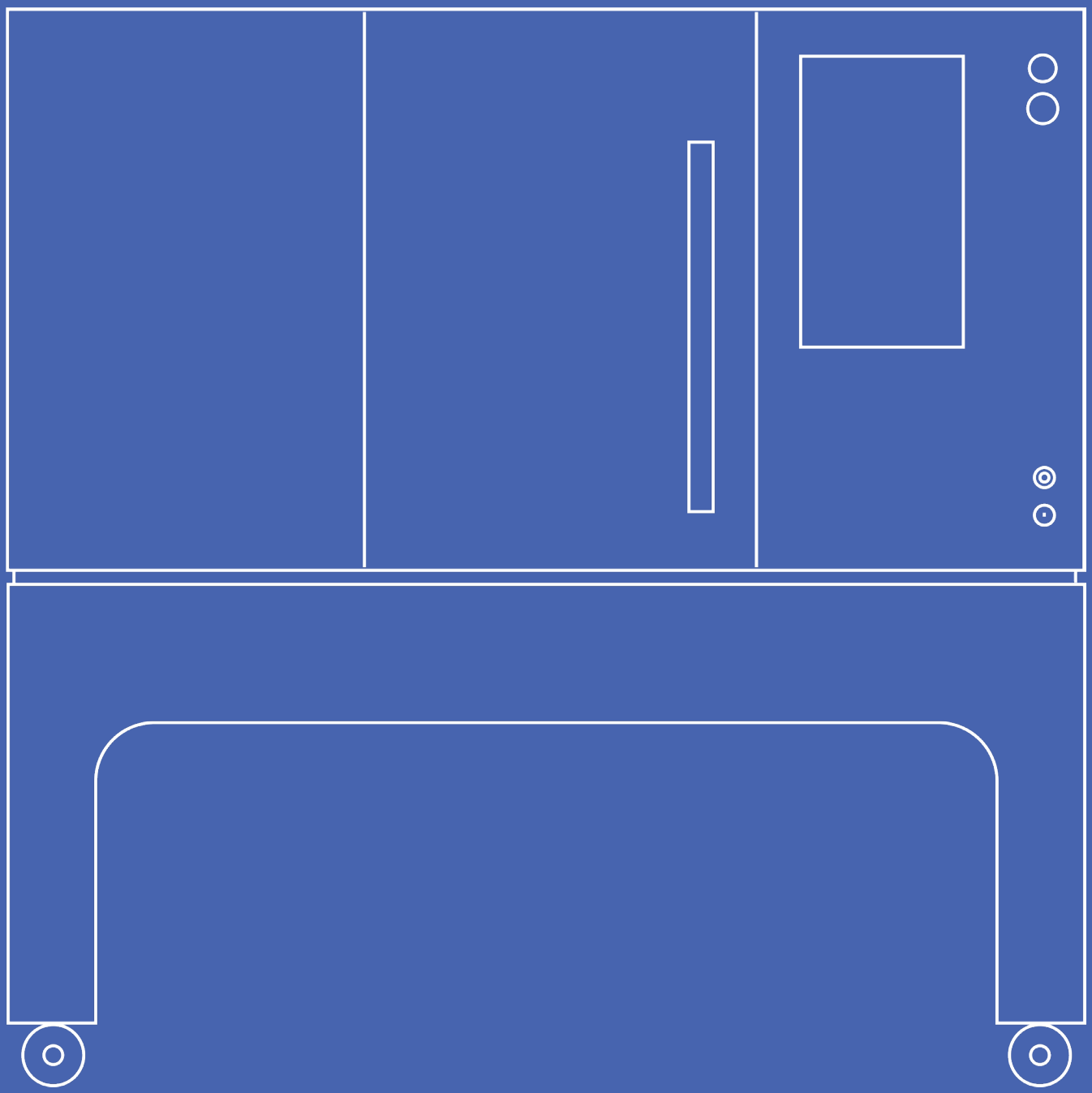
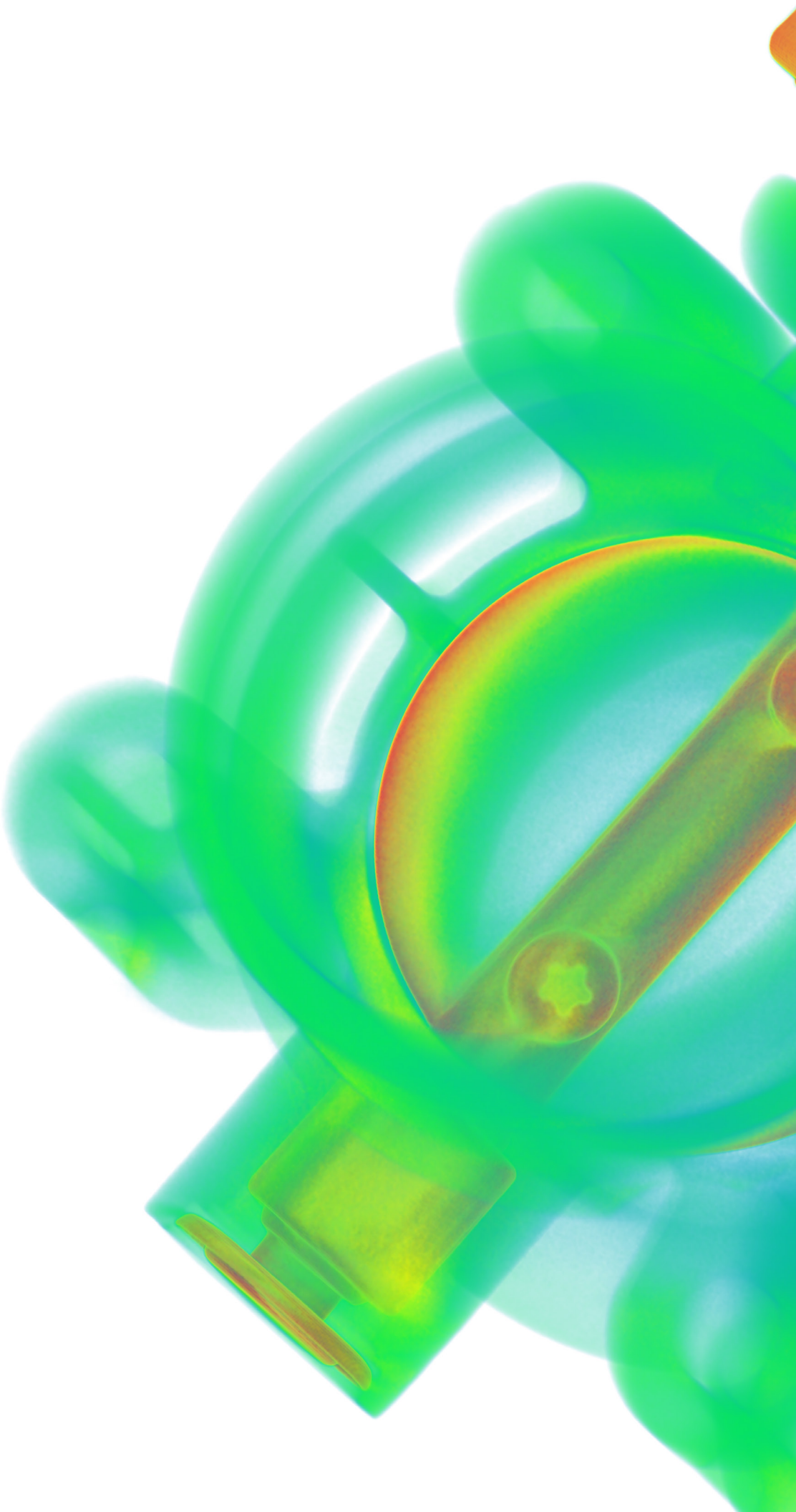
lumafield

