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Experimental Safety Assessment Document (ESAD)

for the Base Equipment in Hall D

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Contents

Chapter 1

Introduction

The ESAD document describes identified hazards of an experiment and the measures taken to eliminate, control, or mitigate them. This document is part of the CEBAF experiment review process as defined in Chapter 3120 of the Jefferson Lab EHS&Q manual, and will start by describing general types of hazards that might be present in any of the JLab experimental halls. This document then addresses the hazards associated with sub-systems of the base equipment of the experimental hall and their mitigation. Responsible personnel for each item is also noted. In case of life threatening emergencies call 911 and then notify the guard house at 5822 so that the guards can help the responders. This document does not attempt to describe the function or operation of the various sub-systems. Such information can be found in the experimental hall specific Operating Manuals.

Chapter 2

General Hazards

2.1 Radiation

CEBAF's high intensity and high energy electron beam is a potentially lethal direct radiation source. It can also create radioactive materials that are hazardous even after the beam has been turned off. There are many redundant measures aimed at preventing accidental exposure of personnel to the beam or exposure to beam-associated radiation sources that are in place at JLab. The training and mitigation procedures are handled through the JLab Radiation Control Department (RadCon). The radiation safety department at JLab can be contacted as follows: For routine support and surveys, or for emergencies after-hours, call the RadCon cell phone at 876-1743. For escalation of effort, or for emergencies, the RadCon manager (Vashek Vylet) can be reached as follows: Office: 269-7551, Cell: 218-2733 or Home: 772-6098.

Radiation damage to materials and electronics is mainly determined by the neutron dose (photon dose typically causes parity errors and it is easier to shield against). Commercial-off-the-shelf (COTS) electronics is typically robust up to neutron doses of about $10^{13} n/cm^2$. If the experimental equipment dose as calculated in the RSAD is beyond this damage threshold, the experiment needs to add an appendix on "Evaluation of potential radiation damage" in the experiment specific ESAD. There, the radiation damage dose, potential impact to equipment located in areas above this damage threshold as well as mitigating measures taken should be described.

2.2 Fire

The experimental halls contain numerous combustible materials and flammable gases. In addition, they contain potential ignition sources, such as electrical wiring and equipment. General fire hazards and procedures for dealing with these are covered by

JLab emergency management procedures. The JLab fire protection manager (Dave Kausch) can be contacted at 269-7674.

2.3 Electrical Systems

Hazards associated with electrical systems are the most common risk in the experimental halls. Almost every sub-system requires AC and/or DC power. Due to the high current and/or high voltage requirements of many of these sub-systems they and their power supplies are potentially lethal electrical sources. In the case of superconducting magnets the stored energy is so large that an uncontrolled electrical discharge can be lethal for a period of time even after the actual power source has been turned off. Anyone working on electrical power in the experimental Halls must comply with Chapter 6200 of the Jefferson Lab EHS&Q manual and must obtain approval of one of the responsible personnel. The JLab electrical safety point-of-contact (Todd Kujawa) can be reached at 269-7006.

2.4 Mechanical Systems

There exist a variety of mechanical hazards in all experimental halls at JLab. Numerous electro-mechanical sub-systems are massive enough to produce potential fall and/or crush hazards. In addition, heavy objects are routinely moved around within the experimental halls during reconfigurations for specific experiments.

Use of ladders and scaffold must comply with Chapter 6231 of the Jefferson Lab EHS&Q manual. Use of cranes, hoists, lifts, etc. must comply with Chapter 6141 of the Jefferson Lab EHS&Q manual. Use of personal protective equipment to mitigate mechanical hazards, such as hard hats, safety harnesses, and safety shoes are mandatory when deemed necessary. The JLab technical point-of-contact (Suresh Chandra) can be contacted at 269-7248.

2.5 Strong Magnetic Fields

Powerful magnets exist in all JLab experimental halls. Metal objects being attracted by the magnet fringe field, and becoming airborne, possibly injuring body parts or striking fragile components resulting in a cascading hazard condition. Cardiac pacemakers or other electronic medical devices may no longer functioning properly in the presence of magnetic fields. Metallic medical implants (non-electronic) being adversely affected by magnetic fields. Lose of information from magnetic data storage driver such as tapes, disks, credit cards may also occur. Contact Jennifer Williams at 269-7882, in case of questions or concerns.

