PHENIX Component Removal and Repurposing Plan

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1.0 OVERVIEW

The PHENIX experiment located in Building 1008 in the RHIC complex will have a major reconfiguration at the end of the RHIC 2016 run in June 2016. The plan is to remove pieces of equipment that are no longer needed, repurpose much of the equipment, and prepare the 1008 complex for a major upgrade to sPHENIX. Equipment and materials from the PHENIX detector will, as appropriate, be collected and preserved for re-use in the PHENIX upgrade, returned to the institutions owning the items, stored for reuse in other projects, or properly disposed of. Removal and repurposing of particular equipment and materials will also take place in the PHENIX Assembly Hall, Power Supply Building, Pump House, Gas Mixing Hut and Gas Pad. No significant changes are anticipated for the 1008 Counting House, or Control Room.

Removal and Repurposing Plan

This removal and repurposing plan is written to take the PHENIX Experimental apparatus and infrastructure from its final operational configuration to a defined starting condition (state) for commencement of activities to convert this facility to the next generation experiment, sPHENIX. This end state of the removal and repurposing activity is a stable configuration of the facility in which all infrastructure (gas systems, electrical supply systems, water cooling systems, etc.) are in a safe condition, and ready to be integrated into the sPHENIX experiment

End-states are the detailed specifications of conditions to be achieved for the facility space, systems, and major equipment. These end-states can be used to determine cost and schedule estimates, demonstrate conformance to previously negotiated agreements, and show compliance with applicable local and federal regulations. During this period, removal of chemicals, radioactive waste, hazardous metals, and other wastes and hazards occur, as well as cataloging and transfer of valuable equipment to other organizations such as C-AD for reuse. Hazards that were not feasible to remove during deactivation will be documented.

2.0 SCOPE

All disposition of equipment associated with the PHENIX equipment removal and repurposing will be coordinated through the BNL Department of Procurement and Property Management in consultation with The Brookhaven Site Office (BSHO) and the Department of Energy Office of Nuclear Physics (DOE-ONP). All tasks will be planned using the C-AD Procedure for Work Planning and Control for Operations for Work-Planning and Safety guidelines. Any activities requiring reviews beyond the normal Work-Planning process, for example, particular rigging operations or jobs involving working at heights, will be reviewed by the appropriate Collider Accelerator Department (C-AD) or BNL Safety Committee. All waste materials shall be properly disposed of as per BNL requirements. All items to be removed from the IR will be handled in accordance with the SBMS Hazard Analysis Plan and screened for possible radiological activation. A preliminary assessment has been made of the amount and type of potentially activated materials and is factored into the cost estimates. Material screening will verify the preliminary assessment.

At the end of the process described in this document, the 1008 Interaction Region, Assembly Hall, Power Supply Building, Pump House, and sections of the Gas Mixing Hut and Gas Pad will be clear of all PHENIX equipment and materials that are unneeded for the upgrade. The 1008 complex will be ready to begin the preparation for and installation of a new experiment.

Objectives of the Equipment Removal and Repurposing End State (Key Performance Parameters)

- All equipment and material not needed for the PHENIX upgraded detector will be removed and dispositioned.
- All 1008 facilities will be available for future use by the PHENIX upgraded detector.

All removed 1008 equipment and materials will be properly stored for re-use by the PHENIX upgraded detector, returned to the equipment's owners, stored for re-use in other projects, or properly disposed of.

3.0 BRIEF DESCRIPTION

This section describes the various areas, components and structures that are included in the scope of this plan.

The construction material used in various parts of the facility consists mostly of steel and aluminum, and, to a lesser extent, lead, copper, and PVC.

The detector systems includes beam and water cooling pipes and various other components such as beam diagnostics, vacuum valves and pumps, heat exchanger systems and power supplies, beam lines, magnets, collimators, optical elements (i.e., mirrors, gratings, etc.), laser systems, vacuum systems, target and detection systems.

Equipment and structures generally to be removed and repurposed can be generalized in to main systems:

Beam Pipe
East Carriage
Muon Magnet South
West Carriage
Central Magnet
Muon Magnet North

Specific schedules and planning is outlined in Attachment 2, PHENIX R&R Work Planning Schedule

4.0 PRINCIPAL HAZARDS AND PHYSICAL CONDITIONS

This section provides an overview of the principal radiological and conventional hazards and physical conditions, focusing on hazardous materials and physical hazards associated with removal/repurposing of PHENIX components and structures.