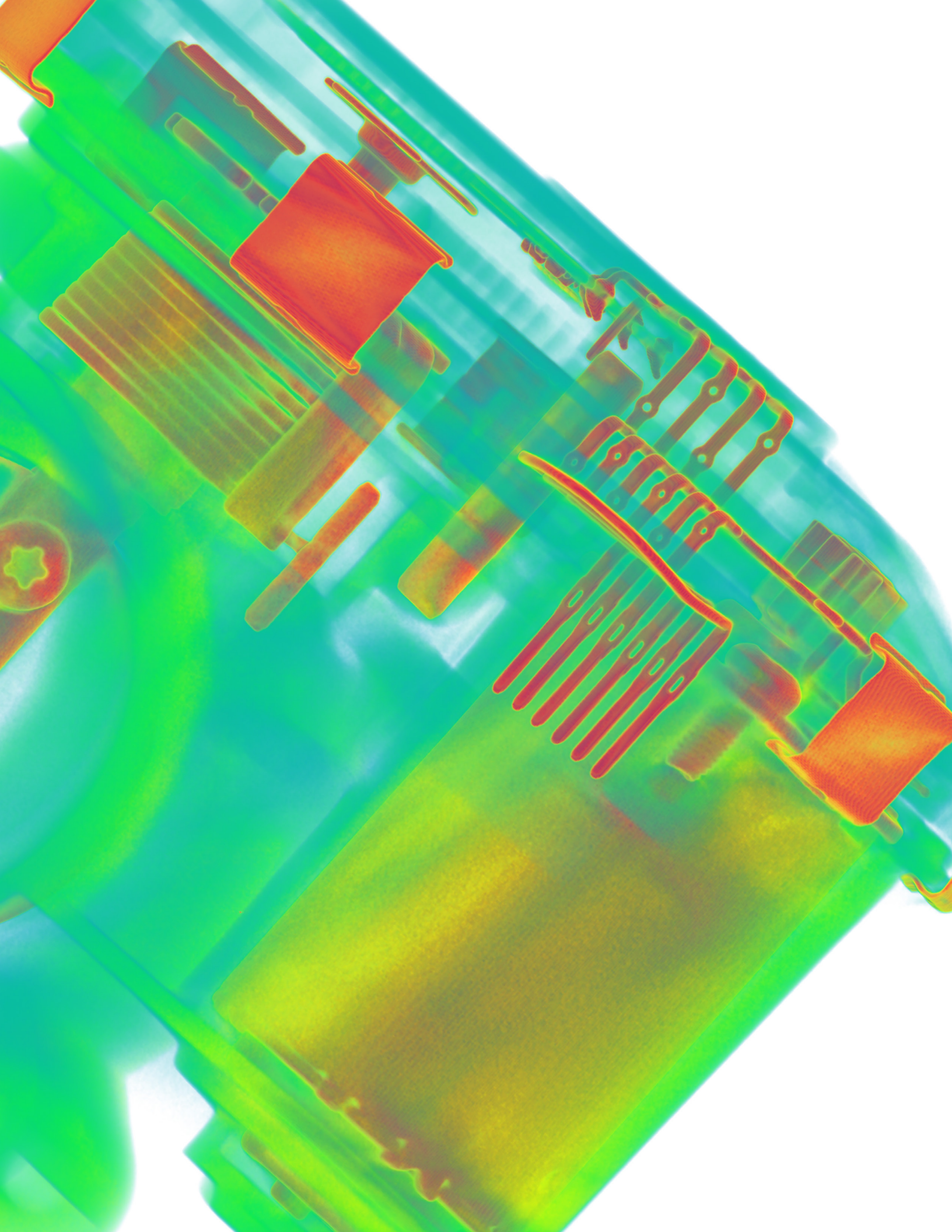


Neptune

User Manual



March 2024



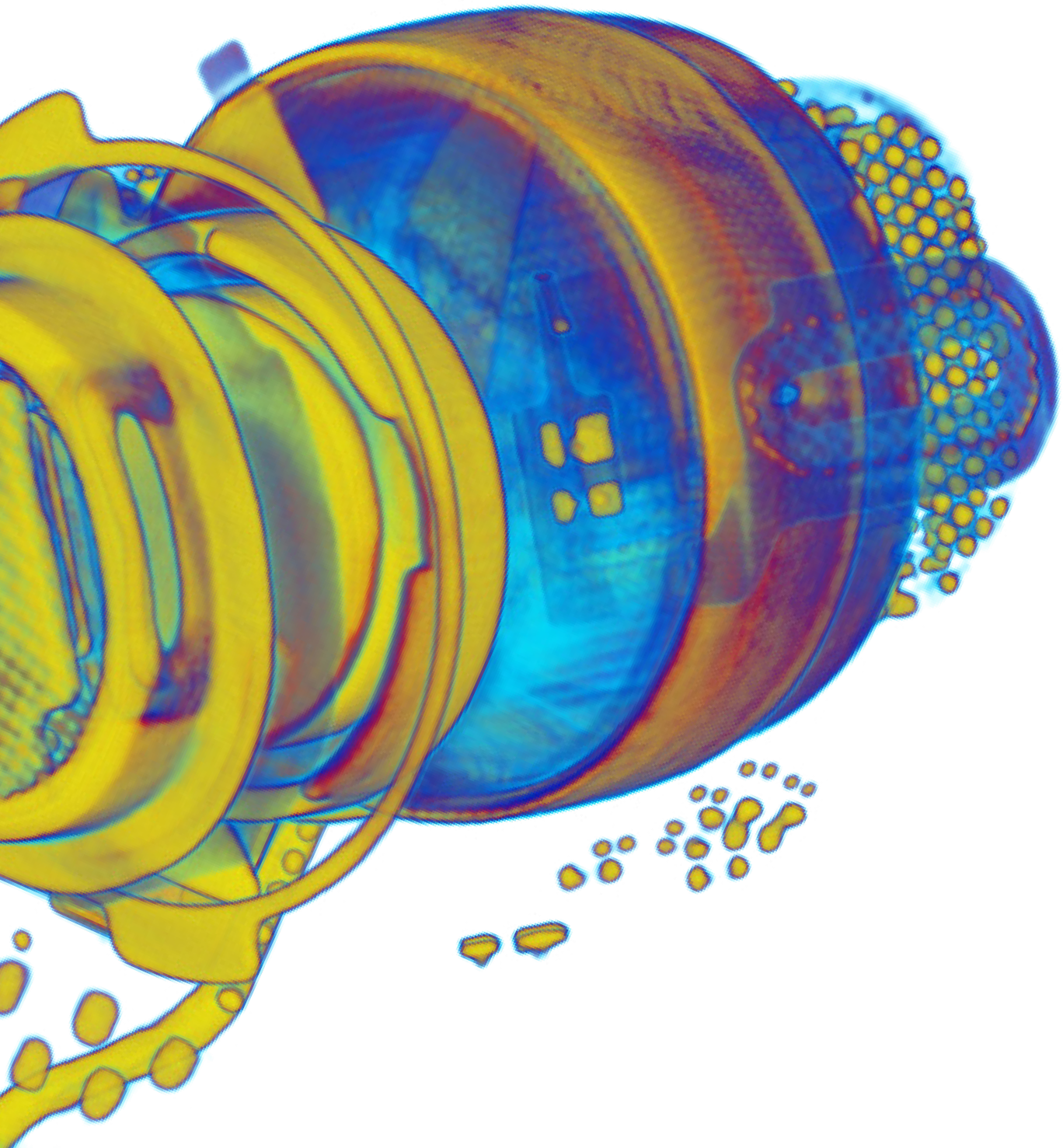
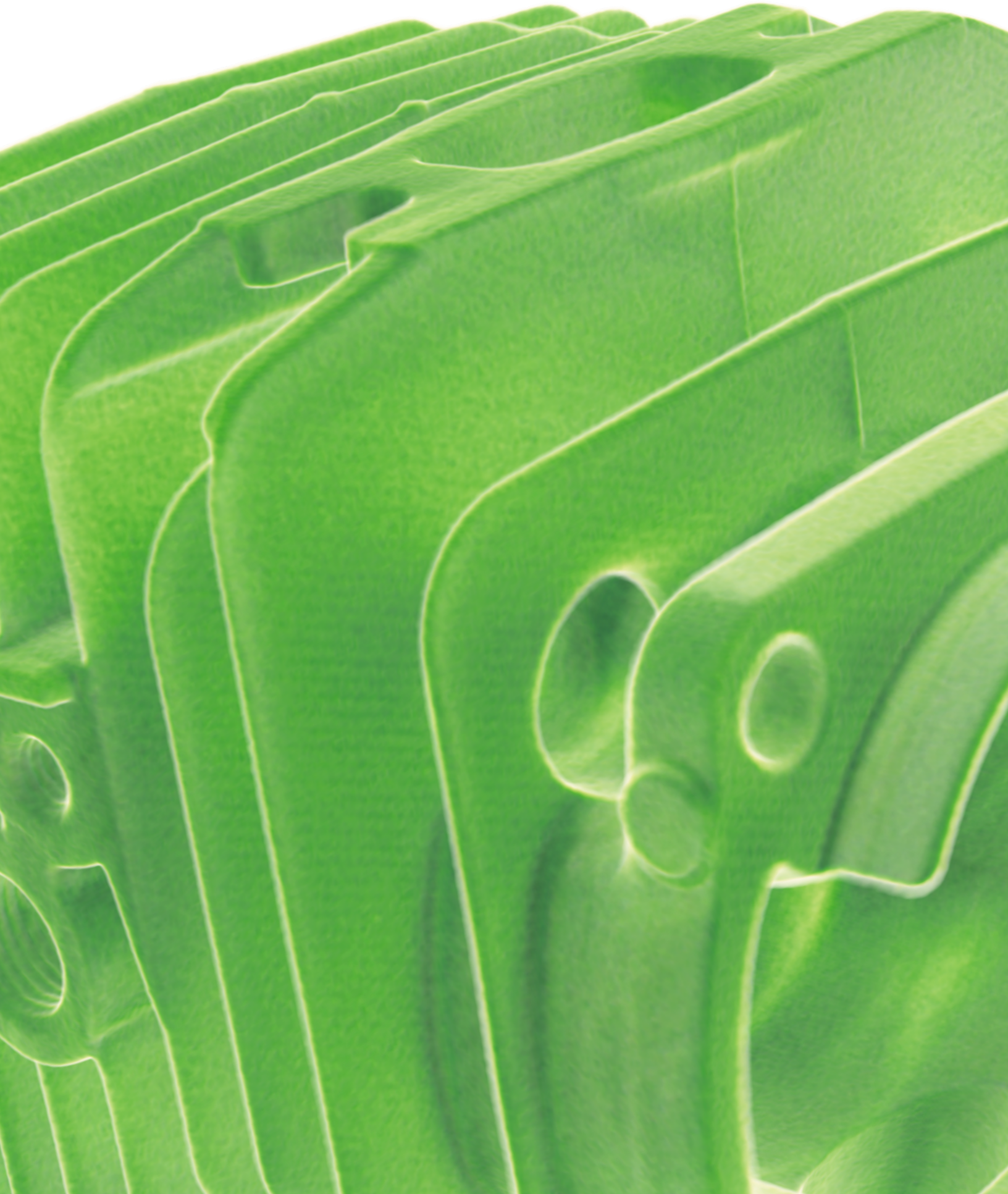
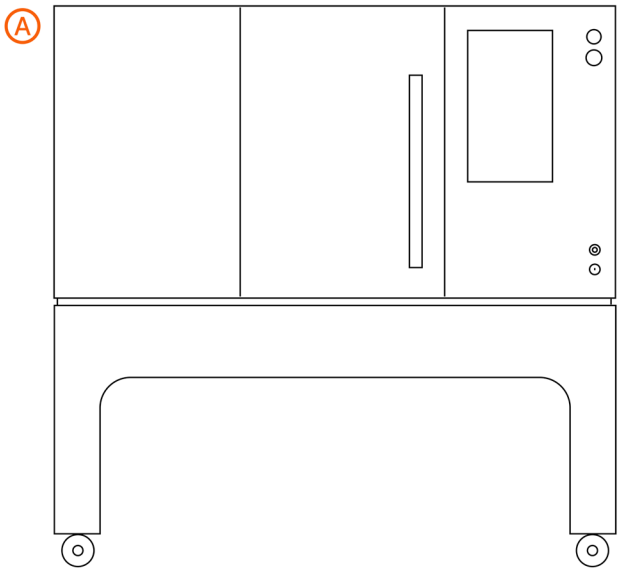


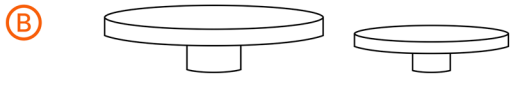
Table of Contents



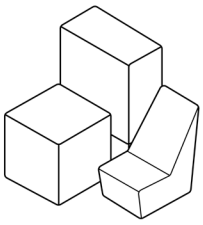
Preface

I. What is Included

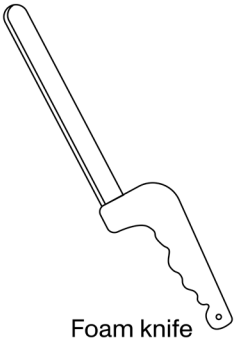




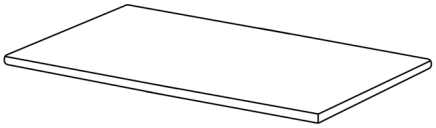
Turntables



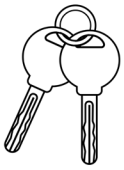
Floral foam



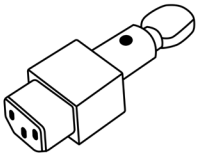
Foam knife



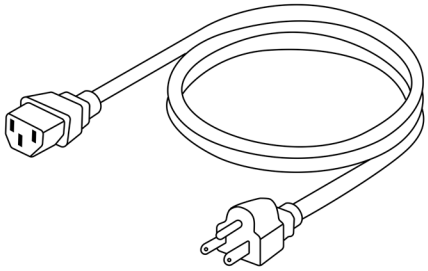
Foam mat



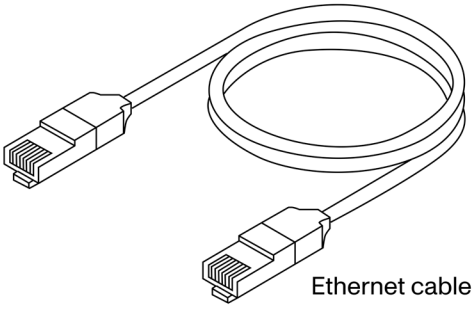
Neptune key



Lockout/Tagout



Power cable



Ethernet cable

Ⓐ Neptune scanner

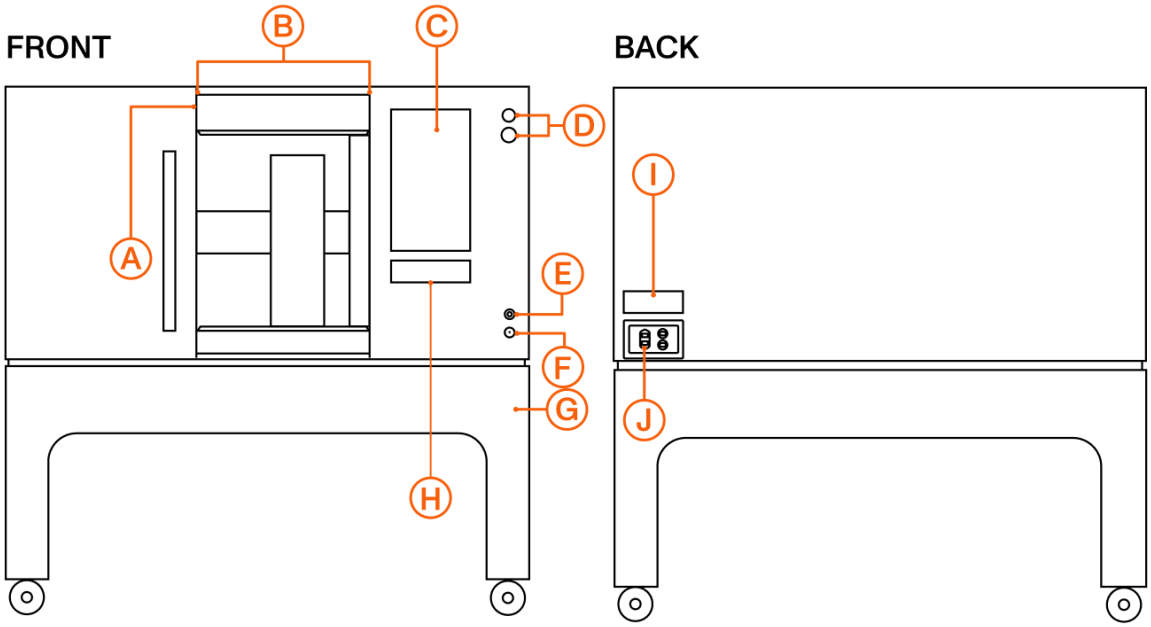
Ⓑ Turntables

Ⓒ Fixturing materials

Ⓓ Other peripherals

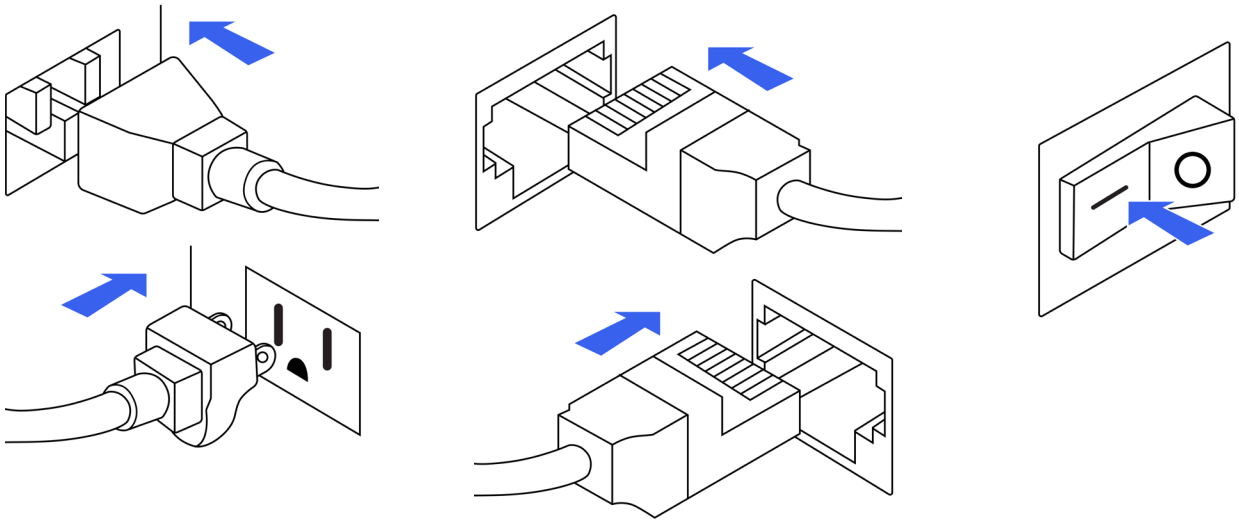
II. Quick Start Guide

A. Machine overview



LEGEND

- (A) Door latch
- (B) Door interlock
- (C) User interface
- (D) Status lights
- (E) Emergency Stop
- (F) Access key
- (G) Stand
- (H) Warning label
- (I) Manufacturer's label
- (J) Power switch and I/O panel



B. Initialization

If this is the first time starting your Neptune, or the first time the scanner has been started in days, there are additional steps that will need to be done before you can start scanning. Neptune's embedded software will guide you through the required steps. As our system evolves, these steps may evolve too. In general, there are two preliminaries required:

I. Warming

X-ray sources require a warming or conditioning step. Think of this as preventative maintenance that Neptune automates for you. To minimize the wear and tear on a source, if it has not been emitting X-rays for a prolonged period, it will need to ramp up to operation slowly. The warmup time can vary depending on how long the source has been inactive. Lumafield's software will guide you in warming the source for the necessary amount of time based on the model of your scanner, vendor guidance, and our fleet health statistics.
NOTE: *Maximum time is around one hour.*

II. Homing

Any time the machine has been fully powered down and turned back on, the motion system will require homing. This ensures that the system knows its positions and can provide repeatable execution of part manipulation.

