A_1^n /d2n ERR Status and Commissioning Run Plan

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- Manpower Update
- ERR overview and status
- 1-pass commissioning runplan

Preparation, Running, and Analysis Manpower Overview

- JLab polarized 3He target lab:
  - currently "run" by Mingyu Chen (UVa), Junhao Chen (W&M), Melanie Rehfuss (Temple)

- 6-8 PhD students (rising year):
- A1n: Mingyu Chen (3rd UVa/Zheng), Melanie Rehfuss (Temple U/Meziani), Michael Berkowitz (Columbia/Hughes); Target: Chris Jantzi (4th UVa/Cates)
- d2n: Junhao Chen (4th W&M/Averett), Shuo Jia (Temple U/Meziani), Murchhana Roy (Kentucky/Korsch)
- 1 TBD (China)

- postdoc: Temple, UVa, W&M, JLab

ERR Status

- ERR on March 18th, 2018
- working on reply to ERR comments, hope to converge before end of year.
- Commissioning Run Plan (1-pass beam)
  - 1-pass running was in the 2010 proposal, and in the beam time request
  - but not yet on the beam schedule,
  - will affect Hall A running (1-pass also).
- Moller Commissioning???

As in 2010 A1n proposal (PAC36 approved A1n for 36 days)

- To check the product of beam and target polarizations $P_b P_t$ and to check the sign of transverse asymmetries, we need 8 hours to measure the longitudinal asymmetry of $\vec{e}-{}^3\vec{\text{He}}$ elastic scattering (including 2 hours of N_2 reference cell runs) and 6 hours to measure the transverse asymmetry of $\Delta(1232)$ production. The beam energy for these two measurements will be 2.2 GeV and both SHMS and HMS will be set at 12.5°;

- optics runs: data will be taken on a multi-foil carbon target with the 2.2 GeV beam to study the optics of the HMS and the SHMS. This will take 8 hours total.

- beam pass change from 2.2 to 11 GeV, 8 hours;

- beam polarization measurements: non-invasive for Compton and 8 hours for 2 Moller measurements (one at each beam energy);

- configuration changes: 10 (angle or momentum) × 0.5 hours + 8 (polarity) = 13 hours;

- target polarization measurements, about 4% of production time (that's 60 minutes per day), or 28 hours.

The total beam time request is 853 hours, or 35.5 days.

1-Pass Commissioning

For large angle running (Fall 2019), the smallest angles of the spectrometers are:
- HMS at 11.7 deg, SHMS at 26 deg; or - SHMS at 8.5 deg, HMS at 26 deg.

Optics: carbon multi foil with δ=-2%,0%,2% (sieve in); repeat single foil – 4.0 PAC hours each for HMS 11.7 deg and SHMS at 8.5 deg → total 8 PAC hours (possibly reduce to 6?)

With SHMS at 8.5 deg for the main calibration measurements; HMS at 26 deg:
7.5 PAC hours – 3He elastic asymmetry (rel 1% PbPt)
5.1 PAC hours – 3He Delta transverse asymmetry (rel 5%)
2.0 PAC hours – N2 pressure curve (5x N2 points)
2.0 PAC hours – BCM, BPM calibrations (can do at 5-pass?)
4.0 PAC hours – Moller measurement for 1 pass

total not including BCM/BPM: 26.6 PAC hours + configuration changes → ? PAC hours

Possibly:
→ pass change day #1 day shift,
→ day #1 swing, day#2 full day, day 3 owl → total 40 cal hours (20 PAC hours)
→ pass change during day #3 day
(if pass change on day #2 daytime, won't have enough time to finish the minimum)

3He Elastic (PbPt) Measurement

For large angle running (Fall 2019), the smallest angles of the spectrometers are:

- HMS at 11.7 deg, SHMS at 26 deg; or
- SHMS at 8.5 deg, SHMS at 26 deg.

3He rate only

Eb (GeV)	theta (deg)	Ep(el) (GeV)	q2(el) (GeV^2)	thStar (deg)	xsec(el) (nbarn/sr)	asym(el) (%phys)	(%raw)	rate(el) (Hz)	time(el) (1%,hrs)	integrated QE xsec (nb/sr)
2.10	11.70	2.0679	0.180	79.85	427.	4.795	2.184	4300.1	1.4	**10205.26**
2.10	8.50	2.0829	0.096	82.60	0.109E+05	2.503	1.140	4500.0*	4.8	**49129.15**
2.10	26.00	1.9522	0.830	68.02	0.193E-01	4.206	1.915	0.1	68136.8	
4.20	11.70	4.0734	0.711	75.66	0.202	0.224	0.102	2.0	*******	
4.20	8.50	4.1321	0.381	79.49	2.15	5.711	2.601	21.7	189.5	
4.20	26.00	3.6478	3.101	60.05	0.279E-07	-24.289	-11.061	0.0	*******	

* limited by DAQ

SHMS at 8.5 deg → DAQ limited, if 2/3 from gas and further 1/3 from elastic → 7.5 hours for a 1% measurement

Delta Transverse Asymmetry

3He rate only

Eb (GeV)	th (deg)	Ep(del) (GeV)	dEp (GeV)	xsec(del) (nbarn/sr/GeV)	asym(del) (%raw)	(%meas)	rate(del) (Hz)	time(del) (5%,hrs)
2.10	11.70	1.6821	0.1468	0.254E+05	1.71	0.78	2570.07	0.72
2.10	8.50	1.7181	0.0793	0.725E+05	1.18	0.54	4500.00	0.86
2.10	26.00	1.4352	0.6101	602.	5.34	2.43	29.62	6.34
4.20	11.70	3.5318	0.6164	0.323E+04	5.39	2.46	313.23	0.59
4.20	8.50	3.6794	0.3395	0.197E+05	3.22	1.47	1992.13	0.26
4.20	26.00	2.6567	2.2586	10.9	18.28	8.32	0.45	35.42

