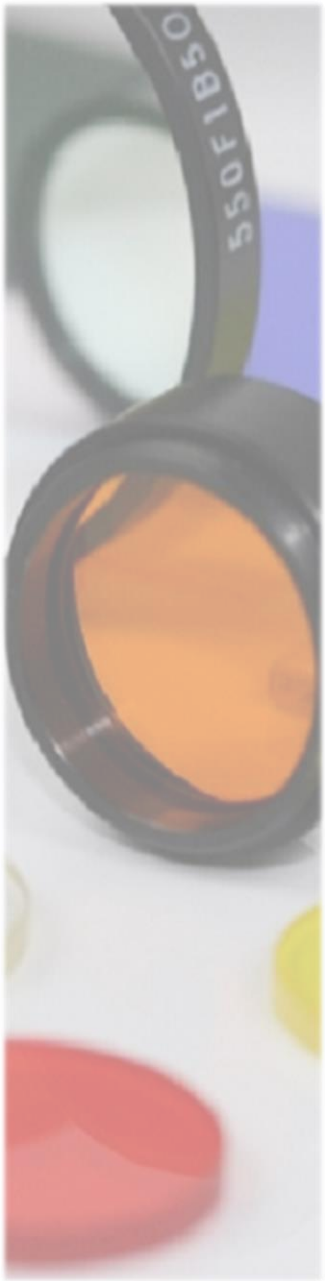
Spectrometer Features and Upgrades



Electronics Features

StellarNet spectrometers are delivered with all important information loaded into internal memory. When the spectrometer is connected to a computer the SpectraWiz software automatically reads its internal data and loads spectrometer detector type and x-axis calibration information. Older models may require manual settings. Review the SpectraWiz "in detail" chapter for more information.

All StellarNet spectrometers are high speed USB2 and include 16-bit detector digitization. Depending on the specific model spectrometer chosen you may have 512, 1024, or most commonly 2048 pixels/ data points. Most exposure times are detector limited but our electronics can capture as fast as 1ms all the way up to 1 minute. With the release of our new 2018 firmware updates exposure times can be as long as 8 minutes!

Detector Options

StellarNet offers are variety of different spectrometer detectors for UV-VIS and NIR applications. The detector arrays include Charge Coupled Devices (CCDs), complementary metal-oxide semiconductors (CMOS), silicon Photo Diode Arrays (PDAs), or NIR InGaAs PDAs. Detector specifications for various spectrometer models are available on the StellarNet website. Sensitivity for these devices is extremely high and range from 100 to 200 V/ (lx * s) as found in the detector manufacturer's specs (e.g.: Sony/Toshiba/Sensors Unlimited/Hamamatsu).

The most common UV-Vis detector StellarNet uses is the SONY ILX CCD that has 2048 elements with 14um x 200um tall pixels each with a 14um pitch. These detectors are the best made for spectroscopy. Additionally, StellarNet offers a uniformity and UV enhancement coating for all of these detectors.

For the near-infrared InGaAs PDA's supplied by Sensors Unlimited are the most popular. These high performance detectors have pixels that are 25um x 500um tall pixels with a 25um pitch. Also, the arrays have < 1% non-adjacent pixel defects. Additionally, due to our close relationship with our vendors we can special order zero defect detectors as well as low noise requirements for many application specific requirements.

Optical Performance

Many StellarNet spectrometers utilize a holographic concave grating to eliminate sensitivity issues, reduce stray light, correct aberrations, improve thermal stability, and improve ruggedness. The concave grating provides superior optical imaging and has many benefits over other standard optical techniques (Czerny turner) designs. Among the advantages are decreased stray light, uniform resolution, better spectral shapes, and increased sensitivity. A flat field is projected onto the detector array directly, thus avoiding the focus of scattered light into the focal plane. An additional intrinsic aberration correction deems it worthy of being called *Research Grade* for spectrometer optics in a small ruggedized package.

Resolving-power Resolution

In order to precisely control optical resolution, a slit is permanently installed in the fiber optic connector. This allows the instrument to maintain resolution when a different fiber size is connected. Optical resolution determines the instrument's ability to resolve adjacent spectral peaks which (for example) could relate to component concentrations or identify elemental composition in plasma analysis.

