

# ALICE ITS2

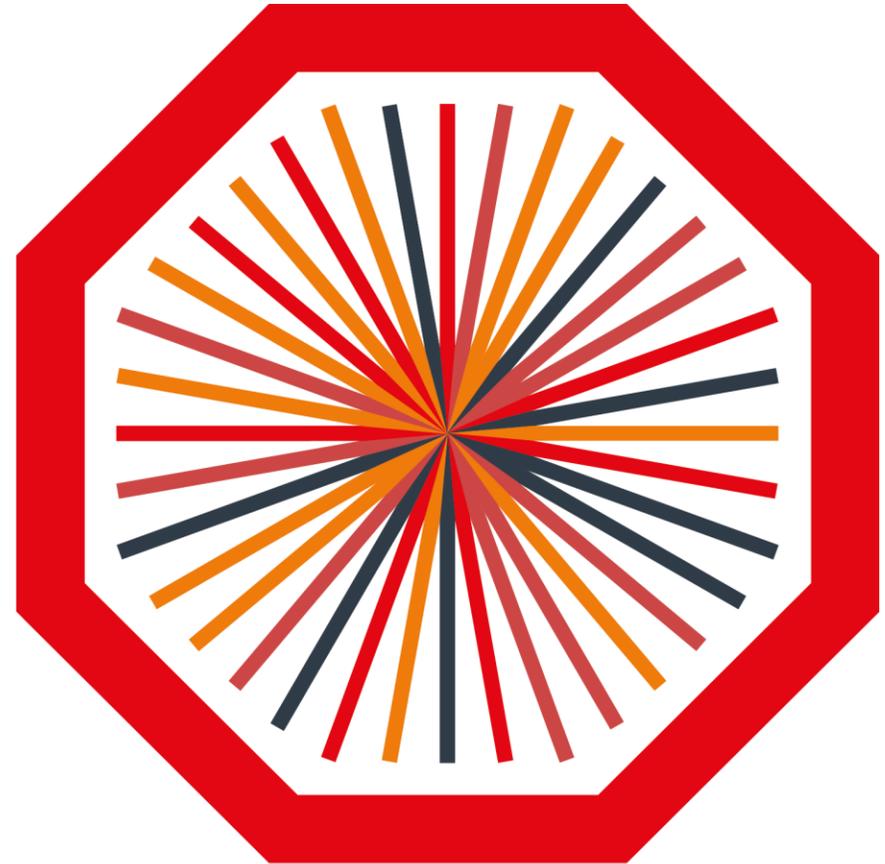
The image shows the interior of the ALICE ITS2 detector. A central copper pipe runs through the center, surrounded by a barrel-shaped structure of gold-plated silicon strips. The strips are arranged in a circular pattern, creating a tunnel-like appearance. The lighting is warm, highlighting the metallic surfaces. In the background, a person is visible, providing a sense of scale. The overall scene is a detailed view of the detector's internal components.

By Wopke Telman

# ALICE

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- A Large Ion Collider Experiment
- LHC at CERN
- 1993
  
