


12GeV CEBAF Status and Plans

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A photograph of the Accelerator Operations Department control room. A person is seen from the side, sitting at a desk with multiple computer monitors displaying data and graphs. The room is dimly lit, with the primary light source being the screens.

Accelerator Operations Department

Outline

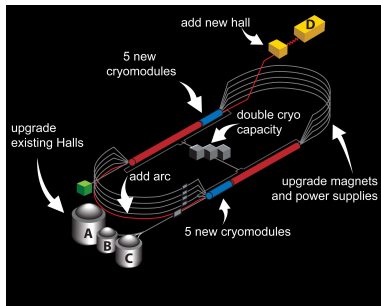
- 1 12GeV Upgrade: Status
 - 12GeV Accelerator Design
 - Down Schedule: LSD
 - Shutdown Work Planning
 - Cryogenics
 - Beam Transport: Magnets
 - Acceleration: SRF
- 2 Path to Beam Operations
- 3 Commissioning Schedule
- 4 HPS Option II: Beam Transport
- 5 Summary



12 GeV CEBAF Design

Constraints/Parameters:

- Use existing 6-GeV CEBAF tunnel
- $E_{GlueX} \geq 12\text{GeV}$
- $P_{beam} < 1\text{MW}$

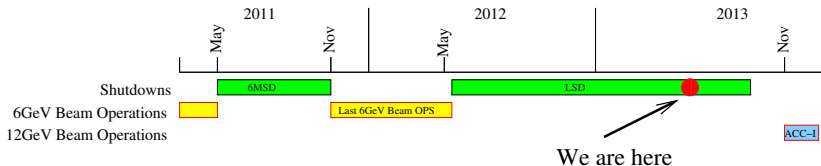


Design:

- Increase the linac energy gain from 600MeV/linac to 1100MeV/linac with the addition of five C100 cryomodules per linac.
- Add an additional arc (Arc10) and pass through the North Linac to bring the beam energy to 12 GeV.
- Add magnetic extraction and Hall-D beamline at the end of the North Linac for the GlueX experiment.
- Upgrade magnets, power supplies, cooling and cryogenics to support the higher beam energy.

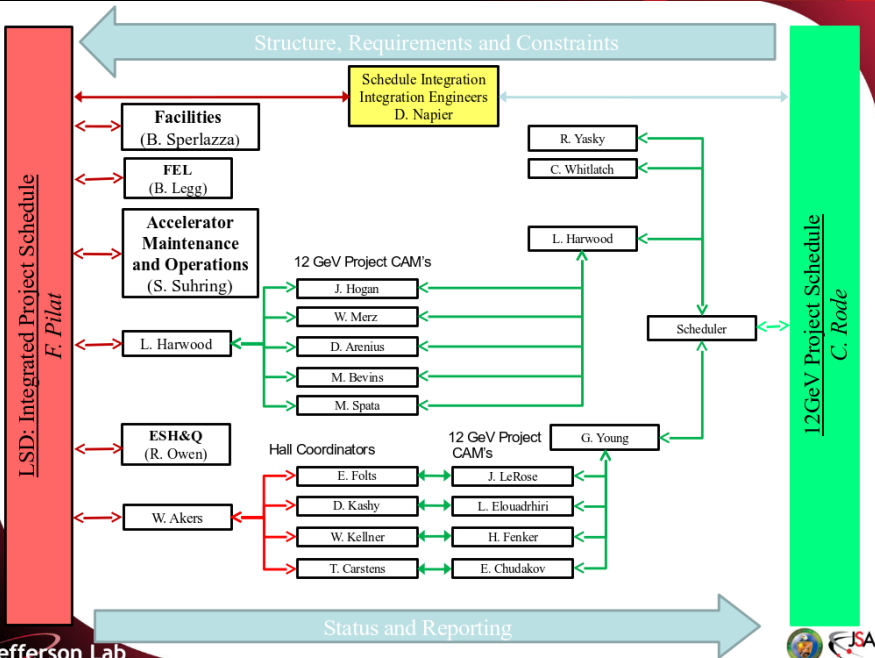
Down Schedule: LSD

Quick Summary



- Long Shutdown, 16 months long. Scheduled from May-2011 to Sep-2013.
 - Overall tasks have gone well, there were a few big surprises:
 - ▶ Underground cooling water pipe for CHL-1 fractured. Three month delay in the start-up of CHL-1 and SRF cavity recommissioning.
- Summary of LSD tasks:**
- LSD tasks likely to extend beyond Sep-2013
 - ▶ To be performed in || with System Check Out.
 - Still maintaining a Nov-2013 start-up

