Instructions for operating the HERA transverse beam polarimeter

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Version 0: April, 2, 2002
Updated April, 17, 2002 (S. Schmitt)
Updated July, 29, 2002 (S. Schmitt)
Updated August, 7, 2002 (S. Schmitt)
Updated October, 14, 2003 (S. Schmitt)

Contents

Chapter 1

Introduction

The main parts of the HERA transverse polarimeter are:

- a 10W cw LASER, located in the HERA west hall (9th floor)
- some optics for light transport, steering, diagnostics
- a small segmented calorimeter for measuring Compton photons, located in the HERA tunnel
- a readout system located in the HERA west hall (9th floor)

The laser light is transported into the tunnel and crosses the lepton beam unde a small angle. Compton photons are backscattered into the calorimeter. Position and energy of the photons are reconstructed and the beam polarisation is determined. Typical parameters of the system are:

- Rate of scattered Compton photons 50-100 KHz
- Accuracy of the polarisation measurement: $\Delta P = 0.01$ averaged over one minute (for lepton currents of 40mA)

Chapter 2

To-do list for polarimeter shifts

The TPOL LASER

Check the status of the TPOL laser on the slow control panel. The laser parameters should be

- On
- Power 10W
- Current less than 60A
- Temperature less than 30 degree
- Shutter open

DAQ errors

Check the messages window regularly for error messages.

During beam (HERA at final energy for five minutes)

Verify that

- The autopilot is running
- The collimators are open
- Polarisation numbers are updating every minute
- All parameters are within limits (not red/yellow)
- Online histograms are updating (check date!)

- Online histograms look ok
- All DAQ processes are running
- Data files are copied to tape

Between fills

Check whether

- The autopilot is running
- The collimators are closed
- A mirror-scan is performed
- The mirror scan gives reasonable results
- A light-polarisation measurement is performed
- The light polarisation measurement gives reasonable results

Chapter 3

The TPOL monitor display

The TpolMonitor (see figure 3.1 is the standard tool to monitor and control the TPOL. It should be used by the HERA BKR and all HERA experiments to monitor the status of the TPOL online.

3.1 How to start TpolMonitor

Probably the best is to go to the TPOL WWW-site and follow the instructions there `http://pctpol03.desy.de/monitor/start.html`. Below is a summary of those instructions:

1. Download the java executable from `http://pctpol03.desy.de/monitor/TpolMonitor.jar`
2. On windows-systems: start the executables by double-clicking on the file `TpolMonitor.jar`.
3. On command-line oriented systems: start java with the correct arguments, e.g.: `java -jar TpolMonitor.jar`

