# SODANET

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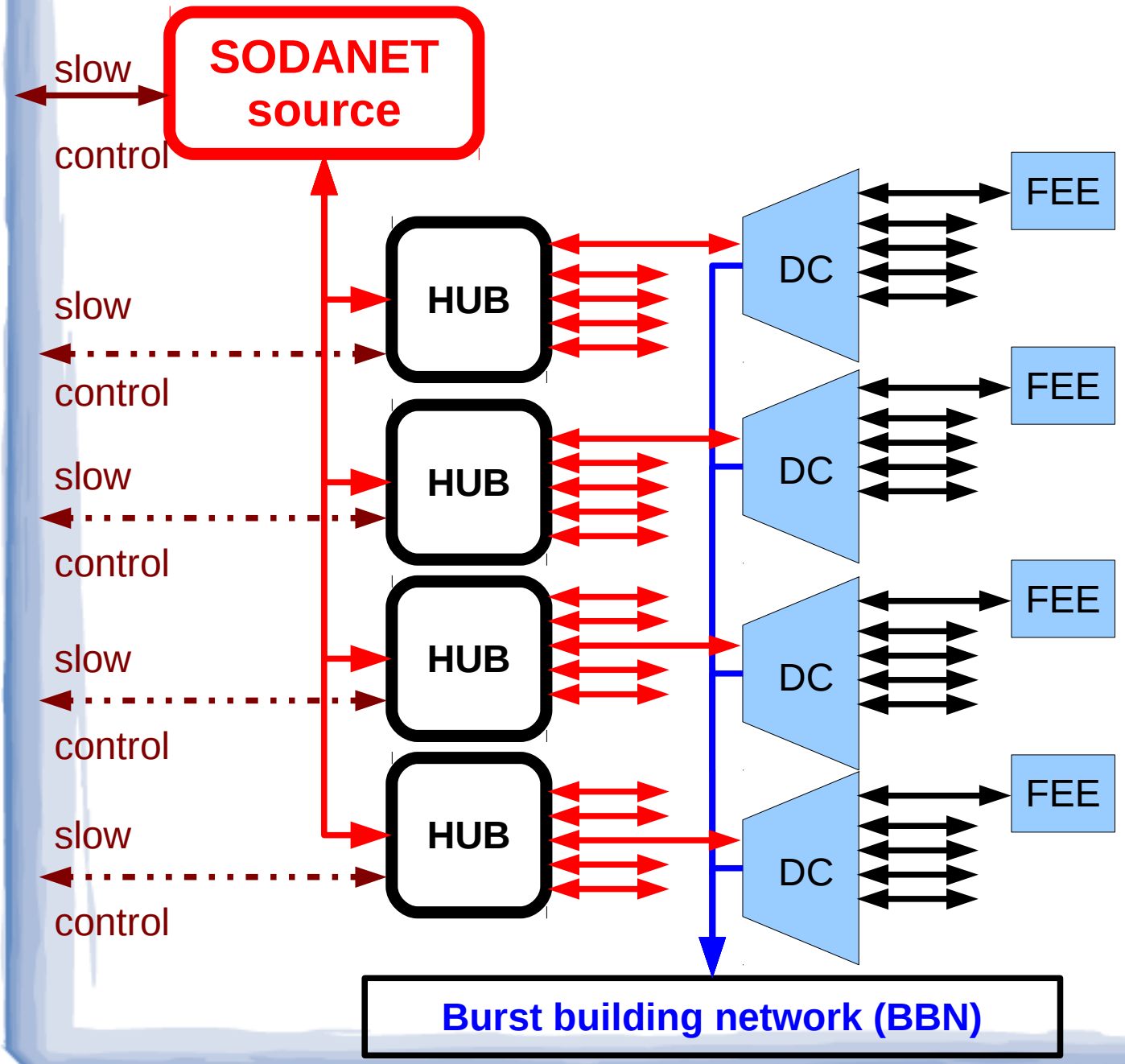
# SODANET Functionality

