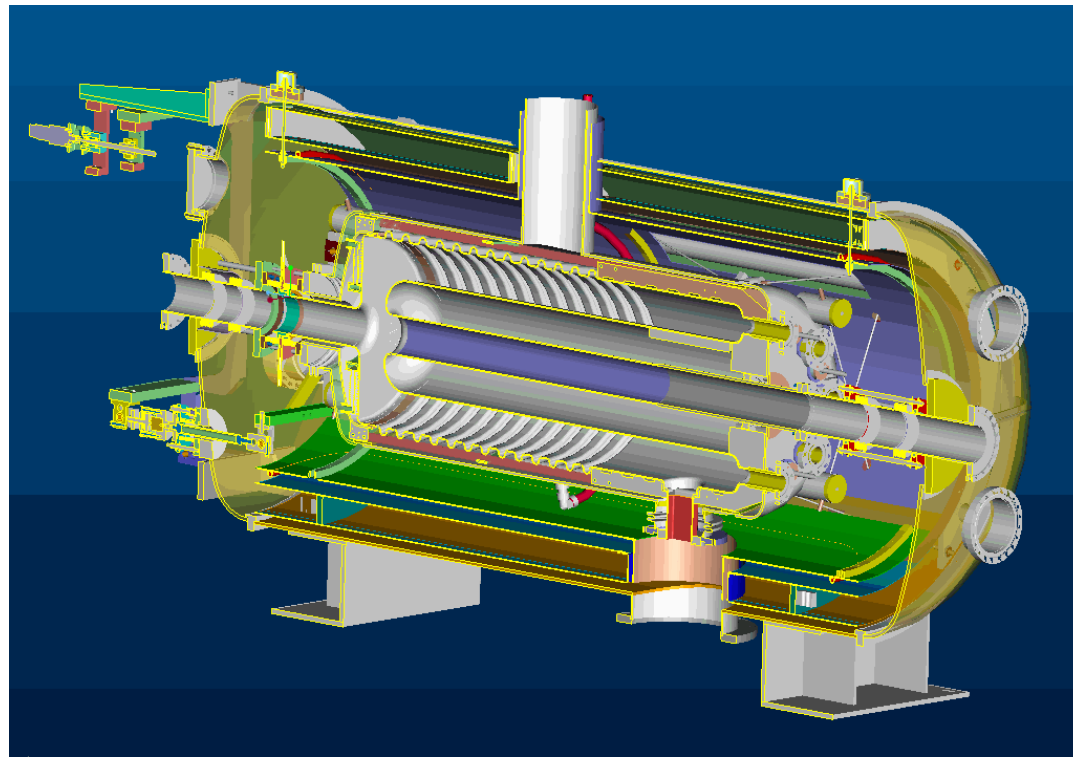


RHIC 56 MHz Cryomodule

External Review 03/08/11

Program overview



Cross-sectional view of 56 MHz Cavity in Vacuum Vessel

RHIC 56 MHz Cryomodule

External Review

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- **RHIC SRF 56 MHz Storage Cavity**
- The C-AD SRF and Electron Cooling Group is developing a SRF cavity to serve as a storage cavity at RHIC.
- The motivation is:
 - To provide a large voltage at minimal power and low cost and space requirements (2.0 MV) at a low frequency, conservatively from single cavity
- Allow for a huge bucket by
 - Adiabatic capture directly from 28 MHz cavity, eliminating the generation of satellite bunches
 - Keeping ions in one bucket -reducing spill and background
 - Improving luminosity in the detector vertex
 - Improving luminosity by allowing a shorter beta function at IP due to a reduced hourglass effect

