THE GEORGE WASHINGTON UNIVERSITY
WASHINGTON, DC

$K_L + p \rightarrow \pi^+ + \Lambda$

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K LONG FACILITY

Jefferson Lab

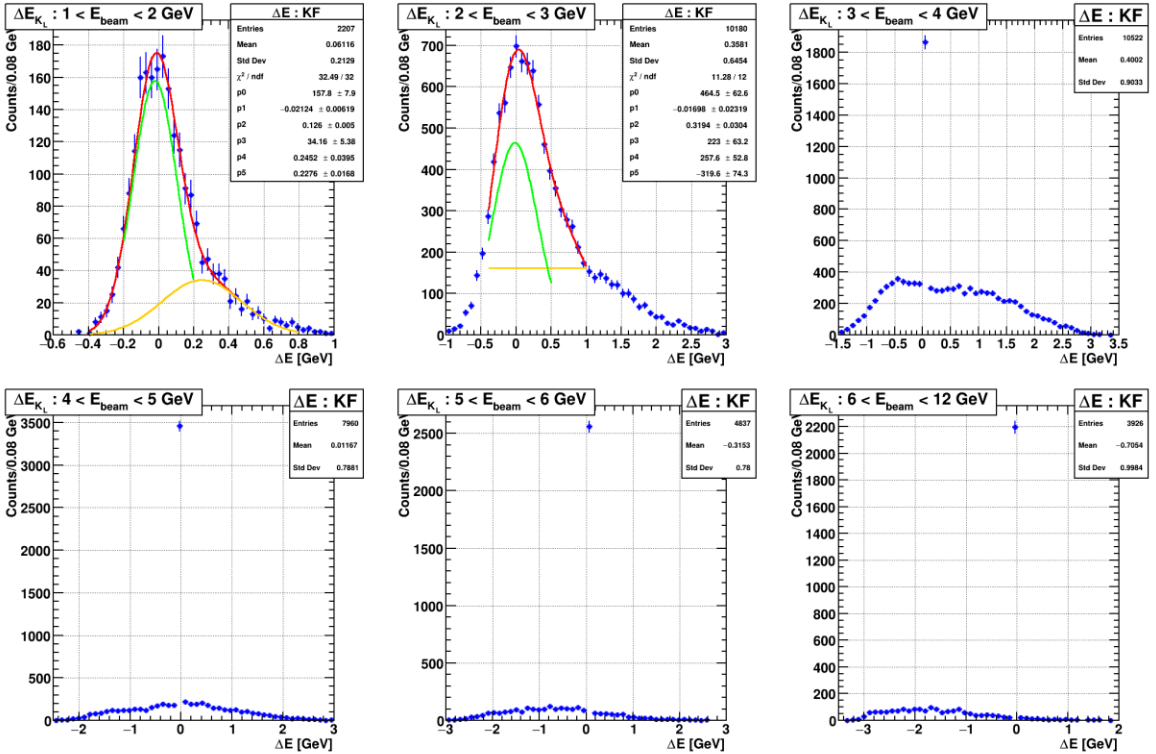
KL4 RXN and Generating Steps

- Kl4 : $K^0_L + p \rightarrow \pi^+ + \Lambda$
  - $\Lambda \rightarrow p + \pi^-$ (63.9%) ; Current priority
  - $\Lambda \rightarrow n + \pi^0$ (35.8%)
- Generated histograms/root files (Monitoring Histograms, ReactionFilter, mcthrown_tree)
  - hd_root --nthreads=8 -PPLUGINS=PEVENTRFBUNCH:USE_TAG=KLong -PVERTEX:USEWEIGHTEDAVERAGE=1 -PPLUGINS=monitoring_hists foo_smeared.hddm
  - hd_root --nthreads=8 -PPLUGINS=PEVENTRFBUNCH:USE_TAG=KLong -PVERTEX:USEWEIGHTEDAVERAGE=1 -PPLUGINS=ReactionFilter –PReaction1=10_14__8_18 foo_smeared.hddm
  - hd_root --nthreads=8 -PPLUGINS=PEVENTRFBUNCH:USE_TAG=KLong -PVERTEX:USEWEIGHTEDAVERAGE=1 -PPLUGINS=mcthrown_tree foo_smeared.hddm

BEAM ENERGY RESOLUTION AS A FUNCTION OF BEAM ENERGY : KF

Resolutions before Sean’s recent update

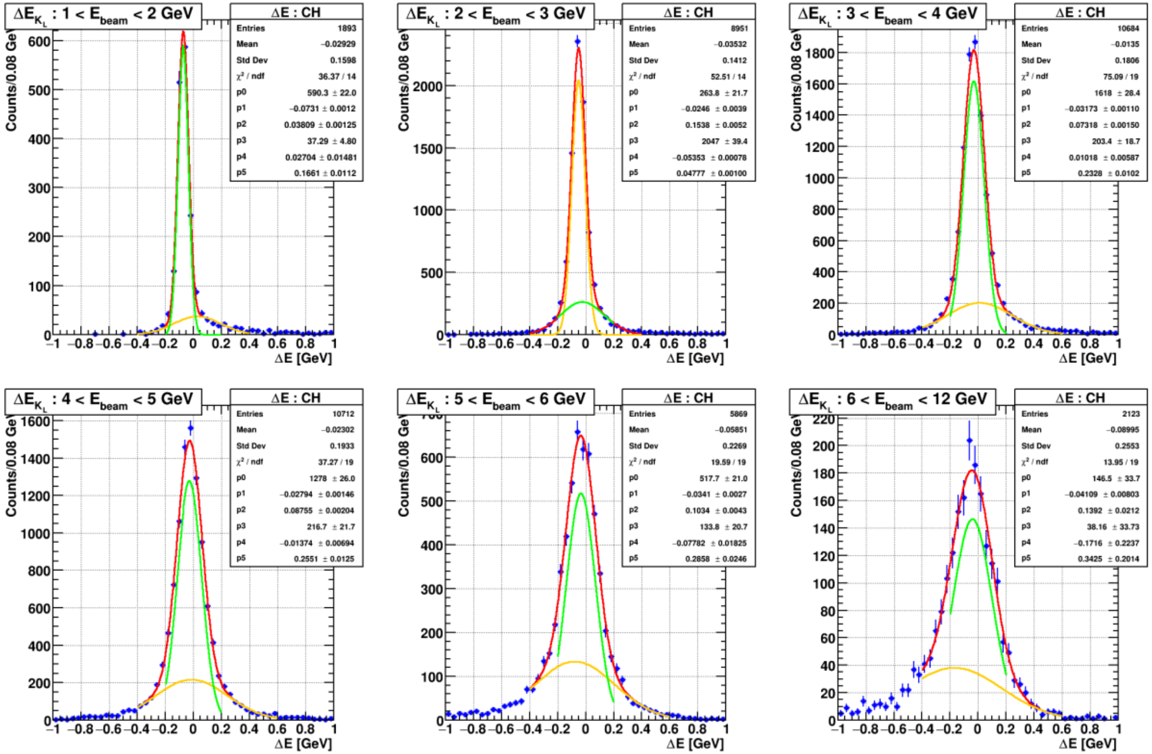
- Above 3 GeV, the resolution is essentially a delta function with a background
- Below 3 GeV
  - Width is 0.126 GeV for 1 < E < 2 GeV
  - Width is 0.319 GeV for 2 < E < 3 GeV
  - Both have a long tail toward higher dE



Beam Energy Resolution as a function of Beam Energy : Measured

Resolutions before Sean's recent update

- The width increases as energy increases, going from 0.03 GeV in the lowest energy bin to 0.1 GeV in the 5 < E < 6 GeV bin and 0.13 GeV in the E > 6 GeV bin.
- Consequently, the amount of background also increases with energy.



Channels of Interest

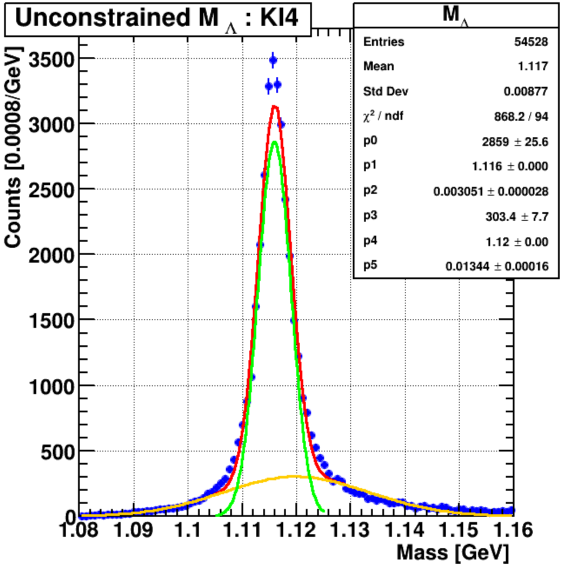
1M unconstrained M_{Λ} events were generated for KL4, Kl3, and Kl6. 100k with unconstrained M_{Ks} for Kl2.

