Pion-LT Run Plan - Part 4A

November 5, 2021

7.937 GeV Beam Plan

Initial beam activities

- 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 = -4.500 GeV/c (negative polarity and magnets cycled).
    4. HMS angle = 13.00 deg (from TV).
    5. HMS momentum = -3.000 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.

- 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.

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 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 at least 10,000 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.

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}
19.88	-5.202	8.26	-7.337	**30 μA**	0.57 kHz	0	480 kHz	10	10 min	6 min	560k
23.53	-4.707	10.26	-6.538	70 μA	0.23 kHz	0	365 kHz	9	10 min	6 min	860k
23.53	-4.707	17.79	-5.512	70 μA	0.23 kHz	0	7.5 kHz	3	10 min	6 min	875k
25.02	-4.395	19.88	-5.422	70* μA	0.28 kHz	0	2.0 kHz	0	10 min	6 min	780k

<div align="center">7.937 GeV Heep-check singles runs</div>

<div align="center">* Beam current may need to be lowered if deadtime >15%</div>

25.02	-4.395	23.53	-4.605	70 μA	0.28 kHz	0	0.9 kHz	0	10 min	6 min	320k
31.15	-3.738	23.53	-4.605	70 μA	0.10 kHz	0	0.9 kHz	0	10 min	0 min	320k
31.15	-3.738	31.15	-3.493	70 μA	0.12 kHz	0	0.2 kHz	0	150 min	15 min	750k

<div align="center">Total Time (including overhead): 11.6 hrs</div>

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

This scan relies on MCC's ability to deliver stable high beam currents. If they can not, then RC will instruct whether to defer the luminosity scan later in the experiment.

(a) Reduce the HMS momentum to -4.100 GeV/c, and the SHMS momentum to -4.500 GeV/c, both negative polarity.

(b) Rotate the HMS to 12.50 degrees, and the SHMS to 8.50 degrees. Record the TV camera angles on the runsheet to 0.005 degree accuracy.

(c) ELREAL trigger in both arms. Set the PS2, PS4 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 LH2 target. Start at the highest current, then go down in current and repeat.

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

(f) Repeat the scans with LD2 target at 40, 25, 18, 10, 5 μA. (70, 55 μA rates on LD2 are too high and can be excluded.)

(g) 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.

(h) Repeat the scans with Carbon 0.5% r.l. target. To compensate for the thinner target, do 20 minute instead of 10 minute runs.

(i) An expert (Jacob?) 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.

μA	Targets	$\frac{Rate_{SHMS}}{LHrun}$	$\frac{PS2}{SHMS}$	$\frac{Rate_{HMS}}{LHrun}$	$\frac{PS4}{HMS}$	DAQ$_{SHMS}$	DAQ$_{HMS}$	$\frac{Time}{run}$
7.937 GeV Luminosity Scans								
$\theta_{HMS} = 12.50$, P_{HMS}=-4.100 GeV/c, $\theta_{SHMS} = 8.50$, P_{SHMS}=-4.500 GeV/c								
70	LH2, C	1110 kHz	10	170 kHz	8	1 kHz	1 kHz	10 min
55	LH2, C	875 kHz	10	135 kHz	7	1 kHz	1 kHz	10 min
40	LH2, LD2, Dummy, C	635 kHz	10	97 kHz	7	1 kHz	1 kHz	10 min
25	LH2, LD2, C	400 kHz	9	61 kHz	6	1 kHz	1 kHz	10 min
18	LH2, LD2, C	285 kHz	8	44 kHz	6	1 kHz	1 kHz	10 min
10	LH2, LD2, C	160 kHz	8	24 kHz	5	1 kHz	1 kHz	10 min
5	LH2, LD2, C	80 kHz	7	12 kHz	4	1 kHz	1 kHz	10 min
Total Time (including overhead): 7 hrs								

Q²=6.00, W=2.40, x=0.55, low ϵ data taking – PART ONE

Nominal Q^2=6.00 GeV²/c^2, W=2.40 GeV, x=0.55 Kinematics

E_e	$E_{e'}$	$\theta_{e'}$	ϵ	$|t|$	p_π	θ_q
GeV	GeV	deg		(GeV/c)²	GeV/c	deg
7.937	2.139	34.58	0.439	0.531	5.512	-11.12

1. $\boxed{d(e, e'\pi^-)pp_{sp}}$ LD2 SHMS right ($\theta = 9.12^o$) run.