Shutdown Work Planning



Cryogenics

Done Maintenance on existing 6GeV infrastructure. Includes: transfer line maintenance and CHL-1 maintenance.

Done Restart CHL-1, **cooldown CEBAF Linacs**

Nearly Done CHL-2 Commissioning

In Progress Support 2K operations for SRF commissioning

In Progress Build transfer lines between CHL-2 and CEBAF

Not Started Commissioning 2nd 2K cold box. scheduled for 2013-Aug

The installed SRF cavities were all thermally cycled for the first time since hurricane Isabel. No **issues** on the subsequent cool down to 2K!!!



Magnets: Spreaders and Recombiners

4-corners of the machine



Done Tear out magnets, stands, girders in the 1S, 1R, 2S, 2R

Done Modified existing magnets, receive new magnets from vendor

Done Install new stands and girders

Nearly Done Field measurements of each (old and new) dipole

Done Install 1R region

Nearly Done Install 1S, 2S and 2R regions



Magnets: BSY, A,B,C & D transport



Done Remove magnets and girders in A, B & C beam lines

Done Removes stands, girders in the Transport/BSY region.

Done Modified existing magnets, receive new magnets from vendor

Done Install new stands in BSY, Transport and D lines

Nearly Done Field measurements of each (old and new) dipole

In Progress Install magnets in Transport and BSY region

In Progress Install magnets in the D transport and beam line

In Progress Install magnets in the A line

Not Started Install magnets in the B & C lines

Acceleration: SRF



Done Install R100 cryomodule in Injector (0L04 slot)

In Progress Install and commission ten C100 cryomodules. 9 out of 10 installed, 5 commissioned.

In Progress Recommission C20/C50 SRF base. About 25% complete.

In Progress Upgrade R100 RF controls and power to support 100MeV energy gain.

In Progress Refurbish weakest C20 module, resurrection of the C50 program (C50-11) for gradient maintenance.

Not Started Commission R100 and C50-11

Not Started Helium process identified weak

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The Accelerator Readiness Review Process

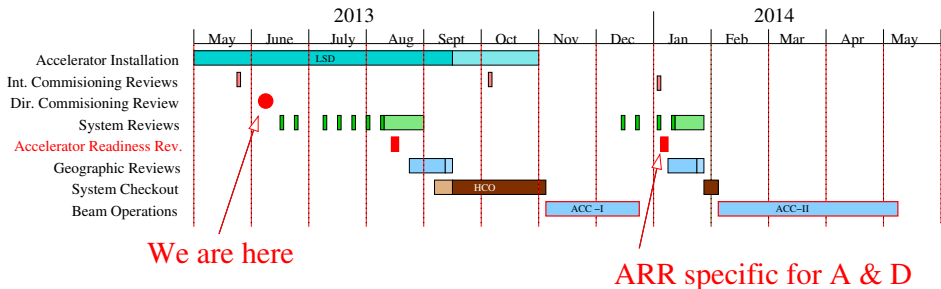
The Accelerator Readiness Review Process emphasizes the following ten items:

- 1 ✓ Final Safety Assessment Document (FSAD)
- 2 ✓ Accelerator Safety Envelope (ASE)
- 3 **Commissioning Plan**
- 4 ✓ Unreviewed Safety Issue Process (USI)
- 5 **Process/Procedure Evaluation**
- 6 ✓ Emergency Response
- 7 Documentation Control
- 8 **Safety**
- 9 **Training and Qualification**
- 10 **Staffing Requirements**

To be reviewed next week at the Director's Commissioning Review. This is one step in the preparation leading up to the ARR process.



