SANE
Pair-symmetric Background Run Plan

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Pair-Symmetric Background

- Target backgrounds
  - Processes that compete with or imitate inclusive inelastic (e,e') scattering
  - Three main sources
    - Bethe-Heitler (bremsstrahlung) into $e^+ e^-$: very small angle with respect to beam $\sim m_e/E$; not a concern for SANE. Møller not important, either.
    - π^0 decays: $\pi^0 \rightarrow \gamma\, e^+ e^-$ (1.2%) and $\pi^0 \rightarrow \gamma\gamma$ (99%): SANE's main concern
    - π misidentified as e: contamination
  - Other particle decays into $e^+ e^-$ or e^- : small probability, will neglect.
- Forward tracker will be able to distinguish charge signs only for $p \leq 1$ GeV/c

Effect of Background on DIS Asymmetry

- Target background for SANE is mostly $e^+ e^-$ pairs: BETA is charge sign insensitive, detects both.
- The measured electron asymmetry A_m must be corrected for the counts N_b and possible asymmetry A_b coming from the target background
- Need to estimate or measure both the background rate and asymmetry

$$N_m = L_m + R_m = N + N_b$$

$$A_m = \frac{(L-R)+(L_b-R_b)}{N_m} = \frac{(N_m - N_b)A + N_b A_b}{N_m}$$

$$A = \frac{A_m - f_b A_b}{1 - f_b}; \qquad f_b = \frac{N_b}{N_m}$$

$$\delta A^2 = \frac{1}{(1-f_b)^2}\left[(\delta A_m)^2 + (f_b \delta A_b)^2 + \left(\frac{A_m - A_b}{1-f_b}\right)^2 (\delta f_b)^2\right]$$

π^0 Related Backgrounds

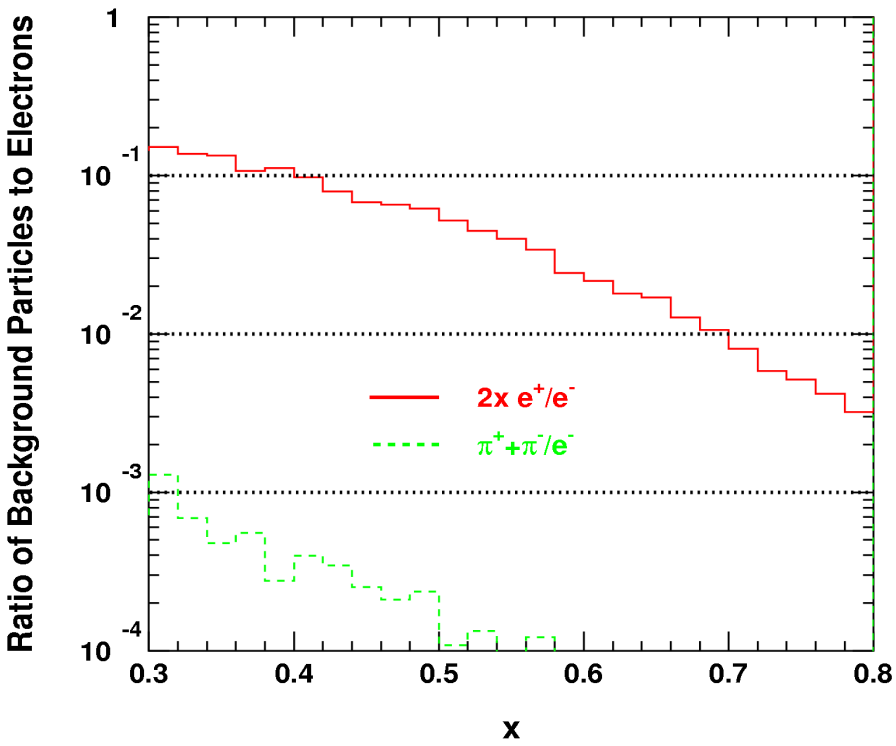
- π^0 Dalitz decay: $\pi^0 \rightarrow \gamma\, e^+ e^-$
  - 1.2% branching ratio
- $\pi^0 \rightarrow \gamma\gamma$
  - $\gamma \rightarrow e^+ e^-$
  - 99% branching ratio*X_0 radiation thickness from target to detector*2 γ's
  - SANE $<X_0>$ = 0.028
- Effective Dalitz pairs >= 29% of π^0
  - (P. Bosted CLAS-Note 2004-005)