- Quark Gluon Plasma (QGP)
- Pb-Pb collisions
- pp collisions

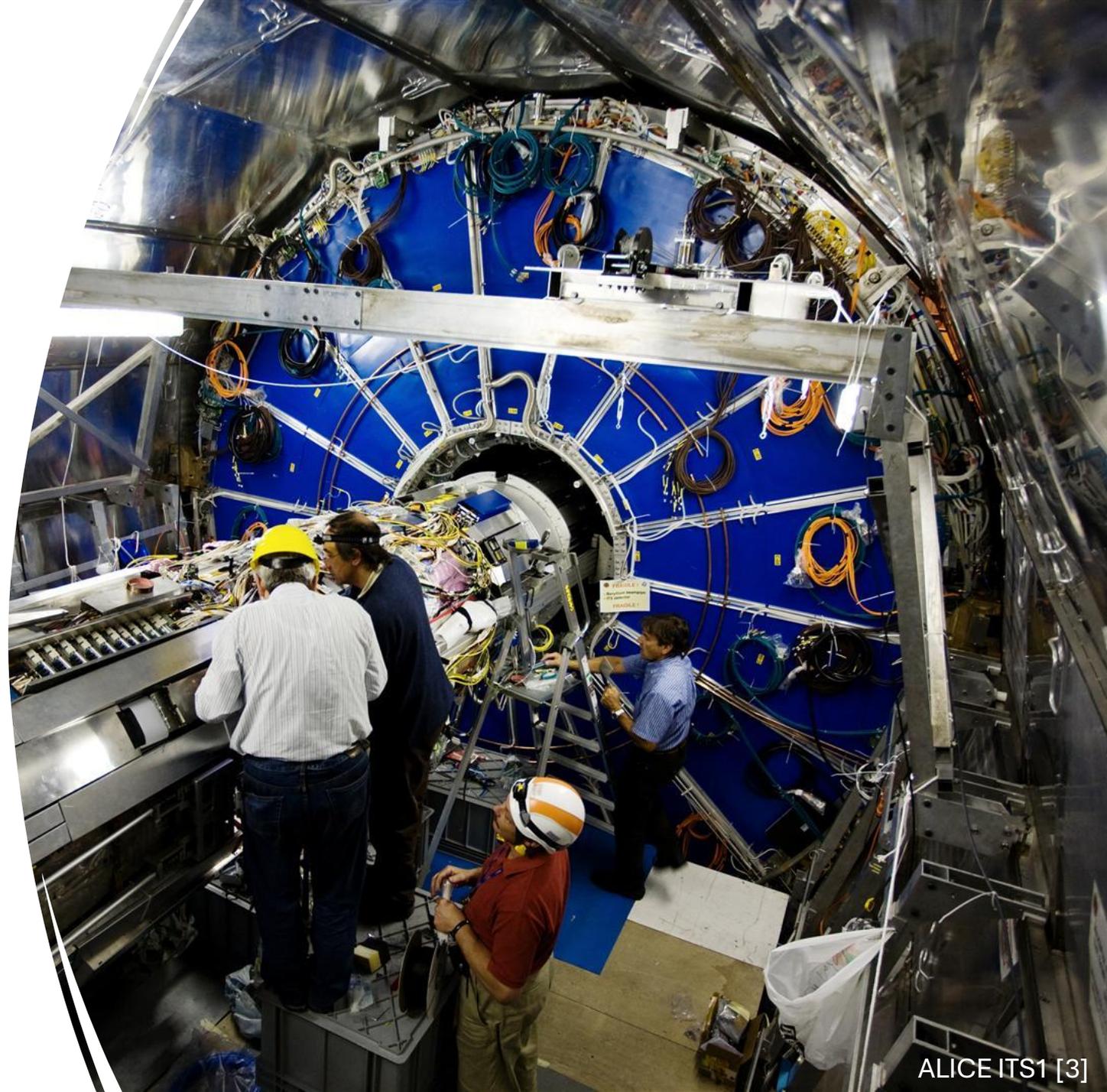


# ALICE

# ALICE ITS1

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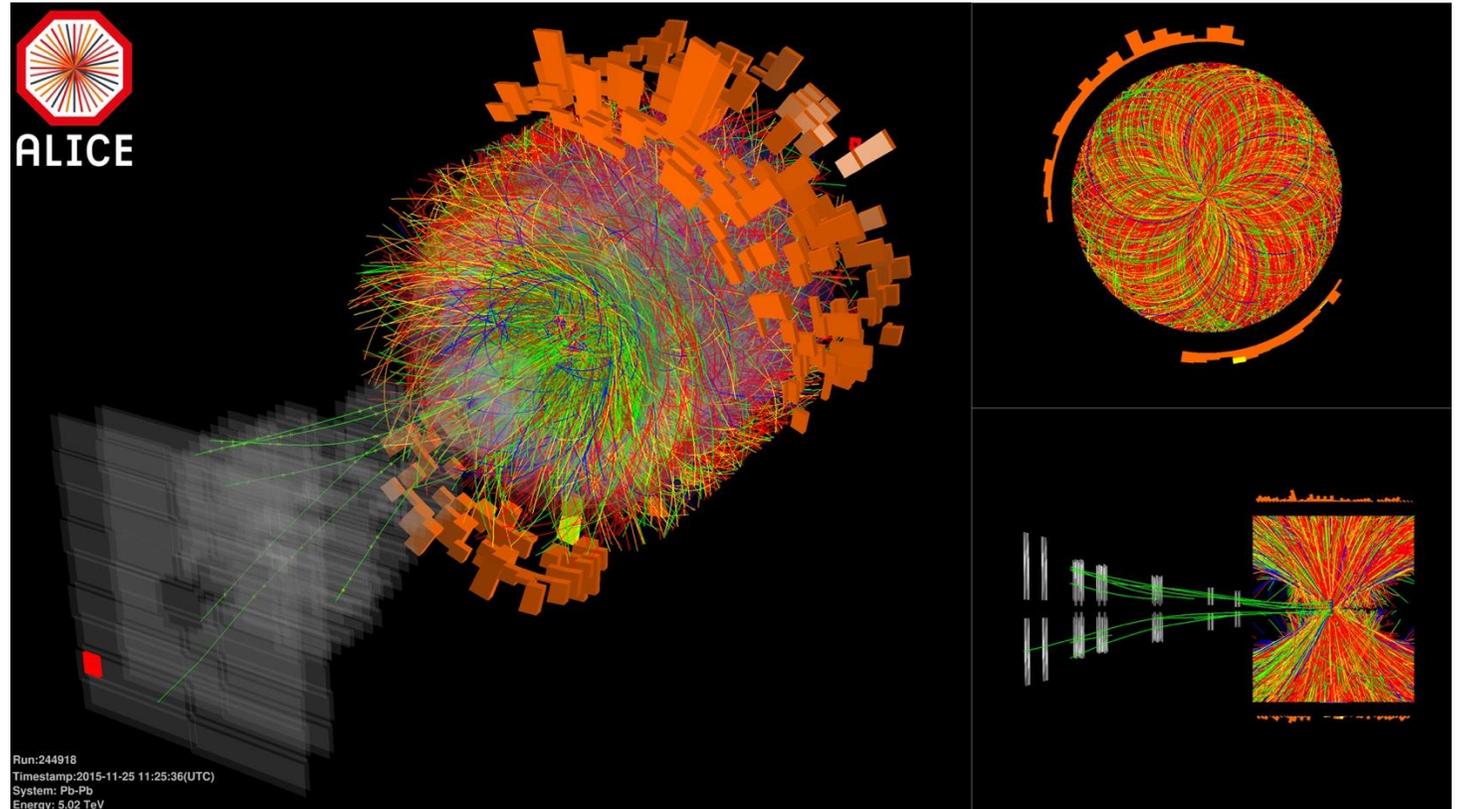
- Inner Tracking System
- 2013-2018
- Silicon detectors
- Runs 1 and 2



