ALICE looks forward:

ALICE measurements of $dN_{ch}/d\eta$ over a broad η range

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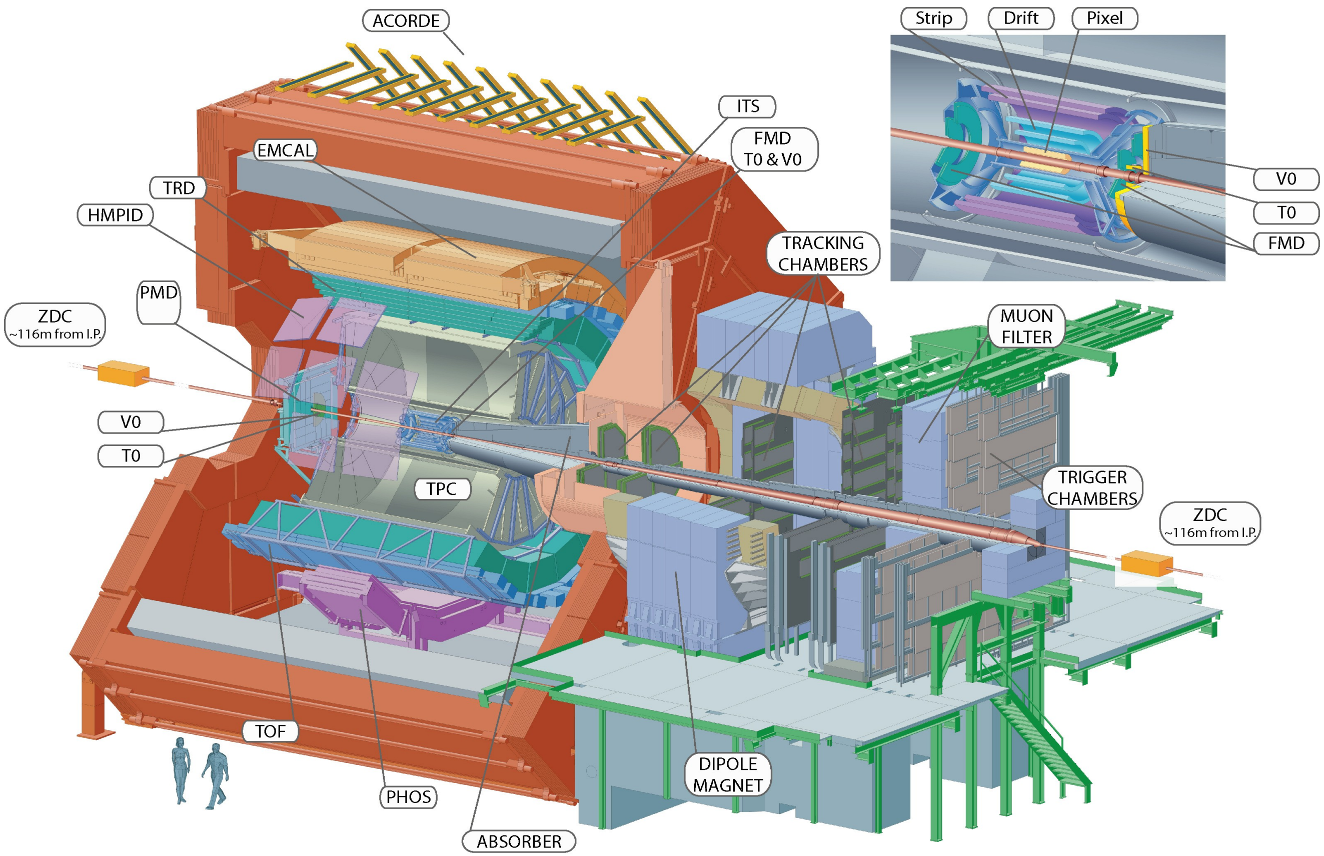
Outline

- Experimental details and analysis methods
- $dN_{ch}/d\eta$ results for:
  - Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV
  - p-Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV

ALICE Detector



Sub-detectors used for measurements of $dN_{ch}/d\eta$:

→**Inner Tracking System (ITS)**
(N_{ch} and trigger)

→**V0** scintillator counters at
$2.8 < \eta < 5.1$ and $-3.7 < \eta < -1.7$
(N_{ch}, trigger and centrality)

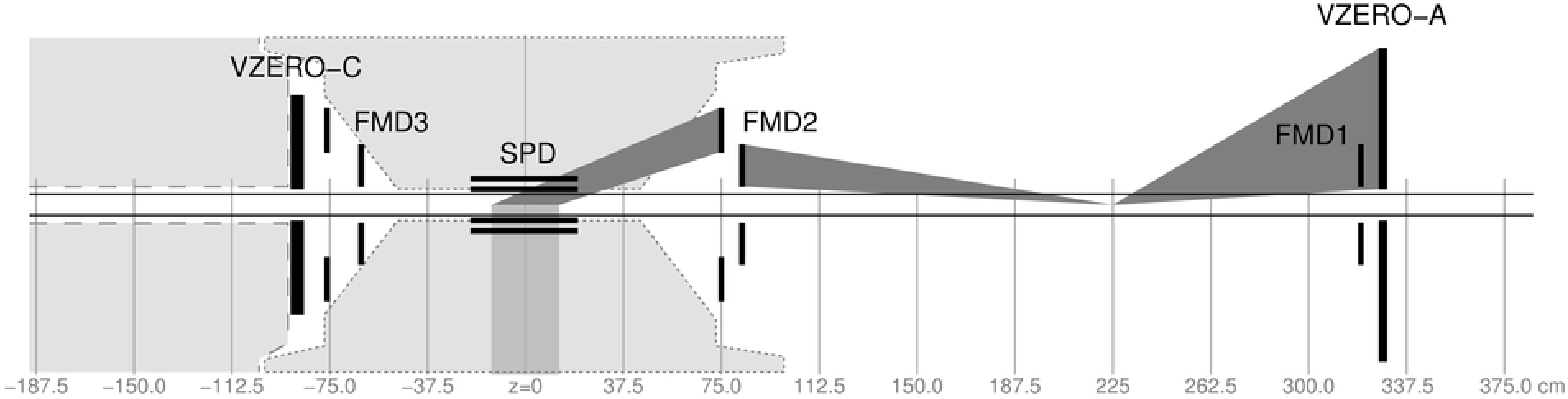
→**Forward Multiplicity Detector (FMD)**, 3 rings of silicon strip detectors placed –69, 79, 320 cm along the beam line
(N_{ch})

