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| **Date:** (1)  **X/Y/ZZZZ** | **Assessed by:** (2)  **A. O. Labuser** | **Validated by:** (3)  PI/Lab manager  Laser safety advisor | **Location:** (4)  **Building X, Room B01** | **Assessment ref no** (5)  **V1** | **Review date:** (6)  Annually, or at change of use |
| **Approval of open beam work by Head of Department/ Director of Institute:** (7)  **Name: ………..………………………………. Signature:……………………** | | | | | |
| **Task and Environment :** (8)  Confocal imaging and laser ablation using a Leica SP8 Inverted confocal microscope  The laser lab has walls that are painted matt white and no windows. This lab is used exclusively for the inverted confocal system. There is a user operated ‘Room in Use’ luminaire above the door outside the lab.  Confocal lasers are housed in enclosed boxes under the microscope and are completely enclosed in interlocked enclosures, fibre optics and flight tubes before delivery to the scanhead. The Micropoint UV ablation (laser 3) is housed separately and is delivered directly to the rear port of the microscope via a fibre optic cable and a dedicated optics module. The scanhead is mounted onto the back of a Leica DMi8 inverted microscope and allows laser light through to the sample via objective lenses mounted on a turret. A condenser module and circular beam shield above the stage blocks laser light that passes through the sample. The system is configured so that laser light cannot be directed through the eyepiece. The SP8 Inverted system also employs blue, green and red RG3 LEDs in a CoolLed pE-300 illumination system. | | | | | |
| **Justification for open beam work:** (9)  The Class 3B laser path is open between the objective and a condenser, however the gap between the objective lens and the condenser is less than 10 cm making direct viewing of the beam physically impossible. A circular beam shield attached to the condenser reduces the risk of short angle specular reflections reaching the users eyes. An environmental control chamber placed around the microscope maintains a safe working distance of at least 20 cm from the laser at the objective. Microscope is configured so that laser light cannot enter eyepieces. | | | | | |
| **Details of Laser(s) used, including ELV/MPE calculations:** (10)    There are three lasers attached to the Leica SP8 inverted confocal microscope:  (1) Blue Diode laser, 405nm, CW, 50mW (<6mW at stage), Class 3B  (2) White light laser, 400nm to 700nm, <500mW, Class 3B  (3) Micropoint UV ablation laser, N-pumped Dye laser, Pulsed, 365-656nm, 15Hz/50uJ, Class 3B.  The hazards posed by the lasers in this system have been assessed by calculating the maximum permissible exposure (MPE) according to PD IEC TR 60825-14:2022, the exposure limit values (ELV) according to Directive 2006/25/EC.  **405nm CW laser (50 mW power; 405 nm; beam diameter 1 mm)**  Accidental exposure time = 0.25 s (ocular); 20 s (skin)  Size of source at objective = 0.609Rad (for 0.3NA 10x lens) = 609mRad (>100mRad) (But laser focuses to point so α<1.5)  **Skin ELV/MPE value**  [ELV/MPE]Skin **= 2000 Wm-2**  **Ocular ELV/MPE value**  [ELV/MPE]Ocular =18t0.75C6 Jm-2 ; (C6 = 1 :Point source)) = 18 x 0.250.75 x 1 = 6.364 Jm-2 = 6.364/0.25 Wm-2 = **25.46 Wm-2**    **Skin Irradiance**  Aperture diameter = 3.5 mm = 0.0035 m ; Power = 0.050 W ; Exposure area = πr2 = 3.141 x 0.001752 = 0.00000962 m2  Irradiance = Power / Exposure area = 0.05 / 0.00000962 = **5200 Wm-2 - exceeds ELV/MPE by factor of 2.6**  **Eye Irradiance**  Aperture diameter = 7 mm ; Exposure area = πr2 = 3.141 x 0.00352 = 0.0000384m2  Irradiance = Power / Exposure area = 0.05 / 0.0000384 = **1300 Wm-2 - exceeds ELV/MPE by factor of 204**  **Nominal Hazard Distances**  Power (P) = 0.05W ; Assumed beam spot diameter (a) = 1mm = 0.001m ; [ELV/MPE]ocular =25.46 Wm-2 ; [ELV/MPE]Skin = 2000 Wm-2  Full beam divergence angle (θ) = 0.609  **NSHD** = (√(4P / (π x [ELV/MPE]skin)) – a) / θ = (√(4x0.05) / (π x 2000)) – 0.00085) / 0.609 = (√(0.2 / 6280) – 0.001) / 0.609  = (√0.0000319 – 0.001) / 0.609 = (0.00565– 0.001) / 0.609 = 0.00465 / 0.609  = **0.00763m (0.8 