Hall Probe and Moving Coil ID Field Measurement System User's Guide

Date: February 17, 2006
Author: **Joseph Z. Xu**
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Reviewed and Approved By: Date
Isaac Vasserman
Tel: 2-9612, Email: Isaac@aps.anl.gov

Reviewed and Approved By: Date
Shigemi Sasaki
Tel: 2-9702, Email: sasaki@aps.anl.gov

Functional Owner Date
Ned D. Arnold
Tel: 2-6332, Email: nda@aps.anl.gov

Functional Owner Date
Elizabeth R. Moog
Tel: 2-2787, Email: moog@aps.anl.gov

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1. EXECUTIVE SUMMARY

Hall Probe and Moving Coil ID Field Measurement System are designed to measure the magnetic field and field integral distributions of IDs. APS has two Hall Probe and Moving Coil ID Field Measurement Systems. Each consists of a granite table (7 meters long for the 6-meter bench and 4 meters long for the 3-meter bench), a 3-axis motorized stage (X-linear, Y-linear, and W-rotary), a calibrated Hall probe sensor, and a moving coil sensor. The sensors are mounted on the stage. The stage is hosted on the granite table with an air bearing that guides it moving along the Z direction.

The control and data acquisition system is a PXI based computer system. With the latest state-of-the-art Field Programmable Gate Array (FPGA) technology, the system is capable of synchronized measurements of X (10 micron in resolution), Y (0.5 micron in resolution), and Z (5 micron in resolution) positions, time (25 ns), voltage (6-1/2 digits resolution), and temperature (0.1 ^{o}C accuracy) with the following options:

1. Hall Probe ID Magnetic Field Measurement
   Multiple measurements of the magnetic filed along any selected axis, shifted across a second axis. Real-time calculation and plot of the 1st and the 2nd field integrals, and the synchrotron radiation brightness with the integrated IDL Magnetic Analysis module.

2. Moving Coil ID Magnetic Field Integral Measurement
   Multiple measurement of the magnetic filed integral along any selected axis. Real-time calculation and plot of the 1st and the 2nd field integrals.

3. Temperature Sensing
   Multi-channel measurements of temperature.

Computer control software has been developed to coordinate and automate the control, data acquisition, and real-time data analysis effort. This document provides the User's Guide information for the Hall Probe Magnetic Field and Moving Coil Field Integral Measurement System. The current issue of the document provides system descriptions, software installation, and detailed step-by-step to the applications of the system. The document is structured to provide descriptions/scenarios and application guiding information, in meeting the current and possible future needs of the scientists who use the system in the lab.

2. INTRODUCTION

The APS Magnetic Measurement Lab is equipped with two (2) ID Hall Probe Measurement Systems. Each consists of a granite table (7 meters long for the 6-meter bench and 4 meters long for the 3-meter bench), a 3-axis motorized stage (X-linear, Y-linear, and W-rotary), a calibrated Hall probe sensor, and a moving coil sensor. The sensors are mounted on the stage. The stage is hosted on the granite table with an air bearing that guides it moving along the Z direction. The motorized X and Y linear stages are APS home-made aluminum stages powered with Animatics frame 23 SmartMotor servo motors. The stages are equipped with optical linear encoders for positions readouts. The W rotary stage is a Huber 408 Circle Goniometer powered with a frame 17 SmartMotor. The sensor holders are attached onto the Goniometer via a Huber Goniometer Head 1003 that has X, Y, Ry, and Rx 4-axis adjustments. The SmartMotors are controlled via RS-232 interface of a PXI control card. The signal of the Hall probe sensor is amplified by a pre-amp mounted on the stage and fed to a 7-1/2 digit PXI DMM module. The signal of the moving coil sensor is fed to a MF-10D Digital Fluxmeter from Walker LDJ Scientific Inc and then digitized by a the PXI DMM module. The Fluxmeter is remotely controlled via RS-232 interface of the PXI control card. The FPGA card is programmed to read the encoder positions and synchronize the DMM readings and/or the 16bit analog input readings with the position readouts.

The software system on the PXI control card has seven main modules, the Motion Control Module, the Temperature Monitoring Module, the Hall Probe Magnetic Field Measurement Module, the Integrator Coil Field Measurement Module, the Moving Coil Field Integral Measurement Module, the IDL Magnetic Analysis Interface Module, and the System Data Parameter Interface Module. Each module provides user with friendly GUI interfaces. The Motion Control Module allows user to monitor the coil voltage, the Hall/Integrator voltage, as well as the positions of W, X, Y, and Z encoders. It also provides the motion and positioning capabilities.

The Temperature Monitoring Module monitors the temperature (up to four channels) and plots the measurement in real time. User can log the temperature data into a file and plot the data files as needed.

The Hall Probe Magnetic Field Measurement Module measures the magnetic field along X, Y, or Z directions, plots each measurement, and save the measurement data along with all the related parameters into a file. Its Magnetic Analysis sub-module plots the measurement file, the

field 1st integral, the field 2nd integral. The sub-module processes the data with the Magnetic Analysis applications in IDL, calculates and plots the X-ray brilliances as well as the particle trajectories. Its Field Calibration sub-module loads the Hall probe sensor calibration file. The Zero Field sub-module is used to measure the sensor zero field, the scan start field, and end field. The Time Dependent Field Measurement sub-module is used to monitor the field time dependency. User can log the data into the file and plot the data files for further analysis.

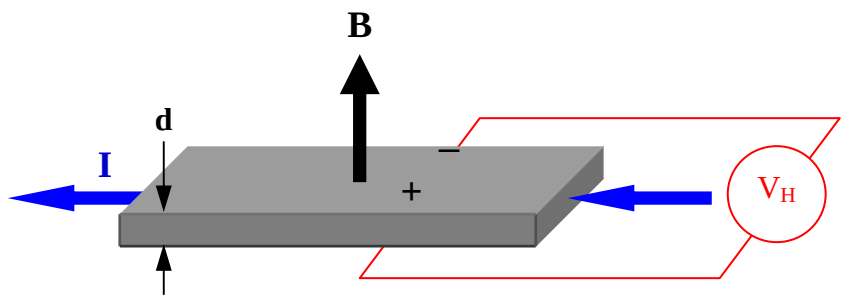
This document provides the detailed User's Guide information for the APS Magnetic Measurement Lab ID Field Integral Measurement System. It includes a general overview of the measurement system, descriptions of all the sub-systems, and the step-by-step guide to the software system that integrates the sub-systems and automates the control and measurements. This document shall be revised to reflect the modification of the system. This is a living document.

3. SYSTEM OVERVIEW

Insertion Devices (IDs) at the APS are characterized and fine tuned against their design specifications at the Magnetic Measurement Lab before they get installed into the storage ring. One of the specifications is to make sure that the IDs have their field profiles meets the design parameters.

3.1 Scanning Hall Probe Theory of Operation

Scanning Hall Probe makes use of the Hall Effect. When a charged particle moves along a direction perpendicular to an applied magnetic field, it experiences a Lorentz Force acting normal to field as well as the motion. The force courses equal and opposite charges accumulate across the Hall element that builds up an electrical potential.



As a result, the Hall Effect is very useful as a means to measure the magnetic field.

By scanning a Hall probe sensor inside a magnetic insertion device, one can map out the magnetic field of the device.

3.2 Moving Coil Theory of Operation

If the magnetic flux going through a coil changes, a signal will be induced in the coil. The coil is designed in such a way that it has a width of the period of the ID. Therefore, if the coil is moving through the ID, any misalignment of the magnets or magnetic poles as well as the total integral will be revealed in the measurement.

4. SYSTEM HARDWARE

The Hall Probe and the Moving Coil Measurement System hardware consists the following sub-systems:

1. A (W) rotary stage that carries the Hall probe or Moving coil sensor holders, remotely controlled by a servo motor.
2. A two axis (X and Y) linear stages that support the rotary stage, remotely controlled by servo motors.
3. A carriage with air bearings that carries the linear stages as well as all the pre-amplifiers and electronics moving along Z direction, remotely controlled by a servo motor through a steel belt.
4. A 7 meter long (or 4 meter long for the 3 meter bench) granite table that host the carriage, the 6.8 meter (3.5 meter long for the 3 meter bench) Z-encoder, as well as the carriages for cables and air tubing.
5. Three linear encoders for X, Y and Z.
6. 1 digital fluxmeter.
7. 1 coil sensor with a DC pre-amplifier with built-in low-pass signal filter.
8. 1 Hall probe sensor with current power supply and pre-amplifier.
9. 1 FPGA reconfigurable data acquisition card.
10. 1 DMM PXI data acquisition card.
11. 1 Temperature PXI data acquisition card.
12. 1 PXI control card.
13. 1 PXI shelf.

4.1 Precision Rotary Positioning Stage

There is a W rotary stage. It is a Huber 408 Circle Goniometer powered with a frame 17 SmartMotor servo motor. The sensor holders are attached onto the Goniometer via a Huber Goniometer Head 1003 that has X, Y, Ry, and Rx 4-axis manual adjustments.

The SmartMotor is a brushless DC servo-motor that uses a built in controller and amplifier to perform programmed motion. The servo controller uses closed loop PID control. The SmartMotors run from commands received from RS232 communication cable.

4.2 Precision Linear Positioning Stages

The precision rotary stage is mounted on a set of (X and Y) precision linear stages. The linear linear stages are APS home-made aluminum stages powered with Animatics frame 23 SmartMotor servo motors. The stages are equipped with optical linear encoders for position readouts.

4.3 Carriage with Air Bearings

A carriage with air bearings, hosted on a 7 meter (4 meter for the 3 meter bench) long granite table. The carriage carries the X and Y linear stages as well as the power supply, the pre amplifiers, the cables, and the air tubing.

4.4 Linear Encoders

There are 3 linear encoders mounted on the X, Y, and Z linear stages of the assembly. For X and Y linear stages, Heidenhain LIDA Incremental Linear Encoders are used. For Z motion, a six meter long ACU-RITE ENC 150 series encoder is used. It has 6 meter measuring length with 0.5 micron resolution. The linear encoder is used to accurately define the positions of the Hall Probe.

4.5 Digital Fluxmeter

The MF-10D Precision Digital Fluxmeter from Walker Scientific takes the moving coil signal, performs a mathematical integration of the volt-second signal from the coil via electronic circuitry, and scales the signal mathematically by doing the necessary proprietary software calculations to produce an output results that is proportional to measured magnetic field.

4.6 Pre-Amplifier with Low-Pass Signal Filter

A differential DC signal conditioner is used as pre-amplifier in the application of Moving Coil. It is Ectron 428-O with auto zero suppression.

Ectron 428-O DC Signal Conditioner

4.7 Digital Multimeter (DMM) Card

The Hall Probe signal feeds into a 6-1/2 digit digital multimeter (DMM) card from National Instruments. The PXI-4070 DMM card has 10 to 23-bit flexible resolution and is capable of acquiring voltage signal at a sampling rate up to 1.8 MS/s.

PXI-4070 Digital Multimeter (DMM) card

4.8 FPGA Reconfigurable Data Acquisition Card

The PXI-7831R FPGA Reconfigurable Data Acquisition card from National Instruments provides a flexible hardware platform for the positioning and synchronization tasks. The 96 channels of on-board digital I/O can be reconfigured at the hardware level into encoder readouts. The 8 channels of on-board 16 bit analog input can be reconfigured into voltage measurement. The 200 MHz clock can be used to synchronize the positions and voltage measurement and provide the time stamp for the measurement to yield the speed information.

PXI-7831R FPGA Reconfigurable Data Acquisition Card

4.9 PXI Control Card

The PXI Control Card is a PXI-8174 embedded controller for PXI and CompactPCI from National Instruments. It has a 566 MHz CPU and 256 MB on-board memory.

PXI-8174 Embedded PXI Controller

4.10 PXI Shelf

The shelf is a PXI-1002 PXI shelf from National Instruments. The shelf has 4 slots. Slot 1 hosts the embedded controller. Slot 2 is occupied with the PXI-7831R FPGA reconfigurable data acquisition card.

5. SYSTEM SOFTWARE

The Hall Probe and Moving Coil Measurement system software has a Main Interface and the following main modules and sub-modules:

1. Advanced Motion Control Module.
    a. Motor Velocity and Acceleration Control and Monitoring Sub-module.
2. Temperature Monitoring Module.
    a. Data Plot Sub-module.
3. Hall Probe Module.
    a. IDL Data Plot and Magnetic Analysis Module.
    b. Advanced Motion Control Module.
    c. Temperature Monitoring Module.
    d. Field Calibration Loading Sub-module.
    e. Zero Filed Measurement Sub-module.
    f. Time-dependant Field Measurement Sub-module.
4. Integrator Magnetic Field Measurement Module
    a. Fluxmeter Control Sub-module.
    b. Data Plot Sub-module.
    c. Time Dependant Integral Measurement Sub-module.
    d. Advanced Motion Control Module.
    e. Temperature Monitoring Module.
    f. Zero Filed Measurement Sub-module.
5. Moving Coil Field Integral Measurement Module.
    a. Data Plot Sub-module.
    b. Advanced Motion Control Module.
    c. Temperature Monitoring Module.
6. Hall Probe IDL Data Plot and Magnetic Analysis Module.
    a. Data Integral Plot Sub-module.
    b. IDL Magnetic Analysis Module.
7. System Parameter Database Interface Module.
    a. Advanced Parameter Database Interface Sub-module.

Each module and sub-module has its own GUI interface. The Main Interface provides an access interface to all the main modules and hence the sub-modules. It checks the status of the FPGA reconfiguration data acquisition. If the FPGA card is not running or is running on different firmware, the module will download and initialize the card with the appropriate firmware. It also checks the status of all 4 SmartMotors. If the motors are not initialized, it will try to re-initialize the motors.

For advanced motion control, the system checks the status of all 4 SmartMotors. If they are not initialized, it will try to re-initialize the motors. The module monitors all 4 motor positions and the encoder positions, as well as voltage measurements. It provides motor absolute motion and relative motion control interfaces. From the advanced motion control, one can access the velocity and acceleration control interface.

The velocity and acceleration control interface sets and gets the motor velocity and acceleration values.

Measurement modules set the measurement parameters, pass the parameters to the FPGA card, set the motor positions, retrieve the measurement data from the DMM and the FPGA on-board memory, carry out real time data analysis, plot out the data and fitting parameters, and write the data, fitting parameters, as well as the ID information to a file.

Each measurement module has its own post-analysis and plot module. The plot modules retrieves the data and parameters from files, fits the data with user defined parameters, and plots them out on the screen.

From each measurement module, one can access the advanced motion control module and the temperature monitoring module.

6. PREPARATIONS

The system involves 110 AC Voltage, Mechanical Motion, and possibly High Magnetic Field. Extra safety precaution has to be taken. Users shall take proper safety training classes before operation of the system.

7. HARDWARE CONNECTIONS

All the hardware sub-system shall be wired appropriately according to their user's manual.

7.1 SmartMotor Connections

Make sure the DB9 connector of RS-232 cable from the back of the Animatics SmartMotors mounted on the motorized stages is connected to the COM1 port of the computer. The connectors to the SmartMotors are labeled and shall be connected in the following sequence:

Motor Axis	Z	X	Y	W
Motor Connector	1	2	3	4

All 4 motors share a single power supply. Please reference to the SmartMotor User's Manual for multi-motor cabling.

7.2 Encoder Connections

For X-axis, the HEIDENHAIN linear encoder to the FPGA data acquisition card connections:

X-axis	A	B	Z	+5V	0V
PIN #	5	8	3	12	10
FPGA	DIO0	DIO1	DIO2	+5V	DGND
MIO PIN#	36	37	38	1	2

For Y-axis, the HEIDENHAIN linear encoder to the FPGA data acquisition card connections:

Y-axis	A	B	Z	+5V	0V
PIN #	5	8	3	12	10
FPGA	DIO3	DIO4	DIO5	+5V	DGND
MIO PIN#	39	40	41	1	7

For Z-axis, the ACU-RITE ENC 150 linear encoder to the FPGA data acquisition card connections:

Z-Axis	A	B	Z	+5V	0V
PIN #	2	4	8	7	6
FPGA	DIO6	DIO7	DIO8	+5V	DGND
MIO PIN#	42	43	10	35	9

Currently, the W-axis does not have any rotary encoder. If the W-axis encoder is installed, the rotary encoder to the FPGA data acquisition card connections:

W-Axis	A	B	Z	+5V	0V
PIN #	2	4	8	7	6
FPGA	DIO9	DIO10	DIO11	+5V	DGND
MIO PIN#	41	11	45	35	9

7.3 Pre-AMP Connections

In the moving coil configuration, the moving coil shall be terminated by a differential pre-amp, that in turn, connected to the FPGA MIO Analog Input 0+ and 0- (MIO ping number 68 and 34).

7.4 Hall Probe Connections

For Hall Probe measurements, the Hall probe signal is wired to the DMM card. Make sure the polarity of the wiring is correct. Make sure the ground of the wire is connected appropriately, as well as the current supply to the Hall probe.

7.5 Integrator Measurement Connections

For Integrator Magnetic Field measurements, the moving coil terminates at the digital fluxmeter. The Corrected Analog Out of the fluxmeter signal wires to the DMM card. Make sure the RS-232C wires to COM2 port of the control card, that is required for the control system to access and provision the fluxmeter.

7.6 Temperature Sensing and Other Connections

For temperature monitoring, up to four pairs of thermocouples are wired to the thermocouple terminal block. Make sure to indentify the types of the thermocouples so the control system settings match the types.

8. COMPUTER REQUIREMENTS

The PXI controller is loaded with Windows XP Professional that is registered to the APS network. Therefore, any computer that is registered to the APS network can access the PXI controller. Currently, the controller can be accessed from a PC based computer through Remote Desktop provided by Microsoft. The application can also be accessed through other machines

such as Apple computers or Unix based computers via http interface in the future. In that cases, the client machine has to load the LabVIEW Run Time Machine from National Instruments.

9. SOFTWARE INSTALLATION

The Hall Probe and Moving Coil Measurement System Control Software Package includes the following files:

1. setup.exe
2. setup.ini
3. install.msi
4. InstMsi.exe
5. InstMsiW.exe
6. data.cab
7. system.db

If the package is on a CD, insert the CD into the CD ROM of the PC, double click the setup.exe file and follow the instruction to install the software package.

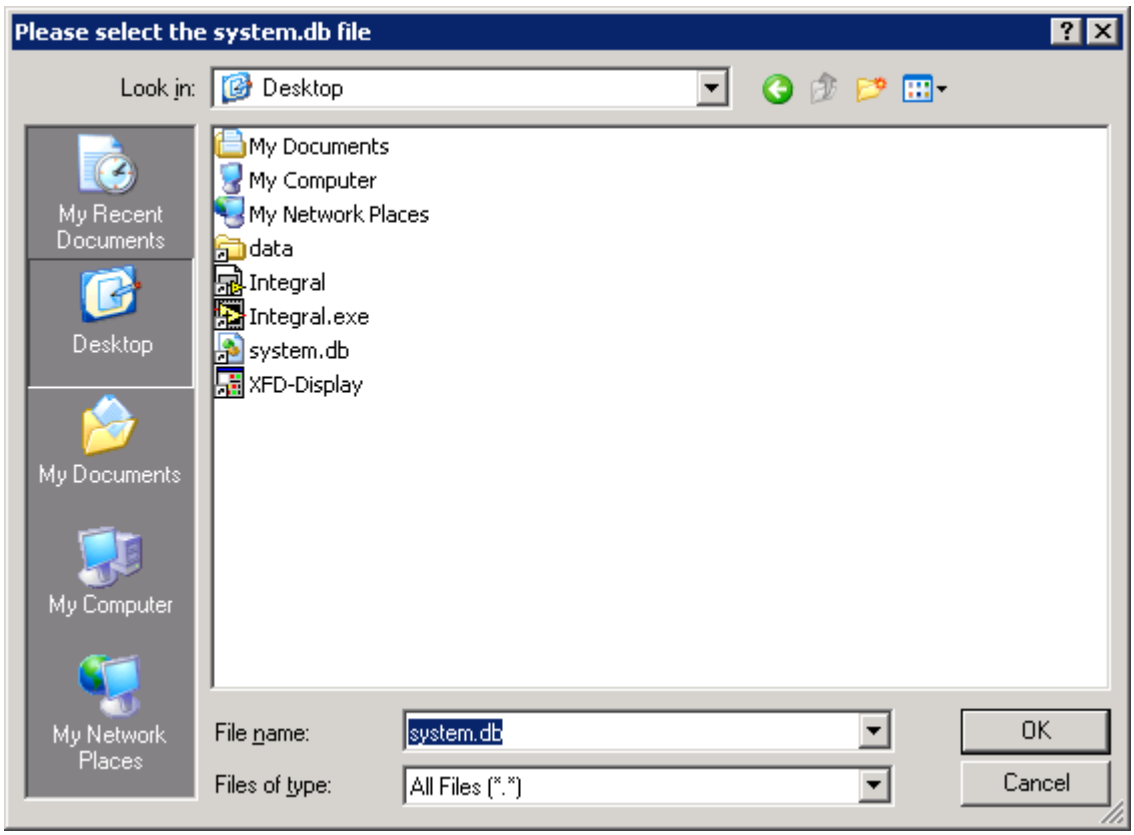
10. SYSTEM CONTROL SOFTWARE INTRODUCTION

The control software consists of the main user control interface, and four user interface modules. The user interface modules include:

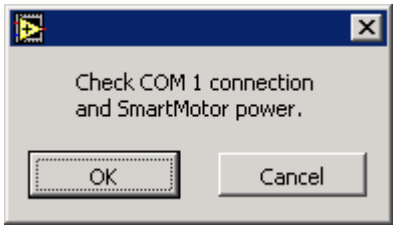
1. Advanced Motion Control Module.
2. Temperature Monitoring Module.
3. Hall Probe Module.
4. Integrator Magnetic Field Measurement Module
5. Moving Coil Field Integral Measurement Module.
6. Hall Probe IDL Data Plot and Magnetic Analysis Module.
7. System Parameter Database Interface Module.

10.1 Main Interface Window

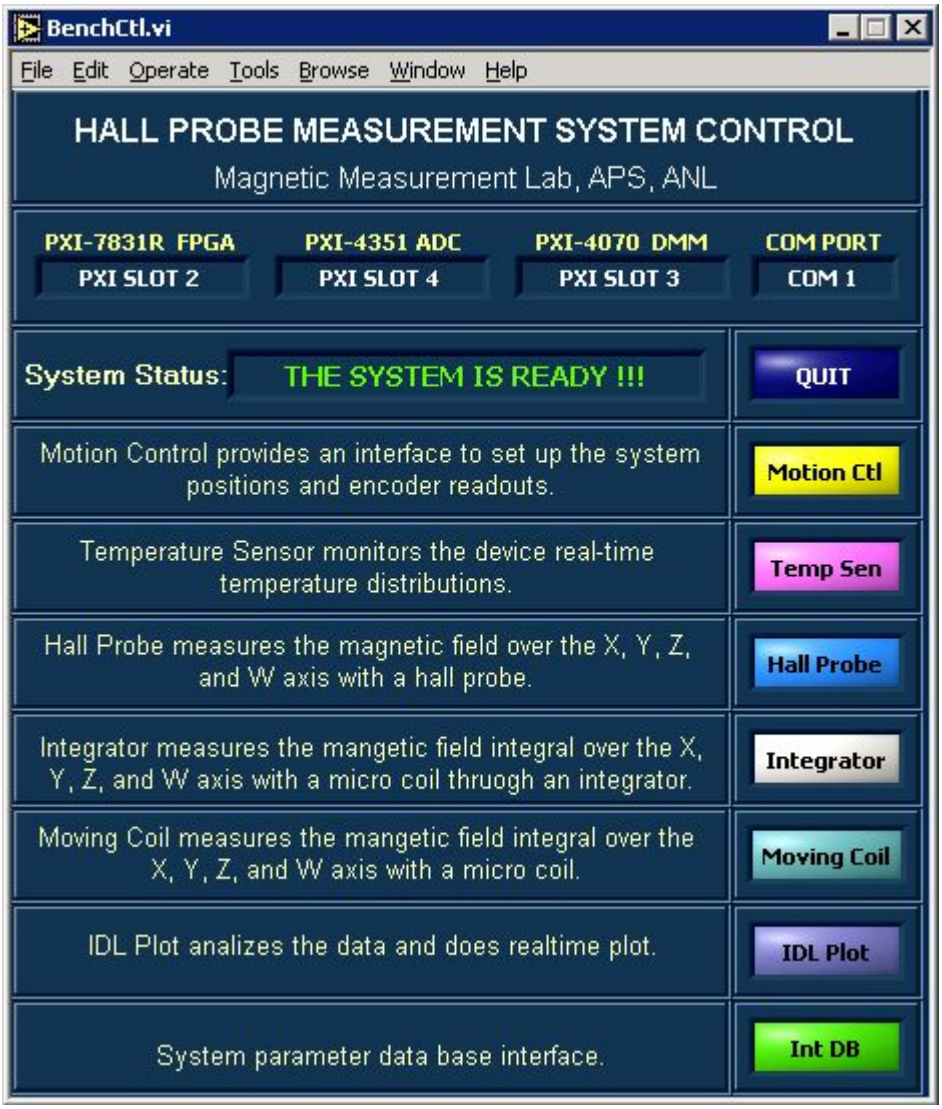
At launch, the main interface asks for the system.db file to be loaded.



After the system.db file gets loaded, the system checks the status of the FPGA reconfiguration data acquisition. If the FPGA card is not running or is running on different firmware, the module will download and initialize the FPGA card with the appropriate firmware. It also checks the status of all 4 SmartMotors. If the motors are not initialized, it will try to re-initialize the motors. If the motors are not powered up or the communication cable is not connected, the system will popup a window to ask you to check.



If every thing is ok, the system will then provide the Main Interface Window that shows the System Status information and an access interface to all the main modules as shown in the diagram.



The Main Interface Window

10.1.1 Display and Control Fields

- **System Status** field at the up side of the window displays the system current status.
- **PXI-7831R FPGA** field shows the slot number for the FPGA card in the PXI shelf. Check the shelf see if the slot number matches the setting. If not, click on the field and select the right shelf slot number in the pull down manual.
- **PXI-4351 ADC** field shows the slot number for the Temperature Monitoring ADC card in the PXI shelf. Check the shelf see if the slot number matches the setting. If not, click on the field and select the right shelf slot number in the pull down manual

- **PXI-4070 DMM** field shows the slot number for the DMM card in the PXI shelf. Check the shelf see if the slot number matches the setting. If not, click on the field and select the right shelf slot number in the pull down manual..
- **COM PORT** field shows the motor communication port. Check the shelf see if the port matches the setting. If not, click on the field and select the right port number in the pull down manual.
- **Motion Ctl** button launches the Advanced Motion Control Interface Window that allows you to set up the system position and encoder readout parameters.
- **Temp Sen** button launches the Temperature Monitoring Control Interface Window. Temperature Monitoring measures the device real-time temperature distributions.
- **Hall Probe** button launches the Hall Probe Magnetic Field Measurement Control Interface Window. Hall Probe measures the magnetic filed over the X, Y, Z, and W axis with the Hall probe.
- **Integrator** button launches the Moving Coil Integrator Measurement Control Interface Window. Integrator measures the magnetic field integral over the X, Y, Z, and W axis with a micro coil through an integrator (fluxmeter)
- **Moving Coil** button launches the Moving Coil Measurement Control Interface Window. Moving Coil measures the magnetic field integral over the X, Y, Z, and W axis with a micro coil without an integrator (fluxmeter).
- **IDL Plot** button launches the Magnetic Analysis Interface Window. It analyzes the Hall probe measurement data and provides the radiation distribution information.
- **Int DB** button launches the System Database Management Control Interface Window. The System Database Management manages the system parameter database.