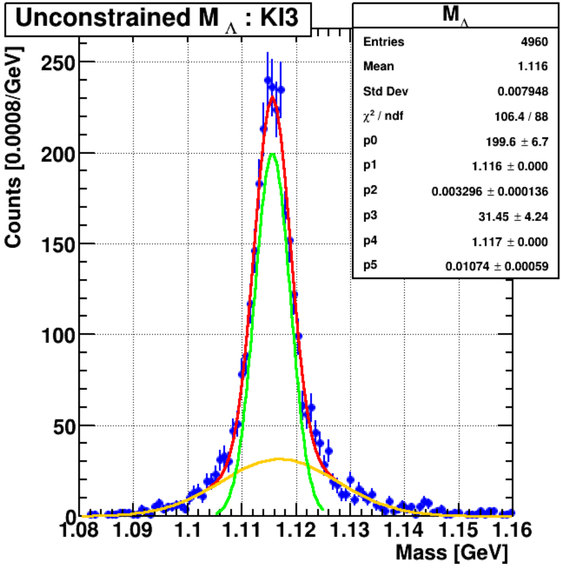
- Signal(**Kl4**) : $K_L + p \rightarrow \pi^+ + \Lambda$; $\Lambda \rightarrow \pi^- + p$
  - Detected particles (charged decay) : $\pi^+ + \pi^- + p$
- Principal Background(**Kl6**) : $K_L + p \rightarrow \pi^+ + \Sigma^0$; $\Sigma^0 \rightarrow \gamma + \Lambda$; $\Lambda \rightarrow \pi^- + p$
  - Detected particles (charged decay) : $\pi^+ + \pi^- + p + \gamma$
  - γ, X kinematic variables
- Ancillary Background(**Kl3**) : $K_L + p \rightarrow K^+ + \Xi^0$; $\Xi^0 \rightarrow \pi^0 + \Lambda$; $\Lambda \rightarrow \pi^- + p$ and $\pi^0 \rightarrow 2\gamma$
  - Detected particles (charged decay) : $\pi^- + p + 2\gamma + K^+$
  - π^+, K^+, γ/π^0, X kinematic variables
- Ancillary Background(**Kl2**) : $K_L + p \rightarrow K_s + p$; $K_s \rightarrow \pi^+ + \pi^-$
  - Detected particles (charged decay) : $\pi^- + \pi^+ + p$
  - Mass of $(\pi^- + \pi^+)$, mass of $(\pi^- + p)$, displaced vertex

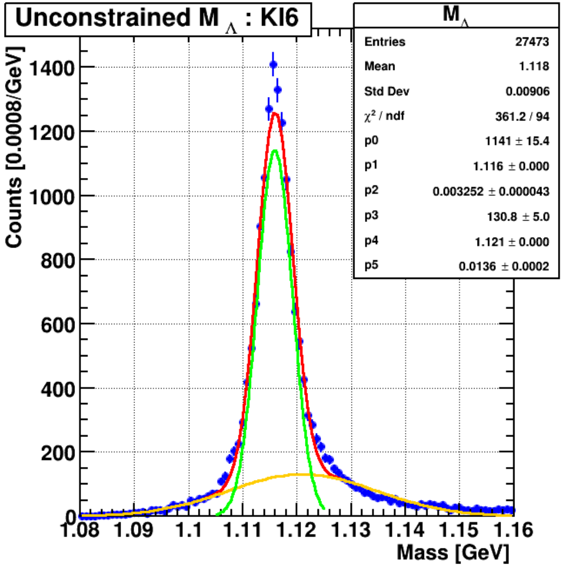
Reaction	Statistics (events)
$K_L p \rightarrow K_S p$	2.7M
$K_L p \rightarrow \pi^+ \Lambda$	7M
$K_L p \rightarrow K^+ \Xi^0$	2M
$K_L p \rightarrow K^+ n$	60M
$K_L p \rightarrow K^- \pi^+ p$	7M

Lambda Mass Distributions for Signal and Background

- The only significant difference between the peaks is that the signal(kl4) has a width about 9% smaller than the backgrounds, i.e. 0.03 vs 0.032 GeV.

