



ELITE SPECTROMETERS  
BY OCEAN OPTICS

# Apex High Performance Spectrometer





## Challenge

- Integrated, high end instruments are required to detect low light levels for challenging Fluorescence and Raman applications
- Higher end systems have a large footprint, are very expensive and cannot be reconfigured or adapted as measurement needs change

## Solution: Elite Spectrometers

- Spectrometers designed with sensitivity in mind
- Novel optical designs and components used to optimize throughput and sensitivity
- Performance of a benchtop instrument in a small, modular spectrometer

# What is the Apex?



*Using a design exclusive to Ocean Optics, the Apex spectrometer features patented, high-throughput virtual slit technology – abbreviated HTVS -- licensed from Tornado Spectral Systems.*

*HTVS eliminates the trade-offs between throughput, resolution and spectral range providing high sensitivity with great optical resolution over a wide Raman shift range.*

**APEX**  
RAMAN SPECTROMETER



# What is the High Throughput Virtual Slit?

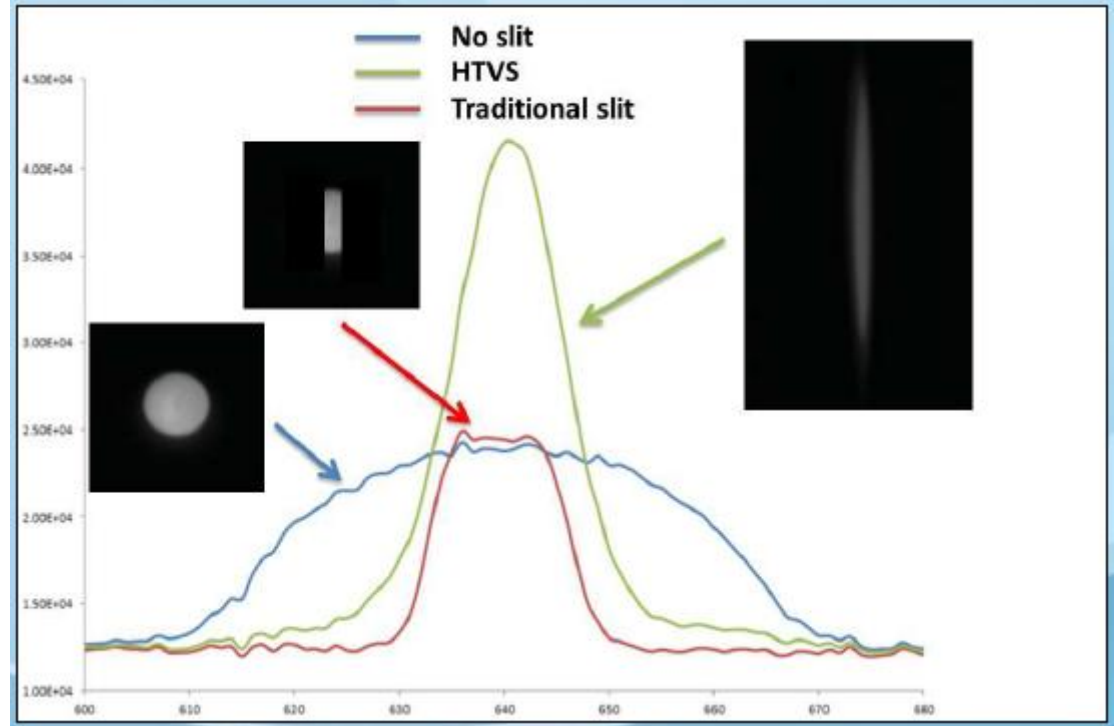


## Problem:

Trade-off between resolution and light throughput in conventional spectroscopy

## Solution:

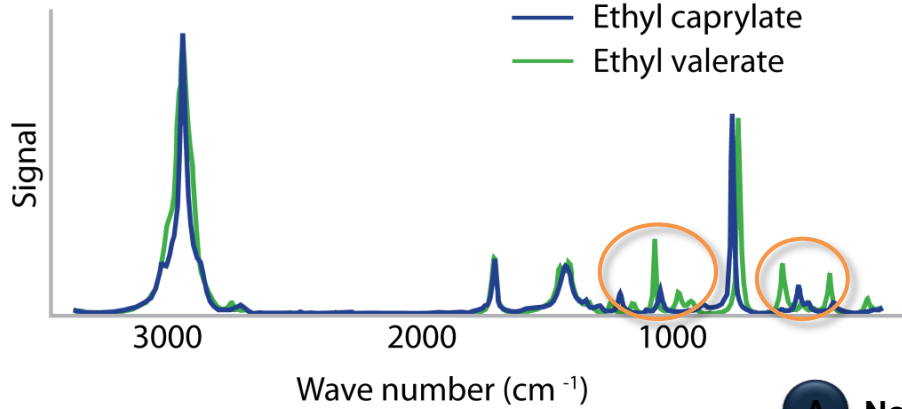
Incorporate HTVS to eliminate the need for a physical slit in order to achieve high resolution



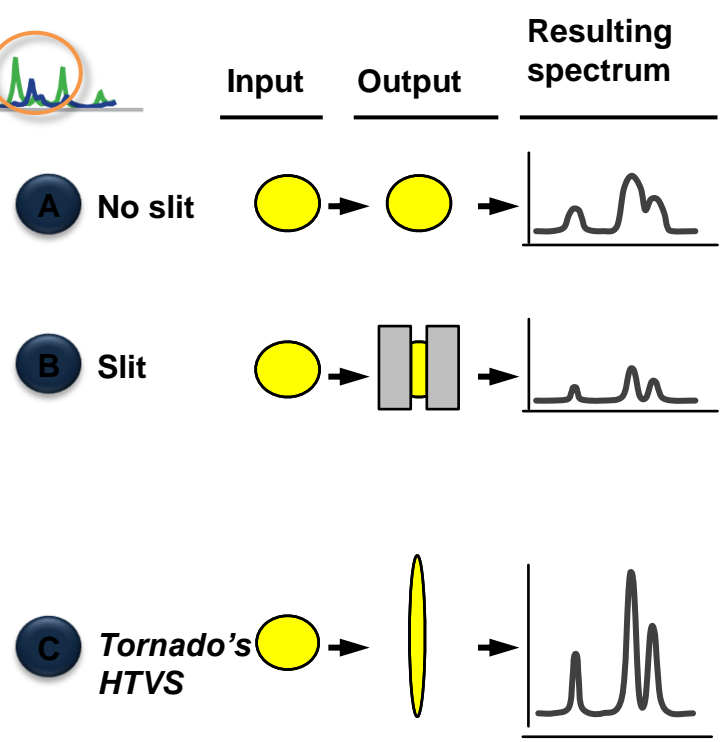
# Example of the HTVS Advantage



Example of two materials with similar spectra:



Identifying the critical differences between spectra requires the high performance that HTVS technology can deliver



Traditional systems use slits to trade-off between resolution & throughput when both are important

