Karlsruher Institut für Technologie

Belle II

Fast t0 extraction with CDC Information

Tracking Meeting | 2.11.2017

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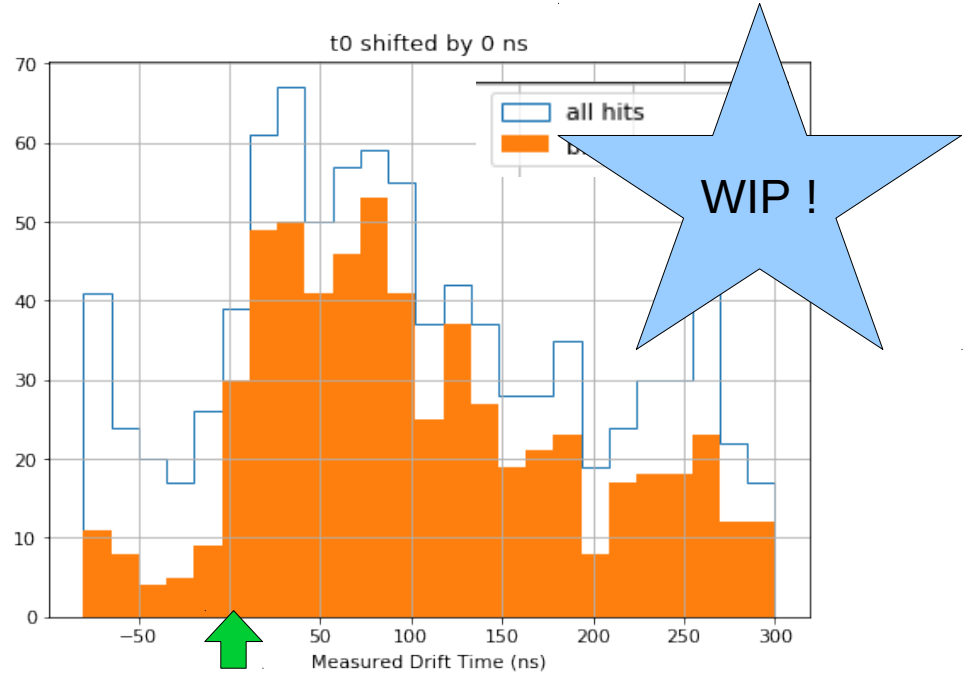
Fast T0 determination for basf2 Reco

- There is an epic for the next release to provide the best possible t0 during the reconstruction stage:
  - https://agira.desy.de/browse/BII-2590
- This is important for Phase II data taking as some parts of our reconstruction code rely on a reasonable estimate of the event time:
  - CDC needs this to refine the drift length which gets computed from the time measured by the CDC hardware
  - Reduction of the ECL cluster which get stored in MDST is only possible if t0 is reasonably known
- Multiple sub-detectors (CDC,ECL,TOP) can be used to estimate the t0 of the event. Ideally each of their measurements are combined.
- We used a CDC-based t0 estimation method which achieved ~ 1ns t0 estimation for the GCR
  - But: this method is slow as it needs the CDC pattern reco to run first and multiple refits of tracks
- This work: Can we get a coarse first estimate of (~10ns) for Phase II before running any reconstruction code. Then run the precise CDC t0 extraction with this as start point.
- The work presented here is **very** preliminary and only a first look on what might be possible with CDC hits only (w/o running any pattern recognition)