10.2 Advanced Motion Control Interface

By clicking the **Motion Ctl** button in the main interface windows above, the system launches the Advanced Motion Control Interface Window as shown bellow.

The Advanced Motion Control Window has over 50 display and control fields. The detailed description of each field is listed in the following paragraphs.

10.2.1 GENERAL

- **SYSTEM STATUS** field at the up left side of the window displays the system current status.
- **INIT** button, forces the system to re-initialize the SmartMotors.
- **Back to Main** button, closes the window.

10.2.2 VOLTAGE

- **COIL VTG (V)** field displays the moving coil voltage measurement average upon the number of measurements set in the **V SMPL NUM** field in volts.
- **V SMPL NUM** field sets the number of voltage samples averaged for each measurement to the entered value.

- **HALL VTG (V)** field displays the Hall probe voltage measurement in volts.
- **RESOLUTION** field sets the resolution of Hall voltage samples measurements to the entered value.

10.2.3 ENCODER

- **W INDEX (deg)** field displays the rotary encoder index position in degree. Since the W-axis does not have a rotary encoder installed, the field is always 0.000.
- **W POS (deg)** field displays the current position of the rotary stage position in degrees. Since the W-axis does not have a rotary encoder installed, the field currently displays the rotary stage position converted from the motor position.
- **W SET (deg)** field let one enter the current rotary position to be set.
- **W SET TO** button, sets the rotary current position to the value entered in the **W RESET (deg)** field.
- **X INDEX (mm)** field displays the linear encoder index position in millimeter.
- **X POS (mm)** field displays the current position of the linear encoder in millimeter.
- **X SET TO (mm)** field let one enter the current linear encoder position to be set.
- **X RESET** button, sets the linear encoder current position to the value entered in the **X SET (mm)** field.
- **Y INDEX (mm)** field displays the linear encoder index position in millimeter.
- **Y POS (mm)** field displays the current position of the linear encoder in millimeter.
- **Y SET TO (mm)** field let one enter the current linear encoder position to be set.
- **Y RESET** button, sets the linear encoder current position to the value entered in the **X SET (mm)** field.
- **Z INDEX (mm)** field displays the linear encoder index position in millimeter.
- **Z POS (mm)** field displays the current position of the linear encoder in millimeter.
- **Z SET TO (mm)** field let one enter the current linear encoder position to be set.
- **Z RESET** button, sets the linear encoder current position to the value entered in the **X SET (mm)** field.

10.2.4 MOTION

- **W STEP SIZE (deg)** field sets the step size for the rotary stage to move in degrees. Click the “>” button sets the rotary stage move positive at the angle set in the step field. “<” button sets the rotary stage move negative at the angle set in the step field.

- **X STEP SIZE (mm)** field sets the step size for the X linear stage to move in mm. Click the “>” button sets the stage move positive at the step set in the step field. “<” button sets the stage move negative at the step set in the step field.
- **Y STEP SIZE (mm)** field sets the step size for the Y linear stage to move in mm. Click the “>” button sets the stage move positive at the step set in the step field. “<” button sets the stage move negative at the step set in the step field.
- **Z STEP SIZE (mm)** field sets the step size for the Z linear stage to move in mm. Click the “>” button sets the stage move positive at the step set in the step field. “<” button sets the stage move negative at the step set in the step field.

10.2.5 POSITION

- **W CUR POS (deg)** field displays the current W motor position converted to the rotary stage angular position unit in degrees.
- **W SET POS (deg)** field sets the targeted W position in degrees.
- **X CUR POS (mm)** field displays the current X motor position converted to the X linear stage position unit in mm.
- **X SET POS (mm)** field sets the targeted X position in mm.
- **Y CUR POS (mm)** field displays the current Y motor position converted to the X linear stage position unit in mm.
- **Y SET POS (mm)** field sets the targeted Y position in mm.
- **Z CUR POS (mm)** field displays the current Z motor position converted to the X linear stage position unit in mm.
- **Z SET POS (mm)** field sets the targeted Z position in mm.
- **SYNC** button sets all the motor current positions (all the **CUR POS** fields) to their encoder positions.
- **CRT OFF** button sets all the motor servo current to zero. In the CRT OFF mode, the **SYSTEM STATUS** field will show **Current Off** and all the LEDs on the SmartMotor shall turn from green to red. This is needed if one desires to move the stages manually.
- **MOVE** button moves the motors to the values shown in the **SET POS** fields.
- **STOP** button stops all motors during motion.
- **RESET** button resets the **SET POS** field values to their **CUR POS** field values respectively.

- **V and A** button launches the motion velocity and acceleration setting windows described in the **Motion Velocity and Acceleration Control** section.

10.3 Motion Velocity and Acceleration Control

By clicking the “A and V” button in the Advanced Motion Control Window, the system launches the Motor Velocity and Acceleration Control interface window as shown bellow.

Motion Velocity and Acceleration Control Window

The Motor Velocity and Acceleration Control Window has over 25 display and control fields. The detailed description of each field is listed in the following paragraphs.

10.3.1 GENERAL

- **SYSTEM STATUS** field at the up left side of the window displays the system current status.
- **Back to Motion Control** button, closes the window.

10.3.2 VELOCITY

- **W CUR V (deg/s)** field displays the current rotation speed for both rotary stages in degrees per second.
- **W SET V (deg/s)** let one enter the current rotation speed to be set.
- **X CUR V (mm/s)** field displays the current motion speed for both X linear stages in millimeters per second.
- **X SET V (mm/s)** let one enter the current X linear motion speed to be set.
- **Y CUR V (mm/s)** field displays the current motion speed for both Y linear stages in millimeters per second.
- **Y SET V (mm/s)** let one enter the current X linear motion speed to be set.
- **Z CUR V (mm/s)** field displays the current motion speed for both Z linear stages in millimeters per second.
- **Z SET V (mm/s)** let one enter the current Z linear motion speed to be set.
- **VLCT DEFAULT** button sets the current velocity values to the system default values as shown in the diagram.
- **VLCT SET ALL** button sets all the system velocity to the values in the **SET V** fields entered by the user.
- **VLCT RESET** button resets all the **SET V** fields to the **CUR V** field values.

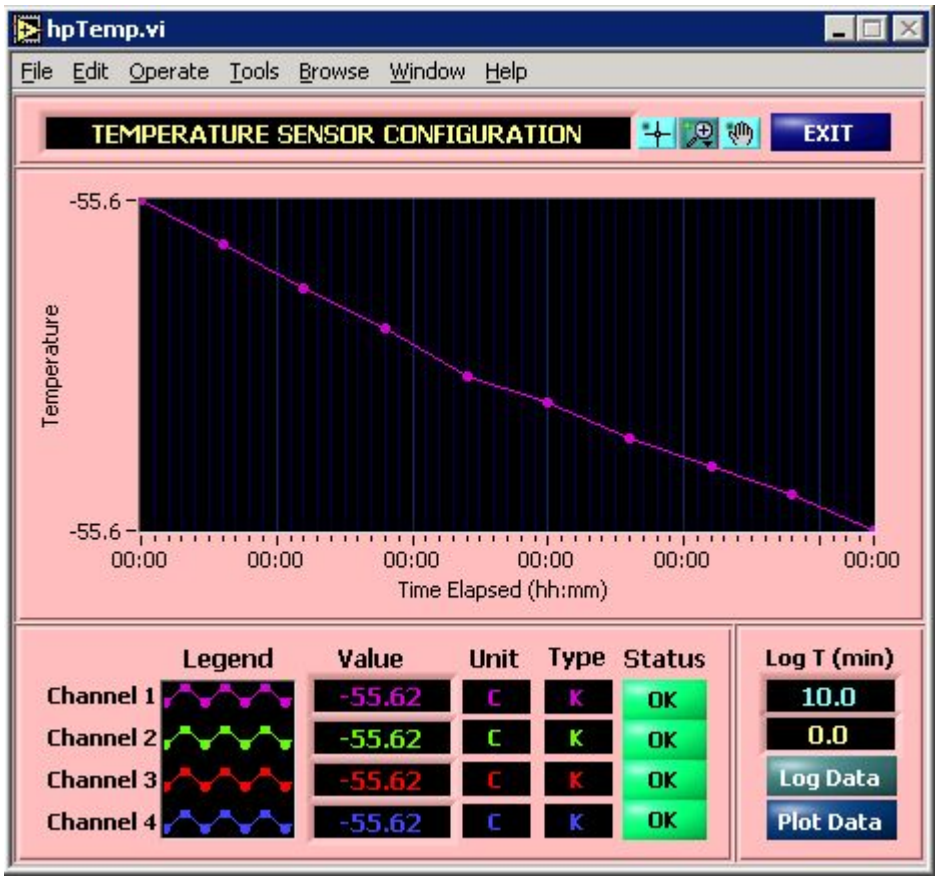
10.3.3 ACCELERATION

- **W CUR A (deg/s2)** field displays the current rotation acceleration for both rotary stages in degrees per second square.
- **W SET A (deg/s2)** let one enter the current rotation acceleration to be set.
- **X CUR A (mm/s2)** field displays the current motion acceleration for both X linear stages in millimeters per second square.
- **X SET A (mm/s2)** let one enter the current X linear motion acceleration to be set.
- **Y CUR A (mm/s2)** field displays the current motion acceleration for both Y linear stages in millimeters per second square.
- **Y SET A (mm/s2)** let one enter the current X linear motion acceleration to be set.
- **Z CUR A (mm/s2)** field displays the current motion acceleration for both Z linear stages in millimeters per second square.
- **Z SET A (mm/s2)** let one enter the current Z linear motion acceleration to be set.

- **VLCT DEFAULT** button sets the current acceleration values to the system default values as shown in the diagram.
- **VLCT SET ALL** button sets all the system acceleration to the values in the **SET A** fields entered by the user.
- **VLCT RESET** button resets all the **SET A** fields to the **CUR A** field values.

10.4 Temperature Monitoring

Temperature Sensing monitors the temperatures of the environment with up to four channels. By clicking the **Temp Sen** button in the main interface windows above, the system launches the Temperature Monitoring Control Interface Window as shown bellow.



10.4.1 GENERAL

- **SYSTEM STATUS** field at the up left side of the window displays the system current status.
- **Exit** button, closes the window.

10.4.2 DISPLAY

- **Y-axis** of the display diagram shows the temperature.
- **X-axis** of the display diagram shows the time stamp.
- **Graph Palette** in between the status window and the exit button provides zone and pan functionalities.
- **Color** of the channels are specified in the Legend window bellow

10.4.3 UNIT, TYPE, AND STATUS

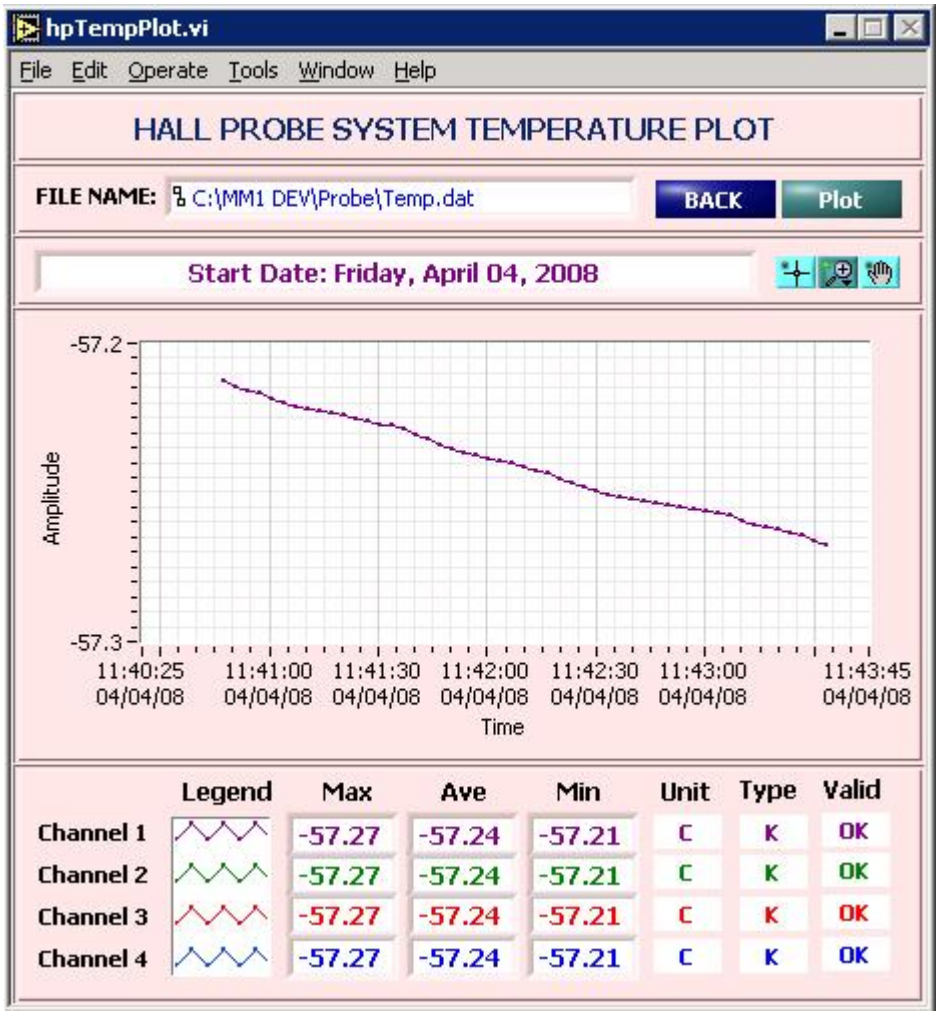
- **Legend** field shows the color of the channel displayed in the plot diagram above.
- **Value** field shows the current values of the measurements for each channel.
- **Unit** field sets the unit of the measurement. One can click on the field to select the desired measurement unit (C, F, K, or R).
- **Type** field sets the type of the thermocouple. One can click on the field to select the correct type of the thermocouple that matches the thermocouple in use (B, E, J, K, R, S, T, or N).
- **Status** indicator shows the status of the channel.

10.4.4 DATA LOGGING

- **Log T (min)** has two fields. The upper one shows the desired data logging time in minutes. The lower one shows the logging time left.
- **Log Data** button starts to log the data into a file. Click the button will launch a window allow one to enter the file name to log.
- **Plot Data** button plots the logged data file.

10.5 TEMPERATURE LOGGING DATA PLOT

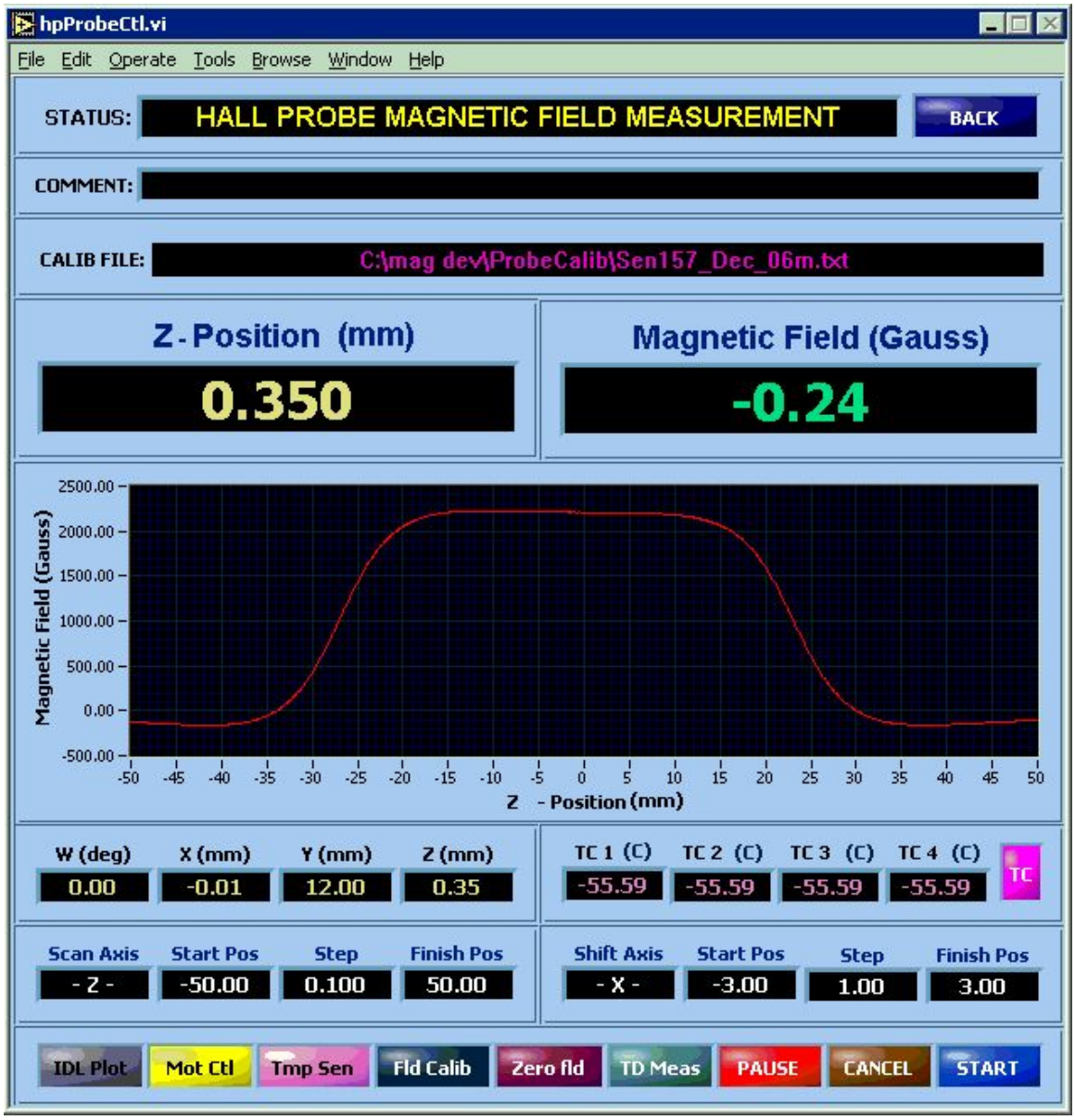
Click the **Plot Data** control button in the temperature monitoring Control Interface Window, a PLOT Sub-Control Panel will display as shown below.



- **FILE NAME:** shows the path and the file name of the temperature data file.
- **BACK** close the window and go back to the temperature monitoring window.
- **Plot** button plots the logged data file.
- **Start Date** shows the date the data file logging started.
- **Diagram** shows the temperature plot out as a function of time and date.
- **Legend** shows the color of the temperature channels as well as the units.

10.6 Hall Probe Measurement

Hall Probe measurement measures the magnetic field over the X, Y, Z, and W axis with a Hall probe. By clicking the **Hall Probe** button in the main interface windows above, the system launches the Hall Probe Magnetic Field Measurement Control Interface Window as shown bellow.



The Hall Probe Magnetic Field Measurement Control Interface Window has over a dozen display and control fields and a data plot field. The detailed description of each field is listed in the following paragraphs.

10.6.1 GENERAL

- **STATUS** field at the up left side of the window displays the system current status.
- **BACK** button, closes the window.

10.6.2 COMMENT AND CALIB FILE

- **COMMENT** field allow one to enter comments as part of the file header in the data scanning file to be saved for each scan.
- **CALIB FILE** field displays the path and the file name of the Hall probe calibration file.

10.6.3 POSITION AND FIELD

- **Position** field shows the current position of the scanning axis.
- **Magnetic Field** field shows the current magnetic field measurement in Gauss, that is converted from the Hall probe voltage with the associated Hall probe calibration data file.

10.6.4 MAGNETIC FIELD PLOT

The magnetic field plot shows real-time plot of the magnetic field measurement plot vs. the scanning axis position.

10.7 CURRENT POSITION INDICATOR

Current position indicators display the current position of the Hall probe.

10.8 CURRENT TEMPERATURE INDICATOR

Current temperature indicators display the temperatures of the thermocouples. By clicking the “TC” button, the field display updates to the current temperature readings.

10.9 SCANNING AXIS PARAMETERS

The system can measure the magnetic field along any of the 4 axis, X, Y, Z, or W.

- **Scan Axis** field sets the desired scanning axis. By clicking the field that activates a pull down manual where you can select the desired axis to scanning. The main position field switches to the display of the current position of the chosen axis.
- **Start Pos** field sets start position for the scan.
- **Step** field sets step size for the scan.
- **Finish Pos** field sets finish position for the scan.

10.10 SHIFT AXIS PARAMETERS

The system is capable of doing two dimensional meshed scans if the shift axis filed is set different to the scan axis.

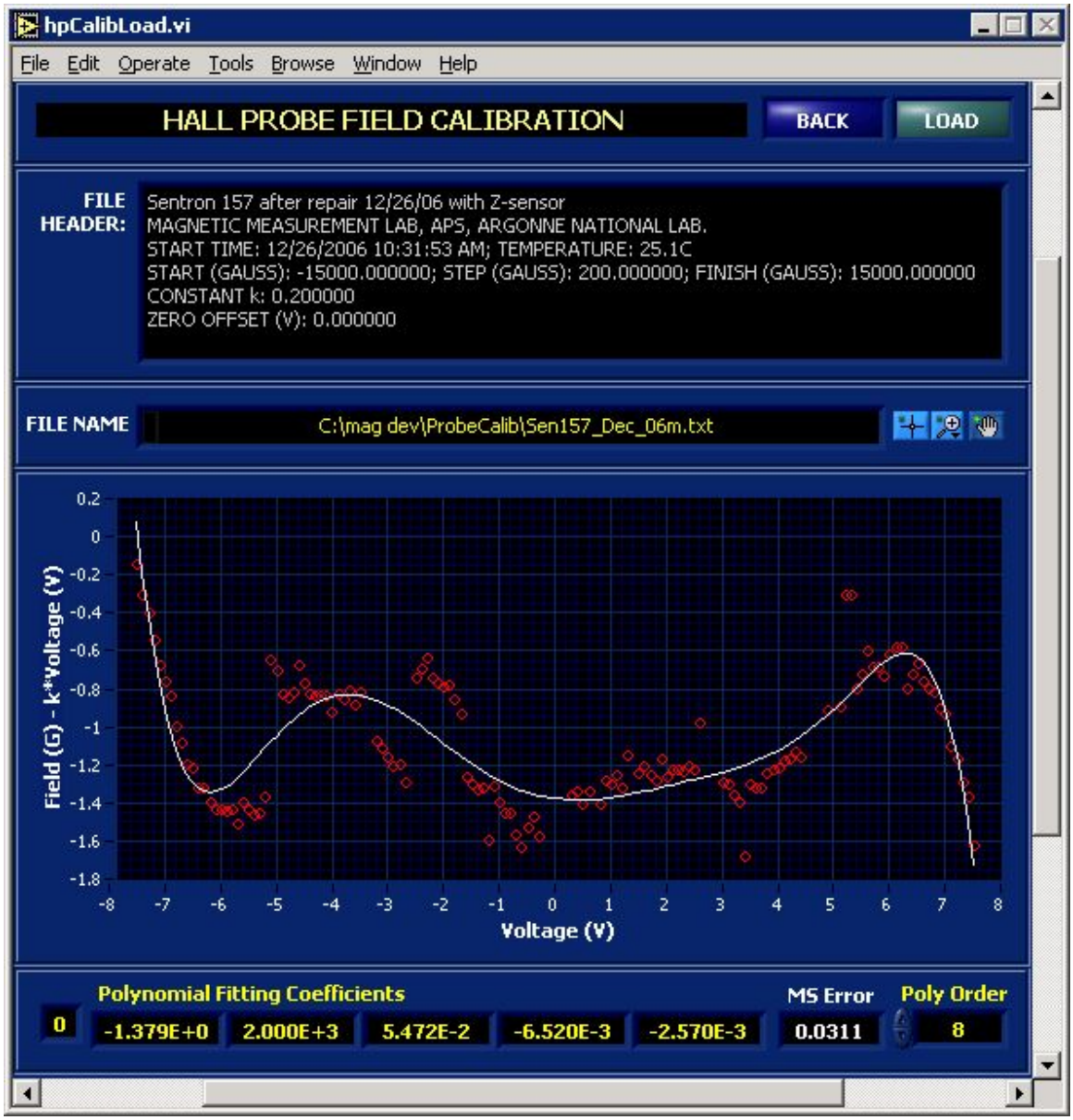
- **Shift Axis** field sets the desired second axis for multiple scans. By clicking the field that activates a pull down manual where you can select the desired second axis for multiple scans.
- **Start Pos** field sets start position for the shift.
- **Step** field sets step size for the shift.
- **Finish Pos** field sets finish position for the shift.

10.11 CONTROL AND PLOT BUTTONS

- **IDL Plot** button launches the IDL plot magnetic analysis windows described in the **IDL Plot Magnetic Analysis Control** section bellow.
- **Mot Ctl** button launches motion control windows described in the **Advanced Motion Control** section above.
- **Tmp Sen** button launches the temperature monitoring windows described in the **Temperature Sensing Control** section above.
- **Fld Calib** button launches the field calibration file loading windows described in the **Magnetic Field Calibration File Loading Control** section bellow.
- **Zero Fld** button launches zero field measurement control windows described in the **Zero Field Measurement Control** section bellow.
- **TD Meas** button launches the time-dependant magnetic field measurement control windows described in the **Time-dependant Magnetic Field Measurement Control** section bellow.
- **PAUSE** button pauses a measurement during a scanning. One may click the button to resume the measurement.
- **CANCEL** button cancels a measurement during a scanning. The system will abort the current scan but save the previous scans and measurement into a file.
- **START** button starts the measurement. It will prompt you to enter the path and the name of the measurement file to be saved.

10.12 Magnetic Field Calibration File Loading

Each time, when a new Hall probe has been installed onto the system, the associated Hall probe calibration file has to be loaded into the control system. By clicking the **Fld Calib** button in the Hall probe measurement interface windows above, the system launches the magnetic field calibration file loading control Interface Window as shown bellow.



- **Status** field shows the status of the system.
- **BACK** close the window and go back to the temperature monitoring window.
- **LOAD** button reads and plots the calibration data file.
- **FILE HEADER** shows the file header information.

- **FILE NAME:** shows the path and the file name of the calibration data file.
- **Diagram** shows the magnetic deviation (Field – k*Voltage) plot out of the calibration data along with the polynomial fitting as a function of voltage. The system uses the polynomial fitting data.
- **Polynomial Fitting Coefficients** fields show the fitting coefficients.
- **MS Error** field shows the fitting MS error.
- **Poly Order** sets the order of the polynomial fitting.

