Hall B and CEBAF 2037

Kickoff Meeting, November 16, 2026

Report to the CLAS Collaboration

Hall B's scientific vision and capabilities for CEBAF 2037

November 19, 2026

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Richard Milner (MIT)



Jefferson Lab

U.S. DEPARTMENT OF ENERGY | Office of Science

The Future of the Continuous Electron Beam Accelerator Facility

CEBAF 2037



What is CEBAF 2037?

A community planning effort to define the science CEBAF should deliver and the accelerator and halls needed to make it possible.

SCIENCE

What should CEBAF aim to discover?

Define the questions for nuclear science.

→

ACCELERATOR & HALL CAPABILITIES

What will it take to deliver that science?

Define the capabilities the program requires.

The goal: a bold, credible science vision shaped and owned by the community.

FIRST STEP **CEBAF 2037 Community Kickoff · MIT · December 10–11, 2026**

Or Hen, "CEBAF 2037 — CLAS12 Collaboration Update," November 16, 2026.

A coordinated Hall B vision for CEBAF 2037

Connect the Hall B program to the scientific questions shaping CEBAF's future.

01 Review the ongoing Hall B program and promising future initiatives.

02 Identify scientific opportunities and the capabilities needed to pursue them.

03 Prepare coordinated Hall B input for the December kickoff and topical workshops.

Meeting Agenda

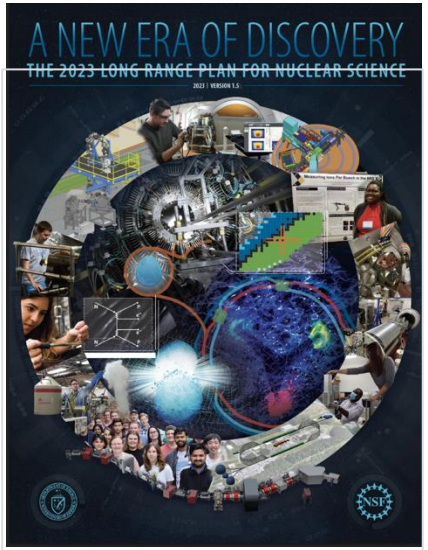
10:00–10:05	**Welcome and Introduction**	Latifa Elouadrhiri
10:05–10:30	**CEBAF 2037 and the December MIT Kickoff**	Or Hen
10:30–11:00	**Perspectives on the 2023 Long Range Plan**	Richard Milner
11:00–11:45	**Hall B and CEBAF 2037**	Stepan Stepanyan
11:45–12:00	**Morning Session Discussion**	
12:00–1:00	**Lunch Break**	
1:00–1:40	**Nuclear Physics**	Raphaël Dupré and Nuclear PWG contributors
1:40–2:20	**Hadron Spectroscopy**	Annalisa D'Angelo and Hadron Spectroscopy PWG contributors
2:20–3:00	**Deep Processes Working Group**	Maria Zurek and Deep Processes PWG contributors
3:00–3:15	**Coffee Break**	
3:15–3:45	**Polarized Target Program Overview**	Chris Keith
3:45–4:00	**Positron Beam Program**	Eric Voutier
4:00–4:15	**Positron Beam Program**	Joe Grames
4:15–4:35	**PRad/X17**	Dipangkar Dutta
4:35–5:35	**Discussion and Next Steps**	All

https://indico.jlab.org/event/1112/

Questions that framed the QCD case in the 2023 NSAC LRP

These questions guide the discussion of CEBAF's science case, following Richard Milner's perspective on the 2023 NSAC Long Range Plan.

01 PROTON STRUCTURE	How big is the proton? Where are quarks and gluons? How does spin arise? Can we image it in 3D?
02 HADRONS & FORCES	What do excited hadrons reveal about QCD? How do quarks and gluons generate pressure and shear?
03 NUCLEI	How does QCD describe nuclei?



CEBAF + CLAS12	**World-class beams and broad acceptance can open up unique and powerful new opportunities for world class research that will be complementary to EIC and extend for more than a decade.**

Richard Milner, "Perspectives on the 2023 NSAC Long Range Plan for U.S. Nuclear Physics," November 16, 2026.

