

# ATLAS strategy for primary vertex reconstruction during Run-II of the LHC

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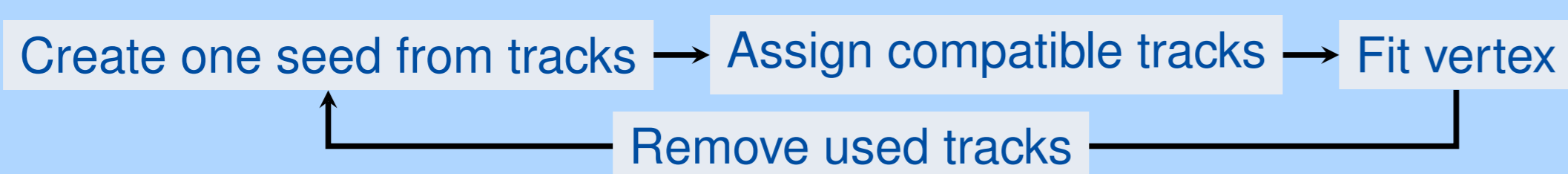


## From Run-I to Run-II

During LHC Run-I, ATLAS saw up to 40 simultaneous  $pp$  collisions ( $\mu$ ). During Run-II, this will continue to increase. Previously, an iterative vertexing strategy tuned to avoid splitting one interaction into two vertices was employed. But at higher  $\mu$ , merging of two interactions into one vertex becomes important.

To reduce merging of two  $pp$  interactions into one vertex, ATLAS is developing a new imaging seeding algorithm.

