OPERATIONAL EXPERIENCE OF THE ALICE PIXEL DETECTOR

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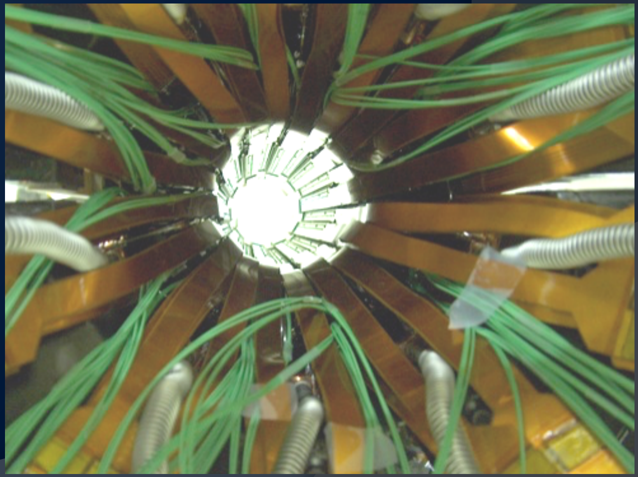
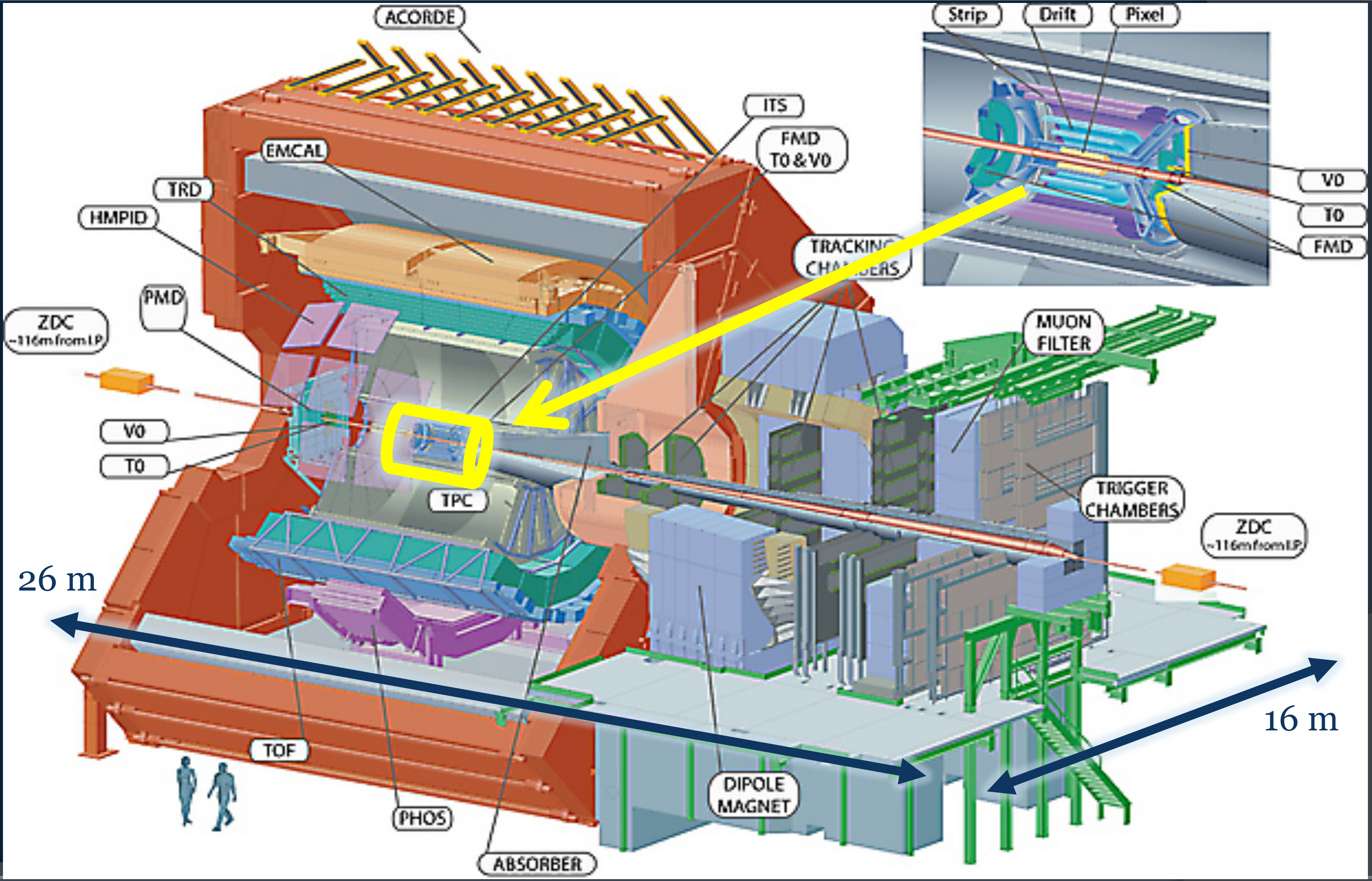
On Behalf of the ALICE Collaboration



Outline

- ALICE Silicon Pixel Detector
  - From Run 1 to Run 2
  - Operation after long shutdown
- Detector status
  - Calibration
- Trigger performances
  - Online Background rejection
  - High multiplicity
  - Double gap diffractive

