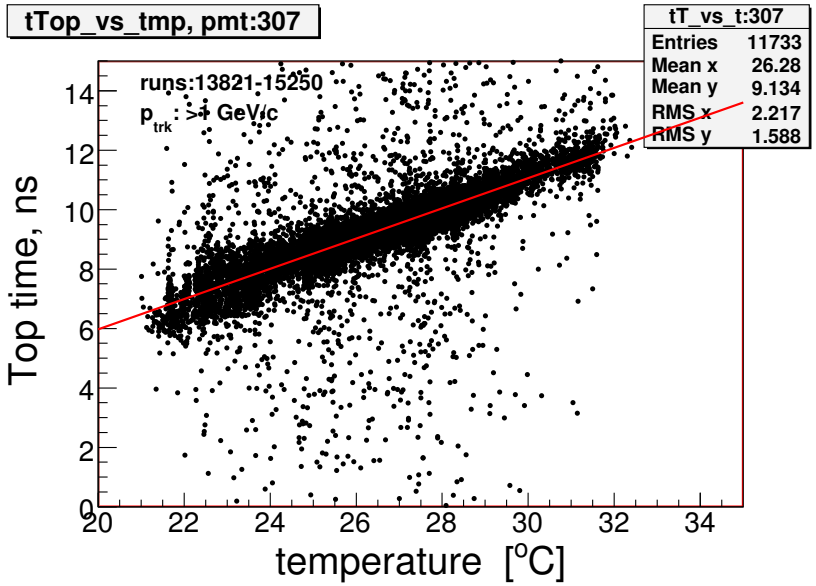
What is the time ToF TDC measuring?

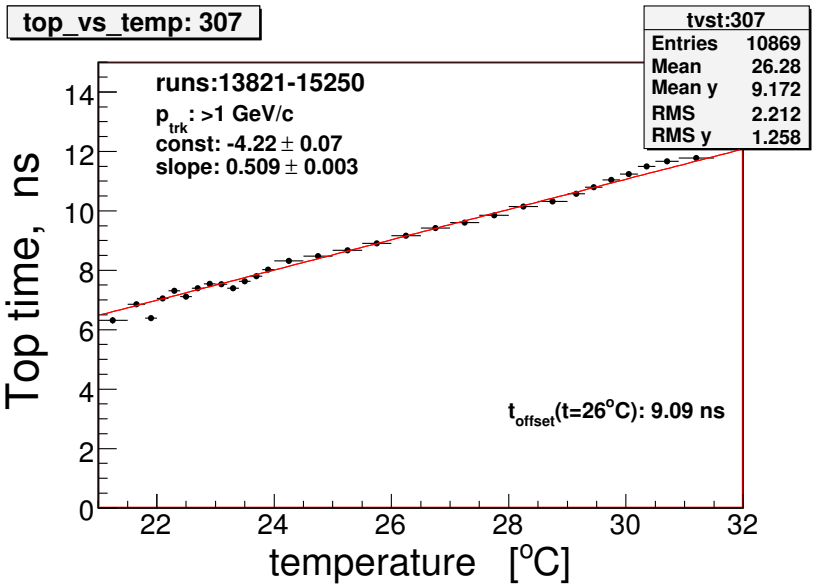
- beam particles flight time from the T01 counter up to the vertex, β=1 (recently applied in analysis)
- particles flight time from the vertex up to the ToF wall, $\beta \leq 1$. It consist from two pieces: a)from vertex up to the UTPC (recently added in analysis) and b)from UTPC up to ToF wall.
- time propagation in the ToF bars
- cable delay in ToF channels
- cable delay in T01 counter (recently added for convenience)
- event T0 variations due to of the pulse height in T01 counter, ..(Andre)
- time variations due to of the pulse height in ToF channels

the temperature dependence

- select data with lowest, middle and highest temperature variations. Overall run range: 13821 - 15250.
- drop two run segments: a)13996 through 14062 and b)14380 through 14453, where data points shifted by 3-4 ns up or down from the general trend. Need more studies.
- collect the ToF TDC time vs the temperature data requiring the track projections within narrow spot at the center of bar (Y:$\pm$10 cm). In this case we might not worry about the speed of light in bar.
- apply the linear fit procedure for the time vs temperature data.
- using the temperature correction, collect the bottom-top time difference vs the track Y position.
- apply the linear fit procedure for the time difference vs track position data, derive the speed of light in bar.
- redo the temperature studies using wide range of track Y positions (Y:$\pm$150 cm).

