# Data synchronisation for HEP experiments

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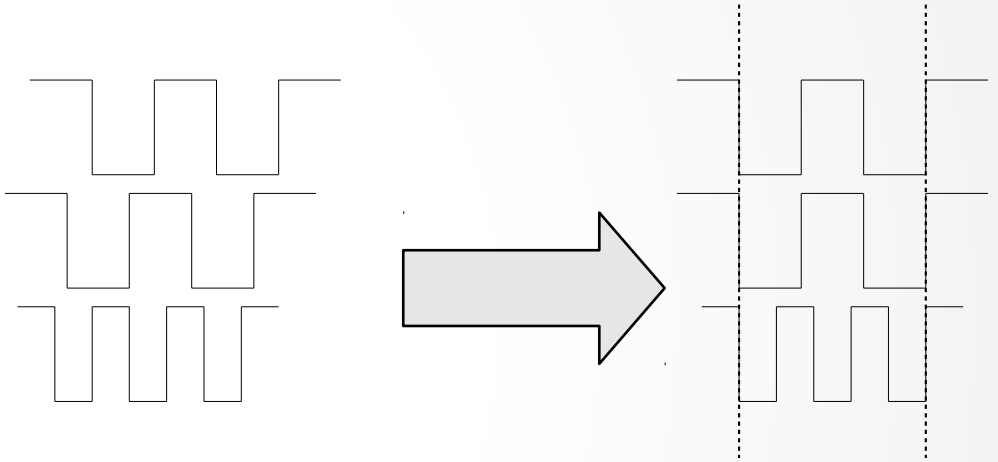
# Definition of synchronisation

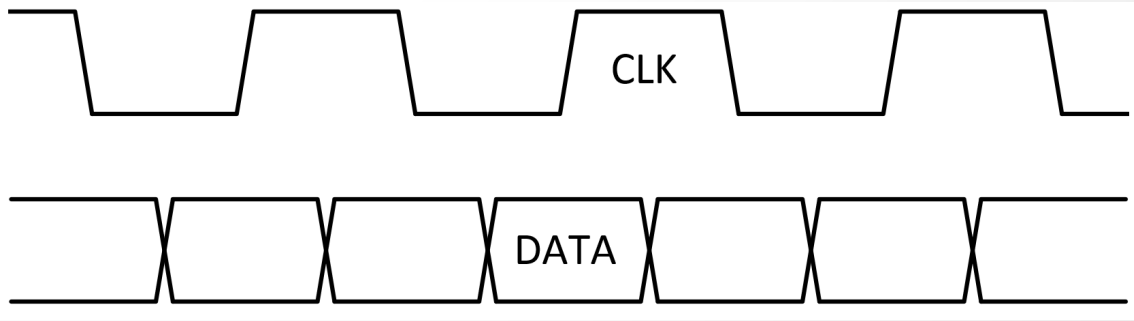
Types of synchronisation:

- clock/phase synchronisation (timing system)
- synchronous data transmission
- data packet synchronisation
- time synchronisation (NTP, PTP)

# Clock synchronisation

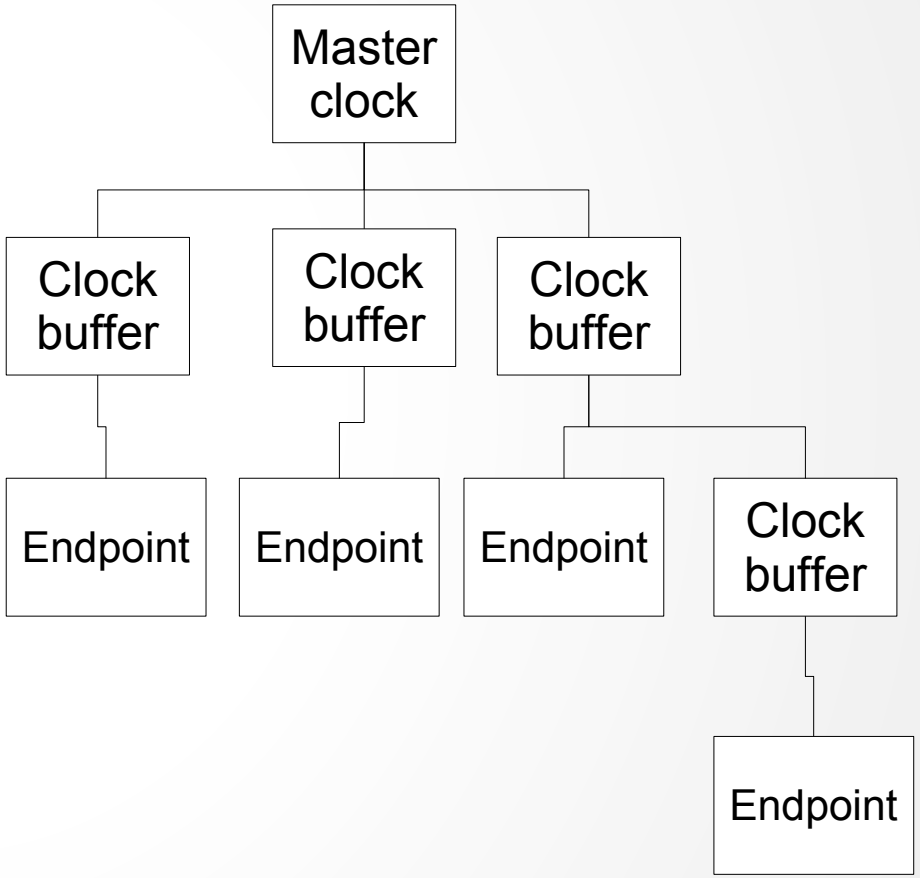
- Frequency synchronisation (syntonization)
- Phase synchronisation
- Often achieved through clock recovery circuits
- Two independent clock sources of the same frequency are not synchronised!





