Nion UltraSTEM™200MC (Nion HERMES™200) pre-installation instructions

(for 200 kV UltraSTEM equipped with a monochromator and EELS)

Introduction

These instructions are for the 200 kV UltraSTEM200MC, equipped with a monochromator (also known as Nion HERMES™=High Energy Resolution Monochromated EELS-STEM). They are similar to the instruction for an UltraSTEM without a monochromator, but there are three major differences: (1) the specifications are more stringent about allowed levels of disturbances, (2) the total power and cooling requirements are increased, and (3) an extra cabinet (rack) of electronics is required.

Different fonts are used to distinguish between key instructions, which are shown in regular font, and commentary, *which is shown in italics.*

Summary of the installation requirement is given in section 1 below, and a checklist of the different tasks to be performed by Nion and the user laboratory is given in section 20 near the end of this document.

1) Summary of Nion UltraSTEM200MC principal installation requirements

Category	Requirement	Note
Microscope suite of rooms	typically 4.5 x 9 meters (15 x 30 feet) The ceiling in the microscope lab should be >3.7 m high. (Rooms that are less tall can accommodate the microscope by placing it in a “dug-out”.)	Space for whole microscope suite including the operator room. Typically, it will be subdivided into 3 separate rooms: the microscope room, the electronics room, and the operator room.
Space for noisy utilities	Separate space, away from the microscope suite. About 3-5 m^2 total floor area.	Noisy water chiller(s) and the mains transformer should be installed >7 m and ideally 10-15 m away from the microscope column, in a space with good acoustic isolation from the microscope room, such as a "service room" or a "service corridor".
Floor strength	The floor must be able to support 1500kg under the column and 300kg under each electronics cabinet.	The floor must also be able to support the microscope base, which weighs about 1000 kg, as it’s wheeled into the room on a dolly at the start of the installation.
Floor vibrations	<1.0 μm/s for frequencies between 0.5 Hz and 2 Hz, and <0.5 μm/s for frequencies between 2 Hz and 500 Hz.	These specifications refer to the floor that the microscope suspension system rests on. If the microscope sits on a vibration-isolated platform, the specification refers to this platform.
Acoustic noise	<50 dB total noise in the microscope room, and no more than 45 dB in any one-third-octave band between 5 Hz and 10 kHz.	
Stray magnetic fields	<10 nT root mean square (0.1 mG r.m.s.) at mains frequency and mains harmonics, and <0.05 mG r.m.s. (5 nT) at all other frequencies.	If the mains frequency field varies with time, this variation should be <5 nT r.m.s. (<0.05 mG r.m.s.).
Electrical Power	12 kVA of 117 VAC +/-5% Auxilliary power should also be provided in wall sockets in the microscope room, **clearly labeled** that nothing that has a ground connection to the microscope and its electronics can be plugged into them.	Provided via a center-tapped isolation transformer with two outputs, each at 58.5 VAC from ground and 180° from the other output (i.e., two live outputs 117 VAC apart rather than a live at 117 VAC and a neutral at 0 V).

Grounding	0.4 Ohm or less connection from microscope to building ground	
Cooling water	500 liters/hr at a temperature of 20±0.5°C (68±1°F) and stabilized to better than 0.1°C/hr (0.2°F/hr). Pressure 2-4 bar, stable to within 0.05 bar, cooling capacity at least 5 kW.	The cooling can be provided by a water chiller such as Haskris R175 . The chiller generates up to 5kW or heat which is best removed by hooking it up to the laboratory's cooling water circuit.
Microscope room climate	Microscope room temperature in the range of 18-22°C, and stable to within 1°C (peak-to-peak) / 24 hours, 0.2°C (peak-to-peak) / 1 hour, and 0.01°C/min. Using water-cooling panels and no airflow in the microscope room is the preferred solution.	The relative humidity of the air in the room must be less than 60%. There must also not be excessive dust in the microscope room. Clean room-compatible materials, i.e. dust-free ceiling, wall and floor coverings, and HEPA air filters, regularly changed, should be used.
Exhaust fan	Exhaust fan with a capacity >6 m^3 / minute (>200 cfm) needs to be installed in the microscope room, with a readily accessible on-off switch.	Fan will be used to remove heat from the room during microscope baking. It will be off during normal operation.
Pressurized gas - microscope	Argon at >6 bar (>90 p.s.i.)	Argon gas from should come from a gas cylinder, ideally capable of holding up to 200 bar (3000 p.s.i.) of gas when full. Nion supplies the regulator. House argon can be used too, provided it's pure, i.e.water moisture and hydrocarbon-free.
Pressurized gas – high voltage electronics	full cylinder of liquified SF6 and an empty cylinder pressurized dry Nitrogen gas (at >4 bar, i.e >60 psi is needed too.	Full cylinder of liquefied SF6, with an adapter to ¼" NPT, minimum 7.5 liter and preferrably 15 liter capacity must be supplied for the installation.
Internet and Telephone Access	A reliable high speed connection to the User computer, available from the start of the installation. A working phone in the user room is needed during the installation, for telephone consultation.	Needed for remote access, so that the Nion USA team can assist with the installation remotely (and also provide post-installation remote service).

2) General space requirements

The UltraSTEM™ microscope is operated remotely, and no access to it is needed during operation. It is best placed in a room that is quiet acoustically, vibration-wise, electrically and magnetically, and with precise temperature control. The operators, on the other hand, may want to talk and do not care about 0.1 °C temperature regulation. The ideal set-up for the microscope is therefore a connected suite of either two or three rooms: one for the microscope, and one for the electronics and the operator console, with the second room ideally further split into separate rooms for the operators and for the electronics. The overall size of such a suite should ideally be 4.5 x 9 meters (15 x 30 feet) for the UltraSTEM™200MC, or bigger. An example of how the suite of rooms can be set up is provided at the end of this document, and many other arrangements are possible too.