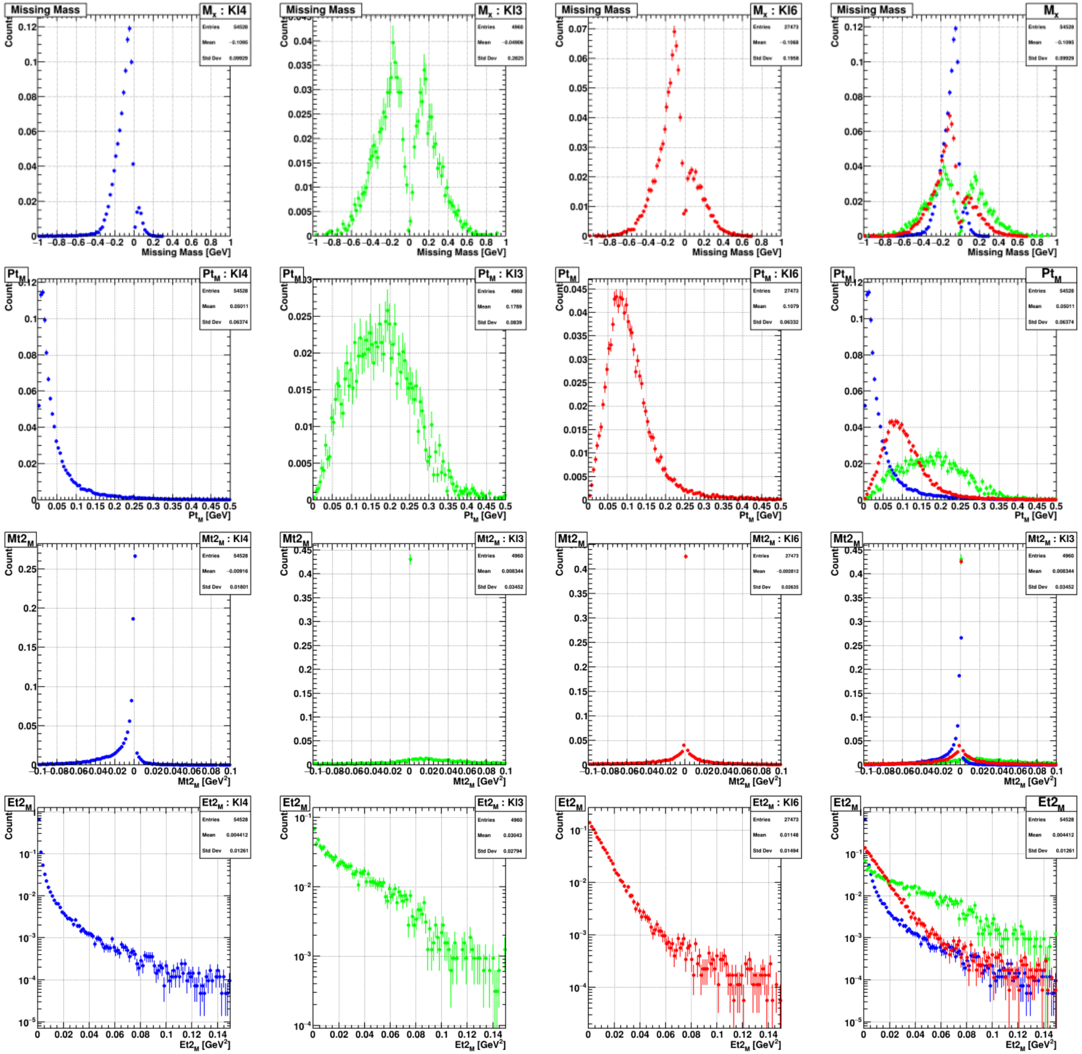






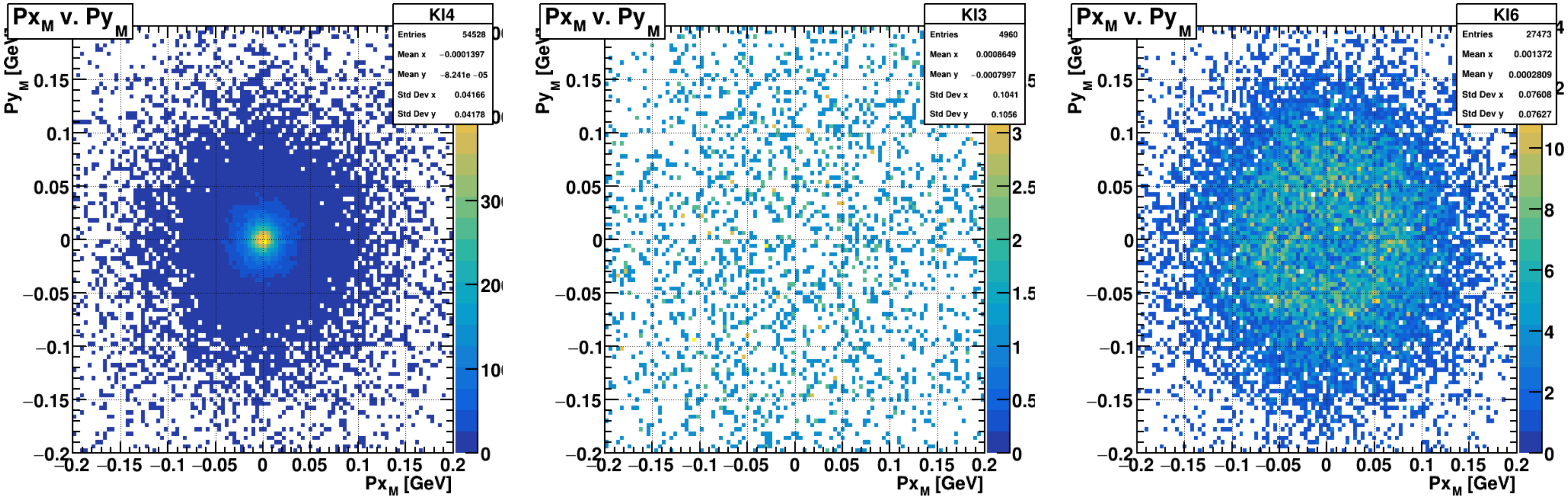
Variables of interest

- Variables related to X, show the largest separation between the signal and the background distributions.
- The transverse momentum, mass and energy show the most promise.
  - $p_T^2 = p_x^2 + p_y^2$
  - $M_T^2 = E^2 - p_z^2$
  - $E_T^2 = E^2 * p_T^2/p^2$



Variables of interest 2

- The px and py momenta of the X particle are also important for discrimination.



First Order Cuts

- The first look at the cuts to remove background are broken up by variable and cuts that leave 90% and 95% of the signal.
- The tables to the left list the cuts, variables, and the percentage of the signal and backgrounds that remain after the cut.

90% Cut

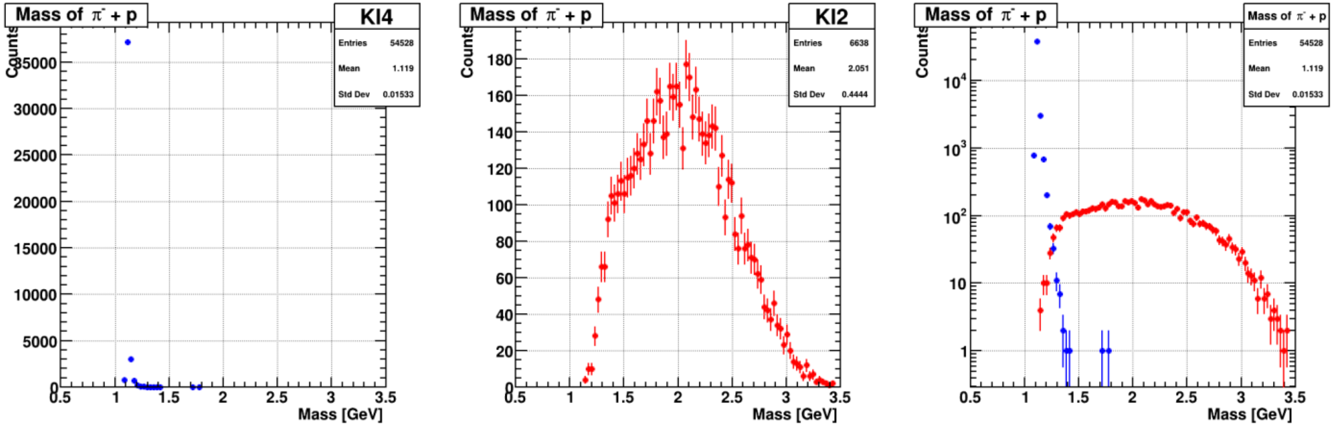
Variable	Cut Value	Kl4	Kl6	Kl3
Et^2	0.01	0.90	0.62	0.29
P_t	0.1183	0.90	0.66	0.26
M_t^2	0.000333	0.92	0.73	0.61
M_x	0.016	0.90	0.70	0.56
P_xP_y Rect.	0.088	0.90	0.55	0.28

95% Cut

Variable	Cut Value	Kl4	Kl6	Kl3
Et^2	0.22	0.95	0.87	0.49
P_t	0.18	0.95	0.90	0.52
M_t^2	0.003	0.95	0.78	0.62
M_x	0.053	0.95	0.82	0.63
P_xP_y Rect.	0.122	0.95	0.80	0.48

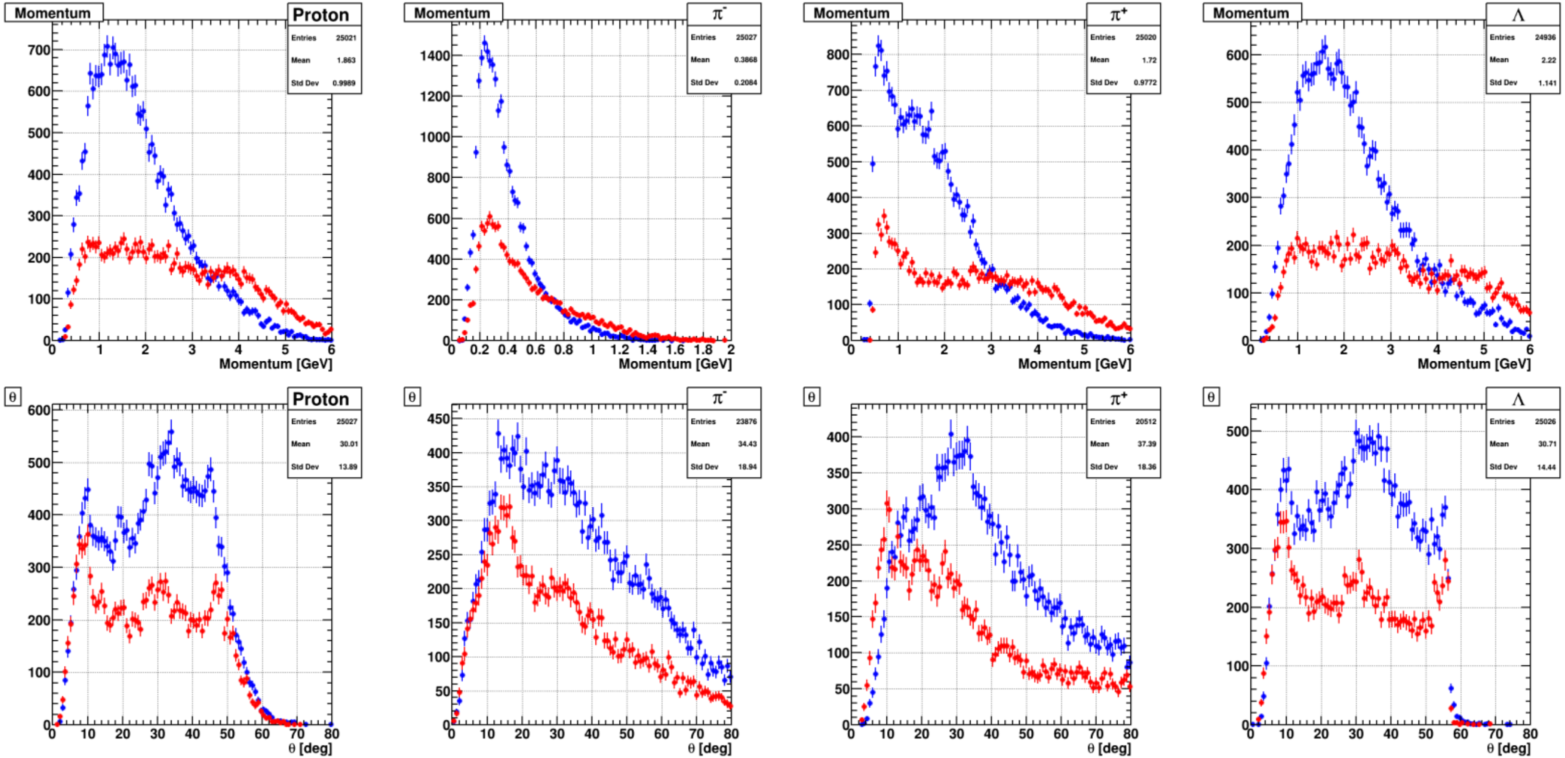
First order cuts 2

- For the Kl2 background, i.e. $K_L + p \rightarrow K_s + p$, which shares the same detected particles as the signal, a simple $m_\Lambda < 1.2$ cut leaves 99.4% of the unfitted signal and less than 0.3% of the background.
- The current Kl2 file was only drawn only with 100k events, unlike the 1M events for each of the other backgrounds.