2.6 Cryogenic Fluids and Oxygen Deficiency Hazard

Cryogenic fluids and gasses are commonly used in the experimental halls at JLab. When released in an uncontrolled manner these can result in explosion, fire, cryogenic burns and the displacement of air resulting in an oxygen deficiency hazard, ODH, condition. The hazard level and associated mitigation are dependent on the sub-subsystem and cryogenic fluid. However, they are mostly associated with cryogenic superconducting magnets and cryogenic target systems. Flammable cryogenic gases used in the experimental halls include hydrogen and deuterium which are colorless, odorless gases and hence not easily detected by human senses. Hydrogen air mixtures are flammable over a large range of relative concentrations: from 4% to 75% H2 by volume. Non-flammable cryogenic gasses typically used include He and nitrogen. Contact Kelly Mahoney at 269-7024 or Mathew Wright at 269-7722 in case of questions or concerns.

2.7 Vacuum and Pressure Vessels

Vacuum and/or pressure vessels are commonly used in the experimental halls. Many of these have thin Aluminum or kevlar/mylar windows that are close to the entrance and/or exit of the vessels or beam pipes. These windows burst if punctured accidentally or can fail if significant over pressure were to exist. Injury is possible if a failure were to occur near an individual. All work on vacuum windows in the experimental halls must occur under the supervision of appropriately trained JLab personnel. Specifically, the scattering chamber and beam line exit windows must always be leak checked before service. Contact Will Oren 269-7344 for vacuum and pressure vessels issues.

2.8 Hazardous Materials

Hazardous materials in the form of solids, liquids, and gases that may harm people or property exist in the JLab experimental halls. The most common of these materials include lead, beryllium compounds, and various toxic and corrosive chemicals. Material Safety Data Sheets (MSDS) for hazardous materials in use in the Hall is available from the Hall safety warden. These are being replaced by the new standard Safety Data Sheets (SDS) as they become available in compliance with the new OSHA standards. Handling of these materials must follow the guidelines of the EH&S manual. Machining of lead or beryllia, that are highly toxic in powdered form, requires prior approval of the EH&S staff. Lead Worker training is required in order to handle lead in the Hall. In case of questions or concerns, the JLab hazardous materials specialist (Jennifer Williams) can be contacted at 269-7882.

2.9 Lasers

High power lasers are often used in the experimental areas for various purposes. Improperly used lasers are potentially dangerous. Exposure to laser beams at sufficient power levels may cause thermal and photochemical injury to the eye including retina burn and blindness. Skin exposure to laser beams may induce pigmentation, accelerated aging, or severe skin burn. Laser beams may also ignite combustible materials creating a fire hazard. At JLab, lasers with power higher than 5 mW (Class IIIB) can only be operated in a controlled environment with proper eye protection and engineering controls designed and approved for the specific laser system. Each specific laser systems shall be operated under the supervision of a Laser System Supervisor (LSS) following the Laser Operating Safety Procedure (LOSP) for that system approved by the Laboratory Laser Safety Officer (LSO). The LSO (Bert Manzlak) can be reached at 269-7556.

Chapter 3

Hall D Specific Equipment

3.1 Overview

The following Hall D subsystems are considered part of the experimental endstation base equipment. Many of these subsystems impose similar hazards, such as those induced by magnets and magnet power supplies, high voltage systems and cryogenic systems. Note that a specific sub-system may have many different hazards associated with it. For each major system, the hazards, mitigation, and responsible personnel are noted.

The material in this chapter is a subset of the material in the full Hall D operations manual and is only intended to familiarize people with the hazards and responsible personnel for these systems. It in no way should be taken as sufficient information to use or operate this equipment.

3.2 Checking Tie-in To Machine Fast Shutdown System

***This paragraph comes from Hall A. Do we need something similar? ***

In order to make sure that hall equipment that should be tied into the machine fast shutdown (FSD) system has been properly checked, the hall work coordinator must be notified by e-mail prior to the end of each installation period by the system owner that the checks been performed in conjunction with accelerator (i.e. checking that equipment's signals will in fact cause an FSD). These notifications will be noted in the work coordinator's final check-list has having been done. System owners are responsible for notifying the work coordinator that their system has an FSD tie-in so it can be added to the check-list.