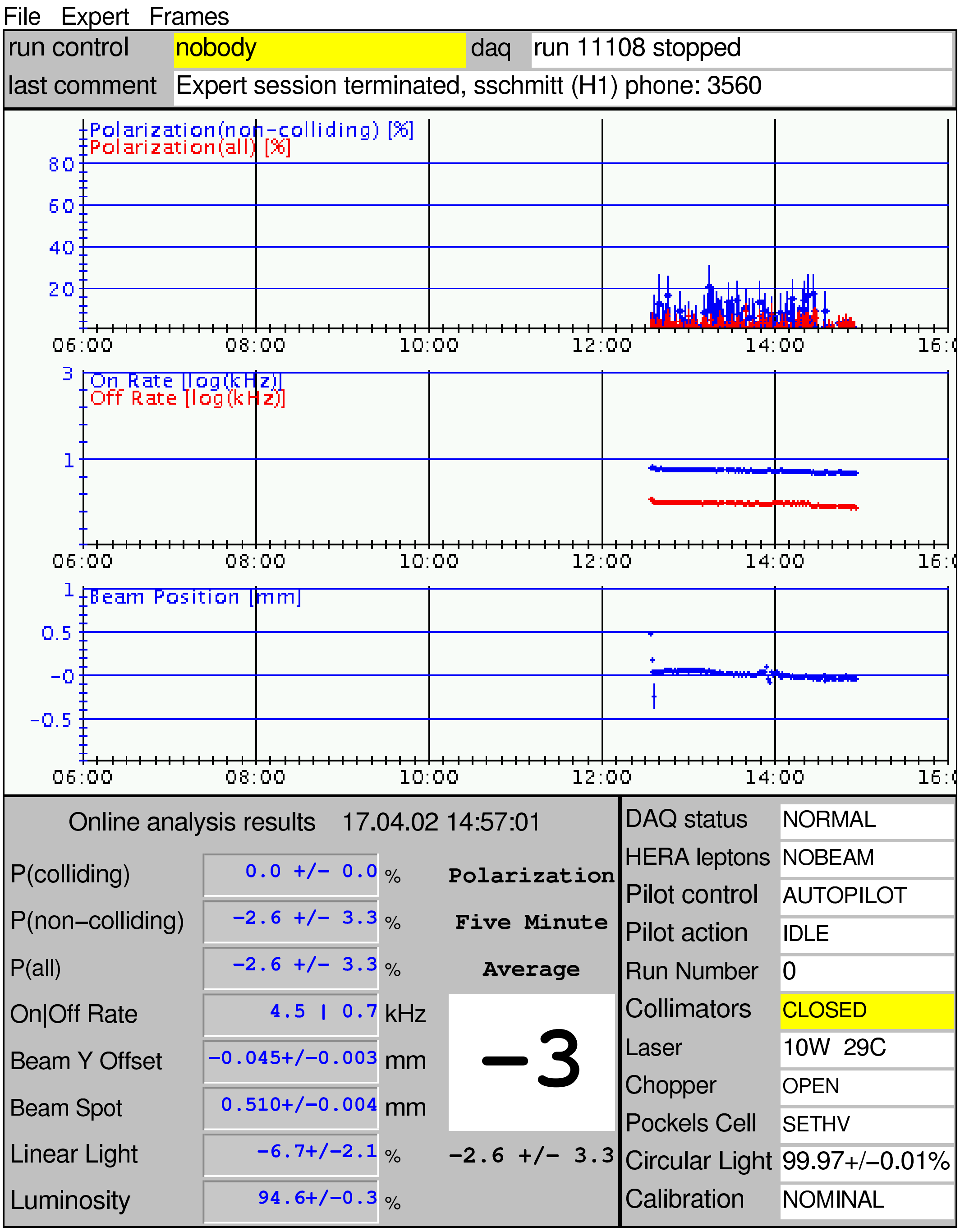

Figure 3.1: The main window of the TPOL monitor

Chapter 4

Run Control

Under normal conditions the TPOL is controlled by the AUTOPILOT. The main purpose of the person on shift is to ensure that the AUTOPILOT works correctly. However, it might happen that the AUTOPILOT fails or that special tasks have to be performed. The person on shift should be able to solve small problems and recover the AUTOPILOT, and to do some of the special measurements on request.

4.1 How to take the Run Control

1. Start the **TpolMonitor** (see Section 3.1 how to do that).
2. Select `Enable expert menus` in the `Experts` menu
3. Open the **Messages** window (select `Messages` in the `Frames` menu). **Note: this window is the main source of information if something goes wrong! Always keep an eye on it!** The Messages window is depicted in Figure 4.1. All messages are also stored on disk and in the Oracle data-base.
4. Open the **RunControl** window (select `RunControl` in the `Frames` menu). This is the main window to get an overview of the current status of the DAQ. The RunControl window is depicted in Figure 4.2.
5. If possible, inform the person which currently owns the Run Control that You are going to take over. In the top left corner of the main window the person currently owning the run control should be displayed. If You can not reach that person by phone write a message into the log-look (give Your phone number and a time limit after which You will take over). Use the lower part of the run-control window to type in messages.
6. Select `control` as `Session type` in the top part of the RunControl window.

7. Give Your name, experiment and the phone number where You may be reached in the form that pops up. You also have to supply the correct password for RunControl access to the TPOL.

8. Press the `Accept` button. Your TpolMonitor program is now connected ad RunControl session. Any other RunControl session will be closed. Your name, experiment and phone number will be registered in the messages window.

9. **If You have the run control, it is Your responsibility to deliver polarisation measurements.**

10. While monitoring/controlling the TPOL do not hesitate to write comments into the log book. They will be displayed in the messages window of all connected TpolMonitor programs.

