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Performance of the ATLAS L1 TRT trigger in heavy-ion collisions at the LHC

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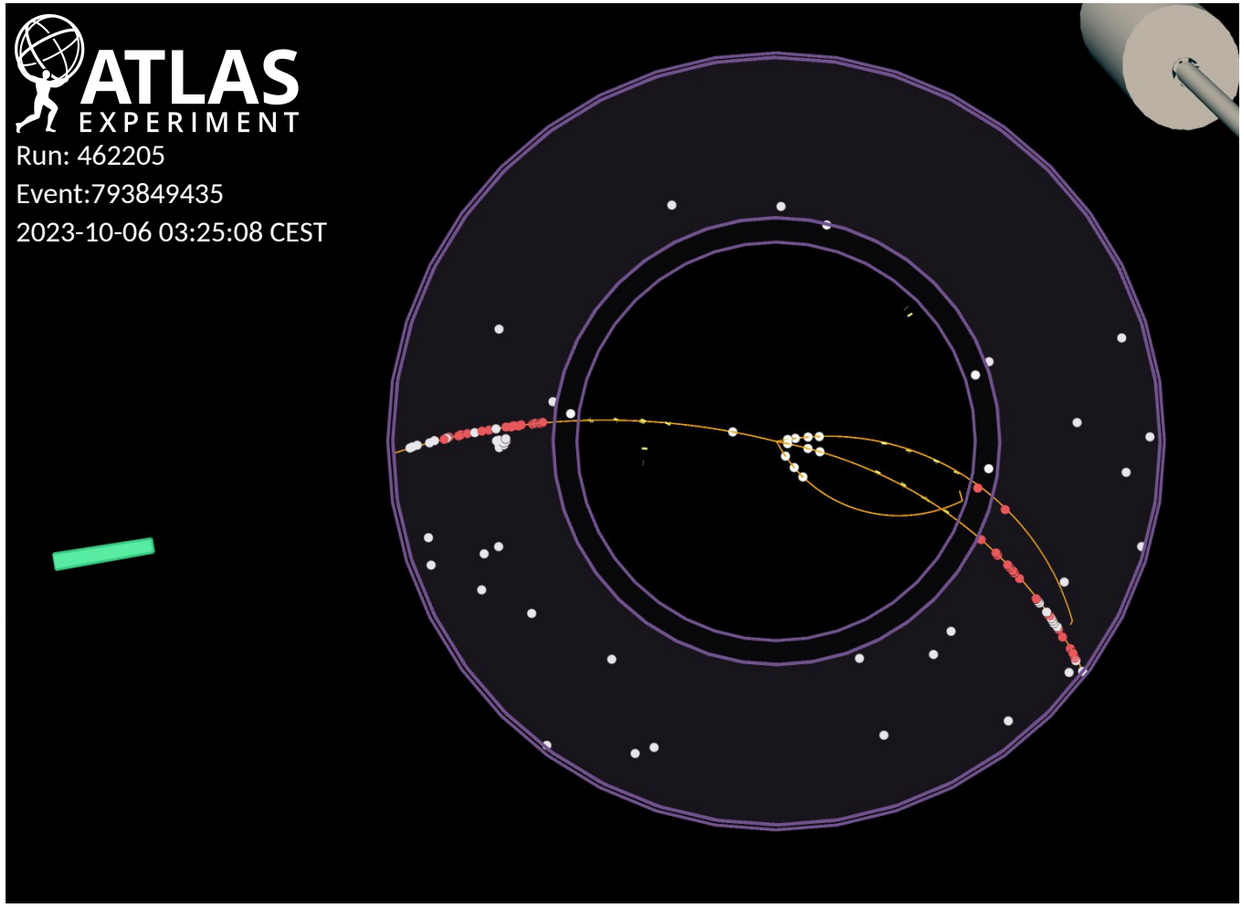
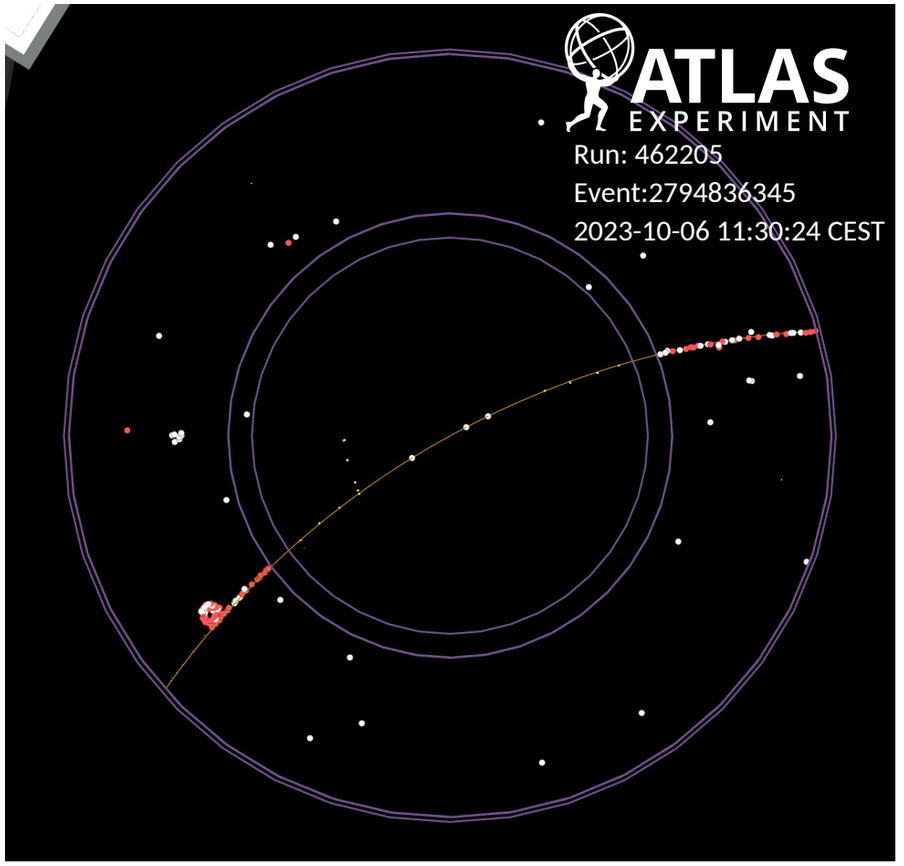
Motivation for triggering with Transition Radiation Tracker