RHIC 56 MHz Cryomodule

External Review

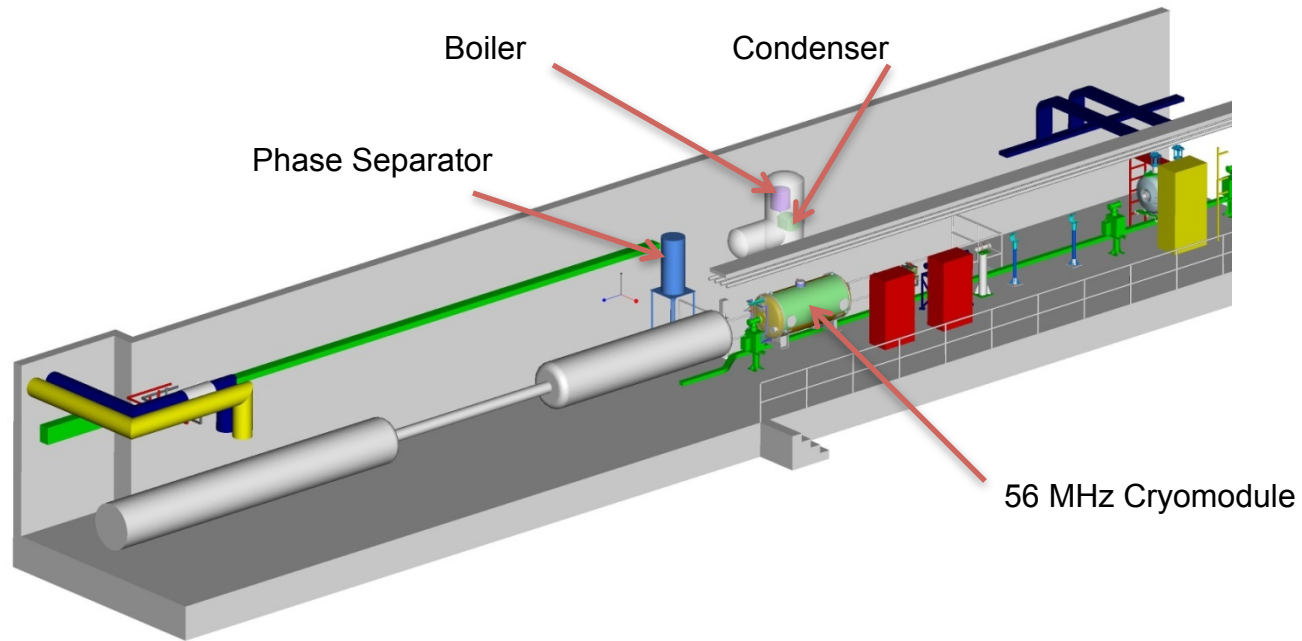
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- **RHIC SRF 56 MHz Storage Cavity**
- SRF Advantages
 - SRF cavities are stable
 - Improved vacuum in RF sector
 - A somewhat lower RHIC impedance due to fewer cavities
- For more information see the following presentations from the February 2008 Machine Advisory Committee:
- http://www.c-ad.bnl.gov/MAC/MAC_08/PDF/07_Ben-Zvi_MAC08_56MHz_RHIC_SRF_Cavityr1.pdf
- http://www.c-ad.bnl.gov/MAC/MAC_08/PDF/08_EChoi_MAC_2008%20Fundamental_and_HOM_damper_designs.pdf
- http://www.c-ad.bnl.gov/MAC/MAC_08/PDF/09_Towne_20080211MACPresentationTowne.pdf

