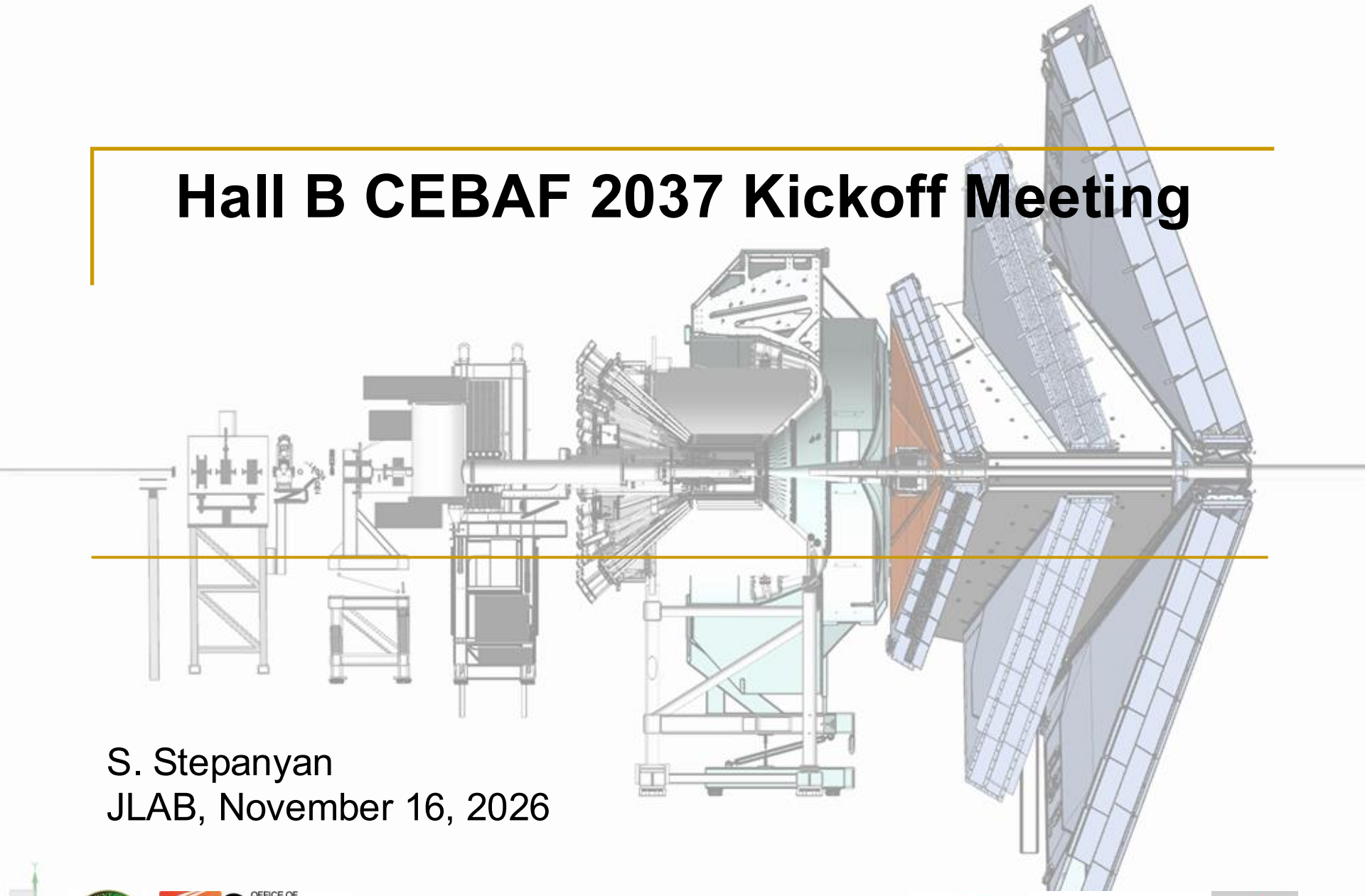
Hall B CEBAF 2037 Kickoff Meeting



S. Stepanyan
JLAB, November 16, 2026

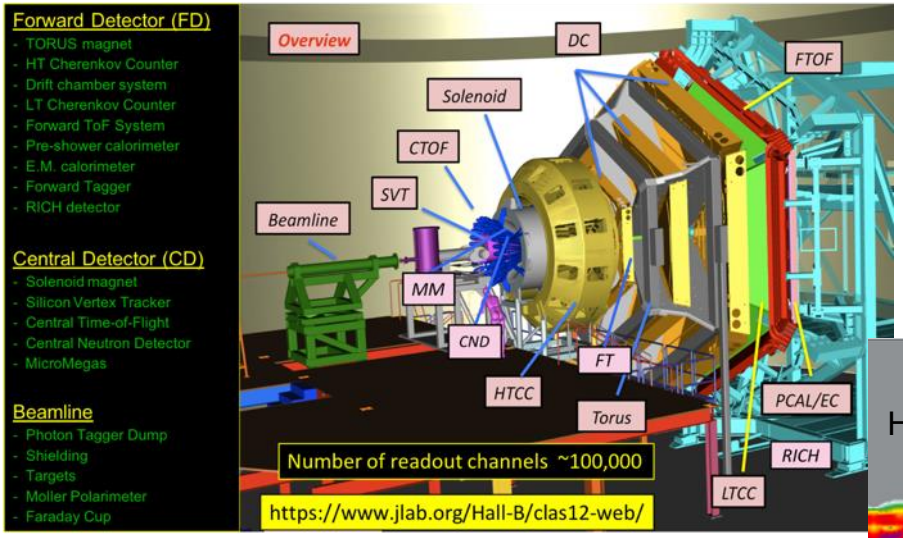
OFFICE OF SCIENCE

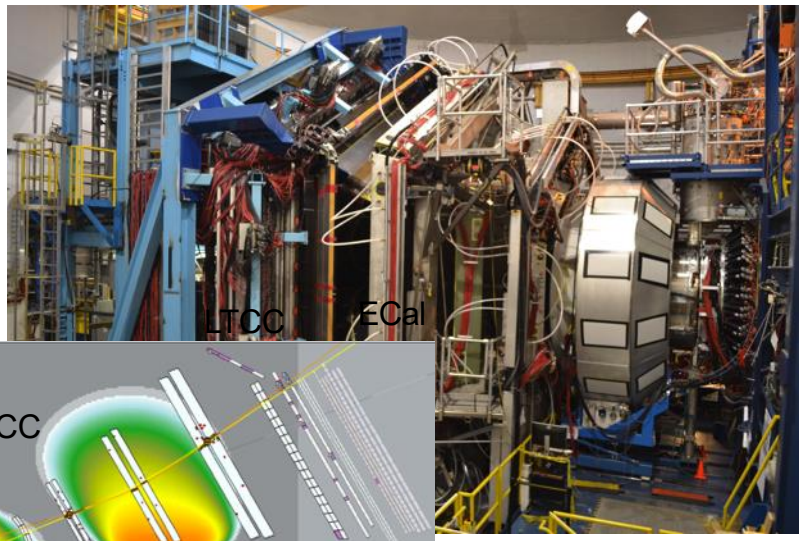
Jefferson Lab
Thomas Jefferson National Accelerator Facility

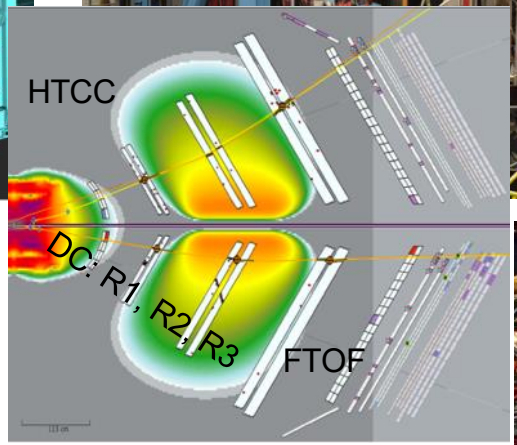
JSA

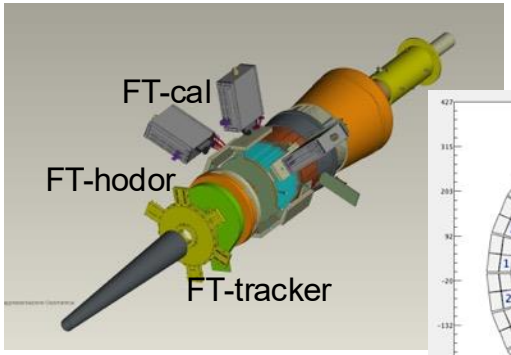
CLAS12 in Hall-B at JLAB

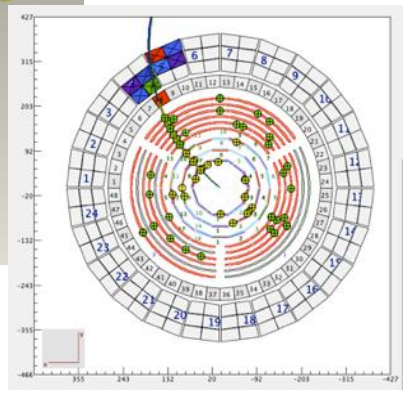
Designed luminosity $10^{35}\mathrm{cm}^{-2}\mathrm{sec}^{-1}$, commissioned in 2017, in production since 2018











Physics targets:

- LH_2, LD_2, LHe, LAr, D, ^{4}He
- ^{12}C to ^{208}Pb
- Polarized NH_3, ND_3, ^{6}LiH, ^{7}LiD, ^{3}He-gas

