TWEPP 2010, Aachen, Germany, 20-24 September

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On behalf of the ALICE Collaboration

PERFORMANCE OF ALICE DETECTOR AND ELECTRONICS UNDER FIRST BEAM CONDITIONS

Outline

- Overview of ALICE and status of selected subsystems
- pp data taking
- Synchronization, luminosity, SEUs

General purpose Heavy Ion detector

- Extreme particle multiplicity (dN/dη=8000)
- ~8 kHz Pb-Pb interaction rate

High granularity tracking, lower readout rate detectors

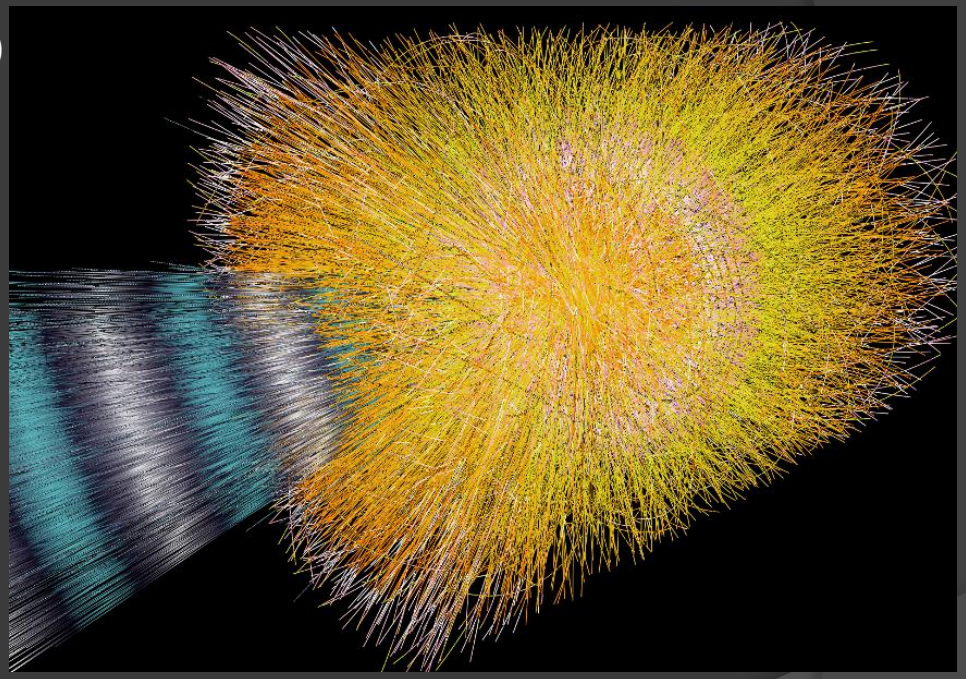
- TPC, Silicon Drift

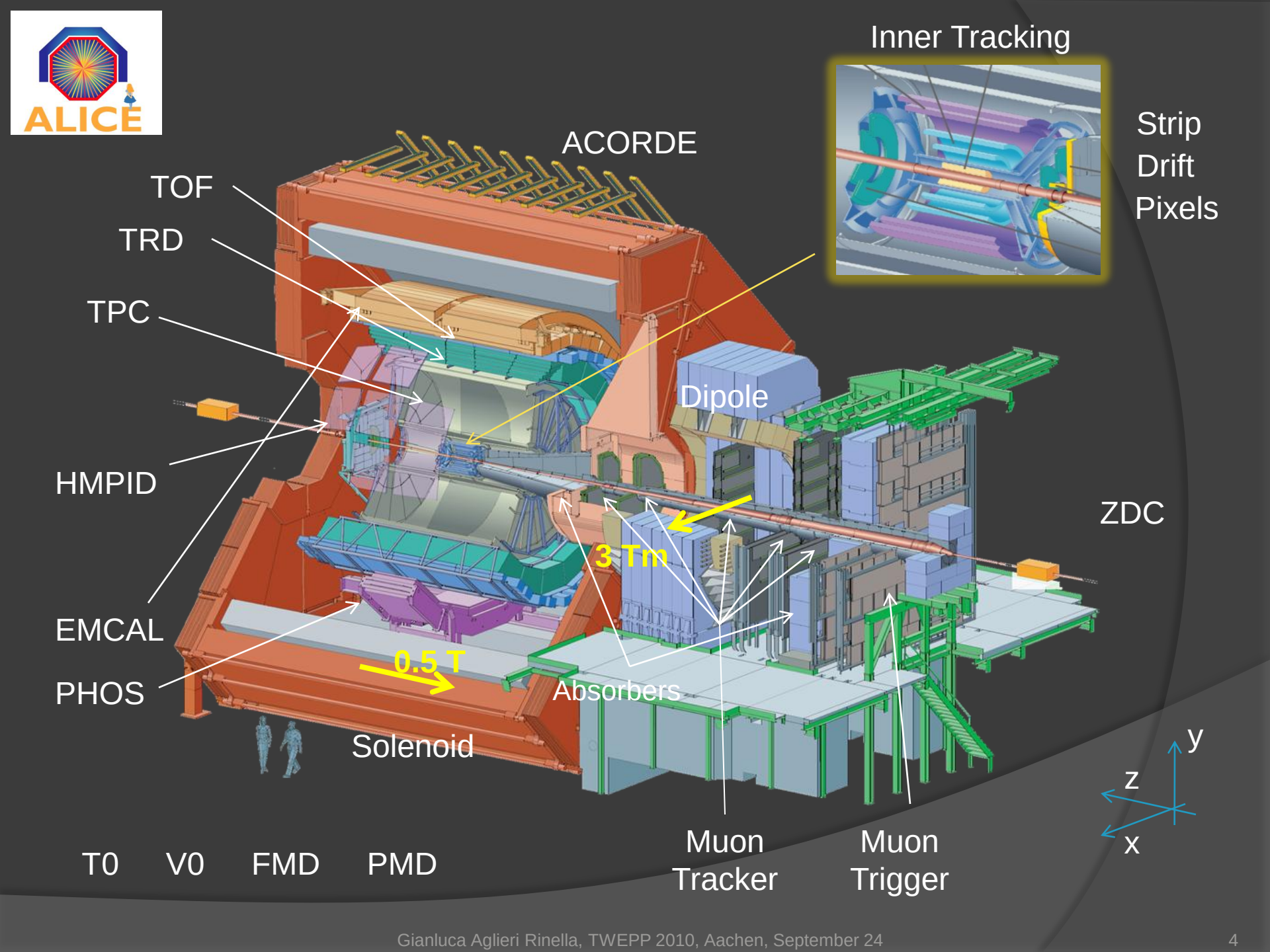
Large event size: ~90 MB (Pb-Pb)

- Specific trigger rate and DAQ bandwidth requirements

p-p collisions data

- Reference for Heavy Ions and complementary to other LHC detectors




Inner Tracking
Strip
Drift
Pixels
ACORDE
TOF
TRD
TPC
HMPID
EMCAL
PHOS
Dipole
ZDC
3 Tm
0.5 T
Absorbers
Solenoid
T0
V0
FMD
PMD
Muon
Tracker
Muon
Trigger
y
z
x

On detector integrated circuits

Inner Tracking System
- Hybrids, Al-Polymide flex circuits

Radiation tolerant ASICs
- 2200 Gy, $8 \cdot 10^{11}$ cm^{-2} (1 MeV neq)
- 26 Gy, $4.1 \cdot 10^{11}$ cm^{-2} (1 MeV neq)

	Inner Tracking	Qty
Pixels	ALICE1LHCb, DigPilot, AnPilot, GOL	1 560
Drift	PASCAL, AMBRA, CARLOS, GOL	9 360
Strips	HAL25, ALCAPONE, ALABUF	27 168

0.250 µm, Mixed Signal, Radiation Tolerant

< 2 Gy, $2.4 \cdot 10^{11}$ cm^{-2} neq

Standard CMOS
Flash based FPGAs

	Tracking - PID	Qty
TPC	PASA (0.35 µm), ALTRO	69 696
TRD	PASA, TRAP (0.18 µm)	55 104
TOF	NINO, HPTDC	38 232
HMPID	GASSIPLEX (0.7 µm), DILOGIC (0.7 µm)	13 440
MUON	MANAS, MARC	85 000

