Procedure for Operating the End Plug Source Drive System

This procedure outlines the steps needed to operate the Purdue source drives for end plug calibration.

Editorial Hand-Processed Changes Other Than Spelling
Require Operations Department Head Approval

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Approvals

(CDF Operations Department Head) (Date)

1.0 Controlled Copies of this procedure.

At least three controlled copies of this procedure will exist.

One will be held in the CDF Department Office Library.

The others will be on the CDF web pages at

http://www-cdf.fnal.gov/cdfsafe/cdfproclist.html

and at

ADMIN.CDF / ES&H / PROCEDURES

All other copies will be marked, " INFORMATIONAL COPY ONLY "

1.1 Procedures

A copy of this procedures document must be kept at the source driver PC.

Sourcing is not permitted during controlled access.

Before each session of wiresourcing, the Operations Manager must be notified, and the activity scheduled so as not to conflict with personnel activities near the plugs or with operations of other parts of the detector.

Any warning-roping requirements must be satisfied before the sourcing is started.

Many other procedural requirements are laid out below, and will be fully understandable only after reading the following description of the sources and the source driver system and its operation.

Only properly trained persons, as defined in this document (see section 5.0 below), are allowed to be the operators of any source driver. One single person may operate the system when personnel access to the detector is restricted and when the operator is not in a location requiring the "buddy system."

Emergency procedures are detailed in Section 8.0 below. Note that these procedures are best understood after thoroughly familiarizing yourself with the contents of this entire document.

2.0 The Apparatus

The Purdue source driver is designed to drive a radioactive source in and out of the detector component, primarily for calibration purposes. The source is a very thin pellet ("seed") of the radioactive isotope ^{60}Co, and is very small in size (< 5 mm long). (^{137}Cs is present in the Central and Endwall source systems, but not in any of the Plug source drivers). The source is inserted into a long, thin, flexible tube, and is located at the tip of that tube. Since the tube is about the same diameter as a wire, it is referred to as the "source wire". The seed is held in place at the end of the source "wire" by an internal retention wire that runs the entire length of the source wire. When the source is not in use, the source wire is wound around a groove in a storage reel and the "hot" end of the source wire (with the radioactive seed) is parked in a lead-brass garage (the pig) which shields it. An indexer arm guides the source wire to the designated channel on the indexer plate during the operation.

When extending, the reel pushes the wire through a sliding tube within the garage pig. The sliding tube is connected to an S-bend "nozzle tube" leading to a nozzle which can be aimed at any one of up to 380 holes in an indexer plate. If the wire meets resistance, such as the end of a closed tube attached to the indexer, the sliding tube in the pig will recoil and a plastic collar on the sliding tube will open a microswitch in series with the reel motor, stopping the extension. A coil spring on the sliding tube is adjusted such that the turn-off force is somewhere in the range 2.0 to 2.5 pounds. If pushed much harder than this the source wire is likely to buckle and kink destructively near where it exits the reel plate.

The source wire has essentially zero backlash in the reel. Therefore, if the source wire is properly installed in the reel and if reel stop screws are correctly located for the length of the source wire, the source will garage consistently near the center of the lead pig when the reel is at the garage limit stop. This should be verified with the appropriate radiation survey meter after a source wire is installed (see Section IV.6).

In an experiment setup, plastic tubes will be connected to the indexer, and secured by paraxial set screws whose threads break through into the 1/8" tube socket and bite into the tubes. The other end of the plastic tube is coupled to a steel tube that is inserted into the detector. It is essential that the total tube length (nylon plus steel tube) be shorter than the source wire length minus two feet. The far end of the tube must be closed. This is so that the extendable wire length exceeds the lengths of all tubes in the installation, permitting the immediate detection of a "wirespill" (an unlikely but serious situation described below). All of these conditions were verified during the installation of the eight source drivers onto the two Plugs in B0.

The source wire position is monitored with two counters, one (index counter) indicates which index channel the wire is pointing to (or through), the other (reel counter) indicates how far the tip of the source wire is from its garaged position. Each reel count is 0.1 mm. If the source is properly garaged, the reel count should be within +- 30

counts of zero. When the source is out of its garaged position, a warning light will also come on.

In the operation, the wire will extend until it reaches the end of the tube, and then retract. For every 50 cm (5000 reel counts) of wire retracted, it needs to extend 5 cm. This reversal of direction is used to release the tension on the wire when it is wound onto the reel.

