Controlled STAR Note ~~#0361B~~
0361A

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Requirements for Safety Interlocks for the STAR Detector

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REQUIREMENTS FOR SAFETY INTERLOCKS FOR THE *STAR* DETECTOR

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REQUIREMENTS FOR SAFETY INTERLOCKS FOR THE

STAR DETECTOR

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Revision A-September 15, 1998 Changed response for fire detection on the platform. Smoke or heat sensor alarm trips a rack row only. In addition, several typographical changes were made.

1. INTRODUCTION

This document describes the requirements for the STAR safety interlock system the STAR detector system, which will be installed in an experimental hall at RHIC. It is intended to provide information on the background and fundamental requirements that is necessary to execute the detailed design of the STAR safety interlock system.

The STAR safety interlock system is designed to allow the STAR detector system to operate safely; it provides protection against major equipment damage, particularly that due to the effects of fire and water leakage.

The STAR detector includes several detector components, including a Silicon Vertex Detector (SVT), a Time Projection Chamber (TPC), an Electromagnetic Calorimeter (EMC) and a Forward TPC (FTPC). Each of these has its particular safety hazards and precautions that must be recognized in the design of the total safety system. Due regard must be taken to safeguard the operational integrity of these individual detector subsystems.

Physically, the detector components are mounted on the movable STAR detector, which can be situated either in the Wide Angle Hall or in the Assembly Hall. In addition, various support subsystems will be housed in the Control room, DAQ (data acquisition) room, Electronics Platforms, Assembly Hall, Wide Angle Hall and the Gas Mixing room.

Typically, each STAR detector component will have its own local interlock system that will detect and react to hazards localized to the particular component (overcurrent or overtemperature, for example) and that is used to guide the power-up and power-down procedures. These local interlock systems will be covered in separate documents.

The overall STAR safety interlocks system is mainly concerned with major hazards, and contains interlock subsystems of the following:

- Fire Detection and Suppression
- Water Leak Detection
- Flammable Gas Detection
- Crash-off equipment protection.

In the following sections, the implementation of these interlock subsystems in the various physical spaces is specified. The nature of the hazard detection equipment is specified and the expected responses to alarms generated by the detection equipment are given. These responses include automatic actions taken to reduce the hazard as well as annunciations of the alarms in various control rooms.

For convenience, the responses are summarized in Table 1.

1.1 Implementation.

Electrical interlocks shall be implemented using fail-safe hardware logic **for protection of equipment safety.** Relay logic, programmable logic controllers (PLCs) and other hardware logic may be used, but computer software or firmware (other than the PLCs) shall not be relied upon for the fail-safe operation of the safety system.

However, computer programs may be used for monitoring the status of interlock systems. Specifically, the EPICS-based software system that provides control and monitoring for the STAR detector system can be used to distribute status information. However, it may not be made an integral part of the STAR safety interlock system—i.e., it must not be able to affect the fail-safety property of the interlock system. The interlock system must remain fully functional even if the computer-based monitoring is not operational.

We have assumed the presence of an Alarm Response Group available at all times that STAR is in operation or that its systems are active. Details of the Alarm Response Group are to be developed; it will probably be based at the RHIC Control room.

1.2 RHIC - STAR interlock interface.

A RHIC safety interlock system, separate from the STAR safety interlock system, provides both personnel and equipment safety. Protection to STAR personnel and access control to the Wide Angle Hall, the Assembly Hall and the Magnet Power Supplies will be provided by RHIC and will be covered in the STAR operational readiness plan which is under preparation.These aspects are beyond the scope of this document.

There will be certain interconnections between the STAR and RHIC interlock systems, which will be defined in the course of developing the two systems. As an example, before the STAR detector can start up, it must receive ‘permission to operate’ from the RHIC safety system.

1.3 General Requirements

It is required that the interlock system satisfies the STAR Grounding Plan (CSN #202A). In particular, there shall be no conductive electrical connections to:

- The platform structure, the body of the STAR detector or the magnet steel;
- The DAQ or slow control systems.

Within each detector subsystem, conductive connections to racks and supporting structures are permitted.

2. FIRE DETECTION AND SUPPRESSION

Wherever possible the STAR detector uses non-flammable materials or materials that will not sustain a fire once the source of ignition has been removed. Materials of interest in this context include circuit board materials, cable insulation and non-metallic support structures.

In spite of the best efforts in this regard, fires are possible within the STAR detector electronics subsystems. Thus, one requirement of the STAR safety interlock system is to minimize the effects of fires by including sensors of adequate sensitivity that detect the products of combustion promptly. In response to detection, the interlock systems shut down electrical power to the affected areas immediately, thereby removing the major source of ignition and, where applicable, shut down sources of flammable gas.

It is a Department of Energy (DOE) requirement that fire suppression systems shall be used where possible and practicable when the value of equipment at risk exceeds the (DOE recommended) value of 250K$.

In the following, the fire detection and suppression requirements of the spaces and detector components of the STAR detector are discussed.

2.1 STAR system overview

2.1.1 Requirement

A fire detection system dedicated to STAR is required. Fire suppression systems will be used where appropriate.

2.1.2 Justification

The STAR detector is a multi-million dollar installation and, under DOE guidelines, must be protected from damage resulting from fire.

2.1.3 Design

Fire detection will be by Multi-Level Spot Smoke Detectors and High-Sensitivity Smoke Detectors.

Fire suppression will use sprinkler systems and Inergen suppression systems. The control panel for the fire system will be on the platform.

Monitoring of the status of the STAR fire system is to be done in the control room. Audible alerts will inform when an alarm has occurred. In most cases, monitoring is

via relay logic or optical-coupled signals to prevent introducing ground loops, which could affect the quality of the signals from the STAR detector.

2.2 STAR Control room

2.2.1 Existing equipment

In the STAR control room, the existing RHIC safety interlock system includes fire detection capability and a sprinkler system.

Shut down of AC power to this room in the event of fire is by manual control—i.e., via a breaker panel in the room.

2.2.2 Requirement

Since adequate fire detection and suppression already exist in the STAR control room, as part of the plant, no additional systems are required within the STAR safety interlock system.

2.2.3 Justification

Additional fire suppression for electronics equipment is not required since the value of the equipment housed in the control room does not exceed 250K$.

2.3 STAR DAQ room

The DAQ room has an existing sprinkler system, which is a permanent part of the building.

2.3.1 Requirement

Both fire detection and suppression is required for the STAR electronics racks in the DAQ room for Row A. Those racks in the DAQ room that are dedicated to the RHIC control system and to Slow Controls (Row C) do not require additional coverage.

2.3.2 Justification

The total value of equipment in each STAR double-rack subdivision in Row A is in excess of 250K$. RHIC rack values and the other racks in Row C are less than 250K$.

2.3.3 Design

The electronics racks are grouped in rows and subdivided into double racks by side panels. A smoke detector will be of a type that allows multiple alarms depending of the amount of smoke; there is one alarm per rack row or double rack where the equipment protected is valued at more than 250K$. A heat sensor is used to trigger a fire suppression system. Experience has shown that this sensor is very reliable and

provides a minimum number of false alarms. A heat sensor will be installed in all racks that have a fire suppression system.

2.3.3.1 Fire detection

Each smoke alarm shall have at least two levels of alert. At minimum, there should be a *low-level* and *high-level* alert.

The low-level gives an early indication of a developing problem or provides an indication of a malfunction. An operational procedure will be developed to provide an adequate response to such an alarm. The locations of low-level alarms are annunciated as 'warnings' in the STAR control room, the RHIC control room and the BNL Fire Department.

A high-level alarm is a clear indication of fire in that enclosed volume. These are annunciated as an 'alarm' in the STAR control room, the RHIC control room and the Fire Department.

2.3.3.2 Response to a low-level alarm

An alarm from a low-level smoke detector is annunciated to the STAR and RHIC control rooms, as well as to the Fire Department.

A low-level signal may be a false alarm. In some cases, however, a low-level alarm may indicate an early warning of a developing fire

2.3.3.3 Response to a high-level alarm

The Fire Department responds.

AC power to DAQ electronics is turned off to remove sources of ignition and to allow safe access for Fire Department personnel. The AC power to all racks in the rack row in which the alarm originated is turned off by a shunt-trip activated by the STAR interlock system.

Building power and lights remain on.

2.3.3.4 Response to a heat sensor alarm

An Inergen suppression system is used in the STAR racks. In response to a high-level alarm, Inergen floods all STAR racks in the DAQ room - Row A.

