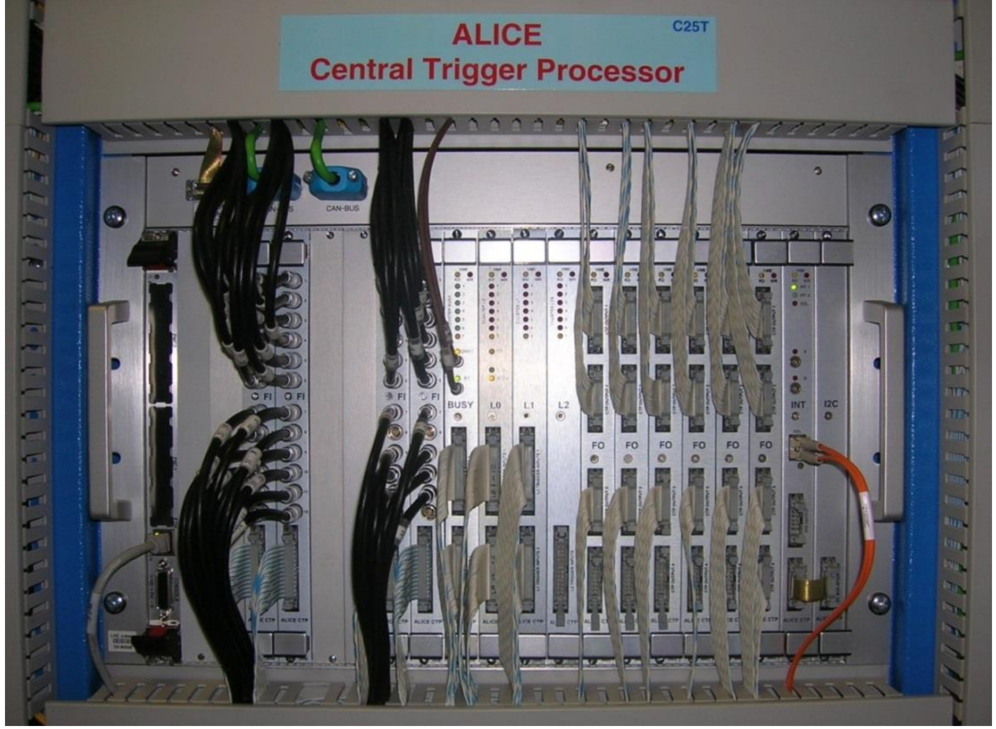


ALICE Trigger Upgrade

M Krivda for CTP group

The University of Birmingham

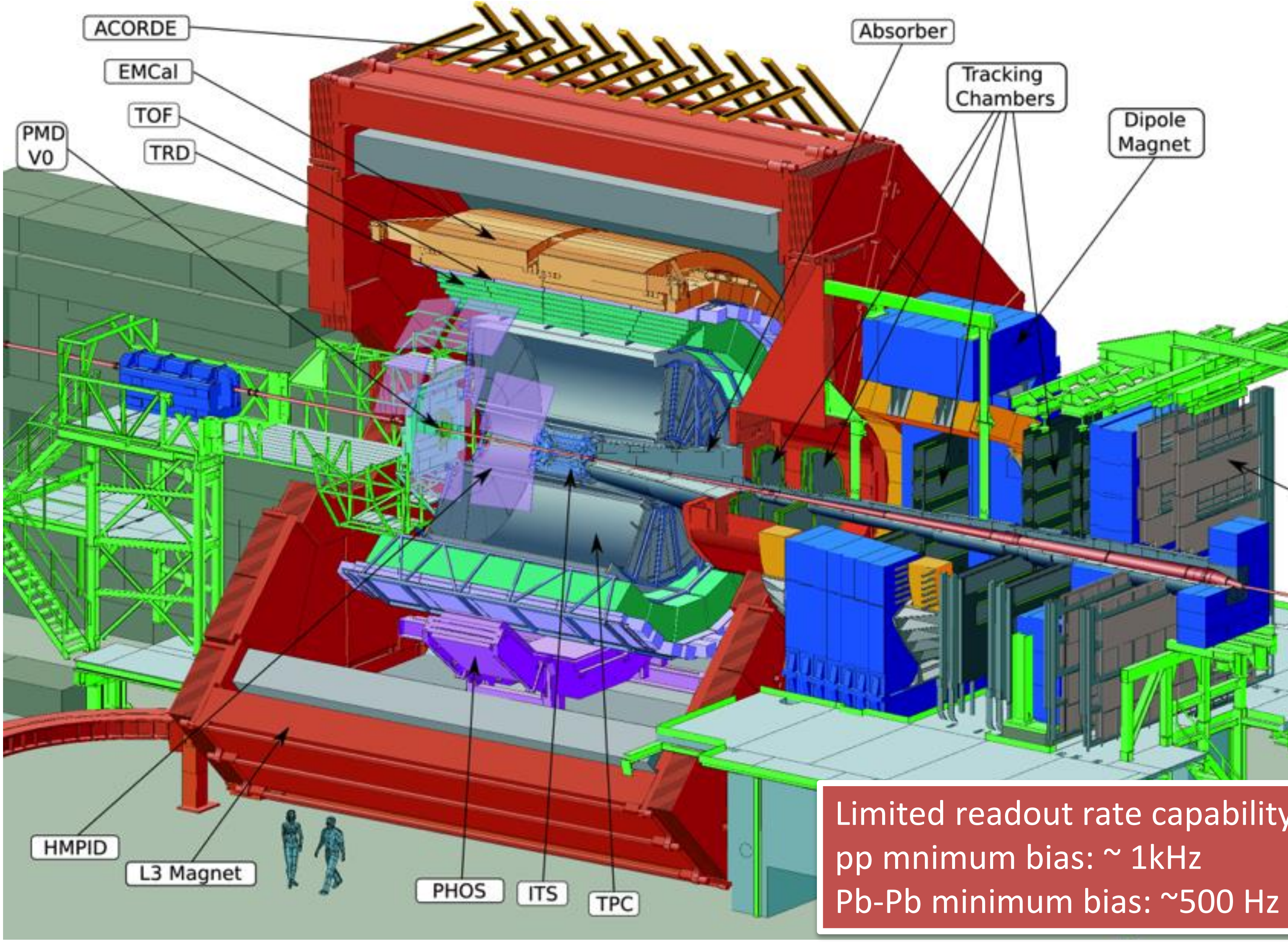
Workshop

CERN

Content

- ALICE after LS2
- Trigger requirements
- Trigger architecture
- Implementation
- Summary

Current ALICE



Limited readout rate capability
pp mnimum bias: ~ 1kHz
Pb-Pb minimum bias: ~500 Hz

ALICE upgrade after LS2

- Target Luminosity:
  - Pb-Pb recorded luminosity ≥ 10 nb^{-1} (50 khz)
  - pp (@5.5 Tev) recorded luminosity ≥ 6 pb^{-1} (200kHz)
  - Minimum bias physics : gain a factor **100**
  - Triggered physics: gain a factor **10**
