# Model 1950

## Large Area Ultra Low Background Alpha Particle Counting System

## Set Up and Operations Manual

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# Section 1

## Model 1950 Ultra Low Background Alpha Particle Counting Systems

The Model 1950 Alpha Particle Counter has gone through many design alterations and improvements since it's inception in 1982. From advancements in construction materials, to user friendly computer based data control, the Model 1950 has become the industry standard in determining trace contamination of alpha particle emitting radionuclides found in IC processing and packaging materials. The Model 1950 is our standard counting tool, comprised of a 1000 square centimeter detector, electronics pack (or CE-99), a Host PC based data acquisition software package, and a P-10 gas delivery set-up.

(1) The proportional counter (or detector) consists of two chambers, the detector chamber and the sample chamber. The two chambers are separated by an extremely thin Mylar film window which is approximately 6 microns (250 mg/cm2) thick. The detector chamber uses a special P-10 nuclear counting gas (90% Argon, 10% Methane), supplied by the user, which flows through the detector at a very low flow rate. The sample chamber accepts the sample tray, which positions the sample close to the Mylar window. As alpha particles are emitted from the sample surface towards the detector, they pass through the Mylar window and ionize the P-10 gas inside the detector chamber. These alpha particle ionization tracks in the detector are sensed, amplified, discriminated, and counted for a user determined period of time.

(2) The electronics pack (CE-99) consists of two primary sections, the analog electronics section and the scaler/timer section. The CE-99 is attached to the back or side of the detector housing, and includes a charge sensitive pre-amplifier, a detector bias power supply, an amplifier, and a discriminator (factory set for 1 MeV). The analog section derives its power from the PC via the USB connector cable. The alpha pulses from the detector are amplified and discriminated, and then routed to the scaler/timer board, which serves as an accumulator.

(3) The user programs the software for a selected data acquisition period (dwell time), and this data is displayed on the Host PC display as a time histogram. Here, the

horizontal line (X axis) represents time intervals, and the vertical line (Y axis) represents alpha observations for that specific time interval. While X axis values are user defined, the Y axis display is automatic, based on the highest current observation. The values for each observation are displayed underneath each graph column, showing the count number and observed alpha counts.

Once a test (“assay”, “run”, “counting session”) has been completed, the user may define the region of interest, or ROI, where upon the software will display the total integral for the ROI. The tool background is subtracted, the result is divided by the sample area, and a correction factor is used to adjust the data for detector counting efficiency, all of which is performed by the Host PC. The computed display provides the corrected data for net alphas per centimeter squared per hour. The data can then be saved for filing and/or printed.

(4) The gas delivery section of the tool consists of two meters and a section of PVC tubing. The large meter is referred to as the two-stage regulator, and allows high pressure gas bottles to be used at a more reasonable delivery rate. The smaller meter is called the flow meter, and displays flow in values of 100 to 500 cc’s per minute. The PVC tubing, which delivers the P-10 gas from the flow meter to the detector, is used for its non-porous and non-conductive properties.

## System Component Specifications

### Model 1950 Detector

Detector Sensitive Area: 1000 $cm^2$

28cm (11") x 35.6cm (14)    20.3cm (8") x 40.6cm (16")

Chamber entrance height = 2.3cm (.9") tall

Type: Gas Flow Proportional

Gas: P-10 Counting Gas (90% Argon, 10% Methane) DOT Class 2.2 Nonflammable Gas

Background: ≤ 3.5* alphas/hour (0.0035 alphas/$cm^2$/hr)

*At time of tool delivery

Detection Efficiency: Greater than 80% (2 pi )

Operating Voltage: +800 VDC

Detector Window: 250 μg/$cm^2$ metalized Mylar

Overall Dimensions: 46cm (18") wide x 55cm (21.5") deep x 11.4cm (4.5") tall

Weight: 7 kg (15 lbs.)

