Collider-Accelerator Department

Hazard Screening Report for Energy Recovery Linac (ERL) Prototype in Building 912

Compiled by

Edward T. Lessard

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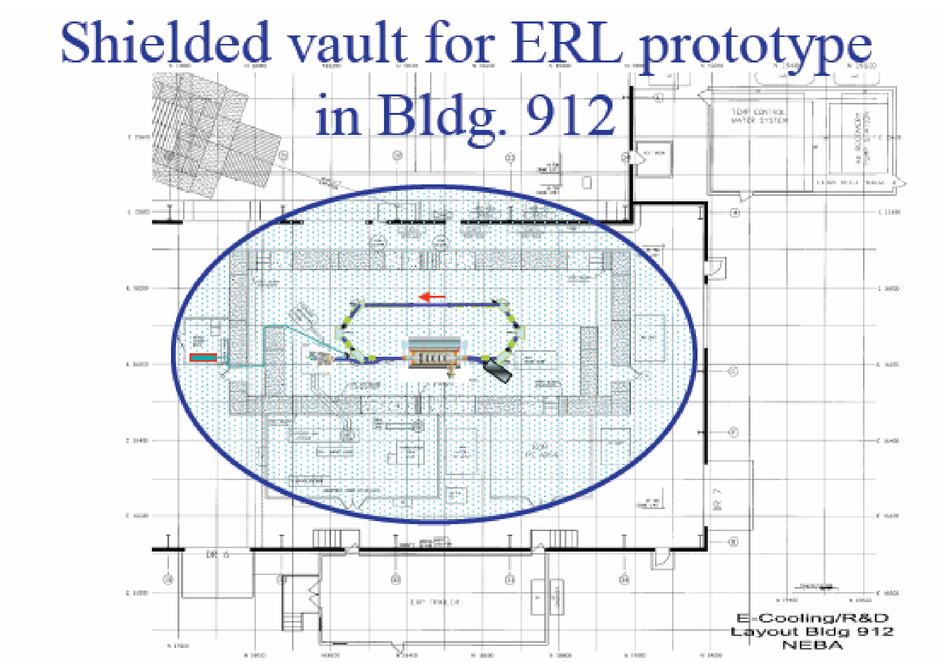


Hazard Screening Report for ERL Prototype Project

Introduction

A hazard screening tool (Appendix 1) was designed to assist in identifying the hazards associated with each sub-system for the ERL Prototype Project to determine the level of hazard analysis required and follow-up actions. The tool was used by each sub-system manager.

In the sections that follow, the ERL Prototype sub-system is listed (first level or one dot), with detail in some cases down to three levels (three dots). This is followed by a summary of the hazards identified using the hazard screening tool, with an associated hazard rating. Also included are follow-up assignments that must be completed by the sub-system manager. These assignments have a designated responsible individual and are tracked in the C-AD Family Action Tracking System

Executive Summary

Details of the proposed hazards and the follow-up safety review actions are described in this report. Responsible-person assignments are identified. Significant follow-up actions will be tracked to closure.

The hazards and controls for ERL Prototype subsystems have been found to be similar to hazards and controls described in the existing C-AD Safety Assessment Document (SAD). However, a separate safety analysis will have to be written and reviewed by the Laboratory ESH Committee, and approved by the BNL Deputy Director for Operations. The safety analysis will be similar to the C-AD SAD, and authorization to commission and operate the ERL Prototype will follow the requirements in DOE Order 420.2B, Accelerator Safety.

ERL Prototype commissioning and operations must be approved by DOE. DOE is also responsible for approving the Accelerator Safety Envelope. Prior to requesting authorization to commission, BNL is responsible for performing an Accelerator Readiness Review, as per the SBMS Subject Area, Accelerator Safety. C-AD is responsible for preparing the authorization documents and achieving readiness in safety, operations and hardware prior to the Review.

C-AD occupational safety and health (OSH) programs and environmental (E) programs to be employed at the job level are described in detail on the C-AD ESH web and are compared to the Integrated Safety Management System for DOE. These OSH and E programs will be adhered to throughout the construction, commissioning and operation of the ERL Prototype.

ERL Prototype facilities or modifications have undergone a National Environmental Policy Act (NEPA)/Cultural Resources review. This review was conducted separately from this hazard screening.

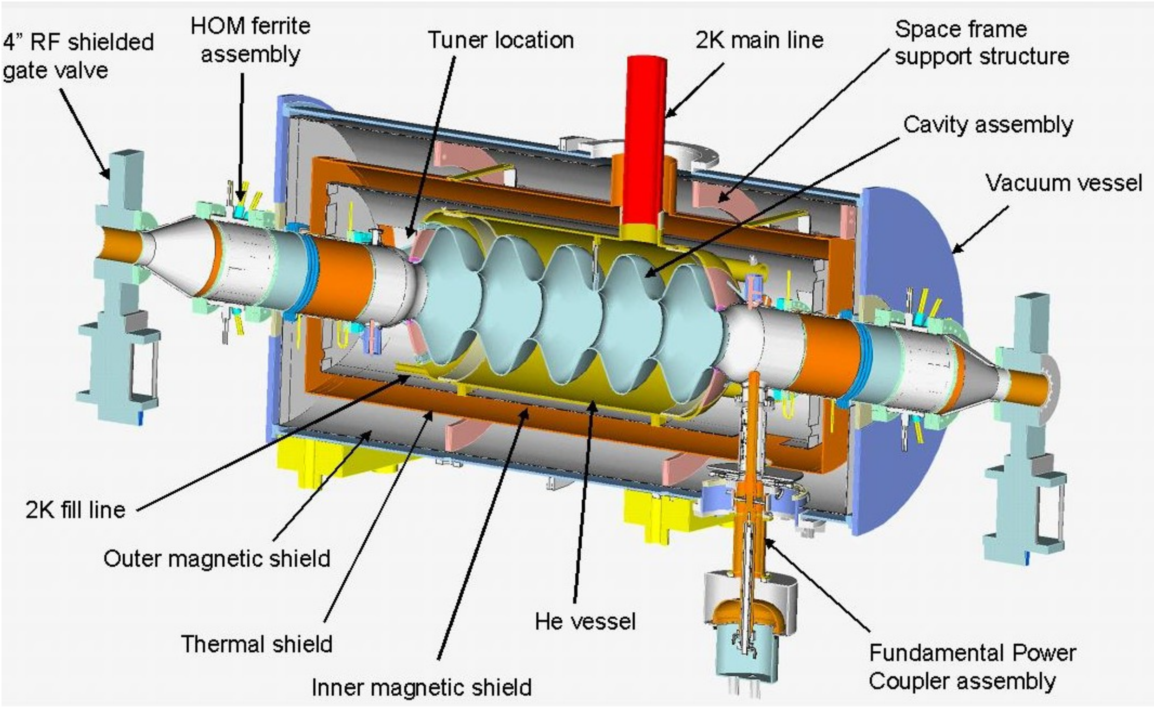
ERL Subsystems (Sub-system Manager), Associated Hazards and Follow-up Actions

2.1 Superconducting RF Cavity (Ilan Ben-Zvi)

The superconducting linac cryomodule (ERL cryomodule) is shown in the figure below. The major structural components will be installed in the ERL Prototype facility in Building 912.

The superconducting linac cryomodule is an assembly used to accelerate electrons in the Energy Recovery Linac (ERL). Its main element is a niobium structure called a cavity. The niobium cavity is shown in the figure below. It comprises 5 cells, to obtain a repeating pattern of the electromagnetic field in order to get efficient acceleration. The cavity resonates at a frequency of 703.75 MHz with microwave power that is fed through a port called the Fundamental Power Coupler. When cooled to liquid helium temperature, the niobium becomes a superconductor, reducing the losses so that high fields (up to 20 MV/m) can be set up in the cavity using a few 10's of watts of RF power. Naturally, such high fields can lead to acceleration of background electrons or even cause field emission of electrons that will then be accelerated by the fields and then result in x-ray radiation through Bremsstrahlung.

The details of the cryomodule are shown in the next figure. The 5-cell niobium cavity assembly is enclosed in a titanium helium vessel. The cavity is equipped with a tuner, fundamental power coupler and beam pipes for bringing the electron beam in and out of the cavity. The beam pipes also serve as conduits for the microwave power generated by the beam passing the cavity, what is call HOM (Higher Order Mode) power. The HOM power is dissipated in ferrite assemblies on either side of the cryomodule. The cavity is maintained at liquid helium temperature by liquid helium brought into the cavity's helium vessel through a 2K main line. To reduce cryogenic losses the cavity system is enclosed in a vacuum vessel equipped with a thermal shield, comprised of a metal envelope covered by Multi-Layer Insulation (MLI). The cavity must be maintained in a low ambient magnetic field while being cooled down, and for this purpose, there are two magnetic shields enclosing the cavity.



Hazard Rating and Follow-up Assignments for Superconducting RF Cavity (Ilan Ben-Zvi)

Explanation of Hazard Rating

- 0 indicates an operation with minimal risk
- 1 indicates an operation with low initial risk
- 2 indicates an operation with moderate initial risk
- 3 indicates an operation with a high initial risk

Because of the hazards identified, this operation has the potential of being an operation with a high initial risk.

The following questions were answered YES and are considered a hazard rating of 3:

2c (1). Does this operation use RGDs that are built locally or are commercially available units that have been modified?

The following questions were answered YES and are considered a hazard rating of 2:

2. Are there any accelerators or other radiation generating devices involved in this operation (other than the Collider-Accelerator)?
2a. Is there an accelerator used in this operation?
2a (1). Does this operation use accelerators that are built locally or are commercially available

units that have been modified?
2b. Are there any radiation generating devices (RGD) used in this operation?
2b(1). Are radiation generating devices capable of creating a High Radiation Area (>100 mrem/hr at 30 centimeters)?
2b(2). Are the radiation generating devices capable of creating a radiation area?
2c. Does the radiation generating device only produce radiation incidental to its primary function (such as electron microscopes, electron beam welders, ion implantation equipment)?
7. Are there any mechanical hazards or work hazards such as material handling, elevated work, vacuum or pressure vessels, scaffolds, stored energy or structural considerations?
7i. Does any equipment operate at pressures above 15 psig or under a vacuum?
7k. Is any part of this system/operation involve a cryogenic system or dewar installation?
13. Are there any controls (i.e., ventilation, fume hoods, interlocks, personal protective equipment, HEPA filters/vacuum cleaners, medical monitoring) associated with this operation?
13b. Are interlocks used in this operation?