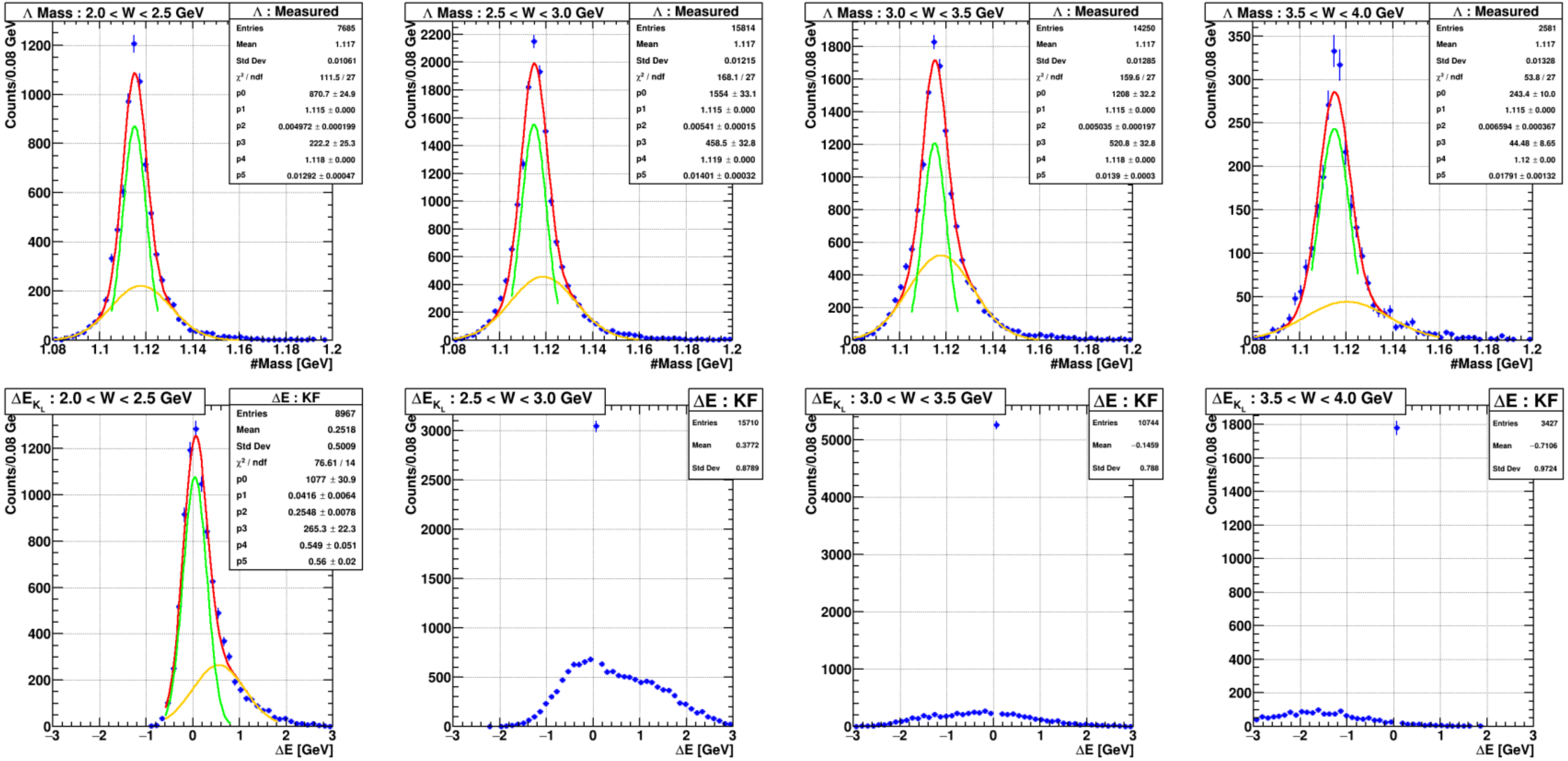


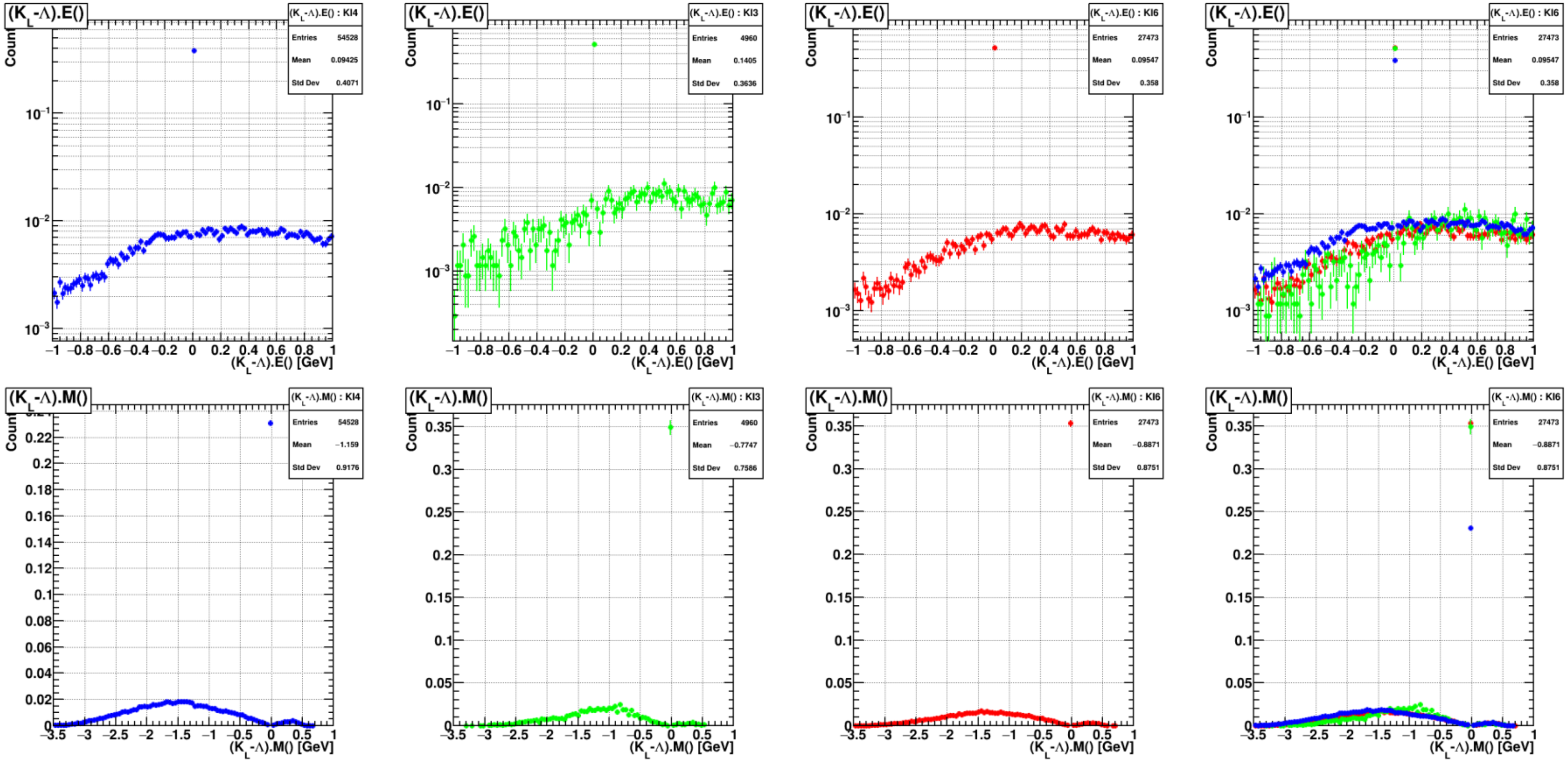
Back up slides

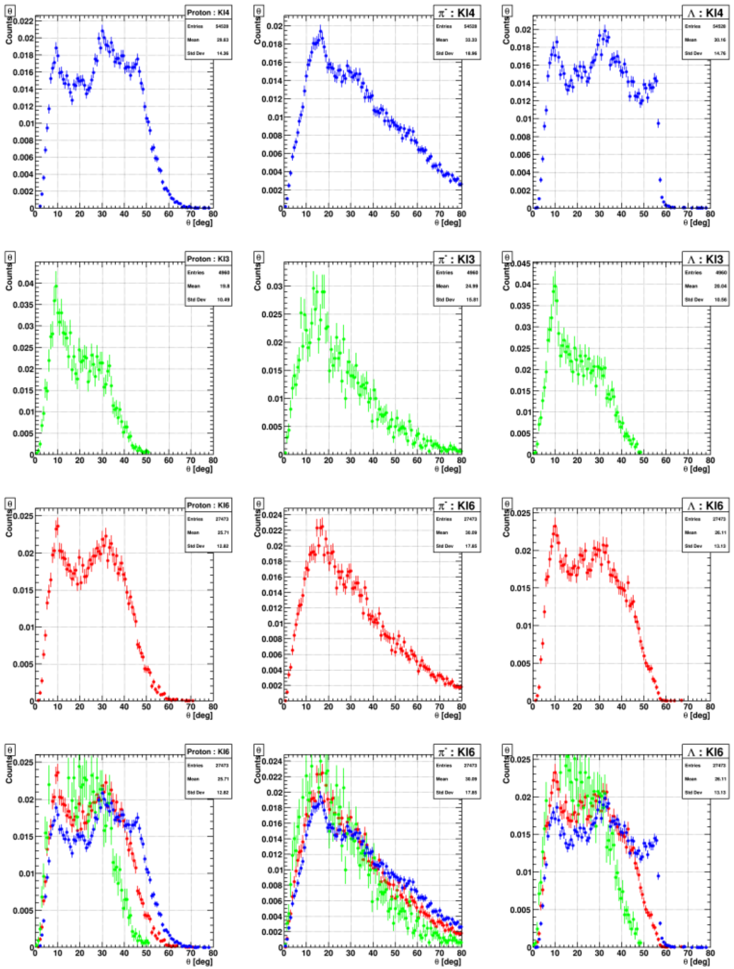
Blue (W < 3 GeV); Red (W > 3 GeV)