cm)**  **NOHD** = (√(4P / (π x [ELV/MPE]ocular)) – a) / θ = (√(4x0.05/ (π x 25.46)) – 0.001) / 0.609 = (√(0.2 / 79.98) – 0.001) / 0.609  = (√0.002500 – 0.001) / 0.609 = (0.05000– 0.001) / 0.609 = 0.04900 / 0.609  = **0.08047m (8.1 cm)**  [So protected by chamber even at full laser power with 10x lens]  **White Light Laser [NKT SuperK Extreme] (0.5W Av. power; 470 to 670 nm; 1.28 kW peak power; 78 MHz; 5 ps pulse length, M2=1.1, 1 mm beam diameter, pulse energy 6.41 nJ)**  Accidental exposure time = 0.25s (ocular); 20s (skin) Size of source at objective = 0.609Rad (for 0.3NA 10x lens) = 609mRad (>100mRad)  78MHz is a pulse period of 12.8 ns, which therefore falls into the high repetition rate regime, and where relevant effective repetition rates of 55,556 Hz (ELV) and 200,000 (MPE) will be used in calculations.  **Skin ELV/MPE values**  [ELV/MPE]single = 2 x 1011 Wm-2 (tpulse = 5 ps = 5x10-12s) x tpulse = 1 Jm-2J  [ELV]train = [ELV]single x N-0.25 (N = pulses in duration time = 20s x 55556 Hz) = 2 x 1011 x 1111111-0.25 = 6.16 x109 Wm-2 x 20 s = 1.23 x1011 Jm-2  [MPE]train = [MPE]single x N-0.25 (N = pulses in duration time = 20s x 20000Hz) = 2 x 1011 x 4000000-0.25 = 4.47 x109 Wm-2 x 20 s = 8.94 x1010 Jm-2  [ELV/MPE]duration-time = 2000 Wm-2 (t = 20 s) = 40000 Jm-2  [ELV]average = [ELV]duration time / N = 40000 / 1,111,111 = 0.036 Jm-2  [MPE]average = N/A  **[ELV/MPE]skin =** Most restrictive **= 0.036 Jm-2**  **Ocular ELV/MPE values**  [ELV/MPE]single = 1.5x10-4C6 Jm-2 (tpulse = 5x10-12s) (C6=1 as is a point source) = 1.5x10-4 Jm-2  [ELV]train = [ELV/MPE]single x N-0.25 (N = pulses in duration time = 0.25s x 55556 Hz = 13889) = 1.5x10-4 x 13889-0.25 = 1.38 x10-5 Jm-2  [MPE]train = [ELV/MPE]single x N-0.25 (N = pulses in duration time = 0.25s x 20000 Hz = 50000) = 1.5x10-4 x 50000-0.25 = 1.00 x10-5 Jm-2  [ELV/MPE]duration-time = 18t0.75C6 Jm-2 (t = 0.25s) (C6=1 as is a point source) = 18 x 0.250.75 x 1 = 6.36 Jm-2  [ELV]average = [ELV]duration time / N = 6.36 / 13889-0.25 = 69.0 Jm-2  [MPE]average = [MPE]duration time / N = 6.36 / 50000-0.25 = 95.1 Jm-2  **[ELV/MPE]**ocular = Most restrictive **= 1.0 x10-5 Jm-2**  **Assuming 0.5W average power**  **Skin Irradiance**  Aperture diameter = 3.5mm = 0.0035m ; Power = 0.5W ; Exposure area = πr2 = 3.141 x 0.001752 = 0.00000962m2  Irradiance = Pulse energy / Exposure area = 6.41 nJ / 0.00000962 = **6.66 x10-4 Jm-2 – below the ELV/MPE**  **Eye Irradiance**  Aperture diameter = 7 mm ; Exposure area = πr2 = 3.141 x 0.00352 = 0.0000384m2  Irradiance = Pulse energy / Exposure area = 6.41 nJ / 0.0000384 = **1.67 x10-4 Jm-2 - exceeds ELV/MPE by factor of 17**  **Nominal Hazard Distances**  Pulse Energy (E) = Average Power / Pulse frequency = 0.5 / 78000000 = 6.41 x 10-9 J  Assumed beam spot diameter (a) = 1mm = 0.001m ; [ELV/MPE]ocular = 3.26x10-7 Jm-2 ; [ELV/MPE]Skin = 0.0000256 Jm-2 ; Full beam divergence angle (θ) = 0.609  NSHD - N/A output below skin MPE  **NOHD** = (√(4E/ (π x [ELV/MPE]ocular)) – a) / θ = (√(4x 6.41x10-9 / (π x 1.0x10-5)) – 0.001) / 0.609 = (√(2.56x10-8 / (3.14x10-5)) – 0.001) / 0.609  = (√0.000816 – 0.001) / 0.609 = (0.029– 0.001) / 0.609 = 0.028 / 0.609  = **0.045m (4.5 cm)**  [So protected by chamber even at full laser power with 10x lens]  **Assuming maximum measured power at lens (30mW) @100% AOTF,**  Pulse Energy (E) = Average Power / Pulse frequency = 0.03 / 78000000 = 3.85 x 10-10 J  **Skin Irradiance**  Aperture diameter = 3.5mm = 0.0035m ; Power = 0.030W ; Exposure area = πr2 = 3.141 x 0.001752 = 0.00000962m2  Irradiance = Pulse energy / Exposure area = 0.385 nJ / 0.00000962 = **4.0 x10-5 Jm-2 – below the ELV/MPE**  **Eye Irradiance**  Aperture diameter = 7mm Exposure area = πr2 = 3.141 x 0.00352 = 0.0000384m2  Irradiance = Pulse energy / Exposure area = 0.385 nJ / 0.0000384 = **9.99 x10-6 Jm-2 – below the ELV/MPE** | | | | | |
| **Provided PPE, including calculated eyewear requirements:** (11)  No PPE required by general users.  Laser alignment will only be performed by a qualified service engineer, who will provide his own appropriate PPE. No one else will be present in the room during alignment. | | | | | |