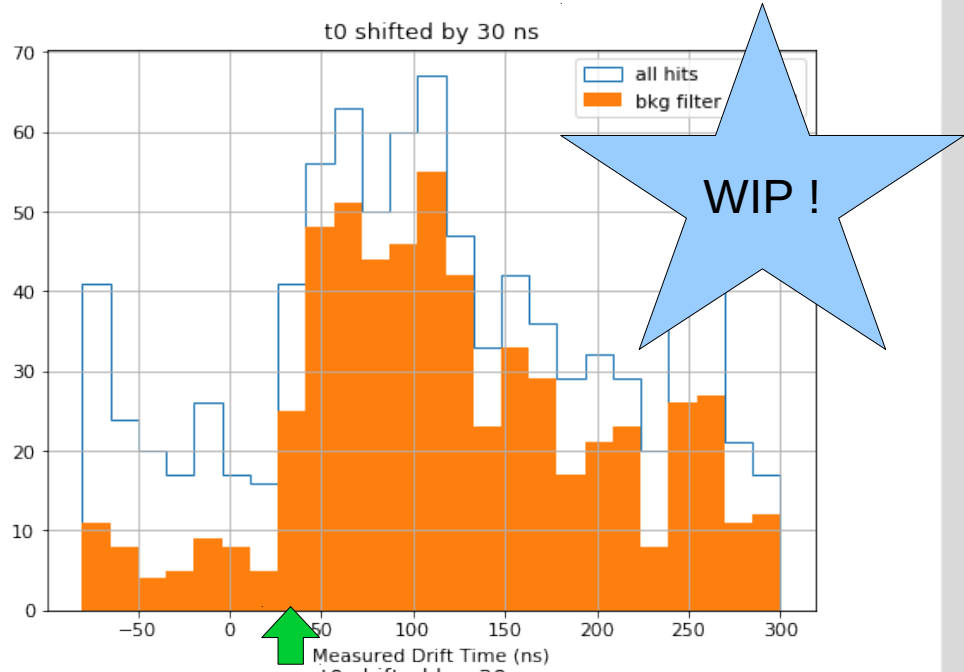
Technical Details

- Running only a very small part of the CDC reconstruction: TFCDC_WireHitPreparer and TFCDC_ClusterPreparer
- TFCDC_ClusterPreparer also does an MVA-based background rejection on hit level
- Assume 50% of the Phase III background for this study

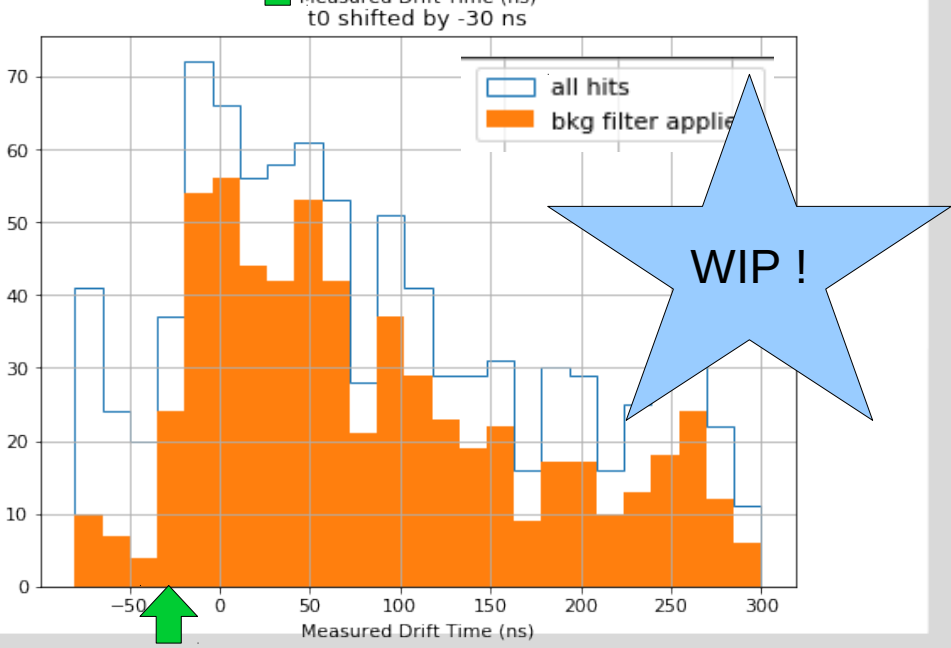
Y4S → generic + 50% Phase III background



WIP !