- **Upgrade the ALICE readout systems (TPC, muons)**
- **Upgrade online systems (CTP, DAQ)**
- Improve vertexing and tracking at low p_T ⇨NEW ITS

Technical Design Report

ALICE trigger challenges

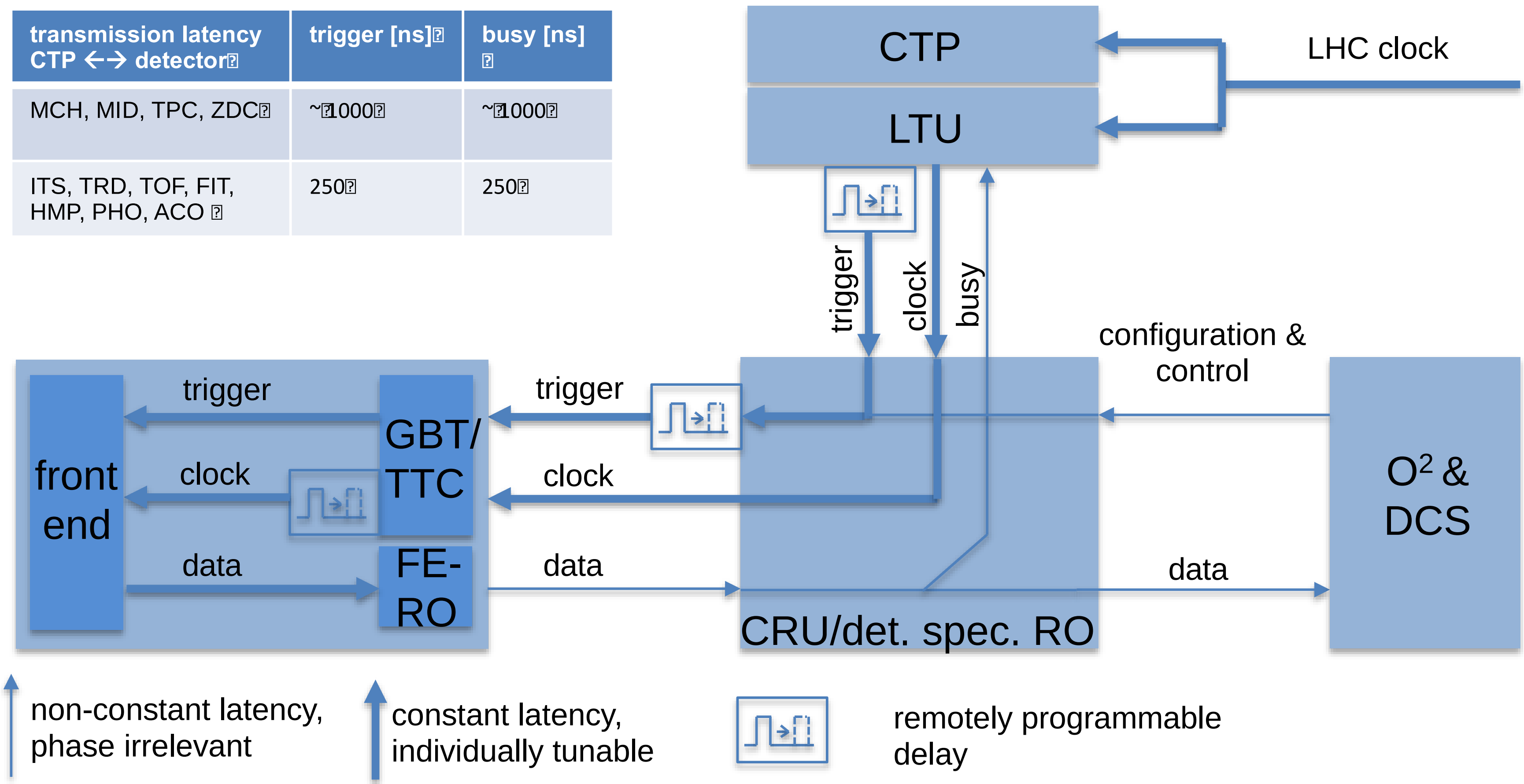
- Select different physics
  - Different triggering detectors
- Optimise for different running scenarios – pp, pA, AA – with different interaction rates
- Optimise use of detectors with
  - Continuous readout
  - Widely different busy times
  - Different latency times
  - Different technologies (TTC and GBT)
- Special triggers (calibration, control, debugging)

