A1900 Fragment Separator and High-Energy Beamline Service Level Description

NSCL experiments generally fall under one of two categories: (a) experiments based in the A1900 Fragment Separator and (b) experiments based downstream from the A1900. Almost all experiments, therefore, are users of the A1900, and many are also users of the high-energy beamlines. Rare-isotope beam development is the responsibility of the NSCL for experiments based downstream of the A1900 and of the user for experiments based in the A1900.

This document describes the level of support provided by the NSCL to A1900 and high-energy beamline users and outlines user responsibilities with respect to these systems. This information is presented in three sections:

I. Standard Configuration
II. Support Level
III. User Responsibilities

Because the A1900 is at the heart of NSCL operations and must maintain readiness to serve all NSCL experiments, a conservative operational philosophy necessarily governs A1900 use.

I. Standard Configuration

The A1900 group makes available the detector and hardware options listed below as part of the standard configuration for experiments based within the A1900 and for carrying out fragment development for experiments based downstream of the A1900. The items marked with an asterisk (*****) are compatible for use in experiments based downstream of the A1900.

The A1900 group can accommodate experiments with needs different from what is covered by the standard configuration. Since the time required for setting up a non-standard configuration prior to an experiment and for restoring the standard one after the experiment prevents the facility from serving other experiments, PAC approval for the adequate time required to modify and restore the standard configuration is necessary so that the benefits of the configuration change to the experiment can be weighed against the cost to the facility in terms of serving other experiments. Examples of configuration changes that require significant time investments are

- Modifications to vacuum chambers
- Installation/testing/debugging/removal of non-standard detectors – particularly if they displace standard detectors/hardware
- Major additions to the A1900 electronics/readout/acquisition

Experimenters should contact the A1900 group via the A1900 device contact for information and assistance when planning experiments that require changes to the standard configuration.

Some tasks associated with A1900 setup are always the responsibility of the A1900 group. Examples of such tasks include production target changes and the venting and pumping of certain vacuum chambers.

Target Position:

- Remotely retractable Faraday cup*****
  - **Purpose:** off-line beam intensity monitor
  - **Profile:** circular, 25 mm diameter
  - **Sensitivity Range:** 10 epA – 100 eμA
  - **Power Limit:** < 5 Watts for exposure times of less than 30 sec
- Remotely selectable standard targets***** and aperture plates*****
  - **Options:** up to seven loaded on a retractable ladder drive – see note 1
  - **Profile:** 50 mm (h) x 25 mm (v)
  - **Power Limit:** < 500 Watts of absorbed beam power; more restrictive limits are sometimes necessary for target materials other than Beryllium to prevent the target from melting (contact the A1900 group for assistance regarding use of non-Beryllium targets)
- BaF detector*****
  - **Purpose:** on-line beam intensity monitor by sampling light particle rate from target
  - **Range of Operation:** for use with beam currents ranging from about 0.1 to about 150 particle nanoAmperes
  - **Calibration:** users should allow about 1 hour of their beam-on-target time for calibration

Dipole 1 (Z026DS) Vicinity:

- D1 Faraday bar readout (Z026L-C and Z026R-C)*****
  - **Purpose:** non-intercepting monitor of primary beam current for fragment settings in cases where the primary beam is deflected enough to reach the Faraday bars on the sides of the dipole
  - **Options** non electron-suppressed current readings available through control system for experimenter monitoring
  - **Sensitivity Range:** 1 enA – 100 eμA
  - **Power Limit:** < 4000 Watts
  - **Calibration:** user calibration required
- D1 Beam Blocker (Z030F-C)*****
  - **Purpose:** remotely positionable, water-cooled beam blocker at the exit of the first dipole to block the primary beam (or a primary beam charge state); note that this device is not positioned at an image
  - **Power Limit:** < 1000 Watts
  - **Profile:** 89-mm thick heavymet, 51 mm (h), 102 mm (v)
  - **Range of motion:** from -125 mm (left of optic axis, retracted from beam) to 100 mm (right of optic axis)
  - **Options** non electron-suppressed reading of current from intercepted beam available through control system for experimenter monitoring
  - **Current Readout Sensitivity Range:** 1 enA – 100 eμA
  - **Calibration:** user calibration of current readout required

Image 1

- Remotely adjustable horizontal slit*****
  - **Purpose:** primary beam blocking, momentum acceptance restriction (down to 0%)
  - **Options** variable horizontal gap from -95 to -0.5 mm (left of optic axis) and 0.5 to 95 mm (right)
  - **Profile:** 29-mm thick heavymet, 25 mm (v)
  - **Power Limit:** < 1000 Watts
- Remotely retractable achromatic wedge OR beam-blocking finger*****
  - **Power Limit:** < 25 Watts
  - **Wedge Options:** see note 2
  - **Wedge Profile:** 115 mm (h) x 44 mm (v)
  - **Finger Profile:** 14-mm thick heavymet, 38 mm (v), with width options of 17, 22, 26, 30, 35, 39, and 43 mm centered on the optic axis
  - **Change-out time:** about 1.5 hour