HTVS technology **eliminates the trade-off**, dramatically increasing performance

# Apex High Performance Advantage



- Achieve high sensitivity without the need for long integration times, detector cooling or high powered excitation sources
- Use shorter measurement times for faster measurements
- Acquire more accurate spectral “signatures” and Raman fingerprint data – better library matching
- Use lower powered excitation sources for less photodestruction

*All the qualities you love about OOI -- exceptional support, modularity, small footprint, low cost -- in a higher performance spectrometer*

# Feature and Benefit Details



FEATURES:	BENEFITS:
High Throughput Virtual Slit (HTVS) provides high resolution and throughput	High sensitivity enables the use of shorter integration times for faster measurements, lower power excitation source and requires no detector cooling to achieve high quality spectral data
HTVS overcomes the trade-off between resolution, sensitivity and spectral range	High resolution combined with high sensitivity enables measurement of previously undetected spectral features providing more information for sample characterization and identification
High efficiency HD Volume Phase Holographic Grating	Maximum diffraction efficiency Extreme low stray light Minimal loss of light to polarization Less light loss in the bench resulting in higher throughput and sensitivity for the detection of lower light levels
NIR enhanced back-thinned silicon detector array	High quantum efficiency, high dynamic range detector designed for low light level detection with superior quantum efficiency in the NIR region



