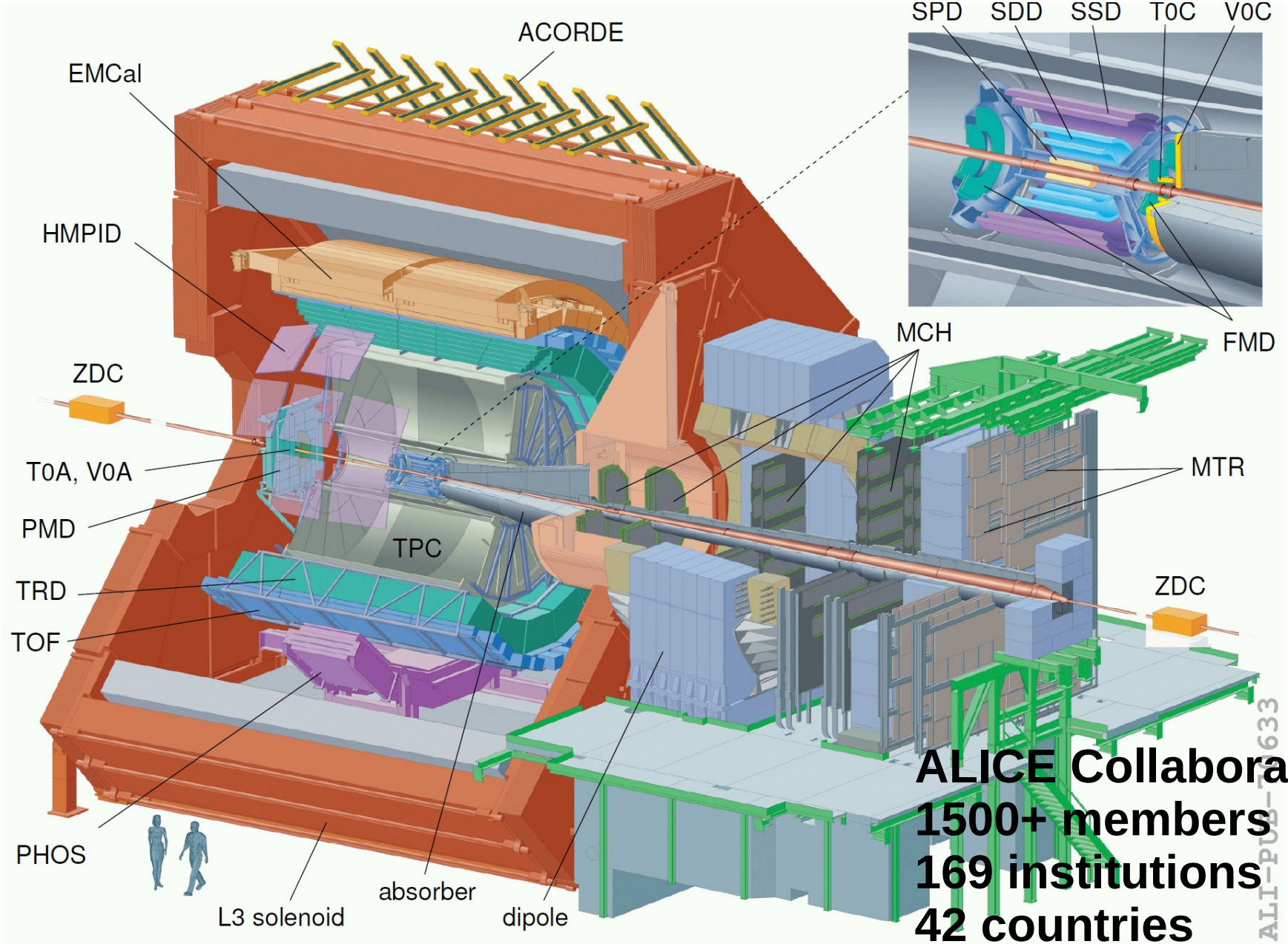
Status and recent highlights from ALICE

Ionut Arsene on behalf of the ALICE Collaboration
University of Oslo

ALICE apparatus

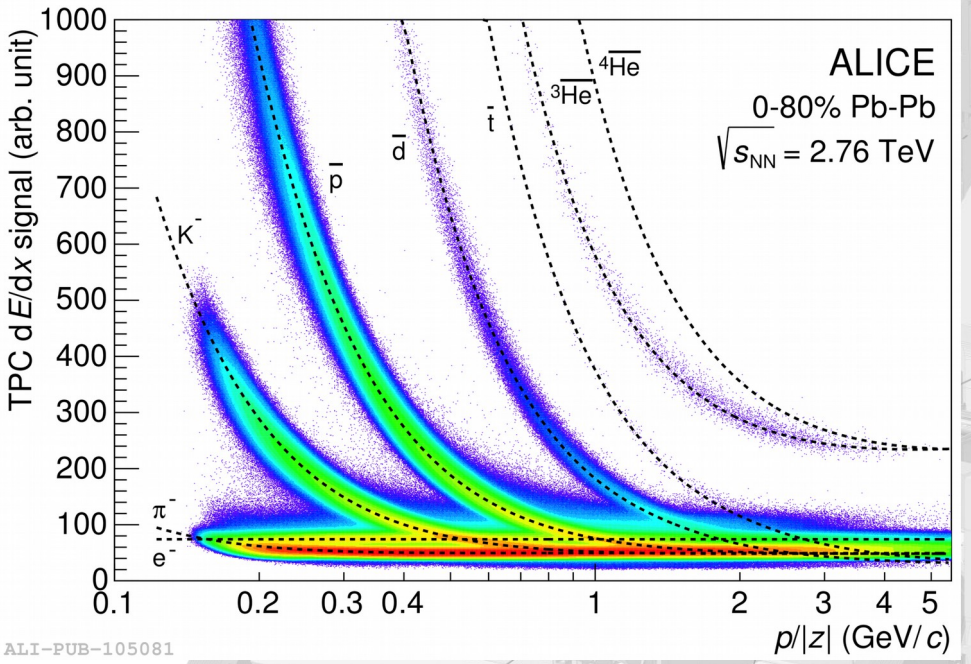


ALICE performance

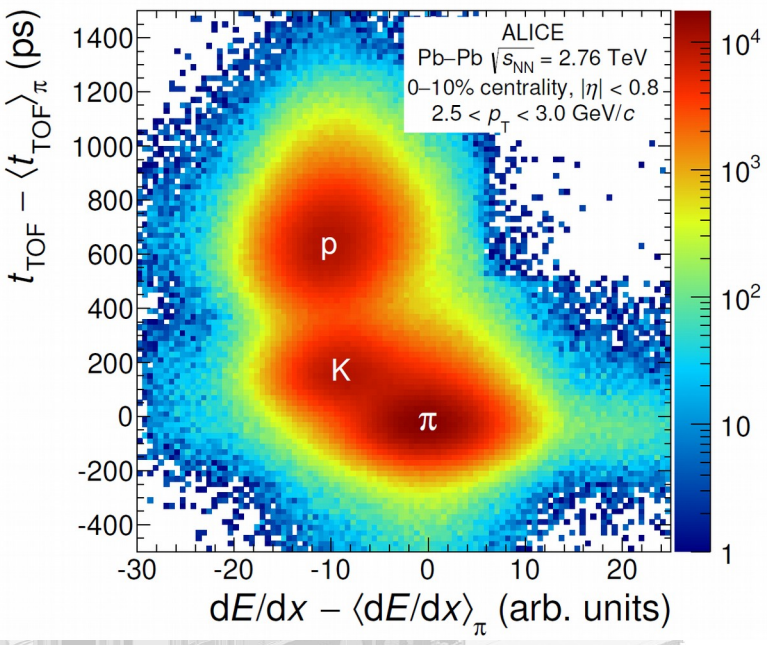
Central barrel:

- **Tracking and PID in $|\eta|<1$**

See talk by Marian Ivanov on monday afternoon



ALICE, PLB752 (2016) 267



ALICE, Eur.Phys.J.Plus 131(2016)5,168

- Precise particle id based on *dE/dx:* TPC, TRD, ITS
- anti-^{4}He nuclei observed directly

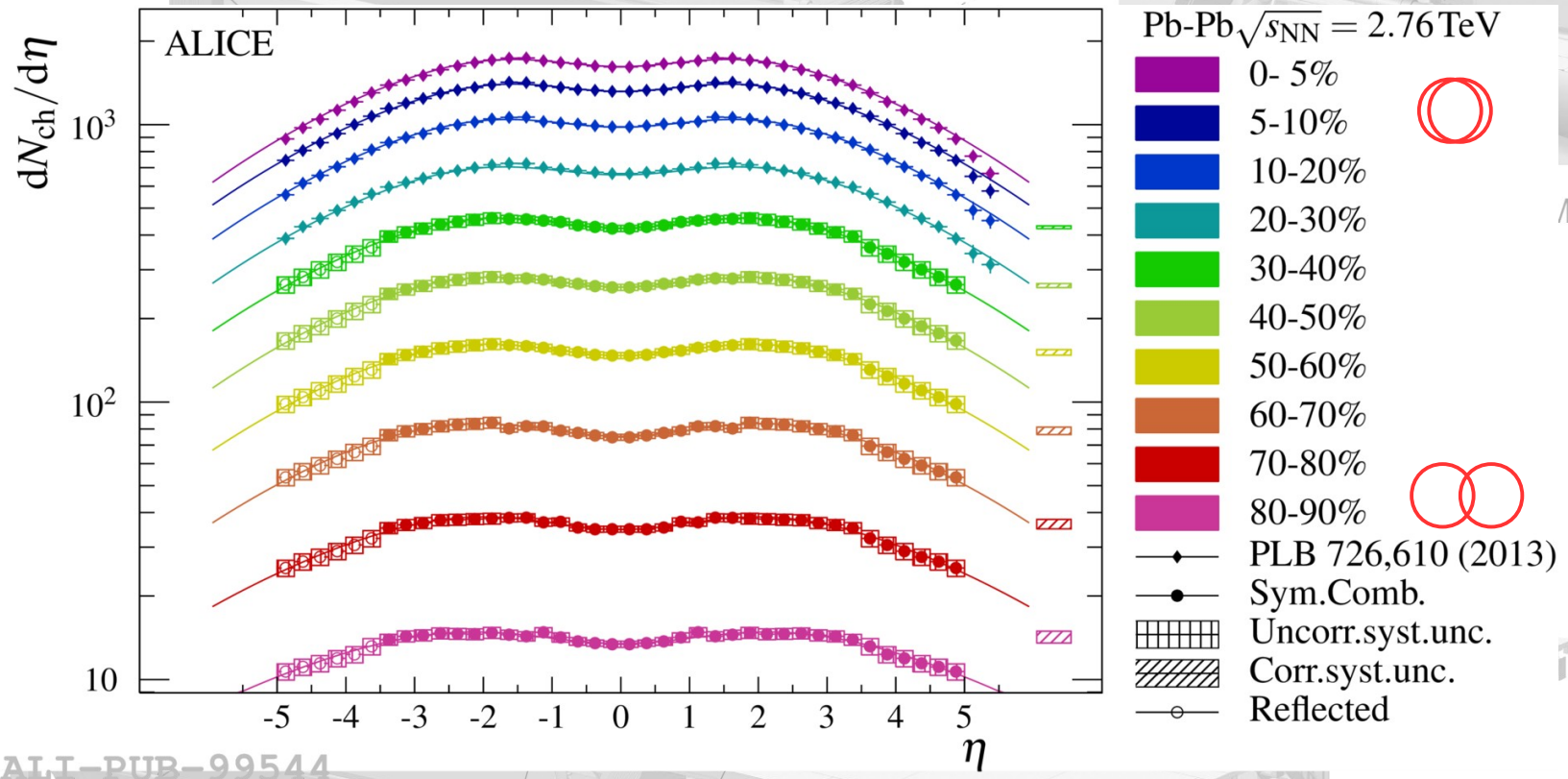
- Combined *dE/dx* and TOF measurements offer π/K/p separation up to high momenta

