Conduct of Operations for the Hall B *PrimEx* Experiment - September 1, 2004

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1 Preface

As part of its mission, JLab provides the resources necessary for international collaborations of scientists to carry out basic research in nuclear physics and related disciplines. This research must be conducted in a manner that ensures that environmental, health and safety (EH&S) concerns receive the highest consideration. At the same time the programmatic goals of the laboratory require that it produce the highest quality physics results efficiently.

Guidance on how to balance thoughtful, measured EH&S concerns with efficient operation has been taken from the JLab EH&S Committee, the JLab EH&S Manual, and the JLab Director's Office. A graded approach is followed in which the measures taken are matched to the scale, cost, complexity, and hazards of the operation.

This document outlines how approved experiment collaborations will conduct operations in a safe and effective manner during the time period that the *PrimEx* experiment is on the floor. Installation and commissioning periods are not covered by this document. Furthermore, this document is directed to physics users and physics staff rather than the Hall B technical staff. It must be read, understood, and followed by all members of the collaboration.

2 Documentation

This experiment uses the standard Hall B equipment, excluding CLAS. All of the procedures to be used during the course of the experiment are contained in the following documents: [1]

- The Conduct of Operations for JLab Experiments (COO), the document you are now reading.
- Experiment Safety Assessment Document (ESAD) for *PrimEx* (referring to the base equipment as well as any experiment-specific changes)
- Radiation Safety Assessment Document (RSAD)
- Hall B Experimental Equipment Operations Manual (EEOM)
- Personnel Allowed to Operate Hall B Equipment
- JLab Emergency Response Plan

Reference copies of these documents will be available in the Counting House for the duration of the experiment. The present document shall hereafter be referred to as the COO. The Experiment Safety Assessment Document shall hereafter be referred to as the ESAD, and the Radiation Safety Assessment Document shall be referred to as the RSAD. The ESAD and COO may also be

[1] The process is documented at http: //www.jlab.org/user_resources/PFX/.

available on the WWW at an experiment-specific web site. **The COO, the ESAD and the RSAD are required reading for shift personnel.**

A full description of the physics motivation for the experiment, collaboration list, and the general plan for carrying out the experiment can be found in the proposals for E-02-103, *A Precision Measurement of the Neutral Pion Lifetime via the Primakoff Effect*, to the JLab Program Advisory Committee (PAC).

3 Shift Personnel Training

All personnel on shift are required to have successfully completed and be current in the following JLab safety training:

- EH&S Orientation (SAF 100)
- Radiation Worker Training (SAF 801)
- Oxygen Deficiency Hazard Training (SAF 103)
- Hall B Safety Awareness Walk-Through (SAF 111)
- Conduct of Operations (SAF 121)

All experiment personnel are required to have radiation badges in their possession during their shifts. The Safety Awareness Walk-Through will emphasize any hazards that are peculiar to the current experimental setup. In addition, all shift personnel will be trained in the safety procedures to be followed for access to the Hall. This training will include a brief discussion of the purpose and operation of the Personnel Safety System (PSS) for the Hall. Individuals within the collaboration may be required to have other, equipment or procedure-specific training. The need for such training shall be determined by the experiment spokespersons in consultation with the Hall Leader and Physics Division EH&S personnel.

In addition, experiment personnel must familiarize themselves with the sections of the JLab EH&S Manual relevant for their work in the Hall. A reference copy of this document is available in the main hallway of the Counting House. It is also available via http://www.jlab.org/ehs/manual/EHSbook.html

Finally, JLab Lock and Tag[2] training is required for all staff/users who will be performing maintenance on electrical and mechanical equipment which cannot be physically and verifiably isolated from an energy source.

4 Organization and Administration

The operation of the experiment is directed by the Spokespersons and the Hall Leader, Volker Burkert. An organization chart for the experiment is found in Figure 1.

[2]The EH&S Manual provides Lockout/Tagout information in Section 6110.

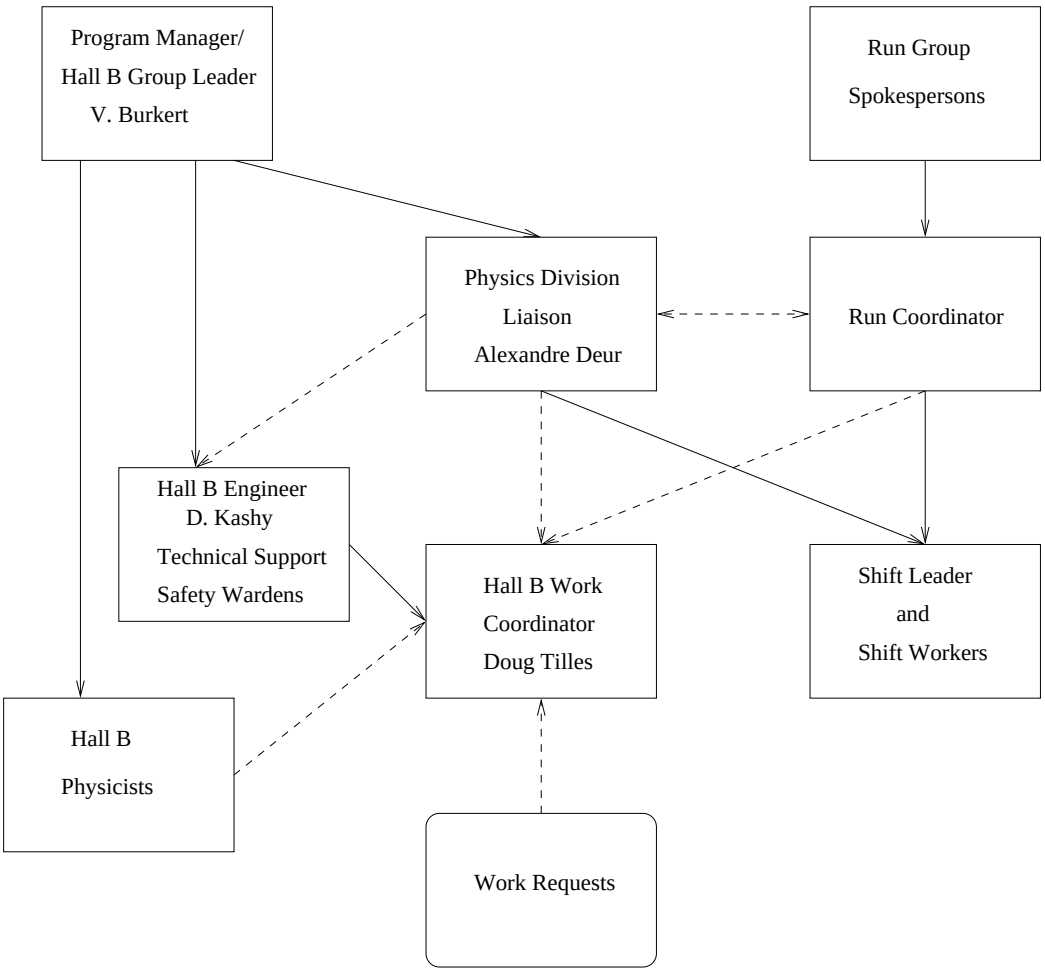


Figure 1: Functional Organization of the Hall B - *PrimEx* Team. Dashed lines indicate information flow, solid lines indicate responsibility.

