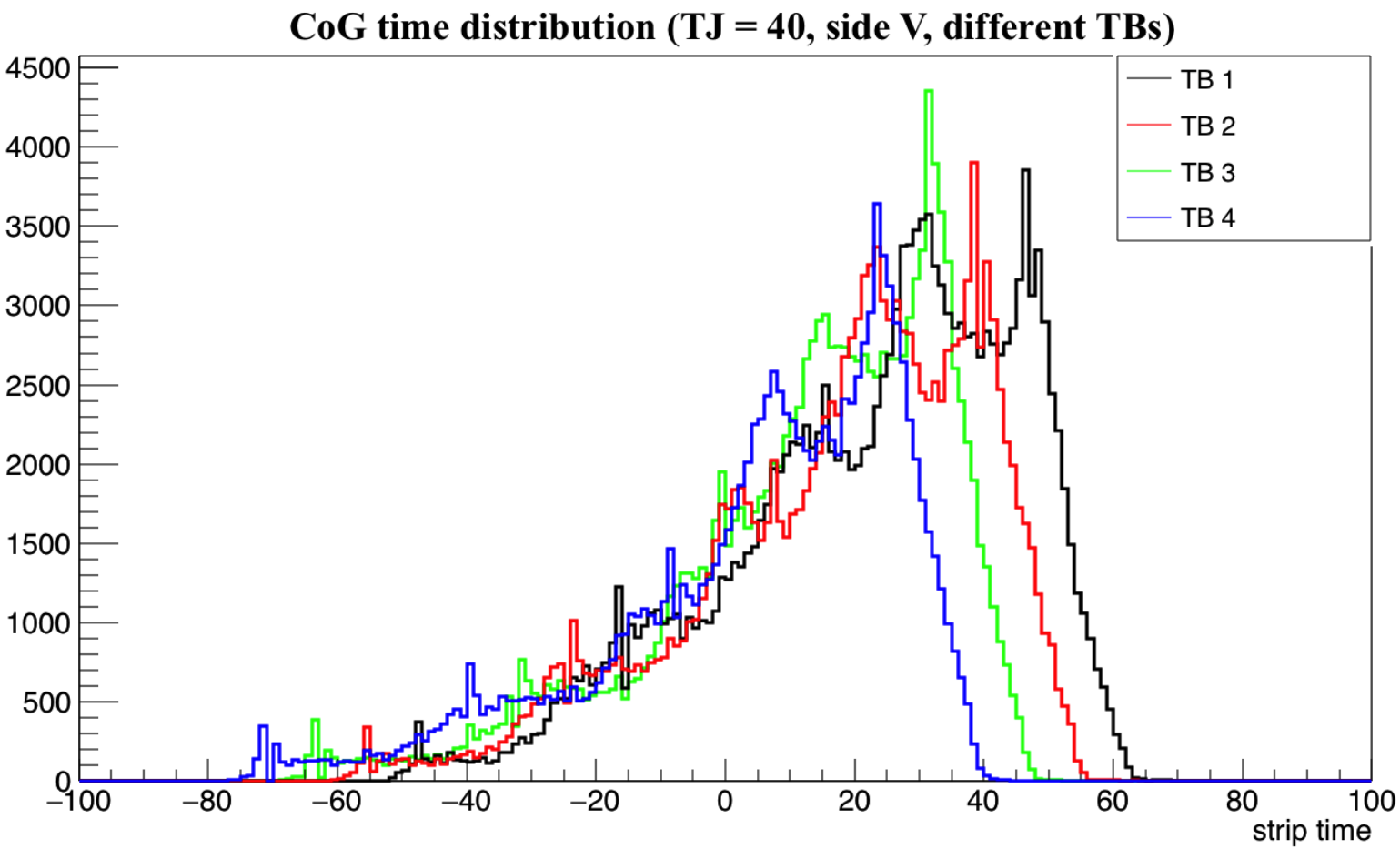

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