Experiment 949
Technical Note K-xxx

TGdEdX Cut

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Abstract

We observed a 9% acceptance loss in *TGdEdX* compared to what Bipul measured in E787-PNN2. I describe how the cut works, changes made to the cut, and the how I re-calibrated this cut with current data.

1 Description

The dEdx of pions in the PNN2 box 140 MeV/c to 199.5 MeV/c changes from 3.08 MeV/cm to 2.47 MeV/cm in scintillator Therefore the target dEdx cut has to be performed as a function of momentum for PNN2. The *TGdEdX* cut calculates the target dEdX "likelihood" using the total measured momentum (*ptot*) target range (*rtg*), and target energy (*etg*). PISCAT monitors are used to determine the expected *rtg* based upon the observed *ptot, etg*. The data was chosen to be in the pion band. The target range was quantified in 5 momentum bins ($< 170 MeV/c, 170-180, 180-188, 188-199.53, > 199.53$ and 14 target energy bins (0-2MeV, 2-4MeV,..., 26-28MeV); The value of a 15th bin is equal to the 14th bin. For each bin we store the fitted mean and sigma of the measured target range. A Gaussian distribution is assumed during the calibration. Signal events are cut by *TGdEdX* if $like_{tgdedx} < 0.05$.

$$like_{tgdedx} = \frac{1}{2} \cdot (1 + erf\left(\frac{rtg - rtg_{exp}(etg, ptot)}{\sigma_{exp}(etg, ptot)}\right)) \quad (1)$$

TGdEdX cuts events when the target range is smaller than expected for a given *etg, ptot*.

2 Changes

In E787-PNN2, *swathccd* does not allow pion hits that occur in kaon flagged fiber; E949 allows this possibility. These K/Pi fibers only exist when $tpi - tk > 15ns$ and so we will not observe these type of hits in Piscat monitors which is used in the calibration. Therefore, we must not include pions hits occurring in a kaon fiber when cutting an event because it is not considered in the calibration sample. *TGdEdX* modifies a local *etg* variable to exclude these hits. All results reported in this note uses this modified version of *TGdEdX*.

3 Calibration

The calibration uses Piscat Monitors. The cuts used to determine the final sample are shown in Table 1. The last cut, $Kpiang > 35°$, was not used in the final determination of the sample due to lack of statistics.

The kumacs used to produce the calibration values and plots seen in this note are stored at `~benjil/bkg/studies/tgdedx/calib/`. The calibration histograms were created from histograms embedded in the piscat acceptance study, see `~/bkg/src/piscatacc.f` and `~/bkg/src/special_plots.f`. The acceptance measurement on *TGdEdX* was done using Kpi2 monitors, see `~/bkg/src/kp2acc.f`.

Figure 6, created by `~benjil/bkg/studies/tgdedx/calib/error_function.kumac` , shows the shape of the distribution for different offsets in the mean and sigma of the gaussian fit. If we plot $Like_{TGdEdX}$ for piscats using the updated calibration parameters then we would see a flat distribution. When we measure $Like_{TGdEdX}$ on Kpi2's, Figure 5, we observe a symeteric distribution with a slight offset to larger values. This implies that our calibration sample has worse resolution that our acceptance sample. This is most likely due to a better determination of the decay vertex in Kpi2's.; Measurement of the decay vertex is the key determination of the target range (*rtg*).

To determine if the calibration removes the energy (*etg*) dependence, I plotted the ratio of the E949 calibration means to the E787 calibration means. Figure 4, indicates that we are calibrating out any energy (*etg*) dependence.

A Piscat sample with a better determination of the decay vertex was obtained by making a cut a *kpiang*, the angle made from the Kaon entering position, decay vertex, and the exiting value of the Pion. An angle of 55° was required in this sample. An additional sample was created by applying the 30% acceptance PV cut, instead of the 60%. The calibration parameters, for *TGdEdX* , were determined and we measured the effect on the Kpi2 monitor sample. Figure 7 shows that there is no difference between the E949 calibration and the tighter PV sample. A small difference is observed between the E949 and the calibration with $kpiang > 55°$ required. Figure 8 show that there is no noticeable dependence on *etg* for the different calibration sets (most relevant points in Figure 8 are *ptot bin 5*.

Table 1: Cuts Used in *TGdEdX* calibration. E949 calibration used the events in red.

Cut name	Events remaining (Acc)
$BADRUN$	5859925 (-)
$DUPEV$	5859925 (-)
RD_TRK	5859442 (-)
$TRKTIM$	5856748 (-)
$TARGET$	5856748 (-)
$STLAY$	4949979 (-)
UTC	4593392 (-)
$RDUTM$	4497125 (-)
PDC	2833580 (-)
$ICbit$	2833580 (-)
$b4abm2$	1986916 (-)
$\|tpi - trs\| \geq 5$	1881543 (-)
$\|ictime - trs\| \geq 5$	1847951 (-)
BAD_STC	**1845076** (-)
$TGCUT$	1508139 (0.817386)
$tgqualt$	1435572 (0.951883)
$npitg$	1435572 (1)
$timcon$	1430524 (0.996484)
$tgtcon$	1390018 (0.971685)
$b4etcon$	1360826 (0.978999)
$targf$	1278186 (0.939272)
$dtgttp$	1278117 (0.999946)
$rtdif$	1181683 (0.92455)
$eiccon$	1149627 (0.972873)
$ticcon$	1149616 (0.99999)
$pigap$	1034138 (0.899551)
$tgdb4$	886404 (0.857143)
$tgdb4tip$	561715 (0.633701)
$tgdvxtip$	466019 (0.829636)
$tgdvxpi$	427166 (0.916628)
TGB4	427166 (1)
$phivtx1$	315481 (0.738544)
$pv(not\ tg)\ Loose60$	87063 (0.275969)
$cos3d$	76823 (0.882384)
$utcqual\ Loose$	72564 (0.944561)
$rngmom$	65767 (0.906331)
$rsdedxmax$	46384 (0.705278)
$rsdedxcl$	41896 (0.903242)
$rslike$	41429 (0.988853)
RSDEDX	41429 (1)
$tgz > -10.$	41244 (0.995535)
$Kpiang > 35°$	23662 (0.573708)
$Kpiang > 55°$	**14323** (0.605317)

