POSITION RECONSTRUCTION STUDIES FOR DEAP-3600

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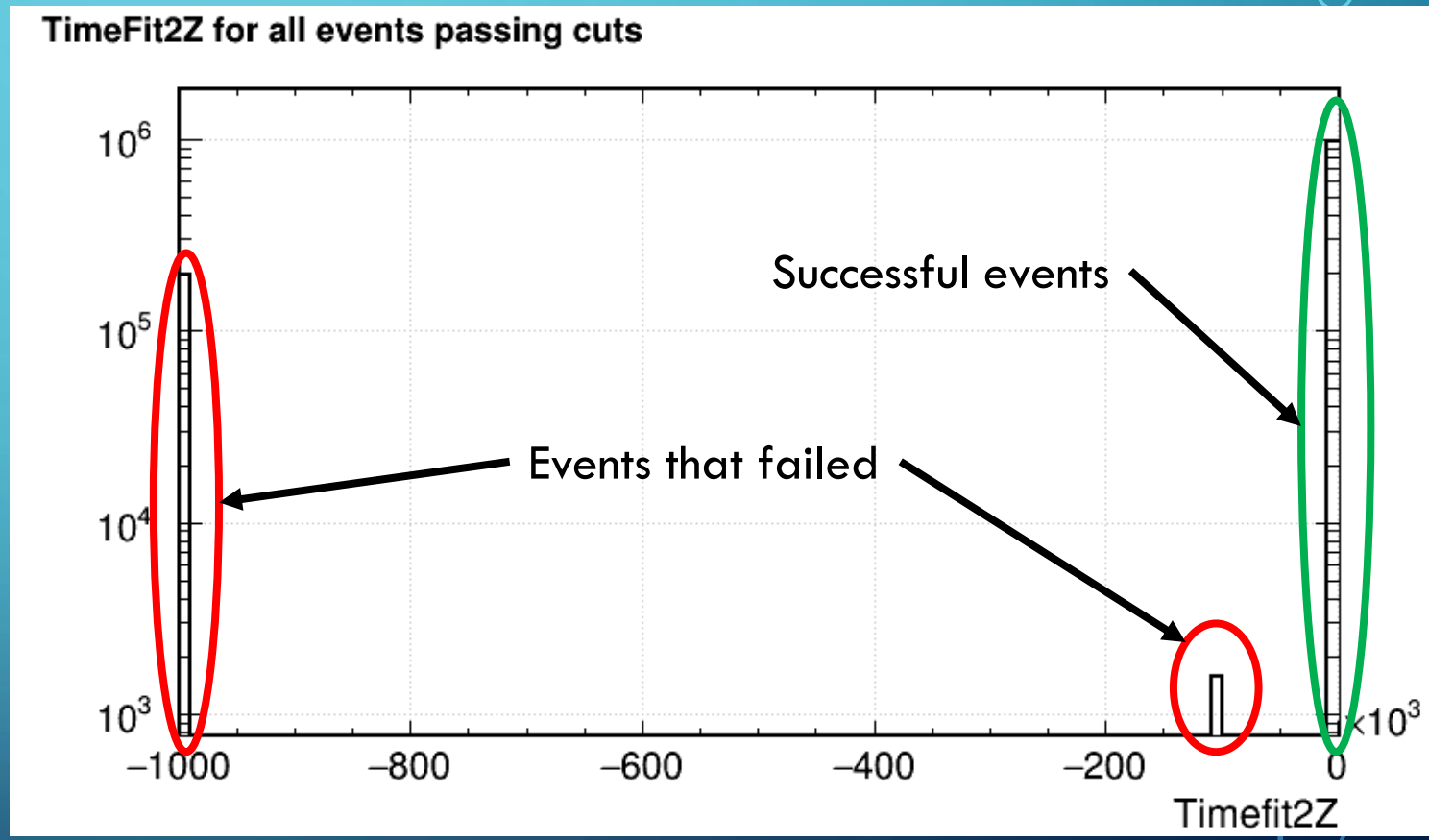
MOTIVATIONS

- Being able to accurately know where events occur within the detector is important in order to cut out events from 'bad regions' (i.e. surface region, fill level)
- There are several open issues related to position reconstruction for the DEAP-3600 detector, and my goal over the summer was to investigate a few of them
- Studies:
  - TimeFit2 Failures
  - Liquid Argon Flow
  - MBLikelihood Surface Spike

TIMEFIT2 FAILURE INVESTIGATION

TIMEFIT2 ERROR POPULATIONS

- TimeFit2 is a position fitter which uses time of flight information to estimate the position of an event
- On occasion it fails, in which case events are given default error positions
- My goal was to identify why events fail and attempt to improve the rate of failure



A LOOK AT EACH POPULATION

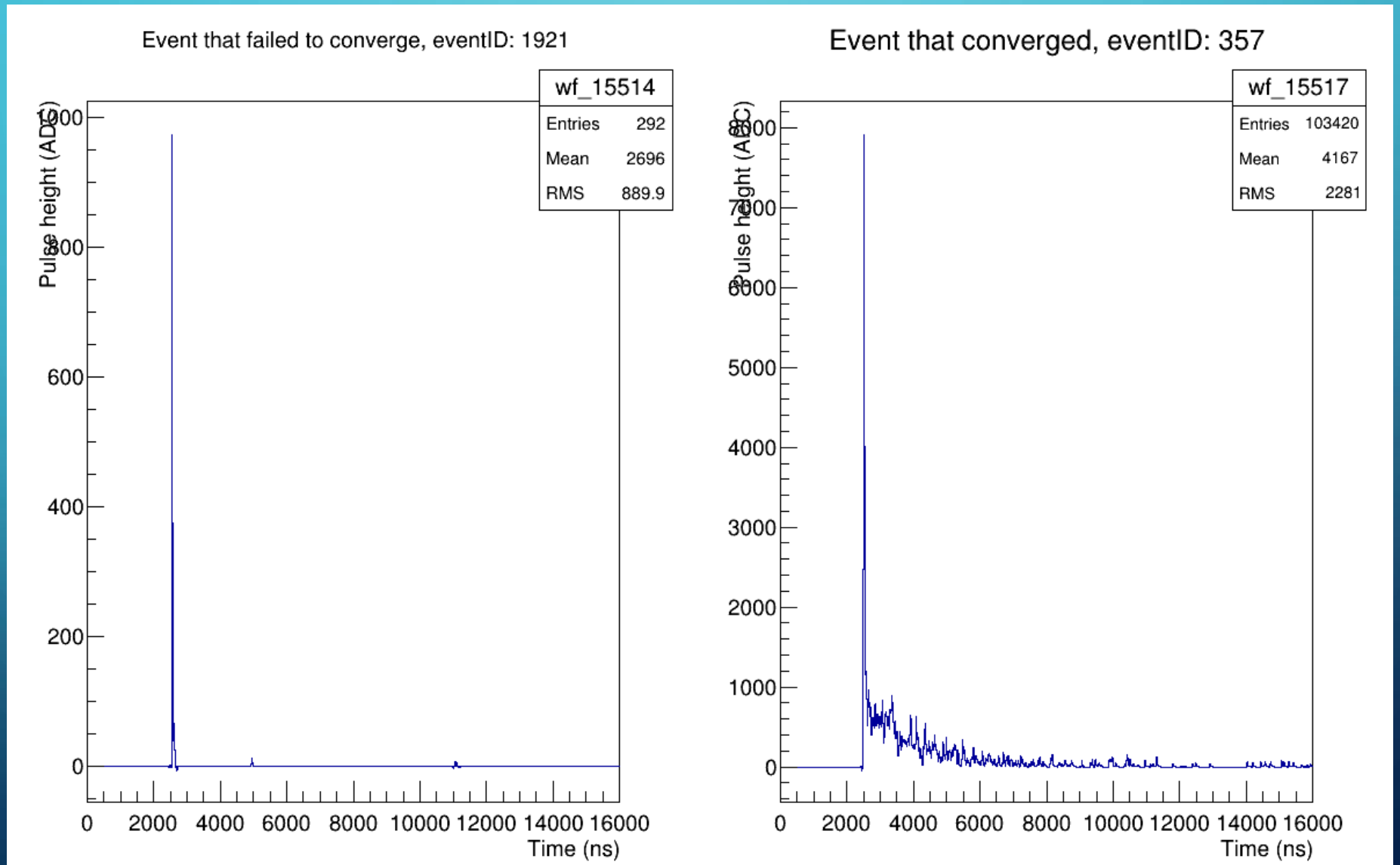
FAILURES DUE TO PROCESSOR CUTS

- When processing events, cuts on variables can be set
- When an event fails one of these cuts TimeFit2 fails and events are given the position of X, Y, Z = -999,999
- This is by design and no changes were necessary