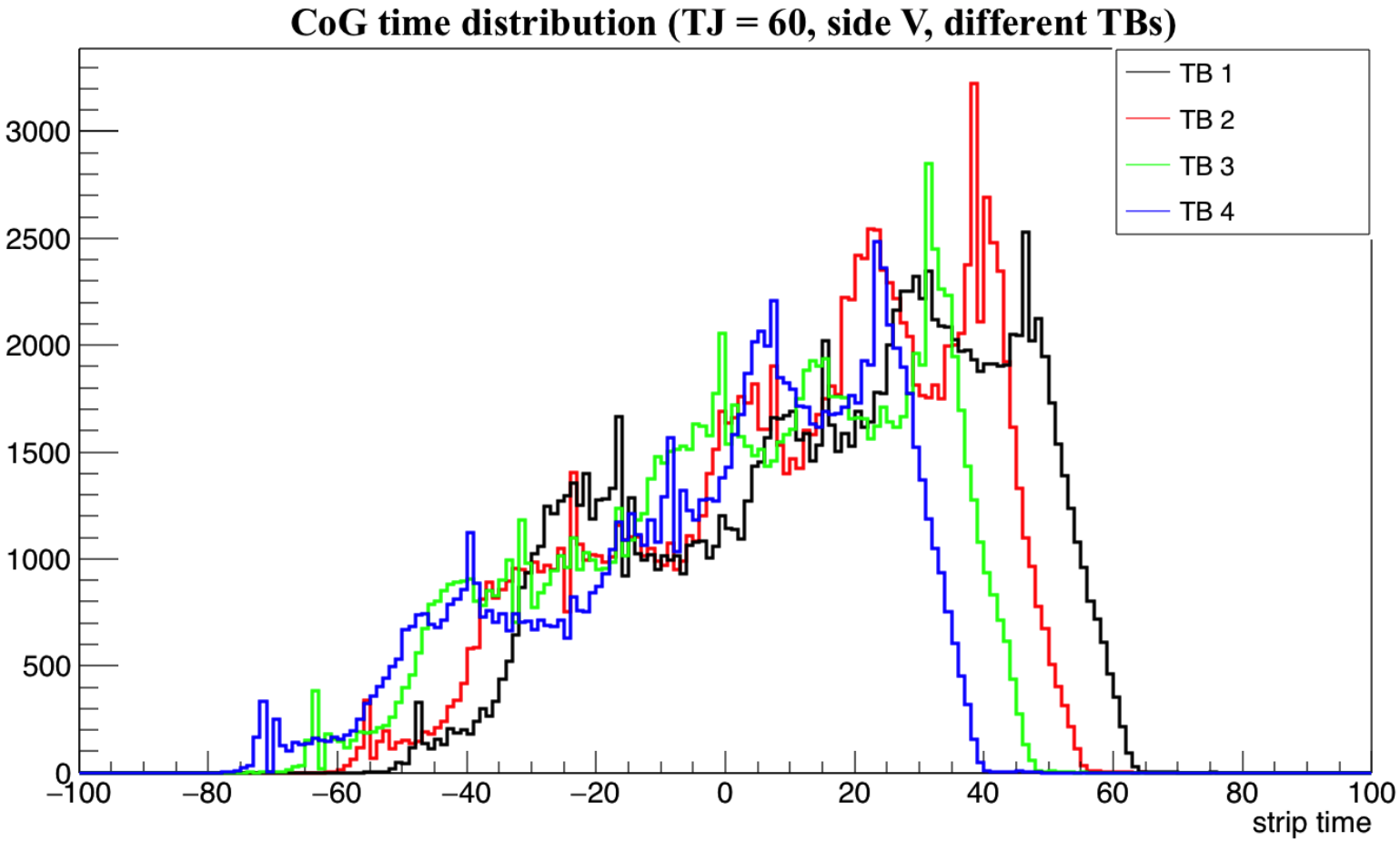
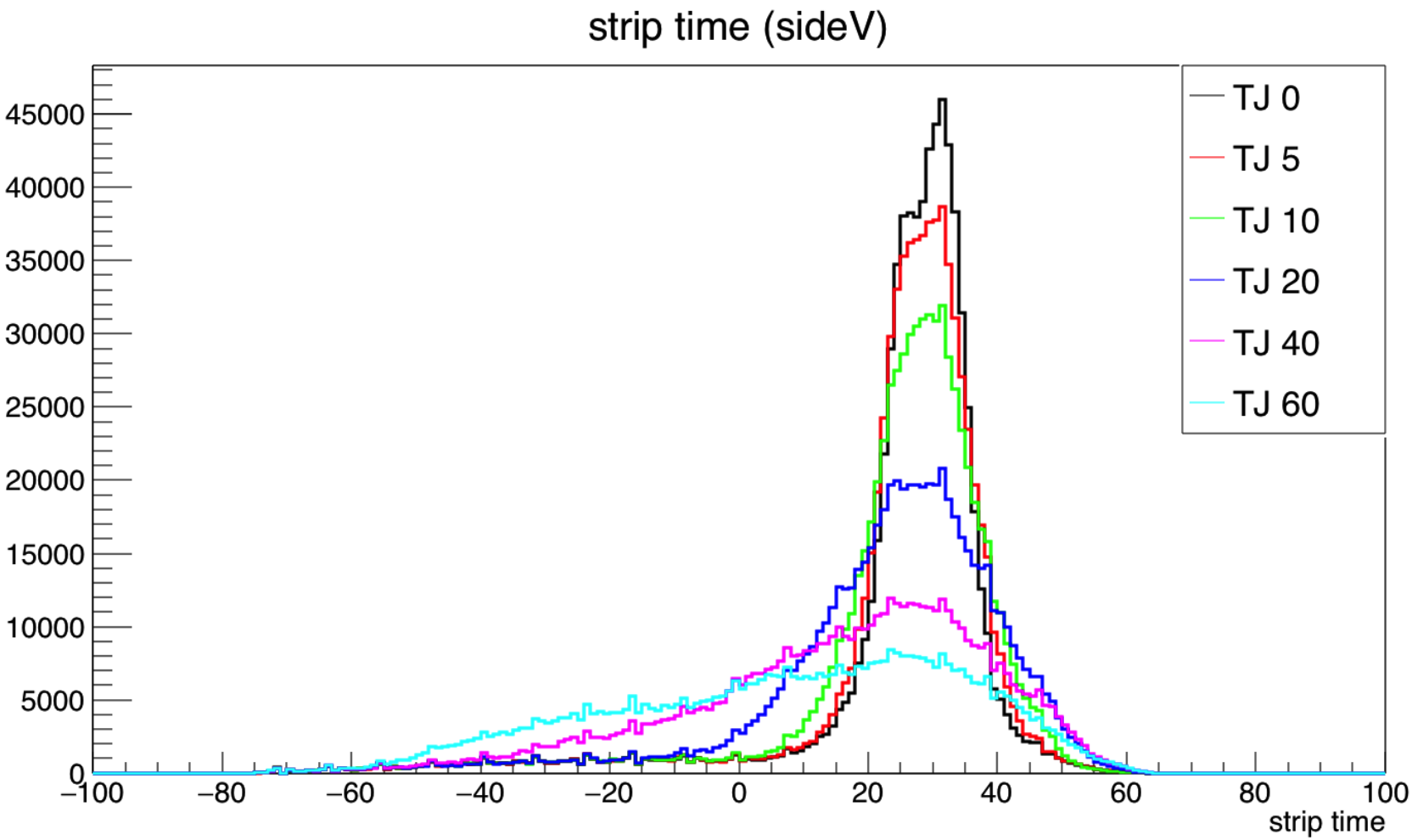
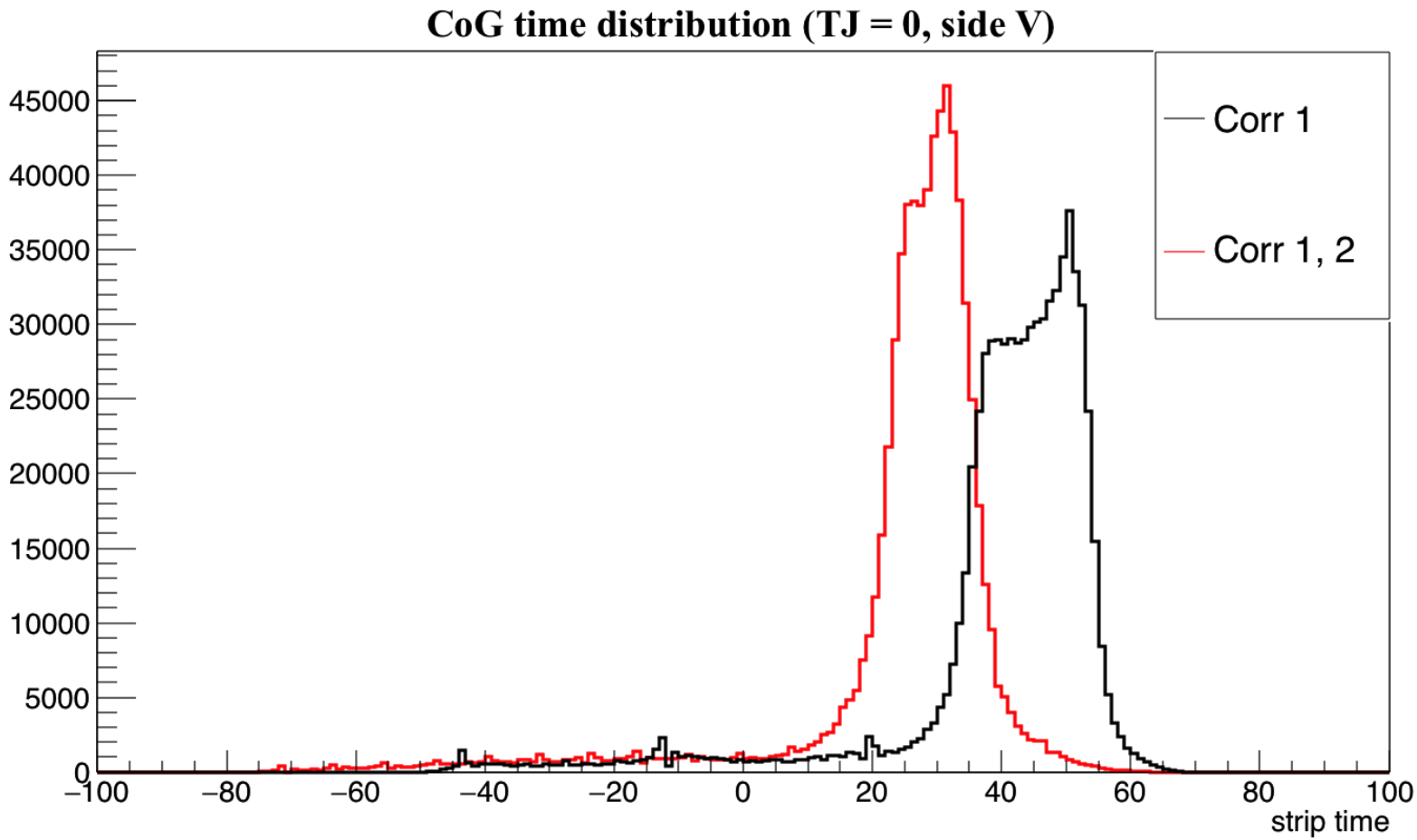