ALICE Inner Tracking System



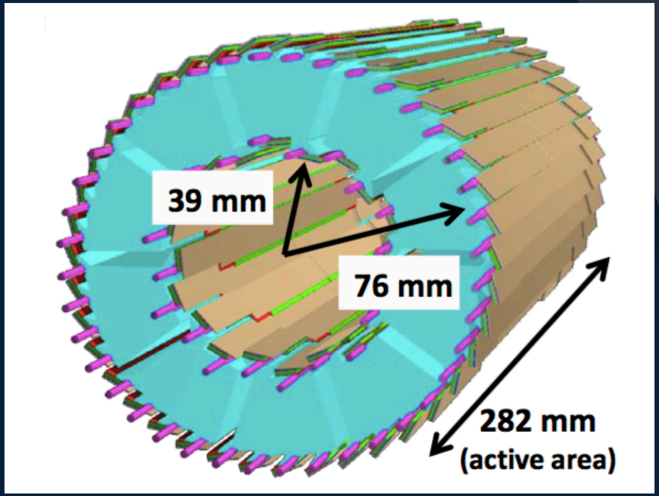
ALICE Silicon Pixel Detector SPD

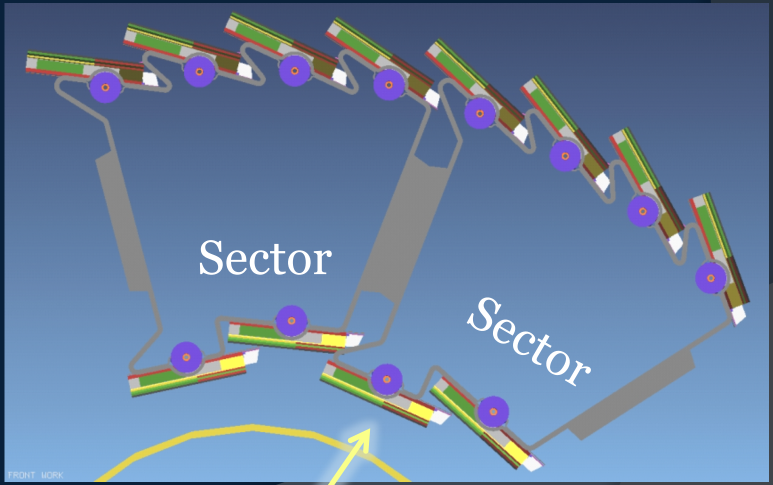
Design goals :

- Primary and secondary vertices
- Contribution to tracking
- Contribution to ALICE L0 Trigger

Detector characteristics :

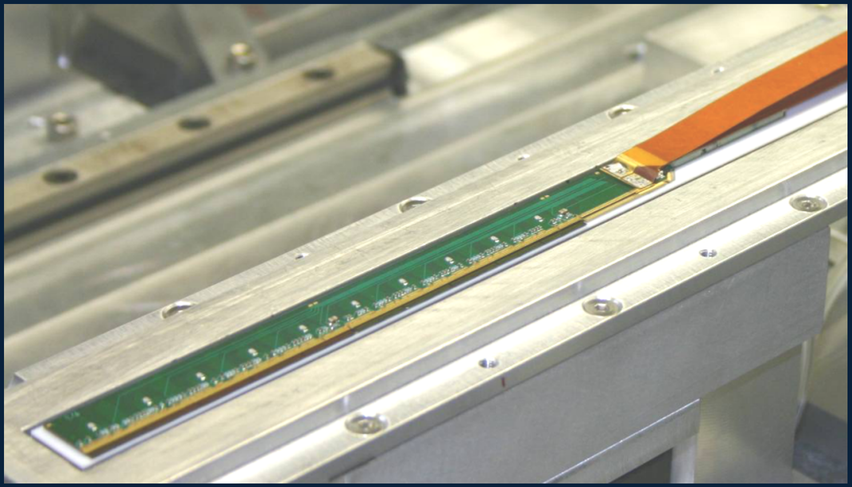
- spatial precision:
  - 12 μm in rφ and 100 μm in z
- Pixel size :425μm x 50μm (z x rφ)
- material budget: ~1.1% X_0 per layer
- Readout time: 256 μs
- power consumption: 1.35 kW (0.5 W/cm²)

