PULSE CHECK

AUTOCORRELATOR

Ser.-No. S01547-07A3

PulseCheck

Manual

APE - Angewandte Physik& Elektronik GmbH
www.ape-berlin.com ape@ape-berlin.de

Plauener Str. 163-165 Haus N 13053 Berlin Germany Phone +49 (0)30 98601130 Fax +49 (0)30 98697885

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1. Description

The autocorrelator PulseCheck consists of two components: an optics unit and a control electronics unit shown in Fig. 1 and 2. The optics unit comprises a Michelson-interferometer, the delay unit, the interaction unit (SHG unit) and the detector module. The control electronics unit comprises the necessary drivers and amplifiers, the display and the power supply.

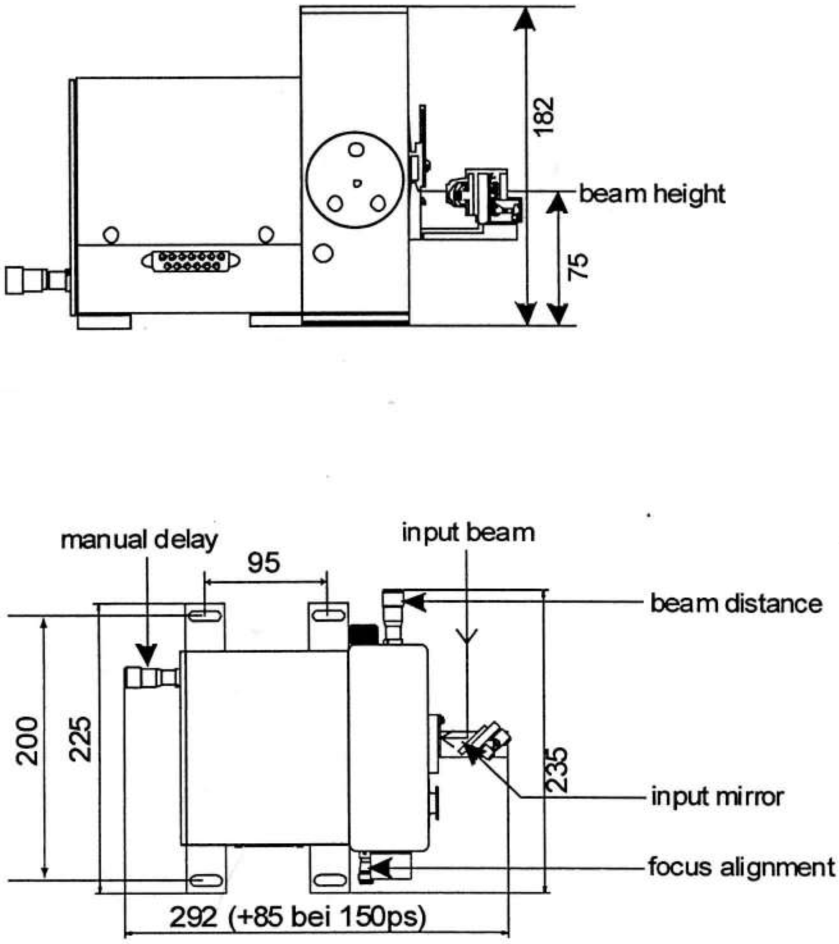


Fig. 1 Optics Unit

The front panel of the control unit is shown in Fig. 2a. There are the power switch and the push buttons for controlling:

- the menu buttons MAIN and RETURN
- the cursors „< / CURSOR / >“
- the phase matching angle „TUNING + / -“,
- the scan range „SCAN RANGE + / -“,

as well as

- 6 soft keys to the right side of the display (their function corresponds with the squares shown at the right hand side of the display which depend on the currently chosen menu),

as well as

- the „GAIN“ - tuning knob and

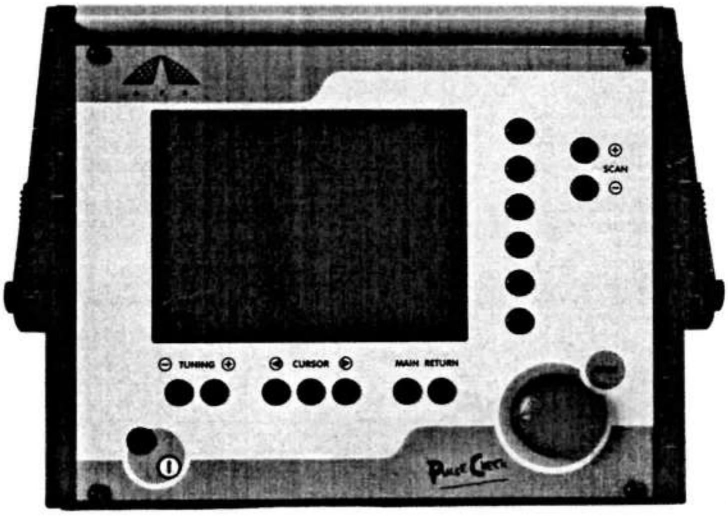


Fig. 2a Control Electronics Front Panel

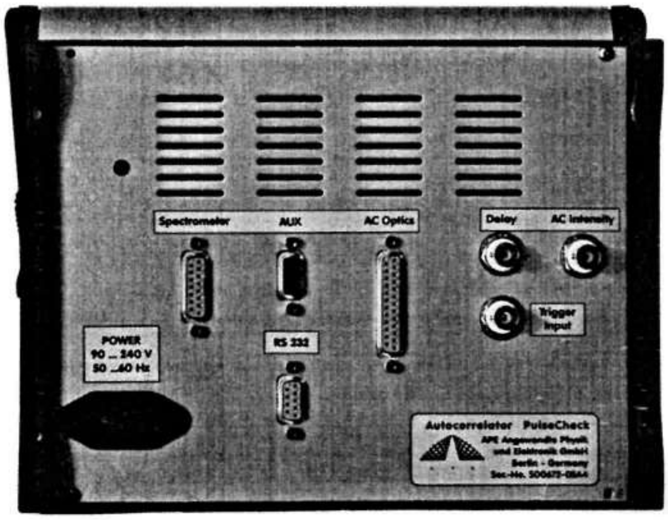
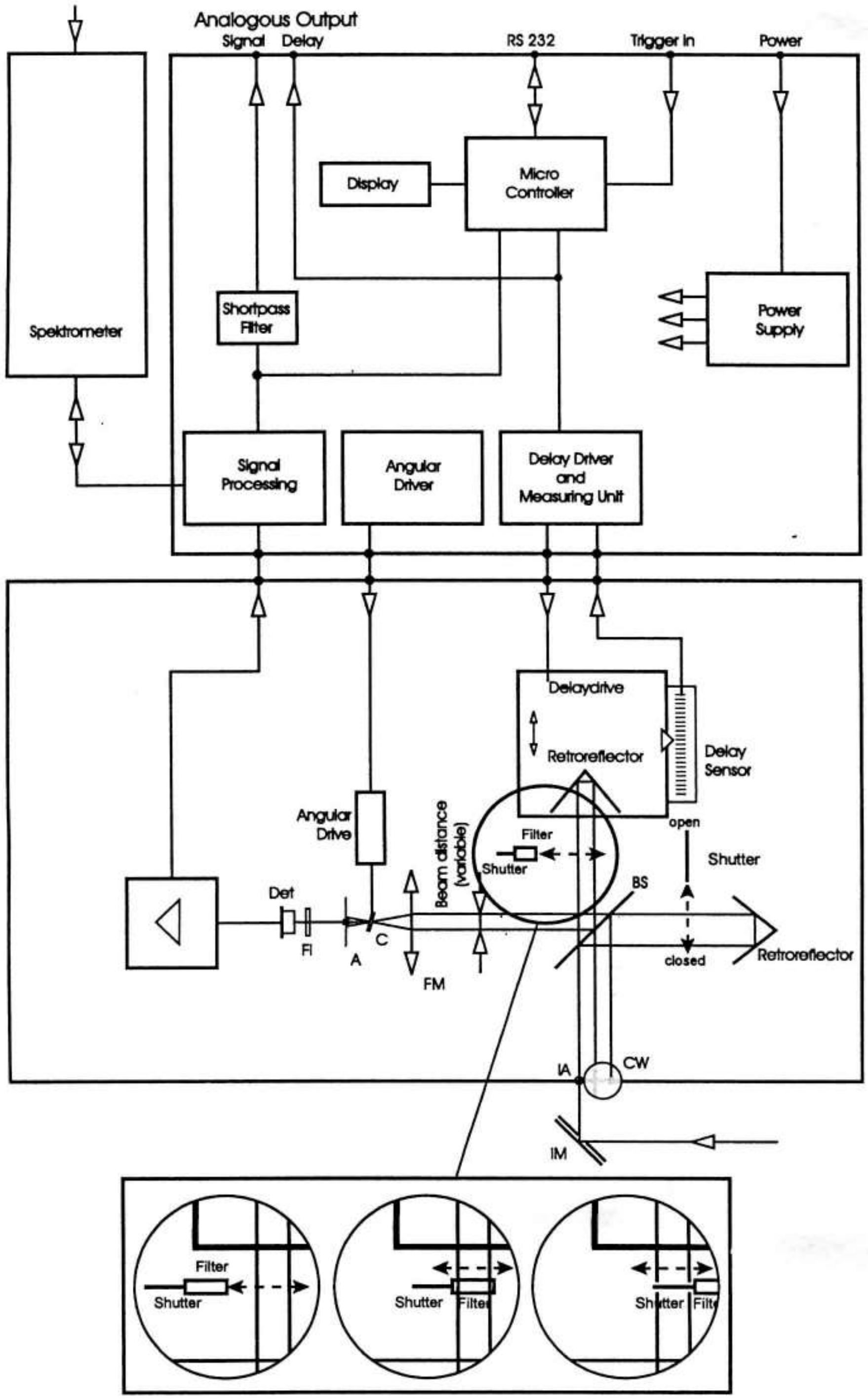


Fig. 2b Control Electronics Rear Panel

At the rear of the unit are the power connector, the connector for the autocorrelator optics unit (25-pol Sub-D), a serial interface (9-pol Sub-D), two linear signal outputs for an oscilloscope (BNC-connectors), the TRIGGER input (BNC connector) and the connector for the spectrometer (15-pol Sub-D). In case of a stepper motor driven autocorrelator, there is an additional connector (7pin-circular) for connecting the stepper drive.

In Fig. 3 the principal optical layout and the main electronical modules are shown schematically.



IM	Input Mirror	FM	Focus Mirror	Det	Detector
IA	Input Aperture	C	SHG-Crystal	CW	Control Window
A	Aperture	BS	Beam Splitter	Fi	Filter

Fig. 3 Optical Layout Scheme

Entering the optical assembly at the input aperture, the laser pulse is divided into two parts at the beamsplitter. Each part traverses an interferometer arm containing a retroreflector. One of the retroreflectors is mounted on a special linear translation stage that can change the length of one interferometer arm in a continuous fashion. The two replica pulses are then recombined by the beam splitter, focussed by a mirror, and overlapped in a nonlinear optical crystal. Light generated in the nonlinear crystal is then detected by a filtered photomultiplier tube.

