Optimal Photon Cuts v3 - Updates

+

resolution effects

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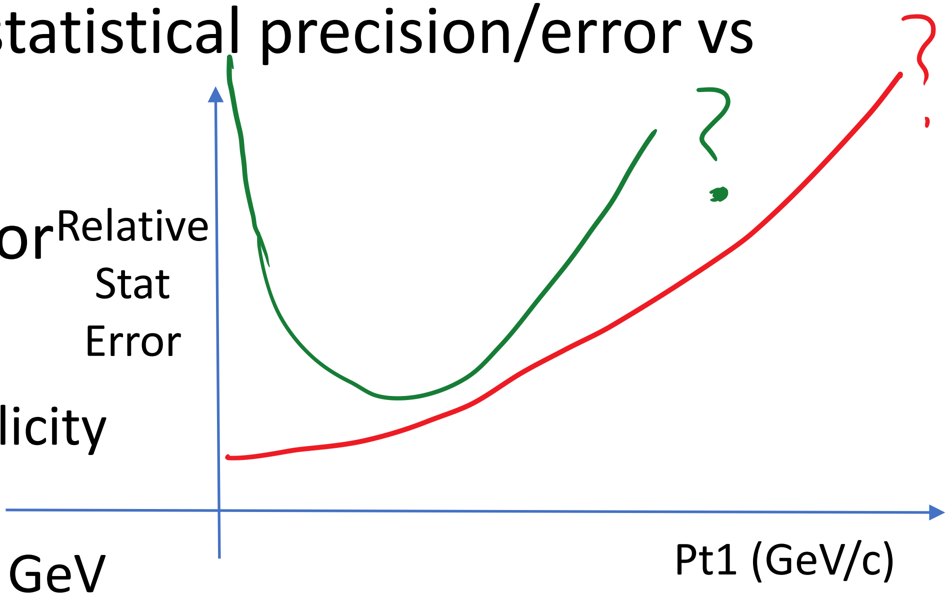
Review: Optimizing energy cuts

as per last wk's discussion this will be focus of last large scale embedding tests

- Two goals:
- 1) Peak fitting robustness to eliminate/minimize human interaction each iteration
  - Most important consideration is S/B (B is mostly combinatoric background)
  - Drives cuts towards high energy decay photons to get good S/B
- 2) Maximize statistical precision per event to minimize number of events needed
  - Drives cuts towards lower energy … e.g. lower than fit considerations
  - statistical precision of fit: S/B: if Comb. Bkg increases fast enough, faster than Signal, as energy is lowered, there may be optimal energy cut values for optimizing statistical precision
- Address 2): want a fairly simple estimator of relative statistical precision/error vs energy cut values without relying on *actual* fitting
  - too slow to do actual analyses for many cut values
- With MDC2 pass used so far, minimum photon E cut for either photon is **now 0.6** this photon 2 E ("E2")
  - There are also energy asymm α cuts

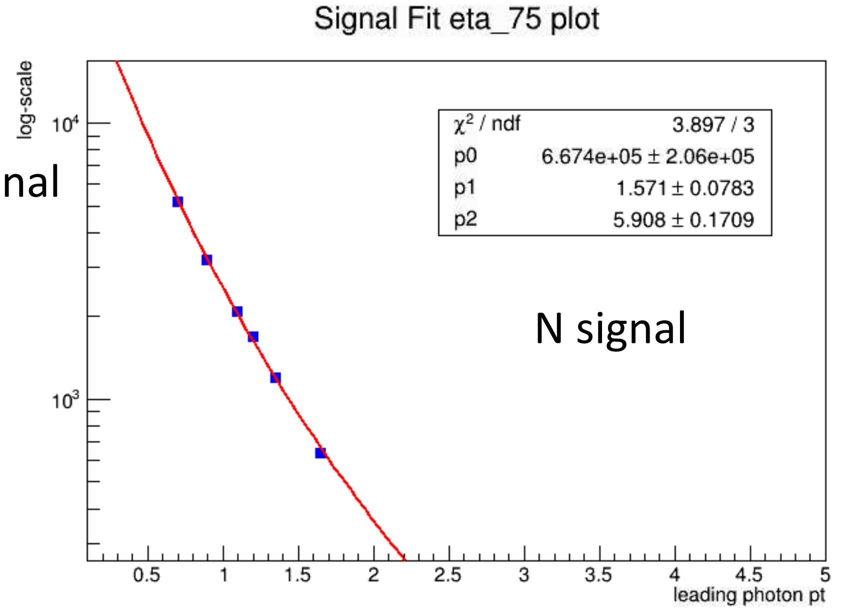
  (α= |E1-E2|/(E1+E2)) but leave this as const < 0.5 for simplicity
- **Vary only photon1 E ("E1" – actually pt1) cuts**
  - Pi0 Pt/energy is about ~ E1+1.1 e.g. for 1.3, pi0 pt/E ~= 2.4 GeV



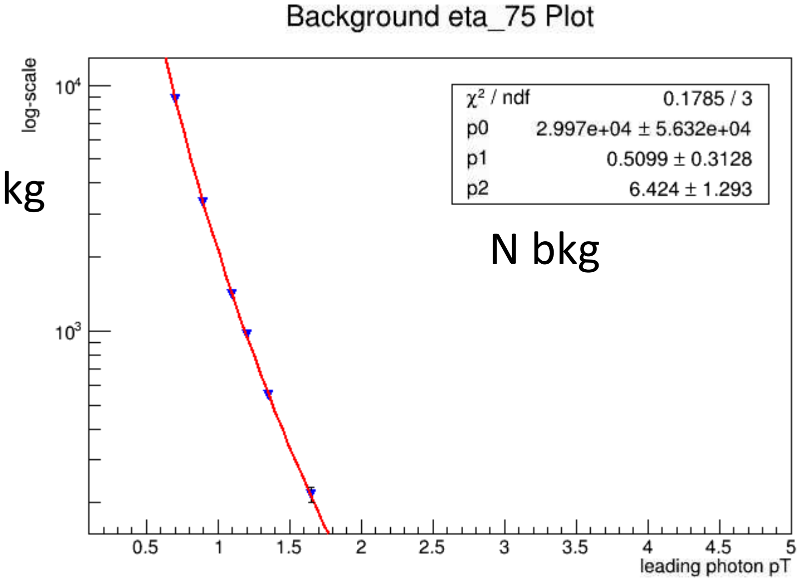
Review: Fit Signal and Background as fn of energy