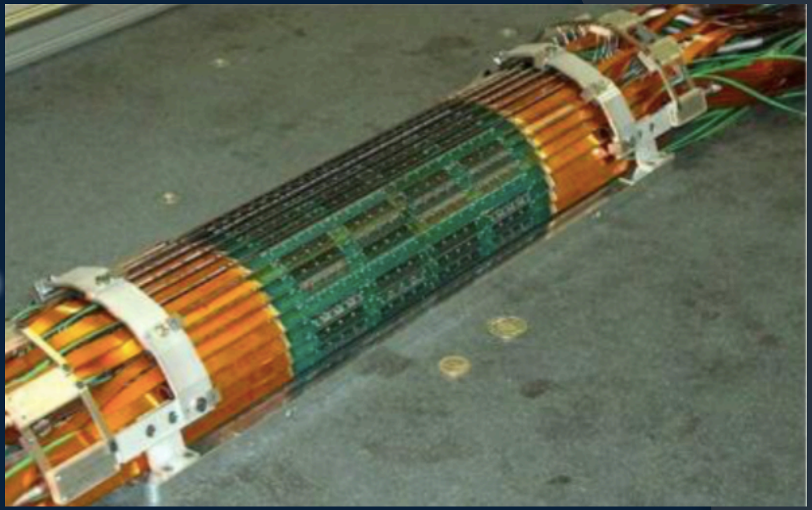


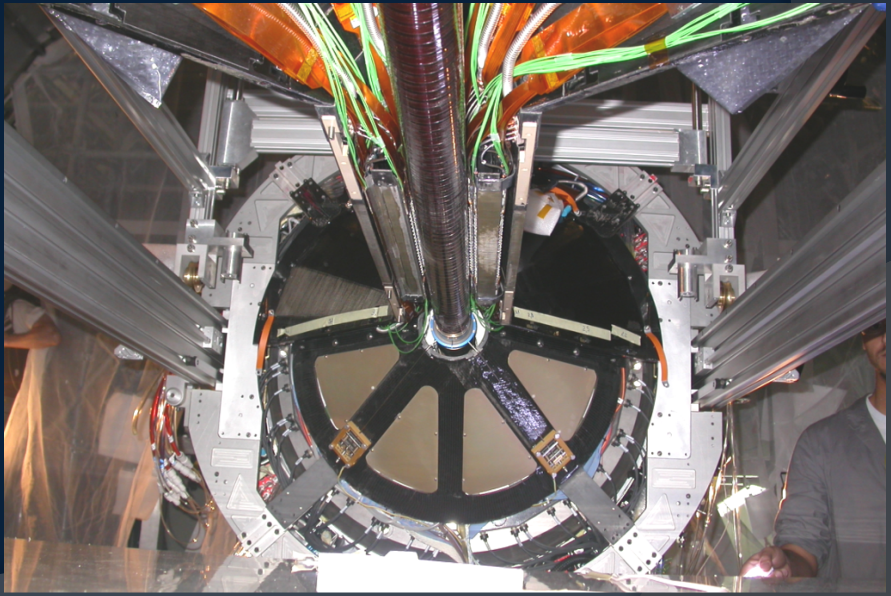


Minimum distance to the beam pipe : 5 mm

ALICE Silicon Pixel Detector SPD





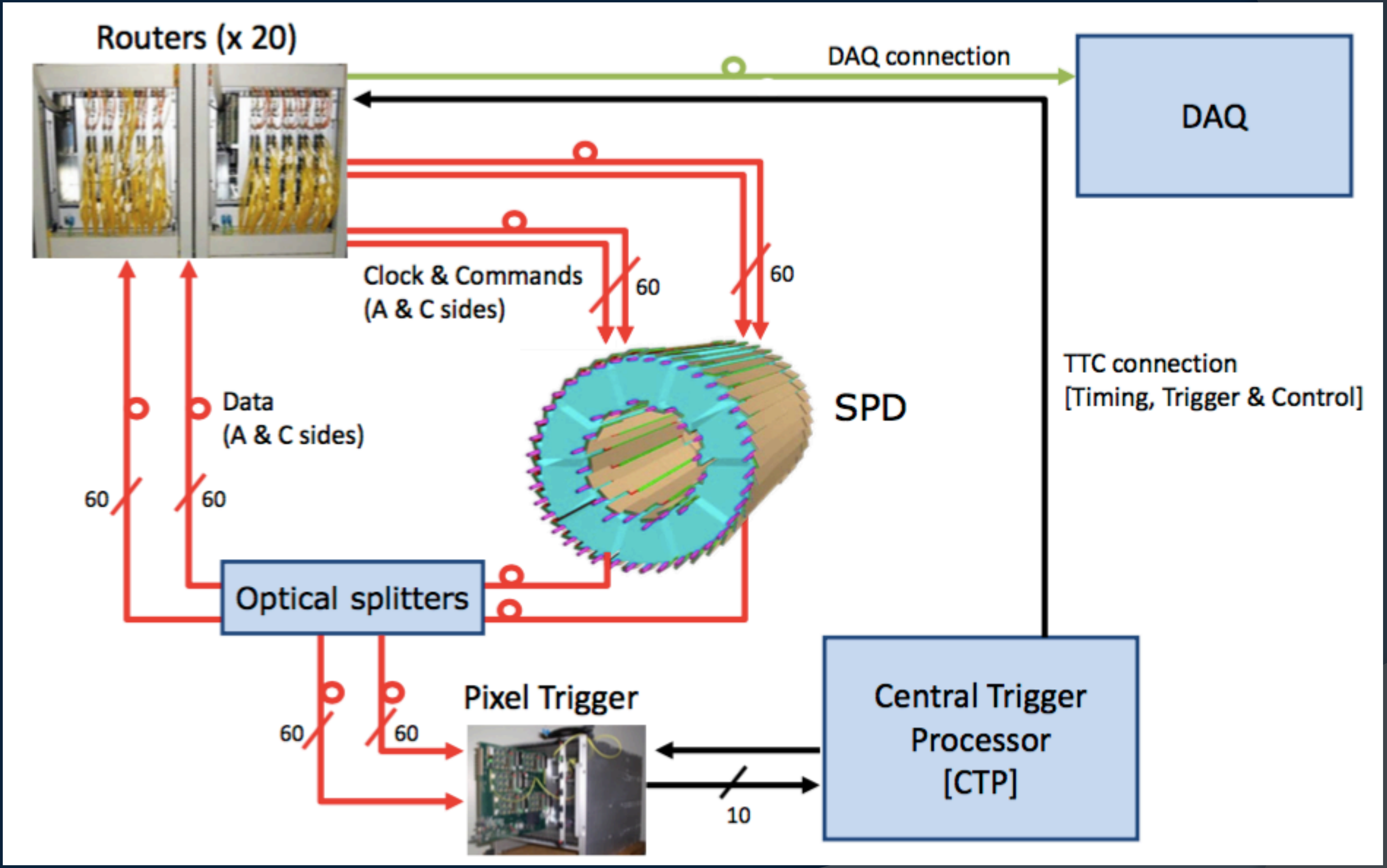


Smallest fully functional block : Half Stave

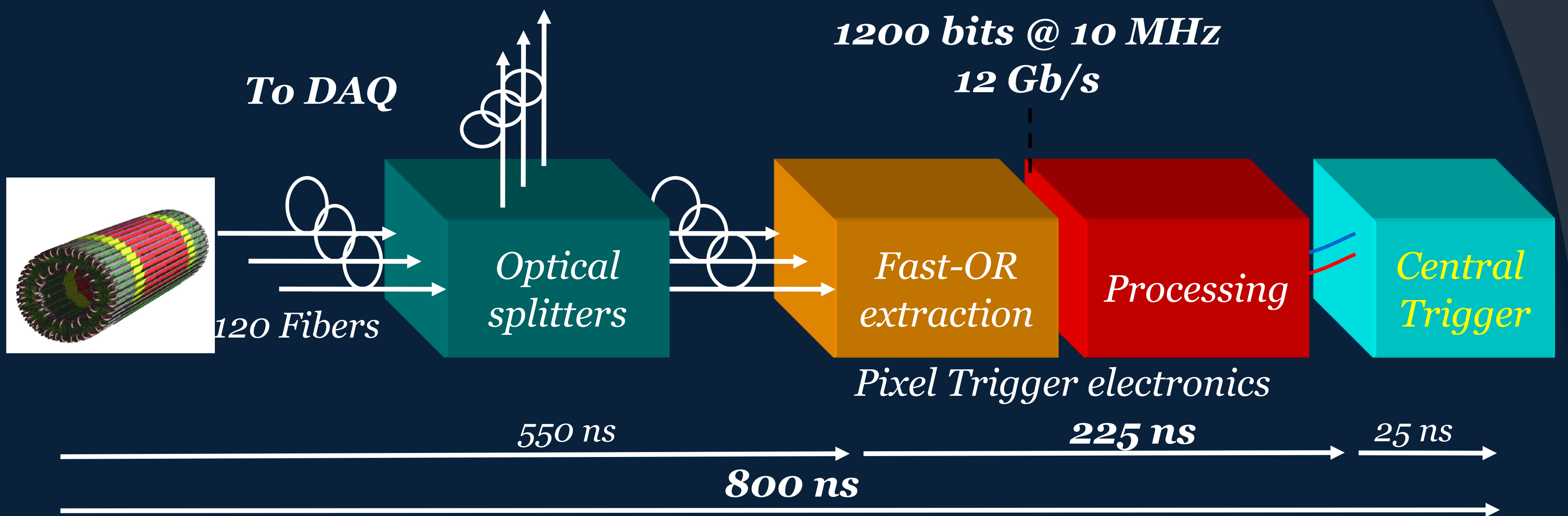
Detector segmentation :
10 Sector
120 half-staves (40 inner +80 outer)
10 pixel chips per half stave
- ➢ 1200 chips (400 + 800)

Each chip has 256 x 32 pixels
- ➢ 9.83×10^6 pixels in total

