$K_{\pi 2}$ Branching Ratio.

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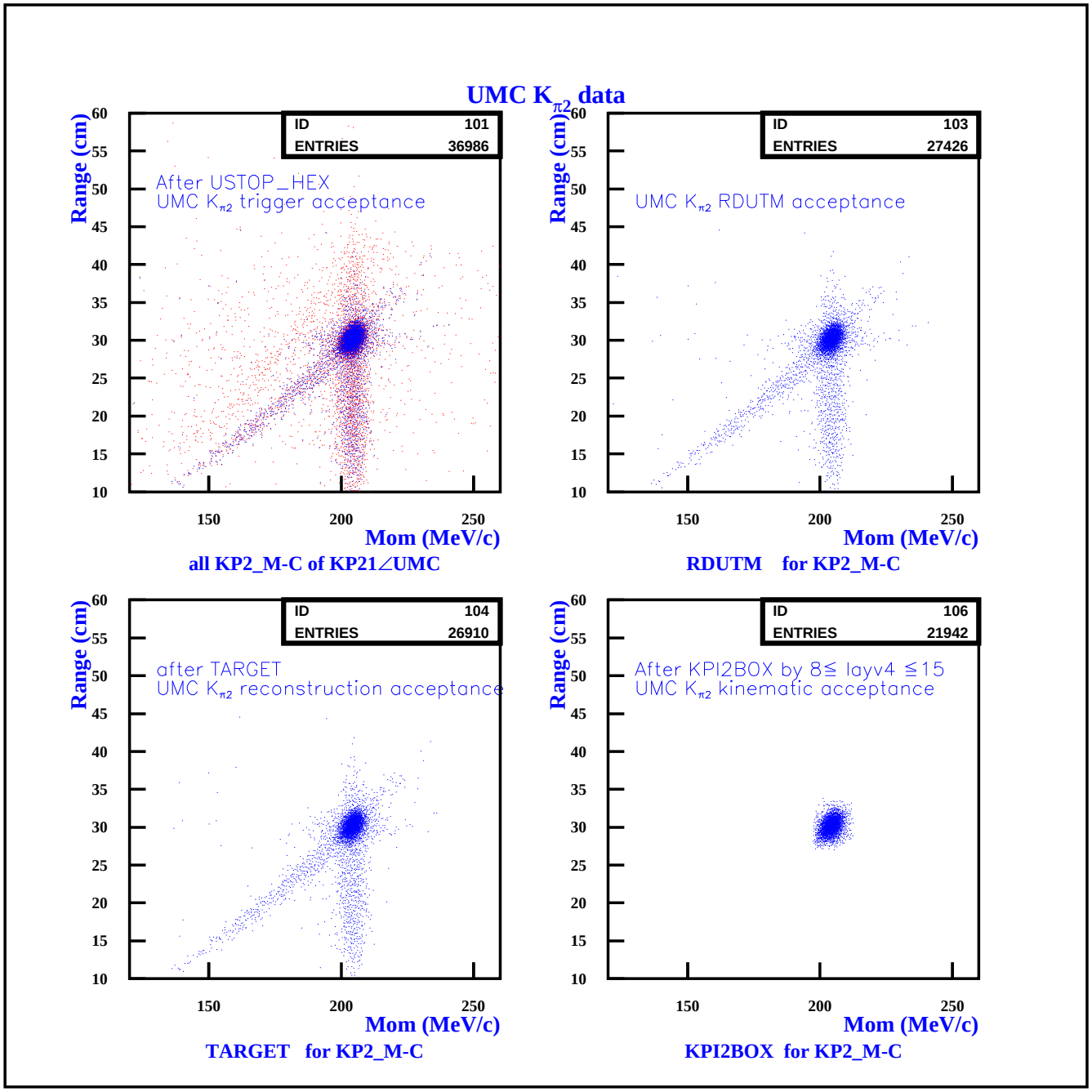

Figure 1: The $K_{\pi 2}$ events range vs momentum. UMC data.

The KP2 events after cuts are shown in blue colour.