# Clock distribution network

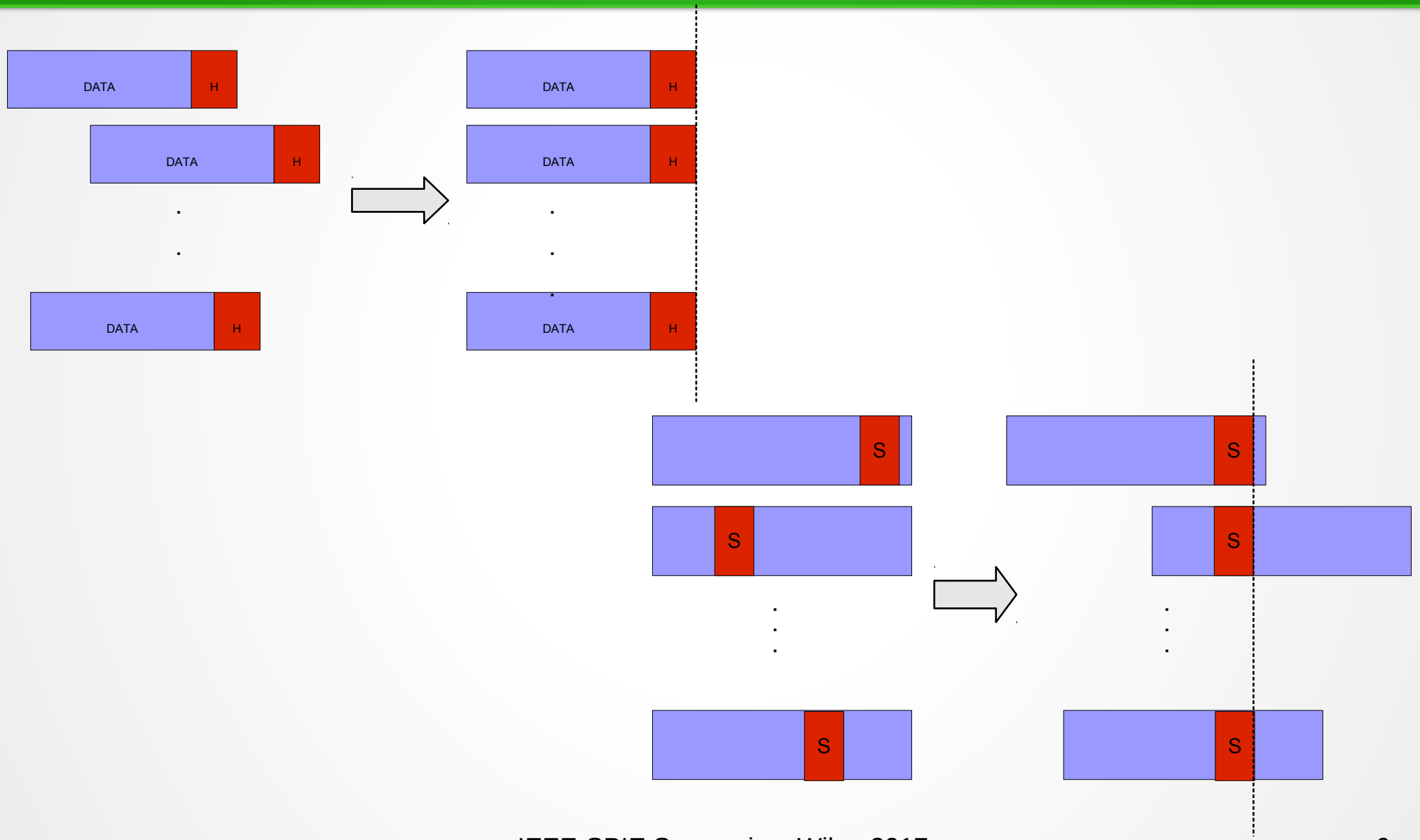
- Distributing synchronous clock for the whole experiment is a challenge on its own
- Complex clock distribution networks
- Challenges: clock jitter, phase control