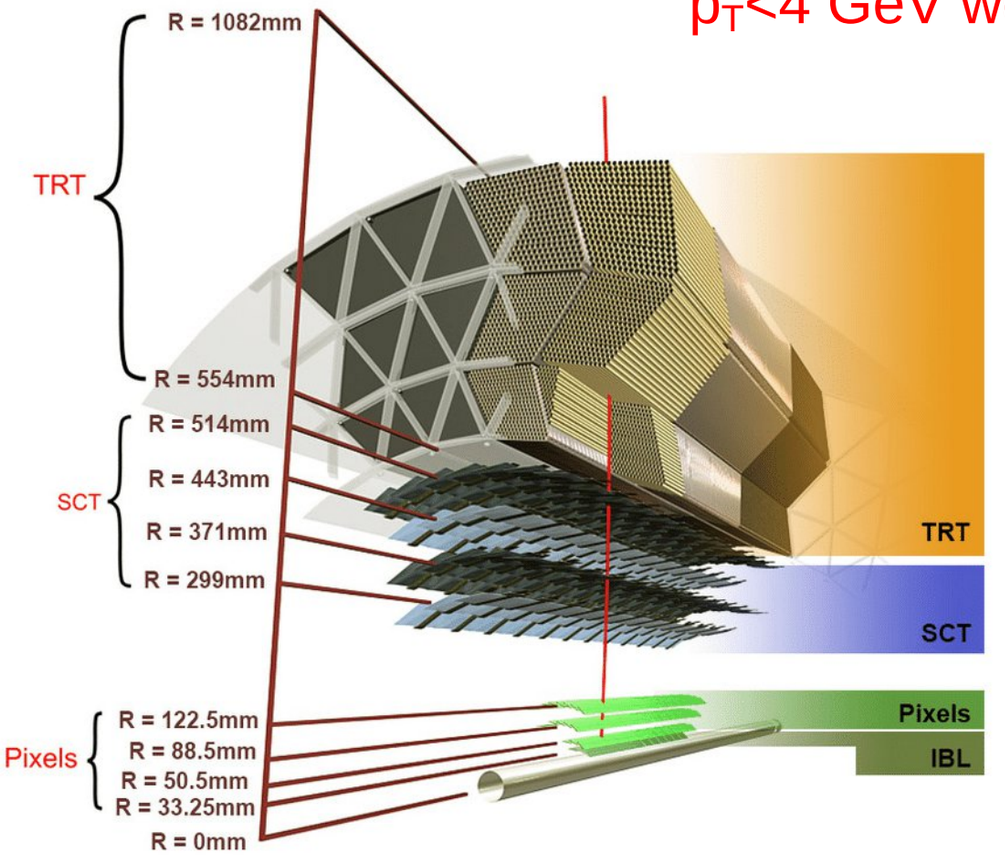
Event display for an exclusive γγ→ττ candidate decaying into an electron and three charged pions [1].



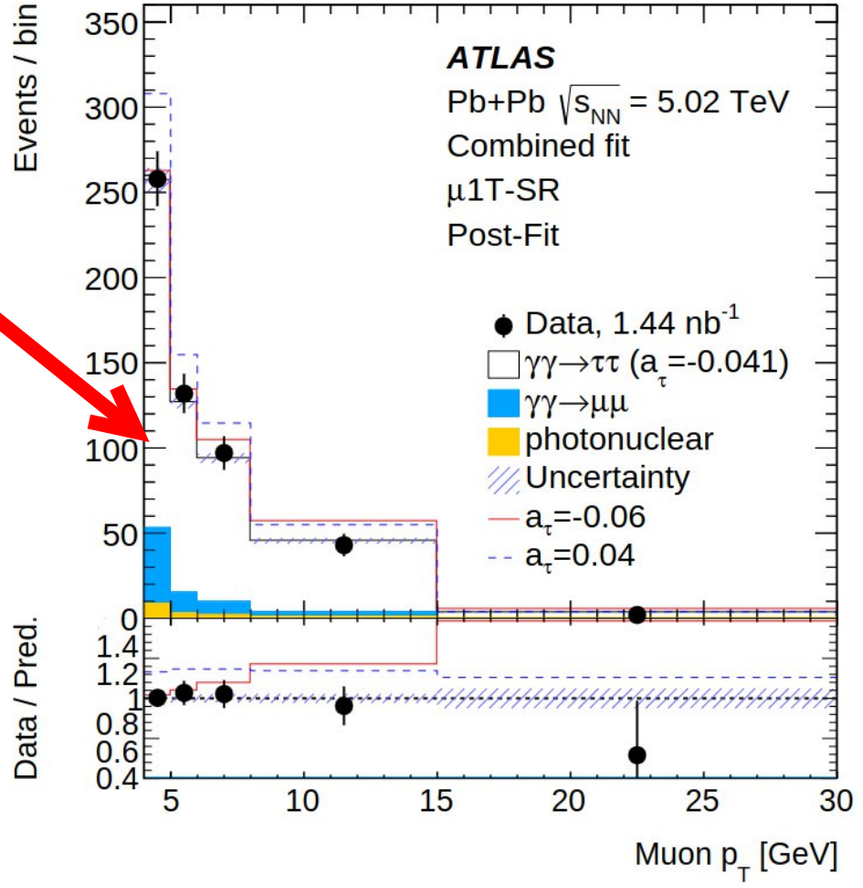
Event display for an exclusive J/Psi candidate decaying into two charged leptons [1].

Motivation for triggering with Transition Radiation Tracker

Many muons with p_T<4 GeV were lost



Sketch of the barrel part of the TRT [2].

