

Extraction, Correction and Smoothing of TPOL 2004 data from ORACLE database for HERMES

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Abstract

This report describes developing of Perl scripts for extraction of TPOL data from ORACLE data base, and the correction of extracted data. The extracted data are used to calculate and plot LPOL/TPOL ratio.

1 Introduction

Electron beam in high-energy storage rings emits synchrotron radiation and because of that radiation beam can become transversely polarized. Polarization is function of time and it is described by formula [1]:

$$P(t) = P_{\infty}(1 - e^{-\frac{t}{\tau}}) \quad (1)$$

In this formula asymptotic polarization P_{∞} and time constant τ are characteristic of storage ring.

In HERA electron ring measurement of polarization is based on Compton scattering of circularly polarized photons. That method was suggested 30 years ago and successfully it have beam used for measuring transverse polarization in storage rings. Same method was also used in some linear accelerators for measuring longitudinal polarization.

In 1992 in the HERA West Section has been constructed Compton polarimeter to measure transverse polarization [3]. In the fall 1996 the longitudinal polarimeter was added to obtain an independent and more precise measurement of polarization at HERA. This polarimeter is placed in the East Section, between spin rotators at HERMES experiment [1]. Since year 2000 TPOL have started to measure polarization separated from LPOL.

2 Apparatus

2.1 Longitudinal polarimeter - LPOL

A circularly polarized laser beam is used to measure polarization. Laser which is used in this experiment is Nd:YAG laser with wavelength of 532nm (energy of photon is $E_\lambda = 2.33eV$). This laser product 3ns long pulses and can work in a range from single shot up to 100Hz. Energy range for laser operation is from 1 to 250mJ. For this experiment laser is set to work at 100Hz and it is synchronized with electron bunches in HERA ring. Energy of the pulse is constant and its value is 100mJ. Laser emits linearly polarized light, and at the beginning of light path to interaction point photon beam is converted to circularly polarized. Polarization of the light is checked regularly with polarization analyzer. At the entrance to the laser transport system there is a set of lenses which expands beam diameter by factor of four. The reason for the expansion is to protect optical components in the light path by reducing energy density. The laser beam is controlled by six mirrors and it travels for 72m through vacuum pipe before coming to interaction point. The interaction point is placed between two bending magnets BH39 and BH90.

At interaction point angle between photon and electron beam is 8.7 mrad. The size of electron beam is $\sigma_x = 0.6mm$ and $\sigma_y = 0.2mm$ and it is 11mm long; laser beam has a diameter of 0.5mm and it's about one hundred times longer than electron bunch. Scattered Compton's photons are detected by calorimeter which is located 16m downstream BH90.

2.2 Transversal polarimeter - TPOL

TPOL experiment uses a 25 W Argon ion laser (INNOVA-200, Coherent Corporation). For this experiment laser emits 10 W beam at wavelength of 514.5nm (energy of photons is 2.41eV) [3]. From laser to interaction point photon beam guided by four mirrors. Same as in the case of LPOL laser, the laser emits linearly polarized light. The polarization is changed using a Pockels cells and quarter-wave plates to left and right circularly polarized. To minimize the degradation of polarization during transport by reflections vertically and horizontally polarized light are transported to the 4th mirror and are converted to circularly polarized light at entrance to machine vacuum.

The electron-photon interaction point is at the end of West straight section at WR-134. At the interaction point angle between photon and electron beam is 3.1 mrad [3].

Detector measure energy and the vertical position of the photon. The photon detector is calorimeter with 12 layers of tungsten and scintillator.

3 Data Extraction

All TPOL data are recorded in ORACLE database, in a table POLFIT. The table is property of POL2000 user, and to access it one can use the user-name

POLREAD. The list of all columns in POLFIT table is possible to find at [?]. In the case where there is a number 0 or 1 at the end of column name it refers to non-colliding and colliding electron bunches.

When the program finishes a job results are saved in a ASCII file with a name user had chosen. For farther processing of data I made a script *calc.pl*. This script reads data from a file created in the previous step and for each type of data in a table it calculate average and error for colliding and non-colliding bunches.

My main task was to extract data from TPOL database for all 2004 year and to save that data in a proper ASCII file. After that I compared those data with LPOL data for the same time interval. Also I wrote a program for calculating a correction in TPOL data. Programs used for extraction and correction of TPOL data are Perl and PAW scripts.

First program I wrote is *kread.pl*. That program extract data form ORACLE database and save them in ASCII file. The script works in two mode - *automatic* and *manual*. To start automatic mode user have to start script by typing *'kread.pl 1'* in command line. In this mode program use default set of names for name of columns it read from database and it only asks user to enter time interval. When program prompts for a date user have to enter the start and end date in format day-month-year (year is a four digits number). Time interval for which program extract the data stars at 00:00:00 time of the first day and finishes at 23:59:59 of the last day. Automatic mode is set in the way that it extract the data in a format readable by scripts described in this report. In data base all data are stored with appropriate Unix-time (multi-plated by 100), so I also had to write a function for converting standard time to Unix-time format. In manual mode (start just with *'kread.pl'*) user have a possibility to choose columns he wants, or even to select all columns in database by entering a sign *'*' as a column name. When the program finishes a job results are saved in a ASCII file with a name user had chosen. For farther processing of data I made a script calc.pl. This script reads data from a file created in the previous step and for each type of data in a table it calculate average and error for colliding and non-colliding bunches. Again, results are saved in a new ASCII file.*

3.1 Testing

I wrote few more Perl scripts to compare a data extracted with CGI [4] script on the web (http://pctpol02.desy.de/cgi-bin/pol_expert.pl) with data my script returned. The data I used for testing are from 1 Mar - 1 Apr 2004. At first difference in results obtained at those two way was big. The number of columns extracted from database was much bigger in results received from CGI script. Second problem was that after calculating a ratio between data obtained in those two ways result would always be 1 (because the data must be exactly same), but it wasn't. After analyst of results I conclude that I have to correct procedure for calculating Unix-time because it must include a time zone. After this change the difference in number have still existed, but I recognized some double records in a data received from web (exactly same row, with same Unix time and all

results). After removing repeating data the number of row was same in data extracted with both scripts. The cause for problem with calculating the ratio was difference in precession used in extracted data.