C. Running a scan

The software will guide you through these steps, but generally scans follow these four steps:

1. Name your scan.
2. Position the part using the motion axis.
3. Set scan duration based on amount of time available and desired quality.
4. Start the scan.

You can find detailed and up-to-date information for this process and user interface on our website at support.lumafield.com.

III. Health and Safety

A. Safety notice

It is important to read ALL safety information, instructions, and accompanying documentation before using the system. This manual is part of the product and must be kept with the X-ray system at all times.

Users must take caution and observe all warnings during routine use of the system. Before using the X-ray system, all system operators must have read and understood the safety information and operating instructions. Only personnel who have been properly trained shall operate the system.

Facilities must comply with any relevant local, state, and federal legislation for the possession and use of X-ray generating equipment.

B. Intended use

The Neptune CT scanner can be used for inspections of non-living objects. These inspections are performed using X-ray radiation.

C. Understanding X-ray radiation

X-rays are a form of ionizing radiation that like ultraviolet light, when experienced in high doses, can cause serious injury.

Lumafield X-ray systems have been designed, built, and certified to comply with standards for cabinet X-ray systems (21 CFR 1020.40).

Neptune Model 59 and Model 61 CT Scanners are certified to emit less than 1.0 microsievert per hour (1.0 µSv/h) five centimeters (5 cm) from all external surfaces of the cabinet. Under normal operating conditions, there is no significant X-ray radiation risk to users.

If the CT scanner has taken damage or safety features are overridden, this does not constitute normal use. Do not use the system if damaged or malfunctioning, and contact Lumafield immediately.

D. Safety features and precautions

The Lumafield Neptune is a Certified Cabinet X-ray System, and adheres to the regulations that guide the design and operation of such systems.

I. X-ray radiation safety features

1. **Surveying**
   The Neptune CT scanner undergoes a radiation emission survey both at the time of manufacture as well as at the time of installation. Annual surveys will be performed by Lumafield or a third party authorized by Lumafield. A copy of the survey results will be provided for facility recordkeeping and reporting purposes.

2. **Shielding**
   The Neptune CT scanner utilizes enclosed lead shielding built into the cabinet. This limits the exposure to radiation to the area outside of the cabinet.

3. **Indicators**
   The user interface has indicators for when the system is ready for X-rays to turn on (green), as well as when X-rays have turned on (red).

4. **Emergency Stop**
   There is a red emergency stop button accessible from the front of the machine. This will immediately cut power to the X-ray source and motion systems.

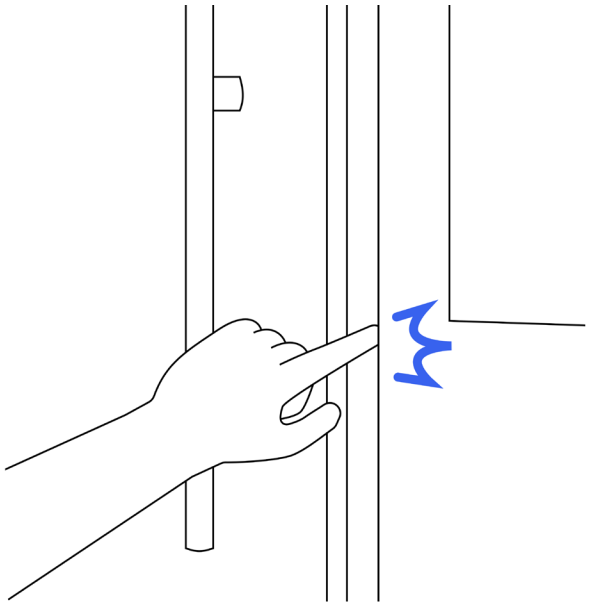
5. **Access control**
   The ability to power the X-ray system requires an access key.

6. **Door locks and interlocks**
   The door has a latching system to lock and hold the door mechanically closed during operation. In addition, redundant interlocks ensure that mechanically opening the door will cut power to the X-ray system.

II. Cabinet safety and precautions

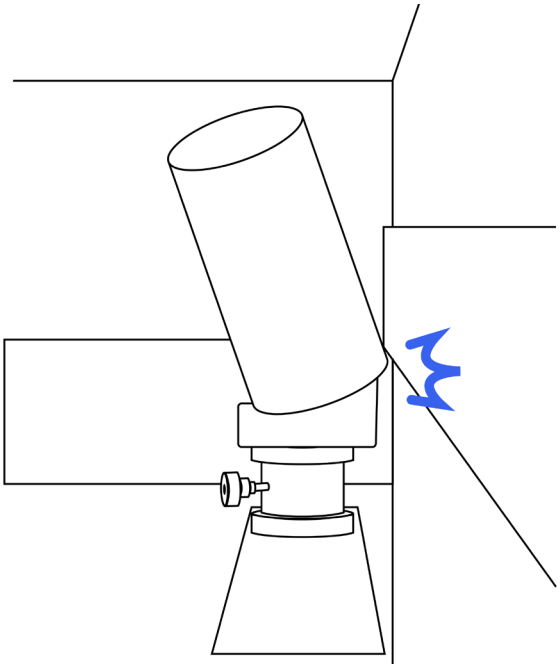
1. Pinch hazards

Be aware and avoid pinch hazards around the machine.



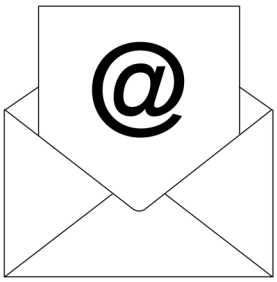
2. Crash event

The machine will attempt to alert the user to unload the machine in the event of movements that could cause a crash. Nevertheless, users should be aware during operation of the potential to crash the motion system, causing damage to the machine or their sample.



3. Maintenance

The Neptune CT scanner is maintained by Lumafield. In the event of any malfunction, contact Lumafield for assistance at support@lumafield.com.



NOTE:

If you see any exposed screws or wires, do not alter them.

E. Compliance statements

This wireless adapter has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This wireless adapter generates, uses, and can radiate radio frequency energy. If the wireless adapter is not installed and used in accordance with the instructions, the wireless adapter may cause harmful interference to radio communications. There is no guarantee, however, that such interference will not occur in a particular installation. If this wireless adapter does cause harmful interference to radio or television reception (which can be determined by turning the equipment off and on), the user is encouraged to try to correct the interference by taking one or more of the following measures:

- Reorient or relocate the receiving antenna of the equipment experiencing the interference.
- Increase the distance between the wireless adapter and the equipment experiencing the interference.
- Connect the computer with the wireless adapter to an outlet on a circuit different from that to which the equipment experiencing the interference is connected.
- Consult the dealer or an experienced radio/TV technician for help.
- NOTE: The adapter must be installed and used in strict accordance with the manufacturer's instructions as described in the user documentation that comes with the product. Any other installation or use will violate FCC Part 15 regulations.

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Caution:
When using IEEE 802.11a wireless LAN, this product is restricted to indoor use due to its operation in the 5.15- to 5.25-GHz frequency range. Industry Canada requires this product to be used indoors for the frequency range of 5.15 GHz to 5.25 GHz to reduce the potential for harmful interference to co-channel mobile satellite systems. High power radar is allocated as the primary user of the 5.25- to 5.35-GHz and 5.65 to 5.85-GHz bands. These radar stations can cause interference with and/or damage to this device. The maximum allowed antenna gain for use with this device is 6dBi in order to comply with the E.I.R.P limit for the 5.25- to 5.35 and 5.725 to 5.85 GHz frequency range in point-to-point operation.

To comply with RF exposure requirements all antennas should be located at a minimum distance of 20 cm, or the minimum separation distance allowed by the module approval, from the body of all persons.

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

Cet appareil se conforme aux normes Canada d'Industrie de RSS permis-exempt. L'utilisation est assujettie aux deux conditions suivantes: (1) cet appareil ne peut pas causer d'interférences, et (2) cet appareil doit accepter des interférences, y compris des interférences qui peuvent causer des opérations non désirées de l'appareil.

Attention:
L'utilisation d'un réseau sans fil IEEE802.11a est restreinte à une utilisation en intérieur à cause du fonctionnement dans la bande de fréquence 5.15-5.25 GHz. Industry Canada requiert que ce produit soit utilisé à l'intérieur des bâtiments pour la bande de fréquence 5.15-5.25 GHz afin de réduire les possibilités d'interférences nuisibles aux canaux co-existants des systèmes de transmission satellites. Les radars de puissances ont fait l'objet d'une allocation primaire de fréquences dans les bandes 5.25-5.35 GHz et 5.65-5.85 GHz. Ces stations radar peuvent créer des interférences avec ce produit et/ou lui être nuisible. Le gain d'antenne maximum permissible pour une utilisation avec ce produit est de 6 dBi afin d'être conforme aux limites de puissance isotropique rayonnée équivalente (P.I.R.E.) applicable dans les bandes 5.25-5.35 GHz et 5.725-5.85 GHz en fonctionnement point-à-point. Pour se conformer aux conditions d'exposition de RF toutes les antennes devraient être localisées à une distance minimum de 20 cm, ou la distance de séparation minimum permise par l'approbation du module, du corps de toutes les personnes.

Selon les règlements de Canada d'Industrie, cet émetteur de radio peut seulement fonctionner en utilisant une antenne du type et de gain maximum (ou moindre) que le gain approuvé pour l'émetteur par Canada d'Industrie. Pour réduire les interférences radio potentielles avec les autres utilisateurs, le type d'antenne et son gain devraient être

choisis de façon à ce que la puissance isotrope rayonnée équivalente (P.I.R.E.) ne soit pas supérieure à celle qui est nécessaire pour une communication réussie.

F. Regulatory markings

Do not tamper with or remove machine labels. If damage occurs, contact Lumafield for replacements.

Caution: X-rays
This equipment produces X-rays when energized.
To be operated only by qualified personnel.

Attention: Rayons X
Cet appareil produit des rayons X lorsqu'il est sous tension.
Son utilisation est réservée au personnel qualifié.

Caution: do not insert body parts during operation

Attention: Ne pas insérer de parties du corps pendant le fonctionnement

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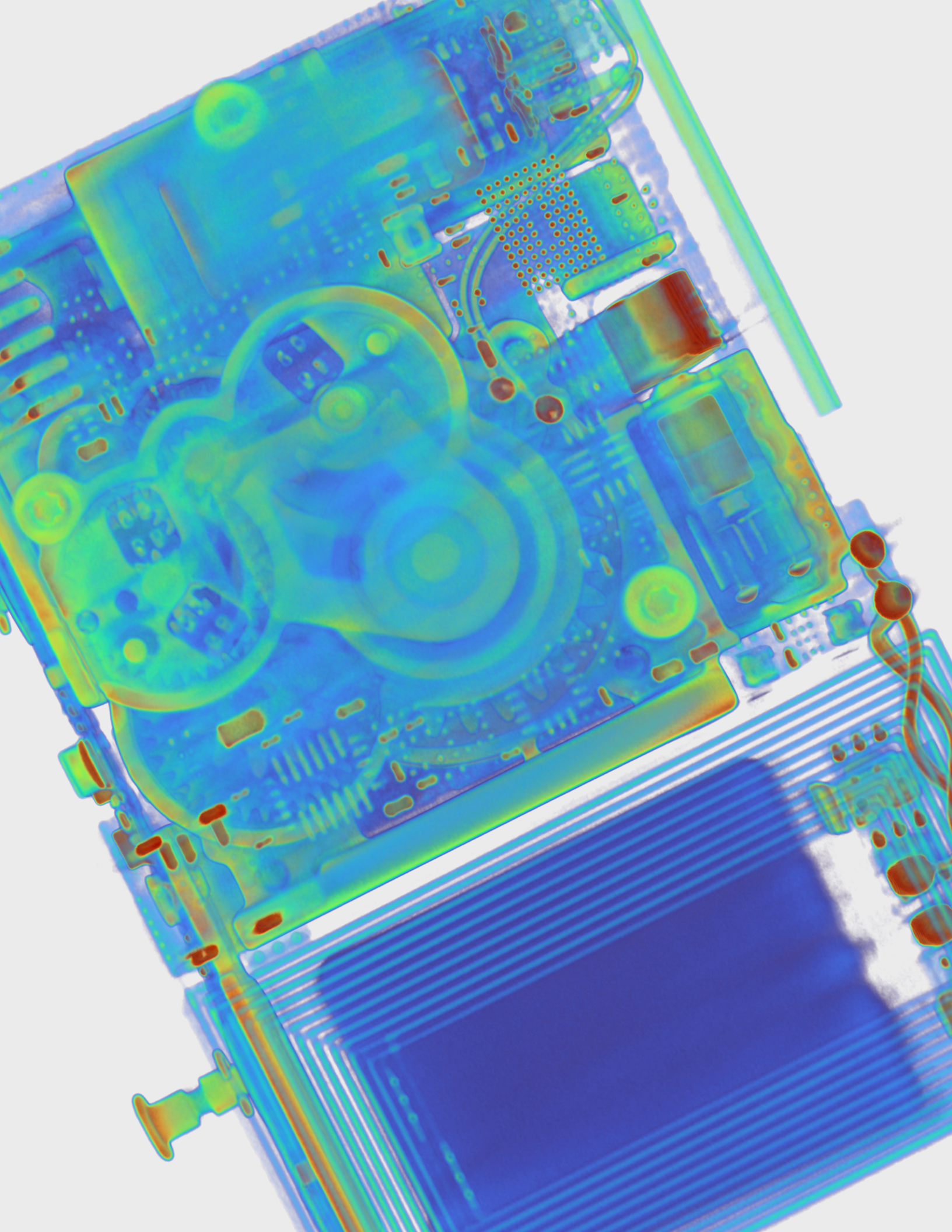
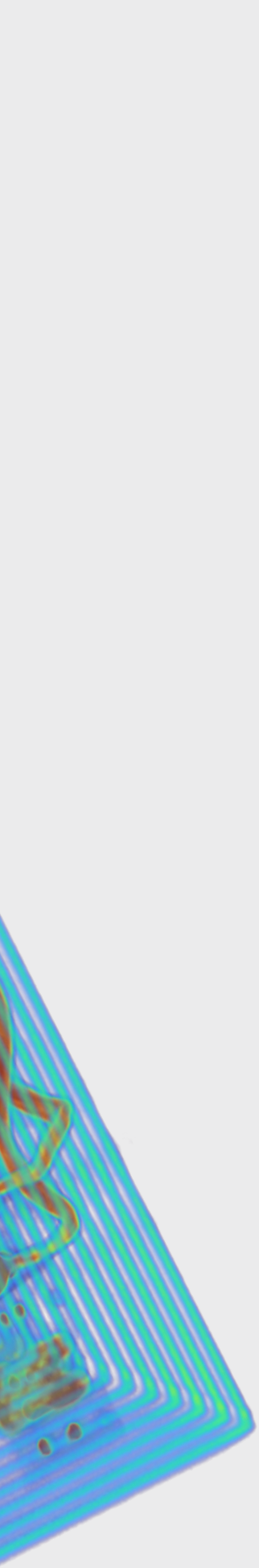
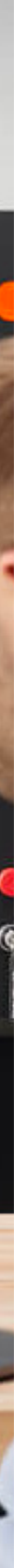




Neptune
User Manual


Start a new scan



1 Introduction

A. The Neptune scanner family

The Neptune family is a collection of industrial CT scanners designed by Lumafield to simplify X-ray computed tomography. By starting from the ground up, the Neptune is more affordable than traditional options and easier to use.

