SAND2012-2294P

FAL 200
FALCON 5000 Training

FLY AWAY LAB

SAND-xxxxxxx

Learning Objectives

- Gamma Spectroscopy Review

- Instrumentation
  - ✓ Introduction
  - ✓ Safety Considerations
  - ✓ Initial Set up
  - ✓ Startup
  - ✓ Quality Control Check
  - ✓ Determining Dead Time

Learning Objectives cont.

- Instrumentation (cont.)
  - ✓ Performing Analysis & Background Counts
  - ✓ Data Control
  - ✓ Laboratory Control -Sample Analysis
  - ✓ Shut down of the system

- Quantitative modeling ISOCS
  - ✓ Modeling of the Sample using the Geometry Composer
  - ✓ Executing the Modeled Source Geometry
  - ✓ Performing the Analysis utilizing the Modeled Geometry

Gamma Spectroscopy Review

Gamma Spectroscopy Review
High Purity Germanium

What is a HPGe detector?

Germanium , silvery-gray, metallic chemical element, Ge, atomic number 32, atomic weight 72.59, melting point 937.4°C (1719°F), and boiling point 2830°C (5130°F), with properties between silicon and tin. Germanium is distributed widely in the Earth's crust in an abundance of 6.7 parts per million (ppm).

Gamma Spectroscopy Review cont.

Germanium is found as the sulfide or is associated with sulfide ores of other elements, particularly those of copper, zinc, lead, tin, and antimony.
The properties of germanium are such that there are several important applications or this element, especially in the semiconductor industry.

The first solid-state device, the transistor, was made of germanium.

Gamma Spectroscopy Review cont.
Semiconductor properties

These detectors are **semiconductors,** which measure and detect radiation by means of the number of charge carriers set free in the detector. The charge carriers are arranged between two electrodes. Since ionizing radiation produces free electrons and holes, the number of electron-hole pairs is proportional to the energy transmitted by the radiation to the semiconductor. As a result, a number of electrons are transferred from the valence band to the conduction band, and an equal number of holes are created in the valence band. Under the influence of an electric field, electrons and holes travel to the electrodes, where they result in a pulse that can be measured in an outer circuit. The holes travel into the opposite direction and can also be measured. As the amount of energy required to produce an electron-hole pair is known, and is independent of the energy of the incident radiation, measuring the number of electron-hole pairs allows the energy of the incident radiation to be identified.

Gamma Spectroscopy Review cont.
HPGe Detector Types

The difference between “P” and “N” type is that the “P-type” semiconductor material have holes as the majority charge carrier and electrons in the conduction band as the minority carrier. “N-type” have electrons as the majority of charge carriers and holes as the minority charge carrier.

N-type has higher efficiency at lower energies (better utilized for the detection of low energy photons)

FALCON 5000 is a ”P” type detector.

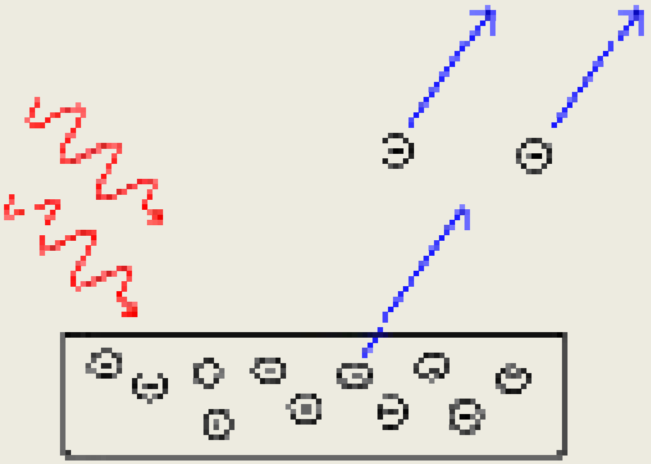
Gamma Spectroscopy Review cont.
Interaction Theory

There are three basic mechanisms in which photons from a sample interact with a detector:

- Photoelectric Effect
- Compton Scattering
- Pair Production.

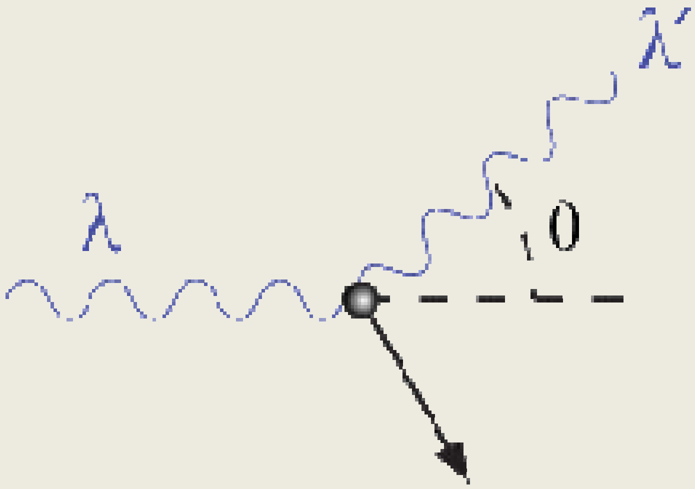
Photoelectric effect:

A gamma photon (<250 keV) is completely absorbed by an atom, which ejects an electron (photoelectron) creating an ion. The electron is charged and detectable.

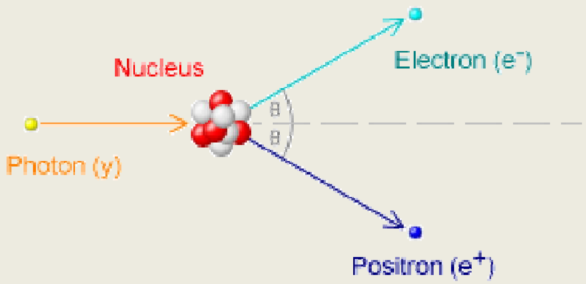


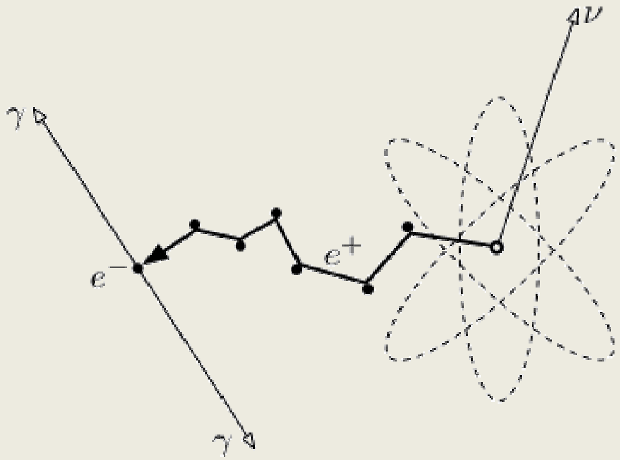
http://www.upscale.utoronto.ca/PVB/Harrison/Flash/Nuclear/XRayInteract/XRayInteract.html

Compton Scattering: gamma photon (0.3 to 5.0 MeV) imparts only a portion of its energy, deflecting an electron and creating a new photon of lower energy.



Pair Production: gamma photon approaches a massive object such as a nucleus. If energetic enough (>1.02 MeV) an electron and positron are created. (This is followed by annihilation of the positron, creating two more photons, each of energy m_e or 511 keV).





http://www.upscale.utoronto.ca/PVB/Harrison/Flash/Nuclear/PairProduction/PairProduction.html

Gamma Spectroscopy Review cont.
HPGe vs NaI Comparisons

<u>Disadvantages of HPGe:</u>

- Lower efficiency (FALCON 5000) 40% efficiency to sodium iodide.
- MUST be cooled to low temperatures to produce spectroscopic data. At higher temperatures, the electrons can easily cross the band gap in the crystal and reach the conduction band, where they are free to respond to the electric field. The system will therefore produce too much electrical “noise” to be useful as a spectrometer. Cooling to liquid nitrogen temperatures, 77.36 K, widens the band gap so that only a gamma ray interaction can give an electron the energy necessary to cross the band gap and reach the conduction band.

Gamma Spectroscopy Review cont.
HPGe vs NaI Comparisons

Advantages of HPGe:

- High Purity Germanium detectors (HPGe) can more reliably identify individual radionuclides from their passive gamma ray emissions since they have a 20-30x improvement in resolution compared to that of Sodium Iodide (NaI) detectors.

- NaI detectors, unlike HPGe detectors, have been shown to perform poorly in mixed isotope, shielded, stand-off, and high background scenarios.

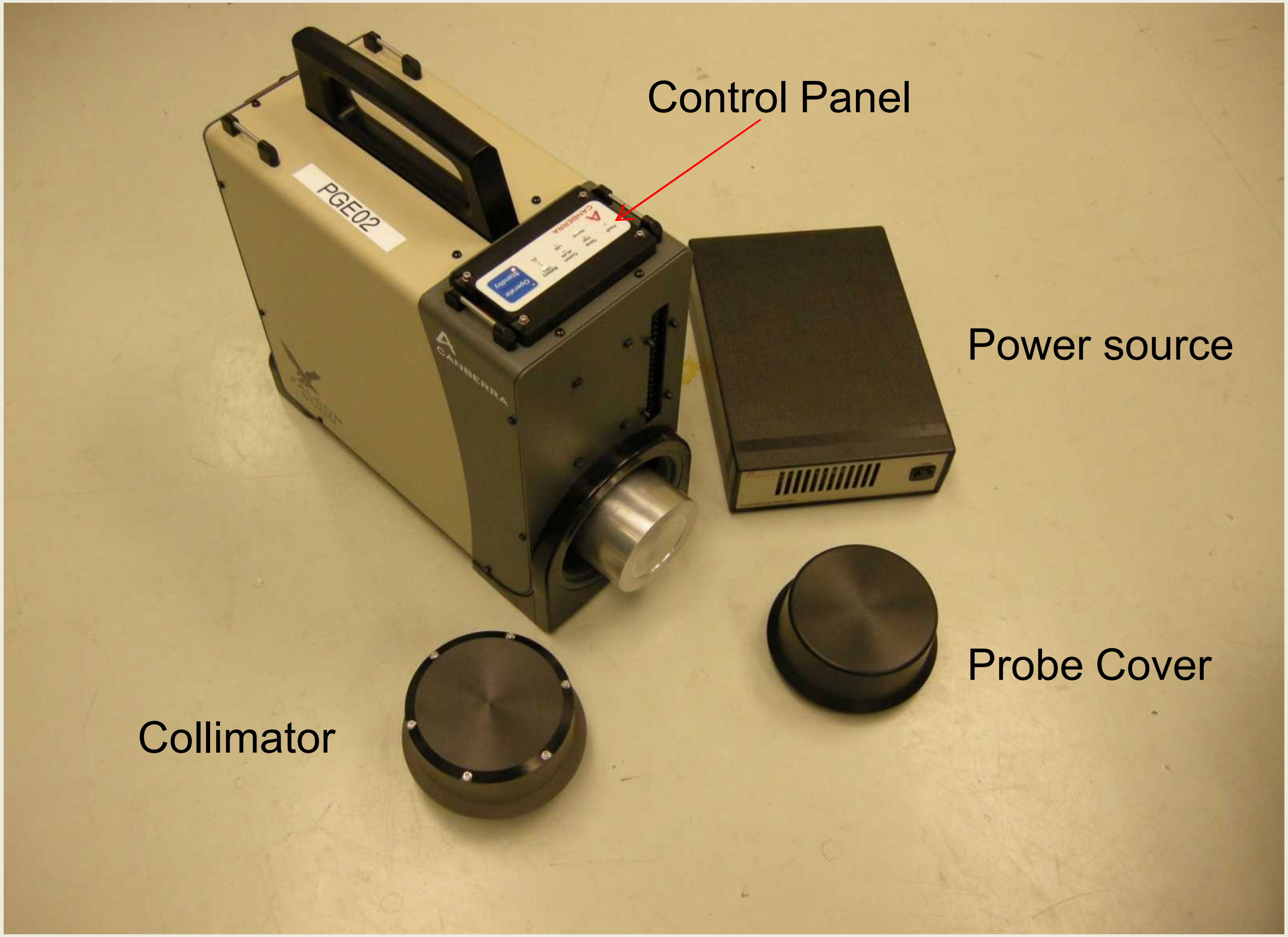
- NaI detectors also are hydroscopic. Good example FIDLER.

Instrumentation

FALCON 5000

Electronically cooled, incorporated Inspector

Can be used remotely up to 3- 6 hours with Re-chargeable Li-Ion batteries*

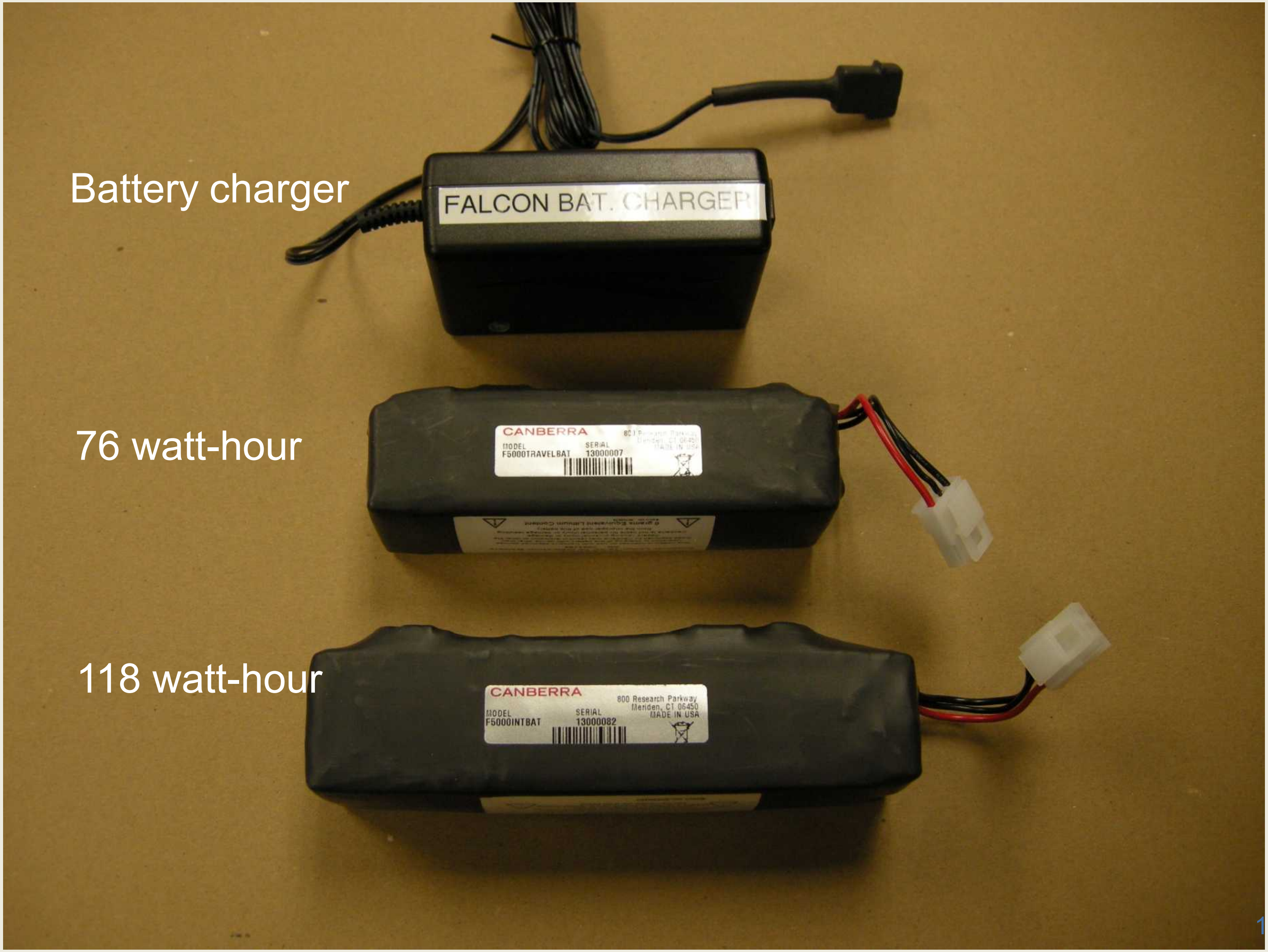


* 76 watt-hour Battery power can be used to cool down detector on the way to an emergency event.