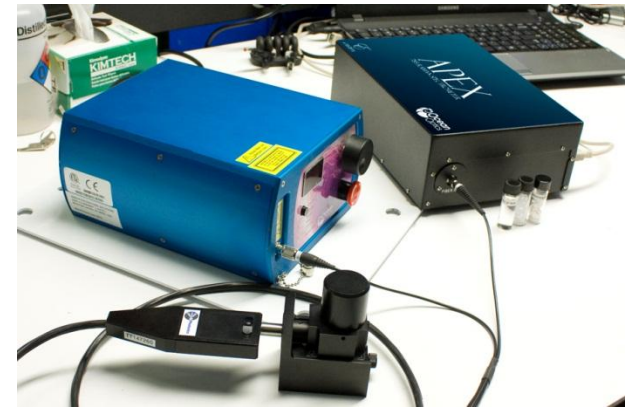
- Researchers looking for *cost-effective* alternatives to integrated systems
- OEMs and other system integrators requiring modular instrumentation for use in their end product
- Users who need to dramatically increase measurement speed
- Academic and basic research scientists who previously used integrated systems for high-performance work
- Users experienced with challenging, low-light level Raman and fluorescence applications



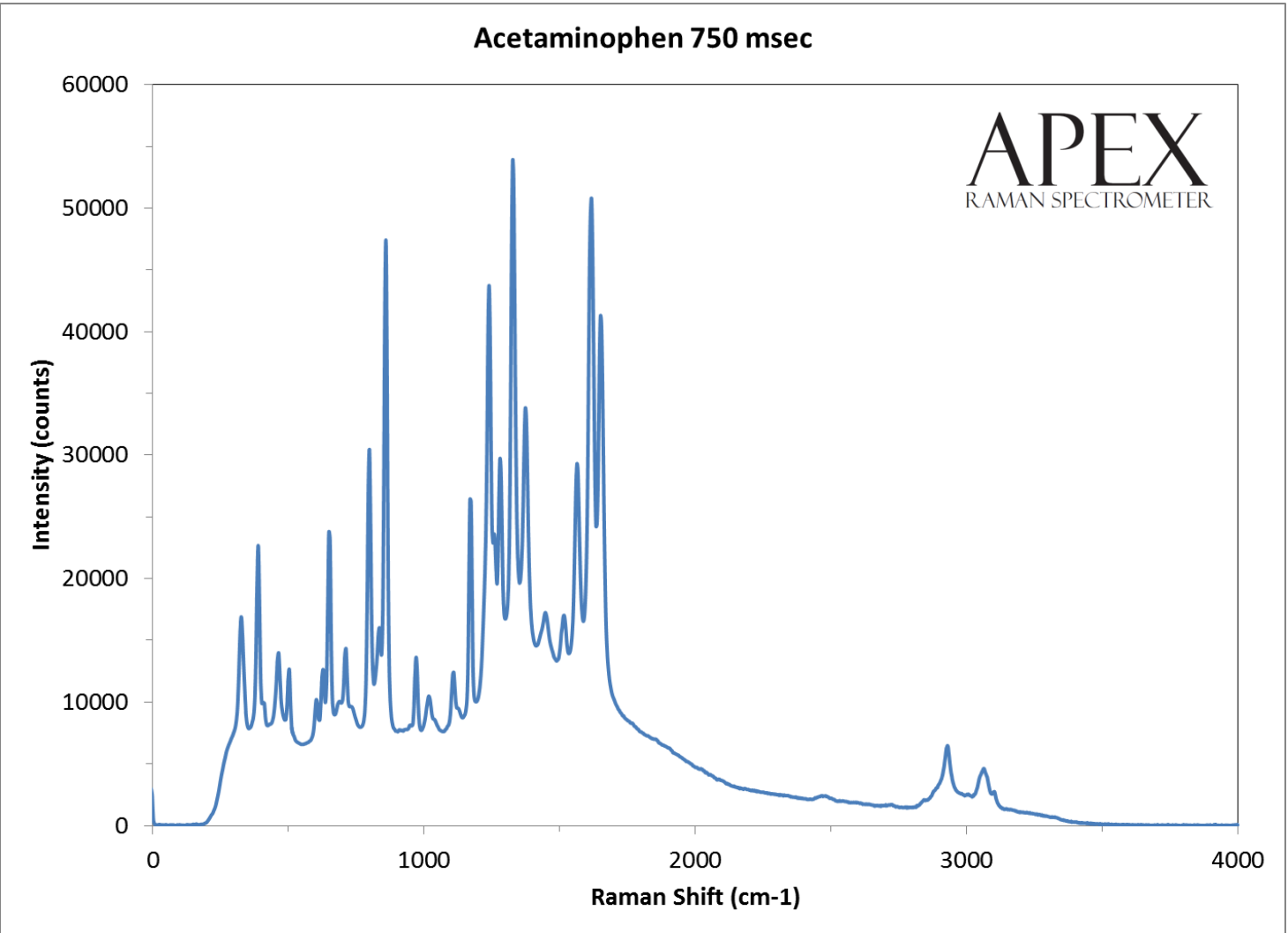


## Basic Raman and Fluorescence research in:

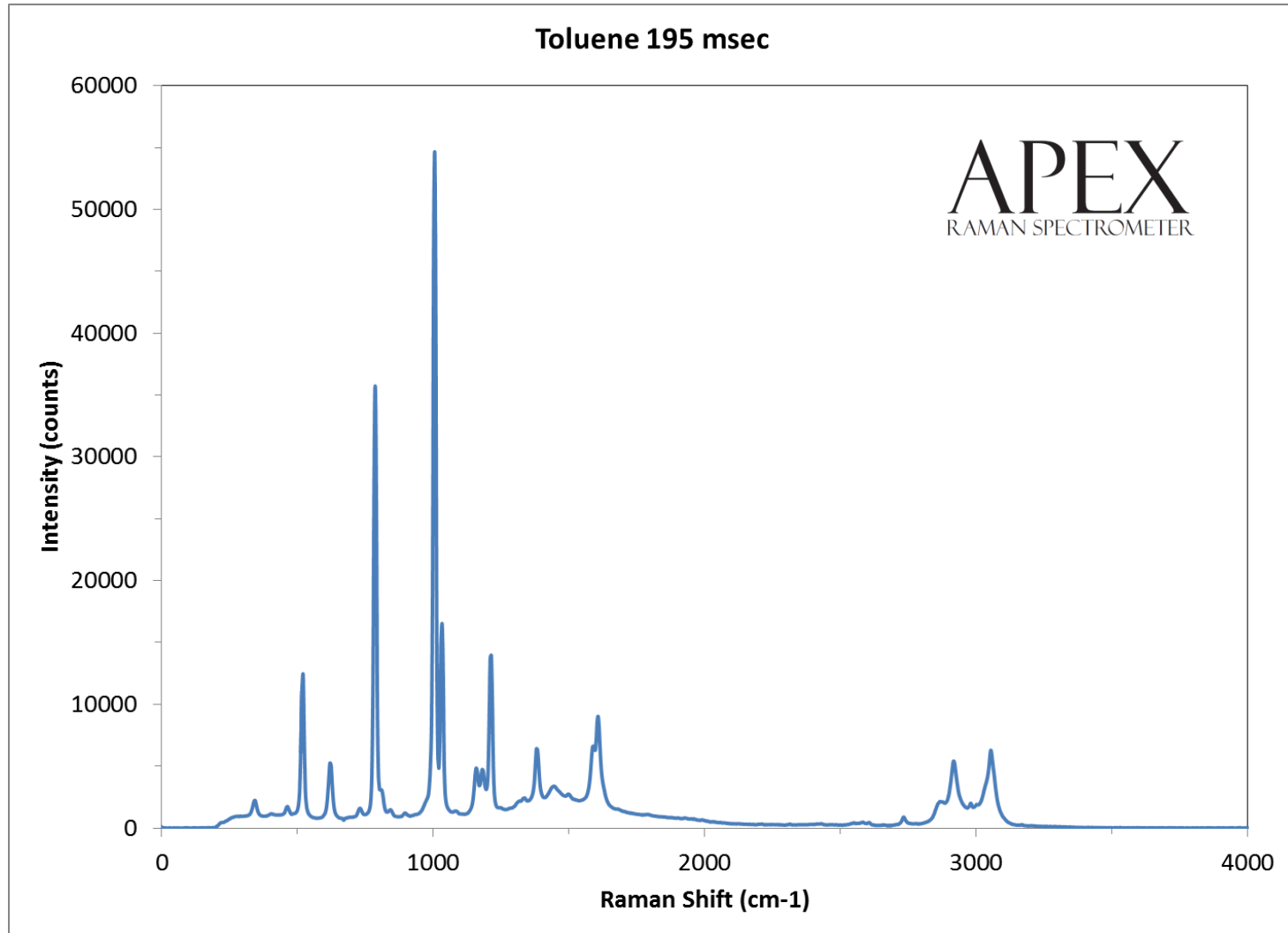
- Life Sciences
- Clinical Diagnostics
- Pharmaceutical R&D and QA/QC
- Materials Science  
Petrochemicals
- Counterfeit Detection
- Security  
Electronics/Semiconductors
- Alternative Energy
- Forensics
- Nanotechnology



