# picoEmerald FT

Tunable
Two-Color
ps Light Source

Microscopy & Spectroscopy

# picoEmerald FT
# Two-Colors in One Box

## Microscopy and Spectroscopy with a Tunable Two-Color Source

Best in class Coherent Raman light source that is as easy to use as a femtosecond two-photon excitation laser.

Tuning speed: 1.5 s for a random tuning step, up to 100x faster than previous generation picoEmerald S.

Highly improved signal-to-noise ratio mainly due to the reduction of the laser repetition rate leads to 10x faster image acquisition compared to picoEmerald S.
Shot noise limited performance of the Pump beam (>5 MHz, 10 mW).

In a single box, picoEmerald provides fully automated, temporally and spatially overlapping picosecond pulse trains: 1032 nm from the laser oscillator and the OPO Signal beam.

Tuning now down to 210 $cm^{-1}$ to access low frequency vibrational bands.


- Two-color turnkey system ideal for stimulated Raman microscopy up to video rate speed
- Perfect temporal and spatial overlap of exit beams
- Tunable between 660 nm ... 2340 nm
- 210 $cm^{-1}$ ... 5450 $cm^{-1}$ energy difference
- 2 ps pulses with 10 $cm^{-1}$ spectral width
- Fully automated and computer controlled
- Shot noise limited -> Extremely low noise compared to all-fiber laser systems
- Compatible with commercial microscopes and homebuilt setups
- Active and passive stabilization, ideal for long-term experiments

# picoEmerald FT
# Application

## Stimulated Raman Scattering Microscopy (SRS)

SRS microscopy is enabled by the picoEmerald system in combination with APE's integrated EOM (Electro-Optic Modulator). SRS microscopy provides nearly background free imaging contrast. It also allows easy spectroscopic identification of the sample fingerprint region based on Raman spectral databases. Very short integration times allow imaging at video rates.

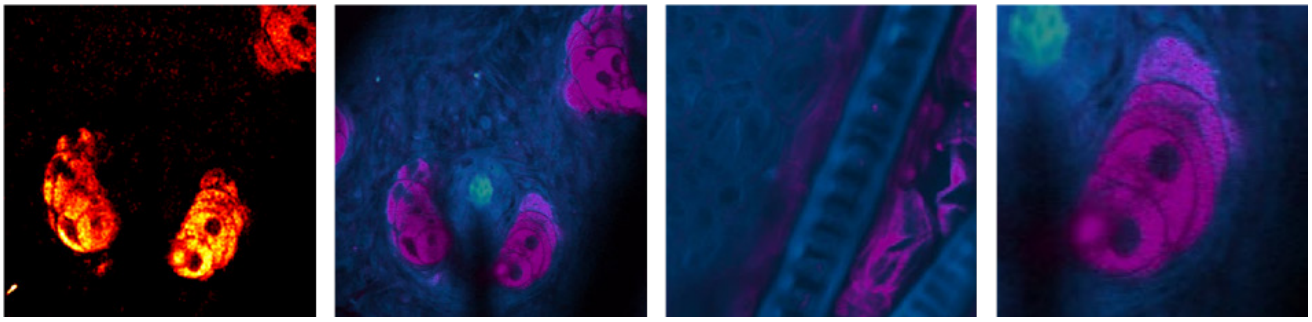


*Image Courtesy: Wei Min and Lu Wei.*
*Live-cell bioorthogonal chemical imaging with Stimulated Raman Scattering Microscopy. Measured with picoEmerald S.*

## Microscopy

- SRS (Stimulated Raman Scattering) Microscopy
- CARS (Coherent Anti-Stokes Raman Scattering) Microscopy
- SRP (Stimulated Raman Photothermal) Microscopy
- Second Harmonics Imaging (SHG)
- Two-Photon Excitation Fluorescence Microscopy
- FLIM / FRET
- SEHRS (Surface Enhanced Hyper Raman Spectroscopy)