The acoustically noisy water chiller and the magnetically noisy isolation transformer should be located either in a service corridor outside the microscope laboratory room(s), or in another room dedicated to "noisy" equipment, with good acoustic separation form the microscope suite. They should be at least 7 m and ideally 10-15 m away from the microscope column, in a straight line. About 4-6 m^2 of floor space is needed, depending on the size of the selected units.

3) Floor strength

The floor must be able to support 1500kg under the column and 300kg under each electronics cabinet. The floor must also be able to support the microscope base, which weighs about 1000 kg, as it's wheeled into the room on a dolly at the start of the installation (with most of the weight on the front 2 wheels of the dolly). Later on, it will need to support the wheels of the movable front half of the microscope enclosure, which weighs about 300kg, the movable service crane, which can carry pieces of up to about 250 kg, and the gun service cart (about 100 kg with the gun on top of it).

4) Floor Vibrations

Measuring with a 1/3-octave bandwidth, for each frequency band the rms vibration needs to be less than 1.0 μm/s for frequencies between 0.5 Hz and 2 Hz and less than 0.5 μm/s for frequencies between 2 Hz and 500 Hz. These specifications refer to the floor that the microscope suspension system rests on. If the microscope is positioned on a vibration-isolated platform, the specification refers to this platform.

If there is a vibration-isolated platform the microscope sits on, such as the TMC Stacis system supporting the microscope's platform (http://www.techmfg.com/products/stacis/stacisiii, http://www.techmfg.com/products/stacis/quiteisland) the platform should be at least 2.0 x 2.2 m in size, so that there is room on it for a) the microscope, b) the microscope cover and c) cable support frame, which needs to be located on the isolated platform so that cables do not bring vibrations to the column. If a passive isolation is used for the platform, the platform needs to be around 4000 kg or more in weight, otherwise the platform's suspension and the Nion suspension may couple to produces strong resonant frequencies. If the platform uses active suspension, then it can be lighter: 2000 kg or more.

*Because external vibrations are somewhat unpredictable, it is a good idea to have a safety margin such that **typical** vibrations throughout the day are at least 2x weaker than the levels given above, i.e. <0.5 μm/s for frequencies between 0.5 Hz and 2 Hz and <0.25 μm/s for frequencies between 2 Hz and 500 Hz.*

5) Acoustic noise and pressure variations

The microscope room should be quiet enough to hear a pin drop, and isolated enough so that doors opening and closing and people walking in other parts of the laboratory basically cannot be heard. In quantitative terms, this means no more than 50 dBZ (unweighted) total noise in the microscope room, and no more than 45 dBZ in any one-third-octave band between 100 Hz and 10 kHz. Furthermore, the sound level in the 5Hz to 100Hz band should not exceed 45dBZ.

An important source of noise can be noise coming in from the electronics room through too-large a cable opening. It's therefore best to use the size for the opening recommended by Nion, and to think about stuffing the remaining empty space with strong plastic bags filled with sand so as to muffle the noise trying to get in through the hole.

When the microscope is not imaging or taking other data, the room can be noisier. This is why the scroll pump that's used during sample exchange and is typically located in the electronics room can be heard clearly in the scope room without any deleterious effect. (The reason for locating the pump outside the microscope room is mainly to prevent temporary heating of the room when the pump is on.)

Acoustic shielding, such as the AERIP48 acoustic banners made by Acoustical Solutions Inc.: https://www.acousticalsurfaces.com/echo_eliminator/ee_hangbaf.htm may need to be added to the laboratory to achieve these levels.

The other rooms in the microscope suite can have up to 60 dB noise levels.

The UltraSTEM microscope with the detachable cartridge stage is not very pressure-sensitive, but the side-entry holder stage version of this microscope does have some pressure sensitivity if the clamshell over the end of the holder is not used. For this version, it is a good idea to minimize abrupt pressure changes originating from other parts of the building, such as doors being opened or closed abruptly, or the overpressure of an air conditioning system released when a door to the outside is opened. Air-tight weather striping around the door into the microscope room may help, and single outside doors for the whole building that the microscope *is in, which produce large drafts of outgoing air when opened should ideally be replaced by a double set of doors, only one of which is open at a time.*

6) Stray magnetic fields

The AC magnetic field in the microscope room, at the place where the column will be located, should be below 10 nT root mean square (0.1 mG r.m.s.) at mains frequency and mains harmonics, and below 5 nT r.m.s. (0.05 mG r.m.s.) at all other frequencies. If the mains frequency field varies with time, this variation should be less than 5 nT (0.05 mG r.m.s.).

In order to achieve this performance level in a busy laboratory, wiring practices that minimize stray magnetic fields must be used:

a) *The "neutral" power wire must never be connected to ground – it should be treated as though it had a live voltage on it. (The reason for this is that if a connection to ground is established from the neutral, the current that should be flowing through it, which normally counters the current in the live wire, will "leak out" via the ground, and the live wire will start radiating magnetic fields like a dipole antenna.)*

b) *Separate wires for the phases should not be used, instead a 3 core cable that carries both phases/ phase+neutral as well as the ground for outlet should be used. The outlet itself must be mounted isolated from the framing and it must get its ground from the ground conductor in the cable.*

c) *For extremely sensitive applications a shielded cable should be used, but for microscope rooms a 3 core cable typically suffices.*

d) *The main power to the microscope is best wired with a 4-core cable with the diagonally opposed conductors in parallel, this dramatically reduces stray fields.*

e) *The "Mecca ground" concept should be used whenever possible: all ground wires should have a unique connection to the building ground, not several connections made in different places (i.e., they should resemble how pilgrims arrive at Mecca on their Haj pilgrimage: each one following a unique path with no cross-talk to the next pilgrim's path, but all arriving at the same place).*

Two principal aspects of the UltraSTEM performance are affected by the stray fields: probe position stability and the EEL spectrum stability.

