

# Fitqun modifications for FADC electronics

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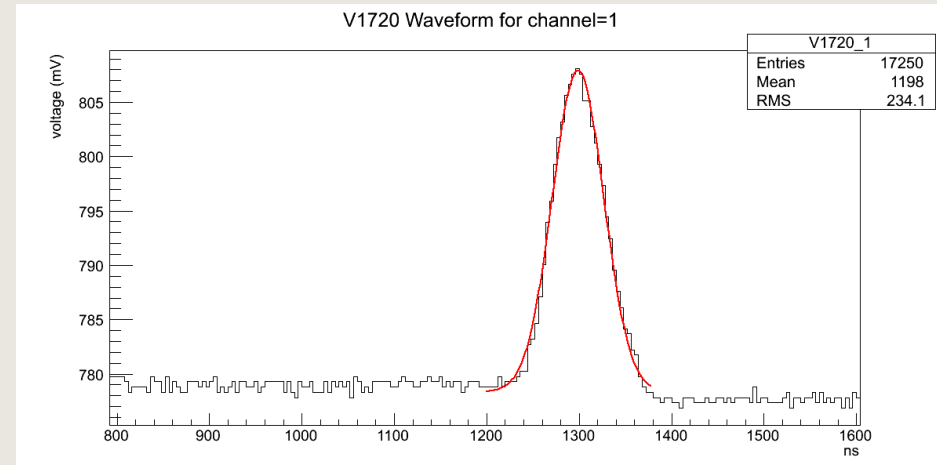
Aug 20, 2015

# Outline

- FADC electronics
- Modifications to splitchan
- Modifications to likelihood function

# FADC Digitization

- Propose new electronics for Hyper-K and nuPRISM that uses FADC to digitize PMT signals.
- Allows more information. Specifically, existing electronics can only record one time/charge per channel per 1us window.
  - So if PMT gets prompt photon, will miss detailed information about any subsequent photons from scattered/reflected light or decay electrons.
- Question: how to modify fitqun to use this additional information?

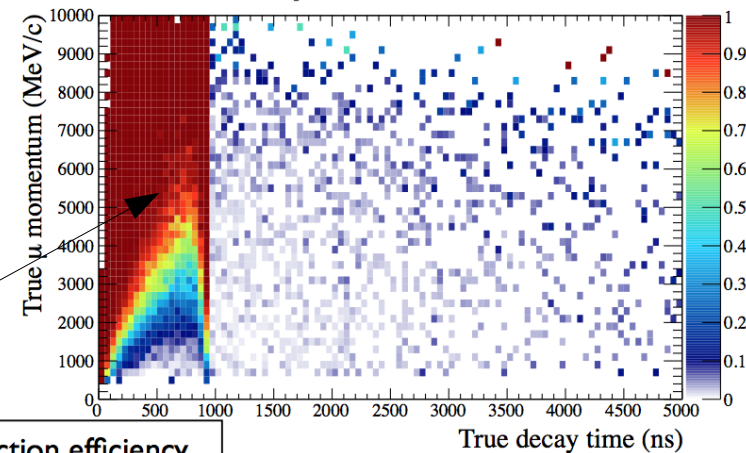


# Potential Improvements in Michel Efficiency

- Plots from Shimpei for fitqun michel electron performance.
- Fraction of time Michel isn't found. (particle gun?)
- Hope is that having more hits in first 1us will reduce inefficiency here.

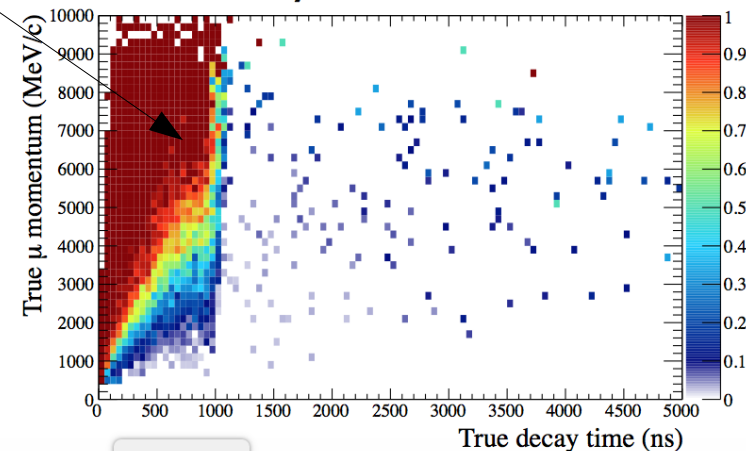
SK2

0 decay detected: 25.9%



SK4

0 decay detected: 24.4%



Photos

# PeakFinder and splitchan

- If I understand fitqun, only need to modify PeakFinder and splitchan in order to be able to check benefits of having additional delayed hits.
  - Ie to see if we find more Michel sub-events
- Probably have UBC undergrad working on this as project class.