# picoEmerald FT
# Application

## SRS Microscopy

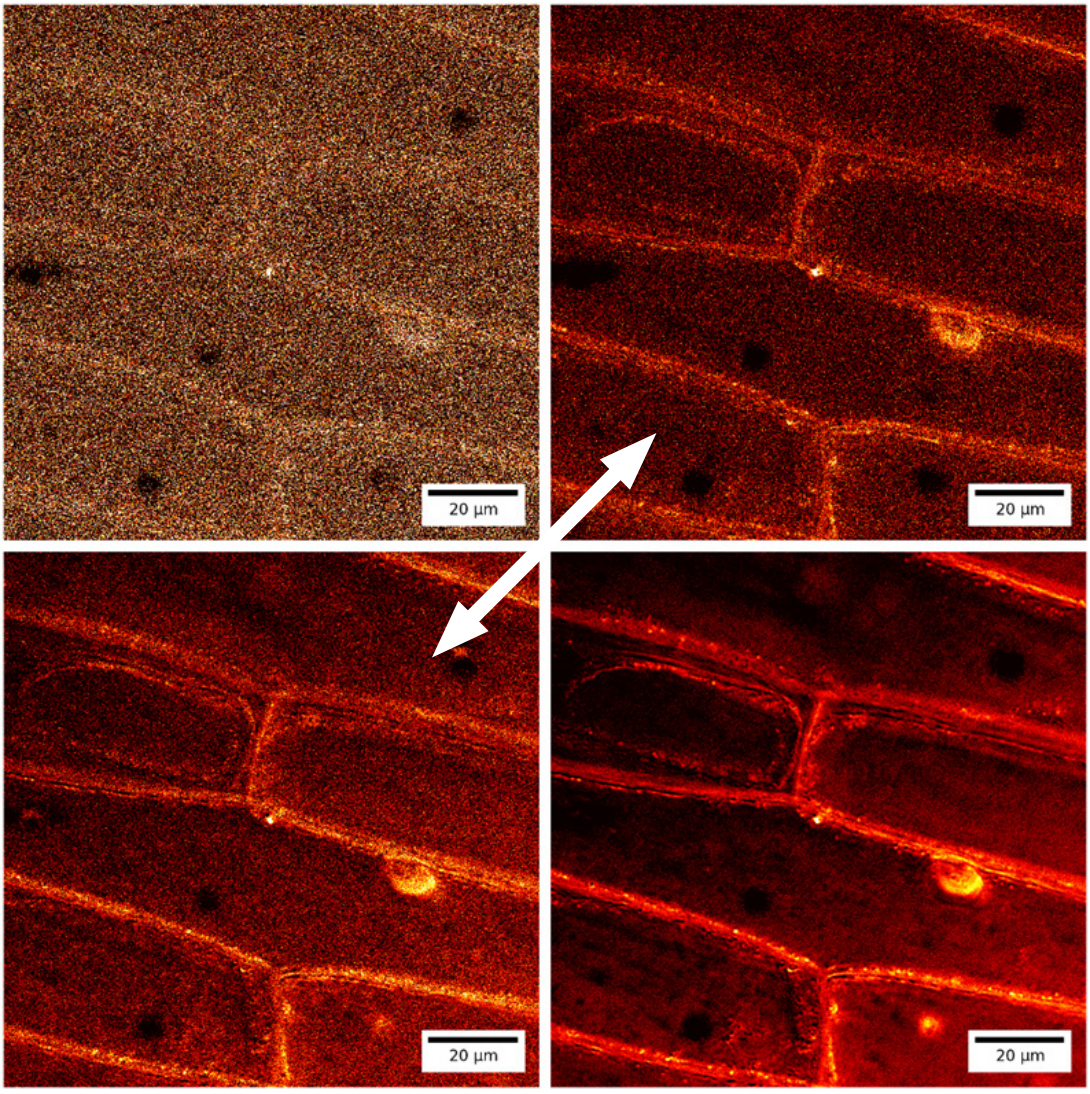
Onion imaged at 880 $cm^{-1}$. Measurements with the picoEmerald FT (40MHz, 20 MHz modulation frequency) are compared to those of the previous model, the picoEmerald S (80 MHz, 20 MHz modulation frequency). The microscopy images where taken for 2 µs and 20 µs pixel dwell time under identical conditions. It can be seen, that the picoEmerald FT yields a 10x faster acquisition speed, compared to the previous picoEmerald S.