The following questions were answered YES and are considered a hazard rating of 1:

11. Will this operation require trained operators or close surveillance?
11b. Will operation require work outside normal working hours?
11c. Will this operation require 2-person rule?
11d. Will this operation require special attention in the event it is left unexpectedly for long periods of time?
11e. Will this operation require an emergency procedure due to unusual or complicated shutdown instructions?
11f. Will group operational procedures be required for normal operation of this equipment?

Follow-up Assignments (Ilan Ben-Zvi)

(2, 2a, 2a (1)) Please list keV of accelerator and general operating guidelines in analysis. Have this accelerator reviewed by the Radiation Safety Committee (RSC). Please contact the RSC Chair, Dana Beavis (x7124).

(2b, 2b (1), 2b (2), 2c, 2c(1)) RGDs require that they be inventoried and that surveys be conducted annually. If your device is not accounted for or is not surveyed annually contact Paul Bergh (x5992). Have this RGD reviewed by the Radiation Safety Committee (RSC). Also, note this registration in the analysis for your operation by the Radiation Safety Committee. Please contact the RSC Chair, Dana Beavis (x7124).

(7, 7i) The SHSD Safety Engineering Group, prior to use, must review pressure systems that operate at greater than 15 psig. Contact the ES&H Coordinator, Asher Etkin (x4006) for additional guidance. Note operating parameters in your analysis.

(7k) Inert cryogens greater than the safe volume in liters (calculated by dividing volume of workspace in cubic meters divided 14) and non-inert cryogens in quantities greater than 2 liters or 50 kg in the case of CO_2 require review. Contact the ES&H Coordinator, Asher Etkin (x4006) for additional guidance. Note operating parameters in your analysis. Also, see the Oxygen Deficiency Hazard Subject Area for guidance. If safe volume has been calculated for your area include this information in the analysis for your operation.

(11) Ensure the operation of the ERL Prototype magnet systems is incorporated into the C-AD Operations Procedure Manual; you will need to create a new Chapter in the OPM specifically for ERL Prototype operations. Contact Dave Passarello (x7277).

(11b, 11c, 11d, 11f) Internal group operational procedures must be developed for normal operations, and a list of trained personnel is required. Contact the QA Manager, Dave Passarello, x7277, to arrange for sign off on group procedures.

(11e) An emergency procedure must be developed in accordance with C-A OPM 3.0. Contact Peter Ingrassia (x4272).

(13, 13b) A logbook of interlock checks should be maintained in the vicinity of the equipment.

2.2 RF Systems for Superconducting Injector and Superconducting Cavity (Alex Zaltsman)

The ERL accelerator consists of a high brightness RF superconducting electron injector followed by a superconducting linac cryomodule used to accelerate electrons. The microwave power used to accelerate electrons in the superconducting electron injector are provided to the cavity by a 1 MW RF klystron delivered via two 500 kW fundamental power couplers at a frequency of 703.75 MHz. The microwave power used to accelerate electrons in the superconducting linac cryomodule is provided by a 50 kW CW IOC that also operates at a frequency of 703.75 MHz. The cavity resonates with microwave power fed through a port called the fundamental power coupler.

The exposure to non-ionizing RF radiation is controlled to prevent the radio frequency power generated by the klystrons from providing a source of personnel hazard. Personnel cannot be near the 1 MW klystron source during operations due to a coordinated key system preventing access to its enclosure. The accelerating RF is in a cabinet, and the entrance to the accelerator enclosure is interlocked during operation via the ERL PASS. Additionally, the radio frequency output power is confined to the vacuum enclosure of the klystrons and accelerator structures, which provides a redundant safety protection system. A break in the vacuum integrity of any of these systems would remove the insulation the system requires to continue generating this power. Finally, the high-power radio-frequency fields contained within the system's waveguides would be surveyed as described in Subject Area: Radiofrequency/Microwave Radiation, and it will be confirmed that ambient RF fields are well within the limits defined by the American Conference of Governmental Industrial Hygienists (ACGIH) and OSHA.

The emission of x-rays due to Bremsstrahlung from the 1 MW RF klystron is prevented via steel shield housing around the tube and tube base.

Hazard Rating and Follow-up Assignments for RF Systems for Injector and Superconducting Cavity (Alex Zaltsman)

Explanation of Hazard Rating

- 0 indicates an operation with minimal risk
- 1 indicates an operation with low initial risk
- 2 indicates an operation with moderate initial risk
- 3 indicates an operation with a high initial risk

Because of the hazards identified, this operation has the potential of being an operation with a high initial risk.

The following questions were answered YES and are considered a hazard rating of 3:

2b(1). Are radiation generating devices capable of creating a High Radiation Area (>100 mrem/hr at 30 centimeters)?

The following questions were answered YES and are considered a hazard rating of 2:

2. Are there any accelerators or other radiation generating devices involved in this operation?
2b. Are there any radiation generating devices (RGD) used in this operation?
2c. Does the radiation generating device only produce radiation incidental to its primary function (such as electron microscopes, electron beam welders, ion implantation equipment)?
8e. Is there any radiofrequency or microwave field generated by a source greater than 7 W in a space that might be occupied?
8f. Does this equipment/operation produce any magnetic fields greater than 4 Gauss?
8j. Is it required for personnel to work in an area with a Noise Level between 85 dBA and 100 dBA?
11b. Will operation require work outside normal working hours?
11d. Will this operation require special attention in the event is left unexpectedly for long periods of time?

(2, 2b, 2b (1), 2c) Radiation generating devices (RGDs) require that they be inventoried and that surveys be conducted annually. If your device is not accounted for or is not surveyed annually contact Paul Bergh (x5992). Also, note this registration in the radiation safety analysis for your operation by the Radiation Safety Committee. Please contact the RSC Chair, Dana Beavis (x7124).

(8e, 8f) Non-ionizing radiation sources (NIRs) must be listed on the C-A NIR inventory and may require measurements to be taken. If your equipment is not part of this inventory, please contact Asher Etkin, ES&H Coordinator, x4006, for further guidance.

(8f) Any workers with pacemakers or medical implants require training, and these workers may not be exposed to fields greater than 5 Gauss.

(8j) If workers can be potentially exposed to excessive noise, contact Peter Cirnigliaro (x5636) for a noise evaluation.

(11b, 11d) Internal group operational procedures must be developed for normal operations, and a list of trained personnel is required. Contact the QA Manager, Dave Passarello, x7277, to arrange for sign off on group procedures.

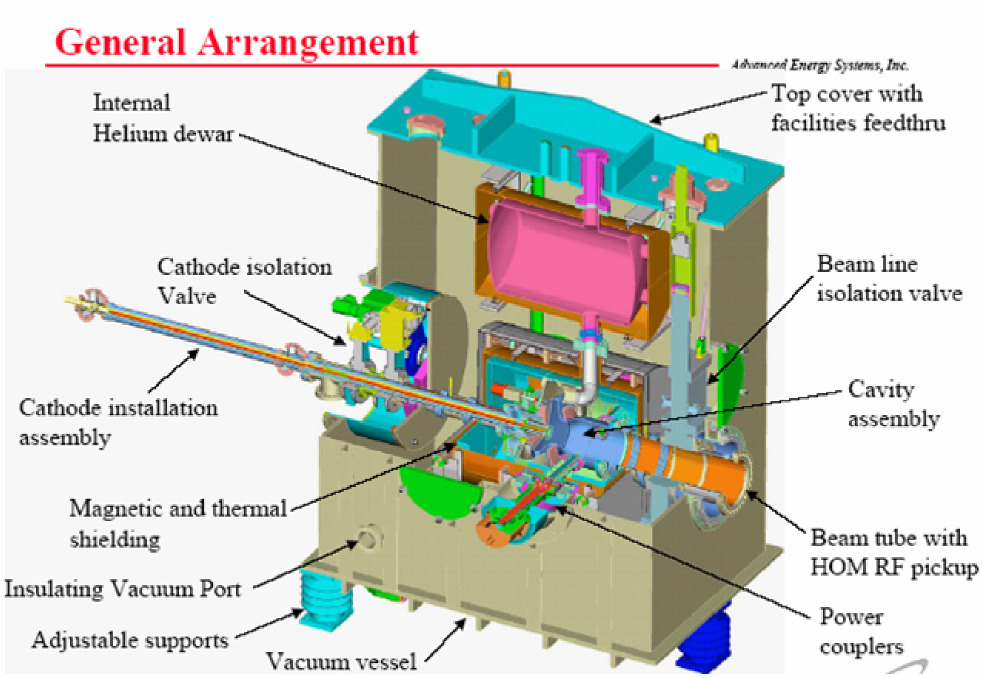
(11e) An emergency procedure must be developed. Contact Peter Ingrassia (x4272).

(13, 13b) A logbook of interlock checks should be maintained in the vicinity of the equipment.

(13c) All PPE requirements must be listed in your work planning documents. Special care must be given when selecting gloves. Always seek manufacture specific information on the gloves being used or contact the ESH Coordinator, Asher Etkin (x4006) for guidance.

2.3 Injector System (Andrew Burrill, Triveni Rao)

The injector system for the ERL is shown schematically below. The injection system is made up of several major subsystems; the superconducting RF photoinjector, the cryogenic system, the cathode insertion device, and the RF system.



The photoinjector is an all niobium 703.75 MHz SRF cavity designed to operate at 2 K to produce and accelerate electrons. The microwave power to accelerate these electrons is provided to the cavity by a 1 MW RF klystron delivered via two 500 kW fundamental power couplers. As niobium is a superconductor at liquid helium temperatures, the surface resistance is effectively zero. This means that the microwave power fed to the cavity is almost exclusively delivered to accelerating the electrons, not heating of the niobium, allowing for CW high average current electron beam generation, part of the goal of this project. This means that the 1 MW RF power can deliver a 0.5 A, 2MeV electron beam to the ERL loop with minimal power dissipated to the liquid helium bath. During start up and conditioning, there may be dark current generated in the injector.

