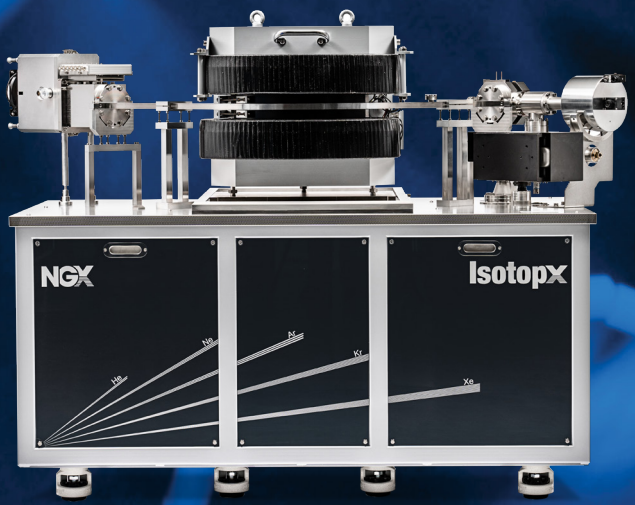
Isotopx



NGX

Noble Gas Mass Spectrometer with ATONA®

Excellence in Mass Spectrometry

isotopx.com

Next Generation **Noble Gas Mass Spectrometry**

Noble gas mass spectrometry is used to study the isotopic composition of the noble gas group of elements - helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe).

The noble gases can be used for dating (e.g. argon isotopes), or as isotopic tracers in earth and cosmochemical evolution. The NGX mass spectrometer from Isotopx is the latest version of this type of mass spectrometer. It features advanced multicollector technology in combination with a low volume, high sensitivity, high mass resolution spectrometer design. The result is a powerful, versatile, sensitive, noble gas mass spectrometer that is intuitive to use, which can also be customised for the most exacting applications. NGX also benefits from the unique, patented ATONA® technology that underpins all of our solutions.

ATONA®: World Class Amplifier Technology

NGX Noble Gas Mass Spectrometer

Fully automated and high precision

The NGX is a fully automated, high precision mass spectrometer with full multicollection capability for the measurement of noble gas isotope ratios at high resolution. It features a high sensitivity cathode 'Nier' type gas source and a low volume static vacuum analyser. The detector array may be populated with a customisable combination of Faraday cups and ion counting electron multipliers. The NGX is fitted with the ATONA® amplifiers as standard.

NGX design features

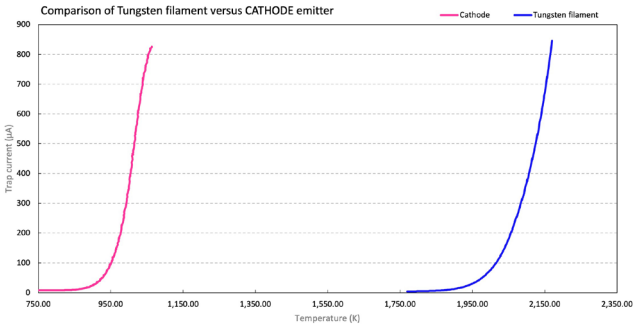
- Compact design
- Large radius magnet for optimal transmission, resolution and stability
- Rotated ion focal plane such that the collector focal plane is perpendicular to the ion trajectory, ensuring optimal peak flat irrespective of collector position across the focal plane
- Revolutionary, patented electronically calibrated ATONA® amplifiers on all Faraday cups
- Low volume design
- Patented high sensitivity cathode source
- High resolution with capability to fully or partially resolve organic interferences and ^{3}He from the HD and ^{20}Ne from doubly charged ^{40}Ar.
- Full multicollection capability with optional ability to measure all nine isotopes of xenon with full coincidence.

The ultimate precision of isotope ratio mass spectrometry is governed by the signal/noise ratio of a measurement. This is of particular significance in static vacuum noble gas mass spectrometry where sample size is often limited and thus, the signal size is constrained by the sensitivity of the source.

Isotopx has successfully managed to improve this signal/noise performance on the NGX by developing two novel technologies. Firstly, improving the sensitivity of the source and secondly, reducing the noise on the Faraday amplifier detectors.