The Fire Department responds.

AC power to DAQ electronics is turned off to remove sources of ignition and to allow safe access for Fire Department personnel. The AC power to all racks in the rack row in which the alarm originated is turned off by a shunt-trip activated by the STAR interlock system.

Building power and lights remain on.

2.4 Electronics Platforms

The electronics platforms contain much of the supplemental electronics for the STAR detector including power supplies, timing circuitry, etc. There are three levels, two of which on the south platform have multiple rows of electronics racks. Each rack row is closed with front panels and rear doors, with cooling air circulating locally through heat exchangers connected to the cooling water system. Fire pillows or their equivalent seals the bottom of the racks from the steel sub-floor and cable tray system. Side panels provide smoke separation between rack subdivisions.

2.4.1 Requirement

A fire suppression system is required on the south platform for Level 1—Rack Row A only. Fire detection and an interlock trip to AC power is not sufficient protection for this row with expensive equipment.

2.4.2 Justification

Where possible racks are subdivided to keep the value of the contents to less than 250K$ per enclosed volume. There are, however, two double racks used in the trigger system where the value is greater than this amount. These racks are located on level 1, row A. Therefore, a suppression system is required for this rack row only. The existing sprinklers in the Assembly Hall and Wide Angle Hall are not effective for the multi-level platforms.

2.4.3 Design:

Detection and suppression is by rack rows and sub-sections of rack rows.

A multiple (level smoke detector and heat sensor is used in each rack row to minimize false alarms and provide sufficient protection. The low-level alarm is annunciated to the RHIC and STAR control rooms as well as to the Fire Department. A high-level alarm indicates a significant occurrence and appropriate action shall be taken. Dividers are used between racks to isolate hardware so that the maximum value is not exceeded. The dividers also provide smoke separation. A heat sensor is used to trigger the fire suppression system.

2.4.3.1 Response to a low-level alarm

An alarm from a low-level smoke detector is annunciated to the STAR and RHIC control rooms, as well as to the Fire Department.

A low-level signal may be a false alarm. In some cases, however, a low-level alarm may indicate an early warning of a developing fire

2.4.3.2 Response to a high-level alarm

A high-level alarm results in the following actions:

- Shunt-trip of the rack row in which there was an alarm. Removing the AC power to racks removes the source of ignition and allows safe access for Fire Department personnel.

- Annunciation of the alarm in the RHIC control room and the STAR control room. STAR control personnel respond appropriately.

- Annunciation of the alarm at the Fire Department. The Fire Department responds.

- Magnet power is ramped down. To allow safe access for fire department personnel, the magnet power supply AC is removed after a 2-minute delay. The delay is intended to reduce the potential danger to the magnet, computer disk drives, etc.

- Building power, lights and rack emergency lights remain energized.

2.4.3.3 Response to a heat sensor alarm

A heat sensor alarm results in the following actions:

- The Inergen system dumps to the rack row in which the alarm originated.

- Shunt-trip of the rack row that had a heat sensor alarm . Removing the AC power to racks removes the source of ignition and allows safe access for Fire Department personnel.

- Annunciation of the alarm in the RHIC control room and the STAR control room. STAR control personnel respond appropriately.

- Annunciation of the alarm at the Fire Department. The Fire Department responds.

- Magnet power is ramped down. To allow safe access for fire department personnel, the magnet power supply AC is removed after a 2-minute delay. The delay is intended to reduce the potential danger to the magnet, computer disk drives, etc.

- Building power, lights and rack emergency lights remain energized.

2.5 STAR Detector

It is deemed impractical to install a fire suppression system inside the STAR detector. However, its construction materials are chosen to be non-combustible insofar as is practical. Thus, removal of sources of ignition will limit the spread of a fire.

2.5.1 Requirement.

A high-sensitivity smoke detector is used to detect the start of pre-combustion in the STAR detector. If smoke is detected, all power to the STAR detector is shut down.

This includes shutting down all DC power supplies as well as the AC supply to the power supplies.

Detection of fire results in an AC power shunt-trip to all detector systems including the magnet, but excluding the DAQ system.

There is no fire suppression system since there is no practical means of suppression inside the STAR detector.

2.5.2 Justification

The construction of the STAR detector is accomplished with the use of non-flammable and non-fire-sustaining materials where possible. In addition, the main heat sources capable of causing fire in the detector are faults in the electrical system. By using materials that will not sustain a fire in the absence of a heat source, further damage to the STAR detector is limited once the AC power is removed.

2.5.3 Design:

The fire detectors installed in the detector will be High Sensitivity Smoke Detectors (HSSDs). Conventional spot smoke detectors are not usable in the magnetic field and radiation environment of the STAR detector.

The High Sensitivity Smoke Detector is a high-reliability and self-checking system. Air is sampled from various parts of the STAR detector and analyzed for the presence of combustion and pre-combustion products. The STAR detector is divided into two zones, one at each end of the detector. Each zone is sampled at the top and bottom of the TPC wheel.

The HSSD can be programmed to provide detection at various levels. For start-up operation, low- and high-level alarms will be programmed. If intermediate warning levels are required or found useful, they will be added later.

The capability to shunt trip AC power at the AC breaker panels is provided for all power supplies feeding the detector.

2.5.3.1 East Zone and West Zone

Each end of the detector is sampled at sectors 11, 12, 1 & 2 and 5, 6, 7, & 8, and 23, 24, 13 & 14 and 17, 18, 19, & 20 (a total of four sampling zones).

2.5.3.2 Response to a low-level alarm

Low-level alarms will be annunciated to the STAR and RHIC control rooms and to the Fire Department. The appropriate response to such an alarm will be defined in a subsequent document.

2.5.3.3 Response to a high-level alarm

In response to a high-level alarm, the following occurs:

- The alarm is annunciated at the STAR and RHIC control rooms.

- The alarm is annunciated at the Fire Department. The Fire Department will respond.
- The AC power for all systems feeding the STAR detector is shut down to remove all possible sources of ignition. This includes AC power to both platforms and the magnet power supplies.
- The TPC Gas system is purged automatically when AC power is shut down.

2.6 Magnet System

2.6.1 Requirement

Spot smoke detectors interlocked to AC power are required in the power-supply area.

2.6.2 Justification

Common practice is to use spot smoke detection located physically above the power supplies.

2.6.3 Design

Spot smoke detectors will be located above the magnet power supplies and interfaced to the magnet power-supply interlock chain. These are redundant to any smoke detectors in the individual power supplies.

The magnet power-supply room has an existing spot detection system and a sprinkler system. It may be possible to tie into this detection system and interface it to the local magnet power-supply interlock chain. If this is not possible, a separate detection system shall be required.

We recommend multiple level smoke detectors be used to minimize false alarms. A low-level alarm from a smoke detector would be annunciated to the RHIC and STAR control rooms as well as to the Fire Department. A high level alarm is required before further action is taken.

2.6.3.1 Response to low-level alarm

A low-level alarm from a smoke detector may be a false alarm, but it may be an early warning of a developing fire.

The low-level alarm is annunciated to the STAR and RHIC control rooms, and to the Fire Department. The appropriate response to such an alarm will be defined in a subsequent document.

2.6.3.2 Response to high-level alarm

A high level alarm results in the following actions:

- Ramp down of magnet current is started immediately. After a two-minute delay, AC to the magnet power supplies is removed via a shunt trip of the appropriate AC breaker. Removing the AC power removes the source of ignition and allows safe access for Fire Department personnel.

- The alarm is annunciated to RHIC control room, STAR control room and Fire Department.

- The alarm is annunciated to the Fire Department. The Fire Department responds.

- Building power, lights and emergency lighting remain active.

- If the fire were internal to the power supplies, the power supplies would have tripped off immediately upon detection by the internal sensors for cabinet temperature, etc., via local interlocks within the power supply. If the fire is in other equipment (pumps, etc.) the supplies will be ramped down via command from the STAR safety interlock system.

2.7 Gas Mixing room

Fire detection and suppression in the gas mixing room is the responsibility of the RHIC safety systems. Removal of AC power starts an automatic purge of the gas system and removes sources of ignition. The room also has a sprinkler system.

Some additional recommendations follow. (Also, see documentation regarding the TPC gas system and the subsequent reviews.)

2.7.1 Recommendation

Spot fire detection interlocked to AC power is recommended.

2.7.2 Justification

Methane will be mixed with Argon in this room to form the gas mixture P10. The possibility of escaping methane represents a fire hazard.

