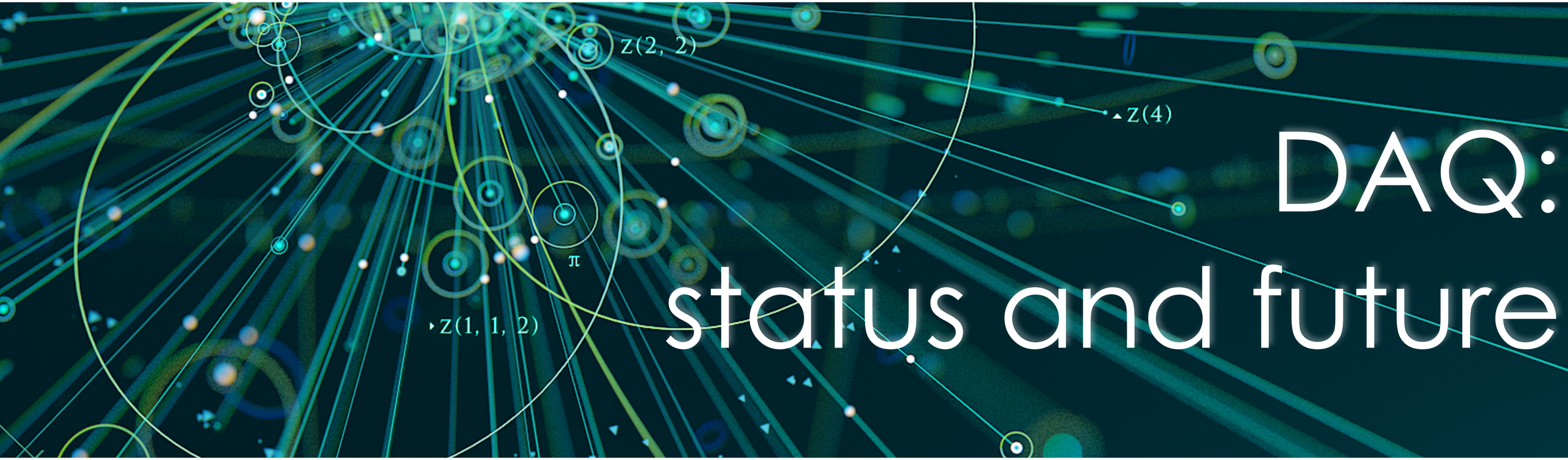


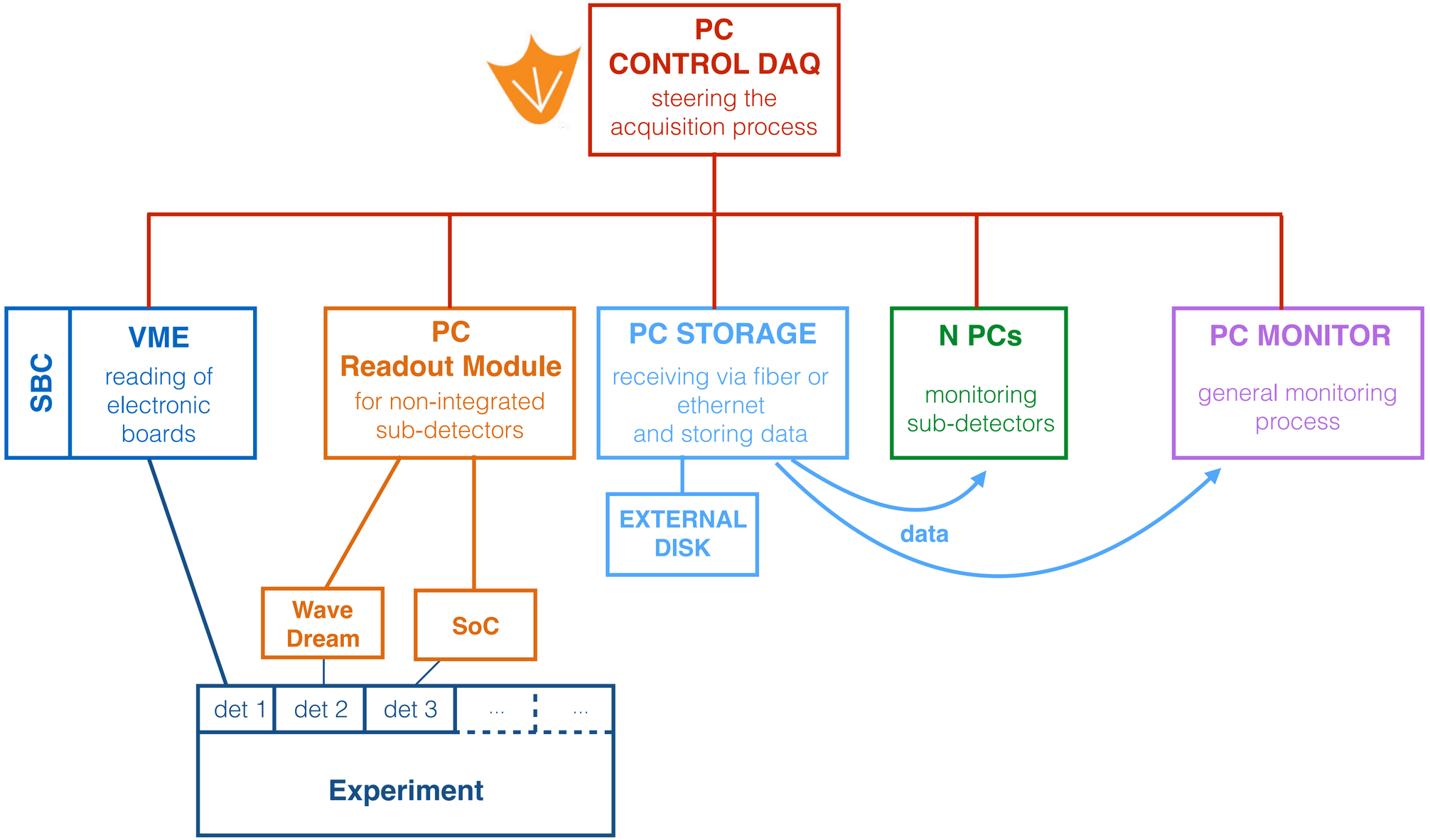
DAQ: status and future