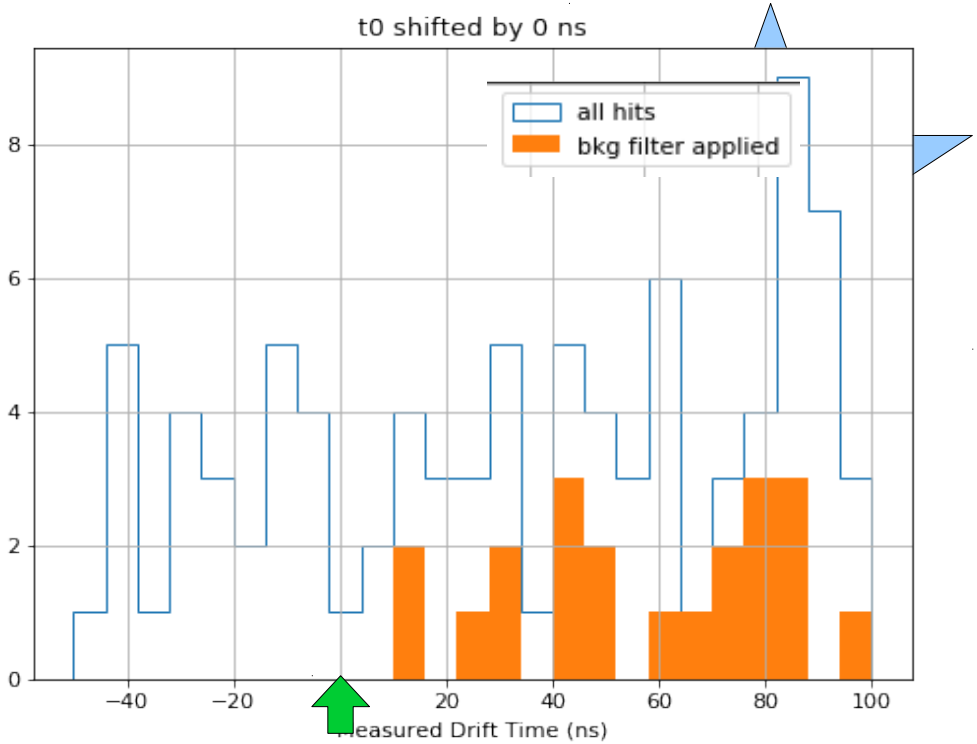
WIP !

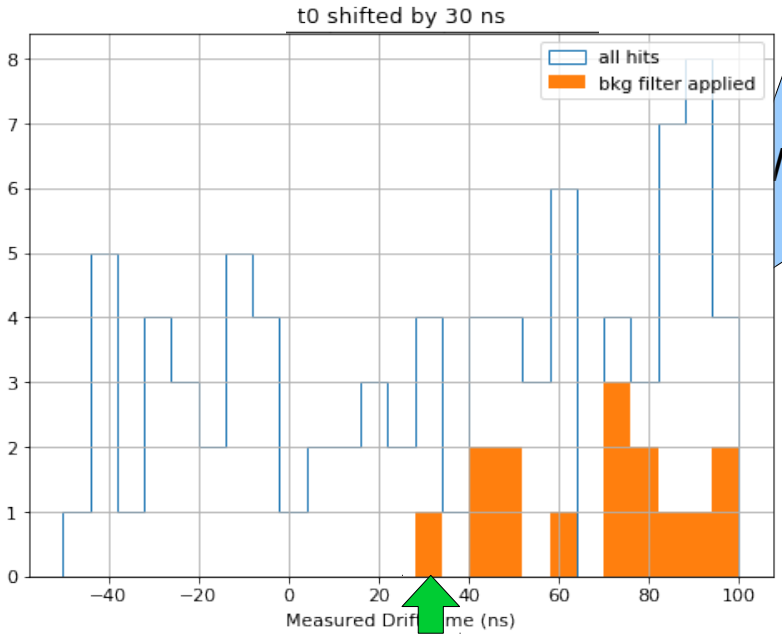


WIP !