4.1 Run Coordinator

The Run Coordinator is the immediate on-site manager of the experiment and is responsible for ensuring that the physics goals of the experiment are met. This individual is designated by the experiment spokespersons and approved by the Hall Leader. The Run Coordinator shall ensure that the Hall Group Leader, Physics Division Liaison, and at least one Spokesperson are aware of all pertinent issues. The Run Coordinator shall promote an environment in which the highest safety standards are maintained. The functions of the Run Coordinator are:

I. To manage daily operation of the experiment:

- to ensure that the run plan is clear to the shift workers.
- to define the data quality appropriate for the goals of each shift.
- to track the progress of the experiment.
- to coordinate and schedule activities (*e.g.*, Hall accesses) in order to optimize productivity.
- to ensure that an experiment checklist is completed every 24 hrs during standby shifts.
- together with the Physics Division Liaison, to ensure that the counting house is manned appropriately: *i.e.*, sufficient personnel are present to safely carry out the experimental program or monitor the apparatus as needed.

II. To coordinate interactions between JLab and the experiment. This entails:

- informing the Program Deputy of the experiment's status and plans at a 7:45 AM meeting in the MCC during the working week, and at an agreed upon time on weekends or holidays.
- representing the collaboration at the 8:00 AM meetings in the MCC during the work week.
- attending the 1:30 PM Wednesday scheduling meeting in the MCC conference room to represent the collaboration and to present a report on the proceeding week.
- remaining in the local area and being available by cell-phone/pager at all times. (If temporarily unavailable, the Run Coordinator must designate another qualified collaborator as a replacement.)
- in conjunction with the Hall Work Coordinator, scheduling work by groups outside the collaboration.

- interact with the Accelerator Program Deputy to plan and conduct unscheduled activities.

III. To submit a written report to the Hall Leader which includes run time statistics and a description of any significant problems with the Hall instrumentation.

4.2 Physics Division Liaison

Broadly speaking, the Physics Division Liaison to the experiment is a Hall B staff member selected by Volker Burkert to oversee the hall's interests with respect to personnel and equipment protection.[3] This is true for all three halls. However, the role of the Physics Division Liaison may include other responsibilities depending upon the experiment and other factors. His/her responsibilities include:

- Oversee that proper rules of safety are carefully followed in the conduct of the experiment.
- Approve a Hall status change to Restricted Access in coordination with the Hall Work Coordinator.
- Training verification of shift workers.
- Together with the Run Coordinator, ensure that the counting house is manned appropriately: *i.e.*, sufficient personnel are present to safely carry out the experimental program or babysit the apparatus as needed.

4.3 Hall Work Coordinator

The Hall Work Coordinator's responsibilities are:

- to act as the **single point of contact for all work in the hall.**
- to determine if the scheduled activities in the hall can be done safely. These activities shall be coordinated with the Physics Division Liaison and the Run Coordinator.
- to ensure that workers are properly trained, are familiar with all significant hazards, and are aware of all applicable work control documents associated with the project.
- in coordination with the Physics Division Liaison, ensure that the hall apparatus is made safe before giving permission to make a transition to Restricted Access (*e.g.*, turn off unused magnets, install protective shields as needed, fulfill specific requirements in the ESAD, *etc.*).

[3] The responsibilities described here correspond to those of the Physics Division Liaison during the operating phase of the experiment as outlined in the EH&S Manual Section 3120/Glossary.

4.4 Shift Leader

Each shift is led by a Shift Leader. The selection of shift leaders is the responsibility of the Run Coordinator and Physics Division Liaison. The Shift Leader has the following responsibilities:

- to carry out the scientific program planned for the shift in a safe and efficient manner.
- to ensure that the logbook contains a complete and accurate description of the events and actions which occurred during the shift.
- to serve as primary contact between the machine control center (MCC) and experiment personnel.
- to oversee that hall equipment is operated properly.
- to ensure the shift checklist is performed every eight hours on operating shifts.
- to ensure that equipment malfunctions are properly labeled and locked-out if necessary and to communicate this to shift personnel and subsystem experts.
- to note in the logbook when workers from outside groups (such as survey and alignment) stop by the counting house before entering the hall when in Controlled Access. Furthermore, to confirm that these workers have communicated with the Run Coordinator and the Hall Work Coordinator.
- to coordinate the response of the shift crew to any emergency situation, including the notification of appropriate individuals as outlined in the JLab Emergency Response Plan.
- to ensure that in any emergency situation the experiment Physics Division Liaison, Run Coordinator, and Hall Leader are notified immediately.
- to notify the Run Coordinator and the Hall Leader, if the hall is down due to equipment failure for more than four hours.

The Shift Leader has the following authority:

- to assign tasks to the shift members as needed.
- to request that the state of the hall be changed (Request for a change to Restricted Access must be approved by the Physics Division Liaison.)
- to limit the number of people in the Counting House or hall if required to effectively and safely carry out the experiment.
- to limit access to hall on-line computers if required to effectively and safely carry out the experiment.

- to authorize qualified personnel to make modifications in the experiment configuration within the allowed parameters, as specified in the EEOM.
- to authorize time accounting for the shift.

4.5 Shift Member

The responsibilities of each shift member are to:

- carry out the scientific goals of the shift in a safe and efficient manner under direction of the shift leader.
- read the logbook to be aware of changes in goals, operating parameters, and new documentation.
- monitor the equipment for problems.
- maintain adequate records of the progress of the shift.
- be present before the start of each shift and coordinate current operating conditions with the previous shift.
- keep all training up-to-date.

5 Operating Procedures

5.1 Shift Routines

There are two types of shifts for active hall experiments: Operating and Standby. Operating shifts are the normal status when beam is available for the experiment. Standby shifts are periods designated by the Run Coordinator when beam is not available or not in use in the hall and none of the equipment, except for the target, requires continuous monitoring. Standby status may result from normal operational planning or from abnormal conditions such as a major down time due to equipment failure.

5.1.1 Operating Shifts

During operating shifts, 24 hour occupation of the counting house area will be maintained by crews of at least two persons [4] in 8 hour shifts. One person per shift is designated as the Shift Leader.

The number of persons assigned to a shift will depend on the tasks assigned during the shift. A shift schedule will be posted in the Counting House listing the times and names of personnel on shift and identifying the Shift Leader and Run Coordinator. The shift schedule may be available at an experiment-specific website. The Run Coordinator may also designate and supervise other teams for duties such as offline analysis.

[4] The readiness review committee may require more personnel depending on the complexity of the experiment. Two people are the minimum required for safe operations.

5.1.2 Standby Shifts

During Standby shifts, shift personnel are not required to be on site at JLab but must be available through telephone contact to come in if they are needed. Monitoring the target system can require the presence of a Target Operator during a standby shift. The Target Operator then also acts as Shift Leader. The Run Coordinator will ensure that the shift checklist is executed at least once every 24 hours.

5.1.3 Operations Turnover

The electronic log book, accessible from the web, is a very effective means of remotely obtaining information about experimental operations. This allows experimenters to log in remotely and view all log book entries prior to commencing their shift. Information which can only be recorded in the paper log book, should be noted accordingly and communicated between incoming and outgoing shift personnel directly.