The driver can be operated either locally via the switches on the control panel, or remotely with a program on a PC. It is generally preferred to use the program since it checks against possible problems and gives appropriate warnings, and does the reversal during garaging automatically.

The PC program "Testmain" was used in ICB and in the B0 assembly hall to "fingerprint" all tiles in the calorimeters, controlling a single source driver. A PC-based DAQ system is used, with temporary signal cables from the phototube boxes to a signal conditioner (1 MegOhm I to V OpAmps) and on to a multichannel DVM in the PC. DC phototube currents from up to 24 channels at a time can be read in, and up to 16 of these channels can be plotted in color on the PC screen. Testmain is programmed to detect possible wirespill conditions (and other possible malfunctions) and to post a warning on the monitor screen.

For the eight source drivers installed on the Plug, a different program, Octoport, can operate any or all of the drivers to run asynchronously while Run Control takes DC current data via the QIEs. Octoport does not itself take DC current data, but it logs wire extension data, checks for malfunctions including possible wirespill, and posts a warning on the PC screen.

Octoport has been upgraded, in the spring of 2001, to communicate with and take requests from the Run Control (RC) computer using Ethernet. Octoport sends reel and index coordinate information to RC and to one (selectable) of the Plug front end crate controllers, along with two coded status words, for incorporation into the event records. A wirespill will result in a warning being posted on the RC monitor screen and Octoport will lock out the affected source driver (in software) until an expert has corrected the situation. **It is imperative to obey all warning messages and not to attempt to operate a driver with a possible wirespill until the situation has been fully corrected – see details in section 3.1.**

2.1 W*ire* Source *Usage* [Activity] in B0, using strong Co-60 sources

It should be noted that a potentially large surface area over equipment, etc. can become contaminated should the source containment be breached. The potential consequences of personnel and privately owned equipment (personal vehicles, home, etc.) becoming contaminated can be significant. The Co-60 seeds used in B0 are Nickel-plated and are essentially non-contaminating. However, the active seed is a fine 0.012-inch diameter wire approx. 2 – 3 mm long. If the seed were directly damaged and broken after falling out of a broken source wire, it could cause contamination.

The radioactive sources used in the Endplug source driver mechanisms were historically Cs-137, but only Co-60 sources are presently used. Their strength will generally be in the range of 1 to 6 mCi. The Endplug Co-60 wire sources were nominally 3 mCi as of July 1998. The half-life of Co-60 is 5.27 years.

For general information, the Central and Endwall calorimeters each have 48 Cs-137 seeds attached to cable-loop drivers. The Cs-137 sources were installed in about 1984, were nominally 1 or 2 mCi in activity, and the half-life is about 30 years. Usage of the 96 Central and Endwall source drivers is not controlled by the present document, and use of those devices is a separate issue dealt with elsewhere.

2.1.1 Garaged Source

When an Endplug Co-60 source is parked in the garage, the maximum field at the contact with the B0 shield-augmented pigs is about 130 mrem/hr, as measured by a radiation survey meter with its probe touching the extra lead shells. The field should be less intense at both ends of the pig. Be careful to keep the meter at the same radius as you move off the lead shell. If the meter peak reading is not found somewhere over the central portion of the pig, the source is not properly garaged. Garaging can also be checked by the meter through the plastic cover, again by moving the meter along the pig at a constant lateral distance.

The dose rate 1 foot from the lexan cover (or from the aluminum baseplate of the driver) is approximately 3 mR/hr at one foot. This has been achieved with an extra 0.5 inches of lead around the pigs, and in the two quadrants where the pig is very close to the lexan cover, a further 0.25 inches of lead has been added.

2.1.2 Un-garaged Source

The dose rate at 1 meter from the tip of an unshielded Co source wire is about 4 mrem/hr and falls with the inverse square of the distance. At one foot from the naked source, the dose rate is about 50 mrem/hr. At 3 meters, the dose is about 0.5 mrem/hr with the naked source. To aid in minimizing exposure, the source shall be garaged when not in use. There should be no need to approach the source closely unless the driver hangs up or stalls, in which case, you should follow the procedure below for a stalled or hung-up source wire. Remember that the source is almost point like (it is a fine wire a few mm long), and that the inverse square law implies very intense radiation

fields within a few inches of the source. Any close approaches should be absolutely necessary and be as brief as possible.

