

## Temporary Operational Safety Procedure (TOSP)

### Cover Sheet

**Division serial number** \_\_\_\_\_

(Assigned by Division EH&S Officer after approvals)

Issue Date:

Expiration Date:

(No later than 3 months after issue date)

**Title: Hall D barrel calorimeter test**

Location: Downstream alcove of Hall B

Risk classification

Without mitigation measures (4, 3, Or 2): 3

With specified measures implemented (2, 1, or 0): 1

Author(s):

### Supplemental technical validations:

Hazard reviewed:

Reviewer signature:

Signatures

EH&S staff reviewer:

Division EH&S officer approval:

Department or group approval:

Other approval(s):

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## **Introduction**

The Hall D BCAL (Barrel Calorimeter) test in the Hall B alcove is scheduled to take data between 22-Sep-2006 and 1-Oct-2006. The BCAL detector module will be located in the Hall B downstream alcove or on a platform upstream of the alcove. The test will not use the CLAS detector itself but will use the Hall B tagging system. The CLAS TPE target will be installed but will be empty.

The BCAL detector is composed of a lead/scintillating fiber matrix roughly 13 cm x 23 cm x 4 m. The test will use a low energy, low intensity bremsstrahlung beam produced by a standard  $10^{-4}$  radiator collimated down to 2.6 mm by the standard CLAS collimation system. The photon beam will traverse the hall and impinge on the BCAL module itself. The electron beam energy will be 0.687 GeV with a maximum current of 5 nA.

The BCAL detector weighs approximately 2000 pounds and will be mounted on a heavy-duty movable cart that supports manual lateral motion of the BCAL module as well as remotely-controlled horizontal rotation of the module around the cart axis. The cart will be located on a heavy steel plate bridging the elevated platform upstream of the alcove and the alcove itself. During the run the cart will be moved to various locations on the plate (i.e. on the platform and in the alcove), the module will be moved to various lateral positions with respect to the cart, and the module will be rotated on the cart to various angles with respect to the photon beam.

## **Purpose**

This TOSP is concerned with safety and procedural issues related to motion of the cart itself and the manual and remote-controlled motion of BCAL module on the cart.

## **Facility**

Hall B facility plans, including drawings of the elevated platform, are the responsibility of the Hall B engineering group. A schematic layout of the BCAL module plus cart in two typical positions on the platform/alcove is shown below:



## Authority and Responsibility

Eric Scott (Indiana University) designed the cart in consultation with Hall B engineering staff. He also developed and is responsible for all cart operating procedures. The following people have been trained to safely move the cart and module and are authorized to move the cart as described in this TOSP. Their signature indicates that they have been trained, have read, and understand this TOSP.

**Table 1**

Name	Signature	Date
Eric Scott		

The following people are certified to train additional people to move the cart and module:

**Table 2**

Name	Signature	Date
Eric Scott		

## **Hazard Analysis and Controls**

### **Platform**

- A steel platform was installed immediately upstream of the downstream alcove in Hall-B
  1. The platform is 16 feet in the air
    - To mitigate the obvious fall hazard safety rails are installed around the entire perimeter.
    - In the event that the railing would need to be removed standard Hall B access controls and safety harnesses will be necessary.
  2. Egress from the platform
    - There are two exits from the platform, one staircase to the hall floor and another to the forward carriage.

### **Installing and removing the test equipment**

- Because the equipment must be assembled and disassembled on the platform that is 16' above the Hall B floor all equipment must be craned into position.
  1. None of the anticipated equipment lifts are classified as critical.
  2. Existing lifting procedures and guidelines will be followed.
  3. Only JLAB employees that are Hall B certified operators will be operating the crane.
  4. All people helping will have steel toed shoes and Hall B safety equipment.