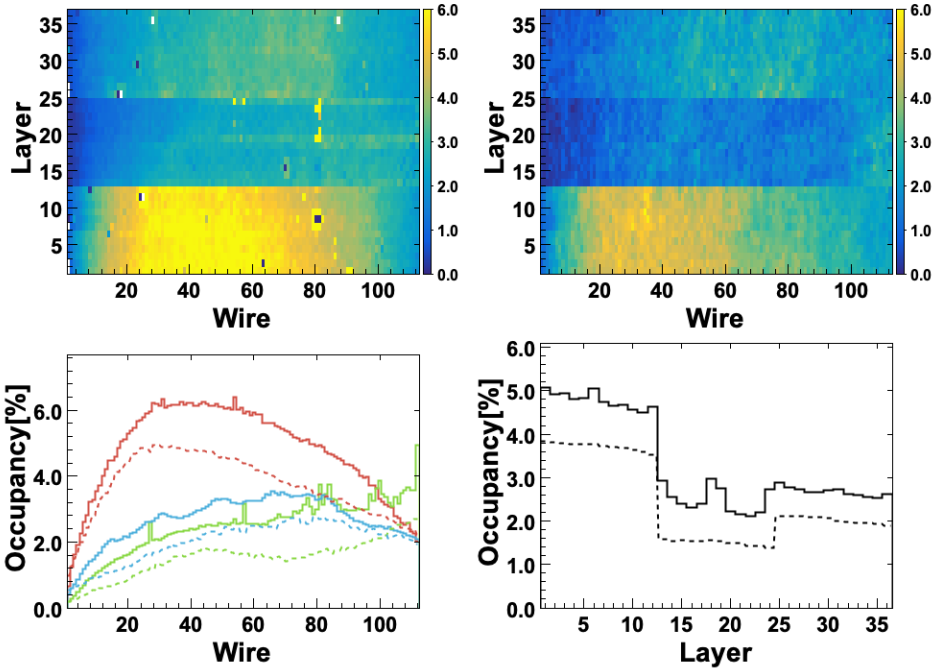


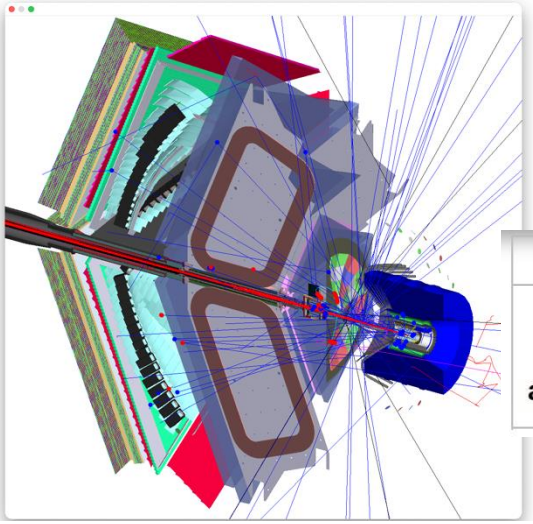
CLAS12 performance

- After commissioning, CLAS12 has run at $\geq 10^{35} cm^{-2} sec^{-1}$ luminosity on a variety of targets.
  - RG-A average luminosity on a 5cm LH_2 was $0.7 \times L$. With vacuum windows and air downstream of the scattering chamber, it was $\sim L = 10^{35} cm^{-2} sec^{-1}$.
    - RG-B ran at $1.5L$ per nucleon, and RG-D ran close to $2L$.
- We made significant efforts to improve forward-tracking efficiency through reconstruction developments, including SI/ML techniques.
- We are pursuing similar improvements for central-detector tracking.
- Significant efforts went into improving detector response and background modeling in the CLAS12 GEANT4 simulation package (GEMC).
- Many SI/ML approaches to PID pushed the limits of detector-only capabilities.

GEANT4 model improvement

- Significant efforts went into improving the CLAS12 GEANT4 model (GEMC).
- Modeling beam background is crucial for high-luminosity detector design.
- The current GEMC reproduces background occupancies in detectors within 25%.





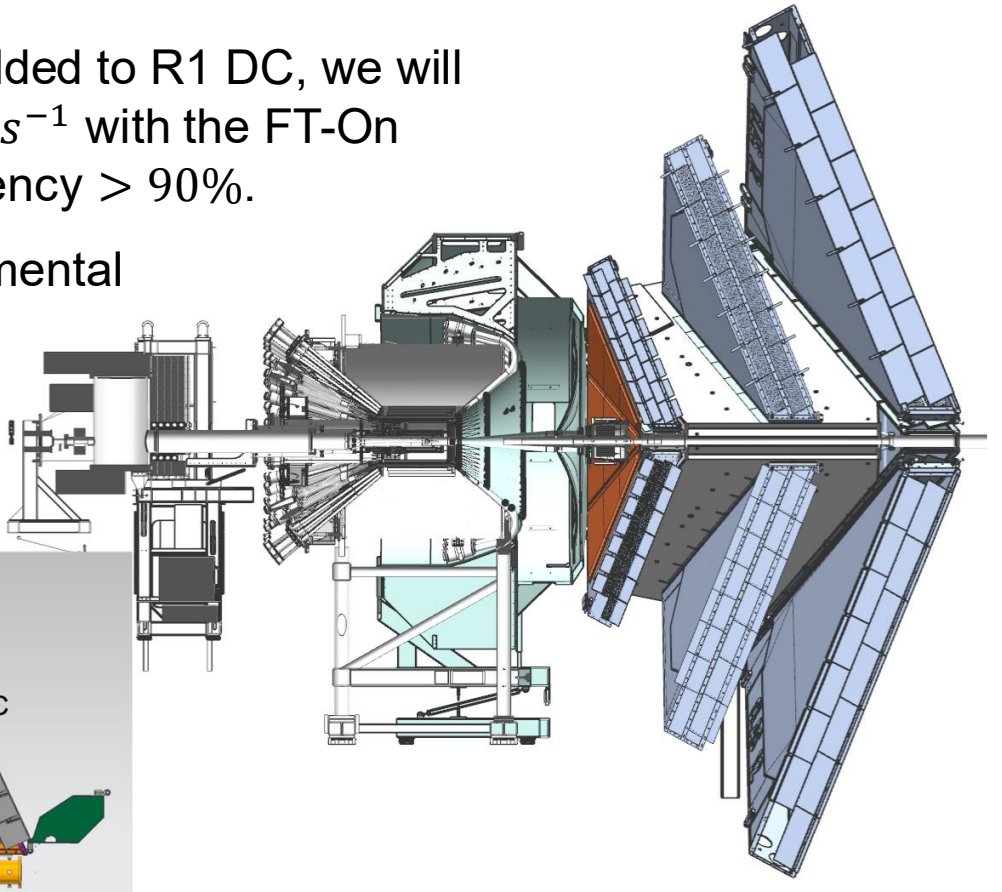
Configuration		FTon	FToff	Elmo	muCLAS12	Elmo7
Average Occupancy at 50 nA (%)	R1	3.71	1.59	0.91	0.49	0.67
	R2	1.51	0.83	0.74	0.58	0.63
	R3	2.02	1.22	1.09	0.76	0.89