Efficient and effective shift changeovers during experiment operation are enhanced by overlapping shifts. Therefore, whenever possible, shift leaders and workers are scheduled in shifts that are staggered by four hours, leading to an overlap of half a shift.

5.1.4 Timely Orders to Operators

The initial run plan is the responsibility of the Run Coordinator and shall be clearly recorded in the log book. This plan specifies the tasks to be performed in the next 48 - 72 hours, including any special conditions or data runs, updated documentation and its location and/or alternate plans. Any changes to the run plan shall be recorded in the log book and the white board in the counting house.

5.1.5 Operator Aid Postings

The day-to-day schedule, contact instructions for key personnel, and any other information relevant to current activities are located on the white board in the Counting House. Shift personnel should consult the white board, especially at the beginning of their shift, to be aware of any updates to current running conditions.

Information pertaining to activities in Hall B must be posted on the bulletin board or written on the white board at the entrance to the hall.

5.2 Hall Access

Access to the hall will be governed by the JLab Beam Containment Policy[5], and work in designated radiation areas will be carried out in accordance with the JLab RadCon Manual. In particular, no material may be removed from the hall

[5] EH&S Manual, Appendix 6310-T2.

after beam delivery without proper approval from the RadCon Group.[6] During operations, no one is allowed in the hall without either being accompanied, or informing shift personnel and checking in on a regular basis.

During a running experiment the hall will normally be in Beam Permit. When temporary access to the hall is needed the Shift Leader can ask the MCC to bring the hall to Controlled Access. If long term access to the hall is required, the Shift Leader may request the hall be brought to Restricted Access. Such a request requires prior approval from the Physics Division Liaison, while the actual transition will be supervised by the Hall Work Coordinator.

Restricted Access is a state where delivery of beam and/or RF power is not permitted, and entry to and exit from the hall is not controlled by the Personnel Safety System. This is the normal state of the hall when the accelerator is off and no experiments are running. Access is "restricted" only in the sense that the hall is not open to the general public. Well-defined check-list procedures are to be followed whenever the hall is brought to and from Restricted Access.

Restricted Access is the period when all major work must be completed in the hall. Consequently, all activities require advanced planning and must be scheduled for resources and safe operation. In order to streamline the activities in the hall and ensure everyone has ready access to the current status and requirements for work, there are two important resources:

- Single point of contact, which is the "Hall Work Coordinator"
- Information board at the entrance to the hall

All work must be scheduled through the Hall Work Coordinator. The content on the information board is the responsibility of the hall safety wardens and the Hall Work Coordinator. The information board will contain all critical information required for safe entry into the hall. This information will include a succinct, one page safety summary covering the hall's current safety hazards and mitigating measures (to be read by all persons working in the hall), active Operational Safety Procedures (OSPs) and Temporary Operational Safety Procedures (TOSPs), required temporary work permits (*e.g.*, Radiation Work Permits), current activities in the hall, points of contact, and required training and safety equipment.

5.3 Collaboration Request for Laboratory Resources

The collaboration may request additional services from Accelerator Division through the Accelerator Division Liaison, Hari Areti. Alternatively, the collaboration may also request additional services from hall personnel through the Physics Division Liaison. These requests should be noted in the logbook. Some requests may require that an SOP, OSP, or TOSP be developed. Major, abnormal, or unanticipated configuration modifications such as stacking or movement of significant shielding, unanticipated vacuum work, unanticipated beam line

[6] For Hall B, approval is only required for equipment along the beamline. For Hall A, approval is not required for equipment inside the detector shielding huts.

modifications, the replacement of a wire chamber, *etc.*, require approval of the Hall B Leader, Volker Burkert [7], and the use of appropriate personnel. The Hall Leader may require that a SOP, OSP, or TOSP be prepared.

5.4 Scheduling of Work by Outside Groups

Work in the hall that is to be performed by groups outside the collaboration such as survey and alignment, plant services, air conditioning, *etc.*, must be scheduled so that it does not endanger personnel or equipment or interfere with the experiment. Non-emergency activities by these groups should be scheduled to coincide with the planned accelerator maintenance periods. To maximize efficiency, the Run Coordinator (representing the collaboration) and the Hall Work Coordinator (representing Hall B) will concur on work scheduling. The Hall Work Coordinator's job is to coordinate activities in the hall so that work can take place smoothly and safely and to insure that multiple activities do not interfere.

The Work Coordinator and the Run Coordinator will meet as needed to plan the work scheduled for the upcoming maintenance period. The product of this meeting will be a list of work in the hall, the required access state of the hall (Controlled or Restricted), appropriate work control documents, and educational or other safety measures (such as escorts) that are needed.

5.5 Control of Equipment and System Status

The operation of the experimental equipment is documented in the Hall B Experimental Equipment Operations Manual. This document includes information on the normal response to alarms and equipment malfunctions. Supplementary information specific to the *PrimEx* experiment may be found in the ESAD.

The document "Personnel Allowed to Operate Hall B Equipment" lists the authorized subsystem experts. This list may be amended as necessary to reflect personnel and training changes with the signed authorization of the subsystem expert. A copy of these amendments will be attached to the main document and kept in the Counting House.

All general equipment installation, maintenance, and testing activities are to be carried out in accordance with the JLab EH&S Manual.

5.5.1 Equipment and Piping Labeling

The experiment and hall equipment shall be properly labeled so it can be quickly identified by both shift and maintenance personnel. Proper labeling helps prevent incorrect operation or modification of equipment by non-experts and facilitates proper and efficient operation by qualified personnel. Labeling also

[7] Configuration changes as outlined above can affect site boundary dose and the production of airborne radioactivity. They require consulting with RadCon or EH&S personnel, as appropriate.

increases the likelihood that proper procedures will be followed in case of emergency.

Improper labels should be corrected immediately if possible. Otherwise, the Shift Leader should be notified so that correct labeling can be requested from the qualified expert.

5.6 Independent Verification

The Run Coordinator will provide the shift crew with a set of measures for checking the quality of the experimental data. The up-to-date Hall B shift checklist (and instructions) shall be made available to shift personnel at hall-specific sites on the data acquisition computers. The checklist will be completed at least once per shift during operating shifts and once per day during standby shifts. Additional items may be added to the list by the Run Coordinator or subsystem experts.

The Hall B Experimental Equipment Operations Manual provides more general check lists for closing the experimental Hall and conditions when the Hall is used as an accelerator dump.

5.7 Logkeeping

Shift personnel will update the electronic logbook, which serves as the record of the experiment. The quality of the information recorded in the logbook determines the utility of the data. All data recorded electronically will be referenced in the computer logbook with the appropriate run number and run information. All relevant activities are to be recorded, including all changes of experiment conditions and equipment failures.

Checklists performed using Hall B-specific forms should also be scanned into the computer logbook when completed. The completed paper forms should be stored in a binder in the counting house. All deviations from normal operating parameters shall be recorded in the logbook.

The computer logbook will also serve as the primary reference for the determination of the operational efficiency of the experimental apparatus in the Hall. As such it is essential that it provide an accurate record of the capability of the equipment to carry out the intended research program. Finally, the computer logbook is the place of record for all safety issues and introductions of new or updated documentation and procedures.