### Iterative vertexing strategy

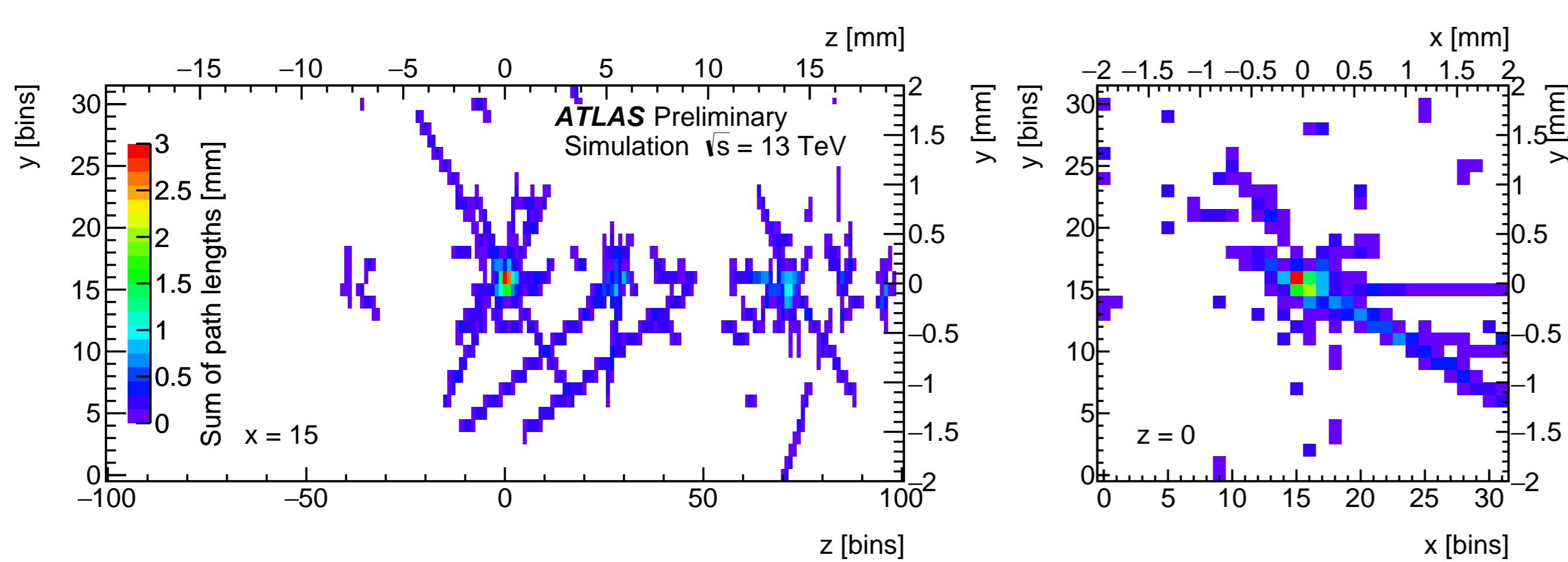


### Imaging vertexing strategy



## Imaging vertices

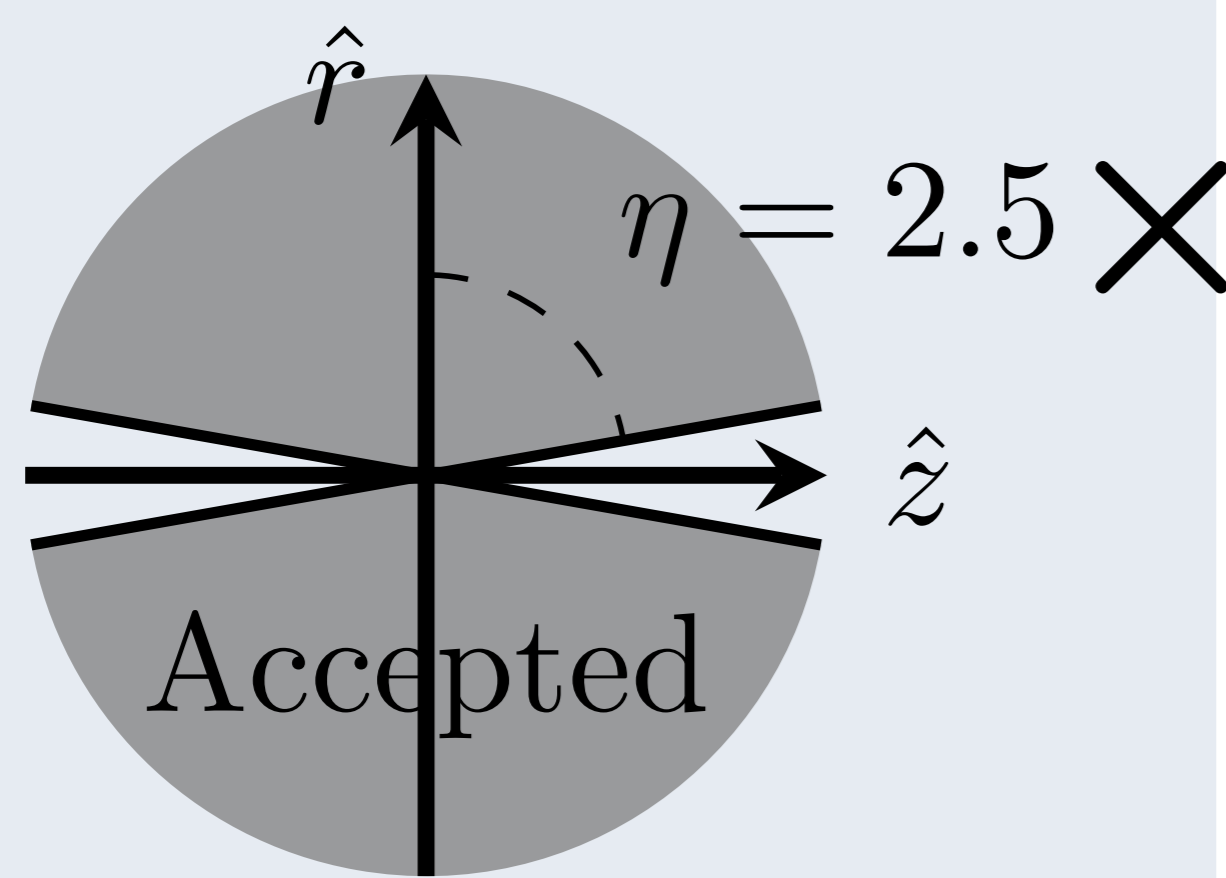