ALICE performance

Central barrel:

- **Tracking and PID in $|\eta|<1$**
- **Multiplicity measurement in $|\eta|<5$**

See talk by Stefania Bufalino on tuesday afternoon



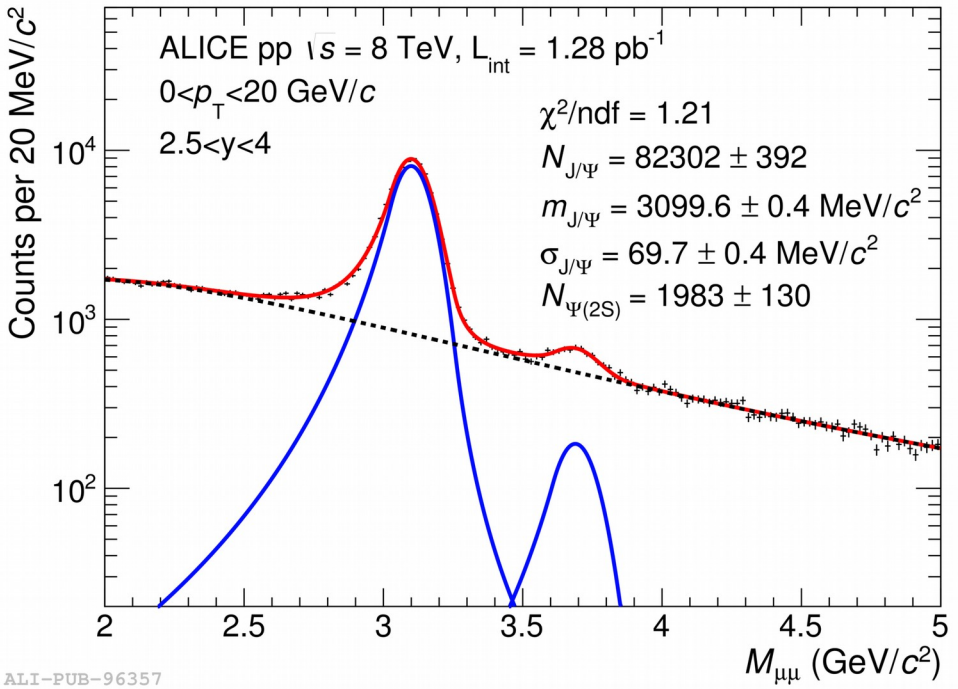
ALICE, PLB754 (2016) 373

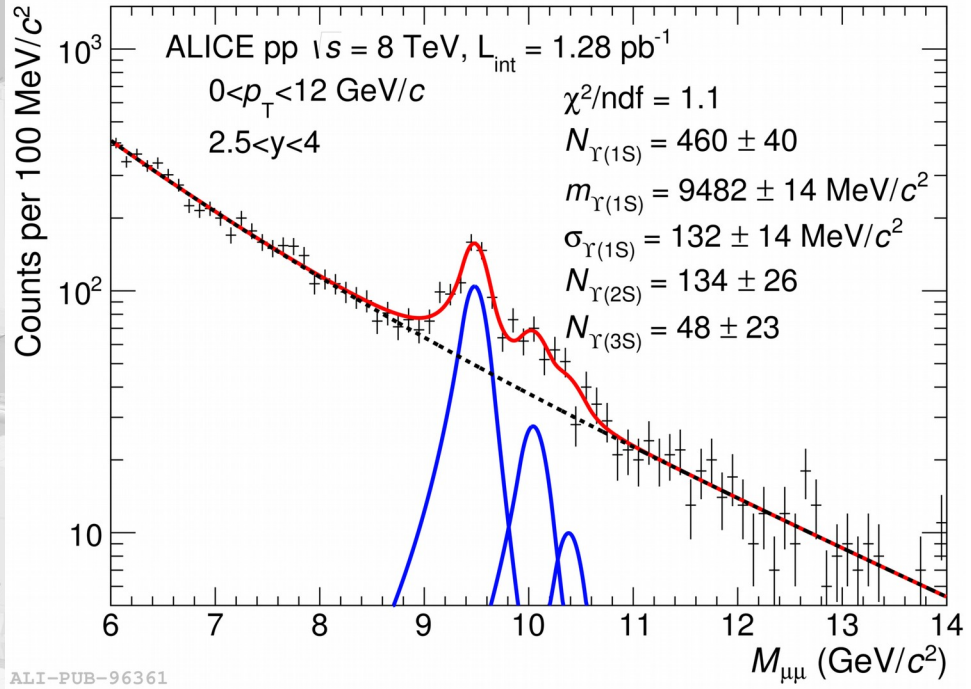
- $dN_{ch}/d\eta$ vs η in Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV, using SPD and FMD

ALICE performance

MUON arm:

- **Muon reconstruction in -4<η<-2.5**
- **ψ and Y measurements down to p_T=0**

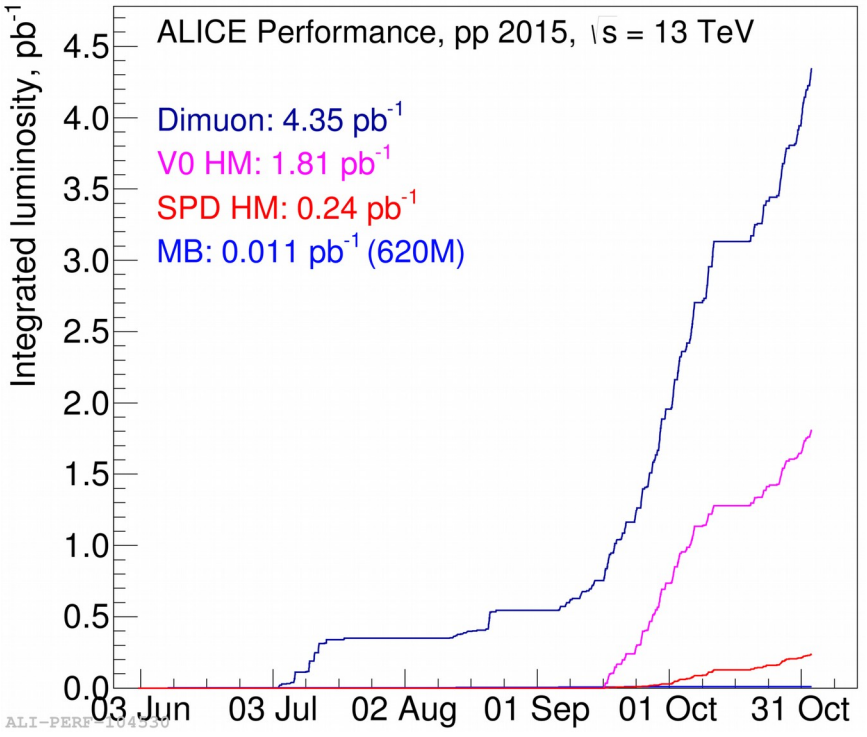


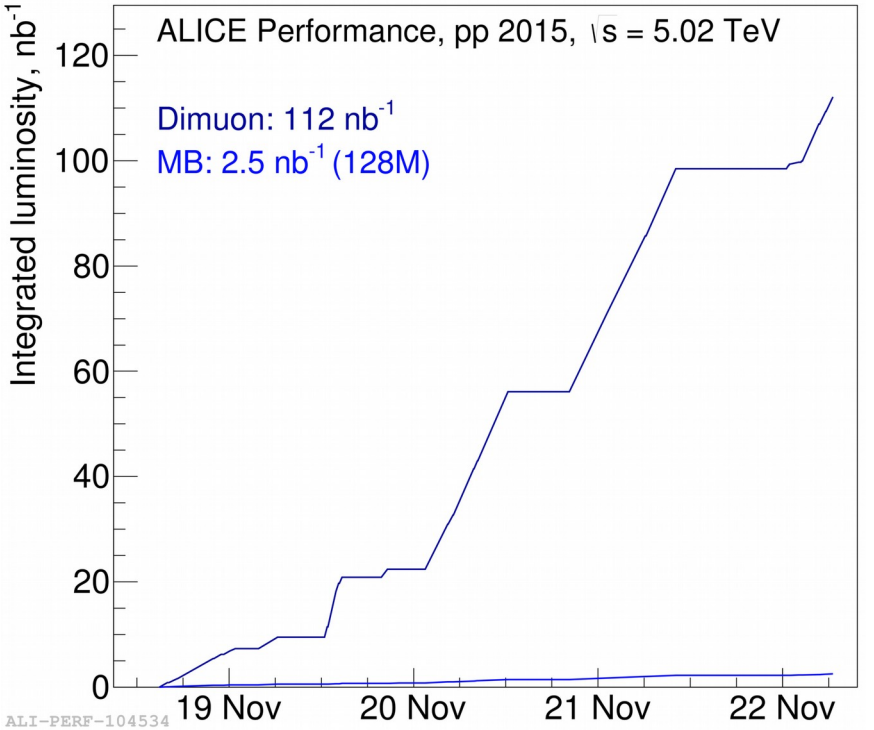


ALICE, EPJ C76 (2016) 4, 184

- ψ and Y cross-section measurement in pp collisions at √s=8 TeV

2015 pp runs





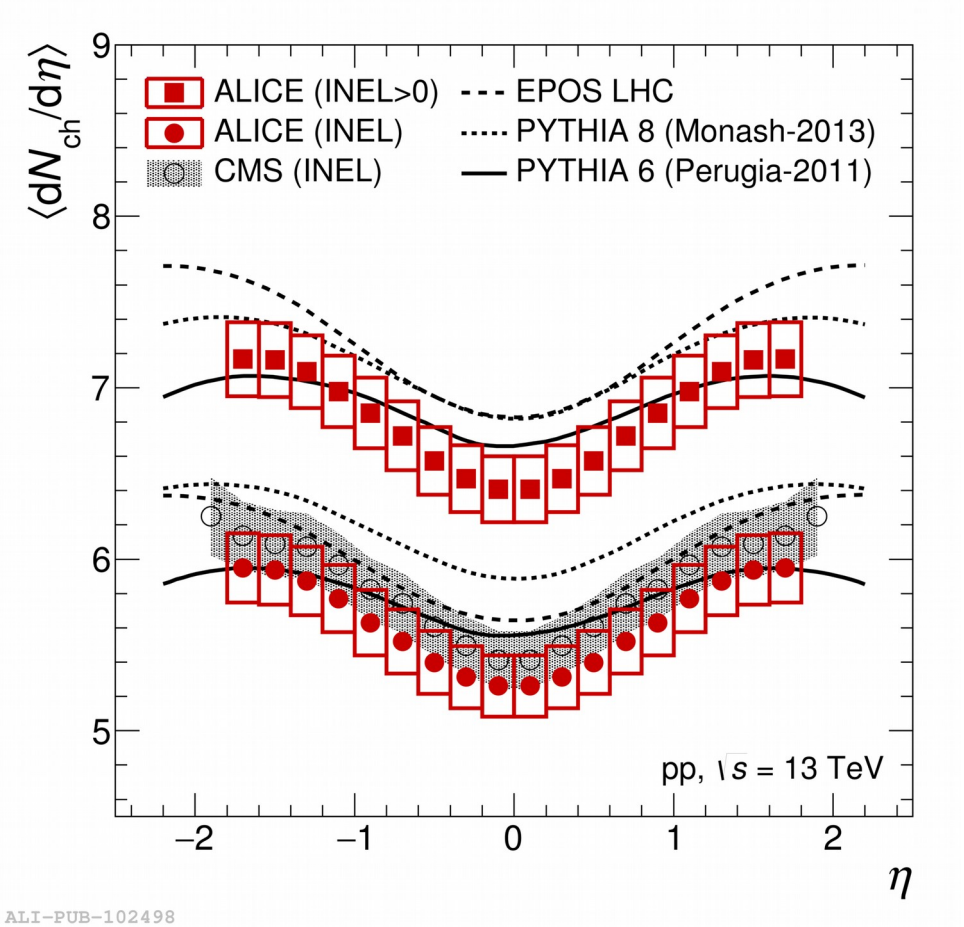
- pp collisions at √*s*=13 TeV
  - Minimum bias: 11 nb^{-1}
  - Dimuons: 4.35 pb^{-1}
  - High multiplicity events: 2.05 pb^{-1}
    - Study of the onset for collective effects in pp collisions

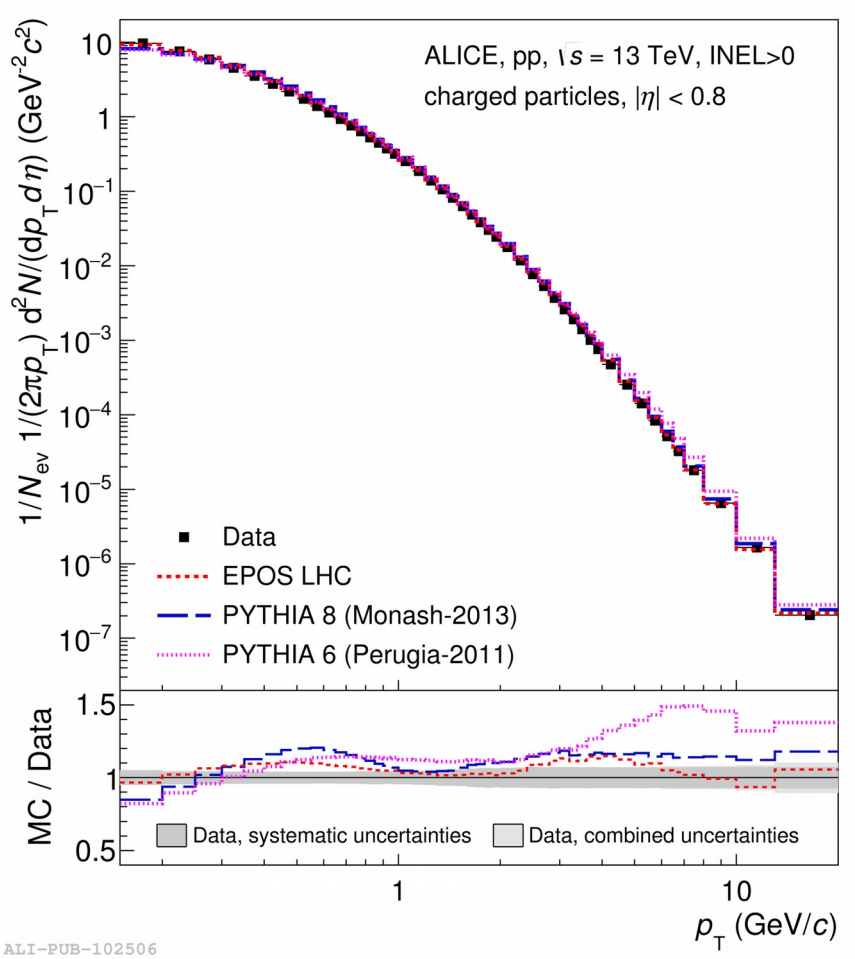
See talk by Vytautas Vislavicius on tuesday morning

- pp collisions at √*s*=5.02 TeV (reference for p-Pb and Pb-Pb measurements)
  - Minimum bias: 2.5 nb^{-1}
  - Dimuons: 112 nb^{-1}

Charged particle density at √s=13 TeV

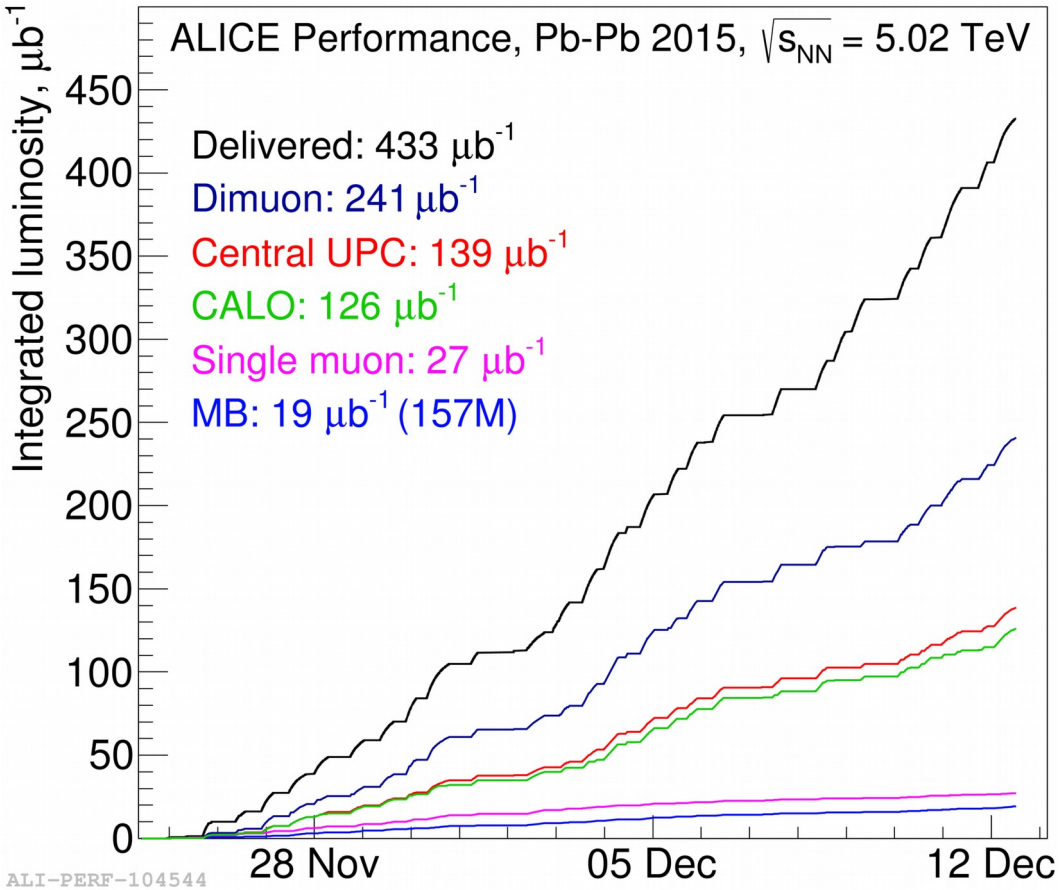
ALICE, PLB753 (2016) 319





- $dN_{ch}/d\eta$ ($|\eta|$<0.5, INEL) = 5.31±0.18
- Good agreement between data and PYTHIA6 calculations for the p_T integrated densities
- EPOS-LHC and PYTHIA8 describe fairly well the p_T dependent densities

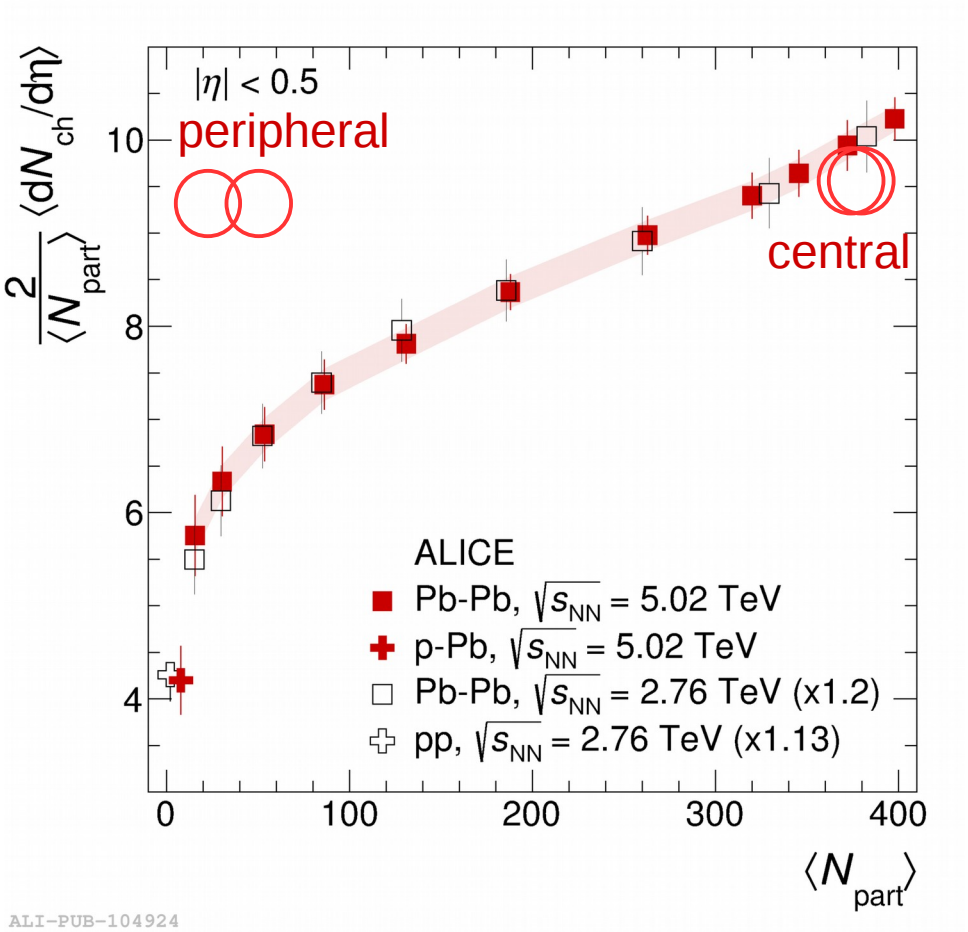
2015 Pb-Pb run at $\sqrt{s_{NN}}$=5.02 TeV



