Pion-LT Run Plan - Part 1A

September 29, 2021

5.563 GeV Special Beam Plan

Initial beam activities

- Configure the spectrometers:

  1. SHMS angle = 20.00 deg (from TV).
  2. SHMS momentum = -2.00 GeV/c (negative polarity and magnets cycled).
  3. HMS angle = 30.00 deg (from TV).
  4. HMS momentum = -2.00 GeV/c (negative polarity and magnets cycled).
  5. $z = 0$ 0.5% r.l. carbon target. If rates are low, we might want to switch to one of the nuclear targets (if the current limits are known).
  6. Prescale GUI settings:

HMS singles DAQ disabled SHMS singles DAQ disabled	all PS=–1 all PS=–1
COIN DAQ:	
PS1(SHMS-3/4) PS2(SHMS-ELREAL) PS3(HMS-3/4) PS4(HMS-ELREAL) PS5(HMS-ELREAL×SHMS-3/4) PS6(HMS-3/4×SHMS-3/4)	0 –1 0 –1 –1 –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.

- BCM calibrations.
  The Run Co-ordinator will coordinate the timing of this with the Program Deputy. This requires MCC's ability to reliably deliver 65-70 μA beam, so this calibration might have to wait at least a few days. The BCM calibration procedure is at `https://hallcweb.jlab.org/doc-public/ShowDocument?docid=957`. Dave Mack will analyze the data later.

Carbon sieve check

1. 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:	5563	20.00	-2000.0
SHMS:	5563	30.00	-2000.0

2. 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.

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

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

Calibration runs with SHMS at negative polarity

1. $\boxed{p(e,e')p}$ 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:
   Stable 70 μA beam with 2×2 **raster on.** 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. We want at least 10,000 elastics, which typically requires at least 500,000 total electron events (times below 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, taken immediately after the corresponding LH2 run. Current limit: 40 μA.

5.563 GeV Heep-check singles runs						
θ_{HMS}	P_{HMS}	θ_{SHMS}	P_{SHMS}	$\frac{Time}{LH2run}$	$\frac{Time}{ALrun}$	$Events_{SHMS}$
12.40	-4.707	7.73	-5.127	15 min	6 min	800k
13.79	-4.707	8.26	-5.127	15 min	6 min	900k
15.79	-4.707	9.73	-5.127	15 min	6 min	750k
17.79	-4.395	10.26	-5.127	15 min	6 min	900k
19.88	-4.395	12.40	-5.127	15 min	6 min	900k
25.02	-3.738	13.79	-5.127	15 min	6 min	750k
23.53	-3.738	11.73	-4.605	15 min	6 min	800k
29.35	-3.271	13.12	-4.605	15 min	6 min	750k
28.30	-3.043	15.79	-4.605	15 min	6 min	550k
29.63	-3.043	17.79	-4.605	15 min	6 min	700k
30.65	-3.043	19.88	-4.605	15 min	6 min	600k
31.15	-3.043	23.53	-3.493	15 min	6 min	625k
31.15	-3.043	25.84	-3.493	15 min	6 min	300k
33.16	-3.043	29.35	-3.493	30 min	6 min	175k
Total Time (including overhead): 13 hrs						

2. Luminosity scans on LH2, LD2 and $z = 0$ Carbon targets.

   (a) Reduce the SHMS momentum to -3.000 GeV/c and keep the HMS at -2.849 GeV/c, both negative polarity.

   (b) Rotate the HMS to 12.50 degrees, and the SHMS to 7.50 degrees. Record the TV camera angles on the runsheet to 0.005 degree accuracy.

   (c) Set the PS1(SHMS-3/4), PS4(HMS-ELREAL) target DAQ rates to 1 kHz, to give a total rate to disk of about 2 kHz.

   (d) Make sure the raster is on (2×2), and take HMS and SHMS runs at 70, 55, 40, 25, 18, 12, 8, 5, 3 μA on LH2 target. Start at the highest current, then go down in current and do next run.

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

   (f) Take one Thick Dummy target run at 40 μA. 125,000 electrons per run, about 0.3 hour. During this run, the Target Operator should park the LH2 target and prepare for LD2 data taking.

   (g) Repeat the scans with Carbon 0.5% r.l. target. If the C rates are too low, we may be able to substitute the Gold target (consult the RC before doing this).

   (h) Repeat the scans with LD2 target at 70, 55, 40, 25, 18, 12, 8, 5, 3 μA. (70, 55 μA on LD2 can be excluded if the rates are too high.)

   (i) An expert (Jacob and Richard) 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.