FALCON Batteries

- FALCON 5000 batteries are hot swappable meaning that they can be changed during operation of the FALCON.
- The external battery charger can be used on both types of batteries (76 and 118 watt-hour).
- Both the 76 and 118 watt-hour battery are UN tested.
- The 76 watt-hour battery can be shipped by commercial air.

FALCON Batteries



Battery charger

76 watt-hour

118 watt-hour

Safety Considerations

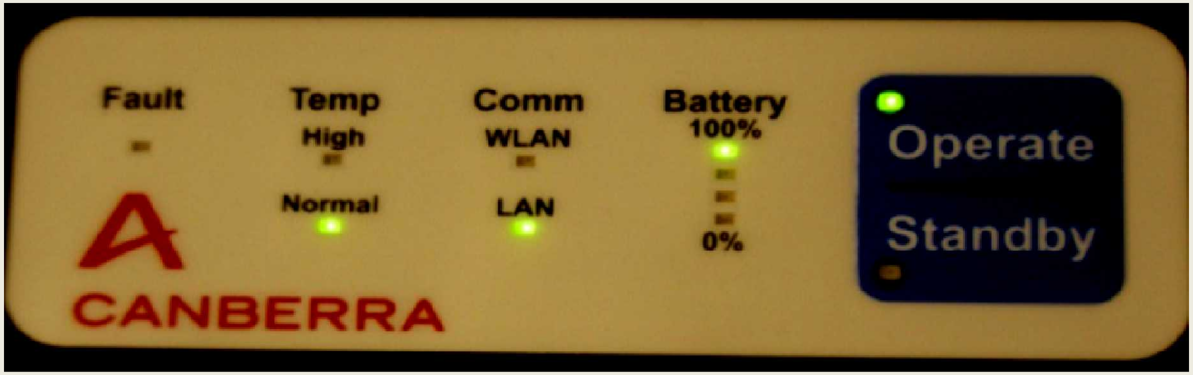
- Note: High Voltage is to be shut off before connecting or disconnecting all components associated with this system.
- Caution must be exercised not to touch the high voltage connections.

  (3 to 5 kV at a few mA).
- One should follow ALARA and minimize handling of the sources.

Initial Set up

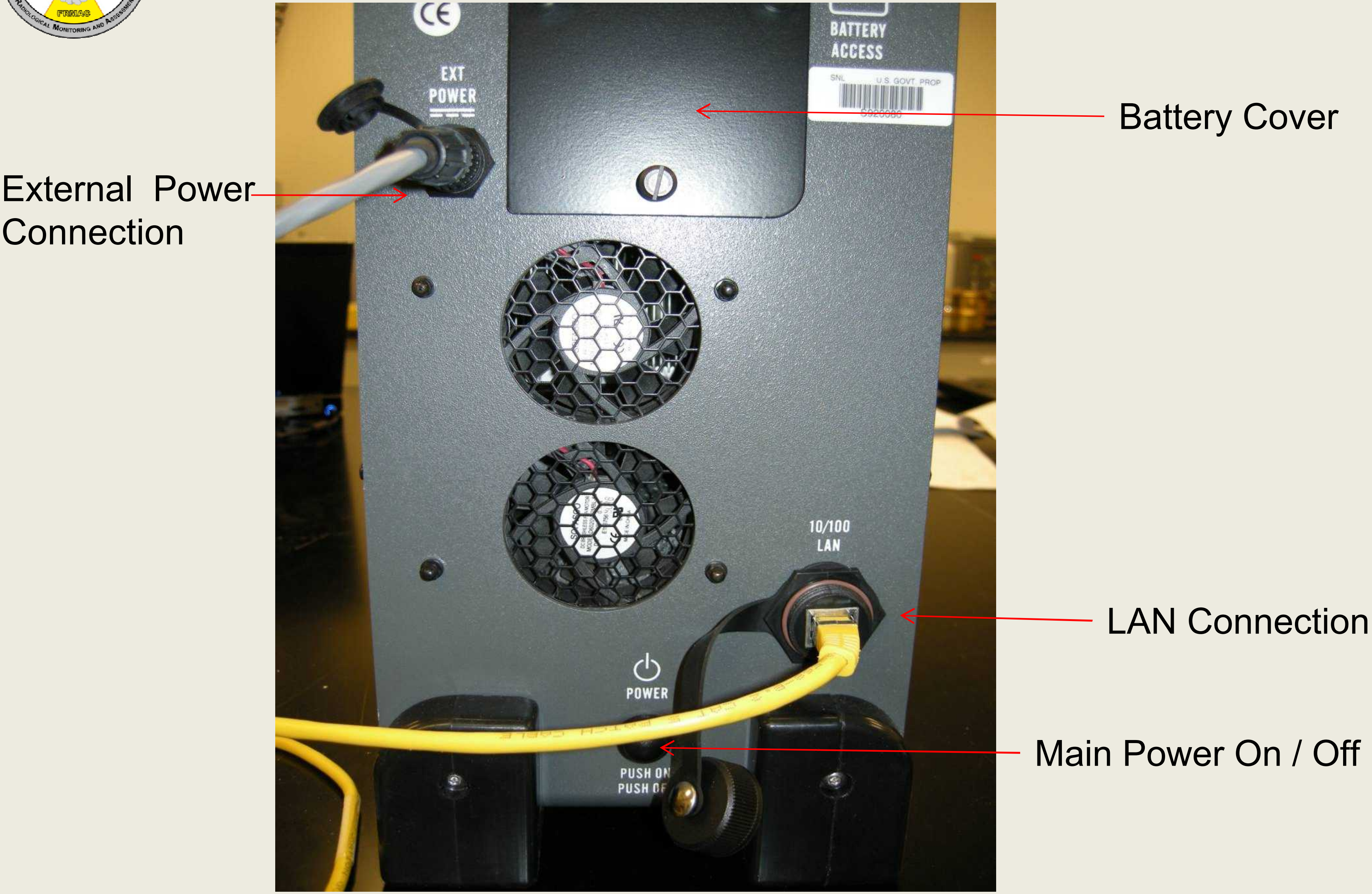
1. Connect external power supply unit.
2. Remove protective end cap and screw on side shield.
3. Connect LAN to computer
4. Press main power pushbutton on the back of the FALCON.
5. Log onto computer.

Control Panel
(top of unit)



- Unit requires approximately **3 hours** to reach the normal operating temperature.
- Cryostat temperature scale indicating Green Light on unit must indicate “Normal” to use. (-160 to -170 ^{o}C or colder).
- When Temperature Light indicates ‘Normal” press the “Operate / Standby” menu button on unit to “Operate”. Hold for (4-5 seconds) .
- “Operate “ light should now be displayed.

Rear of FALCON 5000 showing LAN and Power Connections



Startup -Function Check

Activate detector by clicking on the following icons:

- **Genie 2k**
- **Gamma Acquisition & Analysis**

At top of screen:

- **File Open**
- **Open -Data Source**
- **Detector** -Highlight Detector in upper window.

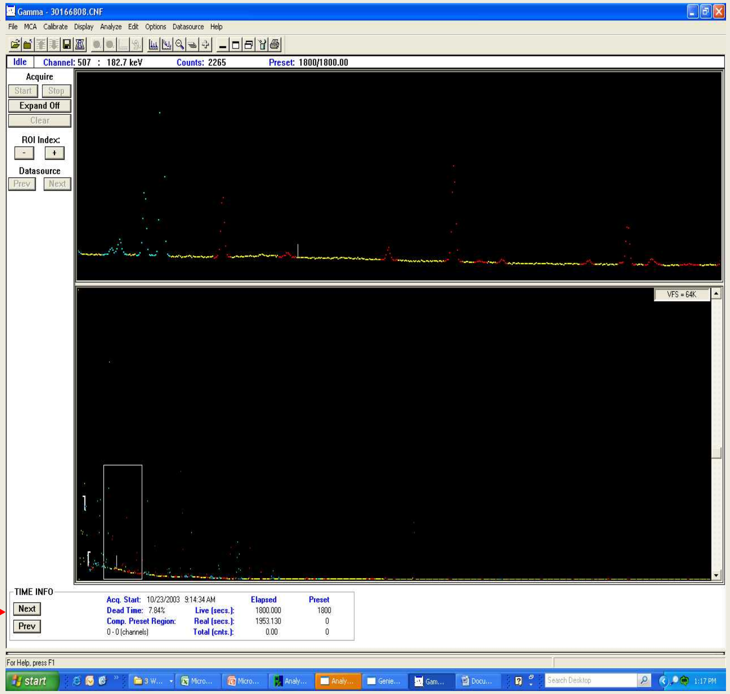
Detector # must match probe. Spectrum will appear.

- **Open**

Apply voltage to detector by :

- **MCA** (from pull down)
- **Adjust** (bottom window will open)

- **High Voltage**
- H.V. control will be on the bottom window.
  Once H.V. is on, exit bottom window.
- **Clear** This will clear the spectrum



Channel: 507 : 182.7 keV Counts: 2265 Preset: 1800/1800.00

Acq. Start: 10/23/2003 9:14:34 AM

Dead Time: 7.84%

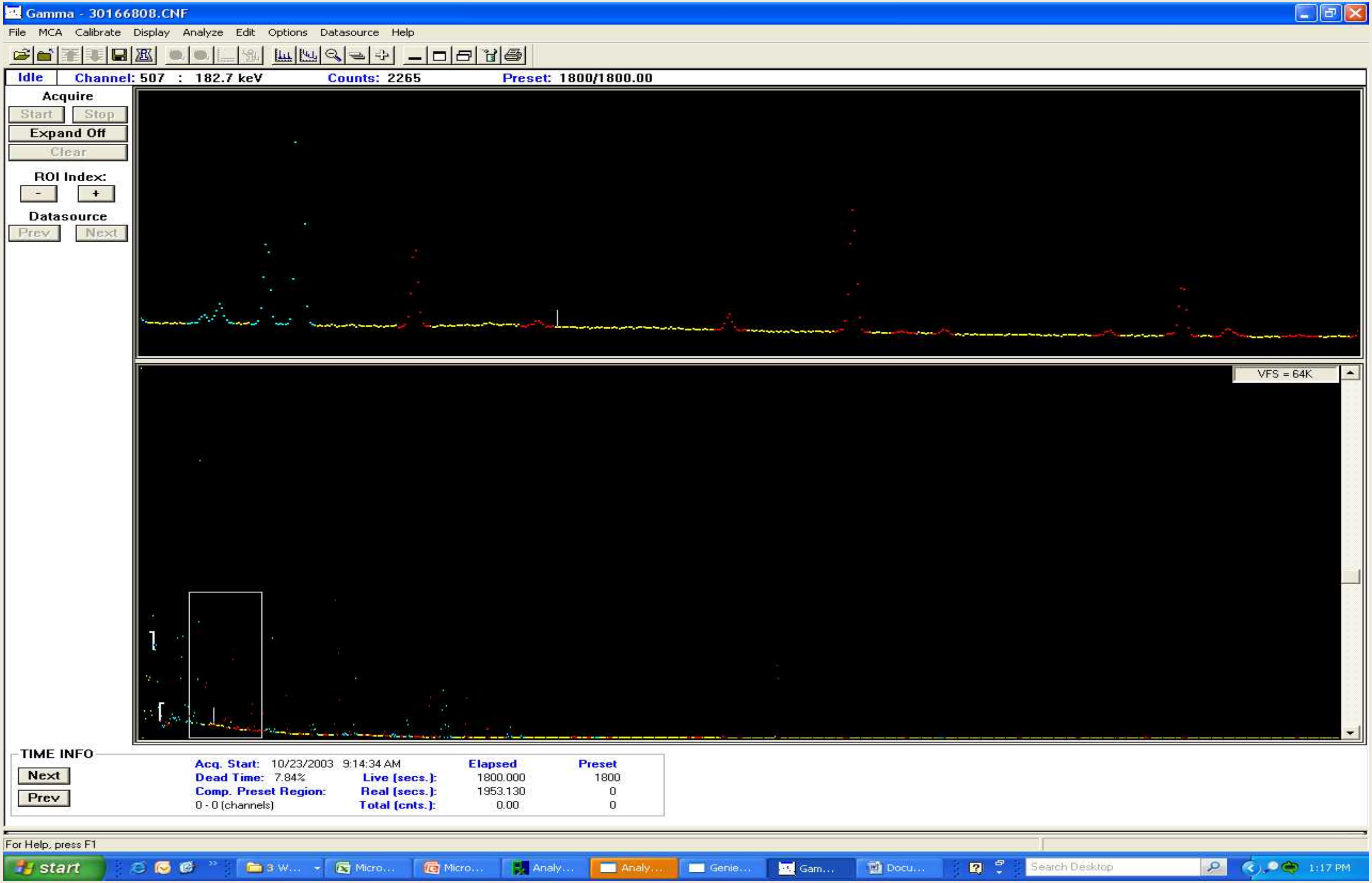
Comp. Preset Region: 0 - 0 (channels)

	Elapsed	Preset
Live (secs.):	1800.000	1800
Real (secs.):	1953.130	0
Total (cnts.):	0.00	0

Place source on the front of the detector and check available source energy lines (example Eu-155: 1274 keV) by clearing spectrum and then clicking on start.

- **Start**

Adjust gain if needed



Gamma - 30166808.CNF

Idle | Channel: 507 : 182.7 keV | Counts: 2265 | Preset: 1800/1800.00

Acq. Start: 10/23/2003 9:14:34 AM
Dead Time: 7.84%
Comp. Preset Region:
0 - 0 (channels)

	Elapsed	Preset
Live (secs.):	1800.000	1800
Real (secs.):	1953.130	0
Total (cnts.):	0.00	0

FALCON 5000
TROUBLE SHOOTING

If when initiating start of FALCON and

“HARDWARE UNAVAILABLE”
Is displayed:

- ✓ Place FALCON in STANDBY
- ✓ Right click on A on bottom of screen.
- ✓ Select Control
- ✓ Restart Service
- ✓ Place FALCON in OPERATE
- ✓ Reinitiate High Voltage in Gamma Acquisition.

Gain Adjustment

Q.C. source attached to front probe Collimator –removed

Gain Adjustment

The Q.C. source contains 1uCi of Na-22 and Eu-155

Use the following lines and respective to adjust gain :

86.5 keV -*channel 237* (Eu-155)

105.3 keV -*channel 288* (Eu-155)

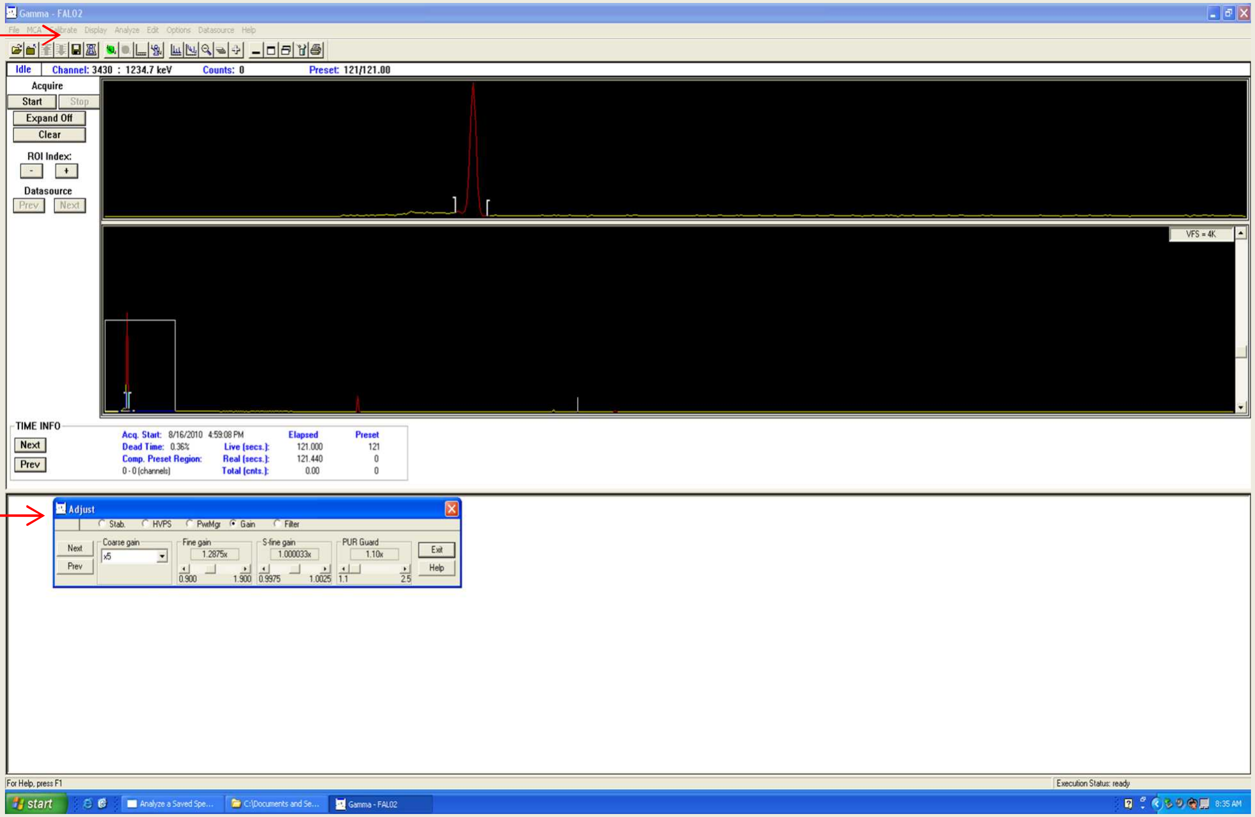
1274.5 keV -*channel 3480* (Na-22)

Gain Adjustment

- If peak is not aligned with centroid, the gain may have to be adjusted.
- Using the peak height (containing the highest number of counts in that particular peak) as a reference to adjust gain up or down along the channels.

