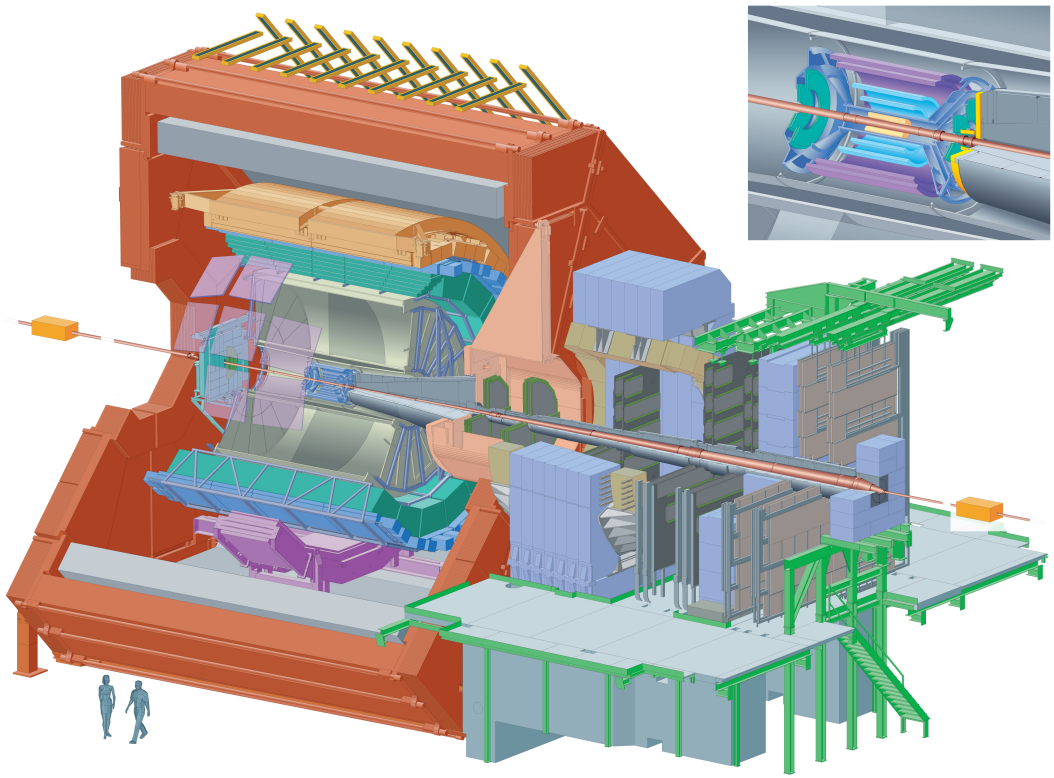
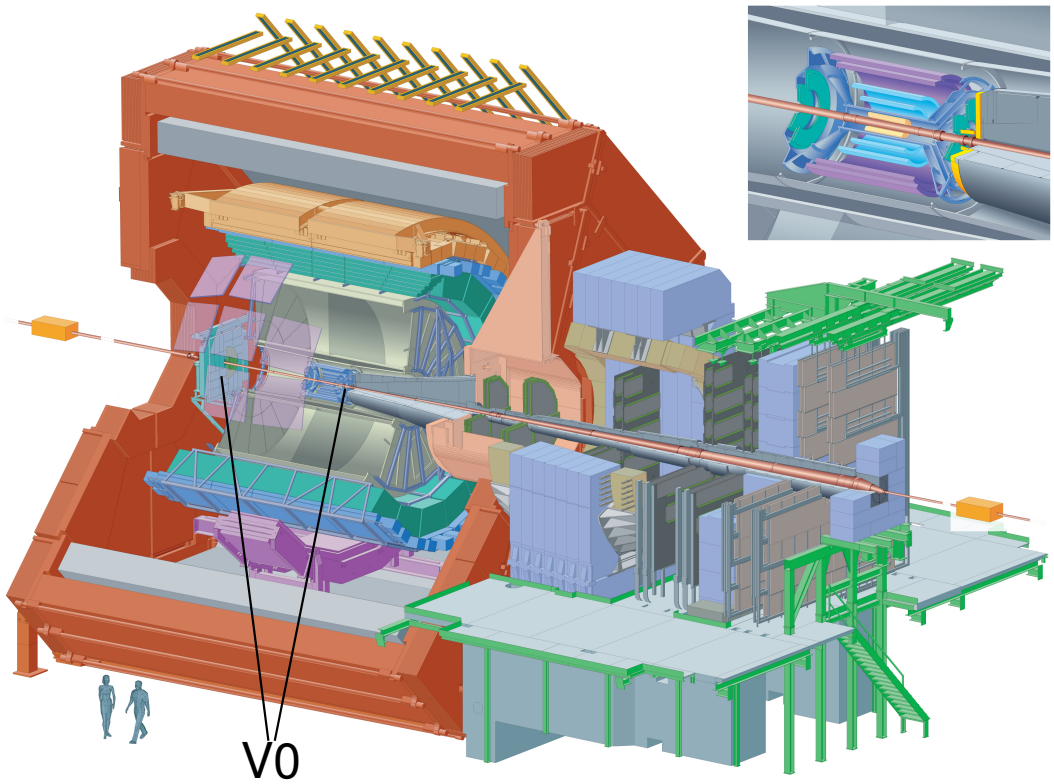
New results related to soft probes in Pb–Pb at $5.02\,\mathrm{TeV}$ with ALICE