- Pb-Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV
- Minimum bias: 19 μb^{-1}
- Dimuons: 241 μb^{-1}
- ECAL: 126 μb^{-1}
- Ultra-peripheral collisions: 139 μb^{-1}
- First papers have been published
  - Charged particle density
    Phys.Rev.Lett. 116(2016)222302
  - Anisotropic flow
    Phys.Rev.Lett. 116(2016)132302

$dN_{ch}/d\eta$ in Pb-Pb at $\sqrt{s_{NN}}$=5.02 TeV

ALICE, PRL116(2016)222302

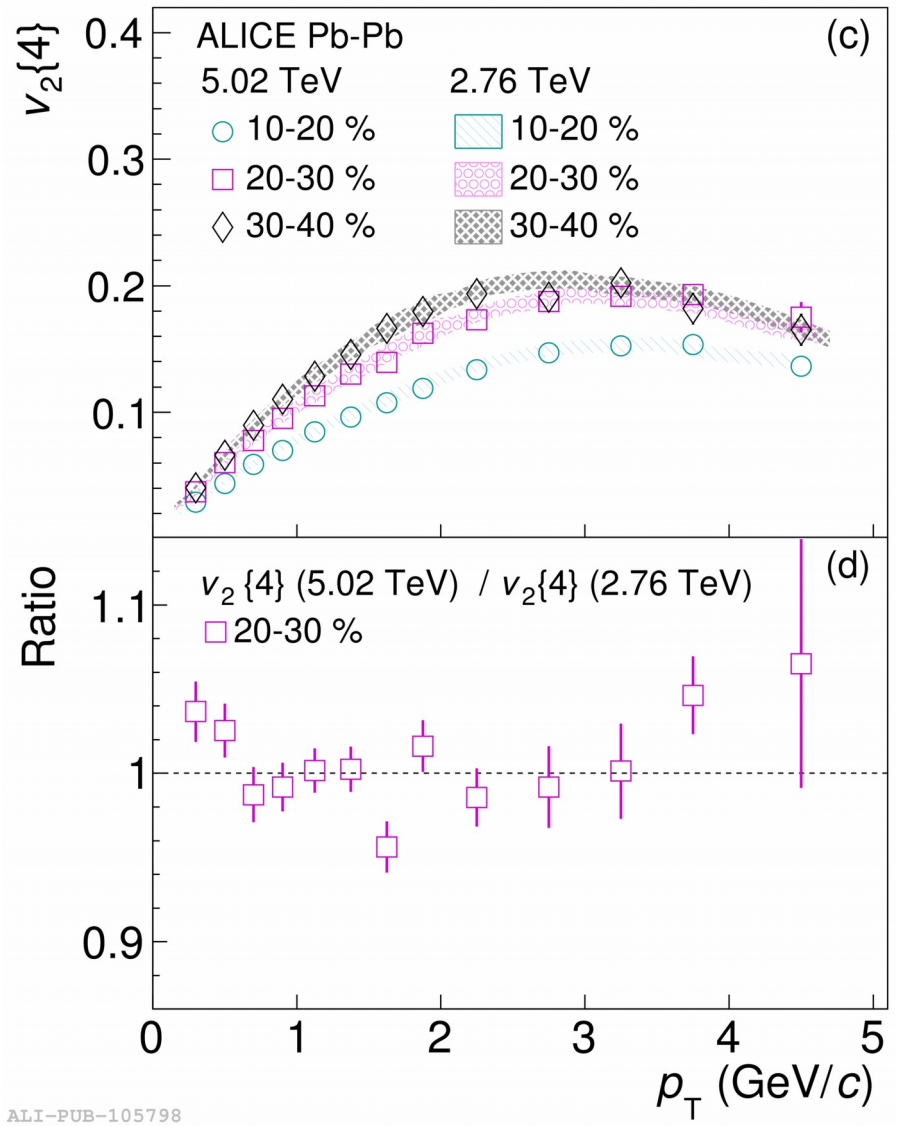


- *$\langle dN_{ch}/d\eta \rangle$ (0-5%) = 1943±54*
  - x 2.5 the average multiplicity per participant pair in a pp collision at the same energy
- The average yield per participant pair is strongly dependent on collision centrality
  - Similar trend seen at $\sqrt{s_{NN}}$=2.76 TeV
  - Yield in peripheral collisions close to the one measured in p-Pb and pp collisions

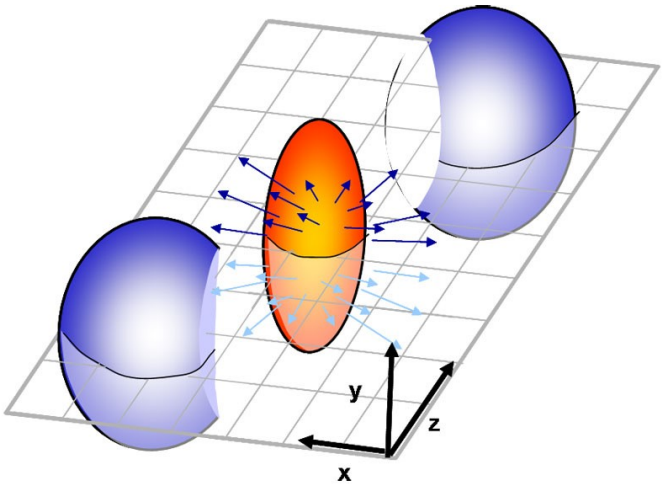
See talk by Christian Holm on tuesday afternoon

Anisotropic flow in Pb-Pb at $\sqrt{s_{NN}}$=5.02 TeV

ALICE, PRL116(2016)132302



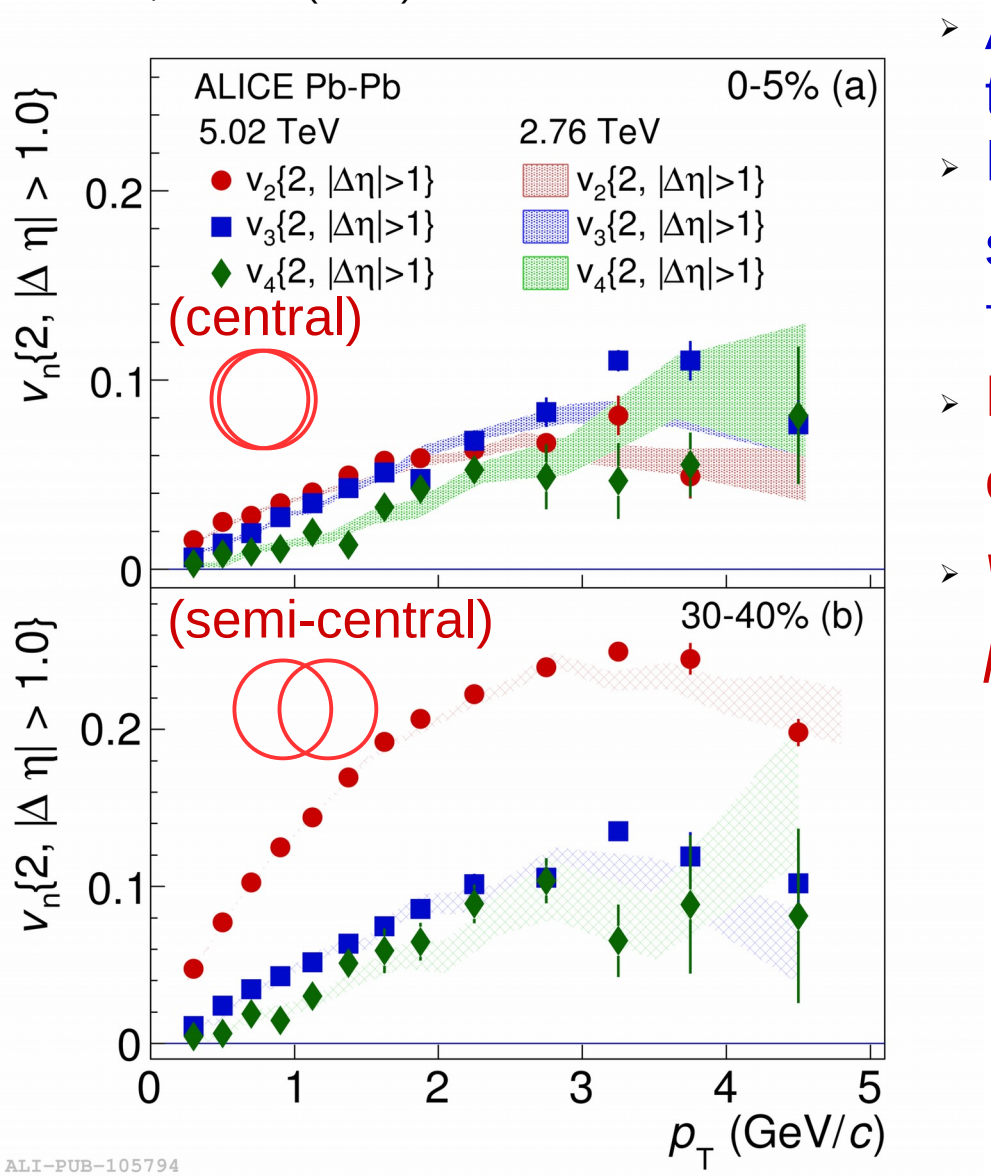
- Anisotropic flow measurements using two- and multi-particle cumulants
- Elliptic flow results $v_2(p_T)$ show very similar values to the ones seen at $\sqrt{s_{NN}}$=2.76 TeV



$$\frac{dN}{d\varphi} \propto 1 + 2v_1\cos(\varphi - \Psi) + 2v_2\cos[2(\varphi - \Psi)] + 2v_3\cos[3(\varphi - \Psi)] + \ldots$$

