The Forbidden and Unexpected Decay of Kaon
($K \to \pi\mu e$)

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1 Introduction

1.1 Overview

Particle physics is the study of the properties of subatomic particles and of the interactions that occur among them. It is the branch of science that deals with the ultimate constituents of matter and the fundamental interactions that occur among them. The subject is known as high-energy physics or elementary particle physics. My project is part of an experiment to search for the rare, possibly forbidden (a process which hasn't been seen) decay of the particle Kaon (K 7t+j.t+e-) (Figure 1). The Kaon has several modes of decay, many of which are easily confused with the decay sought, which implies a need for sophisticated methods of identifying the decays (Figure 2). The most common decay is K+ j.t+Vmuon, which occurs 63time. This could act as a background decay known as an "accidental" if the muon traveled close in time and space to a separate decay vertex, which would confuse the interpretations of other decays. Two more common decays are $K^+ \to \pi^+\pi^+\pi^-$ (Tau) and $K^+ \to \pi^+\pi^+\pi^0$, with $\pi^0 \to e + e - \gamma$ (Kdal, so called because of the Dalitz decay, $pi^0 \to e + e\gamma$, of the pion). One must know all possible outcomes to minimize mistakes in identifying the found events c orrectly. The decay of $K_{\pi\mu e}$ also sheds light on one of the most perplexing problems with the Standard Model (SM: a model of six Quarks and six Leptons as fundamental entities), the origin of mass. The mass offermions (quarks) is not determined in the SM. The SM particle Physics forbids the decay; through the postulate of Lepton Flavor Number Conservation (LFN: Figure 3).

Understanding the postulate of LFN Conservation requires an understanding of at least some of the following topics: the existence of three generations of fermions (Figure 4), because it is only with multiple generations that mixing can occur at all; the origin of mass, which is problematic in the SM and is related to the assumed mass-less ness and degeneracy of the neutrinos required for LFN Conservation; and the difference between the Quark and Lepton Sectors, because the mixing generations is observed in the Quark Sector while it has not, to much lower levels, been observed in the Lepton Sector. My part in this experiment is to use the data collected to study possible backgrounds to this unexpected decay and perhaps even to find a possible candidate for the $K_{\pi\mu e}$ decay.

1.2 Apparatus

The set up of E865 apparatus (Figure 5) also helps to minimize particle decay accidentals. It begins with a beam of protons accelerated to a momentum of 6Ge V (I e V = -e (I Volt)) propelled into a copper target, hence releasing Kaons. The kaons then travel 1OOft. to the first magnet D5, decaying somewhere in this region. The decay products enter D5, which then deflects charged particle trajectories away from the center magnet. D5 also serves to direct positive and negative charged particles to opposite sides of the detector and to sweep decay products away from the beam region. They then pass two proportional wire chambers, PI and P2, which detect their position, by sensing the voltage created when the charged particles ionize methane. The next piece of the apparatus is the Cerevnkov counter C I, which detects particles moving through a material (called a radiator) and will emit light if their speed in the radiator is greater than the speed of light in the radiator. The particles are bent as they enter the magnetic field D6. Their direction after D6 is measured in P3 and P4, which allows us to calculate precisely the momentum of the decay particles. C2, the second Cerevnkov counter, is between P3 and P4. A calorimeter where e- and pions interact follows P4. The last piece is a muon detector, where muons and those pions, which passed through the calorimeter, interact. The calorimeter and muon detector identify the types of particles being detected and allows us to infer their "rest mass."

1.3 Kinematics

The obtaining of the rest mass brings us to "Special Relativity" (Einstein's' energy-mass relationship) Eo = moc2. The mass of the decay products is found by hypothesizing the identity of the particle based on its charge and reaction to the detection devices. Using the conservation of energy (Eo = El + E2 + E3 +...) and Conservation of Momentum (Pxo = PxlC + Px2C +; Pyo = PylC + Py2C +; Pzo = PzlC + Pz2C+). We can calculate the energy with the equation Eo2=E2- (pc)2 thus E2=(pc)2 + (mc12. From the total energy and momentum of the decay product, both ofwhich are conserved in decays, the effective mass of the Kaon can be calculated in the same way, and compared to the known value.

