

# HOW TO ORDER

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# OVERVIEW

The Single Particle Soot Photometer (SP2) is the only instrument in the world that directly measures the black carbon (soot) in individual aerosol particles. Its high sensitivity, fast response, and specificity to elemental carbon make it the premier instrument for characterizing air pollution sources and documenting thin, atmospheric layers of contamination. It is also ideal for measuring soot in snow, ice or water and for calibrating other black carbon-measuring instruments like the Aethalometer.

# APPLICATIONS

- » Pollution characterization
  - » Air quality and visibility
  - » Atmospheric and climate research
  - » Health effects studies
  - » Combustion emissions
  - » Black carbon in water, snow or ice
- Suitable for airborne or ground-based use (fixed-site or mobile sampling)



Mobile Sampling Unit with SP2

# ADVANTAGES

- » Measures black carbon (soot) mass in individual aerosol particles
- » Uses Nd:YAG intracavity laser-induced particle incandescence (LII), a technique that measures black carbon mass independently of particle mixing state and hence yields more accurate results
- » Detects black carbon mass at minute concentrations (below 10 ng/m<sup>3</sup>)
- » Measures particle optical size using light-scattering
- » Provides full data recording of each particle event

# HOW IT WORKS

The SP2 uses the high optical power available intra-cavity from an Nd:YAG laser. Light-absorbing particles containing mainly black or elemental carbon absorb energy and are heated to the point of incandescence. The incandescent emission is measured and correlated to the particle's black carbon mass with the help of black carbon proxies like Aquadag or fullerene soot.

The SP2 also includes a scattering detector, which detects single-particle light-scattering at 1064 nm. The scattering signal can be used to indicate particle size and the black carbon mixing state at the single-particle level. The scattering detector can also be used to detect non-BC-containing aerosol number and mass concentrations.

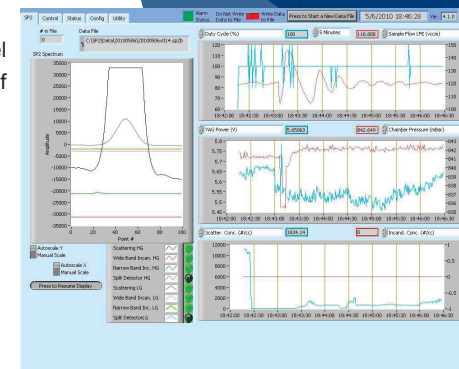
The full scattering and/or incandescence response of each particle is completely digitized for detailed analysis.

# SOFTWARE

## STANDARD SOFTWARE

The SP2 comes with a software program that provides a user-friendly virtual instrument panel for the control, data display, and data logging of the SP2 instrument. For instance, the program enables the user to do the following tasks:

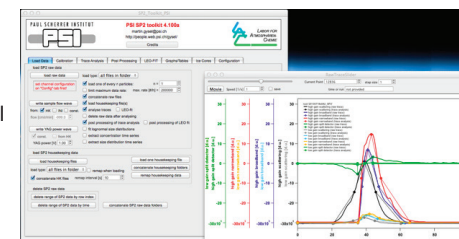
- » View graphs of incandescence and scattering signals from individual particles
- » View the incandescent particle concentration over the last 30 minutes
- » Monitor parameters like laser power and flow measurements
- » Change the charts and data channels displayed in the software



## PSI SP2 TOOLKIT SOFTWARE

The SP2 comes with a free copy of the PSI SP2 Toolkit, developed in IGOR Pro (also included). This software was written by Dr. Martin Gysel and Dr. Marie Laborde at the Paul Scherrer Institute. The toolkit enables the user to perform the following tasks:

- » Process SP2 binary files and collect particle-peak statistics
- » Automate much of the SP2 calibration process
- » Calculate common products such as black carbon mass and number concentrations, black carbon number fraction, and ensemble measurements
- » Analyze data for black carbon mixing state/coating properties
- » Perform data post-processing, including extracting time-series data
- » Create journal-quality graphs and reports



# ACCESSORIES

- » Beam scan camera and software
- » YAG optics kit (spare YAG crystal and output coupler)
- » Laser alignment bench
- » Optional auto-sampler
- » Aircraft Aerosol Inlet (far left)

New! The SP2 Nebulizer (near left)  
SP2 software version 4.2 is compatible with the U5000AT+ Ultrasonic Nebulizer from CETAC



