First results of the upgraded ALICE Inner Tracking System in LHC Run 3

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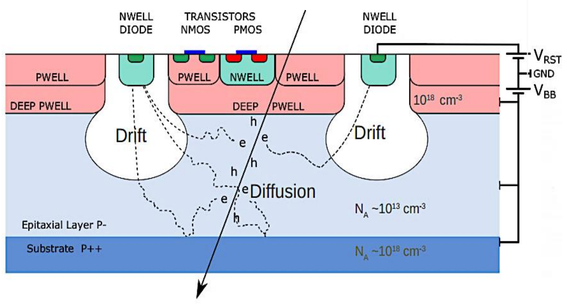
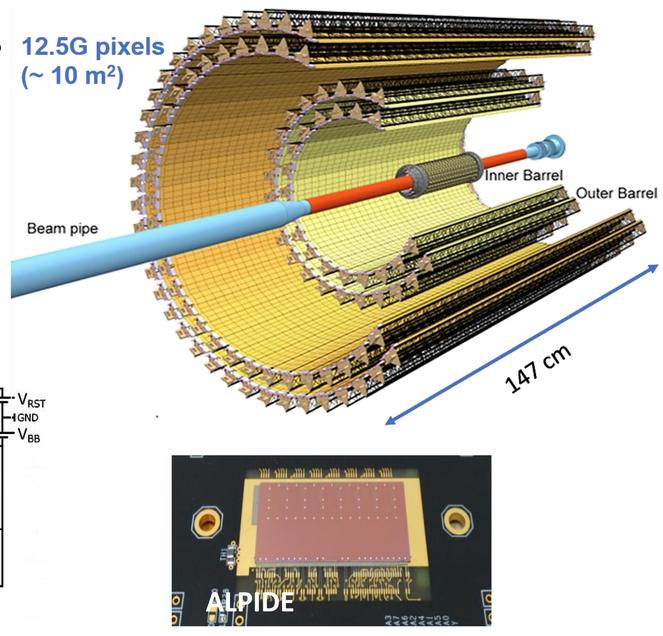
Inner Tracking System upgrade for LHC Run 3 – ITS2

ALPIDE

- TowerJazz 180 nm CiS Process, full CMOS
- High resistivity epi-layer (>1 kΩ·cm)
- Reverse biasing available
- 1.5 x 3 cm, 512 x 1024 pixels
- In-pixel amplification, discrimination and buffering
- Spatial resolution ~5 µm
- Read out up to 1.2 Gbit/s

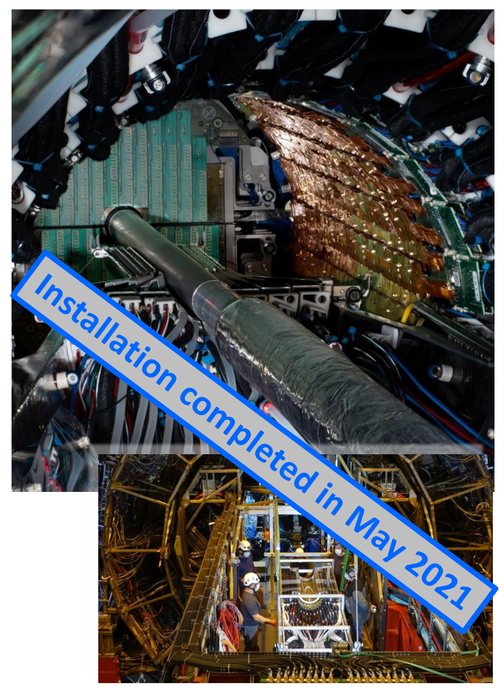




ITS2

- Entirely Monolithic Active Pixel Sensor (MAPS) based
- 7 cylinders covering ~ 10 m^2 area
  - Inner barrel: 3 inner layers
  - Outer barrel: 2 Middle Layers (MLs) + 2 Outer Layers (OLs)
- Fake-hit rate requirement: < 10^{-6} /event/pixel
- Detection efficiency requirement: > 99%