2 Decay Products and Their Interactions

2.1 Particle Identification

Searching for $K_{\pi\mu e}$ requires us to be quite sure of the correct particle type identification. One way to get a real pion, muon, and electron from Kaon Decay is via the chain: $K^+ \to \pi^+\pi^+\pi^-$, with $\pi^+ \to \mu\nu$ and $\pi^- \to e^-\nu_e$. This has a branching ratio of 6.9 X 10-6, in order for the evnt to be see as a Knl-te candidate, the pion must decay with in the apparatus, and the fact that momentum and energy carried off by the neutrinos makes it hard to reconstruct a vertex or to project the Kaon back to the target. According to Douglas Bergrnan, the two biggest backgrounds, for final state pi, mu, e, are $K^+ \to \pi + \pi + \pi^-$ (K3pi) where one pi+ is identified as a μ^+ and the pi- as an electron), and $K \to \pi^0\pi^+$, with $\pi^0 \to ee\gamma$ (Kdal) where the positron is identified as a pi+ and the pi+ is identified as a μ^+. It is difficult to get a good separation between pions and muons, since 7make it through the muon stack to mimic muons. Thus we must then discriminate between pions and electrons. The total rate being dominated by K7t7t7t decays. Electrons appear infrequently in three track Kaon decays. When they do appear it is often via the Dalitz decay of nowhere they are accompanied by a positron. To get a better understanding of this we will look at each particle in each part of our PID apparatus.

2.2 Electrons

Proportional Wire Chambers (PWC). Proportional chambers are particle detectors consisting essentially of a container of gas (argon) subject to an electric field. The PWCs in our detector are PI, P2, P3, and P4. They are used to reconstruct tracks of charged particles and determine their momentum. A trailing particle can leave a trail of electrons and ions in the gas. The charge particle debris are collected at the chamber electrodes and in the process provide an electric signal, indicating the passage of that particle.

Cerenkov Counter Cerenkov counters like the Calorimeter are used to separate the electrons from the pions. Cerenkov counters occurs when the velocity of a charged particle traversing a dialetric medium exceeds the velocity of light in that given medium. There are two independent, atmospheric pressure, threshold Cerenkov counters in the detector. A threshold counter detects the presence of a particle whose velocity exceeds some minimum amount. In this apparatus decay products are usually detected to one side or the other based on their charges. The electron identification system is matched to the charge of the electron and positron, to reduce the K7t7t7t background, the negative electron is sent to the left side of the detector. To reduce the Kdal background, the positron is sent to the right side, where there is an efficient positron veto. The photons are detected by photomultipliers, and the unit of collected light is a "photoelectron" (or p.e.). One photoelectron is the electrical charge output from the photomultiplier which corresponds to the conversion of one photon into an electron in the photocathode of the photomultiplier.

Calorimeter The calorimeter is a device that measures the total energy deposited by a particle or group of particles used to measure the energy of electrons and positrons and to detect photons. Electron (positive and negative) is not a "strong" or "nuclear" reaction, but instead a very effective Electromagnetic interaction. Electron and Positrons Pill are made by comparing the energy given by the calorimeter with that of the momentum given by the spectrometer. This ratio (E/P) should be close to unity. One will see in Chapter 3. that the E/P values for our proposed electron are usually -1. We see that the electron energy is contained in the calorimeter. Thus it is highly unlikely that an electron will make it to the muon range detector, because of the energy loss.

2.3 Pions

Proportional Wire Chambers (PWC) As the pion move through these chambers the pions, being "ionizing" paticles go straight through the ionized gas, and that is how they are detected.