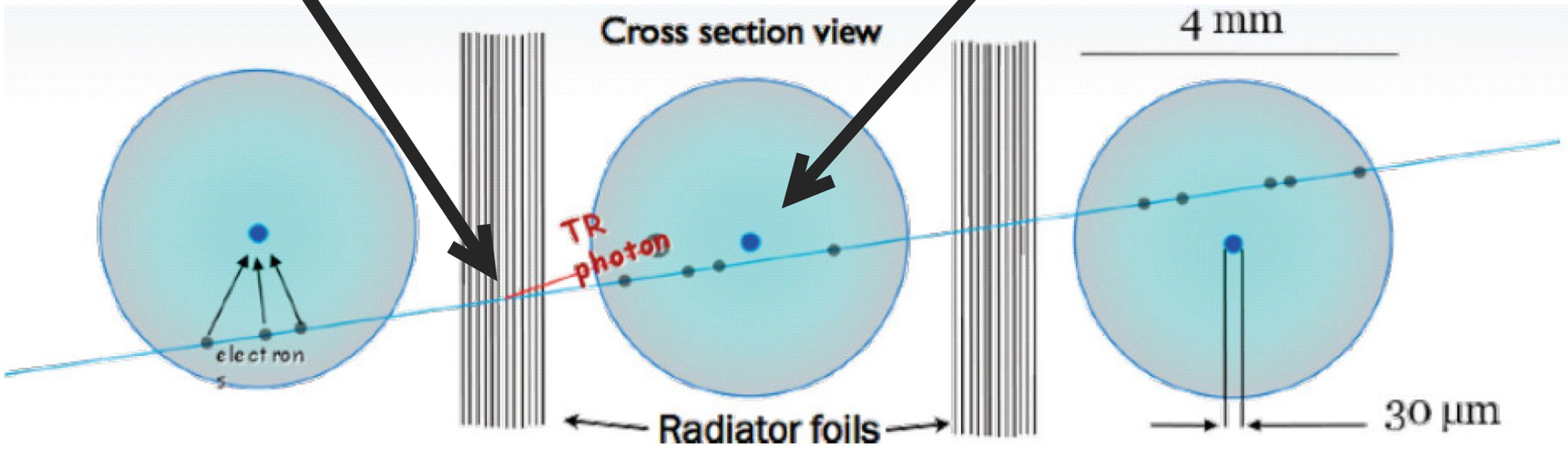


Muon p_T distribution from exclusive γγ→ττ production in heavy-ion UPC [3].

Triggering on high threshold hits

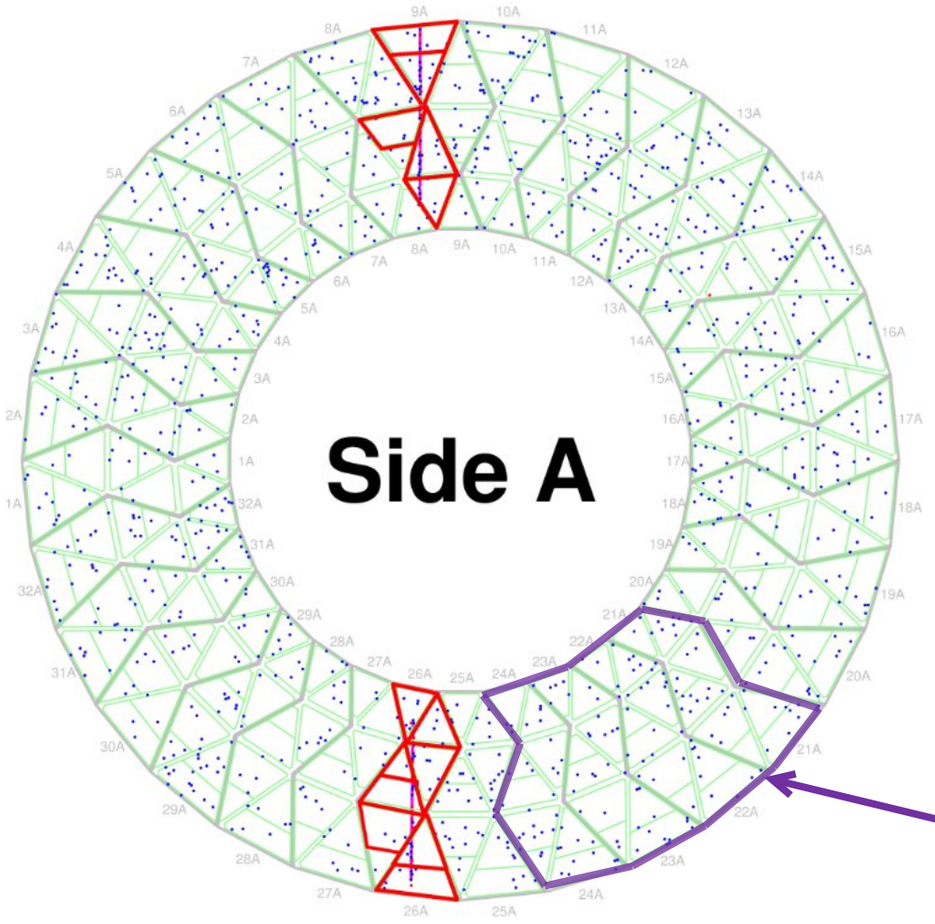
Particle passing through the multi-layer film can produce low energy transition radiation

Transition radiation is easily absorbed in active gas yielding higher amplitudes than MIP

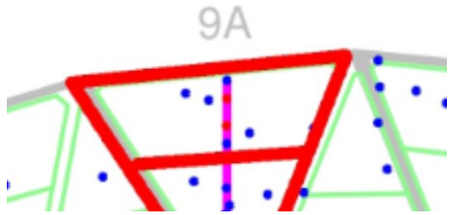


Sketch of the operation mechanism of TRT straw tubes [4].

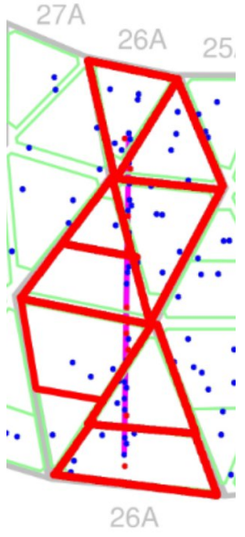
Fast-OR trigger operation principle [5]



The granularity of the trigger is one segment, consisting of 160-240 straws.



