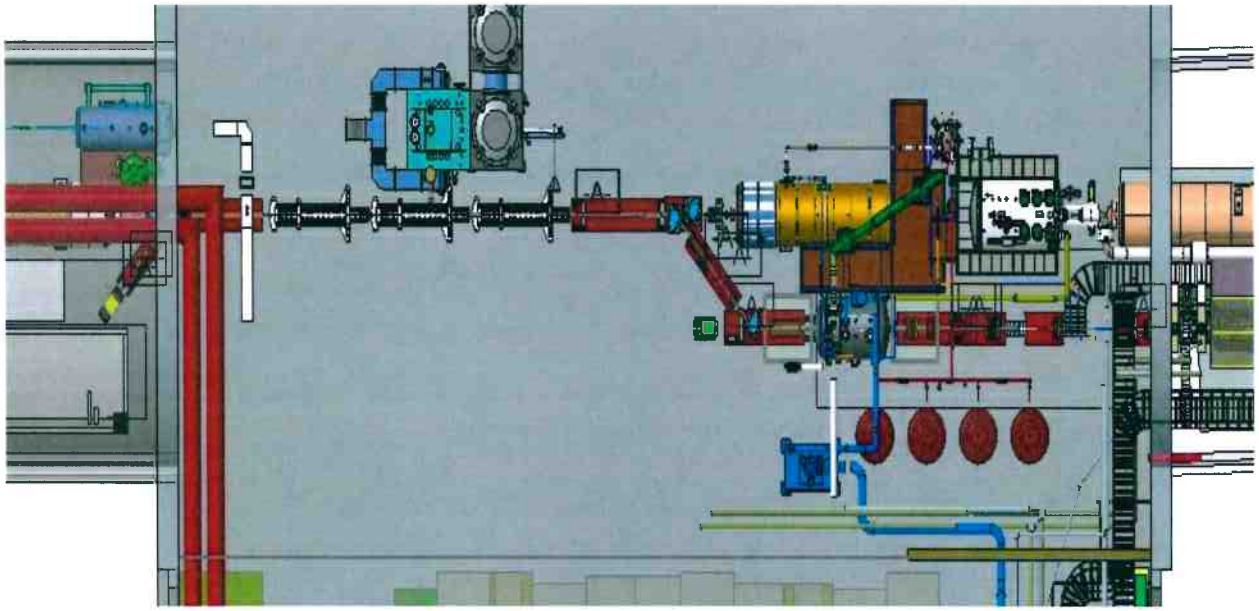
INSTRUMENT READINESS REVIEW REPORT
FOR
COHERENT COOLING PROOF OF PRINCIPLE

December 21-22, 2015



ERL Full Loop Commissioning IRR Team

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Executive Summary

An Instrument Readiness Review (IRR) has been conducted for the Coherent Electron Cooling Proof of Principle (CeCPoP) Experiment per the Charge Letter (see Appendix A) from the Collider-Accelerator Department Head, eRHIC Design. The objective of the IRR was twofold: (1) to provide assurance that high-power commissioning of CeCPoP can be conducted in a safe and environmentally sound manner, and (2) to review the bases for the planned low power test exemption request.

The IRR Team consisted of seven BNL staff. The site visit portion of the IRR emphasized a performance-based approach with a focus on field activities that included walk-downs and inspections of systems and structures, inspections of safety systems, and interviews and roundtable discussions with staff. A set of Lines of Inquiry (LOIs) was developed and used to guide much of the review.

For each topical area, pre-start and post-start findings are presented along with recommendations (opportunities for improvements). The IRR Team identified 63 pre-start findings, 13 post-start findings, and 8 recommendations. A majority of the pre-start actions are related to the Controls System. Pre-start findings should be resolved prior to the on-site portion of the Accelerator Readiness Review (ARR). Post-start findings may be resolved in a reasonable timeframe after the ARR activities and should be entered and tracked to completion in a corrective action tracking system. Recommendations are offered as representative of best practices and are left to C-AD line management for resolution, as appropriate.

Results

1.0 Safety Assessment Document (SAD), Accelerator Safety Envelope (ASE), and Unreviewed Safety Issue (USI) Process

1.1 Observations

A number of ASE-specific limits were physically verified including the Bunching Cavity power supply limit of 50 kW, and the 5-cell super-conducting radio-frequency 704 MHz Cavity power supply limit of 20 kW.

1.2 LOIs

1. Ensure assumptions in the safety analysis are configuration managed.	Adequate
2. Validate that shielding statements in the ASE are accurate.	Adequate
3. Ensure fault conditions and assumptions are reflected in the SAD and procedures.	Adequate
4. Validate that the ASE is up to date, consistent with SBMS requirements, and updates are reflected in procedures and USIs.	Adequate
5. Verify that specifications used in shielding analyses are valid.	Adequate
6. Verify Radiation Safety Committee actions are addressed or being tracked to completion.	Adequate
7. Verify ASE credited controls are understood by operators and configuration managed.	Adequate
8. Verify that Operators have been trained on the facility safety basis.	Not Reviewed
9. Check the status of the Commissioning Plan, Commissioning Sequence, and Commissioning Fault Study Plans.	See CONOPS Section
10. Verify system descriptions in SAD.	Adequate
11. Check bulk shielding thicknesses against the drawing specifications.	See Radiological Shielding Section
12. Verify there are enough Operators and Radiological Control support staff to meet planned commissioning schedule.	Adequate

1.3 Pre-Start Findings

None

1.4 Post-Start Findings

1.4.1 Section 5.1.1 of OPM 2.5.2.2 should be revised to state that the Training Manager ensures supervisors have been provided with training reports for their staff, rather than to ensure training requirements have been completed.

1.4.2 CAD Management should confirm that appropriate CeCPoP staff has been trained in the department's USI screening process.

