KAON-LT Run Plan - Part 5

March 24, 2019

8.204 GeV Beam Plan

Initial beam activities

- Hall entry for SHMS aerogel change. During the linac pass change, and in co-ordination with the RC, the SHMS aerogel expert (Berdnikov and techs) needs to enter the hall to remove the $n = 1.015$ aerogel and replace it with $n = 1.011$ aerogel. Estimated time required – 8 hours.

- Hall entry to move SHMS away from beam pipe. The Run Co-ordinator will need to arrange in advance which expert personnel (e.g. Fowler, Lassiter) need to be present. Our goal is for this to happen day shift Wednesday, March 27.

- While waiting for beam, configure the spectrometers for the carbon sieve run:
  1. SHMS angle = 9.50 deg (from TV).
  2. SHMS momentum = -5.745 GeV/c (negative polarity and all magnets cycled).
  3. HMS angle = 13.00 deg.
  4. HMS momentum = -5.745 GeV/c (negative polarity and all magnets cycled).
  5. Update *standard.kinematics* with the new settings.

  please make logentry of camera images for angles

- Beam checkout.
  Follow the notes at:
  `https://hallcweb.jlab.org/wiki/index.php/Beam_Checkout_Procedures`
  including the "Carbon-hole" check to verify beam+target alignment and MCC raster size calibration. Note, this will be followed by checking beam vertical position with HMS/SHMS sieve (see section Calibration runs below).

Items to be done as soon as possible at this energy (time determined by RC, suggested date: March 28 day shift).

- Superharp scan (BPM calibration check).
  The Run Co-ordinator should let the MCC know in advance that we are planning a Superharp scan. The beam should be stable and less than 25 μA. We want this done with the raster off, so that the beam spot size can be measured. If the spot size at 07A is < 0.1mm (sigma), instruct MCC to increase the spot size and remeasure to verify.

- Energy determination with arc.
  The Run Co-ordinator will coordinate the timing of this with the Program Deputy. MCC will have to set up a clean dispersive tune. It is important for the Shift Leader to make a full hclog entry of the MCC data. Follow the "Hall C Beam Energy Measurement Procedure" at MCC Ops Doc: MCC-PR-06-004.

Calibration runs.

1. HMS and SHMS sieve runs with 1.5% r.l. $z = 0$ carbon target.

   - Spectrometer angles and momenta as on previous page.
   - Sieve slits on both spectrometers.
   - **Raster off.** Current limit=20 μA. Carefully center the beam to the previously determined central position.
   - Verify that MCC has position at target lock on, and energy lock on.
   - Prescale factors:
     HMS singles daq disabled (all PS=-1).
     SHMS singles daq disabled (all PS=-1).
     COIN daq PS1(SHMS-3/4)=–1, PS2=(SHMS-ELREAL)=0, PS3(HMS-ELREAL)=0, PS4(HMS-3/4)=–1, PS5(HMS-ELREAL×SHMS-3/4)=–1,
     PS6(HMS-3/4×SHMS-3/4)=–1.

   Singles runs. Take 100,000 HMS and 100,000 SHMS electron triggers. Adjust PS2(SHMS-ELREAL) and PS3(HMS-ELREAL) as necessary to keep the deadtime at reasonable levels (below 20%).

	E_e	θ'_e	P'_e
HMS:	8204.0	13.00	–5745.0
SHMS:	8204.0	9.50	–5745.0

   Look at HMS and SHMS $x - fp$ vs $y - fp$ scatterplots, and compare to the "reference plots" taken at the beginning of the 10.6 GeV beam time. They should look extremely similar. Ask Mark Jones or Holly Szumila-Vance to verify the data, and if there is a problem, give instructions on what to do next.

2. Luminosity scans on LH2 and $z = 0$ 1.5% r.l. C targets.

The purpose of the study is to study efficiency and live-time corrections versus rate and current, and relies on MCC's ability to deliver high beam currents. If they can not, the RC will instruct whether to defer the luminosity scan later in the experiment.