ALICE



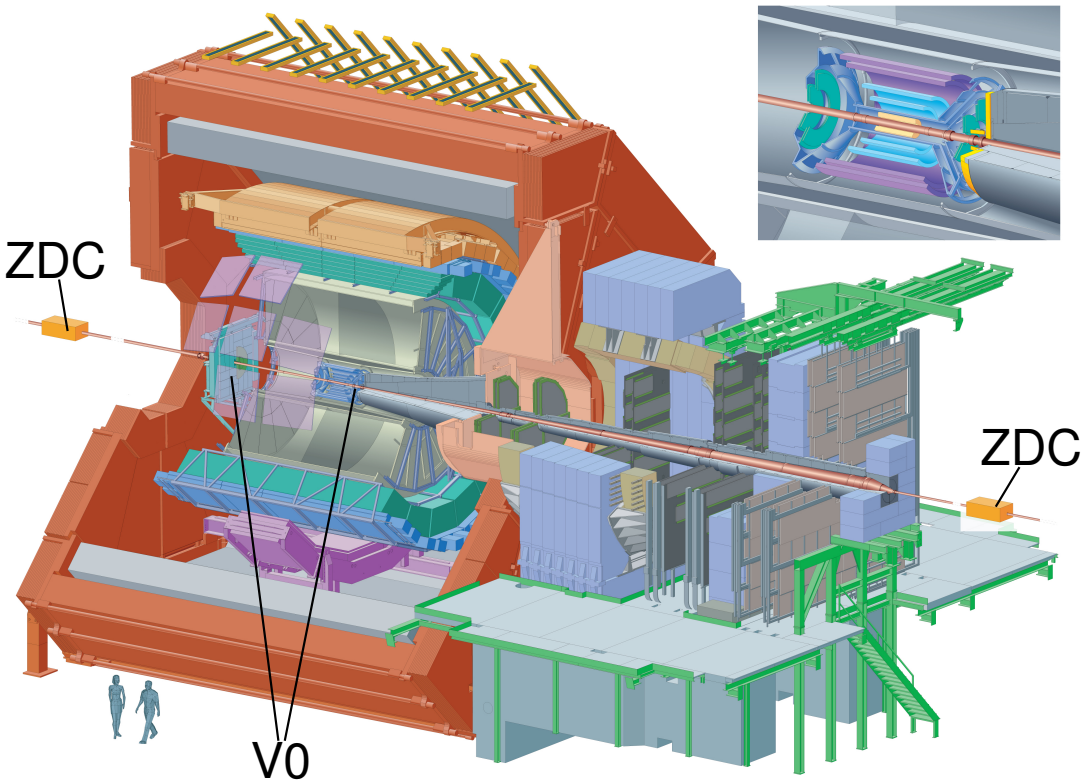
- Detectors used

ALICE



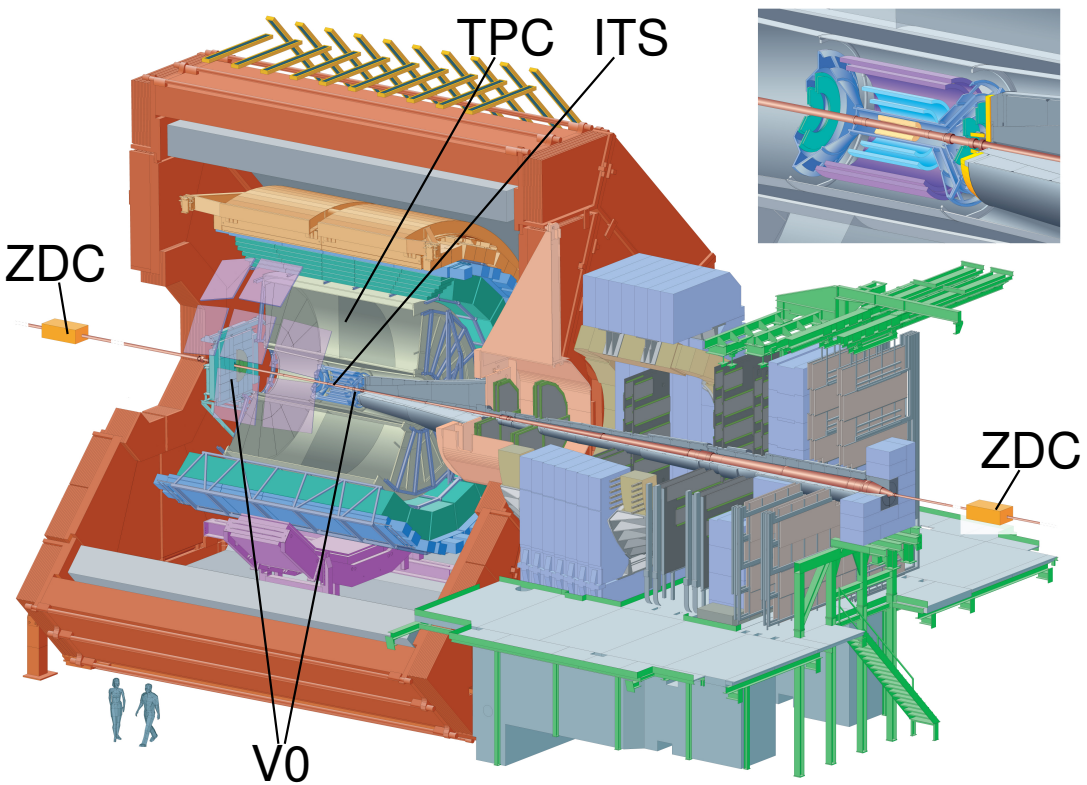
- Detectors used
  - V0: trigger, centrality

