BROOKHAVEN NATIONAL LABORATORY
LASER CONTROLLED AREA
STANDARD OPERATING PROCEDURE (SOP)

This document defines the safety management program for the laser system listed below. All American National Standard Institute (ANSI) Hazard Class 3b and 4 laser systems must be documented, reviewed, and approved through use of this form. Each system must be reviewed annually.

System description: **: Optically Pumped Polarized Proton Ion Source Laser Systems:** The lasers covered by this procedure are part of the Optically Pumped Polarized Ion Source (OPPIS) that provides polarized beams for experiments in the AGS and RHIC. The high power pulsed lasers are used to optically pump the Rb vapor in the polarized charge-exchange cell. The cw probe laser is used to measure the polarization using the Faraday rotation technique.
Location: **C-AD Building 930, Pit I**

LINE MANAGEMENT RESPONSIBILITIES

The Owner/Operator for this laser is listed below. The Owner/Operator is the Line Manager of the system and must ensure that work with this laser conforms to the guidance outlined in this form.

Owner/Operator:		
	Signature on File	
Name: Anatoli Zelenski	*Signature:*	*Date:*

AUTHORIZATION

Work with all ANSI Class 3b and 4 laser systems must be planned and documented with this form. Laser system operators must understand and conform to the guidelines contained in this document. This form must be completed, reviewed, and approved before laser operations begin. The following signatures are required.

C. Weilandics	Signature on File	
BNL LSO printed name	*Signature*	*Date*
Asher Etkin	Signature on File	
C-A Department ES&H Approval printed name	*Signature*	*Date*

APPLICABLE LASER OPERATIONS
☒ Operation ☒ Maintenance ☒ Service ☒ Specific Operation Fiber Optics

LASER SYSTEM HAZARD ANALYSIS

Hazard analysis requires information about the laser system characteristics and the configuration of the beam distribution system. The analysis includes both laser (light) and non-laser hazards. A Nominal Hazard Zone (NHZ) analysis must be completed to aid in the identification of appropriate controls.

LASER SYSTEM CHARACTERISTICS					
Laser Type *(Argon, CO_2, etc.)*	Wavelengths	ANSI Class	Maximum Power or Energy/Pulse	Pulse Length	Repetition Rate
Cr:LiSAF	795 nm	IV	0.3 J	300 uSec	7.5 Hz
Argon	488 to 514 nm	IV	20 Watts	CW	CW
Ti:Sapphire	780 nm	IV	4 Watts	CW	CW
Semiconductor TOPTICA-DL 150	780 nm	IV	150 mW dc	CW	CW

☐ **Cryogen Use**

Describe type, quantity, and use.

NA

☒ **Chemicals & Compressed Gasses**

Describe type, quantity, and use.

Dry nitrogen gas flow used for laser cooling and purging of water vapor

☒ **Electrical Hazards**

Description *(Describe the power supply to the system).*

The CW argon lasers require a 600 volt, 50 amp power supply and semiconductor laser is 120V low current.. The pulsed laser requires a 1.2 KV low current power supply charging a 120 uf capacitor. The power supplies are fully enclosed and will not be operated, or modified in any manner without full compliance to BNL ES&H Standard 1.5.0 Electrical Safety.

