ALICE Trigger in Run1/Run2

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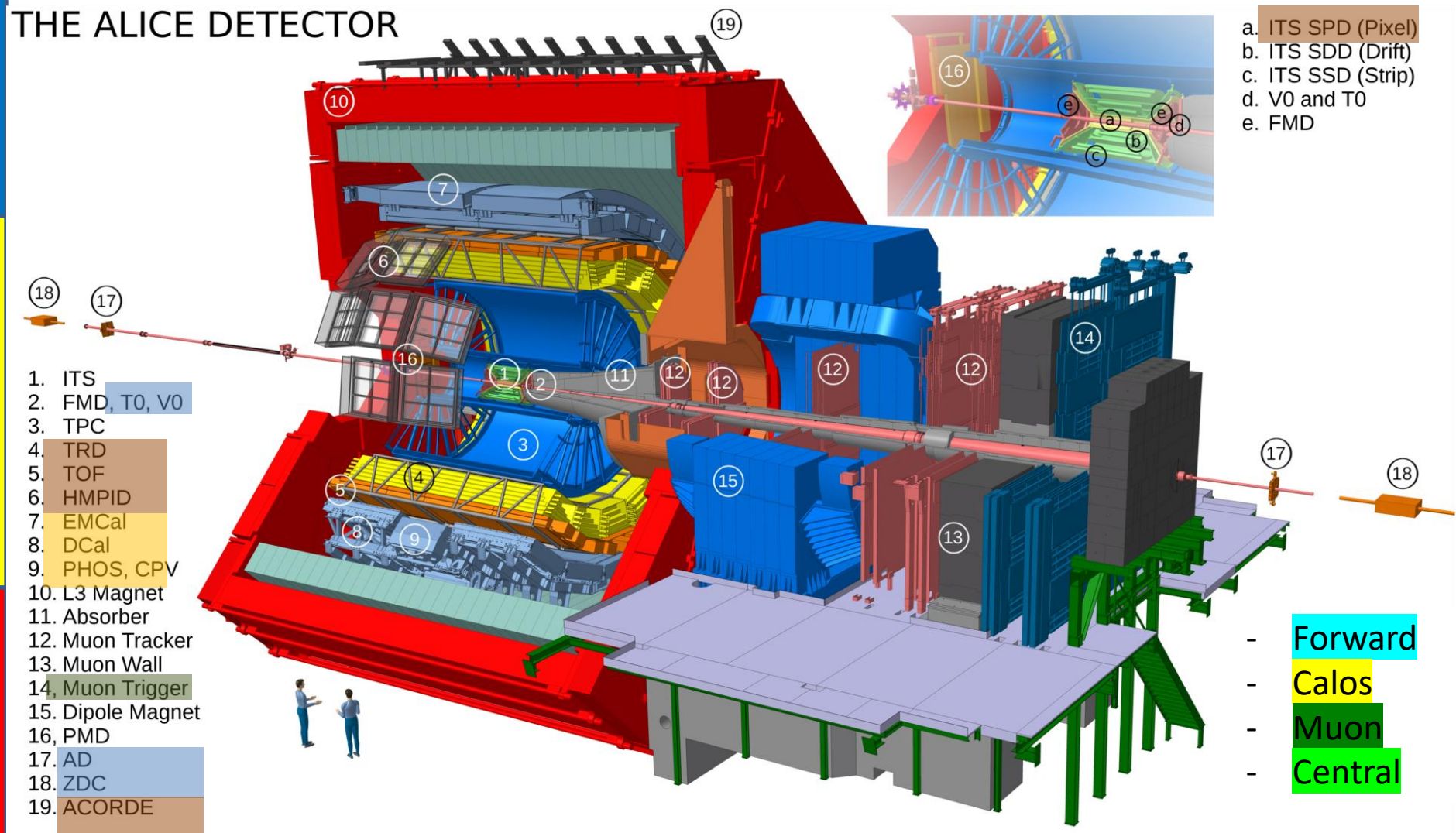
- ALICE detector
- ALICE trigger challenges
- ALICE trigger system hardware
- Main triggers
- Summary

ALICE Triggering Detectors



ALICE Trigger Challenges

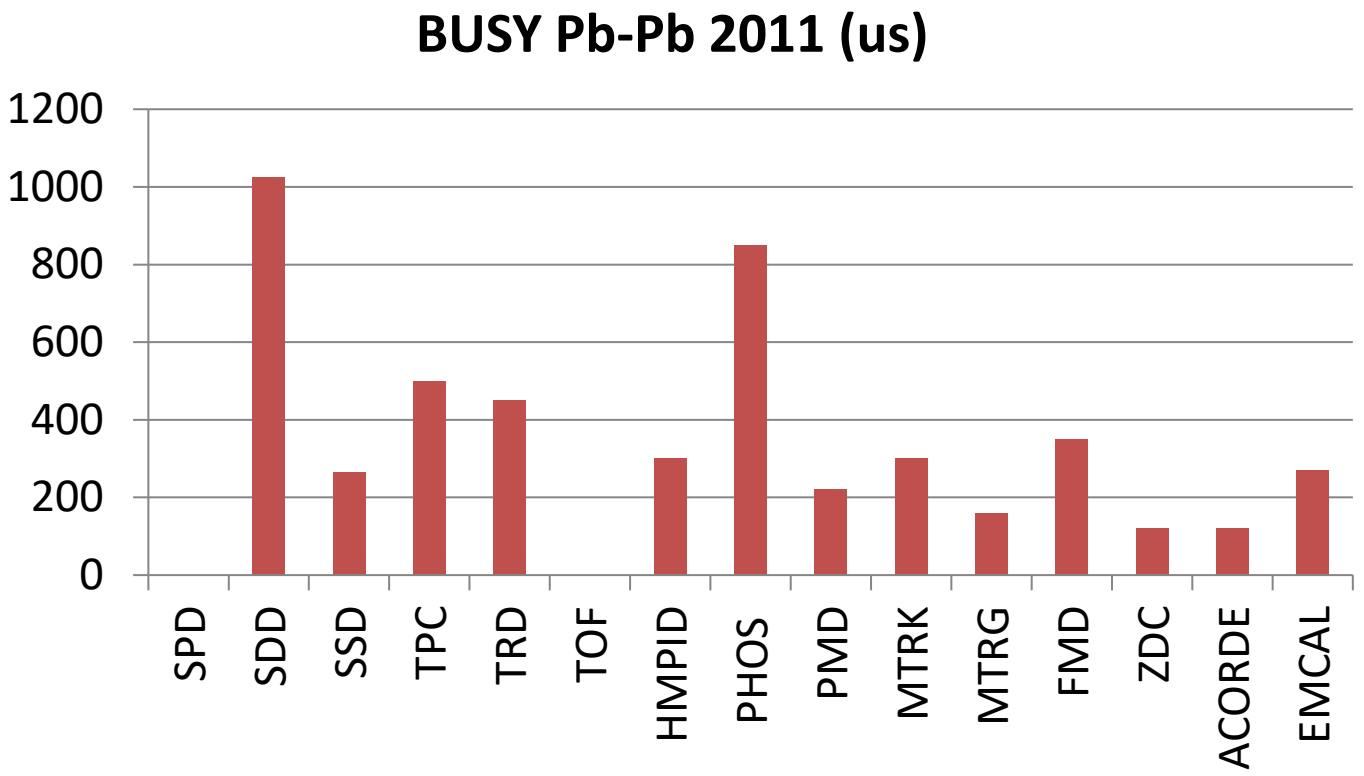
- **Select different physics**
  - Different triggering detectors
- **Optimise rates according to physics requirements**
  - Downscaling
- **Optimise use of detectors with widely different busy times** (generally no pipelining)
  - Detector grouping – trigger clusters
- **Different latency requirements**
  - 3 trigger levels
- **Optimise for different running scenarios**
  - pp, pA, AA – with different interaction rates
  - Interaction record and past-future protection