   Set up the following configuration:

   (a) HMS angle = 34.58 (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

   (b) HMS momentum = –2.139 GeV/c. Negative polarity.

   (c) SHMS angle = 9.12 deg (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

   (d) SHMS momentum = –5.512 GeV/c. Negative polarity. Follow the magnet cycling procedure.

   (e) 10 cm LD2 target.

   (f) Update *standard.kinematics* with the new settings, using neutron mass for the target.

   (g) **Adjust the beam current to keep the SHMS-3/4 rate below 600 kHz.** We project the current for this run to be about 25 μA. Do not change PS5=0!

   (h) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.
   For **25 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 260 Hz DAQ rate overall.

Projected prescale GUI settings:	
PS1(SHMS-3/4)	13
PS2(SHMS-ELREAL)	–1
PS3(HMS-3/4)	–1
PS4(HMS-ELREAL)	3
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 e^- rate	SHMS π^- rate	SHMS K^- rate	Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (e^- + \pi^- + K^-)$	Real coinc. $e^- \cdot \pi$
0.3 kHz	1.4 kHz	466 kHz	53 kHz	2.8 kHz	23 Hz	0.07-0.15 Hz

   (i) **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.**

(j) **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.

(k) **Take data for 30 hours (at 100% efficiency) at 25 μA to get about 17,000 $d(e, e'\pi^-)pp_{sp}$ coincidences.** Use the physics replay to keep track of the event total.

2. $\boxed{Al(e, e'\pi^-)X}$ Thick Dummy target SHMS right ($\theta = 9.12^o$) run.

Now put in the "thick" dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 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 LD2 target).

Take data for 3.0 hour (100% efficiency) at 40 μA.

3. $\boxed{d(e, e'\pi^-)pp_{sp}}$ LD2 SHMS center ($\theta = 11.12^o$) run.

   (a) Move the SHMS to 11.12 deg (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

   (b) Put in the LD2 target. Leave the spectrometer magnet settings unchanged.

   (c) Update *standard.kinematics* with the new settings, using neutron mass for the target.

   (d) **Adjust the beam current to keep the SHMS-3/4 rate below 600 kHz.** We project the current for this run to be about 70 μA. Do not change PS5=0!

   (e) 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 280 Hz DAQ rate overall.

Projected prescale GUI settings:	
PS1(SHMS-3/4)	13
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 e^- rate	SHMS π^- rate	SHMS K^- rate	Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (e^- + \pi^- + K^-)$	Real coinc. $e^- \cdot \pi$
0.8 kHz	3.8 kHz	452 kHz	44 kHz	2.5 kHz	62 Hz	0.2-0.4 Hz

   (f) **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.**

   (g) **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.

   (h) **Take data for 11 hours (100% efficiency) at 70 μA to get about 17,000 d(e, e$'\pi^-$)pp$_{sp}$ coincidences.** Use the physics replay to keep track of the event total.

4. $\boxed{\text{Al}(e, e'\pi^-)X}$ Thick Dummy target SHMS center ($\theta = 11.12^o$) run.

Now put in the "thick" dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 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 LD2 target).

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

5. $\boxed{d(e, e'\pi^-)pp_{sp}}$ LD2 SHMS left ($\theta = 13.12^o$) run.

   (a) Move the SHMS 13.12 deg (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

   (b) Put in the LD2 target. Leave the spectrometer magnet settings unchanged.

   (c) Update *standard.kinematics* with the new settings, using neutron mass for the target.

   (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 200 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 e^- rate	SHMS π^- rate	SHMS K^- rate	Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (e^- + \pi^- + K^-)$	Real coinc. $e^- \cdot \pi$
0.8 kHz	3.8 kHz	158 kHz	12 kHz	0.7 kHz	21 Hz	0.2-0.4 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 11 hours (at 100% efficiency) at 70 μA to get about 17,000 $d(e, e'\pi^-)pp_{sp}$ coincidences.** Use the physics replay to keep track of the event total.

6. $\boxed{\text{Al}(e, e'\pi^-)X}$ Thick Dummy target SHMS left ($\theta = 13.12^o$) run.

Now put in the "thick" dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 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 LD2 target).

