Fire Hazard Analysis
STAR Experimental Complex
Buildings 1006, 1006-A and 1006-C

Brookhaven National Laboratory

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1.0 OVERVIEW AND RECOMMENDATIONS

1.1 Purpose and Methodology

A Fire Hazard Analysis (FHA) was performed for the Building 1006 STAR experimental complex of the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL), Upton, NY. The buildings associated with STAR are Building 1006 (Experimental Hall and Intersecting Region), Building 1006A (Control Room, Technical Support Building), and Building 1006C (STAR Counting House). This report fulfills the requirement for documentation of an FHA as outlined in DOE Order 420.1, Facility Safety. This FHA assesses the risk from fire in Building 1006 complex to ascertain whether the facilities meet the objectives of DOE Order 420.1 and the Brookhaven National Laboratory (BNL) Fire Safety Program. The fundamental goal of the BNL Fire Safety Program is to control fire risks such that:

1. Public and employees are not unreasonably endangered by fire;
2. Vital Laboratory missions are maintained without significant interruption from fire;
3. Property losses are limited to less than $1 million dollars per occurrence, and lower when justified by cost-effective, risk reduction measures;
4. Damage to the environment is averted; and
5. The potential for occurrences of fires are avoided whenever economically feasible.

This FHA is an evaluation of the fire hazards (1) that expose the Building 1006 complex and (2) that are inherent in the buildings or operations. The adequacy of the fire safety features in the buildings and the degree of compliance of the facilities with specific fire safety provisions in DOE orders, and related engineering codes and standards, were determined. The results of the analyses are presented in terms of the fire hazards present, the potential extent of fire damage, and the impact on employee and public safety.

The general approach taken to complete this evaluation involved the identification of fire hazards in the buildings and the fire protection features required to mitigate the adverse consequences of a fire. A determination was made as to the adequacy of the proposed fire protection features to effectively control the fire hazards. Concerns for the protection of safety systems, critical processes, and life safety of building occupants from fire were essential considerations in the analysis. Compliance was determined by a comparison of existing conditions found during the site visits with current code requirements. Where conflicting requirements were found the more conservative requirements were used in this evaluation.

Maximum Possible Fire Loss (MPFL) and Maximum Credible Fire Loss (MCFL) potentials were also evaluated. The MPFL, as defined in DOE Order 420.1, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential, assuming the failure of both automatic fire suppression systems and manual fire fighting efforts. The MCFL, as defined in DOE Standard 1066-99 Fire Protection Criteria, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential. This assumes that all installed fire protection systems function as designed, and the

effect of emergency response is omitted except for post-fire actions. Both MPFL and MCFL fire loss estimates are to include the replacement cost of equipment and property and any applicable decontamination and cleanup costs.

The MPFL scenario was based on a qualitative consideration of several factors; the potential to reach flashover conditions based on combustible loading and the geometry of the space(s) under consideration; adequacy of passive protection features; and continuity of combustibles.

The MCFL scenario is one in which automatic suppression systems function as designed. Since properly designed and installed sprinkler systems should limit the fire growth and/or damage to the design area of the system, this floor area is used in the determination of MCFL potentials when protected by automatic sprinkler systems. Without sprinkler protection the MCFL is the same as the postulated MPFL for that area.

MPFL and MCFL potentials were determined based on an average dollar density of the building replacement value divided by the floor area of the building. Building values were obtained from 2004 replacement costs. The content and equipment value were calculated based on the following assumptions:

- An average of $\$20/ft^2$ for content and equipment value within predominantly office areas.
- An average of $\$100/ft^2$ for content and equipment value within the industrial and experimental areas of the building.

The above cost assumptions are considered adequately conservative to address the requirement to include decontamination and cleanup costs.

A qualitative assessment of the risk presented by conditions found to be deficient was also performed and is included in Section 8, Recommendations. This assessment was made by assignment of a risk assessment code (RAC). The RAC methodology is used in a number of industries as a tool to qualitatively prioritize deficiencies and corrective actions and is derived as follows:

1. Hazard Severity. An assessment of the worst potential consequence, defined by degree of occupational injury, illness or property damage which is likely to occur as a result of the deficiency. Hazard severity categories shall be assigned by roman numerals according to the following criteria:

a. Category I. May cause death, permanent total disability, or loss of a facility/asset.

b. Category II. May cause permanent partial disability, temporary total disability in excess of 90 days (severe injury or severe occupational illness), or major property damage.

c. Category III. May cause minor injury, occupational illness, or property damage.

d. Category IV. Presents minimal threat to personnel safety or health, or property, but is still in violation of a standard.

2. Mishap Probability. The probability that a hazard will result in a mishap or loss, based on an assessment of such factors as location, exposure (cycles or hours of operation), affected populations, experience, or previously established statistical information. Mishap probability shall be assigned an English alphabet symbol according to the following criteria:

a. Subcategory A. Likely to occur immediately or within a short period of time. Expected to occur frequently to an individual item or person or continuously to a fleet, inventory or group.

b. Subcategory B. Probably will occur in time. Expected to occur several times to an individual item or person or frequently to a fleet, inventory or group.

c. Subcategory C. May occur in time. Can reasonably be expected to occur some time to an individual item or person or several times to a fleet, inventory or group.

d. Subcategory D. Unlikely to occur.

3. Risk Assessment Code. Using the matrix shown below, the RAC is expressed as a single Arabic number that is used to help determine hazard abatement priorities.

Hazard Severity	Mishap Probability			
	A	B	C	D
I	1	1	2	3
II	1	2	3	4
III	2	3	4	5
IV	3	4	5	6

RAC Definitions

1-Critical
2-Serious
3-Moderate
4-Minor
5 & 6-Negligible

1.2 Summary

Building 1006 is the STAR Experimental Hall. Building 1006A is the STAR Service Building, and Building 1006C is the STAR Counting House. Refer to Section 4.2 on the construction types of these buildings. This Fire Hazards Analysis (FHA) has been performed to comprehensively assess the risk from fire in the Building 1006 STAR experimental complex (Buildings 1006, 1006A and 1006C). The FHA includes an analysis of the fire and life safety features of the facilities to determine the level of compliance with DOE Order 420.1 Fire Protection objectives.

Based on the analysis, it has been determined that the Building 1006 STAR experimental complex does not comply with DOE Order 420.1 Fire Protection objectives. The following recommendations are the result of this evaluation.

1.3 Findings and Recommendations

1.3.1 New Findings and Recommendations

Finding: The high-current rectifier area in the equipment loft of Building 1006 is not protected with automatic sprinklers. This arrangement does not comply with NFPA 13 requirements to have sprinklers in the area or have the equipment in a 2-hour fire-rated compartment.

Hazard Severity	III
Mishap Probability	C
Risk Assessment Code	4

Recommendation HAI-07-1006-01: Automatic sprinklers should be installed; a 2-hour fire-rated partition should be provided; or an exemption should be obtained for this arrangement extended into the unprotected half of the two mezzanines (See Section 5.1.3).

Finding: The smoke detectors in the TPC Room are not connected to the fire alarm system.

Hazard Severity	III
Mishap Probability	C
Risk Assessment Code	4

Recommendation HAI-07-1006-02: Until sprinkler protection is provided in the TPC Clean Room, the smoke detectors in this room must be connected to the fire alarm system as required by BCNYS (See Section 5.3).

Finding: Audible and visual occupant notification devices are not provided in the Conference Room. BCNYS requires audible and visual occupant notification devices in all public areas.

Hazard Severity	III
Mishap Probability	C
Risk Assessment Code	4

Recommendation HAI-07-1006-03: Provide audible and visual occupant notification devices in the Conference Room (See Section 5.3).

Finding: Data collected from the experiment is vital. This information is collected by the facility and transported to the RHIC Computing Facility in Building 515, Brookhaven Computing Facility (a separate facility several miles away, connected by computer network).

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-07-1006-04: Given the vital nature of the data collected, the protection of records in Building 515 should be reviewed against the requirements of NFPA 232, *Standard for the Protection of Records* (See Section 6.2.1).

Finding: A lightning protection system is not provided for the building.

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-07-1006-05: Based on a risk analysis per NFPA 780, a lightning protection system should be considered for this facility, (See Section 6.6.1).

The following is a summary of recommendations and their relative priority.

Rec.No.	Recommendation	RAC
HAI-07-1006-01	Automatic sprinklers should be installed; a 2-hour fire-rated partition should be provided; or an exemption should be obtained for this arrangement extended into the unprotected half of the two mezzanines (See Section 5.1.3)	4
HAI-07-1006-02	Until sprinkler protection is provided in the TPC Clean Room, the smoke detectors in this room must be connected to the fire alarm system as required by BCNYS (See Section 5.3).	4
HAI-07-1006-03	Provide audible and visual occupant notification devices in the Conference Room (See Section 5.3).	4
HAI-07-1006-04	Given the vital nature of the data collected, the protection of records in Building 515 should be reviewed against the requirements of NFPA 232, *Standard for the Protection of Records* (See Section 6.2.1).	3
HAI-07-1006-05	Based on a risk analysis per NFPA 780, a	3

Rec.No.	Recommendation	RAC
	lightning protection system should be considered for this facility, (See Section 6.6.1).	

