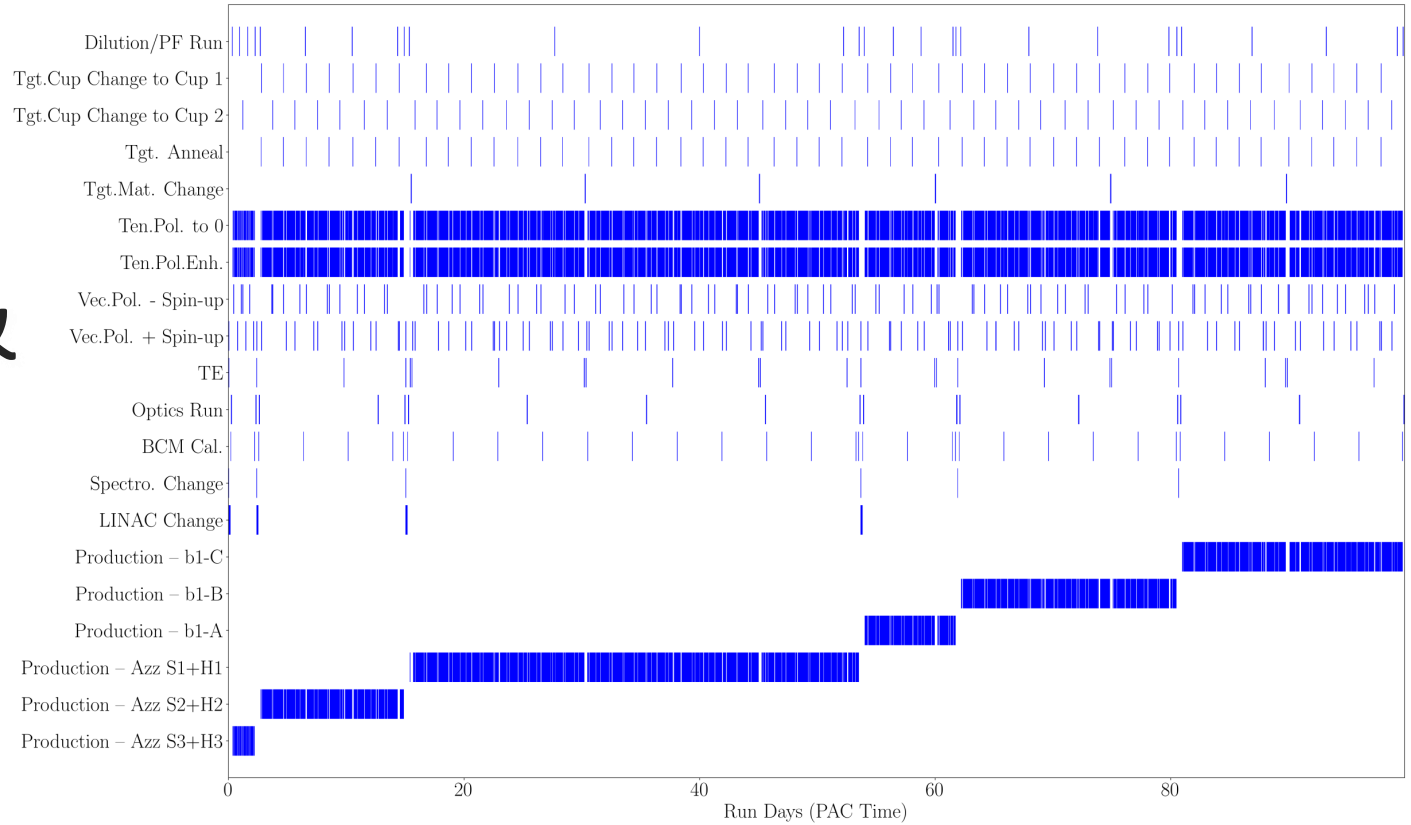
ERR Task List & Run Plan



Elena Long

b1/Azz Tensor Collaboration Meeting

Oct. 13th, 2025

University of New Hampshire

ERR Task List

3 Main Topics:

- Target Tasks
- Beamline Tasks
- Documentation Tasks

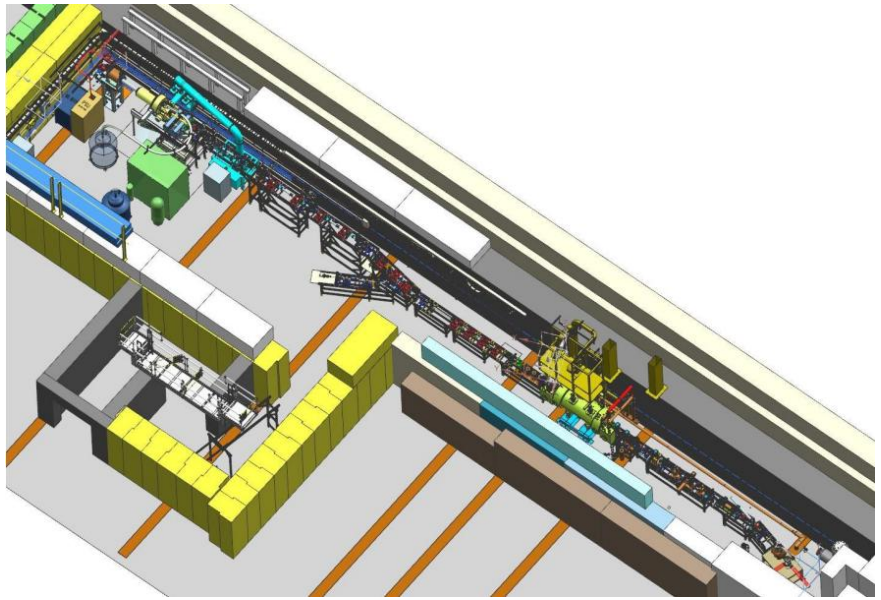
+ any additional tasks recommended from this morning's talks

Target Tasks

Target Tasks
◦ Maximize ND_3 vector polarization

In Progress

- The JLab Target Group is building a new test lab facility to irradiate ND3
  - Irradiation optimization studies with both dose & irrad. Temperature
- Cryostat being built
- Beamline needs shielding for 10uA @ 8 MeV operation
- Aiming for irradiation operations in Spring ‘26



Irradiation

13:50 10/13 **Update on the Irradiation of Materials**
Speaker: Chris Keith (Jefferson Lab)

11:20 10/14 **Modeling the 2 paramegnetic centers in ND3**
Speaker: Sujan Subedi (University of Virginia)

Target Material

11:00 10/13 **UVA Target Group Status and Goals**
Speaker: Jordan Roberts (University of Virginia)

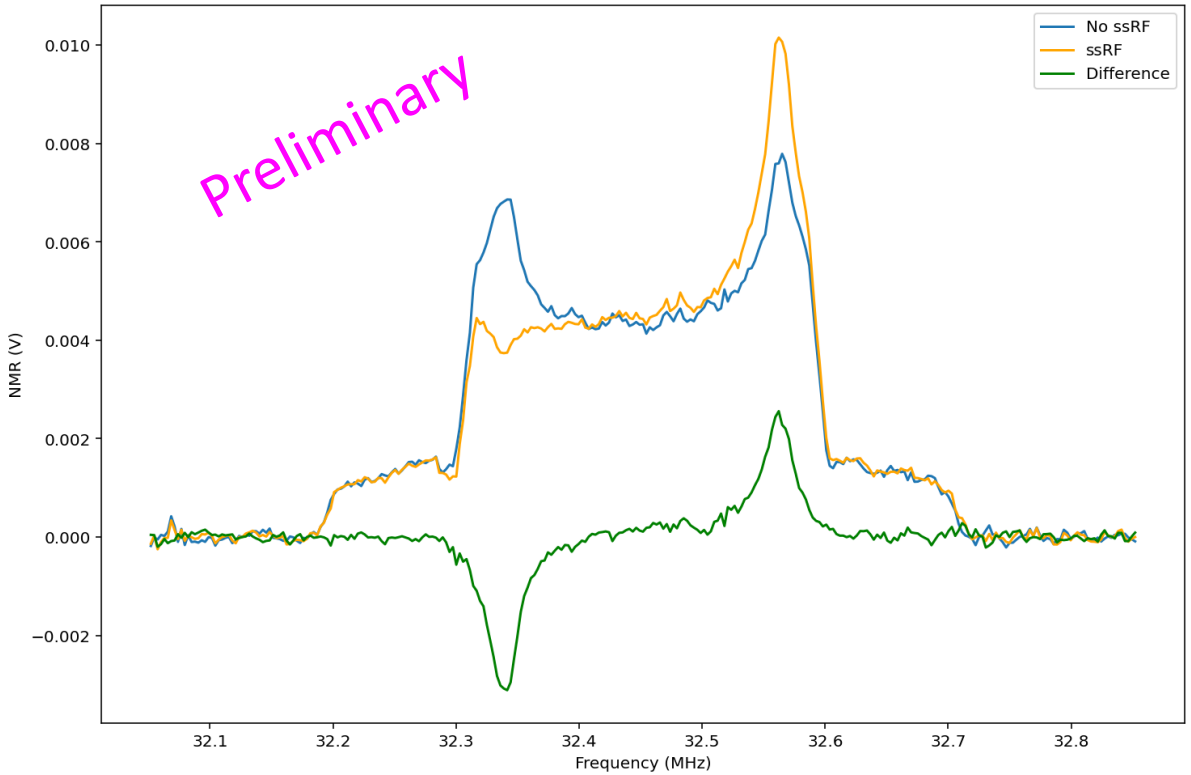
12:05 10/14 **Material Preparation**
Speaker: Eli Phippard (University of New Hampshire)

Target Tasks

In Progress

◦ Demonstrate Tensor Enhancement on ND_3

- Initial studies have been done on warm irradiated ND_3
  - Compared w/ d-butanol, ssRF is sharper & lasts significantly longer
  - Low vector pol. due to 84K irrad
- Cold (1-4K) irradiated ND_3 needed



10:45
10/13

UNH Target Group Status and Goals

Speaker: Karl Slifer (University of New Hampshire)