Trigger Architecture I

- One level synchronous trigger followed by message
- Trigger latency optimised for every detector
- Grouping of readout detectors possible
- Trigger generation and distribution:
  - Central Trigger Processor (CTP) :
    - receives signals from triggering detectors, makes decision and send triggers via LTU to detectors
    - Generates software/calibration triggers
  - Local Trigger Unit (LTU):
    - Interface between CTP and detector
    - Generates TTC or GBT triggers
    - Emulates CTP for development and debugging of detectors
  - Common Readout Unit (CRU): interface between On Detector electronics, DAQ and CTP

Trigger architecture II

transmission latency CTP <-> detector	trigger [ns]	busy [ns]
MCH, MID, TPC, ZDC	~1000	~1000
ITS, TRD, TOF, FIT, HMP, PHO, ACO	250	250



Transmission latency depends on the location of CRU

Triggering detectors

Level	Trigger Input to CTP [ns]	Trigger output at CTP [ns]	Trigger decision at detector * [ns]	contributing detectors
LM	425	525	775	FIT
L0	1200	1300	1500	ACO, EMC, PHO, TOF, ZDC
L1	#6100	#6200	#6400	EMC, ZDC

- ~ 8 triggering detectors
- Three different latencies (levels)

Readout Parameters

Det	triggered by () = optional	design RO rate [kHz]	busy [%]	TTS GBT/TTC	CRU used
TPC	(L0 or L1)	50	0	GBT	y
MCH	(L0 or L1)	100	0	GBT	y
ITS	L0	100	0	GBT	*y
MID	L0 or L1	>100	0	GBT	y
ZDC	L0	>100	0	GBT	y
TOF	L0 or L1	100	0	GBT	n
FIT	L0 or L1	100	0	GBT	n
ACO	L0 or L1	100	0	TTC	n
TRD	LM&(L0 or L1)	50	25	GBT&TTC	y
EMC	#L0&L1	46	100	TTC	n
PHO	#L0&L1	46	100	TTC	n
HMP	#L0&L1	2.5	100	TTC	n

- Mixture of
  - busyless and busy detectors
  - TTC and GBT trigger distribution

BUSY handling

- Busy for upgraded detectors
  - status signal
  - detectors might receive triggers, even though they might not be ready to process them
  - in that case,
    - detectors need to send acknowledge of trigger with information that no data will be sent
- Busy for non upgraded detectors
  - Busy propagated with minimal latency, e.g. by electric cable
  - CTP covers busy propagation from FE to CTP

Software triggers

- Heartbeat trigger:
  - Specific trigger issued by CTP at appropriate ORBIT/BC
  - Reduces trigger data bandwidth
  - Carrying commands and specific synchronization information
  - Used by detectors – create "heartbeat events" sent via output links
  - Used by processing nodes – data segmentation, fault finding, recovery procedures, ...
- Calibration triggers
- Control triggers (Start of Data, End of Data)

Hardware options

- Advanced Telecommunications Computing Architecture (ATCA)
  - off the shelf
  - modification of existing board
- Custom boards
  - VME based (continuation of run2 trigger design)