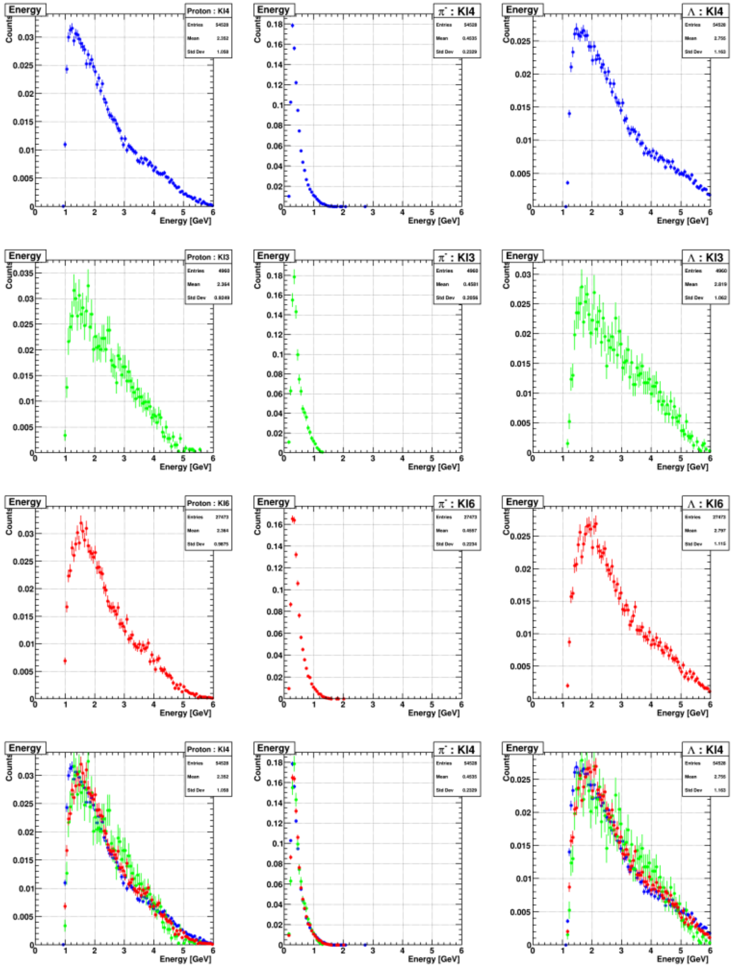


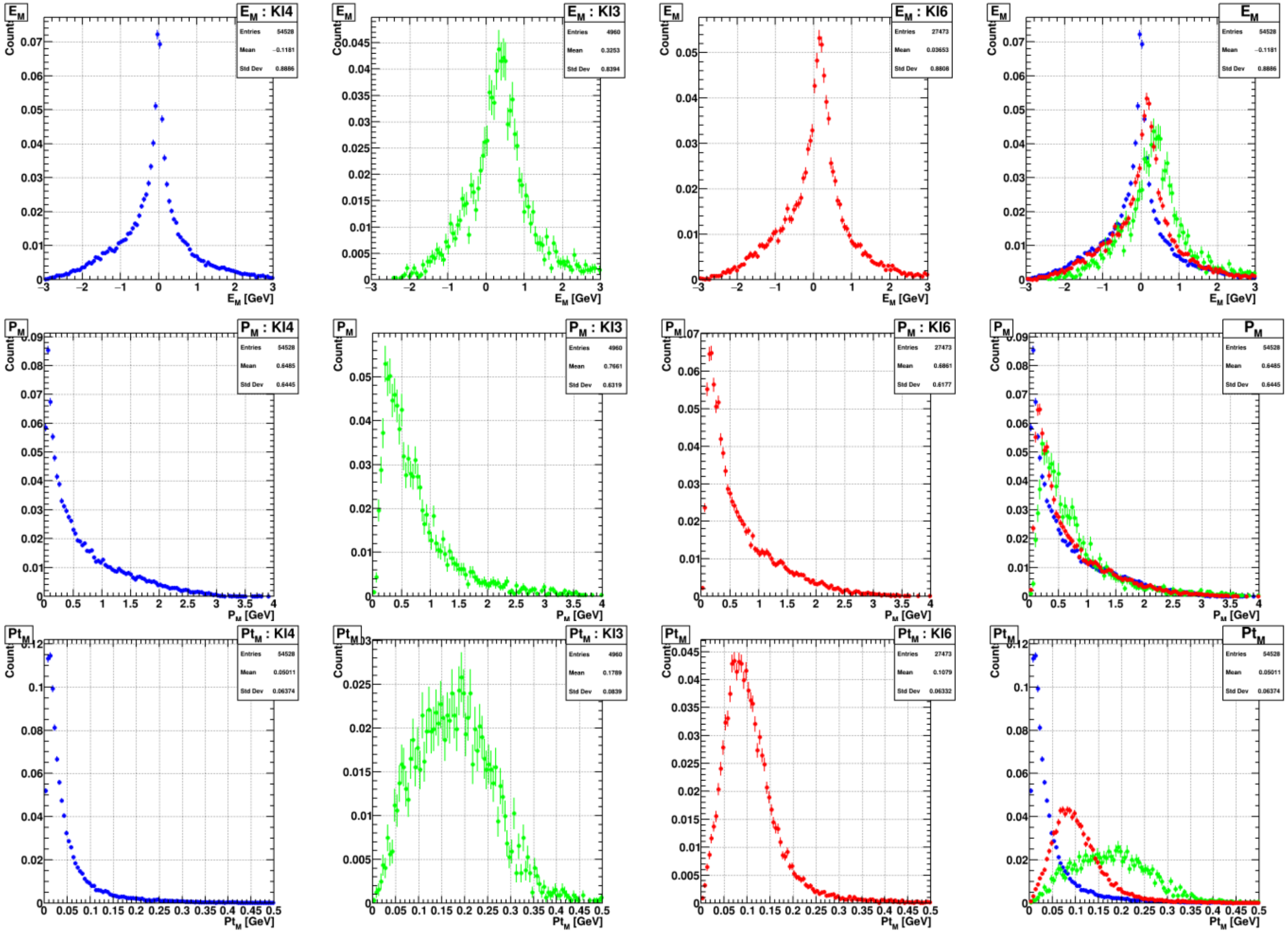
LAMBDA MASS AS A FUNCTION OF W

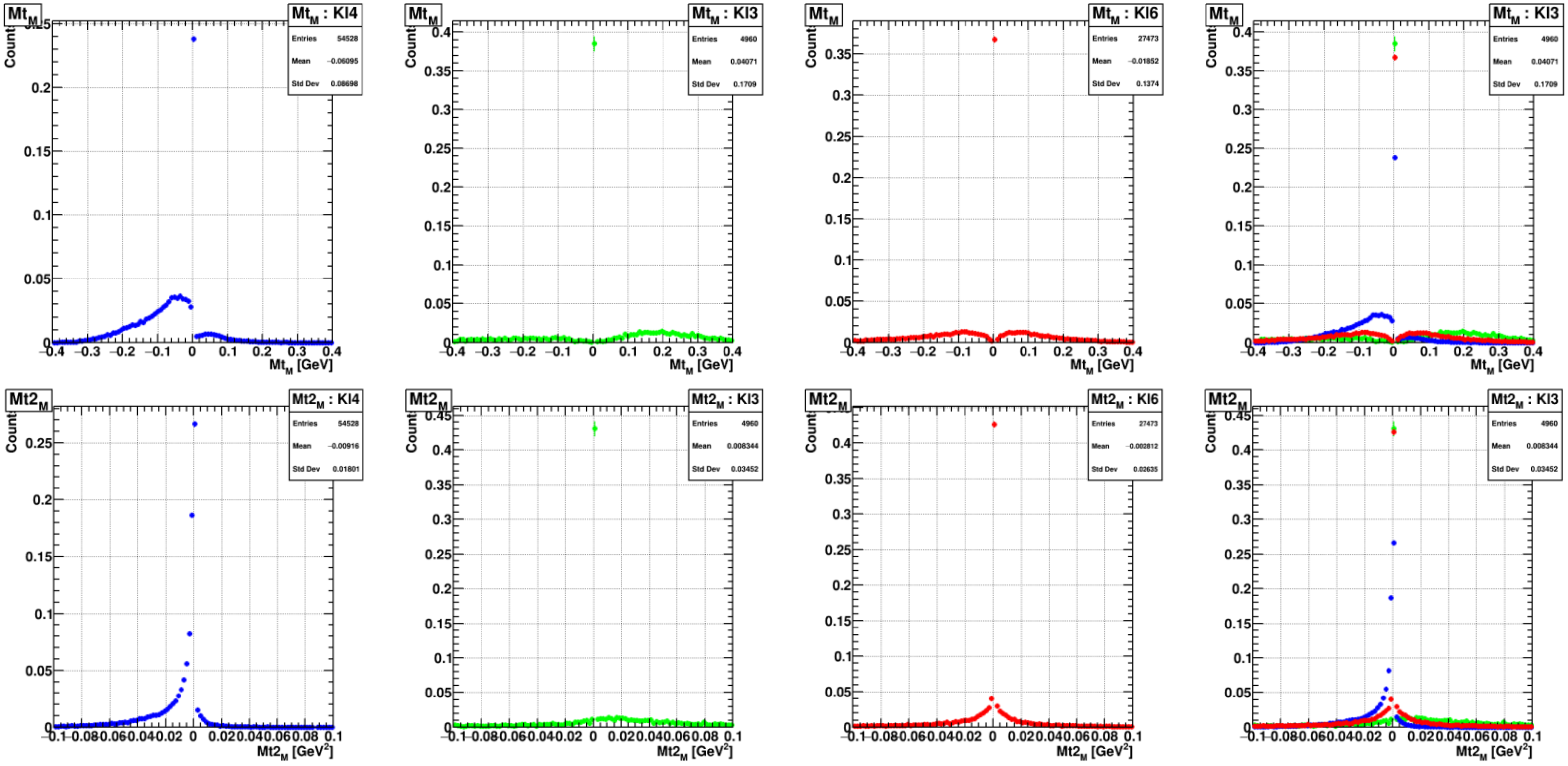



(K_L-Λ).E()
(K_L-Λ).E() : Kl4
Entries 54528
Mean 0.09425
Std Dev 0.4071
(K_L-Λ).E() : Kl3
Entries 4960
Mean 0.1405
Std Dev 0.3636
(K_L-Λ).E() : Kl6
Entries 27473
Mean 0.09547
Std Dev 0.358
(K_L-Λ).E() [GeV]
Count
(K_L-Λ).M()
