T0 and TOF Calibration: The Revised and Expanded Edition

A Presentation on the Most Current Top-Level Algorithm for T0x and TOF Calibration and Its External Requirements

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Dividing up the System

- In T0 subsystem (before target):
  T01 – primary target counter
  TBD – auxillary counter at BC3/SWIC
  T00 – beam counter way back in MC6
- In TOF wall subsystem (after target):
  Beam region (center four bars)
  Rest of the center wal
  East and West wings

Top-Level Flow Chart (T0x):

- For each PMT:
  - Get raw digits from event with pion beams
  - Plot all calibration event ADCs in a histogram and take the mean as the pedestal value
  - Plot all TDC vs. pedestal subtracted ADCs and fit it to a+b/sqrt(ADC-ped)
  - Plot all timewalk (above) corrected TDC vs. hit distance from PMT face (and fit a correction?).
  - Plot the final corrected TDCs in a histogram and take the sigma as resolution
- Then, for each T0:
  - Make a histogram of corrected TDC time differences between each PMT and the lower west PMT and save the mean as a correction (cable delay).
  - Then, using PMT resolutions, plot the weighted average of the four PMTs in a histogram, take the sigma as the counter resolution
  - Plot the histogram of differences between measured time and expected time of flight, and save the mean as a correction (cable delay).

Why use just pions?

- There should be enough statistics at all momenta to calibrate T0 system with just pions
- The expected difference in time of flight from TBD to T01 (~37 m) between 13.3 (lowest value listed in priority 1 run plan) GeV/c pions (mass ~140 MeV/c^2) and light is ~10 ps
- For protons, this difference would be ~30 ps, which is significantly closer to our desired resolution of 50 ps.
- If we have enough pions, then why not just use them?

Fitting pedestals

- Just take the histogram's gaussian fitted mean as the pedestal value and the sigma as the uncertainty in the pedestal value.
- This is done just with events that fire on the calibration trigger (evt.Trig(). Calibration()).

Timewalk

- Use the pedestal subtraced ADCs and plot them on the x axis, while plotting (T01 subracted?) TDCs on the y axis.
- The expected fit is a+b/sqrt(ADC-ped), with b being the operative calibration parameter.
- Tim talked about the power of the (ADC-ped) term being a parameter as well.
- We'll see what happens.

Light Propogation

- Light in our plastic scintillator takes about 50 ps to travel 1 cm.
- If the beam is up to 1 cm wide, then this may have an impact on data, and it is something we should look at.
- Look at it by plotting (T01 subtracted) TDC v. distance of hit from phototube.
- Doing this will require reconstructed BCLines.
- This is easy for T01 and TBD, but T00 is behind three quads and two dipoles; we can't really do this correction for that counter and trust the results.
- Though it is likely the correction will probably just be smudged in the PMTs inherent uncertainty.

PMT Resolution

- When we correct the TDCs, we can plot them in a histogram, and the standard deviation will represent the uncertainty in each TDC measurement made by the PMT.
- We want to have this around to make weighted averages for counter time.
- The mean of this histogram will be used in cable delay correction.

PMT to PMT delay

- The various PMTs will have slight differences in their cable lengths.
- Using the mean of the TDC differences, we can scale this average down to a chosen PMT.
- This will then allow us to get a corrected average of all four PMTs to represent the counter time.

Counter Resolution

- Using the PMT resolutions, we can then plot the weighted average of all four PMTs in a counter
- This average will become the T0Time of this counter.
- We then want to store the sigma of the histogram as the counter resolution

T0 Cable Delay

- The difference in counter times and expected times should also form a fittable histogram
- Just take the mean time of the histogram, and use that as a scaling constant to represent the actual time the particle should have taken to travel from a to b
- This won't need to be done for T01 (T01[i]-T01[i]=0).