TDC time vs the temperature

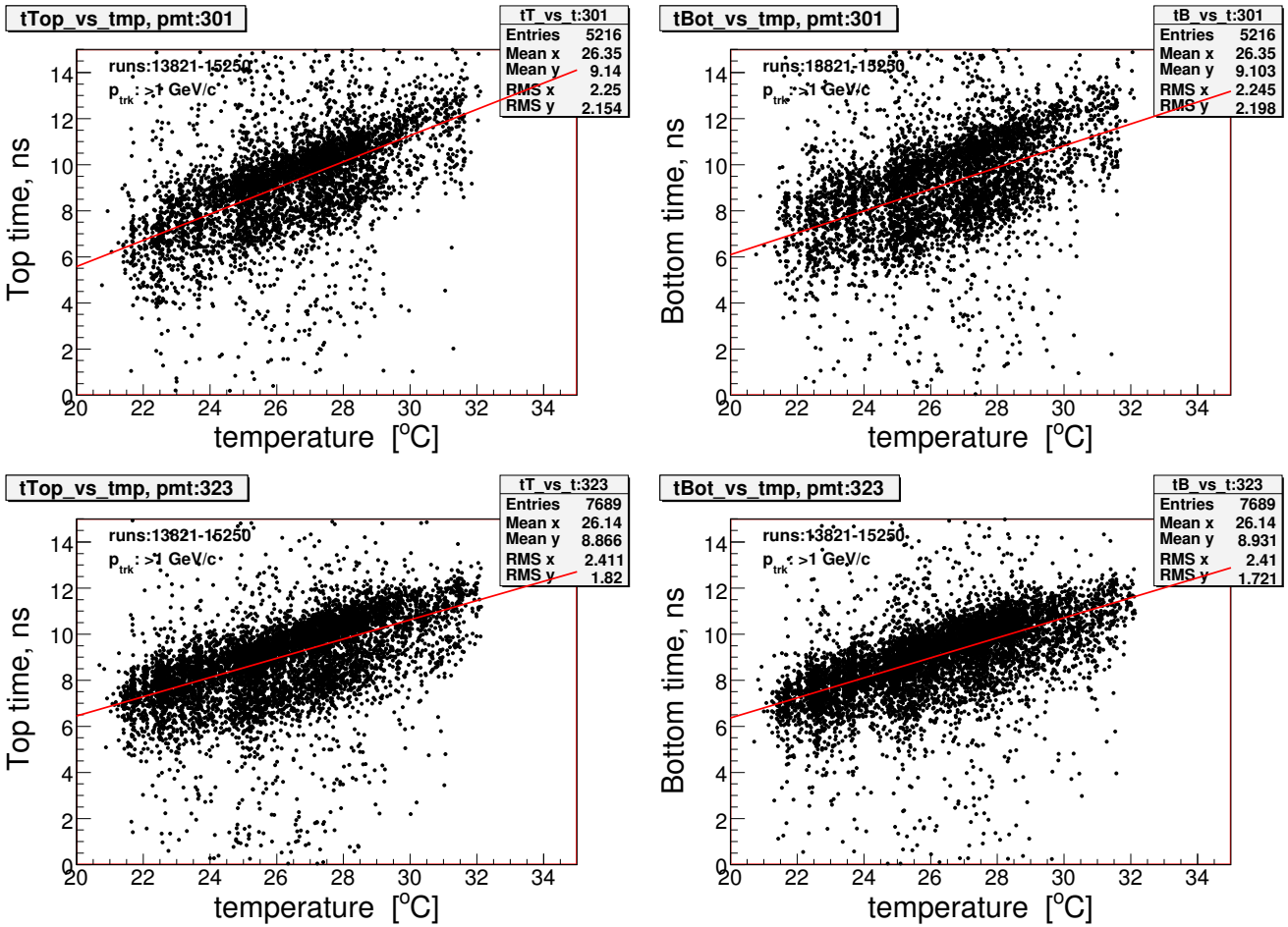




Top plot - the top pmt 307 time vs the temperature. Requirements: the isolated track in bar, the adjacent bar cut and all items on the time formula have been subtracted (except the time-walk). The red line illustrate the fit result. The temperatures 22-24^{O}C and $>$29^{O}C are LH2 and thin target data, the temperatures 24-29^{O}C are NuMI target data.

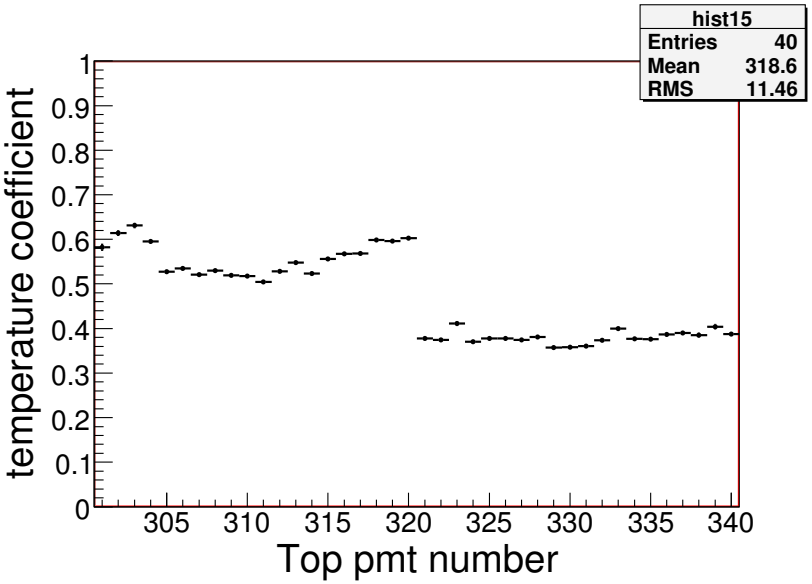
The bottom plot - the profile plot of above data and the fit results. The profile plot was made with an additional cut: select the data points within $\pm$2.5 ns around the red line.

examples of bad channels



List of the “bad” channels: 301 (top and bottom), 323 (top and bottom), 322 bottom, 324 bottom, 329 bottom and 340 bottom.

