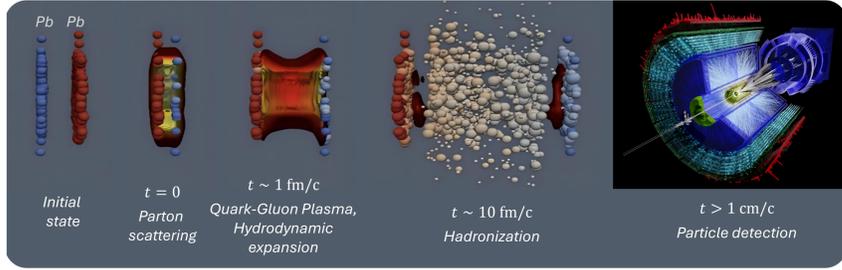




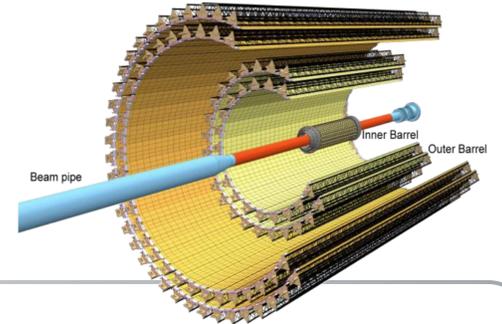
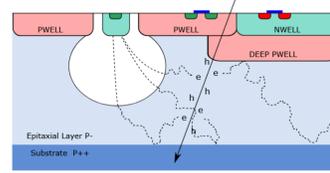
ALICE

**A Large Ion Collider Experiment** is a general purpose experiment at the LHC. It studies the dynamics of strongly-interacting matter produced in heavy-ion collisions.



ALICE underwent a major **upgrade** in 2019-2021, targeting high precision on rare probes especially at very low transverse momentum ( $p_T$ ).

**A completely new Inner Tracking System (ITS2)** made of monolithic active pixel sensors (MAPS). 12.6 billion pixels read out as independent channels and covering a sensitive area of  $\sim 10 \text{ m}^2$ . Currently the largest pixel detector in high-energy physics.



## ITS2 in a nutshell

### ALPIDE chip: the core

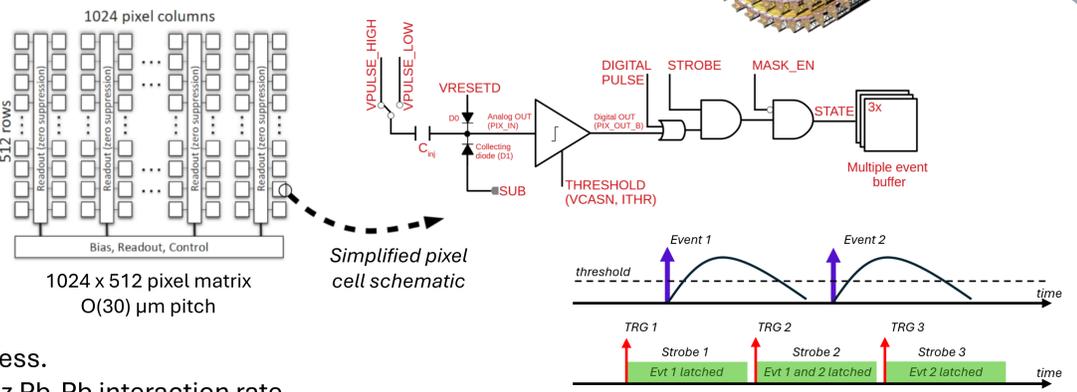
- TowerJazz 180 nm CMOS imaging process: full CMOS circuitry implemented within the  $50 \mu\text{m}$ -thick pixel cell.
- Biases applied chip-wide using DAC registers.
- Matrix read out with zero suppression using 1.2 Gb/s high-speed links.

### Detector design

- 7 layers.
- $5 \mu\text{m}$  single point resolution.
- Close to the interaction vertex: 22 mm.
- Material budget down to  $0.36\% X_0$  / layer.

### Continuous readout

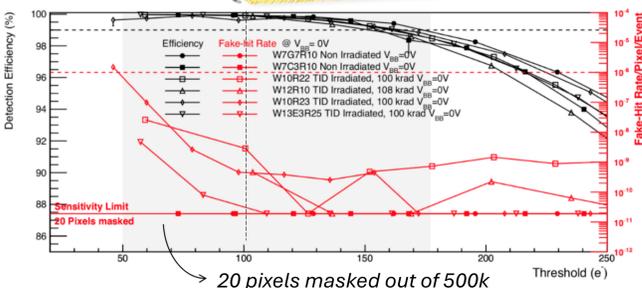
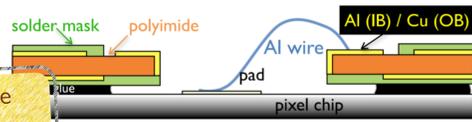
- ALICE is running triggerless.
- Up to 1 MHz pp or 50 kHz Pb-Pb interaction rate.
- 192 FPGA-based readout units working in 0.5 T magnetic field and in radiation environment.