1.3.2 Outstanding Recommendations from Previous Reviews

The previous FHA did not list specific findings and recommendations.

2.0 SCOPE

This FHA is based on information supplied by the Accelerator Department staff, a survey of the facility conducted during a site visit on December 11 – 16, 2006, and a review of available drawings.

The following codes and standards were utilized for this evaluation:

The *Building Code of New York State* - 2002 Edition (BCNYS)

The *Fire Code of New York State* - (FCNYS) 2002 Edition;

National Fire Protection Association (NFPA) Codes, Standards, and Recommended Practices – See Section 9 (Reference Documents) of this report for a complete list.

Factory Mutual Property Loss Prevention Data Sheets – See Section 9 (Reference Documents) of this report for a complete list.

3.0 LOCATION

The Building 1006 STAR experimental complex is located along the southern portion of the RHIC "ring" region of Brookhaven National Laboratory (BNL). The location of RHIC facilities is indicated by their relative clock position, with the STAR complex located at six o'clock. BNL is a 5,000 acre site owned by the Department of Energy and operated by Brookhaven Science Associates. BNL is located in Upton, New York.

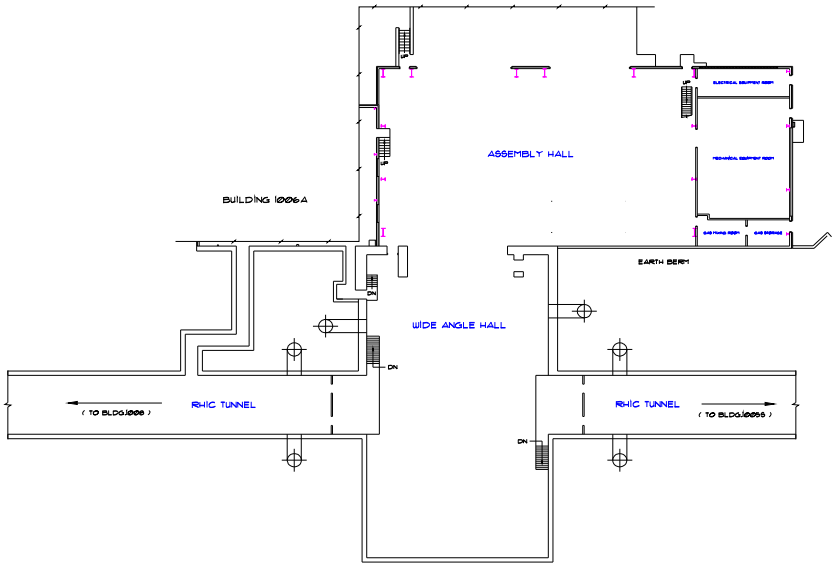
The Building 1006 STAR complex consists of the following structures:

1. Building 1006 – STAR Experimental Hall which includes the Wide Angle Hall and Assembly Hall.
2. Building 1006A – STAR Service Building which includes the DAQ Control Room.
3. Building 1006B – electrical substation for the STAR complex (not included in this FHA)
4. Building 1006C – Counting House and conference room.

Building 1006 (STAR Experimental Hall)

Building 1006 is a one-story, windowless, 16,840-sq ft building. The building is divided into two halves. The south portion of the building is the Wide Angle Hall (WAH) built in 1981 with an approximate square footage of 5,600 sq ft and an approximate ceiling height of 60 ft. To the

east and west, two 900-sq ft openings are provided from the RHIC Tunnel. A 30-ft high shield wall separates the WAH from the 60-ft by 130-ft Assembly Hall (AH) to the north. The Assembly Hall was built in 1997. Within the AH a 60-ft by 30-ft equipment loft mezzanine is located on the east side. Beneath the equipment loft at the main floor elevation of the Assembly Hall are an electrical equipment room, mechanical equipment room, and adjoining gas mixing and gas storage rooms to the east of the Assembly Hall. To the northeast of the Assembly Hall are two transformer yards and a covered gas cylinder shed in which various gases including P10 are stored.



Building 1006A

Built in 1981 with the WAH, the Support Building is a one-story, fiberglass-insulated metal panel building of 2,800 sq ft. A labyrinth connects Building 1006A to the RHIC Tunnel and the DAQ Control Room with the WAH. An exit access door is provided from the DAQ Control Room into the Assembly Hall.

Building 1006C

Built in 1992, Building 1006C was formerly Building 831. It was relocated in 1996 to the south side of Building 1006, and renamed Building 1006C. The one-story structure is constructed from three prefabricated modular units, with a total floor area of 1,700 sq ft.

4.0 CONSTRUCTION

4.1 Occupancy Classification

The following occupancy classifications for Buildings 1006, 1006A and 1006C are based on LSC and BCNYS criteria:

Use	LSC Occupancy Classification	BCNYS Group Classification
Building 1006		
Experimental halls	Existing special purpose industrial	Group F-1
Mechanical and electrical equipment rooms	Incidental	Incidental
Gas mixing and gas storage rooms	Incidental	Incidental
Building 1006A		
DAQ Control Room	Existing business	Group B
Technician office	Existing business	Group B
Mechanical equipment areas	Incidental	Incidental
Building 1006C		
Counting House	Special-Purpose Industrial	Group F-1
Conference room	Classified as part of the predominant occupancy	Group B

The experimental halls are considered as special purpose industrial occupancies based on the relatively low density of population. In addition, much of the area is occupied by equipment.

Since credited fire resistance-rated separations are not provided between occupancies, the building is classified as a mixed occupancy consisting of assembly, business and industrial occupancies based on LSC criteria [§6.1.14.2.2]. Therefore the means of egress facilities, type of construction, protection, and other safeguards must comply with the most restrictive fire and life safety requirements of the occupancies involved [§6.1.14.3.2].

4.2 Construction Type

Building 1006

Building 1006 is a one story, 16,840-sq ft building. The building is divided into two halves. The south portion of the building is the Wide Angle Hall (WAH) built in 1981 with an approximate square footage of 5,600 sq ft. The WAH is 60 ft high, with reinforced concrete roof, walls and floor. To the east and west, two 900-sq ft openings are provided from the RHIC Tunnel. A 30-ft high shield wall fills the opening in the heavy concrete shield wall that separates the WAH from the Assembly Hall (AH) to the north. The facility is windowless and covered by several feet of earth for radiation shielding. The AH, built in 1997 is 60 ft by 130 ft with an approximate square footage of 7,800 sq ft. The roof is a Class I insulated steel deck roof by Factory Mutual standards. Walls are fiberglass insulated metal panels. The floor is reinforced concrete. Within the AH a 60-ft by 30-ft mezzanine is located on the east side. The mezzanine is concrete poured over a metal deck and supported by an unprotected steel frame. First floor rooms located under the mezzanine have 8-in. concrete block walls.

Based on the unprotected steel columns supporting the roof in the Assembly Hall, the construction type is most nearly BCNYS Type IIB and NFPA II (000).

Building 1006A

Building 1006A is a one story, 2,800-sq ft building. The exterior walls of Building 1006A consist of fiberglass-insulated metal panels. The steel deck roof is rated as Class I by Factory Mutual Standards. Interior walls are 8-in. concrete block. The floor is reinforced concrete. The construction types of this building are considered to be BCNYS Type IIB and NFPA Type II (000).

Building 1006C

Building 1006C is a one story constructed from three prefabricated modular units, with a total floor area of 1,800 sq ft. The assembly is one story with a framed roof. Fiberglass insulation, metal studs, and metal framing were used throughout. The floor deck is plywood covered carpet. The construction types of this building are considered to be BCNYS Type IIB and NFPA Type II (000).

Life Safety Code

The LSC does not specify a minimum construction type for existing business and industrial [§39.1.6; §40.1.6] occupancies. Thus, the existing construction for each of the buildings complies with LSC requirements.

Building Code of New York State

Section 503 and Table 503 of the BCNYS contain criteria for the allowable height and area of buildings based on their occupancies and construction type.

Special industrial-style buildings that are required to have large areas and unusual heights in order to accommodate special equipment are exempt from the prescribed height and area limitations [BCNYS §503.1.2]. This code provision is considered applicable to Building 1006.

Based on the limited sizes of Buildings 1006A (2,800 sq ft) and 1006C (1,800 sq ft), the buildings would comply with the construction type criteria for Type IIB structures as prescribed in Chapter 5 of the BCNYS.

4.3 Passive Fire Protection

Passive fire protection features include fire-resistive construction, fire doors, fire windows, and fire and smoke dampers. The features are provided to limit fire spread and damage from the area of fire origin to other portions of the building.

