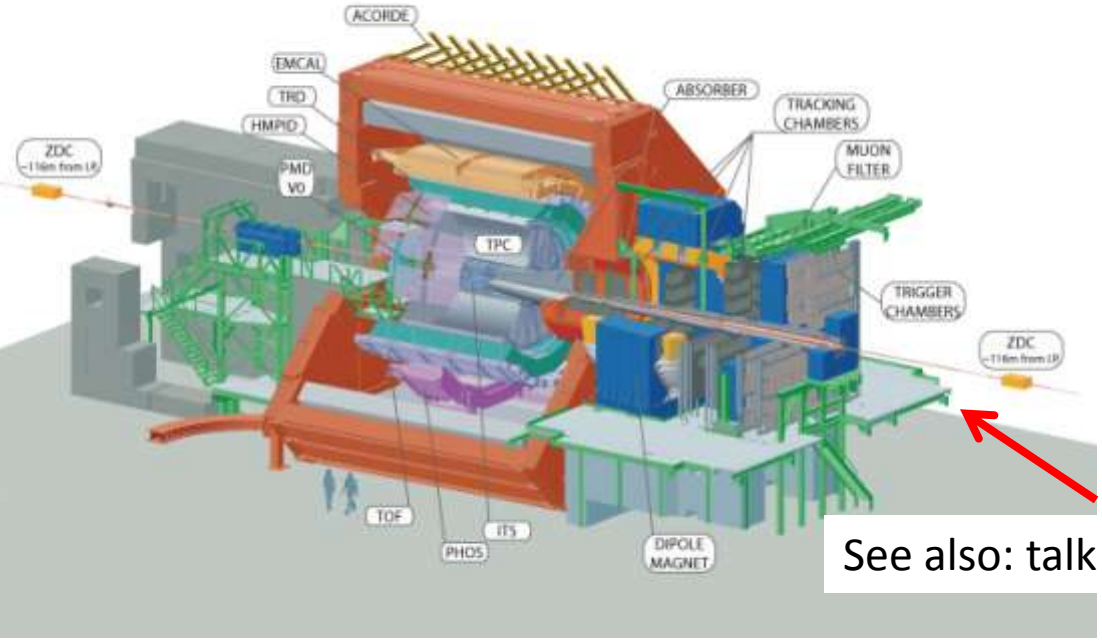
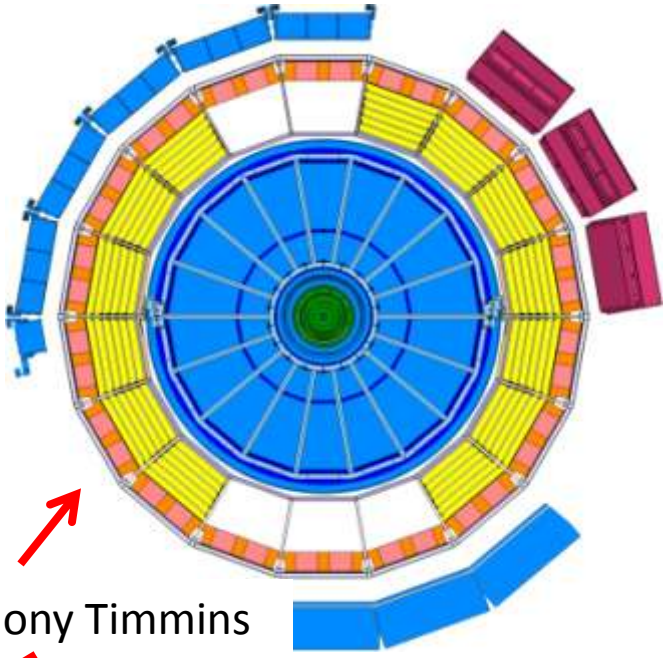
The Ridge and more in Alice

Paul Kuijer on behalf of the Alice collaboration

Detector and dataset

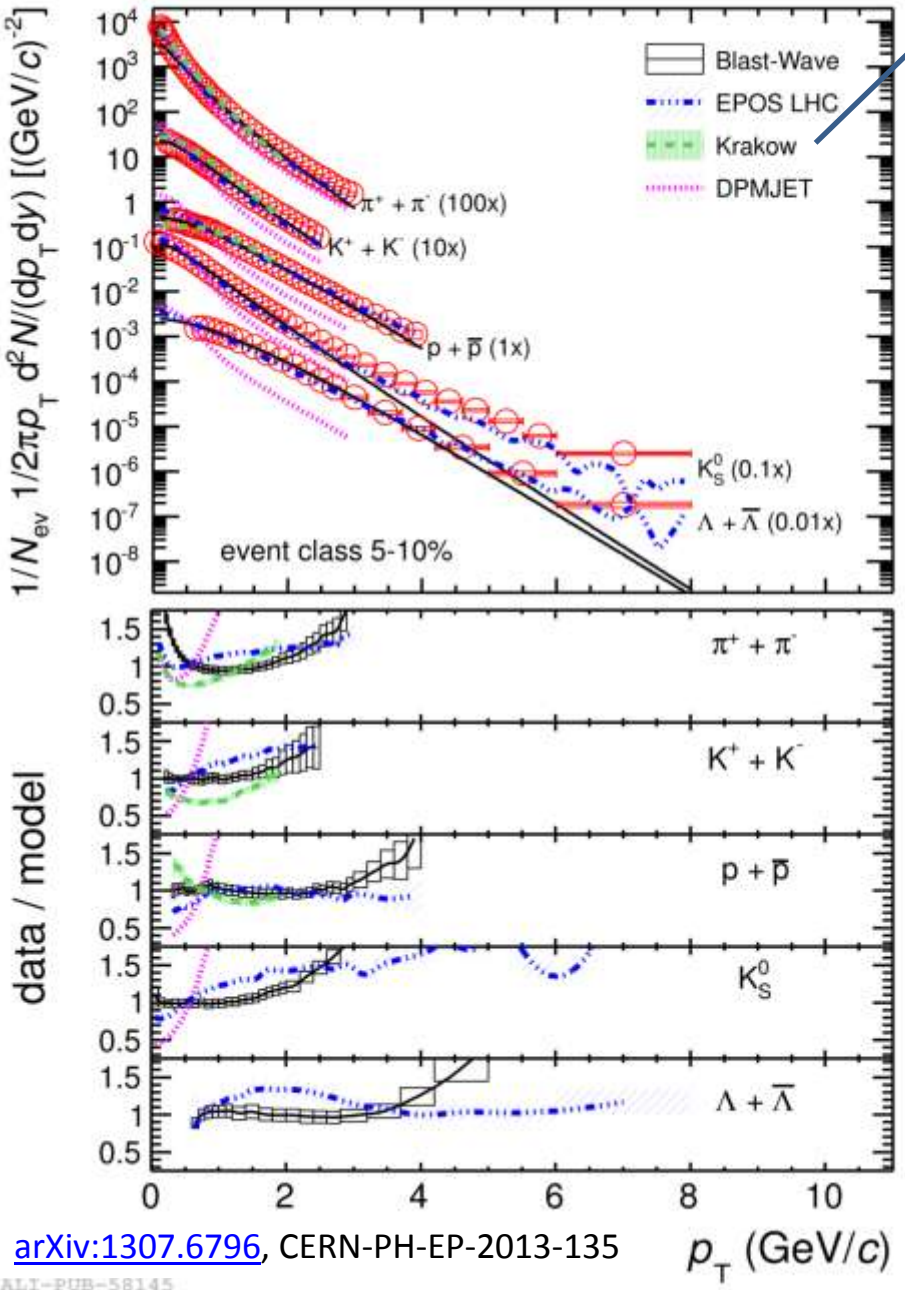




See also: talk by Anthony Timmins

Used about 30 μb^{-1} Non Single Diffractive p-Pb collisions for the analysis presented in this talk

p_T spectra p-Pb

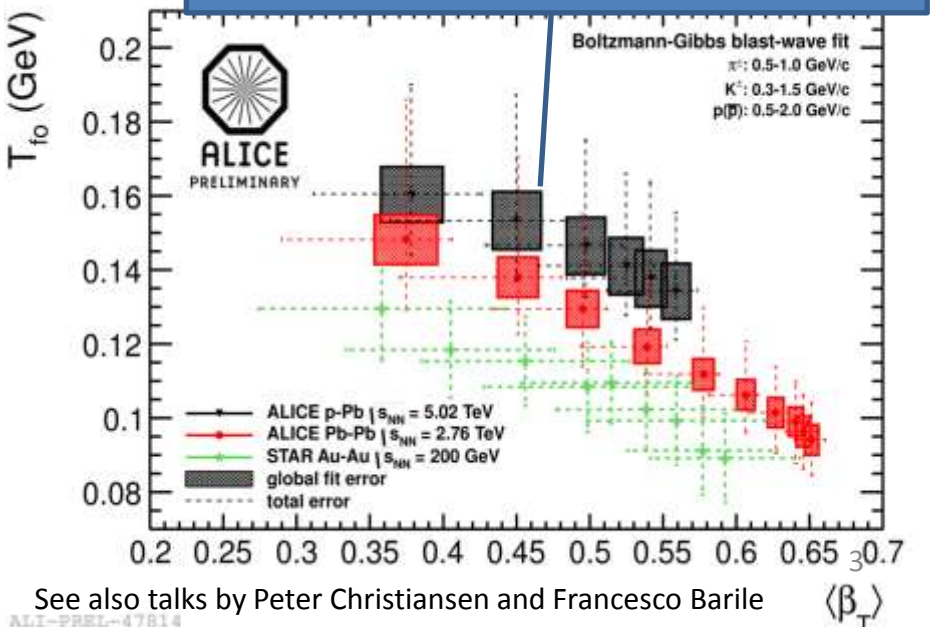


EPOS (T. Pierog, I. Karpenko, J. Katzy, E. Yatsenko, and K. Werner, (2013), hep-ph/1306.0121, parton saturation + collective flow)
Krakow (P. Bozek, Phys. Rev. C85, 014911 (2012), Glauber with fluctuations and hydro)describe the data in p-Pb reasonably at low p_T

