DAQ in a nutshell

Contents

1 Starting DATE

The command `dateControl` starts all processes which are necessary to run DATE:

- Every computer taking part—either as GDC[1], LDC[2], TriggerHost[3] or EDM[4]—needs to have an `rcServer` process running, which acts on behalf of the `runControl`. The presence of the `rcServers` is checked for all possible hosts and instances are started if necessary. Problems starting the `rcServer` are indicated in red color and should be acted upon as indicated; see section 5.2 for more details.
- The interoperation of the participating computers is coordinated by the `runControl` background process, aided by several state machines; the latter being represented in the system by processes named `smiSM` and accompanied by instances of `smi_timeout` and `compass_script`. The existence of this set of processes is checked by `dateControl` and they are started if necessary. Beware that the check for existence is global—in the sense that they are detected also if they are running on a different host—while the starting is done locally. It should not be possible (and generate an error message) if this is done on computers which are reserved for other purposes, like pccofeXX or pccorbXX, but it should still be customary to start them *only* on pccorc01, unless forced otherwise.
- The interface to the shift crew is displayed by a `runControlHI` process, which is started last. Its usage will be detailed in the following sections, but one feature is interesting here: the shift crew interface can also be started separately by issuing the `dateHI` command. Several interfaced can be running at the same time, but only one can actually have control, symbolized by a lock icon next to the COMPASS logo. When the lock is locked and green, this interface can control the DATE processes; click the lock and select *unlock* to relinquish control. When the lock is locked and red, some other interface has control and the present one can only be used for monitoring. When the lock is unlocked and gray, it can be clicked to obtain control over the DATE processes.

  `dateHI` always starts a shift crew interface, whether the other needed processes are running or not. In the latter case it says *RC not running* below the COMPASS writing and you have to close the interface (*Close HI* from the *File* menu) and start over with `dateControl`.

Summary: If you want to actually control DATE, use `dateControl`, preferably on pccorc01. If you are sure that DATE is running and you want to peek over the shift crew's shoulder you can use `dateHI` from any pccorcXX or pccogwXX computer.

2 What do all the windows mean?

2.1 The main window

After starting up, there is only the main run control window with the COMPASS logo, the control buttons and the log. Directly above the log it displays the current run number—the field is empty and very small at first—and the run control status. Above the run status line

[1] *global data concentrator*, aka *event builder*
[2] *local data concentrator*, aka *ROB* or *readout buffer*
[3] responsible for running the scripts which start and stop the trigger
[4] *event distribution manager*

is the strip with settings for number of bursts, online filter, trigger conditions, SLinks and calibration triggers, which will be detailed later on. The main DATE control is exerted via the buttons between the COMPASS logo and the aforementioned strip.

The DATE system can either be in one of the four following states or transitioning between them:

DISCONNECTED This is the initial state, which allows the configuration of participating computers to be changed; see section 4.1 for details.

CONNECTED In this state the set of participating computers is fixed, but their configuration could be changed using the *Define* button below the *Connected Run Parameters* label. This is not usually necessary for the shift crew and the DAQ expert should be consulted before any modification.

READY This should be the default state when no run is running. Online filter and trigger conditions as well as calibration triggers can be set in this state, otherwise the DAQ is only awaiting the command to start a run.

RUNNING This should be the most used state during physics beam, as now data are (hopefully) on their way to disk.

These four states are depicted from left to right in the boxes titled *Disconnected Configuration*, *Connected Run Parameters*, *Ready to start* and *Data Taking*. To move between the first three, use the arrow buttons between the boxes, but be aware that the transition from DISCONNECTED to CONNECTED state usually takes half a minute, more if an error happens. The currently active box is highlighted with a pink label.

When the DAQ is in the READY state, you can switch on/off the recording, the *eventbuilder* and the *EDM* (Event Distribution Manager). While the latter is optional, the event building must always be switched on! We normally also keep recording enabled except when the data really are not interesting for anyone. Starting and stopping a run is discussed separately in section 3.

2.2 The TCS status window

This window is not visible in the disconnected state. If it does not appear after connecting (or someone has closed it) you can open it using *Show TCS Status* from the *View* menu.