- For 6 E1 cut values: estimate S and B <u>counts</u> at all cut values with simple sideband estimates
  - Avg low and high band = Bkg
  - Peak integral = S+B
  - S = Peak integral - Bkg
- Fit dependence of N signal and N bkg vs E1 (actually Pt1)
  - **Starting in last week's results more realistic**
  - **e.g. (modified) power law dN/dE = p0/(p1+E1)^p2**
- Extract Fit Fns of S(E1) and B(E1) at all E1.
- We want to minimize stat error of peak mean (gaus "p1" param—but need formula to avoid actual fit)
  - not directly minimizing S/B
  - **Need estimator fn f(S,B) of peak mean error**

N signal



N bkg



REVIEW (Aug 8 pres) : Estimator fn

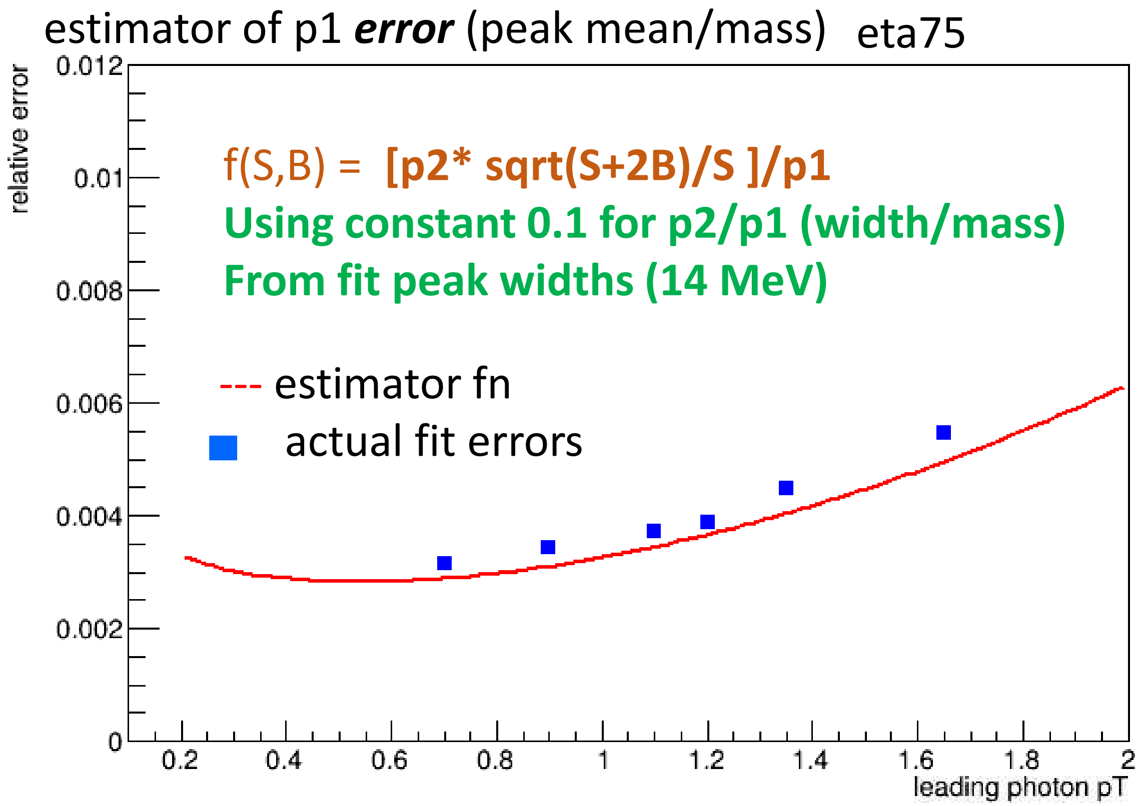
- Naïve relative error of peak **yield** assuming poisson sqrt(S+B)/S
- Better formula known (e.g. CKB thesis*) to be ∝ sqrt(S+2B)
- Found that **g(S,B) = sqrt(S+2B)/S** best estimator of peak **yield** relative error = 1/ sqrt("N_measments")
- For peak **mean** error, use std error of mean formula : std_dev / sqrt("N_measurements")
- peak mean relative error → divided by ~0.135 gaus fit parameters : **f(S,B) = [p2* sqrt(S+2B)/S]/p1**
  - comparison to p1 error from fit, relatively good, ~5- 10% below actual errors– across several cut, eta values

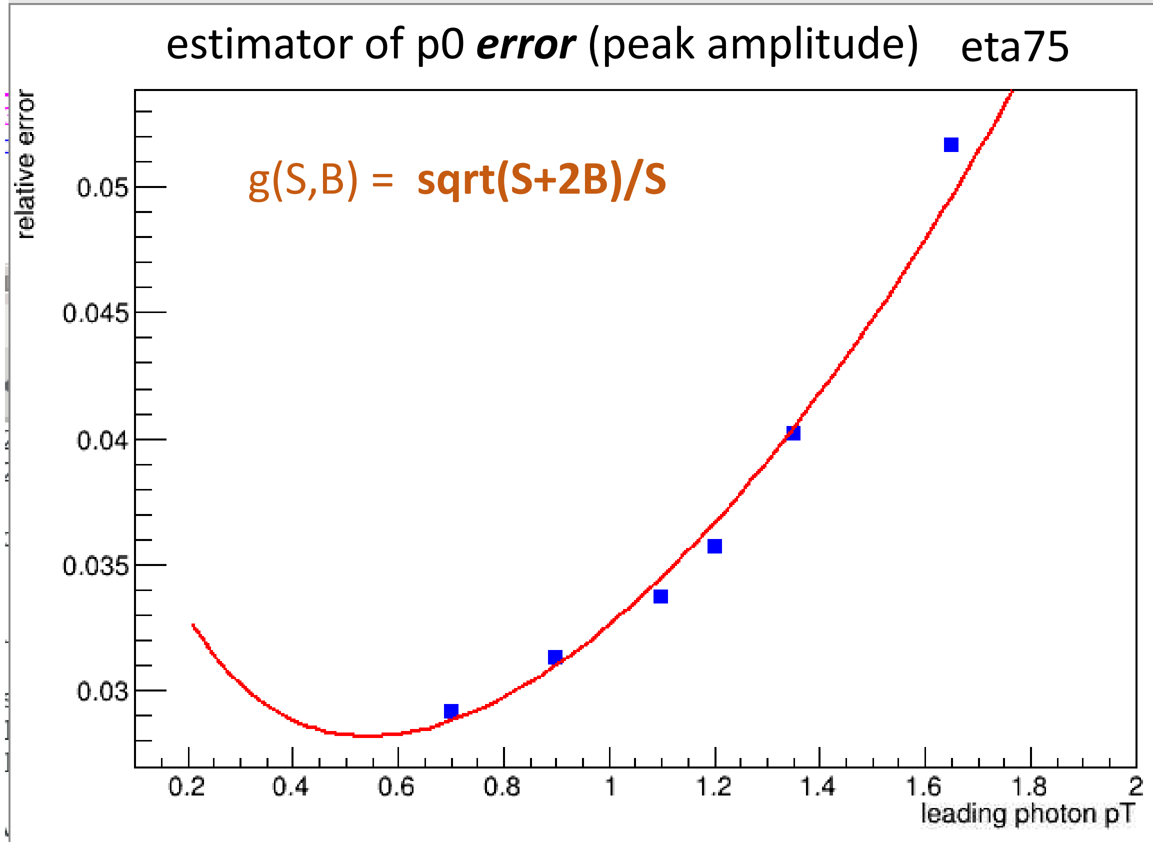
(We made table of various estimator fn's, to determine visually that the above estimator fn's worked roughly the best)