ATCA CTP example

- ATCA crate with 3 TELL40 boards
  - Board 1:
    - AMC CTP
    - AMC LHC interface
    - AMC TFC (Time and Fast Control)
    - AMC TTC (LTU: Trigger to Detectors)
  - Board 2:
    - 4 x AMC (LTU: Triggers to Detectors)
  - Board 3:
    - 4 x AMC (LTU: Triggers to Detectors)

ATCA CTP example: latency

- 1.5 BC synchronisation of trigger inputs
- 2 BC trigger decision/formatting data
- 140 ns serialisation/de-serialisation over backplane
- 1 BC for LTU
- 166 ns for GBT downstream delay
- TOTAL: ~ 420 ns + cable

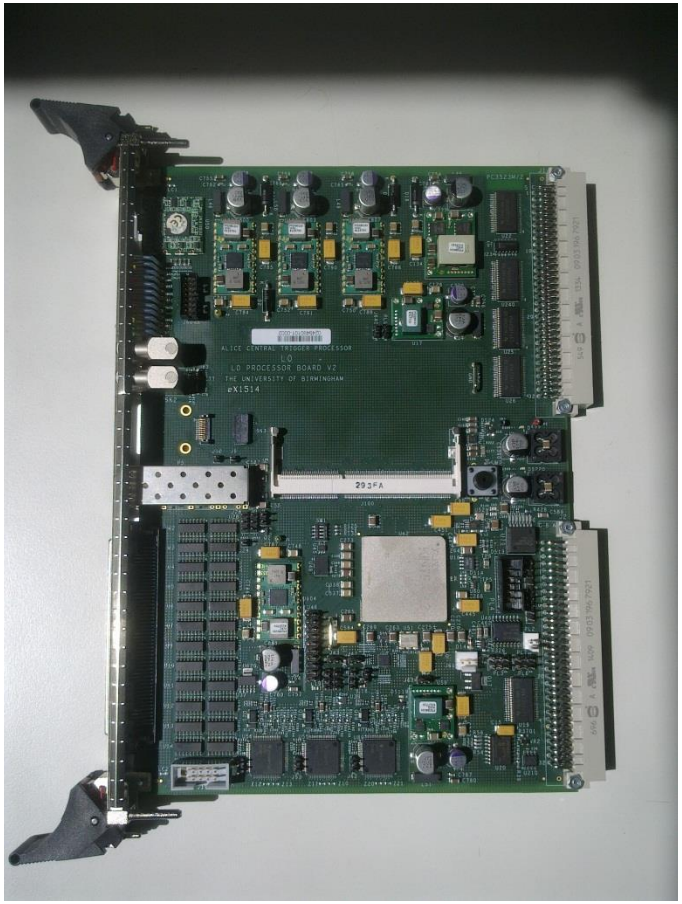
ATCA off the shelf

- ATCA off shelf boards
  - TELL40 + AMC40
  - Custom mezzanine for electrical trigger inputs
  - Mezzanine for TTC interface
  - Problem with achieving low latency
    - Estimated latency over backplane ~ 140 ns (3.2 Gb/sec)
    - 10 G links not available at current version of TELL40
  - Magnetic field ~ 10 mTesla – discussion ongoing
  - Radiation – Total Ionisation Dose ~ $5x10^{-3}$ krad

Custom boards: VME

- Continuation of Run2 electronics
- VME:
  - Mechanical support
  - Power supply
- Board communication