1.5 Recommendations

None

2.0 Alarming and Interlocking Radiation Monitors, Radiation Protection, and Fault Study Plans

2.1 Observations

There are three non-interlocking Chipmunks in the Intersecting Region (IR) that were placed a year ago to characterize local sources (i.e., radiation generating devices). The RSC Chair is planning to add three more non-interlocking Chipmunks in the IR to examine dose rates at shielded locations. None of these six Chipmunks are planned to be alarming. There are two existing alarming chipmunks. One will be at the base of the cable way. The other is in the labyrinth to 1002A.

The Facility Support Group has an adequate number of RCTs and portable instruments to support commissioning. Passive area monitoring with TLDs has been ongoing in the 1002 support buildings for many years.

2.2 LOIs

1. How many Chipmunks are required to support commissioning, and are they calibrated and in place?	Adequate
2. What is the process for determining Chipmunk placement, and is this documented?	Adequate
3. Verify how Chipmunks are configuration controlled.	Adequate
4. Verify that C-AD has a process for controlling and changing alarm and interlock set points.	Adequate
5. Verify that Chipmunk alarms are displayed in the ERL Control Room.	Adequate
6. Has C-AD validated the Chipmunk dose rate displays in the ERL Control Room?	Adequate
7. An appropriate number of trained and qualified RCTs are available to support commissioning.	Adequate
8. An area monitoring plan using passive TLDs exists.	Adequate

2.3 Pre-Start Findings

None

2.4 Post-Start Findings

None

2.5 Recommendations

None

3.0 Conduct of Operations (CONOPS), Commissioning Plan and Sequence, Fault Studies

3.1 Observations

CeCPoP will rely heavily on C-AD's existing conduct of operations program. Some documentation has not been completed as noted below.

3.2 LOIs

1. Verify that a Commissioning Plan has been prepared	Adequate
2. Verify that a Fault Study Plan has been prepared	Not Observed
3. Verify that technical and operations procedures that support commissioning have been prepared and approved	Not Adequate
4. Verify that procedures have been validated	Not Adequate
5. Verify Local Emergency Coordinator effectiveness for Incident Command from the ERL Control Room	Adequate
6. Verify a CONOPS Matrix has been prepared and approved	Adequate
7. Verify that an operations/commissioning organization has been established consistent with the C-AD organization	Adequate
8. Verify that implementing procedures cited in the Matrix have been prepared and approved	Adequate
9. Verify Operators have been trained on procedures	Not Adequate
10. Verify that a CeCPoP operations and qualification program has been established	Adequate
11. Verify JTAs for all positions have been prepared	Not Adequate
12. Verify that a Control Room staffing plan has been established	Adequate
13. Verify R2A2s for commissioners	Not Adequate

3.3 Pre-Start Findings

3.3.1 Evolve the Commissioning Plan into a Commissioning Sequence in the form of a procedure(s). The procedure should make clear the roles and responsibilities of the CeCPoP Shift Leaders and staffing requirements. The procedure should also identify the engineered safety systems that will need to be operable.

3.3.2 Identify by the time of the ARR the number of Shift Leaders required. CeCPoP operation should be prohibited if no Shift Leader is planned to be present in the Main Control Room for periods greater than one hour. The Operations Coordinator shall not be considered the Shift Leader.

3.3.3 Ensure the Commissioning Sequence contains logical points to pause and conduct fault studies.

3.3.4 Formalize the CeCPoP Shift Leader's Job Training Assessment (JTA) and ensure qualifications are completed.

3.3.5 Define CeCPoP Shift Leader Roles, Responsibilities, Accountabilities and Authorities (R2A2) and formally issue in an R2A2.

3.3.6 OPM Chapter 22 (CeCPoP) procedures have been identified. As presently planned, finish writing the procedures and train appropriate staff.

3.3.7 OPM 4.1 "C-A Complex Access Control Procedures for Primary Beam Enclosures" is being revised to incorporate CeCPoP operations. Modify paragraph 5.2.1.9.1.1 to include IR2 as an enclosure that requires a survey by an RCT prior to an access that follows irradiation of the high-powered CeCPoP beam dump.

3.3.8 Further elaborate on the Shift Leader role as stated in OPM 22.2.1 "CeCPoP Experiment Organization for Commissioning/Operations" paragraphs 2.1.1.1.4 and 2.1.1.1.5 by recognizing that in addition to Maintenance and Operations periods there exists periods of opportunistic maintenance that occur for a variety of reasons, especially at the start of a RHIC run and almost daily during a run. The Shift Leader should be tasked to coordinate installation/repair activities with C-AD's Maintenance Coordinator and reserve coordination of operations with beam for the Operations Coordinator.

3.4 Post-Start Findings

None

3.5 Recommendations

None

4.0 Radiation, Laser, ODH, and Magnet Interlocks

4.1 Observations

The PASS has been modified to allow the independent operation of CeCPoP. The Certification and Operation Procedures have been modified and are being reviewed. An ODH warning system for the pump room in Building 1002A has been installed. The Laser SOP for the laser area in Building 1002F has been approved and a laser operating procedure is being prepared. A procedure to ensure proper magnet polarity is being developed.

4.2 LOIs

1. Verify radiation interlocks are fail safe	Adequate
2. Verify critical devices are controlled by a fail-safe interface to the interlock system	Adequate
3. Verify the interlock system requires the enclosure to be searched and secured prior to enabling beam	Adequate
4. Verify that interlock system components are labeled or readily identifiable	Adequate
5. Verify that an appropriate entry control program has been established	Adequate
6. Verify that periodic testing is being performed as required by the BNL Radiological Control Manual	Adequate
7. Verify that the interlock system has been placed under configuration control	Adequate
8. Verify that interlock design documentation has been placed under configuration control	Adequate

4.3 Pre-Start Findings

4.3.1 PASS and ODH certification procedures need to be executed/completed and internally reviewed and accepted.
4.3.2 The Laser SOP for the laser area in Building 1002F needs to be updated to reflect the as-built configuration.
4.3.3 The Laser operating procedure needs to be completed and approved.
4.3.4 The Dipole Magnet polarities need to be verified.
4.3.5 Magnet interlocks for the dipoles and quadrupoles need to be determined.