# Apex 785 nm Raman Spectrum for Acetaminophen



# Apex 785 nm Raman Spectrum for Toluene

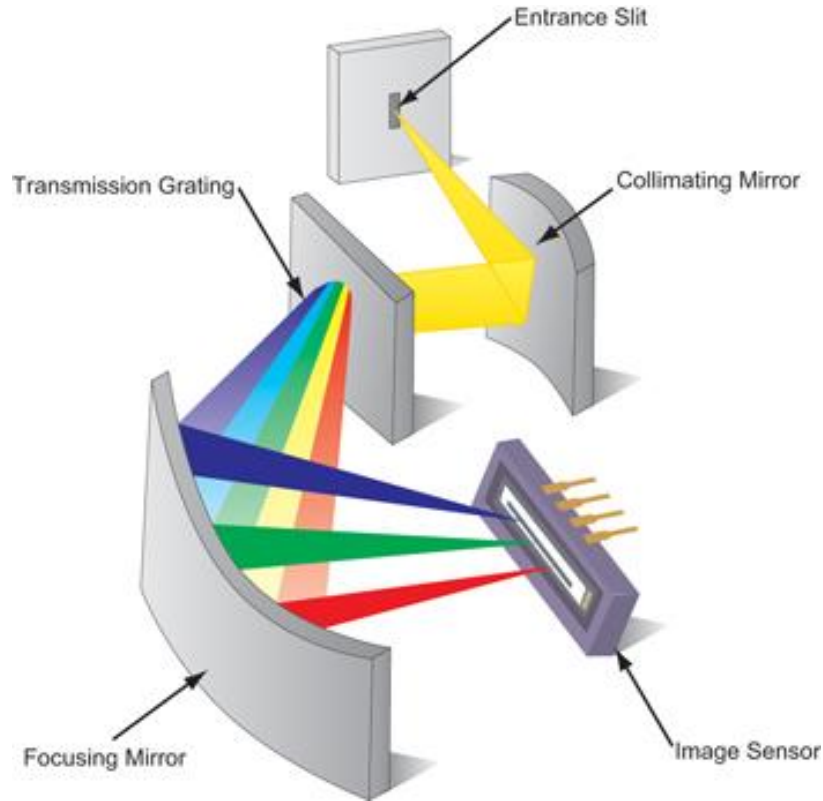


# Additional Information

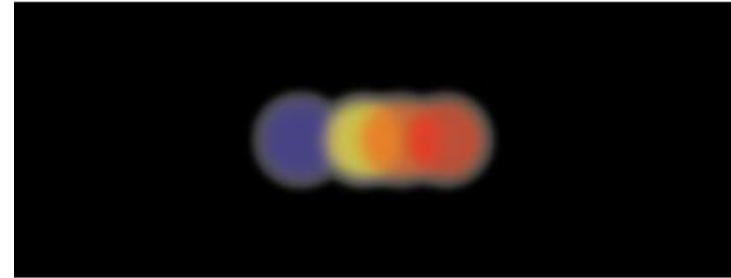


- HTVS Explanation
- Performance Specifications
- Technical Specifications
- Polystyrene Data
- HTVS Enabled Applications
- Additional HTVS Features/Benefits information
- Volume Phase Holographic (VPH) versus Surface Relief Gratings
- VPH Grating Advantages