Silvia Biondi, Mauro Villa, Riccardo Ridolfi
University & INFN of Bologna

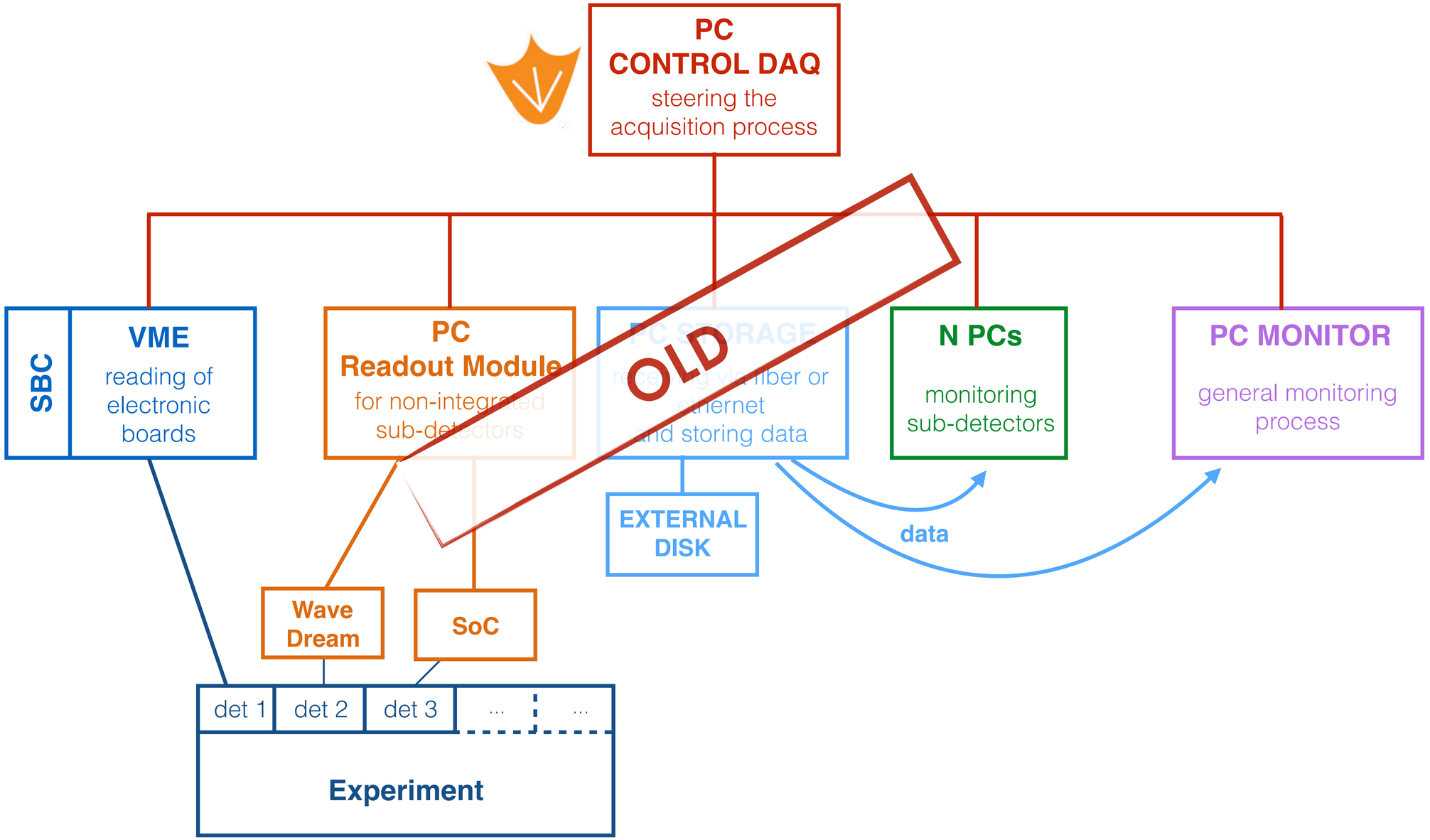
Outline

- Reminder of DAQ system
- Where we were
- What we've done so far
- What's missing
- Conclusions