# SP2 SPECIFICATIONS

Measured Parameters	<ul style="list-style-type: none"> <li>» Single-particle laser incandescence</li> <li>» Single-particle light scattering</li> </ul>
Auxiliary Parameters	<ul style="list-style-type: none"> <li>» Temperature</li> <li>» Pressure</li> </ul>
Derived Parameters	<ul style="list-style-type: none"> <li>» BC mass distribution as function of particle diameter</li> <li>» Particle number distribution as a function of particle size</li> </ul>
Number Concentration Range	<ul style="list-style-type: none"> <li>» 25,000 particles/second</li> <li>» 0 – 12,500 particles/cm<sup>3</sup> at standard flow rate of 120 volumetric cm<sup>3</sup>/minute</li> </ul>
Particle Size Range	<ul style="list-style-type: none"> <li>» <i>Scattering signal</i>: 200 – 430 nm diameter (this range encompasses the accumulation mode of most particles, i.e. range where most mass is found). This range can be extended to 700 nm by doing post-processing of saturated signals.</li> <li>» <i>Incandescent signal</i>: depends on particle density, but 70 – 500 nm mass-equivalent diameter assuming a black carbon density of 1.8 g/cm<sup>3</sup></li> </ul>
Aerosol Medium	Air, 0 - 40 °C (32 - 104°F)
Response Time	1 Hz for standard output products
Lasers	<ul style="list-style-type: none"> <li>» Nd:YAG Laser: 1064 nm, 3 MW/cm<sup>2</sup> intracavity</li> <li>» Pump Laser: 808 nm, 4 W</li> </ul> <p>The pump laser can be controlled either through the SP2 software or through the touch-screen on the SP2 front panel</p>
Sample Flow	30 – 180 volumetric cm <sup>3</sup> /minute (typically 120)
Flow Control	Electronic flow control with a laminar flow element (LFE) and a solenoid valve
Pump	Two single-head diaphragm pumps encased in a box
Minimum Black Carbon Detection Limit	<ul style="list-style-type: none"> <li>» 10 ng/m<sup>3</sup></li> <li>» 0.3 fg/particle</li> </ul>
Routine Maintenance	<p><i>Weekly:</i></p> <ul style="list-style-type: none"> <li>» Refreshing or replacing the desiccant in the drying cartridge on the purge line</li> <li>» Conducting PSL size check to monitor laser power</li> </ul> <p><i>Monthly and around field campaigns:</i></p> <ul style="list-style-type: none"> <li>» Conducting zero check with high-efficiency filtered air sample</li> </ul> <p><i>Annually (more frequently for high-BC environments):</i></p> <ul style="list-style-type: none"> <li>» Checking calibration of the laminar flow element on the sample inlet</li> </ul>
Recommended Service	Annual cleaning and calibration at DMT service facility

Front Panel Display	<ul style="list-style-type: none"> <li>» System power switch</li> <li>» 2 USB 2.0 ports</li> <li>» 1/8 in. Swagelok® sample inlet</li> <li>» Laser ON/OFF indicator light</li> </ul>
Rear Panel Connections	<ul style="list-style-type: none"> <li>» Keyboard port</li> <li>» Mouse port</li> <li>» VGA and HDMI monitor ports</li> <li>» Ethernet port</li> <li>» 2 RS-232 communications ports</li> <li>» 4 USB 2.0 ports</li> <li>» eSATA port</li> <li>» ¼ in. Swagelok® purge line</li> <li>» ¼ in. Swagelok® exhaust line</li> <li>» Exhaust vents</li> <li>» System and pump power connections</li> </ul>
Computer System	<ul style="list-style-type: none"> <li>» On-board Intel®Core™ i7 CPU</li> <li>» 8 GB RAM</li> <li>» 750 GB hard drive for data storage</li> <li>» NI PCI-6133 DAQ interface card</li> <li>» NI PCI-6259 housekeeping data card</li> <li>» User interface via standard keyboard, mouse, and 19" monitor (included)</li> </ul>
Software	<ul style="list-style-type: none"> <li>» SP2 Executable program, written in LabVIEW</li> <li>» PSI SP2 Toolkit program, written in Igor</li> </ul>
Data Storage Capacity	Depends on number of particles; at a concentration of 1,000 #/cm <sup>3</sup> and a standard flow rate of 120 volumetric cm <sup>3</sup> /minute, the SP2 computer has the capacity to store 56 hours of continuous data
Communications Output	Gigabyte Ethernet interfaced through an Intel® PC82573V PCIe GbE controller
Power Requirements	<ul style="list-style-type: none"> <li>» SP2: Universal Voltage</li> <li>» External Pump: 30W</li> </ul>
Dimensions	<ul style="list-style-type: none"> <li>» SP2: 48 cm W x 61 cm L x 26 cm H</li> <li>» Pump: 20 cm W x 25 cm L x 10 cm H</li> <li>» 19" Monitor: 37 cm W x 22 cm L x 39 cm H</li> </ul>
Weight	<ul style="list-style-type: none"> <li>» SP2: 26.1 kg</li> <li>» Pump: 3.4 kg</li> <li>» 19" Monitor: 3 kg</li> </ul>
Shipping Container	Durable Atlas Case Corporation ATA Transit Case that conforms to the Air Transport Association's Specification 300 Category 1 standards
Environmental Operating Conditions	<ul style="list-style-type: none"> <li>» Temperature: 0 – 40°C (32 – 104 °F)</li> <li>» Relative Humidity: 0 – 100% RH non-condensing</li> </ul>

*Specifications are subject to change without notice. The SP2 is a Class I Laser Product with U.S. Patent # 5,920,388 exclusively licensed to DMT.*

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