EVENTS WHERE THE PROCESSOR ITSELF FAILS TO CONVERGE

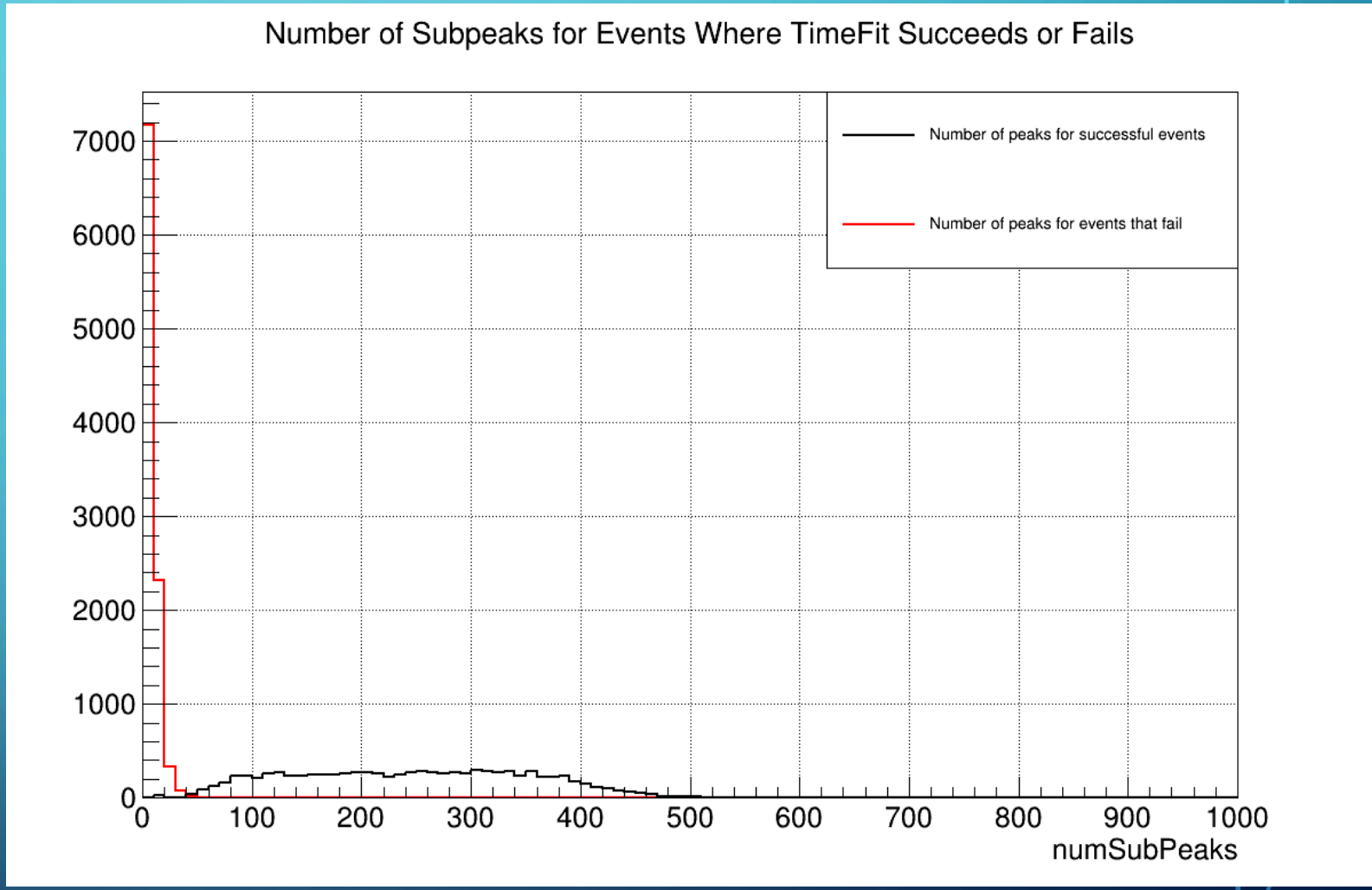
- These events fail one of the internal checks and cause the processor to fail
- This causes the position of the event to be set to X, Y, Z = -99,999
- Further effort needed to be put into understanding these events

WAVEFORM COMPARISON



INTERNAL FAILURE POPULATION

- Events that fail have significantly less subpeaks than good events
- Events that have too few peaks cannot make a reliable fit and thus are failing
- Like before this is the desired behaviour



CONCLUSION OF THE TIMEFIT2 STUDY

- The processor is working properly, both failure populations are now well understood
- Through this study I performed a code review which led to several changes implemented into the processor to improve efficiency and readability as well as resolve some small issues

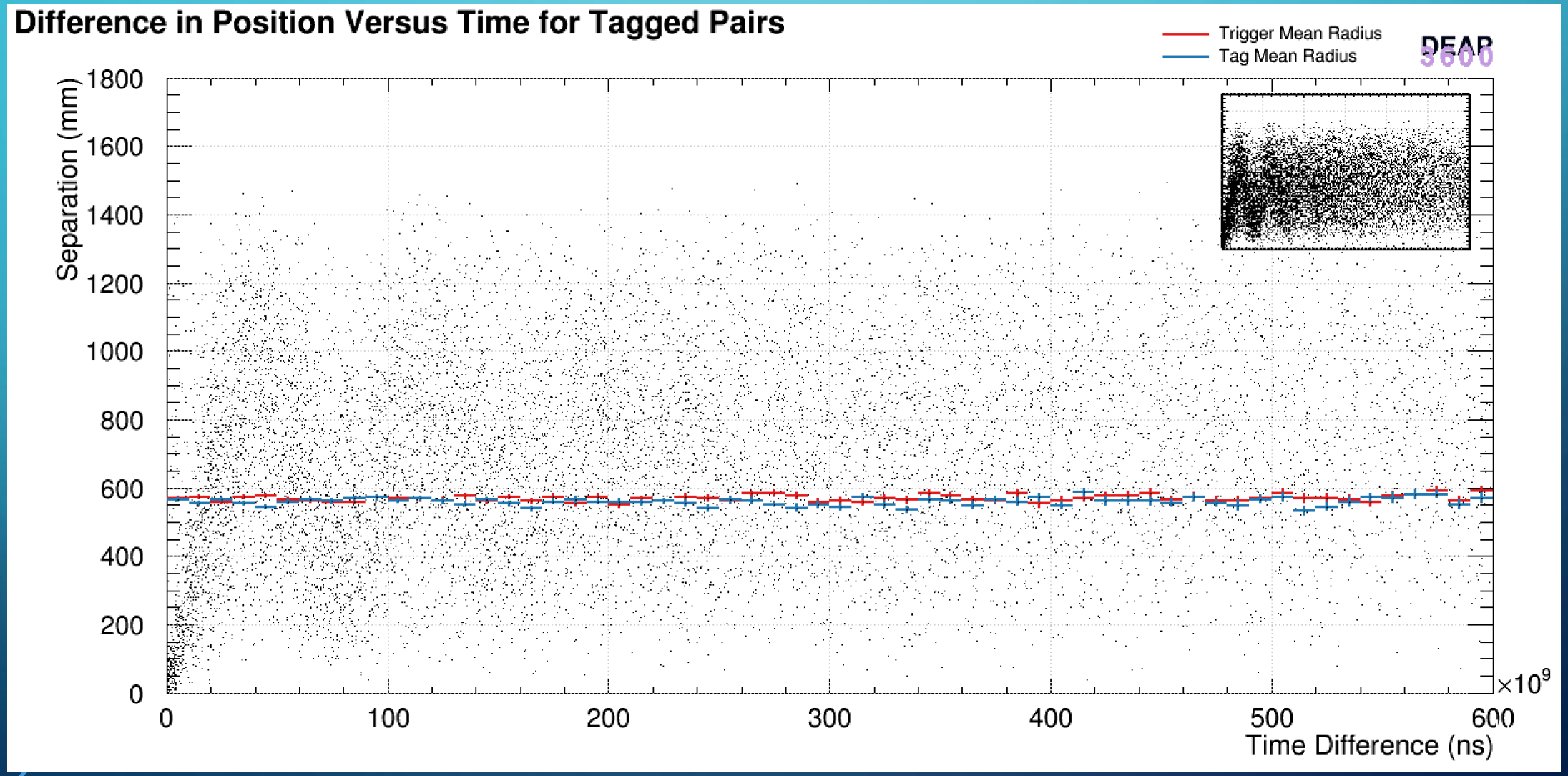
LIQUID ARGON FLOW INVESTIGATION

METHOD

- In the U238 decay chain Rn222 decays to Po218 which has a half life of 3.10 min
- Both undergo alpha decay and can be identified within the detector
- By looking for Po218 decays occurring shortly after Rn222 decays we can tag events where both decays come from the same particle
- Using this we can see how particles move over time