Cut	2002 (acc.)	2007 (acc.)
KT	49997	99993
T•A	22697(0.45397)	44891(0.44894)
Reach Layer B	19090(0.84108)	37605(0.83769)
19ct-bar	18797(0.98465)	36986(0.98354)
UFATE	15910(0.84641)	31222(0.84416)
USTMED	15568(0.97850)	30518(0.97745)
USTOPHEX	13909(0.89344)	27426(0.89868)
$A^{UMC}_{K_{\pi 2},trig}$	0.27820 ± 0.00200	0.27428 ± 0.00141
UTC	13909(1.00000)	27426(1.00000)
RDUTM	13909(1.00000)	27426(1.00000)
UTCQUAL	13489(0.96980)	26910(0.98119)
TARGET	13348(0.98955)	26910(1.00000)
$A^{UMC}_{K_{\pi 2},recon}$	0.95967 ± 0.00167	0.98119 ± 0.00082
KPI2STOP	12831(0.96127)	25789(0.95834)
COS3D	12305(0.95901)	24739(0.95929)
KPI2BOX	11225(0.91223)	22847(0.92352)
$A^{UMC}_{K_{\pi 2},kin}$	0.84095 ± 0.00317	0.84901 ± 0.00218
$A^{UMC}_{K_{\pi 2}}$	0.22451 ± 0.00187	0.22849 ± 0.00133
KPI2BOX	11225(0.91223)	21942(0.88694)

Table 1: UMC $K_{\pi 2}$ acceptance of cuts applied in the$K_{\pi 2}$ branching ratio analysis. NIDIF is on. In E949, the ($\overline{19_{ct} + 20_{ct} + 21_{ct}}$) trigger condition has been changed to $\overline{19_{ct}}$.

$$KP2BOX = abs(rdev).LT.3.AND.abs(edev).LT.3.AND.abs(pdev).LT.3$$

$$(ONLINE\ \ TRIGGER)_{K_{\pi 2}} = KB \times T \cdot 2 \times (6_{ct} + 7_{ct}) \times \overline{19_{ct}} \tag{1}$$

UMC cut definitions

- **T•A ≡ T•2** *Requirement is ext(8) ≡ TRUE ?. Really one is applyed in UMC codes.*
- **Reach layer B** *The inner nine layers of 19 mm thick counters were ganged together into 3 superlayers reffered as the A, B and C having 4,3 and 2 layers of scintillator, respectevely. [1] Requirement is layv4 ≥ 6. Really by Zhe Wang this requirement is* $(6_{ct} + 7_{ct})$. *I believe it ≡ lct(6).and.lct(7)=.true. in ntuple.*
- $\overline{19_{ct}}$ *μ-veto (see for detail in [2] p.207).*
- **UFATE** [a] *requires that the pion stopped without decaying or interacting, this is why it has no acceptance loss for the NIDIF-off case.*
- **USTMED** *requires that the pion stopped in the RS scintillator.*
- **USTOP_HEX** *The offline reconstructed stopping counter agrees with the real one.*
- **RANGE1** *is PASS1 or PASS2 cut.*
- **UTCQUAL** *The UTCQUAL cuts require a track with a minimum of four z position measurements in UTC. A second requirement is a minimum value of* 10^{-5} *for the likelihood function constructed from the number of used xy hits, the number of UTC layers and the number of unused xy hits in each super layer (see for detail in [2] p.71).*
- **TARGET** *is SWATH CCD reconstruction cut.*
  TARGET ≡ ITGQUAL ≥ 2 in PNN1 and ITGQUAL ≥ 9 in PNN2.
- **KP2STOP** *requires the stopping layer to be between layers 8 and 15 inclusive.*
- **COS3D** *Cut any event with a dip angle outside the effective detection region* $-0.5 < cos3d < 0.5$.
- **KPI2BOX** *is a 3σ cut on the* $K_{\pi 2}$ *range, energy and momentum.*

$$199.53 < \quad ptot \quad < 211.67 \tag{2}$$

$$28.2 < \quad rtot \quad < 33.42 \tag{3}$$

$$100.45 < \quad etot \quad < 115.75 \tag{4}$$

[a] UFATE, USTMED and USTOP_HEX [3] are cuts based on UMC truth variables.