17:00
10/13

SSRF decay rates, CAA Quasi-elastic analysis

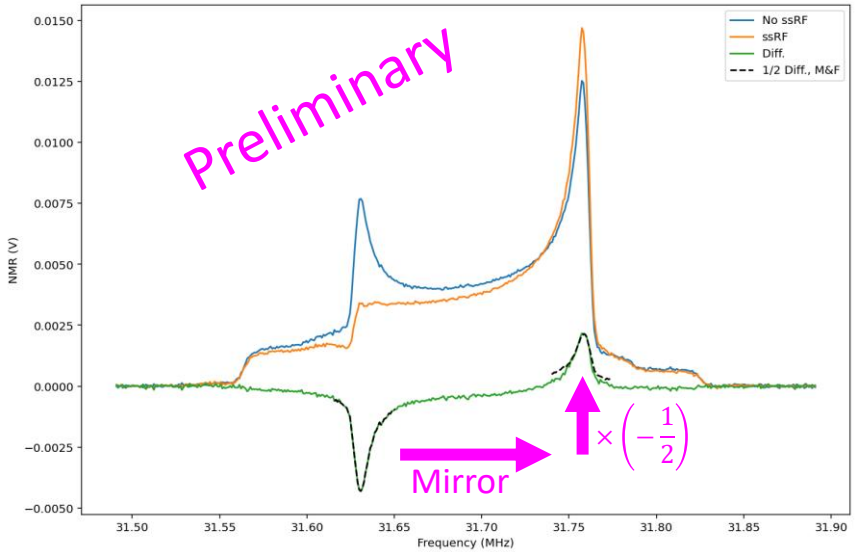
Speaker: Chhetra Lama (University of New Hampshire)

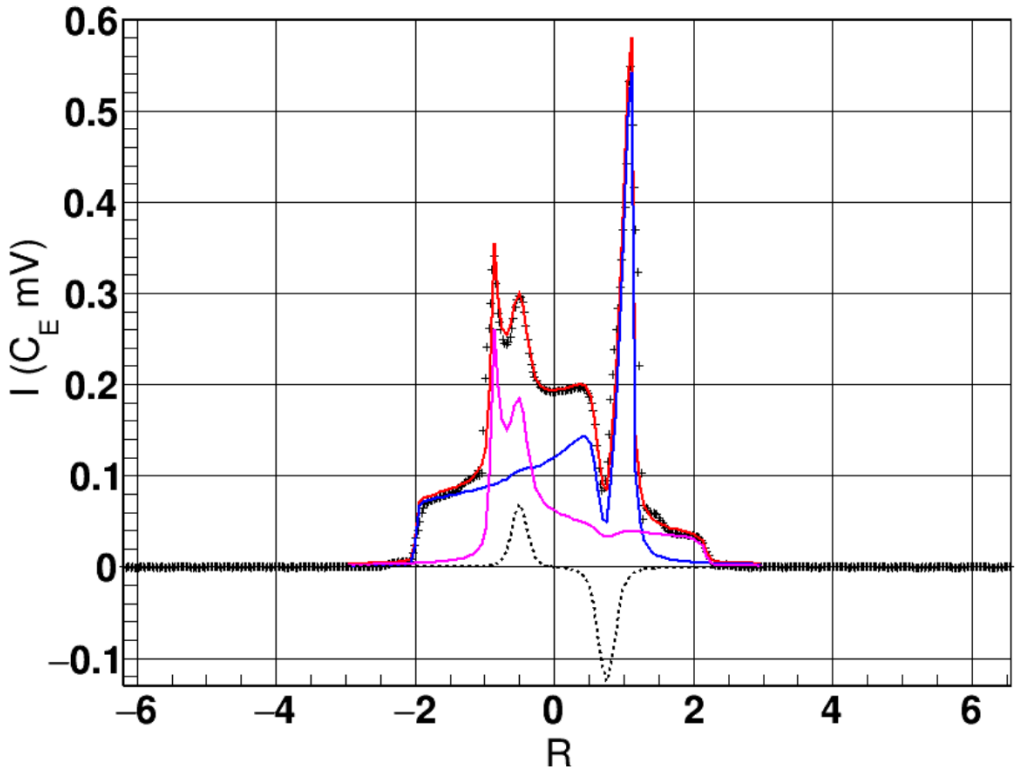
Target Tasks

Complete

◦ Demonstrate $A_{lost} = 2\,A_{gained}$ w/ ssRF

- UVA published results
  - D. Keller, EPJ A **53**, 155 (2017)
  - J. Clements, D. Keller, NIM A **1050**, 168177 (2023)
- UNH results in agreement

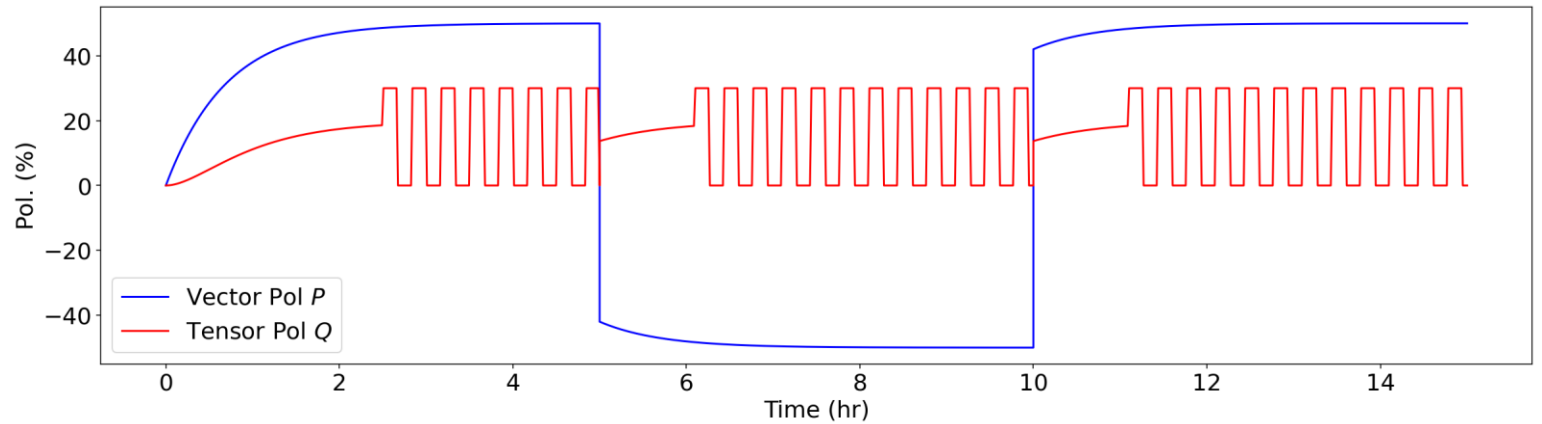




Target Tasks

In Progress

- Demonstrate full polarization cycles (*P* & *Q*)
  - Goal is to create the following plot w/ data:



  - Currently working on optimizing & automating ssRF application/measurement cycles + AFP

UVA

16:00 10/13 **Hardware (AFP, SSRF)**
Speaker: Md Forhad Hossain (University of Vi

16:15 10/13 **AI NMR extraction for Spin 1 signal**
Speaker: Devin Seay (University of Virginia)

11:05 10/14 **Rate Equations**
Speaker: Ian Cruz (University of Virginia)

11:50 10/14 **A model for T1 extraction**
Speaker: Shane Clements (University of Virginia)

UNH

16:30 10/13 **Fully Complex NMR Lineshape Analysis**
Speaker: Michael McClellan (University of New Hampshire)

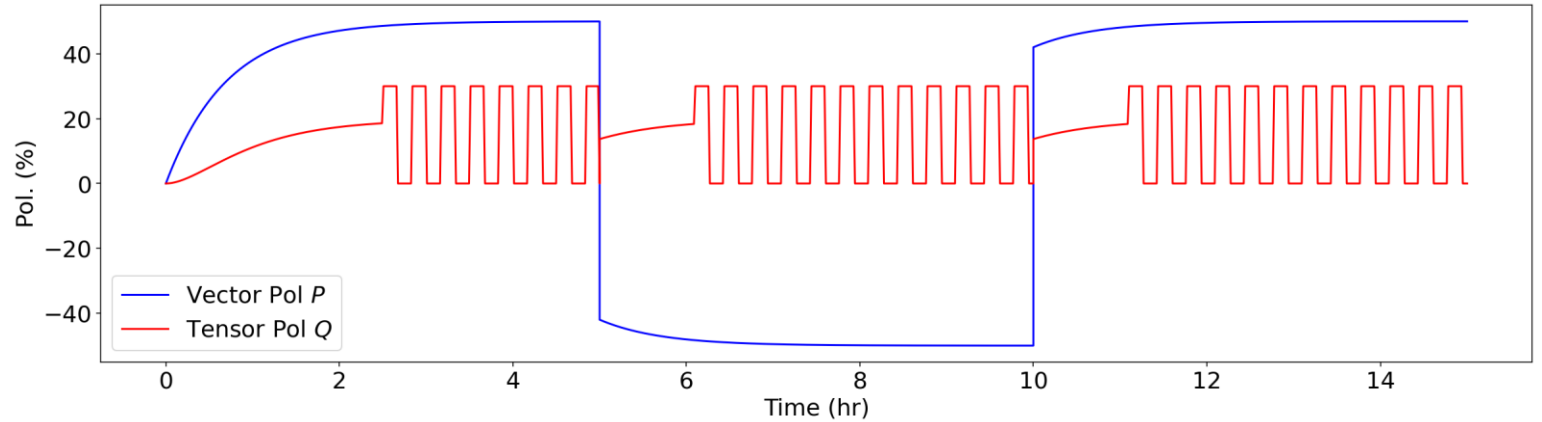
17:00 10/13 **SSRF decay rates, CAA Quasi-elastic analysis**
Speaker: Chhetra Lama (University of New Hampshire)

Target Tasks

In Progress

◦ Design & Optimization of AFP and ssRF

- Goal is to create the following plot w/ data:



- Currently working on optimizing & automating ssRF application/measurement cycles + AFP
  - Hardware + Software

UVA

16:00 10/13 — **Hardware (AFP, SSRF)**
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UNH

