McPherson 15° Mount

Normal incidence designs include the McPherson 15° (classical 1.0 meter focal length) and modern NIM units. The latter features smaller included angles, longer focal lengths (e.g. 3, 4 and 6.65 m) and independent focus and rotation drives.

Generally these units are operated in the 300 to > 5,000 Å region, with their real forte being 300 - 3000 Å (5 - 40 eV). UHV and o-ring sealed versions available.

Built in focal lengths of 1.0 meter and longer the McPherson 15° is popular due to its high resolution and low astigmatism. Resolving powers of 78,000 have been obtained at 464 Å with the long focal length 6.65 meter unit! Even the 1.0 meter unit has low astigmatism. This is an ideal imaging instrument for use with microchannel plate intensified or CCD type array detectors.

Historical

This class of spectrometer is based on the principle that the grating rotates and moves along the angle bisecting the angle subtended by the slits. The rotation of the grating provides wavelength selection while the movement provides focus.

McPherson, Inc. built the "McPherson 15°" in 1965 and took an empirical approach to the calculable wavelength drive properties. A mechanical cam was devised and patented that simultaneously scans and focuses the desired wavelength. According to the McPherson design a mechanical sine drive / lead screw, common to all our instruments, could be used to take advantage of this systems outstanding optical properties.

New, long focal length versions, mostly used at synchrotron facilities, have independent wavelength and focus drives. The elimination of the cam (designed for use with spherical gratings) permits to use varied line space gratings and other non-standard grating formats.

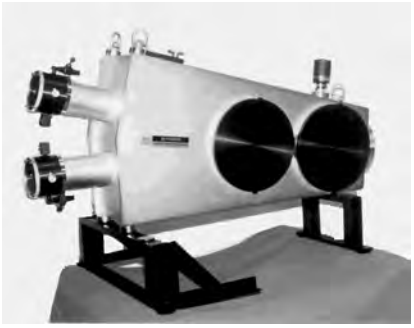


Figure 1. 1.0 m focal length McPherson 15° instrument with a stainless steel housing (Model 225 NOVA)

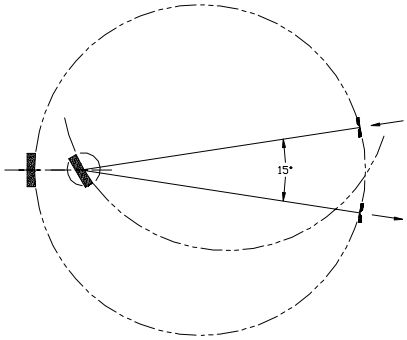


Figure 2. McPherson 15° (patented) geometry in which the grating is rotated about its vertical axis and translated to best focus.

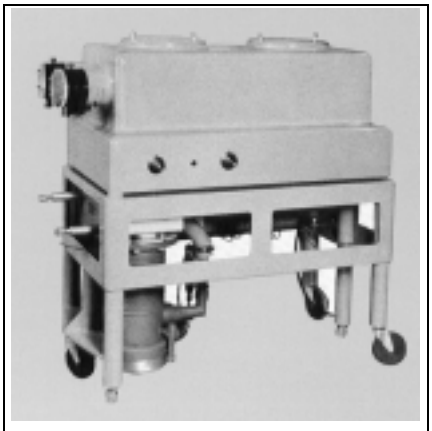


Figure 3. The classical McPherson 225 a 1.0 m focal length McPherson 15° with a hand polished, lacquered finish, circa 1967

Maximum flux density

Minimal astigmatism and polarization

Automatic focus throughout the entire wavelength range

Stainless steel vacuum chamber

Drive external to vacuum chamber

Spectrometer & Spectrograph operation

Multiple grating turrets or kinematic single gratings

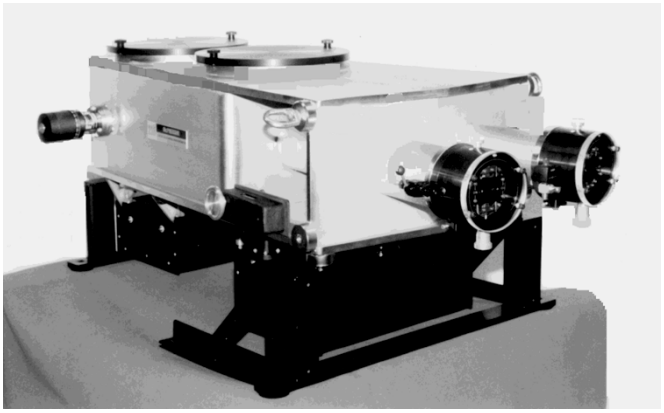


Figure 1. The Model 225 NOVA shown in its most basic configuration.