Path to Beam Operations



Many concurrent tasks and efforts.

- ~Four months remaining of accelerator installation.
- We are at the start of a process to thoroughly review accelerator system status, commissioning plans and process in preparation for the Accelerator Readiness Review(ARR).
- Accelerator Readiness Review process will be a phased approach with the first review scheduled for August 2013.

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- 1 12GeV Upgrade: Status
- 2 Path to Beam Operations
- 3 Commissioning Schedule
 - Creating the Schedule
 - Beam Operations Schedule
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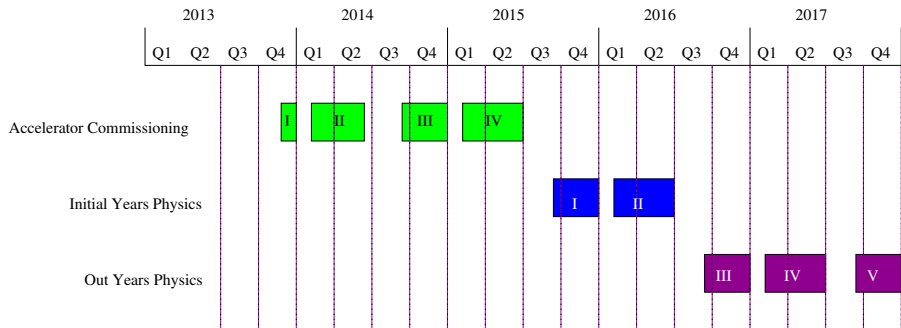
Creating the Beam Commissioning Schedule

Plan First, then Schedule

- Beam Commissioning plan was developed bottoms up without scheduling information. The plan includes:
 - ① 12GeV Project tasks (pre-ops).
 - ② Tasks required to span gaps in the 12GeV Project pre-ops tasks (Support pre-ops).
 - ③ Tasks needed to achieve *physics quality* beams.
 - ④ Tasks to establish routine operations.
- Beam commissioning tasks duration estimated based on previous experience. Estimate includes the expected initial low reliability of the hardware (50% in FY14).
- Number of operating weeks per Fiscal Year developed as part of the annual budgetary process with DOE.
- Beam commissioning **schedule** created that meshes the **plan** with the funded weeks of operation.
 - ▶ The original estimated task duration is retained.



CEBAF 12GeV Beam Operations



- *Constant Effort* scenario: 30 weeks of operation per year.
- Two running periods per year
 - ▶ Fall run typically about 13-14 weeks
 - ▶ Spring run typically 16-17 weeks
- Avoid running in summer months (June, July, Aug) to save power bill