| **Activity** (12) | **Hazard** (13) | **Who might be harmed** (14) | **Existing measures to control risk** (15) | **Risk rating** (16) | **Result** (17) |
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| Use of instrument | Class 3B beam hazard  and RG3 Radiation from LED light sources | Lab Users | Only persons who are adequately trained and authorised may work with the enclosed laser beam. They must: complete the Laser Safety Awareness course (THS42e), attend an SP8 inverted confocal training Session run by a member of Bioimaging staff and be familiar with this risk assessment and the associated local rules. Users must undergo a period of supervised use until both the user and the supervisor are confident that the user is competent to use the system unsupervised. Users must sign the H&S declaration sheet for this microscope to confirm that they have received training and read these local rules.  The gap between the objective lens and the condenser is less than 10 cm making direct viewing of the beam physically impossible. A circular beam shield attached to the condenser reduces the risk of short angle specular reflections reaching the users eyes. An environmental control chamber placed around the microscope maintains a safe working distance of at least 20 cm from the laser at the objective. Microscope is configured so that laser light cannot enter eyepieces.  SOPs and training emphasise that reflective implements must not be placed into the beam path while the laser is scanning, and warns users not to stare at the sample area while the laser is active.  Only authorised SP8 Inverted Confocal users are told the password to log onto the computer and the lasers can only be activated via the software.  Optical fibres are routed at the back of the microscope and are not over stretched. SOPs and training warns users not to remove optical cables. | Medium | A |
| Realignment of lasers | Class 3B beam hazard | Engineer or Technical staff | Only qualified service engineers are permitted to perform laser replacement / alignment. They will provide their own safety eyewear.  The lab will be cleared for alignment and a warning sign and barrier tape placed across the door.  The service engineer must follow his own safe operating procedures for laser alignment, must complete a laser permit to work and must sign off the system as safe to use once work is complete. | Medium | A |
| Basic maintenance |  | Technical staff and/or service engineer | Only Bioimaging staff (X, Y, And Z) or a qualified service engineer may perform basic maintenance on the system (as described in the user manual).  Before disassembling any part of the SP8 system the laser power must be turned off and the power keys removed. Before laser power is restored all fibre optics components, the polychroic beam splitter turret, condenser and laser enclosures must be replaced. | Low | A |
| Use of biological samples | Possible Group I/II biological agent/ GM/Chemical/Radiochemical hazards from some samples | Lab users | Users must submit risk assessments, GM/Biohazard risk assessments, local rules and COSSH forms for their experiments before they are allowed to use the system. Any specific rules for a particular experiment (as set out in the individual risk assessments) must be followed.  Labcoats must be worn at all times. No eating or drinking is allowed.  It is the user’s responsibility to remove biological waste from the facility and dispose of it appropriately. | Medium | A |
| Use of electrical equipment | Hazards associated with electricity.  Burns, shock, arcing, fire, explosion. | Users | All portable electrical equipment is PAT tested in accordance with The Electricity at Work Regulations 1989, and user checks are carried out at the start and end of lab sessions to check for excess noise, overheating, water ingress etc. | Low | A |
| General lab use | Trailing electrical cables  Trips and falls could result in injury | Users | A policy of good housekeeping is encouraged and cable guides/covers are used where appropriate. | Low | A |