	rison of p0			Comparison of p1					
histo number	relerr3 = sqrt(S+B)/(S+B)	relerr4 = sqrt(S+2B) / S	relerr5 = sqrt(S+2B) / (S+2B)	relerr1_p1 = (p2/p1) * (1/sqrt(S))	rel_errfit = (fit error on p1) / p1	relerr2_p1 = (p2/p1)*(sqrt(S+B)/S)	relerr3_p1 = (p2/p1) * (sqrt(S+B)/(S+B))	relerr4_p1 = (p2/p1) * (sqrt(S+2B)/S)	relerr5_p1 = (p2/p1) * (sqrt(S+2B)/(S+2B))
eta_25 (1.1, 1.1)	0.009970	0.043895	0.007638	0.0019744	0.0567241	0.0036263059	0.00107499	0.004733070	0.00082362
eta_25 (1.2, 1.2)	0.011793	0.045553	0.009137	0.0021144	0.0056165	0.0036578294	0.00122224	0.004721088	0.00094698
eta_25 (1.1, 1.3) ??	0.009970	0.043895	0.007638	0.0019744	0.0056724	0.0036263059	0.00107499	0.004733070	0.00082362
eta_25 (1.35, 1.35)	0.014904	0.046890	0.011789	0.0024238	0.0056957	0.0038237317	0.00153646	0.004833927	0.00121537
eta_25 (agg4)	0.033352	0.061947	0.028496	0.0043933	0.0075036	0.0055344146	0.00348748	0.006477524	0.00297971
eta_50 (1.1, 1.1)	0.007549	0.050817	0.005626	0.0017593	0.0067539	0.0039405244	0.00078550	0.005287739	0.00058537
eta_50 (1.2, 1.2)	0.008849	0.049880	0.006662	0.0018941	0.0064750	0.0039019886	0.00091944	0.005182992	0.00069219
eta_50 (1.1, 1.3) ??	0.007549	0.050817	0.005626	0.0017593	0.0067539	0.0039405244	0.00078550	0.005287739	0.00058537
eta_50 (1.35, 1.35)	0.011171	0.052735	0.008513	0.0021244	0.0067229	0.0040292016	0.00112006	0.005287341	0.00085354
eta_50 (agg4)	0.029617	0.062865	0.024720	0.0042102	0.0076105	0.0056038257	0.00316321	0.006714137	0.00264011
eta_75 (1.1, 1.1)	0.009381	0.037073	0.007253	0.0018497	0.0053252	0.0032333813	0.00105816	0.004181874	0.00081816
eta_75 (1.2, 1.2)	0.011078	0.038195	0.008678	0.0020205	0.0054065	0.0033204617	0.00122948	0.004238924	0.00096309
eta_75 (1.1, 1.3) ??	0.009381	0.037073	0.007253	0.0018497	0.0053252	0.0032333813	0.00105816	0.004181874	0.00081816
eta_75 (1.35, 1.35)	0.014028	0.040179	0.011219	0.0023581	0.0053513	0.0035689605	0.00155800	0.004462570	0.00124601
eta_75 (agg4)	0.034021	0.054416	0.029954	0.0047251	0.0069596	0.0056074301	0.00398166	0.006368645	0.00350575
eta_90 (1.1, 1.1)	0.013238	0.040645	0.010501	0.0022450	0.0048840	0.0035034480	0.00143859	0.004416818	0.00114110
eta_90 (1.2, 1.2)	0.014807	0.039247	0.011960	0.0023939	0.0049712	0.0035025978	0.00163611	0.004336561	0.00132147
eta_90 (1.1, 1.3) ??	0.013238	0.040645	0.010501	0.0022450	0.0048840	0.0035034480	0.00143859	0.004416818	0.00114110
eta_90 (1.35, 1.35)	0.018206	0.040847	0.015061	0.0028361	0.0054051	0.0038638335	0.00208176	0.004670638	0.00172216
eta_90 (agg4)	0.042258	0.064684	0.037569	0.0068702	0.0099632	0.0080144949	0.00588922	0.009014716	0.00523579