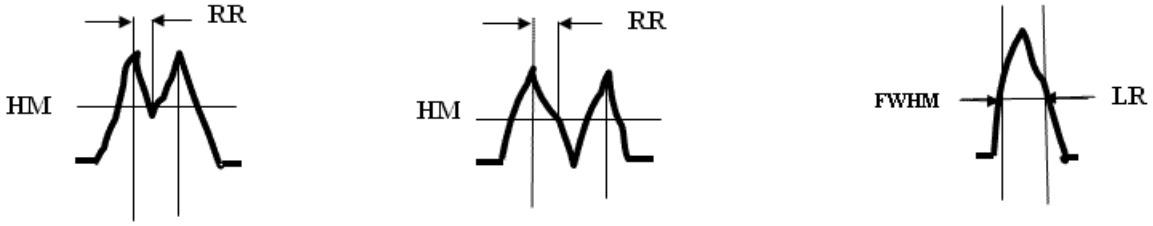
When closely spaced spectral peaks are clearly resolved via RR (such as the 577nm + 579nm Mercury doublet) they can be seen to be separated at Half the Max peak height (HM). The distance between the peak and where its slope intersects the HM position is defined as the resolving resolution in nanometers.

In a spectrograph with a perfectly imaged detector array, the RR will be the nm/pixel dispersion. Larger slits decrease resolution as the image spreads to adjacent detector pixel elements.

Line-width Resolution

When a single peak is measured at its Full Width Half Max (FWHM), the difference where the slopes intersect the HM is the Line-width resolution in nanometers.

Conversion from LR to RR use: LR ~= 2 x RR.



StellarNet estimates the spectrometer optical resolution using RR (Resolving-power Resolution) for standard spectrometer models and FWHM for the HR (High Resolution) series spectrometers.

Upgrades

External Trigger

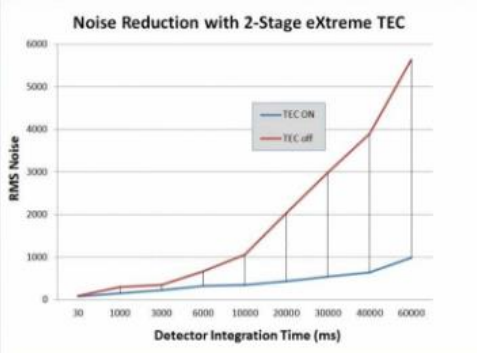
StellarNet spectrometers can be configured with a TLL input (StellarNet Part # JACK-IN to enable the spectrometer to scan when triggered by an external light source (i.e. laser, flash lamp, etc.). These are the same that are used for our PORTA-LIBS systems for elemental analysis.

For the Jack-in trigger, the spectrometer must be upgraded to our newest electronics, if not already configured. This input is located on the back of the spectrometer and a TTL signal pulse is 0 to +5VDC and 1ms wide. When the trigger is at zero level no spectrometer scans are taken. During the rising edge of the pulse the spectrometer is requested to scan and occurs 500ns (500 x 10-9 seconds) later. We are not able to detect jitter as it is virtually instantaneous.

When the Jack-in trigger is engaged it will be set to a low level which prevents the spectrometer from continuously returning spectra. To override the driver "time-out", set the SpectraWiz -> Setup -> External trigger capture = on (checked). Additionally, the detector integration time must be set to 30ms with XTIMING resolution control set to level 3 to capture at the highest resolution.

When testing, a TTL signal is not needed because the positive input is internally tied to the +5 level using a pull-up resistor and in this state the spectrometer runs normally. Here's how to easily test the triggering function: Plug into trigger jack with cable and the 2 wires exposed. With spectrometer running short the 2 wires and the spectrometer stops updating spectra on the screen. Open the 2 wires

Detector TE Coolers (1 & 2 Stage Options)



and the spectra starts updating again.

StellarNet, Inc. offers Thermo Electric Cooling (TEC) upgrades for certain spectrometer models. TECs reduce spectrometer dark noise and increase their overall performance and S/N value. Detector dark current increases with increasing exposure time. Lowering the temperature of the detector with a specialized TE cooled package, heat sink, and airflow design can reduce this effect, most effectively at long exposure times.

At the StellarNet factory, our engineers tune the TE detector coolers for highest performance. Each spectrometer model is designed to run off the provided 5VDC power regulators delivered with the spectrometer and will run at its coolest and highest performing temperature.

Models that can support the TEC upgrade include:

- BLACK-Comet-C/CXR/C-SR/C-XR-SR -TEC
- Raman-HR-TEC
- Raman-TEC-X2
- SILVER-Nova (includes 1-stage TEC)
- SILVER-Nova-TEC-X2
- DWARF-Star (includes 1-stage or 2-stage TEC)
- RED-Wave-NIRX-SR (includes 2-stage TEC)

*TEC-X2 = 2-stage

TEC DISCLAIMER: Thermo Electric Coolers (TEC) installed in spectrometers are not intended to be run for extended periods of time. If left on continuously, damage to detector or spectrometers can occur. When spectrometer is not in use, please disconnect the 5V power from TEC.