**SODANET provides**:

- synchronization of the FEE
- Continuous monitoring of the DC/FEE functionality
- Rough (initial) time calibration of the propagation time of the synchronization signal
- Transfer of a slow-control (FEE configuration/status) information: low priority, transmission of a slow-control package can be interrupted at any time by a synchronization package

# SODANET Topology




**SODANET link**:

- Bidirectional
- Synchronous (only in one direction)
- Transfer:
  - source → DC: synchronization information and FEE configuration
  - DC → source: slow control, used for time calibration

**Data link (DC → BBN)**:

- Unidirectional

**Link DC ↔ FEE**:

- Bidirectional, synchronous
- Protocol up to subsystem

# SODANET Synchronous Packages

**SODANET protocol foresees two types of sync. packages**:

- Command data: issued at any time within super-burst
- Super-burst start (**super burst = 16 bursts of 2.4 μs**): issued at the beginning of each Super-burst

## Package structure

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| K (DC) | Data 31-24 | K (DC) | Data 23-16 | K (DC) | Data 15-8 | K (DC) | Data 7-0 |

**Command package**:

- Bit 31: 0
- Bit 30: Time calibration
- Bit 29: DAQ start
- Bit 28: DAQ stop
- Bit 27: Reset
- Bits 26-8: reserved
- Bits 7-0: CRC checksum (CRC8-CCITT)

**Super-burst start package**:

- Bit 31: 1
- Bits 30-0: Super-burst number

# Synchronous Clocks

- The “**super-burst start**“ package is used to derive clock-phase for each endpoint

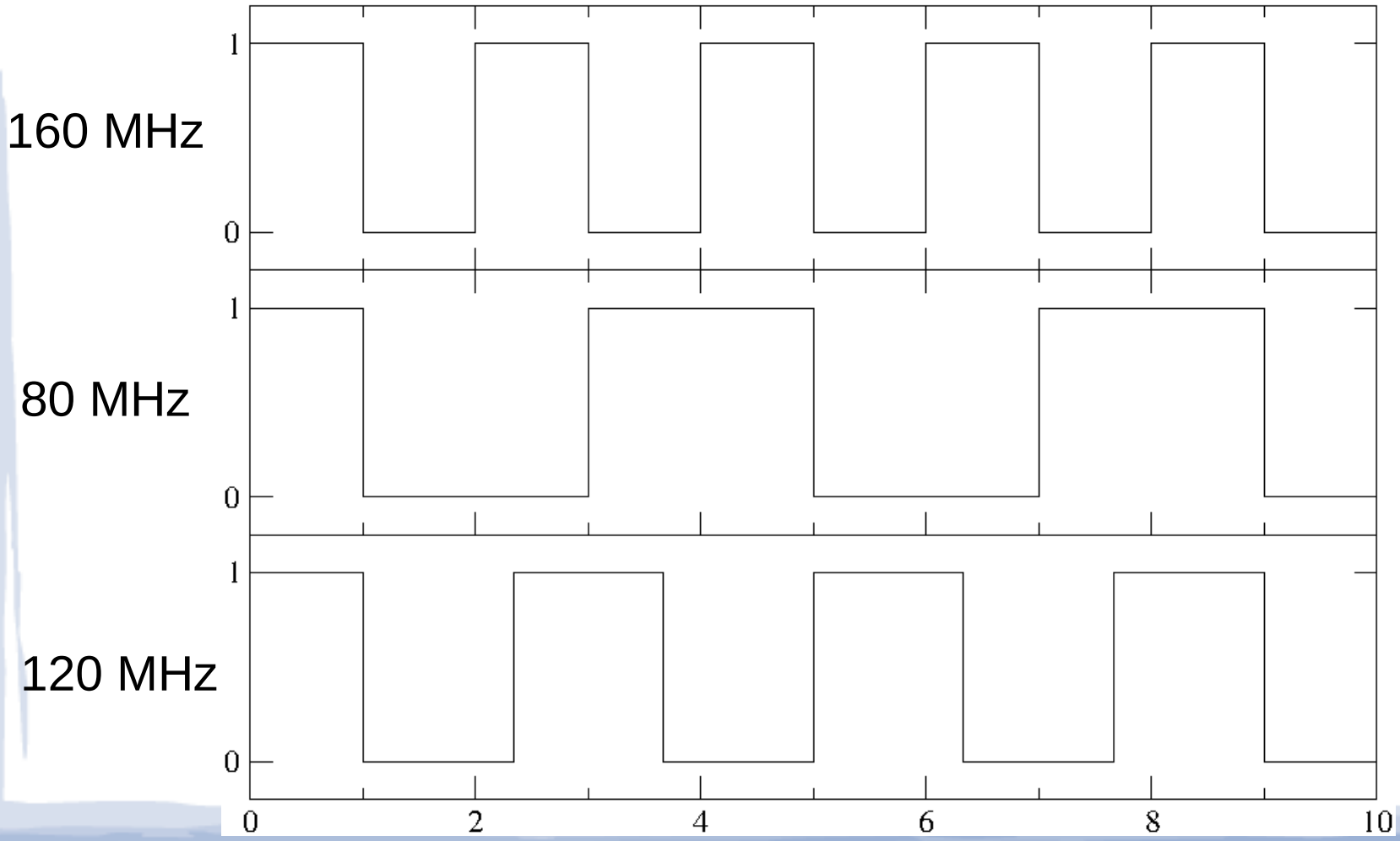
- Medium interface (SERDES with related state machine) should be able insert SODANET synchronous data at any byte of transmitted data. Example:
  - TRB v3 link at 2 Gb/s requires 16-bit (2 bytes) data input
    → state machine should be able to insert SODANET command at any position