Cerenkov Counter Pions that do not shower are not likely to be identified as electrons, however, since they give no light in the Cerenkov counters.

Calorimeter Pions usually have a low E/P .Pions can shower hadronically and in this case have larger E/P ratios up to unity and beyond. This is not probable, but it does contribute to PID efficiency for pions. Pions are sometimes are "minim ionizing particles" in this momentum range and should leave a signal of about 250 MeV in the calorimeter. Pions also may have hadronic interactions in the calorimeter. The calorimeter is not compensated for hadronic showers, and much visible energy of the showers leaks out of the back of the calorimeter. The result is that pions show a minimum ionizing peak at low E/P and a broad shower peak with a max of about .5.

2.4 Muons

Proportional Wire Chambers (PWC) Muons, like that of pions, are also-minimum ionizing particles, and they are read in the ionizing gas as are pions.

Cerenkov Counter

Calorimeter Muons are minimum ionizing particles in this momentum range and should thus leave a signal of about 250 Me V in the calorimeter. Muons are distinguished by the fact that they are too heavy to undergo bremsstrahlung radiation, and thus make a shower in the calorimeter, yet they do not interact hadronically like the pions do. Muons are much more penetrating than any of the other particle types, and are identified by looking for a track penetrating many interaction lengths of steel at the back of the detector.

Muon Detector The muon stack consists of thick plates of steel interspersed with proportional chambers. The muon planes of vertical and horizontal views, each consisting of a number I of modules each containing 32 wires. Muons are required to leave a track in the muon chambers to a depth consistent with their initial momentum. A muon of a given energy has an expected range in the steel of the range stack. This places a lower limit of about .8 GeV on our acceptance for muons. Muons above their momentum are required to reach their expected range, or exit the range stack out the back if they are energetic enough.

3 My Contribution

3.1 Events and Runs

I am working from data file BOX.DAT, prepared by Alexsie Sher, of possible Kpme candidates. Here is the data and the corresponding graphs I have complied together . From the data collected I was able to also figure out which of the tracks were Muons, electrons or pions. I also studied the data and came to a conclusion of possible backgrounds. In studying these events, we have characterized them by: their high momentums indicationg that they are beam muons. We looked at muons which weren't strong muons. We also took into consideration the timing betwen the different tracks, how far or close they were to each other. We also looked at the Chi-square in these events, wether they were too high, to produce any data.

Event 1271299 (Run 4168), No. 1 in Box.dat According to this event, (Figure 6) Track number 1, we see that it is a muon, due to the muon flag. We are also certain this to be true due to the low energy in the calorimeter the E/P (comparison of the energy deposited in the calorimeter to the momentum found by the track fit); muons do not interact strongly and therefore always are minimum ionizing particles and have small E/P ratios. Track 1 is also said to be a "beam muon" because of its high momentum (see appendix 1 for calculations), higher than most three-body decay products. Track 2, we have reason to believe is a pion, because of the pion flaf reads true. Track 3 is an electron because of the E/P value is -1, and the electron flag is true.

The timing of the tracks in the vertex (tracks 1, 2, and 3) are pretty far apart. Tk 1: -.474, 2:-6.287, and 3:1.44.

Table 1: Run: 4168 Event: 1271299 No. ?? in Box.dat

Track No.	Px	Py	Pz	Energy	E/P	Muon flag	C1	C2
1 (μ)	-0.04	-0.11	4.4	0.21	0.05	T	0.6	O.O
2 (π?)	0.05	0.06	0.8	0.22	0.28	F	O.O	O.O
3 (e^-)	-0.01	0.03	0.8	0.78	-1	F	3.1	0.6

Position of the Particle				
Tracks	XC1	YC1	XC2	YC2
1	-25.4	-15.2	-27.877	-22.313
2	-13.5	27.3	-49.97	48.631
3	109.5	16.4	106.219	23.535

Summary: This Event is probably a decay from Kmunu or πmunu decay overlaid on a piece of another decay.