A fraction of the back-reflected beams can be seen on the window next to the input aperture and is used for alignment of the beam into the autocorrelator.

The displacement of the scanning retroreflector is measured online by an analog position measuring system. This signal is used for the stabilization of the scan amplitude according to the currently set scan range. Both measured signals (SHG intensity, delay position) are transmitted to the control electronics where they are amplified and filtered. They are available at analog outputs (BNC-connectors at the rear panel) to be displayed as ACF on an oscilloscope in X-Y-mode.

Within the control electronics these signals are digitized, stored and processed; the ACF and other extracted parameters are now displayed on the LCD screen.

A trigger mode allows for data acquisition at defined times synchronously with a trigger pulse instead of running in a continuous routine (triggered mode for low repetition rate lasers).

The ACF, the measuring conditions and the calculated parameters can be transmitted to a PC via a serial interface, so that the autocorrelator can be remote controlled with a PC (see also Appendix).

2 Specification

Optical parameters:

Version	15	50	150
Max. scan range	15 ps	50 ps	150 ps
Delay resolution	<1 fs	2 fs	< 6 fs
Min. pulse width	50 fs	50 fs	120 fs
Max. pulse width	3.5 ps	12 ps	35 ps
Scan frequency (approx.)	13 Hz	10 Hz	7.5 Hz
	(Slow scan optional)		

Linearity distortions	< 1 %	
Input polarisation	E horizontal (polarisation rotator optional)	
Standard wavelength ranges	VIS I	420 ... 550 nm
	VIS II	540 ... 750 nm
	NIR	700 ... 1100 nm
	IR	1000 ... 1600 nm
	(other ranges optional)	
Sensitivity (P_{AV}*P_{PEAK})	< 10^{-4} W^2 (PMT), 1 W^2 (PD)	
	(PMT: HighSensitivity < 10^{-6} W^2 optional)	
Input beam height	75 mm (FC connector optional)	

Electrical parameters:

Power supply		95 ... 264 V / 50 ... 60 Hz
Outputs	Delay	0 ... 10 V analog
	AC-intensity	0 ... 10 V analog
		serial interface RS232
Trigger input		TTL, ≤ 10 kHz

Mechanical parameters:

Sizes (L x W x H)	
- Optics unit	292 x 235 x 182 mm^3
- Control electronics box	295 x 272 x 176 (max. 249) mm^3
- Spectrometer module	
CCD	172 x 106 x 45 mm^3
Spinning grating	205 x 155 x 70 mm^3
Position of micrometer screw	
Delay „0“ position	...7,00...
Beam distance, collinear	...0,70...
Beam distance, non-collinear	>3,00...
Focus position	...5,42...

3. Installation and Alignment

In case that the device has been exposed to low temperatures for a long time it is recommended to keep it at moderate temperatures for some hours.

If you have purchased more than one optics sets make sure that the one fitting your laser wavelength range is mounted. If not, install the desired optics set as described below. The SHG crystal is packed separately and must be installed in any case before first measurement.

The optics unit is secured by a transportation screw. After unpacking the PulseCheck parts please remove screw (1) and replace with cover pin (2). **ATTENTION!** Before any further transportation the transportation screw has to be attached to the optics unit again.

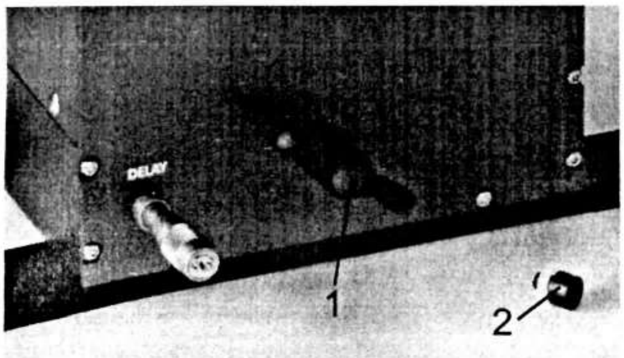


Fig 4a Transportantion screw

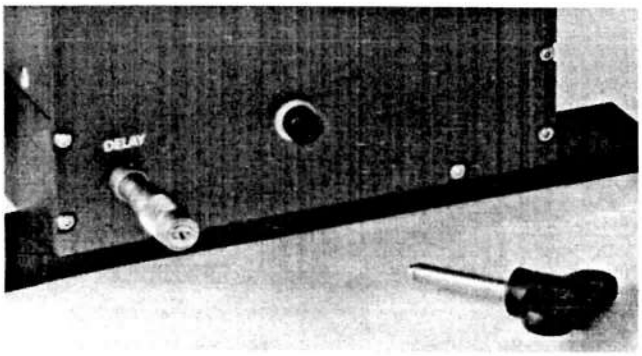


Fig 4b Cover pin

3.1 Mounting / Exchange of SHG crystal

At delivery of the autocorrelator the crystal module (crystal and holder) isn't installed in the optics unit, but comes in a separate box to protect it from damage. It has to be installed before first operation. It may also be necessary to exchange the crystal module, if you need to work in a different wavelength range.

- Switch off controller
- Open crystal lid (pull)
- In order to exchange crystal module, pull it out (as the crystal module is delivered separately, this is not necessary for first time mounting)
- Insert crystal module (ensure slot on crystal module fits into pin of retainer)
- Replace crystal lid
- Start controller and execute angle calibration (correlator menu-> utility-> setup -> calib. alpha)

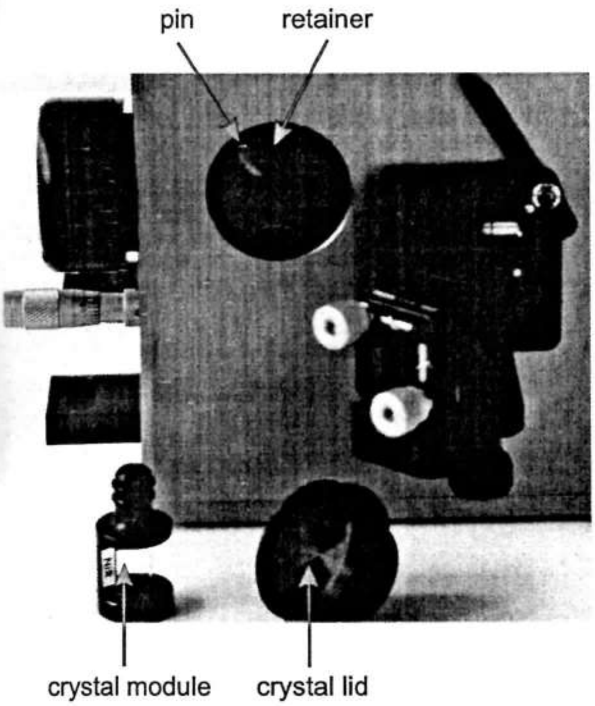


Fig. 5a Optics unit and crystal

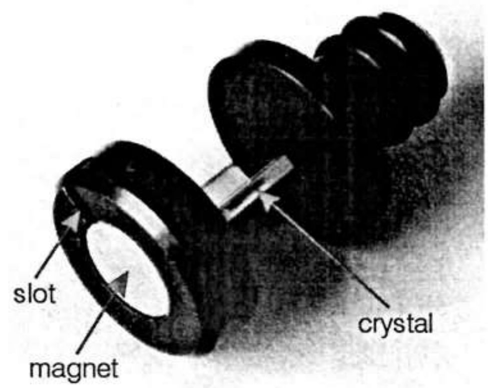


Fig. 5b Crystal module

3.2 Exchange of Detector Unit

Caution! Don't expose the PMT to light!

- Remove top cover (knurled screws),
- Remove the detector unit (hook off bracket and pull up detector block),
- Unplug the electrical connector,
- If using the PMT detector, disconnect the current PMT from power supply, and exchange with the PMT suitable for the respective wavelength range,

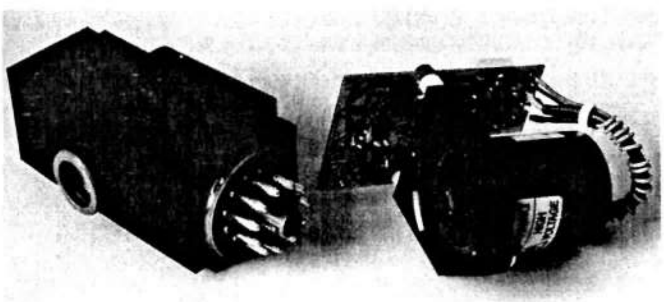


Fig. 6a PMT detector module consisting of PMT (with housing)

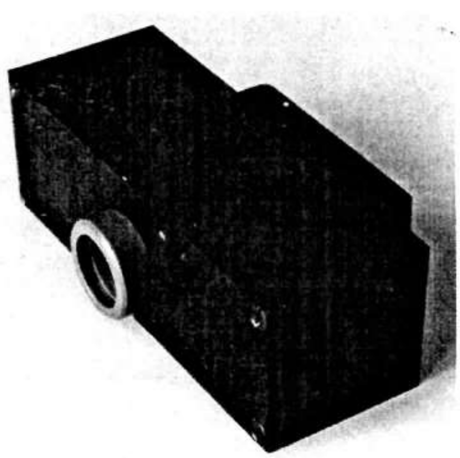


Fig. 6b Photodiode detector module (one piece) and power supply

- Plug in the detector unit and insert it into the autocorrelator till the bracket snaps in,
- Remount top cover.