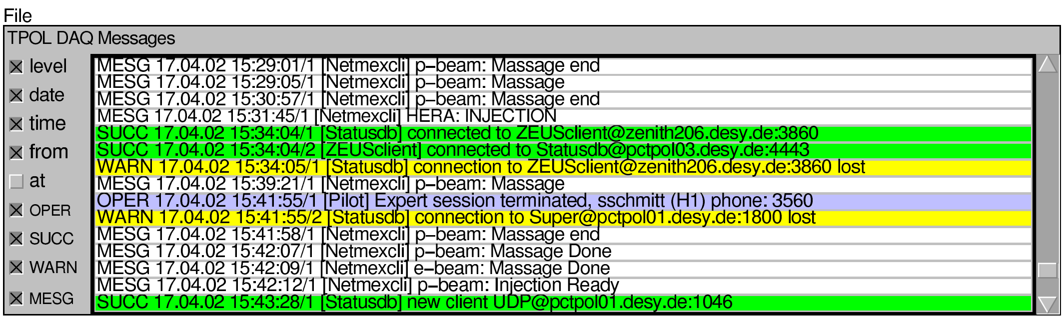

Figure 4.1: The Messages window of the TPOL monitor

4.2 How to drop the Run Control

After disconnecting the TpolMonitor (e.g. click on `monitor` in the Run Control window) You loose the run-control. However, the pilot will continue with whatever measurement it has been doing!
Before dropping the Run Control, make sure there is someone else taking care of the TPOL. If this is not the case, make sure the run is stopped, the autopilot is disabled, and the collimators are closed. See below how to do that.

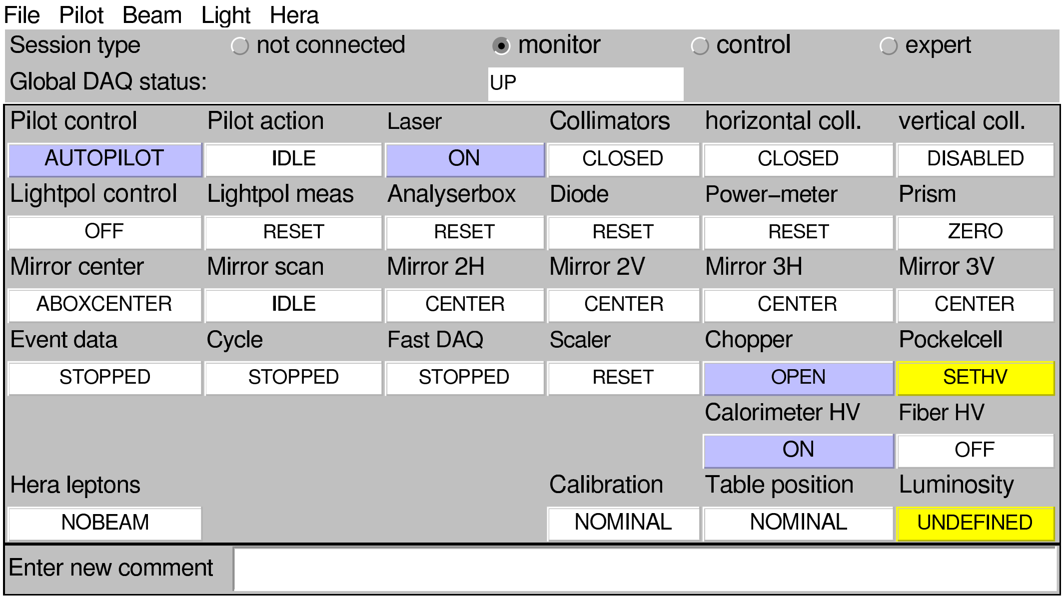

Figure 4.2: The RunControl window of the TPOL monitor

4.2.1 Putting the TPOL to sleep

1. Make sure You own the Run-Control session

2. Make an entry in the log-book

3. Turn off the AUTOPILOT: select `Low level Autopilot` in the `Pilot` menu of the Run Control window. This prevents the TPOL DAQ from doing things by its own will. If Your action was successful, the field `Pilot control` will switch to `LOWLEVEL`.

4. Stop the run if necessary: select `Stop run` in the `Beam` menu

5. Close the collimators if necessary: select `Close collimators` in the `Hera` menu. Note: the collimators will not be moved automatically, since You have turned off the AUTOPILOT.

6. Wait until the collimators are closed and the run is stopped. The run is stopped if the `Pilot action` is `IDLE`.

7. Terminate Your run-control session.

4.3 Standard tasks

- Make sure the DAQ is running:

Window	Field	Requested status
TpolMonitor	DAQ status	NORMAL
TPOL run control	Global DAQ status	UP

  If `DAQ status=no info` and `Global DAQ status=UNKNOWN` Your program has lost the connection (maybe someone else took the run control). Try `Connect` in the `File` menu of the main window to see what is going on. Then again follow the procedure to take over the RunControl if necessary.

  If the DAQ is not running and polarisation measurements are required, contact an expert.

- Make sure the LASER is on

Window	Field	Requested status
TpolMonitor or RunControl	Laser	ON

  If the laser is not on and polarisation measurements are required, contact an expert.

- Make sure the AUTOPILOT is enabled.

