

## I. Standard Configuration

#### A. General

The Radio Frequency Fragment Separator (RFFS) is a filtering device intended to enhance the purity of radioactive beams produced via projectile fragmentation, in particular on the protonrich side of the valley of stability. It is presently located in the combined S1/S2 vault, on the Gline and can therefore only be used with experiments set up at the end of this beam line. The RFFS device is composed of two parts described in the following.

#### 1. The RF cavity

- The RF cavity is about 1.5 meters long, its deflecting horizontal plates are 5 cm apart. The maximum operating voltage is 100 kV, the phase can be adjusted continuously.
- The coarse tuners of the cavity have to be pre-adjusted depending on the RF frequency of the cyclotrons. Because the cavity heats up when high voltage is applied, a compensating feedback loop regulates the frequency by adjusting the fine tuner and eventually the coarse tuners if the range limit of the fine tuner is reached.
- The particles are deflected in the vertical direction by the electric field applied between the deflector plates, and later refocused onto vertical slits located in the downstream focal plane where the selection actually occurs.
- When operated at its nominal 100 kV voltage, the cavity emits a significant amount of x-rays, therefore the perimeter around has to be secured. This is accomplished by closing the S1 door, and securing the S1 area using the yellow chain located at the S1/S2 boundary. A purple flashing light indicates the presence of the radiation, which is also monitored.

## 2. The focal plane

- Located downstream of the cavity and two quadrupole doublets, the focal plane contains the vertical slits where the filtering actually occurs, as well as a detection system used for adjustment and identification of the composition of the radioactive beam.
- The detector system is composed of two Parallel Plate Avalanche Counters (PPAC) located on either side of the selection slits, followed by a plastic scintillator and a Silicon detector stack next to a reentry can.
- The PPACs are used to measure the position of the particles and optimize the focussing at the slit location.
- The plastic scintillator gives a time signal used for time-of-flight measurement, and the first detector of the Silicon stack measures the energy loss for particle identification.
- Depending on the characteristics of the particles being transmitted, the Silicon stack can be configured to stop the ions in the last detector, so that gamma-rays emitted shortly after implantation can be detected via a Germanium detector inserted in the reentry can.



- This allows an unambiguous identification of the nuclei in regions where short-lived (microseconds) isomer are present.
- Each of these detectors can be inserted independently in the beam.
- Following the focal plane are two quadrupole doublets used to transmit the purified beam to the experimental station. They are also used to shape the beam spot desired at the experimental station, depending on the experimental requirements.

## **B.** Optics

The optics of the G-line is tailored to optimize the filtering provided by the RFFS. In particular, the deflection in the RF cavity is maximized by making a parallel beam inside the cavity, while the following two quadrupole doublets rotate the emittance by 90° to convert the deflection angle into a deflection vertical position at the slit location.

The two quadrupole doublets following the focal plane are normally set to a point to point configuration in order to focus the beam at the experimental station. As mentioned in the previous section, this optics can be altered to adjust the beam spot size depending on the experimental requirements.

A number of small steerers are also installed along the G-line, to fine adjust the centering of the beam. In particular, the vertical and horizontal steerers located between the two last quadrupole doublets are used to center the beam spot on the experimental station.

## C. Electronics

The electronics of the RFFS is based on a Mesytec MSCF-16 module which provides the functions of Timing Filter Amplifier (TFA), Constant Fraction Discriminator (CFD) and Shaping Amplifier (SA) for 16 channels. The two PPACs, Silicon detectors and Germanium detector use 13 channels of this module. The timing scintillator uses a conventional CFD. The MSCF-16 is equipped with a USB port for controlling the various settings of the module. A program running on the data acquisition computer allows to control the parameters in real time. An inspect channel patched to the Data-U is used to monitor the various signals.

## **D.** Data acquisition

The data acquisition is performed in a single CAMAC crate equipped with a USB controller (CC-USB) from Wiener electronics. The data acquisition runs on a Mac mini directly connected to the CC-USB via a USB cable. The data acquisition software is not based on the standard NSCL package, but rather on a Tcl interpreter for which a specific Application Programming Interface (API) has been developed. The data provided by this readout software complies with the NSCL event and buffer format standards, and is routed to the network via a socket within the Tcl interpreter. Runs can be recorded on disk, and are readable by the appropriate version of SpecTcl.