The cavity is cooled to superconducting temperatures using 4 K liquid helium provided via external dewars to the cryostat and internal helium reservoir shown in the schematic above. A large vacuum pump is then used to reduce the pressure over the liquid helium and thus reduce the temperature of the liquid helium to 2K, the desired operating temperature.

The electrons are generated using a laser irradiated multi-alkali (CsK_2Sb) photocathode which will be produced in a custom deposition system designed to mate to the cathode installation assembly shown above. The laser system used to irradiate these cathodes will be a Class IV laser system, tentatively with a repetition rate of ~87.75 MHz producing ~8 W of power in 10 ps pulses at 355 nm. The system will consist of an oscillator locked to a master RF clock that drives the cavity, followed by a series of amplifier stages, pulse shaper/selector and harmonic crystals, the exact configuration still under investigation subject to vendor specifications. The laser beam will be transported to the photoinjector in enclosed beam pipes. The laser power will be low for initial alignment and increased gradually to full power.

Hazard Rating and Follow-up Assignments for Injector Systems (Andrew Burrill, Triveni Rao)

Explanation of Hazard Rating

- 0 indicates an operation with minimal risk
- 1 indicates an operation with low initial risk
- 2 indicates an operation with moderate initial risk
- 3 indicates an operation with a high initial risk

Because of the hazards identified, this operation has the potential of being an operation with a high initial risk.

The following questions were answered YES and are considered a hazard rating of 3:

2b(1). Are radiation generating devices capable of creating a High Radiation Area (>100 mrem/hr at 30 centimeters)?
2d. Is the radiation generating device an intentional x-ray generating device which produces radiation as part of the primary function (i.e. x-ray diffractometers, x-ray machines)?
5a. Do personnel use or have the potential to be exposed to Class 4 lasers?

The following questions were answered YES and are considered a hazard rating of 2:

1d. Does this operation use, generate or store flammable or combustible gases, liquids or solids, including solvents?
1e. Does this operation involve the use, storage or generation of caustic/corrosive chemicals or wastes?
2. Are there any accelerators or other radiation generating devices involved in this operation?
2b. Are there any radiation generating devices (RGD) used in this operation?
2b(2). Are the radiation generating devices capable of creating a radiation area?
5. Does this operation involve the use of lasers?
5b. Do personnel use or have the potential to be exposed to Class 3b lasers?
5d Does this operation involve Class1 lasers with embedded 3b or 4 lasers?
7c. Are there any structures supporting heavy loads?
7k. Is any part of this system/operation involve a cryogenic system or dewar installation?
8e. Is there any radiofrequency or microwave field generated by a source greater than 7W in a space that might be occupied?
8l. Is there any possibility of creating an Oxygen Deficient Atmosphere?
11b. Will operation require work outside normal working hours?
11d. Will this operation require special attention in the event is left unexpectedly for long periods of time?

13. Are there any controls (i.e., ventilation, fume hoods, interlocks, personal protective equipment, HEPA filters/vacuum cleaners, medical monitoring) associated with this operation?
13b. Are interlocks used in this operation?
13c. Is any personal protective equipment used in this operation?

The following questions were answered YES and are considered a hazard rating of 1:

1. Are there any chemicals, toxic materials, or hazardous materials handled, generated, used, or stored in this operation, including oils and solvents?
5c. Does the operation involve Class 1, 2 or 3a lasers?
7b. Does the operation include the use of hoist, crane, forklift, or rigging?
7f. Will this operation require any elevated work?
8h. Are there any surface temperatures less than 0 deg F or greater than 150 deg F?
10. Does this operation involve: the use of equipment, tools or materials outside of the design specifications or outside of the manufacturer's recommendations OR the use of equipment or apparatus not commercially available?
11. Will this operation require trained operators or close surveillance?
11c. Will this operation require the 2-person rule?

Follow-up Assignments (Andrew Burrill, Triveni Rao)

(1) Consult with Peter Cirnigliaro (x5636) and review the applicability of requirements in the Working with Chemicals SBMS Subject Area. Implement a process that requires you to review chemicals or hazardous materials with Peter Cirnigliaro (x5636) before they are introduced to ERL in the future.

(1d) For all flammable gases and liquids, a safe volume must not be exceeded. The safe volume is calculated by dividing the volume of the gaseous state of the flammable/combustible material by the total volume of the room and ensuring this number does not exceed ten percent of the lower flammability limit for the material. See Peter Cirnigliaro (x5636) for more information or assistance.

(1e) Work with caustic/corrosive chemicals must be done in an area with an eyewash and shower. See Peter Cirnigliaro (x5636) for more information or assistance.

(2b, 2b (1), 2b (2), 2d) RGDs require that they be inventoried and that surveys be conducted annually. If your device is not accounted for or is not surveyed annually contact Paul Bergh (x5992). Also, note this registration in the analysis for your operation by the Radiation Safety Committee. Please contact the RSC Chair, Dana Beavis (x7124).

(5, 5a, 5b, 5d) All class 3b and 4 lasers require evaluations by the Laser Safety Officer. If your laser has not been evaluated, complete the BNL General Laser Registration Form and return it to Asher Etkin (x4006). In addition, if you are going to use a Class 3b or 4 laser you must receive a medical laser eye exam prior to use. If you need a medical laser eye exam see Requirements for Laser Eye Examination in the Laser Safety Subject Area.

(5c) ANSI Z136.1 requires that Class 2 and 3a lasers have a protective housing and that they be labeled according to their Class. Also, obtain an evaluation from Asher Etkin (x4006) prior to viewing Class 2 or 3a beams through any kind of collecting optics such as microscopes and telescopes, which may concentrate the beam energy and increase the hazard.

(7b) Before using hoist, cranes or rigging equipment, ensure that current, valid annual inspection tags are attached. You need to ensure you add your equipment to the C-AD annual request for these services, notify Joel Scott (x7520).

(7b) Forklifts, powered trucks, platform lift trucks and motorized hand trucks require special training prior to use and require completion of a pre-use inspection. Contact the Training Manager, John Maraviglia (x7343), to ensure all personnel are assigned the correct training requirements.

(7c) Any structures supporting heavy loads or structural changes to cranes or buildings requires review by the Plant Engineering Division and the Chief Mechanical Engineer. Contact Joe Tuozzolo (x3966) for a review.

(7f) Elevated work may require fall protection and/or a fall protection plan. Consult with Peter Cirnigliaro (x5636).

(7k) Inert cryogens greater than the safe volume in liters (calculated by dividing volume of workspace in cubic meters divided 14) and non-inert cryogens in quantities greater than 2 liters or 50 kg in the case of CO_2 require review. Contact the ES&H Coordinator, Asher Etkin (x4006) for additional guidance. Note operating parameters in your analysis. Also, see the Oxygen Deficiency Hazard Subject Area for guidance. If safe volume has been calculated for your area include this information in the analysis for your operation.

(8e) Non-ionizing radiation sources (NIR) sources must be listed on the C-A NIR inventory and may require measurements to be taken. If your equipment is not part of this inventory, please contact the ES&H Coordinator, Asher Etkin (x4006), for further guidance.

(8h) Surface with temperatures less than 0 deg F or greater than 150 deg F must be labeled, please contact the ES&H Coordinator, Asher Etkin (x4006), for further guidance.

(8l) The guidelines of SBMS Subject Area, Oxygen Deficiency Hazard should be followed.

(10) Please list the equipment that you are using outside of design specifications or manufacturer recommendations and/or locally built equipment in your analysis along with associated controls. Certification by the Chief Electrical and/or Chief Mechanical Engineer may be required. Contact Jon Sandberg (x4682) for electrical device review and Joe Tuozzolo (x3966) for mechanical device review.

(11) Ensure the operation of the ERL magnet systems is incorporated into the C-AD Operations Procedure Manual, in the Chapter assigned to ERL Procedures. Contact Dave Passarello (7277).

(11b, 11d) Internal group operational procedures must be developed for normal operations, and a list of trained personnel is required. Contact the QA Manager, Dave Passarello, x7277, to arrange for sign off on group procedures.

(11c) In your procedures, delineate any tasks that require a two-person rule as a control.

(13, 13b) A logbook of interlock checks should be maintained in the vicinity of the equipment.

(13c) All PPE requirements must be listed in your analysis. Special care must be given when selecting gloves. Always seek manufacture specific information on the gloves being used or contact the ESH Coordinator, Asher Etkin (x4006) for guidance.

2.4 Cryogenic Systems (Dewey Lederle)

2.4.1 Ballast tank - Designing and constructing a liquid helium storage volume mounted above the 5 cell cavity. Its purpose is to provide operational time at 2K for the cavity.
2.4.2 1.1 K Vacuum Pump - Specifying and purchasing a vacuum pump for sub cooling the boiling liquid helium.
2.4.3 Warm Piping - Design and installation of ambient temperature piping associated with the ERL cryogenic system.
2.4.4 Transfer Line - Specification and purchasing cryogenic transfer lines to supply liquid helium to the 5 cell cavity.
2.4.5 Instrumentation - Pressure and Temperature Instrumentation and their associated I/O and hardware.
2.4.6 Insulating Vacuum System - Vacuum pump to maintain insulating vacuums.
2.4.7 Process Pressure Relief Valves - Sizing and purchasing relief valves for the ERL cryogenic system.
2.4.8 Installation - Installation of the ERL cryogenic system.
2.4.9 Commissioning - Commissioning of the ERL cryogenic system.

Hazard Rating and Follow-up Assignments for Cryogenic Systems (Dewey Lederle)

Explanation of Hazard Rating

- 0 indicates an operation with minimal risk
- 1 indicates an operation with low initial risk
- 2 indicates an operation with moderate initial risk
- 3 indicates an operation with a high initial risk

Because of the hazards identified, this operation has the potential of being an operation with a moderate initial risk.

The following questions were answered YES and are considered a hazard rating of 2:

1d. Does this operation use, generate or store flammable or combustible gases, liquids or solids, including solvents?
7c. Are there any structures supporting heavy loads?
7k. Is any part of this system/operation involve a cryogenic system or dewar installation?
7m. Are there any sources of stored energy (hydraulic, pneumatic, thermal, mechanical)?
11e. Will this operation require an emergency procedure due to unusual or complicated shutdown instructions?
13. Are there any controls (i.e., ventilation, fume hoods, interlocks, personal protective equipment, HEPA filters/vacuum cleaners, medical monitoring) associated with this operation?
13b. Are interlocks used in this operation?
13c. Is any personal protective equipment used in this operation?