→**Zero Degree Calorimeter (ZDC)**
(centrality)

Analysis methods

- $dN_{ch}/d\eta$ for $|\eta|<2.0$ for all collision systems was measured using the tracklet analysis, first time described for pp collisions in Eur. Phys. J. C (2010) 68: 89–108
- $dN_{ch}/d\eta$ for $|\eta|>2.0$ for 0-30% Pb-Pb was measured using satellite collisions (Phys. Lett. B 726 (2013) 610-622)
- $dN_{ch}/d\eta$ for $|\eta|>2.0$ for 30-90% Pb-Pb and for p-Pb were measured using new method based on an empirical correction presented in arXiv:1509.07299

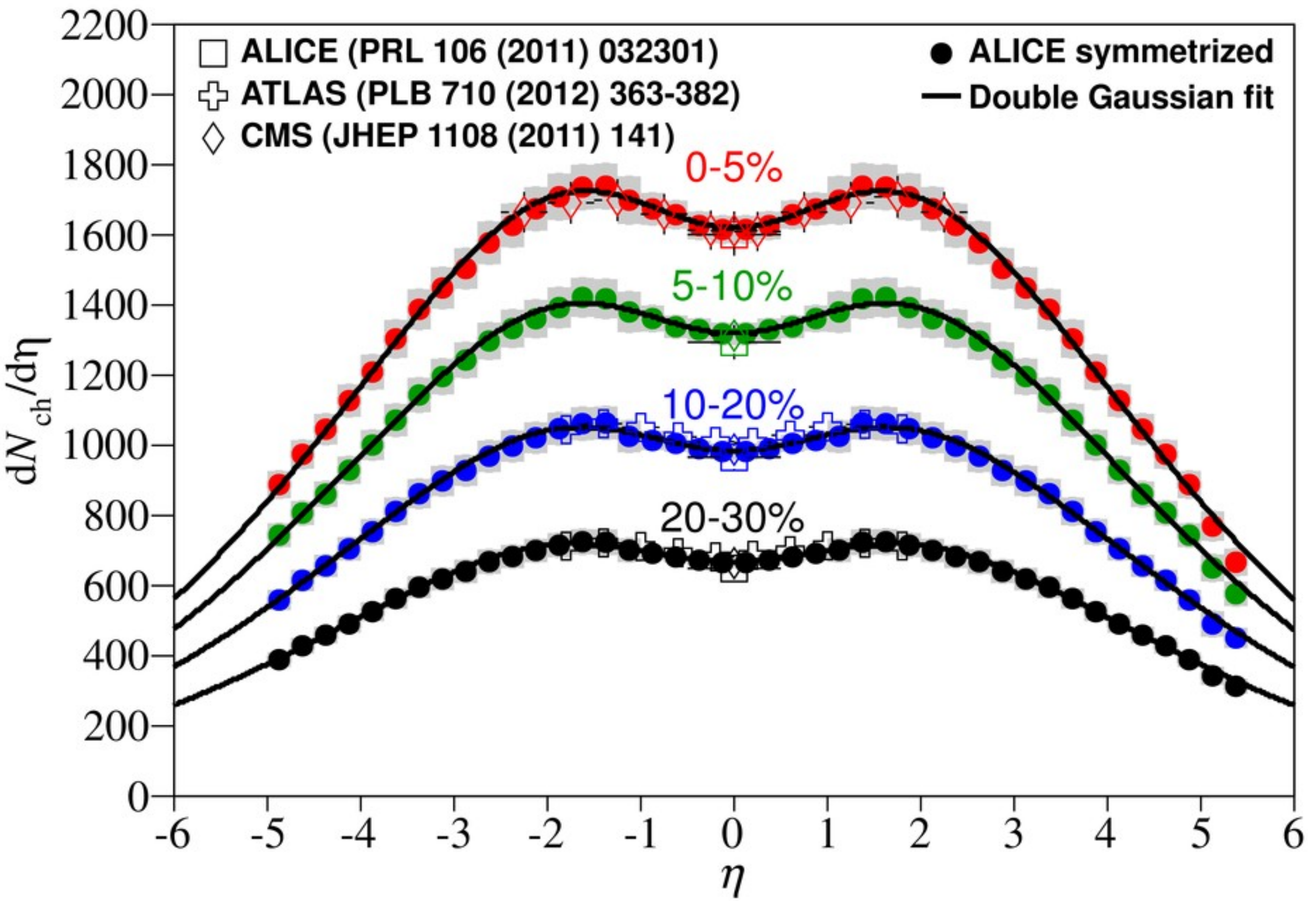
Measurement using satellite collisions



- Satellite collisions were produced by ‘satellite’ bunches and main bunches [1]
- Collisions displaced from nominal collision point
- Satellite collisions = less secondary particles in FMD & V0
- ZDC as centrality estimator (only <30%)
- $dN_{ch}/d\eta$ from: SPD, FMD and V0

[1] C. P. Welsch et al., Conf. Proc. C1205201 (2012) 97–99

Results from satellite Pb-Pb collisions



Fit function: $f(\eta) = A_1 \exp\left(\frac{-\eta^2}{2\sigma_1^2}\right) - A_2 \exp\left(\frac{-\eta^2}{2\sigma_2^2}\right)$

