Pion-LT Run Plan - Part 3

November 5, 2021

9.876 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) needs to enter the hall to remove the n =1.03 aerogel and replace it with n = 1.011 aerogel. Estimated time required – 8 hours.

- 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). 6.39 deg (w/ expert monitoring)
  3. SHMS momentum = -5.500 GeV/c (negative polarity and magnets cycled).
  4. HMS angle = 13.00 deg (from TV).
  5. HMS momentum = -4.000 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.

9.876 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_{SHM}
23.53	-5.202	6.39$^+$	-9.030	**12 μA**	0.02 kHz	0	520 kHz	10	10 min	6 min	610k
$^+$ The RC needs arrange in advance which experts (e.g. Comer, Lassiter) need to monitor remotely.											
23.53	-5.202	7.73	-9.030	**40 μA**	0.06 kHz	0	520 kHz	10	10 min	6 min	610k
23.53	-5.202	6.60$^+$	-8.035	**12 μA**	0.02 kHz	0	570 kHz	10	12 min	6 min	660k
$^+$ The RC needs arrange in advance which experts (e.g. Comer, Lassiter) need to monitor remotely.											
23.53	-5.202	9.29	-8.035	70 μA	0.11 kHz	0	370 kHz	9	10 min	6 min	860k
23.53	-5.202	10.26	-8.035	70 μA	0.11 kHz	0	160 kHz	8	10 min	6 min	750k
23.53	-5.202	11.73	-8.035	70 μA	0.11 kHz	0	52 kHz	6	10 min	6 min	930k
23.53	-5.202	13.79	-8.035	70 μA	0.11 kHz	0	11 kHz	4	10 min	6 min	720k
23.53	-5.202	13.30	-6.538	70 μA	0.11 kHz	0	46 kHz	6	30 min	6 min	2400k
23.53	-5.202	15.65	-6.538	70 μA	0.11 kHz	0	10 kHz	4	18 min	6 min	1200k
23.53	-5.202	17.79	-6.538	70 μA	0.11 kHz	0	2.6 kHz	3	12 min	6 min	920k
23.53	-5.202	19.85	-6.538	70 μA	0.11 kHz	0	0.4 kHz	0	30 min	6 min	470k
19.88	-6.328*	19.05	-6.265	70 μA	0.15 kHz	0	1.2 kHz	0	20 min	6 min	960k
* Follow the HMS magnet cycling procedure!											
Total Time (including overhead): 12.5 hrs											

Heep-check coincidence run

1. $p(e,e'p)$ equal angles setting (with δ_{SHMS}=1%)

9.876 GeV Heep-check coincidence run

θ_{HMS}	P_{HMS}	θ_{SHMS}	P_{SHMS}	$Rate_{HMS}$	$Rate_{DAQ}$	Time
23.05	-5.366	23.05	5.422	2.4 Hz	150 Hz	1.25 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 +5.422 GeV/c.

(c) SHMS angle = 23.05 (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

(d) Set HMS magnets to –5.366 GeV/c

(e) HMS angle = 23.05 (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 150 Hz DAQ rate overall.

Projected prescale GUI settings:	
PS1(SHMS-3/4)	0
PS2(SHMS-ELREAL)	–1
PS3(HMS-3/4)	–1
PS4(HMS-ELREAL)	0
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 10,000 e+p elastic scattering coincidences. The first run should be ~ 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: 1.25 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).

Q^2=1.60, W=3.08, x=0.16, high-2 ϵ data taking

done 11/11/21

Nominal Q^2=1.60 GeV$^2/c^2$, W=3.08 GeV, x=0.16 Kinematics

E_e	$E_{e'}$	$\theta_{e'}$	ϵ	$\lvert t\rvert$	p_π	θ_q
GeV	GeV	deg		$(\text{GeV/c})^2$	GeV/c	deg
9.876	4.437	10.96	0.736	0.026	5.422	-8.69

1. $p(e,e'\pi^+)n$ LH2 SHMS right ($\theta = 6.97^o$) run.

