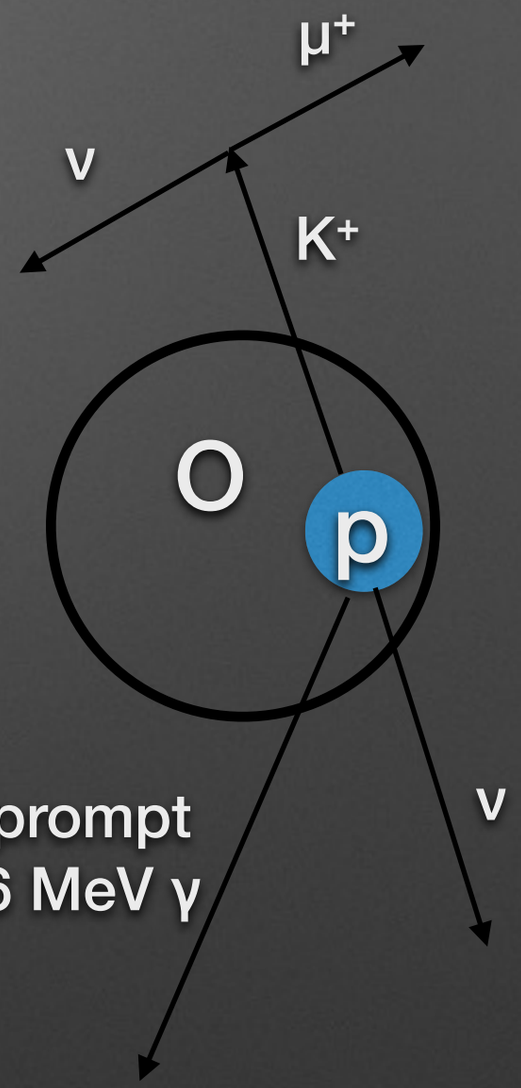
First Look at the New $p \rightarrow K^+\nu$ Fitter