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(+/-0.02 GeV cut on W)

estimated by interpolating in Q2 from prev data

SHMS at 8.5 deg → DAQ limited, if 2/3 from gas and further 1/4 from delta → 5.1 hours for a 5% measurement

or use HMS at 11.7 deg if SHMS cannot do 1.72 GeV/c
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N2 pressure curve measurement

We need N2 ref cell run at 2-atm steps for 5 points:

again only N2 rate

	Eb (GeV)	th (deg)	Ep(el) (GeV)	xsec(el) (nbarn/sr)	rate(el) (2amg,Hz)	time(el) (1M, hrs)	time(5pnts) (hrs)
N3-el	**2.10**	**11.70**	**2.0930**	**168.**	**676.4**	**0.41**	**2.3**
	2.10	**8.50**	**2.0963**	**0.182E+04**	**7335.0**	**0.04**	**----**
	2.10	26.00	2.0663	0.433E-09	0.0	**********	
	4.20	11.70	4.1721	0.760E-06	0.0	**********	
	4.20	8.50	4.1852	0.580	2.3	118.84	271.36
	4.20	26.00	4.0674	0.00	0.0	Inf	Inf

Assuming 1/5 of events are from N2 elastic (not QE or from glass windows) → 20 minutes per point → 100 min or 1.7 hours for all 5 points

QE 3He Calculations (PWIA)

2.1 GeV, 11.7 deg

omega (GeV)	sigqe (nb/sr/MeV)	Q2 (GeV2)	thStar (deg)	Apar (%)	Aperp (%)
0.05000	0.2903E+01	0.1991E+00	77.75	0.428	-2.559
0.06000	0.1192E+02	0.1992E+00	76.47	0.305	-0.728
0.07000	0.3103E+02	0.1996E+00	75.18	0.333	0.133
0.08000	0.6278E+02	0.2002E+00	73.90	0.430	0.592
0.09000	0.1038E+03	0.2010E+00	72.63	0.516	0.856
0.10000	0.1389E+03	0.2020E+00	71.36	0.508	1.044
0.11000	0.1492E+03	0.2032E+00	70.10	0.343	1.222
0.12000	0.1329E+03	0.2046E+00	68.85	0.038	1.393
0.13000	0.1048E+03	0.2061E+00	67.60	-0.347	1.536
0.14000	0.7731E+02	0.2079E+00	66.37	-0.731	1.623
0.15000	0.5543E+02	0.2099E+00	65.14	-1.068	1.648
0.16000	0.3957E+02	0.2121E+00	63.93	-1.381	1.628
0.17000	0.2832E+02	0.2145E+00	62.73	-1.624	1.557
0.18000	0.2058E+02	0.2171E+00	61.55	-1.860	1.459
0.19000	0.1496E+02	0.2199E+00	60.38	-1.927	1.306
0.20000	0.1108E+02	0.2228E+00	59.22	-1.983	1.139
0.21000	0.8331E+01	0.2260E+00	58.08	-1.972	0.953
0.22000	0.6372E+01	0.2294E+00	56.96	-1.914	0.758
0.23000	0.4925E+01	0.2330E+00	55.86	-1.746	0.554
0.24000	0.3855E+01	0.2368E+00	54.77	-1.486	0.350

total qe xsec= 10205.26 nb/sr

2.1 GeV, 8.5 deg

omega (GeV)	sigqe (nb/sr/MeV)	Q2 (GeV2)	thStar (deg)	Apar (%)	Aperp (%)
0.03000	0.7452E+02	0.1058E+00	80.47	0.699	-0.903
0.04000	0.3368E+03	0.1060E+00	78.71	0.435	0.026
0.05000	0.7208E+03	0.1064E+00	76.96	0.425	0.328
0.06000	0.9455E+03	0.1070E+00	75.21	0.328	0.504
0.07000	0.8481E+03	0.1078E+00	73.48	0.088	0.645
0.08000	0.6150E+03	0.1089E+00	71.76	-0.217	0.744
0.09000	0.4098E+03	0.1101E+00	70.05	-0.503	0.790
0.10000	0.2672E+03	0.1115E+00	68.37	-0.733	0.786
0.11000	0.1754E+03	0.1131E+00	66.71	-0.913	0.748
0.12000	0.1171E+03	0.1149E+00	65.08	-1.053	0.686
0.13000	0.7999E+02	0.1169E+00	63.47	-1.156	0.604
0.14000	0.5544E+02	0.1192E+00	61.89	-1.173	0.510
0.15000	0.3945E+02	0.1216E+00	60.35	-1.158	0.410
0.16000	0.2870E+02	0.1242E+00	58.83	-1.095	0.309
0.17000	0.2134E+02	0.1270E+00	57.35	-0.987	0.213
0.18000	0.1618E+02	0.1300E+00	55.90	-0.807	0.131
0.19000	0.1258E+02	0.1332E+00	54.48	-0.613	0.060

