Physics Division Procedure

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Laser Operating Procedure for the Negative Ion Beam Purifier at ISTF-1

Lab Space Manager: Yuan Liu, Tel # 574-4761
Location: Physics Division, Bldg 6000, T-200, Tel # 574-4728
Laser Owner: Yuan Liu, Tel # 574-4761
Procedure Review Date: One year

Signatures

		Signature	Date
Yuan Liu	Originator	Yuan Liu	7/28/2010
ISTF-1 Lab Sp. Manager	Reviewer	Yuan Liu	7/28/2010
Div. Safety Manager	Reviewer	Stephen Austin	7/28/2010
Div. Laser Safety Officer	Reviewer	C C Haven	7/28/2010
Group Leader	Reviewer	SB Kennedy	7/28/10
Division Director	Approver	JR Beene	7/28/2010

Distribution List:

- Record Copy Physics SharePoint Site
- Division Safety Manager (original)
- Division Safety Officer
- Division Laser Safety Officer
- ISTF-1 Lab Space Manager
- Group Leader of ISTF-1 Activity
- Division Director
- ORNL Laser Safety Officer
- Physics Division Web Page Controller

References:

- Physics Div. Res. Safety Summary RSS #445.9 "Ion Source Test Facility-1"
- Physics Division Document Control Procedure
- Division Laser Safety Procedure (ver. 1) on SharePoint Site
- ANSI Z136.1 (available from DLSO)

Contents

1. Laser Specifications

Coherent Model 1064-7-10 Nd:YAG Laser

7 W average power, pulsed at 10 kHz (can operate 0-30 kHz)

< 60 ns pulse width

1064 nm (invisible)

0.55 mm diameter beam size

<3 mrad divergence

Maximum Permissible Exposure (MPE); 10 sec

2.8 mW/cm^2 (eye)

1 W/cm^2 (skin)

MPE Source, Laser Institute of America software

Based on ANSI Z136.1-2000

OD Goggle >6

2. Purpose

The purpose of this Laser Procedure is to guide the owner/operators of the Class IV negative ion beam purifier in ISTF-1 through the identification and analysis of potential hazards associated with the operation of the purifier. The installation relies on engineering and administrative controls to mitigate hazards associated with the operation of the laser. Initially, the laser will be operated under alignment mode. Once the laser parameters are established, panels will be used to enclose the laser beam and adjustment of the mirrors will be done remotely. All panels not interlocked will be taped. The laser purifier will be considered a Class 1 (embedded Class 4) laser. The hazards include (but are not limited to) those as outlined in the American National Standard, ANSI Z136.1, the ORNL SBMS, and any additional hazards associated with the laser as identified by the owner/operator or Safety Officers/Reviewers. The procedure must be approved by the Physics Division Director, and reviewed by the Division Group leader for ISTF-1, the Division Safety Manager, the Division Laser Safety Officer, and the Lab Space Manager. The procedure will be sent to the ORNL Laser Safety Officer for comments. This procedure conforms to requirements set forth in the Physics Division procedure *Document Control.* An inspection of the installation by the Division Laser Safety Officer is

required before the laser is allowed to operate and after any significant configuration change. The Physics Division also requires an experimental review to be performed initially and when any significant changes are made to an experimental apparatus. Appendix A has a list of personnel authorized to perform work on the Class IV laser in alignment mode. All personnel should report any non-compliance so that the appropriate corrective action can begin. This document, along with the appropriate laser training documented in Appendix B, provides site specific training for use of the laser in ISTF-1.