Mike Wilking for Gabriel Santucci
TRIUMF fiTQun! Workshop
August 20th, 2015

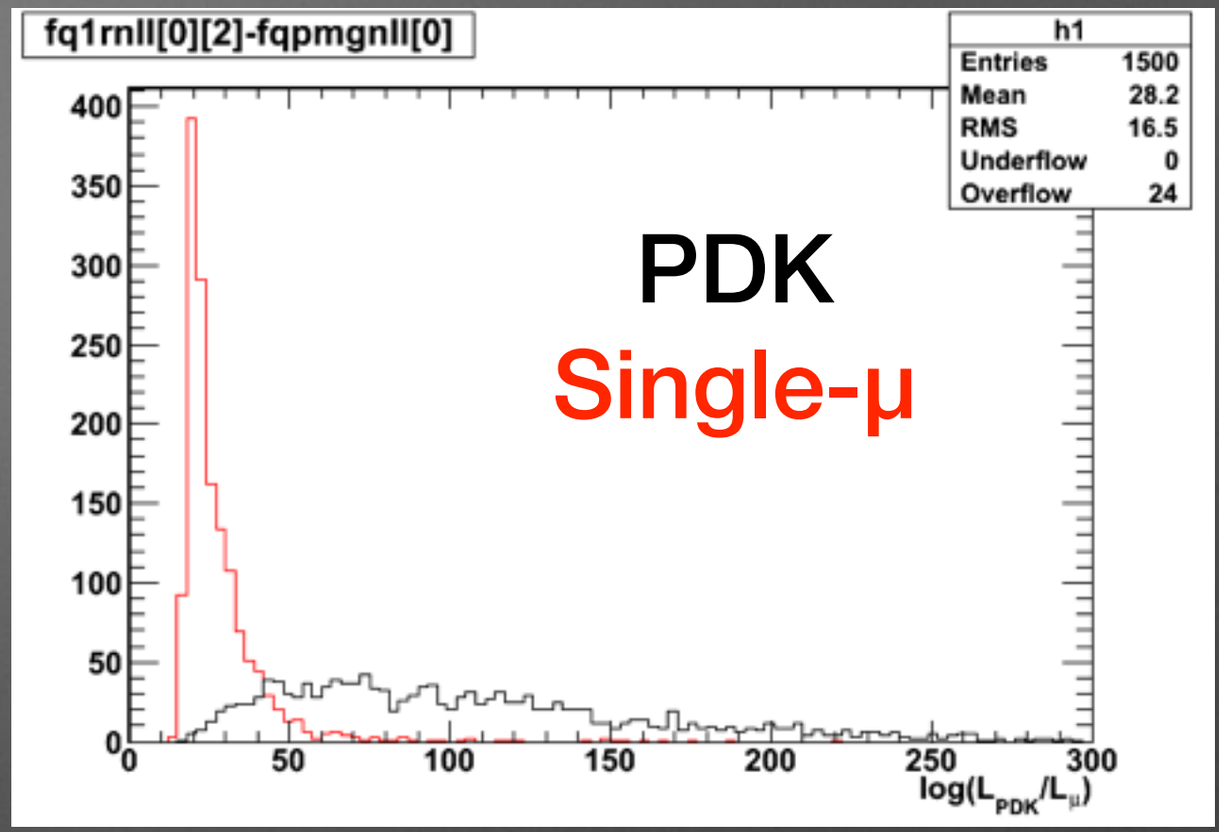
Fitter Overview

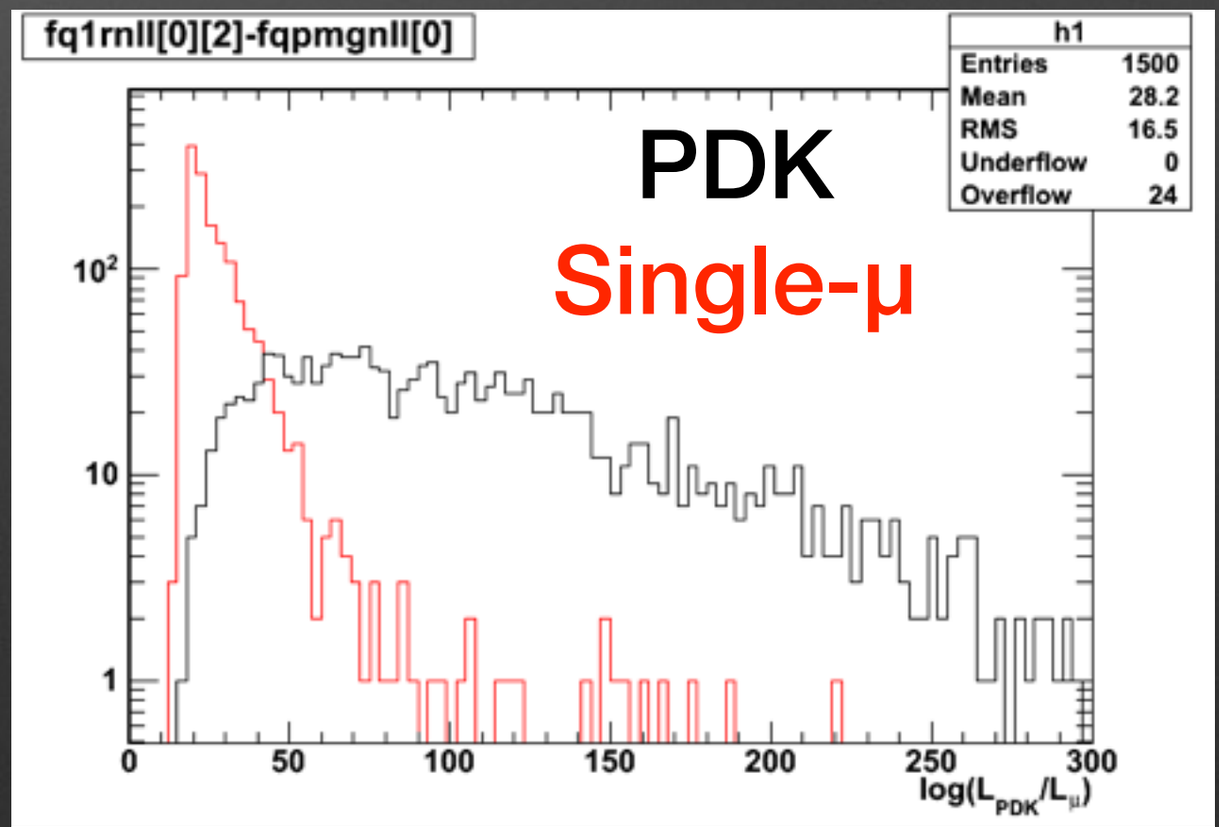
- Proton decays to a K^+ and a neutrino
  - K^+ comes to rest in ~2 ns, and lifetime is 12 ns, so most decays are at rest
  - K^+ 2-body decay produces a mono energetic 235 MeV/c muon
- Up to a 14 parameter fit of a photon and a muon
  - Can constrain the muon and photon 3-vertices to be the same (11 parameters)
    - So far, this is the only configuration we have studied
  - Still fit for the time difference between the muon and the photon
- So far, we have only compared proton decay events to muon particle gun ($220 < p_\mu < 250$) events
- Fit is seeded with the single muon fit result & a directional scan from that vertex with a 6 MeV photon