Cut	$K_{\mu 2}$	$K_{\pi 2}$	$K_{\pi 2}$ 2002	$K_{\pi 2}$ 2007	Cut name Acc02-Acc07
ALL	1012463	81214	81214	86747	ALL
BAD_RUN	1012463	81214	81214(1.00000)	84277(0.97153)	BAD_RUN 2.847%
BAD_STC	1012312	80802	81214(1.00000)	84277(1.00000)	TRIGGER 0.000%
TRIGGER	1012312	80802	80802(0.99493)	83429(0.98994)	BAD_STC 0.499%
RD_TRK	1012312	80802	80802(1.00000)	83429(1.00000)	RD_TRK 0.000%
TRKTIM	1012131	80802	80802(1.00000)	83396(0.99960)	TRKTIM 0.040%
RDUTM	1012131	80802	80802(1.00000)	70338(0.84342)	RDUTM 15.658%
UTCQUAL	871794	70119	70119(0.86779)	59874(0.85123)	UTCQUAL 1.655%
TARGET	858032	67908	67908(0.96847)	59874(1.00000)	TARGET -3.153%
COS3D	822638	64911	64911(0.95587)	56053(0.93618)	COS3D 1.968%
B4DEDX	805954	63298	63298(0.97515)	54032(0.96395)	B4DEDX 1.121%
CPITRS	796131	62406	62406(0.98591)	53020(0.98127)	CPITRS 0.464%
CPITAIL	795417	62352	62352(0.99913)	52973(0.99911)	CPITAIL 0.002%
ICBIT	795125	62328	62328(0.99962)	52966(0.99987)	ICBIT -0.025%
TIC	790785	61766	61766(0.99098)	51873(0.97936)	TIC 1.162%
TIMCON	786883	61285	61285(0.99221)	51169(0.98643)	TIMCON 0.579%
TGTCON	786883	61285	61285(1.00000)	50443(0.98581)	TGTCON 1.419%
DCBIT	678125	52030	52030(0.84898)	42786(0.84820)	DCBIT 0.078%
DELC	581780	44934	44934(0.86362)	36692(0.85757)	DELC 0.605%
CKTRS	562201	43547	43547(0.96913)	35535(0.96847)	CKTRS 0.067%
CKTAIL	544527	42268	42268(0.97063)	34451(0.96949)	CKTAIL 0.113%
BWTRS	513378	39879	39879(0.94348)	32513(0.94375)	BWTRS -0.027%
RVUPV	506246	39114	39114(0.98082)	31733(0.97601)	RVUPV 0.481%
TARGF	481968	37126	37126(0.94917)	30092(0.94829)	TARGF 0.089%
DTGTTP	481881	37116	37116(0.99973)	30086(0.99980)	DTGTTP -0.007%
RTDIF	476187	36697	36697(0.98871)	29767(0.98940)	RTDIF -0.069%
TGQUALT	476187	36697	36697(1.00000)	28700(0.96415)	TGQUALT 3.584%
PIGAP	470855	36298	36298(0.98913)	28352(0.98787)	PIGAP 0.125%
TGB4	442814	34123	34123(0.94008)	26392(0.93087)	TGB4 0.921%
KIC	436050	33611	33611(0.98499)	26047(0.98693)	KIC -0.193%
TGGEO	424754	27745	27745(0.82547)	21455(0.82370)	TGGEO 0.177%
B4EKZ	406721	26719	26719(0.96302)	19659(0.91629)	B4EKZ 4.673%
B4ETCON	406721	26719	26719(1.00000)	19563(0.99512)	B4ETCON 0.488%
TGZFOOL	406721	26719	26719(1.00000)	19298(0.98645)	TGZFOOL 1.355%
PV(noBV)	371206	——	26719(1.00000)	19298(1.00000)	PV_noBV 0.000%
IPIFLG	——	19321	19321(0.72312)	13606(0.70505)	IPIFLG 1.807%
KP2BOX	——	17037	17037(0.88179)	11921(0.87616)	KPI2BOX 0.563%
KP2STOP	——	16972	16972(0.99618)	11877(0.99631)	KP2STOP -0.012%
RTOT40	367233	——	16972(1.00000)	11877(1.00000)	RTOT40 0.000%
$N_{K_{\mu 2}}$ or $N_{K_{\pi 2}}$	367233	16972	16972(0.209)	11877(0.137)	$N_{K_{\pi 2}}$ 2002 or 2007 7.2%

Table 2: For the $K_{\mu 2}$, cuts applied in the f_s analysis. RTOT40 requires range > 40 cm to remove some $K_{\pi 2}$ and radiative $K_{\mu 2}$ not removed by PV(noBV). For the $K_{\pi 2}$, cuts applied in the $K_{\pi 2}$ BR analysis. KP2BOX is a 3σ cut on the KPI2 range, energy and momentum. KP2STOP requires the stopping layer to be between layers 8 and 15 inclusive.

