

# SE-SPS Experiment Guide

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January 2021

## 1 Introduction

This is a small guide meant to help experimenters become acquainted with the Super-Enge Split-pole Spectrograph at FSU (SESPS or SPS). It walks through some of the basic operating principles of the SPS and how to set up a simple SPS experiment. Obviously, this document cannot cover all use cases, so be warned, your mileage may vary.

The SESPPS is a magnetic spectrograph designed to produce high-resolution energy spectra without sacrificing solid angle (read: detection efficiency). Using the Lorentz force:

$$F = q\vec{B} \times \vec{v} \quad (1)$$

and the expression for an object moving in a circle:

$$F = \frac{mv^2}{\rho} \quad (2)$$

we can write the following relation:

$$qBv = \frac{mv^2}{\rho} \quad (3)$$

With some adjustment this becomes:

$$qB\rho = p \quad (4)$$

where  $\rho$  is the bending radius,  $q$  is the charge of the particle,  $B$  is the magnetic field, and  $p$  is the magnitude of the momentum of the particle.  $B\rho$  is also sometimes referred to as the magnetic rigidity. From this relation it is clear that particles are bent according to their momentum-to-charge ratio. Thus, the spectrograph can be used to identify states from different reactions using the momentum and charge. This document outlines the operation and use of the SESPPS and some of the commonly used particle detectors in the SPS.

## 2 Rotating the Magnet

Rotating the magnet is a two person task. One person should follow the steps laid out below while the other watches the pressure gauges on the magnet to make sure that there isn't a leak. If there is a leak make sure that all isolation valves are closed and then return to the last angle which had good vacuum. If vacuum doesn't begin to return, call the person heading the experiment and/or Lagy.

- Any silicon in the chamber should be unbiased (monitor, SABRE, etc). Biases are typically provided by one of the Ortec Quad Bias Supplies located in the rack by the gas handling system. Refer to notes from the experimenter for specific channels. Additionally, any Faraday cup suppression voltage should also be turned off.
- Pull the target ladder all the way up in the scattering chamber slowly, moving too quickly risks damaging the targets
- Close fast valve 9 the end of the linac to protect rest of beam line
- Turn off the ion gauge
- At the magnet close magnet isolation gate valve, scattering chamber vacuum pump gate valve, and beamline isolation valve (in that order). Then open the turbo pump by rotating the black knob near the scattering chamber
- Now can begin to move magnet. Go to side of magnet near ladder and switch gray power box which says Ready to Move to the on position (green light should turn on). Go to motor control right next to the power box and choose which direction you want to move (they're labeled). Make sure that the speed dial isn't set above 20.
- Push and hold the red button to move the magnet. Magnet position is read on the tape measure running around the track. angles in increments of 5 degrees are marked. Use piece of metal attached to spectrograph to measure. If moving up (+) in degrees go past the desired location by a small amount (2 cm) and then move back (-) to desired position. If moving down (-) just go to the desired angle.
- Once in position turn off motor, close turbo pump, open beamline gate valve, scattering chamber vacuum pump gate valve, and then magnet isolation gate valve. Turn on the ion gauge. Place target ladder in proper position, re-bias any silicon, and then open fast valve 9. Re-apply Faraday cup suppression voltage if applicable.
- Begin running

### 3 Turning on the Focal Plane Detector (FPD)

- Close the detector bypass valve on top of the magnet (sideways green handle) and then open both detector isolation valves (two upright green handles)
- Close all To Pump valves on the gas-handling system. Set the electronic flow control valve to auto on the pressure gauge module.
- Ensure that all detector bypass valves are closed, and that the lines connecting the reservoir and the detector are open.
- Ensure that the needle valve is open to half of the first increment.
- Set the pressure knob on the pressure gauge module to the desired pressure.
- Open the isobutane tank and the gas in valve. The pressure should begin to rise slowly in both the reservoir and the detector. If the pressure rises too quickly shut the gas in valve
- Wait for the pressure to reach the desired value. Typically the system overshoots by about 10 torr before decreasing back to the setpoint.
- Once the gas pressure is stable, turn on the anode and cathode high voltage using the power supply module located on top of the magnet (module with the little screen). Wait for yellow lights to stop blinking.
- Turn on the scintillator power and the preamp power.
- Turn on any bias going to the scattering chamber.
- Open the magnet isolation valve.
- Begin experiment.