A Special Procedures for Hall B

A.1 Buddy System

The buddy system is mandatory for work in Hall B. No one may enter Hall B without having identified a specific partner. Communication between the two people responsible for each other shall occur no less often than every five minutes until both have exited the hall.

A.2 Guidelines for Efficient Operation

The following guidelines are suggested for using the expert support available to the shift personnel:

- In case of problems with a specific system such as DAQ, drift chambers, PMT detectors, beamline components, *etc.*, spend no more than 10 min (day/swing) or 20 min (owl) trying to fix the problem unless you have a **clear picture** of how to fix it.
- Call the **expert** pager after not more than twenty minutes of trying **at any time**.
- In case the **expert** pager is not answered, call the next person on the list (the "Current Run Information" binder contains this information) or the Physics Division Liaison.

A.3 *PrimEx* Data-Taking Shift Policy

A.3.1 General Policies

PrimEx shifts are to be manned by two people at all times, one shift expert (or "leader") and one shift worker. Expert shifts start at 00:00, 08:00 and 16:00 and worker shifts start at 04:00, 12:00 and 20:00. The current shift schedule and shift-schedule editor are available at

$$http://clasweb.jlab.org/cgi-bim/clas_shift/SHIFTS/welcome.pl$$

This document only deals with general shift-taking concerned with experimental data-taking. It does not deal with specialized shift-taking concerned with a particular detector or software element.

A.3.2 Shift Taker's Qualifications and Conduct of Operations

Workers

All members of the *PrimEx* Collaboration are eligible for worker shifts.

New graduate students may be assigned *PrimEx* shifts. Undergraduate students may not be assigned shifts without prior approval of the Physics Division

Liaison (PDL, formerly known as the CLAS Chief of Operations or COP). Prior to taking his or her first-ever scheduled shift, a person must be an observer on at least one shift in order to become familiar with procedures and (typically) to finish reading the required documents listed in the COO.

Experts

The list of expert shift takers who can act as shift leaders is determined by the PDL, who is responsible for the safe and effective operation of the system. Expert status implies experience in running Hall B shifts, not necessarily expert knowledge of hardware and software components of the system.

Oral communication skills that enable effective communication with the accelerator staff are required for shift leaders. The PDL must be satisfied that any given shift leading expert has adequate language skills. If an individual is not qualified as an expert, the shift schedule page will not accept him or her for an expert shift. In general, the PDL has the authority to reject a person for a shift if he or she thinks that the person is unqualified. If a shift goes unfilled, either by no-show or no-qualify, the incident will be brought to the attention of the *PrimEx* management for possible action.

B Special Procedures for the *PrimEx* Run

While much of the instrumentation used in the *PrimEx* run will be standard Hall B instrumentation, the use of the new *PrimEx* hybrid calorimeter in Hall B requires some special considerations. In particular, (1) the calorimeter will entail nearly 2000 new high voltage channels and (2) the HYCAL will be remotely moveable.

B.1 The HYCAL high voltage system

The executable "primexHV" which is used to control the HYCAL high voltage is under password protection. There are separate passwords to log in as an Adminstrator with full read/write access, User with limited read/write, and as a guest with only read priveleges. We will use the Admin configuration during commissioning to calibrate the gains on each of the 2000 + HV channels. We will then switch to a specially configured "user" mode for the physics run.

As it is extremely important that the voltages not be inadvertently changed, the Admin password will be restricted to only a few people qualified to change HYCAL HV settings. These people are the expert shift takers.

There is a built in crate definable High Voltage limit that can be set across a whole board. In principle, this can prevent too high of a voltage being placed on a PMT and thus damaging it. However, we are unable to use this feature due to the mixing of Lead Glass and Lead Tungstate detectors on the same board. The maximum voltage for a Lead Tungstate is simply too low for the Lead Glass PMTs to function. Therefore, a software limit has been implemented. This safeguard is based on our naming convention for our detectors. All channels with a "W" as the first letter of their name have a maximum writable voltage of 1300V. Lead glass is similarly protected. The veto counter, light monitoring system, and total absorption counter (TAC) voltages will also be protected in this manner. As long as this naming convention is respected and any changes registered with the maintainers of the code, this protection should be adequate.

The CAEN SY1527 are interlocked to the door, moisture, and chiller interlocks. If an interlocked door is opened, moisture detected, or if the chiller is disabled, the HV is shut down. This prevents damage to the PMTs (w.r.t. the first two interlocks) and prevents rapid heating of the interior of HYCAL (w.r.t. the last interlock), which are vital to the health of the Lead Tungstate.

HV_status_mon: A (separate from "primexHV") status monitoring program will query all channels every 30 seconds regarding trip, over/under voltage conditions, disconnections, disabled, overcurrent and power on/off status. Errors will be written to a file local to the Linux machine running "primexHV" and to either or both the CVS repository or to the PrimEx website for archival and online purposes.

A hardware TTL signal from the SY1527 to the Counting House will also be implemented. This signal will be an OR of all possible status errors that will affect crate and board operation. All of these status errors will generate a message in "HV_status_mon".

B.2 HYCAL motion control

B.2.1 Overview

The purpose of this section is to describe the theory and operation of the Hall B HYCAL transporter control system. Although the system will be controlled via EPICS software, this document will only cover the electronic hardware used to control and interlock the system. There is a distinction made between Software (EPICS) and hardware (electronic) control of the transporter. All hardware interlocks will supersede any software limits that may be implemented. A basic overview of all components involved, theory of operation, and a detailed breakdown of each item that a technician may use to repair or modify the system is provided in this document.

B.2.2 Theory of Operation

The system is composed of two stepper motors that move a large transporter in the X and Y axis (See figure 2). Each axis has hardware switches that limit its path of motion. In addition to end limit switches at the edges of axis travel, there are home switches in mid travel that will facilitate easy positioning during an experiment. To determine the exact location of the transporter, digital and analog encoders are used to transmit its position. The transporter is controlled by our standard EPICS software interface, and there are hardware interlocks installed to prevent unwanted movement of the transporter.

The transporter operates in two modes: normal mode and storage mode. The normal mode is used during an experiment when the transporter is positioned within its normal operation limits. The storage mode is used when the transporter must traverse higher in the Y axis than normal. This is used to clear the area for other experiments or work that may need to be done in the hall.

B.2.3 System Requirements

During normal operation, the system must stay within set boundaries in the beam-line area. This area will be kept clear during an experiment, minimizing the damage risk to personnel and equipment.

During transporter storage, operator alertness is essential. The transporter will traverse the height of the space-frame and an operator must ensure that the path is clear at all times.

Under any operational condition the transporter must be checked for mechanical problems that may arise. Drive-train problems, movement of the transporter outside of preset limits, and unbalanced loading are all examples of events that may cause damage to personnel and equipment. Interlocks have been designed into the system to stop all transporter movement in the event of a problem. With these precautions and operator alertness, the transport will operator efficiently and safely.

B.2.4 Hardware Interlocks

There are two modes of operation, normal mode and storage mode. The main difference between the two modes is the height of the transporter in the Y axis. Above a certain height, an operator must be more alert to the movement of the transporter. A different set of hardware interlocks is used in each of the two modes.