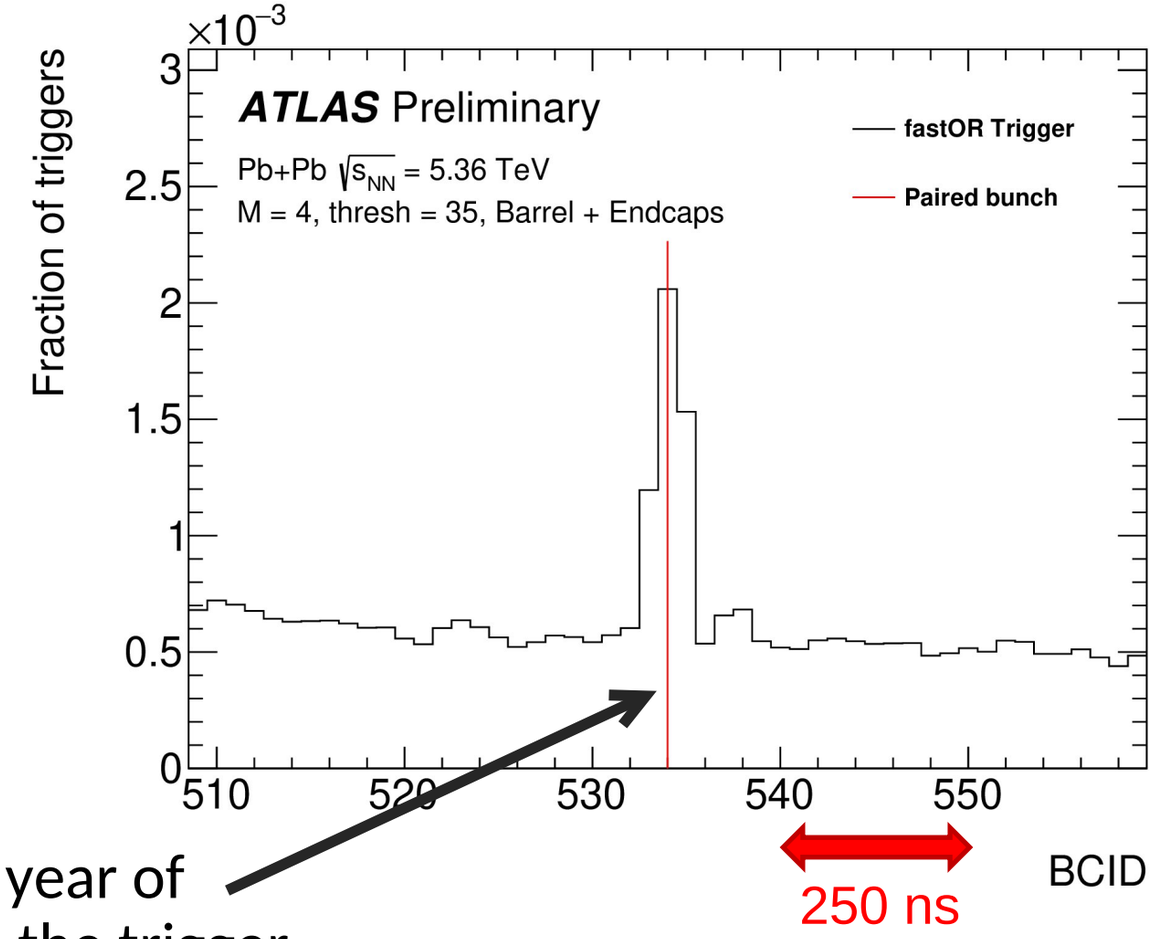
The trigger is divided into 32 „phi sectors”, each consisting of 9 segments.



Signals from 4 adjacent phi sector are aggregated to form the trigger decision.

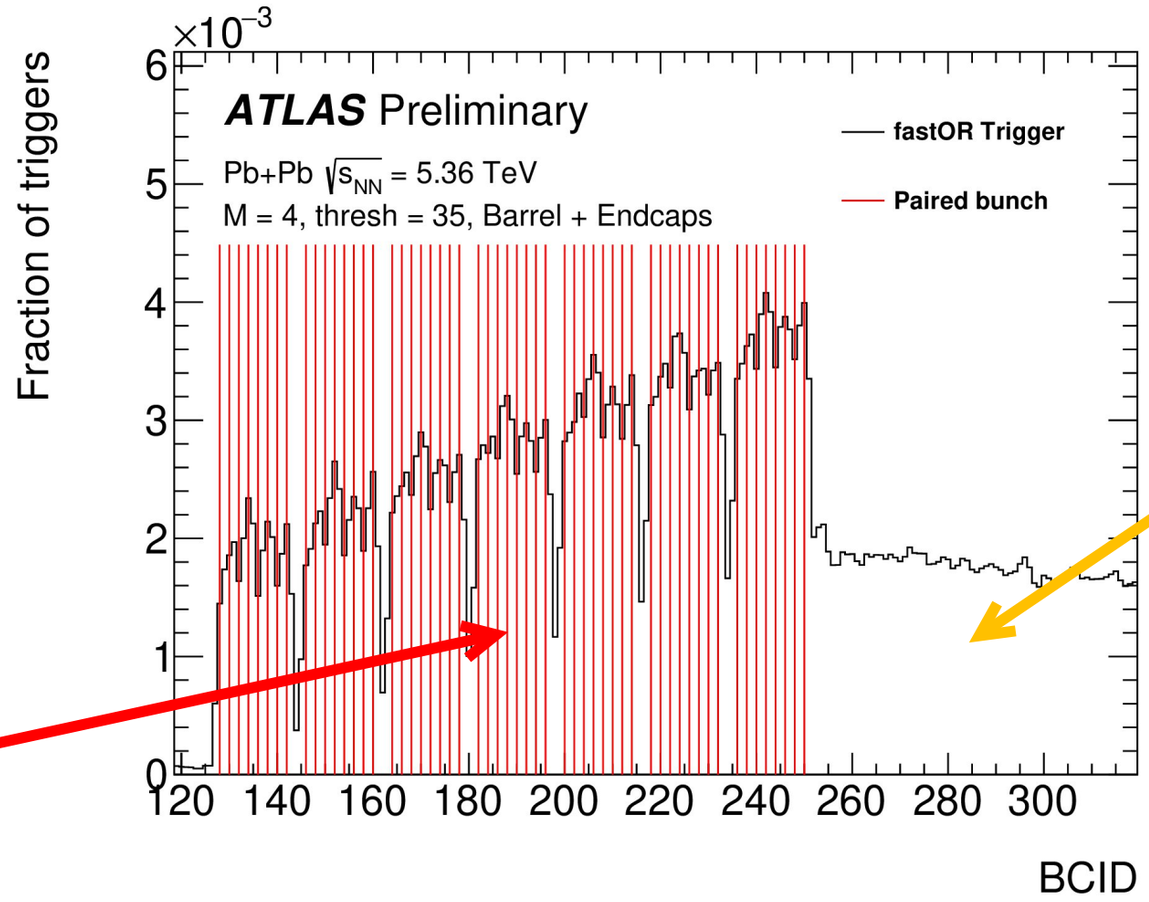
Fast-OR trigger signal arrival vs expected bunch crossing slot

Fast-OR trigger decision is formed by requiring at least **4 front-end boards (M=4)** to register at least one hit passing an energy threshold of **35** (in arbitrary units) that corresponds to approximately **0.67 keV** of energy deposited in the active gas.