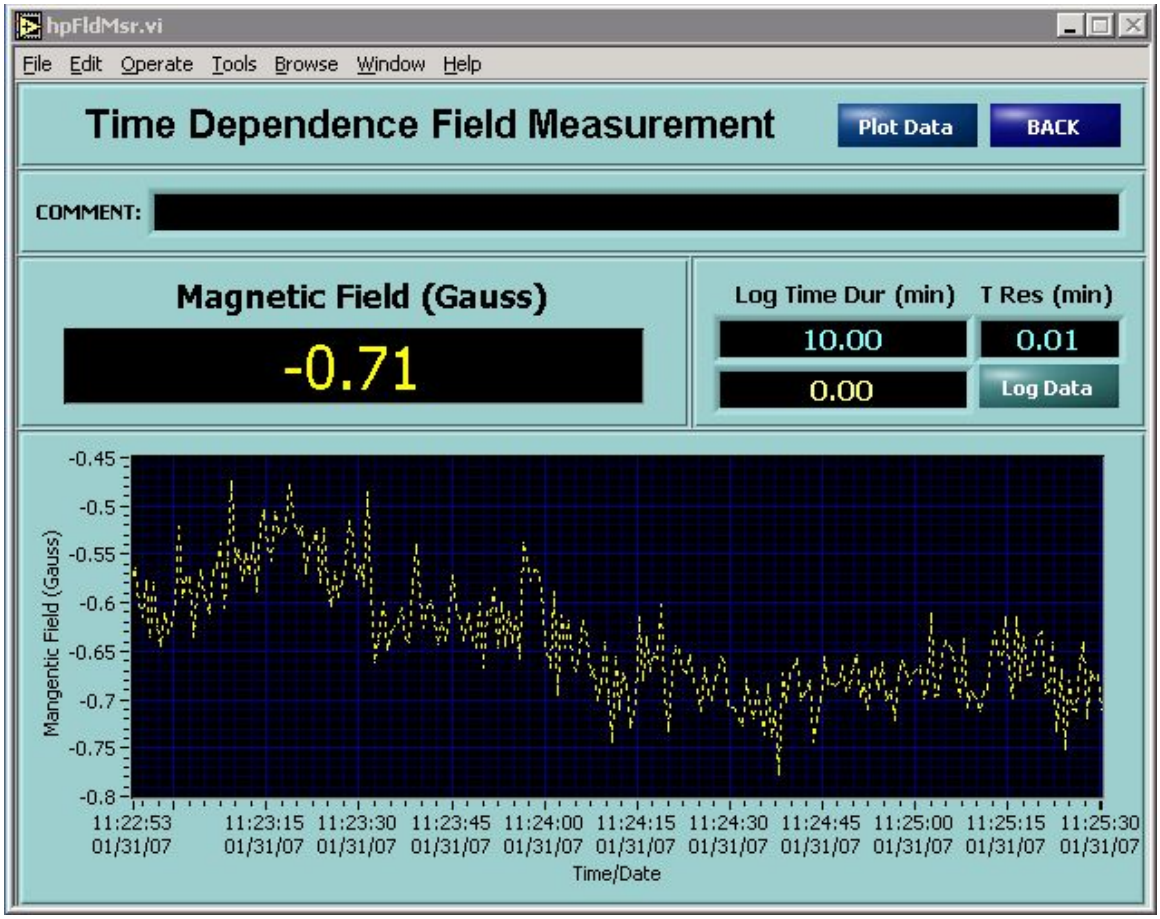
10.13 Zero Field Measurement

Each time, when a new Hall probe calibration file has been loaded into the control system, the system will have to calibrate the zero fields. By clicking the **Zero fld** button in the Hall probe measurement interface windows above, the system launches the zero field calibration file loading control Interface Window as shown bellow.

- **ZERO FIELD DAQ** button starts a zero field measurement. Make sure to put a mu-metal enclosure onto the Hall probe and click the **ZERO FIELD DAQ** button to start zero field measurement.
- **ZERO FIELD (G)** field shows the measurement result and the
- **Zero Field STD (G)** field shows Standard Deviation of the measurement.
- **START FIELD DAQ** button starts a field measurement at the start position on Z-axis. Make sure to move the Hall probe to the start position out of the ID and click the **START FIELD DAQ** button to start the measurement.
- **START FIELD (G)** field shows the measurement result. The field can be manually set as well instead of measurement.
- **Start Field STD (G)** field shows Standard Deviation of the measurement.
- **END FIELD DAQ** button starts a field measurement at the end position on Z-axis. Make sure to move the Hall probe to the end position out of the ID and click the **END FIELD DAQ** button to start the measurement.
- **END FIELD (G)** field shows the measurement result. The field can be manually set as well instead of measurement.
- **End Field STD (G)** field shows Standard Deviation of the measurement.
- **MAGNETIC FIELD (G)** field shows the current real-time magnetic field.
- **Z CUR POS (mm)** field shows the current position on Z-axis.
- **Z SET POS (mm)** field sets the desired position on Z-axis.
- **W POS (deg)** field shows the current position on W-axis.
- **X POS (mm)** field shows the current position on X-axis.
- **Y POS (mm)** field shows the current position on Y-axis.
- **Z POS (mm)** field shows the current position on Z-axis.
- **STEP SIZE** allows entering the motion step size. Click the “>” button sets the stage move positive at the step set in the step field in Z-direction. “<” button sets the stage move negative at the step set in the step field in Z-direction.
- **RESET** button resets the desired position to the current position.
- **SYNC** button synchronizes the motor current position to the encoder position.
- **CRT OFF** button turns off all the servo motor current.
- **STOP** stops all motors during a motion.
- **MOVE** button moves the probe to the desired position set in the **Z SET POS** field.
- **BACK** close the window and go back to the Hall probe magnetic field measurement window.

10.14 Time Dependence Field Measurement

Time Dependence Field Measurement measures the field vs. time and los the measurement result into a file. By clicking the **TD Meas** button in the Hall probe measurement interface windows above, the system launches the time dependence field measurement control Interface Window as shown bellow.

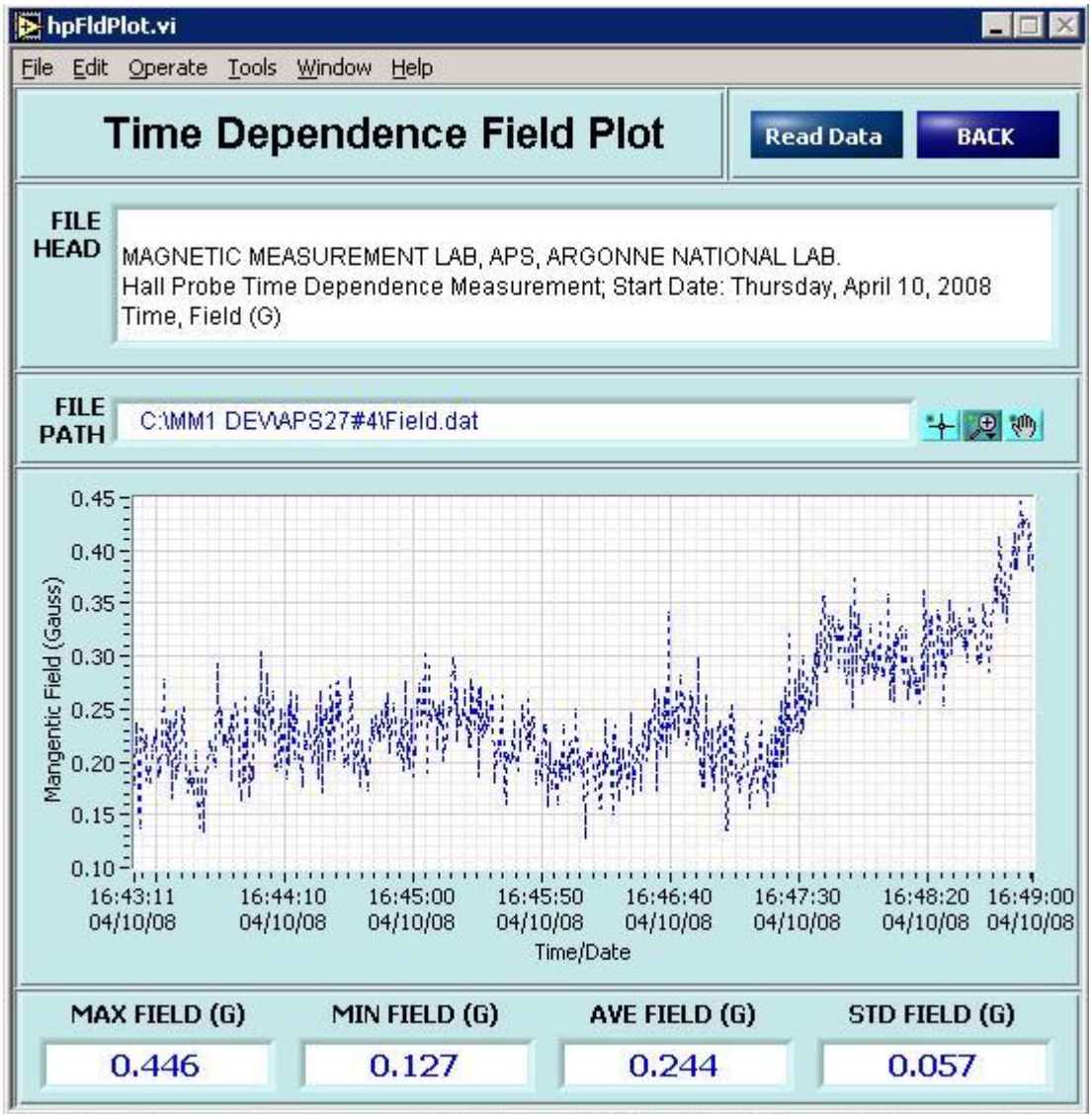


- **Plot Data** control button lunches the time dependence field measurement file plot window.
- **BACK** close the window and go back to the Hall probe magnetic field measurement window.
- **COMMENT** field allows entering comments onto the logging file.
- **Magnetic Field (Gauss)** field shows the current magnetic field measurement.
- **Lon Time Dur (min)** upper field allows to enter the desired logging duration and lower field shows the time left.
- **T Res (min)** sets the desired time resolution or the daq time step size.

- **Diagram** shows the real-time field measurement vs. the time.

10.15 TIME DEPENDENCE FIELD MEASUREMENT DATA PLOT

Click the **Plot Data** control button in the time dependence field measurement control interface window, a PLOT Sub-Control Panel will display as shown below.

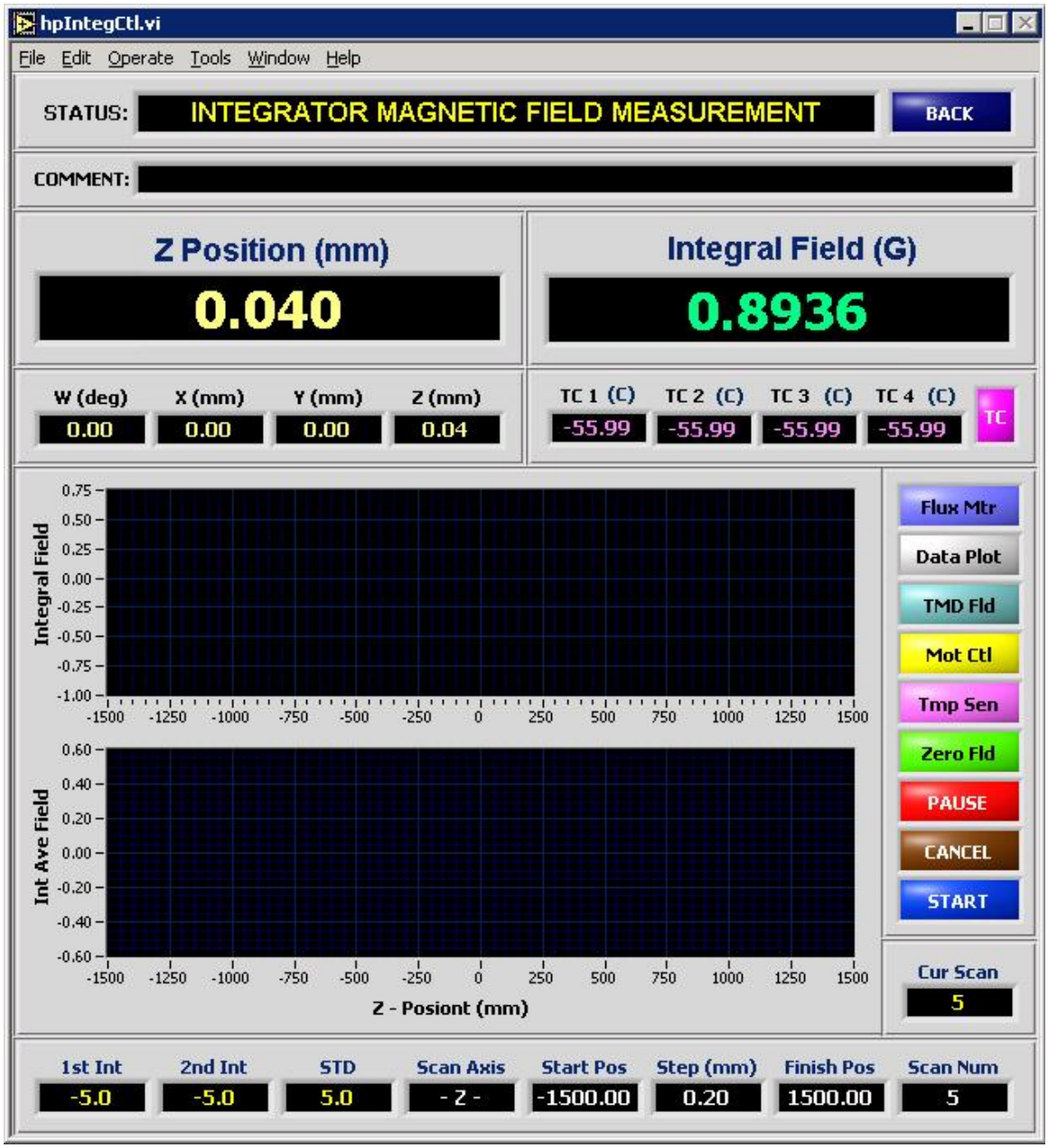


- **Read Data** button launches a window for you to select the file to be plotted.
- **BACK** close the window and go back to the time dependence magnetic field measurement window.
- **FILE HEAD** shows the file header information.
- **FILE PATH** shows the file name and path.

- **Diagram** shows the measurement plot.
- **MAX FIELD (G)** field shows the maximum value of the measurement.
- **MIN FIELD (G)** field shows the minimum value of the measurement.
- **AVE FIELD (G)** field shows the measurement average value.
- **STD FIELD (G)** field shows the standard deviation for the field measurement.

10.16 INTEGRATOR MAGNETIC FIELD MEASUREMENT

Integrator magnetic field measurement measures the magnetic field integrates via a digital integrator over the X, Y, Z, and W axis with a moving coil. By clicking the **Integrator** button in the main interface windows above, the system launches the Integrator Magnetic Field Measurement Control Interface Window as shown bellow.



The Integrator Magnetic Field Measurement Control Interface Window has over a dozen display and control fields and a data plot field. The detailed description of each field is listed in the following paragraphs.

10.16.1 GENERAL

- **STATUS** field at the up left side of the window displays the system current status.
- **BACK** button, closes the window.

10.16.2 COMMENT

- **COMMENT** field allow one to enter comments as part of the file header in the data scanning file to be saved for each scan.

10.16.3 POSITION AND INTEGRAL FIELD

- **Position** field shows the current position of the scanning axis.
- **Integral Field** field shows the current magnetic field measurement in Gauss, that is converted from the Hall probe voltage with the associated Hall probe calibration data file.

10.17 CURRENT POSITION INDICATOR

Current position indicators display the current position of the Hall probe.

10.18 CURRENT TEMPERATURE INDICATOR

Current temperature indicators display the temperatures of the thermocouples. By clicking the “TC” button, the field display updates to the current temperature readings.

10.18.1 INTEGRAL FIELD PLOTS

The **Integral Field (G)** plot shows real-time plot of the integral field measurement plot vs. the scanning axis position.

The **Int Ave Field (G)** plot shows real-time plot of the integral field measurement average plot vs. the scanning axis position

10.19 SCANNING AXIS PARAMETERS AND INTEGRALS

The system can measure the magnetic field along any of the 4 axis, X, Y, Z, or W.

- **Scan Axis** field sets the desired scanning axis. By clicking the field that activates a pull down manual where you can select the desired axis to scanning. The main position field switches to the display of the current position of the chosen axis.
- **Start Pos** field sets start position for the scan.
- **Step** field sets step size for the scan.

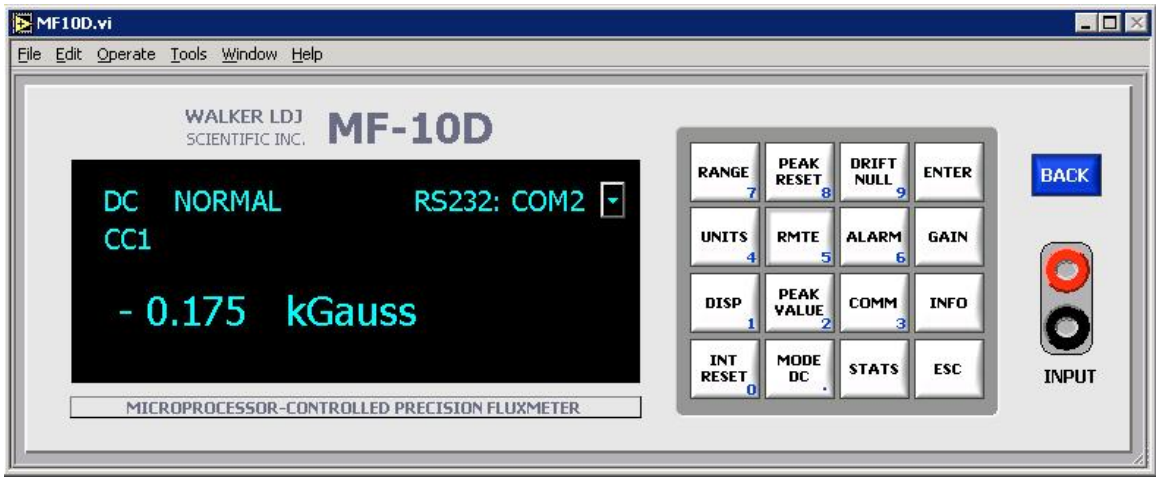
- **Finish Pos** field sets finish position for the scan.
- **Scan Num** sets the number of scans to be carried out.
- **1st Int** shows the first order integral of the measurement.
- **2nd Int** shows the second integral of the measurement.
- **STD** displays the standard deviation of the measurements.

10.20 CONTROL AND PLOT BUTTONS

- **Flux Mtr** button launches the Fluxmeter control window described in the **MF-10D Precision Fluxmeter** section bellow.
- **Data Plot** button launches integrator magnetic field measurement data plot windows described in the **Integrator Magnetic Field Measurement Data Plot** section bellow.
- **TMD Meas** button launches the time-dependant integrator magnetic field measurement control windows described in the **Time-dependant Magnetic Field Measurement Control** section above.
- **Mot Ctl** button launches motion control windows described in the **Advanced Motion Control** section above.
- **Tmp Sen** button launches the temperature monitoring windows described in the **Temperature Sensing Control** section above.
- **Zero Fld** button launches zero field measurement control windows described in the **Zero Integrator Field Measurement Control** section bellow.
- **PAUSE** button pauses a measurement during a scanning. One may click the button to resume the measurement.
- **CANCEL** button cancels a measurement during a scanning. The system will abort the current scan but save the previous scans and measurement into a file.
- **START** button starts the measurement. It will prompt you to enter the path and the name of the measurement file to be saved.
- **Cur Scan** displays the current scan number.

10.21 PRECISION FLUXMETER

Click the **Flux Mtr** control button in the Integrator Magnetic Field Measurement Control Interface Window, the Precision Fluxmeter Control Panel will display as shown below.



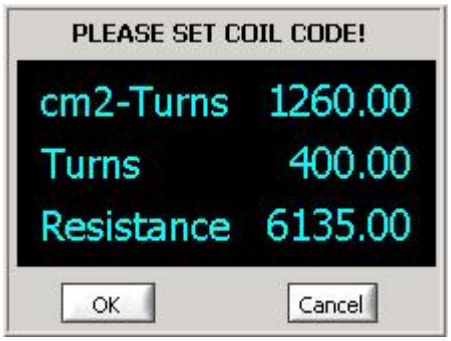
The Precision Fluxmeter Control Panel has over a dozen display and control fields. The detailed description of each control fields is listed in the following paragraphs.

10.21.1.1 FLUXMETER DISPLAY

- **AC/DC** field shows the mode of the operation. The mode can be configured through the **MODE** control button described bellow.
- **NORMAL/PEAK/RMS** field shows the display of the operation. The display can be configured through the **DISP** control button described bellow.
- **RS232** COM port setting sets the COM port for the device to communicate with the control. You may click on the field and select the correct COM port that reflects the right port the fluxmeter is connected to.
- **CC1** field displays the coil code set.
- **Field Integral Measurement Value** displays the real-time field integral measurement value.
- **kGauss/Tesla/kMaxwell/uWebers/kMaxwell Turns/mWeber Truns** field displays the unit of measurement. The display can be configured through the **UNITS** control button described bellow.

10.21.1.2 FLUXMETER CONTROL

- **RANGE (7)** control button sets the coil code. By clicking the control button, the display field underneath the measurement value shows a message asking you to “Press Enter to Set Coil Code”. Click the **ENTER** button, following window shows on the screen:



with a blinking message on the top shows “PLEASE SET COIL CODE!”. Enter the new values in the value fields and click OK sets the system to the new configuration.

- **PEAK RESET (8)** resets the peak value.
- **DRIFT NULL (9)** nulls the drift of the system in DC mode. It takes about 1-2 minutes to complete a null process.
- **ENTER** to confirm the command control action.
- **UNITS (4)** sets the unit of the display. By clicking the control button, and confirmed with the **ENTER** button, following window shows on the screen:

with a blinking message on the top shows “PLEASE SET UNIT!”. Clicking on the display field and select the correct unit in the pull down menu and click OK sets the system to the new unit display unit.

- **RMTE/LOCAL (5)** toggles the system between remote and local control. While the system is in remote control, all control buttons on the local meter are disabled.
- **ALARM (6)** sets the alarm parameters. By clicking the control button, and confirmed with the **ENTER** button, following window shows on the screen:

Enter the new values in the value fields and click OK sets the system to the new configuration.

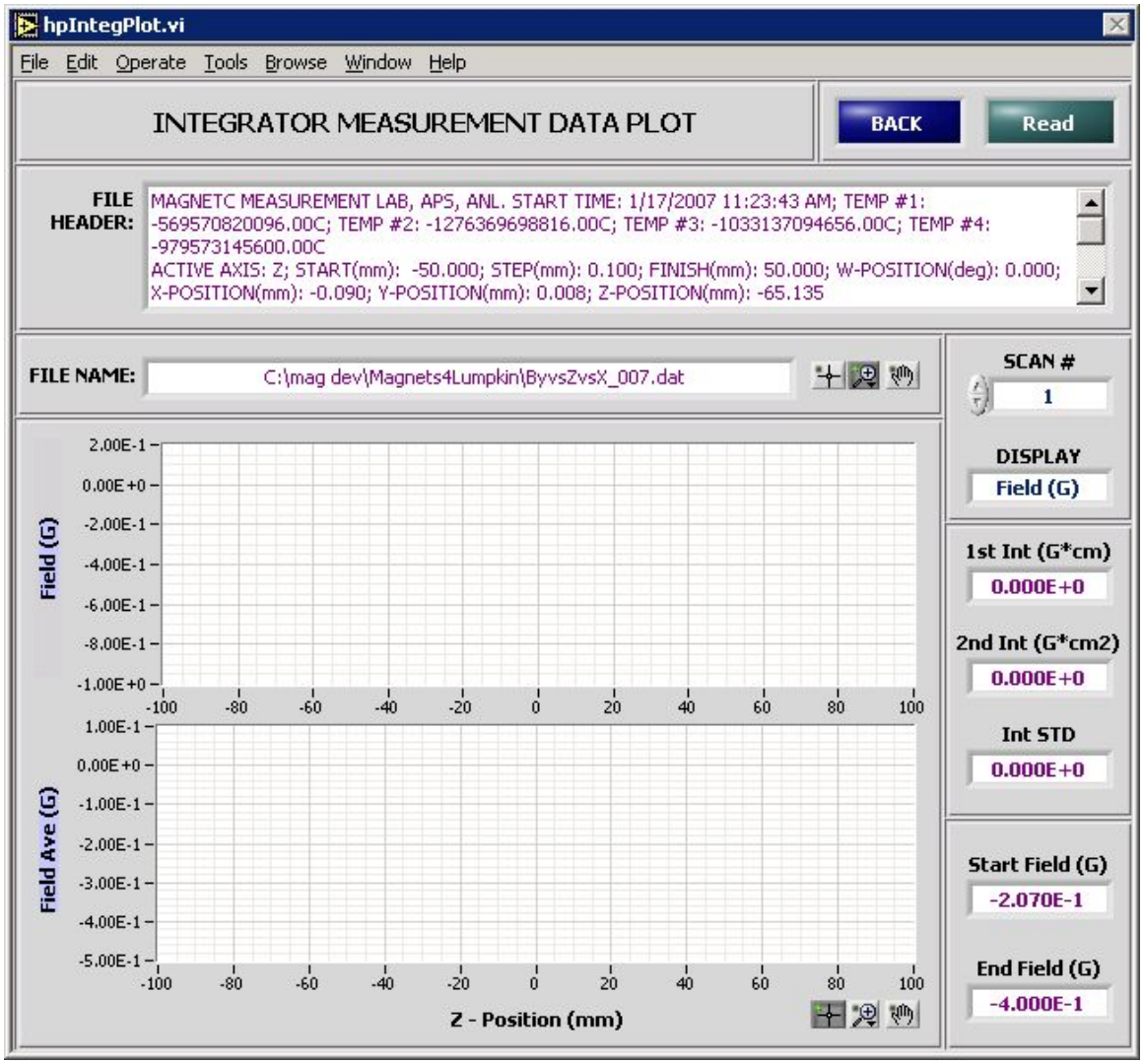
- **GAIN** sets the system gain. By clicking the control button, and confirmed with the **ENTER** button, following window shows on the screen:

Enter the new values in the value fields and click OK sets the system to the new configuration.

- **DISP (1)** sets the display of the system to NORMAL, PEAK, OR PEAK. By clicking the control button, and confirmed with the **ENTER** button, a display setting window shows up. Click on the display field and select the desired and click OK sets the system to the new configuration.
- **PEAK VALUE (2)** sets the display to show the Peak value. Click the **ENTER** button sets the display back to the previous display.
- **COMM (3)** sets the communication Baud Rate parameter.
- **INFO** sets the display to show the firmware release of the meter. . Click the **ENTER** button sets the display back to the previous display.
- **INT RESET (0)** resets the integrator.
- **MODE DC/AC (.)** toggles the system between DC and AC operation modes.
- **STATS** sets the display to show the system status.
- **ESC** is a reserved control button and currently is not in use.
- **BACK** control button quits the window and goes back to the Integrator Magnetic Field Measurement.

10.22 INTEGRATOR MAGNETIC FIELD MEASUREMENT DATA PLOT

Click the **Data Plot** control button in the Integrator Magnetic Field Measurement Control Interface Window, a PLOT Sub-Control Panel will display as shown below.



- **FILE HEADER**: shows the file header information.
- **FILE NAME:** shows the path and the file name of the temperature data file.
- **BACK** close the window and go back to the temperature monitoring window.
- **Read** button reads and plots the data file.
- **FILE NAME:** shows the data file name and path.
- **Field (G)/Field Integral (G*cm)/ Field Integral (G*cm2)** diagram shows the field measurement plot out as a function of distance.

- **Field Ave (G)/Field Int Ave (G*cm)/ Field Int Ave (G*cm2) diagram** shows the field measurement average plot out as a function of distance.
- **SCAN #** sets the number of the current scan to be plotted and the averaged over.
- **DISPLAY** sets the display to field, 1st integral, or 2nd integral. Click on the filed and select the type of desired display in the Field/1st Int./ 2nd Int. pull down menu.
- **1st Int (G*cm)** shows the 1st integral of the measurement.
- **2nd Int (G*cm2)** shows the 2nd integral of the measurement.
- **Int STD** shows the standard deviation of the integrals.
- **Start Field (G)** displays the field at the start position.
- **End Field (G)** displays the field at the end position.