Lumafield designed Neptune to plug into your workspace with ease. It is at home in an office space or on the manufacturing floor. It comes with wheels to easily maneuver through office doors and plugs into standard wall outlets.

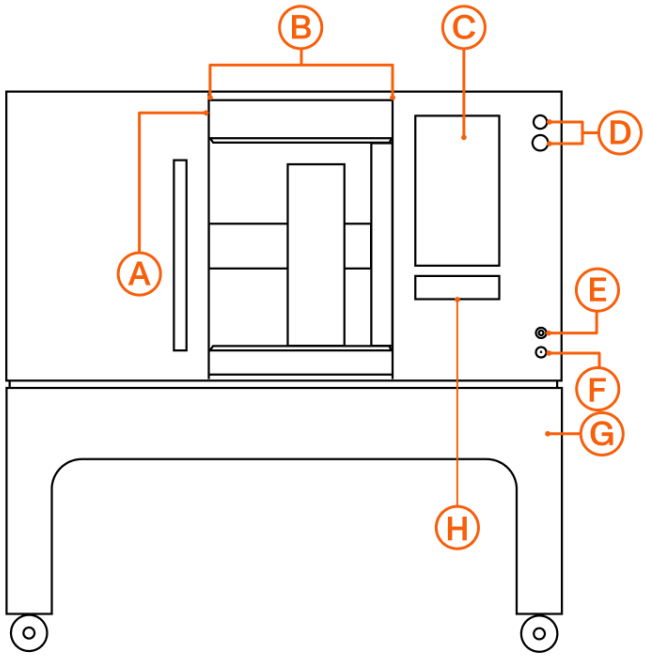
Different options are available in the Neptune family to meet customers' inspection needs. While the specifics of the family may evolve, each model focuses on certain benefits. Some models may have a higher power source that better penetrates heavy metals, while others may have a configuration that provides higher resolution.

All of these options share the same Neptune hardware platform, and all connect to Lumafield's browser-based Voyager analysis software. This means that your Neptune will remain current with the latest software updates. It also means that your scans require no manual data manipulation. Once you hit *Scan*, Lumafield's automated pipeline handles the rest.

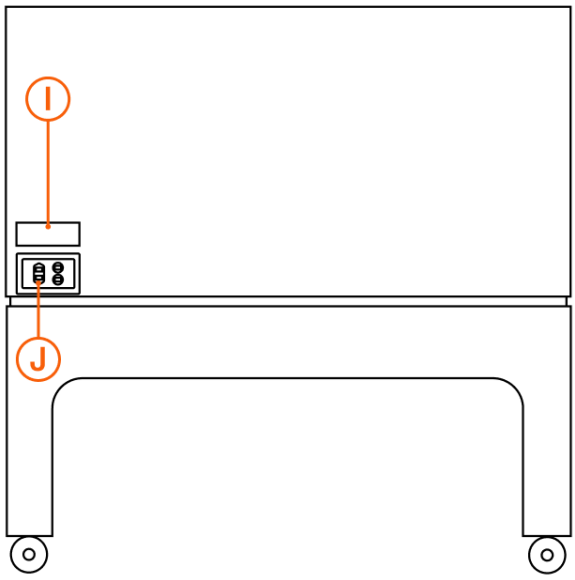
B. Hardware overview

The Neptune hardware platform has a set of standard components.

FRONT



BACK



LEGEND

- (A) Door latch
- (B) Door interlock
- (C) User interface
- (D) Status lights
- (E) Emergency Stop
- (F) Access key
- (G) Stand
- (H) Warning label
- (I) Manufacturer's label
- (J) Power switch and I/O panel

C. User interface and interactions

I. User interface

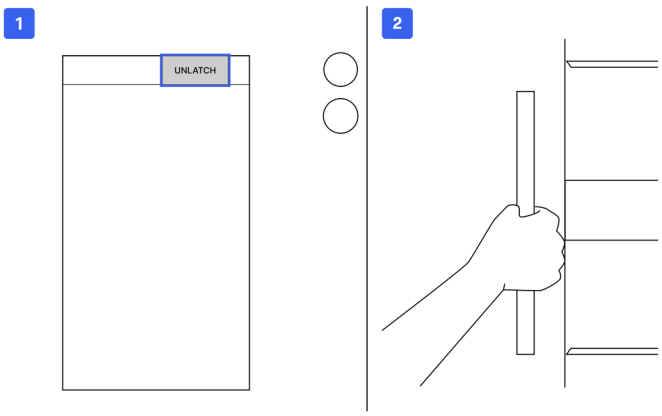
The main point of user interaction is with the touchscreen. The user interface provides access to the embedded control system and means that no additional hardware is required to operate your system.

The software constantly evolves as Lumafield adds new features and improvements to Neptune. While the specifics may change, there are core actions that a user can complete with this interface.

- Turn X-rays on/off
- View X-ray images
- Position samples for inspection
- Configure and launch CT scans
- Manage past scans and routines

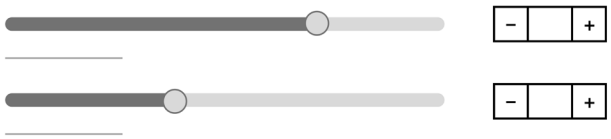
II. Door

The door can unlock via the latching functions available in the touchscreen user interface.



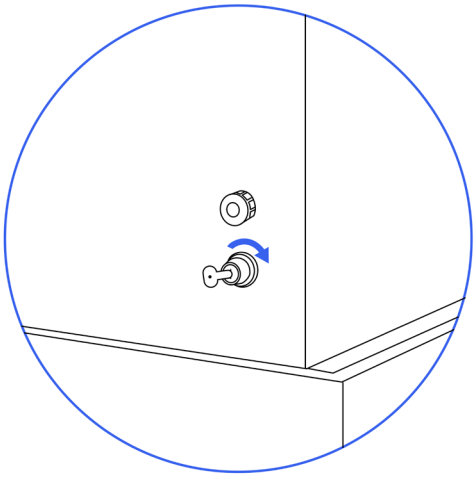
III. Motion system

The user can access the controls for the motion system from the touchscreen user interface.



IV. Access key

A user must first enable a safety circuit with an access key in order to turn on X-rays. A user can activate other parts of Neptune without this, such as the motion stages or the user interface. When the key switch is on, the system is enabled. When the system is enabled, the key may not be removed. When the key is removed, the system is not able to produce X-rays.

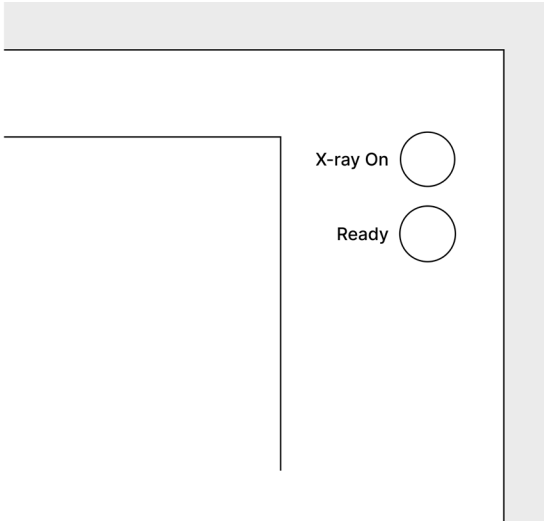


V. Status lights

There are two status lights included. Their states are as follows:

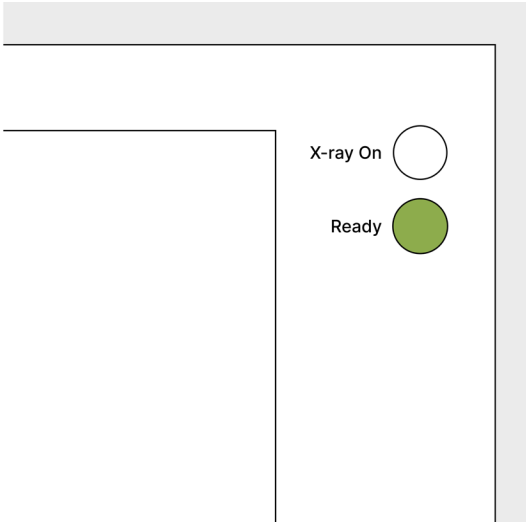
No lights

The user cannot activate the X-ray source in this machine state.



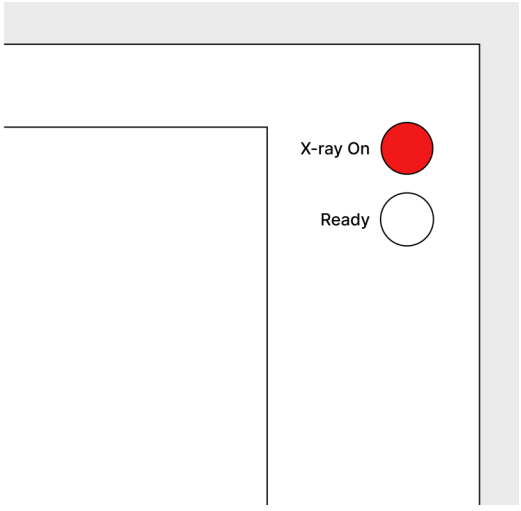
Green light labeled “Ready”

The user can activate the X-ray source.



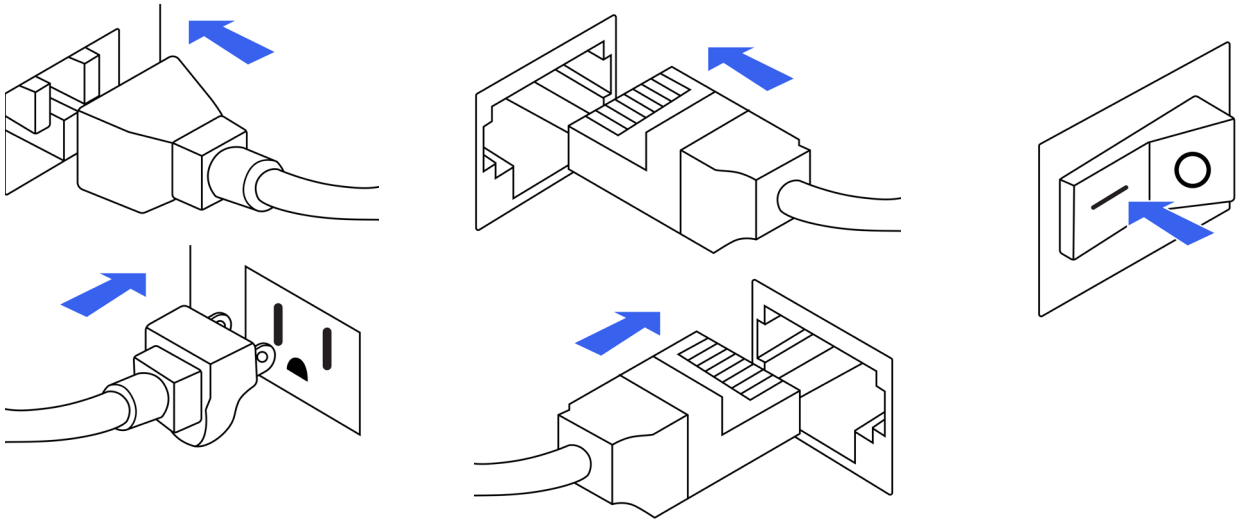
Red light labeled “X-rays on”

The X-ray source is active.



VI. Power switch and IO panel

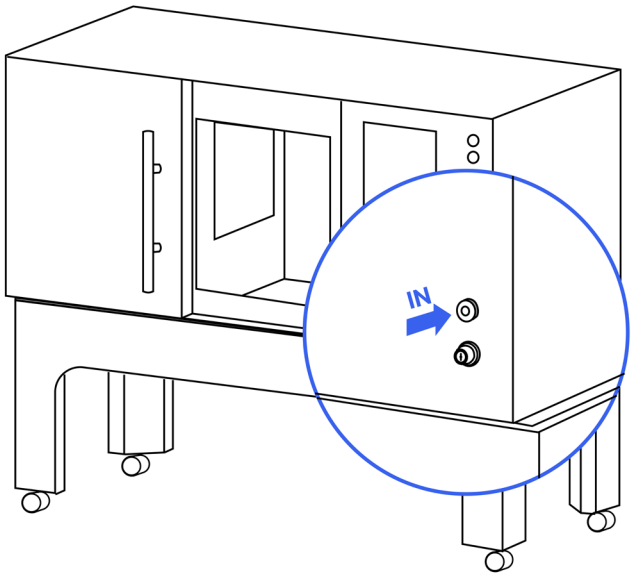
The back of the machine has a panel for plugging into a power outlet as well as a port for internet connection via Ethernet. It also includes a switch to power the device on or off.



