Study of longterm stability of the AMANDA II detector between 2001 and 2003

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This work describes the study of the longterm stability of the AMANDA II detector in the frame work of the summer student program 2003.

Based on the online monitoring information the detector uptime is derived and paramter for for the selection of the optical modules are suggested. The technical part of the project work includes the preparation of the data volume of AMANDA II detector in the years 2001 and 2002 written on DLT tapes. Using methods that was developed for the year 2000 data volume it was necessary to improve the taping procedure. A short overview of the processing is given in the end of the report.

1 Introduction

1.1 The AMANDA II detector

The AMANDA detector array has been working in the current configuration since the austral summer 1999/2000. It consists of 680 optical modules (OMs) distributed over 19 cables (strings). An OM consists of a PMT in a pressure sphere. Due to thermal noise and radioactive decays in the pressure sphere the OMs have a noise rate between 500 and 2500 Hz. This noise is uncorrelated to the μ-induced light and can be used as for the stability estimation. Since the number of OM increased over the years they differ slightly in construction. All the OMs have common features but each module has its own behavior.

For the OMs the ADC[1] and TDC[2] signals are recorded.

Since the construction of the OM varies the DN for groups of the OMs differs as well. It offers a way to investigate the quality of the OM and the whole detector behavior.

1.2 Monitoring Information

The starting point for all the statistical calculations are the information in the run statistic files. These are files written for each run of the array. For each of the 680 OMs a value

ADC, TDC and DN rate for the current run is recorded. The values represent the behaviour of the OM during the run. For each run start and end time in days of the year and hours of the day recorded. The scope of the report is on the study of the DN.

2 Evaluation

2.1 Detector Uptime

The time when the detector was operating is referred to as uptime. The length of a run varies between few minutes up to several hours. Furthermore there are time gaps between the runs when the detector was not running.

The uptime for each run was extracted from the run statistic files. Since the runs have a varying length the uptime was calculated for each hour and for each day of the year. (This was averaged over the time of each run.)

In Fig. 1 is shown the uptime against the days of the years 2001 to 2003. One can clearly identify the three solid blocks of data taking in the austral winter of 2001, 2002 and 2003 up to the current date. For the year 2001 we only have information of the austral winter. During time period during the austral summer 2000/2001 and 2001/2002 we have no run statistic information. Since the beginning of the austral winter 2002 the information are complete up to day. The graph of the plot in Fig. 1 is more smooth in the

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[1] ADC = analog to digital converter
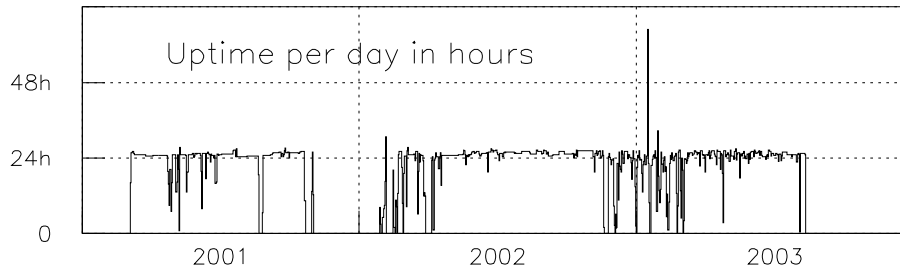[2] TDC = time to digital converter

Fig. 1: *Uptime per day in hours ver 2001 to 2003*

middle of the years. That means nearly every day 24h of data are recorded during the austral winter seasons. In the austral summer the the data taking was interrupted for maintaining the detector.

It can be seen that the effective runtime per day is often slightly more than 24 hours. It is due to the fact that the records in the run statistic files are not always correct but never the less they are still useful. Always regarding this fact the analysing is continued and can be taken as an example.

2.2   Dark noise

The DN rate is calculated in the AMANDA monitoring by counting the number of TDC edges occurring in the first 15 μs of the time window, where no signal is expected.

To derive value for the DN produced by every OM for a specific hour one needs to average over the DN entries for the runs having a share in this hour. The DN behaviour of each om differs from run to run one derives a proportional weight factor for each run depending on its length. Finally one ends up with an averaged value for the DN per hour and per day.

Fig. 3 shows the averaged DN behaviour of some few OMs in day precise resolution. The DN scale differs between the OMs. The OM 18 is clearly down in 2001 but it was repaired in 2002. The OM 1 as an example for string 1 to 4 shows a systematic step to higher noise

in the austral winter 2002. This is due to a exchange of the SWAMPs[3]. When the jumper configuration of the SWAMps was reseted in the end of January 2003 the DN decreased below the 2002 level but did not reach the 2001 standard.

The OM 127 is an example for the OMs at strings 5 to 10 and does not show the noise increase. The OM 309 represents the strings 11 to 13 and the OM 425 represents the strings 14 to 19. The OMs 309 are given as examples for OMs behaving very noisy in several time periods over years. Since the noise is scaled differently one clearly identify the different classes of OMs. Using these information quality parameter of the OMs can be defined. But moreover this classification can be improved.

2.3   Quality Parameter Definition

As a first step a reference noise level was defined. Since from November to February the detector is maintained an often down as seen in Fig. 1. The main season of data taking is the austral winter. Therefore we averaged over austral winter data to achieve a reference noise level. One counts only days where the uptime was not zero. Fig. 2 shows the OM 1 given as an example. The DN values of changes from is varying around the average DN value. We decided to accept data of the OMs when

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[3] Swedish Amplifier by Stockholm group

the DN is within a corridor of the width 2σ around the average where σ is the the standard variation.

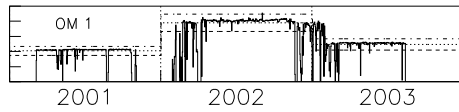$$\sigma = \sqrt{\frac{1}{(N-1)}\sum_{i=1}^{N}(x_i - \bar{x})^2} \qquad (1)$$

Fig. 2: *DN Variation (in Hz) around the average DN level per summer season and $\pm\sigma$ region*

Now one one can single out the days when an OM changes its behaviour significantly.