Material in front of BigCal*	g/cm²	X0
Target cell	0.689	0.016
Target windows	0.156	0.007
Cherenkov windows	0.076	0.002
Cherenkov gas	0.156	0.004
Sub Total	1.077	0.028

* Trigger Cherenkov*BigCal

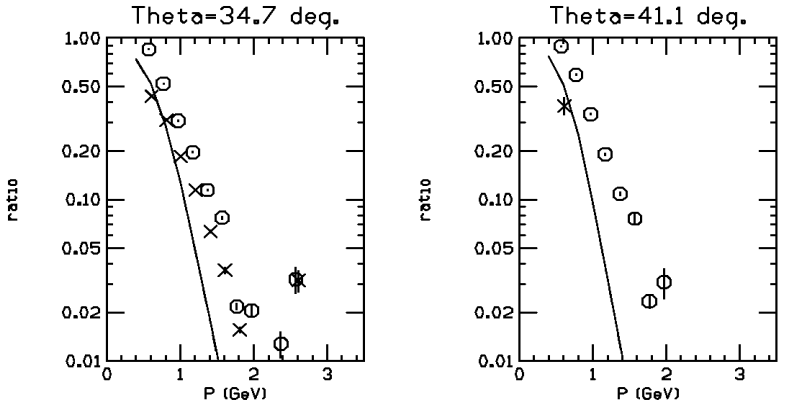
Background Simulation in Proposal

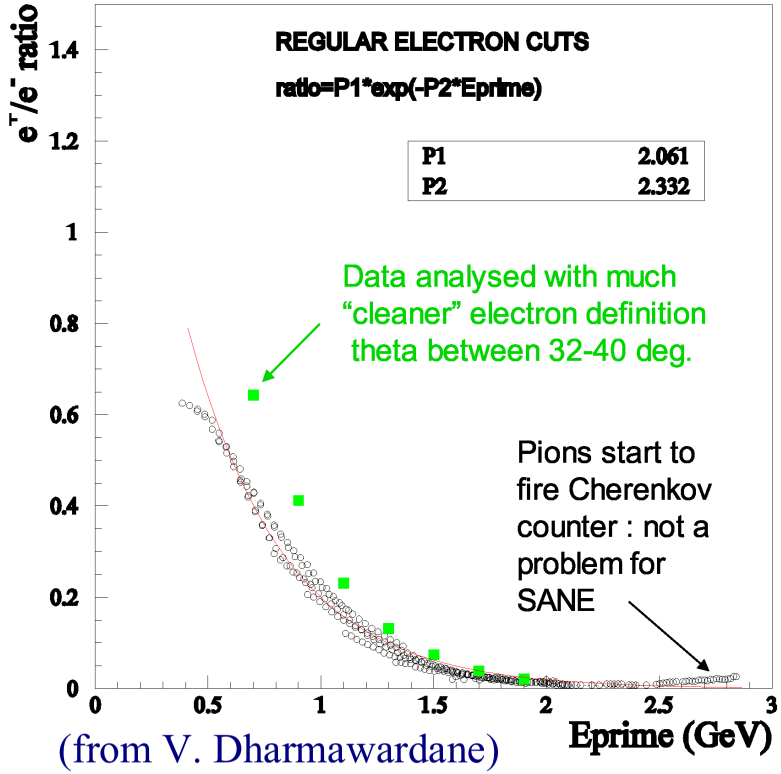
- Charge-symmetric processes from π^0 decays (simulated by G. Warren)
  - SLAC $e^+ e^-$ parameterization
- Reduce positron rates by increasing energy threshold to $E' > 1.3$ GeV
  - Lose some low x range at low Q^2
- Measure dilution in HMS:
  - estimated 75 h at 6 GeV.
- Measure ratio of asymmetries using events with γ, $\gamma\gamma$ and $e^+ e^-$ in BETA
- Hadron backgrounds measured by ignoring Gas Cherenkov in trigger



e^+/e^- Pairs in eg1b (Parallel Field)

- Report by P. Bosted on eg1b e+e- and pion backgrounds
- Relevance for SANE:
  - 5.7 GeV data vs 6 GeV SANE
  - 34.7° and 41.1° vs 40° SANE
  - E' range 0 - 3.6 GeV
- CLAS data analyzed by V. Dharmawardane
  - no angular dependence
  - good 2-parameter fit to ratio
  - $f_{\mathrm{CLAS}}(E') = e_C^+/(e_C^- + e_C^+)$
    $= P_2 \exp(-P_2 E')$