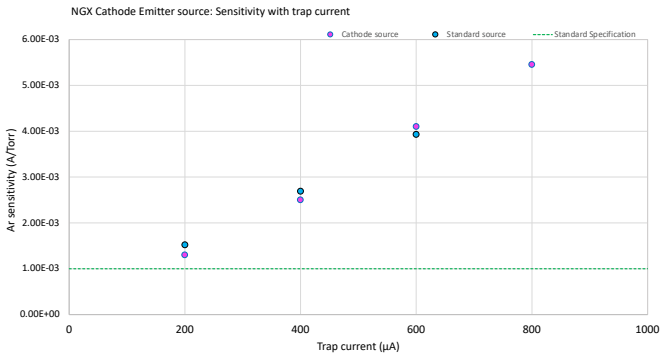
High Sensitivity Cathode Source

Isotopx has developed a new Nier-type source that offers unique sensitivity performance without compromising the lifetime of a filament. Operating at 1/10th of the electrical power of traditional sources, the temperature of the source runs much lower so interfering hydrocarbon volatile species are less prevalent in the vacuum. Our new source can comfortably achieve sensitivities of 7mA/Torr which is seven times the specification of standard sources, whilst maintaining comparable filament lifetimes. Furthermore, as this performance is attained at lower emission temperatures, measured mass 36 backgrounds of 8E-15 ccSTP show a six-fold improvement on the standard specification.



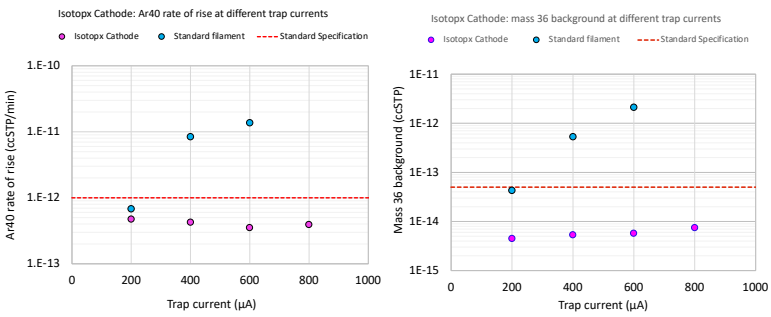
Low Temperature

The new NGX source operates at much lower temperatures than the standard source. This helps to reduce the formation of volatile interference species associated with higher temperature sources.



High Sensitivity

The NGX cathode source produces greater abundance of ionising electrons which means sensitivities can be increased by a factor of 5 compared to standard sources.

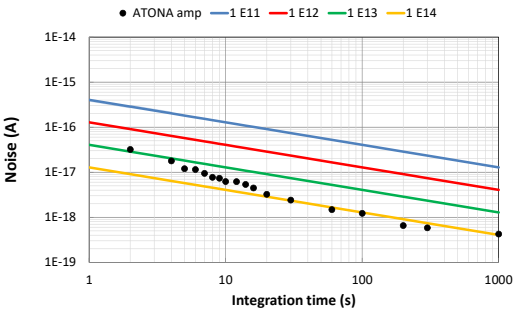


Low Backgrounds

Whilst the new NGX source offers increased source sensitivities, it does not increase the abundance of interfering background species.

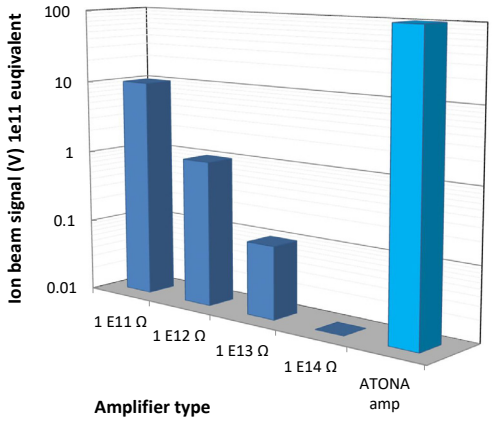
ATONA® Faraday Amplifiers

The unique ATONA® (aA to nA) amplification technology from Isotopx has eliminated the need for a "feedback resistor". The outcome is a significant reduction in amplifier noise, a dramatic increase in dynamic range, rapid amplifier decay, and improved baseline and calibration stability.