3.3 Electron Beamline

***The electron beamline section comes from Hall A. It needs to be modified, but I leave the text because we may wish to use some of it for Hall D ***

The control and measurement equipment along the Hall D beamline consists of various elements necessary to transport beam with the required specifications onto the reaction target and the dump and to simultaneously measure the properties of the beam relevant to the successful implementation of the physics program in Hall D. The beamline in the Hall provides the interface between the CEBAF accelerator and the experimental hall. All work on the beamline must be coordinated with both physics division and accelerator division; in order to ensure safe and reliable transport of the electron beam to the dump.

3.3.1 Hazards

Along the beamline these various hazards can be found. These include radiation areas, vacuum windows, high voltage, and magnetic fields.

3.3.2 Mitigation

All magnets (dipoles, quadrupoles, sextupoles, beam correctors) and beam diagnostic devices (BPMs, scanners, Beam Loss Monitor, viewers) necessary for the transport of the beam are controlled by Machine Control Center (MCC) through EPICS [?]. The detailed safety operational procedures for the Hall D beamline should be essentially the same as the one for the CEBAF machine and beamline. Personnel who need to work near or around the beamline should keep in mind the potential hazards:

- Radiation Hot Spots - marked by an ARM or RadCon personnel,
- Vacuum in the beam line tubes and other vessels,
- Thin windowed vacuum enclosures (e.g. the scattering chamber),
- Electric power hazards in vicinity of the magnets,
- Magnetic field hazards in vicinity of the magnets, and

- Conventional hazards (fall hazard, crane hazard, moving equipment under remote control, etc.).

These hazards are noted by signs and the most hazardous areas along the beamline are roped off to restrict access when operational. In particular, the scattering chamber, with it's large volume and thin windows requires hearing protection once it has been evacuated. Signs are posted by RadCon for any hot spots along the beamline and RadCon must be notifed before work is done in a posted area. The terminals of some magnets are covered with plastic sheets for electric safety. Any access to these magnets requires the Lock and Tag procedure [**?**] and the appropriate training, including the equipment-specifc one. Additional safety information is available in the following documents:

- EH&S Manual [**?**]
- PSS Description Document [**?**]
- Accelerator Operations Directive [**?**]

3.3.3 Responsible Personnel

Since the beamline requires both accelerator and physics personnel to maintain and operate and it is very important that both groups stay in contact that any work on the Hall D beamline is coordinated. The list of responsible personnel are given in Table 3.1.

Name	Dept.	Extension [1]	e-mail	Comment
Tech-On-Call	Hall D	7625	elton	Contact

Table 3.1: List of responsible personnel for the electron beamline.

[1] Phone prefixes are the following: Telephone numbers: 757-269-XXXX, Pager numbers: 757-584-XXXX.

3.4 Photon Beamline

3.4.1 Hazards

3.4.2 Mitigation

3.4.3 Responsible Personnel

Since the beamline requires both accelerator and physics personnel to maintain and operate and it is very important that both groups stay in contact that any work on the Hall D beamline is coordinated. The list of responsible personnel are given in Table 3.2.

Name	Dept.	Extension [1]	e-mail	Comment
Tech-On-Call	Hall D	7625	elton	Contact

Table 3.2: List of responsible personnel for the photon beamline.

3.4.4 Cryogenic target

***We probably need to include a section on the cryo target in the ESAD, perhaps pointing to the OSP? ***

3.4.5 Vacuum Systems

***The vacuum systems section comes from Hall A. It needs to be modified, but I leave the text because we may wish to use some of it for Hall D ***

The Hall D vacuum system consists of 5 separate but interconnected subsystems. The largest is designed to supply the Hall D HRS (see Chapter 3.7) with a self-contained 5×10^{-6} Torr vacuum that enables both spectrometers to be pumped down from atmospheric pressure. in a few hours. The target vacuum system is designed to maintain 1×10^{-6} Torr in order to minimize contamination and provide an insulating vacuum for the cryo target. Rough insulating vacuum for the 4 superconducting magnets is provided by a 360 cfm Roots type blower that can be connected to each magnet. The beam line vacuum is maintained by 1 ‘/s ion pump system used in the accelerator ring and a small turbo pump located near the target. The final subsystem is a differential pumping station located near the target exit port.