3.3 Alignment

- Fasten the optics unit at your optical table and position the electronics unit at a place where you can comfortably handle the control elements and watch the display,
- Connect optics unit and control electronics with cable (25-pin Sub-D) and spectrometer module and electronics with cable (15-pin Sub-D).
- Switch on device. For measuring a low repetition rate laser system (< 1kHz) transmit a trigger signal from the laser to the trigger input „TRIGGER“ at the front panel of the electronics unit,
- Select the acquisition mode ("Trigger" for low rep rate systems or "Free Run" for high rep rate systems) by successive pressing of „CORR MENU“, „ACQUISITION“, „FREE RUN/TRIGG“ and „EXIT“,
- Set „GAIN“ to the minimal value and „SCAN RANGE“ to „ZERO SCAN“,
- Use appropriate optics (e.g. glass plate, beam splitter) to direct a part of the laser beam to be measured to the center of the input mirror (depending on the beam diameter you either close or open beam aperture; see fig. 7); check that the input polarization is horizontal (see 7.2.) and the divergence is small,

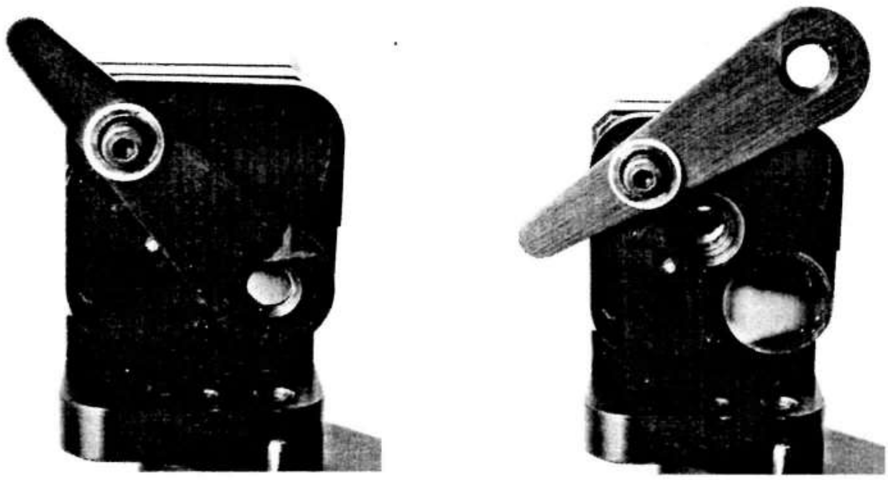


Fig. 7 Beam Aperture - closed for 3mm beam diameter; open for 6mm beam diameter

The next three steps are only applicable in case of free space beam!

- Pivot alignment aperture in front of the input aperture (after adjusting the beam, the alignment aperture has to be brought back into the original position in order not to disturb measurement, see fig. 8 a and b,

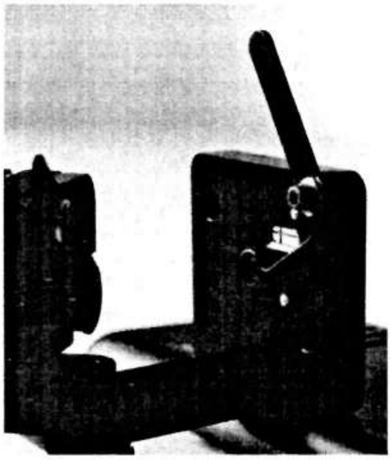


Fig. 8a Alignment aperture - adjustment position

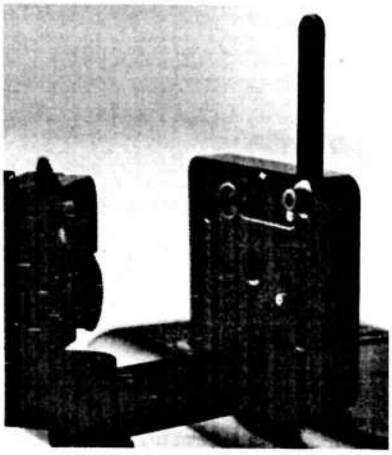
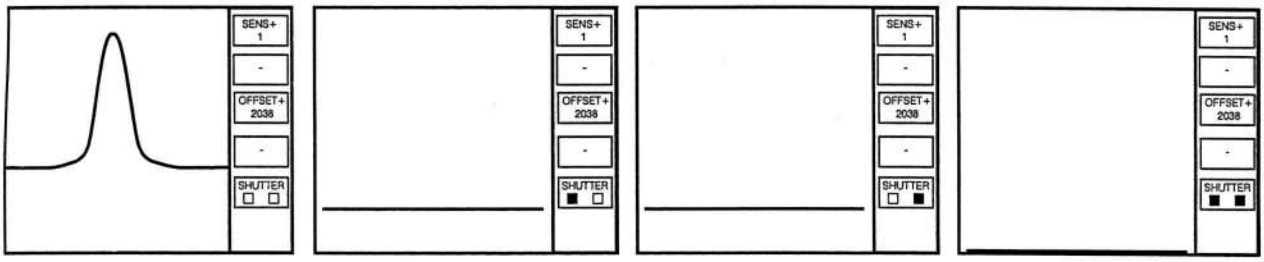


Fig. 8b Alignment aperture - measurement position

- Align the input mirror to have the beam enter the device through the input aperture,
- Adjust the back reflection on the cross-hairs at the window. If there are two back reflections (non-collinear case) they can be united (collinear case) by turning the „BEAM DISTANCE“ screw in order to find the signal more easily,
- Check if the focus slide is at center position (see chapter 2) and correct if necessary,
- Check if the delay slide („DELAY“) is at the „0“ position (see chapter 2) and correct if necessary,
- Slowly increase „GAIN“ up to a clear noise of the blue coloured ACF (if necessary increase display sensitivity),
- Find the optimal phase matching angle indicated by a clear angle sensitive amplitude maximum by tuning the SHG crystal (keys „TUNING“ „+“ or „-“), ,
- Check beam alignment: by repeatedly pressing the „Shutter“ key first close one shutter then the other one (correlator menu -> sensitivity ->shutter), both times the SHG signal should go down to half; close both shutters, the SHG signal goes down to zero,



Shutters open | Shutter 1 closed | Shutter 2 closed | Both shutters closed

Fig. 9 Shutter related signal behaviour

- In case of overload (cut ACF peak, signal output > 10 V) „GAIN“ and/or input power has to be reduced,
- Optimize the SHG signal by optimizing focus (adaption to beam divergence),
- For the measurement of a collinear ACF skip the next four steps,

- Increase the beam distance to approx. 5 mm (check in control window); the moving spot has to be on the right hand side of the static one,
- At the same time the SHG signal should be continuously optimized by focussing, tuning and gain,
- Check beam alignment: first close one shutter then the other one (correlator menu -> sensitivity ->shutter), both times the SHG signal should go down to zero level as it does in case of no phase matching,
- If this is not the case, check and correct beam alignment:
• Beam position at input mirror and cross-hairs
• Focussing
• Phase matching,
- Set „SCAN RANGE“ to the expected pulse duration,

3.4 Autocorrelator with Fiber Connector (optional only)

On autocorrelators with fibre input the control window is replaced by a monitor diode located at the back reflection of the interferometer. This monitor diode has a polarizer on top to detect the light intensity with the „right“ polarisation (E-horizontal) only.

When connecting the monitor diode to an oscilloscope with the supplied cable one can display the intensity of the incoming light. To optimize the autocorrelation efficiency one has to maximize the diode signal (fibre coupling, fibre bending for optimal polarization). To avoid saturation at high signal levels (U > 0.2 V) it is necessary to connect a resistor parallel to the oscilloscope input.

The fibre connector and the input mirror (free beam, see 3.3) are exchangeable. Unscrew the fixing screws of the respective mounted input module and exchange modules. Use the pins for the correct positioning of the respective module.

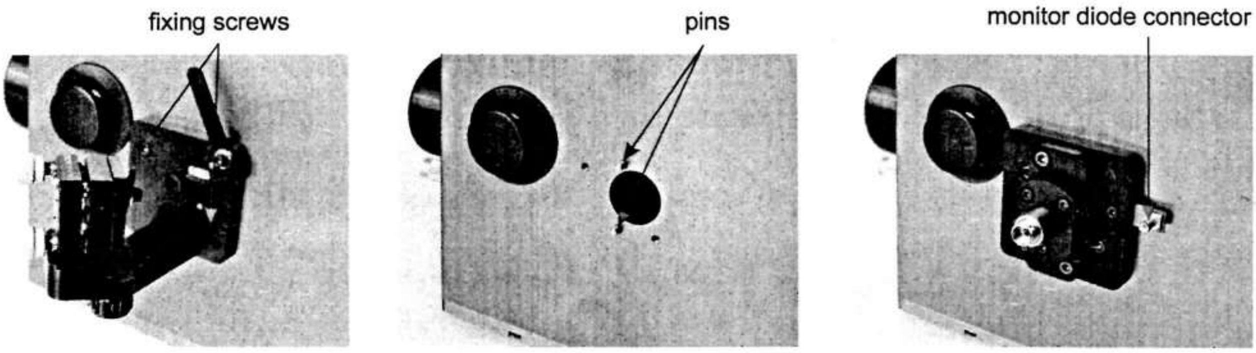


Fig. 10 Exchange of input mirror and fiber collimator

3.5 Spectrometer

To display the spectral function (red curve) make sure that the spectrometer is activated („**DISPLAY MENU**", „**ACF+SPEC**" or „**SPEC**")

3.5.1 CCD- Spectrometer

- Arrange the spectrometer in correct beam height,
- Put the spectrometer on the optical table and reflect a part of the measured laser beam or some stray light to the spectrometer input,
- Set „**INT TIME**" and „**RESOL**" to 1, optimize the amplitude of the spectral function by a careful fine alignment of the spectrometer input beam or the spectrometer position,
- At over load, increase distance to stray light source,
- No or weak signal: increase „**INT TIME**" (**attention:** adjust slowly, because display refresh rate is reduced) and/or reduce distance to stray light source,
- If there is no spectral function, check the actual wavelength of the laser and compare with spectral range of the spectrometer (see specification),
- For detailed spectral function (zoom), activate the control cursor with „**CURSOR**" and „**WINDOW SPECTRUM**" and overlap cursor with the spectral peak. Spread the spectral display area by using the keys „**RESOL**" and „+".

3.5.2 Spinning Grating-Spectrometer

- Arrange spectrometer to the correct beam height, adjust horizontal and fix the two front feet on the optical table,
- Reflect by the means of a beam splitter or glass sheet a part of the measured laser beam to the middle of input focussing lens. Make sure, that the input beam is nearly perpendicular to the front panel of the spectrometer.
- Release one of the front feet an rotate the spectrometer horizontal until the focussed beam entered the input slit. Observe (if necessary use an IR-viewer):

  a) check the window at the right side of spectrometer (a horizontal line has to appear) or
  b) directly at the slit or
  c) with „**GAIN**" max and „**RESOL**" 1 directly at the screen

- Fixing both front feet again,
- Switch „**GAIN**" to max and „**RESOL**" to 1 and optimize spectral function by tilt the spectrometer (rotating the rear foot),
- It is possible to fine adjust by moving the input beam at the focussing lens (tilt reflecting part before the spectrometer)

4. Routine Operation

- Switch on autocorrelator,
- control alignment at cross-hairs,
- measure ACF,
- if changing the wavelength, realign phase matching angle (if necessary also focussing and „GAIN")

5. Handling

5.1 Common Description

The scan range „SCAN RANGE +/-", the gain „GAIN", the phase matching angle „TUNING +/- " and the cursors „< / CURSOR / >" and switching back to the main menu or the preceding menu (MAIN and RETURN are controlled directly with the corresponding buttons on the front panel (see Fig. 2a). For applying the trigger signal from the laser necessary for an operation in the sampling-mode the „TRIGGER" input (BNC connector) on the back panel is used.

All other functions are menu-controlled. Fig. 11 shows an overview of the whole menu structure which is controlled using the 6 soft keys at the right side of the display. Framed texts indicate active commands, texts without frames are for information only.

