

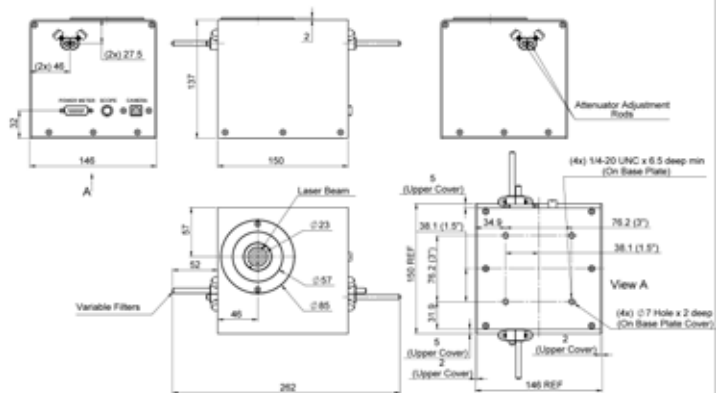
3.7 Integrated Laser Performance Measurements

3.7.1 Beam Cube - Beam Profiling/Power/Focus Spot Position/Temporal Pulse Shape BA- 500 - Integrated Beam Profiling/Power/Energy/Frequency/Temporal Pulse Shape

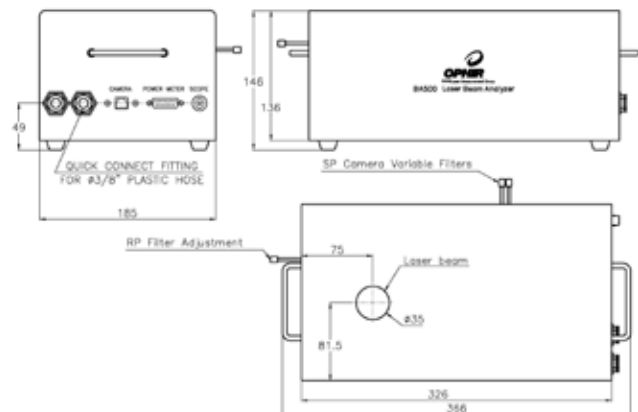
Features

- Monitor all important beam parameters to keep tight control over process
- Powers up to 1500W, energies up to 100J and beam diameters up to 30mm or focal spots down to 50µm
- Portable - can be moved from laser to laser to monitor all lasers in plant
- BA500 measures beam profile, temporal pulse shape, power, energy and frequency up to 1500W. For collimated beams only
- Beam Cube measures beam profile, focal spot position, temporal pulse shape and power, up to 150W
- For measuring at or near focal spot

Beam Cube



BA 500



3.7.1 Beam Profile

The Beam Cube and BA500 are comprehensive laser beam analysis systems for pulsed industrial Nd:YAG and Diode lasers for monitoring all important laser beam parameters so as to obtain reproducible laser cutting/welding process results. While intended for pulsed industrial lasers they can also accommodate cw beams.

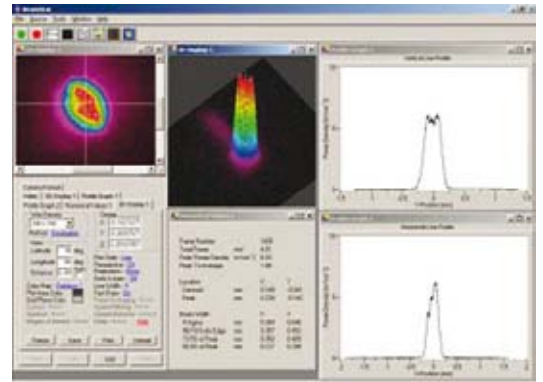
These systems measure average power, energy per pulse, spatial beam profile and temporal beam profile. All these quantities can be recorded in digital form for storage and analysis.

The Beam Cube is a self contained device that is tailored for industrial Nd:YAG or Diode laser systems of up to 150W. There is no need for the user to add any beam modifying beam splitters, attenuators or other components. The compact system easily fits into typical installations and is designed for vertical or horizontal laser beams. The Beam Cube can image the focal spot or a point on the beam not near the focus where the imaged cross section does not exceed ~3mm. It magnifies the beam 2 - 3 times depending on which lens is used so as to get the most resolution of the spot monitored. The lens is externally mounted so it can easily be switched. The lens can also be removed to measure collimated beams of up to 7mm in size.

