

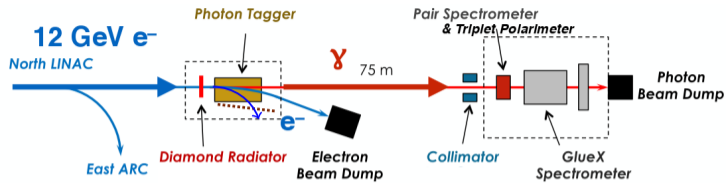
Hall D Status

E.Chudakov¹

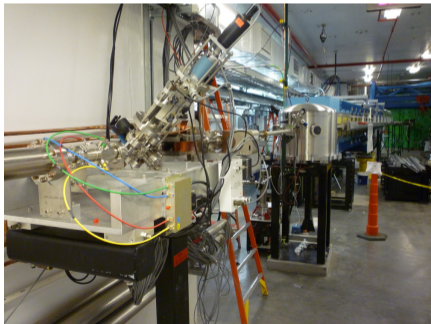
¹JLab, Hall D manager

KLF Experiment ERR-1 Review, 2023 Aug 2

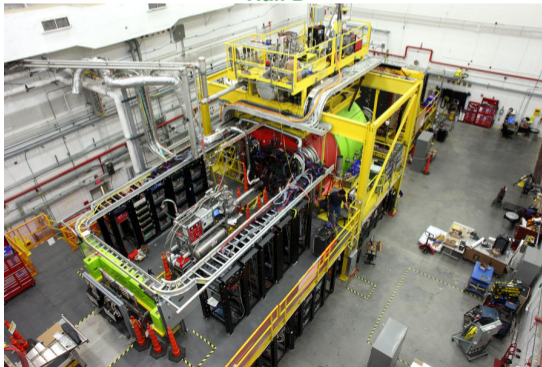
Hall D Apparatus



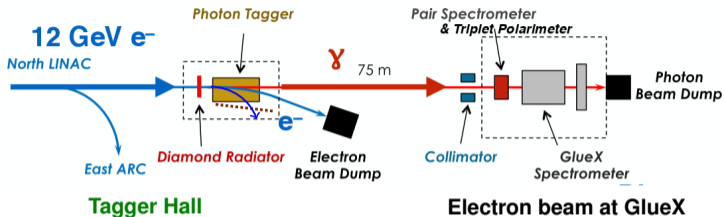
Tagger Hall



Hall D



Hall D Apparatus

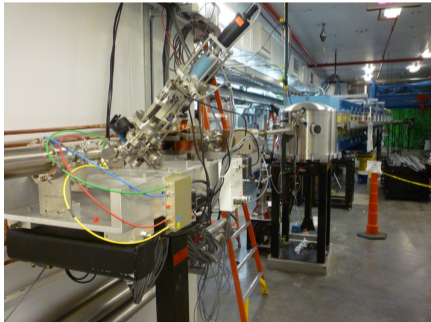


Electron beam at GlueX

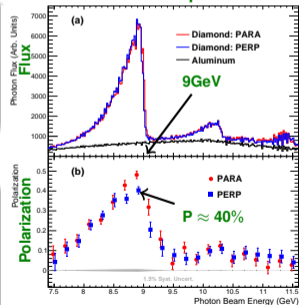
- ▶ < 500 nA
- ▶ Focus at the collimator
- ▶ Steering: active collimator signals
- ▶ $< 5 \mu\text{A}$ the limit of the dump

Photon beam at GlueX

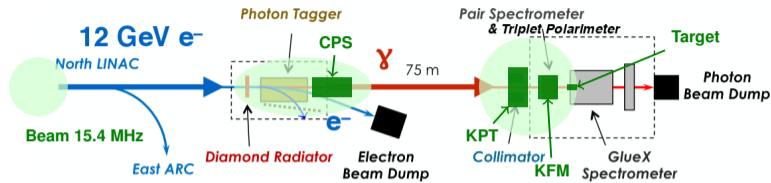
- ▶ Radiator $\approx 4 \cdot 10^{-4}$ RL
- ▶ Tagging $\sigma E/E \sim 0.2\%$
- ▶ Linear polarization $\sim 40\%$ peak
- ▶ Pair Spectrometer & Polarimeter



Photon Beam Spectrum



Hall D Apparatus



KLF installation

1. CPS - Compact Photon Source
2. KPT - Kaon Production Target
3. KFM - Kaon Flux Monitor
4. Target of a larger diameter
5. Injector 4 ns \rightarrow 64 ns

Changes for KLF



Tagger hall

- Tag. magnet off
- Detectors removed
- CPS installed
- New beam controls



Collimator cave

- Replaced completely
- KPT installed
- activation expected
- access limitation



Pair Spectrom.