4.1 CONVENTIONAL HAZARDS

The conventional hazards include those hazards common to any industrial environment, as well as some hazards that arise from the unique experimental components, assemblies and support equipment that comprise the PHENIX Experiment.

4.1.1 Hazardous Materials

Lead is used as additional shielding material and as ballast in some of the components of the PHENIX facility. Some of the material is painted and some is in the raw state. All equipment being removed from PHENIX facility will be cleaned of residual lead contamination to levels acceptable to the receiving facility and the Safety and Health organization prior to removal. There is no asbestos hazard and/or materials associated with PHENIX. The central beam pipe contains beryllium.

Cooling systems will be drained of fluids prior to removal from the PHENIX facility.

C-AD will manage all hazardous waste material generated from the removal/repurposing process.. Materials will be handled, segregated, labeled, and securely packaged in the appropriate containers in accordance with the BNL Standard Based Management System (SBMS).

4.1.2 Electrical Hazards

The PHENIX Facility has a number of DC high-voltage and/or high current power supplies. Conventional AC power distribution is present in the facilities as well. Control circuits are distributed amongst experimental and conventional systems.

4.1.3 Magnetic Hazards

High field conventional electro-magnets are used in the experimental equipment to bend and focus the beam of charged particles emanating from collisions. The high magnetic fields produced by these magnets are mostly contained within the magnet structure, and most of the field is eliminated when the magnets are de-energized. When de-energized, small residual magnetic fields may be present but below the level to have any detrimental effects.

All PHENIX electro-magnets will be de-energized and disconnected so as

to be inoperable during all of the removal/repurposing activities.

4.1.4Cryogenic Hazards

The PHENIX experiment uses no cryogenic materials in its operation. There are, however, cryogenic sources used to store gases used for experimental purposes in cryogenic containers. These containers will be secured/drained, etc. as appropriate for their future use in sPHENIX.

4.1.5 Oxygen Deficiency Hazards

There are no Oxygen deficiency hazards in the PHENIX experimental Hall. (Note: there are areas of potential oxygen deficiency hazards in the RHIC tunnel during RHIC operations, but these are areas are not the subject of this report.

4.1.6 Mechanical Hazards

The building (1008) includes two overhead bridge cranes capable of covering most of the assembly hall and the interaction region.

There is a variety of rotating machinery such as pumps, blowers and fans located within the facility.

Closed loop water distribution systems were utilized to distribute cooling services throughout the facility to experimental infrastructure.

4.1.7 Vacuum and Pressure Hazards

The RHIC beam lines are held under ultra high vacuum. Implosion of vacuum systems could generate small flying objects.

Compressed air lines are routed throughout the facility for industrial use and for the control of valves and actuators. The maximum pressure provided to these units is 120 psig. Personnel using compressed air nozzles will be required to wear safety glasses. Self-sealing quick-connect couplers will be used for temporary connections to compressed air. Shutoff valves are used to isolate and clear compressed air lines before work on the lines.

Gas cylinders in the gas mixing building and on the PHENIX gas pad areas will be removed or gas cylinders will be chained or otherwise restrained to prevent tipping or falling.

4.1.8 Asbestos

There is no asbestos in this facility.

4.1.9 RADIOLOGICAL HAZARDS

The major source of contamination in the PHENIX facility is likely to be in the form of activated metals. At the PHENIX facility, the important materials prone to activation are iron, copper, tungsten and stainless steel. Lead and ordinary concrete in the shielding, aluminum in the composition of the some of the experimental components, and plastics are not likely to be activated.

Components that absorb some of the electron beam from scattering and may become activated include, any narrow beam aperture such as beam pipes and PHENIX experimental equipment immediately adjacent to the beampipe such as background shielding components surrounding the beampipe inside the magnets. Some parts in in detector subsystems close to the beampipe may also become activated to a lesser degree..

The activation of water, which is used in cooling, is not anticipated to be significant. The water may contain metals above the Drinking Water Standard and may contain tritium below the Drinking Water Standard. Cooling water for experimental systems will be drained and placed in the C-AD waste-management system.

5.0 HAZARD REDUCTION FOR DEACTIVATION

BNL, C-AD and PHENIX have Work Planning and Control procedures in place that will be implemented during the PHENIX removal and repurposing activity. If additional procedures are required to support removal and repurposing activities, they will be developed and approved in accordance with PHENIX Work Planning policies and procedures.

A PHENIX/C-AD management structure will be established to develop, maintain and monitor the removal and repurposing program activities. It will have the authority to stop any unsafe work practices.