In former times we had a script named `check_trigger` which had to be manually executed to read the values from the prescaler. The information is now displayed continuously in a run control window to make the trigger system more transparent for the user. Besides the prescaler status, some information from the TCS controller is shown, namely the burst status (0 means offspill, 1 means that particle extraction is going on), the current burst number and the number of accepted triggers in the last spill, grayed out during the spill to indicate updating in progress.

In case the two status labels for the TCS controller and prescaler do not contain the word "okay" in green color, something is wrong with the TCS and must be fixed before a run can be started. An exception is the moment directly after opening the TCS status window, during which the TCS status is first read. Click on the "?" buttons to see which action is necessary. After a reboot of the VME crates housing the TCS components it takes about 1 minute for the state to change to "okay".

2.3 The SMI status window

This window is not visible in the disconnected state. If it does not appear after connecting (or someone has closed it) you can open it using *Show SMI Status* from the *View* menu.

The internal workings of DATE are expressed in terms of state machine logic. This enables the very concise and immediate display of the state of all system components in one window. During one cycle of starting and stopping a run, all green state indicators move from the top to the bottom of their respective range. Click on the yellow bars to see which computer is represented by each one.

The GDC indicators should move first and up to the RUNNING state, then the LDC indicators move up to WAITING_START_OF_DATA, after which at the next beginning off-spill phase (see SPS monitor or TCS Status window) the trigger is started and at the following new spill data should arrive. At that point the LDC indicators should all move to RUNNING and stay there until the run is stopped. If an LDC remains WAITING_START_OF_DATA, its connected equipment somehow did not send data and probably needs to be reinitialized; see section 5.4 for details.

State changes should happen for all GDCs or LDCs at roughly the same time. If one computer consistently lags behind by more than a few seconds, please make a note in the runLogbook and inform the DAQ expert.

2.4 The Status Display

This window is not visible in the disconnected state. If it does not appear after connecting (or someone has closed it) you can open it using *Show Status Display* from the *View* menu.

Detailed information about all computers participating in the data taking is displayed in the biggest window. The values are updated every second. This window gives a more direct feeling that the run is really running, but the interpretation of the values is not always straight forward. E. g. the trigger rates and numbers shown for the LDCs are not the ones happening at the hardware in that very instant, but reflect how events are transferred from the spillbuffer cards to the LDC's main memory. Therefore the burst number displayed in the Status Display might be smaller than the one displayed in the TCS Status window. The event flows are divided across all GDCs, so the recording rates there need to be multiplied by the number of GDCs to obtain the total rates.

In case of readout errors, the affected fields are highlighted, as is the respective label on the left side. There should also be an audible alarm, which is played every ten seconds if there are errors currently happening. In case of temporary errors, which go away after one or two spills, leave the run running. But if the error persists, investigate and possibly stop the run. A useful tool is the button displaying the Interface Status of each LDC. Press it—especially the highlighted ones—to open a window detailing the Slinks and detectors connected to the LDC and offering buttons to reload the hardware—which of course is only enabled if no run is currently running.

3 Starting and Stopping Runs

In order to be able to start a run, the run control must be in state READY, indicated by the pink background color of the *Read to start* label. If the state is DISCONNECTED or CONNECTED, use the [>]-buttons to reach the READY state. After carefully checking the trigger selection (see section 4.2) and the online filter setting (see section 4.5), you are ready to start the run.

3.1 Starting

Click the *START RUN* button. Before the action really starts, a small window appears asking for the run type, which shall be recorded in the electronic logbook. You can click *Cancel* to undo the starting of the run altogether, or *Okay* to proceed; but until you click one of the two buttons, the rest of the run control will appear frozen and not respond to mouse clicks.

You might want to watch the SMI status window to check on the progress of the run. As soon as all LDCs are in state WAITING_START_OF_DATA (see section 2.3 for details) the run control enables the *Stop* button and awaits the first event. If that is not received by all participating LDCs after at most 70 seconds the run is aborted automatically—normally the time to receive the first event should be between 13 and 30 seconds. If you press *Stop* during this time the run will end immediately without recording a single event. Otherwise, only after all LDCs have received the first event, the run is started and recording begins.

