x>1 and EMC Effect (XEM2) Run Plan

October 2, 2022

1 Initial Non-Production Beam Activities

1.1 Coincidence Hydrogen Elastic Data Taking

- **DAQ:** COIN
- **Trigger** PS6 (SHMS 3/4 + HMS 3/4 COINCIDENCE)
- **electron arm:** SHMS & **proton arm:** HMS
- **Prescale:** PS6=0, PS5=-1, PS3=-1, PS2=-1
- Set target rates of **100 Hz** for **PS1 and PS4**
- **electron arm:** SHMS & **proton arm:** HMS
- We will take coincidence elastic data at 6 different settings. At each setting data will be taken with 10 cm LH2 and Al dummy targets. At the lowest two Q^2 settings, we will also take data with the 48Ca Target to measure the possible hydrogen contamination in 48Ca.
- The goal is **10K elastic coincidences** at each setting.
- **For the first setting (KIN 1 with LH2 target):** the first run should be 15 minutes long. Start the second run immediately after ending the first short run. The first short run will be analyzed while taking the second run.
- Follow Table 1 and take data.

Table 1: Coincidence Hydrogen Elastic Data Taking

Setting	P_{HMS} **(GeV)**	θ_{HMS}	P_{SHMS} **(GeV)**	θ_{SHMS}	**Target**	***I*** **(μA)**	**Est. Time**	**Done ?**
KIN 1	+6.476	19.52°	-4.935	26°	LH2	65	5 hrs	
	+6.476	19.52°	-4.935	26°	dummy	40	40 min	
KIN 2	+5.107	24.89°	-6.286	20°	dummy	40	10 min	
	+5.107	24.89°	-6.286	20°	LH2	65	40 min	
KIN 3	+3.738	31.86°	-7.626	15°	LH2	65	10 min	
	+3.738	31.86°	-7.626	15°	dummy	40	10 min	
KIN 4	+2.289	43.09°	-9.005	10°	dummy	40	10 min	
	+2.289	43.09°	-9.005	10°	LH2	65	10 min	
KIN 5	+2.076	45.36°	-9.2	9.24°	LH2	65	10 min	
	+2.076	45.36°	-9.2	9.24°	dummy	40	10 min	
KIN 6	+1.739	49.49°	-9.502	8°	dummy	40	10 min	
	+1.739	49.49°	-9.502	8°	48Ca	40	10 min	
	+1.739	49.49°	-9.502	8°	LH2	65	10 min	

1.1.1 Coincidence Elastic Data with SHMS Sieve Slit

- HMS Collimator: "Large Collimator"
- SHMS Collimator: "Collimator" or "Centered Sieve"
- **Trigger Settings:** PS2, PS4, PS6

Setting 1 (Same as the last setting)

- **SHMS Momentum and Angle:** -9.502 GeV and 8 deg
- **HMS Momentum and Angle:** +1.739 GeV and 49.49 deg

Table 2: Setting 1

SHMS Coll Setting	**Target**	***I*** **(μA)**	**Est. Time**	**Done ?**
Centered Sieve	LH2	70 uA	10 min	
Centered Sieve	Beryllium	70 uA	10 min	

Setting 2

- **SHMS Momentum and Angle:** -9.026 GeV and 8 deg
- **HMS Momentum and Angle:** +1.739 GeV and 49.49 deg

Table 3: Setting 2

SHMS Coll Setting	**Target**	***I*** **(μA)**	**Est. Time**	**Done ?**
Centered Sieve	Beryllium	70 uA	10 min	
Centered Sieve	LH2	70 uA	10 min	
Collimator	LH2	70 uA	10 min	
Collimator	dummy	70 uA	10 min	

Setting 3

- **SHMS Momentum and Angle:** -8.55 GeV and 8 deg
- **HMS Momentum and Angle:** +1.739 GeV and 49.49 deg

Table 4: Setting 3

SHMS Coll Setting	**Target**	***I*** **(μA)**	**Est. Time**	**Done ?**
Collimator	dummy	70 uA	10 min	
Collimator	LH2	70 uA	10 min	
Centered Sieve	LH2	70 uA	10 min	
Centered Sieve	Beryllium	70 uA	10 min	

- Total estimated time for section 1.1 including the momentum and target changes: **12 hrs** with 100% efficiency.