(from V. Dharmawardane)

Polarized Target Pairs in eg1b and Hall C

- Comparison of SANE and eg1b
  - very similar kinematics = similar π^0 production rates
- eg1b effective radiator:
  - $0.028\ X_0 = z_{CLAS}\ (7/9) X_0 +$ Dalitz
- Hall C effective radiator (**HMS**):
  - $0.060\ X_0 = z_{HMS}\ (7/9)\ X_0 +$ Dalitz
- $z_{HMS} = 3\ z_{CLAS}$, or $e^+_{HMS} = R_{H/C}\ e^+_{CLAS}$
- Solve $f_{CLAS}(E')$ for e^+_{CLAS}; $R_{H/C}$=0.06/0.028
  - $\boldsymbol{f_{HMS}\ (E') = R_{H/C} f_C / [1 + f_C (R_{H/C} - 1)]}$
  - $\boldsymbol{f_{SANE}\ (E') = 2R_{H/C} f_C / [1 + f_C (2R_{H/C} - 1)]}$

SANE e+/e- rates (SLAC parameterization)

E' = 1 GeV

θ	SANE e+	SANE e+/(e- + e+)	f_SANE(f_C)
36	1.23	0.55	0.52
40	0.58	0.37	0.52

E' = 1.35 GeV

θ	SANE e+	SANE e+/(e- + e+)	f_SANE(f_C)
36	0.49	0.33	0.29
40	0.17	0.14	0.29

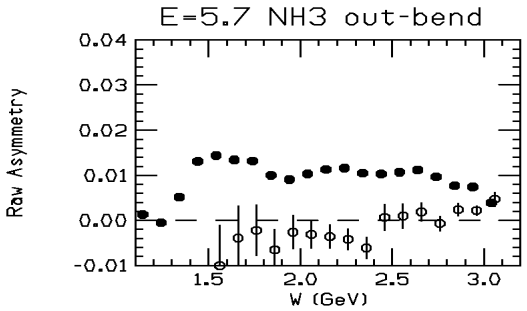
(From Proposal Table 6)

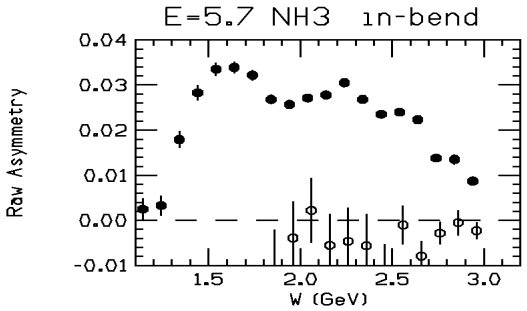
Background Parallel Asymmetry

- eg1b measured parallel A_b e+ asymmetry < ~20% of DIS e- A
- Uncertainty in asymmetry < ~ 100%
- Estimate systematic error in SANE with
  - approximation $A_b \sim 0$
  - 10% relative error in f
- SANE's expected large f magnifies error

$$A = \frac{A_m}{1 - f_b}; \qquad A_b \sim 0$$

$$\frac{\delta A}{A} = \frac{f_b}{(1 - f_b)} \left[\left(\frac{\delta A_b}{A} \right)^2 + \left(\frac{\delta f_b}{f_b} \right)^2 \right]^{1/2}$$