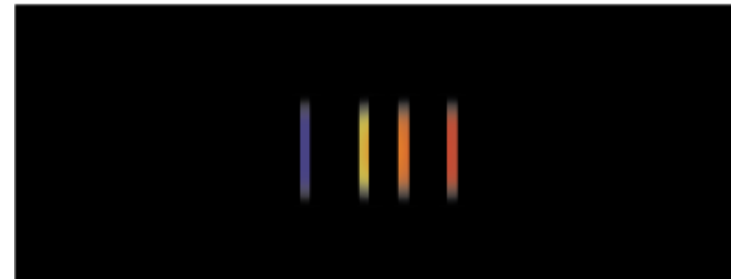
# APEX Design Eliminates Trade-off Between Resolution and Throughput in Dispersive Spectrometers



1. No slit ( high throughput, low resolution)



2. With slit ( low throughput, high resolution)

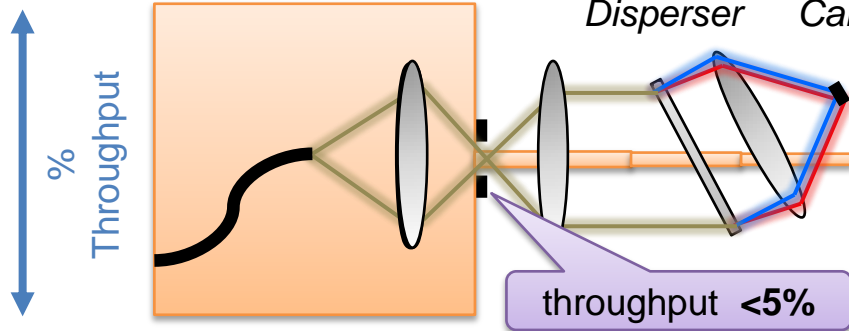


# HTVS-enabled Spectrometers Deliver High Resolution AND High Signal at a Reasonable Cost

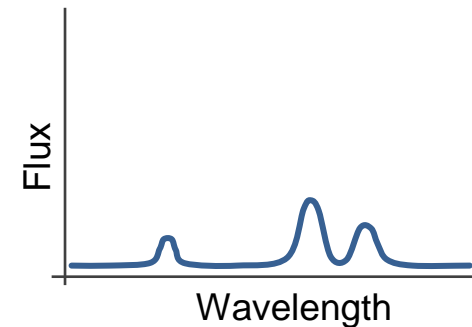


## Conventional Spectrometer

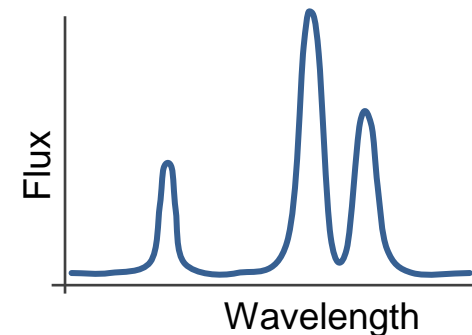
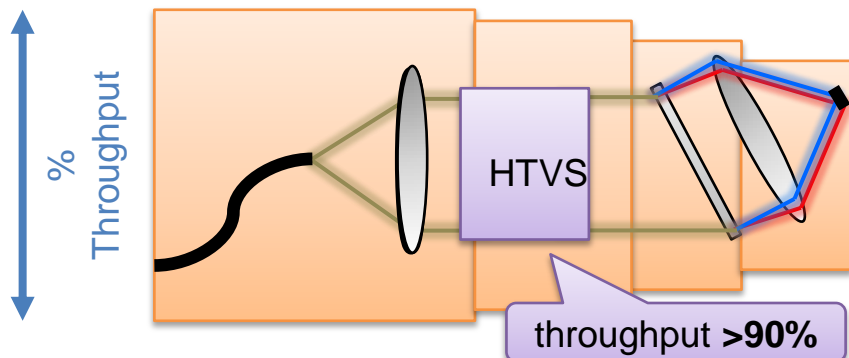
1: Fiber input      2: Slit      3: Disperser      4: Camera