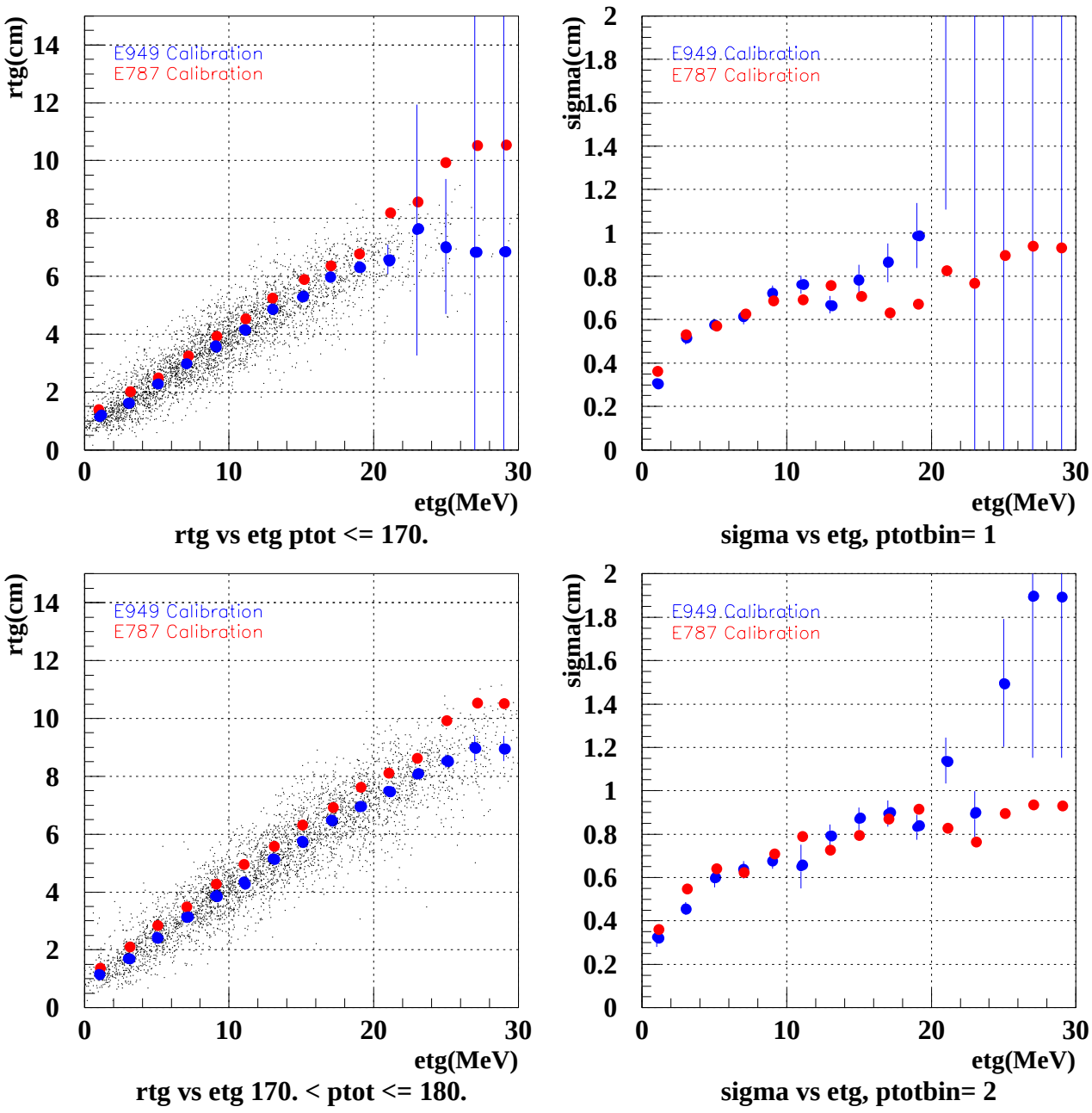


Figure 1: Calibration of new means. Red points are the original means. Blue points are the new means with error bars being the uncertainty on the mean from a gaussian fit