3. General Description

The negative ion beam purifier is located at the Ion Source Test Facility-1 (ISTF-1) in the Physics Division, Bldg. 6000, Room T-200. The layout of the ISTF-1 and the purifier system in the room is shown schematically in Fig. 1 and a more detailed view of the laser and components is shown in Fig. 2. The purifier consists of a 1064 nm 7 Watt (aver max) invisible pulsed (up to 30 kHz) Nd:YAG Laser (Coherent Model 1064-7-10). The laser beam is directed by mirrors into the end of the beam line and overlaps a negative ion beam in the RF quadrupole ion beam cooler. The transmitted laser beam power is monitored at a vacuum window located at the dipole analyzing magnet. A negative ion beam is created by a Cs sputter ion source and is directed down the beam line into the ion cooler (as shown in Fig. 2). In a radioactive beam facility (which is only simulated at ISTF-1) an ion beam may contain unwanted (contaminant) isobaric negative ions (ions which have the same mass as the desired beam). The photons are directed into the ion beam cooler where they 'purify' the ion beam due to a difference in photodetachment cross sections. The setup at ISTF-1 is used as proof-of-principle for future RIB production where isobaric contaminants will be present.

In the present configuration, the laser beam is directed into the ion beam cooler by high power laser mirrors. The mirrors are nearly 100% reflective and transport the beam without detectable loss. A selection of mirrors is available which include slight focusing if needed. Apertures (outside the vacuum) are shown which are placed in the laser beam path to reduce the diameter of the beam that is directed into the beam cooler. Any laser beam hitting the components of the ion beam cooler significantly increase the temperature inside the vacuum and cause a rise in pressure.

ISTF-1

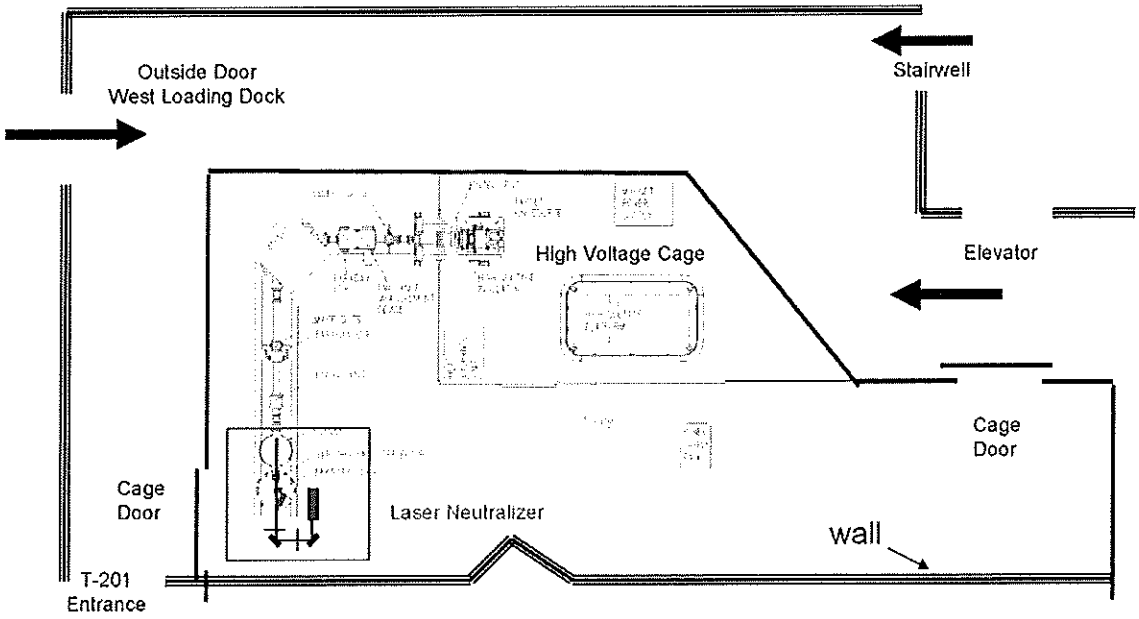

Figure 1. Room layout of ISTF-I.