### Back-project tracks into 3D volume



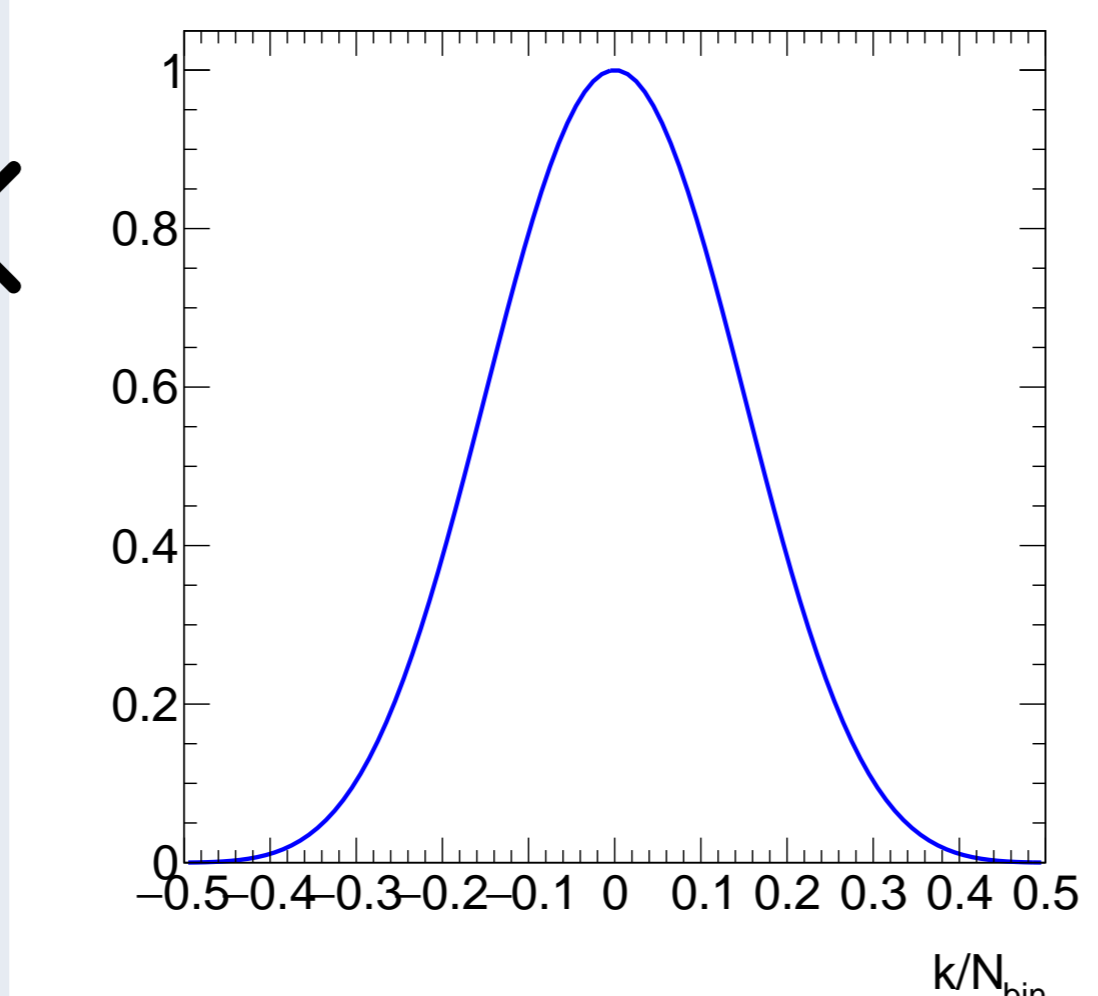
### Fast Fourier Transform to frequency space