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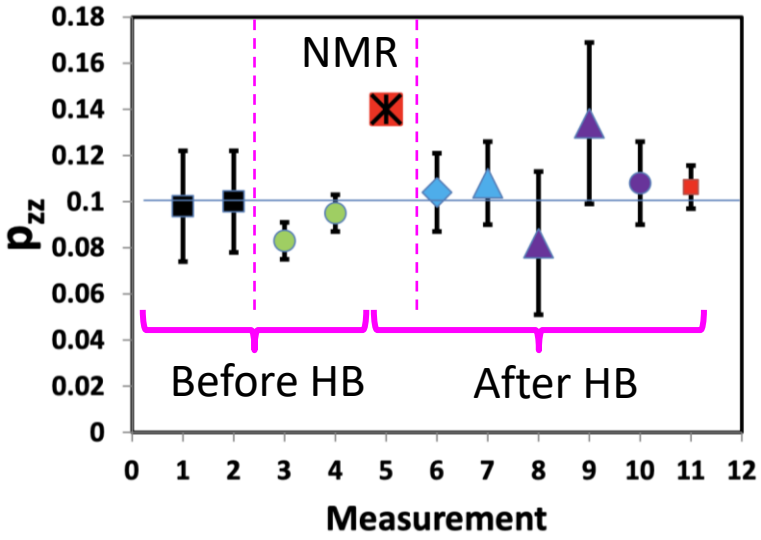
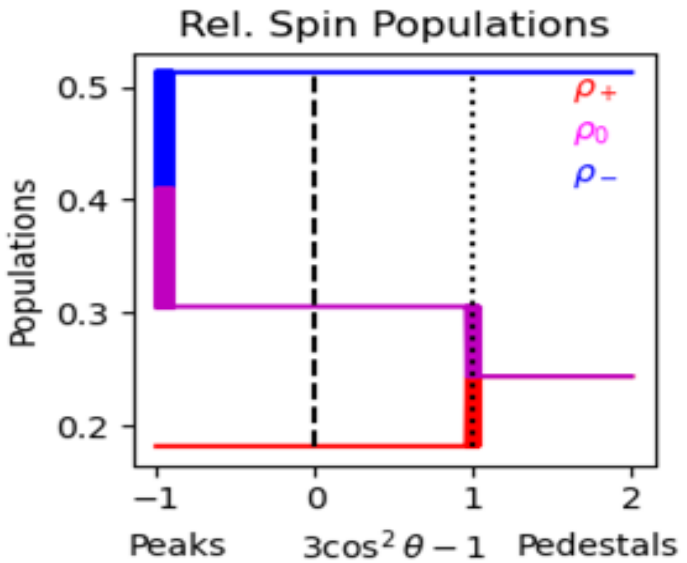
17:00 10/13 — **SSRF decay rates, CAA Quasi-elastic analysis**
Speaker: Chhetra Lama (University of New Hampshire)

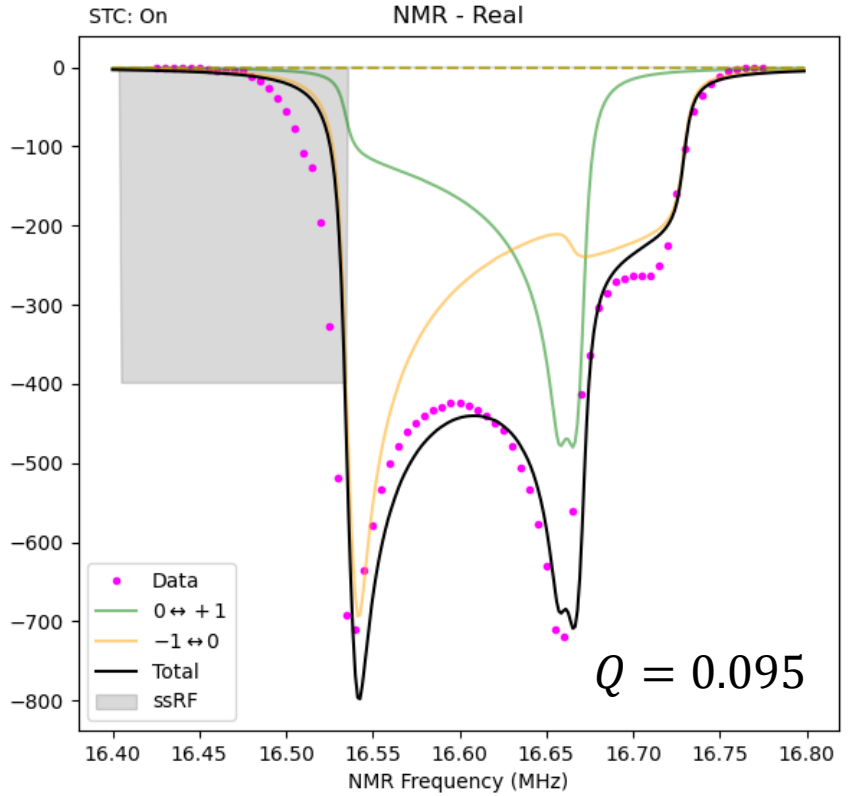
Target Tasks
◦ Revisit Triumf's Tensor Target Results

Near Complete

- No uncertainty listed for $Q = 14\%$
- Scattering data uncertainty is large
  - No contradiction within uncertainty between either $Q = 14\%$ or $Q = 11.5\%$







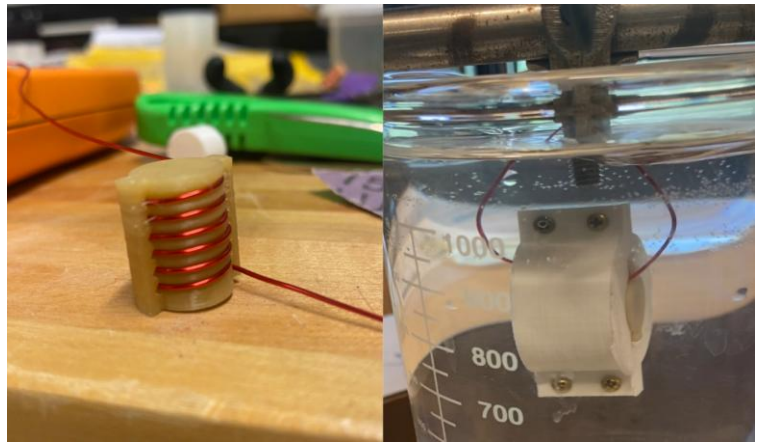
The measured polarization $P = -0.206$ deviates considerably from the value that is estimated in this analysis and, consequently, the result for the alignment could be affected by a large systematic error, which might be due to the neglect of the line broadening in this situation.

Target Tasks
◦ Ensure NMR/ssRF coil uniformity

In Progress

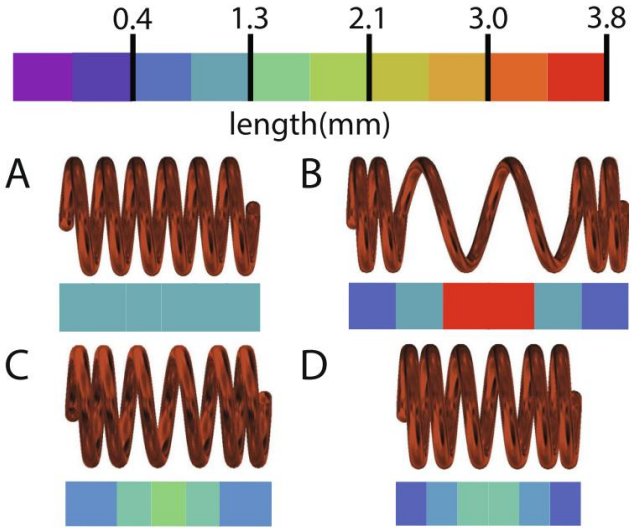
- Want to avoid line-shape issues encountered in Hall B RGC data

- b1/Azz will use NMR coils inside target cups, embedded in material
- Additional work:
  - 3D printing coil forms to improve uniformity



Variable pitch increases homogeneity
J.Mag.Res. **50**, 281 (1982)

3D printing coil forms
J. Mag. Res. **305**, 89 (2019)



J.I.Kelz, et al, J. Mag. Res. **305**, 89 (2019)

Target Tasks
◦ Ensure NMR/ssRF coil uniformity

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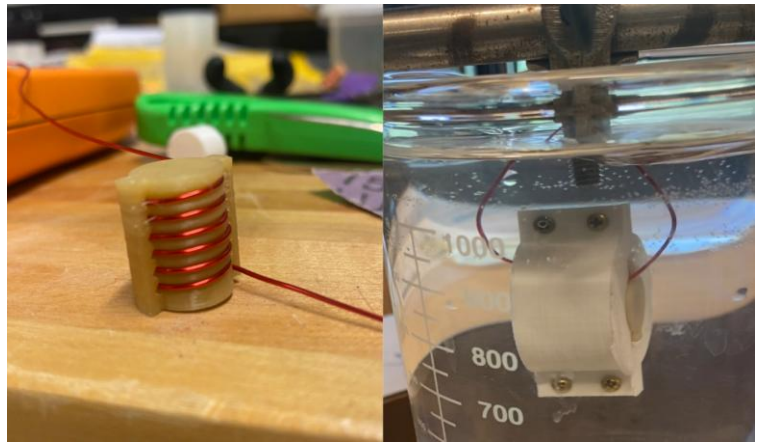
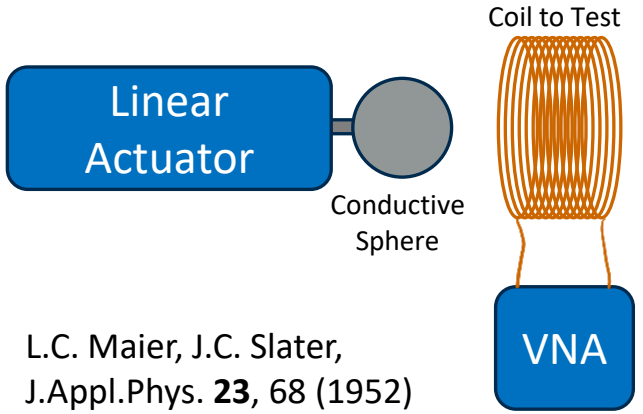
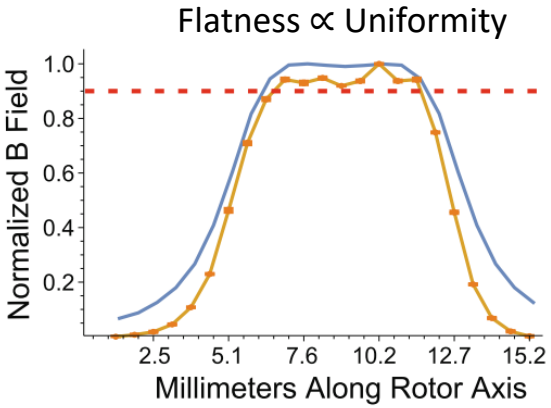