   Set up the following configuration:

   (a) HMS small angle and minimum HMS+SHMS opening angle rotation. **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.**

   - First rotate the HMS to its minimum possible angle to the beamline. According to the test of June 6, this is expected to be 11.03 degrees, but an angle of 10.96 degrees is preferred, if possible.
   - After the HMS is set, rotate the SHMS to the smallest opening angle allowed between the two spectrometers. The minimum opening angle is expected to be 17.99 degrees, which corresponds to a SHMS angle of about 6.97 degrees.
   - Record and photograph the actual achieved vernier angles to 0.005 degree precision. ✓

   (b) HMS momentum = –4.437 GeV/c.

   (c) SHMS momentum = 5.422 GeV/c. (Should already be there.) ✓

   (d) 10 cm LH2 target.

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

   (f) **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!

   30 μA

(g) 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 an 960 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)	9
PS5(HMS-ELREAL×SHMS-3/4)	0
PS6(HMS-3/4×SHMS-3/4)	–1
EDTM Target Prescale Rate	10 Hz
cermode10	ON

2300 Hz

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. $e^- \cdot \pi$
27 kHz	39 kHz	334 kHz	100 kHz	104 kHz	690 Hz	18.5 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) **Take data for approximately 1.5 hours (100% efficiency) at 20 μA to get 140,000 p(e, e'π^+)n coincidences.** Use the physics replay to keep track of the event total.
The first run should be ~~15~~ 5 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.
NOTE: 140k events are needed to end up with about 20k useful events for the L/T-separation after applying diamond cuts.

2. Al$(e, e'\pi^+)X$ Thick Dummy target SHMS right ($\theta = 6.97^o$) 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 0.3 hour (100% efficiency) at 40 μA.

3. $\boxed{p(e,e'\pi^+)n}$ LH2 SHMS center ($\theta = 8.69^o$) run.

(a) Move the SHMS to 8.69 deg (from TV). Beam off for the spectrometer movement. 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 40 μA. Do not change PS5=0!

Can go higher → if pTrig1 < 600kHz &

(e) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.
For **40 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 2600 Hz DAQ rate overall.

live time ~= 100%

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

↑ May be higher at higher current

Go 3million events or 1 hr per run

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. $e^- \cdot \pi$
54 kHz	78 kHz	253 kHz	84 kHz	149 kHz	2300 Hz	37 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.**

Run 1 hour → & >130,000 coin

(g) **Take data for approximately 1 hour (100% efficiency) at 40 μA to get 130,000-190,000 p(e, e'π^+)n coincidences.** Use the physics replay to keep track of the event total.
(5) (especially if rates are high)
The first run should be ~~15~~ 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.
NOTE: 130k events are needed to end up with about 18k useful events for the L/T-separation after applying diamond cuts. Extra beyond that are not essential if the beam current has to be reduced.

4. $\boxed{\mathrm{Al}(e,e'\pi^+)X}$ Thick Dummy target SHMS center ($\theta = 8.69^o$) 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. $\boxed{p(e,e'\pi^+)n}$ LH2 SHMS left ($\theta = 10.69^o$) run.

(a) Move the SHMS 10.69 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) **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 1350 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)	11
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. $e^- \cdot \pi$
95 kHz	137 kHz	138 kHz	50 kHz	57 kHz	1100 Hz	65 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.**

1 hour → ~~$4~~ > 130,000 coin

(g) **Take data for approximately 1 hour (at 100% efficiency) at 70 μA to get 130,000-330,000 p(e, e'π^+)n coincidences.** Use the physics replay to keep track of the event total.
The first run should be ~15 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.
NOTE: 130k events are needed to end up with about 18k useful events for the L/T-separation after applying diamond cuts. Extra beyond that are not essential if the beam current has to be reduced.

6. $\boxed{\text{Al}(e,e'\pi^+)X}$ Thick Dummy target SHMS left ($\theta = 10.69^o$) 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 0.1 hours (100% efficiency) at 40 μA.

