

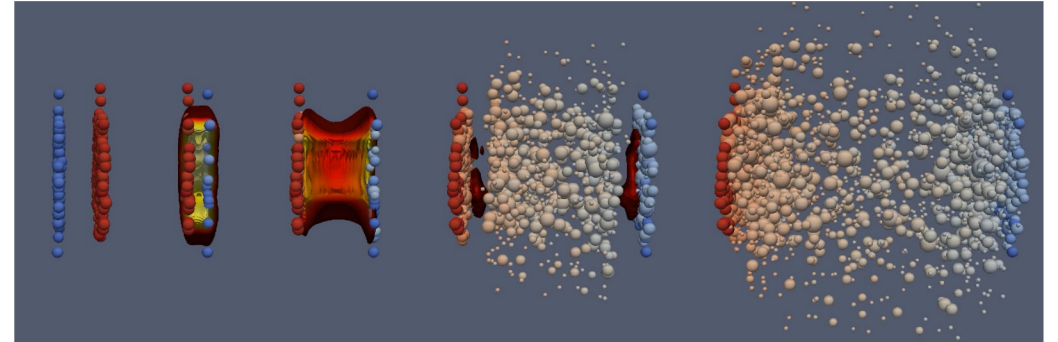
ALICE Future Opportunities

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Physics of the QCD Phase Transition

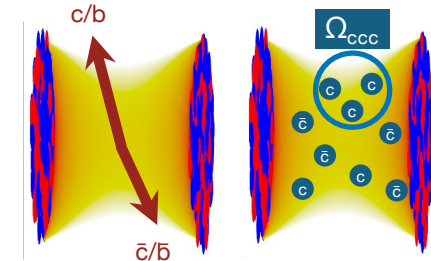
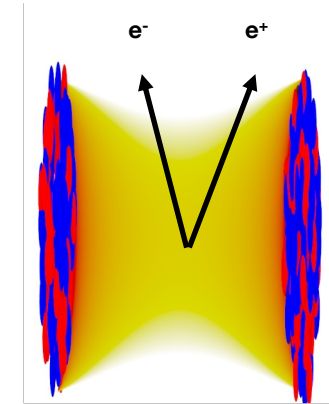
- A quark-gluon plasma (QGP) is created in heavy-ion collisions due to energy density overcoming quark confinement
 - What are the properties of the QGP and how do they emerge from strong-interaction physics?
 - Precision measurements of both long-wavelength properties and microscopic dynamics
 - Mechanism of phase transition back to hadronic matter



Heavy-ion collisions **at the LHC** are ideal to address these questions but require improved detector performance and larger data samples