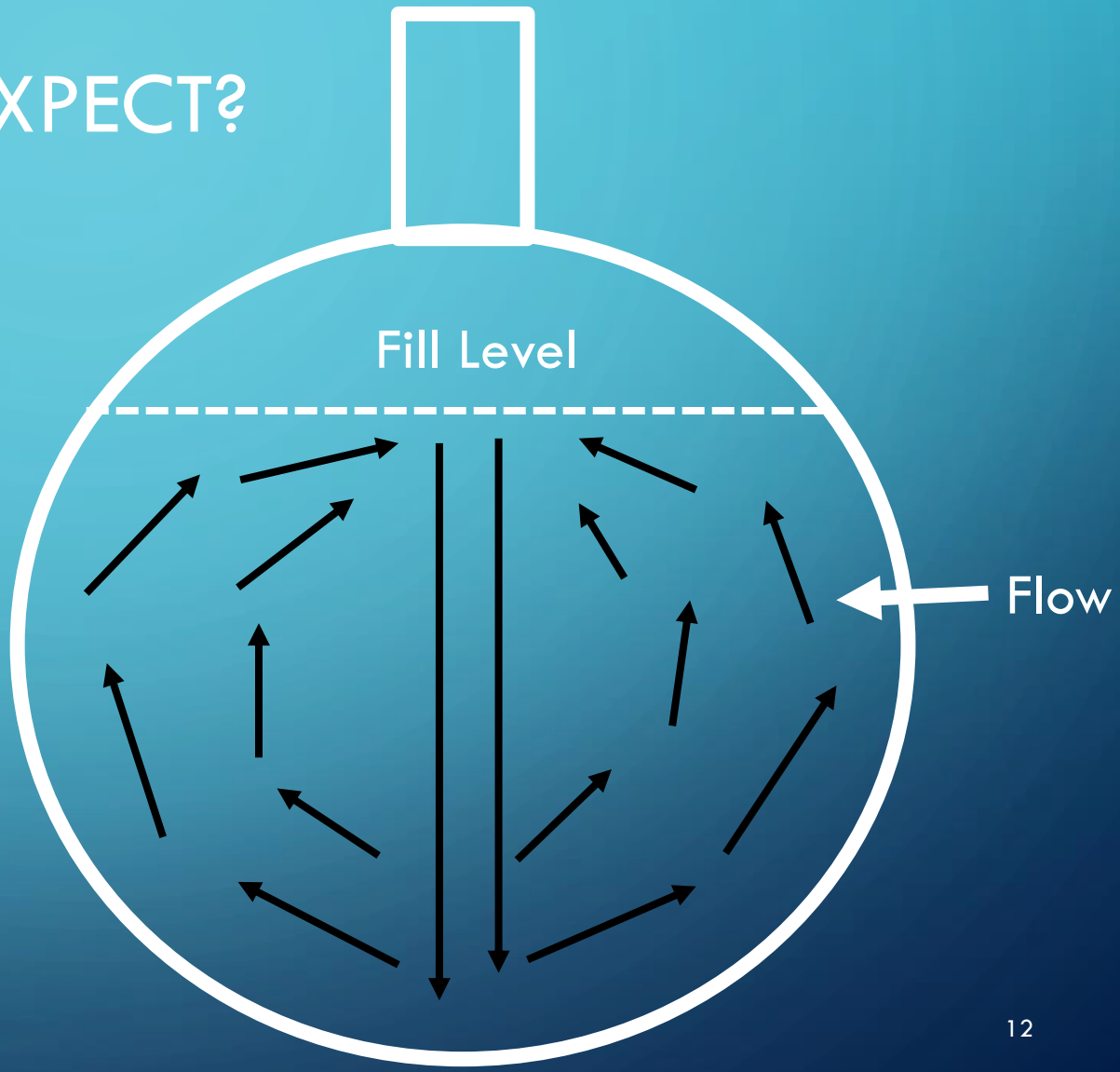
MOTIVATION

Separation = $\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$

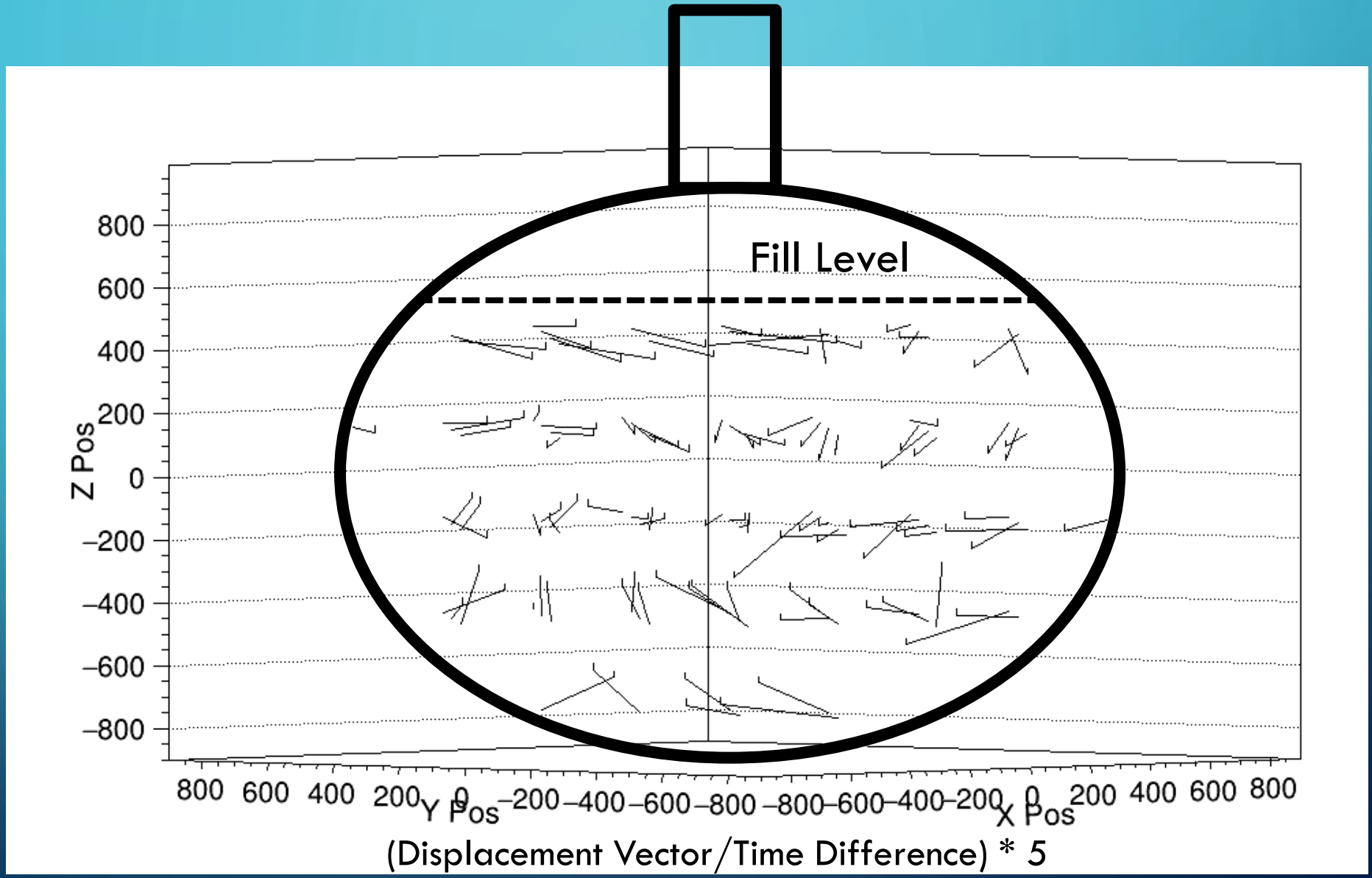


WHAT FLOW DID WE EXPECT?

