

# SODANET

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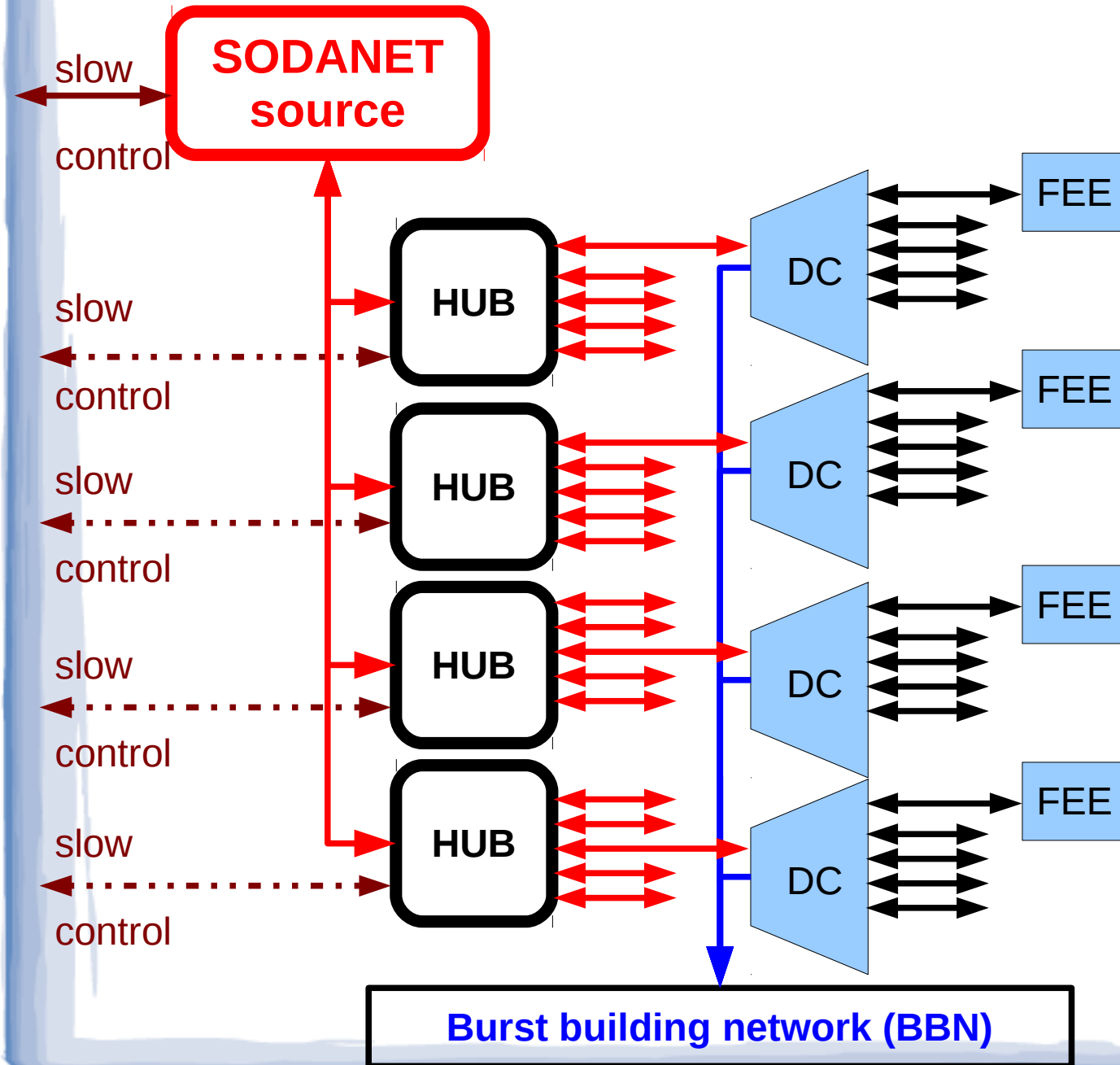
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# SODANET Functionality

## 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  $\mu$ s**): 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
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### 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

