HOW TO SELECT A LASER SYSTEM FOR CT SIMULATION

SUN NUCLEAR corporation

Introduction

Minimizing patient positioning errors starts with selecting the right laser system and workflow for CT simulation. This white paper explains how selecting a laser configuration impacts patient safety, marker accuracy, and clinical workflow.

On the Choice Between Fixed or Moveable Lasers

The decision between fixed or moveable laser systems depends on equipment, clinical workflow preference, and a balance between budget and how much risk a clinic can tolerate. In general, there are two workflows in simulation depending on equipment and preference. The first workflow uses all fixed lasers to mark a temporary setup position of the patient that will later be used as a reference. The second workflow uses all moveable lasers or a combination of fixed and moveable lasers to mark a patient at the site of treatment. In either workflow, it is imperative to acquire the CT scan data of the patient in a reproducible position. Immobilization devices, patient comfort, and stability of skin at the location of marking are all critical to maximizing reproducible setup during each treatment.

WORKFLOW 1

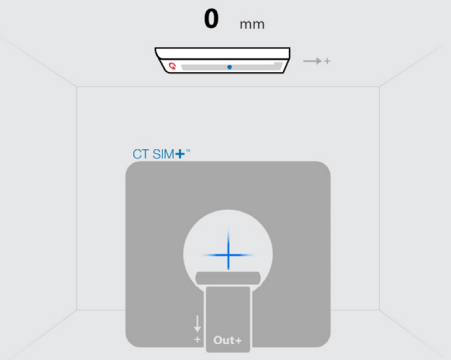
FIXED LASERS ONLY: Define Reference Position

With fixed lasers, the overhead and side lasers are limited to placing simulation marks only. The basic idea of this workflow is to make a suitable set of marks at simulation so that the physician and dosimetrist may use them as a reference point for treatment planning, and the therapists can reposition the patient on the first day of treatment exactly as they were positioned at simulation. The dosimetrist will mark the CT simulation isocenter as reference and choose another coordinate for treatment isocenter. Very rarely will the simulation marks be coincident with the treatment marks with this type of workflow. On Day 1 of treatment the therapists will reproduce the simulation setup at the treatment machine, make shifts defined by dosimetry, and place a second set of marks on the patient's skin to represent the treatment isocenter.

In this clinical workflow, the Radiation Therapist typically uses one color tattoo for simulation and another color tattoo for treatment. Often during planning there are one or more boosts which may require an additional isocenter and thus another set of tattoos to locate them.
A large number of tattoo marks creates risk of patient misalignment. The more positioning marks placed on the patient, the harder it is to identify which set is used for initial alignment (simulation) versus those for treatment. Furthermore, tattoos can look like moles, colors can be misidentified, and marks near one another can be easily confused. When different therapists are setting up the patient, there is an opportunity to align to the wrong tattoos and end up with a misaligned patient for that treatment.

Fixed and 1-arm Laser System workflow:

1. Mark and scan
2. Tattoo patient
3. Send CT data for treatment planning
4. Plan a shift to treatment isocenter
5. Treatment Day 1
    a. Align patient for treatment
    b. Shift patient based on planning
    c. Mark (again) for treatment



Example of 1-arm laser configuration

In summary, because fixed lasers do not typically allow treatment marks to be placed during simulation, they can increase the opportunity for error during treatment. Using moveable lasers instead during CT simulation can help mitigate this risk.

WORKFLOW 2

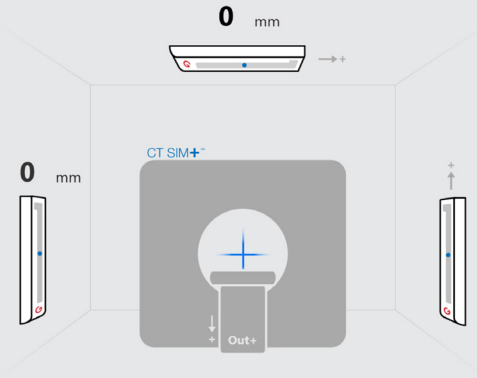
MOVEABLE LASERS: Define Treatment Position

By contrast, a moveable laser system workflow is designed to first make a temporary set of marks on a patient for CT data acquisition, quickly assign a reasonable treatment isocenter with simulation software while the patient is on the table, and finally shift the lasers to this treatment isocenter to make only one set of tattoo marks. The physician and therapist at simulation can define the most appropriate location for treatment isocenter based on patient-specific anatomy, while having the option to place markers on stability and immobilization devices. This method allows the same marks to be used during treatment that were placed during CT simulation.

Moveable laser systems offer a workflow that allows for "live isocenter" placement where the physician can choose the planned isocenter during simulation. In this case, the dosimetrist can make the treatment plan with the already chosen isocenter, reducing or eliminating the need for shifts on Day 1 of treatment. This approach often requires only one set of tattoos on the patient for the entire course of treatment, leading to less risk of patient misalignment.