Q^2=3.85, W=3.07, x=0.31, middle-2 ϵ data taking

Nominal Q^2=3.85 GeV$^2/c^2$, W=3.07 GeV, x=0.31 Kinematics

E_e	$E_{e'}$	$\theta_{e'}$	ϵ	$\lvert t\rvert$	p_π	θ_q
GeV	GeV	deg		(GeV/c)^2	GeV/c	deg
9.876	3.271	19.88	0.569	0.120	6.538	-9.29

1. $p(e,e'\pi^+)n$ LH2 SHMS right ($\theta = 7.29^o$) run.

   Set up the following configuration:

   (a) HMS angle = 19.88 (from TV). Beam off while departing beam line. Be sure to record and photograph the actual vernier value to 0.005 degree precision.

   (b) HMS momentum = -3.271 GeV/c.

   (c) SHMS angle = 7.29 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. Follow the magnet cycling procedure.

   (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 an 550 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 π^+ rate	SHMS K rate	SHMS p rate	Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K$+p)	Real coinc. $e^- \cdot \pi$
5.5 kHz	18 kHz	244 kHz	96 kHz	69 kHz	305 IIz	2.5 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) **Take data for 2.9 hours (at 100% efficiency) at 70 μA to get about 28,500 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.
NOTE: 28.5k events are needed to end up with about 10k useful events for the L/T-separation after applying diamond cuts.

2. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS right ($\theta = 7.29^o$) 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 0.3 hour (100% efficiency) at 40 μA.

3. $\boxed{p(e,e'\pi^+)n}$ LH2 SHMS center ($\theta = 9.29^o$) run.

(a) Move the SHMS to 9.29 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 340 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)	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 π^+ rate	SHMS K rate	SHMS p rate	Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K$+p)	Real coinc. $e^- \cdot \pi$
5.5 kHz	18 kHz	61 kHz	26 kHz	24 kHz	83 Hz	2.5 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) **Take data for 2.9 hours (100% efficiency) at 70 μA to get about 28,500 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.
NOTE: 28.5k events are needed to end up with about 10k useful events for the L/T-separation after applying diamond cuts.

4. $\boxed{\text{Al}(e,e'\pi^+)X}$ Thick Dummy target SHMS center ($\theta = 9.29^o$) 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 0.3 hours (100% efficiency) at 40 μA.

5. $\boxed{p(e,e'\pi^+)n}$ LH2 SHMS left ($\theta = 11.29^o$) run.

(a) Move the SHMS 11.29 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 270 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)	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 π^+ rate	SHMS K rate	SHMS p rate	Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K$+p)	Real coinc. $e^- \cdot \pi$
5.5 kHz	18 kHz	14 kHz	6.6 kHz	7.6 kHz	21 Hz	2.5 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) **Take data for approximately 2.9 hours (at 100% efficiency) at 70 μA to get about 28,500 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.
NOTE: 28.5k events are needed to end up with about 10k useful events for the L/T-separation after applying diamond cuts.

6. $\boxed{\text{Al}(e,e'\pi^+)X}$ Thick Dummy target SHMS left ($\theta = 11.29^o$) 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 0.3 hours (100% efficiency) at 40 μA.

Q^2=5.00, W=2.95, x=0.39, middle ϵ data taking

Nominal Q^2=5.00 GeV$^2/c^2$, W=2.95 GeV, x=0.39 Kinematics

E_e	$E_{e'}$	$\theta_{e'}$	ϵ	$\lvert t\rvert$	p_π	θ_q
GeV	GeV	deg		(GeV/c)^2	GeV/c	deg
9.876	3.043	23.53	0.527	0.209	6.719	-9.73

1. $p(e,e'\pi^+)n$ LH2 SHMS right ($\theta = 7.73^o$) run.

   Set up the following configuration:

   (a) HMS angle = 23.53 (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

   (b) HMS momentum = –3.043 GeV/c. Negative polarity.

   (c) SHMS angle = 7.73 deg (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

   (d) SHMS momentum = 6.719 GeV/c. Follow the magnet cycling procedure.