1.2 Delta Scan with the SHMS

- **DAQ:** COIN
- **Trigger** PS6 (SHMS 3/4 + HMS 3/4 COINCIDENCE)
- **electron arm:** SHMS & **proton arm:** HMS
- **Prescale:** PS6=0, PS5=-1, PS3=-1, PS2=-1
- Set target rates of **100 Hz** for **PS1 and PS4**
- We will take data at 6 different settings. At each setting data will be taken with 10 cm LH2 and Al dummy targets.
- Since this is a delta scan with the SHMS, the central momentum for the SHMS will be kept at -8 GeV for the entire study.
- The goal is **10K elastic coincidences** at each setting.
- Follow Table 5 and take data.

Table 5: Delta Scan with the SHMS

Setting	P_{HMS} **(GeV)**	θ_{HMS}	P_{SHMS} **(GeV)**	θ_{SHMS}	**Target**	I (μA)	**Est. Time**	**Done ?**
KIN 1	+4.18	29.37°	-8.0	16.54°	LH2	65	15 min	
	+4.18	29.37°	-8.0	16.54°	dummy	40	10 min	
KIN 2	+3.77	31.69°	-8.0	15.09°	dummy	40	10 min	
	+3.77	31.69°	-8.0	15.09°	LH2	65	10 min	
KIN 3	+3.35	34.32°	-8.0	13.67°	LH2	65	10 min	
	+3.35	34.32°	-8.0	13.67°	dummy	40	10 min	
KIN 4	+2.94	37.34°	-8.0	12.24°	dummy	40	10 min	
	+2.94	37.34°	-8.0	12.24°	LH2	65	10 min	
KIN 5	+2.51	40.93°	-8.0	10.78°	LH2	65	10 min	
	+2.51	40.93°	-8.0	10.78°	dummy	40	10 min	
KIN 6	+2.08	45.32°	-8.0	9.25°	dummy	40	10 min	
	+2.08	45.32°	-8.0	9.25°	LH2	65	10 min	

- Total estimated time for section 1.2 including the momentum and target changes: **5 hrs** with 100% efficiency.

BEFORE MOVING ON TO THE NEXT SECTION THE DAQ AND EDTM SHOULD BE SET UP FOR THE SINGLE ARM MODE!

1.3 Calibration Data Taking and PID Threshold Checks

- **DAQ:** Single Arm
- At 3 different settings, we will take data with ELREAL trigger on each arm to calibrate the detectors and also with 3/4 trigger on each arm to check the PID trigger thresholds.

1.3.1 Setting 1

- **SHMS Settings:** -4.0 GeV & 20°
- **HMS Settings:** -4.0 GeV & 20°
- **Target:** LH2
- **Trigger**: SHMS/HMS PS2 (ELREAL) **OR** SHMS/HMS PS1 (3/4)
- **Important note on the prescales:** All the other prescales that are NOT specified on each row at the Table 6 should be set to **-1**.
- Adjust the prescales on **EACH** prescale GUI to keep the rates below 3 kHz.
- The goal number of events is **50K-100K** for each setting.
- **For defocusing: Increase the nominal SHMS Q2 and HMS Q2 currents by +20%.**
- Follow Table 6. Take SHMS and HMS single arm data simultaneously.
- Estimated run times are with 100% efficiency.

Table 6: Calibration/PID Threshold Checks - Setting 1

SHMS/HMS Q2	**HMS PS**		**SHMS PS**		***I***	**Est. Time**	**Done ?**
	PS1	**PS2**	**PS1**	**PS2**	**(μA)**		
+20% defocused Q2	-1	0	-1	0	60	15 min	
nominal Q2	-1	0	-1	0	60	15 min	
nominal Q2	0	-1	0	-1	60	15 min	

1.3.2 Setting 2

- **SHMS Settings:** -3.5 GeV & 25°
- **HMS Settings:** -3.5 GeV & 25°
- **Target:** LH2
- **Trigger**: SHMS/HMS PS2 (ELREAL) **OR** SHMS/HMS PS1 (3/4)
- **Important note on the prescales:** All the other prescales that are NOT specified on each row at the Table 7 should be set to **-1**.
- Adjust the prescales on **EACH** prescale GUI to keep the rates below 3 kHz.
- The goal number of events is **50K-100K** for each setting.
- **For defocusing: Increase the nominal SHMS Q2 and HMS Q2 currents by +20%.**
- Follow Table 7. Take SHMS and HMS single arm data simultaneously.
- Estimated run times are with 100% efficiency.