0.250 µm when not explicitly mentioned

Inner Tracking System

	Pixels	Drift	Strips
Readout	Binary	Digitized	Digitized
Total channels	$9.83 \cdot 10^6$	$133 \cdot 10^3$	$2.61 \cdot 10^6$
Active modules	94 of 120 (78%)	240 of 260 (92.3%)	1557 of 1698 (91.7 %)
Active channels in active modules	98.8 % (1.2% dead, 0.01% noisy)	98.3 %	98.5 %
Active channels	**77 %**	**91 %**	**90.3 %**

Pixels

- Modules off for high temperature, low cooling flow
- Electrical issues on 1 module on 120

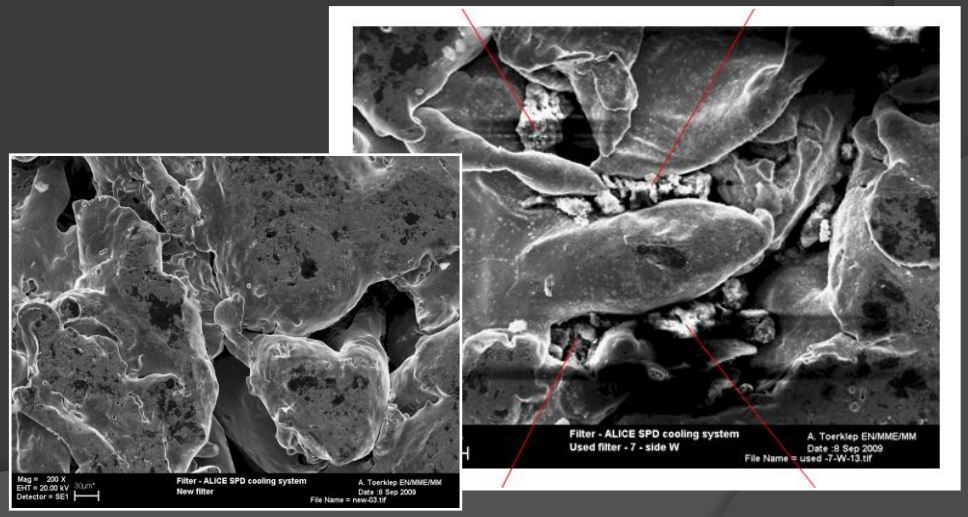
Drift

- Bias or FEE issues on 16 modules
- Broken hybrid connections on 4 modules

Strips

- Electrical issues on 6 half ladders
- Few modules masked for configuration and noise issues

Pixels: clogging of cooling lines filters



Central barrel detectors and muon tracker

	TPC	TRD	TOF	HMPID	Muon tracker
FE features	ADC, Digital filtering on FE	ADC, Tracklet processing on FE	TOT discrimination, TDC inside the magnet	Track&Hold, Analog filtering, digital processing	Track&Hold
FE Modules	4 356	27 552	6 372	3360	17 000
Readout channels	557 568	$4.6 \cdot 10^5$ ($1.18 \cdot 10^6$)	152 928	161 280	$1.08 \cdot 10^6$
Active fraction	**99.7 %**	**91.6 %**	**95 %**	**85 %**	**96 %**

TPC

- 5 FECs damaged by HV trips, 768 ch
- ASICs issues: 362 ch
- Off for noisy location: 576 ch

TRD

- 7 of 18 modules installed
- 6.2 % channels with HV issues
- 2.2 % with FE issues