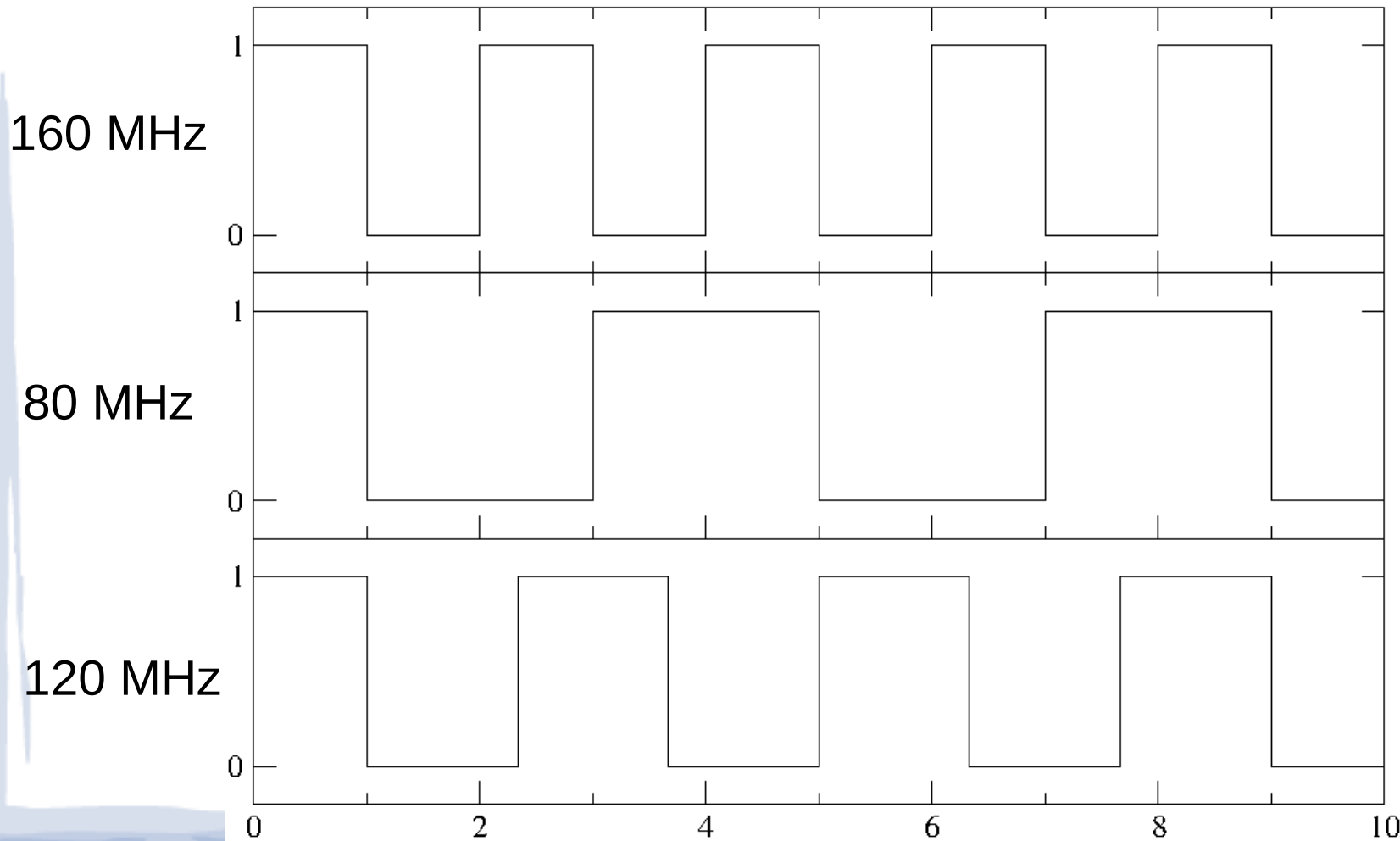
# Synchronous Clocks

$N * 25 \text{ ns}$  (periods of 40 MHz clock)



↓  
**Start of  
superburst**

↓  
**Start of  
superburst**



# Synchronous Clocks

$N * 25 \text{ ns}$  (periode of 40 MHz clock)

