



μ-Joule Meter

Operating instructions

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November 2024 - Rev.04

Contents

- 1 Scope of delivery 1**
- 2 Product description 2**
 - 2.1 μ -Joule Meter function 2
 - 2.2 Measuring principle 2
 - 2.3 Measurement reliability..... 3
 - 2.4 μ -Joule Meter setup..... 3
- 3 Operation..... 5**
 - 3.1 In general 5
 - 3.2 Quick start 5
 - 3.3 User interface 6
 - 3.3.1 Main window 6
 - 3.3.2 Main toolbar 7
 - 3.3.3 Measurement toolbar 7
 - 3.3.4 Settings and statistics pane 8
 - 3.3.5 Options dialog 9
 - 3.3.6 Measurement list..... 14
 - 3.3.7 Measurement information 15
 - 3.3.8 View options dialog 15
 - 3.4 Record chart features 16
 - 3.4.1 Selecting the area of interest 16
 - 3.4.2 Display options..... 17
 - 3.4.3 Statistical Information..... 19
 - 3.4.4 Memory requirements 20
 - 3.5 Printing and Exporting 21
 - 3.5.1 Measurement report..... 21
 - 3.5.2 Export data..... 22

3.6 AutoStop..... 22

3.7 AutoSave..... 23

3.8 Known Bugs 23

4 Appendix..... 24

4.1 Specifications 24

4.2 Maintenance and warranty 25

4.3 Calibration 25

EC Declaration of Conformity 26

1 Scope of delivery

The μ -Joule Meter package contains the following:

- μ -Joule Meter measuring head
- USB cable
- Adapter plate for precision measurements
- Fiber coupling connector
- Information sheet with link to operating software *μ -Joule Meter*



Optional accessories:

- Stand
- SDK - Software Development Kit

2 Product description

The μ -Joule Meter is developed for online monitoring in laser-induced industrial analytics and medical diagnostics. Further application areas are: system developments, process monitoring, calibrations and services. The μ -Joule Meter provides measurements of free beams and light fiber coupled setups.

2.1 μ -Joule Meter function

The μ -Joule Meter is based on a pyro-electrical receiver and can be applied for energy measurements of pulsed laser beams. It provides small pulse energy measurements with a background noise limit of 6 nJ. The transformation of analogue to digital signals in the measuring head minimizes electrical interferences. The μ -Joule Meter is connected via USB port to a PC for data transfer and power supply.

The supplied operating software *μ -Joule Meter* features:

- Selection of four measurement ranges from 250 nJ – 250 μ J
- Operation of up to ten μ -Joule Meters simultaneously.

2.2 Measuring principle

The pyro-electrical pulse detector has the characteristics of a fast AC current source with a small capacity. Its electrical discharge is imaged, transformed and digitally processed. In the measuring head both transformation and correction are combined. The coated absorption layer guarantees a linear sensitivity within the given wavelength range. The sensor is protected from environmental influences by a CaF_2 window. Prior to measurement, the expected power density must be estimated in order to avoid any damage to the sensor. The beam must be narrowed or widened accordingly.

NOTICE

Observe maximum power density!

➞ The maximum applied power density is 10 MWcm^{-2} .

2.3 Measurement reliability

The μ -Joule Meter provides energy measurements of a laser pulse duration up to 50 μ s. Longer laser pulses cause significant errors due to a transition to power measurement. The noise threshold is below the optical sensitivity limit of 30 nJ. Mechanical vibrations can affect the measurement.

The measurement accuracy of ≤ 4 % is valid for a sensor area illumination of > 50 %. Sensitivity dispersions on the receiver area are already taken into account. The measurements can be shown as being up to 5 % too low due to multiple reflections between the optical structure, window and detector surface.

Damage to the window and sensor surface can also lead to measurement errors.

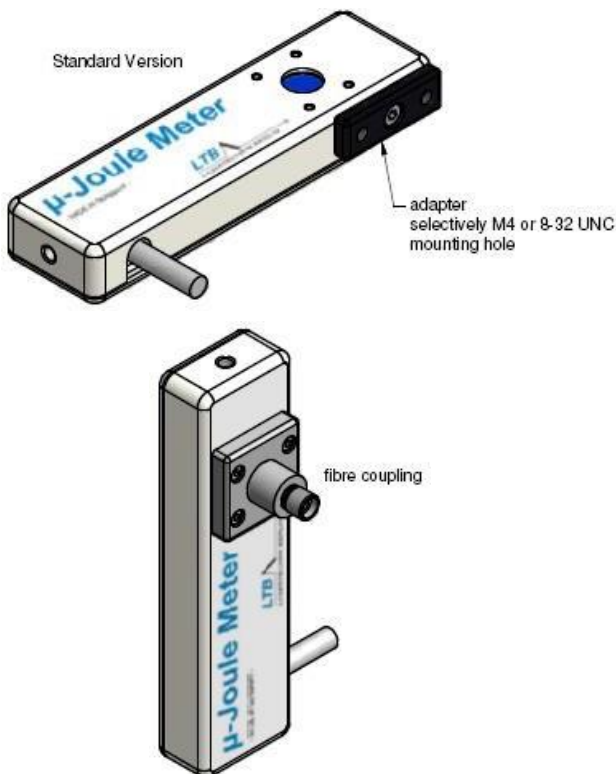
NOTICE

Observe the following!