## Resulting spectra



## HTVS Enabled Spectrometer



# Apex Performance Specifications



Performance Specifications	Apex
Fiber diameter:	Optimized for 200 $\mu\text{m}$ , NA = 0.22 fiber input
Detector:	S11510-1106 (uncooled)
Useable wavelength range:	> 3800 $\text{cm}^{-1}$ (780-1120 nm)
Resolution(FWHM)	< 10 $\text{cm}^{-1}$ @ 800nm
SNR:	> 440:1
Stray light:	< 1% @ 800 nm
Optical input:	SMA 905
Slit:	HTVS
A/D:	16 bit
Dynamic range:	15000:1 (typical)

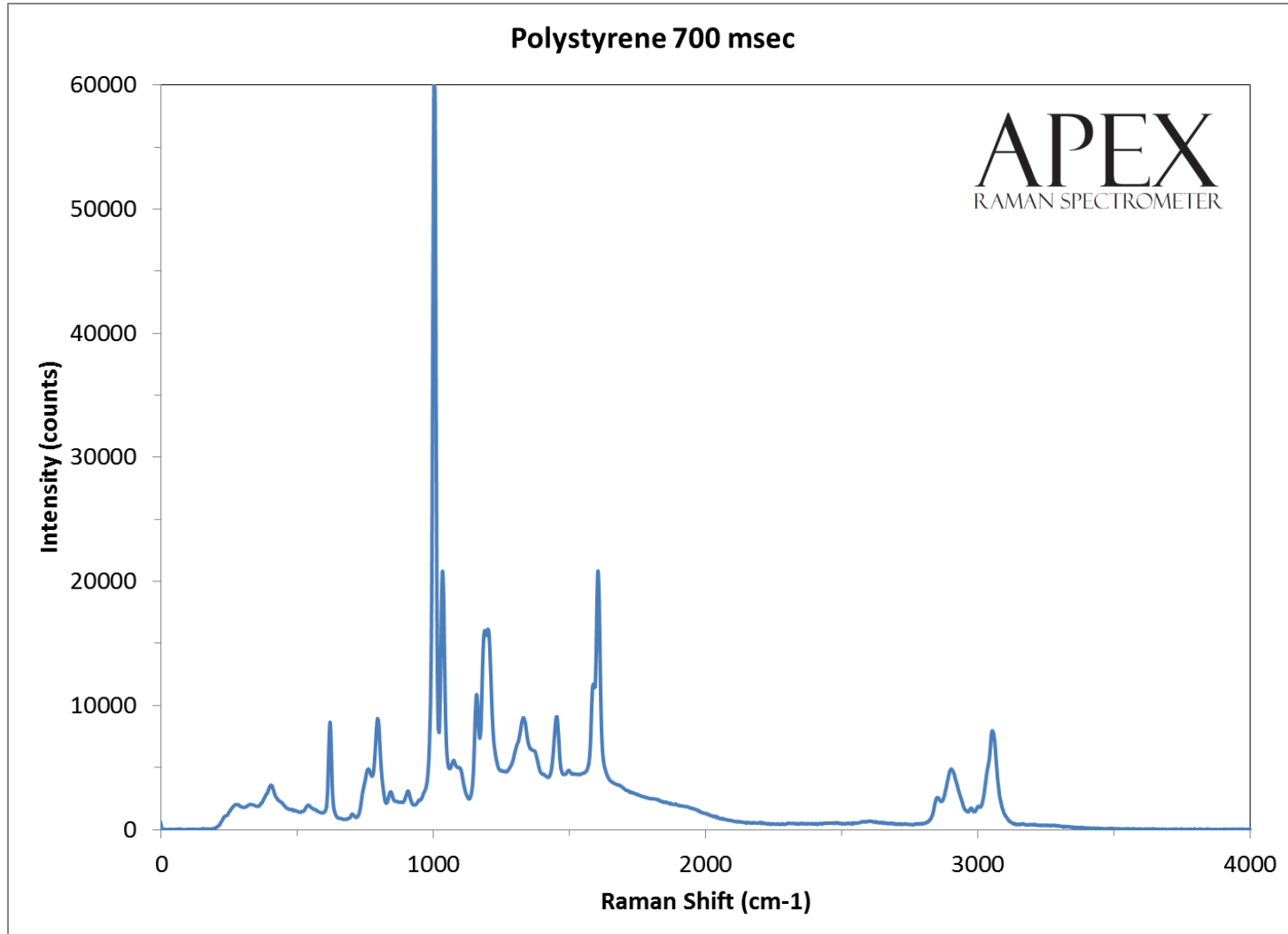
# Apex Technical Specifications



Technical Specifications	Apex
Operating environment:	0 to 50 °C
Compliance:	CE Mark RoHS
Size:	3.2" x 6.6" x 10"
Weight	2.36 kg (5.2 lb)
Communications:	USB (no external accessory connector access)
Operating software:	OceanView SpectraSuite (beta only) OmniDriver USBProgrammer Seabreeze



# Apex 785 nm Raman Spectrum for Polystyrene



# HTVS Enabled Applications



Advantage	Needed for...	Sample applications
<b>Increased spectral resolution</b>	<ul style="list-style-type: none"><li>• Identifying samples with closely spaced spectral features</li><li>• Discrimination between samples with similar spectral features</li></ul>	<ul style="list-style-type: none"><li>• Security screening</li><li>• Threat detection</li><li>• Forensic analysis</li><li>• Material science</li></ul>
<b>Detection of weak signals</b>	<ul style="list-style-type: none"><li>• Low ambient light</li><li>• Raman response (especially with limits on laser power)</li><li>• Measurements taken at longer distances</li></ul>	<ul style="list-style-type: none"><li>• Stand-off detection</li><li>• Trace sample detection</li><li>• Aerial imaging with varying cloud cover</li><li>• Radial velocity measurements</li></ul>
<b>Short acquisition times</b>	<ul style="list-style-type: none"><li>• Moving samples</li><li>• Changing samples</li><li>• Large number of samples</li></ul>	<ul style="list-style-type: none"><li>• In-line process monitoring</li><li>• Security screening</li></ul>