For the probe position, the sensitivity of the UltraSTEM to AC magnetic fields is about 1 Å probe displacement (at the sample) for 100 nT (1 mG) of stray magnetic field (at mains frequency). (This applies to both r.m.s. and peak-to-peak numbers, as long as the same type of unit is used for both the stray fields and the probe displacement.) 10 nT (0.1 mG) AC magnetic field therefore produces about 0.1 Å probe wobble at the mains frequency. This is often acceptable: 0.1 Å r.m.s. probe wobble is not easy to detect in typical STEM images taken with 1-2 Å resolution. However, 0.5 Å resolution images are more sensitive to perturbations, and for those 0.1 Å probe shakes would be quite visible. See Fig. 15-4 in the Krivanek et al. chapter in the Pennycook and Nellist STEM book (https://www.amazon.com/Scanning-Transmission-Electron-Microscopy-Analysis/dp/1441971998/), which illustrates what different instabilities do to STEM images of about 1.5 Å resolution.

The exact sensitivity depends on the microscope operating mode. It grows larger for lower primary kV operation and for less source demagnification, as used to obtain large beam currents (> 100 pA). The sensitivity given in the preceding paragraph is therefore only a rough guide, for about a 50 pA non-monochromated probe. One situation in which the beam current admitted into the monochromator tends to be increased to several hundred pA arises when operating the monochromator with the slit closed down to 20 meV and less, so as to compensate for the loss of beam current at the sample due to the closing of the MC slit. At 500 pA probe current admitted into the monochromator (by the MOA aperture), the probe motion due to *stray fields becomes about 3x larger than it was at 50 pA, i.e. it gives around 3 Å probe displacement (at the sample) for 100 nT (1 mG) of stray magnetic fields. This means that when the monochromator is being used with large input beam currents, it is good to have stray field values that are 2x lower than the specification in the previous paragraph. In non-standard operating modes such as low mag (with the OL off), the probe wobbles grow roughly proportionally to the probe size.*

Note that in regular scanned images, for which the probe per-pixel dwell time is much less than a millisecond, moderate probe motion is not readily visible in scanned images that are synchronized with the mains frequency. This means that even 0.5 Å r.m.s. probe wobble can in most cases be tolerated in mains-synchronized ADF and BF images. For longer probe dwell times, such as those used for EELS and X-ray mapping, mains synchronization cannot "hide" the probe wobble. However, the resolution of EELS and X-ray maps tends to be worse than the ADF resolution, and hence about 2-3x more probe wobble can be tolerated for the mapping than for ADF imaging.

For EEL spectra recorded with the Nion spectrometer, which has thorough magnetic shielding, 100 nT (1 mG) peak-to-peak mains-frequency stray field (measured in near the EELS) causes about 6 meV peak-to-peak EELS spectrum wobble (at 60 keV primary energy). This means that a 10 nT (0.1 mG) r.m.s. AC stray field will cause slightly less than 1 meV r.m.s. EELS wobble, which is added to wobbles produced by ground loops and other causes. The spectrometer also has an "AC compensation" capability, which allows non-varying mains-frequency wobble to be compensated. This function does not compensate for wobbles whose amplitude varies with time, which is why there is a separate specification for the mains-frequency AC field whose amplitude is not constant.

7) Electrical power requirements

The monochromated UltraSTEM200 needs 12 kVA of 117 V +/-5%. The connection of the microscope to the building ground should be as low-resistance as possible: 0.4 Ohm or less.

Ideally, the power should be provided via a center-tapped isolation transformer with two outputs, each at 58.5 VAC from ground and 180° from the other output (i.e., two live outputs 117 VAC apart rather than a live at 117 VAC and a neutral at 0 V). The outlet can be either a wired-in connection with a shut-off switch, or a plug and socket connection with the user lab providing a matching plug for whichever socket is used. This socket or switch, along with any fuse box or panel that separates the live and neutral wires, should be located 5 m or more from the microscope column, in order to avoid the possibility that stray fields emanating from the switch and box/panel will adversely affect the microscope stability.

Power for computers and other auxiliary equipment **that has a ground connection to the microscope** (or the microscope electronics) is provided by the microscope's electronics. The computers are typically housed with the regular Nion electronics, either on top of, or in the microscope electronics cabinets.

Power for extra equipment **that does not have a ground connection** to the microscope, such as for instance an extra light or a vacuum cleaner, should be provided via AC power sockets in the microscope room (and the electronics room), **clearly labeled that plugging equipment with a ground connection to the microscope or its electronics** will produce a ground loop and thus a loss of microscope performance, and is therefore not allowed. Note that the ancillary equipment without a ground connection includes the computer monitors, which can be located a long way from the computers and do not have a ground connection to them.

8) Cooling water

Cooling water flow of at least 500 liters/hr at a temperature of 20±0.5°C (68±1°F) and stabilized to better than 0.1°C/hr (0.2°F/hr) needs to be provided. Short-term cooling water fluctuations must not exceed 0.01 °C/min. The actual flow is adjusted by flow regulators and the chiller needs to have an appropriate bypass valve to accommodate any flow from 0-500 l/h. Pressure 2-4 bar, stable to within 0.05 bar, cooling capacity at least 5 kW.

Care should be taken when routing the chiller water across non-temperature regulated spaces and this can affect cooling water temperature stability. If this is may be the case in your laboratory, the pipes should be provided with thermal insulation jackets.

