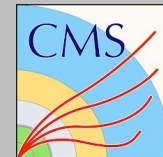


Unveiling the Potential for Ultraperipheral Collisions of Heavy Ions: Novel Trigger Strategies and Optimized Physics Performance in the CMS Experiment at 5.36 TeV

Saray Arteaga Escatel
on behalf of the CMS Collaboration

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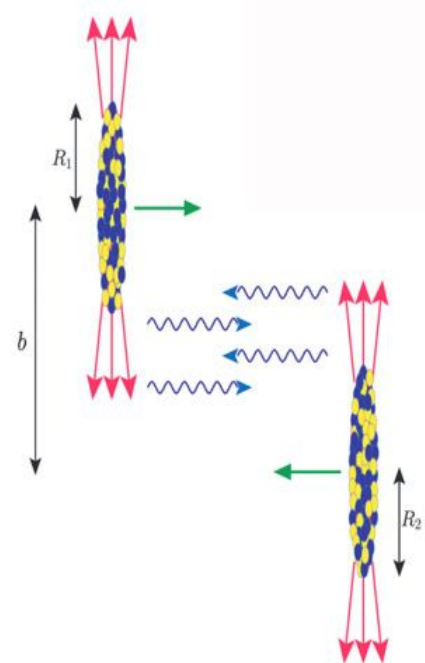
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Introduction

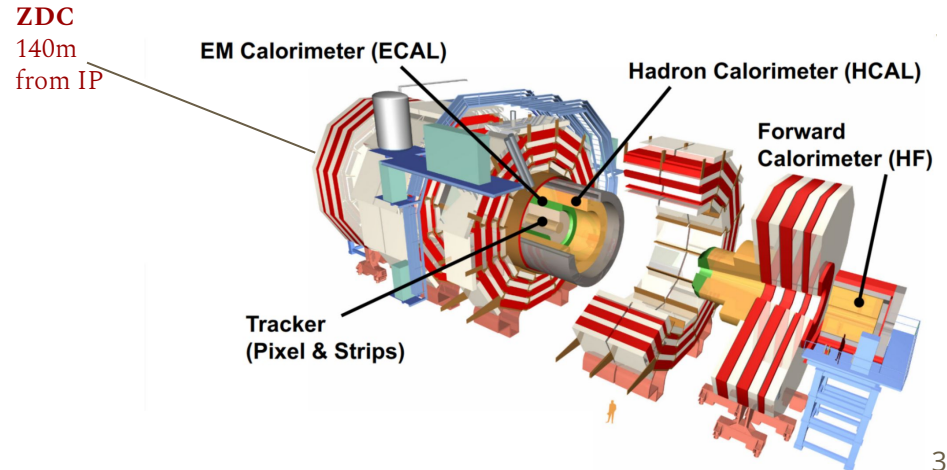
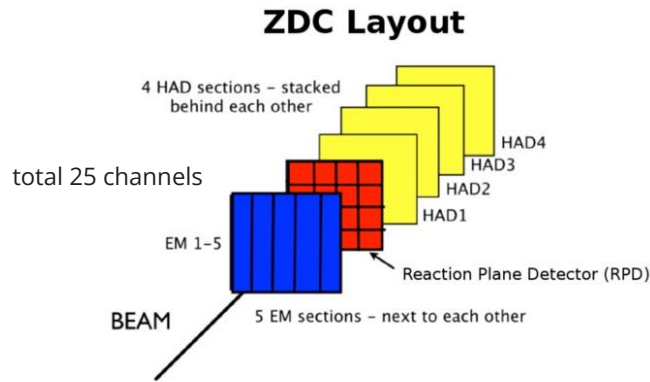
Ultra-peripheral collisions (UPC) with $b > R_1 + R_2$.