Specifically, in the unlikely event that the source is in one of the gray conduits and is near the surface of the conduit, contact could be as close as, say, 3 mm from the active element and at that location the radiation field would be of order 400 R/hr. At one inch from the naked source, the radiation field would be approximately 7 R/hr. Whenever approaching the naked source, i.e. whenever entering within the roped area and the source is ungaraged, use the radiation survey meter to know where the source is and attempt to stay at least 1 meter away from it; and as far away as possible in any case; and limit the duration of your approach as much as possible.

3.0 Checklist at the Initial Setup

Reminder: anytime you work with a loaded source driver and move the source out of the garage, you must wear your TLD dosimeter badge and a pocket dosimeter.

Only the ES&H section personnel transport radioactive sources. Notify and get approval from the local (division / section) RSO before the source is moved to and from their area. The source identification tag should be with the source at all times. Since the tag cannot be attached to the wire, it should be attached to the loaded source driver at a point near the garage pig. ES&H Section Radiation Physics supervision is required during source removal and installation. If a loaded source driver is moved, a copy of this procedure document should move with it.

To insure the safety of the personnel who operate the source drivers and those who work nearby, it is essential to check the following items everytime the driver is physically moved to a new location and/or the coupling between the driver and any of the source tubes is changed. The B0 drivers will already have been permanently installed and all couplings very carefully checked for integrity.

1. Any tube into which the wire will extend, i.e., a "source tube", must have a closed end.

2. The source tube length from the index disc to its far end cannot exceed the source wire length minus two feet (most of this two feet is between the indexer disk and the point where the end of the wire is attached to the reel). All B0 source wires are 30 feet long, and the source tubes are designed to be and will be measured to be short enough that the wire hits the end of all tubes before hitting the maximum reel extension limit. This way, it is always possible to detect a wire spill due to a popped coupling, by using the reel count. If a coupling pops open under the force of the extending wire, the downstream portion of the conduit will in general recoil, and the wire can be pushed out of the conduit and is likely to form one or more unsupported loops.

3. Any hole on the indexer disc that does not have a close-ended source tube connected to it must be masked off. Heavy mylar sheet (> 0.010" thick) can be used to block the holes. But it must be put on the upstream (inner) face of the disc. Make sure the edge of the mylar does not catch on the nozzle of the indexer arm.

4. Ensure that all source tube couplings, nylon tubes in the indexer disc, Parker fitting to nylon tube connections, and the nylon-tipped set screws bearing on the steel tubes are all in good working order. (Applies principally to rare occasions when through-the-skin source "fingerprinting" is done using movable "nozzle bars" mounted on the skins.) For the

permanent tubes, these checks were done carefully at installation time, and many of the couplings are now buried beneath the skins of the calorimeters. A few of the last couplings to be done, of plastic tubes to the indexer disks, were found to be insecure upon tug-testing after a wirespill occurred in May of 2001. All have been fixed, and every indexer couplings has now been tug tested. (The PC alarmed this wirespill, and the wire could have been safely garaged if there had been a visual inspection and a hands-on garaging (see below). The computer warning was accidentally overlooked leading to the destruction of the source wire – a spilled loop was pulled into a 270-degree kink by motorized retraction. when it was attempted to garage the wire using the motor.)

5. A Lexan cover should be attached to the base of the driver and cover the entire driver. This cover and the base of the driver should have an attention sticker attached whenever a source is installed.

6. The source must be in the middle of the pig when it is garaged. To insure this, place the survey meter probe in contact with the pig shielding or in contact with the Lexan cover closest adjacent to the pig. When the probe is opposite the middle of the pig the reading should be the largest. It falls off as the probe is moved towards the ends of the pig (at the same radial distance from the wire). Keep your time close to the pig at a minimum.

   Note: Appropriate survey instruments that can be used at Fermilab are the LSM, Bicron Analyst, Surveyor 50, and Ludlum 14C.

7. The reel counter should be zeroed when the source is parked initially. The counts should not exceed +-30 when the source is properly parked. Note and report any tendency for the reel count to shift repeatedly in the same direction – this would indicate that the encoder might need adjusting. Random jitter between +30 and –30 counts from one garaging to another is +- 3 mm away from nominal position, more or less within the tolerance of the spring actuating the garage limit switch.