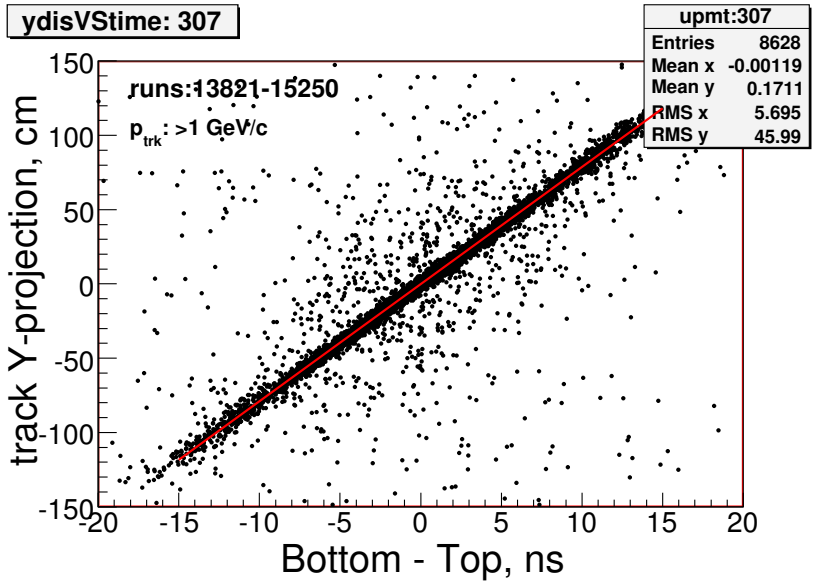
temperature coefficients

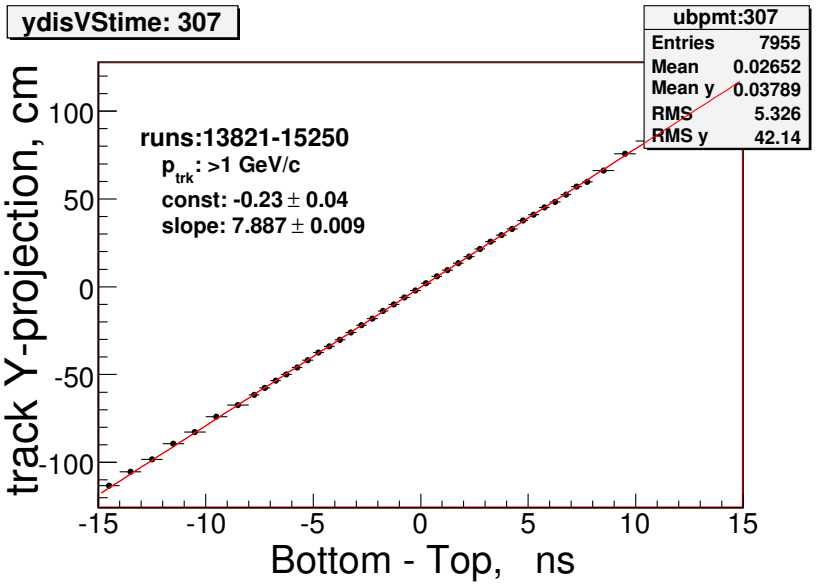


Plots illustrate the temperature coefficients derived using the latest the time formula. Top plot - top pmt's, bottom plot - bottom pmt's.

How these results in compare with early? For the top pmt's there is almost no difference. For the bottom pmt's East side pmts were drop by 3-5% and West side pmt's raised up by about the same amount. So, East and West coefficients became more close to each other.