In chapter 5.2 the menus, their functions and their operation are described in detail.

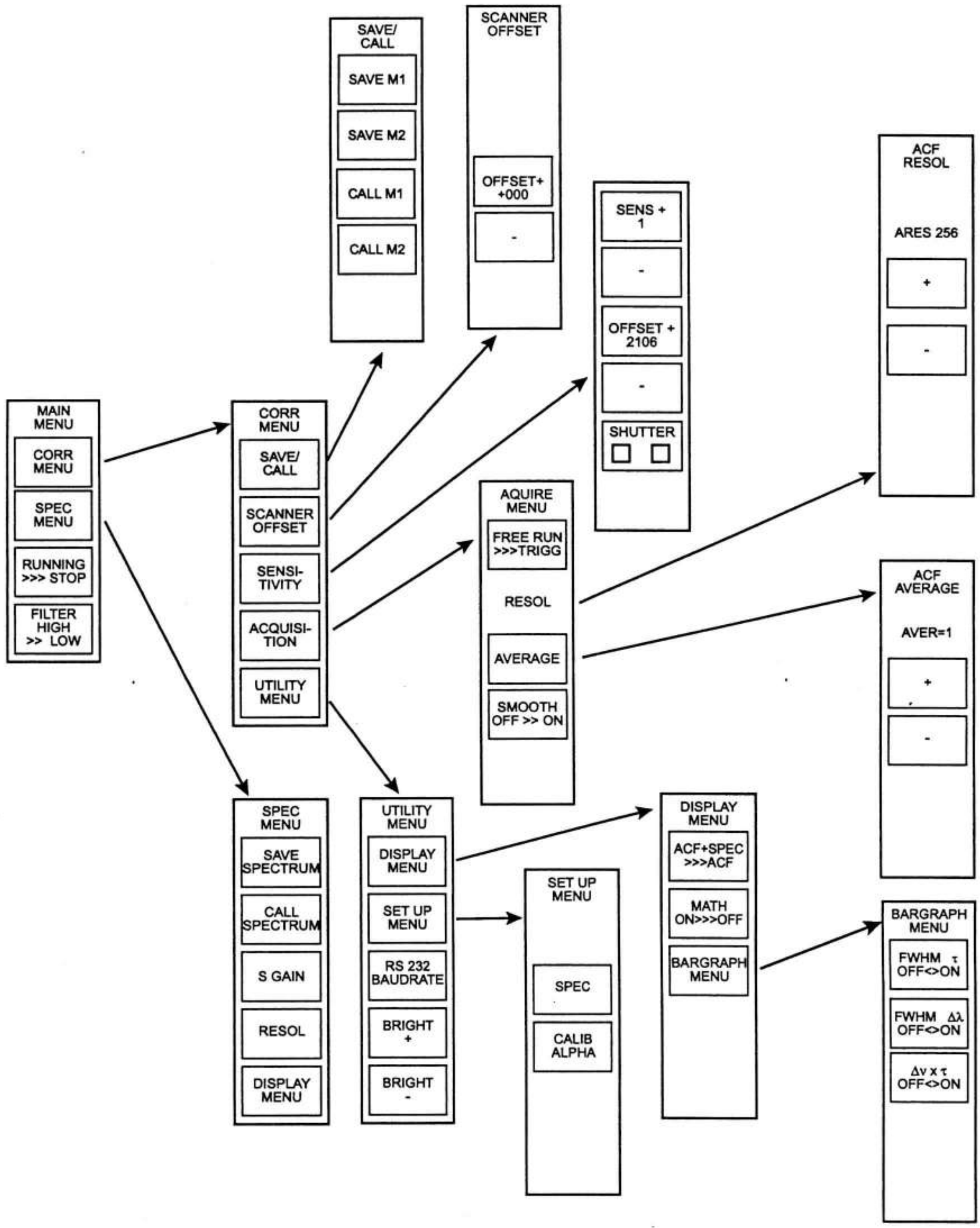


Fig. 11 Menu Structure

5.2 Control Menus

After switching-on and passing the initial routine the autocorrelator starts with the last set of measuring parameters and the main menu (Fig. 12) with the actual detector signal being displayed.

5.2.1 Main Menu

Pushing the corresponding keys
- the autocorrelator menu is activated,
- the spectrometer menu is activated,
- the measurement is stopped or started,
- different filter values for the AC signal channel are selected.

At the lower right corner of the display the actual parameters are shown:
- Scan range,
- Data acquisition mode,
- Correlator sensitivity / Correlator gain (arbitrary units),
- Average number,
- Crystal tuning angle (arbitrary units).

If activated (see display menu) the measured data ACF half width (FWHM) is displayed on top of the display.

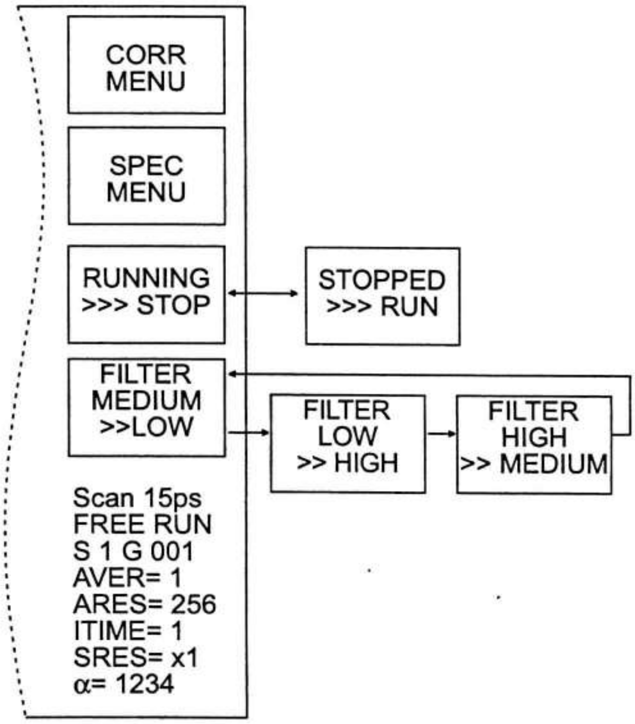


Fig. 12 Main Menu

5.2.2 Correlator Submenus

5.2.2.1 Correlator Basic Menu

By pressing the corresponding key one of 5 submenus can be selected:

SAVE/CALL - Control of ACF memory,
SCANNER OFFSET - Control of delay zero position,
SENSITIVITY - Control of signal amplification
ACQUISITION - Control of data acquisition mode,
UTILITY MENU - Control of basic settings.

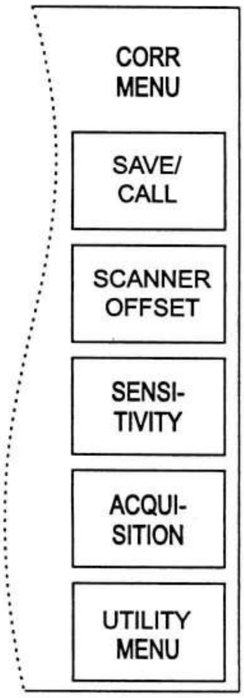


Fig. 13 Correlator Basic Menu

5.2.2.2 Correlator Save/Call Menu

The controller features two memory places for ACF traces. With the Save/Call function the ACF Memory can be controlled. “SAVE M1 / SAVE M2” saves the current ACF to memory M1/M2. “CALL M1 / CALL M2” displays the saved ACF of M1 / M2, while measurement is stopped.

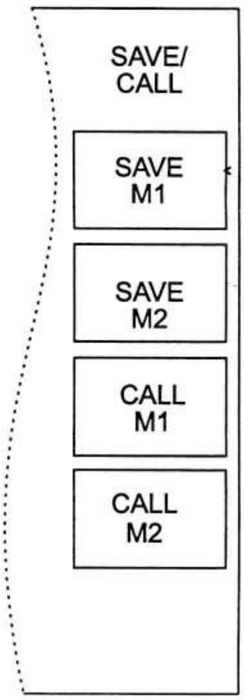


Fig. 14 Correlator Save/Call Menu

5.2.2.3 Correlator Scanner Offset

With autocorrelators without manual delay , e.g. the 150ps version the center position of the scanner can be adjusted via the scanner offset menue. This causes a time shift of the ACF in the measurement window. The Offset value can be set from -300 to +300, there the 0 (no offset) corresponds approximately with the interferometer zero position.

5.2.2.4 Correlator Sensitivity

With the „SENSITIVITY"-function the signal amplification can be varied independently from the „GAIN"-function. By pressing the „+" or „-" key the sensitivity is increased or decreased by a factor of 3 in the range of 1 to 30. At devices with high sensitivity option this range is extended up to a factor of 300.

Also, in this menu the signal offset can be set. The signal offset adds an electronic offset to the measured AC-signal. This offset moves the ACF vertically on the screen. For zero offset compensation close both shutters and bring the signal line with the "+" and "-" offset key near to zero level. Make sure that the signal is not negative. Do not forget to open both shutters before continuing measurement.

With the shutter key both interferometer arms can be blocked independently. The shutter state is symbolized by two squares on the display (black square -> shutter closed, white square -> shutter opened). Successive pressing of the shutter key will switch between

shutter 1	shutter 2
1 open	open
2 closed	open
3 open	closed
4 closed	closed

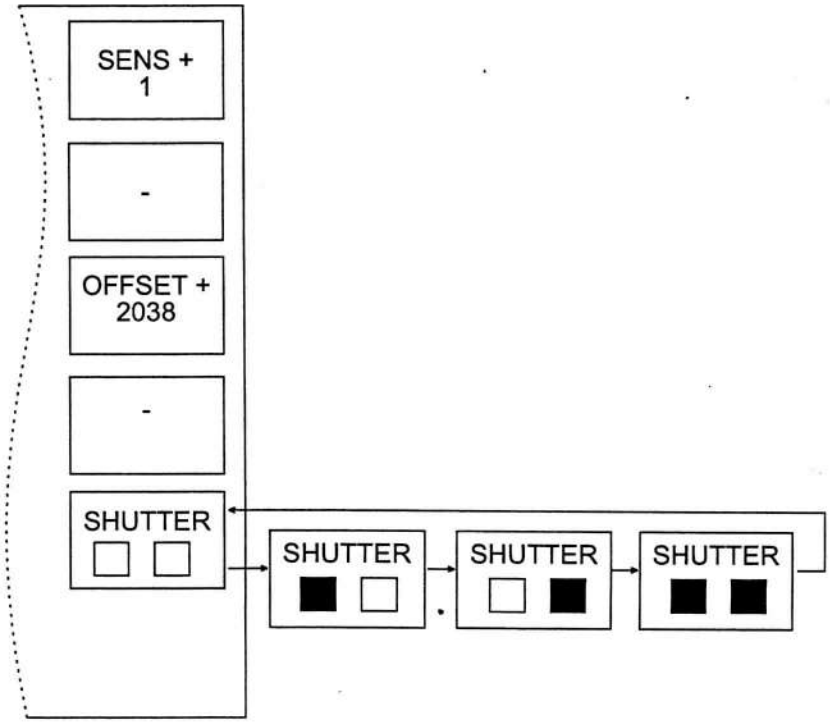


Fig. 15 Correlator Sensitivity

5.2.2.5 Data Acquisition Menu

With the „ACQUIRE MENU“ you can control:

- Measuring modes (FREE RUN for high repetition rates, Trigger for repetition rates < 5 kHz, FRINGES for envelope function for fringe resolved ACF, optional: slow scan for high sensitivity or very low repetition rates < 100 Hz),
- Delay resolution (for reducing measuring time at low repetition rates),
- Signal averaging and Smooth function (for smoothing noisy signals).