Empirical correction

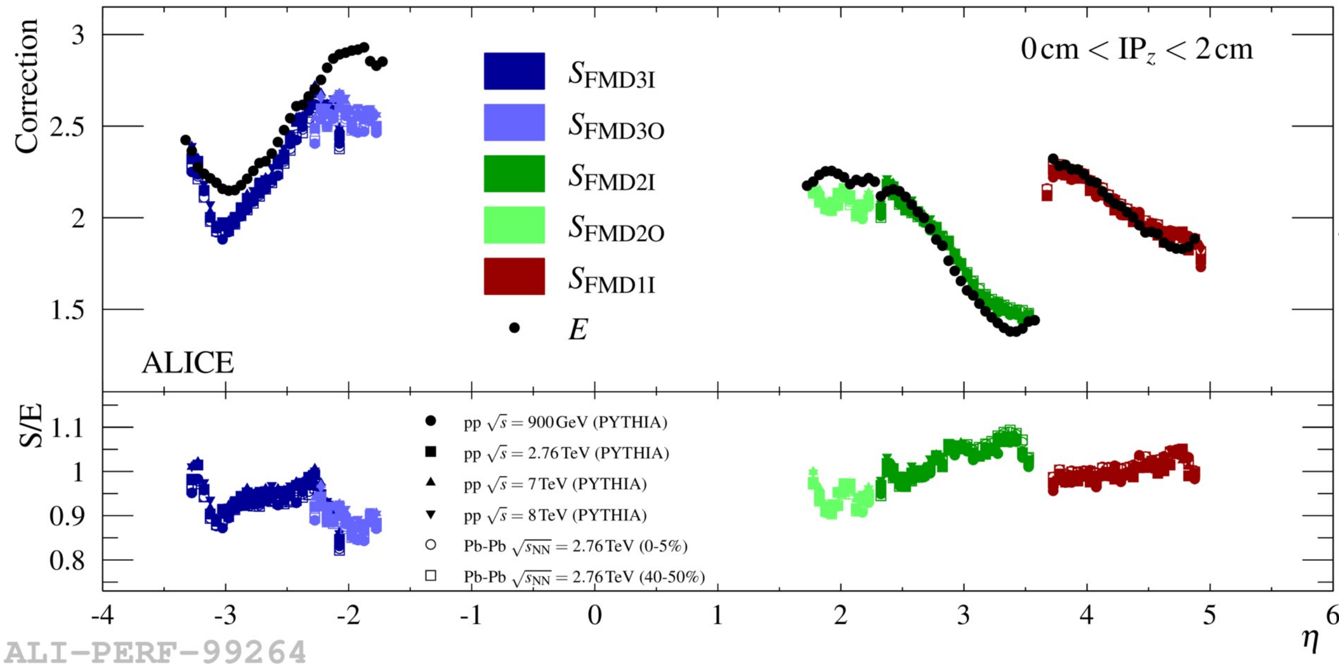
- For collisions at the nominal position, the FMD signal is dominated by the secondary particles produced in interactions with detector material
- To correct the FMD signal an empirical correction (E(η)) was developed (where c is a given centrality bin):

$$E_c(\eta) = \frac{dN_{ch}/d\eta|_{c,inclusive,nominal}}{dN_{ch}/d\eta|_{c,primary,satellite}}$$

Spectrum measured using nominal collisions not corrected for secondary particles

Spectrum measured using satellite collisions corrected for secondary particles using MC

Properties of E(η)



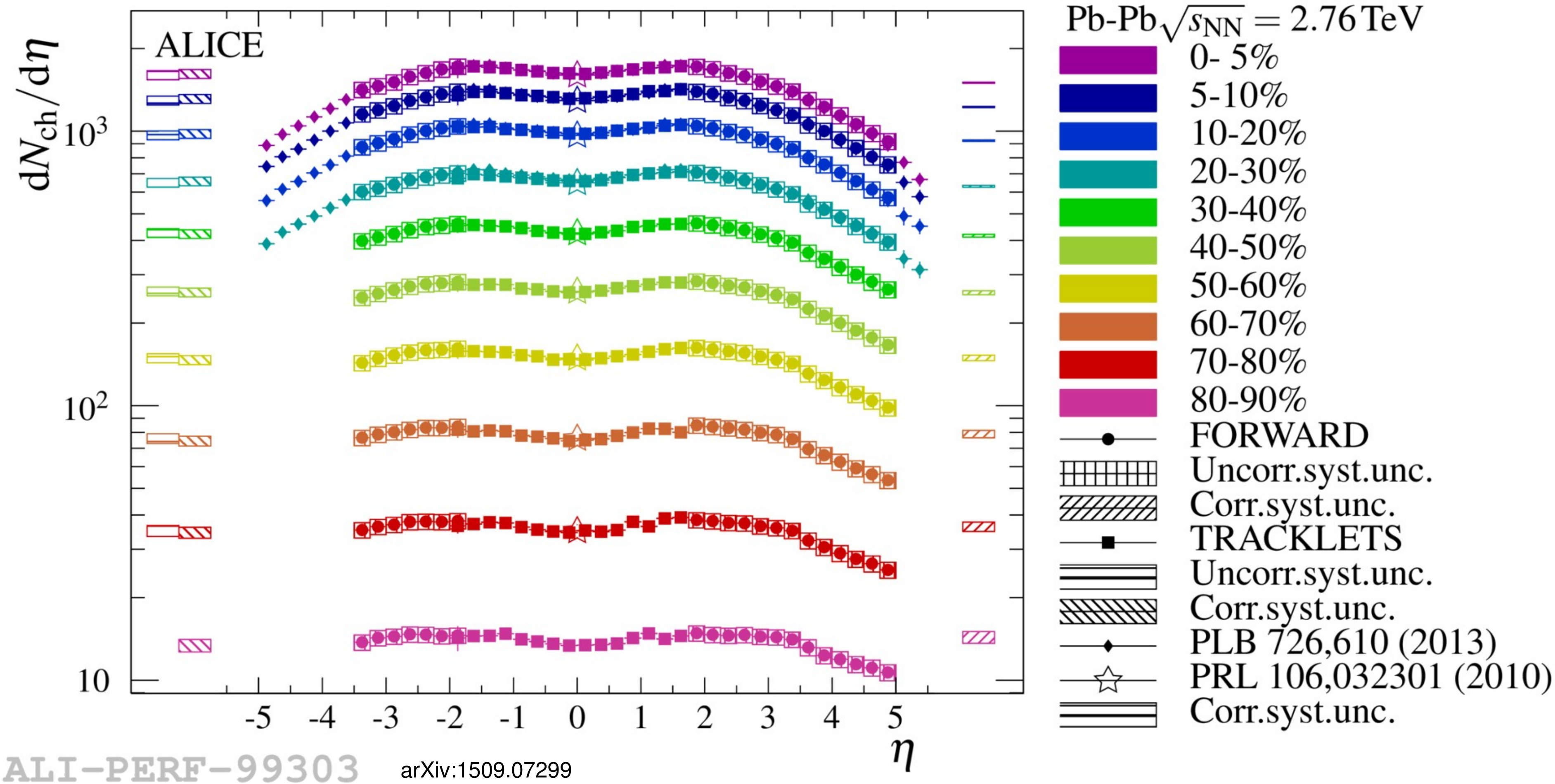
$$S(\eta)_{FMDX} = \frac{\text{number of particle reaching FMDX}}{\text{number of primary particles}}$$

