Central diffraction and ultra-peripheral collisions in ALICE in Run 3 and 4

Burmasov Nazar for the ALICE collaboration
Petersburg Nuclear Physics Institute

The ALICE detector

Optimized for AA events:

- High granularity.
- Low transverse momentum threshold $p_T \approx 0.15$ GeV.
- Good PID capabilities up to $p_T \approx 20$ GeV.

Major upgrade during Long Shutdown 2:

- Time Projection Chamber (TPC) is being equipped with new GEM-based readout chambers;
- The readout electronics of several detectors is being replaced with faster and more flexible technology.
- Most of the detectors will switch to the continuous readout mode.

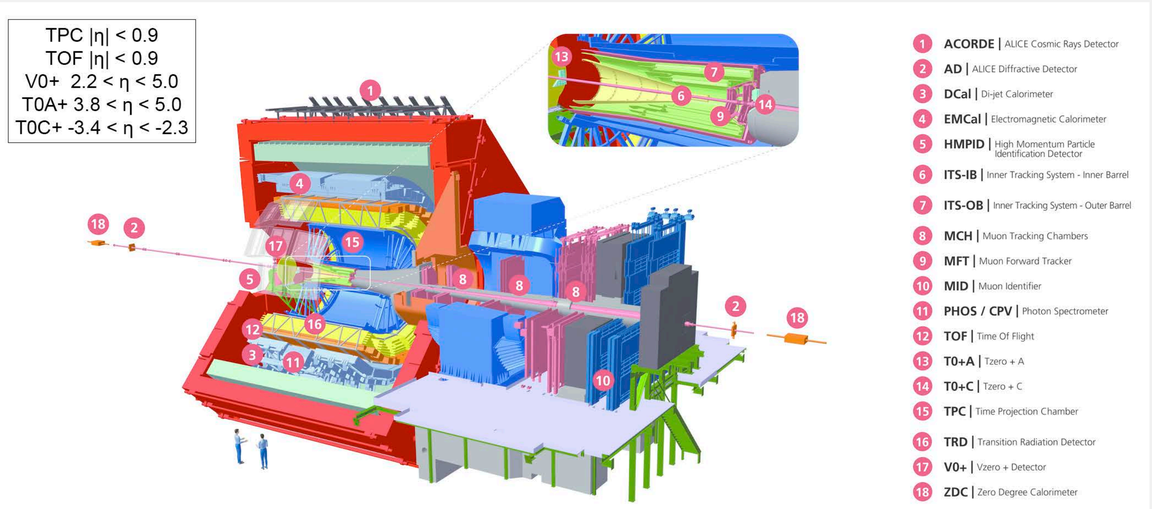

Fig. 1: Upgrade of the ALICE detector systems for Run 3.

Central diffraction

Central diffractive events:

- Double pomeron exchange.
- Rapidity gaps in the distribution of tracks.
- Large sample already available from Run 2 (8 pb^{-1}). Increase up to 200 pb^{-1} is expected in Run3.

Physics programme:

- Probing characteristics of rare resonances.
- Glueball searches.
- Heavy quarkonium state measurements.
- Pomeron spin structure investigations.

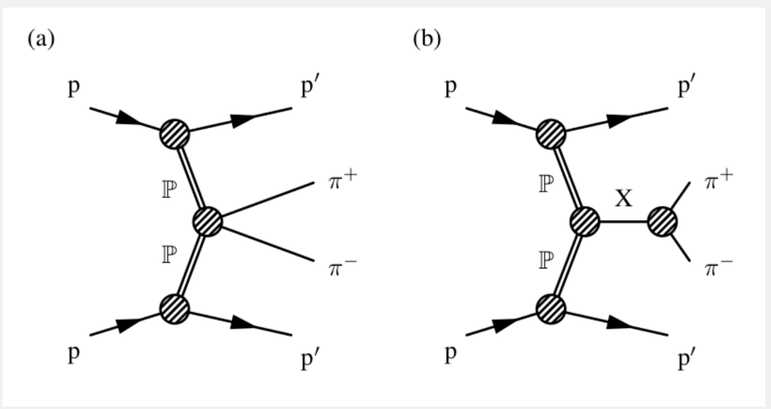

Fig. 2: Non-resonant (a) and resonant (b) CEP.