The following questions were answered YES and are considered a hazard rating of 1:

1. Are there any chemicals, toxic materials, or hazardous materials handled, generated, used, or stored in this operation, including oils and solvents?
7e. Will you be purchasing any ladders or scaffolds?
11. Will this operation require trained operators or close surveillance?

Follow-up Assignments (Dewey Lederle)

(1) Consult with Peter Cirnigliaro (x5636) and review the applicability of requirements in the Working with Chemicals SBMS Subject Area. Implement a process that requires you to review chemicals or hazardous materials with Peter Cirnigliaro (x5636) before they are introduced to ERL in the future.

(1d) For all flammable gases and liquids, a safe volume must not be exceeded. The safe volume is calculated by dividing the volume of the gaseous state of the flammable/combustible material by the total volume of the room and ensuring this number does not exceed ten percent of the lower flammability limit for the material. See Peter Cirnigliaro (x5636) for more information or assistance.

(7c) Any structures supporting heavy loads or structural changes to cranes or buildings requires review by the Plant Engineering Division and the Chief Mechanical Engineer. Contact Joe Tuozzolo (x3966) for a review.

(7e) Ladders must be wooden. Scaffolding must be reviewed by the C-AD ESH Coordinator. Please contact Asher Etkin (x4006).

(7k) Inert cryogens greater than the safe volume in liters (calculated by dividing volume of workspace in cubic meters divided 14) and non-inert cryogens in quantities greater than 2 liters or 50 kg in the case of CO2 require review. Contact the ES&H Coordinator, Asher Etkin (x4006) for additional guidance. Note operating parameters in your analysis. Also, see the Oxygen Deficiency Hazard Subject Area for guidance. If safe volume has been calculated for your area include this information in the analysis for your operation.

(7m) All sources of stored energy must be locked out or disabled prior to working on systems.

(11) Ensure the operation of the ERL cryogenic systems is incorporated into the C-AD Operations Procedure Manual Chapter 7, Cryogenic Operations. All cryogenic systems require review and approval by the Laboratory Cryogenic Safety Sub-Committee prior to operations. Contact E. Lessard, x4250.

(11e) An emergency procedure must be developed in accordance with C-A OPM 3.0. Contact Peter Ingrassia (x4272).

(13, 13b) A logbook of interlock checks should be maintained in the vicinity of the equipment.

(13c) All PPE requirements must be listed in your analysis. Special care must be given when selecting gloves. Always seek manufacture specific information on the gloves being used or contact the ESH Coordinator, Asher Etkin (x4006) for guidance.

2.5 Vacuum Systems (Dick Hseuh)

2.5.1 Vacuum Chambers - Design, fabrication and installation of stainless steel and aluminum vacuum chambers and beam pipes for ERL loop vacuum system.
2.5.2 Vacuum Pumps and Valves - Design, procurement and installation of high vacuum pumps for ERL loop vacuum systems.
2.5.3 Design and procurement of the vacuum gauges and control PLC and PC for ERL loop vacuum system. PLC and PC programming of ERL vacuum monitoring and control system.

Hazard Rating and Follow-up Assignments for Vacuum Systems (Dick Hseuh)

Explanation of Hazard Rating

- 0 indicates an operation with minimal risk
- 1 indicates an operation with low initial risk
- 2 indicates an operation with moderate initial risk
- 3 indicates an operation with a high initial risk

Because of the hazards identified, this operation has the potential of being an operation with a moderate initial risk.

The following questions were answered YES and are considered a hazard rating of 2:

7m. Are there any sources of stored energy (hydraulic, pneumatic, thermal, mechanical)?

The following questions were answered YES and are considered a hazard rating of 1:

7l. Does the operation include the use of typical shop equipment?
11. Will this operation require trained operators or close surveillance?
11a. Will this operation be left unattended?
11f. Will group operational procedures be required for normal operation of this equipment?

Follow-up Assignments (Dick Hseuh)

(7l) Electrically powered hand tools should be double insulated and plugged into grounded system.

(7m) All sources of stored energy must be locked out or disabled prior to working on systems.

(11, 11a) If your operation will be left unattended and it poses a hazard to individuals who may enter the area for whatever reason then you must ensure that the area is posted with the name of the contact and phone number along with associated hazards when unattended.

(11f) Internal group operational procedures must be developed for normal operations, and a list of trained personnel is required.

2.6 Magnet Systems (George Mahler)

The ERL magnet systems include 4 injection-line dipoles, 1 dump magnet, and the ring magnets. The ring magnets include 25 quadrupoles and 6 dipoles.

The electrical power for the accelerator is distributed at 480 volts, 3 phases with a high-resistance grounded delta system. The equipment that requires the 480 line voltage includes the ring magnet, dump magnet and injection-line magnet power supplies. The installation and operation of this power distribution system is according to standard industrial practice for this type of equipment. The safety codes used include the National Electric Code, and the Code of Federal Regulations 10 CFR 851, Worker Safety and Health Program.

Hazard Rating and Follow-up Assignments for Magnet Systems (George Mahler)

Explanation of Hazard Rating

- 0 indicates an operation with minimal risk
- 1 indicates an operation with low initial risk
- 2 indicates an operation with moderate initial risk
- 3 indicates an operation with a high initial risk

Because of the hazards identified, this operation has the potential of being an operation with a high initial risk.

The following questions were answered YES and are considered a hazard rating of 3:

6c. Is it required for personnel to work on energized systems greater than 600 V (Range D)?

The following questions were answered YES and are considered a hazard rating of 2:

6a. Is there any exposed electrical components where there is the potential for personnel to be exposed to voltages greater than 50V (Range A)?
6b. Is it required for personnel to work on energized systems greater than 50V (Range A) but less than 600 V (Range B&C)?
6d. Has this equipment been built locally, modified or NOT listed by a Nationally Recognized Testing Laboratory?
7c. Are there any structures supporting heavy loads?
7m. Are there any sources of stored energy (hydraulic, pneumatic, thermal, mechanical)?
8f. Does this equipment/operation produce any magnetic fields greater than 4 Gauss?
8g. Is it required for personnel to be exposed to a magnetic field greater than 600 Gauss?
8l. Is there any possibility of creating an Oxygen Deficient Atmosphere?
11b. Will operation require work outside normal working hours?
11d. Will this operation require special attention in the event is left unexpectedly for long periods of time?
12b. Does this operation generate, store or use any combustible materials in significant

quantities?
12d. Will this operation change the risk level of fire protection?
13. Are there any controls (i.e., ventilation, fume hoods, interlocks, personal protective equipment, HEPA filters/vacuum cleaners, medical monitoring) associated with this operation?
13b. Are interlocks used in this operation?
13c. Is any personal protective equipment used in this operation?

The following questions were answered YES and are considered a hazard rating of 1:

7b. Does the operation include the use of hoist, crane, forklift, or rigging?
7l. Does the operation include the use of typical shop equipment?
8h. Are there any surface temperatures less than 0 deg F or greater than 150 deg F?
10. Does this operation involve: the use of equipment, tools or materials outside of the design specifications or outside of the manufacturer's recommendations OR the use of equipment or apparatus not commercially available?
11. Will this operation require trained operators or close surveillance?
11c. Will this operation require the 2-person rule?
12e. Could this equipment act as an ignition source?

Follow-up Assignments (George Mahler)

(6) All personnel working with electrical systems must have Electrical Safety and Lockout/Tagout training. It is your responsibility to ensure all personnel are trained prior to working. Contact the Training Manager, John Maraviglia (x7343), to ensure all personnel are assigned the correct training requirements.

(6b, 6c) Working Hot training is required for work on energized equipment. Contact the Training Manager, John Maraviglia (x7343), to ensure all personnel are assigned the correct training requirements.

(6d) The Chief Electrical Engineer must certify devices that are not commercially available. Contact Jon Sandberg (x4682).

(7b) Before using hoist, cranes or rigging equipment, ensure that current, valid annual inspection tags are attached. You need to ensure you add your equipment to the C-AD annual request for these services, notify Joel Scott (x7520).

(7b) Forklifts, powered trucks, platform lift trucks and motorized hand trucks require special training prior to use and require completion of a pre-use inspection. Contact the Training Manager, John Maraviglia (x7343), to ensure all personnel are assigned the correct training requirements.

(7c) Any structures supporting heavy loads or structural changes to cranes or buildings requires review by the Plant Engineering Division and the Chief Mechanical Engineer. Contact Joe Tuozzolo (x3966) for a review.

(7l) Electrically powered hand tools should be double insulated and plugged into grounded system.

(7m) All sources of stored energy must be locked out or disabled prior to working on systems.

(8f, 8g) Any workers with pacemakers or medical implants require training, and may not be exposed to fields greater than 5 Gauss. Workers have 8-hour time-weighted average exposure limits of 600 Gauss to the whole body. Please contact the ES&H Coordinator, Asher Etkin (x4006), for further guidance.

(8h) Surface with temperatures less than 0 deg F or greater than 150 deg F must be labeled, please contact the ES&H Coordinator, Asher Etkin (x4006), for further guidance.

(8l) The guidelines of SBMS Subject Area, Oxygen Deficiency Hazard should be followed.

(10) Please list the equipment that you are using outside of design specifications or manufacturer recommendations and/or locally built equipment in your analysis along with associated controls. Certification by the Chief Electrical and/or Chief Mechanical Engineer may be required. Contact Jon Sandberg (x4682) for electrical device review and Joe Tuozzolo (x3966) for mechanical device review.

(11) Ensure the operation of the ERL magnet systems is incorporated into the C-AD Operations Procedure Manual. Contact Dave Passarello (x7277).

(11b, 11d) Internal group operational procedures must be developed for normal operations, and a list of trained personnel is required. Contact the QA Manager, Dave Passarello, x7277, to arrange for sign off on group procedures.

(11c) In your procedures, delineate any tasks that require a two-person rule as a control.

(12b, 12e) The Fire Protection Engineer must approve generation, storage or use of combustible materials in significant quantities; in addition, nearby ignition sources must be reviewed. Contact Michael Kretschmann (x5274).

(12d) Any deviations from Life Safety Code or change in the risk level of fire protection must be approved by the Fire Protection Engineer. Contact Michael Kretschmann (x5274).