☒ **Other Special Equipment**

Description *(Equipment used with the laser[s]).*

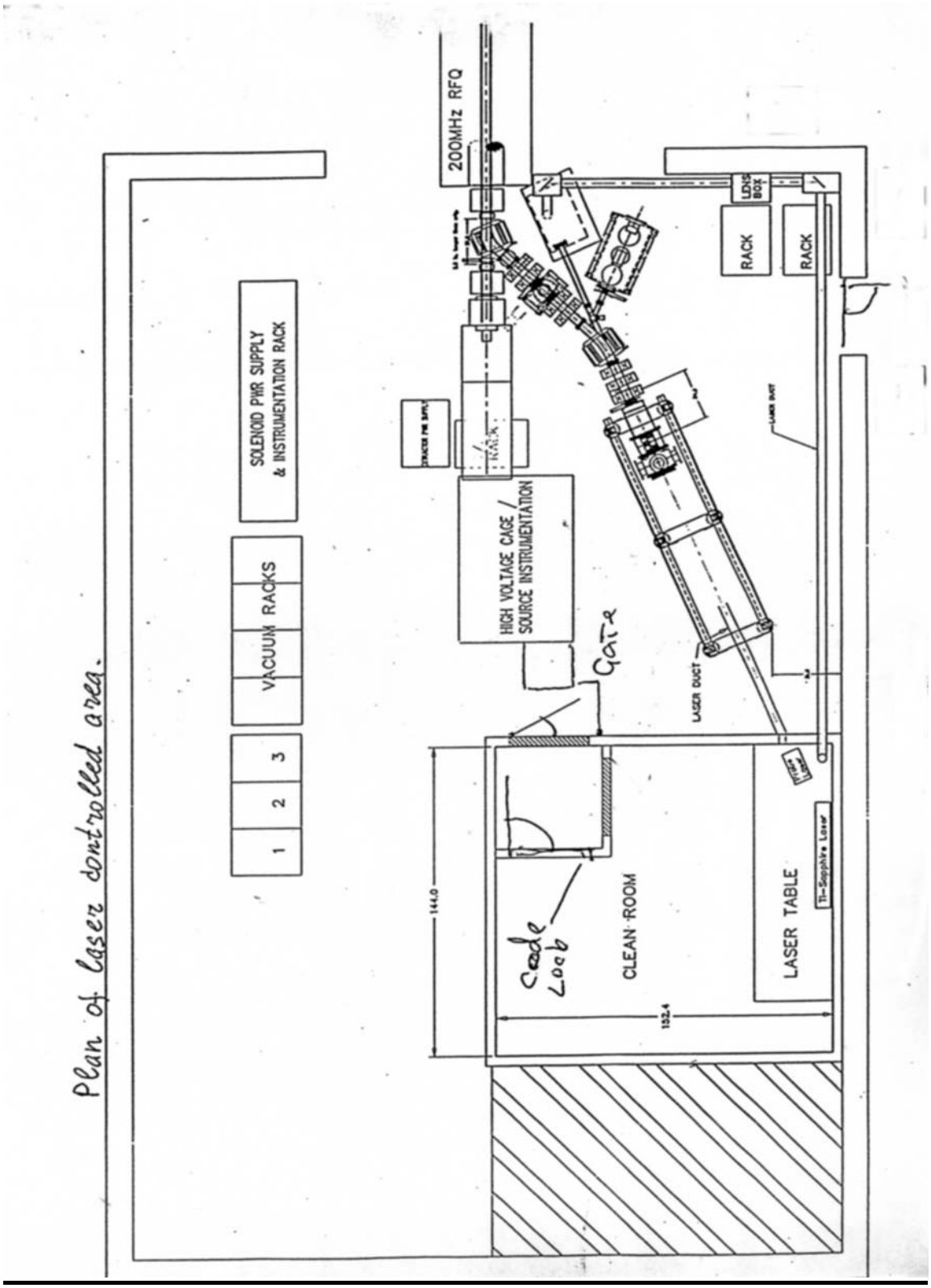
Burleigh WaveMeter's

Laser System Configuration: Describe the system controls *(keys, switch panels, computer controls),* beam path, and optics *(provide a functional/block diagram for complicated beam paths)*.

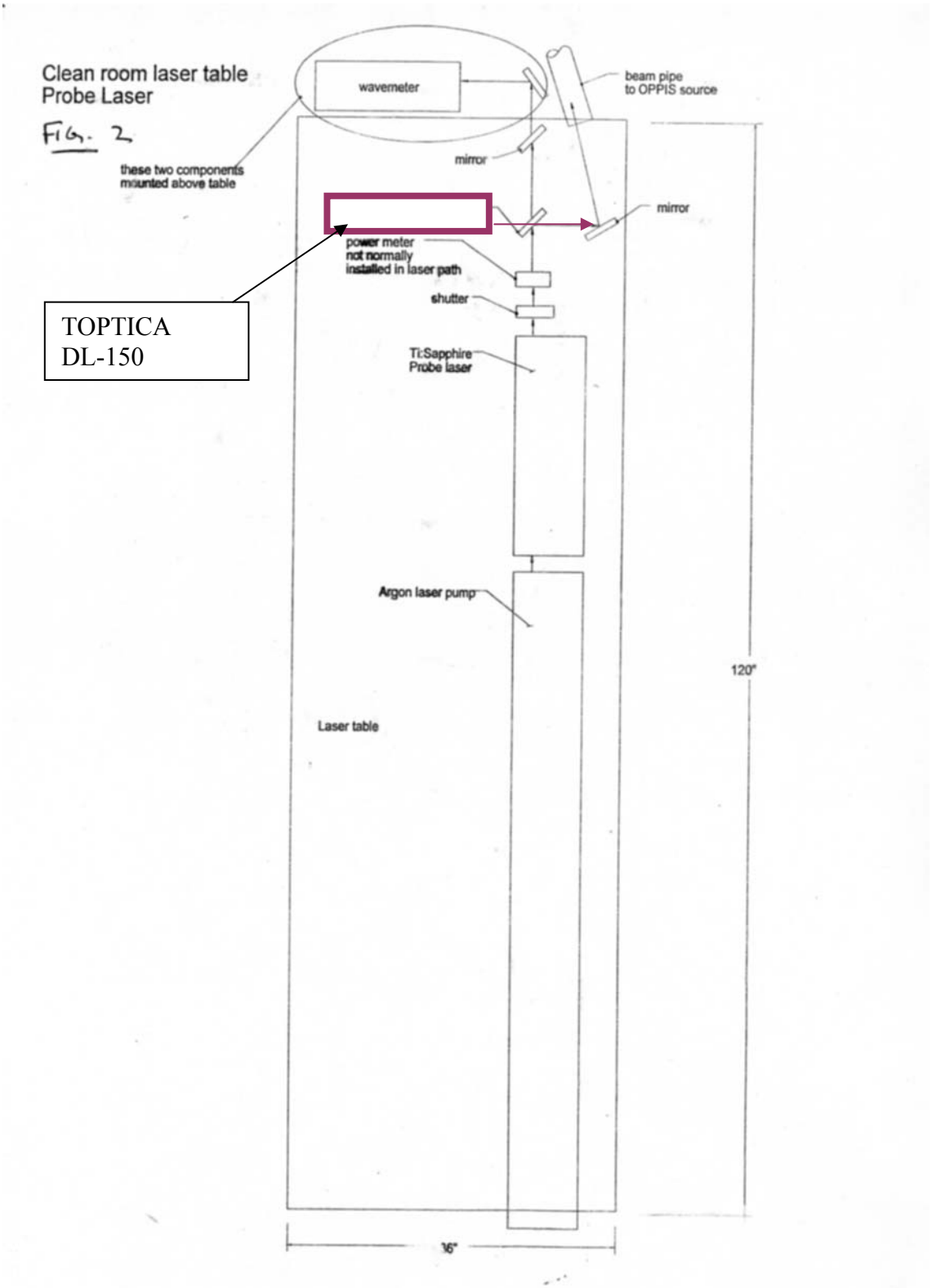
The OPPIS laser system is divided into two sections, the first is located in a room that is used exclusively for the laser and contains all the class 4 lasers along with the majority of optical components. The second part is in OPPIS area and consists of enclosed beam paths and the connection to the source. In the laser room the lasers are mounted on a laser table along with the optical components. The Argon laser, the semiconductor laser and the Ti:Sapphire lasers are commercial systems and the Cr:LiSAF laser is owner built. The argon laser is used to pump the Cr:LiSAF laser. Control of the lasers is local except that the pulse repetition rate and timing is controlled by the accelerator operation control system. For details of the optics configuration see the following figures. Note: Laser table consists of two sketches.