DPMJET (CERN-W5013, QCD inspired) less good

BW fit (E. Schnedermann, J. Sollfrank, and U. W. Heinz, Phys. Rev. C48, 2462 (1993).) ok (at low p_T)

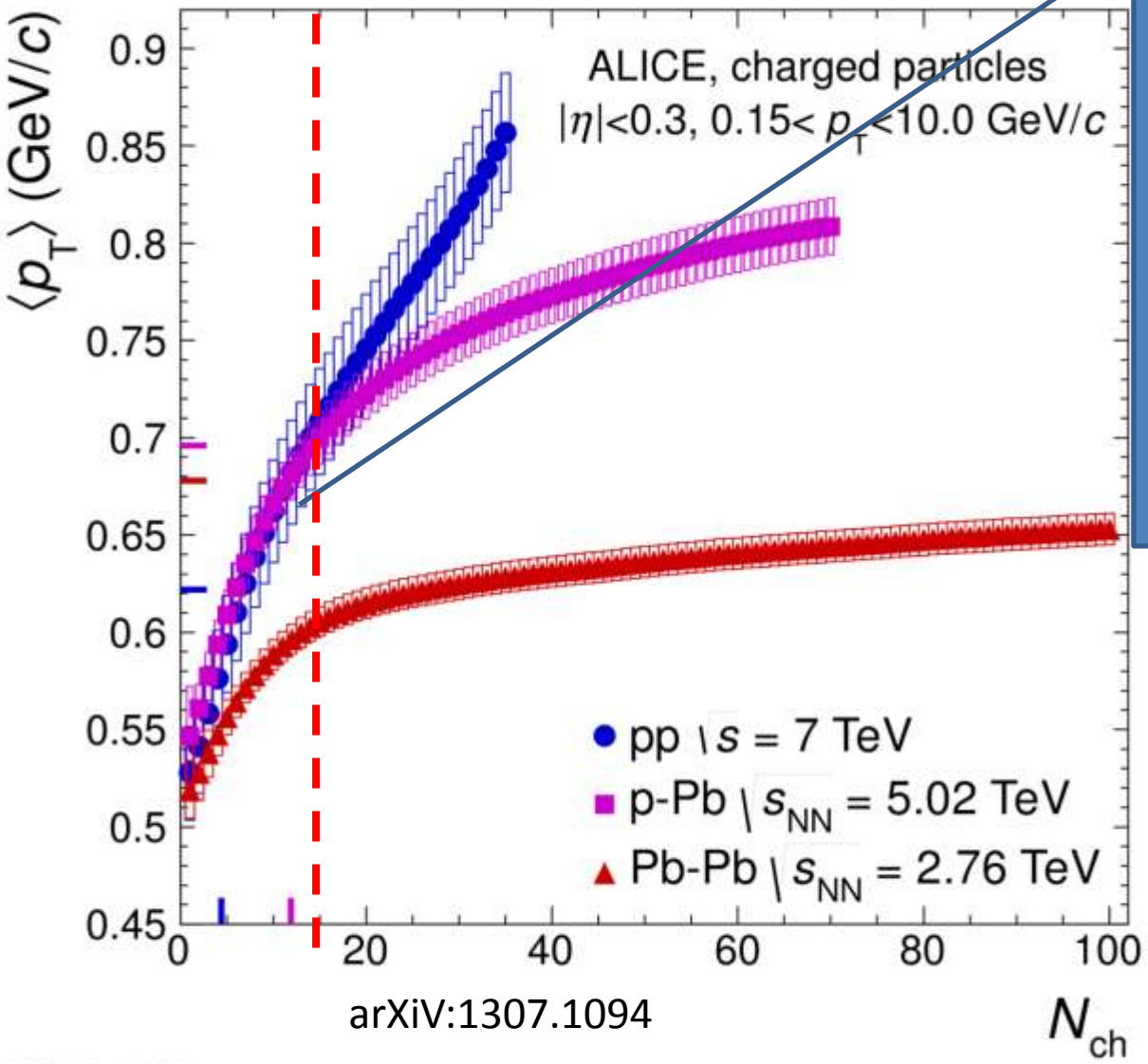
High multiplicity p-Pb qualitatively similar to AA



arXiv:1307.6796, CERN-PH-EP-2013-135

See also talks by Peter Christiansen and Francesco Barile

Mean p_T

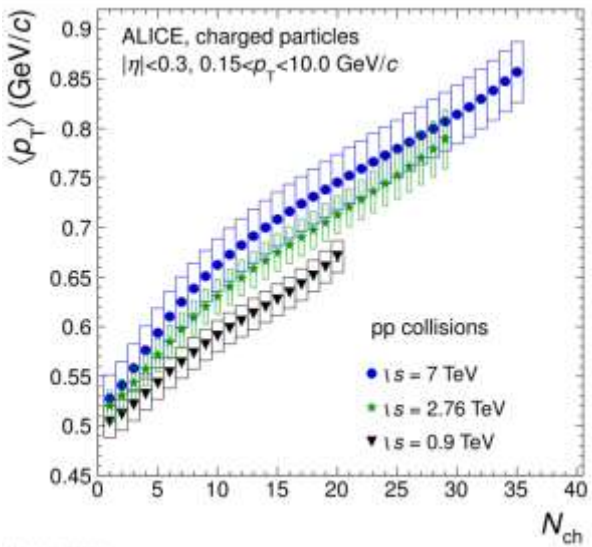


arXiV:1307.1094

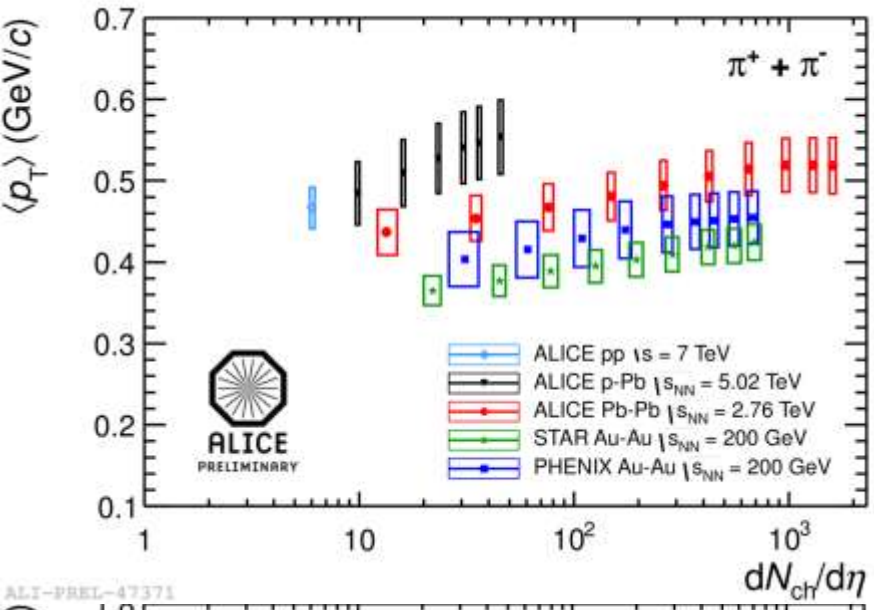
- N_{ch} extrapolated to p_T=0 from measured p_T spectrum in same rapidity range |η|<0.3
- pp and p-Pb comparable for Nch<14
- However:
- Centralities very different
  - 90% pp
  - 50% p-Pb
  - 18% Pb-Pb