Acc-I Schedule

2013-11-04 → 2013-12-20

Accelerator Run Period I Plan

WBS	Name	Note	Start	End	Duration	ProjectAccount	Oct 2013			Nov 2013			Dec 2013					
							30	07	14	21	28	04	11	18	25	02	09	16
2	Long Shutdown/Upgrade	Thi...	Tue 2013-01-01	Mon 2013-11-04	307.0													
2.2	Linac Tasks																	
2.2.1	North Linac		Thu 2013-04-11	Mon 2013-11-04	207.0													
2.2.1.3	R100 Cryomodule		Mon 2013-06-03	Mon 2013-11-04	153.3													
2.2.2	South Linac		Thu 2013-04-11	Fri 2013-11-01	204.0													
2.2.2.3	CS0-11 Cryomodule		Mon 2013-09-09	Fri 2013-11-01	53.0													
3	Hot Check Out		Tue 2013-08-27	Tue 2013-11-19	84.0													
3.3	LEM Data Collection	Ope...	Tue 2013-10-29	Tue 2013-11-19	21.0	MD_NP												
4	12GeV CEBAF Commissioning		Mon 2013-11-04	Fri 2015-06-12	585.0													
4.1	Accelerator Period I: 2.2GeV/pass to 2R, tune-mode beam	The...	Mon 2013-11-04	Fri 2013-12-20	46.5													
4.1.1	Recover: Beam up to 5MeV	Est...	Mon 2013-11-04	Mon 2013-11-11	7.0	Spreops_NP												
4.1.1.1	Beam to FC1		Mon 2013-11-04	Wed 2013-11-06	2.0	Spreops_NP												
4.1.1.2	Beam to 6MeV Spectrometer/Mott		Wed 2013-11-06	Mon 2013-11-11	5.0	Spreops_NP												
4.1.2	Spin up 1pass beam to 2R		Mon 2013-11-11	Fri 2013-12-20	39.5	Preops_12GeV												
4.1.2.1	Beam to the Inj. Spectrometer		Mon 2013-11-11	Sat 2013-11-16	5.0	Preops_12GeV												
4.1.2.2	Beam to the End of the Injector Chicane		Sat 2013-11-16	Tue 2013-11-19	3.8	Preops_12GeV												
4.1.2.3	Beam to End of North Linac		Tue 2013-11-19	Wed 2013-11-27	7.3	Preops_12GeV												
4.1.2.4	Beam to the 1R dumplette		Wed 2013-11-27	Sat 2013-12-07	10.0	Preops_12GeV												
4.1.2.5	Beam to End of South Linac		Sat 2013-12-07	Sat 2013-12-14	7.3	Preops_12GeV												
4.1.2.6	Beam to the 2R dumplette		Sat 2013-12-14	Wed 2013-12-18	4.0	Preops_12GeV												
4.1.2.7	Establish 2.2GeV/pass beam to 2R	Rai...	Wed 2013-12-18	Fri 2013-12-20	2.0	Preops_12GeV												

All effort and duration values are in days. 24/7 scenario

 Container Task
  Normal Task
  Milestone
 Off-duty period

The goal of this 6week run period is to establish 2.2GeV/pass tune-mode beam to the 2R dumplette. If successful, satisfies 12GeV Project CD4A-IV deliverable one year ahead of schedule: 2014-12-19

Acc-II Schedule

2014-02-05 → 2014-05-07

Accelerator Run Period II Plan

WBS	Name	Note	Start	End	Duration	Project/Account	Jan 2014	Feb 2014	Mar 2014	Apr 2014	May 2014
4	12GeV CEBAF Commissioning		Mon 2013-11-04	Fri 2015-06-12	585.0						
4.3	Accelerator Period II: E>1.1GeV/pass, tune-mode beam		Wed 2014-02-05	Wed 2014-05-07	91.0						
4.3.1	3-pass spin up (BSY)		Wed 2014-02-05	Wed 2014-02-19	14.0	Spreops_NP					
4.3.2	1/2/3 pass Magnet/Optics characterization		Wed 2014-02-19	Wed 2014-03-19	28.0	MD_NP					
4.3.3	Hall-A Detector Checkout		Wed 2014-03-19	Wed 2014-03-26	7.0	Preops_12GeV					
4.3.4	5.5-pass spin up to D		Wed 2014-03-26	Wed 2014-04-23	28.0	Spreops_NP					
4.3.5	4/5/5.5 pass Magnet/Optics characterization		Wed 2014-04-23	Wed 2014-05-07	14.0	MD_NP					

All effort and duration values are in days, 24/7 scenario

Container Task Normal Task Milestone
Off-duty period

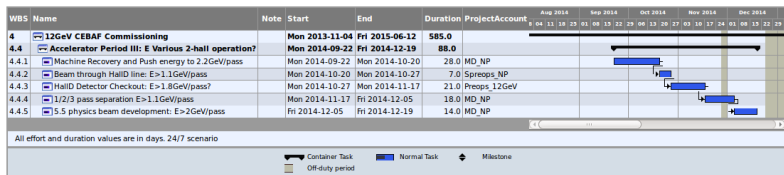
The goals of this run are:

- 1 Establish beam to CW capable dumps, Hall-A, Hall-D or BSY dump
- 2 First CW beam operations in the 12GeV era
- 3 Multi-pass steer up
- 4 Beam to Hall-A for detector tests