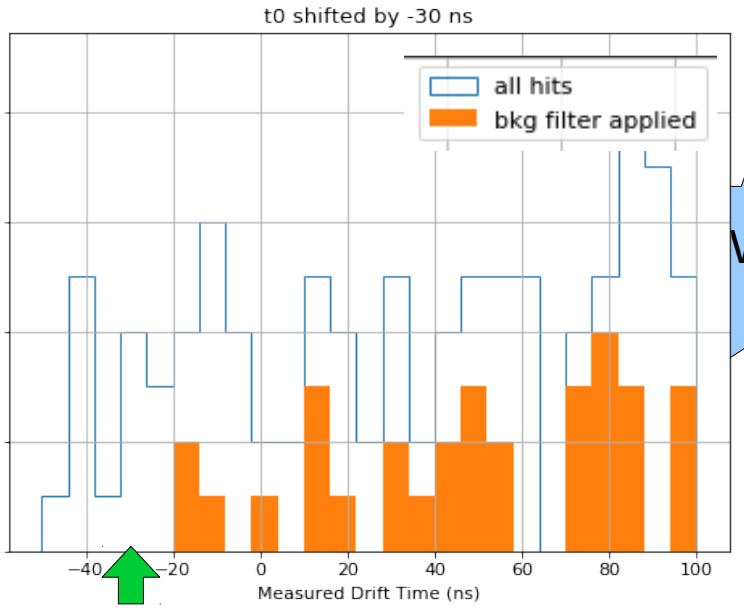
- Displayed are only the hits from one event
- Rise of signal hits very well to see
- Should be possible to fit and extract a t0 estimate < 10ns

Single Muon Track + 50% Phase III Background





WIP !