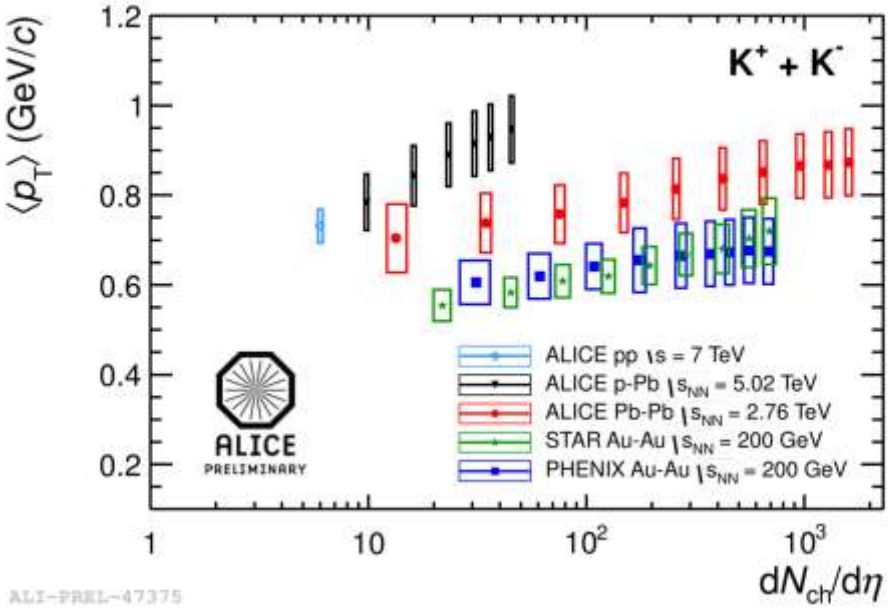
See talk by Alberica Toia

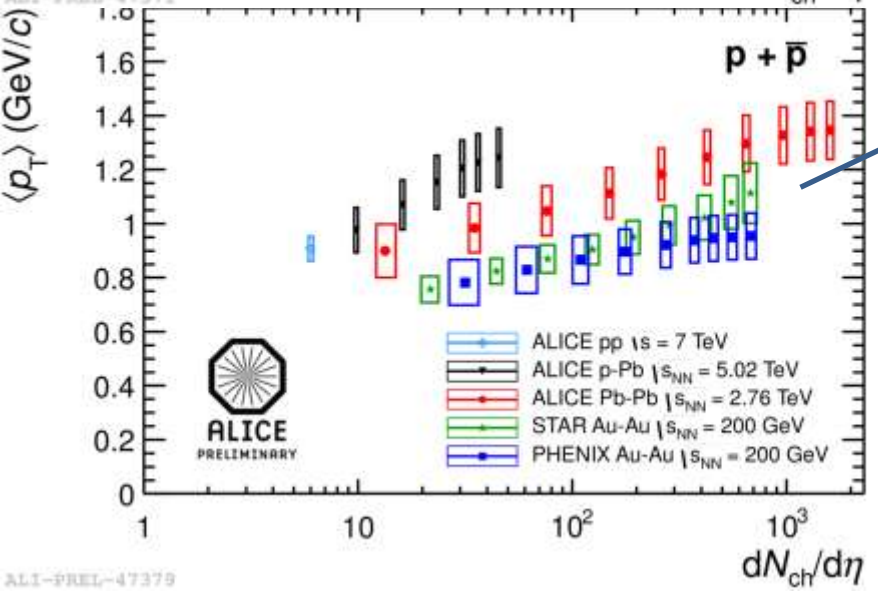
- <p_T> very different
- <N_{ch}> very different
- Modest energy dependence expected



Mean p_T for identified particles



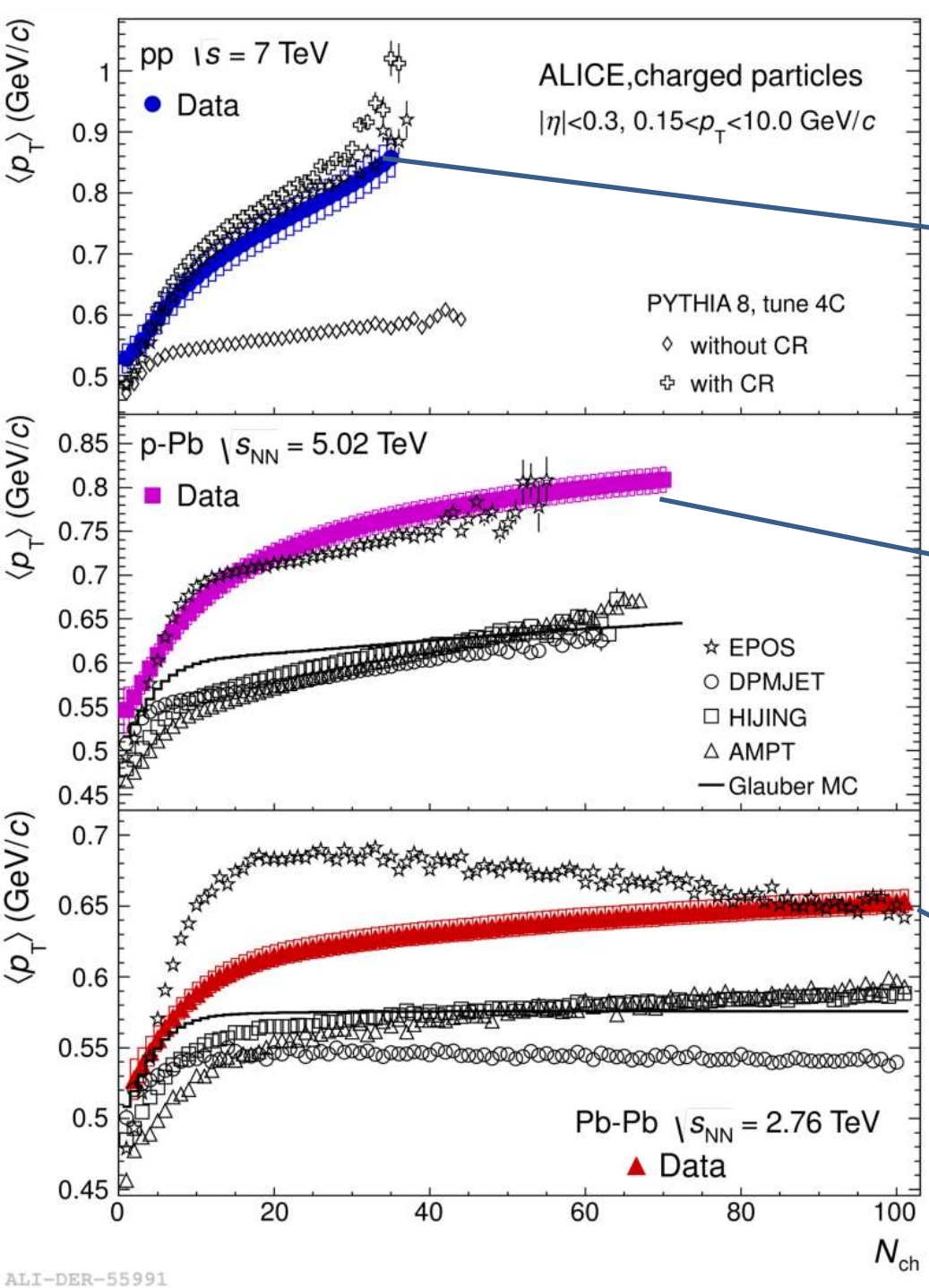




- Modest increase of $\langle p_T \rangle$ with energy in Pb-Pb
- At same N_{ch} higher $\langle p_T \rangle$ for p-Pb than for Pb-Pb
- pp comparable to p-Pb

- Mass ordering !

Models



PYTHIA 8 tune4C needs *Colour Reconnection* to describe the data in pp

EPOS includes *collective effects* to describe the data in p-Pb
Hijing, DPMJET, AMPT, Glauber do not use colour reconnection here

EPOS (with collective effects) fails to describe shape, no quantitative description in any of these models

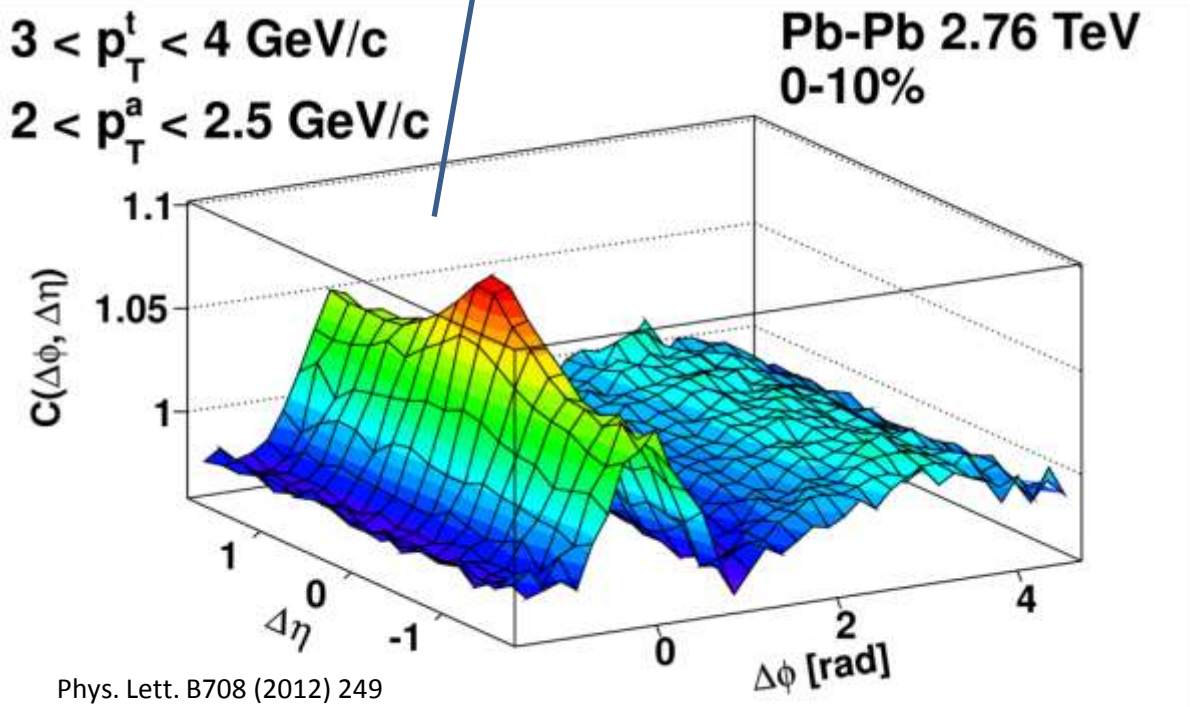
arXiV:1307.1094

Hadron correlations

$$C(\Delta\phi,\Delta\eta)= \frac{1}{N_{\text{trig}}}\frac{\mathrm{d}^2N_{\text{assoc}}}{\mathrm{d}\Delta\eta\mathrm{d}\Delta\varphi} = \frac{S(\Delta\eta,\Delta\varphi)}{B(\Delta\eta,\Delta\varphi)}$$