Fit Results

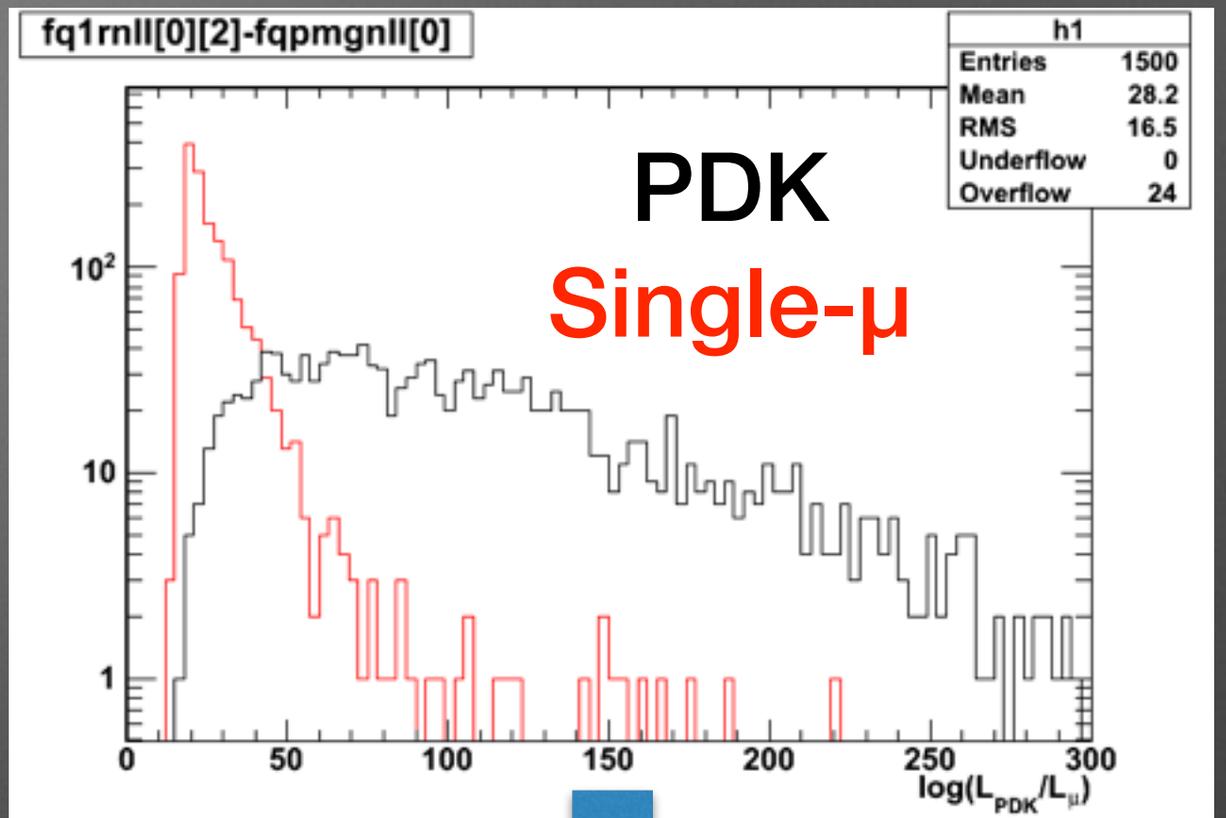
- No cuts yet!
- Likelihood ratio shows clear separation of PDK and single-μ events