	ITS1	ITS2
Technology	Hybrid, drift, strip	MAPS
Layers	6	7
Spatial resolution	12 µm x 100 µm	5 µm x 5 µm
Radius	39 – 430 mm	22 – 400 mm
Pseudorapidity	-1 ≤ η ≤ 1	-1.4 ≤ η ≤ 1.4
Material budget	~ 1.14% X_0	~ 0.3% X_0 (inner barrel), ~ 1% X_0 (outer barrel)
Readout capability	1 kHz	>100 kHz (Pb-Pb), >1 MHz (pp)



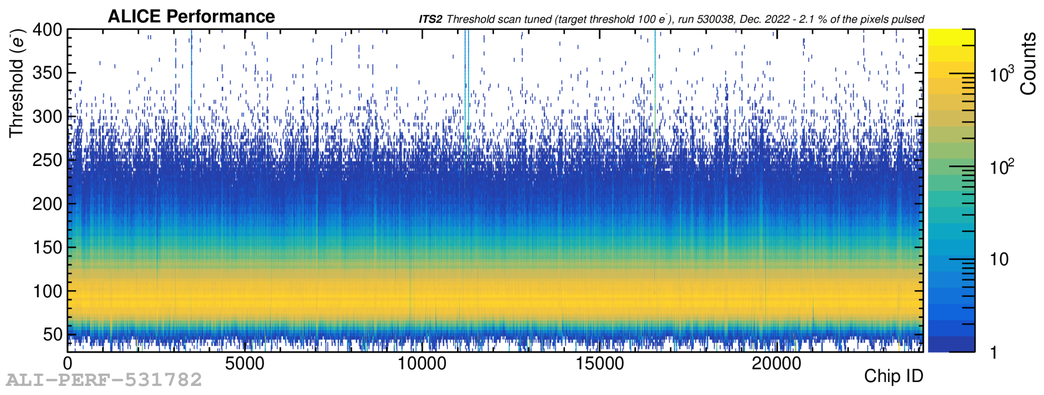
Detector calibration

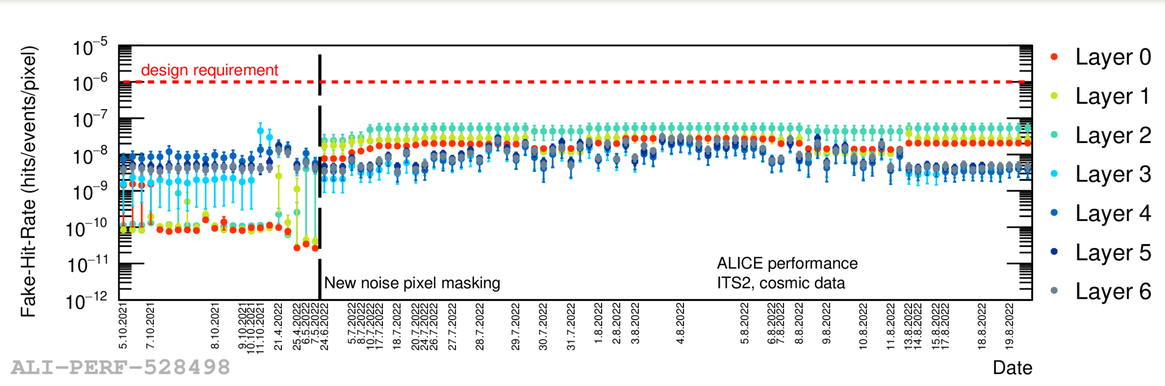
Threshold

- Tuning of analog DACs setting the averaged chip charge threshold
- Online calibration on a representative subset of pixels
- Uniform response across the detector achieved (target to 100 e-). Noise ~5 e- (compatible with production measurements)
- Very satisfying threshold stability over time for 24 k chips