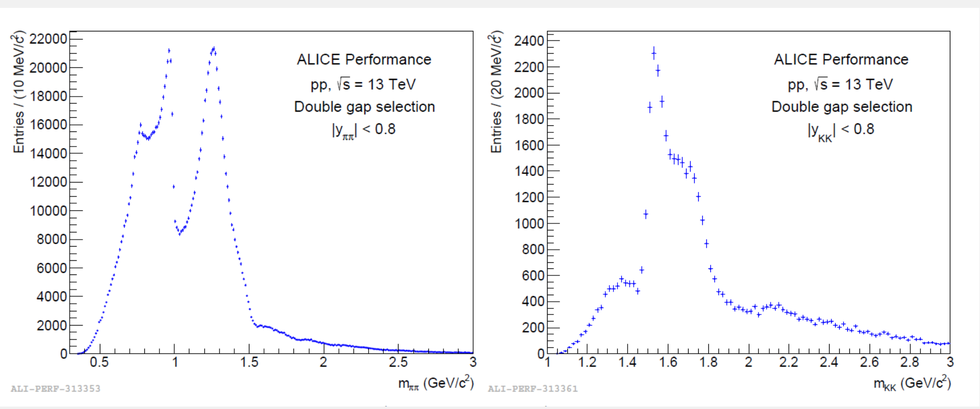

Fig. 3: Raw invariant mass spectra of pion (left) and kaon(right) pairs in central diffractive events collected by ALICE in proton-proton collisions at 13 TeV.

Ultra-peripheral collisions

Ultra-peripheral collisions (UPC):

- The impact parameter is greater than the sum of the radii of the incoming particles.
- Photon processes are dominant.
- Quasi-real photon approach used for EM fields description.

Physics programme:

- Photoproduction of vector mesons can be used for measurements of parton density functions in nuclei (nPDF) at small Bjorken-x.
- Photon interactions – a probe of QED and BSM physics.
- Possible measurements open heavy flavour photoproduction.

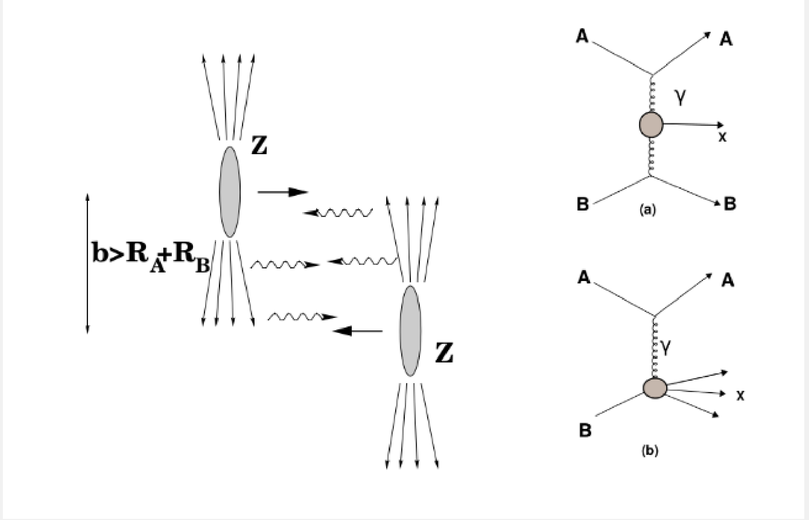

Fig. 4: (left) Ultra-peripheral collision of heavy ions diagram. (right) Photon-photon interaction (a) and photonuclear interaction (b) diagrams.

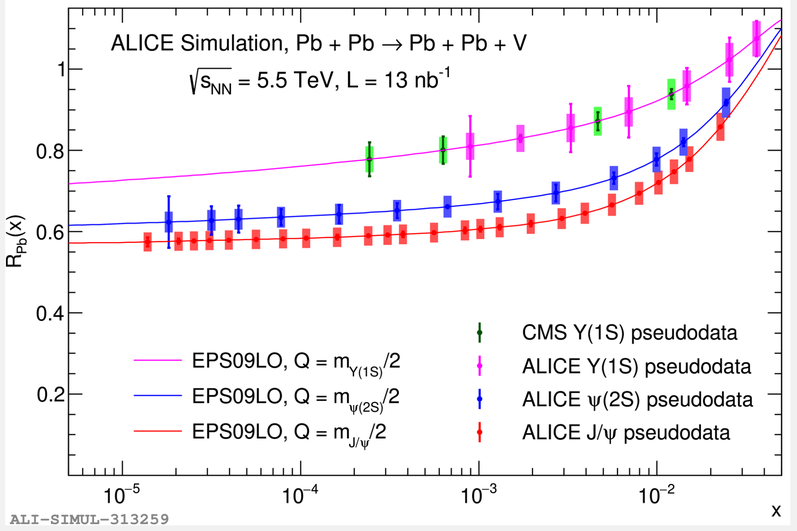

Fig. 5: Pseudodata projections for the nuclear suppression factor by ALICE and CMS measured with the photoproduction of three heavy vector mesons in Pb–Pb ultra-peripheral collisions. The pseudodata points are derived from EPS09-based photoproduction cross section projections. From ref. [2].