Image 2

- Remotely retractable upstream slit*****
  - **Purpose:** momentum acceptance restriction (down to 0%), low-intensity beam charge state blocking
  - **Options:** adjustable gap (0-186 mm) and center – single setting chosen before experiment
  - **Profile:** 25-mm thick heavymet, 76 mm (v)
  - **Power Limit:** < 2 Watts

- Remotely retractable pair of tracking PPAC's (PPAC0 and PPAC1)*****
  - **Purpose:** event-by-event momentum correction based on tracked particle position
  - **Profile:** 400 mm (h) x 100 mm (v)
  - **Particle Rate Limit:** up to 200,000/sec distributed over detector surface with no hot spots
  - **Readout Rate Limit:** a few hundred events/sec
- Remotely selectable achromatic wedges*****
  - **Options:** up to two wedges loaded on retractable ladder drive – see note 2
  - **Profile:** 350 mm (h) x 40 mm (v)
  - **Power Limit:** < 2 Watts
- Remotely retractable downstream slit*****
  - **Purpose:** momentum acceptance restriction (down to 0%), low-intensity beam charge state blocking
  - **Options:** adjustable gap (0-160 mm) and center – single setting chosen before experiment
  - **Profile:** 25-mm thick heavymet, 76 mm (v)
  - **Power Limit:** < 2 Watts
- Remotely retractable thin plastic (BC-400) scintillator*****
  - **Purpose:** measurement of timing and rate, position measurement for momentum correction
  - **Profile:** 0.13-mm thick, 350 mm (h) x 60 mm (v)
  - **Particle Rate Limit:** up to 1,000,000/sec distributed over detector surface with no hot spots
  - **Position Resolution:** about 30 mm (0.5% dp/p)

Image 3

- Remotely adjustable vertical slits*****
  - **Options** variable vertical gap from 0 to 200 mm
  - **Profile:** 25-mm thick heavymet, 279 mm (h)
  - **Power Limit:** < 2 Watts
- Remotely adjustable horizontal slits*****
  - **Options** variable horizontal gap (0-200 mm), variable center
  - **Profile:** 25-mm thick heavymet, 279 mm (v)
  - **Power Limit:** < 2 Watts
- Remotely retractable degrader holder*****
  - **Profile:** accommodates a foil holder or degrader up to 1.5-mm thick, 180 mm (h) x 50 mm (v)
  - **Power Limit:** < 2 Watts
- Remotely retractable beam blocker*****
  - **Profile:** 13-mm thick heavimet, 229 mm (h) x 305 mm (v)
  - **Power Limit:** < 2 Watts

Focal Plane:

- Remotely retractable pair of tracking PPAC's (PPAC0 and PPAC1)
  - **Purpose:** event-by-event position tracking of ions delivered to focal plane
  - **Profile:** 100 mm (h) x 100 mm (v)
  - **Particle Rate Limit:** 30,000/sec
- Remotely adjustable horizontal slits*****
  - **Options** variable horizontal gap (1-100 mm), variable center
  - **Profile:** 25-mm thick heavymet, 102 mm (v), 102 mm (h) on each side of gap
  - **Power Limit:** < 2 Watts
- Remotely adjustable vertical slits*****
  - **Options** variable vertical gap from 1 to 100 mm, variable center
  - **Profile:** 25-mm thick heavymet, 102 mm (h), 102 mm (v) on each side of gap
  - **Power Limit:** < 2 Watts
- Remotely retractable thin plastic (BC-400) scintillator*****
  - **Purpose:** measurement of timing and rate
  - **Profile:** 50 mm (h) x 50 mm (v)
  - **Thickness Options:** 0.13 mm and 1.0 mm
  - **Efficiency for Particle Detection:** >95% for Z > 20; >50% for 10 < Z < 20
  - **Particle Rate Limit:** up to 1,000,000/sec distributed over detector surface with no hot spots
- Remotely retractable silicon PIN detector

Purpose: measurement of energy loss, timing, PID
Profile: 0.5-mm thick, 50 mm (h) x 50 mm (v)
Particle Rate Limit: 1,000/sec