Acc-III Schedule

2014-09-22 → 2014-12-19

Accelerator Run Period III Plan



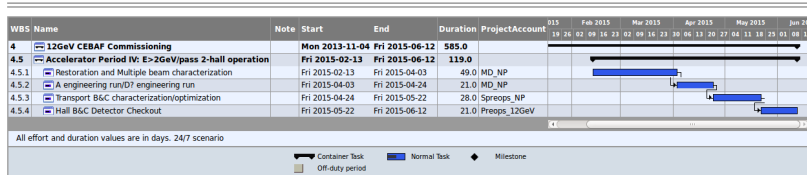
The highlight of this run period is the Hall-D detector checkout (WBS: 4.4.3) to satisfy CD4B-III which has a date of 2016-06-30.

Once the RF separators are commissioned CEBAF will be in a position to support simultaneous activities. With the caveat that the beam to A (or B and C) be at lower pass than where the beam commissioning effort is focused.

Acc-IV Schedule

2015-02-13 → 2015-06-12

Accelerator Run Period IV Plan



The impact of the 12GeV re-baseline has not been incorporated yet into the schedule. Some of these tasks are likely to be deferred.

Converting task 4.5.4 three weeks of 12GeV pre-ops to beam for physics will require NP funding.

Task 4.5.3 likely to be moved to FY16 as well (four weeks of B&C transport optimization) is NP funded.

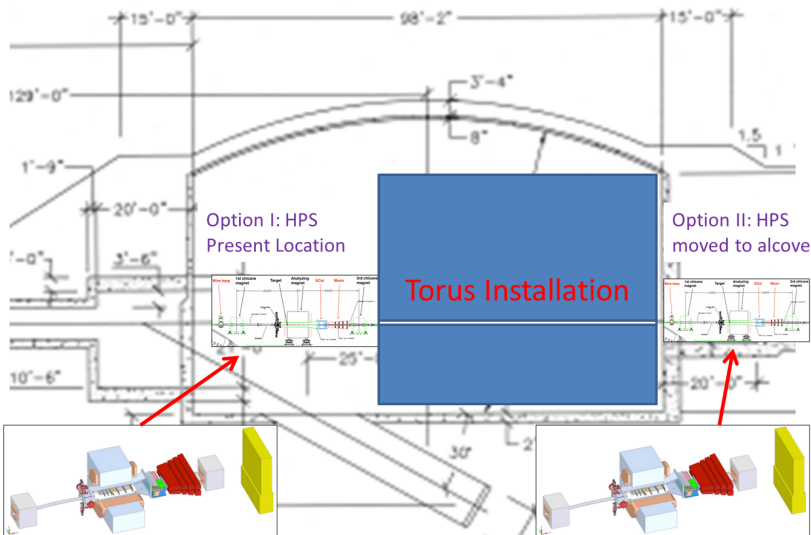
There is potentially a 10wk physics run in this run period (4.5.2 + 4.5.3 + 4.5.4).



HPS Option II

Stolen from Ken's slides

New Options for location of HPS to allow torus installation



Beam Layout: Migrating from HPS → Option II

Maintain steering and diagnostics just upstream on first HPS dipole

What	MyName	Distance to first HPS dipole (m)	Provenance
Vertical Corrector	MBC2H08V	2.5	New
Horizontal Corrector	MBC2H08H	2.35	New
Beam Position Monitor	IPM2H08	2.075	New
Drift			
Beam Viewer	ITV2H09	0.89	ITV2H01?
Wire Scanner	IHA2H09	0.69	IHA2H00
Beam Position Monitor	IPM2H09	0.5	New
Center of HPS 1 st Dipole	MBX2H90	0	Frascati



Beam Layout: Migrating from HPS → Option II

Move focusing elements to *space frame*

What	MyName	Distance to first HPS dipole (m)	Distance to Tagger harp (m)
nA Beam Position Monitor	IPM2H01	27.505	12.914
Beam Position Monitor?	IPM2H02	27.255	13.164
Quadrupole	MQA2H02	26.905	13.514
Quadrupole	MQR2H03	26.305	14.114
Quadrupole	MQA2H04	25.705	14.714
Vertical Corrector	MBC2H04V	25.180	15.239
Horizontal Corrector	MBC2H04H	24.98	15.439
Beam Position Monitor	IPM2H04	24.905	15.514
CLAS Target	ETACLAS	15.415	25.004
Center of HPS 1 st Dipole	MBX2H90	0	40.419