# Synchronous Clocks

**N * 25 ns (periods of 40 MHz clock)**

**Start of superburst**

**Start of superburst**



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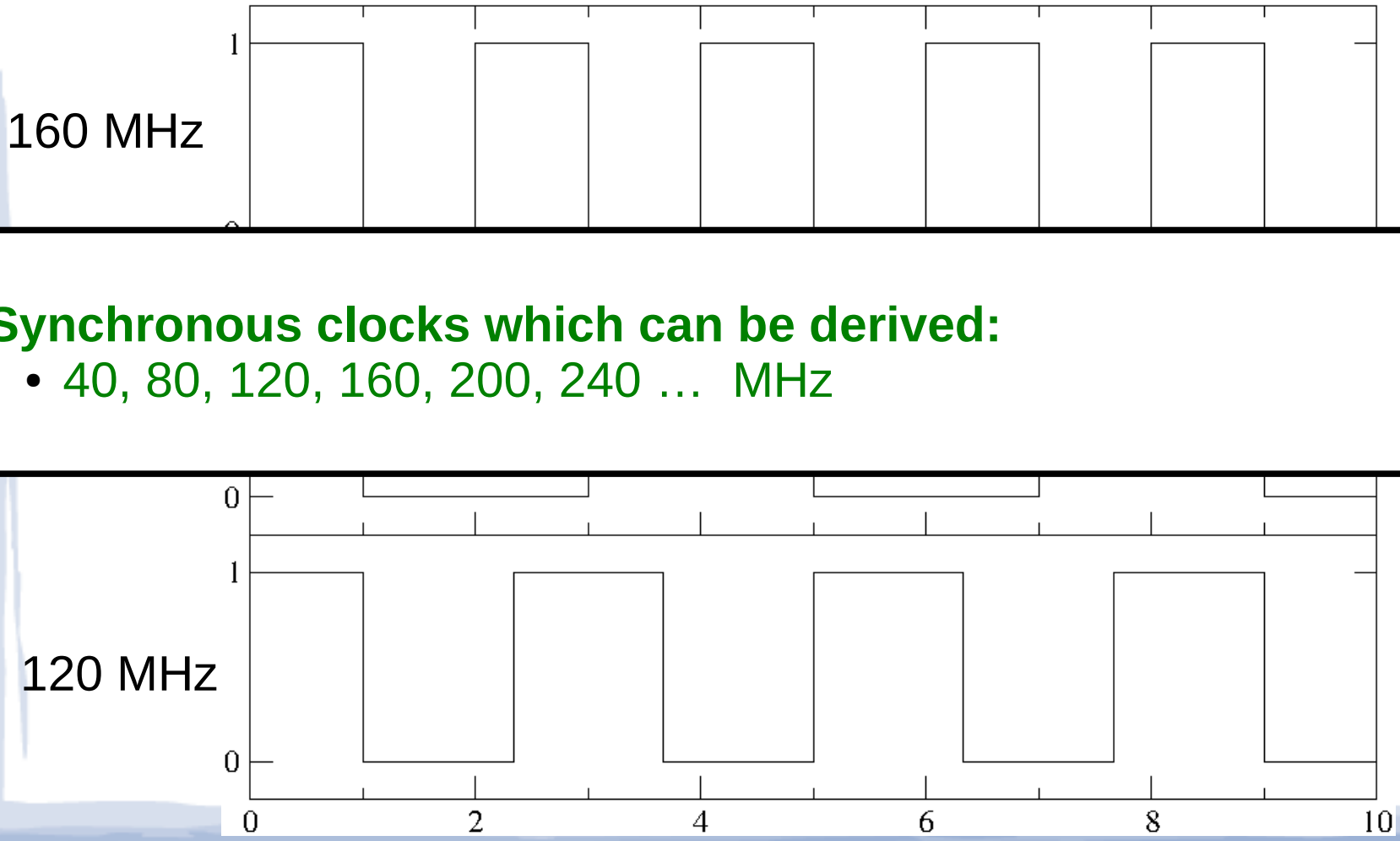
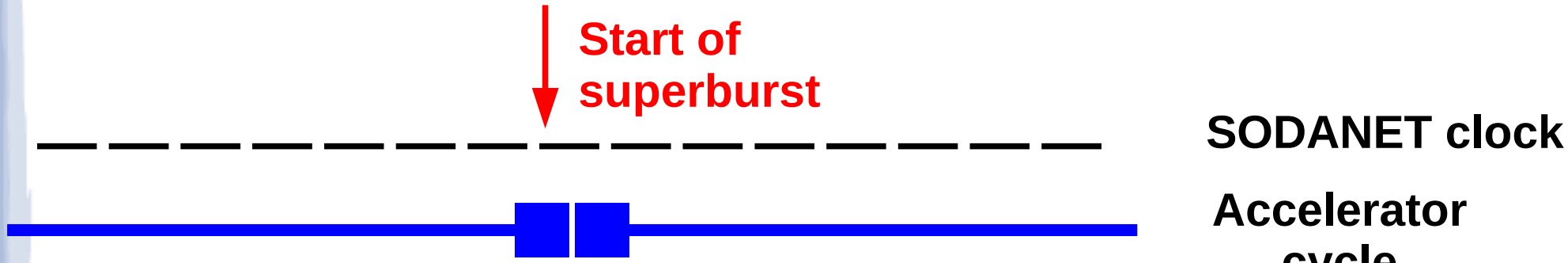