SPD integration in ALICE



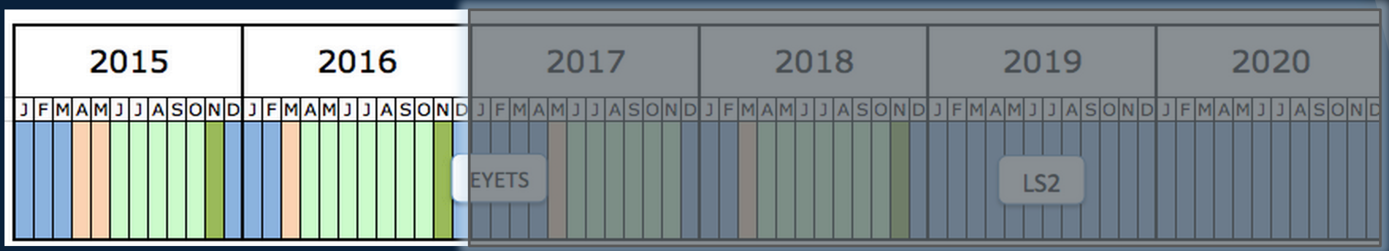
Pixel Trigger Schematics



- ❑ Basic information : FastOr bit per chip
  TRUE if at least one pixel is fired
- ❑ 1200 FastOr bits per event sent to the Pixel Trigger Electronics for processing
- ❑ 10 programmable algorithms based on 1200 bits and boolean logics return 10 boolean responses to CTP

From Run1 to Run2

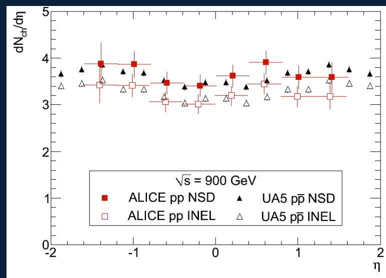
- End of Run1 : March 2013
- Long Shut down 1
- Run2 :