# ITS2 Upgrade

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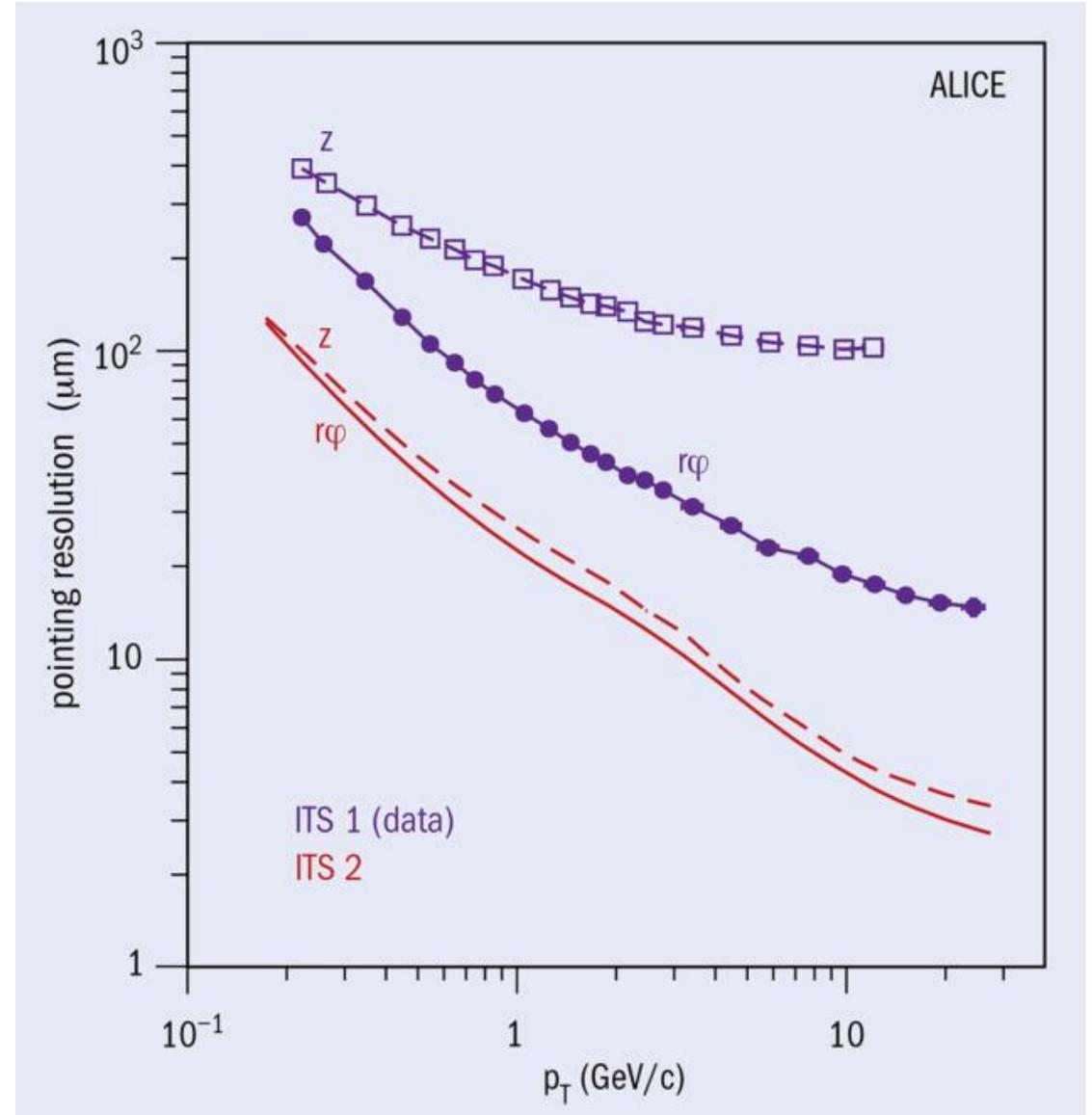
- LHC Long Shutdown 2
- 2022-now
- Run 3
- 7 layer monolithic active pixel sensor-based detector



