

# Vernier Analysis Update

Run 12

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# Outline

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- 3 Comparison To Previous Model
- 4 Conclusion

# Status

# Status

From last time, we discussed a few items, namely:

- Bad matching with Data Derived Bunch z-profiles
  - ▶ Could this be because bunch models are not overlapping at  $z = 0$ ?
  - ▶ Are Beam Profiles appropriately centered?
- Can we improve performance with a simple lookup, as opposed to `TGraph::Eval`?
- Profiles might introduce artifacts resembling crossing angles/different values for  $\beta^*$ .

# Progress

- Density lookup has been implemented, code now runs nice and fast
- Direct comparison between beam profiles from WCM data + simple model are ready - maybe this provides some insight?
- Studied bunch profiles - although all profiles line up relative to each-other, the maximum of the bunch profile was not centered.
- New method:
  - ▶ Find global maxima in WCM profile
  - ▶ Build profile starting from the center, moving left and right
  - ▶ Stop when we hit the edge of the data set
  - ▶ The rest of the profile is set to "0"
  - ▶ Possible option (to account for beam gas, peripheral bunch distributions in Z):
    - ★ Sample background of WCM profile, and fill the peripheral bunch distribution with random fluctuations based on sampled region

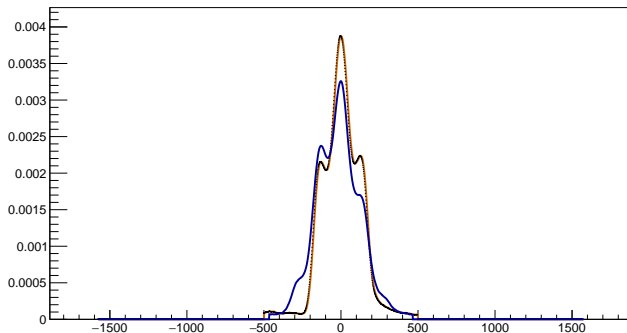
# Issues

There are still remaining issues with the simulation, the z-profile in the ZDC z-vertex distribution is still not matching nicely when we use the WCM data directly. Some thoughts:

- Have we selected an appropriate interaction time?
- Is  $\beta^*$  correction applied correctly to the width?
- Could binning be effecting the final profile?
- Should the old model even be used as a bench-mark?

# Exploring The Z-Profile

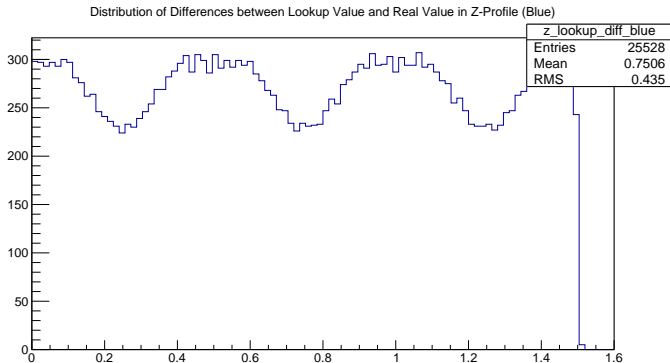
# New Bunch Alignment



**Figure 1 :** Bunches have been aligned such that they line up at their maxima, rather than lining up according to a time window. We define the time binning such that at arbitrary time  $t = 0$ , these maxima overlap.