TOF Wall Flow Chart:

- For each PMT
  - Get TDC and ADC times that correspond to bars which had one partical above a certain momentum (say 5GeV/c) going through them (and keep the position of the hit, too).
  - Fit pedestals from calib events
  - Then use positoin information to make a timewalk correction, with bins in y to account for pulse shape difference and light propogation.
  - Then plot TW subtracted TDC vs. the vertical distance of the hit and fit a correction
  - Plot histogram of TDC times (may also want to plot this against distance) and take the sigma as resolution.
  - Plot corrected differences between PMTs for cable delay.
- For each bar:
  - Plot the weighted average of the top and bottom phototubes (maybe also do this in y bins, too). The sigma is the bar resolution.
  - Now, using hits from tracks that go through both a calibration bar and a vertical bar, plot the difference in corrected time (make sure the track is the only hit in both bars). Use this histogram to calibrate for cable delays between bars.
  - One all the bars are aligned with each other, use beam tracks going through the center bar to scale it to the time of flight that it should be reporting.

Why we need high momentum particles

- The TOF is our momentum detector for particles from ~1-3 GeV/c. Since we have to be able to report different times for these particles, they will way smear TDC distributions. Since we can't correct for momentum to correct for calibration, we can't use these particles.
- Low momentum particles (< 1 GeV/c) don't even reach the TOF wall, so we can't use them.
- We need to use particles with momenta that will produce low time differences.
- Unforunately, even at 10 GeV/c, protons lag behind light by 600 ps, and our desired resolution is 200 ps.

Getting Good High-p tracks

- In order for tracks of the requisite momentumt to be created in interactions, we need high energy beam, say +40 GeV/c. If we can find low multiplicity events, some of these particles, at least, should be above the needed momentum
- NuMI target data probably won't help, because of the extreme multiplicity. I imagine the thin nuclear targets would be the best data to look at.
- Once we get a good interaction, we need some way to insure the kind of particle is appropriate.
- The RICH won't be of much use here, I think: high momentum particles flying off at angles which will hit the outer bars won't get bent back into the RICH volume by Rosie.
- **Maybe we can use the Dckov here?** I don't know too much about the operating parameters of it, however.

Time walk

- Once the pedestals are done, we can then use those to make time walk corrections.
- Due to the extreme length of the bars, the time walk will need to be done in bins small enough so that light propogation effects are small compared to the time walk correction.
- The bins will likely need to be a few centimeters tall. Any bigger, and the distance effect begins to creep in again.
- It may be more advantageous to do the light propogation first, then use that correction to do time walk.

Light Propogation

- Use the timewalk correction in each bin to plot TDC vs. distance in the bar, and then fit that. Use the parameters for a correction.
- Again, this may make more sense to do before timewalk.

Resolution and cable delay

- The scheme for resolution works much in the same way as it does in T0: plot the Tdc histogram for each PMT, do the PMT to PMT cable delay correction, then plot weighted average in a histogram for each bar to make that resolution, then take time differences between bars to fit bar to bar delay, and finallly, scale the beam bar to what we expect the time-of-flight to be.
- The difference here is that we are going to use a much smaller fraction of hits to do bar to bar delay.
- We need hits that go through both a calibration and a vertical bar such that those hits are the only ones in both bars. Then we plot the differences in times between each bar, and the mean of that histogram will be our calibration correction.
- Hopefully the statistics on this are okay.

External needs for calibration

- T0x
  - Beam particle PID
  - Beam particle tracking
  - Pion beam triggered events
- TOF Wall
  - Global tracking
  - Interaction events that produce particles (hopefully pions) with momenta >= 5Gev/c
  - Some way to decern which particles are at this momentum

Database structure

- The only forseeable changes to Tim's DB structure are adding resolution entries, and adding an array of timewalk correction parameters.
- I have never worked with the DB stuff before, so I'm probably going to need some help on that.
- In fact, mastering MippDB stuff should be a specific software workshop goal for me, I think.

Conclusions

- I have presented an algorithm that should take care of TOF calibration from back to front
- Unfortunately, it is a rather picky one, and has some very demanding requirements (5 GeV products).
- “…with a little help from our friends,” finishing TOF calibration is in sight. (maybe even by month's end).

MIPP

Presented to the MIPP software/analysis
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