Sweeper Magnet Service Level Description

FRIB-S30206-RC-007320-R001

Issued 25 March 2021

Prepared by

3/25/2021

X

Thomas J. Baumann
Beam Staff Physicist
Signed by: baumann

Reviewed by

3/25/2021

X

Jorge Pereira
Research Staff Physicist
Signed by: pereira

Approved by

3/29/2021

X

Georg Bollen
Experimental Systems Division Director
Signed by: bollen

Concurred

3/25/2021

X

Jill Berryman
Manager for User Relations
Signed by: berrymaj

Concurred

3/26/2021

X

Antonio Villari
Scientific Instrumentation & Experimental Areas ...
Signed by: villari

Table of Contents

Revision History

Revision	Issued	Changes
R001	25 March 2021	Original Issue

Authorizing Document

None.

Authorized Documents

None.

Authorized Committees and Boards

None.

Named Program Roles

None.

1 Objective

This documents describes the level of service FRIB will be able to provide for the operation of the Sweeper Magnet and for user support for this scientific instrument.

2 Abbreviations

DAQ: Data acquisition system

Data-U: Data-analysis users area

DC: Drift chamber

FRIB: Facility for Radioactive Beams

GUI: Graphical user interface

LISA: Large multi-Institutional Scintillator Array

MoNA: Modular Neutron Array

SLRD: Service level and responsibilities description

Tm: Tesla-meters

3 Sweeper Magnet Overview

The Sweeper is a large gap, large rigidity open dipole magnet designed for experiments using radioactive beams produced by projectile fragmentation. Its main purpose is to sweep charged particles away from 0° while letting neutrons continue their path to a secondary detector. For this reason, it is primarily used in tandem with the MoNA/LISA neutron detector array. However, it could be used either in standalone mode or with other types of secondary detectors as well, such as light charged particle detectors.

4 Standard Configuration

4.1 Physical Configuration

The fragments deflected by the Sweeper enter a “focal plane” box similar to that of the S800, containing the same set of position, energy loss and timing detectors. The information gathered from these detectors can be used for particle identification and tracking. The maximum nominal magnetic field of the Sweeper is 4 Tesla corresponding to the maximum rigidity of 4 Tm (radius is 1 meter), based on the original bending angle of 43°. A planned modification of the bending angle to 30° would increase the magnetic rigidity to about 5.4 Tm.

The solid angle and momentum acceptances of the Sweeper can vary depending on the longitudinal location of some of the focal plane detectors, which are mounted on a rail system. The first position detector always stays as close as possible to the focal plane box entrance, whereas the others are moveable at a distance ranging from 32 cm to 140 cm. The optimum location of the detectors depends on the experimental goals, and is always a trade-off between resolution and acceptance. At the location corresponding to the largest acceptance (32 cm), the solid angle and momentum acceptances are 36 msr and 30 % respectively, whereas they are reduced to 11 msr and 15 % at the location corresponding to the highest resolution (140 cm).

The beam line upstream of the Sweeper is equipped with tracking detectors aimed at the determination of the positions and angles of the incoming particles on the target. This determination is not straightforward though, as several quadrupole lenses are also located on the beam line and need to be taken into account in the calculations.

4.1.1 Trajectory Reconstruction

The Sweeper magnet is not equipped with high-order magnets to correct aberrations. The aberrations introduced mostly by the fringe fields and non-uniformities of the dipole magnet are calculated based of measured field maps, and corrected for analytically (inverse-map calculations). This method avoids tracking of each individual particle in the magnetic fields of the spectrograph, and therefore faster data processing. .

4.2 Detectors

4.2.1 The Target Station

The target pot of the Sweeper contains a thin plastic scintillator (420 μm) for time-of-flight measurements. This detector can be left in the beam during experiments and can withstand rates of up to 1 MHz. Other thicknesses might be available upon request. It is also possible to install other types of detectors in the object box, such as Si pin detector for energy loss measurement. Installation and integration of these optional detectors are under the responsibility of the user, and require coordination with Sweeper device scientists.

4.2.2 The Beamline

The beamline upstream of the target station can be equipped with two 10 cm x 10 cm tracking Parallel Plate Avalanche Counters that provide measurements of positions and angles in both the dispersive and non-dispersive planes. Maximum rates of up to few hundreds of kHz are possible. Best detection efficiencies are achieved for particles with Z>10.

4.2.3 Focal Plane Station

The Sweeper focal plane is equipped with various detectors for trajectory reconstruction as well as particle identification.

Tracking detectors

Two tracking drift-chamber (DC) detectors, with an active area of ± 15 cm by ± 15 cm, are used to measure the positions and angles in the focal plane. Each tracking DC has a position resolution of about 0.5 mm in both dispersive and non-dispersive directions. The detectors can be used with count rates up to 5,000 counts per second.

Particle identification detectors

Downstream of the two tracking DC detectors are the ion chamber for energy loss measurement, followed by a large thin plastic scintillator.

- The tracking DC detectors require at least the timing scintillator functioning to provide a time reference to measure the drift time of the electrons. The timing resolution for a point-like beam spot in the focal plane is around 400 ps. This resolution deteriorates with increasing size of the illuminated area of the focal plane.
- The ion chamber is able to separate elements up to Z=50, after momentum and position corrections are applied.