Initially set the spectrometers to:
HMS=–5.745 GeV/c, 13.00 deg. SHMS=–5.745 GeV/c, 9.50 deg.

ELREAL trigger in both arms. Set the PS2, PS3 target DAQ rates to 1.5 kHz, to give a total rate to disk of about 3 kHz.

The EDTM event trigger rate needs to be increased to about 1 kHz, to ensure that after prescaling there are 10k-100k EDTM events per run. **The number of accepted EDTM events needs to be monitored carefully during the luminosity scan!**

Make sure the raster is on (2 × 2), and take HMS and SHMS runs at 70, 50, 30, 15, 5 μA. Start at the highest current and work down, one target at a time.

Also, take one Thick Dummy target run at 30 μA. 125,000 electrons per run.

Try to get runs with a minimum of beam trips (if possible).

Trotta should do a sanity-check of the EDTM (and any other hardware deadtime measurement system) by comparing runs over a range of detector rates but with low software deadtimes.

8.204 GeV Luminosity Scan						
μA	Targets	$\frac{Rate_{SHMS}}{LHrun}$	$\frac{Rate_{HMS}}{LHrun}$	DAQ_{SHMS}	DAQ_{HMS}	$\frac{Time}{run}$
$\theta_{HMS} = 13.00$, P_{HMS}=-5.745 GeV/c, $\theta_{SHMS} = 9.50$, P_{SHMS}=-5.745 GeV/c						
70	LH2, C	690 kHz	140 kHz	1.5 kHz	1.5 kHz	12 min
50	C, LH2	460 kHz	100 kHz	1.5 kHz	1.5 kHz	12 min
30	LH2, Dummy, C	275 kHz	60 kHz	1.5 kHz	1.5 kHz	12 min
15	C, LH2	137 kHz	30 kHz	1.5 kHz	1.5 kHz	12 min
5	LH2, C	46 kHz	10 kHz	1.5 kHz	1.5 kHz	12 min
Total Time (including overhead): 3.3 hrs						

Note - MCC can only give 65 μA on 1.5% C, this is fine, run with 65 μA on 1.5% C

3. $\boxed{p(e,e')p}$ Hydrogen elastic singles and associated Thick Dummy target runs.

Set up the following configuration:

(a) HMS and SHMS angles and momenta as specified in the tables below. Negative polarity. Cycle all magnets before the first setting.

(b) Record all TV angle values on the runsheets.

(c) HMS large and SHMS collimators.

(d) Update *standard.kinematics* with the new settings.

LH2 target runs:

Take two runs for each of the following HMS, SHMS angle and momentum settings. Stable 70 μA beam with **raster on.** Set the PS2(SHMS-ELREAL) and PS3(HMS-ELREAL) target rates to 1000 Hz, all others disabled (i.e. -1). As a guide, projected rates and PS factors are given in the table below. We want at least 10,000 elastics, which typically requires at least 200,000 total electron events (times below are only a guide). The total event estimate includes inelastics.

Thick Dummy target runs:

One run for each angle and momentum setting, taken immediately after the corresponding LH2 run. Current limit: 40 μA.

8.204 GeV Heep-check singles runs									
θ_{HMS}	P_{HMS}	θ_{SHMS}	P_{SHMS}	$Rate_{HMS}$	$\frac{PS3}{HMS}$	$Rate_{SHMS}$	$\frac{PS2}{SHMS}$	$\frac{Time}{LH2run}$	$\frac{Time}{ALrun}$
18.00	-5.745	18.00	-5.745	1.83 kHz	0	4.26 kHz	3	12 min	12 min
20.00	-5.372	20.00	-5.372	0.76 kHz	0	1.92 kHz	0	12 min	12 min
22.00	-5.013	22.00	-5.013	0.35 kHz	0	0.98 kHz	0	12 min	12 min
24.00	-4.672	24.00	-4.672	0.17 kHz	0	0.52 kHz	0	24 min	12 min
26.00	-4.352	26.00	-4.352	0.09 kHz	0	0.29 kHz	0	45 min	12 min
Total Time (including overhead): 5.1 hrs									

Log entry of camera images for spectrometer angles for each setting!