It required almost a year of work to synchronize the trigger

Fast-OR trigger distribution with respect to the BCID

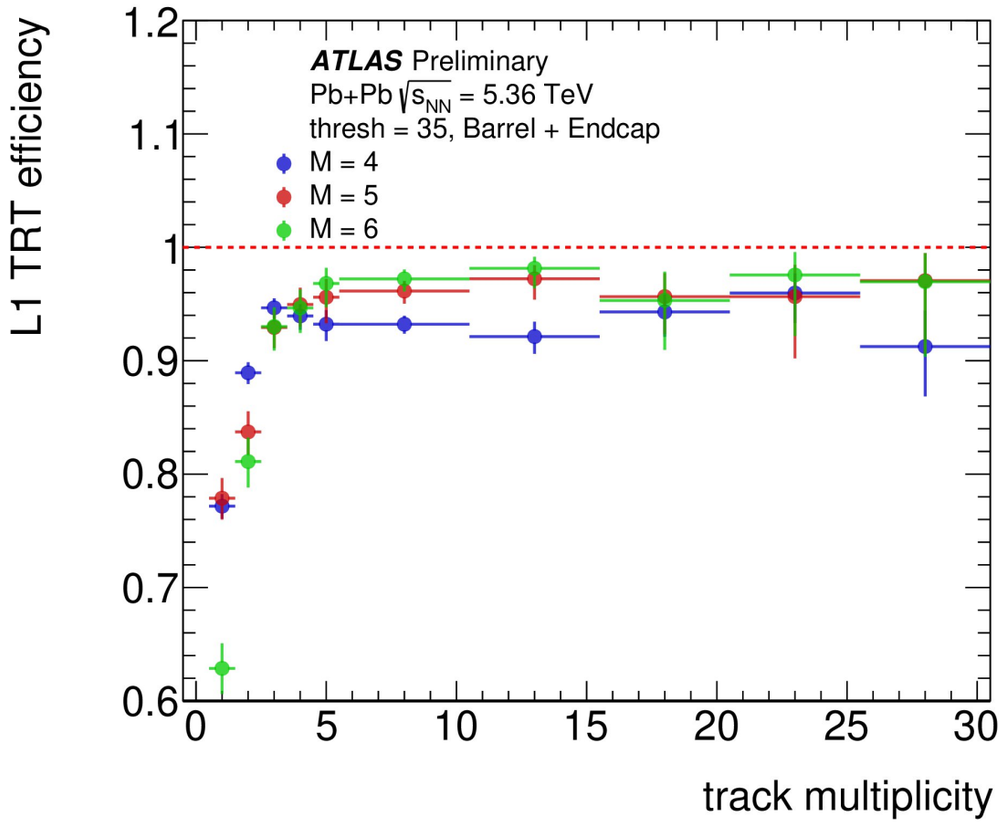


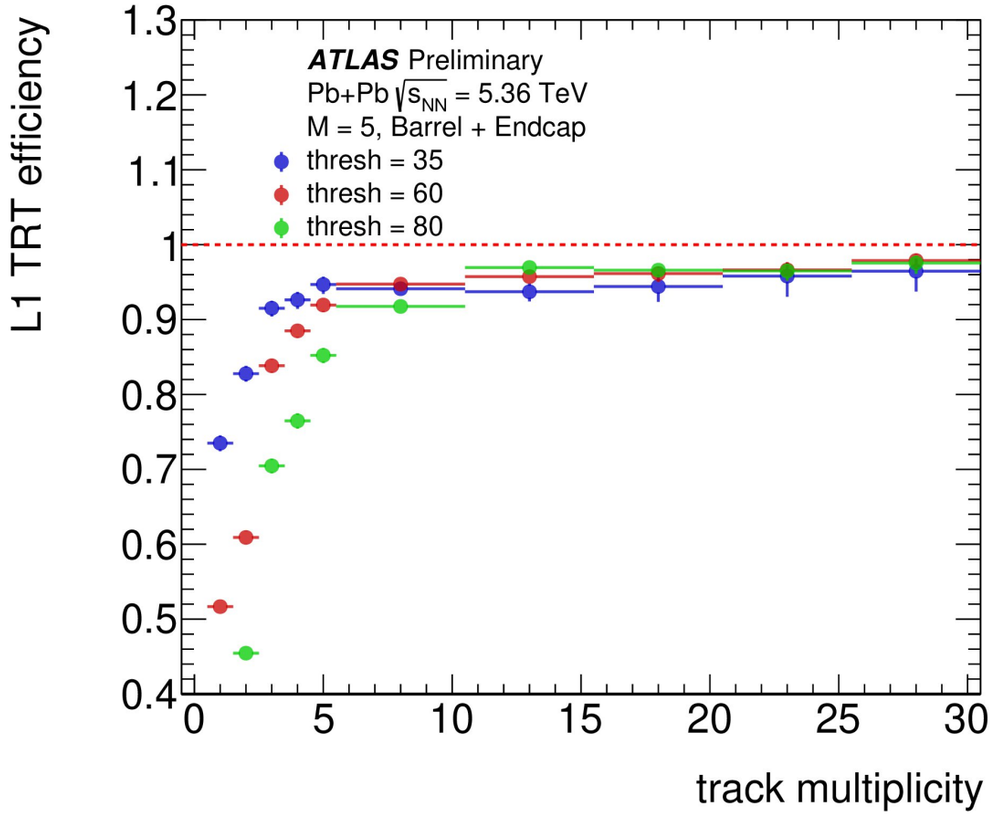
Accumulation of background due to material activation