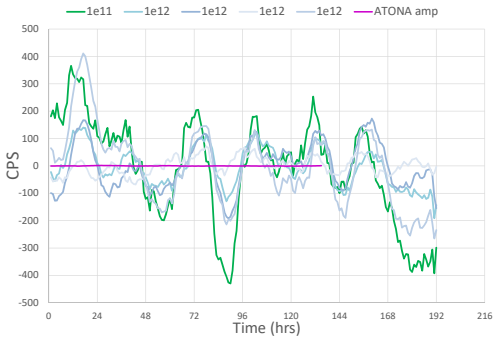
Noise

The ATONA® amplifier exhibits noise levels equivalent to a 1e13Ω resistor at short integration times, but behaves equivalent to a 1e14Ω resistor at integration times greater than 20 seconds.



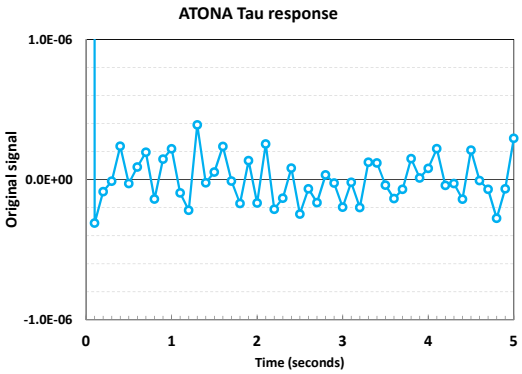
Range

Whilst the ATONA® amplifier exhibits low noise levels, it does not compromise the maximum signal size available to be measured. Ion beams of up to 100V (1nA) can be measured without saturating the amplifiers, which can be the case with resistor amplifier technologies. So ATONA® is ideal if you have high and low abundance isotopes or variable sample sizes



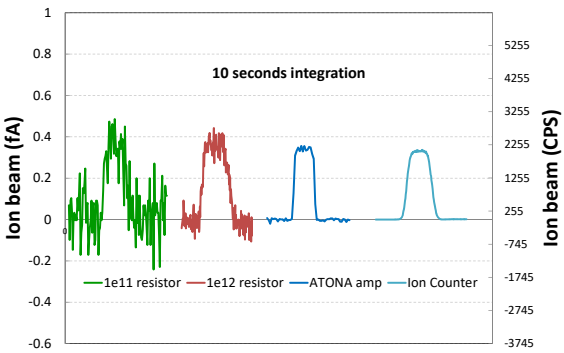
Baseline Stability

The ATONA® amplifier exhibits extremely stable baseline measurements over extended periods of time. The plot above compares the ATONA® amplifier baseline stability against the exsisting resistor amplifier technologies over a period of 5 days.



Tau Response

A limitiation of resistor amplifier technologies is the ability to return to baseline after on peak measurements. This is particularly problematic with higher gain amplifiers. However, the ATONA® amplifier exhibits no such delayed TAU response and returns to within 1ppm of baseline within 100ms.



Detector Comparison

The plot above displays the peak shape of the sime sized ion beam scanned using different detector technologies. It can be seen that the ATONA® amplifier peak, with its low noise performance, appears more similar to that of the ion counting technology than the traditional resistor technology.

Full Multicollection Capability

The ion optics of the NGX are based on the same magnet design as Phoenix TIMS. NGX is fitted with a large 90 degree 27cm radius magnet.

The large radius magnet provides sufficient mass dispersion to allow for the static multicollection of Xe, Kr, Ne and Ar isotopes. Modified magnet exit poles rotate the focal plane of the instrument such that the collector focal plane is perpendicular to the ion trajectory, ensuring optimal peak flat irrespective of collector position across the focal plane. This allows full multicollection capability of the noble gas isotopes including an option to measure up to 9 isotopes of Xe simultaneously on Faraday collectors. This capability is unique to the NGX.

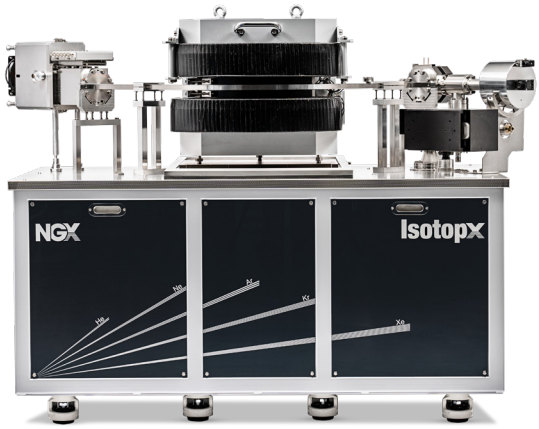


Fig 1. The figure shows coincidence of all nine isotopes of xenon. The ion optics of the NGX permits the simultaneous measurement of all the xenon isotopes.