An OM is marked as stable is considered as stable when the DN did not vary more than 2σ from its yearly average. If the DN level for one day lies above the 2σ-corridor, the OM is marked as hot. If the DN is below the corridor the OM is marked as dead. This can be done for each day or hour whenever the uptime does not vanish. It is represented by a graph Fig. 4. Due to the restriction to the season between 15th February and 30th October no data is drawn for the austral summer. The blocks in diagrams of Fig. 4 refer the data taking season. Again we can see the OM 18 is dead during the season 2001 but it online again since 2002. The OM 117 is an example of an noisy module, It was switched off in winter 2002 because it was to often noisy. After it was repaired in summer 2002/2003 it runs stably until now.

Comparing the plots for OM 309 in Fig.3 and Fig.4 in the middle of the season 2001 the quality parameter turns out to be not well defined since we cannot identify the noisy period.
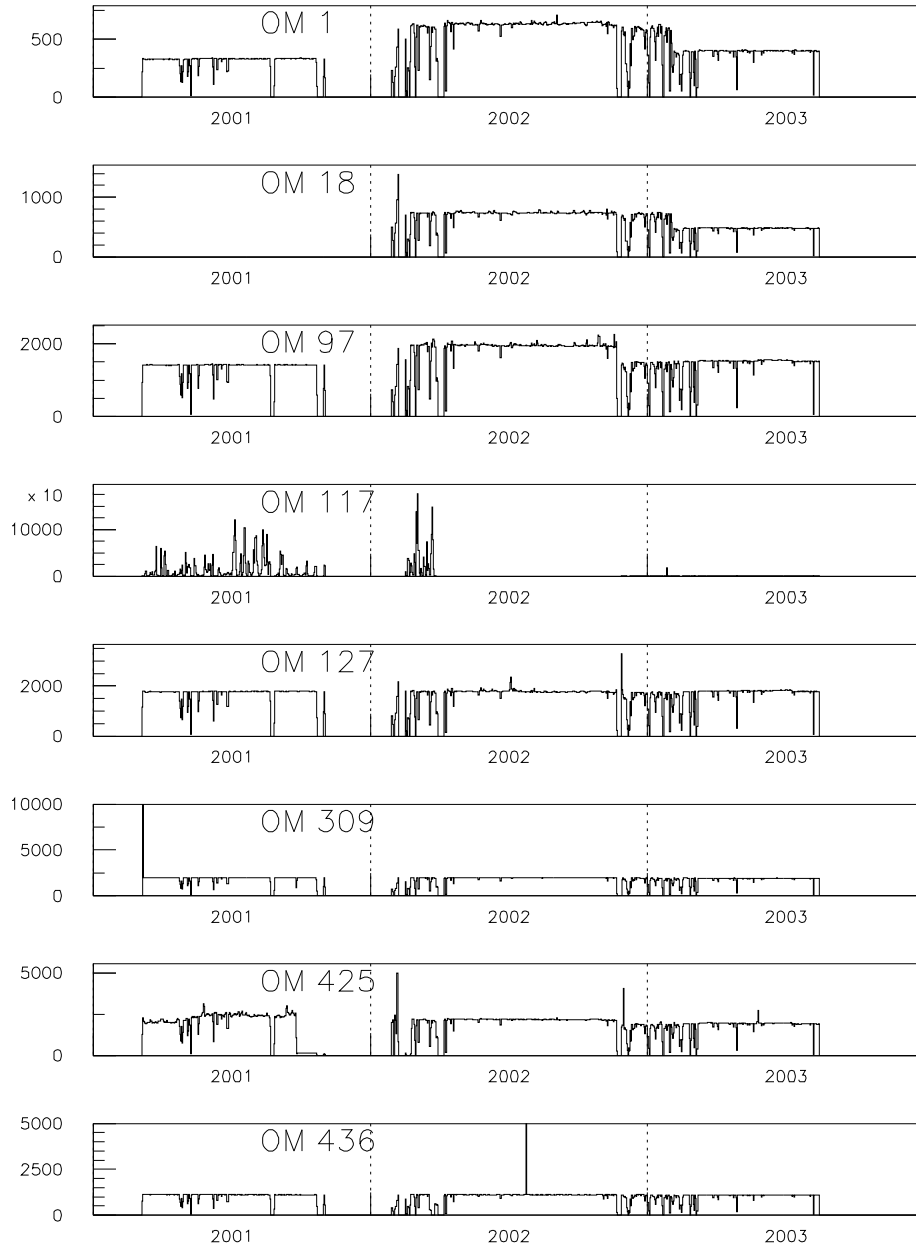
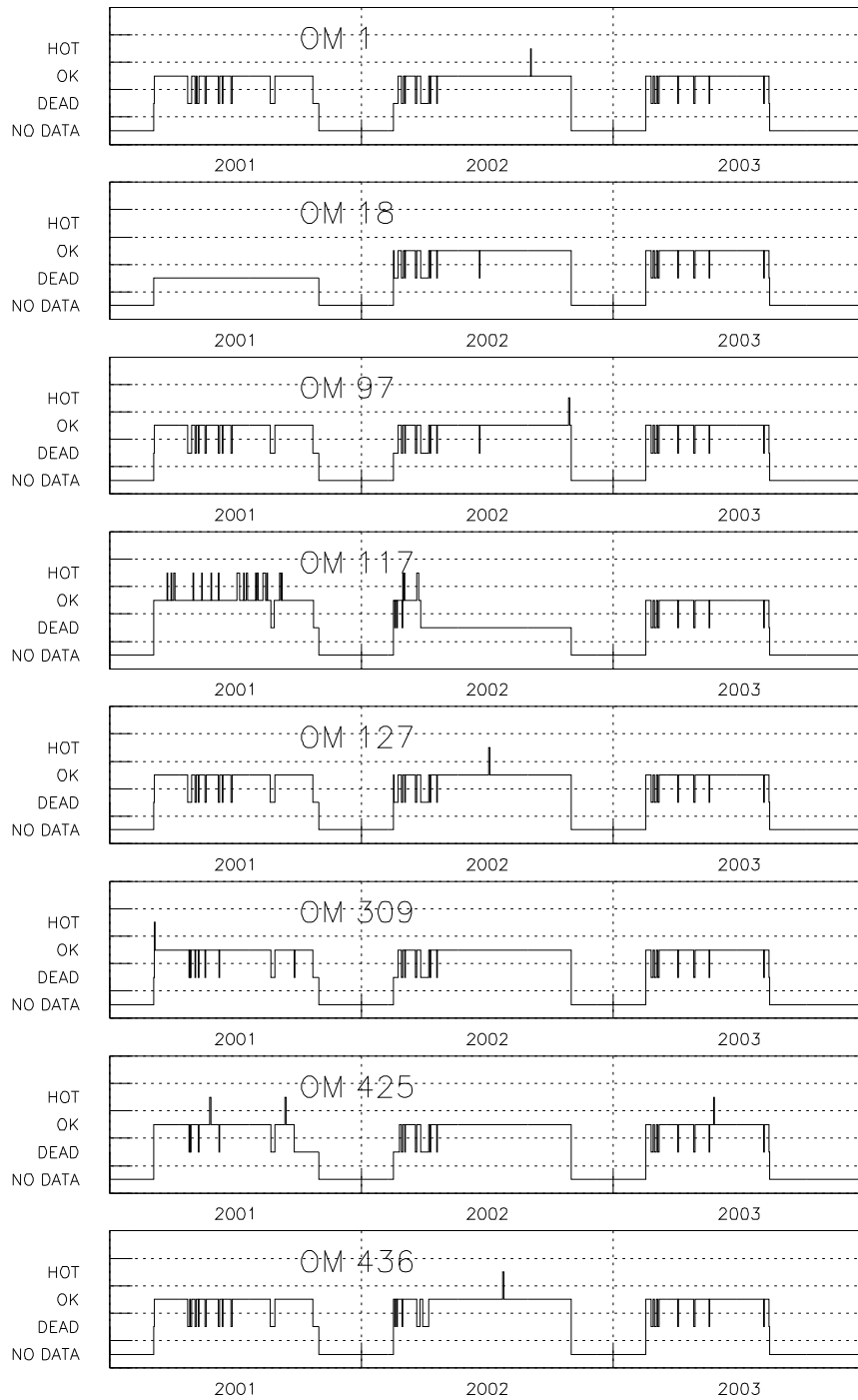Fig. 3: *Average noise per day in Hz of some few OMs*