The measuring mode is selected with the „FREE RUN >>> TRIGG“ key. In the untriggered mode („FREE RUN“, optional „SLOWFREE“) the ACF data is measured continuously with the maximum acquisition rate and displayed and refreshed immediately. In the triggered mode („TRIGGER“, „SLOWTRIG“ optional only) the delay and signal values are measured, digitized and saved only synchronously to an electrical trigger pulse from the measured laser applied at the trigger input. These pairs of measured data are superposed until a complete ACF is displayed. Caution, in this mode there is no ACF measurement without trigger pulse!

The „FRINGES“-mode (not at stepper devices) is a special function to display fringe resolved ACFs. While acquiring with maximum rate, this mode detects the maximum and minimum AC signal value of each delay channel in order to display the envelope of the sinusoidal modulated collinear ACF. Caution, this acquisition routine takes some time! For tuning the phase matching in this mode, it is recommended to switch to zero scan.

The „SLOWFREE“-mode (HighSens option only) combines a high data acquisition rate with drastically reduced scan speed (SlowScan) for an improved noise suppression by extended low pass filtering and strong averaging.

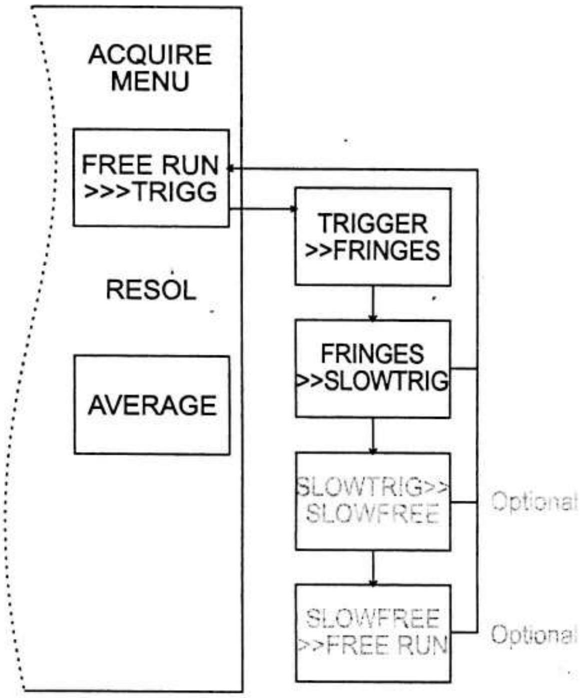


Fig. 16 Data Acquisition Mode

5.2.2.6 ACF Resolution (in Trigger and Fringes Mode only)

With the „ACF RESOL"-function the delay resolution can be reduced for a faster, but more inaccurate measurement in the trigger or fringes mode. By pressing the „+" or „-" keys the resolution is increased or reduced by a factor of 2 in the range of 256 to 32. To compensate for the aliasing of the ACF you can apply Smooth (see chapter 5.2.2.8)

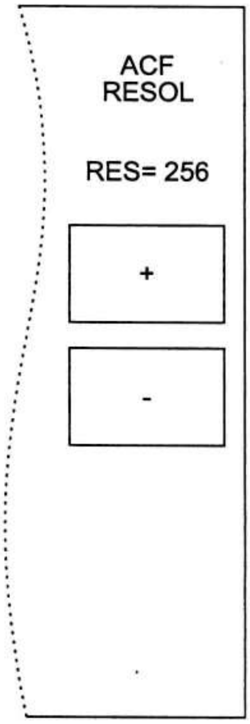


Fig. 17 ACF Resolution

5.2.2.7 ACF Averaging

With the „AVER"-function the ACF can be averaged over n cycles. The displayed number n is the inverse weight. The laset measured data is influencing the actually displayed ACF. The refreshing rate of the display is decreasing correspondingly. The average number is increased or decreased by a factor of 2 by pressing „+" or „-"-key.

By pressing the „EXIT" key the device is set back to the main menu.

There are two different average modes at stepper motor driven autocorrelators „local" and „nx Scan". In the „local" mode the autocorrelator collects n data values at each position and calculates the local before going to the next delay position. This causes a reduced scan rate. In case of the „nx Scan"-average mode the autocorrelator scans with constant rate and averages over the last n scans.

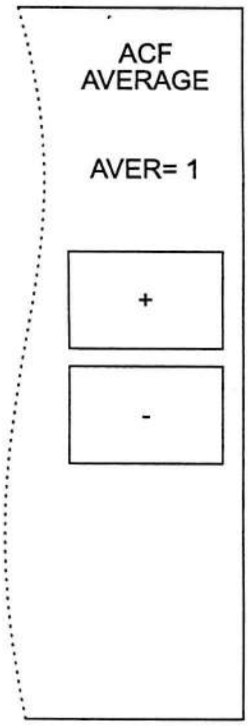


Fig. 18 ACF Averaging

5.2.2.8 ACF smoothing

With the „SMOOTH“ function each data point will be averaged with its neighbour points. This is a fast algorithm for reducing noise. By pressing the “SMOOTH” key the smooth function can be switched on or off.

5.2.3 Spectrometer Submenus

Because of different spectrometer types used at the ***PulseScope***, the spectrometer menus are slightly different. Therefore the next paragraph is split for the two spectrometer versions CCD and spinning grating.

5.2.3.1 Spectrometer Basic Menu

CCD version   Spinning grating version

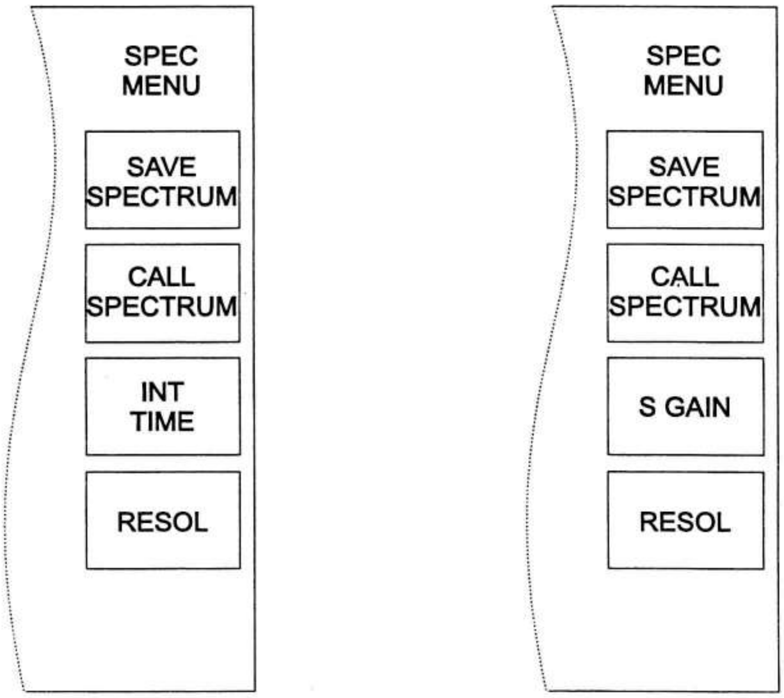


Fig. 19 Spectrometer Basic Menu

By pressing the corresponding key one out of 5 submenus can be selected:

SAVE SPECTRUM	Saving the displayed spectrum,
CALL SPECTRUM	Displaying the saved spectrum while the measurement is stopped,
INT TIME / SGAIN	Changing the integration time (sensitivity) or gain of the spectrometer,
RESOL	Changing the width of the displayed spectrum (zoom),
DISPLAY MENU	Control of data display.

5.2.3.2 Integration Time (CCD)

With the **„INT TIME"**-function the sensitivity of the spectrometer can be changed by a variation of its integration time. By pressing the „+" or „-" keys the integration time can be increased or reduced by a factor of 2, respectively.

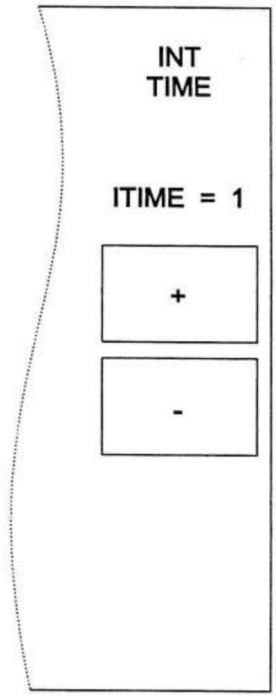


Fig. 20 Integration Time

5.2.3.3 Gain (Spinning Grating)

With the ***„SGAIN"***-function the sensitivity of the spectrometer can be changed by a variation the internal signal amplification. By pressing the „+" or „-" keys the sensitivity can be increased or reduced by a factor of 10, respectively.

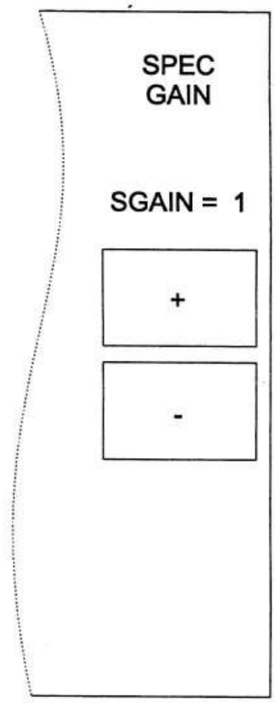


Fig. 21 Gain

5.2.3.4 Resolution (CCD)

With the **„RESOL"**-function the width of the displayed spectrum and with this the spectral resolution can be varied. By pressing the „+" or „-" keys it is increased or reduced by a factor of 2, respectively. The value of **SRES** = nn indicates the width of the displayed interval in nn nanometers (zoom factor 2 ... 8).

For shifting the zoomed part of the spectrum is to be displayed the cursor function **„WINDOW SPECTRUM"** is used, which is activated within the cursor menu (s. 3.2.4.3).