Triggers for empty bunch crossings generated

τ~2μs

Fast-OR trigger efficiency as a function of number of tracks in $|\eta|<2$





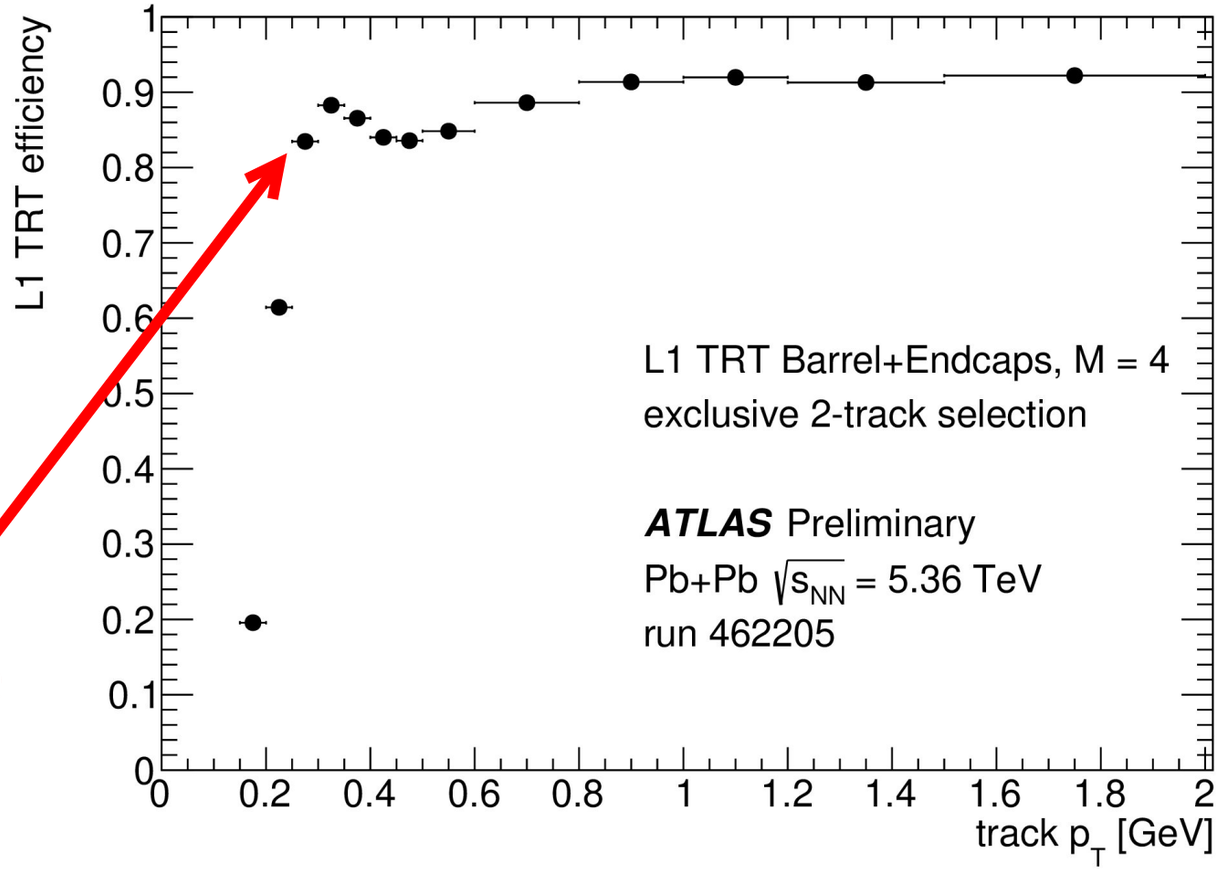
Tracks are required to have **p_T>100 MeV**, **$|d_0|$<2mm**, and pass a standard track quality selection. The efficiency is calculated relative to (photonuclear) minimum bias triggers.

L1 Fast-OR trigger efficiency for exclusive 2-track events

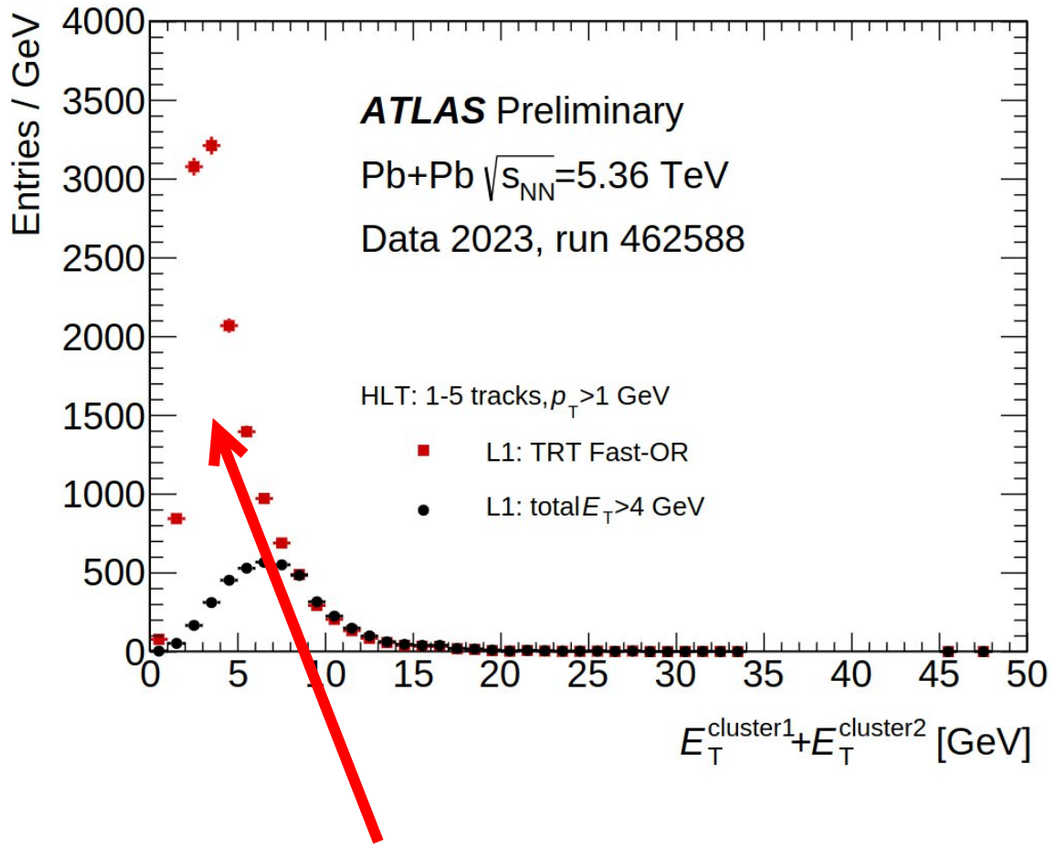
Events are required to have exactly two **back-to-back tracks** of opposite charge with **p_T>100 MeV, $|\eta|$<2, $|d_0|$<2 mm.**

This efficiency is calculated relative to UPC triggers.