Selecting Different Physics

- Minimum bias and Centrality: **V0,T0,SPD,TOF**
  - Global variables (identified particle spectra , HBT, flow, nuclear modification factors)
- Jets: **EMCAL,PHOS**
  - Jets in medium (quenching, fragmentation)
- Photons/electrons: **EMCAL,PHOS,TRD**
  - π^0, η, charm, beauty, quarkonia
- Muons: **Muon Arm**
  - Charm, beauty, quarkonia
  - Weakly interacting probes (W,Z)
- Ultra peripheral: **V0,ZDC,SPD, AD**
  - QED lepton pair production, elmag dissociation, photonuclear reactions

Central Trigger Processor(CTP) tool: Trigger Class

Detector Busy Time



Widely different BUSY times => Group similar detectors

CTP tool: Trigger Cluster

Trigger Levels (Latencies)

Different detectors have different latency requirements:

- L0
  - received by detectors 1.2 μs after interaction (generation, propagation and CTP decision)
  - 24 inputs
- L1
  - 6.5 μs after L0
  - 24 inputs
- L2
  - 105.2 μs after L0
  - 12 inputs

ALICE Running Conditions

	pp	p-Pb	Pb-Pb
$<L>$ cm^{-2} s^{-1}	$< 1x\ 10^{31}$	$(1\text{-}2)x10^{26}$	$10^{(25\text{-}27)}$
σ_{inel} [mb]	~ 70	2500	8000
Rate [Hz]	1×10^{6}	$(2\text{-}4)x10^{5}$	$10^{2\text{-}4}$
dN/dy	4	17	1600

Pb-Pb:

- Modest luminosity rates
- Large event size
- Negligible pile-up

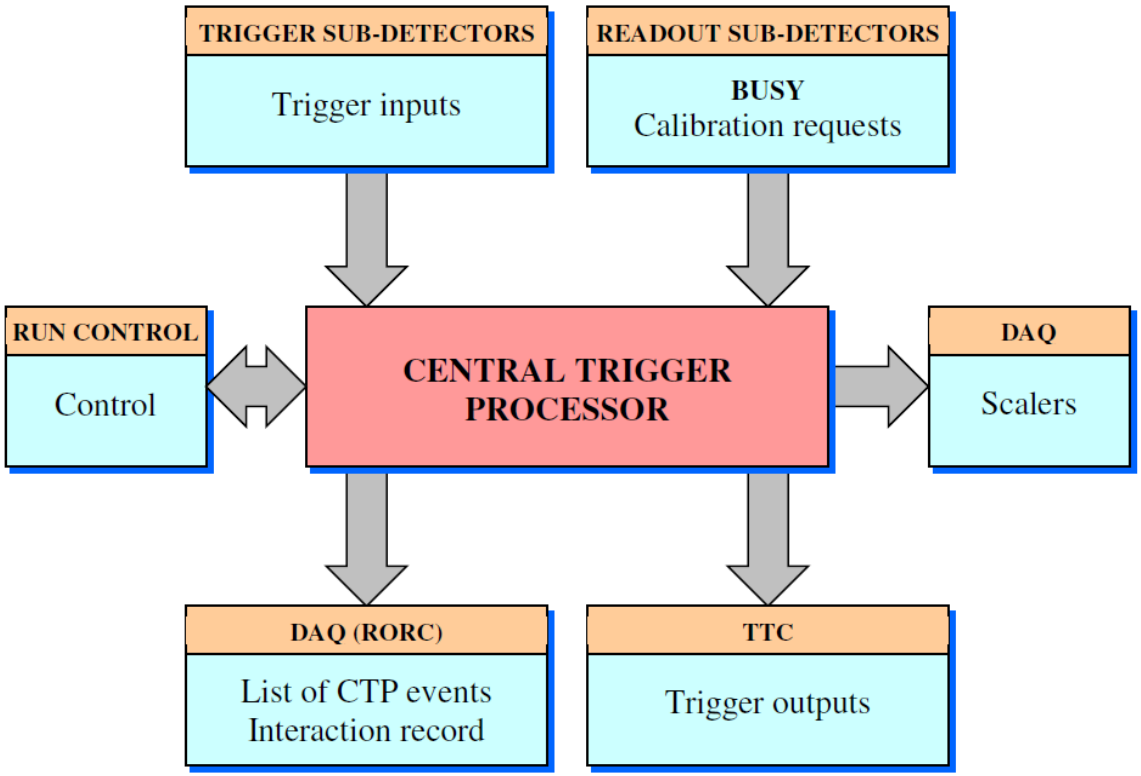
pp:

- high luminosity rates
- smaller event size
- pile-up

Two order of magnitude difference in any variable.