*Christian K. Boesing PHENIX thesis https://zenodo.org/record/4267413

Repeated from last time: Results of Estimator Fn vs Pt1 - w/o E reso

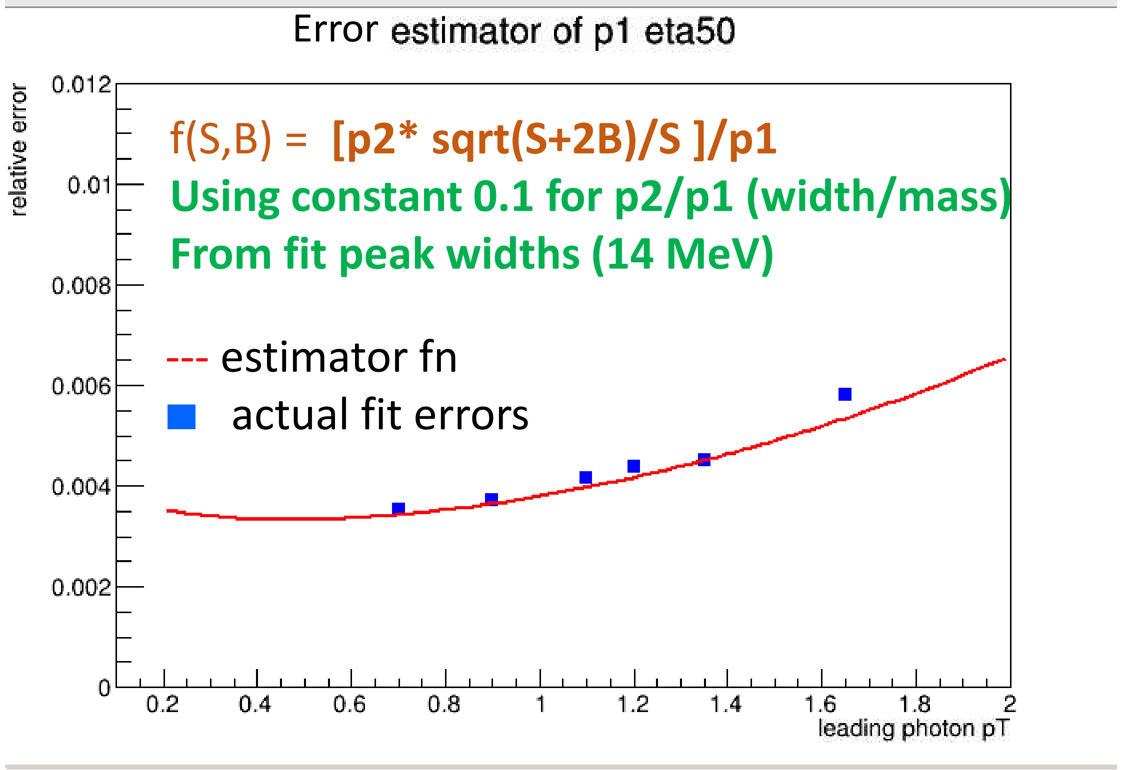


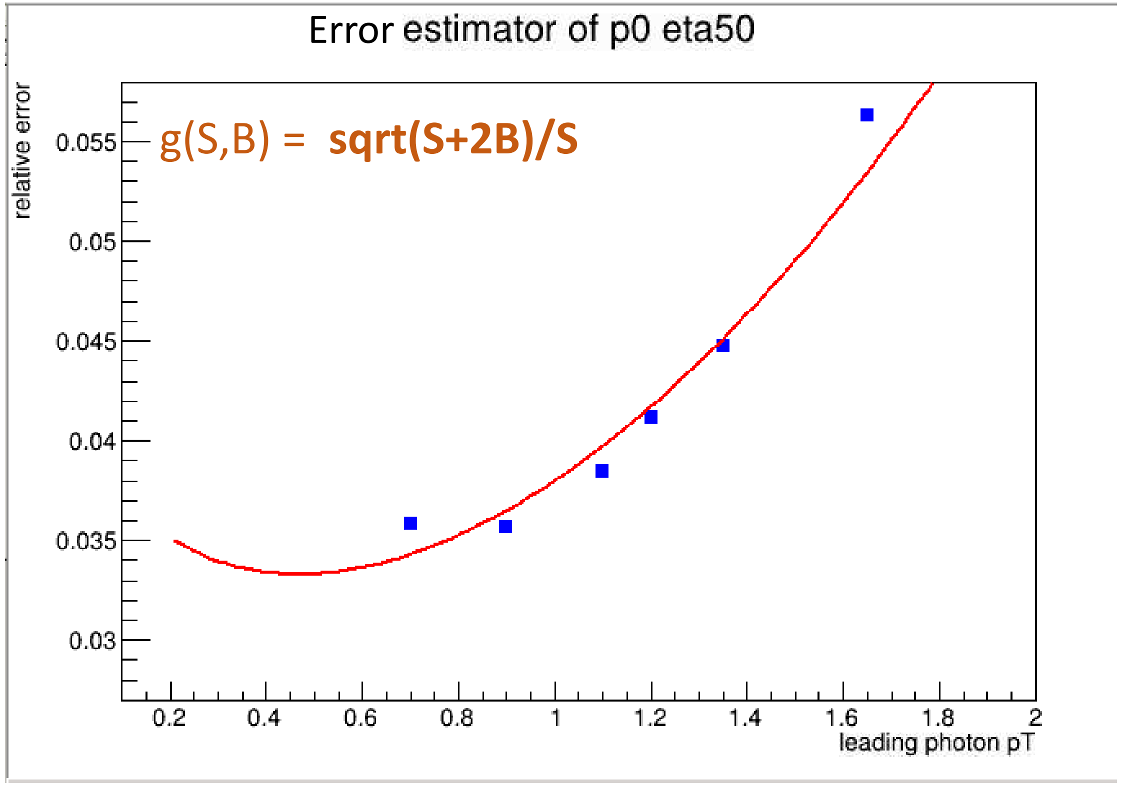


- Effect of lower cuts, and better S, B, fit functions and more points **allows reliable extrapolation over ~whole range** shown
- Generally estimator function g does a little better for simpler peak amplitude, f slightly underestimates p1 (mass), but has correct shape
- Reminder: note that Eresolution would cause p2/p1 in f(S,B) to increase at low energy/pt – ignore that effect here
  - Therefore this shows ONLY effect of statistics – E resolution effects later

- **CONCLUSION** there is a minimum-error (optimal cut value) but- shallow, additional stat precision gain small compared to 0.9-1.2-ish region – therefore fitting reliability (better at pt1 >= ~1 GeV) should be driver for choosing cut values for TowByTow ana

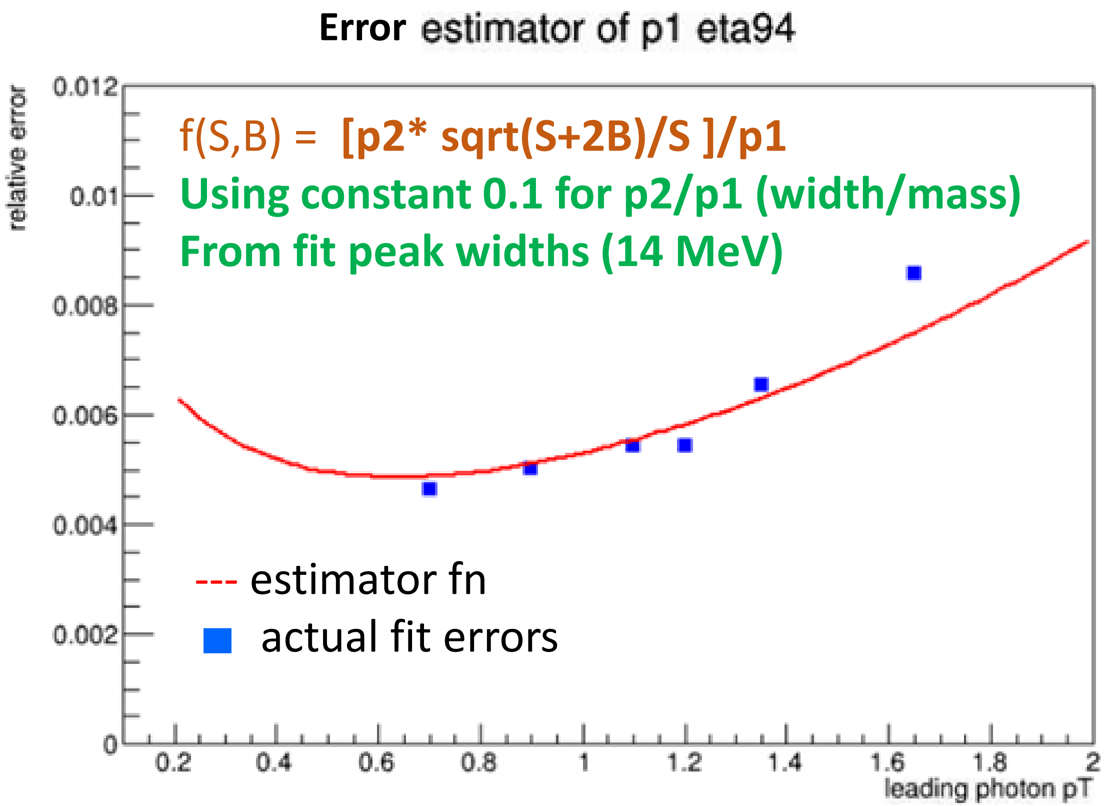
Another Repeat from last time: eta slice eta 50 ~ η = 0 (mid-rapidity)