picoEmerald S

80 MHz
20 mW Pump
9 mW Stokes

picoEmerald FT

40 MHz
20 mW Pump
9 mW Stokes



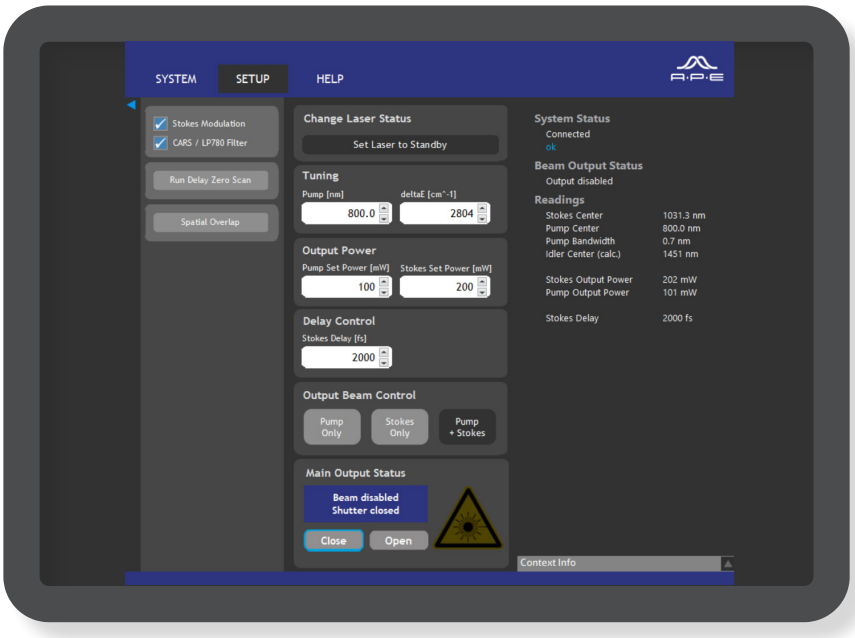

2 µs 20 µs

# picoEmerald FT
## Turnkey

### Turning Complexity into a Turnkey System


The light source is the most critical and complex component of a coherent Raman microscopy system. Proper setup and calibration are essential for accurate and reproducible imaging. picoEmerald is a turnkey system that combines user-friendly automation features and the utility of open-architecture light sources in a single box.

Excitation of coherent Raman microscopy requires two laser wavelengths, one of which must be tunable. The 1 1032 nm beam (2 ps Stokes beam) is generated at 40 MHz repetition rate. The pump beam is provided by the integrated OPO 2 and is tunable from 660 nm ... 1010 nm. An optional Idler output offers tuning from 1055 nm ... 2340 nm. The spatial and temporal overlapping of the Stokes and Pump beams is achieved by dichroic mirrors and a delay stage 3 inside the picoEmerald. The sensors 4 and the integrated beam management for temporal and spatial overlap and a high resolution spectrometer 5 ensure proper system calibration.




*picoEmerald FT software interface*

# picoEmerald FT
# Microscope Compatibility

## Setup and Use with Microscopes

By integrating SRS / CARS technology into Leica's confocal Stellaris microscopy system, Leica Microsystems has tightly integrated the picoEmerald into its ImageCompass user interface.

Software integration with other third-party microscopes or custom setups is also supported. Ethernet TCP/IP interfaces are available with picoEmerald for this purpose. A legacy RS232 serial interface is provided for compatibility.

APE's user-friendly automation combined with a graphical user interface (GUI) also makes it convenient to use picoEmerald and the microscope as independent instruments without the need for software integration.