### Model 1950 Data Acquisition Electronics

USB Communications

Detector Bias Power Supply (1kV)

On board Charge Sensitive Pre-amp

Linear Amplifier

Integral Discriminator (1 MeV)

Scaler/Timer board

Data Acquisition Software

PC

# Section 2

## Unpacking, Connecting P-10 Gas, and Initial Set Up Procedure

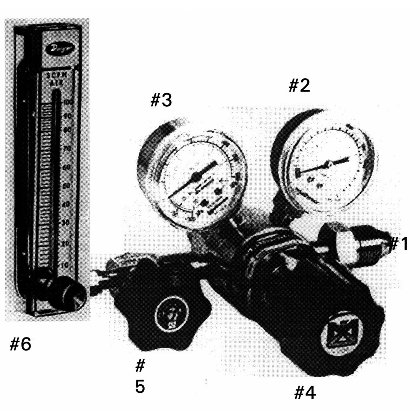
After unpacking the entire tool, inspect for damage. If any damage is noticed, contact Alpha Sciences immediately. After the tool has been set up and is running properly, the general shipping boxes can be discarded. However, it is advised that the box that contained the detector itself be saved. Should your detector ever need to be returned to the factory for service or upgrade, it is best to use the original box.

**CAUTION!**

There are two chambers within the proportional counter, the detector chamber and the sample chamber. The P-10 gas flows into the detector chamber, and then exits into the sample chamber. The "ceiling" or window of the sample chamber is made of extremely fragile aluminized Mylar film, which is < 6 microns thick. This window contains the P-10 gas in the detector chamber, but is thin enough to allow the alpha particles to pass from the sample chamber into the detector chamber, where they ionize the P-10 gas. This window is easily damaged by over-pressure of the P-10 gas, incorrect insertion of the sample tray (or other foreign objects), material stacked too high on the sample tray, etc. Window contamination or rupture requires replacing the window, which is expensive, so *please use caution*.

## Attaching P-10 Gas and adjusting flow rate

Find the two-stage gas regulator (see Fig 2) which has the flow meter threaded onto its outlet portion, and a left handed female inlet. Before connecting this piece, make sure the P-10 bottle valve is completely closed (clockwise). Partially open the flow meter valve (6) by turning counter-clockwise. Close the second stage valve (5) by turning fully clockwise. Close the first stage regulator valve (4) by backing out counter-clockwise until it turns freely. Attach the female threaded coupling to the P-10 gas cylinder male outlet (typically a left handed thread) using a 1-1/8" box wrench, being careful not to over-tighten and making the gauges horizontal and the flow meter vertical. DO NOT connect the other end of the PVC tubing to the detector yet. Once all the valves have been confirmed closed and the regulator is tightened, open the P-10 gas bottle valve. The first pressure gauge (2) should read approximately 2000 psi for a new bottle. Turn the first stage regulator valve (4) slowly in a clockwise direction until the second pressure gauge (3) reads 10 psi. Slowly open second stage valve (5) by turning counter-clockwise; open completely until valve stops. Turn flow meter valve (6), adjusting initial flow rate to 100 cc/min. This purges the line. Confirm the P-10 exhaust tube at the front right of the counter is open. Now attach the loose end of the PVC tubing to the gas inlet port at the rear of the counter . Allow the tool to sit for 1 minute, then slowly adjust the flow rate up to 200 cc/min. Let the system set for another minute, then slowly bring the gas flow up to its final rate, from 250 to 350 cc/min.




1. Connection to P-10 gas tank
2. Tank pressure gauge
3. Delivery pressure gauge
4. Delivery pressure adjustment valve
5. Shutoff valve to flow meter
6. Flow meter adjustment

**Fig. 2 –Dual Stage Regulator and Flow Meter**

## Regulator attachment procedure

1. Close P-10 bottle valve
2. Open flow meter valve (6) counter clockwise
3. Close second stage valve (5) clockwise
4. Close regulator valve (4) counter clockwise
5. Attach regulator to P-10 bottle
6. Open P-10 bottle valve
7. Open regulator valve (4) clockwise until gauge 3 reads 10 psi
8. Open second stage valve (5) counter clockwise
9. Adjust flow meter valve (6) down to 100 cc/min
10. Attach tubing to detector
11. Slowly adjust flow up to normal 350 cc/min

## Changing a P-10 Gas Bottle

Once the flow meter valve (6) and first stage regulator valve (4) have been set, there is no need to adjust them again for a gas bottle change. Once a P-10 bottle reaches 500 psi, it is time to attach a new supply bottle. If you change the gas supply immediately, you may leave the High Voltage switch on. If the gas change will take more than 1 hour, it is best to switch off the High Voltage. Close second stage valve (5) completely by turning clockwise until it stops. Close the P-10 bottle valve completely by turning clockwise until it stops. Using a 1-1/8" box wrench, loosen the female coupling to the bottle. You may hear a slight escape of trapped P-10. Attach the regulator assembly to the new P-10 bottle and tighten the female coupling. First open the P-10 bottle valve and see that the first pressure gauge (2) reads about 2000 psi. ***Slowly*** open second stage valve (5) by turning counter-clockwise. Watch the flow meter as you slowly open the valve. Once completely opened, the flow rate should stabilize to its preset value.