10.23 ZERO FIELD INTEGRATOR MEASUREMENT

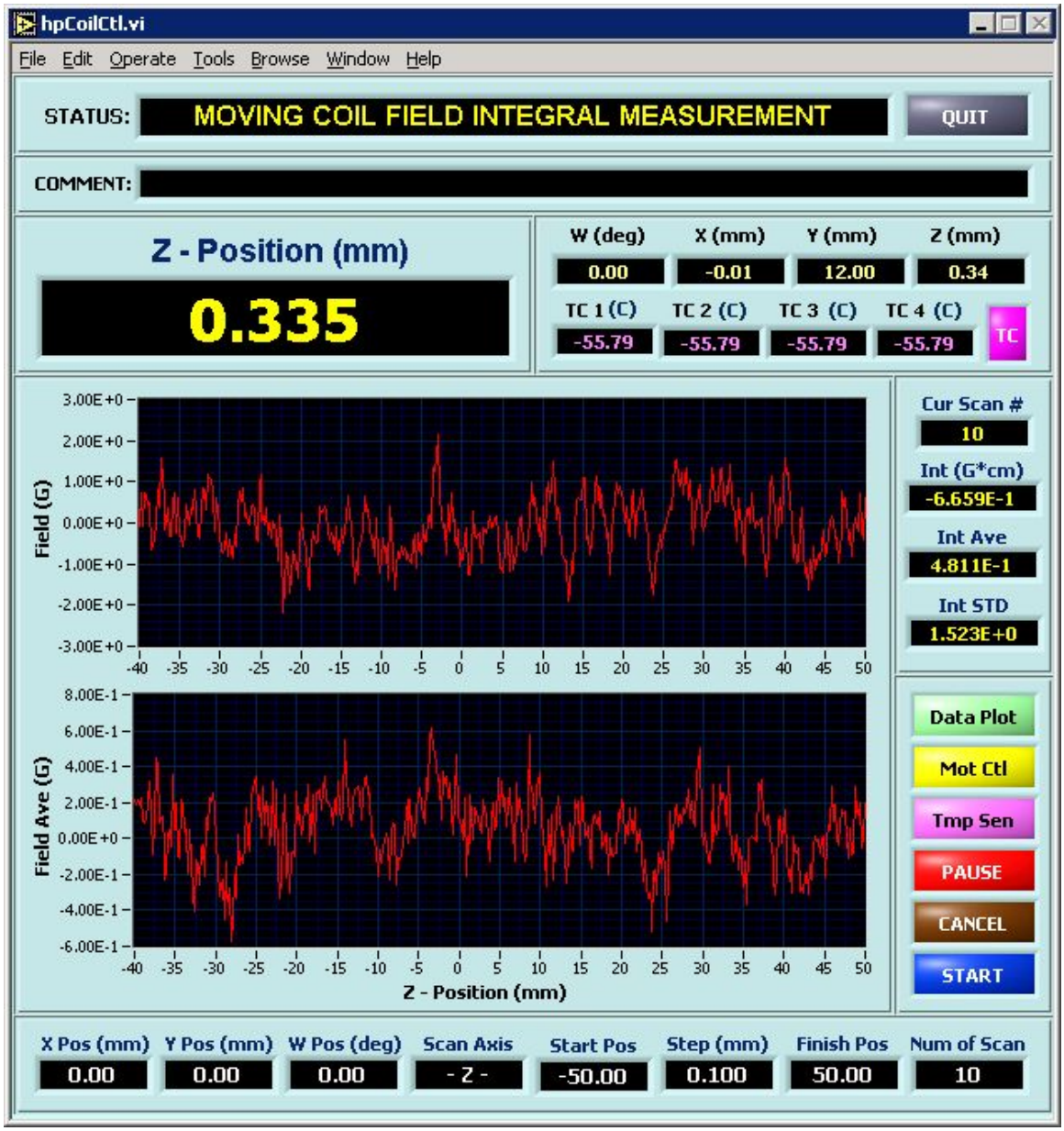
Click the **Zero Fld** control button in the Integrator Magnetic Field Measurement Control Interface Window, a zero field integrator measurement Sub-Control Panel will display as shown below.

- **START FIELD DAQ** button starts a field measurement at the start position on Z-axis. Make sure to move the coil to the start position out of the ID and click the **START FIELD DAQ** button to start the measurement.

- **START FIELD (G)** field shows the measurement result. The field can be manually set as well instead of measurement.
- **Start Field STD (G)** field shows Standard Deviation of the measurement.
- **END FIELD DAQ** button starts a field measurement at the end position on Z-axis. Make sure to move the coil to the end position out of the ID and click the **END FIELD DAQ** button to start the measurement.
- **END FIELD (G)** field shows the measurement result. The field can be manually set as well instead of measurement.
- **End Field STD (G)** field shows Standard Deviation of the measurement.
- **MAGNETIC FIELD (G)** field shows the current real-time magnetic field.
- **Z CUR POS (mm)** field shows the current position on Z-axis.
- **Z SET POS (mm)** field sets the desired position on Z-axis.
- **W POS (deg)** field shows the current position on W-axis.
- **X POS (mm)** field shows the current position on X-axis.
- **Y POS (mm)** field shows the current position on Y-axis.
- **Z POS (mm)** field shows the current position on Z-axis.
- **STEP SIZE** allows entering the motion step size. Click the “>” button sets the stage move positive at the step set in the step field in Z-direction. “<” button sets the stage move negative at the step set in the step field in Z-direction.
- **RESET** button resets the desired position to the current position.
- **SYNC** button synchronizes the motor current position to the encoder position.
- **CRT OFF** button turns off all the servo motor current.
- **STOP** stops all motors during a motion.
- **MOVE** button moves the probe to the desired position set in the **Z SET POS** field.
- **BACK** close the window and go back to the integrator magnetic field measurement window.

10.24 MOVING COIL MAGNETIC FIELD MEASUREMENT

Moving coil magnetic field measurement measures the magnetic field integrates via a moving coil over the X, Y, Z, and W axis. By clicking the **Moving Coil** button in the main interface windows above, the system launches the Moving Coil Magnetic Field Measurement Control Interface Window as shown bellow.



The Moving Coil Magnetic Field Measurement Control Interface Window has over a dozen display and control fields and a data plot field. The detailed description of each field is listed in the following paragraphs.

10.24.1 GENERAL

- **STATUS** field at the up left side of the window displays the system current status.
- **BACK** button, closes the window.

10.24.2 COMMENT

- **COMMENT** field allow one to enter comments as part of the file header in the data scanning file to be saved for each scan.

10.25 CURRENT POSITION INDICATOR

Current position fields show the current position of the scanning axis.

10.25.1 CURRENT POSITION AND TEMPERATURE INDICATOR

- Current position indicators display the current positions of the moving coil.
- Current temperature indicators display the temperatures of the thermocouples. By clicking the “TC” button, the field display updates to the current temperature readings.

10.25.2 INTEGRAL FIELD PLOTS

The **Integral Field (G)** plot shows real-time plot of the integral field measurement plot vs. the scanning axis position.

The **Int Ave Field (G)** plot shows real-time plot of the integral field measurement average plot vs. the scanning axis position

10.26 SCANNING AXIS PARAMETERS AND INTEGRALS

The system can measure the magnetic field along any of the 4 axis, X, Y, Z, or W.

- **X/Y/Z/W Pos (mm)** fields set the X/Y/Z/W-position where the scan is going to be carried out.
- **Scan Axis** field sets the desired scanning axis. By clicking the field that activates a pull down manual where you can select the desired axis to scanning. The main position field switches to the display of the current position of the chosen axis. The rest of the axis will be displayed in the **X/Y/Z/W Pos (mm)** fields.
- **Start Pos** field sets start position for the scan.
- **Step** field sets step size for the scan.
- **Finish Pos** field sets finish position for the scan.

- **Scan Num** sets the number of scans to be carried out.

10.27 DISPLAY FIELDS

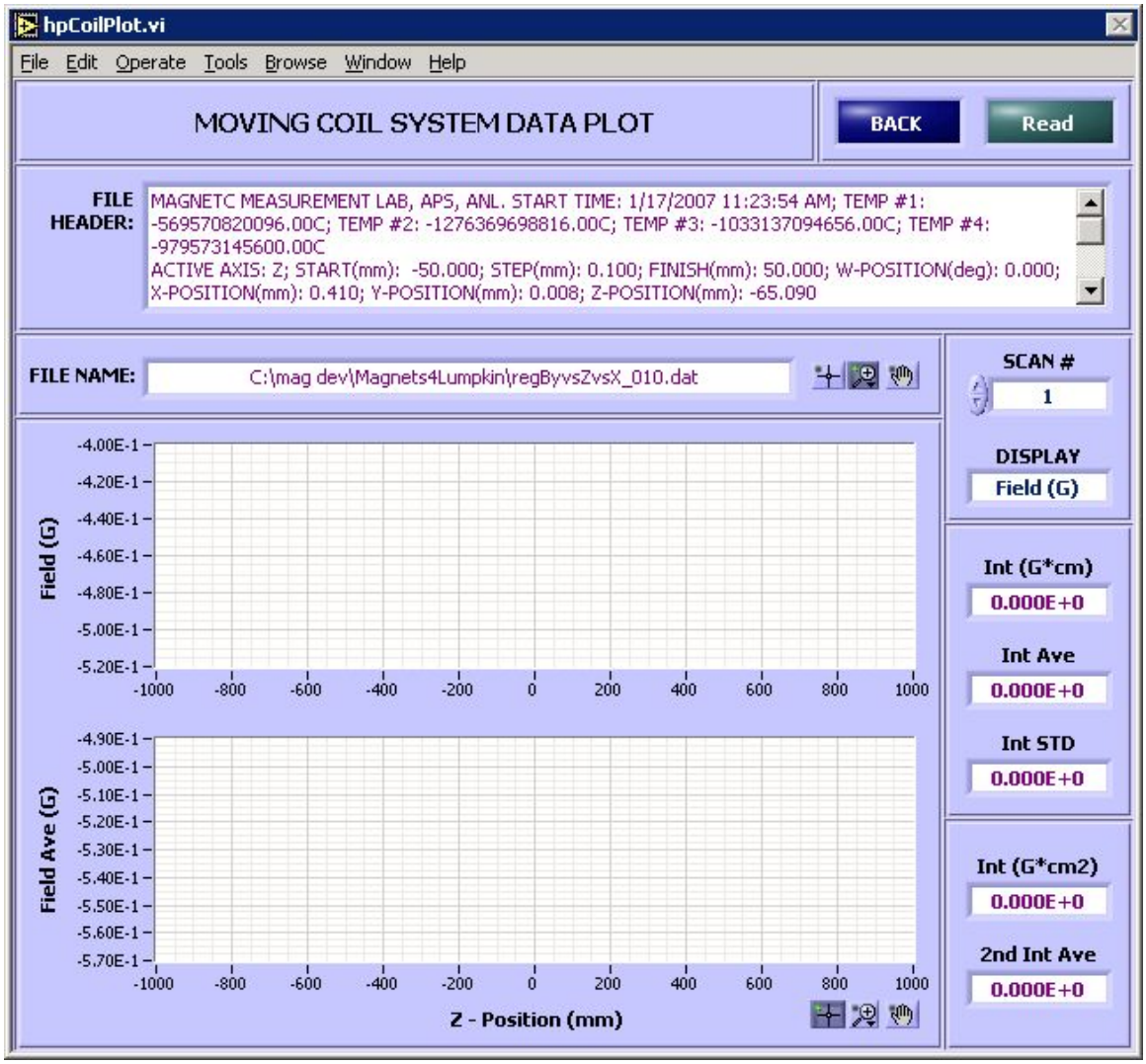
- **Cur Scan #** displays the current scan number.
- **1st Int** shows the first order integral of the measurement.
- **2nd Int** shows the second integral of the measurement.
- **STD** displays the standard deviation of the measurements.

10.28 CONTROL AND PLOT BUTTONS

- **Data Plot** button launches moving coil magnetic field measurement data plot windows described in the **Moving Coil Magnetic Field Measurement Data Plot** section bellow.
- **Mot Ctl** button launches motion control windows described in the **Advanced Motion Control** section above.
- **Tmp Sen** button launches the temperature monitoring windows described in the **Temperature Sensing Control** section above.
- **PAUSE** button pauses a measurement during a scanning. One may click the button to resume the measurement.
- **CANCEL** button cancels a measurement during a scanning. The system will abort the current scan but save the previous scans and measurement into a file.
- **START** button starts the measurement. It will prompt you to enter the path and the name of the measurement file to be saved.

10.29 MOVING COIL MAGNETIC FIELD MEASUREMENT DATA PLOT

Click the **Data Plot** control button in the Moving Coil Magnetic Field Measurement Control Interface Window, a PLOT Sub-Control Panel will display as shown below.

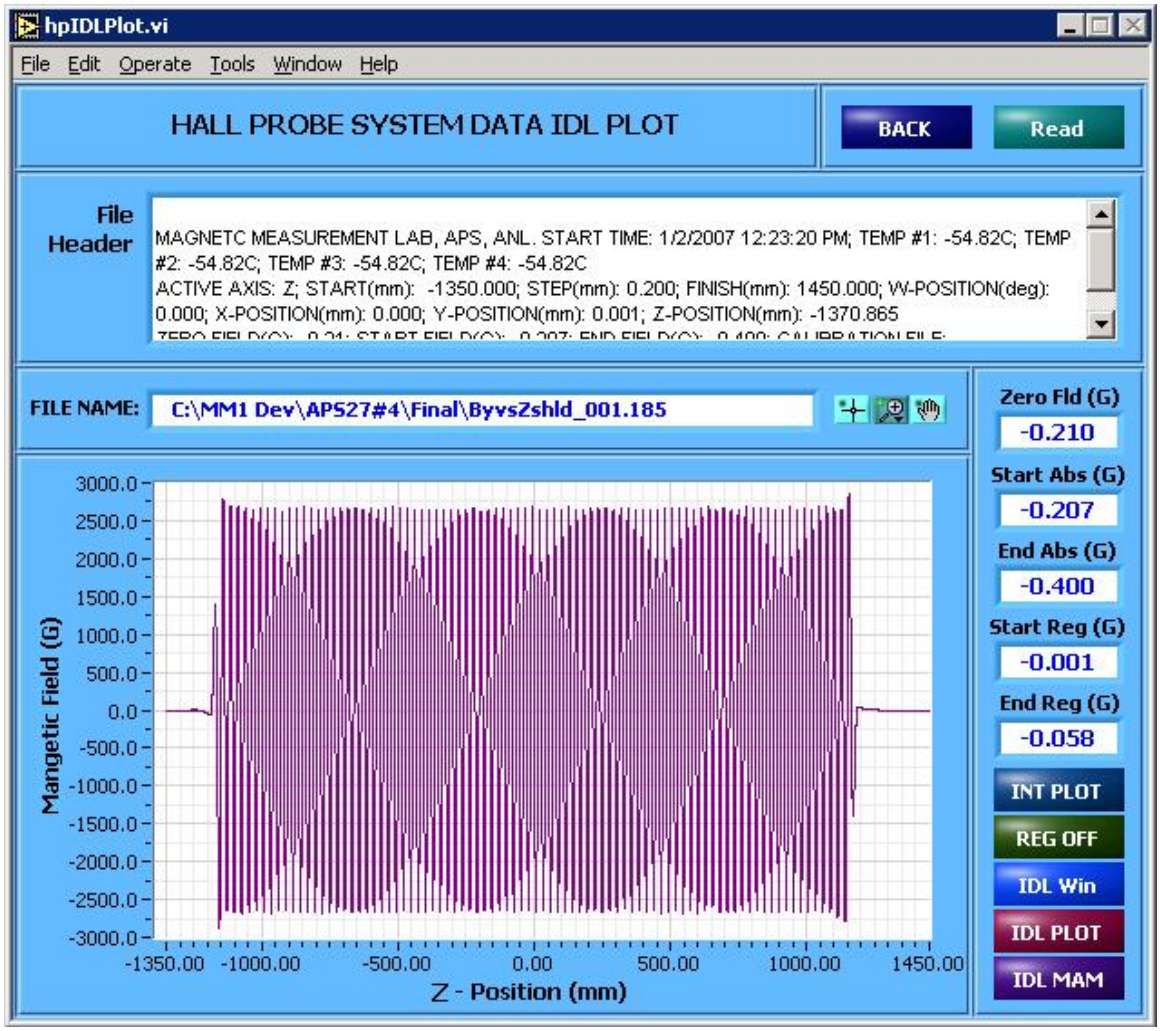


- **FILE HEADER**: shows the file header information.
- **FILE NAME:** shows the path and the file name of the temperature data file.
- **BACK** close the window and go back to the Moving Coil Magnetic Field Measurement Control Interface Window.
- **Read** button reads and plots the data file.
- **Field (G)/Field Integral (G*cm)/ Field Integral (G*cm2)** diagram shows the field measurement plot out as a function of distance.
- **Field Ave (G)/Field Int Ave (G*cm)/ Field Int Ave (G*cm2) diagram** shows the field measurement average plot out as a function of distance.
- **SCAN #** sets the number of the current scan to be plotted and the averaged over.
- **DISPLAY** sets the display to field, 1st integral, or 2nd integral. Click on the filed and select the type of desired display in the Field/1st Int./ 2nd Int. pull down menu.

- **Int (G*cm)** shows the 1st order integral of the measurement.
- **Int Ave** shows the 1st order integral average of the measurements.
- **Int STD** shows the standard deviation of the integrals.
- **2nd Int (G*cm2)** shows the 2nd order integral of the measurement.
- **2nd Int Ave** shows the 2nd order integral average of the measurements.

10.30 IDL MAGNETIC ANALYSIS AND PLOT

IDL Magnetic Analysis and Plot module plots out the Hall probe magnetic field measurement data file. It interfaces with the IDL Magnetic Analysis module that analyses the field and provides the X-ray brilliances simulations. By clicking the **IDL Plot** button in the main interface windows above, the system launches the IDL Magnetic Analysis and Plot Control Interface Window as shown bellow.

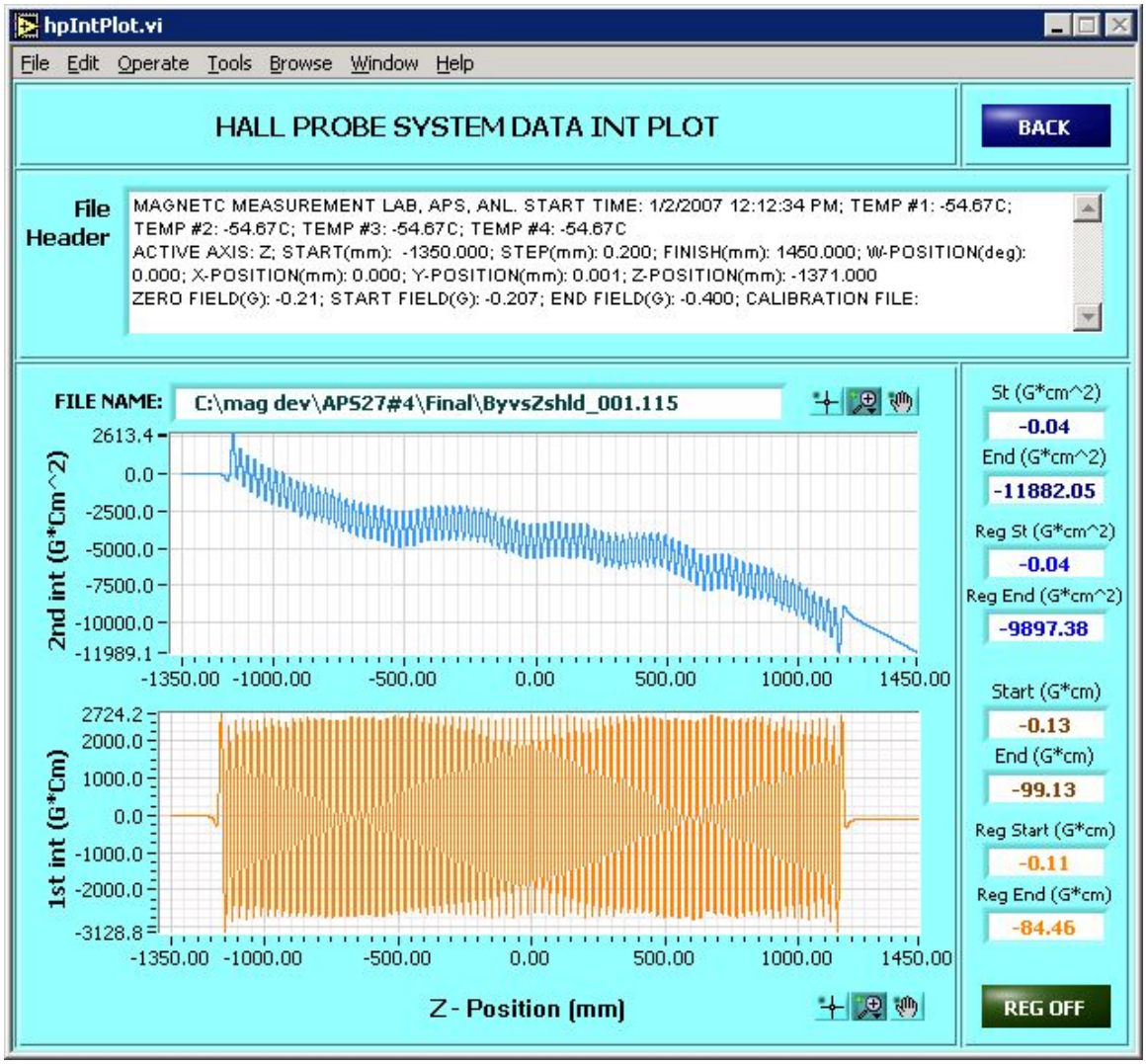


The IDL Magnetic Analysis and Plot Control Interface Window has over a dozen display and control fields and a data plot field. The detailed description of each field is listed in the following paragraphs.

- **READ** button reads the data file. Clicking the button launches a window for entering the file name and path for the data file to be read and analyzed.
- **BACK** button, closes the window.
- **FILE HEADER**: shows the file header information.
- **FILE NAME:** shows the path and the file name of the temperature data file.
- **MAGNETIC FIELD DIAGRAM** plots the distribution of the magnetic field in distance.
- **Zero Fld (G)** shows the strength of the zero field.
- **Start Abs (G)** shows the strength of the field at the start position.
- **End Abs (G)** shows the strength of the field at the end position.
- **Start Reg (G)** shows the strength of the regression field at the start position.
- **End Reg (G)** shows the strength of the regression field at the end position.
- **INT PLOT** button launches the integration plot window described bellow.
- **REG ON/OFF** button turns on/off the regression of the data plot.
- **IDL Win/iTool** button selects the mode of the **IDL PLOT** as described in the IDL Magnetic Analysis section bellow.
- **IDL PLOT** button launches the IDL Magnetic Analysis and associated displays of analysis results as described in the IDL Magnetic Analysis section bellow.
- **IDL MAM** button launches the IDL Multiple Magnetic Analysis and associated consol display of analysis as well as data file results as described in the IDL Multiple Magnetic Analysis section bellow.

10.31 MAGNETIC FIELD INTEGRAL PLOT

Click the **INT PLOT** control button in the Hall Probe System Data IDL Plot Control Interface Window, a Magnetic Filed Integral Plot Sub-Control Panel will display as shown below.



- **BACK** close the window and go back to Hall Probe System Data IDL Plot Control Interface Window.
- **FILE HEADER**: shows the file header information.
- **FILE NAME:** shows the path and the file name of the temperature data file.
- **2nd int (G*cm2)** diagram shows the 2nd order integral of the field measurement plot out as a function of distance.
- **1st int (G*cm)** diagram shows the 1st order integral of the field measurement plot out as a function of distance.
- **St (G*cm^2)** shows the 2nd order field integral value at the start position.
- **End (G*cm^2)** shows the 2nd order field integral value at the end position.
- **Reg St (G*cm^2)** shows the regression value of the 2nd order field integral at the start position.

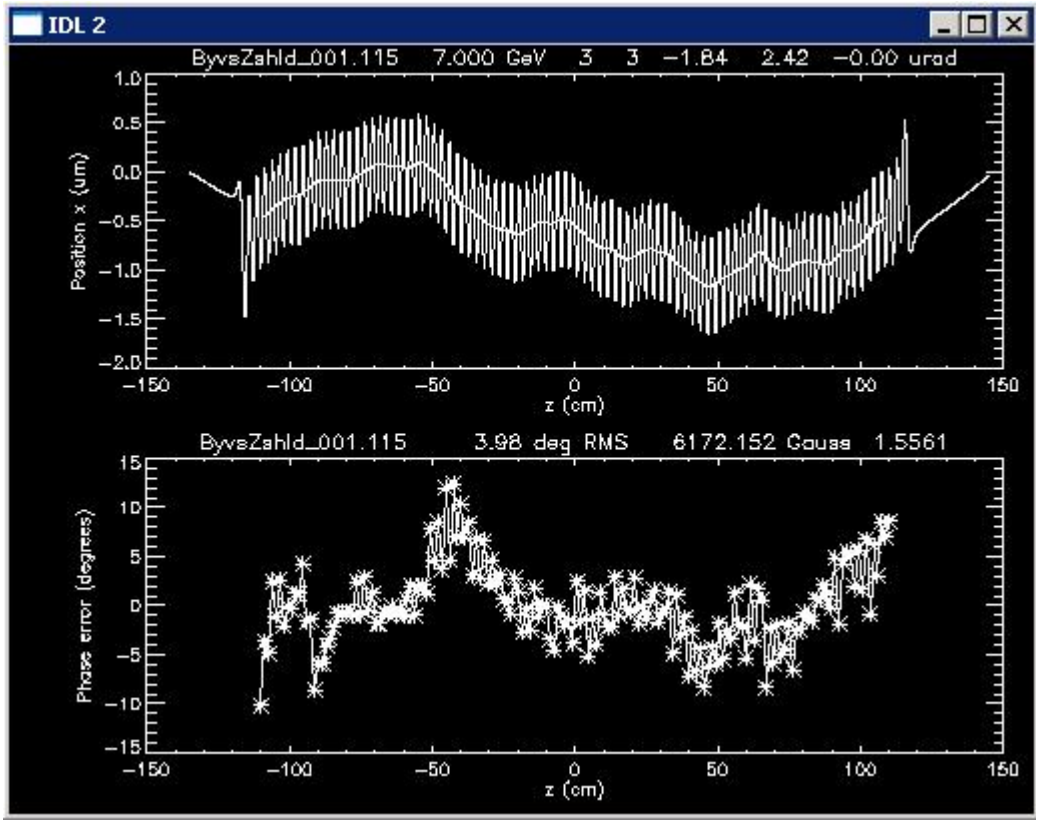
- **Reg End (G*cm^2)** shows the regression value of the 2nd order field integral at the end position.
- **Start (G*cm)** shows the 1st order field integral value at the start position.
- **End (G*cm)** shows the 1st order field integral value at the end position.
- **Reg Start (G*cm^2)** shows the regression value of the 1st order field integral at the start position.
- **Reg End (G*cm^2)** shows the regression value of the 1st order field integral at the end position.
- **REG ON/OFF** button turns the regression on and off in the plots.

