The detector read-out in ALICE during Run 3 and 4

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for the ALICE collaboration

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OUTLINE

- 1st PART: INTRODUCTION TO ALICE UPGRADE
  - Motivation.
  - Requirements.

- 2nd PART : THE DETECTOR READOUT
  - Main difference from the current readout schema.
  - System operation in triggered mode.
  - System operation in continuous mode.

- 3rd PART : RESULT and CURRENT STATUS

INTRODUCTION TO ALICE RUN3

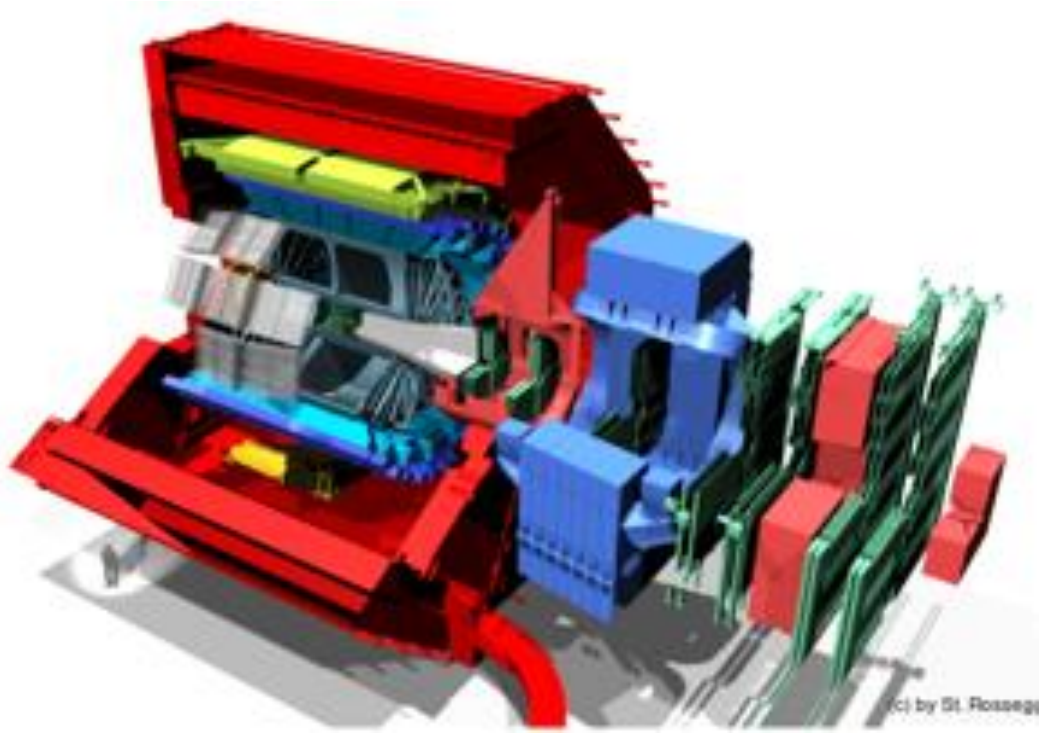
ALICE Upgrade Strategy

GOAL:

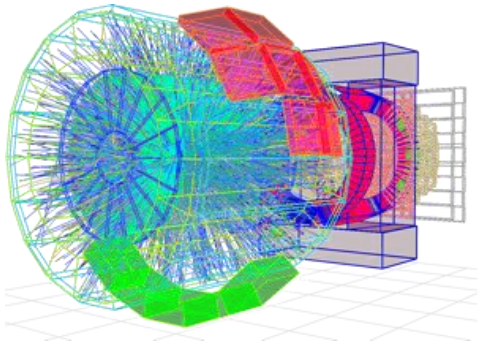
- High precision measurements of rare probes at low p_T which cannot be selected with a trigger. Target a recorded Pb-Pb luminosity > 10 nb^{-1} => $9x10^{10}$ events to gain a factor 100 in statistics over the Run1 + Run2 programme.
- Significant improvements of vertexing and tracking capabilities

DETECTOR:

- Read-out all Pb-Pb interactions at a maximum rate of 50kHz (i.e. L = $6x10^{27}$ $cm^{-1}s^{-1}$) upon a minimum bias trigger
- Read-out all pp and p-Pb interaction at a maximum rate of 200 kHz.
- Perform online data reduction based on reconstruction of cluster and tracks
- Improve vertexing and tracking at low p_T => New Inner Tracking System (ITS)
- TPC continuous readout to keep up with 50 kHz interaction rate, to deal with event pile-up and avoid trigger generated dead time.



ALICE UPGRADE



3.6 TByte/s into PC farm

O^2 (Online Offline) System

Partial calibration and reconstruction online, replacing the original raw data with compressed data