  - Measuring coil uniformity w/ ball shift probe



L.C. Maier, J.C. Slater, J.Appl.Phys. **23**, 68 (1952)



J.I. Kelz, et al, J. Mag. Res. **305**, 89 (2019)

Target Tasks

- Confirm annealing/material change estimates w/ Hall B RGC data

Near Complete

- Analysis of Hall B RGC data in progress
- Target CLAS Note expected in the near future

14:50
10/14
JLab target update (unconfirmed)
Speaker: JLab Target Group Representative

10:00
10/14
Run Group C 2027 run
Speaker: Sebastian Kuhn (Old Dominion University)

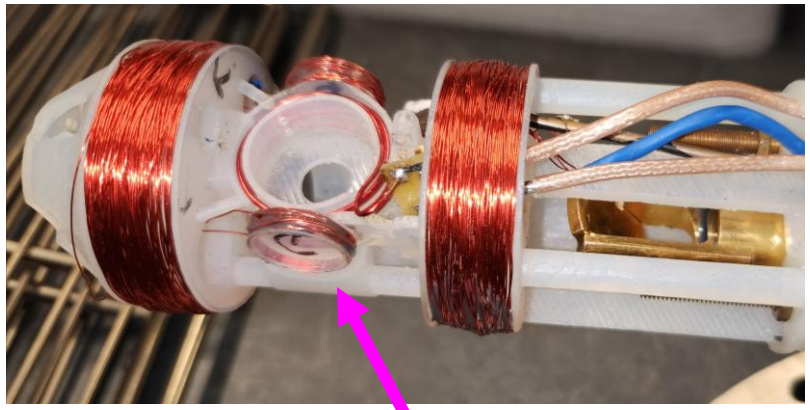
11:15
10/13
PbPT cross checks, CAA b1 analysis
Speaker: Muhammad Farooq (University of New Hampshire)

16:45
10/14
Faraday Cup, JLAB NMR, CAA SIDIS analysis
Speaker: Hector Chinchay (University of New Hampshire)

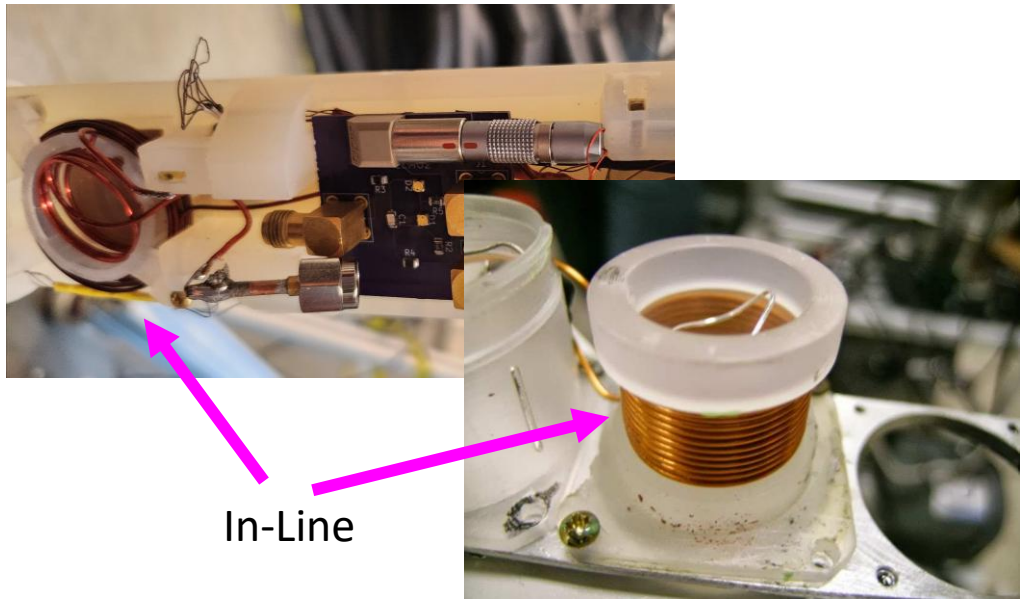
Target Tasks
◦ Final Design of Target Ladder & Coils

In Progress

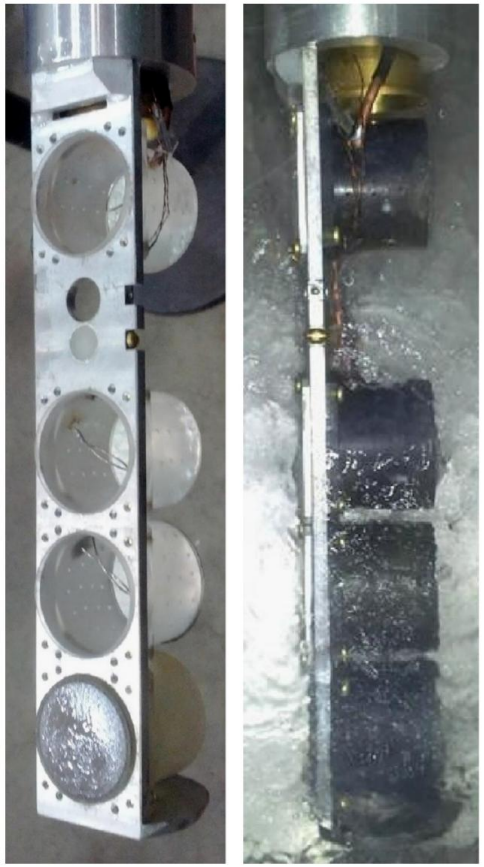
- Will use target cups similar to g2p
- ssRF/AFP coil design and optimization in progress
  - Currently testing in-line and Helmholtz-like configurations



Helmholtz-like



In-Line



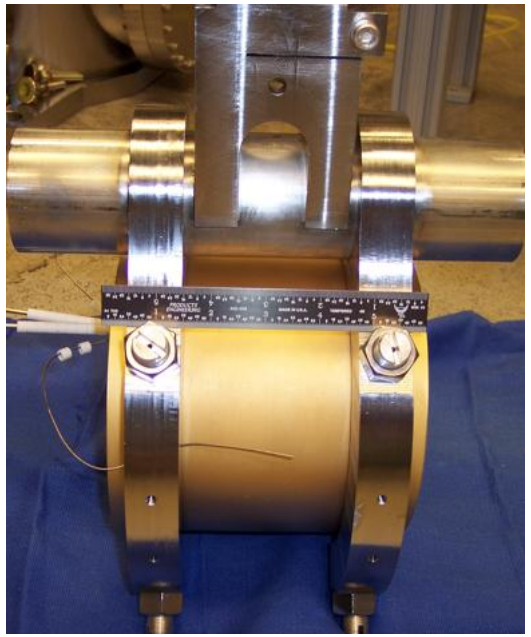
J. Pierce, et al, NIM A **738**, 54 (2014)

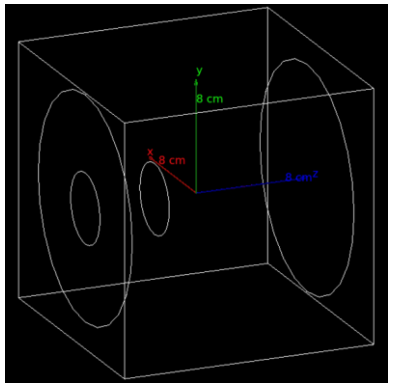
Beamline Tasks

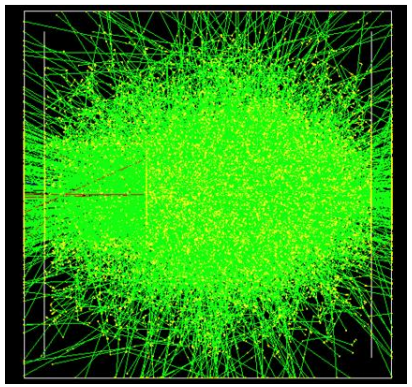
Beamline Tasks:
◦ Build Charge Monitoring Equipment

In Progress

- Need to keep charge uncertainty below the 10^{-4} level
- Faraday cup being built & studied for this purpose
  - Recommissioned W-Cu calorimeter from Hall A





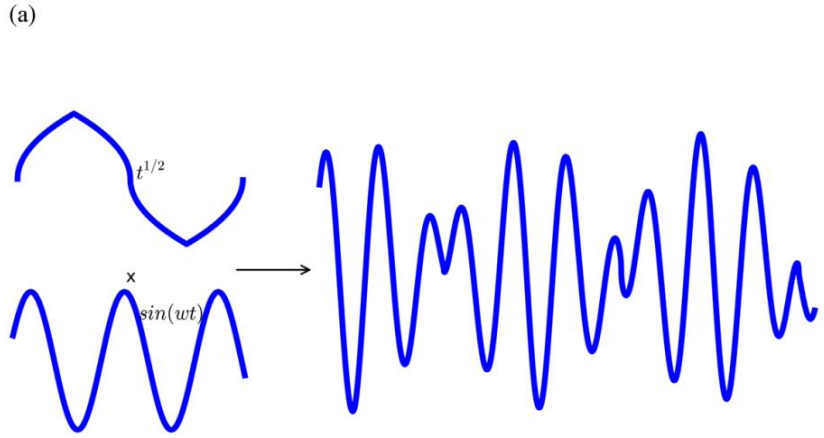


14:35
10/13
Systematics/Faraday Cup
Speaker: David Mack (JLab)