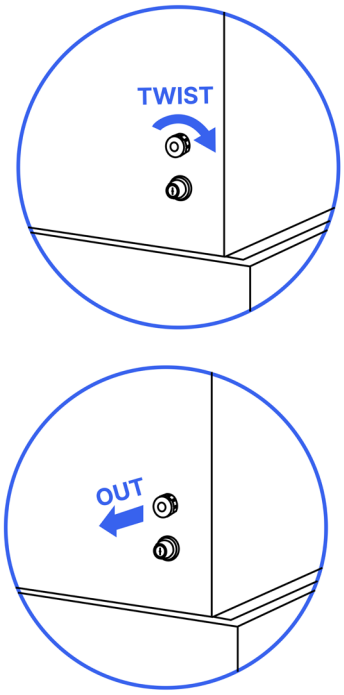
VII. Emergency Stop

Below the touchscreen is a red Emergency Stop button. In case of an unexpected issue, such as a crash of the motion system, a user can press this button to cease all scanner actions.

1 Emergency Stop



2 Reset Emergency Stop

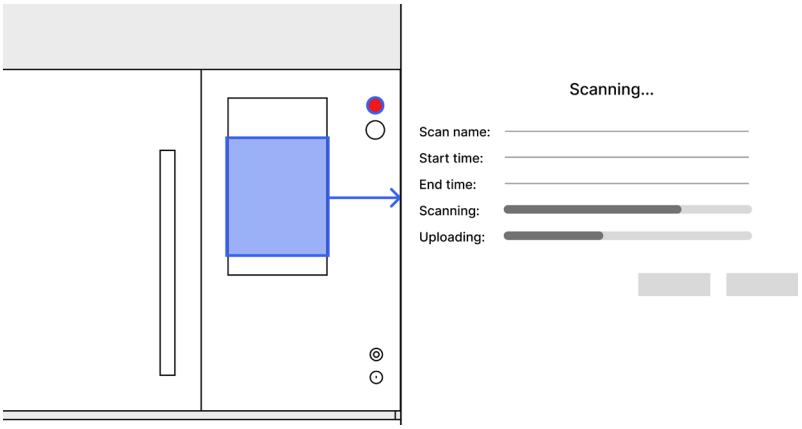


2 Running a CT scan

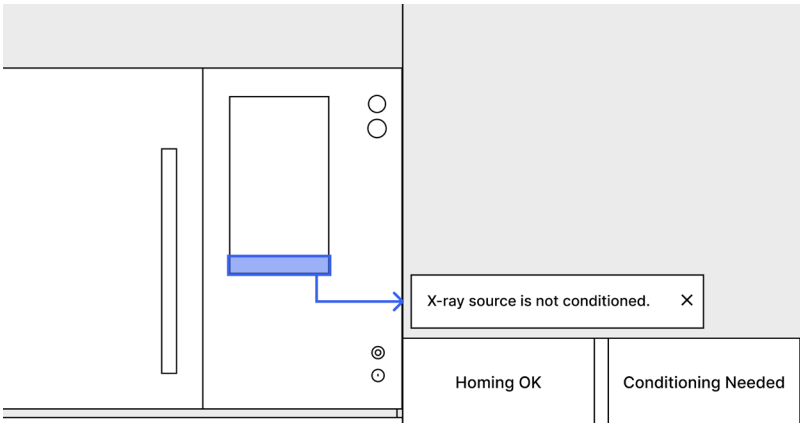
A. Checking machine status

At a glance, you will be able to understand if your scanner is ready for a new scan, is currently scanning, or if user interactions are required.

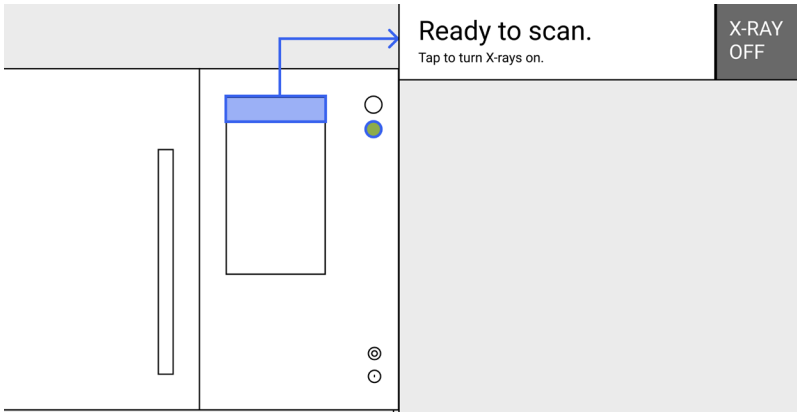
I. Scan in progress state



II. User interaction required



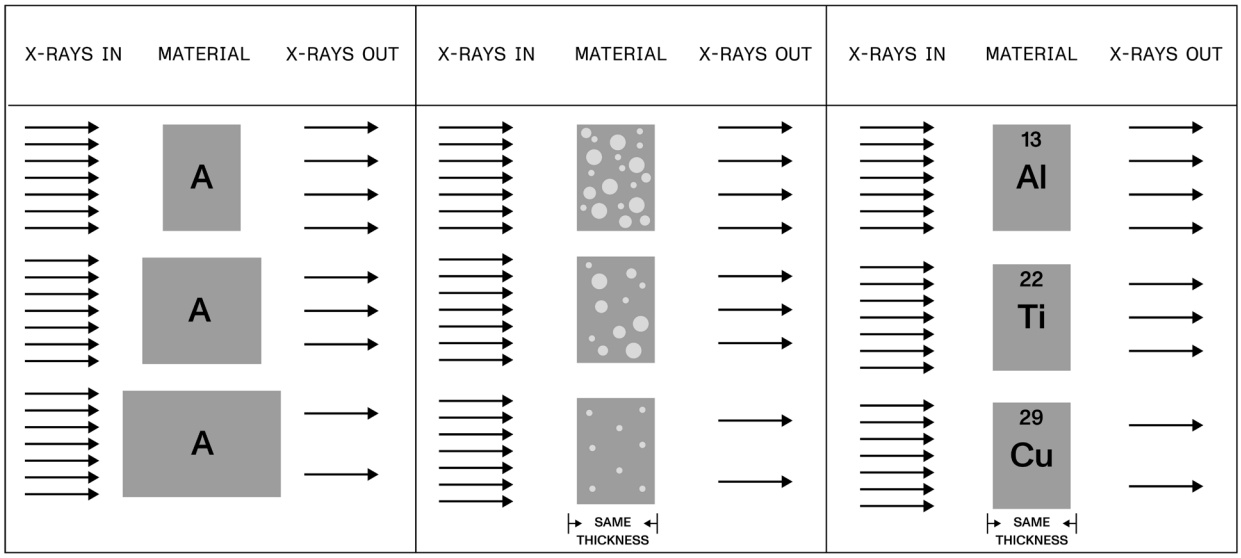
III. Ready to scan



B. Assessing your part

It's important to understand your part's composition and structure in order to produce the best scan.

There are two main factors to consider for how your part absorbs X-rays. X-ray absorption depends on how much material the X-rays must penetrate and the composition of that material. The denser or thicker the material, the more X-rays will be absorbed. In general, the thicker or denser the part, the longer the scan will need to be.



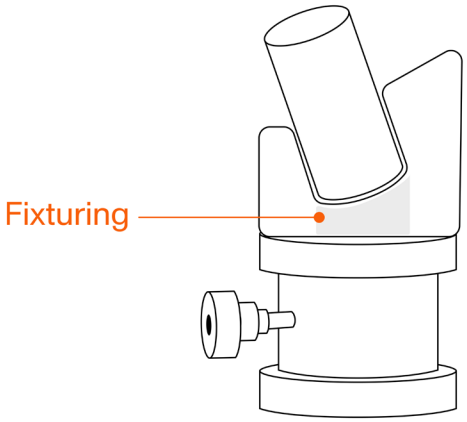
Another factor to consider is the makeup of the part, whether it is mono-material (i.e., all aluminum) or multi-material (i.e., aluminum with steel screws).

Lumafield's Autoscan functionality takes this into account when determining the best scan strategy.

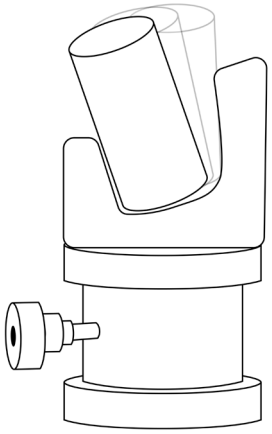
C. Fixturing your part

Fixturing is an essential step in the scanning process. Below are some pointers to serve as guides in your fixturing efforts.

I. Isolate the object you are scanning from things you do not want to see (such as the turntable).



II. Prevent unwanted motion of the part by securing it firmly in the fixturing material. Any motion other than the intentional rotation of the part by the stage is unwanted.

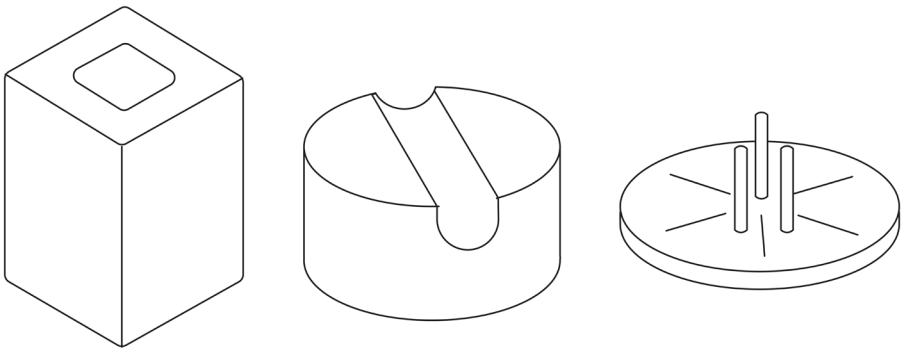


III. Minimize artifacts by centering the part as well as possible.

For a detailed fixturing tutorial, please visit support.lumafield.com or scan the QR code to the right.

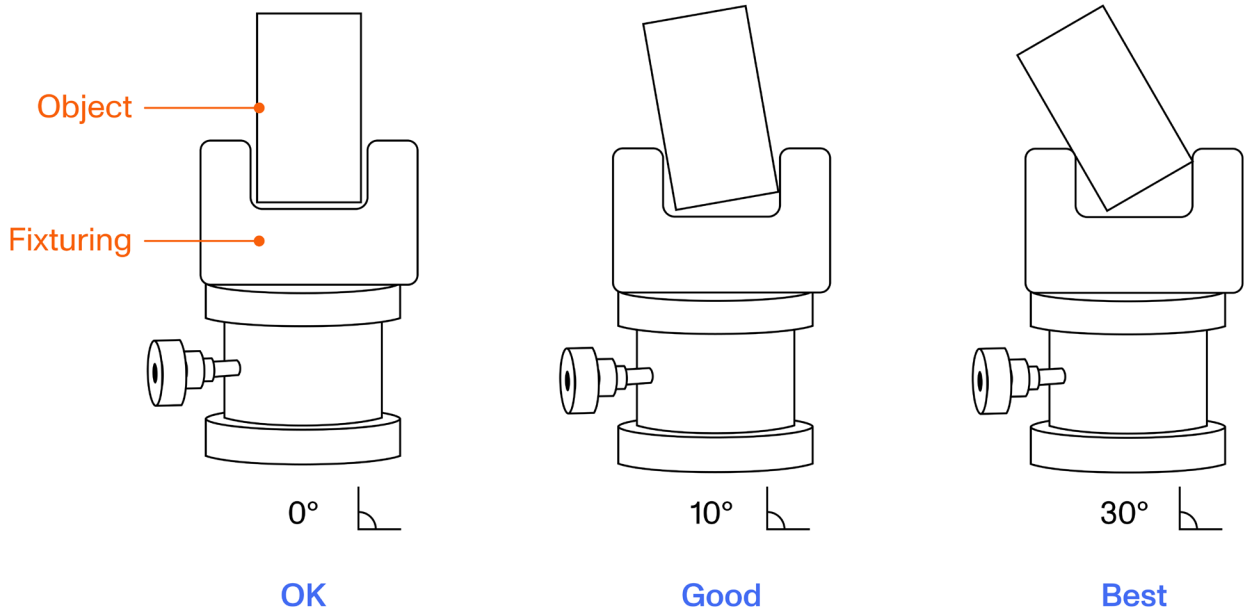
IV. Fixturing materials

Consider the density of the material you are scanning when determining the materials to fixture with. Floral foam is ultra-low density, allowing you to easily separate even lower-density plastics from the foam in the resulting scan. However, if scanning denser materials such as aluminum, 3D-printed plastics may provide the required contrast.



V. Fixturing angle

Oftentimes it is best practice to mount your part to avoid flat surfaces perpendicular to the axis of rotation. These flat surfaces can introduce artifacts.