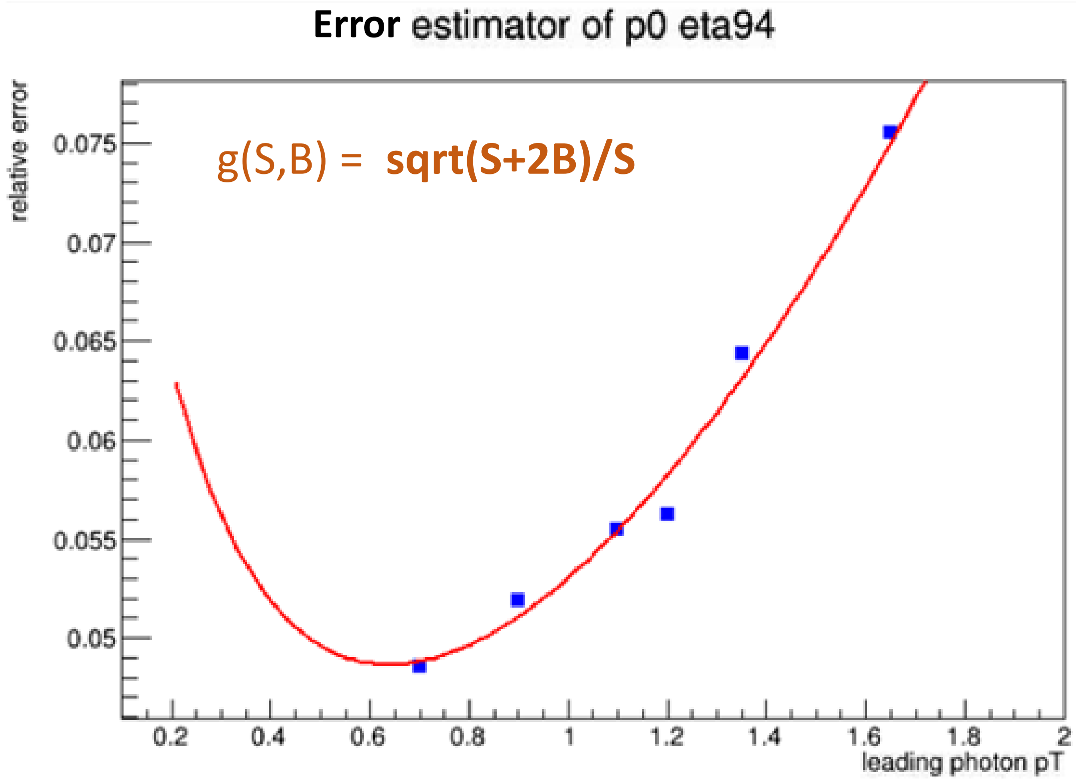




- Very similar results overall at mid-rapidity
- We are only looking to verify previous conclusion roughly detailed location of minimum doesn't matter
- Changes very little with pseudo-radidty (eta) – as expected since Signal statistics should depend on pt ~independently of eta

NEW : Estimator fn for eta slice near edge of detector: eta~+1 (eta94)

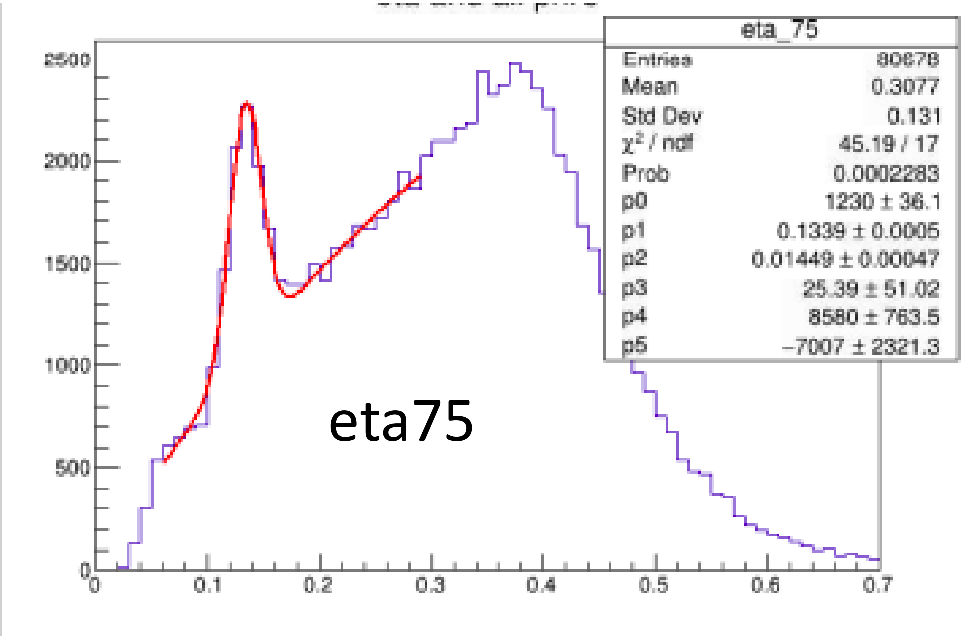




- Also very similar results overall to smaller eta results
- Note that overall relative stat precision less in this study because it was run quickly last week after presentation over a smaller fraction of the statistics (only function shapes matter)