Particle tracks Pb collision [5]

# ITS2 Upgrade

- Increase in Pb-Pb collision rate
- Improved precision of the reconstruction of the primary vertex
- Pixels with the same granularity
- Low material budget ( $\sim 0.36\%$   $X_0$  per layer)



Impact parameter resolution as a function of the transverse momentum[6]

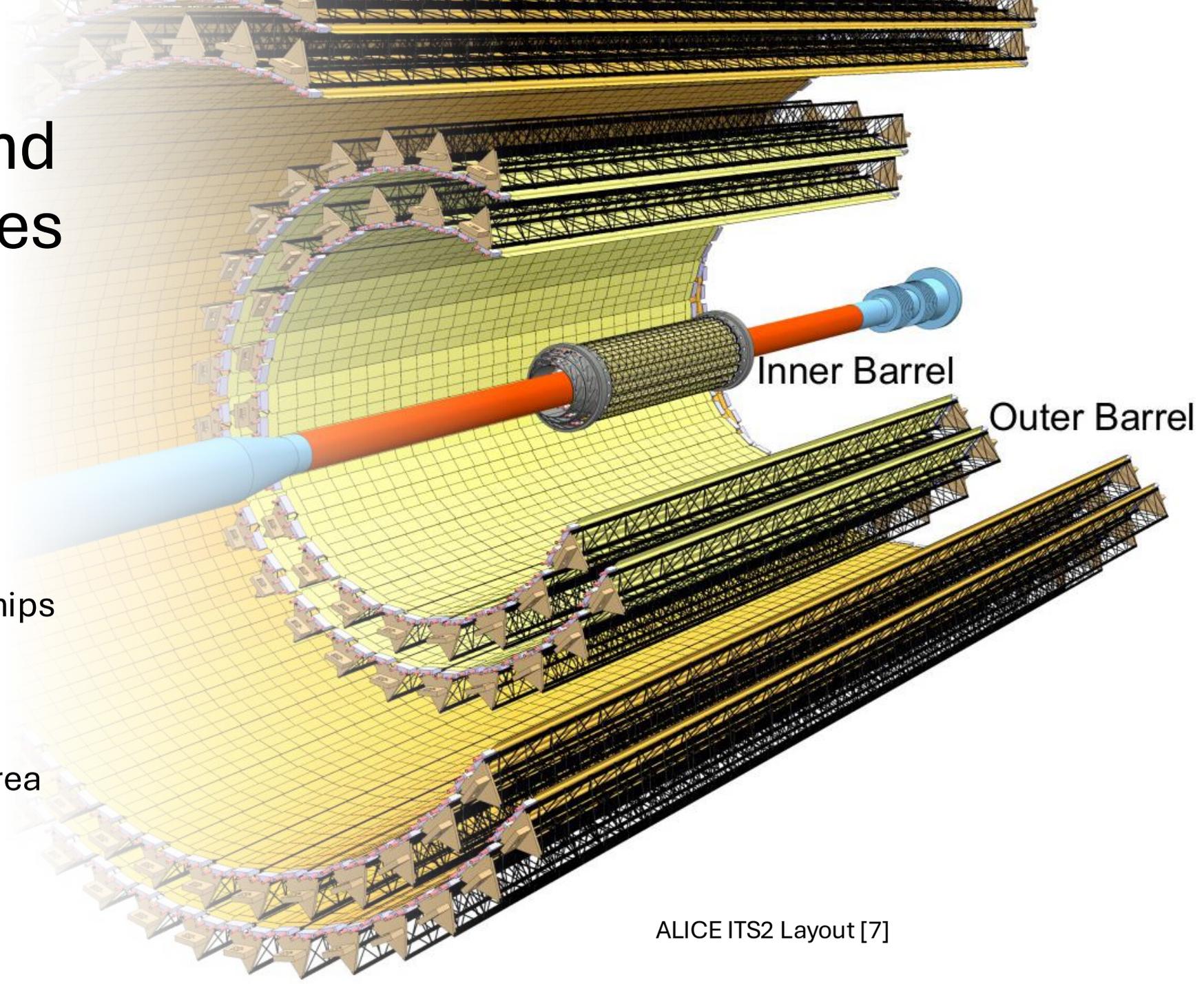
# Comparison ITS1 – ITS2 [7]