The BA500 is a larger self contained device that is tailored for industrial Nd:YAG or Diode laser systems of up to 1500W. It is designed to image parallel beams of up to 30mm diameter and reduces the beam 7X.

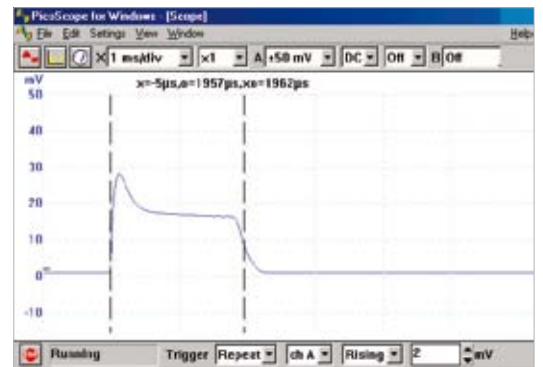
Diagnostic Capabilities: Spatial Beam Profile

The BA500 and Beam Cube show you the intensity profile of your beam in real time and allow you to adjust your laser resonator and beam delivery optical system for optimum beam quality on line. You can also measure the cross section at any point as shown. The illustration shows the intensity distribution of a pulsed Nd:YAG laser where the X and Y profiles are taken at the cursor lines which can be placed anywhere on the beam. This data can be saved, brought back and manipulated at any time so you can compare the present profile with a reference. These systems all have an exclusive optical system making it easy for you to adjust the intensity to get the optimum picture by just pushing and pulling the attenuating filter adjustment levers. The beam profile can also be shown in a three-dimensional form which can be rotated to different angles and elevations.



Temporal Pulse Shape

The temporal profile of laser pulses, important in obtaining consistent process results, can now be easily monitored. Shown to the right is the pulse shape of the same pulsed Nd:YAG laser with 2ms pulses. It is being measured with a PC oscilloscope available as an accessory. You can display the pulse shape alone or together with the beam profile on your PC. Alternately, plug the BA500 or Beam Cube output into an oscilloscope to observe the temporal pulse shape of your laser beam.



Average Laser Power

With the Ophir USB Interface between the BA500 and Beam Cube unit and your PC or laptop, you can measure the average power of your laser to an accuracy of $\pm 3\%$. The BA500 RP power/energy measuring head has an exclusive damage resistant coating with a damage threshold of $3\text{kW}/\text{cm}^2$.

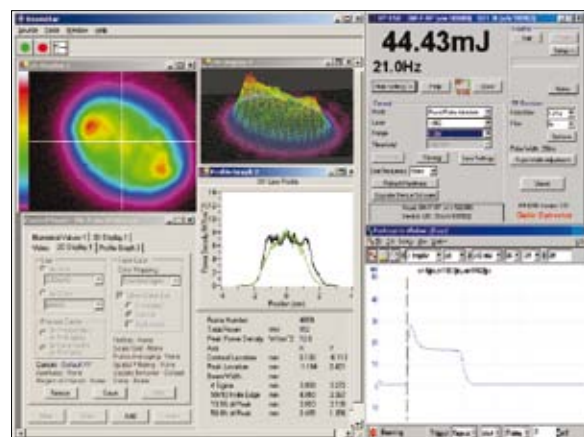
Energy per Pulse and Frequency

The patented RP head inside the BA500 is able to measure the energy per pulse and the frequency of the laser to high accuracy. With the USB Interface you can display this on your PC or laptop screen.