**Synchronous clocks which can be derived:**

- 40, 80, 120, 160, 200, 240 … MHz

# Start of a Super-burst



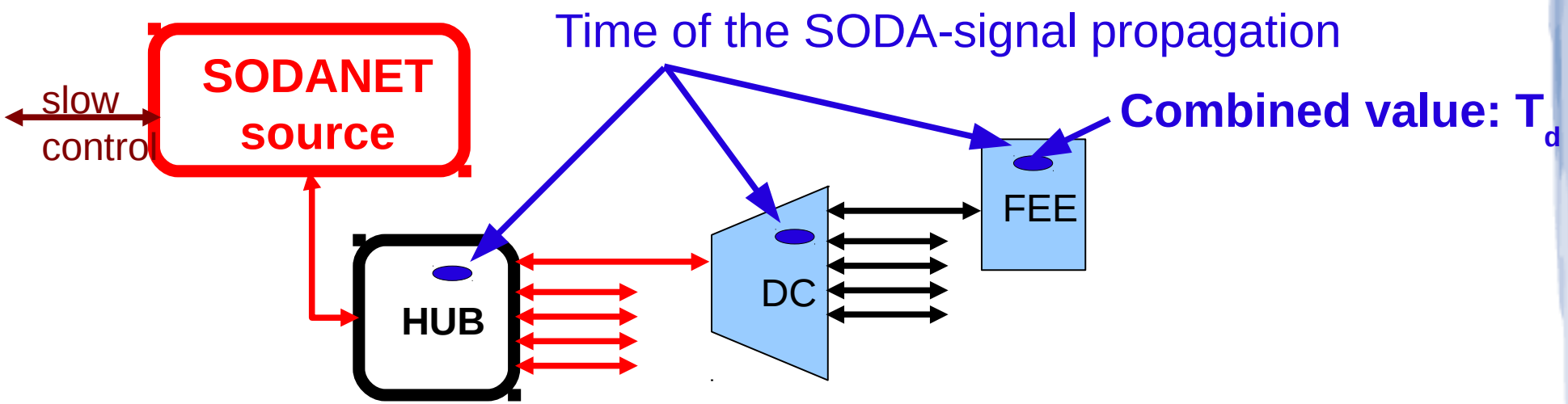

**Accuracy of the super-burst start:**

- 160 MHz clock: 6.25 ns
- **40 MHz clock: 25.00 ns**

**Super-burst signals will not be periodic:**

- ➔ most of the super-bursts have the same length
- ➔ once in several cycles a “correction” (shorter/longer by one cycle) super-burst will be issued
- ➔ In general, global timing is not required

# Timing with SODANET




**Procedure of time-stamp assignment:**

- Each digitizer (FEE) has own timing
- Local “time zero” is reset with each SODA command “start of a super-burst”
- Each hit time-stamp is corrected with a $T_d$ value
- After correction the time-stamp the hit data, including current super-burst number, are sent to DC module
- At the DC module decision is taken to which superburst the hit belongs

# Synchronous Packages

- Have highest priority (interrupt any other transfer)
- Each received SODANET packed – acknowledged:
  continuous monitoring of the readout
  - Malfunction of one of the DC/FEE → trigger slow control;
    the malfunction DC – added to the list of non-uses recipients

- Burst counting (within Super-burst) – at each DC
  Error handling:
  - DC checks if received super-burst number is sequential
  - In case of error:
    - the DC uses number distributed by the SODANET,
    - set special error bit in the output data,
    - informs slow-control system
  - If part of SODANET message is missing:
    - DC uses super-burst number from a local counter,
    - reports problem to the slow-control system.

# Time Calibration

- Dedicated “time calibration” command is issued by the slow-control system
- Once the command is received:
  - reply sent to the transmitter side,
  - original message is forwarded further through the network.
- Propagation time:
  - calculated at the transmitter side
  - stored in a register
  - the register values – read out by a slow control system.
- The delay data – used to pre-calculate signal-propagation delays ( ~10 ns precision); there is possibility of precise monitoring of the link length (temperature effects)
- Delay values – used at the DC for proper assignment of a hit to a super-burst.

# “Triggered” Mode

## Compatibility mode of operation

- External “trigger” signal is feed to one of the DC/SODANET source
- “trigger” is timestamped, and sent to the burst-building network
- Event builder will select only hits with timestamps, which are in coincidence with the “trigger” signal

# DC Output Data-format

- DC can start transmitting FEE data once it is available
  (without waiting till the end of a super-burst)
- If no data are available –
  DC sends an empty package at the end of the Super-burst

**Data-package**

| 31 16 | 15 0 |
|---|---|
| last-packet flag; packet number | data size in bytes |
| Not used (same as HADES) | Not used (same as HADES) |
| Status and error | System ID |
| Super-burst number | |
| Data | |

