Pion-LT Run Plan - Part 2

November 5, 2021

5.986 GeV Beam Plan

Initial beam activities

- Hall entry for SHMS aerogel change. During the linac gradient change, and in co-ordination with the RC, the SHMS aerogel expert (Berdnikov) needs to enter the hall to remove the n =1.011 aerogel and replace it with $n = 1.03$ aerogel. Estimated time required – 8 hours.
- Hall entry to move SHMS away from beam pipe, to 8.00 deg. The RC will need to arrange this in advance with expert personnel (e.g. Lassiter, Comer).
- While waiting for beam, configure the spectrometers for beam checkout:

  1. **Change SHMS polarity to negative.** Carefully follow the magnet cycling procedure.
  2. SHMS angle = 8.00 deg (from TV).
  3. SHMS momentum = -2.000 GeV/c (negative polarity and magnets cycled).
  4. HMS angle = 13.00 deg (from TV).
  5. HMS momentum = -2.000 GeV/c (negative polarity and magnets cycled).
  6. Update *standard.kinematics* with the new settings (Reminder: all momenta should be entered as positive quantities).
  7. Prescale GUI settings:

HMS singles DAQ disabled	all PS=–1
SHMS singles DAQ disabled	all PS=–1
COIN DAQ:	
PS1(SHMS-3/4)	0
PS2(SHMS-ELREAL)	–1
PS3(HMS-3/4)	0
PS4(HMS-ELREAL)	–1
PS5(HMS-ELREAL×SHMS-3/4)	–1
PS6(HMS-3/4×SHMS-3/4)	–1
EDTM Target Prescale Rate	10 Hz
cermode10	ON

- 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.

- Fix beam angle at target.
  Do this step only if MCC is unable to restore the beam positions used at the previous energy.
  Use the gui at: `/home/cdaq/users/gaskelld/target_bpm/target_bpm.py`
  Adjust 3H07Ax,y to remove slope while keeping 3H07Cx,y fixed
  Recheck carbon hole and iterate as necessary.

Items to be done as soon as possible at this energy (time determined by RC).

- 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 with SHMS at negative polarity

1. Carbon sieve check

   (a) Set SHMS magnets to -2.000 GeV/c (should already be there).

   (b) SHMS angle = 20.00 deg (from TV).

   (c) Set HMS magnets to –2.000 GeV/c (should already be there).

   (d) HMS angle = 31.00 deg (from TV).

   (e) Insert the Carbon 0.5% r.l. target and sieve slit collimators on both SHMS and HMS. **Raster off. Current limit=40 μA.** Take 100,000 HMS and 100,000 SHMS good electron events with $-8\% < \delta < +8\%$ in HMS and $-10\% < \delta < +24\%$ in SHMS. Adjust PS1(SHMS-3/4) and PS4(HMS-ELREAL) as necessary to keep the deadtime at reasonable levels (below 20%).

	E_e	θ'_e	P'_e
HMS:	5986	20.00	-2000.0
SHMS:	5986	31.00	-2000.0

   (f) Look at HMS and SHMS $x - fp$ vs $y - fp$ scatterplots. The "hourglass" should be nicely aligned vertically, indicating alignment of the beam with the HMS and SHMS optical axes. Mark Jones or Holly Szumila-Vance should be consulted if anything looks amiss.

   (g) Do a **second run with the $z = \pm 3$ cm carbon optics target.**

   (h) Do a **third run with the $z = \pm 8$ cm carbon optics target.**

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

   Set up the following configuration:

   (a) HMS and SHMS angles and momenta as specified in the tables below. Both spectrometers are negative polarity, and both will have to be cycled initially.

   (b) Record all TV angle values on run sheets and hclog. Update *standard.kinematics* with the new settings.

   (c) 10 cm LH2 and "thick" dummy target data should be taken with the HMS large and SHMS collimators.