Anisotropic flow in Pb-Pb at $\sqrt{s_{NN}}$=5.02 TeV

ALICE, PRL116(2016)132302



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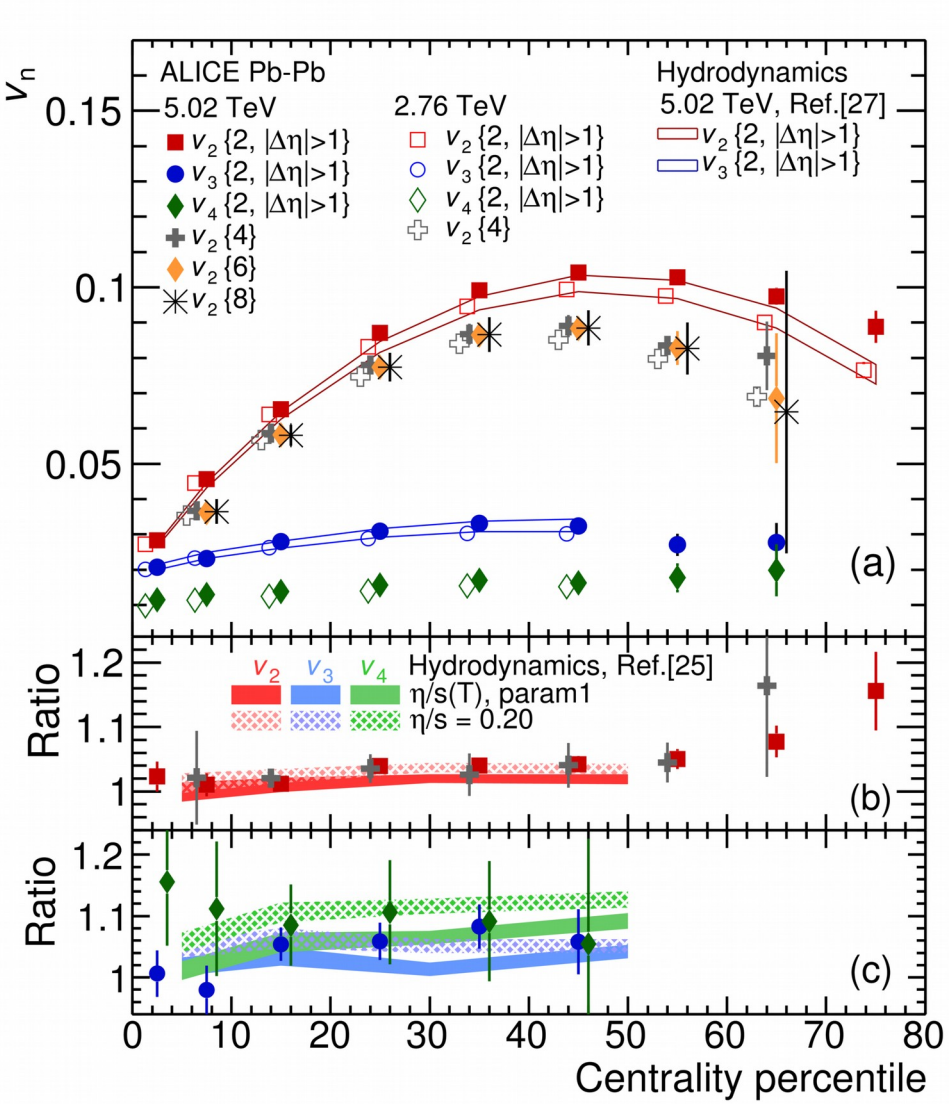
- Elliptic flow results $v_2(p_T)$ show very similar values to the ones seen at $\sqrt{s_{NN}}$=2.76 TeV
- Higher harmonics (v_3,v_4) as functions of p_T are also unchanged with energy
- v_3 becomes larger than v_2 at p_T>2 GeV/c in central collisions

$$\frac{dN}{d\varphi} \propto 1 + 2v_1\cos(\varphi-\Psi) + 2v_2\cos[2(\varphi-\Psi)] + 2v_3\cos[3(\varphi-\Psi)] + \ldots$$

Anisotropic flow in Pb-Pb at $\sqrt{s_{NN}}$=5.02 TeV

ALICE, PRL116(2016)132302



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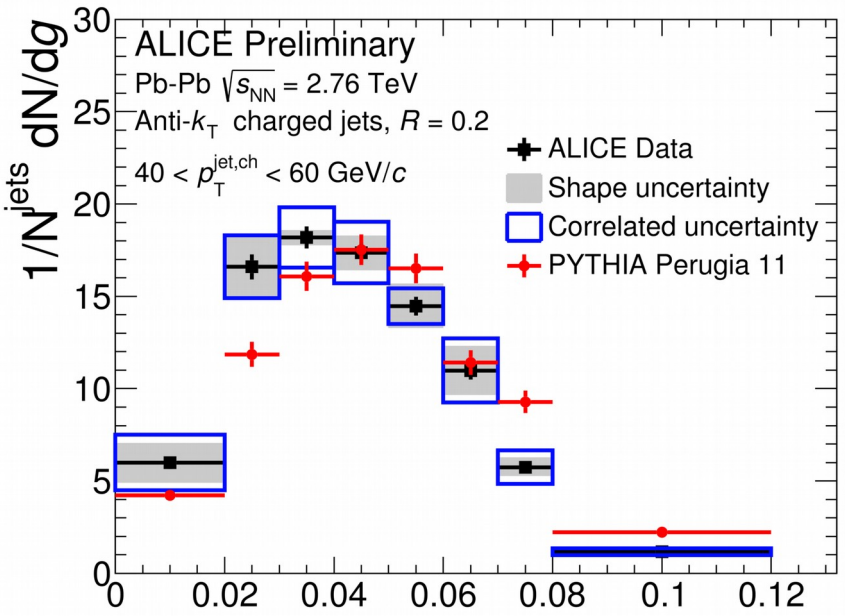
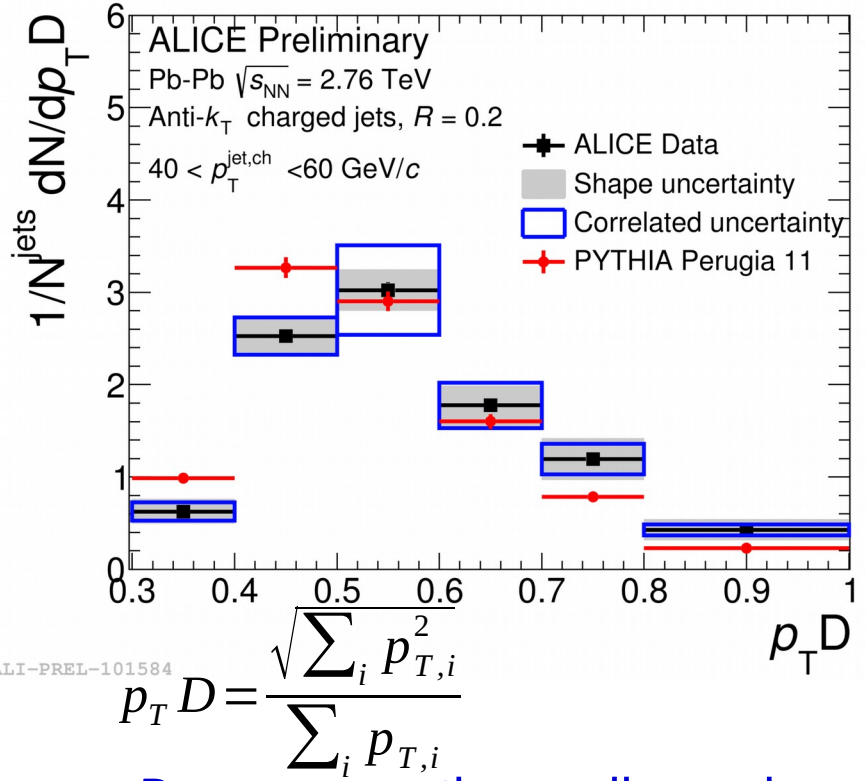
- v_3 becomes larger than v_2 at p_T>2 GeV/*c* in central collisions
- p_T-integrated v_2, v_3 and v_4 indicate a mild increase with collisions energy attributed to the increase in $\langle p_T \rangle$
- Good agreement with hydrodynamical calculations
  - Measurements support a low value for the shear viscosity to entropy density ratio (η/s)

$$\frac{dN}{d\varphi} \propto 1 + 2v_1\cos(\varphi - \Psi) + 2v_2\cos[2(\varphi - \Psi)] + 2v_3\cos[3(\varphi - \Psi)] + \ldots$$

Run-1 recent highlights
Jets

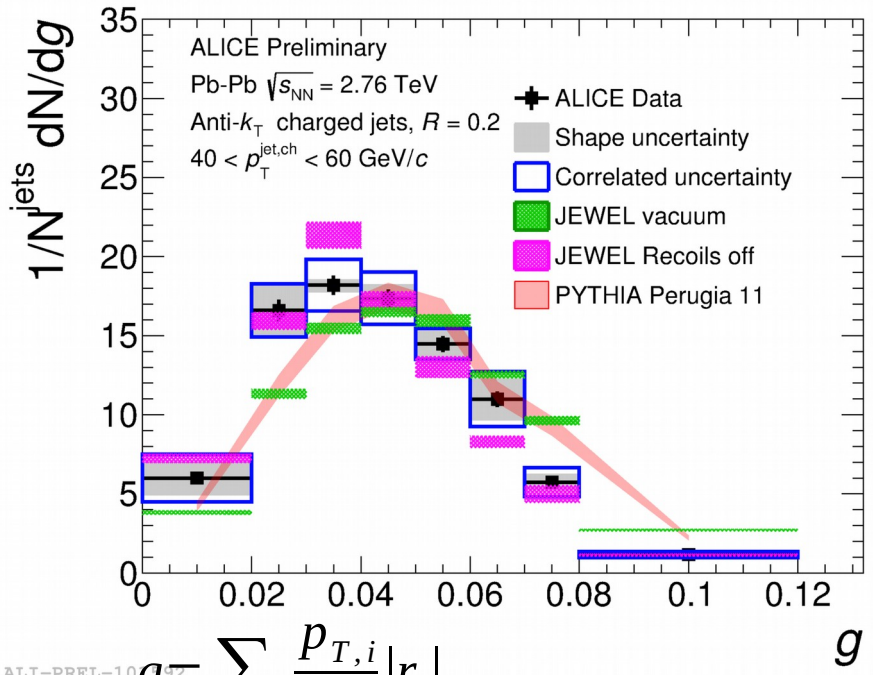
Jet shapes in Pb-Pb at $\sqrt{s_{NN}}$=2.76 TeV



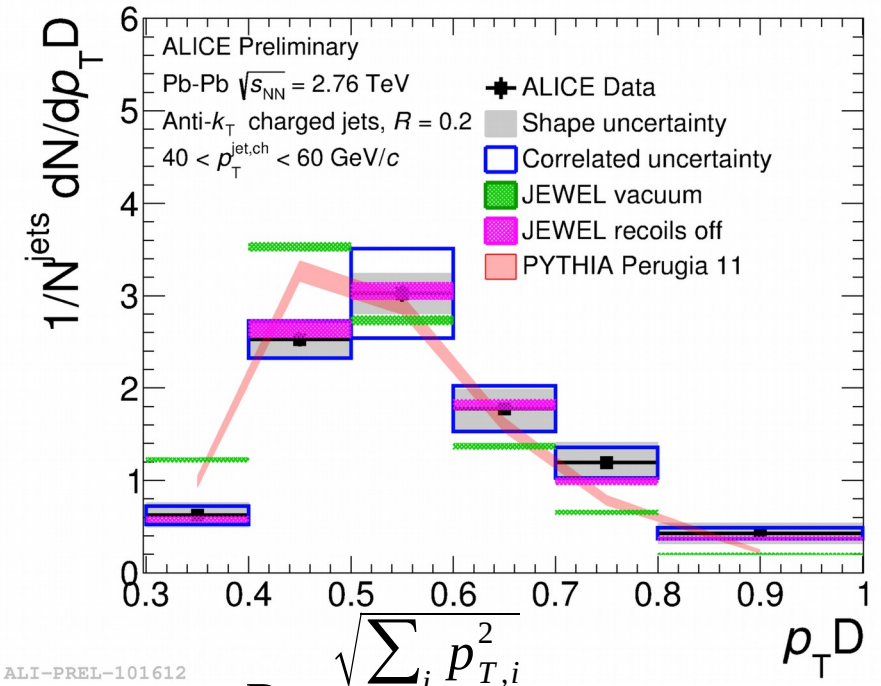


- Radial moment (g) is a p_T-weighted width of a jet
  - Collimated jets have lower g
- $p_T D$ measures the p_T dispersion
  - Jets with fewer constituents typically have higher $p_T D$
- Radial moment shifted to lower values in Pb-Pb relative to PYTHIA
  - Jet cores are more collimated in Pb-Pb
- $p_T D$ shifted to higher values in Pb-Pb relative to PYTHIA
  - Fewer jets constituents and/or larger p_T dispersion

