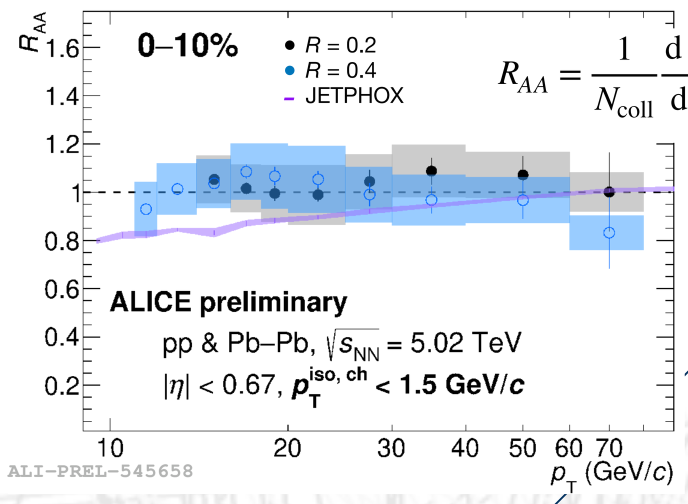
Isolated photon-hadron correlations in Pb—Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV with ALICE

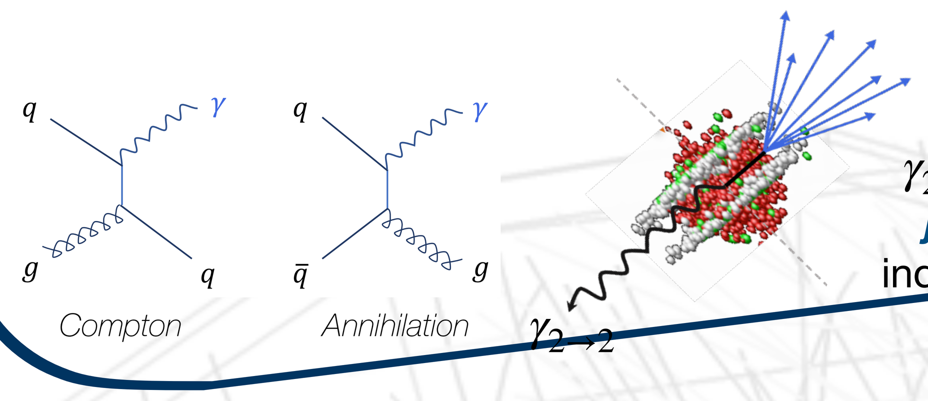
Carolina Arata on behalf of the ALICE Collaboration

156$^{\mathrm{th}}$ LHCC meeting - Poster session | 27/11/23

Why photons in heavy-ion collisions?

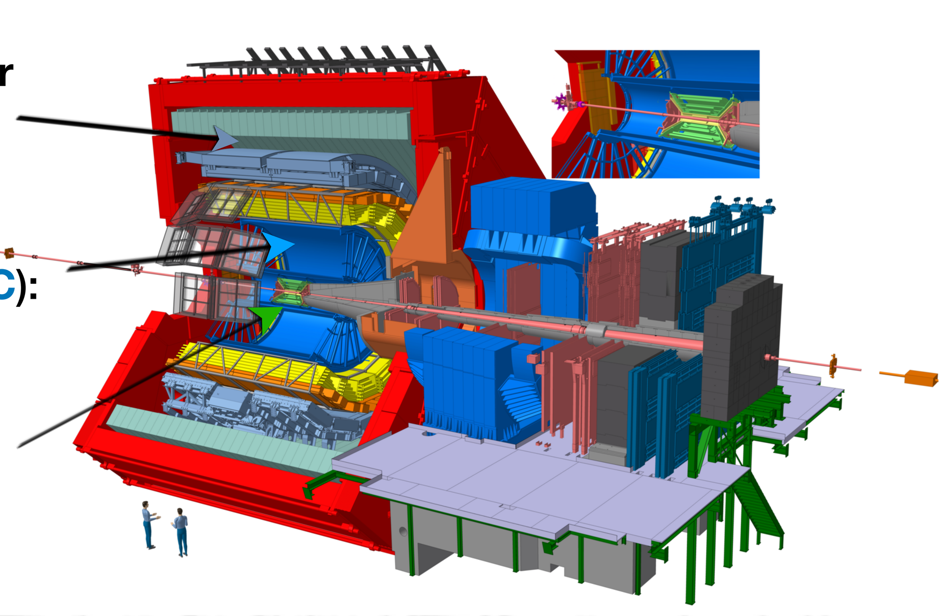
- Photons are colour-neutral: **not affected** by QCD medium
- Direct prompt photons produced in initial hard scattering come from 2→2 processes
  - Allow to **tag the initial energy** of the parton $p_T^{\gamma} \approx p_T^{\mathrm{parton}}$
    → **calibrated reference**