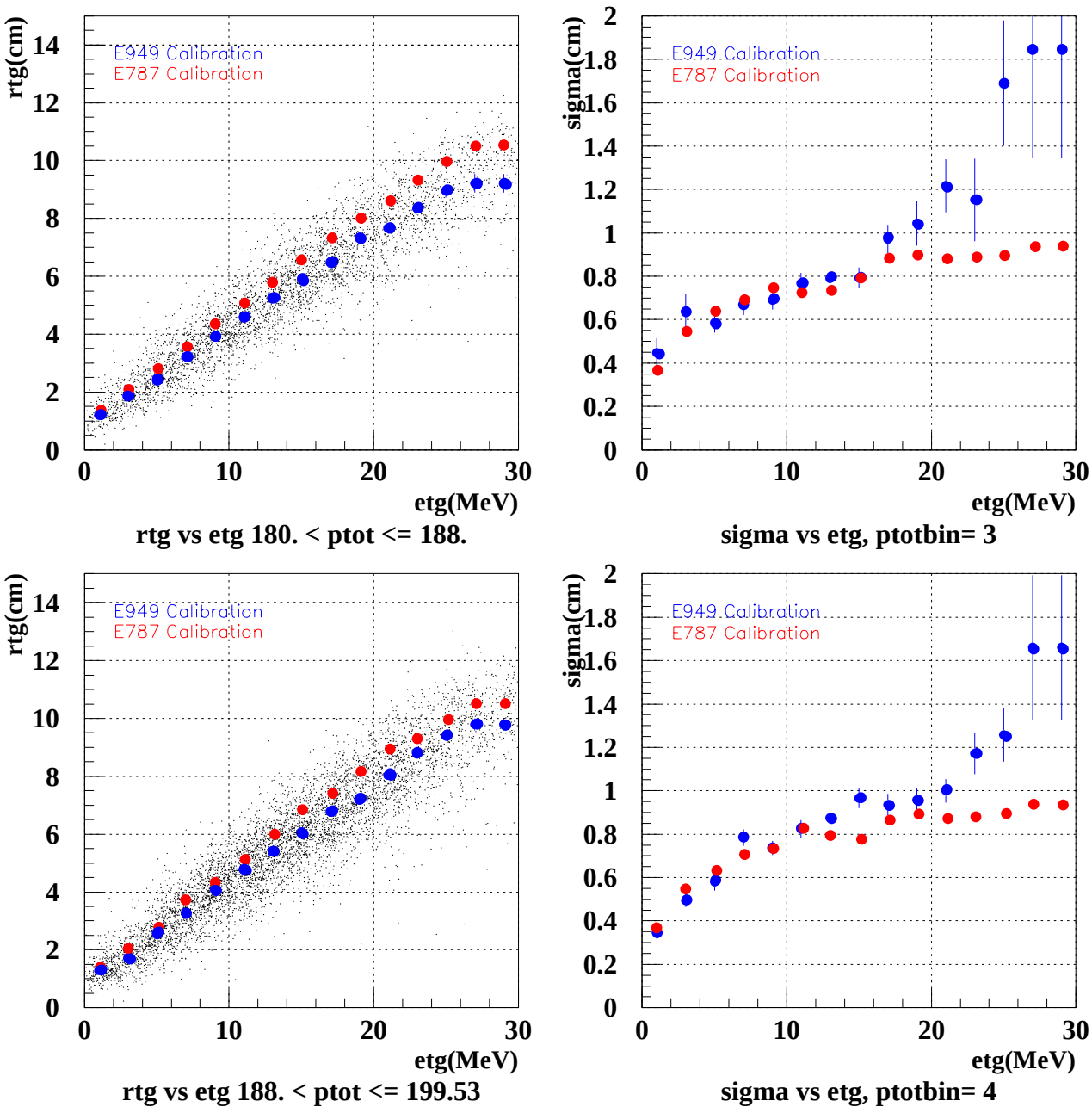


Figure 2: Calibration of new means. Red points are the original means. Blue points are the new means with error bars being the uncertainty on the mean from a gaussian fit

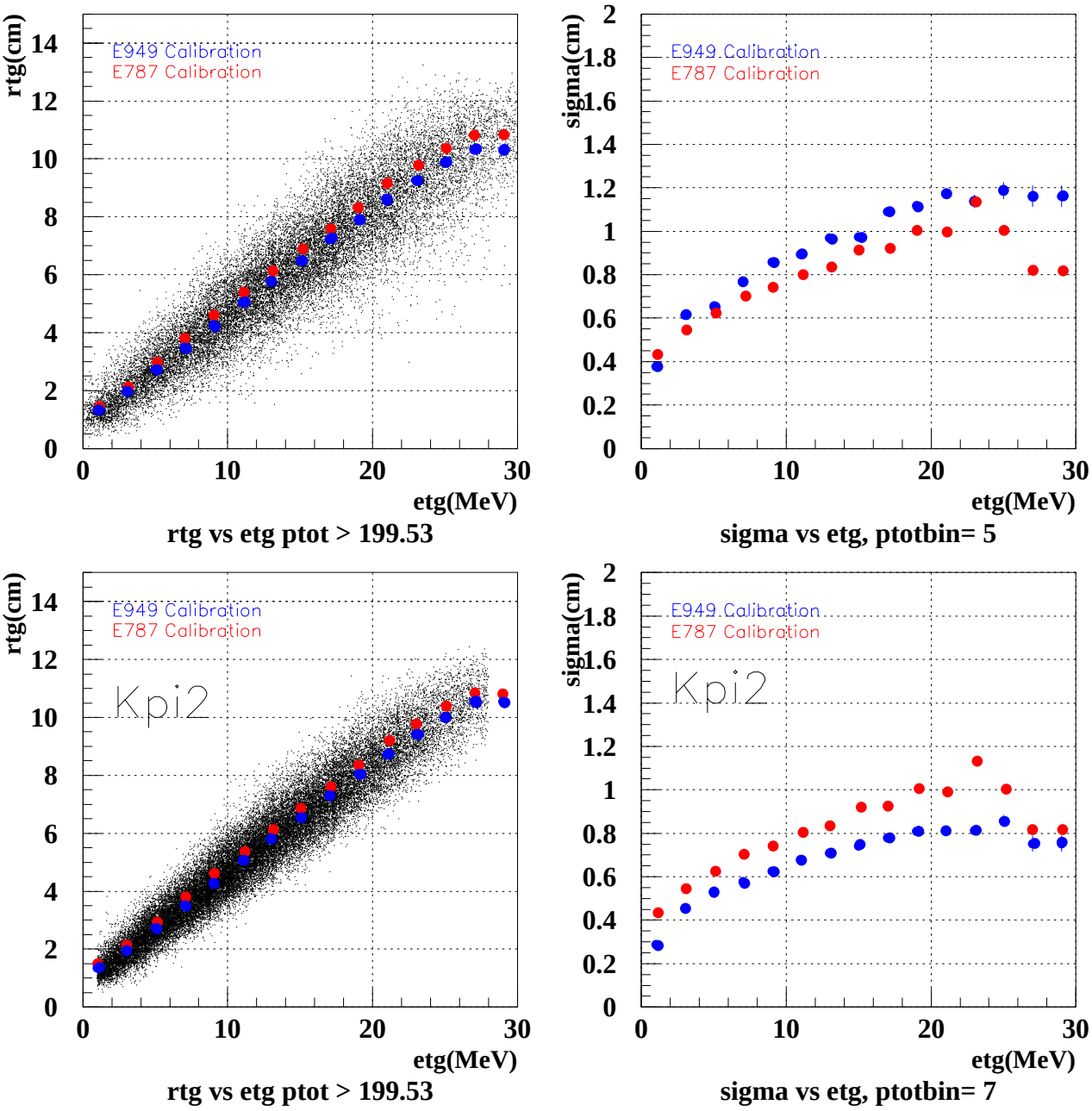


Figure 3: Calibration of new means. The bottom plot is doing the calibration process on Kpi2 montiors. Red points are the original means. Blue points are the new means with error bars being the uncertainty on the mean from a gaussian fit