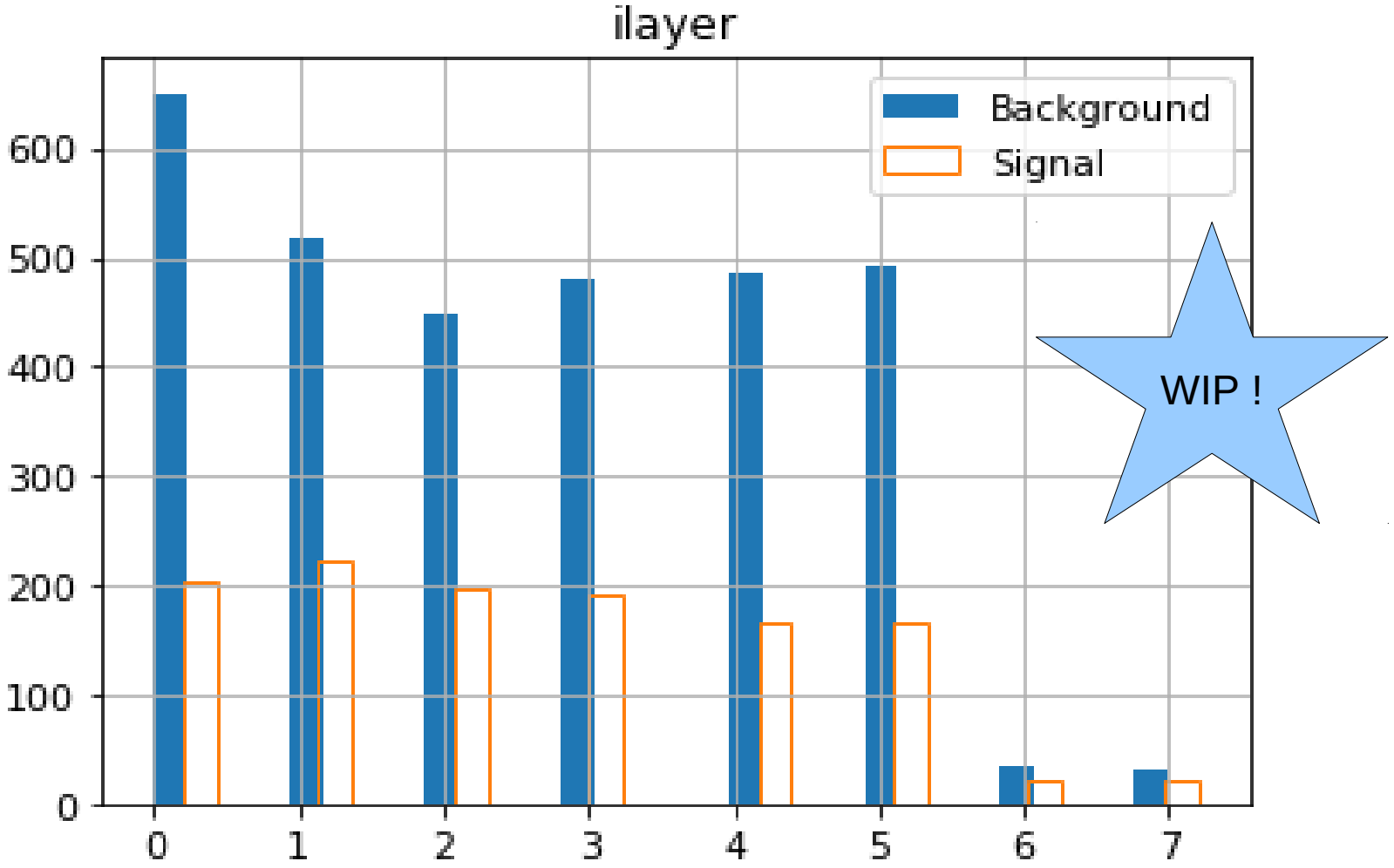


WIP !

- Most difficult scenario
- Background rejection works well
- Orange distributions look reasonable well to fit

Single Muon Track + 50% Phase III Background

Output from CDC Signal/Background Classifier

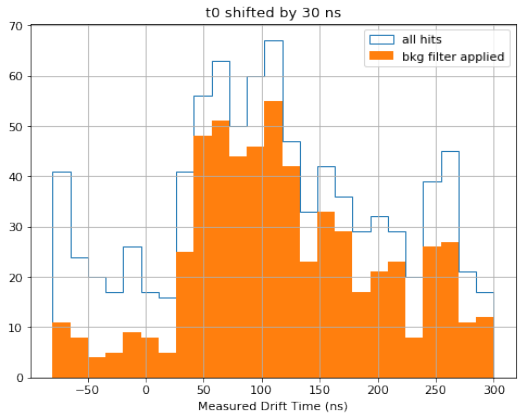


Method to fit T0 distribution

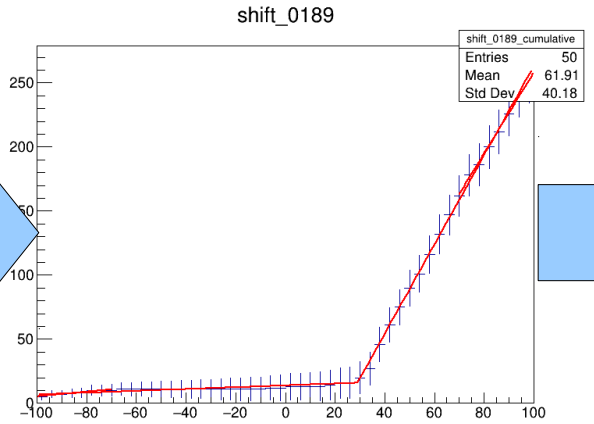
- Fitting the hit time measurement directly is difficult due to few entries and fluctuations (tried Sigmoid function)
- Difficult to properly extract the t0 time (steep rise of distribution)
- Better method: Create a cumulative histogram and fit this with segmented (non-steady) line:

$$f(x) = a(x+|x+t0|)) + b(x-|x+t0|) + c$$

Bkg Part Sig Part



Cumulate



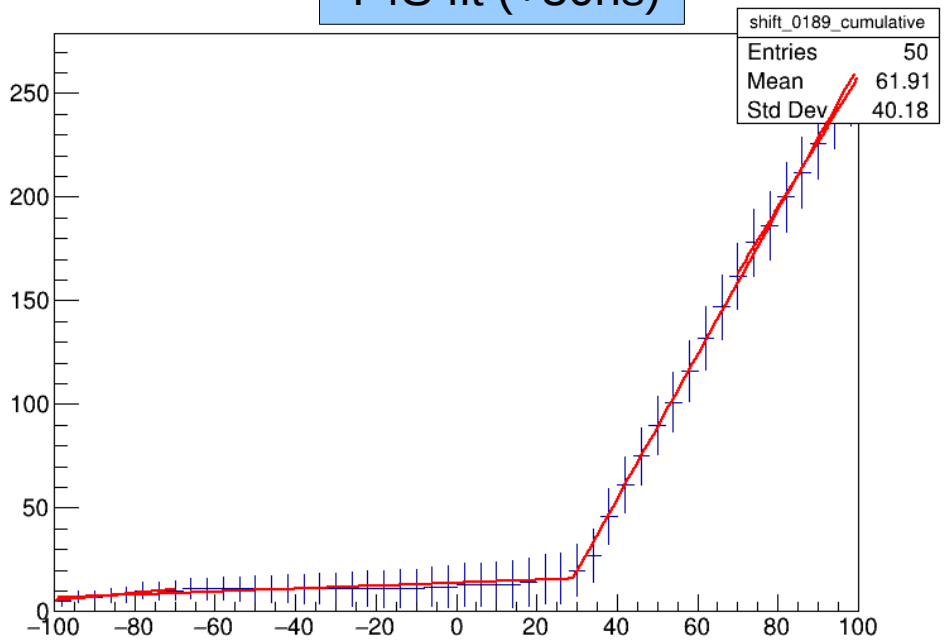
Fit f(x)

T0 Estimate

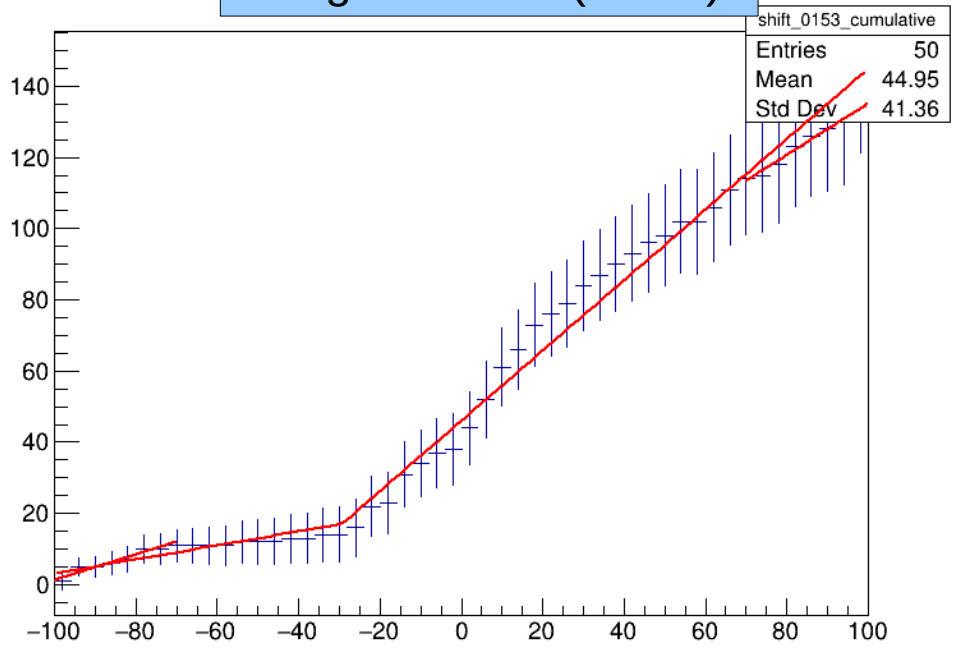
Fitting of cumulated hit times

- Some tuning was required to get the fit stable in almost all cases
- By eye, the t0 ist visible in almost all cumulated plots
  - But getting the fit to converge is more challenging
- Staged fit:
  - First fit the background and signal part of f(x) to background only (from -100 to -70 ns) and with signal + background (from 70 to 100 ns)
  - Use the a and b parameters (steepness) retrieved there to initialize the fit of the full f(x)
  - Also use the intersection of background and signal part of f(x) for an intial t0 for the full fit

Y4S fit (+30ns)