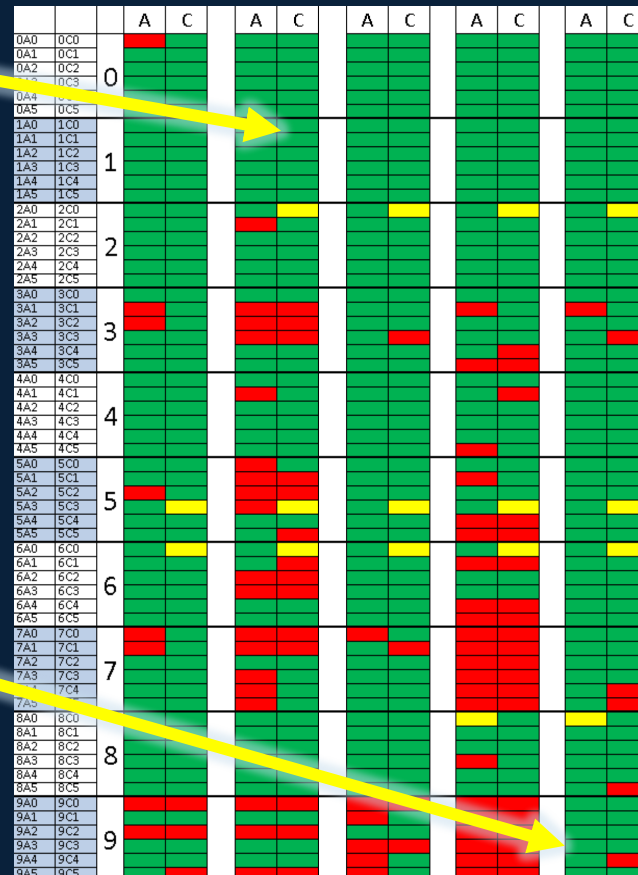
  - Recommissioning with beams in May 2015
    - Energy increase up to 6.5 TeV per beam
    - 25 ns bunch spacing in trains
  - Instantaneous luminosity up to 5 Hz/ub
  - Campaign for minimum bias and rare triggers at low pile up (μ)
  - Pb-Pb collisions in December 2015
  - P-Pb collisions foreseen in December 2016

Operational half-staves from Run1 to Run 2

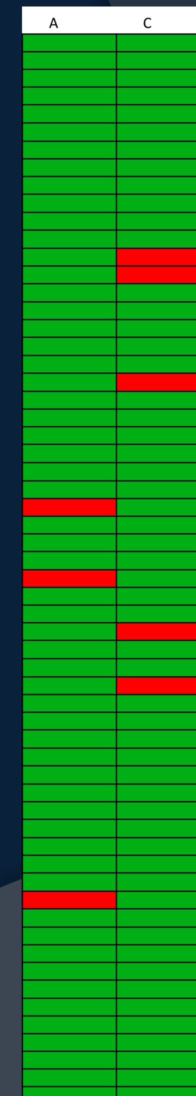
First collisions 2009
-> 1° ALICE paper



Run 1 : 2008 to 2013



Run 2



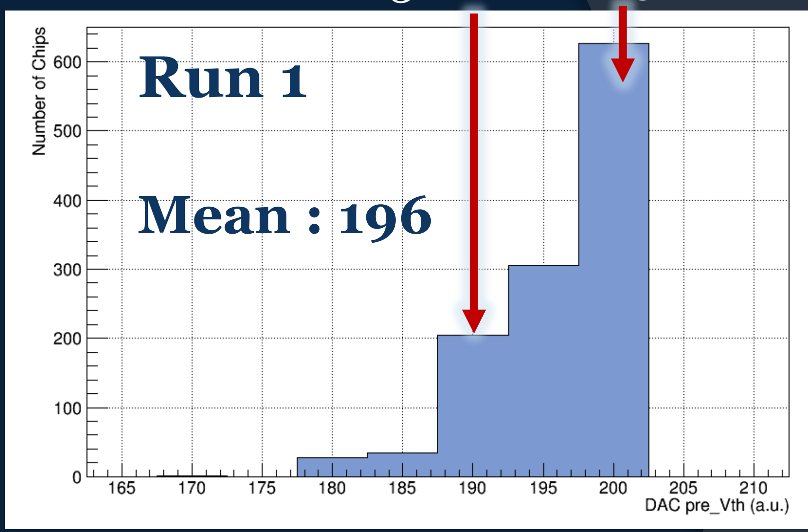
End 2012 :
Challenging filter
drilling operation

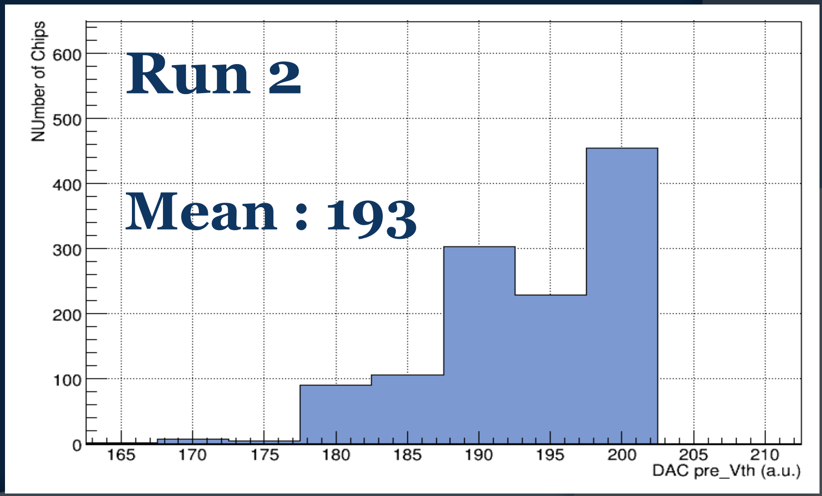
- Half staves included in DAQ :
  - Run 1 110
  - Run 2 112

Detector Configuration

- FEE configuration similar to Run 1
  - Threshold campaign
  - Timing campaign
- Same noisy pixel fraction as in Run 1 $\approx 10^{-4}$
- Change of the latency of the trigger signals from the CTP lead to a timing campaign that aimed to match the internal data readout delay with the arrival of the trigger. A mis-match between the Fast-OR and the pixel data was found and solved.