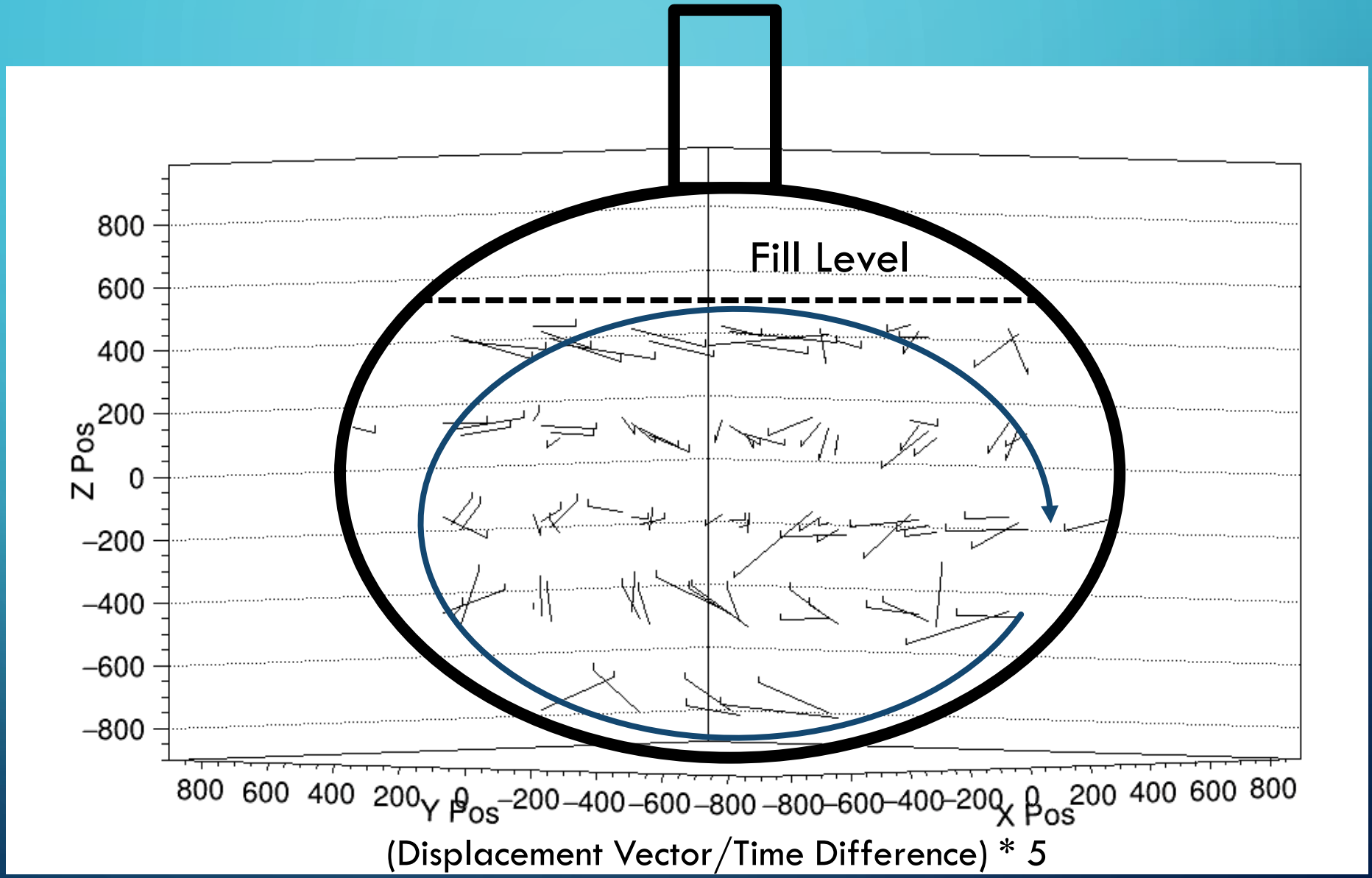
- We expected to see flow descending in a column under the neck and rising along the edges



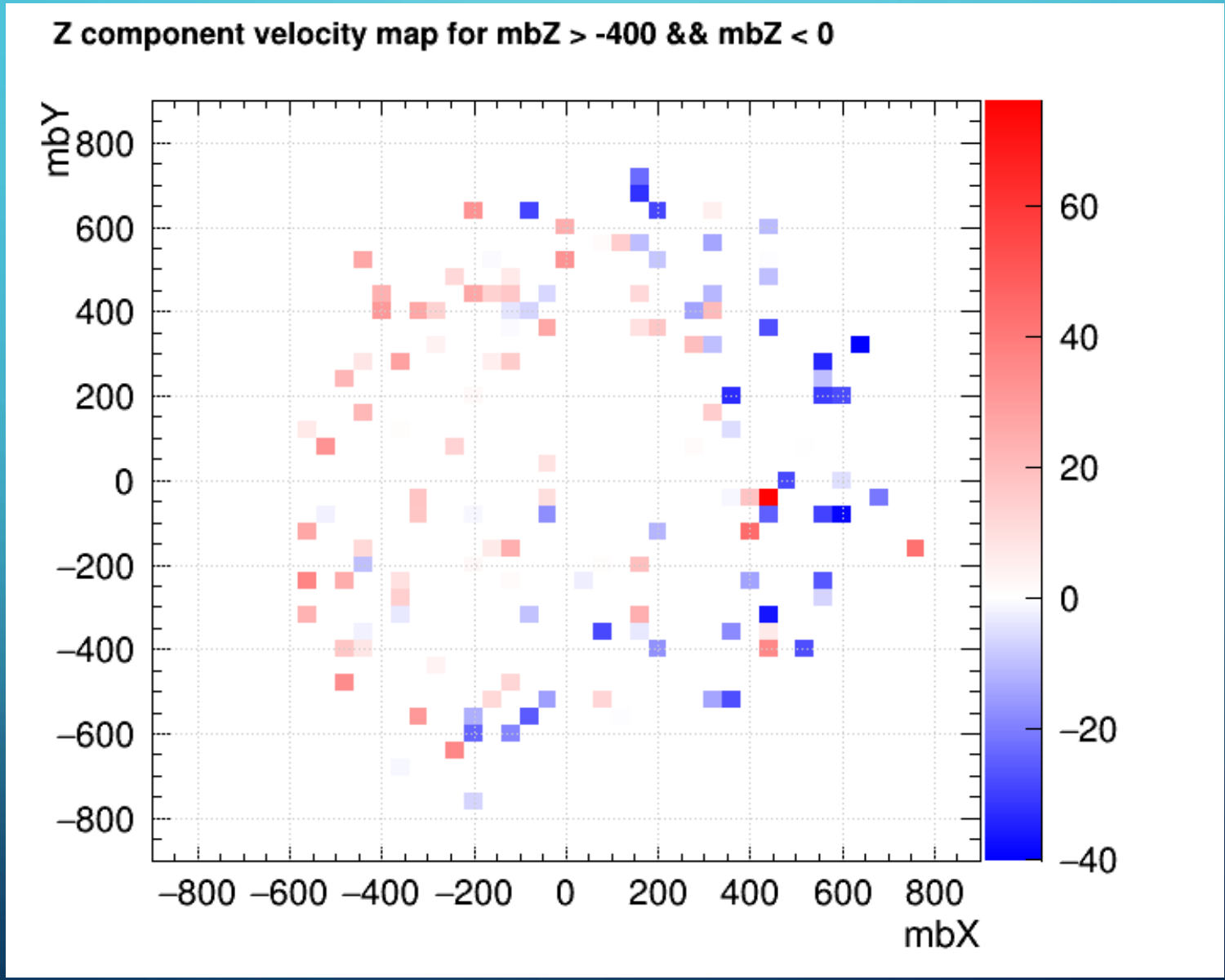
WHAT FLOW DO WE SEE?