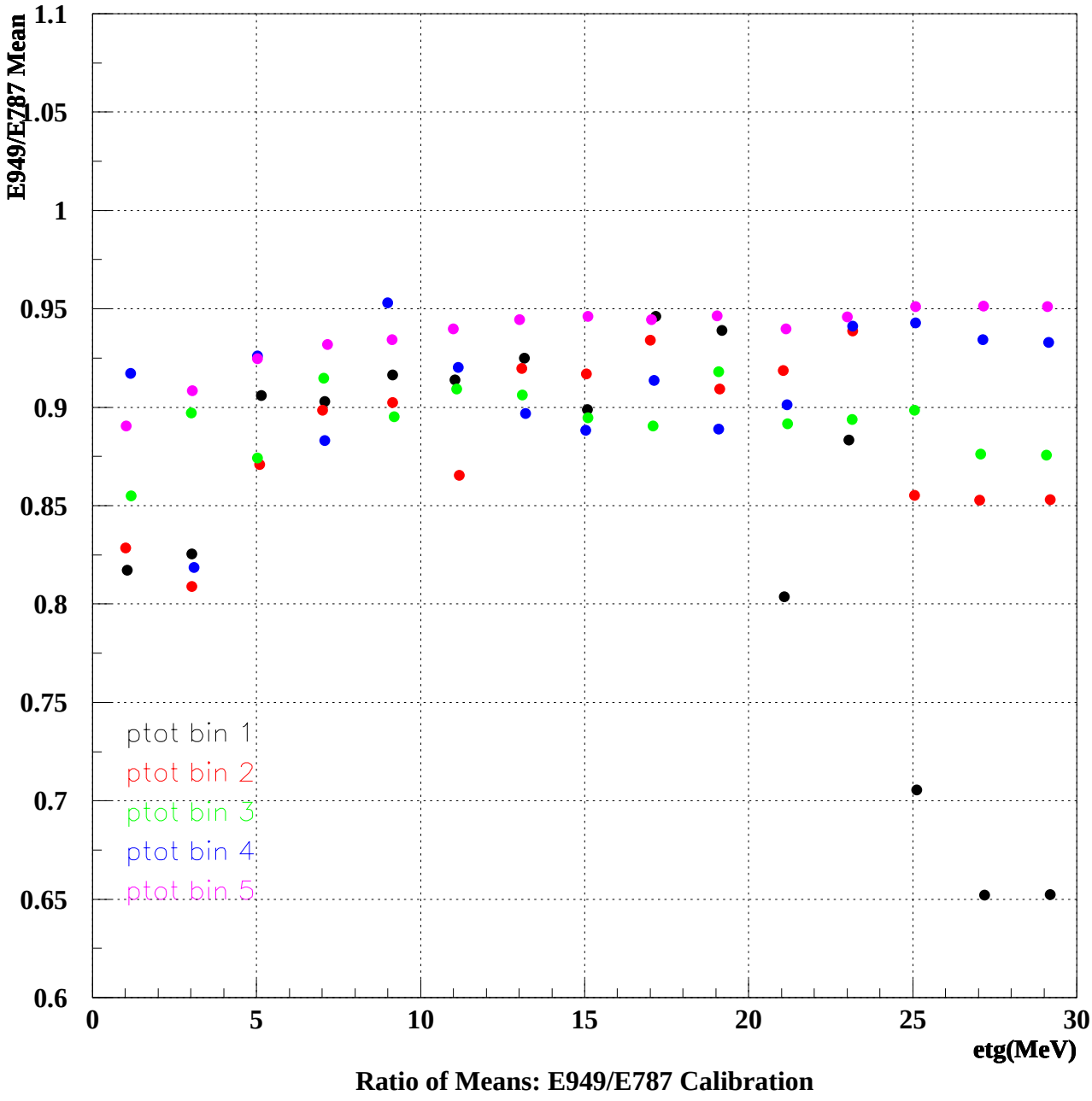


Figure 4: Ratios of the E949/E787 Calibrations.

3.1 Original Parameters

The means and sigmas are listed below in the 5 *ptot* bins, meanN such that $N = 1 : \ ptot < 170MeV/c$, $N = 2 : \ 170 < ptot \leq 180$, $N = 3 : \ 180 < ptot \leq 188$, $N = 4 : \ 188 < ptot \leq 199.53$, $N = 5 : \ ptot > 199.53$; Same notation for sigmas. The 15 numbers in each row are for $etg = 1MeV, \ 3MeV, ..., \ 29MeV$.

data mean1/1.41,1.99,2.51,3.28,3.92,4.56,5.23,5.88,6.30,6.77,8.2,8.6,9.95,10.5,10.5/
data sigm1/0.36,0.53,0.57,0.62,0.69,0.70,0.76,0.71,0.64,0.67,0.83,0.77,0.90,0.93,0.93/
data mean2/1.41,2.09,2.82,3.50,4.29,5.02,5.62,6.31,6.96,7.60,8.17,8.58,9.95,10.5,10.5/
data sigm2/0.36,0.54,0.64,0.62,0.71,0.79,0.72,0.79,0.88,0.91,0.83,0.77,0.90,0.93,0.93/
data mean3/1.41,2.09,2.82,3.53,4.36,5.05,5.83,6.60,7.29,7.99,8.61,9.33,9.95,10.5,10.5/
data sigm3/0.36,0.54,0.64,0.70,0.74,0.72,0.73,0.79,0.89,0.90,0.87,0.89,0.90,0.93,0.93/
data mean4/1.41,2.09,2.82,3.72,4.28,5.17,6.06,6.83,7.39,8.17,8.93,9.33,9.95,10.5,10.5/
data sigm4/0.36,0.54,0.64,0.71,0.73,0.83,0.79,0.78,0.86,0.90,0.87,0.89,0.90,0.93,0.93/
data mean5/1.48,2.15,2.97,3.75,4.58,5.37,6.10,6.84,7.64,8.36,9.16,9.77,10.38,10.83,10.83/
data sigm5/0.44,0.54,0.62,0.71,0.74,0.80,0.84,0.91,0.92,1.0,0.99,1.14,1.0,0.81,0.81/

3.2 New Parameters

data mean1/1.15,1.64,2.27,2.96,3.59,4.16,4.83,5.29,5.95,6.35,6.58,7.,7.5,8.0,8.0/
data sigm1/0.31,0.52,0.57,0.61,0.72,0.76,0.67,0.79,0.86,0.99,1.04,1.28,1.28,1.28,1.28/
data mean2/1.17,1.69,2.45,3.15,3.86,4.35,5.17,5.77,6.49,6.91,7.50,8.05,8.53,8.96,8.96/
data sigm2/0.33,0.46,0.60,0.64,0.68,0.65,0.79,0.87,0.90,0.83,1.14,0.89,1.50,1.89,1.89/
data mean3/1.20,1.87,2.46,3.23,3.91,4.59,5.29,5.91,6.50,7.34,7.67,8.35,8.95,9.21,9.21/
data sigm3/0.45,0.64,0.59,0.67,0.69,0.77,0.79,0.79,0.97,1.04,1.22,1.15,1.69,1.85,1.85/
data mean4/1.29,1.71,2.61,3.29,4.08,4.77,5.43,6.07,6.76,7.27,8.04,8.78,9.40,9.80,9.80/
data sigm4/0.35,0.49,0.58,0.78,0.74,0.82,0.87,0.97,0.94,0.96,1.00,1.17,1.26,1.66,1.66/
data mean5/1.32,1.96,2.74,3.50,4.27,5.04,5.76,6.47,7.21,7.91,8.59,9.25,9.88,10.30,10.30/
data sigm5/0.38,0.61,0.66,0.77,0.86,0.89,0.97,0.97,1.09,1.12,1.17,1.14,1.19,1.16,1.16/

3.3 Manual changes

The fit in the *ptot* range of $< 170MeV/c$ and $etg > 20MeV$ was very poor due to lack of statistics. I modified the last 5 values. The means were determine by constraining the values below the values observed in mean2(11-15) and doing a linear extrapolation from the previous set of points. This was done by "eye". The last 4 sigmas were determine by doing a fit on rtg values with a slice of $20 < etg < 30$ and performing a gaussian fit. I determined the sigma for the $etg = 19MeV$ by extending the etg-slice to $17 < etg < 21$.