3.2 Running

While the run is running you should check the *MurphyTV* and *infoBrowser* screens mounted above the run control screens for error messages. In a perfect run there should be no red source IDs on the former and no messages on the latter. In case of persisting non-fatal messages—meaning that the run does not abort by itself and the messages are repeated for the same LDC and interface or source ID across multiple runs—please inform the detector expert. You can find out which detector is involved by looking at the lists attached to the board in front of you (sorted by *source ID* or *ROB slot* aka *LDC interface*).

3.3 Stopping

The run can stop for three reasons:

- You pressed the *Stop* button. At the next begin of offspill time the TCS controller is informed of your wish, so at the beginning of the next spill the last event in the run will be sent from all detectors, causing the LDCs to shut down, which in turn lets the GDCs stop after which the run is stopped.
- The maximum burst number was reached. This number can be set using the [->]-button, also during the run, which copies the value entered in the left field to the right field and thereby to the configuration memory of all connected computers. As soon as the first LDC recognizes this situation, the same procedure is followed as in the previous case.
- One LDC or GDC requested the end of run due to an error. This is informally known as a "crashed run". In that case the LDCs do not wait for the last event in the run but shut down quickly. However, depending on the kind of error there might be timeouts on individual computers which delay the procedure.

The stopping procedure is not yet free of bugs. While these bugs do not harm the data, they might prevent a successful shutdown. Typically some LDCs don't leave the STOPPING_RECORDER state. If no progress is made for 30 seconds the *Abort* button is activated. You should press it if it stays clickable for more than a few seconds. After that the shutdown should proceed quickly. If not consult section 5.5.

4 Configuration

This section covers the configuration topics relevant to shift crew use. Advanced configuration beyond the scope covered here is to be done by the DAQ expert only!

4.1 Including/Excluding Detectors

Including or excluding certain detectors might change the set of LDCs required for the readout. Therefore the run control needs to be in the DISCONNECTED state to perform this operation. Use the [<]-button in case this is not fulfilled.

The [Slink]-button invokes a new window with three parts. In the upper part you can enable or disable whole detector types by clicking with the left mouse button on their respective entries. If a detector type is read out via more than one link—this is the common case—it might be that not all links are consistently enabled or disabled. In such a mixed situation the entry for that detector type is grayed out and it cannot be clicked with the left mouse button. Using the right mouse button selects the chosen detector type for closer display in the middle part of the window, where the individual links aka *ROB slots* are shown. Here again the links can be switched on and off using the left mouse button on the entries or on the *all* and *none* buttons, which bring the detector type into a consistent state if necessary. The lower part of the window displays the Technical Board names of the detector planes attached to the link selected in the middle part, unless there is no such information in the Frontend Database for the selected readout modules.

All modifications on the Slinks are registered immediately in the database, and after each click the current database contents is read and used for setting the state of the buttons. Only the selection of LDCs participating in the data taking is done when the *Done* button is pressed. This is why there is no *Abort* button as that could create an inconsistent situation.

In general during regular data taking all detectors should be enabled. However, in the commissioning phase there might be people working on individual detectors, making it necessary to exclude those in order to achieve successful running. If the error recovery steps detailed in section 5 do not converge on a working setup, ask the respective detector experts about possible reasons and/or workarounds.

4.2 Trigger Selection

When the DAQ is in state READY you can select the trigger setting by clicking on the [v]-button in the trigger selection box. There are several predefined trigger compositions for physics running, alignment, etc. The *random_1*, *random_10* and *random_100* selections contain only random trigger, prescaled with divisors 1, 10 and 100, respectively. You can see the effect of changing the trigger composition nearly in realtime—you have to wait 1–2 SPS spills to allow for transient effects—in the TCS status window.

There is one special entry in the trigger menu labeled *custom*. Selecting it pops up a window which allows direct setting of the prescaling divisors for all 12 hardware trigger inputs. If you need a setting which is not available in the predefined set, use this tool.

4.3 Deadtime Selection

For detector calibration it might be necessary to read them in a slower latch all mode (e. g. GEM and Silicon), which requires a different deadtime setting than the default. You can select between several predefined settings using the menu button at the bottom part of the TCS Status window.