Fig. 4: *Stability estimation of OM 1 to 6*

3   Results

3.1   Quality Selection

Based on the quality selection defined above one can estimate the fraction uptime during which the an OM was running OK. We call that OM uptime. Fig.6 shows the increase in percent for the first 15 OMs for the three years. As we expect from former plots, the percentage of the days when specific OMs run stable within the 2σ-corridor increased over the years.

We are now able to to mark clearly dead OM (eg. OM 3). An absolute estimation including all three years may be problematic since we know the run statistics are incorrect. However we have know the procedure that should allow an estimation using the correct information.

For further analysis it is necessary to select good and and bad OMs. We consider an OM to be good if it runs stable for more than 90% of the uptime per year. Fig. 5 shows the total number of good OMs. A detailed is added in the appendix. The number of OMs with more than 90% OM uptime increased from 2001 to 2002 and slightly to 2003. Again we mark out that the plot can be problematic due to the incorrect run statistics.

Percentage of bad OMs	
2001	11.32%
2002	8.38%
2003	8.24%

4   Conclusion

A prototype of an OM stability has been developed. Records of independent run periods have been combined.

As the example analysis it was shown that the DN can be used to define the status of the OMs. From the observation of a whole run period stable and unstable OMs can be identified. This can be an important input for the data analysis.