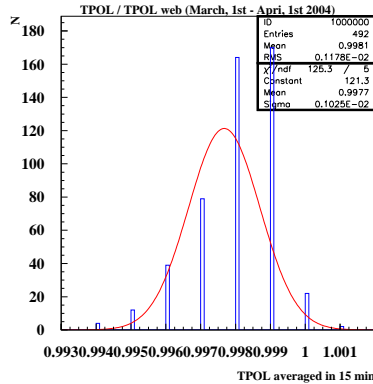


Figure 1: $TPOL_{mmilan}/TPOL_{cgi}$ ratio, 1 Mar - 1 Apr 2004

In database all data are recored with 5-6 decimal places, my script print all decimal places that exist in a database, but CGI script from the wab uses only 3 decimal places and it truncs all the other. I did the same with my data and the result was good (result is shown at Fig. 1). After comparison I returned my script to work again with all decimal places available in database.

4 Data Correction

It have been observed that results of TPOL measurement depends of the size of Compton beam at calorimeter. The size of Compton beam is related to the size of electron beam at interaction point. At HERA the size of focus varies from fill to fill. The calibration of the P^{online} measurement have been developed. The corrected TPOL polarization P^{corr} cab be calculated using a formula [2]:

$$P^{corr} = P^{online} \cdot (1 + 0.6649mm^{-1} \cdot (f - 0.44358mm)) \quad (2)$$

The corrected statistical uncertainty is same as uncorrected one because the uncertainties on f are small and may be neglected.

The script *tpolcorr.pl* reads the data from a file created with *calc.pl* and calculates a corrected TPOL data. Results are saved in a new ASCII file. The format of that file is: *Unix time, corrected polarization, error, luminosity, linear polarization, focus, beam position, corrected event rate, freq. with laser left (non-coll. bunches), freq. with laser right (non-coll. bunches), freq. with laser left (coll. bunches) and freq. with laser right (coll. bunches).*

5 Plotting

At this step process of requesting and preparing data for analysis and comparison with LPOL is finished. I used *ratio.c* program written by Andreas Most, Stephan Brauksiepe and Marc Beckmann to calculate ratio of LPOL and TPOL data, and a PAW script written by same authors for plotting the results. I have written a PAW script for plotting histograms for TPOL/LPOL ratio distribution. Also, I had to make a few simple changes in C program and PAW script to work with TPOL data extracted by my programs. I plot ratio between LPOL/TPOL and $LPOL/TPOL_{corr}$ data for all 2004 years, and both plots for two more time intervals: 1 Jan - 25 Mar and 25 Jun - 16 Aug 2004. All plots are included in this report.

6 Smoothing

When I had all these data and plots I used C program and PAW script written by Avetik Airapetian for smoothing $TPOL_{corr}$ data. For that purpose I made a Perl script that makes it automatic (*smooth.pl*). Results I got after smoothing are saved in *avet.desy.de/TPOL/TPOL2004s/* directory. The final results are saved in a files which name finishes with *'smoothes1'*. Those files have six columns: *time start*, *time end*, *polarization*, *error*, *scale factor* and *gap*. Last script *'fill.pl'* collect data from all smoothed files and save them in one file *fills.txt*.

References

- [1] M. Beckmann *et al.*, The Longitudinal Polarimeter at HERA (2001).
- [2] F. Corriveau *et al.*, A calibration of the HERA transverse polarimeter for the 2003/2004 data (2004).
- [3] D.P.Barber *et al.*, High spin polarization at HERA electron storage ring, Nucl.Instr.Meth. A338 (1994), 166-184.
- [4] Transverse Polarimeter, <http://pctpol03.desy.de/>