(13b) A logbook of interlock checks should be maintained in the vicinity of the equipment.

(13c) All PPE requirements must be listed in your analysis. Special care must be given when selecting gloves. Always seek manufacture specific information on the gloves being used or contact the ESH Coordinator, Asher Etkin (x4006) for guidance.

2.7 Magnet Electrical Systems (Bob Lambiase)

2.7.1 Large Unipolar Power Supplies - Design, manufacture, install and test Large Unipolar Power Supplies
2.7.2 Small Unipolar Power Supplies - Design, manufacture, install and test Small Unipolar Power Supplies
2.7.3 Bipolar Trim Power Supplies - Design, manufacture, install and test Bipolar Trim Power Supplies
2.7.4 Bipolar Steering Power Supplies - Design, manufacture, install and test Bipolar Steering Power Supplies
2.7.5 D5 Power Supplies - Design, manufacture, install and test D5 Power Supplies and cable.
2.7.6 DC Cable for Power Supplies - Design, manufacture, install and test cable for 2.7.1 through 2.7.4

Hazard Rating and Follow-up Assignments for Electrical Systems (Bob Lambiase)

Explanation of Hazard Rating

- 0 indicates an operation with minimal risk
- 1 indicates an operation with low initial risk
- 2 indicates an operation with moderate initial risk
- 3 indicates an operation with a high initial risk

Because of the hazards identified, this operation has the potential of being an operation with a moderate initial risk.

The following question was answered YES and is considered a hazard rating of 2:

6d. Has this equipment been built locally, modified or NOT listed by a Nationally Recognized Testing Laboratory?

The following questions were answered YES and are considered a hazard rating of 1:

7b. Does the operation include the use of hoist, crane, forklift, or rigging?
11a. Will this operation be left unattended?

Follow-up Assignments (Bob Lambiase)

(6) All personnel working with electrical systems must have Electrical Safety and Lockout/Tagout training. It is your responsibility to ensure all personnel are trained prior to working. Contact the Training Manager, John Maraviglia (x7343), to ensure all personnel are assigned the correct training requirements.

(6d) The Chief Electrical Engineer must certify devices that are not commercially available. Contact Jon Sandberg (x4682).

(7b) Before using hoist, cranes or rigging equipment, ensure that current, valid annual inspection tags are attached. You need to ensure you add your equipment to the C-AD annual request for these services, notify Joel Scott (x7520).

(7b) Forklifts, powered trucks, platform lift trucks and motorized hand trucks require special training prior to use and require completion of a pre-use inspection. Contact the Training Manager, John Maraviglia (x7343), to ensure all personnel are assigned the correct training requirements.

(11, 11a) If your operation will be left unattended and it poses a hazard to individuals who may enter the area for whatever reason then you must ensure that the area is posted with the name of the contact and phone number along with associated hazards when unattended.

2.8 Electron Beam Dump Systems (Ady Hershcovitch)

As its name suggests, the beam dump is where electron bunches end up while depositing energy unrecovered by the ERL. Energy of ERL discarded electrons will be either 2 or 5 MeV. Under present design, the beam will impinge on a flat water-cooled, copper plate measuring approximately 36 inch by 48 inch. This large area is to insure that local boiling of the cooling water does not occur. The beam will be spread over this large surface area by rastering it with magnetic field coils. One set of coils will be for vertical scanning and the second set for horizontal scanning.

The rectangular beam dump will be attached to the end of a stainless steel scan chamber. The beam dump will have an overall length of approximately 9 feet. The width of the device will depend on the mounting orientation and could range from 4 to 5 feet depending on the preferred orientation of the copper plate. Average cross section of the copper beam dump plate is approximately 1 inch thick, and it has approximately 80 percent copper and the water channels constitute about 20 percent of its volume. Average cross section of the stainless steel scan chamber walls is approximately 0.375 inches thick and it has approximately 94 percent stainless steel and 6 percent water by volume.

Hazard Rating and Follow-up Assignments for Electron Beam Dump Systems (Ady Hershcovitch)

Explanation of Hazard Rating

- 0 indicates an operation with minimal risk
- 1 indicates an operation with low initial risk
- 2 indicates an operation with moderate initial risk
- 3 indicates an operation with a high initial risk

Because of the hazards identified, this operation has the potential of being an operation with a high initial risk.

The following question was answered YES and is considered a hazard rating of 3:

2b(1). Are radiation generating devices capable of creating a High Radiation Area (>100 mrem/hr at 30 centimeters)?

The following questions were answered YES and are considered a hazard rating of 2:

2. Are there any accelerators or other radiation generating devices involved in this operation?
2b. Are there any radiation generating devices (RGD) used in this operation?
2b(2). Are the radiation generating devices capable of creating a radiation area?
2c. Does the radiation generating device only produce radiation incidental to its primary function (such as electron microscopes, electron beam welders, ion implantation equipment)?

Follow-up Assignment (Ady Hershcovitch)

(2, 2b, 2b(2), 2c) Please indicate the energy deposition, heat transfer properties and potential activation of the beam dump and cooling water15 and general operating guidelines of the beam dump in an analysis. Have this analysis reviewed by the Radiation Safety Committee (RSC). Even though this beam dump is not an "experiment", please refer to OPM 9.1.15, Radiological Review Criteria for Collider-Accelerator Experiments and Procedures, as it may be useful guidance in preparing for the RSC review. Please contact the RSC Chair, Dana Beavis (x7124).

<u>2.9 Beam Instrumentation (Pete Cameron)</u>

Beam Instrumentation is functionally divided into subsystems; position monitors, current monitors, profile monitors, and loss monitors. Beam Instrumentation specialists will provide the beam line sensors, signal and control cables, readout electronics and software for these subsystems. The majority of the hardware and software is not available commercially off-the-shelf, but rather is designed and produced specific to the intended function. With the exception of loss monitors, all sensors will be integral to the vacuum envelope. None of the subsystems will be interfaced to the personnel protection system. Initially, the loss monitors will be interfaced to the machine protection system, and possibly the current monitors. As operational experience is gained, portions of additional subsystems may be interfaced to the machine protection system.

Hazard Rating and Follow-up Assignments for Beam Instrumentation (Pete Cameron)

Explanation of Hazard Rating

- 0 indicates an operation with minimal risk
- 1 indicates an operation with low initial risk
- 2 indicates an operation with moderate initial risk
- 3 indicates an operation with a high initial risk

Because of the hazards identified, this operation has the potential of being an operation with a moderate initial risk.

The following questions were answered YES and is considered a hazard rating of 2:

5. Does this operation involve the use of lasers?
6b. Is it required for personnel to work on energized systems greater than 50V (Range A) but less than 600 V (Range B&C)?
6d. Has this equipment been built locally, modified or NOT listed by a Nationally Recognized Testing Laboratory?
6e. Does your operation require the development of an Electrical Hot Work Permit (EHWP)?
8f. Does this equipment/operation produce any magnetic fields greater than 4 Gauss?
8m. Is it required for any personnel to work in an existing Oxygen Deficiency Hazard Area?

Follow-up Assignments (**Pete Cameron**)

(5) If you use a laser in the instrumentation, then the laser must be evaluated. Upon purchase, please complete the BNL General Laser Registration Form and return it to Asher Etkin (x4006).

(6b, 6c) Electrical Safety Training is required for work on energized equipment. Contact the Training Manager, John Maraviglia (x7343), to ensure all personnel are assigned the correct training requirements.

(6d) The Chief Electrical Engineer must certify devices that are not commercially available. Contact Jon Sandberg (x4682).

(6e) The Chief Electrical Engineer must be contacted to authorize Permits for Working on or Near Energized Parts. Contact Jon Sandberg (x4682).

(8f) Any workers with pacemakers or medical implants require training, and may not be exposed to fields greater than 5 Gauss.

(8m) If the ERL area you will work in is classified an ODH Area, then you will require ODH training. Please contact the Training Manager, John Maraviglia (x7343), to ensure all personnel are assigned the correct training requirements.

2.10 Control Systems (Brian Oerter)

The ERL control system shall be an extension of the RHIC controls system. To the maximum degree possible, solutions chosen for the ERL system shall be appropriate for the RHIC e-Cooling facility. The basic elements of the system will comprise a networked family of front-end interfaces connected via Ethernet to ERL control console workstations and to central C-AD servers.

2.10.1 Network and Links

Existing fiber optic infrastructure in Building 912 will provide access to the C-AD controls subnet, with switched 100 Mbit Ethernet on copper to individual front-end nodes and console computers. The standard controls interface infrastructure will comprise VME chassis, CPU, utility link interface, battery-backed SRAM, event decoder-delay modules, remote power reset, and terminal server for serial port access to CPUs. Some engineering may be needed for module redesign driven by parts obsolescence. Software support for an updated CPU will also be needed.

The C-AD Real-Time Data Link (RTDL) will be delivered via fiber to provide the facility-standard, time-of-day reference for all front-end chassis. This time base will be common to all logged data. Pulse timing will be provided by a local version of the standard Event Link system with provision for encoded events. It will provide a standard real-time clock and asynchronous, software- or hardware-initiated encoded event signals for triggering equipment.
A fast beam inhibit system will be required to protect the equipment from uncontrolled operation of the high power beam. It will be patterned after the present RHIC/AGS systems. Equipment will indicate, *"operation permitted"*, by providing a fail-safe current signal to one of 24 input channels. The system will be modular so that additional inputs may be added economically. Redundancy will be provided as needed to drive *critical devices* used to shut off the system. New software will be required to manage the specifics of the ERL system.

2.10.2 Control Console

A work console composed of standard 19-inch racks with writing shelf attachments will be provided in the facility control room. Each of 3 "seats" will be equipped with a Linux workstation and 4 flat-panel monitors, configured as a single continuous display resource. Rack space will be provided at the console for some other rack-mounted equipment, telephone, and the access control system panel display and key-tree. A color printer will also be provided. General purpose and project-specific application software for operating and monitoring the equipment and beam characteristics will be provided. It is expected that a majority of the required services will be met by existing software tools for simple device control, sequencing, data logging, comfort displays, alarms, and e-log. In addition, the RHIC *post mortem* system, that comprises automatic data recording by front-ends after an *abort* and associated display and summary tools, will be adapted for ERL fast beam inhibit response.