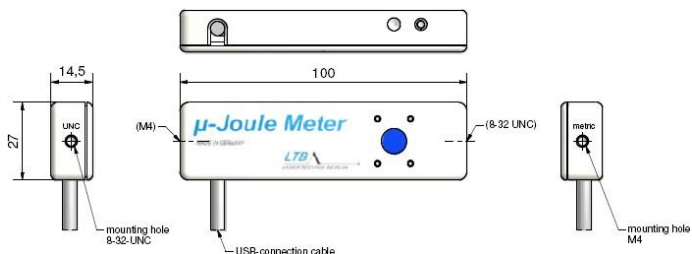
- ➔ ONLY use cleaning solutions designed for sensitive optics.
- ➔ Observe maximum applied power density.

2.4 μ -Joule Meter setup

The μ -Joule Meter in the standard version is delivered with fiber coupling connector, adapter plate for precision measurements and USB cable.



The adapter plate allows screwing a stand underneath the μ -Joule Meter in order to achieve more stability during the measurement process; the plate contains two mounting holes, for metric or inch screws.



3 Operation

3.1 In general

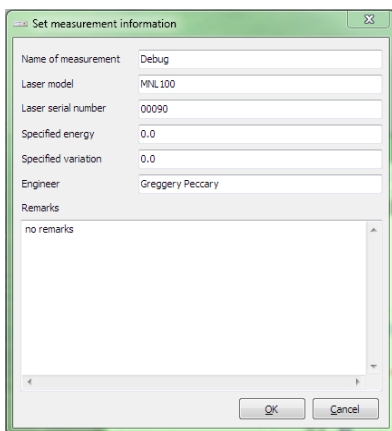
The μ -Joule Meter software is the user interface for the LTB μ -Joule Meter. It serves as a display for the currently measured value, as well as a tool for recording and evaluating a series of energy values. It provides several features such as statistical evaluation or exporting, saving, generating reports of recorded energy runs.

The μ -Joule Meter software can be used with Microsoft Windows XP, Windows Vista, Windows 7, Windows 8 and Windows 10.

3.2 Quick start

For a quick start, please do as follows:

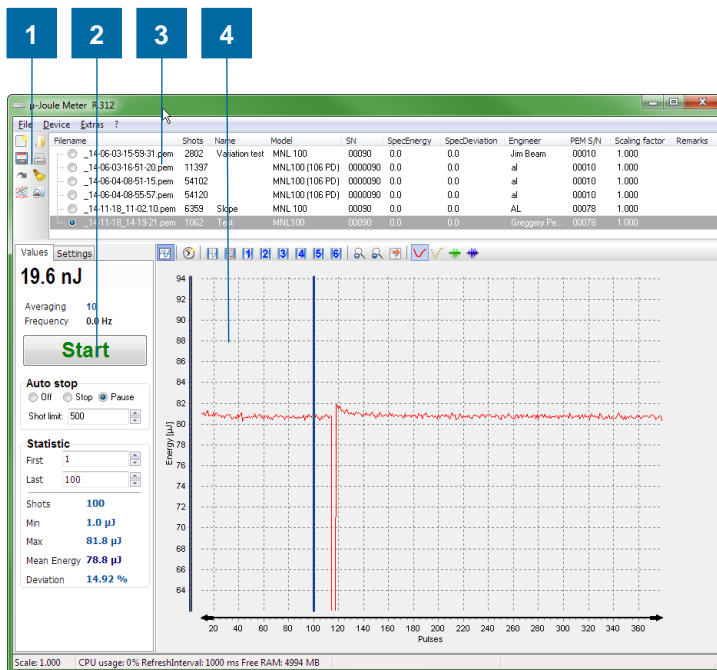
1. Start the μ -Joule Meter software.
2. Click the button *New Measurement*.
3. Enter your information in the *Measurement Information* dialog and press the *OK* button.
4. Currently measured values can be seen on the left side of the main window. If you want to begin with recording your measurements now click *Start*



The screenshot shows a dialog box titled "Set measurement information". It contains several input fields and a text area. The fields are: "Name of measurement" (containing "Debug"), "Laser model" (containing "MNL100"), "Laser serial number" (containing "00090"), "Specified energy" (containing "0.0"), "Specified variation" (containing "0.0"), and "Engineer" (containing "Greggery Peccary"). Below these fields is a "Remarks" section with a text area containing "no remarks". At the bottom right of the dialog are "OK" and "Cancel" buttons.