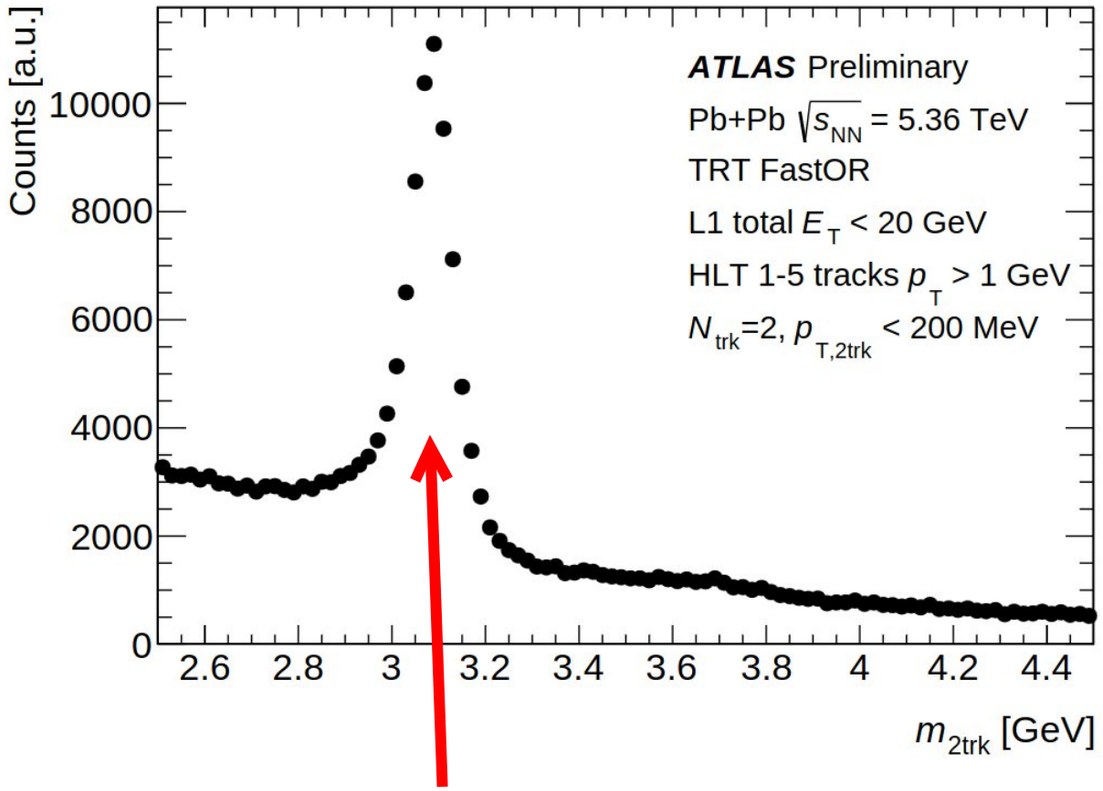
At track p_T = 250 MeV the efficiency is about 83%



Improvement of statistics achieved by the TRT Fast-OR trigger



Improvement to the electron trigger



Peak at J/Psi mass of ~3.1 GeV

Summary

1. The TRT Fast-OR trigger works well, and was able to record many e^+e^- and J/Psi event candidates. The achieved improvement in J/Psi statistics is of the factor of ~50 relative to Run 2 data.
2. The trigger reaches an efficiency of about 83% for tracks with p_T as low as 250 MeV.
3. Accumulation of empty triggers, resulting from TRT material activation, is observed throughout the collisions.
4. This is a first attempt to use the information from inner detector for triggering at Level 1 in heavy-ions.

Thank you for your attention!

This work was realized as part of the NCN PRELUDIUM BIS 4 project 2022/47/O/ST2/00148

Bibliography

[1] ATLAS Event Displays Repository, UNSG-2023-101.

[2] K. Potamianos, The upgraded pixel detector and the commissioning of the inner detector tracking of the atlas experiment for run-2 at the large hadron collider (2016), arXiv:1608.07850 [physics.ins-det].

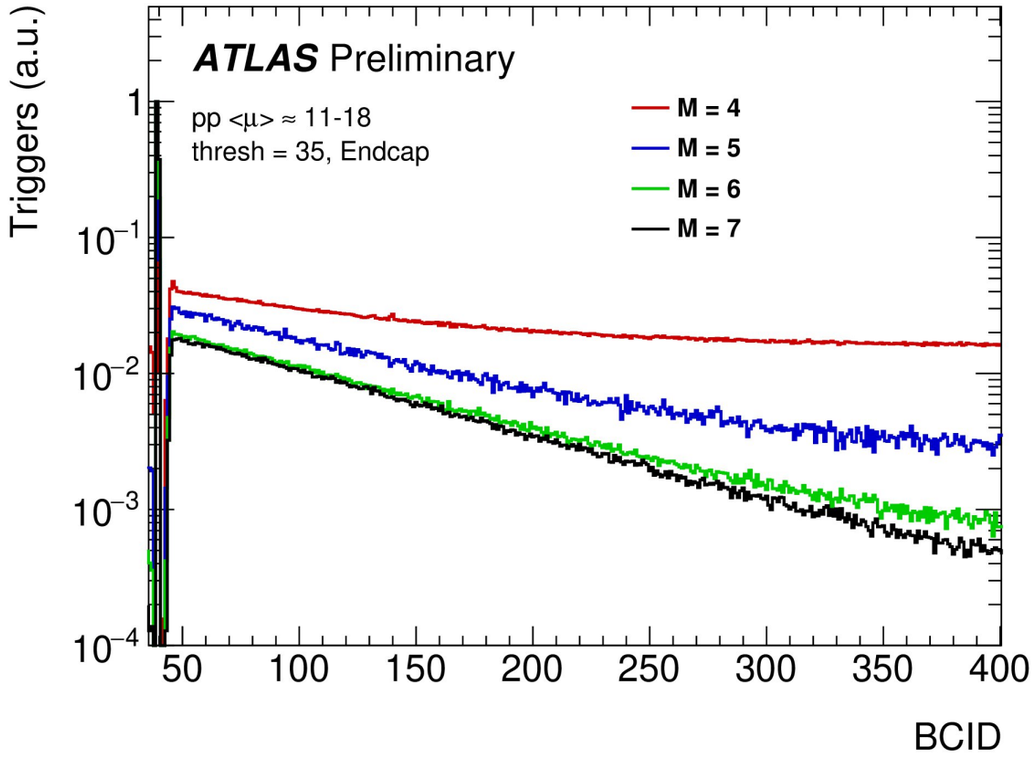
[3] ATLAS Colaboration, Observation of the γγ→ττ Process in Pb+Pb Collisions and Constraints on the τ -Lepton Anomalous Magnetic Moment with the ATLAS Detector, Phys. Rev. Lett. 131, 151802 (2023), arXiv:2204.13478 [hep-ex].