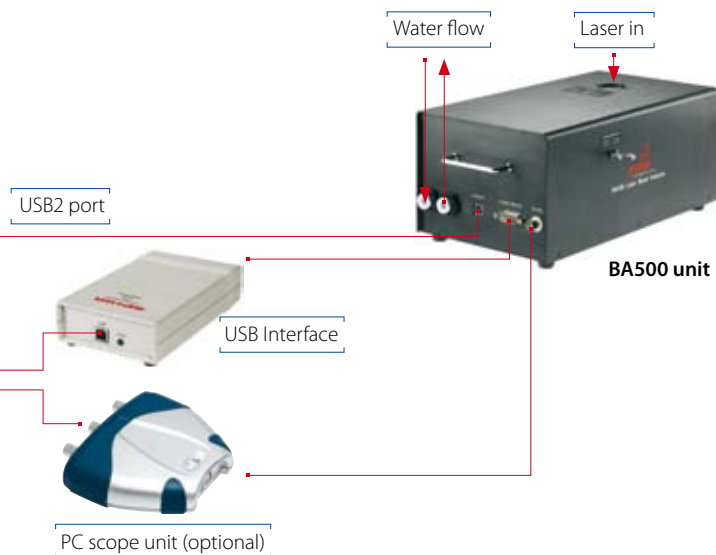
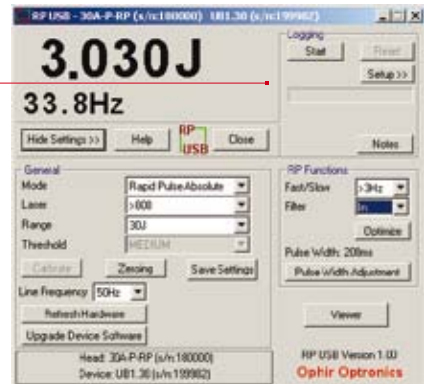
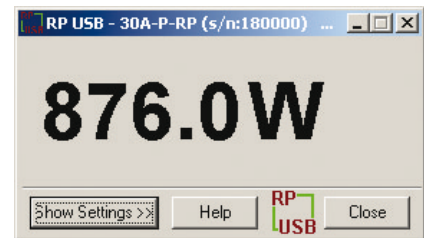
Statistics

The Beam Cube/BA500 with USB Interface is able to record and store an unlimited number of points in your PC. The software provided has a number of ways of displaying the statistics of the data.

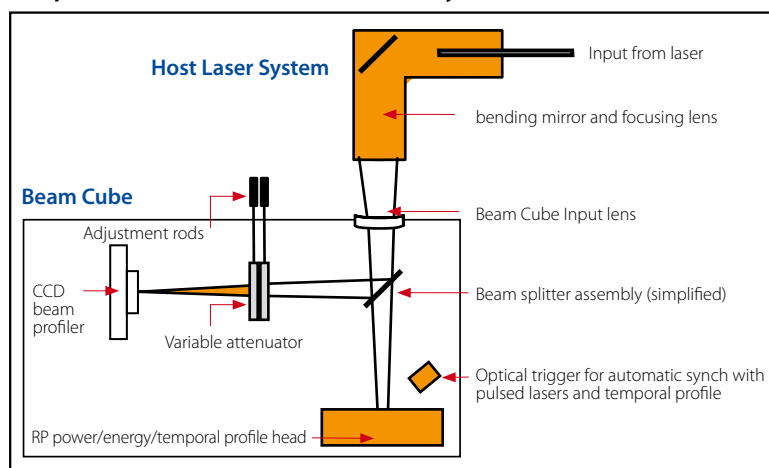
Schematic setup of a BA500 system



Laptop or desktop PC screen showing spatial beam profile, temporal profile, power, energy and frequency