At low p_T in Pb-Pb:
Near side ridge
Long range and reproduced by *hydro models*

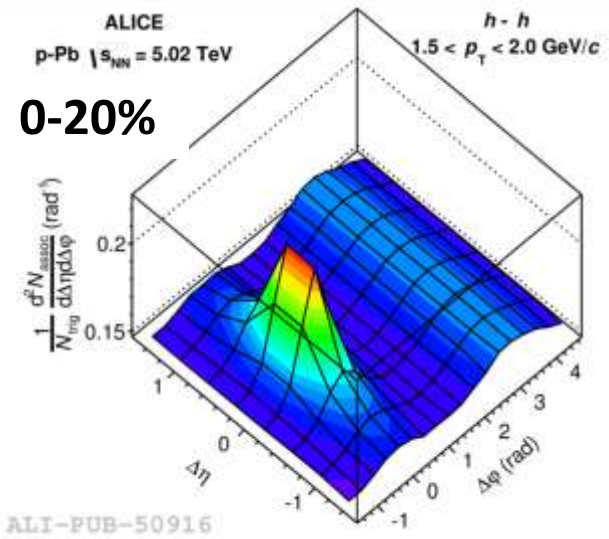
$$S(\Delta\eta,\Delta\varphi) = 1/N_{\text{trig}}\ \mathrm{d}^2N_{\text{same}}/\mathrm{d}\Delta\eta\mathrm{d}\Delta\varphi$$
$$B(\Delta\eta,\Delta\varphi) = \alpha\ \mathrm{d}^2N_{\text{mixed}}/\mathrm{d}\Delta\eta\mathrm{d}\Delta\varphi$$

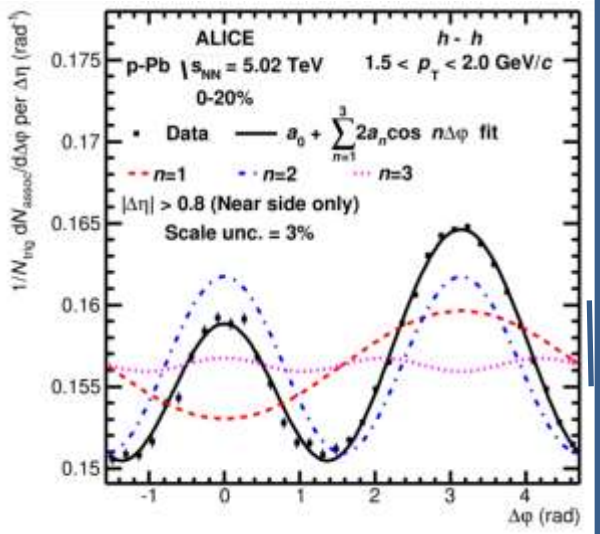


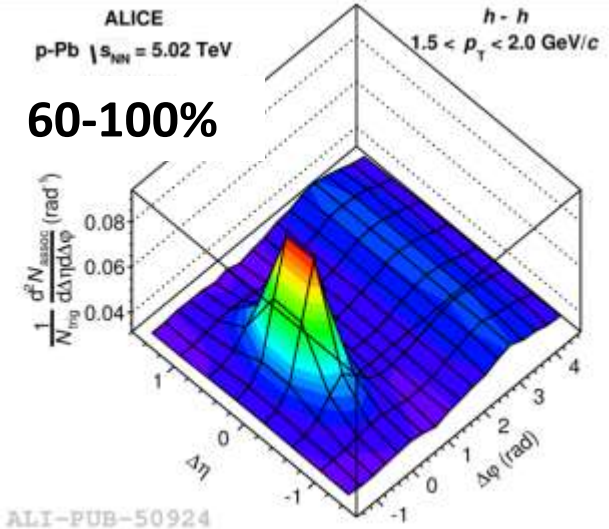
Phys. Lett. B708 (2012) 249

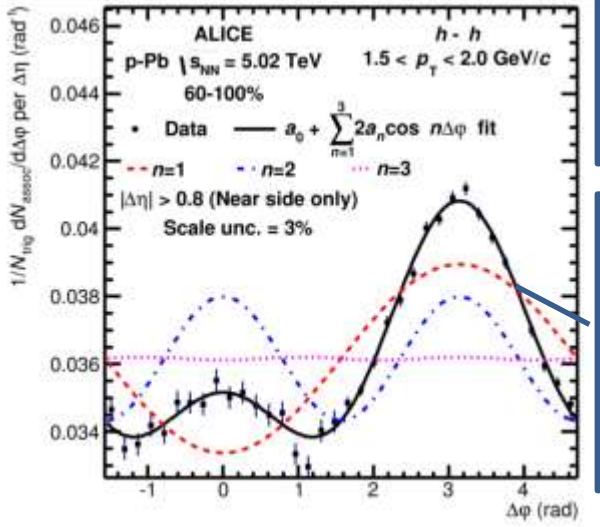
h-h correlation in p-Pb

Phys lett B in press









Similar structures in high multiplicity p-Pb events

→

Study the ridge by cutting out the jet peak (|Δη|>0.8,near side only) and projecting on Δϕ

→

Fourier decomposition

Still contains:

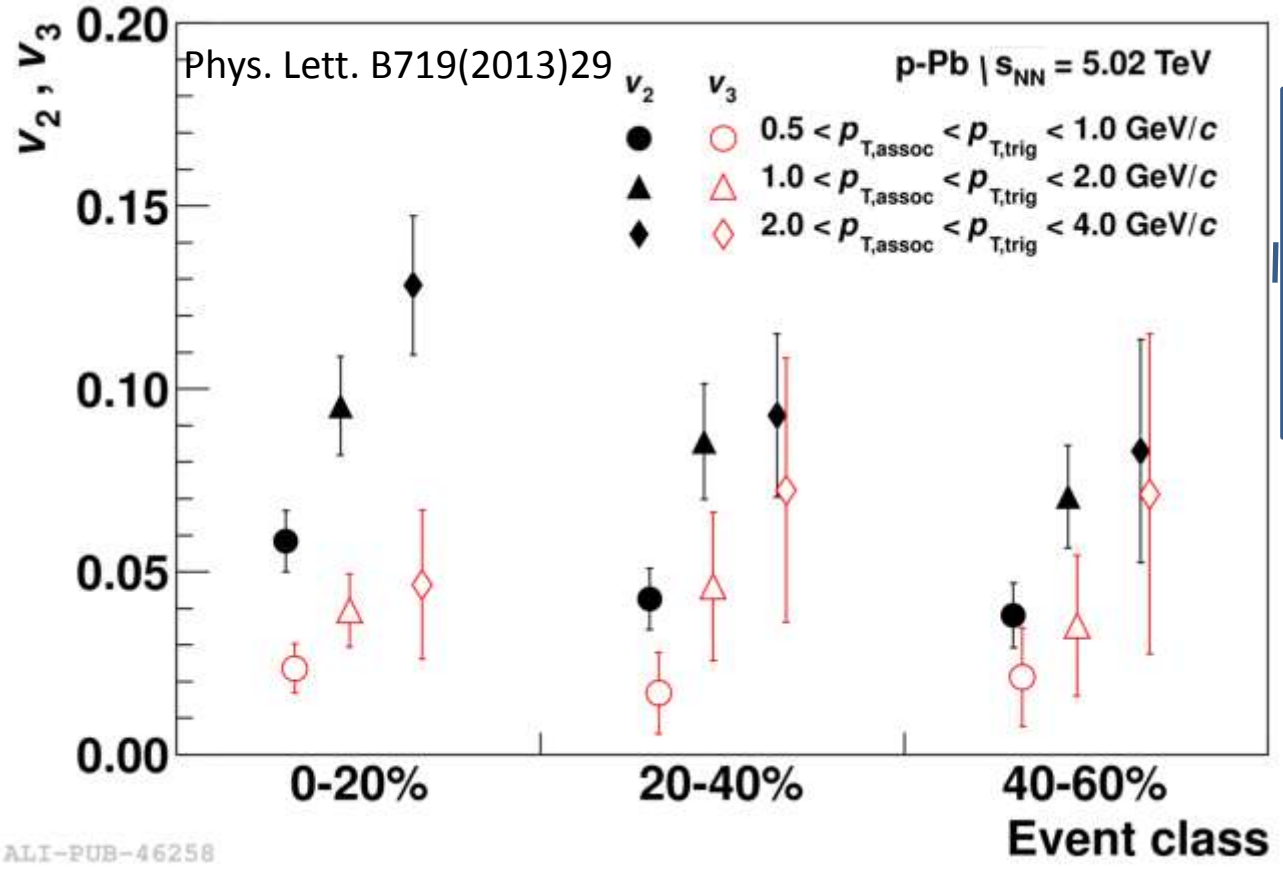
*Recoil jet

*Jet

* ridges

Fitting the ridge yields with a Fourier series shows a large v1 component and a v2 component. V3 is smaller and higher terms are negligible