4.3 Post-Start Findings

None

4.4 Recommendations

None

5.0 Controls System, Cyber Security

5.1 Observations

During interviews it was apparent that everyone had a solid grasp of the work that needs to be completed. Transparency was never an issue.

5.2 LOIs

1. Verify wiring/cabling for the controls hardware meets code	
2. Validate process for managing configuration of computer software controls	Adequate
3. Ensure necessary cyber security requirements are met pertaining to control system networks	Adequate
4. Ensure necessary training is in place for personnel that operate, test and maintain the control system	Adequate
5. Verify alarm set point configuration control	Not Reviewed
6. Verify wiring/cabling documentation and configuration control for controls hardware	Adequate
7. Assess control system reaction to a power outage	Not Reviewed
8. Check that alarm response is clearly defined	Not Reviewed
9. Review list of open items	Adequate
10. Review tools for controlling the release of controls system drivers and applications	Adequate
11. Examine controls reaction to a power outage	Not Reviewed
12. Examine and concur on process to change/modify hardware and software related to controls during commissioning	Adequate
13. There is a plan that addresses cyber security on a site-wide basis and specifically for accelerator controls	Adequate
14. The cyber security risk assessment for accelerator controls adequately identifies threats and vulnerabilities specific to the operating environment	Adequate
15. The cyber-risk assessment for accelerator controls adequately identifies risks and counter measures to reduce risk to an acceptable level	Adequate
16. There is an authority to operate the system used to control accelerator functions within acceptable risks	Adequate
17. The cyber security plan incorporates recommended practices and protocols	Adequate
18. There are adequate personnel resources to maintain the cyber security program and processes	Adequate
19. There are adequate fiscal resources to maintain the cyber security equipment through near-term software and hardware upgrades	Adequate
20. There is adequate infrastructure to maintain and support cyber security for accelerator controls	Adequate
21. Software QA supports activities related to commissioning	Adequate
22. The development of accelerator controls is governed by	Adequate

applicable standards	
23. Accelerator controls software has accurate configuration information from users/owners for device control	Adequate
24. There are resources that allow controls software to be tested before implementation	Adequate
25. There is an adequate user feedback mechanism to resolve software issues	Adequate
26. Accelerator controls software is configuration managed	Adequate
27. There are adequate personnel resources to maintain the accelerator controls software applications	Adequate
28. There is adequate infrastructure to maintain and support accelerator controls software applications	Adequate
29. Software QA supports activities related to commissioning	Adequate

5.3 Pre-Start Findings

5.3.1 Controls Group Tasks

5.3.1.1 Install and test Beam Sync Timing chassis
5.3.1.2 Develop, install, integrate, and test MPS system
5.3.1.3 Develop MPS test procedure
5.3.1.4 Perform Beam Position Monitor system software integration
5.3.1.5 Install laser shutter open/close control
5.3.1.6 Finish modifications to remote laser interface
5.3.1.7 Develop Current Transformer software interface
5.3.1.8 Test power supply remote interface software
5.3.1.9 Provide configuration support for additional vacuum gauges
5.3.1.10 Configure Motion Feedback system for 704MHz Tuner
5.3.1.11 Program, install, and test V294 laser pulse limiter
5.3.1.12 Ensure presence and removal of V294 by accounting for it in checklists/procedures

5.3.2 RF Group Tasks

5.3.2.1 Complete cabling for 704MHz cavity (when tray installed)
5.3.2.2 Have RFI/EMI certification performed
5.3.2.3 Generate Turn-On Procedures for 112MHz and 704MHz cavities
5.3.2.4 Perform MPS checkout

5.3.3 Power Supply Group Tasks

5.3.3.1 Install remaining supplies
5.3.3.2 Install remaining network connections
5.3.3.3 Test PET page interfaces
5.3.3.4 Install remaining magnet cables (bake out dependent)

5.3.4 Vacuum Group Tasks

5.3.4.1 Perform MPS checkout
5.3.4.2 Perform valve control checkout
5.3.4.3 Complete cable termination
5.3.4.4 Bake Cathode, Dogleg, Dump and IR2 common beam line
5.3.4.5 Establish vacuum in 7 sectors (Cathode to Dump)

5.3.5 Instrumentation Group Tasks

5.3.5.1 Install and test Interlock Chassis with MPS
5.3.5.2 Install remaining Beam Position electronics
5.3.5.3 Install all Beam Position intra-rack cables
5.3.5.4 Install Dump ICT (performed by Vacuum Group)
5.3.5.5 Test ICTs with MPS
5.3.5.6 Install 2 Beam Profile Monitor Assemblies (after bake out)
5.3.5.7 Complete Emittance Slit upgrade work (impedance cages)
5.3.5.8 Finish Beam Loss Monitor installations
5.3.5.9 Finish Dump Faraday Cup installation
5.3.5.10 Complete Dump Temperature Monitoring installation
5.3.5.11 Complete Wiggler Laser diagnostic work
5.3.5.12 Install Chipmunks
5.3.5.13 Install 704MHz Cavity Tuner motion control

5.4 Post-Start Findings

5.4.1 Controls Group Tasks

5.4.1.1 Perform Beam Loss Monitor system software integration
5.4.1.2 Complete Camera Viewer application modifications
5.4.1.3 Develop Infrared Wiggler Light Analysis tool
5.4.1.4 Finish MPS installation documentation
5.4.1.5 Finish Pulse Limiter (V294) documentation