STORAGE

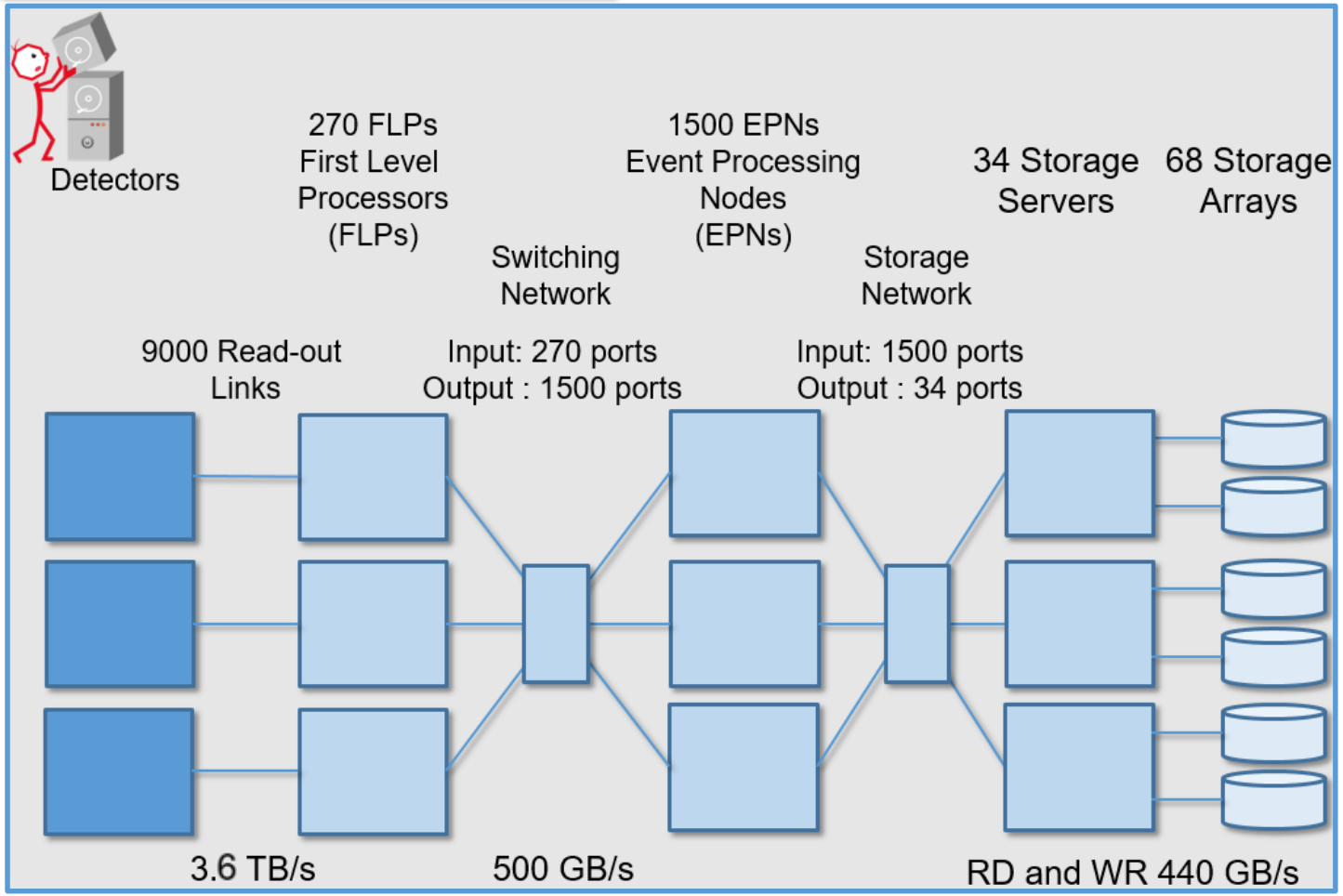
90 GB/s

Acq rate:
Pb-Pb 50 kHz
pp and p-Pb up to 200 kHz

Complete change in detector readout
- continuous
- triggered

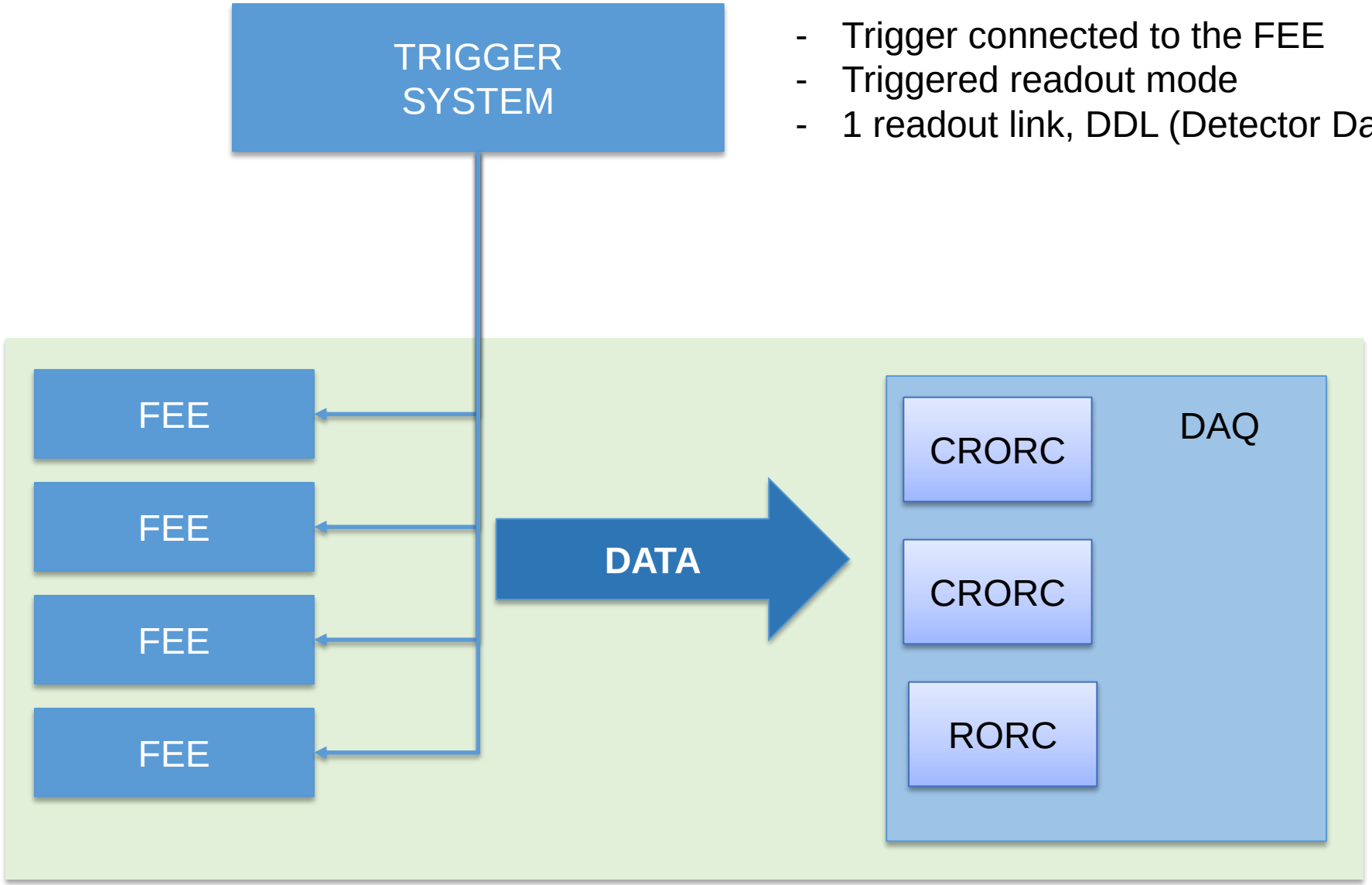
New DAQ - HLT - OFFLINE systems.

O^2 computing farm:
- ~ 100 k CPU cores
- ~ 5000 GPUs and ~500 FPGAs
- ~ 60 PB of storage