5.563 GeV Luminosity Scans				
μA	Targets	DAQ_{SHMS}	DAQ_{HMS}	$\frac{Time}{run}$
$\theta_{HMS} = 12.50$, P_{HMS}=-2.849 GeV/c, $\theta_{SHMS} = 7.50$, P_{SHMS}=-3.000 GeV/c				
70	LH2, C, LD2	1 kHz	1 kHz	10 min
55	LH2, C LD2	1 kHz	1 kHz	10 min
40	LH2, Dummy, C, LD2	1 kHz	1 kHz	10 min
25	LH2, C, LD2	1 kHz	1 kHz	10 min
18	LH2, C, LD2	1 kHz	1 kHz	10 min
12	LH2, C, LD2	1 kHz	1 kHz	10 min
8	LH2, C, LD2	1 kHz	1 kHz	10 min
5	LH2, C, LD2	1 kHz	1 kHz	10 min
3	LH2, C, LD2	1 kHz	1 kHz	10 min
Total Time (including overhead): 8 hrs				

3. Second set of Luminosity scans on LH2, LD2 and $z = 0$ Carbon targets.

   (a) If there is still time, we could to do a second set of luminosity scans. In Fpi-2, this proved helpful in disentangling rate and current effects in the π^- analysis. In this scan, the rates are roughly half of the first scan, at the same current.

   (b) Move the HMS to 14.00 deg, and the SHMS to 9.00 deg (on TV). Leave the momentum settings unchanged.

   (c) Set the PS1(SHMS-3/4), PS4(HMS-ELREAL) target DAQ rates to 1 kHz, to give a total rate to disk of about 2 kHz.

   (d) Make sure the raster is on (2×2), and take HMS and SHMS runs at 70, 55, 40, 25, 18, 10, 5 μA on LD2 target. Start at the highest current, then go down in current and do next run. (70, 55 μA on LD2 can be excluded if the rates are too high.)

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

   (f) Take one Thick Dummy target run at 40 μA. 125,000 electrons per run, about 0.3 hour. During this run, the Target Operator should park the LD2 target and prepare for LH2 data taking.

   (g) Repeat the scans with Carbon 0.5% r.l. and LH2 targets at 70, 55, 40, 25, 18, 10, 5 μA. If the C rates are too low, we may be able to substitute the Gold target (consult the RC before doing this).

5.563 GeV Luminosity Scans #2				
μA	Targets	DAQ_{SHMS}	DAQ_{HMS}	$\frac{Time}{run}$
θ_{HMS} = 13.00, P_{HMS}=-2.849 GeV/c, θ_{SHMS} = 9.00, P_{SHMS}=-3.000 GeV/c				
70	LD2, C, LH2	1 kHz	1 kHz	10 min
55	LD2, C, LH2	1 kHz	1 kHz	10 min
40	LD2, Dummy, C, LH2	1 kHz	1 kHz	10 min
25	LD2, C, LH2	1 kHz	1 kHz	10 min
18	LD2, C, LH2	1 kHz	1 kHz	10 min
10	LD2, C, LH2	1 kHz	1 kHz	10 min
5	LD2, C, LH2	1 kHz	1 kHz	10 min
Total Time (including overhead): 6 hrs				

Heep-check coincidence runs

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

5.563 GeV Heep-check coincidence run

θ_{HMS}	P_{HMS}	θ_{SHMS}	P_{SHMS}	$Rate_{HMS}$	$Rate_{DAQ}$	Time
29.09	-3.183	29.09	3.183	0.02 kHz	800 Hz	1 hr

Set up the following configuration:

i. Set the SHMS magnets to +3.183 GeV/c (follow the magnet cycling procedure).

ii. SHMS angle = 29.09 deg (from TV).

iii. Set HMS magnets to –3.183 GeV/c.

iv. HMS angle = 29.09 deg (from TV).

v. Prescale GUI settings:

PS1(SHMS-3/4)	100 Hz target rate
PS2(SHMS-ELREAL)	–1
PS3(HMS-3/4)	–1
PS4(HMS-ELREAL)	100 Hz target rate
PS5(HMS-ELREAL×SHMS-3/4)	0
PS6(HMS-3/4×SHMS-3/4)	–1
EDTM Target Prescale Rate	10 Hz
cermode10	ON

vi. HMS large and SHMS collimators.

vii. Stable 70 μA beam with 2×2 raster on.

viii. Update *standard.kinematics* with the new settings.

Take two runs with a combined total of 70,000 $e + p$ elastic scattering coincidences. The first run should be 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.