Polarimeter Comparison

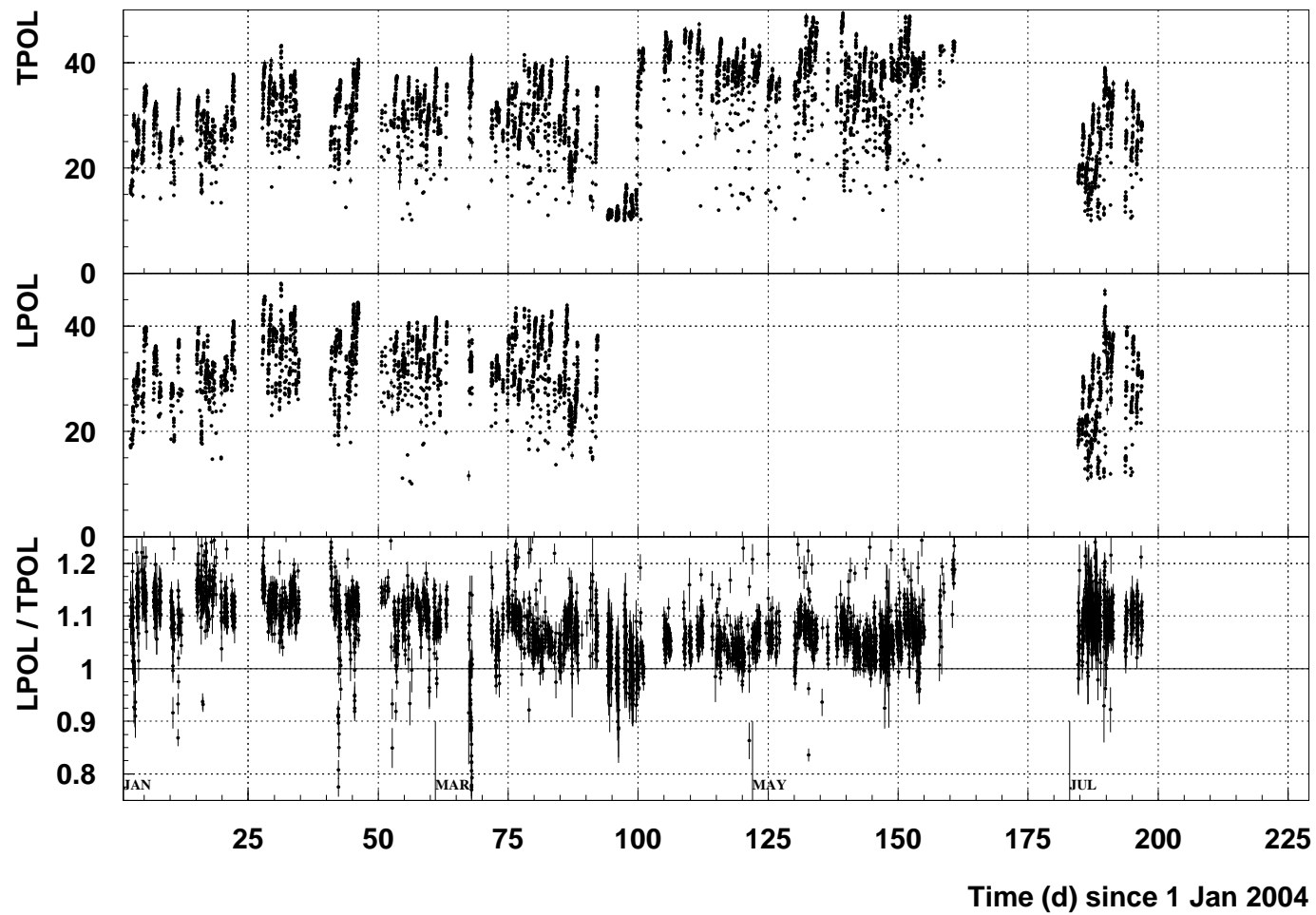


Figure 2: $LPOL/TPOL$ ratio

Polarimeter Comparison

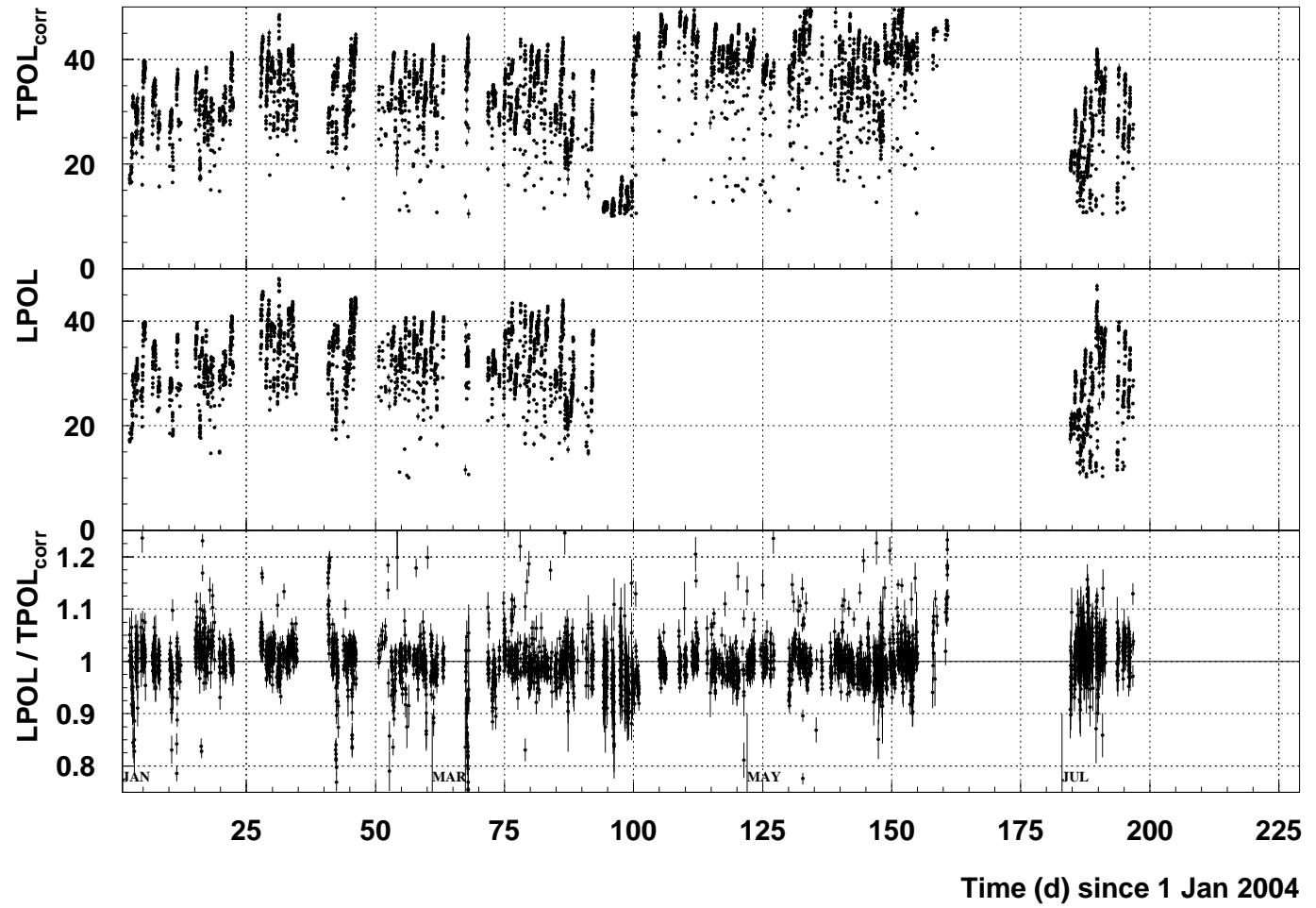


Figure 3: Corrected $LPOL/TPOL_{corr}$ ratio

Polarimeter Comparison