Fig. 1 OPPIS injector and laser system layout
Fig. 2 Clean Room Laser Table Pumping Laser
Fig. 3 Clean Room Laser Table Probe Laser
Fig. 4 Optics Box

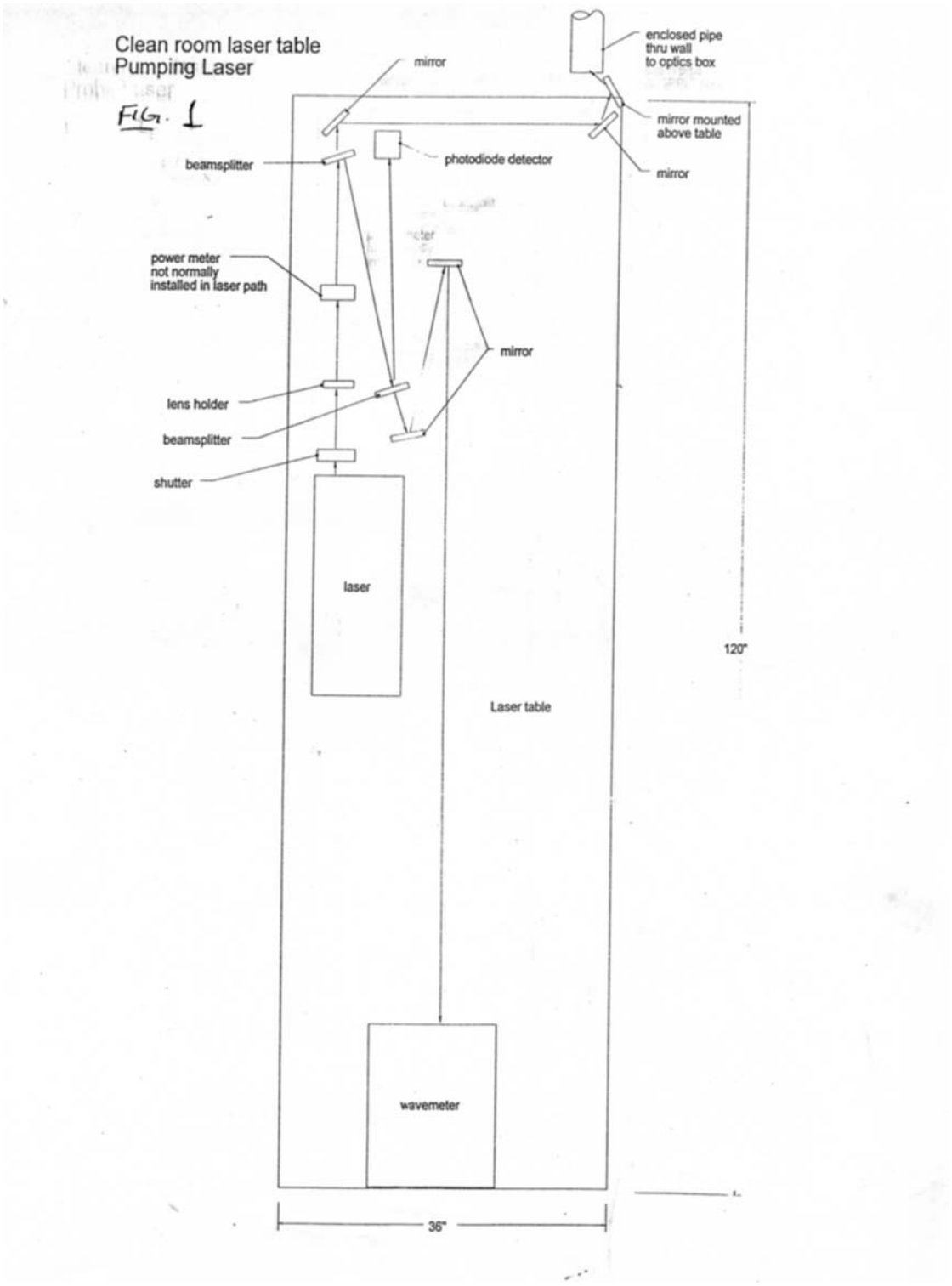
OPPIS injector and laser system layout. Fig. 1