TOF

- Off channels: TDC boards to replace, crates cooling

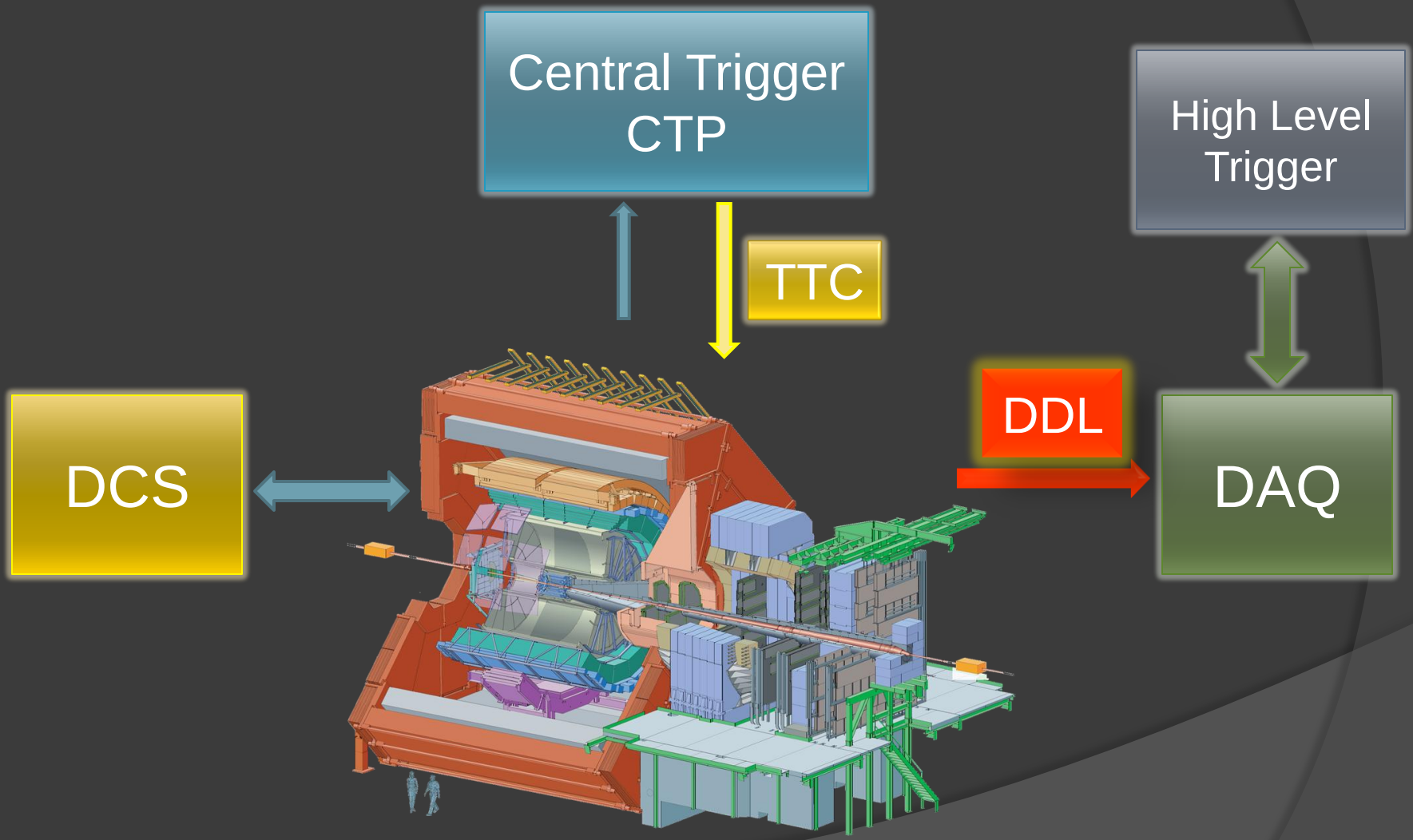
HMPID

- Cherenkov radiators damaged
- 0.2% channels dead/noisy

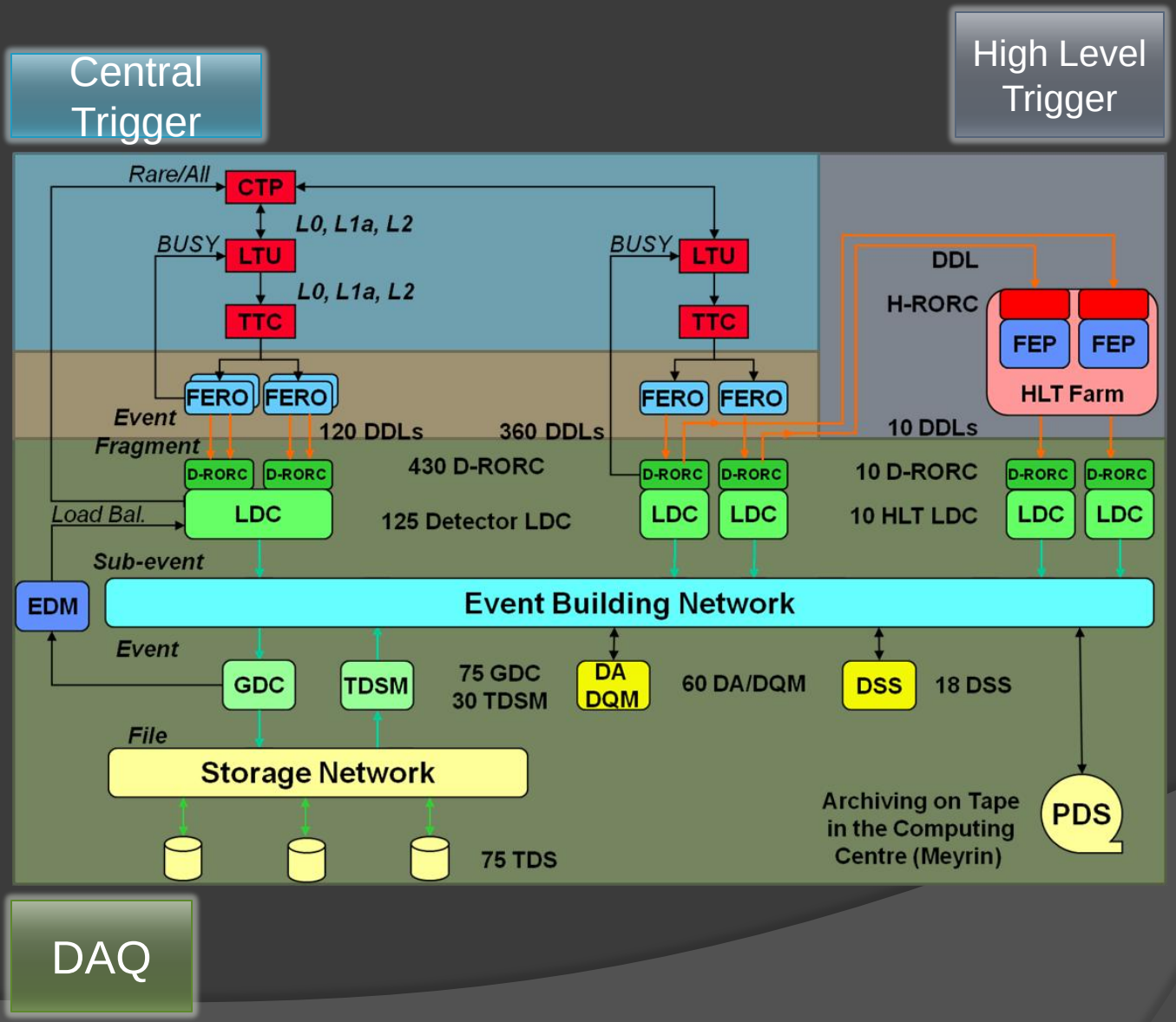
MUON

- 4% channels with LV instabilities, replacement of LV connections

ALICE Central Systems

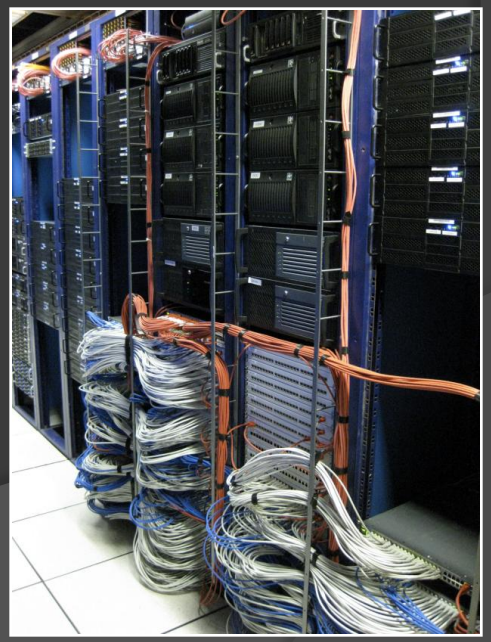


Trigger, DAQ, High Level Trigger



DAQ and HLT status

DAQ Data throughput	Required	Tested
DAQ to Transient Storage	1.25 GB/s (H.I.)	4.5 GB/s
DAQ to Permanent Storage	100 MB/s (pp) 1.25 GB/s (H.I.)	2.5 GB/s



HLT front end and infrastructure nodes
final and complete
~1000 CPUs

53 of 153 computing nodes installed

Full pp, partial HI processing capability

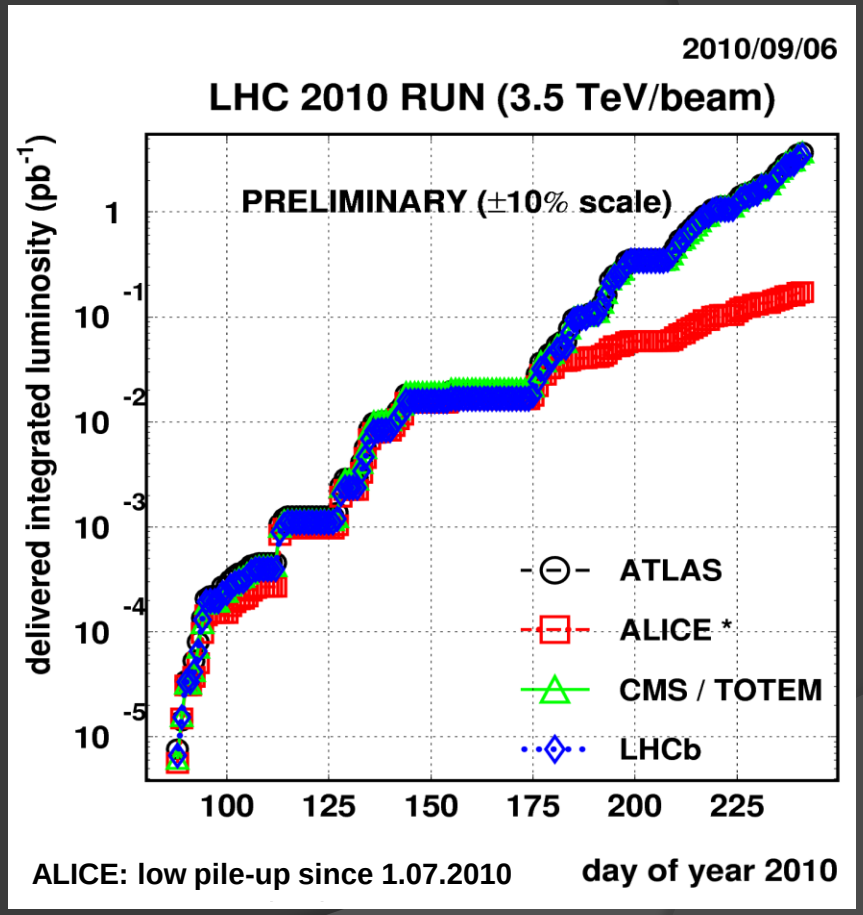
- Overview of ALICE and status of selected subsystems
- pp data taking
- Synchronization, luminosity, SEUs

Luminosity at LHC IP 2

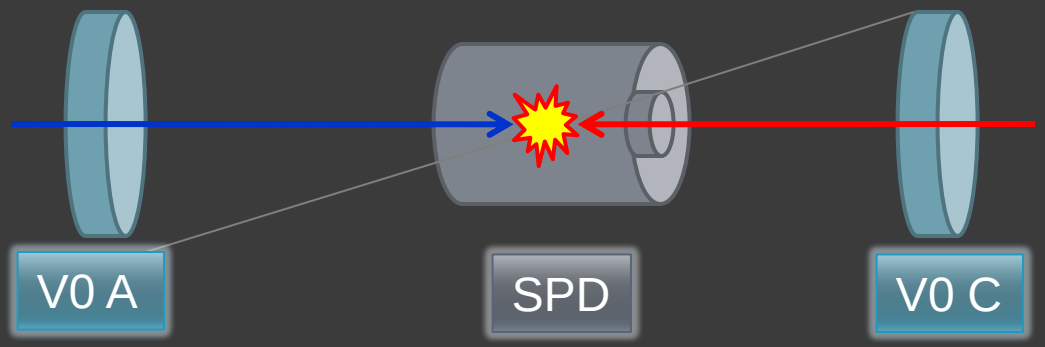
ALICE 2010 pp objective
- Efficiently collect good minimum bias sample
  - Low pile-up in TPC
  - ~ 1 collision per event

~ 10 kHz pp interaction rate

Beams displaced
- β*= 3.5 m, Δx= 266 μm (3.8 σ)
- L ~ $2.5 \cdot 10^{29}$ $cm^{-2}s^{-1}$ (14 coll. bunches)



Trigger configuration (2010 pp)



Interaction trigger (Minimum Bias)	At least one particle in V0 or SPD ($\Delta\eta = 8$)
Muon trigger	High p_t muon in the forward muon arm
High multiplicity trigger	High SPD occupancy