4. $p(e,e'p)$ Heep-check coincidence run.

Set up the following configuration:

(a) Cycle HMS magnets and set to –4.672 GeV/c (negative polarity).

(b) HMS angle = 24.00 deg (from TV).

(c) Switch the SHMS to positive polarity (follow the cycling procedure) and set to 4.371 GeV/c.

(d) SHMS angle = 25.77 deg (from TV).

Log entry of angles once set

(e) 10 cm LH2 target.

(f) Prescale factors PS1(SHMS-3/4)=0, PS3(HMS-ELREAL)=0, PS5(HMS-ELREAL×SHMS-3/4)=0. All others disabled (i.e. -1).

(g) HMS large and SHMS collimators.

(h) Stable 70 μA beam with raster on.

(i) Update *standard.kinematics* with the new settings.

Take two runs with a combined total of 50,000 $e+p$ elastic scattering coincidences. The first run should be ~ 30 minutes, and should be immediately analyzed, checking E_m and p_m, while taking the second run.

8.204 GeV Heep-check coincidence run

θ_{HMS}	P_{HMS}	θ_{SHMS}	P_{SHMS}	$Rate_{SHMS}$	$Rate_{DAQ}$	Time
24.00	-4.672	25.77	4.371	0.65 kHz	815 Hz	2.8 hr

5. $\mathrm{Al}(e,e'p)X$ Thick Dummy target run for Heep-check.

Insert the "thick" dummy target (±5 cm) and **run for 18 minutes** at 40 μA (assuming 100% efficiency).

Do 1X 30 min, check it and run 2X ~1 hour runs

Q^2=4.4, W=2.74, x=0.40, low ϵ data taking

Nominal Q^2=4.4 GeV$^2/c^2$, W=2.74 GeV, x=0.40 Kinematics

E_e GeV	$E_{e'}$ GeV	$\theta_{e'}$ deg	ϵ	$\|t\|$ (GeV/c)^2	p_K GeV/c	θ_q deg
8.204	2.328	27.77	0.4805	0.507	5.389	-10.01

1. $p(e,e'K^+)\Lambda$ LH2 SHMS center ($\theta = 10.01^o$) run.

   Set up the following configuration:

   (a) HMS momentum = −2.328 GeV/c (negative polarity).

   (b) HMS angle = 27.77 deg (from TV).

   (c) SHMS momentum = 5.389 GeV/c (positive polarity). Magnets cycled.

   (d) SHMS angle = 10.01 deg (from TV).

   Logentry of angles (images too) once set

   (e) 10 cm LH2 target.

   (f) Update *standard.kinematics* with the new settings.

   (g) Set the PS1(SHMS-3-4) and PS3(HMS-ELREAL) target rates to 100 Hz, PS5(HMS-ELREAL×SHMS-3/4)=0, all others disabled (i.e. -1). For the projected rates listed below, these should correspond to factors of about PS1(SHMS-3/4)=12, PS3(HMS-ELREAL)=6, giving 100 Hz HMS and SHMS singles event rates to disk, and a 520 Hz DAQ rate overall, for 70 μA beam.

HMS e^- rate	HMS π^- rate	SHMS π^+ rate	SHMS K rate	SHMS p rate	Random coinc. $(e^- + \frac{\pi^-}{5})\cdot(\pi + K + \text{p})$	Real coinc. $e^- \cdot K$
1.5 kHz	10 kHz	100 kHz	37 kHz	41 kHz	65 Hz	0.04-0.05 Hz

   The real rate above is only for the $p(e,e'K^+)\Lambda$ reaction, exclusive π^+ and p coincidence reactions are likely to at least triple this rate.

   Take data for approximately 16.3 hours (at 100% efficiency) to give 2,500-3,100 $\mathbf{p(e,e'K^+)\Lambda}$ coincidences. Use the physics replay to keep track of the event total.