(K_L-Λ).M() : Kl4
Entries 54528
Mean −1.159
Std Dev 0.9176
(K_L-Λ).M() : Kl3
Entries 4960
Mean −0.7747
Std Dev 0.7586
(K_L-Λ).M() : Kl6
Entries 27473
Mean −0.8871
Std Dev 0.8751
(K_L-Λ).M() [GeV]

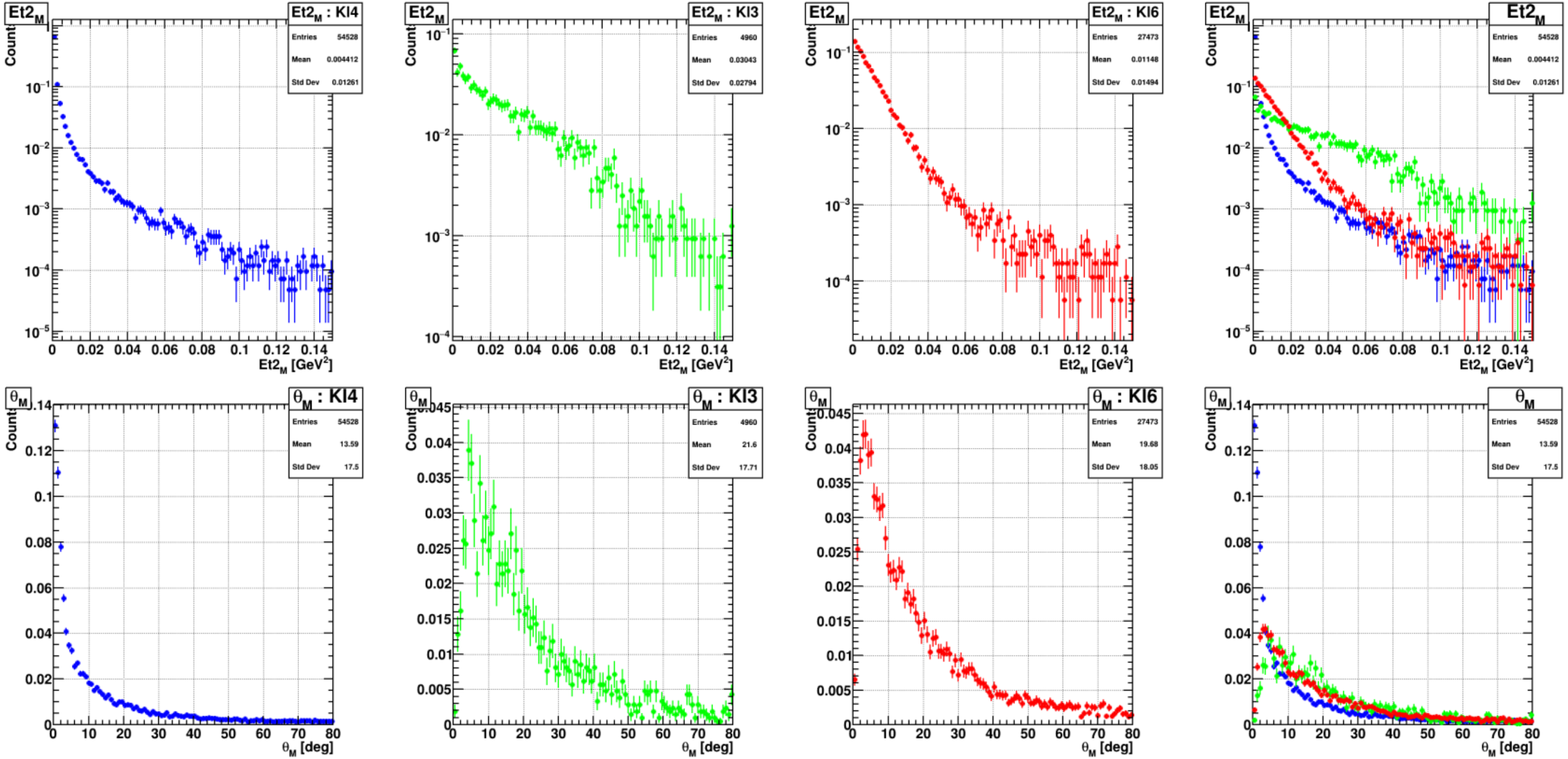

Proton : Kl4
π^- : Kl4
Λ : Kl4
Proton : Kl3
π^- : Kl3
Λ : Kl3
Proton : Kl6
π^- : Kl6
Λ : Kl6
Proton : Kl6
π^- : Kl6
Λ : Kl6
Counts
θ [deg]