Detector Lens

Detector Lenses (DLENS) are nice upgrades for BLUE-Wave spectrometers for 3x signal gain when using 600um or 1000um fiber optic input cables. The DLENS is permanently installed at our factory and

can also be upgraded at a later time. However, if upgraded later an x-axis recalibration service and inspection would also be required.

Most other spectrometer models already contain some sort of detector lens assemblies so this upgrade is primarily for BLUE-Wave spectrometers.

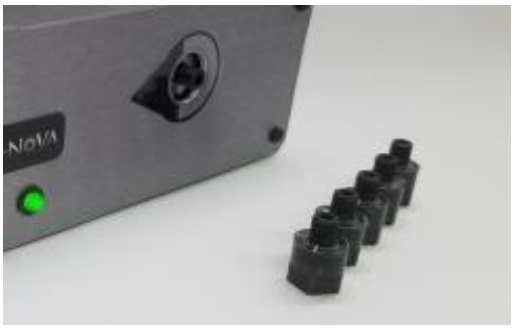
UV Detector Upgrades

UV Detector upgrades (UDET) are often included in the model spectrometer and added to the spectrometer's price. The process of UV upgrade requires a specialized phosphor coating applied to the CCD's active surface. This special phosphor enhances the silicon detectors sensitivity to UV light below 400nm and, in addition, smooths the overall response of the detector as a function of wavelength. Most wide range spectrometers from StellarNet include this upgrade as part of the model.

Over time and with constant UV light measurements this phosphor can break down; however, most of these cases are for spectrometers over 10 years old with continuous UV applications. In these cases, detector replacement can easily be performed to get you up and running again.

Interchangeable Slits

The interchangeable slit upgrade is available for StellarNet HR optics, SILVER-Nova, SILVER-Nova-X2, Raman-HR-TEC, and Raman-HR-TEC-X2 spectrometers. This upgrade includes modification to the optical bench entrance and a pack of interchangeable slits. 14, 50, 100, 200um are included in the pack and a 25um slit is installed and delivered in the instrument when ordered. The smallest slit (14um) is used for best resolution and largest slit (200um) is used for highest sensitivity.



The spectrometer's entrance modification includes precision internal mounting hardware which allows the interchangeable slits to lock in place when arriving at proper alignment location. The spectrometers are calibrated with the smallest slit and all production paperwork will reflect the smallest slit being installed.

- There are alignment arrows provided on the entrance and slits for easy input.
- Also, a slit extractor is included with the slit pack to allow you to easily pull the slits out of their tight alignment locations. To use the slit extractor simply screw onto the slits SMA threading and pull.

When not in use always make sure there is a slit installed. Leaving the interchangeable slit entrance "open" can lead to accumulated dust and debris which ultimately can cause instrument failure.

Electronics Upgrades

StellarNet offers zAutomation Processor (or zAP) options 1 and 2 for their spectrometer electronics available in most spectrometer models. These new features allow users a variety of powerful automation control not before seen in a low cost, compact spectrometer.

zAP 1 allows a user to control the electronic gain and baseline of their spectrometer via software. This feature is extremely useful for applications where long exposure time or detector cooling may increase the detector's baseline dark scan. The user can now "reset" or "optimize" the baseline for their specific set of experimental conditions allowing for the highest possible dynamic range. Likewise, the detector gain can also auto-adjust to find the best condition for measurement. Another feature of zAP 1 is a "Burst Mode" that allows up to 120 consecutive spectra to be saved onto the spectrometers internal memory. This allows for automatic high speed burst captures of events often critical for time decay and pulsed applications where typical USB lag may bottleneck results. zAP 1 is currently available for new purchases of certain model spectrometers. Check individual spectrometers specifications for more information.

zAP 2 adds an integrated wireless CPU with Wifi access to your spectrometer and/or control of application from a smart phone. This feature automates applications for OEMs and end users and turns your spectrometer into a portable wireless analyzer with real world data output such as %concentration of your sample, CIELAB color values, UV or total light power, or just about anything you can dream of. Programmable memory allows customization using the popular python language. Current users can upgrade their spectrometer to add zAP 2 at any time and once added the spectrometer will run as normal pulling power from your computer's USB port. When external 5VDC power is connected to the the spectrometer, the zAP 2 CPU initializes and wireless communication begins.

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