Key Measurements

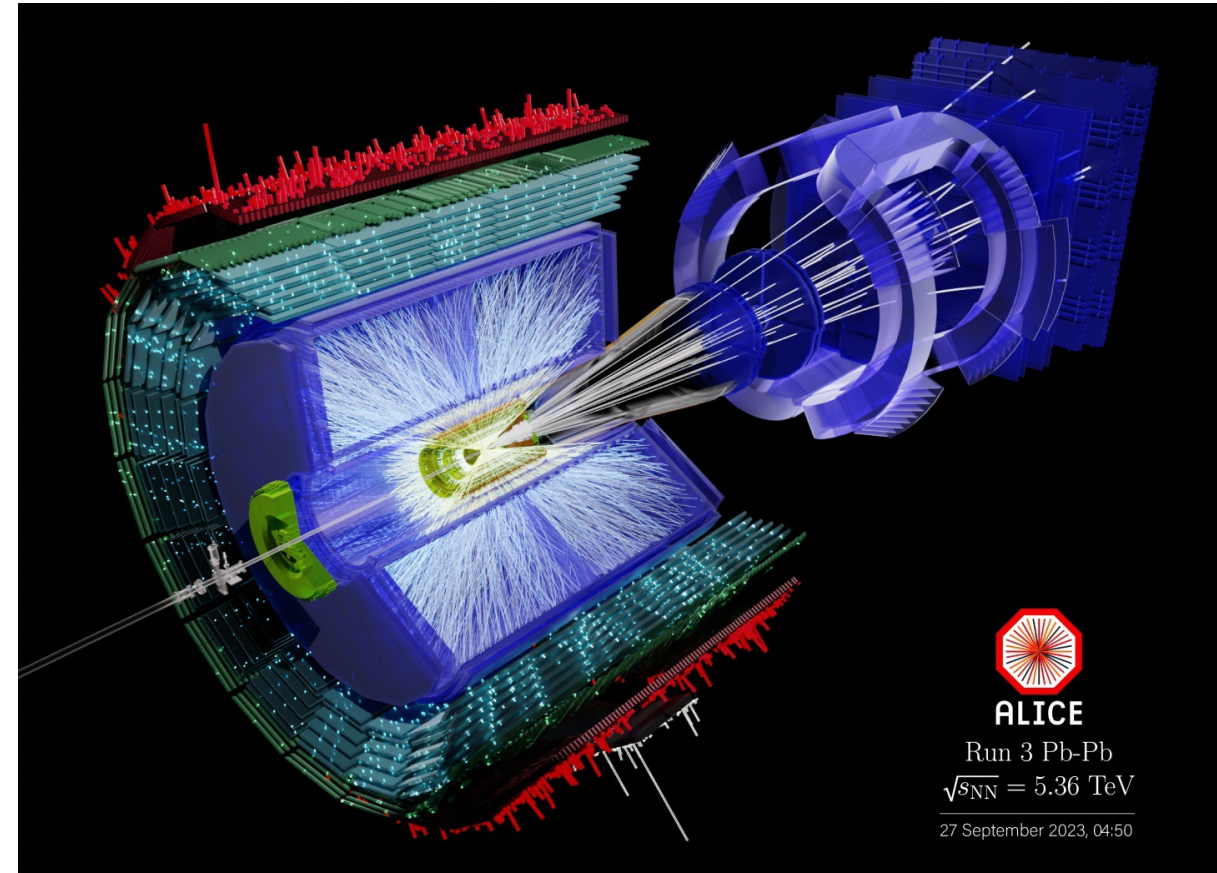
- Di-lepton measurements
 - Radiation from QGP via thermal (GeV) photons
 - Chiral symmetry restoration and modified hadron masses around the phase transition
- Heavy flavour measurements
 - Correlations between heavy quarks e.g tagged jets, mesons
 - Multi-charm objects e.g. Ω_{ccc}
- QCD ‘factory’ via hadronization
 - Light anti-nuclei, Y-N (Y-Y, N-N-N etc.) potentials