arXiv:1509.07299

- Imperfect simulations => $E(\eta) \neq S_{FMDX}(\eta)$
- S_{FMD} is similar for all collision systems → E is universal and can be used to correct measurement for any collision system, so:

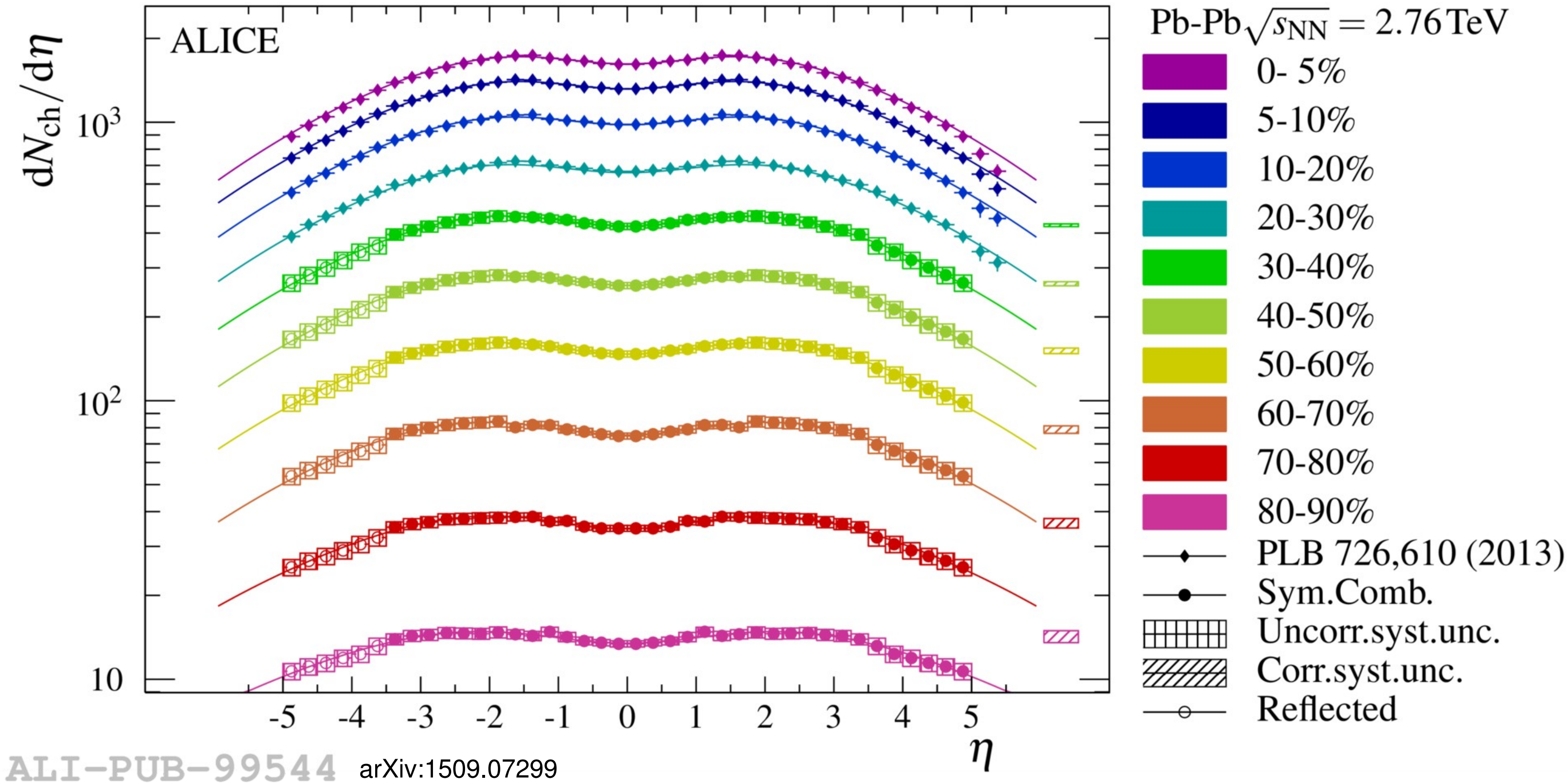
$$dN_{ch}/d\eta|_{primary,nominal} = \frac{1}{E_c(\eta)} dN_{ch}/d\eta|_{inclusive,nominal}$$