The following hardware interlocks are used during normal mode:

1. Pitch and roll tilt sensors
2. Emergency stop buttons
3. Analog Y-axis encoder

The following hardware interlocks are used during storage mode:

1. Pitch and roll tilt sensors
2. Emergency stop buttons
3. Dead-man switch
4. X center limit switch

During normal operation, all transporter movement will stop in the event of a tilt sensor alarm, an emergency stop button is depressed, or the analog encoder goes above a predetermined Y-axis range.

During storage operation, all transporter movement will stop in the event of a tilt sensor alarm or emergency stop button is depressed. The transporter must have the dead-man switch depressed and the X-axis centered for any movement in the Y-axis.

See figure 4 for a logic diagram.

B.2.5 Hardware Layout

The main transporter system is located on the space-frame. Its normal operating range during an experiment is limited to travel around the beam-line area, and when stored it is positioned much higher in Y and limited to a centered position on the X axis.

The control system is located on level 2, North-East side of the space-frame. A rack contains the VME crate and the Motor Driver chassis. All hardware

interlocks are housed in the Motor Driver chassis. When an interlock has been generated, power to the axis X and/or Y motor is removed via an All Windings Off (AWO) selection at the driver. This prevents motor movement at the end of the control chain. Hardware interlocks supersede any other control logic used. Please see figure 2 for the hardware layout.

Listed below are the major hardware components of the system:

- Stepper for motors X and Y motion.
- Dual upper and lower limit switches per axis.
- Home limit switches, X and Y axis.
- Emergency stop buttons.
- Dead-man switch.
- X center limit switch.
- Tilt sensor box.
- Analog encoder for position monitoring and interlocking of the Y axis.
- Two digital encoder for positioning on Y axis and one on the X axis.
- Motor Driver Chassis.
- VME crate with IOC.
- VME Motor Driver control board.
- VME Motor Driver ADC board.

B.2.6 System Components

A schematic diagram of the connections among the following system components is shown in figure 3.

VME Crate

The VME crate is located on level 2 of the space frame NE side. It contains the Input Output Controller, Motor Driver Board, and the Analog Input Module.

MVME 2306 IOC Board

The IOC controls the entire crate and serves variable to EPICS so that a software interface may be used to control the transporter. Refer to reference [1] for more information.

OMS VS-040 Motor Driver Board

This board receives command from the IOC and transmits motor movements to the Motor Driver Chassis. As well, it receives inputs from the digital encoders

via the Motor Driver Chassis for use by EPICS. Refer to reference [2] for more information.

XVME-560 Analog Input Module

The XVME-560 board is used to convert signals from the analog encoder and the tilt switches into a format usable to EPICS. This is for EPICS use only. In addition, both the analog encoder and the tilt switches are hardwired to the interlock system. Refer to reference [3] for more information.

Motor Driver Chassis

The Motor Driver Chassis houses two motor driver modules for the X and Y axes, a VME break-out board, and a hardware interlock board. All system hardware interlocking is implemented through this chassis. All hardware interlocks override any software interlocks that may be in place. A triggered interlock will remove power from its associated motor by using the All Windings OFF (AWO) selection at the driver module. Please see: figure 3, figure 4, figure 5, and figure 6.

Interlock Board

The Interlock Board in the Motor Driver chassis is the heart of the interlock system. This board controls two relays that supply power to the X and Y axis motor driver modules. If the interlocks are not made, no power will be available to drive a motor in a any direction. The board has bypass switches and indicating lights so that it may be easily modified by a technician to meet non-standard system interlock requirements. Please see: figure 6.

Stop Buttons

Four stop buttons are provided that will prevent movement of the transporter in the X and Y axis. The switches must be pulled back out to reset the interlock. There is one switch per level of the space-frame and one in the Hall B Counting House. The stop switches enable a constant high voltage level to the Interlock Board. If it is removed, power to the X and Y drives will be disabled. If the cabling for the stop switches is unplugged, the interlock will automatically disable the drives.

Dead-Man Switch

The dead-man switch is used to insure an operators physical presence when moving the transporter in the storage mode. It is a momentary on push button that must be depressed to meet the interlock requirements of the Motor Driver Chassis.

Tilt Switches

The Tilt Switches sense pitch and role of the transporter. There is a sensor box on the transporter and a control module in the control rack on the second level of the space frame. The control module provides input to EPICS and interlock inputs to the Motor Driver chassis that must be made to meet interlock

requirements for system operation. It is wired in a similar fashion as the Stop Switches in that an unplugged cable will prevent motor driver operation. Refer to reference [4] for more information on it hardware.

B.2.7 Summary

While the operators of the transporter must be trained in its use, there are important measures designed into the system to prevent damage to personnel and the system. The hardware interlocks supersede any software interlocks that may be put into place, and will ensure the system is in a safe state in the event of an error or malfunction.

References

[1] Motorola Inc, *MVME162 Embedded Controller User's Manual*

[2] Oregon Micro Systems Inc, *OMS Intelligent Motor Controllers User's Manual*

[3] XYCOM Inc, *XVME-560 Analog Input Module*

[4] Rieker Electronics Inc, *RDDR16-4-a Manual*, *http* : *//www.riekerinc.com/DigitalInclinometers.htm*

C Hall B Checklists - Preparing for Beam

The following basic check list shall be completed prior to closing Hall B in preparation for beam.

Table 1: General Checklist of Hall B and Beamline - Preparing for Beam. The following checklist was completed on .....

System	Contact	Initial
Call list	Hall B PDL	
Cryogenic Target	Christo	
Beamline	Stepanyan	
GUI's exercised, IOC's up		
Beam halo PMT's and BOM turned on		
Harps are ready		
Radiator, collimator out of beam		
1nA cavity BPMs operational		
Viewer screen on video		
Magnets	Bruhwel	
LCW flow rate turned up		
Magnets swept for magnetic material		
All magnets turned on and in remote		
Valves checked for extraneous lock outs		
Sniffer System	Brooks	
Fire Safety Inspection	Tilles	
Remove cables above all crates in racks		
Remove all transient trash		
Remove all transient ignition sources		
Test the fire early-warning system		
Grounding straps to fwd carriage and clam shell		
VESDA ok?		
HYCAL	Ito	
Transporter clear		
***PrimEx* TAC and scintillating fiber monitor**	Ito	
Transporter clear		
Cabled up		
Data Acquisition	D. Lawrence	
CLON cluster and networks ready	V. Sapunenko	
Final house keeping	Tilles	
Final walk-through	Manzlak	

D Hall B Checklists - Preparing for Photon Beam

When preparing for a photon beam run, this checklist must be completed in addition to the previous "Preparing for Beam" checklist.

Table 2: Checklist - Preparing for Photon Beam. The following checklist was completed on .....