Energy
Proton : Kl4
π^- : Kl4
Λ : Kl4
Proton : Kl3
π^- : Kl3
Λ : Kl3
Proton : Kl6
π^- : Kl6
Λ : Kl6
Proton : Kl4
π^- : Kl4
Λ : Kl4
Counts
Energy [GeV]

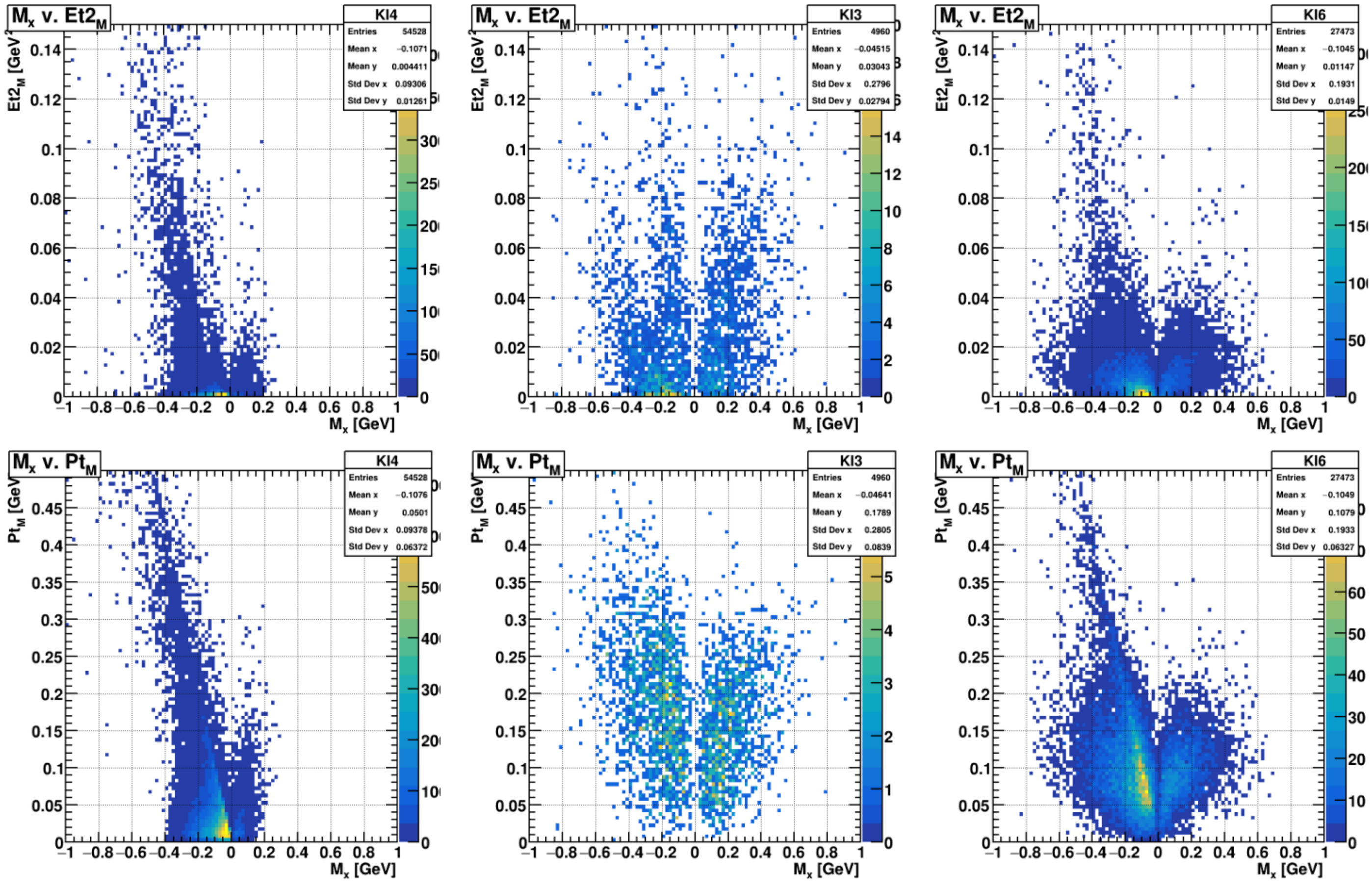

E_M : Kl4
E_M : Kl3
E_M : Kl6
E_M
E_M [GeV]
P_M : Kl4
P_M : Kl3
P_M : Kl6
P_M
P_M [GeV]
Pt_M : Kl4
Pt_M : Kl3
Pt_M : Kl6
Pt_M
Pt_M [GeV]
Count
Entries
Mean
Std Dev



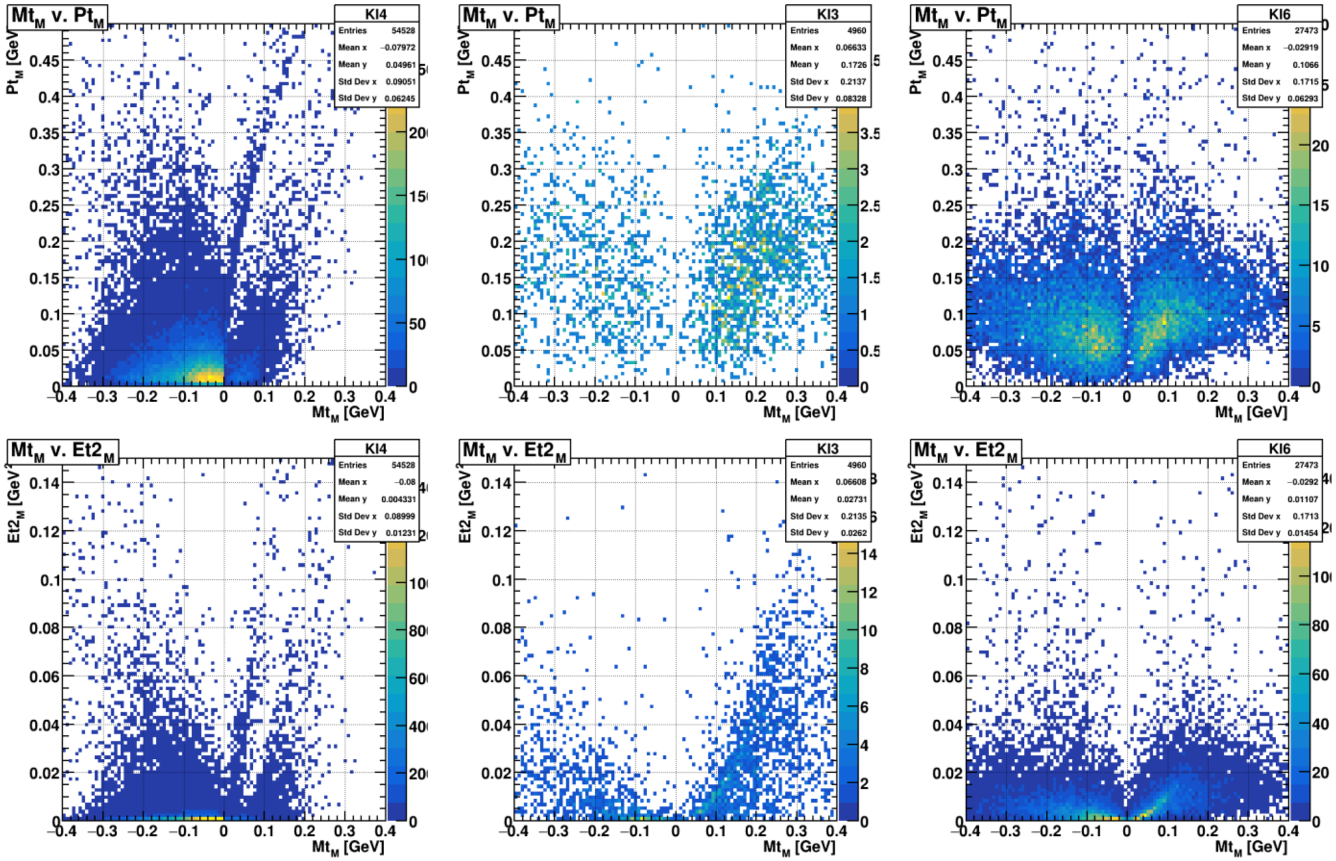
Mt_M : Kl4
Entries 54528
Mean -0.06095
Std Dev 0.08698
Mt_M : Kl3
Entries 4960
Mean 0.04071
Std Dev 0.1709
Mt_M : Kl6
Entries 27473
Mean -0.01852
Std Dev 0.1374
Mt_M : Kl3
Entries 4960
Mean 0.04071
Std Dev 0.1709
Mt_M [GeV]
Counts
Mt2_M : Kl4
Entries 54528
Mean -0.00916
Std Dev 0.01801
Mt2_M : Kl3
Entries 4960
Mean 0.008344
Std Dev 0.03452
Mt2_M : Kl6
Entries 27473
Mean -0.002812
Std Dev 0.02635
Mt2_M : Kl3
Entries 4960
Mean 0.008344
Std Dev 0.03452
Mt2_M [GeV^2]
Counts