Event selection

Event selection in Run 3:

Continuous readout mode leads to an increase in data stream up to 100 times in comparison to Run 2. Advanced event selection is necessary.

Possible event selection strategies:

1. On-line event preselection without full reconstruction;
2. Full real-time event reconstruction;
3. Offline reconstruction.

- **UPC and CEP**: searching for events with few tracks in an otherwise empty detector (e.g. two/four-prong events).

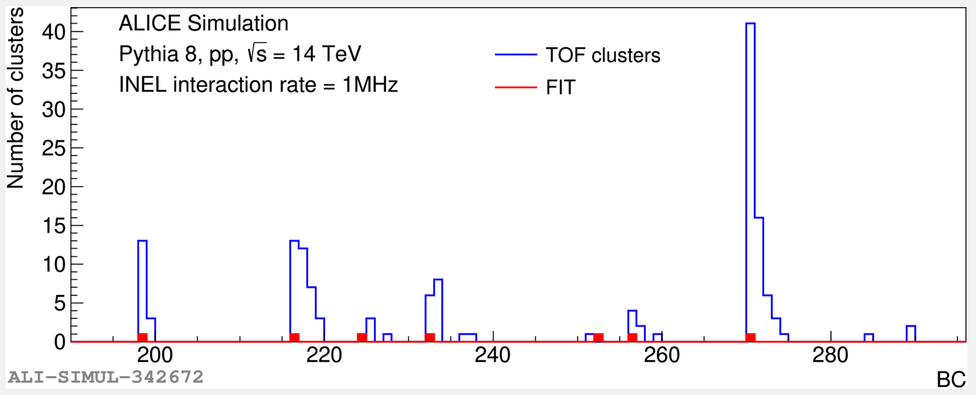

Fig. 6: Pythia8 simulation: typical distribution of FIT and TOF clusters at 1MHz interaction rate in pp at 14 TeV; “BC” stands for “bunch crossing” – typical time between interacting bunches ≈ 25 ns.

Pythia8 pp for background simulations:

- Non-diffractive event simulations.
- **Problem**: need TOF information to determine track times required for matching with forward detectors.
- Many bunch crossings with 2 hits in TOF - online preselection without full reconstruction is not possible

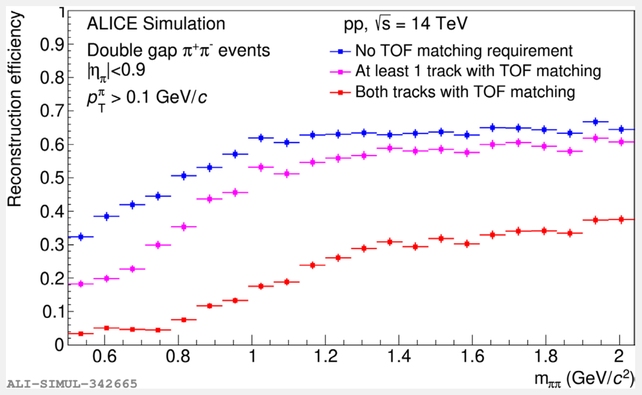

Fig. 7: Reconstruction efficiency for pion pairs in central diffractive events in pp at 14 TeV.

Event reconstruction efficiency:

- Custom pion-pair generator.
- Different selection approaches applied.
- No significant efficiency drop if one TOF-matched track is required.
- One matched track is enough for TOF-FIT matching

References

[1] ALICE Collaboration, “Future high-energy pp programme with ALICE”. In: CERN CDS, ALICE-PUBLIC-2020-005.

[2] Z. Citron et al. “Report from Working Group 5: Future physics opportunities for high-density QCD at the LHC with heavy-ion and proton beams”. CERN Yellow Rep.Monogr. 7 (2019) 1159