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

Insert the "thick" dummy target ($\pm$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).

(c) $\boxed{p(e,e'p)}$ setting for HMS angle and both spectrometer momenta

5.563 GeV Heep-check coincidence run

θ_{HMS}	P_{HMS}	θ_{SHMS}	P_{SHMS}	$Rate_{HMS}$	$Rate_{DAQ}$	Time
31.15	-3.043	27.37	3.493	0.02 kHz	800 Hz	1 hr

Set up the following configuration:

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

ii. SHMS angle = 27.37 deg (from TV).

iii. Set HMS magnets to –3.043 GeV/c.

iv. HMS angle = 31.15 deg (from TV).

v. Prescale GUI settings:

PS1(SHMS-3/4)	100 Hz target rate
PS2(SHMS-ELREAL)	–1
PS3(HMS-3/4)	–1
PS4(HMS-ELREAL)	100 Hz target rate
PS5(HMS-ELREAL×SHMS-3/4)	0
PS6(HMS-3/4×SHMS-3/4)	–1
EDTM Target Prescale Rate	10 Hz
cermode10	ON

vi. HMS large and SHMS collimators.

vii. Stable 70 μA beam with 2×2 raster on.

viii. Update *standard.kinematics* with the new settings.

Take at least two runs with a combined total of 60,000 e+p elastic scattering coincidences. The first run should be 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.

(d) $\boxed{\text{Al}(e,e'p)X}$ 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).

(e) δ scan with $p(e,e'p)$ coincidences

i. SHMS momentum = +2.242 GeV/c.

ii. SHMS angle = 38.92 deg (from TV).

iii. HMS momentum = -4.523 GeV/c (follow the cycling procedure).

iv. HMS angle = 20.25 deg (from TV).
item10 cm LH2 target.

v. Projected prescale GUI settings:

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

vi. HMS large and SHMS collimators.

vii. Stable 70 μA beam with 2×2 raster on.

viii. Take data as listed in the table. The goal is 100k prompt $p(e,e'p)$ elastic coincidences per setting.

ix. Update *standard.kinematics* with the new settings.

x. For each setting, take one Thick Dummy target run for about 6 minutes (100% efficiency).
DO NOT modify *standard.kinematics* for the Dummy runs (i.e. keep as for LH2 target runs).

5.563 GeV $p(e,e'p)$ δ scan							
δ_{HMS}	P_{HMS}	δ_{SHMS}	P_{SHMS}	DAQ$_{SHMS}$	DAQ$_{HMS}$	$\frac{Time}{LH2run}$	$\frac{Time}{Dummy}$
θ_{HMS}=20.25^o, θ_{SHMS}=38.92							
-10%	-4.523	0%	2.242	1 kHz	1 kHz	0.25 hr	0.1 hr
-9%	-4.474	0%	2.242	1 kHz	1 kHz	0.20 hr	0.1 hr
-8%	-4.425	0%	2.242	1 kHz	1 kHz	0.17 hr	0.1 hr
-7%	-4.377	0%	2.242	1 kHz	1 kHz	0.17 hr	0.1 hr
-4%	-4.241	0%	2.242	1 kHz	1 kHz	0.17 hr	0.1 hr
-2%	-4.154	0%	2.242	1 kHz	1 kHz	0.17 hr	0.1 hr
0%	-4.071	0%	2.242	1 kHz	1 kHz	0.17 hr	0.1 hr
0%	-4.071	-18%	2.734	1 kHz	1 kHz	1.10 hr	0.15 hr
0%	-4.071	-16%	2.669	1 kHz	1 kHz	0.25 hr	0.1 hr
0%	-4.071	-14%	2.607	1 kHz	1 kHz	0.17 hr	0.1 hr
0%	-4.071	-12%	2.548	1 kHz	1 kHz	0.17 hr	0.1 hr
0%	-4.071	-10%	2.491	1 kHz	1 kHz	0.17 hr	0.1 hr
0%	-4.071	-5%	2.360	1 kHz	1 kHz	0.17 hr	0.1 hr
0%	-4.071	5%	2.135	1 kHz	1 kHz	0.20 hr	0.1 hr
0%	-4.071	10%	2.038	1 kHz	1 kHz	0.25 hr	0.1 hr
0%	-4.071	12%	2.002	1 kHz	1 kHz	0.50 hr	0.1 hr
0%	-4.071	20%	1.868	1 kHz	1 kHz	1.25 hr	0.15 hr
Total Time (including overhead): 21 hrs							

Total Time for this Run Plan: 2.3 to 3 days