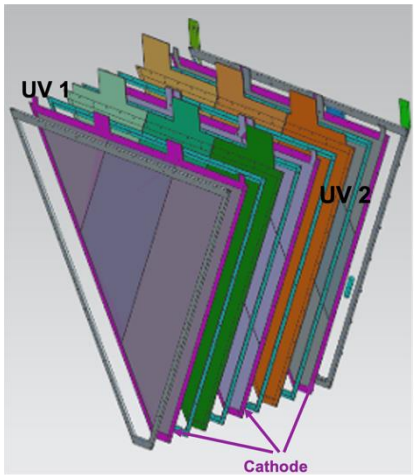
Improving CLAS12 performance

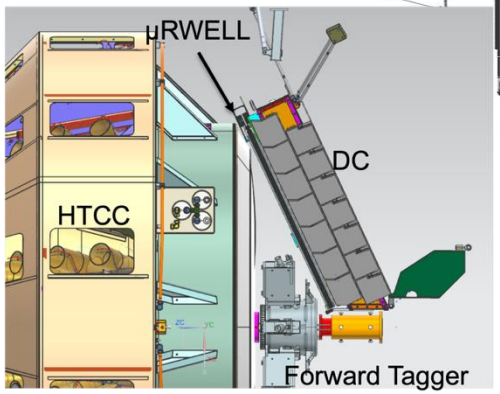
- With the μRWELL tracking upgrade complete, I consider the forward detector well positioned to support future CLAS12 physics programs.
- We should be realistic about the other upgrades. It is not only about money but also about people.
- A few major CLAS12 projects are already underway, and resources are scarce.
- The central detector, however, is a different story. Upgrading it to a more rate- and radiation-tolerant system is essential for the long-term physics program.
- This upgrade is already part of μCLAS12 proposal. But the options discussed in the proposal are not the best. Better solutions exist, although they may cost somewhat more and must be studied.
- We are planning to perform high luminosity studies

Next few years

- With the current state of the software, we can run close to $L \approx 2{\times}10^{35} cm^{-2} s^{-1}$ in RG-A configuration.
- With μRWELL tracking detectors added to R1 DC, we will comfortably run at $L \geq 2{\times}10^{35} cm^{-2} s^{-1}$ with the FT-On configuration and FD tracking efficiency $> 90\%$.
- Fully supports the approved experimental program with CLAS12.