3.3 User interface

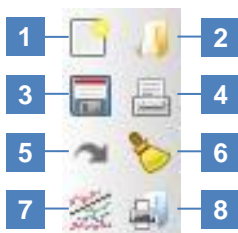
3.3.1 Main window



Main window of the μ -Joule Meter software:

- 1 **Main toolbar:** quick access to key functions
- 2 **Settings and statistics pane:** Start/stop a measurement, statistical values
- 3 **Measurements list:** a list of loaded measurements
- 4 **Measurement chart and toolbar:** displays data from loaded measurements and provides means to operate

3.3.2 Main toolbar



- 1 New measurement
- 2 Open measurement
- 3 Save measurement
- 4 Print report on measurement
- 5 Export measurement
- 6 Clear values of measurement
- 7 Display all measurements or only selected measurement
- 8 Print report for selected measurements

3.3.3 Measurement toolbar



- 1 **Show/Hide measurement chart:** to show only the currently measured value, reduce the main window size by clicking this button
- 2 **Switch between time and pulse based display:** set the x-axis to either time or pulse based
- 3 **Move cursors to the min and max values of the x-axis:** use this button to recapture the cursors after you have zoomed into a measurement
- 4 **Automatically shift right cursor:** when new measured values are being added to the chart the right cursor will be automatically shifted to the most recent value
- 5 **Set cursors to predefined position** (see 0

- 6 Display Tab)
- 7 **Zoom in the chart:** you can also zoom in by dragging a rectangle over the chart (keep left mouse button clicked) from left to right.
- 8 **Zoom out of the chart:** you can also zoom out by dragging a rectangle from right to left.
- 9 **Automatically shift x-axis:** the x-axis is automatically shifted with every new value
- 10 **Activate line display of measured values**
- 11 **Activate point display of measured values**
- 12 **Show moving average line**
- 13 **Show standard deviation line**

3.3.4 Settings and statistics pane

3.3.4.1 Values tab

Values Settings

1 **80.35 μ J**

2 Averaging 10

3 Frequency 0.0 Hz

Start

Auto stop

☐ Off ☐ Stop ☒ Pause

Shot limit: 500

Statistic

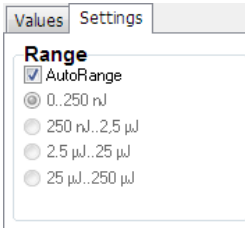
5 First [1] [v]

Last 100 [v]

Shots	100
Min	1.0 μ J
Max	81.8 μ J
Mean Energy	78.8 μ J
Deviation	14.92 %

- 1 **Currently measured energy value**
- 2 **Average value:** averaging of the measured values. Modify the averaging rate in the *Options* dialog or by pressing '+' or '-' on the keyboard.
- 3 **Frequency:** the frequency of the currently measured laser shots.
- 4 **Auto stop or Pause options** (see 3.6 AutoStop)
- 5 **Statistic values:** displays statistic evaluation of the current measurement. The statistic values refer to the range that is determined by the two blue cursors in the measurement chart.

3.3.4.2 Settings tab

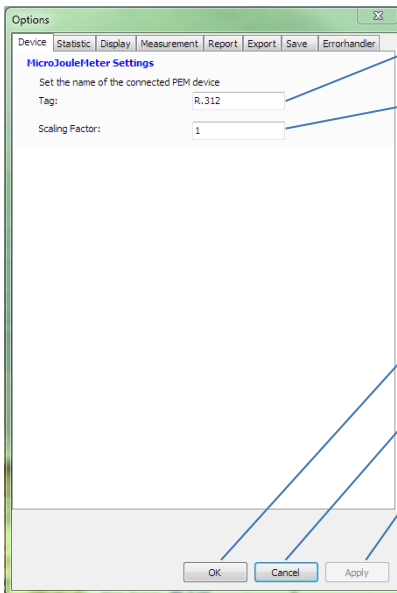


Range of the μ -Joule Meter – switch either to a constant range value or use the **AutoRange** option

3.3.5 Options dialog

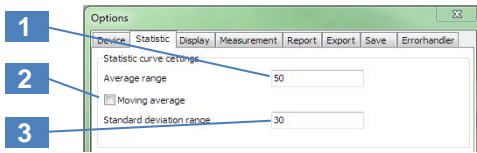
You can access the *Options* dialog by clicking **Extras** → **Options** in the main menu bar. The *Options* dialog allows you to modify basic settings of the software.