The water in the chiller should be denatured by ethanol at a concentration of 10%-15%, not by any form of glycol. Ethanol has significant benefits over glycol mixtures: it is non-conductive and evaporates without residue, which minimizes the damage to components in case of spills. It is also much less toxic than glycol.

The chiller generates up to 5 kW or heat, which is best removed by the laboratory's cooling water circuit. Water chillers that "dump" the heat into the surrounding air are significant heat sources, and the generated heat places higher requirement on the air conditioning system's capacity.

The water chiller should be located outside the suite of microscope rooms, in a service area with good acoustic insulation (see section 19), not too close to the electron microscope.

Care should be taken that the water chiller does not produce oscillations in the water pressure of few tens of Hz. This typically means that the chiller needs to use a turbine pump rather than a displacement pump (which would produce noticeable pulsing of the water pressure) and that its pressure regulator(s) need to be set up such that they are not likely to oscillate.

The chiller water will be routed to a Nion-supplied water distribution box, which is wall mounted, via 5/8" ID opaque flexible hoses. The position of the water distribution box should be noted in the room layout, and should not be over the High-Voltage or Microscope main power cables. Due to the large number of fittings in the distribution box, there is a statistically higher chance of a water leak developing there.

The compressor motor in many chillers can cause strong shaking of the chiller, which can be easily transferred to the ground and to the water pipes, and can affect the vibrations near the microscope column. A strongly vibrating chiller is best placed on a soft suspension such as rubber anti-vibration pads (e.g. http://www.andrehvac.com/anti-vibration-pads-c-1.php), and it should be connected to fixed wall-mounted pipes via flexible hoses. Most chillers also emit stray magnetic fields of several hundreds of nT (several mG, at the chiller) and produce a lot of noise. This is why it's essential to place the chiller more than 7 m and ideally 10-15 m from the microscope column (in a straight line). Too large a distance should be avoided too, as the water pressure may drop too much if passing through more than 20 m of hoses on its way to the Nion water distribution box.

An example of a suitable chiller is Haskris R175 (http://www.haskris.com/R-Series/Haskris_R175.pdf , see also http://www.haskris.com/Haskris_Options.pdf) with options H-tight temperature control and R4- low pulsation pump, hose of 19 mm (3/4") ID or greater between the chiller and the Nion water distribution box, other options as needed for the user lab site.

Important warning: If the water chiller temperature is set to a temperature lower than the dew point of the microscope or the electronics room(s), water condensation on the cooling pipes and on the components cooled by them becomes inevitable. The condensed water is likely to lead to conducting paths established where there were none before, in lens, deflector and multipole coil windings, and in the microscope electronics. Such paths are likely to change the currents going through the coils and deflectors, and lead to things like defocus, astigmatism, coma and probe position (=image) drifts and instabilities.

Worse still, the conducting paths may persist even after the water has dried up, and their resistance may vary with time. This may result in column coils and/or electronics PCBs that need replacing. Such replacement can of course be arranged, but it will fall outside the warranty and the regular service contract for the instrument.

The dew point depends on the temperature of the room and the humidity. In general, the only safe temperature to set the cooling water temperature to is equal to or greater than the air temperature. (However, if relative humidity of 50% or less can be guaranteed, then it's O.K. to set the water up to 5 °C cooler than the air.)

Also note that should the air-conditioning fail and the room temperature rise, the water chiller temperature needs to be adjusted accordingly. If the microscope or the electronics room becomes hotter and muggier than usual, the only safe thing to do is to stop running the microscope altogether and switch off the water chiller.

9) Microscope room climate

The microscope is only guaranteed to attain its specified stabilities if the microscope room temperature is in the range of 18-22°C, and stable to within 1°C (peak-to-peak) / 24 hours, 0.2°C (peak-to-peak) / 1 hour, and 0.01°C/min. The relative humidity of the air in the room must be less than 60%.

Air flow in the microscope room (if air-conditioning is used) should be uniform (no strong air jets) and preferably less than 10 cm/min.

In addition to temperature control, an exhaust fan with a capacity >6 m^3 / minute (>200 cfm) should be provided for the microscope room. This fan will be off at all times except when baking the microscope, at which point it will be used to extract the heat generated by the bake from the room. Ideally, there should be a shutter in front of the exhaust fan that is closed except when the fan is on.

The preferred way of maintaining constant temperature in the microscope lab is to house the microscope in an environment in which the temperature outside the lab is nearly constant throughout the day (e.g., do not house the microscope in a room with an outside wall that can get hot due to full sun exposure, especially if there are sun-exposed windows leading into the microscope room), such as an underground room or one surrounded by air-conditioned rooms, and to install a large number of water-cooled panels in the microscope room, cooled by a chiller unit able to attain stabilization better than 0.1°C/hr (0.2°F/hr), for controlling the lab temperature. Suitable cooling panels are made by http://www.kigo-swiss.com/wq_pages/en/site/page-20.php . *They should cover >50% of the available wall space.*

If air-conditioning is used, it must be a proportional system, in which an air-cooling unit runs continuously and the air is reheated as needed to maintain the required temperature. On/off regulation, with temperature swing >0.1 C will not attain the needed level of temperature stability.

10) Dust and particles

HEPA filters in the air-conditioning are required, and should be changed on a regular schedule. The microscope room should be built to clean room standards. Dust-free wall, ceiling and floor coverings are needed for this: i.e., no carpets, no acoustic ceiling tiles and preferably also no exposed acoustic foam should be used.