speed of light in bar

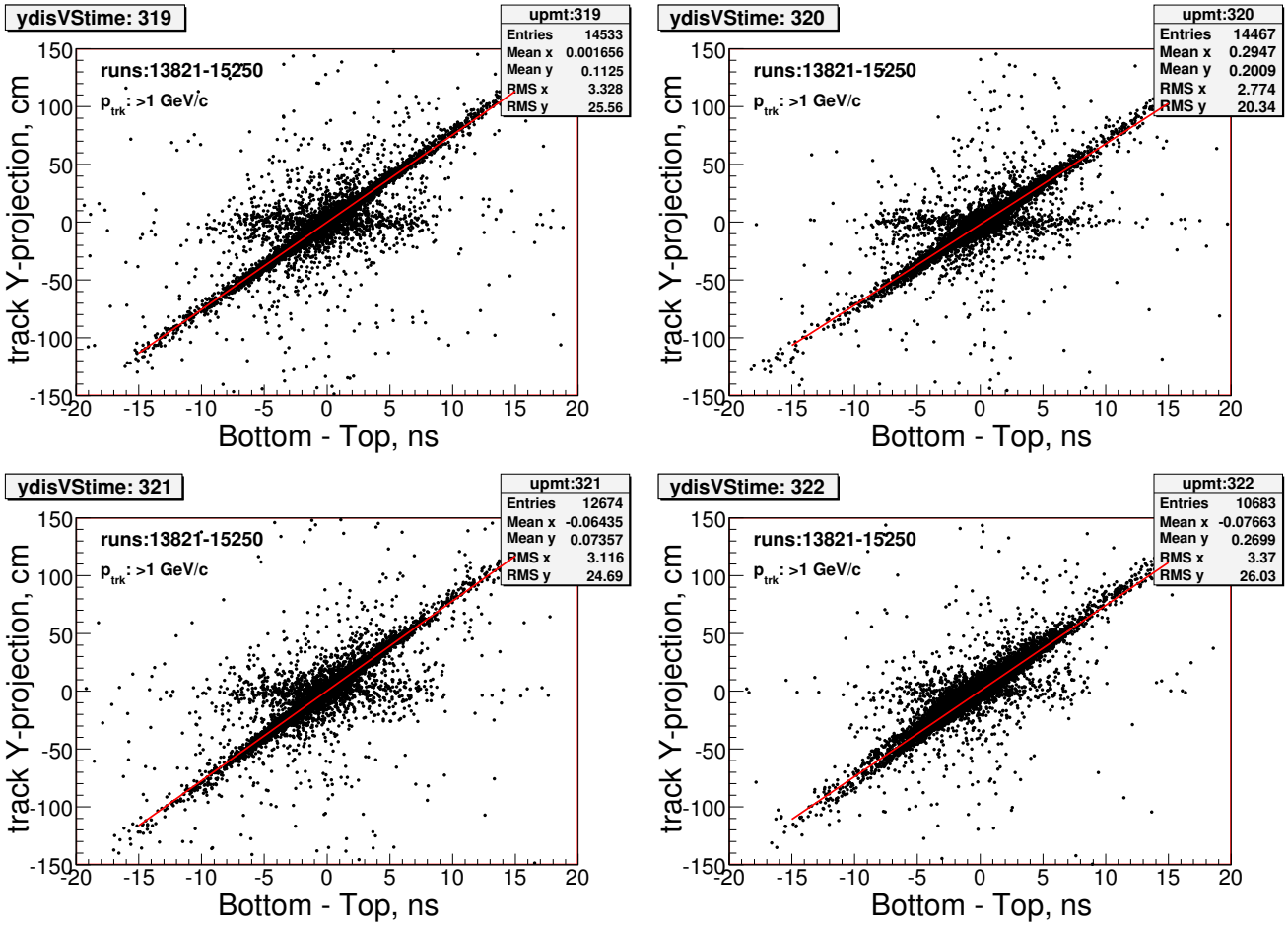




Top plot - the bottom-top time difference in bar 307 vs the track position. Requirements: the isolated track in bar, the adjacent bar cut and all items on the time formula have been subtracted (except the time-walk). The red line illustrate the fit result.

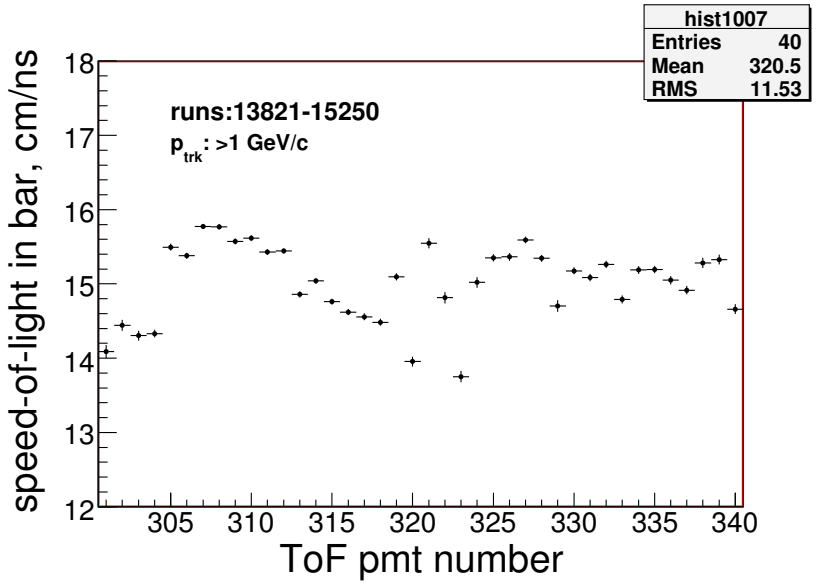
The bottom plot - the profile plot of above data and the fit results. The profile plot was made with an additional cut: select the data points within $\pm$20 cm around the red line. This cut works okay for the peripheral bars, but not sufficient for the central (see following plots).

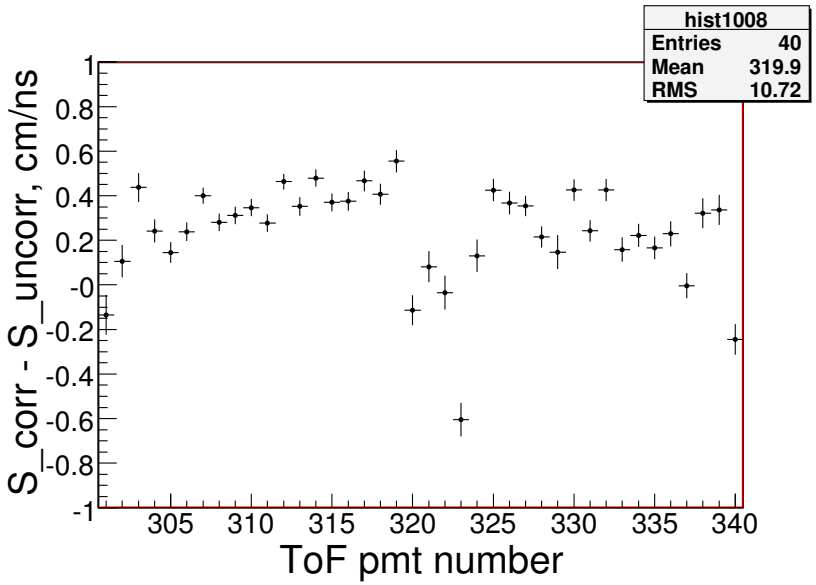
speed of light in bar, cont



Plots illustrate that the fitted straight line might be off due to of the background at Y=0 line. We applied corrections for this effect. It is in level of 0.3-0.8% with $\pm$20 cm cut and 0.3-3.0% with $\pm$30 cm cut.