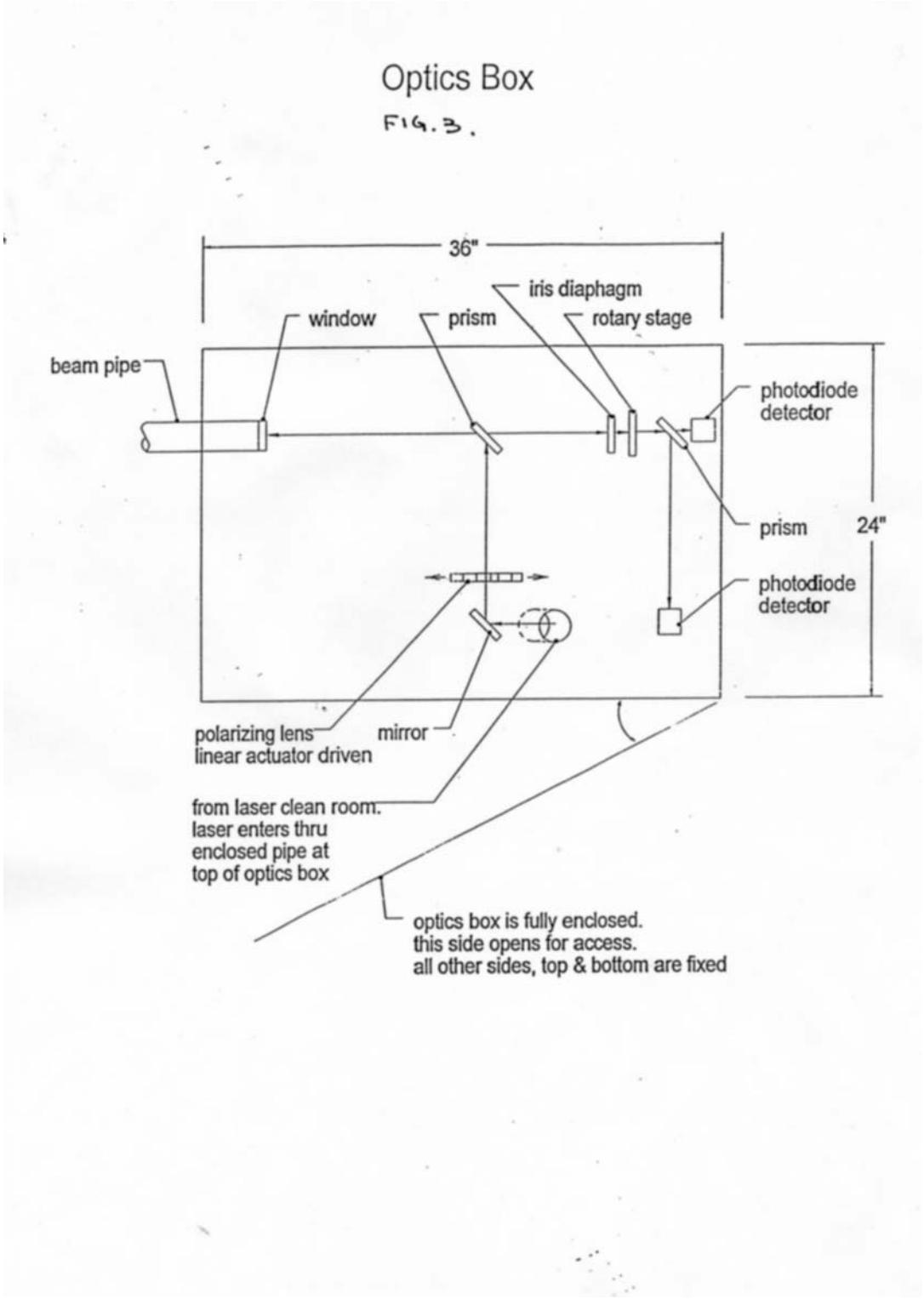
The probe laser table layout. Fig. 2



The Cr:LiSAF laser table layout. Fig. 3



The optics box optics layout. Fig. 4



DEVELOP CONTROLS
IDENTIFY ES&H STANDARDS

Recognition, evaluation, and control of laser hazards are governed by the following documents.

American National Standards Institute (ANSI) Standard for Safe Use of Lasers;
(ANSI Z136.1-2000)

Laser Safety Subject Area

Brookhaven National Laboratory Environment Safety and Health Standard: 1.5.3 INTERLOCK SAFETY FOR PROTECTION OF PERSONNEL

ENGINEERING CONTROLS

☒ Beam Enclosures
☒ Beam Stop or Attenuator
☒ Activation Warning System
☐ Ventilation
☒ Protective Housing Interlocks
☒ Key Controls
☒ Other Interlocks
☒ Emission Delay
☐ Other

Describe each of the controls in the space provided below this text. Interlocks and alarm systems must have a design review and must be operationally tested every six months. Controls incorporated by the laser manufacturer may be referenced in the manuals for these devices. **If any of the controls utilized in this installation requires a design review, a copy of the design review documentation and written testing protocol must be on file. Completed interlock testing checklists should be retained to document the testing history.**

Engineering Controls Description:

1. The laser optical table and laser power supplies are located in a laser room whose entrance is interlocked with a coded key pad which allows a 15 second entrance window prior to closing the shutters.
2. Two Emergency Crash Buttons are installed which close the beam shutters. They are located both internal and external of the Laser Room
3. The beam transport lines are enclosed in protective ducts and boxes from the secured Laser Room to the source.
4. <u>The active lasers have a key controls needed to make the lasers operational. The keys will be turned off when the laser is not in use to avoid unintentional laser operation.</u>
5. <u>Once switched on the active lasers will emit laser radiation only after an emission delay set by the manufacturer.</u>
6. <u>The active lasers are outfitted by the manufacturers with illuminated activation indicators.</u>
7. Shutters are installed on the laser table. They are included in the turn-on and interlock system. The shutters will automatically close upon unauthorized entrance to the Laser Room, Optics Box or the removal of the Probe Laser protective duct.

8. The entrance to the laser Clean Room has interlocks which are connected to the shutters for the active lasers. When the door is opened, the laser power supply is stopped and a laser shutter installed. In addition, there are interlocks located on the entryway doors to the laser controlled area outside the laser Clean Room as well as beam enclosures (tubes).
9. The Probe Laser duct is interlocked to insure safety during ECR Source maintenance. The interlock system design is documented in Sch. Drawings D22-E511 Sheet 1 & 2 that are controlled by the C-AD Configuration Management System. These drawing and future ECN's must be approved by the C-AD Laser Coordinator.

See OPM 8.4~ CA-930-1 Interlock Test Checklist

ADMINISTRATIVE CONTROLS

☒ Laser Controlled Area ☒ Signs ☒ Labels ☒ Operating Limits

The format and wording of laser signs and labels are mandated by BNL and ANSI standards. Only the standard signs are acceptable. Standard signs are available from the BNL Laser Safety Officer.

All lasers must have a standard label indicating the system's wavelength, power, and ANSI hazard class. Required labels must remain legible and attached. The manufacturer should label commercial systems.

Standard Operating Procedures (SOPs) are required for laser system operation, maintenance (including alignment), and servicing. The SOPs need only contain the information necessary to perform these tasks and identify appropriate control measures including postings and personal protective equipment. The BNL Laser Safety Officer must approve SOPs and copies should be available at the laser installation for reference and field verification of stated control measures.

Administrative Controls Description:

1. While aligning the laser beam line [outside the laser room], a laser Controlled area is demarcated by interlocked doors and gates.
2. Laser Warning signs are posted on the entrance doors and gates
3. A lighted warning sign is posted at the entrance to the laser room and is activated when one of the laser power supplies is turned on.
4. Lighted warning signs are posted at both area entrances and are activated when the alignment mode is set
5. Laser warning labels are posted on all transport tubes, ducts and boxes.
6. Laser power range is indicated on the labels

See OPM 8.4 Att. CA-100_-_ Guidance for Alignment/Maintenance Operations
See OPM 8.4 Att. CA-100_-_ Guidance for Normal Operations

CONFIGURATION CONTROL

A checklist must be developed for the purpose of verifying the placement and/or status of components that are used to mitigate hazards by configuration control. Examples include any protective housings, beam stops, beam enclosures, and any critical optics *(mirrors or lenses that could misdirect the beam and result in personnel hazard)*. Entries should also be included to ensure placement of required signs and labels and status of interlock verification. Completed checklists must be posted at the laser location. The checklist does not have to be redone unless there has been a system modification, extended shutdown, or change of operations.