Event 59808 (Run 4324) No. 2 in Box.dat Track 1 (Figure 7), may be a pion due to the low energy and low E/P (.09); and the pion flag is ture. Track 2 is an electron the E/P is close to -1; and the electron flag is ture. The 2nd and the 3rd tracks have low XMEE of. 078, which indicates a low mass pair. And this can be seen from the position II in the Cerenkov counter. Thus we cannot tell if there is any electron activity or not. Because of the high E/P there may also be two electrons, tracks 3 and 4 may be positrons, (has the same mass an spin as an electron but opposite charge; anti- electron) or a type of shower. However, th pion flag is true for both Tracks 3 and 4. In track 3, the muon flag is also true, but the position shows that this would be a marginal muon, thus not a "good" muon.

Table 2: Run: 4324 Event: 59808 No. 2 in Box.dat

Track No.	Px	Py	Pz	Energy	E/P	Muon flag	C1	C2	
1 (μ)	-0.19	0.01	2.6	0.25	0.09	F	O.O	0.O	
2 (e^-)	0.08	-0.04	1.5	1.97	-1.3	F	7.33975	5.04273	
3 (e^-)	0.11	0.041	.7	2.27	1.37	4	0.6	1.48	

Position of the Particle				
Tracks	XC1	YC1	XC2	YC2
1	-84.5	3	-104.665	4.462
2	92.8	-17.5	107.455	-22.283

Summary: The timing of the tracks in the vertex (1,2 and 3) are pretty close the are set apart by nano sec. Tracks 1:4.3; 2:4.8;3:3.4. This is a Dalitz Decay.

Event 11060694 (Run 4415) Track 1 looks like a positron because of the E/P .It is also marginal for Cl and C2 detection (Figure 8, we can see C2 and the hole indicationg where a particle may be or marginal or not seen at all) and its XMEE is .053; however, the pion flag is true. Track 2 is a pion (the pion flag is true) or an "accidental source". Track 3 is an electron because of the E/P (Figure 9), and the electron flag. This event has good timing track 1:1.15;2:1.825;3:2.048.

Table 3: Run: 4415 Event: 11060694 No. 3 in Box.dat

Track No.	Px	Py	Pz	Energy	E/P	Muon flag	C1p.e.	C2 p.e.
1				2.32	1.25	F	O.O	0.376
2				0.21	0.09	F	O.O	O.O
3 (e^-)				1.65	-1.04	F	2.00935	0.82142

Position of the Particle				
Tracks	XC1	YC1	XC2	YC2
1	-22.2081	-11.6305	-8.948	-17.074
2	-81.4776	11.65112	-104.752	17.59
3	87.29404	2.698735	104.44	4.289

Summary: This event is A Dalitz Decay.

Event 547782 This event did not produce any data. The reason being may be because of the bad "chi-square" for the vertex.

Event 318302 (Run 4499) Track number 4, (Figure 10) is considered an "accidental source", because it has a high momentum of 4.74. Track 3 we also consider to be an electron, the E/P value is - 1.06; there were no flags indicated in this event, therefore there is not a "solid electron". No light was given off in the C2 and it was in time with track 2. Track 2 is a muon because of the muon flag, and the hits in the muon detector (MUX: 12; MUY:11). There was no data on track one. This event had more than three tracks.

Summary: The timing was also off in this event. This event is more than likely a Dalitz Decay.