A HEPA-filtered vacuum cleaner for keeping the microscope dust-free should be provided, e.g. the Nilfisk-Advance GM80 Vacuum ULPA see http://www.nilfiskcfm.com/IndustrialVacuums/GM_80_Vacuum/1

Small cotton hairs (0.5 mm to a few mm in length) that make up a large part of ordinary dust are particularly worrisome. Some laboratories have high levels of these hairs floating in the air and settling on free surfaces, and thus court potential problems, e.g. when one of these sticks to an O-ring in the airlock lid, or worse: a small hair entering the column, settling somewhere close to the beam, and charging up and deflecting the beam intermittently.

A quick check for dust level is as follows:

i) Mark an area 5 x 5 cm on a surface in the room.

ii) Blow the area free of dust with a Dust-Off can.
iii) After 24 hours, count the number of particles of dust that have settled in the marked area. Shine a strong light at a shallow angle onto the surface to help in identifying the dust particles. Note the total number of particles visible by naked eye, and also the number of small hairs longer than 0.5 mm.

If the total number of particles that settled on the area in 24 hours is greater than 10, or there are 2 or more small hairs of >0.5 mm total length, then the air-conditioning should be upgraded.

11) Pressurized gas - microscope

Argon gas from a gas cylinder will be needed for operating the microscope pneumatics and venting the airlock. It should come from a gas cylinder capable of holding up to 200 bar (3000 p.s.i.) of gas when full, and there should be a spare cylinder nearby. The Nion gas distribution piping starts with a ¼" NPT female fitting. In other words, an adapter bringing the gas out of the cylinder and terminating in a male ¼" NPT high pressure fitting needs to be provided at the site. (Dry nitrogen is not suitable for this function on the UltraSTEM.).

House argon can be used too, provided it's pure - water moisture and hydrocarbon-free - and available at 6 bar (90 psi) or greater pressure.

12) Pressurized gas – high voltage electronics

Some of the high voltage (HV) components of Nion 200 kV microscope system use SF_6 gas for electrical insulation. Two cylinders are needed for handling the SF_6:

- full cylinder of liquefied SF6, with an adapter to ¼" NPT, minimum 7.5 liter capacity. We recommend a 15 liter cylinder 18 cm diameter x 80 cm tall, and
- empty cylinder which will be needed for SF6 reclaim and recycling. This cylinder must be fillable, which may require a slight modification.

Nion will supply the regulators, valves and gas lines for handling the SF gas. However, because pressurized gas tanks cannot be air-shipped, the filled SF6 bottle needs to be supplied locally.

In addition, dry nitrogen is needed for the HV-generating (multiplier) tank. The user should supply either a nitrogen tank and adapter to ¼" NPT, or connection to an existing nitrogen line at 4 bar (60 psi) or above.

13) Mobile crane and mobile workbenches

Servicing the microscope requires a mobile crane (lifting device) that has pure up-down travel (many hydraulic cranes travel sideways at the same time as up/down and are not acceptable) and is rated for at least 250 kg (550 lb). Because of different safety regulations in different laboratories, it is best if the crane is purchased by the lab that will be using it.

For its monochromated microscopes, Nion recommends a straddle base Genie model SLA-15 lift with a boom rather than forks, see http://www.genielift.com/Brochures/Material_Lifts/SLA.pdf . (For non-monochromated Nion microscopes, the shorter Genie SLA-10 lift is adequate.)

If another lifting device is preferred by the user lab, Nion needs to be advised of the crane that will be used before the installation begins.

The user lab also needs to supply, prior to the installation, two mobile workbenches - sturdy carts that the microscope column sections can be placed on when the instrument is disassembled such as when a problem in the column need to be fixed just above the microscope table. The carts should be capable of supporting a load of 800 kg or greater each. Suitable such carts are available from McMaster-Carr (see the McMaster-Carr on-line catalog at www.mcmaster.com, product number 2463T11 , ~$500 each).

For access to the microscope door used for sample loading, the user laboratory should supply a sturdy 3-step stepladder, such as https://www.amazon.com/Cosco-Folding-Lightweight-Flatform-Resistant/dp/B074D1C58F/ .

For servicing the EELS and other components mounted high on the microscope column, a 2.4 m (8 ft) high ladder is needed and should be supplied by the user laboratory. Tripod ladders with a wide base such as Werner FTP6208 ladder (https://www.amazon.com/Werner-FTP6208-300-Pound-Rating-Fiberglass/dp/B0002MH1JE/) or similar are especially recommended.

If the user laboratory would prefer not to deal with ordering these parts, Nion can supply the mobile crane, the two workbench carts, the stepladder, and the ladder, with a 20% handling fee added to the supplier and shipping costs.

14) Sample baking station

Nion supplies a vacuum baking station for ex-situ baking of samples prior to their insertion in the microscope. Two different versions of the baking station are available, matched to the type of the sample cartridges/rods that will be used by the microscope: either detachable sample cartridges that are loaded up to 5 at a time into the microscope sample storage magazine (for the Nion detachable cartridge sample stage), or side entry rods (for the Nion side entry sample stage).

The baking station needs to be located somewhere other than the microscope room. This is because the low frequency noise (which is barely audible but actually quite strong) from its diaphragm pump induces microscope vibrations. It should also be situated somewhere other than the operator room, as the background noise from the station can get annoying. In a 3-room lab, the best place for the station can usually be found in the electronics room.

The dry gas for the venting is usually best supplied from a gas bottle that is separate from the main microscope Ar supply, so that using the bake station the wrong way does not deplete the microscope gas supply and does not stop the microscope from operating. (A separate Ar cylinder can also serve as a spare for the main microscope gas supply, should it run out at a particularly inconvenient time.) Nion supplies the hoses and the pressure regulator for the Ar gas, the user lab needs to supply the Ar bottle and a secure attachment to the wall, ideally close to the baking station.