### 4 Turning off the Focal Plane Detector (FPD)

- First turn off both anodes and the cathode. This is done by pressing the off button on the first three channels for the FPD power supply. The supply is located in the rack on the top of the spectrograph in a gray box with a small screen. While the yellow lights on the power supply are blinking the high voltage is being reduced. **WAIT UNTIL THE LIGHTS STOP BLINKING TO PROCEED.**
- Turn off the scintillator power supply, as well as any bias for the scattering chamber.
- Close the magnet isolation gate valve (reference the section on Rotating the Magnet for a location) to prevent gas from flowing up the beam line in the event of a blown window

- Now go to the gas handling rack at by the detector end of the splitpole. First close the isobutane tank valve to stop the flow of isobutane into the detector. Then close the valve labeled "Gas In" at the upper left of the gas handling.
- Now close the electronic flow control valve. The valve control is located on the pressure gauge module on the gas handling system. The flow control valve knob should be moved from auto to close.
- Close the valve connecting the reservoir to the detector
- Open the To Pump Valve at the top of the handling system to empty the lines leading to the reservoir. Neither gauge should show a change in pressure.
- Open the To Pump valve connected to the reservoir. The gauge on the gas-handling system should go to 0 very quickly. The gauge on the top of the spectrograph should not change.
- Very slowly open the "To Pump" valve at the bottom of the gas handling system. You should now begin to see the pressure gauge drop on the top of the magnet. The pressure should be taken down slowly to avoid rupturing the mylar window. Flow out at approx. 1 torr/second. Continue opening the valve to maintain flow rate.
- Now close the two upright detector isolation valves on the top of the spectrograph (two upright green handles), then open the detector bypass valve (green handle on its side next to the isolation valves).
- Go check the magnet pressure gauge on the other side of the magnet; if the pressure has gone above  $10^{-3}$  torr, call Lagy
- If the magnet pressure has only gone up into the  $10^{-4}$  torr range and is decreasing, the detector has been safely emptied.

## 5 Turning on the Magnet and Changing the B-field

- To turn on the magnet go to the back side of the spectrograph and locate the magnet power supply (large blue thing)
- Turn the power supply on and set the AC state to 1. If the water system interlock trips, set the AC back to 0 and then back to 1. Repeat as needed.
- Set the current to the appropriate value using either the number pad or the dial. There is a graph relating power supply current to magnetic field strength on the supply.

- To get an exact measurement of the field, use the NMR probes and the field module, which should have an oscilloscope connected. The module is located in the top bin in the rack next to the power supply. The NMR probes are located on next to the ladder on the spectrograph. If the field is less than 9 kG use the low field probe. Otherwise use the high field probe.
- To measure the field, set the field module to manual mode and slowly adjust the field value until you begin to see the characteristic resonances. Then set the module to lock and make sure the resonances don't disappear. Use the graph of field to current as a guide for the starting point. Then the field displayed by the module is the field in the spectrograph.

## 6 Using SABRE and the Digitizers

SABRE is the silicon array in the splitpole scattering chamber. Due to the large number of channels to be read out, the data is collected from SABRE (and the focal plane detector) in CAEN digitizers.

- To bias SABRE, first ensure that the scattering chamber is at stable vacuum and that the aluminum foil cover is in place over the view port into the scattering chamber.
- Next, the bias supplies are located in the rack next to the gas-handling system. There are two Ortec quad bias supply modules, with tape labeling active channels (1-5). Each of the 5 channels should be set to  $-60\text{V}$  (use the 100V scale). Slowly increase the bias, and at  $-10\text{V}$  check the leakage current on each channel to ensure that they are not significantly outside standard operating values, which are given below:

Channel 1:

Channel 2:

Channel 3:

Channel 4:

Channel 5:

- Leave the bias supplies set to show the largest leakage current in each module. There will be a camera displaying to a monitor in the control room. If the leakage current significantly exceeds standard operating values, stop the beam and contact either the experimenter or Lagy.

- A sixth bias is given (the channel below 2) for the target ladder, which is set to 600V (use the 1kV scale).
- Unbiasing SABRE and the target ladder is straightforward; just slowly reduce each channel until it reads 0V on the bias supply.

The following outlines cycling the power to the digitizers:

- If for some reason the CoMPASS software crashes and cannot be restarted, the power to the digitizers will most likely need to be cycled. To do this first make sure the CoMPASS program is completely killed. Also, make sure that all of the fans in the rack are on and operating
- Then locate the red crate in the rack by the gas-handling system that contains all of the digitizers. Turn this crate off, wait for 5 sec, and then power back on.
- Try to reload the CoMPASS acquisition using the steps outlined in the Spectrograph Data Acquisition section. If this fails again, call the experimenter.

## 7 Spectrograph Data Acquisition: CoMPASS

Data from the splitpole is recorded on the computer located out on the desk by the gas-handling system. While running an experiment, one starts the data acquisition in the control room using the following steps:

- Open a terminal on the computer in the control room. Enter the command

```
vncviewer 128.186.111.203:5901
```

The password is 14Nalpha. This opens a view port into the splitpole acquisition computer from which you will operate.