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| **Action plan** (18) | | | | |
| **Ref No** | **Further action required** | **Action by whom** | **Action by when** | **Done** |
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**User Declaration**

*I have read and understood this document and agree to abide by its requirements at all times. I accept that we are all jointly responsible for one another’s safety and undertake not to knowingly permit the infringement of these requirements by others.*

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| **Name** | **Signature** | **Date** |
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**Notes to accompany Laser Risk Assessment Form**

This form is adapted from the one recommended by Safety Services, and used on the University’s risk assessment training courses. It is strongly suggested that you use it for all new assessments, and when existing assessments are being substantially revised. However, its use is not compulsory. Providing the assessor addresses the same issues, alternative layouts may be used.

1. **Date** : Insert date that assessment form is completed. The assessment must be valid on that day, and subsequent days, unless circumstances change and amendments are necessary.
2. **Assessed by** : Insert the name and signature of the assessor. The assessor should have completed the Laser Safety Awareness course THS42e and Advanced Laser Safety Awareness course THS43e. General guidance on completing risk assessments can be found on the safety services website: https://www.healthandsafety.manchester.ac.uk/toolkits/ra/
3. **Checked/Validated by** :

**Checked by** : Insert the name and signature of someone in a position to check that the assessment has been carried out by a competent person who can identify hazards and assess risk, and that the control measures are reasonable and in place. The checker will normally be a line manager, supervisor, principal investigator, etc.

**Validated by** : Insert the name and signature of your Local Laser Safety Advisor (or their designated deputy), they will need to check that your safety calculations and control measures are adequate.

1. **Location** : insert details of the exact location, ie building, floor, room or laboratory etc. If off-campus, provide information about expected location(s) or attach itinerary.
2. **Assessment ref no** : use this to insert any local tracking references used by the school or administrative directorate.
3. **Review date** : insert details of when the assessment will be reviewed as a matter of routine. Usually this is for 1 years’ time, but might be less for a short programme of work. Note that any assessment must be reviewed if there are any significant changes – to the work activity etc.
4. **Approval of open beam work :** Where open beam work with class 3B and 4 lasers is essential, it must be signed off by the Head of School/ Department/ Institute.
5. **Task**: insert a brief summary of the task, eg research project [title] involving the use of X equipment.
6. **Justification for open beam work:** where open beam work with class 3B and 4 lasers is essential, it must be robustly justified
7. **Details of Laser(s) used, including ELV/MPE calculations:** include make, model and other details of the laser system(s) in use, including wavelength, power, energy, pulse duration and beam size where known. This is also the place to include details of ELV/MPE calculations. If the calculations are extensive (covering multiple wavelengths etc.) then the results can be summarised here and given in full in a separate referenced document.
8. **Provided PPE, including calculated eyewear requirements:** list what PPE is available, and summarise what eyewear your calculations have specified. If the eyewear available does not match that specified then clearly state what wavelength/energy rages are covered. Also include here plan for how eyewear condition will be checked regularly and monitored/recorded.
9. **Activity** : use the column to describe each separate activity covered by the assessment. The number of rows is unlimited. For example activities might include: in one particular lab or for one particular project might include: Use of Lasers, Open beam work, Experimental process, Lone Working, General lab use, Use of substances hazardous to health, etc
10. **Hazard** : for each activity, list the hazards. Remember to look at hazards that are not immediately obvious. The same activity might well have several hazards associated with it. For example ‘Use of lasers’ would include personnel exposure to beam (from the laser output), fire (from high power beams) , electrical (from power supplies), water leaks (from cooling systems), trip hazards (from cables), irritants (from laser cutting). The ‘Open beam work’ hazard would personnel exposure to beam during alignment.