√ 2. $\text{Al}(e,e'K^+)X$ Thick Dummy target SHMS center ($\theta = 10.01^o$) run.

   Now put in the "thick" dummy target (±5 cm) and initially set prescale factors to the same as the LH2 run. If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, then the PS1,3 factors can be decreased accordingly.

   Take data for 1.1 hours (100% efficiency) at 40 μA.

done.

Take image and log on Elog

3. $\boxed{p(e,e'K^+)\Lambda}$ LH2 SHMS left ($\theta = 13.01^o$) run.

   (a) Move the SHMS to 13.01 deg (from TV), and put the 10 cm LH2 target back in. Leave the magnet settings unchanged.

   (b) Update *standard.kinematics* with the new settings.

   (c) Set the PS1(SHMS-3-4) and PS3(HMS-ELREAL) target rates to 100 Hz, PS5(HMS-ELREAL×SHMS-3/4)=0, all others disabled (i.e. -1). For the projected rates listed below, these should correspond to factors of about PS1(SHMS-3/4)=9, PS3(HMS-ELREAL)=6, giving 100 Hz HMS and SHMS singles event rates to disk, and a 250 Hz DAQ rate overall, for 70 μA beam.

HMS e^- rate	HMS π^- rate	SHMS π^+ rate	SHMS K rate	SHMS p rate	Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$	Real coinc. $e^- \cdot K$
1.5 kHz	10 kHz	16 kHz	6.5 kHz	10 kHz	11.5 Hz	0.035-0.04 Hz

The real rate above is only for the $p(e,e'K^+)\Lambda$ reaction, exclusive π^+ and p coincidence reactions are likely to at least triple this rate.

Take data for approximately 16.3 hours (at 100% efficiency) to give 2,250-2,550 $\mathbf{p(e,e'K^+)\Lambda}$ coincidences. Use the physics replay to keep track of the event total.

DONE ✓ 4. $\boxed{\mathrm{Al}(e,e'K^+)X}$ Thick Dummy target SHMS left ($\theta = 13.01^o$) run.

Now put in the "thick" dummy target (±5 cm) and initially set prescale factors to the same as the LH2 run. If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,3 factors can be decreased accordingly.

Take data for 1.1 hours (100% efficiency) at 40 μA.

Q^2=3.0, W=3.14, x=0.25, low ϵ data taking

Nominal Q^2=3.0 GeV^2/c^2, W=3.14 GeV, x=0.25 Kinematics

E_e GeV	$E_{e'}$ GeV	$\theta_{e'}$ deg	ϵ	$\|t\|$ (GeV/c)^2	p_K GeV/c	θ_q deg
8.204	1.821	25.89	0.3935	0.219	6.053	-6.91

1. $p(e,e'K^+)\Lambda$ LH2 SHMS center ($\theta = 6.91^o$) run.

   Set up the following configuration:

   (a) SHMS angle = 6.91 deg (from TV). **Beam off during the SHMS movement. Pay close attention to the hall cameras while approaching the beamline, and be prepared to hit the rotation kill switch, if necessary.**

   (b) SHMS momentum = 6.053 GeV/c (positive polarity). Magnets cycled.

   (c) HMS angle = 25.89 deg (from TV).

   (d) HMS momentum = −1.821 GeV/c (negative polarity).

   (e) 10 cm LH2 target.

   (f) Set the PS1(SHMS-3-4) and PS3(HMS-ELREAL) target rates to 100 Hz, PS5(HMS-ELREAL×SHMS-3/4)=0, all others disabled (i.e. -1). For the projected rates listed below, these should correspond to factors of about PS1(SHMS-3/4)=13, PS3(HMS-ELREAL)=8, giving 100 Hz HMS and SHMS singles event rates to disk, and a 1160 Hz DAQ rate overall, for 70 μA beam. 70 μA trips DC, run at 55μA

HMS e^- rate	HMS π^- rate	SHMS π^+ rate	SHMS K rate	SHMS p rate	Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K$+p)	Real coinc. $e^- \cdot K$
2.4 kHz	85 kHz	270 kHz	100 kHz	75 kHz	900 Hz	0.05-0.10 Hz

   The real rate above is only for the $p(e,e'K^+)\Lambda$ reaction, exclusive π^+ and p coincidence reactions are likely to at least triple this rate.