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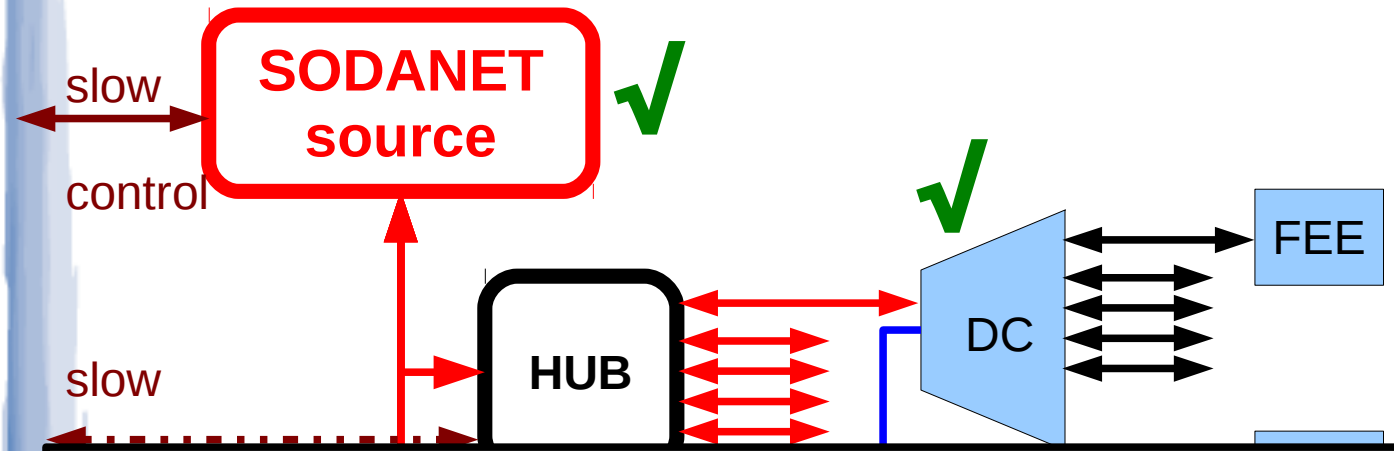


**SODANET link**:

- Bidirectional
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- Transfer:
  - source → DC:
  - Protocol up to subsystem