4.4 Calibration Triggers

In addition to the hardware trigger the TCS can also generate artificial triggers with a fixed rate. There are 26 different trigger types of this sort, enough to supply each detector type with its own calibration trigger. In reality only a handful are really used. Most noticeably the calorimeters need their LED pulser always running, which is connected to trigger type 13. In addition to the frequency (between 1Hz and 300Hz), the triggers can be enabled separately for the onspill and offspill times, where in general it makes most sense during the offspill, since then there are no accidental particle hits which might disturb the calibration procedures.

The calibration triggers can be configured when the DAQ is in state READY. Click on the `CalTrig`-button to get the configuration window. The state of the triggers is stored in the TCS controller and the values shown when the window opens are read directly from there. As soon as you are finished with your modification, click the *Done* button to write the changes into the TCS controller.

Since the values are stores in the TCS controller FPGA, they are lost after a power cycle of the crate housing pccofe02 or after issuing a `LOAD -A 1025`.

4.5 Online Filter

For physics data taking under normal trigger conditions we need the online filter to be able to store all the data on disk and later on tape. Therefore the default setting of the filter configuration should be "filter-active". For details on how/when the button works see the section 4.2.

However, the online filter—named Cinderella after the famous fairy tale—needs certain detectors present and fully calibrated to function, so during commissioning or tests without beam it should be set to "pass-through" or "off"; in the latter case the `cinderella` processes are not even started, while in the former case the additional buffering provided by `cinderella` can improve DAQ throughput.

If there is beam the online filter fulfills another important function, namely the readout of the scalers for our integrated luminosity measurement. The values obtained for each spill are stored in a database which is important for later analysis of the data. Unless there is a very good reason and the week coordinator agrees, the filter configuration during runs with SPS beam should always be "filter-active", "mark-only" or "scaler-only".

5 Error Recovery

These instructions are intended to make the COMPASS shift crew more efficient and to spare the DAQ expert a few wakeup calls. Please make use of them, and only in case the problem cannot be solved call the expert.

5.1 Console access to the computers in the DAQ barrack

All computers in the DAQ barrack are connected to a cascaded console switch. To invoke its menu press the left `ctrl`-key three times in rapid succession. Then navigate the menu to find the machine you are looking for. While eventbuilders are abbreviated *EVB*, ROBs are registered as their native DATE name *LDC*, both matching the labels on the actual computers.

If there are problems accessing the console switch at all, try to reboot the KVM-over-IP box, which is a long black device lying in the rack behind the screen. You can either use a

very narrow and long object to press the reset buttong (but you'll rarely find a tool fit for the job), or you simply unplug and plug the power cord. After that wait a minute for the device to restart.

5.2 Problems starting `dateControl`

If during the `rcServer` of executing the `dateControl` or `dateStart` commands some lines are printed in red, immediate action is required. This typically involves accessing the console, which is described in section 5.1.

Machine is dead signifies that there was a connection timeout which is usually caused by the computer not responding to network traffic. It might be switched off or in a bad state. In any case you need to go to the DAQ barrack, look at the console of the computer in question and switch on or reboot. Please make a comment in the electronic logbook so that the DAQ expert is up-to-date on the status of the system.

DATE services not running (restart xinetd?) means that the computer is alive but does not properly respond to the DATE request. It is advisable to call the DAQ expert after checking that a reboot (press `ctrl`-`alt`-`del` on the console after switching to the right computer) does not fix it.

5.3 Connection problem with XXX

When going from DISCONNECTED to CONNECTED state, all participating `rcServer` processes are asked for their status, and if any of them do not answer the `runControl` will go back to the DISCONNECTED state after a timeout. In that case there is an error message in the log of the run control main window. As a first step, try `dateStart`. This repeats some of the steps described in section 1. If errors occur, follow the instructions of section 5.2, otherwise try connecting again.

5.4 LDC does not receive START_OF_DATA within timeout

An LDC remains in the WAITING_START_OF_DATA state after the other LDCs moved on to RUNNING if the connected equipment do not send any data (if corrupt data were sent, there would be a specific error message mentioning this on the infoBrowser screen). Typically this error stems from uninitialized frontend electronics. Issue the command `LOAD -A pccorb<N>`, replacing `<N>` by the LDC number(s) given in the error messages. If there are loading errors, find out which detectors are involved (see FEDB listing above run control screens) and contact the detector experts. Otherwise try again to start a run.