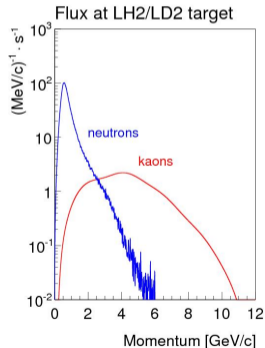
- Removed converters, detectors, shielding
- KFM installed

Electron beam at KLF

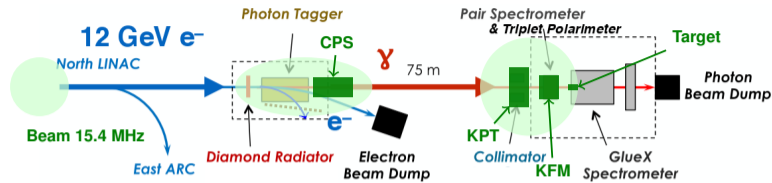
- ▶ 5 μ A
- ▶ Focus at KPT - the same location
- ▶ New beam instrumentation?
- ▶ Steering: a new active collimator?

Photon beam at KLF

- ▶ Radiator 10% RL
- ▶ Bremsstrahlung spectrum
- ▶ No tagging
- ▶ 6 kW power (\times 4000 GlueX)



Hall D Apparatus



KLF installation

1. CPS - Compact Photon Source
2. KPT - Kaon Production Target
3. KFM - Kaon Flux Monitor
4. Target of a larger diameter
5. Injector 4 ns \rightarrow 64 ns

Changes for KLF



Tagger hall

- Tag. magnet off
- Detectors removed
- CPS installed
- New beam controls



Collimator cave

- Replaced completely
- KPT installed
- activation expected
- access limitation



Pair Spectrom.

- Removed converters, detectors, shielding
- KFM installed

Electron beam at KLF

- ▶ 5 μ A
- ▶ Focus at KPT - the same location
- ▶ New beam instrumentation?
- ▶ Steering: a new active collimator?

Photon beam at KLF

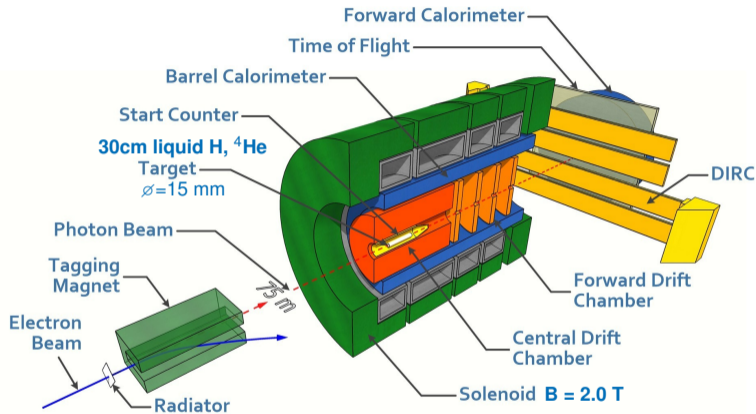
- ▶ Radiator 10% RL
- ▶ Bremsstrahlung spectrum
- ▶ No tagging
- ▶ 6 kW power (\times 4000 GlueX)

A major beamline change!

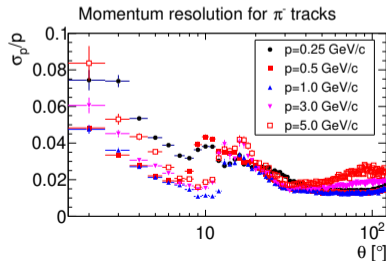
The facility's requirements

- No irreversible impact on the existing equipment including radiation damage
- Smooth installation of KLF and re-installation of the photon beam after KLF completion