Main differences between RUN2 & RUN3

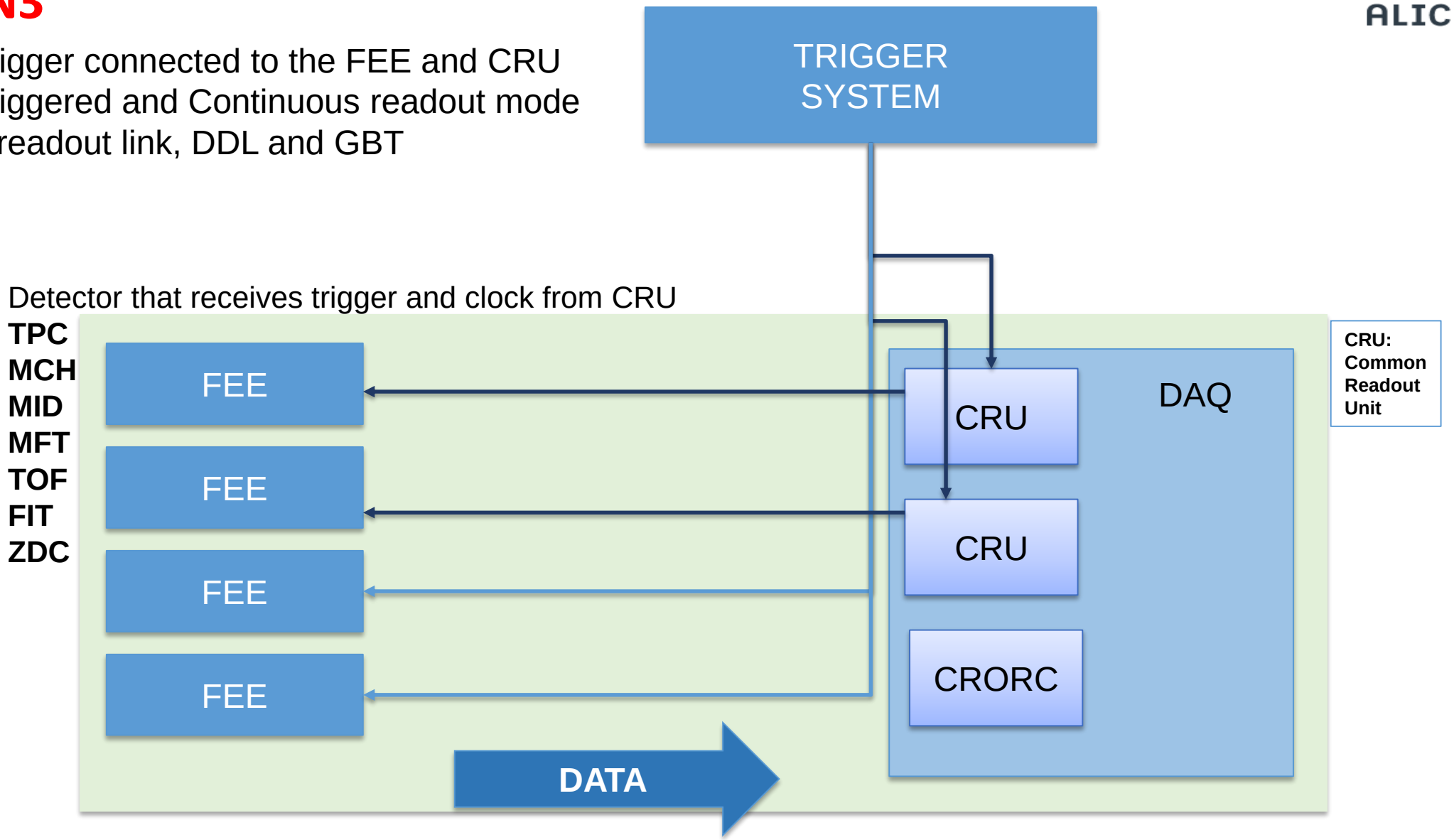
RUN2



- Trigger connected to the FEE
- Triggered readout mode
- 1 readout link, DDL (Detector Data Link)

RUN3

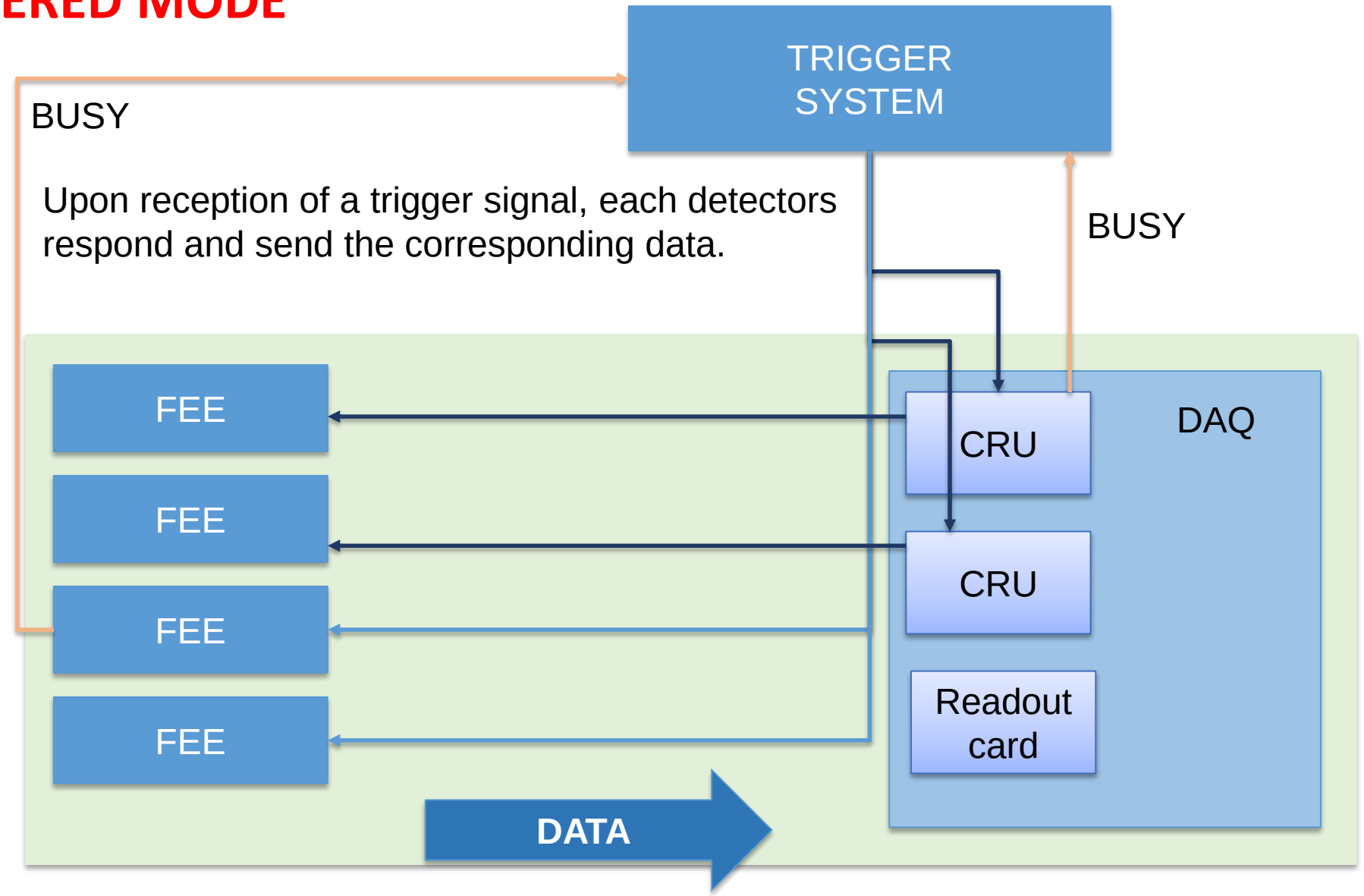
- Trigger connected to the FEE and CRU
- Triggered and Continuous readout mode
- 2 readout link, DDL and GBT



