

# Recent Hybrid $\pi^0$ Studies

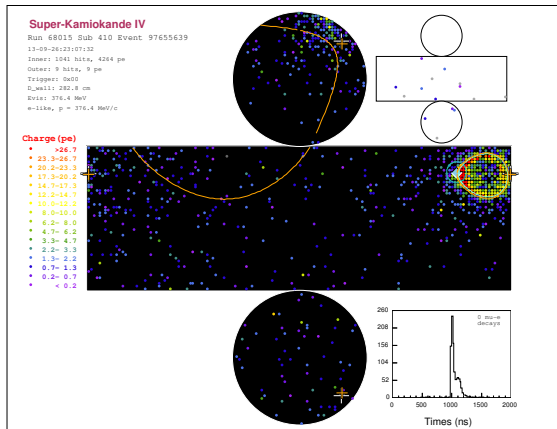
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fiTQun! Workshop

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- Hybrid  $\pi^0$  sets are a useful tool for testing background rejection performance in SK.
- Hybrid samples have been used in previous analyses, but when reconstructed in fiTQun a systematic data/MC shift appears.
- At the spring T2K meeting, it was demonstrated that for higher-energy events, fiTQun misplaces the lower-energy ring, resulting in an incorrect  $\theta_{\gamma\gamma}$  and thus an improperly reconstructed mass.

# Recap

Since the most recent meeting, I have been trying to investigate various time-related issues in  $\pi^0$  reconstruction as a possible source of misplaced low-e rings.



Sanity check: are we looking at an issue introduced by fiTQun, or an inherent timing distribution difference?

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# Raw Hit times (Uncorrected)

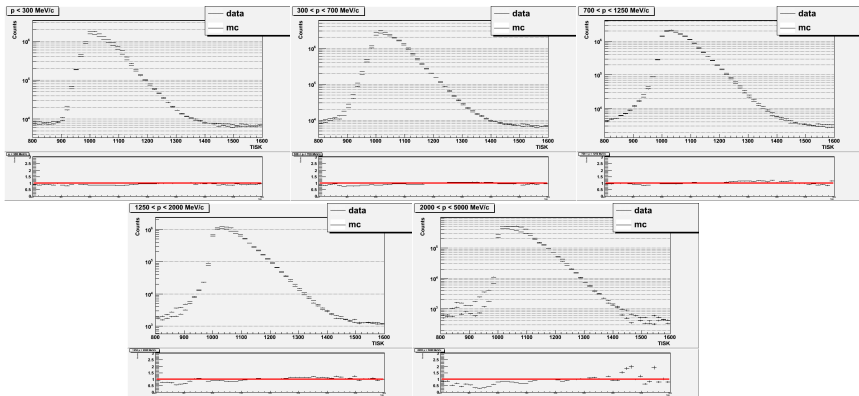


Figure: Raw PMT hit times for data and MC hybrid samples.

# TISK Hit times (TOF corrected)

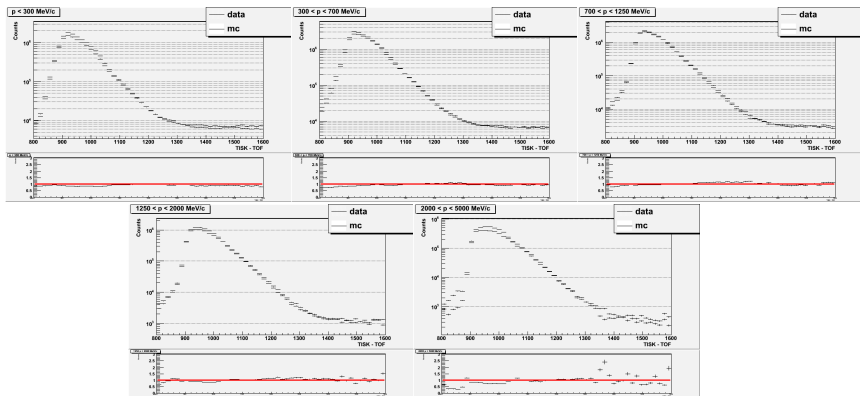


Figure: TOF-subtracted PMT hit times for data and MC hybrid samples.

## Timing Conclusion [better title needed?]

It's unclear that there is any serious systematic shift in the raw or corrected hit times that affects higher-energy events in particular.  
→ It appears unlikely that there is a problem at the level of individual hit times causing the data/MC disagreement.



The next level up from individual hit times is at the splitChan clustering level. Note that after some recent discussion, it was discovered that the hybrid samples under consideration were reconstructed with an older version of fitQun that has since had changes made to splitChan.