Hazards

Hazards associated with the vacuum system are due to rapid decompression in case of a window failure. Loud noise can cause hearing loss.

Mitigation

To mitigate the hazard, all personnel in the vicinity of the large chamber with a window are required to wear ear protection when the chamber is under vacuum. Warning signs must be posted at the area. The scattering chamber is equipped with a large 0.016 in aluminum window that allows the spectrometers to swing from 12.5 to 165 on the left side and 12.5 to 140 on the right side. In order to protect this window when the Hall is open, lexan window guards are installed. At the inlet of the sieve slit a 8" diameter 7 mil kapton window is provided to separate the target chamber from the spectrometers. Finally, under the HRS detectors, a 4 mil titanium window is provided. Additionally, all vacuum vessels and piping are designed as pressure vessels.

Responsible Personnel

The authorized personnel is shown in Table 3.3.

Name	Dept.	Extension [1]	e-mail	Comment
Tech-On-Call	Hall D	7625	elton	Contact

Table 3.3: List of responsible personnel for the Hall D target.

3.5 Solenoid

3.5.1 Hazards

3.5.2 Mitigation

3.5.3 Responsible Personnel

The individuals responsible for the operation of the trigger counters are shown in Table 3.4.

Name	Dept.	Extension [1]	e-mail	Comment
Tech-On-Call	Hall D	7625	elton	Contact

Table 3.4: List of responsible personnel for the time-of-flight (TOF) system.

3.6 Detector Gas Supply System

3.6.1 Hazards

3.6.2 Mitigation

3.6.3 Responsible Personnel

The individuals responsible for the operation of the VDC are shown in Table 3.5

Name	Dept.	Extension [1]	e-mail	Comment
Tech-On-Call	Hall D	7625	elton	Contact

Table 3.5: List of responsible personnel for the time-of-flight (TOF) system.

3.7 Forward Drift Chamber

The Forward Drift Chamber (FDC) is a 12,672 channel system consisting of four packages, each having six chambers (cells). Each chamber has a wire plane sandwiched between two cathodes consisting of readout strips. The chambers within a package have independent gas volumes, but are separated with a flexible mylar membrane. Positive (up to 2300V) and negative (up to 500V) HV is applied on the sense and field wires respectively with currents not exceeding 10 μA per HV channel. The detector (including cables) emits a total power of about 1500 Watt, of which about 900 Watt inside the magnet, due to the LV applied on the detector pre-amplifieres; a cooling system using Fluorinert is used to keep the temperature on the pre-amplifiers below 50^0 C.

3.7.1 Hazards

The hazards associated with the HV and LV are discussed in the electronics section of this document.

Damage to the detector can occur if the pressure in the chambers is more than 200 Pa above the atmospheric or if it is below the atmospheric pressure. Damage to the detector can occur if the pressure difference between the chambers within a package exceeds 30 Pa.

Damage to the equipment can occur if the cooling system fails while the pre-amplifiers are powered.

3.7.2 Mitigation

The gas control system is designed in a way to warn and prevent over/under-pressure in the chambers. The internal pressure in the chambers is constantly monitored to prevent high pressure differences between chambers within a package.

A hardware interlock turns off the pre-amplifier supply in case the cooling system fails.

3.7.3 Responsible Personnel

The individuals responsible for the operation of the FDC are shown in Table 3.6

Name	Dept.	Extension [1]	e-mail	Comment
Lubomir Pentchev	Hall D	5470	pentchev	Contact
David Butler	Hall D	????	debutler	Contact
Beni Zihlmann	Hall D	5310	zihlmann	Contact

Table 3.6: List of responsible personnel for the Forward Drift Chamber (FDC) system.

3.8 Central Drift Chamber

The Central Drift Chamber (CDC) is a straw tube chamber with 3522 straws 150 cm in length. The downstream end gas plenum has a thin aluminized Mylar window of 2 mil thickness. The anode wires are from made of 20 μm thick gold plated tungsten. The nominal high voltage (HV) applied to the wires is about 2100V. The detector is in the magnet bore but the electronics is facing upstream passed the end of the barrel calorimeter. A low voltage (LV) system powers the 149 pre-amplifier cards each consuming about 1.5 Watt. That does not include the power dissipated in the cables.

3.8.1 Hazards

The hazards associated with the HV and LV are discussed in the electronics section of this document.