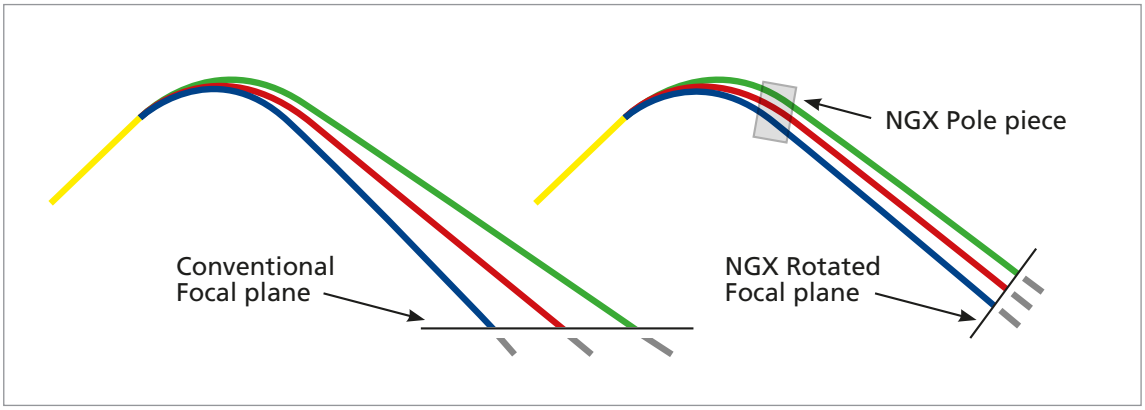


Fig 2. shows the rotated pole pieces of the NGX as compared to the conventional focal plane of a typical mass spectrometer

NGX Multicollection

The NGX offers versatility whereby the configuration of both the number and type of detector is governed by the end user and their particular application.

The collector array can be configured with multiple detector modules. Each detector module can be either a Faraday cup or an ion counting discrete dynode multiplier. The most common application is for Ar dating where the collectors are positioned to coincide with the 5 applicable argon isotopes, using a combination of Faraday cups and ion counters.

The Faraday cups are used in conjunction with the patented Isotopx ATONA® amplifier electronics. This technology offers unprecedented dynamic range, amplifier noise and Tau performance. The amplifiers are electronically inter-calibrated and housed in an evacuated, temperature-controlled enclosure.

The ion counting detectors use compact discrete dynode Secondary Electron Multipliers (SEM) and have typical efficiencies of ~90% with dark noise <10cpm.

