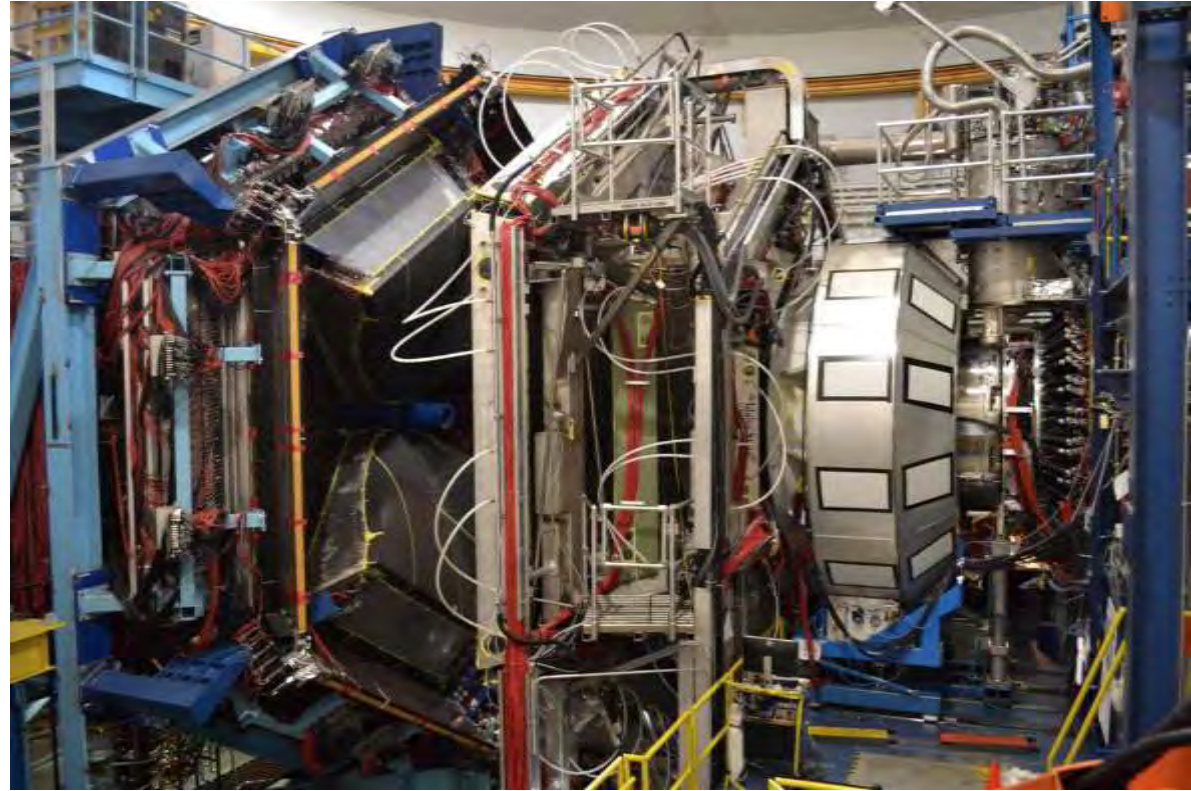


Hall B Status Report

- News from the Hall B Group
- Hall B Setup Changes
- Status of RG-C Data Taking
- Status of Alignments & Calibrations
- Developments and Upgrades
- Updated Run Group Schedule
- Collaborations & Cooperations
- Backup: Recent Analyses and Papers

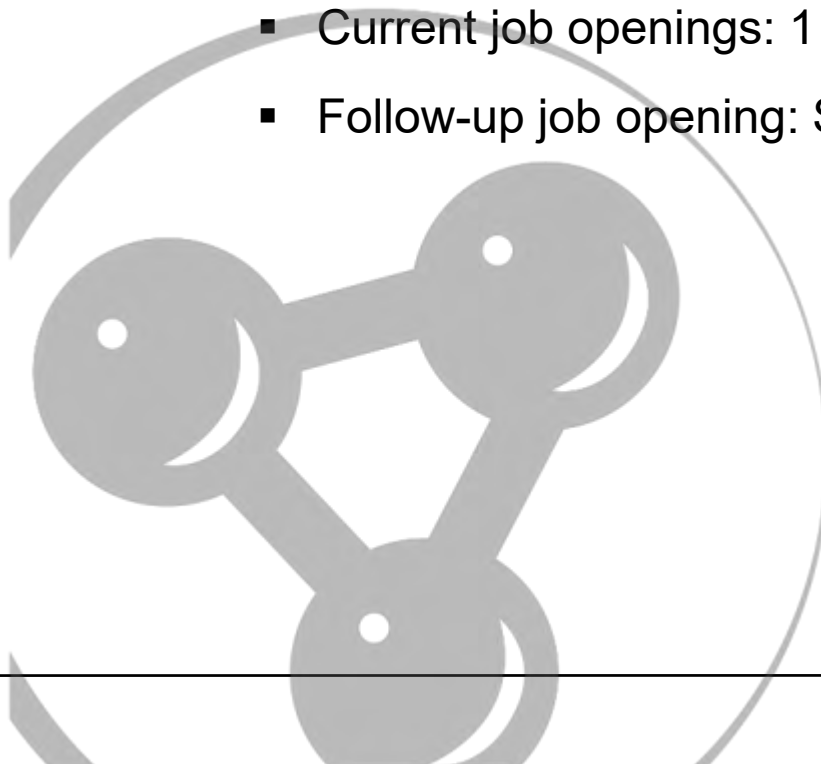


[V.D. Burkert, L. Elouadrhiri, et al., Nuclear Inst. and Methods in Physics Research, A 959 (2020) 163419]

Patrick Achenbach
March 2023

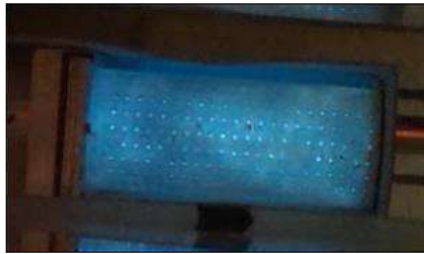
Hall B Group News

- Joseph Newton left from his postdoc position
- Linda Ceraul retired after working with Hall B for decades;
Thanks a lot for her long-standing support of our activities!
- New administrative support and travel coordinator is Jessica Adams
Email: jadams@jlab.org
Point of contact for users
Help in organizing meetings on site
- Current job openings: 1 Staff Scientist, 1 Postdoc, 1 Senior Designer
- Follow-up job opening: Staff Scientist



Hall B Setup: Polarized Target, Møller Shield, RICH Detectors

Longitudinally polarized cryo-target inside solenoid
→ James: [Performances of the longitudinally polarized target for CLAS12](#)



Proton

Deuteron

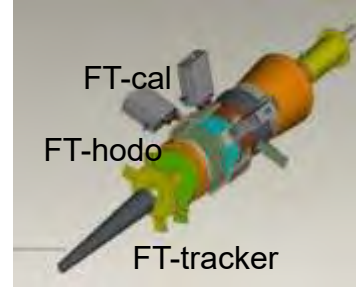


< ~ 80% H polarization
< ~ 45% D polarization
DNP by 140 GHz μ waves
1 K with 4 He refrigerator

Forward Tagger

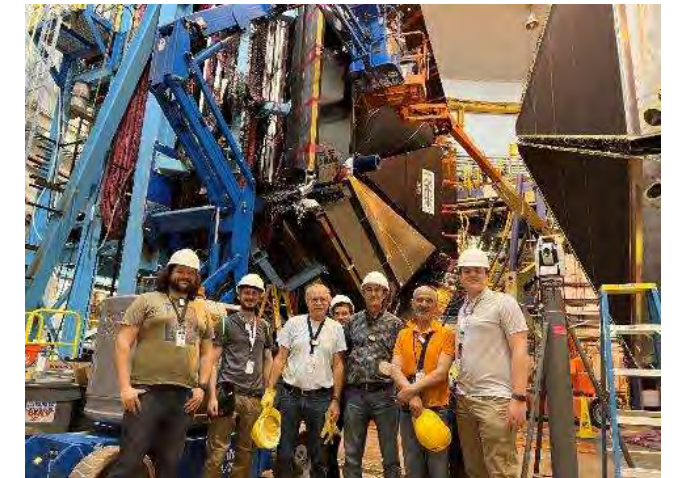
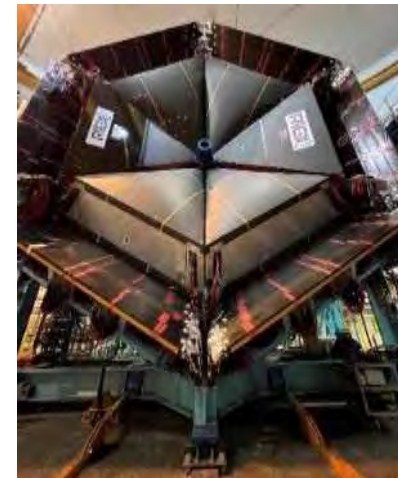
Replaced with ...

