


# 12GeV CEBAF Status and Plans

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A photograph of the Accelerator Operations Department control room. A person is seated at a workstation 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

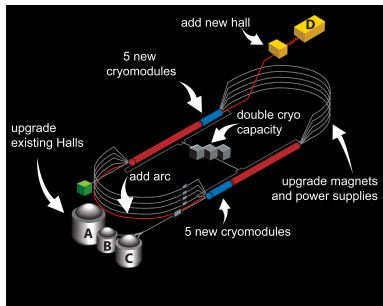
- 1 12GeV Upgrade: Status
  - 12GeV Accelerator Design
  - Down Schedule: LSD
  - Cryogenics
  - Beam Transport: Magnets
  - Acceleration: SRF
  - CEBAF Status Table
- 2 12GeV Project: Rebaseline
- 3 Path to Beam Operations
- 4 Commissioning Schedule
- 5 Summary



# 12 GeV CEBAF Design

## Constraints/Parameters:

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

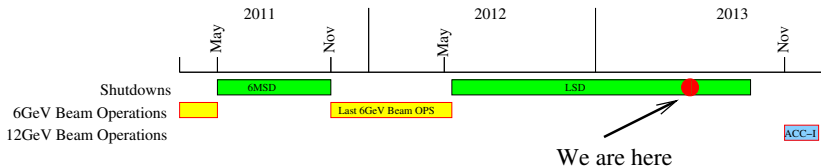


## Design:

- 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.
- LSD tasks likely to extend beyond Sep-2013**
- ▶ To be performed in || with System Check Out.
- Still maintaining a Nov-2013 start-up

# 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 2<sup>nd</sup> 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 10 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 cryomodules



# CEBAF Status

Region	2012-12 WAG % complete	2013-06 WAG % complete	2013-06 Independent WAG
Injector	90	90	
2R merge	20	50	40
NL C20/C50	80	95	
NL C100	30	80	
1S Spread	20	80	75
East Arc	95	97.5	88
1R Recombiner	45	100	
SL C20/C50	90	90	
SL C100	70	80	
2S Spread	15	50	25
BSY	15	50	
West Arc	95	97.5	88
Hall-A	5	50	
Hall-D Line	5	50	40

# Outline

- 1 12GeV Upgrade: Status
- 2 12GeV Project: Rebaseline
  - Implications of Proposed 12GeV Project Re-baseline
  - Constraints on Initial Program
- 3 Path to Beam Operations
- 4 Commissioning Schedule
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# 12GeV Project Re-baseline

*While the November Lehman panel wasn't satisfied with the plan that was presented then, the May panel was generally complimentary of the updated plan, although there were some concerns about the super conducting magnets. They gave some homework that needs to be addressed. The timeline for the next formal discussion of the Rebaseline is August.*

## Accelerator Scope:

- Hall-D nA BPM moved to FY14
- Hall-D feedback moved to FY14
- Some Safety Systems scope moved to FY14
- Tunnel Air-conditioning moved to FY15

## Physics Scope:

- Hall-B beam commissioning proposed FY16 Q2
- Hall-C beam commissioning proposed FY16 Q2



# Implications of Project Re-baseline

**Hall-B/Hall-C New Dates** 7-weeks of beam commissioning for B&C in **Acc-IV** needs to be pushed to later dates.

**Hall-D nA BPM/feedback** The initial  $e^-$  beam commissioning presently schedule for Spring 2014 will be performed without these systems. The systems should be ready by Fall 2014 for Engineering and subsequent initial Physics run periods.

**Tunnel Air Conditioning** Without tunnel air conditioning the air temperature is estimated to rise to 135F ( $\Delta T \approx 65F = 36C$ ) for 5.5 pass 12GeV operation (5-pass 11GeV to A,B,C).

- Electronics in the tunnel not rated to work at this elevated temp
- Concrete thermal expansion,  $\alpha = 9.8\mu\text{m}/\text{m}\cdot\text{K}$ : 350 $\mu\text{m}/\text{m}$  and its impact of machine pathlength.