### **Motion hazards and controls**

Note that a flashing red light is connected to the cart power system to alert personnel that the cart potentially can move (rotate) on its own. Also, permanent support fixtures will be attached on either side of the carriage/module to ensure that the CG of the carriage/module is always between two supports (one has wheels, the foot of the other ends an inch or less above the floor). A temporary jack stand will be placed at the end of carriage/module if one of the permanent supports must be moved (two stands are available).

- Rotational Motion

- Possibility that someone could be hit by the system while it is under remote control.
  1. There are drive power kill switches located next to the two access points for the alcove. If the buttons are pressed the AC power is cut to the drive system. This power can only be restored by resetting the stop switch and pressing an interlock restore button on the cart.
  2. The system moves slowly so you can easily walk out of the way.
  3. Under normal operation the cart would only move when the hall is locked up.
  4. During calibration of the drive system and limit switches someone will be standing next to the cart.
  5. During remote operation of the cart someone must watch the system on camera.
- Moving the carriage (Minimum 3 persons required)
  - The carriage is manually positioned and requires more than one person to move it. Two persons can push it, but by this TOSP a third person must be there to watch for problems.
    1. The system has stops built in so that it cannot fall off of the rollers.
    2. You might be able to push the carriage past center and the cart might tip over.
      - To mitigate this possibility the outrigger wheels are mounted in their second position on the right. This mechanically constrains the carriage so that it cannot be put in an unstable configuration.
      - If another configuration is needed all constraints can be moved to their mirror position on the opposite side.
      - Stops are installed to prevent the carriage from being moved past center in on the side without the outrigger assembly.
- Moving the cart (Minimum 3 persons required)
  - Moving from the platform position to the alcove position could cause strain.
    1. Three people are necessary to maneuver the cart. Two people will be moving the cart and one will watch for problems.
    2. The cart does not transition floor levels.
      - Steel has been added to make the two positions all on the same level
  - Moving the cart could tip the cart over.
    1. The carriage must be in the rolling position and locked before motion starts.

This places some of the load on the outrigger making it more stable.

2. During testing the cart was found to be very stable while moving it with 125% load.

### **Drive System Hazards**

- By its nature the drive system can pinch or crush fingers if they are stuck into the system while it is energized.
  1. There is a safety cage surrounding the open or pinching portions of the chain drive.
  2. All work performed on the drive system while the cover is removed must be in a power off condition.
- The drive can start and stop with no visible operator.
  1. Drive power kill switches are provided.
  2. If the CAMAC crate is powdered down the computer also cannot move the system.
  3. The computer is password protected to prevent unauthorized use.
- People that are working on the system will be made aware of pinch point areas through an orientation.

### **Rotational Collision Hazards**

- While under remote control the device could collide with a wall or other obstruction.
  1. To constrain the motion for normal operation, three separate limits are used.
    - A. The controlling software is designed to operate using software limits. These encoder values are checked during operation and if someone tries to exceed them the software prints an error and exits. Rerun the program to re-enter request in proper range.
    - B. The CAMAC crate holds the Joerger SMC24B motor controller which has limit switch inputs that disable drive pulses in the limited direction.
    - C. The AC limit contains all the other limit conditions and tripping will shut off power to the drive motor. It can only be reset by a qualified person physically pushing a button on the cart.
      - This system also has the Stop buttons in it. If they are pushed, the system cannot move until reset by a qualified person.
      - There is a spare AC limit switch that can be located near any obvious obstructions as an added precaution.

- The procedures for setting appropriate limits, ensuring that the area is clear by visual inspection, and necessary calibrations are outlined in this TOSP.

### **Shock Hazards**

- Care has been taken to shield all electrical connections on the cart and drive mechanisms.
- Systems built at Indiana University are sealed shut with screws requiring tools to open to keep unauthorized people out.
- No electrical system will ever be worked on while it is plugged in.
- All other systems were assembled as per manufacturer recommendations or with the equipment they supplied. In one case additional shielding was added to a transformer to prevent accidental access.
- Everything plugs into one power strip. If there is ever a concern, the entire AC electrical system on the cart can be rendered dead by unplugging this one cord.