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

Q²=3.85, W=3.07, x=0.31, low ϵ data taking – PART ONE

Nominal Q^2=3.85 GeV^2/c^2, W=3.07 GeV, x=0.31 Kinematics						
E_e	$E_{e'}$	$\theta_{e'}$	ϵ	$\|t\|$	p_π	θ_q
GeV	GeV	deg		(GeV/c)^2	GeV/c	deg
7.937	1.332	35.12	0.288	0.120	6.538	-6.39

1. $\boxed{d(e, e'\pi^-)pp_{sp}}$ LD2 SHMS left ($\theta = 8.39^o$) run.

   Set up the following configuration:

   (a) HMS angle = 35.12 (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

   (b) HMS momentum = –1.332 GeV/c. Negative polarity.

   (c) SHMS angle = 8.39 deg (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

   (d) SHMS momentum = –6.538 GeV/c. Negative polarity. Follow the magnet cycling procedure.

   (e) 10 cm LD2 target.

   (f) Update *standard.kinematics* with the new settings, using neutron mass for the target.

   (g) **Adjust the beam current to keep the SHMS-3/4 rate below 600 kHz.** We project the current for this run to be about 20 μA. Do not change PS5=0!

   (h) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.
   For **20 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 620 Hz DAQ rate overall.

Projected prescale GUI settings:	
PS1(SHMS-3/4)	13
PS2(SHMS-ELREAL)	–1
PS3(HMS-3/4)	–1
PS4(HMS-ELREAL)	7
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 e^- rate	SHMS π^- rate	SHMS K^- rate	Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (e^- + \pi^- + K^-)$	Real coinc. $e^- \cdot \pi$
0.4 kHz	31 kHz	635 kHz	14 kHz	0.5 kHz	360 Hz	0.09 Hz

   (i) **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.**

(j) **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.

(k) **Take data for 25 hours (at 100% efficiency) to get about 8,300 $\mathbf{d(e, e'\pi^-)pp_{sp}}$ coincidences.** Use the physics replay to keep track of the event total.

2. $\boxed{\text{Al}(e, e'\pi^-)X}$ Thick Dummy target SHMS left ($\theta = 8.39^o$) run.

Now put in the "thick" dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 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 LD2 target).

Take data for 2.5 hour (100% efficiency) at 40 μA.

3. $\boxed{d(e, e'\pi^-)pp_{sp}}$ LD2 SHMS center ($\theta = 6.39^o$) run.

   (a) Move the SHMS to 6.39 deg (from TV). **The Run Co-ordinator will need to arrange in advance which expert personnel (e.g. Amy Comer, Steve Lassiter) need to monitor remotely.** Be sure to record and photograph the actual vernier value to 0.005 degree precision.

   (b) Put in the LD2 target. Leave the spectrometer magnet settings unchanged.

   (c) Update *standard.kinematics* with the new settings, using neutron mass for the target.

   (d) **Adjust the beam current to keep the SHMS-3/4 rate comfortably below 1 MHz.** We project the current for this run to be about 6 μA. Do not change PS5=0!

   (e) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.
   For **6 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 400 Hz DAQ rate overall.

Projected prescale GUI settings:	
PS1(SHMS-3/4)	14
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 e^- rate	SHMS π^- rate	SHMS K^- rate	Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (e^- + \pi^- + K^-)$	Real coinc. $e^- \cdot \pi$
0.1 kHz	9.3 kHz	978 kHz	16 kHz	0.6 kHz	170 Hz	0.03 Hz

   (f) **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.**

   (g) **HMS-3/4 trigger run:** Since the HMS momentum is fairly low, take daily 1 hour runs 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.

   (h) **Take data for 83 hours (100% efficiency) at 6 μA to get about 8,300 d($e, e'\pi^-$)pp$_{sp}$ coincidences.** Use the physics replay to keep track of the event total.

4. $\boxed{\text{Al}(e, e'\pi^-)X}$ Thick Dummy target SHMS center ($\theta = 6.39^o$) run.

Now put in the "thick" dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 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 LD2 target).

Take data for 8.3 hours (100% efficiency) at 20–40 μA.

Q²=6.00, W=2.40, x=0.55, low ϵ data taking – PART TWO

Nominal Q^2=6.00 GeV²/c^2, W=2.40 GeV, x=0.55 Kinematics						
E_e	$E_{e'}$	$\theta_{e'}$	ϵ	$|t|$	p_π	θ_q
GeV	GeV	deg		(GeV/c)²	GeV/c	deg
7.937	2.139	34.58	0.439	0.531	5.512	-11.12

1. $\boxed{d(e, e'\pi^+)nn_{sp}}$ LD2 SHMS right ($\theta = 9.12^o$) run.