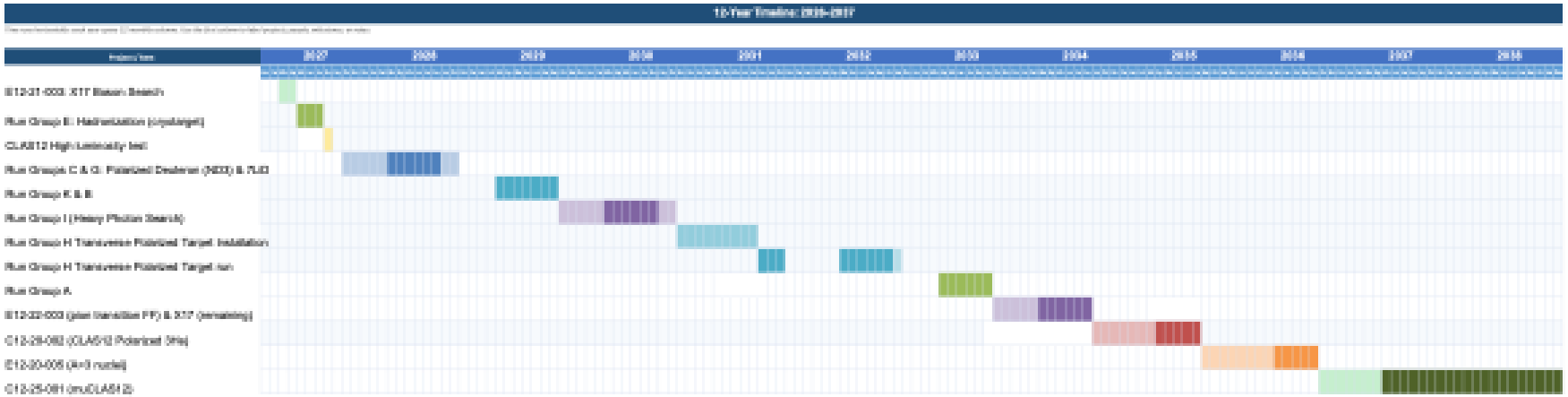
Experiment ID	Proposal title	Contact	PAC rating	Days approv.	PAC	Aloc. PAC's run	Detector	Beam energy	Hall-A contact	Target	Days complete	% complete	Days remain	Total publications	Latest publication	Publications in peer-reviewed journals
E12-06-119(a)	Deeply virtual Compton scattering	M. DeLoura	A	80	30	48, 50								1	1	PRL 128, 21802 (2022), arXiv:2008.20889
E12-06-108	Hard exclusive electro-production of π^0, η	P. Stoler	B	80	38	48, 50								1	1	PL B 848, 138409 (2024)
E12-12-007	Exclusive η meson electroproduction	P. Bosted, S. Mayilyan	B+	50	50	48, 50										
E12-06-112	Proton's quark dynamics in SIDIS pion production	H. Avakian	A	60	38	48, 50								5	5	PRL 129, 132001 (2022), PRL 129, 162001 (2022), PRL 130, 162001 (2023), PL B 830, 137189 (2022), PRL 134, 024904 (2025)
E12-06-117, E12-06-117A, E12-06-117B	Semi-inclusive π production in target fragmentation region	M. Mirazita			42	48, 50										PRD 113, 052019 (2026)
E12-06-122B	Collinear nucleon structure at twist-3 in inclusive SIDIS	M. Mirazita				48, 50								1	1	PRL (arXiv:2602.1477)
E12-06-107(a)	Study of partonic distributions in kaon SIDIS	W. Armstrong	A-	110	35	48, 50								1		PRC 112, 055202 (2025)
E12-11-001	Timelike Compton scattering and J/ψ photoproduction	P. Nadel-Turonski	A-	120	39	48, 50								1	1	PRL 127, 262501 (2021)
E12-12-001A	Near threshold J/ψ photoproduction and LHCb pentaquarks	S. Stepanyan		45		48, 50								1		PRC 113, 065203 (2026)
E12-09-003	Nucleon Resonance Studies with CLAS12	H. Szumila	B+	40	34	48, 50								2		PRC 112, 035201 (2025), arXiv:2008.10995
E12-06-109A	Exclusive N^* to $K\Lambda$ studies with CLAS12	D. Carman		42		48, 50								1		PRC 112, 035208 (2025)
E12-06-108B	Transition form factor of the η' meson with CLAS12	S. Stepanyan		60		48, 50										
E12-11-005	Hadron spectroscopy with forward tagger	M. Battaglieri	A-	110	37	48, 50										
E12-11-005A	Photoproduction of very strange baryon	L. Guo			40	48, 50										
E12-07-104	Neutron magnetic form factor	G. Gilfoyle	A-	30	32	48, 50										
E12-06-107(b)	Study of partonic distributions in kaon SIDIS	W. Armstrong	A-	110	35	48, 50										
E12-07-108A	Quasi-real photoproduction on deuterium	F. Hauenstein		67		48, 50										
E12-09-008	Beam Motoro asymmetry in case SIDIS with H and D targets	M. Contalbrigo		56	38	48, 50										
E12-06-105B	Collinear nucleon structure at twist-3 in inclusive SIDIS	M. Mirazita		42		48, 50										
E12-11-003	DVCS on the neutron	S. Niccolai	A (HD)	90	38	48, 50								1	1	PRL 133, 21901 (2024)
E12-11-003A	In medium structure functions, SRC, and the EMC effect	O. Hen		40		48, 50										
E12-11-003B	Study of J/ψ photoproduction from the deuteron	Y. Ilieva		60		48, 50										
E12-09-109	Longitudinal spin structure of the nucleon	S. Kuhn	A	50	30	48, 50										
E12-06-109A	DVCS on the neutron with polarized deuterium target	S. Niccolai			44	48, 50										
E12-06-119(b)	DVCS on longitudinally polarized proton target	M. DeLoura	A	120	30	48, 50										
E12-07-107	Spin-orbit correlations with longitudinally polarized target	H. Avakian	A-	100	35	48, 50										