- Photon fluxes enhanced $\sim Z^2$.
- Very clean environment to study quantum electrodynamics (QED) within the Equivalent Photon Approximation framework and to probe also saturation/CGC since we probe the high gluon density in the heavy object.
- Enhancement of cross sections in Pb+Pb wrt proton-proton (pp) collisions.
- **Zero Degree Calorimeters (ZDC)** offer control over backgrounds and impact-parameter dependence.
- **Why UPC ?**
 - gamma-gamma and gamma-nuclear interactions.
 - Nuclear matter at small x and nPDFs.
 - good tool for searches for beyond Standard Model (BSM) physics (ALP, g_τ^{-2}).



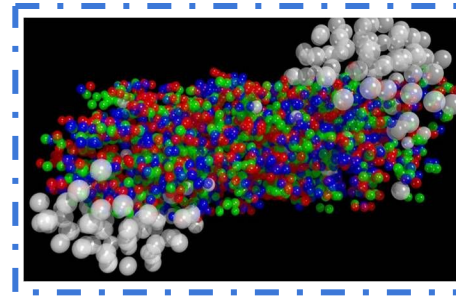
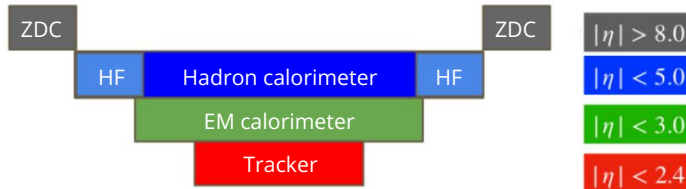
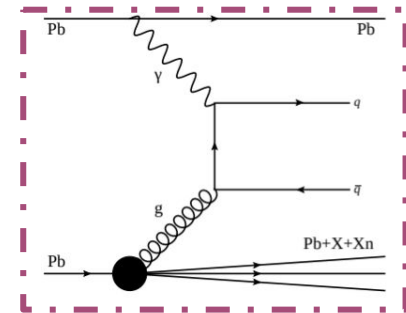
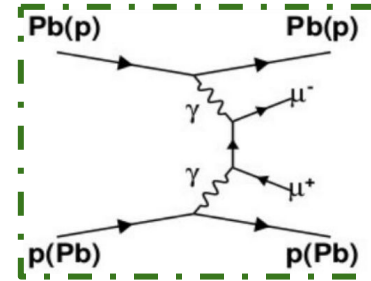
Zero Degree Calorimeter (ZDC)

- ZDCs (plus and minus) located in the **Target Absorber** for **Neutrals** (TAN) at 140m from the IP (+- z direction).
- Each individual ZDC includes two independent calorimeter sections, **Electromagnetic section** (EM) and **Hadronic section** (HAD).
- EM and HAD: compact, extremely fast, and radiation hard calorimeters of tungsten-plates/quartz-fiber-ribbons.
- In addition, implementation of **Reaction Plane Detector** (RPD) sandwiched between the EM and HAD section to measure the deflection of forward neutrons in the direction of reaction plane.