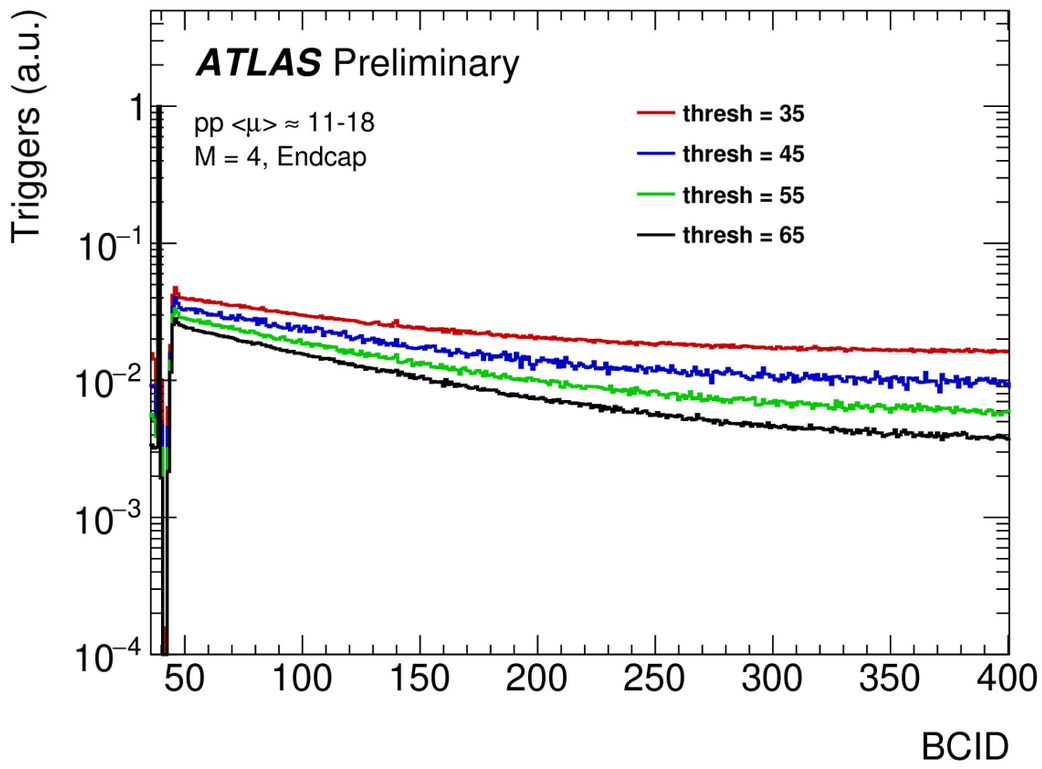
[4] A. Bing ̈ul, The atlas trt and its performance at lhc, Journal of Physics: Conference Series 347, 012025 (2012).

[5] ATLAS Colaboration, The TRT Fast-OR Trigger, Tech. Rep. (CERN, Geneva, 2009).

Backup

Background trigger rate due to collision-induced radioactivity





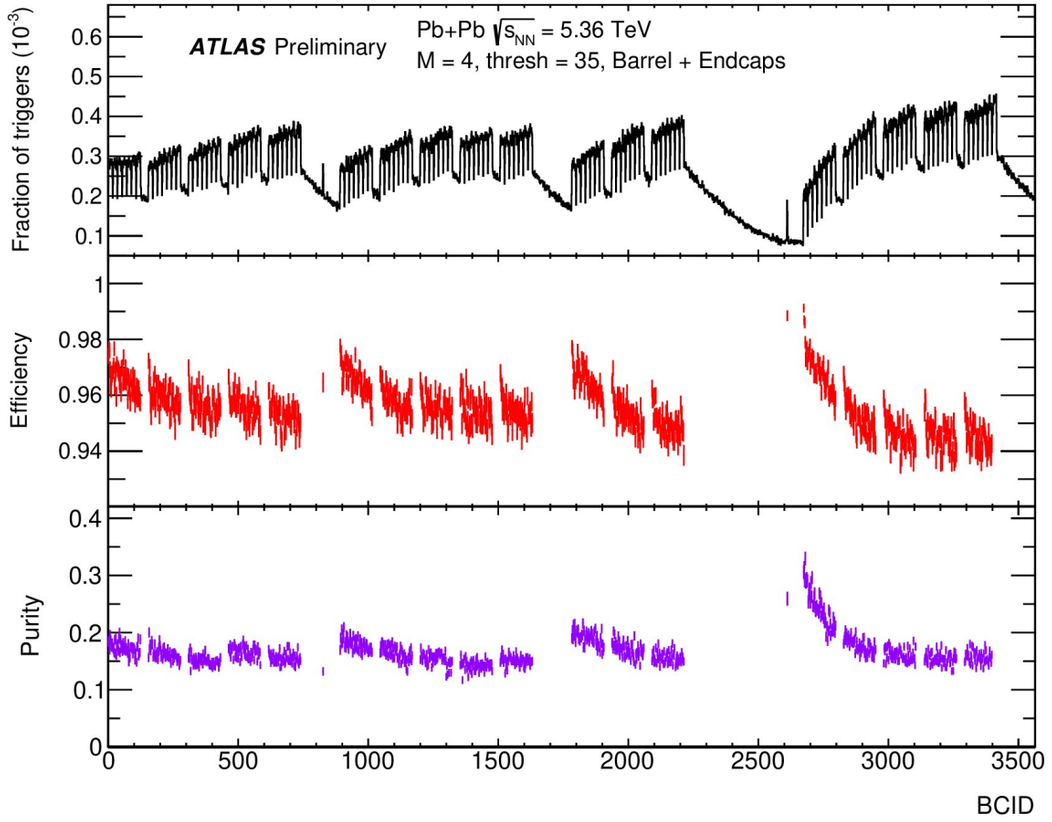
Colliding bunches are located in BCID 39.

Fast-OR trigger fraction of triggers, efficiency, and purity

Efficiency of the **Fast-OR trigger** combined with a calorimeter-level energy veto of 200 GeV (**VTE200**) with respect to inclusive **photonuclear triggers** based on ZDC at L1.

Events selected by reference triggers are required to have 5 or more reconstructed tracks with **p_T>100 MeV** consistent with prompt production (**$|d_0|$<2 mm**).

Purity is calculated as the fraction of events with at least one reconstructed track consistent with prompt production.



Efficiency for isolated-bunch pairs vs the bunch train.

All tracks are required to have:

- **p_T>100 MeV,**
- **$|\eta|$<2,**
- **$|d_0|$<2mm.**

A bunch train has a structure of 8 bunches separated by 50 ns, and is separated by a gap of 100 ns from another train.