#### Multiply by filters:

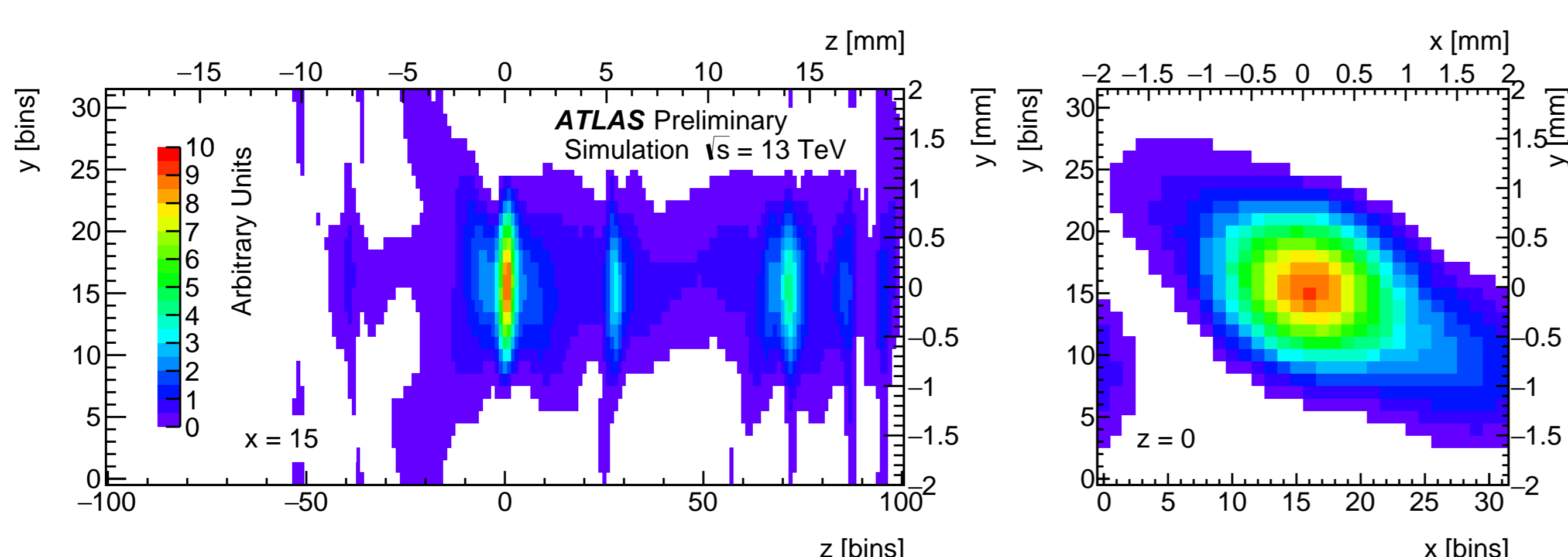
Inverse of Fourier transform of acceptance