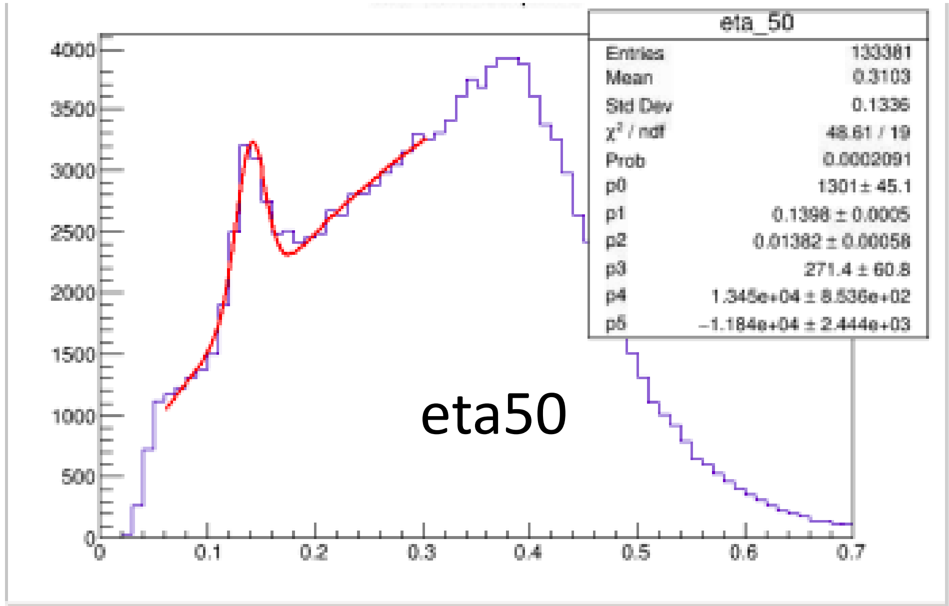
Mass plots photon pt1 cut = 0.7 GeV/c, eta75 (eta~0.5) eta50 (eta ~0)

This is 0.7 pt1 cut → lowest, worst S/B case ---




```
=====================
N1 counts: 3637
N2 counts: 13932
N3 counts: 13905
p0: 1230.28
p0 error: 36.0887
p1: 0.133944
p1 error: 0.000452193
p2: 0.0144931
p2 error: 0.000465436
==================
Signal: 5161
Background: 8771
root [1]
```

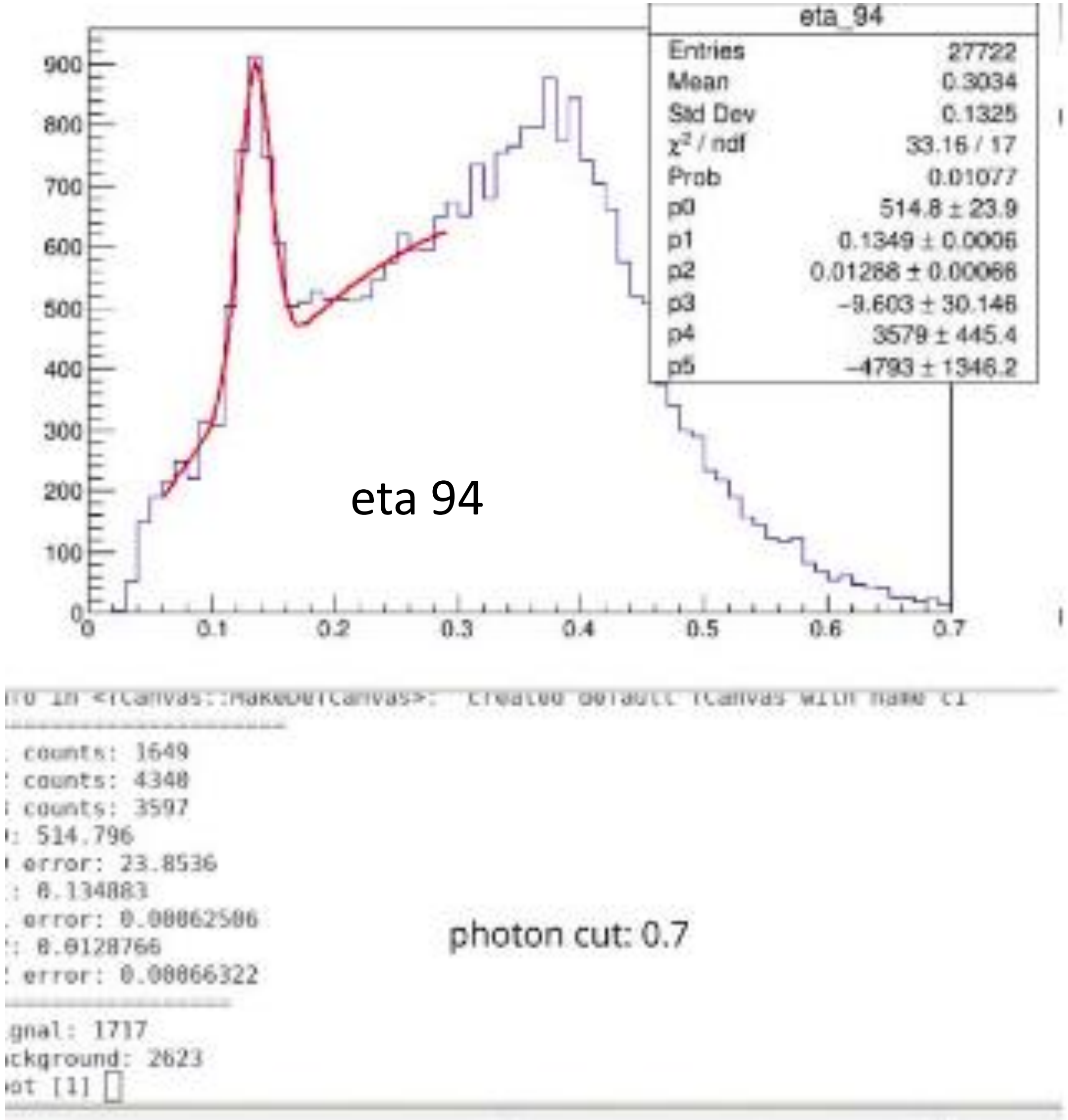
photon cut: 0.7




```
Processing macro_to_get_data_for_google_sheet.C("corr_v14_0.7.root", 50)...
Info in <TCanvas::MakeDefCanvas>:  created default TCanvas with name c1
=====================
N1 counts: 8695
N2 counts: 19929
N3 counts: 20763
p0: 1300.99
p0 error: 45.1052
p1: 0.139826
p1 error: 0.000528371
p2: 0.013824
p2 error: 0.000582144
==================
Signal: 5200
Background: 14729
root [1]
```