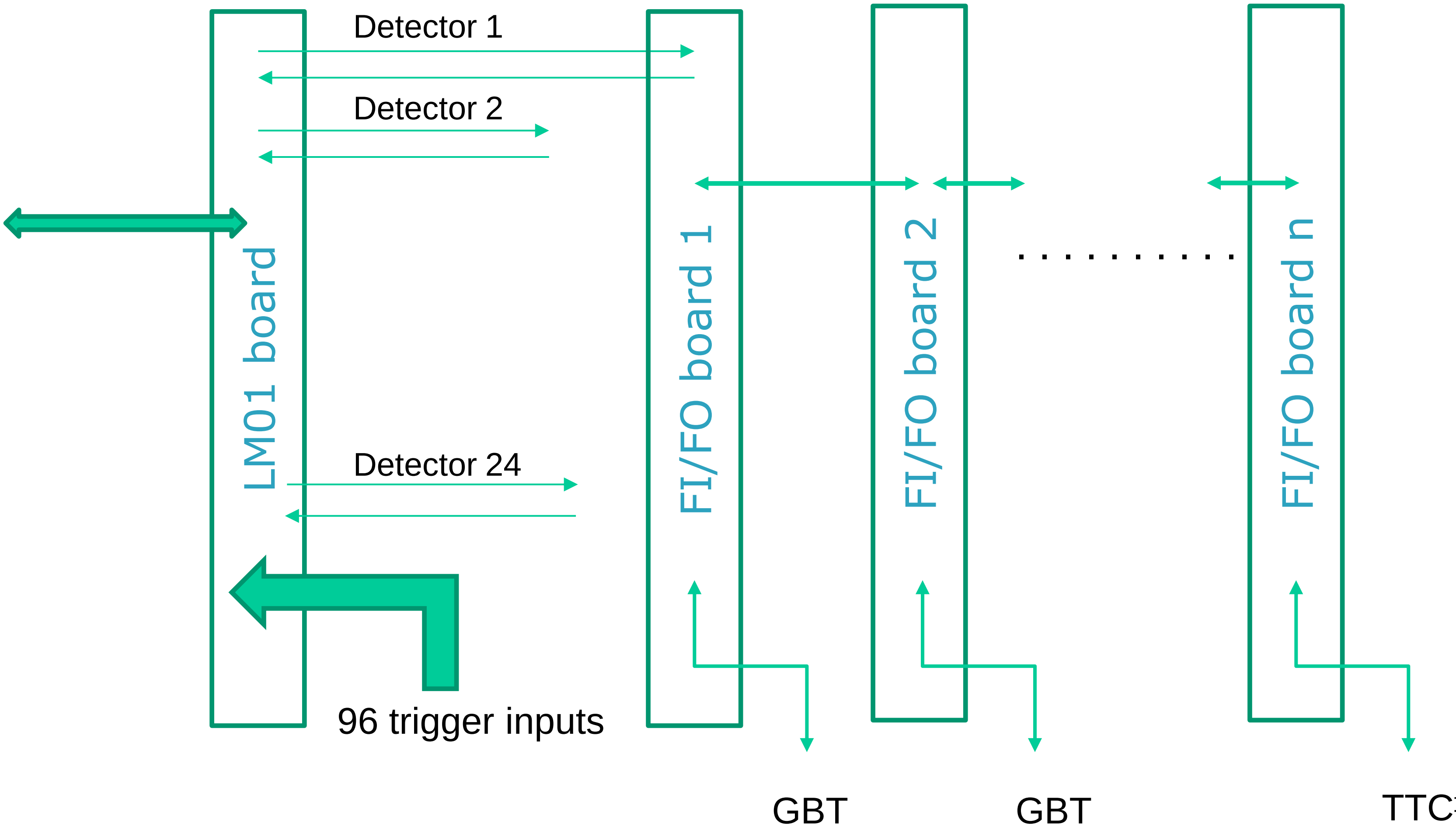
via fast links



Distribution of trigger signals

Custom protocol
Electrical or optical
transmission

Daisy – chain of FI/FO boards in case that more than one FI/FO board is necessary



Summary

- Major upgrade of ALICE detector, for installation in 2018/19, to cope with Pb-Pb collisions at high rates
- CTP:
  - Minimum bias trigger
  - High pt calorimeter triggers
  - Special triggers (Calibration, control, debugging)
- Several options for implementation considered: decision to be taken at beginning of 2015

BACK UP

Future Plans

- **2013-2014 – Long Shutdown 1 (LS1)**
  - Completion of detector (TRD, Calorimeters)
  - CTP upgrade (see Marian Krivda's talk tomorrow)
- **2015-2017**
  - 10 x increase in statistics in Pb-Pb at $\sqrt{s}$ =5.5 TeV, i.e $\approx$ 1nb^{-1} to be collected
- **2018 ALICE upgrade – Long Shutdown 2 (LS2)**
  - **High precision measurements of rare probes at low p_T :**
    - **Increase rate capability – continuous readout and new online systems** **(for CTP see MK talk tomorrow)**
    - **Improve vertexing and low p_T tracking – new silicon vertex tracker**
- **2019-2021 (Ar-Ar,p-Pb,Pb-Pb)**
  - 10nb^{-1}

Alice Running Conditions

- Pb-Pb:
  - luminosity: $\geq 10\ nb^{-1}$, 50kHz (i.e. $L = 6x10^{27}\ cm^{-1}s^{-1}$)
- pp:
  - Luminosity: $\geq 6\ pb^{-1}$