Live time sharing between MB and rare triggers

HLT selection running

No events rejected, sufficient DAQ capability

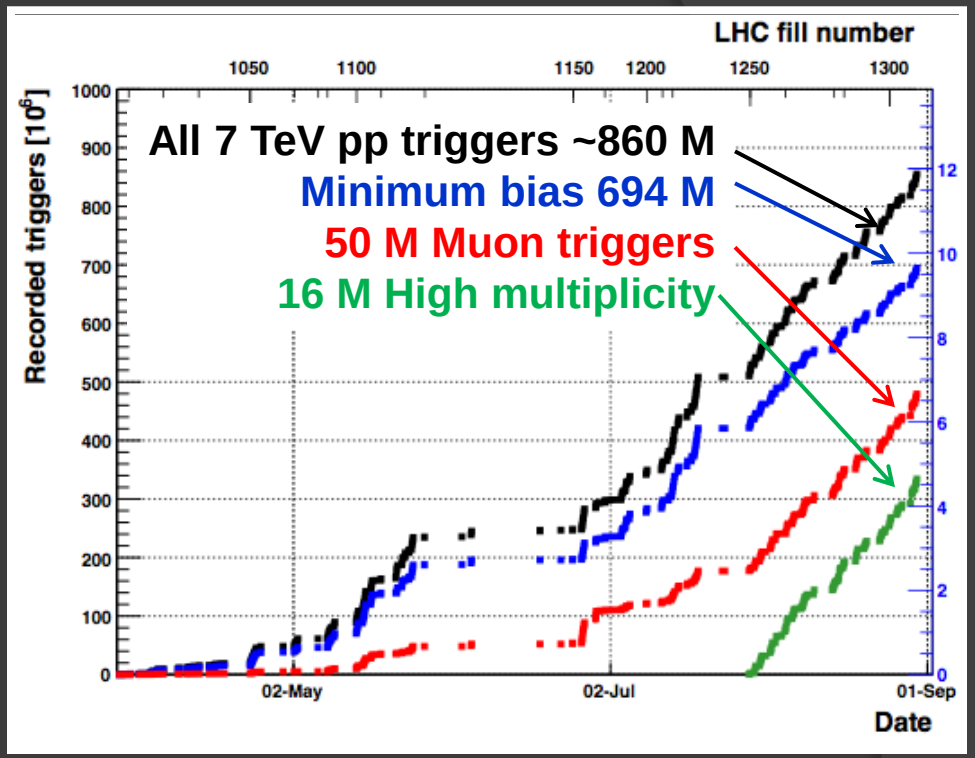
Data taking

Efficiency	79 %
Typical run duration	1 h

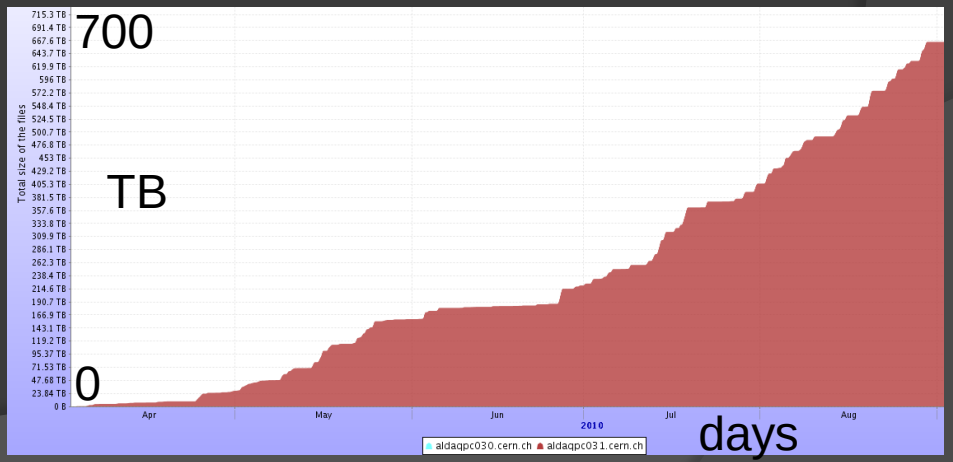
	7 TeV pp run*
Rate to tape	530 Hz
- MB	420 Hz
- Muon	60 Hz
- High Mult	34 Hz
Event Size	~980 kB
Bytes to tape	530 MB/s

(*) 6h 7 TeV pp run 130795, logbook values
- LHC fill scheme 1000ns_50b_35_14_35
- 14 interacting bunches
- ~9 kHz interaction rate, μ < 0.05

Recorded triggers



File size on CASTOR

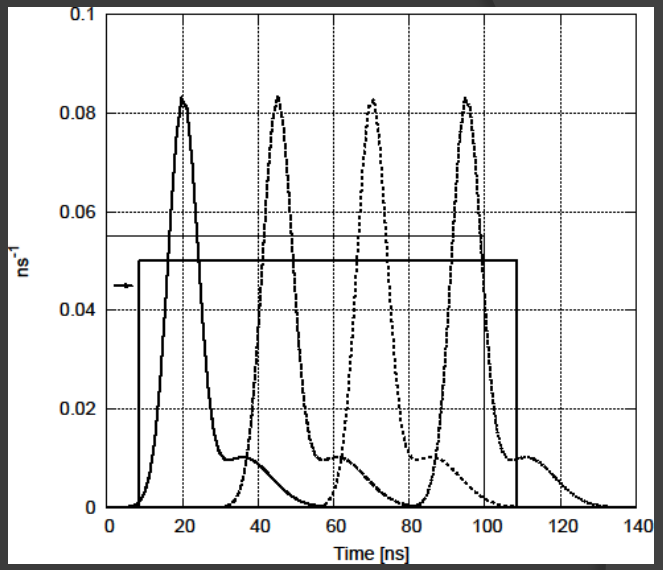


- Overview of ALICE and status of selected subsystems
- pp data taking
- Synchronization, luminosity, SEUs

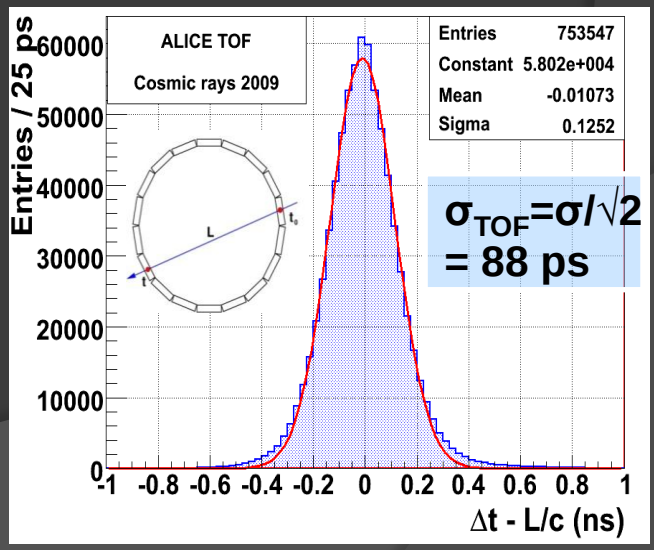
Fine phase tuning of detectors clock

- SPD
  - Compensated fiber lengths and transmitters skew (+/- 1 ns)
  - Fine time scan (TTCrx fine delay) of SPD clock with colliding beams
  - Set optimal phase in the clock domain

SPD strobe window time tuning

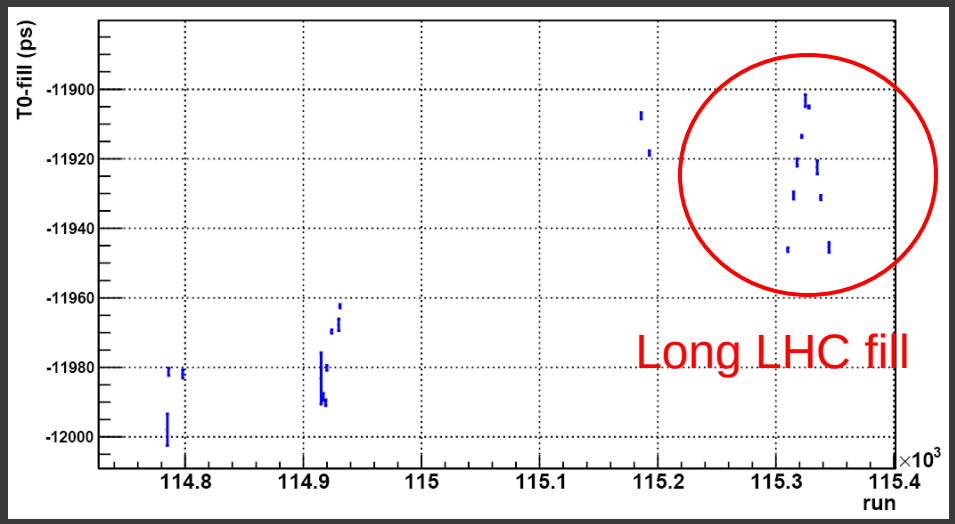


- TOF
  - Dedicated low jitter clock used (no TTC data)
  - Compensated skew across 72 crates due to fiber lengths (+/- 1 ns)
  - Phase alignment (TTCrx fine delay)