ALICE



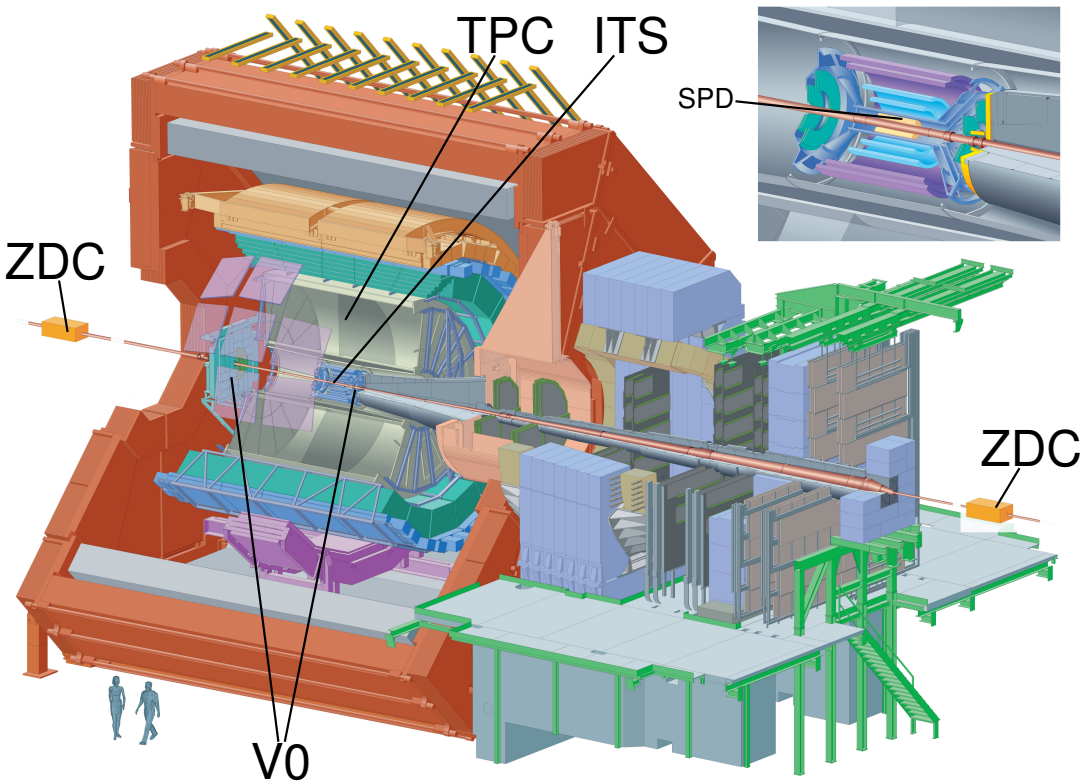
- Detectors used
  - V0: trigger, centrality
  - ZDC: Background rejection

ALICE



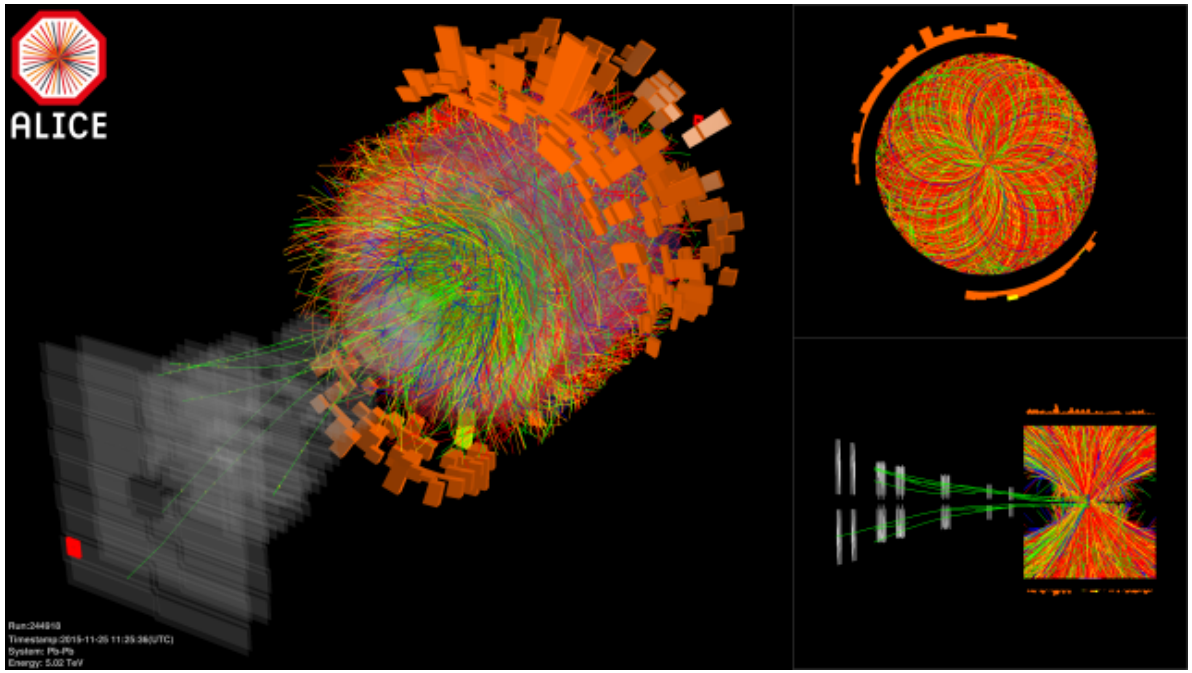
- Detectors used
  - V0: trigger, centrality
  - ZDC: Background rejection
  - TPC & ITS: tracking

ALICE



- Detectors used
  - V0: trigger, centrality
  - ZDC: Background rejection
  - TPC & ITS: tracking
  - SPD: N_{ch}

Lots of data



Pb-Pb at $\sqrt{s_{\mathrm{NN}}} = 5.02\,\mathrm{TeV}$

- 3 weeks of data
- $\approx 150\,\mathrm{M}$ events
- Here, only low-intensity beams
  - Small pile-up background
  - Analysis not statistics limited