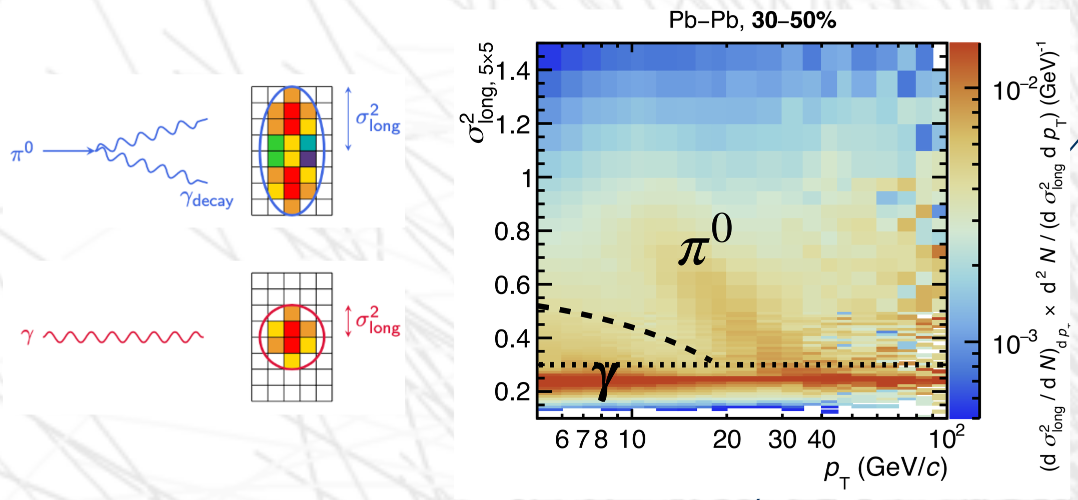
$\gamma_{2\to2}$ - hadrons **correlations** can give access to: the ***jet "fragmentation function"*** and ***modifications*** induced by the medium created in heavy-ion collisions the ***Quark-Gluon Plasma (QGP)***

The ALICE detector



Photon identification with EMCal

Clusters: E deposits in adjacent calorimeter cells



$\sigma^2_{\mathrm{long,\,5\times5}}$ **lateral dispersion** of a cluster to discriminate:

- γ : $0.1 < \sigma^2_{\mathrm{long,\,5\times5}} < 0.3$
- π^0 : $\sigma^2_{\mathrm{long,\,5\times5}} > 0.4$

Isolation method

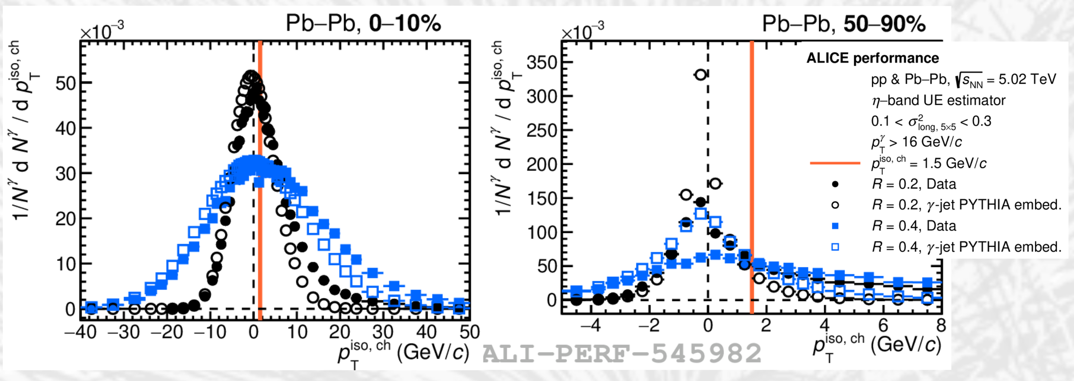
- To identify $\gamma_{2\to2}$ **photons**: low hadronic activity in a cone R around them, except collision **underlying event (UE)**:

$\gamma_{2\to2}$ **photons** are isolated

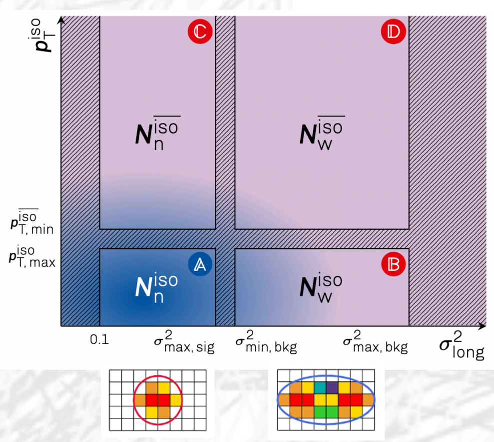
$$R = \sqrt{(\eta_{\mathrm{track}} - \eta_{\gamma})^2 - (\varphi_{\mathrm{track}} - \varphi_{\gamma})^2} = 0.2$$

$$p_T^{\mathrm{iso,\,ch}} = \sum p_T^{\mathrm{tracks\ in\ cone}} - \rho_{UE}\,\pi R^2 < 1.5\ \mathrm{GeV}/c$$

- ρ_{UE} , UE density estimated in η-band outside the cone with same φ width



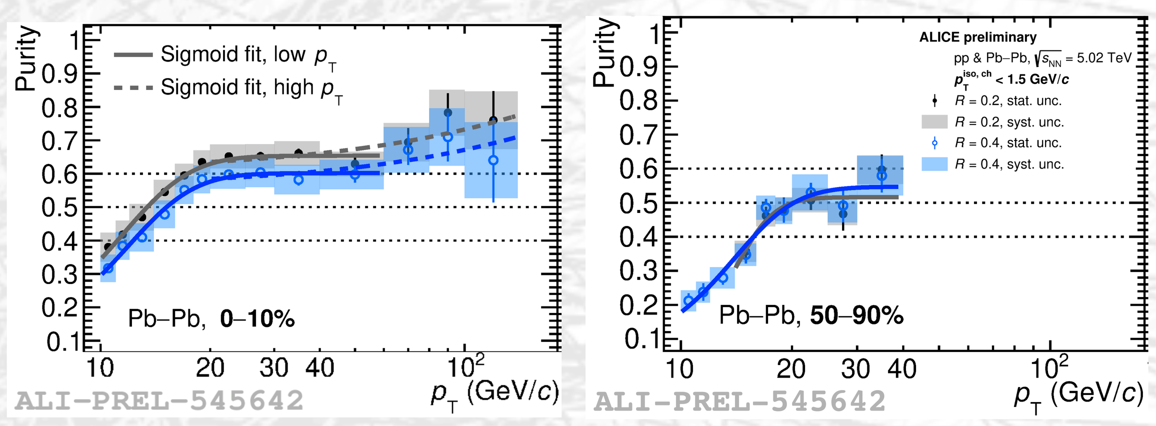
Purity: ABCD method



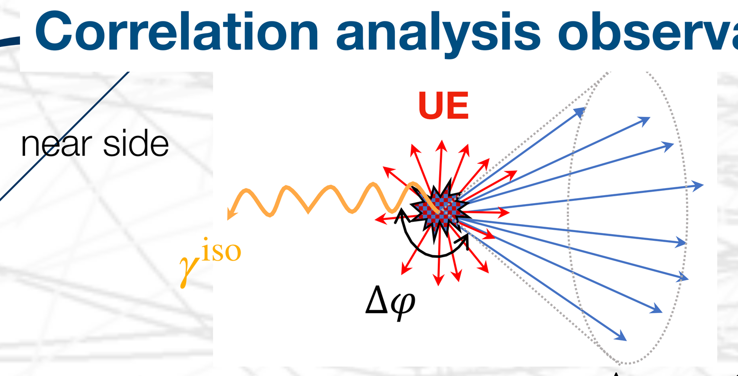
Phase space of calorimeter clusters divided in 4 regions: 3 background dominated regions (BCD) used to estimate the background contribution in the signal region (A)

$$N = S + B$$

$$P = 1 - \left(\frac{N_n^{\mathrm{iso}}/N_n^{\overline{\mathrm{iso}}}}{N_w^{\mathrm{iso}}/N_w^{\overline{\mathrm{iso}}}}\right)_{\mathrm{data}} \times \left(\frac{B_n^{\mathrm{iso}}/N_n^{\overline{\mathrm{iso}}}}{N_w^{\mathrm{iso}}/N_w^{\overline{\mathrm{iso}}}}\right)_{\mathrm{MC}}$$