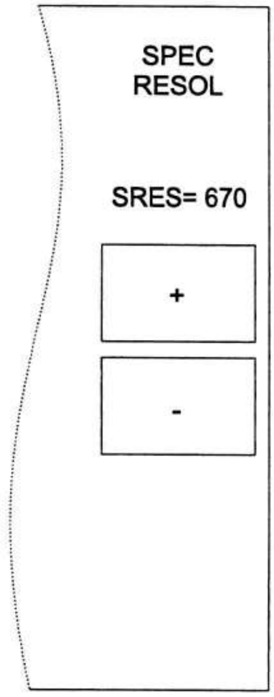


Fig. 22 Resolution (CCD)

5.2.3.5 Resolution (Spinning Grating)

With the **„RESOL"**-function the width of the displayed spectrum and with this the spectral resolution can be varied. By pressing the „+" or „-" keys the pixel number of it is increased or reduced by a factor of 2, respectively. The value of **SRES** = nn indicates the actual zoom factor (2 ... 127).

For shifting the zoomed part of the spectrum is to be displayed the cursor function **„WINDOW SPECTRUM"** is used, which is activated within the cursor menu (s. 3.2.4.3).

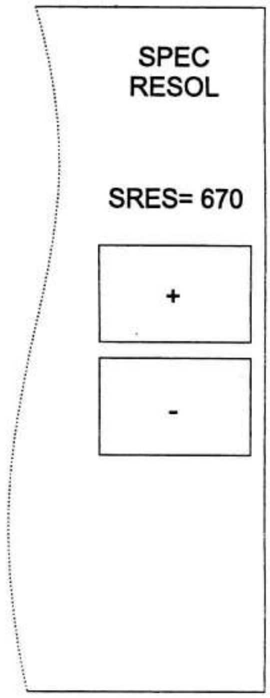


Fig. 23 Resolution (Spinning Grating)

5.2.4 Utility Menu

The UTILITY MENU controls basic settings of the display (shown elements and brightness), interface baudrate and crystal angle centering.

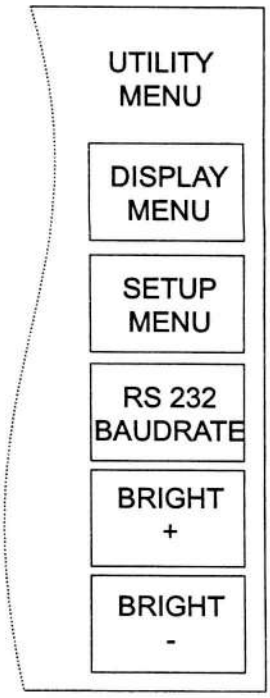


Fig. 24 Utility menu

5.2.4.1 Display Menu

The „DISPLAY MENU“ is used for controlling the displayed functions and parameters. With this the FWHM calculation can be switched on or off and a bargraph menu can be selected.

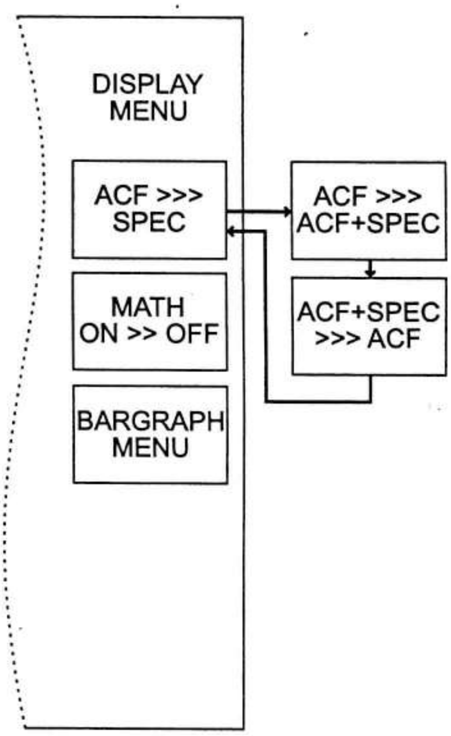


Fig. 25 Display Menu

The BARGRAPH MENU is a submenu of the DISPLAY MENU. It is used to switch on and off a bargraph which displazs the actual ACF half width. When a spectrometer is connected the spectral bandwidth and the time-bandwidth product can be displayed as well.

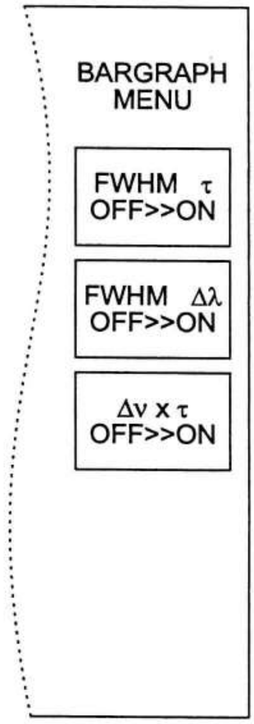


Fig 26 Bargraph menu

5.2.4.2 SET UP Menu

Several basic device specific settings can be adapted in this menu. SPEC is used for adjustiong the signal offset to zero.

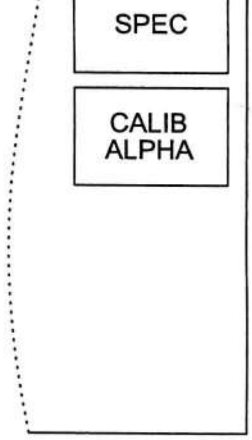


Fig 27 SET UP menu

It is recommended to use the submenu CALIB ALPHA after mounting or exchanging the crystal to ensure the crystal angle is correct. The crystal is brought to zero angle position, where a step counter is reset. The angle value is measured in relation to this point. After this, the crystal angle is automatically tuned back to the former value.

5.2.5 Cursor Control

5.2.5.1 Cursor Selection Menu

The **„CURSOR MENU“** which is started independently of the actual menu by pressing the middle **„CURSOR“** button below the display controls the cursors. These cursors are used for manual measurements of the curve parameters alternatively to the automatic readout and moreover for the shifting the zoomed display area of the spectral function.

By pressing the keys **„ACF $\Delta\tau$“** or **„SPECTRUM $\Delta\lambda$“** the cursors for the corresponding function are activated (see 3.2.4.4). By pressing the key **„WINDOW SPECTRUM“** a vertical green cursor is displayed, which indicates the centre of the currently displayed spectral region (λ_0= nn nanometers) and which can be shifted by pressing the „<“ and „>“ keys. Activating the cursors suppresses the display of the automatically measured parameters.

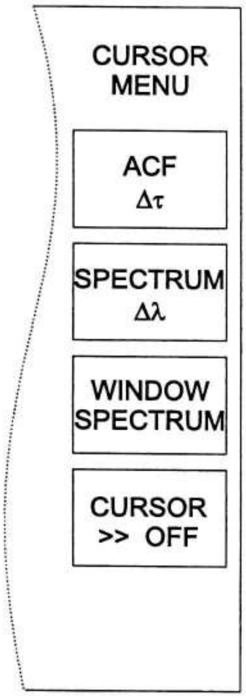


Fig. 28 Cursor Basic Menu

5.2.5.2 Cursor Control Menu

After the activation of the cursors **„ACF $\Delta\tau$“** or **„SPECTRUM $\Delta\lambda$“** a new menu appears and 3 horizontal and 2 vertical green lines are displayed with one of them marked by higher intensity. This one is the cursor which can be moved with the **„CURSOR </>“**-keys below the display. By pressing the corresponding keys **„HOR 1/2“** and **„VERT 1/2“**, the active cursor can be changed. The third horizontal line in the middle shows the half amplitude between the lower and the upper horizontal cursors. When they are set to the peak and the background level of the ACF or the spectrum the crossings of the half amplitude cursor with the corresponding function give its actual half width which can then be measured with the vertical cursors. At the top of the display the actual positions of the vertical cursors are displayed (in the ACF the time difference only, in the spectrum their wavelength values and the difference).

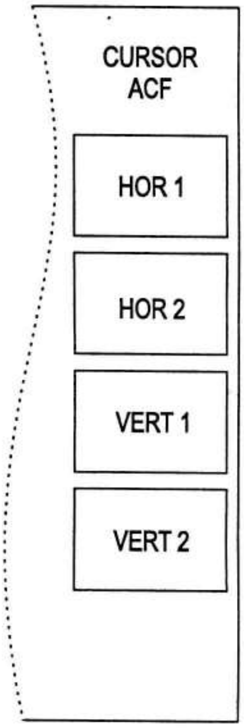


Fig. 29 Control of Cursors in ACF

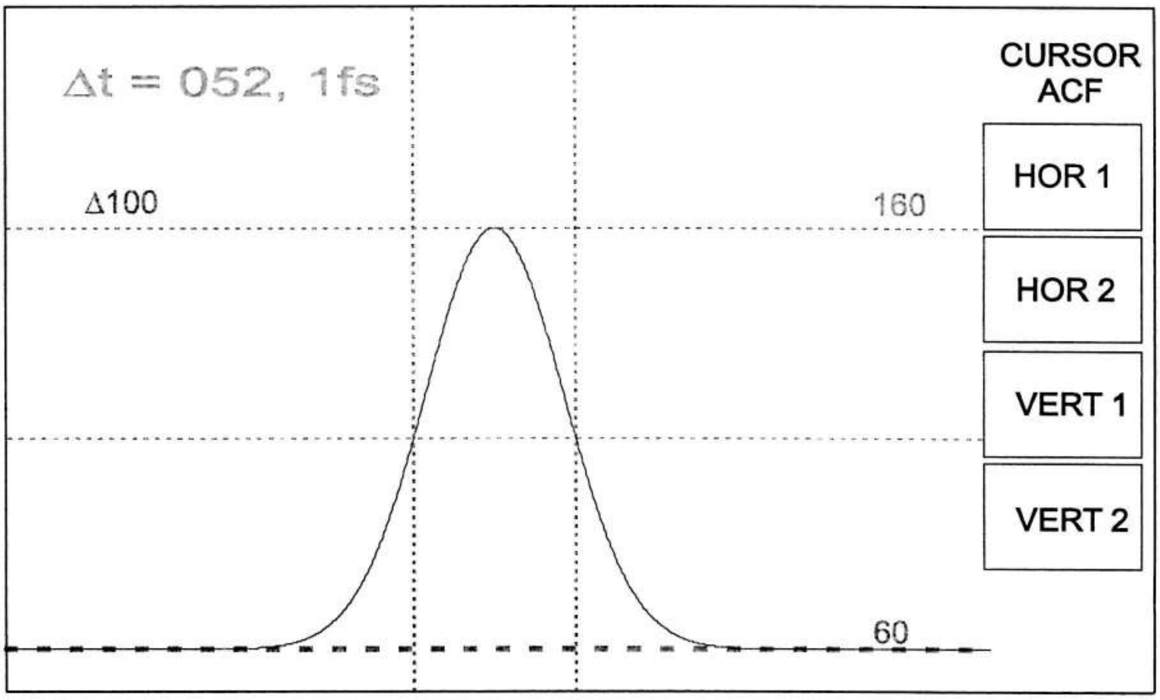


Fig. 30 Cursor Control

6. Additional Important Hints

6.1 Phase Matching

In the main menu the actual crystal angle is displayed in arbitrary units (100 - 3000). When reaching the limits the movement is automatically stopped and you have to reverse the direction.

