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Subject: Result of π and e^+ Background for Test Run
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1. Data analysis for pion and positron background for test run

1.1 Summary for test run

The test run started at 3:00pm, July 10 and ended at 7:33pm, July 11. First 6 electron runs (2 for each kinematics) were done smoothly, followed by a few good positron runs for $p_e = 1.50$ GeV/c. Positron runs for $p_e = 0.90$ GeV/c started with a high deadtime, but things were going fine after resetting the pre-scaler to large numbers.

Run#	run time (min)	average charge (mC)	scaler /charge(3x) (/mC)	Total accepted triggers	PS	average dead time	E arm Momentum (GeV/c)
2773	30.316	129.556	3121.6	393070	1	0.0325	1.500
2774	14.869	56.519	3151.4	173370	1	0.0311	1.500
2775	10.706	30.884	70717.9	765012	1	0.6498	0.900
2776	5.696	9.995	71144.2	303126	2	0.1479	0.900
2777	5.423	23.515	198758.1	1310365	2	0.4394	0.550
2778	9.433	24.605	198813.6	926232	5	0.0538	0.550
2779	7.713	0.249	40584040.0	1232513	5	0.3919	1.050
2780	2.336	0.073	40180626.0	491727	5	0.1682	1.050
2781	0.770	0.030	6018686.9	35798	5	0.0006	0.900
2782	10.259	0.346	5583444.2	1309085	1	0.3222	0.900
2783	4.450	0.127	5434862.5	505303	1	0.2699	0.900
2784	4.133	0.938	65578.1	59024	1	0.0409	1.500
2785	3.386	1.371	62662.6	75885	1	0.1175	1.500

Run#	run time (min)	average charge (mC)	scaler /charge(3x) (/mC)	Total accepted triggers	PS	average dead time	E arm Momentum (GeV/c)
2786	30.282	33.998	62367.3	1803176	1	0.1502	1.500
2787	38.442	33.632	62695.0	1792841	1	0.1503	1.500
2788	11.069	6.573	63072.8	352291	1	0.1509	1.500
2789	35.372	17.515	63371.2	944823	1	0.1494	1.500
2790	28.299	34.155	62528.3	1804377	1	0.1557	1.500
2791	13.193	2.380	1171888.0	1805844	1	0.3525	0.900
2792	16.026	2.365	1174834.0	1809858	1	0.3486	0.900
2793	14.929	2.351	1173312.6	1805590	1	0.3455	0.900
2794	13.633	2.359	1173717.5	1808156	1	0.3471	0.900
2795	12.793	2.359	1172376.4	1807670	1	0.3464	0.900
2796	12.126	2.372	1173246.9	1808210	1	0.3504	0.900
2797	12.693	2.373	1172706.4	1808990	1	0.3500	0.900
2798	13.326	2.179	1173589.9	1665258	1	0.3488	0.900
2799	5.923	0.166	141168670.0	1806835	1	0.9228	0.550
2800	10.459	18.852	3380146.7	1809264	1	0.9716	0.550
2801	9.693	20.012	3396436.8	1810441	1	0.9734	0.550
2802	7.223	22.623	3392491.7	1816050	1	0.9763	0.550
2803	22.992	3.748	3388851.0	335942	1	0.9735	0.550
2804	1.120	0.250	3526435.7	38374	1	0.9564	0.550
2805	4.830	0.142	218808310.0	1611425	1	0.9482	0.550
2806	7.523	0.159	202709990.0	1819351	1	0.9436	0.550
2807	0.720	0.021	181758700.0	239474	1	0.9387	0.550
2808	1.040	0.031	179089260.0	305048	1	0.9454	0.550
2809	7.276	-0.004	-1203500.0	4857	1	-0.0000	0.550
2810	7.756	0.232	171864170.0	1812545	20	0.0921	0.550
2811	2.433	0.052	176859830.0	436098	20	0.0526	0.550
2812	13.476	49.918	3384868.2	1692356	100	0.0030	0.550
2813	9.256	26.989	3381463.5	1803444	50	0.0142	0.550
2814	6.956	26.924	3392409.5	1805373	50	0.0140	0.550
2815	6.990	26.961	3394497.9	1809950	50	0.0134	0.550
2816	7.023	26.951	3394932.6	1810738	50	0.0128	0.550
2817	7.056	26.878	3397113.2	1808348	50	0.0120	0.550
2818	4.860	15.637	3396565.2	1052631	50	0.0114	0.550

