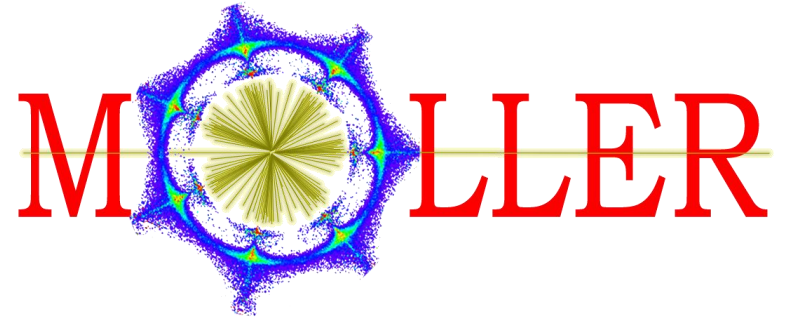


# MOLLER Accelerator Jobs

Operations StayTreat

June 6, 2023



Riad Suleiman



# Introduction

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- **MOLLER: Measurement Of Lepton Lepton Elastic Reactions**
- **Physics Outcome:** an ultra-precise measurement of the weak-mixing angle using Møller scattering  
<https://moller.jlab.org/cgi-bin/DocDB/public/DocumentDatabase>
- **Organization:**
  - **Accelerator Parity-Quality-Beam Liaison:** Riad Suleiman
  - **APEL:** Yves Roblin
  - **Ops Hall A Liaison:** Daniel Moser and Adam Schoene
  - **Hall A Liaison:** Ciprian Gal
  - **MOLLER Liaison:** Caryn Palatchi and Kent Paschke

# Parity-Violating Experiments at CEBAF

PV Experiment	Energy (GeV)	Pol (%)	I ( $\mu\text{A}$ )	Target	$A_{\text{pv}}$ (ppb)	Charge Asym (ppb)	Position Diff (nm)	Angle Diff (nrad)	Size Asym ( $\delta\sigma/\sigma$ )
HAPPEX-I 1998 – 1999	3.3	38.8 68.8	100 40	$^1\text{H}$ (15 cm)	15,050	200	12	3	$<10^{-3}$
G0-Forward 2003 – 2004	3.0	73.7	40	$^1\text{H}$ (20 cm)	3,000- 40,000	300 $\pm$ 300	7 $\pm$ 4	3 $\pm$ 1	$<10^{-3}$
HAPPEX-II 2004 – 2005	3.03	87.1	55	$^1\text{H}$ , $^4\text{He}$ (20 cm)	1,580	400	2	0.25	$<10^{-3}$
G0-Backward 2006 – 2007	0.359, 0.688	85.8	60	$^1\text{H}$ , $^2\text{H}$ (20 cm)	9,700- 37,400	-30 $\pm$ 300	47 $\pm$ 9	1.2 $\pm$ 0.5	$<10^{-3}$
HAPPEX-III 2009	3.484	89.4	100	$^1\text{H}$ (25 cm)	23,800	200 $\pm$ 10	3	0.5 $\pm$ 0.1	$<10^{-3}$
PVDIS 2009	6.067	89.0	105	$^2\text{H}$ (20 cm)	60,000- 160,000	100	100	40	$<10^{-3}$
PREx-I 2010	1.056	89.2	70	$^{208}\text{Pb}$ (0.5 mm)	657 $\pm$ 60	85 $\pm$ 1	4	1	$<10^{-4}$
QWeak 2010 – 2012	1.162	88.7	180	$^1\text{H}$ (34 cm)	226.5 $\pm$ 9.3	20.5 $\pm$ 1.7	-4.6 $\pm$ 0.2	-0.07 $\pm$ 0.01	$<10^{-4}$
PREx-II 2019	0.953	89.7	70	$^{208}\text{Pb}$ (0.5 mm)	550 $\pm$ 18	20.7 $\pm$ 0.2	2.2 $\pm$ 4	0.3 $\pm$ 0.3	$<6\times 10^{-5}$
CREx 2019-2020	2.18	87.1	150	$^{48}\text{Ca}$ (5 mm)	2668 $\pm$ 113	-88 $\pm$ 026	-5.2 $\pm$ 3.6	- 0.13 $\pm$ 0.08	$<6\times 10^{-5}$
MOLLER 2026-2028	10.8	90	65	$^1\text{H}$ (125 cm)	35.6 $\pm$ 0.74	$<10$	$<0.6$	$<0.12$	$<10^{-5}$