- From fits

  data mean1/1.15,1.64,2.27,2.96,3.59,4.16,4.83,5.29,5.95,6.35,6.58,7.60,7.03,6.84,6.84/

  data sigm1/0.31,0.52,0.57,0.61,0.72,0.76,0.67,0.79,0.86,0.99,2.02,3.64,3.84,12.70,12.70/

- By hand

  data mean1/1.15,1.64,2.27,2.96,3.59,4.16,4.83,5.29,5.95,6.35,6.58,7.,7.5,8.0,8.0/

  data sigm1/0.31,0.52,0.57,0.61,0.72,0.76,0.67,0.79,0.86,0.99,1.04,1.28,1.28,1.28,1.28/

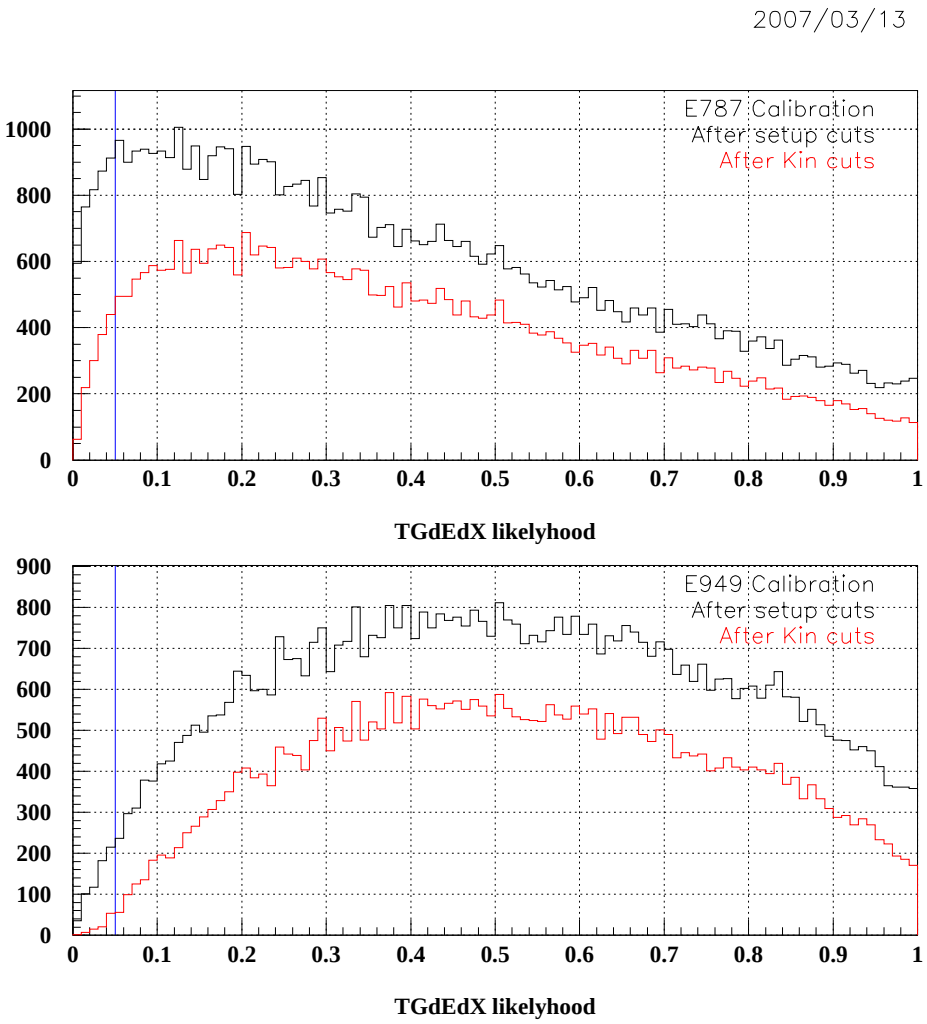


Figure 5: Before and after calibration of $like_{TGdEdX}$. The plots are done in the Kpi2-TG Kinematic acceptance study. The setup cuts are all cuts applied before $TGdEdX$ cut is applied. The Kin cuts are all cuts in the acceptance study except for $TGdEdX$. $TGdEdX$ cuts events less than 0.05, shown as the blue line.