1.2 Electron(positron) pion separation for test run – pion background

Kinematics: Beam energy = 5.650 GeV, $\theta_e = 45^O$
Target: 4 cm LH2 for electron runs, 15 cm LH2 for positron runs

p_e (GeV/c)	run#	cuts	e^- (e^+)	total	π^-/e^- (detected)	π^-/e^- (real)
1.50	2773	$E_{preshower} > 250 - 0.14 \times E_{shower}$	29185	318337	9.91	17.00
	2774	0.65<ep-ratio<4.0	12780	139499	9.92	–
	2786		77	1572702	–	–
	2788		9	305428	–	–
	2789		46	818330	–	–
	2790		67	1579627	–	–
0.90	2775	$E_{preshower} > 150 - 0.08 \times E_{shower}$	9789	692503	69.74	206.54
	2776	0.65<ep-ratio<4.0	3980	274530	67.98	–
	2791		611	1288158	–	–
	2793		640	1290782	–	–
	2794		668	1291353	–	–
0.55	2777	$E_{preshower} > 160 - 0.12 \times E_{shower}$	14570	1159028	74.95	286.33
	2778	0.60<ep-ratio<4.0	10372	813698	73.67	–
	2814		1612	1118462	–	–
	2815		1679	1122901	–	–
	2816		1655	1130667	–	–
	2817		1627	1143697	–	–

★ positron runs are shown in color;
★ Cherenkov ADCs (48 channels) have been calibrated manually so the distribution of output of each channel is aligned to the same position;
★ global cuts applied: $0 < E_{shower} < 2000$ and $50 < E_{preshower} < 4000$;
★ π^- ratio after decay (drift distance 23.4m from target to spectrometer):
25.95% for 0.55 GeV/c; 33.33% for 0.90 GeV/c; 41.70% for 1.50 GeV/c

Data analysis for run # 2773 (electron run, $p_e = 1.50$ GeV/c) and run # 2786 (positron run, $p_e = 1.50$ GeV/c) are shown in Figure 1