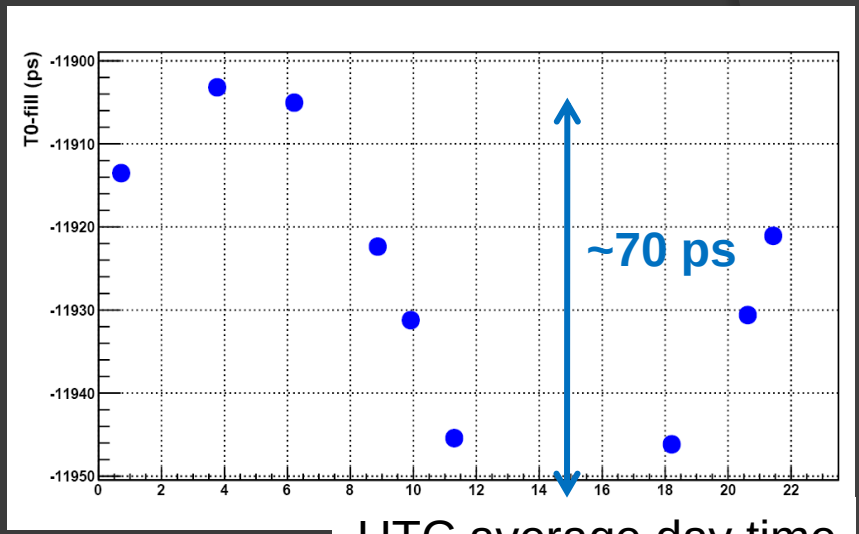


Bunch clock drift first seen by TOF

TOF saw clock variations soon (22/4/2010)