System	Contact	Initial
Tagging Spectrometer Shutter	E. Pasyuk	
Must be OUT		
Tagger counters and trigger	E. Pasyuk	
All HV and signal cables checked		
E and T signals to scalers checked		
T-counter programable logic checked		
Photon Devices Control GUI working		
Beamline	S. Stepanyan	
Check Beam Delivery is interlocked to Tagger Magnet		
TV camera and light on the tagger dump viewer checked		
PS, TAC and photon profilers		

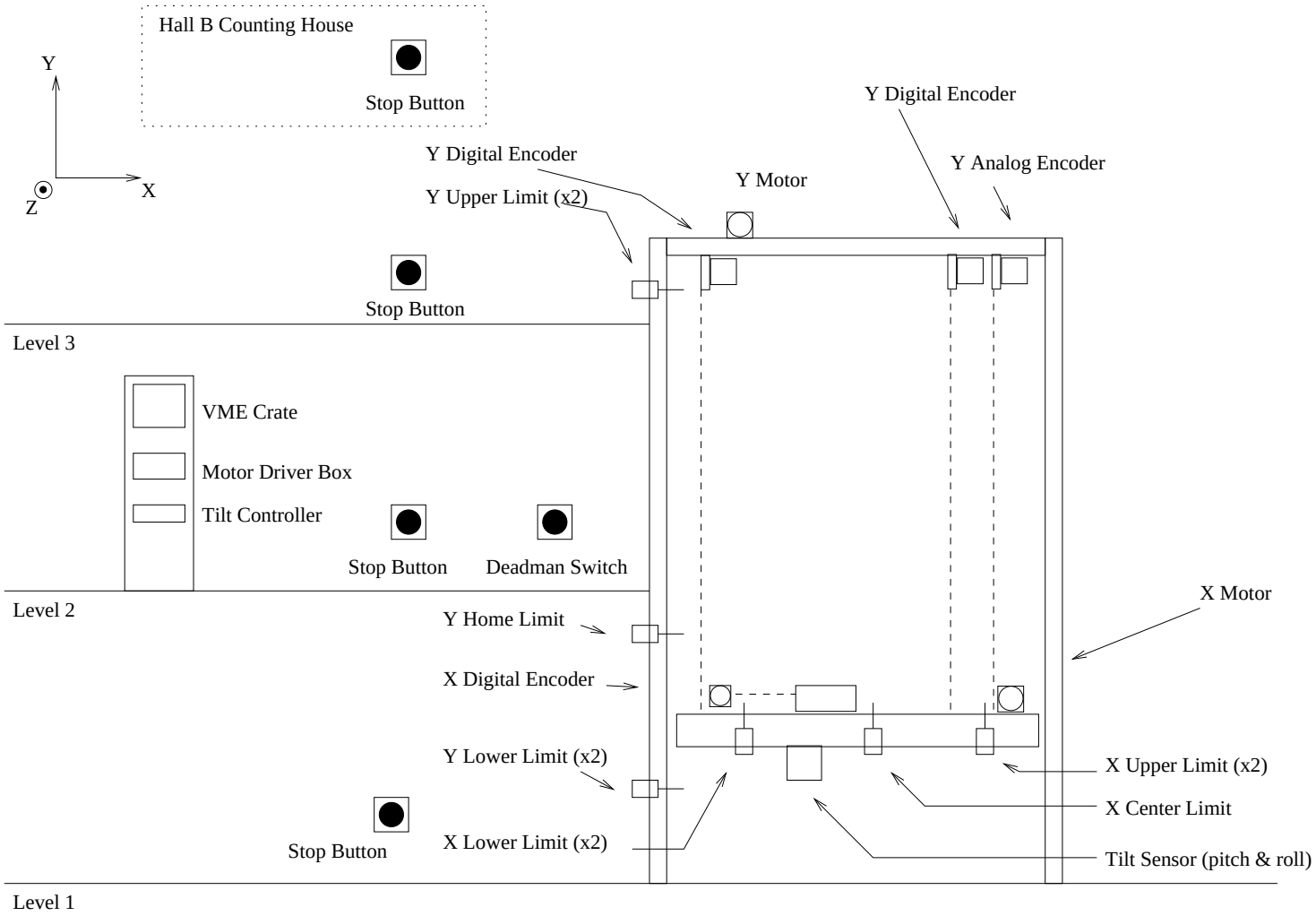


Figure 2: Hardware Overview

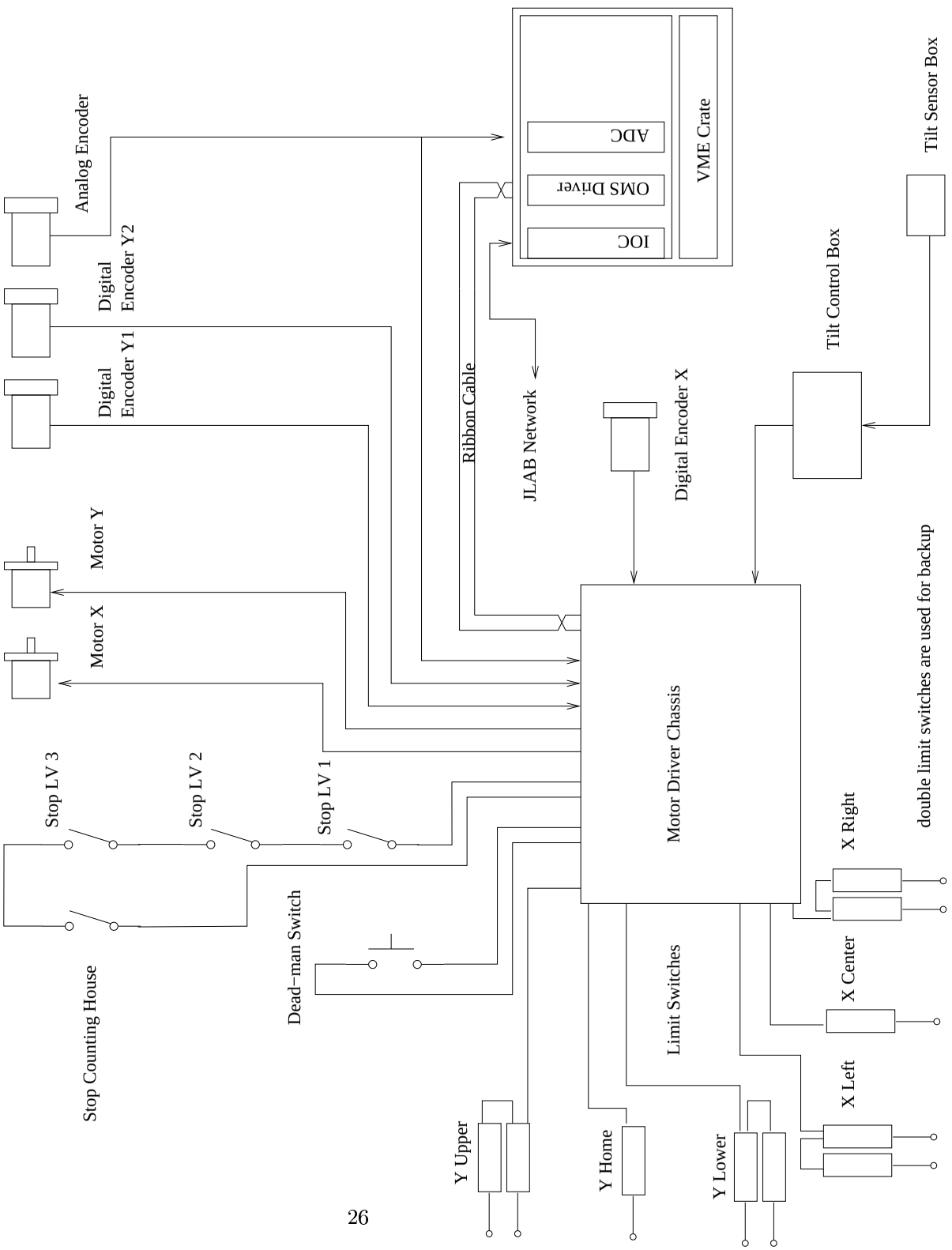
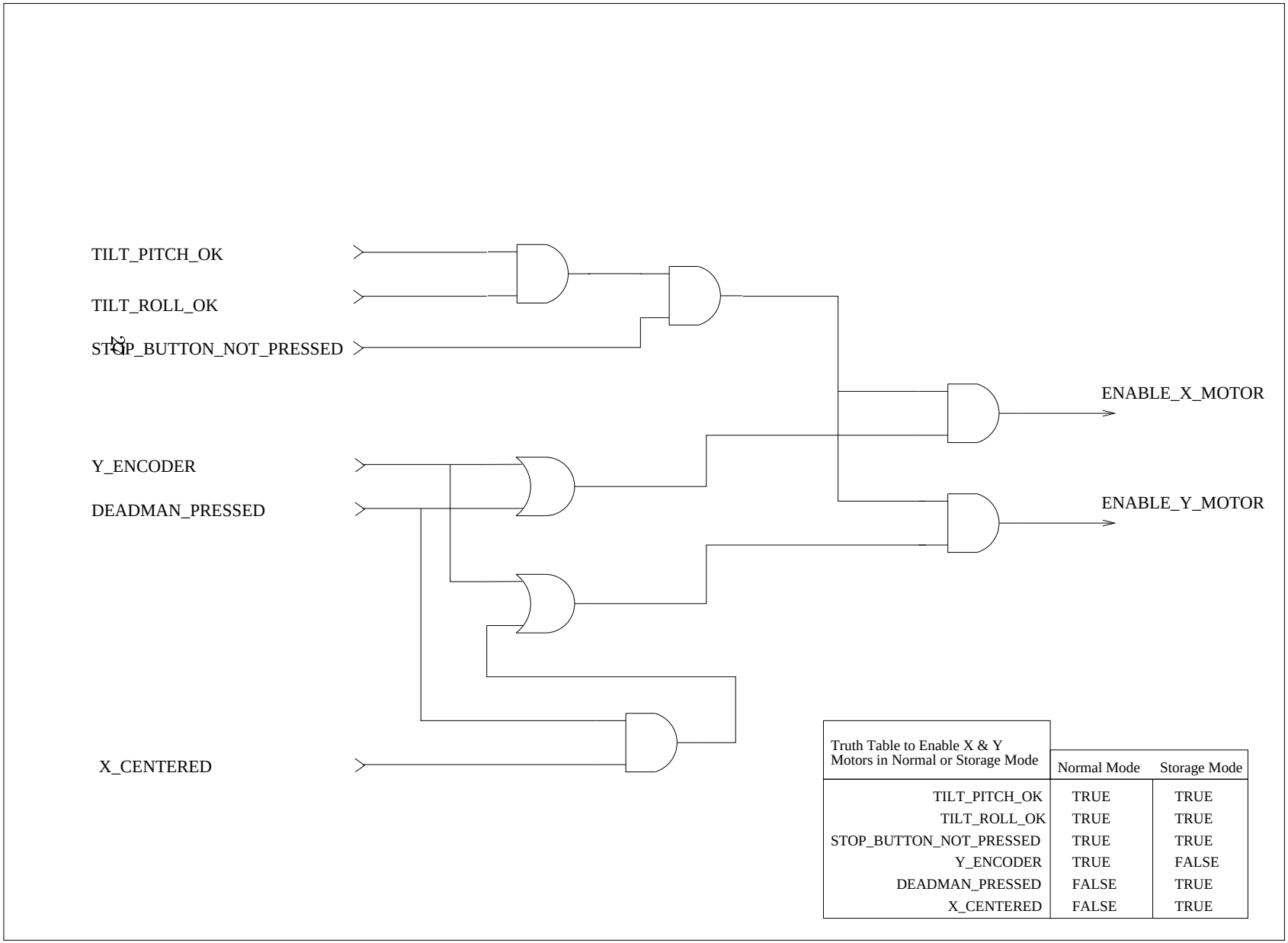


Figure 3: Motor Driver Chassis Connections



Truth Table to Enable X & Y Motors in Normal or Storage Mode	Normal Mode	Storage Mode
TILT_PITCH_OK	TRUE	TRUE
TILT_ROLL_OK	TRUE	TRUE
STOP_BUTTON_NOT_PRESSED	TRUE	TRUE
Y_ENCODER	TRUE	FALSE
DEADMAN_PRESSED	FALSE	TRUE
X_CENTERED	FALSE	TRUE

