BIOPAT® BIOPROCESSING

with TORNADO RAMAN ANALYZERS

tornado
spectral systems

CONTENT

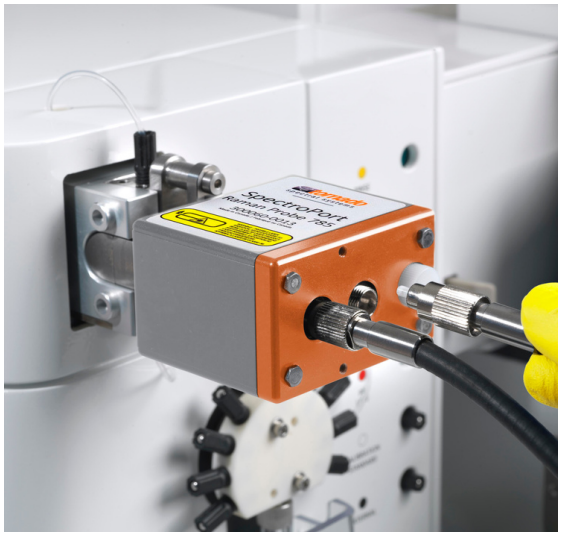
Measurements you can trust

Tornado-Sartorius Partnership

The well-known capabilities of Raman spectroscopy include the delivery of robust data leading to reliable results and superior process control. However, in the past, the potential of Raman has been challenging to dependably replicate at scale.

The integration of Tornado Raman analyzers and probe to Sartorius BioPAT® Spectro platform has unlocked another level of Raman applications in bioprocessing. This integration offers Quality by Design (QbD) models that allow seamless scale-up and model transfer from lab systems to production/commercial scales.

Tornado, a global provider of chemical analysis & measurement systems for Process Raman Spectroscopy is one of the companies partnering with Sartorius, a leading international life science group, to offer full integration of its Raman analyzers and probe with Sartorius Ambr® 15 and Ambr® 250 analysis modules.



BioPAT® Spectro

BioPAT® Spectro embraces Quality by Design (QbD) principles to unlock the full potential of Raman spectroscopy. Automated data acquisition and consolidation in high-throughput, small scale Ambr® system leads to highly robust models that can be applied in high-throughput process development. BioPAT® Spectro is compatible with the Tornado's Raman Analyzers.

Tornado's Raman Analyzers have been developed with compatibility to a wide range of automated bioreactor systems including Ambr® system. Via the integration to the Sartorius Ambr® systems, or via automated transfer of bioreactor sample data, Tornado Raman Analyzers can return sensitive, accurate analytical results in real-time. Tornado's Raman Analyzers (the HyperFlux™ PRO Plus and the Process Guardian™ also referred to as the PGR™) with the SpectroPort™ probe measure key process parameters and critical metabolites (i.e., glucose, glutamate, lactate, and others), making it the ideal solution for monitoring bioprocesses and cell cultures.

no need for regular maintenance including cleaning and sterilization

This collaboration enables non-contact Raman collection as such there is no need for regular maintenance including cleaning and sterilization.

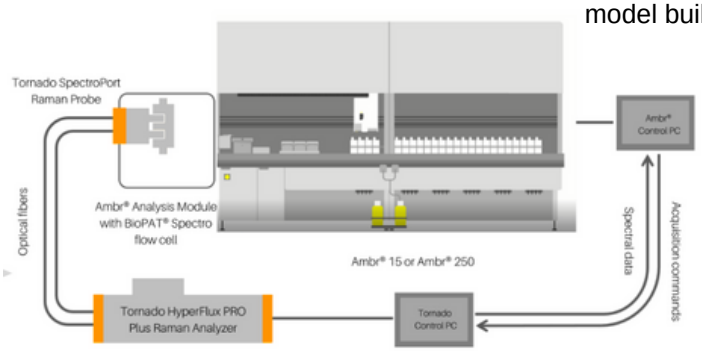
Key Features of Tornado's Raman integration with Sartorius BioPAT® Spectro:

- **Tornado Raman Analyzers' integration with Ambr® enables maximum performance and reproducibility with easier, faster, simpler, and quicker sampling**
- **Both HyperFlux™ PRO Plus and the Process Guardian™ Raman (PGR™) are fully integrated with Sartorius Ambr® 15 and Ambr® 250 high throughput systems which supports QbD**
- **Direct path to manufacturing with BioPAT® Spectro**
- **Non-contact sampling, same probe used for both cases**
- **HyperFlux™ PRO Plus can monitor up to 8 separate STR reactors**
- **Tornado Raman Analyzers provides a scalable approach and a more efficient transfer for manufacturing**

Tornado Raman Analyzer for Ambr® and Biostat STR®

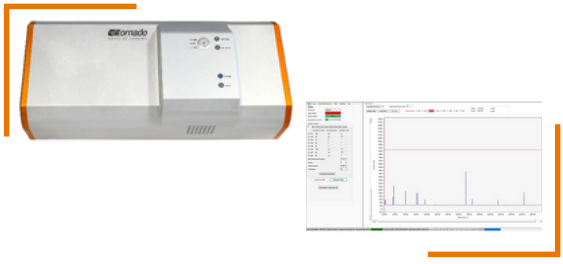
The Tornado's HyperFlux™ PRO Plus multi-channel analyzer is compatible with Ambr® 15 and Ambr® 250, for Raman model building and Raman monitoring of high throughput cell culture process development. The two systems work together as follows:

- HyperFlux™ PRO Plus analyzer with Raman spectrometer and SpectralSoft™ software fully integrated into the Ambr® system.
- Ambr® set-ups make full-time use of Tornado's SpectroPort™ probe to repeatedly collect samples from Ambr® 15 or Ambr® 250 vessels.
- Ambr® software controls the Tornado Raman spectra data collection and consolidates and stores all the data.
- Data from integrated at-line analyzers can be automatically aligned with the spectral data, or offline data can be added manually during the run.
- After the run, a consolidated and contextualized data file can be exported from the Ambr® software, ready for model building in SIMCA®



Tornado Products Featured in the Integrated Systems

Ambr® set-ups make full-time use of Tornado's SpectroPort™ probe to repeatedly collect samples from Ambr® 15 or Ambr® 250 vessels



HyperFlux™ PRO Plus analyzer with Raman spectrometer and SpectralSoft™ software fully integrated into the Ambr® system

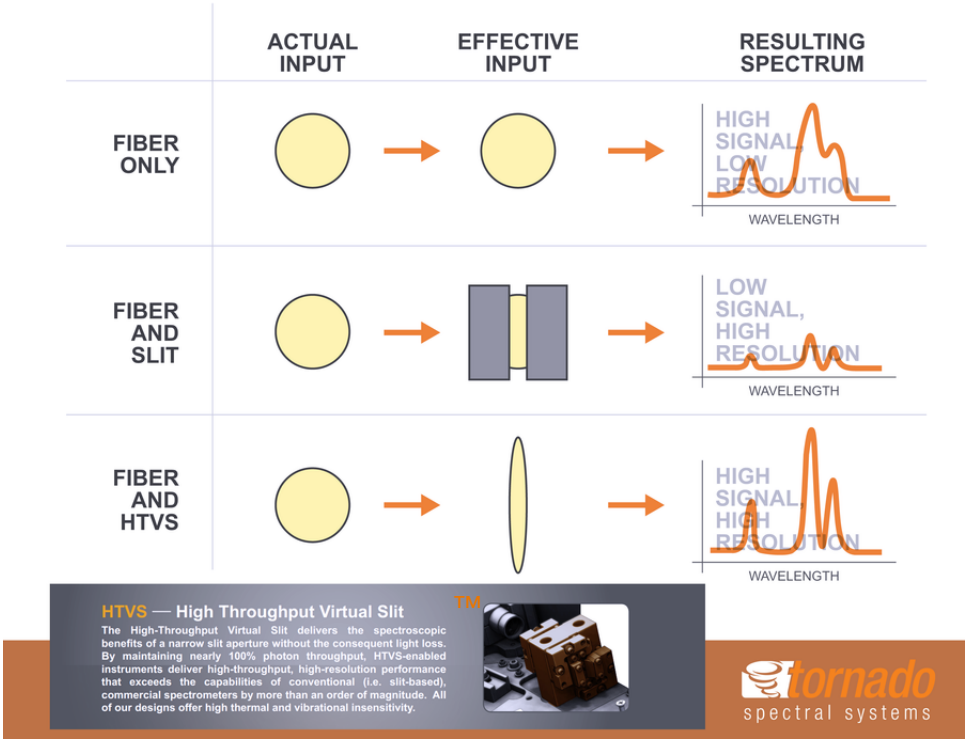
WHY GO WITH TORNADO?