- Remotely retractable thick scintillator
  Purpose: timing and total energy measurement
  Profile: 100-mm thick, 50 mm (h) x 50 mm (v)
  Particle Rate Limit: up to 100,000/sec distributed over detector surface with no hot spots
  Use Restrictions: cannot be inserted simultaneously with germanium detector or with stack detector drive
- Locally retractable germanium detector with re-entrant can
  Purpose: detection of gamma rays emitted in a time window on the order of a microsecond from particles stopped on catcher or detectors mounted on the stack detector drive
  Ge Detector Options: p-type Ortec detector with either 80% or 120% relative efficiency
  Photopeak Efficiency: on the order of 1% for 300 keV gamma rays
  Filling Requirement: manual filling of the detector with liquid nitrogen is the responsibility of the user and requires about 15 minutes of vault access time per day.
  Use Restrictions: only installed when requested (installation and calibration time is about 2 hours); cannot be inserted simultaneously with thick scintillator; must be retracted for beam delivery to locations downstream of A1900
- Remotely retractable stack detector drive
  Purpose: Mounting of user-supplied silicon PIN detectors and/or passive particle catchers for use in close geometry with germanium detector
  Use Restrictions: cannot be inserted simultaneously with thick scintillator

Beam Diagnostics and Controls:

- Rate dependent beam shut-off*****
  Purpose: beam shut-off in response to user-supplied NIM pulses
  Note: use of this option for a high-intensity primary beam might require recovery time
  Response Time: 200 ms < t < 1 sec
  Cutoff Rate Limit Range: 0.5-20 kHz
- Signal input for emergency primary beam shut-off*****
  Purpose: latched beam shut-off in response to a user-supplied signal (5 V, 5 mA signal = beam on)
  Note: use of this option for a high-intensity primary beam might require recovery time
  Response Time: < 500 microseconds
- Signal input for primary beam pulsing*****
  Purpose: cyclotron beam pulsing via user-supplied NIM signal (true = beam off)
  Response Time: beam off: 150 microseconds; beam on: 700 microseconds
  Options user-defined beam on-off patterns

Note 1: Targets and Apertures.

The list below gives the thickness options currently available (in mg/cm^2) for beryllium targets used at the A1900 target position. Each target is 50 mm wide by 25 mm tall.

The aperture plates used at the A1900 target position are 50 mm wide by 25 mm tall. The circular apertures are centered horizontally and vertically within the plate so that they coincide with the optic axis. The aperture plates are 13 mm thick and are available in both copper and heavymet. The aperture diameters available are 2 mm and 4 mm.

47	352	540	775	1175	1645	2021	2538	3525
94	376	564	846	1222	1692	2068	2585	4113
141	399	610	893	1269	1763	2139	2609	4700
188	423	611	940	1316	1810	2233	2655	
235	446	658	987	1363	1857	2350	2726	
282	470	681	1034	1410	1904	2397	2820	
305	493	705	1081	1480	1951	2444	2938	
329	517	752	1151	1551	1998	2491	3196	

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Note 2: Wedges.

The wedges are made from sheets of aluminum (curved to be achromatic) and are available in thicknesses ranging from 0.15 mm (45 mg/cm^{2}for the standard Image 2 profile) to 3.5 mm (1050 mg/cm^2) in steps of 0.05 mm (15 mg/cm^2).

II. Support Level

This section describes the service level the A1900 group provides NSCL users in terms of beam delivery and A1900 usage support. The A1900 group responsibilities are listed according to the stages of planning and executing the experiment and are presented separately as they apply to experiments based downstream of the A1900 (most experiments) and to experiments based in the A1900 (some experiments).

Experiments Based Downstream of the A1900

- Proposal Submission and PAC Review
  - Provide users the tools and information they need to be able to make sound proposals
  - Provide feedback to the PAC on the feasibility of proposed experiments in terms of fragment development and beam delivery
- Planning an Approved Experiment
  - Assign an A1900 Group member to serve as a contact person to the experimental group for beam delivery and A1900 configuration planning
  - Make the user group aware of the tools available for meeting its responsibilities with respect to beam delivery and fragment development
  - Work with the experiment spokesperson to determine the standard A1900 configuration options needed and to map out a detailed plan for beam delivery
- Experiment Setup
  - Setup and support the agreed-upon standard hardware configuration options
  - Provide the necessary video equipment to ensure proper beam delivery within the experimental setup
- Experiment Execution
  - Develop, deliver, and document PAC-approved primary and/or secondary beams to the experimental setup
  - Provide the experiment group any training it will need to help execute fragment development
  - Provide and verify requested A1900 detector signals to the experiment
  - Availability:

Time	Service Level
Monday-Friday, 8 am – midnight	Full beam delivery support (Work after 5 pm by prior arrangement)
Saturday-Sunday, 8 am – midnight	Changes between previously developed settings (By prior arrangement)
All other times	Emergency, on-call coverage in case of facility failure