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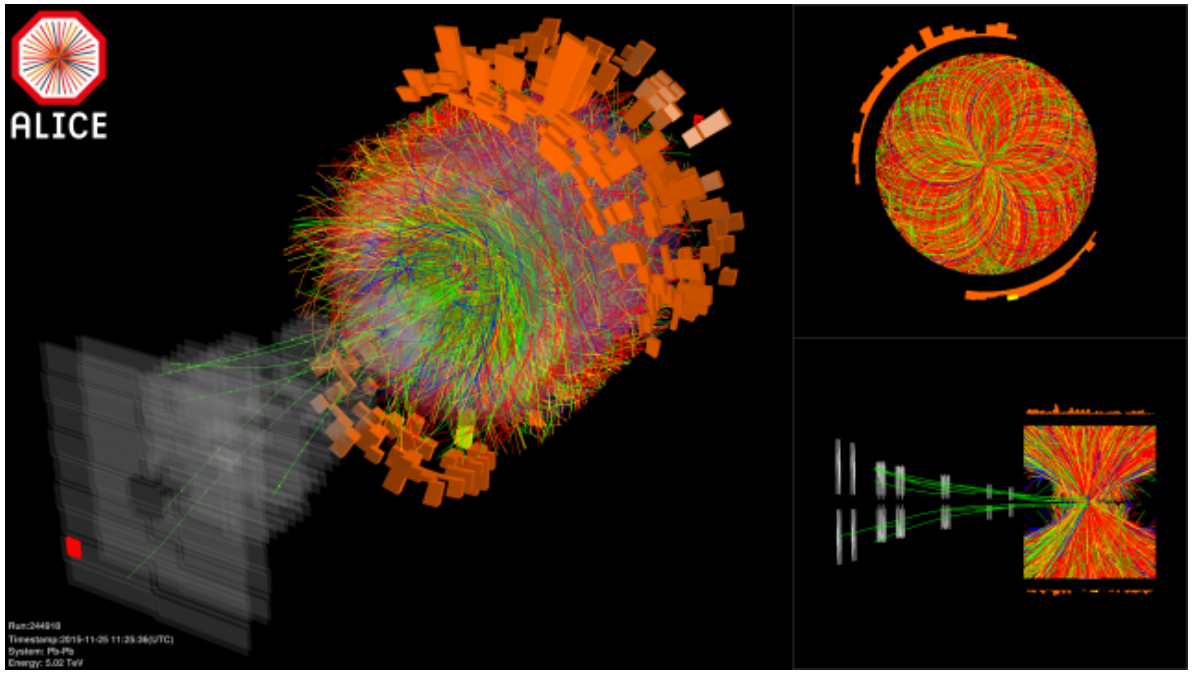

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- $\approx 150\,\mathrm{M}$ events
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  - Small pile-up background
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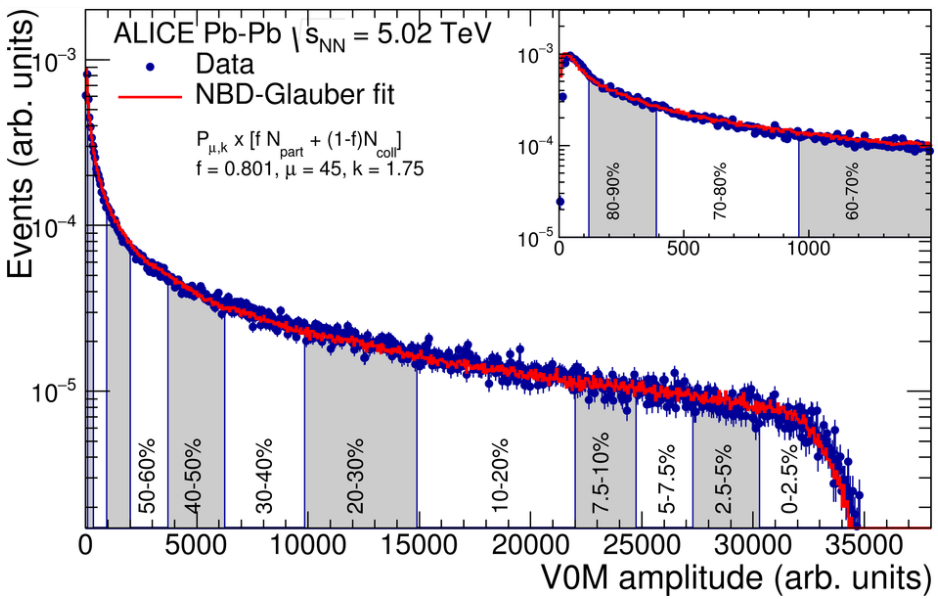
pp at $\sqrt{s} = 5.02\,\mathrm{TeV}$

- 5 days of data
- $\approx 130\,\mathrm{M}$ events
- Important for comparisons

Cross–section at $\sqrt{s_{\mathrm{NN}}} = 5.02\,\mathrm{TeV}$

Centrality proxy for impact parameter

- Small centrality, large nuclear overlap
- Large centrality, small nuclear overlap



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- Slice V0 amplitude distribution
- Fit NBD–Glauber
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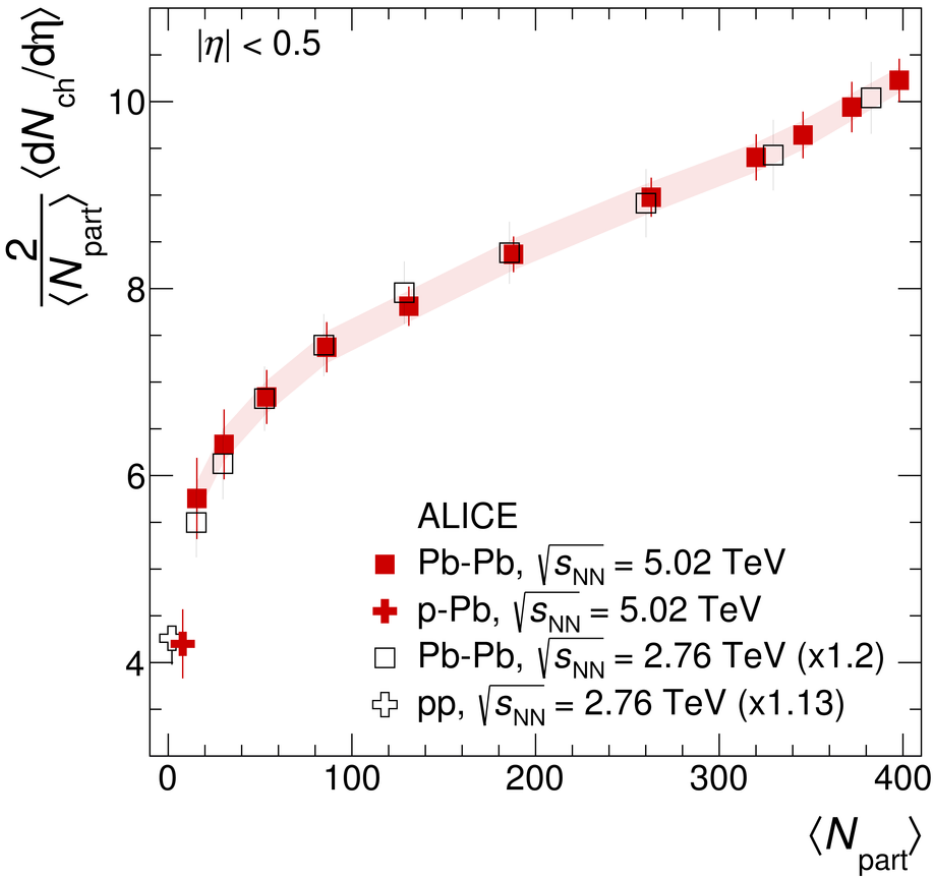
  - Extract $\langle N_{\mathrm{part}} \rangle$
  - Extract $\sigma_{\mathrm{Pb-Pb}} = (7.72 \pm 0.22)\,\mathrm{b}$
- Model 'ancestors' as