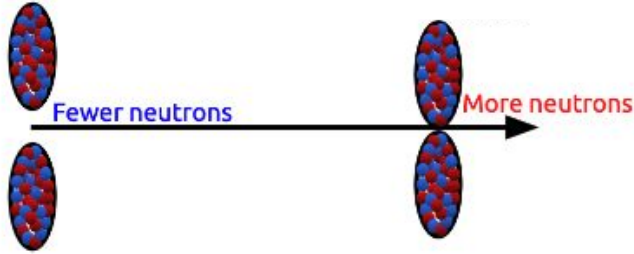
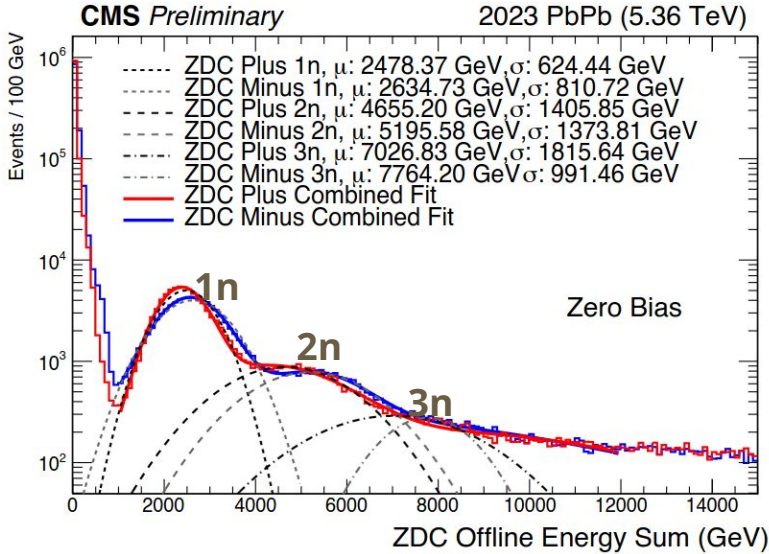
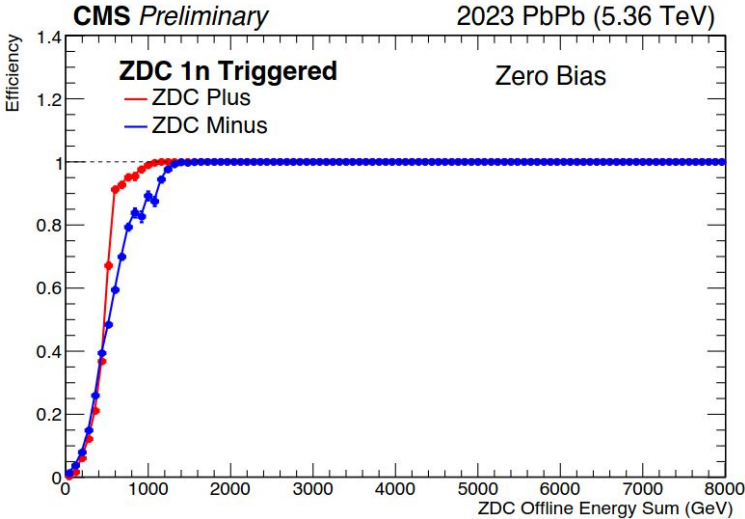
Why ZDC?

- ZDC allows for detection of far-forward neutral particles produced during A+A, p+A collisions.
- We can classify different physics processes by their neutron topology:
 - **0n0n** No neutrons on either side -> **gamma-gamma processes**.
 - **Xn0n/0nXn** Neutrons only on one side -> **dominated by photonuclear processes**.
 - **XnXn** Neutrons on both sides -> **dominated by spectators in hadronic processes**.



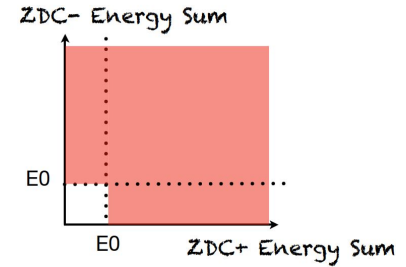
ZDC as L1 trigger

- ZDC in global trigger **for the first time!**
- Commissioned and fully operational on time.
- Neutron peaks are clearly seen.
- ZDC+ has slightly better resolution.
- Trigger efficiency above 1n > 95% for both ZDCs.

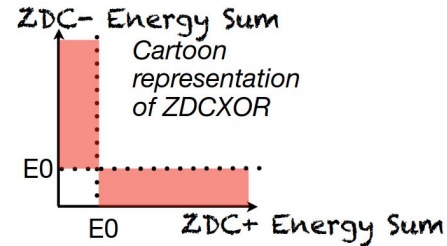


New triggers for photo-nuclear events

- **ZDCOR** : At least one of the ZDCs with signal above threshold (E_0). **Good for low p_T measurements** -> Used for MB trigger noise cleaning.

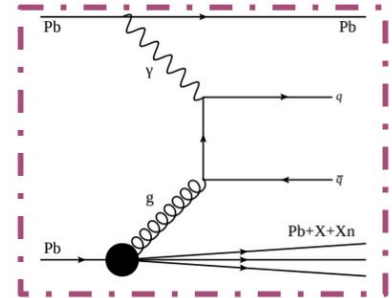


- **ZDCXOR** : Signal in one ZDC, but not the other.

