

DAQ: experience at the GSI run and the future

S. Biondi, A. Mengarelli, R. Ridolfi, M. Villa

University and INFN

Bologna

Pavia, 5/06/2019



Outline

- GSI integration experience
 - What worked
 - What needs improvements
 - for DAQ-WD and DAQ-VTX integration
- DAQ-WD interface
- DAQ-VTX interface
- Next steps



(Runs, Offline event building → Alberto's talk)

GSI integration experience

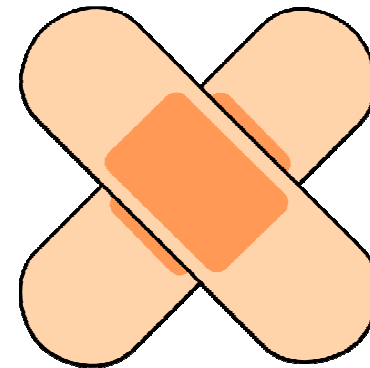
- These lists show the TDAQ point of view (not the data content)
- What worked without problems:
 - Beam Monitor (VME boards only; not a single DAQ problem; all information stored; all thresholds stored). But... no HV in DB
 - Network: everybody was able to have a cable connection.
 - Storage: too few data taken - good runs in less than 50 GB!
 - DAQ and detectors in standalone mode

What needs improvements

- Too much workload on the DAQ shifter
 - Trigger configuration: fixed at GSI
 - WD and VTX starting procedures: needs to be automatic
- Several minor details at the TDAQ level: all meant to reduce shifter workload or to have automatic data, configuration and counters savings
- Online monitoring and warnings
 - Although present, they were not fully used
 - Online histograms were not stored

DAQ-WD interface problems - 1

- BCO start, timestamp start
(used for event synchronization);
WD starts early;
TDAQ sends two BCOResets:
WD uses the first, trigger module uses the second
(BTW: too few bits in the BCO#)
- Trigger start;
 - **WD provides first triggers before the actual run start**
(between the first and the second BCOReset)
 - Cured with changes in the V2495 firmware



DAQ-WD interface problems - 2

- WD event losses
 - Examples from run 2212 - 116 k events for daq:
 - WD evt 0 not matchable
 - WD evt 1-12350 matched with daq 0-12349
 - From WD evt 12350-41367 **one every three WD events is not written out** (hw trig # jumps)
 - **No more data after WD evt 41367**, hw trig 51948 (daq has 64k more events)
 - Same pattern in other runs: **ONE** unmatchable event at the beginning, ~10k perfect, then 1 over three lost, stop recording at some point

DAQ-WD interface successes

- Except for the begin, all WD triggers are correctly handled by the DAQ (no losses), the busy logic works ok,
- BCO timing difference are OK (all matches within ± 1 us)
- Event size contained in about 29 kB/event
 - Thanks for the efforts to have the sparsification/zero suppression!
- Partial conclusion:
 - Once solved for start-of-run problems and event losses (need a SSD), the events can be built online reliably and automatically.

DAQ-VTX interface problems - 1

- Integration done only at GSI - not ideal...
- Busy signal from vertex missing; decided for a fixed busy length (about 2-3 ms) costing us a DAQ rate of 300 Hz
- BCO not forwarded to VTX
 - > problems in event building
 - > Timestamp candidates:
 - framecounter (185 us period)
 - internal clock value (0.5 us period)
- VTX is missing triggers (run dependent)

DAQ-VTX interface problems - 2

- Basically all variables that can be used for event building are NOT reliable:
 - HW triggers restarts after the first 100-200 event (approx 11 s VTX black-out)
 - Sequential events with the **same frame counter value** have been observed
 - Clearly **wrong frame counter values**
 - **Out of sequence** internal clock values and/or frame counters
 - Buggy HW trigger counters (rare)
 - **Wrong** event-internal clock value **association** (constantly off by 1 event)

DAQ-VTX interface problems - 3

- Observed VTX freezing:
 - About 11 s long, always after 100-250 events from the start, consistently on all runs and implying an hw trigger reset
 - Can happen also during runs and without hw trigger reset (e.g.: run 2212, VTX evts 39450-39451 matched with 40975 and 41248, 930 ms apart)
- Observed internal VTX time misalignment:
 - The 4 sensors are read out independently and shipped out via 4 UDP connections independently. The time alignment usually lasts till the first hw reset (i.e. on the first 100-250 events where most of the VTX tracks are found)
 - Exception: run 2211 where VTX detectors keep the time alignment after the hw reset for a total of 18641 events (out of 61322 in total)
 - Needed: internal VTX re-building for GSI runs;
 - Monitoring for next data taking!