LH2 target runs:

- Set the PS1(SHMS-3/4) and PS4(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.
- Projected beam currents are listed below, we desire to keep the SHMS-3/4 rate below 600 kHz so adjust accordingly. Stable beam with 2×2 **raster on.**
- We want about 100,000 elastics in the SHMS for each setting, which typically requires at least 700,000 total electron events (times are only a guide). The total event estimate in right-most column includes inelastics.

Thick Dummy target runs:

One run for each angle and momentum setting, current limit: 40 μA.

To be efficient, please minimize target changes and do LH2, Dummy for first setting, followed by Dummy, LH2 for second setting, etc.

5.986 GeV Heep-check singles runs

θ_{HMS}	P_{HMS}	θ_{SHMS}	P_{SHMS}	Current	$Rate_{HMS}$	$\frac{PS4}{HMS}$	$Rate_{SHMS}$	$\frac{PS2}{SHMS}$	$\frac{Time}{LH2run}$	$\frac{Time}{ALrun}$	Evt_{SHMS}
12.40	-5.202	9.43	-5.512	30 μA	79 kHz	7	530 kHz	10	12 min	6 min	620k
13.79	-5.202	8.26	-5.512	12 μA	16 kHz	5	530 kHz	10	10 min	6 min	750k
15.79	-5.202	7.73	-5.512	8 μA	1.6 kHz	0	540 kHz	10	10 min	6 min	630k
17.79	-4.707	7.29	-5.422	6 μA	0.7 kHz	0	590 kHz	10	10 min	6 min	690k
19.88	-4.395	10.26	-5.422	50 μA	2.5 kHz	1	550 kHz	10	12 min	6 min	770k
25.02	-3.738	12.40	-5.422	70 μA	0.6 kHz	0	190 kHz	8	10 min	6 min	880k
23.53	-3.738	13.79	-5.422	70 μA	1.8 kHz	0	79 kHz	7	10 min	6 min	720k
29.35	-3.271	17.79	-4.605	70 μA	0.18 kHz	0	19 kHz	5	30 min	6 min	2000k
29.55	-3.043	19.88	-4.605	70 μA	0.4 kHz	0	4.8 kHz	3	20 min	6 min	1200k
30.50	-3.043	29.35	-3.493	70 μA	0.24 kHz	0	0.3 kHz	0	30 min	6 min	280k
32.80	-3.043	27.37	-3.493	70 μA	0.04 kHz	0	0.8 kHz	0	20 min	6 min	620k
32.80	-3.043	23.40	-3.493	70 μA	0.04 kHz	0	5.9 kHz	3	20 min	6 min	1250k

Total Time (including overhead): 13 hrs

Heep-check coincidence runs

1. $p(e,e'p)$ equal angles and momenta setting

5.986 GeV Heep-check coincidence run

θ_{HMS}	P_{HMS}	θ_{SHMS}	P_{SHMS}	$Rate_{HMS}$	$Rate_{DAQ}$	Time
28.28	-3.400	28.28	3.400	20 Hz	200 Hz	1 hr

Set up the following configuration:

(a) **Change SHMS polarity to positive.** Turn the beam off while ramping the SHMS, and carefully follow the magnet cycling procedure.

(b) Set the SHMS magnets to +3.400 GeV/c.

(c) SHMS angle = 28.28 deg (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

(d) Set HMS magnets to –3.400 GeV/c (follow the magnet cycling procedure).

(e) HMS angle = 28.28 deg (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

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

(g) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.
For 70 μA beam and the projected rates listed above, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 200 Hz DAQ rate overall.

Projected prescale GUI settings:	
PS1(SHMS-3/4)	4
PS2(SHMS-ELREAL)	–1
PS3(HMS-3/4)	–1
PS4(HMS-ELREAL)	1
PS5(HMS-ELREAL×SHMS-3/4)	0
PS6(HMS-3/4×SHMS-3/4)	–1
EDTM Target Prescale Rate	10 Hz
cermode10	ON

(h) HMS large and SHMS collimators.

(i) Stable 70 μA beam with 2×2 raster on.

fadcmode10 Run: Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button.**

Data: Take two runs with a combined total of 70,000 e+p elastic scattering coincidences. The first run should be $\sim$ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed, checking E_{miss} and p_{miss}, while taking the second run.