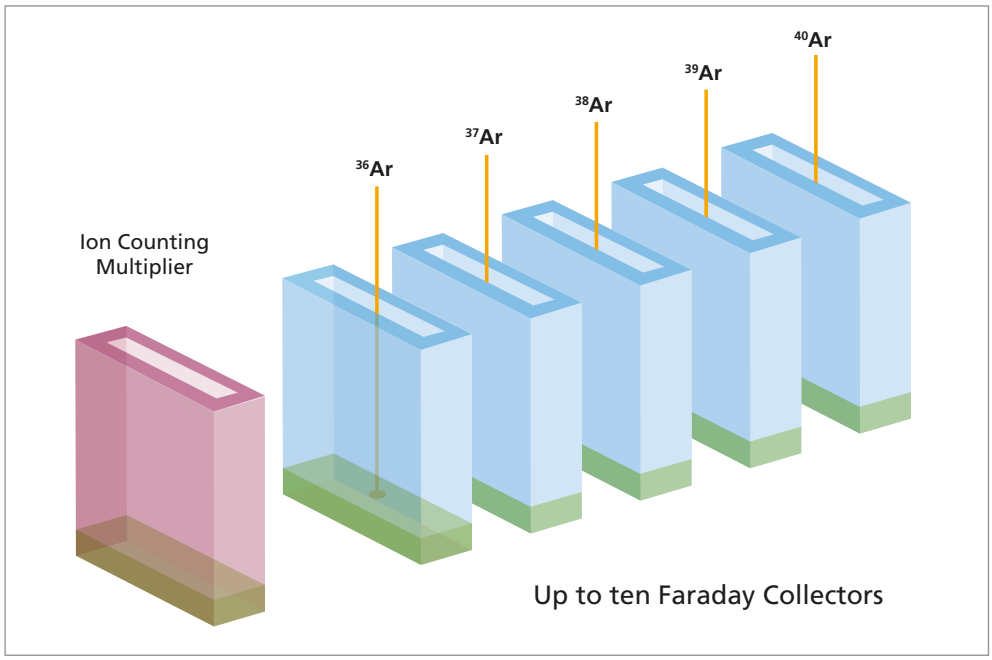


Fig 3. shows a configuration with detectors strategically fixed in position to be able to multi-collect Ar isotopes. But the collectors can also be used to measure all other noble gases in 'peak-jumping' mode. The resolution (5% height) is ~600 which allows full separation of ^{3}He from the interfering HD^{+}/$3H^{+}$ doublet.

High **Resolution**

Interferences from hydrocarbons and other species can limit the accuracy of analysis in noble gas mass spectrometry. The base resolution of the NGX is >600 at 10% valley with 100% ion transmission, offering full sensitivity with a 0.25mm ion beam width at the source.

This resolution is sufficient to resolve hydrocarbons and many other interfering species from the centre of the peaks of interest. The mass dispersion of the large radius magnet is also sufficient to allow for static multicollection of Xe, Kr, Ne and Ar at this resolution.

Fig 4. The ^{3}He peak is clearly mass resolved from the HD molecule. This is only possible due to the inherent large mass resolution of the NGX. This scan on the multiplier shows the ^{3}He (on the left) fully mass resolved from the HD molecular peak on the right. There is no evidence of the ^{4}He peak tail which would be apparent on the right of the scan. Note the width and flatness of the ^{3}He peak, this makes it ideal for accurate ^{3}He determination.

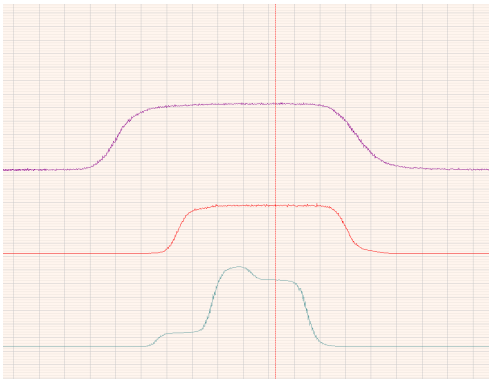


Fig 5. The figure shows the coincidence of the Neon isotopes on the multicollector. The ^{20}Ne is a complex peak as the $^{40}Ar^{++}$ (doubly charged ^{40}Ar) is isobaric with the ^{20}Ne.

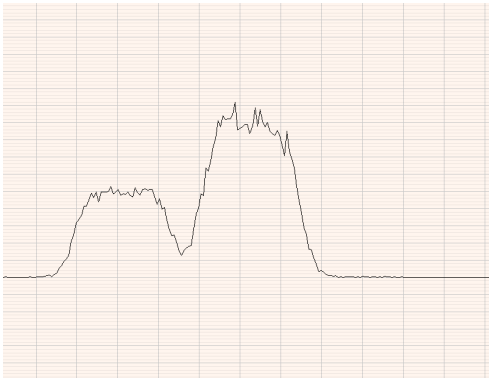


Fig 6. shows the complete peak separation of ^{40}Ar peak from the C_3H_4 organic peak

High **Precision Analysis**

The NGX is the only noble gas mass spectrometer to combine multicollection, high resolution and high sensitivity in a single compact instrument. This inherent design combination provides analyses of the highest precision.