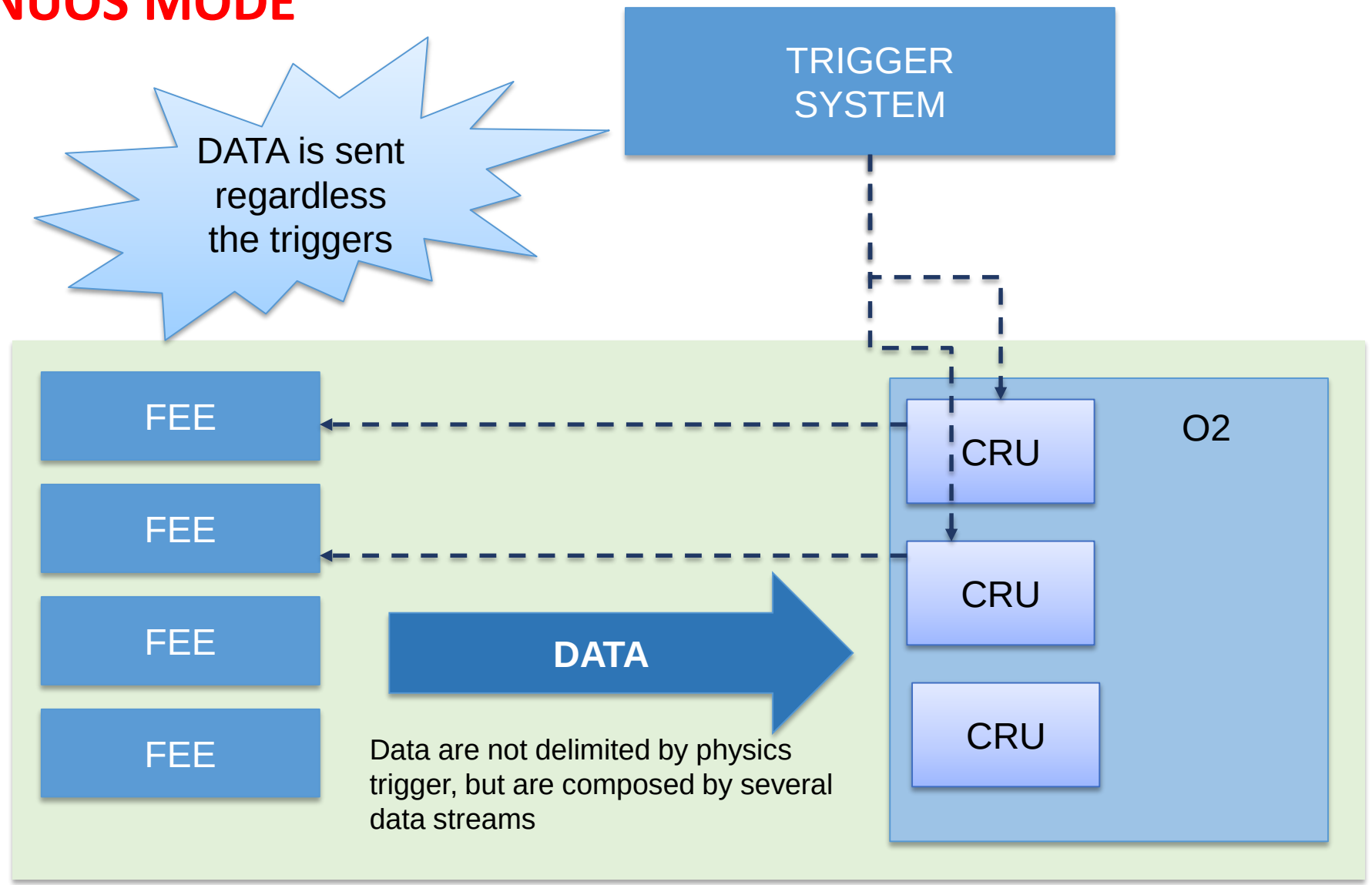
ALICE

The detector readout during RUN3

TRIGGERED MODE



CONTINUOS MODE



Heart Beat (HB)

issued in continuous &
triggered modes
to all detectors

HBF and TF rates programmable
Typical values:
- HB: 1 per orbit, 89.4 µs: ~10 kHz
- TF: 1 every ~20 ms: ~50 Hz
- → 1 TF = ~256 HBF

Continuous read-out

Heart Beat (HB)

issued in continuous & triggered modes
to all detectors

Physics trigger

can be sent to upgraded detectors
will be sent to
non-upgraded detectors

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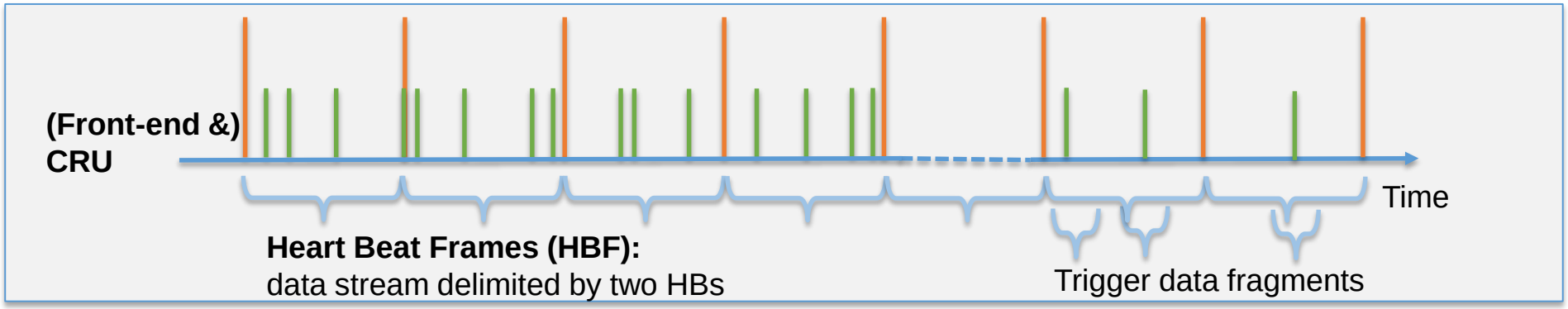
Triggered read-out