See OPM 8.4~ CA-930-1 Configuration Control Checklist

PERSONAL PROTECTIVE EQUIPMENT

☐ Skin Protection ☒ Eye Wear

Skin Protection: For UV lasers or lasers that may generate incidental UV in excess of maximum permissible exposure (MPE) describe the nature of the hazard and the steps that will be taken to protect against the hazard.

Eye Wear: All laser protective eyewear must be clearly labeled with the optical density and wavelength for which protection is afforded. Eyewear should be stored in a designated sanitary location. Color - coding or other distinctive identification of laser protective eyewear is recommended in multi-laser environments. Yellow is used for 530 nm and Green is used for all 780 nm applications. Eyewear must be routinely checked for cleanliness and lens surface damage.

1. For invisible beams, eye protection against the full beam must be worn at all times unless the beam is fully enclosed.
2. For visible beams, eye protection against the full beam must be worn at all times during gross beam alignment.
3. Where hazardous diffuse reflections are possible, eye protection with an adequate Optical Density for diffuse reflections must be worn within the nominal hazard zone at all times.
4. If you need to operate the laser without wearing eye protection against all wavelengths present, explain the precautions that will be taken to prevent eye injury.

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Define eyewear optical density requirements by calculation or manufacturer reference and list other factors considered for eyewear selection. The BNL Laser Safety Officer will assist with any required calculations.

EYE WEAR REQUIREMENTS					
Laser System Hazard	Wavelength (nm)	Calculated Intra-beam Optical Density	Diffuse Optical Density*	NHZ** (meters)	Appropriate Eye Wear***
Ti:sapphire(CW)	780 nm	3.8(10sec.)	1(600sec.)	0.5m	
Toptica DL-150	780 nm	2.4(10sec.)	NA	<0.2m	
Argon	488 to 514 nm	4.3(0.25sec.)	3(600 sec.)	0.6m	
Cr:LiSAF(pulsed)	795 nm	5.5(10 sec.)*	2.5(600 sec.)	3.5m	

* Diffuse ODs are calculated assuming a 600 second exposure, a viewing distance of 20 cm, perfect reflectivity, and viewing normal to the surface. The ODs required can decrease for more typical conditions in the laboratory.

**The Nominal Hazard Zone is that zone or distance inside which exists a hazard to the eye from a diffuse reflection (as well as direct or specularly reflected light) for the time specified, in this case, 600 seconds (10 minutes).

***Specified eyewear may not be the only possible option, but represents an approved choice; depending on other laser hazards present in the lab, other eyewear may be acceptable provided the optical densities are equivalent or greater than those required.

EYE WEAR SPECIFICATIONS		
Laser System Eyewear Identification	Wavelengths	Optical Density
Cr:LiSAF KENTEK- GW-51	795 nm	5+
Argon Laser KENTEK - GW 52	500 nm	4.5+
Ti:Sapphire KENTEK- GW-51	780 nm	5+
TOPTICA, DL-150 KENTEK- GW-51	780 nm	5+

TRAINING

LASER SAFETY TRAINING

Laser Operators must complete sufficient training to assure that they can identify and control the risks presented by the laser systems they use. Owners/Operators and Qualified Laser Operators must complete the awareness level BNL World Wide Web based training course (TQ-LASER) every two years.

Qualified Laser Operators must also complete system-specific orientation with the system owner/operator. **System-specific training must be documented with a checklist that includes**

- Trainee name and signature
- Owner/Operator signature
- Date
- Brief list of topics covered e.g.
  - Review of SOPs;
  - Review of working procedures, and other program specific documentation.

All laser safety training must be repeated every two years.

See BTMS

Operating In The Laser Clean Room, Building 930

1. Check that the Laser Interlocks have been tested within the past 6 months.

2. Laser safety glasses must be worn.

3. All shutters on the optical table are closed.

4. Cooling water to argon ion laser is switched on.

5. Argon laser and/or .the TOPTICA, DL-150 power supplies are switched on

6. After 5 minute delay, argon laser is switched on.

7. Ti-Sapphire laser comes on directly with The Argon laser.

8. Check That cooling water is on, laser PS is I/L with water flow.

9. Turn on main Cr:LiSAF power supply switch.

10. Turn on pulsed PS switch "Vc".

11. Check Triggering from OPPIS VME Create.

12. Check output with power meter.

At this point all the lasers will be running and confined to the laser table. If the beam paths outside the laser room are properly shielded, the shutters may be safely opened. IT IS THE RESPONSIBILITY OF THE LASER OPERATOR TO CHECK THAT IT IS SAFE TO OPEN THE SHUTTERS.