### **Description of Cart Interlock System**

The cart has three separate protective layers to keep it away from obstacles. There are two separate hardware interlock layers and one software layer. For clarification Clockwise (CW) and Counter Clockwise (CCW) directions are written on the aluminum encoder disk. Each protective layer is contained inside of the next like this:

{ AC CW { SMC24B CW { SOFTWARE CW / CCW } SMC24B CCW } AC CCW }

The SOFTWARE CW / CCW layer checks that the encoder readback values are within the acceptable range and will stop motion if these exceed values which were calibrated to alert before the hardware limit switches are reached.

The system is protected by hardware logic when limit switches are set when the module exceeds its expected range of motion. The SMC24B module, which is located in the CAMAC crate, will stop sending clock pulses to the motor in the direction of the tripped limit switch. These limit switches are outside the SOFTWARE CW / CCW boundaries and can only be reached by operating the motor from the CW / CCW switch on the front of the SMC24B module or if something goes wrong with the SOFTWARE CW / CCW layer.

The AC CW / CCW interlock switch turns off a relay that controls the power to the stepping motor transformer and must be reenabled by someone physically resetting the error condition. This limit switch is in place incase the SMC24B CW / CCW limit switches or CAMAC module fail. There is a second limit switch that will be located along the carriage in front of the closest obstacle. This limit switch is an added level of protection to keep the cart from colliding with anything.

The AC CW / CCW interlock relay also has two red stop buttons tied to it. They can be used to disable the stepping motor while someone is walking up to the equipment or to promptly stop all motion during the testing of the limit switches. One switch will be located at the entry point of the platform and one will be on a long cord so that it can be positioned close to one of the cart calibration crew.



To turn the relay back on after any tripped condition two things must happen:

1. The condition that tripped the relay must be cleared by (A) resetting the stop switch (pull up till it clicks) or (B) clearing the error condition that tripped one of the limit switches.
2. The button shown in the picture to the right must be pressed.

Under normal circumstances if the green light does not come on after the button is pressed then one of the above two conditions is still exists.



This interlock and motor power connection is wired as an appliance (it plugs into 110 VAC) and has two fuses inside the box: one (1) amp fuse for the interlock loops, and a ten (10) amp fuse for the motor transformer.

The interlock box is to remain closed at all times and secured with the cover screw. Removal requires power disconnection and special procedures beyond this TOSP.

## Standard Operating Procedures

It is assumed that the cart and barrel calorimeter module have been moved up into the alcove based on the outline given in the Appendix. This section covers moving and calibrating of the system.

### Moving the cart from one position to another (Alcove / Platform)

- Moving the cart from one position to another requires three authorized persons from Table 1. For purposes of orientation the following convention is used: Facing the side of the cart that has the CAMAC modules in it the cart Right will be to your right and the cart Left will be to your left.
  1. All personnel on the platform and involved in the cart move must be wearing steel toed boots in addition to the standard hall B safety equipment.
  2. Carriage must be moved to the marked transport position and secured in place with at least 2 screw-in stops.
  3. The outrigger wheels are allowed in only two transport positions (one on each side). The allowed locations will be clearly marked during installation on the outside of the channels and interference set screws will be installed in the bolt holes that should not be used. The normal position (cart right) is clearly marked in yellow paint on the carriage.
  4. If the outrigger needs to be moved to the cart left position follow the instructions below.
  5. Outrigger caster locks need to be released so that the wheels are free to swivel.
  6. The cart foot lock (found under the cart left side) must be released.
  7. The cart friction stabilization legs need to be screwed up so they clear the floor by about 1/2" (there are 4 of them).
  8. Two people are necessary to push the cart and a third person needs to watch for obstructions while moving it and align it in its new position.
  9. Location-specific instructions must be followed (see below).
- Moving the Outrigger
  1. This activity requires three authorized persons from Table 1.
  2. The cart must be parked with at least 5 feet of clear space on each end and

the friction stabilization legs fully extended. Screw them down till the touch the floor and then turn them ¼ turn with a wrench.