### Note:

You will need to carefully monitor the consumption of P-10 gas. Never let the tank empty out completely. In addition to supplying an ionizing medium for the alpha particles, the P-10 gas keeps the electrode structures dry and clean. If you should run out of P-10 gas while the High Voltage is on, damage could occur to the detector. Damage occurs in the form of High Voltage arcing due to moisture in the air getting into the detector chamber. If you are going to place the detector on idle for an extended period of time, turn off the HV, and turn the gas flow down, but not off. This will keep the detector clean and in a semi-ready state, without using too much gas.

## Section 3

### Initial System Set Up

Once the system has been fully unpacked and inspected, and P-10 gas is flowing through the detector, you are ready to begin the system assembly. See Fig. 3 for general cable routing and connections. While there is no truly “exact” way to set up your detector, there are some basic guidelines that should be observed. For the most part, the user should decide the final layout based on where the detector is to be located, be it a lab table, work bench, etc. From an ergonomic point of view, the detector itself should be easy to load and unload, the keyboard easy to access, and the monitor easy to see. Keep in mind the detector should be located so that it will not be accidentally bumped, jarred, or vibrated. Drafts, vent ducts, and sources of dust should be avoided to prevent external background influences.

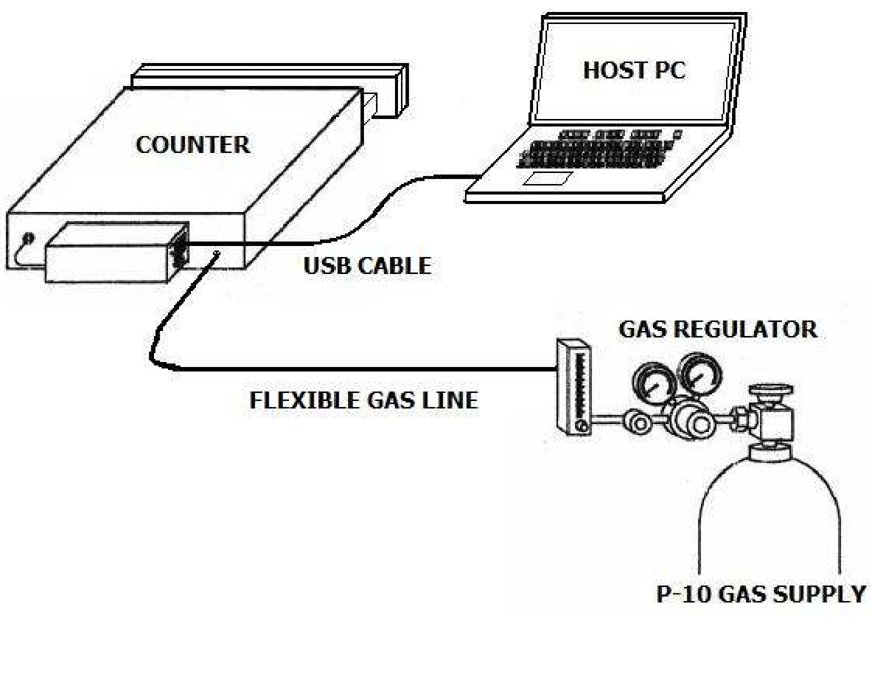



**Fig 3 – Cable connections and routing.**

The system should be powered from a dedicated 115V AC @60Hz outlet near the detector. The Host PC is typically a laptop PC, which can be run on battery, but will not sustain the power required for the counter. The Host PC (laptop) must be powered from an AC source using the included power cable. Do not use extension cords. If a dedicated circuit is not available, then be aware of any electronic noise on the power line that could raise the detector background level. Although the unit is equipped for EMI suppression, operation in the vicinity of high-power electromagnetic devices may affect system performance. The USB "B" type connector cable that connects the detector to the PC is shielded from external sources of RF, and should be routed so that no other cables are touching it..

Confirm the High Voltage locking toggle switch on the back of the detector, near the USB connection, is in the down "OFF" position before making this connection. Pull switch outward to clear locking notches when switching. Place the detector and PC in their locations. As soon as the PC is powered up, you will see the green indicator light on the back of the detector electronics go on, meaning power is being supplied to the analog electronics, but with the HV switch in the "OFF" position, the HV power supply will be off.