Hall D: GlueX Spectrometer

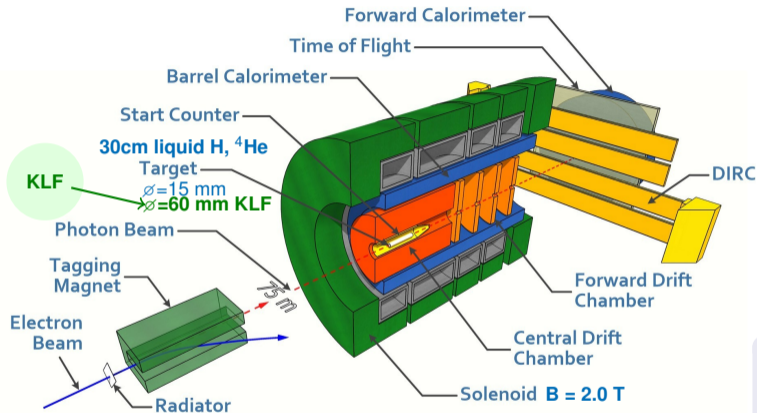


- ▶ Acceptance: $1^\circ < \theta < 120^\circ$
- ▶ Resolutions:
 - h^\pm : $\sigma_p/p(\theta) \sim 1 - 5\%$
 - γ : $\sigma_E/E \sim 5.5\%/\sqrt{E} \oplus 4.5\%$
- ▶ Trigger: all photoproduction at $E_{\text{BEAM}} > 7\text{ GeV}$
 DAQ in 2021: **85 kHz** (photoproduction + EM background)



GlueX studies exclusive reactions. A good event selection and momentum/mass resolution are achieved with the help of 4C kinematic fit which uses the $\approx 0.1\%$ energy resolution of the beam photon.

Hall D: GlueX Spectrometer



- ▶ Acceptance: $1^\circ < \theta < 120^\circ$
- ▶ Resolutions:
 - h^\pm : $\sigma_p/p(\theta) \sim 1 - 5\%$
 - γ : $\sigma_E/E \sim 5.5\%/\sqrt{E} \oplus 4.5\%$
- ▶ Trigger: all photoproduction at $E_{BEAM} > 7 \text{ GeV}$
DAQ in 2021: 85 kHz (photoproduction + EM background)

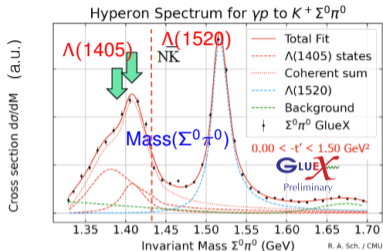
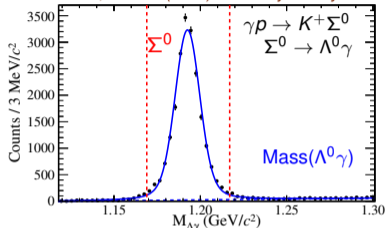
KLF target

- $\varnothing 15 \text{ mm} \Rightarrow 60 \text{ mm}$
will add some:
- Secondary interactions
 - Multiple scattering

GlueX studies exclusive reactions. A good event selection and momentum/mass resolution are achieved with the help of 4C kinematic fit which uses the $\approx 0.1\%$ energy resolution of the beam photon.

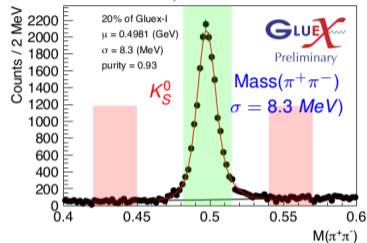
GlueX experiment: Illustration of hyperon reconstruction

PRC 101, 065206 (2021) beam asymmetry

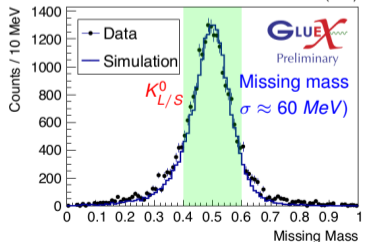
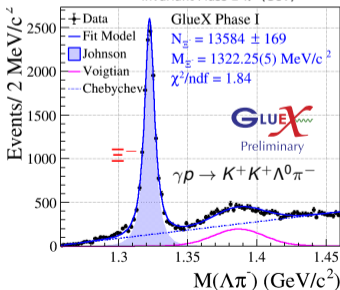
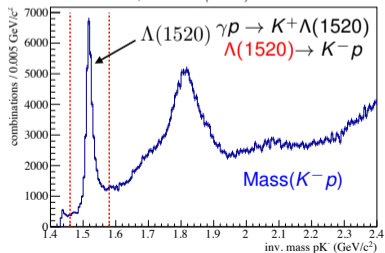