To adjust gain:
•MCA
•ADJUST
Gain adjustment

Click Next until Gain%
is displayed



Idle Channel: 3430 : 1234.7 keV Counts: 0 Preset: 121/121.00

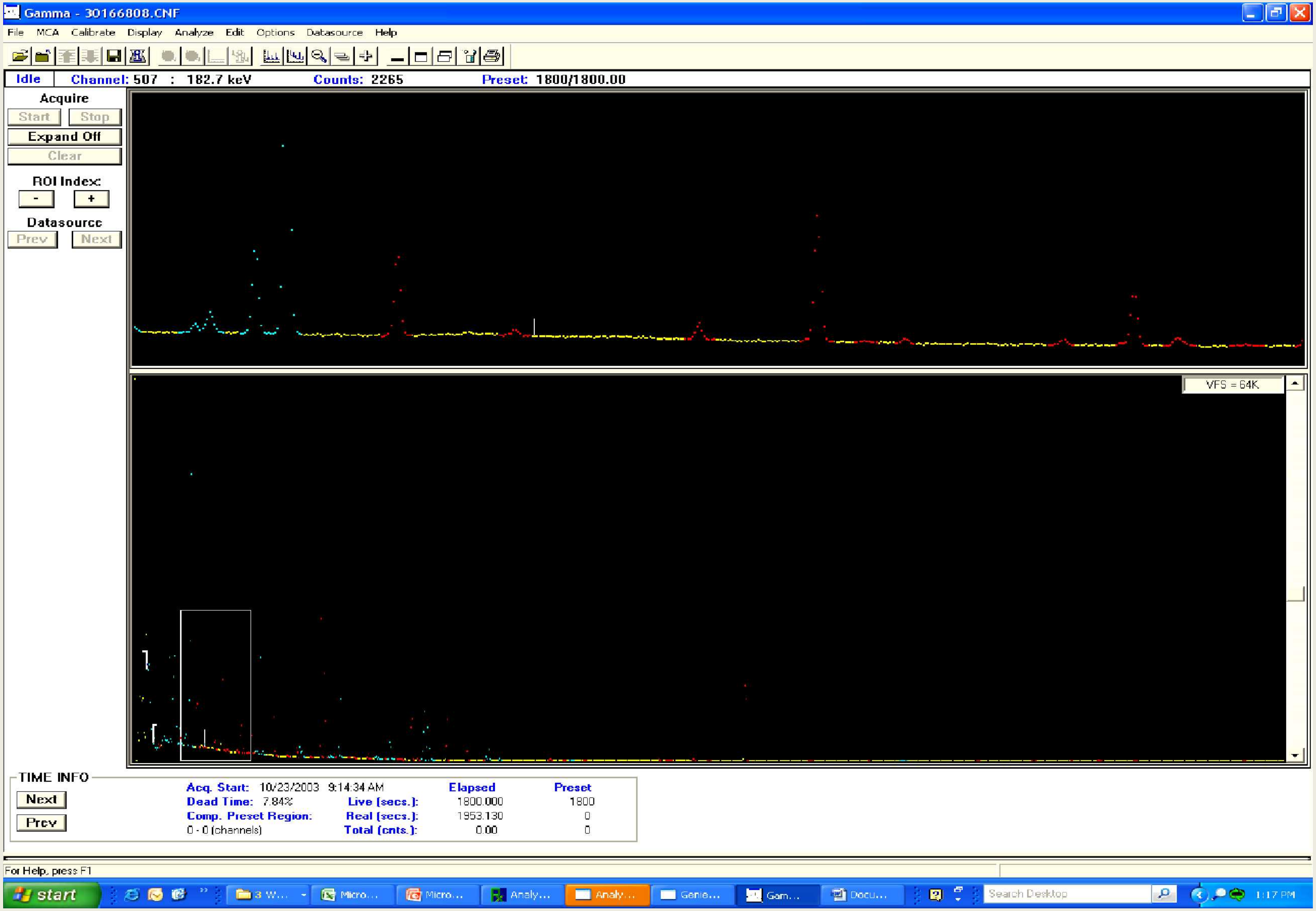
Acq. Start: 8/16/2010 4:59:08 PM
Dead Time: 0.36%
Comp. Preset Region:
0 - 0 (channels)

	Elapsed	Preset
Live (secs.):	121.000	121
Real (secs.):	121.440	0
Total (cnts.):	0.00	0

Coarse gain: x5
Fine gain: 1.2875x (0.900 – 1.900)
S-fine gain: 1.000033x (0.9975 – 1.0025)
PUR Guard: 1.10x (1.1 – 2.5)

Execution Status: ready

Gain Adjustment



Idle Channel: 507 : 182.7 keV Counts: 2265 Preset: 1800/1800.00

Acq. Start: 10/23/2003 9:14:34 AM
Dead Time: 7.84%
Comp. Preset Region:
0 - 0 (channels)

	Elapsed	Preset
Live (secs.):	1800.000	1800
Real (secs.):	1953.130	0
Total (cnts.):	0.00	0

Quality Control Check:

(Peak Centroid, FWHM, Efficiency)

Open :**Genie 2k Folder**

Routine Acquisition Folder.

- **Routine QC**
- **User I.D.** Example: **krsanso**
- **OK**

As directed by the batch procedure, place the appropriate source on the front of the detector. The source is on a jig that will fit uniformly to the front of the unshielded detector.

- **OK**

Q.C. source attached to the front of the FALCON 5000.
Note: collimator has been removed .

QUALITY CONTROL CHECK CONT.

QC Batch Program will:

- ✓ Clear the MCA
- ✓ Acquires a spectrum
- ✓ Performs and analyzes an efficiency and FWHM
- ✓ check.

The QC parameters are saved in the FALQC#.QAF file.
(where # is the detector number).

The quality assurance report is then sent to the computer screen for review with possibility of being printed.

Quality Control cont.

- After Q.C. …QA Report
- Action (“Ac”) or Investigation (“In”) may appear in “SD” (sample driven) column.

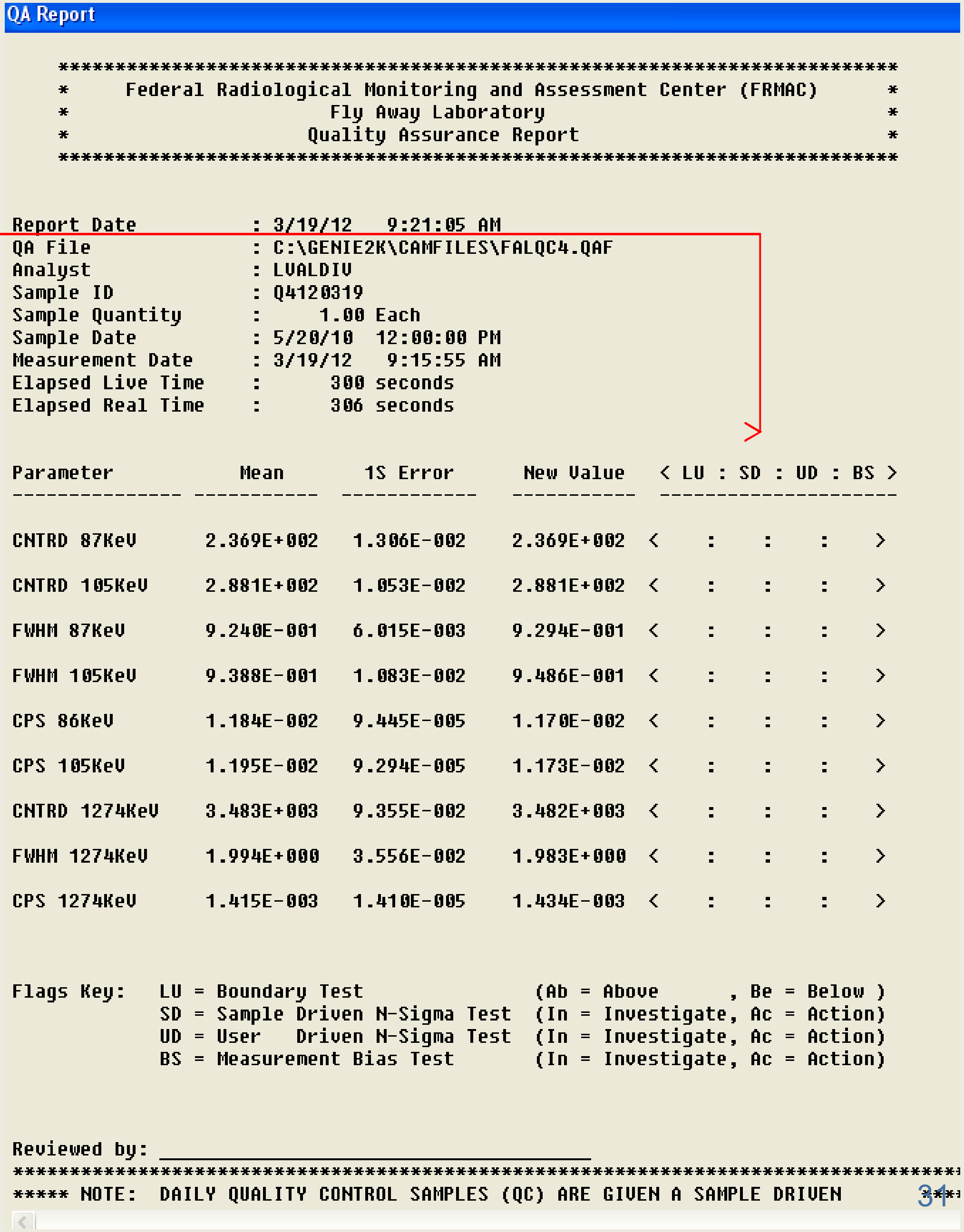
- No “Ac” or ”In” indicated =
- Ready for Use.

- If “In”or “Ac” Rerun Q.C. check.

- If QC still questionable rerun Gamma Acquisition and readjust gain, move source and rerun Q.C.

- If Q.C. still questionable record in log and investigate

- This may be printed out for your records.



```
     ****************************************************************************
     *     Federal Radiological Monitoring and Assessment Center (FRMAC)       *
     *                          Fly Away Laboratory                             *
     *                        Quality Assurance Report                          *
     ****************************************************************************


Report Date             : 3/19/12    9:21:05 AM
QA File                 : C:\GENIE2K\CAMFILES\FALQC4.QAF
Analyst                 : LVALDIV
Sample ID               : Q4120319
Sample Quantity         :     1.00 Each
Sample Date             : 5/20/10  12:00:00 PM
Measurement Date        : 3/19/12    9:15:55 AM
Elapsed Live Time       :      300 seconds
Elapsed Real Time       :      306 seconds


Parameter           Mean       1S Error      New Value   < LU : SD : UD : BS >
--------------- ----------- ------------   -----------  ---------------------

CNTRD 87KeV      2.369E+002  1.306E-002    2.369E+002  <    :    :    :    >

CNTRD 105KeV     2.881E+002  1.053E-002    2.881E+002  <    :    :    :    >

FWHM 87KeV       9.240E-001  6.015E-003    9.294E-001  <    :    :    :    >

FWHM 105KeV      9.388E-001  1.083E-002    9.486E-001  <    :    :    :    >

CPS 86KeV        1.184E-002  9.445E-005    1.170E-002  <    :    :    :    >

CPS 105KeV       1.195E-002  9.294E-005    1.173E-002  <    :    :    :    >

CNTRD 1274KeV    3.483E+003  9.355E-002    3.482E+003  <    :    :    :    >

FWHM 1274KeV     1.994E+000  3.556E-002    1.983E+000  <    :    :    :    >

CPS 1274KeV      1.415E-003  1.410E-005    1.434E-003  <    :    :    :    >



Flags Key:  LU = Boundary Test              (Ab = Above       , Be = Below )
            SD = Sample Driven N-Sigma Test (In = Investigate, Ac = Action)
            UD = User   Driven N-Sigma Test (In = Investigate, Ac = Action)
            BS = Measurement Bias Test      (In = Investigate, Ac = Action)



Reviewed by: ______________________________________
*****************************************************************************
***** NOTE:  DAILY QUALITY CONTROL SAMPLES (QC) ARE GIVEN A SAMPLE DRIVEN    ****
```

Dead Time

- Dead Time is the time after each event (photon interaction) within the detector during which the system is not able to record another event.

- For all analysis Dead Time should be < 20%.

- If Dead Time exceeds 20% increase sample distance

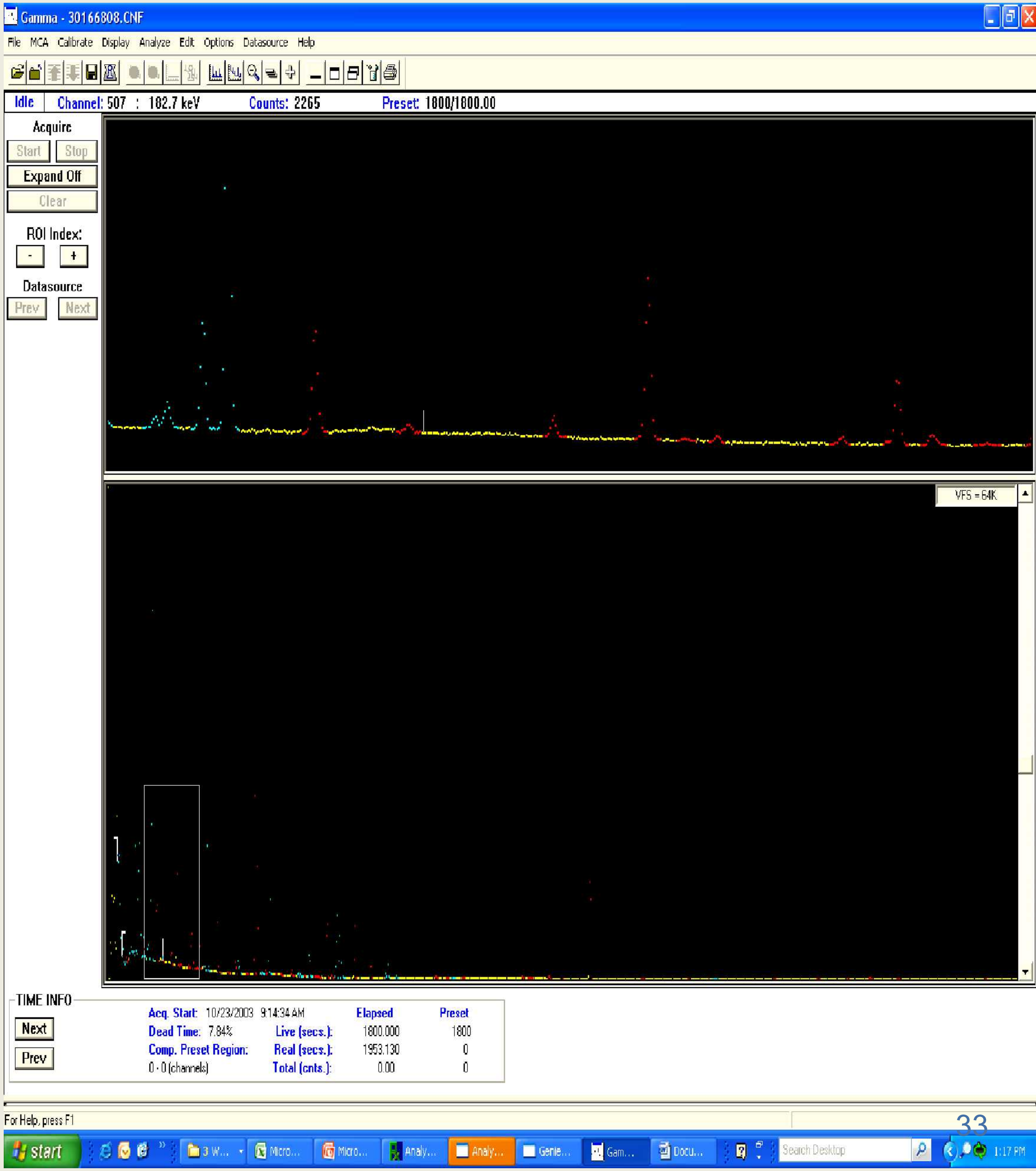
- *NOTE: with the exception of Air Filters there is a 1 ft and 3 ft efficiency geometry for the Vegetation, Water, and Soil samples*