Fourier decomposition of remaining ridges



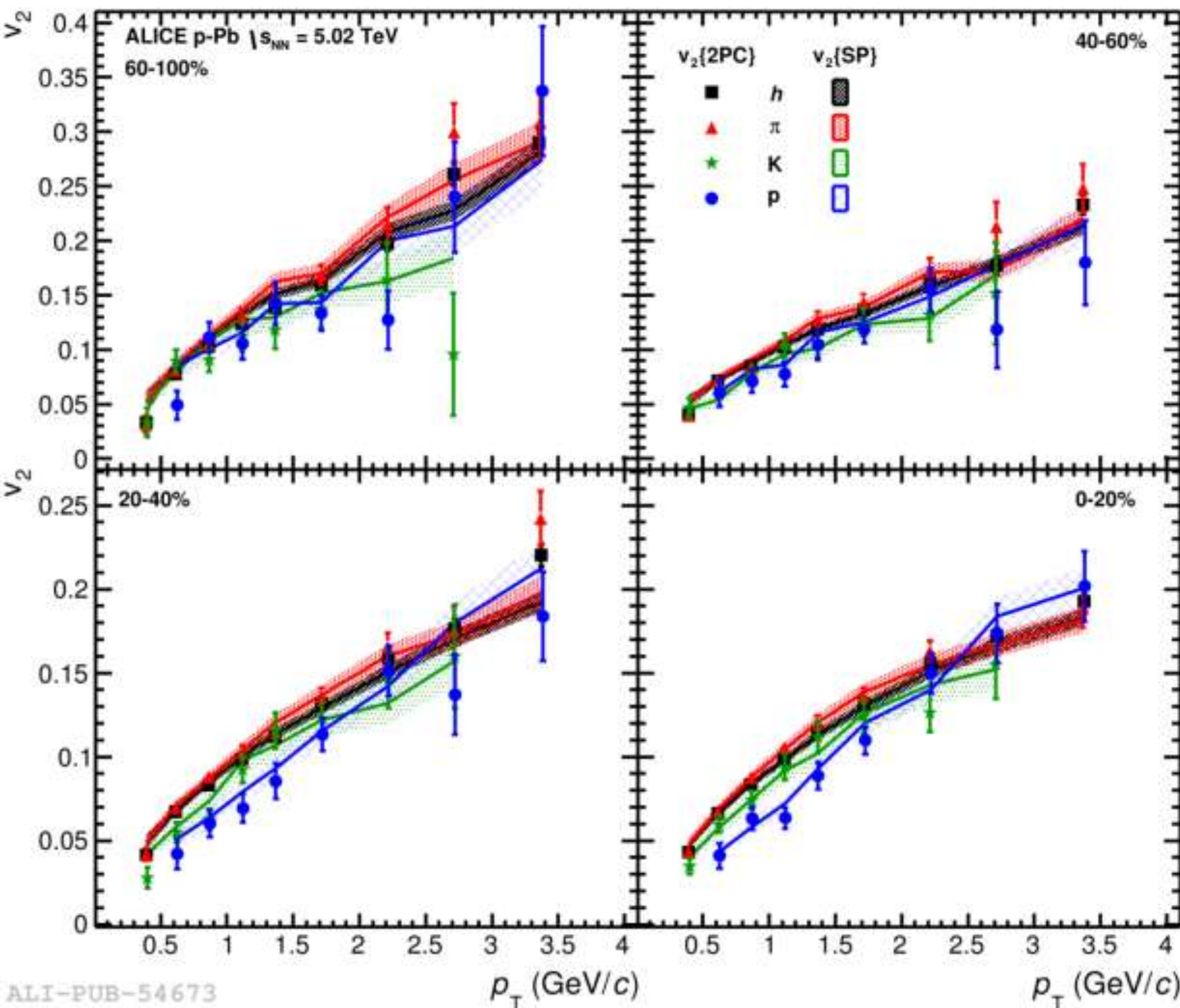
Second harmonic larger than third
Higher harmonics negligible
Increasing with p_T
Depending on centrality

Initial state:
- Color glass condensate?

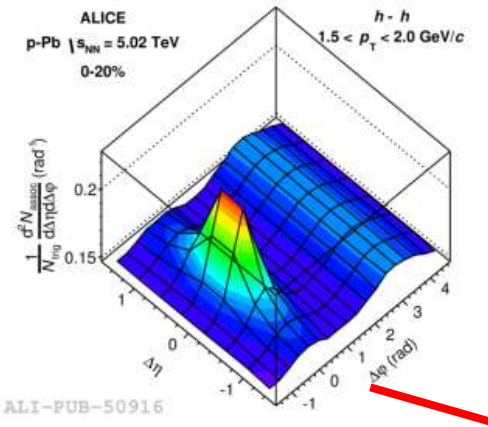
Final state:
- Multiparton interactions?
- Collective effects?

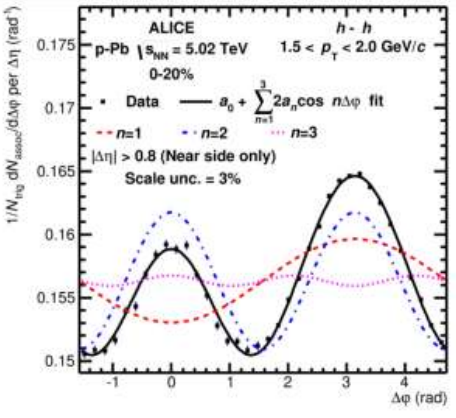
Comparison to untriggered (scalar product) correlations for identified particles

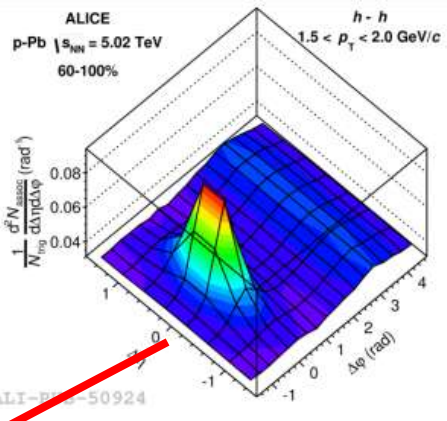
Phys lett B in press

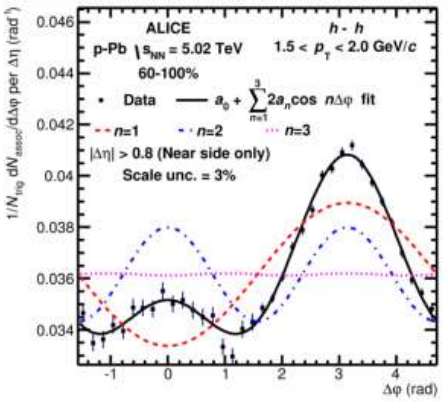


The shape of the ridges is compatible to the v2 measurement with classical flow methods









0-20%

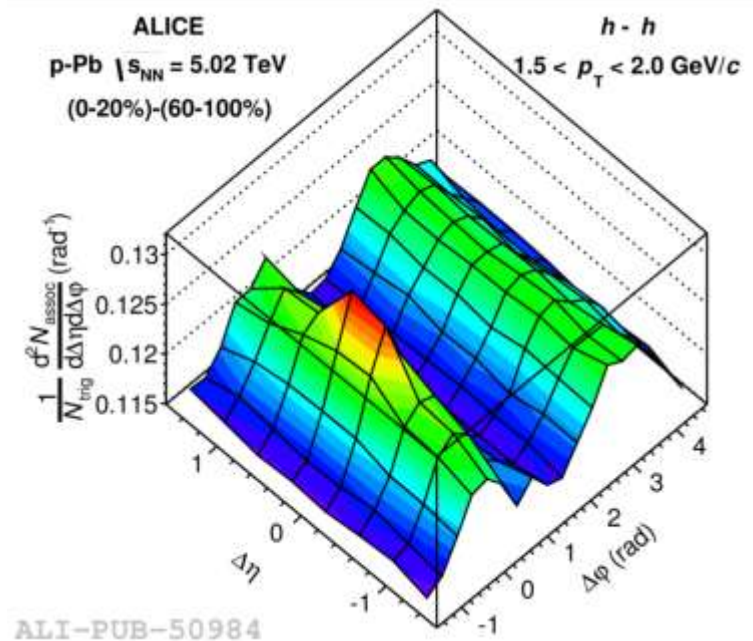
60-100%

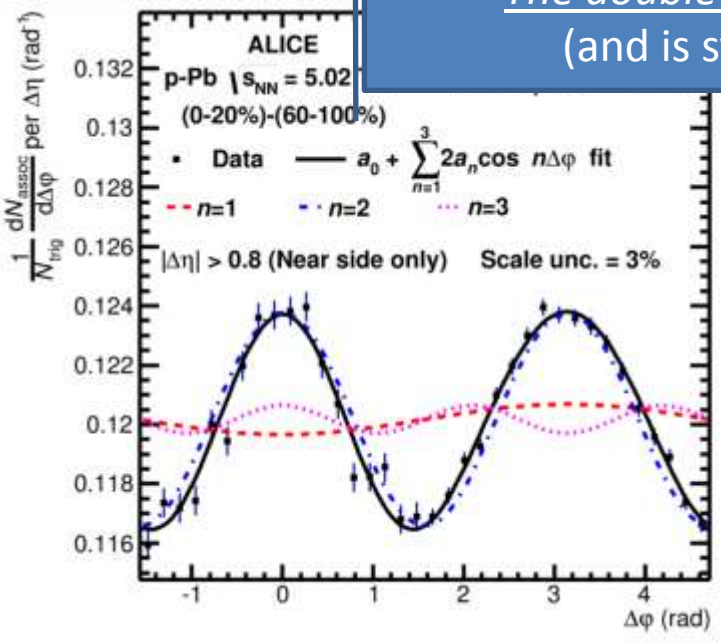
subtract

Assuming an unmodified jet structure, the jet contribution is further suppressed by subtracting low multiplicity events.