Reaction with a missing particle

$$\gamma p \rightarrow p K_S^0 (K_{L/S}^0), K_S^0 \rightarrow \pi^+ \pi^-$$

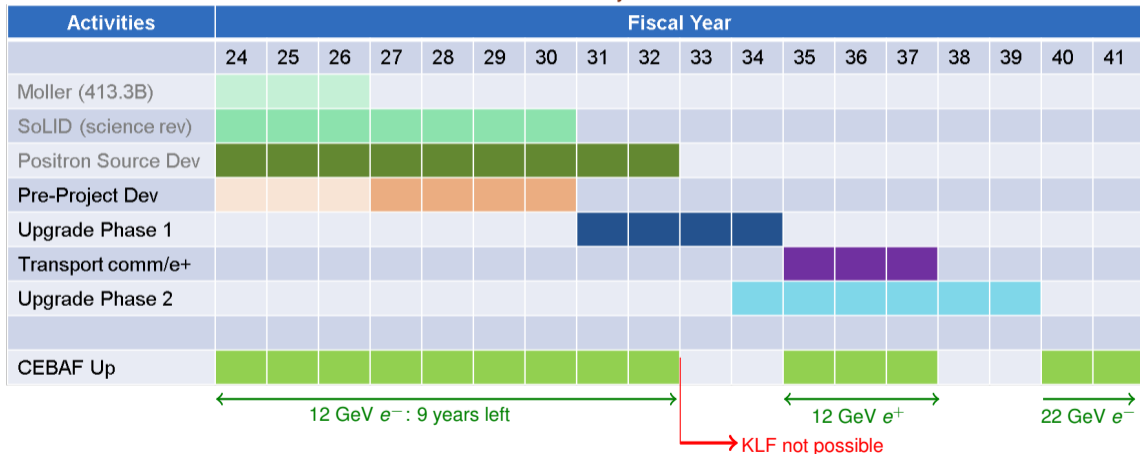


PRC 105, 035201 (2022) SDME



JLab extended schedule, plans

From JLUO 2023 talk by David Dean



Physics Program in Hall D

Experiment	name	Title	PAC rating	PAC days	data taken
E12-06-102	GlueX-I	Mapping the Spectrum of Light Quark Mesons and Gluonic Excitations with Linearly Polarized Photons	A	120	100%
E12-12-002 A	GlueX-II	A study of meson and baryon decays to strange final states with GlueX in Hall D	A	220	46%
	JEF	Eta Decays with Emphasis on Rare Neutral Modes: The JLab Eta Factory(JEF) Experiment	Grp	100	0%
E12-10-011	PrimeX- η	A Precision Measurement of the eta Radiative Decay Width via the Primakoff Effect	A-	79	100%
E12-13-008	CPP/NPP	Measuring the Pion Polarizability in the $\gamma\gamma \rightarrow \pi\pi$ Reaction	A-	25	100%
E12-19-003	SRC/CT	Studying Short-Range Correlations with Real Photon Beams at GlueX	B+	15	100%
<i>Not yet scheduled</i>					
E12-19-001	KLF	Strange Hadron Spectroscopy with Secondary KL Beam in Hall D	A-	200	
E12-20-011	REGGE	Measurement of the high-energy contribution to the Gerasimov-Drell-Hearn sum rule	A-	33	

- considerable installation / new equipment required
 - finished data taking
- JEF: fully budgeted, installation in progress
- KLF: partly budgeted, design in progress
- REGGE: not yet budgeted

Physics Program in Hall D

LOI/proposals to PAC51

- Proposal: SRC/CT: conditionally approved C2
- LOI: GlueX at luminosity frontier
- LOI: GlueX+TRD Spectroscopy + charmonia
- LOI: GlueX GDH on nuclei

Experiment	Category	Description	Priority	AC ys	data taken
E12-0				20	100%
E12-1				20	46%
		Eta Factory(JEF) Experiment		100	0%
E12-10-011	PrimeX- η	A Precision Measurement of the eta Radiative Decay Width via the Primakoff Effect	A-	79	100%
E12-13-008	CPP/NPP	Measuring the Pion Polarizability in the $\gamma\gamma \rightarrow \pi\pi$ Reaction	A-	25	100%
E12-19-003	SRC/CT	Studying Short-Range Correlations with Real Photon Beams at GlueX	B+	15	100%
<i>Not yet scheduled</i>					
E12-19-001	KLF	Strange Hadron Spectroscopy with Secondary KL Beam in Hall D	A-	200	
E12-20-011	REGGE	Measurement of the high-energy contribution to the Gerasimov-Drell-Hearn sum rule	A-	33	