3.3.5.1 Device Tab



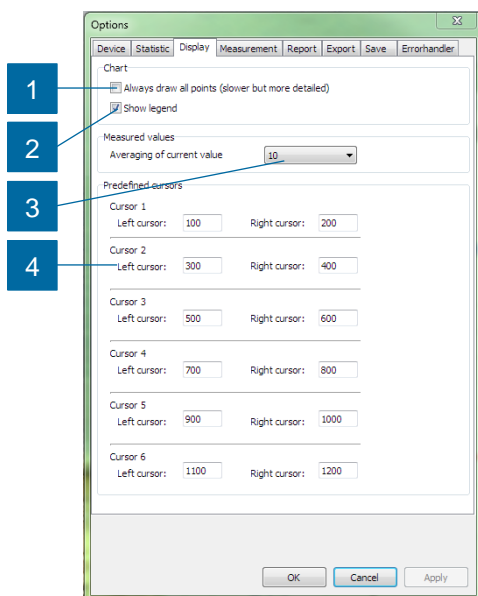
- 1 **Tag:** Change the tag of the currently connected device. You can re-name your devices as desired.
- 2 **Scaling Factor:** Change the scaling factor of your μ -Joule Meter. 1.00 is the default setting. You may have your measured values multiplied by this pre-set factor.
- 3 **OK:** Apply changes, close dialog
- 4 **Cancel:** Close dialog, discard changes
- 5 **Apply:** Apply changes, keep dialog open

3.3.5.2 Statistic Tab



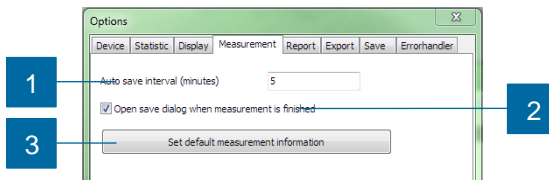
- 1 **Average range:** Sets the range of the average line (see 3.3.3 Measurement toolbar)
- 2 **Moving average:** If this checkbox is checked the average line is a moving average. Otherwise the average line shows the average of the stated range and only every (in this case) 50 values, a new average value is calculated.
- 3 **Standard deviation range:** Sets the range of the standard deviation line (see 3.3.3 Measurement toolbar)

3.3.5.3 Display Tab



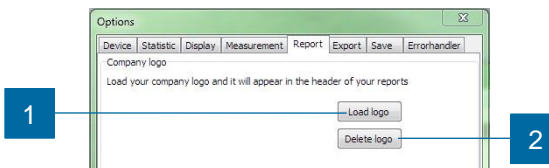
- 1 **Always draw all points:** in order to increase the performance of the software, the chart will stop drawing all points once the number of values exceeds 10^5 shots. This might cause not all peaks being displayed properly. By checking this option you can force the software to always draw all points.
- 2 **Show Legend:** shows a legend of all curves below the graph
- 3 **Averaging of current value:** modify the averaging rate in the options dialog or by pressing + or – on your keyboard
- 4 Positions of **Predefined Cursors 1...6**

3.3.5.4 Measurement Tab



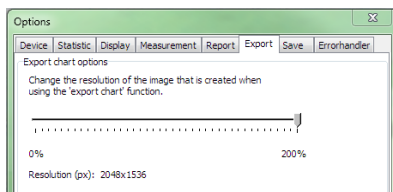
- 1 **Auto save interval:** Sets the interval to save the recorded data automatically. It will be saved to the file Autosave.pem in the folder C:\Users\<USERNAME>\AppData\Local\LTB Lasertechnik Berlin\ μ -Joulemeter.
- 2 **Open “save dialog”:** If activated, the software will automatically open the “Save to” dialog when a measurement is stopped.
- 3 **Set default measurement information:** Set default settings to describe new measurements. Every measurement has some information attached to it, for example: name of measurement, serial number of laser, engineer and so on. If any of this information is the same for a number of your measurements you can define it here. Whenever you create a new measurement now, this setting will be preset.

3.3.5.5 Report Tab



- 1 **Load logo:** use the *Load logo* button to select a JPG or BMP file. This picture will be included in the measurement report (see 3.5.1 *Measurement* report).
- 2 **Delete logo:** use the *Delete logo* button to remove the selected picture from the measurement report.

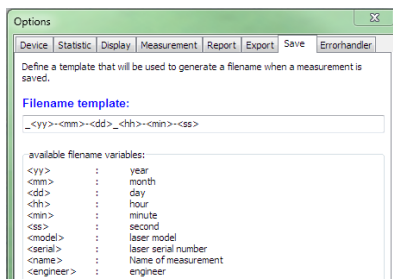
3.3.5.6 Export Tab



Select the resolution of the JPG file that will be created by the *Export chart* function.