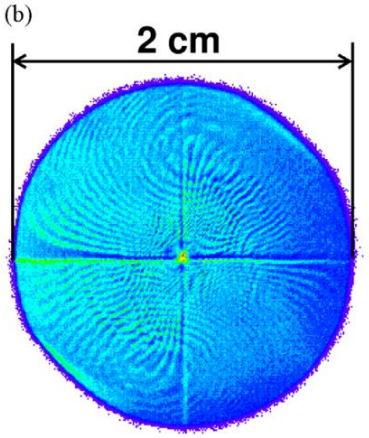
16:45
10/14
Faraday Cup, JLAB NMR, CAA SIDIS analysis
Speaker: Hector Chinchay (University of New Hampshire)

Beamline Tasks:
◦ Commissioning of Slow Raster

- Slow raster of electron beam required for DNP target



Magnet current waveform for the slow raster



The 2D histogram of magnet current signals of slow raster

Hall A slow raster for g2p
P. Zhu, NIM A **808**, 1 (2016)

14:10
10/13

Beamline, Raster configuraton, magnets. Relation to g2p2

Speaker: Dave Gaskell (Jefferson Lab)

Beamline Tasks:
◦ List Detector & Trigger Configuration

In Progress

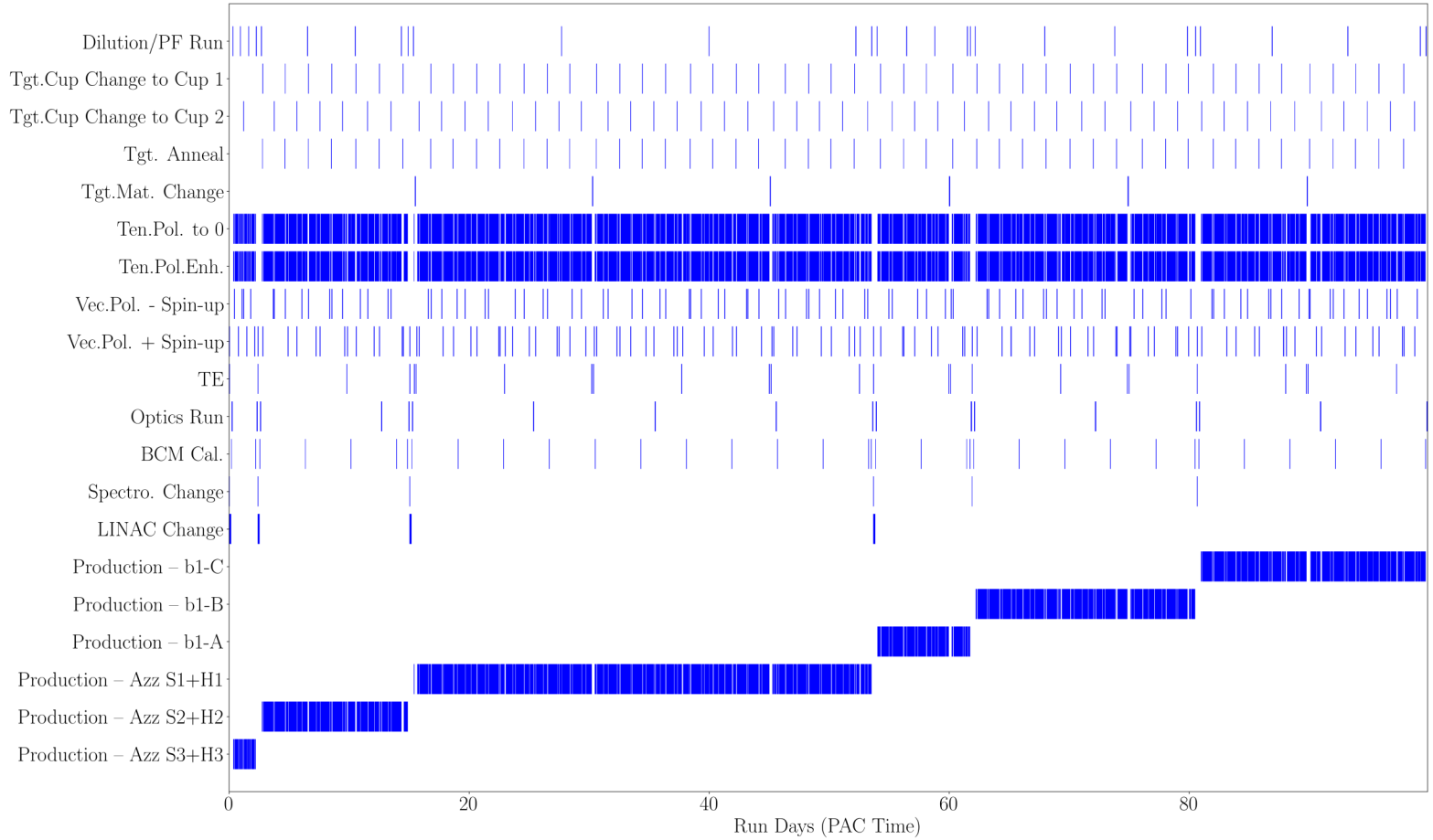
- Draft run plans have been created for both Azz and b1

11:35 10/13 **ERR Tasklist / Runplan and Polarization Configuration**
Speaker: Elena Long (University of New Hampshire)

14:10 10/13 **Beamline, Raster configuraton, magnets. Relation to g2p2**
Speaker: Dave Gaskell (Jefferson Lab)

14:35 10/13 **Systematics/Faraday Cup**
Speaker: David Mack (JLab)

15:00 10/13 **DAQ**
Speaker: Hanjie Liu (Jefferson Lab)



Beamline Tasks:
◦ Confirm Beam Pol. & Measurement

In Progress

- b1/Azz need $P_b = 0$
- Will integrate the helicity states of the pol. e-beam

- Also potential for future datamining to extract beam-target double-spin vector & tensor asymmetries

$$\sigma(h_e, P, Q) = \sigma_u\left[1 + h_e\left(A_e + PA_{ed}^V + QA_{ed}^T\right) + PA_d^V + QA_d^T\right]$$

b1/Azz

13:50 10/14 **Vector and beam/target asymmetries from b1/Azz data**

Speaker: Elena Long (University of New Hampshire)

Documentation Tasks

Documentation Tasks

- Workforce for running — Near Complete
- Write EH&S Documents — Not Started
- Complete ERR documentation — In Progress

17:15 → 18:00 **Planning Session**

10/13

Conveners: Ishara Fernando (University of Virginia), Karl Slifer (University of New Hampshire)

Run Plan

Overhead Assumptions (Real Time)

```
Beam Assumptions:
  Beam Current: 85 nA
  Beam Efficiency: 0.5 (Scaled to 1)

Target Configuration Assumptions:
  Target Cup Radius: 1.5 cm
  Target Cup Configuration: 2 cups
      | ||
      |/  \      Microwaves
      |ND3       Prod. Mat.
      |ND3       Prod. Mat.
      |C         Optics
      |EMP       Empty Cell
      |___
```

Based on data from P.M. McKee, NIM A 526, 60 (2004)

```
Target Annealing/Material Assumptions:
  Dose between anneals: 5.25e+15 e/cm^2
  Time Between Anneals for 2 Cups: 3 days, 5:42:46
  Time required for Anneal: 1:00:00
  Time required for Cup Change: 0:10:00
  Time Between Cup Changes: 1 day, 14:51:23
  Time required for target material change: 4:00:00
  Dose between target material changes: 5.00e+16 e/cm^2
  Time between target material changes for 2 Cups: 30 days, 20:07:20
```

Based on Hall B RGC Spin-Ups

```
Target Polarization, TE, & PF/Dilution Run Assumptions:
  Time constant for vector pol. spin-up: 0:50:00
  # of vector pol. time constants before beam: 3.91
  Time required for vector pol. spin-ups: 3:15:30
  Time between each vector pol. spin-up: 2 days, 0:00:00
  Time required for target TE measurements for all 2 cups: 3:00:00
  Time between TEs: 15 days, 10:03:40 (2 b/w Each Material Change)
  Time required for packing fraction/dilution runs: 3:00:00
  # of packing fraction/dilution runs per kinematic setting: 5
  Time to Tensor Enhance: 0:00:30
  Time to Tensor Unpol: 0:00:10
  Time Between Tensor Pol/Unpol Cycles: 0:30:00
```

Based on UVA & UNH data

```
Beamline & Hall Configuration Assumptions:
  Time required for BCM calibration: 2:00:00
  Beam time between BCM calibrations: 7 days, 12:00:00
  Time required for each Optics run: 4:00:00
  Beam time between Optics runs: 20 days, 0:00:00
  Time required for each Linac change: 8:00:00
  Time required for each Spectrometer Momentum/angle change: 2:00:00
```

Dose Between Anneals & Mat. Changes

- Analyzed data from P.M. McKee, NIM A **526**, 60 (2004)

Positive P

Subset #	$d\ \left(\times 10^{15}\ \frac{e^-}{\mathrm{cm}^2}\right)$
1	3.265
3	6.02
5	4.548
7	4.188
9	4.2964
11	4.139
12	3.5597
13	3.998
15	2.3091

Positive $d_{ave} = 4.04 \times 10^{15}\ \frac{e^-}{\mathrm{cm}^2}$

Negative P

Subset #	$d\ \left(\times 10^{15}\ \frac{e^-}{\mathrm{cm}^2}\right)$
2	5.35
4	5.86
6	6.52
8	6.967
10	3.5
12	3.641
14	3.9454