$$f N_{\mathrm{part}} + (1-f) N_{\mathrm{coll}}$$

  - Large f: mostly soft
  - $f \approx 0.8$ same as $\sqrt{s_{\mathrm{NN}}} = 2.76\,\mathrm{TeV}$
  - Other models: equally good description

$\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta|_{|\eta|<0.5}$: 20% increase from $\sqrt{s_{\mathrm{NN}}} = 2.76\,\mathrm{TeV}$



Average $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$ in $|\eta| < 0.5$

- $\langle N_{\mathrm{part}} \rangle$ from Glauber
- $\langle N_{\mathrm{part}} \rangle$ dependence similar to $\sqrt{s_{\mathrm{NN}}}$=2.76 TeV
- Increase of $\approx 20\%$ per nucleon pair w.r.t. $\sqrt{s_{\mathrm{NN}}} = 2.76\,\mathrm{TeV}$

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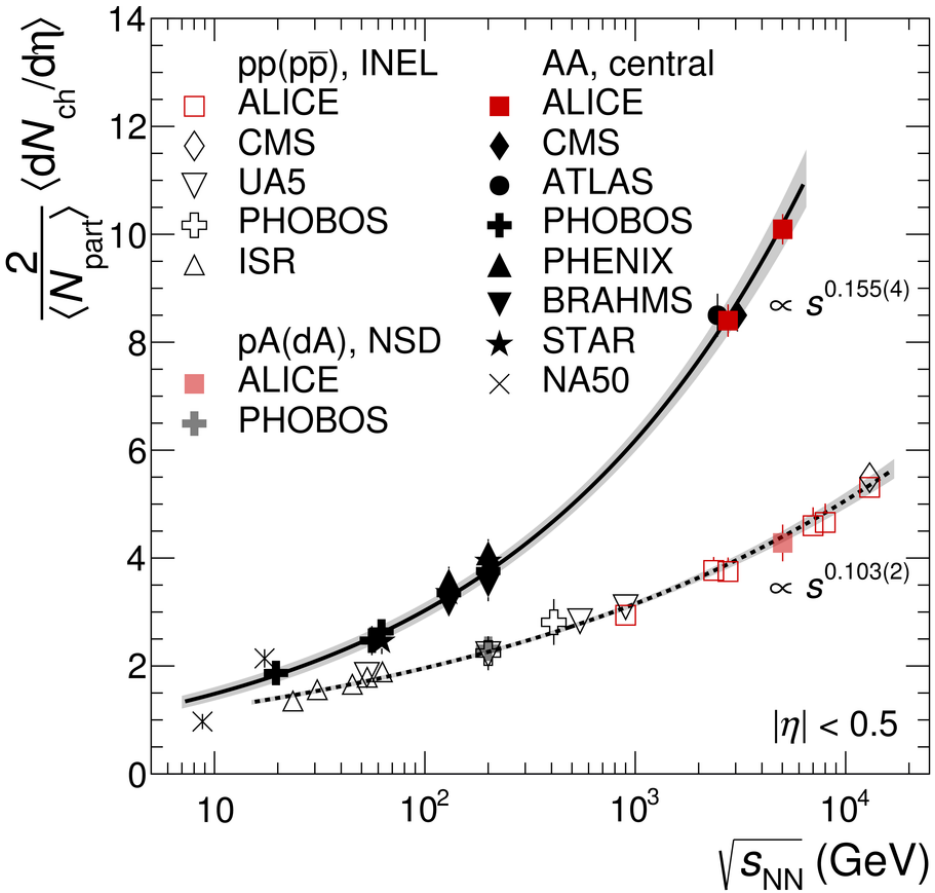
Excitation function of N_{ch}: Power–law scaling



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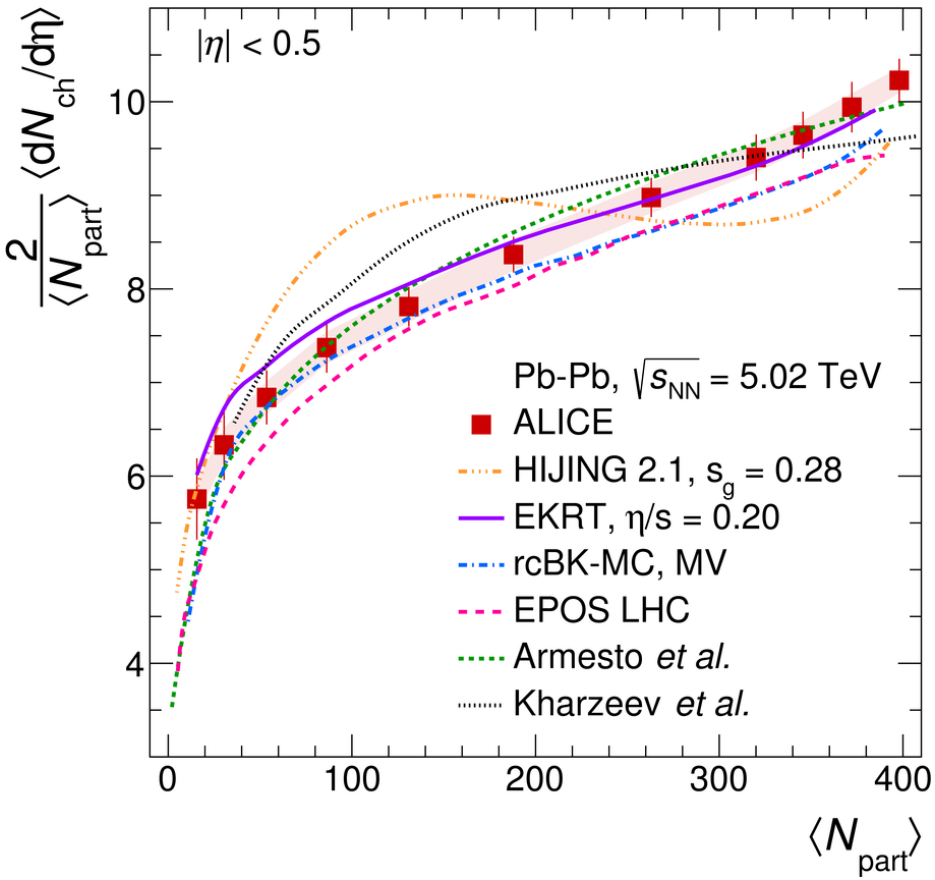
$\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta|_{|\eta|<0.5}$ vs. $\sqrt{s_{\mathrm{NN}}}$