The Model 225 NOVA uses a spherical grating to collect and focus energy and is only a true Rowland circle mount while it is at central image, or zero order. In this condition all the spectrometer parts (grating and slits) lie on the Rowland circle. When scanning to or at longer wavelengths the Rowland circle condition is no longer fulfilled. Since the entrance and exit slits are at fixed positions the grating motion must compensate for changes in wavelength and focus.

When compared to other normal incidence instruments (esp. the Seya-Namioka designs) several notable features are available with the McPherson 15° (Model 225 NOVA). In fact due to its improved optical performance (lower astigmatism), frequently 10 times more energy is measured at the detector at comparable wavelengths and slit settings.

The polarization produced by the 15° angle is much less than that produced by the 70° 15' angle. Also, the optical geometry is ideal for a simpler adaptation to 2 dimensional detectors as microchannel plates or CCD detectors.
A wide range of standard features are available for this proven instrument. It can be used in any orientation and can include: multiple input or output port systems, systems for in line or 180° degree operation, array (MCP or CCD) detector adapters, multiple grating turrets, optional UHV construction, focal lengths of 1, 2.2, 3, 4 and 6.65 meters with a variety of included angles from 15° to 1.5° depending on the applications space restrictions.

Model 225 NOVA
part #: 8183-0234-1

Focal length: 1,000 mm
Included angle: 15°
f/number: 10.4
Resolution: 0.01 nm***
Dispersion: 0.56 nm/mm**
Accuracy: 0.1 nm
Reproducibility: 0.05 nm
Base vacuum: 1 x 10^{-7} torr

*** with 1200 G/mm, measured with 10 um slits x 4 mm high.**

****Other gratings available, multiply resolution and dispersion values by the difference in groove densities.**

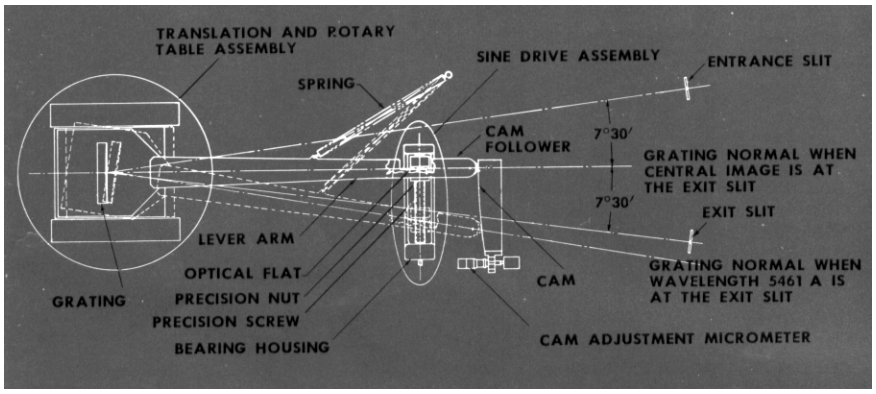
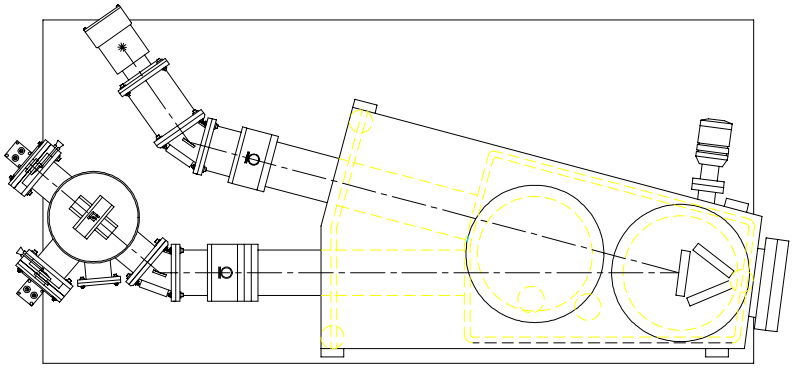


Figure 2. For high resolution spectrophotometer systems the Model 225 can be integrated. Systems as the VUVRAS PLUS (shown) measure transmittance, emmision and reflectance of larger samples. Samples can be positioned on an in vacuum adjustable sample stage permitting to map large areas.