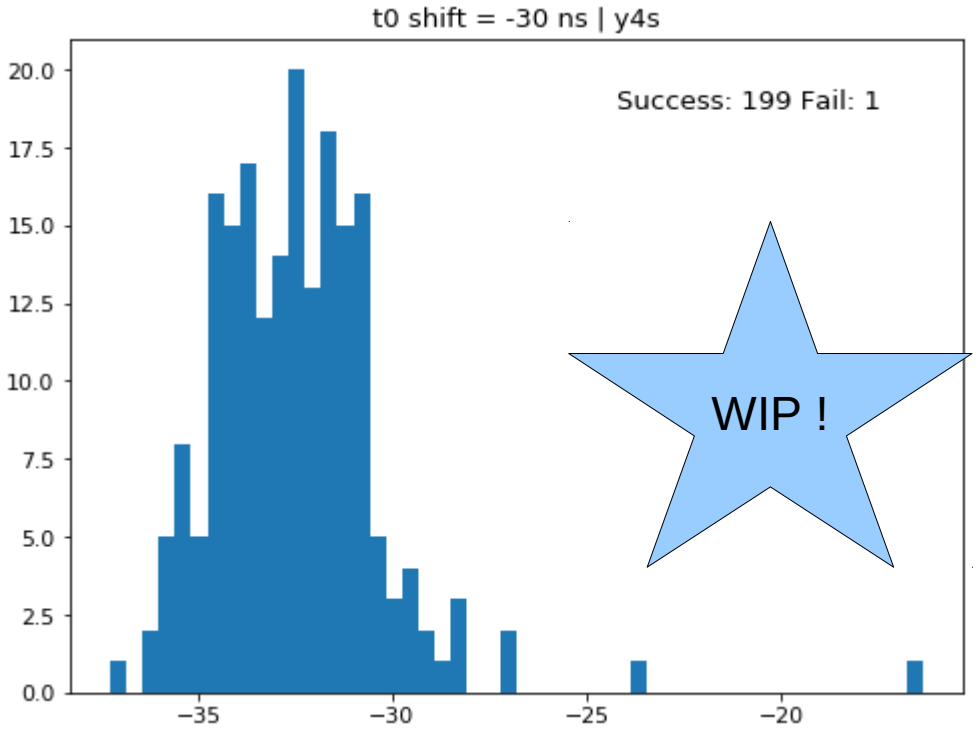


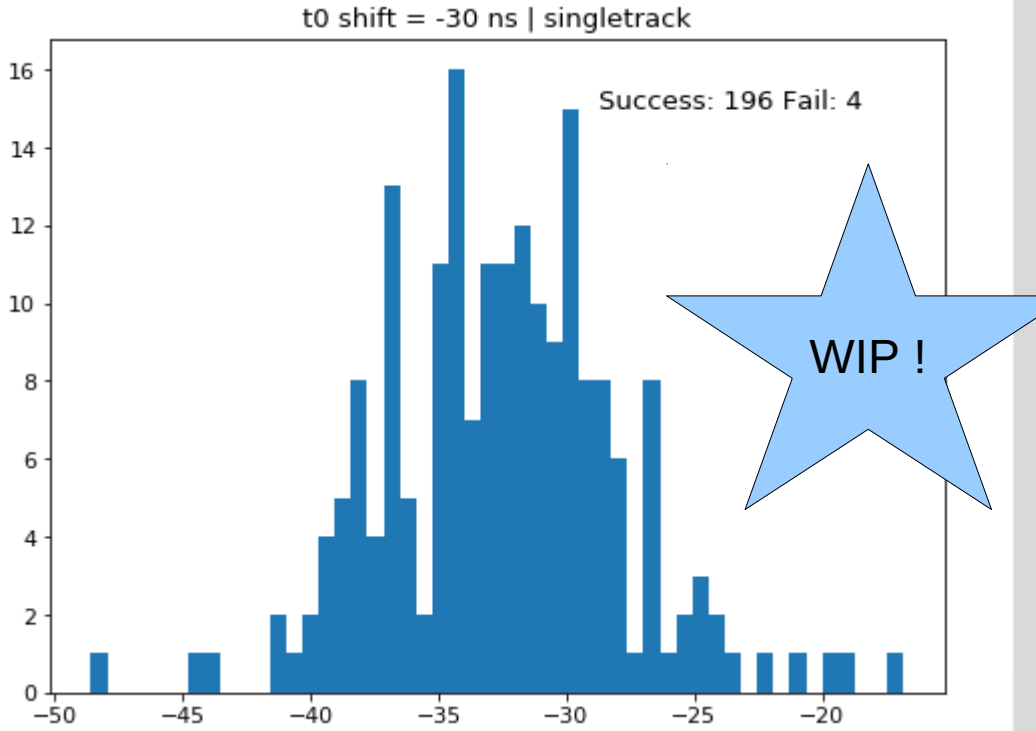
Single track fit (-30ns)