   Take data for approximately 40.2 hours (at 100% efficiency) to give 8,200-15,200 $\mathbf{p(e,e'K^+)\Lambda}$ coincidences. Use the physics replay to keep track of the event total.

2. $\mathrm{Al}(e,e'\pi^+)X$ Thick Dummy target SHMS center ($\theta = 6.91^o$) run.

   Now put in the "thick" dummy target (±5 cm) and initially set prescale factors to the same as the LH2 run. If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, adjust the PS1,3 factors accordingly.

   Take data for 2.8 hours (100% efficiency) at 40 μA.

3. $\boxed{p(e,e'K^+)\Lambda}$ LH2 SHMS left ($\theta = 9.91^o$) run.

   (a) Move the SHMS to 9.91 deg (from TV). **Beam off during the SHMS movement. Pay close attention to the hall cameras while departing the beamline, and be prepared to hit the rotation kill switch, if necessary.**

   (b) Leave the magnet settings unchanged.

   (c) Put the 10 cm LH2 target back in.

   (d) Set the PS1(SHMS-3-4) and PS3(HMS-ELREAL) target rates to 100 Hz, PS5(HMS-ELREAL×SHMS-3/4)=0, all others disabled (i.e. -1). For the projected rates listed below, these should correspond to factors of about PS1(SHMS-3/4)=10, PS3(HMS-ELREAL)=8, giving 100 Hz HMS and SHMS singles event rates to disk, and a 450 Hz DAQ rate overall, for 70 μA beam.

HMS e^- rate	HMS π^- rate	SHMS π^+ rate	SHMS K rate	SHMS p rate	Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K$+p)	Real coinc. $e^- \cdot K$
2.4 kHz	85 kHz	38 kHz	17 kHz	18 kHz	150 Hz	0.04-0.06 Hz

The real rate above is only for the $p(e,e'K^+)\Lambda$ reaction, exclusive π^+ and p coincidence reactions are likely to at least triple this rate.

Take data for approximately 40.2 hours (at 100% efficiency) to give 6,100-9,100 $\mathbf{p(e,e'K^+)\Lambda}$ coincidences. Use the physics replay to keep track of the event total.

4. $\boxed{Al(e,e'K^+)X}$ Thick Dummy target SHMS left ($\theta = 9.91^o$) run.

Now put in the "thick" dummy target (±5 cm) and initially set prescale factors to the same as the LH2 run. If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,3 factors can be decreased accordingly.

Take data for 2.8 hours (100% efficiency) at 40 μA.

Q^2=5.5, W=3.02, x=0.40, low ϵ data taking

Nominal Q^2=5.5 GeV^2/c^2, W=2.995 GeV, x=0.40 Kinematics						
E_e	$E_{e'}$	$\theta_{e'}$	ϵ	$\lvert t \rvert$	p_K	θ_q
GeV	GeV	deg		(GeV/c)^2	GeV/c	deg
8.204	0.962	49.31	0.1838	0.514	6.755	-5.50

Note: We have had to compromise on the value of W due to the lower beam energy and SHMS forward angle clearance issues.

1. $p(e, e'K^+)\Lambda$ LH2 SHMS left ($\theta = 8.50^o$) run.

   Set up the following configuration:

   (a) SHMS angle = 8.50 deg (from TV). **Beam off during the SHMS movement. Pay close attention to the hall cameras while approaching the beamline, and be prepared to hit the rotation kill switch, if necessary.**

   (b) SHMS momentum = 6.755 GeV/c (magnets cycled).

   (c) HMS momentum = ~~0.962~~ -0.962 GeV/c. Negative polarity.

   (d) HMS angle = 49.31 deg (from TV).

   (e) 10 cm LH2 target.