RHIC 56 MHz Cryomodule

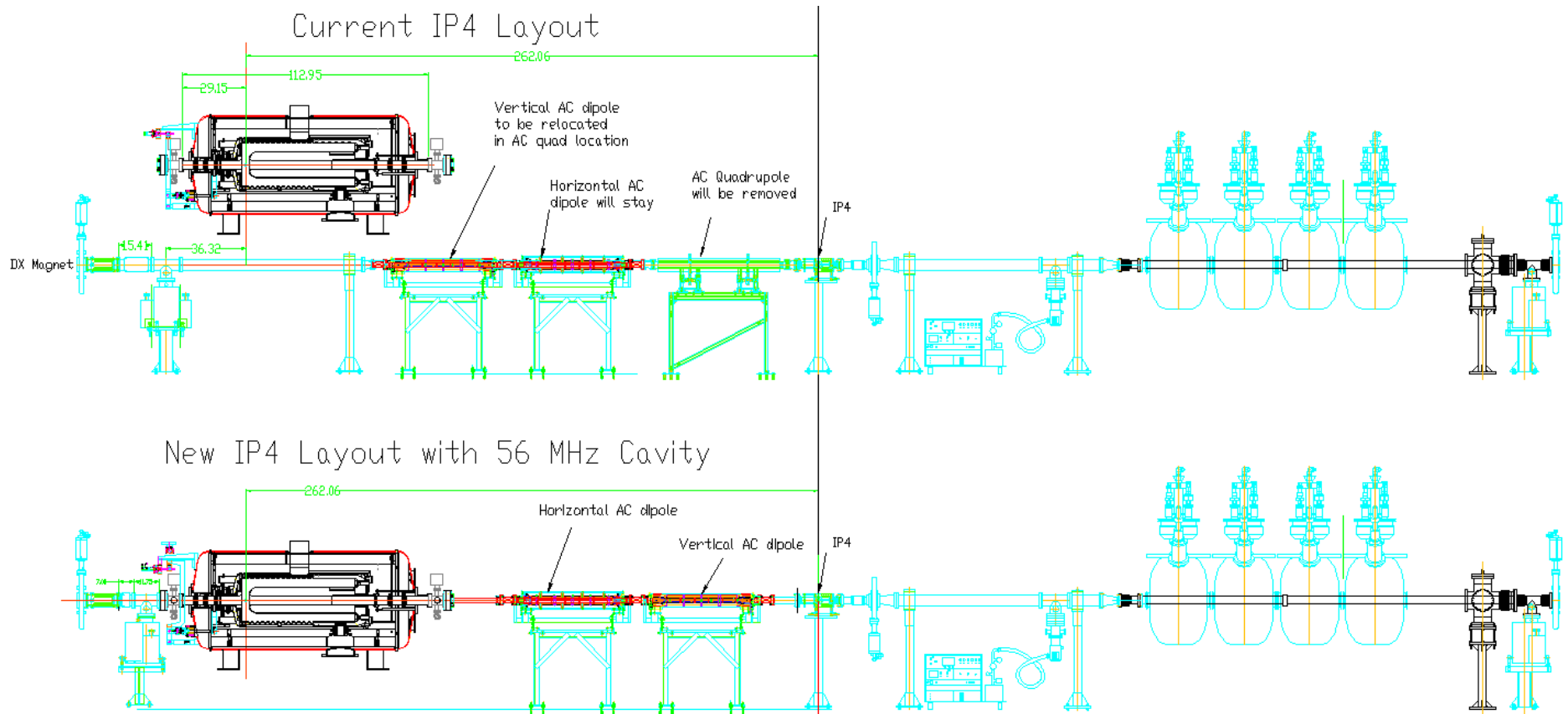
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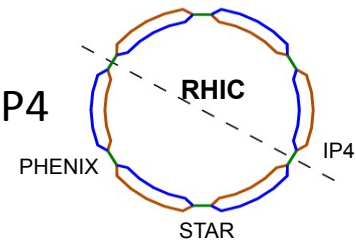


Layout of IP4 with 56 MHz Cryomodule and Cryogenic Components
(Preliminary)