2.7.3 Design

Multiple level smoke detectors in each protected location are recommended to minimize false alarms. The dollar value of the hardware protected by smoke detectors is less than 250K$.

2.7.3.1 Response to low-level alarm

A low-level alarm from a single smoke detector may be a false alarm or it may be an early warning of a developing fire. All low-level alarms are annunciated to the STAR and RHIC control rooms as well as to the Fire Department

2.7.3.2 Response to high-level alarm

A high level alarm from a smoke detector results in the following actions:

1) It results in a shunt-trip of all AC power to the gas mixing room except for building power, lights and emergency lighting. (All lights in the area will be in explosion-proof enclosures.) Removing the AC power removes sources of ignition and allows safe access for Fire Department personnel.
2) The alarm is annunciated in the RHIC control room and the STAR control room.
3) The alarm is annunciated to the Fire Department. The Fire Department responds.

2.8 RHIC facilities

A High-Sensitivity Smoke Detector (HSSD) currently exists in the Assembly Hall and a similar system is scheduled to be installed in the Wide Angle Hall. At present, this detector system is not covered by this document—a connection to the STAR safety interlock system may be defined in the future.

Fire Alarm pull stations and portable fire extinguishers currently exist near exits to the area and other prominent locations. The STAR detector does not shutdown automatically if a fire alarm is pulled.

3. WATER LEAK DETECTION

Water cooling is used for most of the electronics in the STAR detector. In spite of the best efforts to design, build, and install a reliable water cooling system, the possibility of leaks must be anticipated and protected against. Damage to powered electronics from a water leak can be expected if the power is not removed within 10 minutes.

The TPC, SVT and FTPC Front-end electronics systems use a conventional water cooling system. The SVT detector uses a leakless system, in which the cooling water circulates at less than atmospheric pressure to reduce the chance of water leaks.

A Tracetek leak detection system is planned with a controller allowing up to eight detection cables.

3.1 STAR Control Room

There is no water-cooled electronic equipment in the control room.

3.2 STAR DAQ room

3.2.1 Requirement.

Leak detection is required in the STAR electronics racks

3.2.2 Justification

This equipment uses circulating air for direct cooling. The circulating air is cooled in heat exchangers attached to the cooling water system.

3.2.3 Design

One zone of the Tracetek system will be used for the electronics racks in the DAQ room.

Up to 1500 feet of cable can be used. The mapping feature allows determination of the location of a water leak (fault) along the cable to within a few feet. Slow water leaks that do not constitute a hazard to the equipment may be 'mapped out' of the system—i.e. ignored--by commands transmitted via the slow control interface.

3.2.3.1 Response to faults

In response to detection of a water leak, the following actions occur:

1) Circulation of cooling water is shut down via solenoid valves. There is one solenoid valve per double rack. Individual shutoff valves will limit the amount of water spilled in the event of a major hose break.
2) The slow controls computer system is notified; it annunciates the alarm on the appropriate display.
3) AC power to racks is shut down after a two-minute delay. A two-minute delay is long enough to allow an orderly shutdown of electronic equipment, including disk drives etc., but is short enough to prevent damage to the hardware. This delay is programmed into the programmable logic controller (PLC) system. The shutdown process does not depend on slow controls for its action to occur.

3.3 Electronics Platforms

3.3.1 Requirement

Leak detection is required in electronics racks.

3.3.2 Justification

Cooling water is used, via heat exchangers, to condition the recirculating air used to remove heat from the racks.

3.3.3 Design

Two zones of the Tracetek system will be dedicated to the Platform electronics racks.

Up to 1500 feet of cable can be used with mapping feature to isolate faults. Faults may be mapped out of the system by reprogramming the Tracetek via commands transmitted via the slow control system (EPICS).

3.3.3.1 Response to fault

In response to detection of a fault, the following actions occur:

1) Cooling water is shut off via a solenoid valve at the affected rack. Individual shutoff valves at each rack will limit the amount of water spilled in the event of a major hose break.
2) The EPICS slow controls system is notified.
3) AC power to the platforms is shut down after a two-minute delay. The shunt-trip of the AC power will be at the rack-row distribution panels.

   A two-minute delay is long enough to allow an orderly shutdown via subsystem interlocks and slow controls, but is short enough to prevent damage to the hardware. The delay is programmed into the programmable logic controller (PLC) system. The shutdown does not depend upon the EPICS system for execution.

3.4 STAR Detector

3.4.1 Requirement

Leak detection and appropriate response is required in the STAR detector.

3.4.2 Justification

Cooling water is used for the TPC and SVT front-end electronics and the SVT Detector.

3.4.3 Design

Two zones of the Tracetek system will be dedicated to the STAR detector, one for each end.

The Tracetek cable will be routed to sectors 5, 6, 7 & 8 on the west TPC wheel and 17, 18, 19, & 20 on the east TPC wheel and to the SVT water manifold.

3.4.3.1 Response to a fault

In response to detection of a leak fault within the detector, the following actions occur:

1) Cooling water to the STAR detector is shut down. Subsystems using cooling water include the TPC, SVT and FTPC subsystems and the Magnet.

   Since the Tracetek system cannot determine the source of the water, all the above systems must be shut down.

2) Power to the STAR detector is shutdown immediately.

   The potential for high cost damage to the detector is too high to risk delaying the shutdown of power.

3) Magnet current is ramped down and AC magnet power removed after a two-minute delay.

   Since risk to the magnet is not as high, a ramp-down of magnet current is permitted, but after two minutes the AC power to the magnet power supplies is shut down.

4) Gas system power is not shutdown automatically and the gas system is not purged automatically.

3.5 Magnet System

3.5.1 Requirement

Leak detection is required at the magnet power supplies and at the magnet itself.

3.5.2 Justification

Cooling water is used for the magnet power supplies and for the magnet power buses.

3.5.3 Design

Water leak detection in the power supplies is by means of water mats internal to the supplies. These are interlocked to the local magnet power supply interlock chain.

One zone of the Tracetek system may be dedicated to detection at the magnet or water mats underneath the power bus-to-magnet connection area may be used as long as good coverage of the connection area is achieved.

In the following, distinction is made between a “normal” fault (a slow water leak) and a major fault such as a blown cooling-water hose. The means of distinguishing between the two conditions has not yet been determined.

3.5.3.1 Response to a “normal” fault at the magnet power supplies

In response to detection of a leak fault at the magnet power supplies, the following actions occur:

1) The magnet system cooling water is shut down. This is done to minimize quantity of water leaked.

2) The EPICS slow controls system is notified.

3) Magnet current is ramped down and AC magnet power removed after a 2-minute delay.

   Since risk to the magnet is not as high, a ramp-down of magnet current is permitted, but after two minutes the AC power to the magnet power supplies is shut down. A two-minute delay is long enough to allow an orderly shutdown via subsystem interlocks and slow controls, but is short enough to prevent damage to the hardware. The delay is programmed into the programmable logic

controller (PLC) system and does not does not depend on the EPICS system for execution.

3.5.3.2 Response to “normal" water leaks at the magnet

Small water leaks detected at magnet initiates a ramp down of magnet power. The AC power to the magnet power supply is shut down after a two-minute delay.

Gas system power is not shutdown automatically and the gas system is not purged automatically.

3.5.3.3 Response to large water leaks at the magnet

In response to detection of a large water leak fault equivalent to a blown cooling water hose, the following actions occur:

1) Magnet AC power is shut down without delay. Since the risk of damage internal to the detector is so high and the cost to repair or replace is so high, no delay is allowed for the removal of power.
2) Magnet DC current is shut down without delay.
3) All power to all detector systems is also shut down without delay.
4) Gas system power is not shutdown automatically and the gas system is not purged automatically.

3.6 Gas Mixing Room

There are no requirements for water leak detection in the Gas Mixing room, since water leaks are not a potential hazard to the installed equipment in this room.

3.7 RHIC Facilities

There are no requirements for water leak detection in the STAR safety interlock system to cover RHIC facilities.

4. FLAMMABLE GAS DETECTION

The present plans for the physical construction of detector assemblies in the STAR detector include the use of the following types of gases.

- The TPC will use P10—which is composed of 10% methane and 90% argon—in its active volume.
- The TPC will use nitrogen as an insulating gas surrounding the TPC.
- The FTPC will use 50% carbon dioxide, 50% argon.
- The EMC will use 50% carbon dioxide, 50% argon.