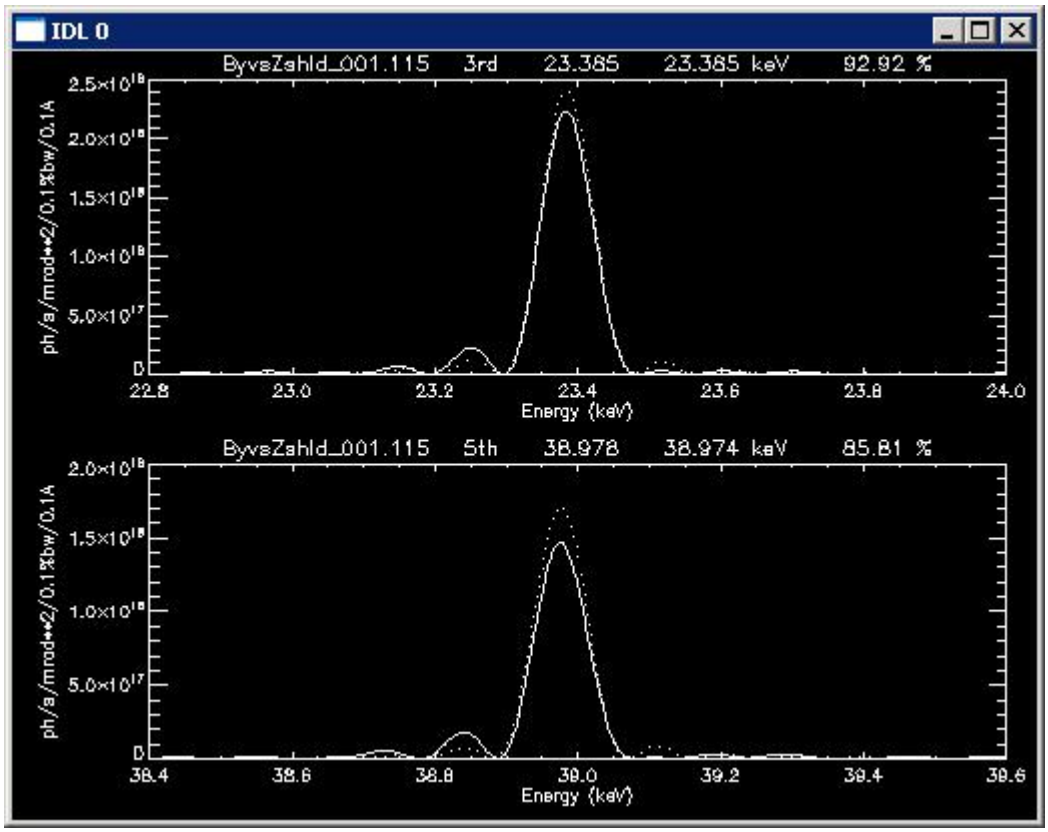
10.31.1 IDL MAGNETIC ANALYSIS

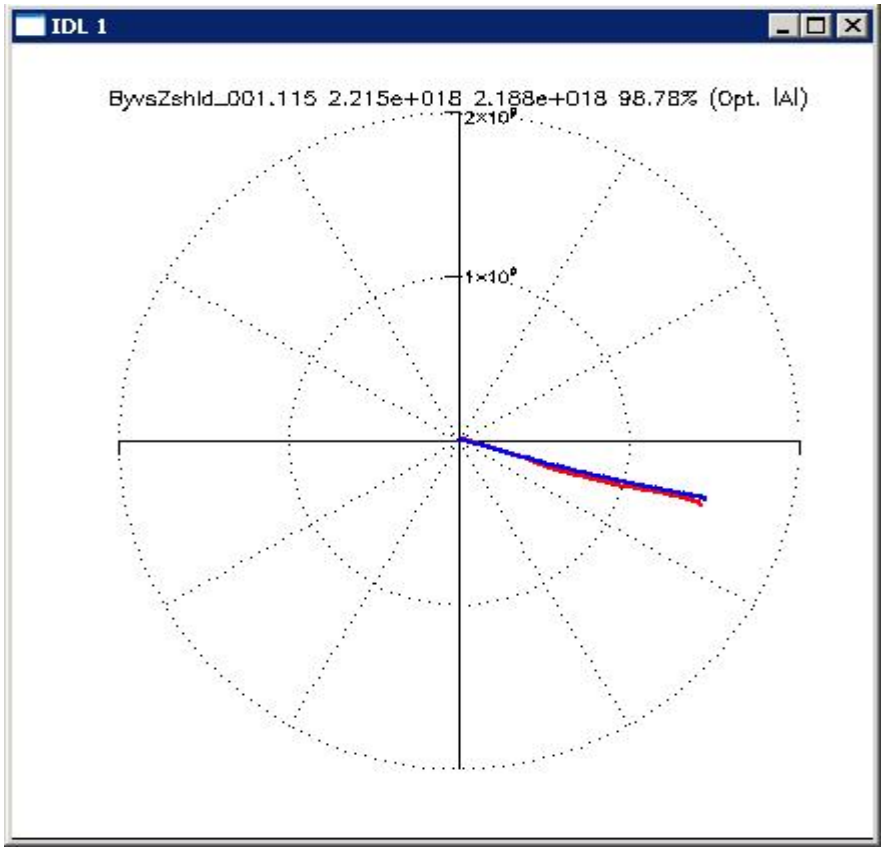
IDL Magnetic Analysis is a magnetic field analysis module written in IDL. By clicking the **IDL PLOT** button in the IDL Magnetic Analysis and Plot control window, the system will activate the IDL magnetic analysis module and pass data file to the IDL module to carry out the magnetic analysis. While in (default) **IDL Win** mode, the analysis information and results will be displayed in the following windows.

Ma Output Console

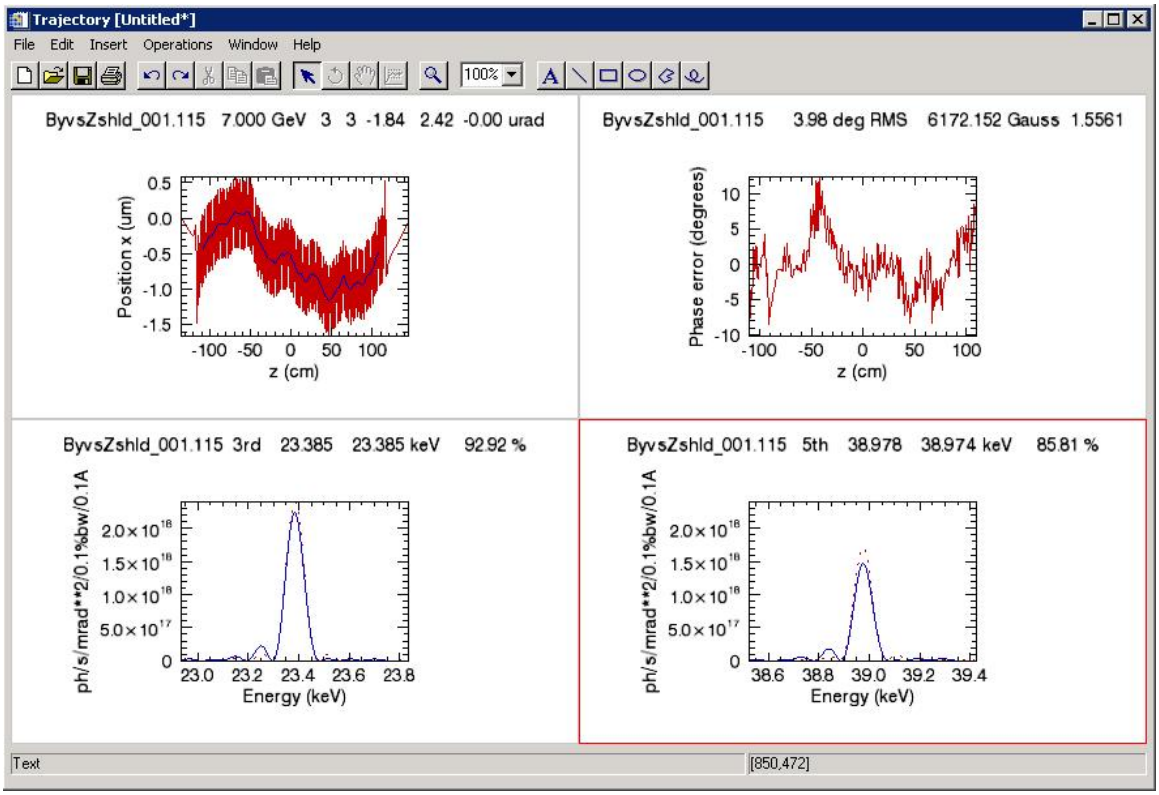
```
*** Magnetic Analysis Code v.2.0 ***
Entering Read magnetic measurement data file (fname in location MDATA)
out of read...
Integration routine: Gill & Miller
Energy (GeV), omit # of extremas for phase analysis at begining, end:
           7.000                3                3
Poles: total # of poles, end-poles, skip-phase, skip-spectrum
       used  # of poles for phase, spectrum
             174                4                6                0
             164              174
LSQ-fit: b (Gauss), period (cm), phase (cm)
      -6172.7989      -100.08205      -1.0857179     0.065368350    0.0043384199
       2.7001472
      -110.04020      -110.04073      -110.04594      -110.07747      -110.97687
LSQ-fit: device length (m), period (cm), # of periods, # of poles
           2.336          2.7001            86.5             174
LSQ-fit: beff (Gauss), keff, l1 (Angstrom), e1 (keV)
        6172.889          1.5563         1.59075           7.794
Peak field variation: mean peak field (Gauss), rms (Gauss)
        6273.043           29.00
RMS field errors: residuals (Gauss), peaks (%), half-period integrals (%)
           49.47            0.46            0.69
Average angles @ poles (urad): est. phase error (degree/urad), abs. ave, ave
            2.67            1.66           -0.00
Angles         @ poles (urad): min, max, negative ave, positive ave
           -4.60            4.37           -1.68            1.71
RMS phase error (deg.), opt. view angle (urad), betax0, betax1 (1.0e-6)
            3.98           -0.00           -1.84            2.42
Phase analysis: beff (Gauss), keff, l1 (Angstrom), e1 (keV)
              : beff (Gauss), keff, l1 (Angstrom), e1 (keV) w/ view angle incl.
        6172.152          1.5561         1.59054           7.795
        6172.152          1.5561         1.59054           7.795
Desired values: beff (Gauss), keff, l1 (Angstrom), e1 (keV)
        5842.598          1.4730         1.50000           8.266
```

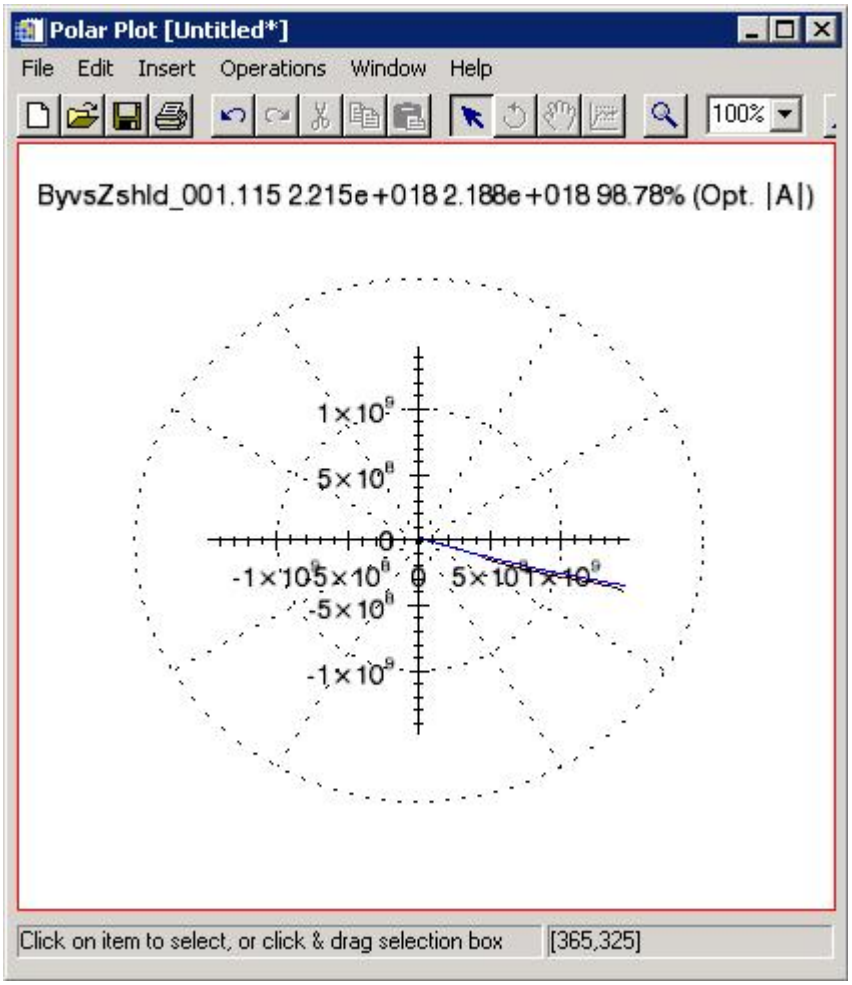

IDL 2
ByvsZahld_001.115 7.000 GeV 3 3 −1.84 2.42 −0.00 urad
Position x (um)
z (cm)
ByvsZahld_001.115 3.98 deg RMS 6172.152 Gauss 1.5561
Phase error (degrees)
z (cm)


IDL 0
ByvsZahld_001.115 3rd 23.385 23.385 keV 92.92 %
ph/s/mrad**2/0.1%bw/0.1A
Energy (keV)
ByvsZahld_001.115 5th 38.978 38.974 keV 85.81 %
ph/s/mrad**2/0.1%bw/0.1A
Energy (keV)



IDL Plot also has the option of having the magnetic analysis result plotted with the iTool activated by toggling the **IDL Win** button to **iTool**. By clicking the **IDL PLOT** button in the IDL Magnetic Analysis and Plot control window, in the **iTool** mode, the plot outs of the analysis information and results can be graphically scaled, manipulated, and saved as desired. The plot out windows will be displayed in the following figures.


Trajectory [Untitled*]
File Edit Insert Operations Window Help
100%
ByvsZshld_001.115 7.000 GeV 3 3 -1.84 2.42 -0.00 urad
Position x (um)
z (cm)
ByvsZshld_001.115 3.98 deg RMS 6172.152 Gauss 1.5561
Phase error (degrees)
z (cm)
ByvsZshld_001.115 3rd 23.385 23.385 keV 92.92 %
ph/s/mrad**2/0.1%bw/0.1A
Energy (keV)
ByvsZshld_001.115 5th 38.978 38.974 keV 85.81 %
ph/s/mrad**2/0.1%bw/0.1A
Energy (keV)
Text
[850,472]

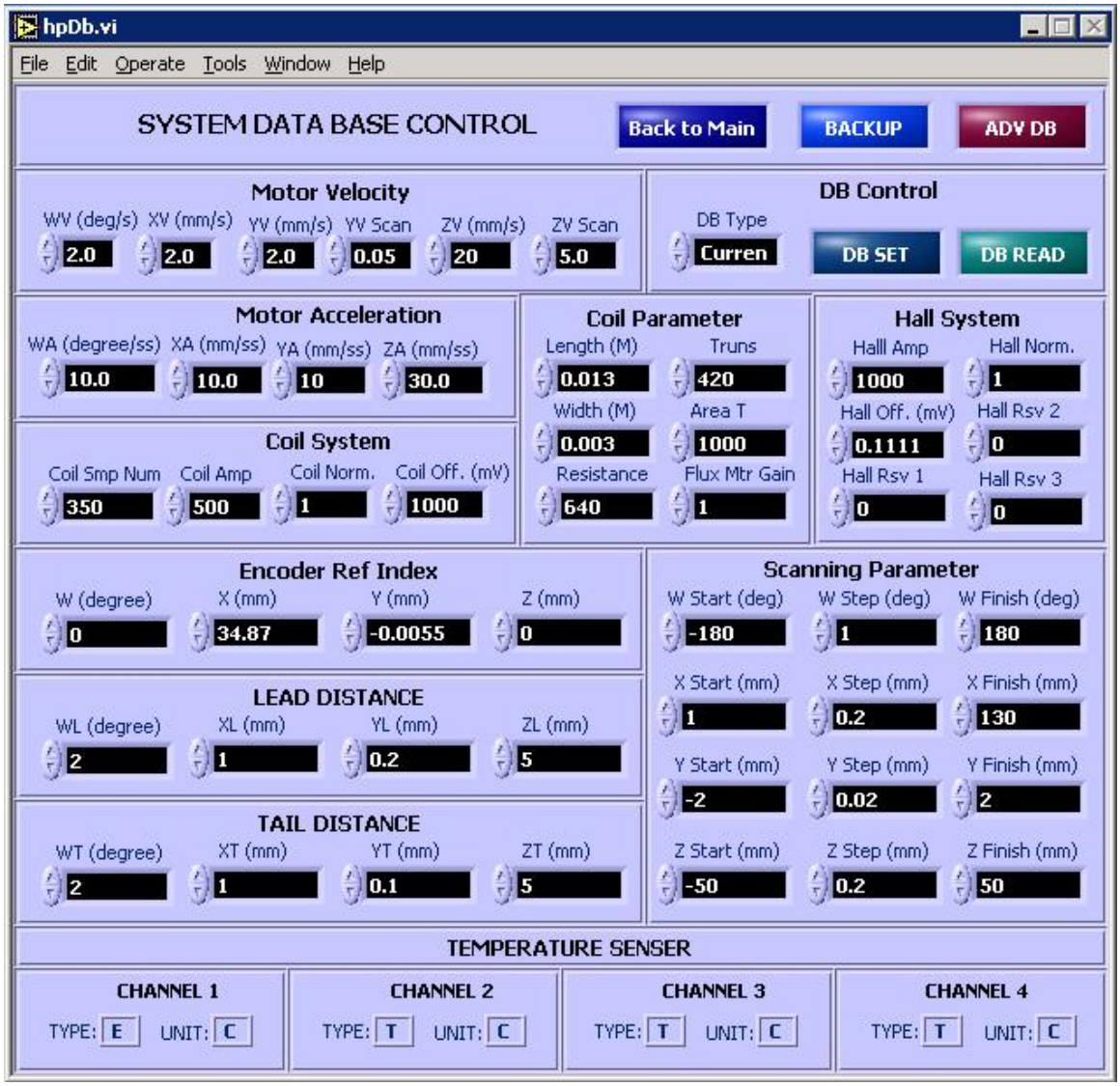


10.31.2 IDL MULTI-MEASUREMENT MAGNETIC ANALYSIS

IDL Mult-measurement Magnetic Analysis is a magnetic field analysis module written in IDL that handles multi-measurements. By clicking the **IDL MAN** button in the Hall Probe System Data IDL Plot control window, the system will activate the IDL multi-measurement magnetic analysis module and pass data files to the IDL module according to the files with their extensions listed in the ma.dat file inside the IDL magnetic analysis module folder ../../../Ma. You may have to add or modify the file extension list in the ma.dat file to include all the files you want to have analyzed. The analysis plot out results will be recorded into a postscript file in the same fold where the data files reside with the extension of .ps. The analysis result parameters will be recorded into a text file in the same fold where the data files reside with the extension of .jnl.

10.32 SYSTEM DATA BASE CONTROL

System Data Base Control provides an interface for retrieving, modification, and storing of system parameters. By clicking the **Int DB** button in the main interface windows, the system launches the System Data Base Control Interface Window as shown bellow.



The System Data Base Control Interface Window has several dozens of display and control fields. The detailed description of each field is listed in the following paragraphs.

10.32.1 GENERAL

- **Back to Main** button closes the window and goes back to the main interface window.

- **BACKUP** button allows backup the database to another file. By clicking the BACKUP control button, the system will launch a window to allow user to enter the path and file name of the file to be backed up to.
- **ADV DB** button launches the advanced database control interface described bellow.

10.32.2 DB CONTROL

- **DB Type** field displays the DB types. Click the filed and choose the DB type to be operated.
- **DB SET** button writes the parameters into the database. By clicking the DB SET control button, the system will write the parameters show in the window into the database file according to the DB type.
- **DB READ** button reads the database parameters. By clicking the DB READ control button, the system will read the parameters according to the DB type and populate them in fields.

10.32.3 MOTO VELOCITY

- **WV (deg/s)** field allow one to enter the Hall probe rotary stage speed of motion in the unit of degrees per second.
- **XV (mm/s)** field allow one to enter the Hall probe X-linear stage speed of motion in the unit of mm per second.
- **YV (mm/s)** field allow one to enter the Hall probe Y-linear stage speed of motion in the unit of mm per second.
- **YV Scan** field allow one to enter the Hall probe Y-linear stage speed of measurement scan in the unit of mm per second.
- **ZV (mm/s)** field allow one to enter the Hall probe Z-linear stage speed of motion in the unit of mm per second.
- **ZV Scan** field allow one to enter the Hall probe Z-linear stage speed of measurement scan in the unit of mm per second.

10.32.4 MOTO ACCELERATION

- **WA (deg/ss)** field allow one to enter the Hall probe W-rotary stage acceleration of motion in the unit of degrees per second^2.
- **XV (mm/ss)** field allow one to enter the Hall probe X-linear stage acceleration of motion in the unit of mm per second^2.
- **YV (mm/ss)** field allow one to enter the Hall probe Y-linear stage acceleration of motion in the unit of mm per second^2.
- **ZV (mm/ss)** field allow one to enter the Hall probe Z-linear stage acceleration of motion in the unit of mm per second^2.

10.32.5 ENCODER REFERENCE INDEX

- **W (degree)** field displays W-rotary stage encoder index position. User may enter a new index reference position into the field. Currently, the system has no rotary encoder installed.
- **X (mm)** field displays X-linear stage encoder index position. User may enter a new index reference position into the field.
- **Y (mm)** field displays Y-linear stage encoder index position. User may enter a new index reference position into the field.
- **Z (mm)** field displays Z-linear stage encoder index position. User may enter a new index reference position into the field.

10.32.6 LEAD DISTANCE

- **WL (degree)** field displays the distance between the Hall probe measurement scan start position and the data acquisition start position in W-rotary axis. User may enter a new number into the field to define the distance.
- **XL (mm)** field displays the distance between the Hall probe measurement scan start position and the data acquisition start position in X-linear axis. User may enter a new number into the field to define the distance.
- **YL (mm)** field displays the distance between the Hall probe measurement scan start position and the data acquisition start position in Y-linear axis. User may enter a new number into the field to define the distance.

- **ZL (mm)** field displays the distance between the Hall probe measurement scan start position and the data acquisition start position in Z-linear axis. User may enter a new number into the field to define the distance.

10.32.7 TAIL DISTANCE

- **WT (degree)** field displays the distance between the data acquisition finish position and the Hall probe measurement scan finish position in W-rotary axis. User may enter a new number into the field to define the distance.
- **XT (mm)** field displays the distance between the Hall probe measurement scan start position and the data acquisition start position in X-linear axis. User may enter a new number into the field to define the distance.
- **YT (mm)** field displays the distance between the Hall probe measurement scan start position and the data acquisition start position in Y-linear axis. User may enter a new number into the field to define the distance.
- **ZT (mm)** field displays the distance between the Hall probe measurement scan start position and the data acquisition start position in Z-linear axis. User may enter a new number into the field to define the distance.

10.32.8 COIL PARAMETER

- **Length (M)** field defines the length of the moving coil in meters.
- **Width (M)** field defines the width of the moving coil in meters.
- **Resistance** field defines the resistance of the moving coil in Ohms.
- **Turns** field defines the number of turns for the moving coil.
- **Area T** field defines the Area Turn of the moving coil.
- **Flux Mtr Gain** field defines the fluxmeter gain setting for the moving coil.

10.32.9 HALL SYSTEM

- **Hall Amp** field sets the Hall probe signal amplification parameter.
- **Hall Off. (mV)** field sets the Hall probe signal offset parameter in mV.
- **Hall Rsv 1, 2, and 3** fields are reserved Hall probe parameters.
- **Hall Norm** field sets the Hall probe signal normalization parameter.

10.32.10 SCANNING PARAMETER

- **W Start (deg)** field sets the W-axis scanning start position.
- **W Step (deg)** field sets the W-axis scanning step size.
- **W Finish (deg)** field sets the W-axis scanning finish position.
- **X Start (mm)** field sets the X-axis scanning start position.
- **X Step (mm)** field sets the X-axis scanning step size.
- **X Finish (mm)** field sets the X-axis scanning finish position.
- **Y Start (deg)** field sets the Y-axis scanning start position.
- **Y Step (mm)** field sets the Y-axis scanning step size.
- **Y Finish (mm)** field sets the Y-axis scanning finish position.
- **Z Start (mm)** field sets the Z-axis scanning start position.
- **Z Step (mm)** field sets the Z-axis scanning step size.
- **Z Finish (mm)** field sets the Z-axis scanning finish position.

10.32.11 TEMPERATURE SENSORS

- **TYPE** field sets the thermocouple type. Clicking on the filed to display a pull down table thermocouple types and select the desired type.
- **UNIT** field sets the thermocouple unit. Clicking on the filed to display a pull down table thermocouple types and select the desired unit.

10.32.12 ADVANCED SYSTEM DATABASE CONTROL

Advanced System Data Base Control provides an interface for retrieving, modification, and storing of the advanced system parameters. By clicking the **ADV DB** button in the System Data Base Control interface windows, the system launches the Advanced System Data Base Control Interface Window as shown bellow.

The Advanced System Data Base Control Interface Window has over two dozens of display and control fields. The detailed description of each field is listed in the following paragraphs.

10.32.13 MOTOR RESOLUTIONS

- **W (pulses/rev)** field sets the W-axis motor resolution in pulses per revolution.
- **X (pulses/rev)** field sets the X-axis motor resolution in pulses per revolution.
- **Y (pulses/rev)** field sets the Y-axis motor resolution in pulses per revolution.
- **Z (pulses/rev)** field sets the Z-axis motor resolution in pulses per revolution.

10.32.14 ENCODER RESOLUTIONS

- **W Enc Res (deg)** field sets the W-axis encoder resolution in degree per step.
- **X Enc Res (mm)** field sets the X-axis encoder resolution in mm per step.
- **Y Enc Res (mm)** field sets the Y-axis encoder resolution in mm per step.
- **Z Enc Res (mm)** field sets the Z-axis encoder resolution in mm per step.

10.32.15 STAGE GEAR RATIOS

- **W (rev/degree)** field sets the W-axis rotary stage gear ration in motor revolution per stage degree rotation.
- **X (rev/mm)** field sets the X-axis linear stage gear ration in motor revolution per stage mm motion.
- **Y (rev/mm)** field sets the Y-axis linear stage gear ration in motor revolution per stage mm motion.
- **Z (rev/mm)** field sets the Z-axis linear stage gear ration in motor revolution per stage mm motion.

10.32.16 MOTOR VELOCITY RATIOS

- **W (s/rps)** field sets the W-axis rotary stage motor velocity ratio in scaled motor encoder counts per sec/rps.
- **X (s/rps)** field sets the X-axis linear stage motor velocity ratio in scaled motor encoder counts per sec/rps.
- **Y (s/rps)** field sets the Y-axis linear stage motor velocity ratio in scaled motor encoder counts per sec/rps.
- **Z (s/rps)** field sets the Z-axis linear stage motor velocity ratio in scaled motor encoder counts per sec/rps.

10.32.17 MOTOR ACCELERATION RATIOS

- **W (ss/rpss)** field sets the W-axis rotary stage motor acceleration ratio in scaled motor encoder counts per sec^2/rps^2.
- **X (ss/rpss)** field sets the X-axis linear stage motor acceleration ratio in scaled motor encoder counts per sec^2/rps^2.
- **Y (ss/rpss)** field sets the Y-axis linear stage motor acceleration ratio in scaled motor encoder counts per sec^2/rps^2.
- **Z (ss/rpss)** field sets the Z-axis linear stage motor acceleration ratio in scaled motor encoder counts per sec^2/rps^2.