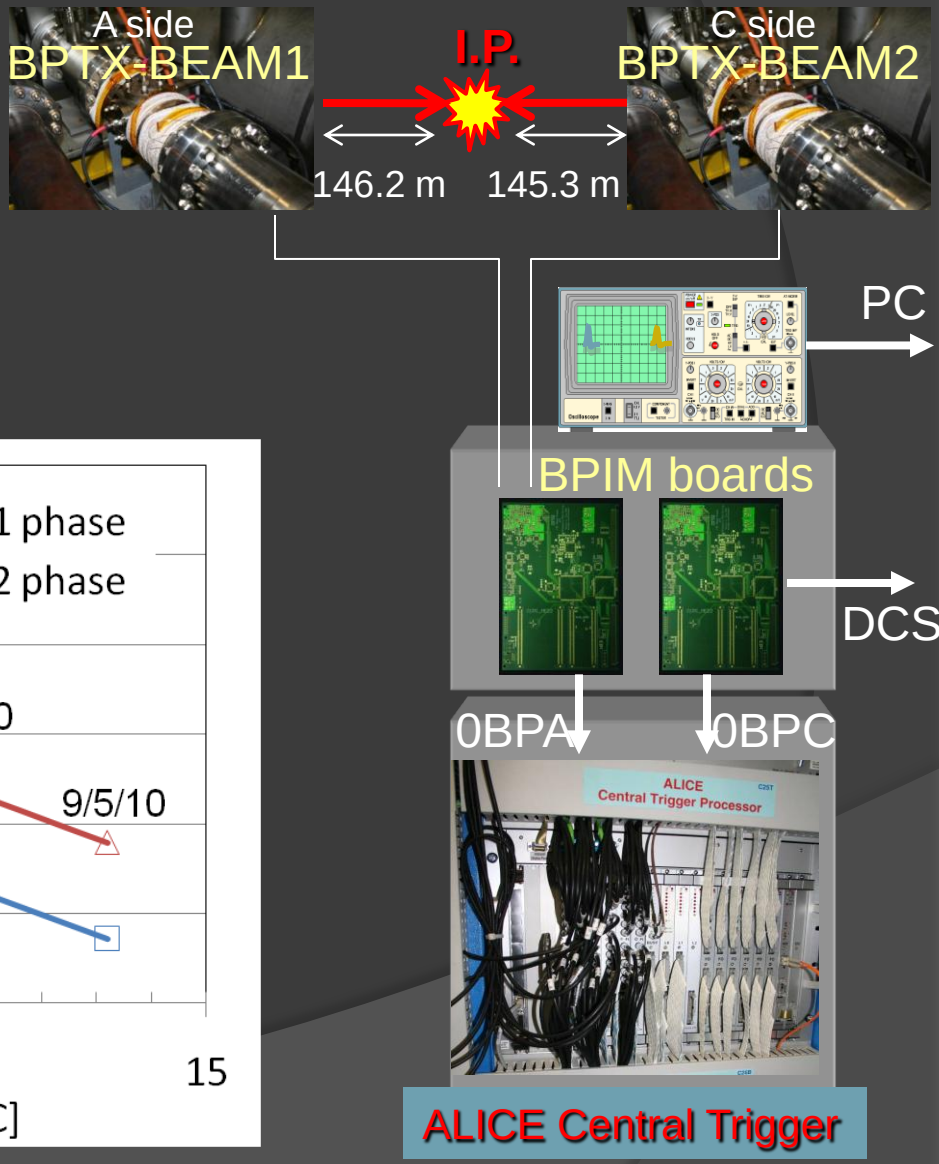
Day-night variations

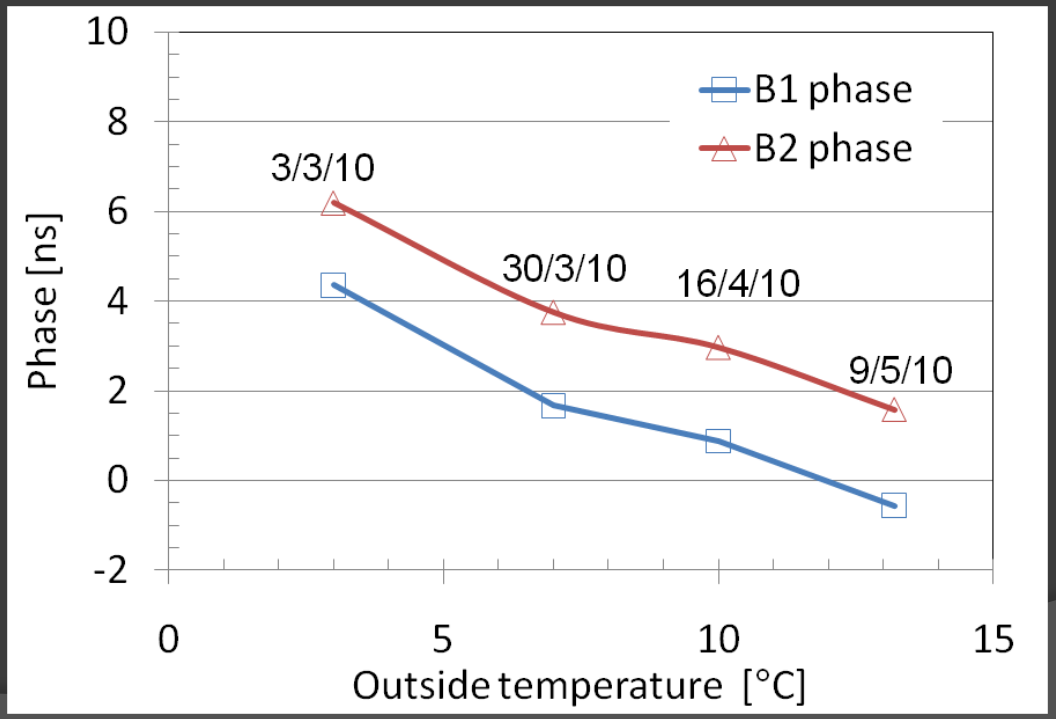


Beam Pickup BPTX/BPIM

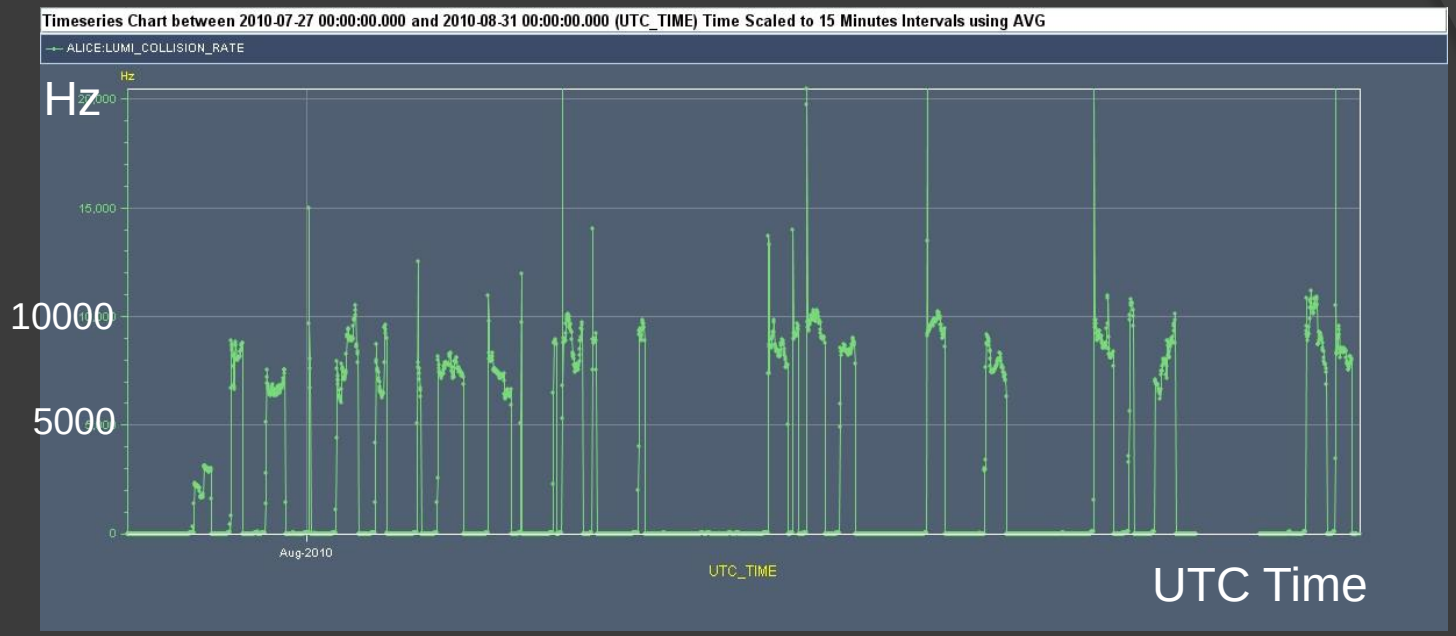
Monitoring of bunches wrt to LHC clock
- Seasonal clock phase drift
- Check fill scheme, abort gap, ghost bunches
- Triggering
- Bunch crossing z (cogging)

Electronics in common with LHCb
- See talk by F. Alessio at 12:00





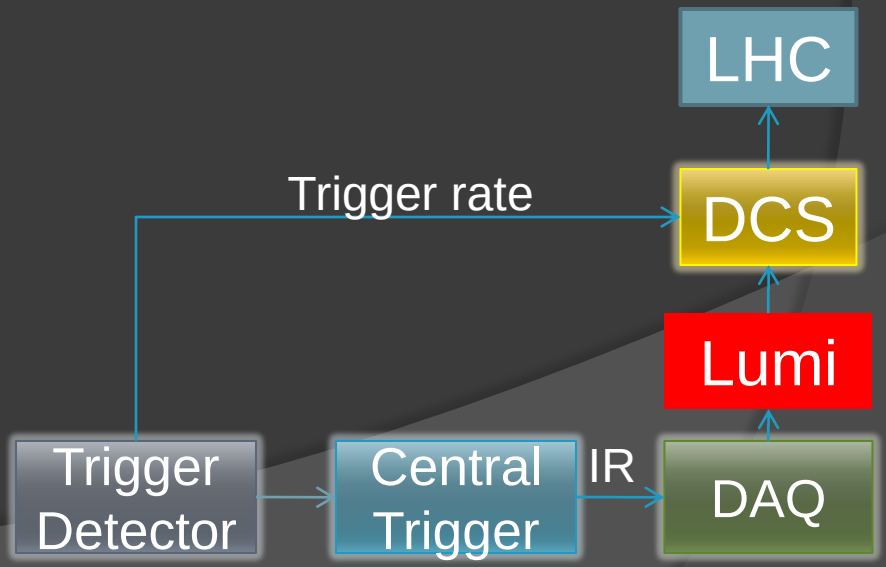
Luminosity monitoring



Rate of interaction trigger

Interaction record (IR)

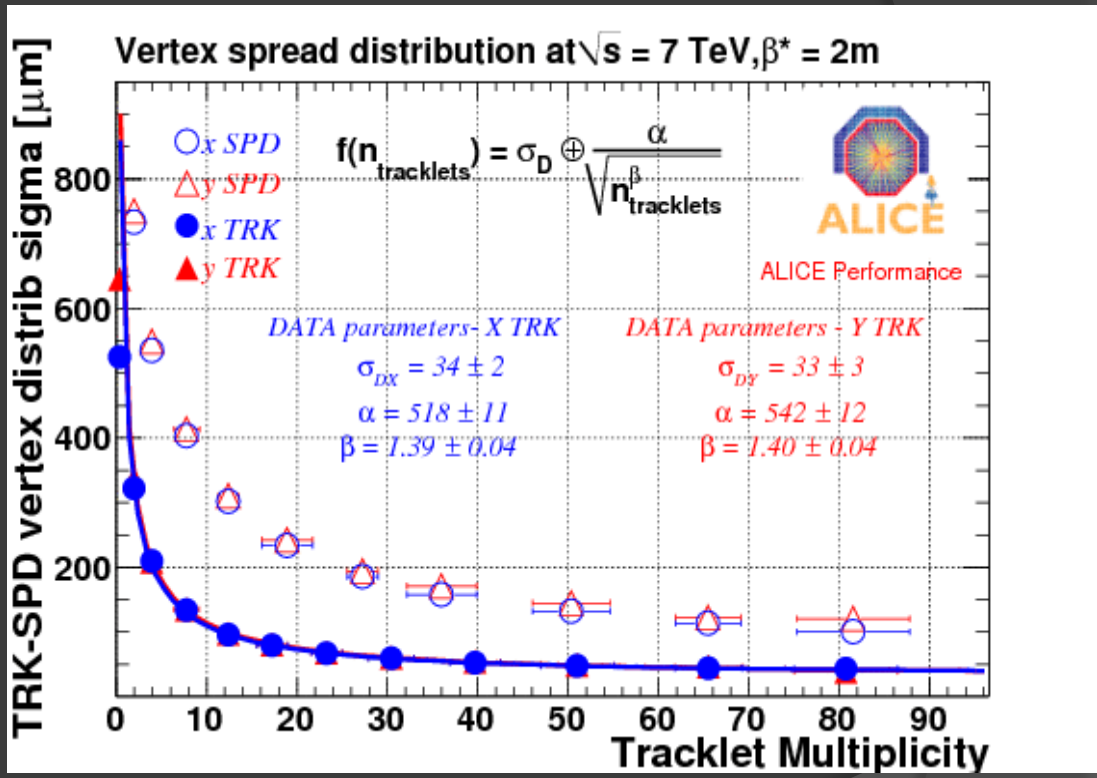
- Interaction rate vs bunch ID measured
- Bunch by bunch specific luminosity