Of these gases, only P10 presents a possible fire hazard. When mixed with an appropriate proportion of oxygen, P10 burns very slowly; at other proportions, it is not flammable. P10 is considered a flammable gas at BNL.

The STAR gas detection system is for equipment safety. RHIC will provide personnel safety.

Flammable gas detection systems are planned for the Gas Mixing room and the Wide Angle Hall. Building exhaust fans are included as well. A gas detection system is required for the Assembly Hall since P10 will be used therein. This document will not describe the detailed design of the RHIC detection system.

4.1.1 Requirement

A gas detection system is required.

4.1.2 Justification

The presence of a gas, that can ignite, results in the requirement that a flammable gas detection system is needed.

4.1.3 Design

An air sampling system is to be provided. In response to a gas alarm, typically the system where gas was detected will be shut down and the gas system purged.

4.2 STAR Control Room

Flammable gas detection is not needed in the STAR control room, since no gas equipment is in that room.

4.3 STAR DAQ room

Flammable gas detection is not needed in the STAR DAQ room, since no gas equipment is in that room.

4.4 Electronics Platforms

The platforms are a central area where the gas detection system will be mounted, but detection capability is not required in this area.

4.5 STAR Detector

A flammable gas detection system is required because of the use of flammable gas components in TPC.

4.5.1 Requirement

A flammable gas detection system is required. When the detector is in the Assembly Hall, fans are required to provide air circulation around the detector.

4.5.2 Justification

The possibility of a leak from the TPC gas system results in the requirement for flammable gas detection.

4.5.3 Design

An air sampling system will monitor the interior of the STAR detector to detect trace amounts of flammable gas.

It will have two zones of operation: the East and West wheels of the TPC. Each zone is sampled at sectors

- 11, 12, 1 & 2 (west side—top),
- 5, 6, 7 & 8 (west side—bottom),
- 23, 24, 13 & 14 (east side—top), and
- 17, 18, 19 & 20 (east side—bottom)

—a total of four sampling areas.

Three levels of alarms are possible—low, mid and high.

4.5.3.1 Response to low-level alarm

In the event of a low-level alarm, the following actions are taken:

1) The STAR control room is notified.
2) The RHIC control room is notified.
3) The fire department is notified
4) The EPICS slow controls system is notified.

4.5.3.2 Response to mid-level alarm

The mid-level alarm will be implemented at a later date if needed.

4.5.3.3 Response to high-level alarm

In the event of a high-level alarm, the following actions are taken:

1) The STAR control room is notified.
2) The RHIC control room is notified.
3) The fire department is notified and then it responds.
4) The EPICS slow controls system is notified.
5) The TPC gas system purges automatically.

6) The building exhaust fans are activated.

7) All AC power for the STAR detector is tripped. AC power includes power to the platforms, the magnet power supplies and the gas system. This must be at a breaker outside the building to avoid a spark hazard from the breaker operation.

4.6 Magnet System

Flammable gas detection is not needed in the magnet system, since it uses no gas.

4.7 Gas Mixing Room

This system is not detailed in this document. RHIC systems cover this area. STAR recommends as follows:

4.7.1 Recommendation

A flammable gas detection system is required.

4.7.2 Justification

Methane is mixed with argon in this room to supply the TPC.

4.7.3 Design

In the event of the detection of flammable gas within the room, the following actions should be taken:

1) The remote AC breaker for the gas system is shunt-tripped. This results in an automatic purge of the gas system.

2) The remote AC breaker for the STAR electronics (A1) is shunt-tripped to reduce spark hazard.

3) The event is annunciated to the STAR control room, the RHIC control room and to the Fire Department using intrinsically safe wiring. Intrinsically safe wiring is such that any sparks due to shorts, etc., are of insufficient energy to cause ignition of flammable gases.

4) The slow controls computer system is notified.

5) Exhaust fans are activated.

6) Building AC power and lights remain on.

4.8 RHIC facilities

This system not detailed in this document. The RHIC safety interlock systems cover this area. The following is recommended:

4.8.1 Recommendation

A system to detect flammable gas in the Wide Angle Hall and the Assembly Hall is required.

4.8.2 Justification

There is potentially flammable gas in the Wide Angle Hall because of the gas used in the TPC.

4.8.3 Design

In the event of the detection of flammable gas within the room, the following actions should be taken:

1) The remote AC breaker for the gas system is shunt-tripped. This results in an automatic purge of the gas system.
2) The remote AC breaker for the STAR electronics (A1) is shunt-tripped to reduce spark hazard.
3) The event is annunciated to the STAR control room, the RHIC control room and the Fire Department.
4) Exhaust fans are activated.
5) Building AC power and lights remain on.

5. POWER CRASH-OFF SYSTEM

The power crash-off system is intended for the emergency use of personnel who detect hazardous conditions that require immediate action. Clearly labeled manually operated Power crash-off buttons are to be located at strategic locations in the STAR area.

The STAR power crash-off system is interlocked to the AC power distribution system and via shunt-trips can force circuit breakers to open, thereby positively removing electrical hazards, and to provide purging of the TPC gas system.

In the Wide Angle Hall, the power crash-off buttons associated with the STAR safety interlock system shall be clearly labeled to be easily distinguishable from the crash-off buttons associated with the RHIC interlock system.

5.1 STAR Control Room

A power crash-off button is to be installed in the STAR control room. This crash-off is a last resort backup to all other STAR safety systems. Operation of this button results in a complete shutdown of the STAR detector and all associated equipment.

5.1.1 Requirement

Power crash-off shall be available in the STAR control room.

It shall be a double-action switch to prevent accidental operation. Double-action switches are designed to require two different physical actions—such as push, then pull—to actuate the switch.

5.1.2 Justification

The purpose is to provide hardware protection in emergencies where immediate action is imperative.

5.1.3 Design

The use of a crash-off button in the STAR control room will shut down the entire STAR experiment. This requires shunt tripping of all AC power to all parts of the STAR detector system, and a gas system purge. To insure that this happens, it may be necessary to supply AC power through multiple breakers—i.e., to supply each circuit via two or more breakers wired in series and located in separate panels.

A system wide crash-off is required to allow safe access for the Fire Department.

5.2 STAR DAQ room

5.2.1 Requirement

There is no requirement for a crash-off button in the DAQ room. Local circuit breaker panels are sufficient protection against electrical hazards in this room.

Circuit breakers for electronics racks must be located in DAQ room and readily accessible.

5.3 Electronics Platforms

5.3.1 Requirement

A power crash-off button is required on each level of the North and South platforms. Power crash-off buttons shall be located near stairways or exits on each level.

5.3.2 Justification

The crash-off buttons are needed to provide hardware protection in the event of safety interlock system malfunction.

5.3.3 Design

Operation of a crash-off button on the Electronics Platforms results in the following:

1) All AC power to the platforms and to the magnet power supplies is shut down immediately.

2) The action is annunciated in the control room.

5.4 STAR Detector

5.4.1 Requirement

At least two crash-off buttons are to be located around the perimeter of the detector.

5.4.2 Justification

The crash-off buttons are needed to provide hardware protection in the event of safety interlock system malfunction.

5.4.3 Design

Operation of any crash-off button in the detector area results in the following:

1) All AC power to the platforms, the magnet power supplies and the gas system is shut down immediately.
2) The gas system is purged. All flammable gas is removed from the system and vented to the outside of the building.

5.5 Magnet System

5.5.1 Requirement

An adequate number of crash-off buttons near power supplies is required. In addition, a crash-off button shall be installed at the foot of the stairs leading to the power supply room.

5.5.2 Justification

The crash-off buttons are needed to provide hardware protection in the event of a safety interlock system malfunction.

5.5.3 Design

Activation of a crash-off button immediately shuts down AC power to magnet power supplies via removal of the STAR “enable operation” permissive signal to the local magnet power supply interlock chain. The magnet current decays through a free-wheeling diode.

5.6 Gas Mixing Room

The safety interlocking within the gas mixing room is under the purview of the RHIC safety systems and is therefore not detailed by this document. However, the following recommendations are made.

5.6.1 Recommendation

A local crash-off button is recommended.

5.6.2 Justification

The crash-off button is needed to provide personnel and hardware protection in the event of a safety interlock system malfunction.

5.6.3 Design

The activation of the crash-off button should result in the shunt trip of the AC breaker feeding the gas mixing system. This breaker must be remotely located to remove any spark hazard resulting from operation of the breaker.

Removal of AC power should cause an automatic purge of the gas system to remove any flammable gases.