Blackman-Harris window to damp high frequencies



### FFT back to position space

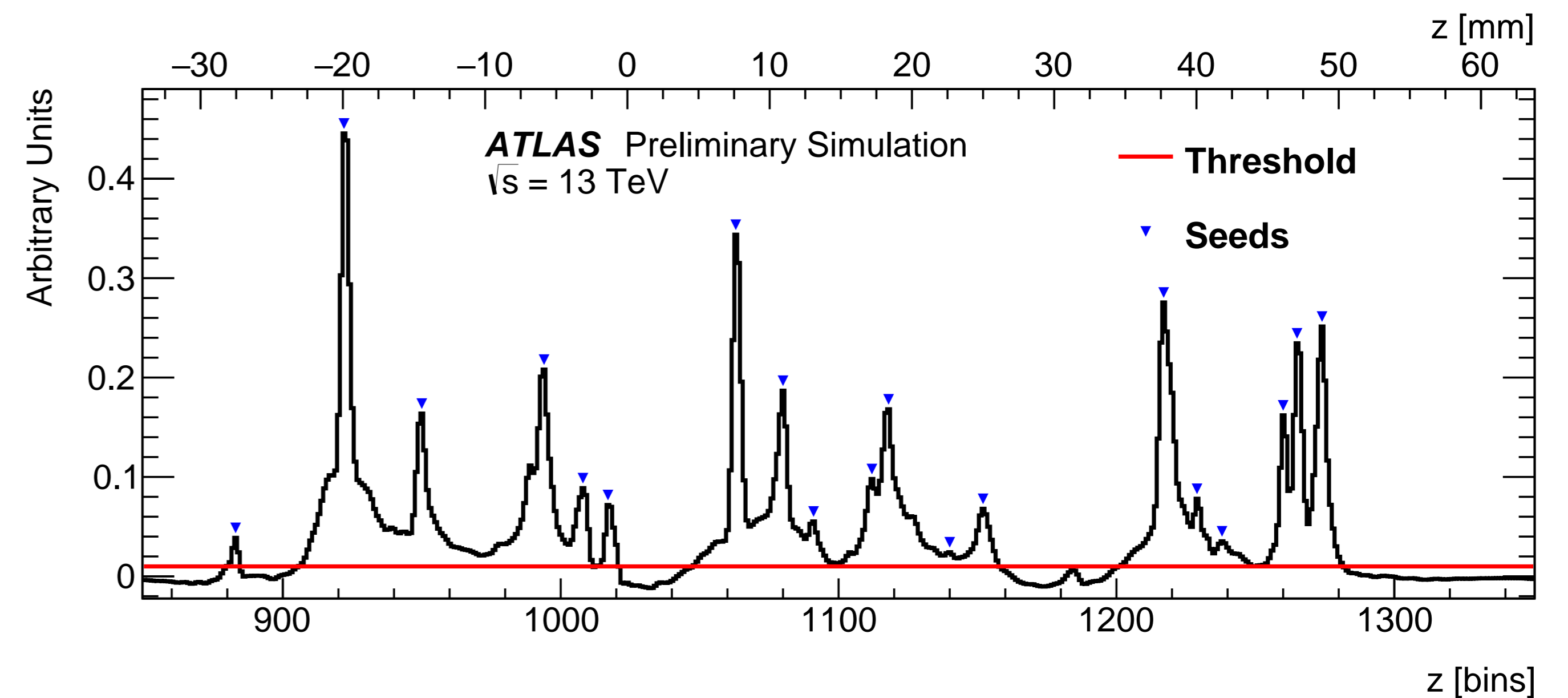


## Modularity

The creation of the image, the identification of seeds in the image, the assignment of tracks, and the final vertex fits are all separate algorithm modules. They can each be configured at run time to optimize performance in different contexts. Alternative modules can be developed in parallel, and substituted at run time.