Finally, if using a printer, connect the printer cable to the PC and place the printer in a location at least 3 feet (1m) from the detector. This too will aid in preventing noise created by the printer from potentially effecting the alpha counter. Once all the equipment has been placed for normal operation, confirm that the communications cables are not touching any equipment or other cables. Turn on the Host PC. Windows desktop should appear, with an icon for the ProXL program. Note the power indicator lamp (green LED) is lit on the detector analog electronics. After the detector as been purged with P-10 (4 hours), the HV locking toggle switch on the back of the detector should be set to the middle "NORMAL" position for normal operation. This completes the initial setup. Please see the "**ProXL Software Manual**" for details on how to use the software.

# Section 4

## Sample Trays for Standard and Powdered Samples

### Sample Tray Cleaning

Provided with the detector is a standard sample tray. The sample tray is used to introduce solid samples (or sources) to be counted into the chamber. Solid samples refers to silicon wafers, rolled lead sections, ingots, etc. Powdered or loose samples require a powder tray, described below. By using a sample tray, the bottom of the detector chamber will remain clean. The sample tray is made from a non-alpha emitting material, and is sometimes delivered with the protective film in place. This film prevents scratches on the tray during shipping. It is very important to remove this film prior to use, as the adhesive contains alpha emitters. Remove the film and clean the surface thoroughly with isopropyl alcohol to remove any residue. Then wipe dry. **Note**: Anytime you clean the tray, it will charge slightly with static, attracting Radon. Therefore, if you place a freshly cleaned tray into the detector, you will see background counts for the first few hours, which will recede as the Radon decays off. At our labs, we clean the sample trays and then place them in a simple glove box purged with P-10, usually overnight, before use. This is also a good way to store unused sample trays.

### Sample Tray Adjustments

On the bottom side of the sample tray, you will see four adjustable feet. These are provided to optimize the sample (or source) geometry (distance) to the detector window. Obtain a sample of the material you wish to count which represents the maximum thickness of the material you will place in the detector. This is necessary for adjusting the sample tray height so that the sample is as close as possible, but not touching, the fragile detector window material. Place the sample upon the tray, and open the detector to determine if you need to adjust the tray for clearance. Adjust the four bottom feet so that the distance from the top of the sample (or source) is approximately 1-2mm. Make sure to adjust all four feet equally for an even reading. It is important that all samples be adjusted to this height in order to obtain optimal performance.

**Inserting a Sample Tray**

Once the height has been adjusted, the sample tray can be inserted into the chamber. It is a good idea to position yourself so you can see into the chamber and watch the sample going in so as to prevent any damage to the window. Depending on where you prepared the sample tray, it might make sense to lightly wipe the bottom feet of the tray clean before inserting it into the detector chamber. Once you have inserted the loaded sample tray, close the Radon Blocking Door and gently tighten the thumb-wheels. This is required to provide a positive pressure in the sample chamber, allowing the P-10 gas to enter the detector chamber and exit through the sample chamber. Any time a sample is introduced into the detector, Radon gas will cause an influence on the first few hours of counting.

In the event that powdered or loose samples are to be counted in the 1950 detector, it is STRONGLY recommended that the special powder tray and Mylar film be used to prevent the migration of sample material into the chamber. Migration in turn could cause contamination and incorrect background and sample results. The Mylar film is so thin as to be essentially transparent to energetic alpha particles, so it does not effect the counting results of the sample.

Load the powder tray with the sample to be analyzed. Notice that the powder tray has a shallow lip around it's entire edge. The lip serves two functions; first the lip provides a well for containing the powdered sample; and second, the top surface of the lip is used as a mounting surface for the double-sided adhesive tape, which in turn secures the Mylar film in place.

The powder tray requires approximately 200cc (1 cup) of powder to completely fill the powder tray cavity. Carefully pour the powdered sample into the tray cavity, distributing the sample over the entire tray cavity. Ideally, the sample to should be equal to or close to the height of the containment lip. (Note: At the very least, there should be enough material to cover the bottom of the tray cavity with a homogeneous layer.) Using a clean straight edge, carefully level the sample in the tray until it is of uniform height. Using a lint free wipe wrapped around a finger tip (dampened with IPA, if available), wipe the top surface of the containment lip to remove any stray material. Once cleaned, apply a strip of double sided adhesive tape along the entire top surface of the four sides. The sample and tray are now ready to be covered with the Mylar film.