Window	Field	Requested status
TpolMonitor or RunControl	Pilot control	AUTOPILOT

  To enable the AUTOPILOT, select `Enable full autipilot` in the `Pilot` menu of the run control window.

  If the AUTOPILOT was not enabled, try to find the reason for it (check the messages window for error emssages etc). If there was an error, try to understand it and fix it if necessary before enabling the autopilot.

- If there is no beam in the machine, verify that the AUTOPILOT measures (or has measured) the mirror position and the light polarisation by scrolling back in the messages window.

  - Mirror measurement: the run type is MIRRORSCAN. If the mirror optimisation was successfull, four entries will be in the messages window, reporting the new mirror positions, e.g:

run 10704 mirror 2 has been updated, pos=-1340 step=539
run 10704 mirror -2 has been updated, pos=1523 step=232
run 10704 mirror 3 has been updated, pos=1593 step=1946
run 10704 mirror -3 has been updated, pos=437 step=874

  - Light polarisation measurement: the run type is LIGHTPOL. If the run was successful, two entries will be made in the messages window, reporting the new Pockel's cell settings and the residual linear light polarisation, e.g:

    run 10705 the linear light polarisation is neg=2.5563 pos=2.49
    run 10705 new PCell HV settings neg=1482 pos=1547

- If there is no beam or HERA is filling or ramping, verify that the AUTOPILOT has closed the collimators.
- if HERA has reached its final energy, verify that the AUTOPILOT opens the collimators
- verify that the TPOL starts the polarisation measurement five minutes after HERA has reached the final energy. Usually the pilot will first do a LUMISCAN, then go to BEAMPOL, then CENTERTABLE, then BEAMPOL etc.
- **verify that the polarisation measurements are updating regularly (every minute) on the main window.**

4.4 Run types

Under normal conditions any actions on the TPOL happen within a run. The run type can be deduced from the TpolMonitor window or the RunControl window (field `Pilot action`). The valid run types are summarized in Table 4.1.

4.4.1 Run type MIRRORSCAN

During such a run the mirrors are moved around their nominal center (M2 horizontal and vertical, M3 horizontal and vertical). For each point the laser power arriving in the tunnel is measured. After a full scan has been taken, new center positions and step sizes are calculated.

4.4.2 Run type LIGHTPOL

The power behind a prism is measured for positive and negative Pockel's cell voltage. The prism is moved by a certain angle and the measurement is repeated,

run type	done by autopilot	description
IDLE	if beam condition changes	current run is stopped
MIRRORSCAN	no beam: every 5h	optimize laser power
LIGHTPOL	no beam: every 5h	measure linear light pol.
LUMISCAN	with beam: every 2h or if $\mathcal{L} < 45$ every 5 min	maximize trigger rate
CENTERTABLE	with beam: if $\Delta y + 2\delta y > 60\,\mu$m	center calorimeter on beam
BEAMPOL	with beam: if otherwise idle	measure beam pol.
TILTSCAN	never	scan beam profile
FOCUSSCAN	never	scan focus size
CALIBRATE	with beam: if the calibration is bad	calibrate calorimeter HV
TESTRUN	never	for tests

Table 4.1: Run types valid for the TPOL

until a full turn was seen. From this data the linear polarisation component of the laser light is determined. Then the Pockel's cell HV is changed and the scan is repeated. This is done for several HV settings around the nominal value. In the end the positive and negative Pockel's HV is calculated such that the linear light component is minimal.

4.4.3 Run type LUMISCAN

The mirror M3 (horizontal) is moved and the corresponding trigger rate is recorded. Then a new M3 position is calculated, expected to give the highest trigger rate.

4.4.4 Run type CENTERTABLE

Calorimeter data is collected with laser on and laser off. Then the full online analysis is performed (including polarisation measurement). If the beam is not centered on the calorimeter, the table is moved, and the cycle is repeated. If the beam is centered, the run is stopped automatically.

4.4.5 Run type BEAMPOL

The laser is periodically switched on and off using a chopper wheel. After one such on-off cycle the full online analysis is performed and the cycle is repeated. The duration of such a cycle is: 45 seconds laser on, 15 seconds laser off. This is the default method to obtain polarisation measurements of the lepton beam once per minute.

4.4.6 Run type TILTSCAN

Calorimeter data is collected with laser on then laser off. The full offline analysis is performed after each cycle and the mirror M3 (horizontal) is moved. After a certain number of points have been collected, the run is stopped. A new center position for M3 (horizontal) is calculated in order to maximize the luminosity. In addition the tilt angle of the beam ellipsis is calculated and written to the messages window.