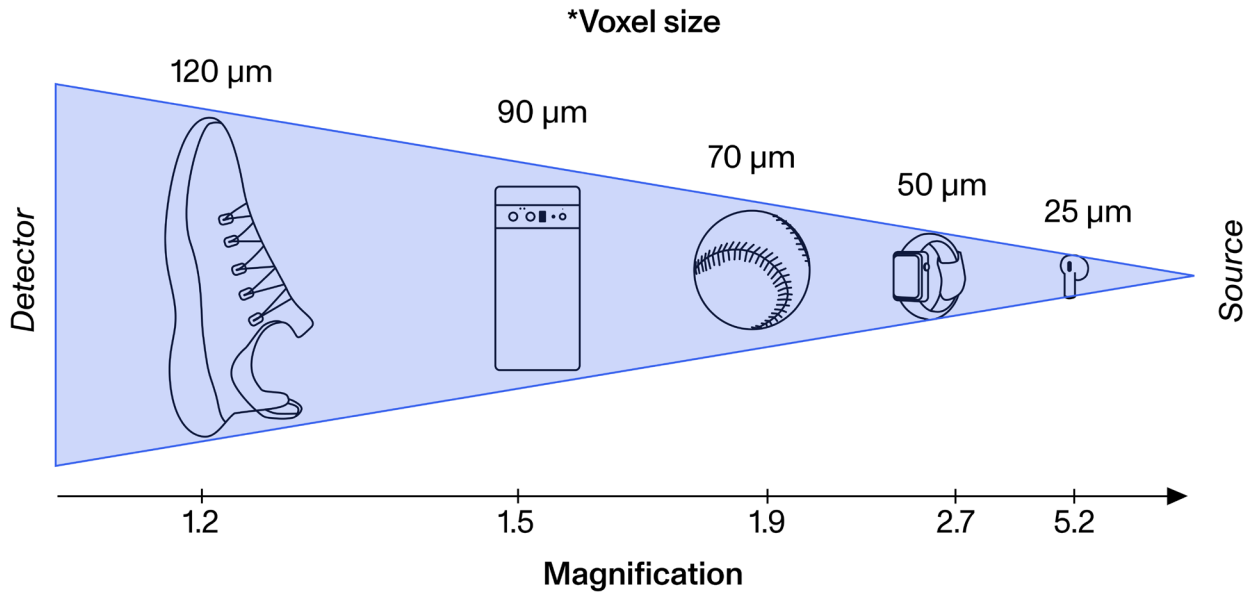


D. Positioning your part

The Neptune offers controls to optimize your part positioning. Typically, this includes X, Y, Z motions, and the use of the rotation elements to ensure the relevant parts of your object will stay in the field of view during a full scan.

I. Magnfiication

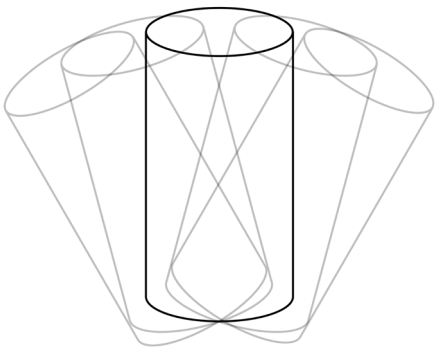
By moving the part closer to the source, you gain more magnification of the part. This results in higher-resolution scans, but reduces the field of view and resulting scan volume.



** High Resolution Module*

II. Verify bounds

The rotation functions allow for the part to simulate a full scan quickly and allow the user to confirm that the part is positioned correctly. With the exception of advanced scanning modes, if a region of the part leaves the field of view during rotation, no data will be reconstructed for that region.



E. Understanding key settings

I. Beam energy

The beam energy or voltage (kV) of an X-ray system is directly related to the system's ability to penetrate materials. The higher the kV, the better the system will be able to penetrate dense materials.

II. Time

One of the biggest relationships to understand is the tradeoff between time and scan quality. As a general rule, longer scans will have better quality. However, there are diminishing returns after a certain point depending on the combination of the system and the object being scanned.

III. Filter

The X-ray source emits X-rays of varying wavelengths. Metallic filters (such as copper) can be used to reduce the contribution of weaker X-ray wavelengths (and the artifacts they may create) at the expense of longer exposure times. When scanning multi-material parts (parts with a wide range of densities), adding filters to the beam can improve the contrast of scans.

F. Online documentation for latest software updates

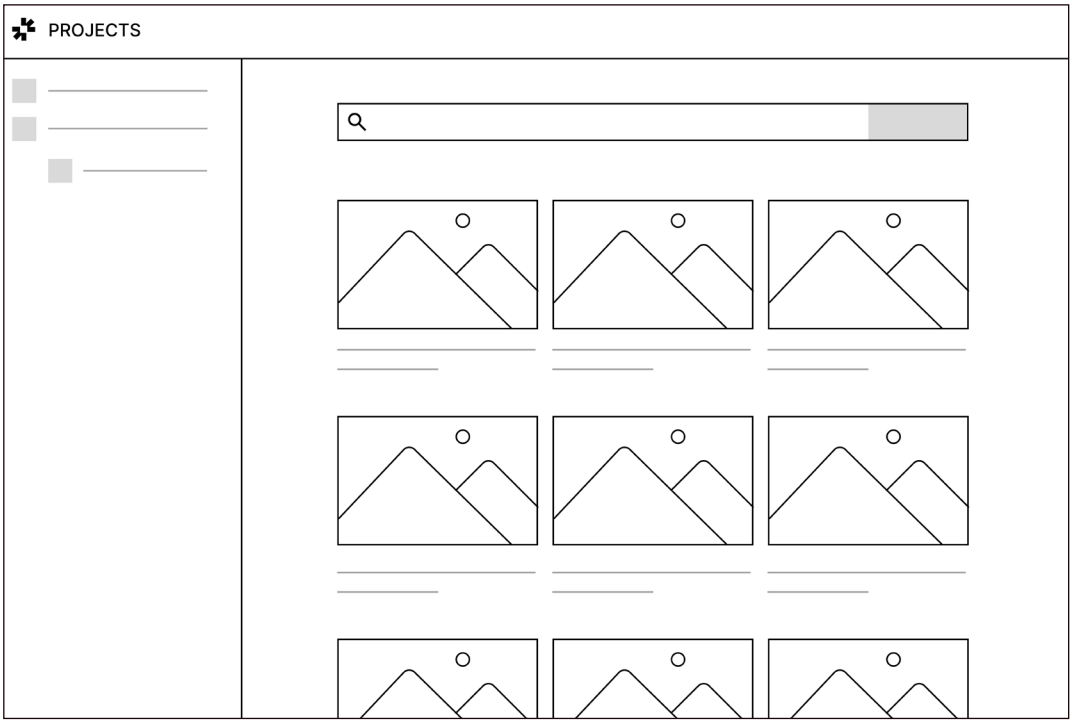
The Lumafield Neptune is a product that continuously evolves. Lumafield is always updating its software, user interface, and features. As such, you can reference support.lumafield.com for the most up-to-date documentation on the user interface, software features, and troubleshooting.

3 Analyzing a CT scan

A. Introducing Voyager

Voyager is Lumafield's cloud-based web application and CT scan analysis software. Voyager serves as your persistent repository of data, your inspection studio, and your collaboration environment.

You can access Voyager anytime at app.lumafield.com. It is free to sign up for an account, and it also includes access to a living library of public demonstration datasets.



With your Neptune scanner comes a managed Organization to securely upload and store your scan data. When members are added to an Organization, they get access to paid-for features and software modules, as well as access to any data generated with their Organization's Neptune.

B. Core data types

I. Images/2D data

Voyager works with several types of 2D data. For example, radiographs are 2D X-ray images that the scanner generates as part of every full scan. The preview image on your Neptune is a radiograph. Use Voyager to scroll through a full rotation of your part after your scan is complete.

II. 3D voxel data

Reconstructions are 3D volumes of your scans that the Voyager platform generates from 2D radiographs. Reconstructions are made up of voxels, which are roughly equivalent to cubic 3D pixels. Each voxel has an attenuation value, which is a measure of the relative density of that voxel normalized across the entire volume.

III. 3D surface/CAD data

A mesh is a surface representation made of polygons. In Voyager, meshes are used to represent the surface within your scan (also known as a boundary or segmentation). Voyager is also capable of representing design files input by the user.

IV. Analysis Data

Several tools in Voyager empower users to create analyses of defects in their scans. For example, in comparative workflows such as CAD Comparison and Scan to Scan Comparison, a user can run a geometric comparison between two scans and get the resulting deviation field. Another example would be the output of a Porosity Analysis, which would highlight the voids found within a part and visualize them with the rangemapper.

C. Example analysis workflow

Voyager allows you to explore your data with analysis, visualization, and measurement tools. Below is an example of a common workflow that would allow you to assess whether an injection-molded part is manufactured to specification:

Step 1: Create a Region of Interest (ROI) for your part.
Step 2: Create a mesh of the surface of the material of the part in question.
Step 3: Upload the CAD file of the corresponding surface of the part.
Step 4: Align the CAD file with the mesh using the Auto Alignment feature.
Step 5: Submit a comparison to Voyager for analysis.
Step 6: Inspect the comparison results, and create useful bookmarks.

D. Collaborating

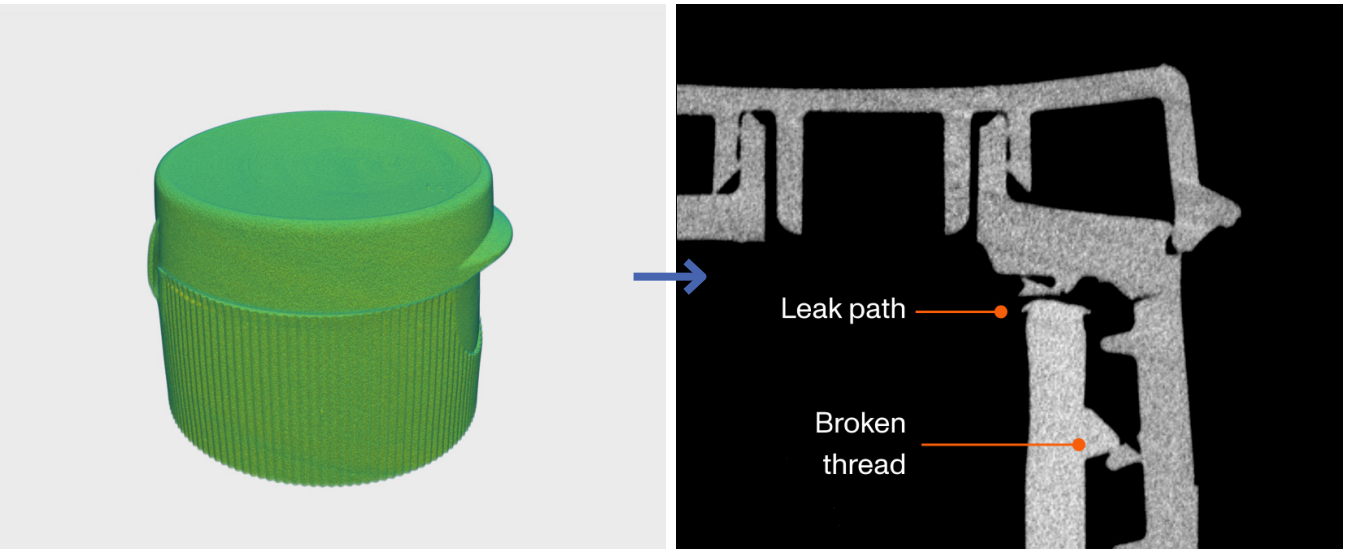
Your CT scans can help you and your team make actionable data-driven decisions about your manufacturing process. Lumafield products support a growing number of collaborative workflows that let you provision both viewing and editing access to different groups of scans.

E. Online documentation for latest software features

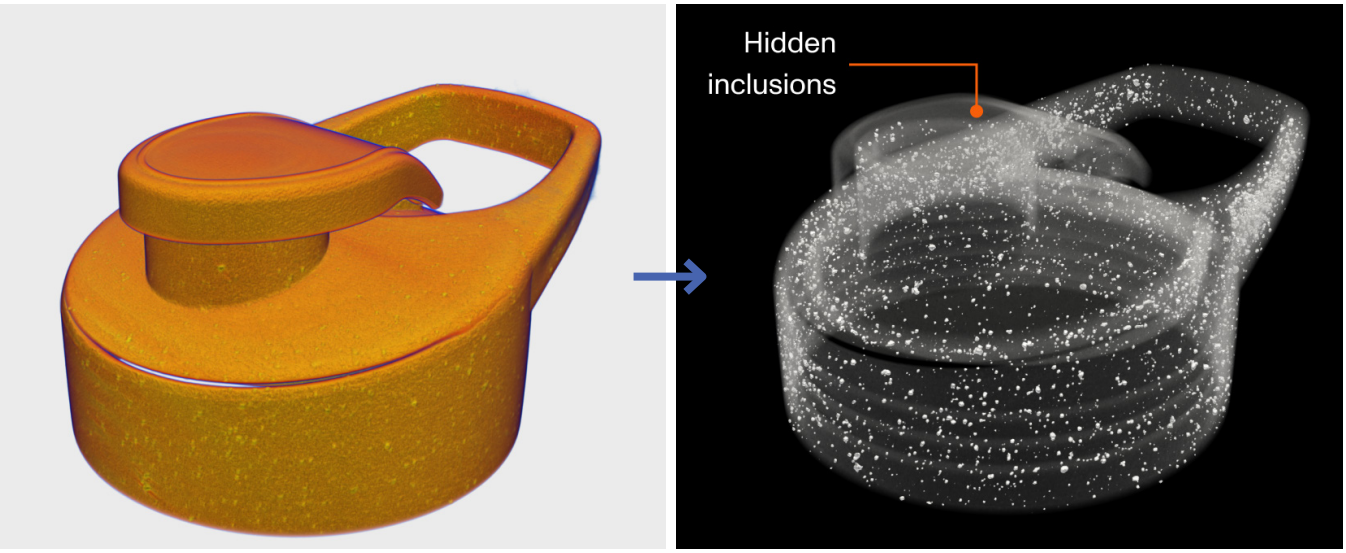
Lumafield's products are constantly evolving. Visit support.lumafield.com to access our ever-growing knowledge base. Documentation, case studies, tutorials, and more are all available.