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- Layers: 6 – 7
- Pb-Pb read out: ~1kHz – 50 kHz
- Innermost layer to interaction point: 39mm – 23mm
- Pixel size:  $50 \times 425 \mu\text{m}^2$  –  $30 \times 30 \mu\text{m}^2$
- Material budget  $\sim 1.14\% X_0$  –  $\sim 0.36\% X_0$

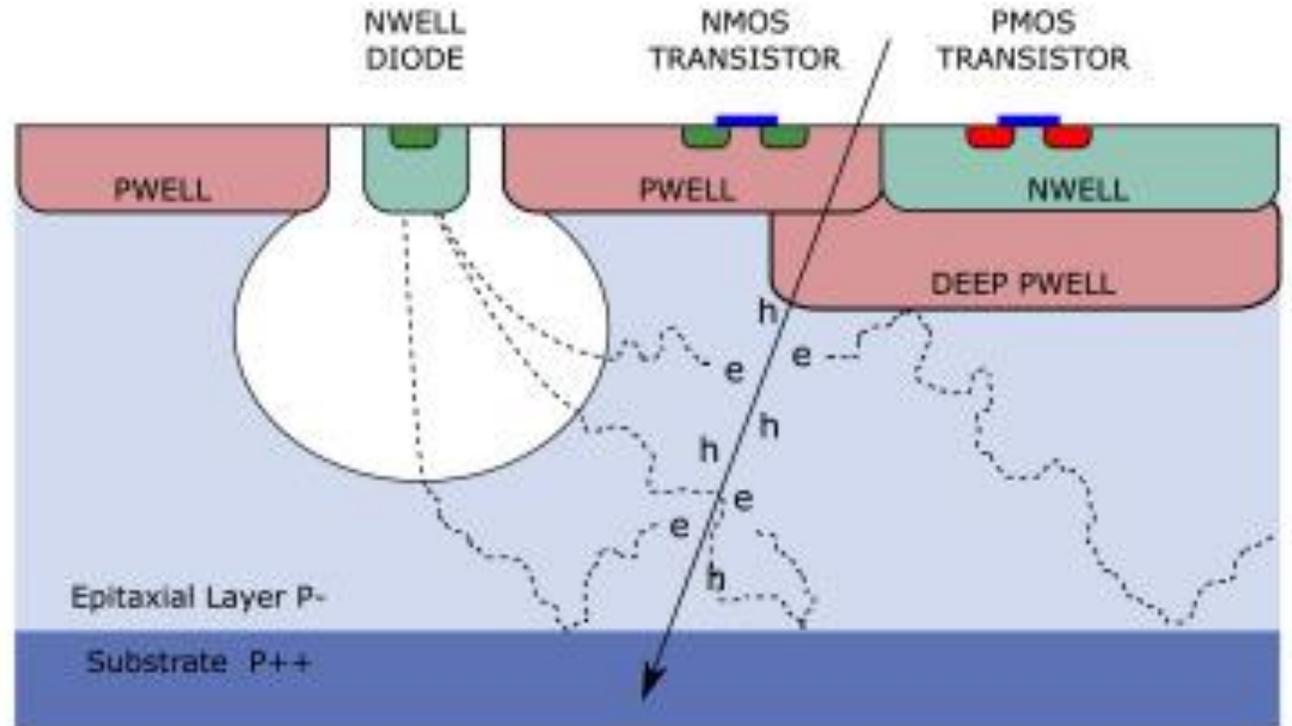
# ITS2 Layout and Design Features

- 7 layers (3/2/2)
- 192 staves (48/54/90)
- IB: 9 ALPIDE chips
- OB: HICS, 2 rows by 7 chips
- 50-100  $\mu\text{m}$  layers
- 10m<sup>2</sup> of active silicon area