The act of placing the Mylar film down onto the powder sample tray is one best performed with two people (four hands). If you are using one of our Mylar Film Jigs, it can be performed by one person, and directions for this are supplied with the Film Jig. Otherwise, it is best to incorporate the assistance of another. Remove enough Mylar film from its dispenser roll to cover the sample, with a few inches of play on each end. Then, by grasping the four corners of the sheet, pull the material tight and wrinkle free. Moving down together, apply the Mylar film to the double sided tape, where it will stick on the first application. It is best to move slowly for accuracy and so as not to disturb the sample. The goal is a smooth Mylar film surface free of major wrinkles, sags, or tears. Once the Mylar film is down, use another lint free wipe (dry) wrapped around your finger tip and gently run finger tip around entire rim of the tray, ensuring there is good adhesion between the lip/double-sided tape/Mylar film interface. After the seal is complete, excess film can be trimmed away using a razor. The powder tray is now ready for insertion into the counting chamber.

Once a sample has been counted, remove the film, tape and sample. Clean the tray with a mild detergent and water solution. Rinse well in clean water and wipe dry. Allow the tray to dry completely. There should be little fear of cross contamination as any remaining previous sample residue will be covered by the new sample, which should be thick enough to stop any alpha particles which may emanate from the bottom of the tray cavity.

## Section 5

### Background Determination

Background refers to the inherent noise that comes from the detector itself, and from several other influences. The following items will affect the background you will observe at your location:

- Altitude (Cosmic Rays)
- Electronic and RF noise on 120V AC
- Vibration
- Atmospheric Radon concentration

Some of these factors can be remedied, some cannot. Cosmic rays are very energetic particles which originate in deep outer space and penetrate deep into the earth. Shielding is next to impossible as energetic cosmic rays will penetrate over 40 feet of lead. The only way to subtract the background effects of cosmic rays is to use an anti-coincidence scheme. The sensitivity of the Model 1950 to cosmic rays is minimal. Electronic noise is fairly well eliminated via good electronic design principles. RF noise can be troublesome but can be eliminated either by power line filtering or relocation of the counting system to a less noisy environment.

Alpha Sciences, in manufacturing the detectors, has carefully selected proportional counter materials, which are relatively free of radioactive contamination. Therefore, a very small percentage of the background is due to this source. The remaining background factor, Radon-daughter products, needs special attention. The earth's crust contains large deposits of Uranium and Thorium. After a few billion years, these natural occurring radioisotopes decay to stable (non-radioactive) lead. During this decay process, one of the daughter products is Radon, an inert radioactive gas. The earth's atmosphere and the air around us is heavily contaminated with this inert radioactive gas. It cannot be eliminated even by laminar flow HEPA filtering. In short, you cannot escape from Radon contamination. However, Radon has a relatively short half-life. It decays to a radioactive, heavy metal, which immediately falls out of the atmosphere. Therefore, the very moment you have loaded samples onto the sample tray, they are immediately contaminated with Radon-daughter-products, which emit alpha particles. This is why the first four hours of data of any count performed here at our labs is recorded but not factored into the equation.

Once the detector has been installed and P-10 gas is flowing, refer to the software section of this manual to start a counting period. The count is performed with the chamber empty as we are trying to determine the inherent background of the tool and the background of the tool's location. The final value of background is referred to in either alpha per hour for the entire detector area (ex. 5 counts per hour) or in terms of actual square centimeter value (ex. 5 counts per hour divided by detector area, 1000 square centimeters, equals 0.005 alpha per sq cm.).

In cases where samples count at or below the background level, a statistical means of counting is used. This is called the Lower Limit of Detection (LLD), and refers to the lowest detection ability of the counter. Please see the annex section on "Lower Limit of Detection" in the **ProXL Software Manual**.

### *Important Note: Background and Sample time period*

The means of determining the final sample emission value are based on statistical formulas that require the background time period match the sample time period. Thus, a sample that is observed for 48 hours must be preceded or followed by a background run of 48 hours. A counter that has demonstrated a history of stable backgrounds can safely count up to three samples between backgrounds, as long as each sample is not counted more than 48 hours. Longer sample observations (like 72 hours) would require more frequent backgrounds. For the most part, this is to protect the user from having to re-count too many samples, should it be found that the counting chamber suddenly had a high background. It is a good idea to keep a log of past backgrounds so that any trends in background (appreciable rises or drops) can be spotted. Such trends usually indicate a contaminated or damaged window.