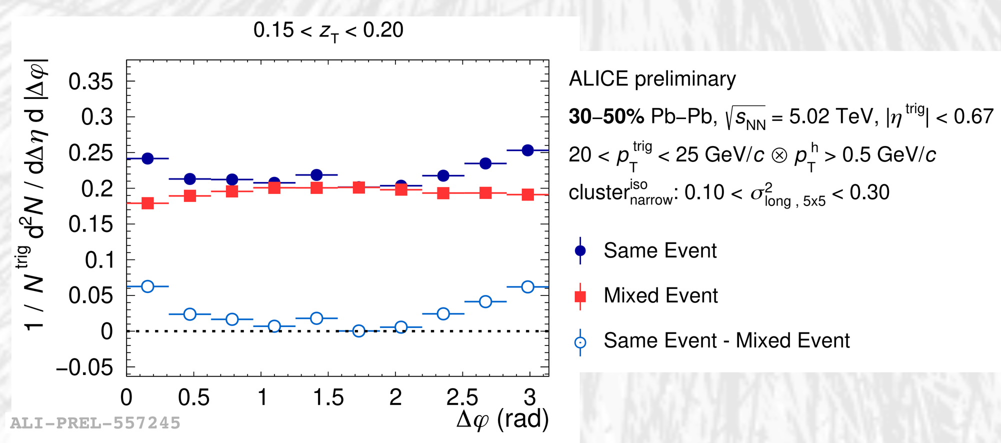
Correlation analysis observables & analysis flow



- Azimuthal correlation distributions $\Delta\varphi = (\varphi^{\gamma} - \varphi^{h})$ are characterised by:
  - no **near side** azimuthal correlation because the trigger photon is **isolated**
  - the **away side** azimuthal correlation at $\Delta\varphi \simeq \pi$
    → hadrons emitted opposite to the trigger due to **parton fragmentation**
  - **Underlying event (UE)**: tracks uncorrelated to the hard process in a collision
- Correlations measure in $z_T = p_T^h / p_T^{\gamma}$ bins

- UE subtraction

- **Underlying event** shifts up azimuthal correlations distributions
- **Mixed Event**: artificial dataset created combining our trigger particle from a given collision with tracks from other collisions
  - Way to subtract UE in the azimuthal distributions