   (f) Update *standard.kinematics* with the new settings.

   (g) Set the PS1(SHMS-3-4) and PS3(HMS-ELREAL) target rates to 100 Hz, PS5(HMS-ELREAL×SHMS-3/4)=0, all others disabled (i.e. -1). For the projected rates listed below, these should correspond to factors of about PS1(SHMS-3/4)=10, PS3(HMS-ELREAL)=7, giving 100 Hz HMS and SHMS singles event rates to disk, and a 300 Hz DAQ rate overall, for 70 μA beam.

HMS	HMS	SHMS	SHMS	SHMS	Random coinc.	Real coinc.
e^- rate	π^- rate	π^+ rate	K rate	p rate	$(e^- + \frac{\pi^-}{5}) \cdot (\pi + K$+p)	$e^- \cdot K$
1.15 kHz	34 kHz	33 kHz	16 kHz	15 kHz	52 Hz	0.0036-0.0040 Hz

The real rate above is only for the $p(e, e'K^+)\Lambda$ reaction, exclusive π^+ and p coincidence reactions are likely to at least triple this rate.

Take data for approximately 40.1 hours (at 100% efficiency) to give 525-600 $\mathbf{p(e, e'K^+)\Lambda}$ coincidences. Use the physics replay to keep track of the event total.

2. $\boxed{Al(e,e'K^+)X}$ Thick Dummy target SHMS left ($\theta = 8.50^o$) run.

Now put in the "thick" dummy target (±5 cm) and initially set prescale factors to the same as the LH2 run. If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, then the PS1,3 factors can be decreased accordingly.

Take data for 2.8 hours (100% efficiency) at 40 μA.

3. $\boxed{p(e,e'K^+)\Lambda}$ LH2 SHMS center ($\theta = 6.20^o$) run. Wednesday afternoon ~4pm

(a) Move the SHMS 6.20 deg (from TV), or as close to the beamline as it is allowed to go. **This requires a hall access. The Run Co-ordinator will need to arrange in advance which expert personnel (e.g. Fowler, Lassiter) need to be present.** Our goal is for this to happen on day shift Thursday, April 11.

(b) SHMS fringe field beam steering check: For this beam energy, Jay Benesch does not require a full beam steering study. However, the RC should confirm in advance whether he would like some other simple checks done, provided they do not take too much time.

(c) Leave the magnet settings unchanged.

(d) Put the 10 cm LH2 target back in.

(e) Update *standard.kinematics* with the new settings.

(f) Set the PS1(SHMS-3-4) and PS3(HMS-ELREAL) target rates to 100 Hz, PS5(HMS-ELREAL×SHMS-3/4)=0, all others disabled (i.e. -1). For the projected rates listed below, these should correspond to factors of about PS1(SHMS-3/4)=13, PS3(HMS-ELREAL)=7, giving 100 Hz HMS and SHMS singles event rates to disk, and a 470 Hz DAQ rate overall, for 70 μA beam.

HMS e^- rate	HMS π^- rate	SHMS π^+ rate	SHMS K rate	SHMS p rate	Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + \text{p})$	Real coinc. $e^- \cdot K$
1.15 kHz	34 kHz	200 kHz	81 kHz	54 kHz	265 Hz	0.0037-0.009 Hz

The real rate above is only for the $p(e,e'K^+)\Lambda$ reaction, exclusive π^+ and p coincidence reactions are likely to at least triple this rate.

Take data for approximately 40.1 hours (at 100% efficiency) to give 525-1,000 $\mathbf{p(e,e'K^+)\Lambda}$ coincidences. Use the physics replay to keep track of the event total.

4. $\boxed{\mathrm{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS center ($\theta = 6.20^o$) run.

Now put in the "thick" dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run. If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, then the PS1,3 factors can be decreased accordingly.

Take data for 2.8 hours (100% efficiency) at 40 μA.

5. **To be determined in consultation with the RC:** If there is extra time left over before the next pass change, go back to the $p(e, e'K^+)\Lambda$ setting with the lowest statistics and take more data.