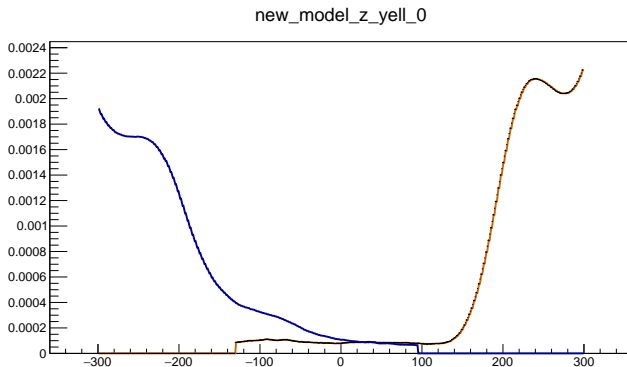


# Lookup Accuracy



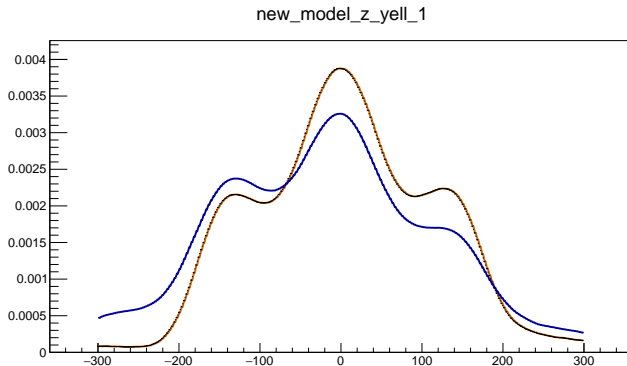
**Figure 2 :** Instead of interpolation between defined profile points, we instead bin time finely, which results in a spatial binning of 1.5 cm in  $z$ . Pictured here is a histogram, binned in  $z$ , where we fill it with the difference between the looked up  $z$  value, and the  $z$ -value desired. The yellow beam lookup calls are identical.

# Do Bunches Collide Maximally Overlapped?



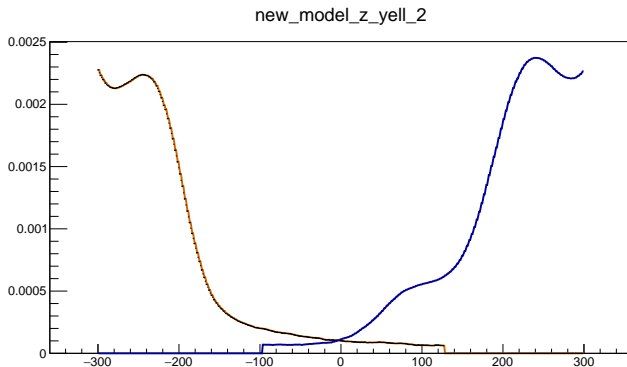
**Figure 3 :** Pictured here, we observe the blue and yellow bunches from a fixed point in space ( $z = 0$ ). Blue is incoming from the right, yellow, from the left. The time resolution of the simulation is  $\approx 2.5$  ns. Shown: 12.5 ns before collision

# Do Bunches Collide Maximally Overlapped?



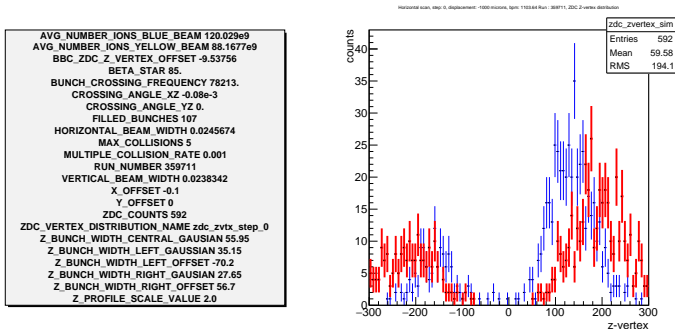
**Figure 4 :** Pictured here, we see the blue and yellow bunches at the nominal interaction time,  $t = 0$ . The maxima of each bunch aligns exactly with  $z = 0$ . Again, we observe from a fixed point in space, at  $z = 0$ .

# Do Bunches Collide Maximally Overlapped?



**Figure 5 :** Finally, we observe the bunches after the nominal interaction time, from a fixed z-position. Another 12.5 ns have passed, and we can see the blue bunch as continued to the right, and the yellow to the left.

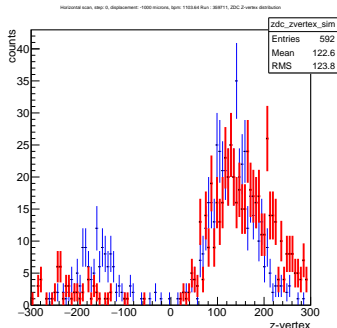
# Resulting ZDC Z-Profile



**Figure 6 :** We get slightly better results by adjusting the interaction between bunches to overlap at  $z = 0$ , but the distribution is still not well aligned. The peaks seem to be separated too much.