# Peak Finder

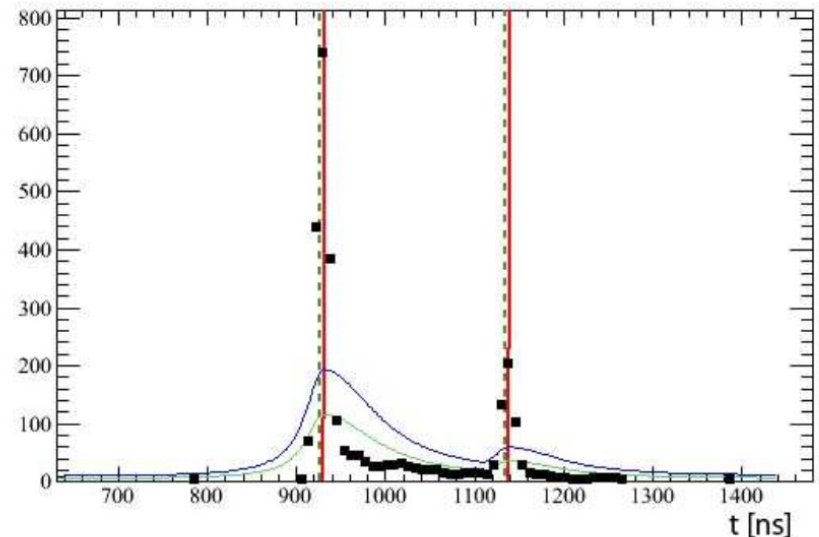
- From fitqun technote:

As stated in the previous section, the vertex goodness Eq.(21) takes a large value when it is evaluated at the vertex position  $x$  and time  $t$  which are close to where an actual particle is located, since in such a case the residual hit time distributes near zero for hits that are produced by direct light emitted by the particle. Using this fact, the peak finder searches for subevents by fixing the vertex position  $x$  at the value the vertex pre-fitter returned, and scanning the goodness while varying the time  $t$ . Assuming that the vertex positions of both the primary particles and the decay electrons lie close to the pre-fit vertex, subevents appear as large peaks in the distribution of the goodness as a function of  $t$ .

- At first glance it seems that vertex pre-fitter function should work with multiple hits per PMT.

$$G(\mathbf{x}, t) \equiv \sum_i^{\text{hit}} \exp(-(T_{\text{res}}^i / \sigma)^2 / 2),$$

Vertex prefitter function



# Splitchan + cluster/peak association

- In technote detailed description of subsequent splitchan steps for producing clusters of hits and then association of hit clusters to peaks in PeakFinder distribution.
- I have a little trouble with this section, but no obvious reason why it wouldn't work with multiple hits per PMT.

# PeakFinder/SplitChan Questions

- Does fitqun technote correctly described how PeakFinder/splitchan works for HK fitqun?
- Has PeakFinder/splitchan been validated for HK fitqun?

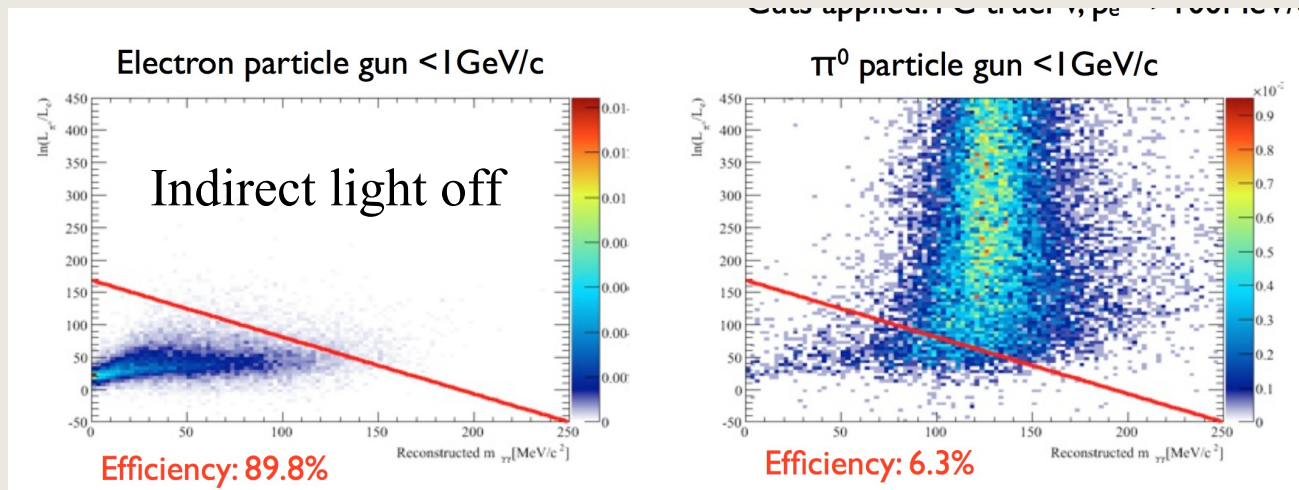
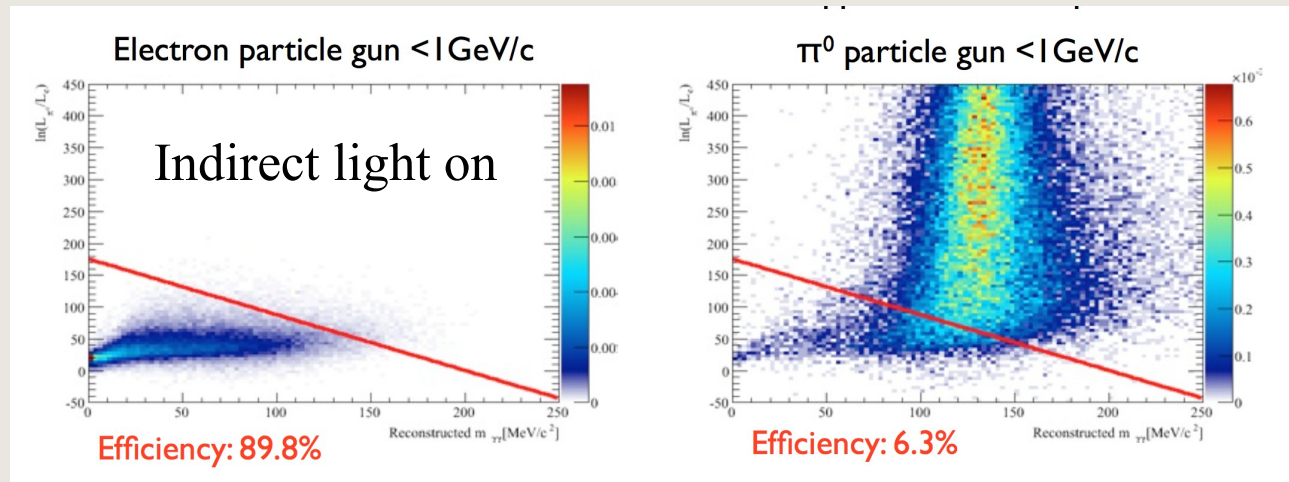