Table 7: Calibration/PID Threshold Checks - Setting 2

SHMS/HMS Q2	**HMS PS**		**SHMS PS**		***I***	**Est. Time**	**Done ?**
	PS1	**PS2**	**PS1**	**PS2**	**(μA)**		
+20% defocused Q2	-1	0	-1	0	60	15 min	
nominal Q2	-1	0	-1	0	60	15 min	
nominal Q2	0	-1	0	-1	60	15 min	

1.3.3 Setting 3

- **SHMS Settings:** -2.5 GeV & 35°
- **HMS Settings:** -2.5 GeV & 35°
- **Target:** LH2
- **Trigger**: SHMS/HMS PS2 (ELREAL) **OR** SHMS/HMS PS1 (3/4)
- **Important note on the prescales:** All the other prescales that are NOT specified on each row at the Table 8 should be set to **-1**.
- Adjust the prescales on **EACH** prescale GUI to keep the rates below 3 kHz.
- The goal number of events is **50K-100K** for each setting.
- **For defocusing: Increase the nominal SHMS Q2 and HMS Q2 currents by +20%.**
- Follow Table 8. Take SHMS and HMS single arm data simultaneously.
- Estimated run times are with 100% efficiency.

Table 8: Calibration/PID Threshold Checks - Setting 3

SHMS/HMS Q2	**HMS PS**		**SHMS PS**		***I***	**Est. Time**	**Done ?**
	PS1	**PS2**	**PS1**	**PS2**	**(μA)**		
+20% defocused Q2	-1	0	-1	0	60	15 min	
nominal Q2	-1	0	-1	0	60	15 min	
nominal Q2	0	-1	0	-1	60	15 min	

- Total estimated time for section 1.3 including the momentum and target changes: **4 hrs**. Estimated run times are with 100% efficiency.

1.4 SHMS Hodoscope Paddle Test

At the 8 degree SHMS settings, we will run with all hodoscopes, and then with four different subsets turned off to check the acceptance. Same for 8.5 with a limited subset.

JRA: No HMS plan for this setting; maybe we can squeeze in some parasitic PID checks or something...

1.4.1 Setting 1

- **DAQ:** Single Arm, SHMS only
- **SHMS Settings:** -9.2 GeV & 8°
- **Target:** LD2 or 12C
- **Trigger**: SHMS PS2 (ELREAL) **OR** SHMS PS1 (3/4)
- **Important note on the prescales:** All the other prescales that are NOT specified on each row at the Table 9 should be set to **-1**.
- Adjust the prescales on **EACH** prescale GUI to keep the rates below 3 kHz.
- Estimated run times are with 100% efficiency.

Table 9: SHMS acceptance test with some hodoscopes turned off at 8.0°

Setting	**HV off**		**SHMS PS**		**Target**	***I***	**Est. Time**	**Done ?**
	S1X	S2X	PS1	PS2		(μA)		
1	none	none	-1	0	LD2	60	10 min	
	none	none	-1	0	12C	60	10 min	
	none	none	0	-1	12C	60	10 min	
2	1-7	1-6	0	-1	12C	60	10 min	
	1-7	1-6	-1	0	12C	60	10 min	
	1-7	1-6	-1	0	LD2	60	10 min	
3	1-8	1-6	-1	0	LD2	60	10 min	
	1-8	1-6	-1	0	12C	60	10 min	
	1-8	1-6	0	-1	12C	60	10 min	
4	1-7	1-7	0	-1	12C	60	10 min	
	1-7	1-7	-1	0	12C	60	10 min	
	1-7	1-7	-1	0	LD2	60	10 min	
5	1-8	1-7	-1	0	LD2	60	10 min	
	1-8	1-7	-1	0	12C	60	10 min	
	1-8	1-7	0	-1	12C	60	10 min	

1.4.2 Setting 2

- **DAQ:** Single Arm, SHMS only
- **SHMS Settings:** -9.2 GeV & 8.5°
- **Target:** LD2 or 12C
- **Trigger**: SHMS PS2 (ELREAL) **OR** SHMS PS1 (3/4)
- **Important note on the prescales:** All the other prescales that are NOT specified on each row at the Table 10 should be set to **-1**.
- Adjust the prescales on **EACH** prescale GUI to keep the rates below 3 kHz.
- Estimated run times are with 100% efficiency.