56 MHz Cryomodule- RHC Installation



Cryomodule will be placed in the Sector 3 side of IP4

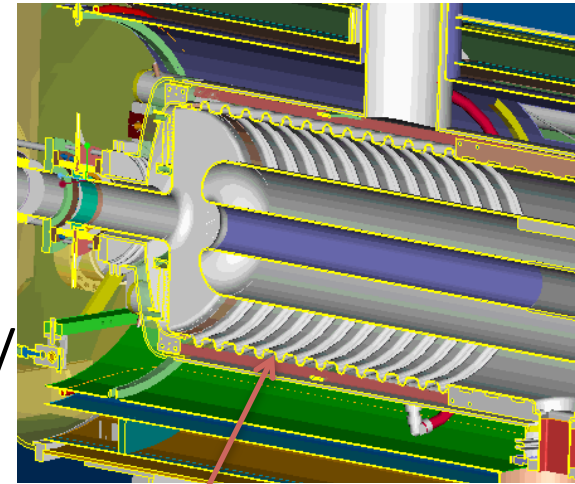


RHIC 56 MHz Cryomodule

External Review

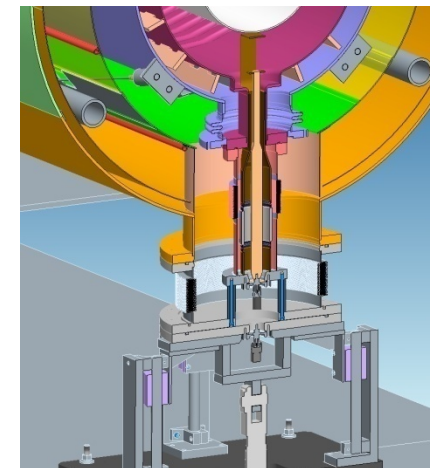
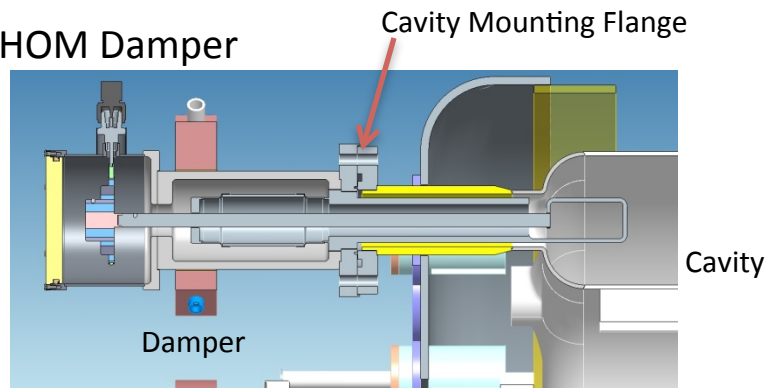
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- Cavity Design Characteristics
 - All Niobium / NbTi Construction
 - Non-traditional QWR cavity orientation (usually rotated 90°)
 - “Corrugated” Outer Conductor to reduce / eliminate Multi-pacting
 - Unique design of high order mode (HOM) dampers
 - Insertion of Fundamental Damper “removes” cavity from RHIC



OC “Corrugations”

Cross-Section of HOM Damper



Fundamental Damper
(inserted)

RHIC 56 MHz Cryomodule

External Review

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- Cavity and Helium Vessel presently being fabricated by Niowave, Inc of Lansing, MI



- Cavity Processing to be performed at AES, Inc. of Medford, NY
- Vertical testing and cleanroom assembly to be performed at BNL / C-AD.



RHIC 56 MHz Cryomodule

External Review

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AIP: 56MHz SRF System (71095)		Total Burdened Cost&Contingency	Funds Committed
<i>Cavity Processing</i>	Bulk & light BCP / HPR (AES), furnace treatment (BNL) and cleanroom assembly (BNL)	\$ 203,601	
Tuner	All components, including drive controllers	\$ 186,569	
Cavity & Helium Vessel	Contract awarded - Fabrication underway	\$	\$ 1,492,250
Cryomodule	All components: space frame, MLI, shields, etc. (not TUNER) in design	\$ 978,393	
RF System	RF amplifier, Low Level RF system & cables	\$ 107,080	\$ 73,920
Couplers and Dampers	HOM Dampers, Fundamental Damper, FPC, Pick-up Probes	\$ 1,433,690	
Vacuum	Pumps, gauging, chambers, valves and controls	\$ 184,668	
Total :		\$ 3,094,001	

RHIC 56 MHz Cryomodule

External Review

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AIP: Low Noise Helium System (71073)

	Total	Burdened	Cost &Contingency
Warm Compressor System			\$ 1,275,657
Cold Vapor Heating System			\$ 149,129
Cold Transfer Line System			\$ 457,081
Warm Piping System			\$ 236,328
Controls / Instrumentation			\$ 222,780
Condenser Cryostat System			\$ 1,127,539
<hr/>			
	Total :		\$ 3,468,514

