Laser Alignment Guidelines

The most likely time for a laser accident to occur is during alignment of laser beams. It is therefore very important to take appropriate precautions while performing this task and to ensure that the SOP has a section outlining the way in which laser alignment must be conducted.

The techniques for laser alignment listed below are to be used to help prevent accidents during alignment of a laser or laser system.

1. Pre-alignment recommendations

- Exclude unnecessary personnel from the laser area.
- Remove all reflective objects such as, watches, rings, dangling badges, necklaces, and reflective jewelry to reduce accidental reflections. Use of non-reflective tools should also be considered.
- Post a "Warning Notice" sign at entrances when temporary Laser Controlled Areas are set up (e.g. where the lasers are normally Class 1/enclosed lasers) or unusual conditions warrant that additional hazard information be available to personnel wishing to enter the area.
- Ensure that the individual conducting the alignment activities is authorized to do so by the PI or Center Director.
- It is recommended that at least two authorized users are present during the alignment activities.
- Plan ahead to ensure that all equipment and materials needed are present prior to beginning the alignment.
- Remove all unnecessary equipment, tools, and combustible materials (if the risk of fire exists) to minimize the possibility of stray reflections and non-beam accidents.
- Have all beam location devices ready (e.g., sensor cards, viewers, etc.).
- Review the SOP for alignment of the laser beam.

2. Alignment recommendations

- Wear laser eye protection during alignment (as indicated in the SOP), either with full protection for invisible beams or aligned for visible beams.
- Wear skin protection on face, hands and arms when aligning lasers emitting in the UV range of wavelengths (i.e. less than 400 nm).
- When aligning invisible (e.g. UV, IR) beams, use beam display devices such as image converter viewers or phosphor cards to locate the beams.
- If possible, use low-power visible lasers for path simulation of high power visible or invisible lasers.
- When aligning high-power lasers, use the lowest possible power level. Reduce beam power by using neutral-density filters, beam splitters, or dumps, or by reducing power at the power supply.

- Use a shutter or beam block to block high-power beams at their source except when actually needed during the alignment process. Make sure that the beam block is rated to terminate high power beams.
- Place beam blocks behind optics (e.g. turning mirrors) to terminate beam paths that might miss mirrors during the alignment process.
- Label areas where the beam path leaves the horizontal plane.
- Secure optics, optic mounts and beam blocks to the table as much as possible.
- If possible, locate and block all unused beams, stray reflections before proceeding to the next optical component as well as at the end of the alignment procedure.
- Use beam blocks and/or laser protective barriers where alignment beams could stray into areas with uninvolved personnel.
- Be sure all beams and reflections are properly terminated before switching back to high-power operation.

3. Post-alignment recommendations

- Normal laser-hazard controls must be restored when the alignment is completed. Controls include replacing all enclosures, covers, beam blocks, and barriers and checking affected interlocks for proper operation.
- Remove the “Warning Notice”.
- Let everyone know in the laboratory that alignment is completed and full power operation is set to start.

4. Additional suggestions

- To find the optimum point while adjusting an optical mount, first, intentionally overdial, then tune toward the optimum point. Pass it, intentionally, overdial on the other side, then move back onto the optimum point (making sure to truly find the optimum point).
- When performing a sensitive optimization, always release finger-touch pressure from the adjustment knob between each adjustment iteration.
- Whenever possible, mark the edge of all new optics using a pencil or a permanent fine marker, indicating at a minimum:
  - Reflective/polished surface using an arrow (e.g., >);
  - Coating parameters (e.g., AR.10 = UV, AR.14 = 532 nm, AR.16 = 800 nm);
  - Substrate details (e.g., FS, BK7, 0dur, etc.);
  - Other key details when needed/appropriate (e.g., s/n, PO#, ref#, etc).
- Avoid fingerprints (or clean immediately) on coated optics; acid from fingers permanently damages the coating when left on optics for an extended time.
- Always use a proper optic container to store optics, or, if not possible, wrap optics in lens tissues, or temporarily deposit the optics face down (on lens tissue layers) on a safe and clean flat surface (away from drop or damage risks).