Anti-He absorption
(cosmic ray, DM)
EoS neutron star

Current and near-term ALICE

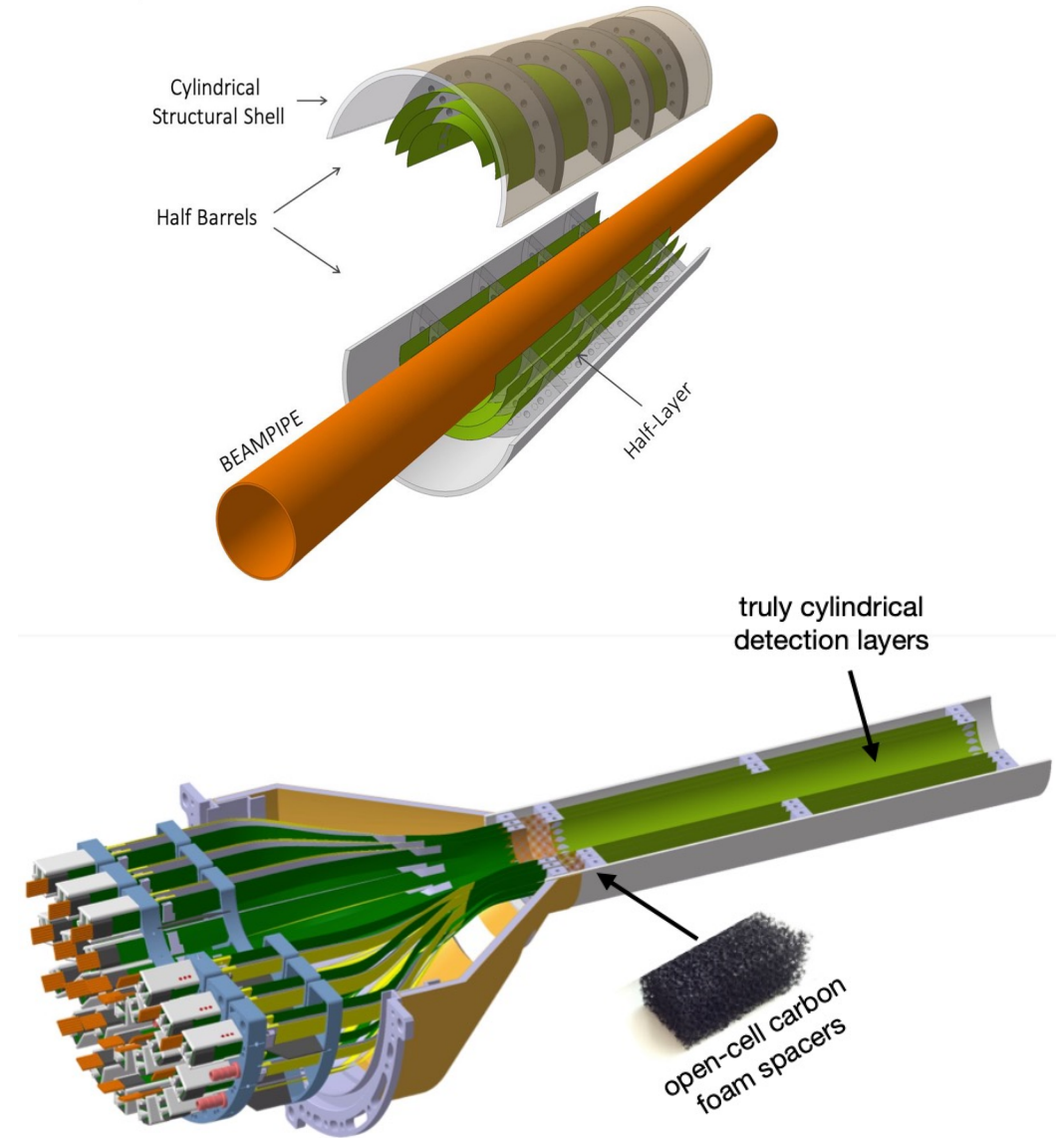
- ALICE upgrade completed in 2021
 - Complete replacement of inner tracker with 7-layer Si pixel detector
 - Re-instrumentation of TPC to allow continuous readout up to 50 kHz Pb-Pb (several 100 kHz pp)
 - Major upgrade of data pipeline, online and offline processing (TB/s)
- LHC Run 3 underway
 - Large heavy-ion data set (40x previous) collected in Autumn 2023, already reco'd, currently being analysed



Further running in 2024 and 2025 before Long Shutdown 3 (2026-2028)