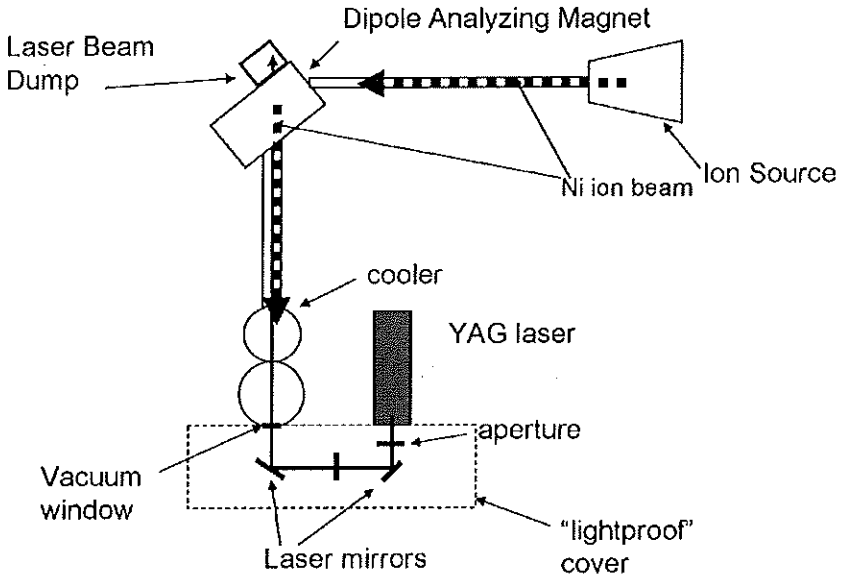

Figure 2. Details of the laser setup at ISTF-I.

4. Hazards

4.1 Beam Hazard to eyes and skin

Scattered and/or diffuse laser energy is a hazard. Radiation at 1064 nm is invisible to the eye and hence exposures are not mitigated by the blink response of the eye but are assumed to be 10sec. According to the ANSI standard, the maximum permissible exposure (MPE) for 1064 nm radiation is 2.8 mW/cm^2 average power for ocular exposure and 1 W/cm^2 for exposure to the skin. Sources of radiation include the laser beam path itself as well as reflections or diffuse energy from any components near or in the laser beam path (especially optics and apertures). While the laser power levels are in watts, the beam's small diameter makes the power densities a significant hazard if an accidental exposure occurs near the output of the laser. The radiation exits the vacuum beam line through a standard viewport and impinges onto a laser beam dump. The radiation is monitored by a power meter at the dipole magnet. Shielding around the power monitor is used to eliminate stray or reflected laser radiation. Viewports located on the beam line must be covered.

4.2 Electrical Hazards

The power supply for the laser is interlocked with a key as is required by ANSI for a Class IV laser. The power supply is rack mounted and is not readily accessible. Repair of the power supply will be performed by the manufacturer.

5. Laser Log Book

A laser logbook is kept near the beam purifier in the ISTF-I area. The logbook contains a copy of this laser procedure. The logbook will also contain documentation of the panel interlock and Emergency Off interlock check (see section 9).

6. Maintenance/Service

There is no normal maintenance to perform on the laser. All service will be performed by the manufacturer offsite.

7. Interlock Check

The interlock on the laser access panel and the function of the emergency off switch will be checked upon initial startup and at three months intervals while the laser system is operational (interlock check is not required when the laser not operational). Interlock checks must be documented in the lab book. The test will guarantee that no laser light exits the laser (e.g., power supply is shut off or shutter inserted in the laser cavity) when either the access panel is not secure or the emergency off button has been pushed. The interlock on the panel will be failsafe (consists of two interlocks). Each interlock will be tested separately.

8. Goggles

Goggles available for use during laser alignment include two pairs with an OD = 7. Laser power density = 7 watts/ .55 mm dia. After 10 cm with 3 mRad divergence the beam diameter is (.085 cm X .085 cm) making the power densities 0.969 kWatts/cm^2. An OD of 6 corresponds to attenuation of 10^6 which reduces the power density to 1 mWatt/cm2 (MPE = 2.8 mW/cm^2). For both goggles, 7 Watts (the full beam) would be attenuated well below the MPE for 1064 nm radiation for an exposure of 10 sec. The goggles cannot withstand the full beam for any length of time (due to heating of the plastic). The goggles are to be worn at all times during operation of the laser in alignment mode.