10.32.18 SYSTEM PARAMETERS

- **DMM Range (V)** field sets the digital multi meter voltage measurement range in volts.
- **DMM Res (V)** field sets the digital multi meter voltage measurement resolution in volts.
- **DMM Sttl T (S)** field sets the digital multi meter voltage measurement settling time in seconds.
- **Coil Res (bit/V)** field sets the coil measurement digital to analog converter resolution in steps per volt.

10.32.19 DB CONTROL

- **DB Type** field displays the DB types. Click the filed and choose the DB type to be operated.
- **DB SET** button writes the parameters into the database. By clicking the DB SET control button, the system will write the parameters show in the window into the database file according to the DB type.
- **DB READ** button reads the database parameters. By clicking the DB READ control button, the system will read the parameters according to the DB type and populate them in fields.
- **Back to Main** button closes the window and goes back to the main interface window.

11. SYSTEM OPERATION PROCEDURES

A detailed system operation procedure includes the following steps:

1. System Setup.
2. System Preparation.
3. System Alignment.
4. System Measurement.

If you are sure that the system has been properly set up and aligned, you may skip the System Setup part of the procedures.

11.1 SYSTEM SETUP PROCEDURE

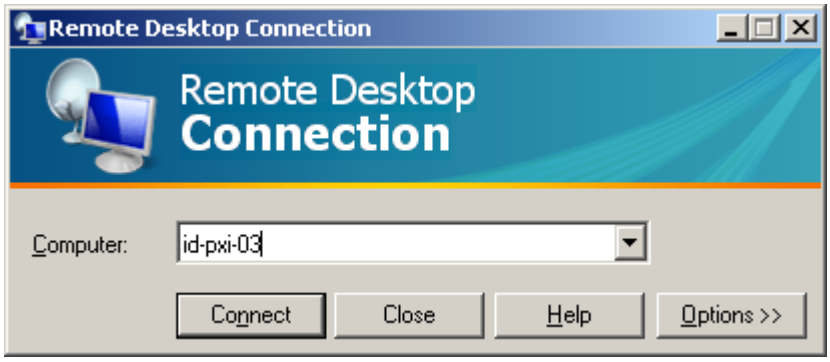
Before launching the software system, the hardware sub-system connections have to be checked and powered on. If any of the sub-system is not connected and powered on appropriately, the software system will inform you that the specific hardware system is not connected or power up or communication port address is not set correctly.

Step 1. Check all the cables, the network cables to the PXI shelf and the host computer, the smart motor RS-232 communication cables, the smart motor power supply cables, the encoder cobles, and the signal cables are properly connected and secured accordingly.

Step 2. The smart motor power supply is powered on.

Step 3. The PXI shelf is powered up.

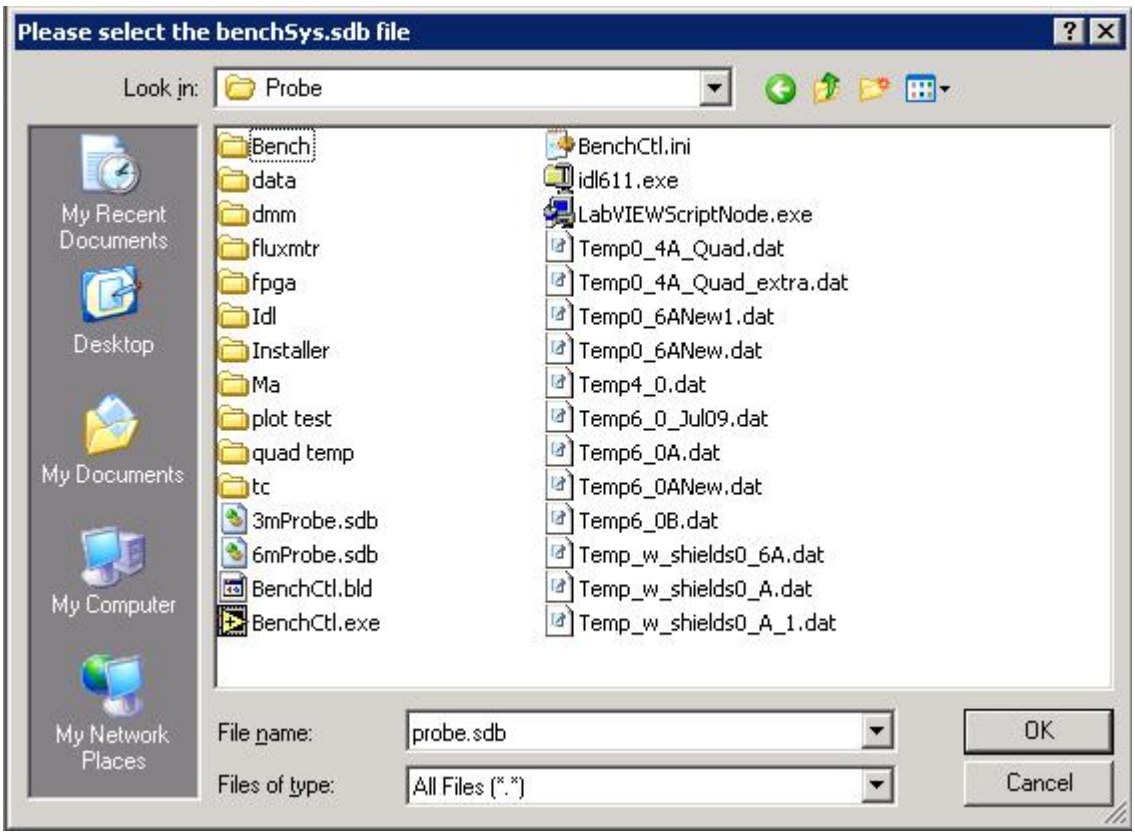
Step 4. Log on to any APS host computer. Start **Remote Desktop Connection** from **Start**, **Programs**, **Accessories**, and **Communications**. In the **Computer** field, type in **id-pxi-03** (for 3 meter bench) or **id-pxi-04** (for 6 meter bench), as show in the following figure, click **Connect**.



Enter the login name (id_ctl) and password (contact Joseph Xu at 630-252-8379 if you don't have one).

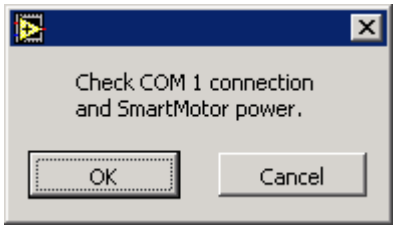
Step 5. Launch the Hall Probe Measurement Control System Software by double click the 3 Meter Bench Control (or 6 Meter Bench Control) icon on the Remote Desktop.

Step 6. The system will prompt you with a window ask for the right path to load the system.db file.

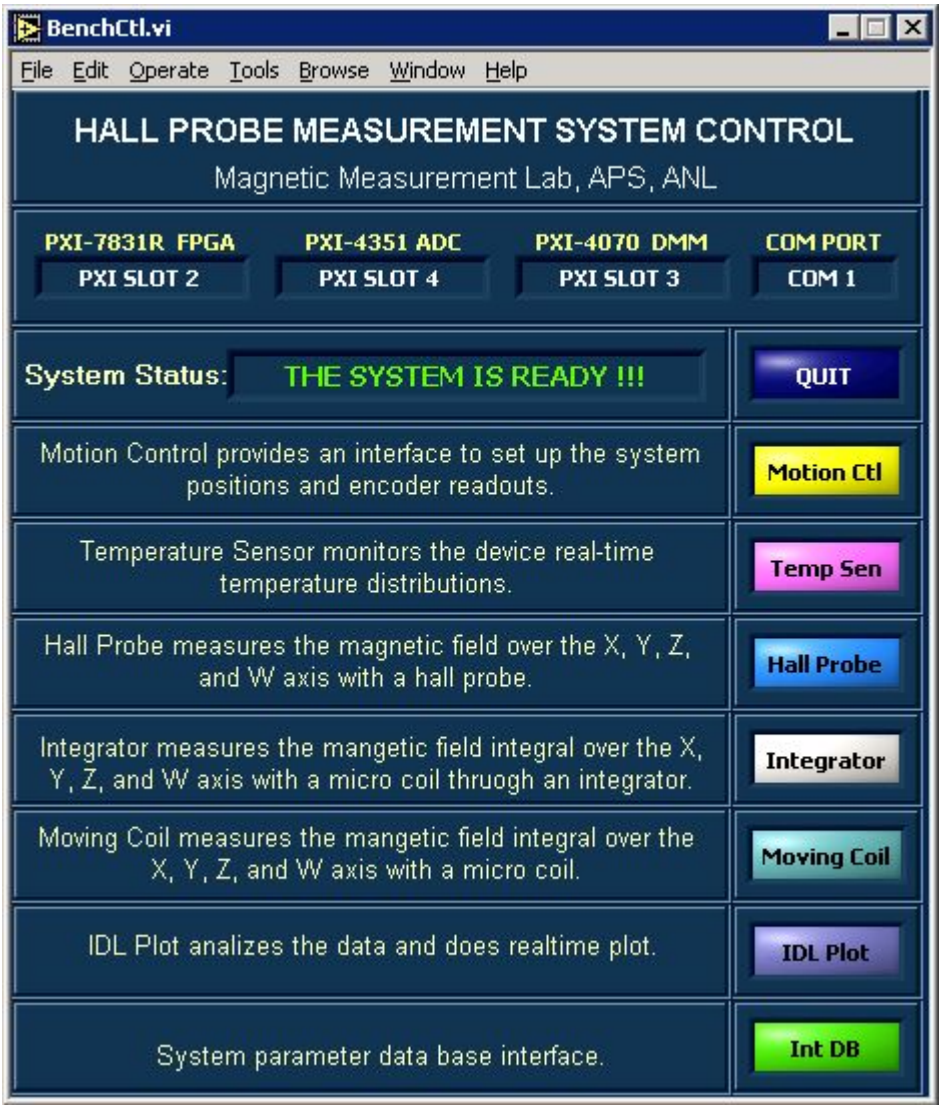


Select the right path where your 3mProbe.sdb (or 6mProbe.sdb) file is located and click **OK**.

Step 7. If the following window pops up, check the appropriate cable connections, power cables, and address settings, and click OK button to continue.



If the servo motors are not initialized, the system will try to initialize the motors automatically. If every thing is ok the following system main interface window will show with the status of “THE SYSTEM IS READY!!!”



11.2 SYSTEM PREPARATION PROCEDURE

Before each measurement, collect all the information about the ID to be measured. The preparation procedure includes the following steps:

Step 8. Collect the ID information including:

- The manufacture.
- The part number.
- The serial number.
- The period (in millimeters).
- The environment temperature.
- Other information as necessary.

Step 9. Check all the control cable connections from the ID control racks to the ID motors and encoders. Check all the power switches are on in the control racks. Launch the ID Control MEDM windows. Test the ID control system and make sure the ID gap moves accordingly.

11.3 SYSTEM ALIGNMENT PROCEDURE

After the preparation, the system needs to be properly aligned, before measurements scan can be executed.

Step 10. Align the ID gap leveled horizontally, in the reach of the Hall probe and is parallel with the Hall probe Z-axis. You may have to disengage the Z-motion clutch and manually move the carriage in Z-direction to verify the ID alignment.

Step 11. Click the **Motion Ctl** control button in the Hall Probe Measurement control interface window to launch the Advanced Motion Control interface window. Use the motion control interface to carefully move the Hall probe into the center of the ID gap by move the X, Y and Z axis to the center of the ID gap as well as the center of the ID.

Step 12.

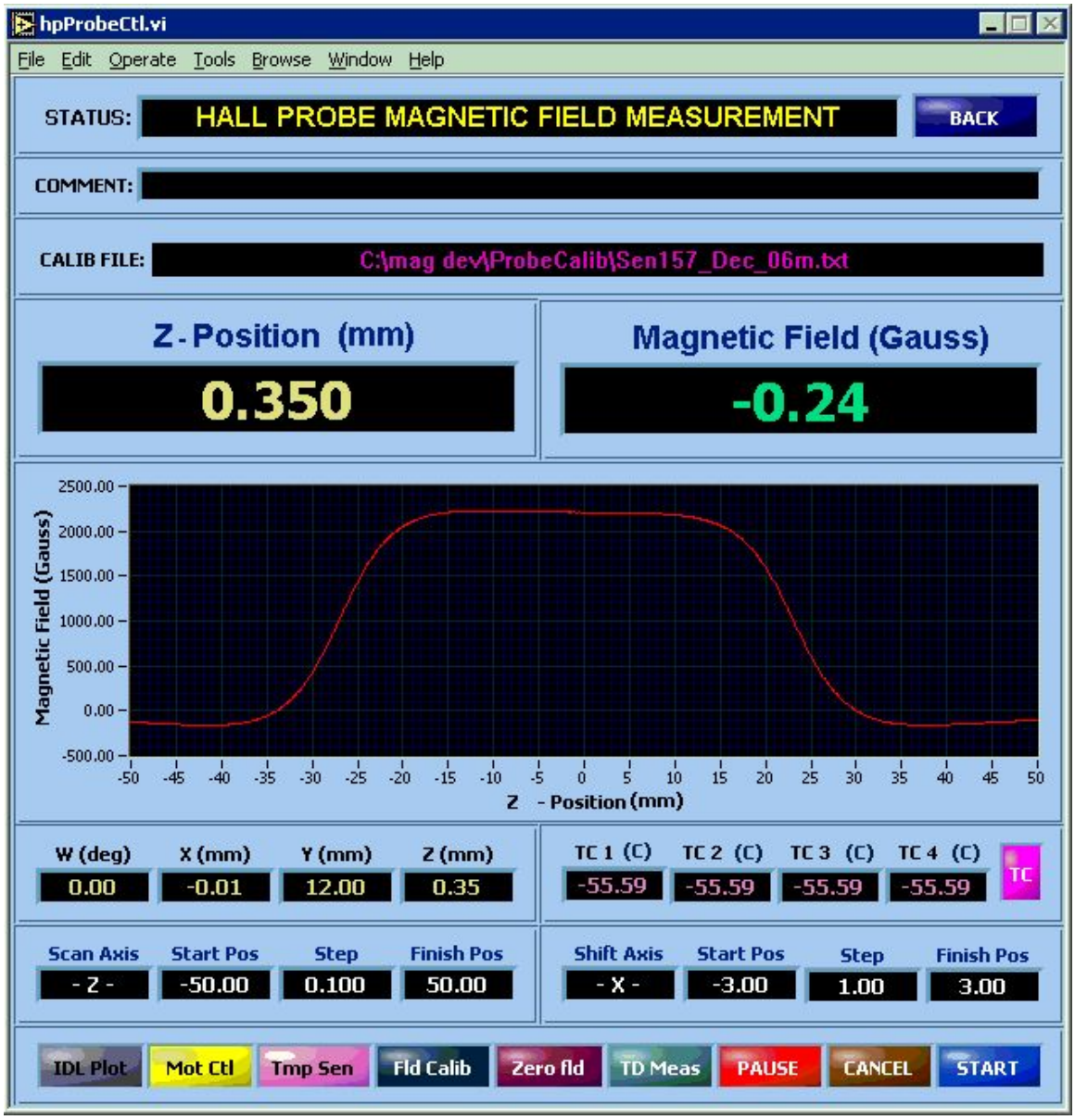
Step 13. *Reset* the linear encoder readouts to zero. Synchronize the motor positions to the encoder readouts by clicking the **SYNC** button.

NOTE: *if you wish to manually more any of the stages, you may do so by clicking the* ***CRT OFF*** *button to turn off the motor servo holding currents.*

NOTE: *if the motors don't move or move too fast or too slow, you may go to the advanced motion velocity and acceleration control by clicking the* ***V and A*** *button to lunch the control window. You may also go back to the main control window and click the* ***Int DB*** *button to set the parameters in the system database interface.*

11.4 HALL PROBE FIELD MEASUREMENT PROCEDURE

Click the **Hall Probe** control button in the Main Control Windows to launch the Hall Probe Field Measurement Control Interface window.



Before you click the **START** control button, the following Steps have to be completed.

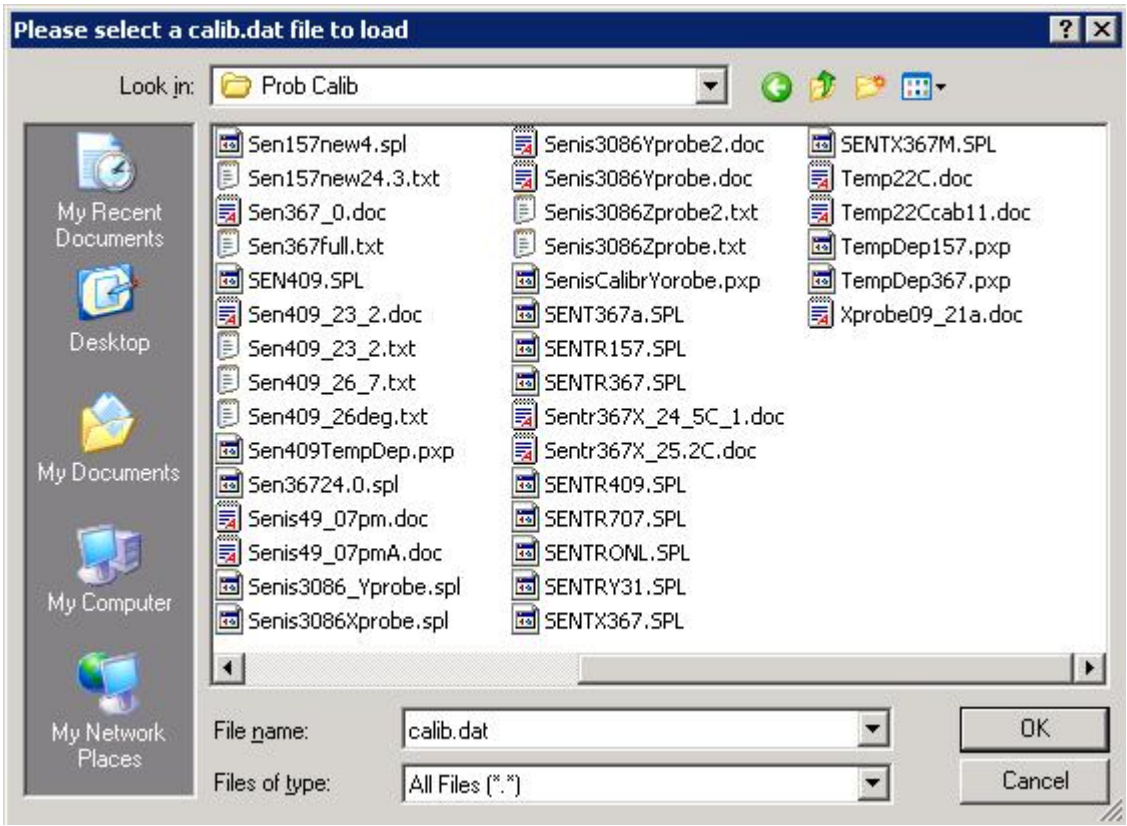
Step 14. Verify that the Hall probe current power supply is connected and powered on. Verify that the Hall probe signal wires are connected to the PXI-4070 DMM card with the right polarity.

11.4.1 HALL PROBE CALIBRATION FILE LOADING

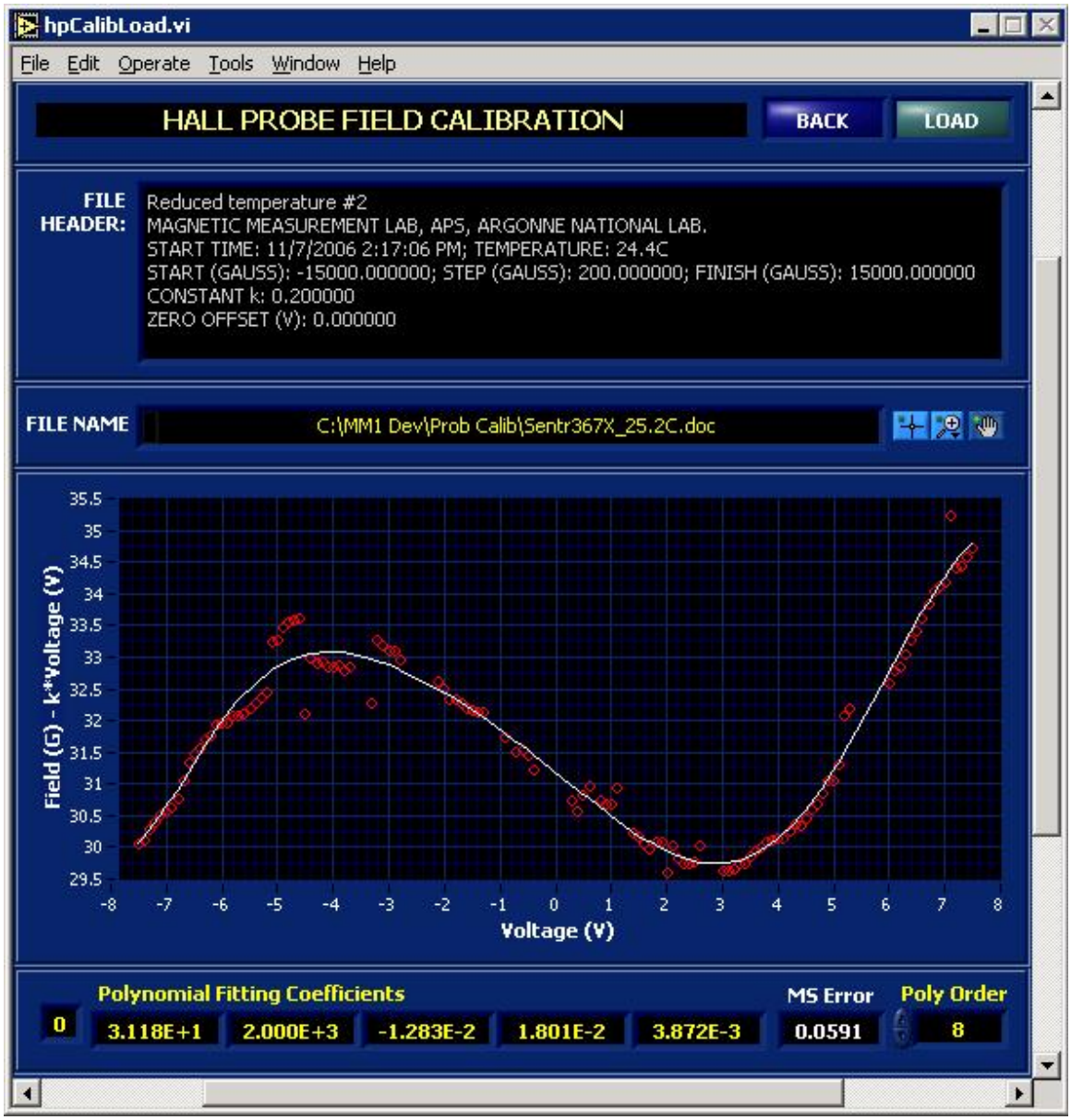
Step 15. Verify that the file name and path in the **CALIB FILE** filed matches the calibration file of the Hall probe you are using. If not, click the **Fld Calib** button to load the correct

Hall probe calibration file into the system. Otherwise, go to the ZERO FIELD CALIBRATION section..

Step 16. By clicking the **Fld Calib** button in the Hall probe measurement control window, the system will launch the Hall probe field calibration file loading interface with a file selection window as show bellow:



Select the correct path and file name of the calibration and click OK to enter the calibration data entry window as bellow:



Step 17. Select the appropriate polynomial fitting parameter order to visually inspect the fitting. Increase the **Poly Order** till the number in the **MS Error** field does not change while increasing the order. Go back to the lowest order when the **MS Error** stop changing.

Step 18. Click the **BACK** button to close the window. Every time a new calibration file has been loaded into the system, the system will automatically prompt you to the Zero Field Calibration control interface with a message window as follow:

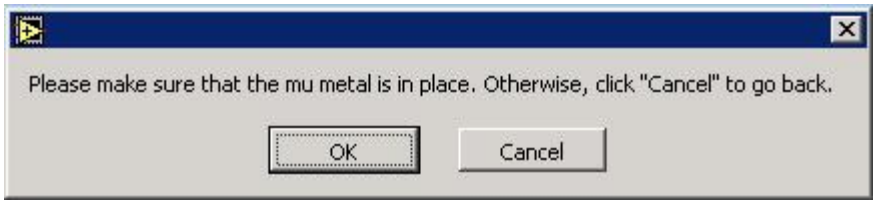
Click OK to proceed to the Zero Field Calibration Procedure

11.4.2 ZERO FIELD CALIBRATION

Step 19. If a new ID has been placed into the place or the environment has a big change in terms of the magnetic and electrical fields, or if a new Hall probe has been installed and a new Hall probe calibration file has been loaded into the system, the Hall probe zero field has to be calibrated. By clicking the **ZERO FLD** button in the Hall probe magnetic field measurement control window, the system launches the following window.

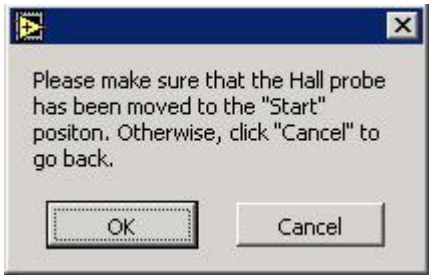
NOTE: *you may want to go back to the main control window, click the Int DB button to check the Hall system parameters such as the Hall Amp and Hall Norm parameters to make sure they matches your Hall probe settings.*

Step 20. Click the **ZERO FIELD DAQ** button, following message window shows.



Put the zero field (mu metal) enclosure onto the Hall probe, click **OK** to proceed.

Step 21. Click the **START FIELD DAQ** button, following message window shows.



Move the Hall probe to the start position (the furthest position downstream of the ID in Z-direction), click **OK** to proceed.

Step 22. Click the **END FIELD DAQ** button, following message window shows.

Move the Hall probe to the end position (the furthest position upstream of the ID in Z-direction), click **OK** to proceed. Click the BACK button to go back to the Hall Probe Magnetic Field Measurement control window after the Zero Field Calibration procedure is done.

11.4.3 HALL PROBE MAGNETIC FILED MEASUREMENT

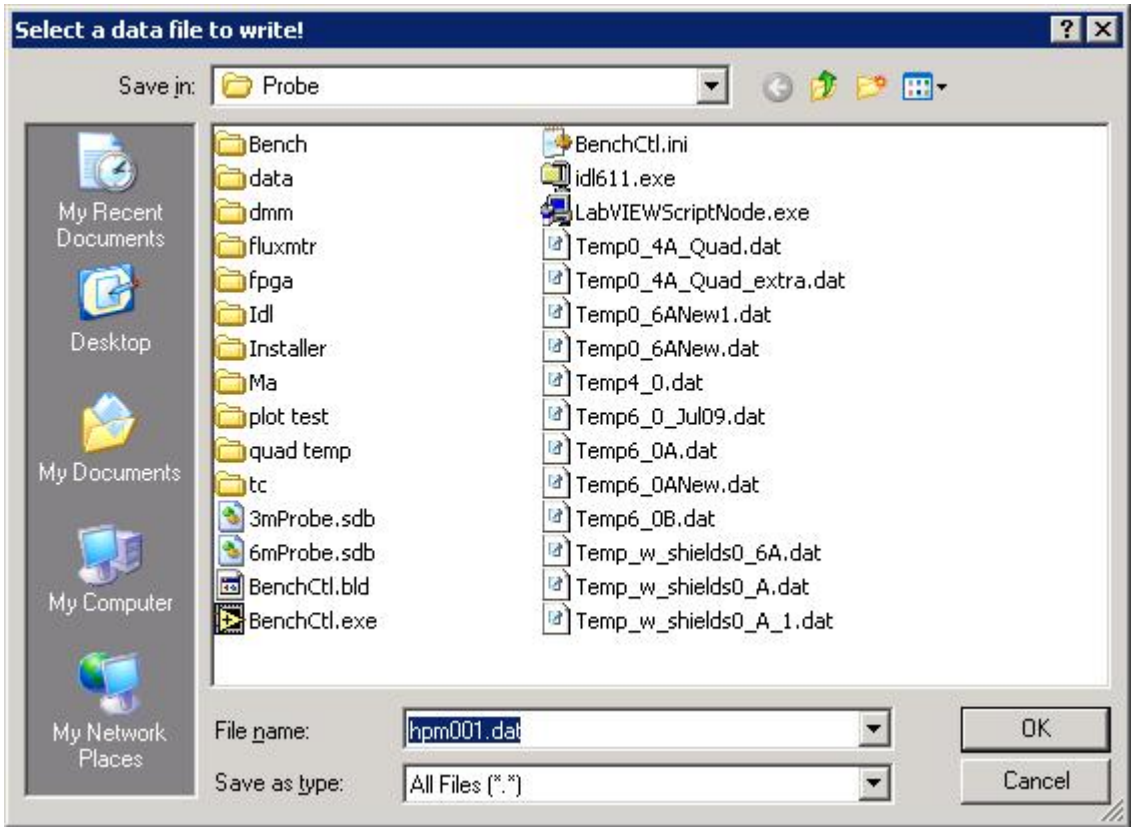
Step 23. Enter the ID information of the probe needs to be calibrated into the **COMMENT** field. If the information does not fit into one line in the field, you can always enter a carriage return to start a new line. The number of lines of information has no limit.