# Cluster Timing (Old)

Cluster start times seem to match relatively well between data and Monte Carlo:

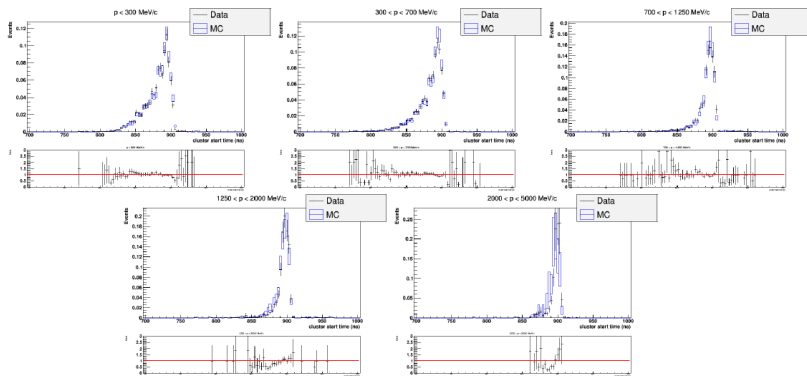


Figure: Cluster start times for events passing selection cuts.

End times, however, have a clear systematic shift, with MC ending times being systematically shifted earlier with respect to the data.

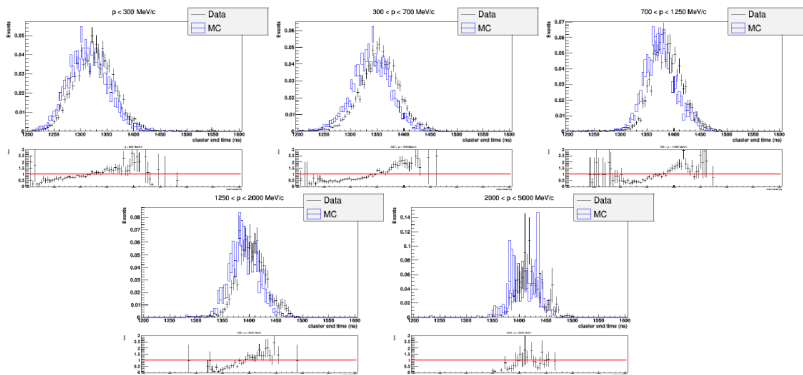
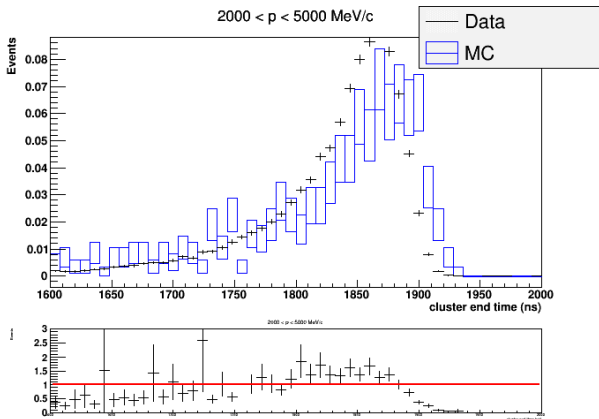


Figure: Cluster end times for events passing selection cuts.

# Cross-check: Cluster Timing (Cosmic)

Recently, Okumura-san suggested checking for systematic shifts in clusters from the cosmic data/MC. High-energy sample cluster timings are shown below. A slight shift is apparent, but as strong an effect as in the hybrid sample.



## Re-reconstructing Samples

After it was brought to light that our samples had been reconstructed with an older version of fiTQun, I began trying to re-reconstruct them, but along the way I've run into several snags and haven't been able to finish this study yet.

To investigate the hypothesis of imperfect modeling of reflections, I decided to consider the effect of directly changing reflectivities in SKDETSIM. A particle gun sample was used to see how much this systematic affects distributions of variables relevant to the hybrid study at hand.

# Reflection Check Results

No significant discrepancies appear as a result of changing the reflectivity in SKDETSIM.

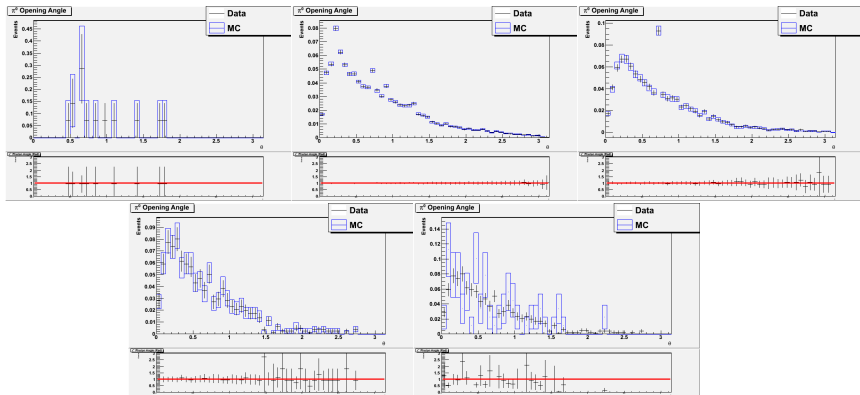


Figure: Angle values for normal (black) and tuned (blue) MC.

# Conclusions

- Raw PMT hit times do not seem to be at the root of the data/MC discrepancy.
- There is, however, a clear difference in cluster timings
  - This is from an older version of fitQun/splitChan
  - Currently trying to update this reconstruction to the current version, but have not finished.
- Changing the MC directly at the level of SKDETSIM does not appear to affect the  $\pi^0$  reconstruction significantly - apparently mis-modeled reflectivity is not a major issue.