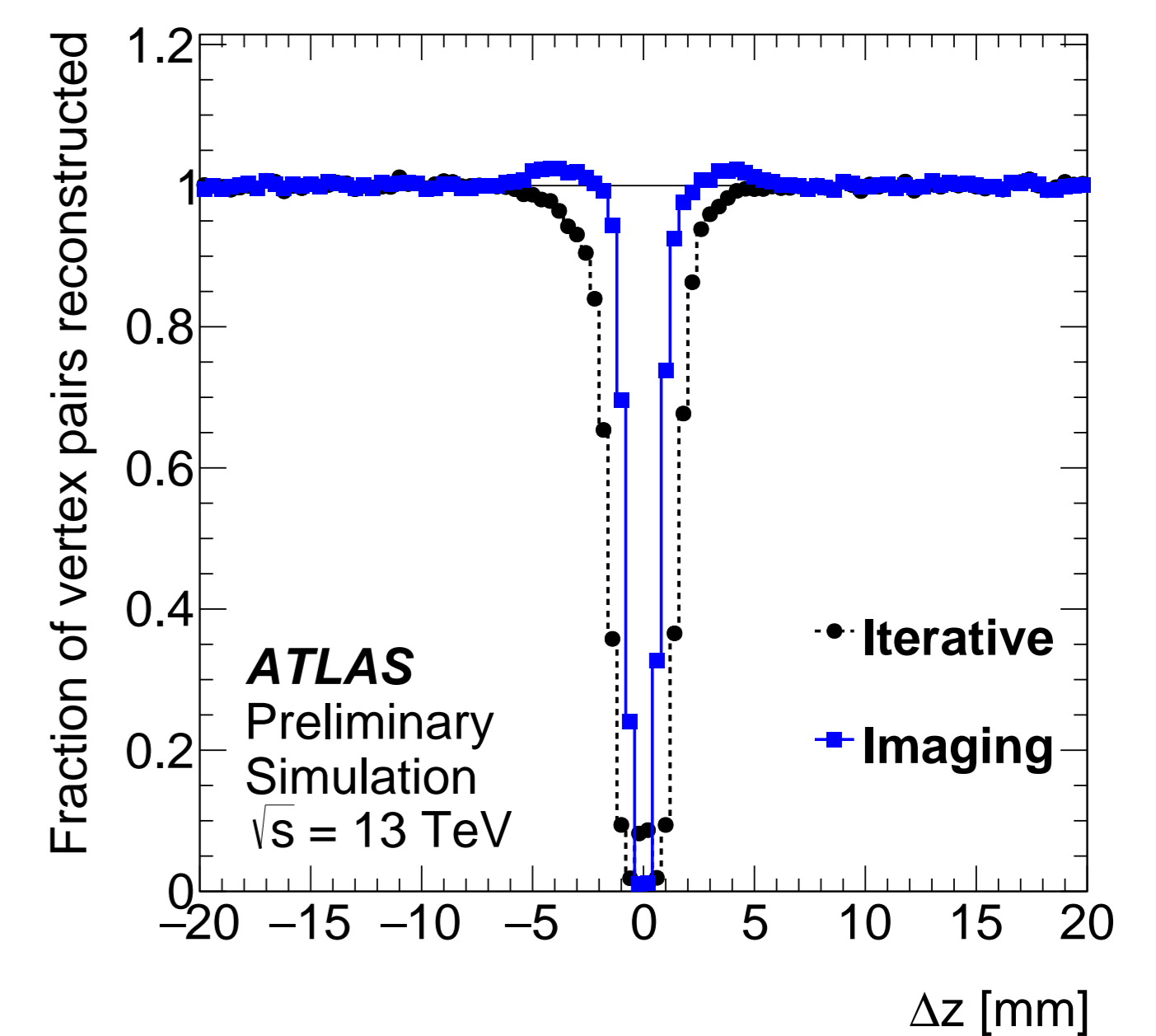
## Example seeding strategy

Use a 1D z-projection to identify local maxima above a threshold. The lower of two peaks is eliminated if the minimum between it and the other is greater than 90% of its value. The resulting set of seeds is used as input to track assignment, and ultimately vertex fitting.