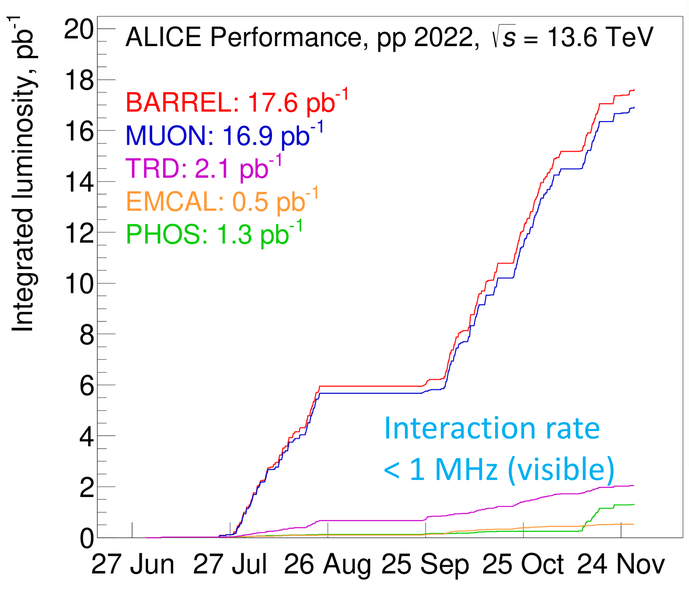
Fake-hit rate

- Possibility to run with static masks already proven during surface commissioning
- OB masking: pixels with 10^{-6} hits/event
- IB masking: almost no mask (10^{-2} hits/event + stuck pixels) → prioritization of efficiency over data rate reduction
- Fraction of masked pixels: 0.15‰
- Stable noisy pixel map → occasionally noise calibration is sufficient





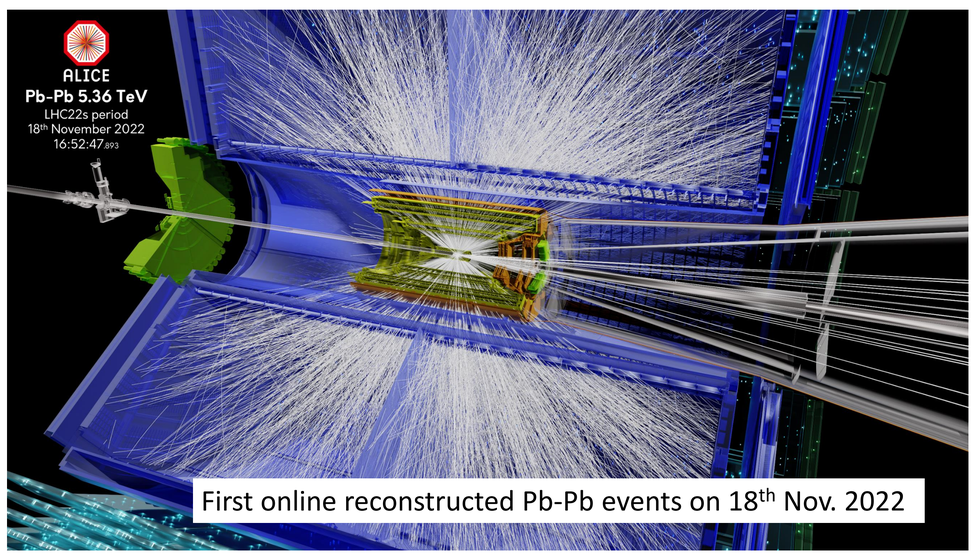
Performance in the first phase of Run 3



Data taking from 2022 to 2023

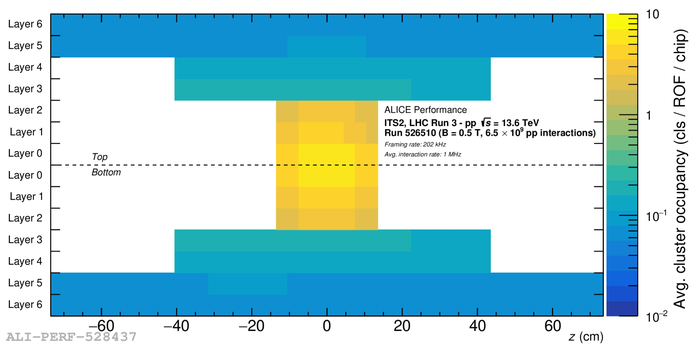
- ITS nominal readout settings
  - pp: 202 kHz framing rate
  - Pb-Pb: 45 kHz framing rate
- In 2022
  - 13.8 pb^{-1} of 13.6 TeV pp data @ 500 kHz (visible interaction rate) collected
  - O(10^6) hadronic interactions recorded in low-rate Pb-Pb collisions at 5.36 TeV per nucleon
- Resumed pp data taking in May 2023; first Pb-Pb physics data taking expected in October 2023