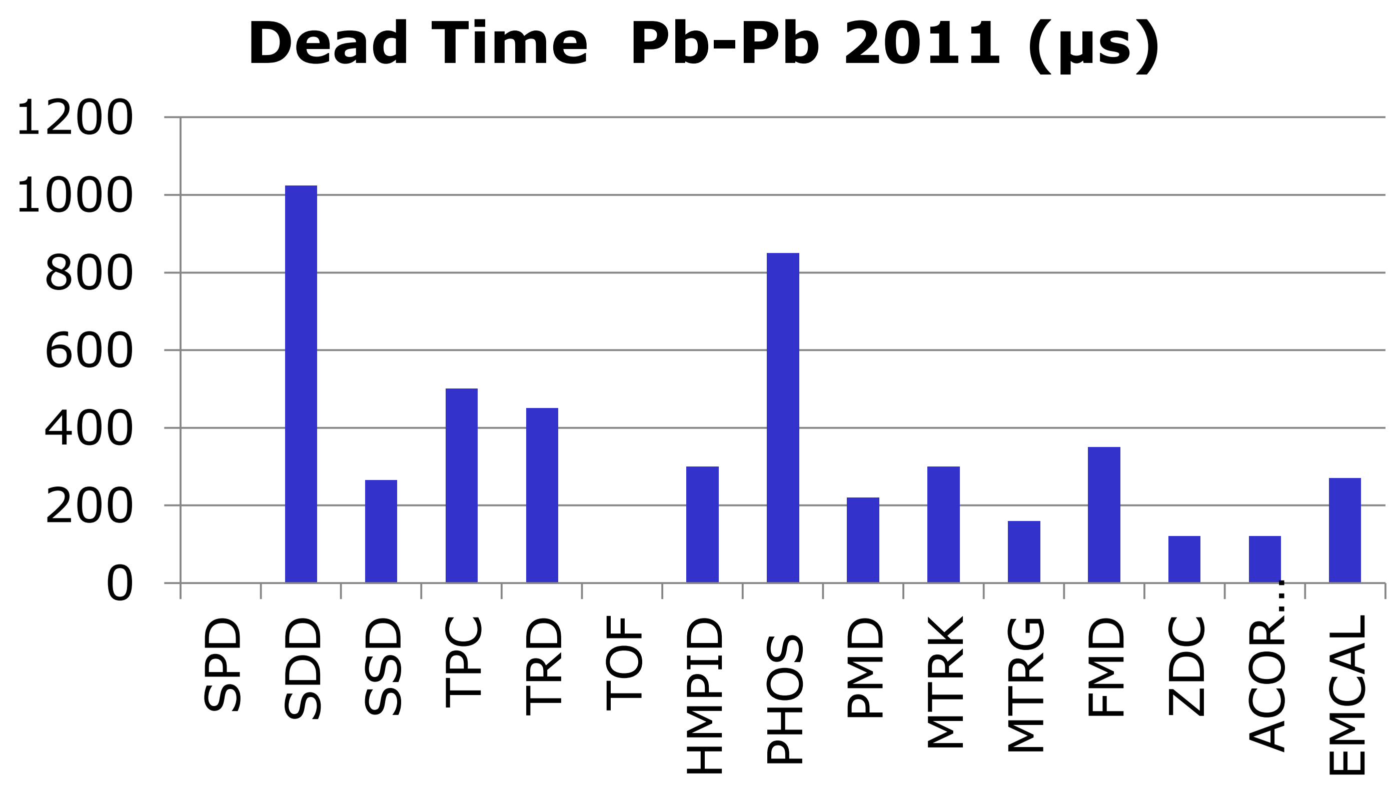
ALICE focus after LS2

Precision measurement of the QGP parameters at $\mu_b = 0$ to fully exploit scientific potential of the LHC – unique in:

- large cross sections for hard probes
- high initial temperature

- Main physics topics, uniquely accessible with the ALICE detector:
  - measurement of heavy-flavour transport parameters:
    - study of QGP properties via transport coefficients (η/s, $\hat{q}$)
  - measurement of low-mass and low-p_T di-leptons
    - study of chiral symmetry restoration
    - space-time evolution and equation of state of the QGP
  - J/ψ , ψ', and χ_c states down to zero p_T in wide rapidity range
    - statistical hadronization versus dissociation/recombination