5.7 RHIC facilities

RHIC crash-off buttons in the Wide-angle Hall and tunnel areas are primarily intended as a radiation safety system.

The safety interlocking within the RHIC facilities is under the purview of the RHIC safety systems and is therefore not detailed by this document. However, the following recommendations are made.

5.7.1 Recommendation

Means to initiate a crash-off for access control violation is recommended.

5.7.2 Justification

The crash-off button is needed to provide personnel protection in the event of safety procedure violation or an interlock system malfunction.

5.7.3 Design

Activation of a RHIC crash-off button in the Wide Angle hall, the Assembly Hall or the Magnet Power Supply room should be annunciated as an alarm to STAR control room as well as to the RHIC control room.

STAR Interlock Summary

													Action														
Safety System	Location	Fault	DAQ room rack-AC off	DAQ room rack-AC off after 2 minute delay	platform-AC immediate off	Platform-AC off after 2 minute delay	STAR-AC off at external breaker (A1)	magnet power supply AC immediate off	magnet power ramped off;AC off after 2 min delay	mag. power supplies AC off at external breaker	gas-AC external breaker trip	building AC off	RHIC notified	STAR notified	Fire Dept notified	Fire Dept responds	Inergen suppression system activates	local sprinkler system available	TPC water off	SVT water off	rack-row water off	magnet water off	gas system purge	building exhaust fans on	RHIC crash off available
Fire Detection																											
	STAR DAQ room	Smoke low level											x	x	x												
	Electronics Platform	Smoke low level											x	x	x												
	Detector	HDDS low level											x	x	x												
	magnet power supplies	Smoke low level											x	x	x												
	gas mixing room	Smoke low level											x	x	x												
	RHIC facilities	HDDS low level											x	x	x												
	STAR control Room	local building system											x	x	x	x		x									
	STAR DAQ room	Smoke high level	x										x	x	x	x		x									
	STAR DAQ room	Heat Sensor	x										x	x	x	x	x	x									
	Electronics Platform	Smoke high level			x				x				x	x	x	x							x				
	Electronics Platform	Heat Sensor			x				x				x	x	x	x	x						x				
	Detector	HSSD high level			x					x	x		x	x	x	x							x				
	magnet power supplies	Smoke high level								x			x	x	x	x		x					x				
	gas mixing room	Smoke high level									x		x	x	x	x		x					x				
	RHIC facilities	HSSD high level			x					x	x		x	x	x	x		x					x				