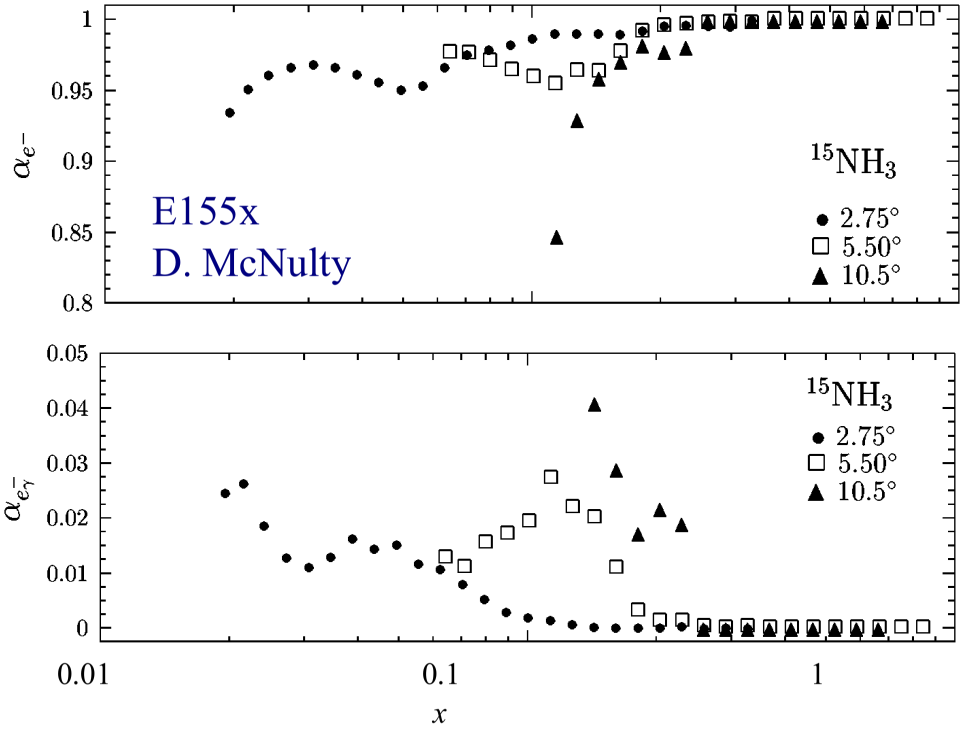


E' [GeV]	θ	x	f	df / f	dA/A
1	36	0.24	0.55	10%	28%
	40	0.3	0.37	10%	13%
1.35	36	0.35	0.33	10%	11%
	40	0.42	0.14	10%	4%

(Using dAb/A = 20% corresponding to dAb/Am = 0.2/(1-f))

SANE 80°

- For SANE 80°
  - e+/e- rates same as for parallel
  - Data from SLAC E155x
    - $E' > 9$ GeV
    - e+/e- < ~ 0.02
  - A_b/A_m ratio:
    - E155x set $A_{e+} = 0$ (low statistics)
  - need to measure during SANE



Pairs Systematic Errors

- SANE's 80° DIS asymmetry expected **statistical errors ~ 8%**
- Need to keep **systematic errors** due to pair background to **~5%** or less
- Choose $f \sim 1/3$ as reference, corresponding to a ½ magnification
  - < ~7% source errors needed
- Develop run plan to measure dilution to keep DIS asymmetry error at 5% level
- Get background asymmetry from γ, $\gamma\gamma$ and e^+e^- asymmetries in BETA
  - compare with eg1b for parallel
  - also measure with HMS

$$\left(\frac{\delta A}{A}\right)_{max} \le \frac{f_b}{1-f_b}\left[\left(\frac{\delta A_b}{A}\right)^2 + \left(\frac{\delta f_b}{f_b}\right)^2\right]^{1/2}$$

$$\left(\frac{\delta f_b}{f_b}\right) = \frac{1}{\sqrt{1+c^2}}\frac{1-f_b}{f_b}\left(\frac{\delta A}{A}\right)_{max}$$

$$\left(\frac{\delta A_b}{A}\right) = c\left(\frac{\delta f_b}{f_b}\right), \qquad c \ge 1$$

Preliminary HMS Parallel Run Plan

- Measure ***f*** during parallel run
- Estimate DIS electron rates in HMS with *RSS*'s montecarlo for 1 GeV ≤ *E*' ≤ 2 GeV and 32°, 40°, 48°
- Convert to pair rates using Vipuli D.'s eg1b parameterization
- Compute run times for 5% pair background systematic error

E = 4.6 GeV θ = 32° **Goal dA / A = 5%**

E' GeV	fCLAS	fSANE	fHMS	e- rate Hz	e+ rate HMS	de+/e+HMS (dfS/fS)	time e+ [h]	de-/e-HMS	time e- min	dA_bg /A	dfS / fS
1.0	0.20	0.52	0.35	6.2	3.3	2%	0.21	3%	2.9	4%	2%
1.1	0.16	0.45	0.29	6.5	2.6	3%	0.17	4%	2.0	6%	3%
1.2	0.13	0.38	0.24	6.7	2.1	3%	0.13	4%	1.4	7%	4%
1.3	0.10	0.32	0.19	6.4	1.5	4%	0.12	5%	1.1	9%	5%
1.4	0.08	0.27	0.15	6.2	1.1	5%	0.10	6%	0.8	12%	6%
1.5	0.06	0.22	0.12	5.9	0.8	6%	0.09	7%	0.6	16%	8%
1.6	0.05	0.18	0.10	5.4	0.6	8%	0.08	9%	0.4	20%	10%
1.7	0.04	0.15	0.08	5.0	0.4	10%	0.07	11%	0.3	26%	13%
1.8	0.03	0.12	0.06	4.6	0.3	12%	0.06	13%	0.2	33%	16%
1.9	0.02	0.10	0.05	4.1	0.2	15%	0.05	16%	0.2	41%	21%
2.0	0.02	0.08	0.04	3.5	0.1	19%	0.05	20%	0.1	53%	26%
2.2	0.01	0.05	0.03	2.3	0.1	31%	0.05	31%	0.1	85%	42%