4.3.1 Fire Areas

A fire area is defined as a portion of a building that is bounded by a combination of fire-resistive walls and floor/ceiling assemblies, and/or exterior walls. In DOE facilities, fire areas are typically provided for property protection. The Implementation Guide for DOE Order 420.1 requires credited fire areas to be separated from the remainder of the building by a minimum of 2-hour fire barriers (walls and horizontal assemblies). Fire areas may also be provided for compliance with building code limitations for building additions. Although the building is not subdivided with physical fire barriers multiple fire areas are possible due to construction features, inherent fire resistance, and operational considerations.

4.3.2 Fire Barrier Integrity

The STAR Detector represents the majority of the dollar value (>$60 million design and construction costs; replacement cost of $30 million) with the balance of the facility and contents providing support functions. The Detector is primarily located in the WAH where it is placed in the beamline to collect data from particle interactions. During experimental runs the heavy concrete shield wall separates the WAH from the AH to the north. The Detector is transferred to the AH for servicing (several times per year). The RHIC Tunnel opens to the WAH to allow the Beam Transport System (a string of magnets) to enter the WAH. A fire barrier would be required to segregate the high value accelerator from the WAH. However, a fire barrier or fire wall is not provided. This condition deviates from DOE's requirement to isolate high value equipment with fire resistance-rated construction.

An Exemption Request has been granted from DOE allowing the Fire Walls to be omitted. [“Exemption Request for the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL),” dated March 8, 1999 from Joseph E. Fitzgerald, Jr. Deputy Assistant Sectary Worker Health and Safety to George Malosh, Manager Brookhaven Group.] The following is a list of mitigating features described in the granted exemption request:

1) Low combustibility of RHIC Tunnel and contents.

2) Spot type smoke detection in the tunnel, on alternating zones for reliability and with separate redundant rate of rise/fixed temperature heat detection units at each detector location.

3) Automatic smoke removal system (in the tunnel and the WAH).

4) Highly sensitive smoke detection in the WAH.

5) Highly sensitive smoke detection in the Detector.

6) Low combustible contents and construction of the detector.

7) Ceiling-mounted, wet-pipe sprinkler system.

8) The vapor barrier for the oxygen deficiency hazard posed by helium will also act as a smoke barrier between the tunnel and the WAH on both sides (Herculite fabric on metal frame).

The equipment loft mezzanine in the upper level of the AH houses magnet power supplies and cooling systems. The floor is poured concrete on metal pan. The wall partitions are non-combustible. An insulated metal door and roll-up door are present. The partition is not fire rated.

The first floor, north area, under the mezzanine in the AH houses power transformers for normal building support services. This area is fully sprinklered and not fire rated. The first floor also contains electrical control centers and water systems (pumps, chillers, water treatment equipment).

The first floor south, under the mezzanine, contains the gas mixing equipment and gas storage room. The bulk gas systems are located outside and the gas storage room no longer contains gas cylinders. Solid piping passes through this area into the gas mixing equipment. There are no relief valves nor are there “frequently made or broken” connections. Therefore this area is not exposed to combustible gases. The gas mixing and gas storage rooms are not enclosed with fire resistance-rated construction.

5.0 FIRE PROTECTION

Existing fire protection systems that provide protection to all or portions of this facility can be classified into four categories; Automatic Fire Suppression Systems, Fire Alarm Systems, Automatic Detection Systems, and Fire Extinguishers. The following is a description of the existing systems in the building.

5.1 Automatic Fire Suppression Systems

5.1.1 Site Water Supply

BNL has a combination domestic and fire protection water supply system. The system is supplied by several deep wells and is stabilized by two elevated water storage tanks (one 1 million gallon and 300,000 gallon capacity). The wells have electric primary drivers and a limited number have backup internal combustion drivers. The system can sustain three days of domestic supply and a maximum fire demand (4,000 gallons per minute (GPM) for 4 hours) for BNL with two of the system's largest pumps out and one storage tank unavailable. The piping distribution network is well gridded. BNL has a combination domestic and fire protection water supply system. The system is supplied by several deep wells and is stabilized by two elevated

water storage tanks (one 1 million gallon and 350,000 gallon capacity). The wells have electric primary drivers and a limited number have backup internal combustion drivers. The system can sustain three days of domestic supply and a maximum fire demand (4,000 gpm for 4 hours) for BNL with two of the system's largest pumps out and one storage tank unavailable. The piping distribution network is well gridded. Water supplies around the RHIC Ring Road are fed from two well separated connections to the BNL system. Ample valves provide isolation in case of a main break. Static water pressure to the STAR complex is typically 70 psi. Water supplies to Buildings 1006 and 1006A are capable of supplying 1,700 gpm with 60 psi residual pressure.

Frost proof fire hydrants are provided within 300 ft of each facility. Frost proof hydrants are needed since the frost line extends to 4 feet below the surface in the winter. BNL and the local Suffolk County Fire Departments use National Standard Thread couplings.

BNL's Plant Engineering Division maintains the water supply system. BNL's Fire/Rescue Group conducts valve inspections on the distribution system to ensure reliability of firefighting water supplies.

5.1.2 Building Water Supply and Fire Department Connection

Building 1006

Each sprinkler system riser is provided with a Fire Department Connection (FDC) which are located on the east and south sides of the building. The nearest hydrant is less than 100 feet from the fire department connections as required by code. The two 2 ½ inch outlets on the FDCs conform to National Standard Thread couplings standard. The piping between the Fire Department Connections and the supply side of the Alarm Check Valve Assembly is 4 inch. The pipe connects to the system side of the Alarm Check Valves.

5.1.3 Sprinkler Systems

Automatic wet-pipe sprinkler systems are installed in the WAH and the AH. Installation of the sprinkler system complies with NFPA 13. The system protecting the WAH has been designed to provide a 0.17 gpm per sq ft density over 3,000 sq ft with 250 gpm for hose streams (NFPA 13 Standard). The AH system is supplied by the same system riser as the WAH. The AH system was installed as an ordinary hazard 2-3-5 Pipe Schedule System. Waterflow alarms are connected to the building fire alarm system. Sprinkler valve supervision reports through the Site Fire Alarm System as supervisory devices.

The TPC Clean Room located within the AH is not sprinklered. Automatic sprinkler protection is required in this room.

The high-current rectifier area in the equipment loft of Building 1006 is not sprinklered due to the perceived electrical hazard. Sprinklers may be omitted from electrical equipment rooms if all of the following conditions are met [NFPA 13 (2002), 8.14.10.3; NFPA 13 (2007), 8.15.10.3]:

(1) The room is dedicated to electrical equipment only.

(2) Only dry-type electrical equipment is used.
(3) Equipment is installed in a 2-hour fire-rated enclosure including protection for penetrations.
(4) No combustible storage is permitted to be stored in the room.

The floor of the equipment loft mezzanine is poured concrete on metal pan. The wall partitions are non-combustible. An insulated metal door and roll-up door are present. The partition is not fire rated. This arrangement does not comply with NFPA 13 requirements to have sprinklers in the area or have the equipment in a 2-hour fire-rated compartment. Sprinklers should be installed (and a non-combustible water spray pan can be provided to protect the equipment from sprinkler water discharge); a 2-hour fire-rated partition should be provided; or an exemption request should be obtained for this arrangement (**See Recommendation HAI-07-1006-01**).

Building 1006A

Building 1006 A is protected throughout with a wet-pipe sprinkler system.

Building 1006C

Building 1006 C is not sprinklered protected.

5.1.4 Fire Standpipe Systems

Standpipes with 1½-in. hose connections (no hose) are provided in the WAH and AH via the wet pipe standpipe system serving the RHIC Accelerator Tunnel.

5.1.5 Gaseous Suppression System

An Inergen® gaseous fire suppression system is provided in the Assembly Hall for protection of rack row 1A on the first platform due to the value of the equipment. An Inergen gaseous fire suppression system is provided in the DAQ Control Room in Building 1006A for the protection of rack row "A." An Ansul AutoPulse IQ-301 fire alarm panel serves as the releasing panel for the Inergen® system. These systems are monitored by the building fire alarm system for general alarm and trouble conditions. The Inergen fire suppression system is activated (release of agent) by heat detectors. This system is also monitored for general alarm and trouble conditions by the building fire alarm system.

In addition to the building's fire detection and alarm system which is provided for life safety purposes, supplemental detection systems are provided for protection of the experimental equipment which is mission critical and/or high-value.

5.2 Fire Alarm Systems

The facility has a fire alarm system that is connected to the Site Fire Alarm system.

5.2.1 Site Fire Alarm System

Brookhaven National Laboratory provides central fire alarm station coverage using a fault tolerant sever infrastructure based multiplexed Site Fire Alarm System. The system is an Andover Continuum; installed in 2005 (Andover is a part of Simplex Grinnell). The system complies with the requirements of NFPA 72 defined as a Style 6 Class "A" System.

Two mirrored servers are located in separate buildings. If the lead server fails the system automatically switches over to the working server. The Site Fire Alarm System operates on a fault tolerant high speed Ethernet infrastructure that utilizes network switches and fiber wiring between each of the major components.