Luminous region

Vertex reconstruction offline
- Intensive fitting algorithm
- Full ITS + TPC

Unfolding of vertex reconstruction resolution



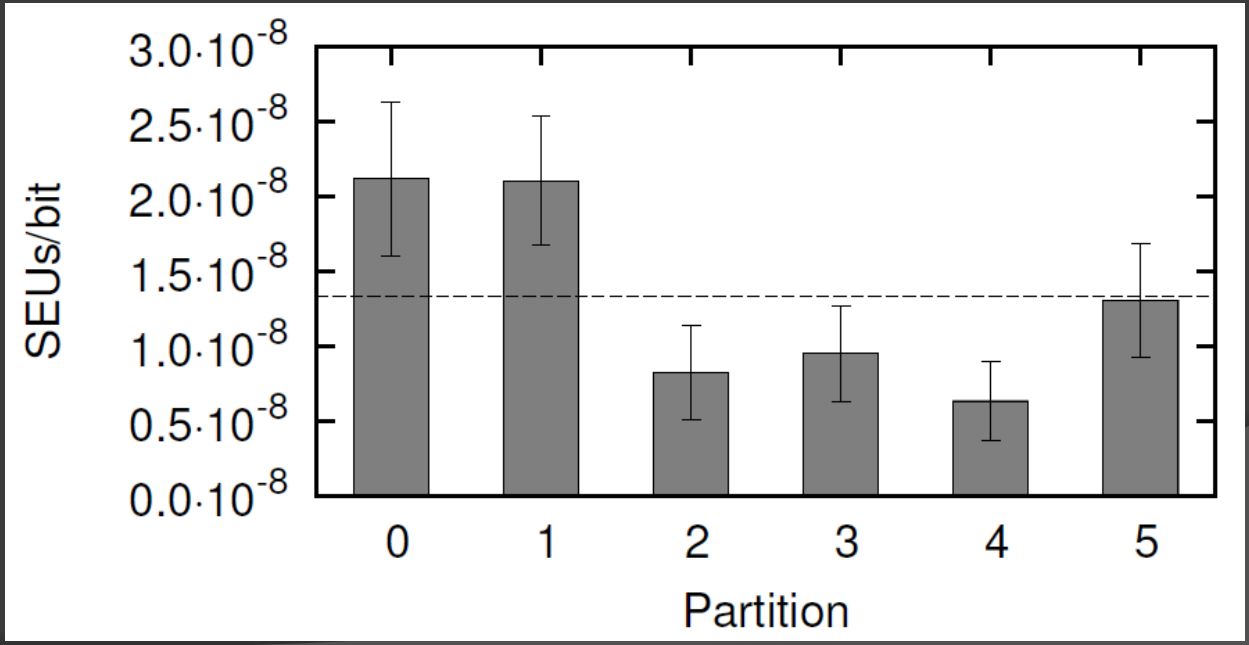
σ_{dx} ~= 34 μm

TPC SEU measurement

- Write fixed bit pattern to ALTRO pedestal memory
- Read the pattern at the end of run

Interactions (*)	Bits	SEUs
381 600	$5.60 \cdot 10^9$	58
154 500	$5.60 \cdot 10^9$	17
OFF	$4.90 \cdot 10^9$	0

(*) Time integral of LHC.BRANB.4L2:TOTAL_LUMINOSITY



Summary

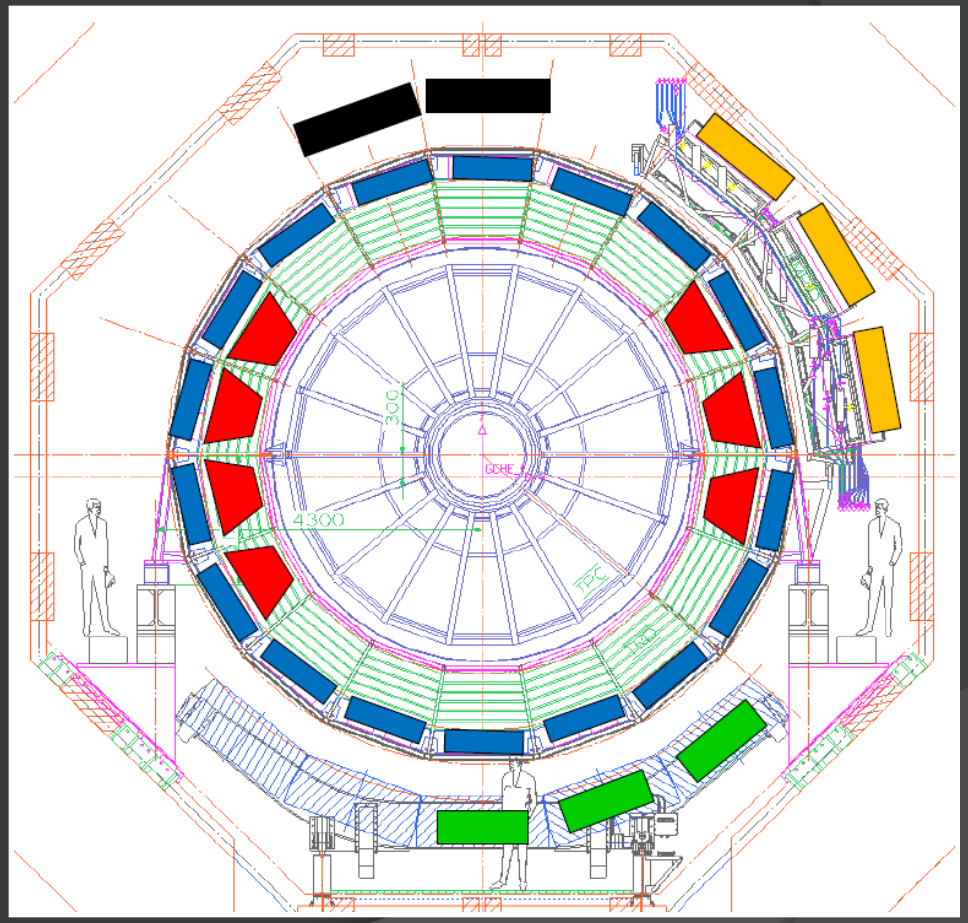
- ALICE recording pp data according to research programme
- Installed electronic systems working to specifications
- Consolidation of systems progressing

Looking forward to Pb-Pb collisions

Spares

Detectors configuration 2010

ITS, TPC	100 %
TOF, HMPID	100 %
V0, T0, FMD, PMD, ZDC	100 %
TRD (7/18)	39 %
PHOS (3/5)	60 %
EMCAL (4/10)	40 %



Full hadron and muon capability

Partial photon, electron
(PHOS, EMCal, TRD)

Central barrel

Tracking	
Inner Tracking (SPD, SDD, SSD)	Silicon Pixels, Drift, Strips Low p_t spectrometer, Vertex dE/dx particle identification (Drift, Strips) Pixel Trigger
Time Projection Chamber (TPC)	High resolution, efficient, large p_t range tracking dE/dx particle identification 90 m^3, $Ne/CO_2/N_2$, MWPC

Particle Identification	
Transition Radiation Detector (TRD)	> 1GeV/c electrons identification and tracking Trigger, Tracklet processor distributed in the FE
Time of Flight (TOF)	Hadronic identification, Trigger 100 ps, Multi-gap Resistive Chambers
High Momentum PID (HMPID)	Highest p_t hadron identification 10 m^2 Proximity focusing RICH with CsI photocathode

Electromagnetic calorimeters	
Photon Spectrometer (PHOS)	High resolution, high granularity electromagnetic calorimeter $PbWO_4$ scintillating crystals, Trigger
Electromagnetic Calorimeter (EMCAL)	Large acceptance, Pb scintillator sampling calorimeter Enhance jet capabilities, jet quenching, Trigger

Muon Arm and Forward Detectors

Forward Muon Spectrometer	
Muon Tracking	Stand-alone muon spectrometer, passive absorbers, dipole magnet Heavy quark vector-mesons resonances (J/ψ …) 10 planes, Cathode pad chambers, 100 m^2 • 100 μm resolution, high occupancy
Muon Trigger	Low p_t, high p_t thresholds (0.5-2 GeV/c) • 4 planes Resistive Plate Chambers, 140 m^2

Forward and Trigger detectors	
T0	25 ps resolution event time measurement (TOF) Cherenkov counters
V0	Minimum bias trigger, beam-gas rejection Segmented scintillators
Forward Multiplicity Det. (FMD)	Forward charged particles multiplicity Rings of silicon strip sensors
Photon Multiplicity Det. (PMD)	Arrays of gas proportional counters
Zero Degree Calorimeter (ZDC)	Energy of non-interacting nucleons, geometry of HI collisions Quartz fiber sampling hadron and em calorimeters, PMTs
ACORDE	Cosmic rays physics Array of very large scintillators on top of the solenoid Hight p_t cosmic muon trigger for alignment and calibration

On detector integrated circuits

Inner Tracking System
Hybrids, Al-Polymide flex circuits

Radiation tolerant ASICs
2200 Gy, $8.0 \cdot 10^{11}$ cm^{-2} neq (Pixels)
26 Gy, $4.1 \cdot 10^{11}$ cm^{-2} neq (Strips)