# ALPIDE and Readout System

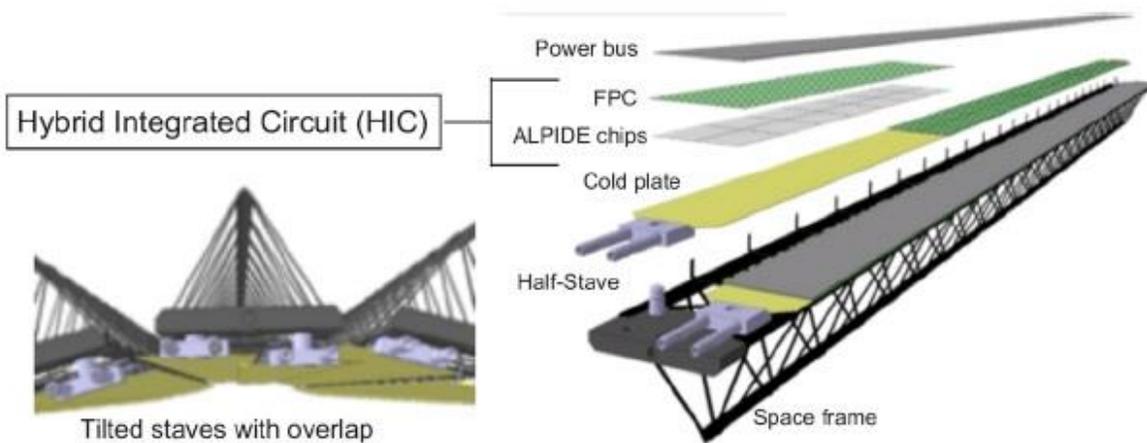
- ALICE PIXEL DETECTOR:
- MAPS (Monolithic Active Pixel Sensor)
- Low power and noise (Fake-hit rate  $< 10^{-6}$  per pixel per event)
- Radiation tolerant
- Readout:
- Continuous
- Synchronization with LHC orbit frame
- Two-phase CO<sub>2</sub> cooling system



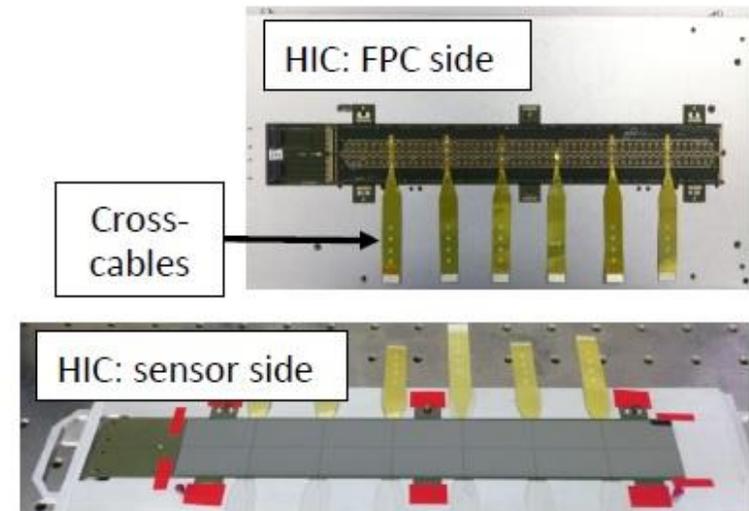
Cross-section pixel sensor [8]

# Tracking and Data Rate

- Improvements in Tracking and Resolution
- Low noise and stability ( $\sim 0.15\%$  of pixels had to be masked for noise out of 12.5 billion)
- High-rate data taking: Continuous 50 kHz Pb–Pb readout achieved (TS1:  $< 1\text{kHz}$ )
- Calibration and alignment ( $\sim 5\ \mu\text{m}$  accuracy)
- First fully MAPS-based tracker