- $0-5\%$ most central
  (PHOBOS, ATLAS: $0-6\%$)
- Fit power–law: $a \cdot s^b$
  - NN: $b = 0.155 \pm 0.004$
  - pp: $b = 0.103 \pm 0.002$
- Change w.r.t. $\sqrt{s_{\mathrm{NN}}}$, $\sqrt{s} = 2.76\,\mathrm{TeV}$ at $|\eta| < 0.5$ for

Pb-Pb: 20%
pp: 13%

- Confirms trend from lower energies

Saturation of particle production at $|\eta| < 0.5$?



Predictions from various models

- HIJING: More gluon shadowing
- CGC-like models (rcBK-MC, Armesto, Kharzeev) give envelope around data
- EKRT: pQCD mini-jets+saturation+viscous hydro reasonable.
- EPOS-LHC: parton ladders — qualitatively close, but low

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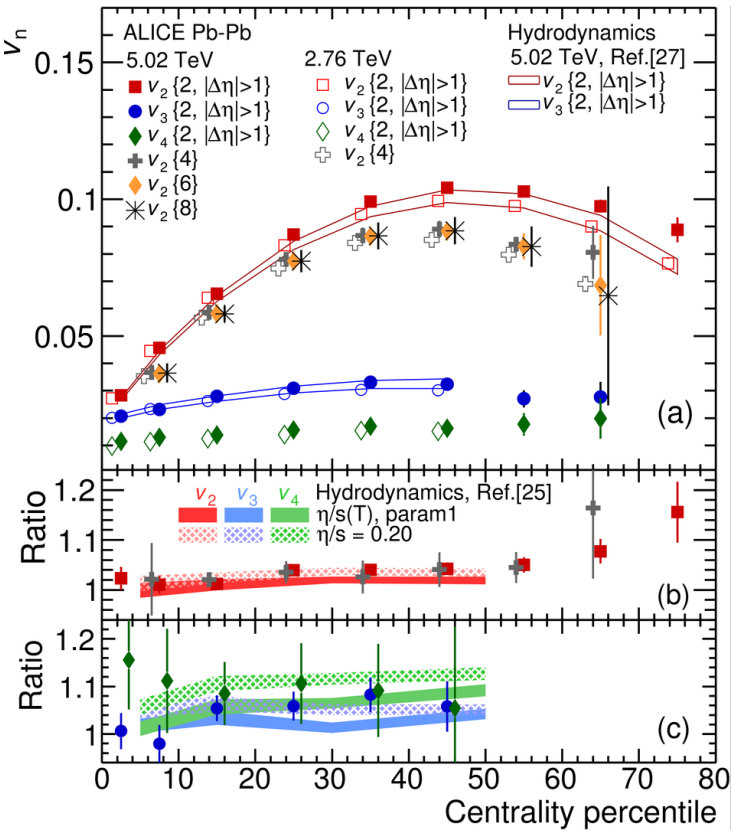
Models: PRC83(2011)014915, arXiv:1106.0978, arXiv:1011.5161, PRL94(2005)022002, NPA747(2005)609, PRC92(2015)034906