Estimated Running Time: 1 hour at 100% efficiency.

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

   Insert the "thick" dummy target (± 5 cm) and **run for 10 minutes** at 40 μA (assuming 100% efficiency).
   DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 target).

3. $p(e,e'p)$ setting for HMS angle and both spectrometer momenta

5.986 GeV Heep-check coincidence run

θ_{HMS}	P_{HMS}	θ_{SHMS}	P_{SHMS}	$Rate_{HMS}$	$Rate_{DAQ}$	Time
29.17	-3.271	27.50	3.493	18 Hz	200 Hz	1 hr

Set up the following configuration:

(a) Set the SHMS magnets to +3.493 GeV/c (follow the magnet cycling procedure).

(b) SHMS angle = 27.50 deg (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

(c) Set HMS magnets to –3.271 GeV/c.

(d) HMS angle = 29.17 deg (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

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

(f) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.
For 70 μA beam and the projected rates listed above, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 200 Hz DAQ rate overall.

Projected prescale GUI settings:	
PS1(SHMS-3/4)	4
PS2(SHMS-ELREAL)	–1
PS3(HMS-3/4)	–1
PS4(HMS-ELREAL)	1
PS5(HMS-ELREAL×SHMS-3/4)	0
PS6(HMS-3/4×SHMS-3/4)	–1
EDTM Target Prescale Rate	10 Hz
cermode10	ON

(g) HMS large and SHMS collimators.

(h) Stable 70 μA beam with 2×2 raster on.

fadcmode10 Run: Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button.**

Data: Take at least two runs with a combined total of 64,000 $e+p$ elastic scattering coincidences. The first run should be $\sim$ 30 minutes (at 100% data taking efficiency), and should be immediately analyzed, checking E_m and p_m, while taking the second run.

Estimated Running Time: 1 hour at 100% efficiency.

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

   Insert the "thick" dummy target (± 5 cm) and **run for 10 minutes** at 40 μA (assuming 100% efficiency).
   DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 target).

Q^2=3.85, W=2.02, x=0.54, low ϵ data taking

Nominal Q^2=3.85 GeV$^2/c^2$, W=2.02 GeV, x=0.54 Kinematics

E_e GeV	$E_{e'}$ GeV	$\theta_{e'}$ deg	ϵ	$\lvert t\rvert$ (GeV/c)^2	p_π GeV/c	θ_q deg
5.986	2.229	31.15	0.580	0.487	3.493	-15.79

1. $\boxed{p(e,e'\pi^+)n}$ LH2 SHMS right ($\theta = 13.79^o$) run.

   Set up the following configuration:

   (a) HMS angle = 31.15 (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

   (b) HMS momentum = –2.229 GeV/c. Negative polarity.

   (c) SHMS angle = 13.79 deg (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

   (d) SHMS momentum = 3.493 GeV/c (should already be there).

   (e) 10 cm LH2 target.

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

   (g) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.
   For 70 μA beam and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and an 260 Hz DAQ rate overall.

Projected prescale GUI settings:	
PS1(SHMS-3/4)	12
PS2(SHMS-ELREAL)	–1
PS3(HMS-3/4)	–1
PS4(HMS-ELREAL)	5
PS5(HMS-ELREAL×SHMS-3/4)	0
PS6(HMS-3/4×SHMS-3/4)	–1
EDTM Target Prescale Rate	10 Hz
cermode10	ON

HMS e^- rate	HMS π^- rate	SHMS π^+ rate	SHMS K rate	SHMS p rate	Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + \mathrm{p})$	Real coinc. $e^- \cdot \pi$
1.4 kHz	2.5 kHz	94 kHz	43 kHz	88 kHz	34 Hz	1.2-1.6 Hz

   (h) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button.**

(i) **HMS-3/4 trigger run:** Since the HMS momentum is fairly low, take a 1 hour run with HMS-3/4 triggers enabled instead of hELREAL (i.e. PS6 instead of PS5, and PS3 instead of PS4). This is to monitor the ELREAL threshold and will count as part of the physics run total. If the PS3 trigger rate is excessive, adjust PS3 to a higher level to compensate.