8. The indexer counter should be aligned with the indexer arm position. The count should be one when the arm points to the first hole on the disc. This should be verified initially and re-verified at least once every few hours of use by extending the wire into channel 0, where it should stop at a reel count of approximately 3500 as it hits the indexer; and again extend the wire in channel 1 and it should run freely past the indexer position. It is also possible to check the index count at the upper edge of the permanent tubes: Tube 116 should pass the wire freely. Tubes 117 through 158 are blocked at about 10,000 counts, at the bulkhead (these are where the nozzle bar tubes are attached during through-the-skin sourcing; this point is blocked by a cover during normal sourcing of permanent tubes).

9. An easy way to zero the index count is to run the indexer Down, Continuously until it hits the limit and stops. Then switch to Next

Channel, and then switch to UP. Typically the indexer will move upwards a fraction to the next exact channel. ZERO the index counter at this point, and verify that it is correct by using procedure 8) above. It is possible for the indexer limit switch spring to bend slightly so that procedure 9) is off by one or more channels -- this should be fixed as soon as possible by an expert, since the PC program presently uses 9) but not 8) to establish the indexer zero.

3.1 Check List for Each Operation

For each session, the following items must be observed:

1. The user wears a TLD badge (personnel dosimeter) and a pocket dosimeter. Log your pocket dose increments at the end of each day, on the sheet maintained at the supervised access key desk on the second floor of B0.

2. Before doing anything, read the section on "Emergency Procedures".

3. Check the apparatus as in the previous section. Particularly items .6, 7, and 8.

4. Rope off the area about 1.5 meter from where the source will travel, post signed "Caution, Radiation Area: Personnel Monitoring Devices Required". For B0: Clearly, when the collision hall is radiation interlocked, roping is not required for sourcing.

   4.1 When an upper driver (mounted on the higher of the two orange box beams) is in use, rope off the area underneath the high radiation zone to prevent entry and use of lift-lofts. The Operator should be present whenever the driver is running to enforce the *stay-clear* zone.

   4.2 This section applied during "fingerprinting" activities in the assembly hall at B0, and is not relevant to sourcing activities in the collision hall. When a lower driver (mounted under the lower of the two orange box beams) is in use, rope off the radiation zone with floor-level (3-foot high) notification barrier. For work on the East Plug, move the PC station to the remotest corner of the East Bay (or as far away as the Lemo cable bundles from the phototube boxes to the signal conditioner permit) to reduce the radiation field ALARA for the operators. The goal is to be below 1 mR/hour. Again, the operator should be present at all times that the source driver is running to enforce the *stay-clear* zone. Similar appropriate arrangements should be made for the West Plug when it is sourced.

5. Make sure the radiation survey meter is calibrated and functions properly. For use in a controlled area, the radiation field in the area outside the rope should be less than 5 mR/hour.

6. Make sure the warning light on the driver comes on when the wire is moving. It should be on when the wire moves a few mm away from its garaged position.

7. Full time attendance is required when the source driver is operated and especially when the wire source is running. This is required also for sourcing operated through Run Control and/or through the eight-driver PC running the Octoport program on the first floor of B0. Do not enter the roped off area while the source is running or out of the garage, unless some unusual circumstance requires closer approach. You must use a survey meter whenever you enter the roped area and the source is not garaged, to be sure you know where the source is. Stay as far away from the source as the work permits.

8. When running Octoport or Testmain, make sure the reel count limit on how far the source wire should extend is set correctly in the PC. The limit should be set to extend no more than the longest tube length the wire will encounter plus a small tolerance of about 2000 counts, which is about 8 inches. In no case should this limit be set larger than the maximum possible extension of an unconstrained wire. Tube lengths will have been measured in advance using a dummy wire, and must be kept in an accessible logbook or in a data base. It is best to adjust the "wire spill limit" for each small group of tubes which make up a data run, to minimize the possible length of spilled wire.