To turn off the lasers the step 3-7 are reversed. Cooling water should be left running for 10 minutes after the laser power supplies are shut off.

If the laser beam is present when the cover to the optic box is open the following precautions must be performed:

1. Laser safety glasses must be worn.

2. Warning signs must be posted to alert personnel to the danger

3. The optic box must not be left unattended while the laser beam is present and the cover is open.

Laser alignment for OPPIS, Building 930

This procedure authorizes the listed persons to carry out the alignment of lasers and laser beam transport lines, as specified in this document. New users may be added to the list of authorized personnel by the first line manager, provided they have completed the training and medical examination requirements for laser users.

SCOPE OF WORK AUTHORIZED:
The lasers and laser transport lines covered by this procedure are part of the Optically Pumped Polarized Ion Source (OPPIS), which provides polarized beams for experiments in the AGS and RHIC. The general OPPIS and laser system layout is shown in Fig.1. The laser and table optics scheme is shown in Fig.2,3, 4. The high power pulsed laser is used to optically pump the Rb vapor in the polarized charge-exchange cell. The cw probe laser is used to measure the polarization using the Faraday rotation technique. The lasers may also be used in future development work of the OPPIS.

LASER DESCRIPTION
The lasers listed below are covered by this procedure. No class 3B or 4 lasers may be operated in this lab unless listed here.

1) Spectra Physics 2030, argon ion, 488-541 nm, 20W max. 8W typ., continuous
2) Spectra Physics 3900S Ti:sapphire, 795 nm, 4W max. 1W typ., continuous
3) Flash lamp pumped,Cr:LISAF: 795 nm, 300E-3 J/pulse, 300 цsec, 7.5 Hz
4) Miscellaneous HeNe, 633 nm, 1-5 mW alignment lasers may be used.
5) Semiconductor laser TOPTICA DL-150, 150 mW dc , wavelength 780 nm.

PERSONNEL AUTHORIZED TO USE LASERS UNDER THIS PROCEDURE:
Only personnel listed in this SOP are authorized to operate the lasers under this procedure. Please note that all laser users must complete laser safety training as required by the ARC Local Practice for Laser Safety, and that they must have had a laser eye exam.

EYE PROTECTION:
Eye protection will be worn when there is a possibility of eye damage.
During the alignment of the lasers the laser power will be kept as low as practical and will only be increased once the alignment has been completed. During gross alignment of the argon laser, the GPT Argon Laser safety glasses with an OD >4.5 will be worn. When the beam is fully aligned, we will switch to the GPT Ti:sapphire laser safety glasses with an OD 3-4 before turning on the pulsed lasers at 795 nm. The primary argon beam is accessible in the Ti:sapphire laser, but may not be adjusted unless the argon goggles are worn.

Laser alignment procedures.

Argon laser Spectra Physics 2030. The alignment procedure is described in laser manual. See the list of attached papers. Initial alignment, with the open covers is done at the lowest power level.

Spectra Physics 3900S Ti:sapphire. The alignment procedures are described in laser manual. See the list of attached papers.

Flash lamp pumped: Cr:LISAF: 795 nm. Initial laser alignment (with the cover off) is done with the low power alignment laser. Final alignment for maximum power is done with the covers on. Laser mirror cleaning is done with the laser off.

Laser beam transport line alignment procedure.
The beam of pulsed Cr:LiSAF laser is transported in the completely enclosed laser transport lines from the laser room to the optics box , where it is introduced in the OPPIS through the quartz window (see Fig.1). The probe laser beam (Ti:sapphire) is introduced into the OPPIS through the window in the ECR source.

For initial laser beam transport system alignment, the OPPIS area is locked by the gate and entrance door (see Fig.1), which prevents unauthorized personnel access to the area. The door and gate are interlocked to shut laser beams off. The alignment is done for one beam at the time at the reduced power level.

The OPPIS area is also locked for the Faraday polarimeter optics alignment, which requires the laser operation with the open optics box door.

Laser maintenances for OPPIS, Building 930

This procedure authorizes the listed persons to service listed lasers as specified in this document. Any changes in lasers or scope of operations require an amendment or revision of this procedure, approved by the second line manager and the laser safety officer. New users may be added to the list of authorized personnel by the first line manager, provided they have completed the training and medical examination requirements for laser users.

SCOPE OF WORK AUTHORIZED:
The lasers covered by this procedure are part of the Optically Pumped Polarized Ion Source (OPPIS), which provides polarized beams for experiments in the AGS and RHIC. The high power pulsed lasers are used to optically pump the Rb vapor in the polarized charge-exchange cell. The cw probe laser is used to measure the polarization using the Faraday rotation technique. The lasers may also be used in future development work of the OPPIS.

LASER DESCRIPTION
The lasers listed below are covered by this procedure. No class 3B or 4 lasers may be operated in this lab unless listed here.