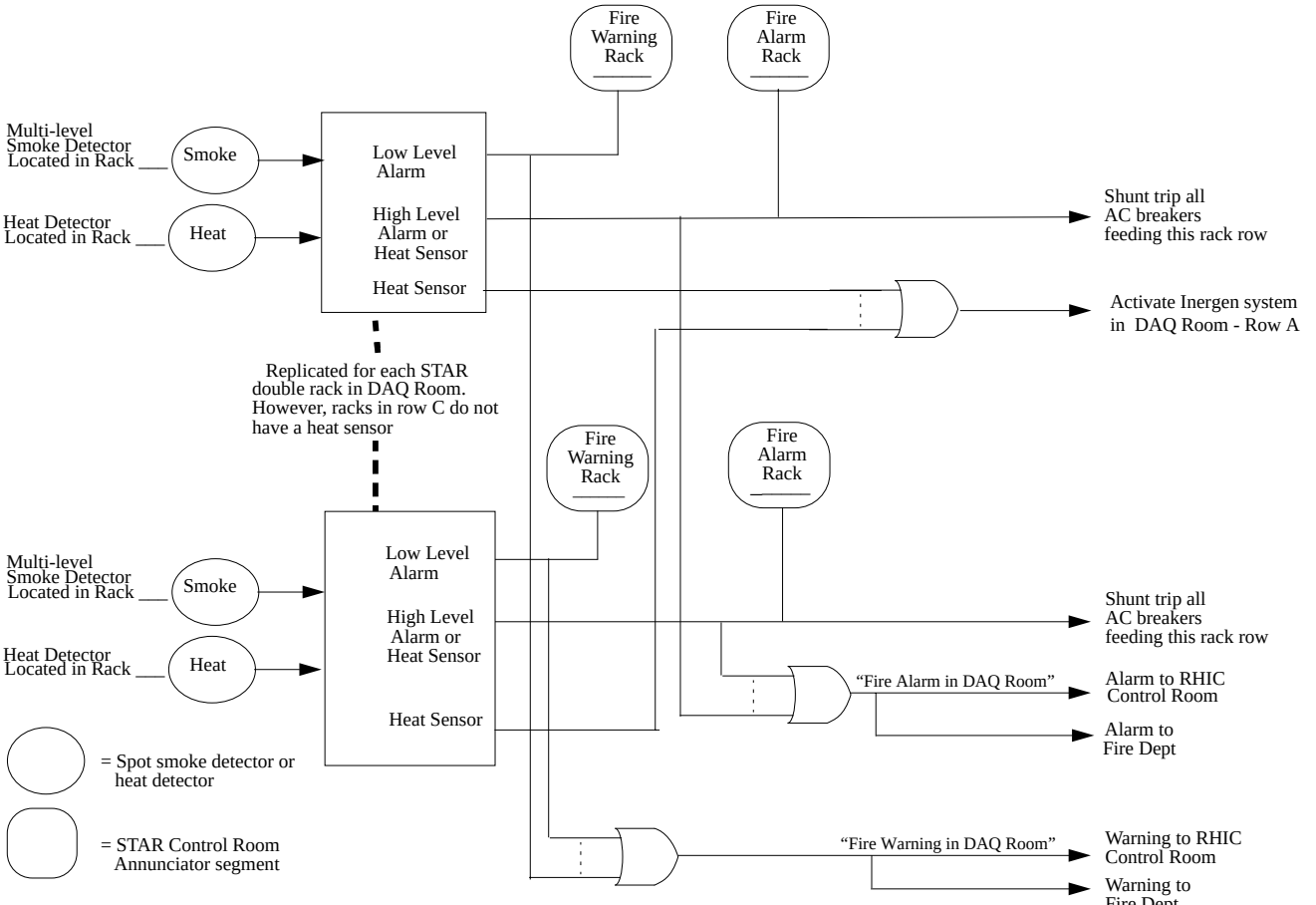
Table 1—Page1

STAR Interlock Summary

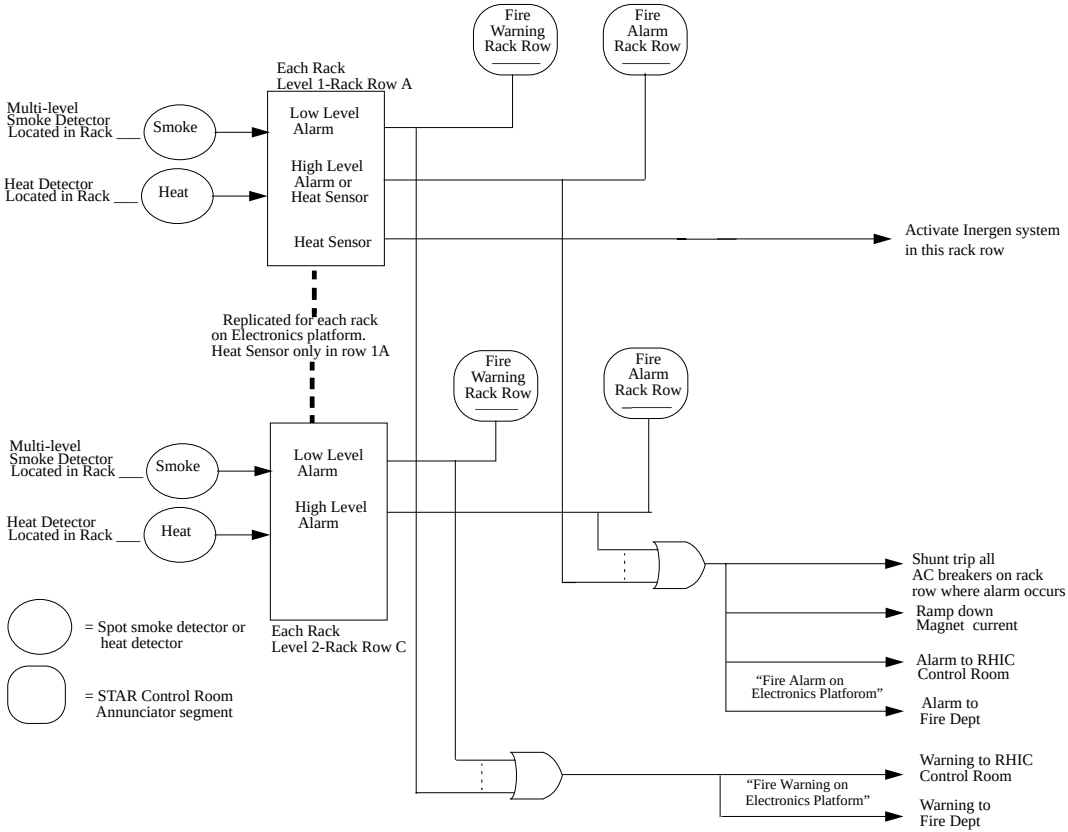
Safety System	Location	Fault	DAQ room rack-AC off	DAQ room rack-AC off after 2 minute delay	platform-AC immediate off	Platform-AC off after 2 minute delay	STAR-AC off at external breaker (A1)	magnet power supply AC immediate off	magnet power ramped off:AC off after 2 min delay	mag. power supplies AC off at external breaker	gas-AC external breaker trip	building AC off	RHIC notified	STAR notified	Fire Dept notified	Fire Dept responds	Inergen suppression system activates	local sprinkler system available	TPC water off	SVT water off	rack-row water off	magnet water off	gas system purge	building exhaust fans on	RHIC crash off available
Water System Leak Detection																									
	STAR DAQ room	TraceTek		x										x							x				
	Electronics Platform	TraceTek				x								x							x				
	Detector	TraceTek			x				x					x					x	x		x			
	magnet pwr supplies	water mat							x					x								x			
	magnet pwr leads—low	TraceTek							x																
	magnet pwr leads—high	TraceTek			x				x					x								x			
Gas Detection																									
	gas mixing room	(RHIC)					x			x	x		x	x	x	x							x	x	
	Assembly Hall and WAH	(RHIC)					x			x	x		x	x	x	x							x	x	
Crash Off																									
	STAR control Room						x			x	x		x	x	x										
	DAQ room	n/a																							
	Electronics Platform				x			x					x	x	x										
	Detector				x			x			x		x	x	x										
	WAH	(RHIC)											x	x	x										x
	Assembly Hall																								
	magnet system							x					x	x	x										
	gas mixing room										x		x	x	x										

Table 1—Page2

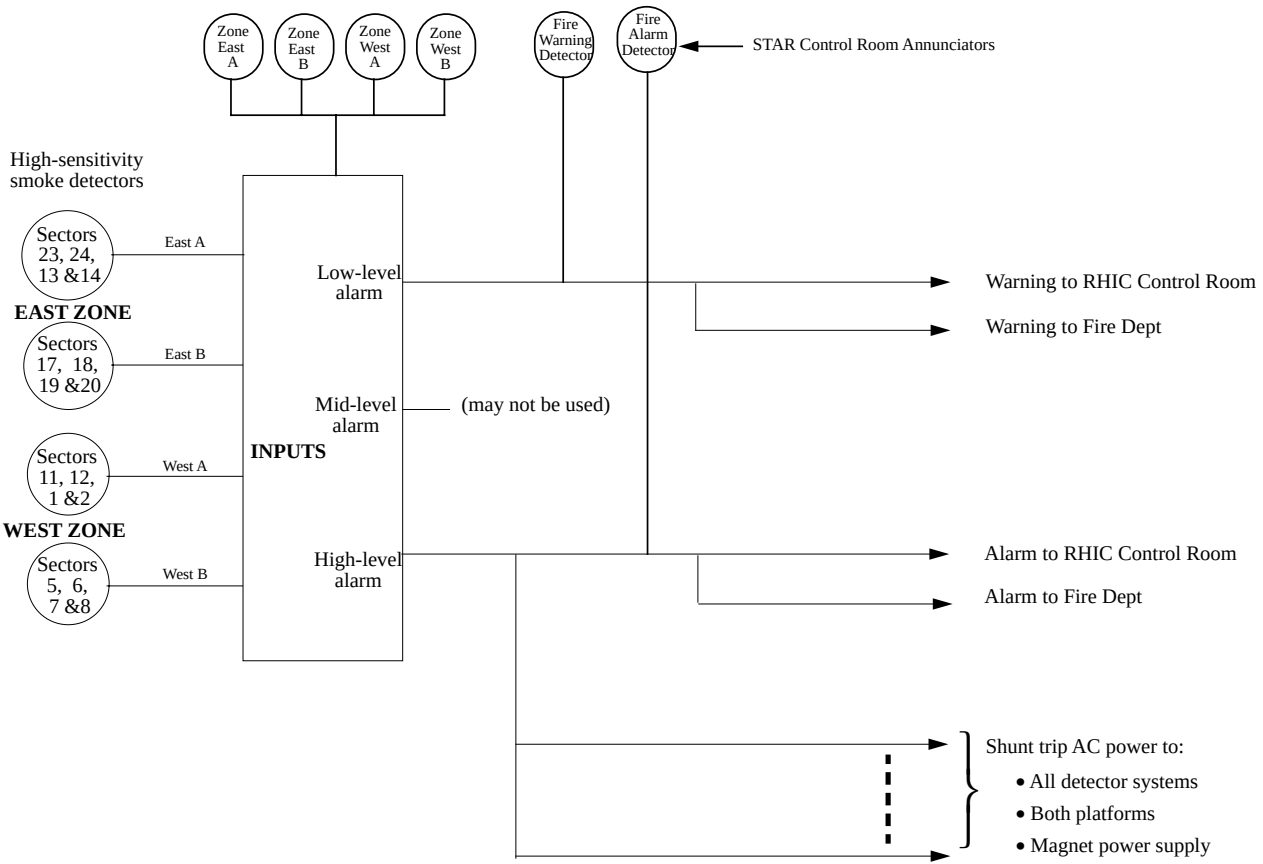
DAQ Room Fire Detection and Suppression -- Reference: Section 2.3



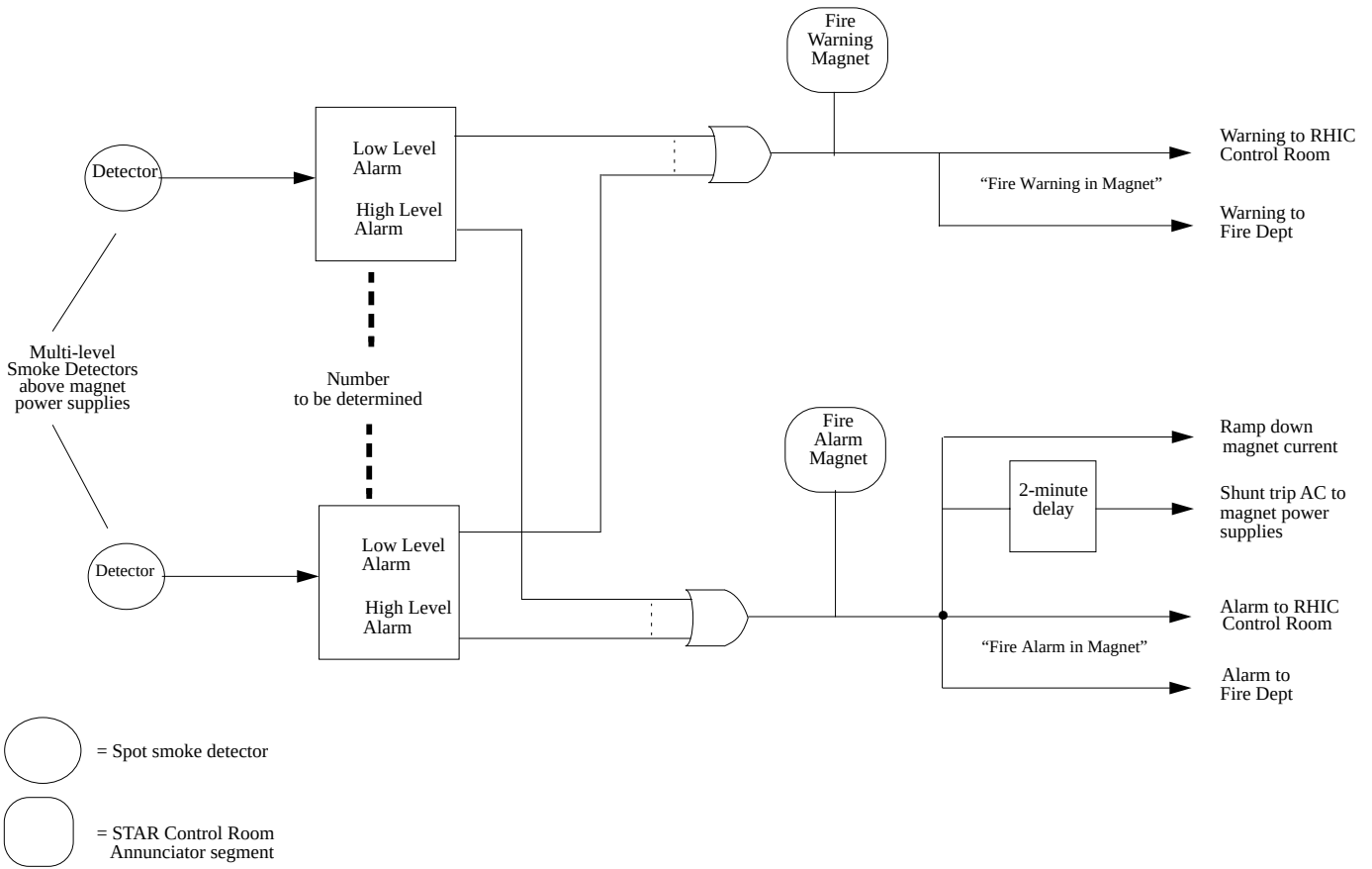
Electronics Platforms Fire Detection and Suppression -- Reference: Section 2.4