Nion finds that two things are needed to prevent sample contamination in a STEM: a clean microscope and a clean sample. We have made sure that the whole microscope is based on clean UHV principles, and that it can be cleaned by baking. The result is that on a clean sample, contamination is not a problem in the Nion microscope no matter how long the sample is left in it. But if the sample arrives with contamination on it, e.g. because it was prepared in a not-so-clean ion mill, because it was touched by not-so-clean tweezers, etc., contamination will be a problem even in a clean microscope. Heavily contaminated sample can easily contaminate the sample chamber of the microscope, whereupon previously clean samples may start contaminating too.

To clean each sample reliably before it is inserted into the UltraSTEM, Nion provides a baking station that bakes either a whole magazine's worth of sample cartridges (for the detachable-cartridge type of Nion microscopes), or up to 4 sample rods at a time (for the side-entry rod type of Nion microscopes), in a vacuum provided by a dry turbo pumping station.

At the end of the bake cycle, the baking station needs to be vented, often while the samples are still hot. To prevent chemical changes in samples exposed to a gas while hot, and also to prevent oxidation of the electrical contact used by the heating circuit, the venting is best done by argon rather than dry nitrogen or air.

15) Sample loading station

Nion supplies a binocular optical microscope to make the sample loading easier, and a desiccator box for storing the sample cartridges (or sample holders) when not in use.

The user lab should supply a small table to put the microscope on.

The user lab should supply clean UHV Al foil, e.g. for lining the table area on which samples will be handled. Suitable such foil is available from
https://www.soscleanroom.com/product/facilities/ultra-high-vacuum-uhv-foil-cleanroom-aluminum-foil/

Note that kitchen-type Al foil tends to be lightly greased, and the grease causes instant contamination on any sample that comes into contact with it!

The user lab should also supply vacuum tweezers such as:
http://www.tedpella.com/grids_html/520.htm

The ideal location for the sample loading station is in a quiet, non-dusty place where samples can be loaded without any distraction or contamination, and which people are likely to respect as a "gloves only area" rather than say put their coffee mugs on. It should also not be far from the baking station, which will be the next stop for the user once a cartridge magazine has been filled up with cartridges that need to be baked, or a side entry rod that has been freshly loaded up with a sample.

16) Internet and Telephone Access

Part of the installation is normally carried out remotely via the Internet – e.g., the electronics specialists back at Nion may check that the electronics has come through the shipment unharmed by logging onto the microscope remotely. A reliable high speed connection to the User computer needs to be available for this **from the start of the installation**. If there are security / firewall issues to be resolved, **this needs to be done before the installation commences.** A functioning telephone also needs to be available in the operator's room **at the start of the installation.**

17) Microscope room dimensions – UltraSTEM200MC

The outer enclosure for the UltraSTEM200MC is 3.4 m high. About 0.3 m free height above the enclosure is needed, and hence the ceiling in the microscope room should be at least 3.7 m high (with no protruding fixtures such as lights, air conditioning outlets, or fire alarm sprinklers above the microscope).

The enclosure splits into two halves for microscope service, during which the front half is rolled away. An empty space 2 m deep and 2 m wide is needed in front of the microscope to accommodate this maneuver.

A room with dimensions of 4.5 m x 5.5 m (see the figures at the end of this document) will provide adequate room for:

* the microscope enclosure (when open),
* a movable crane moving into position to lift off column sections , and
* a movable workbench moving into position so that column sections can be placed on it.

Doorway dimensions should be at least 1.5 m (Wide) x 2.0 m (High).

Smaller and irregular-shape rooms have been used to house Nion microscopes in the past, and Nion will consider any room that looks like it will provide a good environment for its microscope.

18) Detailed room layouts

A practical example of a well-designed layout of a laboratory housing a monochromated UltraSTEM200MC is shown in Fig. 1. Note that this example shows the minimum space that should be allotted to the microscope. Larger microscope laboratory and/or electronics and operator rooms are of course fine too. Rotations and mirror reflections of the plans that preserve the integrity of the rooms are fine.

The ideal layout, which may not be practical in every laboratory, places the microscope in a connected set of three rooms, large enough to accommodate the UltraSTEM200MC comfortably:

a) **The microscope room.** This room houses the microscope column with its suspension and shielding box, the cable switchover tower, the cable support frame, two mobile work carts (for the stacking of column modules during column modifications and repairs, each one capable of supporting >500 kg) and a lift (Genie SLA-15 is recommended, see 13 above)). The room needs to be quiet electrically, magnetically, acoustically and ground vibration-wise, as described earlier in this document (sections 2-6), and it needs to have a well-regulated temperature but minimized airflow. Because the microscope's major heat-producing components are water-cooled, the instrumentation in this room generates only about 100 W of heat and hence there is no need for special cooling to remove the heat.

   A ventilator fan, as described in section 9, or at least a door that can be opened is required for this room, to allow extra heat generated when the microscope is baked to escape.

b) **The electronics room.** This room houses the microscope's electronics including the HT power supply, and typically also various auxiliary elements such as a scroll pump used to evacuate the airlock during sample exchanges (or the whole microscope after venting for servicing), the water distribution box, and optionally also the sample loading table and sample vacuum bake station.

   For the monochromated UltraSTEM200MC, the electronics room needs to accommodate six 19.5" electronics cabinets (54 cm wide, 70 cm deep, 176 cm tall, and ideally have space for one more electronics cabinet for optional future expansion. 90 cm of space is needed both in front of the cabinets and behind them, for servicing access. A room 3 m wide and 4.5-5.5 m long (depending on whether room for future expansion is provided or not) is best. It should be quiet electrically and magnetically, with peak stray fields smaller 0.5 mG r.m.s (50 nT r.m.s.) Peak heat-removal capacity for this room needs to be 2.0 kW or greater, airflow should be moderate.