Negative $d_{ave} = 5.11 \times 10^{15}\ \frac{e^-}{\mathrm{cm}^2}$

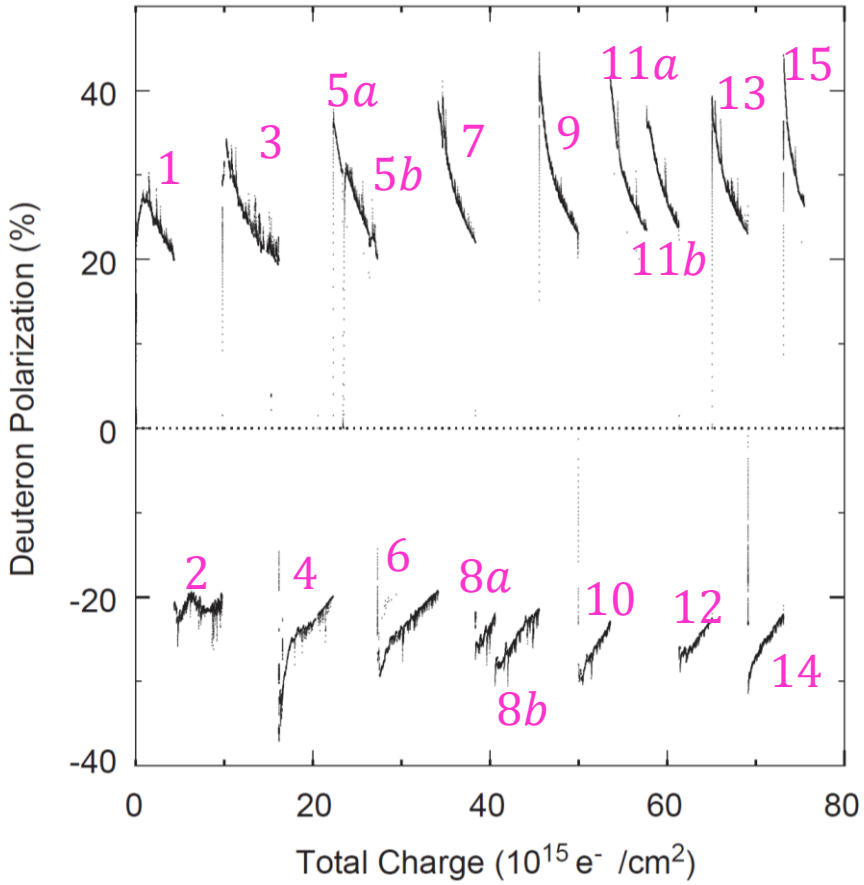
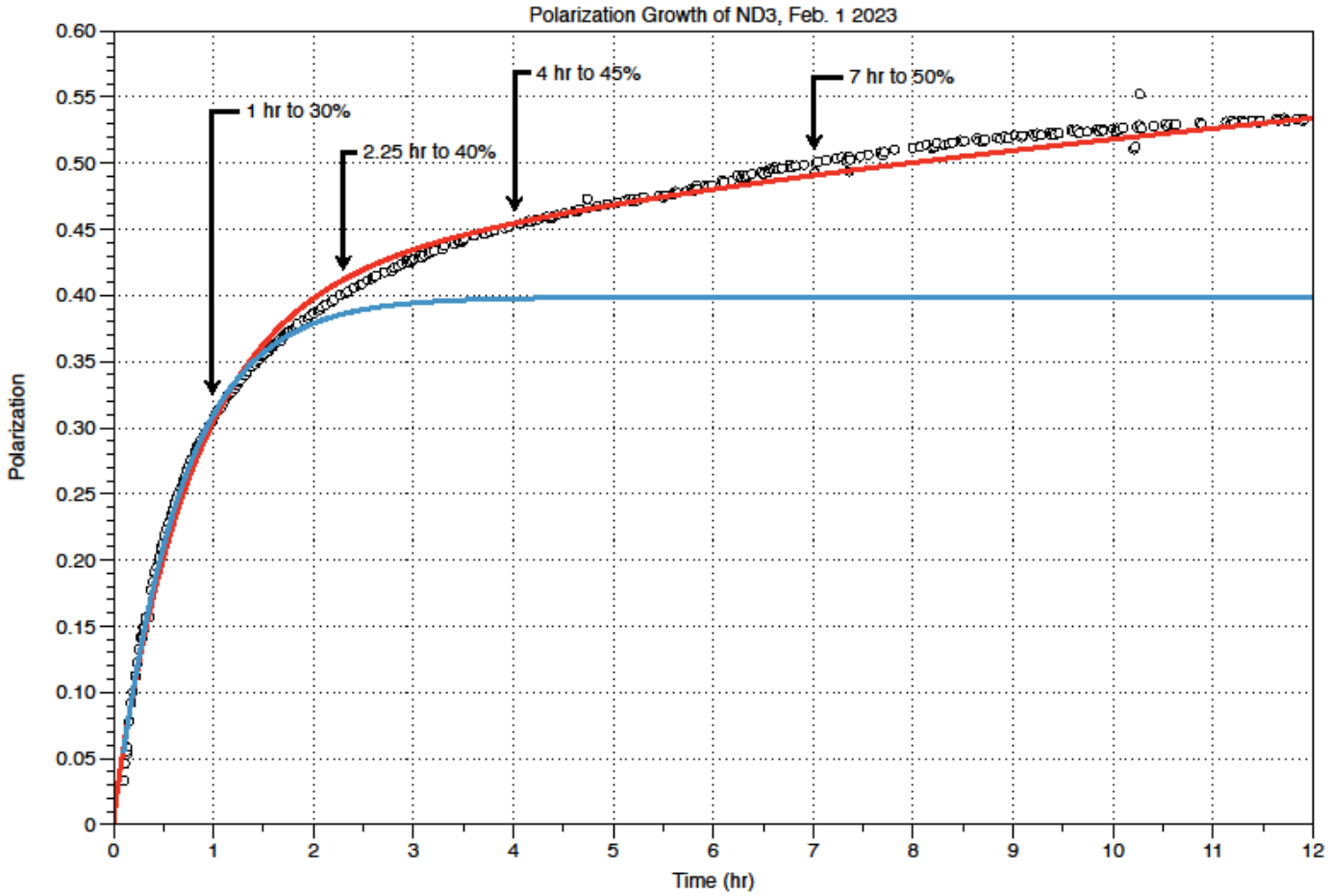


Fig. 1. History of one batch of $^{15}ND_3$.

Hall B RGC Spin-Up

- ~ 4 hours to $P = 45\%$
- AFP will be used between spin-flips to significantly reduce flip time



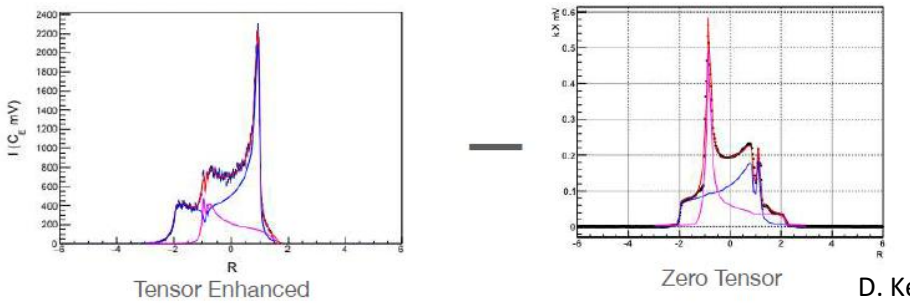
11:15
10/13

PbPT cross checks, CAA b1 analysis

Speaker: Muhammad Farooq (University of New Hampshire)

Rapid Tensor Flips: 4 State Measurement

- Rapid tensor enhancement/suppression while maintaining large vector polarization
  - Highly suppresses drift effects on systematics
  - 1 cycle/hour instead of 1 cycle/day
  - $\delta A_{zz}^{drift} \propto \frac{1}{\sqrt{N_{flips}}}$ improved by $\frac{1}{\sqrt{24}}$



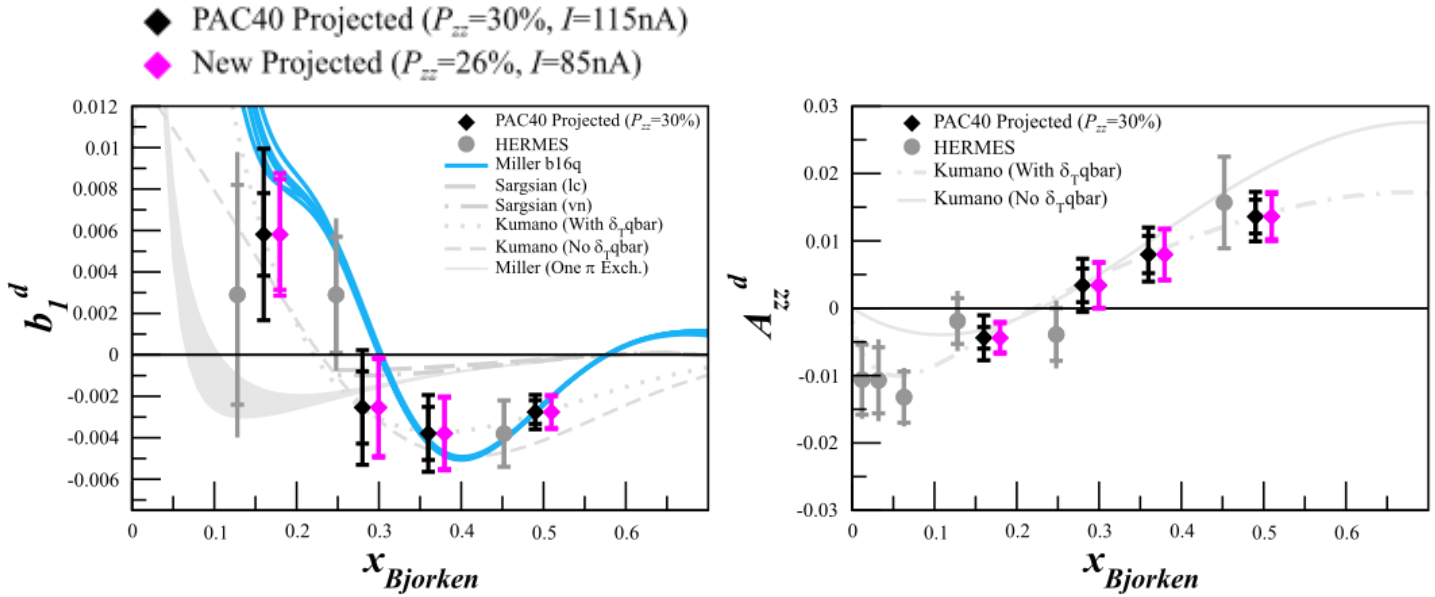
D. Keller

$$A_d^T \begin{pmatrix} h_1,h_2,h_3,h_4 \\ P_1,P_2,P_3,P_4 \\ Q_1,Q_2,Q_3,Q_4 \end{pmatrix}_4 = A_d^T \begin{pmatrix} 0,0,0,0 \\ P,-P,P,-P \\ Q,Q,0,0 \end{pmatrix}_4 = R_4^Q \left(1 - \frac{A_d^V}{R_4^P}\right),$$