Values > 1024 (100%) are recommended.

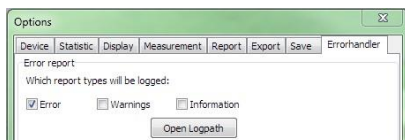
3.3.5.7 Save Tab



Use this tab to select a filename template to save measurement data.

Enclose filename variables in '<' and '>' characters.

3.3.5.8 Errorhandler Tab



A log file is saved while the software is running which is dedicated to provide support in case of malfunction.

Use this tab to specify which report types will be logged.

Open Logpath displays the Windows Explorer at the folder where the log file is saved.

3.3.6 Measurement list

The measurement list gives you an overview over all opened measurements.

Filename	Shots	Name	Model	SN	SpecEnergy	SpecDeviation	Engineer	PEM S/N	Scaling factor	Remarks
_14-06-03-15-59-31.pem	2802	Variation test	MNL100	00090	0.0	0.0	Jim Beam	00010	1.000	
_14-06-03-16-51-20.pem	11397		MNL100 (106 PD)	0000090	0.0	0.0	al	00010	1.000	
_14-06-04-08-51-15.pem	54102		MNL100 (106 PD)	0000090	0.0	0.0	al	00010	1.000	
_14-06-04-08-55-57.pem	54120		MNL100 (106 PD)	0000090	0.0	0.0	al	00010	1.000	
_14-11-18_11-02-10.pem	6359	Slope	MNL100	00090	0.0	0.0	AL	00078	1.000	

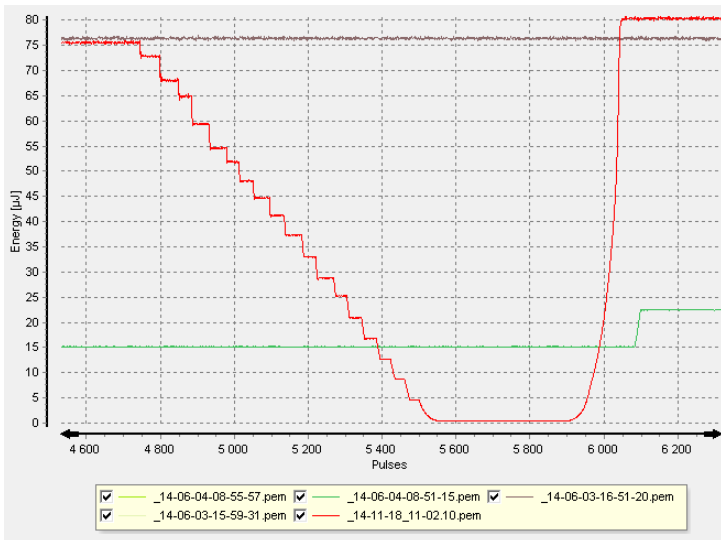
The measurement with the selected radio button is the main measurement. When you start a measurement by clicking the Start button new values are being attached to this measurement. The cursors in the measurement chart refer to this measurement as well.

If you want the software to draw all measurements into the chart, click the *Show all / selected* button:

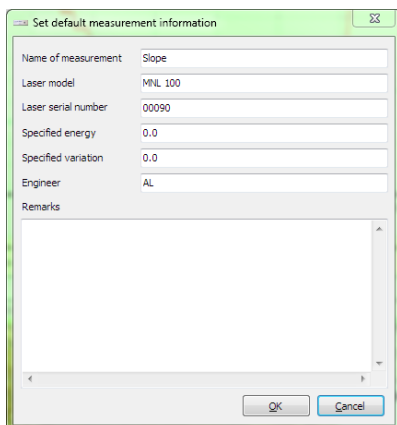


Now all opened measurements will be displayed in the chart window.

Filename	Shots	Name	Model	SN	SpecEnergy	SpecDeviation	Engineer	PEM S/N	Scaling factor	Remarks
_14-06-03-15-59-31.pem	2802	Variation test	MNL100	00090	0.0	0.0	Jim Beam	00010	1.000	
_14-06-03-16-51-20.pem	11397		MNL100 (106 PD)	0000090	0.0	0.0	al	00010	1.000	
_14-06-04-08-51-15.pem	54102		MNL100 (106 PD)	0000090	0.0	0.0	al	00010	1.000	
_14-06-04-08-55-57.pem	54120		MNL100 (106 PD)	0000090	0.0	0.0	al	00010	1.000	
_14-11-18_11-02-10.pem	6359	Slope	MNL100	00090	0.0	0.0	AL	00078	1.000	