speed of light in bar, cont





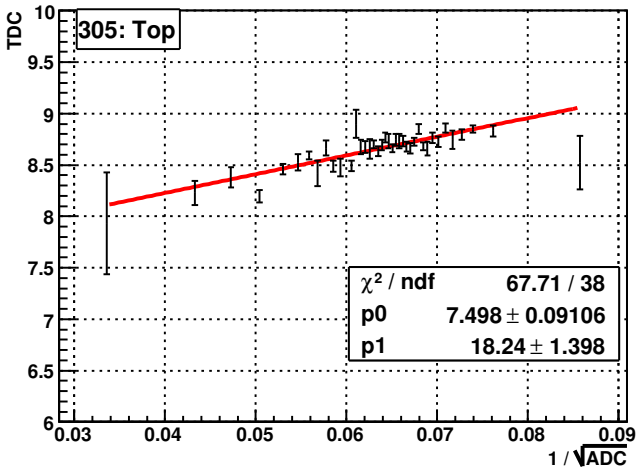
Top plot - the speed of light vs the bar number using the latest the time formula (without the time-walk correction). Data points in the central bars (315-325) are uncorrected.

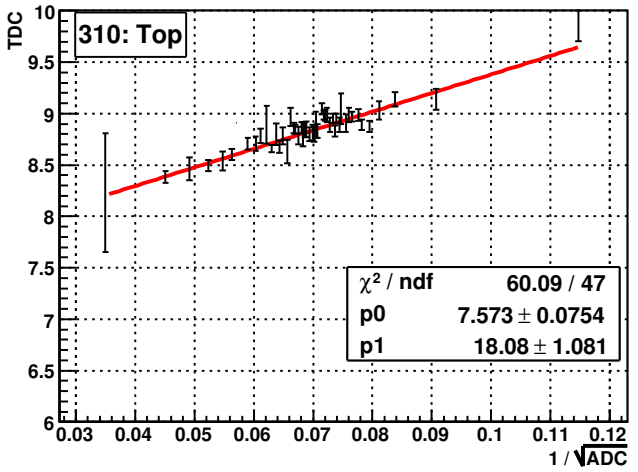
Bottom plot - the difference between the latest result vs what was while ago. So, the latest speed is about 0.3 cm/ns is higher. The central data values are lower, because the means are shifted due to of the background at Y=0 line.

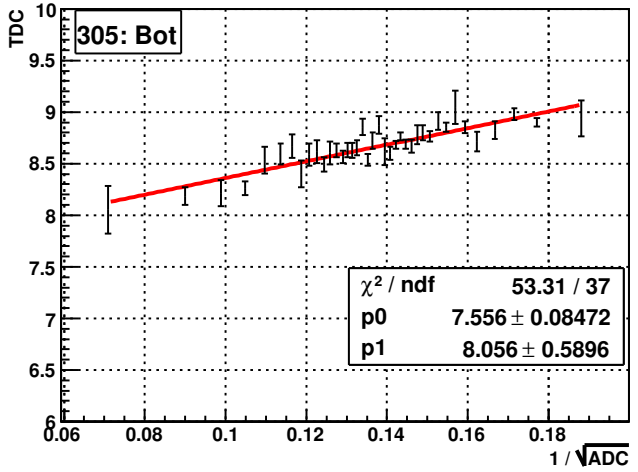
Time-walk Correction

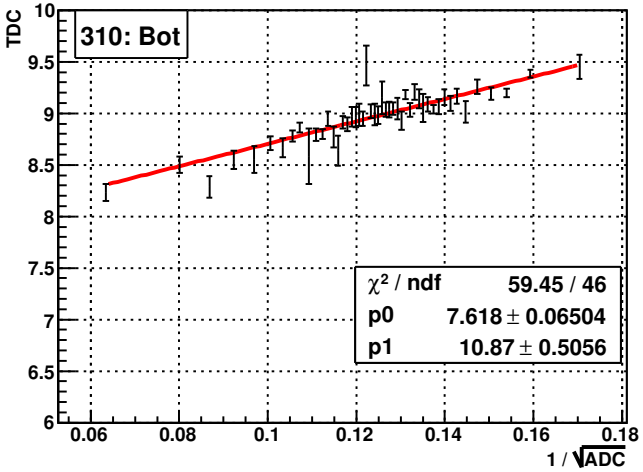
- NuMI target data, 1-4 GeV/c, single tracks match, no adj hits
- TDCs corrected for temperature, all terms in the time formula, ADC's corrected for attenuation
- read ADC pedestals and widths from DB. In a few runs the values are negative or no entries at all
- ADC's pedestals subtracted, ADC is valid if ADC $>$ ped + 3σ
- store TDC and 1/$\sqrt{ADC}$
- sort entries $\rightarrow$ get mean TDC (gaussian fit) and average 1/$\sqrt{ADC}$ for groups of at least 80 entries $\rightarrow$ Fit to first order polynomial
- similar to what Andre did for T0 (he restricted the range of ADC's and fit TDC vs 1/$\sqrt{ADC}$ to a second order polynomial)