Step 24. Select the scan axis and shift axis by clicking the fields. The system will scan the Hall probe along the scan axis at the shift axis positions to complete a “two-dimensional” measurement and recode each scan into a data file. If you wish to only do a single scan along a desired axis, say, Z-axis, you may choose Z as the **Scan Axis** as well as the **Shift Axis**.

Step 25. Enter the scan Start Position, Step, as well as Finish Position. Make sure the positions plus the lead and tail distances are open and clear to reach.

Step 26. Enter the shift axis Start Position, Step, as well as Finish Position Make sure that the positions are open and clear to reach along the whole Scan Axis.

Step 27. Click the **START** button, the system launches a window allows you to enter a file name and its path for the data file to be saved as show bellow. Enter the desired file name in your desired path and click OK. If you change your mind, you may click Cancel and start again later.



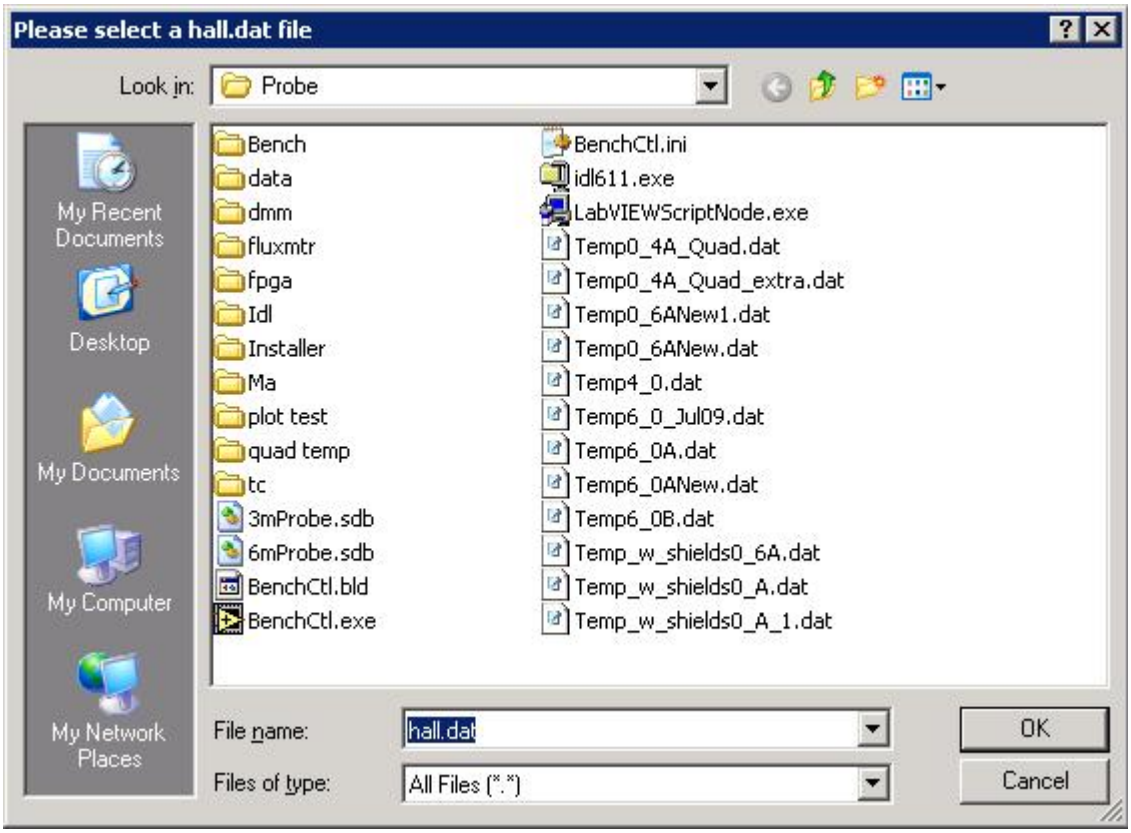
NOTE: *the actual file names will be recorded as hpm001_001.dat, hpm001_002.dat, and so on for each scan if the name you enter is hpm001.dat.*

NOTE: *in case you want to pause the system during a scan, you may do so by clicking the* ***PAUSE*** *button at any time. The button becomes* ***RESUME*** *and the system will pause till you click the* ***RESUME*** *button. The system will then resume the scan. THE* ***PAUSE*** *ALSO SERVES TO STOP THE MOTION DURING A SCAN IN EMERGENCY A SITUATION.*

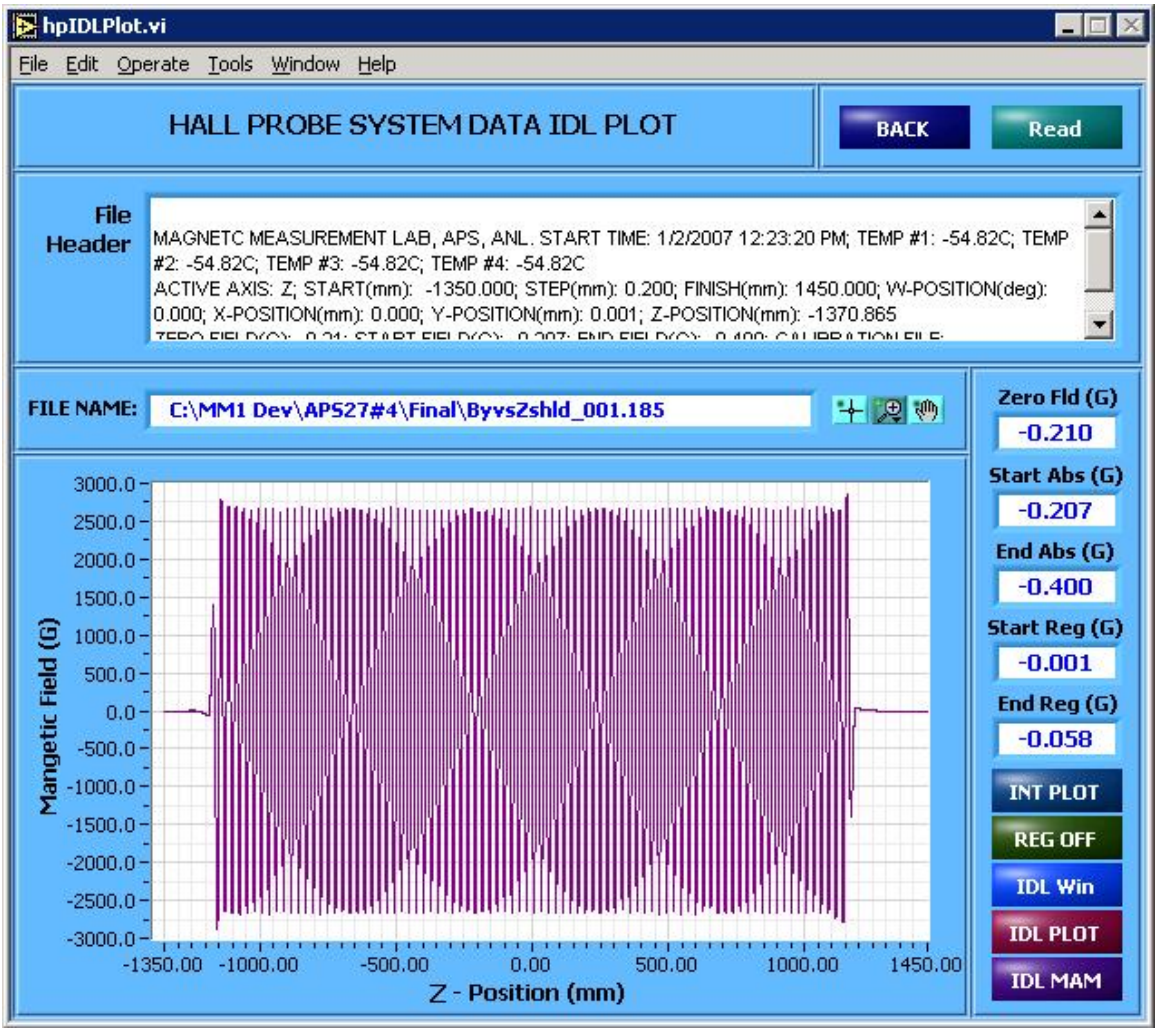
NOTE: *if you wish to cancel the scan, you may do so by clicking the* ***CANCEL*** *button. The system will finish the current scan and save the data into the file, and move the Hall probe back to its original position.*

11.4.4 HALL PROBE MAGNETIC FILED ANALYSIS

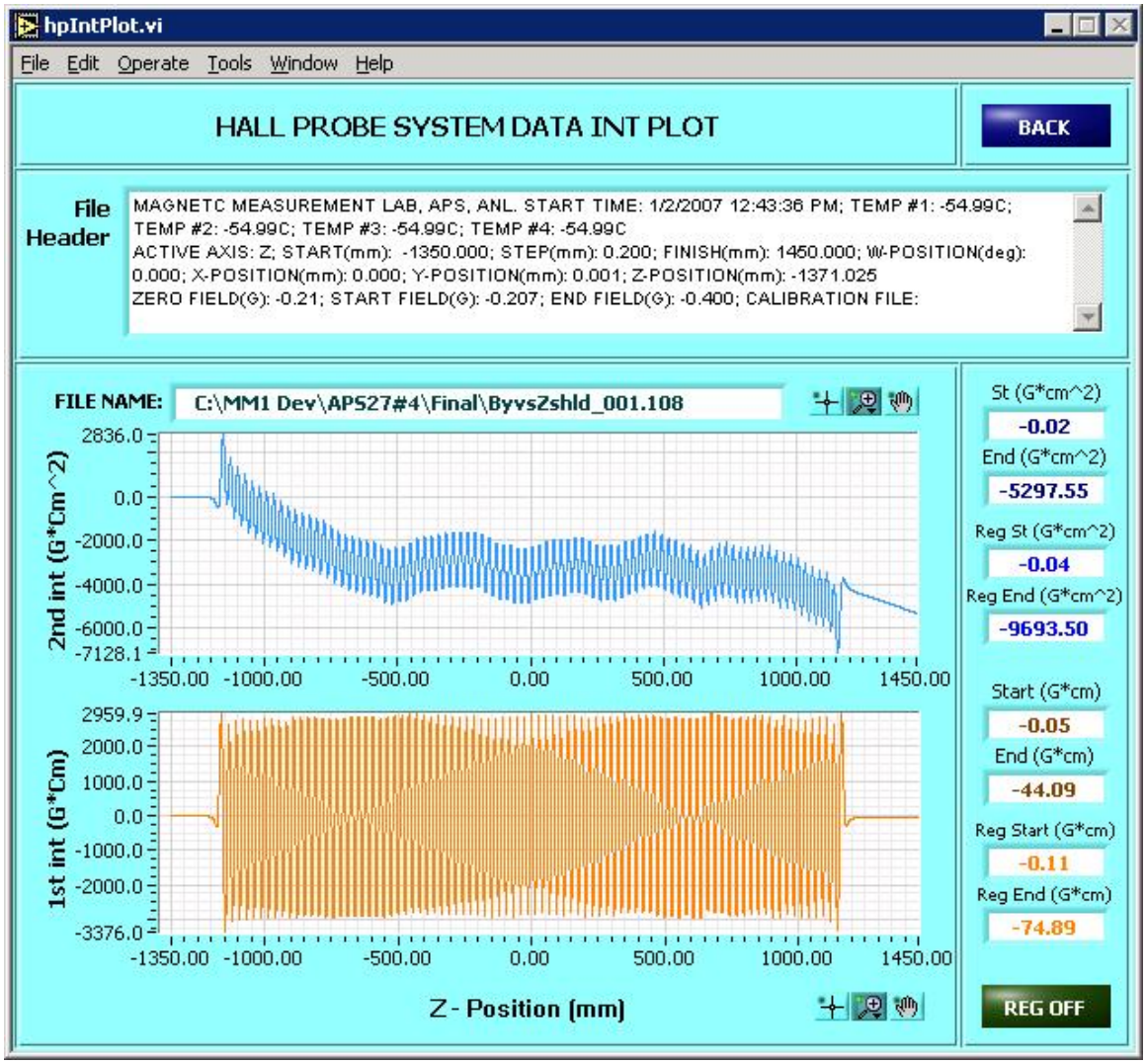
Step 28. Click the IDL Plot button, the system launches a Hall Data File selection message window for you to select the desired Hall data file to be analyzed.



Step 29. Select the desire file and the system launches the Hall Probe Magnetic Filed Analysis control window.

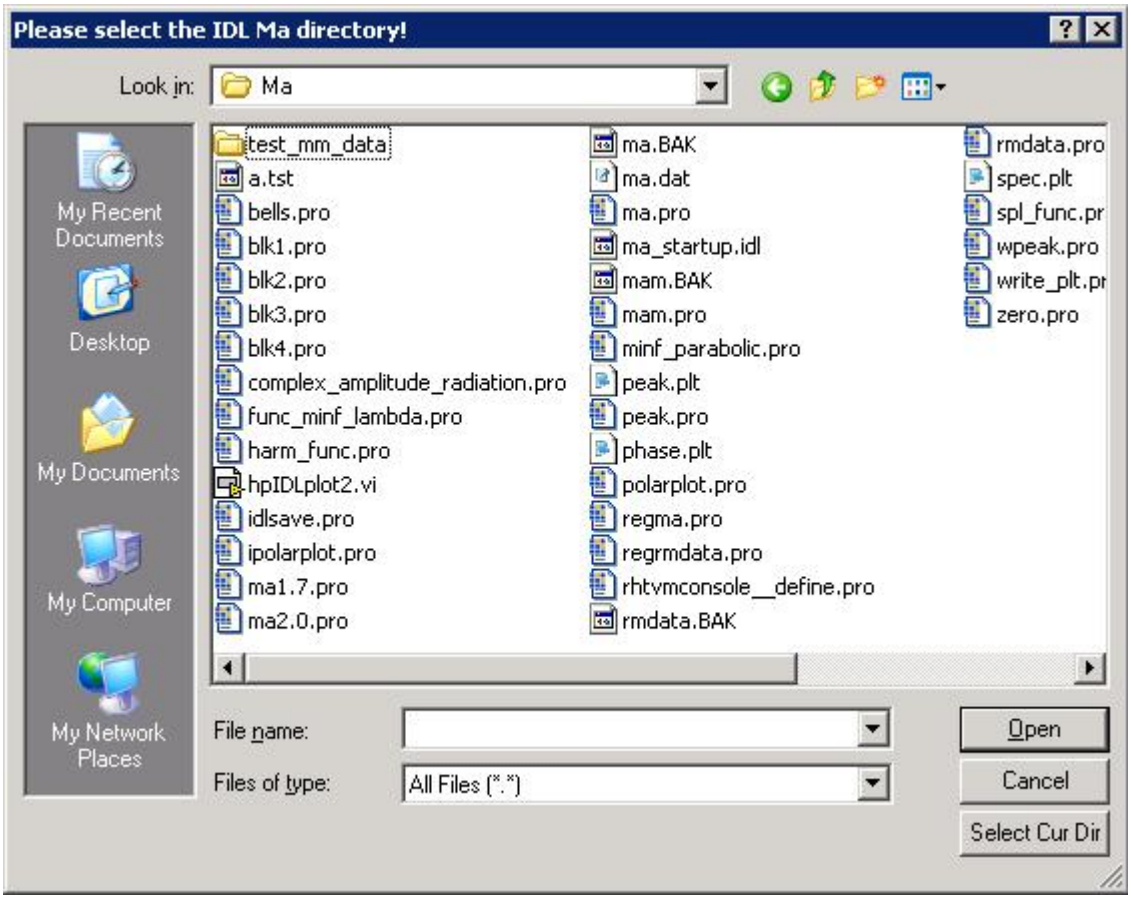


Step 30. Check the field integrals by clicking the **INT PLOT** button to launch the field integrals as show bellow.

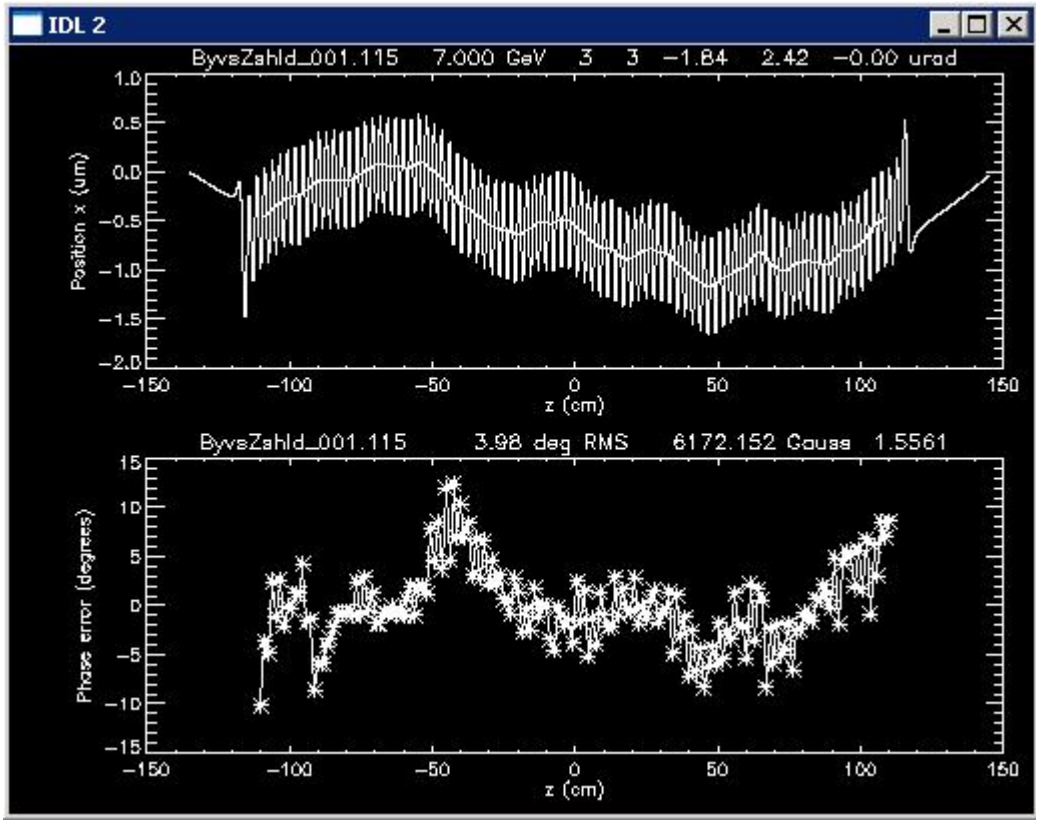


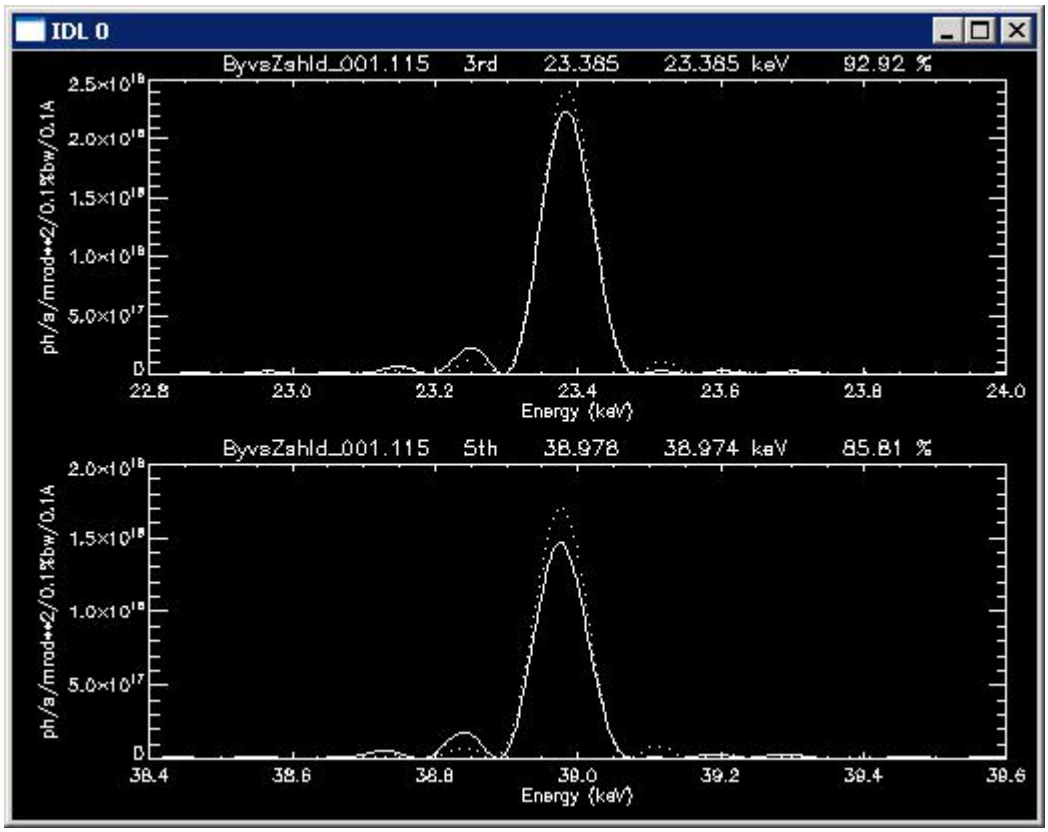
After you check the plot outs and parameters, you may click the **BACK** button to go back to the Hall Probe Magnetic Filed Analysis control window.

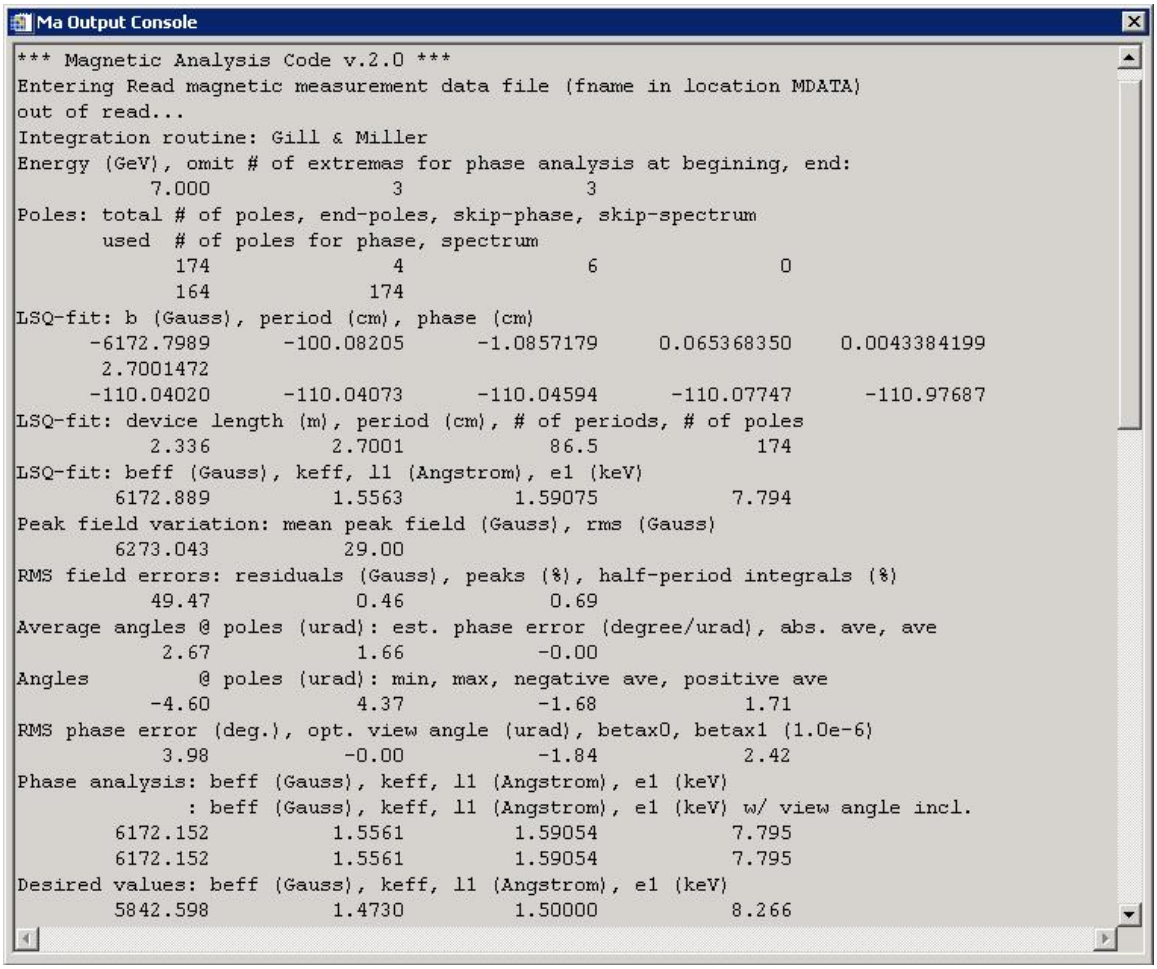
Step 31. Click the **IDL PLOT** button to launch the IDL magnetic analysis. You may want to leave the **REG OFF** and **IDL Win** as default. If the main system has been launched the fist time, it will ask for the path and the directory of the IDL MA folder as show bellow.



Select and open the **Ma** directory and click the **Select Cur Dir** button in the message window. The system will call the magnetic analysis module written in IDL and plot out the analysis results as follow.