   (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 an 300 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)	6
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. $e^- \cdot \pi$
2.2 kHz	6.7 kHz	145 kHz	61 kHz	46 kHz	73 Hz	0.9 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) **Take data for 11.5 hours (at 100% efficiency) at 70 μA to get about 50,000 p(e, e'π^+)n coincidences.** Use the physics replay to keep track of the event total. NOTE: 50k events are needed to end up with about 10k useful events for the L/T-separation after applying diamond cuts.

2. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS right ($\theta = 7.73^o$) 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 1.2 hour (100% efficiency) at 40 μA.

3. $\boxed{p(e,e'\pi^+)n}$ LH2 SHMS center ($\theta = 9.73^o$) run.

   (a) Move the SHMS to 9.73 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 260 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)	6
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. $e^- \cdot \pi$
2.2 kHz	6.7 kHz	34 kHz	16 kHz	15 kHz	19 Hz	0.9 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) **Take data for 11.5 hours (at 100% efficiency) at 70 μA to get about 50,000 p(e, e'π^+)n coincidences.** Use the physics replay to keep track of the event total.
   NOTE: 50k events are needed to end up with about 10k useful events for the L/T-separation after applying diamond cuts.

4. $\boxed{\mathrm{Al}(e,e'\pi^+)X}$ Thick Dummy target SHMS center ($\theta = 9.73^o$) 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 1.2 hours (100% efficiency) at 40 μA.

5. $\boxed{p(e,e'\pi^+)n}$ LH2 SHMS left ($\theta = 11.73^o$) run.

   (a) Move the SHMS 11.73 deg (from TV). Be sure to record and photograph the actualvernier 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 240 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)	6
PS5(HMS-ELREAL×SHMS-3/4)	0
PS6(HMS-3/4×SHMS-3/4)	−1
EDTM Target Prescale Rate	10 Hz
cermode10	ON

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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. $e^- \cdot \pi$
2.2 kHz	6.7 kHz	7.5 kHz	3.6 kHz	4.4 kHz	5 Hz	0.9 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) **Take data for 11.5 hours (at 100% efficiency) at 70 μA to get about 50,000 p(e, e'π^+)n coincidences.** Use the physics replay to keep track of the event total.
   NOTE: 50k events are needed to end up with about 10k useful events for the L/T-separation after applying diamond cuts.

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6. $\boxed{\mathrm{Al}(e,e'\pi^+)X}$ Thick Dummy target SHMS left ($\theta = 11.73^o$) 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 1.2 hours (100% efficiency) at 40 μA.

$Q^2 = 6.0$, $W = 3.19$ Run Plan

→ Do a DUMMY TARGET RUN (~1 hr) EVERY DAY.

→ Do a HMS-3/4 TRIGGER RUN AT EVERY SETTING.

$\theta_{SHMS} = 8.60°$

→ Take ~ 7½ shifts of data until Friday Morning.

$\theta_{SHMS} = 6.60°$

→ Rotate Friday morning
- requires Amy / Steven remotely.

→ Take ~ 11 shifts of data until late Mon Swing (Tentative).

$\theta_{SHMS} = 8.60°$

→ Rotate back to 6.60°.

→ Take ~ 4 shifts of data until pass change Wed morning.

Q^2=6.00, W=3.19, x=0.39, middle ϵ data taking

Nominal Q^2=6.00 GeV$^2/c^2$, W=3.19 GeV, x=0.39 Kinematics

E_e	$E_{e'}$	$\theta_{e'}$	ϵ	$\lvert t\rvert$	p_π	θ_q
GeV	GeV	deg		(GeV/c)^2	GeV/c	deg
9.876	1.725	34.52	0.300	0.214	8.035	-6.60

1. $p(e,e'\pi^+)n$ LH2 SHMS left ($\theta = 8.60^o$) run.

   Set up the following configuration:

   (a) HMS angle = 34.52 (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

   (b) HMS momentum = –1.725 GeV/c. Negative polarity.

   (c) SHMS angle = 8.60 deg (from TV). Be sure to record and photograph the actual vernier value to 0.005 degree precision.

   (d) SHMS momentum = 8.035 GeV/c. Follow the magnet cycling procedure.