   Set up the following configuration:

   (a) Switch the SHMS to positive polarity (follow the cycling procedure) and set to +5.512 GeV/c.

   (b) Move the SHMS 9.12 deg (from TV). Beam off while departing the beam line. Record and photograph the actual achieved vernier value to 0.005 degree precision.

   (c) HMS momentum = –2.139 GeV/c. Follow the magnet cycling procedure.

   (d) HMS angle = 34.58 (from TV). Record and photograph the actual vernier value to 0.005 degree precision.

   (e) 10 cm LD2 target.

   (f) Update *standard.kinematics* with the new settings, using proton mass for the target.

   (g) **Adjust the beam current to keep the SHMS-3/4 rate below 600 kHz.** We project the current for this run to be about 70 μA. Do not change PS5=0!

   (h) 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 245 Hz DAQ rate overall.

Projected prescale GUI settings:	
PS1(SHMS-3/4)	13
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. $e^- \cdot \pi$
0.8 kHz	3.8 kHz	234 kHz	89 kHz	92 kHz	52 Hz	0.2-0.4 Hz

   (i) **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.**

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(j) **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.

(k) **Take data for 13.5 hours (at 100% efficiency) to get about 21,500 d$(e, e'\pi^+)$nn$_{sp}$ coincidences.** Use the physics replay to keep track of the event total.

2. $\boxed{Al(e, e'\pi^+)X}$ Thick Dummy target SHMS right ($\theta = 9.12^o$) run.

Now put in the "thick" dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 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 LD2 target).

Take data for 1.3 hour (100% efficiency) at 40 μA.

During this period, the Target Operator should park the LD2 target and prepare for LH2 data taking.

3. $\boxed{p(e, e'\pi^+)n}$ LH2 SHMS right ($\theta = 9.12^o$) run.

   (a) How put in the 10 cm LH2 target and leave the spectrometer settings unchanged.

   (b) 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 200 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)	4
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. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$	Real coinc. $e^- \cdot \pi$
0.4 kHz	1.9 kHz	117 kHz	45 kHz	46 kHz	13 Hz	0.2-0.4 Hz

   (c) **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.**

   (d) **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.

   (e) **Take data for 13.5 hours (at 100% efficiency) to get about 21,500 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total.

4. $\boxed{p(e, e'\pi^+)n}$ LH2 SHMS center ($\theta = 11.12^o$) run.

   (a) Move the SHMS to 11.12 deg (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

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

   (c) Update *standard.kinematics* with the new settings, using proton mass for the target.

   (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 210 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)	4
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. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$	Real coinc. $e^- \cdot \pi$
0.4 kHz	1.9 kHz	34 kHz	14 kHz	18 kHz	4 Hz	0.2-0.4 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 13.5 hours (100% efficiency) at 70 μA to get about 21,500 p(e, e'π^+)n coincidences.** Use the physics replay to keep track of the event total.

5. $\boxed{\mathrm{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS center ($\theta = 11.12^o$) 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 LD2 target).

Take data for 1.3 hours (100% efficiency) at 40 μA.

During this period, the Target Operator should park the LH2 target and prepare for LD2 data taking.

6. $\boxed{d(e, e'\pi^+)nn_{sp}}$ LD2 SHMS center ($\theta = 11.12^o$) run.

   (a) Put in the LD2 target. Leave the spectrometer magnet settings unchanged. Leave *standard.kinematics* unchanged, using proton mass for the target.

   (b) 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 210 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. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$	Real coinc. $e^- \cdot \pi$
0.8 kHz	3.8 kHz	44 kHz	28 kHz	36 kHz	14 Hz	0.2-0.4 Hz

   (c) **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.**

   (d) **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.

   (e) **Take data for 13.5 hours (100% efficiency) at 70 μA to get about 21,500 d(e, e'π^+)nn$_{sp}$ coincidences.** Use the physics replay to keep track of the event total.

7. $\boxed{d(e,e'\pi^+)nn_{sp}}$ LD2 SHMS left ($\theta = 13.12^o$) run.

   (a) Move the SHMS 13.12 deg (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

   (b) Put in the LD2 target. Leave the spectrometer magnet settings unchanged.

   (c) Update *standard.kinematics* with the new settings, using proton mass for the target.