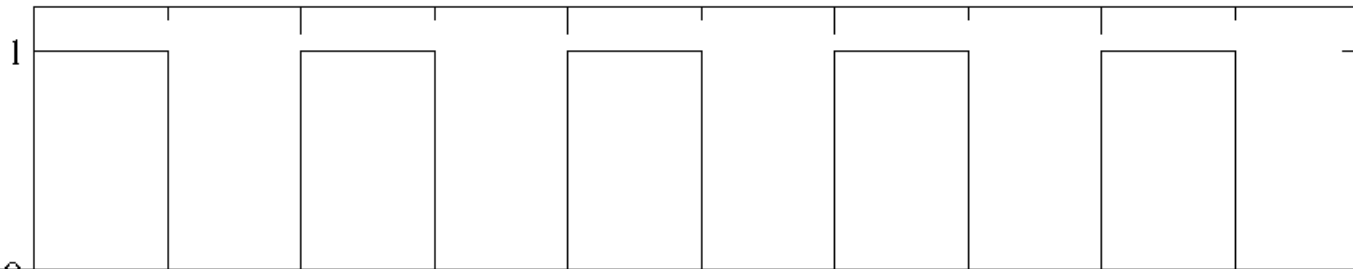


Start of  
superburst



Start of  
superburst

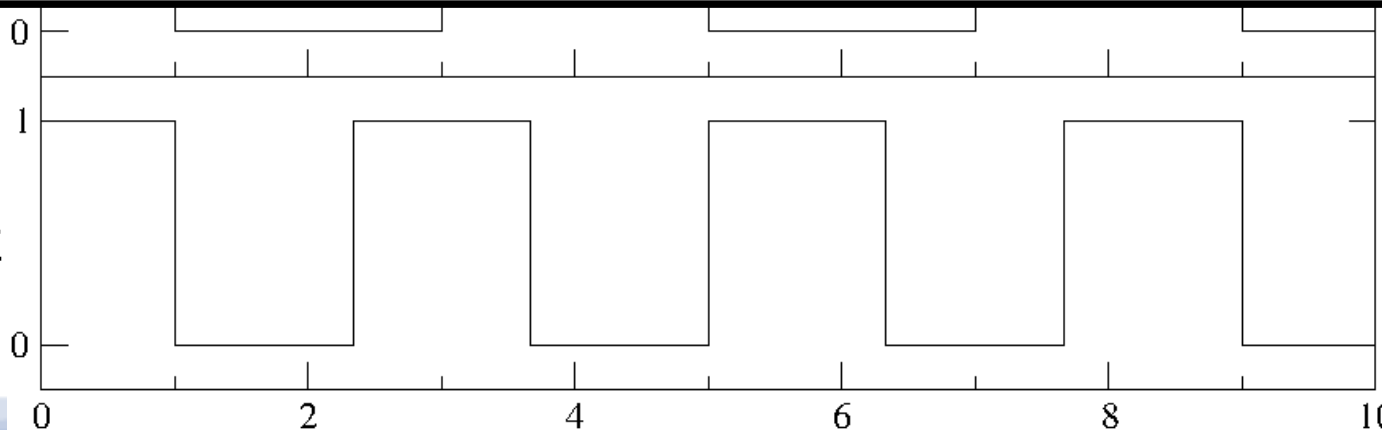
160 MHz



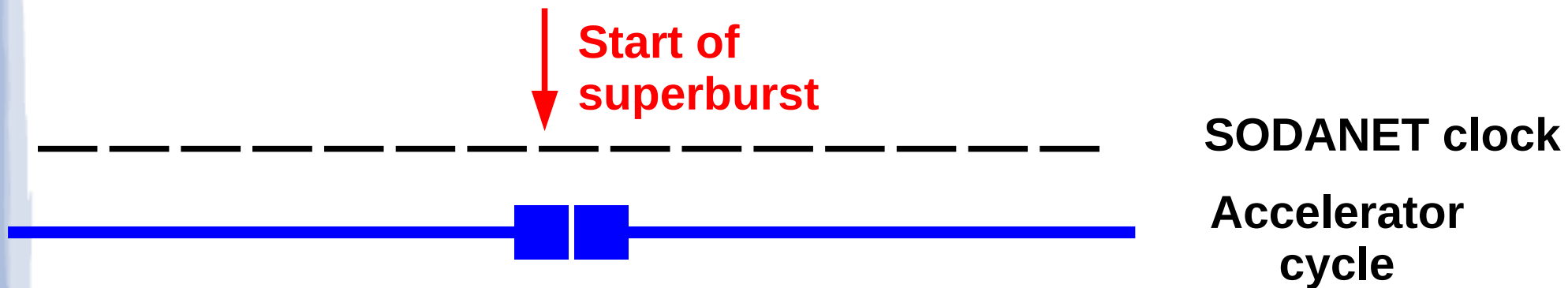
**Synchronous clocks which can be derived:**