4.4.7 Run type FOCUSSCAN

Calorimeter data is collected with laser on then laser off. The full offline analysis is performed after each cycle and the mirror M3 (vertical) is moved. After a certain number of points have been collected, the run is stopped. The data may be used to manually adjust a new position for M3 (vertical).

4.4.8 Run type CALIBRATE

Calorimeter data is collected with laser on then laser off. The full offline analysis is performed after each cycle. If the gain calibration of the four calorimeter channels is not good, new Phototube HV settings are calculated and applied, and this cycle is repeated. If the gain calibration is good, the run is stopped automatically.

4.4.9 Run type TESTRUN

By default nothing happens. This is useful for experts only.

4.5 The AUTOPILOT

If active, the AUTOPILOT will start and stop runs following the rules given in table 4.1. In addition to those rules it will stop runs of type BEAMPOL after 45 minutes to avoid having very long runs. To activate the AUTOPILOT, select `Enable full autopilot` in the `Pilot` menu of the run control window.
To partially disable the autopilot select `Low level autopilot` in the `Pilot` menu of the run control window. If the AUTOPILOT is partially disabled, the `Pilot Control` field will switch to `LOWLEVEL`.
Do not switch off the AUTOPILOT completely. In that case the `Pilot Control` field will indicate `OPERATOR` and most things will not work!

4.6 Manually starting and stopping runs

To avoid conflicts with the AUTOPILOT while doing manual runs, the AUTOPILOT should be partially disabled.
To manually stop a run, select `Stop run` in the `Beam` menu or `Stop measurement` in the `Light` menu of the run control window. Beware that the AUTOPILOT (if active) will immediately start a new run if required by the rules given in table 4.1. If the run should stay off, the AUTPILOT has to be partially disabled (see Section 4.5). If a run is stopped from the menu, a dialog opens where a comment can be given (optional).
To manually start a run, select the corresponding function from the `Beam` of `Light` menu, as summarized in table 4.2. Note that the AUTOPILOT (if active) will immediately interrupt the new run if it does not match the rules given in table 4.1. If a run is started from the menu, a dialog opens where a comment has to be given (why the run was started).
Never forget to enable the AUTOPILOT again after the manual runs are finished.

Menu	Menu text	run type
Beam	Center table	CENTERTABLE
Beam	Calibrate calorimeter	CALIBRATE
Beam	Optimize luminosity	LUMISCAN
Beam	Normal beam pol. measurement	BEMAPOL
Light	Optimize mirrors	MIRRORSCAN
Light	Optlimize linear light pol.	LIGHTPOL

Table 4.2: Run types avaiable in the menu bar

Some special runs can not be selected from the menu. These have to be started by clicking on the `Pilot action` field. See table 4.3 for details.

4.7 Trouble shooting

During office hours always contact an expert if there is a problem You can not solve. Always make an entry in the electronic log-book if You observe something strange. Contact the expert at any time in case of severe problems (e.g. power-cut) or if polarisation measurements are needed but You do not succeed to get the TPOL operational.
General: Error messages in the messages window and persistent yellow or red fields in the run control window indicate a problem.

Menu text	run type
Start lightpol HV scan	LIGHTPOL
Start mirror scan	MIRRORSCAN
Start polarisation measurement	BEAMPOL
Start luminosity optimisation	LUMISCAN
Start beam tilt measurement	TILTSCAN
Start focus optimisation	FOCUSSCAN
Center table on beam	CENTERTABLE
Calibrate calorimeter	CALIBRATE

Table 4.3: Run types which can be started from the Pilot action sub-menu

4.7.1 Beam-off measurements

Run control session is lost during a scan

Sometimes the java program fails to update the display fast enough. After a while it will stop to receive the data, then loose the connection. All fields in the Run-control menu will turn red. In this case, simply start the run-control session again by selecting `control` as `Session type`.
Note: data collected during such a break will not appear in the history plots. DAQ messages recevied during such a break are lost for Your display. If the break was longer than a few seconds, it is better to terminate the TpolMonitor and start again from scratch (when started, the TpolMonitor downloads all the relevant data automatically).

Errors or warning messages

If a MIRRORSCAN or a LIGHTPOL measurement fails, try to find out why it failed by looking at the error messages and at the scan data. Do not forget to put Your findings into the electronic log-book.
You can look at the scan data using the `Graphs` window (activate the window from the `Frames` Menu of the main window). The Graphs window is depicted in figure 4.3. Click on `Choose data set` and select the type of scan You wish to see

- mirror2 scan: the scan result for mirror 2 (horizontal and vertical). Expect to see two Gaussian-like curves
- mirror3 scan: the scan result for mirror 3 (horizontal and vertical). Expect to see two Gaussian-like curves
- light polarisation: the light polarisation scan result. Expect to see two V-like curves.