   (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)	9
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. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$	Real coinc. $e^- \cdot \pi$
0.8 kHz	3.8 kHz	19 kHz	8 kHz	13 kHz	5 Hz	0.2-0.4 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 13.5 hours (at 100% efficiency) at 70 μA to get about 21,500 $d(e, e'\pi^+)nn_{sp}$ coincidences.** Use the physics replay to keep track of the event total.

8. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS left ($\theta = 13.12^o$) run.

   Now put in the "thick" dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 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 LD2 target).

   Take data for 1.3 hours (100% efficiency) at 40 μA.

   During this period, the Target Operator should park the LD2 target and prepare for LH2 data taking.

9. $\boxed{p(e, e'\pi^+)n}$ LH2 SHMS left ($\theta = 13.12^o$) run.

(a) Put in the LH2 target. Leave the spectrometer magnet and angle settings unchanged.

(b) 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)	8
PS2(SHMS-ELREAL)	-1
PS3(HMS-3/4)	-1
PS4(HMS-ELREAL)	4
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. $e^- \cdot \pi$
0.4 kHz	1.9 kHz	9.5 kHz	4 kHz	6.6 kHz	1 Hz	0.2-0.4 Hz

(c) **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.**

(d) **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.

(e) **Take data for 13.5 hours (at 100% efficiency) at 70 μA to get about 21,500 p(e, e'π^+)n coincidences.** Use the physics replay to keep track of the event total.

Q²=2.45, W=3.20, x=0.21, low ϵ data taking

Nominal Q^2=2.45 GeV²/c^2, W=3.20 GeV, x=0.21 Kinematics						
E_e	$E_{e'}$	$\theta_{e'}$	ϵ	$\|t\|$	p_π	θ_q
GeV	GeV	deg		(GeV/c)²	GeV/c	deg
7.937	1.644	25.02	0.372	0.048	6.265	-6.16

1. $\boxed{p(e, e'\pi^+)n}$ LH2 SHMS left ($\theta = 8.16^o$) run.

   Set up the following configuration:

   (a) Set the SHMS to +6.265 GeV/c (follow the cycling procedure).

   (b) Move the SHMS 8.16 deg (from TV). Beam off while approaching the beam line. Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision.

   (c) HMS momentum = –1.644 GeV/c. Negative polarity.

   (d) HMS angle = 25.02 (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

   (e) 10 cm LH2 target.

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

   (g) **Adjust the beam current to keep the SHMS-3/4 rate below 600 kHz.** We project the current for this run to be about 70 μA. Do not change PS5=0!

   (h) 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 760 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)	10
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. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$	Real coinc. $e^- \cdot \pi$
3.3 kHz	158 kHz	73 kHz	32 kHz	29 kHz	530 Hz	1.6 Hz

   (i) **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.**

(j) **HMS-3/4 trigger run:** Since the HMS momentum is fairly low, take a 20 minute 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.

(k) **Take data for 1.8 hours (at 100% efficiency) to get about 11,600 p(e, e'π^+)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 left ($\theta = 8.16^o$) 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 0.2 hour (100% efficiency) at 40 μA.

3. $\boxed{p(e, e'\pi^+)n}$ LH2 SHMS center ($\theta = 6.16^o$) run.

(a) Move the SHMS to 6.16 deg (from TV). **This requires a hall access. The Run Co-ordinator will need to arrange in advance which expert personnel (e.g. Amy Comer, Steve Lassiter) need to be present.** 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) **Adjust the beam current to keep the SHMS-3/4 rate below 600 kHz.** We project the current for this run to be about 70 μA. Do not change PS5=0!

(e) 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 1500 Hz DAQ rate overall.

Projected prescale GUI settings:	
PS1(SHMS-3/4)	13
PS2(SHMS-ELREAL)	−1
PS3(HMS-3/4)	−1
PS4(HMS-ELREAL)	10
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. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$	Real coinc. $e^- \cdot \pi$
3.3 kHz	158 kHz	272 kHz	32 kHz	29 kHz	1330 Hz	1.6 Hz

(f) **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.**

(g) **HMS-3/4 trigger run:** Since the HMS momentum is fairly low, take a 20 minute 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.

(h) **Take data for 1.8 hours (100% efficiency) at 70 μA to get 11,600 p(e, e'π^+)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 ($\theta = 6.16^o$) 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 0.2 hours (100% efficiency) at 40 μA.

5. **To be determined in consultation with the RC:** Nominal end of data taking before Christmas break. If there is time remaining, go back to the $(e, e'\pi^{\pm})$ setting with the lowest statistics and take more data, or do one of the deferred calibration studies.