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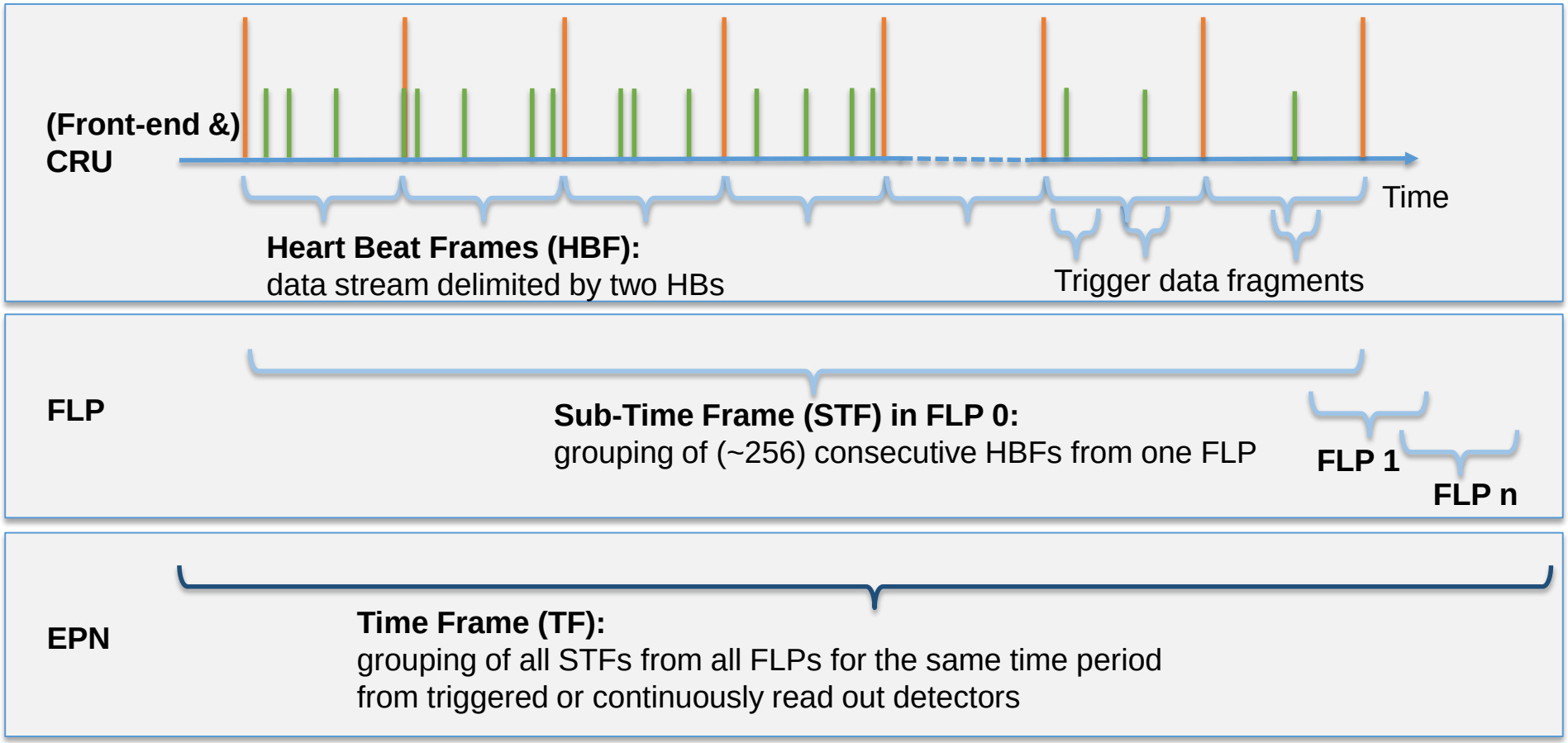
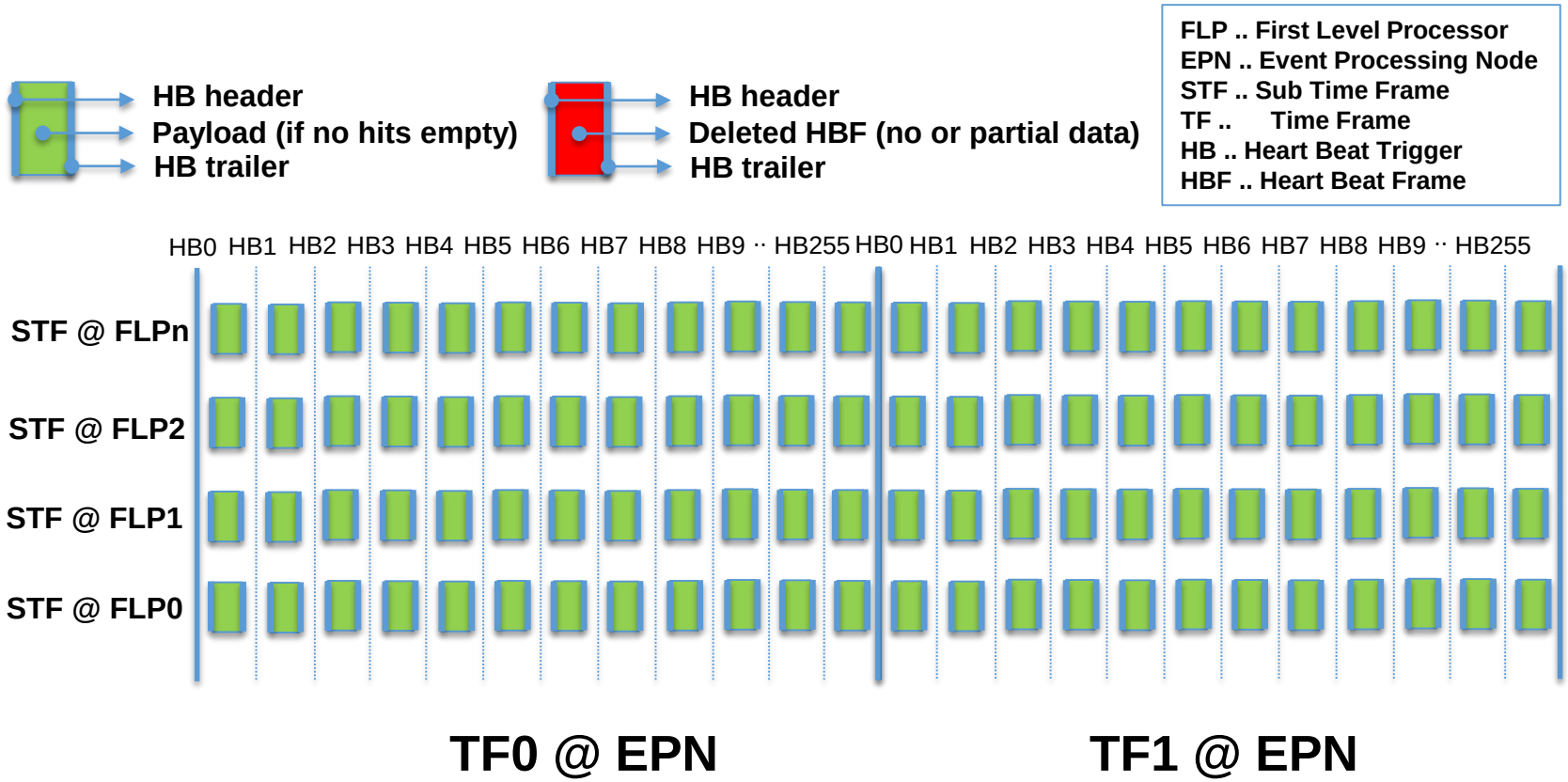
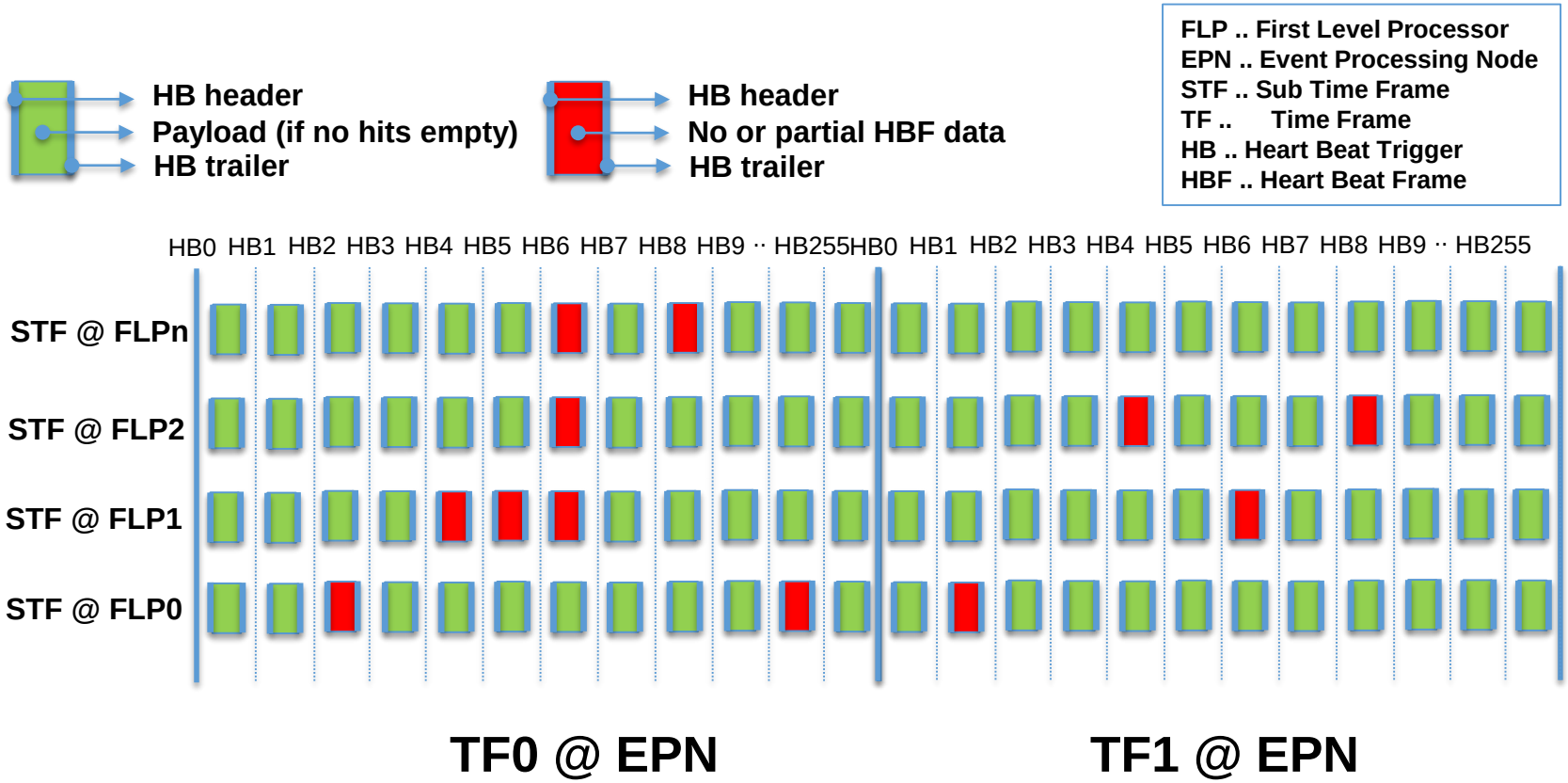
Triggered read-out