Preliminary HMS Parallel Run Plan

- Measure ***f*** during parallel run
- Estimate DIS electron rates in HMS with *RSS*'s montecarlo for 1 GeV ≤ *E*' ≤ 2 GeV and 32°, 40°, 48°
- Convert to pair rates using Vipuli D.'s eg1b parameterization
- Compute run times for 5% pair background systematic error

E = 5.7 GeV θ = 40° **Goal dA / A = 5%**

E' GeV	fCLAS	fSANE	fHMS	e- rate Hz	e+ rate HMS	de+/e+HMS (dfS/fS)	time e+ [h]	de-/e-HMS	time e- [h]	dA_bg /A	dfS / fS
1.0	0.20	0.52	0.35	0.109	0.058	2%	12	3%	3	4%	2%
1.1	0.16	0.45	0.29	0.129	0.052	3%	8	4%	2	6%	3%
1.2	0.13	0.38	0.24	0.131	0.040	3%	7	4%	1	7%	4%
1.3	0.10	0.32	0.19	0.120	0.028	4%	6	5%	1	9%	5%
1.4	0.08	0.27	0.15	0.099	0.018	5%	6	6%	1	12%	6%
1.5	0.06	0.22	0.12	0.073	0.010	6%	7	7%	1	16%	8%
1.6	0.05	0.18	0.10	0.049	0.005	8%	8	9%	1	20%	10%
1.7	0.04	0.15	0.08	0.028	0.002	10%	12	11%	1	26%	13%
1.8	0.03	0.12	0.06	0.014	0.001	12%	20	13%	1	33%	16%
1.9	0.02	0.10	0.05	0.006	0.000	15%	39	16%	2	41%	21%

Preliminary HMS Run Plans

- Proposal for ***f*** during ***parallel*** run:
  - measure central and large angle during 4.6 GeV run: 75 h including overhead
  - measure small and central angle during 5.7 GeV run: 24 h including overhead
  - measure pair asymmetry at 40° at each energy: plan TBD
- Proposal for **80°** run:
  - measure pair asymmetry at each energy at 24°: plan TBD
- Measure packing fractions: plan TBD