E12-07-109A	Single baryon production in the target fragmentation region	T. Hayward			50	50										
E12-09-007(a)	Study of partonic distributions using SIDIS K production	W. Armstrong	A-	80	35	48, 50										
E12-06-107A	Ollestron electroproduction in DIS	C. Dilks			48	50										
E12-09-009	Spin-orbit correlations in K production with collinear targets	H. Avakian	B+	100	35	48, 50										
E12-06-108	Color transparency in exclusive vector meson production	L. El Fassi	B+	50	30	48										
E12-06-109A	Nuclear TMDs	R. Dupre			45											
E12-06-117	Quark propagation and hadron formation	W. Brooks	A-	60	30	48										
E12-06-117A	Ollestron measurements in electron-nucleus scattering	M. Amaryan			48											
E12-09-112	Free neutron structure at large x	S. Bueltmann	A	40	30											
E12-06-119A	Neutron DVCS measurements with BONuS12	W. Hathway			47											
E12-14-001	EMC effect in spin structure functions	W. Brooks	B+ nA	50	35	48, 50										
E12-11-111	SIDIS on transverse polarized target	M. Contalbrigo	A+C/D+A	110+120	39, 50	48, 50										
E12-12-009	Transversity with ollestron on transverse target	H. Avakian	A+C/D+A	110+120	30, 50	48, 50										
E12-12-010	DVCS with transverse polarized target	L. Elouadrhiri	A+C/D+A	110+120	39, 50	48, 50										
E12-11-111A	Measurements of target spin asymmetries in exclusive production of kaons with 11 GeV transversely polarized electrons	H. Avakian			45											
E12-14-001	A search for hybrid baryons	A. D'Angelo	A-	100	45	48										
E12-10-103A	Nucleon Resonance in exclusive KY electroproduction	D. Carman			44	48										
E12-06-108B	DVCS at 6.6 and 8.8 GeV	L. Elouadrhiri			45	48										
E12-10-103C	Separation of the σ_L and σ_T contributions to hadron production	H. Avakian			45											
E12-17-012	Partonic structure of light nuclei	Z. Meziani	A-	55	45											
E12-11-112A	Tagged EMC measurements on light nuclei	R. Dupre			45											
E12-11-112B	Spectator-tagged DVCS on light nuclei	W. Armstrong			45											
E12-11-112C	Other physics opportunities with ALERT	R. Dupre			45											
E12-17-008	Electrons for neutrinos addressing neutrino-nucleus issues	O. Hen	A	45	45											
E12-16-005	Exclusive studies of short-range correlations in nuclei	O. Hen			45											
C12-28-002	Spin dependent electron scattering with polarized ^{3}He target	R. Milner	C1 (A-)	30	48											
E12-25-005	Precision measurements of A=3 nuclei	H. Szumila-Vance	A-	60	40											
E12-25-013	Measuring Short-Range Correlations with ALERT	F. Hauenstein	A	17	50											
C12-25-001	Electro- and photo-production of muon pairs with μCLAS12	S. Stepanyan	C1 (A)	240	50											
Non-e CLAS RDs																
E12-11-005	Heavy Photon Search (HPS)	T. Nelson	A	150	37, 39	48, 50										
E12-11-106	High precision measurement of proton charge radius (PRad)	A. Gasparian	A	15	39											
E12-20-004	High precision measurement of proton charge radius (PRad-II)	A. Gasparian	A	45	45											
E12-21-003	A direct detection search for hidden sector vector particles (DarkMatter)	A. Gasparian	A	60	60											
E12-23-005	Precision measurement of neutral pion transition form factor	I. Larin	A-	57	50											