- Requests for emergency support must be directed to the Operator in Charge who will decide whether to call in support from the A1900 group
- A1900 group members who are participants in experiments may allocate their research time for A1900 and experiment support

Experiments Based in the A1900

- Proposal Submission and PAC Review
  - Provide users the tools and information they need to be able to make sound proposals
  - Provide feedback to the PAC on the feasibility of proposed experiments in terms of fragment development and in terms of A1900 usage
- Planning an Approved Experiment
  - Assign an A1900 Group member to serve as a contact person to the experimental group for A1900 use planning
  - Make the user group aware of the tools available for meeting its responsibilities with respect to A1900 usage
  - Work with the experiment spokesperson to determine the standard A1900 configuration options needed for the experiment
  - Provide the experiment group the training it will need for responsible use of the A1900
- Experiment Setup
  - Setup and support the agreed-upon standard hardware configuration options
  - Provide a working copy of the standard A1900 data analysis and acquisition software; necessary modifications to this software are the responsibility of the user
- Experiment Execution
  - Verify the functionality of requested A1900 standard configuration options
  - Availability:

Time	Service Level
Monday-Friday, 8 am – midnight	Consultation support (Work after 5 pm by prior arrangement)
All other times	Emergency, on-call coverage in case of facility failure

- Requests for emergency support must be directed to the Operator in Charge who will decide whether to call in support from the A1900 group
- A1900 group members who are participants in experiments may allocate their research time for A1900 and experiment support

III. User Responsibilities

This section describes user responsibilities with respect to beam delivery and A1900 use. These responsibilities are listed according to the stages of planning and executing the experiment and are presented separately as they apply to experiments based downstream of the A1900 (most experiments) and to experiments based in the A1900 (some experiments).

Experiments Based Downstream of the A1900

- Proposal Submission and PAC Review
  - Obtain PAC approval for the estimated time necessary to deliver each and every beam required for the experiment
  - If the experiment requires a setup incompatible with the standard A1900 configuration, obtain PAC approval for the estimated time necessary to modify and restore the standard A1900 configuration
- Planning an Approved Experiment
  - Obtain Director approval (via a written request to the Associate Director for User Relations) for any beam changes (isotope or energy) from what was specified in the proposal; obtain director approval for any changes in plans for A1900 use that will impact other experiments
  - Have the experiment spokesperson work with the A1900 group (a) to determine the standard A1900 configuration options needed for the experiment and (b) to map out a detailed plan for beam delivery
- Experiment Setup
  - Install adequate diagnostics (e.g. viewers, aligned fiducial references, setup of A1900-supplied video equipment) to enable successful beam delivery
  - Make the setup so that sensitive experimental equipment will be protected during beam tuning
- Experiment Execution
  - Provide support during fragment development to make decisions about setting optimization options offered by the A1900 group
  - Provide support with the experimental setup during beam delivery to protect user equipment and to debug any problems that arise with the experimental setup
  - Provide support during beam delivery to provide information about needed beam optical characteristics and to verify that delivered beam properties meet user needs
  - Work with the A1900 group to complete any needed beam quality checks before use of the beam is turned over to the experiment
  - For experiments involving extensive fragment preparation time, assist the A1900 group with fragment development by providing two trained people to serve on over-night shifts to conduct rigidity scans (this training requires about 4 hours of work with the A1900 group during fragment development)

  - Monitor composition of cocktail beams in cases where detailed knowledge of beam composition is required for the experiment's success (the ratio of components in a cocktail beam can shift significantly over time for depending on the setting)

Experiments Based in the A1900

- Proposal Submission and PAC Review
  - Provide details on plans for A1900 usage and any fragment development to be carried out by the experimental group
  - If the experiment requires a setup incompatible with the standard A1900 configuration, obtain PAC approval for the estimated time necessary to modify and restore the standard A1900 configuration
- Planning an Approved Experiment
  - Obtain Director approval (via a written request to the Associate Director for User Relations) for any changes in plans for A1900 use from what was specified in the proposal
  - Have the experimental spokesperson work with the A1900 group (a) to determine the standard A1900 configuration options needed for the experiment and (b) to map out a detailed plan for experiment setup and post-experiment cleanup
  - Obtain any necessary training from the A1900 group
- Experiment Setup
  - Carry out all aspects of the setup that are not part of the standard A1900 configuration
  - Be responsible for any needed data-acquisition and analysis software development and debugging
- Experiment Execution
  - Develop any fragment beams required for the experiment
  - Provide at least one person per shift who is competent to operate the A1900 (a novice needs to spend about a month working with the A1900 group during normal operations to gain this competency)
- Experiment Follow-up
  - Restore any changes to the A1900 standard configuration within the time granted for this purpose by the PAC