RICH firmware / DAQ

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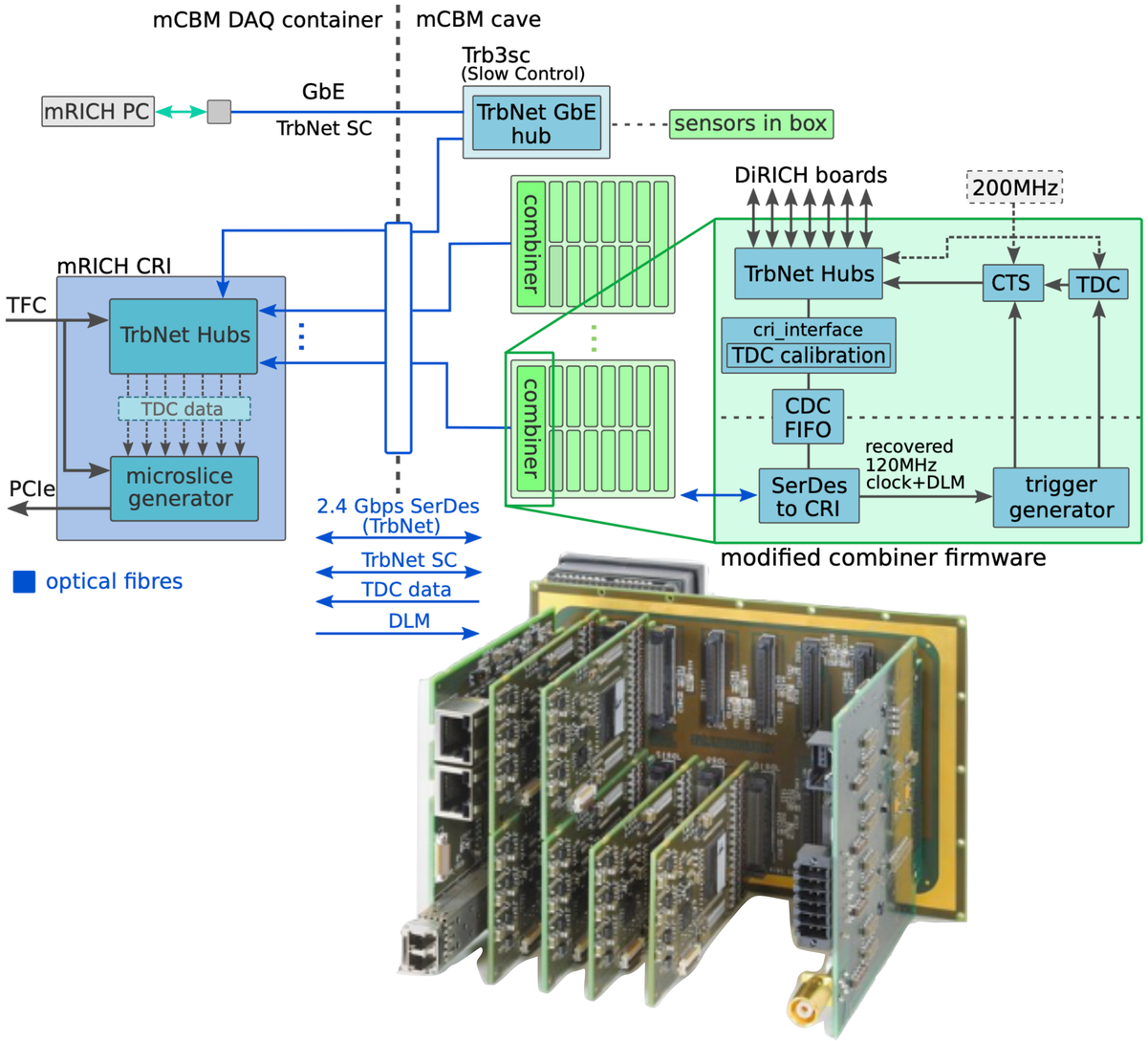
Current Readout Scheme

- Adopted from HADES
- Based on TRBnet
- Quasi free streaming operation with high rate pulse trigger —> gapless readout
- CRI controls and receives data from concentrator boards acting as TRBnet hubs
- 200 DIRICH concentrators are handled by 6 CRI1 boards



Current Readout Limitations

- Designed and developed for triggered system
- Key feature: Receive data from all endpoints to create complete events before next trigger arrives
  - Misbehaving endpoints may corrupt entire data acquisition
- Single Link for Data Transfer, Synchronization, Triggering and Slow Control
- Static Setup, where endpoints are scanned once and configuration is not supposed to change