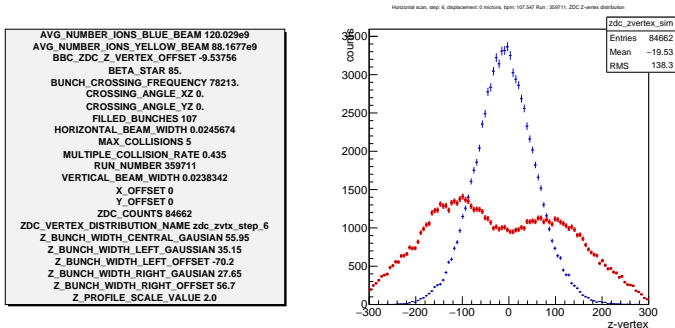
# Resulting ZDC Z-Profile - With Hand Tuning

```
AVG_NUMBER_IONS_BLUE_BEAM 120.029e9
AVG_NUMBER_IONS_YELLOW_BEAM 88.1677e9
BBC_ZDC_Z_VERTEX_OFFSET -9.53756
      BETA_STAR 50.
BUNCH_CROSSING_FREQUENCY 78213.
CROSSING_ANGLE_XZ -0.55e-3
CROSSING_ANGLE_YZ 0.
FILLED_BUNCHES 107
HORIZONTAL_BEAM_WIDTH 0.0245674
      MAX_COLLISIONS 5
MULTIPLE_COLLISION_RATE 0.001
RUN_NUMBER 359711
VERTICAL_BEAM_WIDTH 0.0238342
      X_OFFSET -0.1
      Y_OFFSET 0
      ZDC_COUNTS 592
ZDC_VERTEX_DISTRIBUTION_NAME zdc_zvtx_step_0
Z_BUNCH_WIDTH_CENTRAL_GAUSSIAN 55.95
Z_BUNCH_WIDTH_LEFT_GAUSSIAN 35.15
Z_BUNCH_WIDTH_LEFT_OFFSET -70.2
Z_BUNCH_WIDTH_RIGHT_GAUSSIAN 27.65
Z_BUNCH_WIDTH_RIGHT_OFFSET 56.7
Z_PROFILE_SCALE_VALUE 2.0
```



**Figure 7 :** We get slightly better results by tuning  $\theta_{XZ}$  and  $\beta^*$ . As expressed in previous weeks, I am concerned that the simulations present a fine tuning problem, but based on this output, I think we may be ready to try for brute-force convergence. Note the values for  $\theta_{XZ}$  and  $\beta^*$ , which are quite different then the values from the simple model (next slide).

# Resulting ZDC Z-Profile - With Hand Tuning



**Figure 8 :** As a sanity check for the WCM z-profile driven simulation, as Sasha recommended last week, we look at the maximum overlap distribution. The simulated beams do not seem to be aligned, though there is no offset provided in the horizontal or vertical directions. I'm not sure what is causing this behavior

# Discussion

- So far, we are not getting good results from the WCM z-profiles.
- What else could be causing this behavior...(assumption is bug in code, but where)
- Feeling a bit stuck, ideas welcome!



## Comparison To Previous Model

# Comparison Between Old and New Profiles

- While both distributions have approximately the same width (after scale-factor is applied), the internal structure is quite different.
- Notably, the simple profile model is extremely asymmetric.

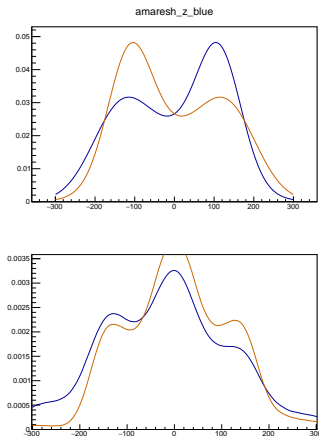


Figure 9 : Bottom: the "real" profile, Top: the "simple" profile used in other analyses.

# Conclusion

# Concluding Remarks

- Still some bugs to work out in the simulation, but not sure how to move forward.
- Simulation code has one-to-one correspondence between structures and transformations between the models - the only difference is between the new model, and old model, is the z-profile used.
- Could it be that maybe nothing is wrong, and I just need to run over a very large parameter space? It is somewhat distressing to not be able to get an okay convergence by hand.

# End

Thanks for the discussion!