$$KP2BOX = abs(rdev).LT.3 \quad .AND. \quad abs(edev).LT.3 \quad .AND. \quad abs(pdev).LT.3$$

Loose cut to remove kmu2 events and duplication event (by Shaomin Chen)

$$IF(\quad rngmom\_new3(0.) \quad .GT. \quad 3 \quad .OR. \quad cut(6) \quad)$$

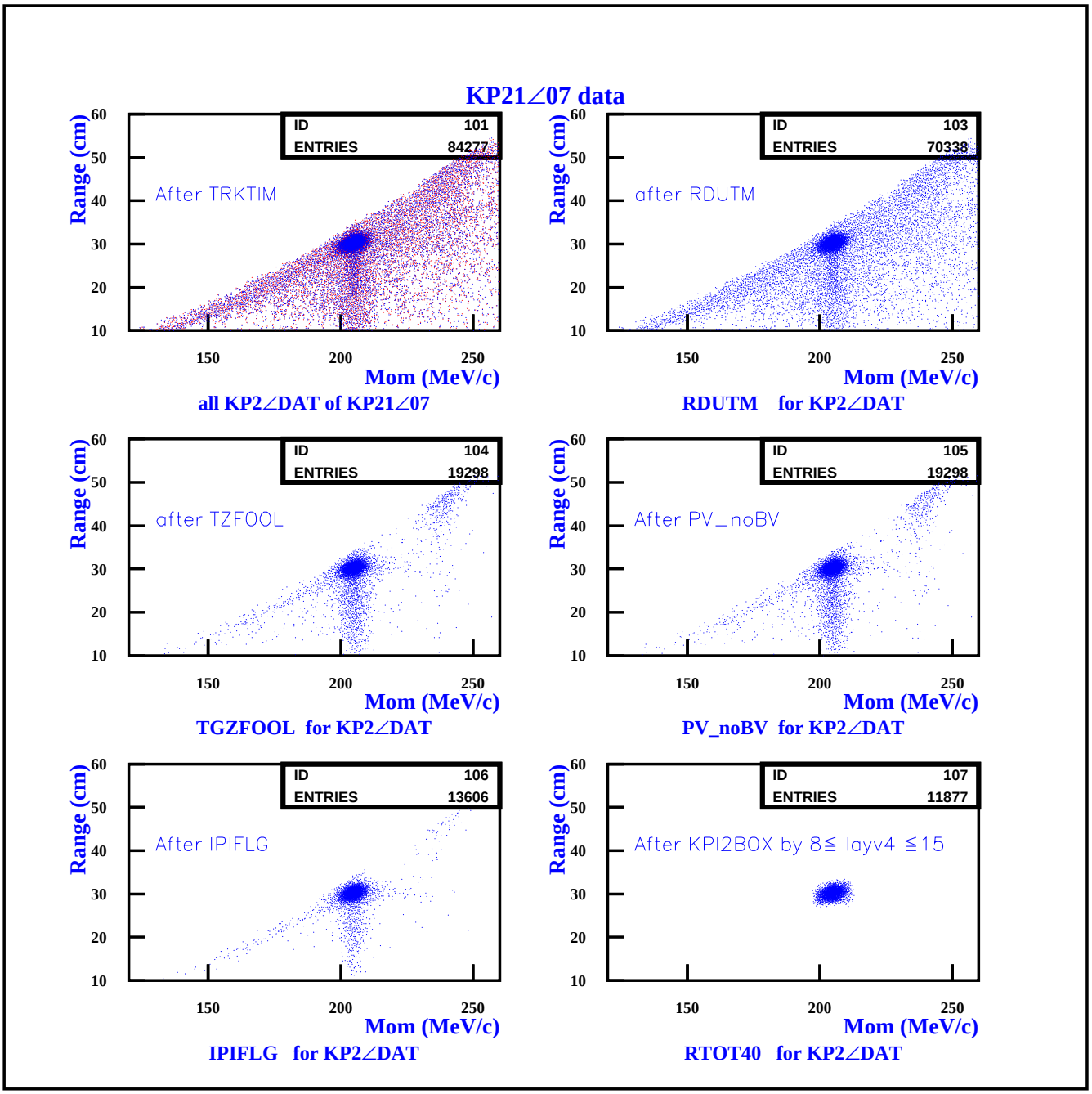

Figure 2: The $K_{\pi 2}$ events range vs momentum. $K_{\pi 2}(1)$ Monitoring data

The KP2 events after cuts are shown in blue colour.