5.4.2 RF Group Tasks

5.4.2.1 Re-condition 112MHz cavity
5.4.2.1 Condition 704MHz cavity

5.4.3 Power Supply Group Tasks

None

5.4.4 Vacuum Group Tasks

None

5.4.5 Instrumentation Group Tasks

5.4.5.1 Complete and test ZYNQ Interlock interface programming

5.5 Recommendations

5.5.1 C-AD should ensure Housekeeping in the CeCPoP work area is improved.

6.0 Conventional Safety, Cryogenic and Pressure Safety

6.1 Observations

Building 1002F Laser Support Building:

To support the use of a high power laser system, a small modular building, Building 1002F, was installed outside of the 1002IR shield wall. OPM 23.7: "Building 1002D Laser Lab" will be used for the system (Note: OPM title should be 1002F, not 1002D). The OPM uses the standard operation procedure found in the SBMS Laser Safety Subject Area as its basis. The OPM was reviewed by the Laboratory's Laser Safety Officer in July, 2015. The OPM includes different laser systems that can be used. The laser safety interlock system in Building 1002F was not installed at that time and needs to be documented/tested/controlled as required by the subject area. Prior to laser operation, the Laboratory's Laser Safety Officer needs to verify that the requirements of the SOP are met.

Pressure System Safety:

The CEC system uses both cryogenically cooled components: the112-MHz Electron Gun and 704-MHz Superconducting RF Cavity; and water cooled components (MHz Cavity and High Energy Beam Dump.

CEC uses high pressure helium from the RHIC cryogenic system, using a connection from the DX magnet header. To supply the required low pressure liquid helium for the components, a 1000-liter dewar was installed. The dewar supplies liquid helium and cold helium vapor to the112-MHz Electron Gun and 704-MHz Superconducting RF Cavity.

The Quiet Helium Source (QHS) system provides cooling for the112-MHz Electron Gun. The QHS is a liquid helium-to-liquid helium heat exchanger, designed to reduce vibration from the cryogenic system.

To provide the 2K for the 704-MHz Superconducting RF Cavity, compressors are used to reduce the pressure for the cavity. These compressors are installed in Building 1002A. A heater system will be used to ensure that the cold helium gas warm to acceptable temperature before entering the compressors. ***At the time of the IRR, the heater system has not been installed and tested.***

Helium gas from these systems is returned to the RHIC Warm Gas Return Header using a recovery compressor, also installed in Building 1002.

Cryogenic components have been reviewed by the Laboratory Experimental Safety and Health Committee's (LESHC) Pressure and Cryogenic Sub-committee. This sub-committee has been given Authority Having Jurisdiction (AHJ) authority by the Department of Energy's Brookhaven Site Office (BSHO) with respect to pressure code requirements (as defined in 10CFR851). All components have either met the applicable pressure safety codes or have demonstrated and equivalent level of safety and have been approved for use. Records of the design and pressure testing of the components are documented in the PTC WindChill system managed by C-AD.

The following Cryogenic System drawings were reviewed:

P&ID: 0031M0003: 112 MHz QW SRF Gun Cryostat
P&ID: 0041M0003: 704MHz 5-cell SRF Cryostat
P&ID: 0102M0002: Small Helium Recovery Compressor
P&ID: 0102M0003: 4.5K LHe Supply System
P&ID: 0102M0004: QHS Quiet Helium Source
P&ID: 0102M0005: FPC 1 atm Return
P&ID: 0102M0007: Gas management & Warm Piping, [need to release revision B]
P&ID: 0102M0024: 4.5KHe Cold Vapor Return
P&ID: 0103M0002: 20 Torr Vapor Return Heating
P&ID: 0103M0004: Sub-Atmospheric Pumping System
P&ID: 0103M0005: Skid #1 Sub-Atmospheric Pumping System
P&ID: 0103M0006: Skid #2 Sub-Atmospheric Pumping System
P&ID: 0103M0007: Skid #3 Sub-Atmospheric Pumping System

Example of ASME Boiler and Pressure Vessel Code Stamp on CEC Components

The CEC uses previously used water-cooled High Energy Beam Dump and RF cavities. These components will use RHIC Deionized (DI) water system that can provide up to 100-psig pressure. The CA-D Water systems group performed a hydrostatic test of the high power beam dump to 180 psig successfully. At the time of the IRR, the results of the testing of the water cool components were not available for review/documented.

High Energy Beam Dump

Equipment Installation

To access the cryogenic system in the RHIC 1002 IR, working platforms were designed. These platforms are accessed using vertical fixed ladders. These platforms were reviewed by Safety Engineering and meet laboratory standards. The ladder to access the upstream platform complies with OSHA 10910.27 requirements but not laboratory requirements (pass through is 18-inches, not 24-inches) and has been classified as Yellow in accordance with the laboratories Fixed Ladder Subject Area. The posting on the ladder doesn't meet the laboratory's requirement. The department is aware of the issue and is in the process of posting the ladder.

Downstream Compliant Ladder

Upstream Non-Compliant Ladder

Undulators (Wiggler Magnets) are installed around the beam pipe. These Undulators produce a high magnetic field within the magnets (@ < 6-inches, magnetic field > 600-Gauss). Additional electromagnets are to be installed for the system. Magnet field mapping of the final installation, specifically the 5-Gauss determination, needs to be performed as required by the SBMS Static Magnetic Fields Subject Area.

Undulator Location	Undulator Caution

The High Power Beam Dump will be installed on the clockwise end of the 1002IR. Radiation shield will be needed to be installed also. These components will be installed partially over a service pit that is covered by a grate. The floor loading requirements must be verified to ensure that there is adequate strength for these components. These components will also intrude in the egress path for staff exiting from the clockwise section of the RHIC tunnel. Note that there is a short ramp that will lead into the proposed location of the High Energy Beam dump. Consideration of egress path, include items to safely direct traffic toward the egress exits must be considered.