Power supply control:

DC power supplies will be connected to the Accelerator Control System via standard PSI to PSC interfaces. 16-bit resolution will be used for setpoints and readbacks.

Beam Dump:

The residual energy of the beam after recovering most of the energy will be about 1 megawatt. The beam will be spread across the face of the beam dump to prevent hotspots. Dump power supply controls will have synchronized horizontal and vertical waveforms to provide the sweep. A monitoring system shall be developed to monitor the sweep and verify proper operation as input to a fast beam permit system. A commercial DSP module will monitor the sweep waveform and the power supply current to see that they are within defined limits, either high or low. The controls hardware group will develop the DSP software. Software drivers and a pet page to configure and monitor the DSP status will be required. State control and status for the dump supplies will be via a PLC. Some additional digital monitoring (interlocks) may be required.

Vacuum and water cooling for the dump will be included in the vacuum and conventional systems. Beam current monitoring of the dump will be provided by instrumentation.

Instrumentation:

A new BPM module (VME) will be developed by the Instrumentation group. There will be16 planes of BPMs. A VME chassis and standard front-end electronics will be provided by Accelerator Controls for these modules.

There will be two Bergoz current transformers. The output will be a DC level, digitized via standard Accelerator Controls ADC.

Loss monitors shall consist of analog electronics (instrumentation), a comparator module (instrumentation) and a channel by channel DC reference (controls, VMIC 4140) this is to monitor losses for a fast permit input. A fast digitizer, in VME form factor, will be used for data acquisition of the loss monitor system.

Synchrotron Light: Four cameras brought to two PCs.

RF:

Standard infrastructure modules and a VME64X chassis are the only components supplied by the Accelerator controls group.

Vacuum:

The vacuum interface to the controls system will be via a PLC communicating on Ethernet.

Timing:

A separate timing system will be provided to allow timing independent of the AGS, Booster or RHIC. The timing system will not be beam synchronous. Any synchronous data acquisition will use a direct timing signal from the RF.

There will be three basic modes of operation:
- Commissioning: low duty factor, about 100Hz rep rate. One bunch per pulse.
- RHIC mode: 9.37 MHz operation
- "Navy" mode: 700 MHz continuous.

Photocathode (injector):

Injector controls will consist of four axis of motion for mirrors to accurately direct beam to the photocathode. One axis of motion is needed to control a polarizing filter to control intensity. A 'scope' will be used to monitor the photodiode. The photodiode signal is a pulsed signal.

A new injection ramp "chopper" module will be designed to support the three modes of operation and to provide a ramp-up of beam intensity. As designed, the RF cavity can only accelerate one bunch without suffering a droop in cavity voltage. When that initial bunch returns to the cavity (after one turn), out of phase, all but a small amount of its energy is recovered. This allows a new bunch to be accelerated with the recovered energy, plus a second bunch. The new beam intensity ramp module will provide a gate to control how many bunches are injected and to smoothly increase the number of bunches in the ring. The bunch intensity gate must be synchronized to the 700 MHz RF in order to rise and fall between bunches. The ramp up in intensity of the beam has to be synchronized to the revolution period of the ring in order to take advantage of the energy recovery of the previously injected bunches. This will limit the droop of the RF cavity. A fine delay of some sort will be necessary, on board, to fine tune the gate taking into account propagation delay to the injector. Inputs to the module will be the rotation clock and 700 MHz RF clock. A synchronous gate will be output. Signal levels of inputs and outputs are to be determined. A pet page will be necessary for the new ramp module to control ERL "mode" increment rate and adjust fine timing delay values.

Hazard Rating and Follow-up Assignments for Controls (Brian Oeter)

Explanation of Hazard Rating

- 0 indicates an operation with minimal risk
- 1 indicates an operation with low initial risk
- 2 indicates an operation with moderate initial risk
- 3 indicates an operation with a high initial risk

Because of the hazards identified, this operation has the potential of being an operation with a moderate initial risk.

The following questions were answered YES and is considered a hazard rating of 2:

6d. Has this equipment been built locally, modified or NOT listed by a Nationally Recognized Testing Laboratory?
11b. Will operation require work outside normal working hours?
11d. Will this operation require special attention in the event is left unexpectedly for long periods of time?
15. Are you aware of any other hazardous conditions or potential sources of hazards that have not previously been addressed by these questions that you feel deserve further consideration?

The following question was answered YES and is considered a hazard rating of 1:

12e. Could this equipment act as an ignition source?

Follow-up Assignments (**Brian Oerter**)

(6d) The Chief Electrical Engineer must certify devices that are not commercially available. Contact Jon Sandberg (x4682).

(11b, 11d) Internal group operational procedures must be developed for normal operations, and a list of trained personnel is required. Contact the QA Manager, Dave Passarello, x7277, to arrange for sign off on group procedures.

(15) Since beam rastering is required from an equipment protection standpoint; that is, to prevent melting of the face of the beam dump, and since the control system will be used to ensure the magnetic field coils used in the rastering are operational, please contact J. W. Glenn, Chair of the Accelerator Systems Safety Review Committee (x4770), to ensure additional control is not required from a safety or environmental standpoint.

2.11 Not Assigned

2.12 Conventional Facilities (Dave Phillips)

The conventional facilities service the needs of ERL with building space, environmental control (HVAC), cooling water, electric power, cable tray, radiation shielding, fire detection, rigging and survey. Located inside the NEBA section of Building 912 is the 4-foot thick concrete "Block House", the Klystron Power Supply Building and a 2-story equipment building. The Block House will require rigging to open and close the roof to allow the larger pieces of experimental equipment to be installed. The Klystron Power Supply Building is to be installed by an outside vendor. The equipment building will house security, vacuum and cryogenic control systems, magnet power supplies, a laser room and the Klystron. Outside of NEBA are the Experimental Control Room, two equipment buildings and Building 966, which is office and work space.

Hazard Rating and Follow-up Assignments for Conventional Facilities (Dave Phillips)

Explanation of Hazard Rating

- 0 indicates an operation with minimal risk
- 1 indicates an operation with low initial risk
- 2 indicates an operation with moderate initial risk
- 3 indicates an operation with a high initial risk

Because of the hazards identified, this operation has the potential of being an operation with a moderate initial risk.

The following question was answered YES and is considered a hazard rating of 2:

5. Does this operation involve the use of lasers?
6d. Has this equipment been built locally, modified or NOT listed by a Nationally Recognized Testing Laboratory?
7c. Are there any structures supporting heavy loads?
7g. Does work require fall protection equipment (harness, lanyard)?
7m. Are there any sources of stored energy (hydraulic, pneumatic, thermal, mechanical)?
8j. Is it required for personnel to work in an area with a Noise Level between 85 dBA and 100 dBA?
11b. Will operation require work outside normal working hours?
12d. Will this operation change the risk level of fire protection?
13. Are there any controls (i.e., ventilation, fume hoods, interlocks, personal protective equipment, HEPA filters/vacuum cleaners,
medical monitoring) associated with this operation?
13c. Is any personal protective equipment used in this operation?

The following questions were answered YES and are considered a hazard rating of 1:

3. Are radioactive materials (including sealed sources and wastes) generated, handled, processed, used or stored?

3a. Does this operation involve handling of radioactive materials or sources?
7b. Does the operation include the use of hoist, crane, forklift, or rigging?
7e. Will you be purchasing any ladders or scaffolds?
7f. Will this operation require any elevated work?
7l. Does the operation include the use of typical shop equipment?
11. Will this operation require trained operators or close surveillance?
11a. Will this operation be left unattended?
11f. Will group operational procedures be required for normal operation of this equipment?
12e. Could this equipment act as an ignition source?

Follow-up Assignment (Dave Phillips)

(3) Work with radioactive materials such as activated shield blocks may require an RWP. Contact the FSS Representative, Paul Bergh (x5992).

(3a) If the ERL enclosure will make use of C-AD's activated shield blocks, appropriate posting and radioactive material controls are required. Contact the FSS Representative, Paul Bergh (x5992).

(5) Since the Survey Group may purchase a new Tracker Laser for this project, have the laser evaluated. Complete the BNL General Laser Registration Form and return it to Asher Etkin (x4006).

(6d) The Chief Electrical Engineer must certify devices that are not commercially available. Contact Jon Sandberg (x4682).

(7b) Before using hoist, cranes or rigging equipment, ensure that current, valid annual inspection tags are attached. You need to ensure you add your equipment to the C-AD annual request for these services, notify Joel Scott (x7520).

(7b) Forklifts, powered trucks, platform lift trucks and motorized hand trucks require special training prior to use and require completion of a pre-use inspection. Contact the Training Manager, John Maraviglia (x7343), to ensure all personnel are assigned the correct training requirements.

(7c) Any structures supporting heavy loads or structural changes to cranes or buildings requires review by the Plant Engineering Division and the Chief Mechanical Engineer. Contact Joe Tuozzolo (x3966) for a review.

(7e) Ladders must not be wooden. Scaffolding must be reviewed by the C-AD ESH Coordinator. Please contact Asher Etkin (x4006).

(7f) Elevated work may require fall protection and/or a fall protection plan. Consult with Peter Cirnigliaro (x5636).

(7g) Personnel wearing fall protection equipment must be trained. Contact the Training Manager, John Maraviglia (x7343), to ensure all personnel are assigned the correct training requirements.

(7l) Electrically powered hand tools should be double insulated and plugged into grounded system.

(7m) All sources of stored energy must be locked out or disabled prior to working on systems.

(8j) If workers can be potentially exposed to excessive noise, contact Peter Cirnigliaro (x5636) for a noise evaluation.

(11, 11b, 11f) Ensure the safe operation of the cooling-water systems and other conventional facilities are incorporated into procedures; use the C-AD Operations Procedure Manual or create Group procedures. Contact Joel Scot for review of water system procedures (x7520).

(11a) If conventional facilities operations will be left unattended and it poses a hazard to individuals who may enter the area for whatever reason then you must ensure that the area is posted with the name of the contact and phone number along with associated hazards when unattended. This information and instructions for a safe shutdown should be included in Group procedures or the C-AD OPM.

(12d, 12e) Any deviations from Life Safety Code or change in the risk level of fire protection must be approved by the Fire Protection Engineer. The Fire Protection Engineer should also review potential ignition sources. Contact Michael Kretschmann (x5274).