From proton radius to 3D tomography

Three breakthroughs transformed our picture of the proton, from a measured size, to point-like quarks, to a 3D image.

1935–1961

NOBEL PHYSICS

Pions & proton size



Yukawa



Powell



Hofstadter

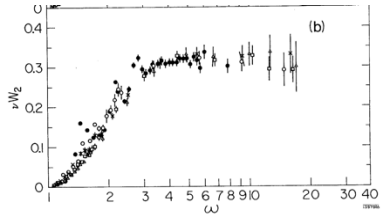
Yukawa proposed the pion as the nuclear-force carrier. Powell discovered it; Hofstadter's scattering measured the proton's finite size. Pions later probed excited nucleons.

PIONS • SCATTERING • NUCLEON EXCITATIONS

1969

NOBEL 1990

Point-like partons

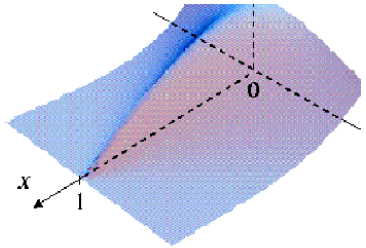


SLAC scattering revealed Bjorken scaling: the proton's constituents behave as point-like partons, later identified with quarks.

FRIEDMAN • KENDALL • TAYLOR

1990s–today

3D tomography



GPDs link quark momentum with transverse position, opening a path to three-dimensional proton imaging.

MÜLLER • JI • RADYUSHKIN

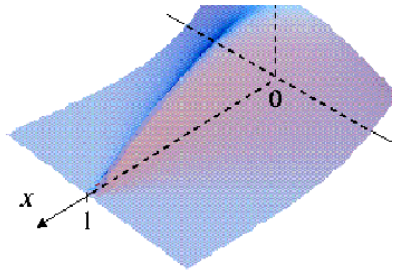
CLAS: first JLab DVCS observation (2001)

FINITE SIZE → POINT-LIKE QUARKS → 3D TOMOGRAPHY

Beyond Imaging: The proton's energy–momentum tensor

From 3D GPD imaging to the gravitational form factors that encode mass, spin and force.

01 3D TOMOGRAPHY



GPDs map quark momentum
and transverse position.

02 GRAVITATIONAL STRUCTURE

THE SAME STRONG INTERACTION CORE

EM CURRENT
Vector J = 1





GRAVITY
J = 2

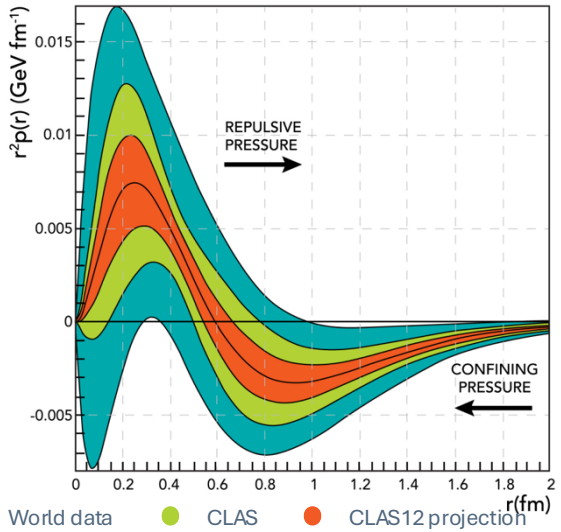
ENERGY–MOMENTUM TENSOR
Gravitational form factors

M_p · mass | J_p · spin | D_p · D-term

GPD moments connect 3D imaging to mass, spin and internal forces.