Proposed Installation High Power Dump & Shielding	Beam Dump Location (View looking Counterclockwise)	Beam Dump Location (View looking Clockwise)

Piping Support and Labeling:

Cooling water systems to support the water cooled RF cavities and the compressors supporting the cryogenic system need to be labeled in accordance with the Piping System section of the SBMS Signs, Placards, and Labels for Environmental, Safety and Health (ESH) Hazards Subject Area. Also, the distribution system for the water cooled RF cavities does not have any independent support system (nylon ties are used to support each other). Vibration induced chaffing and damage to the lines could occur. Also, some of the vacuum jacketed cryogenic transfer lines do not have any intermediate supports. The department should consider the use of piping supports improve system reliability.

Examples of Unlabeled Piping Systems

Example of Unsupported Piping System

Oxygen Deficiency Hazard (ODH) Monitoring

The installation of the helium sub-cooling and recovery compressors induces a potential for a large helium inventory into 1002A in the case of a failure. Building 1002A has been classified as an ODH-0 space; however the hazard is only present when the CEC cryogenic system is operational. Prior to operation, the ODH advisory light on Building 1002A should be identified and the Hazard Validation Placard should be updated to include the ODH hazard (technically, there is no cryogens present in Building 1002A as indicated on the HVT placard). To mitigate the hazard, ODH monitors were installed in 1002A. The system uses Oxigraf Oxygen Sensors (O2IM) to provide alarm and fan control. These sensors are a different technology (laser) than that used in the majority of RHIC ODH classified areas. Testing is performed using OPM 4.120.26.h, "1002A Stand Alone ODH Warning Systems Tests." The OPM references the manufacture's instruction manual. The manufacturer's instructions contain notes that affect testing and that are not used for the other RHIC ODH monitors such as: warm-up times (> 10 minutes); excessive flow rates (> 350 ml/min). As an improvement for human performance, these important parameters should be identified in the OPM used to record successful calibration.

Building 1002A Access Door

Building 1002A HVT Placard

Sweep Procedures:

The C-AD OPM 46-53 series is used to control access to RHIC areas for radiation protection. With the addition of the CEC components, potential radiation exposure, especially at elevation has changed. Current procedures, such as OPM 4-56ia, does not address the verification of staff at the platforms in the 1002IR that supports the CEC cryogenic system. Other procedures, such as OPM 4.56.cc (RHIC 2 O'clock Fenced Berm Area Sweeps) and 4.56.ca (Access Control of the Fenced Berm Areas Above the RHIC Ring at the 2, 4, 6, 8, 10 and 12 O'clock Sites) need to include the new laser support building, 1002F. A scaffold system

was built adjacent to the 1002IR shield wall (inboard of 1002B). The scaffold is outside of the fenced area and access control is needed to be addressed.

Scaffold Access outside 1002IR

Equipment Emergency Devices

A number of system components such as the helium compressors located in Building 1002A and power supplies in Building 1002B have emergency stop or emergency off (EMO) switches. Staff should be trained how to restore the system, such as whose permission is required and what precautions to use, prior to resetting the system if these devices are used (other than for planned testing/operation).

Examples of EMO/Stop Devices

6.2 LOIs

1. Assess adequacy of procedures and practices related to fall protection, elevated work, material handling, compressed gas storage and use, use of cryogens, fire safety, life safety and laser safety	Adequate
2. Determine whether prior safety committee actions have been addressed and closed out	Adequate
3. Verify training for expected hazards that workers may encounter in ERL work spaces.	Adequate

6.3 Pre-Start Findings

6.3.1 The 1002F laser system installation needs to be reviewed by the Lab's Laser Safety Officer to verify compliance with C-A D OPM 23.7 (Building 1002D Laser Lab) prior to operation.

6.3.2 The cryogenic system installation (vacuum cold gas system) needs to be completed and requires pressure testing prior to operations.

6.3.3 C-AD needs to ensure the tunnel egress pathway is protected/maintained after the installation of the High-Power Beam Dump and shielding.

6.3.4 C-AD needs to document floor loading requirements for the High-Energy Beam Dump installation.

6.3.5 Prior to cryogenic operations, ensure ODH monitors are calibrated/tested, the ODH indication lights are identified and that the building posting is accurate.

6.3.6 Water-cooled cavities and associated CEC ID water distribution systems need to be hydrostatically tested and documented (as per ASME B31.3).

6.3.7 Sweep Procedures need to be updated to include configuration changes (Cryogenic System Platforms, Scaffolding, Building 1002F).

6.4 Post-Start Findings

6.4.1 Prior to high power commissioning, the High-Energy Beam Dump water system testing needs to be documented (as per ASME B31.3).

6.4.2 Non-laboratory compliant vertical fixed ladder to access cryogenic system elevated platform needs to have posting installed.

6.5 Recommendations

6.5.1 Cryogenic piping and water-cooled cavities contain hoses and vacuum-jacketed piping that are self-supporting. There is some risk of failure. C-AD should assess this risk and add additional supports as needed.

6.5.2 OPMs to test the Oxigraf ODH monitors should include the specific parameters identified in the manufacturer's operating manual.

6.5.3 Emergency-STOP buttons are installed on various CeCPoP components. C-AD should issue an operating procedure on their use and recovery from initiation of an emergency stop.

7.0 Radiological Shielding

7.1 Observations

Extensive calculations have been completed to design the radiation shielding and to ensure both radiation safety and regulatory compliance. Calculation results have been presented to C-AD's Radiation Safety Committee and the Laboratory's ESH Committee. Penetration shielding blocks have been moved to accommodate construction and will need to be moved back into position prior to operations.

Arrangements have been made to have some shielding calculations verified by NSLS II personnel.