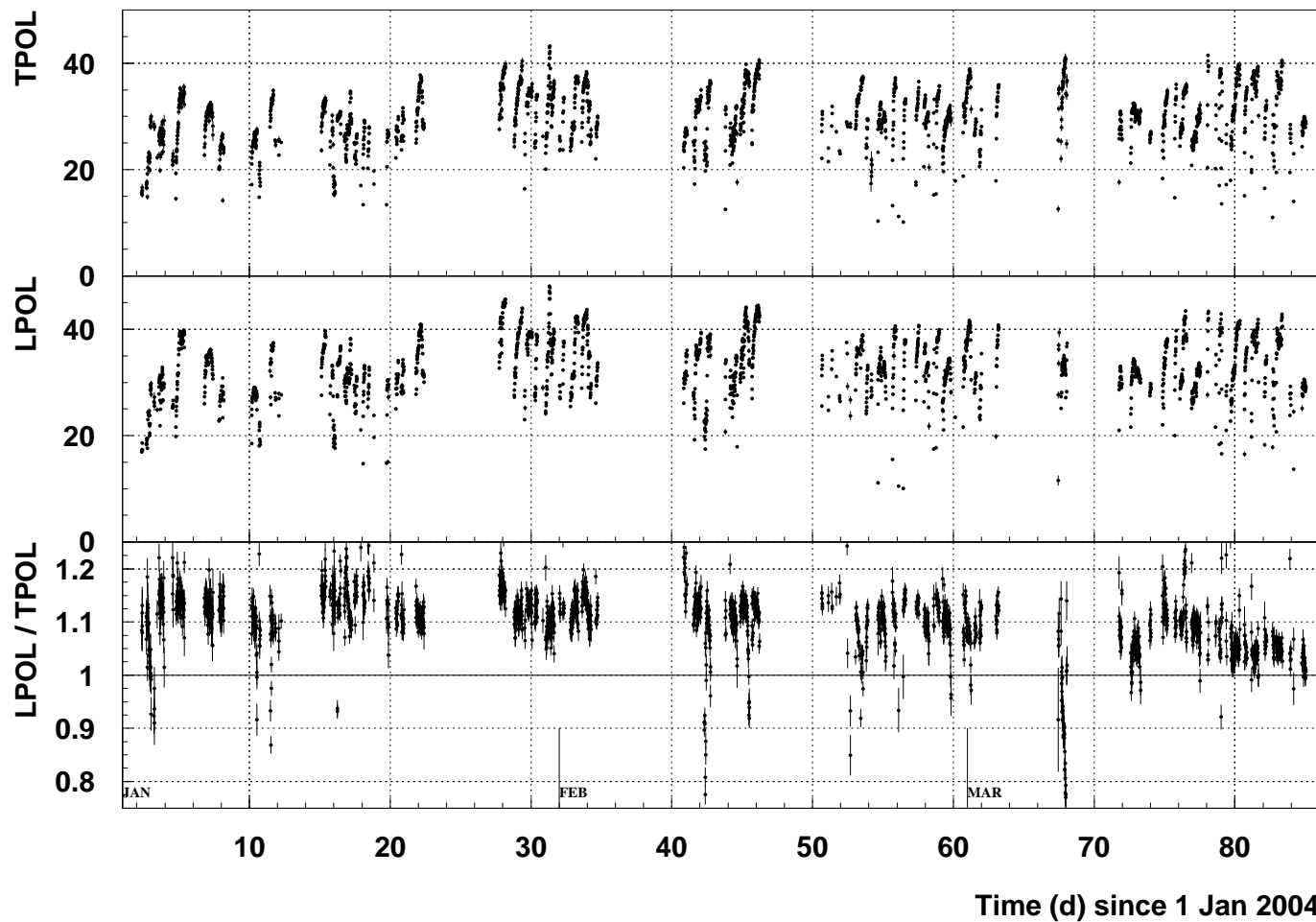


Figure 4: *LPOL/TPOL* ratio, 1 Jan - 25 Mar 2004

Polarimeter Comparison

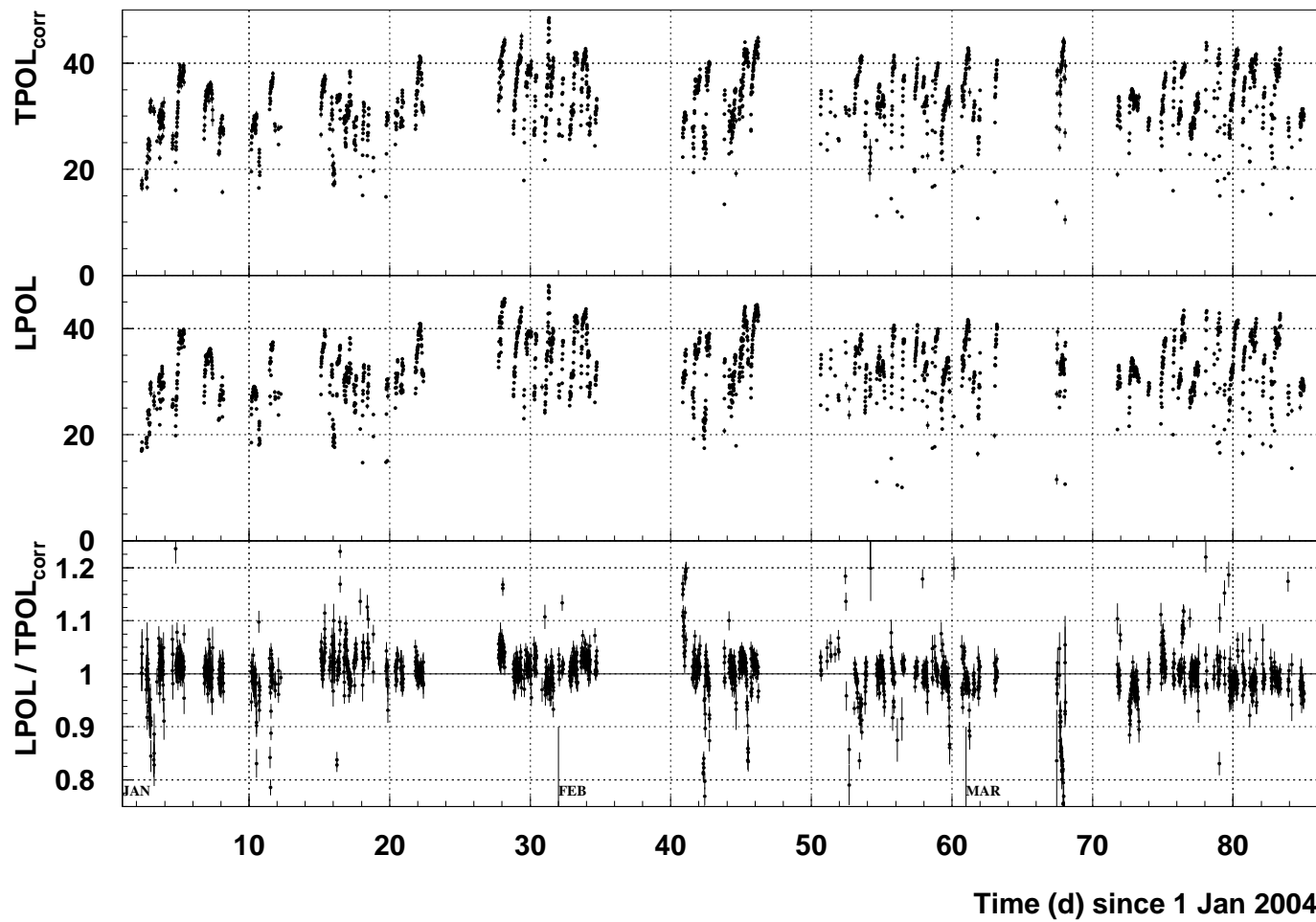


Figure 5: Corrected $LPOL/TPOL_{corr}$ ratio, 1 Jan - 25 Mar 2004

Polarimeter Comparison