Detector Dead Time

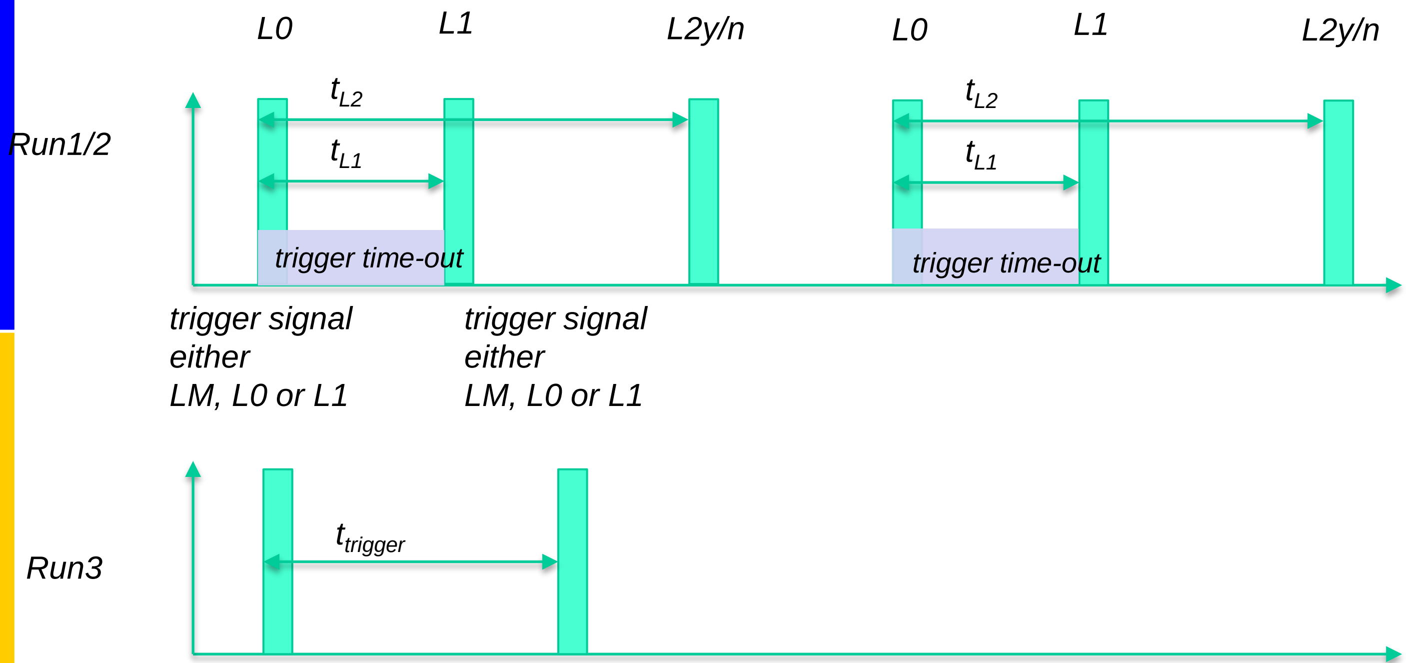


Detector Dead Time: average time of BUSY after valid trigger.

Dead Time depends on:

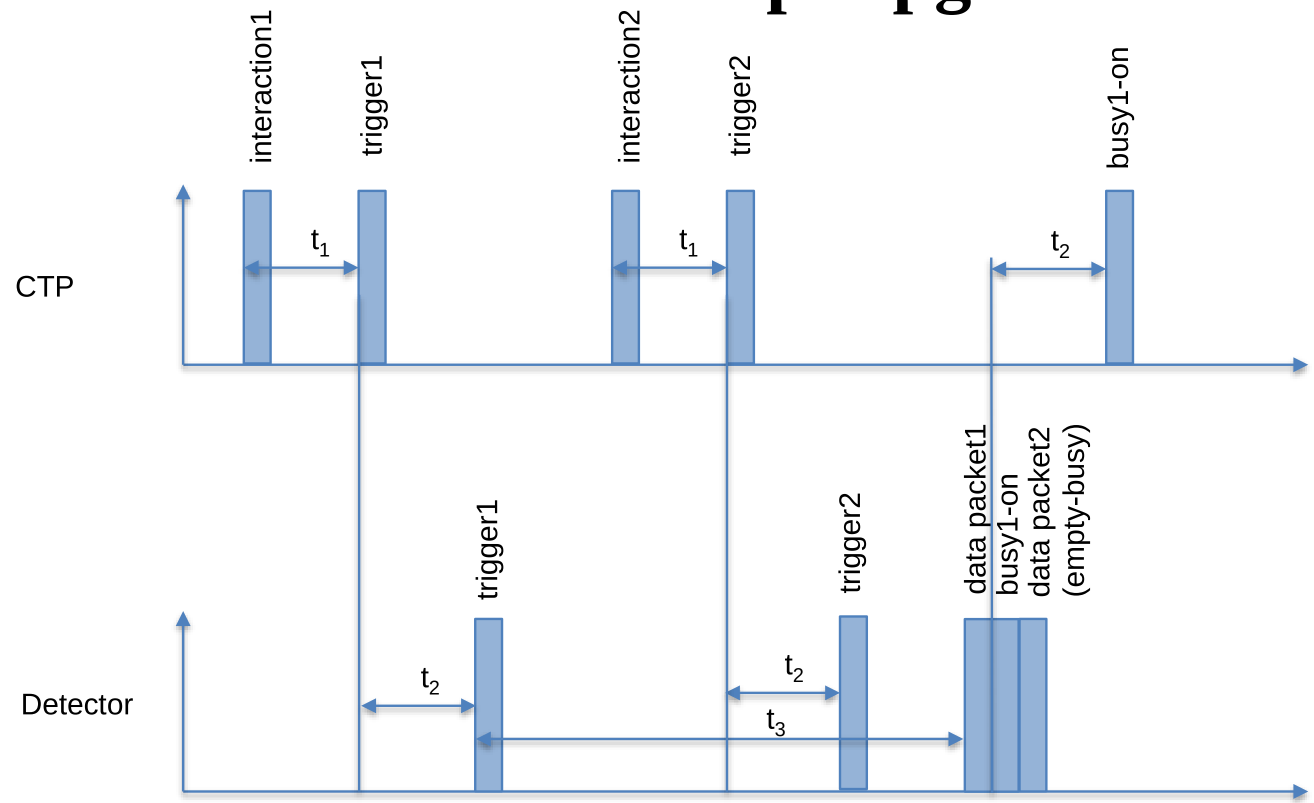
- Readout time
- Multi-event buffer

Trigger signals run1/2 & run3



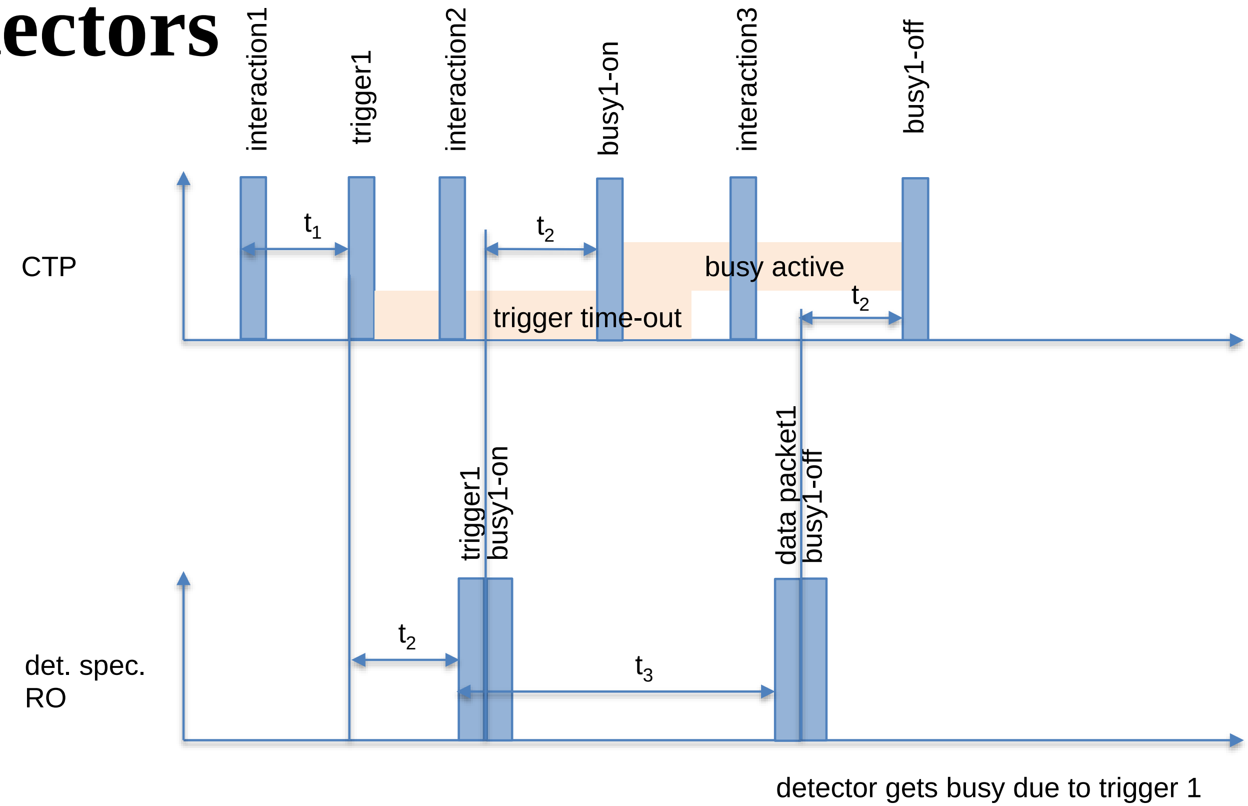
Signal	Note	Explanation
run1/2 t_{L1}	Time between L0 and L1, in practice serves as trigger time-out	No L0 is allowed before L1, busy needs to arrive within t_{L1} (~6 µs) at CTP
run3 $t_{trigger}$	Time between two successive triggers, in principle 25 ns, time for busy transmission to CTP too short	if busy needs to be taken into account (not upgraded detectors), CTP needs to implement additional dead time → decreases read-out efficiency

Run3 read-out control loop: upgraded detectors



Signal	Note	Latency
t_1	Time between interaction and CTP trigger output	not relevant for control loop constant latency programmable between 775 to 6400 ns
t_2	Propagation of trigger/busy between detector and CTP	for trigger: constant latency ~ 1 µs
t_3	Read-out time	busy is extracted from data stream: > 1 µs

Run3 read-out control loop: not-upgraded detectors



Signal	Note	Latency
t_1	Time between interaction and CTP trigger output	not relevant for control loop constant latency programmable between 775 to 6400 ns
t_2	Propagation of trigger/busy between det. spec. RO and CTP incl. processing	250 ns
t_3	Read-out time	non-constant, detector specific, i.e. TRD: ~6 µs, EMC/PHO: ~19 µs