DAQ-VTX interface successes

- Data size: 650 B/evt (still noise dominated)
- 7 april runs
 - Long sequences of events that can be matched (DAQ-VTX), starting from event 0
 - Not many VTX fragment losses (<3%).
- 8 april runs (high vtx threshold → 300 B/evt)
 - Clearly different from 7 april runs.
 - No matching starts from evt #0
 - LOTS of triggers are lost (busy too short?)
 - eg run 2240: 20004 daq evts, 10238 vtx evts (50%), 8749 matches from evt 128 to 19954

Almost all VTX triggered events are recorded
(wrt WD, events are small)

Next steps

- DAQ improvements
 - HW simulator for beam (done)
 - More controls on threading (done)
 - Event building online (with online checks)

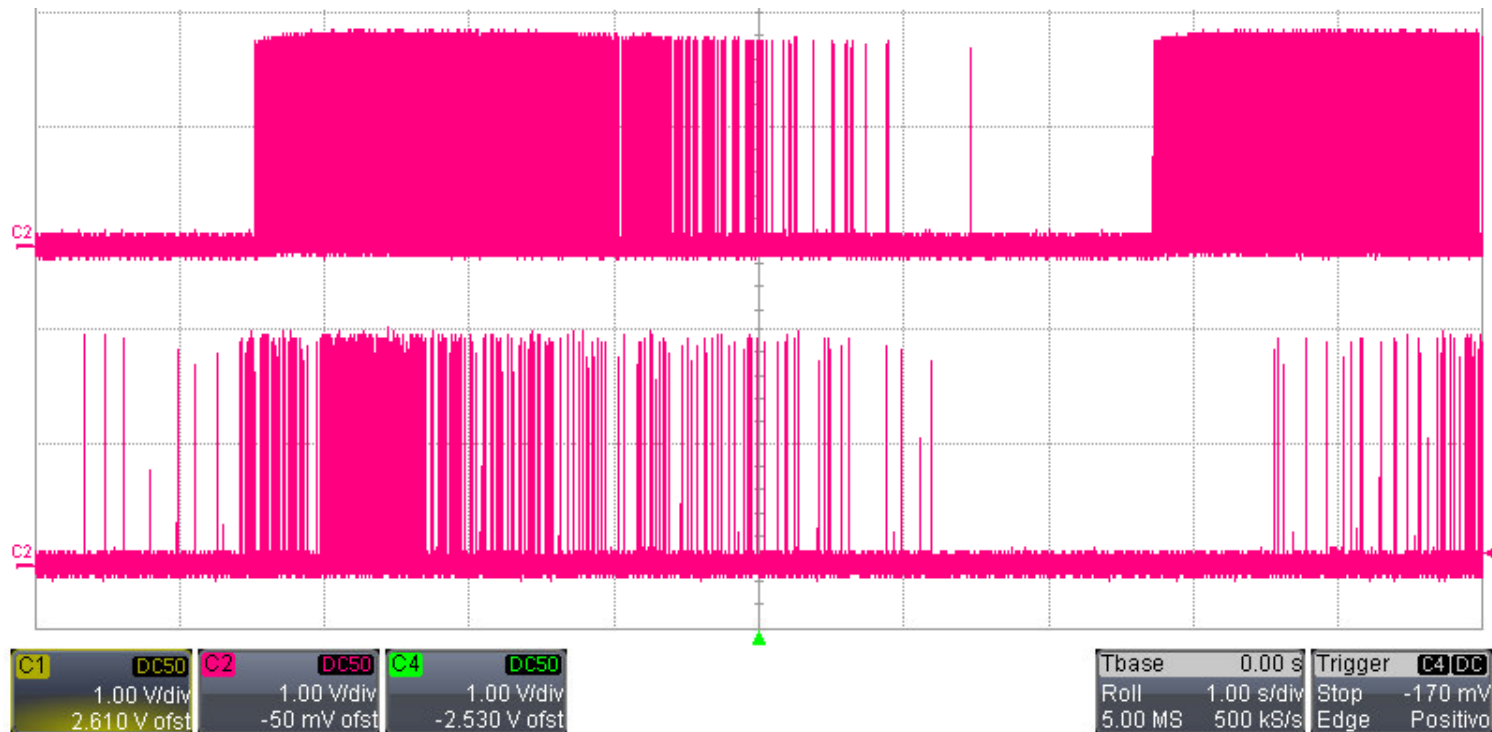


- Beam Monitor
 - no problems seen
 - no requests received
 - Maybe store HV values?
 - Improve online monitoring?