# Data packet synchronisation

- Transmitted data is usually organized into packets of fixed length
- In multi-channel systems there is usually a need to align packet frames in time
  - variable fiber length
  - different source types
  - inherent silicon characteristics
- Packets may contain headers, or other bitfields of superflous data which may be used as synchronisation marks

# Data synchronisation

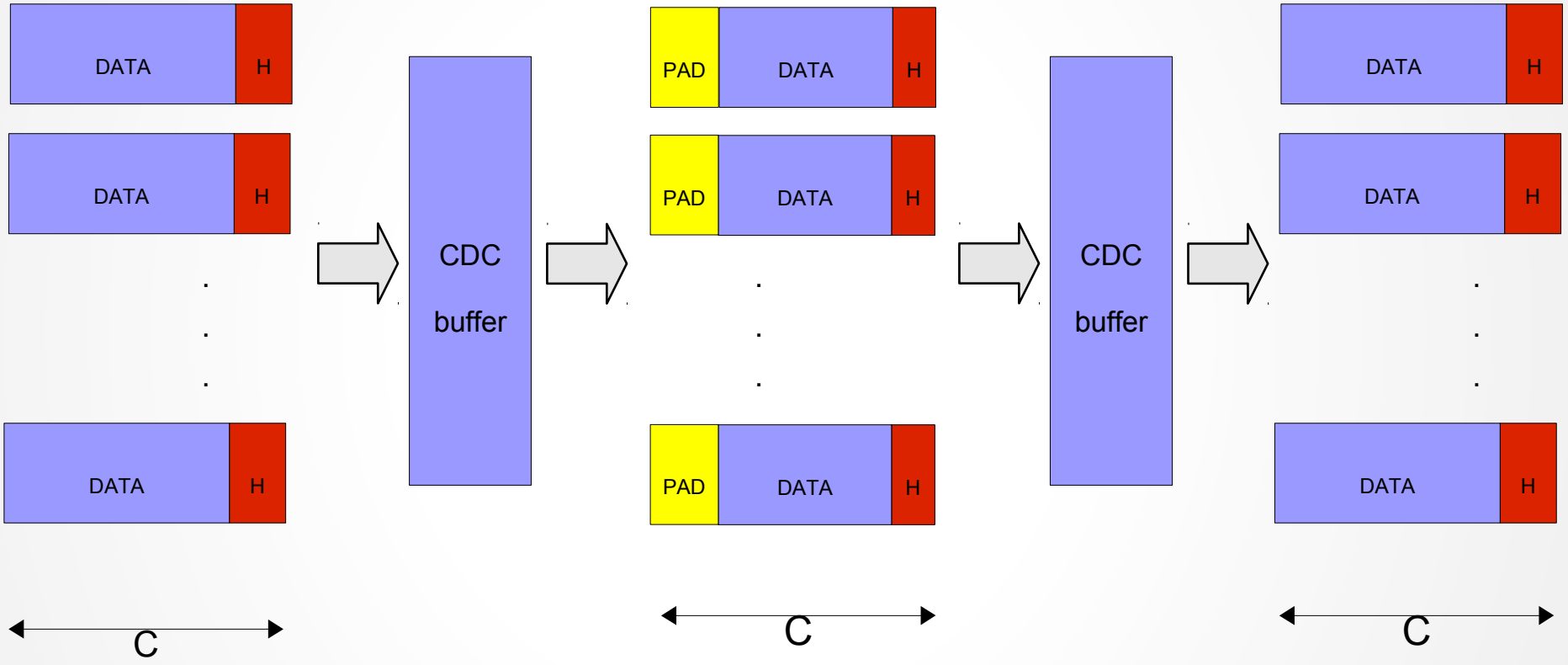


# Asynchronous links

It is possible to send synchronous data over asynchronous link:

- data throughput of asynchronous link must be higher than that of a corespoding serial link
- async clock period must be within strict relationship with sync clock period
- data packet must contain a synchronisation marker

# Asynchronous links



# Asynchronous links

Disadvantages:

- additional circuitry needed
- higher risk of synchronisation loss

Example:

- MP7 protocol (**CMS**) – 9.6 Gbps synchronous data stream over 10 Gbps link

# Source-synchronous links

Clock signal can be transmitted with data:

- separate clock line
- embedded in data stream

Advances in modern electronics allow for easy implementation of Clock Data Recovery (CDR) circuits. This trend becomes visible also in HEP.

Example:

- GBTx ASIC from CERN (together with GBT-FPGA IP)

# Mixed-mode systems

- In practice most systems are a mix of different synchronisation techniques
- Higher-level layers are usually system synchronous or asynchronous
- Frontend components are more likely to be source-synchronous
- There is general trend towards source synchronous systems (GBT, White Rabbit)

# Mixed-mode systems