Table 4: Run: 4499 Event: 318302 No. 5 in Box.dat

Track No.	Px	Py	Pz Energy	E/P	Muon flag	C1 p.e.	C2 p.e.	
1			0.73	0.27	F	O.O	O.O	
2 (Muon)			0.24	0.17	T	O.O	O.O	
3			1.25	-1.06	F	2.244	O.O	
4			4.74	0.57				

Position of the Particle				
Tracks	XC1	YC1	XC2	YC2
1	-42.9102	-2.95868	-42.416	-4.342
2	-84.9398	44.00331	-94.516	62.844
3	91.87349	-23.7986	111.791	-34.516

Table 5: Run: 4559 Event: 32089873 No. 6 in Box.dat

Track No.	Px	Py	Pz	Energy	E/P	Muon flag	C1p.e.	C2p.e.	
1	(Muon)			0.28	0.09	T	O.O	O.O	
2 (muon)			0.36	0.28	T	O.O	O.O		
3			1.57	-1.06	F	3.02495	5.43998		
4			1.45	-0.18					

Position of the Particle				
Tracks	XC1	YC1	XC2	YC2
1	-42.7349	-10.4739	-51.671	-16.75
2	-59.6118	6.85322	-54.057	9.143
3	103.6715	42.09175	124.879	59.06

Event 2089873 (Run 4559) Track 1, Track 1 is a muon, a beam muon, becasue of the high momentum (3.71). Track 2is a pion, due to the pion flag. Track 3 is considered an electron. The E/P of 4 is very low (-.18). Electrons are required to have an E/P with in .2 of unity (Figure 11). This event also has extra tracks. They arE also out of time.

Summary: This event is a decay from πmunu.

Event 1308914 (Run 4648) This Event did not produce any data. We figure the reason being is because of the bad "chi-square" at the vertex (figure 12).

Event 40515 (Run 4678) Track 1 is a pion due to the pion flag. Track 2 may be a pion, however it is out of C2 mirrors and marginal in C1. Tack 3, is an electron based on its E/P value, and electron flag. Track 4 has a low E/P and a XMEl of.0171; it may be a low mass pair with Track 2 (Figure 13). Track 4 doesn't have a flag. This event had more than three tracks.

Summary: This event doen't have a "good" muon. It is a Dalitz Decay.

Event 403280 (Run 3847) Track 1 is a pion, because of the pion flag. Track 2 is a muon, a beam particle muon, because of the high momentum (4.27) and the muon flag. Track 3 is an electron due to the E/P value, and the electron flag is true. (Figure 14).

Summary: This event doesn't have a "good" muon. Tracks 1 and 3 are Dalitz Decays and track 2 is a decay kaon to muon and muon neutrino.

Table 6: Run: 4678 Event: 40515 No. 7 in Box.dat

Track No.	Px	Py	Pz	Energy	E/P	Muon flag	C1p.e.	C2p.e	
1		2.17	0.24	0.11	F				
2		1.24 7 0.26	0.21						
3		-2.62	2.93	-1.21	F				
4			2.17	0.09					

Position of the Particle				
Tracks	XC1	YC1	XC2	YC2
1	-100.929	-17.9518	-125.293	-22.993
2				
3	50.52234	6.982666	57.34	10.387

Table 7: Run: 3847 Event: 403280 No. 8 in Box.dat

Track No.	Px	Py	Pz	Energy	E/P	Muon flag	C1p.e.	C2p.e.	
1				0.37	0.44	F	O.O	O.O	
2 (Muon)				0.27	0.06	T	O.O	3.80E-01	
3				0.8	-1.04	F	1.25241	3.64049	

Position of the Particles				
Tracks	XC1	YC1	XC2	YC2
1	-73.3943	-44.7034	-49.946	-59.049
2	-19.497	17.21177	18.200	25.566
3	108.8702	-10.7396	106.235	-12.371

Event 178066 (Run) Track 1 is a pion because of the E/P, and pion flag. Track 2, on other hand is a muon, based on the muon flag. Track 3 is an electron. Track 3 is an electron due to the electron flag and the energy deposition. There is a large light yield in C2 for track 3. Track 4 is a pion becausse of the pion flag, it looks like an "accidental."