<b>Lower electrical power requirements</b>	<ul style="list-style-type: none"><li>• High quality signal without use of a cooled detector</li></ul>	<ul style="list-style-type: none"><li>• Portable analyzers</li></ul>
<b>No moving parts</b>	<ul style="list-style-type: none"><li>• Rugged designs</li><li>• Minimal calibration</li></ul>	<ul style="list-style-type: none"><li>• Portable systems for military and civilian applications</li></ul>
<b>Lower weight</b>	<ul style="list-style-type: none"><li>• Mobile sensing</li><li>• Smaller volume</li></ul>	<ul style="list-style-type: none"><li>• Aerial imaging for fuel and weight-sensitive applications</li><li>• Any portable system</li></ul>

# Volume Phase Holographic vs Surface Relief Gratings



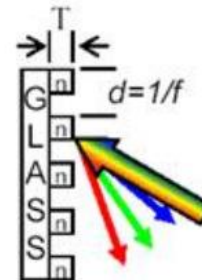
## VPH

- Constant thickness with a periodic change in refractive index
- Transmission geometry
- Masters can usually be made for spatial frequencies  $>900$  lpmm
- Master copied optically so neither master or copy degrade over time

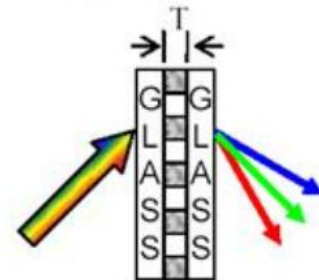
## Surface Relief

- Periodic change in thickness with a constant refractive index
- Made in reflection geometry
- Masters copied mechanically so both master and copy will degrade over time as the number of copies increases

Surface Relief Grating:  
Reflection



Volume Phase Holographic  
Grating (VPHG): Transmission



# VPH Gratings - Advantages



- Removes surface scattering effects reducing stray light
- Higher efficiencies
- Low absorption in the visible and NIR
- Low polarization dependent loss (PDL)
- Wide bandwidths
- Sealed in glass - long-lived, easy to handle, scratch resistant, and easy to clean
- Anti-reflection (AR) coatings applied to one or both surfaces to minimize Fresnel reflections and increase overall output