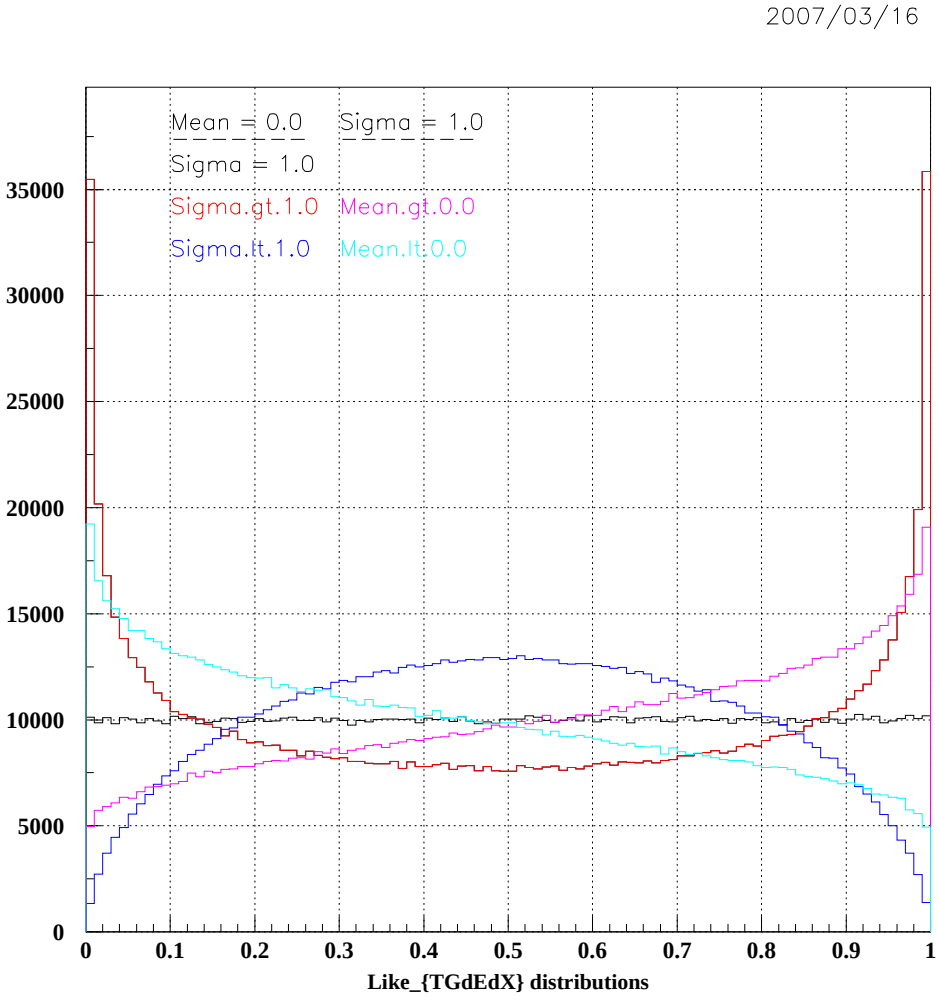
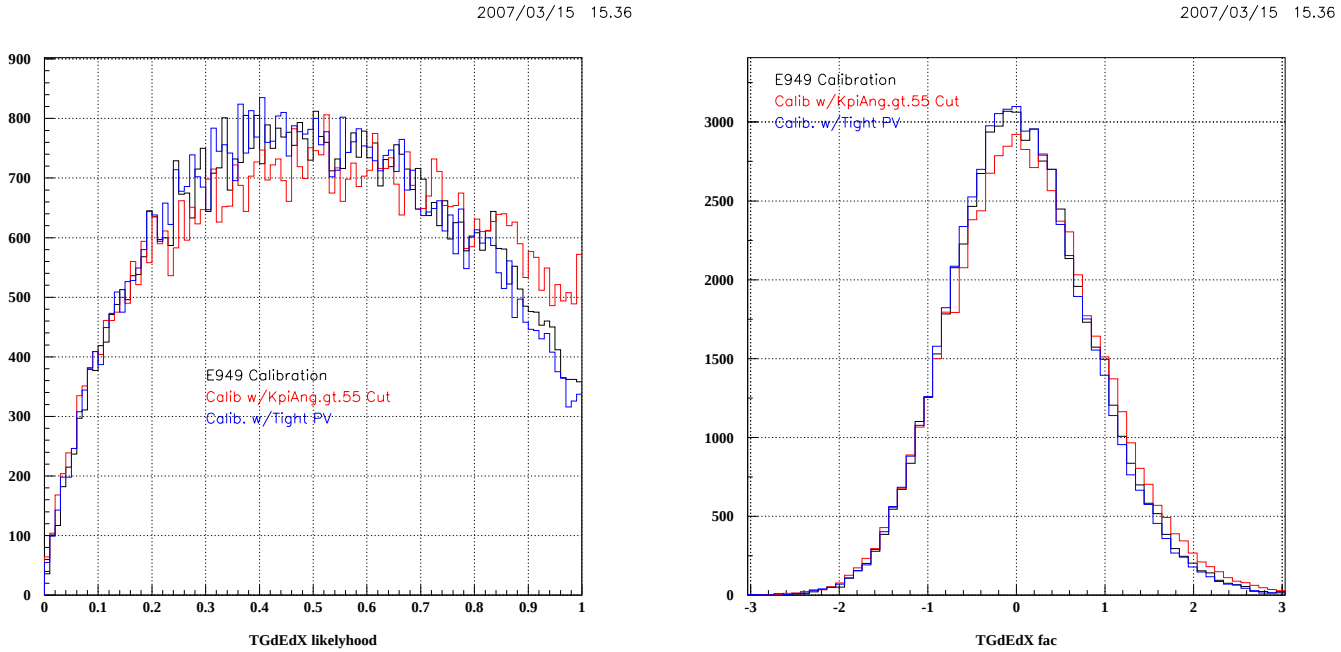


Figure 6: $like_{TGdEdX}$ distributions for different offsets in the calibration.



(a) $like_{TGdEdX}$ (b) $\frac{rtg-rtg_{exp}(etg,ptot)}{\sigma_{exp}(etg,ptot)}$

Figure 7: Distributions for different piscat calibrations.

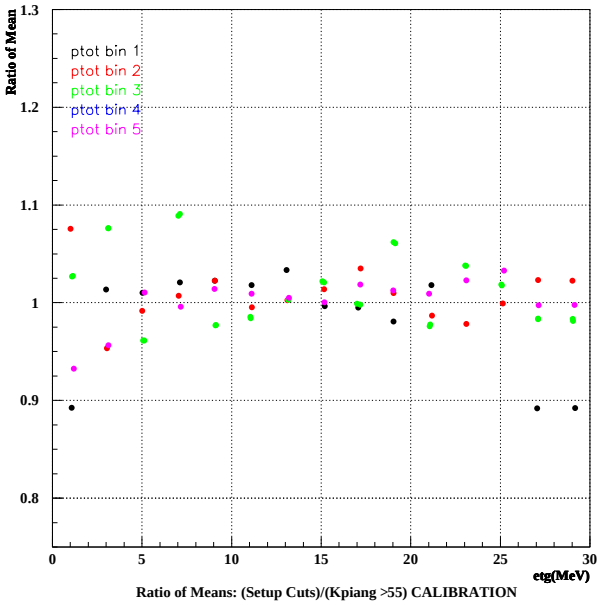


Figure 8: Ratio of calibration means used in Figure 7.

4 Acceptance Sample

E787-PNN2 measured an acceptance of 0.9858. Using the E787-PNN2 calibration, I measure an acceptance of 0.9339. With the new parameters the acceptance of *TGdEdX* increases to 0.989; An increase of 5.2%. The overall acceptance increase in the Kpi2 TG-Kinematic study is 2.0%. The correlation of *epitg* and *chi567* mitigates the increase observed in *TGdEdX*.

Table 2: Kpi2 TG-kinematic Acceptance

Cut Applied	Events remaining (Acc)
SetupOPS	62149 (-)
opsveto	60535 (-)
TGPVCUT	**59882** (-)
TGDEDX	59231 (0.989129)
tger	59215 (0.99973)
tgenr	57283 (0.967373)
*tglike*1	56252 (0.982002)
*tglike*2	55351 (0.983983)
TGLIKE	55351 (1)
epitg	49614 (0.896352)
epimaxk	49614 (1)
tgedge	49348 (0.994639)
drp	49263 (0.998278)
*chi*567 *Loose*	42369 (0.860057)
*chi*5*max*	**39447** (0.931034)
Total Acc.	0.658746 ± 0.00269197

5 Rejection Sample

E787 tuned the cut to a $Rej_{TGdEdX} = 1.44$, but *TGdEdX* had no rejection after all cuts. This is due to high correlation with *chi567*.