... new large Møller shield



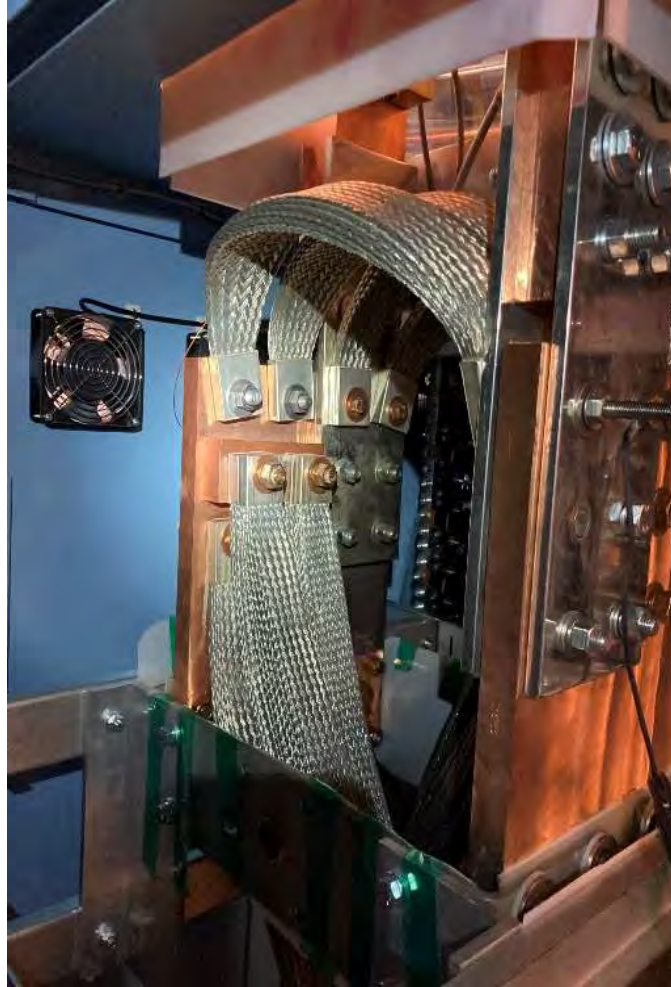
Additional
2nd RICH:

2-sector coverage with 50,048 channels



Solenoid Power Supply Failure

Polarity reversal at $> 1000\text{ A}$
→ melted copper links and
contacts (11/11/22)



Team from Danfysik, DC
Power, Hall B, DSG

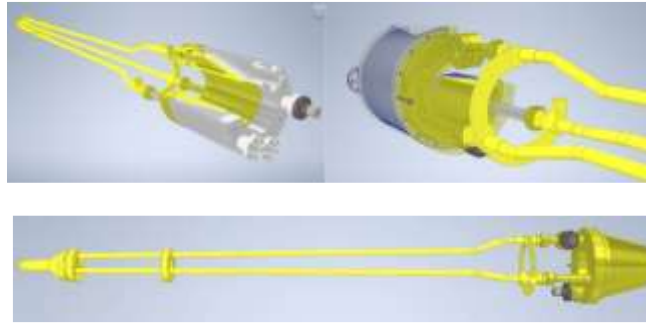


Repair completed (01/30/23)

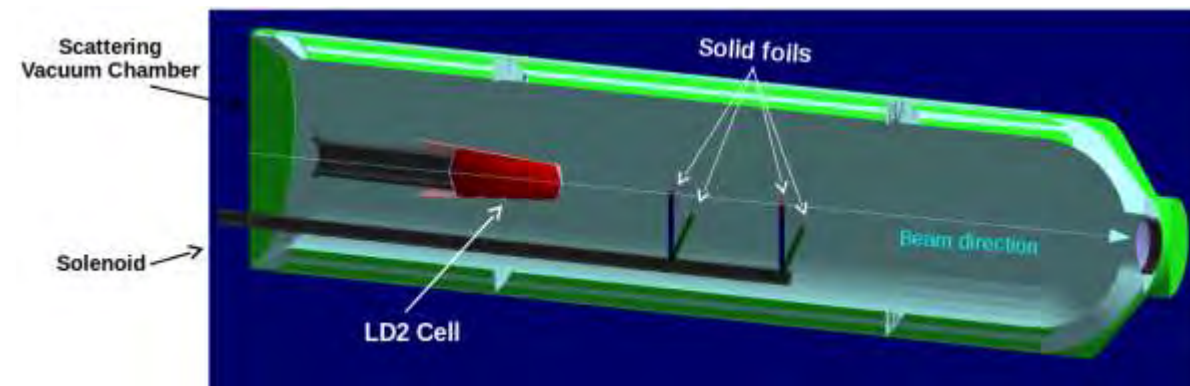
Hall B was down for 80 days during current RG-C run →
Approved physics program could not get completed before SAD 2023

Run Group D Preparations at JLab

Development of unpolarized cryo target

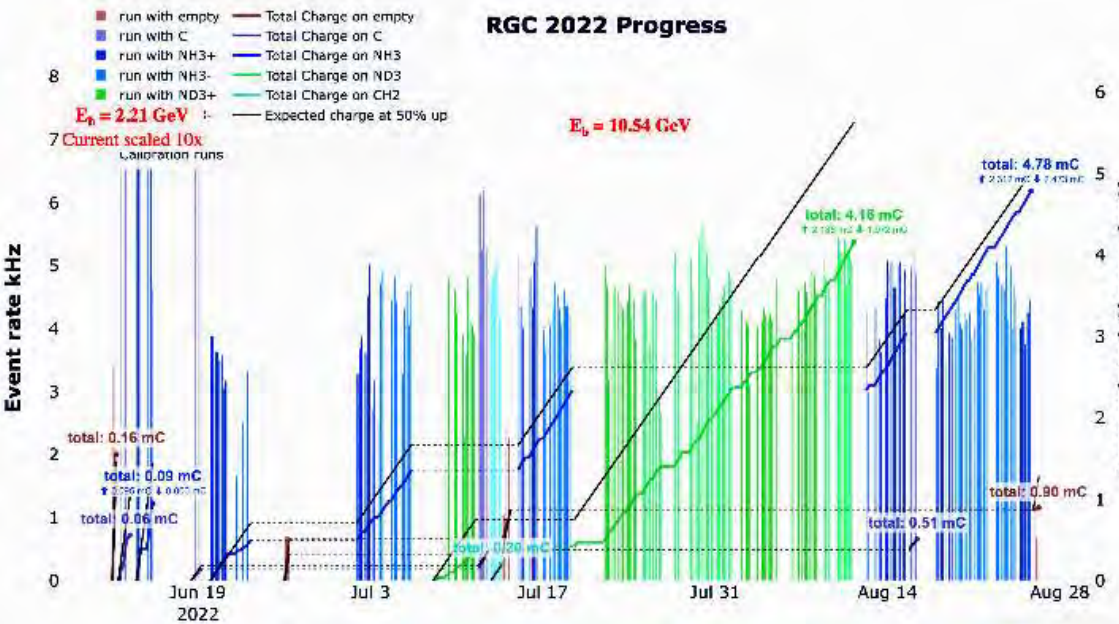


Refurbishment of non-maintained Saclay target

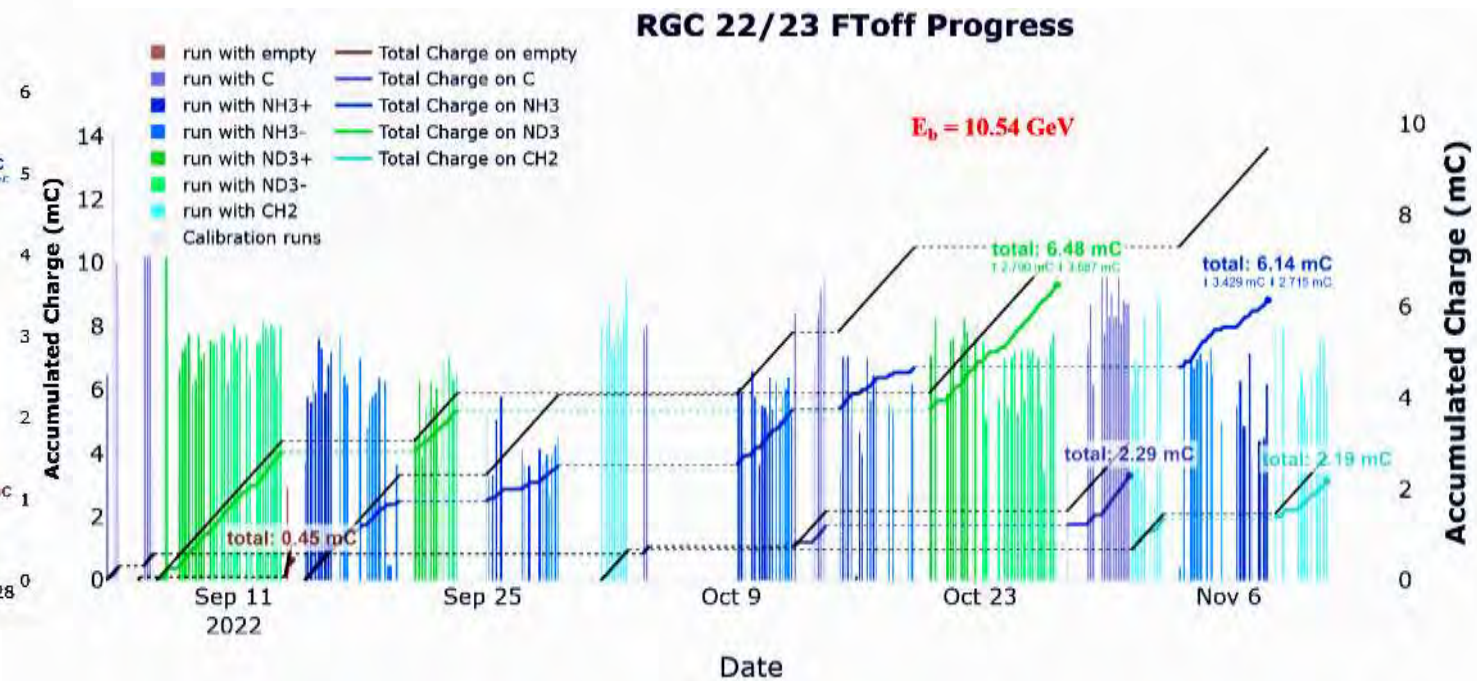


→ Xiangdong: [Status of the Hall-B targets for CLAS12 experiments](#)