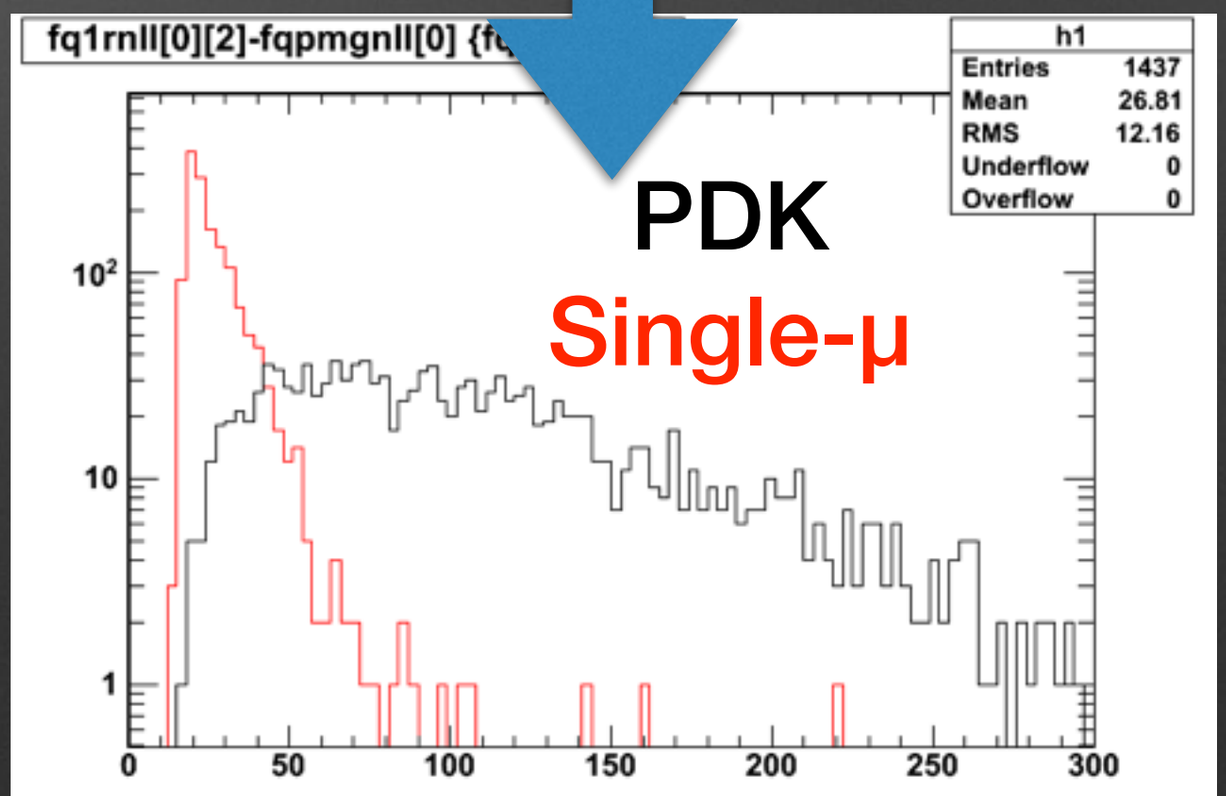




2 Subevents

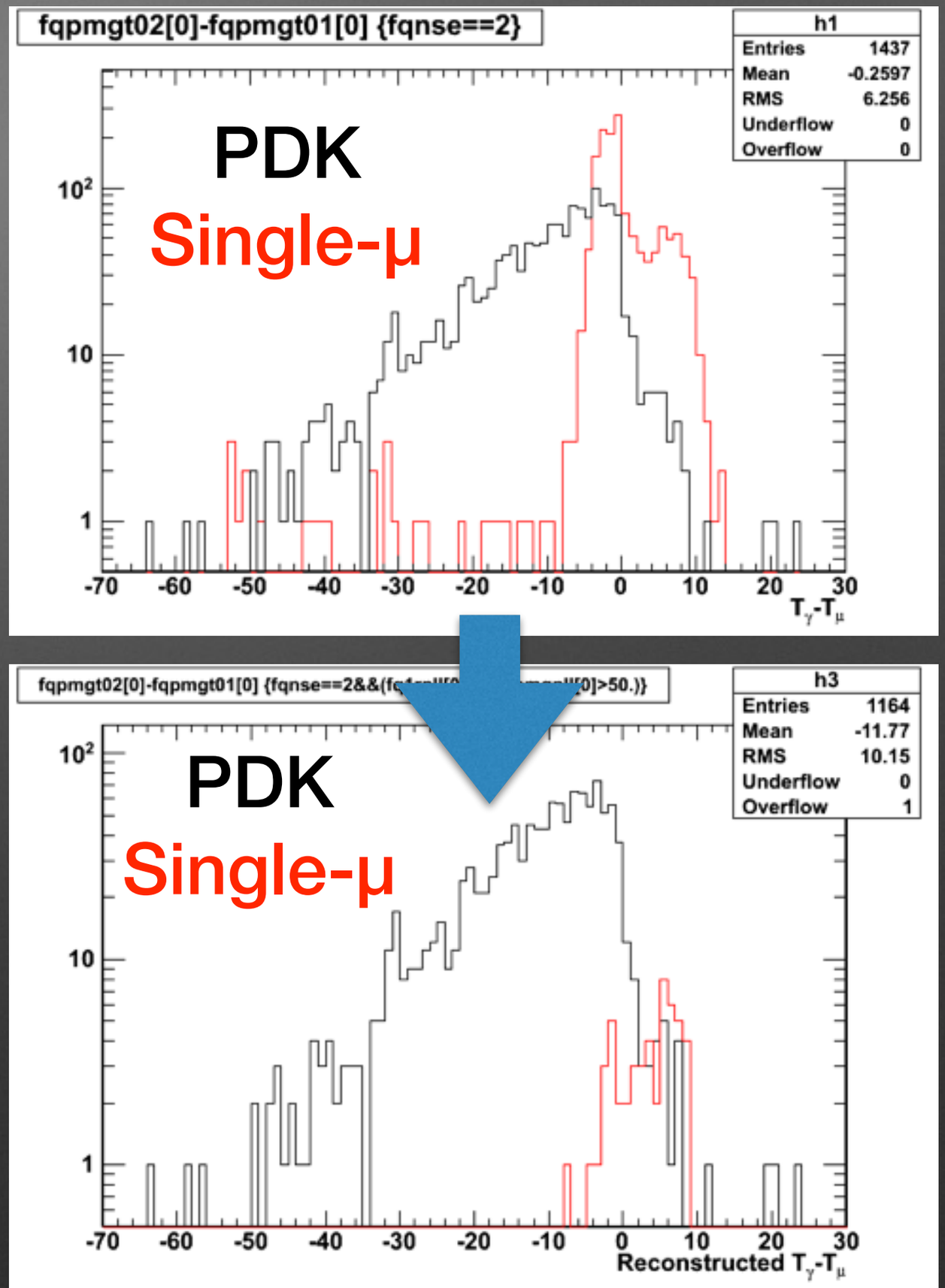
- Michels close in time to their parent muons can look like de-excitation photons
  - May be able to separate these in other ways, since the energies of Michels are higher and the times should be later
- For now, this remove 6.5% of events