03 PRESSURE PROFILE

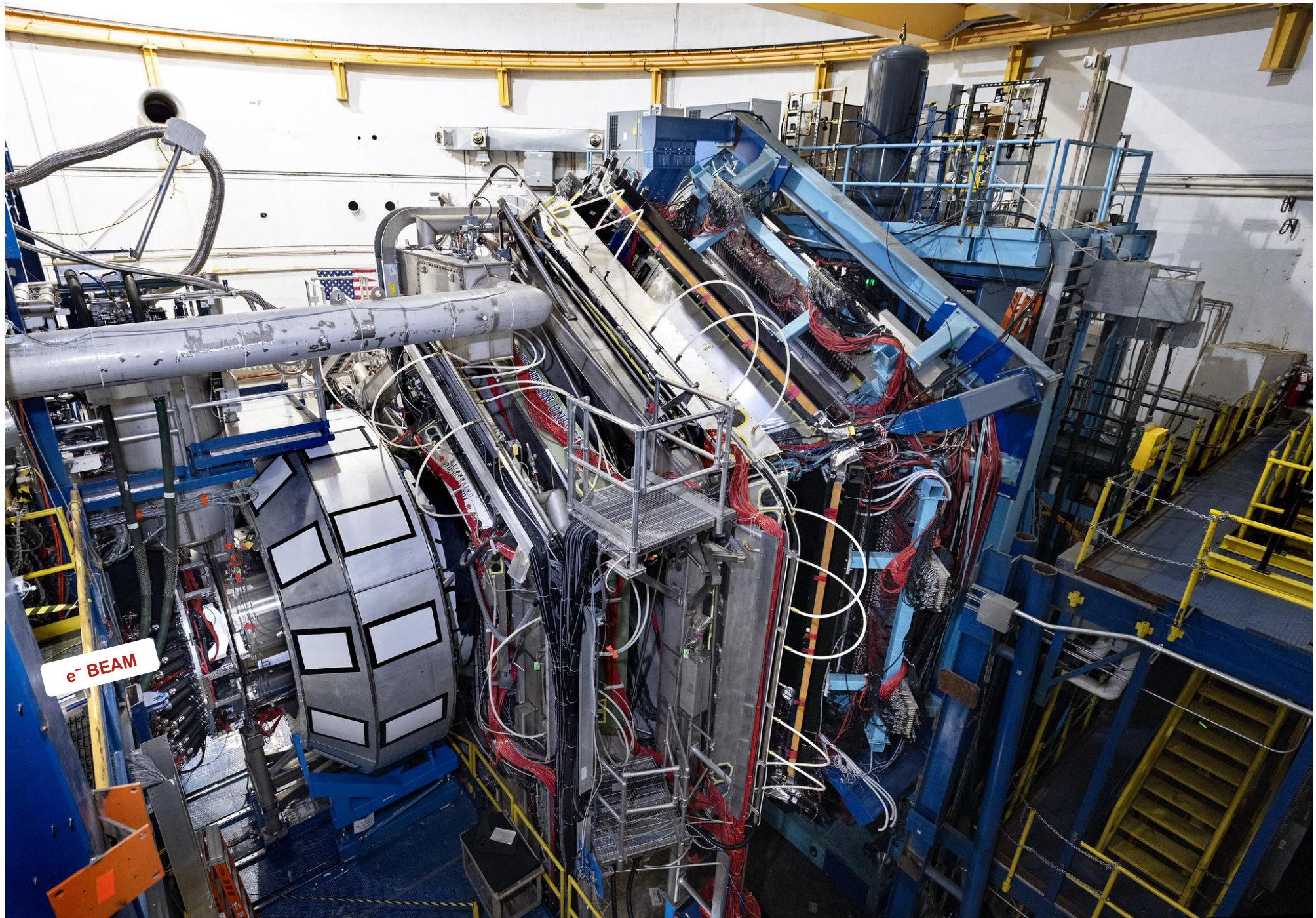
Burkert • Elouadrhiri • Girod | Nature 557 (2018)



M. Polyakov (2003)

ENERGY–MOMENTUM TENSOR MATRIX ELEMENT

$$\langle p_2|\hat{T}^q_{\mu\nu}|p_1\rangle = \bar{U}(p_2)\left[M_2^q(t)\frac{P_\mu P_\nu}{M} + J^q(t)\frac{i(P_\mu\sigma_{\nu\rho}+P_\nu\sigma_{\mu\rho})\Delta^\rho}{2M} + d_1^q(t)\frac{\Delta_\mu\Delta_\nu - g_{\mu\nu}\Delta^2}{5M}\right]U(p_1)$$



CLAS12 Detector

COMMISSIONED IN 2018

The detector has operated successfully since.