Current Readout Limitations

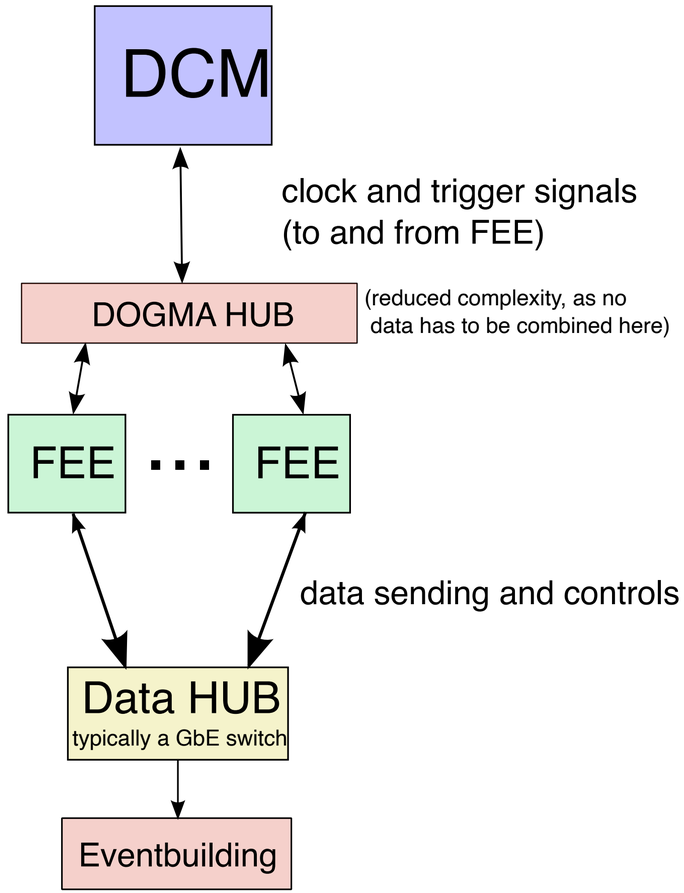
- Less suitable for high radiation environments
  - Single Event Upsets have high impact on entire DAQ chain
- Reintegration into DAQ is not foreseen
  —> full reboot with reinitialization is inevitable and already shown to be a design flaw in mCBM
- TRBnet not actively development anymore at GSI

Future Readout Concept

- Successor for DIRICH modules in active development: **DOGMA**
- Based on (nearly) same hardware
- Focus on
  - non-interruptible data taking
  - Modular system, where endpoints restart and reintegrate automatically
  - Utilize standard protocols for conventional tasks

Future Readout Concept

- DOGMA Control Module (DCM) fully synchronizes all endpoints
- Synchronization and Triggering via proprietary protocol,
  but fully separated from data link
  —> requires 2 optical links per DIRICH instead of 1
  - Hubs are used for fanout and synchronization
  - 10ps timing precision
  - Deterministic latency
- Data Transfer and Slow Control use Ethernet UDP
  - Hubs can be realized by commercial GbE switches