Table 8: Run: Event: 178066 No. 5 in Box.dat

Track No.	Px	Py	Pz	Energy	E/P	Muon flag	C1p.e.	C2p.e	
1			2.66	0.86	0.32	F	O.O	O.O	
2			1.34	0.4	0.3	T	O.O	O.O	
3			-1.94	2.07	-1.07	F	3.73734	6.119172	
4				1.19	0.94				

Position of the Particle				
Tracks	XC1	YC1	XC2	YC2
1	-37.774	13.78689	-38.76	22.185
2	-57.7829	45.81354	-49.696	68.223
3	42.51291	-34.7017	41.761	-53.129

Summary: This may be an accidental combination because of the high Chi-square. Or an overlap of decays.

Event 10265512 Track 1, is a muon, it also has a low-energy deposition. It also has low hits in MUY (4) of the muon detector. Track 2 is a pion, due to the high-energy deposition. Track 3 is an electron due to the electron flag and E¶, as well as track 4.

Table 9: Run: Event: 10265512 No. 9 in Box.dat

Track No.	Px	Py	Pz	Energy	E/P	Muon flag	C1p.e.	C2p.e.	
1			1.69	0.24	0.14	T	0.0	O.O	
2			2.38	0.69	0.29	F	O.O	O.O	
3			-1.74	1.79	-1.03	F	1.3804	2.0254	
4				1.99	-1.4				

Summary: This event is a Dalitz Decay.

Event 974863 Track 1, is most probably a pion, due to the pion flag. However it is somewhat marginal, and may not be seen in the Cerenkov counter. Track 2 is a muon, because of the muon flag. Track 3 is an electron because of the E/P value and the electron flag. Track 4, due to the high-energy value is most likely to be an "accidental source", because it isn't on the vertex. Its pion flag is ture though.

Table 10: Run: Event: 974863 No. 10 in Box.dat

Track No.	Px	Py	Pz	Energy	E/P	Muon flag	C1p.e.	C2p.e.	
1			1.81	0.96	0.53	F	0.6069	8.28172	
2			1.76	0.22	0.12	T	O.O	0.0	
3			-2.3	2.41	-1.05	F	O.O	O.O	
4				3.25	0.26				

Summary:This event is a Dalitz Decay.

4 After Midterms

Smaller sample I looked at the smaller samples first and decieded to make cuts in them first. The cuts made were if they had one muon, whether the momentum of the muon was greater than 3, the timing, and vertex. However, most of the twelve were eliminated after the two muon cuts (Appendix 2). From the flow chart one can see the swift decline in events with the cuts made. The cuts made in the smaller sample were used as a strategy for the bigger sample of events.

Larger Sample In looking at the bigger data file of events and the FORTRAN program, "pass1-jt" (See Appendix 3 for Flow Chart). I began to investigate the file down my making adjustments to the program regarding the following charateristics: poor muon information, beam muons, poor timing agreement between tracks, and poor vertex fit. With this criteria I was able to narrow my search down among the events in the file. I also changed the "ntuple" file adding 13 new names to the file (Appendix 4). On each decay I looked at, the Dalitz (Eler4729), the Tau, and Kpme, I made cuts based on the number of muon flags. The cuts shown in the flow charts are: momentum of the muon, the chi-square, XME, XMEE, and the timing, just like in the smaller sample.

4.1 Tau

I cut down the file for the Tau by using the program to make adjustments. I started with 1954 events and ended without X cuts and including timing cuts with 739. Before the timing cuts it ends with 858. With X-cuts it was left with 639 (Appendix 5) .You can see this by following the cuts in the flow chart. The histograms (Figure 15) also provide a way to see the cuts. These histograms include timing cuts at the end histograms 801 and 802.

4.2 Dalitz

The same cuts for the Dalitz were used. The only thing that changed was the numbers (Figure 16). I started with 9443 events. Without timing cuts and without X-cuts the final number was 4825. With x-cuts and no timing cuts the final number was 4256. With timing cuts and X-cuts the final number was 2445 (Appendix 6).