$K_{\pi 2}$ SETUP	component cuts
$SETUP_{RD}$	TRIGGER, ICBIT, $t_{IC} - t_{Ck} > 5$ ns[a], B4DEDX, UTC, TARGET
$SETUP_{recon}$	TRIGGER, ICBIT, $t_{IC} - t_{Ck} > 5$ ns, B4DEDX, CPITRS, CPITAIL, CKTRS, CKTAIL, BWTRS, RVUPV, A_{RD} cuts,
$SETUP_{rest}$	TRIGGER, ICBIT, A_{RD} cuts, A_{recon} cuts, KP2BOX, KP2STOP, IPIFLG, COS3D.

[a] $t_{IC} - t_{Ck} > 5$ ns $\equiv$ ICTIME-CKTBM

Table 3: **Setup cuts used in the $K_{\pi 2}$-based acceptance measurement and used for $K_{\pi 2}$-based acceptances of cuts applied in $K_{\pi 2}$ BR analysis.(Table 58 on page 201 tn-k034)**

Blue color cut names have been upgraded (updated or even added) on Table 4

Cut	$K_{\mu 2}$	$K_{\pi 2}$	Cut	$K_{\pi 2}$ 2002	$K_{\pi 2}$ 2007
$SETUP_{RD}$	649651	49651	49651(0.61136)	45400(1.00000)	$SETUP_{RD}$ -38.864%
RD_TRK	649651 (1.00000)	49651 (1.00000)	49651(1.00000)	45400(1.00000)	RD_TRK 0.000%
TRKTIM	649604 (0.99940)	49651 (1.00000)	49651(1.00000)	45400(1.00000)	TRKTIM 0.000%
$A_{RD,f_s\ or\ Br}$	0.9999 ± 0.0000	1.0000 ± 0.0000	A_RD,Br	1.00000 ± 0.00000	1.00000 ± 0.00000
$SETUP_{recon}$	494472	32370	32370(1.00000)	37058(1.00000)	$SETUP_{recon}$ 0.000%
RVUTM	494472 (1.00000)	32370 (1.00000)	32370(1.00000)	36802(0.99309)	RDUTM 0.691%
UTCQUAL	440700 (0.89125)	29370 (0.90732)	29370(0.90732)	33089(0.89911)	UTCQUAL 0.821%
TARGET	438603 (0.99524)	29063 (0.98955)	29063(0.98955)	33089(1.00000)	TARGET -1.045%
$A_{reco,f_s\ or\ Br}$	0.8870 ± 0.0005	0.8978 ± 0.0017	A_RECO,Br	0.89784 ± 0.00168	0.89290 ± 0.00161
$SETUP_{rest}$	615680	32875	32875	30008	$SETUP_{rest}$ 0.000%
TIC	614469 (0.99803)	32789 (0.99738)	32789(0.99738)	29888(0.99600)	TIC 0.138%
TIMCON	612346 (0.99654)	32657 (0.99597)	32657(0.99597)	29763(0.99582)	TIMCON 0.016%
TGTCON	612346 (1.00000)	32657 (1.00000)	32657(1.00000)	29424(0.98861)	TGTCON 1.139%
DCBIT	540341 (0.88241)	28892 (0.88471)	28892(0.88471)	26181(0.88978)	DCBIT -0.507%
DELC	466647 (0.86362)	25149 (0.87045)	25149(0.87045)	22694(0.86681)	DELC 0.364%
CKTRS	458785 (0.98315)	24469 (0.97296)	24469(0.97296)	22103(0.97396)	CKTRS -0.100%
CKTAIL	447271 (0.97490)	23767 (0.97131)	23767(0.97131)	21476(0.97163)	CKTAIL -0.032%
B4DEDX	439839 (0.98338)	23357 (0.98275)	23357(0.98275)	21128(0.98380)	B4DEDX -0.105%
CPITRS	437777 (0.99531)	23130 (0.99028)	23130(0.99028)	20933(0.99077)	CPITRS -0.049%
CPITAIL	437514 (0.99940)	23119 (0.99952)	23119(0.99952)	20920(0.99938)	CPITAIL 0.015%
TARGF	418909 (0.95748)	22120 (0.95679)	22120(0.95679)	20107(0.96114)	TARGF -0.435%
DTGTTP	418832 (0.99982)	22114 (0.99973)	22114(0.99973)	20103(0.99980)	DTGTTP -0.007%
RTDIF	414112 (0.98873)	21917 (0.99109)	21917(0.99109)	19917(0.99075)	RTDIF 0.034%
TGQUALT	414112 (1.00000)	21917 (1.00000)	21917(1.00000)	19268(0.96742)	TGQUALT 3.259%
PIGAP	410775 (0.99194)	21731 (0.99151)	21731(0.99151)	19074(0.98993)	PIGAP 0.158%
TGB4	387160 (0.94251)	20560 (0.94611)	20560(0.94611)	17771(0.93169)	TGB4 1.443%
KIC	383704 (0.99107)	20409 (0.99266)	20409(0.99266)	17548(0.98745)	KIC 0.520%
TGGEO	380160 (0.99076)	16788 (0.82258)	16788(0.82258)	14450(0.82346)	TGGEO -0.088%
B4EKZ	366883 (0.96508)	16240 (0.96736)	16240(0.96736)	13371(0.92533)	B4EKZ 4.203%
B4ETCON	366883 (0.96508)	16240 (0.96736)	16240(1.00000)	13299(0.99462)	B4ETCON 0.538%
TGZFOOL	366883 (1.00000)	16240 (1.00000)	16240(1.00000)	13113(0.98601)	TGZFOOL 1.399%
BWTRS	353452 (0.96339)	15503 (0.95462)	15503(0.95462)	12506(0.95371)	BWTRS 0.091%
RVUPV	351946 (0.99574)	15278 (0.98549)	15278(0.98549)	12247(0.97929)	RVUPV 0.620%
$A_{rest,f_s\ or\ Br}$	0.5716 ± 0.0006	0.4647 ± 0.0028	A_REST,Br	0.46473 ± 0.00275	0.40813 ± 0.00284
$SETUP_{PV}$	380967	——	$SETUP_{PV}$		
PV(noBV)	351946 (0.92382)	——	PV(noBV)		
A_{PV,f_s}	0.9238 ± 0.0004	——	A_{PV,f_s}		
$SETUP_{BAD}$	1011793	81167	$SETUP_{BAD}$		
BAD_RUN	1011793 (1.00000)	81167 (1.00000)	BAD_RUN		
BAD_STC	1011793 (1.00000)	80756 (0.99494)	BAD_STC		
TRIGGER	1011793 (1.00000)	80756 (1.00000)	TRIGGER		
A_{FITPI}	——-	0.8350 ± 0.0054	A_{FITPI}		
A_{μ}^{acc}	——-	0.9931 ± 0.0002	A_{μ}^{acc}		
$A_{K_{\pi 2},f_s\ or\ Br}$	0.4684 ± 0.0006	0.3460 ± 0.0031	$A_{K_{\pi 2},Br}$		