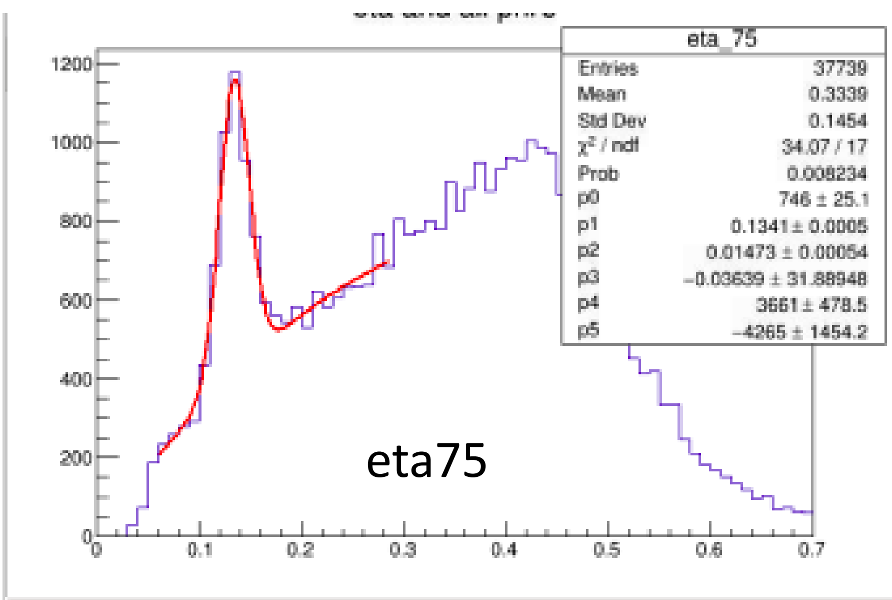
photon cut: 0.7

Mass Plot Eta 94 (eta =~+1.0), pt1 cut = 0.7 GeV/c



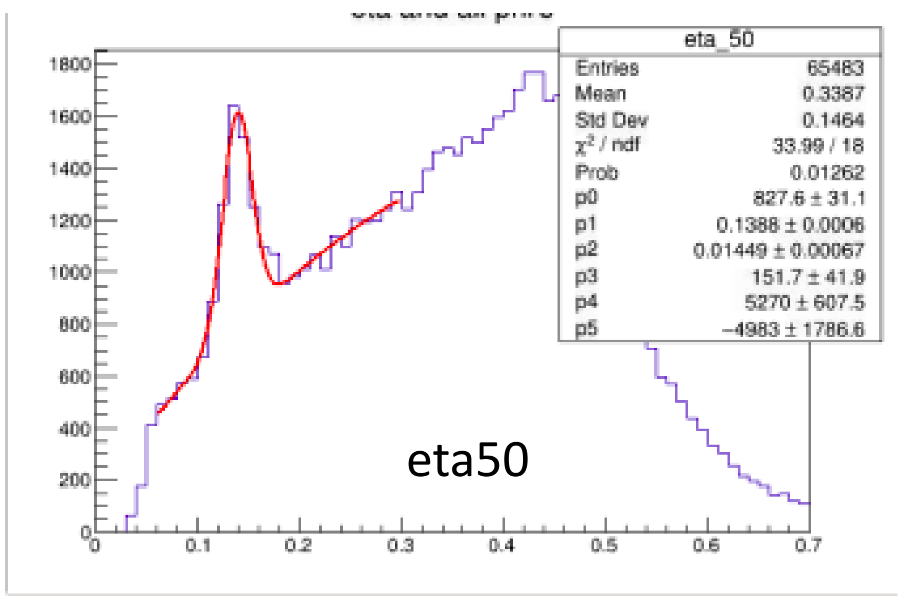
slightly better energy/mass resolution at high eta

pt1 cut= 0.9 mass distributions




```
Processing macro_to_get_data_for_google_sheet.C("corr_v14_0.9.root", 75)...
Info in <TCanvas::MakeDefCanvas>:  created default TCanvas with name c1
======================
N1 counts: 1355
N2 counts: 6493
N3 counts: 5295
p0: 746.007
p0 error: 25.1044
p1: 0.134139
p1 error: 0.000507345
p2: 0.0147345
p2 error: 0.00053771
==================
Signal: 3168
Background: 3325
root [1]
```

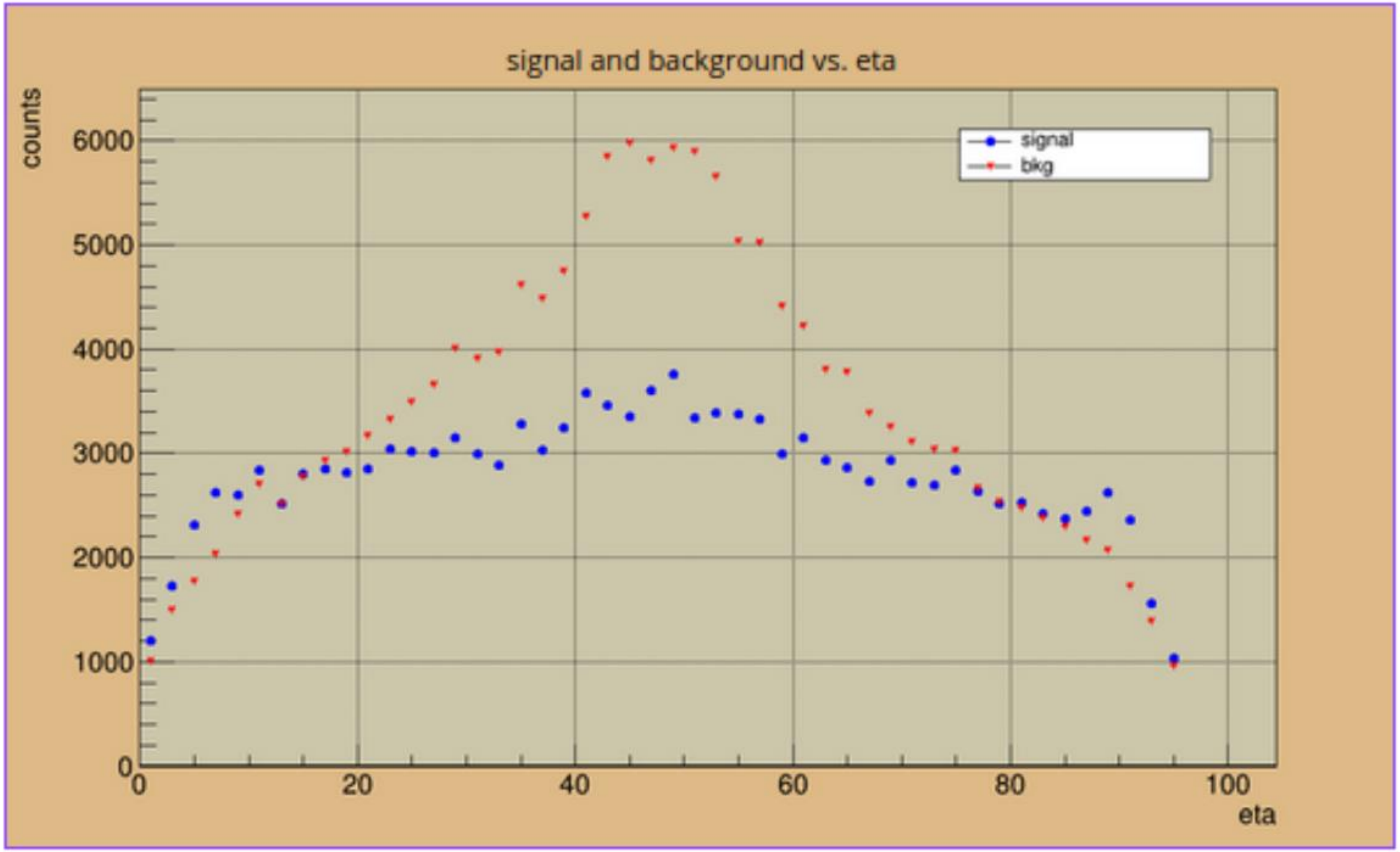
photon cut: 0.9




```
Processing macro_to_get_data_for_google_sheet.C("corr_v14_0.9.root", 50)...
Info in <TCanvas::MakeDefCanvas>:  created default TCanvas with name c1
======================
N1 counts: 3505
N2 counts: 9398
N3 counts: 8348
p0: 827.623
p0 error: 31.088
p1: 0.138813
p1 error: 0.000574499
p2: 0.0144878
p2 error: 0.000667771
==================
Signal: 3471.5
Background: 5926.5
root [1]
```