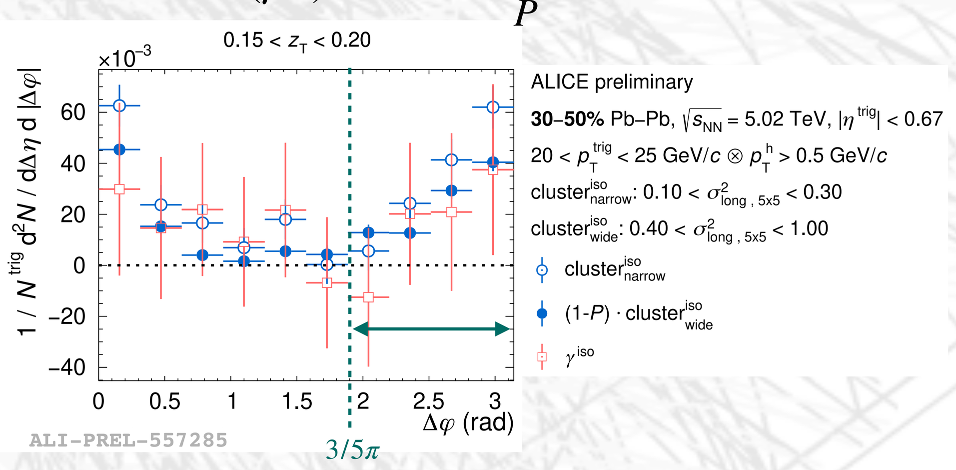


- Purity correction

- Remove residual background (π^0) with **purity correction**

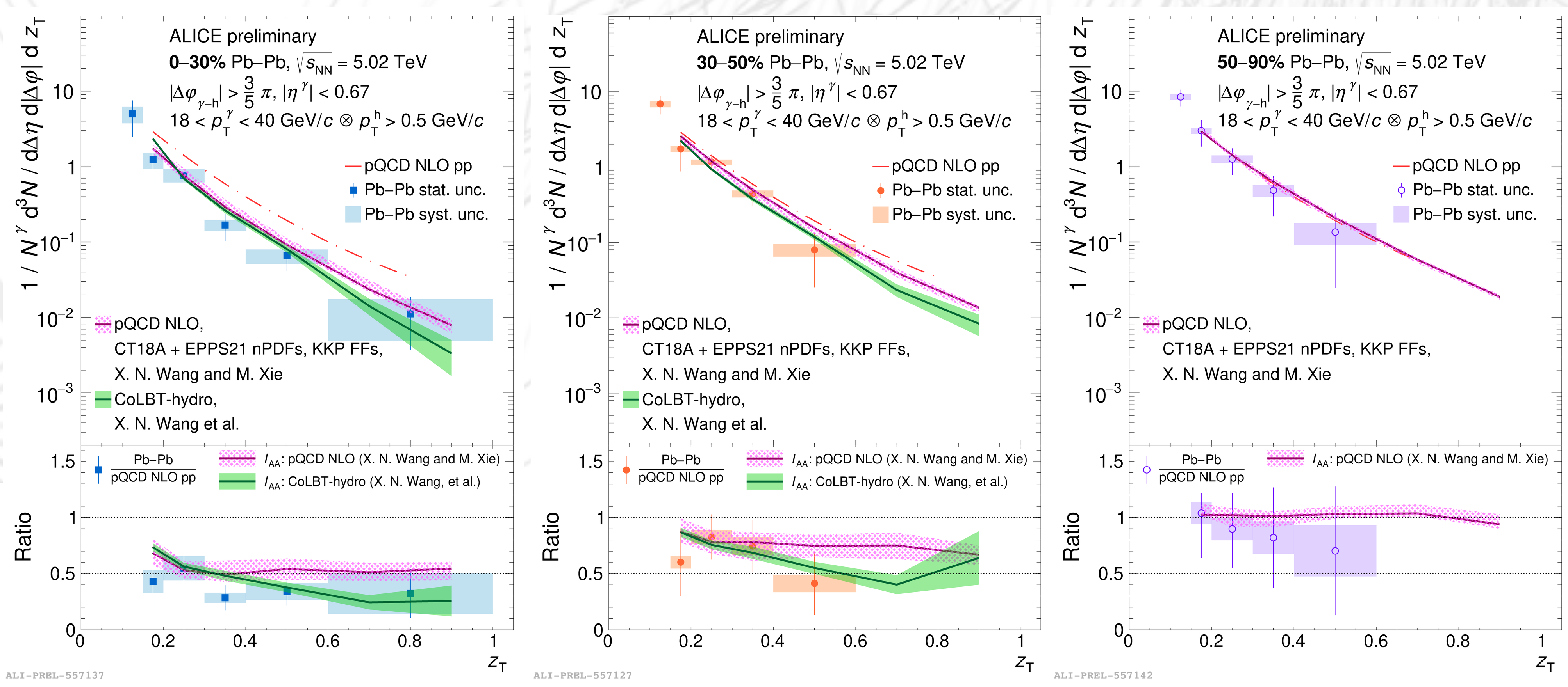
Assume correlations triggered by cluster$^{\mathrm{iso}}_{\mathrm{wide}}$ equivalent to the background for cluster$^{\mathrm{iso}}_{\mathrm{narrow}}$