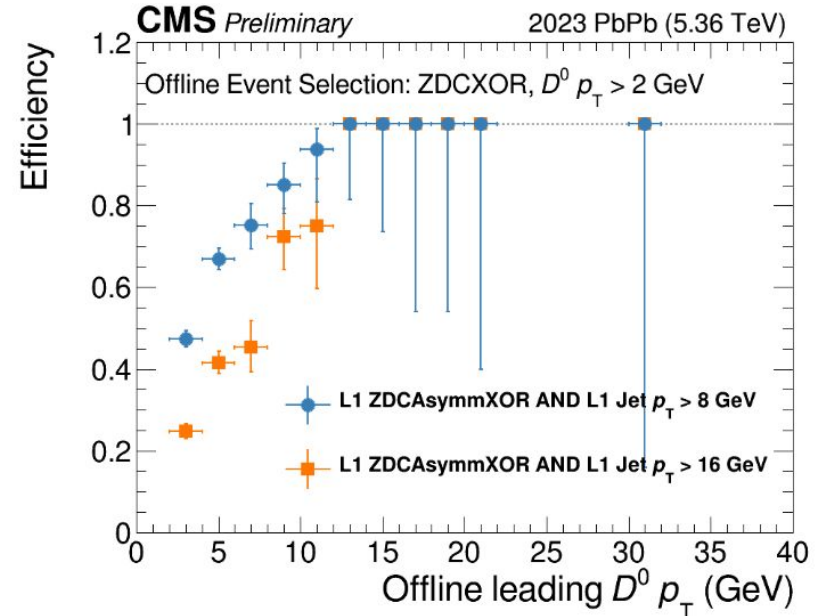
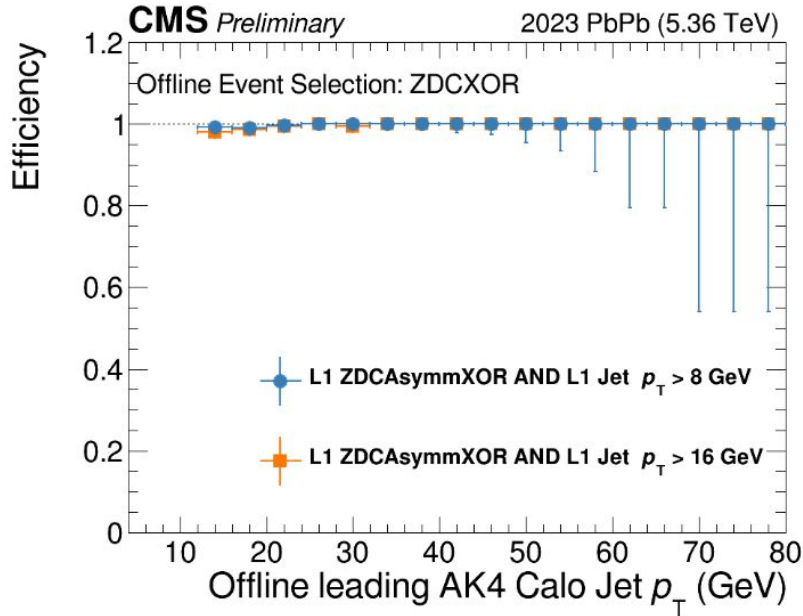


L1 trigger strategy

- For low p_T -> ZDC OR (1 nucleus intact, 1 broken) - no jet to trigger on.
- For high p_T , -> ZDCXOR+Jet triggers