- 40, 80, 120, 160, 200, 240 ... MHz

120 MHz



# Start of a Super-burst



## Accuracy of the super-burst start:

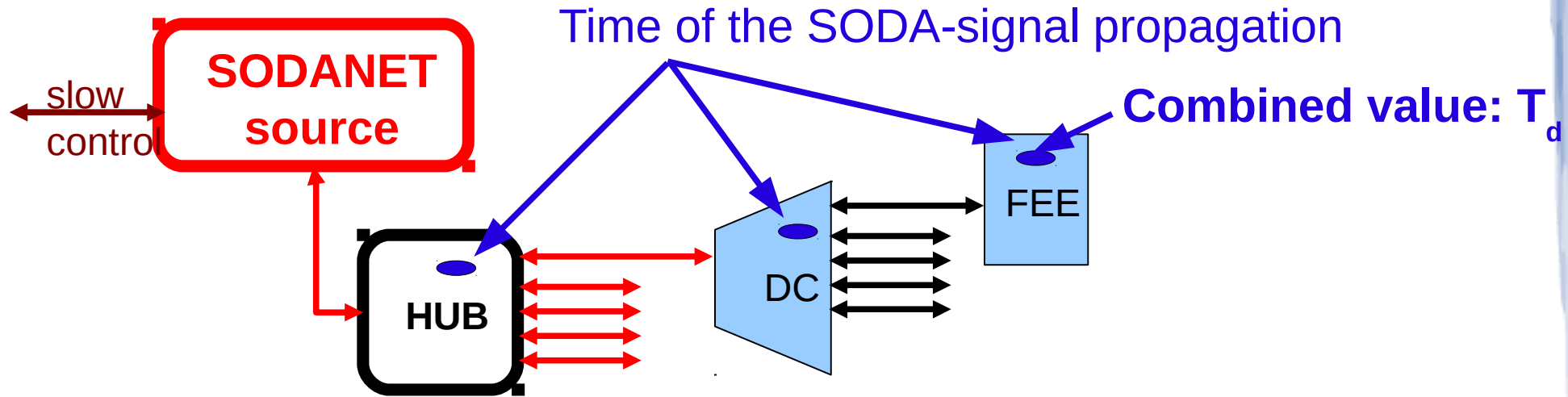
- 160 MHz clock: 6.25 ns
- **40 MHz clock: 25.00 ns**

## 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 (  $\sim 10$  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



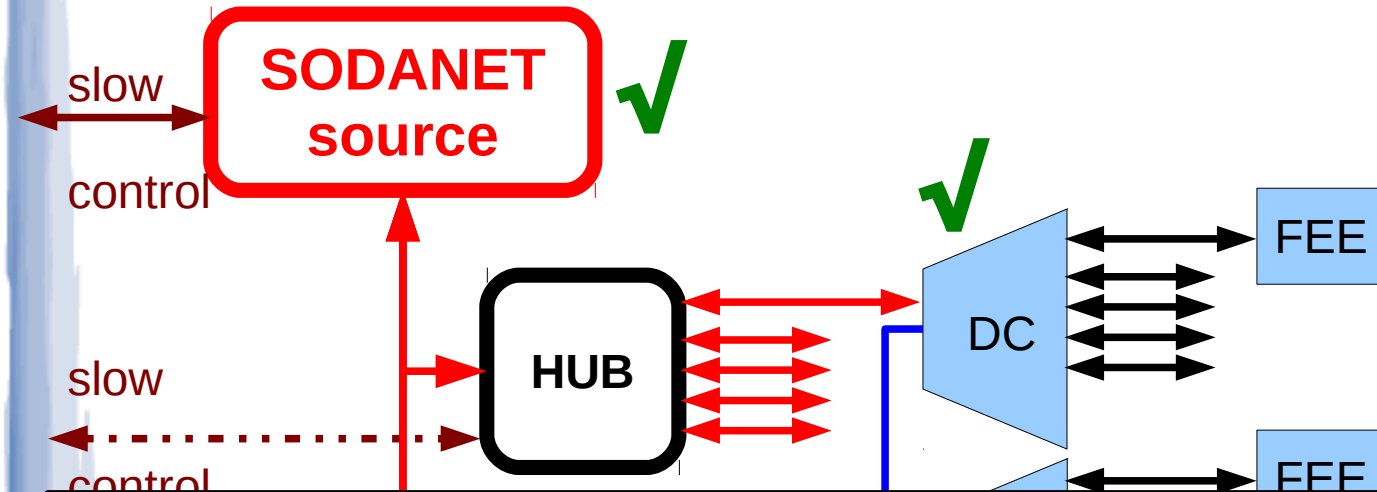
# DC Output Data-format

- 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			

# SODANET Topology



## SODANET link:

- Bidirectional
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- Transfer:
  - source → DC: synchronization