RHIC 56 MHz Cryomodule

External Review

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	Total Estimated Cost
56MHzCavity Process Tooling (18036)	
<i>RF Cavity BCP Fixture (cage) & Adapter</i>	\$35,025
<i>Tack / Rolling Weld Fixture</i>	\$21,333
<i>Alum-a-Lift Liftcart & Rotating Clamp</i>	\$77,564
<i>Roll Cart / Flip Cart</i>	\$16,894
<i>VTA Support Adaptor</i>	\$7,071
<i>String Assembly Tooling</i>	\$37,658
<i>Cryomodule Assembly Tooling</i>	\$42,380
<i>Cryomodule Installation Tooling</i>	<u>\$15,280</u>
Total :	\$253,205

RHIC 56 MHz Cryomodule Milestone Schedule

includes Cold Testing of Cryomodule outside of RHIC ring

ID	Task Name	Notes	Duration	Finish	2010		2011		2012		2013					
					H1	H2	H1	H2	H1	H2	H1	H2				
1	56 Mhz SRF Cavity Program Start, Blue Ring AIP Funding Released	1	0 days	Wed 1/2/08												
2	Design Development		720 days	Fri 10/14/11												
3	56 Mhz SRF Cavity with Helium Vessel Design Complete	13	0 days	Tue 3/9/10	◆ 3/9											
4	HOM Dampers Design Complete	8	0 days	Wed 2/23/11			◆ 2/23									
5	Fundamental Damper Design Complete	5	0 days	Fri 5/20/11			◆ 5/20									
6	Fundamental Power Coupler Design Complete	9	0 days	Thu 4/28/11			◆ 4/28									
7	Cavity Tuner Design Complete	25	0 days	Wed 6/22/11			◆ 6/22									
8	Cryomodule Component Design Complete	36	0 days	Fri 10/14/11					◆ 10/14							
9																
10	External Design Review Complete	11	0 days	Fri 1/9/09												
11	Second External Design Review Complete		0 days	Wed 3/9/11			◆ 3/9									
12																
13	LESHC & ASSRC Reviews (Initial)	10	0 days	Tue 1/27/09												
14																
15	Component Procurement		159 days	Wed 4/11/12												
16	Cavity Fabrication Complete	170	0 days	Thu 9/1/11					◆ 9/1							
17																
18	HOM Dampers Procurement Complete	48	0 days	Mon 12/12/11					◆ 12/12							
19	Fundamental Damper Procurement Complete	44	0 days	Fri 12/23/11					◆ 12/23							
20	Fundamental Power Coupler Procurement Complete	52	0 days	Thu 1/5/12					◆ 1/5							
21																
22	Cryomodule Components Procurement Complete	59	0 days	Wed 4/11/12					◆ 4/11							
23																
24	Testing and Process Equipment		159 days	Wed 4/11/12												
25	Vertical Test Facility Complete	79	0 days	Tue 9/27/11					◆ 9/27							
26																
27	Cavity Process Tooling Complete	135	0 days	Fri 9/2/11					◆ 9/2							
28																
29	Cavity String & Transport Tooling Complete	100	0 days	Mon 1/30/12					◆ 1/30							
30	Cryomodule Assembly Tooling Complete	102	0 days	Wed 4/11/12					◆ 4/11							
31																
32	Cavity Processing Complete, including Vertical Testing	230	0 days	Tue 2/14/12					◆ 2/14							
33																
34	Cavity String Assembly Complete	255	0 days	Wed 4/25/12					◆ 4/25							
35																
36	Cavity Cryomodule Assembly Complete	291	0 days	Fri 8/24/12					◆ 8/24							
37																
38	Cryomodule Cold Testing	304	189 days	Mon 6/24/13												
39																
40	Cryomodule moved to RHIC Tunnel	364	0 days	Wed 7/3/13								◆ 7/3				
41																
42	ASSRC Walkthrough Checklist issued	391	0 days	Wed 8/7/13								◆ 8/7				
43																
44	In-Tunnel Installation Complete	391	0 days	Mon 8/26/13								◆ 8/26				
45																
46	All Cavity System Complete / Run Approval Received	392	0 days	Tue 9/10/13								◆ 9/10				