Determination of Dead Time

With all units energized address the following icons:

- *Genie 2000*
- *Gamma Acquisition & Analysis*
- *File Open -Data Source*
- *Detector* –Select Detector #
- *Open*
- *Select MCA,* from pull down:
- *Select Adjust - bottom window will open*
- *select HVPS* Under Status
- *On*
- *Close out of bottom window.*
- *Clear spectrum*
- *Start*

- *Click Next until Dead Time % is displayed*



Idle Channel: 507 : 182.7 keV Counts: 2265 Preset: 1800/1800.00

Acq. Start: 10/23/2003 9:14:34 AM

Dead Time: 7.84%

Comp. Preset Region:

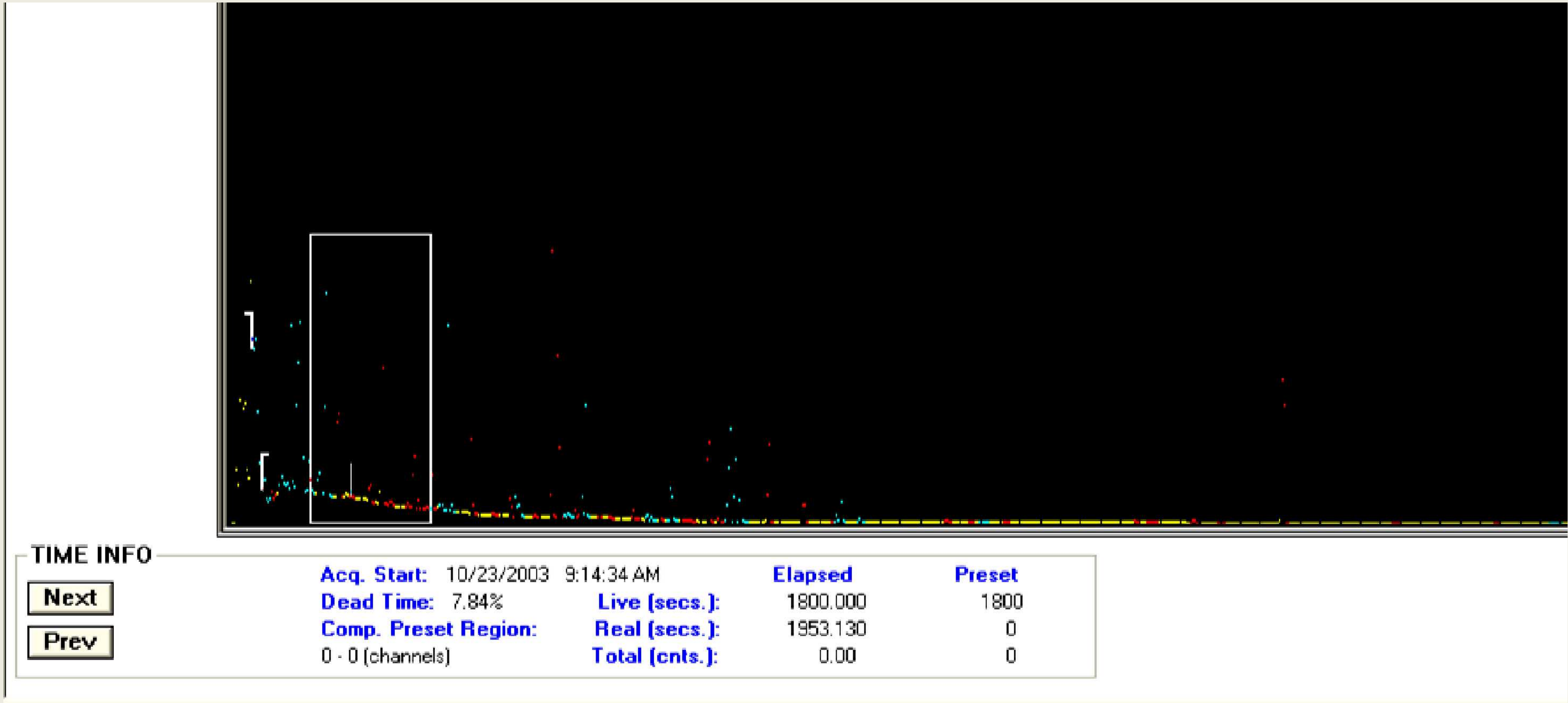
0 - 0 (channels)

	Elapsed	Preset
Live (secs.):	1800.000	1800
Real (secs.):	1953.130	0
Total (cnts.):	0.00	0

Determination - Calculation of Dead Time

Check Dead Time with sample in front of detector. Dead Time (should be **< 20%)** if not increase sample distance from probe face – measure distance.

$$\text{Dead Time} = \frac{(\text{Real Time - Live Time})}{\text{Real Time}}$$



```
Acq. Start:   10/23/2003   9:14:34 AM        Elapsed        Preset
Dead Time:   7.84%            Live (secs.):    1800.000         1800
Comp. Preset Region:          Real (secs.):    1953.130            0
0 - 0 (channels)              Total (cnts.):       0.00            0
```

EXERCISE

Determine the Dead Time of the Q.C. Source

Developing a Background

- The following steps are to be taken when the detector is going to be stationary and not moved with the understanding that sample(s) are to be brought to the detector for analysis.

✓ *Select Folder :Routine Batch Files*
✓ *Routine Aqusition*
✓ *Select detector*

- At this time you must clear area of any items that may contribute to radiological contribution.
- Enter Count Time*

✓ *Start*

- This will establish a background spectrum that should be recounted with a new background when radiological conditions in the area may change.

** Background count time typically should equal that of sample analysis time.*

Background Contributions

Sample(s) should ideally be counted in same area as where Background count was performed.

Variations from NORM contributions.

Contributions from other source material / radioactive samples.

Background Naming Convention

Assign Background* numeric convention: **B4YMMDD#**
Under SCF Identification space

Where:

- **B** designates the sample file as a background .
- **4** is detector number (FAL 04).
- Y is the year of the count . (example 2012 =2)
- MM is the month of the count .
- DD is the day of the count.
- Background # sequential : 0-9
- Example: **B4**204129

Performing a Background

Data Entry Sheet {Fill in empty fields}

Analysis Request #

SCF log sample I.D.#

Even t I.D.

Customer’s Program I.D. : ______(EVENT NAME)

Sample Matrix / Type : BL (blank)

Sample Description: describe sample

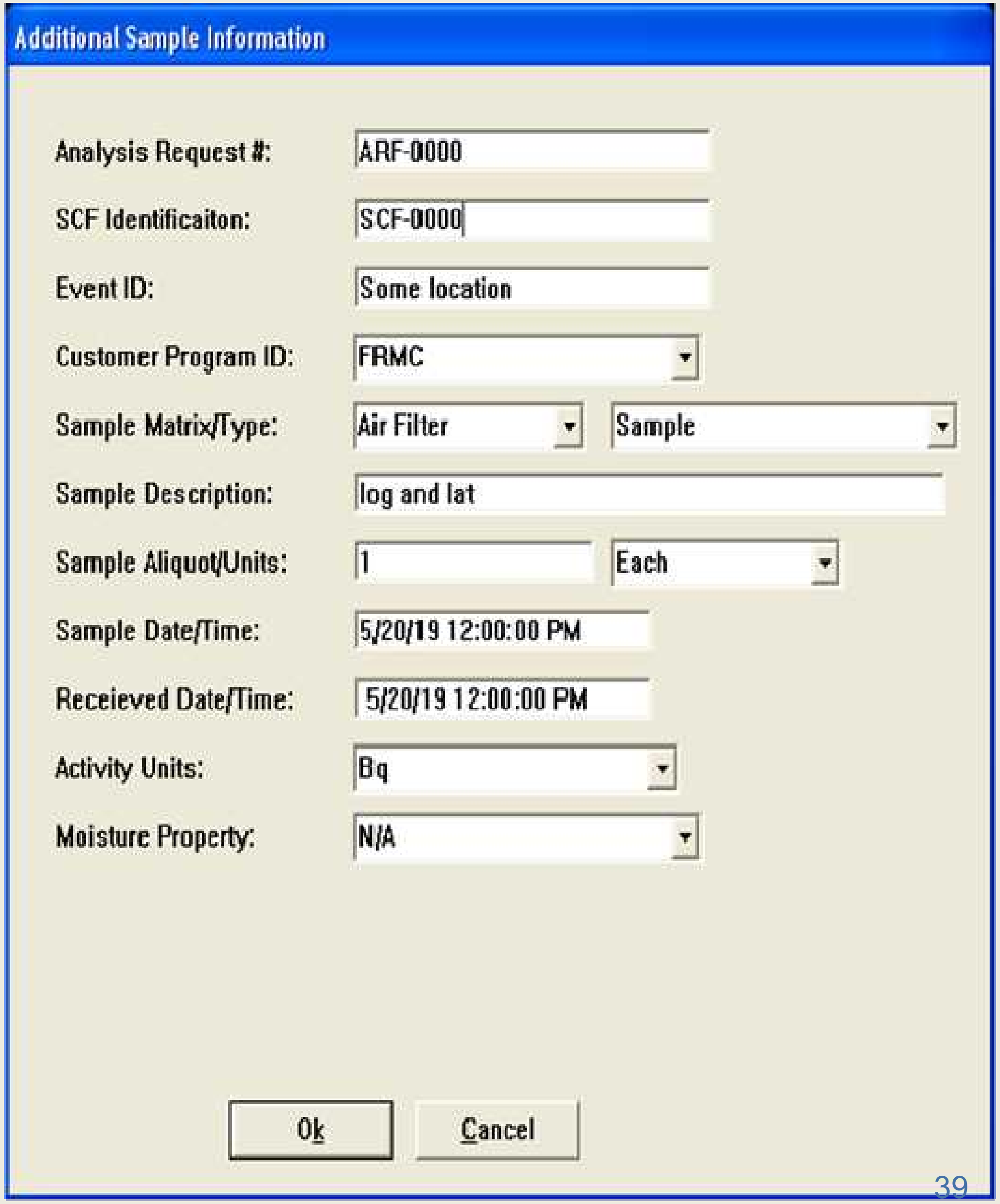
Sample Aliquot units: __#_____(grams, liters, kg, etc)

Sample Date/ Time & Received Date / Time

Activity Units:_______(NSU, pCi, Bq etc.)

Moisture (N/A)

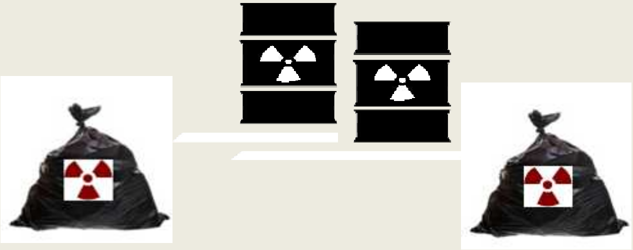
O.K.



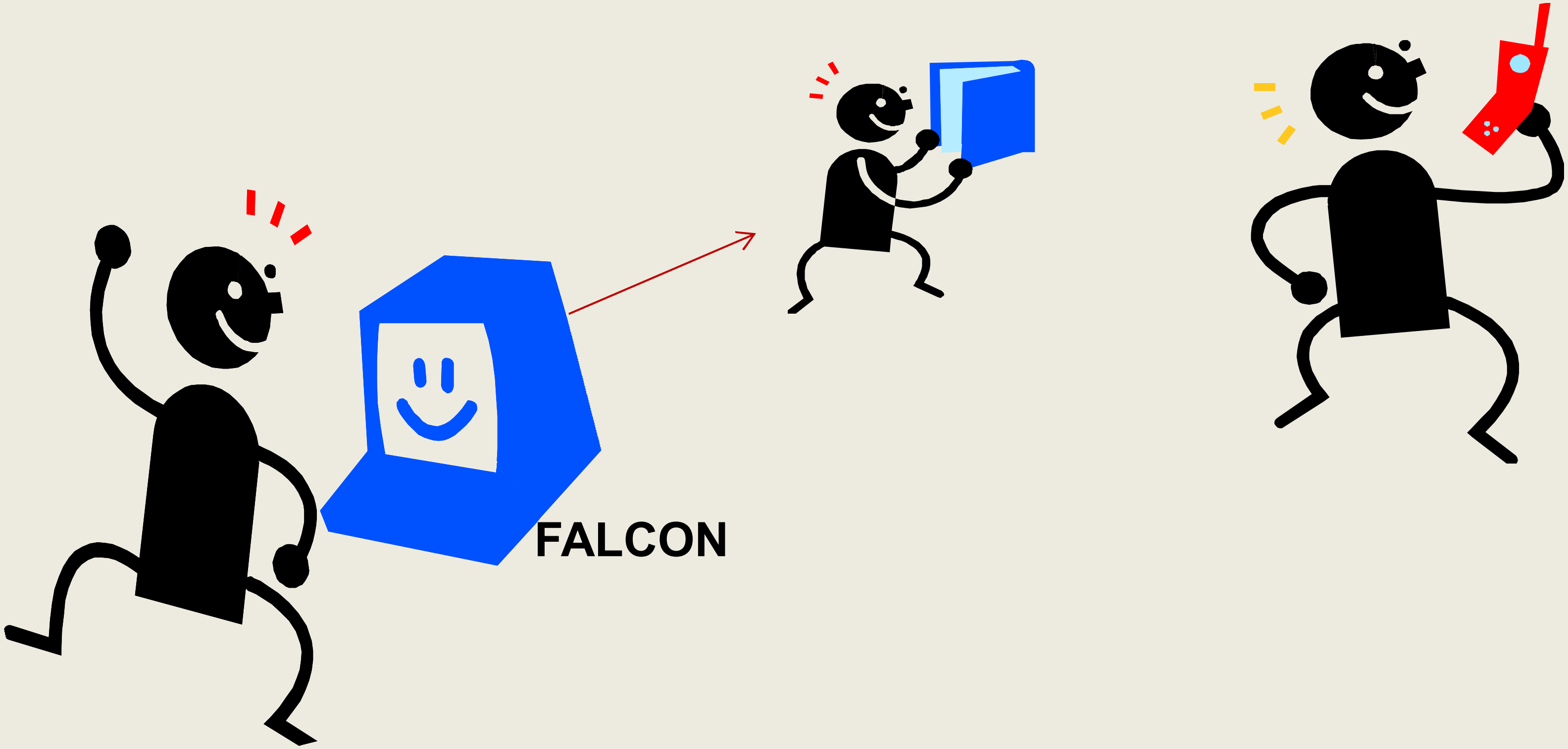
Additional Sample Information

Analysis Request #: ARF-0000
SCF Identificaiton: SCF-0000
Event ID: Some location
Customer Program ID: FRMC
Sample Matrix/Type: Air Filter Sample
Sample Description: log and lat
Sample Aliquot/Units: 1 Each
Sample Date/Time: 5/20/19 12:00:00 PM
Receieved Date/Time: 5/20/19 12:00:00 PM
Activity Units: Bq
Moisture Property: N/A