Reminder: DAQ system

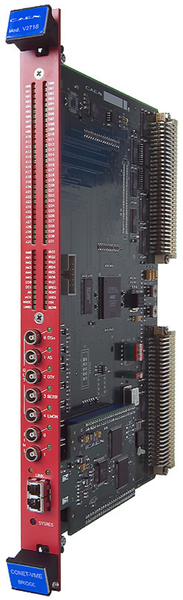


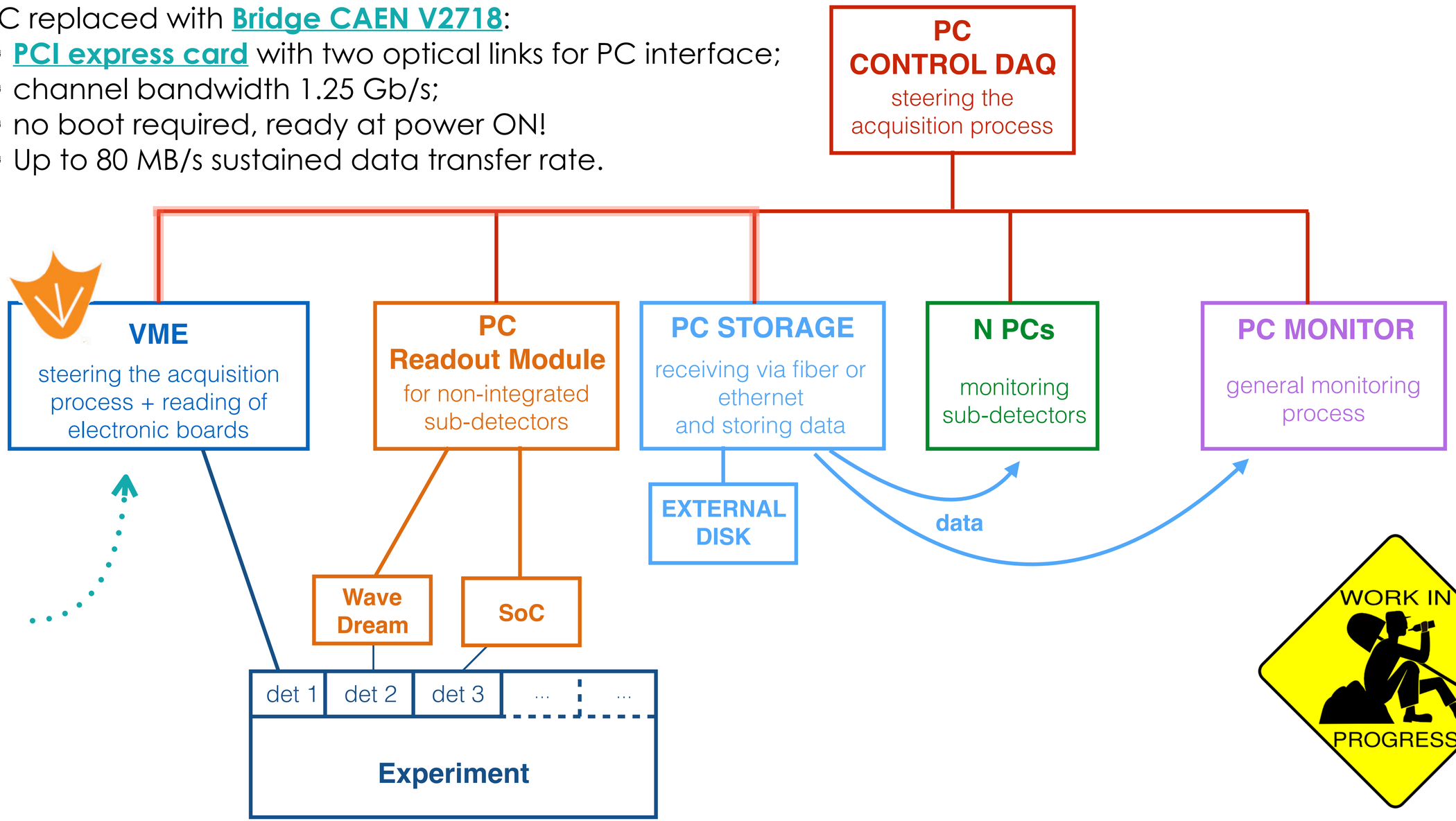
Reminder: DAQ system



New DAQ structure

- SBC replaced with **Bridge CAEN V2718**:
  - **PCI express card** with two optical links for PC interface;
  - channel bandwidth 1.25 Gb/s;
  - no boot required, ready at power ON!
  - Up to 80 MB/s sustained data transfer rate.

