# Miniature Atomic Source Manual

V4.0-2026

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# Contents

# Introduction

The Miniature Atomic Source (MAS) is a high-efficiency fused silica laser-heated atom source. The atomic flux can be controlled by adjusting the optical power of the heating laser, within a recommended operational range. Due to its high thermal efficiency and homogeneous glass construction, the MAS can be run continuously, producing neutral atom densities suitable for ion trapping while presenting a negligible heat load.

# System alignment

To ensure alignment between the mounted MAS and ion trap, we can provide an alignment module which has the same outer envelope as the MAS, Figure 1. Light can be propagated through the fibre of the alignment module to show the expected propagation direction of the atomic flux, Figure 2. After the mounting direction is verified, the alignment module can then be replaced with the MAS.


*Figure 1: The packaged alignment module.*

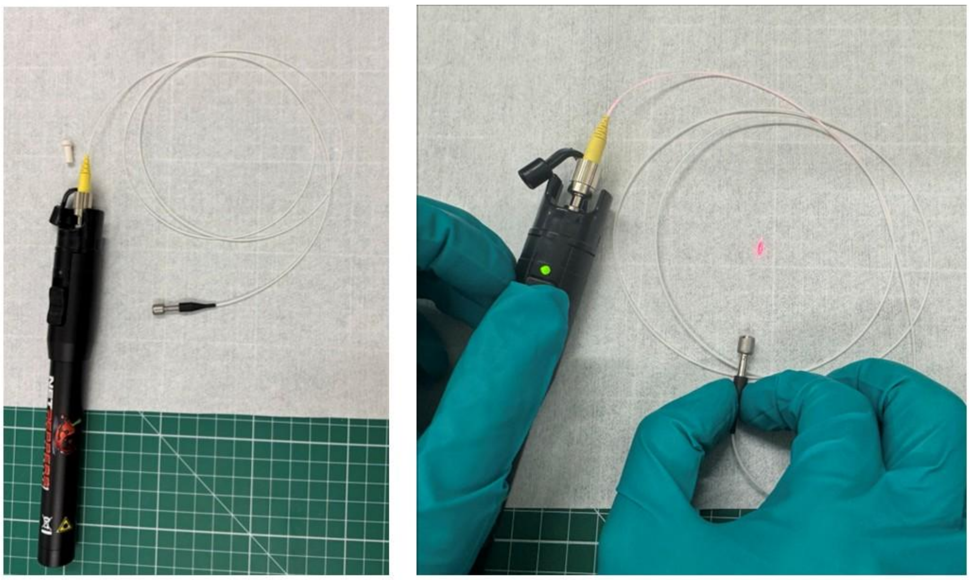


*Figure 2: Connect a visual fault locator (630nm) onto the alignment module for a visual representation of atomic flux [Left-side shows connection, Right-side shows red laser output spot].*

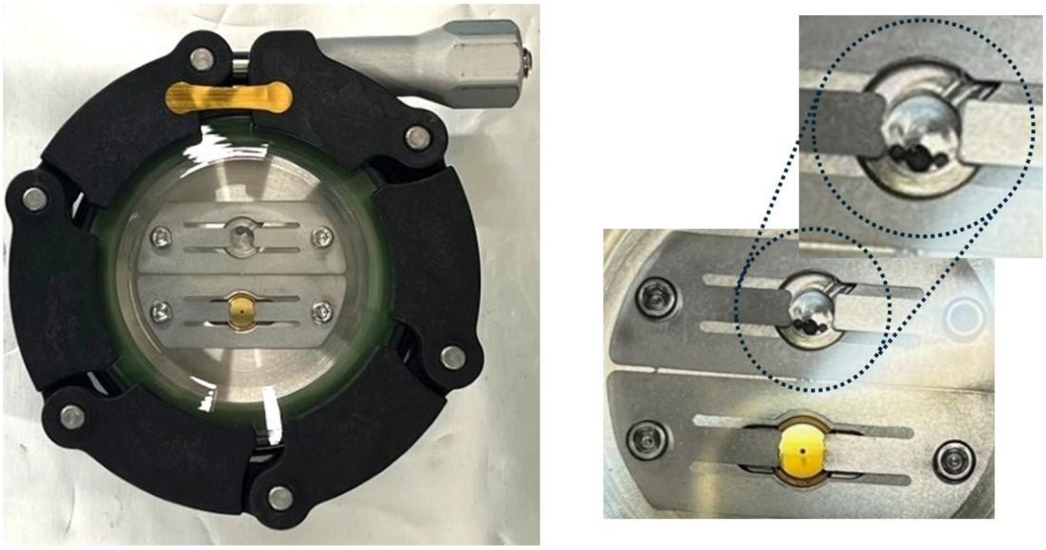
# Installation of the MAS

**WARNING:**
***It is vital to limit exposure to oxygen and moisture-vapour to protect the function and longevity of the MAS.***

Therefore, we recommend performing the handling steps within an inert glovebox environment (oxygen and moisture levels <20ppm).