- In the view port open a terminal and run the command (which can be tab completed)

```
CoMPASS
```

which will open the CoMPASS environment

- Open the project environment by using the load button and selecting the current experiment directory. This will load all of the appropriate digitizer settings and controls.

Experiment directory:

- Before starting the acquisition, the sync wizard must be run. Located under the sync tab, and select the sync wizard. The only page which requires input is the method by which signal propagation is performed (page where a diagram of signal connections are shown). From the drop down menu select the TRIG OUT SYNC IN option. All of the other pages don't need any modification.
  - To begin data acquisition switch to the acquisition tab of the CoMPASS gui, and first ensure that it is set to List Mode and not Waves. Next make sure the name follows the `run_#` format, and if you wish to write the file select to write UNFILTERED data. Double check that the data format is selected to be BIN (binary). Then click the green run arrow at the top of the gui.
  - At the bottom of the CoMPASS window, there is a dialog indicating that the acquisition is starting. Wait until the cancel button next to the dialog becomes un-grayed to press the start button on the gate generator in the control room (blue module, only one in its bin)
  - Now the acquisition should be running. To ensure that data is coming you can check the statistics tab, which will show the data rate on each digitizer which should have approximate rates as outlined below:
- 
- You can also monitor the histograms in CoMPASS, of which there is a simple counting spectrum for each channel. To clear the histograms click the brush icon at the top of the window.
  - To stop the run, press the stop button in the CoMPASS program (red box) and then press the stop button on the gate delay generator.

## 8 Spectrograph Data Analysis

Due to the online analysis limitations of CoMPASS, along with computational resource limitations while running CoMPASS, basic analysis will need to be performed in a separate program after data is collected while the CoMPASS acquisition is not being run. The following are instructions for running this analysis.

- In the view port to the splitpole acquisition computer open a new terminal and move to the event builder directory using

```
cd ~/GWM_EventBuilder/
```

- Typically, the experimenter will be using the GUI version of the event builder. To run this simply run the command

```
./bin/GWMEVB
```

which will launch the event builder. The configuration can be loaded using the File menu and selecting Load. This will open a dialog window asking you to either select an input from the file viewer or type one in yourself. The file for the current experiment is:

- Once the configuration is loaded, select an operation type. The typical pipeline is to first run ConvertSlowA and then run Plot, although specifics may vary experiment to experiment (see notes)
- Check the histograms specified by the experimenter to ensure that the data is coming in properly.
- If the analyzer seg faults or runs into some other error, check to make sure that the files are specified correctly. If the input file seems correct, then one easy thing to try is to rebuild the program. To do this run the following commands:

```
make clean  
make
```

and then reopen the event builder gui. If it still isn't functional, or if something doesn't seem to match up, contact whoever is running the experiment.

## 9 FAQ

- **What do I do if there is a detector spark?**  
Go to the focal plane detector power supply (see Figure 5). Use the menu button and the selection wheel to select the control menu. Go to the Clear All Events option and select Yes. Turn the high voltage back on for the sections that tripped. Wait to see that the power is stable (yellow light stops blinking).



## 10 Experiment Notes

## 11 Appendix: Figures

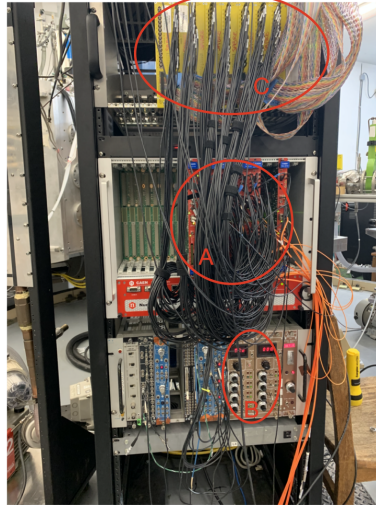


Figure 1: SPS electronics crate A) CAEN Digitizers and Crate B) Ortec Power Supplies C) MDU Modules (for use with SABRE)

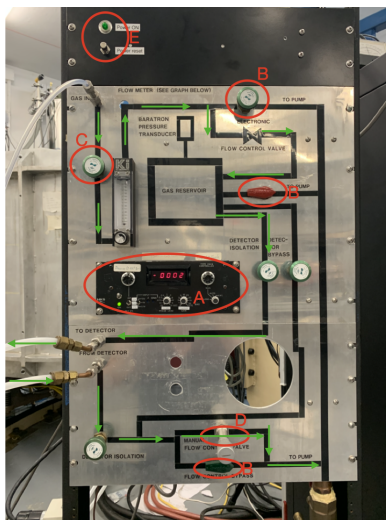


Figure 2: FPD gas-handling system controls. Green arrows indicate direction of flow during normal operation. A) Gas Reservoir pressure gauge and control module B) Flow control by-pass (To Pump) valves C) Gas-In valve D) Needle valve E) Power indication light and switch