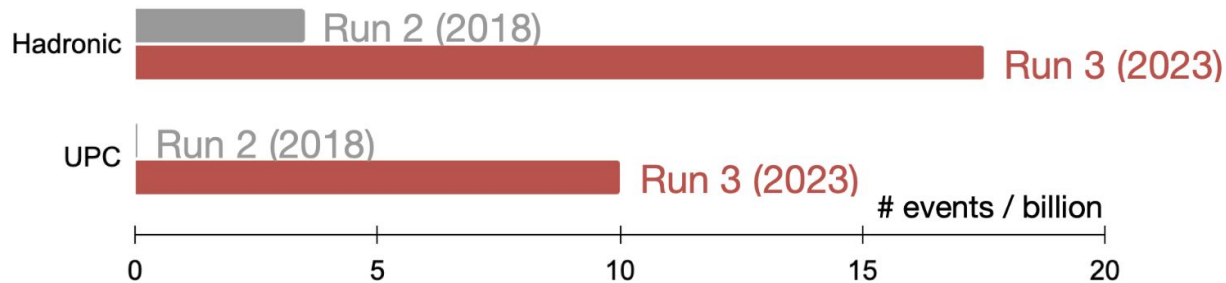
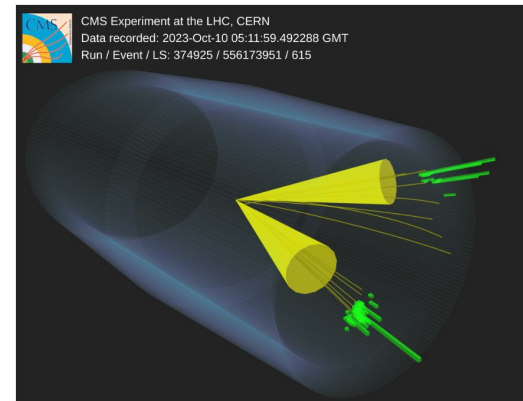
ZDC XOR Events + Jet events



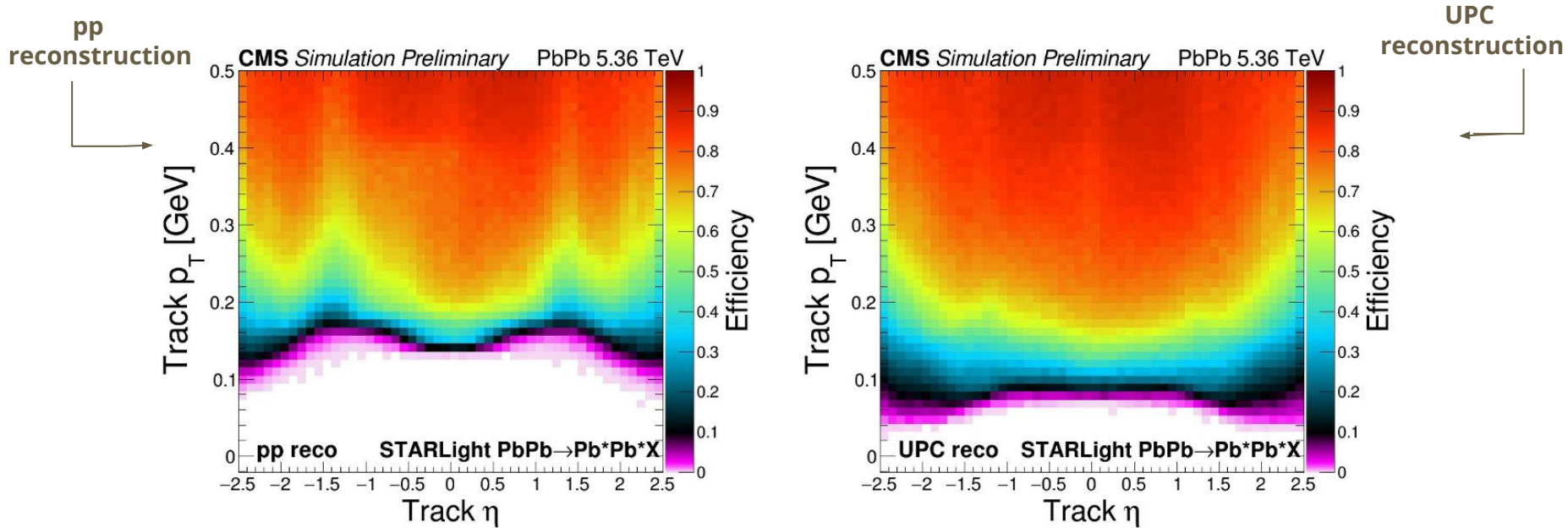
- Seeds based on ZDCXOR AND jets. It is possible to tag D^0 decays down to low p_T

UPC dijet and hadronic events Run3 vs Run2

- ~5 weeks of PbPb at 5.36 TeV.
- Recorded: 1.82 nb⁻¹ (1.7 nb⁻¹ in 2018).
- **Large increase** in the amount of **hadronic events recorded** in Run 3 (2023) vs. Run 2 (2018).
- **Unprecedented sample of UPC** events.