The Site Fire Alarm System monitors fire alarm panels located throughout BNL by uses the existing site telephone cable plant. RS232 signals are sent via full duplex line drivers. Each fire alarm panel has two channels connected to the Site Fire Alarm System. The panels are divided into 9 communication "loops." It is currently monitoring 9,700 points. Response time from alarm at the panel to alarm indication at the Central Station is less than 82 seconds, which is within the 90 seconds allowed by NFPA 72.

The main console is at the Firehouse, Bldg. 599. This station monitors all fire alarm signals, trouble and communication status alarms. A satellite station is provided at Safeguards and Security, Bldg. 50, and receives only the fire alarm signals. If the Firehouse does not acknowledge an alarm within 90 seconds, the satellite station at Bldg. 50 will receive an audible indication to handle the alarm. A second satellite station is provided at AGS Main Control Room, Bldg. 911, and receives only the fire alarm signals from the RHIC/AGS accelerator buildings. A team of Collider-Accelerator Control Room operators and Health Physics Support personnel respond during accelerator operating times.

5.3 Automatic Detection Systems

Based on the automatic sprinkler protection provided throughout Buildings 1006 and 1006A, automatic fire detection is not required by the LSC or BCNYS.

Smoke detectors are provided in the TPC Clean Room in the AH. These smoke detectors are not connected to the fire alarm system. Actuation of these smoke detectors isolates power to the room by shunt trip. Until sprinkler protection is provided in the TPC Clean Room, the smoke detectors in this room must be connected to the fire alarm system as required by BCNYS (**See Recommendation HAI-07-1006-02**).

Photoelectric smoke detectors are provided in rack rows "A" and "B" in the DAQ Control Room in Building 1006A. Ceiling-mounted and underfloor (in the raised floor space) smoke detectors are also provided in the room. Heat detectors are provided in rack row "A" for release of the Inergen fire extinguishing agent. Actuation of smoke detection in the rack rows or under the raised floor will shunt trip power to the electronic equipment.

With the exception of the conference room in Building 1006C, occupant notification is provided throughout the buildings. BCNYS requires audible and visual occupant notification devices in all public areas (**See Recommendation HAI-07-1006-03**).

5.3.1 STAR Detector Electronics Cabinets

On the STAR Detector, electronics are housed in enclosed steel racks. The most significant racks are on the two lower levels of the South Platform. Given the high value of the equipment, smoke detection has been installed at the first and second levels (the third level is directly under the ceiling's High Sensitivity Smoke Detection system, and consequently smoke detection is not required at this level). The detection and releasing system travels with the Detector and is tied into the building fire alarm system (except during actual movement when everything is powered off and gas is removed). Building fire alarms and the rack fire alarm panel have battery backup (24 hour capacity) and emergency generator power (24 hour capacity).

5.3.2 Highly Sensitive Smoke Detection (HSSD)

A Highly Sensitive Smoke Detection (HSSD) System is provided within the STAR Detector. The HSSD system monitors the volumes around the interior electronics. Similar to the WAH HSSD, the units have three levels of alarm. First level alarms require STAR Detector operator attention. Second level alarms involve the operator and summons the Fire/Rescue Group for investigation. A third level alarm shuts down the electric supply, initiates flammable gas detector purge/vent sequences, and activates the building emergency exhaust ventilation for the WAH.

This application of HSSD technology does not fit standard installation rules. Best engineering judgment has been used for detector port placement. Factors influencing placement included normal air flow, collection points for smoke, location of ignition sources (electronic printed circuit cards, power devices as opposed to signal circuits). Detector ports have been spaced at 400 sq ft spacing. The HSSD Control Panel is tied into the building fire alarm system and will activate building-wide audible/visual devices upon a third level alarm. The building fire alarms and the HSSD system have battery backup (24 hour capacity) and emergency generator power (24 hour capacity).

5.3.3 Combustible Gas Detection

An air-sampling combustible gas detection system is installed for experimental operations using flammable gases within the STAR Detector. The air-sampling system consists of a network of tubes that connect to a selector valve system. The selector valves and detection assembly are located outside of the WAH. Sample points are located on and around the detector based on potential leak points, potential collection points, normal air flow patterns, and the detector's construction. There is no installation standard for this type of application. The flame ionization system uses a selector valve system to cycle through the sampling tubes and monitor combustible gas levels. Detection cycles and lengths of sampling points will ensure response to a leak within 90 seconds. Individual channel values are displayed and programmed for alarm and output functions. There will be warning levels in the ppm range, in which operators will

investigate and monitor the situation. Higher readings will force action levels at 25% of the Lower Explosive Limit, which will entail notification of Fire/Rescue, electrical shutdowns, vent and purge of detector chambers. The system will be on emergency power to provide continued operations during power outages.

5.4 Fire Extinguishers

Portable fire extinguishers are required in existing business and industrial occupancies [§39.3.5;].

Halon 1211 fire extinguishers are provided. A CO_2 agent fire extinguisher is provided in Building 1006C. The location and placement of portable fire extinguishers is in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*.

6.0 FIRE HAZARDS

Fire hazard potentials are classified into four major categories; Building Materials, Special Occupancies, Exterior Hazard Exposure, and Natural Hazard Exposure. The following is an evaluation of the Building 1006 complex for each category.

6.1 Occupancy and Associated Fire Hazards

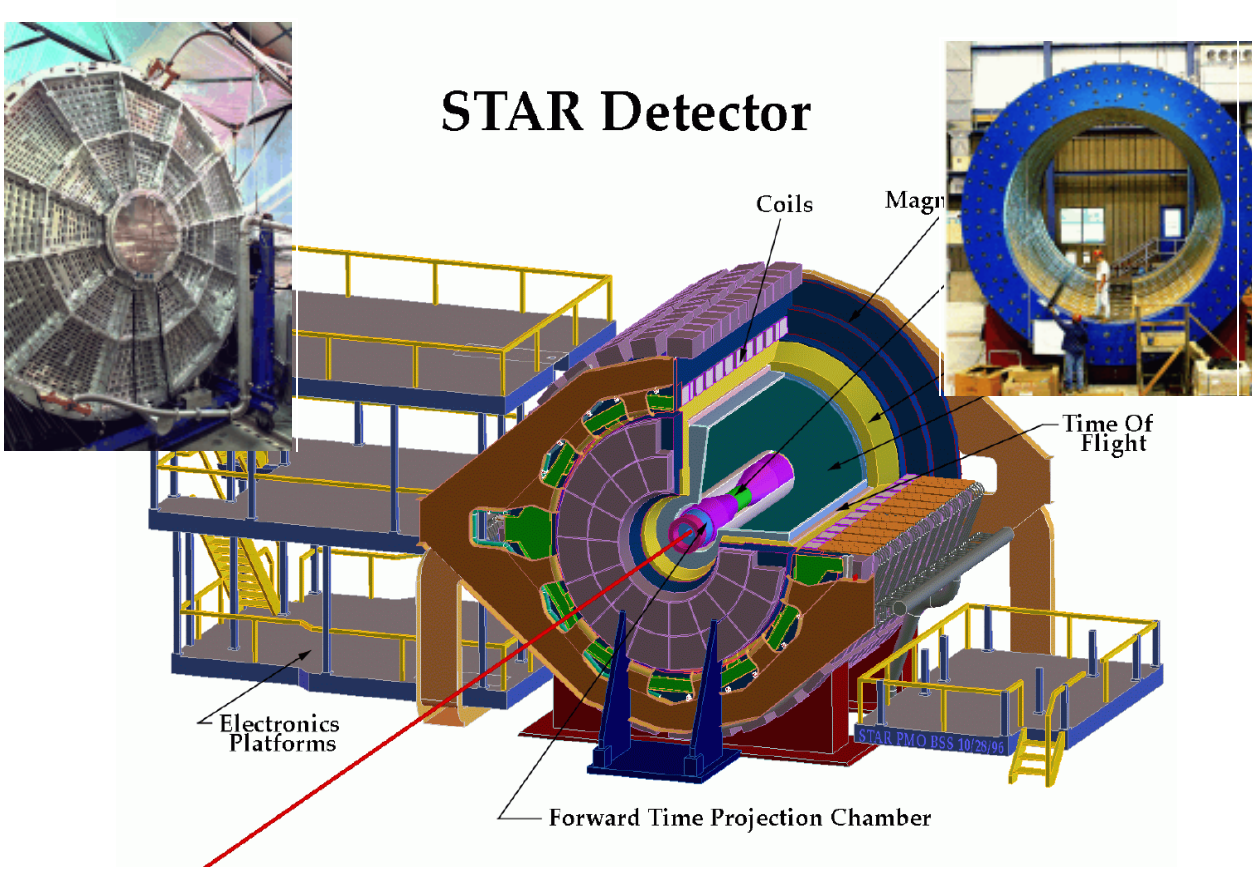
6.1.1 STAR Detector

The STAR Detector consists of the Main Magnet, North Platforms and South Platforms. The Main Magnet is a 5.6 meters by 6.2 meters long solenoid magnet made from aluminum coils and 1,200 tons of steel. Various subsystems are used to detect interaction events from the intersecting heavy ion beam with crosses at the center of STAR. A beryllium beam pipe is used to transport the beam through the magnet. The Detector has an array of subsystems. In the center is the Silicon Vertex Tracking (SVT) Detector which is composed of an assembly of low mass circuit boards and wafers on a beryllium frame. The combustible metal is of sufficient thickness not to pose an easily ignitable combustible material, even if the RHIC beam impinges on it (maximum calculated temperature rise of 1 degree C with impingement). During the design of STAR's various detector subsystems, materials were selected to be low combustibility (FR4 printed circuit boards, fire rated cables, etc.). By selection of these materials, small ignition sources would be insufficient to develop a sustained flame.