Medium term

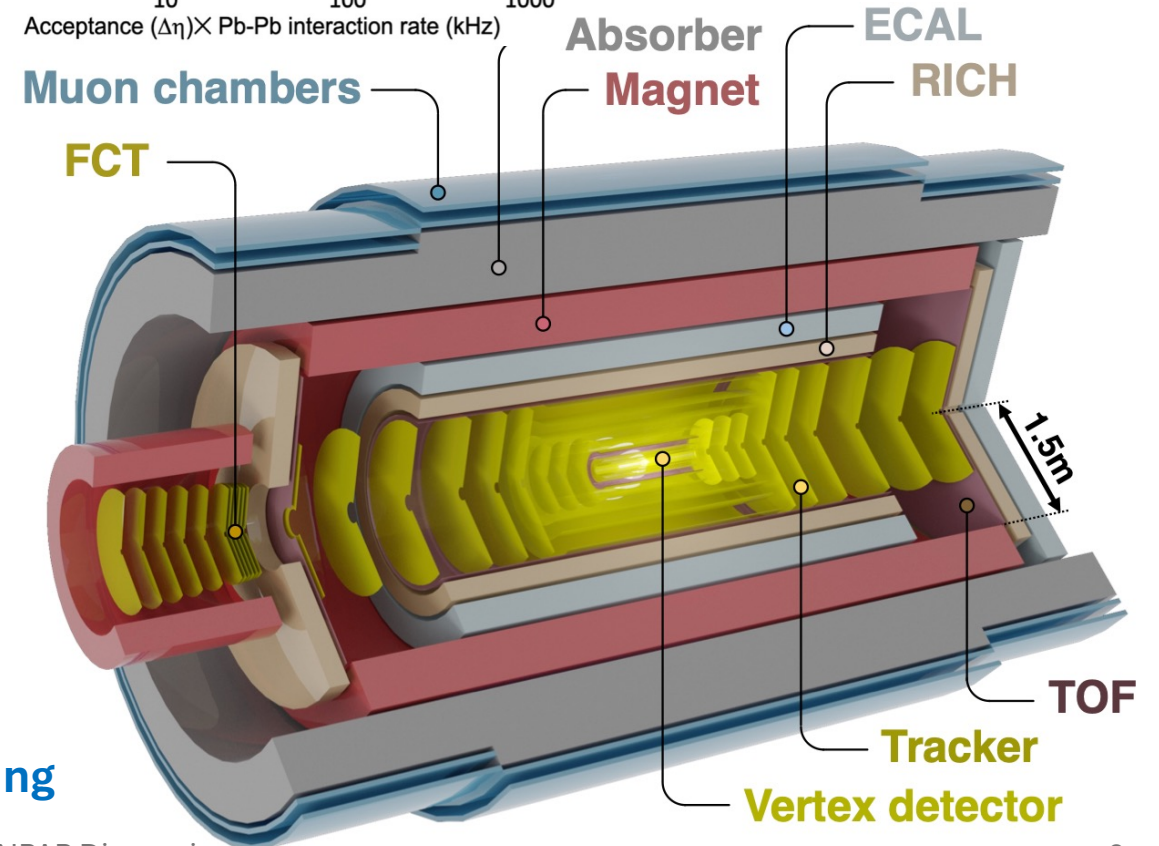
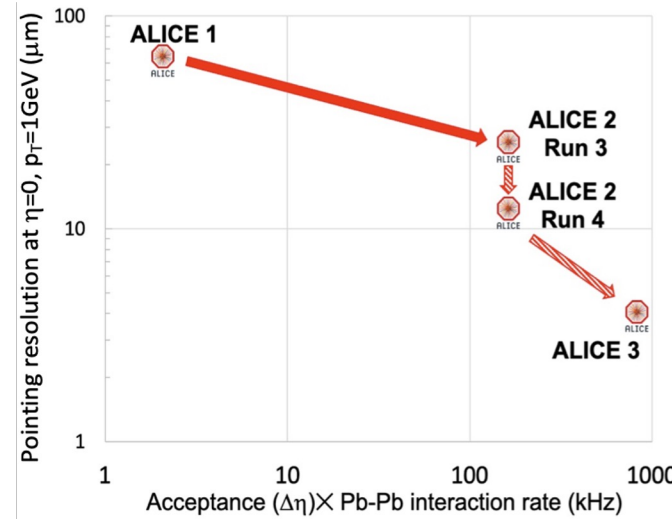
- ALICE will replace the inner 3 tracker layers with 'ITS3'
 - Thin flexible wafer bent at radii
 - Modified beampipe
- Key benefits
 - **Very** low material budget $0.07\% X_0$
 - Homogenous material distribution: negligible systematic error from this source
 - Improved (x2) pointing resolution
- In place for 2029-32 (Run 4)