# MOLLER Quick Summary – Notable Things for MOLLER

1. MOLLER Apparatus is designed for nominal beam energy:  $10.8 \pm 0.2$  GeV with low RF trip rate (<6)
2. 65  $\mu$ A with 90% polarization (max 70  $\mu$ A for target studies)
3. Fast helicity reversal:
  - I. 1920 Hz, 10  $\mu$ sec settle time, 64-window pattern, 128-window delay
4. Slow helicity reversals:
  - I. Insertable half-wave plate (IHWP)
  - II. Wien Filters (using new 200 keV injector)
  - III.  $g_e$ -2 ( $\Delta E \sim 0.10$  GeV)
5. Feedbacks on:
  - I. Helicity-correlated beam charge
  - II. Helicity-correlated position and angle
  - III. Polarization orientation
6. Small helicity-correlated beam asymmetries
7. Adequate adiabatic damping of transverse phase-space (for both  $xx'$  and  $yy'$ ) – a factor of 100 is desired, a factor of 10 is required. Ideally,  
$$\sqrt{P_f/P_{gun}} = \sqrt{10800/0.494} = 148$$
8. Acceptable beam halo (MOLLER Halo Monitor: to be specified, Compton Polarimeter: <100 Hz/ $\mu$ A)

# CEBAF Long Term Schedule – potential conflicts

**MOLLER experiment in Hall A: installation starts in Jan 2025 and physics run starts in Jan 2026 for three years**

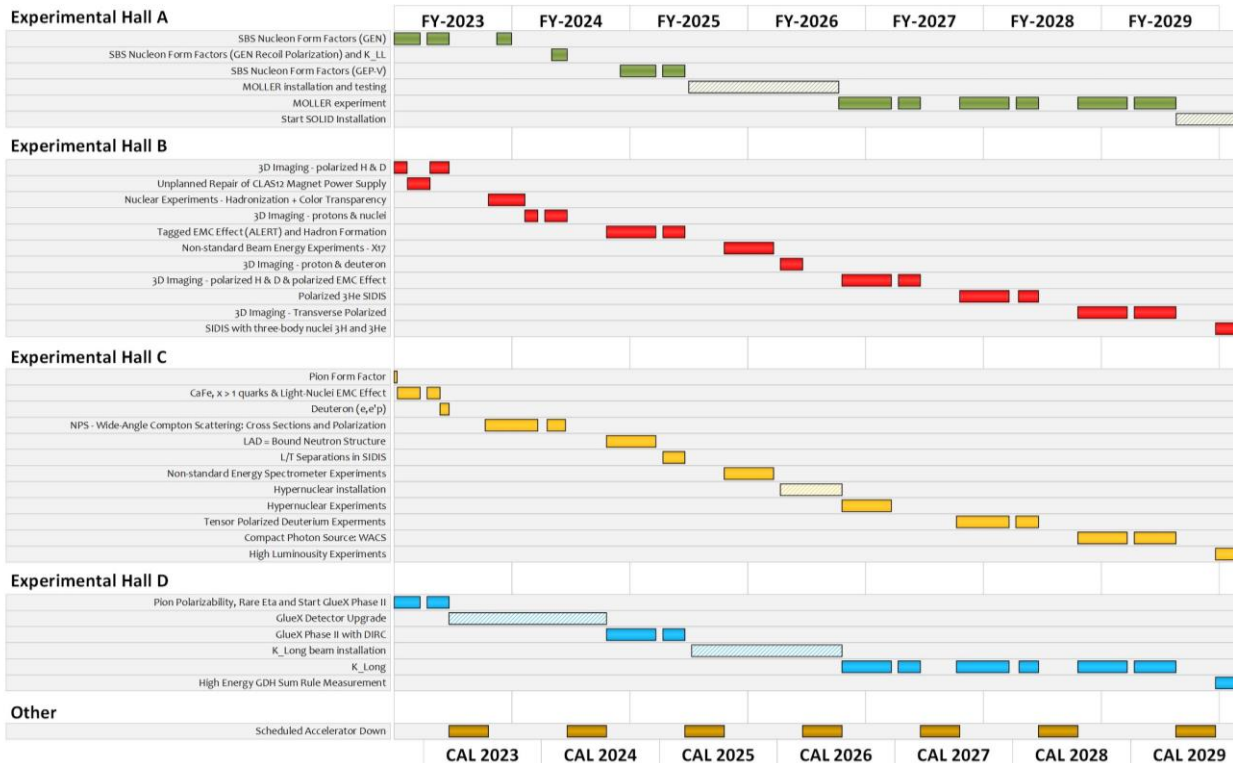
- **Hall A (MOLLER)**  
0.26 pC @ 249.5 MHz (4 ns, 65  $\mu$ A average beam current)