fit of the time-walk data, bars 305 and 310



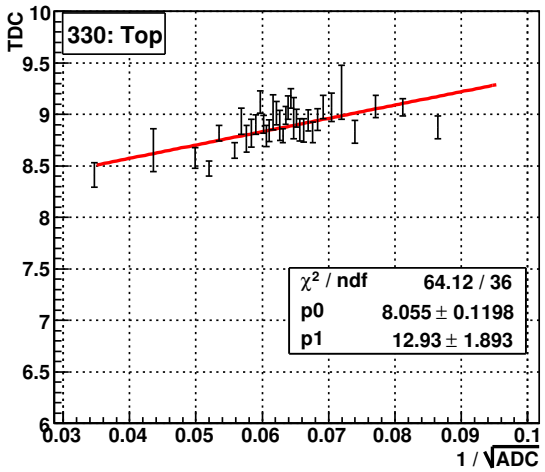


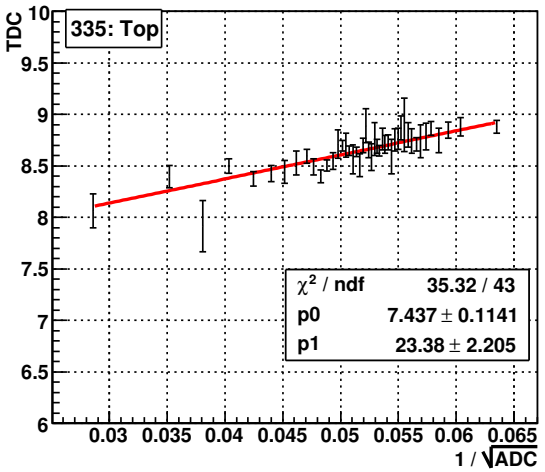


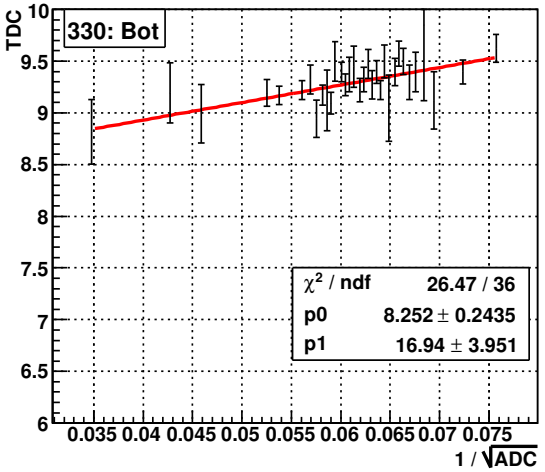


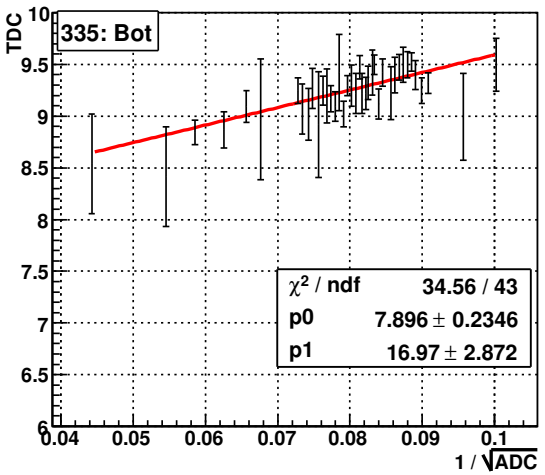
Fit of the TDC vs $1/\sqrt{ADC}$ for bars 305 and 310. We applied the least square and the likelihood methods.