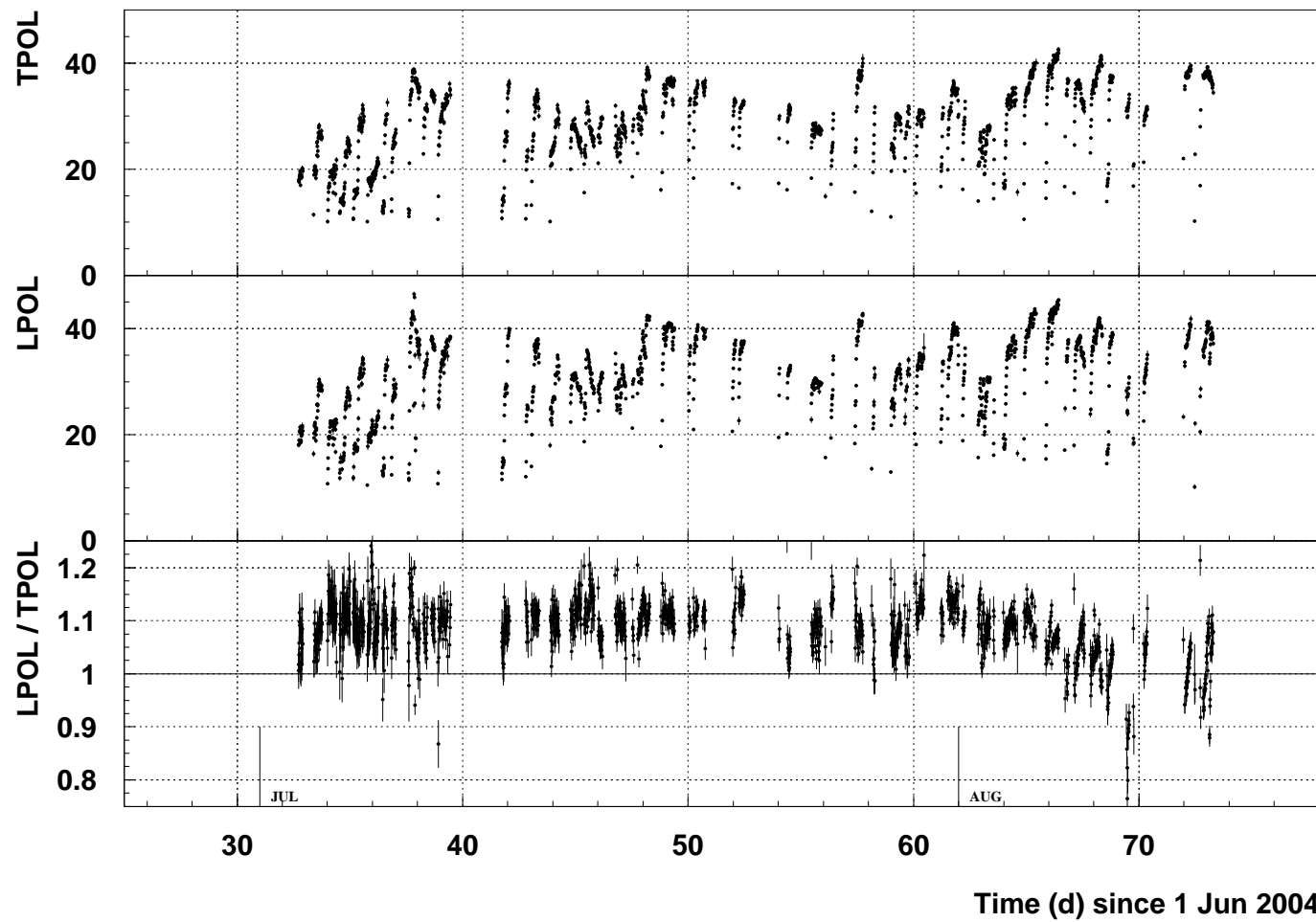


Figure 6: $LPOL/TPOL$ ratio, 25 Jun - 16 Aug 2004

Polarimeter Comparison

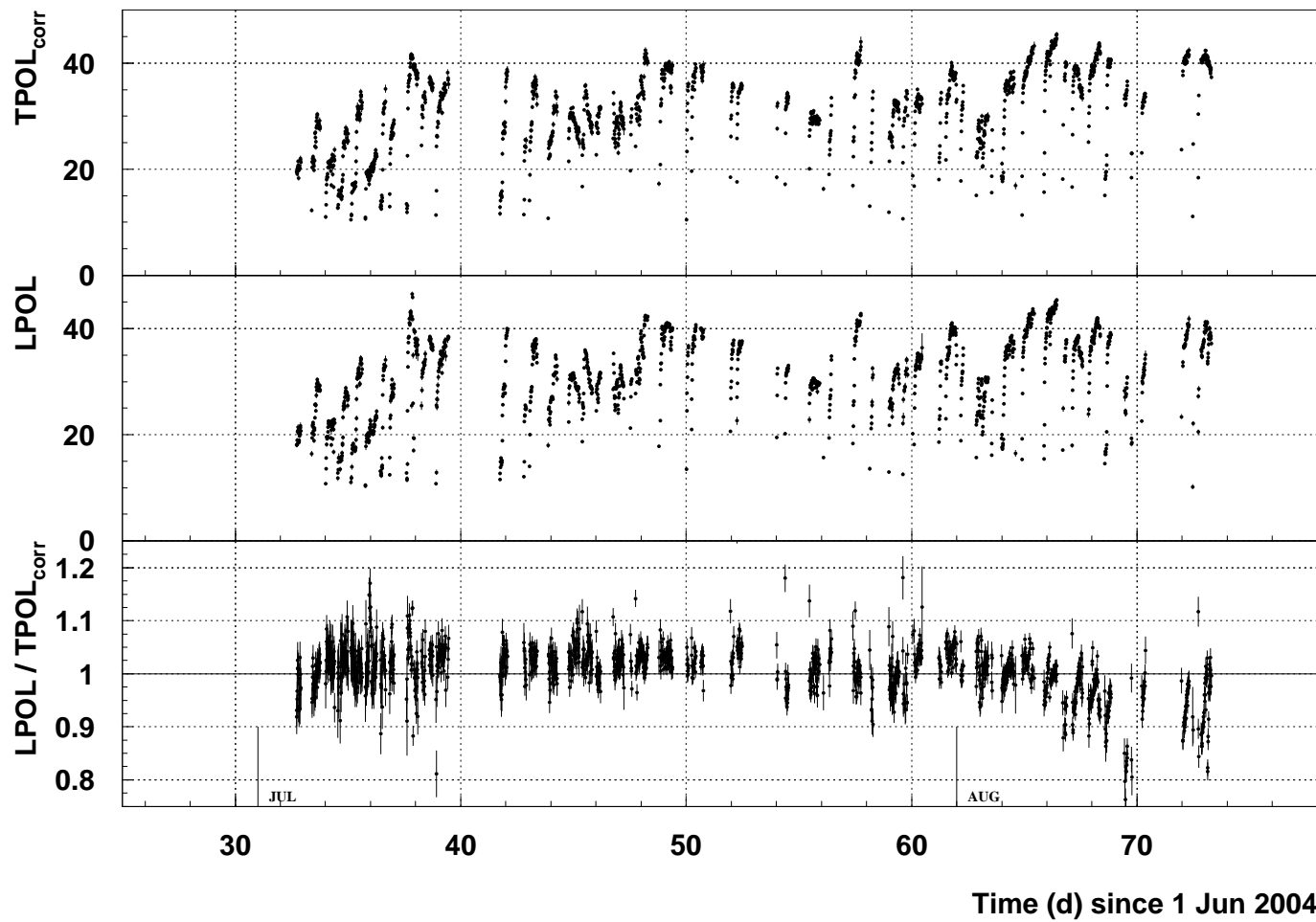


Figure 7: Corrected $LPOL/TPOL_{corr}$ ratio, 25 Jun - 16 Aug 2004

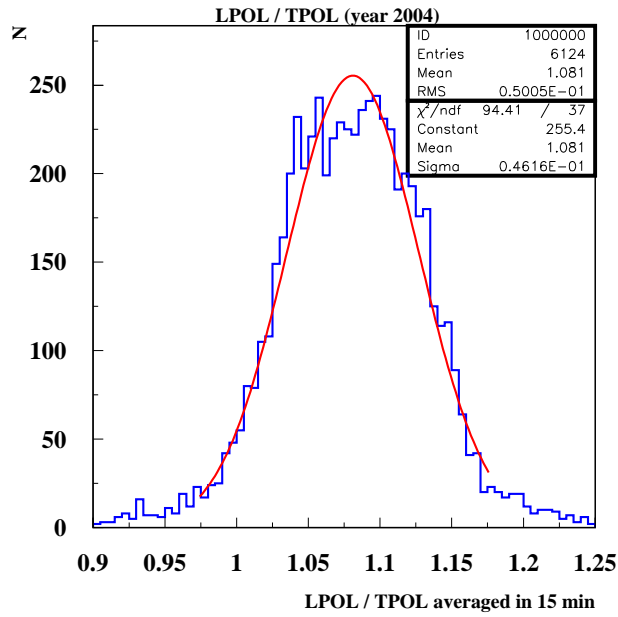