The energy delivered into ignition sources was limited by the installation of fusing down to the board level. During RHIC Experimental Safety Committee Reviews, 80 watts maximum was established for over-current loads. Most designers of sub systems choose polyfuses for over-current protection. Polyfuses are semi-conductor devices that shutdown at twice their rated operating currents. Polyfuses remain off until all power is removed from them, thereby allowing remote resetting while latching under fault conditions. The intent was to limit maximum power dissipation, provide a highly sensitive detection system on the magnet to turn off power, and to have materials that self extinguish when a small initiating power is terminated.

One of the subsystems at STAR, the Time Projection Chamber (TPC), has an inventory of 50,000 cubic liters P-10. P-10 is a blend of 10% methane in 90% argon. While the Department of Transportation classifies this gas as a non-flammable gas, it does support combustion (mainly by methane diffusion from the blend). Because of the very narrow "single point" explosive range (i.e. LEL=UEL) the flammability of P-10 does not extend very far past a potential leakage point. STAR has addressed this situation by treating the P-10 as a flammable gas to ensure sensitive equipment is not severely damaged.

The TPC has an Inner Field Cage constructed of aluminum frames with G10 boards covering the openings. It can withstand 5 milibars of pressure. The Inner Field Cage is insulated from the Outer Field Cage by a blanket of nitrogen gas. Nitrogen is required as an electrical insulator for



the 85 kV electrical potential. Process controls will measure moisture and oxygen content. These are interlocked to shutoff power and start a purge in the event leakage occurs. The outer field cage is further insulated from the TPC's outer shell by another nitrogen blanket with similar process monitoring systems and interlocks. The TPC purges the P-10 with nitrogen at the rate of 450 liters per minute, taking approximately 1.5 hours to displace one volume. Since P10 has an upper explosive limit equal to its lower explosive limit, any dilution will render it non-flammable.

STAR blends their own mixture of P-10. Strict controls and redundant systems are used to monitor the proportions of argon to methane for operational and safety reasons. For example, loss of argon flow will automatically shut off the flow of methane. Gas is monitored as it is mixed and as it is recirculated within the TPC. Oxygen and moisture levels in the ppm range and leakage are monitored. The bulk supply of gas is stored to the east of Building 1006 in an outdoor location. It is delivered into the building through metal piping which is protected from mechanical damage. The gas mixing equipment and gas storage room are located on the first floor adjacent to the Assembly Hall. The bulk gas systems are located outside and the gas storage room no longer contains gas cylinders. Solid piping passes through this area into the gas mixing equipment. There are no relief valves nor are there "frequently made or broken" connections. Therefore this area is not exposed to combustible gases. The gas mixing and gas storage rooms are not enclosed with fire resistance-rated construction.

6.1.2 General

The facility is classified as Group F-1, special-purpose industrial occupancy.

The North Platform of STAR contains mainly mechanical services, monitoring systems for the magnet, water pumps, and some water cooled electrical busses. There are no unusual fire hazards associated with these mechanical systems.

The South Platform contains the majority of electronics and is the most vital. The electronics and power supplies do not pose an unusual fire hazard. Metal cabinets house the majority of the equipment. Metal dividers act as barriers between high valued components to the reduce damage potential to adjacent equipment. The electronics were designed using less combustible materials for printed circuit boards (FR4) and cabling. Several power conduits were constructed of PVC plastic due to the need for electrical isolation and experimental signal quality. These run under the magnet and do not expose the platforms.

6.1.3 Assembly Hall

The AH contains similar hazards as in the WAH. P-10 gas will not be present in the Detector when it is moved from the WAH to the AH.

The AH mezzanine area contains the main magnet power supplies, water systems for the magnet, MCWS, Power Supply/Buss, and the cooling tower. Water systems include pumps, filters, and resin beds. This equipment is considered common industrial hazards. The water

cooled power supplies are not oil insulated. The occupancy is considered an ordinary hazard industrial facility for the purpose of classifying this facility for code applications.

6.1.4 Building 1006A

The DAQ Room in Building 1006A houses data acquisition equipment, and control and monitoring systems. The facility is classified as a predominantly Group B, business occupancy with incidental equipment spaces.

6.1.5 Building 1006C

Building 1006C contains offices. The facility is classified as a Group B, business occupancy. The conference room has an occupant load of fewer than 50 persons and is also classified as Group B, business.

6.2 Special Occupancies

6.2.1 Vital and Important Records Storage

Vital records are those records which are essential to the mission of an important program and which, if lost, could not be reproduced or obtained elsewhere. Important records are those records possessing a high value to the mission of an important program but which, if lost, could be reproduced or reconstructed with difficulty or extra expense.

Based on the above definition, the data collected from the experiment is vital. Given the vital nature and cost associated with the collection of the data, the protection of records in Building 515 should be reviewed (**See Recommendation HAI-07-1006-04**). This information is collected by the facility and transported to the RHIC Computing Facility in Building 515, Brookhaven Computing Facility (a separate facility several miles away, connected by computer network). Except for a minimally sized buffer arrangement, on-site storage of data in not provided.

6.2.2 Trailers and Portable Structures

There are no trailers or portable structures associated with Building 1006.

6.2.3 Electrical Substations

Two transformers and switchgear are located on the west side of Building 1006A and the east side of Building 1006. These areas could not be accessed during this survey. The transformers are located in a fenced area that is provided with a dike. According to the previous FHA the installation complies with the recommendations in Factory Mutual Loss Prevention Data Sheet 5-4 for fire protection. The transformers do not present an exposure hazard to the facility or each other.

6.2.4 Flammable Liquid and Gas Storage

Flammable liquids and gases are appropriately stored and secured. Flammable liquid storage cabinets are used in various locations. In addition, storage and use of gas bottles is segregated. Bottles are adequately secured against falling. Gas cylinder storage is in compliance with NFPA 55.

6.3 Housekeeping in Vital Areas

Acceptable housekeeping and control of combustibles was observed during this survey. The BNL Plan Review Process screens conventional construction operations.

6.4 Building Materials

There are no building or construction materials that pose a significant fire hazard.

6.5 Exterior Exposure Hazards

Any exterior structure, area or piece of equipment that is subject to harmful effects from, or can cause harmful effects to this facility is defined as an exterior exposure. Exterior exposures can be categorized as: elements outside of the facility, and as components of the facility.

The STAR gas mixing operation and gas storage pads meet the National Fire Protection Association and Factory Mutual Loss Prevention Data sheets separation guidelines. These exposures do not present an undue hazard to Building 1006.

The electrical sub station to the west of Building 1006A for experimental power and the house power from the sub station to the east meet the Factory Mutual Loss Prevention Data Sheet on electrical transformer yard separation. The emergency generator is separated by a two hour fire wall from the house transformer yard. These exposures do not present an undue hazard to Building 1006.

Elements Outside of the Facility

The following is a summary of fire exposures to Building 1006. All exposures are evaluated using FM Data Sheet 1-20 “Protection against Exterior Fire Exposure.” These exposures do not present an undue hazard to Building 1006.

6.5.1.1 North Exposures

Building 1006C is located to the north of Building 1006A. Based on the limited exterior wall openings between buildings, the light hazard occupancy of the Counting Room and the conference room, and the automatic fire suppression in Building 1006A, fire exposure between buildings is minimal.

6.5.1.2 South Exposures

Exposures to the south are minimal.

6.5.1.3 East Exposures

Exposures to the east consist of two transformer yards and the gas cylinder farm. The transformers are in compliance with Factory Mutual requirements. The gas cylinders are stored in compliance with NFPA 55. Therefore exposure is considered minimal.

6.5.1.4 West Exposures

Building 1006A adjoins the west wall of the AH in Building 1006. Building 1006A is fully-sprinklered and thus does not pose significant fire hazard [NFPA 80A].

6.5.2 Components of the Facility

Exposures between components of the facility are minimal. Sprinkler protection and passive fire barriers are in place to provide adequate separation.

6.6 Natural Phenomenon Hazard Exposure

Natural Hazards can be classified in five hazard categories: lightning, windstorm, wild fire, earthquake and flooding. The following is an evaluation for each category.