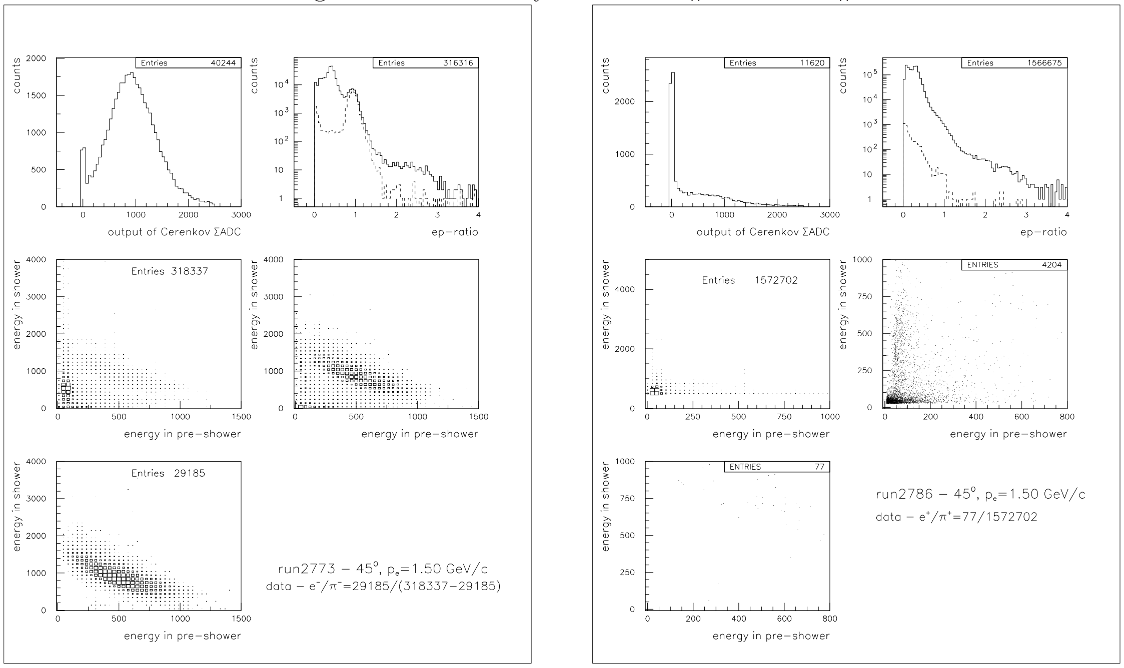
1.3 Positron background for test run

$$\begin{aligned} \sigma \quad &\propto \quad \frac{(\#\text{of events}) \times (\text{scaler per charge})}{\text{total accepted triggers}} \times \frac{1}{\text{target length}} \qquad (1) \\ \frac{\sigma_{e^+}}{\sigma_{e^-}} \quad &= \quad \frac{N_{e^+}}{N_{e^-}} \times \frac{[\text{accepted triggers} \times \text{target length}]_{e^-}}{[\text{accepted triggers} \times \text{target length}]_{e^+}} \times \frac{[\text{scaler per charge}]_{e^+}}{[\text{scaler per charge}]_{e^+}} \end{aligned}$$

$$\text{for} \quad p_e = 1.5\text{GeV/c} \qquad \frac{\#2786}{\#2773} = \frac{70}{29185} \times \frac{393070 \times 4}{1803176 \times 15} \times \frac{62367.3}{3121.6} = 0.28\% \qquad (2)$$

$$\text{for} \quad p_e = 0.9\text{GeV/c} \qquad \frac{\#2791}{\#2776} = \frac{611}{3980} \times \frac{303126 \times 4}{1805844 \times 15} \times \frac{1171888.0}{71144.2} = 11.32\% \qquad (3)$$

Figure 1: data analysis for run #2773 and #2786



$$\text{for}\quad p_e = 0.55\text{GeV/c} \qquad \frac{\#2778}{\#2815} = \frac{1679}{10372} \times \frac{926232 \times 4}{1809950 \times 15} \times \frac{3394497.9}{198813.6} = 37.72\% \tag{4}$$

1.4 Comparison between code and data for π and e^+ background

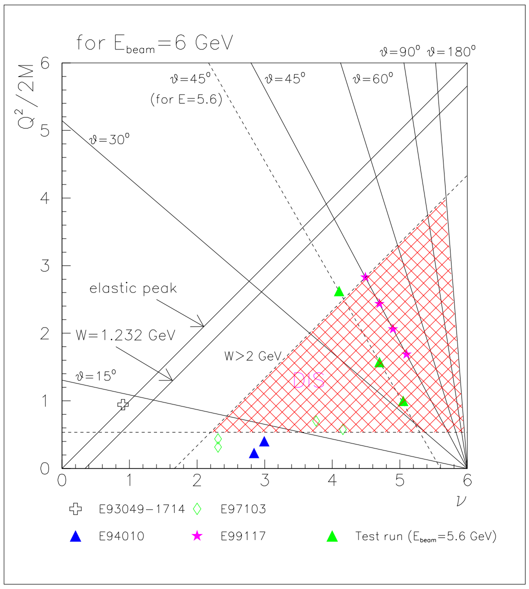
Different kinematic regions where different fit/parameterization (based on experimental data) are listed as follows:

⧫ epc: photoproduction of pion/nucleons in elastic scattering and resonance regions;
⧫ Wiser: photoproduction of pion/nucleons in DIS (Deep Inelastic Scattering) region;
⧫ qfs: electron scattering in elastic and resonance regions;
⧫ Whitlow: electron scattering in DIS region;

Kinematic region for test run and E99-117 are shown in Figure 2

Kinematics: Beam energy = 5.650 GeV, $\theta_e = 45^O$
Target: 4 cm LH2 for electron runs, 15 cm LH2 for positron runs