## Preliminary performance

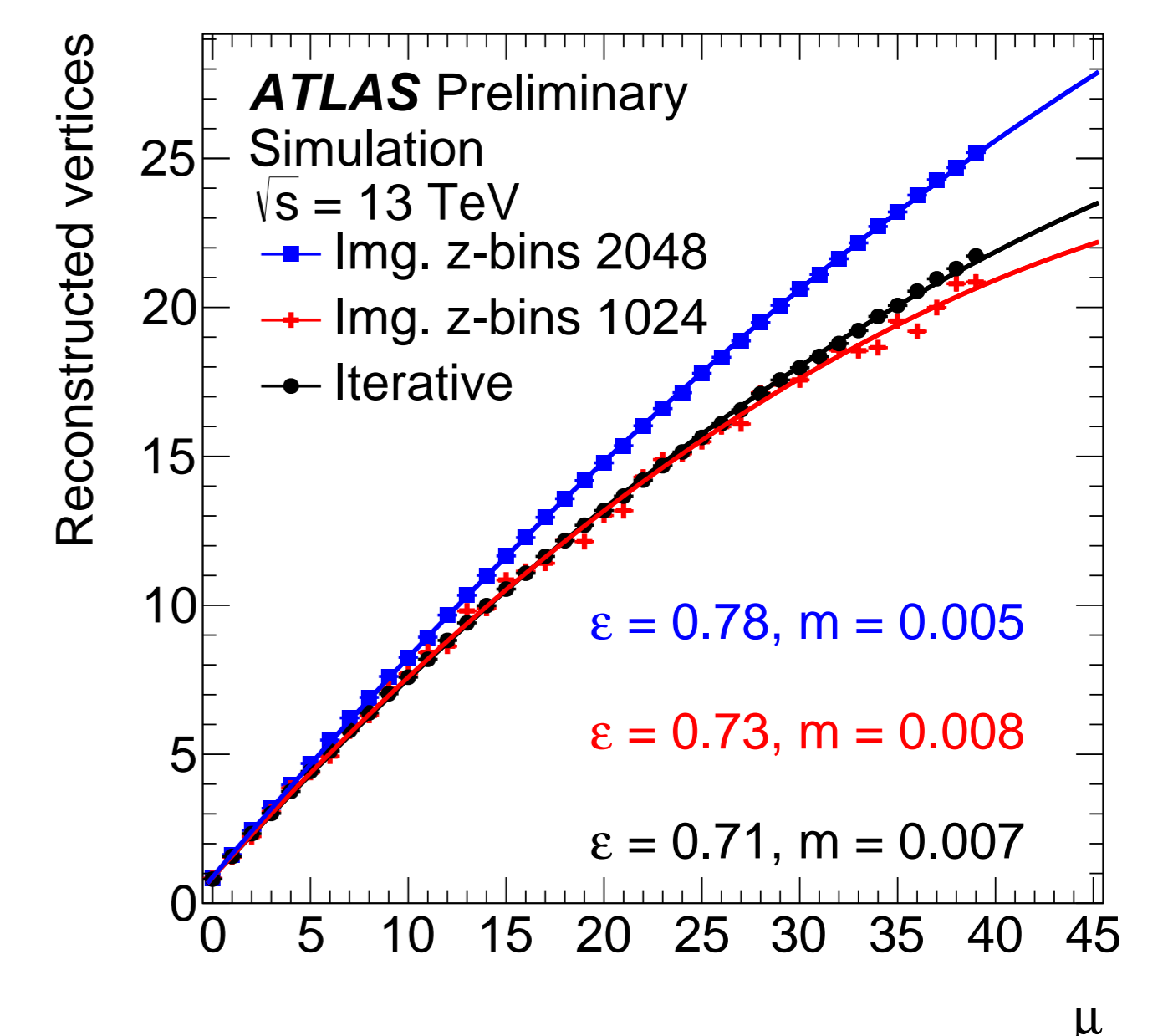
The imaging algorithm with 2048 z-bins can reconstruct separate collision vertices closer together in the z direction than the iterative approach, reducing the merging rate. The iterative algorithm will produce one seed compatible with tracks from both collisions; the imaging algorithm produces two seeds before track assignment is performed.