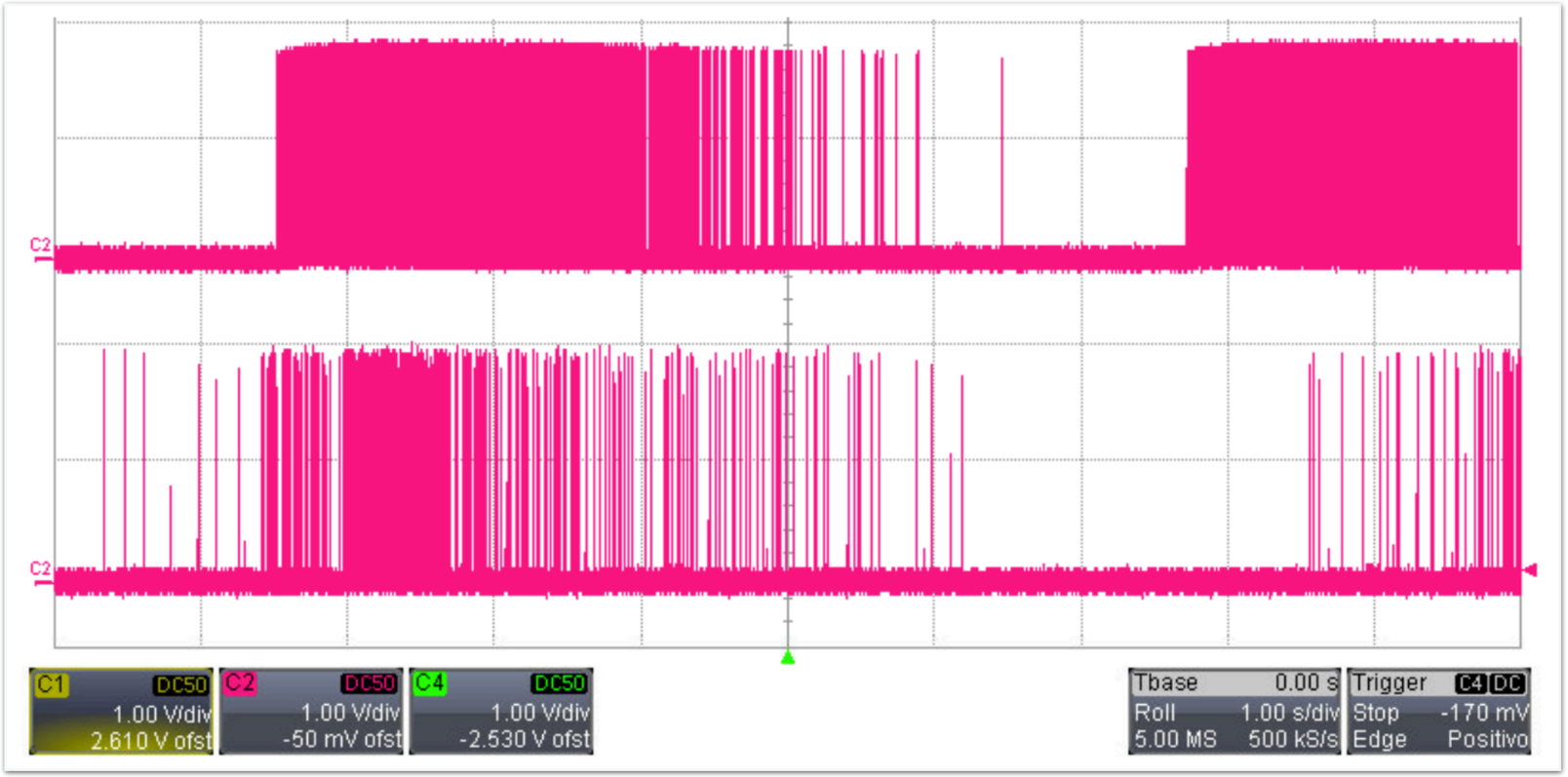




Beam simulator

- Simulation of the beam we had at GSI;
- **more realistic environment** for debugging systems integrations;
- **simulations are not enough.**

- 6-8 s periods, varying intensity, random trigger.



Beam Monitor DAQ

- VME boards only: no particular issues to run smoothly with DAQ;

- **Workplan:**
  - HV to be added in central DataBase;
  - improve online monitoring;
  - build a trigger system to reduce the T_0 jitter (now ~10 ns);
    - need a discussion among DAQ, WD-DAQ and BM-DAQ.

Event size: ~500 B/evt

Wave Dream DAQ

- System in Bologna from June, for a long time
  - thanks to Pisa group's availability! :)

- **What we got:**
  - easier and more user-friendly trigger configuration;
  - synchronisation of DAQ event segment and WD event segment;
  - online event building still need some work, mainly by detector experts.

- **Workplan:**
  - improve online monitoring;
  - test event building to check no event loss happens anymore;
    - decided to wait for the DataCollector board;
    - system to be re-tuned (with TCP/IP connection).
  - more controls on threading;
  - starting procedure needs to be automatic!