Each MAS is supplied in a custom transport assembly (see Figure 3) then sealed inside a foil bag to maintain an inert environment during shipping and storage at your facility until used. This assembly has been designed to include a transparent viewing window so that the contents of the package can be inspected prior to opening. The MAS is located inside a machined pocket (Figure 3a), secured in place underneath a metal clamping spring. There’s a second machined pocket to house multiple moisture indicator beads, which are covered by a small glass window and again secured in place using a metal clamping spring (Figure 3b).

Instructions for opening the packaging assembly are shown below, however after cutting open the outer foil bag to reveal the assembly, first verify that the moisture indicator beads remain darkly coloured in appearance (Figure 3b). **If there's evidence of white spots on any of the beads, or evidence of some white powder inside the pocket then do not open the packaging assembly and contact QFX immediately to seek further advice.**



a) Overview of MAS Transport Package Assembly. MAS located in lower pocket.

b) Higher magnification images showing dark indicator beads located inside upper pocket

*Figure 3: MAS transport assembly.*

Figure 4 shows a photograph of the tools required to safely open the transport assembly and extract the MAS, including:

i) a sheet of Ultra High Vacuum grade aluminium foil to act as a clean work surface;
ii) protective gloves (e.g., powder-free nitrile gloves);
iii) clean scissors;
iv) 13mm socket wrench (or 13mm spanner);
v) 1.5mm metric hex key, and
vi) clean metal tweezers (e.g., Lindstrom TL SM108-SA).

*Figure 4: Transport assembly oriented vertically while bolts are being loosened.*

**WARNING:**

***To protect the MAS from oxygen and moisture exposure, handling should ideally be performed inside an inert glovebox (<20 ppm $O_2$/moisture).***

To open the assembly and access the MAS:

1. Using the scissors, cut open the gold securing tab (Figure 5)
2. Using the socket wrench with 13mm adaptor (or the 13mm spanner) loosen the plastic chain clamp thumb nut by rotating counterclockwise (Figure 6)
3. Once open, unlatch the thumb nut then manually detach the plastic chain clamp and set aside (Figure 7)
4. Manually remove the front window and O-ring assembly from the metal base and set aside (Figure 8)
5. Using the 1.5mm hex key, unscrew both bolts on the metal clamping spring and set aside (Figure 9)
6. Using the tweezers, remove the metal clamping spring and set aside (Figure 10)
7. Using the tweezers, remove the MAS from its locating pocket (Figure 11)