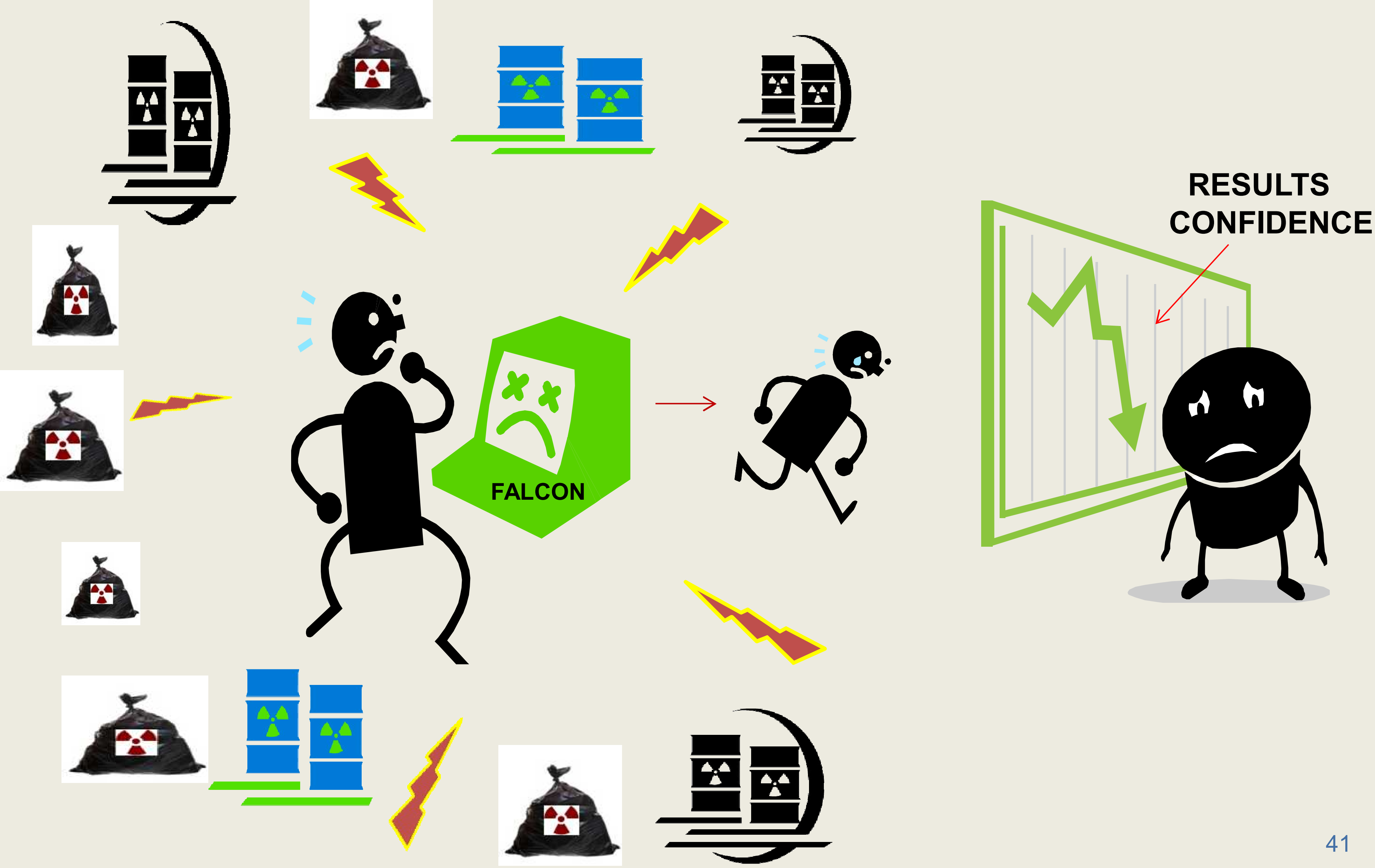
SMALL # Samples Affecting BACKGROUND in Analysis Area



Here are the RESULTS!



LARGE # of Samples affecting BACKGROUND in Analysis Area



Performing a Sample Analysis

- Click on the following FOLDER:

✓ Routine Batch-Ops

- The following pop-ups will appear:

✓ Routine Acquisition & Analysis

✓ I.D. Detector # (select detector #) -OK

✓ Standard Geometry? -NO-YES (refer to geometry page #31)

✓ Solid Angle Correction? -NO

✓ Select Efficiency File eg. (AFOAT3FT)

✓ Enter run-count time of analysis eg. (6000 seconds)

✓ Select Library (FRMAC)

✓ Background Subtraction? (YES) background is already analyzed (at this time a pull down sheet will appear- select THE BACKGROUND)

Performing a Sample Analysis

Data Entry Sheet {Fill in empty fields}

Analysis Request #

SCF log sample I.D.#

Event I.D.

Customer's Program I.D. : ______(EVENT NAME)

Sample Matrix / Type : Soil, Water , Swipe, Vegetation, Moving A.F., Moving Instrument, Other   / sample)

Sample Description: describe sample

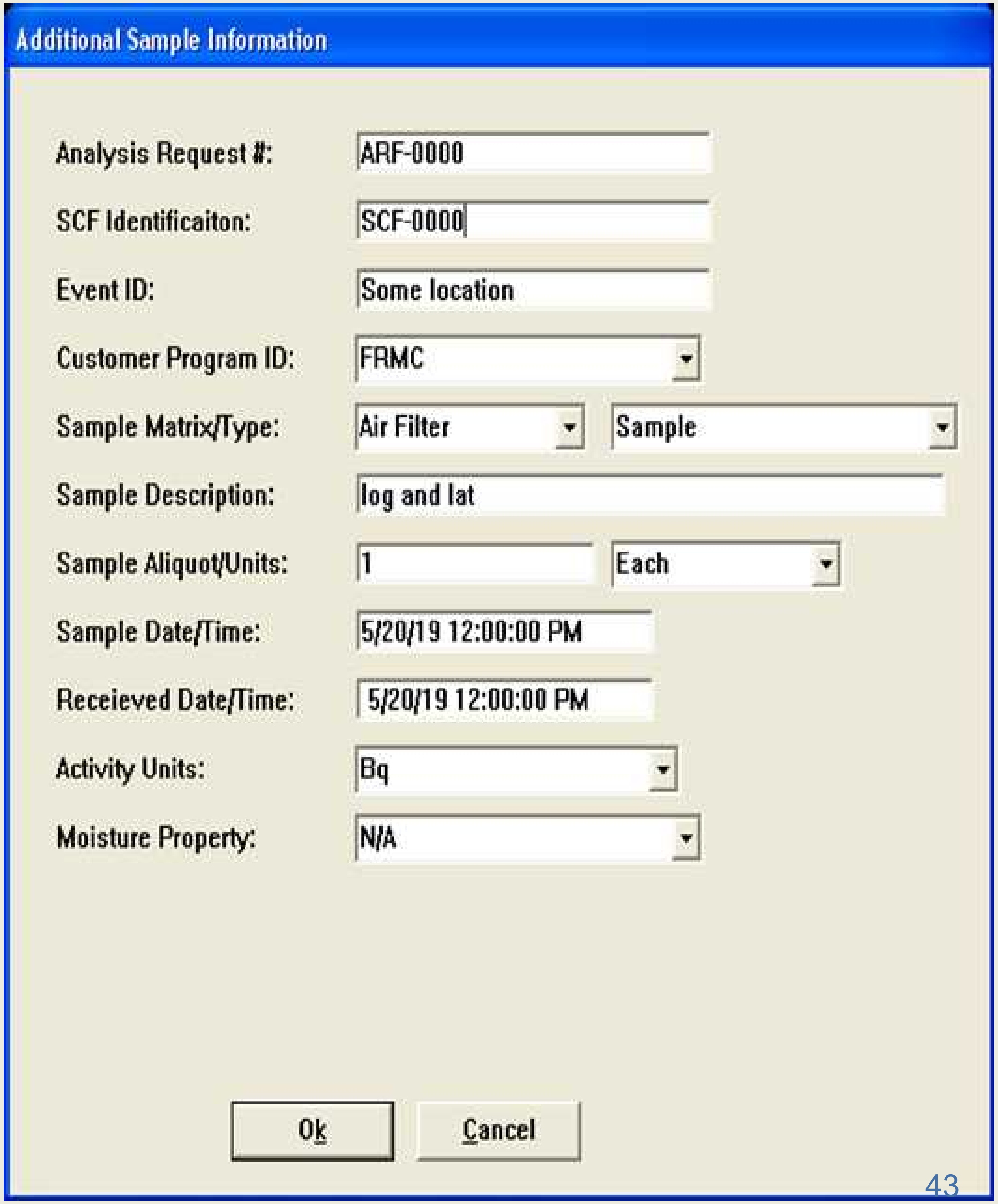
Sample Aliquot units: __#_____(grams, liters, kg, etc)

Sample Date/ Time & Received Date / Time

Activity Units:_______(NSU, pCi, Bq etc.)

Moisture Property (only soils)   Wet, Dry , N/A

O.K.



Additional Sample Information

Analysis Request #: ARF-0000

SCF Identificaiton: SCF-0000

Event ID: Some location

Customer Program ID: FRMC

Sample Matrix/Type: Air Filter | Sample

Sample Description: log and lat

Sample Aliquot/Units: 1 | Each

Sample Date/Time: 5/20/19 12:00:00 PM

Receieved Date/Time: 5/20/19 12:00:00 PM

Activity Units: Bq

Moisture Property: N/A

STANDARD SAMPLE GEOMETRIES

AF0.CAL	**POINT SOURCE on CONTACT**
AFOAT2F.cal	**POINT SOURCE @ 2 ft**
AF2.cal	**2" AIR FILTER on CONTACT**
AFCC.cal	**CHARCOAL CANISTER CONTACT**
AF4.cal	**4" AIR FILTER on CONTACT**
GCWATcont.cal	**1 GAL. CUBIC CONT. WATER on CONTACT (ISOCS)**
GCWAT3F.cal	**1 GAL. CUBIC CONT. WATER @ 3 ft (ISOCS)**
GCWAT1F.cal	**1 GAL. CUBIC CONT. WATER @ 1 ft (ISOCS)**
gladScont.cal	**GLAD SOIL on CONTACT (ISOCS)**
gladS3F.cal	**GLAD SOIL @ 3 ft (ISOCS)**
gladS1F.cal	**GLAD SOIL @ 1 ft (ISOCS)**
galVEGcont.cal	**GALLON BAG VEGITATION on CONTACT (ISOCS)**
galVEG3F.cal	**GALLON BAG VEGITATION @ 3 ft (ISOCS)**
galVEG1F.cal	**GALLON BAG VEGITATION @ ft (ISOCS)**

Non-Standard Sample Geometries

When a sample is brought in for a gamma spectral analysis that is not a standardized geometry it may be a candidate for In-situ Source-less Object Counting System (ISOCS) modeling.

- Record the following:

- ✓ Length
- ✓ Height
- ✓ Width
- ✓ Known material type (if any)
- ✓ Weight (to develop mass)
- ✓ Any other physical or chemical that can be used to eventually model the item.

MDA /related count times for Selected Geometries

- The MDAs were developed from Critical Level values Appendix B FRMAC Laboratory Analysis Manual

- MDA values are related to the most restrictive activity of the following nuclides (Am-241, Co-60, Cs-137) .

- Am-241 lower Critical Level Value (2 orders magnitude less than I-131).

- These nuclides were selected because they span the lower (59keV) , middle (661keV) ,and upper (1332 keV) energy channels on the calibrated spectrum.

MDA /related count times for Selected Geometries

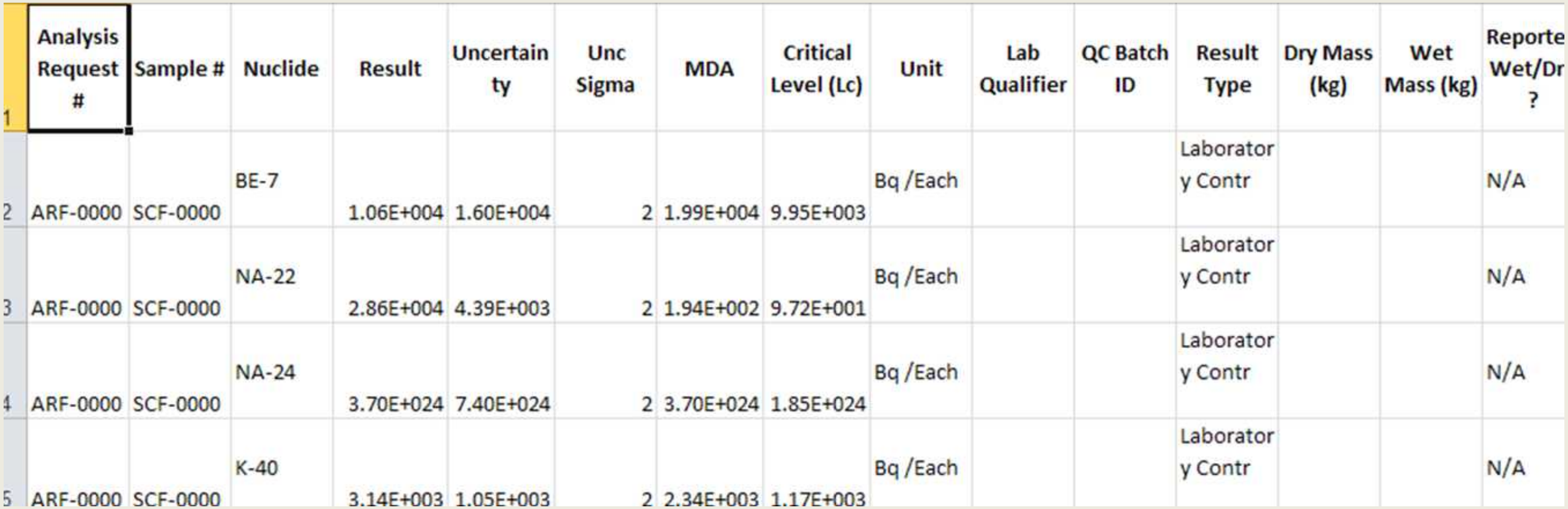
SAMPLE TYPE / Analysis Geometry	Volume / Mass	Nuclide	MDA OBTAINED	MDA* REQUIRED	COUNT TIME (Seconds)
AIR FILTER 2" (contact) **AF2.CAL**	29 m^3	Co-60	1.82E-6 $\mu Ci/m^3$	2.12E-6 $\mu Ci/m^3$	7000
AIR FILTER 4" (contact) **AF4.CAL**	29 m^3	Co-60	2.25E-6 $\mu Ci/m^3$	2.12E-6 $\mu Ci/m^3$	7000
AIR FILTER 2" (contact) **AF2.CAL**	>50 m^3	Co-60	1.48E-6 $\mu Ci/m^3$	2.12E-6 $\mu Ci/m^3$	4000
AIR FILTER 4" (contact) **AF4.CAL**	>50 m^3	Co-60	1.82E-6 $\mu Ci/m^3$	2.12E-6 $\mu Ci/m^3$	4000
AIR FILTER 2" (contact) **AF2.CAL**	>100 m^3	Co-60	7.38E-7 $\mu Ci/m^3$	2.12E-6 $\mu Ci/m^3$	4000
AIR FILTER 4" (contact) **AF4.CAL**	>100 m^3	Co-60	9.09E-7 $\mu Ci/m^3$	2.12E-6 $\mu Ci/m^3$	4000
FORAGE (contact) **GALVEGCONT.CAL**	1.0 kg	Cs-137	2.01E-2 $\mu Ci/kg$	1.88E-2 $\mu Ci/kg$	6000
FORAGE (contact) **GALVEGCONT.CAL**	2.0 kg	Cs-137	1.01E-2 $\mu Ci/kg$	1.88E-2 $\mu Ci/kg$	6000
WATER (contact) **GCWATCONT.CAL**	3.8 L	Cs-137	3.47E-4 $\mu Ci/L$	1.56E-2 $\mu Ci/L$	1000
SOIL (contact) (short term) **GLAGSCONT.CAL**	0.5 kg (Glad Sample)	Co-60	5.84E-4 $\mu Ci/kg$	2.12E-2 $\mu Ci/kg$	2000
SOIL (contact) (short term) **GLAGSCONT.CAL**	0.5 kg (Glad Sample)	Co-60	9.28E-4 $\mu Ci/kg$	2.12E-2 $\mu Ci/kg$	1000
MILK (contact) **GCWATCONT.CAL**	3.8 L	Am-241 *	2.55E-4 $\mu Ci/kg$ ***	1.08 E-5 $\mu Ci/kg$	**9000**
FOOD (contact) **GALVEGCONT.CAL**	3.0 kg	Am-241 *	8.63E-3 $\mu Ci/kg$ ***	1.08E-5 $\mu Ci/kg$	**9000**

*** Does not meet MDA

Processing & Retrieving Data

- Once data acquisition is complete, the spectrum and a detailed report is generated along with an output excel file . Provide the EDD excel file on a thumb drive along with the hardcopy of the detailed report to the FAL manager for review.