Unlike for the S800 Spectrograph or Sweeper devices, the data stream from the RFFS focal plane is not intended to be part of the experiment. Much like in the case of the A1900 focal plane, the



RFFS focal plane data is solely used to adjust the parameters of the device and control the composition and purity of the transmitted radioactive beam.



## **II. Support level**

#### A. General

- The NSCL support level of the RFFS involves the 3 standard phases of an experiment: preparation, running and analysis.
- The support provided during these phases covers only the standard configuration (described above). Any modifications or additions are under the sole responsibility of the users.
- The device and beam physicists responsible for the RFFS provide the following support:
  - Answer technical questions for users during the preparation of experiment proposals
  - Train users in operating the device prior to the experiment.
  - Provide access to the data taken on the focal plane data acquisition during the device tuning phase of the experiment.
  - Ensure the proper functioning of the device as specified in the standard configuration.
  - Perform device setting changes as required by the experiment.
  - Provide emergency support during the experiment to ensure proper functioning of the device.
  - Assist users in inspecting and understanding the characteristics of the radioactive beams delivered to their experimental station.
  - Assist users during the off-line analysis phase.
- Some tasks, such as venting or pumping the focal plane, are always the responsibility of the device or beam physicists.
- Users are expected to become proficient in and perform others tasks after proper training. They include the following:
  - Change the phase setting of the RF cavity.
  - Change the setting of the vertical slits located in the focal plane.
  - Operate the security systems used to secure and deliver beam in the vault.

## **B.** Details

#### 1. Device support coverage (Experimental Device Tuning or XDT)

- Device support for working days is limited and runs only during normal hours (from 8:00AM to 5:00PM).
- Due to limited personnel resources, evening support (5:00PM to 12:00AM) can be planned in advance provided the users schedule it and inform the device or beam physicists at least one day in advance.



- Emergency support (on call duty) is provided from 12:00AM to 8:00AM and during non-working days. For all emergency support, users are required to first inform the Operator in Charge, who will then decide to call the device or beam physicist for help
- In case a device or beam physicist is also one of the experimenters, his/her research time can also be allocated to device support.

#### 2. Training time estimates

- This training is offered once per experiment, at a pre-arranged time that suits the experimenters' convenience.
  - Change of the phase setting: 1/2 hour
  - Change of the vertical setting: 1/2 hour



#### **III.User responsibilities**

- We expect an active involvement of the experimenters *during the setup and preparation* of the experiment to become familiar with the device.
- For each experiment, a student, postdoc or faculty member is expected to be at the NSCL 2 days in advance of the experiment (or the first run of the "campaign" the experiment is scheduled in) to actively participate in the setup and shake down.
- This is intended to give the experimenters the opportunity to gain the necessary experience with the RFFS.
- Time estimates for training offered by the device and beam physicists are outlined in the "support level" section.
- We stress that this training is a necessary requirement for users to be able to run shifts and actively and safely participate in experiments using the RFFS.
- The experimenter in charge is expected to:
  - Document changes in running conditions and actions taken by experimenters
  - Inform the device or beam physicists immediately in case of abnormal occurrences observed in the operation of the device
  - Check the quality of the incoming data according to the device or beam physicist's and spokesperson's instructions
  - Perform changes as instructed during training
- The spokesperson of the experiment is expected to:
  - Communicate the points outlined above to their experimenters in charge
  - Take the leading role in decision making during the running phase of the experiment
  - Discuss necessary changes to the experiment with the device or beam physicists in a timely manner
  - Schedule changes in the device setting in advance and in coordination with the device or beam physicist
  - Check the integrity and quality of the incoming data and instruct the experimenters in charge how to do so
  - Make tape copies of the data immediately after the end of the experiment
- We recommend that the device or beam physicist be consulted for technical questions during the preparation of the proposal and during the planning of the experiment several weeks in advance of the run.