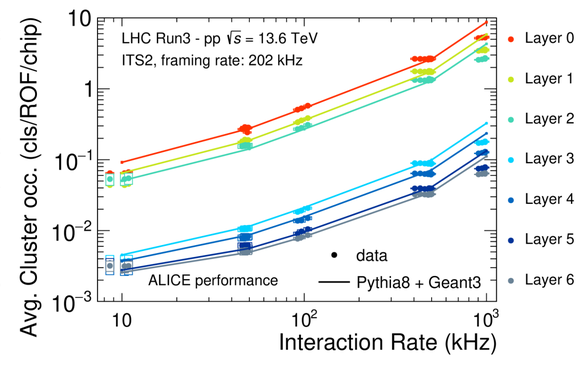
Successful data taking and excellent detector performance achieved in the first period of Run 3!

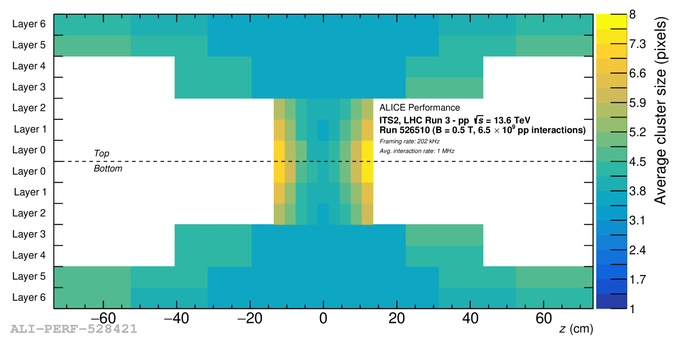


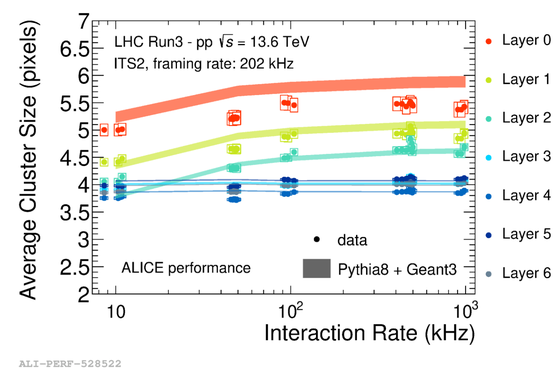
Cluster

- Cluster occupancy dependent on interaction rates and framing rates; stable over time; good agreement with MC simulations;
- Average cluster size ranging from 3 to 8 depending on pseudo-rapidity η; independent from interaction rates; good agreement with MC simulations (deviation ~5%)