The PHENIX 1008 facility will be repurposed for the sPHENIX experiment and placed in a safe and stable condition including removal or reduction of hazards to ensure adequate protection of the worker, public health and safety, and the environment. Actions include draining and de-energizing nonessential experimental systems; disconnecting all utility services to experimental equipment, removal of stored radioactive and hazardous materials, and actions related to the removal and repurposing of PHENIX experimental equipment/apparatus.

5.1 CONVENTIONAL HAZARDS

This section examines the general types of hazards, associated with conditions discussed in section 5, which could be encountered during deactivation activities.

5.1.1 Physical Hazards

These are hazards that are routinely encountered in general industry and will be reviewed in the work planning process.

Special analysis may be required to define safe operational parameters, encountered during routine work including: lifting, hoisting and rigging, noise, slips, trips, and falls.

5.1.2 Hazardous Material Hazards

Accumulated hazardous material will be transferred to the designated storage areas to reduce any unnecessary exposure to workers and prevent unauthorized use or disposal of hazardous material.

Personnel will be protected from direct exposure to lead by various means. Review of all lead handling will be performed by C-AD ESSHQ staff. Appropriate controls will be implemented to protect the workers and the environment from exposure. Components suspected of being contaminated with lead will be cleaned to acceptable levels prior to being transferred to the new facility. Beryllium beam pipe will be removed in accordance with C-AD work Planning and Control and review by C-AD ESSHQ staff.

Oils and chemicals will be identified and labeled prior to transport from PHENIX.

Water systems are to be drained and water collected prior to disassembly of water cooled experimental equipment and cooling systems.

5.1.3 Electrical Hazards

Conventional electrical systems supporting the experimental electrical systems shall be placed in a safe state prior to the removal of equipment as per BNL LOTO procedures.

All experimental electrical systems will be disconnected and removed from the electrical distribution system by qualified electricians and therefore present no hazards to deactivation workers.

Conventional electrical systems will still be required to provide power to conventional facilities and equipment such as lighting. Therefore they will not be disconnected and some electrical hazards may still be present during deactivation activities.

5.1.4 Magnetic Hazards

There are no large permanent magnets at PHENIX. Electromagnets present no magnetic hazards because they will be disconnected from

power supplies. Therefore no signs or postings for magnetic field warnings will be necessary during removal and repurposing activities.

5.1.5 Cryogenic Hazards

None

5.1.6 Oxygen Deficiency Hazards

None

5.1.7 Mechanical Hazards

The cranes will be locked out of operation except during use. Crane operations will comply with BNL SBMS requirements.

Pumps, blowers and fans will be de-energized prior to removal.

5.1.8 Vacuum and Pressure Hazards

During deactivation, qualified personnel will open all components under vacuum.

Gas cylinders in the experimental areas will be removed or gas cylinders will be chained or otherwise restrained to prevent tipping or falling.

Compressed air will be identified throughout the facility. Compressed air utilized for experimental components will be removed or locked out and tagged.

5.2 RADIOLOGICAL HAZARDS

Operationally, the exposures to accelerator-induced activity are almost entirely direct external exposures. The probability of ingestion of radionuclides from components or dust is very small. Nevertheless control over cutting of activated components will be maintained by PHENIX/C-AD staff.

Activated materials will be identified prior to transport to from PHENIX.

6.0 SURROUNDING NATURAL AND SOCIAL ENVIRONMENT

Removal and repurposing activities outside the PHENIX facility involves removing experimental components and transport to temporary storage elsewhere in the C-AD complex, and incidental rigging.

Removal and repurposing of the PHENIX facility, taking into account the appropriate mitigation measures, are not likely to cause any significant adverse environmental effects.

7.0 APPROACH TO REMOVAL AND REPURPOSING

Removal and repurposing includes work planning, surveillance and maintenance, decontamination, radiological surveys, industrial hygiene surveys, and dismantling. These actions are taken with adequate regard for the health and safety of workers, the public and protection of the environment. The ultimate goal of this removal and repurposing plan involves removing the re-usable and non-re-useable equipment and leaving the facility in a safe, stable condition. Transport of the PHENIX experimental equipment to be reused to C-AD storage areas and transfer of the PHENIX apparatus to C-AD temporary storage until final disposition will allow preparation of the 1008 facility for the next generation sPHENIX experiment. This removal and repurposing plan helps the eventual sPHENIX installation operations by minimizing exposures to workers at that time and reducing the amount of hazardous and radioactive material that ultimately must be disposed of. The plan also has as its goals the minimizing of exposures to workers and the public, maximizing protection of the environment, and satisfying the concerns of the various stakeholders.