WHAT FLOW DO WE SEE?

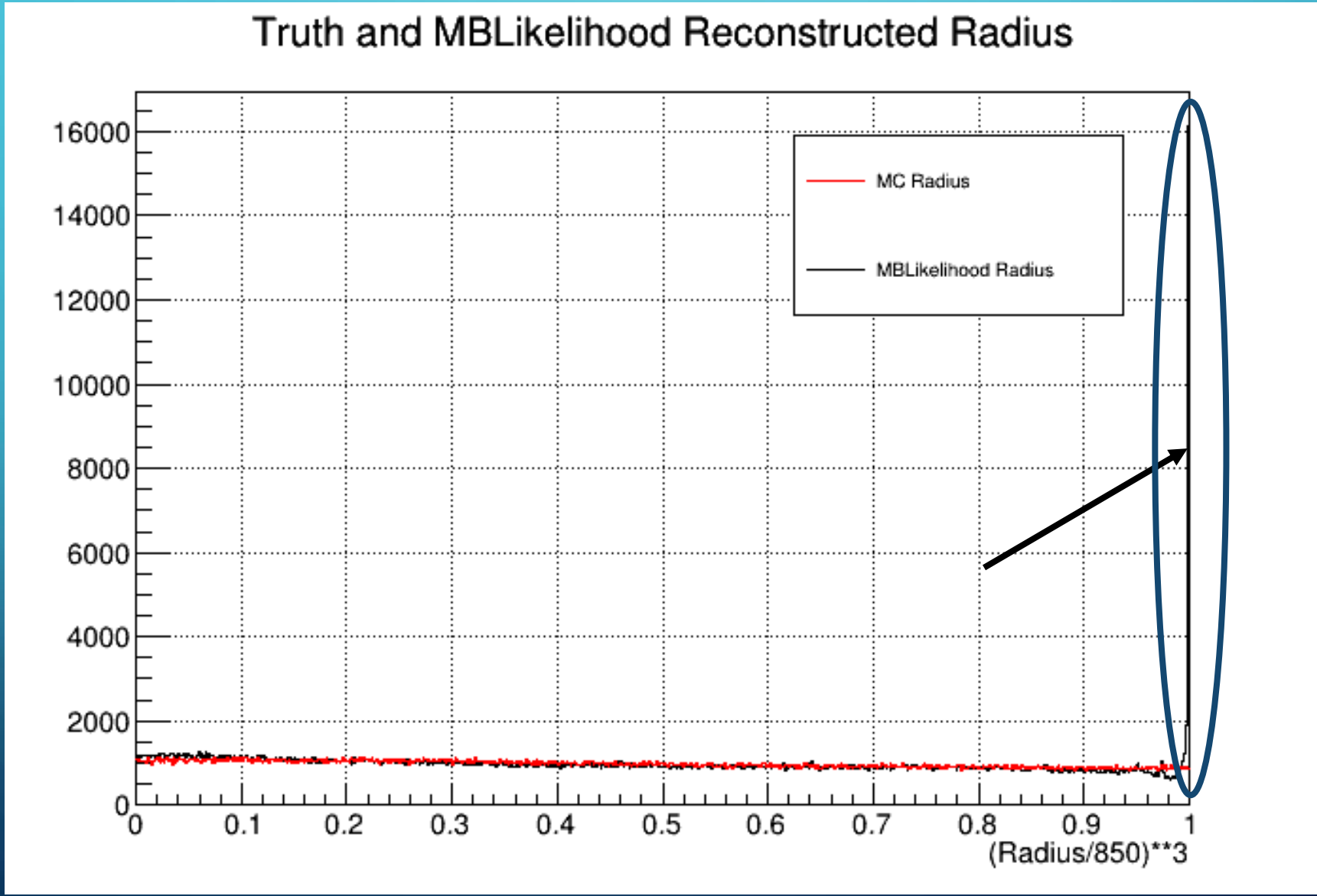


VERTICAL VELOCITY MAP FOR DETECTOR SLICE

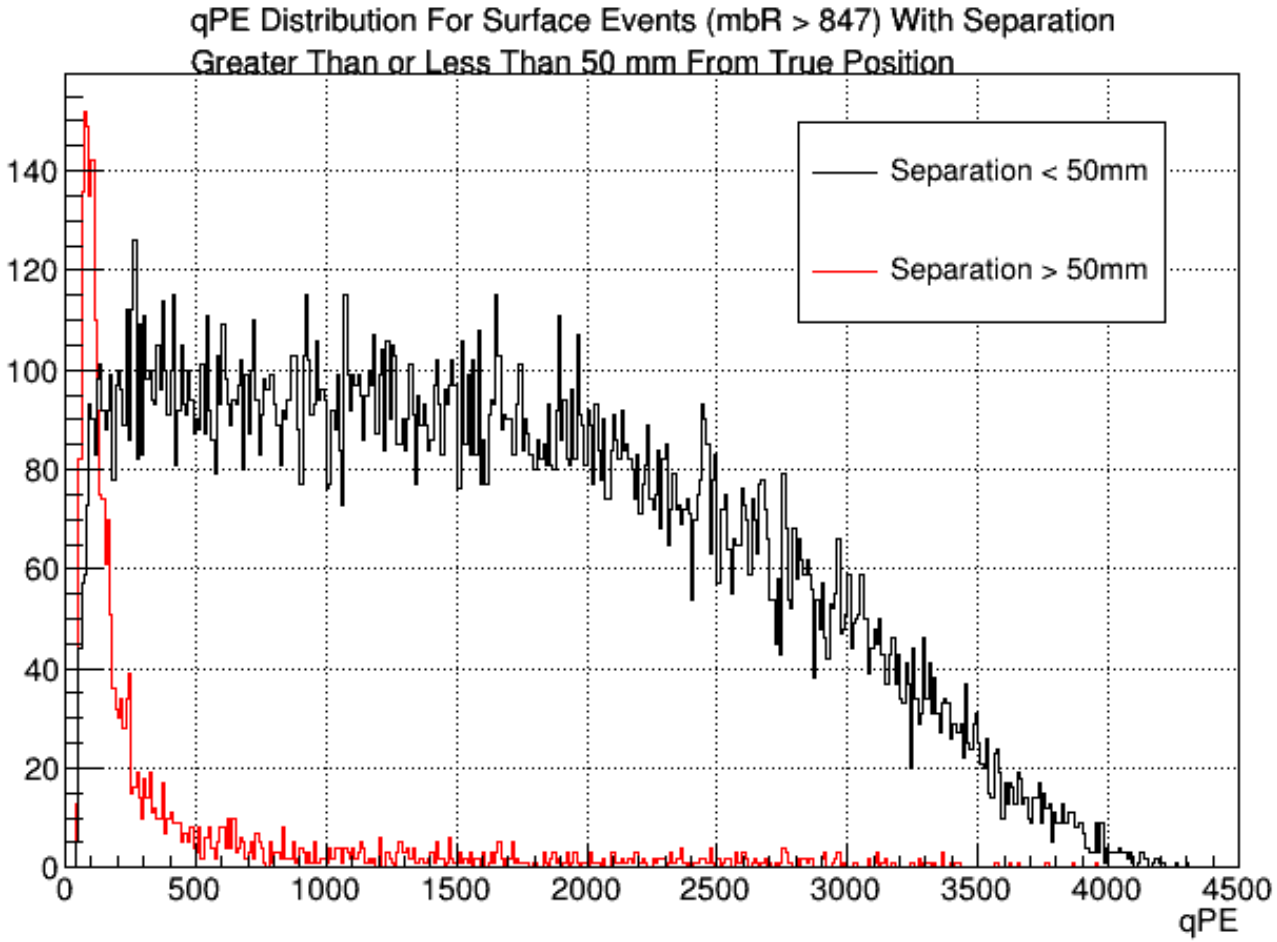


MBLIKELIHOOD SURFACE SPIKE

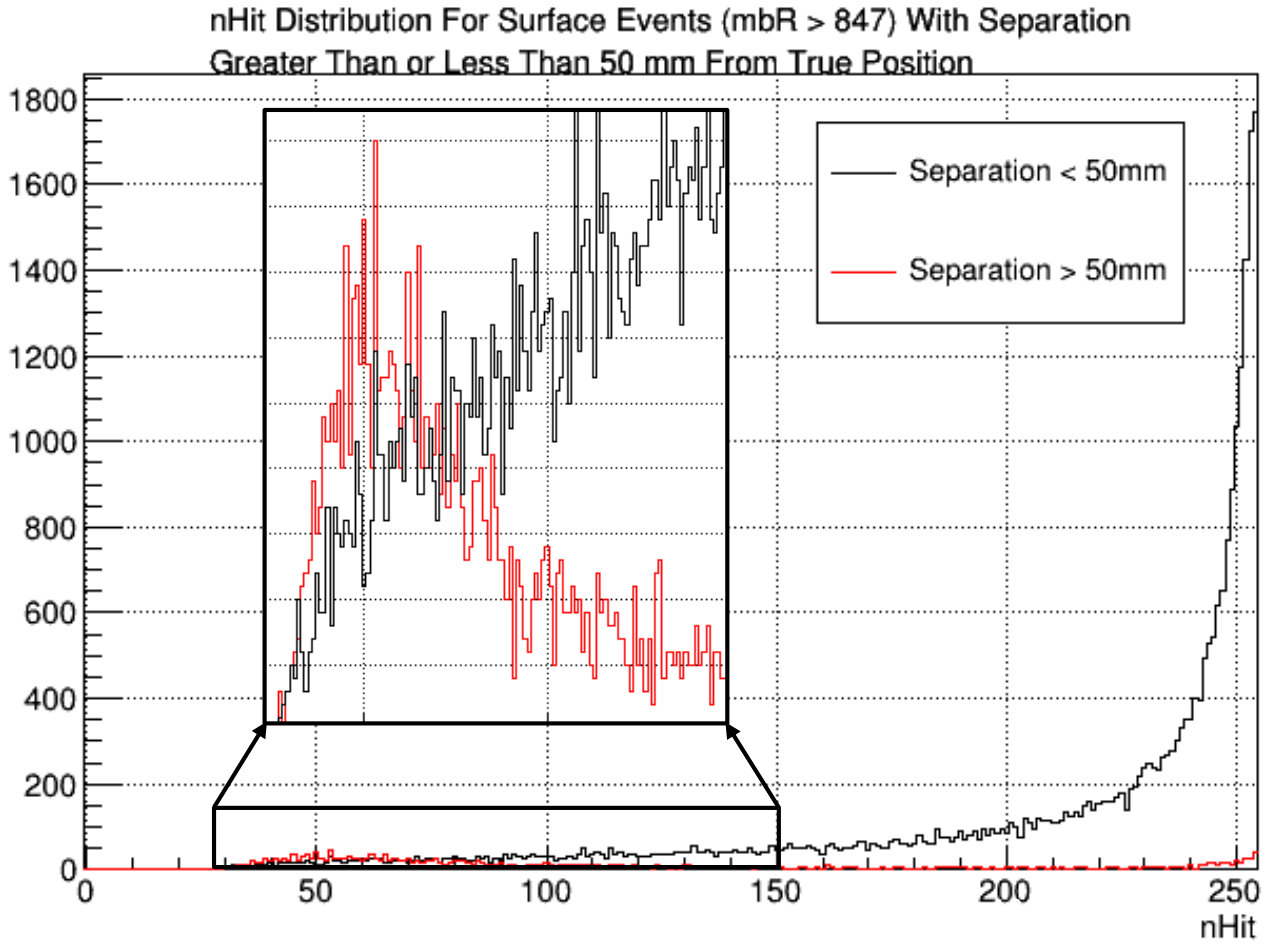
A LOOK AT THE MBLIKELIHOOD SURFACE SPIKE



SOME INTERESTING COMPARISONS