$$N(\gamma^{\mathrm{iso}}) = \frac{N_n^{\mathrm{iso}} - (1-P)\,N_w^{\mathrm{iso}}}{P}$$



- Integration of the **away side** $(3/5\pi < |\Delta\varphi| < \pi$ rad) peak for various z_T bins to obtain the ***"fragmentation function"*** $D(z_T)$

Results: $D(z_T)$ distributions

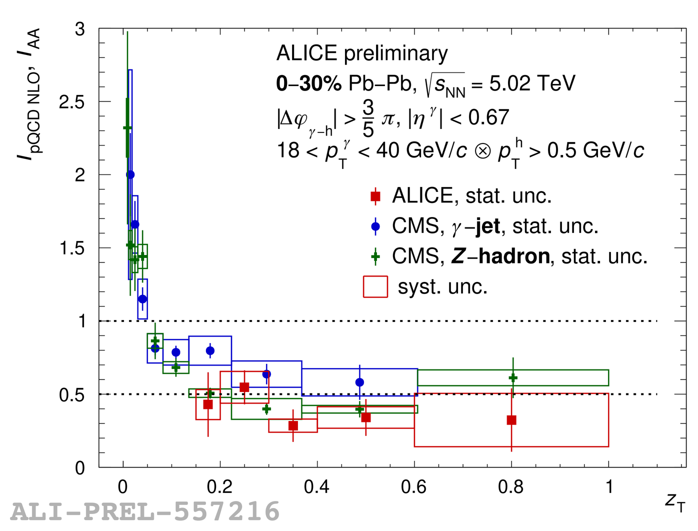


- Strong and clear modification with respect to **pQCD NLO pp** [1, 2] calculation
  - Suppression of $D(z_T)$ yield in central collisions, almost no modification in peripheral collisions
  - hints of higher suppression at higher hadron z_T (p_T)
- Data compared with theory: **pQCD NLO with energy loss added** [1, 2] and **CoLBT-hydro** [3] (0-50%)
  - Agreement with both models
  - Discrimination between models not possible yet with our data
- Ratio with respect to **pQCD NLO pp** [1, 2] calculation
  - Ratio < 1 → **modification due to the medium**
  - I_{AA} from **pQCD NLO with energy loss added** [1, 2] and **CoLBT-hydro** [3] → agreement with data

Comparison to CMS results

- CMS, γ—jet, **0-10%** , $p_T^{\gamma} > 60$ GeV/c [4]
- CMS, Z—hadron, **0-30%** , $p_T^{Z} > 30$ GeV/c [5]
- same $\sqrt{s_{\mathrm{NN}}}$ and system
- different selections and measurements

Not completely apples-to-apples comparison, but similar behaviour



Conclusions

- Despite limited statistics, we can still see a difference between central and peripheral
  - $D(z_T)$ modification stronger for central compared to peripheral collisions
- Results described by models, but discrimination not possible yet due to the current uncertainties

References:
[1] *Phys. Rev. C 103, 034911*, Xie, Wang and Zhang
[2] *Phys. Rev. Lett. 103, 032302*, Xie, Wang and Zhang
[3] *Phys.Lett.B 777 (2018) 86-90* , Chen et al.
[4] *Phys. Rev. Lett. 121, 242301*, CMS Collaboration
[5] *Phys. Rev. Lett. 128, 122301*, CMS Collaboration

carolina.arata@cern.ch