Performance of Pb-Pb $dN_{ch}/d\eta$ analysis



arXiv:1509.07299

Pb-Pb results

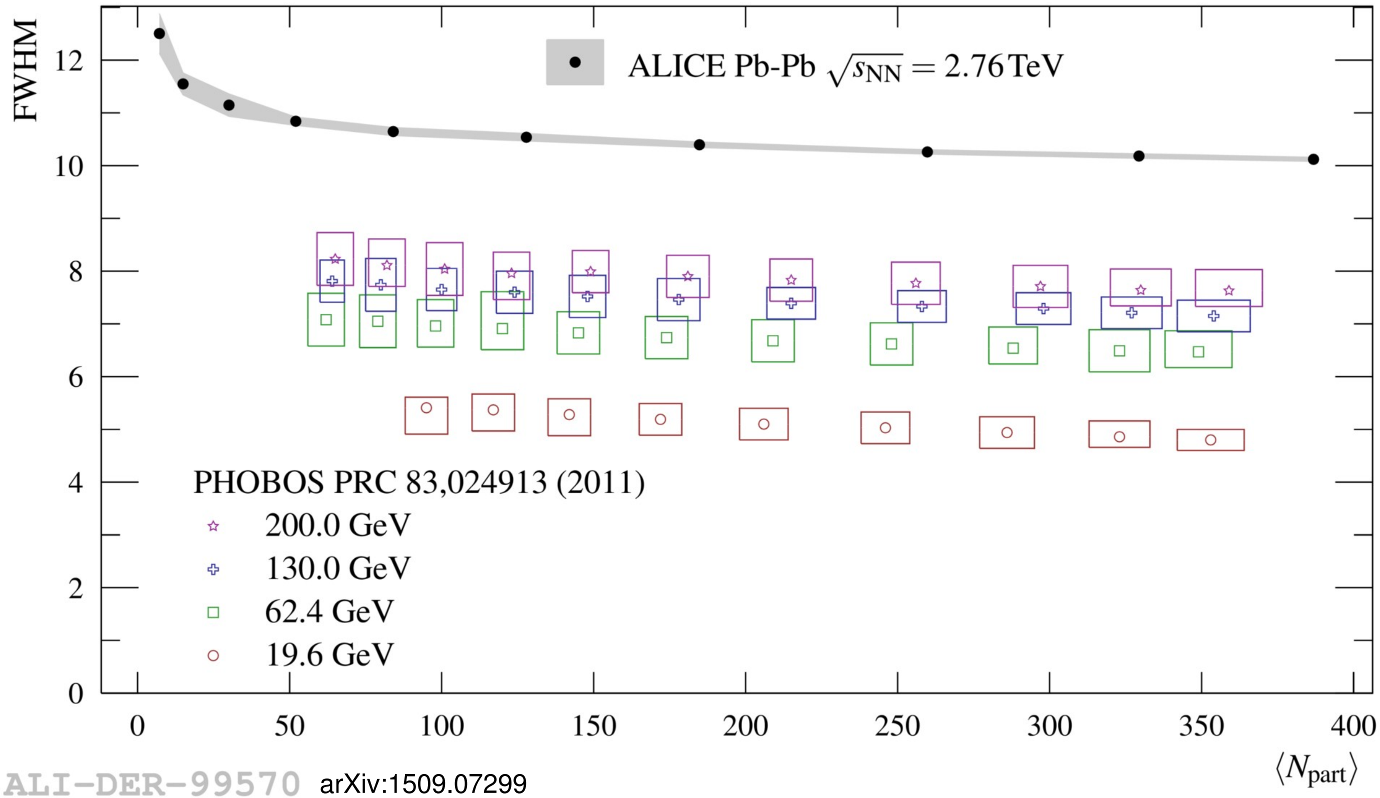


arXiv:1509.07299

Fit function: $$f(\eta) = A_1 \exp\left(\frac{-\eta^2}{2\sigma_1^2}\right) - A_2 \exp\left(\frac{-\eta^2}{2\sigma_2^2}\right)$$

A_1/A_2 and σ_1/σ_2 are rather constant along centralities → shape of the distribution does not change much with centrality

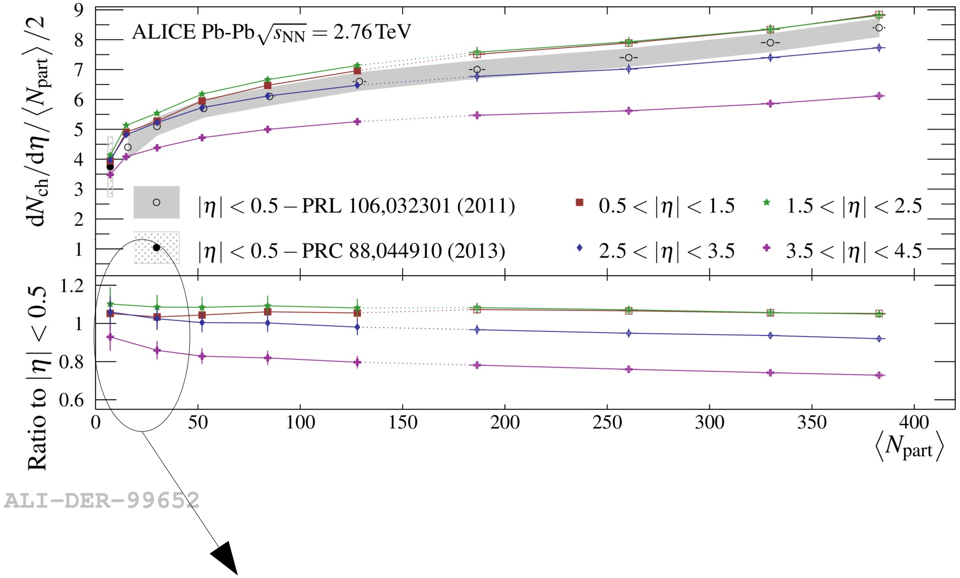
$dN_{ch}/d\eta$ shape evolution with centrality