4.3 Kpme

I started with 1478 events. The final number for the Kpme with X-cuts and timing cuts is 6 (Figure 17). Without timing cuts and no X-cuts the final number is 125. With timing cuts and without X-cuts is 14, however, Kpme sample events were choosen out of time (Appendix 7). With X-cuts and no timing the final number is 75. The momentum cuts loose more signals (10and Tau Decays.

5 Probablity

We decided to use an event probablity instead of the huge cuts, in hopes of avoiding such large losses. From the Dalitz and the Tau events and the simulated Kpme we evaluated the componets of the probablity, and applied them to all events to see the effect. The cuts were harder on Kpme than on the Tau and Dalitz decays. The components of the probablity were the number of tracks, the vertex, pbusy, mee, and we have the overall probablity and event probablity. To find the topograpical probablity we took the muon prob, vtx, pbusy, and track prob. and multiplied them together. We estimated probablity by looking at combinations of Tau and Dalitz of reconstructed events, data and Monte carlo events. The track probablity came from the observed Tau and Dalitz decays. The vertexprob was found by taking 1- probablity stored (CHI-PROB), since the probablity came from a previous fit to vertex hypothesis. The muon probablity came from the Taus,only since the number of muons for Dalitz is smaller, and because muons were previously removed. "Pbusy" is the number of PWC hits * clusters in cal * number of counter hits * number of D counter hits * rates; it is the product of things which indicate high rates. At high rates it is harder to reconstrut things, therefore, it is reasonable to get rid of things that have high rates. Detailed figures refered to below. Data that has to do with extra tracks, and hits have to come from the data because we have no way of simulating them, however, things from events which have to do with kinematics of decays and to see how Kpme looks we have to look at the kinematics of the simulation. The kinematics probablity is the mee(effective mass of a negative and positive particle track 3) * mom. The event probablity is the the topographical * kinematics. In figure 21 the event probablity for each decay is placed side by side so that we can compare. The Tau and Dalitz decays have similar distributions, however the Kpme candiates are very much different.

5.1 Tau Probablity

Prob TK I first looked at the number of tracks and then from there the total number divided my each tracks' total number. The total number in this case is 9146.

Track No.	Number of events	Number Divided by Tot.
3	796	.796
4	1541	.16849
5	285	.03116
6	34	.00372
7	5	.00055

We used these values to make probabilty cuts in the program and from the data we were able to see these porbablities in our histogrmas. In (Figure 18) histogram 821 we are able to see the Probablity of a moun. Also in histogram 822 the track probablity, and in 824 the Pbusy, we see that it is a fast drop. We can also see the Track probablity which has about the same number of entries as the muon probablity. We can also see the probablity of Tau verses the Kpme and Dalitz decays Kmass in histograms 841, 842 and 843.

Track No.	Number of events	Number Divided by Tot.
3	1199	.790
4	260	.171
5	51	.03362
6	7	.00461

5.2 Dalitz Probablity

The same process described above for Tau was done for the Dalitz. We got different data regarding the number tracks though. I started with 1517 entries.

The numbers for the Dalitz and the Tau are very close. In Figure 19, we can see the the probablities for each of our probablity components. An average was used decieding on the probablity to be used in the program. In histogram 842, we can see some Tau mass in with the Dalitz.

Track No.	Number of events	Number Divided by Tot.
3	473	.45177
4	427	.40783
5	125	.11939
6	2	.00191

5.3 Monte Carlo

The Monte carlo is actually a simulation of the Kpme process. The Monte CArlo momentum and MEE distrubutions are those we would expect from real Kpme events, therefore we use these for probmom, and ProbMEE distributions. In Figure 22, I have placed the MEE from the Kpme candiates and the Monte Carlo side by side. The distinction is more than clear, one can easily tell them apart. This follows for the other probablities also, histograms 821,822,823, and 824.

5.4 Kpme Probabilty

The probablity determined for the Tau, dalitz and Monte Carlo Kpme were applied to Kpme candiates. For the number of tracks we startd with 1074 events."Pbusy" drops less fast than any other decay for the kpme (Histogram 824).