Figure 8: Histogram for $LPOL/TPOL$ ratio

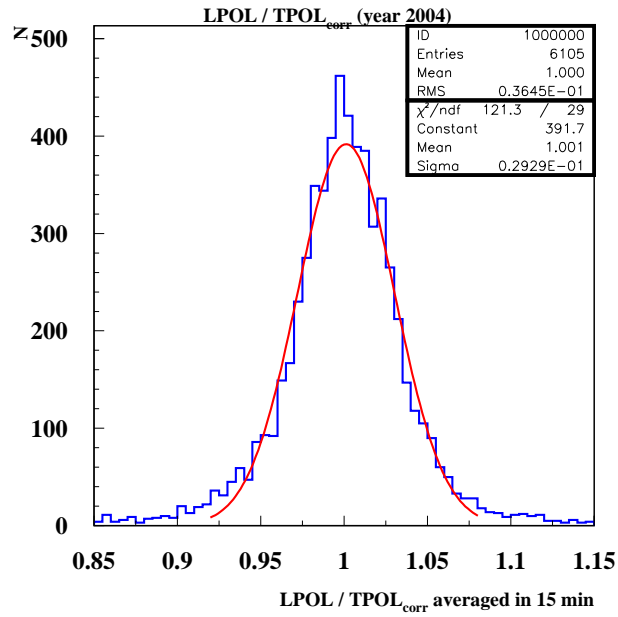


Figure 9: Histogram for corrected $LPOL/TPOL_{corr}$ ratio

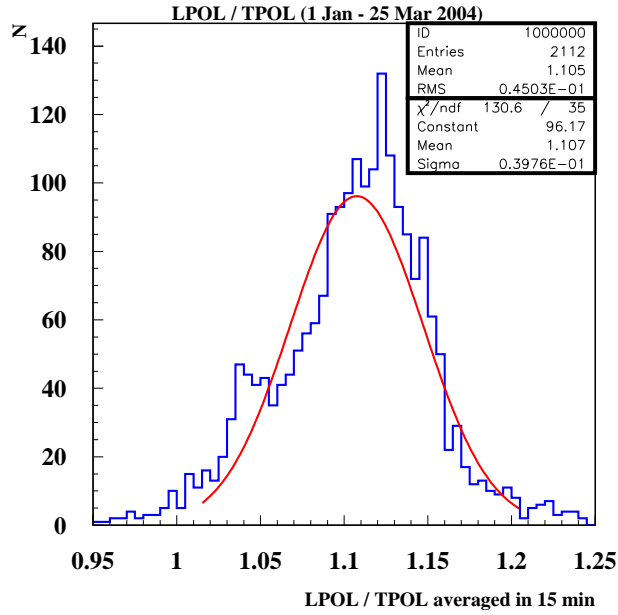


Figure 10: Histogram for $LPOL/TPOL$ ratio, 1 Jan - 25 Mar 2004