total qe xsec= 49129.15 nb/sr

2.1 GeV, 26 deg – the other spectrometer can take data here

omega (GeV)	sigqe (nb/sr/MeV)	Q2 (GeV2)	thStar (deg)	Apar (%)	Aperp (%)	rate in bin (Hz)
0.17000	0.1806E-04	0.9329E+00	67.13	13.897	24.893	0.02
0.18000	0.6001E-04	0.9319E+00	66.53	11.672	27.770	0.00
0.19000	0.1161E-03	0.9312E+00	65.94	10.289	28.206	0.01
0.20000	0.1956E-03	0.9306E+00	65.35	8.946	26.517	0.01
0.21000	0.3230E-03	0.9303E+00	64.75	7.432	22.163	0.02
0.22000	0.5447E-03	0.9301E+00	64.16	5.927	16.428	0.03
0.23000	0.9352E-03	0.9302E+00	63.56	4.705	10.880	0.05
0.24000	0.1615E-02	0.9304E+00	62.97	3.767	6.155	0.09
0.25000	0.2725E-02	0.9308E+00	62.38	2.998	2.762	0.16
0.26000	0.4447E-02	0.9315E+00	61.78	2.384	0.533	0.26
0.27000	0.7101E-02	0.9323E+00	61.19	1.852	-0.708	0.41
0.28000	0.1108E-01	0.9334E+00	60.60	1.348	-1.110	0.64
0.29000	0.1696E-01	0.9346E+00	60.01	0.904	-0.943	0.98
0.30000	0.2560E-01	0.9361E+00	59.41	0.499	-0.383	1.47
0.31000	0.3797E-01	0.9377E+00	58.82	0.127	0.386	2.18
0.32000	0.5550E-01	0.9396E+00	58.24	-0.185	1.215	3.19
0.33000	0.7984E-01	0.9416E+00	57.65	-0.447	2.023	4.59
0.34000	0.1130E+00	0.9439E+00	57.06	-0.646	2.748	6.49
0.35000	0.1571E+00	0.9463E+00	56.48	-0.776	3.356	9.03
0.36000	0.2140E+00	0.9490E+00	55.89	-0.844	3.843	12.30
0.37000	0.2851E+00	0.9518E+00	55.31	-0.848	4.207	16.39
0.38000	0.3693E+00	0.9549E+00	54.73	-0.805	4.465	21.22
0.39000	0.4624E+00	0.9581E+00	54.16	-0.748	4.647	26.58
0.40000	0.5555E+00	0.9616E+00	53.58	-0.711	4.781	31.93

Next step:

- calculate Glass window contributions

- run full simulation to include all target material, choose momentum setting to minimize QE contribution to 3He elastic, 3He Delta, and N2 elastic runs

- include 3He ref cell elastic runs (pressure curve) if possible.

Backup Slides

A_1^n / d_2^n Timeline Overview

A1n/d2n Timeline

month	year	Installation	Beamline			Target cell production	JLab Target Lab	UVa Target Lab	W&M Target Lab
4	2018	install cables, optical fiber, complete platform fabrication				5 cells order placed	(1) Making things to work for Hall C; (2) polarimetry; (3) density measurement; (4) full characterizatio n of new cells	(1) Fabricate/ fill and initial testing of new cells; (2) EPR k0 study	(1) Making reference cell system; (2) EPR k0 study; [(3) testing new cells if needed]
5			Moller prep (DG)	Beamline mod. for target	fast circular raster (MJ+MB)				
6									
7									
8									
9						order 5 more cells			
10			Moller test-out (DG)						
11									
12									
1	2019								
2									
3		prepare to install						Testing new cells if needed	(testing new cells if needed)
4									
5									
6		Target installation					move to Hall		
7									
8									
9									
10		Running: A1n 30 deg							
11									
12									
1	2020	Target rotation							
2		Running: d2n + A1n 12.5 deg							
3									
4									

As in 2010 A1n proposal (PAC36 approved A1n for 36 days)

(In addition to production 3He running)

Additional beam time include:

- Commissioning of the spectrometers, the beamline and the Compton polarimeter. Assuming this is not the first experiment in Hall C to use the newly-installed polarized ^{3}He target, the commissioning will likely take 4 calendar days (or 3 PAC days). The commissioning time will be longer if we also need to commission the target.

- To check the dilution factor due to unpolarized material in the target, we need to measure the nitrogen cross section using reference cells filled with nitrogen: 2 hours at the HMS (SHMS) kinematics 1 (A), 2 (A), and 4 hours at kinematics B, 3 (C) and 4 (C). This requires a total of 16 hours for DIS production settings; For resonance kinematics we request a total of 2 hours for the nitrogen measurement.

As in 2010 A1n proposal (PAC36 approved A1n for 36 days)

of beam and target polarizations $P_b P_t$ to a 0.5% (statistical) level and to check the sign of transverse asymmetries. The kinematics stay the same as the original proposal, only rates and the beam time are different.

Table 3: Kinematics for elastic longitudinal and $\Delta(1232)$ transverse asymmetries. The HMS and SHMS will have the same momentum and angle settings.