Damage to the detector may occur if the gas pressure inside exceeds ∼200 pascal at the downstream gas plenum.

Damage to the electronics can occur if the cooling system fails while the pre-amplifiers are powered.

3.8.2 Mitigation

The gas control system is designed to prevent over-pressure at the downstream gas plenum by hardware. The internal pressure in the downstream gas plenum as well as the input and output pressure of the detector is constantly monitored and connected to the epics alarm system.

Temperature sensors are installed in the vicinity of the pre-amplifier cards to monitor the temperature and are connected to the epics alarm system.

3.8.3 Responsible Personnel

The individuals responsible for the operation of the CDC are shown in Table 3.7

Name	Dept.	Extension [1]	e-mail	Comment
Beni Zihlmann	Hall D	5310	zihlmann	Contact
David Butler	Hall D	????	debutler	Contact
Michael Staib	Hall D	????	mstaib	Contact

Table 3.7: List of responsible personnel for the Central Drift Chamber (CDC) system.

3.9 Barrel Calorimeter

The barrel calorimeter (BCAL) is a lead-scintillating fiber matrix readout with 3840 S12045 Hamamatsu multi-pixel photon counters (MPPCs). The MPPC light sensors operate at a typical voltage of 75 V. Liquid coolant is circulated through the readout assemblies to set and maintain the temperature of the sensors at their operating temperature between 5 and 25°C.

3.9.1 Hazards

Damage to the equipment can occur if the temperature in the readout assemblies exceeds prescribed limits. If the system reaches low temperatures, condensation can form in the electronics of the readout assemblies. If the chiller fails and the power is on, temperatures will rise uncontrolled and also damage electronics.

3.9.2 Mitigation

An interlock system, based on PLCs, checks the temperature and humidity in the readout assemblies and coolant flow through the system. It shuts off the power to the MPPC electronics and the chiller in case limits are exceeded. Alarms are issued prior to activating the interlock.

3.9.3 Responsible Personnel

The individuals responsible for the operation of the BCAL are shown in Table 3.8.

Name	Dept.	Extension [1]	e-mail	Comment
Tech-On-Call	Hall D	7625	elton	Contact

Table 3.8: List of responsible personnel for the BCAL system.

3.10 Forward Calorimeter

The forward calorimeter (FCAL) is a circular array of 2800 lead-glass blocks, each viewed by FEU 84-3 photomultiplier tubes. The high voltage to operate the photomultiplier tubes is generated internally to the base assembly using a Cockcroft-Walton voltage divider assembly. External supplies deliver 24 V to power the bases.

3.10.1 Hazards

The photomultiplier tubes are operated inside a dark room attached to the back of the lead-glass array, which allows trained personnel to operate the system when the bases are powered. Damage to the equipment can result if the photomultiplier tubes are exposed to room light.

3.10.2 Mitigation

The power to the photomultiplier tubes is interlocked using sensors that verify that the room is dark and closed. Access to the dark room is administratively controlled to trained personnel and crash buttons are installed if an experimenter need to exit quickly. Procedures for use of the dark room and a description of required training are detailed in D00000-01-06-P006.

3.10.3 Responsible Personnel

The individuals responsible for the operation of the FCAL are shown in Table 3.9.

Name	Dept.	Extension [1]	e-mail	Comment
John Leckey	Indiana U.	7625	leckey	Contact
Elton Smith	Hall D	7625	elton	Contact

Table 3.9: List of responsible personnel for the FCAL system.

3.11 Time-of-Flight System

The time-of-flight (TOF) system is an array of plastic scintillator viewed by 2”-diameter Hamamatsu H10534MOD photomultiplier tubes. The photomultiplier tubes are powered using commercial CAEN A1535SN negative high voltage, where the typical operating voltage is 1750 V.

3.11.1 Hazards

The personnel hazard with these devices is the high voltage. This same hazard can damage the equipment if the voltage is left on when a tube is exposed to room lighting.

3.11.2 Mitigation

The high voltage delivery uses CL2 rated cables and SHV high voltage connectors. The maximum HV rating for the photomultiplier tubes is 2000 V, which is limited via EPICS control screens that place limits on HV settings and set current trip levels. ???? The HV cables must be disconnected prior to replacement or maintenance of photomultiplier tubes.