6.6.1 Lightning Potential

The lightning damage potential for Building 1006 is a concern based on NFPA 780 Annex L "Lightning Risk Assessment" calculation. Following the Risk Assessment methodology the expected lightning frequency (Nd) of 0.0394 is greater than the tolerable lightning frequency (Nc) of 0.0002 (calculations shown in Appendix B of this report). NFPA 780 recommends that a lightning protection system be installed when the expected frequency is greater than the tolerable frequency (**See Recommendation HAI-07-1006-05**).

6.6.2 Windstorm Potential

The Long Island area basic wind speed (3-second gust) is 120 MPH based on Factory Mutual Data Sheet 1-28 and BCNYS figure 1609.4. The ground roughness exposure category for the Building 911 area is 'Exposure B." Based on the calculations this building should have roof assemblies classified as "Class 90" rated assemblies. The steel deck roofs are in good repair and are expected to withstand local windstorms.

6.6.3 Brush Fire Potential

An analysis was completed consistent with the requirements and guidelines of NFPA 1144 *Protection of Life and Property from Wildfire* (2002) to determine the wildfire risk to Building 911. The risk assessment was conducted in accordance with the Wildfire Hazard Severity Form

checklist of NFPA 1144. The checklist is a summary of typical desirable characteristics found in various wildfire hazards analyses. Elements include emergency response ingress and egress, type of vegetation, topography, building construction and roofing materials, available fire protection, and utilities.

The STAR Complex is located in the middle of the Pine Barrens. Pine trees and shrubs do pose a potential exposure to the insulated metal structures.

Based on the analysis, the hazard from wildfire to the Building 1006 Complex is "LOW." Specifics of the Wildfire Hazard Severity Analysis are shown in Appendix C of this report.

6.6.4 Earthquake Potential

The seismic damage potential for this facility is classified as low based on a Natural Hazards analysis produced for the BNL campus titled "DOE Accelerator Order 5480.25 Implementation Plane for Brookhaven National Laboratory National Phenomena Hazards Evaluation" dated April 1994. A low seismic classification means that the buildings and fire protection systems are not required to comply with seismic design standards.

6.6.5 Flooding Potential

Flood potential from bodies of water overflowing their normal levees is low for the BNL area. The flooding potential for this facility was classified as low in a Natural Hazards Analysis report produced for the BNL site, dated April 1994, titled "DOE Accelerator Order 5480.25 Implementation Plane for Brookhaven National Laboratory National Phenomena Hazards Evaluation."

Ground water runoff from a severe rainstorm could be a concern for the Building 1006 complex due to the surrounding terrain which is at a higher elevation along the south side of the WAH (an earth berm is provided along the RHIC tunnel). However, further evaluation is beyond the scope of this analysis.

6.7 Toxic Fire Potential

There are no known toxic materials present in the building that present a release potential due to fire.

6.8 Biological Fire Potential

There are no known biological materials present in the building that present a release potential due to fire.

6.9 Radiation Fire Potential

By the nature of the operations of the accelerator, various pieces of equipment can be expected to become activated. This activation is not expected to pose a significant environmental impact in the event of a fire since the material will not be easily disbursed.

For calibration of instruments, several small sealed calibration sources will be present. These sources do not have the curie content or the physical state to be disbursed and contaminate large areas.

No other radioactive materials are used or stored in the STAR Complex.

7.0 PRE-FIRE AND EMERGENCY PLANNING

The BNL Fire Department maintains an adequate pre-fire plan book for this facility (http://intranet.bnl.gov/emergencyservices/runcards/main_i.asp). The pre-plan was reviewed as part of this analysis.

7.1 Protection of Essential Safety Class Systems

There are no essential safety class systems associated with this non-nuclear facility.

7.2 Protection of Vital Programs

Based on previous discussions, the data collected from the experiment is vital. Given the vital nature and cost associated with the collection of the data, the protection of records in Building 515 should be reviewed (**See Recommendation HAI-07-1006-04**). This information is collected by the facility and transported to the RHIC Computing Facility in Building 515, Brookhaven Computing Facility (a separate facility several miles away, connected by computer network). Except for a minimally sized buffer arrangement, on-site storage of data in not provided.

7.3 Protection of High Value Property

High value equipment is generally regarded as any single item that is valued at $1 million or more, or where the loss of a single item could result in a loss of program continuity of greater than six months.

The majority of the dollar value is concentrated in the WAH and the DAQ Room. During periods of maintenance, the STAR Detector is relocated to the AH. With over $30 million (replacement value) concentrated in the WAH, multiple fire systems have been installed.

The HSSD detection system on the STAR Detector, combined with the on-site Fire/Rescue Group, is considered the primary response system. This system will summon aid at the earliest practical stages (local alarms and signals to Fire/Rescue) and initiate protective actions (power off, vent/purge flammable gases, activate emergency vent in WAH). This primary response posture is unusual in the DOE arena; typically automatic sprinkler protection is considered the primary protection with detection and manual response redundant protection. However, based on the type of hazards involved with the STAR experiment, the automatic sprinklers are considered the third level of response capability due to their relative slow activation in this type of environment. Spot-type smoke detectors have been placed above the platform racks and initiate the same actions as the HSSD. Printed circuit boards are FR-4 (flame resistant). Wires, cables, and materials were also specified as flame resistant.

A secondary level of protection is provided by the building's ceiling-level HSSD system. It will detect a fire in the WAH/AH and start the same protective actions (fire department response) as the HSSD on the Detector.

A third level of protection will be provided by the wet-pipe sprinkler system. It is anticipated that this system will only activate when a sustained fire occurs in the Detector and all other controls have failed. As addressed above, normally automatic sprinklers would be considered the primary protection, but due to the long activation time, for this case sprinklers are considered the third level of protection.

7.4 Critical Process Equipment

The STAR Detector is divided into several sub-systems, some of which are not required for the entire experiment to operate. However without the full compliment of systems, the quality of physics will suffer. The following is a matrix of subsystems, total construction costs (including engineering and design), and a replacement value for as-is systems.

System	Total Construction Cost	Estimated Replacement Cost
Conventional Systems	$1.5 million	$1.0 million
Magnet	$11.4 million	$4 million
Time Projection Chamber	$11 million	$5 million
Forward TPC	$2.4 million	$1.5 million
Electro Magnetic Cal	$11 million	$7 million
Front End Electronics	$4 million	$1.5 million
Silicon Vertex Tracker	$7 million	$4 million
Computing (DAQ, Processing)	$5 million	$3 million

The Support Systems (such as magnets, cooling water, electrical power) are required for STAR operations. The majority of components in these systems are common and easily deliverable. Custom parts in other sub systems do have limited spares. The major exceptions are the large structural elements, such as the Main Magnet, and TPC. It is impractical to have spares for these massive devices. Concurrently, it is unlikely that a fire event will cause significant damage to these devices.

7.5 Maximum Possible Fire Loss (MPFL) and Maximum Credible Fire Loss (MCFL)

The MPFL, as defined in DOE Order 420.1, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential, assuming the failure of both automatic fire suppression systems and manual fire fighting efforts. The fire loss estimate

includes the replacement cost of equipment and property and any applicable decontamination and cleanup costs.

In accordance with the BNL Fire Safety Program, protection is required for facilities having an MPFL in excess of established thresholds as follows:

- When the MPFL exceeds $1 million an automatic sprinkler system designed in accordance with applicable NFPA standards is required;
- When the MPFL exceeds $25 million, a redundant fire protection system is required such that, despite the failure of the primary fire protection system, the loss will be limited to $25 million; and
- When the MPFL exceeds $50 million, a redundant fire protection system and a 3-hour fire resistance rated barrier are required to limit the MPFL to $50 million.

7.5.1 MPFL Scenario

A single MPFL is considered for the STAR experiment.

The following fire area tabulations are utilized when determining the MPFL and MCFL loss potentials.

Fire Area	Building Area (ft^2)
STAR Experiment	16,801

7.5.2 MPFL Calculation

The building has a replacement value of approximately $3.5 million. The building value was obtained from 2004 replacement costs. The average dollar density of the building is the replacement value divided by the floor area of the building ($3,500,000/16,801 ft^2 = $208/$ft^2$.

The content and equipment value is calculated based on the following assumptions:

- An average of $20/$ft^2$ for content and equipment value within predominantly office areas.
- An average of $100/$ft^2$ for content and equipment value within the industrial and experimental areas of the building.
- The STAR experiment has a replacement value of approximately $30,000,000.

STAR Experiment (16,801 ft^2)		$ Value
Building		$3,500,000
Contents – STAR Experiment		$30,000,000
Contents – Misc.		$500,000
	MPFL	$34,000,000

7.5.3 MCFL Scenario

The MCFL, as defined in DOE Standard 1066-99 Fire Protection Criteria, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential. This assumes that all installed fire protection systems function as designed, and the effect of emergency response is omitted except for post-fire actions.