**So far stable operation only of point-to-point SODANET link was demonstrated (source – endpoint)**

**Does not work:**

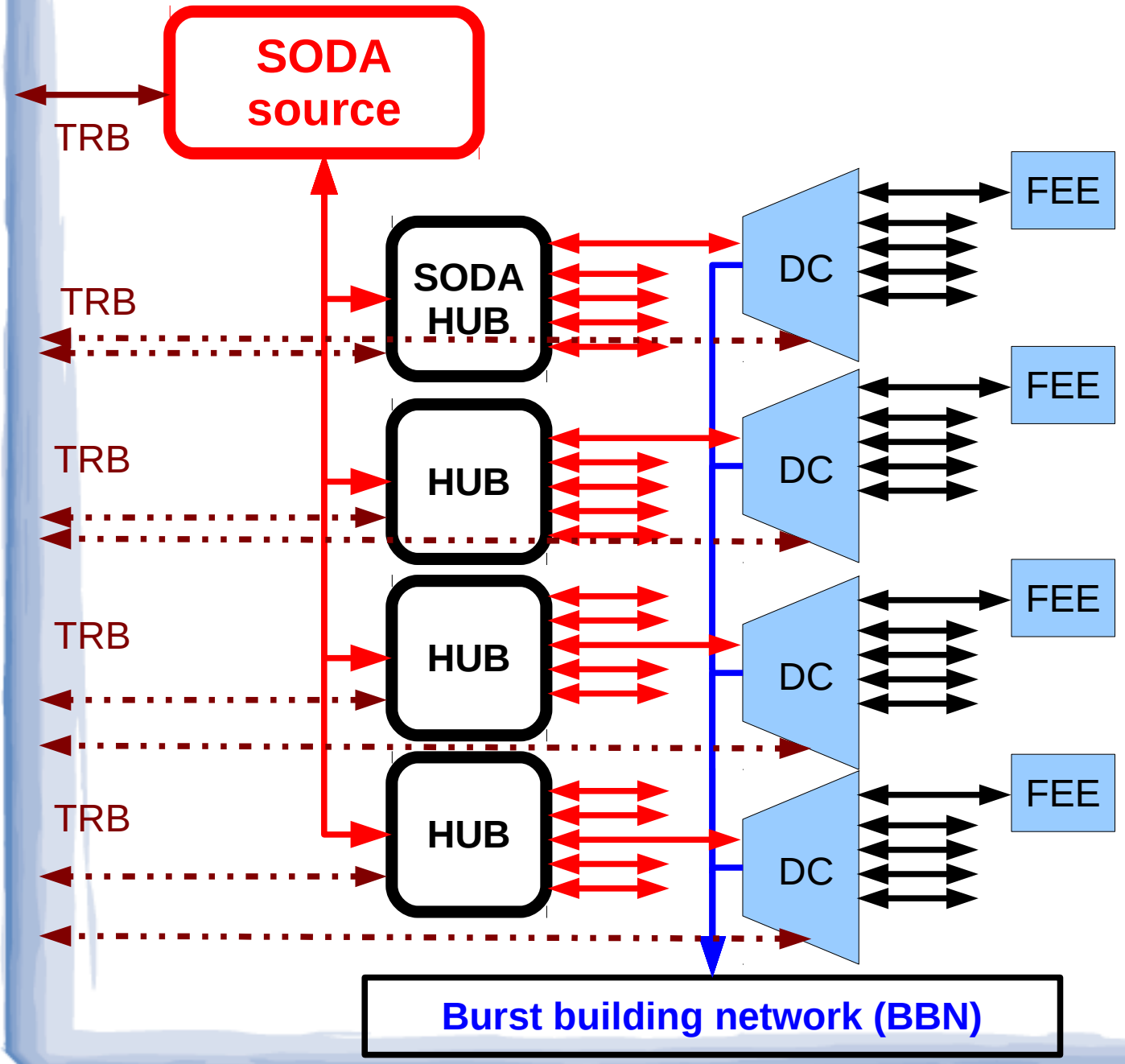
- SODANET HUB (required for multiple endpoints):
  - SODA commands go through the HUB while the TRB hub is hanging