3.3.7 Measurement information



Set default measurement information

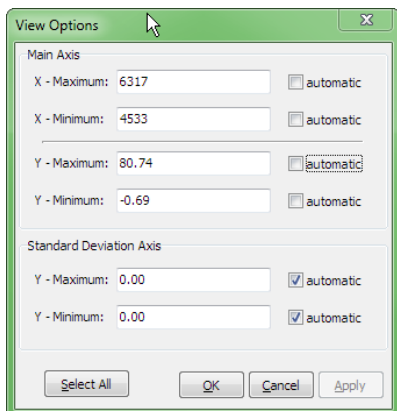
Name of measurement	Slope
Laser model	MNL 100
Laser serial number	00090
Specified energy	0.0
Specified variation	0.0
Engineer	AL
Remarks	

OK Cancel

To change the information that describes your measurement, right click on the measurement in the measurements list and select *Properties*.

In the *Options* dialog (see 0 Measurement Tab) you can set default settings for this information.

3.3.8 View options dialog



View Options

Main Axis

X - Maximum:	6317	<input type="checkbox"/> automatic
X - Minimum:	4533	<input type="checkbox"/> automatic
Y - Maximum:	80.74	<input type="checkbox"/> automatic
Y - Minimum:	-0.69	<input type="checkbox"/> automatic

Standard Deviation Axis

Y - Maximum:	0.00	<input checked="" type="checkbox"/> automatic
Y - Minimum:	0.00	<input checked="" type="checkbox"/> automatic

Select All OK Cancel Apply

To manually change the scaling of the axis in your recording chart, click on either axis. The following dialog will show up.

Select the axis to be scaled automatically or enter manual scaling values.

3.4 Record chart features

3.4.1 Selecting the area of interest

3.4.1.1 Zoom with the mouse

To zoom into an area of interest click at the upper left corner of the area and press the left mouse button and then drag the mouse to the lower right corner and release the mouse button.

To switch back to automatically scaled axes press the left mouse button at the chart area and drag the mouse to the left and release the mouse button.

3.4.1.2 Zoom by values

You can left-click at each axis to enter the *View Options* dialog. There you can define the borders of your area of interest by entering the values (see 3.3.8 View options dialog).

3.4.1.3 Shift the displayed area with the mouse

To shift the displayed area right-click with your mouse into the chart and drag the mouse while keeping the mouse button clicked.

3.4.1.4 Automatically shift the displayed area with every new value

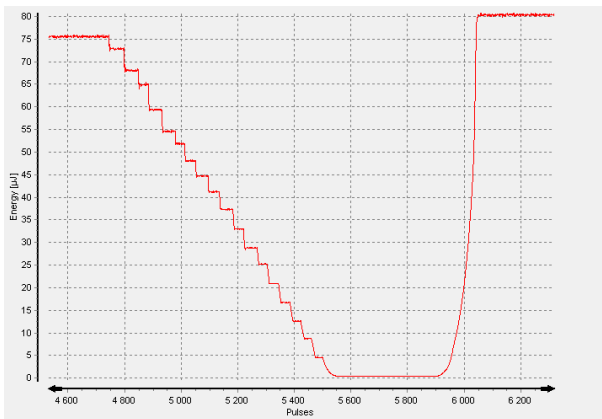
If you zoom into an area of interest during a running measurement you might want the displayed area to be shifted by every additional measured value. By clicking the *Automatically shift zoomed area* button this behavior is being activated.



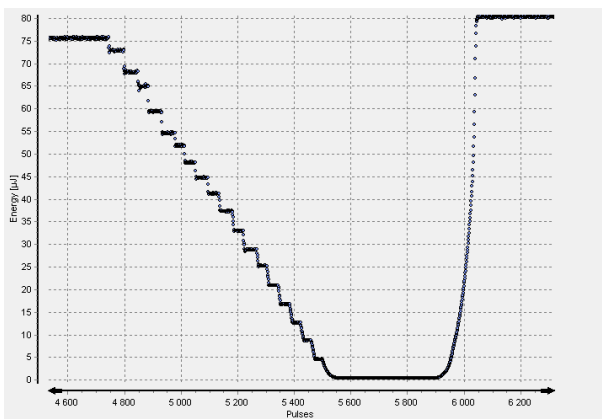
3.4.2 Display options

The record chart provides you with several features. First of all there are different ways to display your measurements.