764 PAC days remain for the CLAS12 11 GeV e^- program. About 8.5 years of running, with 26 weeks per year of CEBAF availability for physics.

For non-CLAS12 experiments, the remaining beam time is 199 PAC days, or about 2+ years of running (26 weeks).

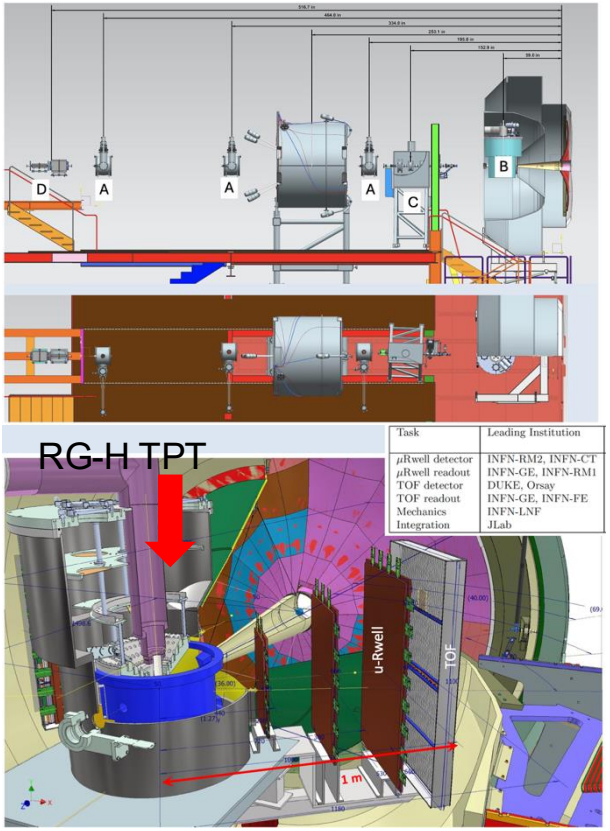
Another two to three years are needed to complete the 12 GeV e+ program.

Straw-man schedule



High-importance experiments

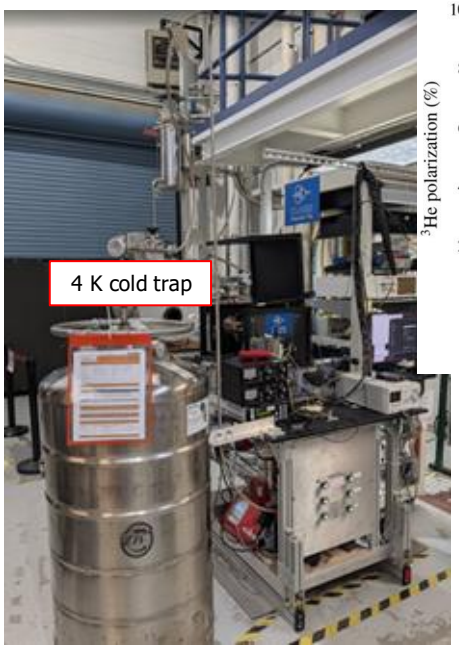
CLAS12 RG-H: Transversely Polarized Target - approved for 125 PAC days with a scientific rating of "A", C12-11-111(A), C12-12-009, C12-12-010.