Our *Unfair* Advantage

Tornado's High Throughput Virtual Slit (HTVS™) technology provides unequivocal photon power to tackle the most difficult Raman measurements and overcome these challenges, thus enabling greater customer success. Tornado's Raman spectrometers including HyperFlux™ ProPlus and PGR deliver significantly enhanced photon collection power.

HTVS™ eliminates the physical slit of a conventional spectrometer and avoids signal losses while maintaining high spectral resolution, allowing for faster measurements and lower detection limits.

The performance of Tornado Raman spectrometer systems allows for more accurate chemical identification, and quantitation even with challenging mixtures and low concentrations. They offer faster measurements of dynamic reactions, and low laser power operation in hazardous environments.



The highest proven performance and most reliable Raman analyzers on the market

- ***Flexibility**: Optimal performance bioprocessing probes compatible with all known applications with flexible sampling capabilities*
- ***Non-destructive, real-time measurement***
- ***Reliable and Trustworthy**: ISO 9001:2015 certified operations in additions to ATEX, IECEx, TÜV SÜD and CE certifications*
- ***Worldwide Distribution**: A global distribution network of Raman and process automation experts*
- ***High Resolution**: Collects higher quality data with higher resolution and/or higher signal strength*
- ***Time-Saving**: Reduces acquisition times for a given source*
- ***Adaptability**: Compensates for weak light sources or input*
- ***Versatility**: Enables new spectroscopy applications*
- ***Cost-Saving**: Reduces weight and cost by minimizing the size of cooling equipment for detectors and lasers, and cooling technique*

WHY GO WITH TORNADO?

HTVS-enabled Raman analyzers - Our patented technology is employed in the HyperFlux™ PRO Plus and the next generation analyzer - the PGR, offering **Higher Raman Sensitivity Than Ever Before Possible**

HyperFlux™ PRO Plus

LASER WAVELENGTH	785 nm
LASER POWER	20 mW up to 495 mW
SPECTRAL RANGE	200 cm⁻¹ to 3300 cm⁻¹ (Raman shift from 785 nm excitation)
PROBES	Immersion and Non-Contact
INPUT POWER REQUIREMENTS	100 V to 240 V AC line power
FIBER LENGTH	3 meters standard - Different lengths are available upon request
DIMENSIONS	18.4 x 8.5 x 5.4 in (46.7 x 21.6 x 13.7 cm)
WEIGHT	22 lbs (9.8 kg)

Tornado's HyperFlux™ PRO Plus is a complete Raman spectroscopy system including a proprietary HTVS™-enabled spectrometer, a high-quality stabilized laser, multiple laser safety interlocks, temperature monitoring and dynamic re-calibration, and automated system health monitoring and fault detection.

This powerful, reliable, and easy-to-use instrument is contained in a small, lightweight, cost-effective package which is readily deployed in both in-line process and laboratory settings. The PRO Plus is compatible with a broad range of probes, chemometric software packages, and hazardous environment configurations. All these features combine to provide unequaled Raman sensitivity, quality, and convenience for process and laboratory applications.