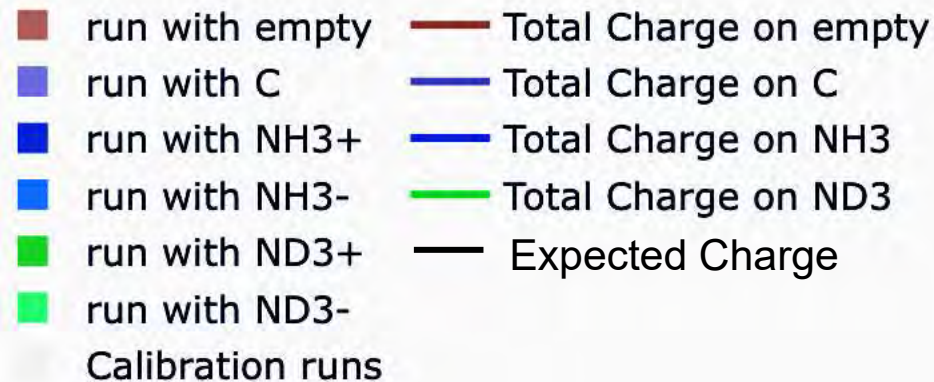
Run Group C Data Taking 2022



1st period: June – Aug 2022

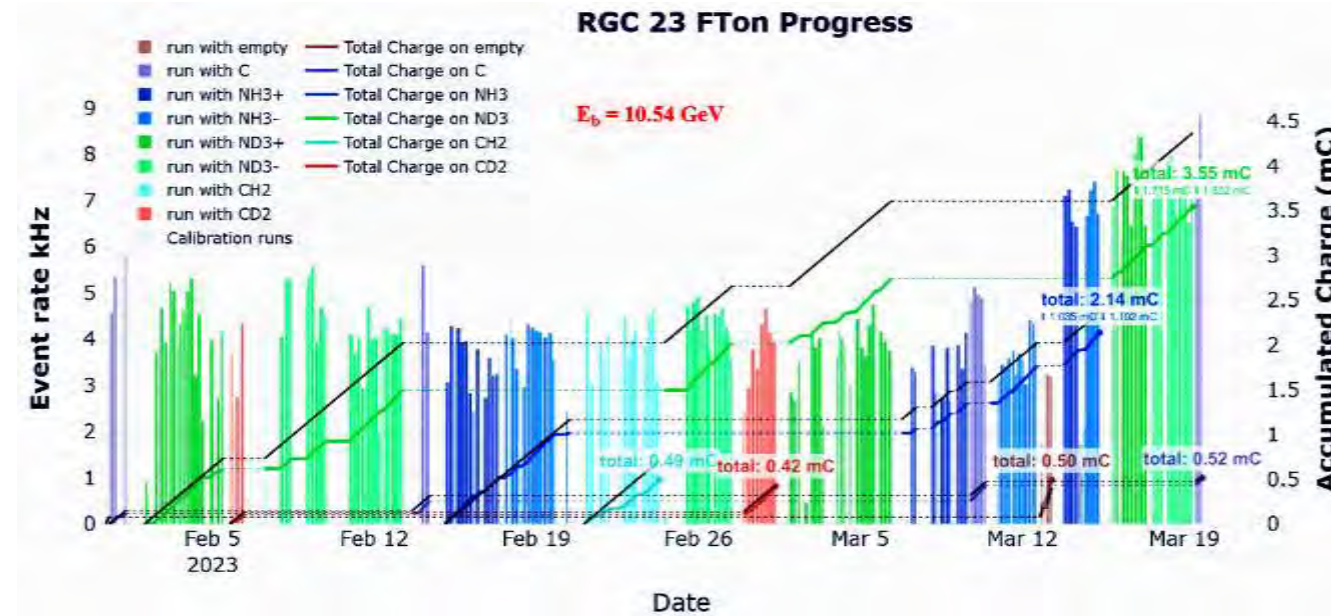


2nd period: Aug – Nov 2022

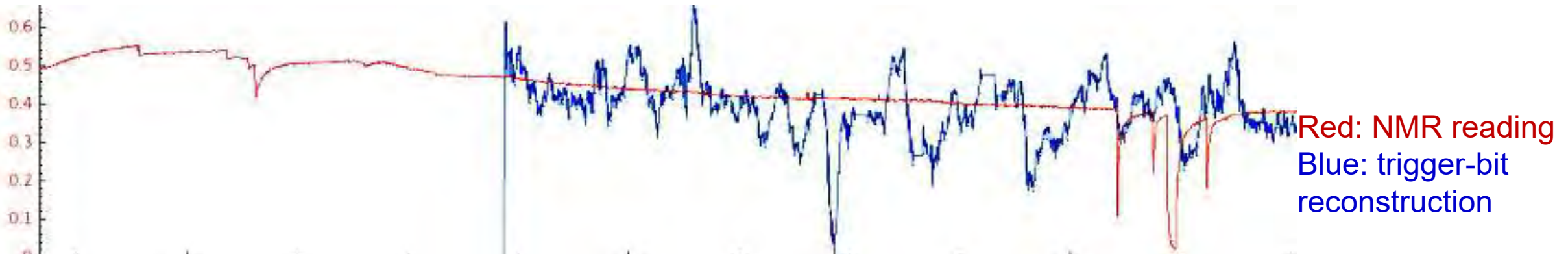


Physics: NH_3 & ND_3
Calibration (dilution factor, background subtraction, alignment):
C, CH_2 , CD_2 , empty, zero-field

Run Group C Data Taking 2023



- Back in business since end of January reaching 96% of total scheduled data
 - Online trigger-bit polarization reconstruction follows relative NMR reading closely
 - Highest degree of polarization in ND₃ ever observed by the target experts
- Noémie: [RG-C end of run and first look at physics](#)



Detector Alignment, Calibration, Reconstruction

Status:

- Calibration work proceeding efficiently with good interactions across the groups
 - RG-B (LD2 @ 11 GeV): pass-2 review held on Oct. 28 for Spr19
 - RG-A (LH2 @ 11 GeV): pass-2 review upcoming soon for Spr19
 - RG-K (LH2 @ 6.5/7.5 GeV): subsystem calibration for pass2 now getting underway
 - RG-M (e4n @ 2/4/6 GeV): pass-1 review expected
 - RG-C (long polarized target @ 11 GeV): alignments and subsystem calibration for pass-1
- pass-2 cooking submissions delayed waiting for official pass-2 reconstruction software

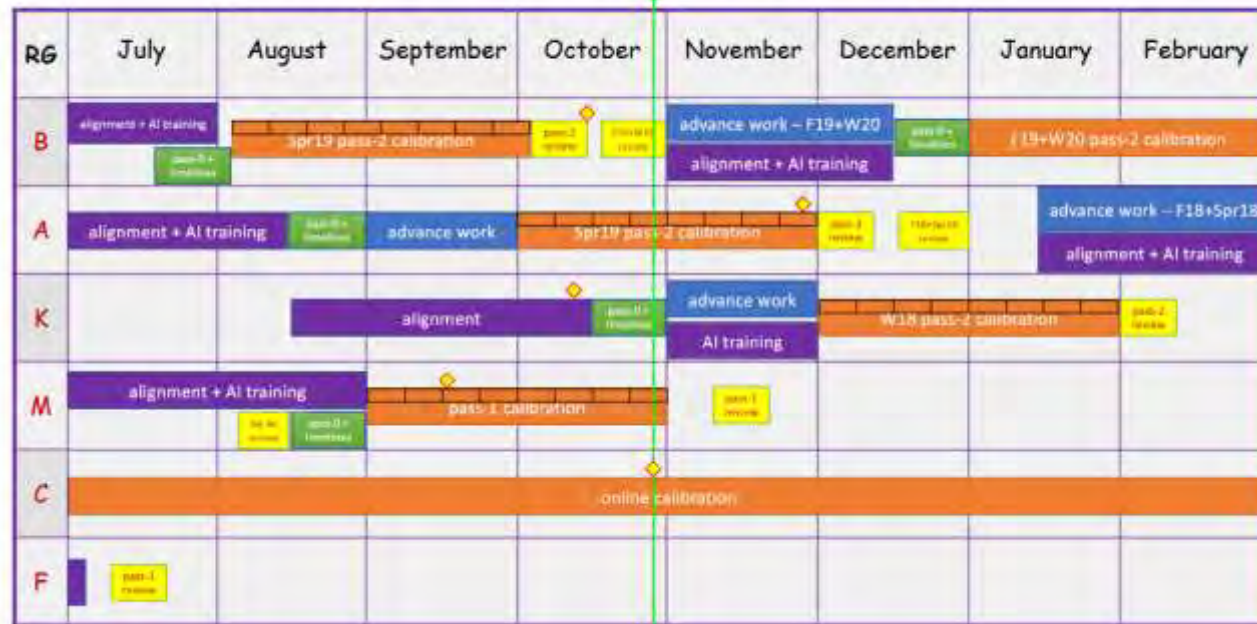
[Daniel Carman, Feb. 2023]