HPS Requirements:

- horizontal ribbon beam
- $250 < \sigma_x < 300 \mu\text{m}$
- $\sigma_y < 40 \mu\text{m}$

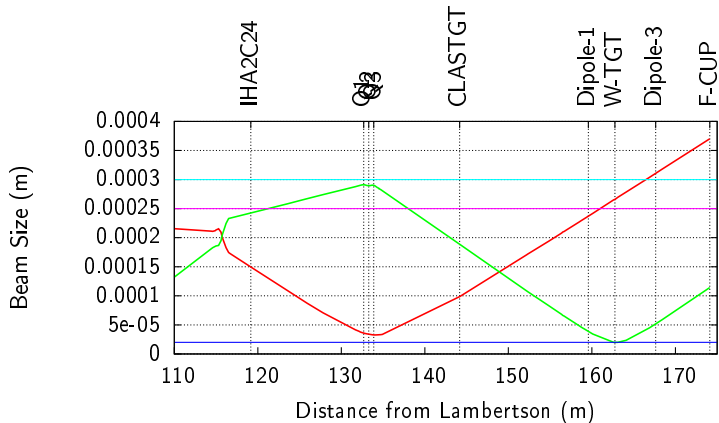
Fit Convergence Criteria:

- $250 < \sigma_x < 300 \mu\text{m}$
- $\sigma_y < 20 \mu\text{m}$

The factor of two on σ_y is a safety factor. A mis-matched beam will only make the beam larger. The incoming beam emittance is more likely to be larger not smaller than design. The HPS beam test to demonstrate a ribbon beam at the tagger harp measured a beam width that was about $2\times$ larger than design.

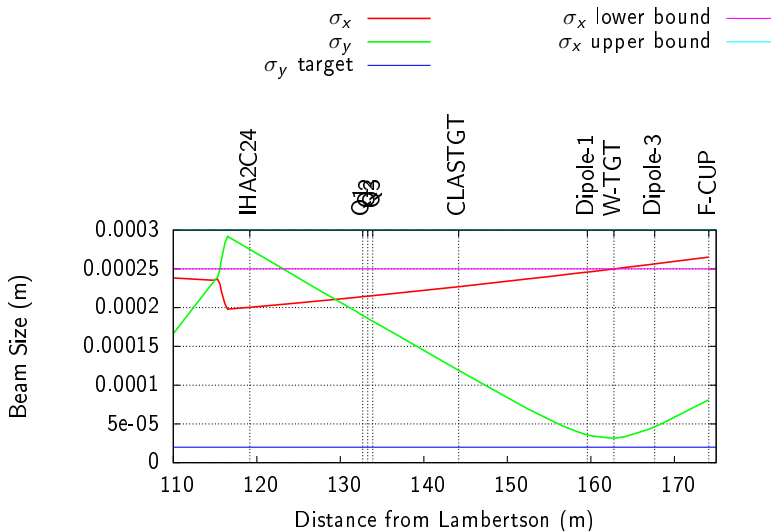
Invoking the three HPS quads

σ_x — (red line)
 σ_y — (green line)
 σ_y fit target — (blue line)
 σ_x lower bound — (magenta line)
 σ_x upper bound — (cyan line)



Converges to constraint, life is good.

Can we live without the three HPS quads?



Does not converge to constraint. But does result in values that satisfy the HPS requirements. But this is accomplished with some quads at the maximum setting.

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 - The Final Word



Accelerator Status Summary

- Barely holding to the 2013-Nov-04 date for the first 12GeV Commissioning activities.
- First beam to halls Spring 2014, for detector tests in Hall-A.
- Possibilities for beams for Physics in FY15

HPS Option II Summary

- Retain diagnostics and correctors magnets upstream of HPS.
- Option II is viable
- A set of magnet settings can be found to achieve HPS beam size on target requirements without adding additional quadrupole magnets.
 - ▶ This configuration has very little safety margin.
- Quadrupole triplet just upstream of CLAS provides for a more robust configuration more likely to achieve HPS requirements.