	Inner Tracking	Qty
Pixels	ALICE1LHCb, DigPilot, AnPilot, GOL	1 560
Drift	PASCAL, AMBRA, CARLOS, GOL	9 360
Strips	HAL25, ALCAPONE, ALABUF	27 168

0.250 µm, Mixed Signal, Radiation Tolerant

< 2 Gy, $2.4 \cdot 10^{11}$ cm^{-2} neq

Standard CMOS
Flash or SRAM based
FPGAs

	Tracking - PID	Qty
TPC	PASA (0.35 µm), ALTRO	34848+34848
TRD	PASA, TRAP (0.18 µm)	141 696
TOF	NINO, HPTDC	19116+19116
HMPID	GASSIPLEX (0.7 µm), DILOGIC (0.7 µm)	10080+3360
MUON	MANAS, MARC	85 000

Central systems

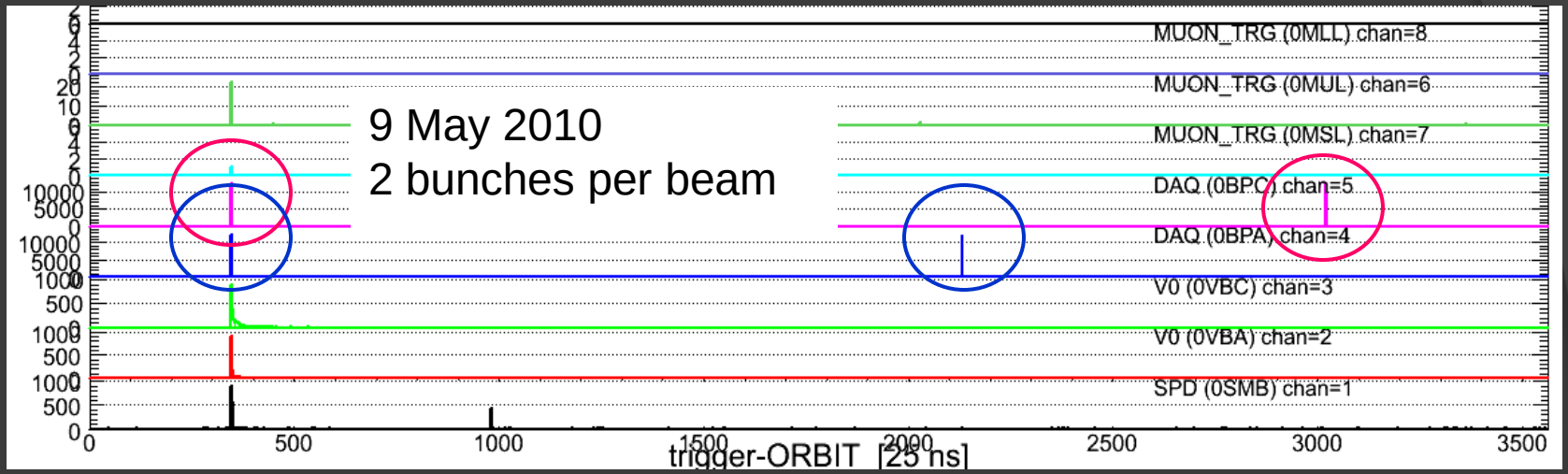
Central Trigger Processor (CTP)	ALICE interface to LHC clock signals Trigger decision on trigger detectors inputs Past Future Protection for HI pile-up Distribution of clock, orbit, trigger messages to all detectors on TTC LTU interface to all detectors FERO
DAQ	Very large bandwidth from FEROs, to/from HLT, to storage 200 MB/s custom optical data link (DDL) from all detectors
HLT	Event selection, event size compression, QA Independent Farm Very flexible at the price of larger bandwidth
DCS	Configuration and control of all systems Interface to LHC
ECS	Supervisory control and configuration interfaces ALICE Configuration Tool

Event sizes and readout rates

Readout rates depend on occupancy. Values quoted were tested with no beams.
pp event sizes from 6h pp reference run 130795, low pile-up conditions.

		pp event size [kB]	Pb-Pb size [kB]	Max readout rate [Hz]
Pixels	SPD	6	140	3300
Drifts	SDD	15	1500	990
Strips	SSD	40	160	3265
Time Projection Chamber	TPC	700	75 900	3500
Transition Radiation Detector	TRD	64	8000	3500
Time of Flight	TOF	21	180	2400
High Momentum PID	HMPID	18	120	3300
EM Calorimeter	EMCAL	16		1600
Photon Spectrometer	PHOS	11	20	1200
Muon tracker Muon trigger	MTK MTR	34 7	150	1200 6500
Zero Degree Calorimeter	ZDC	0.7		9000
Photon Multiplicity Detector	PMD	26	120	1200
Forward Multiplicity Detector	FMD	15		4800
V0	T0	6		13000
T0	V0	0.3		35000
ALICE Cosmic Ray Detector	ACORDE	0.1		9000
ALL ALICE		**980**	**86 300**	

Alignment of first level trigger inputs



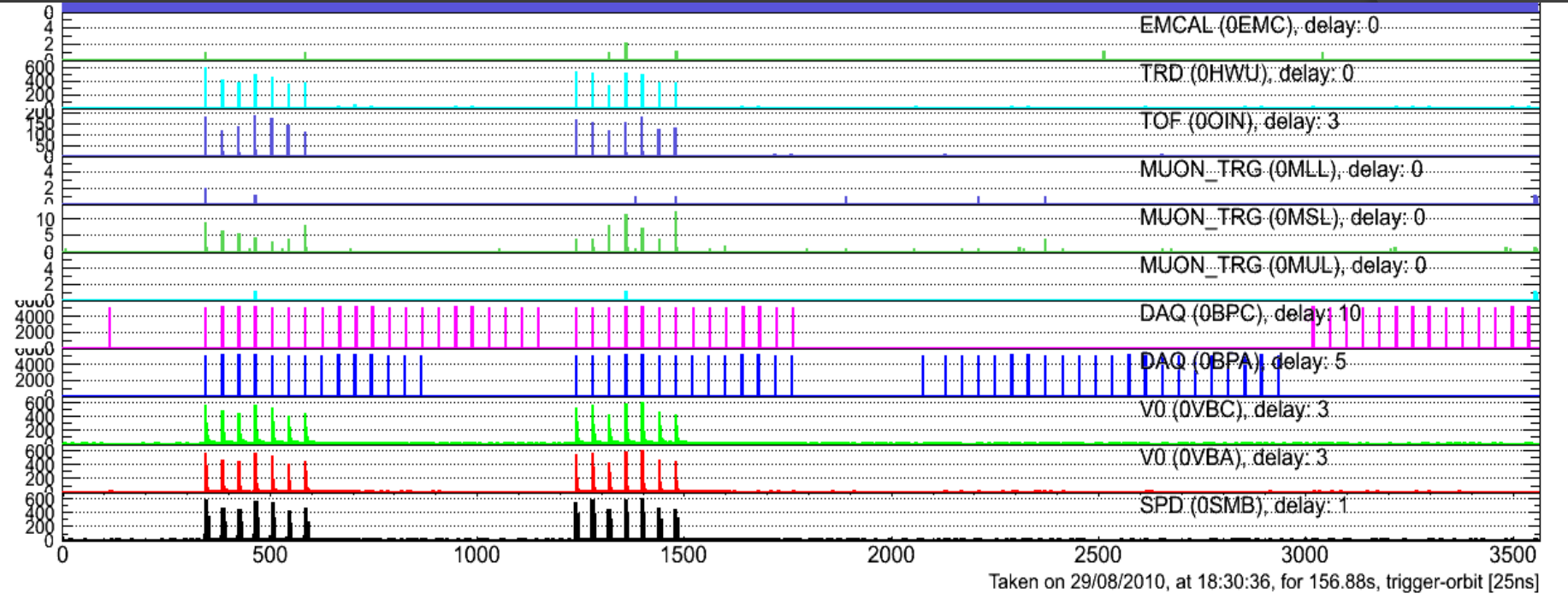
Central Trigger samples all inputs with BC clock

- Snapshot Memory
  - Real time recording of trigger inputs over ~300 orbits

Time alignment

- Reduction of firmware and cabling latencies

Alignment of first level trigger inputs



Central Trigger samples all inputs with BC clock

- Snapshot Memory
  - Real time recording of trigger inputs over ~300 orbits

Discrete time alignment

- Reduction of firmware and cabling latencies