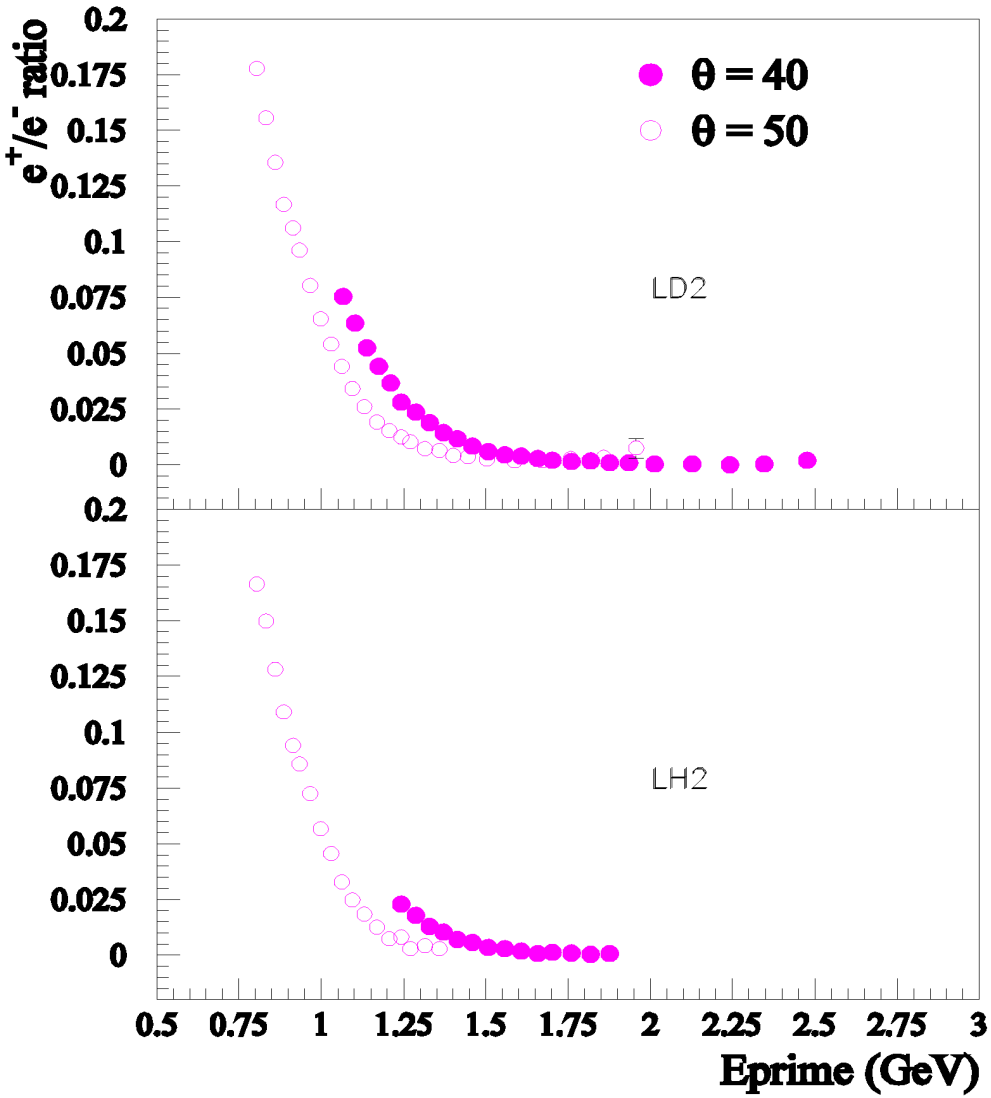
Summary of times

E	θ	e+ h	e- h
4.6 GeV	32˚	1	0
	40˚	7	1
	48˚	50	7
Total data time 4.6 GeV		59	8
Overhead		7	7
Momentum changes		32	
Time in main run plan [PAC h]		72	
5.7 GeV	32˚	2	0
	40˚	11	1
	48˚	126	13
Total data time 5.7 GeV		139	15
Overhead		8	8
Momentum changes		34	
Time in main run plan [PAC h]		120	
Time/ mom. change[h]		0.20	
Angle changes		3	
Time/ angle change[h]		0.25	

Hall C pairs study

- Preliminary Hall C analysis from Jason Seely
- Clear theta dependence
- Contamination is small at large angles

From:
Vipuli Dharmawardane
SANE report 4/21/05



Estimated Systematics for 6 GeV

Radiative Corrections	1.5%
Dilution Factor	2.0%
Target Polarization	2.5%
Beam Polarization	1.0%
Nitrogen Correction	0.4%

	A1p		g2	
	$x = 0.3$	$x = 0.6$	$x = 0.3$	$x = 0.6$
R	0.8%	1.2%	1.5%	1.3%
Kinematics	0.4%	0.5%	2.7%	4.5%
Background	1.0%	1.0%	3.7%	1.8%
Local	2.1%	2.3%	4.0%	4.1%
Global	3.3%	3.3%	4.6%	4.7%
Total	4.2%	4.0%	6.8%	6.7%

Rates in BETA

Gas Cerenkov (> 20 MeV)

E	e^-	$\pi-$	Trig
4.8	28.1	242.0	30.5
4.8	1590.0	223.0	1592.2
6.0	25.3	255.0	27.9
6.0	1510.0	236.0	1512.4

Calorimeter (> 900 MeV)

E	e^-	$\pi-$	π°+N	Trig
4.8	0.3	1.0	7.2	8.5
4.8	0.3	1.0	7.1	8.4
6.0	0.3	1.1	8.1	9.5
6.0	0.3	1.2	8.0	9.4

BETA Trigger Rates

E	True	Accd	offline A/T
4.8	0.31	0.03	0.0%
4.8	0.31	1.34	0.6%
6.0	0.31	0.03	0.0%
6.0	0.31	1.43	0.6%