(13, 13c) All PPE requirements must be listed in your work planning documents. Special care must be given when selecting gloves. Always seek manufacture specific information on the gloves being used or contact Peter Cirnigliaro (x5636) for guidance.

2.13 Safety Systems (Jonathan Reich)

The proposed Access Control Safety system (ACS) for the eCooler and ERL facility will use Programmable Logic Controllers [PLC] as the basis of the system. In order to provide the required dual independent protection the area served by ACS has two independent PLC's [A and B divisions]. Each division independently provides full protection. All the I/O's (gate switches, critical devices, etc.) are redundantly monitored by both PLC systems. In addition, redundant monitoring of radiation level and ODH concerns will be incorporated in the safety system.

The Control Room (CR) operator interface utilizes touch screen displays [flat panels] on a command network that is connected through a firewall machine to the separate divisions. See block diagram on next page (Figure 1).

eCooler PASS BLOCK DIAGRAM

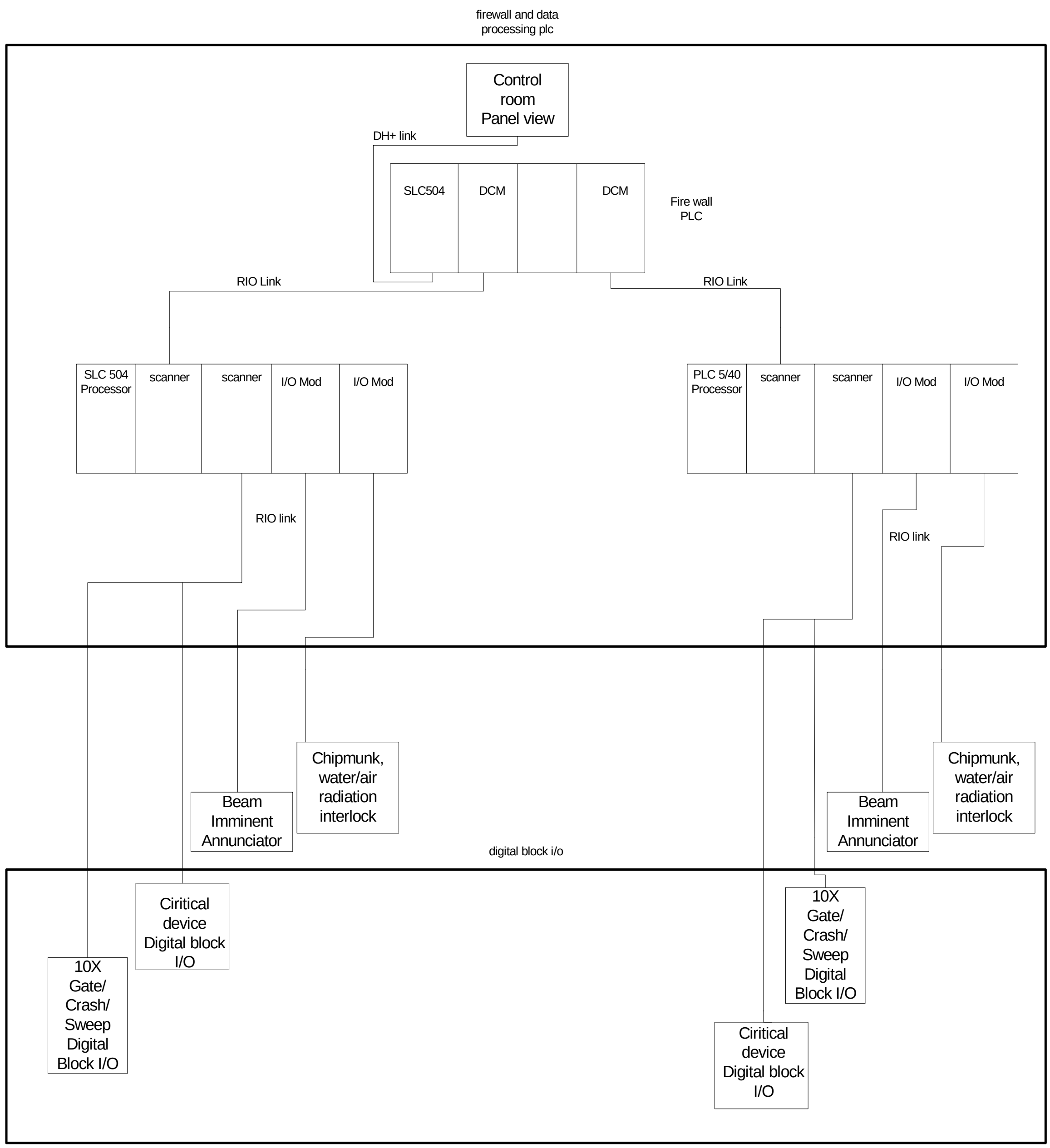


Figure 1.

Hazard Rating and Follow-up Assignments for Safety Systems (Jonathan Reich)

Explanation of Hazard Rating

- 0 indicates an operation with minimal risk
- 1 indicates an operation with low initial risk
- 2 indicates an operation with moderate initial risk
- 3 indicates an operation with a high initial risk

Because of the hazards identified, this operation has the potential of being an operation with a moderate initial risk.

The following questions were answered YES and is considered a hazard rating of 2:

6d. Has this equipment been built locally, modified or NOT listed by a Nationally Recognized Testing Laboratory?
11b. Will operation require work outside normal working hours?
13. Are there any controls (i.e., ventilation, fume hoods, interlocks, personal protective equipment, HEPA filters/vacuum cleaners, medical monitoring) associated with this operation?
13b. Are interlocks used in this operation?

The following question was answered YES and is considered a hazard rating of 1:

11. Will this operation require trained operators or close surveillance?

Follow-up Assignment (Jonathan Reich)

(6d) The Chief Electrical Engineer must certify devices that are not commercially available. Contact Jon Sandberg (x4682).

(11, 11b) Ensure the operation of the ERL access control system is incorporated into the C-AD Operations Procedure Manual, Chapter 4. Contact Asher Etkin for review of testing procedures (x4006).

(13, 13b) The Radiation Safety Committee must approve interlock logic and documentation. Contact Dana Beavis, RSC Chair, x7124.

2.14 Cryomodule and e-Gun Installation (Gary McIntyre)

This activity concerns the assembly and testing associated with the assembly of the ERL 5-cell Cavity cryomodule and the ERL electron gun. In each case, each device will be received as a string under vacuum. The strings will contain the cavities with other components attached to them (e.g., ferrite absorbers, beam tube thermal transitions, beam tube diameter transitions). The strings will be thermally insulated, magnetically and thermally shielded and installed into their respective vacuum vessels (a.k.a. cryomodules). The 5-cell string will be supported by stands while being worked on. The 5-cell stand will run directly from the string assembly, cavity or space frame, to the ground.

The e-Gun string, suspended by Nitronic rods from its cryomodule top plate, will be supported from the top by a support structure. Then, using the 25-ton crane in the NEEBA area, the insulated and shielded strings will be craned in their respective prepared vacuum vessel lower shell. The cryomodule installation will be complete as the last layers of insulation and magnetic shielding are applied.

The assembly will be welded on and piping and vacuum systems will be pressurized and vacuum leak checked through out the assembly process.

Hazard Rating and Follow-up Assignments for Cryomodule and e-Gun Installation Systems (Gary McIntyre)

Explanation of Hazard Rating

- 0 indicates an operation with minimal risk
- 1 indicates an operation with low initial risk
- 2 indicates an operation with moderate initial risk
- 3 indicates an operation with a high initial risk

Because of the hazards identified, this operation has the potential of being an operation with a moderate initial risk.

The following questions were answered YES and is considered a hazard rating of 2:

7c. Are there any structures supporting heavy loads?
12b. Does this operation generate, store or use any combustible materials in significant quantities?
13c. Is any personal protective equipment used in this operation?

The following questions were answered YES and is considered a hazard rating of 1:

4c. Is any waste generated from this operation?
7b. Does the operation include the use of hoist, crane, forklift, or rigging?
7f. Will this operation require any elevated work?
7l. Does the operation include the use of typical shop equipment?

10. Does this operation involve: the use of equipment, tools or materials outside of the design specifications or outside of the manufacturer's recommendations OR the use of equipment or apparatus not commercially available?
11c. Will this operation require the 2-person rule?

Follow-up Assignment (Gary McIntyre)

(4c) Waste generators must have proper training. Contact Joel Scott (x7520), Environmental Coordinator, for more information.

(7b) Before using hoist, cranes or rigging equipment, ensure that current, valid annual inspection tags are attached. You need to ensure you add your equipment to the C-AD annual request for these services, notify Joel Scott (x7520).

(7b) Forklifts, powered trucks, platform lift trucks and motorized hand trucks require special training prior to use and require completion of a pre-use inspection. Contact the Training Manager, John Maraviglia (x7343), to ensure all personnel are assigned the correct training requirements.

(7c) Any structures supporting heavy loads or structural changes to cranes or buildings requires review by the Plant Engineering Division and the Chief Mechanical Engineer. Contact Joe Tuozzolo (x3966) for a review.

(7f) Elevated work may require fall protection and/or a fall protection plan. Consult with Peter Cirnigliaro (x5636).

(7l) Electrically powered hand tools should be double insulated and plugged into grounded system.

(10) Please list the equipment that you are using outside of design specifications or manufacturer recommendations and/or locally built equipment in your analysis along with associated controls. Certification by the Chief Electrical and/or Chief Mechanical Engineer may be required. Contact Jon Sandberg (x4682) for electrical device review and Joe Tuozzolo (x3966) for mechanical device review.

(12b) The Fire Protection Engineer must approve generation, storage or use of combustible materials in significant quantities; in addition, nearby ignition sources must be reviewed. Contact Michael Kretschmann (x5274).

(13c) All PPE requirements must be listed in your analysis. Special care must be given when selecting gloves. Always seek manufacture specific information on the gloves being used or contact the ESH Coordinator, Asher Etkin (x4006) for guidance.

2.15 Authorization (E. Lessard)

The hazards and controls for ERL Prototype subsystems must be written and addressed in a Safety Assessment Document similar to the C-AD SAD. The SAD must be reviewed by the Laboratory ESH Committee, and approved by the BNL Deputy Director for Operations. Responsible person is E. Lessard.