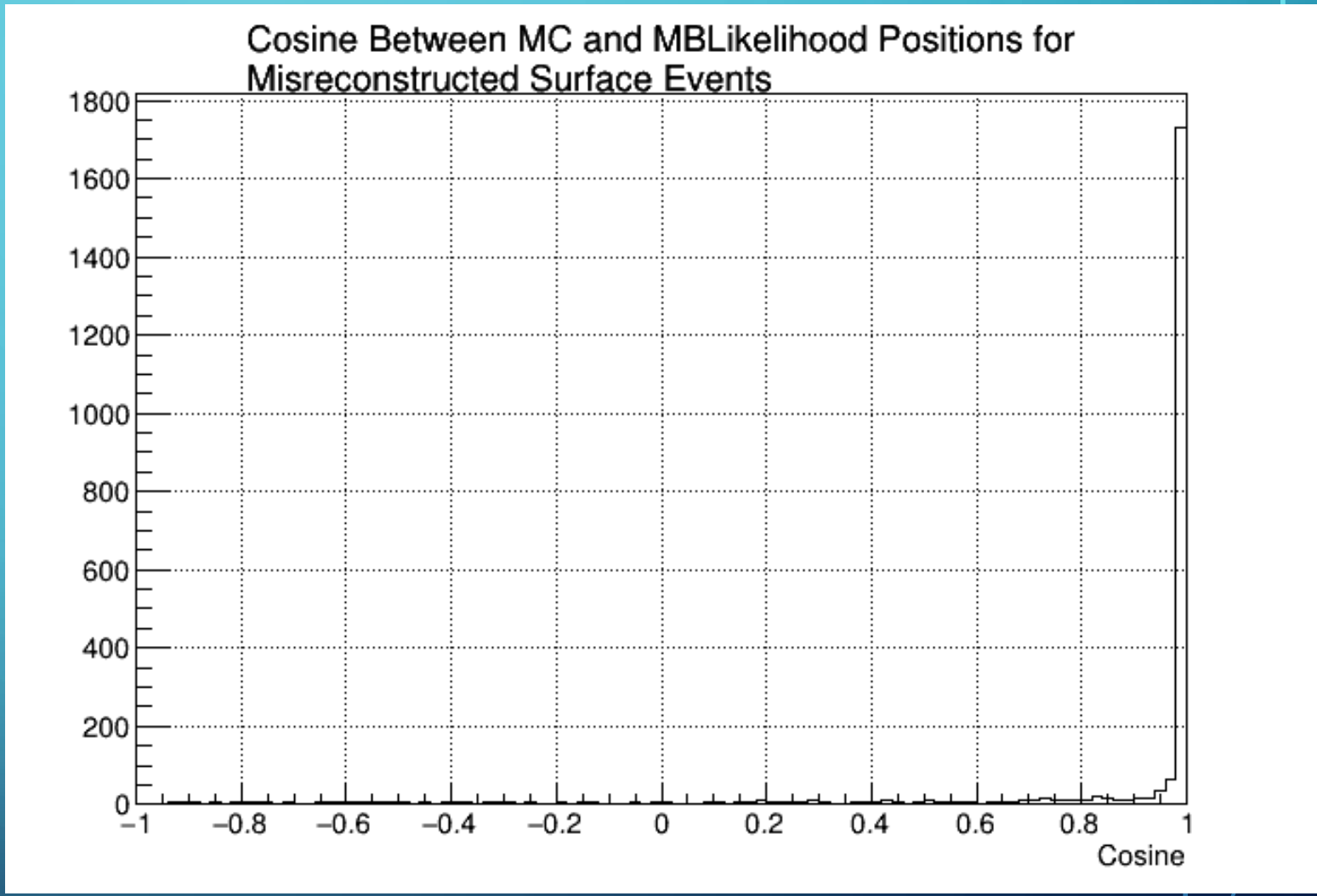
qPE: Number of photoelectrons seen i.e. energy of the event



nHit: Number of PMTs that see light in an event

COSINE RELATIONSHIP

- Although the position radius is wrong most events are along the same direction as the truth position
- Events are being brought to the surface along this line

