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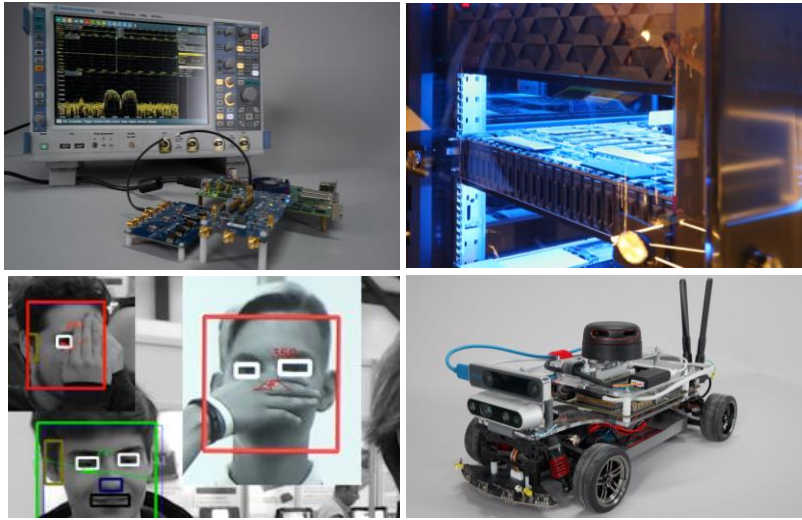

SPD Meeting

December 13th, 2021

Proposed approaches for the time synchronization in the streaming DAQ at SPD

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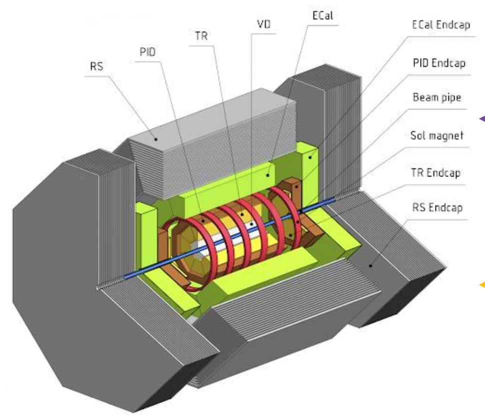
DAQ-SPD time synchronization

- Time synchronization is a major challenge in the DAQ development
- All the DAQ nodes must be synchronized with accuracy not worse than 1 ns
- All the acquired data must be annotated with time stamps
- SPD is a triggerless system — trigger-based approaches are not suitable
- Bunch crossing signal from NICA is used as timing reference for the DAQ
- Bunch crossing rate is ~12.5 MHz

Synchronization of NICA and SPD

SPD



Reference Clock

Time synchronization

NICA

Bunch crossing time stamp

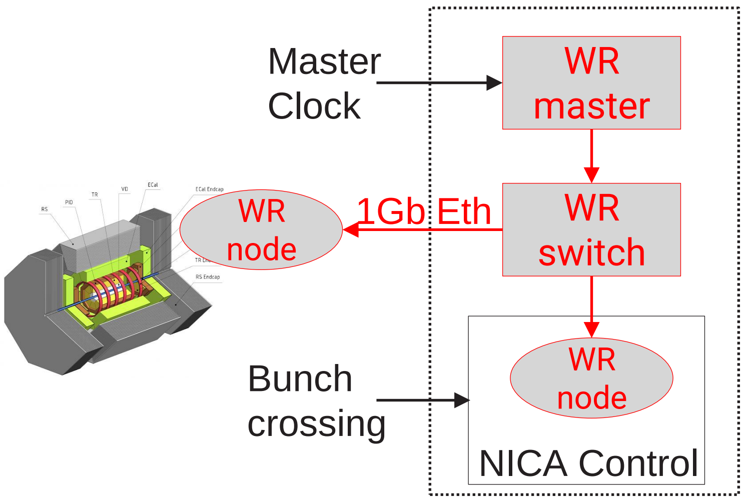
Bunch crossing signal

Synchronization of NICA and SPD

- NICA uses its own local time
- SPD's time should be the same
- DAQ synchronization subsystem should obtain bunch crossing signal time stamp (bunch clock) and distribute it to the online computers
- NICA supports White Rabbit sub-nanosecond synchronization protocol
- Planning to use WR to synchronize clocks — need to implement WR node