The maximum credible fire scenario is one in which automatic suppression systems function as designed. The sprinkler design criterion for this building is based on an ordinary hazard pipe schedule method. For the purposes of the MCFL determination a design area of 3,000 ft^2, based on the sprinkler design area, is assumed. Since properly designed and installed sprinkler systems should limit the fire growth and/or damage to the design area this floor area was used in the determination of MCFL potentials when protected by automatic sprinkler systems. Without sprinkler protection the MCFL is the same as the postulated MPFL for that area.

STAR Experiment (16,801 ft^2)		
Building	3000 ft^2 x \$208/ft^2 =	\$624,000
Contents - Typical	3000 ft^2 x \$20/ft^2 =	\$60,000
Contents – High Value	Engineering Judgment	\$200,000
	MCFL	\$884,000

7.5.4 MPFL/MCFL Summary

Fire Area	MPFL	MCFL
Building 1006	\$34,000,000	\$884,000

7.6 Recovery Potential

The recovery time to rebuild the STAR Experiment could easily exceed 6 months.

7.7 BNL Fire/Rescue Group

The BNL Fire/Rescue Group is a full time, paid department. Minimum staffing is five firefighters and one officer per shift. The firefighters are trained to meet Firefighter Level III by International Fire Service Training Association standard, National Fire Protection Association (NFPA) Fire Fighter Level II standard, and (NFPA) Hazardous Material Technician Level and they are Suffolk County Certified Confined Space Rescuers.

The BNL Fire/Rescue Group also provides emergency medical services to an on-site population of 3200 people. Minimums of two members per shift hold New York State "Emergency Medical Technician - D" certifications ("D" is for defibrillation). Normally all five firefighters have EMT status. The Group operates a New York State Certified Basic Life Support ambulance. Medivac services are available to BNL via the Suffolk County Police Department. Additionally the Fire/Rescue Group has two 1500 GPM "Class A" Pumpers, one

Rescue Vehicle for initial hazardous material incident response and heavy rescue operation, and one Incident Command Vehicle.

The single Fire Station is located on the west side of the BNL Site. Response time to the most remote section of the BNL Site is less than eight minutes. Response time to Building 1006 is estimated at 5 minutes.

BNL participates in the Suffolk County Mutual Aid Agreement. This allows the resources from over 130 departments to assist BNL. BNL is also a member of the Town of Brookhaven Foam Bank. BNL has a mutual aid agreement for hazardous material incidents with the Town of Brookhaven and Stonybrook University.

7.8 Fire Apparatus Accessibility

Fire apparatus accessibility is adequate for the facility. Current parking lot configurations allow access by apparatus in the event of an emergency. The parking lot is accessed from the RHIC ring road.

7.9 Security Considerations Related to Fire Protection

There are no security considerations which relate to fire protection at this facility.

8.0 LIFE SAFETY CONSIDERATIONS

Life safety considerations for this facility include means of egress consisting of exit access, exits and exit discharge, exit signage, and emergency lighting. This building is required to comply with state building codes and NFPA 101, the *Life Safety Code* (LSC). The requirements of both the 2002 edition of the Building Code of New York State (BCNYS) and the 2006 edition of the LSC have been applied to this analysis. It should be noted that the BCNYS is not intended to apply to existing structures. Appendix K of the BCNYS addresses alterations to existing structures.

8.1 Occupancy Load Factor and Calculations

The occupant load per floor level for code purposes is calculated in Table 8.1-1 based on applicable occupant load factors specified in LSC Table 7.3.1.2. An occupant load factor of 300 sq ft per person was applied to special-purpose industrial and mechanical/electrical equipment areas. Factors for these spaces are not specified in the LSC.

Table 8.1-1

Occupant Load Calculation

Building	Floor Area (sq ft)	Occupant Load Factor (sq ft per person)	Occupant Load (persons)
Building 1006	16,840	300	57
Building 1006A	4,255	100	43
Building 1006C	1,800	100	18

8.2 Means of Egress

8.2.1 Number and Arrangement of Exits

The LSC requires that a floor with an occupant load of 500 or fewer persons must have a minimum of two means of egress [§7.4.1.1]. Additional exits may be required for compliance with exit capacity or arrangement of exits criteria.

Building 1006

The Assembly Hall is provided with two exits directly to the exterior. The electrical equipment, mechanical equipment, and gas (storage and mixing) rooms are each provided with exit doors to the exterior. Means of egress from the Wide Angle Hall consists of exit access doors leading into the Assembly Hall at the north end of the Wide Angle Hall.

Building 1006A

Each of the three spaces in Building 1006A are provided with exit doors leading directly to grade. The DAQ Control Room is also provided with an egress door leading into the Assembly Hall.

Building 1006C

The building is provided with two exit doors opening onto landings from which exterior stairs lead down to grade.

8.2.2 Capacity of Exits

The egress capacity provided from a floor or portion thereof must be sufficient to accommodate the occupant load. The egress capacity for an egress component is based on the width of the component. For stairways, the factor of 0.3 in. of stair width per person is applied. For doors, ramps, corridors, and other level components, the factor of 0.2 in. of width per person is applied.

Based on the limited occupancy of the buildings and the egress widths of exit doors, the egress capacity provided is adequate for the buildings.

8.2.3 Travel Distance

The exit access travel distance is the distance from an occupiable point to the nearest exit or exit enclosure. The maximum exit access travel distances for the occupancies involved are provided in Table 3.2.3 [LSC §39.2.6; §40.2.6].

Occupancy	Maximum Allowable Exit Access Travel Distance (ft) (sprinklered)
Business (sprinklered)	300
Special-Purpose Industrial	400

Where open stairways serve as means of egress, the travel distance must include the travel on the stairway and the distance to reach an outside door or other exit [§7.6.2].

The buildings are in compliance with exit access travel distance limitations.

8.2.4 Common Path of Travel

The maximum allowable common path of travel for business and special purpose industrial occupancies is 100 ft (sprinklered)/75 ft (nonsprinklered) and 100 ft respectively. The common path of travel from mechanical equipment rooms, boiler rooms, and similar spaces is permitted to be not more than 100 ft [LSC §7.12.1(1) (c)].

Two egress paths are provided from the platforms in the Wide Angle Hall. Unenclosed equipment access stairways are provided along the east side of the south platform and on the north side of the north platform. A bridge which spans the Detector is provided to connect the 3rd levels of the platforms. Thus, a common path of travel is not considered to exist from the third level. The common path of travel from the second levels of the platforms as determined from the most remote occupiable point on the platform, down the access stairs to the main WAH floor does not exceed 100 ft.

The equipment loft in Building 1006 is provided with an open access stairway leading down to the Assembly Hall floor and with a fixed ladder leading to grade on the east side of the building.

8.2.5 Dead Ends

Dead-end corridors must not exceed 50 ft in industrial and business occupancies [LSC §39.2.5.2; Table 40.2.5]. The BCNYS limits dead-end corridors to not more than 50 ft in fully-sprinklered Group B or Group F occupancies [§1004.3.2.3, Ex. 2]. No dead-end corridors exceeding these limitations were identified.

8.2.6 Security Considerations Related to Fire Protection

There are no security considerations which relate to fire protection at this facility. Radiation Security barriers comply with the Life Safety Code for egress.

8.2.7 Separation of Means of Egress

Where two exits or exit access doors are required, they must be located at a distance from one another not less than one-third the length of the maximum overall diagonal dimension of the building or area served [LSC §7.5.1.3.2; BCNYS §1004.2.2.1, Ex. 2]. The buildings comply with the separation of means of egress criteria as required by the BCNYS and LSC in all areas.

8.3 Exit Signs and Emergency Lighting

Exit signage is required in accordance with Section 7.10 of the LSC. Exit signs should be placed in corridors and in rooms required to have at least two means of egress. Internally-illuminated exit signs and exit placards are provided in the buildings.

Emergency lighting for means of egress is required in accordance with Section 7.9 of the LSC. Emergency lighting is required in a building classified as a business occupancy where the business occupancy is subject to 100 or more occupants above the level of exit discharge, the building is two or more stories in height above the level of exit discharge, or the business occupancy is subject to 1,000 or more total occupants [§39.2.9.1]. Emergency lighting is required in industrial occupancies [§40.2.9.1] except special-purpose industrial occupancies without routine human habitation. Emergency lighting is provided throughout the buildings. Ceiling light fixtures connected to the emergency generator are distributed in many areas. Emergency light modules equipped with battery packs are provided elsewhere.

8.4 Egress through Adjoining/Intervening Spaces

Exit access from rooms or spaces is permitted to be through adjoining or intervening rooms or areas, provided that such rooms or areas are accessory to the area served and the intervening rooms or areas are not spaces identified under Protection from Hazards (e.g., storage rooms) [LSC §7.5.1.6]. The buildings comply with this requirement. Intervening rooms through which required egress occurs are accessory and not higher hazard to the area served.

8.5 Exit Discharge

Exits are required to terminate directly at a public way or at an exterior exit discharge. Exits provided from the buildings discharge to the exterior of the buildings as required.

8.6 Fire Protection Systems Required by Code

Automatic sprinkler protection is required to address the MPFL potential in the building.