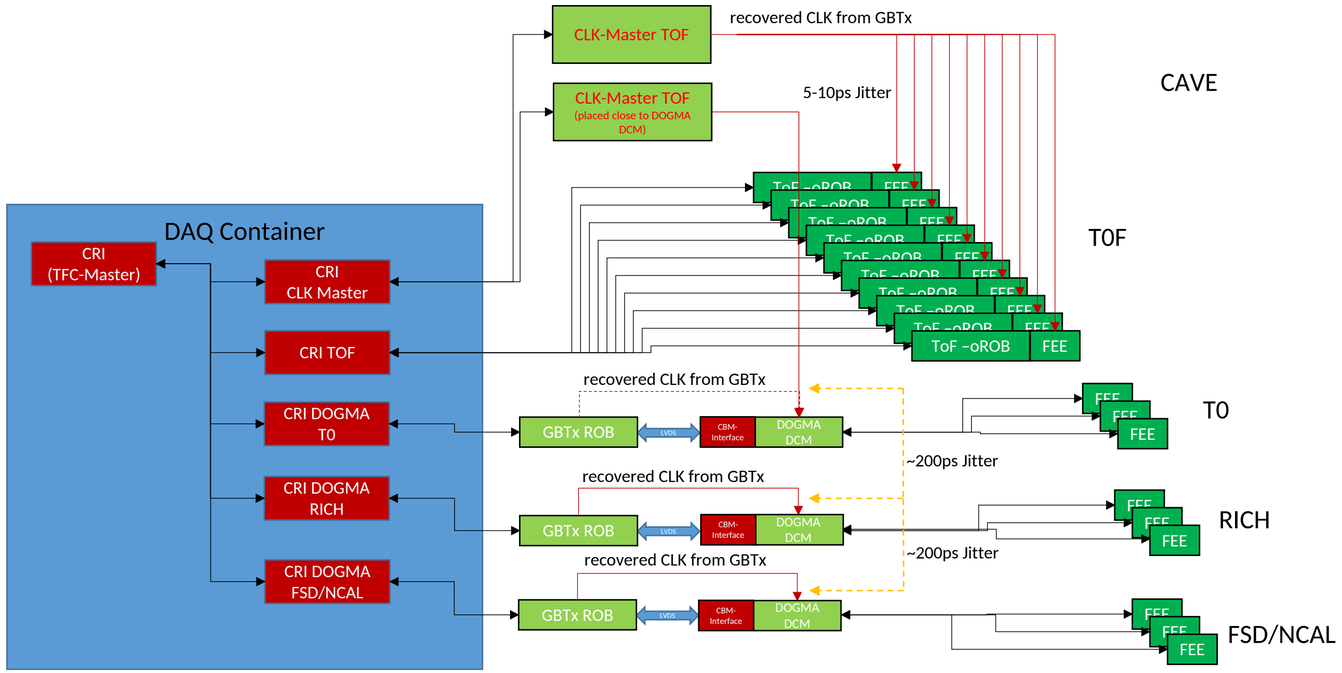
Future Readout in CBM

- DOGMA replaces TRBnet on DIRICH front-ends
- Media access interface and UDP data receiver will be integrated into CRI firmware (similar to TRBnet)
- DOGMA DCM receives system clock + micro slice ID + synchronization from CRI-based CBM DAQ, and forwards to endpoints

- Development of new concentrator board
  - Act as Ethernet hub and dogma hub to reduce number of FE links
  - Reuse existing DIRICH
  - Anyhow necessary to increase data rate between front-end boards and CRI (current bottleneck)

Future Readout in CBM

- DOGMA DCM will be interconnected via existing iROB GBTx interface by TOF
  - One CRI will do entire steering for RICH
  - Other DIRICH-based sub-detectors showed interest in transition
- DIRICH and DOGMA as FPGA-based alternative to ASIC-based front-ends



Ongoing Work

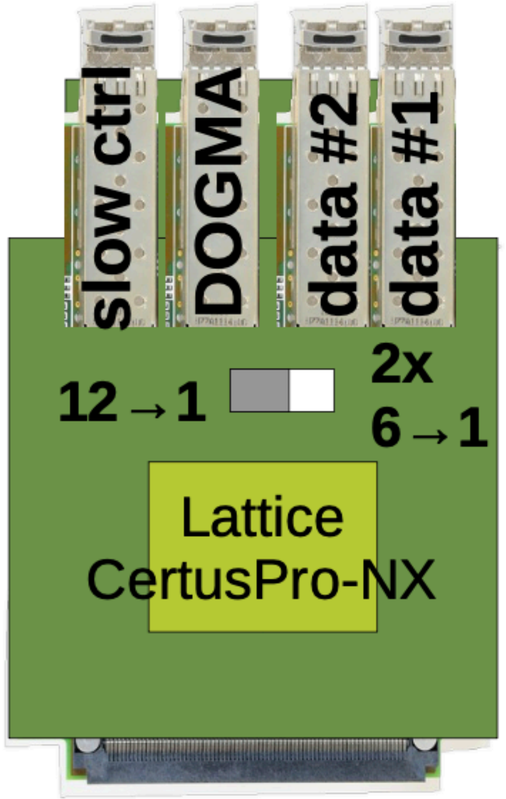
- Implementation of Ethernet interface on CRI
  - Start from existing firmware design, where many parts can be reused (micro time slice building, ...)
  - Ethernet support from DOGMA group
- Implementation of CRI —> iROB GBTx —> LVDS —> DOGMA CTS interface
  - First steps already done by Esteban Rubio @ GSI test setup
  - Support on final steps promised by GSI

Ongoing Work

- Implementation of test setup on existing concentrator (single HS link available)
  - H. Heggen / M. v. Bülow (GSI) working on DOGMA hub integration to prepare first full test setup soon, maybe even with mRICH
  - Old ECP3 FPGA causes some troubles

Future Work

- Design new DOGMA Concentrator for RICH
  by M. Traxler, H. Heggen, et. al.
  - Upgrade FPGA to Lattice CertusPro-NX for improved radiation hardness
  - Upgrade single SERDES link on backplane to 1x SERDES + 1x LVDS link for data (Ethernet) and clock/sync
  - Upgrade single 2.4 Gbps SFP optical link to 2x 10Gbps SFP optical link + 1x SFP clock/sync [+ 1x SFP slow control]



Summary

- Current readout protocol *TRBnet* has proven to work reliable in mRICH,
  but DAQ integrity is impacted in radiation environments

- New DOGMA protocol for existing hardware tackles this by allowing endpoints to be
  removed and reintegrated flexibly during data taking

- Firmware development for CRI on trigger and receiver side has started,
  targeting first test system by end of 2025