→ Nathan: [Reconstruction: what comes after pass2](#)

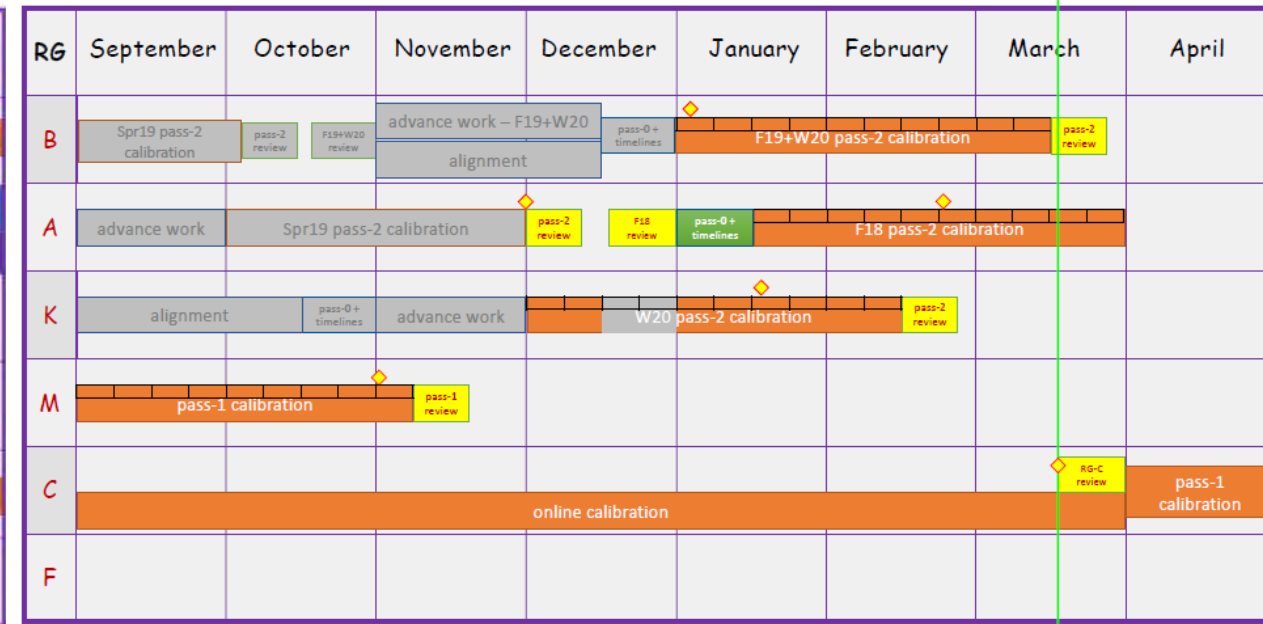
→ Veronique: [CVT tracking, status and plans](#)

Comparison of Oct and Mar Calibration Timelines

Calibration Timeline: July 2022 - February 2023 Oct. 28, 2022



Calibration Timeline: September 2022 - April 2023 Mar. 17, 2023



Improvements to pass-2 code (among other things) for AI-assisted de-noising of hits in the DC, cluster separation in the calorimeter, hit losses in CND, CPU efficiency, displaced vertex finder (?), RICH reconstruction, new banks & flags, ...

Preliminary Run Group Scheduling in Hall B

Preliminary Hall B Run Groups and Schedule

2023-2026								Scheduled PAC days = cal. days/2	Remaining PAC days after end date
START DATE	END DATE	Calendar Days	Remaining PAC Days	Setup/Exp.	Target	Beam Energy	Run Group		
2022-06-14	2022-11-11	143	120		long. polarized NH ₃ /ND ₃	11	RG-C	71,5	49
2022-11-12	2022-12-19	37		downtime					
2022-12-20	2023-01-12	23				Winter break			
2023-01-21	2023-01-29	8		downtime					
2023-01-30	2023-03-19	48	49		long. polarized NH ₃ /ND ₃	11	RG-C	24	25
2023-03-20	2023-07-20	122		setup change	target change	SAD 2023			
2023-07-21	2023-09-17	58	30		liq. D2 & nucl. (JLab)	11	RG-D	29	1
2023-09-18	2023-09-22	4			target change				
2023-09-23	2023-12-17	85	88		liq. H ₂	6,6	RG-K	42,5	45,5
2023-12-18	2024-01-10	23			target change	Winter break			
2024-01-15	2024-03-17	62	60		liq. D2 & nucl. (Chile)	11	RG-E	31	29
2024-03-18	2024-07-18	122		setup change	target change	SAD 2024			
2024-07-29	2024-11-12	106	55	ALERT	high pressure gas	11	RG-L	53	2
2024-11-12	2024-11-16	4			target change				
2024-11-20	2024-12-15	25	46		liq. H ₂	8,8	RG-K	13	33
2024-12-16	2025-01-12	27				Winter break			
2025-01-13	2025-03-17	63	33		liq. H ₂	8,8	RG-K	32	2
2025-03-18	2025-07-23	127		setup change	target change	SAD 2025			

- 2023 SAD for installation of cryo-target and solids
- RG-D:** Jul to Sept 2023, ~30 PAC days to **complete**
- RG-K: Sept to Dec 2023, to reach ~50% PAC days
- RG-E: Jan to Mar 2024, to reach ~ 50% PAC days
- 2024 SAD for installation of ALERT
- RG-L:** Jul to Nov 2024, ~55 PAC days to **complete**
- RG-K:** Nov to Mar 2025, ~45 PAC days to **complete**
- 2025 SAD for setup/target change

Remaining PAC days for run groups

- RG-A: >70 PAC days
- RG-B: +/- 40 PAC days
- RG-C: +/- 25 PAC days
- RG-E: 30 PAC days
- RG-M: 10 PAC days

Not scheduled

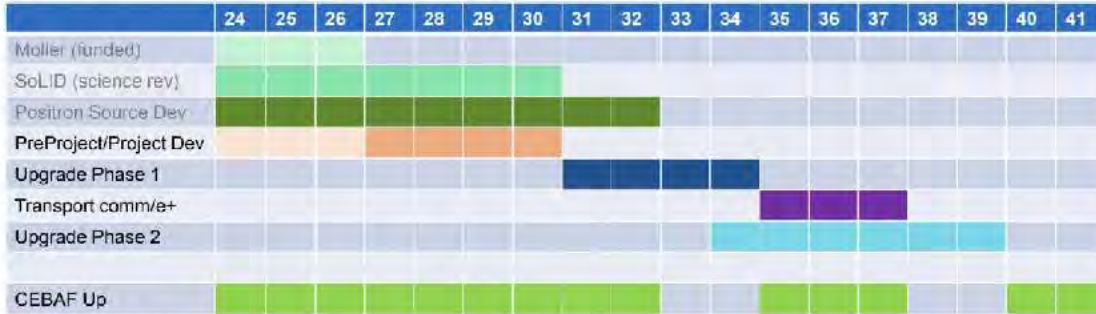
- Non-CLAS12 experiments: PRad-II, π^0 TFF, X17
- CLAS12 experiments: Polarized He-3, H-3 and He-3, transv. polarized H/D, long. polarized LiH/LiD

- SAD 2023: With more gradient (overhead) but same energy should mean a stable machine
- Mid-2025 is a time non-standard beam energy experiments

Update on Long-Term Schedule

Notional CEBAF & upgrade schedule (FY24 – FY42)

- Accelerator/engineering team have worked up an early schedule and cost estimate
 - Schedule assumptions based on a notional timing of when funds might be available (near EIC ramp down based on EIC V3 profile)
 - For completeness, Moller and SoLID (part of 12 GeV program) are shown; early positron source development also shown



- JLab plan to run the 12 GeV electron beam until 2032
- JLab plan to run the 22 GeV electron beam from 2040

- Yves: [The CEBAF Positron Beam upgrade](#)
- Alex: [Status of CEBAF upgrades](#)
- David: [Status of Jefferson Lab](#)
- Patrizia: [Physics Perspectives for an energy upgrade at Jefferson Lab](#)