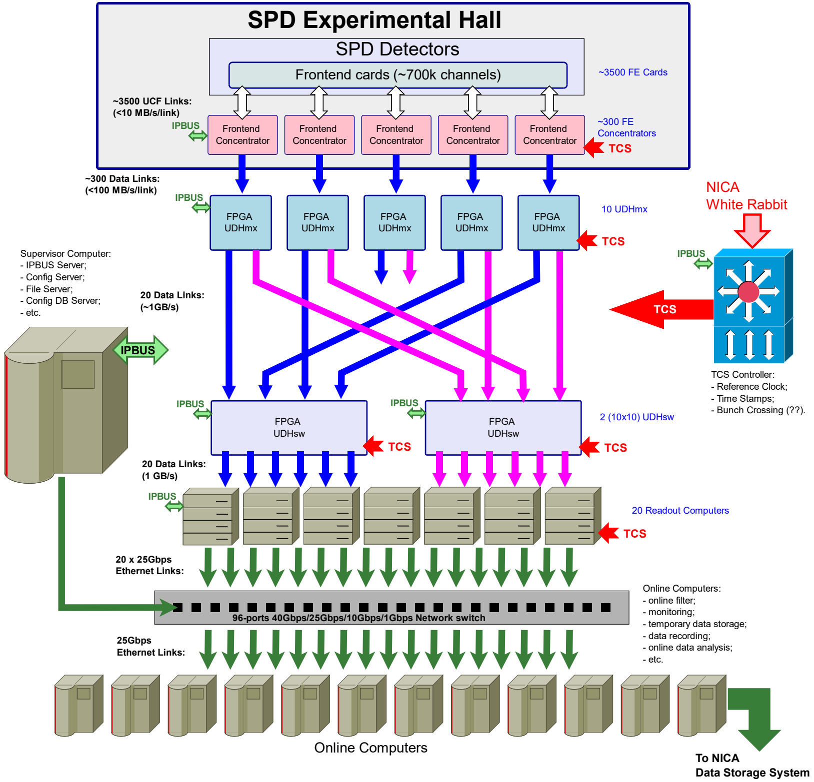
Synchronization of NICA and SPD

- WR uses standard Gigabit Ethernet
- Possibly could also be used to obtain bunch crossing time stamp
- NICA uses standard WR switch
- Our goal — integrate a compatible WR node into DAQ hardware
- Expected synchronization accuracy 150-200 ps



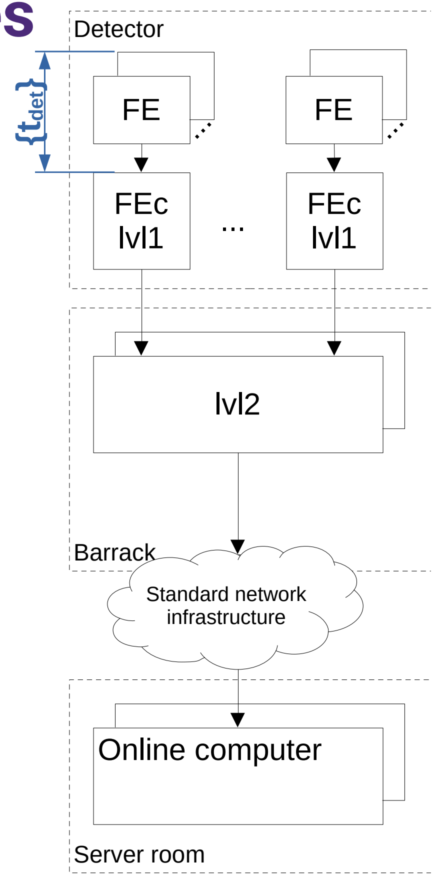
Clock distribution into DAQ-SPD

- We have a precise clock from NICA. Now what?
- SPD-DAQ has up to 500 front-end concentrators inside the detector
- All of them should be synchronized with ~1 ns accuracy