## Done (stable operation of the hardware/firmware):

- SODANET source
- SODANET endpoint (DC)

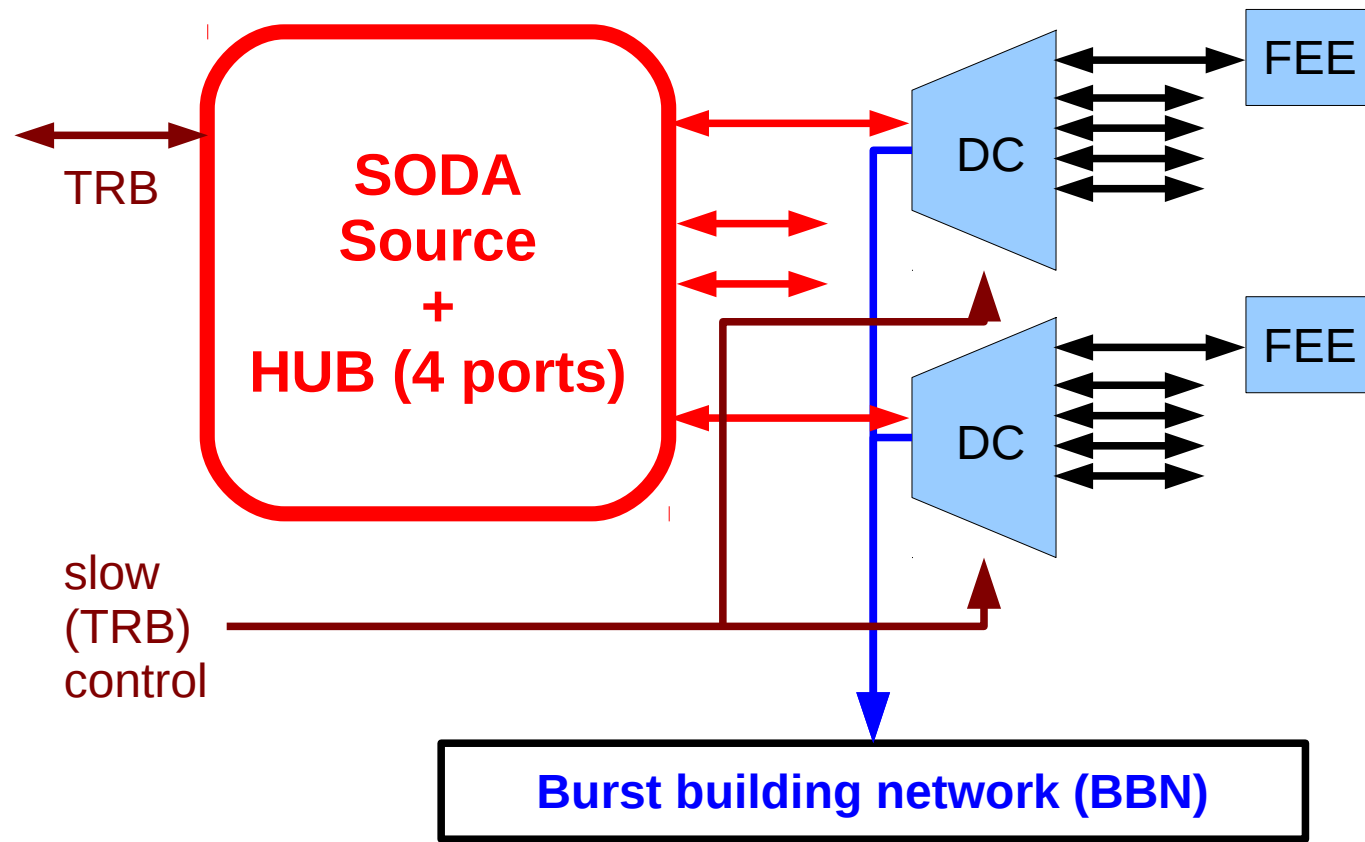
## Does not work:

- 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)**

Burst building network (BBN)

- Protocol up to subsystem

# Current Test Set-up



- The readout system may include up to 4 DCs
- Each DC has separate inputs for SODA and TRB
- SODA hub is being developed

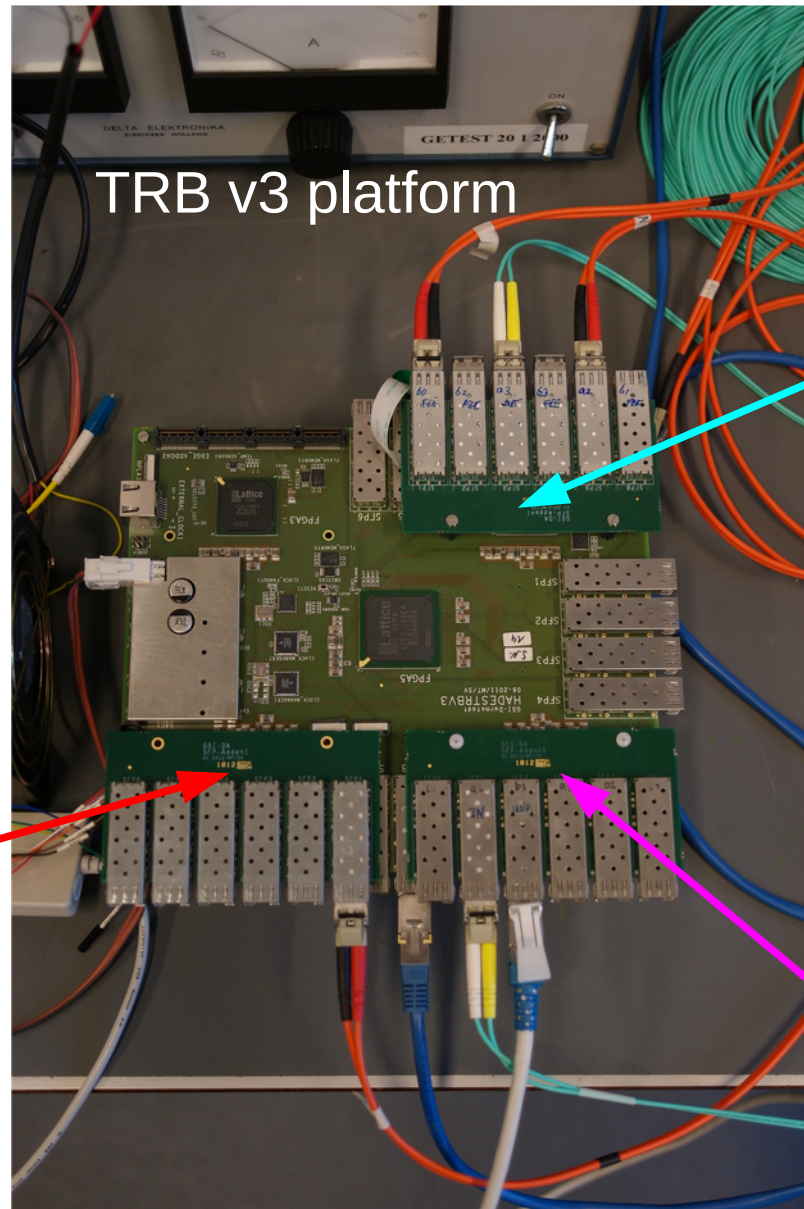
# Current Test Set-up

All optical links  
operate at 2 Gb/s

↕ Synchronous  
Clocks

ADC operates at  
80 MHz

**SODA source  
+  
Hub (4 ports)**



## EMC DC:

- 4 FEE inputs
- 1 SODA input (has built-in SODA source for stand-alone operation)
- 1 output to BBN (2 Gb/s link)
- 1 TRB input (copper pair from the central FPGA)

## BBN receiver

(PC interface):