System components:

- Model 632 Deuterium source
- Model 615 optimizer (2 places)
- Model 225 with triple grating turret
- Model 121 reflectance / transmittance sample chamber for oversized samples



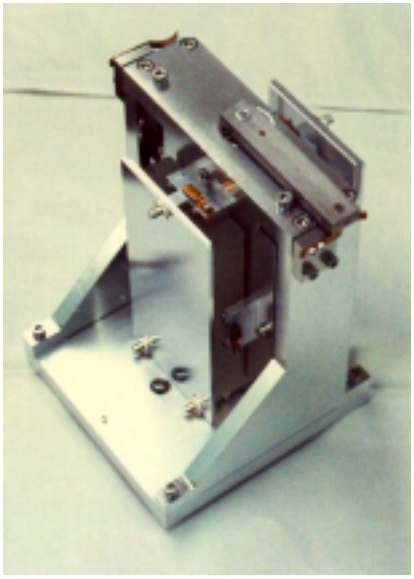


Figure 4. Model 225 can be equipped with single grating holders which are kinematically mounted and easily interchangeable, or with dual or triple grating turrets. Dual grating turret is shown.

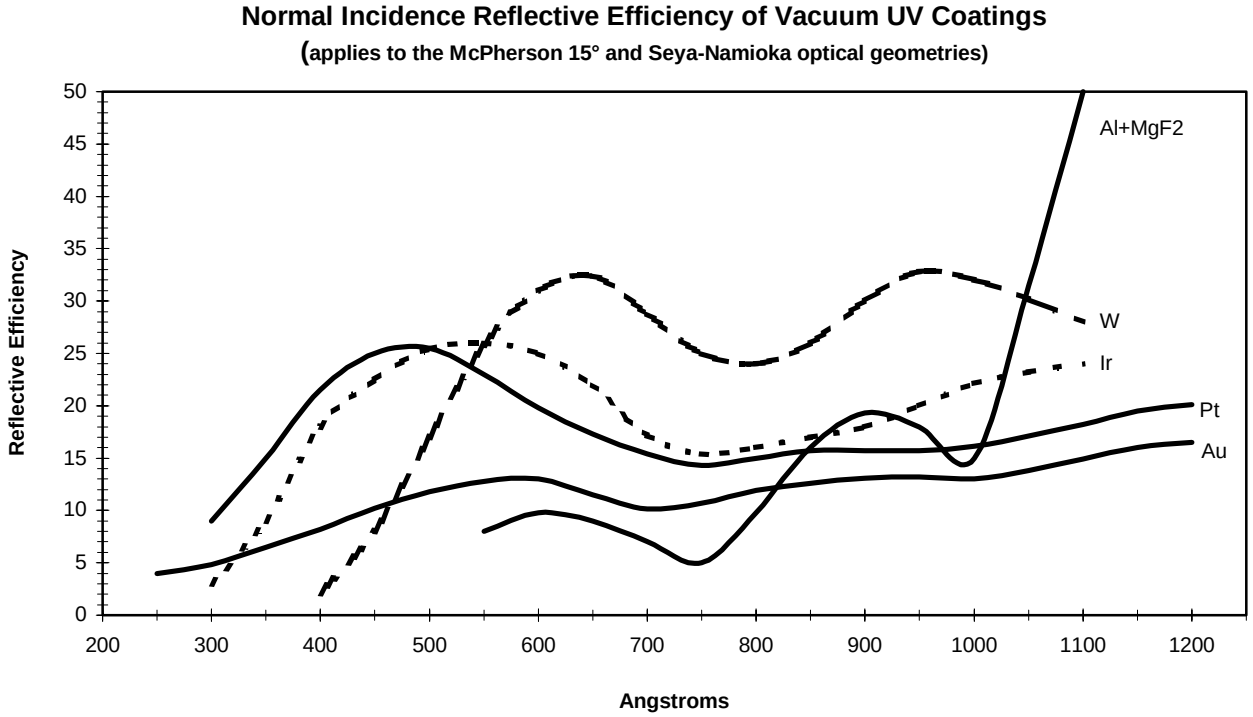


Figure 3. Normal incidence reflectance data for various evaporated metal coatings in the vacuum UV. Measured on a Model 225 at NASA Goddard Space Flight Center (Osantowski, Caruso and Toft)

Spectrograph Operation

The Model 225 NOVA uses a spherical grating which produces spectra in focus on the Rowland circle. The Model 225s auto focus feature keeps the wavelength in the center of the detectors area in focus but the edges move through and out of focus as the grating rotates. A variable angle adapter is recommended for working over a range of wavelengths.