12 GeV Ce⁺BAF : present high level goals

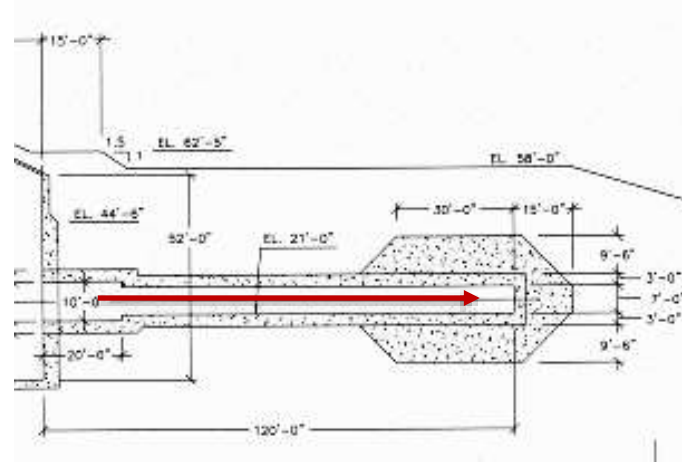
Machine Parameter	Electrons	Positrons	
Hall Multiplicity	4	1 or more	Hall multiplicity tied to intensity and rep rate
Energy (ABC/D)	11/12 GeV	11/12 GeV	
Beam Repetition	249.5/499 MHz	249.5/499/1497 MHz	Cannot copy existing pulsed mode technology
Duty Factor	100% cw	100% cw	
Unpolarized Intensity	170 μA	> 1 μA	Beam distributions are characteristically different
Polarized Intensity	170 μA	> 50 nA	
Beam Polarization	> 85%	> 60%	Few positrons with highest spin polarization
Fast/Slow Helicity Reversal	1920 Hz/Yes	1920 Hz/Yes	



[Thia Keppel & Joe Grames, Positron Workshop, Mar. 2023]

- 9 more years for present CLAS12 Run Groups
- included about 1 year running of non-CLAS expts.
- CLAS positron program for 2035 – 37
- Axel: [Proposal for TPE with positron beam](#)
- 50 nA max. current for polarized beam fits well

Beam Dump (Phase 1) Upgrade



Hall-B needs:

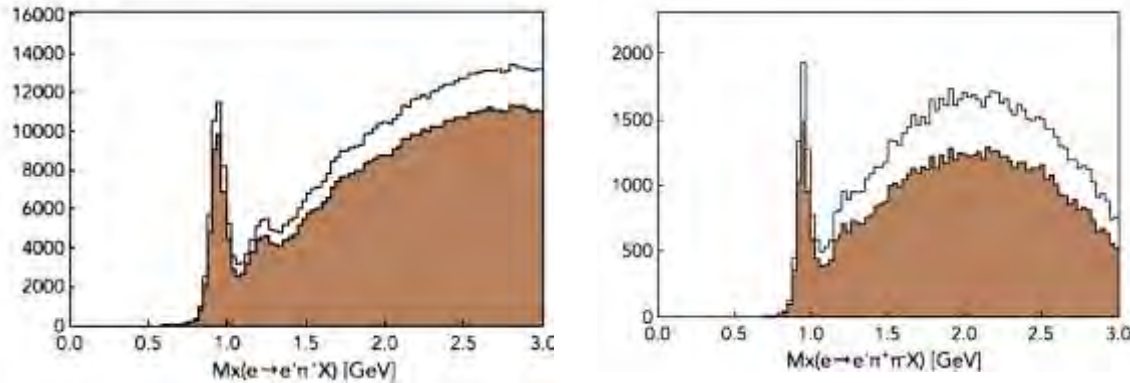
- Alert: 500 – 900 nA
- He-3 expt: 2500 nA
- Lumi upgrade: 5000 nA



- No need for beam blocker anymore due to new safety evaluation
- Faraday cup will get moved down towards the end of the tunnel
- Work to be accomplished in current scheduled accelerator down
- Phase 2 upgrade requires entirely new high-power dump

Software Developments & Plans

- AI/ML for improved track reconstruction

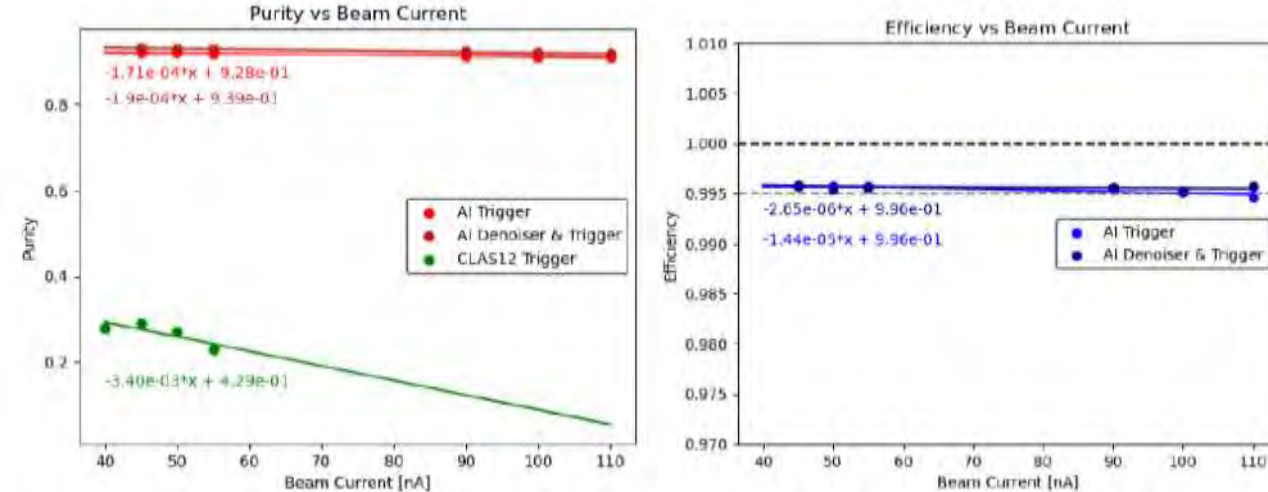


- Neural networks developed for CLAS12 forward drift chamber tracking led to 15% – 35% increase in physics outcome depending on experiment

- Other developments include

- Displaced vertex finder for hyperon identification by Veronique
- Improved DC tracking by Tongtong

- AI/ML level-3 trigger running on GPUs



[Richard Tyson, Gagik Gavalian et al. 2023]

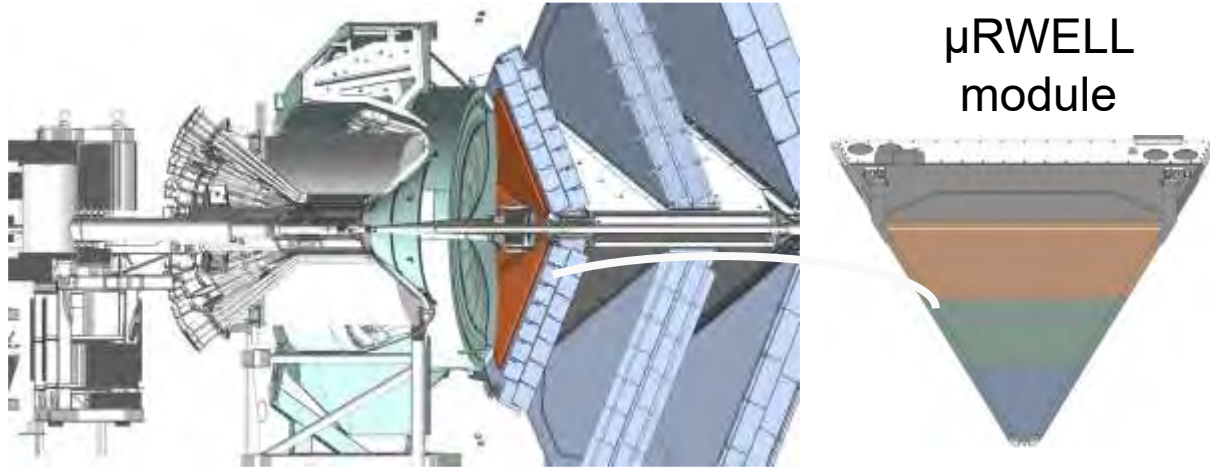
- Includes implementation of secondary event transfer system
- Can significantly reduce amount of recorded data

Evaluation of Subsystem Performance for x2 Design Luminosity

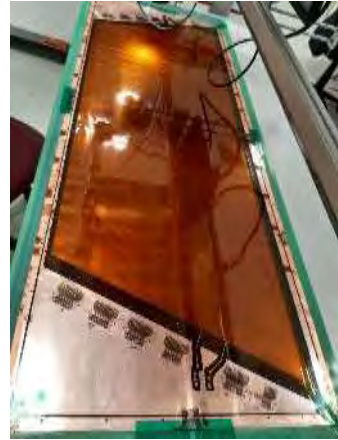
- Series of Task Force Meetings
- RG-A with average luminosity of $0.7 \times L$ and $\eta = 0.8$ for a single track
→ in pass-1, analysis with two particles in the final state will get only ~40% of the expected statistics
- Renewed evaluation of beamline, forward tagger (FTCal, FTHodo), PMT devices (HTCC, LTCC, RICH, FTOF, ecal, CND, CTOF), forward detector tracking, central detector tracking, DAQ/trigger
- From the summary by Stepan:
 - Most of the CLAS12 subsystems will perform at luminosities $L \approx 2 \times 10^{35} \text{ cm}^{-2} \text{ sec}^{-1}$ with efficiencies and resolutions we have now.
 - The main concern is CVT: BMT lifetime and the low efficiency of CVT tracking (will be $\approx 50\%$). The efficiency issue may be possible to mitigate with the inclusion of MLA into CVT tracking.
 - There are requests from various detectors for more dedicated performance studies at high luminosities to iron out some details. We will coordinate with run groups D and K, Nathan and Stepan PDLs. (*FT has to wait, these runs are with FTOff*).
 - There are three items on critical path for the upgrade in 2-3 years time frame:
 - μ RWELL detector development (R&D and prototyping started);
 - FEE development for MM and μ RWELL detectors based on SAMPa and VMM3 chips.
 - The BMT problem – no spares and low chance of replacing degraded tiles.