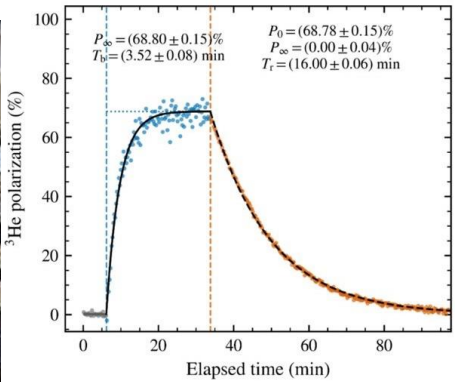
Task	Leading Institution
μRwell detector	INFN-RM2, INFN-CT
μRwell readout	INFN-GE, INFN-RM1
TOF detector	DUKE, Orsay
TOF readout	INFN-GE, INFN-FE
Mechanics	INFN-LNF
Integration	JLab

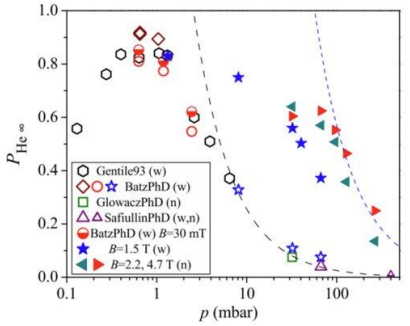
CLAS12 RG-N: Polarized 3He Target - approved for 30 PAC days with a scientific rating of "A-", C12-20-002.

Tests at 1, 10, & 50 mbar gave good polarization results.
A 100 mbar test gave poor results, practically 0%.
The problem is traced to gas impurities, especially hydrogen.
Better cleaning and purification – Bake to 400 C, **add a 4 K cold trap**



From Chirs Keith





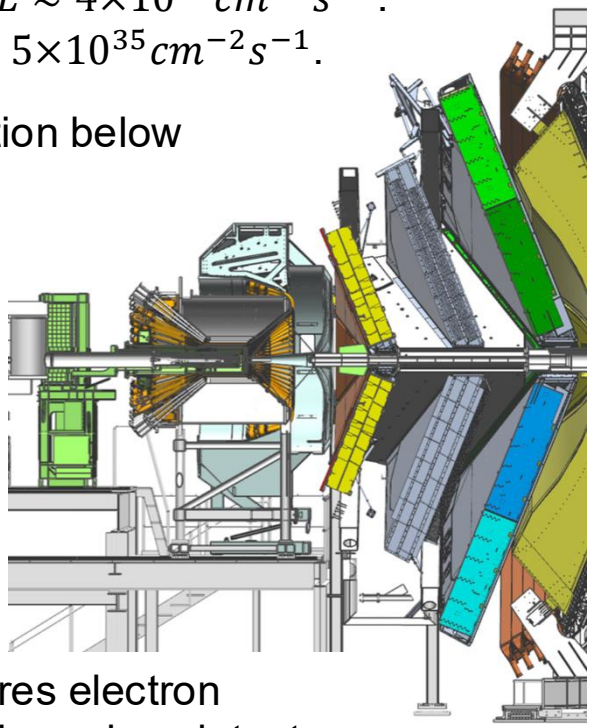
Solid points above 1 T

From Gentile, Nacher, Saam, Walker (2017.)

Both require significant CE investment and resources from the Lab – beamline and the target, which must be carefully coordinated.

Upgrades: Next few years

- Variations of CLAS12 configurations with different Moller cone coverage have already been used to lower the background (FT-Off and No-FT configs).
  - A large Moller cone, covering up 5° (*Elmo*) will get us to $L \approx 4\times10^{35} cm^{-2}s^{-1}$. Cone covering up to 7°, *Elmo7,* can allow running at $L \approx 5\times10^{35} cm^{-2}s^{-1}$.
  - NO FT, no e'/γ tagging, and for Elmo7, no particle detection below 7°. May require enhanced capabilities for CVT and FVT.

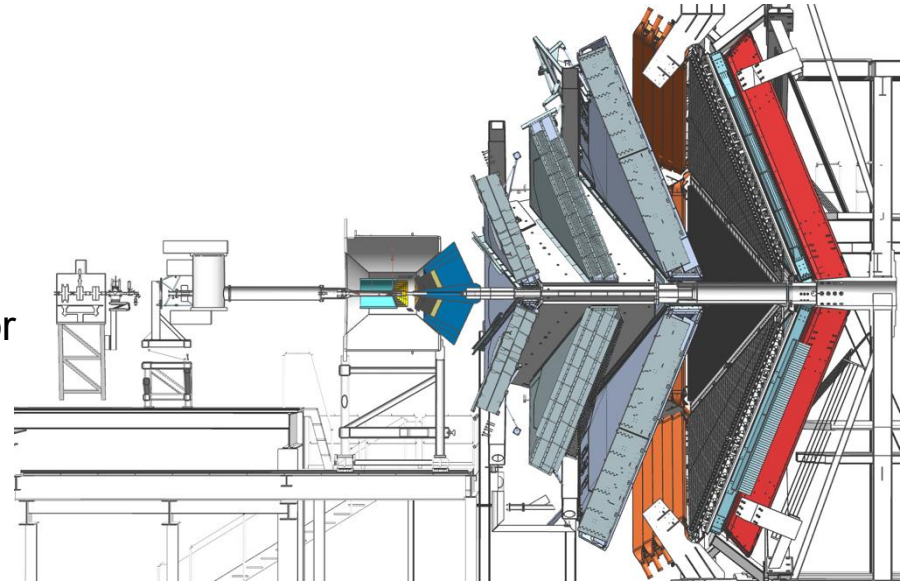


The loss of particle detection at very forward angles has a limited impact on the existing physics program (MesonX and DVCS are most impacted) while enabling ***high-statistics measurements in demanding kinematic domains such as high Q^2*** *and* ***-t****.*

One of the physics topics discussed (N* program) requires electron detection in CD. Replacing the CTOF with an aerogel Cherenkov detector using SiPM-based light readout could provide the required capability. Further studies are needed to evaluate its feasibility and performance.