5.5 Run does not end

For each phase of the stopping of the run there is a 30sec timeout, after which the *Abort* button is enabled. If pressing this button does not result in a quick shutdown and the READY state is not reached after some time, try `cleanDate` and start the `dateControl` again. Remember to do this on pccorc01.

5.6 Run control windows are frozen/not repainted

Make sure that there is not a configuration dialog or runLogbook run type selection window open anywhere. These pop up near the center of the screen and demand an immediate answer; if they are moved out of the way to do something else the run control cannot continue until the window is closed.

If the state is not caused by an open dialog window, issue a `cleanDate` and start the `dateControl` again. Remember to do this on pccorc01.

6 DAQ Shutdown in case of a Power Cut

All computers in the DAQ barrack are connected to the UPS which also powers the emergency lights and other systems. In contrast to the computing center we don't have a diesel generator to supply the DAQ with electricity during a power cut, which means that the UPS battery's main function is to allow a clean shutdown of the DAQ system in case of an extended power failure. The nominal capacity allows for 10 minutes of full power consumption, but as we use only about half the maximum current, the reserve should last around 20 minutes. This is more than enough time to shut everything down, but you should not waste time in any case to leave as much energy as possible for the operation of the emergency lights.

6.1 The Procedure

Go to the DAQ barrack and press the left `ctrl`-key three times in rapid succession. In the console switch menu navigate to NEW-EVB, then PCCOFS01 and press enter. If the screen is black, hit the enter key again. As soon as you see messages or the login prompt of the file server, press the combination `alt`-`cursor up`. This switches to a new console and displays the DAQ control screen. Type `shutdown DAQ` to send the shutdown command to all DAQ computers except for the file server. You should use the console switch to monitor the shutdown sequence of all computers and as soon as they complete the sequence—either by powering off or by displaying a message like "system halted" or "please switch power off"—switch back to the file server and type `shutdown fs`. After the file server has switched itself off, switch off manually those computers which did not power off themselves (these are mainly some old ROBs).

Please do not switch off the fans in the cooling doors of the racks, since it would be fatal to forget switching them on before powering on the computers. They use less power than the emergency lights anyway.

6.2 Possible Complications

If the file server does not react, check that the console switch is working with other computers, and if that is the case, try to reboot the file server. If the console switch does not work, power cycle it. If you don't succeed within five minutes, start switching off the DAQ computers using a manual sequence: navigate the console switch to each computer and press the sequence of combinations

`alt`-`PrtScr`-`s`, `alt`-`PrtScr`-`u`, `alt`-`PrtScr`-`o`

For those computers which cannot power off by themselves, press the power switch longer than 5 seconds to switch them off.

If some computer gets stuck during shutdown, maybe because the file server is already shut down, use the manual shutdown sequence described above.

6.3 Switching on again after power is restored

It is imparative to switch on the file server PCCOFS01 first and wait for it to complete the boot sequence. After that, switch on the database server PCCODB01 and wait again for it to complete the boot sequence. As soon as both servers are running, you can switch on all other computers. Any DAQ computers—including run control and VME CPUs—booted before the servers were running need to be rebooted at that point, otherwise the network file systems might not work correctly.

7 Advanced Topics

The methods presented here are for experts only. Wrong use might result in the destruction of the DAQ setup.

7.1 Running commands on all machines in parallel

The `do_all` script simplifies carrying out operations on a set of computers. Try it without arguments or option `-h` for a short help. Options parsing ends at the first unrecognized option or at the `--` token. If computers are selected which are not reachable, the script will wait some time for a connection timeout unless option `-w` is given. Useful option combinations are:

`do_all -f eb <cmd>`	Invoke the command on all eventbuilders and in addition to writing a log file for each computer, print the output generated by the command on the first one. Replace `eb` with `rb` or `fe` to select ROBs or pccofes instead.
`do_all -f eb -l <cmd>`	Like the previous, but instead of writing log files print the output of all computers on the screen. The output is not ordered in any way and might be garbled.
`do_all -f eb -s <cmd>`	Like the previous, but do the computers one after the other. Takes much longer, but the output should be readable.
`do_all -f eb -F '22|23' <cmd>`	Execute command on all eventbuilders except for 22 and 23.