- The electronic data deliverable (EDD) excel file is located in c:\genie2k\repfiles*.xls. File name = SCF--##.XLS



Analysis Request #	Sample #	Nuclide	Result	Uncertainty	Unc Sigma	MDA	Critical Level (Lc)	Unit	Lab Qualifier	QC Batch ID	Result Type	Dry Mass (kg)	Wet Mass (kg)	Reporte Wet/Dr ?
ARF-0000	SCF-0000	BE-7	1.06E+004	1.60E+004	2	1.99E+004	9.95E+003	Bq /Each			Laboratory Contr			N/A
ARF-0000	SCF-0000	NA-22	2.86E+004	4.39E+003	2	1.94E+002	9.72E+001	Bq /Each			Laboratory Contr			N/A
ARF-0000	SCF-0000	NA-24	3.70E+024	7.40E+024	2	3.70E+024	1.85E+024	Bq /Each			Laboratory Contr			N/A
ARF-0000	SCF-0000	K-40	3.14E+003	1.05E+003	2	2.34E+003	1.17E+003	Bq /Each			Laboratory Contr			N/A

- You can retrieve Sample and Background spectrum from laptop:
  C:\ Genie 2K \ Camfiles\ sample# (*.CNF files).

EXERCISE

Perform an Background Analysis

Laboratory Control Samples

- A laboratory control sample (LCS) must be run within each QC batch of samples.
- A QC batch must be less than or equal to 20 samples including any QC samples.
- The LCS is used to track instrument performance and help ensure data quality.
- An LCS must be run on each detector that is used to count samples of the same QC batch. For example, if ten samples are batched together and two detectors are used, then there must be one LCS for each detector within the batch.
- The Fly Away Laboratory will use the Falcon QC source as the gamma spectroscopy laboratory control sample.

Lab Control Counting Procedure

- Obtain the Falcon QC source.

- Place the source on the detector as seen in the section.

- On the Windows desktop double click the folder "Routine Batch Files".

- Once the User has come to this point a series of pop-ups will guide the user through the remainder of the analysis. The following steps show the pop-ups and explain the response the computer is expecting.

Lab Control Counting Procedure

- The computer will prompt the user to enter a user id (person performing analysis)

- The User will then be prompted to select a detector ID, FAL##, where ## is the detector number.

- The User will be prompted to select a background spectrum that is to be subtracted from the LCS count.

- Choose the most current background spectrum.

- The appropriate background is usually but not always the background counted last (i.e. the background with a time-stamp nearest to the acquisition time of the LCS).

- Consult the FAL manager if there is any doubt as to what background to choose.

Lab Control Counting Procedure cont.

- A window will appear that prompts the user to input the sample information:

- Input the ARF number that corresponds to the samples that the LCS applies to.

- For “SCF Identification” enter a unique identifier with the following format: LCS-MMDDYY-## where MMDDYY is the date and ## is a sequence starting with 01, 02, … that denotes the LCS number run that day.

- Enter the Event ID.

- In the sample type field, choose “Laboratory Control Sample”.

- For sample date/time, enter the date/time of the count that determined the LCS’s activity. Click OK.

- The program will acquire a spectrum and then transfer the results to the QA engine which will generate a report.

Performing a Lab Control Sample

Data Entry Sheet {Fill in empty fields}

Analysis Request #

SCF log sample I.D.#

Event I.D.

Customer's Program I.D. : ______(EVENT NAME)

Sample Matrix / Type : OTHER / LCS

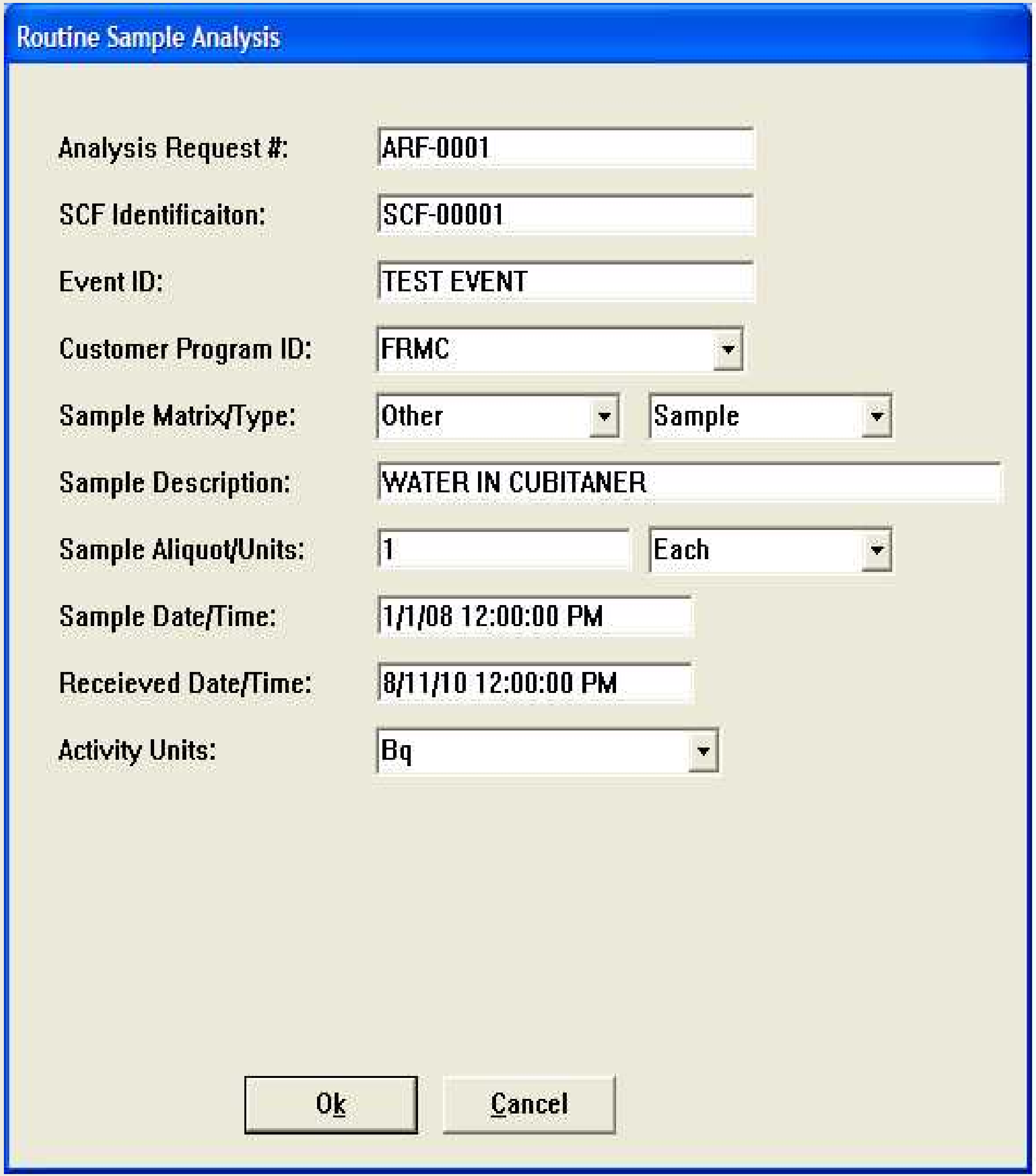
Sample Description: describe sample

Sample Aliquot units: __#_____(grams, liters, kg, etc)

Sample Date/ Time & Received Date / Time

Activity Units:_______(NSU, pCi, Bq etc.)

O.K.



Routine Sample Analysis

Analysis Request #: ARF-0001

SCF Identificaiton: SCF-00001

Event ID: TEST EVENT

Customer Program ID: FRMC

Sample Matrix/Type: Other Sample

Sample Description: WATER IN CUBITANER

Sample Aliquot/Units: 1 Each

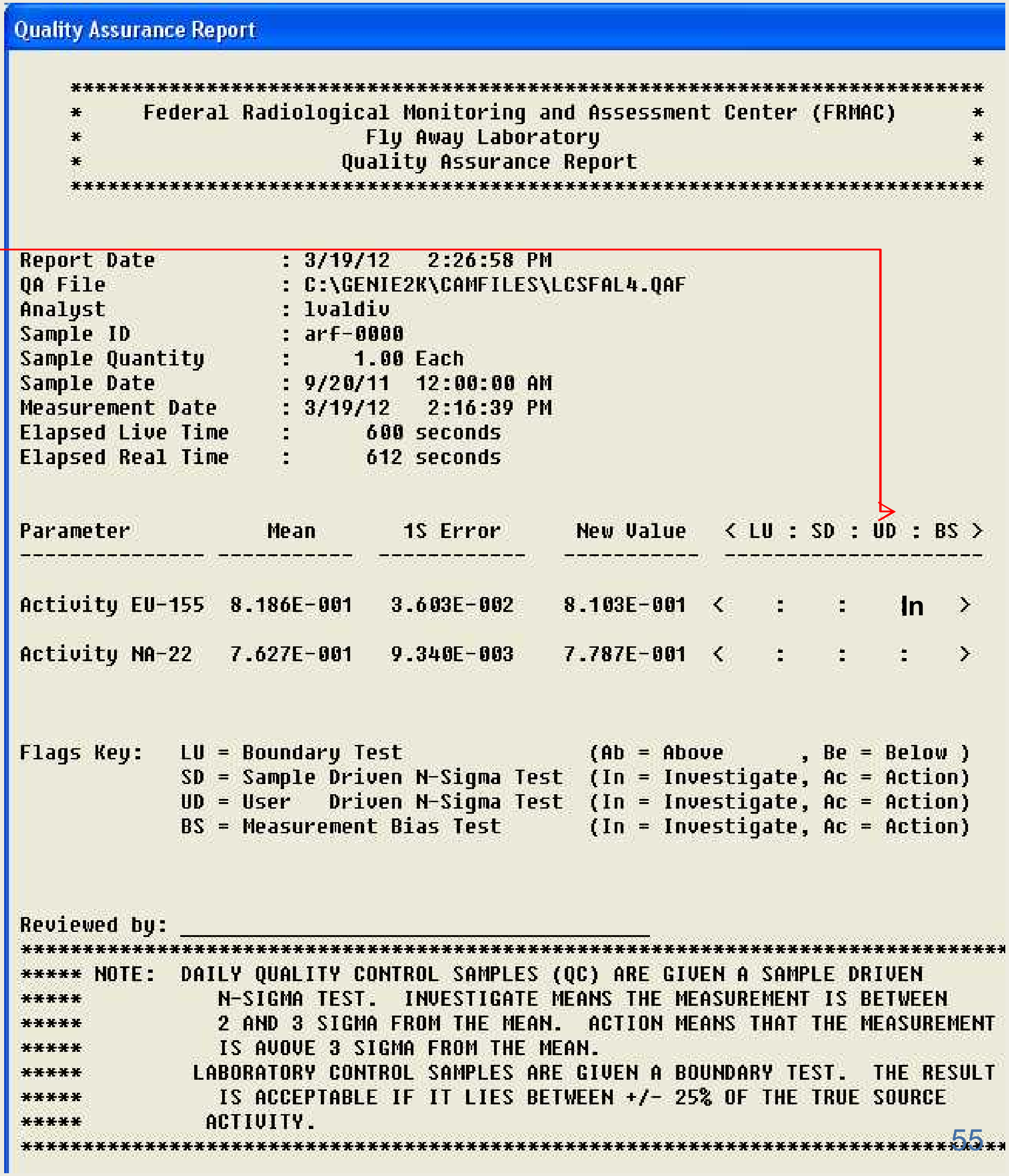
Sample Date/Time: 1/1/08 12:00:00 PM

Receieved Date/Time: 8/11/10 12:00:00 PM

Activity Units: Bq

Laboratory Control Sample

- After LCS Report is performed this report will be generated:
- ("Ac") or Investigation ("In") may appear in "UD" (sample driven) column.
- If "In"or "Ac" Rerun LCS.
- No "Ac" or "In" indicated = Ready for Use.



```
    ***********************************************************************
    *     Federal Radiological Monitoring and Assessment Center (FRMAC)     *
    *                       Fly Away Laboratory                             *
    *                     Quality Assurance Report                          *
    ***********************************************************************


Report Date           : 3/19/12   2:26:58 PM
QA File               : C:\GENIE2K\CAMFILES\LCSFAL4.QAF
Analyst               : lvaldiv
Sample ID             : arf-0000
Sample Quantity       :     1.00 Each
Sample Date           : 9/20/11   12:00:00 AM
Measurement Date      : 3/19/12   2:16:39 PM
Elapsed Live Time     :      600 seconds
Elapsed Real Time     :      612 seconds


Parameter             Mean        1S Error       New Value    < LU : SD : UD : BS >
---------------- ----------- ------------   -----------  ---------------------

Activity EU-155  8.186E-001   3.603E-002    8.103E-001  <    :    :   In    >

Activity NA-22   7.627E-001   9.340E-003    7.787E-001  <    :    :    :    >


Flags Key:   LU = Boundary Test              (Ab = Above      , Be = Below )
             SD = Sample Driven N-Sigma Test (In = Investigate, Ac = Action)
             UD = User   Driven N-Sigma Test (In = Investigate, Ac = Action)
             BS = Measurement Bias Test      (In = Investigate, Ac = Action)


Reviewed by: ______________________________________
*******************************************************************************
***** NOTE:  DAILY QUALITY CONTROL SAMPLES (QC) ARE GIVEN A SAMPLE DRIVEN
*****           N-SIGMA TEST.  INVESTIGATE MEANS THE MEASUREMENT IS BETWEEN
*****           2 AND 3 SIGMA FROM THE MEAN.  ACTION MEANS THAT THE MEASUREMENT
*****           IS AVOVE 3 SIGMA FROM THE MEAN.
*****         LABORATORY CONTROL SAMPLES ARE GIVEN A BOUNDARY TEST.  THE RESULT
*****           IS ACCEPTABLE IF IT LIES BETWEEN +/- 25% OF THE TRUE SOURCE
*****          ACTIVITY.
*******************************************************************************
```

Lab Control Counting Procedure cont.

- If any of the parameters of the quality assurance report are outside of +/- 25% of the measured LCS activity, rerun the LCS.
- If the second count returns any parameter outside of +/- 25%, tag the detector as out of service and investigate the problem.
- Record any malfunctions or analysis that do not pass in the instrument logbook.
- If no parameters are flagged, the LCS checks pass, print the report, date, and initial it.
- Once data acquisition is complete, the spectrum and a detailed report is generated along with an output excel file . Provide the EDD excel file on a thumb drive along with the hardcopy of the detailed report to the FAL manager for review.
- The electronic data deliverable (EDD) excel file is located in c:\genie2k\repfiles*.xls. File name = LCS-YYMMDD-##.XLS

EXERCISE

A. Define the requirements for performing a Laboratory Control Analysis.

B. Perform a Laboratory Analysis.

Shut Down of the FALCON

- Close any programs that are running.
- Go to the main screen and click on the HV shutdown window. This will turn off the High Voltage to the unit.
- Manually shut down both the computer and FALCON.

**Remember it may take 2-3 hours to cool the unit down before you can operate it again so if possible place in STANDYBY.*

Quantitative Modeling of the Analysis

ISOCS GEOMETRY COMPOSER

Introduction:
A wide variety of sample configurations are analyzed with portable gamma spectral systems such as the FALCON 5000 initially producing qualitative analysis results . Non-standardized geometries can be quantified by modeling utilizing CANBERRA ISOCS code in conjunction with the standard ISOCS and/or LabSOCS geometry templates. This task is accomplished by the creation of sample models using a "generic" detector within the Genie 2000 Geometry Composer application and producing a pair of files with the ***.geo** and ***.gis** format for each requested model. The actual ISOCS/LabSOCS characterization file(s) for the customer's specific detector(s) as part of each geometry definition, and generate additional files with the ***.ecc** and ***.cal** format. (The final ***.cal** efficiency calibration files can then be applied directly within the customer's Genie 2000 and/or Apex software environment).