fit of the time-walk data, bars 330 and 335



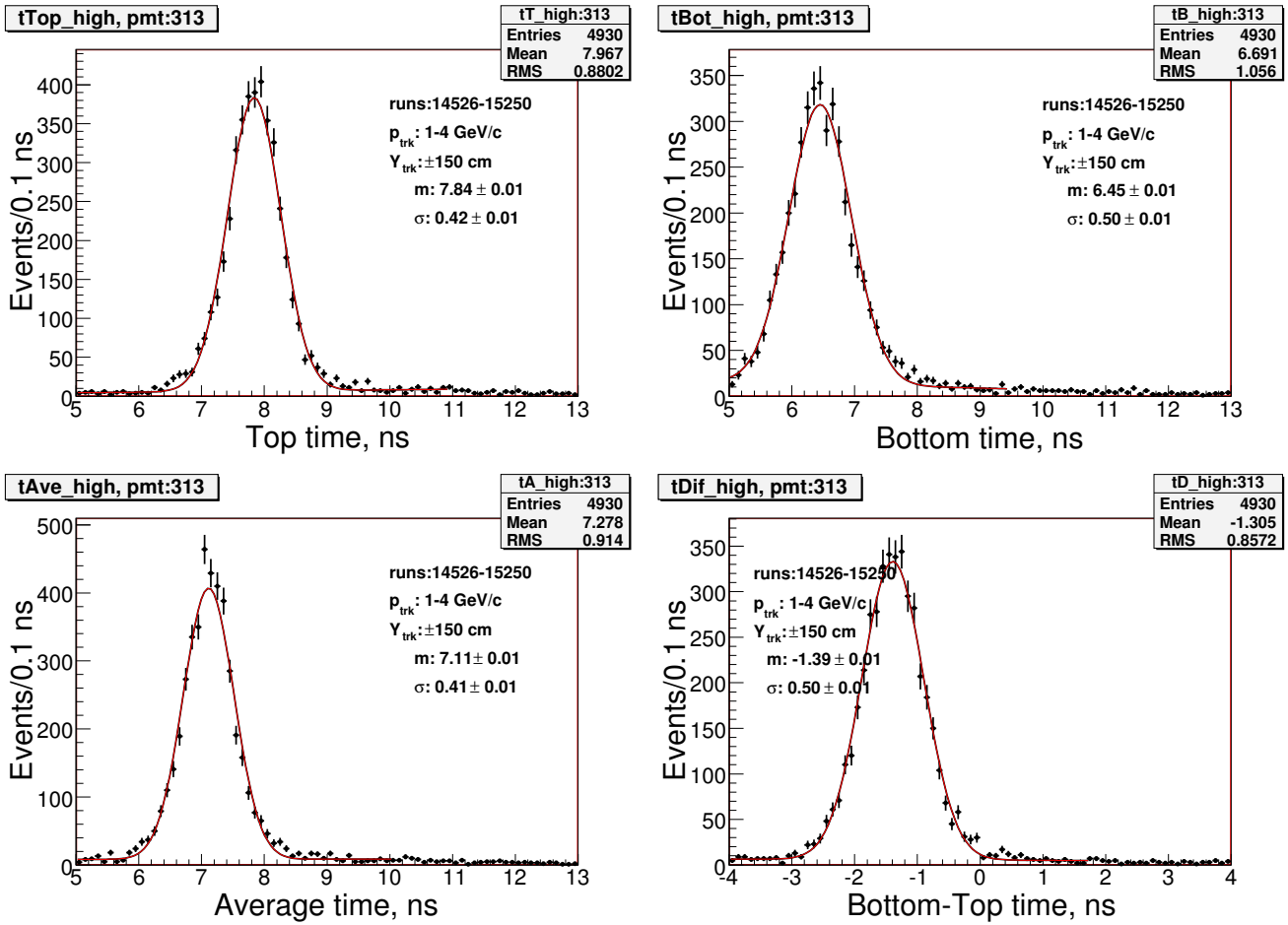






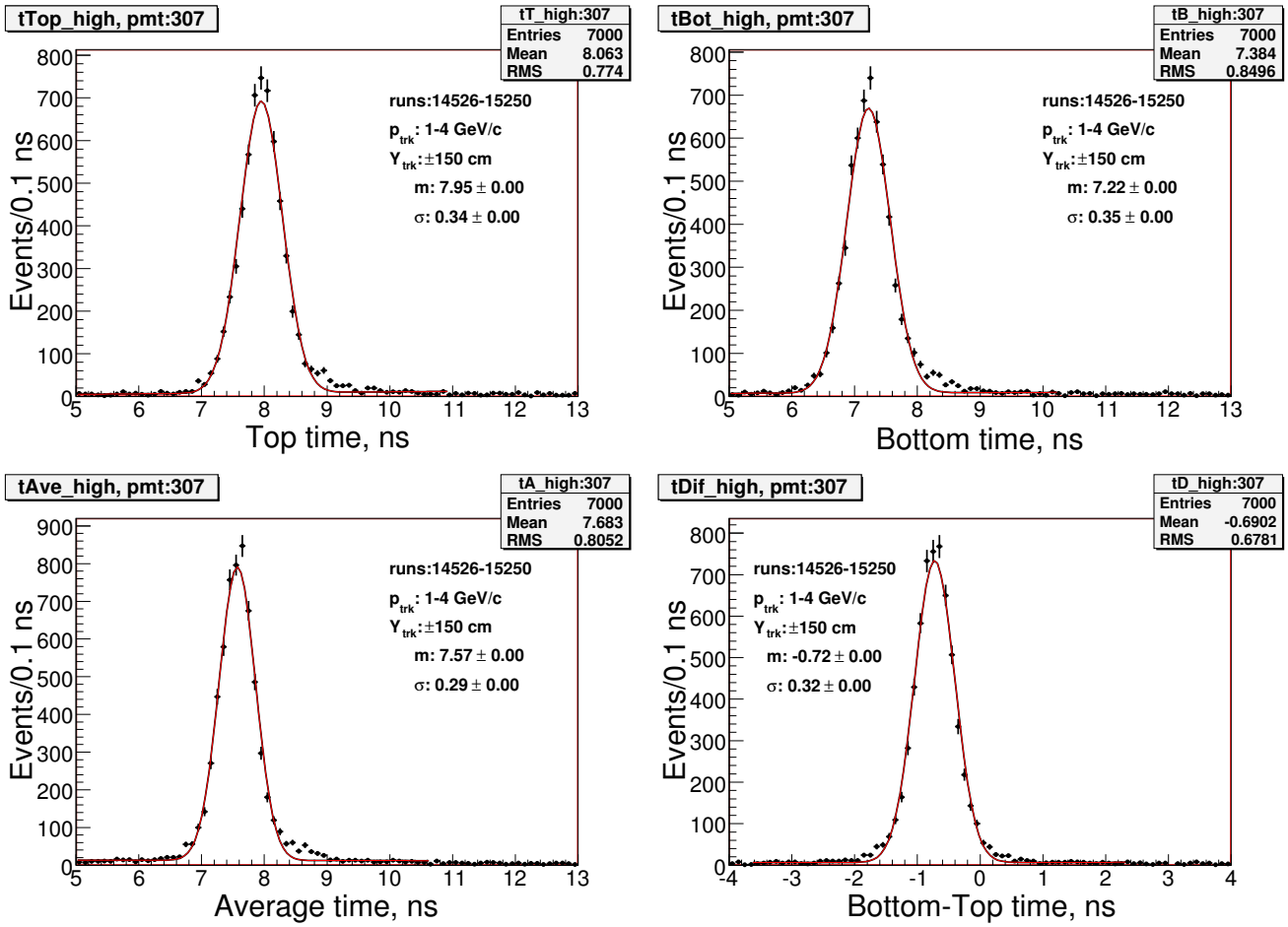
Fit of the TDC vs $1/\sqrt{ADC}$ for bars 330 and 335.We applied the least square and the likelihood methods.