■ - considerable installation / new equipment required

■ - finished data taking

- JEF: fully budgeted, installation in progress
- KLF: partly budgeted, design in progress
- REGGE: not yet budgeted

Hall D physics runs

Year	Dates	Calendar days	Beam, GeV	ABU ¹ + BANU	ABU	Experiment	PDL	Comment	PAC days ³	PAC days total
2016	Feb, 3 - Mar, 23	49	12.0	?	?	E12-06-102	B.Zihlmann	Engineering run, solenoid at 1200A	3+25	25
2017	Jan, 30 - Mar, 9	40	11.7	58%	51%	E12-06-102	B.Zihlmann	Production	20	45
2018	Jan, 12 - Mar, 5	52	11.7	52%	46%	E12-06-102	B.Zihlmann	Production	26	71
2018	Mar, 29 - May, 6	38	11.7	58%	52%	E12-06-102	B.Zihlmann	Production	19	90
2018	Sep, 21 - Nov, 26	66	11.7	53%	47%	E12-06-102	B.Zihlmann	Production	33	123
2019	Feb, 8 - Feb, 21	13	11.6	45%	N/A	E12-12-002	B.Zihlmann	1/2 DIRC Commissioning	6	6
2019	Feb, 21 - Mar, 5	15	11.6	52%	37%	E12-10-011	L.Pentchev	Installation	7.3	7.3
2019	Mar, 8 - Apr, 15	38	11.2	73%	68%	E12-10-011	L.Pentchev	Production	16.1	23.4
2019	Nov, 25 - Dec, 20	25	11.4	34%	32%	E12-12-002	B.Zihlmann	DIRC Commissioning, 3. PAC days = 0.32*25	8	14
2020	Jan, 10 - Mar, 24	75	11.4	62%	56%	E12-12-002	B.Zihlmann	Production on LHe, design rate. First 2 weeks - lower rate	38	52
2020	Jul, 27 - Sep, 21	56	11.4	46%	38%	E12-12-002	B.Zihlmann	Production on LHe, DIRC at high rate	21.5	73.5
2021	Sep, 16 - Nov, 4	50	10.1	51%	45%	E12-10-011	L.Pentchev	Production on LHe, FOM=0.56 ⁴	14	37.4
2021	Nov, 8 - Dec, 21	43	10.9	70%	60%	E12-19-003	L.Pentchev	Production on LHe, LD, C FOM=0.73 ⁵ PAC=43*0.6*0.73=19	19	19
2022	Jun, 8 - Aug, 17	71	11.6	46%	41%	E12-13-008	S.Taylor	CPP/NPP	29	29
2022	Aug, 27 - Dec, 18	113	11.6	64%	59%	E12-10-011	L.Pentchev	PrimeX-η Production on LHe, FOM=0.91 ⁴ *0.85(TAGM)	51.6	89
2023	Jan, 12 - Mar, 19	67	11.6	48%	42%	E12-12-002	B.Zihlmann	GlueX-II Production. ABU was used to calculate the PAC days	28.1	102.
23-24	Mar, 20 - Jul, 18	460						FCAL2 installation		
2024	Jul, 19 - Dec, 15	150	12?			E12-12-002	B.Zihlmann	GlueX-II + JEF <i>Draft schedule</i>	75 ?	177.
2025	Jan, 13 - Mar, 16	62	12?			E12-12-002	B.Zihlmann	GlueX-II + JEF <i>Draft schedule</i>	31 ?	209.
25-26	Mar, 17 - Jul, 18	460						<i>Planning:KLF installation</i>		