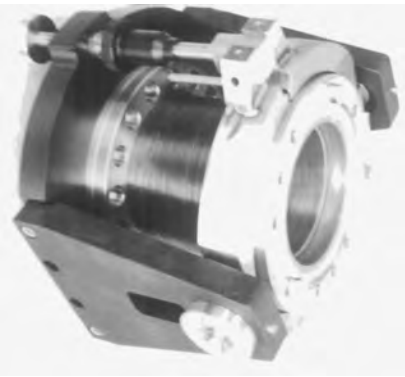


Figure 6. Model 225 NOVA variable angle spectrograph adapter

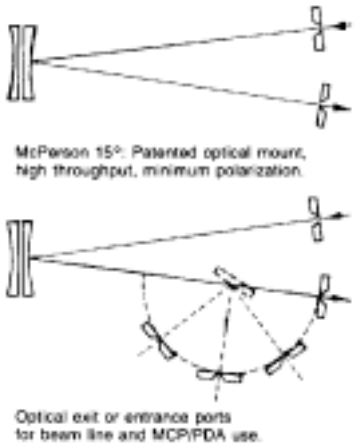
Refer to the Normal Incidence Spectrograph Adapter section for details on mounting planar array detectors to Rowland circle instrumentation.

MCP's requires a clean vacuum system capable of consistent 10^{-6} torr operation. The Model 225 NOVA offers a cleaned stainless steel, contaminant free finish permitting rapid pump down and insuring a clean environment for the MCP's.

Multiple Port Instruments

The 225 NOVA PLUS ONE is a system which includes an extra entrance and/or exit port. Ports are generally selectable while under vacuum via plane turning mirrors and can be provided as straight through, 180°, optical paths (as used in our 2.2 meter version at NIST's SURF II facility) or semi-grazing, 22°, paths to maintain good reflective efficiency at shorter wavelengths. Extra ports are added to increase detector options or add sources for calibration and alignment.

Figure 5. Model 225 NOVA Plus One UHV with an extra exit port. Added to provide an array detector port in addition to the standard scanning exit slit port.



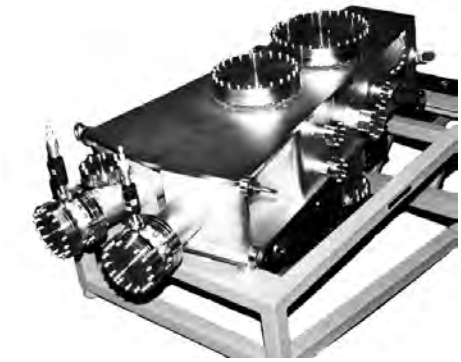


Figure 7. Model 225 NOVA UHV suitable for operation to the 10-10 torr region.

Ultra High Vacuum (UHV) & Contaminant Free

The Model 225 NOVA can be supplied in versions featuring all metal sealed construction for Ultra High Vacuum (UHV) applications. This units offer all the features of the standard 225 NOVA (multiple ports, grating turrets, etc.) but additionally provides the ability to bake hot (200°C) and to pump into the 10^{-10} torr region.

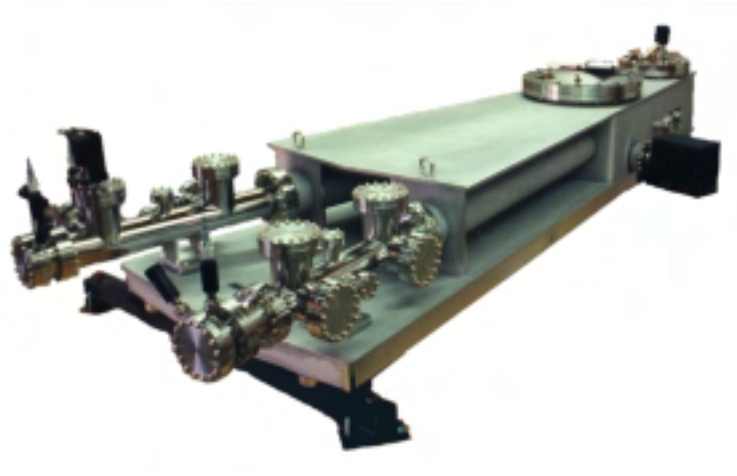
Used primarily at synchrotron storage rings or fusion experiments the clean UHV design has all wavelength drive parts external to the vacuum further improving its high vacuum compatibility.