Time Frames/Heart Beat Frames



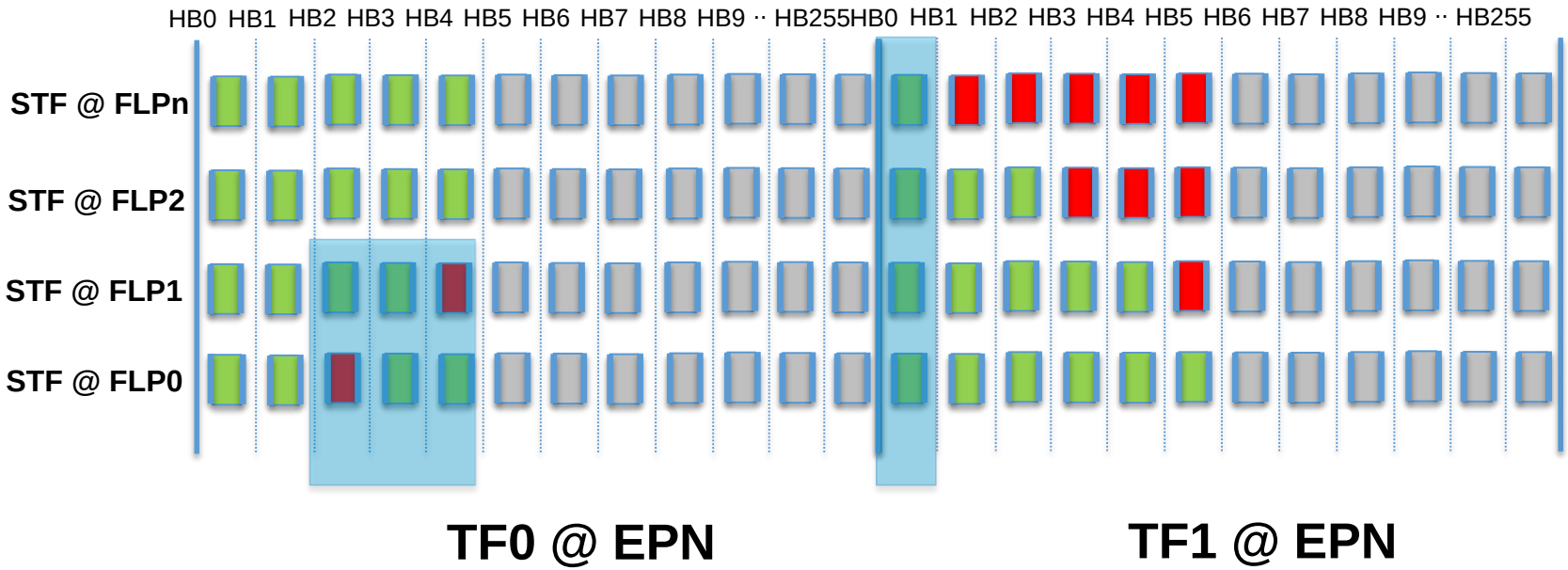
What happens if CRU buffers get full?



The main goal is to collect one complete TF or at least one or more HBFs

What happens if CRU buffers get full?

FLP .. First Level Processor
EPN .. Event Processing Node
STF .. Sub Time Frame
TF .. Time Frame
HB .. Heart Beat Trigger
HBF .. Heart Beat Frame

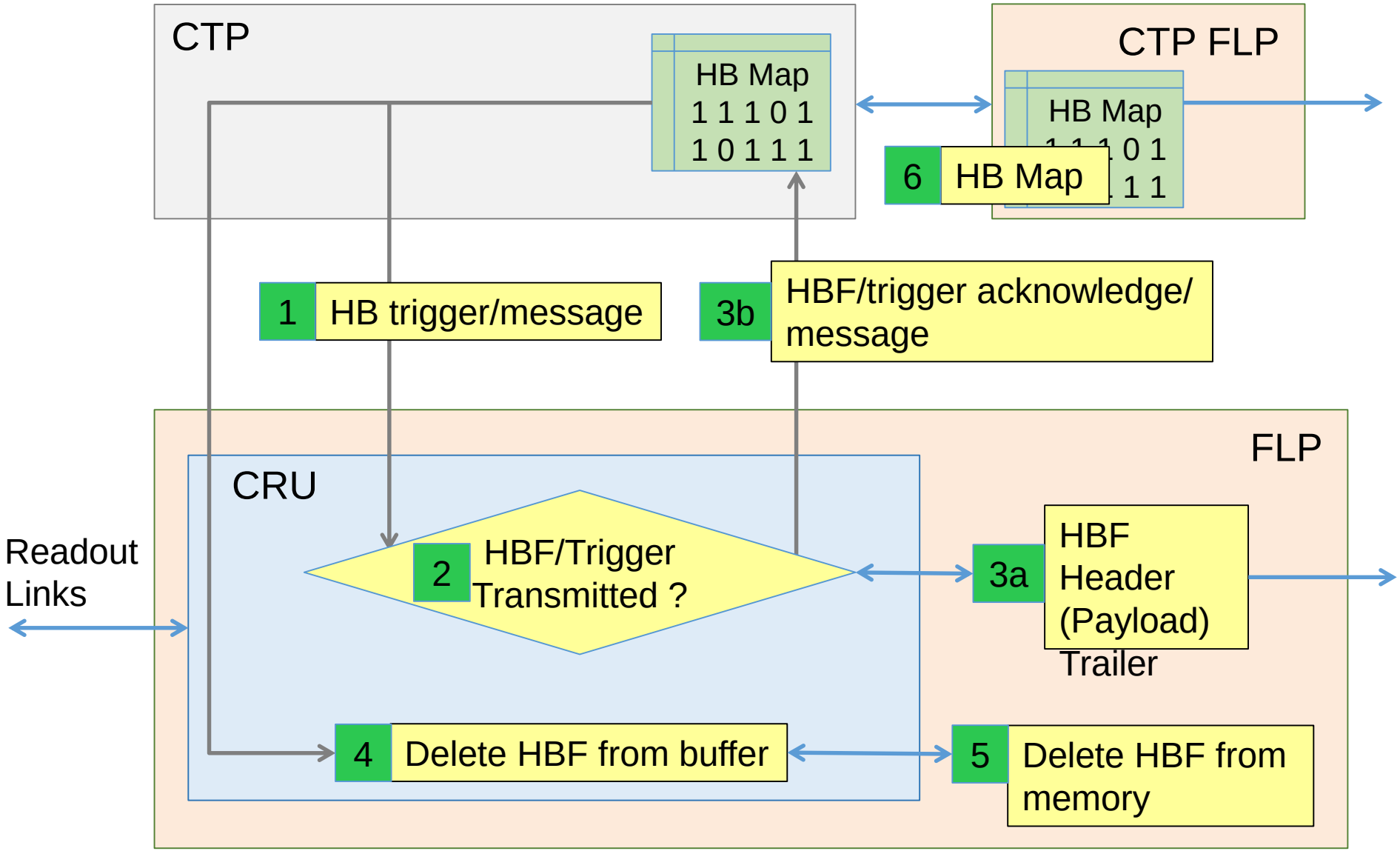


What happens if CRU buffers get full?