About 9 weeks of beam commissioning (**Acc-III and Acc-IV**) and characterization at design energy will need to be deferred to later dates.



# Constraints on the Initial 12GeV Program

- Box Power Supplies** Arc7-Arc10 box supply milestone is **2014-Jan**. Cannot delivery full energy beam until these box supplies are delivered and connected (potential impact on **Acc-II** plans).
- Box Power Supplies** LAM3, XSEP8, XSEP10 box supply milestone is **2014-May**. Until these supplies are delivered 11GeV(12GeV) capability to A,B&C (D) is not possible (potential impact on **Acc-II** plans).
- DogLeg Upgrade** Scheduled for completing **Summer 2014**. Without the doglegs expect longer than normal down times due to pathlength adjustment when at 12GeV setting. (**Acc-II**)
- Tunnel Air-conditioning** 12GeV Project re-baseline proposed installation date: **Summer 2015**, original plan Summer 2014. Without tunnel AC, tunnel temperature rises to 135F at 12GeV settings. This is not acceptable (electronics, concrete expansion, pathlength ...). Without AC, maximum 5(5.5) pass energy is capped at 9GeV(10GeV). (**Acc-II, Acc-III, Acc-IV**)



# Outline

- 1 12GeV Upgrade: Status
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- 3 Path to Beam Operations
  - Accelerator Readiness Process
- 4 Commissioning Schedule
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# The Accelerator Readiness Review Process

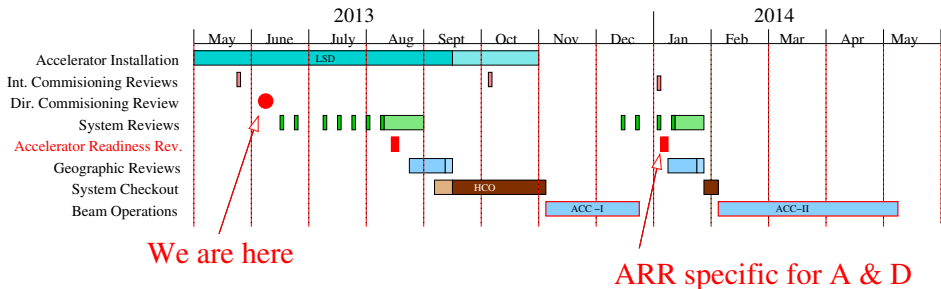
The Accelerator Readiness Review Process emphasizes the following ten items:

- 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.



# Outline

- 1 12GeV Upgrade: Status
- 2 12GeV Project: Rebaseline
- 3 Path to Beam Operations
- 4 Commissioning Schedule
  - Creating the Schedule
  - Beam Operations Schedule
- 5 Summary



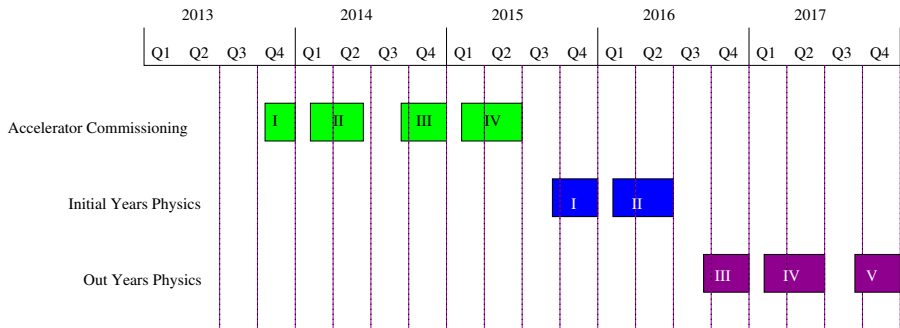
# Creating the Beam Commissioning Schedule

## 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		Thu 2013-04-11	Mon 2013-11-04	207.0													
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	Spreeps_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	Spreeps_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