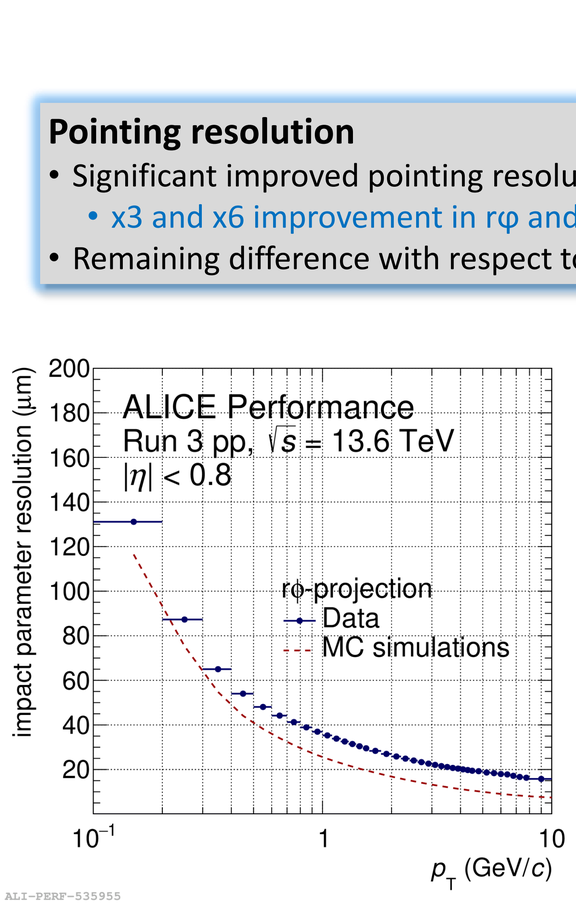


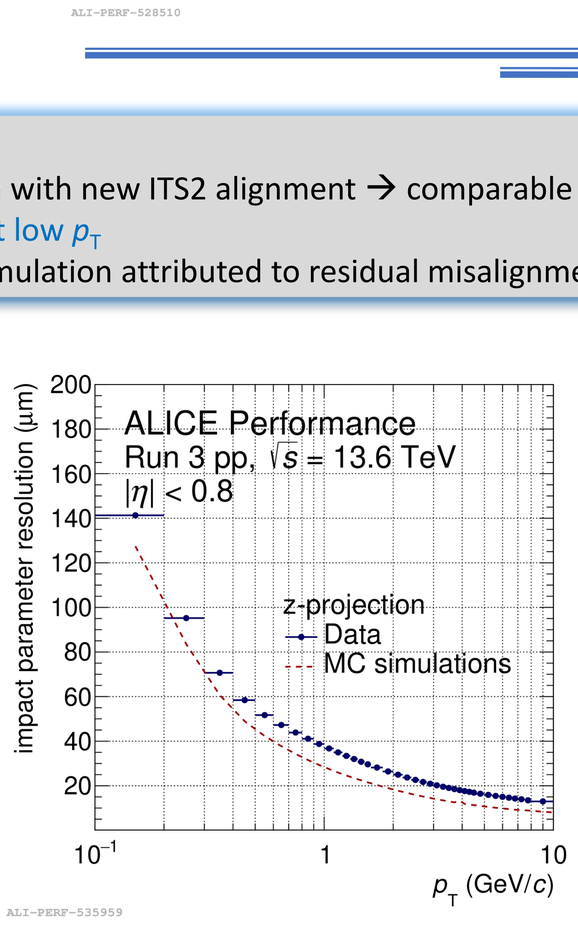


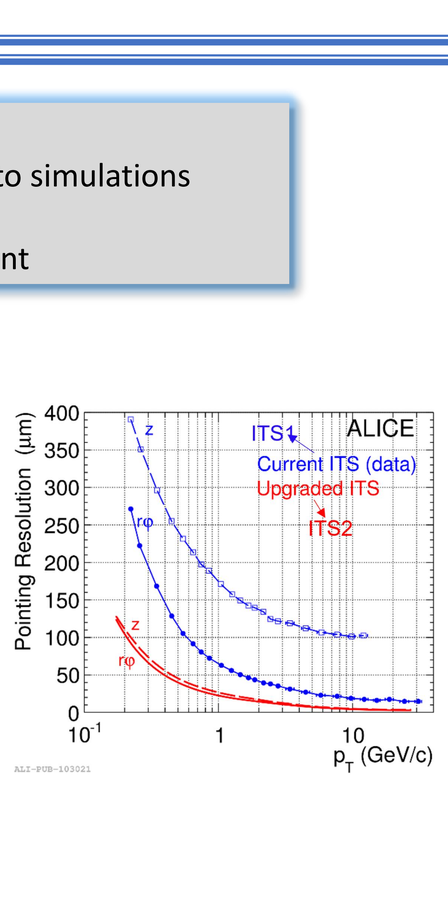


Pointing resolution

- Significant improved pointing resolution with new ITS2 alignment → comparable to simulations
  - x3 and x6 improvement in rφ and z at low p_T
- Remaining difference with respect to simulation attributed to residual misalignment







Invariant mass of K_S^0

- Signal of K_S^0 can be extracted with ITS standalone tracking
- Further studies ongoing to improve performance