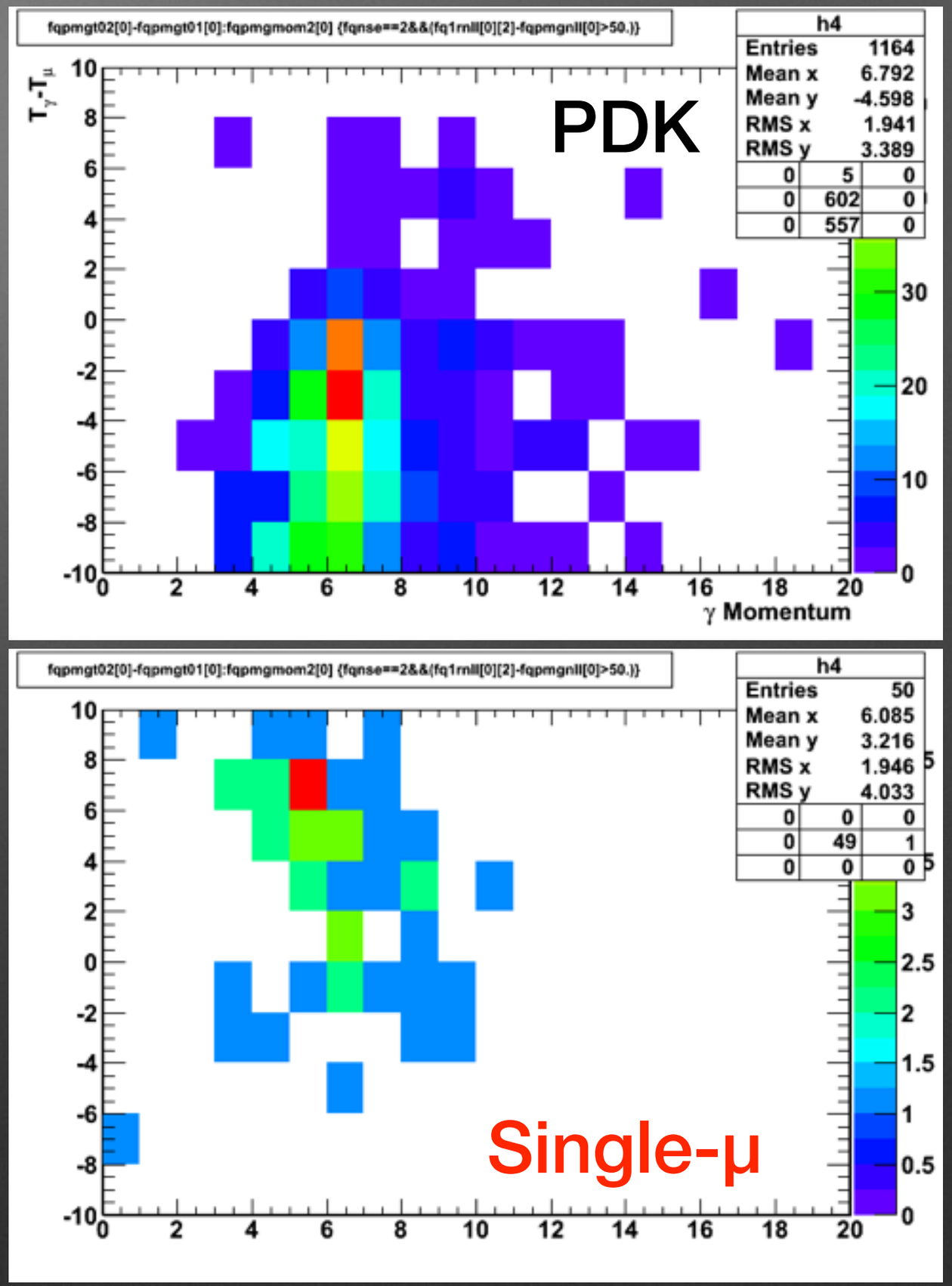
Likelihood Cut on ΔT Distribution

- Other main tool of the new fitter is the reconstructed time difference between the photon and the muon
- Likelihood cut of 50 removes all of the early photon time background events