3. The carriage must be in the center position.
  4. The carriage stopping bolts will have to be moved.
    - Remember if you take it off one side put it in the same spot on the other side.
    - Visually verify that the bolts prevent the carriage from getting overextended in an unsupported position.
  5. The carriage must have at least two of the locking bolts tightened.
  6. Remove the six ½-13 bolts that hold the outrigger in place.
  7. Loosen the wheels so that they pivot. Once they are aligned with the direction the outrigger needs to travel tighten the locking screws.
  8. Slide the outrigger along the carriage. If necessary adjust the height to let it slide easier. This adjustment may involve the crank and the twelve ½-13 bolts on the outermost wheels.
  9. Using two people to guide the outrigger, roll it to the other side.
  10. Insert it into the C-channel guides and slide it into the location on the other side. Only install in the marked location.
  11. Insert the six bolts and tighten.
- Cart in the platform position
1. Must have at least three authorized persons on the platform to move the carriage on top of the cart or push the cart to a new location. Two people will be pushing or pulling while the third watches for hazards.
  2. The cart motion system shall be disabled in the power off condition by unplugging it.
  3. Ensure the outrigger is in its clearly marked "normal" position (second bolt location on the cart right side).
  4. Ensure that the cart is secured:
    - The stabilization legs need to be extended and rotated 1/4 turn with a wrench after hand tightening into the floor.
    - The foot lock (found under the left side of the cart) must be set.
    - The large wheels need to have the wooden wedges placed on either side of them.
  5. When moving the carriage in relation to the cart
    1. Slide carriage (This portion must be repeated for each new

carriage position):

- a. Loosen locks on outrigger casters.
  - b. Loosen Locks on carriage.
  - c. One person watches for hazards while two people pull or push the carriage to the desired location.
  - d. Tighten at least 2 locks on the carriage.
  - e. Use a small jack under the steel plate next to the heavy caster to just lift the casters off the floor so that they can be spun 90 degrees. Leave the locks loose.
2. To reach the ends of the module it may be necessary to reposition the cart following the above procedure.
- Cart in alcove position
1. Must have at least three authorized persons on the platform to move the carriage on top of the cart. Two people will be pushing or pulling while the third watches for hazards.
  2. Ensure that the cart is secured:
    - a. Bolt the cart to the alignment angles on the floor.
    - b. The stabilization legs need to be extended and rotated 1/4 turn with a wrench after hand tightening into the floor.
    - c. The foot lock (found under the left side of the cart) must be set.
    - d. The large wheels need to have the wooden wedges placed on either side of them
  3. Slide carriage (This portion must be repeated for each new carriage position):
    - a. Loosen locks on outrigger casters.
    - b. Loosen Locks on carriage.
    - c. One person watches for hazards while two people pull or push the carriage to the desired location.
    - d. Tighten at least 2 locks on the carriage.
    - e. Use a small jack under the steel plate next to the heavy caster to just lift the casters off the floor so that they can be spun 90 degrees. Leave the locks loose.
- Prepare cart for operation of angular motions.
1. Make sure the floor is clean and clear

2. Turn CAMAC Crate ON.
3. Turn ON motor AC interlock (Button on the cart right side, when engaged a green light below the button comes on and motor hums.)
4. Loosen all locking bolts on the casters
5. Jack the outrigger up just enough to pivot the casters around so they are facing the correct direction. Please note the jacking position is labeled.
6. Remove the jack.
7. Rotate the carriage by computer (a) or manually (b)
  - a. Computer operation
    - i. Make sure cart computer is on (Blue light on cart left).
    - ii. Login
    - iii. Run the Hardware test program, move in small increments and rotate the carriage in the direction you set the casters until they track to the correct angle. Remember always move away from obstructions while doing this and verify that the limit switches are still properly set. If not the system must be recalibrated (see section on calibration).
  - b. Manual Operation
    - i. Using the CW / CCW direction switch on the front of the Joerger SMC24B module engage the drive system and rotate the carriage in the direction you set the casters until they track to the correct angle. Remember always move away from obstructions while doing this and verify that the limit switches are still properly set. If not the system must be recalibrated (see section on calibration).
8. Lock the casters using the locking bolts.
9. Check for clearance and proper CAMAC limit activation through the entire angular travel before turning system over to remote control.
  - a. Either move the system with the CW / CCW controls on the front of the SMC24B motor control module or log into the computer using the screen and keyboard plugged into the cart computer to test the limit adjustments.
  - b. Check the limits under software control one last time before turning the system over for remote operation.
10. The system is now ready for angular motions of the module.