1) Spectra Physics 2030, argon ion, 488-541 nm, 20W max. 8W typ., continuous

2) Spectra Physics 3900S Ti:sapphire, 795 nm, 4W max. 1W typ., continuous
3) Flash lamp pumped, Cr:LISAF: 795 nm, 30E-3 J/pulse, 300 цsec, 7.5 Hz
4) Miscellaneous HeNe, 633 nm, 1-5 mW alignment lasers may be used
5) Semiconductor laser TOPTICA, DL-150, cw, 150 mW, 780 nm.

PERSONNEL AUTHORIZED TO USE LASERS UNDER THIS PROCEDURE:
Only personnel listed in this SOP are authorized to operate the lasers under this procedure. Please note that all laser users must complete laser safety training as required by the ARC Local Practice for Laser Safety, and that they must have had a laser eye exam.

EYE PROTECTION:
Eye protection will be worn.
*
During the alignment of the lasers the laser power will be kept as low as practical and will only be increased once the alignment has been completed. During gross alignment of the argon laser, the GPT Argon Laser safety glasses with an OD >4.5 will be worn. When the beam is fully aligned, we will switch to the GPT Ti:sapphire laser safety glasses with an OD ~4 before turning on the pulsed lasers at 795 nm. The primary argon beam is accessible in the Ti:sapphire laser, but may not be adjusted unless the argon goggles are worn.

The nominal hazard zone (NHZ) here describes the space within which, the level of diffusely scattered radiation during normal operation exceeds the appropriate maximum permissible exposure (MPE). The NHZ distance here is that specified for 600 seconds. It should be understood that the NHZ for direct or specularly reflected beams is much greater, hence the need for the controlled areas and barriers.

SKIN PROTECTION:
Each time a laser is turned on, a thorough survey will first be conducted to verify that all unwanted laser beams have been properly terminated.

ELECTRICAL HAZARDS:
The Argon Ion laser requires 600V and 50A. The pulsed lasers require capacitors of 120μF and 1.2kV. In general, neither the lasers nor the power supply will be opened unless the equipment is de-energized, locked out, and the capacitors have been discharged and the grounding jumper is installed. Users must not service these lasers unless they comply fully with electrical safety and lock-out/tag-out requirements.

Maintenance procedures.

Argon laser Spectra Physics 2030. Reference Argon laser Spectra Physics Model 2030 Manual, the maintenance procedures are described in the manufactures laser manual located in Pit I.
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Spectra Physics 3900S Ti:sapphire. Reference Argon laser Spectra Physics Model 2030 Manual, the maintenance procedures are described in the manufactures laser manual located in Pit I.

Flash lamp pumped: Cr:LISAF: 795 nm, ~100 mJ/pulse, 300 цsec, 7.5 Hz. The maintenance includes the flashlamp replacement. The electrical power must be off.

TOPTICA, DL-150 – maintenance according to standard manual.

Usually there is no need for major laser realignment. Laser mirrors cleaning is done with the laser off.

OPM 8.4~ CA- CA-100_-_ Interlock Testing Checklist

Testing Laser interlocks for Laser Clean Room Building 930

Frequency: Every Six Months

1.____ Verify that the sign above the laser room door is illuminated when the power to any laser is enabled.

2.____ Shutdown all laser power supplies.

3.____ Verify that the shutters close when the door to the laser room is opened.

4.____ Verify that the shutters remain closed when the door to the laser room is closed until the reset button is pushed.

5.____ Verify that the shutters close when the power is removed from the interlocks.

6.____ Verify that the shutter closes when the probe laser duct is removed between the laser room and the ion source.

7.____ Verify that the shutter remains closed when the probe laser duct is reinstalled until the reset button is pressed.

8.____ Verify that the shutters close when the cover to the optics box is opened.

9.____ Verify that the shutters remain closed when the cover to the optics box is closed until the reset button is pressed.

10.____ Verify that the optics box cover cannot be closed with the interlock bypass activated.

11.____ Verify that the shutters close when the gate to the OPIS area is opened and the cover to the optics box is open.

12.____ Verify that the shutters close when the door to the OPIS area is opened and the cover to the optics box is open.

13.____ Verify that the shutters remain closed after the gate and door are closed until the reset button is pressed.

14.____ Verify that the sign above the door to the OPIS area is illuminated when the cover to the optics box is open and the shutters are open.

15.____ Verify that the shutters on the commercial lasers operate as per manufactures specifications

16.____ Verify that the keypad laser room access switch allows 15 sec. to enter

Operators Name: (print)_____ date:_____

Signature:_____

OPM 8.4~ CA-930-1 Configuration Control Checklist

Pre Start Check List

To be used prior to restart after shutdown

1.____ Confirm that all protective barriers are in place and in good condition.
2.____ Insure that the Interlock system has been recently tested.
3.____ Confirm that all postings are in place and in good condition.

Operators Name: (print)_____ date:_____

Signature:_____