During the analysis of of the records of some few modules the method turned out to be buggy. However we now have a prototype analysis which can be improved regarding the selection criteria and can be applied for further OM selection methods.
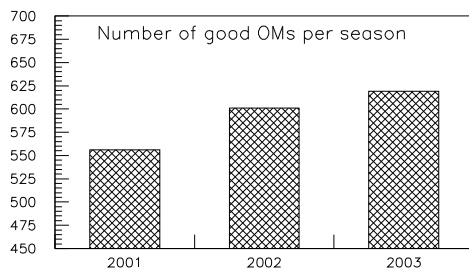
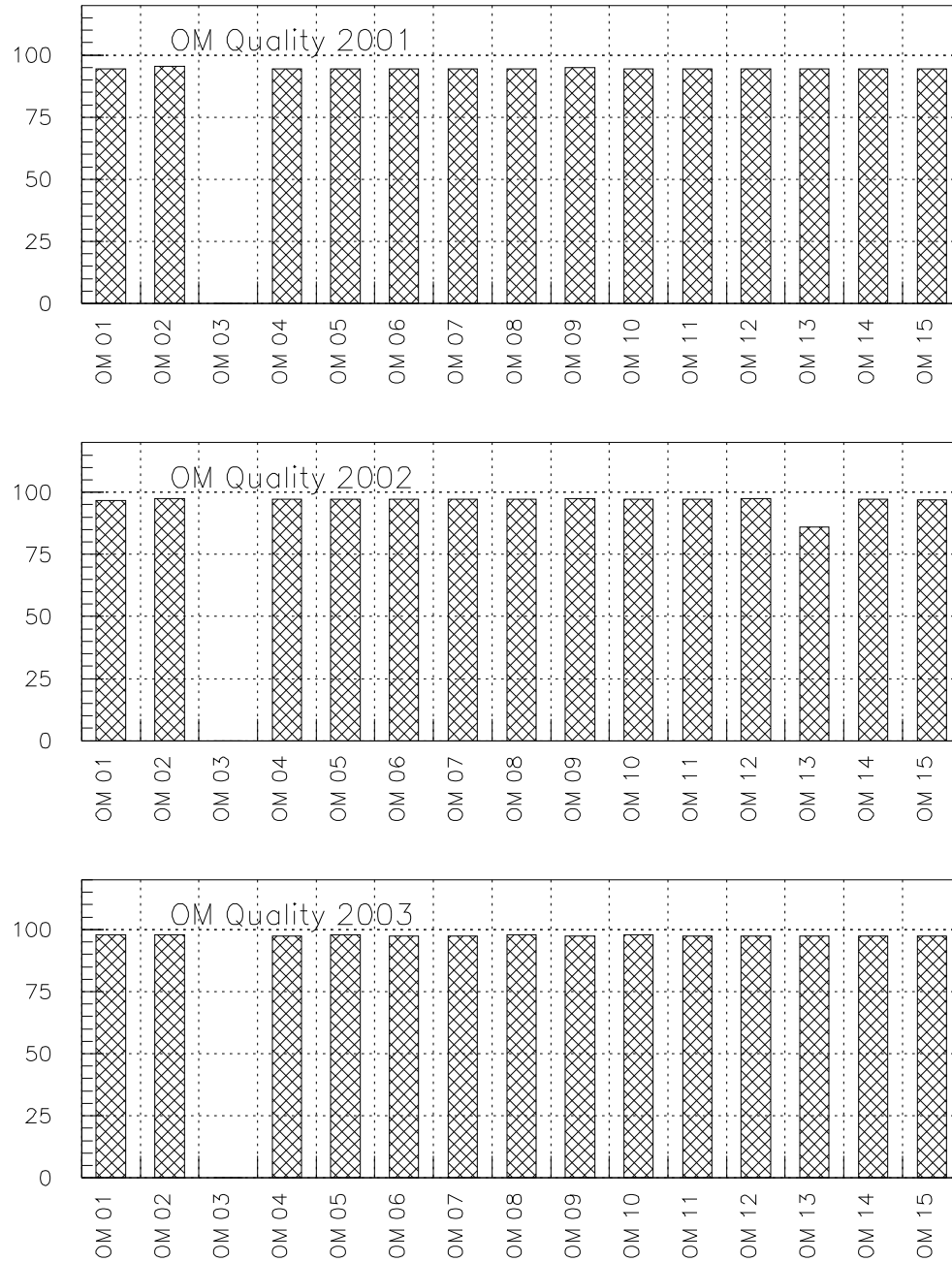Fig. 5: *Total number of OMs with more than 90% Efficiency*

Fig. 6: *Quality of the OMs 1 to 15 during the season 2001, 2002, 2003*

A   Technical stuff

The user will find a in on the disk 24 in the directory **/disk24/falkg/** four sudirectories containing all the codes and tools that we used to do the calculation discussed above. The directory **/disk24/falkg/monitoring/** is for summerizing all the results from the one year analysis. The directories **/disk24/falkg/monitoring[year]/scripts** contain the codes. Following codes doing the calculations: **hour.2001.pl, hour.2002.pl, hour.2003.pl**. The codes **fast_statist.2001.pl, fast_statist.2002.pl, fast_statist.2003.pl** do a run based analising and do not contribute to the discussed process.

The codes are also labelled with the year which referring to the year. The input for the programs is taken from the runstats which cn be found in **/disk7/leu/taping/moni/moni[year]**. The programs **hour.[year].pl** produce 680 (for each OM) files hour based files and 680 day based files. The hour based files are named **hourstat_[year]_om_[nr].dat** and can be found **/monitoring[year]/om_hour_statistic_[year]**, the day based files are named **daystat_[year]_om_[nr].dat** and can be found in **/monitoring[year]/om_day_statistic_[year]**.

The output files have 7 columns: (year/hour(or day)/OM Nr/Uptime/DN/ADC/TDC).

These DN/ADC/TDC are the the weighted values per hour or day. If the uptime is zero or we have no data the default value is -100.

In the directory **/disk24/falkg/monitoring/scripts** the user will find the programs **fast_time_stat.pl, selec.pl** and **badom.pl**. The fast_time_stat.pl takes the hour based files (day based) as input and produces the files **daystat_om_[nr].dat** in **/monitoring/om_hour_statistic** and **hourstat_om_[nr].dat** in **/monitoring/om_day_statistic** having also the 7 columns with the same headings.

The program selec.pl does the statistic taking the files in **/monitoring/om_hour_statistic** and **/monitoring/om_day_statistic** as input. It returns several output files in **/monitoring/selectiv/** summerised below.

Output files	Description
om_[nr].dat	/year/day/OM Nr/status/factor/ status = -1 for no data status = 0 OM is dead status = 1 OM in ok status = 2 OM is hot factor has no further meaning
sigma_om_[nr].dat	/year/day/OM Nr/DN of the day/DN average - σ/DN average/DN average + σ/
om_eff.dat	/OM Nr/Quality 2001/Quality 2002/Quality 2003/ (Quality means percentage of OM uptime in detector uptime.)
numom.dat	numbers of OMs with more than 90% OM uptime in 2001, 2002, 2003

B Figures and Tables

B.1 First OM Selection

As former mentioned an OM is considered as bad if it run more then 10% of the uptime in the season between 15th Feb and 30 Oct to noisy or to quiet. The result is the list given below.