6.2 Scan Range Variation

Each scan range is measured by a position sensor for amplitude stabilization. The delay output is normalized to a 10 V_{pp} amplitude. After switching to another scan range it takes some time (5 ... 30 s) to reach the new range.

6.3 „ZERO" - Scan

The „ZERO SCAN"-function stops the delay at the zero position.

6.4 Low Pass Filter

This switchable filter suppresses higher frequent noise from the detector or the interference fringes in the collinear case. For the measurement in triggered mode it is automatically switched off.

6.5 Collinear and Background-free (non-collinear) ACF

These interaction types can be chosen with the „BEAM DISTANCE" screw on the optics unit. Thereby the beam distance can be changed between 0 ... 6 mm (direct control at the window next to the input aperture). The moving spot has to be at the right side of the static one. If changing the beam distance, the focussing, the sensitivity and the phase matching angle should be optimized accordingly. It is advisable to proceed in small steps, so that the ACF never disappears.

6.6 Interference Modulation

If exactly aligned in the collinear case, the ACF is modulated by the fundamental beam interference fringes of the interferometer (sinusoidal modulation - fringe resolved ACF). They can either be suppressed by the low pass filter (simple intensity ACF) or displayed with the „FRINGES"-mode, displaying the envelope of this function. This mode helps to check the pulse for chirp. The more the beams are changing from being collinear to noncollinear the more these interferences are spatially averaged and the less they modulate the AC signal.

In the triggered mode, where the low pass filter is not active, and in „ZERO SCAN" the fringes simulate strong amplitude fluctuations, which makes it difficult to align the optimal phase matching. That's why it is useful to increase the beam distance slightly to measure a nearly collinear ACF without interferences.

6.7 Change Wavelength Range (Crystal and Detector Exchange)

The wavelength range of the autocorrelator depends on the phase matching angle of the crystal (crystal type and cut angle) and on the wavelength range of the detector. The detector has to be insensitive to the fundamental signal and highly sensitive to the SHG signal. Therefore the useful range for the detector is necessarily smaller then one octave ($\lambda_U > \lambda_o / 2$). So the wavelength range is chosen by selecting the detector unit and the block filter. The detector unit with filter and the crystal (= optics set) have to be exchanged when another wavelength range is required.

6.8 Calculation of the ACF Half Width

After getting the ACF displayed one can measure the half width of the autocorrelation function. It is defined as FWHM (Full Width at Half Maximum) which means the width at the half intensity level between the maximum of AC peak and the baseline outside the peak (fig. 31). Most comfortable is the application of cursors, otherwise the oscilloscope grating can be used. Measure ACF width b and complete scan width B (maximum scan).

Due to the automatic scan control the complete width B is defined by the actually selected scan range. Therefore the autocorrelation half width FWHM is calculated as:

FWHM = b/B x Scanbereich.

To get the real pulse duration one has to correct the AC-width with a form factor depending on pulse shape:

τ = FWHM x F

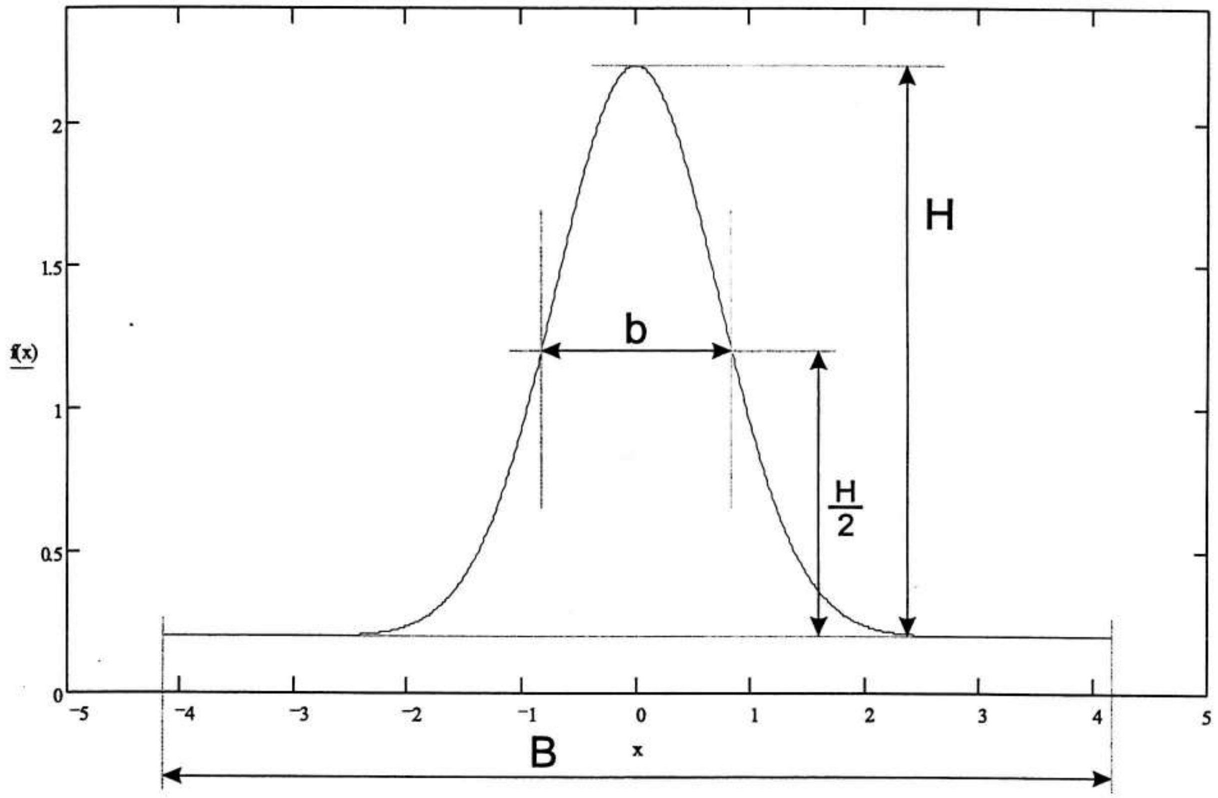


Fig. 31 Calculation of ACF Half Width

6.9 Signal Level

The sensitivity range is very wide in order to adapt the autocorrelator to different input levels. This might cause a high noise level at high gain and a loss of linearity at low gain because of the PMT physics. Therefore it is advisable to adapt the input level to an operation with middle gain values for the most exact measurements.

The operation in triggered mode with very short pulses at low repetition rates is most critical. In this case, the detector can be overloaded at high input levels with low gain causing a suppression of the ACF peak. To prevent this it is strictly recommended to operate this mode with PD detectors only.

7. Error

7.1 Trouble Shooting

Error characteristics		**Possible reason**	**Check and removal**
No SHG-signal		Wrong polarization direction	Check with polarization rotator. (see 7.2.) Introduce a polarization rotator in the input beam.
		Wrong alignment	Check beam position at input aperture. Check back reflection at control window. Check „*FOCUS*"-position. Check phase matching.
		No or too long input pulses	Check with an independent method. (fast photodiode, spectral width etc.)
		Input power too small	Compare with sensitivity (see Specifications).
		Delay-zero-position outside of scan range	Check at wider scan ranges, check the „*DELAY*"-position (see Specifications, offset setting.
No clear ACF		Wrong scan range	Check at wider scan ranges.
		No or too long input pulses	Check with an independent method. (fast photodiode, spectral width etc.)
SHG-signal w/o ACF-peak	Non-collinear case	Wrong alignment of beam on detector	Check with „*SHUTTER*", if it reacts to one shutter Realign in horizontal direction only.
	Collinear case	Wrong „*FOCUS*"-position	Check and correct „*FOCUS*"- position
		Delay-zero-position outside scan range	Check at wider scan ranges. Check and correct „*DELAY*"-position (see Specification, offset setting).

No spectral function	Fiber not or not correctly connected	Check connection at optics unit and spectrometer
	Wrong alignment	Check position of back reflection at control window
	Wavelength outside spectral range	Compare laser wavelength with specification
	Input power too small	Increase input power

7.2 Rotation of Plane of Polarization

Usage of a Polarization Rotator ($\lambda/2$-plate)

By tilting the plate by α the polarization is rotated by 2α. The effect of polarization rotation can be very wavelength sensitive.

Rotation by a Double 90°-Beam Steering (periscope type)

Two mirrors mounted at a 45° angle to the input beam and steering it in different planes flip the plane of polarization by 90°. This is very efficient and wavelength independent. Such a polarization rotator can be ordered at APE GmbH Berlin.

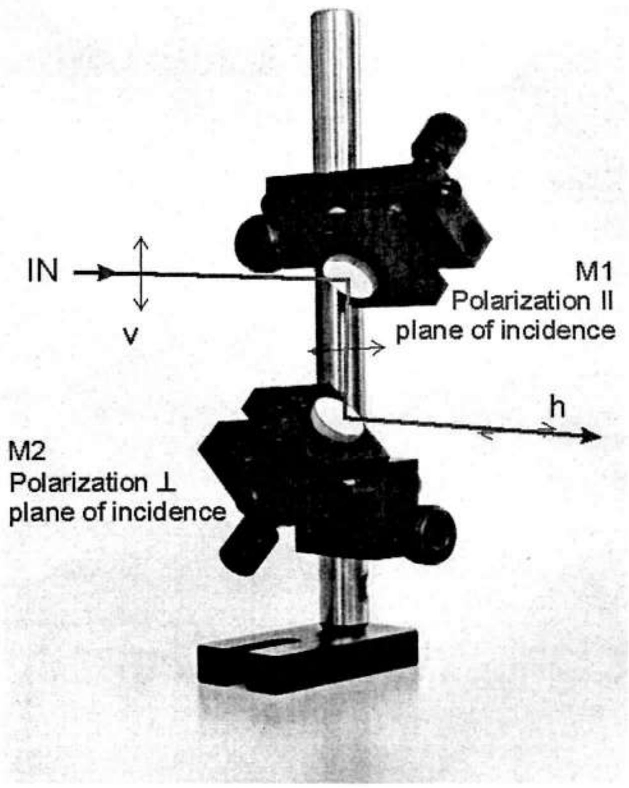


Fig. 32 Polarization rotator (periscope type)

7.3 Fundamental Overload

At very extreme wavelengths and input power levels the ACF can be superposed up to being completely covered by a background signal from the fundamental wave in the collinear case. This can be avoided by using the non-collinear interaction or deploying special filters and detectors. They can be ordered at the APE GmbH Berlin.

8. Safety

For the application of lasers you have to pay attention to safety rules according to the used laser class! Incorrect handling and operation of lasers can be hazardous to your health!

Protect the autocorrelator from humidity, because the SHG crystals are slightly hygroscofig and they are not mounted in housing because of dispersion risks.