- **Hall B**  
0.002 pC @ 249.5 MHz (4 ns, 50 nA average beam current)

- **Hall C**  
0.12 pC @ 249.5 MHz (4 ns, 35  $\mu$ A average beam current)

- **Hall D ( $K_L$ )**  
0.32 pC @ 15.6 MHz (64 ns, 5  $\mu$ A average beam current)

➤ One task aims to study co-operation of MOLLER with  $K_L$  long experiment in Hall D



# MOLLER Requirements

- Details about MOLLER action items can be found here:  
[https://wiki.jlab.org/ciswiki/images/2/2b/MOLLER\\_Accelerator\\_MainJobs\\_details\\_June2023.docx](https://wiki.jlab.org/ciswiki/images/2/2b/MOLLER_Accelerator_MainJobs_details_June2023.docx)
- MOLLER has other requirements that can be found here:  
[https://wiki.jlab.org/ciswiki/images/7/7b/MOLLER\\_beam\\_requirements\\_22March2023.pdf](https://wiki.jlab.org/ciswiki/images/7/7b/MOLLER_beam_requirements_22March2023.pdf)
- Accelerator jobs are summarized in next four slides (**listed are Deliverable Dates**)

Abbreviation	Staff/People	Group
CIS	Accelerator	Center for Injectors and Sources
CASA	Accelerator	Center for Advanced Studies of Accelerators
Ops-SW	Accelerator	Accelerator software Group
Ops-Inj	Accelerator	Injector group
Ops-MCC	Accelerator	MCC Operations Group
I&C	Engineering	Instrumentation and Controls Group (EESICS)
RF	Engineering	Radio-Frequency Group
SSG	Engineering	Safety Systems Group
Fast Electronics	Physics	Fast Electronics Group
Hall A	Physics	Hall A group
RCG	EH&S	Radiological Control Group
MOLLER	Users	MOLLER Collaboration

# MOLLER Accelerator Jobs

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- 1. Helicity Generator boards (SAD 2024)**
  - Groups (CIS, MOLLER, Fast Electronics, Ops-SW)
- 2. Helicity Decoder boards (SAD 2024)**
  - Groups (CIS, MOLLER, Fast Electronics)
- 3. New RTP High Voltage (HV) Driver (SAD 2024)**
  - Groups (CIS, MOLLER, I&C, Ops-SW)
- 4. Upgrade laser Intensity-Attenuator (IA) system (SAD 2024)**
  - Groups (CIS, MOLLER, I&C, Ops-SW)
- 5. Upgrade Helicity Magnets control (SAD 2024)**
  - Groups (CIS, CASA, MOLLER, I&C)
- 6. Feedback on polarization orientation (December 2024)**
  - Groups (CIS, Ops-Inj, MOLLER, CASA)
- 7. Wien filters slow reversal – Wien Flip (December 2023)**
  - Groups (Ops-Inj, CIS, MOLLER)