~3100 e- ~2500 e-

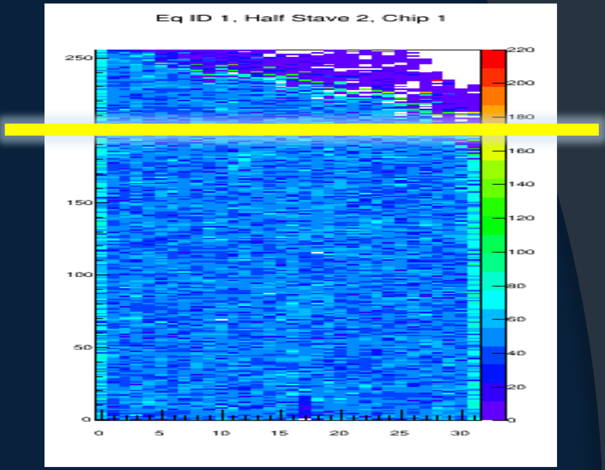




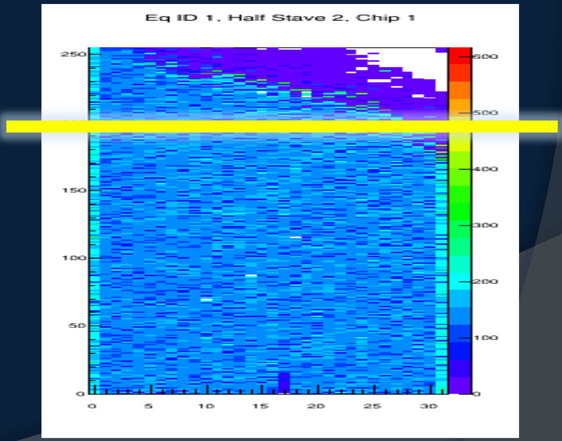
Detector Configuration

- Expected increase of dead areas
- Switching on and off HV => thermal cycles that in turn cause the detaching of the readout chips from the sensor
- Dead pixels are due to missing bump bondings at the 4 corners of the chip. Other contributions are from
  - Dead pixel from construction
  - Inefficient pixels
- Inefficient and dead pixel in hs in DAQ :
  - Run 1 (2013) 2%
  - Run 2 (2015) 4.5%

Run 1



Run 2



Detector Operation

- Same as in Run 1 :
  - Configuration done once, then tuned. Further checks only after a technical stop.
  - Noisy pixels rarely appear. Usually very few in a run (<3)
  - The detector configuration parameters of front-end and trigger algorithms are checked automatically at each run by means of the Alice Configuration Tool (ACT)
  - Same working conditions in pp and PbPb also in Run 2
    - New higher luminosity regime in pp

- Smooth operation of the detector during Run 2
  - Loss of configuration of one hs or few chips during data taking
  - Data format errors (missing header/trailer)

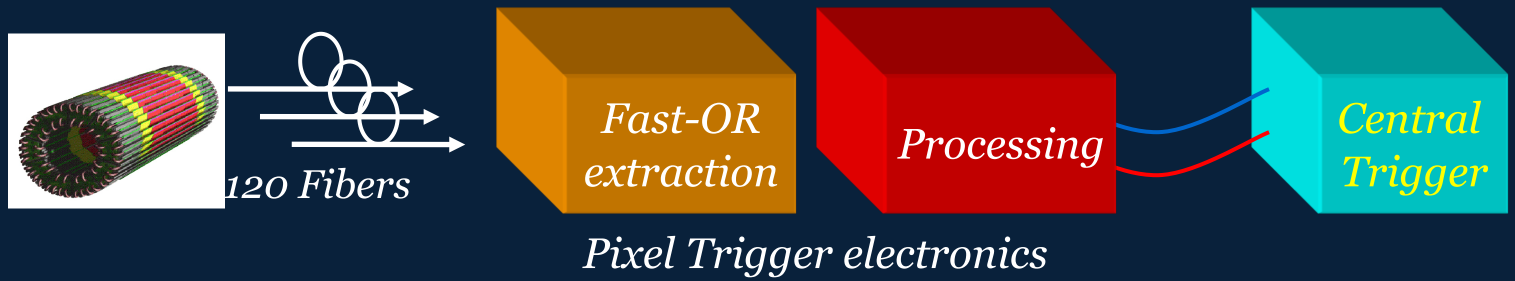
- Fraction of Phyiscs Runs with SPD :
  - Run 1 (2013) = 86%
  - Run 2 = 93%

- EOR caused by SPD :
  - Run 1 : 2%
  - Run 2 : 4%

New Feature in Run 2

- New trigger classes used in ALICE as L0 from Pixel Trigger :
  - Online Background rejection studies
  - High Multiplicity studies
  - Double gap diffractive studies
    - New firmware deployed

2015 (Online Background rejection studies, High Multiplicity studies)
→ 2016 (Double gap diffractive studies)