- A good method to clean optics is first to use a canned air duster (or compressed and filtered air) to remove the dust. If the optics still need cleaning then the use of solvent and lens tissue is required. Acetone can be used to remove tough contamination such as finger prints but it usually leaves a milky film on the optics. Methanol is a softer solvent than acetone (i.e. cannot remove tough contamination) but leaves the optics cleaner. Therefore, a good solvent for optic cleaning consists of a mix of 60% acetone and 40% methanol. It is recommended that this mixture is kept in a glass bottle and prepared fresh; if large bottles are used they can be kept for less than 6 months and if pipette bottles are used the mix should be prepared before every cleaning procedure.
- Wideband Ti:sapphire oscillators are very sensitive to dust, and therefore sensitive to cleaning as well. Periodically clean the cavity optics and the Ti:sapphire crystal (never let the oscillator performance drop by more than 10%).

5. Special alignment suggestions

5.1 Flash lamps and YAG high-energy 532-nm beams

- Always align beams at low power [one way is to detune the Q-switch (QSW)] timing versus flash lamp timing to reduce green power.
- Always verify the YAG beam profile prior to sending it to a Ti:sapphire crystal or other crystals. Hot spots will likely cause severe irreversible damage to the crystal lattice or the crystal coating. Performing a dummy test on sapphire crystals can be an inexpensive way to ensure integrity of the Ti:sapphire when it is being pumped.
- Practical temporary beam blocks for a YAG 10-Hz green beam are white packing foams, which diffuse the powerful green beams temporarily during specific and approved alignment procedures.
- Any black anodized metal surfaces used as beam blocks should be rough, not a shiny, flat black. White ceramic is the preferred permanent beam-block material for YAG energetic beams.
- Photographic “burn paper” or non-developed photo paper (black) can be used to visualize the beam quality. Make sure to put the paper into a clear plastic bag to avoid debris blasts and avoid overexposure (use of back burns sometimes helps) to maintain profile information content of the burn marks. Beware of laser reflections on the plastic bag.

5.2 YAG/YLF high-power 532/527-nm beams

- Wear approved alignment goggles, which allow a faint green beam to be visible.
- Avoid placing your finger in a focused high-power beam.
- High-power, high-repetition-rate beams will ablate the black anodization of most beam blocks, leaving residues on nearby optics.

5.3 800-nm ultrafast beams

- For an 800-nm compressed beam (at peak power), alignment using white bleached business cards (while wearing eyewear) allows the user to see the second harmonic generation (SHG) (blue color) beam on the card for alignment purposes.

- When aligning large-diameter beams that are compressed or very intense, use the SHG beam on a white business card to center the beam on alignment irises. Center the beam on the iris looking at the throughput beam (which is the symmetrically clipped SHG blue beam). When aligning small-diameter beams, use the IR viewer to look at the concentric beam around the hole of the iris, or use an orange card when looking at the throughput beam.
- Beware of the secondary lasing cavity caused by back reflections when introducing the reflective surface in a pumped amplifier with flat (not Brewster) Ti:sapphire crystals (this is valid for other types of gain mediums). Always use the minimum possible number of mirrors required to realign an amplifier. Thin white ceramic plates are useful and safe for both low- and high-power beams.

5.4 For UV wavelengths (180–266 nm)

- Always wear gloves and long sleeves when aligning UV beams to prevent skin exposure, which could lead to skin cancer.
- Calcium fluoride (CaF_2) substrate for transmissive optics should be used to prevent red-fluorescence nonlinear absorption effects when used with high-energy, high-power UV beams. Red fluorescence ultimately leads to a permanent increase of optical transmission loss (which appears as a brownish color).
- For reflective optics, fused-silica substrate is known to reduce coating absorption. Aluminum-coated gratings, even when coated against oxidation, will degrade rapidly when used for UV high energy beams.

Remember: the lower the wavelength, the smaller the spot size for a given focal-length lens/optic. When looking at a beam profile on camera, ensure that all harmonics are filtered out.

5.5 Ultrafast optical-parametric-amplifier beams (166 nm–20 µm)

- For NIR and IR beams, liquid-crystal paper (sold by Thorlabs, Inc., Edmund Optics, Inc., etc.) can be very helpful to detect the position of far-IR beams that are outside the range of conventional beam viewers.
- The harmonic components of the beam can be misleading, so be aware that you may not have a correct setup even if you think you do.

Document History

REV	DATE	PREPARED BY	DESCRIPTION
01	Apr. 2020	D. Darios	New document