8.7 Operational Requirements that are Required by Code

There are no other fire protection related operational requirements required by code.

9.0 REFERENCE DOCUMENTS

9.1 National Fire Protection Association

NFPA 10, *Standard for Portable Fire Extinguishers*, 2002 Edition

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2002 Edition

NFPA 30, *Flammable and Combustible Liquids Code*, 2003 Edition

NFPA 51B**,** *Standard for Fire Prevention during Welding, Cutting, and Other Hot Work*, 2003 Edition

NFPA 55, *Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks*, 2005 Edition

NFPA 70, *National Electrical Code*®, 2005 Edition

NFPA 72®, *National Fire Alarm Code*®, 2002 Edition

NFPA 80, *Standard for Fire Doors and Fire Windows*, 1999 Edition

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, 2002 Edition

NFPA 101®, *Life Safety Code*®, 2006 Edition

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2004 Edition

NFPA 1144, *Standard for Protection of Life and Property from Wildfire*, 2002 Edition

9.2 FM Global Loss Prevention Data Sheets

5-4, Transformers

APPENDIX A –

FHA FIGURES

APPENDIX B –

LIGHTNING RISK CALCULATION

The expected lightning frequency (Nd) is **0.0394** and the tolerable lightning frequency (Nc) is **0.0002**. Based on NFPA 780, If Nd > Nc, a lightning protection system should be installed.

EXPECTED LIGHTNING STROKE FREQUENCY FROM NFPA 780 ANNEX L

$$N_d = (N_g)(A_e)(C_1)(10^{-6})$$

N_d = **0.0394** = yearly average flash density in the region where the structure is located

(N_g) = **2.0** = the yearly lightning strike frequency to the structure

(C_1) = **1.00** = the environmental coefficient

(A_e) = **19,722** = the equivalent collective area of the structure in square meters from calculation below

Length (L)	**130**	Feet
Width (W)	**130**	Feet
Height (H)	**60**	Feet
	0.25	

Figure H.4.2(a) Results 19,722 sq. meters

Figure H.4.2(b) Results 9,456 sq. meters

Table H.4.3 Determination of Environmental Coefficient C_1

Relative Structure Location	C_1
Structure located within a space containing structures or trees of the same height or taller within a distance of $3H$	0.25
Structure surrounded by smaller structures within a distance of $3H$	0.5
Isolated structure, no other structures located within a distance of $3H$	1
Isolated structure on a hilltop	2

Assume

1.00

Figure H.4.2(a) Calculation of the equivalent collective area for a rectangular structure.

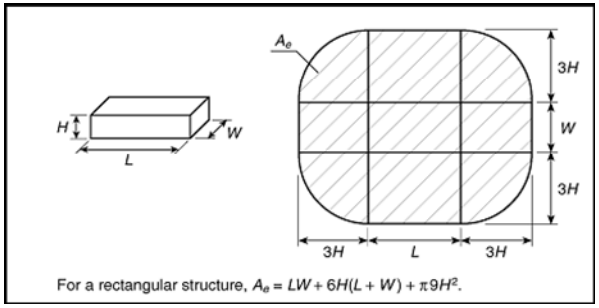
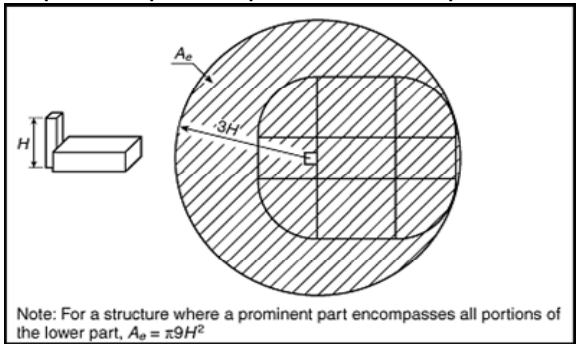


Figure H.4.2(b) Calculation of the equivalent collective area for a structure where a prominent part encompasses all portions of the lower part of the structure.



= input required

TOLERABLE LIGHTNING FREQUENCY FROM NFPA 780 APPENDIX L

$$N_c = \frac{1.5 \times 10^{-3}}{C}$$

where $C = (C_2)(C_3)(C_4)(C_5)$.

N_c = **0.0002**

Assume **1.0**

C_2 — Structural Coefficients			
		Roof	
Structure	**Metal**	**Nonmetallic**	**Flammable**
Metal	0.5	1.0	2.0
Nonmetallic	1.0	1.0	2.5
Flammable	2.0	2.5	3.0

Assume **2.0**

Structure Contents	C_3
Low value and nonflammable	0.5
Standard value and nonflammable	1.0
High value, moderate flammability	2.0
Exceptional value, flammable, computer or electronics	3.0
Exceptional value, irreplaceable cultural items	4.0

Assume **1.0**

Structure Occupancy	C_4
Unoccupied	0.5
Normally Occupied	1.0
Difficult to evacuate or risk of panic	3.0

Assume **5.0**

Lightning Consequence	C_5
Continuity of facility services not required, no environmental impact	1.0
Continuity of facility services required, no environmental impact	5.0
Consequences to the environment	10.0

= input required

APPENDIX C –

DETERMINATION OF WILDFIRE HAZARD SEVERITY USING NFPA 1144

ELEMENT	POINTS
A. Means of Access	
1. Ingress and egress	
a. Two or more roads in/out	**0**√
b. One road in/out	7
2. Road width	
a. >= 24 ft	0
b. >= 20 ft and < 24 ft	**2**√
c. < 20 ft	4
3. All-season road condition	
a. Surfaced road, grade <5%	**0**√
b. Surfaced road, grade > 5%	2
c. Non-surface road, grade < 5%	2
d. Non-surface road, grade > 5%	5
e. Other than all-season	7
4. Fire Service Access	
a. <= 300 ft with turnaround	**0**√
b. > 300 ft with turnaround	2
c. < 300 ft with no turnaround	4
d. >= 300 ft with no turnaround	5
5. Street Signs	
a. Present	**0**√
b. Not present	5
B. Vegetation (Fuel Models)	
1. Characteristics of predominate vegetation within 300 ft.	
a. Light (e.g., grasses, forbs, sawgrassess, and tundra) NFDRS Fuel Models A,C,L,N,S, and T	5
b. Medium (e.g. light brush and small trees) NFDRS Fuel Models D,E,F,H,P,Q, and U	**10**√
c. Heavy (e.g. dense brush, timber, and hardwoods) NFDRS Fuel Models B,G, and O	20
d. Slash (e.g. timber harvesting residue) NFDRS Fuel Models J,K, and L	25
2. Defensible space	
a. More than 100 ft of vegetation treatment from the structures	1
b. 71 ft to 100 ft of vegetation treatment from the structures	
c. 30 ft to 70 ft of vegetation treatment from the structures	**10**√
d. < 30 ft of vegetation treatment from the structures	25
C. Topography Within 300 of Structures	
1. Slope < 9%	**1**√
2. Slope 10% to 20 %	4
3. Slope 21% to 30%	7

4.	Slope 31% to 40%	8
5.	Slope > 41%	10

D. Additional Rating Factors

1.	Topographical features that adversely affect wildland fire behavior	0-5 [**0**√]
2.	Areas with a history of higher fire occurrence than surrounding areas due to special situations	0-5 [**0**√]
3.	Areas that are periodically exposed to unusually severe fire weather and strong dry winds.	0-5 [**0**√]
4.	Separation of adjacent structures that can contribute to fire spread	0-5 [**0**√]

E. Roofing Assembly

1.	Class A roof	0
2.	Class B roof	**3**√
3.	Class C roof	15
4.	Nonrated	25

F. Building Construction

1.	Materials		
	a.	Noncombustible/fire-resistive siding, eaves, and deck	**0**√
	b.	Noncombustible/fire-resistive siding and combustible deck	5
	c.	Combustible siding and deck	10
2.	Building setback relative to slopes of 30% or more		
	a.	>= 30 ft to slope	1
	b.	< 30 ft to slope	5

G. Available Fire Protection

1.	Water source availability		
	a.	Pressurized water source availability	
		500 gpm hydrants <= 1000ft apart	**0**√
		250 gpm hydrants <= 1000ft apart	1
	b.	Nonpressurized water source availability	
		>= 250 gpm continuous for 2 hours	3
		< 250 gpm continuous for 2 hours	5
	c.	Water unavailable	10
2.	Organized response resources		
	a.	Station <= 5 miles from structure	**1**√
	b.	Station > 5 miles from structure	3
3.	Fixed fire protection		
	a.	NFPA 13	**0**√
	b.	None	5

H. Placement of Gas and Electric Utilities

1.	Both underground	**0**√
2.	One underground, one aboveground	3
3.	Both aboveground	5

I. Total **18**

Hazard Assessment	Total Points
Low hazard	**< 40**
Moderate hazard	40-69
High hazard	70-112
Extreme hazard	> 112

A Wildfire Severity Level of 32 = A LOW Hazard