15th Feb - 30th Oct 2001	
Bas OMs	3 18 28 32 39 40 47 50 57 61
77	62 78 81 85 86 96 143 172 185 186
	195 197 215 231 232 235 265 266 303 304
	305 306 354 361 363 364 377 400 401 406
	408 412 416 418 421 424 428 444 447 455
	494 503 509 543 556 557 558 563 564 569
	571 573 574 575 577 578 587 590 604 610
	620 632 638 647 651 675 677

15th Feb - 30th Oct 2001	
Bad OMs	3 28 32 40 47 50 57 62 78 96
56	195 197 199 231 232 267 303 304 305 306
	352 354 387 400 401 406 416 418 447 455
	494 503 509 543 557 559 560 561 563 564
	569 571 573 574 575 577 578 587 601 604
	610 620 632 654 675 677

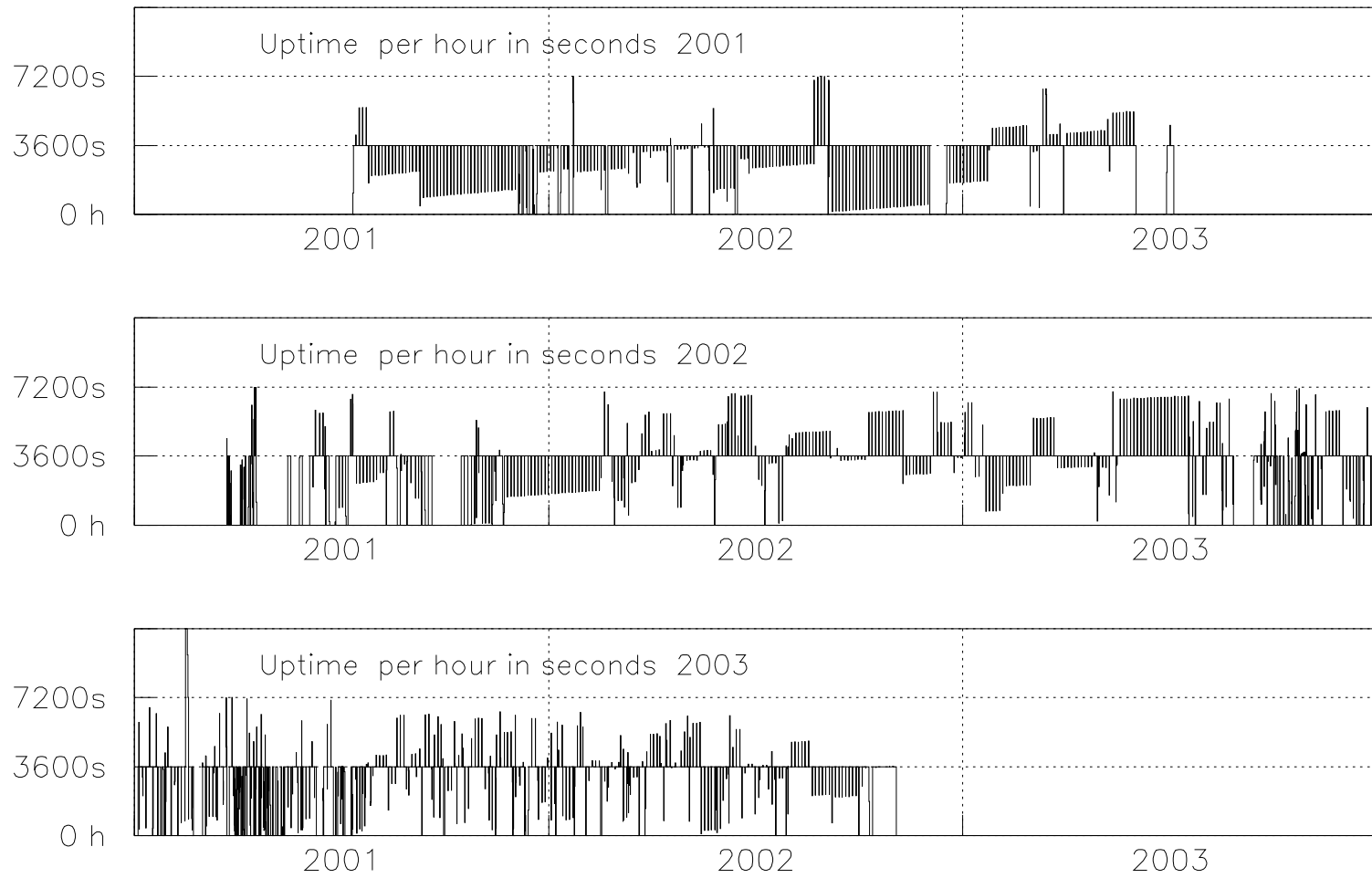| 15th Feb - ... 2003	
Bad OMs	3 28 32 40 47 50 57 62 78 96
52	143 172 186 195 197 231 232 265 266 267
	303 304 305 306 354 387 400 401 406 418
	447 455 494 503 543 557 563 564 569 573
	574 575 577 578 587 601 604 610 620 632
	675 677