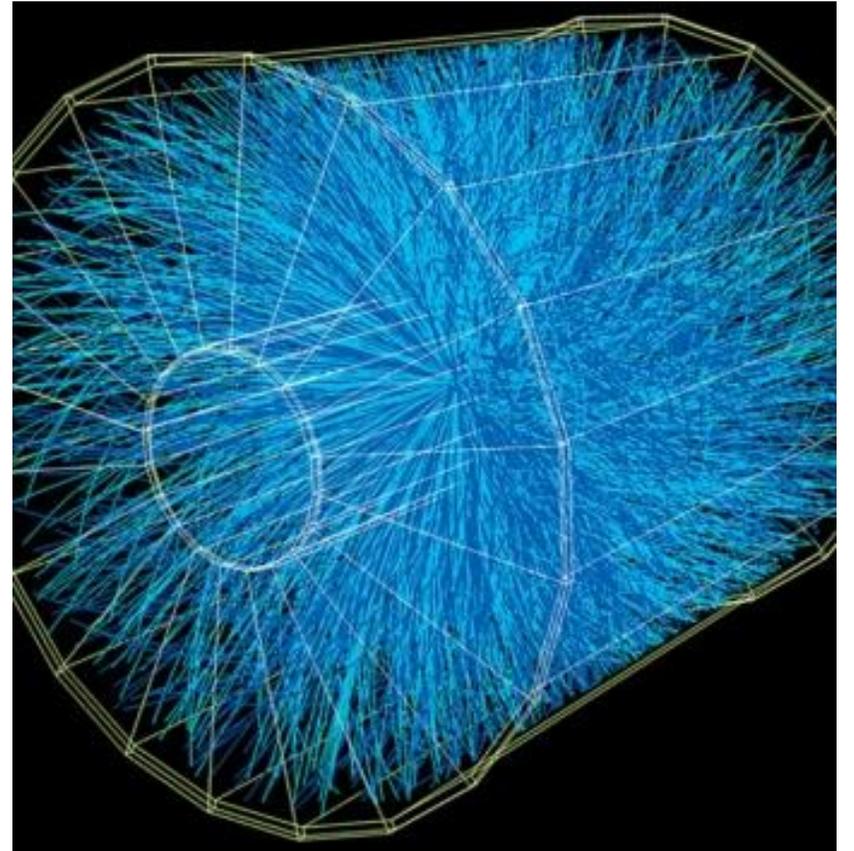
HIC [1]



# Heavy-Ion Physics Enabled by ITS2

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- ITS2 enables measuring more charmed and beauty hadrons, including baryons, to determine heavy-flavour transport coefficients [9]
- Low- $p_T$  reach: track charged particles down to zero momentum with efficiency [10]
- High statistics
- Rare probes: exotic states and rare signals
- Forward and future synergy: better forward-rapidity vertexing for muonic decays with MFT

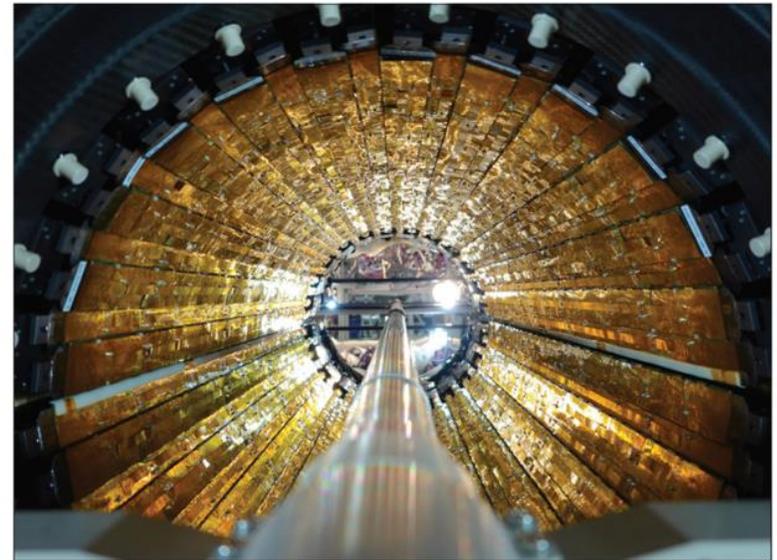
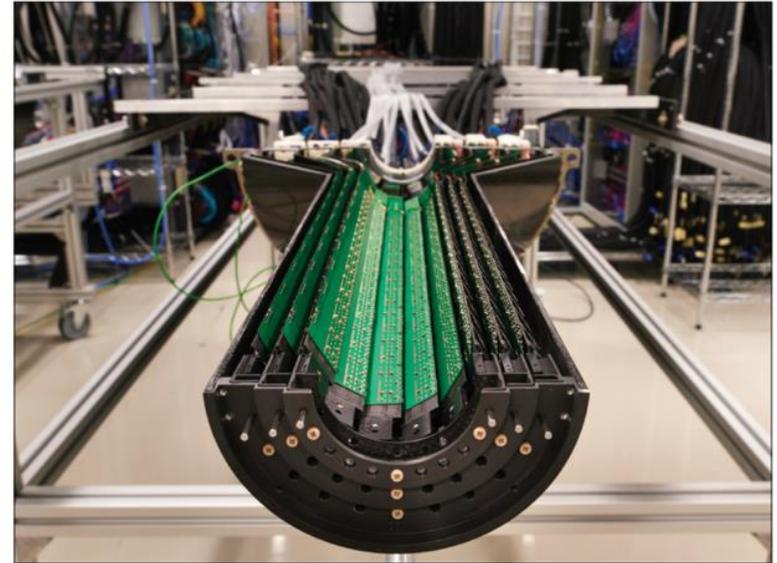


Pb-Pb collision [11]