Stability of Air Shots

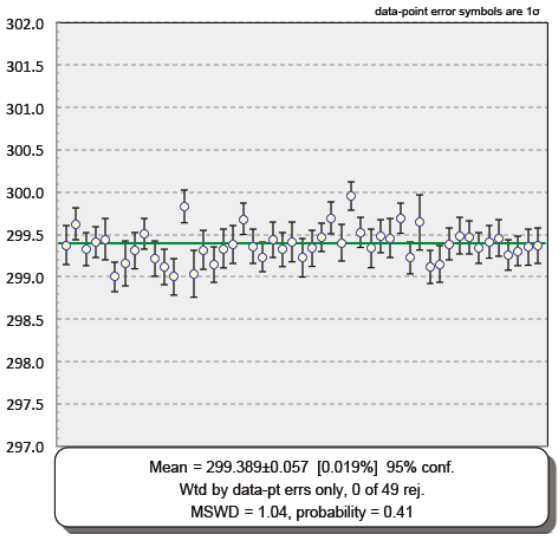


Fig 7. This graph shows the precision that can be expected from replicate airshots provided by the automated preparation system. Data was collected with 1 x$10^{11}\Omega$ amplifiers in the ^{40}Ar and ^{36}Ar collectors. Peak hopping (18 cycles; 15s integrations), on an air standard (~2 x10^{-12}moles ^{40}Ar) gave a 4V ^{40}Ar ion beam on 1 x$10^{11}\Omega$. The weighted mean was 299.389 ±0.057 (0.19‰, n=49) 1RSD = 0.66‰

Linearity

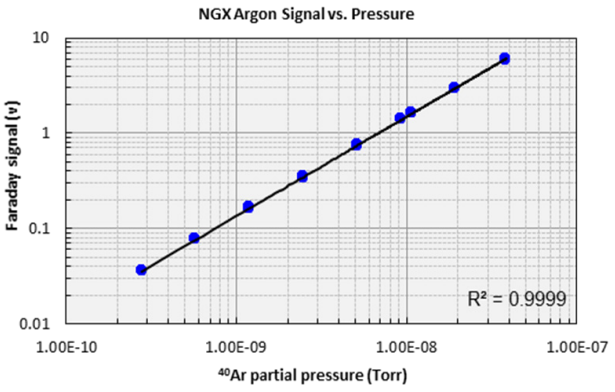


Fig 8. This graph shows the linear response of the source to gas pressure. The plot displays the ^{40}Ar partial pressure versus beam intensity, on a Faraday cup equipped with 1x$10^{11}\Omega$ amplifier

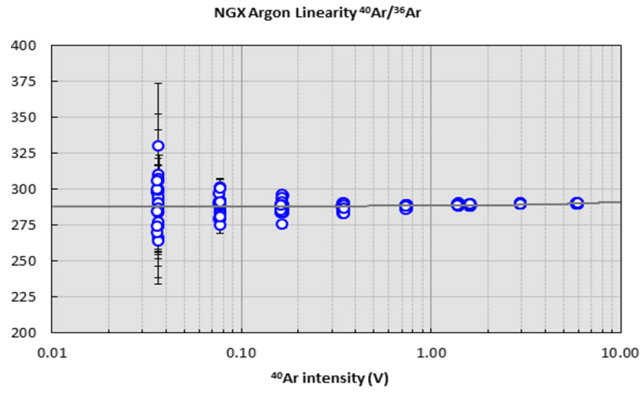


Fig 9. This plot shows that the isotopic composition remains constant irrespective of the ion intensity. The plot displays the ^{40}Ar/^{36}Ar ratio over multiple orders of magnitude ^{40}Ar beam intensity. Note, the sensitivity is 5x10^{-13} mol/V

Preparation System and Accessories

Isotopx provides a gas purification line that allows full, automated clean-up of all noble gases and separation if required, prior to analysis with the NGX mass spectrometer. Using UHV techniques and knowledge amassed over many years, Isotopx is able to provide a low volume extraction line to suit any application.

The gas purification line comprises a 80l/s turbomolecular pump backed with a dry diaphragm pump for instances that require the removal of high gas loads, coupled with a 40l/s ion pump for clean pumping applications.

It includes a pair of GP50 SAES getters (St101 alloy), each supplied with their own power supply to maintain a constant operating temperature in order to target particular gas species.