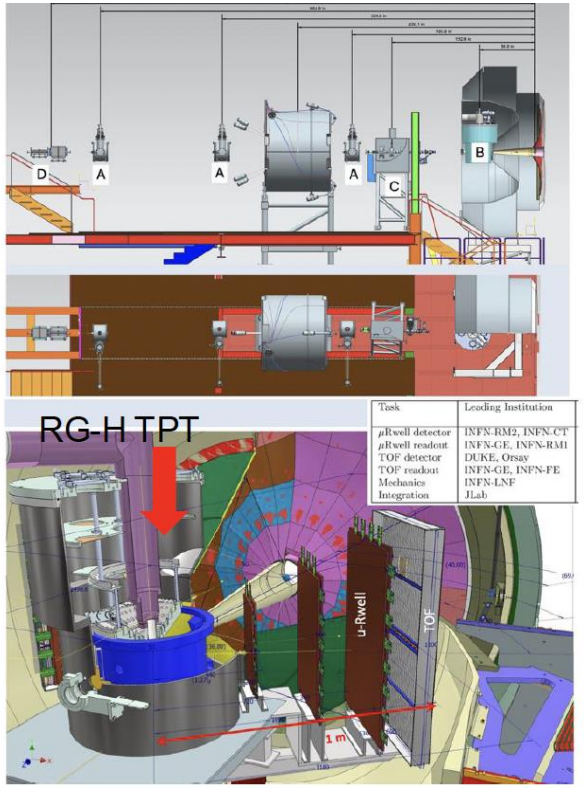
SCIENCE OUTPUT

Peer-reviewed papers including cross-section results submitted for publication show the breadth of CLAS12 science.

Other CLAS12 high-impact experiments

CLAS12 RG-H: Transversely Polarized Target

Approved for 125 PAC days with a scientific rating of “A”.
C12-11-111(A), C12-12-009, C12-12-010.



CLAS12 RG-N: Polarized ^{3}He Target

Approved for 30 PAC days with a scientific rating of “A–”. C12-20-002.



Both projects require significant resources. Beamline and target work must be carefully coordinated.

S. Stepanyan and C. Keith Hall B CEBAF-2037 kickoff, Nov. 16, 2026,

The Hall B approved science program represents ~11 years of running

963

PAC DAYS REMAINING

in the approved 12 GeV electron program

≈ 10.7 years

at ~90 PAC days per year

CLAS12

764

PAC days remaining

~8.5 run years

Other Hall B experiments

199

PAC days remaining

~2.2 run years

12 GeV e+ program

210

PAC days approved

~2–3 additional years

Run-year estimates assume ~26 weeks of physics availability per year; positron running is separate.

The estimate excludes future experiments, additional setup and commissioning time, and scheduling-related losses.

S. Stepanyan, Hall B CEBAF-2037 kickoff, Nov. 16, 2026

CEBAF 2037 comes at a pivotal moment for Hall B

Since its commissioning in 2018, CLAS12 has operated successfully. Hall B is strengthening its software, calibration, and analysis tools, including through advances in AI. The cross section program has produced one published paper, with two more submitted for publication. This progress reflects the collaboration's detailed understanding of CLAS12 performance. Hall B has also demonstrated its ability to accommodate specialized experiments requiring new detection systems and to transition efficiently between CLAS12 and other experimental configurations. The collaboration is advancing designs for a transversely polarized target and a polarized ^{3}He target, while developing new initiatives, including higher luminosity program.

Now is the moment for Hall B to build on its proven foundation and help shape the science program and capabilities of CEBAF's next era.