Kine	E_b GeV	E_p GeV	θ (°)	elastic x-sec (nb/sr)	elastic rate (Hz)	Asymmetry	Time (hours)
Elastic	2.200	2.160	12.5	106.986	2840.3	$A_{\parallel} = 0.0589$	5.1
$\Delta(1232)$	2.200	1.815	12.5	-	-	$A_{\perp} \sim$ a few %	6

Total Beam Time Allocation (ERR)

- Run-group A1n/d2n commissioning of the beamline, target, and spectrometers: 3 PAC days or 72 PAC hours (not including initial Moller commissioning)
- 1-pass elastic PbPt and Δ transverse asymmetries: 14 PAC hours (incl N2 runs);
- optics: 8 PAC hours;
- Moller: at least 3 measurements at 11 GeV (10 PAC hrs), one at 2.2 GeV (6 PAC hrs).
- beam pass change from 2.2 to 11 GeV: 8 PAC hours
- Production: DIS 636 PAC hours, RES 48 PAC hours (2-arms equivalent)
- Reference cell runs (N_2, ^3He, H_2 and empty): 12 PAC hours (2hr each at kine#1 and #2 or #A and #D, 4hr each at #3 and #4 or #B and #C)
- Configuration changes: 12x0.5 PAC hrs (angle or momentum or target spin directions), 8 PAC hrs polarity, 14 PAC hours total
- Target polarization measurements: 4% of production, 28 PAC hours total
- Total beam time: **36 PAC days**

A_1^n Kinematics and Production Beam Time (updated)

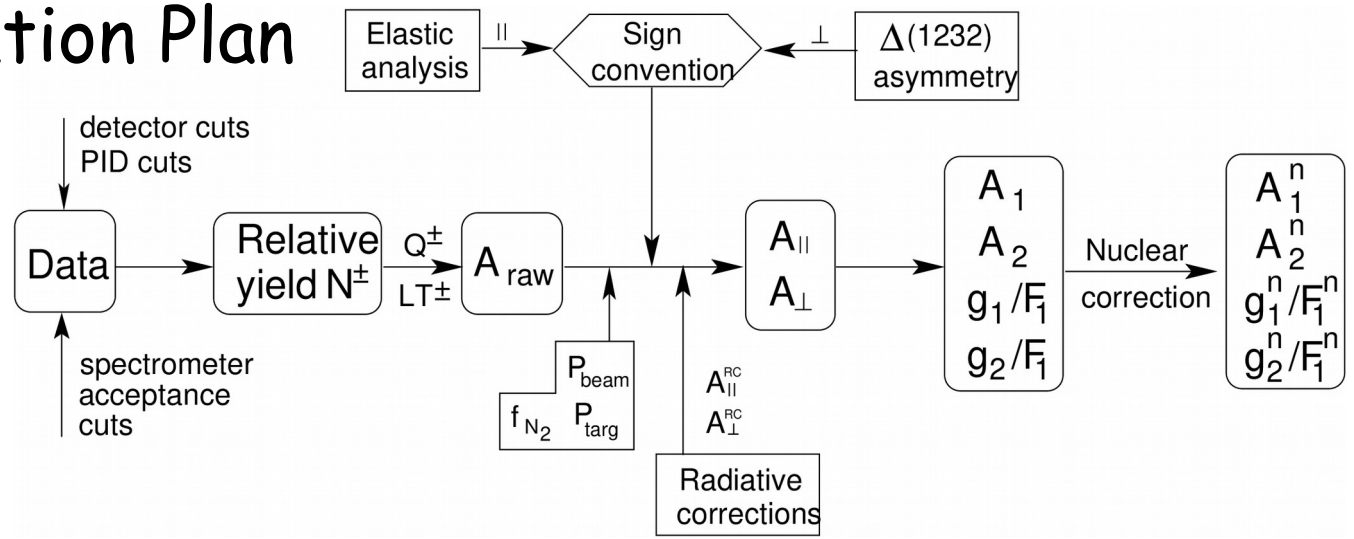
- Ebeam;
- same beam time for HMS vs. SHMS for the large angle running
- p0 setting optimized using latest simulations
- Elastic/Delta (not shown here): Ebeam=2.05 GeV, no other change

Kine	E_b (GeV)		θ (°)	E_p (GeV)	e^- production (hours)	e^+ prod. (hours)	Tot. Time (hours)
DIS							
1	11.0	HMS	12.5	5.70	12	0	12
2	11.0	HMS	12.5	6.80	24	0	24
3	11.0	HMS	30.0	2.82	96	0	96
4	11.0	HMS	30.0	3.50	551	1	552
A	11.0	SHMS	12.5	5.80	36	0	36
B	11.0	SHMS	30.0	3.00	464	0	464
C	11.0	SHMS	30.0	2.25	88	0	88
Resonances							
D	11.0	SHMS	12.5	7.50	96	0	96

Kine	Ebeam (GeV)	Spec	p0	θ0	e- production time (hours)	e+ (hours)
1	10.5	HMS	5.7	12.5	12.0	0.0
2	10.5	HMS	6.8	12.5	24.0	0.0
3	10.5	HMS	2.9	30.0	88.0	1.0
4	10.5	HMS	3.5	30.0	511.0	1.0
A	10.5	SHMS	5.8	12.5	36.0	0.0
B	10.5	SHMS	3.4	30.0	511.0	0.0
C	10.5	SHMS	2.4	30.0	88.0	0.0
D	10.5	SHMS	7.5	12.5	96.0	0.9

Analysis and Publication Plan

- online scripts for PID, counting electrons and forming asymmetry
- Preliminary asymmetries expected within 1 month from end of run;



period	student #1	student #2	student #3
months 1-2	making good prod. run list	making good prod. run list	detector calib., fiducial cuts and efficiencies
months 3-4	optics calibration	detector PID cuts and efficiencies	target polarimetry analysis
by month 6	optics calibration / simulation	elastic and Delta analysis	target polarimetry analysis
by month 12	dilution and density/ relative cross sections	forming asymmetries – data set 1/2	forming asymmetries – data set 2/2
by month 18	radiative corrections	nuclear correction + finalizing systematics	nuclear correction + finalizing systematics