9. When running Testmain or when running the Octoport program from the first floor, with or without master control from a Run Control terminal, any wirespill warning displayed on either the PC or RC screen means that the particular source driver **must not be operated until a visual inspection has taken place and the situation has been fully corrected as described in the following paragraphs. The ribbon cable from the PC to the source driver control box should be unplugged, and the power switch on that control box should be turned off, and a warning tag tied to the power switch, until the situation is corrected.**

10. If the reel count goes beyond the longest tube limit or beyond what you expect for a particular tube, or if you have reason to suspect a "wire spill" due to a decoupling somewhere, visually inspect as much of the tube path as possible and if the spill can be seen, carefully and gently try to manually garage the wire, by turning the reel by hand, being careful to untangle any loops that may have formed. It is best to loosen the motor bracket and remove the red belt before this manual garaging (before loosening the belt, feel the tension by pushing sideways and remember it when reinstalling the belt.) Note that drawing a spilled loop into a kink can result in severe damage to the wire. Be aware of the location of the active tip of the wire, stay as far away from it as possible, and if it is necessary to wipe dust off the wire, use a large wadded tissue to keep all parts of your hand at least an inch from the wire and wipe the last couple of feet quickly (working at arm's length). If a wire spill has occurred, log all relevant details, and be sure that an expert has analyzed and fully

    corrected the decoupled tubes. When reinstalling the belt, be sure that there is no "hidden slack" due to mismatch between gear teeth and belt.

Turn the reel by 180 degrees and back, then re-tension if necessary, being sure to end up with tension similar to what you felt before moving the motor bracket. **The loose coupling must still be securely fixed. An expert should be called to verify that the wire is properly garaged and to analyze the couplers and verify that any loose couplings have been securely fixed. The expert can then authorize putting that driver back into service and, if Octoport is involved, remove the software "lock" on the source driver.** If a wire spill has occurred, log all relevant details

11. If no spill is visible, no attempt should be made to garage the source except by an expert. An expert should be called in (see the list below). The expert may choose to very gently attempt to garage the wire, following the procedures of the preceding paragraph while feeling for any unusual resistance to retraction. This would be a reasonable choice if, for example, the wirespill alarm limit is set close to the tube length, so that a loop is unlikely to have formed. The expert may choose to declare that the wirespill is not correctable at that time (without undue risk of damaging the wire – and requiring a later access under the Plug skin. One set of couplers under the skin at the rear of the Plug is accessible without withdrawing the Plug.) This would leave the source somewhere in the detector. This is believed not to affect any data taking or the functioning of any part of the detector. It may be necessary to rope off a small area whenever personnel work around the Plug. Note that the maximum possible radiation field at 1 meter is less than about 4 mR/hour, and it obeys the inverse-square law. If a wire spill has occurred, log all relevant details.

12. (This section applies only to running under the Testmain program, and is not relevant to sourcing using Run Control and/or the Octoport program on the source driver control PC on the first floor of B0:) Watch the towers' source current peaks on the PC screen and see if the profile and sequence match what is expected. If not, this may indicate that the source tubes or signal cables are not connected to the correct places (or possibly that not all phototube signals are getting into the PC DAQ). Garage the wire locally (manually) with the switches on the control box first if you intend to inspect the setup. Remember to reverse the direction every 5000 counts during garaging.

13. (This section is not relevant when the source drivers are inaccessible in the collision hall. It is expected that the general radiation survey which is done upon first entry of a controlled access will verify that no source is out of a garage:) At the end of each session, make sure the source is

properly garaged, i.e. the warning light is off, the reel count is within 30, and the radiation field is strongest near the middle of the pig and falls off as the survey meter probe moves away from the center.

14. At the end of each session, turn off all power switches to control boxes and counters in the relay rack on the first floor of B0

15. The posted area shall be reduced to the close vicinity of the source driver, when not in use.

4.0 Deviations from the Procedure

The CDF Operations Department Head must approve all deviations from the above procedure.

5.0 Required Training and Authorized Training Personnel.

Anyone who operates the source driver (the operator) must get training from the Fermilab ES&H. The required courses are FN000048 (source training) and FN000301 (Radiological Worker training). Training is valid for two years.

The user should also be familiar with the content of this procedure and follow the safety procedures documented here.

Lift training, and either controlled access training or supervised access training, may be needed if required for appropriate access to the source drivers. The only obvious exception is sourcing when the collision hall is secured and access is not possible.

The user should be trained by one of the experts (see Sect. 7) to use the driver and get familiar with the mechanism. The user should be aware of the possible problems one may encounter, including contamination, the likely causes of those problems, and what steps to take when a warning message comes up while running the program on a PC.