Runs 2022-2023
251 calendar days
109 PAC days

E12-12-002 GlueX-II
E12-10-011 PrimeX-η
E12-19-003 SRC
E12-13-008 CPP/NPP

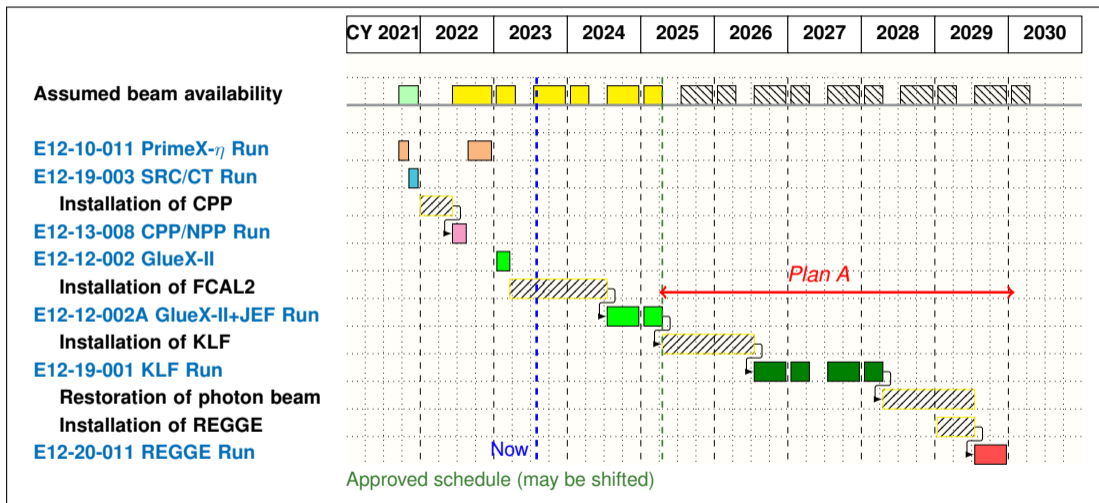
Hall D physics runs

Year	Dates	Calendar days	Beam, GeV	ABU ¹ + BANU	ABU	Experiment	PDL	Comment	PAC days ³	PAC days total
2016	Feb, 3 - Mar, 23	49	12.0	?	?	E12-06-102	B.Zihlmann	Engineering run, solenoid at 1200A	3+25	25
2017	Jan, 30 - Mar, 9	40	11.7	58%	51%	E12-06-102	B.Zihlmann	Production	20	45
2018	Jan, 12 - Mar, 5	52	11.7	52%	46%	E12-06-102	B.Zihlmann	Production	26	71
2018	Mar, 29 - May, 6	38	11.7	58%	52%	E12-06-102	B.Zihlmann	Production	19	90
2018	Sep, 21 - Nov, 26	66	11.7	53%	47%	E12-06-102	B.Zihlmann	Production	33	123
2019	Feb, 8 - Feb, 21	13	11.6	45%	N/A	E12-12-002	B.Zihlmann	1/2 DIRC Commissioning	6	6
2019	Feb, 21 - Mar, 5	15	11.6	52%	37%	E12-10-011	L.Pentchev	Installation, Production on Be, LHe, FOM=0.97 ⁴	7.3	7.3
2019	Mar, 8 - Apr, 15	38	11.2	73%	68%	E12-10-011	L.Pentchev	Production on LHe, FOM=0.85 ⁴	16.1	23.4
2019	Nov, 25 - Dec, 20	25	11.4	34%	32%	E12-12-002	B.Zihlmann	DIRC commissioning, actual start Dec, 3. PAC days = 0.32*25	8	14
2020	Jan, 10 - Mar, 24	75	11.4	62%	56%	E12-12-002	B.Zihlmann	Production with DIRC at high rate. First 2 weeks - lower rate	38	52
2020	Jul, 27 - Sep, 21	56	11.4	46%	38%	E12-12-002	B.Zihlmann	Production with DIRC at high rate	21.5	73.5
2021	Sep, 16 - Nov, 4	50	10.1	51%	45%	E12-10-011	L.Pentchev	Production on LHe, FOM=0.56 ⁴	14	37.4
2021	Nov, 8 - Dec, 21	43	10.9	70%	60%	E12-19-003	L.Pentchev	Production on LHe, FOM=0.73 PAC=43*0.6*0.73=19	19	19
2022	Jun, 8 - Aug, 17	71	11.6	46%	41%	E12-13-008	S.Taylor	CPP/NPP	29	29
2022	Aug, 27 - Dec, 18	113	11.6	64%	59%	E12-10-011	L.Pentchev	PrimeX production on LHe, FOM=0.91 ⁴ *0.85(TAGM)	51.6	89
2023	Jan, 12 - Mar, 19	67	11.6	48%	42%	E12-12-002	B.Zihlmann	GlueX-II Production. ABU was used to calculate the PAC days	28.1	102.
23-24	Mar, 20 - Jul, 18	460						FCAL2 installation		
2024	Jul, 19 - Dec, 15	150	12?			E12-12-002	B.Zihlmann	GlueX-II + JEF <i>Draft schedule</i>	75 ?	177.
2025	Jan, 13 - Mar, 16	62	12?			E12-12-002	B.Zihlmann	GlueX-II + JEF <i>Draft schedule</i>	31 ?	209.
25-26	Mar, 17 - Jul, 18	460						<i>Planning:KLF installation</i>		

