Tower Slope Notes

7/2

Objectives:

1.) Add a hello World. (✓)

2.) Run Multiple Trials (5 trials for # of events edit the amount of looping). (✓)

3.) change the shift value.
Goal 4%

4.) Quick Overview of what code is doing / some detail. (Read Tech Guide & JB masters thesis.)

5.) Check why # entries is not the same as # of counts.

6.) try multiple TF1's compare and contrast.

• **Note:** for each task try a logy() and talk about what it's doing.

Task #1 Adding a hello world

•) <u>Quick note:</u>

- There are multiple ways to Run this program.

<u>option# 1</u>:

root testslope.C "(# of events)"

<u>option #2</u>:

open root

↓

Load file : .L testslope.C

execute it : testslope(# of events)

<u>option # 3</u> :

open root

.X testslope.C "(# of events)"

- To run a simple helloworld one can use printf or cout inside the testslope void function.

ex)

```
Void testslope(int stats)
{
   ⋮
   cout << "Hello World" << endl;
   ⋮
}
```

Task #2: Running multiple trials.

objectives:

trial type: 100, 1000, 10,000, 100,000, 1,000,000, 1,000,000,000. (# of events)

within each trial type:

Change the amount of iterations of histotally's.

try from 5, 10, 25

trial #1A :

# of events : 100

# of iterations : $k = 5, 10, 25$

- With 5 iterations :

•) the fitting is not great for refrence histogram.

•) the tally histogram bins iterations ~~are~~ not very precise. (not close together)

•) the refrence and shifted histograms have a great overlap.

•) In logy() scales very sporadic statistics not great.

•) GF ratio = 0.953575.

•) mean (tally) = 0.965.

trial # 1B :

- # of events = 100
  k iterations = 10

- GF = 0.711744
  mean = 0.8247
  (tally4)

- The statistics of this were lose couldn't get a refence histogram in viewpoint.

- Important notes: I am only seeing the reference histogram.

Trial #1C:

\# of events = 1000
\# of iterations = 25

ratio = 0.857943.
mean = 0.7954.

.) **key notes:**

- htally still imprecise
- for refrence and shifting histogram not a linear best fit.

Trial # 2A :

- # of events = 1000
- # of iterations = 5

- ratio = 1
  mean = 1.002

- With 1000 events best fit is captured around 0-4 GeV energy range.

- In log y linearity

is better fit but only still capture low energy levels.

- Statistics dies off faster.
- Max level to get is around 14 GeV.

(Now just stick to 5 iterations throughout.)

Trial # 3 :

- # of events = 10,000
- ratio (GF) = 0.904762
- mean (h tally) = 0.8796
- Best fit in regular and log scales are better
- Sporadic statistics around 1-10 GeV.
- higher energy levels are

detected around (≈ 1000cd)

Trial # 4 :

- # of events = 100,000 .
- # of iterations = 5 .

- mean(htally) = 1.04
- ratio (GF) = 1.08956

- The htally bins are more close together more precise around (0.8 - 1.1)

- Energy that the histograms reach is around ≥ 1000 GeV

- Fitting is even more improved regular and log y scales.

Trial # 5 :

- # of events = 1,000,000
- mean(htally) = 1.017
- ratio = 1.03773

Trial # 6 :

- # of events = 1×10^9
- mean(htally) = 0.7746
- ratio = 0.7746

Key Notes / Properties by Running multiple trials

- key things were the fitting got better at more events, better statistics.

- Log(y) became more sporadic at higher event count.

- higher energy limits at beggining of histogram with higher event count.

Task #6

Try multiple TF1's doing (repeat Task #2)

•) <u>Functions to try</u> :

1.) $f(x) = e^{-x}$
(exponential decay)

2.) $f(x) = ax^{-b}$
(Polynomial decay)

3.) ax^{-1}
(Inverse decay)

(n) <u>Trials by event #</u>:

1.) $n = 100$
2.) $n = 1000$
3.) $n = 10{,}000$
4.) $n = 100{,}000$
5.) $n = 1{,}000{,}000$
6.) $n = 7{,}000{,}000$

- k = 5 iteration of making H-tally histogram.