CTP tools: Interaction Record and Past-Future protection

Central Trigger Processor Context



Trigger Class

Trigger Conditions:

- Logical combination of trigger inputs
- BC mask: Usually corresponds to LHC filling scheme
- Internal trigger

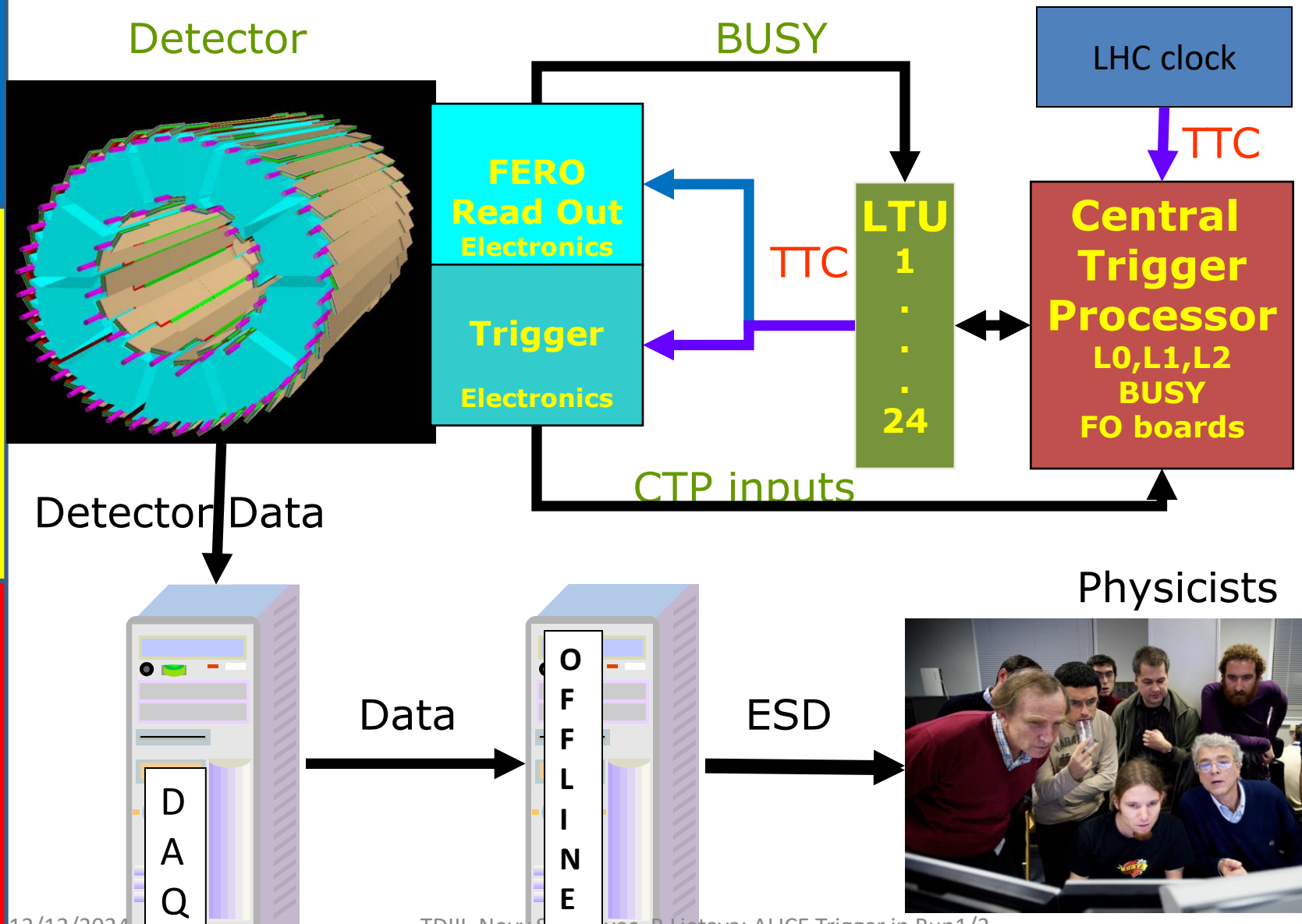
Trigger Cluster: Group of detectors to be readout

Trigger Vetoes:

- Cluster BUSY
- Downscaling
- Past-Future Protection

Trigger Class = Trigger Condition + Trigger Cluster + Trigger Vetoes

Central Trigger System

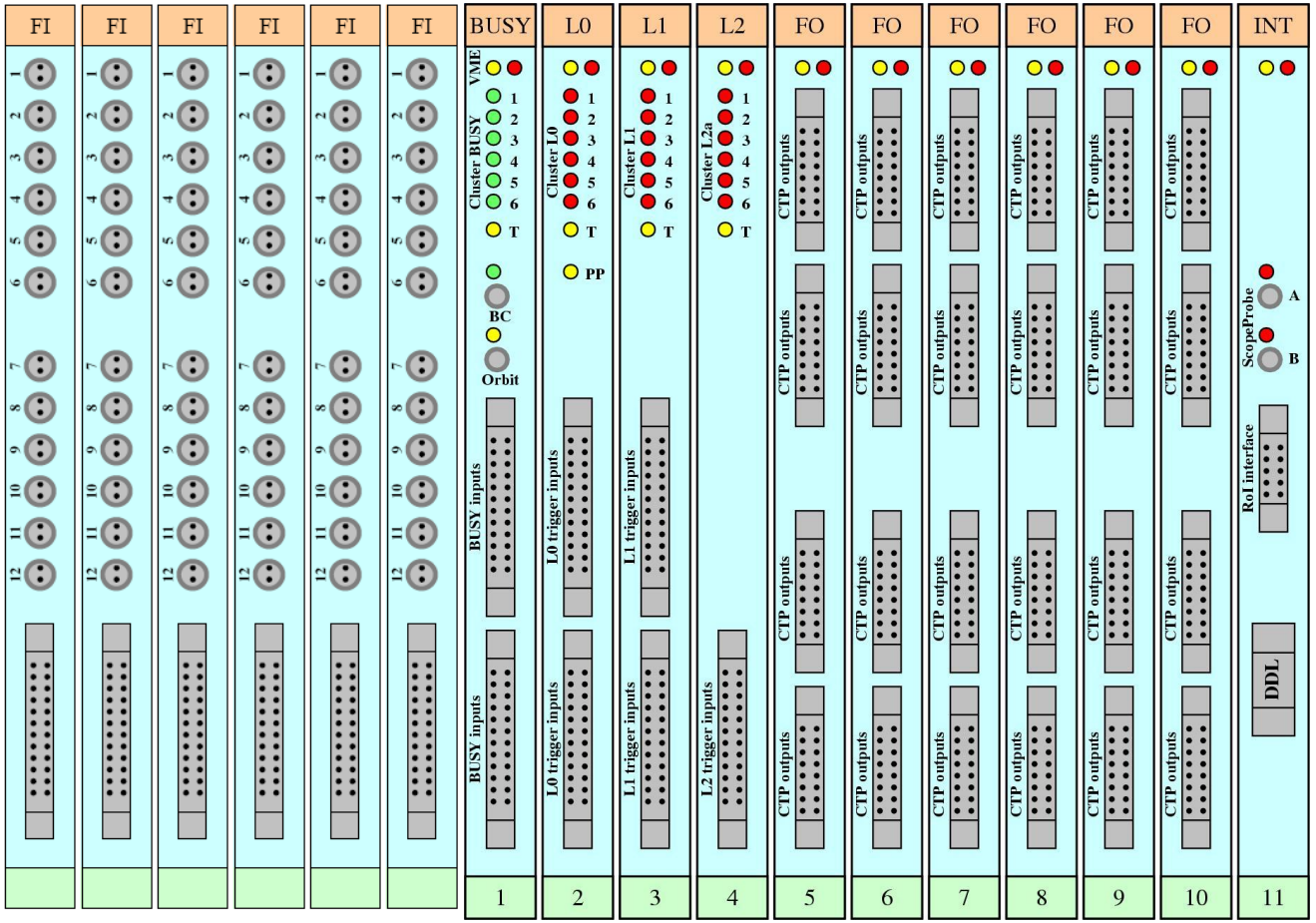


Central Trigger Processor

6U VME boards

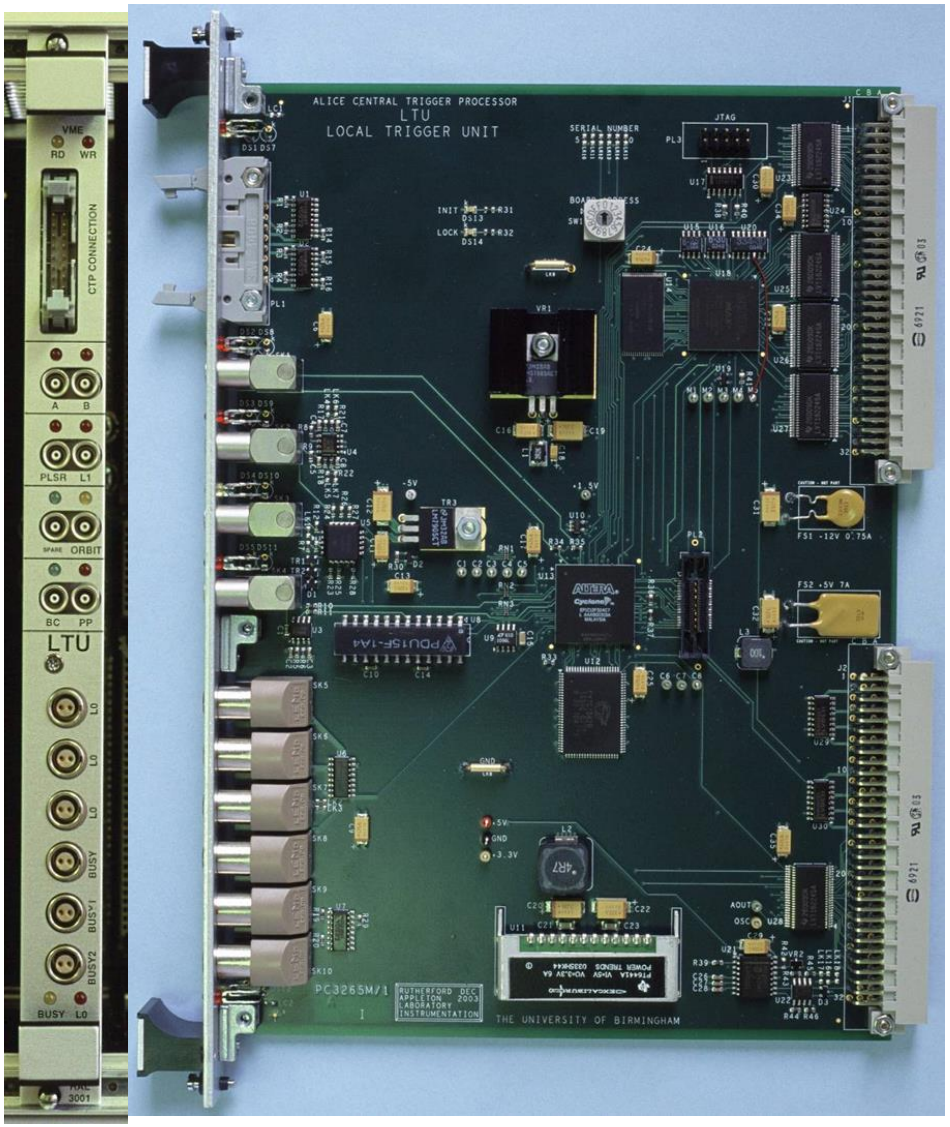
Trigger inputs are LVDS

Outputs are sent to Local Trigger Units (LTUs) where conversion to output format occurs



Local Trigger Unit (LTU)

- Uniform interface between the CTP and sub-detectors:
  - easier control
  - easier mods/upgrades
- Unique features:
  - Full CTP emulation (stand-alone mode)
  - Error emulation (front-end tests)
- VME, 6U form-factor
- Similar to other CTP boards



RUN2 Upgrade

L0 board replaced with NEW LM board

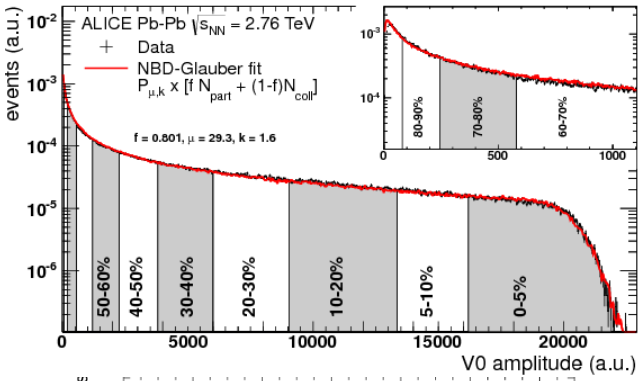
New functionality:

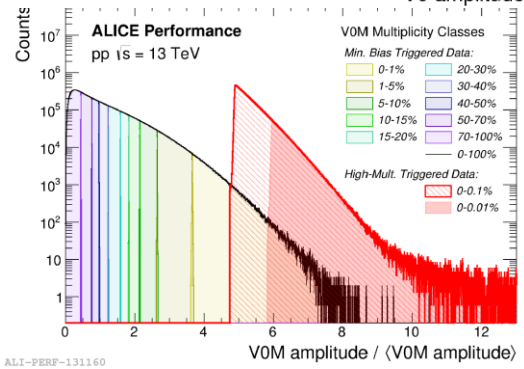
- New trigger level LM (Level Minus One) with latency ~ 0.8 μs at detector
  - Increase TRD cluster trigger efficiency
- 100 Classes (50 before upgrade)
- Trigger Input switch part of the LM board
- New Past- Future protection
- New additional DDL link from CTP to DAQ:
  - Interaction record with all 48 inputs available

ALICE Triggers I

- Minimum Bias (LM for TRD and L0 for others)
  - V0 coincidence (+ ZDC for Pb-Pb, L1)
- Centrality (Pb-Pb, L0)
  - V0 amplitude (central , semi-central)
- Multiplicity (pp, L0)
  - V0 amplitude
  - SPD hits