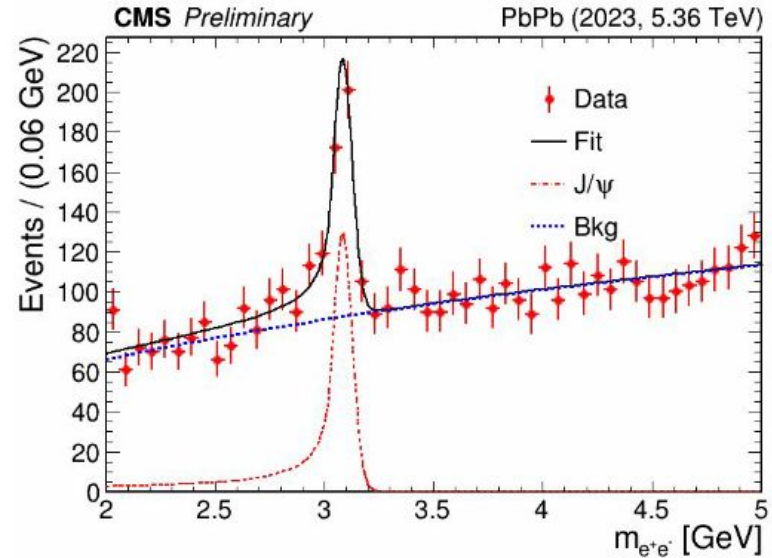
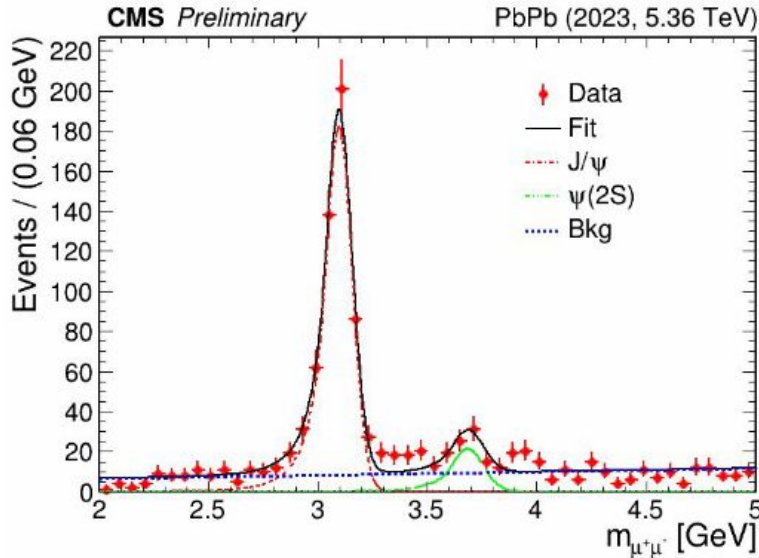


Charged track reconstruction for UPC events



- Established a dedicated UPC setup to enhance the low- p_T tracking reconstruction. tracks down to $\rightarrow p_T = 0.05$ GeV.

Dilepton reconstruction for UPC events



- Validation of the low- p_T lepton reconstruction in UPC events -> Good resolution for intermediate-mass resonances. Clear peaks for J/ψ and $\psi(2s)$

Summary

- New set of UPC physics channels thanks to the use of the ZDC in global trigger.
- ~10B UPC events recorded during Heavy Ion Run 3.
- Offline optimization for low- p_T reconstruction.
- **Very successful start of Run 3!**