Peak-Time & TB Corrections Applied

Overall CoG distribution



Peak-Time Correction vs Peak-Time & TB Corrections
TJ = 0



Peak-Time Correction vs Peak-Time & TB Corrections

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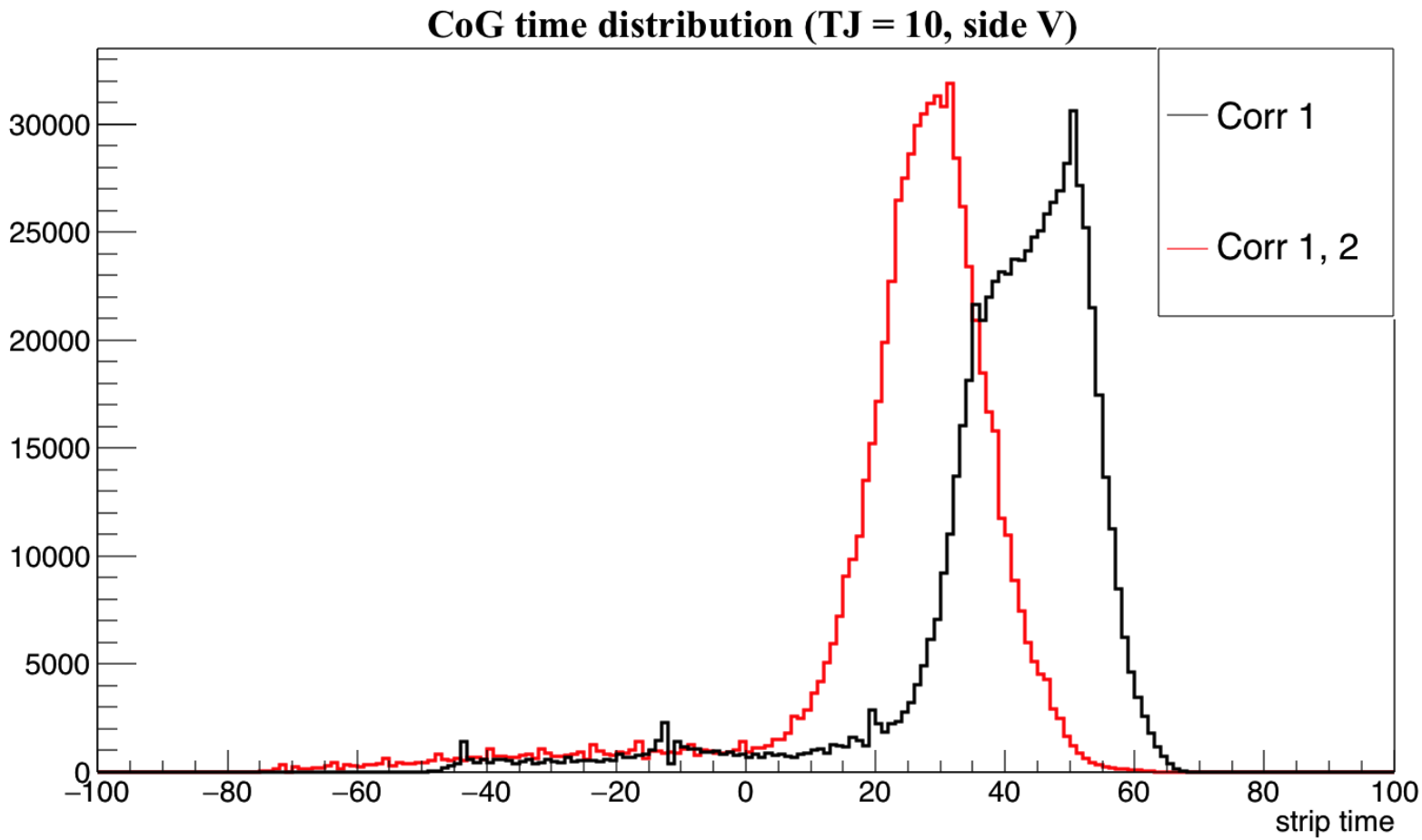

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