# First Results from Run 3 (pp and Pb–Pb)

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- Data collected: 80 pb<sup>-1</sup> of pp collisions, 2 nb<sup>-1</sup> of Pb-Pb collisions
- Heavy-ion performance; clear signals of heavy-flavor hadrons
- New analysis avenues:
  - Non-prompt heavy flavor in Pb–Pb
  - First look at doubly charmed baryons and heavy exotica

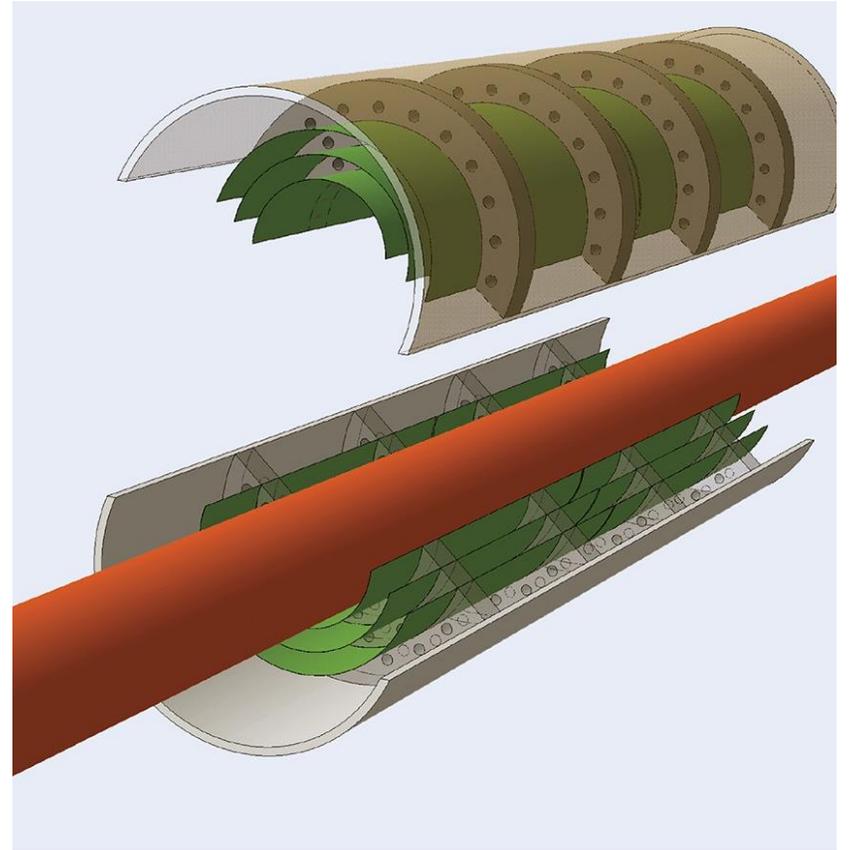


Inner and outer barrel ITS2 [6]

# Summary and Future Outlook (ITS3 and Beyond)

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- Summary of ITS2: met its design goals
- ITS3 (Long Shutdown 3, 2027), material budget to  $\sim 0.05\% X_0$  [12]
- Future experiments
- Concluding remark



Conceptual design ITS3 [12]

# References

- [1] <https://www.technology.stfc.ac.uk/Pages/Project-Showcase/Inner-Tracking-System-2-%28ITS2%29---ALICE-upgrade%E2%80%AF%E2%80%AF-.aspx>
- [2] <https://ep-dep.web.cern.ch/organisation/alice>
- [3] [https://en.wikipedia.org/wiki/ALICE\\_experiment](https://en.wikipedia.org/wiki/ALICE_experiment)
- [5] <https://www.innovationnewsnetwork.com/inside-the-upgraded-alice-nuclear-physics-experiment-at-cern/20346/>
- [6] <https://cerncourier.com/a/alice-tracks-new-territory/>
- [7] Isakov, A. (2025). ALICE ITS2: overview and performance. arXiv preprint arXiv:2502.04781.
- [8] Mager, M., & ALICE collaboration. (2016). ALPIDE, the Monolithic Active Pixel Sensor for the ALICE ITS upgrade. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 824, 434-438.
- [9] <https://cerncourier.com/a/alice-tracks-new-territory/#:~:text=of%20new%20phenomena,understanding%20the%20interplay%20between%20the>
- [10] <https://ep-news.web.cern.ch/content/alice-its-upgrade-pixels-quarks#:~:text=The%20brand,all%20collisions%2C%20translates%20to%20an>
- [11] <https://cerncourier.com/a/heavy-ion-physics-past-present-and-future/>
- [12] Liu, J., & ALICE collaboration. (2024). ALICE ITS3: A truly cylindrical vertex detector based on bent, wafer-scale stitched CMOS sensors. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 169355.