→ **This issue is being investigated by the TRB expert (Jan Michel)**

**To proceed with the development of the synchronization protocol a "split" version SODA-NET has been developed**

**Burst building network (BBN)**

# SODA-NET

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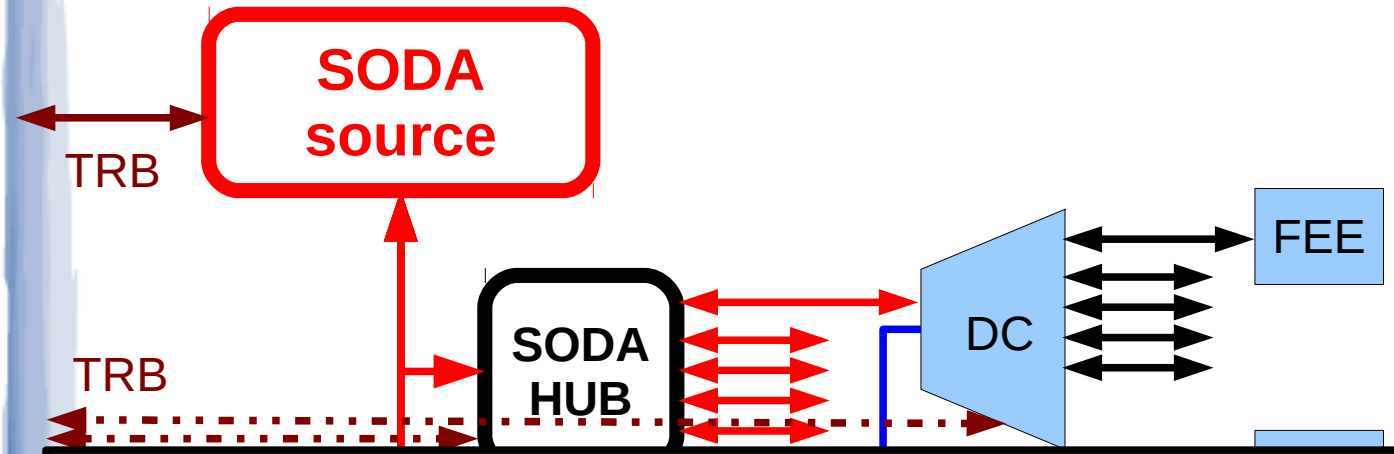