Luminosity Upgrade with Additional Tracker

- μ RWELL development for luminosity upgrade to $L = 2 \times 10^{35} \text{cm}^{-2} \text{sec}^{-1}$

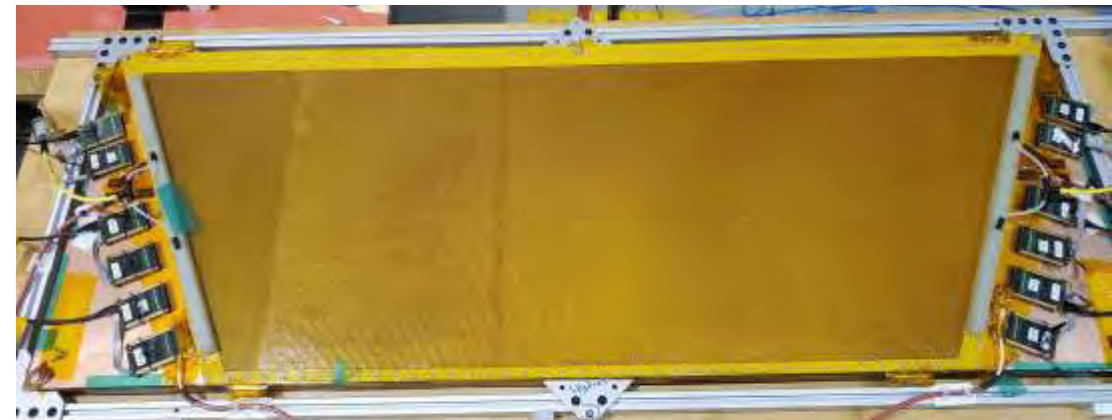


- Simulation studies with background merging and μ RWELL + DC + AI result in improved inefficiency of better than 0.1 % per nA, better than upgrade design goal
- CLAS12 readiness for higher luminosities is key for future success



- μ RWELL with capacitive sharing readout provides 2D points in front of drift chambers
- Work on prototype at UVa, CERN, and JLab during the last months
- Time frame of 2 to 3 years for completion

→ Rafayel: [Luminosity upgrade for CLAS12](#)



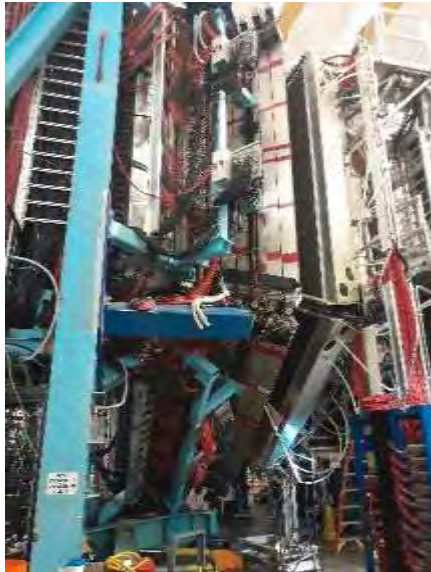
Hardware Developments & Plans



- First beam test of a large-area μ RWELL during the last days



- Some data were taken, to be continued ...



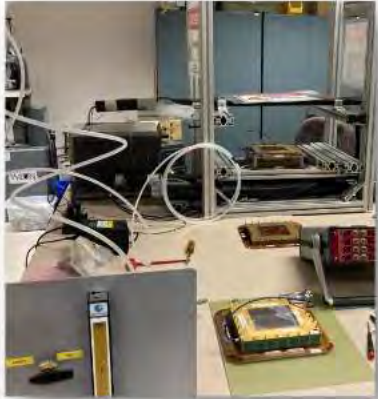
- Implementation of a tracking algorithm with AI/ML
→ Gagik: [Usage of Machine Learning in CLAS12](#)

- Cylindrical μ RWELL Detector for high luminosities with CLAS12: DOE Early Career Award application “Low-mass, fast-timing micro-pattern gaseous detector for CLAS12 at ultra-high luminosities” prepared by Florian

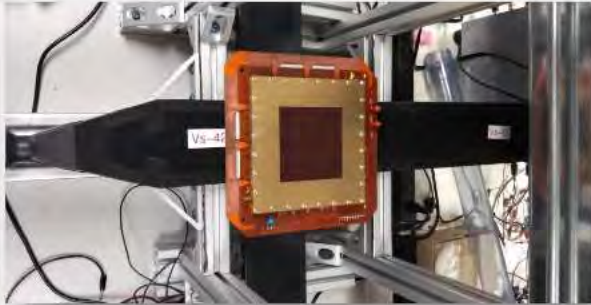


- DOE Innovative Fusion Technology and Collaborative Fusion Energy Research “Spin Polarized Nuclei for Injection into DIII” application by Xiangdong

Micro Patterned Gaseous Detectors Lab(s)



Equipping ARC lab for Micro Patterned Gaseous Detector (MPGD) development. Ability to deliver ArCO_2 and N_2 to two different MPGD test beds. (Kondo Gnanvo, Eric Christy, Brian Kross, Seungjoon Lee)



Expanding MPGD work into lab F117 of CEBAF Center F-wing. Will install 6' x 8' and 8 x 12 cleanrooms (Brian Kross, Eric Christy, Kondo Gnanvo)



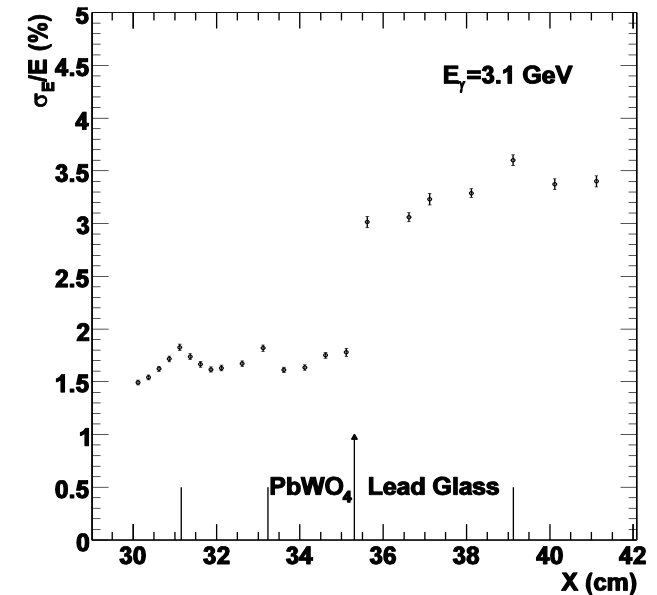
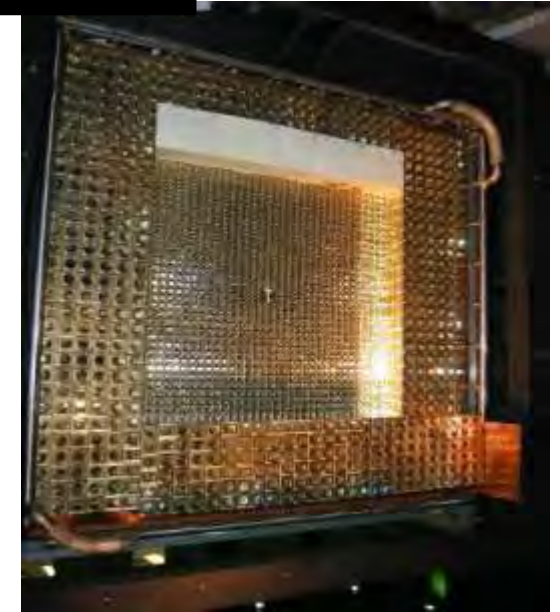
[Drew Weisenberger, Leadership Meeting, Mar. 2023]

- Declared need for MPGDs R&D facility in the US for the Nuclear Physics community
- MPGD facility could be modeled on Gaseous Detector Development laboratory at CERN

- JLab is expanding its R&D activities in MPGDs
- CLAS luminosity upgrade will benefit strongly