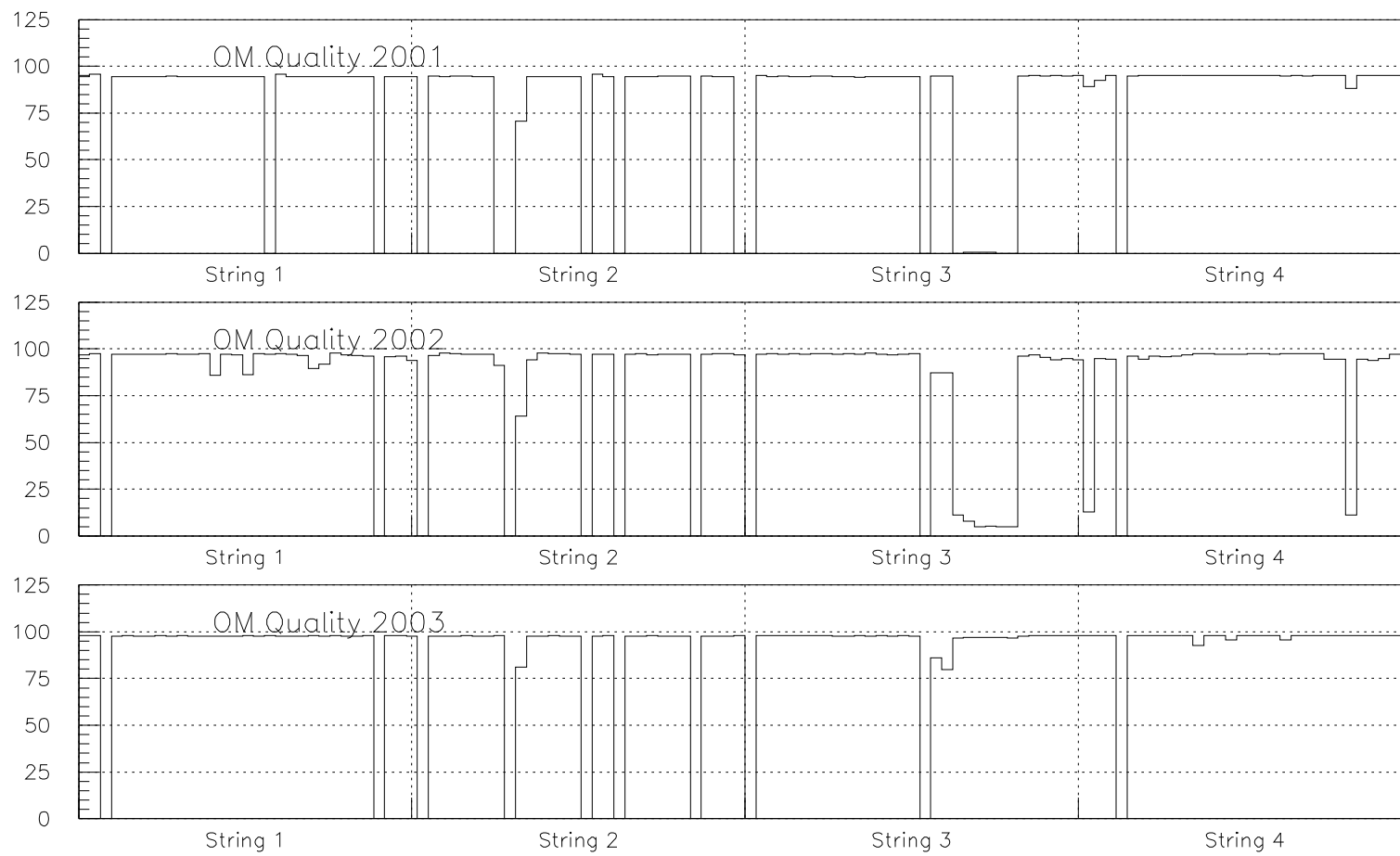Fig. 7: *Uptime in hour resulution 2001, 2002, 2003*

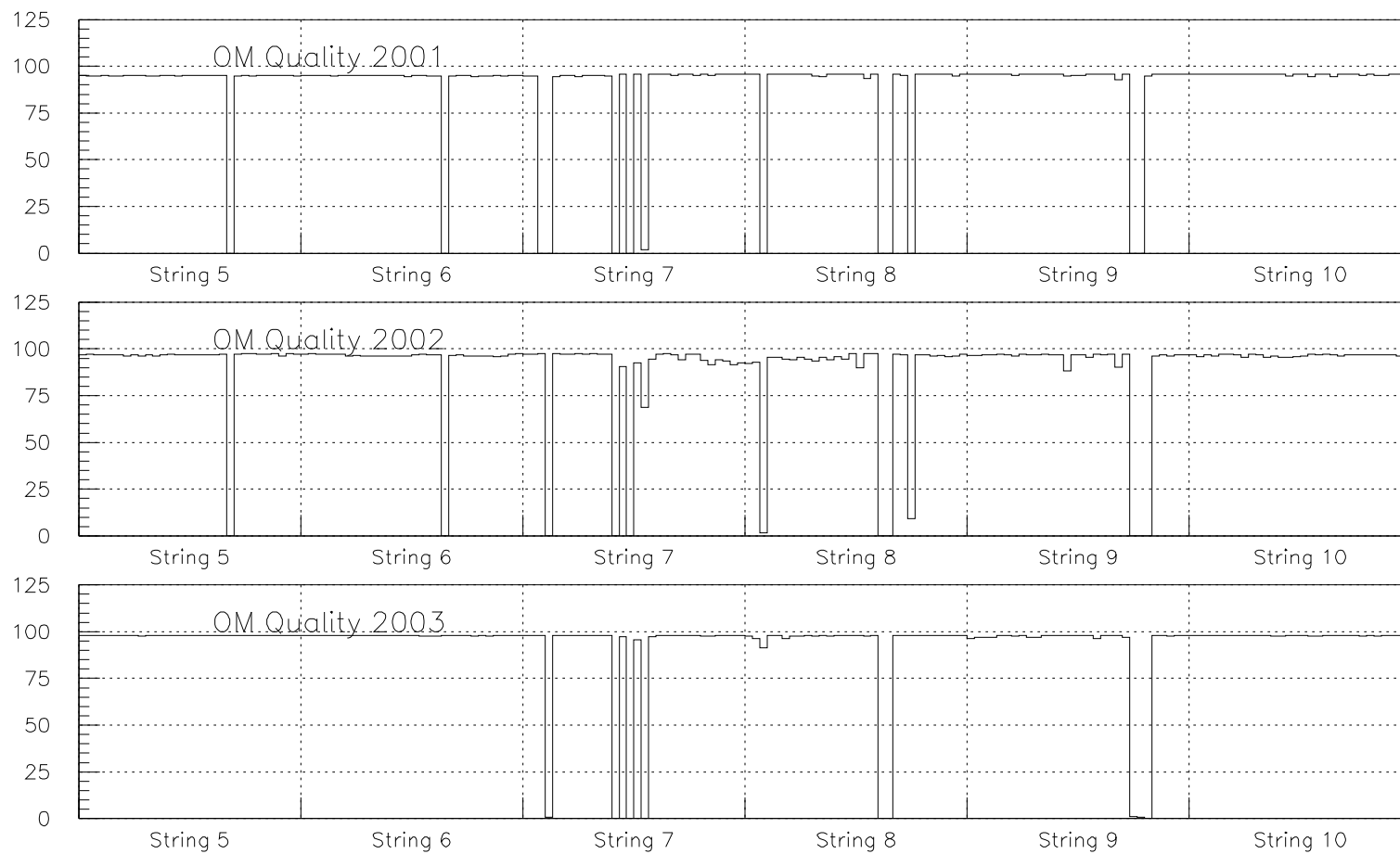Fig. 8: *Quality of the OMs on string 1-4 to 15 during 2001, 2002, 2003*