If you want to start a program which waits for input but you don't want to give any, try option `-i`, which redirects standard input from `/dev/null`. Option `-q` suppresses any output, logging the command's output to files. Unless the `-l` option is given, each selected host is tested with a ping (timeout 1 second) before trying the SSH connection.

7.2 Accessing the Databases

Although there is really only one database server hosting the different COMPASS online databases (runLogbook, Frontend Database, DATE configuration, DATE logging, Beam Database), there are different possible access mechanisms, depending on the purpose. The commonly used ones are described in the following sections.

7.2.1 SQL command line

As user `daq`, an alias named `dateMysql` opens a MySQL command line client with the DATE configuration database of the current DATE site selected. If you are using this, you certainly do know what you are doing, so the details are not described in this text.

7.2.2 DATE `editDb`

DATE comes with its own Tcl/Tk based configuration tool. If you need to change shared memory layout, event building rules or the pool of LDCs or GDCs, etc. use this tool. It uses

the notion of transactions, so after every change you made you have to press the "Commit" button to actually write the modification to the database.

Remember that the enabling and disabling of equipments is completely handled by the "Slink" button in the run control (see section 4.1).

7.2.3 Frontend Database

While it is not impossible to manipulate the FEDB with the SQL command line, it is strongly discouraged. This database has a mechanism to record the history of changes which you can easily break by manual intervention. The official tool for modifications is a web site at

`http://pccodb01/cgi-bin/fedb/fedb.pl`

Its use should be mostly self-explanatory. The single most-reported cause for user confusion is an error message like Duplicate entry for key XXX, listing the names/IDs of the equipment you tried to register. Each table has a primary key, which must be unique for each database entry, and the error message tells you that you tried to register e. g. a Detector/Geographic_ID/Version_tag combination that exists (possibly with State=0) already. You have to DELETE entries of equipment which is to be moved from one source ID to another using the DEL setting in the Edit page.

7.2.4 TCS configuration

TCS takes its configuration files not from an actual file system, but instead reads their contents from the database. They are stored as BLOBs in the FILES and FILES_PROT tables of the Frontend Database (devdb). There are a set of tools to access and modify these files:

`fdb_ls`	Lists all files in the selected database.
`fdb_cat <host>:<path>`	Prints the selected file to the screen; this is not the same as using `fdb_cp` and `cat`, because it might append a newline at the end of the file if there is none, which is usually exactly what you want.
`fdb_edit <host>:<path>`	Opens the selected file in an editor and writes it back after editing.
`fdb_rm <host>:<path>`	Deletes the selected file.
`fdb_cp <host>:<path> <file>`	Copies the file from the database into the normal file system.
`fdb_cp <file> <host>:<path>`	Copies the file from the normal file system into the database.

All commands accept a set of options to select a database, user name, database server name, password and to choose between the FILES and FILES_PROT tables:

`-d <database>`	selects a database—e. g. devdb—instead of the DATE configuration database
`-u <username>`	normally the daq user is enough, but for editing the FILES_PROT table only the `trigger` user is authorized.
`-h <server>`	you should not need to connect to a different than the default database server

`-p[password]` is necessary in case you want to connect as a different user than the default. Giving the password on the command line is optional but discouraged, because in that case anybody could see it in the process listing. Notice the missing whitespace between option and argument (if an argument is given).

`-P` selects the FILES_PROT table

`--` ends the options parsing

For database pseudo-paths the ':' is mandatory, even if the <host> part remains empty. The latter is only relevant for DATE's configuration files as they are in separate databases for each DATE site. TCS configuration of different sites is distinguished in the Frontend Database by means of the "TCS name", a string stored in $DATE_SITE_CONFIG/tcs_name—you'll mostly need "main", for the main DAQ. A hands on example would be

```
fdb_edit -d devdb -u trigger -p -P main:/tcs/tcs.config
```

You will be asked for the trigger password. There is a shortcut for the more frequently used listing of the TCS configuration:

```
fdb_cat -d devdb -P `cat $DATE_SITE_CONFIG/tcs_name`:/tcs/<name>
```
is the same as
```
tcs_cat <name>
```

But beware that the file config/deadtime.config is stored in the unprivileged FILES table (meaning that you have to use the long form without the -P) so that the shift crew can select a deadtime setting via the TCS window (cf. section 4.3).