DAQ-SPD time synchronization approaches

- We assume deterministic latencies inside the detector
- Latencies on the higher levels of the DAQ are unpredictable
- Lvl1 FE concentrator generates clock for FE cards, it must be synchronized with NICA
- There is no need of bunch crossing time stamps on lvl1 and lvl2, it should go straight to the online computers

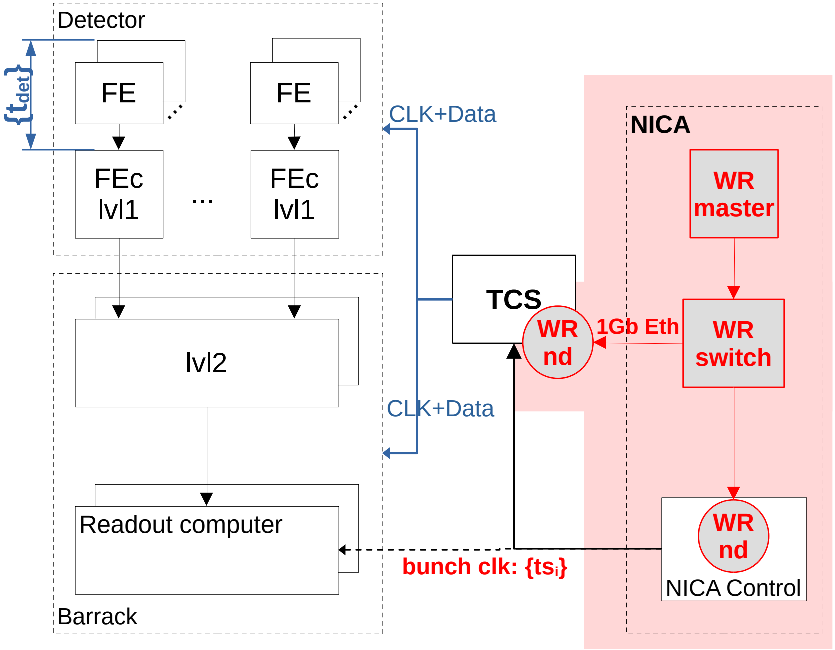


DAQ-SPD time synchronization approaches: TCS

- TCS: Trigger (Timing) and Control System
- Designed for the COMPASS project
- Originally used to distribute triggers and follow-up data to Front-End
- Could be adopted for triggerless system using e.g., bunch clock instead of triggers
- The original COMPASS TCS should be redesigned for DAQ-SPD

DAQ-SPD time synchronization approaches: TCS

- Redesigned TCS will include WR node to synchronize with NICA
- Generates clock and control data for DAQ
- Could be used to translate bunch clock to online computers
- Might suffer problems with achieving the demanded synchronization accuracy due to non-deterministic latencies



White Rabbit basics

- Originally was designed in CERN to synchronize all the units of experiment, even front-end cards
- Supports thousands of nodes
- Allows to achieve <100ps synchronization accuracy
- Uses Gigabit Ethernet (1000Base-X)
- Open-source software and hardware
- We have some experience in implementing WR node on a custom platform