- draft publication (short) within 18 months of end of run → another 12 months to write the long archival paper

A1n Running Conditions (ERR)

- First experiment to require polarized beam in Hall C after the upgrade: 85% requested, (minimum 80%), measured to 2%; transverse beam polarization < 1% desired.
- Beam size no larger than 300μm in σ, 200μm in σ desired.
- 11 GeV (min 10.5 GeV), 30 μA, beam trip goal: (6-10) per hour or less
- circular rastering of beam spot to a radius of 2.5 mm and "no hot spot", current ramping at (0.5-1.0) μA/sec on polarized target cell;
- changing beam IHWP status every 12 hours or at least half-way of each kinematics;
- beam charge asymmetry controlled to under 200ppm (average over each run);

- First time to use polarized 3He target in Hall C: Stage-I target upgrade: 12amg, 40cm, 30uA, Pt=(55-60)%; 3% polarimetry
- Both longitudinal and transverse spin configurations; spin direction known to ±0.5 degree desired and ±1.0 degree required; density known to 3% (2% from fill density and 2% from operating temperature).

- Q^2 known to 1% desired (Ebeam at the ±1E-3 level; spectrometer momentum to ±1E-3, angle to ±0.06 deg).
- PID performance: pion rejection > 10,000 desired by combining calorimeter and Cherenkov, > 5000 required, while keeping electron efficiency at 99% (desired) or 95% (min) each (worst case at SHMS momentum 2.25 GeV/c and HMS 2.82 GeV/c).

Even Earlier Slides

A_1^n Kinematics and Production Beam Time (previous)

Kine	E_b (GeV)		θ (°)	E_p (GeV)	e^- production (hours)	e^+ prod. (hours)	Tot. Time (hours)
DIS							
1	11.0	HMS	12.5	5.70	12	0	12
2	11.0	HMS	12.5	6.80	24	0	24
3	11.0	HMS	30.0	2.82	96	0	96
4	11.0	HMS	30.0	3.50	551	1	552
A	11.0	SHMS	12.5	5.80	36	0	36
B	11.0	SHMS	30.0	3.00	464	0	464
C	11.0	SHMS	30.0	2.25	88	0	88
Resonances							
D	11.0	SHMS	12.5	7.50	96	0	96

both $A_\parallel$ and $A_\perp$

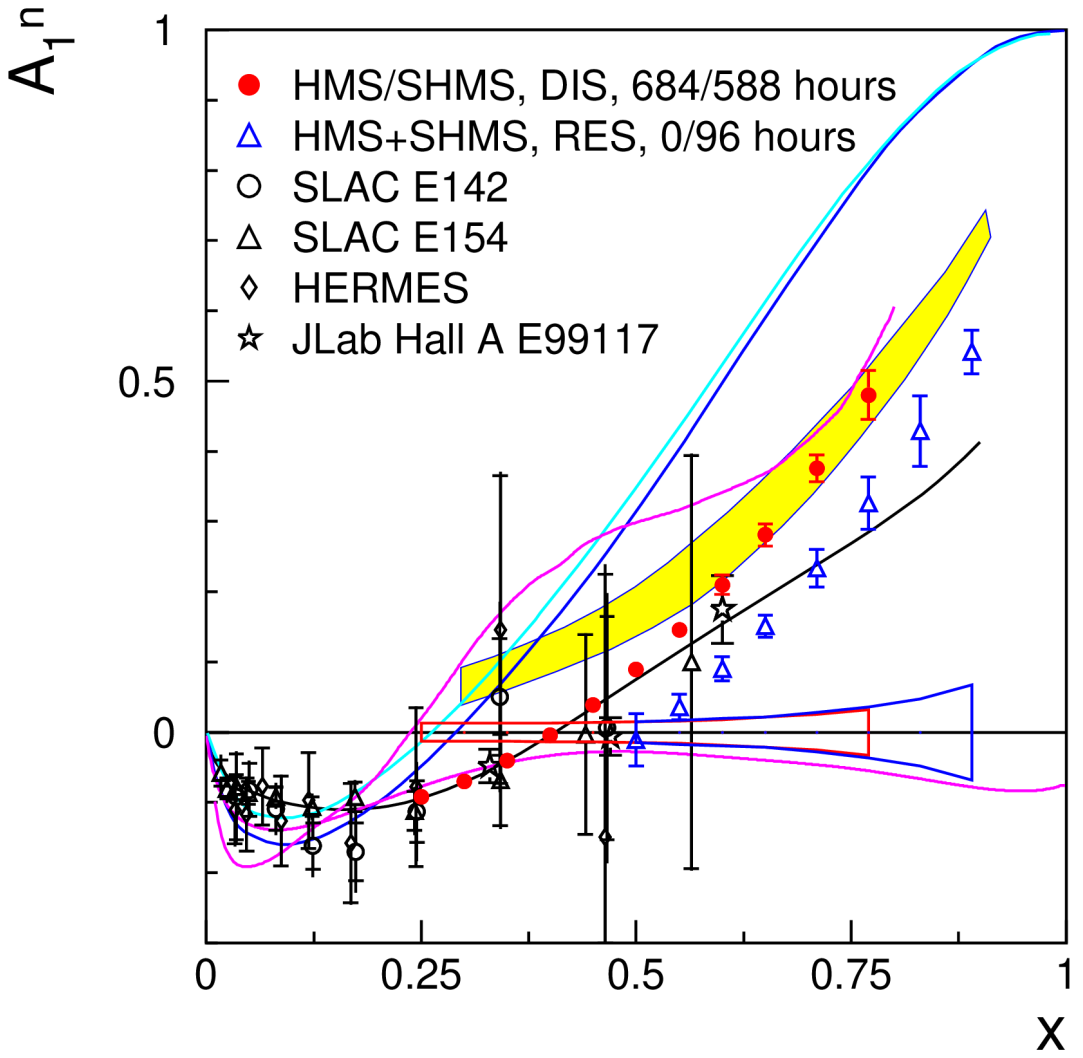
Kine	E_b GeV	E_p GeV	θ (°)	elastic x-sec (nb/sr)	elastic rate (Hz)	Asymmetry	Time (hours)
Elastic	2.200	2.160	12.5	106.986	1293.9	$A_\parallel = 0.0589$	11.2
$\Delta(1232)$	2.200	1.815	12.5	-	-	$A_\perp \sim$ a few %	6