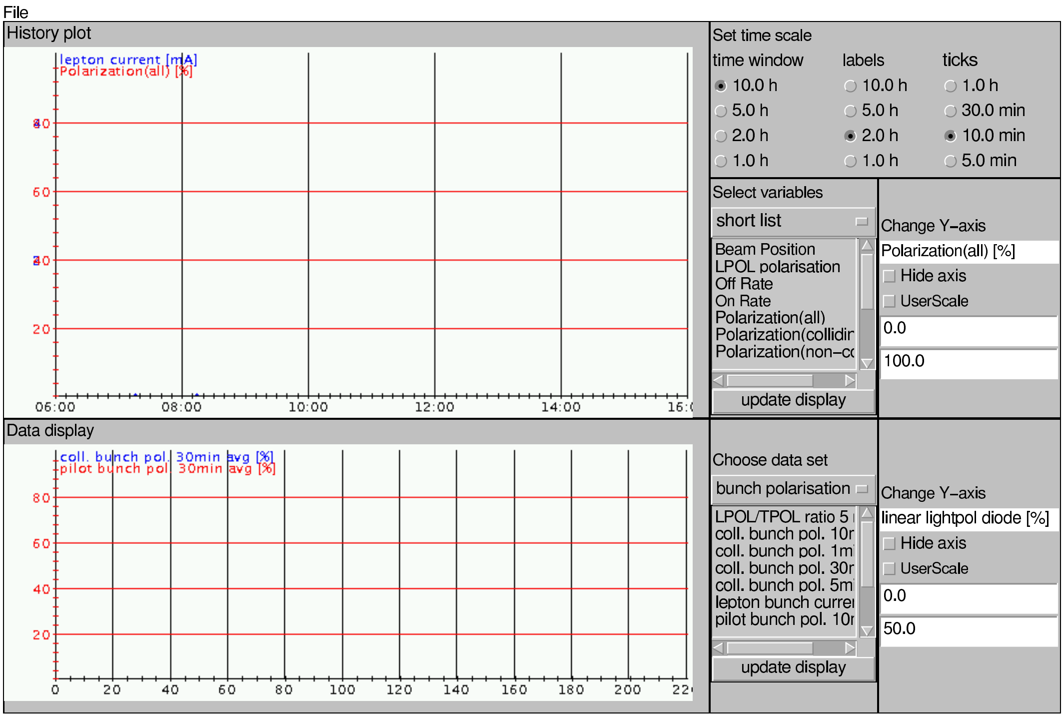

Figure 4.3: The Graphs window of the TPOL monitor

You can try to repeat the measurement if there is enough time before HERA ramps to full energy by starting a new MIRRORSCAN or LIGHTPOL measurement. A MIRRORSCAN takes approx. 3 minutes. A LIGHTPOL measurement takes approx 15 minutes.
Note: if HERA has beam in the machine, it might be necessary to partially disable the AUTOPILOT (see Section 4.5) in order to complete the measurement. If enabled the AUTOPILOT will interrupt any LIGHTPOL measurement if HERA is ramping.

4.7.2 Beam related measurements

Error message: *(6) motor vcalo unknown error*

Sometimes the motor controller gets stuck during a run of type CENTERTABLE, while being moved to the new table center. In this case there is an error message

(6) motor vcalo unknown error

In addition the run will be stuck, with the field `Table position` indicating `UNKNOWN` or `UNDEFINED`. In both cases the colour will be dark-yellow. This error message