   If only a smaller room is available for the electronics, the "divider tank" electronics cabinet, which is electrically quiet and generates very little waste heat, can be optionally located in the microscope room.

   A cable conduit/shelf needs to be installed in the electronics room prior to the installation of the microscope, so that the cables from the electronics can be routed to the microscope at about 2 m height, and not lay on the floor, where they can be easily trampled. The location of the cable conduit is typically shown on the drawing of the room layout that Nion will produce prior to installation.

   The Nion microscope is supplied with a small vacuum baking station that removes sample contamination by pre-baking the sample magazine with all its sample cartridges (or side-entry rods), prior to insertion into the microscope. The baking station has a footprint of 75 x 45 cm, and is ideally placed in the electronics room, where the noise of the turbo does not create a distraction for the operators.

   A small table (120x60 cm is sufficient, to be supplied by the user lab) for specimen loading should be located next to the baking station. The Nion-suplied optical microscope for sample loading will be located on top of the table, and the table area will be "gloves only".

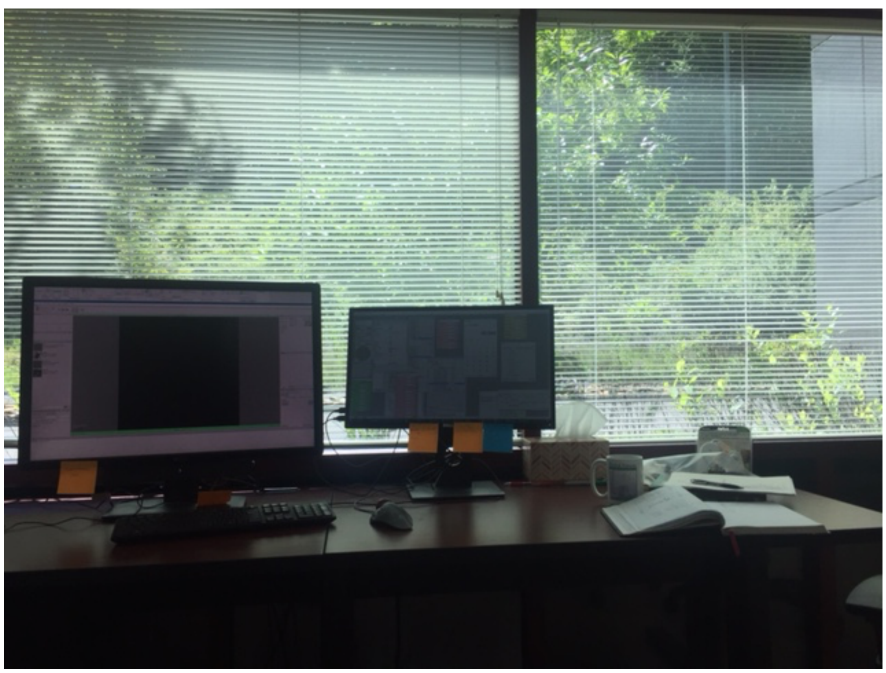
If needed, the electronics room can also house the operators, with the typical arrangement being that the operator's table(s) are placed directly in front of the electronics cabinets, and the table has castor wheels so that it can be easily moved out of the way if access to the electronics is needed for servicing. The room will then need to be larger, ideally >4 m wide times 4-5 meters long. The vacuum baking station and the sample loading table should then be located elsewhere.

c) **The operator room.** This room can be relatively noisy, and temperature regulation is not critical. A large desk with space for 3 large computer displays is needed. The desk, to be supplied by the user lab, should ideally be about 180x75 cm or larger.

Heat removal capacity of 1 kW for the computers plus 100 W per each operator is needed. A larger room will not feel crowded when several people are operating the microscope together. The precise choice of the room's dimensions is left up to the user laboratory.

Although it is not necessary that the operator room be located right next to the microscope room, Nion recommends that it should be reasonably close, so that access to the microscope from the operator room is fast and obstacle-free.

The operator room can have natural light and even sunlight, and the work quality tends to improve in pleasant surroundings. An example of how the operator's desk can be nicely arranged is shown below.



Nion UltraSTEM100MC operator desk, ORNL

The three rooms of the microscope suite need to be in a cluster such that the cables provided with the system are able to reach from the cable switchover box (situated near the microscope column) to the electronics cabinets (these cables are either 6 m or 8 m long, depending on where in the electronics they go), from the electronics cabinets to the computers (6 m), and from the column itself to the computers (10 m). Note that some 1-2m of the cables are used up within the electronics cabinets, which means that the full cable length is not available for covering the distance between the units. Longer cables, if essential for your site, must be specified at the time of ordering.

The user room can be optionally located 10-30 m or even further from the other rooms. The monitors and keyboards are then connected to the computers, which are housed in the electronics room, via fiber optic cables. The electronics and the microscope rooms, however, do need to be adjacent.

Prior to each installation, Nion normally produces a design drawing for how the components of the microscope system should be situated in the available space and how the cables should be routed. The user lab should therefore supply the precise room dimensions when placing an order for the instrument. **The ideal time to produce the site plan drawing is at the time of the order (or slightly before).**

19) Space for auxiliary equipment

The acoustically noisy water chiller and the magnetically noisy isolation transformer should be located either in a service corridor outside the microscope laboratory room(s), or in another room dedicated to “noisy” equipment. They should ideally be at least 7 m, and ideally 10-15 m away from the microscope column, in a straight line.