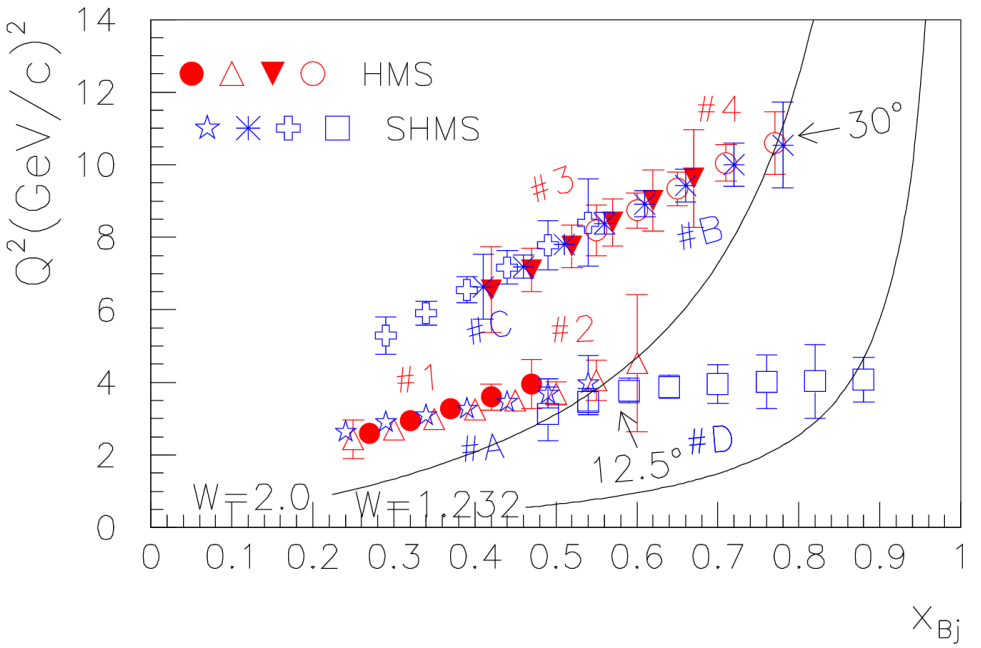
$A_\parallel$

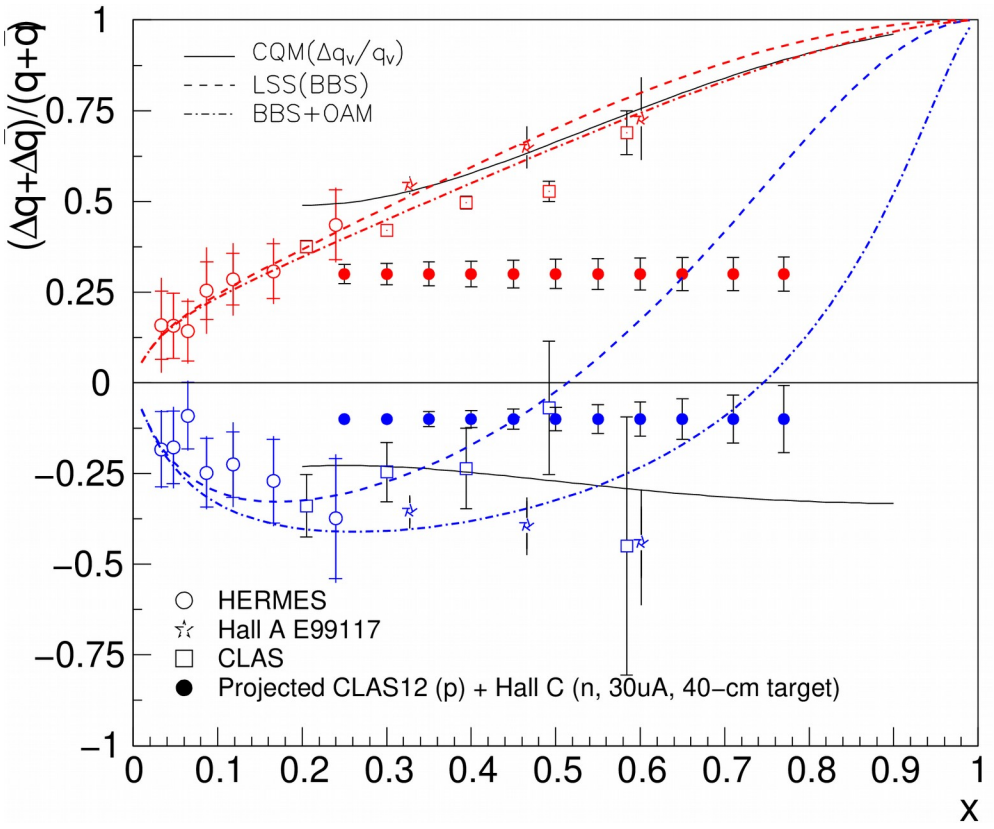
$A_\perp$

A_1^n Kinematics and Expected Results (approved 36 days)