The Process Guardian™

Technical Specifications	
LASER WAVELENGTH	785 nm wavelength, Configurable power output from 5 to 495 mW; Output power stability <± 1%
LASER POWER	20 mW up to 495 mW
SPECTRAL RANGE	200 cm⁻¹ to 3300 cm⁻¹ (Raman shift from 785 nm excitation)
FIBER OPTIC INTERCONNECT	LC Duplex (excitation/collection) Fiber break detection Dual interlock optional expansion
FIBER LENGTH	2 m standard - Different lengths available upon request
X-AXIS	Spectral Range: 200-3300 cm⁻¹ Spectral Resolution: < 5 cm⁻¹ (average across spectral range) Wavenumber Stability: ± 0.1 cm⁻¹
Y-AXIS	Dynamic Range: 45,000 counts (pre-calibration) Instrument Detection Limit: 4 counts (minimum acquisition 34ms, peak at 1001.4 cm⁻¹)
COMMUNICATIONS	Dual Independent LAN (Gigabit Ethernet) OPC UA Modbus TCP
STANDALONE PREDICTION	SIMCA .usp PEAKACT .pxm
USB EXPANSION ACCESSORIES	HDMI (external display) Dual USB (keyboard, mouse or accessory) 4 I B channel fiber switch (rack mountable) OPIS 35™ ATEX/IECEx certified laser (shelf mountable)
PROBES	Immersion and Non-Contact
ENVIRONMENTAL	Operating temp 0 °C to +35 °C Operating relative humidity ≤ 65% non-condensing
MOUNTING	Bench top or shelf mounting (19" rackmount compatible)
ELECTRICAL	100 V to 240 V AC line power; 60 W
DIMENSIONS	7.7 x 17.6 x 24.7 in (19.5 x 44.6 x 62.6 cm)
WEIGHT	33 lbs (15 kg)

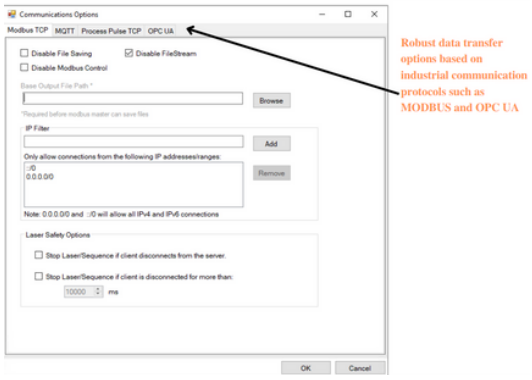
The Process Guardian™ Raman is a new process Raman spectrometer. In addition to its superior measurement performance, this next generation HTVS-enabled analyzer embodies all critical requirements for straightforward deployment into a process environment. Uncompromised measurements you can trust are now available from a ruggedized standalone platform.

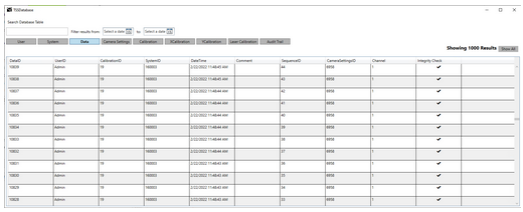
- **Raman measuring principle**
- **Embedded 785 nm laser**
- **Powerful embedded processor**
- **A smart Raman analyzer that can monitor its own health providing remote clients with status and alarms**
- **More accurate identification and quantification for challenging mixtures and low concentration levels**
- **Faster measurements of dynamic reactions**
- **Turbocharged by Tornado's patented High Throughput Virtual Slit (HTVS™) technology**
- **Probe options for broad range of application**
- **Includes OPC UA and ModBus TCP services**

WHY GO WITH TORNADO?

Continuous Concentration Results - Raw spectrometer signal is automatically translated into useful chemical information

SpectralSoft™ Software





SpectralSoft™ empowers the user and provides many options for the most demanding process Raman applications.

- Operating SpectralSoft™ is simple and intuitive enabling even inexperienced users to become proficient quickly
- SpectralSoft™ includes enhanced interoperability with external platforms and expanded data processing options
- In a busy industrial setting, there should be no need to open multiple programs to adjust basic parameters such as laser power, exposure time, number of repeats, etc. Tornado's design has all parameters available on one interface
- Complete with a real-time graphical spectrum display

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tornado spectral systems

About Us

Founded in 2013, Tornado Spectral Systems designs, manufactures and sells chemical analysis systems based on Raman spectroscopy. Bolstered by its patented High Throughput Virtual Slit (HTVS™) technology, Tornado's Raman spectrometers deliver significantly enhanced photon collection power.

Tornado's headquarters is located in Mississauga, Canada, housing sales and marketing, engineering, technical support, and operations. With a strong commitment to providing the best possible support, Tornado Spectral Systems has assembled an elite network of experienced distributors worldwide for their ability to demonstrate the unique value of our chemical analysis solutions.

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