Appendix

Description of Serial Interface of Autocorrelator PulseCheck

The PC-control of the autocorrelator by means of a serial interface is done by commands consisting of ASCII strings. They either cause changes of the operation status (control commands) or the transmission of another ASCII-string from the autocorrelator to the PC containing the displayed autocorrelation data or information about the actual status (parameter read out). The Windows Control Software for communication via serial interface is available at APE GmbH. There is also Lab View drivers available at APE GmbH which facilitates an integration of the autocorrelator into existent LabView software solutions.

1. Parameters of RS232

Baudrate	9600 / 19200 / 38400
Datenbits	8
Parität	non
Stopbits	1
Handshake	DTR - CTS

2. Cable

Autocorrelator	PC
1 DCD	DCD 1
2 TXD	RXD 2
3 RXD	TXD 3
4 DTR	DTR 4
5 GND	GND 5
6 DSR	DSR 6
7 RTS	RTS 7
8 CTS	CTS 8

List of Commands

Control Commands

Command	Meaning	Parameter n
An,	AVERAGE 1,	2, 4, 8, 16
Dn,	DISPLAY	0 - only ACF 1 - only Spectrum 2 - ACF + Spectrum
Fn,	FILTER	1 - low 2 - medium 3 - high
GNn,	GAIN	000 … 999
In	INTEGRATION TIME (CCD Line)	0 - factor 1 1 - factor 2 2 - factor 4 3 - factor 8
	SPEC GAIN (spinning grating)	1 - factor 1 2 - factor 10 3 - factor 100
Ln,	LINLOG	0 - linear 1 - logarithmic
Mn,	MATHEMATIK	0 - off 1 - on
Pn,	PREAMPLIFIER	0 - off 1 - on
REn,	RESOLUTION	5 - 32 Pixel/Scan 6 - 64 Pixel/Scan 7 - 128 Pixel/Scan 8 - 256 Pixel/Scan
RSn,	RUNSTOP	0 - Stop 1 - Run
SRn,	SCANRANGE (depending on maximum scan range)	0 - zero scan 1 - 0,15 / 0,5 / 1,5 ps 2 - 0,5 / 1,5 / 5 ps 3 - 1,5 / 5,0 / 15 ps 4 - 5,0 / 15 / 50 ps 5 - 15 / 50 / 150 ps
SYn,	SENSITIVITY	1 - 1 2 - 3 3 - 10 4 - 30

Command	Meaning	Parameter n
TFn,	TRIGGERED FREERUN	0 - FreeRun 1 - Triggered 2 - Fringes 3 - SlowScan
TUn,	TUNING	0 - Crystal angle decrement 1 - Crystal angle increment

Check commands for ACF, spectrum and parameter transmission

Command	Meaning	Answer
GAC,	GETACF	256 equidistant ACF-values as a row of 512 Byte with the following structure: 1. Byte 00_{HEX} ... FF_{HEX} high byte of 1. ACF value 2. Byte 00_{HEX} ... $C0_{HEX}$ low byte of 1. ACF value (only bit 7 and 6 significant) * * * 511. Byte 00_{HEX} ... FF_{HEX} high byte of 256. ACF value 512. Byte 00_{HEX} ... $C0_{HEX}$ low byte of 256. ACF value (only bit 7 and 6 significant)
GAV,	GETAVERAGE	01_{HEX} - 1 * * * 40_{HEX} - 64
GD,	GETDISPLAY	00_{HEX} - only ACF 01_{HEX} - only Spec. 02_{HEX} - ACF + Spec.
GF,	GETFILTER	01_{HEX} - low 02_{HEX} - medium 03_{HEX} - high
GG,	GETGAIN	00_{HEX}... 03_{HEX} (High Byte) 00_{HEX}... FF_{HEX} (Low Byte) 0 ... 999
GI,	GETINTEGRATIONTIME (CCD LINE)	00_{HEX} - 1 01_{HEX} - 2 02_{HEX} - 4 03_{HEX} - 8
	GETSPECTROMETER GAIN (spinning grating)	01_{HEX} - 1 01_{HEX} - 10 02_{HEX} - 100

Command	Meaning	Answer
GM,	GETMATHEMATIK	00 $_{HEX}$ - off 01 $_{HEX}$ - on
GPA,	GETPREAMPLIFIER	00 $_{HEX}$ - off 01 $_{HEX}$ - on
GPM,	GETPHASEMATCHING	00 $_{HEX}$ ... FF $_{HEX}$ - 0... 255
GRE,	GETRESOLUTION	02 HEXX - 4 Pixel / Scan 03 $_{HEX}$ - 8 Pixel / Scan 04 $_{HEX}$ - 16 Pixel / Scan 05 $_{HEX}$ - 32 Pixel / Scan 06 $_{HEX}$ - 64 Pixel / Scan 07 $_{HEX}$ - 128 Pixel / Scan 08 $_{HEX}$ - 256 Pixel / Scan
GRS,	GETRUNSTOP	00 $_{HEX}$ - Stopped 01 $_{HEX}$ - Running
GSP,	GETSPECTRUM (spinning grating)	32768 equidistant spectrum-values as a row of 65536 Byte with the following structure: 1. Byte 00 $_{HEX}$ ... FF $_{HEX}$ high byte of 1. Spectrum value 2. Byte 00 $_{HEX}$ ... C0 $_{HEX}$ low byte of 1. ACF value (only four bit significant) * * * 65535. Byte 00 $_{HEX}$ ... FF $_{HEX}$ high byte of 32768.Spectrum value 65536. Byte 00 $_{HEX}$ ... C0 $_{HEX}$ low byte of 32768. Spectrum value (only four bit significant)

Command	Meaning	Answer
	(CCD Line)	2048 equidistant spectrum-values as a row of 4096 Byte with the following structure: 1. Byte 00_{HEX} ... FF_{HEX} high byte of 1. Spectrum value 2. Byte 00_{HEX} ... $C0_{HEX}$ low byte of 1. ACF value (only four bit significant) * * * 2047. Byte 00_{HEX} ... FF_{HEX} high byte of 256. Spectrum value 2048. Byte 00_{HEX} ... $C0_{HEX}$ low byte of 256. Spectrum value (only four bit significant)

Command	Meaning	Answer
GSF,	GETSPECTRUMFAST (spinning grating)	256 equidistant spectrum-values (Display) as a row of 516 Byte with the following structure: 1. Byte 00 $_{HEX}$ ... FF $_{HEX}$ high byte of 1. Spectrum value 2. Byte 00 $_{HEX}$ ... C0 $_{HEX}$ low byte of 1. ACF value (only bit 7 and 6 significant) * * * 511. Byte 00 $_{HEX}$ ... FF $_{HEX}$ high byte of 32768. Spectrum value 512. Byte 00 $_{HEX}$ ... C0 $_{HEX}$ low byte of 32768. Spectrum value (only bit 7 and 6 significant) 513. Byte (high byte) 514. Byte (low byte start channel 515. Byte (high byte) 516. Byte (low byte) n x channel (channel step)
GSR,	GETSCANRANGE (depending on maximum scan range)	00 - zero scan 01 - 0,15 / 0,5 / 1,5 ps 02 - 0,5 / 1,5 / 5 ps 03 - 1,5 / 5,0 / 15 ps 04 - 5,0 / 15 / 50 ps 05 - 15 / 50 / 150 ps
GSY,	GETSENSITIVITY	01 $_{HEX}$ - 1 02 $_{HEX}$ - 3 03 $_{HEX}$ - 10 04 $_{HEX}$ - 30
GTA,	GETTAU	00 $_{HEX}$ - 0 * * * FF $_{HEX}$ - 255

Command	Meaning	Answer
GTF,	GETTRIGGFREERUN	00 $_{HEX}$ - FreeRunning 01 $_{HEX}$ - Triggered 02 $_{HEX}$ - Fringes 08 $_{HEX}$ - 256 Pixel / Scan
GRS,	GETRUNSTOP	00 $_{HEX}$ - Stopped 01 $_{HEX}$ - Running
GSP,	GETSPECTRUM (spinning grating)	32768 equidistant spectrum-values as a row of 65536 Byte with the following structure: 1. Byte 00 $_{HEX}$ ... FF $_{HEX}$ high byte of 1. Spectrum value 2. Byte 00 $_{HEX}$ ... C0 $_{HEX}$ low byte of 1. ACF value (only four bit significant) * * * 65535. Byte 00 $_{HEX}$ ... FF $_{HEX}$ high byte of 32768. Spectrum value 65536. Byte 00 $_{HEX}$ ... C0 $_{HEX}$ low byte of 32768. Spectrum value (only four bit significant)

Command	Meaning	Answer
	(CCD Line)	2048 equidistant spectrum-values as a row of 4096 Byte with the following structure: 1. Byte 00 $_{HEX}$ ... FF $_{HEX}$ high byte of 1. Spectrum value 2. Byte 00 $_{HEX}$ ... C0 $_{HEX}$ low byte of 1. ACF value (only four bit significant) * * * 2047. Byte 00 $_{HEX}$ ... FF $_{HEX}$ high byte of 256. Spectrum value 2048. Byte 00 $_{HEX}$ ... C0 $_{HEX}$ low byte of 256. Spectrum value (only four bit significant)

Command	Meaning	Answer
GSF,	GETSPECTRUMFAST (spinning grating)	256 equidistant spectrum-values (Display) as a row of 516 Byte with the following structure: 1. Byte 00 $_{HEX}$ ... FF $_{HEX}$ high byte of 1. Spectrum value 2. Byte 00 $_{HEX}$ ... C0 $_{HEX}$ ow byte of 1. ACF value (only bit 7 and 6 significant) * * * 511. Byte 00 $_{HEX}$ ... FF $_{HEX}$ high byte of 32768. Spectrum value 512. Byte 00 $_{HEX}$ ... C0 $_{HEX}$ low byte of 32768. Spectrum value (only bit 7 and 6 significant) 513. Byte (high byte) 514. Byte (low byte start channel 515. Byte (high byte) 516. Byte (low byte) n x channel (channel step)
GSR,	GETSCANRANGE (depending on maximum scan range)	0 - zero scan 01 - 0,15 / 0,5 / 1,5 ps 02 - 0,5 / 1,5 / 5 ps 03 - 1,5 / 5,0 / 15 ps 04 - 5,0 / 15 / 50 ps 05 - 15 / 50 / 150 ps
GSY,	GETSENSITIVITY	01 $_{HEX}$ - 1 02 $_{HEX}$ - 3 03 $_{HEX}$ - 10 04 $_{HEX}$ - 30
GTA,	GETTAU	00 $_{HEX}$ - 0 * * * FF $_{HEX}$ - 255

Command	Meaning	Answer
GTF,	GETTRIGGFREERUN	00 $_{HEX}$ - FreeRunning 01 $_{HEX}$ - Triggered 02 $_{HE}$ - Fringes