Table 3: *TGdEdX* Rejection Table. The red *TGdEdX* is the measured value at this point in the table, but *TGdEdX* is not applied on the events for remain cuts in this table.

Cut Applied	Events remaining (Rej)
BADRUN	30408052 (0.00)
DUPEV	30408048 (1.00)
TRIGGER	15232707 (2.00)
ICbit	15232564 (1.00)
lhex	15232564 (1.00)
DC	15232516 (1.00)
*Lev*11	15232516 (1.00)
RD_TRK	15232515 (1.00)
TRKTIM	15232515 (1.00)
TARGET	15232515 (1.00)
STLAY	15232515 (1.00)
UTC	15232515 (1.00)
RDUTM	15232515 (1.00)
BAD_STC	15232515 (1.00)
PDC	15232515 (1.00)
*pv(not tg) Loose*60	12954315 (1.18)
TGCUT	7142934 (1.81)
tgqualt	6765533 (1.06)
npitg	6765533 (1.00)
timcon	6685429 (1.01)
tgtcon	6316877 (1.06)
b4etcon	6184009 (1.02)
DCBIT	6184009 (1.00)

continued on next page

Cut Applied	Events remaining (Rej)
DELCO	4280023 (1.44)
Delc Loose	3595811 (1.19)
PSCUT	2185154 (1.65)
b4dedx	2169877 (1.01)
bwtrs	1799849 (1.21)
cpitrs	1797020 (1.00)
cpitail	1796540 (1.00)
cktrs	1781679 (1.01)
cktail	1762093 (1.01)
b4trs	1674587 (1.05)
b4ccd	1650344 (1.01)
upvtrs	1623531 (1.02)
rvtrs	1615563 (1.00)
tggeo	1060126 (1.52)
b4ekz	886102 (1.20)
tgzfool	870567 (1.02)
targf	826789 (1.05)
dtgttp	826779 (1.00)
rtdif	819240 (1.01)
tgktim	811136 (1.01)
eiccon	792084 (1.02)
ticcon	792075 (1.00)
pigap	774063 (1.02)
tgdb4	760772 (1.02)
tgdb4tip	752741 (1.01)
tgdvxtip	746892 (1.01)
tgdvxpi	729199 (1.02)
TGB4	729199 (1.00)
phivtx1	672405 (1.08)
ccdpul	166933 (4.03)
timkf	149649 (1.12)
verrng	135863 (1.10)
angli	135717 (1.00)
ALLKfit	133136 (1.02)
tpics	133047 (1.00)
kic	133004 (1.00)
epionk	132901 (1.00)
BOX Loose	12503 (10.63)
icodel14	12503 (1.00)
cos3d	12181 (1.03)
layv4	12181 (1.00)
zfrf	12158 (1.00)
zutout	12134 (1.00)
FIDUCIAL	12134 (1.00)
utcqual Loose	11226 (1.08)
prrf1	10855 (1.03)
prrfz	9906 (1.10)
PRRF	9906 (1.00)
rsdedxmax	9406 (1.05)
rsdedxcl	6725 (1.40)
rslike	6725 (1.00)
RSDEDX	6725 (1.00)
rngmom	1016 (6.62)
tgdb4	1016 (1.00)
tgdb4tip	1016 (1.00)
tgdvxtip	1016 (1.00)
tgdvxpi	1016 (1.00)
TGB4	1016 (1.00)
piflg	990 (1.03)
elveto	924 (1.07)
tdfool	920 (1.00)
tdvarnn02 Loose	849 (1.08)
TD *Loose*	**849** (1.00)
TGDEDX	**629** (1.35)
epitg	551 (1.54)
epimaxk	551 (1.00)
chi567 Loose	415 (1.33)
chi5max	389 (1.07)
TGDEDX	**365** (1.07)

6 Results

I decided to use the cut parameters as outlined in the *New Parameter* section. These numbers were based upon the piscat sample with the largest statistics . The other samples ($kpiang > 55°$, tight PV) did not show any improvement in making the sample more signal like. In addition, the statistics of these samples were lacking in the lower momentum bins. Also, the acceptance after calibration being the same as was measured in E787 is a convincing argument that I implemented the calibration study correctly and these parameters are acceptable.

Determining *TGdEdX* 's cut value (nominal value of 0.05) is shown in Figure 10. The *acceptance*, *rejection*, and *acceptance* × *rejection* is plotted as a function of the cut value. The *acceptance* × *rejection* indicates that we can improve our signal to background by tightening this cut. However, I recommend that we keep this current cut value of 0.05 to maximize our acceptance.

cut value	*Acc*	*Rej*	*Acc* × *Rej*
E787 0.05	0.9858	1.44	1.42
E949 0.05	0.989	1.35	1.34

Table 4: *TGdEdX* Acceptance Rejection Table. The *TGdEdX* cut is $like_{TGdEdX} < cut\ value$.