More long-term: μCLAS12 to $L \geq 10^{37} cm^{-2} s^{-1}$

- **μCLAS12 (E12-25-001,** *EPJ A 62*, 157, 2026**) approved by PAC53**:
  - Configuration – **wECAL,** $PbWO_4$ calorimeter with APD readout, and **Pb shield** to replace FT and HTCC.
  - Central and forward vertex tracker and a scintillation hodoscope for recoil detection.
  - Transforms the CLAS12 forward detector into a high-rate muon detector optimized for rare exclusive processes.



- **Physics goals of E12-25-001**:
  - **DDVCS and eJ/ψ** in the final state $e'\mu^+\mu^-$.
  - **pTCS** in the final state $p'\mu^+\mu^-$.

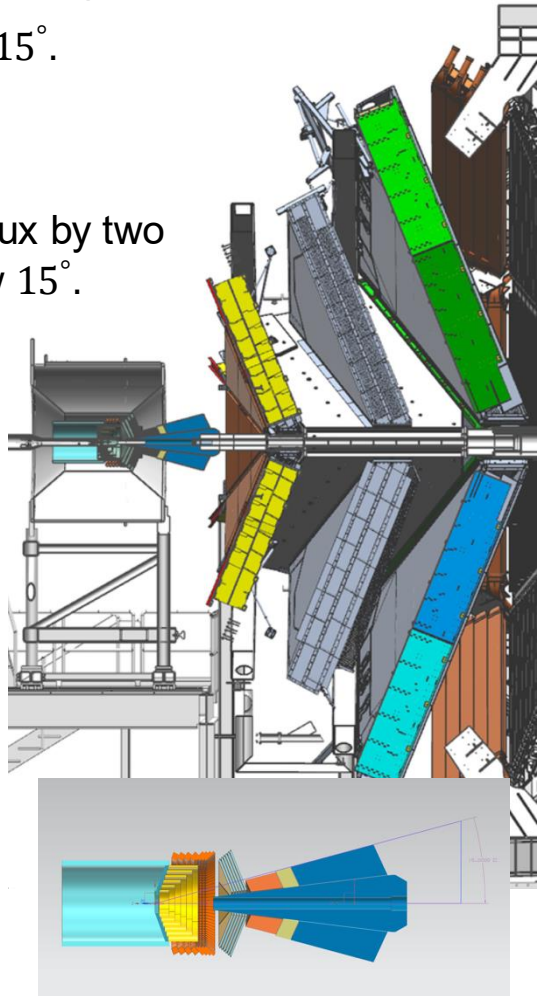
- **Other physics** (discussed at the high luminosity workshop):
  - Any reaction that, in the final state, has $\mu^{\pm}$ and/or e' and γ forward and charged hadrons at $40^{\circ} < \vartheta < 80^{\circ}$.

To manage the technical challenges of the upgrade while enabling an earlier start to the physics program, the collaboration adopted a phased implementation of **μCLAS12**.

Intermediate step: Mini-μCLAS12

Halfway to μCLAS12. Occupancies in FD will allow running at $L \approx 10^{36} cm^{-2} s^{-1}$.

- wECal and the lead shield cover the angular range from 7° to 15°.
- Above 15°, the forward detector is the same.
- The wECal can detect electrons and photons.
- wECAL and the lead shielding suppresses the charged-pion flux by two orders of magnitude, enabling clean detection of muons below 15°.
- ***Will*** require enhanced capabilities for the Central (CVT) and Forward (FVT) Vertex Trackers, and better shielding downstream of the torus for R3 DC.



Physics case:

- Nucleon recoils from near-threshold J/ψ production produced in 15° and 30° the angular rage, well suited for **near-threshold J/ψ production studies on deuterium and heavier nuclei**, enabling studies of the gluonic structure of matter, sub-threshold production, and EMC-type effects.
- **pTCS** and a first stab at **DDVCS**.
- The setup is also very similar to what we had for the CLAS-DVCS program, it enables **high-statistics DVCS** measurements.

Summary

- **Approved physics program:** ~11 years of experimental running time on the books. This does not include future experiments, additional setup and commissioning time, or scheduling-related losses.
- **Near-term capability:** Following the FD tracking upgrade with μRWELL detectors, Hall B can comfortably operate at $L \geq 2\times10^{35} cm^{-2}s^{-1}$ with the FT-On and FD tracking efficiency $> 90\%$.
- This fully supports the approved CLAS12 experimental program with high statistical precision.
- **Future luminosity path:** Ongoing work toward higher luminosities: $4\times10^{35} cm^{-2}s^{-1} \Rightarrow 10^{36} cm^{-2}s^{-1} \Rightarrow 10^{37} cm^{-2}s^{-1}$.
- **Technical challenges:** Higher luminosities require additional detector upgrades, including vertex-tracking systems, but are technically achievable.
- Physics case for μCLAS12 with $10^{37} cm^{-2}s^{-1}$ luminosity received highest rating and approval from PAC53.
- Intermediate luminosity stages could support a broader physics program, but require new physics proposals to make them happen.