Pixel trigger I/O

- Input : 1200 bits
- Output : 10 programmable algorithms

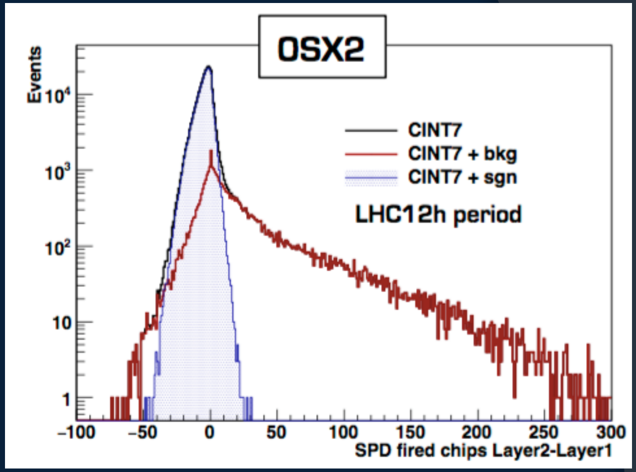
Pixel Trigger Algorithms

Output	Name	Algorithm
1	Minimum Bias	$(I+O)\geq th_0$ and $I\geq th_1$ and $O\geq th_2$
2	High Multiplicity 1	$I\geq th_1$ and $O\geq th_2$
3	High Multiplicity 2	$I\geq th_1$ and $O\geq th_2$
4	High Multiplicity 3	$I\geq th_1$ and$O\geq th_2$
5	High Multiplicity 4	$I\geq th_1$ and$O\geq th_2$
6	Generalized topological trigger with programmable acceptance	Based on tracklets
7	Less Than	$I\leq th_1$ and $O\leq th_2$
8	Spare background	$O \geq I+ offset_{Outer}$
9	Background	$(I+O) \geq th_{(Inner+Outer)}$
10	Cosmics	Selectable coincidence

Online background estimator (2015)

Main idea :

- Bunch-Bunch collisions expected to have equal number of Fired Chips in the two layers. The event distribution peaked around difference in Layer1–Layer2 equals to 0
- Bunch-Gas collisions expected to have large difference in the number of Fired Chips in the two layers

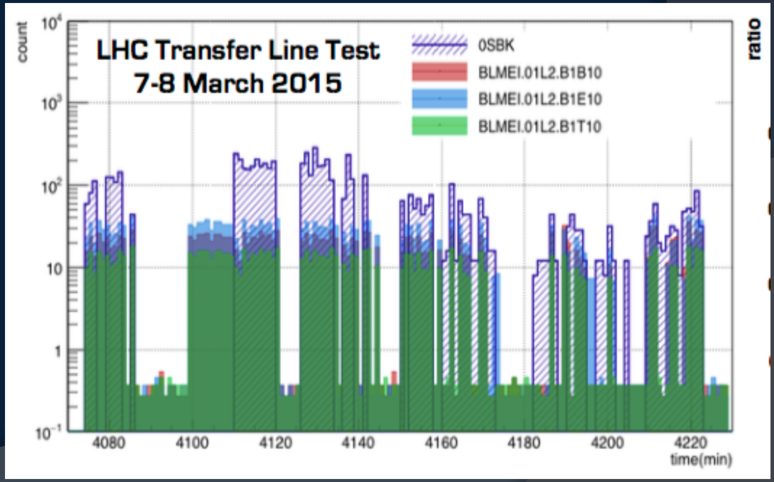


Background trigger algorithm :
I > O + Threshold

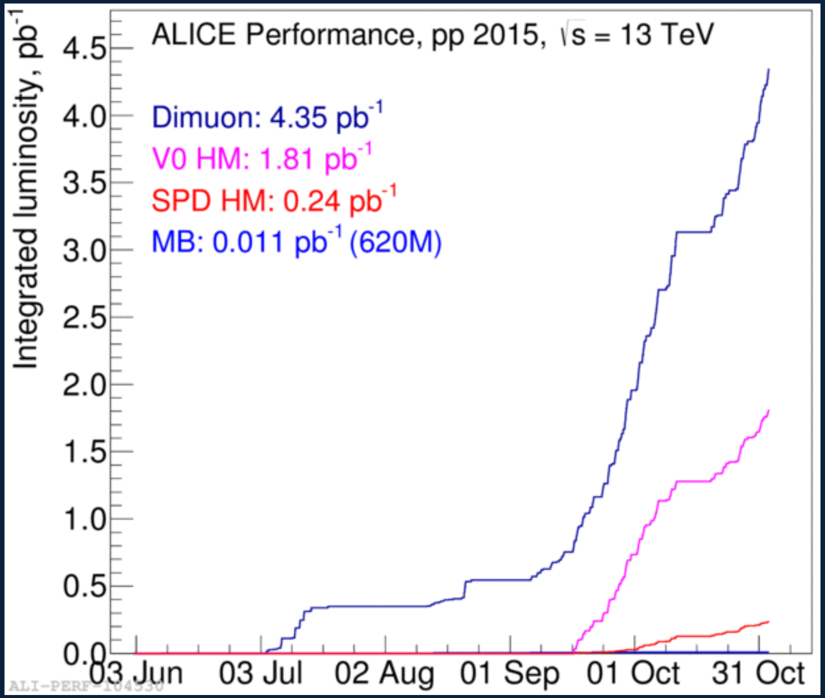
Recent studies performed on data taken in 2012 prove that background can be efficiently separated

- E.g. with a Threshold = 20 the background reduction is ~40%

LHC Transfer Line Test (7-8 March)
beam quenched on the TDI : correlation found between BLM and 0SX2