Int. J. Mod. Phys. A 29 (2014) 1430044

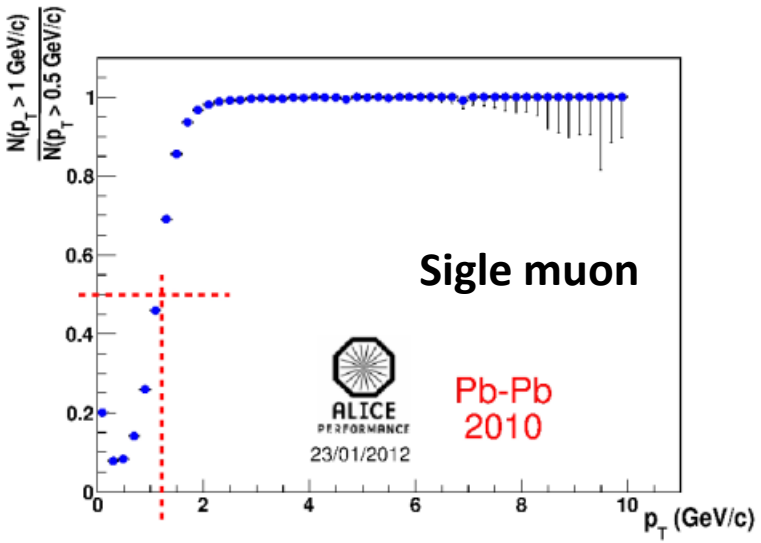




-3.7 < h < -1.7 (V0C), 2.8 < h < 5.1 (V0A)

ALICE Triggers I

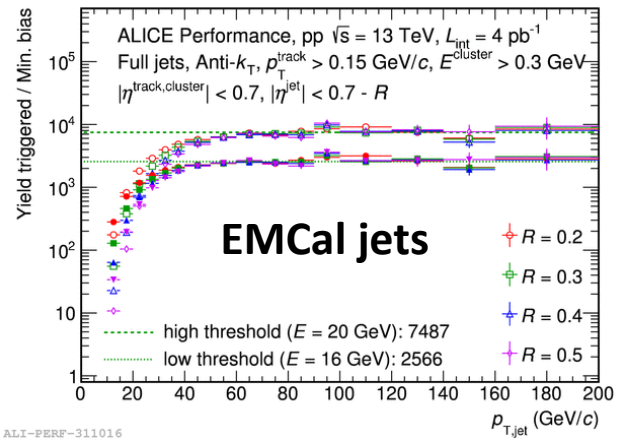
- Minimum Bias (LM for TRD and L0 for others)
  - V0 coincidence (+ ZDC for Pb-Pb, L1)
- Centrality (Pb-Pb, L0)
  - V0 amplitude (central , semi-central)
- Multiplicity (pp, L0)
  - V0 amplitude
  - SPD hits
- Muon (L0)
  - Di-muon, single muon (2 p_T thresholds)



JINST 7 (2012) T12002

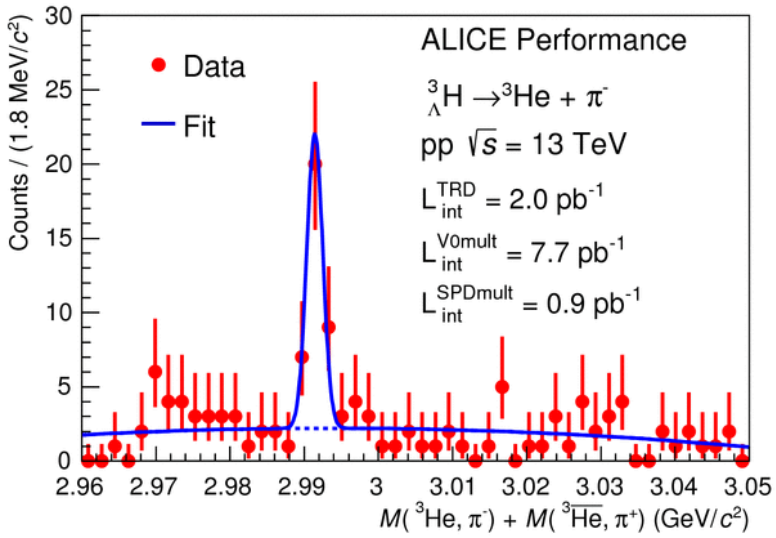
ALICE Triggers I

- Minimum Bias (LM for TRD and L0 for others)
  - V0 coincidence (+ ZDC for Pb-Pb, L1)
- Centrality (Pb-Pb, L0)
  - V0 amplitude (central , semi-central)
- Multiplicity (pp, L0)
  - V0 amplitude
  - SPD hits
- Muon (L0)
  - Di-muon, single muon (2 p_T thresholds)
- EMCal (L0/L1)
  - Gamma/electron (2 p_T thresholds)
  - Jets (2 p_T thresholds
- PHOS (L0/L1)
  - Gamma/electron



ALICE Triggers II

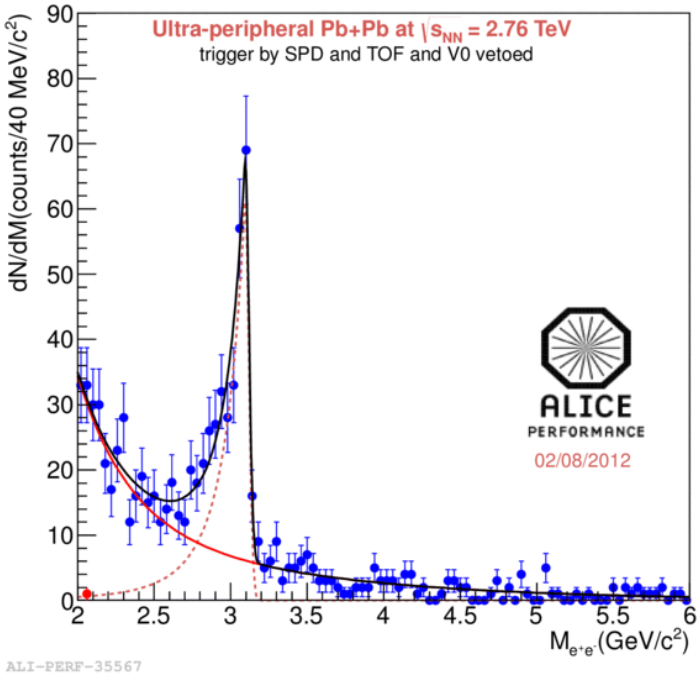
- TRD (L1)
  - Electron, quarkonium, jets, nuclei