8.0 FINAL END-STATE OBJECTIVES

It is established that the removal and repurposing of the PHENIX Experimental facility will consist of:

- Dismantling, retaining or otherwise converting to a safe state, documenting, and verifying all components of the PHENIX Experiment and the infrastructure for the PHENIX Experiment have been accounted for, either scrapped, repurposed or reused as is.
- All utilities and other associated materials have been terminated, removed, or placed in a safe state until needed for future use, in accordance with BNL requirements
- Transporting removed PHENIX components to C-AD facility for temporary storage until disposed or reused.
- Leaving the building, offices, lecture rooms, and mechanical rooms, and associated conventional services intact.

9.0 REMOVAL AND REPURPOSING WORK PACKAGES

Table 1 lists the work packages, main activities under each work packages and the anticipated hazards associated with each work package. Complete PHENIX Work Planning and Control procedures will be used as detailed work packages, Attachment 13.2.

The principal hazards anticipated during deactivation include physical hazards, electrical hazards, and potential exposure to Pb during dismantling of shielding, and potential exposure to activated material during dismantling, moving and packaging potentially activated accelerator components.

Table 1: Brief description of the main deactivation work packages.

Work Packages	Main Activities	Expected hazards
Administrative/Regulatory	• Project Management • Engineering • Prepare deactivation plan • Safety review • Implement Work Planning and Control • Documentation and records • Periodic radiation surveys • Training • Safety meetings	• Radiological • Physical • Hazardous Materials
East Carriage (EC) Removal and Repurpose	• End of Run activities to make all systems safe and move EC to Assembly Hall (AH) • EC rack removal • DC east removal, disposition • PC1, PC3 & TEC east removal, disposition • Rich east removal, disposition • EMCal east removal, disposition • TOF east removal, disposition • Carriage structural removal, disposition • Radiological characterization	• Radiological • Electrical • Mechanical • Physical

Work Packages	Main Activities	Expected hazards
Beampipe Removal and Repurpose	• close vacuum gate valves, purge beampipes with N2 • Disconnect and remove beam pipes • Move beampipes to C-AD temporary storage for future reuse • Install temporary beampipes and beampipe stands • Bakeout temporary beampipes • Ready for next RHIC run without PHENIX	• Electrical • Mechanical • Physical • Radiological • Hazardous material (Be)
South Muon Magnet (MMS) Removal and Repurpose	• Move to AH • Remove and store racks at C-AD • MPC-Ex south removal, disposition • MPC south removal, disposition • MuTr Sta1 removal, disposition • MuTr sta 2&3 removal, disposition • MMS Structural removal, disposition • Radiological characterization •	• Electrical • Mechanical • Physical • Radiological • Hazardous Material (Pb)
Central Magnet (CM)	• CM Rack • Survey and categorize and dispose non-radioactive material • Tag and move as required • Transport to C-AD	• Electrical • Mechanical • Physical • Radiological • Hazardous Material (Pb) •
West Carriage (WC) Removal and Repurpose	• WC rack removal • DC west removal, disposition • PC1, PC3 & TEC west removal, disposition • Rich west removal, disposition • EMCal east removal, disposition	• Electrical • Mechanical • Physical • Radiological

Work Packages	Main Activities	Expected hazards
	• TOF west removal, disposition • Carriage structural removal, disposition • Radiological characterization	
North Muon Magnet (MMN)Removal and Repurpose	• Remove and store racks at C-AD • MPC-Ex north removal, disposition • MPC north removal, disposition • MuTr Sta1 north removal, disposition • MuTr sta 2&3 north removal, disposition • MMN Structural removal, disposition • Radiological	• Electrical • Mechanical • Physical • Radiological • Hazardous Material (Pb)
Other PHENIX Infrastructure Removal and Repurpose	• Remove cables, trunk lines, gas ;lines, electrical service lines and fiber optic lines formerly connected to PHENIX experimental components to IR entry point • Remove conduits and ducts and cable trays • Cap gas/air systems at IR entry points •	• Radiological • Physical • Hazardous Materials (Flammabl e Gases)

9.1 ADMINISTRATIVE

Removal and repurposing activities will begin immediately after RHIC run 16 concludes. Work planning and control will be performed and coordinated by the PHENIX Work Control Managers and C-AD Liaison Engineer Work Control Coordinator. Additional Work Control by Integrated Facilities Management and outside vendor's services will be coordinated as required.

Project management activities including documentation and inventory of equipment removed by PHENIX shall be performed by PHENIX Experiment staff .. Transfer of BNL bar-coded equipment will be coordinated and be performed in accordance with Procurement and Property Management requirements.