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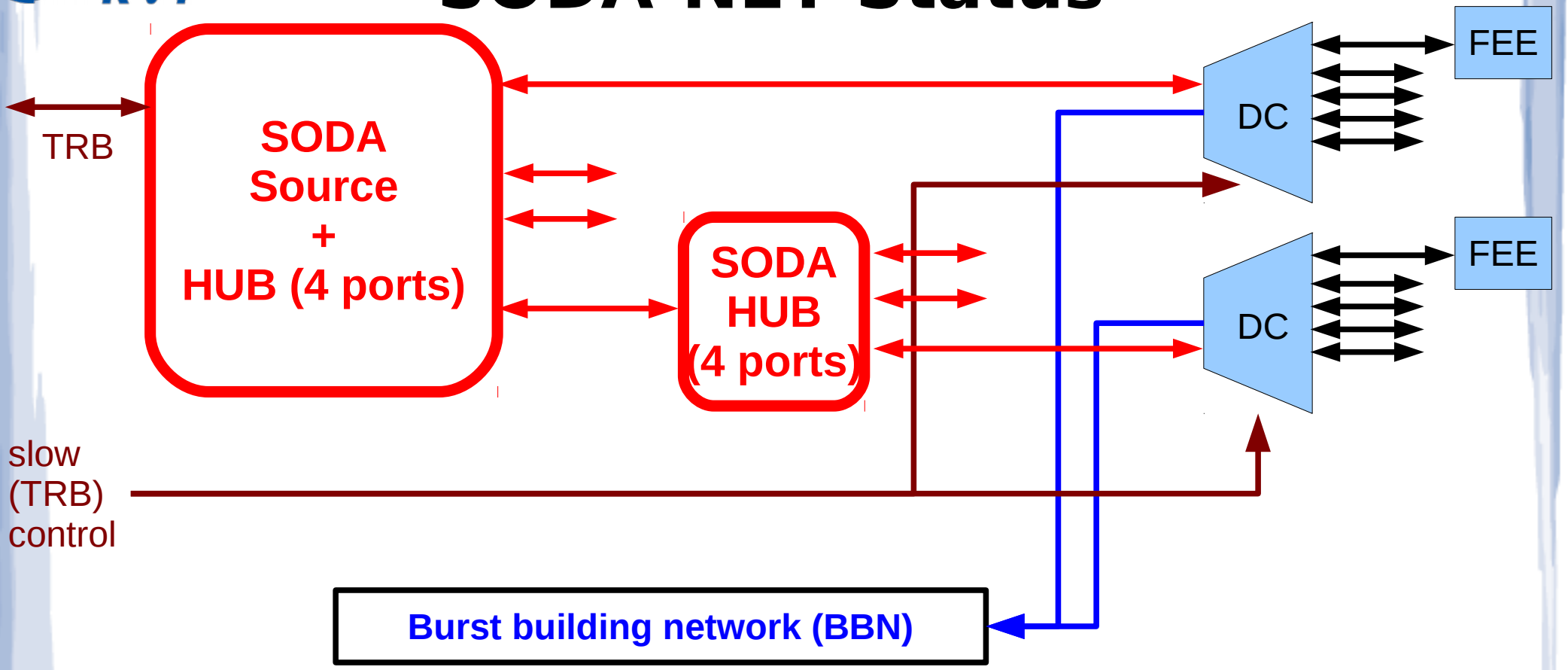
**SODA-NET allows:**

- To test performance of the time-distribution network in terms of jitter, scalability of the system
- To develop data concentrator firmware (migration from SODA-NET to SODANET is straightforward)
- To build complex readout systems with multiple DC/FEE modules

subsystem

**Burst building network (BBN)**

# SODA-NET Status




Prototype of the system with all components (two TRB boards and two EMC digitizers) operates stable: first tests are successful.

After completion of the tests with a small-scale system, larger system is required for scalability tests (>ten TRB board)

**All subsystems should start using the SODA-NET**

# Development of the SODANET
## Planning

- Fix SODANET hub
- Port firmware to Kintex-7 platform
- Implement deterministic messages up-stream
- Consider using GBT IP-cores as medium interface

# Summary

**SODANET** is an universal protocol for communication between FPGA-based hardware which can serve PANDA and CBM experiments

Thank you for your attention!