TRD Hypertriton

ALICE Triggers II

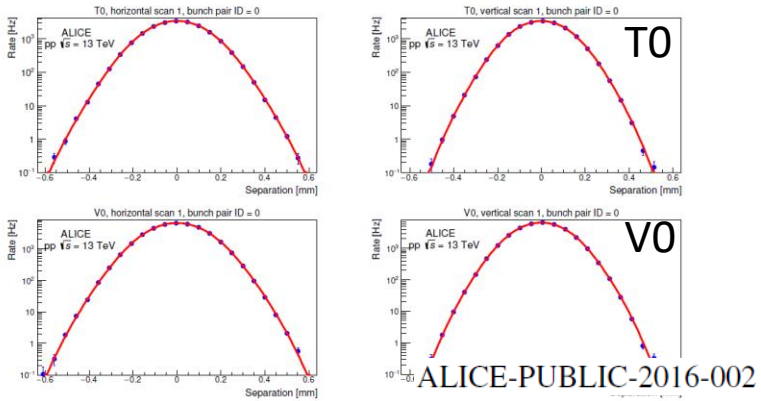
- TRD (L1)
  - Electron, quarkonium, jets, nuclei
- Ultra-Peripheral and diffractive (L0)
  - V0 and AD veto + SPD topology + TOF (central η) + muon (forward η)



Ultra-peripheral
Central rapidity

ALICE Triggers II

- TRD (L1)
  - Electron, quarkonium, jets, nuclei
- Ultra-Peripheral and diffractive (L0)
  - V0 and AD veto + SPD topology + TOF (central η) + muon (forward η)
- ZDC (L1)
- Luminosity signals
  - T0 and V0 (L0) and ZDC (L1)



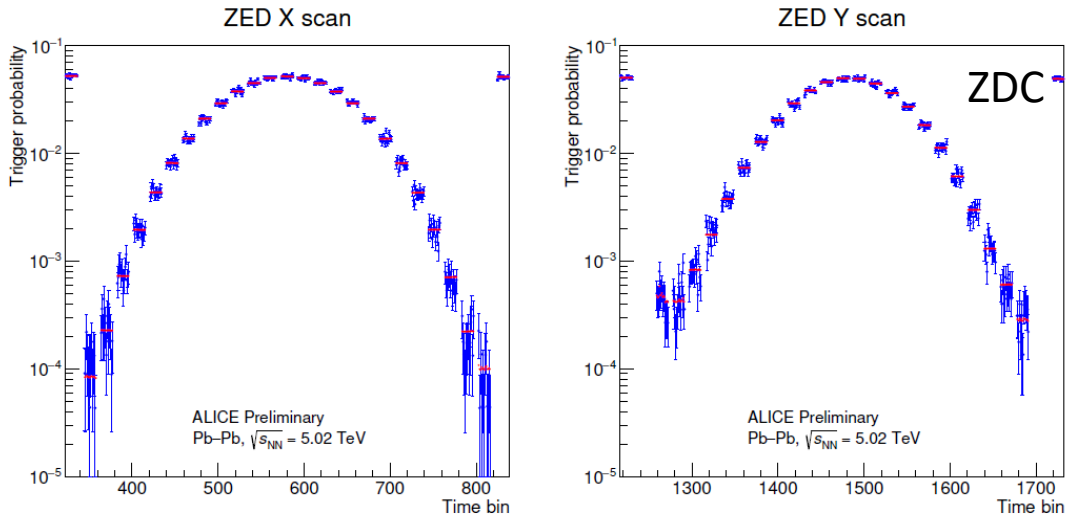
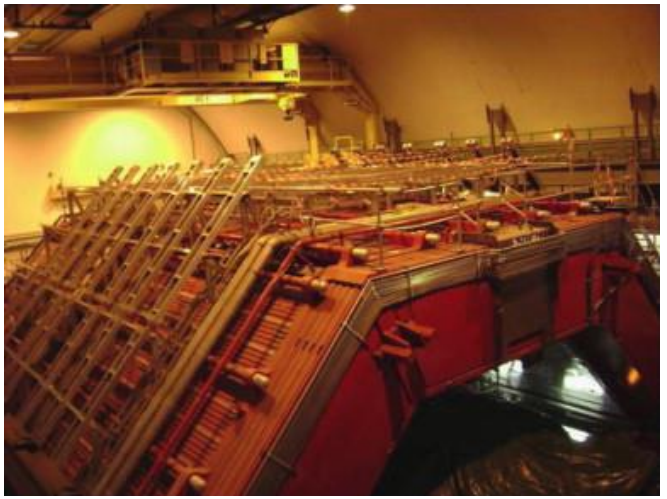


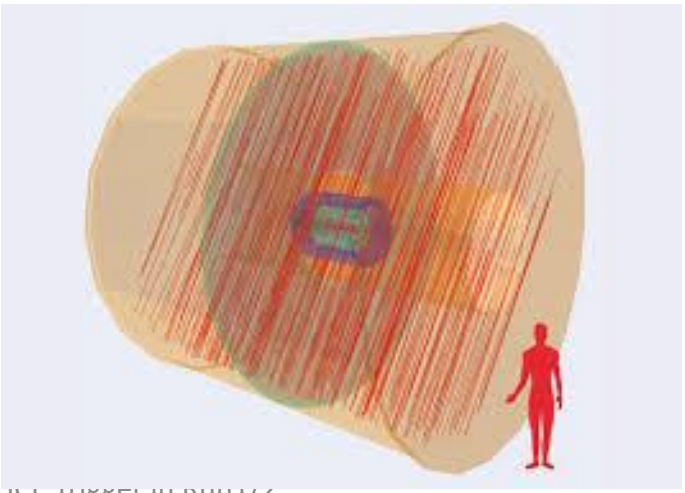
Fig. 2: (Colour online) V0M and ZED trigger probabilities per bunch crossing for a typical colliding bunch pair, as a function of time, during the first horizontal and vertical vdM scan. Each time bin corresponds to an acquisition window of ∼ 2 s. The uncertainties are statistical only. The fit expectation values are also shown. Time bins during which the beams are being displaced, not considered in the analysis, are not shown.