Little change in flow



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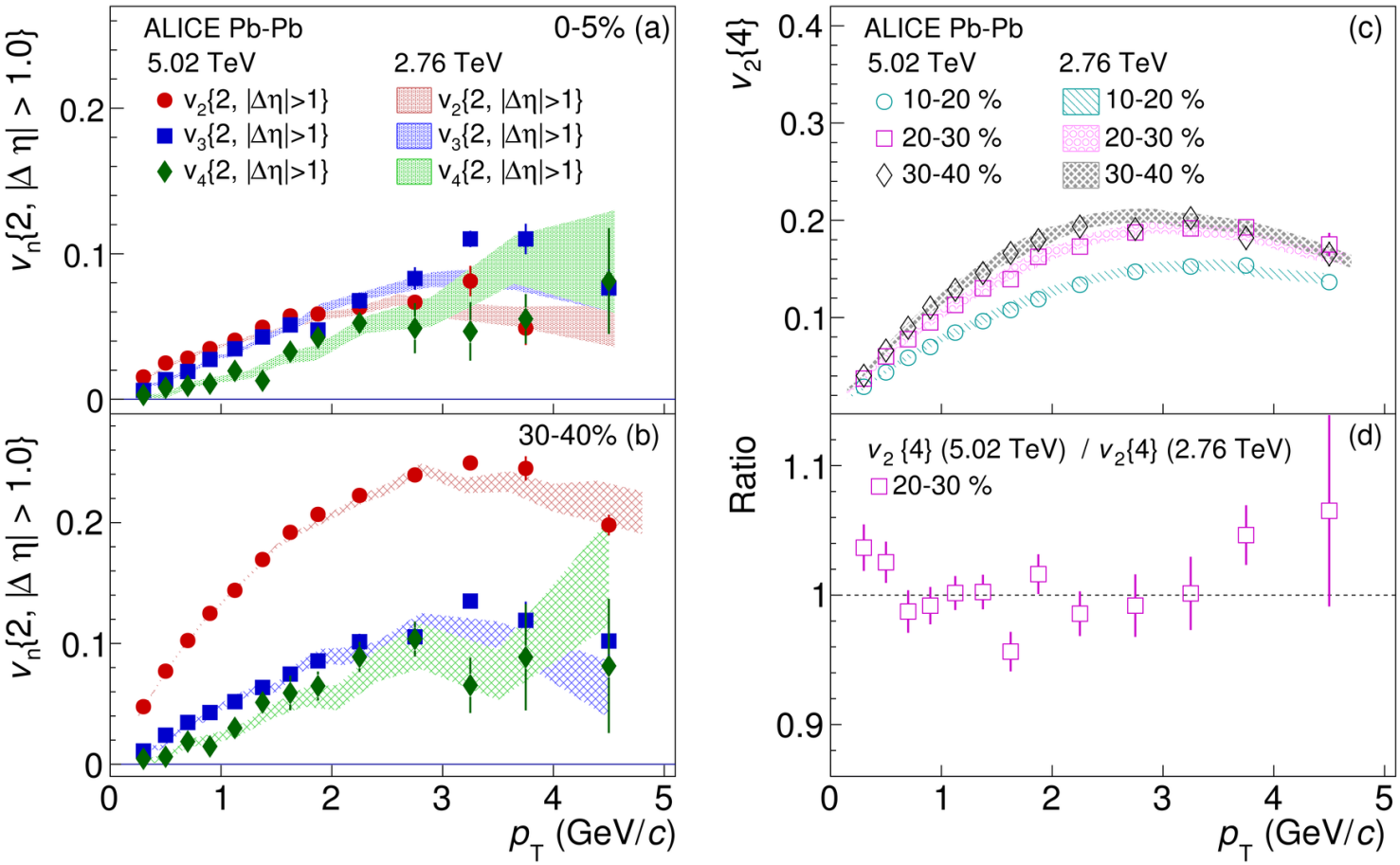
Models: [25] arXiv:1511.04296, [27] arXiv:1511.06289

Flow parameters vs. centrality

- 2-particle v_2, v_3, and v_4 w/η-gap
- 4, 6, 8-particle v_2
- Same dependence on centrality as in $\sqrt{s_{\rm NN}} = 2.76\,\text{TeV}$
- v_2 and v_3 moderate ($\approx 3-4.3\%$) change w.r.t. $\sqrt{s_{\rm NN}} = 2.76\,\text{TeV}$
- v_4 increased by $\approx 10\%$ w.r.t. $\sqrt{s_{\rm NN}} = 2.76\,\text{TeV}$
- Hydro (EKRT [27], Noronha-Hostler *et al* [25]) consistent over $0-50\%$

$\sqrt{s_{\mathrm{NN}}} = 2.76\,\mathrm{TeV} \rightarrow 5.02\,\mathrm{TeV}$: Larger v_4, larger $\langle p_{\mathrm{T}} \rangle$



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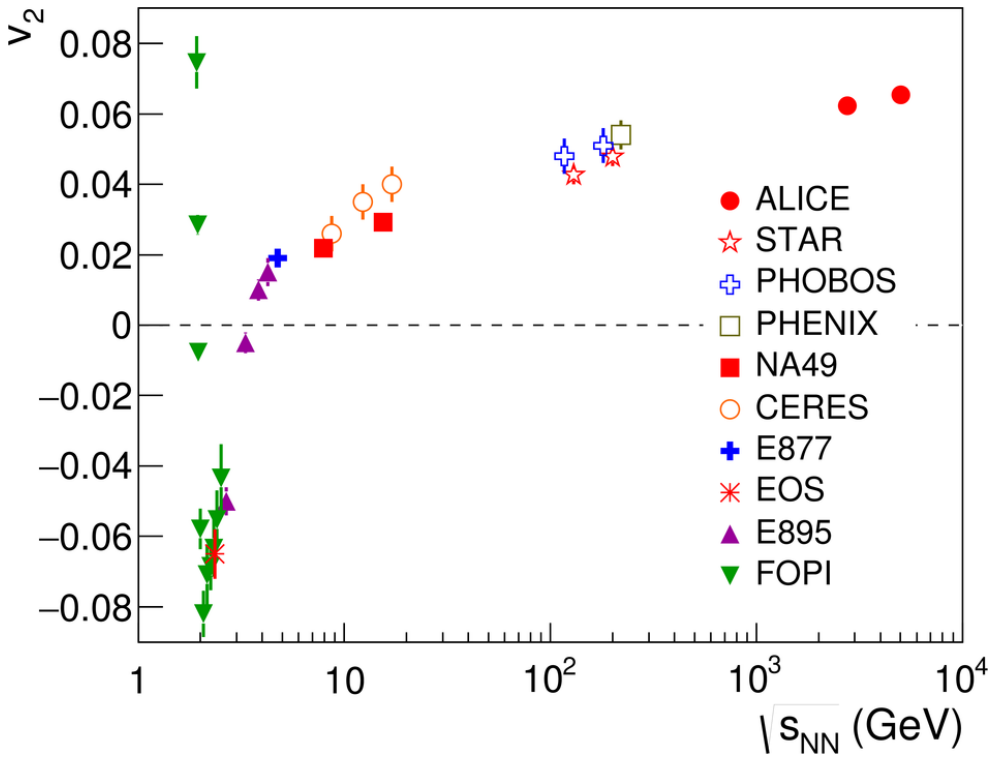
- p_{T} dependent v_2, v_3, and v_4 — No significant change w.r.t. $\sqrt{s_{\mathrm{NN}}} = 2.76\,\mathrm{TeV}$
- Change in centrality dependent v_4 from larger $\langle p_{\mathrm{T}} \rangle$ than $\sqrt{s_{\mathrm{NN}}} = 2.76\,\mathrm{TeV}$
  See talk by J.M.Gronefeld tomorrow