Jet shapes in Pb-Pb at $\sqrt{s_{NN}}$=2.76 TeV



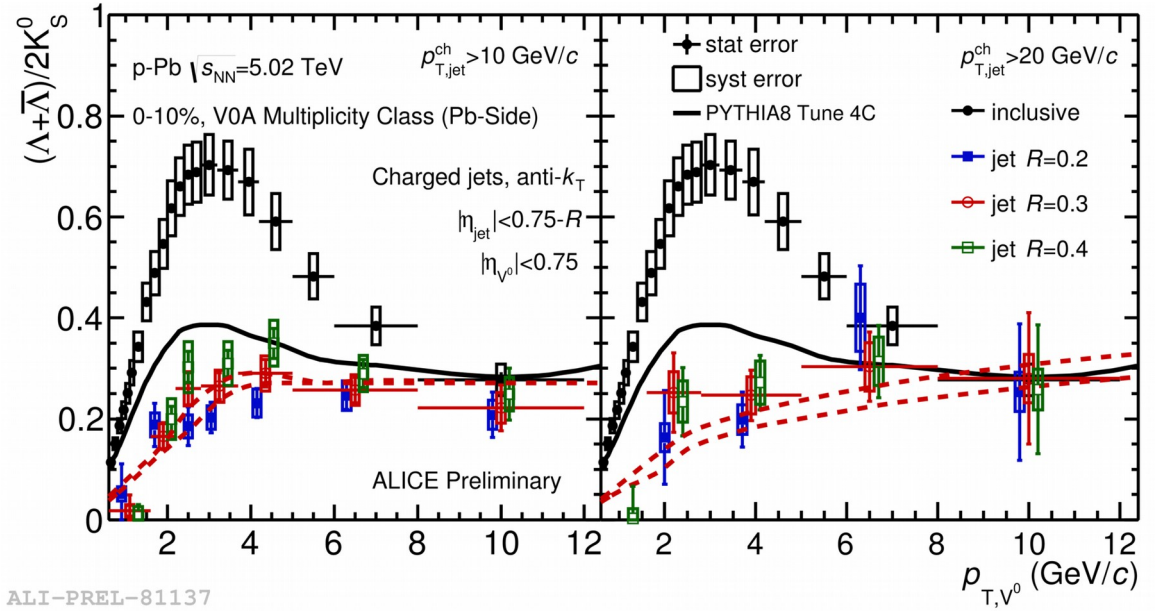
$$g = \sum_{i \in jet} \frac{p_{T,i}}{p_T^{jet}} |r_i|$$

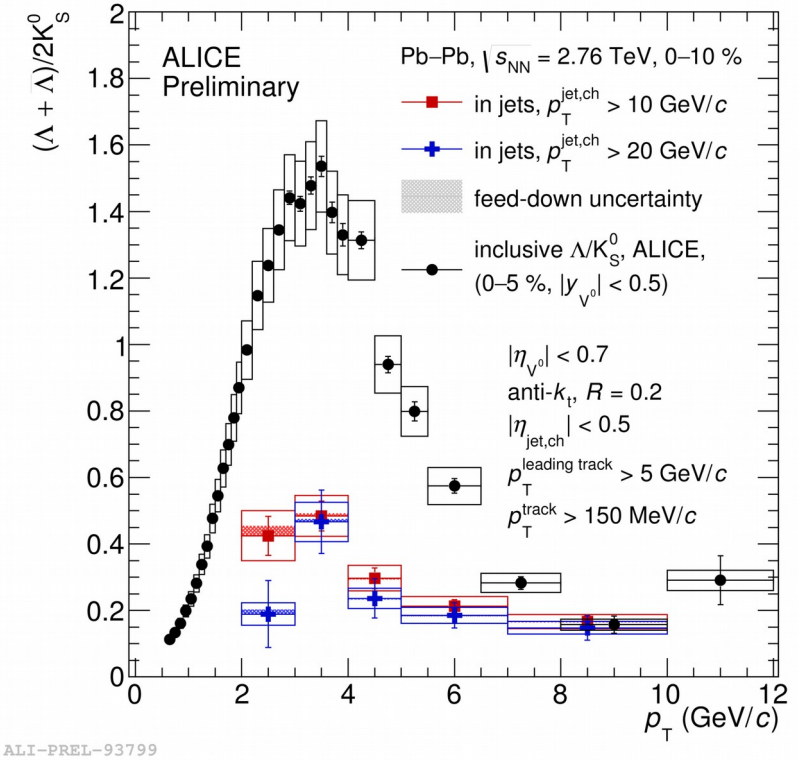


$$p_T D = \frac{\sqrt{\sum_i p_{T,i}^2}}{\sum_i p_{T,i}}$$

- Qualitative agreement with JEWEL model calculations
  - Jets in model calculations become collimated due to soft particle emission at large angles, which ends up outside the jet cone

Production of strange hadrons in jets





- Λ/K^0_S ratio in jets significantly lower than for the inclusive measurements in high multiplicity p-Pb and Pb-Pb collisions
  - Ratio in jets consistent with PYTHIA expectations (i.e. vacuum fragmentation)
  - Baryon enhancement seen in p-Pb and Pb-Pb collisions does not originate in jets

Charged jet production in p-Pb at $\sqrt{s_{NN}}$=5.02 TeV

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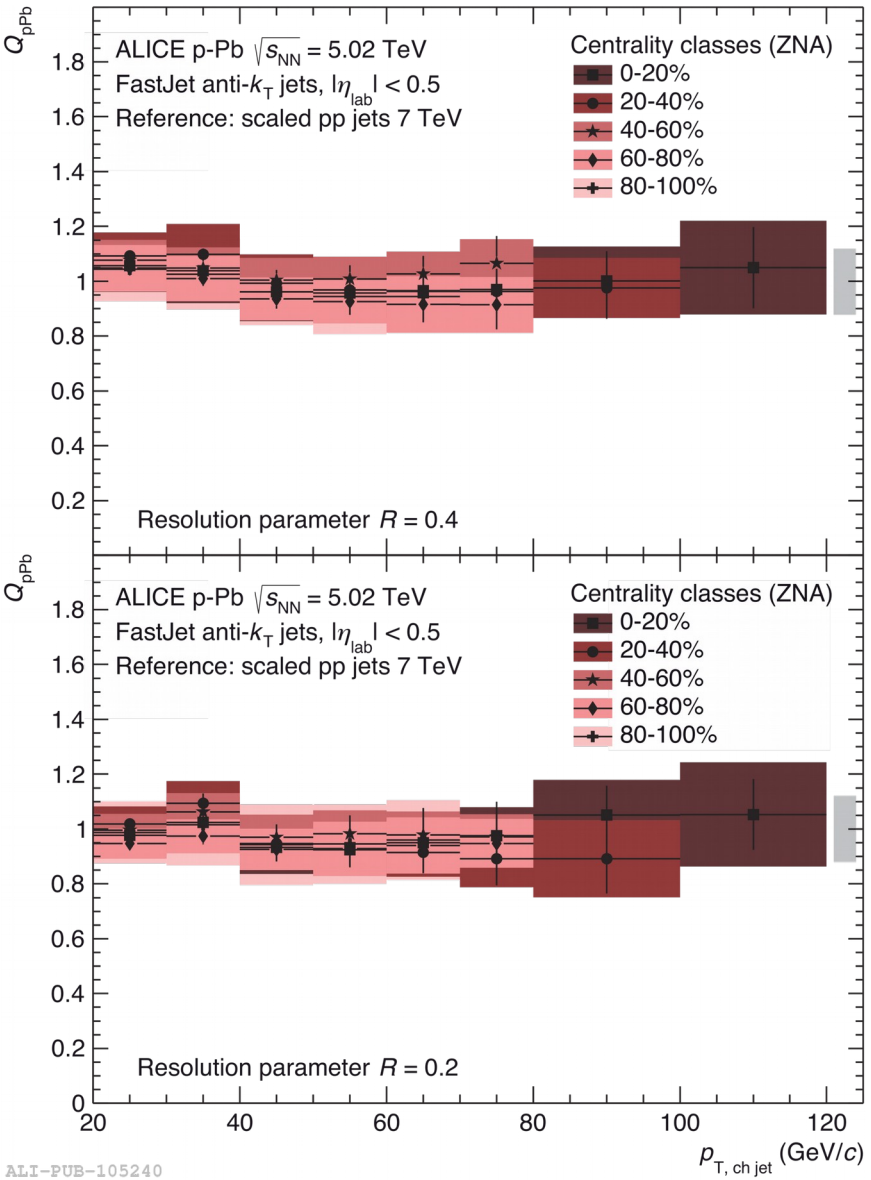


$$Q_{pPb} = \frac{d^{2N}_{pPb}/d\eta dp_T}{\langle N_{coll} \rangle d^2 N_{pp}/d\eta dp_T}$$

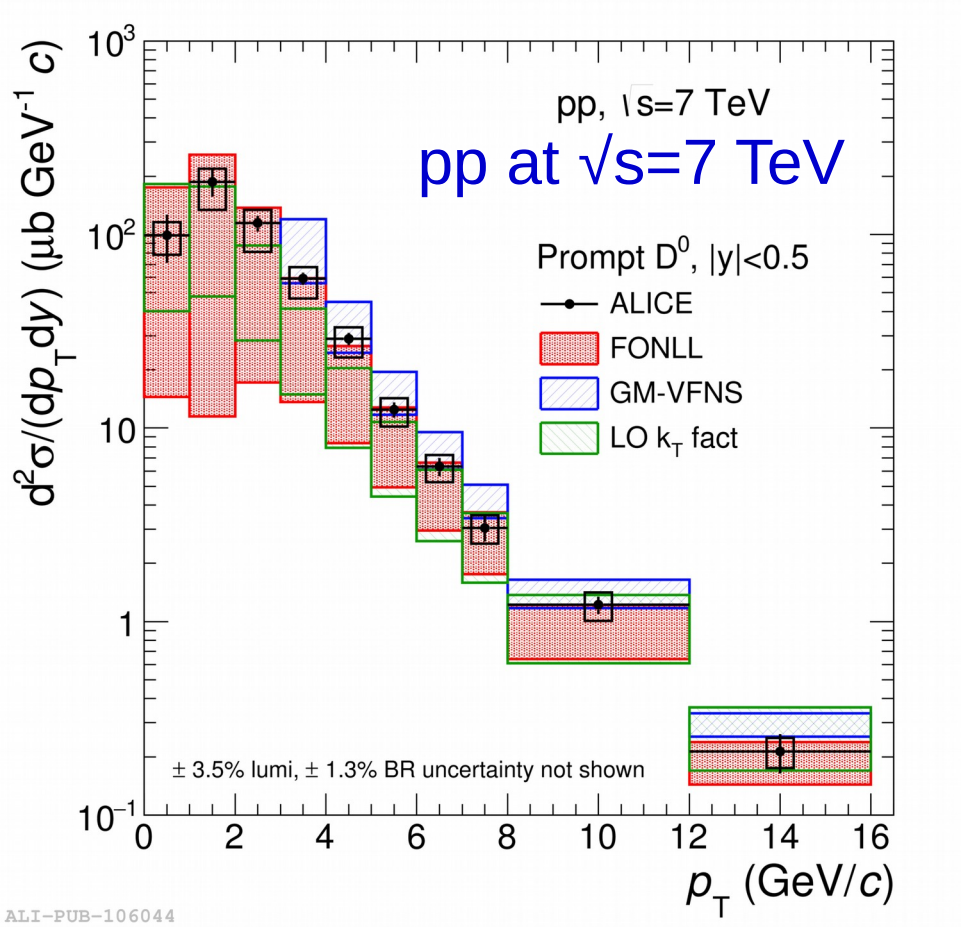
- Charged jets production in p-Pb collisions measured as a function of centrality
- Q_{pPb}~1 for all centrality classes and independent of the resolution parameter R and jet p_T
  - No or very small CNM effects in this kinematic range