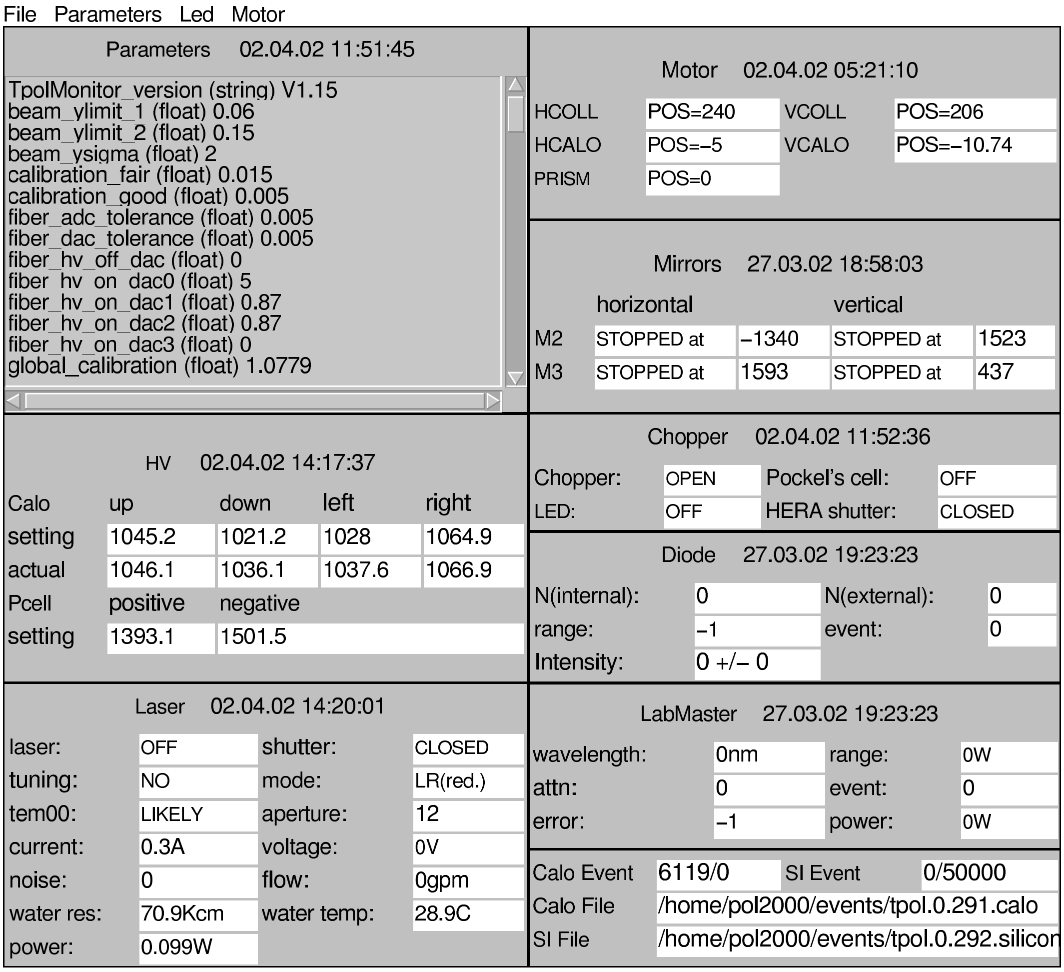

Figure 4.4: The Slow control window of the TPOL monitor

could indicates that some part of the motor hardware is broken. However, in the past this was never the case. To recover from this error, follow the procedure described below:

1. Open the Slow control window (select `SlowControl` in the `Frames` menu of the main window). The Slow control window is depicted in Figure 4.4.

2. Select `Reset VCALO` in the `Motor` menu of the Slow control window. This resets the motor controller error condition.

3. Close the Slow control window

4. If the run is still stuck, with the field `Table position` indicating `UNKNOWN` or `UNDEFINED`, click on `Table position` in the Run Control window and

select `Stop transition`. This tells the pilot that the motor is not moving anymore. The AUTOPILOT should then take care of resuming the table movement.

5. If the error comes back again immediately, contact an expert.

Error message: *bunch zero is at ??*

This could be an indication that the HERA first bunch signal has jumped. If the HERA first bunch signal has jumped, the parameter `bunch0_position` needs to be adjusted.

1. Make sure the HERA clock really has jumped: in this case the message will be repeated every time the LASER-on data is analyzed (i.e. once per minute if the run type is BEAMPOL). Make sure to have at least two consecutive error messages showing the same number
2. Find the current number for the parameter `bunch0_position`. The DAQ parameters are listed in the slow-controls window (see Figure 4.4). In the top left part there is a scroll-window. The parameters are listed alphabetically in three groups: parameter (string), ...parameter (float), ...parameter (int). The parameter `bunch0_position` is of type (int), so it is in the lower part of the list, following the (float) parameters.
3. calculate the new value for the parameter, using the formula

$$\text{new} = \mod(\text{old} + \text{shift}, 220)$$

   The parameter shift is taken from the error message.