$$R_4^Q(Q,Q,0,0) = \left(\frac{1}{f}\right)\left(\frac{(Y_1+Y_2)-(Y_3+Y_4)}{Q(Y_3+Y_4)}\right),$$

$$\frac{1}{R_4^P(P,-P,P,-P)} = 0.$$

E. Long, EPJ A (in review)



13:50
10/14

Vector and beam/target asymmetries from b1/Azz data

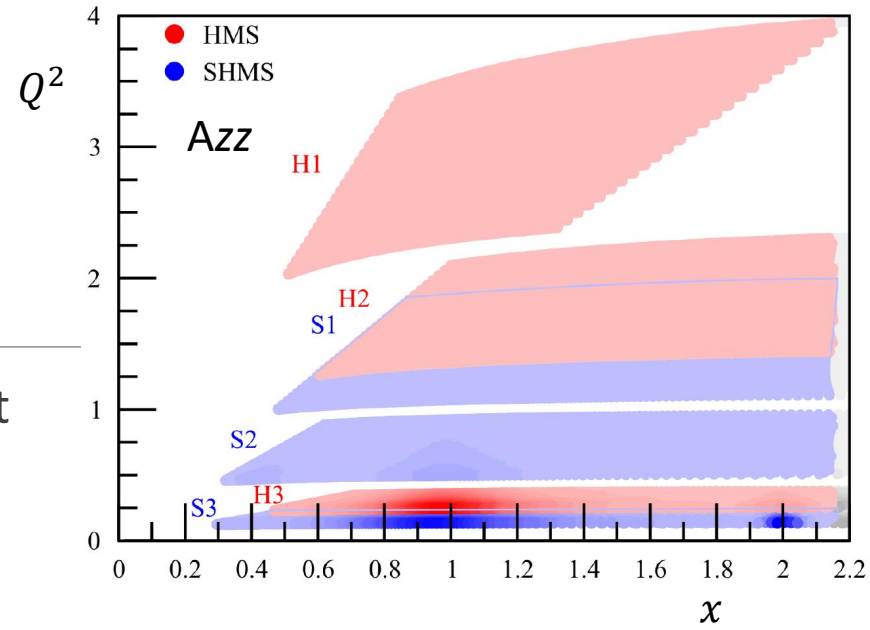
Speaker: Elena Long (University of New Hampshire)

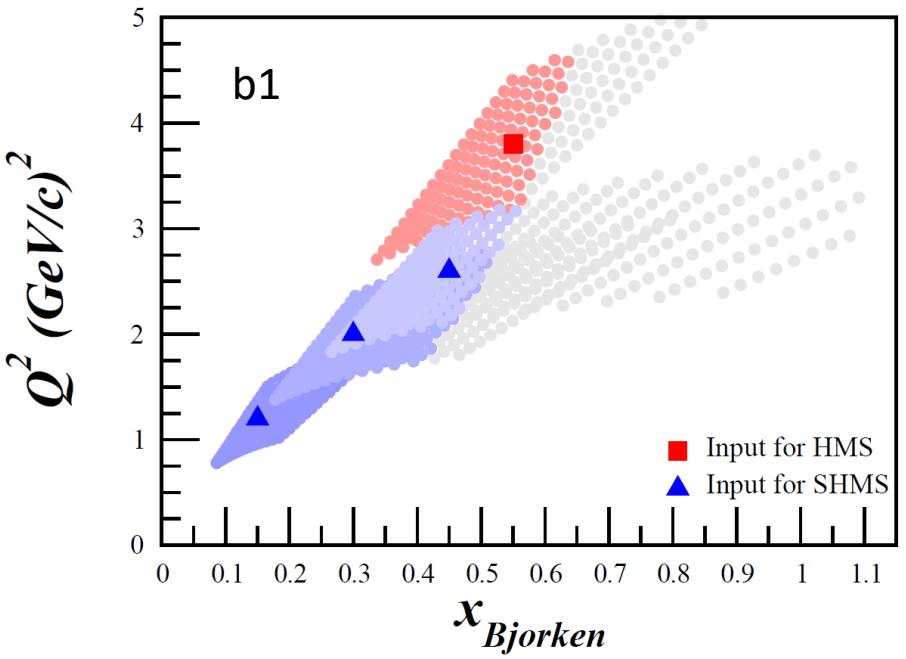
b1/Azz Kinematics Running

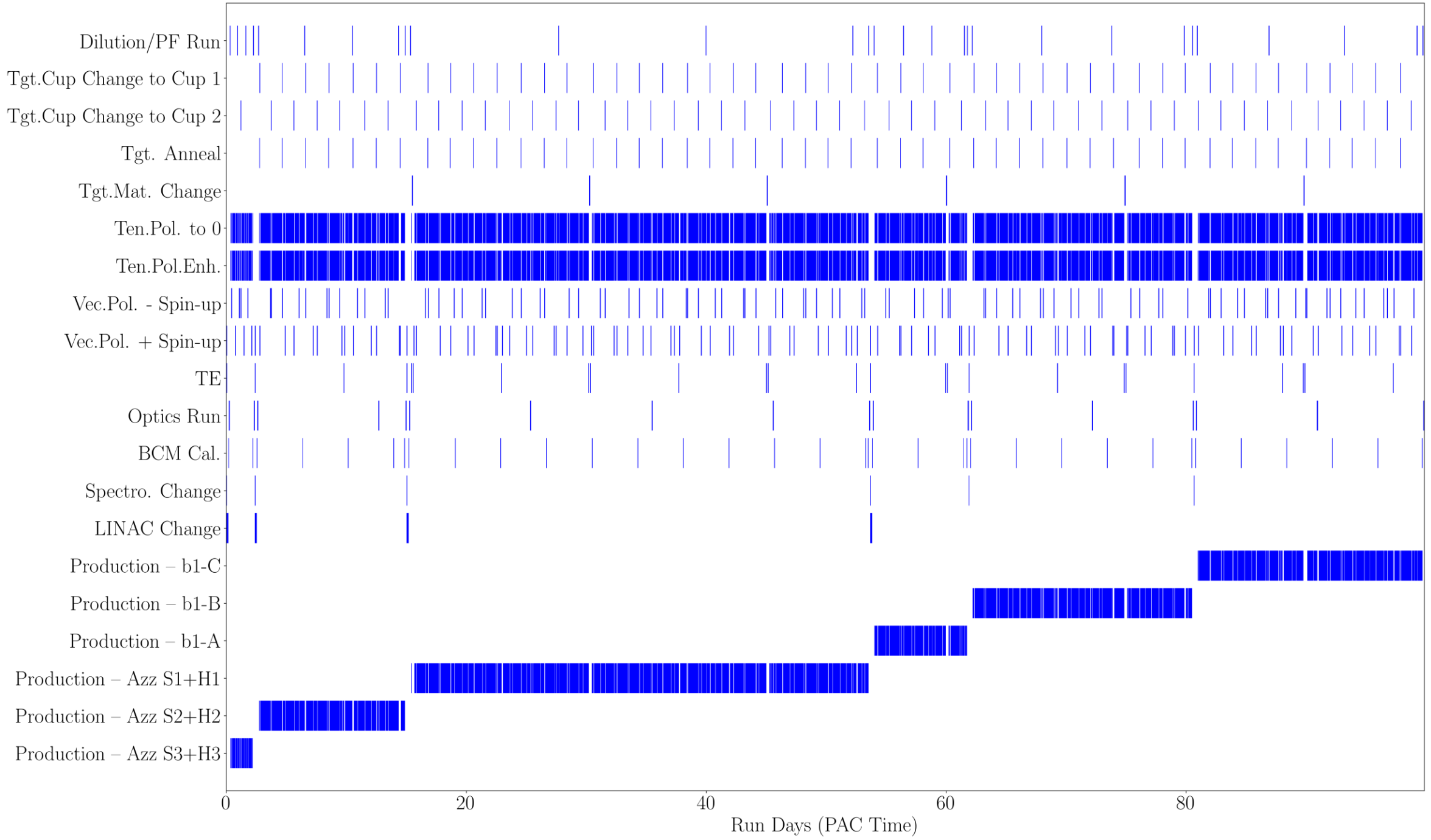
Draft run plan from smallest beam/detector energies to highest

Kinematics Settings:

Setting Name	Spec.	E0 (GeV)	Q^2 (GeV^2)	E' (GeV)	Theta (deg)	Run Time (PAC)	Run Time (Real)
Azz-A	SHMS	2.2	0.2	2.15	10.9	1 day, 0:00:00	2 days, 0:00:00
	HMS		0.3	2.11	14.9		
Azz-B	SHMS	6.6	0.7	6.35	7.5	8 days, 0:00:00	16 days, 0:00:00
	HMS		1.8	5.96	12.3		
Azz-C	SHMS	8.8	1.5	8.36	8.2	25 days, 0:00:00	50 days, 0:00:00
	HMS		2.9	7.26	12.2		
b1-A	SHMS	11	1.21	6.70	7.35	6 days, 0:00:00	12 days, 0:00:00
	HMS		3.81	7.31	12.5		
b1-B	SHMS	11	2.00	7.45	8.96	9 days, 0:00:00	18 days, 0:00:00
	HMS		3.81	7.31	12.5		
b1-C	SHMS	11	2.58	7.96	9.85	15 days, 0:00:00	30 days, 0:00:00
	HMS		3.81	7.31	12.5		






Dilution/PF Run
Tgt.Cup Change to Cup 1
Tgt.Cup Change to Cup 2
Tgt. Anneal
Tgt.Mat. Change
Ten.Pol. to 0
Ten.Pol.Enh.
Vec.Pol. - Spin-up
Vec.Pol. + Spin-up
TE
Optics Run
BCM Cal.
Spectro. Change
LINAC Change
Production – b1-C
Production – b1-B
Production – b1-A
Production – Azz S1+H1
Production – Azz S2+H2
Production – Azz S3+H3
0
20
40
60
80
Run Days (PAC Time)

Thank you!