ALICE-PUBLIC-2021-001

ALICE triggers II

- TRD (L1)
  - Electron, quarkonium, jets, nuclei
- Ultra-Peripheral and diffractive (L0)
  - V0 and AD veto + SPD topology + TOF (central η) + muon (forward η)
- ZDC (L1)
- Luminosity signals
  - T0 and V0 (L0) and ZDC (L1)
- Cosmic (L0)
  - Alice Cosmic Ray Detector
  - SPD, TOF





Trigger Menu Example

Class prefix	Clusters (* no ACE)	Description	classes	Downscaling	L2a rate @ 180kHz
CTRUE-[B,ACE]	ALLNOTRD	No bias	2	rnd = 50 Hz	3
CINT7-[B,ACE]	ALL, ALLNOTRD	Min. bias V0AND	4	fixlum = 30 Hz/b	35
CSHM7-[B,ACE]	ALL, ALLNOTRD*	Centrality	3	fixpower4 = 40 Hz/mb	5
CPHI7-[B,ACE]	ALL, ALLNOTRD	PHOS L0	4	fixloss = 39 Hz/mb	7
CEMC7-[B,ACE]	CENT, CENTNOTRD	EMCAL L0 (thr. 3 GeV, rejection 100)	4	fixloss = 5.1 Hz/mb	3.5
CEMC7EG1-B	CENT, CENTNOTRD	EMCAL L1 gamma high, ~2kHz L0 inspection	2		16
CEMC7EG2-B	CENT, CENTNOTRD	EMCAL L1 gamma low, ~2kHz L0 inspection	2	fixloss = 23 Hz/mb	3.5
CEMC7EJ1-B	CENT, CENTNOTRD	EMCAL L1 jet high, ~2kHz L0 inspection	2		18
CEMC7EJ2-B	CENT, CENTNOTRD	EMCAL L1 jet low, ~2kHz L0 inspection	2	fixloss = 9.2 Hz/mb	4
CEMC7WUHEE-B	CENT	EMCAL-TRD L1, ~ 2kHz L0 inspection	1		0
CINT7WUHJT-[B,ACE]	CENT,FAST*	TRD L1 jet, ~10kHz L0 inspection	3	fixloss = 28 Hz/mb	L0a: CENT ~ 6.5k FAST ~ 7.3k
CINT7WUHSE-[B,ACE]	CENT,FAST*	TRD L1 electron, ~10kHz L0 inspection	3	fixloss = 28 Hz/mb	
CINT7WUHQU-[B,ACE]	CENT,FAST*	TRD L1 quarkonium, ~10kHz L0 inspection	3	fixloss = 28 Hz/mb	
CMSL7-B	ALLNOTRD	Single muon low-pt for mu-hadron cor.	1	fixloss = 4 Hz/mb	9
CMSL7-[B,ACE]	MUON	Single muon low-pt	2	fixlum = 3 Hz/mb	180
CMSH7-B	MUON	Single muon high-pt	1		150
CMLL7-B	MUON	Dimuon like-sign low-pt	1	fixlum = 10 Hz/mb	50
CMUL7-B	MUON	Dimuon unlike-sign low-pt	1		200
CMUP8-[B,ACE]	ALLNOTRD	UPC muon forward	2		12
CMUP9-[B,ACE]	ALLNOTRD	UPC muon semi-forward	2		8
CCUP7-[B,ACE]	CENTNOTRD	UPC central barrel	2		10
C0LSR-ABCE	CENTNOTRD	Calibration: TPC laser	1		
C0TVX-[B,ACE]	ALLNOTRD	Lumi monitoring: 0TVX	2		
CVGO-ABCE	ALLNOTRD	Bgd monitoring: A or C (downscaled)	1	fixed = 0.005%	0.7
Total TPC rate			**50**		**170**

Trigger menu: pA_rare.v33

ALICE Integrated Luminosity Run1/2

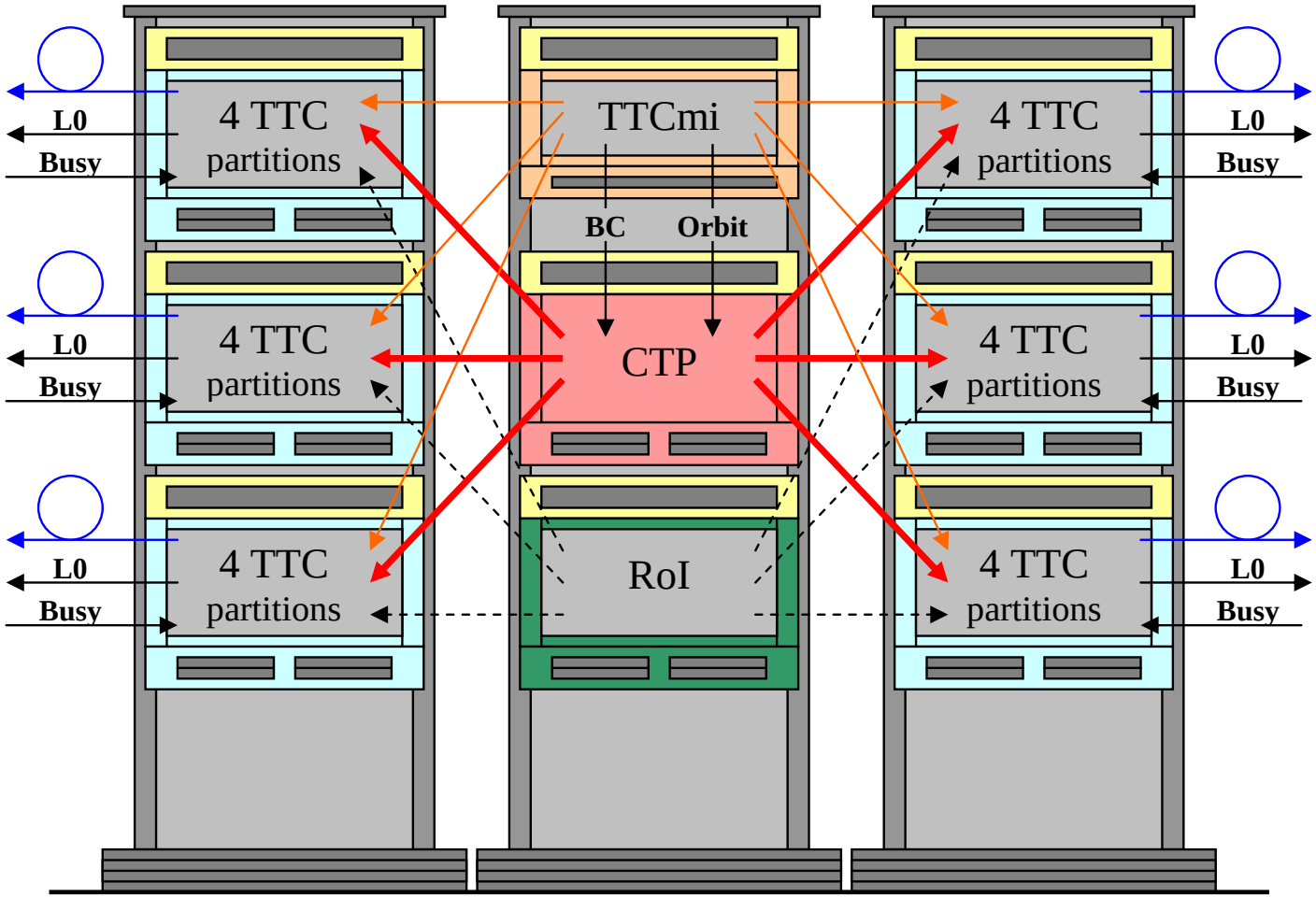
A. Kalweit / Nuclear Physics A 982 (2019) 1–7