*Figure 5: Cut open the securing tab.*

*Figure 6: Loosen the thumb nut on the plastic chain clamp using socket wrench.*

*Figure 7: Remove plastic chain clamp from assembly.*

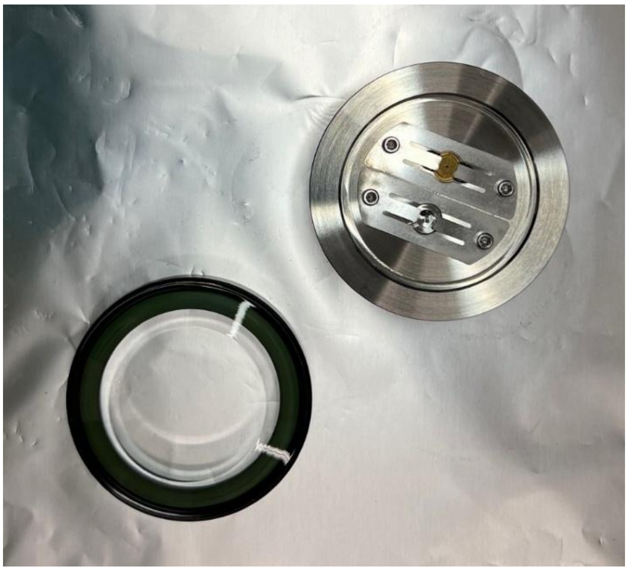


*Figure 8: Remove front window and O-ring from metal holder.*

*Figure 9: Unscrew hex bolts from metal clamping spring securing the MAS.*

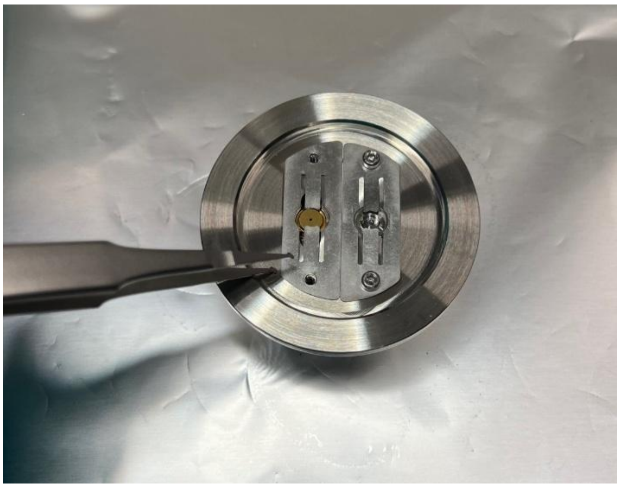


*Figure 10: Remove metal clamping spring using tweezers.*

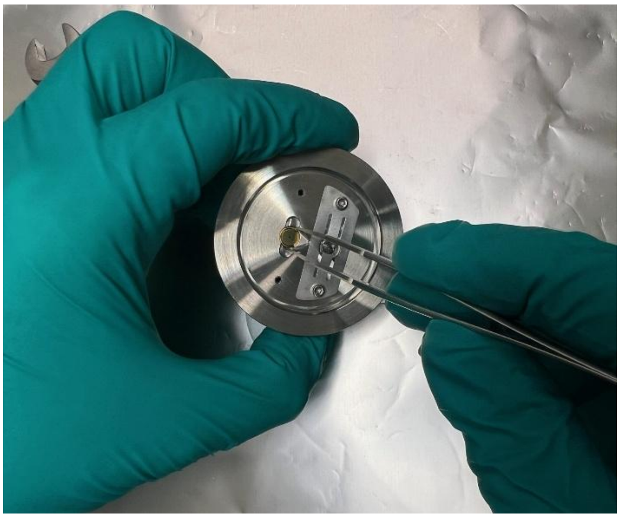


*Figure 11: Using tweezers remove MAS unit from its pocket.*

# Setting up the alignment system

With the vacuum system closed and under vacuum, the heating laser must be aligned with the heating aperture on the rear surface of the MAS.

The recommended alignment system shown in Figure 13 consists of the heating laser, a beam splitter, a camera lens, a camera, and an objective lens.

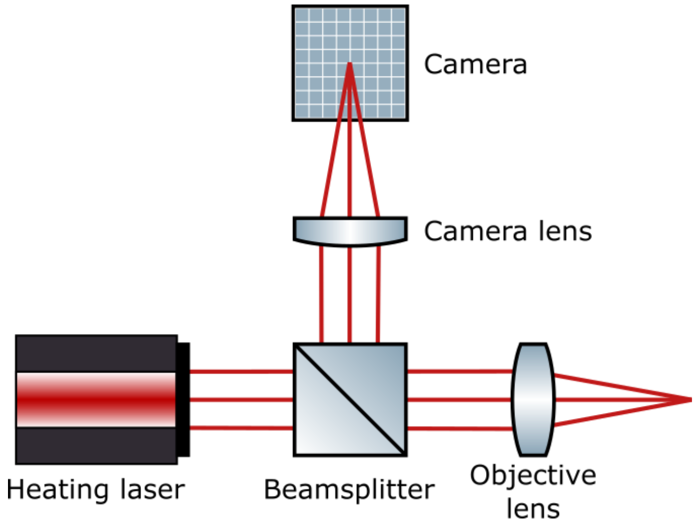



*Figure 13: Schematic of the alignment system*

The spot size (1/e² diameter) of the heating laser should be approximately $s = (25 \pm 5)\mu\text{m}$ in diameter to fit comfortably into the 50-μm aperture hole of the MAS.

The required focal length can be calculated from the collimated beam diameter $d$ using

$$f = \frac{\pi s}{4\lambda}\sqrt{d^2 - s^2},$$

where $\lambda$ is the wavelength of the heating laser. If the heating laser is delivered by a fibre with numerical aperture $\mathrm{NA_{fib}}$ and is collimated by a lens with focal length $f_{\mathrm{col}}$, the collimated diameter will be given by $d = 2f_{\mathrm{col}}\mathrm{NA_{fib}}$. Table 1 lists the recommended range of focal lengths for various collimated beam diameters, assuming a heating laser wavelength of 780nm.

| Collimated diameter / mm | 2 | 4 | 6 | 8 | 10 |
|---|---|---|---|---|---|
| Focal length / mm | 50±10 | 100±20 | 150±30 | 200±40 | 250±50 |

*Table 1*

The objective lens is placed on a 3-axis translation stage, with the transverse degrees of freedom (normal to the heating beam propagation direction) requiring high positional accuracy whilst the longitudinal translation (focal distance) can be coarse.

Note that mounting the beam collimation optics on a translation stage and keeping the position of the objective lens fixed will not provide sufficient degrees of freedom to align properly to the MAS.

A beamsplitter (90:10 or similar) is placed between the laser source and the objective lens, with most of the power transmitted towards the MAS. The beamsplitter then directs a portion of the back-reflected light from the object onto a camera.