# MOLLER Accelerator Jobs ... continued

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- 8. Injector transmission and parity-quality beam (December 2023)**
  - Groups (Ops-Inj, MOLLER)
- 9. Matching and adiabatic damping from 200 keV to Hall A (December 2024)**
  - Groups (CASA, CIS, Ops-Inj, MOLLER)
- 10. Fast Feedback (FFB) system resurrection (December 2024)**
  - Groups (CASA, Ops-SW, I&C)
- 11. Compton Polarimeter setup (December 2024)**
  - Groups (CASA, Hall A)
- 12. Beam Modulation (December 2024)**
  - Groups (Hall A, CASA, Ops-SW, I&C, MOLLER)
- 13. Phase Advance (December 2024):**
  - Groups (CASA, MOLLER)



# MOLLER Accelerator Jobs ... continued

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## **14. Study co-operation of MOLLER with K-long experiment in Hall D (SAD 2024)**

- Groups (CIS, Ops-Inj, CASA, MOLLER, Hall A)

## **15. Control of charge asymmetry on Halls B, C, and D beams (December 2024)**

- Groups (MOLLER, CIS, Ops-SW)

## **16. Parity-Quality Beam (PQB) studies in Injector and Hall (December 2024)**

- Groups (MOLLER, CIS, Ops-INJ, CASA)

## **17. Halo Monitors in Hall A (March 2025)**

- Groups (Hall A, MOLLER, I&C, Ops-SW, SSG)

## **18. Robust beam mis-steer protection / fast shutdown detectors in MOLLER apparatus (March 2025)**

- Groups (Hall A, MOLLER, RadCon, Ops-MCC)

# MOLLER Accelerator Jobs ... continued

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## **19. New BPM Digital Receivers in Hall A line – instead of Sample/Hold cards (March 2025)**

- Groups (Hall A, MOLLER, I&C, Ops-SW)

## **20. New BCMs electronics in Hall A line (March 2025)**

- Groups (Hall A, MOLLER, I&C, Ops-SW)

# Accelerator Beam Tests (June – July 2023)

- **200 kV Gun Optics and Gun-Exit Steering:** measure beam angle and displacement from new gun as a function of laser spot position
- **Beam studies of New Booster:** measure beam emittance upstream and downstream of Booster, beam kicks, energy spread, and x/y coupling caused by Booster
- **Injector Optics:** study gun kick, MFX2I01 auto-centering, 200 keV Wien, and 15 degree dipole
- **200 keV Wien Filter Optics:** optimize Wien filter operation at any angle with no significant impact on transmission (>95%) or downstream optics
- **200 keV E/B Calibrations of V-Wien and H-Wien:** determine E and B field settings which do not deflect electron beam at 200 keV energy
- **200 keV Spin Dance Calibrations of V-Wien, H-Wien, and Spin Solenoids:** Calibrate spin rotators using Mott polarimeter

# PQB Beam Tests (June – July 2023)

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- Measure beam properties (e.g. widths of beam asymmetries, position differences along injector) from new gun and Booster and compare to before
  
- 1. DAQ and Channel Access Setup
  
- 2. RHWP Scan – Vacuum Window Assessment
  
- 3. Wein-Flip Symmetry Measurement
  
- 4. 200 keV Transmission and Noise
  
- 5. Post Upgrade 200 keV RTP Position Difference Sensitivity and Feedback Convergence FC2
  
- 6. Post Upgrade Chopper Scan at 200 keV

# Summary

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- MOLLER installation starts in Jan 2025 and physics run starts in Jan 2026 for three years
- Very demanding experiment – preparations must start now
- Managers: please use MOLLER Accelerator Jobs document to plan resources:  
[https://wiki.jlab.org/ciswiki/images/2/2b/MOLLER\\_Accelerator\\_MainJobs\\_details\\_June2023.docx](https://wiki.jlab.org/ciswiki/images/2/2b/MOLLER_Accelerator_MainJobs_details_June2023.docx)
- More info about parity-violating experiments can be found at CIS Wiki:  
[https://wiki.jlab.org/ciswiki/index.php/Parity\\_Quality\\_Beam](https://wiki.jlab.org/ciswiki/index.php/Parity_Quality_Beam)