Figure 3: NMR Probe Readout and Settings A) Probe control and readout module B) Oscilloscope for viewing waveforms



Figure 4: SPS Magnet power supply and control panel

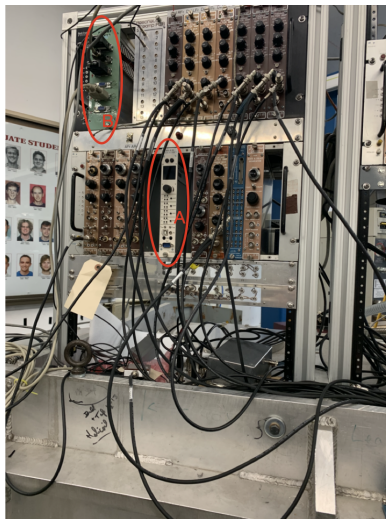


Figure 5: FPD electronics crate on top of magnet. A) FPD power supply (anodes and cathode) B) Pre-amp power supply

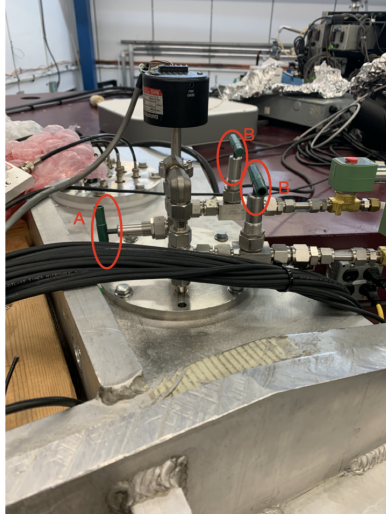


Figure 6: Gas valves on top of magnet. A) By-pass to magnet B) Detector isolation valves

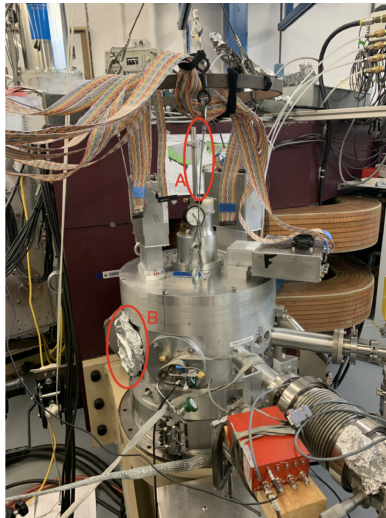


Figure 7: SPS Scattering Chamber Front-view A) Target ladder B) Viewport (covered in foil)

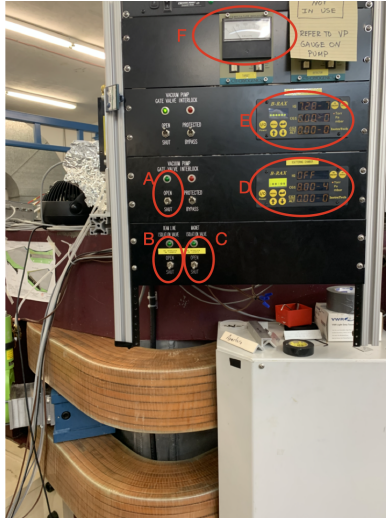


Figure 8: SPS Vacuum Controls and Readout A) Scattering Chamber Cryo-pump gate valve B) Beamline gate valve C) Magnet gate valve D) Scattering chamber pressure gauge readout and power switches E) Magnet pressure gauge and power switches F) Scattering Chamber Cryo-pump temperature

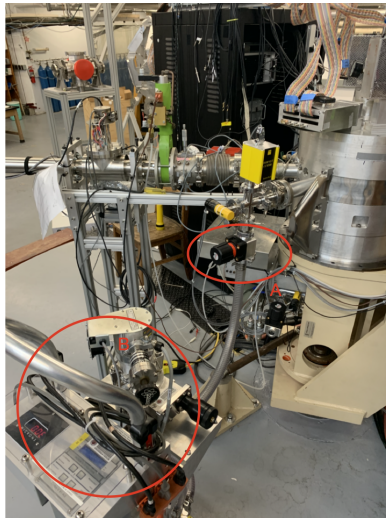


Figure 9: SPS Scattering Chamber Side-view A) Hand-valve to pumping cart B) Pumping cart (turbo and roughing pump)



Figure 10: Magnet Motor controls A) Motor power B) Speed and direction control C) Angle readout