Assessment of simple chemical risks (eg use of cleaning chemicals in accordance with the instructions on the bottle) may be recorded here. More complex COSHH assessments eg for laboratory processes, should be recorded on the specific COSHH forms.

Describe how harm might come about, eg an obstruction or wet patch on an exit route is a hazard that might cause a trip and fall; use of electrical equipment might give rise to a risk of electric shock; use of a ultraviolet light source could burn eyes or skin.

1. **Who might be harmed**: insert everyone who might be affected by the activity and specify groups particularly at risk. Remember those who are not immediately involved in the work, including cleaners, young persons on work experience, maintenance contractors, Estates personnel carrying out routine maintenance and other work. Remember also that the risks for different groups will vary. Eg someone who needs to repair a laser may need to expose the beam path more than users of the laser would do. Vulnerable groups could include children on organised visits, someone who is pregnant, or employees and students with known disabilities or health conditions (this is not a definitive list).
2. **Existing measures to control the risk** : list all measures that already mitigate the risk. For example, in normal operation the risk of exposure to beam has been mitigated by fully enclosing the system, and interlocking to the laser output any access panels. For exposure to beam during alignment extra precautions would be needed, access controls, further training, appropriate PPE etc.
3. **Risk Rating** : the simplest form of risk assessment is to rate the remaining risk as high, medium or low, depending on how likely the activity is to cause harm and how serious that harm might be.

The risk is **LOW** - if it is most unlikely that harm would arise under the controlled conditions listed, and even if exposure occurred, the injury would be relatively slight.

The risk is **MEDIUM** - if it is more likely that harm might actually occur and the outcome could be more serious (eg some time off work, or a minor physical injury.

The risk is **HIGH** - if injury is likely to arise (eg there have been previous incidents, the situation “looks like an accident waiting to happen”) and that injury might be serious (broken bones, trip to the hospital, loss of consciousness), or even a fatality.

1. **Result** : this stage of assessment is often overlooked, but is probably the most important. Assigning a number or rating to a risk does not mean that the risk is necessarily adequately controlled. The options for this column are:

**T = trivial risk**. Use for very low risk activities to show that you have correctly identified a hazard, but that in the particular circumstances, the risk is insignificant.

**A = adequately controlled, no further action necessary.** If your control measures lead you to conclude that the risk is low, and that all legislative requirements have been met (and University policies complied with), then insert A in this column.

**N = not adequately controlled, actions required**. Sometimes, particularly when setting up new procedures or adapting existing processes, the risk assessment might identify that the risk is high or medium when it is capable of being reduced by methods that are reasonably practicable. In these cases, an action plan is required. The plan should list the actions necessary, who they are to be carried out by, a date for completing the actions, and a signature box for the assessor to sign off that the action(s) has been satisfactorily completed. Some action plans will be complex documents; others may be one or two actions that can be completed with a short timescale.

**U = unable to decide. Further information required.** Use this designation if the assessor is unable to complete any of the boxes, for any reason. Sometimes, additional information can be obtained readily (eg from equipment or chemicals suppliers, specialist University advisors) but sometimes detailed and prolonged enquiries might be required. Eg is someone is moving a research programme from a research establishment overseas where health and safety legislation is very different from that in the UK.

**For T and A results**, the assessment is complete.

**For N or U results**, more work is required before the assessment can be signed off.

(18) **Action Plan**. Include details of any actions necessary in order to meet the requirements of the information in Section 11 ‘Existing measures to control the risk’. Identify someone who will be responsible for ensuring the action is taken and the date by which this should be completed. Put the date when the action has been completed in the final column.