4.3 Electronics and Data Acquisition

4.3.1 Detector Electronics

The Sweeper detector electronics and data acquisition is based on VME and CAMAC electronics. The dead time of the Sweeper DAQ is ~20% at trigger rates ~2000 pps. The Sweeper detector electronics is installed in a dedicated rack in the S2 vault. The electronics is full responsibility of the Sweeper device scientists. Logic and linear signals from the Sweeper detectors can be sent from this rack to different experiment areas (target station and Data-U) so that users can include them into their experiment electronics. This requires coordination with the Sweeper device scientist.

4.3.2 Sweeper Trigger Module

The standalone Sweeper trigger logic is used in "slave" mode and simply route the MoNA/LISA master trigger to the various gate generators. This module provides 4 inspect channels routed to the Data-U to visually check the timing of the signals throughout the trigger module.

4.3.3 Sweeper Data Acquisition

The DAQ software is based on the standard NSCLDAQ system. The formatted events from the Sweeper data stream can be immediately processed by the supported Sweeper back end software package (scalers, SpecTcl, event dumper…).

4.3.4 Merging of Sweeper DAQ with Ancillary DAQs

The FRIB data acquisition system provides means to combine various devices together in event driven streams of data. The merging of ancillary DAQs with the Sweeper DAQ is the responsibility of the users. If necessary, support from the Sweeper-Magnet device scientists should be explicitly requested.

4.4 Analysis Software and Tools

4.4.1 Sweeper Analysis Software

The standard Sweeper data analysis software is based on SpecTcl. It is kept on a remote git repository and available to users upon request to Sweeper device scientists. The development of analysis software for ancillary data acquisition systems merged with the Sweeper DAQ is under the responsibility of the users. Support from Sweeper device scientists should be explicitly requested.

4.4.2 Dedicated Software for Sweeper Operation

All Sweeper software is restricted to be used by device and beam scientists, as well as trained users for some of the functionality.

In standard configuration, this comprises the following controls applications:

- Full CSStudio tuning page, needed to tune the Sweeper beamline and change magnetic settings
- Knob-control box software
- NCS applications (PanelMate, ChannelLog, etc.)
- High Voltage control GUI
- Gas Handling system GUI
- Trigger control via a GUI
- Constant Fraction Discriminator GUI

- Sweeper scalers
- Sweeper standalone SpecTcl
- Readout GUI for Sweeper data acquisition

4.4.3 Sweeper Configuration Files

The configuration of the Sweeper data acquisition is stored in configuration files located in the Sweeper account (/user/sweeper/sweeperdaq/Configurations). It is possible to automatically copy these configuration files alongside the "raw" and "formatted" data files for each run of a running experiment. This requires coordination between users and Sweeper device scientists.

4.5 Ancillary Systems

In the present standard configuration, the Sweeper is run in tandem with the MoNA/LISA array as secondary detector. Because of timing constraints in the MoNA/LISA array, it is preferable to generate the master trigger in MoNA and use the Sweeper trigger in slave mode. For other secondary detectors, this situation could be reversed and the master trigger could be generated in the Sweeper trigger module.

5 Instrument Support Level

5.1 Support by Device Scientist

FRIB provides support of Sweeper by a device scientist. Setup of the instrument will be coordinated by the device scientist. On-site support is normally available from 9 a.m. to 5 p.m. on working days. On-call support for critical technical assistance during the experiment outside of the normal working hours can be requested by contacting the operator in charge (OIC), who will then contact the device scientist on call.

The FRIB support level of the Sweeper magnet involves the 3 standard phases of an experiment: preparation, running, and analysis. The support provided by laboratory staff during these phases covers only the standard configuration (described above). Any modifications or additions are under the sole responsibility of the users.

The device scientists responsible for the Sweeper provide the following support:

- Answer technical questions for users during the preparation of experiment proposals.
- Provide software packages necessary for using the Sweeper data acquisition and data analysis.
- Ensure the proper functioning of the device as specified in the standard configuration.
- Perform device setting changes during the experiment as required by the experimenters.
- Provide support during the experiment to ensure proper functioning of the device.
- Assist users in inspecting and understanding the on-line data from Sweeper detectors.
- Assist users during the off-line analysis phase.

5.2 Additional Support

Sweeper-magnet device scientists can train users to operate part of the Sweeper equipment. Training sessions are offered once per experiment, at a pre-arranged time with the experimenters. Offered training segments (with training durations) include

- Target change: 1/2 hour.
- Installation of camera in target area: 1/2 hour.
- Tracking DC detectors calibrations (use of masks): 1/2 hour.

- Operation of Sweeper DAQ and Sweeper SpecTcl analysis software: 2 hours.
- Diagnostics and monitoring using Sweeper SpecTcl: 1 hour.
- Securing the vault: 1/2 hour.
- Basic DAQ troubleshooting procedures: 1 hour.
- Basic operation of drives (e.g. masks, gate valves, beam blockers, etc.): 1/2 hour.
- Recording of setting savesets and calculation of inverse maps (see section 4.2.2): 1/2 hour.

6 Additional Instrument Support not Covered in this Service Level Description

Any request for support not covered in this SLRD should be submitted to the FRIB Manager of User Relations prior to the submission of an experiment proposal for pre-approval.