IDL 2
ByvsZahld_001.115 7.000 GeV 3 3 −1.84 2.42 −0.00 urad
Position x (um)
z (cm)
ByvsZahld_001.115 3.98 deg RMS 6172.152 Gauss 1.5561
Phase error (degrees)
z (cm)


IDL 0
ByvsZahld_001.115 3rd 23.385 23.385 keV 92.92 %
ph/s/mrad**2/0.1%bw/0.1A
Energy (keV)
ByvsZahld_001.115 5th 38.978 38.974 keV 85.81 %
ph/s/mrad**2/0.1%bw/0.1A
Energy (keV)

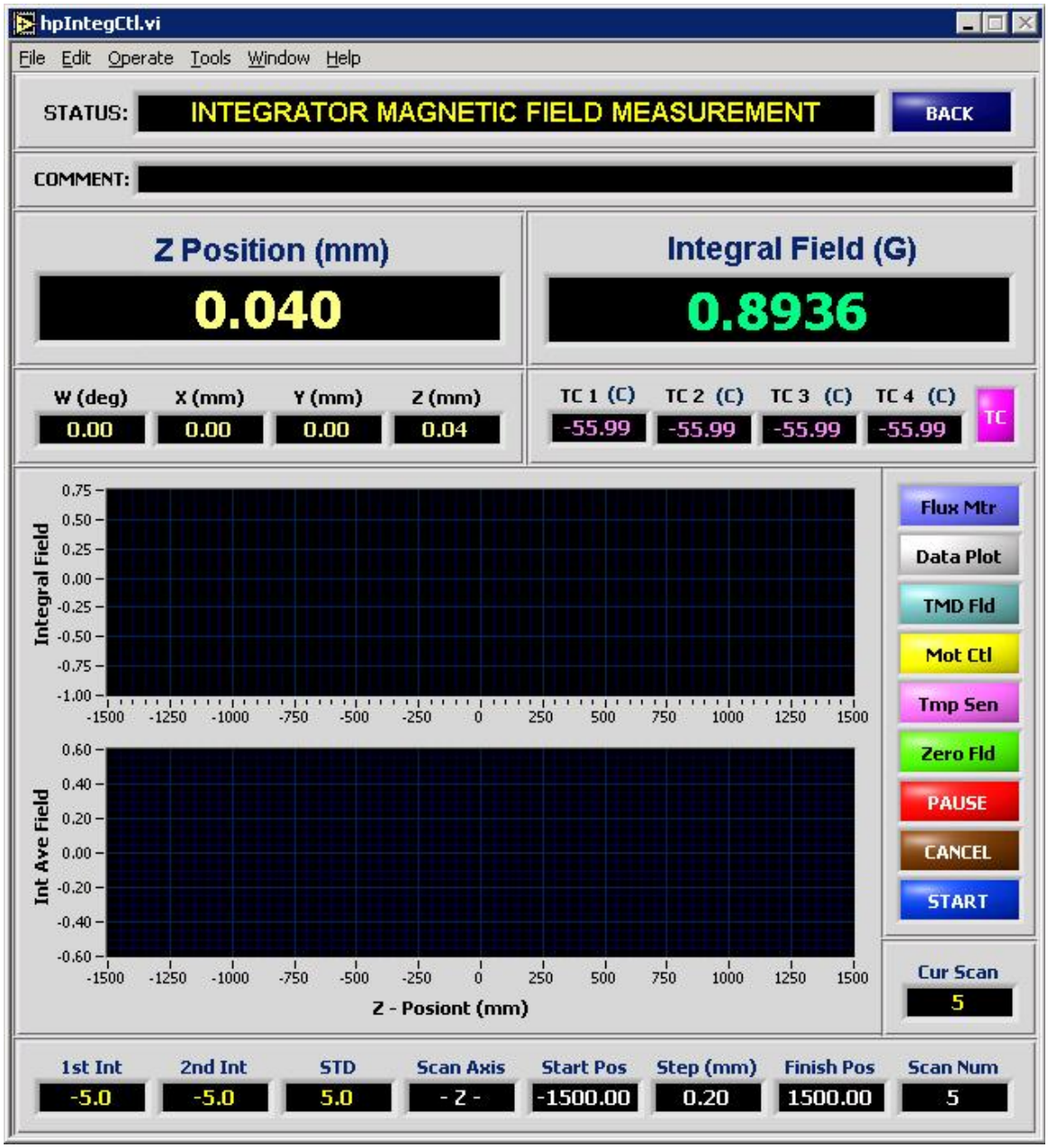


```
Ma Output Console
*** Magnetic Analysis Code v.2.0 ***
Entering Read magnetic measurement data file (fname in location MDATA)
out of read...
Integration routine: Gill & Miller
Energy (GeV), omit # of extremas for phase analysis at begining, end:
          7.000              3              3
Poles: total # of poles, end-poles, skip-phase, skip-spectrum
       used  # of poles for phase, spectrum
             174              4              6              0
             164            174
LSQ-fit: b (Gauss), period (cm), phase (cm)
      -6172.7989      -100.08205      -1.0857179     0.065368350    0.0043384199
       2.7001472
      -110.04020      -110.04073      -110.04594      -110.07747      -110.97687
LSQ-fit: device length (m), period (cm), # of periods, # of poles
          2.336          2.7001           86.5            174
LSQ-fit: beff (Gauss), keff, l1 (Angstrom), e1 (keV)
        6172.889          1.5563         1.59075           7.794
Peak field variation: mean peak field (Gauss), rms (Gauss)
        6273.043           29.00
RMS field errors: residuals (Gauss), peaks (%), half-period integrals (%)
          49.47            0.46            0.69
Average angles @ poles (urad): est. phase error (degree/urad), abs. ave, ave
           2.67            1.66           -0.00
Angles         @ poles (urad): min, max, negative ave, positive ave
          -4.60            4.37           -1.68            1.71
RMS phase error (deg.), opt. view angle (urad), betax0, betax1 (1.0e-6)
           3.98           -0.00           -1.84            2.42
Phase analysis: beff (Gauss), keff, l1 (Angstrom), e1 (keV)
              : beff (Gauss), keff, l1 (Angstrom), e1 (keV) w/ view angle incl.
        6172.152          1.5561         1.59054           7.795
        6172.152          1.5561         1.59054           7.795
Desired values: beff (Gauss), keff, l1 (Angstrom), e1 (keV)
        5842.598          1.4730         1.50000           8.266
```

Step 32. Based on the above analysis results in different ID gaps, you may want to adjust the field profile by shimming the ID. Details refer to the Insertion Devices Tuning_Shimming documentation.

11.4.5 MAGNETIC FILED INTEGRAL MEASUREMENT

Click the **Integrator** control button in the Main Control Windows to launch the Field Measurement Control Interface window.

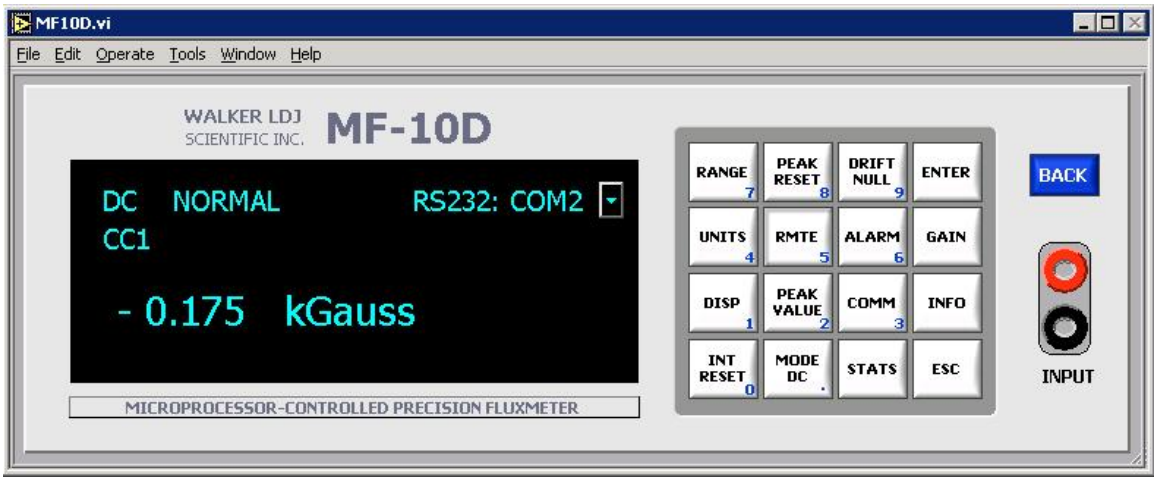


Before you click the **START** control button, the following Steps have to be completed.

Step 33. Verify that the measurement coil is connected to the MF-10D Flux Meter and the meter is powered on. Verify that the Flux Meter signal wires are connected to the PXI-4070 DMM card with the right polarity.

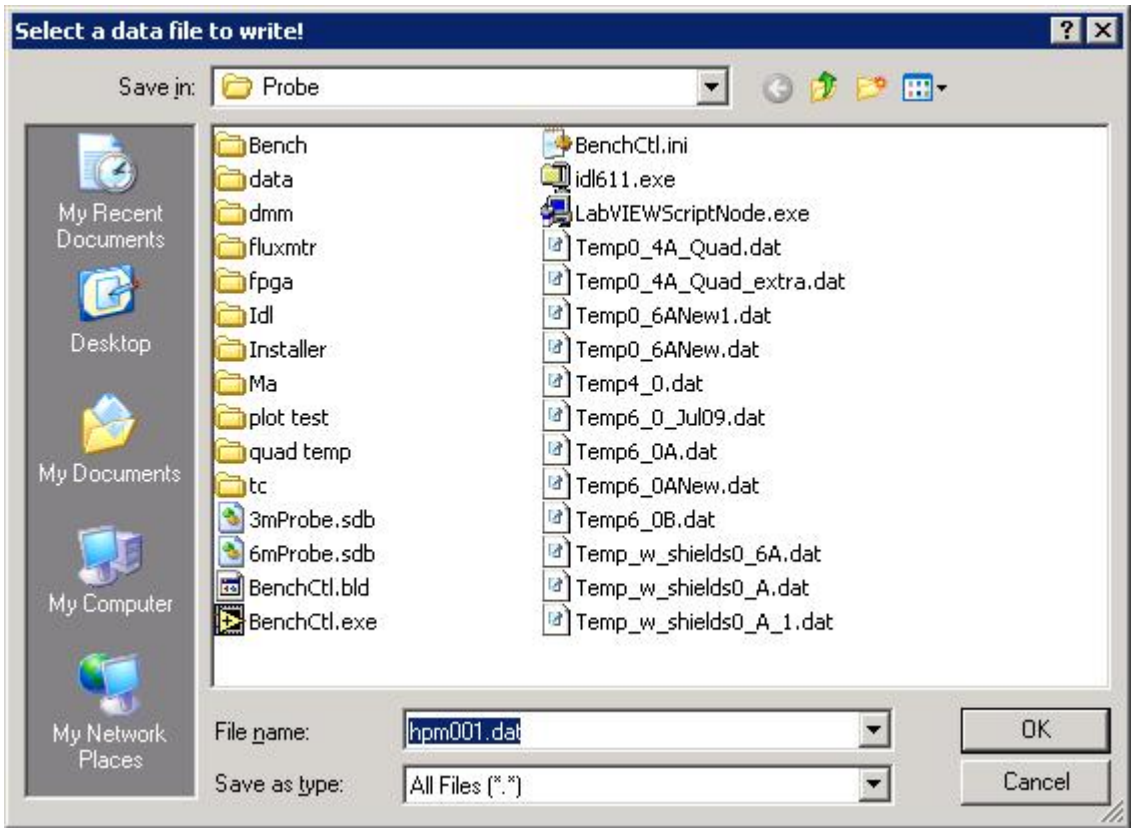
11.4.6 MF-10D PRECISION FLUXMETER

Step 34. Click the **Flux Mtr** control button in the Field Measurement Control Interface window to launch the Flux Meter Control Interface window.



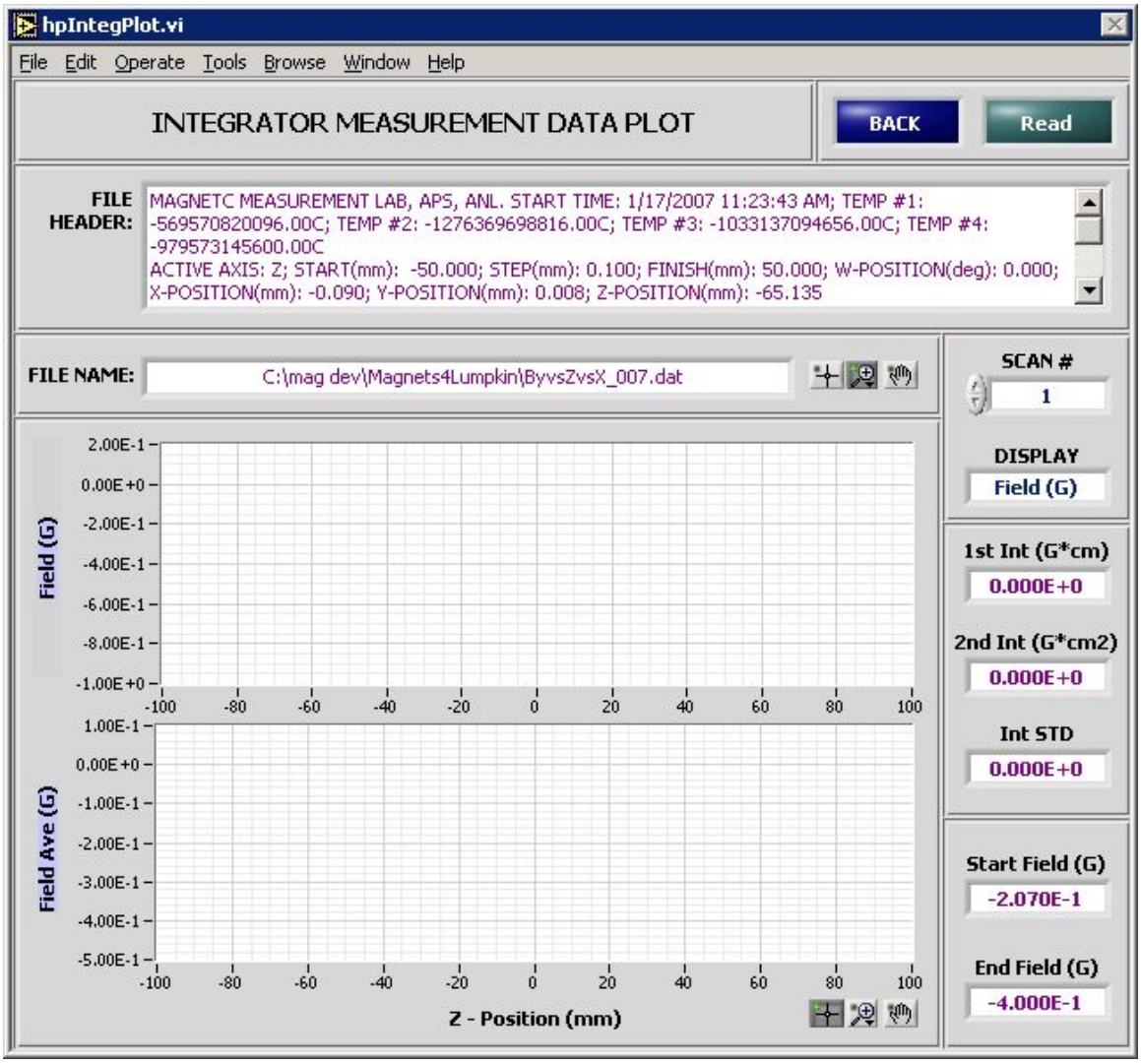
Make sure the range and the units match the coil in place. Make sure the absolute resting integral is stable (less then 0.1 kG/second). Otherwise, click **DRIFT NULL** to null the drifts. Click **BACK** to go back to the Field Measurement Control Interface window.

Step 35. Set the axis to scan, the start position, step (resolution), finish position, and number of scans, click **START** to scan. Following window launches:



Select the desired directory, enter the desired name of the file, and click OK to start the scan.

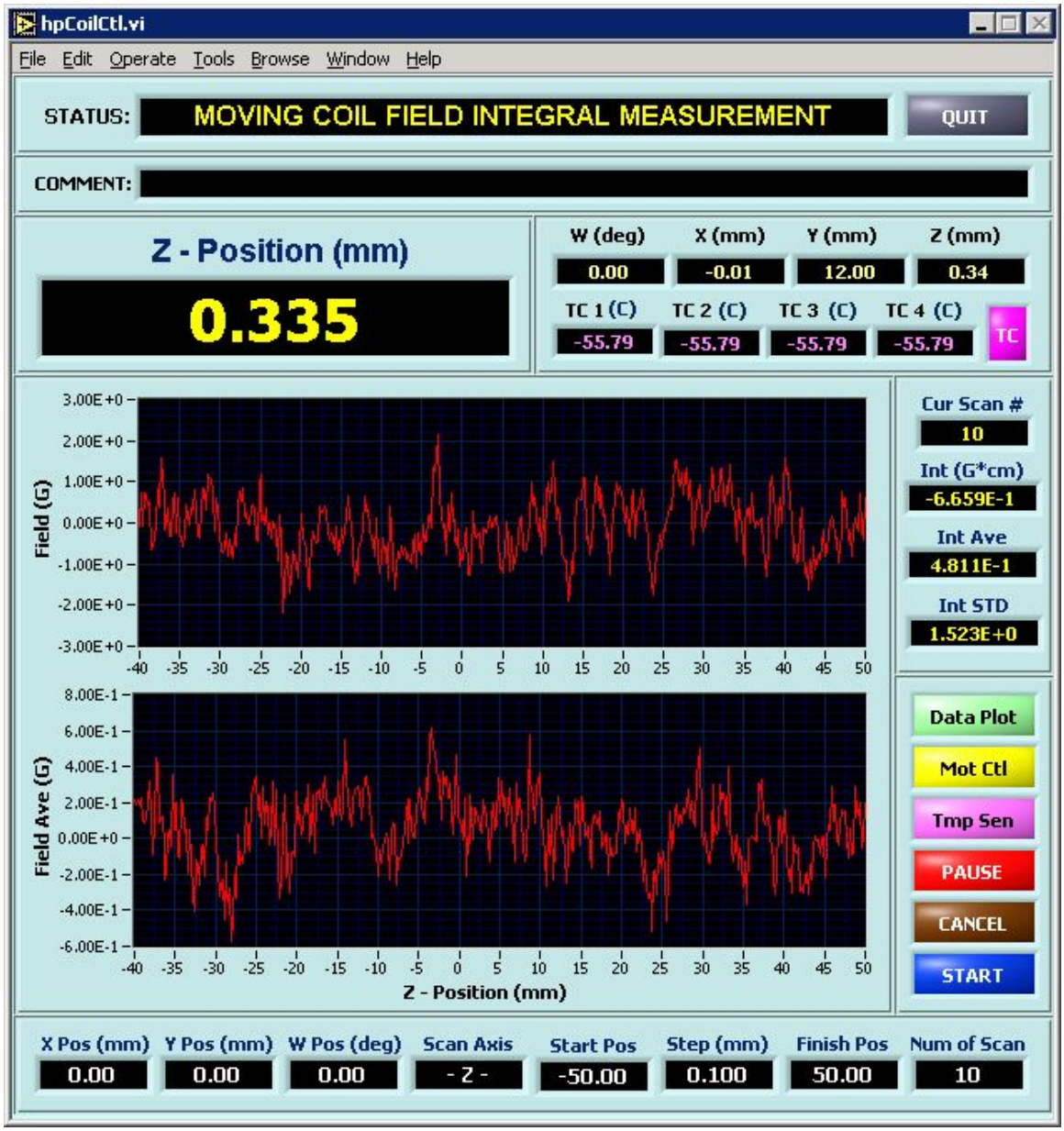
Step 36. Click the **Data Plot** control button in the Field Integral Measurement Control Interface window to launch the Control Interface window to read and plot the saved data file.



Click the BACK control button to close the window.

11.4.7 MOVING COIL MEASUREMENT

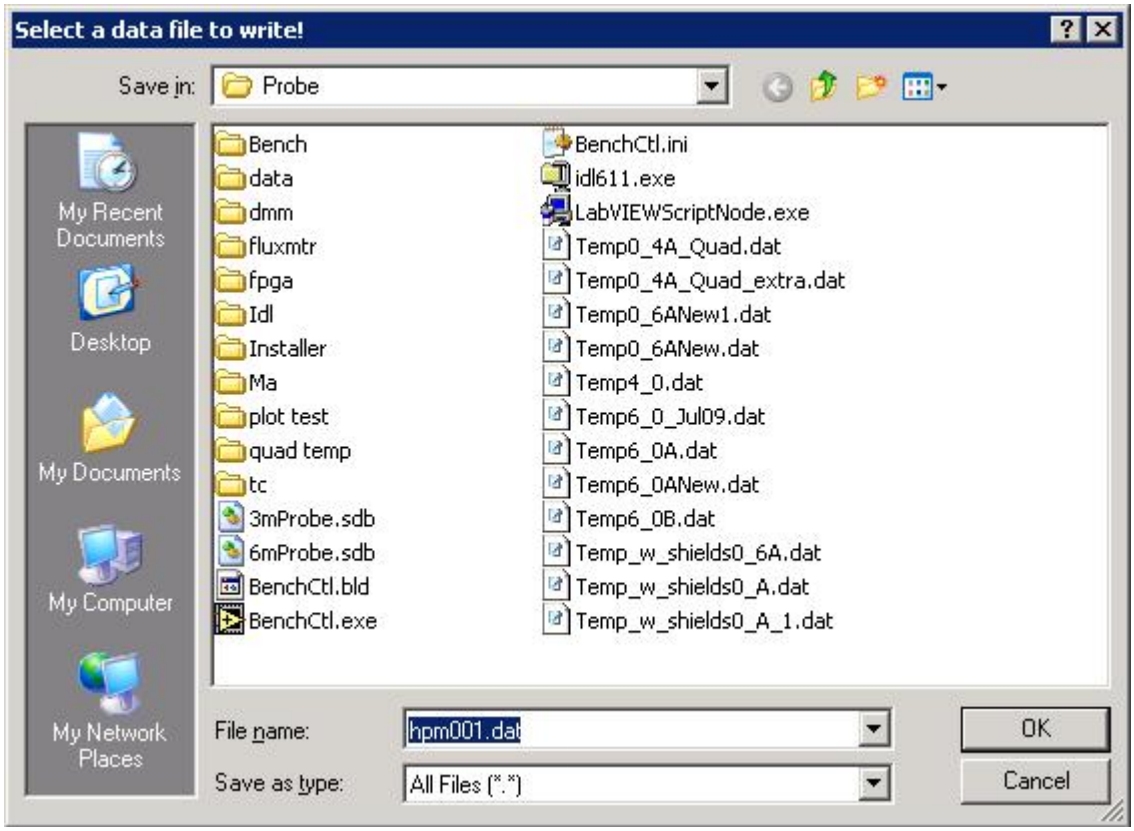
Step 37. Click the **Moving Coil** control button in the Hall Probe Measurement Control Interface window to launch the Moving Coil Measurement Control Interface window.



Before you click the **START** control button, the following Steps have to be completed.

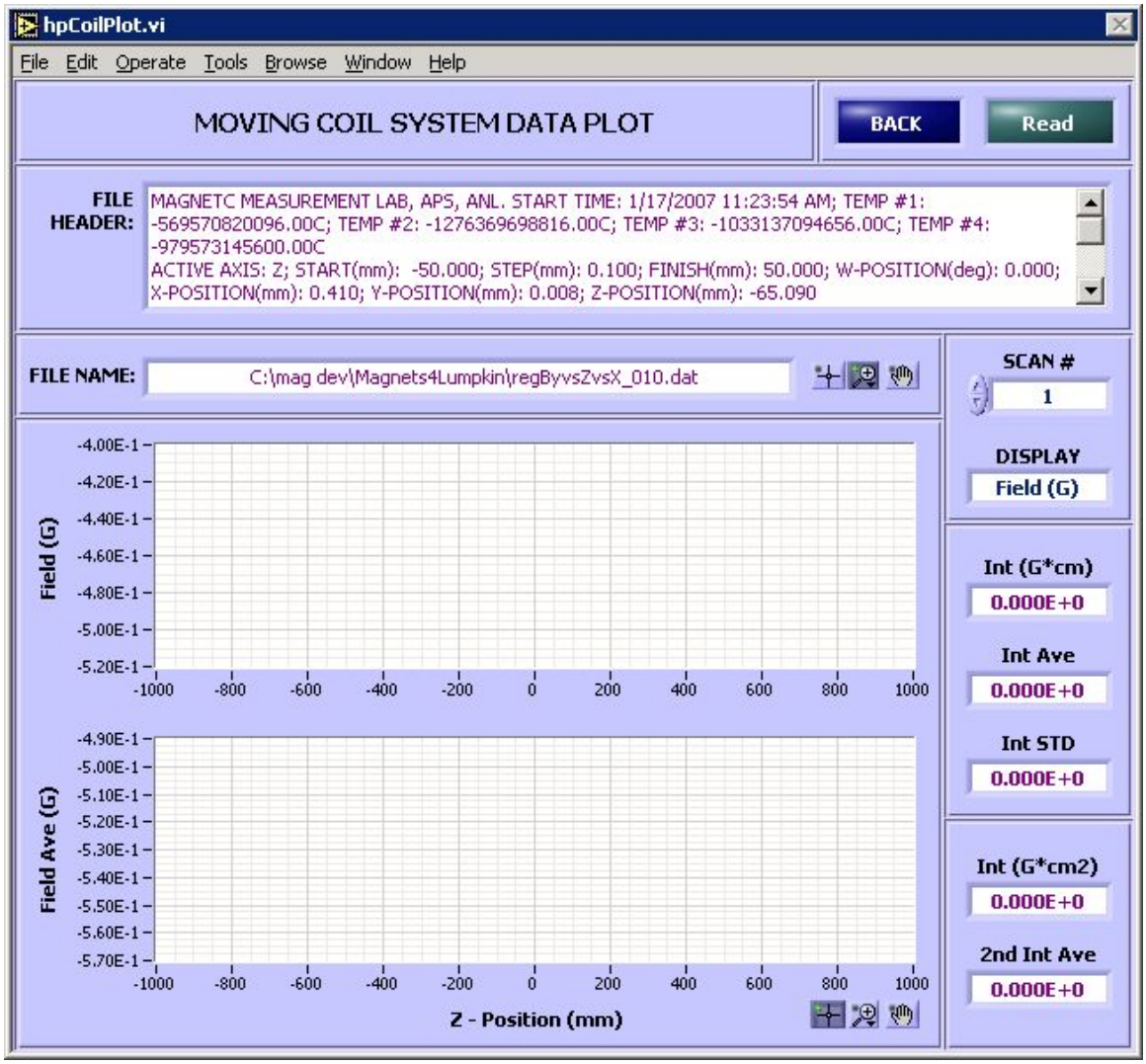
Step 38. Verify that the measurement coil is connected to the DC Pre-amplifier and the amplifier is powered on. Reset the amplifier null button to null the offset.

Step 39. Set the axis to scan, the start position, step (resolution), finish position, and number of scans, click **START** to scan. Following window launches:



Select the desired directory, enter the desired name of the file, and click OK to start the scan.

Step 40. Click the **Data Plot** control button in the Field Integral Measurement Control Interface window to launch the Control Interface window to read and plot the saved data file.



Step 41. After all the measurements, click the **BACK** control button to close the window.

12. TROUBLE SHOOTING

12.1 Magnetic Analysis Interface

In some cases, the IDL PLOT in the Hall probe system data IDL plot interface does not generate the Magnetic Analysis results. That is caused by the settings of the Magnetic Analysis IDL file ma.pro. If the measurement results of the end magnetic field strength exceeds certain ratio or the number of magnetic poles exceeds certain number, the IDL Magnetic Analysis will not proceed with the analysis. You have to consult with Roger Dejus at the APS to modify the IDL interface file to resolve the issues.

13. OPEN ISSUES

If the motor power supply gets a power recycle, the motor address will get lost. The system will pop up a window inform user that the power supply or COM port got disconnected. User has to recycle the power switch of the motor power supply and reinitialize the motor addresses by click the OK control button in the popup window.

14. ACRONYM LIST

APS	Advanced Photon Source
GUI	Graphic User Interface
ID	Insertion Device