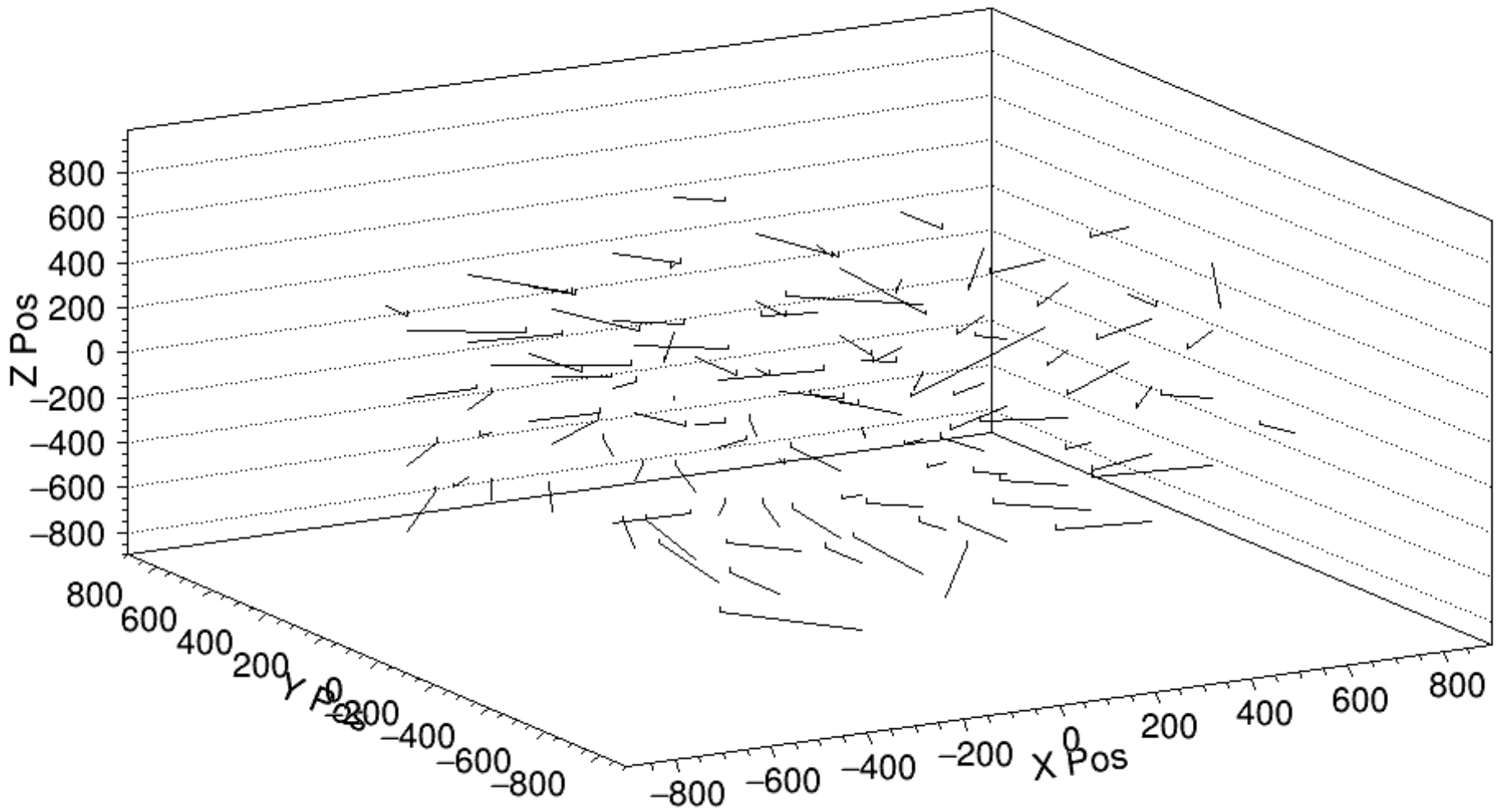


CONCLUSIONS

- The failures for some events in TimeFit2 are due to cuts set in the processing scripts or because there isn't enough information to have a reliable fit. The processor is functioning as expected.
  - Some small code changes were implemented
- There does seem to be LAr flow within the detector, and it appears to move along one large circle around the center
- The nature of the surface spike in MBlikelihood remains a mystery, however most events are in the same direction as the truth position
  - Also found that events with low energy are more likely to reconstruct at the surface
  - Events where few PMTs see light will be more likely to reconstruct at the surface

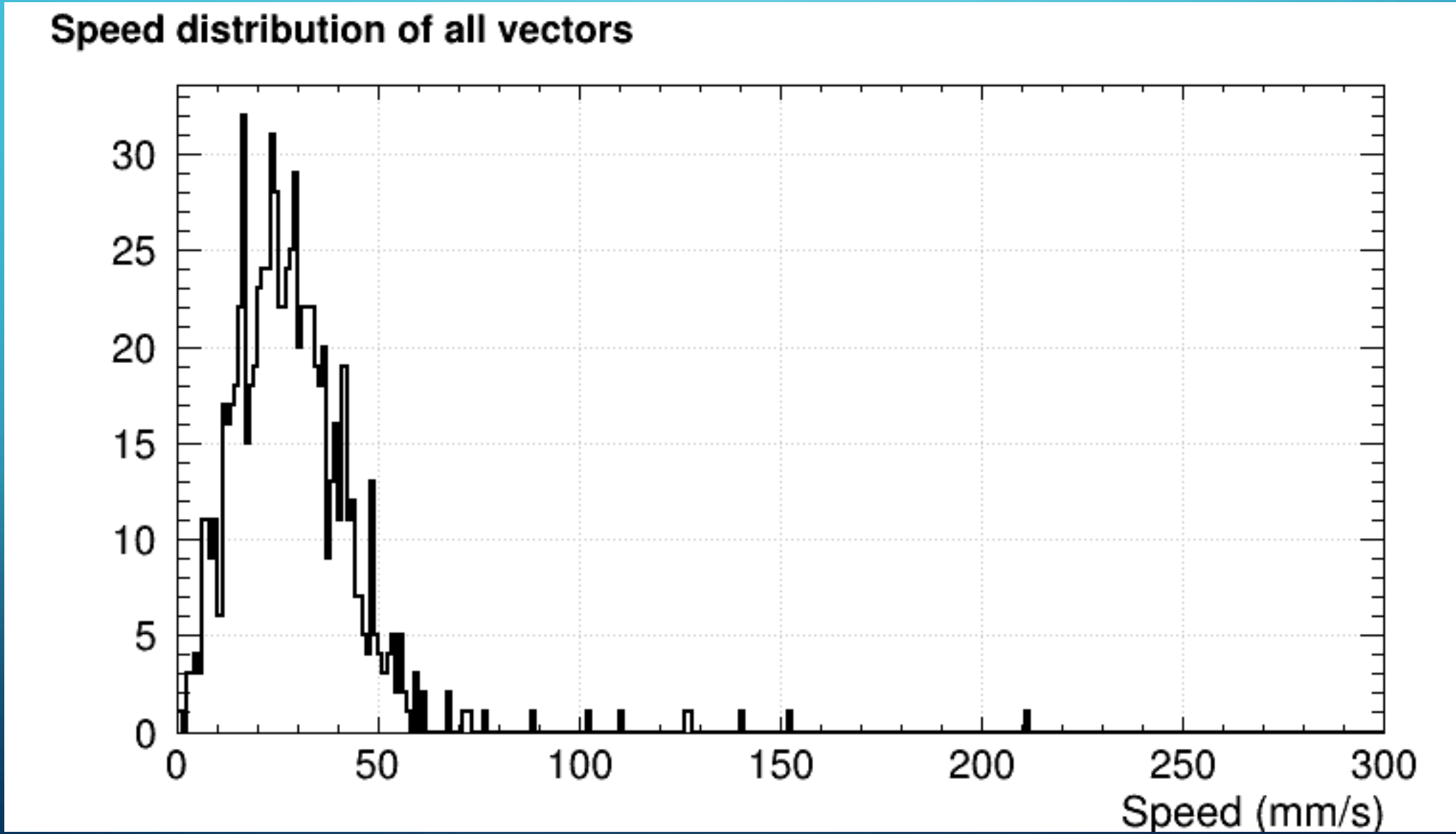
BONUS SLIDES

WHAT FLOW DO WE SEE?