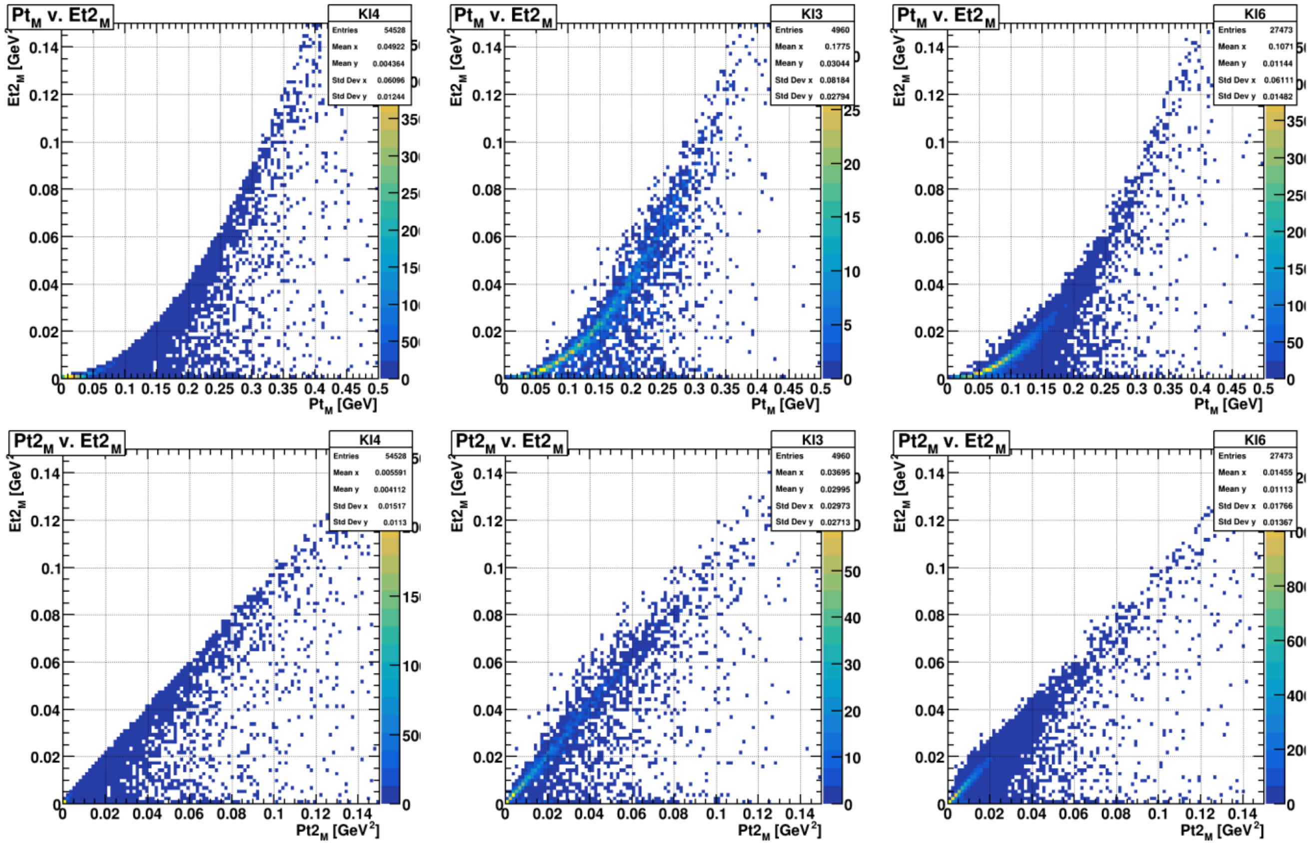


Et2M : Kl4
Entries 54528
Mean 0.004412
Std Dev 0.01261
Et2M : Kl3
Entries 4960
Mean 0.03043
Std Dev 0.02794
Et2M : Kl6
Entries 27473
Mean 0.01148
Std Dev 0.01494
Et2M
Entries 54528
Mean 0.004412
Std Dev 0.01261
Count
Et2M [GeV²]
θM : Kl4
Entries 54528
Mean 13.59
Std Dev 17.5
θM : Kl3
Entries 4960
Mean 21.6
Std Dev 17.71
θM : Kl6
Entries 27473
Mean 19.68
Std Dev 18.05
θM
Entries 54528
Mean 13.59
Std Dev 17.5
θM [deg]



Mx v. Et2M
Kl4
Entries 54528
Mean x −0.1071
Mean y 0.004411
Std Dev x 0.09306
Std Dev y 0.01261
Et2M [GeV²]
Mx [GeV]
Mx v. Et2M
Kl3
Entries 4960
Mean x −0.04515
Mean y 0.03043
Std Dev x 0.2796
Std Dev y 0.02794
Et2M [GeV²]
Mx [GeV]
Mx v. Et2M
Kl6
Entries 27473
Mean x −0.1045
Mean y 0.01147
Std Dev x 0.1931
Std Dev y 0.0149
Et2M [GeV²]
Mx [GeV]
Mx v. PtM
Kl4
Entries 54528
Mean x −0.1076
Mean y 0.0501
Std Dev x 0.09378
Std Dev y 0.06372
PtM [GeV]
Mx [GeV]
Mx v. PtM
Kl3
Entries 4960
Mean x −0.04641
Mean y 0.1789
Std Dev x 0.2805
Std Dev y 0.0839
PtM [GeV]
Mx [GeV]
Mx v. PtM
Kl6
Entries 27473
Mean x −0.1049
Mean y 0.1079
Std Dev x 0.1933
Std Dev y 0.06327
PtM [GeV]
Mx [GeV]


Mt_M v. Pt_M
Kl4
Entries 54528
Mean x −0.07972
Mean y 0.04961
Std Dev x 0.09051
Std Dev y 0.06245
Mt_M v. Pt_M
Kl3
Entries 4960
Mean x 0.06633
Mean y 0.1726
Std Dev x 0.2137
Std Dev y 0.08328
Mt_M v. Pt_M
Kl6
Entries 27473
Mean x −0.02919
Mean y 0.1066
Std Dev x 0.1715
Std Dev y 0.06293
Pt_M [GeV]
Mt_M [GeV]
Mt_M v. $Et2_M$
Kl4
Entries 54528
Mean x −0.08
Mean y 0.004331
Std Dev x 0.08999
Std Dev y 0.01231
Mt_M v. $Et2_M$
Kl3
Entries 4960
Mean x 0.06608
Mean y 0.02731
Std Dev x 0.2135
Std Dev y 0.0262
Mt_M v. $Et2_M$
Kl6
Entries 27473
Mean x −0.0292
Mean y 0.01107
Std Dev x 0.1713
Std Dev y 0.01454
$Et2_M$ [GeV^2]
Mt_M [GeV]



Pt_M v. Et2_M
Kl4
Entries 54528
Mean x 0.04922
Mean y 0.004364
Std Dev x 0.06096
Std Dev y 0.01244
Pt_M v. Et2_M
Kl3
Entries 4960
Mean x 0.1775
Mean y 0.03044
Std Dev x 0.08184
Std Dev y 0.02794
Pt_M v. Et2_M
Kl6
Entries 27473
Mean x 0.1071
Mean y 0.01144
Std Dev x 0.06111
Std Dev y 0.01482
Et2_M [GeV^2]
Pt_M [GeV]
Pt2_M v. Et2_M
Kl4
Entries 54528
Mean x 0.005591
Mean y 0.004112
Std Dev x 0.01517
Std Dev y 0.0113
Pt2_M v. Et2_M
Kl3
Entries 4960
Mean x 0.03695
Mean y 0.02995
Std Dev x 0.02973
Std Dev y 0.02713
Pt2_M v. Et2_M
Kl6
Entries 27473
Mean x 0.01455
Mean y 0.01113
Std Dev x 0.01766
Std Dev y 0.01367
Pt2_M [GeV^2]