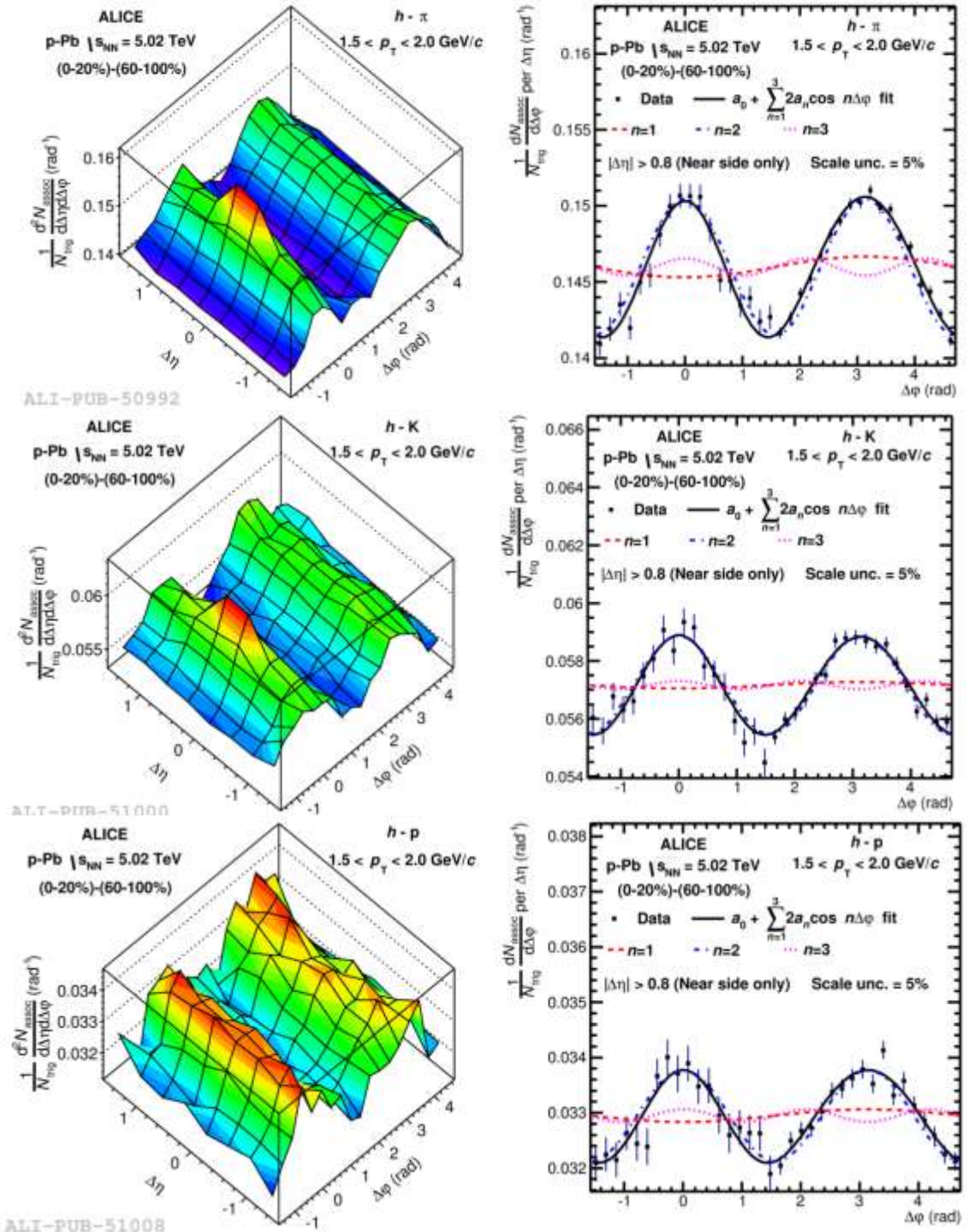
The double ridge remains!

(and is symmetrical)