Five CLAS12 science themes

01

Confinement and internal forces

GPDs and exclusive reactions connect the proton's structure to mass, pressure and shear. Multiple energies

02

3D structure and spin

GPD E, neutron flavor separation, SIDIS, TMDs and polarized targets. Multiple energies.

03

Formation and spectroscopy

Excited and exotic hadrons, hadronization and the transition across reaction regimes.

04

QCD in nuclei and at high x

SRC, EMC, tagged DIS, high-x structure and in-medium hadronization.

05

Precision tests and new physics

Positron comparisons, two-photon exchange and precision opportunities discussed at the meeting such as Prad and X17.

Proposed CLAS12 synthesis for discussion, not a formal priority ranking

Five CLAS12 science themes

A Hall B roadmap mapped to Or Hen's five fundamental questions

01

Confinement and internal forces

GPDs and exclusive reactions connect the proton's structure to mass, pressure and shear. Multiple energies

OR HEN FRAME

MASS / STRUCTURE

02

3D structure and spin

GPD E, neutron flavor separation, SIDIS, TMDs and polarized targets. Multiple energies.

OR HEN FRAME

STRUCTURE

03

Formation and spectroscopy

Excited and exotic hadrons, hadronization and the transition across reaction regimes.

OR HEN FRAME

FORMATION / MASS

04

QCD in nuclei and at high x

SRC, EMC, tagged DIS, high-x structure and in-medium hadronization.

OR HEN FRAME

NUCLEI / STRUCTURE

05

Precision tests and new physics

Positron comparisons, two-photon exchange and precision opportunities discussed at the meeting such as Prad and X17.

OR HEN FRAME

BSM

Proposed CLAS12 synthesis for discussion, not a formal priority ranking

Beam energy: extending Hall B's physics reach

Start from the delivered 10.6 GeV beam; judge each possible increase by the physics reach it adds.

11 GeV

DELIVERED BEAM

Full use of the delivered beam strengthens high-x measurements.

+1–2 GeV

POTENTIAL INCREASE

Could enhance J/ψ photoproduction yields and extend high-x reach, especially at higher luminosity.

A BROADER Q^2 LEVER ARM

10.6 GeV DATA → 16 GeV SCENARIO

Combining JLab energy settings with HERMES and COMPASS broadens Q^2 coverage. The wider lever arm supports model-independent separation of dynamical contributions with controlled systematics, sharpens GPD extractions, and strengthens the EIC connection.

More beam energy expands the Hall B science program to higher kinematics, and opens L/T separation at higher Q^2.

Energy scenarios frame science opportunities

Capabilities that turn new physics into measurements

The key upgrades are complementary: preserve broad CLAS12 acceptance while adding dedicated capabilities for exclusive, forward-angle, and high-luminosity measurements.

PHYSICS CASE	DETECTOR / TARGET NEED	BEAM / KINEMATIC NEED
GPDs & proton forces	High-resolution photon calorimetry at 2.5°–5°; γ/π^0 separation to ~9 GeV; recoil protons at 40°–65° and 150–500 MeV/c.	Large −t coverage, especially smallest −t (down to ~0.02 GeV^2); exclusive final-state reconstruction.
DDVCS / μCLAS12	Muon ID in forward detector; dedicated shielding and detectors; recoil-proton detector near target for exclusivity.	High luminosity; pair production with $\mu^+\mu^-$; use electron detection in new wide-angle calorimeter.
N* / meson spectroscopy	Broad acceptance and high-statistics tracking; electron-angle acceptance toward 70° for the highest Q^2 reach.	At 2×10^{35}: $Q^2\approx12$ GeV^2 ($\pi^+\pi^-p$); up to ~16 GeV^2 with wider electron-angle coverage; meson program targets W>3 GeV.
Nuclei / radii / e^+ program	Polarized H, ^{3}He and tritium targets; magnet-free calorimeter + GEM tracking + recoil detector for precision radii; e^+ polarimetry and charge measurement.	High-x: delivered 11 GeV and higher luminosity; e^-/e^+ comparisons; dedicated low-Q^2 reach for charge radii.