A ISOCS CALIBRATED Detector is needed for analysis !!!

The next slides present a step by step instruction with icons related to functions within the ISOCS program that will enable an analyst to model a qualitative analysis result.

Sample Modeling using ISOCS

Procedure:

1. Open **GENIE2K** folder.

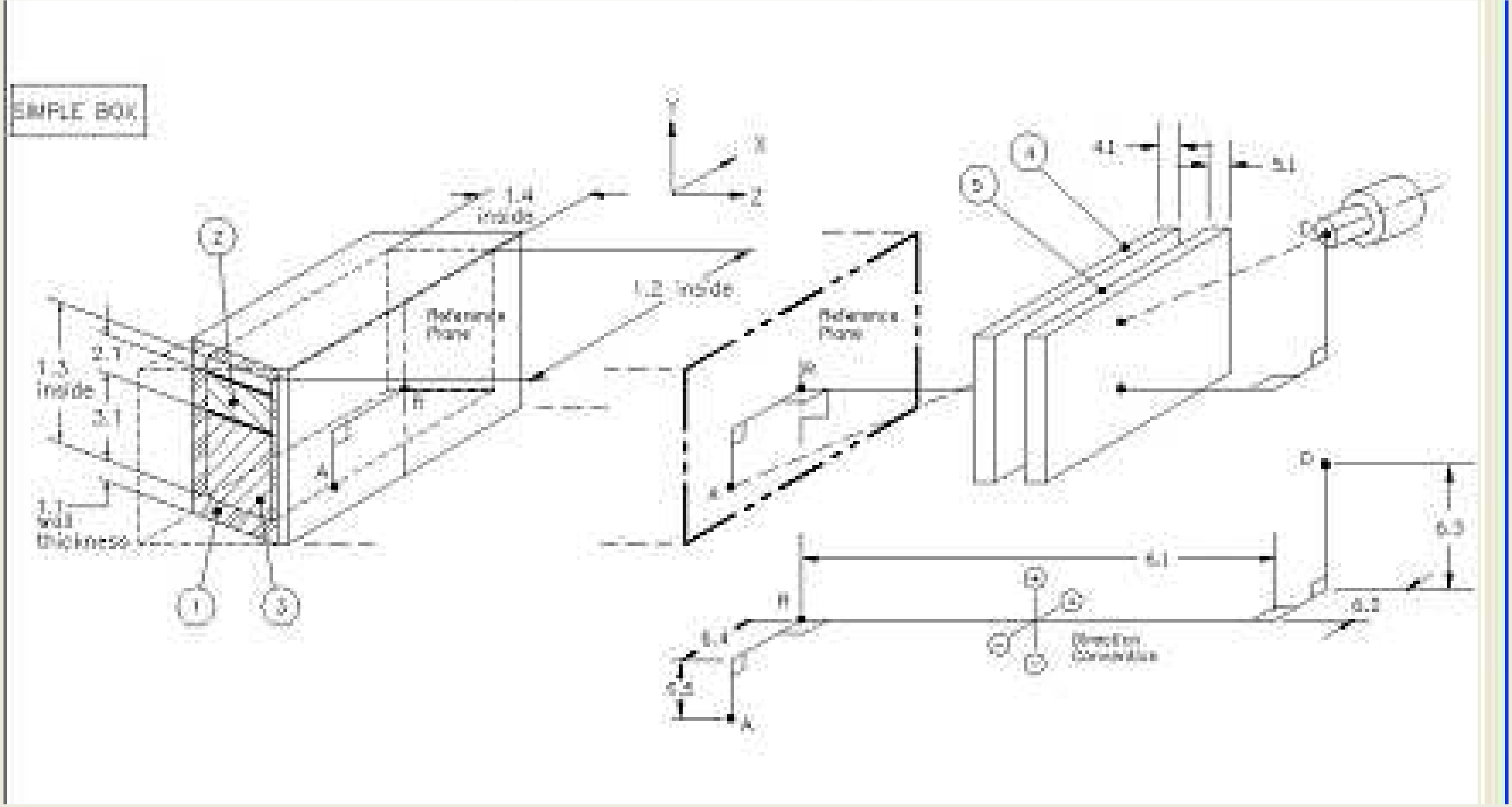
2. Open the **Geometry Composer** from the Genie2000 folder
on the desktop- Select **File -> NEW** and select the template that
Best defines the geometry you would like to model.
EXAMPLE: PLANE SPHERE, RECTANGULAR VOLUME, DRUM ETC

3. Select the detector Spectrum was aquired on. example :FAL03, FAL04 .

4. Edit Dimensions of the geometry chosen by selecting this ICON.

Sample Modeling using ISOCS

Below is an example of the template provided in the ISOCS program (Simple Box shown)



Collimator

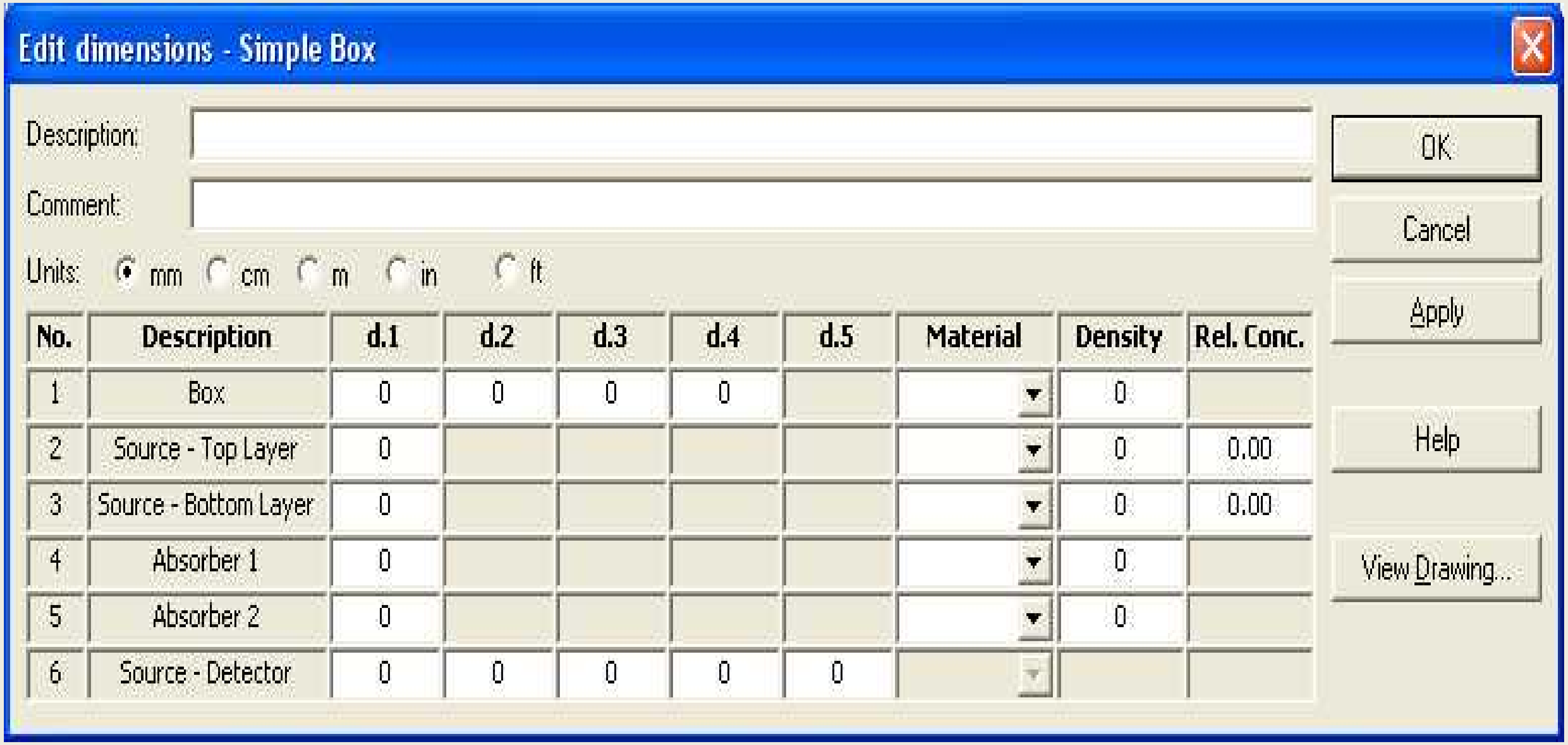
If the spectrum was obtained with a collimator on the FALCON click on the top symbol box icon to add the collimator to your model.

The acrylic cover must be added as an ABSORBER with a 0.245 “ dimension.

acrylic cover

Based on the template , input the related dimensions and materials of the sample here. Be mindful of units ie: mm, cm, inches.

If a units dimension is altered after saving a the file a “LOSS OF PRECISION “ dialog box will appear.



Description:

Comment:

Units: ● mm ○ cm ○ m ○ in ○ ft

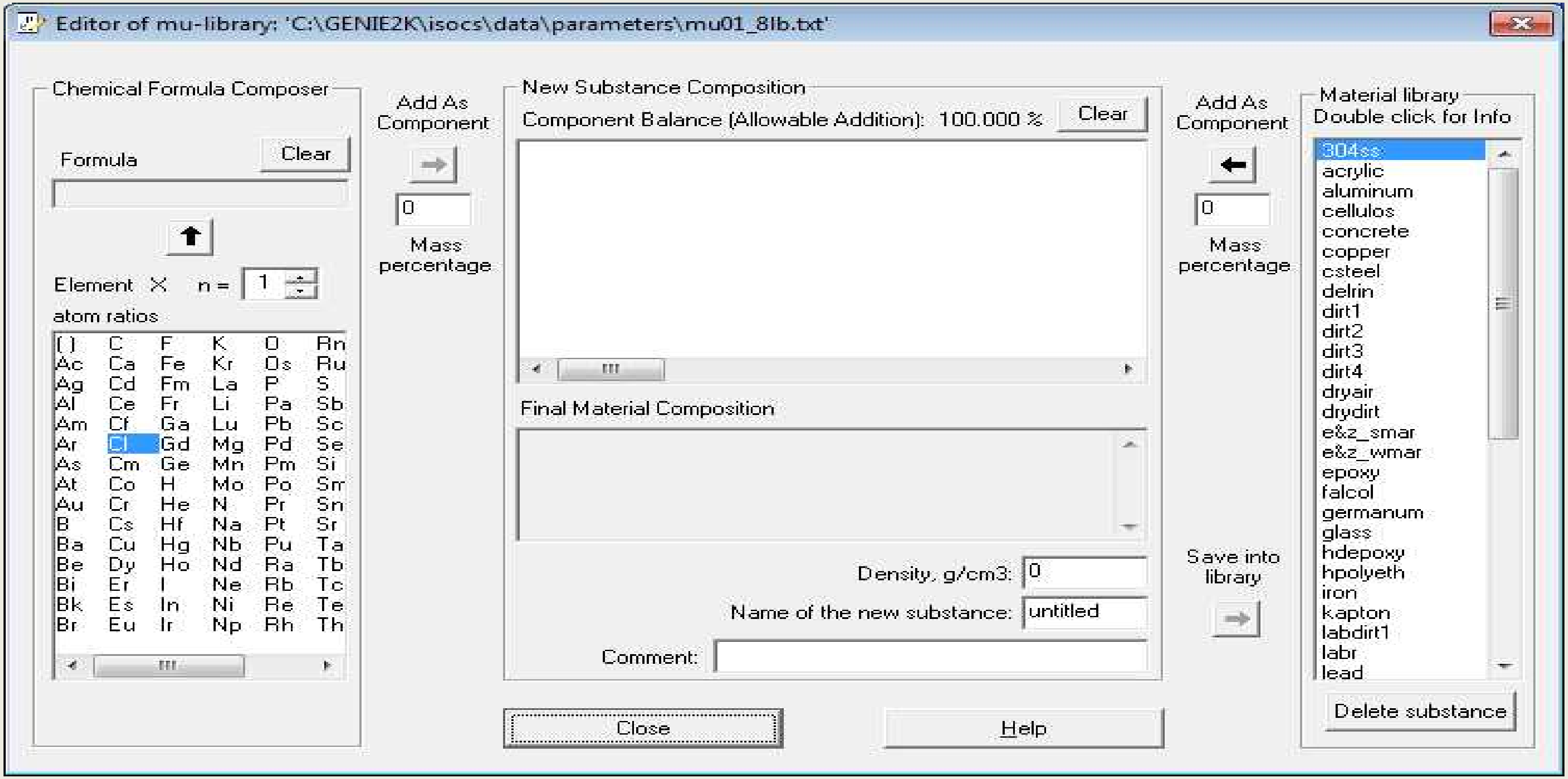
No.	Description	d.1	d.2	d.3	d.4	d.5	Material	Density	Rel. Conc.
1	Box	0	0	0	0			0	
2	Source - Top Layer	0						0	0.00
3	Source - Bottom Layer	0						0	0.00
4	Absorber 1	0						0	
5	Absorber 2	0						0	
6	Source - Detector	0	0	0	0	0			

CREATION OF NON-STANDARDIZED MATERIAL

- *If a material description is not listed in the pull-down lists that matches (or is very close to) the material being analyzed, the "mu editor" can be used to create new materials in the library. Edit –material library*

- *The next slide provides an example of the template provided in the ISOCS program that will allow the user to input related elemental composition and calculated density of sample material to be modeled.*

MATERIAL LIBRARY



Editor of mu-library: 'C:\GENIE2K\isocs\data\parameters\mu01_8lb.txt'

n = 1

[ ]	C	F	K	O	Rn
Ac	Ca	Fe	Kr	Os	Ru
Ag	Cd	Fm	La	P	S
Al	Ce	Fr	Li	Pa	Sb
Am	Cf	Ga	Lu	Pb	Sc
Ar	Cl	Gd	Mg	Pd	Se
As	Cm	Ge	Mn	Pm	Si
At	Co	H	Mo	Po	Sm
Au	Cr	He	N	Pr	Sn
B	Cs	Hf	Na	Pt	Sr
Ba	Cu	Hg	Nb	Pu	Ta
Be	Dy	Ho	Nd	Ra	Tb
Bi	Er	I	Ne	Rb	Tc
Bk	Es	In	Ni	Re	Te
Br	Eu	Ir	Np	Rh	Th

Mass percentage: 0

Component Balance (Allowable Addition): 100.000 %

Density, g/cm3: 0

Name of the new substance: untitled

Comment:

Mass percentage: 0

- 304ss
- acrylic
- aluminum
- cellulos
- concrete
- copper
- csteel
- delrin
- dirt1
- dirt2
- dirt3
- dirt4
- dryair
- drydirt
- e&z_smar
- e&z_wmar
- epoxy
- falcol
- germanum
- glass
- hdepoxy
- hpolyeth
- iron
- kapton
- labdirt1
- labr
- lead

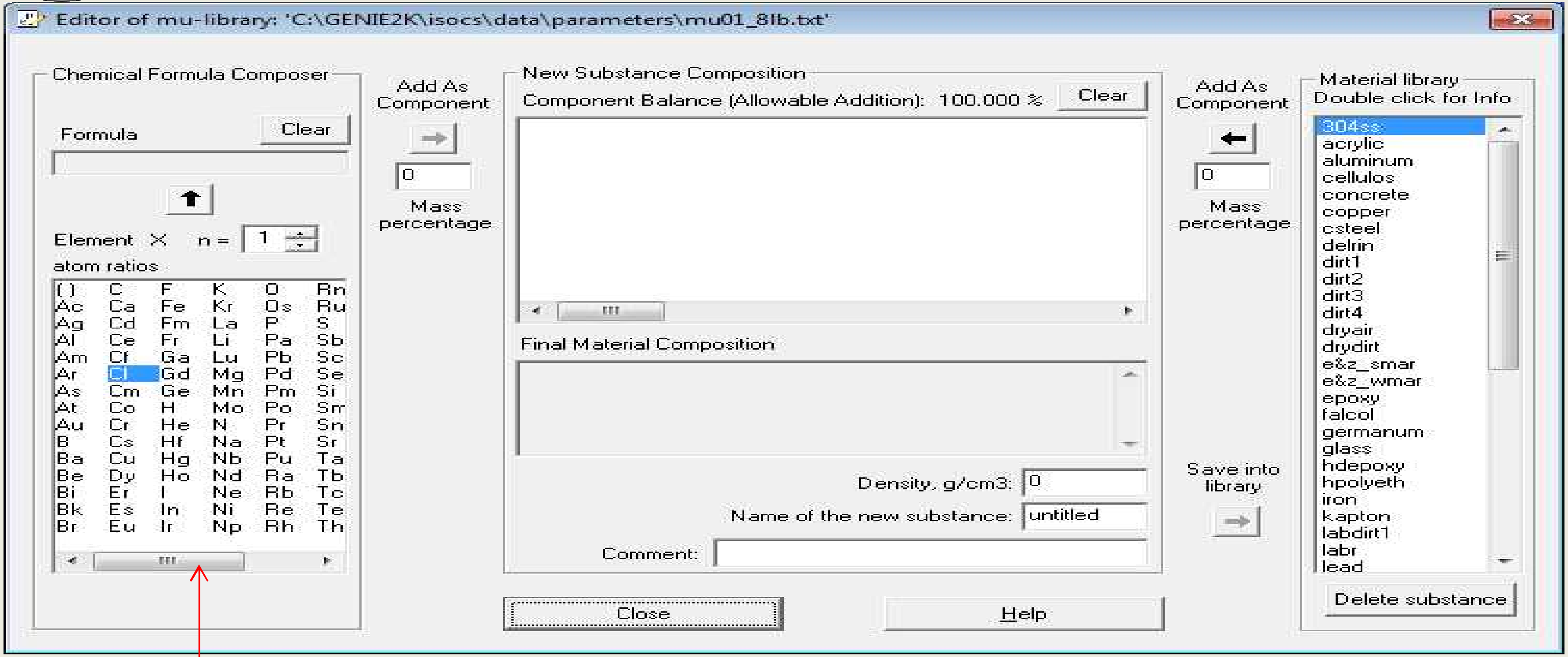
Modification of Material

To modify material:

- Top of screen
- Edit
- Material Library
- Select elements / material
- Mass percentage of each
- Add as Component
- Save and give unique name for the material type you just developed..