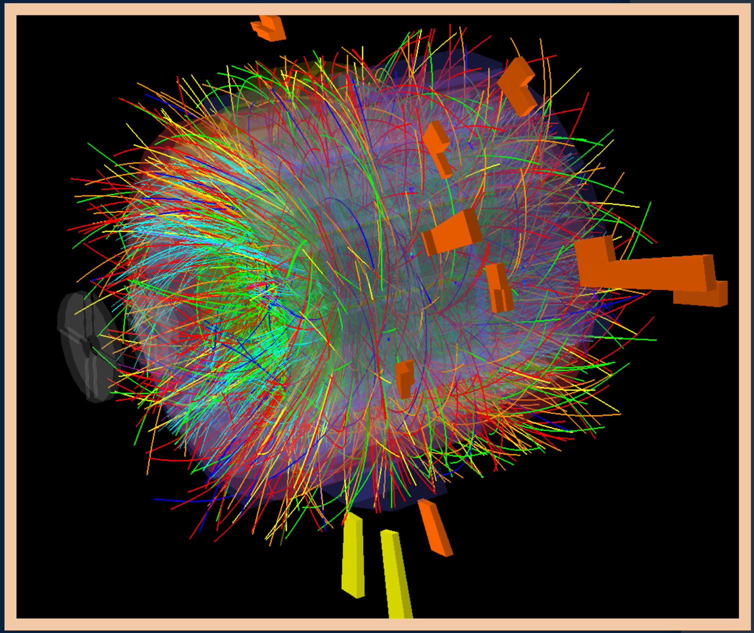
High Multiplicity Trigger (2015)



I≥0 and O ≥ 70

High background

p-p @ 13 TeV

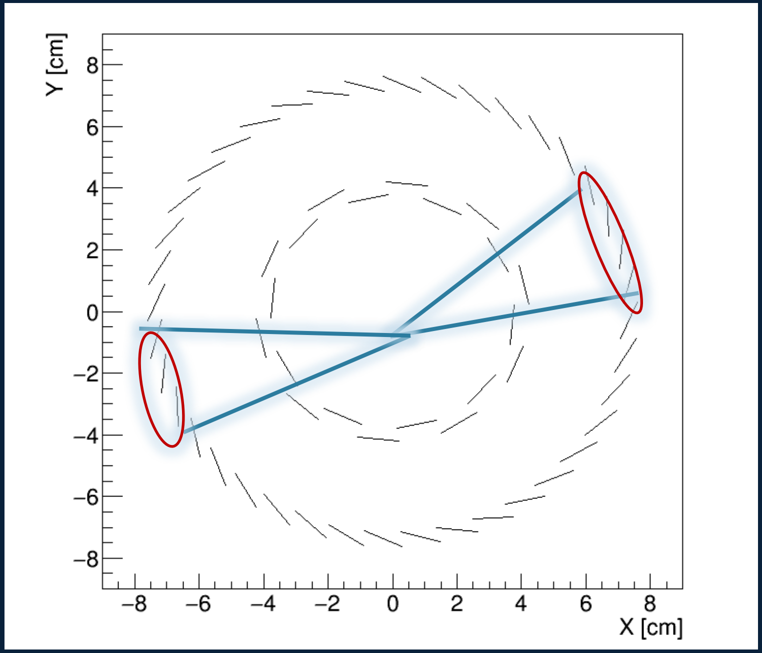


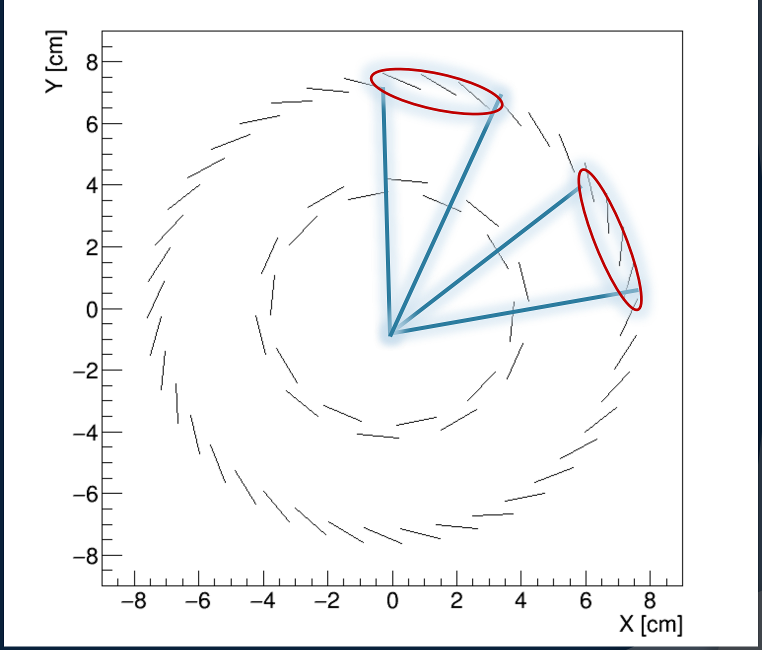
High multiplicity pp event

Topological Trigger (2016)

Tracklet : correlation in rϕ between chips in the inner layer and chips in the outer layer

Topological trigger : based on chip inside cones





Input parameters foresee also :
- opening angle between two tracklets
- Number of tracklets (min and max)

Under study

Summary

- All leftover issues from Run 1 solved during Long Shutdown
- The re-commissioning of the detector and the new data taking went smoothly. The number of half-staves in read-out is the same as in Run1
- Exploitation of new trigger capabilities such as online background rejection, High Multiplicity, topological trigger for double gap diffractive events
- Detector proved to be robust providing key data and trigger information since the very beginning of LHC running
- The very good performance of the SPD during data-taking provides a fundamental information to many physics analysis that result in published papers

Backup

Activities during LS1

- Readout electronics issue in Run 1 : high busy time
  - problem in the firmware identified and solved
- New VME controller for crates with readout electronics
  - replaced National Instruments controller with CAEN controller
- Migration of DCS software
  - New operating systems installed in machines at P2
  - Old PVSS software for User Interface moved to the new platform WinCC
- Cooling Intervention : further improvement!
  - Issues with a pump at the cooling plant in Run 1 solved by changing the pump with a gear pump. Good stability since its replacement in March.
  - Replacement of broken compressor
- 4 new HV boards