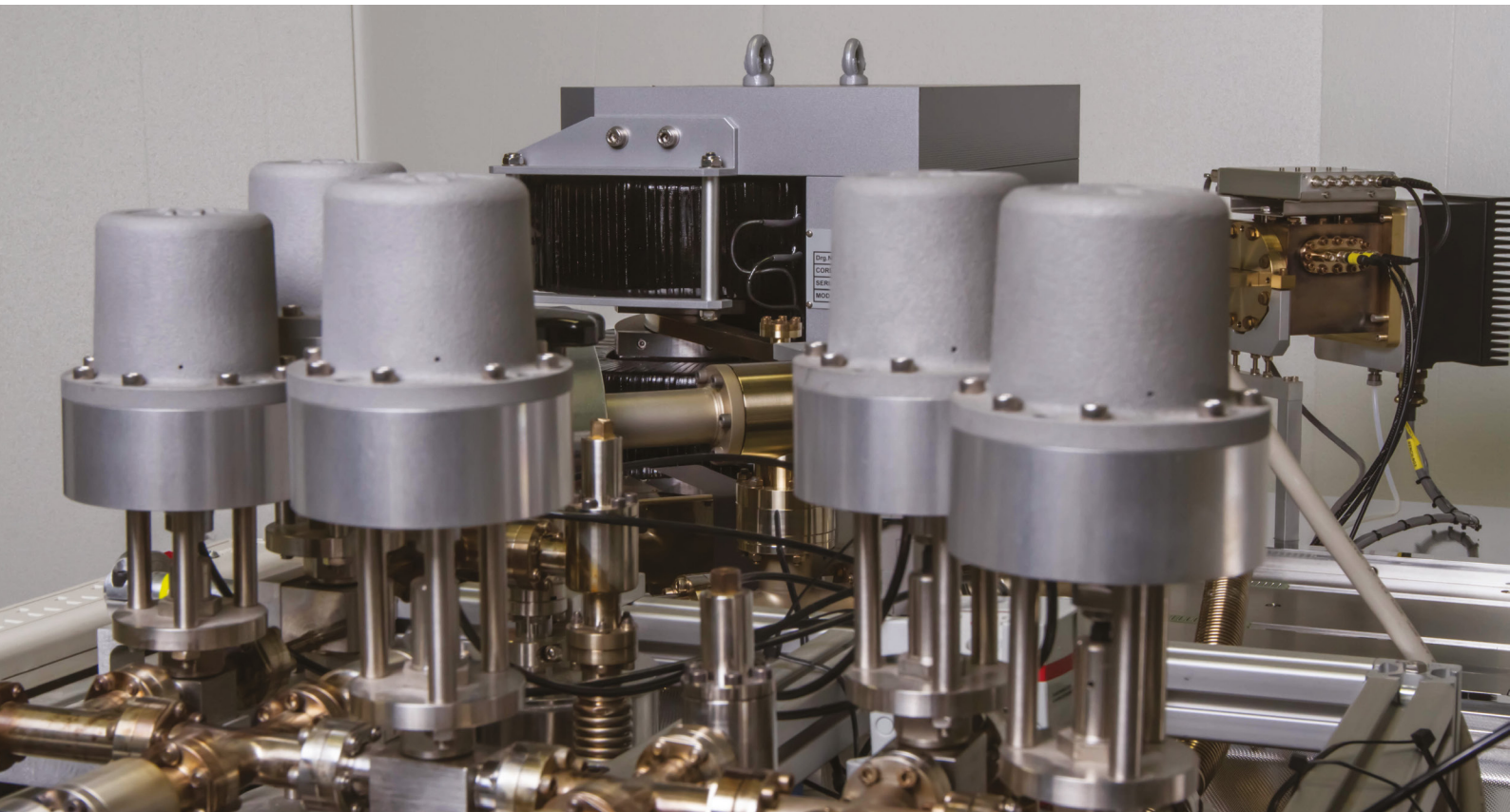
As standard, the prep bench comes with a 0.2cc pipette in combination with a 4,000cc reservoir tank, which allows the ability to prepare and admit air standards or spike aliquots.

A cold finger is provided with ~1cc of activated charcoal which if cooled with liquid nitrogen has the ability to trap all the heavy noble gases. Optionally, a cryotrap (8K-450K) can be considered for a more rigorous separation technique isolating individual gas species.

Valves are automated where necessary to allow for full automation of pre-analysis sample preparation and post-analysis clean up.

The vacuum assembly uses "off-the-shelf" vacuum components, which are readily available and allow for ease of expansion. All components are fully bakeable to 250°C using heater tapes provided. An ion gauge is provided to monitor pressure levels and vacuum integrity. Dynamic pressure levels are typically <1e9mBar. Blank ports facilitate flexibility providing the ability for future expansions or upgrades.

Optional additional accessories include an RGA quadrupole which can be used as a gas sampler or leak checker, a resistance furnace or a laser ablation or laser fusion system.



Software

The NGX has been designed for fully automated operation. All system parameters are controlled via the PC including all pneumatic isolation and inlet valves, source tuning parameters, magnetic current of the analyser and detector selection.