(j) **Take data for approximately 2.4 hours (at 100% efficiency) to give 11,700 $\mathbf{p(e,e'\pi^+)n}$ coincidences.** Use the physics replay to keep track of the event total.
The first run should be $\sim$ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

2. $\boxed{\mathrm{Al}(e,e'\pi^+)X}$ Thick Dummy target SHMS right ($\theta = 13.79^o$) run.

Now put in the "thick" dummy target ($\pm$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 PS1,4 factors can be decreased accordingly.
Current limit: 40 μA.
DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 target).

Take data for 0.25 hour (100% efficiency) at 40 μA.

3. $\boxed{p(e,e'\pi^+)n}$ LH2 SHMS center ($\theta = 15.79^o$) run.

(a) Move the SHMS to 15.79 deg (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

(b) Insert the LH2 target. Leave the spectrometer magnet settings unchanged.

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

(d) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.
For 70 μA beam and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 270 Hz DAQ rate overall.

Projected prescale GUI settings:	
PS1(SHMS-3/4)	11
PS2(SHMS-ELREAL)	–1
PS3(HMS-3/4)	–1
PS4(HMS-ELREAL)	5
PS5(HMS-ELREAL×SHMS-3/4)	0
PS6(HMS-3/4×SHMS-3/4)	–1
EDTM Target Prescale Rate	10 Hz
cermode10	ON

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. $e^- \cdot \pi$
1.4 kHz	2.5 kHz	69 kHz	20 kHz	49 kHz	21 Hz	1.5 Hz

(e) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button.**

(f) **HMS-3/4 trigger run:** Since the HMS momentum is fairly low, take a 1 hour run with HMS-3/4 triggers enabled instead of hELREAL (i.e. PS6 instead of PS5, and PS3 instead of PS4). This is to monitor the ELREAL threshold and will count as part of the physics run total. If the PS3 trigger rate is excessive, adjust PS3 to a higher level to compensate.

(g) **Take data for 2.4 hours (100% efficiency) at 70 μA to get about 11,700 $\mathbf{p(e,e'\pi^+)n}$ coincidences.** Use the physics replay to keep track of the event total.
The first run should be $\sim$ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

4. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS center ($\theta = 15.79^o$) 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 PS1,4 factors can be decreased accordingly.
Current limit: 40 μA.
DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 target).

Take data for 0.25 hours (100% efficiency) at 40 μA.

5. $\boxed{p(e,e'\pi^+)n}$ LH2 SHMS left ($\theta = 17.79^o$) run.

(a) Move the SHMS 17.79 deg (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

(b) Put in the LH2 target. Leave the spectrometer magnet settings unchanged.

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

(d) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.
For 70 μA beam and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 250 Hz DAQ rate overall.

Projected prescale GUI settings:	
PS1(SHMS-3/4)	10
PS2(SHMS-ELREAL)	–1
PS3(HMS-3/4)	–1
PS4(HMS-ELREAL)	5
PS5(HMS-ELREAL×SHMS-3/4)	0
PS6(HMS-3/4×SHMS-3/4)	–1
EDTM Target Prescale Rate	10 Hz
cermode10	ON

HMS e^- rate	HMS π^- rate	SHMS π^+ rate	SHMS K rate	SHMS p rate	Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + \mathrm{p})$	Real coinc. $e^- \cdot \pi$
1.4 kHz	2.5 kHz	29 kHz	9 kHz	26 kHz	10 Hz	1.5 Hz

(e) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button.**

(f) **HMS-3/4 trigger run:** Since the HMS momentum is fairly low, take a 1 hour run with HMS-3/4 triggers enabled instead of hELREAL (i.e. PS6 instead of PS5, and PS3 instead of PS4). This is to monitor the ELREAL threshold and will count as part of the physics run total. If the PS3 trigger rate is excessive, adjust PS3 to a higher level to compensate.