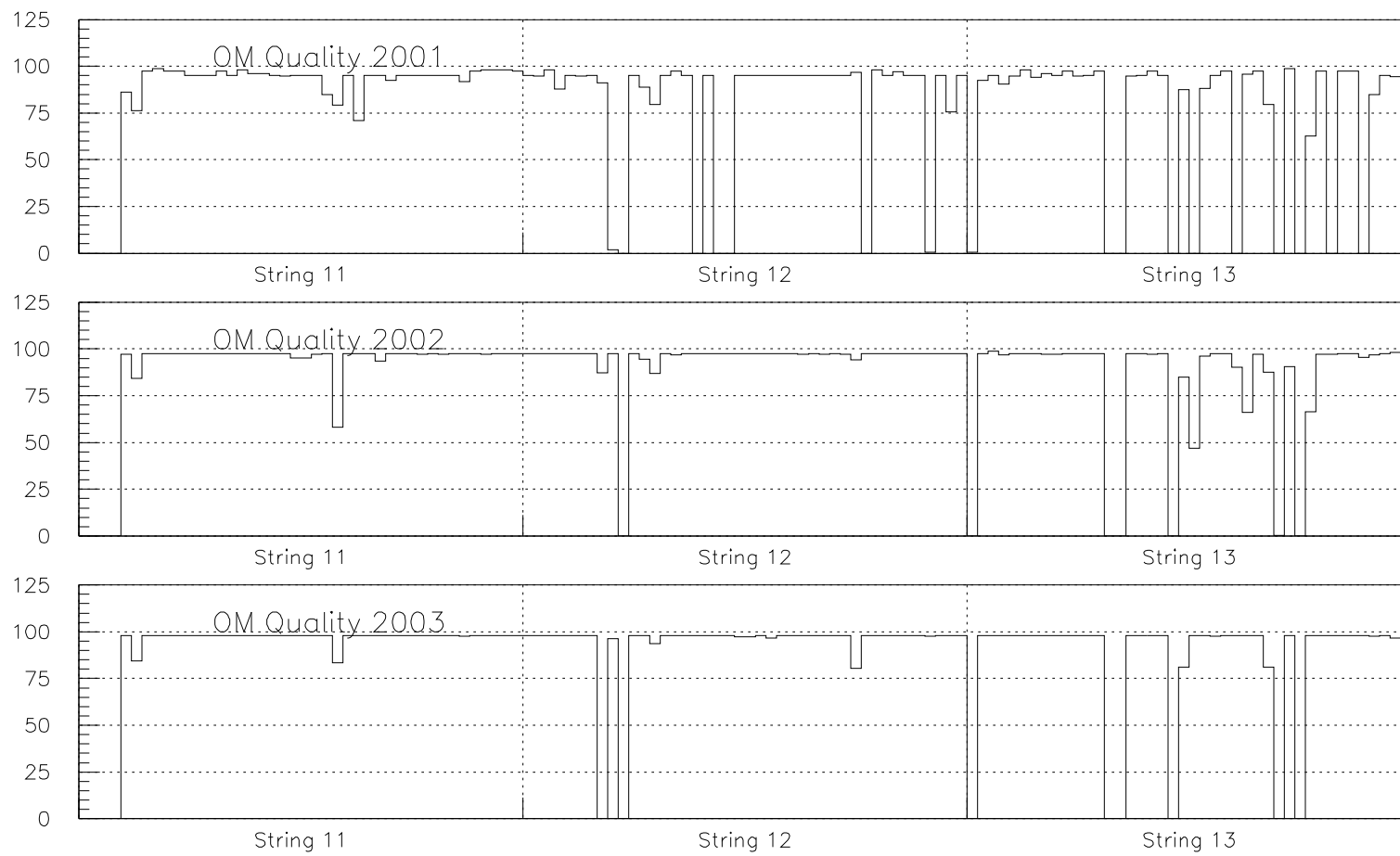Fig. 9: *Quality of the OMs on string 5-10 to 15 during 2001, 2002, 2003*