Beam simulator

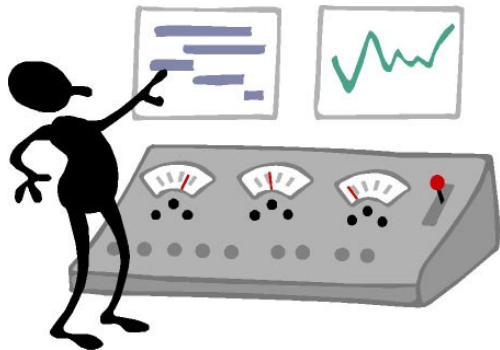
- 6-8 s period, varying intensity, top intensity same as at GSI, random trigger



- Needed for system integration debugging purposes

Next steps - Wave Dream

- System in Bologna from 11 june for 4 weeks
 - Workplan:
 - To ease the trigger changing
 - Solve observed starting sequence problem
 - Have online event building as designed + controls!
 - Try to connect directly the WDBs to our switch
 - Try to eliminate the intermediate PC
(we'll keep the local WD stream file anyway)



Next steps - VTX

– Workplan:

- Have all the trigger/busy/timestamp signals connected
- Have a automatic start/stop procedure
- Have **ONE TCP/IP** stream for vertex
- Event building online + controls + local VTX file
- Improve online monitoring
- 2 day beam test with VTX/DAQ only? Where?

– When:

- Sometime in july - with the system in BO?
- Sometime in autumn - on a beam?



Next steps - MSD

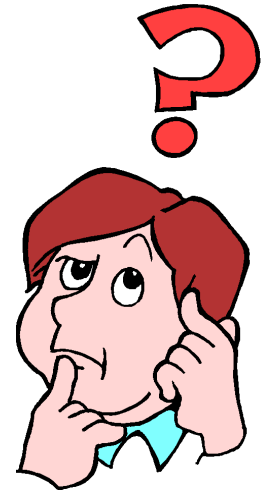
- Integration to be started this summer if possible
- In principle it will be handled by the DAQ as the VTX
 - i.e. same approach - DE10 board
- Joint DAQ-MSD HW tests in september / october?
To Be Decided



Next steps - Calo

- DAQ System yet to be designed.
- The main issue here will be the data size:
 - Plain FADC option: 320 channels x 1024 samples x 2 bytes = **640 kB/event** (x20 WD), corresponding at **640 MB/s** at 1kHz rate (MAX VME bandwidth is **80 MB/s**);
 - A way to reduce data size and bandwidth required is **mandatory**: sparsification, zero suppression, online feature extraction... whatever
 - For the time being, I assume an average of:
14 hit cells/event -> 28 kB/event -> 28 MB/s
(doubles the FOOT event size)

Global DAQ is/will be tuned on these numbers



Memento: from CDR

Table 4 – DAQ components, rates and bandwidths.

Detector	Board(s)	DAQ channels	max event rate (kHz)	Event size (bytes)
Trigger	V2495	1	10	40 B
Start Counter	DreamWave	4	1	8.2 kB
Beam Monitor	TDC	36	5	0.1 kB
Vertex detector	SoC on DEx	$4 \cdot 10^6$	2	0.9 kB
Inner tracker	SoC on DEx	$28 \cdot 10^6$	2	2.1 kB
Outer tracker	Custom	$6 \cdot 10^3$	2	0.5 kB
$\Delta E/\Delta x$	DreamWave	80	1	8.4 kB
Calorimeter	QDC	400	2	1.7 kB
Totale DAQ	Storage PC	-	1	22 kB

- Numbers from GSI experience

DAQ (trigger+BM+file structure):

530 B

VTX:

650 B

SC+TOFW:

29 kB

30 kB

Conclusions

- Several problems have been observed at GSI - and can be observed only with real detectors (simulations are not enough) and enough time.

- For WD and VTX a path to solve all (or part of) the observed problems has been drafted.

Ready for tests starting from september.



- Integration of other detectors will proceed as soon as they will be available. Experience showed us once more we need to plan for a **long** integration phase before going on a test beam.

(we used to say **5 months** in advance!)

The end



Central DAQ status



Sub-detector	What we will use	What we need	From which institute	What we have now
Start Counter	Wave Dream	?	Roma+Pisa	-
Beam Monitor	TDC	parameters for board configuration	Milano+Roma	TDC (V1190B)
Vertex/IT	Achille Board	front-end electronics for board tests	Frascati	Achille Board
MSD	de0_nano (?)	software for Pg board-de0_nano connection	Perugia	de0_nano
TOF	Wave Dream	?	Roma+Pisa	-
Calorimeter	?	?	Torino	-

Whatever the deadline is, we need any piece to be integrated in the DAQ system 5 months before!