E12-12-002	GlueX-II
E12-10-011	PrimeX-η
E12-19-003	SRC
E12-13-008	CPP/NPP

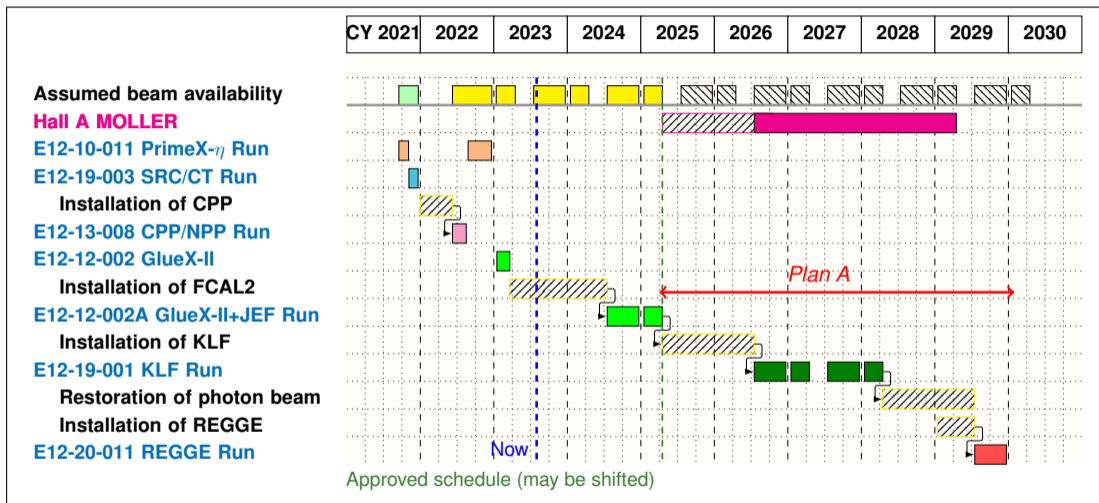
Scheduled for 2024-2025

Hall D running schedule: outlook



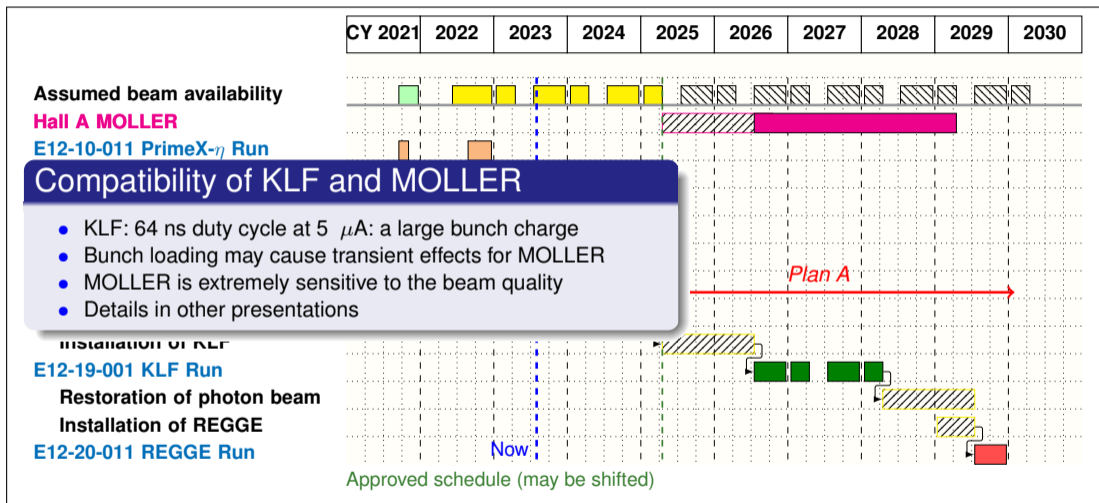
- Assuming 31 weeks/year for Hall D running in 2024/07-2025/03 and 30 weeks afterwards
- Assuming KLF compatibility with MOLLER, and timing budgeting for KLF and REGGE
- Assuming timely construction of JEF,KLF,REGGE