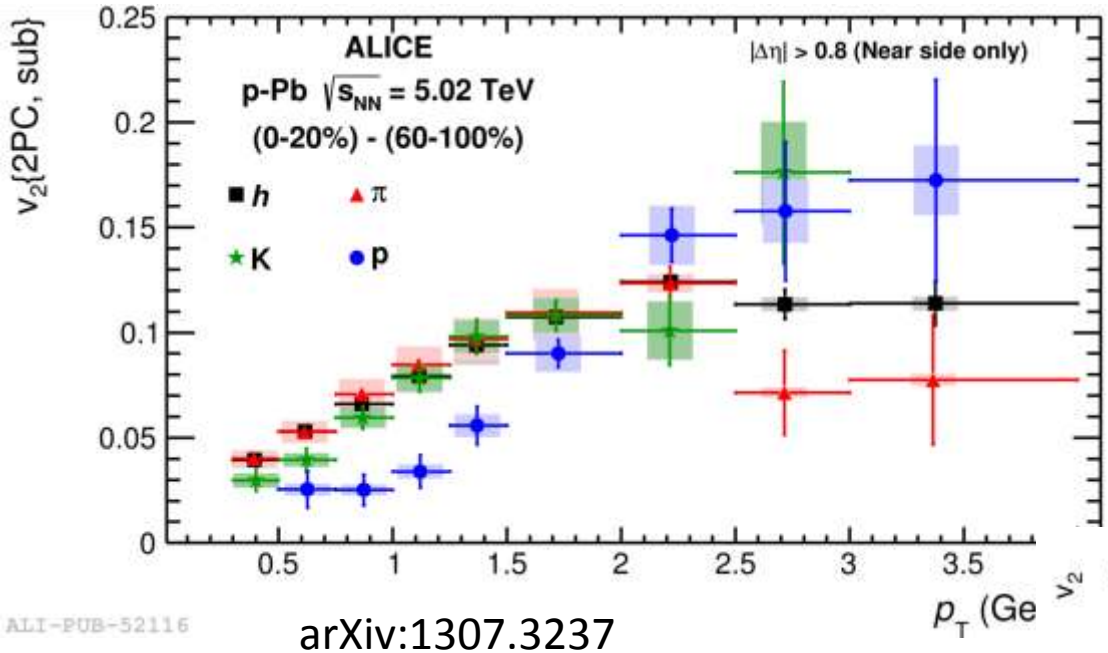


Identified particles



Same subtraction procedure for identified particle correlations

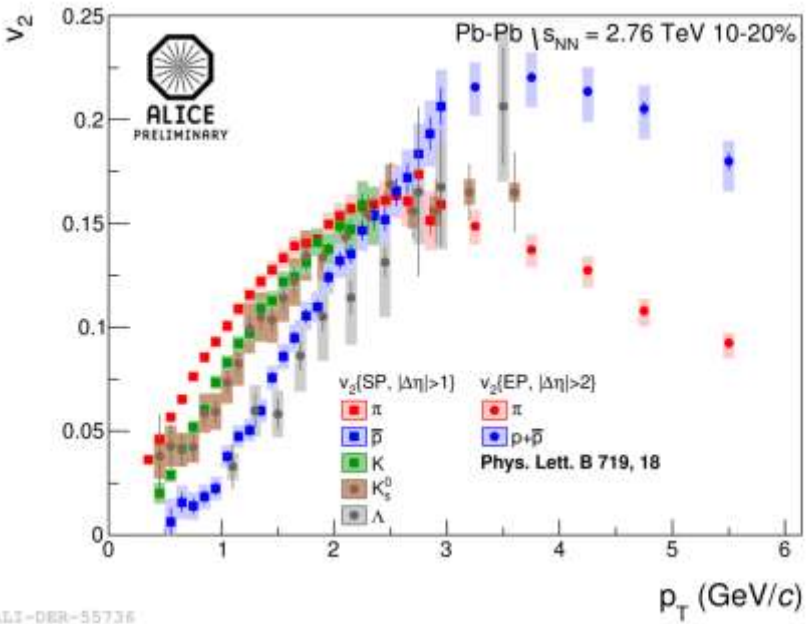
Identified particle v_2 vs p_T



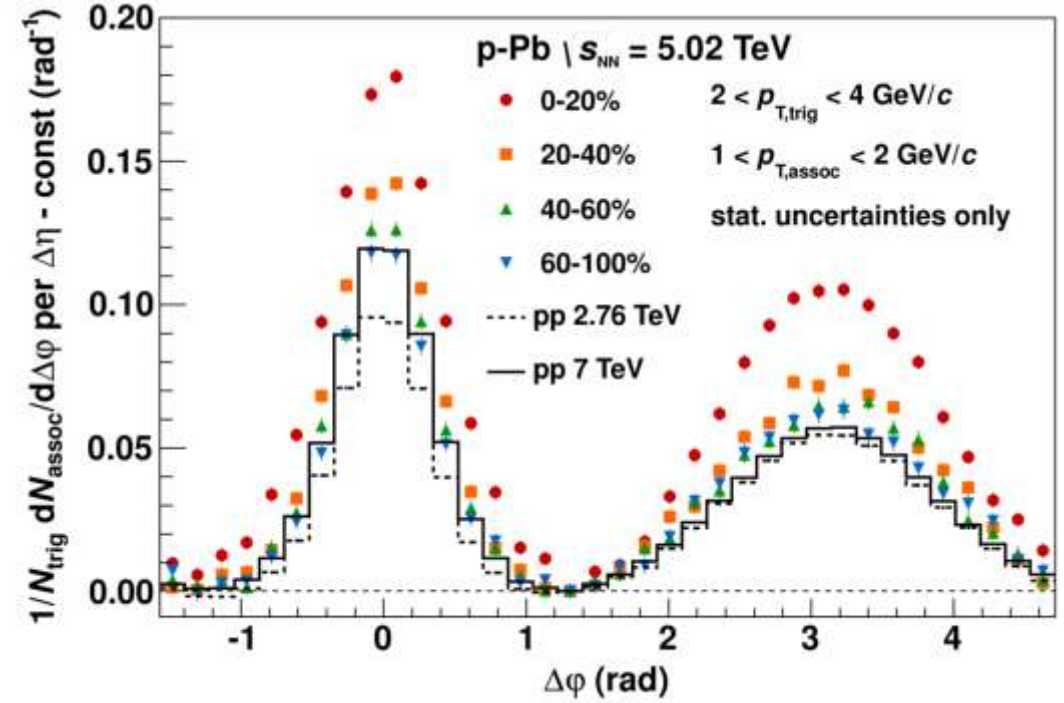
arXiv:1307.3237

Mass ordering similar to Pb-Pb

Proton v_2 crossing π v_2 near 2 GeV/C
Kaons probably below pions

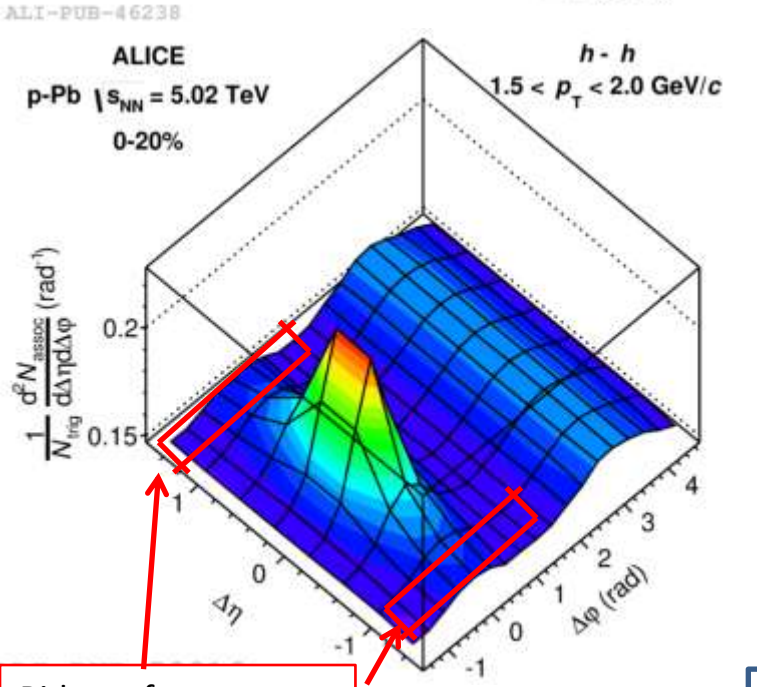


Jet structure by subtracting the ridges

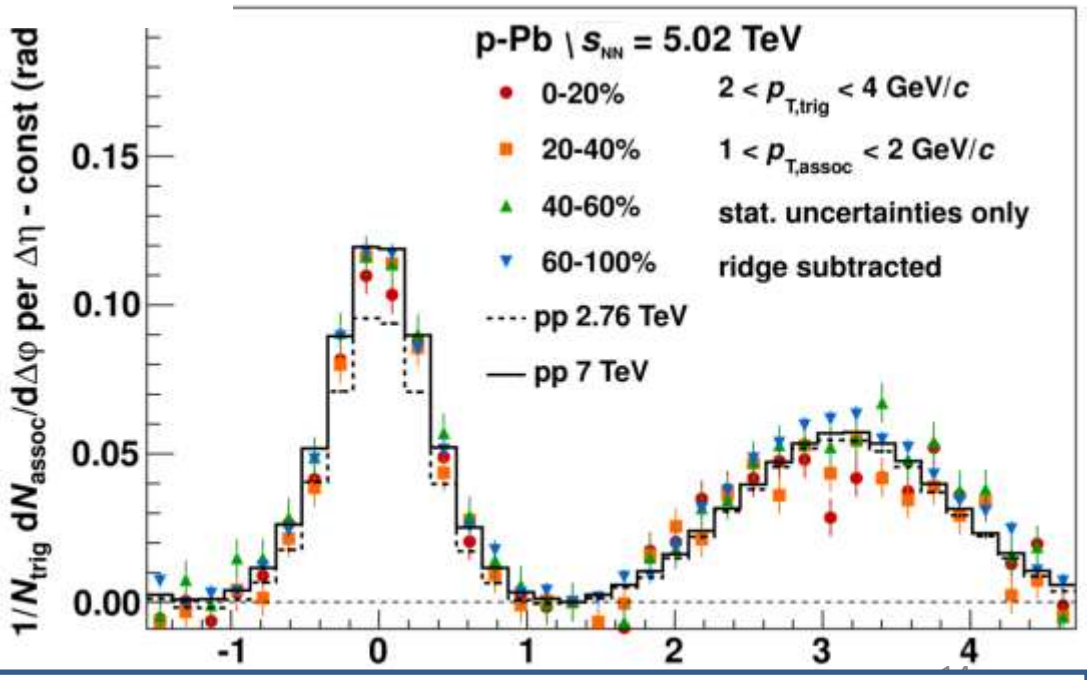


Near side ($1.2<|\eta|<1.8$), mirrored to away side and extended to full rapidity range

Jet production: talk by Jiri Kral
Jet/ high p_T hadrons: M Ploskon



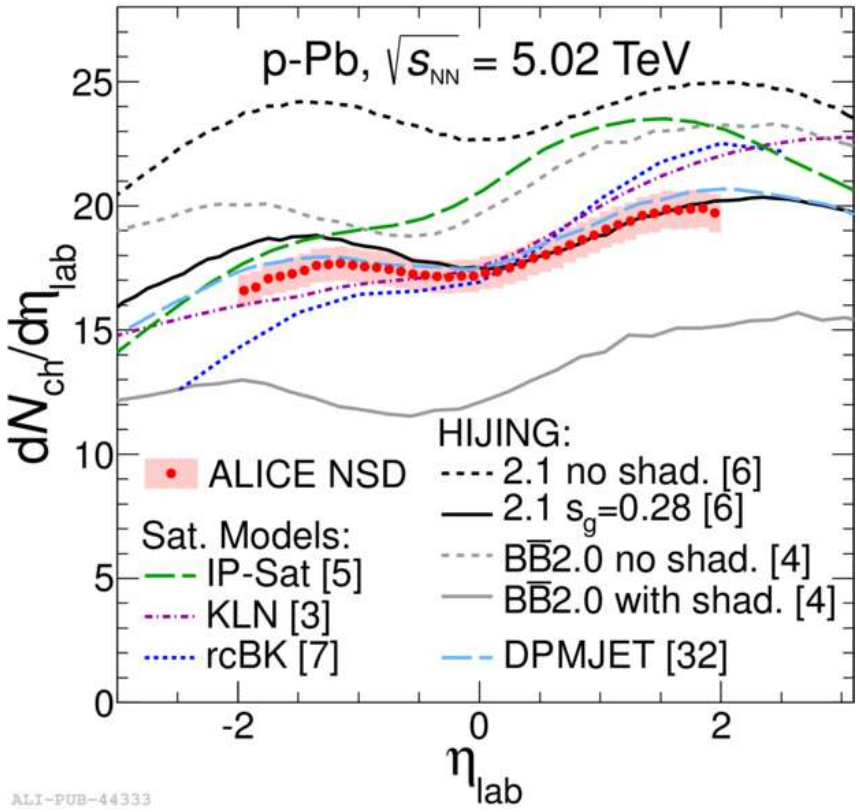
Ridge reference area



Jet structure appears the same for all multiplicities

Pseudo rapidity density p-Pb (NSD)

Hijing and DPMJET do fairly well (with shadowing)
Saturation models do less well (larger difference forward/backward)