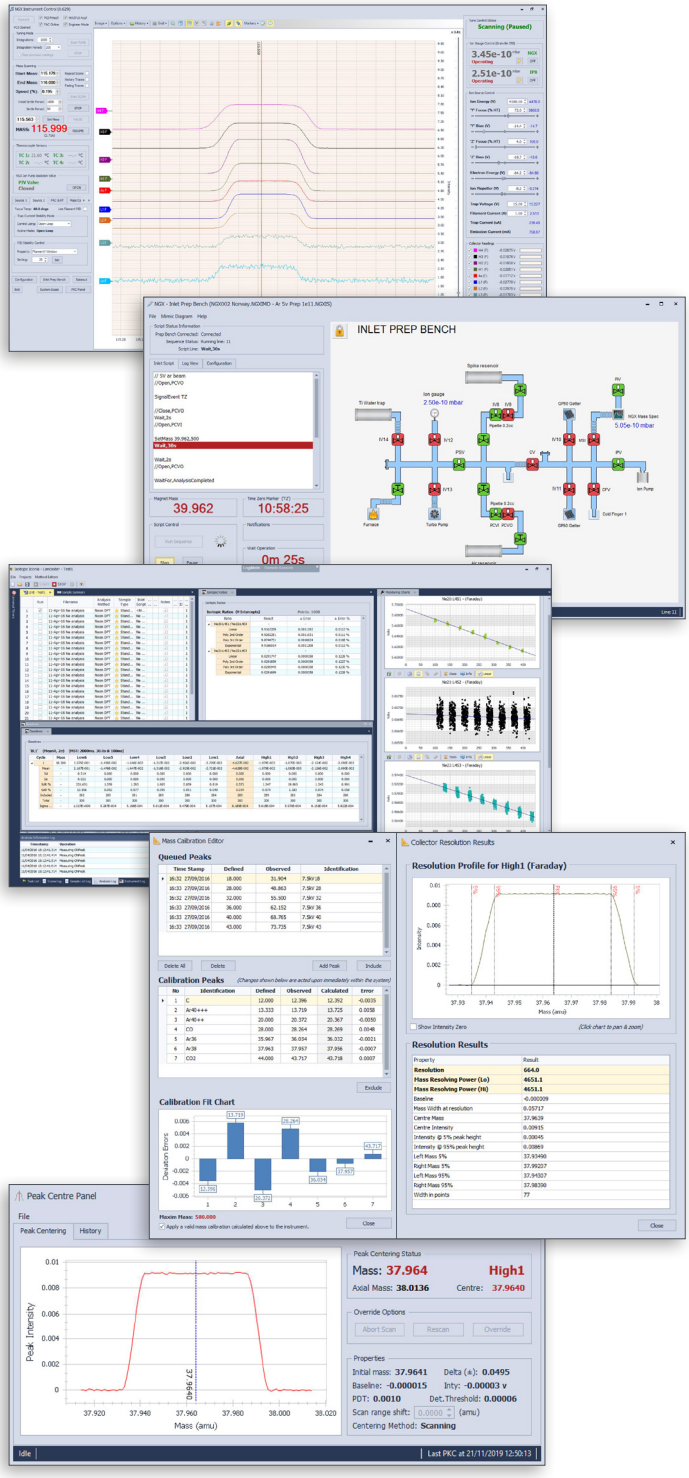
Furthermore, instrument monitors are displayed through the software including ion gauge and ion pump readbacks, turbo pump speed and temperature, valve status and all source tuning parameters

The NGX software is optimised to make full use of the instrument's leading-edge electronics.

Operating under Windows® environment it provides dedicated data acquisition, control, error reporting and data processing.

The NGX software includes the following features:

- Real-time display of source parameters, system vacuum status and collector readings.
- Advanced charting tools for easy visual analysis of collector intensities in mass scanning and intensity tuning modes.
- Includes mass and intensity markers, history scans and user annotation capabilities.
- Provides calibration and profiling tools, e.g. peak resolution, mass resolving power, source consumption, amplifier gain calibration etc.
- Allows easy access to all system parameters for manual control.
- Provides a time stamped log forming a record of all system activity.
- Exporting of raw data in various third-party formats.
- Comprehensive analysis method editor and reporting tools.
- Support for external inlet and furnace systems.
- Remote Control Server (RCS) which allows the end user to communicate to the NGX using TCP/IP protocol via other software programs or languages e.g. Labview, Pascal, C, C++, ArArCalc, Pychron, MassSpec



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