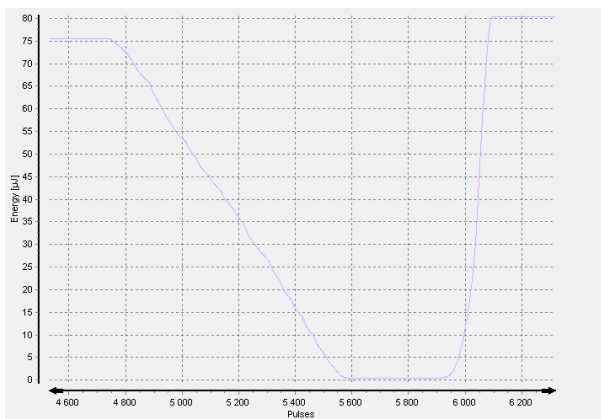
- **Line:** default way of displaying your energy value record



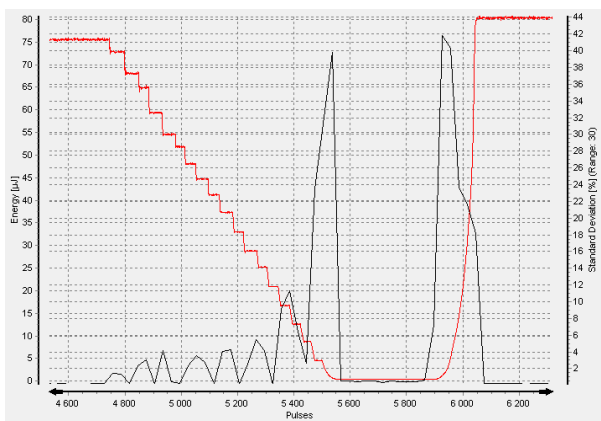
- **Points:** every point represents a single shot




- **Average:** set the options of this line in the *Options* dialog (see 3.3.5)



- **Standard Deviation:** set the options of this line in the *Options* dialog (see 3.3.5). The standard deviation line is black and has its own axis on the right side.

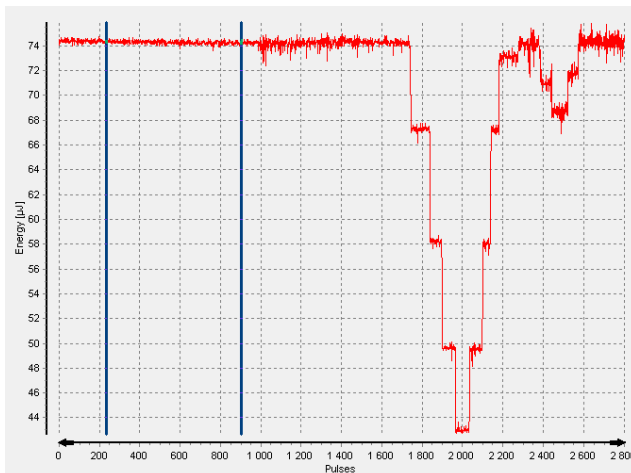


3.4.3 Statistical Information


To display statistical information of your recorded data, there are two cursors in the recording chart. Depending on their position the statistical values on the left side of the main window are being calculated. In case you don't see any cursors click the *Set cursors to min/max* button: 

Now the cursors will be placed at the minimum and maximum values of the x-axis.

Statistic	
First	235
Last	903
<hr/>	
Shots	669
Min	73.6 μJ
Max	74.7 μJ
Mean Energy	74.3 μJ
Deviation	0.18 %



During a running measurement it may be useful to have the right cursor always being placed to the last measured value.

To activate this feature press the *Automatically shift right cursor* button: 

3.4.4 Memory requirements


To start a long term measurement, you have to check that the available physical memory of the computer fulfils the requirements of your experiment. One million data points require 60 MB of physical memory.

For example: To record 5 million data points, you need 300 MB of available physical memory.

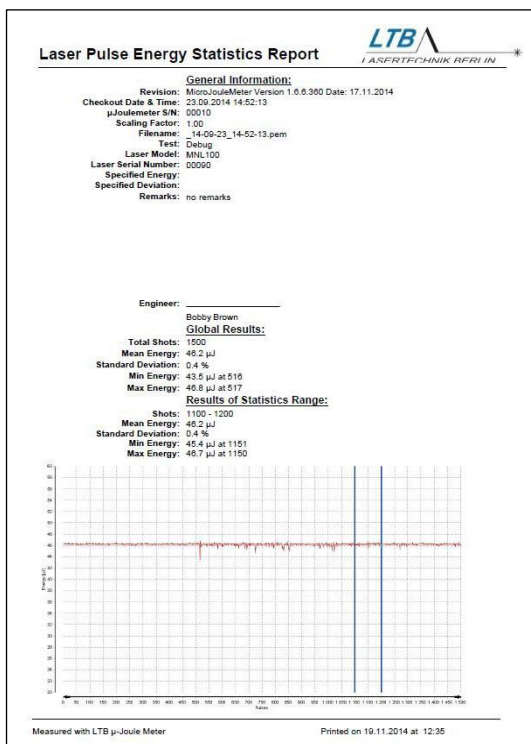
Use the Windows Task Manager to determine how much physical memory is available.