(g) **Take data for approximately 2.4 hours (at 100% efficiency) at 70 μA to get about 11,700 p$(\mathbf{e},\mathbf{e}'\pi^+)$n coincidences.** Use the physics replay to keep track of the event total.
The first run should be $\sim$ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

6. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS left ($\theta = 17.79^o$) 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 PS1,4 factors can be decreased accordingly.

   Current limit: 40 μA.

   DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 target).

   Take data for 0.25 hours (100% efficiency) at 40 μA.

δ scan with $p(e,e'p)$ coincidences

This scan depends on how much time remains before the beam pass change. Do all or part, as time permits.

1. SHMS momentum = +2.305 GeV/c.
2. SHMS angle = 38.92 deg (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.
3. HMS momentum = -4.929 GeV/c (follow the cycling procedure).
4. HMS angle = 19.05 deg (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.
5. 10 cm LH2 target.
6. Projected prescale GUI settings:

HMS singles DAQ disabled	all PS=–1
SHMS singles DAQ disabled	all PS=–1
COIN DAQ:	
PS1(SHMS-3/4)	see table (100 Hz desired)
PS2(SHMS-ELREAL)	–1
PS3(HMS-3/4)	–1
PS4(HMS-ELREAL)	see table (100 Hz desired)
PS5(HMS-ELREAL×SHMS-3/4)	0
PS6(HMS-3/4×SHMS-3/4)	–1
EDTM Target Prescale Rate	10 Hz
cermode10	ON

7. HMS large and SHMS collimators.
8. Stable 70 μA beam with 2×2 raster on.
9. Take data as listed in the table. The goal is 100k prompt $p(e,e'p)$ elastic coincidences per setting.
10. Update *standard.kinematics* with the new settings.
11. For each setting, take one Thick Dummy target run for about 6 minutes (100% efficiency). To be efficient, please minimize target changes and do LH2, Dummy for first setting, followed by Dummy, LH2 for second setting, etc.
    DO NOT modify *standard.kinematics* for the Dummy runs (i.e. keep as for LH2 target runs).

5.986 GeV $p(e,e'p)$ δ scan									
δ_{HMS}	P_{HMS}	δ_{SHMS}	P_{SHMS}	Rate$_{SHMS}$	$\frac{PS1}{SHMS}$	Rate$_{HMS}$	$\frac{PS4}{HMS}$	$\frac{Time}{LH2run}$	$\frac{Time}{Dummy}$
θ_{HMS}=20.25^o, θ_{SHMS}=38.92									
-10%	-4.929	0%	2.305	1.9 kHz	5	2.2 kHz	5	10 min	6 min
-9%	-4.875	0%	2.305	1.9 kHz	5	2.2 kHz	5	10 min	6 min
-8%	-4.822	0%	2.305	1.9 kHz	5	2.3 kHz	5	10 min	6 min
-7%	-4.770	0%	2.305	1.9 kHz	5	2.5 kHz	5	10 min	6 min
-4%	-4.621	0%	2.305	1.9 kHz	5	3.4 kHz	6	10 min	6 min
0%	-4.436	0%	2.305	1.9 kHz	5	5.5 kHz	7	10 min	6 min
0%	-4.436	-18%	2.811	0.01 kHz	0	5.5 kHz	7	40 min	9 min
0%	-4.436	-16%	2.744	0.04 kHz	0	5.5 kHz	7	15 min	6 min
0%	-4.436	-14%	2.680	0.1 kHz	0	5.5 kHz	7	15 min	6 min
0%	-4.436	-12%	2.619	0.2 kHz	0	5.5 kHz	7	10 min	6 min
0%	-4.436	-10%	2.561	0.3 kHz	2	5.5 kHz	7	10 min	6 min
0%	-4.436	-5%	2.426	0.9 kHz	4	5.5 kHz	7	10 min	6 min
Total Time (including overhead): 10.5 hrs									

Estimated Total Time for this Run Plan: 52.5 hours