UK involvement in simulation, prototype, test beam

ALICE 3 Concept

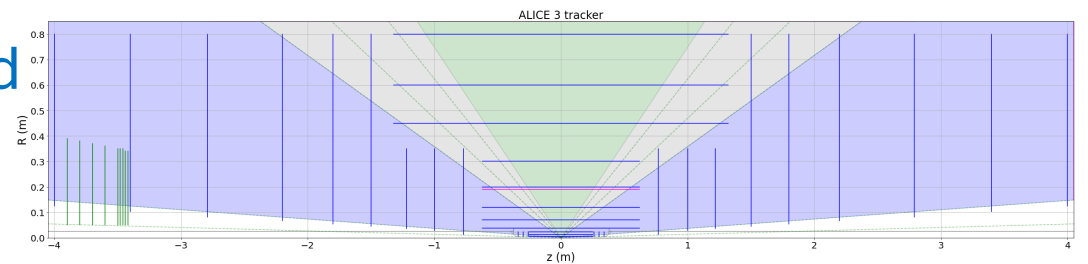
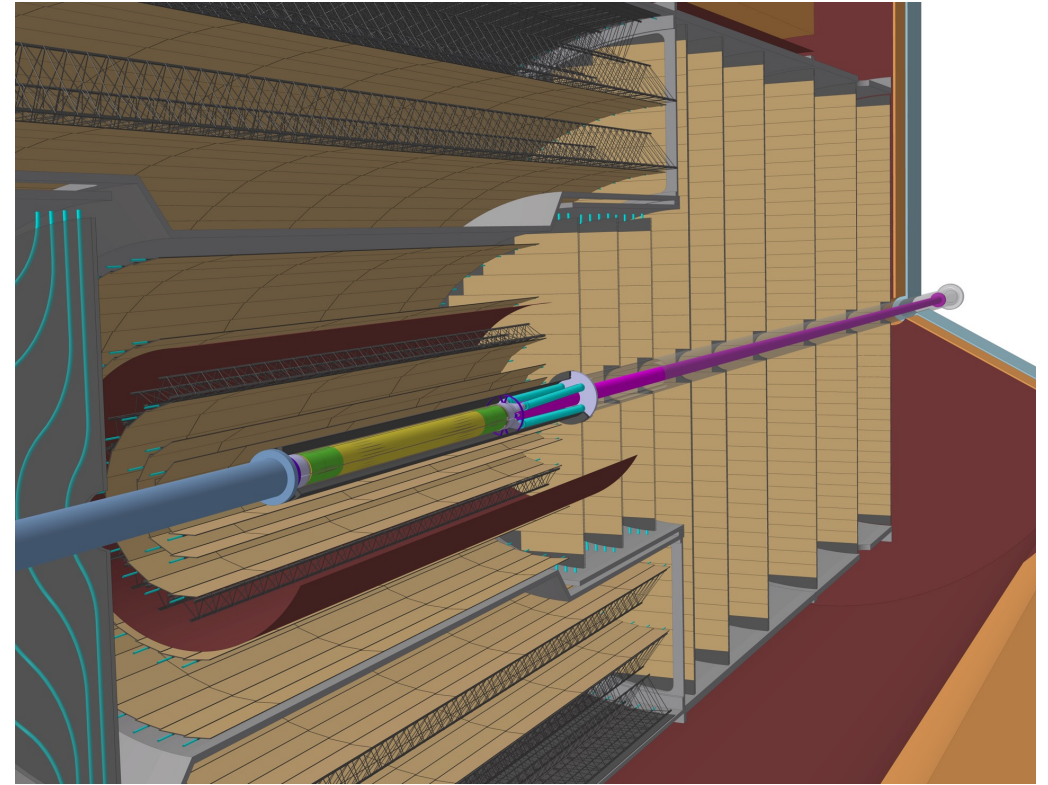
- Novel and innovative detector concept
 - Compact and lightweight all-silicon tracker
 - Retractable vertex detector
 - Extensive particle identification
 - Large acceptance
 - Superconducting magnet system
 - Continuous read-out and online processing