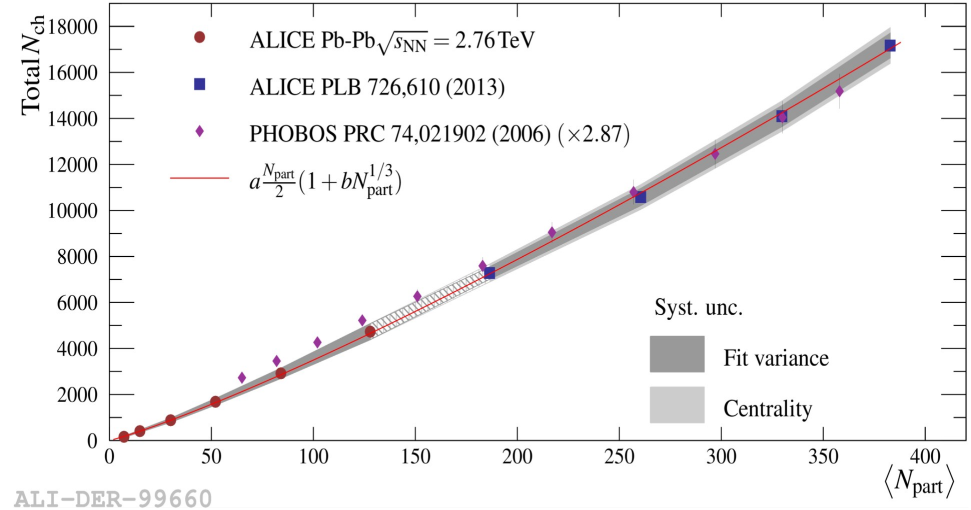


ALI-DER-99570 arXiv:1509.07299

- The Full–Width at Half Maximum (FWHM) vs. $<N_{part}>$ (from Glauber model) increases only in the most peripheral collisions
- For other centralities FWHM follows the same trend as PHOBOS results

$\langle N_{part} \rangle$ scalings



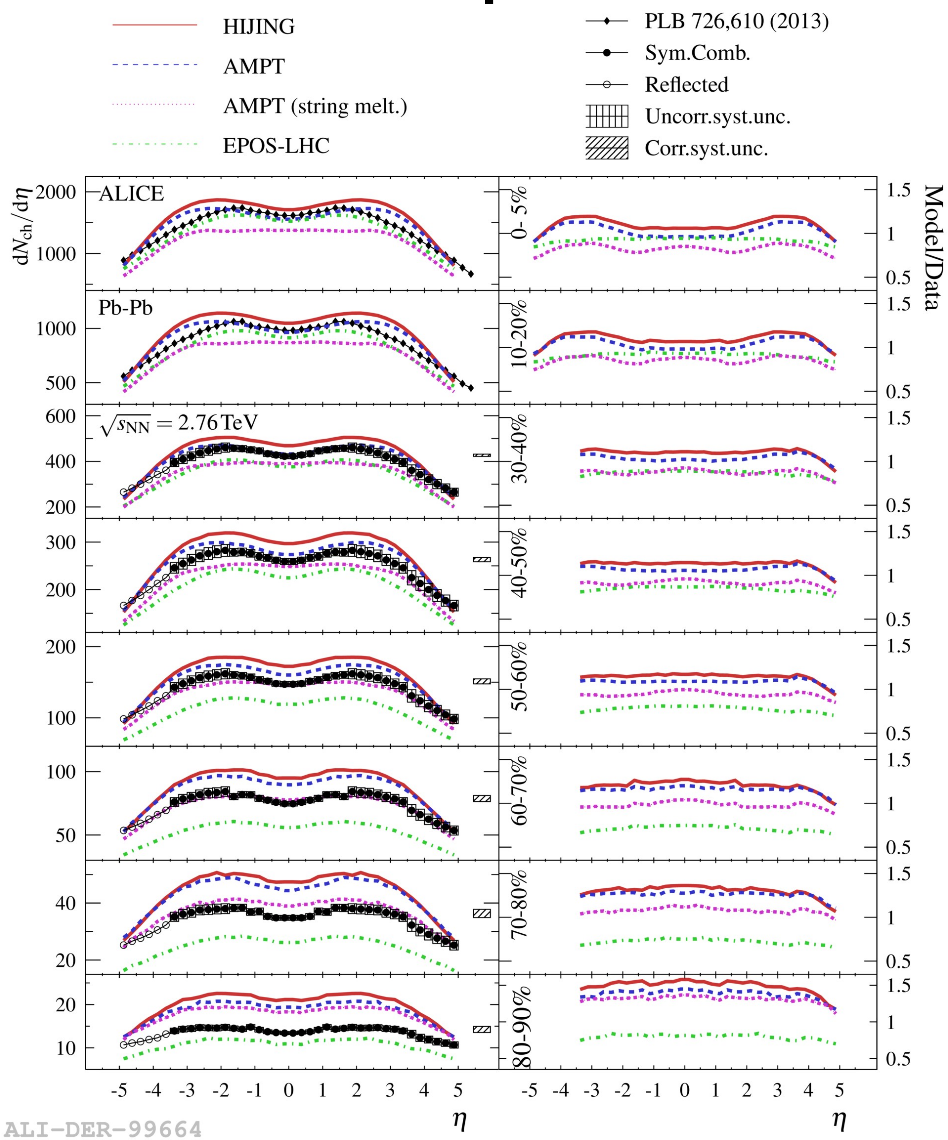


Slight increase for peripheral collisions

arXiv:1509.07299

- N_{ch} vs. $\langle N_{part} \rangle$ similar as at RHIC
- Factorization: $N_{ch}=f(\langle N_{part} \rangle)g(s)$ still valid
- Scaling with $\langle N_{part} \rangle$ → hard contributions to the "Total" N_{ch} are small