Appendix 8 is an event that met all our cuts,and we are able to see the particles as they move in our apparatus. The muon track appears to be in an area not centered by the Cerenkov counters, such events should be removed; but we have not completed this study.This is followed by the event data, and probablity histograms.

Figure 1 shows some distributions related to electrons: the low mee resulting from the neutral pion decay (part a), the ratio of deposited energy to momentum (of order 1 for an electron, shown in part a), and the to tal number of photoelectrons in C1 and C2 (parts c and d).

These figures are similar to those found in the theses of Bergman [1] and Pislak [2] , but were found from the final Kpme running in 1998.

References

[1] D. Bergman. *A search for the decay $K^+ \to \pi^+\mu^+e^-$.* PhD thesis, Yale University, (1997).

[2] S. Pislak. *Experiment E865 at BNL: A search for the decay $K^+ \to \pi^+\mu^+e^-$.* PhD thesis, University of Zürich, (1997).

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3. Smith, Anne J .Magnetic Field Comparison ofD6. REUP-FOM Summer 2000. February 2001.

4. Bergman, Douglas R. A search for the Decay K + -+7t+ +e- . A dissertation presented to the Faculty of the Graduate School of Yale University in Candidacy for the Degree of Doctor of Philosophy. Dec 1997.

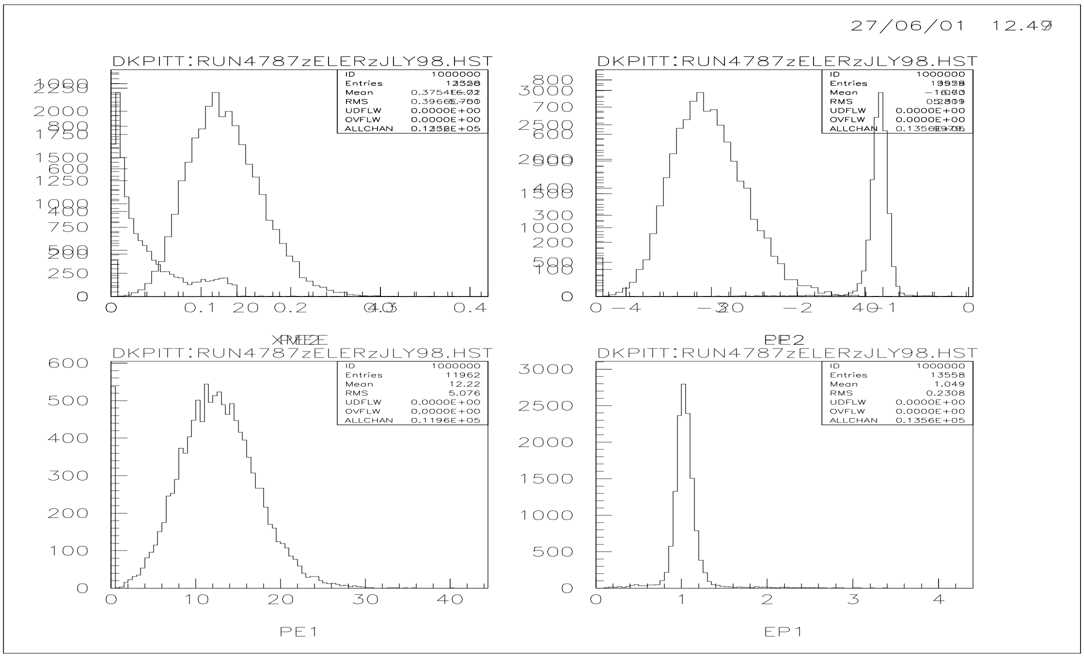

Figure 1: Mee, E/p and number of photoelectrons in C1 + C2 for members of selected ELER triggers, candidates for events arising from a neutral pion Dalitz decay to photon, e+ e-