UK proposed involvement in **outer tracker** and **triggering**

ALICE 3 Outer tracker

- 60 m² silicon pixel detector (MAPS)
 - Larger coverage: 8 units pseudorapidity
 - ‘Compact’: outer radius 80 cm, $z \pm 3.5$ m
 - High-spatial resolution $\sim 10 \mu\text{m}$, pixel size $50 \times 50 \mu\text{m}^2$
 - Low material density, material budget
- R&D
 - Concept of module $\sim 10 \times 10 \text{ cm}^2$ based on a process which can be **standardized for industry**
 - Reduce/eliminate interdependence between modules (allow replacement)



ALICE 3 UK

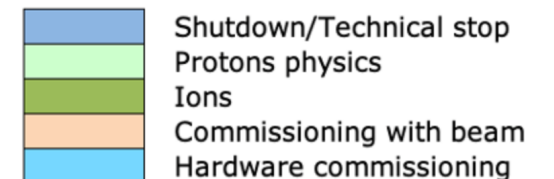
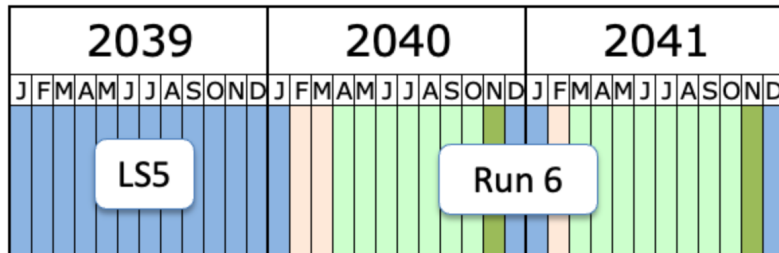
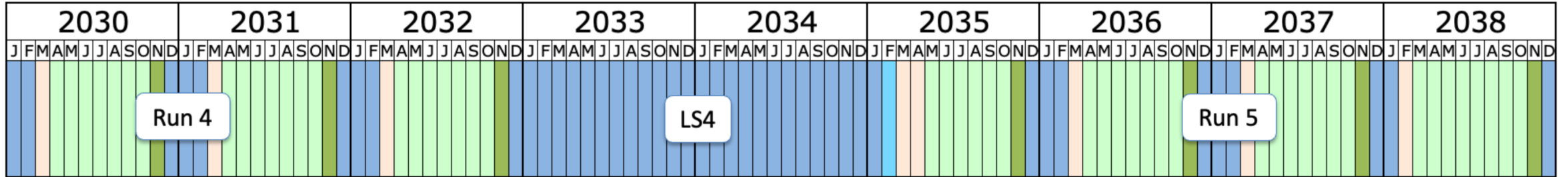
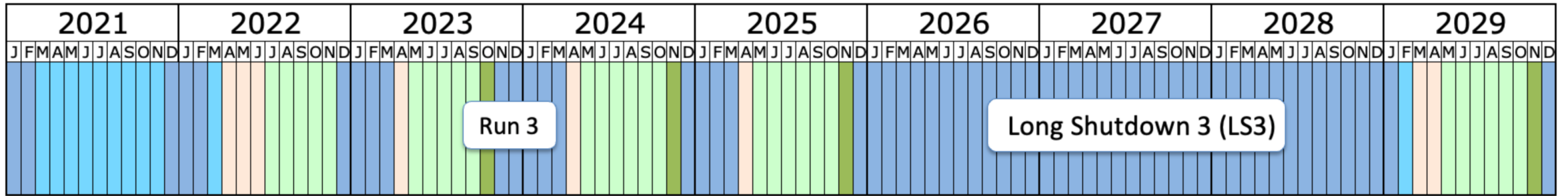
- People: Four existing group, universities of Birmingham, Liverpool and Derby and STFC Daresbury
 - Ownership of ALICE trigger, track record in Si detector design and build
 - Leadership track record with Collaboration Board chair, various coordinators, system running, trigger utilization, physics working groups, editorial board...
- Interest from beyond current groups with Si detector interests
- Resource: ALICE 3 is a (€/£/\$)100 M project
 - UK are around 2% of 'senior' members
 - Seeking larger strategic O(5M) investment in view of complementary development and synergies in detectors for future colliders