7.2 LOIs

1. Verify that shield drawings and related Engineering Change Notices (ECNs) have been approved and are under configuration management	Adequate
2. Verify whether shielding calculations have been independently reviewed and verified	Adequate
3. Verify that shielding design assumptions are configuration managed	Adequate
4. Verify that the organizational Radiation Safety Committee recommendations or requirements have been formally addressed	Adequate

7.3 Pre-Start Findings

7.3.1 Relocate internal shield blocks to their final configuration.

7.3.2 Update and approve the final shield drawings.

7.3.3 Continue the process for completing the independent review of CeCPoP shielding calculations by NSLS-2 personnel.

7.4 Post-Start Findings

None

7.5 Recommendations

None

8.0 Past Actions and Reviews, Quality Assurance, Configuration Management, Documents and Records, CAS, Drawings

8.1 Observations

C-AD's Quality Assurance, Configuration Management and Contractor Assurance Systems appear to be well established. They are being managed by individuals who fully understand the requirements and the documented system that is in place. Many internal procedures exist to help ensure compliance. Forms are attached to procedures to facilitate data collection, as needed. Assessments are being regularly conducted to help ensure a compliant system. Assessments are scheduled and managed by use of an internal database.

8.2 LOIs

1. Key Records are identified	Adequate
2. Records are managed and stored properly	Adequate
3. Determine if CAS provides a comprehensive internal assessment process	Adequate
4. Determine if the CAS Program uses external assessment: employs peer reviews and assessments that include accelerator subject matter experts from other accelerator facilities	Adequate
5. Determine if the CAS Program is adequate to support commissioning	Adequate
6. Determine if the configuration of Credited Controls are properly managed during accelerator operation and maintenance	Adequate
7. Determine if Configuration Management is applied to defense-in-depth controls on a graded approach	Adequate
8. Determine if the Configuration Management Program is adequate to support commissioning	Adequate
9. Were there any procedures that have not be completed	See Pre Start Finding 8.3.1
10. Were there any drawings that were not complete and up to date	See Pre-Start Finding 8.3.2, and Post-Start 8.4.1

8.3 Pre-Start Findings

8.3.1 There are 12 CeCPoP procedures that are in the process of being developed. These procedures need to be completed or withdrawn prior to the ARR.

8.3.2 There are several drawings that have not been finalized and released. These drawings need to be completed and approved prior to the ARR.

8.4 Post-Start Findings

8.4.1 Referenced on the CeCPoP beamline lattice drawing (# 0021M0003) there is a specification that is called out as "ANSI/ASME Y 14.5 1994", Dimensioning and Tolerancing. This is an obsolete standard. The latest revision is 2009. C-AD should correct this outdated reference.

8.5 Recommendations

8.5.1 C-AD should review the department's assessment database and remove possible redundant assessments and update the database to clearly indicate those assessments that have been completed or canceled.

8.5.2 C-AD should improve its planning process to reduce work with drawings that have not been approved or released.

8.5.3 CeCPoP Project Management should triage those procedures and installed hardware needed for near-term low-power testing as compared to those needed for high-power commissioning.

8.5.4 Efforts should be made to ensure the correct standards are being used and referenced on drawings. An alternative approach would be to leave the year off and make a reference in a procedure that any reference to a standard is the latest revision of that standard.

8.6 Noteworthy Practices

8.6.1 The Quality organization has very limited staffing, but has been able to develop some very robust systems to support Operations. Dedicated staff use these tools to help ensure assignments are completed in a timely fashion.

8.6.2 The C-AD Associate Chair for ESSHQ has implemented an internal web page to track procedures and checklists that are under development. These items also have working links to the documents. This is an impressive tool for managing new controlled documents.

Summary of Pre-Start and Post-Start Findings

Table 1
Summary of Pre-Start Findings

Identifier	Review Area	Finding
Pre-Start 1	Commissioning Sequence	Evolve the Commissioning Plan into a Commissioning Sequence in the form of a procedure(s). The procedure should make clear the roles and responsibilities of the CeCPoP Shift Leaders and staffing requirements. The procedure should also identify the engineered safety systems that will need to be operable
Pre-Start 2	Commissioning Sequence	Ensure the Commissioning Sequence contains logical points to pause and conduct fault studies
Pre-Start 3	CONOPS	Identify by the time of the ARR the number of Shift Leaders required. CeCPoP operation should be prohibited if no Shift Leader is planned to be present in the Main Control Room for periods greater than one hour. The Operations Coordinator shall not be considered the Shift Leader
Pre-Start 4	CONOPS	Formalize the CeCPoP Shift Leader's Job Training Assessment (JTA) and ensure qualifications are completed
Pre-Start 5	CONOPS	Define CeCPoP Shift Leader Roles, Responsibilities, Accountabilities and Authorities (R2A2) and formally issue in an R2A2
Pre-Start 6	CONOPS	OPM Chapter 22 (CeCPoP) procedures have been identified. As presently planned, finish writing the procedures and train appropriate staff
Pre-Start 7	CONOPS	OPM 4.1 "C-A Complex Access Control Procedures for Primary Beam Enclosures" is being revised to incorporate CeCPoP operations. Modify paragraph 5.2.1.9.1.1 to include IR2 as an enclosure that requires a survey by an RCT prior to an access that follows irradiation of the high-powered CeCPoP beam dump
Pre-Start 8	CONOPS	Further elaborate on the Shift Leader role as stated in OPM 22.2.1 "CeCPoP Experiment Organization for Commissioning/Operations" paragraphs 2.1.1.1.4 and 2.1.1.1.5 by recognizing that in addition to Maintenance and Operations periods there exists periods of opportunistic maintenance that occur for a variety of reasons, especially at the start of a RHIC run and almost daily during a run. The Shift Leader should be tasked to coordinate installation/repair activities with C-AD's Maintenance Coordinator and reserve coordination of operations with beam for the Operations Coordinator
Pre-Start 9	Interlocks	PASS and ODH certification procedures need to be executed/completed and internally reviewed and accepted.
Pre-Start 10	Interlocks	The Laser SOP for the laser area in Building 1002F needs to be updated to reflect the as-built configuration
Pre-Start 11	Interlocks	The Laser operating procedure needs to be completed and approved
Pre-Start 12	Interlocks	The Dipole Magnet polarities need to be verified
Pre-Start 13	Interlocks	Magnet interlocks for the dipoles and quadrupoles need to be determined