System-level drivers: luminosity, forward-angle acceptance, recoil / neutral / muon identification, and target flexibility.

Planned CLAS12 Upgrade Path

LUMINOSITY PATH

$2\times10^{35} \rightarrow 4\text{–}5\times10^{35} \rightarrow \sim10^{36} \rightarrow \geq10^{37}\ \mathrm{cm^{-2}\ s^{-1}}$

COMPLETE / BASELINE

µRWELL on R1 DC

$\geq2\times10^{35}$

With FT-on, the detector targets >90% forward-tracking efficiency and supports the approved CLAS12 program.

CONFIGURATION STUDIES

Møller cone

$4\text{–}5\times10^{35}$

Elmo (5°) and Elmo7 (7°); FT-off and No-FT configurations have been used to reduce background. Trade-off: reduced very-forward detection; CVT/FVT enhancements may be needed.

INTERMEDIATE CONCEPT

Mini-µCLAS12

$\sim10^{36}$

wECal + Pb shield covers 7°–15°. Requires stronger CVT/FVT capability and added shielding for R3 drift chambers. Intermediate stages need new physics proposals.

PAC53 APPROVED / PHASED

µCLAS12

$\geq10^{37}$

wECal with APD readout + Pb shield replaces FT/HTCC; central and forward vertex trackers and a recoil hodoscope. Phased implementation.

S. Stepanyan, Hall B CEBAF-2037 kickoff, Nov. 16, 2026

From kickoff to the CEBAF 2037 white paper

Or Hen's timeline moves from community questions to science and technical workshops, then a reviewed program and white paper.

DEC 10–11, 2026

MIT kickoff

Refine the scientific questions; map opportunities and challenges.

Q1 2027

Science workshops

Develop physics opportunities, key measurements, and theory needs.

Q2 2027

Technical workshops

Address accelerator, detector, and computing needs; assess feasibility and resources.

SUMMER 2027

Emerging program

Discuss the emerging program with the community and review it with the Lab.

MARCH 2028

White paper

Deliver a community-supported paper and share it with key stakeholders.

Workshop reports and community input feed a transparent, Lab-led review and prioritization process.

Schedule shown in Or Hen's CEBAF 2037 presentation at the Nov. 16, 2026 CLAS kickoff.

Hall B timeline to a December 2027 white paper

A focused sequence can deliver Hall B's science and capability case by December 2027.

NOV– JAN 2027	**Organize and frame**	Confirm working-group leads, scope, writing roles, and the Hall B paper outline.
Q1 2027	**Build the science cases**	Each group defines the core questions, major advances, key measurements, theory needs, and CEBAF–EIC connections.
Q2 2027	**Define capabilities**	Translate the science into beam energy, luminosity and polarization; target, detector, DAQ, and computing requirements; note feasibility and resources.
SUMMER 2027	**Integrate the program**	Synthesize the working-group cases; review the emerging Hall B program with the community and Lab.
SEP–OCT 2027	**Write and review draft**	Complete a full draft with science rationale, measurement reach, capability roadmap, figures, and references; conduct cross-group review.
NOV 2027	**Community review**	Circulate the draft, resolve comments, and complete technical and editorial checks.
DEC 2027	**Deliver Hall B paper**	Finalize the Hall B white paper and its contribution to the CEBAF 2037 process.

Hall B target: December 2027 • CEBAF-wide white paper: March 2028

Summary

- Hall B unites a strong collaboration around a broad, coherent program in nucleon structure, confinement, hadron spectroscopy, structure of excited states, nuclear QCD, and precision measurements.
- New initiatives are taking shape, expanding Hall B's scientific reach.
- Targeted upgrades can provide the capabilities this program needs and sustain Hall B's discovery potential over the next two decades.
- A positron beam and higher energies will extend Hall B's program to new regime.
- Strong participation at the December MIT meeting, continued engagement, and new collaborators across the physics community will help shape a clear JLab white paper with broad community support.

Together, these strengths position Hall B to make a major contribution to CEBAF 2037.