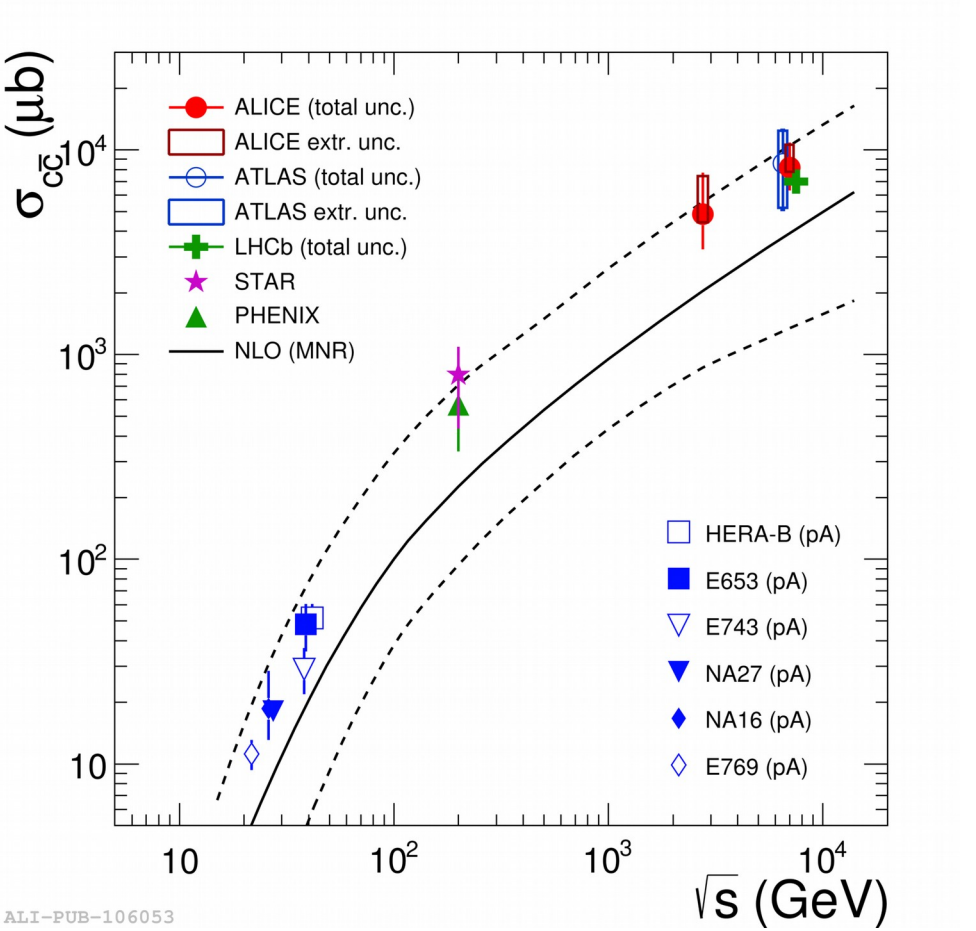
Run-1 recent highlights
Heavy flavour

See talk by Chiara Zampolli on thursday afternoon

D^0 cross-section down to p_T=0 in pp at √s=7 TeV

ALICE, arXiv: 1605.07569

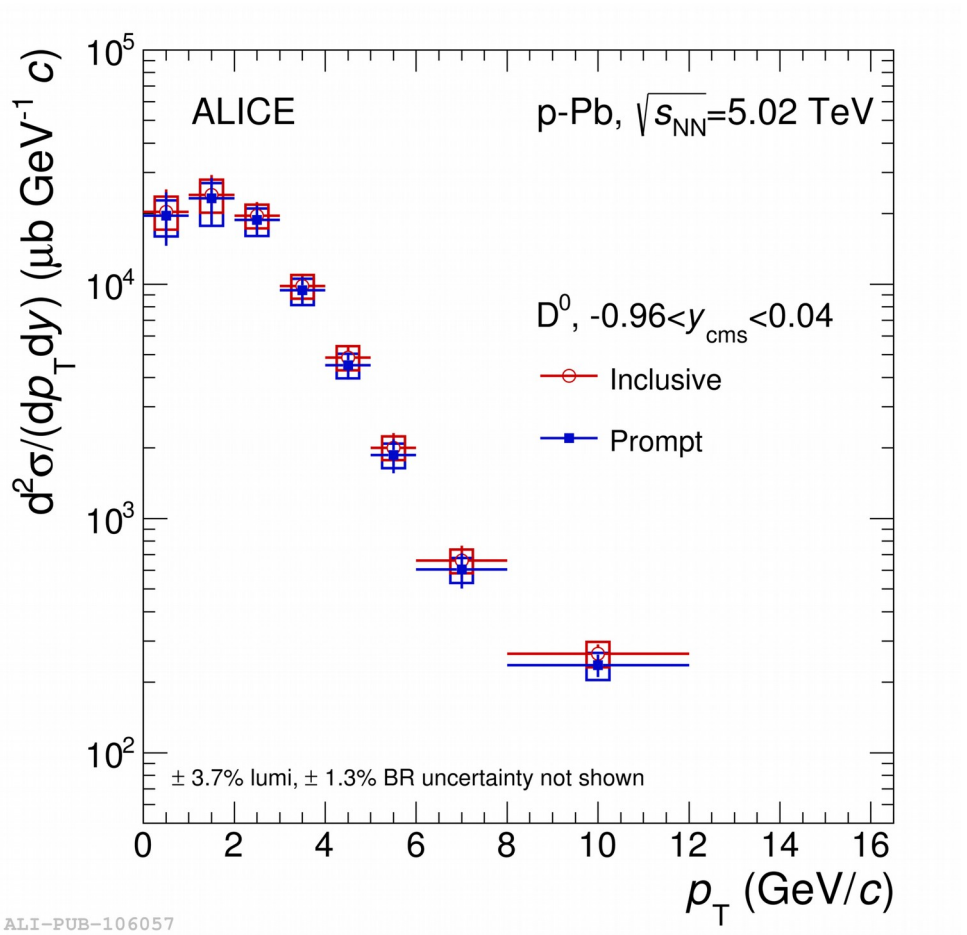




- Data and theory calculations in agreement
- Theoretical uncertainties are currently larger than those of the measurements
- $d\sigma/dy$ (prompt D^0) = $518 \pm 43(\text{stat.})^{+57}_{-102}(\text{syst.}) \pm 18(\text{lumi.})\,\mu b$
- Updated total charm production cross-section

D^0 cross-section down to p_T=0 in p-Pb at $\sqrt{s_{NN}}$=5.02 TeV

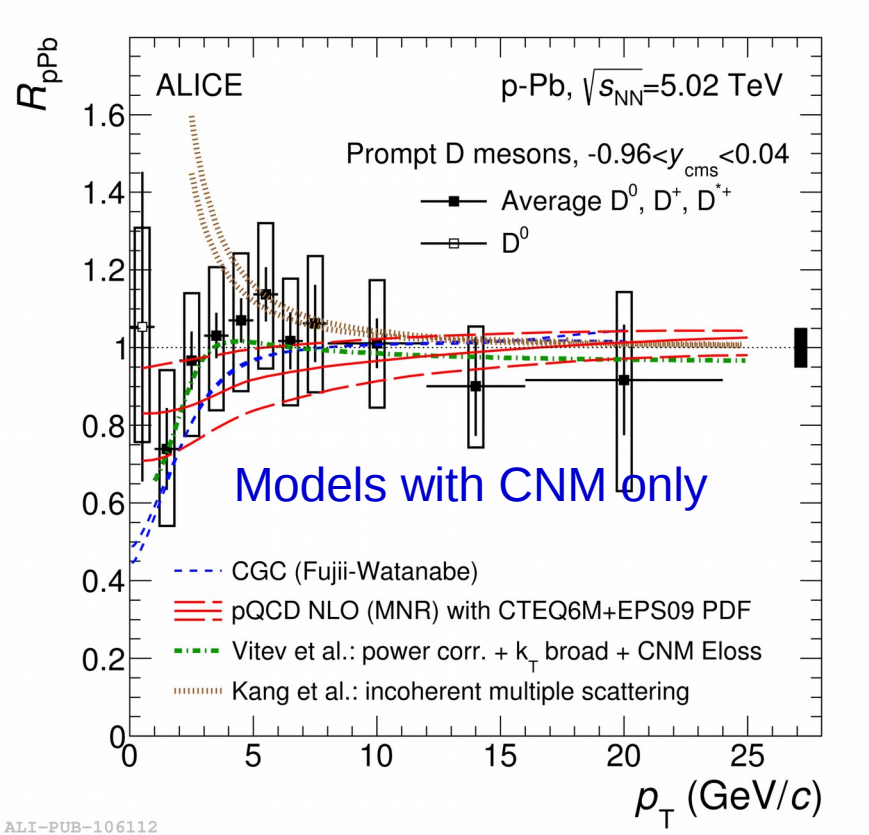
ALICE, arXiv: 1605.07569

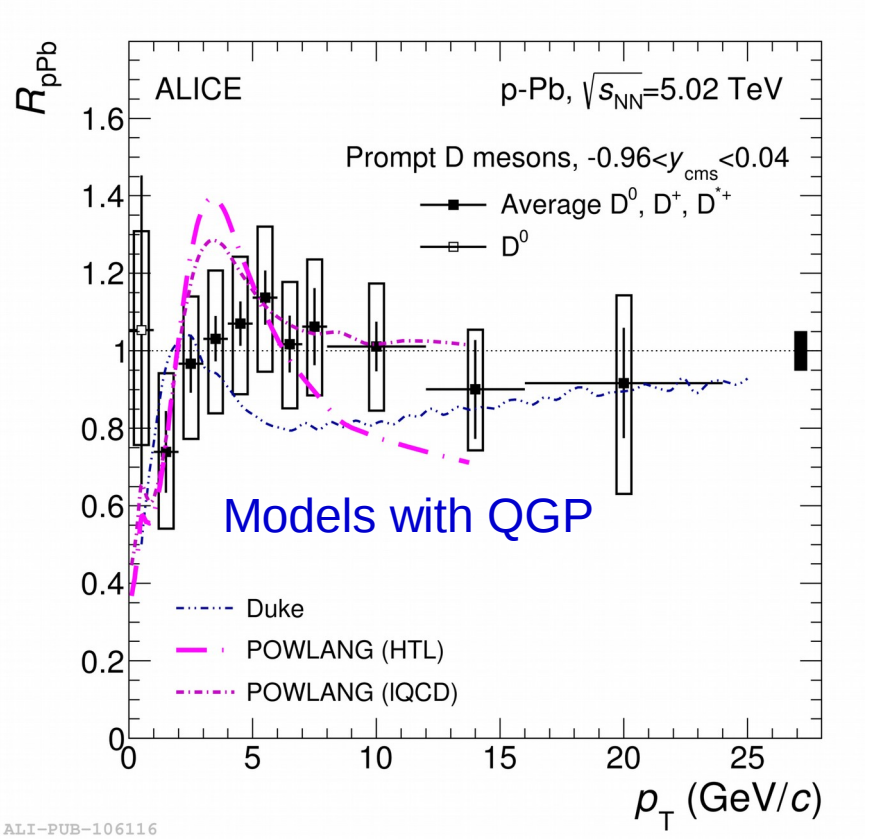


- $d\sigma/dy$ (prompt D^0) = $79.0 \pm 7.3(\text{stat.})^{+7.1}_{-13.4}(\text{syst.}) \pm 2.9(\text{lumi.})$ mb
- Charm production cross-section in p-Pb
  - strong constrain on the size of CNM effects due to nPDF modifications