photon cut: 0.9

Signal and Background counts as a function of rapidity



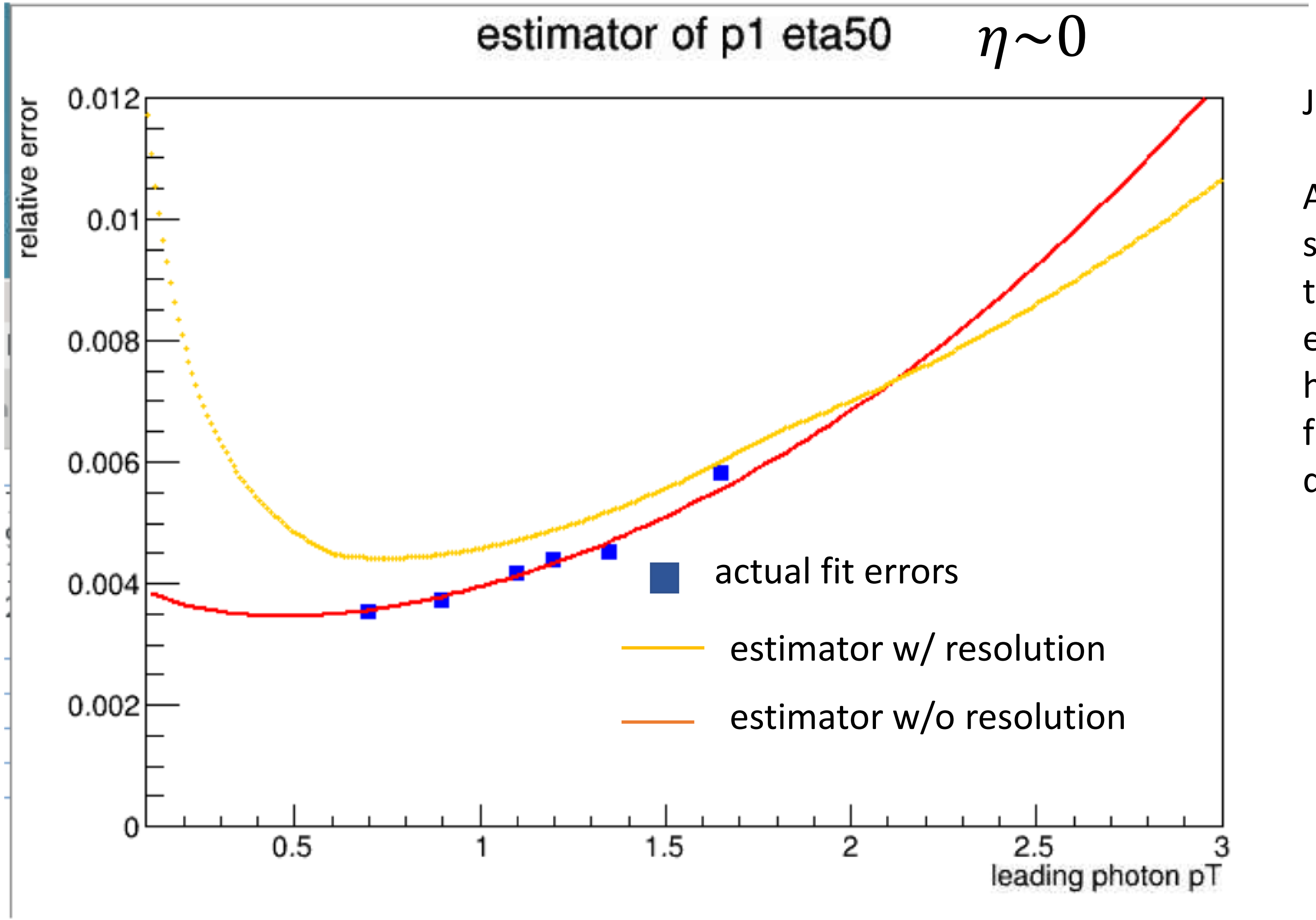
leading **PHOTON CUT: 0.9**

Signal pi0 flat as expected w/ eta (because of pt cut)

We believe peaking of bkg at eta ~0 is mostly due to alpha cut increasing min E2 (partner E), because E1 must increase (due to cut on pt1)
– higher E2 → lower stats

-still verifying

PREVIEW: Estimator including energy resolution effects



Justin (F) will present this

As expected only strengthens conclusion that anywhere in the expected cut value area has similar stat precision, fitting reliability should determine cut value