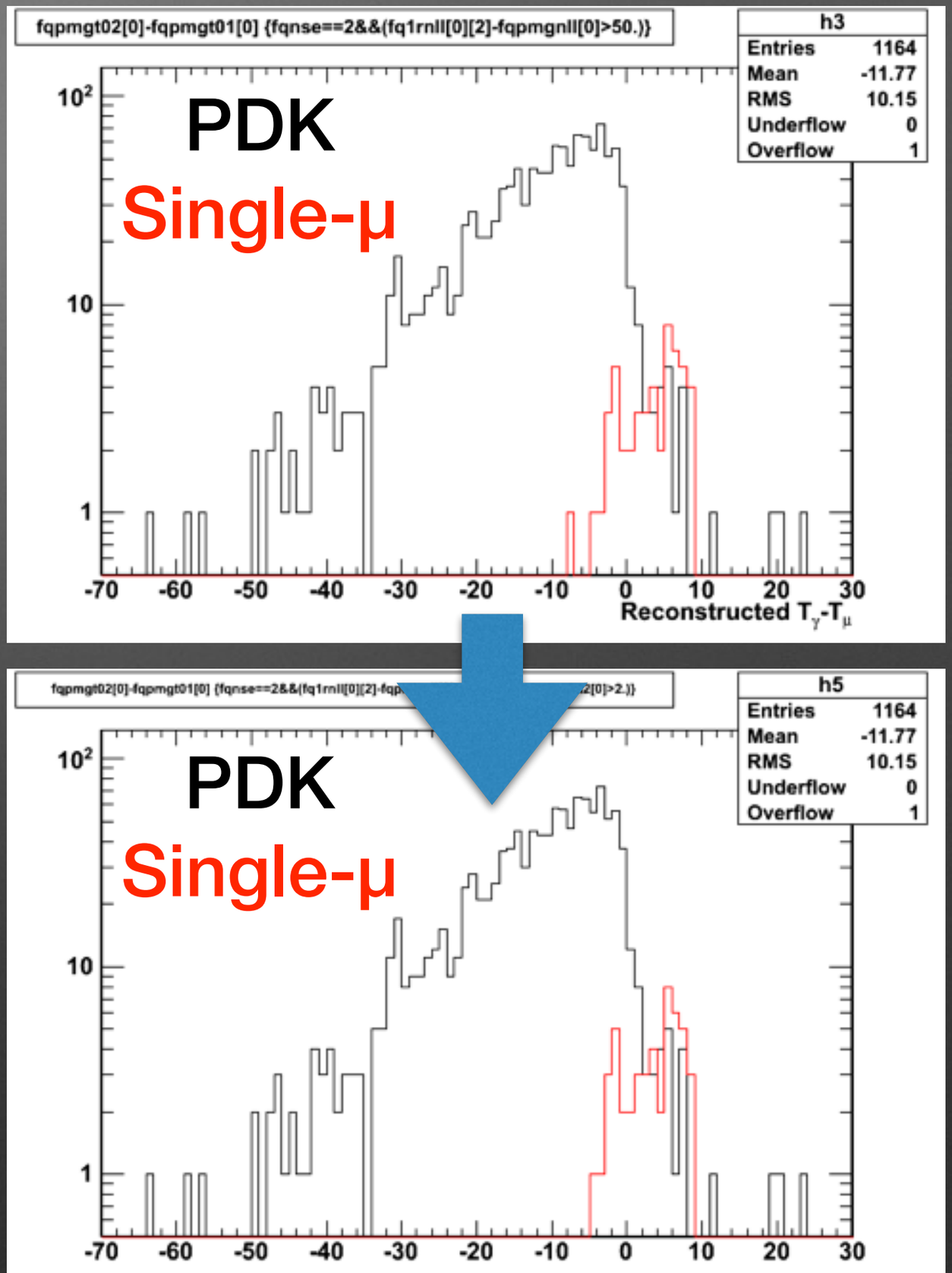
ΔT vs E_γ

- Often the photon found for single-mu is at low energy
  - This is particularly true if the photon time is early
- In this case, only 1 such event remaining
- Require more than 2 MeV of photon energy