## Compatibility (Examples)

- Leica Stellaris and SP Series
- Evident (Olympus) FV-Series
- Nikon Eclipse Ti2- Platform
- Thorlabs Multiphoton
- Zeiss LSM-Series
- Horiba
- Home-built setups

## Additional Features

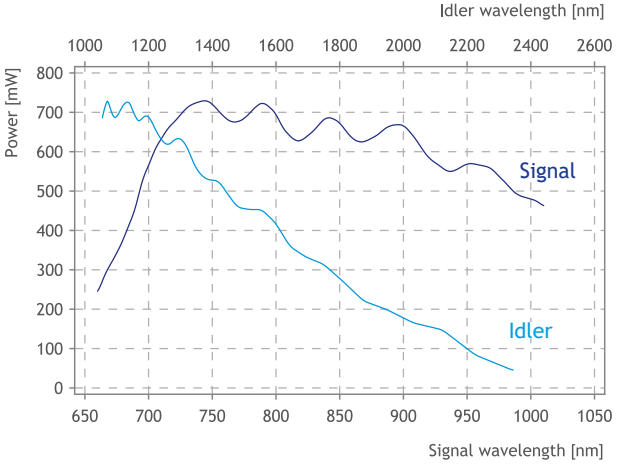
- Automated optical delay management to compensate for microscope dispersion
- Independent power control for 1032 nm beam and Signal beam (Pump and Stokes beam)
- Remote-service via Ethernet
- Compatible with: HarmoniXX for wavelength extension down to UV / VIS, pulseSelect for repetition rate reduction and pulseSlicer for spectral narrowing

# picoEmerald FT
# Specifications

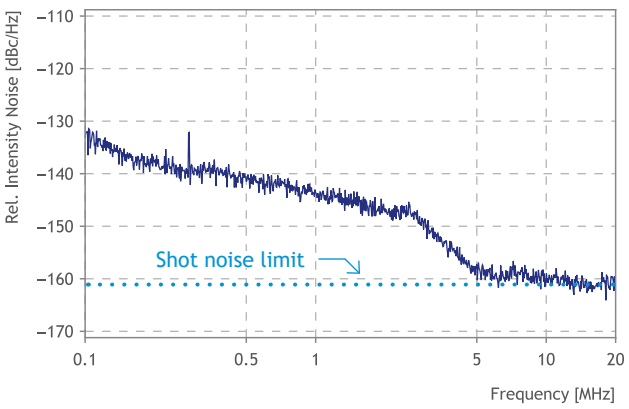
## Main Parameters

| | |
|---|---|
| Type of Source | Automated picosecond (narrow-band) tunable light source |
| Wavelength 1 1032 nm beam* | 1032 nm (± 1.5) nm |
| Wavelength 2 OPO Signal | 660 nm ... 1010 nm |
| Wavelength 3 OPO Idler* | 1055 nm ... 2340 nm |
| Power 1 1032 nm beam* | >700 mW unmodulated<br>>350 mW modulated at 20 MHz<br>(customized versions on request) |
| Power 2 OPO Signal | >600 mW at 800 nm |
| Power 3 OPO Idler* | >400 mW at 1250 nm |
| Δv OPO Signal - 1032 nm beam* | 210 $cm^{-1}$ ... 5450 $cm^{-1}$ |
| Pulse Width | 2 ps |
| Repetition Rate | 40 MHz |
| Spectral Bandwidth Signal,<br>1032 nm beam | 10 $cm^{-1}$ |
| Beam Diagnostics | Integrated spectrometer for Signal wavelength and bandwidth<br>Integrated sensors for 1032 nm and Signal beam of power, position and temporal overlap |
| Pointing Stability | <100 µrad per 100 nm |
| $M^2$ | <1.2 (OPO Signal), typ. 1.2 (1032 nm beam) |
| Polarization | Linear; Horizontal >100:1 |
| Beam Divergence** | 0.8 (± 0.2) mrad (at 800 nm and 1032 nm) |
| Beam Diameter at 2 m after exit** | 3.0 (± 0.5) mm at 800 nm; 3.2 (± 0.5) mm at 1032 nm |

picoEmerald FT – typical output power




picoEmerald FT – Relative Intensity Noise (RIN)
measured at 800 nm with 10 mW – engineering data




*The picoEmerald FT is a modular platform. 1032nm output, EOM and Idler output are optionally available.
**Beam parameters optimized to generate foci with same size and z-position for Pump and Stokes.