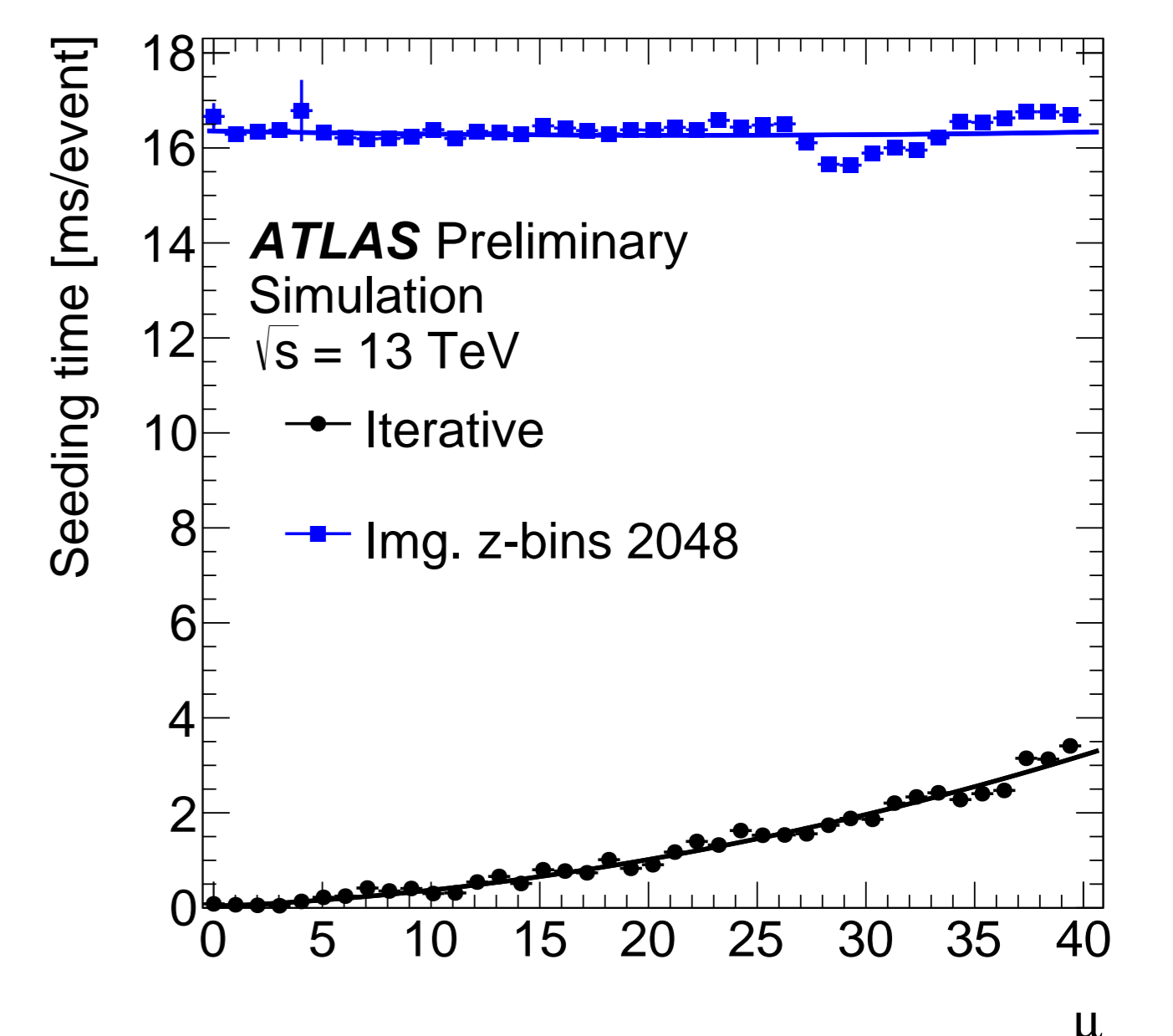
With fewer merged vertices, the imaging algorithm exhibits less quadratic losses ( $m$ ) as  $\mu$  increases:

$$N_{\text{vtx}}^{\text{reco}} = c_0 + \varepsilon\mu(1 - m\mu)$$

The underlying linear slope  $\varepsilon$  increases as well, due to an increase in the number of split vertices.



The imaging algorithm time is dominated by the time spent transforming and filtering to reconstruct the image, and shows a weaker dependence on the number of in-time pile-up events from the other steps of the algorithm.



## Conclusions

Imaging provides a highly configurable approach to vertex seeding. Preliminary simulation studies corresponding to early LHC Run-II show reduced merging. The algorithm is modular, allowing for the development of more sophisticated image processing techniques in the future. With optimization still to come, this algorithm shows promise for vertex seeding as the number of simultaneous collisions increases.

Imaging seeding can find vertices at smaller z separation and reduce merging.