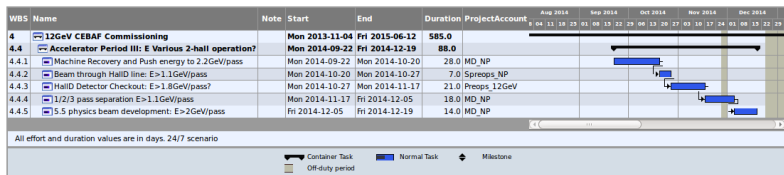
The goals of this run are:

- 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



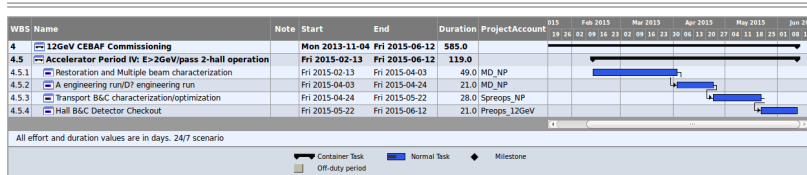
The highlight of this run period is the Hall-D detector checkout (WBS: 4.4.3) to satisfy CD4B-III which has a date of 2016-06-30.

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).



# Outline

- 1 12GeV Upgrade: Status
- 2 12GeV Project: Rebaseline
- 3 Path to Beam Operations
- 4 Commissioning Schedule
- 5 Summary
  - The Final Word





## The seas are challenging:

- The work is not yet complete.
- The number of tasks that extend beyond the Sep-19 (end of the LSD) is growing.
- We are only two weeks into hurricane season and had a tropical storm pass through.

## The winds are favorable:

- There have been challenges to the Accelerator upgrade; they have been squashed without major impact to the scheduled start of beam commissioning.
- At the cusp of an extensive review cycle in preparation for the Accelerator Readiness Review.
- Discussions on scheduling experiments have started.

# END HERE!!!

Thank You for your time and attention.



# Beam Requirements for Initial Operations

Hall	Emittance (nm-rad)	Energy Spread $\sigma$ (%)	Spot Size $\sigma$ ( $\mu\text{m}$ )	Halo
<b>A</b>	$\varepsilon_x < 10$ $\varepsilon_y < 5$	$< 0.05$ (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>B</b>	$\varepsilon_x < 10$ $\varepsilon_y < 10$	$< 0.1$	$\sigma_x < 400$	$< 2 \times 10^{-4}\dagger$
			$\sigma_y < 400$	
<b>C</b>	$\varepsilon_x < 10$ $\varepsilon_y < 10$	$< 0.05$	$\sigma_x < 500$	$< 2 \times 10^{-4}\dagger$
			$\sigma_y < 500$	
<b>D</b>	$\varepsilon_x < 50$ $\varepsilon_y < 10$	$< 0.5$	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 $\sigma$ (%)	Spot Size $\sigma$ ( $\mu\text{m}$ )	Halo
<b>A</b>	$\epsilon_x < 10$ $\epsilon_y < 5$	$< 0.05$ (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>B</b>	$\epsilon_x < 10$ $\epsilon_y < 10$	$< 0.1$	$\sigma_x < 400$ $\sigma_y < 400$	$< 1 \times 10^{-4}\dagger$
<b>C</b>	$\epsilon_x < 10$ $\epsilon_y < 5$	$< 0.05$	$\sigma_x < 400$	$< 1 \times 10^{-4}\dagger$
		$< 0.03$ (6 GeV)	$\sigma_y < 200$	
<b>D</b>	$\epsilon_x < 10$ $\epsilon_y < 5$	$< 0.5$	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

Endstations	6GeV	12 GeV					
	OPS	CD-4		Initial 12GeV		Out-Years	
	ABC <sup>†</sup>	ABC	D	ABC	D	ABC	D
Energy (GeV)	6	≥6	≥10	11 <sup>‡</sup>	12 <sup>‡</sup>	11	12
Current (μA)	200	0.002	0.002	85	5	85	5
$\epsilon_x$ (nm-rad)	<1	NA	20	10	50	10	10
$\epsilon_y$ (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

<sup>†</sup> The values for ABC represent the most stringent requirement of the three end-stations during the 6 GeV era.

<sup>‡</sup> 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.