   (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 220 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)	6
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	16 kHz	13 kHz	7 kHz	6 kHz	7 Hz	0.12-0.15 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 35 hours (at 100% efficiency) at 70 μA to get about 20,000 p(e, e'π^+)n coincidences.** Use the physics replay to keep track of the event total.
NOTE: 20k events are needed to end up with about 10k useful events for the L/T-separation after applying diamond cuts.

2. $\boxed{\mathrm{Al}(e,e'\pi^+)X}$ Thick Dummy target SHMS left ($\theta = 8.60^o$) 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 3.5 hour (100% efficiency) at 40 μA.

3. $\boxed{p(e,e'\pi^+)n}$ LH2 SHMS center ($\theta = 6.60^o$) run.

✓ (a) Move the SHMS to 6.60 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 achieved vernier value to 0.005 degree precision.

✓ (b) 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 275 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)	6
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	16 kHz	70 kHz	36 kHz	23 kHz	38 Hz	0.12-0.15 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.**

in progress... ✓ (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.

done by 20/11/21 (Day) ✓

(h) **Take data for 35 hours (at 100% efficiency) at 70 μA to get about 20,000 p(e, e'π^+)n coincidences.** Use the physics replay to keep track of the event total.
NOTE: 20k events are needed to end up with about 10k useful events for the L/T-separation after applying diamond cuts.

4. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS center ($\theta = 6.60^o$) 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 3.5 hours (100% efficiency) at 40 μA.

Estimated Total Time for this Run Plan: 297 hours (12.4 days)

OPTIONAL EXTRA: If there is time before the pass change, do at least part of this study, which could assist in understanding fADC deadtime issues.

$p(e,e'\pi^+)n$ coincidences fADC deadtime study

1. HMS momentum = -3.583 GeV/c. Follow the cycling procedure.
2. HMS angle = 15.12 deg (from TV).
3. SHMS momentum = +6.265 GeV/c.
4. SHMS angle = 8.29 deg (from TV).
5. Update *standard.kinematics* with the new settings.
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, goal is 100 Hz
PS2(SHMS-ELREAL)	–1
PS3(HMS-3/4)	–1
PS4(HMS-ELREAL)	see table, goal is 100 Hz
PS5(HMS-ELREAL×SHMS-3/4)	0
PS6(HMS-3/4×SHMS-3/4)	–1
EDTM Target Prescale Rate	10 Hz
cermode10	ON

7. Make sure the raster is on (2 × 2), and take coincidences at 70, 40, 18 μA. The goal is 50k prompt $p(e,e'\pi^+)n$ coincidences per setting. Use the physics replay to keep track of statistics.
8. At 40 μA, take one Dummy target run, about 0.3 hour.
9. If there is time remaining, return to LH2 target, and take coincidences at 55, 25 μA. Divide the remaining time to get roughly equal statistics for each current, hopefully at least 10k prompt $p(e,e'\pi^+)n$ coincidences per setting.

9.876 GeV $p(e,e'\pi^+)n$ fADC Deadtime Study								
Q^2 = 2.45 GeV^2, W=3.20 GeV, ϵ=0.62								
μA	Targets	$\frac{Rate_{SHMS}}{LHrun}$	$\frac{PS1}{SHMS}$	$\frac{Rate_{HMS}}{LHrun}$	$\frac{PS4}{HMS}$	DAQ_{SHMS}	DAQ_{HMS}	$\frac{Time}{run}$
70	LH2	294 kHz	12	102 kHz	9	1 kHz	1 kHz	1.0 hr
40	LH2, Dummy	168 kHz	12	58 kHz	9	1 kHz	1 kHz	1.5 hr
18	LH2	76 kHz	10	26 kHz	7	1 kHz	1 kHz	3.5 hr
55	LH2	231 kHz	12	80 kHz	9	1 kHz	1 kHz	1.3 hr
25	LH2	105 kHz	11	36 kHz	8	1 kHz	1 kHz	2.5 hr
Total Time (at 100% efficiency): 10 hrs								

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