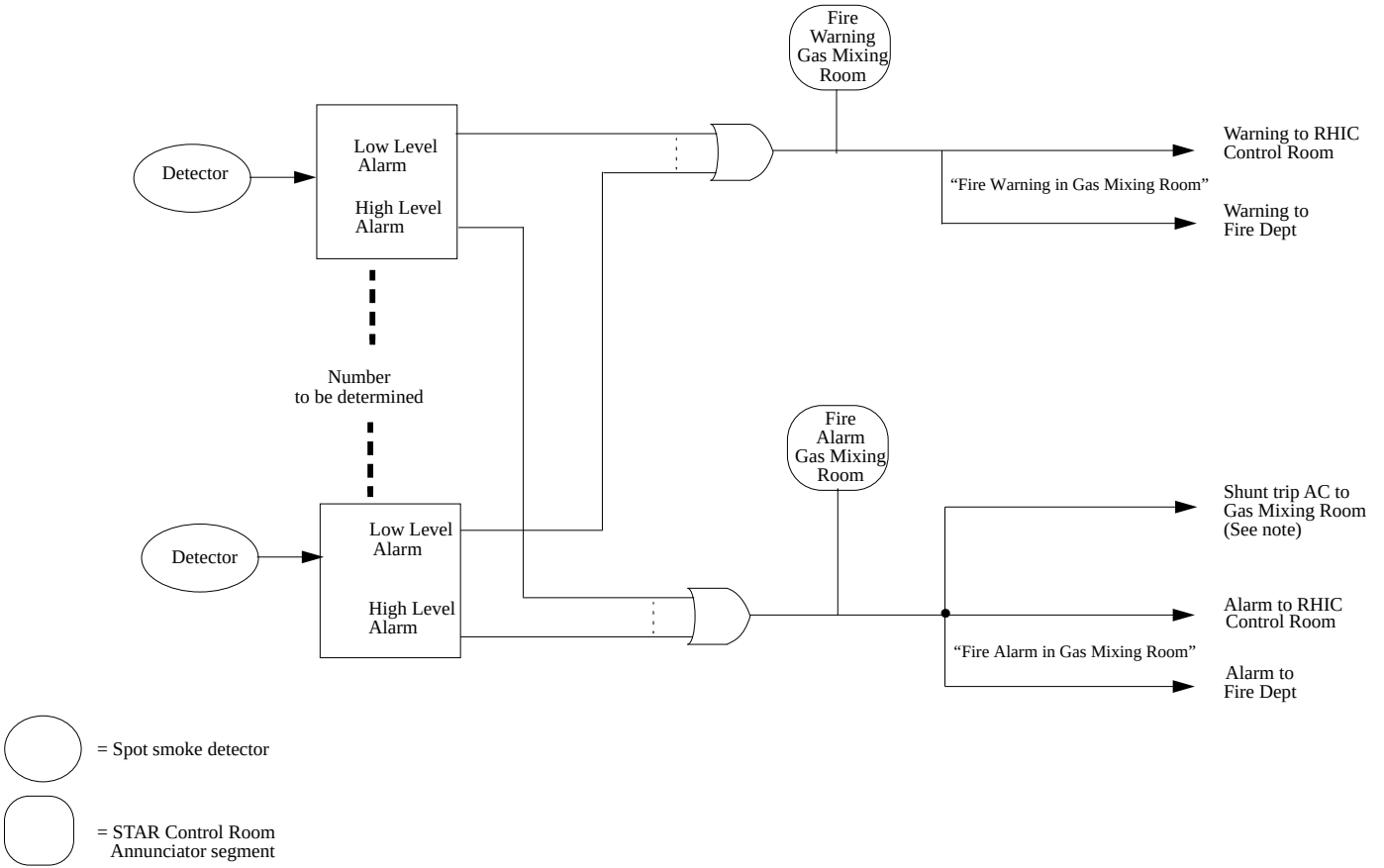
STAR Detector Fire Detection -- Reference: Section 2.5



