

The new Inner Tracking System for the ALICE Upgrade

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Goals of the ALICE Upgrade

Physics motivations for the Upgrade -> High precision measurements of rare probes over broad $p_{\rm T}$ range

- \succ Heavy flavour dynamics and hadronization at low p_{T}
- \succ Charmonium down to zero p_{T}
- \succ Thermal dileptons, photons, vector mesons
- \succ High-precision measurement of light and hyper-nuclei

Main upgrade requirements

- \succ Continuous read-out rate in excess of > 50 kHz to fully exploit the LHC Pb-Pb and pp interaction rate during Run3 and Run4
- Improved tracking performance down to very low p_{T}

Upgrade strategy

- New silicon trackers: ITS (mid-rapidity), MFT (forward rapidity)*
- **New TPC read-out chambers (GEMs) and electronics****
- New Fast Interaction Trigger (FIT)
- Fast read-out of other detectors (TOF, TRD, Muon arm, ZDC,...)
- New Online plus Offline system (O2 project)

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ITS upgrade - Requirements and design

ITS upgrade requirements:

- Improve impact parameter resolution
 - Reduce distance from IP to first layer \rightarrow new beam pipe
 - Reduce material budget
 - Reduce pixel size
- Improve tracking efficiency and p_{T} resolution at low p_{T}
 - Increase granularity \rightarrow from 6 to 7 layers, all pixels
- Increase read-out capabilities

	ITS Run1/Run2	ITS ເ
Number of layers	6 (pixel, drift, µstrip)	7 (N
Rapidity range	lηl < 0.9	lηl
Material budget per layer	1.14% (SPD)	0.3
Distance to interaction point	39 mm	22
Pixel size	50 x 425 μm²	29 x
Spatial resolution (rφ x z)	12 μm x 100 μm**	5 μm
Max. readout speed Pb-Pb	1 kHz	10
	** SPD	* Monoli Pixel :









» 54 staves in ML + 90 staves in OL







ITS upgrade - Layout and components (Inner Barrel)











ITS upgrade - Layout and components (Outer Barrel)











ITS upgrade - Component production status

-ALPIDE Chips:

- Institutes: >
- 50 um CERN
- 100 um Yonsei, Pusan

- Total # chips tested: ~70000
- Total # of wafers: ~1700
- Total yield: 63.7%
- Series test ended in mid 2018

Production completed!

Inner Barrel HICs and Staves:

- **Institutes: CERN** >
- ~140 staves assembled with yield of 73% >
- Enough for 2 fully working copies of IB
- ~140 staves assembled with yield of 73%

Production completed!

Outer Barrel stave metrology results







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ITS upgrade - Component production status

Readout electronics:

- Production completed! **Institutes:** Austin (US), Bergen (NO), CERN, Nikhef (NL), Padova (IT)
- 192 FPGA based RUs, operating in a mild radiation environment (<10 krad, 10¹² 1 MeV/n_{eq})
- Board production completed. Functional test ongoing





-Power System

Institute: Berkeley (US)

Production completed!

- CAEN powering modules available and in use in commissioning setup
- Power board production completed. Functional test ongoing (until July 2019)



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- \succ Fully equipped clean-room at CERN (Bld. 167) for layer assembly and commissioning → Same backend system that will be used in the experiment (Cooling plant, Power and **Read-out racks, Trigger and DAQ system)**
- Layer assembly proceeds with the availability of staves (Outer Barrel)
- DCS and DAQ systems: development of full functionalities ongoing
- Commissioning before installation
- \succ continuous operation 24/7
- data taking with cosmic rays and calibration scans
- Fully automatised data quality control flow under preparation





Inner Barrel





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- All staves and mechanical supports available
- IB-HL-0: able to read out all staves >
- Final powering and read-out chain
- \succ IB-HL-1: fully connected to electronics and under test
- ➤ IB-HL-2 : connection under preparation
- Remaining HLs will follow with the availability of RUs
- Commissioning ongoing of IB-HL-0 \succ



Threshold Tuning for IB-HL-0



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- 25 - 20 - 15 - 15 - 15 - 10



Inner Barrel





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Threshold Tuning for IB-HL-0



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- 25 - 20 15 - 15 Threshold [DAC] - 5



Outer Barrel



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All Staves assembled on following half-layers

- OB-HL-3 \rightarrow Integration ongoing
- OB-HL-4 \rightarrow Completed
- OB-HL-5 \rightarrow Completed!
- OB-HL-6 \rightarrow Completed!
- ➤ Cabling ongoing on OB-HL-6
 - Next HL to be included in the commissioning









ITS upgrade - Conclusion and outlook

- \succ Detector component production almost completed \rightarrow
 - Two IB 100% \rightarrow completed!
 - OB ~ $85\% \rightarrow$ End by September 2019
 - RU boards, Power boards and Service barrel structure \rightarrow completed!
- \succ Stave integration progressing
- Commissioning on surface started in May 2019
 - → until May 2020

Prepairing of P2 services for detector installation on schedule

 \rightarrow 6 months of commissioning after installation in ALICE



- First reconstructed cosmic ray track in the IB-HL-0
- Thanks to the overlap between adjacent staves
- Three aligned pixel clusters observed in staves 6, 7 and 8 as shown in the figures

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ITS upgrade - Backup slides



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ITS upgrade - Backup slides

» Similar assembly procedure for stave in IL, ML and OL

» Extensive characterisation and quality checks in many assembly steps



HICs alignment **Space Frame** 5 and gluing to the gluing Cold Plate HICs **Power bus** Electrical soldering and (D)interconnection folding **Space Frame gluing Cold Plate glue distribution** IL and O staves **HICs electrical interconnection**

Power bus folding