Comparison with MC Models



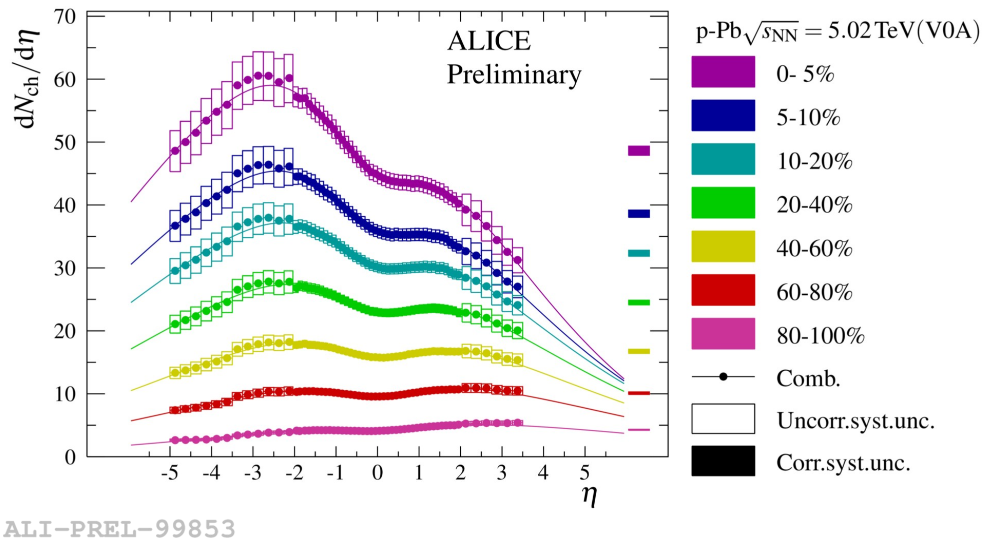
- HIJING (Phys. Rev. D44 (1991) 3501–3516.) overshoots data and decreases with increasing |η| faster than data
- AMPT without string melting (Phys. Rev. C72 (2005) 064901) reproduces the data at central region for the most central collisions (it was tuned there) but it fails in peripheral collisions and decreases with |η| faster than the data (like HIJING)
- AMPT with string melting is very flat in the central region and underestimates the data, except for peripheral collisions
- EPOS–LHC (Phys. Rev. C 92, 034906) reproduces the shape fairly well, but underestimates the data by 10 to 30%.

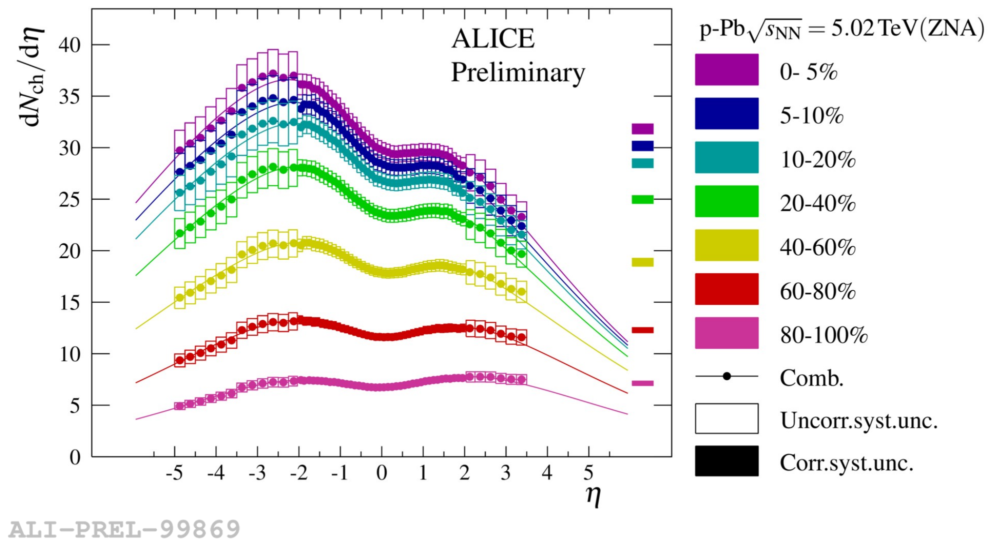
arXiv:1509.07299

p-Pb collisions

- Empirical correction was applied to p-Pb collisions and combined with tracklet analysis
- Two centrality estimators were used: V0 and ZDC in the Pb-going side
- In p-Pb collisions centrality estimator can cause potential biases on measurements, more information in Phys. Rev. C 91 (2015) 064905

p-Pb results

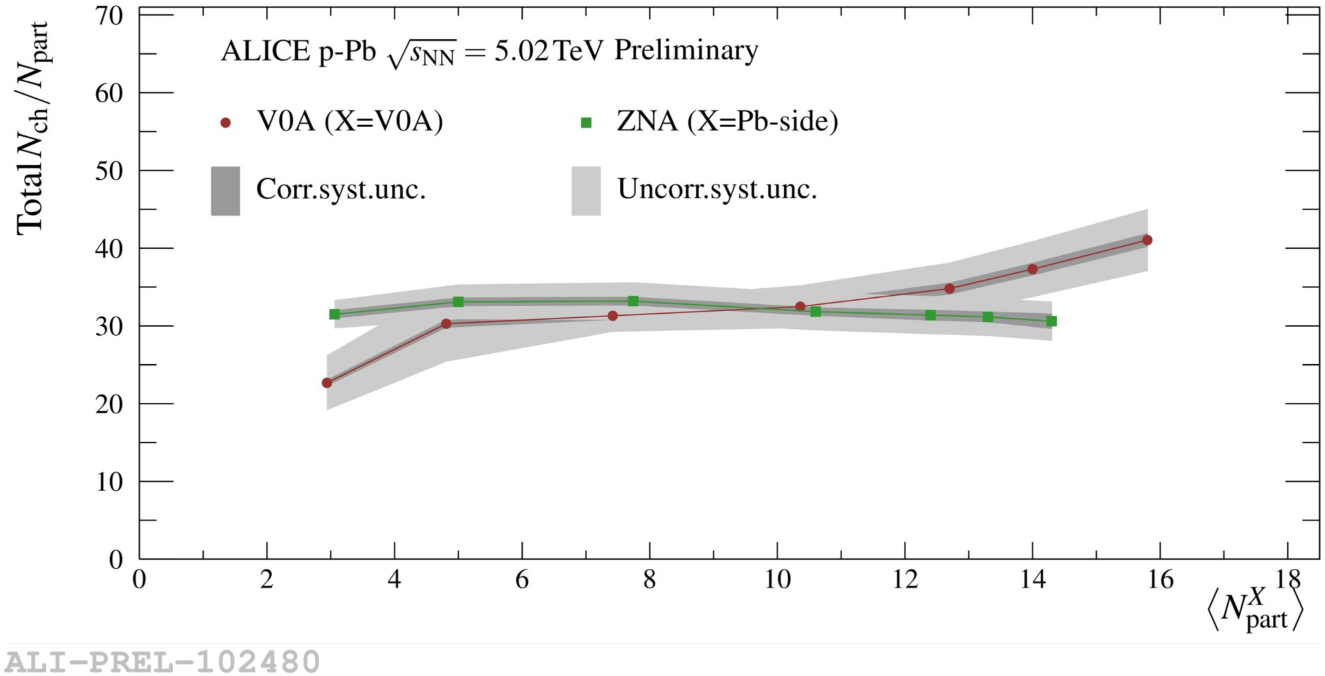




Fit function : $$f(\eta)=(a+b\cdot\eta)\left(A_1\exp\left(\frac{-\eta^2}{2\sigma_1^2}\right)-A_2\exp\left(\frac{-\eta^2}{2\sigma_2^2}\right)\right)$$