Table 4: $K_{\mu 2}$-based acceptances of cuts applied in the f_s analysis. The SETUP cuts are defined in Table 3. SETUP_BAD is ICBIT. $K_{\pi 2}$-based acceptances of cuts applied in the $K_{\pi 2}$ BR analysis. The FITPI acceptance is measured using π_{scat}'s (counting method) similar to the $\pi\bar{\nu}$ measurement of FITPI acceptance, except that here the π_{scat}'s are selected using KP2BOX and KP2STOP instead of BOX and LAYV4. The SETUP cuts are defined in Table 3. PV(noBV) is not applied; and KM2PBOX is replaced by KP2BOX, KP2STOP and FITPI. SETUP_BAD is ICBIT. (Table 69 on page 217 tn-k034)

References

[1] André Spence Turcot, "Search for the decay $K+ \to \pi^+\nu\bar{\nu}$" The University of Victoria, Ph.D. Thesis (1994).

[2] S. Chen, J. Hu, A. Konaka, J. Mildenberger, K. Mizouchi, T. Sekiguchi, D. Vavilov, **2002 $\pi^+\nu\bar{\nu}$ data analyses**, E949 K-034.

[3] Ilektra-Athanasia Christidi, "Search for the rare decay $K+ \to \pi^+\nu\bar{\nu}$ with $p_{\pi^+} < 199 MeV/c$", The Stony Brook University, Ph.D. Thesis (2006).