- CRU will autonomously abort the read-out of corresponding HBF
- Delete HBF data from buffer
- Send negative HB acknowledge to CTP
- Send negative acknowledge to FLP in the HB header/trailer pair
- Read-out continues
- Counter and state machine
  stay consistent

In nominal conditions occurrence assumed to be negligible

What happens if CRU buffers get full?



Current status of the development & RESULTS

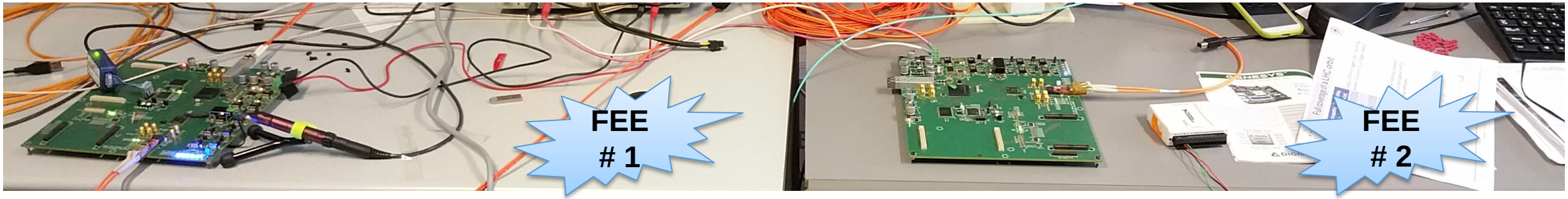
Current status

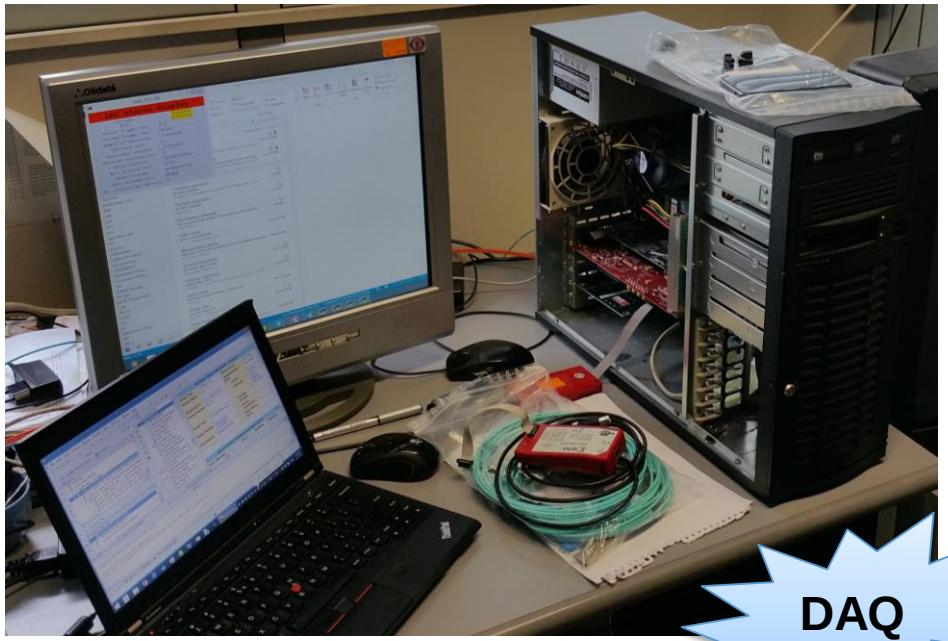
Several detectors have a readout chain using GBT to test their FEE prototype.
The readout modes are triggered and continuous

Detector	number of GBT	readout mode
TOF	2	triggered
ITS	1	triggered
FIT	1	triggered
MCH	1	triggered
MID	1	continuous
TPC	2	continuous

TOF setup

2 GBT links connected to the readout system





DAQ_TEST_SD

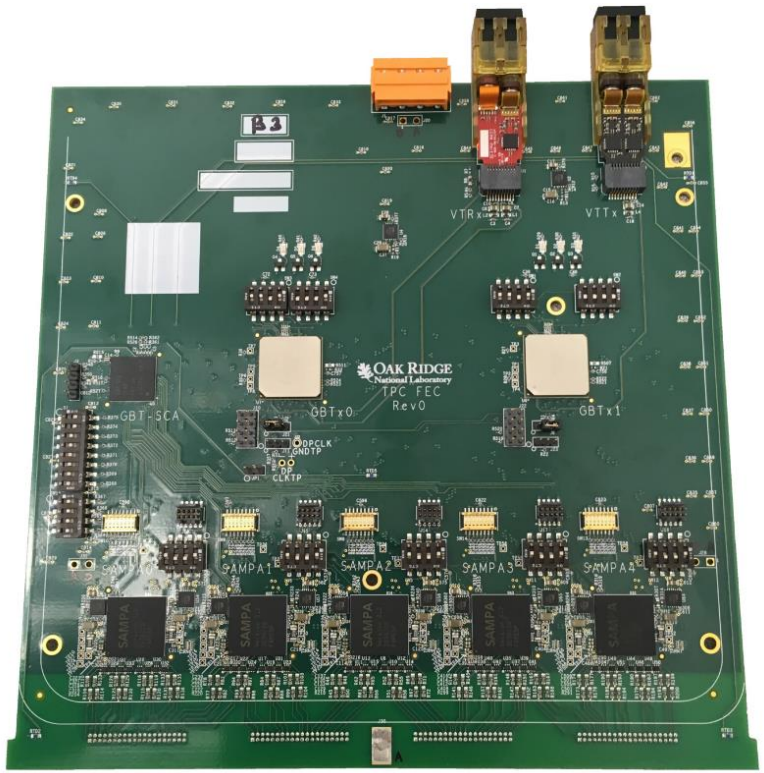
LDC status display

LDC name host	aloneldc pcdaq4
Current Trigger rate	159807.0
Average Trigger rate	151596.4
Number of sub-events	18191564
Sub-event rate	159805
Sub-events recorded	18191566
Sub-event recorded rate	159807
Bytes injected	79242452944
Byte injected rate	696.113 MB/s
Bytes recorded	79242452944
Byte recorded rate	696.122 MB/s
Nb. evts w/o HLT decision	0