## Past • Assembly and commissioning

30 institutes from North America, Europe and Asia involved in the assembly and characterization.

Mechanical ageing of the outer barrel modules qualified in Pavia and Bari

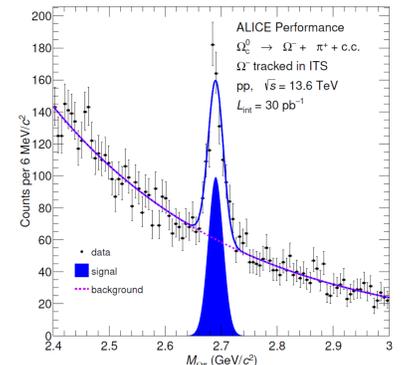
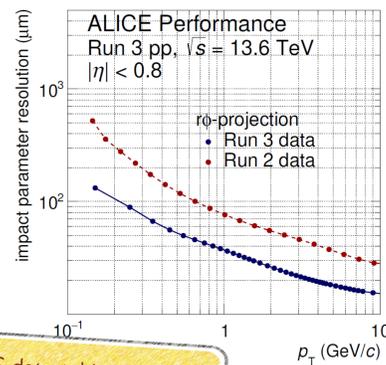


Detection efficiency and fake-hit rate well within the requirements. ITS can run with loose and static pixel masks. The charge threshold is set to 100 electrons. ENC (noise) is  $\sim 5 e^-$ . Stable across 24k chips.

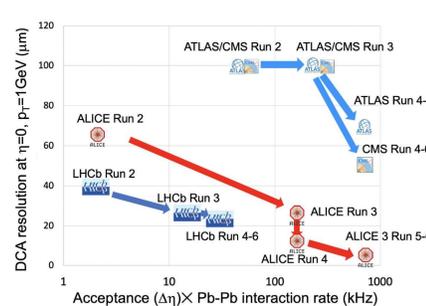
## Present • Selected highlights from data taking

**Track impact parameter resolution** • Twofold improvement compared to the previous ITS1 detector.

**Strangeness tracking** • Weakly decaying particles can be detected directly in the ITS. The measurement of mass and life-time of charmed  $\Omega_c$  baryons is an example of how complex decays are reconstructed in ALICE.



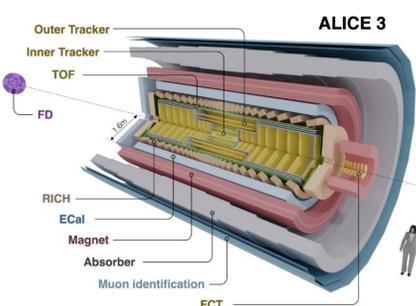
## Future • Upgrades



**ITS3** • A truly cylindrical monolithic pixel detector, it will replace the ITS innermost layers in Run 4. Foundry-level stitching allows for wafer-scale sensors, bent around the beam pipe:

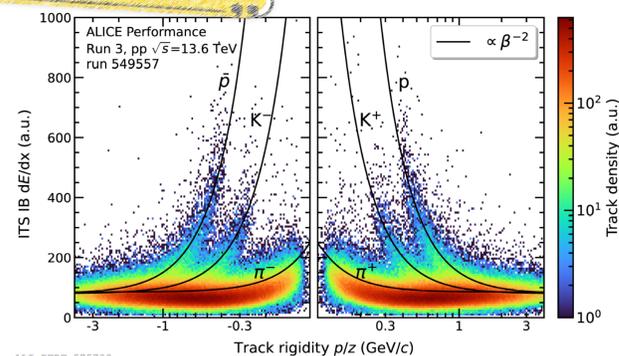
- down to  $0.09\% X_0$  per layer;
- closer to the vertex.

**ALICE 3**  
Unprecedented low material budget, with the innermost layers possibly positioned inside the beam pipe.



Same concept as ITS3 is adopted by the experiment at the Electron-Ion Collider (EIC, BNL). Pavia is also on that...  
S. Costanza, G. Boca, N. Valle + M. Radici

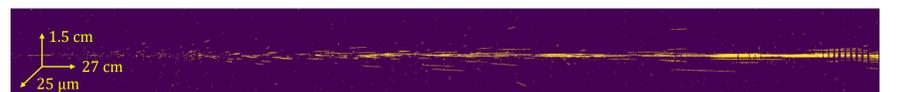
Pavia: ITS data-taking coordination at Run 3 start-up



First  $dE/dx$  measurement in a MAPS pixel tracker. The time over threshold of the analog signal in each pixel is measured by over-sampling the digital response and calibrated using pulse injection.

Particle showers originating upstream are crossing the ITS chips at a very shallow angle, provoking dead time in the readout ...  
... an example of how experience with the current detector guides the development of its upgrades.

The studies on LHC background are coordinated in Pavia



Get in touch for more information or thesis projects



susanna.costanza@unipv.it  
nicolo.valle@pv.infn.it