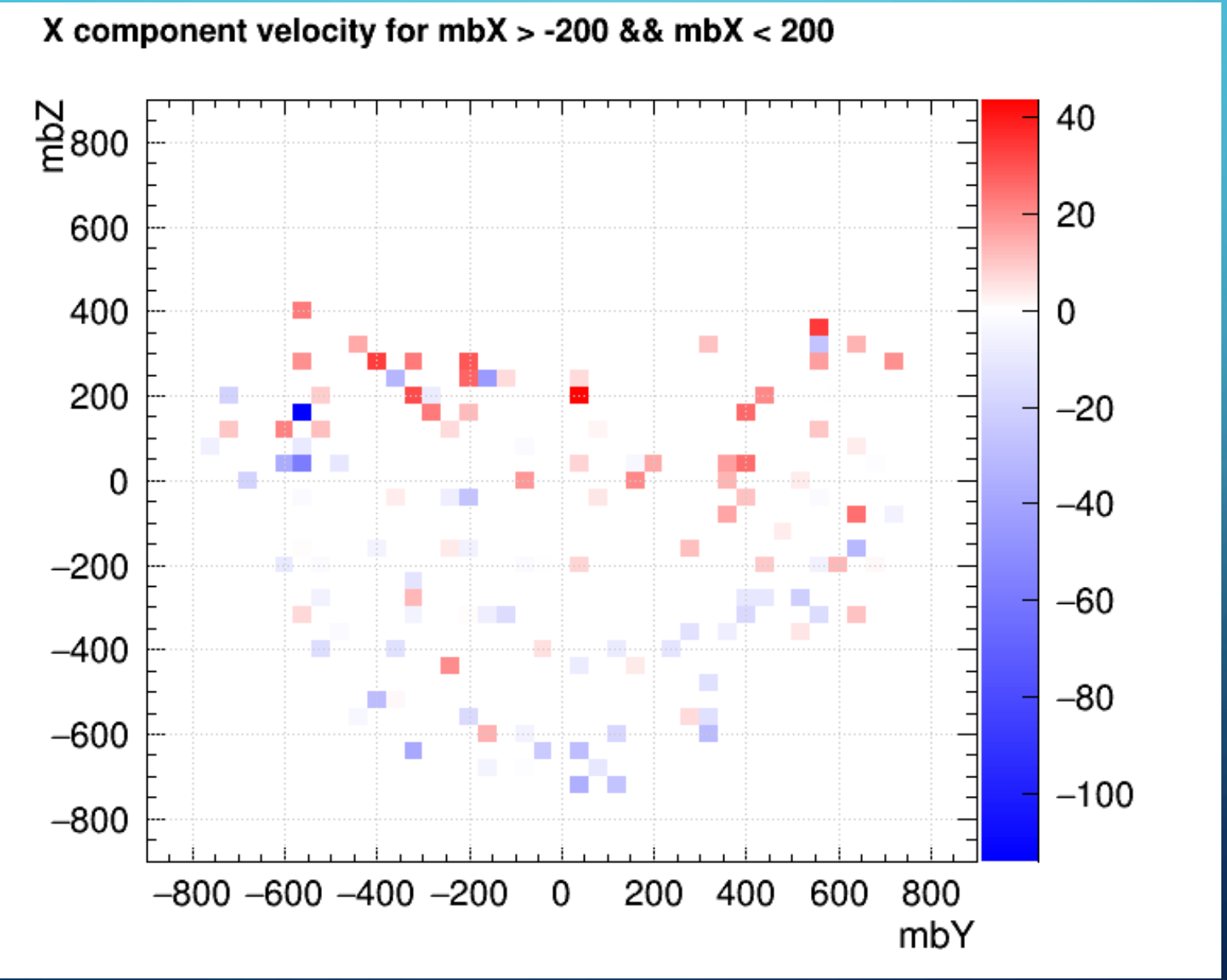


(Displacement Vector/Time Difference) * 5

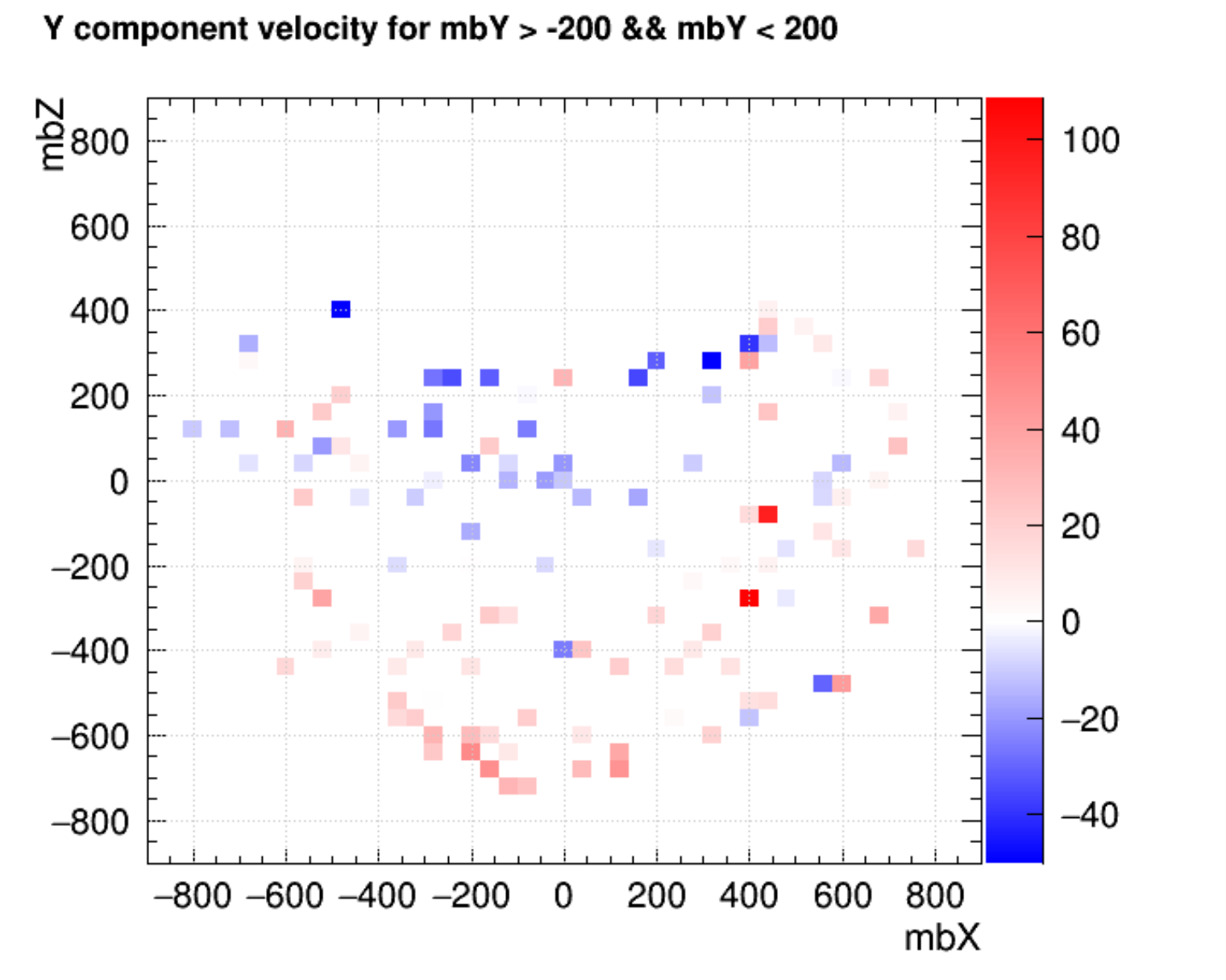
SPEED DISTRIBUTION FOR INDIVIDUAL TAGGED PAIRS



MBLIKELIHOODX VELOCITY MAP FOR CENTER SLICE



MBLIKELIHOODX VELOCITY MAP FOR CENTER SLICE



VERTICAL VELOCITY MAP FOR HIGHER DETECTOR SLICE