ERL Prototype commissioning and operations must be approved by DOE. DOE is responsible for approving an Accelerator Safety Envelop and for authorizing commissioning and operations of this prototype accelerator. Prior to requesting permission to commission and/or operate the ERL, BNL must perform an Accelerator Readiness Review, as per the SBMS Subject Area, Accelerator Safety. The responsible person for preparing authorization documents and requesting a Accelerator Readiness Review is E. Lessard.

Appendix 1: Questions Used in the Collider-Accelerator Department's Hazard Identification Tool

1. Are there any chemicals, toxic materials or hazardous material handled, generated, used, or stored in this operation, including oils and solvents?

1a. Does this operation use or transport any chemicals with a Threshold Limit Value, or chemical that is regulated by OSHA?

1b. Are any chemicals or chemical wastes used, stored or generated in this operation either known or suspected human carcinogen?

1c Does this operation involve the use, storage or generation of peroxide forming chemicals, shock sensitive chemicals or picric acid?

1d. Does this operation use, generate or store flammable or combustible gases, liquids or solids, including solvents?

1d (1). Does this operation involve the use of hydrogen gas?

1e. Does this operation involve the use, storage or generation of caustic/corrosive chemicals or wastes?

1f. Will this operation involve the use of beryllium - other than articles made of beryllium or that contain beryllium?

1g. Will this operation involve more than 30 minutes handling time with lead? Will this operation involve use of heavy metals such as mercury, silver or cadmium?

1i. Does this operation involve the use or transportation of explosives or explosive wastes?

2. Are there any accelerators or other radiation generating devices involved in this operation (other than the Collider-Accelerator)?

2a. Is there an accelerator used in this operation?

2a (1). Does this operation use accelerators that are built locally or are commercially available units that have been modified?

2b. Are there any radiation generating devices (RGD) used in this operation?

2b(1). Are radiation generating devices capable of creating a High Radiation Area (>100 mrem/hr at 30 centimeters)?

2b(2). Are the radiation generating devices capable of creating a radiation area?

2c. Does the radiation generating device only produce radiation incidental to its primary function (such as electron microscopes, electron beam welders, ion implantation equipment)?

2c(1). Does this operation use RGDs that are built locally or are commercially available units that have been modified?

2d. Is the radiation generating device an intentional x-ray generating device which produces radiation as part of the primary function (i.e. x-ray diffractometers, x-ray machines)?

2d (1). Is the device built locally or been modified OR is it being used outside design specifications?

3. Are radioactive materials (including sealed sources and wastes) generated, handled, processed, used or stored?

3a. Does this operation involve handling of radioactive materials or sources?

3b. Does this operation involve radionuclides listed in the Radionuclide Threshold Table in amounts that exceed 10% of the quantity listed?

3c. Is dispersible radioactive material being used in this operation?

3d. Will any radioactive material/waste be transported as a result of this operation?

3e. Does this operation involve any accountable sources? (Sealed Radioactive Source Accountability Table)

3f. Any radioactive material being left or stored at Collider-Accelerator facilities?

4. Are there any possible environmental impacts with this operation?

4a. Are there any non-radioactive emissions or effluents from this operation?

4b. Are there any radioactive emissions or effluents from this operation?

4c. Is any waste generated from this operation?

4c(1). Is the waste radioactive?

4c(2). Is the waste hazardous?

4c(3). Is the waste mixed waste?

4d. Are any hazardous materials (such as lead, mercury or beryllium) being left or stored at Collider-Accelerator facilities?

4e. Does this operation require any new above or under ground storage tanks?

4f. Does this operation use ozone depleting substances?

4g. Are any changes required to the Environmental Management System (as determined by the Environmental Compliance Rep)?

4h. Is this work being done within 1/2 mile of the Peconic River?

5. Does this operation involve the use of lasers?

5a. Do personnel use or have the potential to be exposed to Class IV lasers?

5b. Do personnel use or have the potential to be exposed to Class IIIb lasers?

5c. Does the operation involve Class I, II or IIIa lasers?

5d. Does this operation involve Class I lasers with embedded IIIb or IV lasers?

5e. Have any of the lasers involved in this operation been built locally or have any commercially available lasers been modified?

5f. Is the laser registered at BNL with the Laser Safety Officer?

6. Is any energized electrical equipment used in this operation?

6a. Is there any exposed electrical components where there is the potential for personnel to be exposed to voltages greater then 50V (Range A)?

6b. Is it required for personnel to work on energized systems greater than 50 V (Range A) but less than 600 V (Range B&C)?

6c. Is it required for personnel to work on energized systems greater than 600 V (Range D)?

6d. Has this equipment been built locally, modified or NOT listed by a Nationally Recognized Testing Laboratory?

6e. Does your operation require the development of an Electrical Working On or Near Energized Conductors Permit?

6f. Are emergency shut-off controls provided for shutting down electrical power?

6g. Is required fusing provided for all relevant equipment?

7. Are there any mechanical hazards or work hazards such as material handling, elevated work, vacuum or pressure vessels, scaffolds, stored energy or structural considerations?

7a. Are there any material handling devices including all large moving equipment?

7b. Does the operation include the use of a hoist, crane, forklift, or rigging?

7c. Are there any structures supporting heavy loads?

7d. Does this operation require a structural change to any crane or building?

7e. Will you be purchasing any ladders or scaffolds?

7f. Will this operation require any elevated work?

7g. Does work require fall protection equipment (i.e. harness, lanyard)?

7h. Does the operation include the use of hydraulic or pneumatic lift?

7i. Does any equipment operate at pressures above 15 psig or under a vacuum?

7j. Does this system have any vacuum windows?

7k. Is any part of this system/operation involve a cryogenic system or dewar installation?

7l. Does the operation include the use of typical shop equipment?

7m. Are there any sources of stored energy (hydraulic, pneumatic, thermal, mechanical)?

7m1. Is the source capable of being easily isolated or can it be LOTO'd?

7m2. Is disassembly required to isolate energy (i.e. inserting blank flange)?

8. Does this operation require work with or generate any of the following physical hazards--confined spaces, RF or microwave radiation, magnetic fields, hot or cold surfaces, high noise levels, or oxygen deficiency?

8a. Does this operation create any space that might meet the definition of a confined space?

8b. Is it required for personnel to enter any Class 1 Confined Spaces?

8c. Is it required for personnel to enter any Class 2A or 2B Confined Spaces?

8d. Is it required for personnel to enter any Class 2C Confined Spaces?

8e. Is there any radiofrequency or microwave field generated by a source greater than 7W in a space that might be occupied?

8f. Does this equipment/operation produce any magnetic fields greater than 4 Gauss?

8g. Is it required for any personnel to be exposed to a magnetic field greater than 600 Gauss?

8h. Are there any surface temperatures less than 0 deg F or greater than 150 deg F?

8i. Does this operation generate any equipment which could operate at greater than 80 dbA?

8j. Is it required for personnel to work in an area with a Noise Level between 85-100 dBA?

8k. Is it required for personnel to work in an area with a Noise Level above 100 dBA?

8l. Is there any possibility of creating an Oxygen Deficient Atmosphere?

8m. Is it required for any personnel to work in an existing Oxygen Deficiency Hazard Area?

9. Are there any additional hazards, not mentioned above, that should be considered? Such as biological hazards, ergonomics or heat stress?

9a. Could a worker be exposed to any biological hazard including handling of human body fluids, human tissues, or mouse droppings?

9b. Will personnel perform functions that involve repetitive motion, excessive force or vibration, lifting, or other ergonomic concerns?

9c. Will personnel be required to perform this operation in extreme climates or temperatures?

10. Does this operation involve the use of equipment, tools or materials outside of the design specifications or outside of the manufacturer's recommendations OR the use of equipment or apparatus not commercially available?

10a. Has this equipment received review by the C-A Chief Mechanical Engineer and/or Chief Electrical Engineer?

10b. Was this equipment built at a University or Laboratory in another country?

11. Will this operation require trained operators or close surveillance?

11a. Will this operation be left unattended?

11b. Will operation require work outside normal working hours?

11c. Will this operation require 2-person rule?

11d. Will this operation require special attention in the event it is left unexpectedly for long periods of time?

11e. Will this operation require an emergency procedure due to unusual or complicated shutdown instructions?

11f. Will group operational procedures be required for normal operation of this equipment?

11g. Is there a list of designated and trained personnel for this equipment/operation?

11h. During construction, use, or storage of spare parts and materials, are valuable materials attractive for theft and worth more than $1000 (e.g. precious metals; or copper, platinum, tungsten, stainless, aluminum) involved with this project?

12. Are there any fire protection or life safety concerns in this operation?

12a. Will welding or cutting or spark/flame producing operations be conducted in association with this operation?

12b. Does this operation generate, store or use any combustible materials in significant quantities?

12c. Will this operation require a deviation from the Life Safety Code (consider changes in exits, change in occupancy?

12d. Will this operation change the risk level of fire protection?

12e. Could this equipment act as an ignition source?

13. Are there any engineering controls or Personal Protective Equipment (PPE) required (i.e., ventilation, fume hoods, interlocks, HEPA filters/vacuum cleaners, respirators)?

13a. Is any local ventilation used in this operation?

13b. Are interlocks used in this operation?

13c. Is any personal protective equipment used in this operation?

13c(1) Are gloves used in this operation?

13d. Are HEPA filters in place/used?

13d(1). On ventilation systems?

13d(2). HEPA vacuum cleaners?

13e. Will respiratory protection be required for this operation?

14. Do you rely on any facility utilities (listed as sub questions) to provide safety controls for your operations?

14a. Compressed Air

14b. Compressed Gas

14c. Chilled Water

14d. De-Ionized/De-mineralized Water

14e. Electric Power (includes Grounding and UPS)

14f. Emergency electrical power

14g. Fire Protection

14h. Hoists and Cranes

14i. Heating Water

14j. Non-potable Water

14k. Oxygen Monitoring System

14l. Public Address

14m. Potable Water

14n. Process Cooling Water

14o. Sanitary Sewer

14p. Steam

14q. Utility Gas (natural gas)

14r. Vacuum

14s. Ventilation Supply/Exhaust

15. Are you aware of any other hazardous conditions or potential sources of hazards that have not previously been addressed by these questions that you feel deserve further consideration?