30uA, 85% beam, 40cm, 60% target







A_1^n Uncertainties (ERR)

Table 3: Projected statistical and systematic uncertainties for DIS data at different x and Q^2. As a comparison, the 6 GeV result at $x = 0.61$ was $A_1^n = +0.175 \pm 0.048(\text{stat.})^{+0.026}_{-0.028}(\text{syst.})$. And the 2010 proposed values are $\Delta A_1^n(\text{stat.}) = 0.0288$ and $\Delta A_1^n(\text{total}) = 0.0446$.

x	ΔA_1^n(stat.) low Q^2	ΔA_1^n(stat.) high Q^2	ΔA_1^n(stat.) two Q^2 combined	ΔA_1^n(syst.)	ΔA_1^n(total)
0.25	0.0034	–	0.0034	0.0131	0.0135
0.30	0.0037	–	0.0037	0.0130	0.0135
0.35	0.0048	0.0157	0.0046	0.0129	0.0137
0.40	0.0062	0.0159	0.0058	0.0134	0.0146
0.45	0.0085	0.0123	0.0070	0.0138	0.0154
0.50	0.0124	0.0112	0.0083	0.0146	0.0168
0.55	–	0.0122	0.0107	0.0159	0.0192
0.60	–	0.0135	0.0134	0.0180	0.0224
0.65	–	0.0157	0.0157	0.0217	0.0268
0.71	–	0.0189	0.0189	0.0254	0.0316
0.77	–	0.0346	0.0346	0.0325	0.0475

Table 4: Projected statistical and systematic uncertainties for resonance data at different x and Q^2. Resonance data will be taken at a scattering angle of 12.5° (same as the low Q^2 DIS data). The DIS fit for A_1 was used in the systematic uncertainty study.

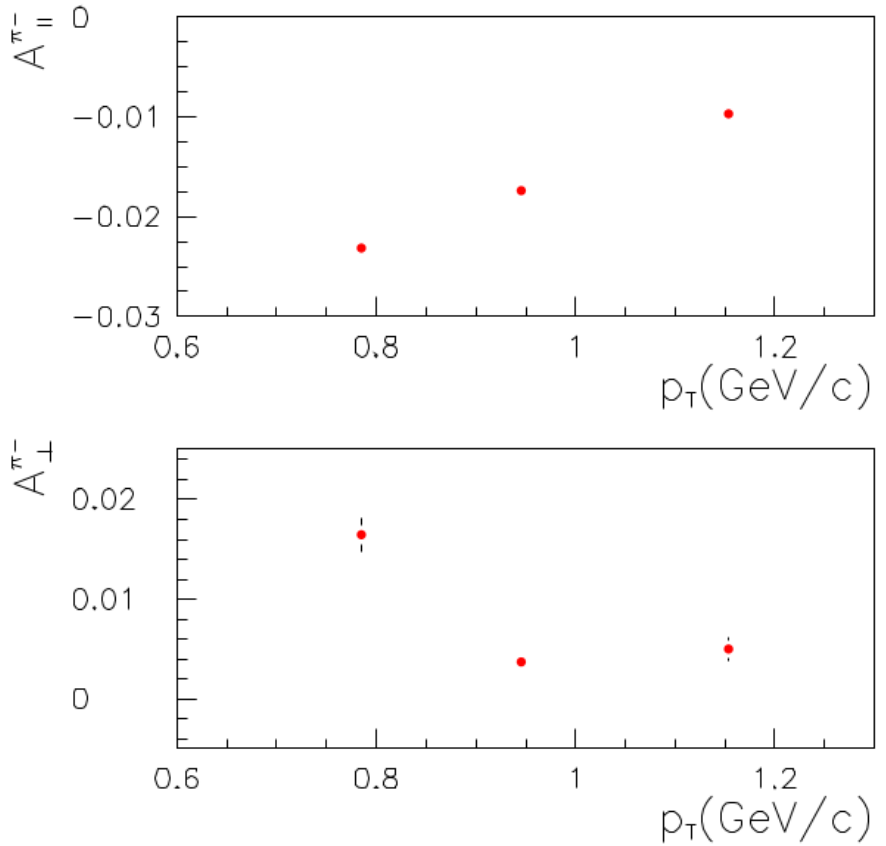
x	ΔA_1^n(stat.)	ΔA_1^n(syst.)	ΔA_1^n(total)
0.55	0.0180	0.0171	0.0249
0.60	0.0171	0.0198	0.0261
0.65	0.0158	0.0215	0.0266
0.71	0.0269	0.0279	0.0388
0.77	0.0371	0.0362	0.0518
0.83	0.0505	0.0476	0.0694
0.89	0.0310	0.0678	0.0746

Size of Measured Asymmetries from 6 GeV

Table 6.1: ^{3}He results – $A_{\parallel}^{^3\mathrm{He}}$ and $A_{\perp}^{^3\mathrm{He}}$.