9.2 PHENIX FACILITY Component Removal and Repurposing (R&R)

During PHENIX R&R the following activities would have been completed:

1. Termination of operation and PHENIX facility stabilization, including disconnecting unessential electrical and mechanical systems for the experimental facilities.
2. The services for the conventional facilities such as the building, office space will remain.
3. Radiological and Industrial hygiene survey characterization will be undertaken. The objective of survey characterization is to identify the intrinsic safety hazards and risks present in the PHENIX facility. Characterization includes identifying radioactive and hazardous contaminants, their locations, and their magnitude. This information becomes part of the risk assessment when decisions are being made on which methods to deploy in order to minimize exposures to workers during the deactivation activity.
4. Drainage and drying or blow-down of all systems not in operation. The hazard is minimal as long as proper personal protection equipment is worn.
5. Removal of combustible material. This includes paper, plastic, wood products and removal of other waste from the R&R activity.

9.3 DISCONNECTING AND DISMANTLING EXPERIMENTAL SERVICES

Activities involve disconnecting power supplies, magnets, vacuum apparatus, and scientific instrumentation. Only qualified personnel will perform the work following established policies and procedures for electrical safety and Lockout/Tagout.

9.4 DISMANTLING ACCELERATOR/BEAMLINES

Activities involve dismantling accelerator beamline components and supporting systems. Component removal and dismantling will be performed by qualified workers following established policies and procedures for electrical and mechanical safety and Lockout/Tagout.

9.5 BULK SHIELDING REMOVAL

Activities that involve bulk shielding surrounding will be performed by qualified workers following established policies and procedures.

Shielding within the PHENIX experiment will be characterized for radiological hazardous then removed to C-AD facilities for final disposition (repurpose, recycle, and/or disposal as appropriate and in accordance with BNL SBMS requirements.

9.6 RADIOLOGICAL MEASUREMENTS

All components of the PHENIX Experiment will be characterized and surveyed by qualified RCD technicians. All of these components would be categorized by types and radioactivity level and would be scheduled for removal.

9.7 RADIOACTIVE WASTE MANAGEMENT

The removal would deal with three categories of components:

- Contamination/activation free components would be moved to a temporary storage space, within the C-AD complex.
- Items that could be used again but have some residual radioactivity would be moved under the supervision RCD and stored in a separate radiological controlled location. Such items might be magnets and beam pipes.
- Non-reusable components with some residual radioactivity would be moved to a temporary storage space, within the C-AD complex.

9.8 FACILITY FINAL CLEAN-UP

The clean-up involves 1008 areas within the facility, and removing and disposing of any remaining non-hazardous waste resulting from from the deactivation activities described in this plan.

10.0 PROPOSED SCHEDULE

This proposed schedule for PHENIX R&R activities is shown in the attached PHENIX Removal & Repurposing Plan document (Attachment 13.1) which was submitted to DOE and approved. The project is expected to take approximately 1-1/2 years and be completed in time to commence installation of the proposed sPHENIX experiment upgrade to PHENIX.

11.0 RECORDS

The following records will be maintained for future use and for the purpose of periodically updating this plan if necessary:

1) Work Planning Policies and Procedures:
   - Ensure adequate coverage of radiation protection and control, industrial safety and industrial hygiene
2) Residual Radiological Surveys data:
   - Used in initial radiological characterization, to identify any hot spots and contamination and to establish the extent of activation.
3) Inventory of repurposed and remaining at PHENIX, temporarily stored at C-AD transferred to others and/or scrapped/bulk recycled.

- Help account for all materials.
- Ensure compliance with Procurement and Property Management requirements.

4) Hazardous material inventory and usage records
   - Help determine the amount of hazardous material and account for all hazardous material at the facility

5) Records of spills and leaks
   - Identify any areas or locations requiring decontamination

6) Existing PHENIX drawings
   - Identifies layout and locations of various components and systems and prevents disconnecting or modifying key systems.

12.0 REFERENCES

12.1 DOE Order Order 420.2C, Safety of Accelerator Facilities

12.2 DOE Guide 420.2-1A, Accelerator Facility Safety Implementation Guide for DOE O 420.2C, Safety of Accelerator Facilities

13.0 ATTACHMENTS

13.1 Brookhaven National Laboratory (BNL) Pioneering High Energy Nuclear Ion eXperiment (PHENIX) Removal and Repurposing Plan as submitted to DOE for Approval.

13.2 PHENIX R&R Work Planning Schedule.