RHIC 56 MHz Cryomodule

External Review

03/08/11

- Cavity and Helium Vessel
- Design Complete 03/09/10
- Contract Awarded 05/10/10
- Fabrication Complete 09/01/11
- Processing Complete (including VTF) 02/14/12
- String Assembly Complete 04/25/12
- Cryomodule Complete 08/24/13
- Cryomodule Cold Testing Complete 06/24/13
- RHIC IP4 Installation Complete 08/25/13

RHIC 56 MHz Cryomodule

External Review

03/08/11

- Tuner
- Design Complete 06/22/11
- Parts Procurement Complete 02/15/11
- Mock-up Assembly Complete 03/15/12
- Tuner in Cryomodule & Tested 05/22/12

RHIC 56 MHz Cryomodule

External Review

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- Cryomodule Components

(Vacuum Vessel, Shielding & Support System)

- Magnetic & Heat Shields Designs Complete 05/18/11
- Shields Procurement Complete 11/08/11
- Space Frame Design Complete 06/21/11
- Space Frame Procurement Complete 12/14/11
- Vacuum Vessel Design Complete 10/14/11
- Vacuum Vessel Procurement Complete 04/10/12

RHIC 56 MHz Cryomodule

External Review

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- Cavity-Mounted Components

(High Order Mode Dampers, Fundamental Damper, Fundamental Power Coupler & IR Detector)

- High Order Mode Dampers Design Complete 02/23/11
- HOM Procurement Complete 12/12/11
- Fundamental Damper Design Complete 05/20/11
- Fundamental Damper Procurement Complete 01/23/12
- Fundamental Power Coupler Design Complete 04/28/11
- Fund. Power Coupler Procurement Complete 01/05/12

RHIC 56 MHz Cryomodule

External Review

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Cavity-Mounted Components (cont' d)

Infrared Detector Preliminary Design Complete	03/10/11
IRD Test Components Procurement Complete	05/04/11
IR Detector Windows Testing Complete	05/24/11
Selected IR Detector Procurement Complete	07/27/11
IR Detector Installed in Cavity – VTF#2 Cold Testing	12/06/11
IR Detector Installed in Cavity String	02/08/12

RHIC 56 MHz Cryomodule

External Review

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- Process Tooling

BCP/HPR Cage Fabrication Complete	06/14/11
BCP/HPR Adapters Fabrication Complete	06/20/11
Liftcart & Mounts Specified & Procured	08/23/11
Rollcart / Flipcart Fabrication Complete	09/02/11
Weld Fixtures Fabrication Complete	10/24/11
VTF Mounting Fixture Fabrication Complete	08/31/11
String Assembly Tooling Fabrication Complete	01/30/12
Cryomodule Assembly Tooling	04/11/12
Cryomodule Installation Tooling	06/21/12

RHIC 56 MHz Cryomodule

External Review

03/08/11

- Major Cryogenic Components Milestones

(Not part of this technical review - FYI only)

Vacuum Jacketed Supply/Return & 1 st Separator Installed	11/23/11
He Compressor Ordered , Warm Piping Installed	10/31/12
Ambient Vaporizer Installed	10/31/12
Cryogenic Controls & Instrumentation installed	10/12/12
Cryostat / Condenser Installed	08/31/13

RHIC 56 MHz Cryomodule

External Review

03/08/11

- RF System

RF Amplifier Procured	07/27/09
Install Amplifier & Test at Horiz. Test Area	05/15/12
Procure Waveguides/Cables & Install at HTA <small>(Waveguides for Cold Test and RHIC Installation)</small>	07/06/12
System Test Complete-Ready for Cold Test	08/03/12
Amplifier System Moved to RHIC	07/12/13
Connect RF System to 56 MHz cryomodule & Test	08/12/13

RHIC 56 MHz Cryomodule

External Review

03/08/11

- Vacuum System

Specific Components

05/13/11

Procure Vacuum Components & Testing Complete 08/31/11

Low Particulate Processing of Vacuum Components 02/28/12

Install Components in String Assembly

03/05/12

At this time, all components on schedule.