3.5 Printing and Exporting

3.5.1 Measurement report

The software provides you a report generation of your measurement. To generate a report press the print button in the main toolbar: 

The report contains a snapshot of your current recording chart, all information that has been entered, the measurement information window as well as statistical information.



You may select an image file to be included in the upper right corner of the report (see 3.3.5.5 Report Tab).

3.5.2 Export data

The recorded measurement data are saved in a proprietary compressed file format. If you want to use the data in other applications you can export it by pressing the export button in the main toolbar:

You may select from two formats:

- **Text file (.txt)**
The data will be stored as an ASCII file with the file extension *.txt in the following format:
 - first time value; energy value
 - second time value; energy value
 -
- **Excel file (.xls)**
The data will be stored as an Excel file with the file extension *.xls. The exported file will consist of two columns: time and energy values.

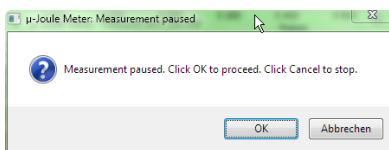
3.6 AutoStop

The auto stop features provide you with the opportunity to automatically stop the measurement after a preset number of shots or to pause measuring. Select either *Stop* or *Pause* and enter a number of shots.

Important: Set this option **before** starting a measurement.

Stop: After a measurement has reached the a preset number of shots it will be stopped.

Pause: After a measurement has reached the a preset number of shots it will be paused until you confirm the proceed dialog.



3.7 AutoSave

If enabled, the μ -Joule Meter software will automatically save your measurements within a preset interval. This is intended to prevent data loss if your computer is accidentally shut down, for example during a power outage.

Set the Autosave interval in the *Options* dialog
(see 3.3.5.4 Measurement Tab).

The data will be saved into a file called *AutoSave.pem* in the directory C:\Users\<USERNAME>\AppData\Local\LTB Lasertechnik Berlin\ μ -Joulemeter.

3.8 Known Bugs

If the software stops responding, you can restart it and load the data file *Autosave.pem*. Please use the options dialog for the setup of the auto-save interval.

4 Appendix

4.1 Specifications

General	Max. repetition rate	Hz	500
	Pulse width	ps - μ s	3 - 50
	Detection threshold	nJ	30
	Measuring ranges	μ J	0.25; 2.5; 25; 250; 500 ***
	Max. peak density	MW/cm ²	10
	Spectral sensitivity	μ m	0.19 - 1.2
	Linearity	%	< 1 *
	Accuracy	%	\pm 4 **
	Calibration wavelength	nm	337 **
	Dynamic range	bit	14
	Sensor area	mm	\varnothing 8
	Nominal voltage	V	5 V DC via USB interface
	Dimensions	mm	100 x 27 x 14.5

Connection to PC	Connector		USB
	Cable length	m	1.7

Environment and conditions of use	Operating temperature	°C	+15...+38
	Storage temperature	°C	-10...+60
	Max. rel. air humidity	%	85
	Air pressure	mbar	750...1300

* for the calibration wavelength range

** customization possible

*** with PEM500

4.2 Maintenance and warranty

The μ -Joule Meter device is maintenance free. The outside of the device can be cleaned with a slightly damp cloth when required. For heavily soiled equipment an ethanol solution may be necessary.

The warranty is valid for 1 year from date of invoice.

4.3 Calibration

The μ -Joule Meter is calibrated; a traceable calibration certificate is part of the delivery.

We recommend calibrating the μ -Joule Meter once per year.

EC Declaration of Conformity

Equipment name/ Model No.: μ -Joule Meter/ PEM 250

Product description: USB-powered energy meter for the measurement of small pulse energies based on the pyroelectric effect. The compact device provides all modules for data collection, handling and storage, parameter setting, software calibration and digitalization.

Manufacturer/ Address: LTB Lasertechnik Bertin GmbH
Am Studio2c
12489 Bertin / Germany
Tel.: +49.30.912075-100
Fax: +49.30.912075-199
E-Mail: info@ltb-berlin.de

European Representative: LTB Lasertechnik Berlin GmbH

Applicable Directives: General Product Safety 2001/195/EC
EMC Directive 2014/30/EU
Low Voltage Directive 2014/35/EU

Applicable Standards: Conformity of this product is based on harmonised Standards:

- Safety requirements for electrical equipment for measurement, control and laboratory use:
DIN EN 61010-1, 3rd Edition
- Electromagnetic compatibility:
DIN EN 6100D-3-2
DIN EN 61000-3-3
DIN EN 61000-5-1
DIN EN 6100D-6--3

We hereby declare that the equipment model series identified above conforms to the specified Directives and Standards. CE marking was first affixed in 2009.



Christian Scholz
(CEO)