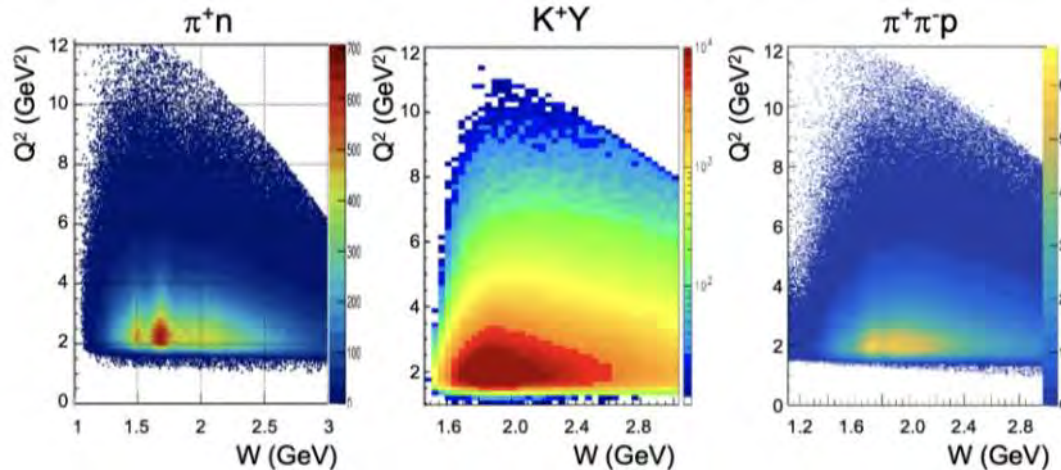
Upgrade of HyCal Calorimeter

- Combination of PbWO_4 and Pb-glass detectors ($118 \times 118 \text{ cm}^2$)
 PbWO_4 crystals \rightarrow high resolution
Pb glass \rightarrow low budget
- Two upgrade needs identified:
 - All $1152 \text{ PbWO}_4 + 576 \text{ Pb glass}$ detectors need new readout
 \rightarrow inner part upgrade with FADC250v3 by JLab
 - Light yield of Pb glass is too low for future high-resolution measurements in Hall B \rightarrow new PbWO_4 crystals needed
- Application for MRI Consortium: "Track 2 Development of an enhanced magnetic-spectrometer-free apparatus for ultra-precise forward angle electron scattering experiments " by Ashot Gasparian and collaborators

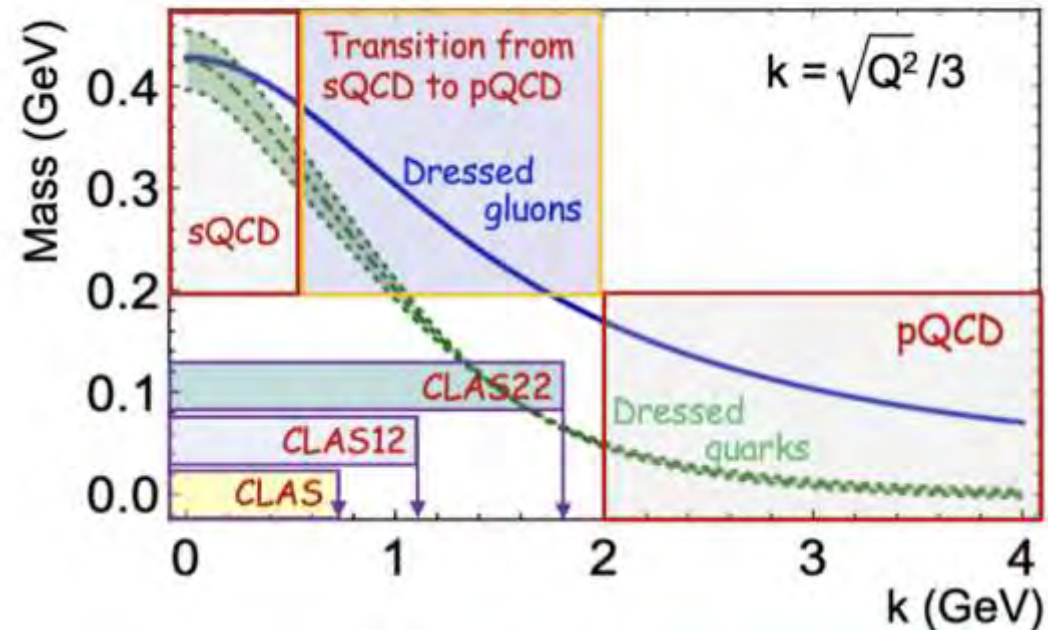


Cooperation with Theoreticians to Explore Emergence of Hadron Mass

- Extension of results on electrocouplings of N^* states in from pN , ppN , KY , K^*Y , KY^* exclusive channels to access quark momenta where $\sim 50\%$ of dressed quark mass is generated in order to resolve the problem on Emergence of Hadron Mass
- Long-stay visitor Adnan Bashir to explore N^* transition amplitudes with Continuum Schwinger Method
- "Nucleon Resonance Electroexcitation Amplitudes and Emergent Hadron Mass" in "Particles 6, 416–439 (2023)
- Common Workshop at DNP-JPS Joint Meeting: Exploring excited nucleons with meson, electron, and photon beams



Meson electroproduction yields measured with the CLAS12



Cooperation with COMPASS

- Task Force Meeting in which Harut discussed the need for stronger cooperation across the labs

→ Jan: [AMBER: a new QCD facility at CERN](#)

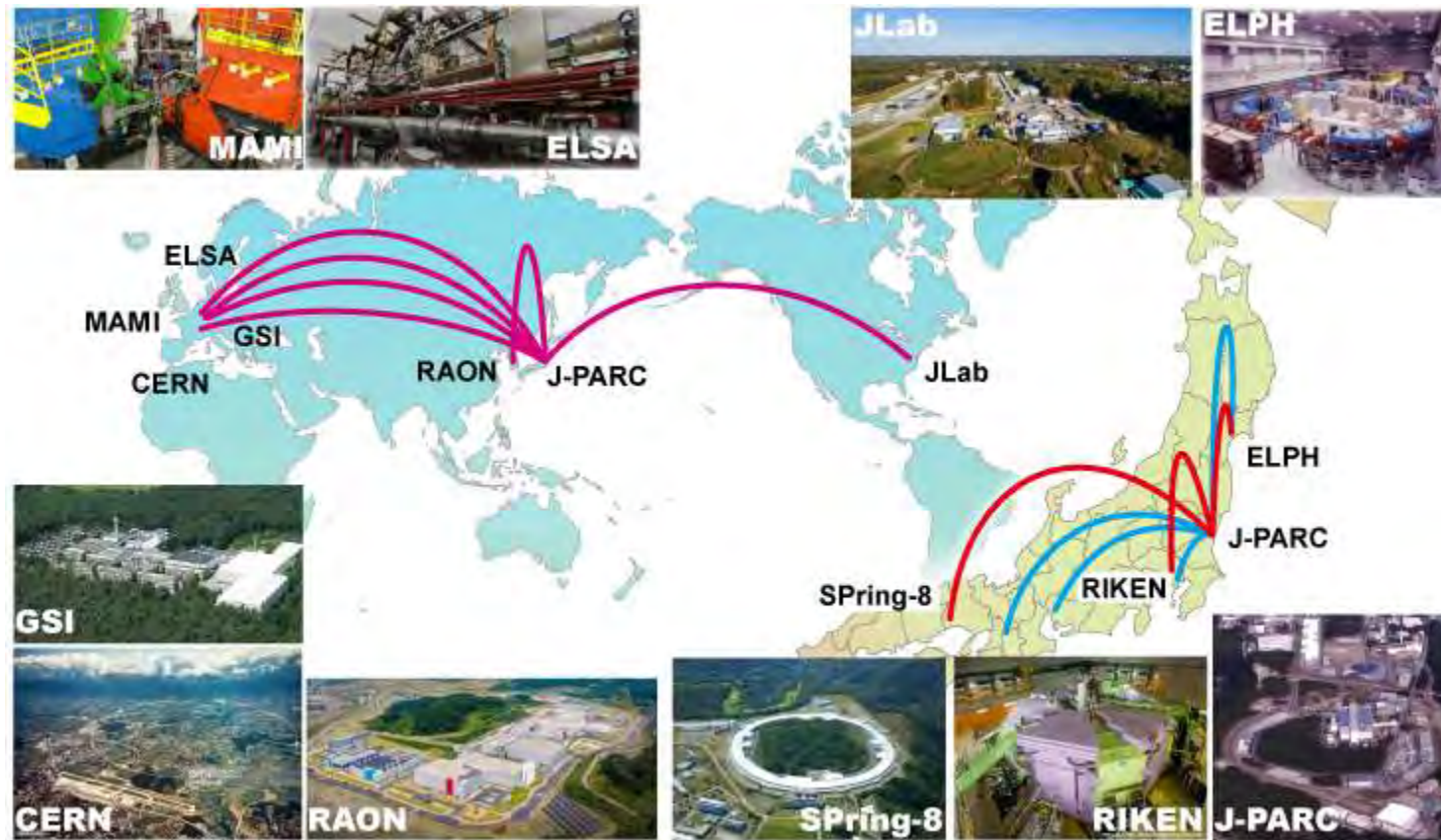
- From Harut's summary:

Extending JLab measurements to a wider range in x, Q^2 and P_T with energy upgrade, will be crucial in studies of QCD dynamics, including studies of evolution properties and transverse momentum dependences of PDFs.