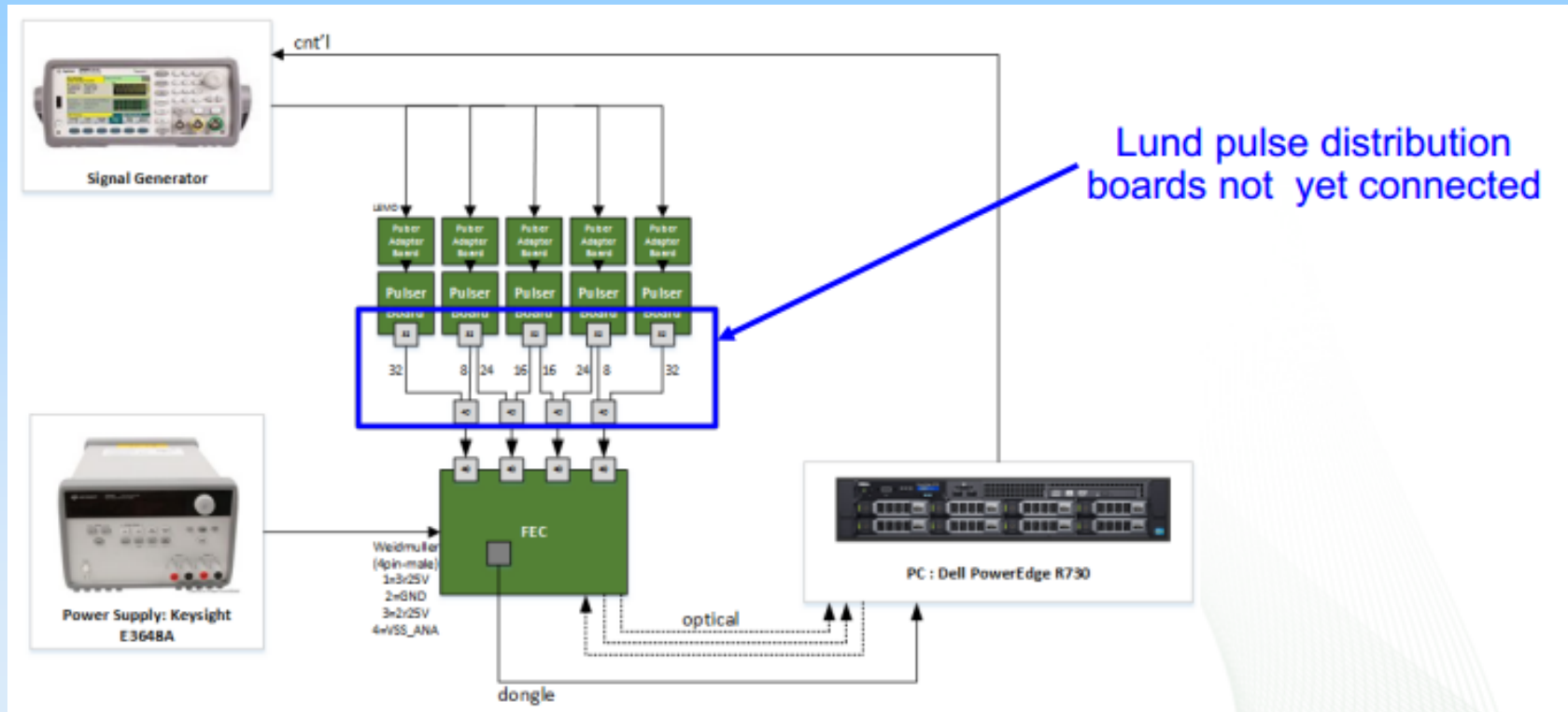
→ 160 kHz

→ 700 MB/s

TPC setup



Readout system used to collect data in continuous mode and to configure the FEE electronics using the GBT protocol



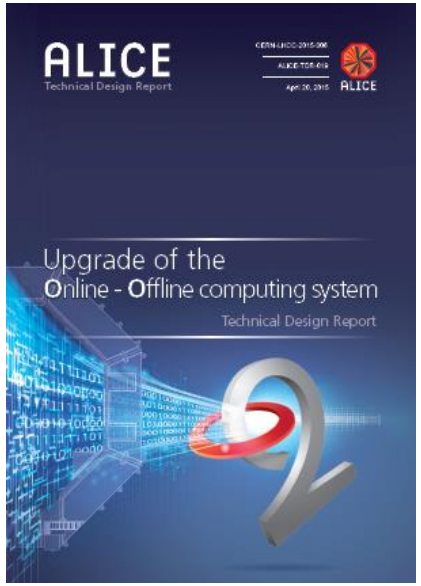
QUESTIONS?

ALICE

THANK YOU

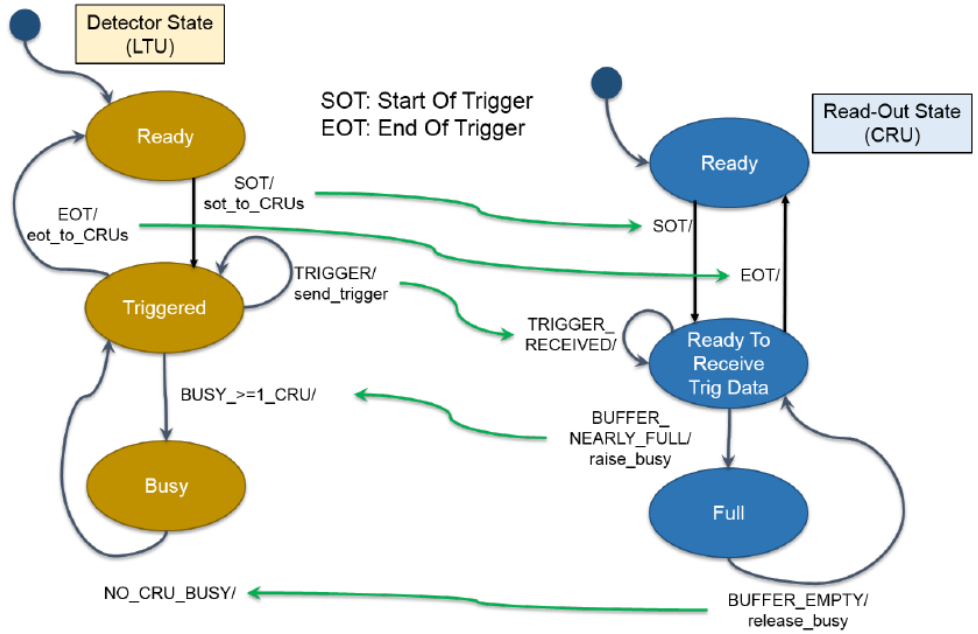
Schedule

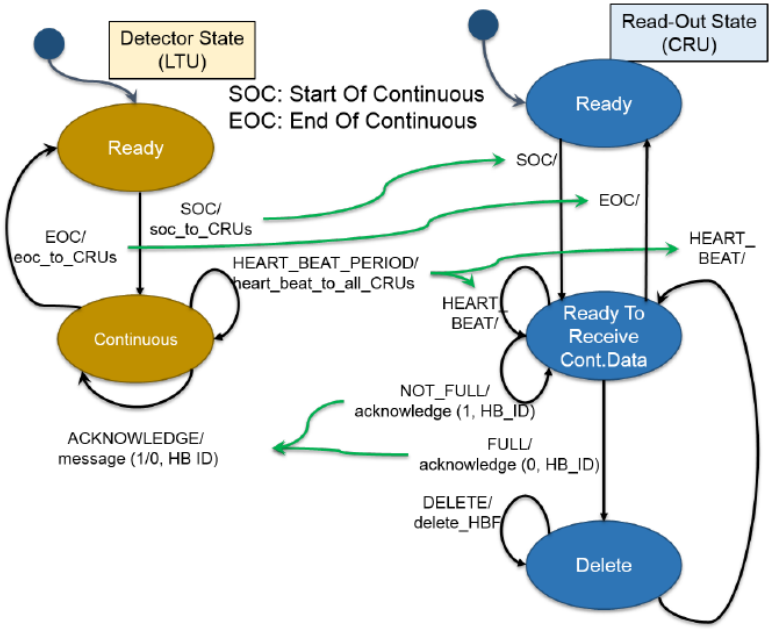
2012-2013	2014-2015	2016-2017	2018-2019	2020-2021
High-Level Design R&D Project organization	Design R&D Demonstrators TDR Products selection	Detailed design R&D Prototyping Development Products selection Prototypes	Detailed design R&D Prototyping Development Products selection Prototypes Final components Deployment Commissioning	Development Products selection Final components Deployment Commissioning Production



https://cds.cern.ch/record/2011297/files/ALICE-TDR-019.pdf

Busy, throttle schema





Active Data Streams	
GBT to CRU	CRU to FLP
0	0
1	1
1	0