After the initial training, the user should operate the driver mechanism in the presence of one of the experts until the expert can authorize the user as an operator. After the completion of the training, the user's name will be added to the list of qualified operators maintained by the Source Physicist. The list should be maintained in a binder that contains this procedure document and should be referenced in this portion of the procedure. The binder should be kept at the source driver PC station.

6.0 Training Materials.

A copy of this procedure.

7.0 List of Trained People for this procedure.

The list of trained people for this procedure will exist in written form in the CDF Department copy of this procedure. [Only CDF technicians will be trained in the procedure.]

Virgil Barnes Alvin Laasanen Arnold Pompos Alexei Sedov

The list may eventually reside in a Lab-wide database as well.

Name	Date	Trainer Signature	Comments

8.0 References and Supporting Documentation

Emergency Procedures

As stated earlier, it is highly recommended to run the driver through the PC program. The program will warn the user of problems, the possible causes of them, and how to fix them if possible. In addition to these warnings, one can spot problems by looking at the detector response on screen (Sect. 3.1 # 10), but only when running the older "Testmain" program in the "portable PC DAQ" configuration, where a small section of the Plug signals is directly connected to an ADC in the PC. .

If the source driver operator ("user") is unable to run the driver via the PC program or the control box and the source is inside the garage, contact the area Radiation Safety Officer (RSO) or one of the source driver experts.

In the case the source is outside of the garage and cannot be garaged using the PC program or the control box, the user may try to garage the source by turning the reel by hand if ALL following conditions are true:

1. The user is sure the source is not broken;
2. The user has received training in how to reel the wire into the garage by hand;
3. Experts cannot be contacted immediately;
4. The reel can be turned easily, do not force the reel at any time.
5. The user has carefully inspected all observable couplings and either found them OK or is able to control all loops and snags so that they do not develop into kinks as the wire is wound in.
6. The user has verified that the wire has not slipped between the reel and the polyethylene slide sheet – by looking edgewise at the reel near the exit groove and seeing no gap (the wire thickness is only 0.028 inches).

If the source cannot be non-destructively and properly housed in its garage (and an expert cannot be summoned in a timely way); OR if you suspect that the source or source wire has been damaged: maintain the roped and posted area, call in a Radiation Safety Officer who is knowledgeable about removing the wire from the source driver (such as Joe Leo) to take the wire into custody. If the wire can not be extracted, the RSO should reduce the roped area using the survey meter to the minimum necessary to protect nearby personnel**.** The source driver control box should be turned off, tagged, and the ribbon cable from the PC unplugged from the control box until the wire can be retrieved by deeper access to the detector.

List of Contacts

Emergency: x3131 --- It is believed that none of the wiresource situations described in this document require calling the emergency number. The experts and the RSOs are by far the best people qualified to deal with such situations. Proper roping procedures (or removal of a source wire) are believed to be sufficient to control any potential hazards.

Purdue Source Driver Experts:

Virgil Barnes	(765) 494-5199 (Office) (765) 743-1177 (Home) barnes@physics.purdue.edu
Alvin Laasanen	(765) 494-5398 (Office) (765) 463-0383 (Home) laasanen@physics.purdue.edu
Arnold Pompos	x8410 (Office) x4241 (Home) pompos@physics.purdue.edu

Division/Section Radiation Safety Officers (RSO's) and ES&H Section Personnel:

Beams Division:	Mike Gerardi	x4570	Pager 0591	gerard@fnal.gov
	Gary Lauten	x8360	Pager 0170	glauten@admail.fnal.gov
	Tony Leveling	x4401	Pager 0827	hamburg@fnal.gov
	Roger Zimmermann	x3857	Pager 0815	zimmermann@fnal.gov
Particle Physics Div.:	Wayne Schmidt	x4407	Pager 0246	wschmidt@fnal.gov
ES&H Section:	Kathy Graden	x4939	Pager 0735	graden@fnal.gov
		Home: (630) 851-0636		
	Sue McGimpsey	x8386	Pager 0320	mcgimpsey@fnal.gov
	Joe Leo	x3743	Pager 0192	leo@fnal.gov
		Home:(847) 438-3193		
	Bob Kingsley	x4081	Pager 0298	kingsley@fnal.gov
	Billy Arnold	x3741	Pager 0399	billy_arnold@fnal.gov
B0	Dee Hahn	x2354		
	Keith Schuh	x4575		