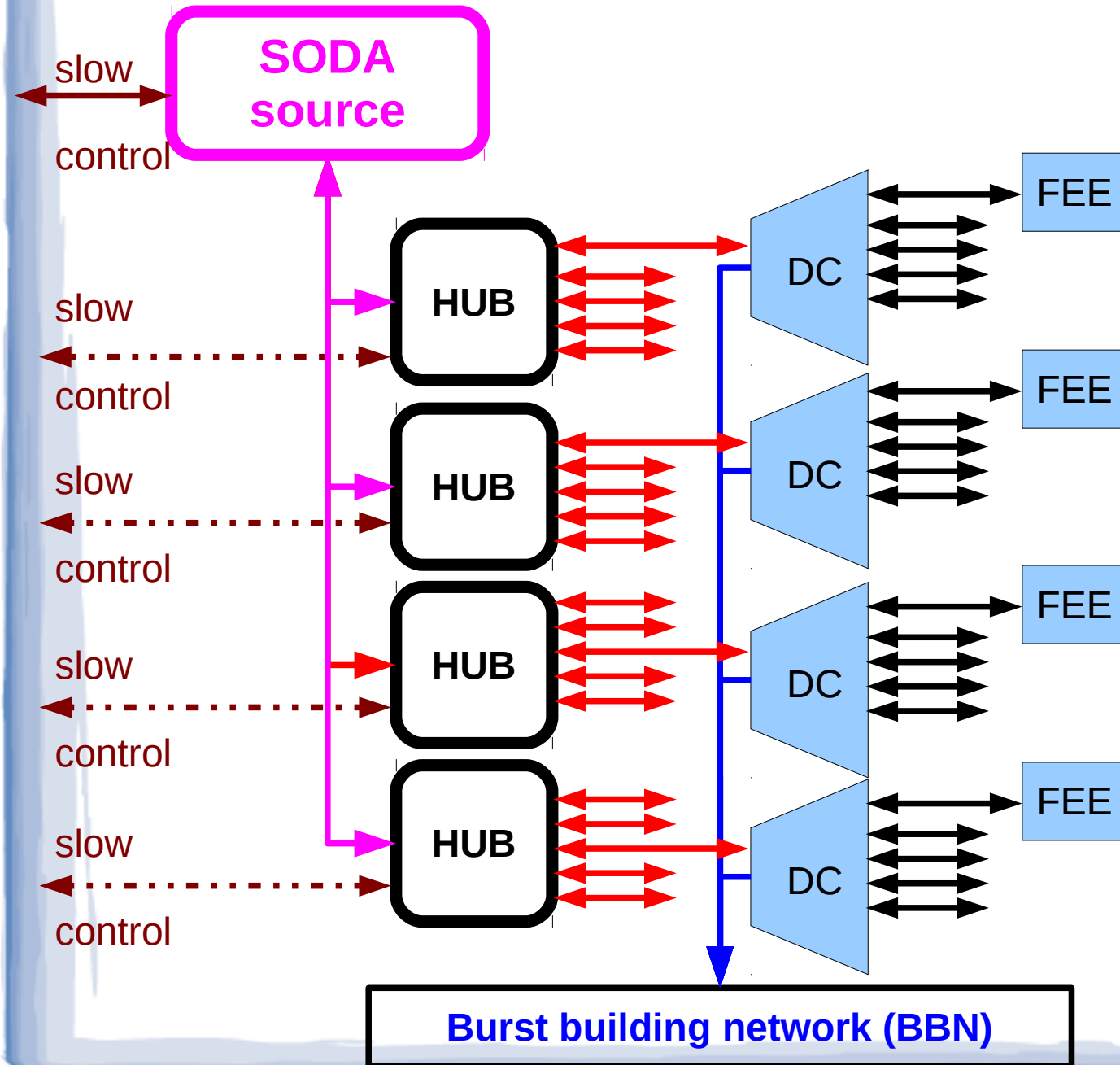
- Receives data from DC (2 Gb/s link)
- Re-transmit data using GBE link (UDP protocol)





# Step II

## Each HUB has separate separate TRB input



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# Summary

- **SODANET on TRB v3 (Lattice ECP3) platform**
  - SODA-only source with four outputs is completed
  - Complete system with two EMC DC and two EMC FEE has been tested
  - Generation of synchronous clocks multiple of 40 MHz is implemented and tested
  - The complete SODANET-HUB code is being checked by the TRBNET expert (Jan Michel)
- **SODANET on Xilinx Kintex-7 platform**
  - Is required for the EMC, MVD subsystems in PANDA