# picoEmerald FT
# Specifications

## Software

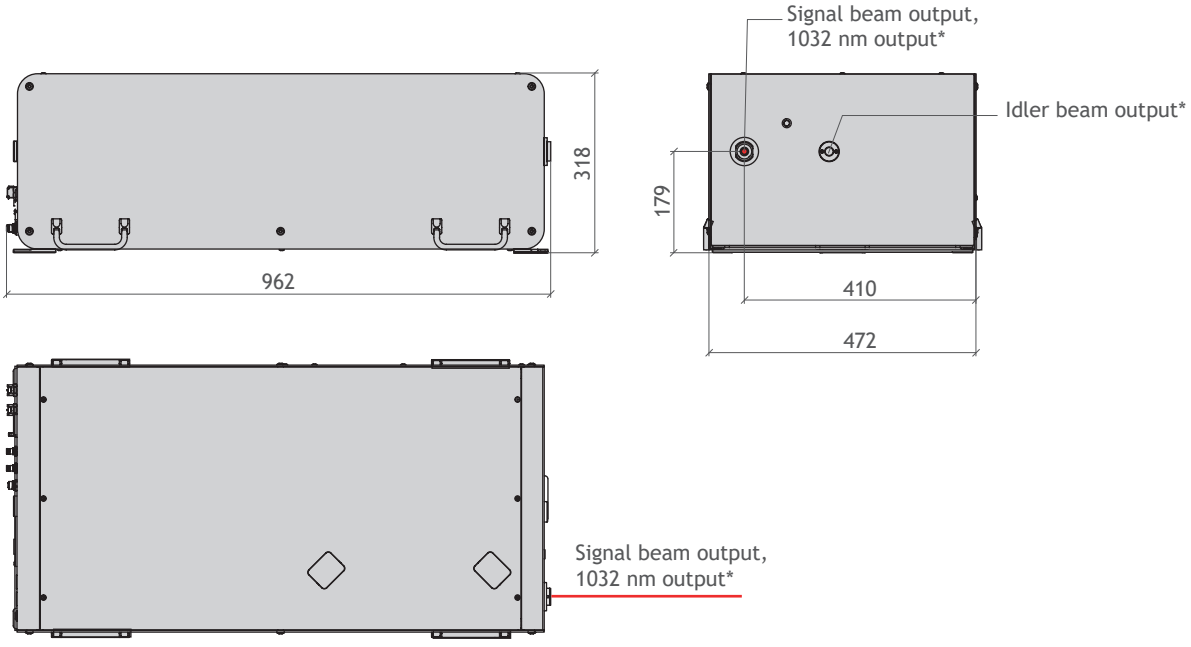
| | |
|---|---|
| Software | Graphical User interface (GUI) for Windows PC |
| Remote Control | Ethernet TCP/IP / Serial RS232 |

## EOM Modulator*

| | |
|---|---|
| Stokes Modulation | EOM with 20 MHz modulation frequency, exactly half of the repetition rate, built into picoEmerald |

## Dimensions, Power Consumption, Environment

| | |
|---|---|
| Dimension | picoEmerald: 962 mm x 318 mm x 472 mm, 104 kg (see drawing for details)<br>Laser Control Unit: 19 inch (4 U), 11 kg<br>Chiller: 197 mm x 330 mm x 279 mm, 10 kg |
| Power | 100 V ... 240 V, 50 Hz ... 60 Hz, max. 450 W (setup without Chiller)<br>100 V ... 240 V, 50 Hz ... 60 Hz, max. 600 W (Chiller) |
| Environmental Conditions | ambient temperature and humidity during operation / standby: +18 … +25°C, temperature fluctuation: <1°C recommended, humidity: <60% |




*The picoEmerald FT is a modular platform.
1032nm output, EOM and Idler output are optionally available.

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