9. Emergency Off

The laser purifier will have a clearly marked emergency off button which will connect to the laser power supply or shutter. Rotating the key to the left also shuts the laser/power supply down.

10. Spectators

In alignment mode, spectators will be allowed only if they are informed of the hazards, wear laser goggles with an OD >6, and only during

measurements where only minor adjustments are made on the optics and the beams are well-shielded and confined as much as possible. Spectators must have high power laser training with an eye exam if observing the alignment mode. When the laser is operated as a Class 1 (embedded Class 4) laser, spectators may observe operation if they are informed of the hazards and wear goggles with an OD>5.

11. Operation as a Class 1 (embedded Class 4) Laser

When all enclosures are in place - either interlocked or taped – and the operator has performed and documented the first three steps for Class 1 status (see "To Operate as a Class 1" at the end of this section), the laser is considered to be in Class 1 (embedded Class 4) mode. Enclosures include the enclosure of the output power meter used for tuning. All panels will be labeled with a laser danger sign. The DLSO will initially inspect the configuration of the enclosures. The laser operator will verify the enclosure configuration before operation to confirm a Class 1 mode. Low power laser training is strongly recommend for persons present during Class 1 operation but may be substituted with onsite hazard/mitigation instruction by the laser operator. Laser goggles with OD>5 (diffuse reflection source) are required around the laser/ laser enclosures if not laser trained. OD>6 is required when operating shutter if not laser trained. Follow manufacturer's directions for start-up and shut-down, verbally inform others of the laser operation. It is recommended that the curtain be drawn and sliding doors closed (locked) to ISTF-1 for operation as a Class 1. (A barrier to restrict entry into the area with the shields can be substituted for closing the door nearest the elevator). Laser warning signs should be affixed to the outside of the doors (barriers).

To operate as a Class 1 (embedded Class 4)

The following procedure can only be performed by an approved laser trained operator defined in Appendix A.

Step1. Laser operator verifies shields near the laser exit, over the mirrors, at the entrance to the chamber, and around power meter are in place with corners taped.

Step 2. Operator verifies the beam line, magnet box, and chamber vacuum windows are covered and light tight. Note there is a vacuum window on the magnet, on the beam line near the

vacuum gauge, and two windows on the chamber which need to be covered.

Step 3. Operator closes curtain and slides doors shut. Laser danger signs are affixed at appropriate locations, including outside the doors. Operator offers laser goggles to anyone present inside the cage at ISTF-1. Note that goggles are recommended if working around laser shields and highly recommended if operating shutter. Goggles are required for personnel not high power laser trained.

Step 4. Operator verbally warns personnel at ISTF-1 when the laser is to be turned on.

To end Class 1 status, the operator turns off the laser and removes and stores key. The operator informs personnel at ISTF-1 the laser is off. The operator opens doors and removes signs.

12. Alignment Procedure

Section 12 of this procedure only applies to operation in alignment mode. Section 12 includes startup and shutdown steps. The checklist in Appendix C will be used.

Step 1. The following steps can only be performed by personnel approved for laser alignment, as defined in Appendix A. A list of approved personnel will be kept at ISTF-1. A checklist will be filled out during each laser startup. Initial alignment will not be performed alone. Initial alignment occurs when installing optical mirrors and possibly a collimator.

Step 2. Approved person checks 6000:T200 and T201 for personnel.

a. If personnel are present in T201 and need to remain, doors to T201 are covered with an opaque material. A telephone number is provided to personnel in T201 to be used for permission to exit. Exit out of T201 by walking through T200 outside the ISTF-1 cage will only be allowed when the laser cavity is spoiled by the shutter.

b. Approved person informs HRIBF control room (574-4720) of intent to operate laser and restrict access to T200 and T201

c. Note that no personnel are allowed outside the ISTF-1 cage with laser radiation present.

Step 3. Approved person secures T200 with barriers and Laser Danger Signs.