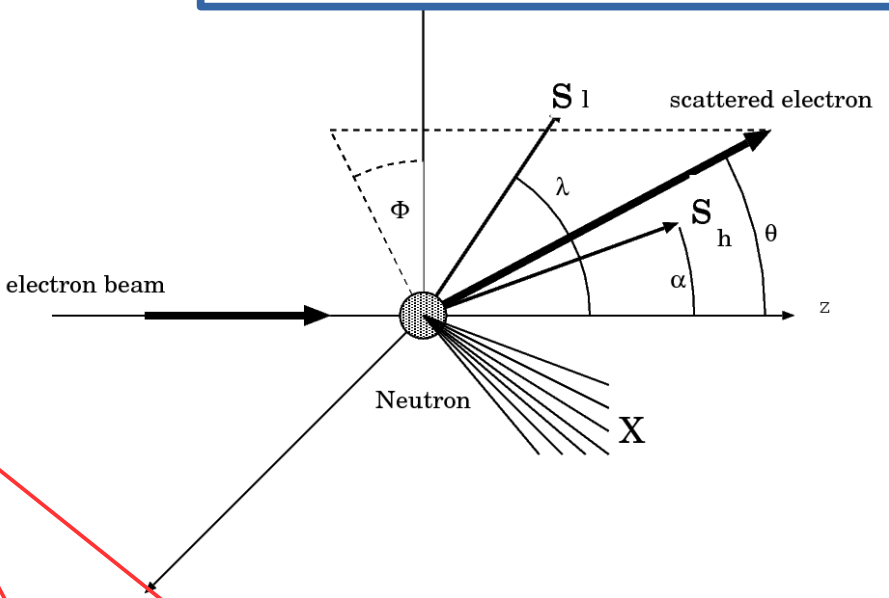
x	Q^2	$A_{\parallel}^{^3\mathrm{He}} \pm \mathrm{stat.} \pm \mathrm{sys.}$	$A_{\perp}^{^3\mathrm{He}} \pm \mathrm{stat.} \pm \mathrm{sys.}$
0.327	2.709	$-0.01397 \pm 0.00475 \pm 0.00071$	$-0.00216 \pm 0.00955 \pm 0.00011$
0.466	3.516	$-0.00722 \pm 0.00449 \pm 0.00036$	$0.01359 \pm 0.00790 \pm 0.00069$
0.601	4.833	$0.01036 \pm 0.00739 \pm 0.00052$	$-0.01173 \pm 0.01550 \pm 0.00059$

Figure 6-10: Pion asymmetry A^{π^-} results.



Beam Transverse Polarization

ref: E94010 tech note #6



transverse beam spin is suppressed by γ_e

$$A_{\parallel}^{Jlab} = \frac{\frac{d^2\sigma}{d\Omega dE'}^{\swarrow\Uparrow} - \frac{d^2\sigma}{d\Omega dE'}^{\nearrow\Uparrow}}{\frac{d^2\sigma}{d\Omega dE'}^{\swarrow\Uparrow} + \frac{d^2\sigma}{d\Omega dE'}^{\nearrow\Uparrow}} = \frac{g_1[(2xy - \frac{Q^2(\nu+\frac{Q^2}{2E})}{2ME^2})\cos\lambda + \frac{E'\sin\theta(\nu+\frac{Q^2}{2E})}{ME}\frac{\sin\lambda}{\gamma_e}] - g_2\frac{xQ^2}{E^2}\cos\lambda}{xy^2F_1 + (1 - y - \frac{y^2\gamma^2}{4})F_2}$$

and the transverse asymmetry :

$$A_{\perp}^{Jlab} = \frac{\frac{d^2\sigma}{d\Omega dE'}^{\swarrow\Leftarrow} - \frac{d^2\sigma}{d\Omega dE'}^{\nearrow\Leftarrow}}{\frac{d^2\sigma}{d\Omega dE'}^{\swarrow\Leftarrow} + \frac{d^2\sigma}{d\Omega dE'}^{\nearrow\Leftarrow}} = \frac{g_1[(2xy - \frac{E'^2\sin\theta^2}{ME})\frac{\sin\lambda}{\gamma_e} + \frac{Q^2E'\sin\theta}{2ME^2}\cos\lambda] + g_2[2xy\frac{\sin\lambda}{\gamma_e} + \cos\lambda\frac{2xE'\sin\theta}{E}]}{xy^2F_1 + (1 - y - \frac{y^2\gamma^2}{4})F_2}$$

Requirement on target angle

A1n analysis is dominated by $A_{||}$, which is less sensitive to the target field angle than Aperp:

$$\left(\frac{\Delta\sigma_{pol}}{\sigma_{pol}}\right)_{\alpha=0+\delta\alpha}=(\delta\alpha)\frac{E'\sin\theta}{\frac{g_1}{g_2}\left(yE+\frac{1}{2xM}\left[\nu-\left(E-E'\cos\theta\right)\right]\left(E-E'\cos\theta\right)\right)+\left[yE-\left(E-E'\cos\theta\right)\right]}$$

$$\left(\frac{\Delta\sigma_{pol}}{\sigma_{pol}}\right)_{\alpha=\frac{\pi}{2}+\delta\alpha}=(\delta\alpha)\frac{\frac{g_1}{g_2}\left(2xyE-\frac{1}{M}\left[\nu-\left(E-E'\cos\theta\right)\right]\left(E-E'\cos\theta\right)\right)+2xyE-2x\left(E-E'\cos\theta\right)}{2xE'\sin\theta}$$

Requirement on Q^2

- dilution – relative cross sections
- kinematic variables used to extract $A_{1,2}$ from measured asymmetries
- $F_{1,2}$ (p, n, 3He) used in nuclear corrections
- A_1^p, PDF (d/u) used in extracting $\Delta q/q$