- Go back to EDIT DIMENSIONS

Under material pull down select material with unique name. Density will automatically calculate to dimension developed.



Editor of mu-library: 'C:\GENIE2K\isocs\data\parameters\mu01_8lb.txt'

Component Balance (Allowable Addition): 100.000 %

Density, g/cm3: 0

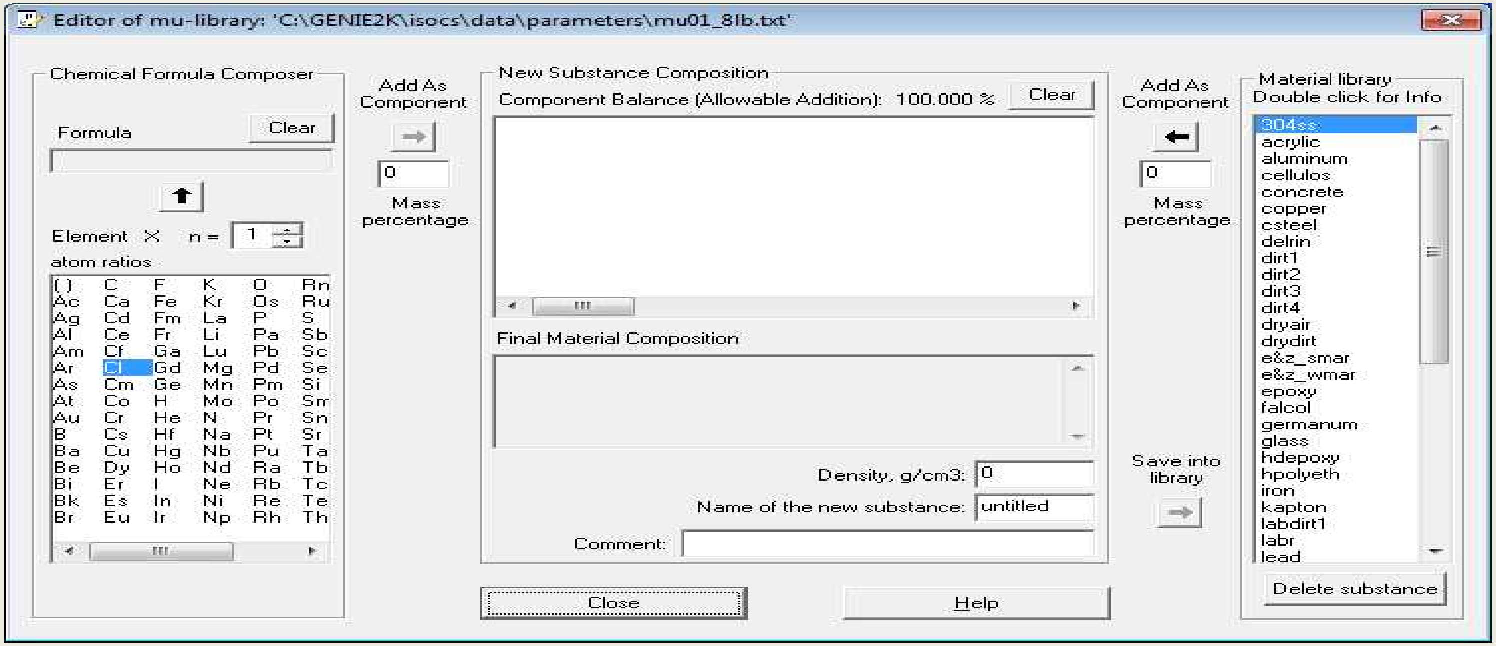
Name of the new substance: untitled

Comment:

If the ***elemental*** *mass ratios are known for the material, it can be defined by using the element selection box to the left. The atomic ratios of each molecule can be input using the "n = " selection box. For example. Water consists of two hydrogen atoms attached to one oxygen atom.*

To enter this, the user will select "H" from the box,

Increase "n =" so that it equals 2, and then the up arrow.



Editor of mu-library: 'C:\GENIE2K\isocs\data\parameters\mu01_8lb.txt'

Component Balance (Allowable Addition): 100.000 %

Element Cl n = 1

Mass percentage: 0

Density, g/cm3: 0

Name of the new substance: untitled

Comment:

- *To add the oxygen, the user will select “O” from the list, change “n=” to 1 and then hit the up arrow.*
- *If the matrix consists only of water, then the mass percentage would be 100.*
- *If there was salt in the water, then the mass ratio would have to be calculated and the salt would have to be added separately.*
- *Alternatively, the user can make a new substance by combing any ratio of the materials in the library using the utility at the right of the screen.*

EXERCISE

- ✓ Develop a Geometry for a soil sample (dirt #1) contained in a 4” x 4” x 2” plastic box with .001” sides.
- ✓ The detector face is centered (no offset) 3 inches away from the sample box.
- ✓ The box is 50% full.

EXECUTING THE MODELED SOURCE GEOMETRY

Once the new material is listed in the center box and the "Component Balance" is equal to 0, the user must enter the mass density of the material, give it a name, and enter an optional comment to help identify the material. By clicking the "Save into library" button, the new material will be saved to the library and can be used in any future models.

- Once the correct dimensions and materials have been selected the model is efficiency codes are ready to be executed.

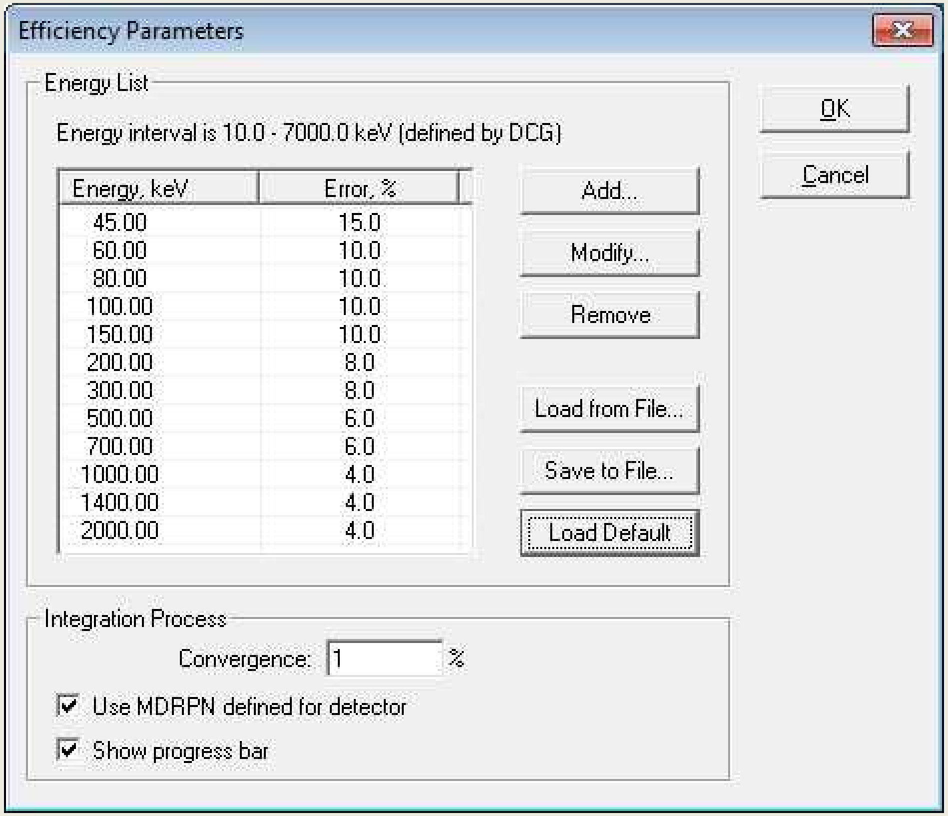
- Check geometry validity by pressing this icon:

- This utility checks the geometrical parameters to make sure that a logical model has been created.
- **SAVE**

Error messages are usually self-explanatory and the user will be able to determine how to remedy the problem. For errors that are not easily understood, refer to the Canberra ISOCS manual.

EXECUTING THE MODELED SOURCE GEOMETRY

- Modify and load Energy list by pressing this ICON:
- The following energy list editor will appear, you may add lines to this list that are in the spectrum or use a default list
- Note, when adding energy lines, interpolate the % Error values linearly from the default values



Energy interval is 10.0 - 7000.0 keV (defined by DCG)

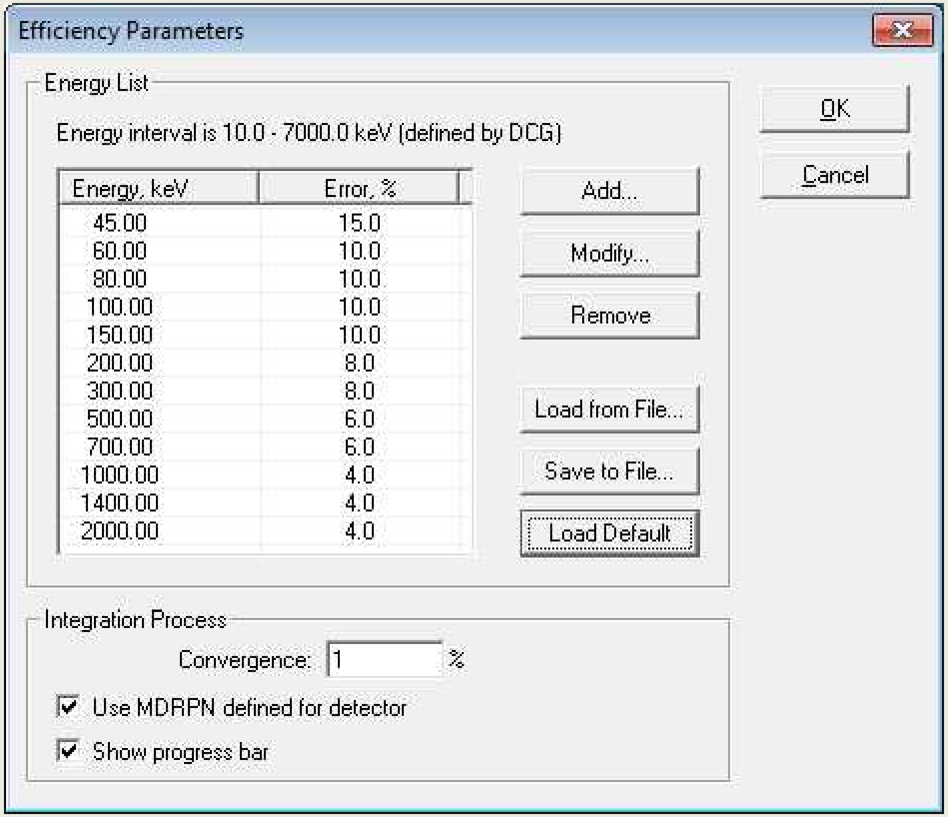
Energy, keV	Error, %
45.00	15.0
60.00	10.0
80.00	10.0
100.00	10.0
150.00	10.0
200.00	8.0
300.00	8.0
500.00	6.0
700.00	6.0
1000.00	4.0
1400.00	4.0
2000.00	4.0

Convergence: 1 %

☑ Use MDRPN defined for detector

☑ Show progress bar

With this utility, the user can choose the Energies to bedeveloped for certain efficiencies. For most applications, the default energy list and Convergence % will suffice. A rule of thumb is to be sure that there are at least 10 data points and that both the lowest and highest gamma energy of all the nuclides of interest are within the bounds of the energies selected. Just like the mu editor, the energy list can be saved and loaded into future models.



Energy interval is 10.0 - 7000.0 keV (defined by DCG)

Energy, keV	Error, %
45.00	15.0
60.00	10.0
80.00	10.0
100.00	10.0
150.00	10.0
200.00	8.0
300.00	8.0
500.00	6.0
700.00	6.0
1000.00	4.0
1400.00	4.0
2000.00	4.0

Convergence: 1 %

☑ Use MDRPN defined for detector

☑ Show progress bar

EXERCISE

Modify the Energy List that would be used to quantify a sample containing Co-60 (keV 661, 1332).

- Save the model with a unique identifying filename (like the sample control form number “SCF#”) ***Take note of where you saved the file***

- To run the efficiency calculator press the following icon: EFF
  Take note of where the .ecc file was saved.
- ***SAVE***

- Select **File ->Print** to print out the geometry report.
  Retain this as part of the record.
- Date and initial the ISOCS report
- Have a reviewer that is familiar with ISOCS review, sign and date your work

At this point you are finished with the Geometry Composer.

Using the Modeled Geometry

To use the newly developed efficiency curve, open:

- **Select GENIE2K** (From the Genie 2000 folder on the desktop)
- Open Gamma Acquisition & Analysis
- **Select File -> Open data source**:
  - Select the CNF. File of the spectrum that is to be analyzed with the ISOCS geometry.
- Select **Calibrate -> Efficiency -> by LABSOCS / ISOCS…**
- Select the model that was just performed (.ecc file *pulldown)*
- Select **Geometry Composer.**
- Select **Next >**
- Select **“Efficiency”**
- Select **Next >**
- Select **Show>**
- Under CURVE WINDOW select **“Linear”** as the curve type.

Using the Modeled Geometry cont.

- Examine both linear and log scales, ensure that all of the data points lie very close to the calculated curve fit. If a point needs to be dropped from the fit, select

- Press **List** and drop points as necessary.
  Make certain to have an experienced gamma spectroscopist review the results before data is submitted.
- When satisfied with the fit, select **OK.**
- Print the both **linear** and **log** scales
- Select **Report…** Print this report
- ***OPTIONAL If the model is going to be used again:*** STORE the calculation.
  Make certain when you store to include information in the filename that points to what detector and geometry it pertains to under cal files using the detector number as the first digit.
- Select **FINISH,** completing the attachment of the new ISOCS efficiency.
- Select **File** -> **Save**
  - **Do not change the filename!**

Reanalyzing the Modeled Geometry

- **Go to FRMAC Routine Operations** folder located on the desktop.
- Run the REANALYZE .REXX file
- Select "No" when the dialog asks if the user would like to attach a new efficiency calibration. The efficiency has already been attached to the spectrum in the previous steps.
- Follow the on-screen prompts to complete the analysis. (See section on sample analysis).
- Print, Sign, and date the reports that are generated.
- Have a 2nd person review, sign, and date the reports.
- Follow procedure on data submission (see section on sample analysis).

EXERCISE

Pull up a spectrum and apply a ISOCS calibrated efficiency file to it.

Questions?