DAQ-SPD time synchronization approaches: WR

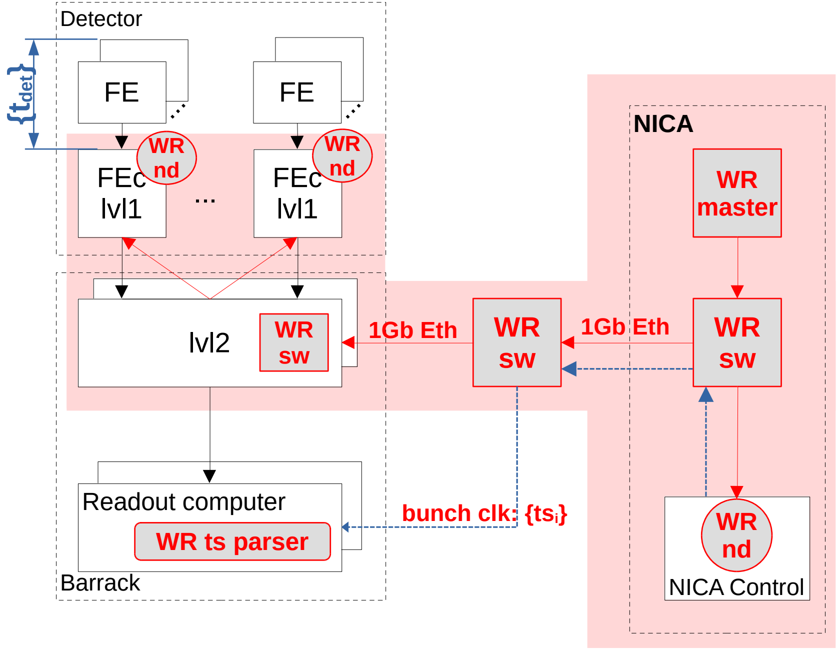
- The main idea is to integrate WR node into front-end (lvl1) concentrators with adding the following functions:
    - Distribute/convert WR clock to the main clock and all control signals to eLink outputs;
    - Add time-stamp with accuracy about 1 ns to the data flux;
    - Distribute a periodical signal for a front-end time calibration;
- TCS can only distribute clocks

White Rabbit switch

- Developed in Spain by Seven Solutions
- Price ~$5k
- Has 18 ports: 1 for upstream and 17 for nodes
- Open hardware and software
- To operate 500 front-end concentrators, we will need to have ~30 WR switches

DAQ-SPD time synchronization approaches: WR

- NICA clock and local time is distributed down to FE concentrators
- Numerous WR switches are used
- Bunch crossing information can be transferred directly to the online computers



WR vs TCS: advantages

- Slices in each detectors will start in the same astronomic (logical) time, time calibration needed only for the front-end electronics and cables from detector.
- Only one ethernet link needed for clock distribution from a barrack to the experimental hall. No need for a dedicated high-power optical splitter as in TCS.
- Easy adding of a new branch/detector at any distance.
- Commercially available WR switch, "CERN support".