Function class #1

exp decays: $f(x) = e^{-x}$; $K = 5$

Trial #1 :

$n = 100{,}000$

ex) (how to build TF1)

TF1 *function =
new TF1("function", nslit,
-5.,5,2)

fnslit → Draw()

•) $f(x) = e^{-x}$

•) TF1 *myexp

= new TF1
("myexp0", "e^-x", 0.3, 6)

•) Here is TF1 I created

•) Double_t fitf(D_t *x, D_t *par)
{
return TMath::Exp
} (par[0] + par[1]*x[0]);

also ;

TF1 *myexp = new TF1
("myexp", exp([0] + [1]*x[0]));
SetParameter , it .

•) Issue right now for exponential fit Htally is not taking data •

•) Read lines 25-85

1.) Check histogram fillings
2.) Verify fit results

htally mean = 0.962'
ratio = 0.95557

Trial #2 :

- $n = 1 \times 10^6$ events (counts)
- htally mean = 1.023
- ratio = 1.04617

Trial #3 :

- $n = 7 \times 10^6$ events (counts)
- htally mean = 1.017
- ratio = 1.00513

Function class #2

polynomial decay;

$f(x) = a x^{-b}$; $K=5$

•) <u>Test Function</u>:

$f(x) = 90{,}000\, x^{-3}$

•) <u>Trial #1</u>:

$n = 1 \times 10^{5}$ events (counts)

htally mean $= 1.014$

ratio = 0.818179

) **Trial # 2 :**

$n = 1 \times 10^6$ events (counts)

htally mean = 0.968

ratio = 1.04494

Trial #3 :

- $n = 7 \times 10^6$ events
- htally mean $= 1.002$
- ratio $= 1.02817$

Task #3
Changing the shift value to 4%

•) To show the 4% shift from 1% shift of h1 and h2 histograms.

•) <u>Originally</u> :

h2→Fill(myexp→GetRandom() * 1.015);

New Change :

$h2 \rightarrow Fill(myexp \rightarrow GetRandom() * 1.04);$

•) the ratio and htally means are diffeent with 1% to 4% difference for h1 and h2.

originally ($n = 1 \times 10^5$ counts) :

htally mean = 1.04

ratio = 1.08956

% diff = 4.65

new ($n = 1 \times 10^5$ counts):

ratio = 1.11765

htally mean = 1.054

% diff = 5.68

- The biggest difference is the gain factors scale from 1% difference to 4% difference.

- This can be helpful to see how and scale factors are needed as when each histograms

New Run/Fast trials (Re-testing statistics)

- **Data metrics to test:**

1.) μ_{ntally} (mean)

2.) σ_{ntally} (mean) (Lower std deviation can tell better Rel Cal)

Use $N = 5$ measurements

- try $m = 15$ trials runs for 3-test functions.

  - Each iteration increase 1% shifts.

% shifts = 1%, ... 15%

Test function #1

$$f(x) = \frac{a}{(b+x)^c}$$

trial Runs

Trial #1 :

- m → represents % of histogram shift.

m = 1.5% shift

- $\mu_{\text{ntally}} = 1.017$
- $\sigma_{\text{ntally}} = 0.01314 \approx 1.314\%$ error
- $N = 5$ bins
- $n \rightarrow$ number of events
  $n = 1 \times 10^6$ events
- $\dfrac{\sigma_{\text{ntally}}}{\sqrt{N}} = 0.00588$
  $\approx 0.587\%$ rel error

Trial #2:

- $m = 2.5\%$ shift difference

$M_{ntally} = 1.028$

$\sigma_{ntally} = 0.01421 \approx 1.42\%$ rel error

$N = 5$ bins

$\frac{\sigma_{ntally}}{\sqrt{N}} = 0.00635 \approx 0.635\%$ rel error

$n = 1 \times 10^6$ events

trial #3 :

- $m = 3.5\%$ shift differenc

$M_{tally} = 1.038$

$N = 5$ bins

$\sigma_{tally} = 0.01616 \approx 1.616\%$ rel error

$\frac{\sigma_{tally}}{\sqrt{N}} = 0.007227 \approx 0.723\%$ rel error

$n = 1 \times 10^6$ events

Trial #4 :

- $m = 4.5\%$ shift difference

$\mu_{tally} = 1.045$

$\sigma_{tally} = 0.01358 \approx 1.358\%$ rel error

$N = 5$ bins

$\sigma_{tally}/\sqrt{N} = 0.00607 \approx 0.607\%$ rel error

$n = 1 \times 10^6$ events

Trial #5:

- $m = 5.5\%$ shift difference

$\mu_{tally} = 1.06$

$\sigma_{tally} = 0.01287$

$\sigma_{tally}/\sqrt{N} = 0.005756$

$N = 5$

$n = 1 \times 10^6$ events

Trial #6:

- $m = 6.5\%$ shift difference

$$\mu_{tally} = 1.07$$

$$\sigma_{tally} = 0.01455$$

$$\frac{\sigma_{tally}}{\sqrt{N}} = 0.006507$$

$$N = 5$$

$n = 1 \times 10^{6}$ events

trial #7:

- $m = 7.5\%$ shift diff

$\mu_{tally} = 1.082$

$\sigma_{tally} = 0.01591$

$\frac{\sigma_{tally}}{\sqrt{N}} = 0.007115$

- (n is always; $n = 1 \times 10^6$ events
  N is always; $N = 5$)

Trial #8:

- $m = 8.5\%$ shift diff

$\mu_{tally} = 1.09$

$\sigma_{tally}/\sqrt{N} = 0.007576$

$\sigma_{tally} = 0.01694$

Trial #9 :

- $m = 9.5$ shift difference

$M_{tally} = 1.099$

$\frac{\sigma_{tally}}{\sqrt{N}} = 0.007303$

$\sigma_{tally} = 0.01633$

Trial #10 :

- $m = 10.5$ shift difference

$\mu_{tally} = 1.108$

$\sigma_{tally} = 0.01672$

$\frac{\sigma_{tally}}{\sqrt{N}} = 0.0074774$

Trial #11 :

- $m = 11.5$ shift difference

$\mu_{tally} = 1.117$

$\sigma_{tally} = 0.01822$

$\frac{\sigma_{tally}}{\sqrt{N}} = 0.00814823$

Trial #12:

- $m = 12.5$ shift difference

$\mu_{tally} = 1.119$

$\sigma_{tally} = 0.01703$

$\frac{\sigma_{tally}}{\sqrt{N}} = 0.007616$

Trial #13 :

- m = 13.5% shift difference

$$\mu_{tally} = 1.129$$

$$\sigma_{tally} = 0.01833$$

$$\frac{\sigma_{tally}}{\sqrt{N}} = 0.0081974$$

Trial #14:

- $m = 14.6$ shift diff

$\mu_{tally} = 1.135$

$\sigma_{tally} = 0.01556$

$\frac{\sigma_{tally}}{\sqrt{N}} = 0.00696$

Trial #15 :

- $m = 15.5\%$ shift diff

$\mu_{tally} = 1.139$

$\sigma_{tally} = 0.01789$

$\dfrac{\sigma_{tally}}{\sqrt{N}} = 0.008$

(7/17)

New Towerslope macro trials for:

$f_1(x) = \dfrac{a}{(b+x)^c}$, $f_2(x) = ae^{-x}$, $f_3(x) = ax^{-3}$

- T → number of trials
  T = 7 each.

- n → number of iterations of shift factor.
  n = 0.5, 1.0, ..., 3.5
  for every 0.1

- Edit Root file to save as png file to run multiple iterations.
  all on one macro.

Root file edits:

-) Call each root file trial 2 extension.
-) Do 16 htally measurements.
-) Shift factor I noticed can't be negative or close to zero.

Code Edits:

- Void Testslope(int stats, double shift_factor, string f_1, string f_2)

- String f_e = ".Png" (or ".Pdf")

- TCanvas *C1 = new TCanvas("c1")

- for(int j = 0; j < stats/7 ; shift_factor)

{ h2 → Fill(myexpo → GetRandom() * shift_factor)

3

```
• string save_Path1 = f_1 + f_e;
  C1→SaveAs(Save_Path1.c_str());

string SavePath2 = f_2 + f_e;
C2→SaveAs(savePath2.c_str());
```

7/25

New Towerslope tasks to do

1.) Make fit plots in Log Scale (TCanvas::SetLogY())

2.)

9/19

Towerslope Data collection 9/19/24

Instructions :

- $n = 1 \times 10^6$ stats/events
- $n = 1 \times 10^7$ stats/events
- $n = 1 \quad 10^8$ stats/events

1.) Histogram measurement of $x = 0.5 - 1.2$ MeV then $x = 1.5 - 3.2$ MeV

2.) Make TgraphErrors including All energy ranges function $\bar{x}$(shift-input).