- o Operating cart under remote control
  1. Ensure that camera is working and a clear view of the cart is possible.
  2. Log into the cart computer, using the BCAL Motion software enter the angle you want to move to and log the carriage position and watch the encoder value and camera for anything out of the ordinary.
  3. If a problem arises: **\*press Ctrl-C\*** this halts the drive system. Access the hall using established methods and evaluate the problem. If necessary contact Eric Scott.

### **Training Requirements**

Eric Scott will train personnel in the above procedures. He will additionally train a few people so that they can train others. See the section on Authority and Responsibility above.

### **Unusual Emergency Procedures**

The procedures above are adequate to cover emergency procedures. Unplugging the single A/C power cord to the cart cuts all power to the motors.

### **Calibration Procedures**

The system limit switches and software will be calibrated during installation or adjusted as necessary by an expert listed in Table 3.

**Table 3**

Name	Signature	Date
Eric Scott		

1. During all motion of the cart, carriage and angular motion of the module, all relevant sections of the present TOSP will be followed as well as the following procedures.
2. The calibration expert from Table 3 plus two trained assistants from Table 1 are necessary.
3. A networked laptop or direct monitor and keyboard connection to the cart computer are necessary.

4. Only adjust the limit switches with the stepping motor AC power cord unplugged.
5. Adjust the AC CW / CCW limits as necessary on the cart left side near the back to provide the necessary range of motion and stop before any obstructions are encountered.
6. Adjust the SMC24B CW / CCW limits as necessary. The two limit switches are located on the cart right side under the turn table and are each labeled with the direction they cover (CW or CCW).
7. Test the range of motion and update the software encoder limits based on the numbers from this test.
8. Either move the system manually with the CW / CCW controls on the front of the SMC24B motor control module, or log into the computer using a local laptop or a screen and keyboard plugged into the cart computer to test the limit adjustments.
9. Check the limits under software control one last time before turning the system over for remote operation. If a problem arises: **\*press Ctrl-C\*** this halts the software controlled drive system.

## **Appendix: Installation**

The initial lifting of equipment into the alcove will take place under the guidance of a Task/Hazard analysis list prior to complete review and approval of this TOSP. However, the nominal installation plan is included here for reference and completeness.