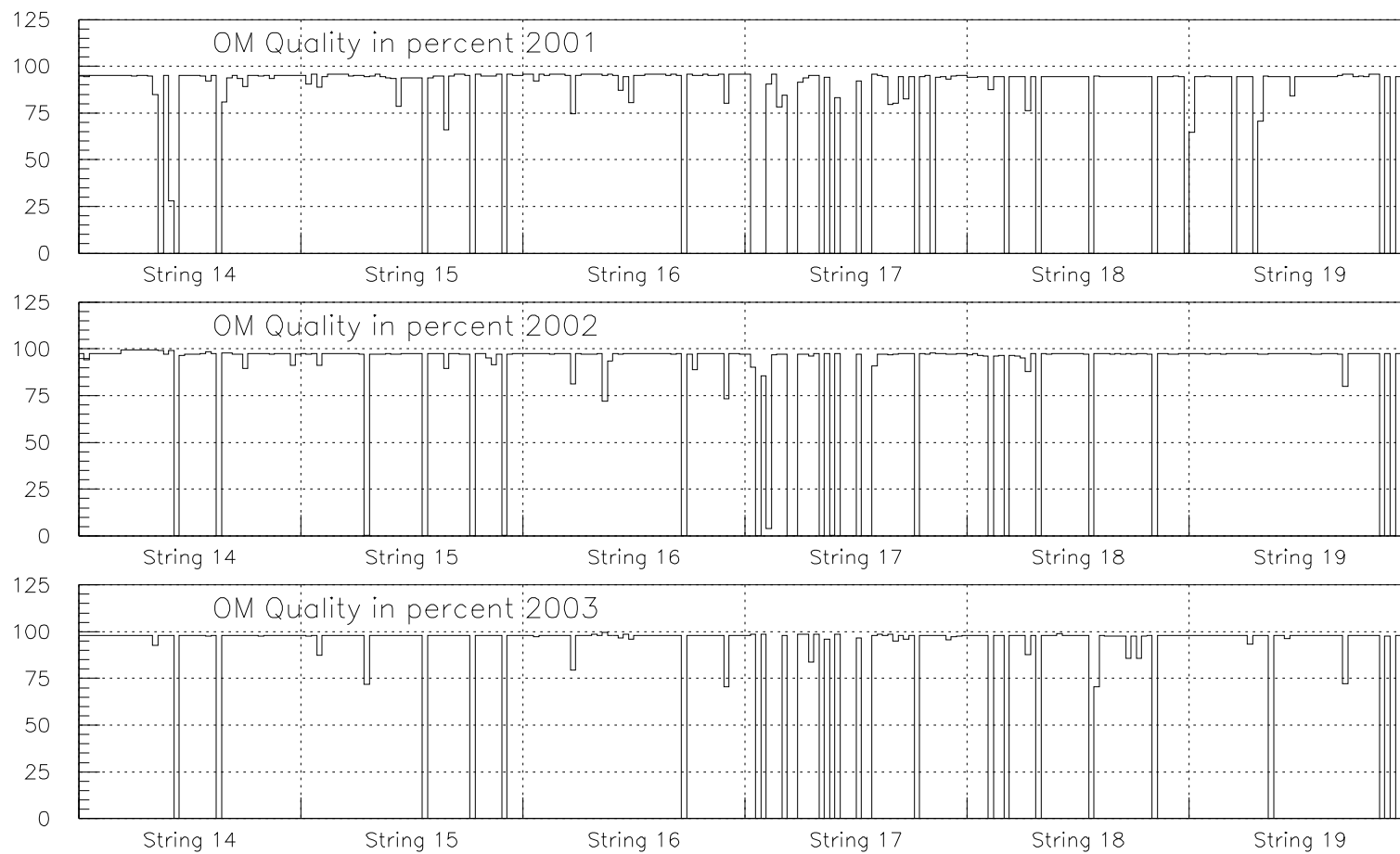Fig. 10: *Quality of the OMs on string 11-13 to 15 during 2001, 2002, 2003*

Fig. 11: *Quality of the OMs on string 14-19 to 15 during 2001, 2002, 2003*

B.2 Scripts for Datahandling 2002

tape_to_disk.2002.script	
Arguments	tape number, Slot number, in-disk number
Files written	/tape_02.scr/log/tape_to_disk_tape[nr].log /tape_02.scr/log/DBs/Database_tape[nr].tape
Description	The program copies the content of the tape in slot [nr] and in an directory data_in on the in-disk [nr]. All copied files are listed tar wise in log file and in in the Datanbase labelled with the given tape number.

sort_files.2002.script	
Arguments	tape number, in-disk number
Files needed	/tape_02.scr/log/DBs/Database_tape[nr].tape
Files written	/tape_02.scr/log/sort_files.tape[nr].2002.log/ /tape_02.scr/log/sort_files.tape[nr].2002.error /tape_02.scr/log/DBs/Database_tape[nr].sort /tape_02.scr/log/DBs/Database_all.2002.dat
Description	The program sorts the files that have been copied from the tape [nr] using the paths that are saved in the file Database_tape[nr].tape. It creates subdirectories in an directory data_out an a hard disk with a number that is a parameter in the source code. (usually it is the same as the in-disk number). All all the final paths sub directories and file size is saved in the Database_all.2002.dat as well as in Database_tape[nr].sort. The log and error files contain the information about the sorting process.

fatman2robot.2002.pl	
Files needed	/tape_02.scr/log/check_complete_file.2002.log
Files written	/tape_02.scr/log/log/disk_to_rob/fatman2robot_2002.[run nr].log
Description	The program list the contents of the Amanda data archive that is already on the robot. It makes a list of all runs that are complete and not copied yet. It tars the files of each run in blocks of 10 files and copies the tarred files into the robot archive. The report of the process is written in the log files.

check_and_update.2002.pl	
Files needed	tape02_src/log/DBs/Database_all.2002.dat tape02_src/chomperlogs/tape[nr]_copy2.log
Files written	/tape_02.scr/log/check_complete_file.2002.log /tape_02.scr/log/check_report.2002.log /tape_02.scr/log/missing_list.2002.log /afs/ifh.de/user/a/amatape/www/tape2002_stat.html
Description	The program checks what tapes are copied onto disk reading Database_tape[nr].tape which tapes are already sorted reading Database_tape[nr].sort By comparing all the entries of Database_all.2002.dat with the entries chomperlogs/tape[nr]_copy2.logs a list of completed runs is created and a list of eventually missed or truncated files is written. All the information are written in the web page in in the files check_complete_file.2002.log, missing_list.2002.log. and check_report.2002.log