Figure 2: illustration of different kinematic regions



Kin: p_e(GeV/c)	1.5	0.9	0.55
π^- (epc)	0.000	0.000	0.000
π^-(Wiser)	5.403	360.431	2807.432
e^-(qfs)	0.496	1.709	3.876
e^-(Whitlow)	0.452	2.182	3.961
e^+(epc)	0.00217	0.00376	0.00741
e^+(Wiser)	0.01769	1.62190	18.1455
π^-/e^-(Wiser/qfs)	10.896	210.849	724.387
π^-/e^-(Wiser/Whitlow)	11.958	165.156	708.803
π^-/e^-(epc/qfs)	0.000	0.000	0.000
π^-/e^-(data,detected)	9.91	68.86	74.31
π^- decay ratio	41.70%	33.33%	25.95%
π^-/e^-(data, corrected)	17.00	206.54	286.33
e^+/e^-(epc/qfs)	0.434%	0.224%	0.193%
e^+/e^-(epc/Whitlow)	0.485%	0.174%	0.188%
e^+/e^-(Wiser/qfs)	3.543%	96.318%	472.09 %
e^+/e^-(Wiser/Whitlow)	3.962%	74.887%	460.47 %
e^+/e^-(Wiser/Born)	0.0472%	0.830%	7.52%
e^+/e^-(data)	0.28%	11.32%	37.72%

★ The radiation length for 4cm liquid H_2 target is:
2.8 mil Al + 20 cm Air + 4 cm/2 LH2 = 0.31%
for 15cm liquid H_2 target is:
2.8 mil Al + 20 cm Air + 15 cm/2 LH2 = 0.95%
★ Radiation tail of elastic scattering not included yet;

★ Available data show wiser might has an overestimation by a factor of 3;

2. Prediction for pion and positron background for E99-117

2.1 Estimation of π and e^+ background for E99-117

Kinematics: Beam energy = 6.0 GeV, $\theta_e = 45^O$, 40cm ^3He target

Kin: p_e(GeV/c)	1.5	1.31	1.10	0.90
π^- (epc)	0.260	0.293	0.334	0.394
π^-(Wiser)	16.908	81.934	315.380	1144.040
e^-(qfs)	1.289	2.170	3.150	4.488
e^-(Whitlow)	0.783	1.530	2.540	3.800
e^+(epc)	0.00547	0.00625	0.00812	0.00998
e^+(Wiser)	0.06606	0.34462	1.58369	6.40059
π^-/e^-(Wiser/qfs)	13.117	37.764	100.114	254.909
π^-/e^-(Wiser/Whitlow)	21.581	53.541	124.183	301.082
π^-/e^-(epc/qfs)	0.201	0.135	0.106	0.088
π^- decay ratio	41.67%	39.31%	36.57%	33.33%
π^-/e^- (detected)	~30	<50	<50	<50
e^+/e^-(epc/qfs)	0.425%	0.288%	0.258%	0.222%
e^+/e^-(epc/Whitlow)	0.699%	0.408%	0.320%	0.263%
e^+/e^-(Wiser/qfs)	5.125%	15.884%	50.273%	142.615%
e^+/e^-(Wiser/Whitlow)	8.432%	22.520%	62.359%	168.447%
e^+/e^-(Wiser/Born)	0.087%	0.292%	0.375%	1.965%
e^+/e^-(conservative)	~<2%	~4%	~10%	~20%

★ The radiation length for 40cm ^{3}He target is:
10 mil Be + 10 mil Al + 0.012 mm Pyrex + 20 cm Air + 40 cm/2 ^{3}He (10atm)=0.3574%
★ No Wiser code for D2 or He3 is available, so use 3 times Wiser for proton as He3 result;
★ Final result (the last row) of pion and positron background is the code result corrected by over/under-estimation factor obtained from test run.

2.2 Conclusion

Can see that the pion background is not too high. Cerenkov detector and shower-preshower detectors are sufficient for pion/electron separation. But the positron background is much higher than what we expected before, so positron runs are necessary during the experiment for subtracting the positron background from total events.