Figure 4: Interlock Logic

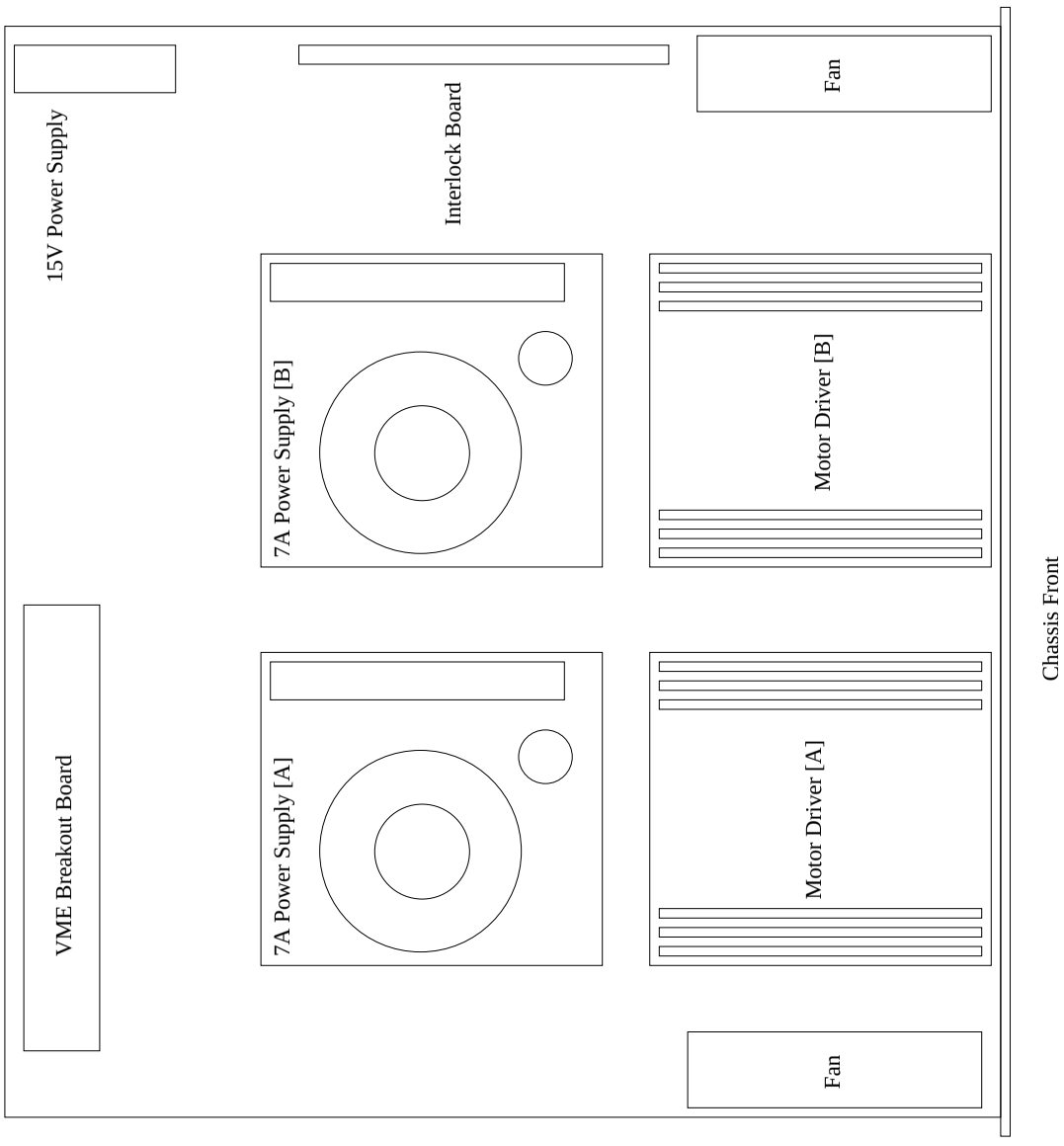


Figure 5: Motor Driver Chassis

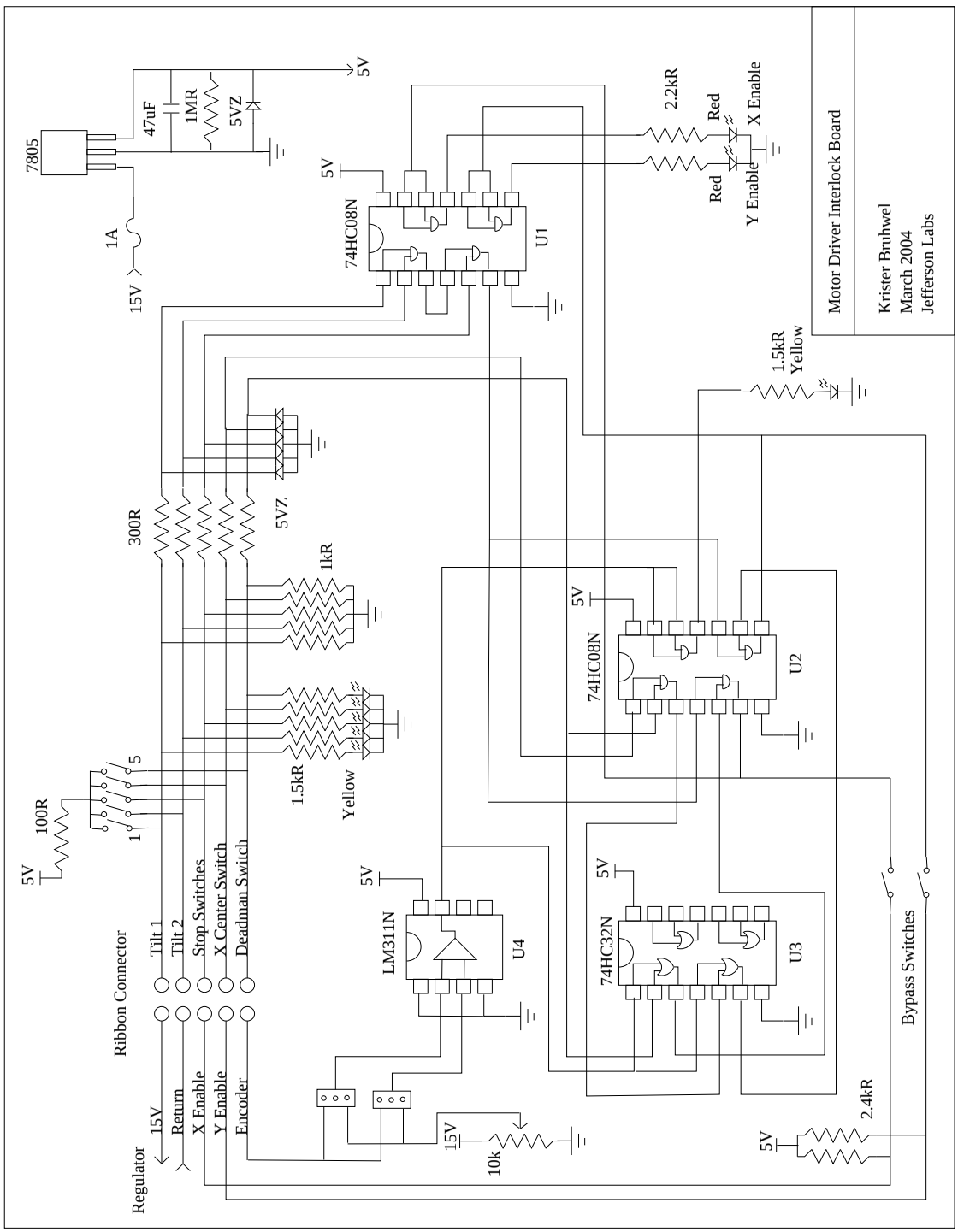


Figure 6: Motor Driver Interlock Board

Table 3: Checklist for *PrimEx* Documentation. The status of documentation was checked on .....

Binder	Contact	Initial
Overview	Mark Ito	
Current Run Information	Physics Division Liaison	
Conduct of Operations	Physics Division Liaison	
Procedures		
Beamline	Stepanyan, Ito	
DAQ	Sergey Boyarinov	
Online	Sergey Boyarinov	
Trigger	Sergey Pozdnyakov	
Computers	Vladimir Sapunenko	
Monitoring	Mark Ito	
Slow Controls	Mark Ito	
Experimental Safety Assessment Document	Physics Division Liaison	
Special Systems		
Torus Magnet	Krister Bruhwel	
Primex Magnet	S. Stepanyan, M. Ito	
HYCAL	M. Ito	

E Hall B Checklists - Extended Shutdown

The following basic check list shall be completed before an extended shutdown of Hall B.

Table 4: Checklist - Preparing for Extended Shutdown of Hall.The following checklist was completed on .....

System	Comment	Initial
Beamline and Magnets Torus Magnet Ramp Down Page Krister Bruhwel and Report Status Tagger Magnet Ramp Down Call MCC		
Drift chamber system Turn HV OFF Page DC Expert and Report Status		
Time of Flight system Turn HV ON/OFF Page TOF Expert and Report Status		
Cerenkov counters Turn HV ON/OFF Page CC Expert and Report Status		
Forward electromagnetic calorimeters Turn HV ON/OFF Page EC Expert and Report Status		
Large angle electromagnetic calorimeters Turn HV ON/OFF Page LAC Expert and Report Status		
Data Acquisition Dumpdisk Send e-mail to vvsap@jlab.org		
Target Empty Target Page Target Expert and Report Status		
Call list		

F Hall B Checklists - Maintenance

The following tasks must be completed periodically as part of Hall B maintenance.

Table 5: Checklist - Periodic Maintenance of Hall B. Verification that the maintenance of the following items is current was completed on .....

Task	Contact	Initial	Date
Manlifts	Tilles		
Air Handlers	Tilles		
Check water in chiller	Tilles		
LCW filters	Tilles		