Simplified Schematic of Beam Cube System



Specifications

| General | | Beam Cube | BA500 |
|---|-------------|---|---|
| Max and min average power | | 1W to 100W continuous and to 150W for up to 1 min | 10W to 1500W |
| Maximum average power density ^{(a), (c)} | | 4kW/cm ² at entrance window | 4kW/cm ² at entrance window |
| Max and min energy | | 20mJ ^(b) to 100Joules | 100mJ ^(b) to 100 Joules |
| Maximum energy density | pulse width | max energy density | max energy density max rep rate for energy measurement |
| and repetition rate at entrance window vs. pulse width | 10ms | 20J/cm ² | 150J/cm ² 80Hz |
| | 2ms | 5J/cm ² | 40J/cm ² 800Hz |
| | 0.5ms | 1.5J/cm ² | 8J/cm ² 1kHz |
| Cooling System | | Conduction cooled | Water-cooled Min flow rate: 2.5 liter/min |
| Dimensions | | 22cm L x 16cm W x 14cm H | 33cm L x 18cm W x 14cm H |
| Spectral Range | | 400 - 1100nm (calibrated for 1064nm) | 800 - 1064nm (calibrated for 1064nm and 800nm) |
| Beam profiler unit | | | |
| Camera | | Standard Beam Cube: SP503U 640x480 pixel camera with 9.9µm spacing Beam Cube 620: SP620U 1600x1200 pixel camera with 4.4µm spacing | SP620U 1600x1200 pixel camera with 4.4µm spacing |
| PC interface | | USB2 | USB2 |
| Shutter speeds | | Continuously variable 1/frame rate to 1/6,000, manual or automatic | |
| Gain control | | 0dB to 27dB in ~700 steps (each step is ~0.035dB). Manual or automatic control | |
| Frame rate at 640x480 pixel ROI | | Std Beam Cube: 60Hz. Auto synch with laser | 20Hz, auto synch with laser |
| Software features | | Beam Cube 620: 20Hz. Auto synch with laser | |
| | | Automatic gain and shutter control. Peak and Centroid position tracking. 2D and 3D contour map. Sophisticated noise and background control. Best fit to gaussian or top hat profile 3D display viewable from any angle or elevation. Store and recall screens in single or video fashion. 3 different measures of beam width, of peak, 4 sigma and 90/10 knife edge. Save numerical data files of profiles. Log data with time. Full on line instructions and help. Fully flexible screen format. | |
| Minimum PC system requirements | | Pentium-4 2GHz, 256 MB Memory, Operating system, Windows XP Service Pack 2 or Vista 32. | |
| Intensity adjustment | | Continuously variable filters actuated from outside the unit. | |
| System optical performance | | | |
| Field of view | | ±6° | ±2.5° |
| Maximum beam size | | Ø22mm at entrance for converging beam, Ø7mm for collimated beams | Ø30mm |
| Beam reduction or expansion | | Expanded 2-3X. With no lens 1X | Reduced 7X |
| Resolution | | ~5µm | ~80µm |
| Power / energy / temporal profile unit | | | |
| Temporal pulse shape response time into oscilloscope | | 200µs resp. time. Maximum peak power 1000W. | 1µs resp. time. Maximum peak power 10,000W |
| Software functions with USB Interface connected to PC or laptop | | average power, statistics | average power, energy per pulse, pulse rate, statistics, missing pulses |
| Data logging | | Can send unlimited number of points in real time to PC via USB Interface at >1000 point/s. Windows software provided for data analysis. | |

Notes: (a) The power density limitation applies to any surface that the beam hits. For Beam Cube, since the object plane is outside the instrument, focal spots of much higher power density can be imaged as long as the power density limit on the optical surfaces is not exceeded.

Notes: (b) The BA500 will not resolve pulses of energy below 100mJ unless the pulse rate is high. If the energy deposited in 1/50th of a second exceeds 100mJ, then the unit will be able to show the pulses even though the individual energies are below 100mJ. The same applies to the Beam Cube except the minimum is 20mJ.

Notes: (c) If the beam power or energy density on the entrance window exceeds specifications, the window can be removed and not used, assuming that the power and energy density on the first beam splitter is below the damage threshold.

Ordering Information

| Item | Description | Ophir P/N |
|----------------------------------|--|-----------|
| Beam Cube 503 | To be used with oscilloscope of Beam Cube system for beam profile, pulse shape, power and energy. user's choice. Includes -100mm lens assembly. Uses SP503 beam profiling camera | SP786015 |
| Beam Cube 620 | Same as above but with higher resolution SP620 camera | SP786016 |
| Replacement -100mm lens assembly | Replacement -50mm lens assembly for Beam Cube | SPZ08256 |
| -50mm lens assembly | Optional -50mm lens assembly for Beam Cube | SPZ08255 |
| BA500-V2 | BA500-V2 system for beam profile, pulse shape, power and energy To be used with oscilloscope of user's choice | SP786013 |
| Optional Carrying case for BA500 | Carrying case for BA500 unit, optional oscilloscope and cables | 1J02048 |
| Optional PC oscilloscope | 1MHz virtual oscilloscope for Beam Cube or BA500 to turn your PC into an oscilloscope displaying the temporal pulse shape. Uses PC or laptop USB port | SPE10008 |
| Optional USB Interface | USB Interface for displaying the laser power on your PC | 7Z01200 |