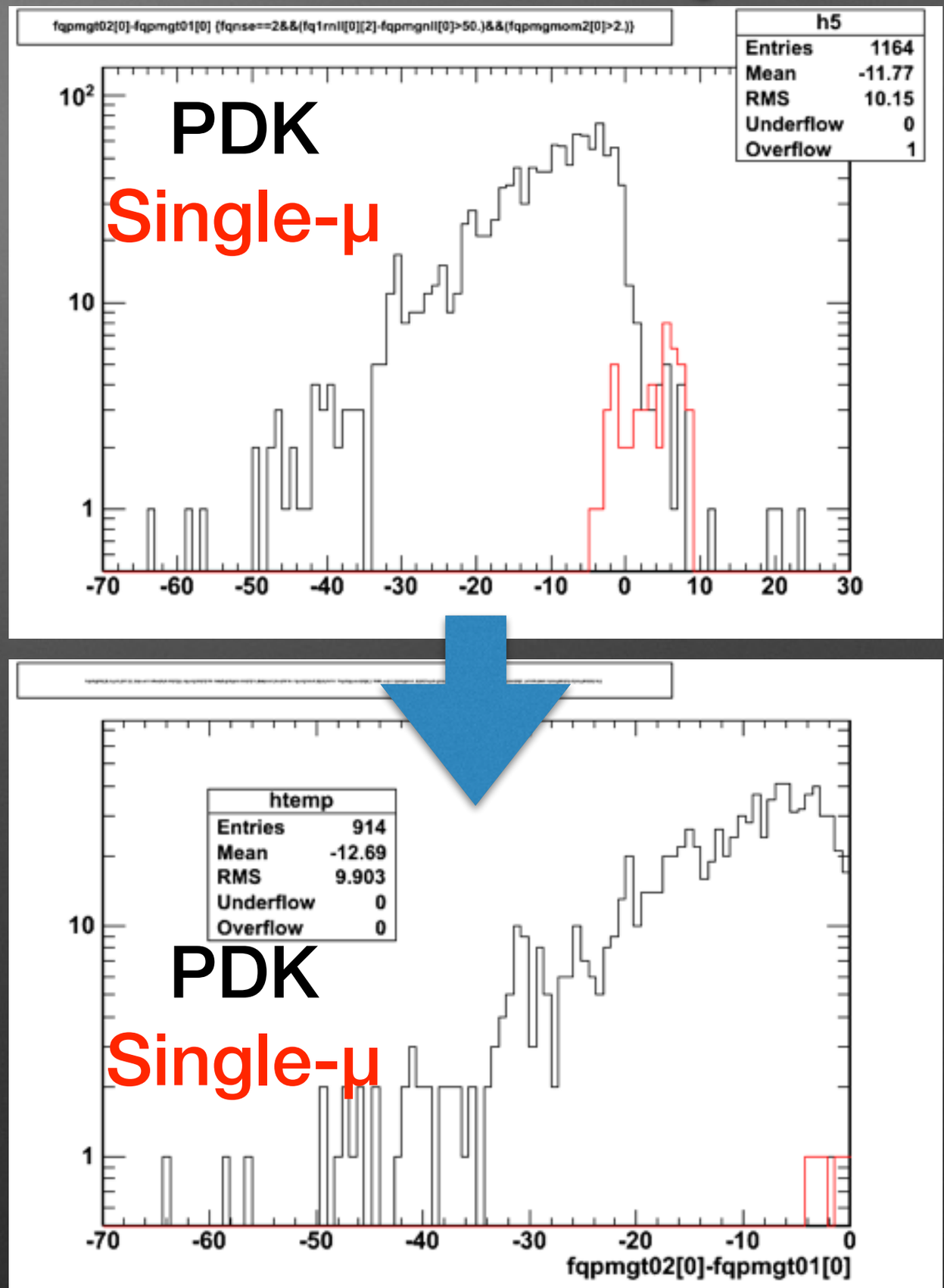
E_γ Cut

- Small impact in this case



Fiducial Cut (& ΔT < 0 Cut)

- 5 background events remaining
- 21.5% efficiency loss
- Moving the ΔT cut to -5 removes all background and an additional 23% of the signal



Summary

- New p ➜ $K^+\nu$ fitter looks to be a powerful tool for selecting proton decay events

- Quick, initial selection cuts show good rejection of single muon background events
  - More detailed study is needed

- Simplest possible fit seeding is currently used
  - More work on this is likely needed to optimize the photon search

- Very early stages, but initial results are promising