Pre-Start 14	Controls	Install and test Beam Sync Timing chassis
Pre-Start 15	Controls	Develop, install, integrate, and test MPS system
Pre-Start 16	Controls	Develop MPS test procedure
Pre-Start 17	Controls	Perform Beam Position Monitor system software integration
Pre-Start 18	Controls	Install laser shutter open/close control
Pre-Start 19	Controls	Finish modifications to remote laser interface
Pre-Start 20	Controls	Develop Current Transformer software interface
Pre-Start 21	Controls	Test power supply remote interface software
Pre-Start 22	Controls	Provide configuration support for additional vacuum gauges
Pre-Start 23	Controls	Configure Motion Feedback system for 704MHz Tuner
Pre-Start 24	Controls	Program, install, and test V294 laser pulse limiter
Pre-Start 25	Controls	Ensure presence and removal of V294 by accounting for it in checklists/procedures
Pre-Start 26	Controls (RF)	Complete cabling for 704MHz cavity (when tray installed)
Pre-Start 27	Controls (RF)	Have RFI/EMI certification performed
Pre-Start 28	Controls (RF)	Generate Turn-On Procedures for 112MHz and 704MHz cavities
Pre-Start 29	Controls (RF)	Perform MPS checkout
Pre-Start 30	Controls (PS)	Install remaining supplies
Pre-Start 31	Controls (PS)	Install remaining network connections
Pre-Start 32	Controls (PS)	Test PET page interfaces
Pre-Start 33	Controls (PS)	Install remaining magnet cables (bake out dependent)
Pre-Start 34	Controls (VAC)	Perform MPS checkout
Pre-Start 35	Controls (VAC)	Perform valve control checkout
Pre-Start 36	Controls (VAC)	Complete cable termination
Pre-Start 37	Controls (VAC)	Bake Cathode, Dogleg, Dump and IR2 common beam line
Pre-Start 38	Controls (VAC)	Establish vacuum in 7 sectors (Cathode to Dump)
Pre-Start 39	Controls (INST)	Install and test Interlock Chassis with MPS
Pre-Start 40	Controls (INST)	Install remaining Beam Position electronics
Pre-Start 41	Controls (INST)	Install all Beam Position intra-rack cables
Pre-Start 42	Controls (INST)	Install Dump ICT (performed by Vacuum Group)
Pre-Start 43	Controls (INST)	Test ICTs with MPS
Pre-Start 44	Controls (INST)	Install 2 Beam Profile Monitor Assemblies (after bake out)
Pre-Start 45	Controls (INST)	Complete Emittance Slit upgrade work (impedance cages)
Pre-Start 46	Controls (INST)	Finish Beam Loss Monitor installations
Pre-Start 47	Controls (INST)	Finish Dump Faraday Cup installation
Pre-Start 48	Controls (INST)	Complete Dump Temperature Monitoring installation

Pre-Start 49	Controls (INST)	Complete Wiggler Laser diagnostic work
Pre-Start 50	Controls (INST)	Install Chipmunks
Pre-Start 51	Controls (INST)	Install 704MHz Cavity Tuner motion control
Pre-Start 52	Conventional Safety	The 1002F laser system installation needs to be reviewed by the Lab's Laser Safety Officer to verify compliance with C-A D OPM 23.7 (Building 1002D Laser Lab) prior to operation
Pre-Start 53	Conventional Safety	The cryogenic system installation (vacuum cold gas system) needs to be completed and requires pressure testing prior to operations
Pre-Start 54	Conventional Safety	C-AD needs to ensure the tunnel egress pathway is protected/maintained after the installation of the High-Power Beam Dump and shielding
Pre-Start 55	Conventional Safety	C-AD needs to document floor loading requirements for the High-Energy Beam Dump installation
Pre-Start 56	Conventional Safety	Prior to cryogenic operations, ensure ODH monitors are calibrated/tested, the ODH indication lights are identified and that the building posting is accurate
Pre-Start 57	Conventional Safety	Water-cooled cavities and associated CEC ID water distribution systems need to be hydrostatically tested and documented (as per ASME B31.3)
Pre-Start 58	Conventional Safety	Sweep Procedures need to be updated to include configuration changes (Cryogenic System Platforms, Scaffolding, Building 1002F)
Pre-Start 59	Radiological Shielding	Relocate internal shield blocks to their final configuration
Pre-Start 60	Radiological Shielding	Update and approve the final shield drawings
Pre-Start 61	Radiological Shielding	Complete the independent review of CeCPoP shielding calculations by NSLS-2 personnel
Pre-Start 62	Documents and Records	There are 12 CeCPoP procedures that are in the process of being developed. These procedures need to be completed or withdrawn prior to the ARR
Pre-Start 63	Drawings	There are several drawings that have not been finalized and released. These drawings need to be completed and approved prior to the ARR