- means - y
- Shifinp - x
- Error bars / (standard error of mean)

Questions: (RMS comparisons)

- For ~~error~~ no bars for RMS what uncertainty do I use? Or comparison of two RMS's?
- what/how do I include in htally A parameter for plotting?

3.) Repeat Process for Rhich and exp function.

4.) RMS plot vs. Inp and RMS vs. (pl) htally points. (htally includes errors)

9/21/24

Data/Results for Calibrations: L3, Rhich, exp

- $\underline{1 \text{ mill events}}$: $(n = 16)$

- $Inp = 0.75$
  $\bar{X} = 0.817$
  $\sigma = 0.0718$
  $\sigma_{std\text{-}err} = 0.01795$

- $Inp = 1.0$
  $\bar{X} = 1.003$
  $\sigma = 0.06407$
  $\sigma_{std\text{-}err} = 0.016017S$

- $I_{np} = 1.25$
  $\bar{x} = 1.174$
  $\sigma = 0.1329$
  $\sigma_{stderr} = 0.033225$

(Low E Range: [0.5 - 1.2 GeV])

- $I_{np} = 0.75$
  $\bar{x} = 0.7924$
  $\sigma = 0.1965$
  $\sigma_{stderr} = 0.049125$

- $Inp = 1.0$

  $\bar{X} = 0.8013$

  $\sigma = 0.1839$

  $\sigma_{std} = 0.045975$

- $Inp = 1.25$

  $\bar{X} = 0.8407$

  $\sigma = 0.2059$

  $\sigma_{std} = 0.05147S$

  (High E Range: [1.4-3] GEV)

• <u>10 mill events</u>:

C LowR: 0.5–1.2 GEV:

• $I_{np} = 0.75$

$\bar{X} = 0.7643$

$\sigma_{std} = 0.00679$

• $I_{np} = 1.0$

$\bar{X} = 0.9942$

$\sigma_{std} = 0.00699$

• $I_{np} = 1.25$

$\bar{X} = 1.236$, $\sigma_{std} = 0.00627$

(H EngR ; 1.4-3 GeV) :

- $Inp = 0.75$

  $\bar{X} = 0.8883$

  $\sigma_{err} = 0.0136$

- $Inp = 1.0$

  $\bar{X} = 0.9477$

  $\sigma_{err} = 0.00631$

- $Inp = 1.25$

  $\bar{X} = 1.004$

  $\sigma_{err} = 0.0150$

• 100 million events :

(LowR : 0.5-1.2 GeV) :

• Inp = 0.75

$\bar{X}$ = 0.7517

σ_{err} = 0.00106

• Inp = 1.0

$\bar{X}$ = 1.004

σ_{err} = 0.00252

• Inp = 1.25

$\bar{X}$ = 1.252 , σ_{err} = 0.00221

(HighR : 1.4-3 GeV)

- $\mathrm{Inp} = 0.75$
  $\bar{x} = 0.7798$
  $\sigma_{err} = 0.00690$

- $\mathrm{Inp} = 1.0$
  $\bar{x} = 0.9851$
  $\sigma_{err} = 0.00440$

- $\mathrm{Inp} = 1.25$
  $\bar{x} = 1.233$
  $\sigma_{err} = 0.00582$

• 5 million events :

• Input = 0.75

$\bar{X}$ = 0.7667

σ_{err} = 0.00946

• Inp = 1.0

$\bar{X}$ = 0.9875

σ_{err} = 0.0122

• Inp = 1.25

$\bar{X}$ = 1.24

σ_{err} = 0.0119

(Low Range : 0.5 - 1.2 GeV)

- Input = 0.75

  $\bar{x}$ = 0.859

  σ_{err} = 0.0206

- Input = 1.0

  $\bar{x}$ = 0.928

  σ_{err} = 0.0143

- Input = 1.25

  $\bar{x}$ = 0.984

  σ_{err} = 0.0136

(High R: 1.4-3.0 GeV)

Fit Parameters extraction

1 million events:

Low R: $P1 = 1.25 \pm 0.0046$
(0.75 shift)

Low R: $P_1 = 0.989 \pm 0.0393$
(1.0 shift)

Low R
(1.0 shift)