4 Applications

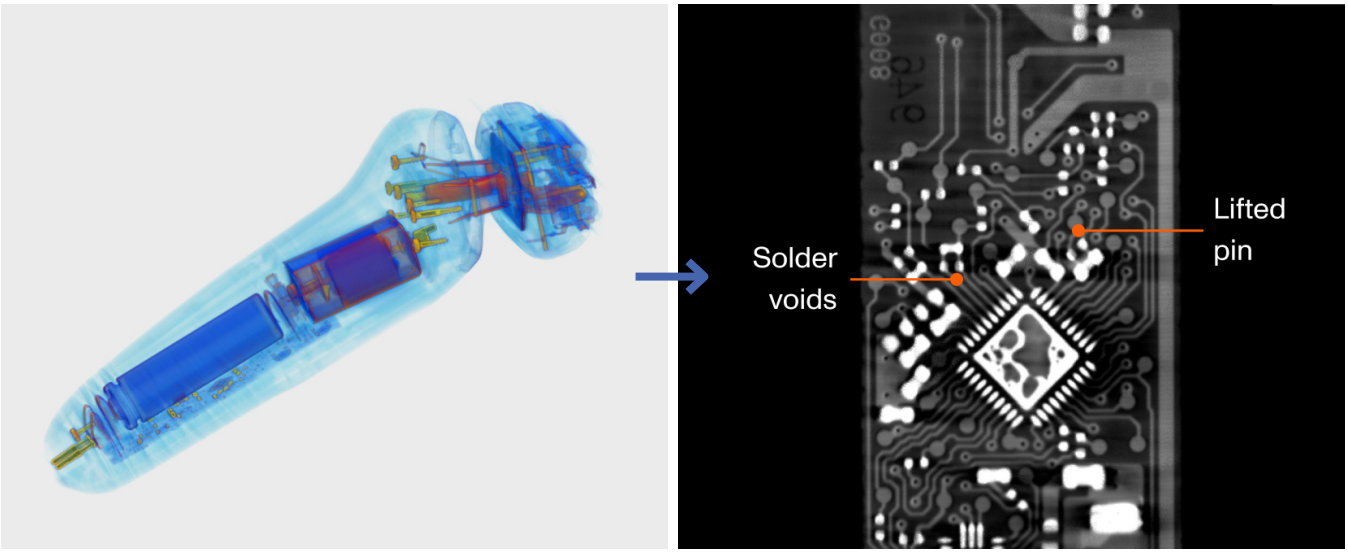
Giving an engineering team X-ray CT is like giving them a superpower. The day any engineer receives the first part they designed is filled with wonder and anticipation. But without seeing inside, engineers can never completely understand what they hold in their hands. X-ray CT is the final step to close the loop on manufactured goods.



Leaky packaging
Identify leak paths in complex assemblies without destructive measures.

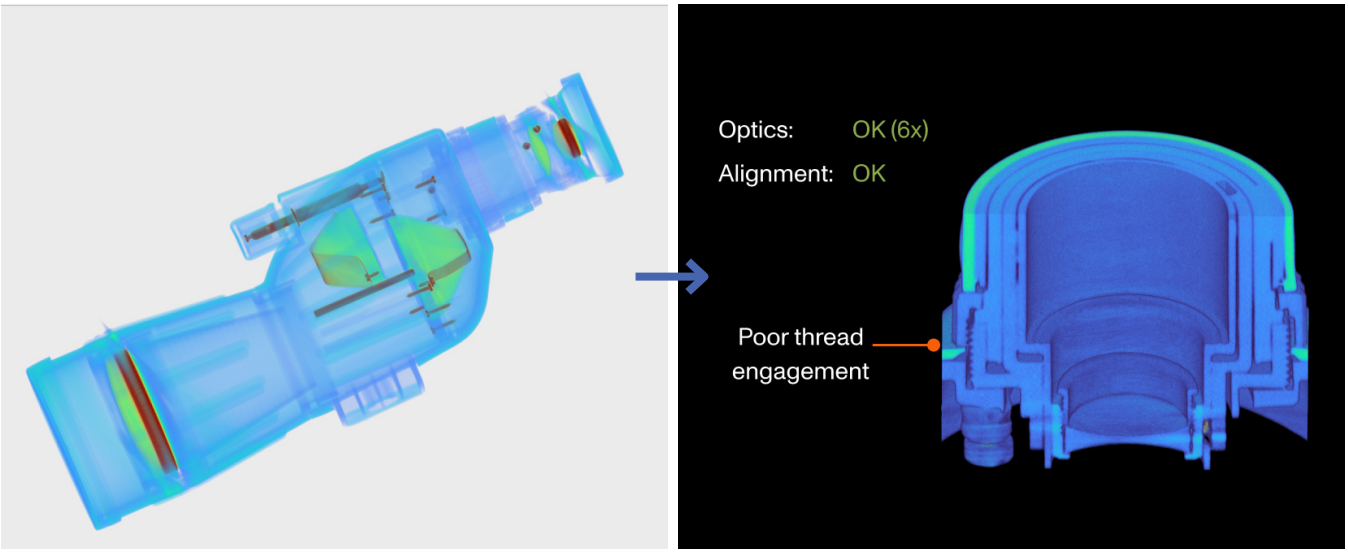


Damaged housings
Use CT to uncover hiding sources of failure, such as unexpected inclusions.



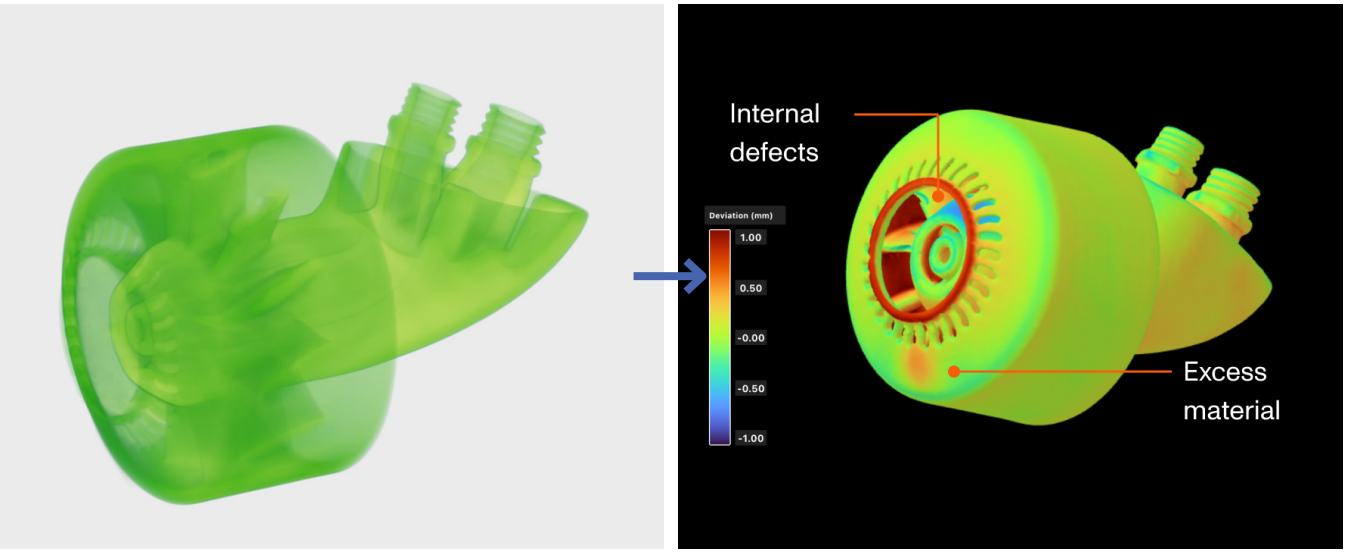
Electronics failures

Identify hidden sources of failure such as solder shorts or lifted pads.



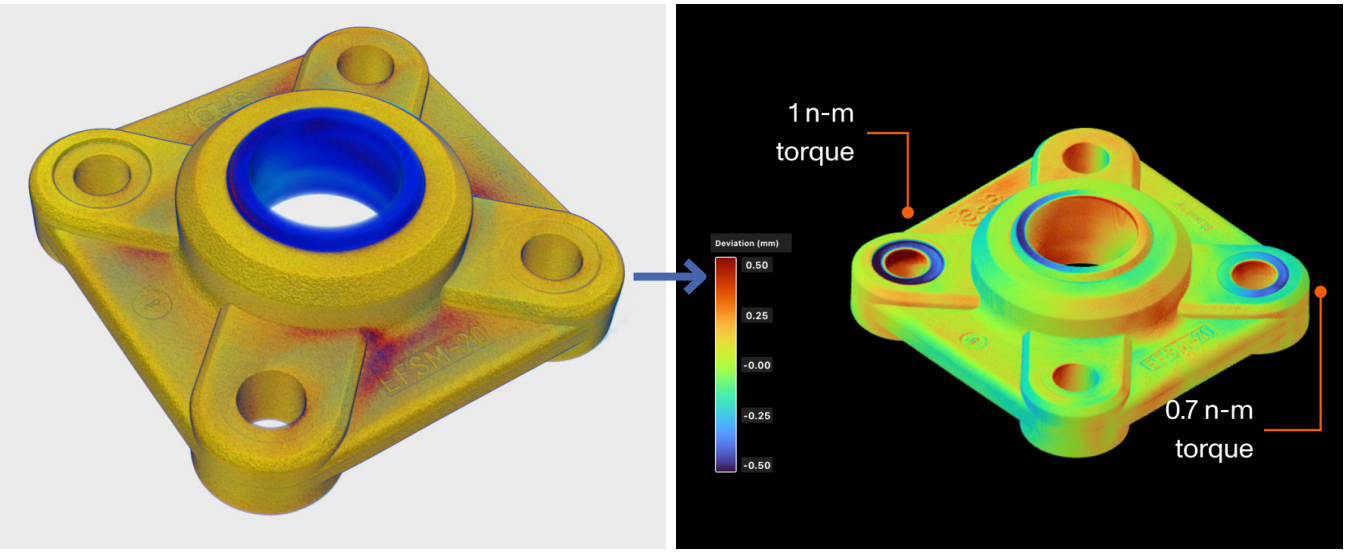
Assembly failure

Identify and count components, check orientation and validation positions.



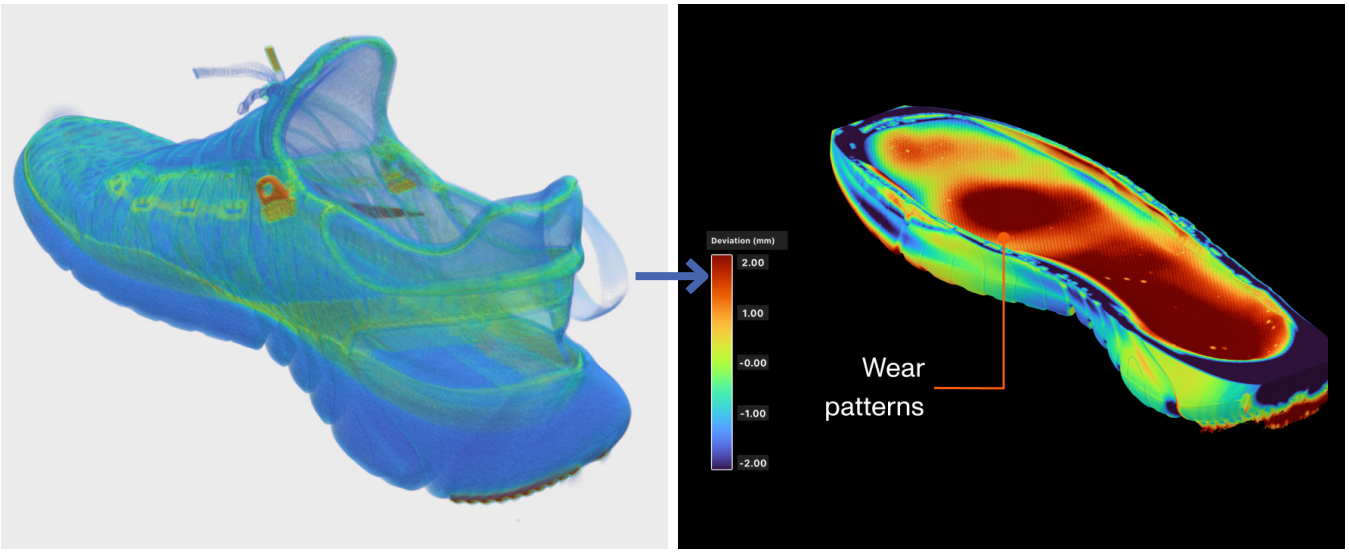
Design validation

Use CAD Comparison to visualize the as-manufactured state versus the design intent.



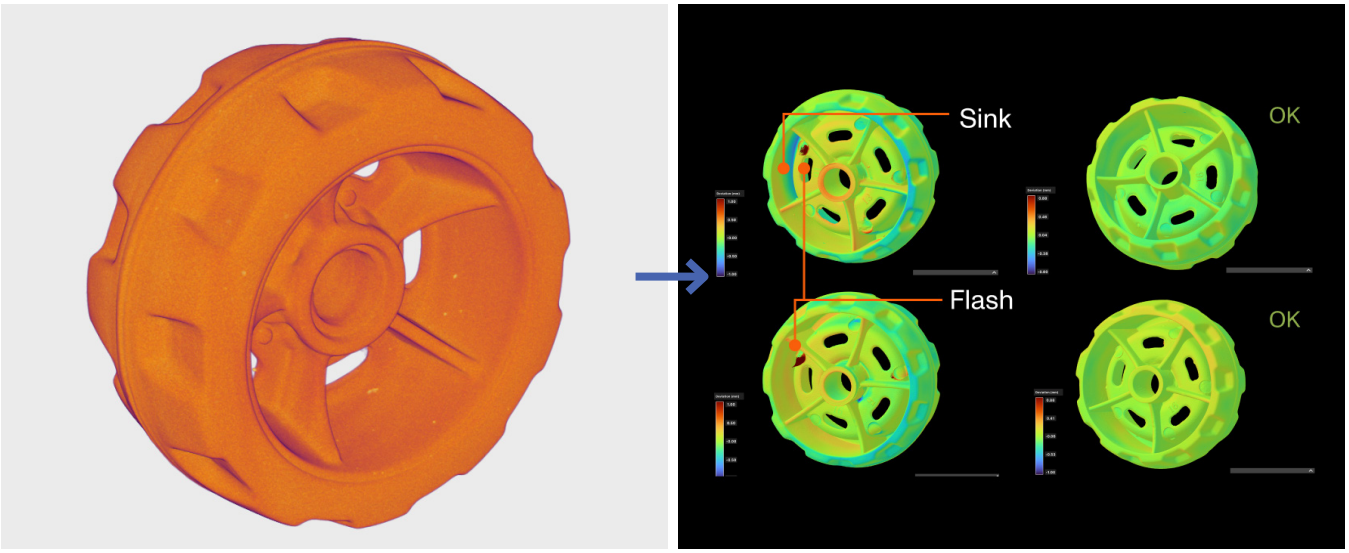
Assembly process design

Use CT to power studies, for example the impacts of screw torques on components.