Table 2
Summary of Post-Start Findings

Identifier	Review Area	Finding
Post-Start 1	SAD/ASE/USI	Section 5.1.1 of OPM 2.5.2.2 should be revised to state that the Training Manager ensures supervisors have been provided with training reports for their staff, rather than to ensure training requirements have been completed
Post-Start 2	SAD/ASE/USI	CAD Management should confirm that appropriate CeCPoP staff has been trained in the department's USI screening process
Post-Start 3	Controls	Perform Beam Loss Monitor system software integration
Post-Start 4	Controls	Complete Camera Viewer application modifications
Post-Start 5	Controls	Develop Infrared Wiggler Light Analysis tool
Post-Start 6	Controls	Finish MPS installation documentation
Post-Start 7	Controls	Finish Pulse Limiter (V294) documentation
Post-Start 8	Controls (RF)	Re-condition 112MHz cavity
Post-Start 9	Controls (RF)	Condition 704MHz cavity
Post-Start 10	Controls (INST)	Complete and test ZYNQ Interlock interface programming
Post-Start 11	Conventional Safety	Prior to high power commissioning, the High-Energy Beam Dump water system testing needs to be documented (as per ASME B31.3)
Post-Start 12	Conventional Safety	Non-laboratory compliant vertical fixed ladder to access cryogenic system elevated platform needs to have posting installed
Post-Start 13	Drawings	Referenced on the CeCPoP beamline lattice drawing (# 0021M0003) there is a specification that is called out as "ANSI/ASME Y 14.5 1994", Dimensioning and Tolerancing. This is an obsolete standard. The latest revision is 2009. C-AD should correct this outdated reference

Appendix A: Charge Letter

Gentlemen:

Please assemble as an IRR team and review preparedness for commissioning of Coherent Electron Cooling – Proof of Principle Experiment. Your expertise and work is greatly appreciated to continue to move this project forward. Below is the charge. A brief commissioning plan and draft agenda for the on-site review on December 21 and 22, 2015 are attached.

Thank you again for your continued involvement.

Regards.

Vladimir N Litvinenko

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Charge

- Perform an independent evaluation of CeCPoP readiness for full-current full-energy commissioning
- Identify actions that are needed for a successful Accelerator Readiness Review in February 2016

Please focus on the following areas:

- Training, procedures, USI document
- Records of past reviews, incidents, actions
- Conduct of Operations procedures
- QA (and other assurance systems)
- Interlocking safety systems
- Controls system
- Conventional safety practices such as LOTO
- Configuration Management of Safety Systems

The following table summarizes IRR Team Members, Focus Areas and Counterparts

Charles Schaefer IRR Team Lead	SAD, ASE, USIs, Activities and Records Counterparts: V. Litvinenko, J. Tuozzolo, E. Lessard
Chuck Gortakowski	Past Actions and Reviews, Quality Assurance, Configuration Management, Documents and Records, CAS, Drawings Counterpart: D. Passarello
Charles Theisen	Controls System Counterpart: Jim Jamilkowski
Peter Ingrassia	Conduct of Operations, Commissioning Plan, Commissioning Sequence, Fault Studies Counterparts: L. Hammons, V. Litvinenko, D. Beavis
Charles Schaefer	Alarming and Interlocking Area Radiation Monitors, Radiation Protection and Fault Study Plan Counterparts: D. Beavis, J. Reich, P. Bergh
Michael Gaffney	Conventional Safety, Cryogenic and Pressure Safety Counterparts: P. Cirnigliaro, L. Hammons
Asher Etkin	Personal Protection Systems: Interlocks for ACS, ODH, Laser, Magnets Counterparts: J. Reich, B. Sheehy
Henry Kahnhauser	Independent Review of Shielding Counterpart: D. Beavis

In addition to using your own professional judgment to review potential issues, the review process should consider:

- Lines of Inquiry (see General LOIs)
- Document reviews
- Counterpart discussions
- Observations

Please report the following action items:

Pre-Start – actions that should be addressed prior to the Accelerator Readiness Review
Post-Start – actions that will not be completed prior to the Accelerator Readiness Review; the IRR team should recommend that these actions be identified to the ARR, and the plan and schedule for completing the actions provided to and discussed with the Accelerator Readiness Review team
Opportunities for Improvement – action that the IRR team believes would significantly enhance the Accelerator Readiness Review process.

Please prepare a report as follows:

Contents

- Brief discussion of the Findings and Observations within each area of the IRR
- Brief comments on opportunities for improvement
- Pre-start and post-start action items and opportunities for improvement

Schedule

- Please prepare a draft report within 7 to 11 days following the on-site work
- Please submit the draft to counterparts for factual accuracy and comments
- Please submit the final report to C-AD management within approximately one week after comments received

Thank you.

Appendix B: CeCPoP IRR

A G E N D A

Monday December 21, 2015 (DAY 1)

Conference Room	Time	Description	Lead (s)
LCR	8:30 – 9:00	IRR Team Meeting	C. Schaefer
LCR	9:00 – 9:10	Welcome & Introductions Safety Briefing	V. Litvinenko E. Lessard
	9:10 – 9:25	Readiness Status and Look Ahead	V. Litvinenko
	9:25 – 9:40	ASE and SAD/Credited Controls	E. Lessard
	9:40 – 9:55	Past Action Items	D. Passarello
	9:55 – 10:10	Interlocks	J. Reich
LCR	10:10 – 10:30	Coffee Break	
LCR	10:30 – 10:45	Radiological Issues - Shielding	D. Beavis
LCR	10:45 – 11:00	Conventional Safety Issues	P. Cirnigliaro
LCR	11:00 – 11:45	Commissioning Plan, Training, Conduct of Operations	V. Litvinenko L. Hammons
	11:45 – 12:45	Tour of CeCPoP Area	V. Litvinenko
SCR	12:45 – 1:45	Lunch Break	
LCR	1:45 – 5:00	Team Interviews, documents & records reviews, system walk-downs, work observations, discussions, breakout sessions	Team Members & Counterparts

Tuesday December 22, 2015 (DAY 2)

Conference Room	Time	Description	Lead (s)
LCR	8:30 – 9:00	IRR Team Meeting	C. Schaefer
	9:00 – 12:00	Team Interviews, documents & records reviews, system walk-downs, work observations, discussions, breakout sessions	Team Members & Counterparts
SCR	12:00 – 1:00	Lunch Break	
LCR	1:00 – 4:00	IRR Team Meeting	C. Schaefer
LCR	4:00 – 5:00	C-AD Debrief	C. Schaefer