Wider picture

- ALICE 3 is the **clear preference** of the UK community but still at pre-approval stage, gathering funding agency commitments etc. (Not dependent on STFC/UKRI decision)
- Other LHC experiments participate in, and plan to continue with, HI running
 - e.g. Planned **LHCb** upgrade allows recording full centrality spectrum (up to $dN_{ch}/d\eta \sim 2000$), leverages (very) large UKRI investment
- We could conceivably seek to join and lead efforts in this area
 - needs discussion with STFC and experiments
- ALICE 3 **needs R&D support and future commitment** during this 10-year period to be ready for Runs 5&6 (2035-2038 & 2040-41) [NuPECC]

Backup

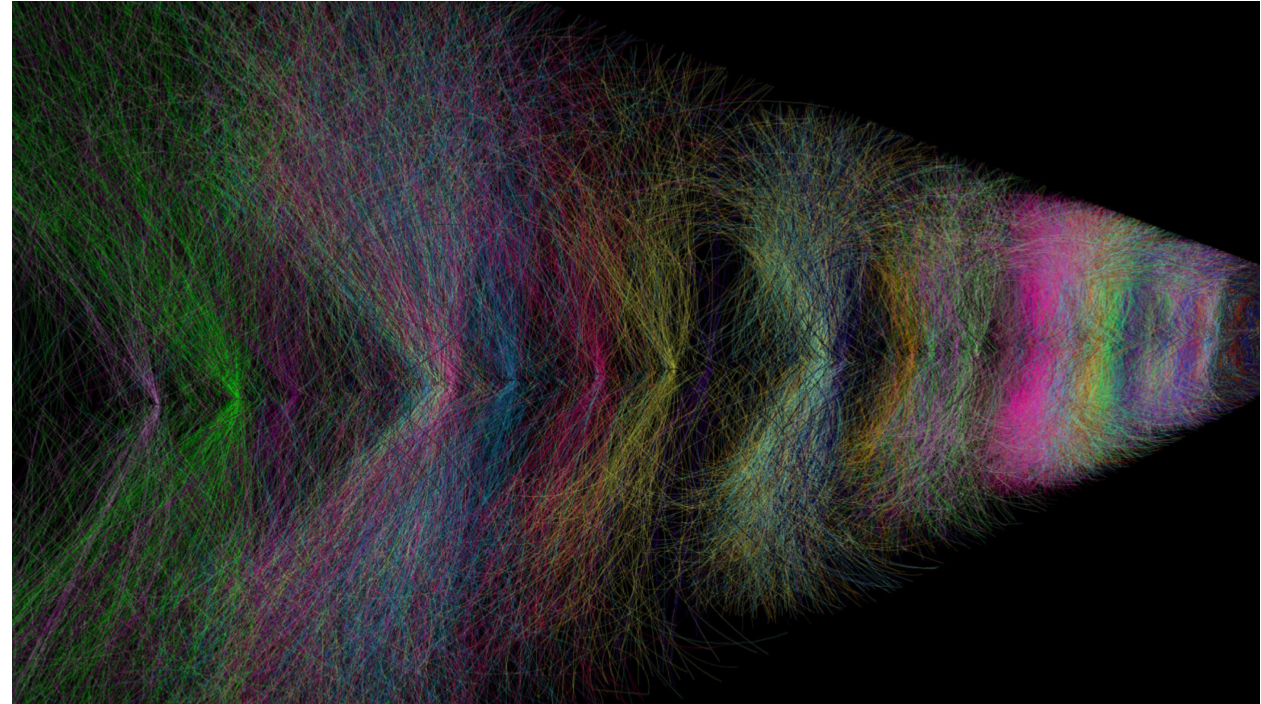
LHC Long term schedule



Last update: April 2023

Reconstruction with continuous readout

- Assigning particle tracks to individual Pb-Pb interactions, represented by different colours, in a continuous readout mode



ALIPIDE

- Monolithic Active Pixel Sensor
- Currently employed in ALICE inner tracking pixel detector
- Developments for ITS3, thinner flexible sensor, and for ALICE 3