20) Quick check-list

Nion will be supplying:

- the complete microscope and its electronics checked for optimum performance
- a high power cable for bringing power to µscope
- pneumatic gas distribution system for microscope
- cooling water distribution box
- sample baking station
- gas distribution system for baking station
- optical microscope for mounting samples
- desiccator box for storing sample cartridges in their boxes
- tool chest with tools and spares
- computers, keyboards and monitors
- remote operation from Nion, helping to bring the microscope up

The user lab needs to supply:

- the rooms to put the microscope and electronics in, checked for satisfying Nion environmental specification
- isolation transformer (see section 7)
- wall-mounted fuse box, with prominent on/off switch
- 2x Ar gas cylinders (about 50 L capacity) safely secured in place (see section 11)
- cylinder of pressurized (liquefied) SF6. 15 liter cylinder 18 cm diameter x 80 cm tall is recommended (see section 12)
- dry N_2 gas cylinder safely secured in place (see section 12)
- water chiller, ideally 10-15 m away from the microscope (see section 8)
- cooling water for the water chiller, to remove the heat generated in the chiller.
- 20 gallons of spare distilled water for chiller (in case flushing is needed)
- 2 gallons of denatured alcohol for mixing with chiller water
- climate control for the microscope lab, and electronics and operator rooms (see sections 9 and 18)
- lifting device (Genie SLA-15 or other Nion-approved lifting device, see section 13)
- mobile workbench (500 kg load capacity)
- 3-step stepladder (e.g. Cosco 11-839 GGO)
- 2.4 m (8 ft) tripod ladder (Louisville FT1508 or similar)
- HEPA-filtered vacuum cleaner, such as http://www.nilfiskcfm.com/IndustrialVacuums/GM_80_Vacuum/1
- sample-mounting table - a clean (gloves only) area - plus a supply of UHV Aluminum foil
- a desk to put the keyboards and monitors on
- fast Internet connection, and remote access to microscope

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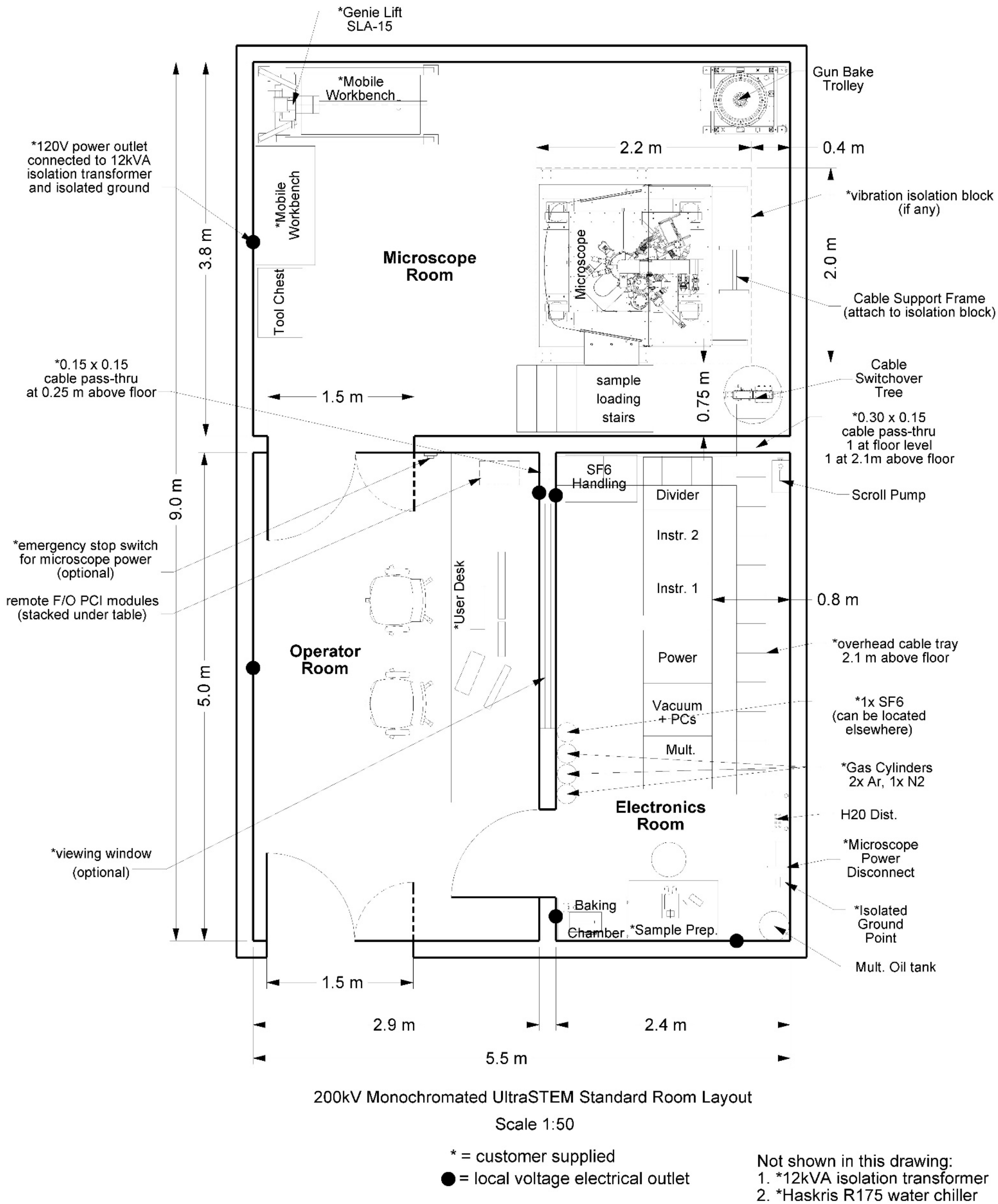

Fig. 1. Example of an optimized layout of a monochromated UltraSTEM™100 laboratory. Dimensions in meters.