3.11.3 Responsible Personnel

The individuals responsible for the operation of the TOF system are shown in Table 3.10.

Name	Dept.	Extension [1]	e-mail	Comment
Paul Eugenio	FSU	7625	eugenio	Contact
Mark Ito	Hall D	7625	marki	Contact

Table 3.10: List of responsible personnel for the time-of-flight (TOF) system.

3.12 Start Counter

The start counter consists of 30 scintillators surrounding the target, which are read out with Hamamatsu S10931-50P MPPCs. The operating bias for these sensors is 75 V???? The system is air cooled.

3.12.1 Hazards

There are no special hazards associated with the start counter system???

3.12.2 Mitigation

None???

3.12.3 Responsible Personnel

The individuals responsible for the operation of the trigger counters are shown in Table 3.11.

Name	Dept.	Extension [1]	e-mail	Comment
Werner Boeglin	FIU	7625	boeglinw	Contact
Mark Ito	Hall D	7625	marki	Contact

Table 3.11: List of responsible personnel for the start counter system.

3.13 Electronics

3.13.1 Hazards

3.13.2 Mitigation

3.13.3 Responsible Personnel

The individuals responsible for the operation of the trigger counters are shown in Table 3.12.

Name	Dept.	Extension [1]	e-mail	Comment
Fernando Barbosa	Hall D	7625	barbosa	Contact

Table 3.12: List of responsible personnel for Hall D electronics.

3.14 Tagging Spectrometer

The tagging spectrometer resides in the tagger hall. It consists of the dipole magnet and two detector systems: the fixed array hodoscope and the microscope. The fixed array is an array of scintillation counters covering the energy range of 3.048 to 11.78 GeV, excluding the coherent peak range. They are viewed using Hamamatsu R9800 pmts equipped with custom dividers that include an amplifier. The microscope covers the coherent peak range from 8.1 to 9.1 GeV using an array of square fibers. The fibers are viewed using Hamamatsu S10931-050P MPPCs. The MPPCs operate at a voltage of 75 V???

3.14.1 Hazards

Operation of the dipole is controlled by the accelerator to guide the full energy beam to the electron dump. For a 12 GeV-electron beam, the magnet is operated at the nominal current of .....A and .....V. Any changes to its settings must be coordinated with the accelerator machine control center (MCC). Maintenance and servicing of the dipole can only be conducted by trained personnel according to the OSP......The terminals of the magnet are covered by plastic sheets for safety.

- thin window/vacuum
- electrical power

- radiation damage, especially to MPPCs in microscope
- high voltage for fixed array

High Voltage

The high voltage for the fixed array hodoscope is provided using the commercial CAEN A1535SN HV system. The high voltage limits and trip currents are set using the EPICs slow control system. The maximum voltage for the R9800 photomultiplier tube is 1500 V. The HV cables must be disconnected prior to replacement or maintenance of photomultiplier tubes.

3.14.2 Mitigation

Operation of the dipole is controlled by the accelerator to guide the full energy beam to the electron dump. For a 12 GeV-electron beam, the magnet is operated at the nominal current of .....A and .....V. Any changes to its settings must be coordinated with the accelerator machine control center (MCC). Maintenance and servicing of the dipole can only be conducted by trained personnel according to the OSP......The terminals of the magnet are covered by plastic sheets for safety.

- thin window/vacuum
- electrical power

Radiation environment

The radiation environment in the tagger area is more similar to that in Halls A and C, than it is to Hall D. The 5.5 pass electron beam is delivered to the tagger enclosure and dumped in the connected beam dump. Even after the beam is stopped, radiation damage, especially to MPPCs in microscope

High Voltage

The high voltage for the fixed array hodoscope is provided using the commercial CAEN A1535SN HV system. The high voltage limits and trip currents are set using the EPICs slow control system. The maximum voltage for the R9800 photomultiplier tube is 1500 V. The HV cables must be disconnected prior to replacement or maintenance of photomultiplier tubes.

Shielding for microscope. Hearing protection?

3.14.3 Responsible Personnel

The individuals responsible for the operation of the trigger counters are shown in Table 3.13.

Name	Dept.	Extension [1]	e-mail	Comment
Tech-On-Call	Hall D	7625	elton	Contact

Table 3.13: List of responsible personnel for the time-of-flight (TOF) system.