D^0 – meson nuclear modification in p-Pb

ALICE, arXiv: 1605.07569

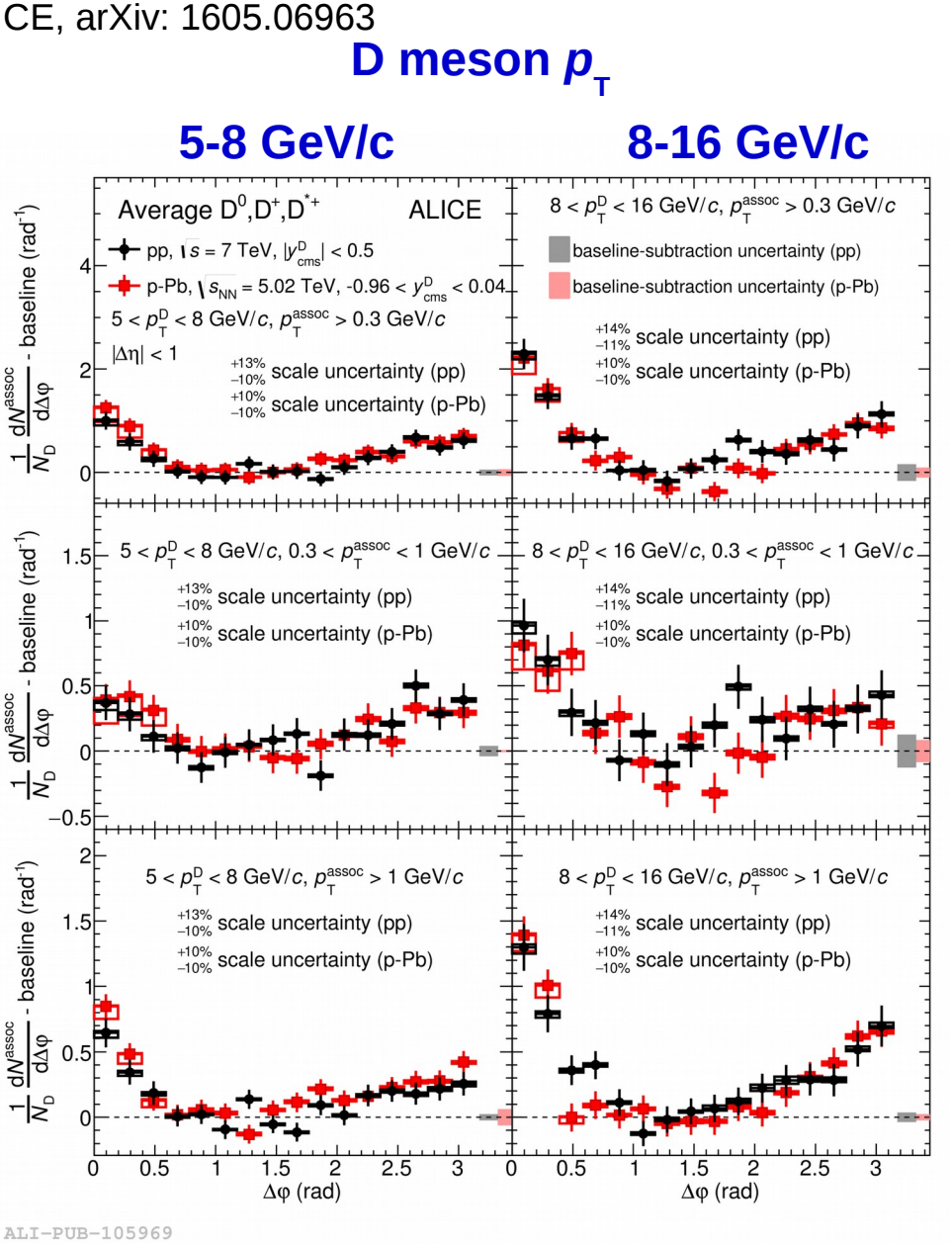


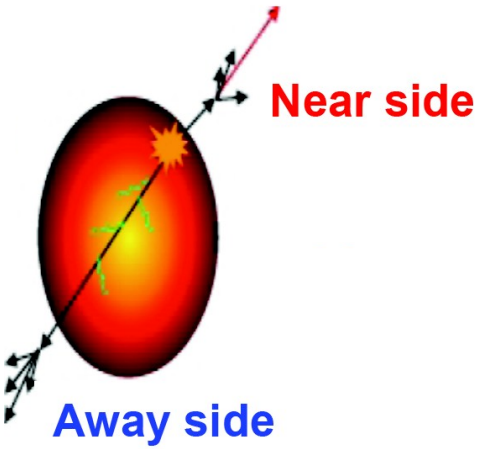


- $R_{pPb}(p_T>0, -0.96<y_{cms}<0.04) = 0.89\pm0.11(stat.)^{+0.13}_{-0.18}(syst.)$
- Measurement compatible with no CNM effects
- Experimental uncertainties are still too large to distinguish between the existing models
  - Much larger sample of p-Pb collisions and pp reference to be collected soon

D – hadron correlations in pp and p-Pb

ALICE, arXiv: 1605.06963

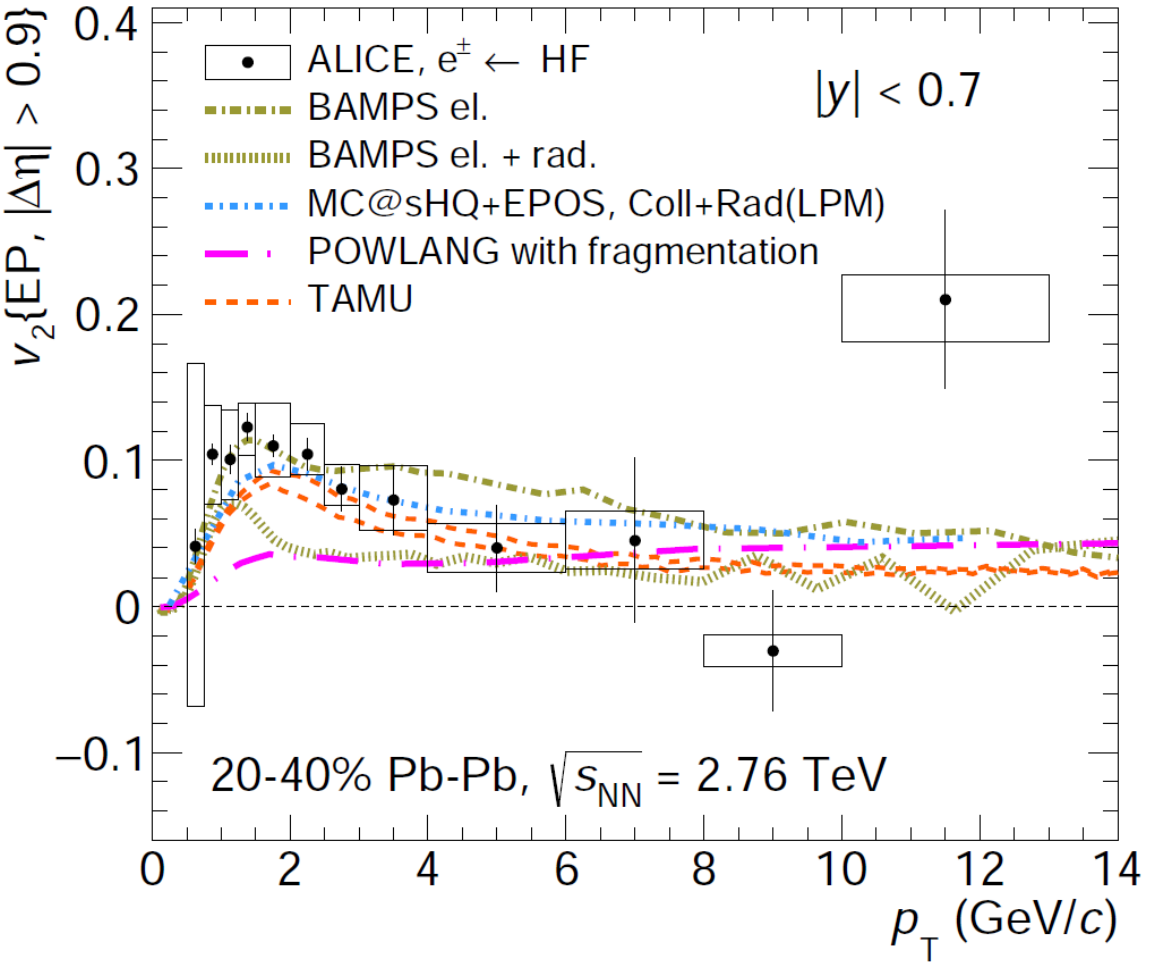




- Look for hadronic activity near and away from the direction of the D-meson momentum vector
- Very similar correlation functions obtained in both pp and p-Pb for all the scanned kinematic ranges
  - Charm-quark fragmentation unmodified by CNM effects ?

Anisotropic flow of heavy-flavour decay electrons in Pb-Pb collisions

ALICE, arXiv: 1606.00321



- Does heavy flavour thermalize and consequently flows in the QGP?
- Heavy flavour elliptic flow sensitive to transport properties of QGP
- Significant non-zero elliptic flow observed
- Models which implement strong collisional energy loss and hadronisation via coalescence agree with the data

Summary

- The ALICE status and recent highlights were presented
- Run-2 news
  - First results from pp collisions at $\sqrt{s}$=13 TeV on charged particle multiplicity are published
  - ALICE published 2 papers from the Pb-Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV
    - Charged particle multiplicity vs centrality
    - Anisotropic flow using multi-particle cumulants
  - ...and much more very soon!
- Run-1 highlights
  - Jet shapes in Pb-Pb collisions $\sqrt{s_{NN}}$=2.76 TeV
  - Lambda-to-kaon ratio inside jets in p-Pb and Pb-Pb collisions
  - Jet production in p-Pb collisions
  - D^0 cross-sections in pp and p-Pb at mid-rapidity measured down to zero p_T
  - Open-charm cross-section and D-hadron correlations nuclear modifications in p-Pb
  - HF electron elliptic flow in Pb-Pb collisions