Event size: 29 kB/evt

VTX DAQ

- GSI has been an extremely useful experience
  - more info about problems found in backup

- **What we learned:**
  - not reliable event building without all the trigger/busy/time stamp signals connected
  - need to have an automatic start/stop procedure
  - need to have just one TCP/IP stream for VTX
    - event building of 4 layers inside VTX system, with necessary synchronisation checks;
  - need to have an improved online monitoring

- Plan to work on this with the system in Bologna, not yet happened
- **Workplan:**
  - integration in Bologna, to be decided with interested people
  - 2-day test beam with DAQ+VTX only?

Event size: 650 B/evt

MSD DAQ

- Plan to start the integration, not yet happened
  - general FPGA+CPU framework has been sent to Perugia people

- In principle it will be handled by the DAQ with the same approach as for the VTX

- **Workplan:**
  - need to start asap a joint DAQ-MSD HW tests
    - likely around January;
  - in Bologna we have now 3 engineer students!

Calorimeter DAQ

- DAQ system yet to be designed

- **Main issue: data size**
  - plain FADC option:
    - 10/20 FPGA boards;
    - 320 channels x 1024 samples x 2 bytes = 640 kB -> 640 MB/s at 1 kHz rate;
    - exceeding the max bandwidth of VME (~80 MB/s) and writing on SSD (~200 MB/s)
  - reduction of data size and bandwidth is mandatory
    - we assume an intermediate PC for this reduction (to 2/3 kB)

- Global DAQ will be tuned on these numbers

Status of DAQ integration

Sub-detector	What we will use	What we need to work on	From which institute	What we have now
Start Counter	Wave Dream	PC interface	Roma+Pisa	working system*
Beam Monitor	TDC	parameters for board configuration	Milano+Roma	TDC (V1190B)*
Vertex	DE10 ?	software for TCP connection (CPU)	Frascati	DE0
IT	Achille Board ?	software for TCP connection (CPU)	Frascati	Achille board
Micro Strips	DE10 ?	software for board connection (CPU + FPGA)	Perugia	DE0
DE/TOF	Wave Dream	PC interface	Roma+Pisa	working system*
Calorimeter	?	strongly dependent on the type of chosen readout	Torino	-

Online monitoring

- **GNAM infrastructure**
  - need to add all the info from different detectors
  - possibility to check directly comparisons between different systems

- **Online Histograms infrastructure**
  - some already implemented
  - need a strong collaboration with detector experts to store useful info

- All this info can be **used by shifters during data taking**
  - not to overload the DAQ shifters too much (from GSI experience)
  - all detector expert should be “shifters” to check their own info

Reminder: from our CDR

from CDR

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
Total 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**
  - all of them could be observed only with real detectors (and with enough time!)

- **WD system in Bologna**
  - enough time to test solutions and alternatives;
  - still some work needed but in good shape.

- **VTX system still as it was at GSI**
  - some solutions have been drafted;
  - tests foreseen with the detector experts.

- **Other systems (IT, MSD, Calo)**
  - tests foreseen with detector experts, Calo when the readout will be defined;
  - need to define many technical points for all these systems;
  - integration will proceed as soon as they will be available
    - we need to plan for a long integration phase well in advance ($\geq$ **5 months**) wrt a test beam.

- **Works ongoing to finalise the DAQ structure (both HW and SW)**
  - online monitoring;
  - reducing levels in DAQ structure;
  - etc etc

Supporting material

DAQ-VTX interface problems - 1

- Integration done only at GSI – not ideal…
- Busy signal from vertex missing; decided for a fixed busy lenght (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-WD interface problems - 1

- BCO start, timestamp start

  (used for event synchronization);

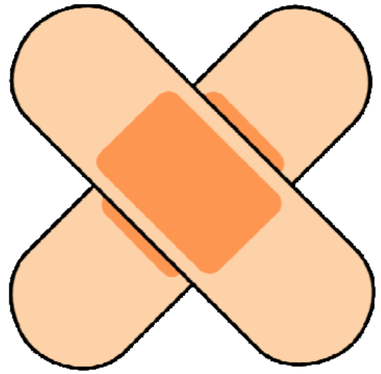
  WD starts early;

  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