Hall D running schedule: outlook



- Assuming 31 weeks/year for Hall D running in 2024/07-2025/03 and 30 weeks afterwards
- Assuming KLF compatibility with MOLLER, and timing budgeting for KLF and REGGE
- Assuming timely construction of JEF, KLF, REGGE

Hall D running schedule: outlook

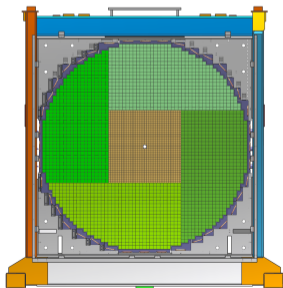


- Assuming 31 weeks/year for Hall D running in 2024/07-2025/03 and 30 weeks afterwards
- Assuming KLF compatibility with MOLLER, and timing budgeting for KLF and REGGE
- Assuming timely construction of JEF,KLF,REGGE

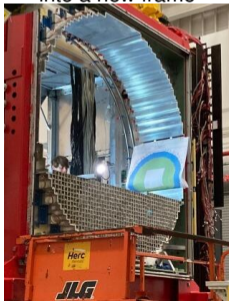
Ongoing projects for future experiments

FCAL2 PbWO₄ insert: Installation

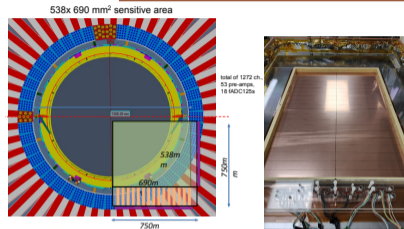
- Replacement of 400 lead glass blocks (out of 2800) with 1600 PbWO₄ crystals
- Twice better energy and spacial resolution, much better radiation hardness
- Required for the JEF experiment (to run with GlueX-II in 2024-2025)
- Installation on track



Re-stacking LG blocks into a new frame



GEM TRD: prototyping and testing



- Goal: additional PID for electrons and positrons, pion suppression ~ 10 at $\sim 90\%$ electron efficiency
- Prototype of 25% of area has been built
- Prototypes testes in test beams (JLab and FNAL)
- Electronics for the full project: VPX electronics, developed for PANDA; communication and contract with a Jülich group.
- Xe cost jumped: purification is needed

LOI to PAC51 for running of GlueX+TRD

ENP Budget/Staff Plans for Hall D

- **FY23 capital budget:**

- ▶ FCAL Upgrade: \$130k (bases etc)
- ▶ KLF \$400k : Designer's work, procurement of materials (the collimator cave), pending on the results of the readiness review (August) and may depend on the MOLLER compatibility conclusion

- **FY23 operation budget**

- ▶ Operation costs
- ▶ FCAL2/generic equipment
- ▶ GEM-TRD project
- ▶ Supported: 3 university postdocs (at a 50% level)
- ▶ Development for future

Hall D Staff:

- Scientific group: 13 staff scientists
2 Hall D postdoc positions (1 is currently open)
- Technical group: 1 mechanical engineer, 1 designer and 5 techs
1 additional ME position planned for FY24

ENP Budget/Staff Plans for Hall D

● FY23 capital budget:

- ▶ FCAL Upgrade: \$130k (bases etc)
- ▶ KLF \$400k : Designer's work, procurement of materials (the collimator cave), pending on the results of the readiness review (August) and may depend on the MOLLER compatibility conclusion

● FY23 operation budget

- ▶ Operation costs
- ▶ FCAL2/generic equipment
- ▶ GEM-TRD project
- ▶ Supported: 3 university postdocs (at a 50% level)
- ▶ Development for future

Hall D Staff:

- Scientific group: 13 staff scientists
2 Hall D postdoc positions (1 is currently open)
- Technical group: 1 mechanical engineer, 1 designer and 5 techs
1 additional ME position planned for FY24

Expected budget for KLF

- Capital: about \$2.4 M (design and equipment/materials)
\$53k spent so far for designer work
- More ME/MD work needed, options:
 - Engineering Dept (Capital)
 - Hall D staff (OPS)
- Operations: labor from ENP
general purpose equipment