# SECTION 6

## Calibration

As the counter is being used, it is important to ensure that it remains in calibration. How often the calibration is performed is a user-defined parameter. Frequency of calibration will depend on how often the tool is used, and of what type samples are being run. Also, if the counter is to be stored for some period and then used at a later date, it is wise to run a calibration after re-starting the counter. Counter calibrations can be performed by Alpha Sciences here at our labs. Or, for customers with their own source material, the calibration can be performed on site.

### How a calibration works

A source of known value is placed upon the sample tray, pushed inside the counter and observed for a pre-determined period of time. Since the source lies about 1-2mm from the counter window, we can expect to see about 80 to 84% of the emission from that source. This is referred to as the "efficiency" of the counter. The reason we see only 80% to 84% of the source is because some of the alpha particles are traveling at such a steep angle (sideways) that they will not reach the window of the counter. If the observation falls between 80 to 84% of the value of the source, then no adjustment is needed. If the reading is >86% of the value, a slight reduction in the gain is needed. Allowing the counter to run at a higher (>86% ) efficiency makes the tool more sensitive to external influence such as RF, ESD, EMI, vibration, etc. Also, high energy Beta particles could be interpreted as alpha strikes and counted. On the other hand, if the reading is <79%, a slight increase in the gain is required. If the counter runs at a lower efficiency (<79%), the background counts will be very low, and the sensitivity of the counter to lower energy alpha particles is diminished.

### Gain Adjustment

During calibration procedures, it may become necessary to adjust the gain. This requires a mini-pot "tweaker" or small non-conductive screwdriver. Remove the "High Voltage" cover on the back of the counter. The HV components inside are shielded by a secondary shield, but use caution when working in this area. The gain is accessed by the small hole in the rear of the silver aluminum shielding. As you are facing the rear of the counter:

- Rotating the gain adjustment pot in (**clockwise**) will decrease the gain, lowering the observed counts.
- Rotating the pot out (**counter-clockwise**) will increase the gain.

**Performing the Calibration**

01. Confirm counting chamber is empty.
02. Confirm gas flow (250-350 cc/min), HV switch in "Normal" position.
03. Open the counting chamber door.
04. Insert an empty sample tray halfway into the counting chamber
05. Place the calibration source in the center of the tray, source up.
06. Adjust tray height, source to window needs to match sample to window height.
07. Insert the tray and source all the way into the counter.
08. Close the chamber door.
09. Allow the P-10 gas to re-saturate the counting chamber, about 5 minutes.
10. Start 10 x 1 minute observations. See Observation Parameters, p.16
11. Perform calibration calculation. See Defining Results, p.16
12. If needed, continue calibration. Gain adjustment, p.15 and re-test.
13. If tool is in calibration, remove calibration source from counter.
14. Place calibration source in protective case and store properly.
15. Begin extended background count (typically 48 hours)

See Post Calibration Backgrounds, p. 16

**Observation Parameters**

When performing a calibration, the calibration source is only to be observed for a short period of time. Do not leave the calibration source inside the counter for more time than is required for this testing. The calibration source is calibrated based on 1 minute emissions. When counting(observing) the calibration source, set Dwell time to 1 minute, Total Assay time to 10 minutes, so you end up with 10 x 1 minute observations. There is a default setting in the software for this task. We want to see how many alphas are being counted, per minute, by the detector window. After 10 observations are done, click the compute button to determine the average CPM (counts per minute) value.

**Defining Results**

Alpha particle calibration sources used by Alpha Sciences are defined in terms of 2 pi alpha emission at 100% and at 84%. The counter is factory calibrated to read between 80% and 84% of the emission rate. The average of the 10 observations is defined by clicking on the compute data button in the software window. Using the PC calculator, define the square root of the average. This is the tolerance of the calibration counts. All 10 of the observations should fall within the tolerance of the average CPM +/- the square root. *If more than two of the ten observations are outside this tolerance, re-adjustment of the gain is required, and another calibration sequence must be run.*

**Post Calibration Backgrounds**

After a calibration has been performed, there will be residual activity from both the calibration source, and from the act of opening and closing the counter door. It is suggested that post calibration backgrounds be run for a minimum of 48 hours to allow for all the activity from the calibration source to decay away. Once a stable background has been achieved, the counter is ready for sample counting. Normal backgrounds between samples are still run for their suggested time periods, see p.13.