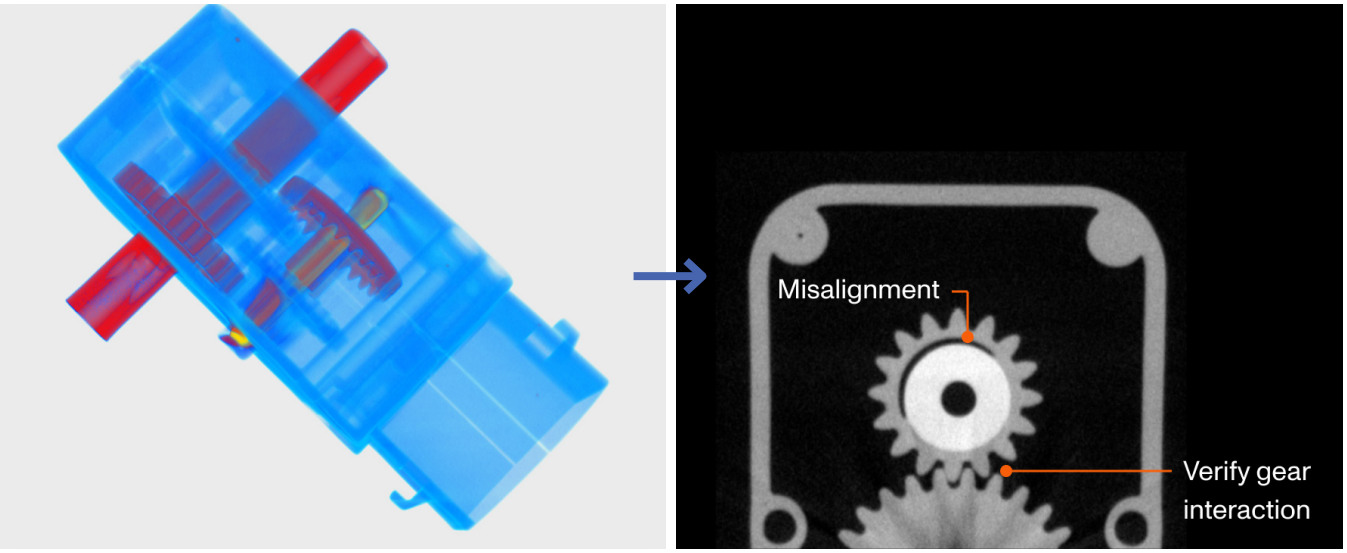
Wear testing

Scan component through lifecycle testing to monitor performance and degradation.

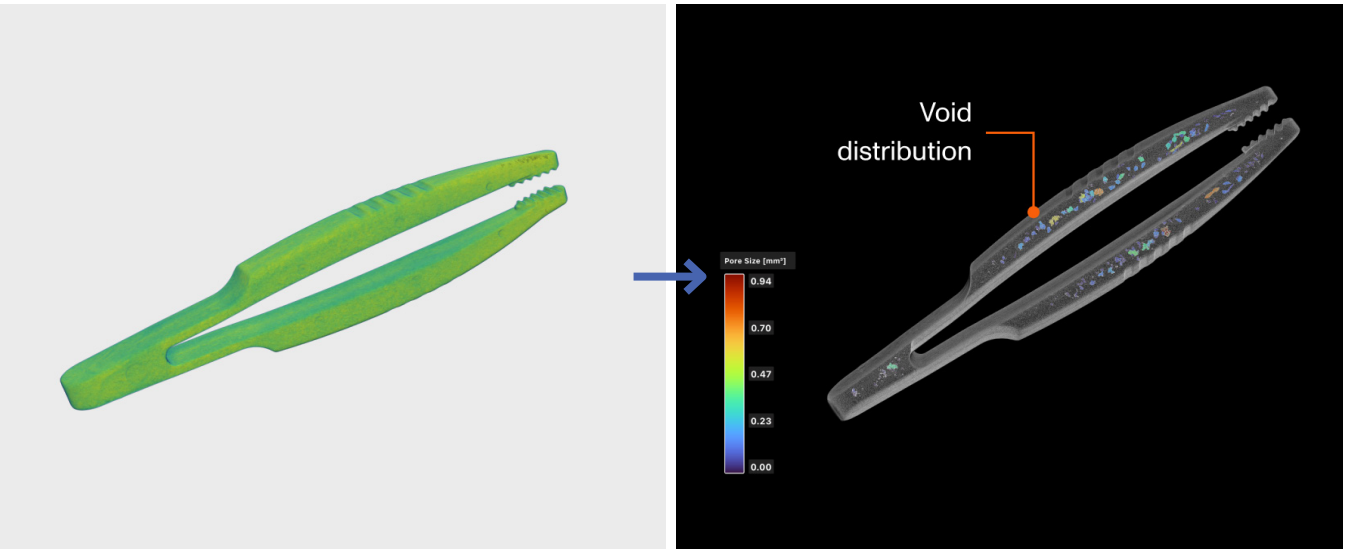


First Article Inspection

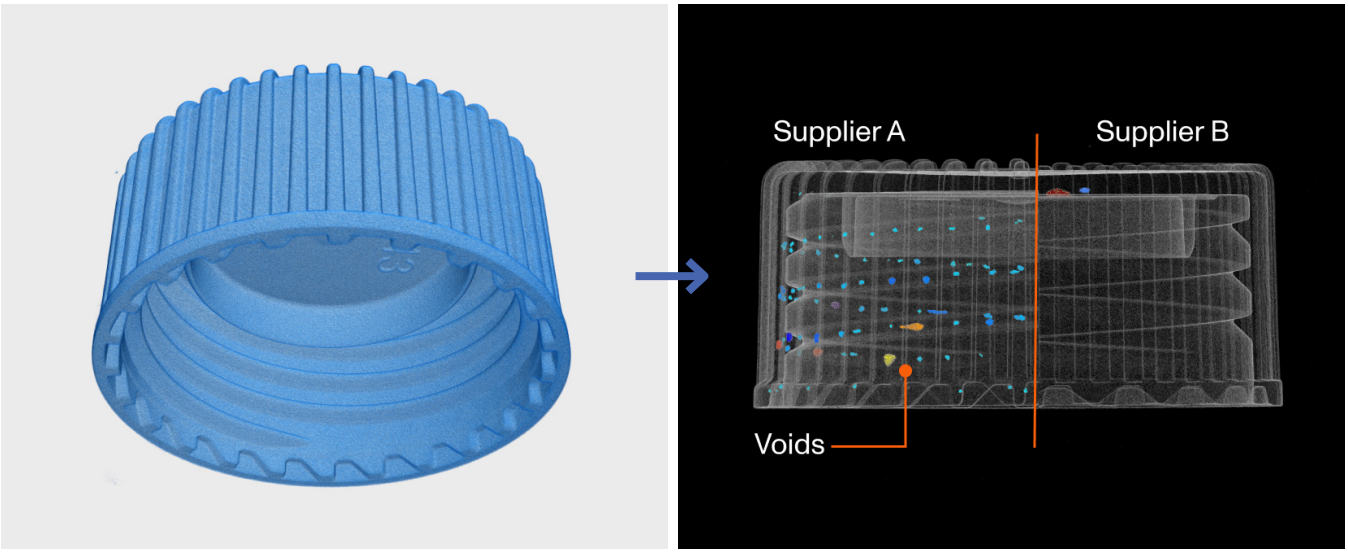
Scan batches to spot variation between cavities, incoming lots, or suppliers.



Assembly interactions
Virtual slices let you inspect complex assemblies non-destructively.

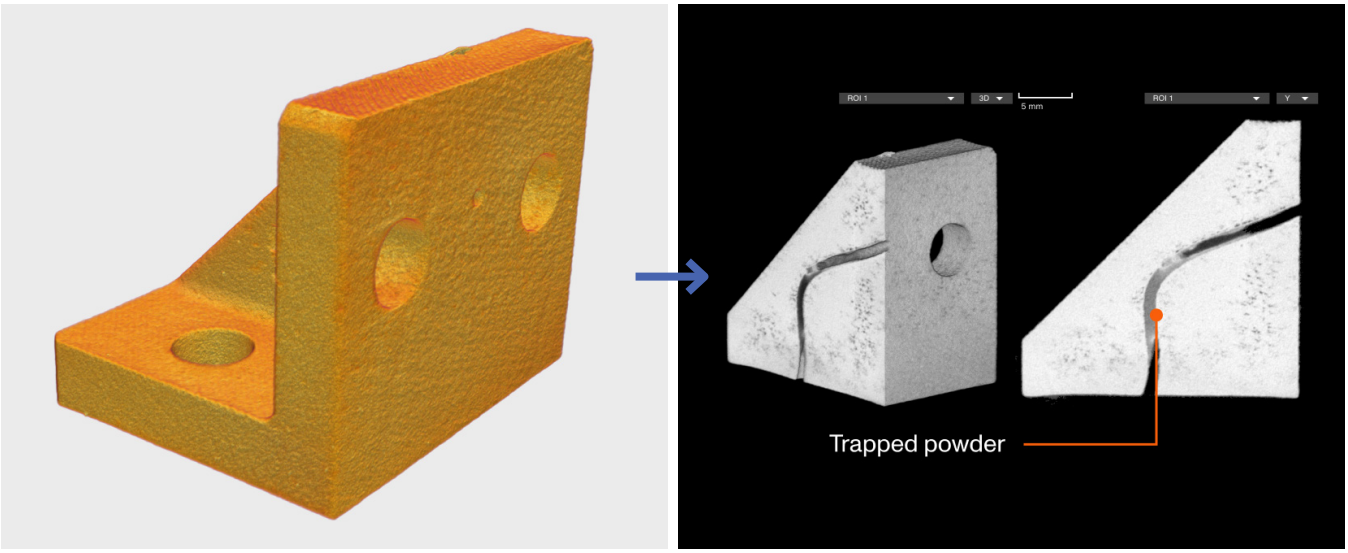


Quantify hidden defects
Porosity Analysis helps quantify molding defects hiding below the surface.



Supplier qualification

Identify differences when dealing with complex supply chains.



Process development

Spot defects such as trapped powder when qualifying additive manufacturing.

5 Routine Maintenance

A. Maintenance by Lumafield

I. Surveying

Lumafield performs a radiation emissions survey at the time of installation. Surveys will be conducted annually by Lumafield, unless local regulations mandate a higher frequency.

II. Interlock testing

Lumafield will perform interlock testing to ensure the safety of the system annually, unless local regulations mandate a higher frequency.

B. Maintenance by user

I. General cleaning - Quarterly

During the use of the machine, dust and debris may accumulate inside of the cabinet enclosure. Periodically clean or vacuum the interior to remove any debris. Check the air filter below the detector for cleanliness.

II. Interlock checks - Quarterly

Verify that the interlock system works correctly. Fully close the door, and ensure that the X-rays can be powered on. With the X-rays powered on, ensure the door is latched.

III. Survey of safety features - Quarterly

Check to ensure that the following safety features remain in working order:

- Emergency Stop
- Access key switch
- Indicator lights
- Door latch
- Door interlocks

6 Troubleshooting

A. FAQ

I. **Why didn't my scan upload?**
The Lumafield Neptune is a cloud-connected device. Ensure that your internet connection is in working order. Check the Ethernet port, and use another device to ensure that the port still has connection to the internet, if needed. Rebooting the scanner may help restart an upload process. The top bar of the scanner will display if the scanner is Online or Offline.

II. **Why isn't my scan available yet?**
Voyager relies on data uploading from the Lumafield Neptune. Once the data has been uploaded, reconstructions are typically completed within an hour. If you have confirmed that your scan has uploaded from the Neptune, but the reconstruction is taking several hours, reach out to support@lumafield.com for assistance.

III. **How do I move my scanner?**
You should not attempt to move your scanner without consulting Lumafield. Reach out to your Lumafield Solutions Engineer, Account Executive, or support@lumafield.com.

IV. **How do I access the software?**
Any user can sign up for a free Voyager account at app.lumafield.com. After that, you will need to be added to your company's Organization to access its scan data. Talk to your system administrator.

V. **How do I fixture this part?**
Fixturing should hold your part rigidly in a low-attenuation material to prevent unwanted motion while allowing you to separate the part from the fixture in the CT scan. From there, there are several tricks to tailor fixtures to specific intent. See the Fixturing section (2C.) in this User Manual, or visit support.lumafield.com for more detail. You may also reach out to support@lumafield.com with specific questions.

VI. **What is the factory-set password?**
The factory password for the Lumafield Neptune is "lookwithin" without the quotes. If this does not work, double check support.lumafield.com for the latest support docs, or reach out to support@lumafield.com for assistance.

B. Contact support

Your Neptune includes on-demand technical and application support for your entire contract. Your Lumafield Solutions Engineer or Account Executive should be your first points of contact. They are always happy to provide guidance and help you get the most out of both your Neptune scanner and Lumafield's Voyager analysis software. If you do not know who your Solutions Engineer or Account Executive are, speak with the owner of the equipment at your company. You may also reach out to the email addresses below anytime with questions:

support@lumafield.com - Technical and applications support
sales@lumafield.com - Sales inquiries