### **Installation of cart and module equipment at JLAB in Hall-B (All dates are tentative).**

- Survey will happen before we move equipment into the hall.
  - Survey is providing a line on the floor indicating the center of the beam.
  - Survey is providing some marks on the wall indicating beam elevation that we can use to set up the laser.
- Aug. 16
  - Ship BCAL Cart equipment with Roadway as a sealed-divided guaranteed AM delivery from IU for arrival at JLAB before noon on Aug. 21.
- Aug. 21
- Roadway truck arrives before noon. Equipment is unloaded and placed in a reasonably dry location.
- Aug. 22
  - Hall-B Staff moves crates into Hall-B.
  - Uncrate BCAL module, cart, carriage, light guide boxes and pivot leg.
  - Hall-B Staff lifts PMT shipping crate (estimated at 50 lbs.) and pivot leg (estimated at 140 lbs.) onto platform using straps and then will stash the equipment at the back of the alcove.
  - HBS lifts cart assembly (estimated at 1,700 lbs.) onto platform using straps and Eric will prepare it to receive the carriage assembly.
  - Hall-B Staff assists in building carriage assembly. First a layer of cloth or black plastic is laid down on the carriage (estimated at 770 lbs.). Then the BCAL module (estimated at 1,680 lbs.) is lifted out of its shipping container and placed on the rockers (provided by Regina, see [\[\[http://argus.phys.uregina.ca/drupal/gluex/node/274\]\]](http://argus.phys.uregina.ca/drupal/gluex/node/274), [\[\[http://argus.phys.uregina.ca/drupal/gluex/node/275\]\]](http://argus.phys.uregina.ca/drupal/gluex/node/275)). The rockers will rotate the module onto its side where it can be picked up and placed on the plastic and secured with the 8 locking clamps. Then the light guide boxes (estimated at 177 lbs. each) are bolted onto either end, but not compressed against the module.

- Need
  - 3/4" Box End Wrench (2 or more)
  - 3/4" Socket with Drive
  - 7/16" Box End Wrench
  - 7/16" Socket with Drive
  - 3/16" Allen Wrench
  - 1/4" Allen Wrench
- Hall-B Staff lifts carriage assembly (estimated at 2,804 lbs.) onto platform using straps attached to the carriage steel frame and sets onto the cart and secures. This lifting procedure will use straps attached to the steel frame of the carriage.
- Cart is rolled into the platform position.
- Aug. 23
  - Hall-B Staff assist with anchoring cart in alcove position. Holes are drilled into the deck plate to bolt cart down to prevent the cart from spinning. This only needs to happen at the alcove position. It will be necessary to align the cart to the beam by dropping a plumb bob to the pre-marked deck. We have not decided if we are welding or drilling and tapping.
  - Need
    - 1/2" Transfer Punch
    - Hammer
    - Mag-Based Drill
    - 1/2" Center Drill
    - 27/64" Drill
    - Cutting Oil
    - 1/2-13 Tap
    - Tap Handle
    - Broom, Dustpan & Vacuum
- Aug. 24
  - Sylgard sheets are installed on the end of the module and light guide boxes are pressed up against the ends. We may have to shine a light down the steel tubes at one end to check the seal at the other end.
  - Sylgard cookies are placed on the ends of the PMT - base assemblies, cables are attached. The foam spring is installed and the assembly is slid into the steel tube with the cables being routed through the 3-point locker

- mechanism.
- Safety AC crash switches are installed at points of access to disable drive system (there are two).
- Signal cables are routed along carriage so that they come off behind the pivot point
- Need
  - Cable Ties
  - Wire Cutters
  - Black Tape, Black Foam, Black Calk
- PMT's are installed and module is checked for light-tight status
- Need
  - XP2020 & 8575 PMT's and Bases
  - HV & Signal Cables
  - Cable Ties
  - Flashlight or Drop Light
- Horizontal line laser mounted on wall (or forward carriage) needs to be installed and surveyed in to beam height. Laser needs to be visible in all run positions of the module or on some common location on module. There is some concern that the shimming floor will not be flat and the floor may move when the BCAL and cart are put on it. The laser is an independent indicator of elevation.
  - Need
    - Survey
    - Laser Level (Class IIA  $\leq 1\text{mW}$ , Wavelength: 650nm)
    - Hammer Drill (if attached to wall)
    - Concrete Anchors (if attached to wall)
    - Anchor Setting Tool (if attached to wall)
    - Broom, Dustpan & Vacuum
- Various positions along the module in relation to the beam are checked and aligned
  - Need
    - Plumb Bob
    - Chalk Line
    - Tape Measure
- Aug. 25
  - Cart Operation Plan must be followed.
  - Cart Interlock System is calibrated.

- The cart is exercised in the platform position by moving the carriage to several positions.
- The motion control computer is brought up and the drive system is checked out in the alcove position.
- Final [[Cart Safety Review]] can happen now.