Magnet Fire Detection -- Reference: Section 2.6

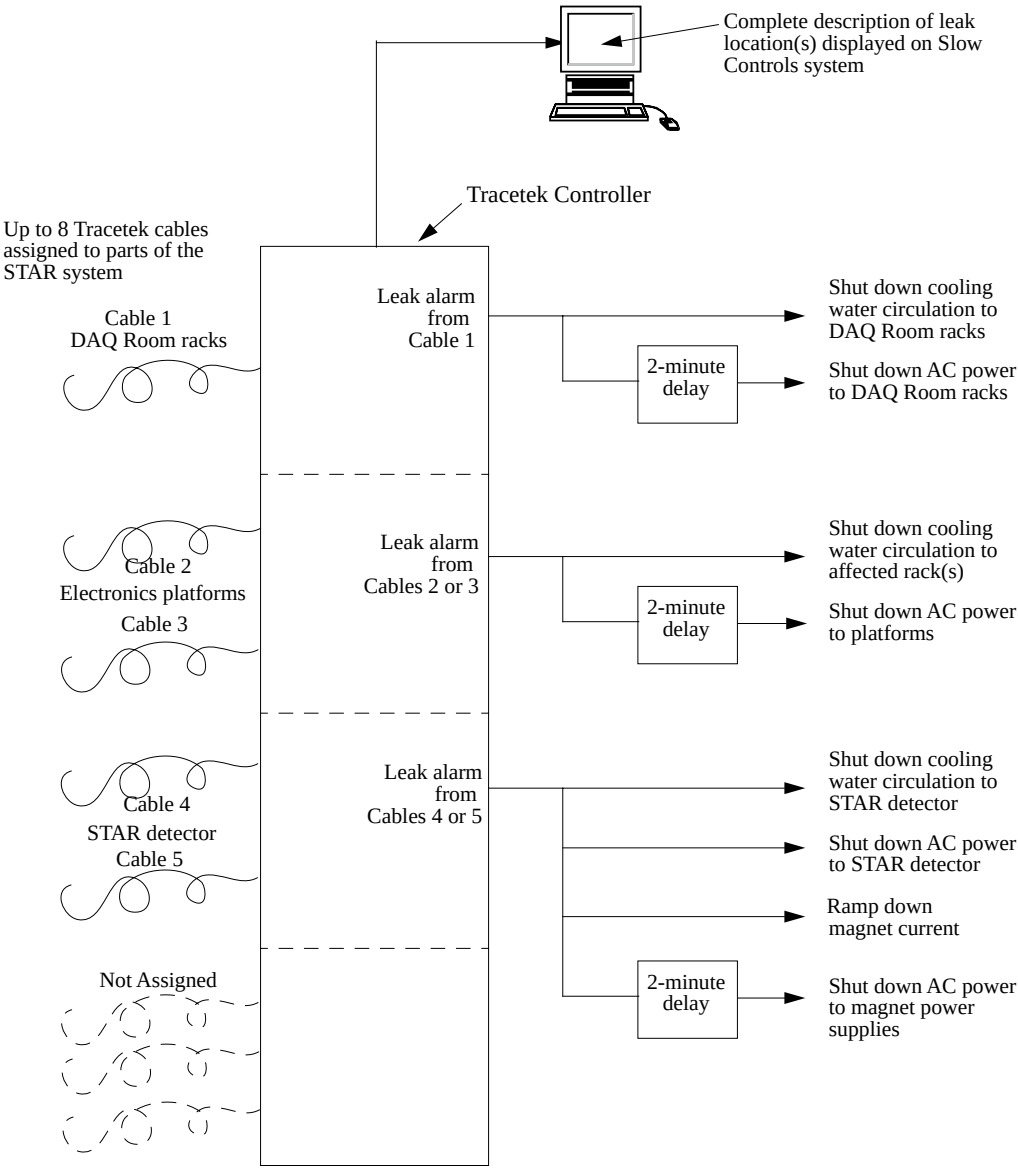


Gas Mixing Room Fire Detection -- Reference: Section 2.7

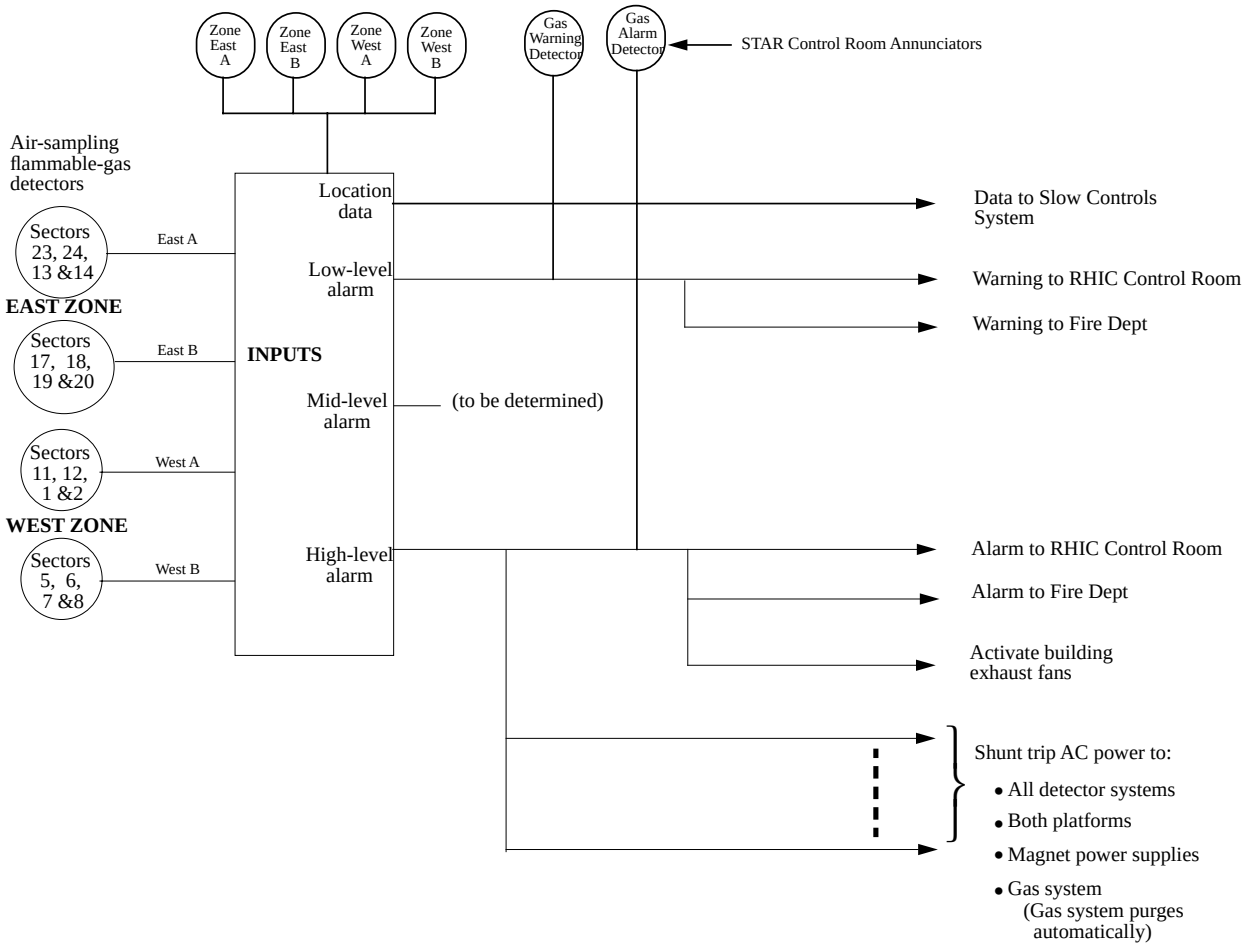


Note: Building power, lights and emergency lights not affected.

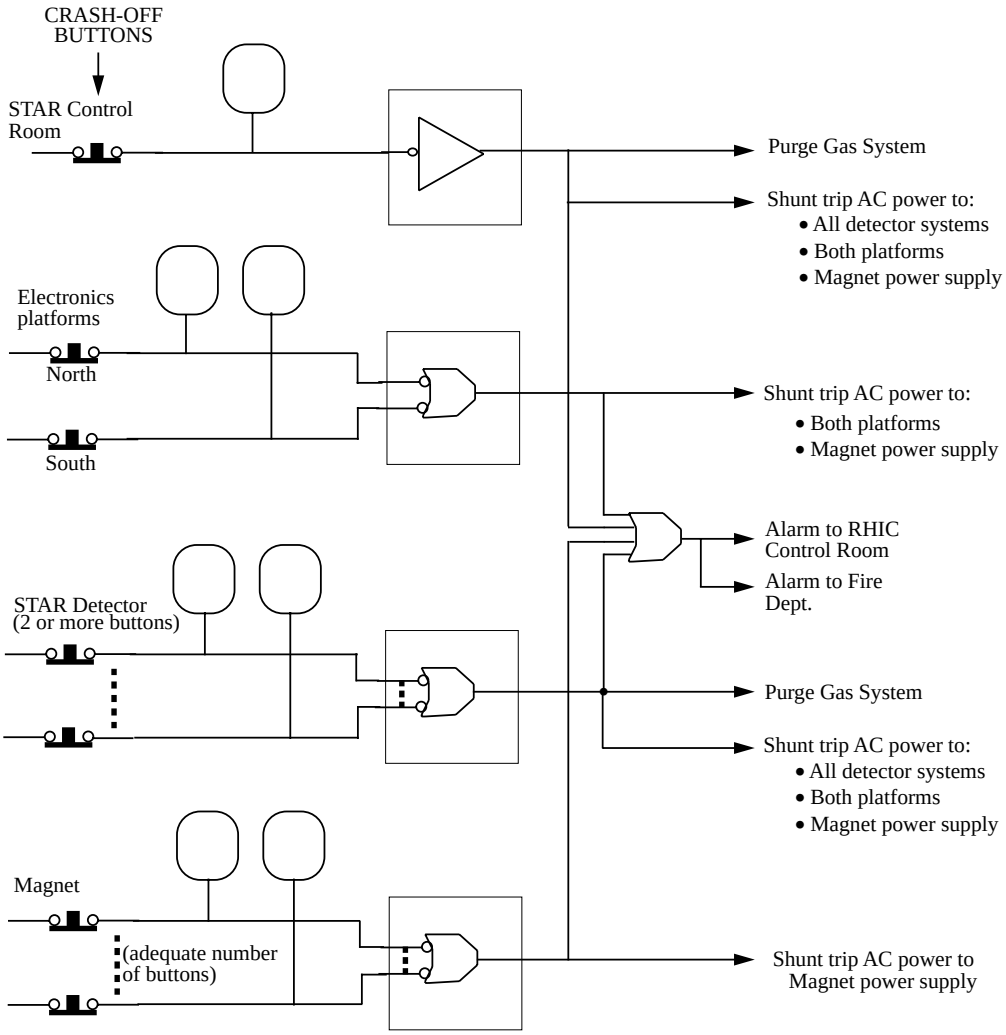
Water Leak Detection for DAQ, platforms and Magnet - Reference: Sections 3.2, 3.3 and 3.4



STAR Detector Gas Detection -- Reference: Section 4.5



Crash-Off Buttons -- Reference: Sections 5.1, 5.3, 5.4, 5.5



= Star Control Room annunciator with appropriate legend indicating location of alarm origin

= Crash-off Button