Coordination of efforts at JLab and COMPASS will help both, also in pushing for analysis frameworks for making extractions and projections with controlled systematics

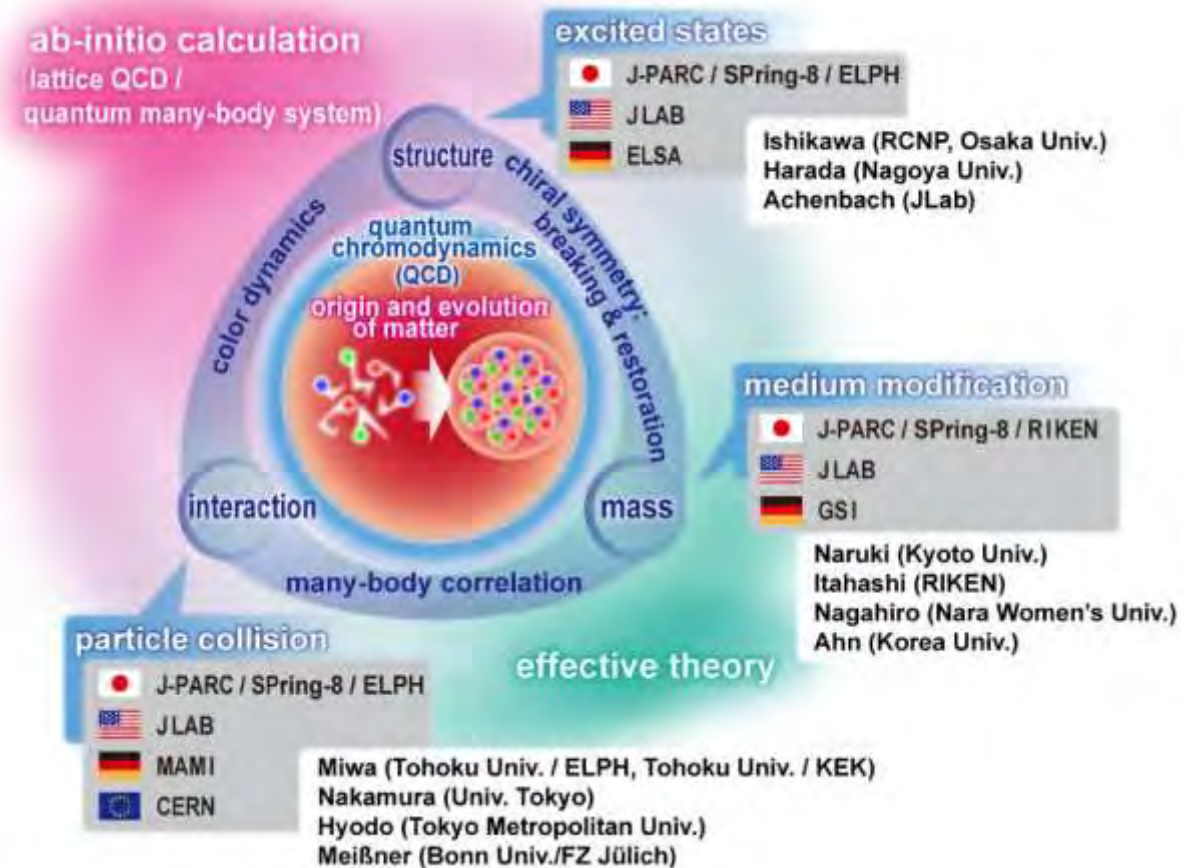
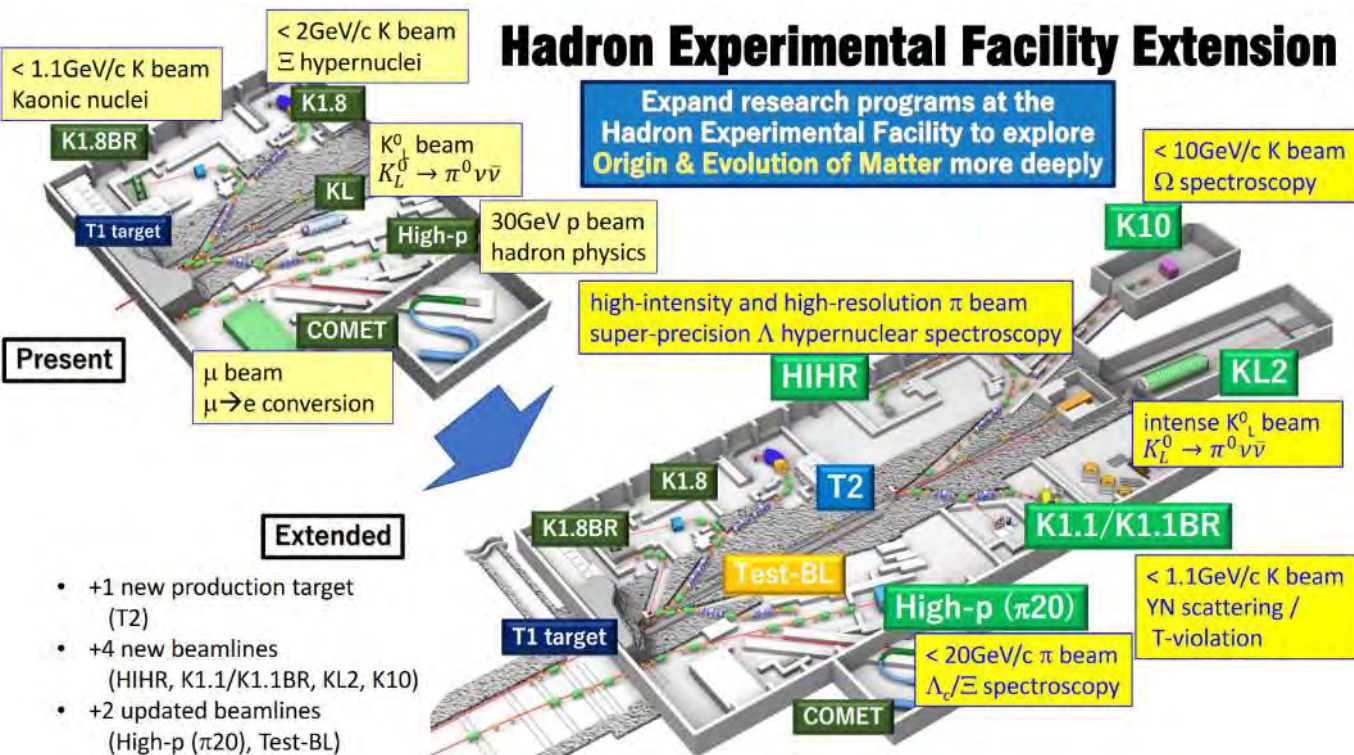
Cooperation with J-PARC

- Japan is one of the key players sharing the same objectives in understanding hadron physics, hadron structure, hadron interaction, and hadron mass
- The role of international projects in hadron physics at J-PARC is increasing
- CLAS Collaboration should seek connection to leading groups



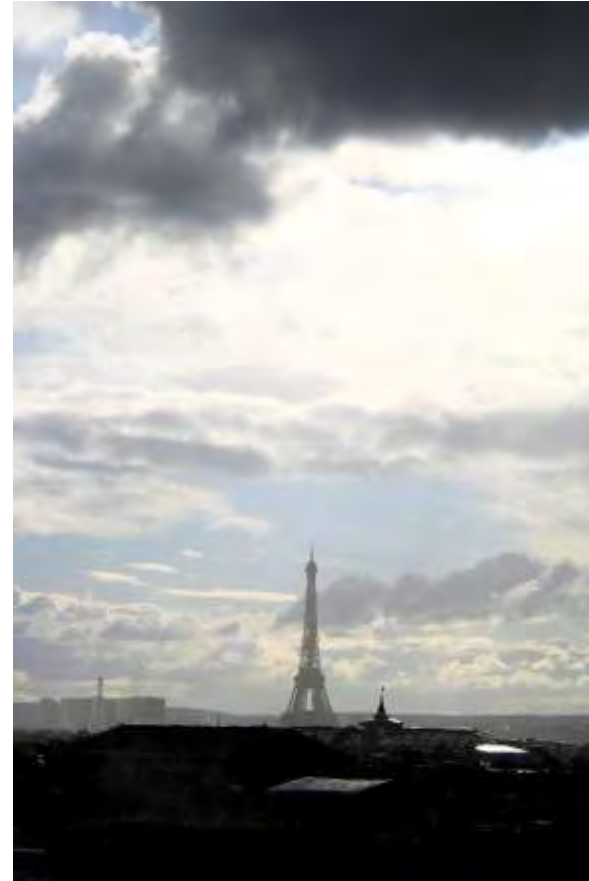
Creating a Platform to Strengthen Collaboration

- Currently, J-PARC Hadron Facility Extension Project is largest upgrade project
- Proposal for “International Leading Research” has been submitted in 2023
 - Formation of baryons with multiple strange quarks
 - Λ -p interactions
 - Emergence of hadron mass



Summary in Black & White

- Run Group C successfully conducted first polarized target experiment with CLAS12, ... but not completed
- Tracking/reconstruction upgrades, mostly AI assisted, improve performance, ... but still no pass-2 cooking
- Detector und beam dump upgrades are progressing, ... but μ RWELL operation is on a long and winding road
- Several publications submitted and analyses in review, ... but still no absolute cross sections published



Thanks for the invitation to the center of intellectual Enlightenment,
...but sometimes it feels like Paris in the rain