Results for Simulated t0 = -30ns

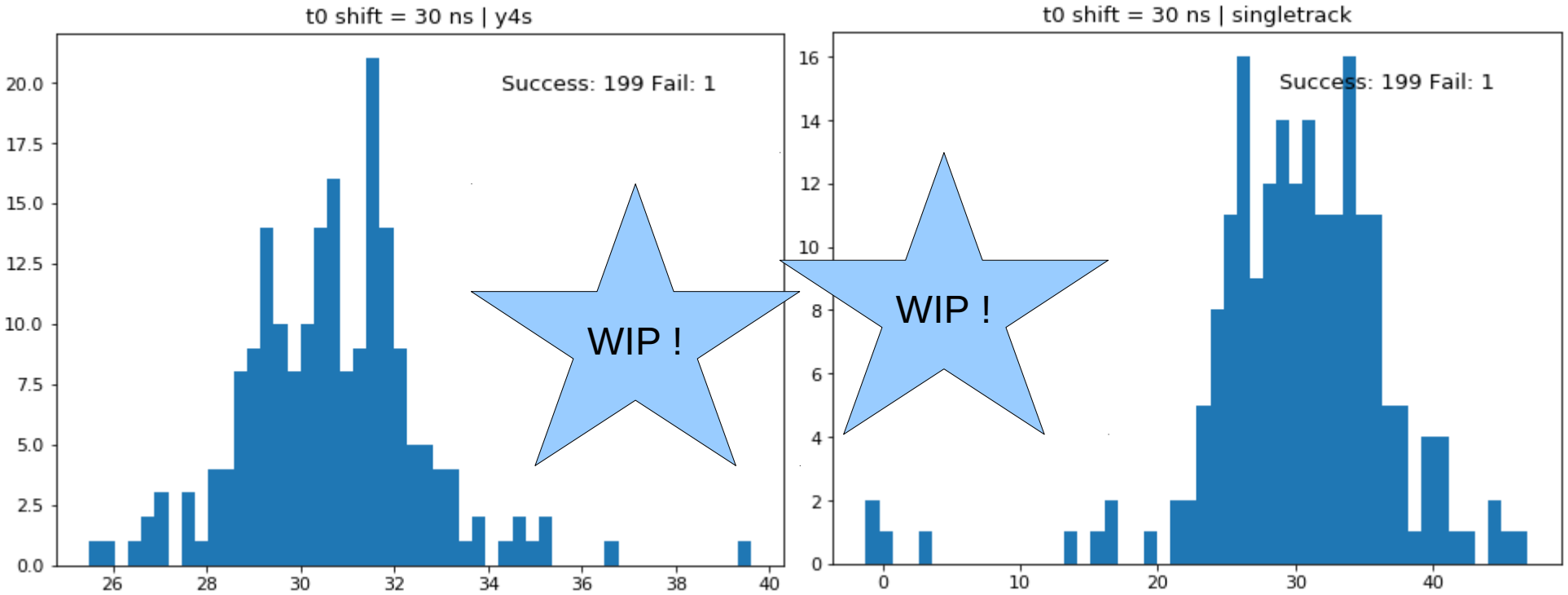
- Extraction works very well in almost all cases
- As expeceted: better resolution for more tracks (y4s)
- Bias torwards smaller to → investigating





Results for Simulated t0 = 30ns

- No bias here ...



Next Steps

- C++ module is implemented
- Confirm performance with C++ module and study resolution in more detail
- Put it in realease (next week)
- Test some ideas I have to be more background-resilient