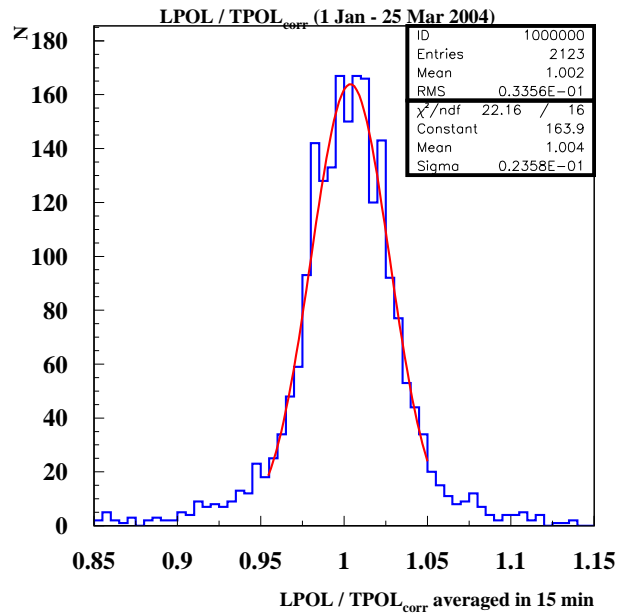


Figure 11: Histogram for corrected $LPOL/TPOL_{corr}$ ratio, 1 Jan - 25 Mar 2004

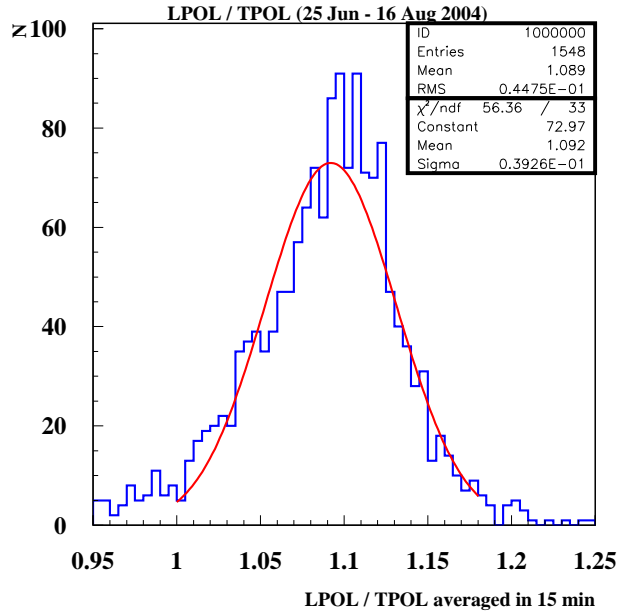


Figure 12: Histogram for $LPOL/TPOL$ ratio, 25 Jun - 16 Avg 2004