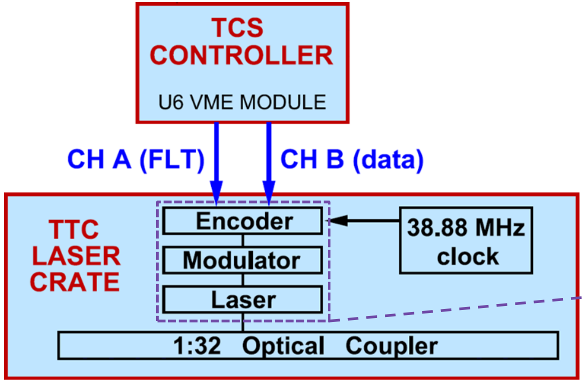
WR vs TCS: disadvantages

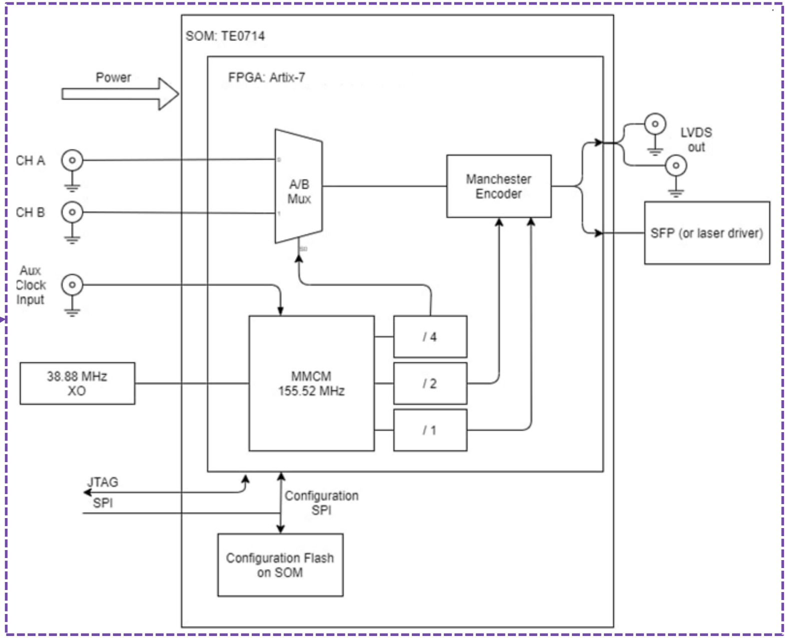
- Front-end concentrator with WR node would be more complex especially for radiation tolerant implementation
- Increased development and testing time
- Higher Price. FE concentrator price will increase slightly by adding WR node, but many WR switches should be purchased (>$100k)

Conclusion

- Both approaches should be evaluated thoroughly according to system requirements
- Working on TCS redesign will help to evaluate this approach
- Possibility of using WR for control flow distribution: bunch clock, lvl1 commands, etc. — TBD
- Front-end electronics should be radiation tolerant — development might be challenging, especially if it will include WR node

TCS (COMPASS) reengineering for DAQ-SPD



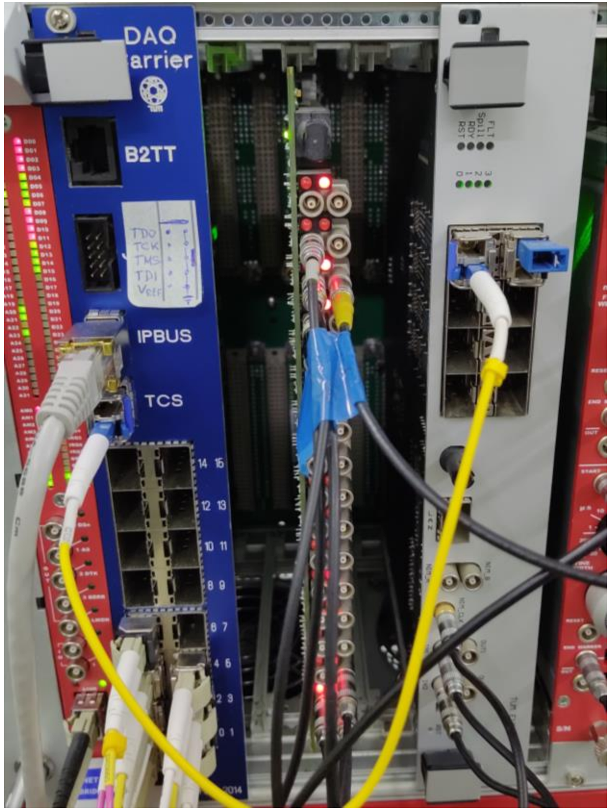


- Fully function-compatible with the original COMPASS TCS
- Xilinx Artix-7 FPGA-based hardware platform
- Rapid device development using Trenz TE0714 SoM
- Different form factor – no need of using VME for standalone device
- Planned implementation in a 19-inch rack unit with standard AC power supply – TCS does not require high-precision or exotic supply voltages
- Low-cost solution

TCS (COMPASS) reengineering for DAQ-SPD

ROADMAP: TCS FOR STRAW TRACKER

- **Schematic and PCB design – TCS Controller + Encoder**
- **TCS Encoder FPGA design**
- **TCS Encoder debugging and testing in the real straw tracker experiment environment**
- Full TCS FPGA design
- Full TCS debugging and testing in the real straw tracker experiment environment



ROADMAP: FURTHER STEPS

- TCS architecture redesign for DAQ-SPD: adding WR node
- New TCS development, debugging and testing
- Optimization of online processing tasks and DAQ

Thank you for your attention

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