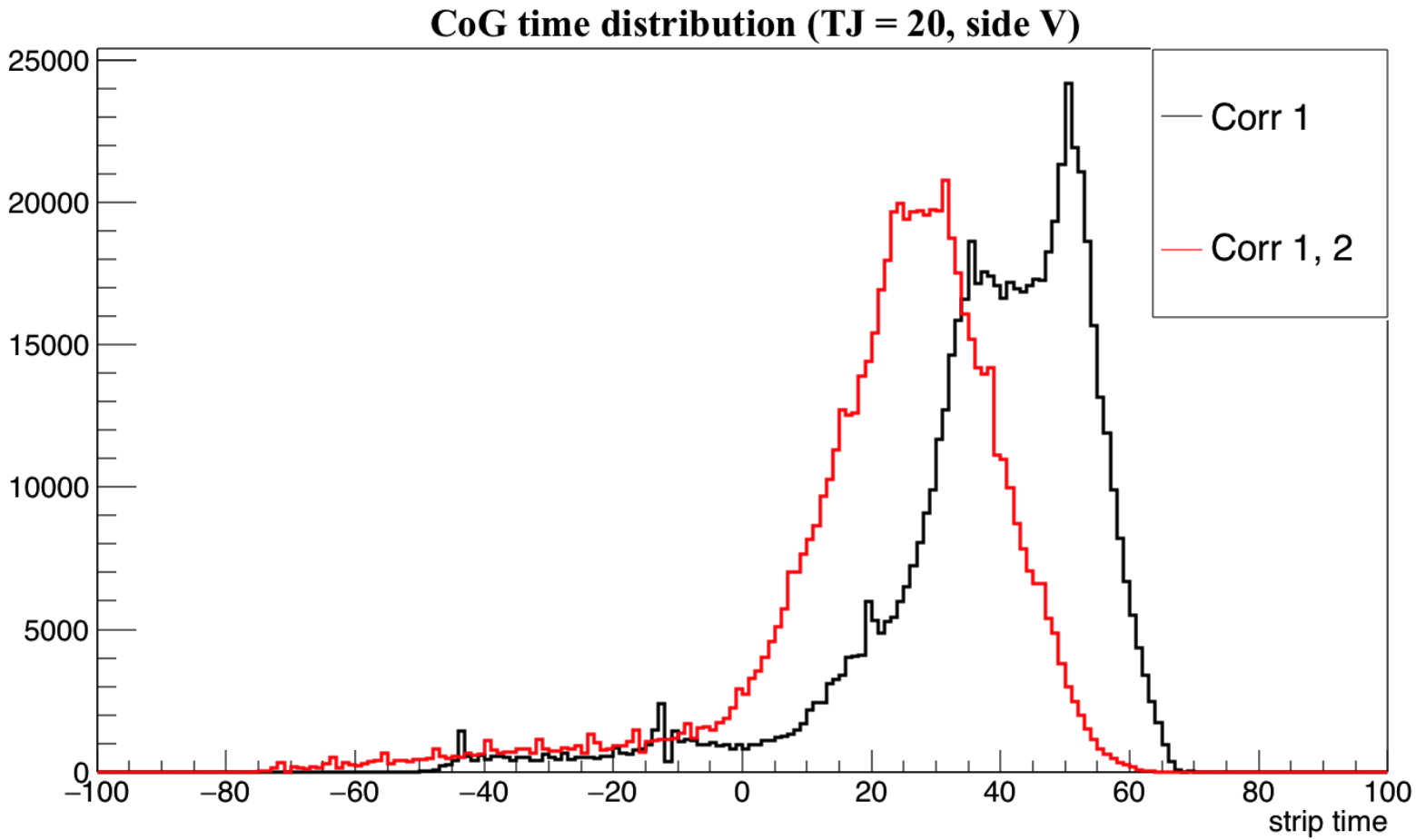

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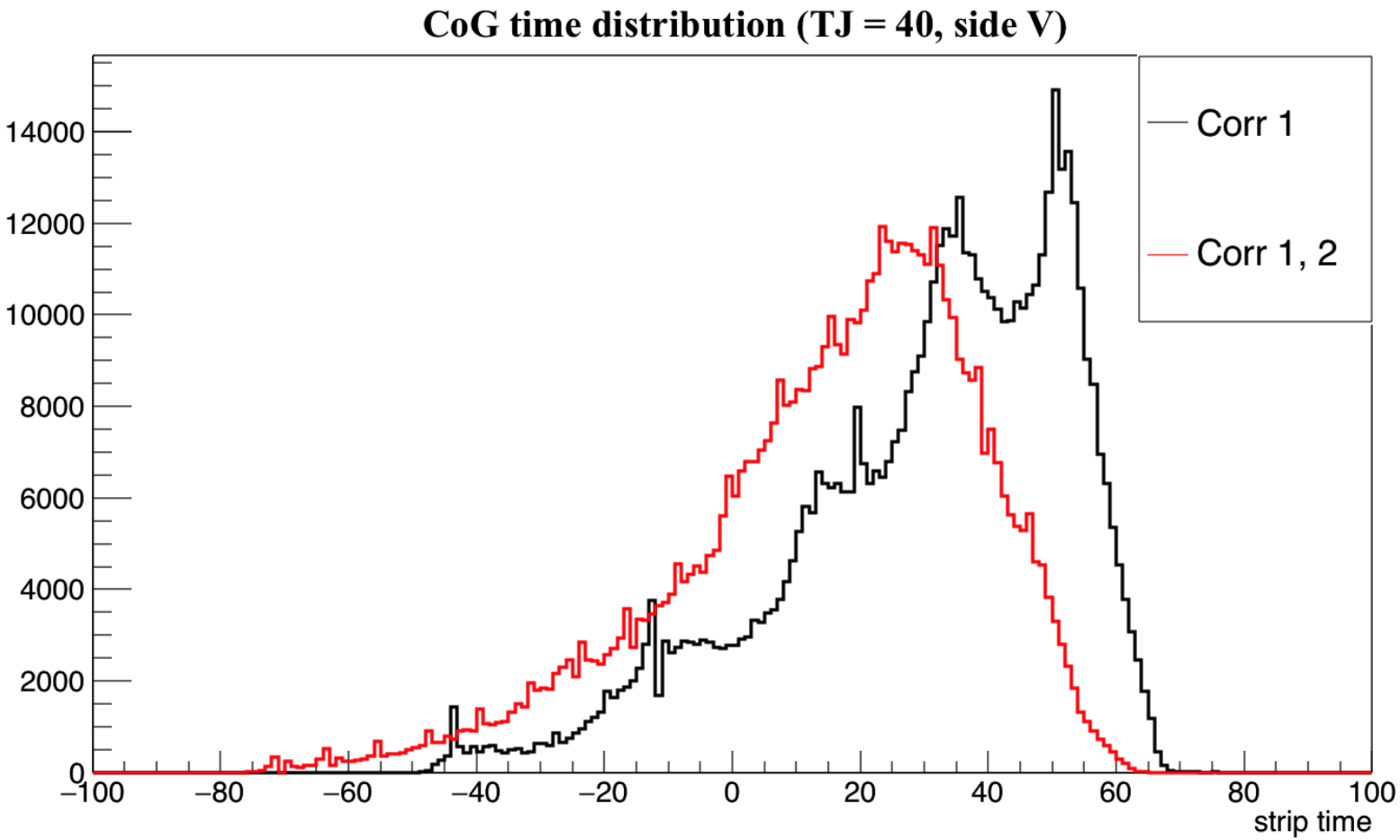

Peak-Time Correction vs Peak-Time & TB Corrections

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