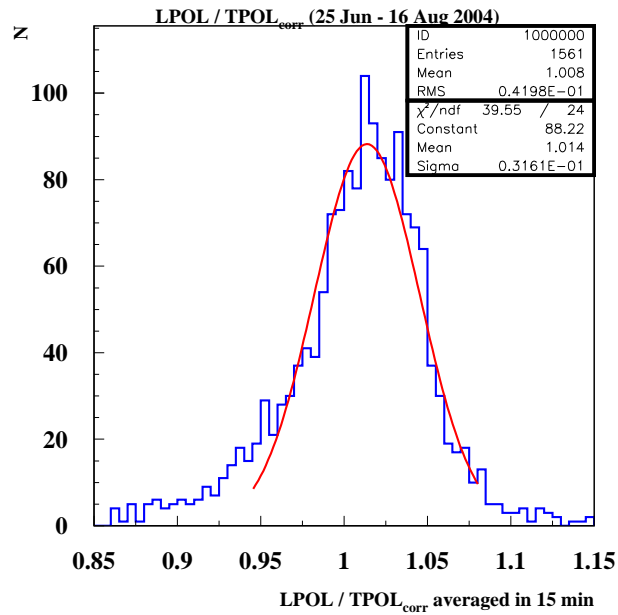


Figure 13: Histogram for corrected $LPOL/TPOL_{corr}$ ratio, 25 Jun - 16 Avg 2004

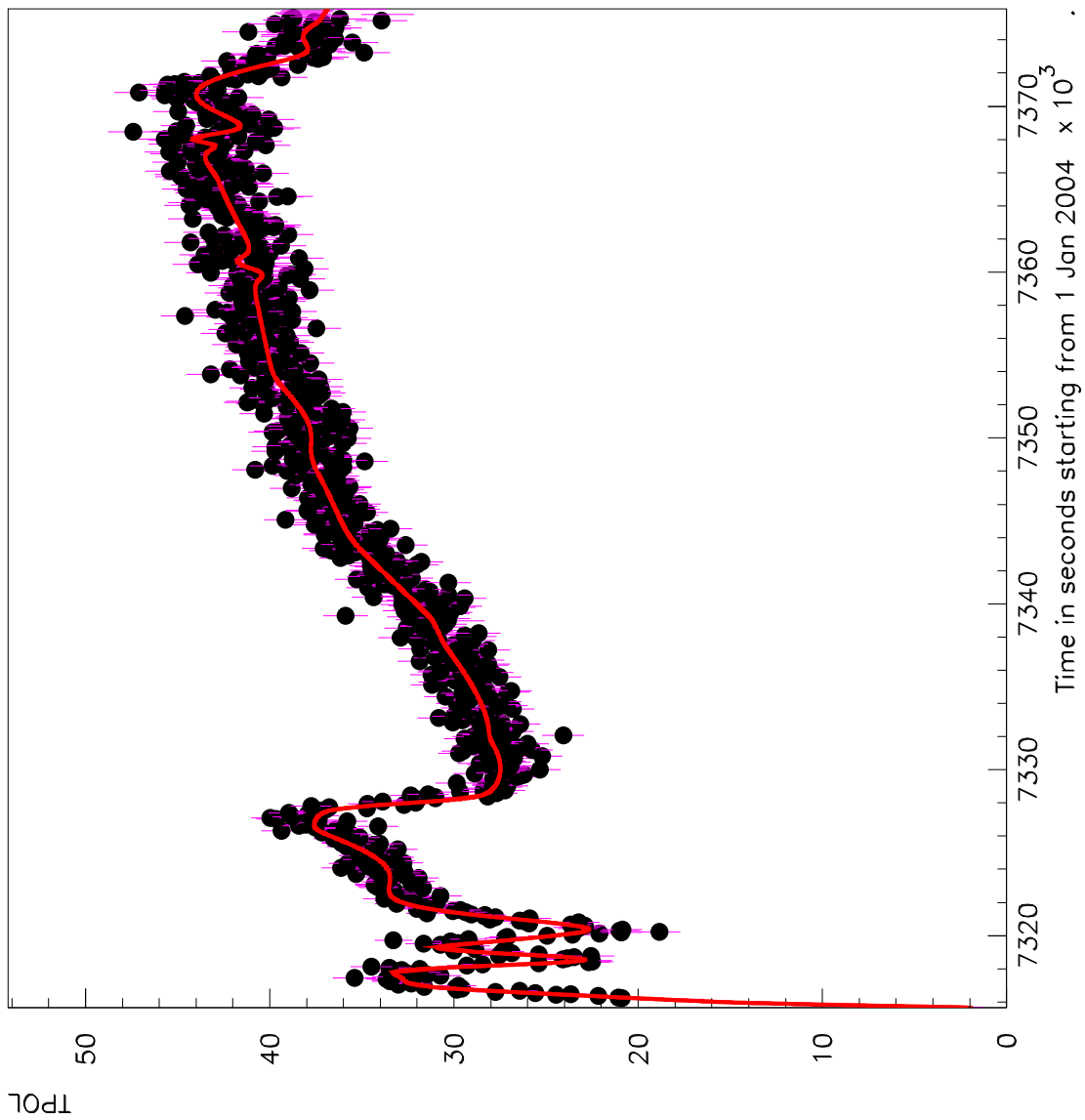


Figure 14: One of the smoothed files; fill: 25 Mar 2004, 16:07:44 - 26 Mar 2004, 08:51:06