Table 10: SHMS acceptance test with some upper hodoscopes turned off at 8.5°

Setting	**HV off**		**SHMS PS**		**Target**	***I***	**Est. Time**	**Done ?**
	S1X	S2X	PS1	PS2		(μA)		
1	none	none	0	-1	12C	60	10 min	
	none	none	-1	0	12C	60	10 min	
	none	none	-1	0	LD2	60	10 min	
2	1-5	1-7	-1	0	LD2	60	10 min	
	1-5	1-7	-1	0	12C	60	10 min	
	1-5	1-7	0	-1	12C	60	10 min	
3	1-6	1-8	0	-1	12C	60	10 min	
	1-6	1-8	-1	0	12C	60	10 min	
	1-6	1-8	-1	0	LD2	60	10 min	

BEFORE MOVING ON TO THE NEXT SECTION TURN ALL OF THE HODOSCOPE HV CHANNELS BACK ON!

1.5 Target Boiling Studies - Part I

- This study requires stable high current. It will be postponed if high current beam is unavailable at the moment.
- **DAQ:** Single Arm
- **SHMS/HMS Trigger:** PS2 (ELREAL)/PS2 (ELREAL)
- **SHMS Settings:** -4.0 GeV & 20°
- **HMS Settings:** -4.0 GeV & 20°
- Adjust the prescales (SHMS PS2 and HMS PS2) to keep the rates below 3 kHz. All the other prescales should be set to **-1**.
- The goal number of events is 50K-100K for each target at every current.

1.5.1 Boiling studies - LH2 target

- Move target to LH2 and take one run with **each current setting**.

Table 11: Boiling Studies - LH2 Target

Target	***I*** **(μA)**	**est. time**	**Done ?**
LH2	80 μA	10 min	
LH2	60 μA	10 min	
LH2	40 μA	10 min	
LH2	30 μA	10 min	
LH2	20 μA	10 min	
LH2	10 μA	10 min	

1.5.2 Boiling studies - LD2 target

- Move target to LD2 and take one run with each current setting.

Table 12: Boiling Studies - LD2 Target

Target	***I*** **(μA)**	**est. time**	**Done ?**
LD2	80 μA	10 min	
LD2	60 μA	10 min	
LD2	40 μA	10 min	
LD2	30 μA	10 min	
LD2	20 μA	10 min	
LD2	10 μA	10 min	

1.5.3 Al dummy target data for target wall subtraction

- Move target to Al dummy and take a 10 min run at 40 μA.
- Since this data will be used for the target wall subtraction, no current scan will be performed. We will take data only with 40 μA current.

Table 13: Al dummy target data for target wall subtraction

Target	***I*** **(μA)**	**est. time**	**Done ?**
dummy	40 μA	10 min	
dummy	30 μA	10 min	
dummy	20 μA	10 min	
dummy	10 μA	10 min	

1.5.4 Boiling studies - Beryllium target

- Move target to Beryllium and take one run with each current setting.

Table 14: Boiling Studies - Beryllium Target

Target	***I*** **(μA)**	**est. time**	**Done ?**
Beryllium	70 μA	10 min	
Beryllium	60 μA	10 min	
Beryllium	40 μA	10 min	
Beryllium	30 μA	10 min	
Beryllium	20 μA	10 min	
Beryllium	10 μA	10 min	

1.5.5 Boiling studies - Carbon target

- Move target to Carbon and take one run with each current setting.

Table 15: Boiling Studies - Carbon Target

Target	***I*** **(μA)**	**est. time**	**Done ?**
Carbon	70 μA	10 min	
Carbon	60 μA	10 min	
Carbon	40 μA	10 min	
Carbon	30 μA	10 min	
Carbon	20 μA	10 min	
Carbon	10 μA	10 min	

Total estimated time for section 1.5 including the momentum and target changes: **7 hrs** with 100% efficiency.