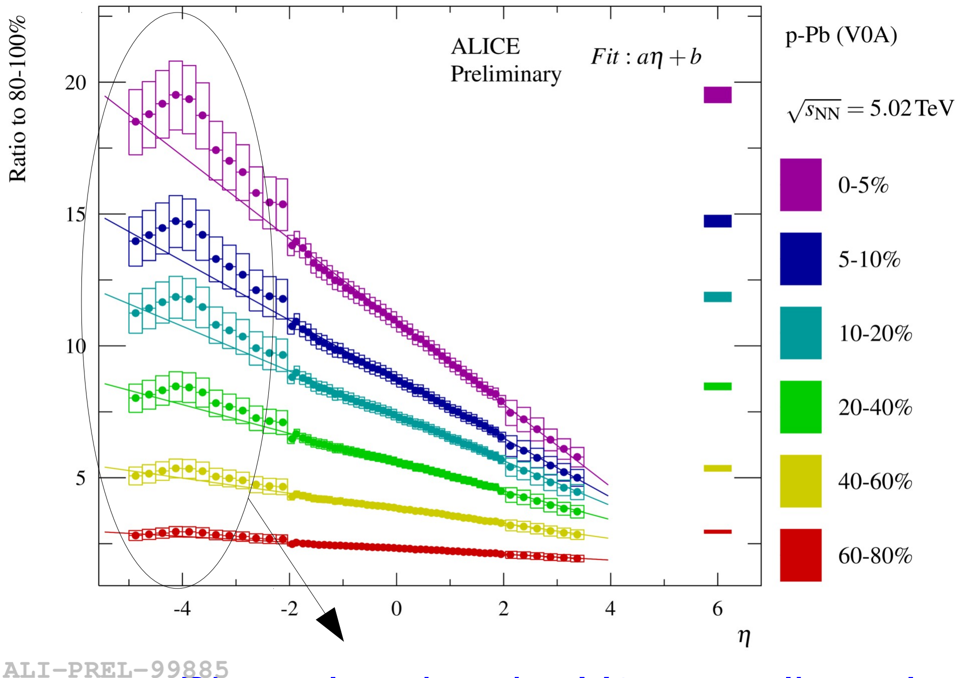
- As in Pb-Pb rather constant ratios of A_1/A_2 and σ_1/σ_2
- Effect of using different centrality estimators seen as $dN_{ch}/d\eta|_{V0A\ 0\text{-}5\%} > dN_{ch}/d\eta|_{ZNA\ 0\text{-}5\%}$

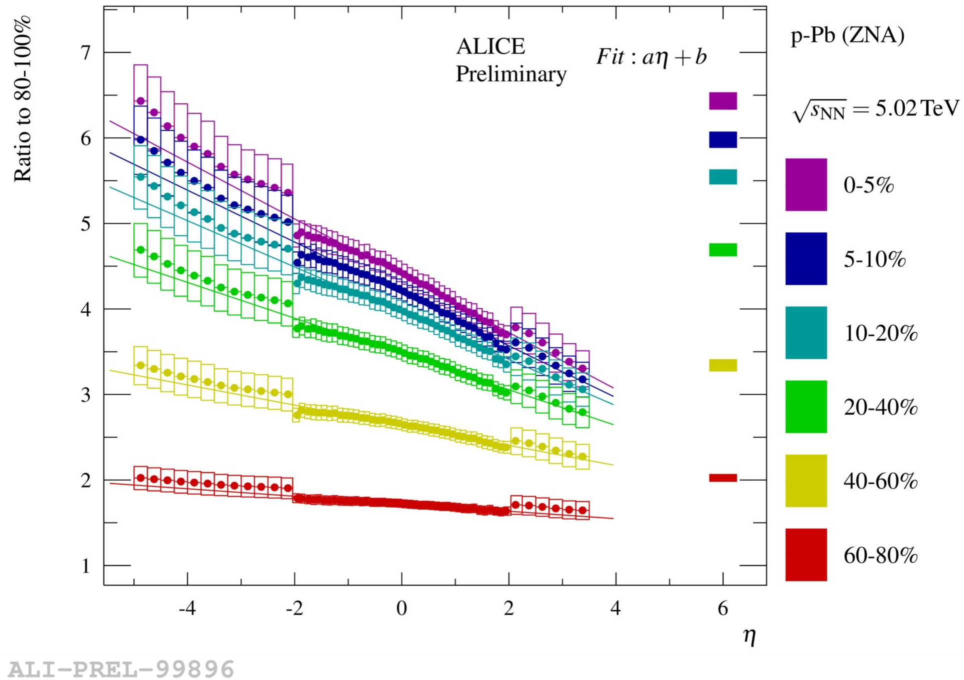
Total N_{ch} vs. $<N_{part}>$ in p-Pb



"Total" $<N_{ch}>$ scales with $<N_{part}>$ → saturation is disfavored

p-Pb scaling





Bias related to the V0 centrality selection

Scaling based on approach proposed in arXiv:nucl-ex/0703002, where pA distribution is obtained from pp distribution by:

- shifting particle rapidities according to the initial-state kinematics
- scaling particle production linearly with $N_{part}/2$

Summary

- We have well-tested methods to measure $dN_{ch}/d\eta$
- For Pb-Pb collisions:
  - Lack of strong evolution of overall shape of $dN_{ch}/d\eta$ with centrality is observed
  - Total N_{ch} scales approximately with $\langle N_{part} \rangle$
- Measurements for p-Pb collisions are biased by a centrality estimator
- Last results from Run 1 forthcoming
- New results from Run 2 imminent