System	Year(s)	$\sqrt{s_{\mathrm{NN}}}$ (TeV)	L_{int}
Pb-Pb	2010-2011	2.76	$\approx$75 μb^{-1}
	2015	5.02	$\approx$250 μb^{-1}
	by end of 2018	5.02	$\approx$1 nb^{-1}
Xe-Xe	2017	5.44	$\approx$0.3 μb^{-1}
p-Pb	2013	5.02	$\approx$15 nb^{-1}
	2016	5.02, 8.16	$\approx$3 nb^{-1}, $\approx$25 nb^{-1}
pp	2009-2013	0.9, 2.76	$\approx$200 μb^{-1}, $\approx$100 nb^{-1}
		7, 8	$\approx$1.5 pb^{-1}, $\approx$2.5 pb^{-1}
	2015,2017	5.02	$\approx$1.3 pb^{-1}
	2015-2017	13	$\approx$25 pb^{-1}

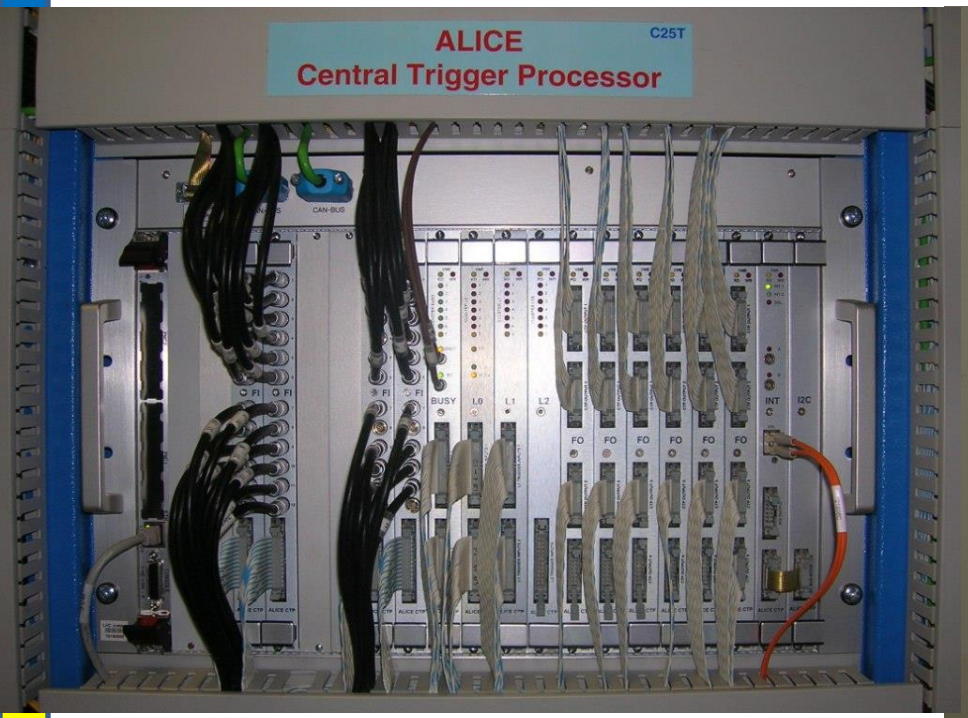
RUN1 and RUN2 integrated luminosity collected/inspected

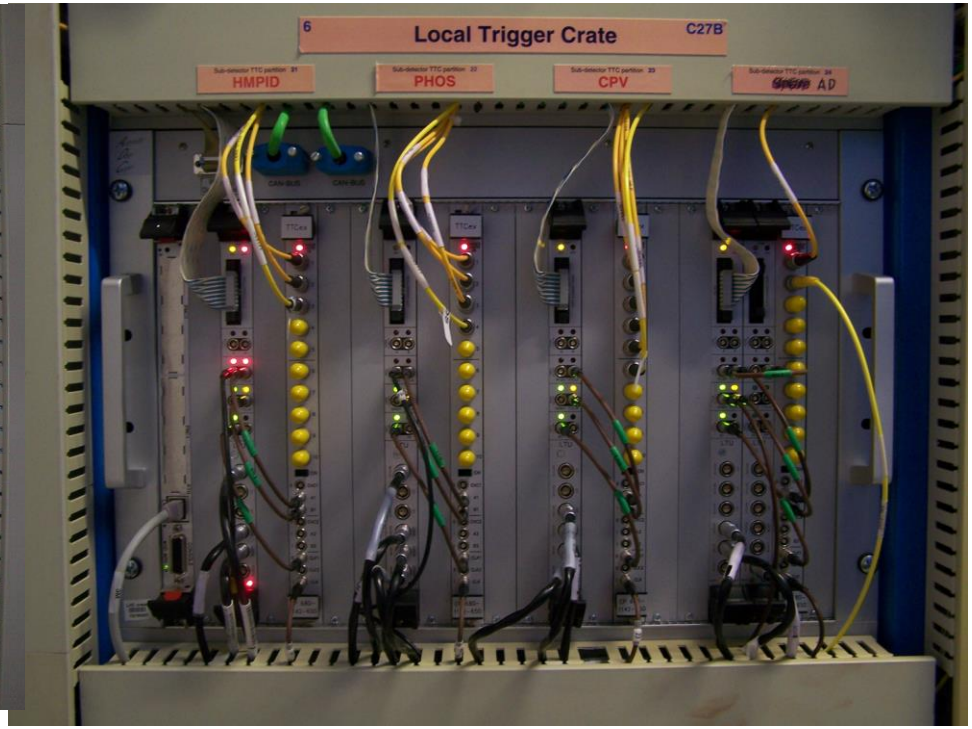
Extra Slides

Layout of ALICE trigger system



Central Trigger System RUN1





History

- Pre 1995: first CTP schema
- 1995 – ALICE Technical Proposal
- 1999 July - Trig Protocol ALICE INT note
- 2000 June – first draft User Requirement Document
- 2002 October 10 – LTU design Review
- 2003 - Technical design report
- 2004 July - LTU production started
- 2004 July 8 - CTP Design Review
- 2005 June – 2006 June: CTP boards production
- 2006 July - CTP installed in CERN CTP lab and connected with DAQ
- 2007 May - CTP installation in P2
- 2008 September 10 – first beam
- 2009 November 23 - collisions at 450 GeV
- 2010 April 30 - collisions at 7 TeV
- 2013-2015 - LS1 CTP upgrade
- 2015 5/4 – first beam of run2
- 2015 3/6 - collisions at 13 TeV
-

2018 - December 2 – LAST TRIGGER:
Run 297624
Period=2
Orbit=0xd4063b