Moveable Systems workflow:

1. Scan and send images for isocenter planning
2. Choose isocenter position
3. Mark and tattoo treatment isocenter
4. Treatment Day 1
    a. Align patient to treatment marks
    b. No shifting necessary
    c. No additional marks necessary



Example of 3-arm laser configuration

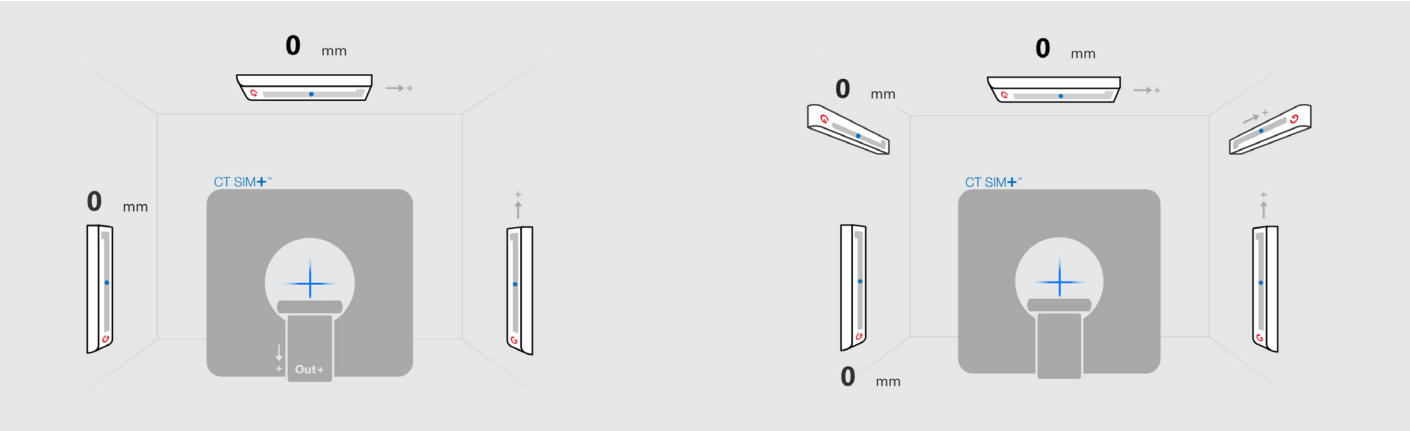
How Many Moveable Lasers Should I Use?

3-Arm Moveable Systems

3-Arm Moveable Systems provide a motion of the sagittal and coronal planes, while depending on the table travel, rather than a moving laser, to position the coordinates of the axial plane. With the 3-arm system, the clinic can mark the planned treatment isocenter at simulation, eliminating the need for a second set of marks during the treatment phase, allowing flexibility for all marking strategies.

5-Arm Moveable Systems

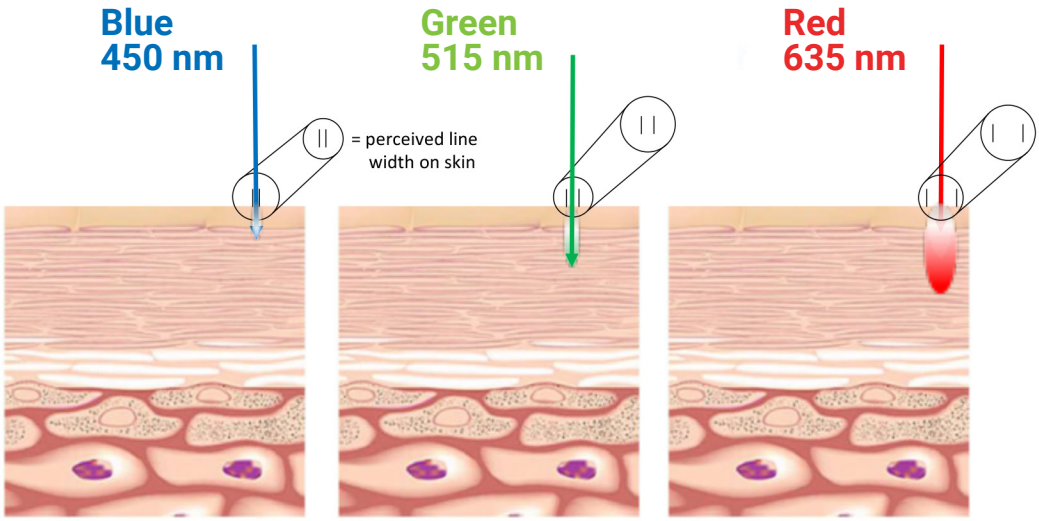
5-Arm Moveable Systems provide motion of all three coordinates (x, y, and z) of the patient isocenter. Like a 3-arm, a 5-arm system also allows flexibility for all marking strategies, while providing the clinic additional versatility of maintaining the longitudinal table position by moving the lasers instead of the table. This can provide opportunities for departmental growth with new or rotating physicians that may prefer different workflows.



CT Plane	1-Arm	3-Arm	5-Arm
Sagittal	Moveable	Moveable	Moveable
Coronal, Lateral (2x)	Fixed	Moveable	Moveable
Axial, Lateral (2x)	Fixed	Fixed	Moveable

Which Color Should I Use?

Historically, the only color option was red, so many clinics have maintained red lasers for consistency. Today's lasers can be manufactured in red, green, or blue. The sharpness of the laser line is directly impacted by the wavelength of the color shown on the skin. It is commonly noted that green laser lines are sharper than red, and blue lines are sharper than green. The sharpness of the line is uniquely perceived as the light reflects off the patient's skin. Due to shorter wavelength, blue lasers penetrate skin the least compared to green and red, resulting in less opportunity to scatter and blur at deeper depths. Blue laser photons remain superficial and observers of the skin perceive a sharply-focused line.



The shorter wavelength blue laser deposits the light closer to the surface creating a more crisp line on the skin surface.

The longer wavelength red laser deposits the light photons deeper in the skin creating a less crisp appearance on the skin surface.

Conclusion

The decision to select a fully moveable 5-arm laser system to immediately mark treatment coordinates during the simulation process is the safest choice. Because patients are marked clearly with only one set of positioning markers rather than both simulation and treatment marks, mistakes in patient positioning during treatment can be avoided. Additionally, 5-arm systems do not rely on the additional step of moving the table to reach the treatment coordinate, as required by 1- and 3-arm systems. After choosing the laser configuration, selecting the proper laser color is the final decision. Blue diodes offer a sharp line on skin that does not blur to the extent of red. This makes blue the preferred choice for the most accurate patient positioning.

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