- Chains outside of door, aluminum shields on door glass with Laser Danger Sign facing out
- Place chains (or laser warning tape) and danger signs at elevator and stair entrance (see Fig 1)

Step 4. Secure cage:

- Verify no direct view of laser outside cage
- Verify Laser danger signs visible on both cage gates and close gates
- Only approved personnel allowed in cage (spectators are allowed under certain conditions given in Section 10)

Step 5. Prepare for lasing:

- All personnel in cage put on laser goggles with OD> 6 for 1064 nm.
- Do not expose highly flammable clothing to beams.
- Remove jewelry and secure dangling badges
- Eliminate reflective material from vicinity of beam
- Pay attention to reflections around aperture in cavity
- Pay attention to good housekeeping
- Preliminary alignment should be made with the laser operating at the lowest stable power (~watts). Place shields around beam path where possible. Check around fence for stray light.

Step 6. Initiate lasing

- Place power meter (or beam stop) at exit of laser
- Turn key to on position

- Verbally warn others in room lasing is to begin
- Press fire button
- Adjust power to a few watts
- Lower laser supply current if laser power > a few watts
- Place beam block in beam, remove power meter

Step 7. Align optics for maximum transmission through cooler

- Block beam at exit of laser when inserting or removing stable optics, cavity aperture, beam stops, or shielding around beam path
- Laser beam always terminated by a beam stop (power meter)
- Watch for stray beams created at any object in the beam path
- Never allow eyes to approach axis of laser or laser beam
- Remember to place beam stop or power meter outside magnet viewport

Step 9. Perform measurements:

- Maximize shielding around open laser beams
- Turn power up if needed, make only minor adjustments on mirror mounts or laser mirrors.
- Do not leave laser unattended with laser power supply on
- Block beam at laser exit and reduce laser diode current

Step 10. Laser Shutdown:

- Reduce current, place power meter or beam block at exit of laser
- Turn off laser, remove key
- Open cage gates, cover laser signage on gates
- Remove laser signage, chains at entrances to T200
- Inform HRIBF control room (574-4720) and any personnel in T201 laser is off.

Appendix A - Personnel allowed to align the Negative Ion Purifier as a Class IV Laser in alignment mode.

Requirements: Signature indicates that

- High Power Laser Training (ORNL Module 90872 or equivalent) was completed and updated every three years
- Documented Laser Eye Exam has been completed and given to the Division Laser Safety Officer
- This ISTF-1 Laser Operating Procedure has been read and understood
- The checklist (Appendix B, attached) for site-specific training has been completed.

Personnel Allowed To Work on Laser	Signature	Date
Charles C. Havener		
Yuan Liu		
Ilija Draganic		

Appendix B - Laser System-Specific Training Checklist

Laser User	
Principal Investigator (PI)	
Laser System	

Topic	User Signature/Date	Owner Signature/Date
High Power Laser Training • Laser Classifications • Specific Laser Hazards • Maximum Permissible Exposure • Laser procedure • Laser Authorization • Good Practice in Lab		
Interlocks • Configuration • Operation		
Laser Output Characteristics • Wavelength • Pulse energy/ Average Power		
Goggles • Optical Density • Damage Threshold (plastic or glass) • Use		
Normal Operation • Power on/off • Shutter operation • Normal experimental configuration • Nominal Hazard Zone		
Non-Normal Operation • Gross Alignment (hands on demonstration) • Troubleshooting		
Laser Safety Officer • Laser Safety Resource • Inspections for New or Reconfigured Systems		

Appendix C - CHECK LIST FOR ISTF-1 ALIGNMENT OPERATION

DATE:_____ TIME:_____

ALIGNMENT

	Only approved persons permitted in Room T200 (ISTF-1)
	All (three) entrances to T200 posted and secured
	Room T201 checked and appropriate plans in place to deal with workers in T201
	Clear glass on exit door covered with aluminum
	Cage doors closed
	Warning signs at entrances to cage
	HRIBF Control Room notified
	All personal in cage have removed jewelry and dangling badges, and have laser safety goggles

Inspector: _____