time resolution for bar 313, NuMI target



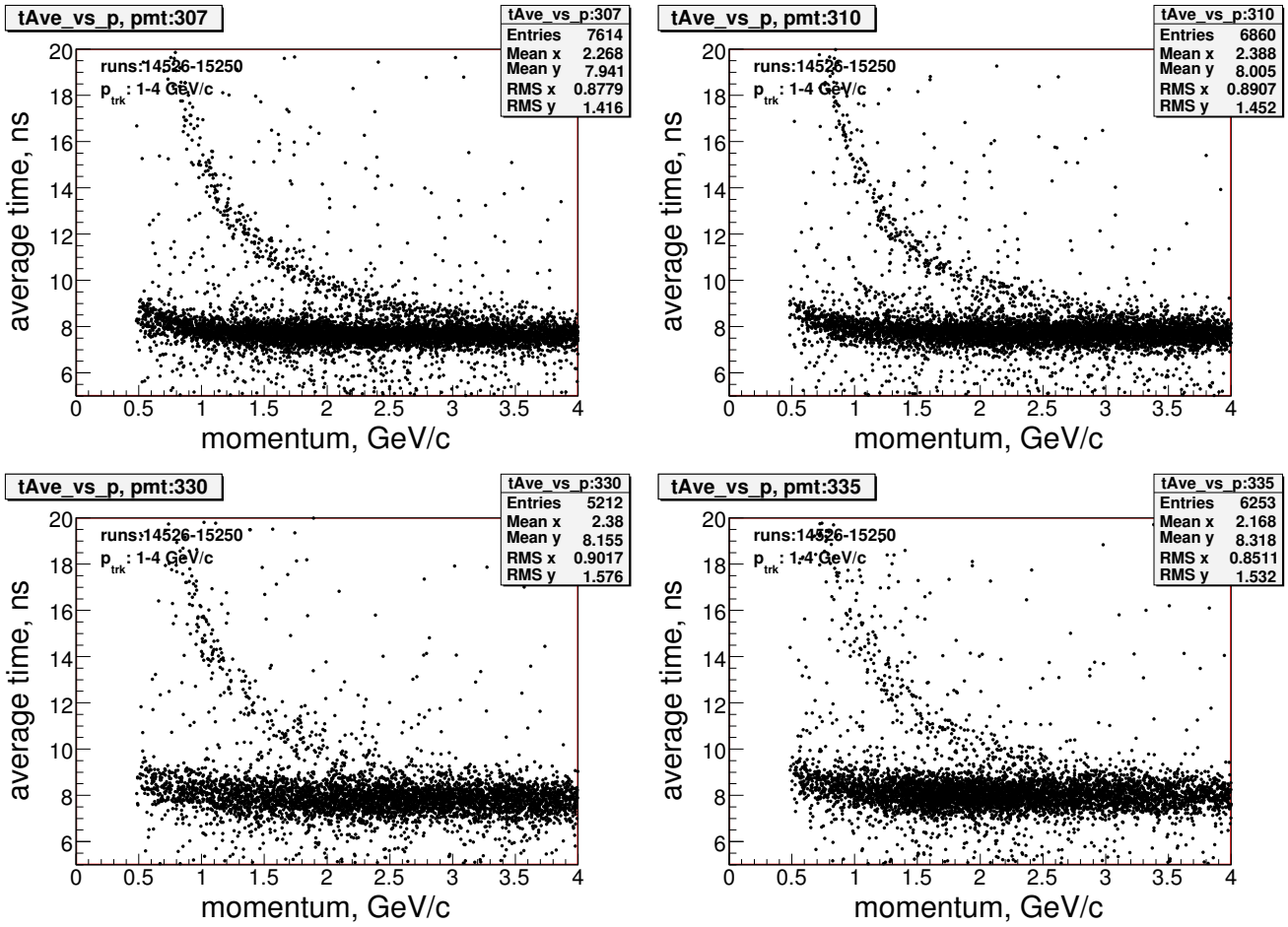
NuMI target data. Top left - the Top time, top right - the Bottom time, bottom left - the Average time, bottom right - the Bottom-Top time. Corrections listed in the time formula and the time-walk effects are taken on the account. Bar 313 represents bars with the most common time resolution.

time resolution for bar 307, NuMI target



NuMI target data. Top left - the Top time, top right - the Bottom time, bottom left - the Average time, bottom right - the Bottom-Top time. Corrections listed in the time formula and the time-walk effects are taken on the account. Bar 307 has the best time resolution.

average vs p, NuMI target data



The average time assuming β=1 vs the particles momentum distributions. The most populated band of the data points represents the pions. The top band indicates presence of the protons. On bars 310 and 335 within 0.5-1.5 GeV/c region there is a tiny band indicating kaons?

Next:

- recalculate the time-walk coefficients for combined data
- calculate the light attenuation for each bar
- apply the time-walk and attenuation for the temperature dependence and speed of light in bar

Remaining questions:

- resolution for East bars is better than for West. Why?
- what is resource(s) for the time resolution?