The spare port on the beamsplitter can be used for monitoring laser heating power delivered to the MAS, with appropriate calibration.

1. Collimate the heating laser light (factory aligned collimators should be used where possible for best collimation).
2. Adjust the camera lens such that the camera is infinity-focussed. Ensure that an object placed >100m away appears sharp on the camera (note that laboratory-scale distances are not sufficient to ensure infinity-focus).

Following steps 1 and 2 ensures that the object plane of the camera coincides with the heating laser focus, and from this point onward neither the collimation lens nor the camera lens should be adjusted.

The preparation of the alignment system is now finished, and it can be moved to the target vacuum system to align the heating laser onto the MAS.

## Alignment of the heating laser

1. Illuminate the MAS with a diffuse light source and position the alignment system such that its back surface is imaged sharply onto the camera, Figure 14.

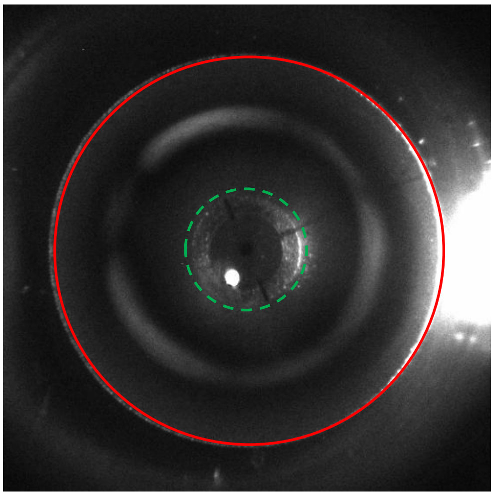


*Figure 14: The image of the rear surface of the MAS should clearly show the alignment crosshair in focus, seen at the centre of the above image within the dashed green ring. The laser beam can be seen in the lower left region of the alignment crosshair. The 'outer annulus' is circled in red.*

2. Turn on the heating laser at sufficiently low power to avoid saturating the camera sensor. This power will be well below the MAS operating power and may be below the lasing threshold of the laser diode.
3. Adjust the transverse position of the objective lens until the heating laser spot lies within the crosshair region of the MAS. Note that this adjustment will appear on the camera as a movement of the MAS rather than the heating laser; this behaviour is expected from the construction of the optical system.
4. Verify that the spot size is consistent with the target spot size (~25μm) by counting the illuminated pixels and multiplying this number by the pixel size and the magnification of the imaging system. This will give inconsistent results if the camera is saturated.
5. Further adjust the transverse position of the heating laser spot to enter the rear aperture of the MAS (in the centre of the crosshairs), where the back-reflected power should drop significantly.

Even with perfect optical alignment, the spot will not fully disappear, but a distinct diffraction pattern will be visible. At high powers, this should become a distinct ring of laser light, as shown in Figure 15.

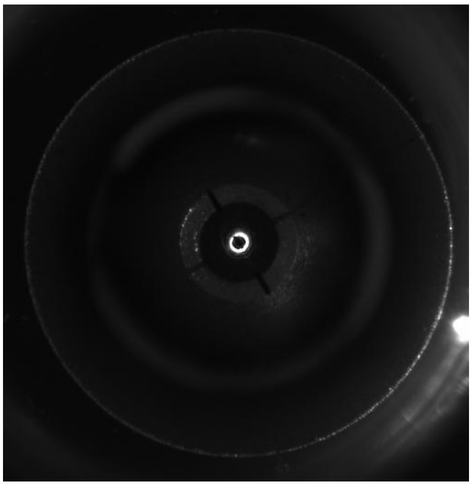


*Figure 15: Once aligned to the rear aperture of the MAS, the back-reflection from the laser heating beam will be a clear ring pattern at higher laser powers and an unusual diffraction/interference pattern at lower powers.*

6. (Optional) Remove the camera and replace it with a photodiode.
7. (Optional) Optimise the transverse position of the objective lens by minimising the power reflected to the photodiode. This can result in better alignment than using the camera alone, but only small tweaks to alignment should be made. If alignment into the rear aperture is lost during this stage, replace the camera and return to step 5. The photodiode can be used to monitor drifts of the heating laser alignment.

## Cracking the MAS

If the MAS has been exposed to ambient conditions during handling, then an oxide layer can form on the surface of the metal. If this has occurred, this layer must be broken up by initially heating the MAS at higher laser powers, until neutral fluorescence is observed from the atom beam. This procedure is referred to as 'cracking'. Once first fluorescence is observed, the running power of the MAS should be minimised. Extended running at high optical powers may damage the MAS, increasing the divergence of the output atom flux. **Please do not exceed the maximum optical power stated in the technical datasheet provided with the MAS.**