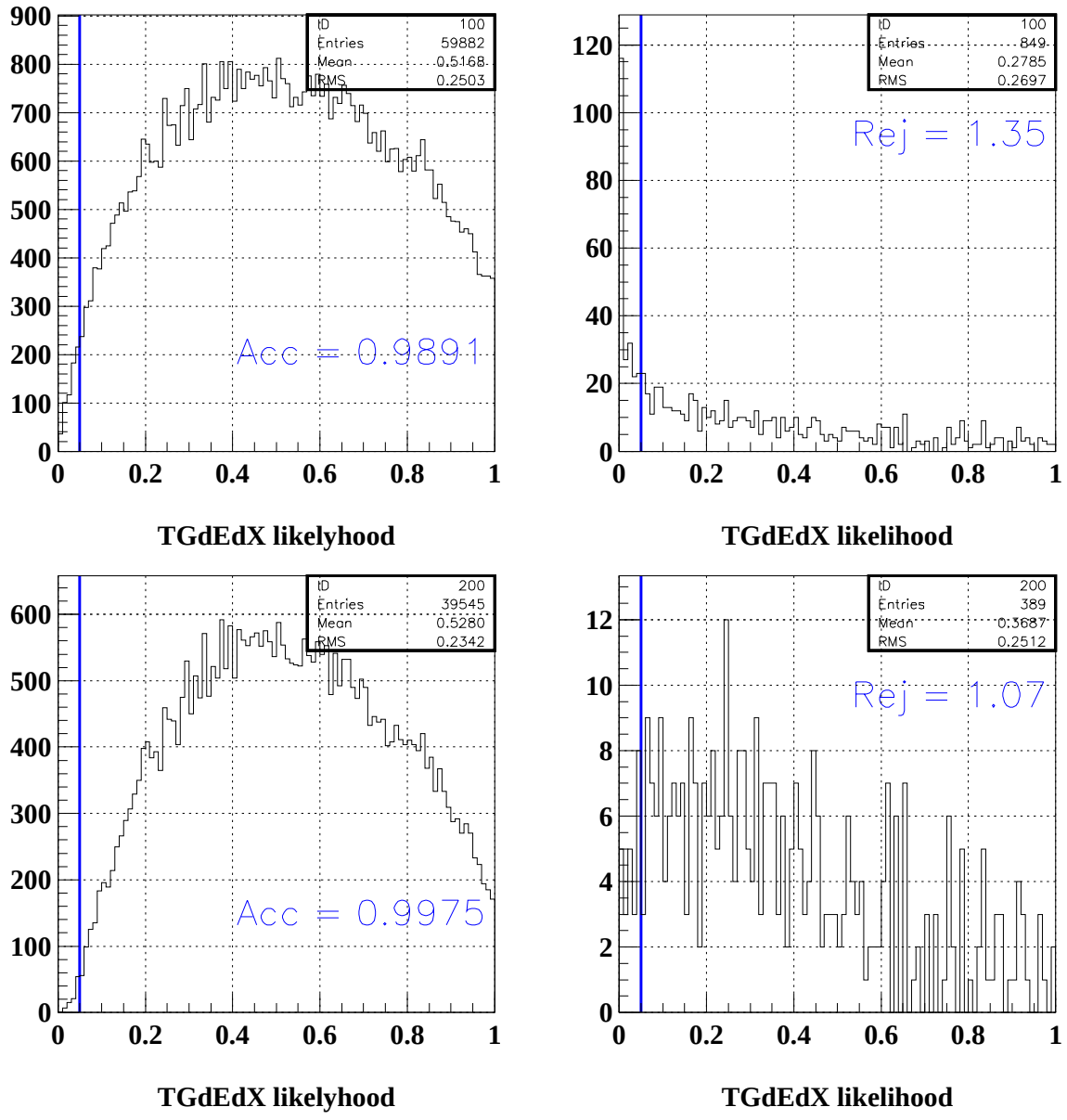


Figure 9: Bipul had a rejection of 1.44. No rejection after all cuts.

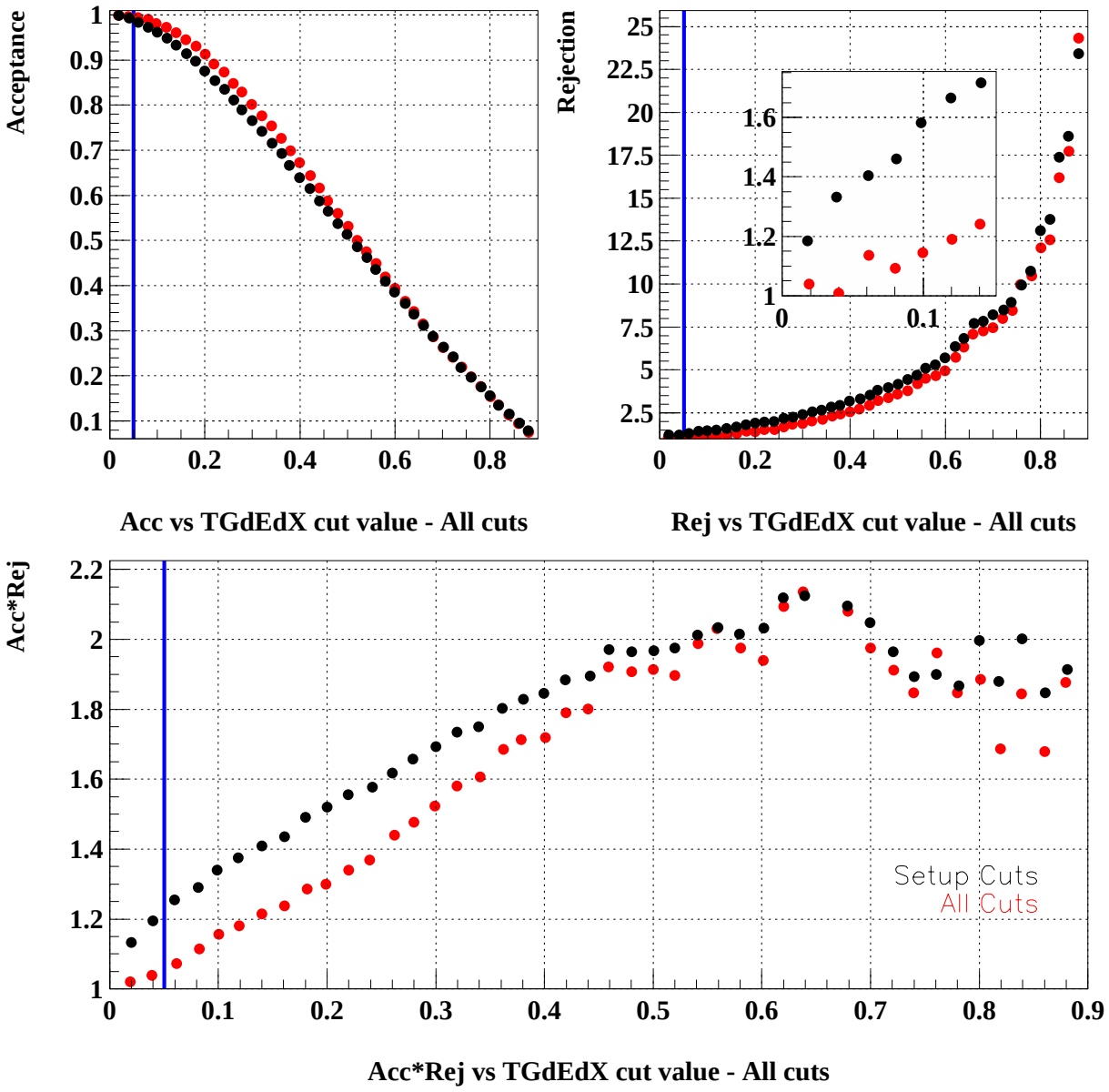


Figure 10: Acceptance and Rejection versus *TGdEdX* cut value. The *TGdEdX* cut is $like_{TGdEdX} < cut\ value$. The blue line is at the nominal cut value of 0.05. The red points are after all other cuts in the