END HERE!!!

Thank You for your time and attention.



Beam Requirements for Initial Operations

Hall	Emittance (nm-rad)	Energy Spread σ (%)	Spot Size σ (μm)	Halo
A	$\varepsilon_x < 10$ $\varepsilon_y < 5$	< 0.05 (12 GeV)	$\sigma_x < 400$	$< 1 \times 10^{-4}\dagger$
		< 0.003 (2-4 GeV)	$\sigma_y < 200$ ($\sigma_y < 100$) (2-4 GeV)	
B	$\varepsilon_x < 10$ $\varepsilon_y < 10$	< 0.1	$\sigma_x < 400$	$< 2 \times 10^{-4}\dagger$
			$\sigma_y < 400$	
C	$\varepsilon_x < 10$ $\varepsilon_y < 10$	< 0.05	$\sigma_x < 500$	$< 2 \times 10^{-4}\dagger$
			$\sigma_y < 500$	
D	$\varepsilon_x < 50$ $\varepsilon_y < 10$	< 0.5	At Radiator: $\sigma_x < 1550, \sigma_y < 550$	$< 1\%\ddagger$
			At Collimator $\sigma_x < 540, \sigma_y < 520$	

\dagger Ratio of the integrated non-Gaussian tail to Gaussian core.

\ddagger Ratio of Halo background event rate to physics event rate.

(GlueX-doc-775-v4, GlueX-doc-646-v5)

Beam Requirements for Out-Year Operations

Hall	Emittance (nm-rad)	Energy Spread σ (%)	Spot Size σ (μm)	Halo
A	$\epsilon_x < 10$ $\epsilon_y < 5$	< 0.05 (12 GeV)	$\sigma_x < 400$ $\sigma_y < 200$	$< 1 \times 10^{-4}\dagger$
		< 0.003 (2-4 GeV)	$(\sigma_y < 100)$ (2-4 GeV)	
B	$\epsilon_x < 10$ $\epsilon_y < 10$	< 0.1	$\sigma_x < 400$ $\sigma_y < 400$	$< 1 \times 10^{-4}\dagger$
		< 0.05 < 0.03 (6 GeV)	$\sigma_x < 400$ $\sigma_y < 200$	$< 1 \times 10^{-4}\dagger$
C	$\epsilon_x < 10$ $\epsilon_y < 5$	< 0.05 < 0.03 (6 GeV)	$\sigma_x < 400$ $\sigma_y < 200$	$< 1 \times 10^{-4}\dagger$
		< 0.5	At Radiator: $\sigma_x < 1550, \sigma_y < 550$ At Collimator: $\sigma_x < 540, \sigma_y < 520$	$< 1\%\ddagger$

\dagger Ratio of the integrated non-Gaussian tail to Gaussian core.

\ddagger Ratio of Halo background event rate to physics event rate.

([GLueX-doc-775-v4](#), [GLueX-doc-646-v5](#))

Beam Requirements

Endstations	6GeV	12 GeV					
	OPS	CD-4		Initial 12GeV		Out-Years	
	ABC [†]	ABC	D	ABC	D	ABC	D
Energy (GeV)	6	≥6	≥10	11 [‡]	12 [‡]	11	12
Current (μA)	200	0.002	0.002	85	5	85	5
ϵ_x (nm-rad)	<1	NA	20	10	50	10	10
ϵ_y (nm-rad)	<1	NA	20	5	10	5	5
$\delta p/p$ (% RMS)	0.003	NA	NA	0.05	0.5	0.05	0.5
HALO (ppm)	ND	NA	NA	100	100	100	10

[†] The values for ABC represent the most stringent requirement of the three end-stations during the 6 GeV era.

[‡] High availability 5.5(5) pass operation restricted to be at or below 10(9) GeV for Hall-D(ABC) in FY14 due to insufficient Dog-Leg range.