4. Example:
   Error: `bunch zero is at 54`
   Old parameter: `bunch0_position (int) 202`

$$\text{new} = \mod(202 + 54, 220) = \mod(256, 220) = 256 - 220 = 36$$

5. Update the value of `bunch0_position`: select `bunch0_position` using the mouse, then select `Change parameter` in the `Parameters` menu of the Slow-controls window.
6. **Note: clock jumps are often observed if HERA is operated with leptons only.**

Error message: Analysis did not finish in time

This can happen during all measurements which use "short" cycles in order to measure beam related quantities. The following run types can be affected: CENTERTABLE, CALIBRATE, FOCUSSCAN, TILTSCAN. For runs of type CENTERTABLE and CALIBRATE the message can safely be ignored. If in doubt, stop the current run and start a new one.
Measurements of type FOCUSSCAN or TILTSCAN will usually be compromized after this error was observed, so they should be repeated.

Chapter 5

Expert actions

Some operations on the TPOL should be performed by an expert only. Among these are:

1. Changing important DAQ parameters
2. Switching on or off the LASER or changing its parameters
3. Step Motor reset and reference move
4. (Re-)start the data acquisition or parts of it

5.1 Connect an expert session

There are several ways to connect as an expert:

1. Select `expert` as `session type` in the Run Control window. This is the recommended way to connect.
2. Start the `session` program on `pctpol03`. This is useful for things which are not yet in the TpolMonitor and for screens which do not support graphics. However, currently the pilot is not supported properly and error messages are not displayed.
3. Start the `super` program on `pctpol03`. This is very dangerous. Commands have to be typed in as plain text. Syntax errors will cause DAQ crashes.

Only the first method will be described in more detail in the following.

5.2 Change DAQ parameters

Many DAQ parameters can be changed at any time without compiling the software. Such a change will be recognized immediately by all parts of the DAQ using that parameter. To change a parameter, do the following:

1. Select the name of the parameter in the `Parameters` panel of the Slow control window using the mouse (under linux: double-click on the parameter name or mark it using the mouse)
2. Then select `Change parameter` in the `Parameters` menu
3. change the value of the parameter in the dialog which pops up

5.3 Laser control

The laser can be switched off and on from the Run Control window in expert mode. Click on the Laser field to find the corresponding menu. After switching on the laser, wait a few seconds until it displays `SWITCHON`. Wait one minute until the laser is on (display changes to `SHUTTER`), then open the shutter (in the same menu). After opening the shutter again wait a few seconds until the display is updated. If the shutter does not open within 30 seconds, the interlock is not set. Otherwise the display will change to `ON` or `HERASHUTTER`. In the latter case the shutter controlled by the HERA beam interlock is still closed and You have to wait for the HERA wide *Strahlfreigabe*.
More detailed information about the laser is available on the slow control panel. The `Laser` menu contains many functions to control the laser in greater detail.

5.4 Step motor control

The step motors may be reset and moved to their reference position using the `Motor` menu of the Slow control window. It is currently not possible to directly change the position of a motor. To change a motor position, change the relevant DAQ parameter (the current nominal position) and let the pilot do the work. Alternatively, use the `session` program, but be aware that the AUTOPILOT may change the position back or get confused.

5.4.1 Table position

Make sure the pilot is not using the table (disable the AUTOPILOT, then stop the run). Then change the nominal table position:

- `table_x_nominal` is the horizontal position
- `table_y_nominal` is the vertical position

Then select `move table to center` in the `Table position` field of the Run-control panel. Then enable the AUTOPILOT again.

5.4.2 Collimator position

The relevant DAQ parameters are

- `hcollimator_closed`
- `hcollimator_open`
- `vcollimator_closed`
- `vcollimator_open`

In addition there are parameters `hcollimator_enabled` and `vcollimator_enabled`. It is not necessary to change them directly. Use the pop-up menues connected to the collimator buttons to enable/disable/ignore a collimator.
Note that the AUTOPILOT will immediately try to adjust the collimator position after the nominal position was changed. If that is not what You want, disable the AUTOPILOT before changing the parameters. If You change the "open" position of a collimator which is disabled, it is wise to enable that collimator before changing the nominal position. If the AUTOPILOT is disabled, the collimators may be controlled (opened or closed) from the Run control window.
Note on disabled collimators: a collimator which is not in the nominal "open" position but it is disabled is causing an error condition. The reason is the following:

- if the collimator is disabled but open, the beam can be controlled using the other collimator.
- if the collimator is disabled but not open, the beam can not be controlled by the other collimator (because the disabled colimator may be blocking the beam)

To circumvent this feature there is an option `ignore collimator`. After selecting this option the position of that collimator is completely ignored by the pilot.

5.5 Restarting the data acquisition

Currently this documenation is available on the www only. See
`http://pctpol03.desy.de/experts/expert_tasks.html`
for details.

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