Ultra High Resolution
Long Focal Length

The Model 225 is produced in 2, 3, 4, 5 and 6.6 meter focal length spectrometers or spectrographs for both ultra high vacuum (UHV) and VUV operation. Wavelength operation from < 300 Å up to 1 um can be achieved with selected gratings. The 15° included angle is frequently lessened in long focal length instruments to reduce the instruments footprint, typical angles are from 7.5° to 1.5°.

Long focal length instruments are built in three optical geometry's: the McPherson 15°, the off-plane Eagle design which is similar to the McPherson 15° but alters the slit orientation with respect to the plane of dispersion, and the synchrotron designated normal incidence monochromator (NIM).

The latter is a normal incidence instrument which doesn't use the McPherson method for automatic focusing. Separate drives are employed for focus and wavelength, improved software and closed loop encoders have enabled this approach. It is useful when using gratings as varied line space (VLS) or other custom made diffraction gratings.



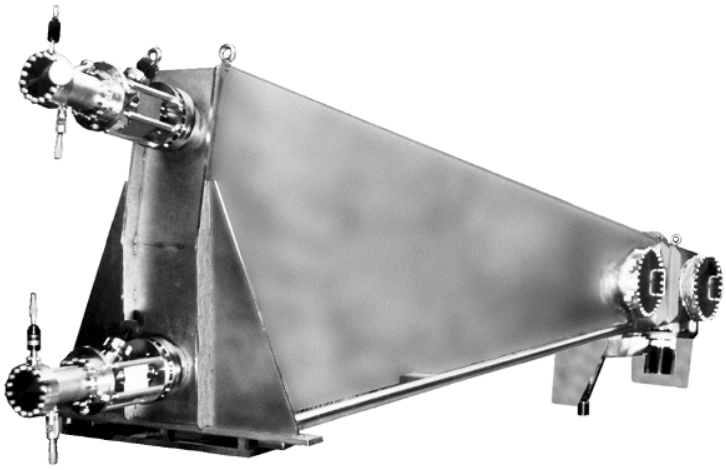


Figure 9. UHV McPherson 15° instruments built with 7.5° and 5° included angles minimize the instrument footprint when built in 3.0 meter (Model 2253, above) or 5.0 meters (Model 2255, below) focal lengths.

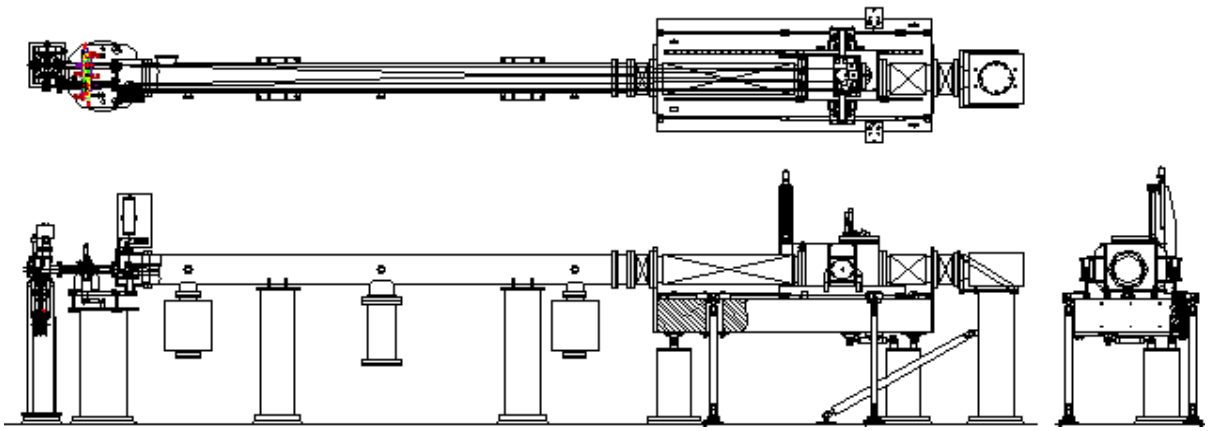


Figure 8. Diagram of the 6.65 meter focal length Off-plane Eagle monochromator designed and built for the Lawrence Berkeley National Laboratory , Advanced Light Source. This ultra high resolution Normal Incidence Spectrometer is capable of providing 78,000 resolving power at about 460 Å (0.005Å resolution) in first order.