# Modifications of fitqun likelihood

- A more complicated task: for a particular sub-event, can we modify likelihood function to treat scattered/reflected photons separately from direct photons?
  - Can imagine ways of doing this; perhaps by treating each channel as having two possible hits:
    - a prompt hit
    - then a later hit ( $>50\text{ns}$  after prompt hit).
- But can we figure out beforehand if there is benefits to this additional information?

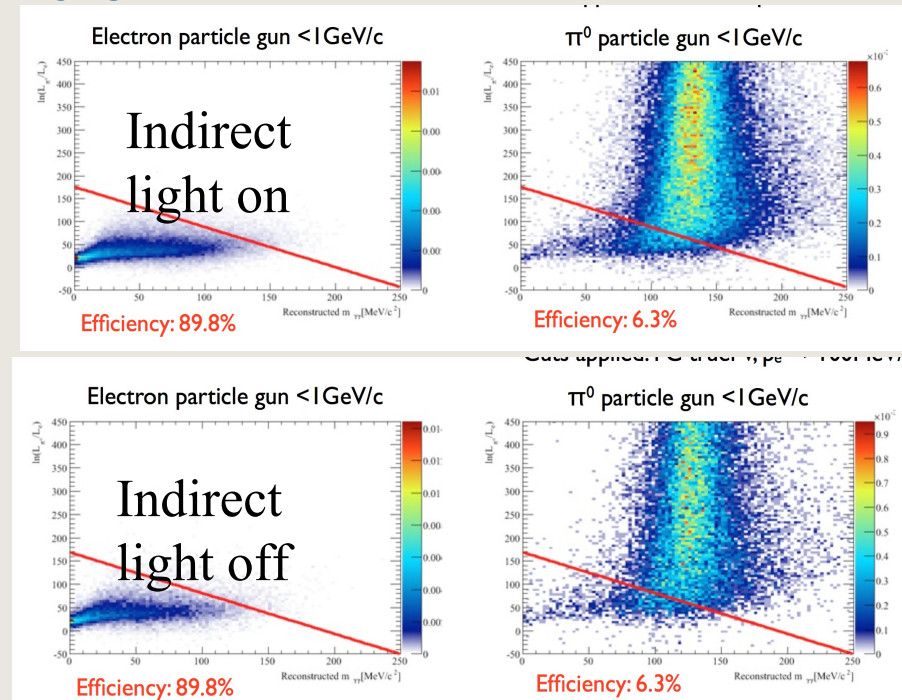
# Light/no-light Study

- Looked at electron/ $\pi^0$  separation with indirect light on/off.
- No difference in e/ $\pi^0$  separation.



# Light/no-light Study

- Shimpei says this may make sense. Studies for SK-Gd suggest that increasing scattering by a factor of several does not affect e/pi separation; so scattering maybe isn't critical for e/pi0.
- However, maybe we should do more tests with higher momentum (where there will be more scattered light).
- Also tests of e/mu separation and ring counting.
  - So may be more relevant for higher energy atmospheric analysis.
  - Is there more studies from SK-Gd work?



# Conclusion

- Most promising study seems to be improving Michel efficiency for higher energy energy muons.
  - Will work on this fall.
- Also can do more studies with seeing if PID/RC improves by separating direct/indirect light.