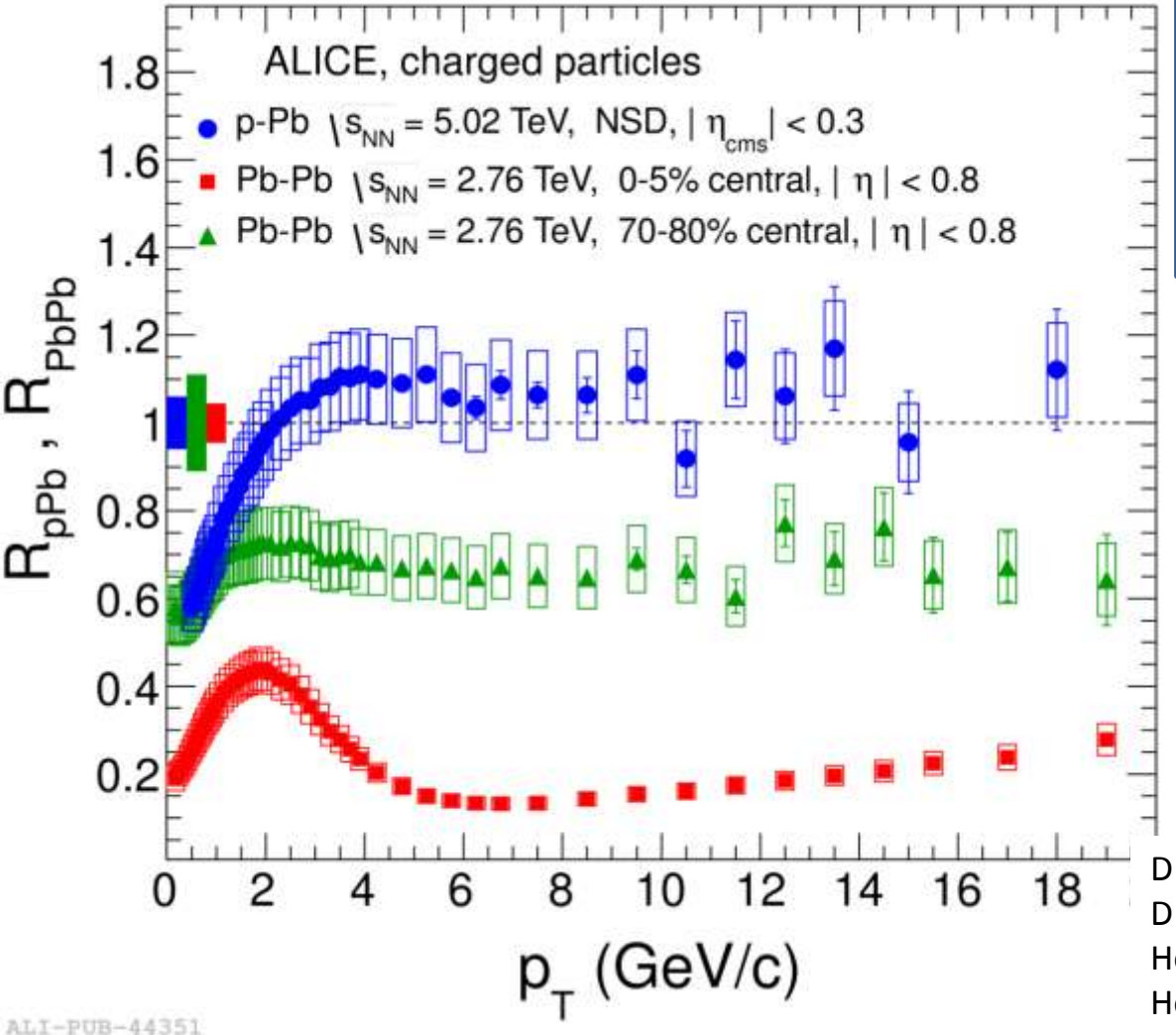
PRL 110, 032301 (2013)

	$dN_{ch}/d\eta_{lab}$ −2.0	0.0	2.0	$\frac{dN_{ch}/d\eta_{lab}\|_{\eta_{lab}=2.0}}{dN_{ch}/d\eta_{lab}\|_{\eta_{lab}=-2.0}}$
ALICE	16.65 ±0.65	17.24 ±0.66	19.81 ±0.78	1.19 ±0.05
Saturation models				
IP saturation [5]	17.55	20.55	23.11	1.32
KLN [3]	15.96	17.51	22.02	1.38
rcBK [7]	14.27	16.94	22.51	1.58
HIJING				
2.1, no shadowing [6]	23.58	22.67	24.96	1.06
2.1 s_g = 0.28 [6]	18.30	17.49	20.21	1.10
BB̄2.0, no shadowing [4]	20.03	19.68	23.24	1.16
BB̄2.0, with shadowing [4]	12.97	12.09	15.16	1.17
DPMJET [31]	17.50	17.61	20.67	1.18

'Slope' of the yield comparable to data for models with shadowing

R_{pPb} (NSD)

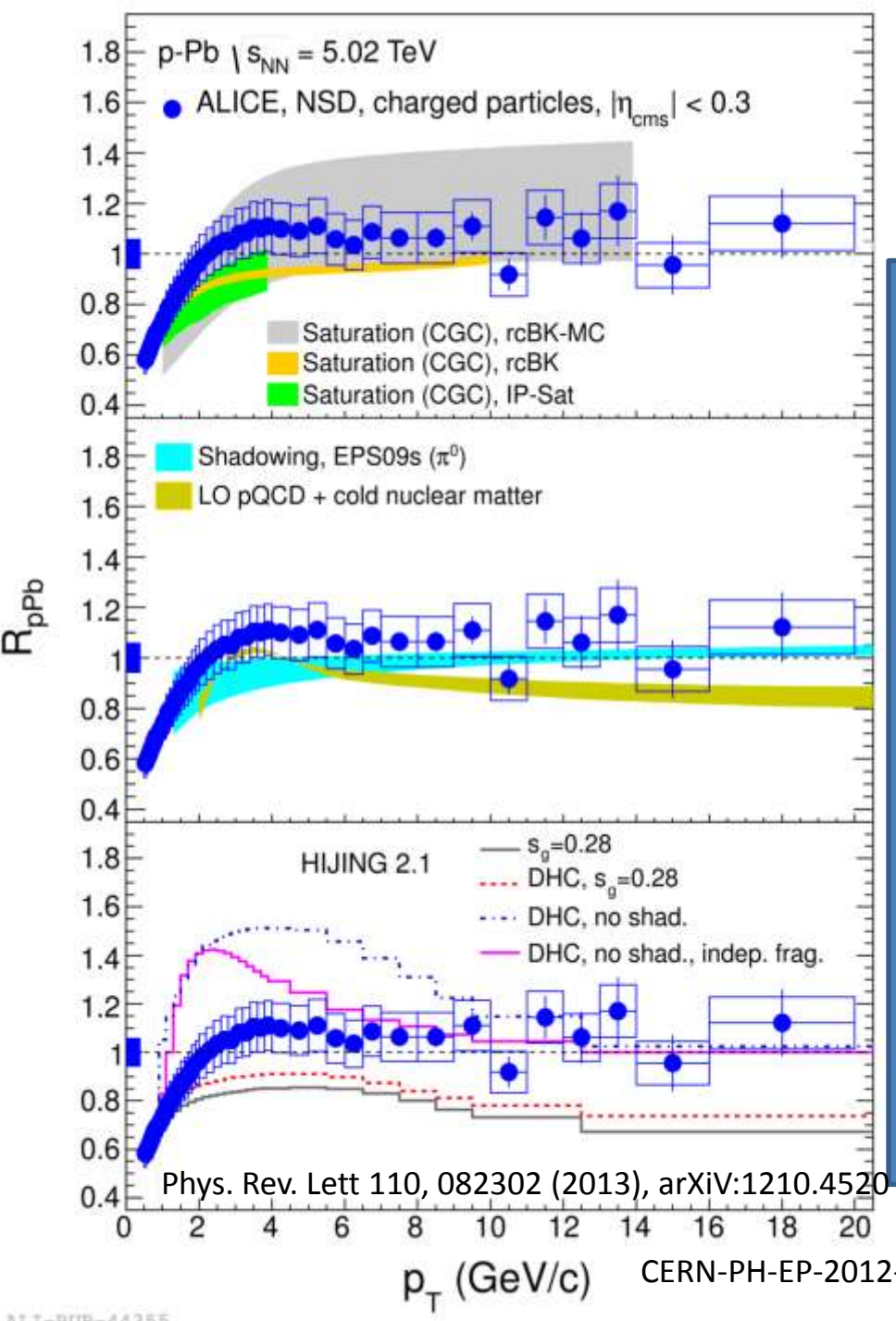
Phys. Rev. Lett 110, 082302 (2013), arXiV:1210.4520



- R_{pPb} Unity above 2 GeV/c
- Small (if any) enhancement at 3-5 GeV/c (Cronin)

D meson R_{pPb} talk by Andrea festanti
D meson R_{Pb-Pb} talk by Gian Michele Innocenti
Heavy flavour production talk by Shingo Sakai
Heavy flavour via leptons: talk by Sarah LaPointe

R_{pPb} vs models



- Inclusion of SD events would decrease the measurement by up to 4%

- **Color Glass condensate**
  - PLB710, 125(2012), arXiv:1112.2445
  - IP-Sat and rcBK-MC ok within model systematics
  - rcBK slightly underpredicts

- **EPS09s**
  - JHEP 1207, 073(2012), arXiv:1205.5359
  - NLO with EPS09s parton distribution and DSS fragmentation functions for π^0 → ok

- **Hijing 2.1**
  - arXiv:1204.1998
  - Needs shadowing to describe the data

CERN-PH-EP-2012-306, arXiV:1210.4520

Conclusions

- p_T spectra
  - Models with final state effects closer to the data
- In pp and p-Pb: $\langle p_T \rangle$ increase with N_{ch}
  - Need multiple parton interactions with color reconnection in PYTHIA for pp
  - EPOS with parton saturation and (preliminary) collective flow describes p-Pb (but not Pb-Pb)
- Double ridge observed in p-Pb
  - Identical near-away side ridges consistent with colour glass condensation models
  - Mass ordering of v2 similar to hydro models
- Subtraction of ridges leaves jet structure
  - Correlation shape in $\Delta\phi$ independent of multiplicity (no visible jet modification)
- Shadowing models do better for dN/dη
- R_{pPb}
  - unity for $p_T > 2$ GeV/c, No initial state contribution to R_{AA}
  - Shadowing and/or saturation needed

- initial-final state effects not yet disentangled

Quarkonia: talk by Hugo Pereira Da Costa
J/Ψ: talk by Laurent Aphecetche