From P. Rossi's Talk

Specific for this review

- While the C1 conditional status has been lifted, the review panel reminded the collaboration that the bar for passing the Experimental Readiness Review will be significantly higher.

- The next review will include the original charge elements:

1. What technique(s) will be used to produce "a tensor polarization of 30% under standard experimental conditions"
2. How will the tensor polarization be measured and with what uncertainty? What crosschecks or auxiliary measurements can be made to validate the results? Will this uncertainty be sufficient to achieve meaningful physics results?
3. What assumptions are made regarding the vector polarization of the target? How is the tensor polarization expected to respond as the vector polarization decays in beam?
4. What is the current experimental situation? What is the maximum tensor polarization that has been achieved under the anticipated polarizing conditions of 5 T and 1 K?

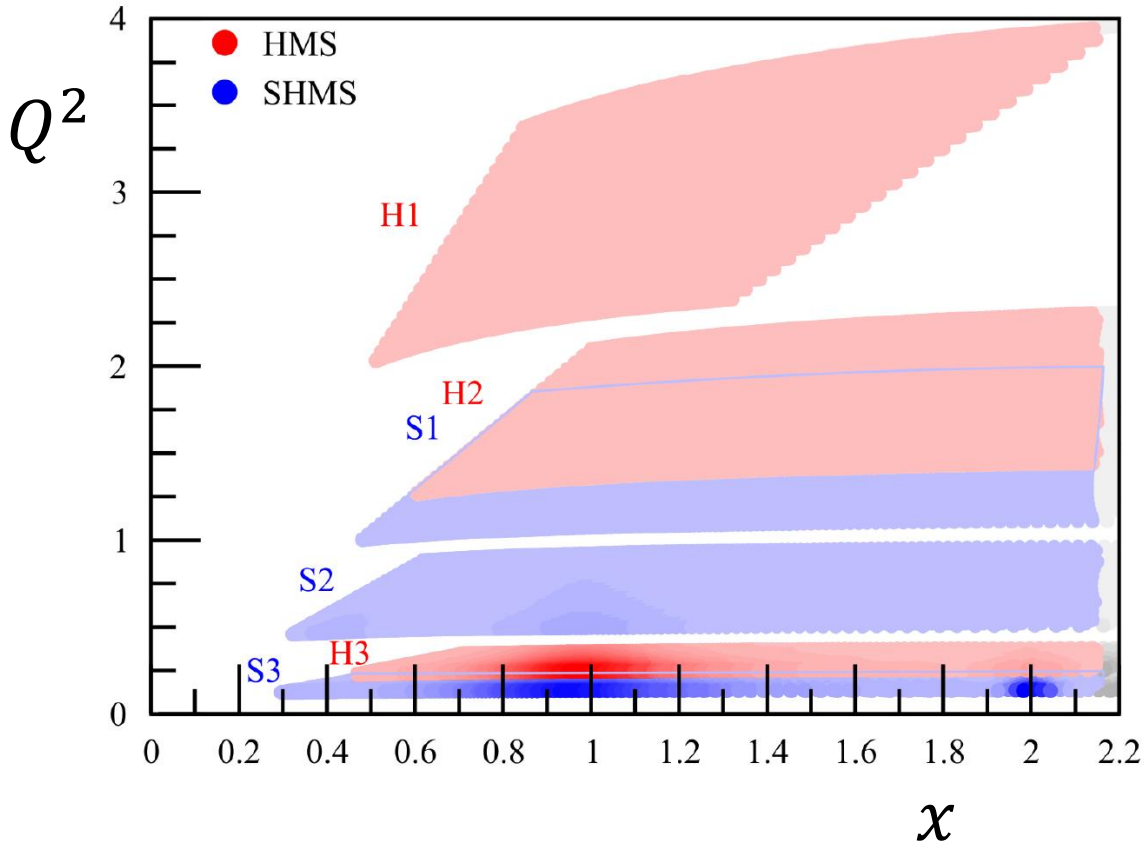
but will now incorporate an additional critical element focused on risk mitigation and scientific impact.
The collaboration must prepare to address the following new contingency planning questions:

5. What is the detailed plan if the average polarization of 30% is not reached?
6. Can the experiments still be run under those lower-polarization conditions?
7. What is the precise impact on the final scientific results (e.g., uncertainties, statistical significance) if the 30% polarization goal is not met?

Azz Kinematics & Overhead

		E_0 (GeV)	Q^2 (GeV^2)	E' (GeV)	$\theta_{e'}$ (°)	Rates (kHz)	PAC Time (Days)
SHMS	(S1)	8.8	1.5	8.36	8.2	0.38	30.5
HMS	(H1)	8.8	2.9	7.26	12.2	0.04	30.5
SHMS	(S2)	6.6	0.7	6.35	7.5	3.57	9.7
HMS	(H2)	6.6	1.8	5.96	12.3	0.09	9.7
SHMS	(S3)	2.2	0.2	2.15	10.9	10.5	1.2
HMS	(H3)	2.2	0.3	2.11	14.9	3.23	1.2

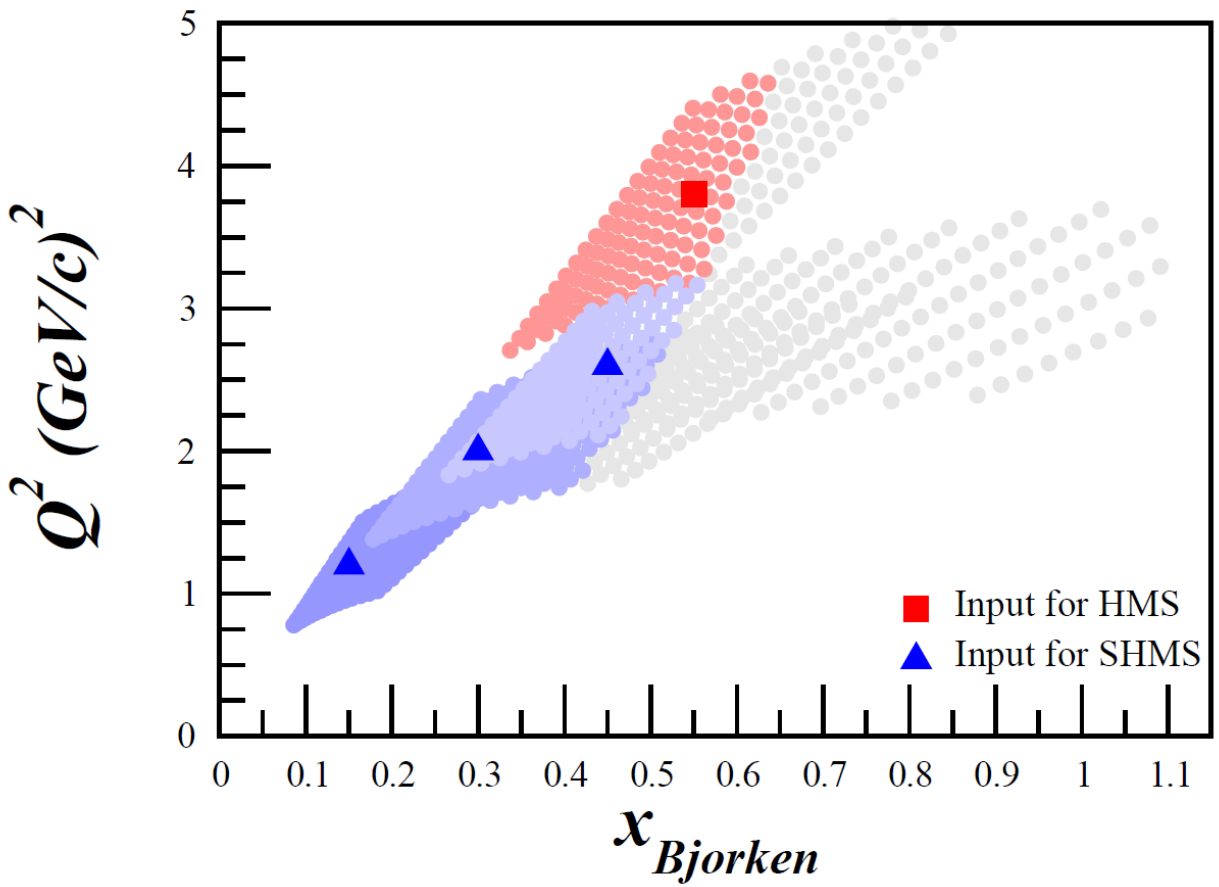
Overhead	PAC Time
Vector Polarization/Depolarization	7 days, 13 hours
Packing Fraction/Dilution Runs	22.5 hours
Target T.E. Measurements	21 hours
Optics Runs	20 hours
BCM Calibration Runs	18 hours
Target Anneals	13 hours
Linac Changes	12 hours
Tensor Pol. Spin Flips	11 hours
Target Cup Changes	4 hours
Target Material Changes	4 hours
Momentum/Angle Changes	3 hours
	11.4 days



b1 Kinematics & Overhead

		$\overline{x}$	$\overline{Q^2}$ (GeV^2)	$\overline{W}$ (GeV)	P_0 (GeV)	θ (deg.)	Rates (kHz)	time (days)
A	SHMS	0.15	1.21	2.78	6.70	7.35	1.66	6
B	SHMS	0.30	2.00	2.36	7.45	8.96	0.79	14.65
C	SHMS	0.452	2.58	2.00	7.96	9.85	0.38	15
A+B+C	HMS	0.55	3.81	2.00	7.31	12.50	0.11	35.65

Overhead	PAC Time
Vector Polarization/Depolarization	7 days, 6 hours
Target T.E. Measurements	22.5 hours
Packing Fraction/Dilution Runs	22.5 hours
BCM Calibration Runs	18 hours
Optics Runs	16 hours
Target Anneals	15 hours
Tensor Pol. Spin Flips	9.5 hours
Target Cup Changes	5 hours
Target Material Changes	4 hours
LINAC Changes	4 hours
Momentum/Angle Changes	3 hours
	11.7 days



Target Tasks

Complete

◦ Demonstrate $A_{lost} = 2\,A_{gained}$ w/ ssRF

- UVA published results
  - D. Keller, EPJ A **53**, 155 (2017)
  - J. Clements, D. Keller, NIM A **1050**, 168177 (2023)
- UNH results in agreement