Smooth evolution of v_2 from $\sqrt{s_{\mathrm{NN}}} \approx 10\,\mathrm{GeV}$ to $5.02\,\mathrm{TeV}$



- v_2 for $20-30\%$ central
- $\sqrt{s_{\mathrm{NN}}}$ dependence

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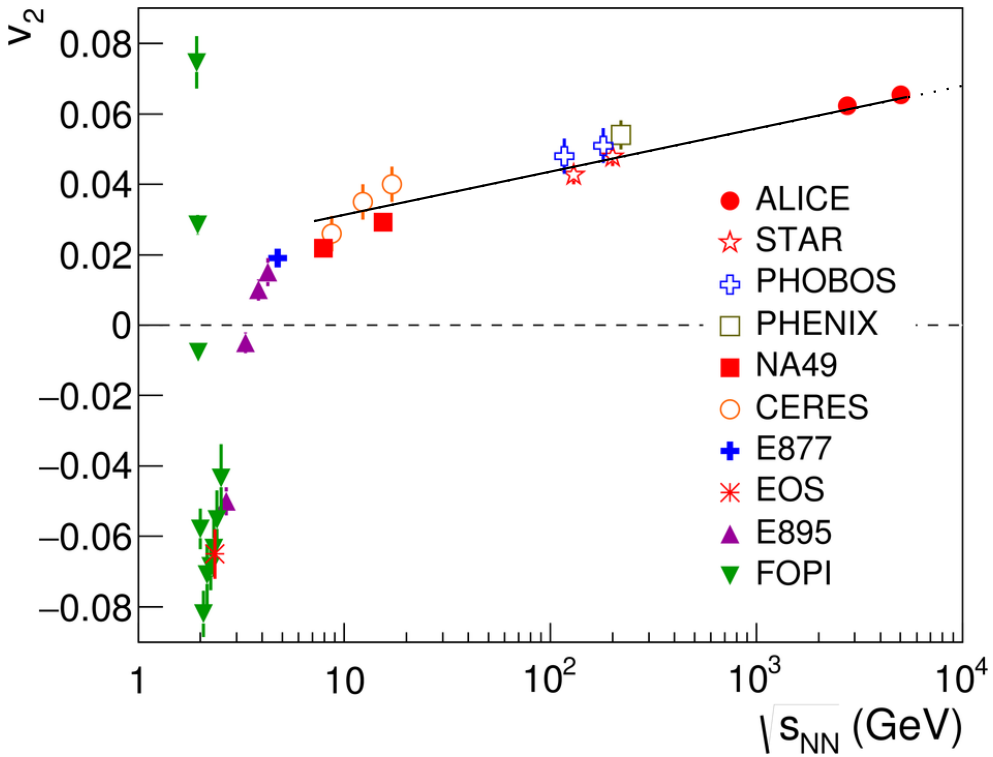

- v_2 for $20-30\%$ central
- $\sqrt{s_{\mathrm{NN}}}$ dependence

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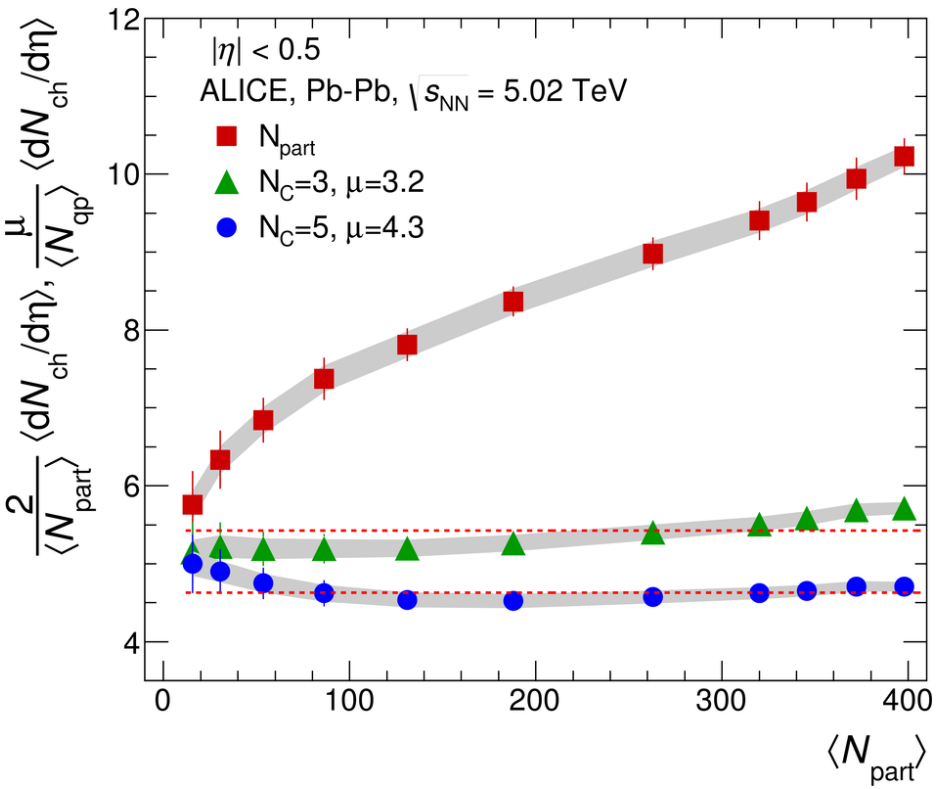
Summary

- Hydrodynamic expansion of hot and dense phase models data well at midrapidity
  - Fixed $\eta/s = 0.20$ perhaps slightly preferred
  - Dynamic η/s with minimum of 0.12 also feasible
- Smooth evolution from $\sqrt{s_{\mathrm{NN}}} = 2.76\,\mathrm{TeV}$
  - Power-law scaling of most central $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta|_{|\eta|<0.5}$ versus $\sqrt{s_{\mathrm{NN}}}$
  - Linear rise of v_2 with $\sqrt{s_{\mathrm{NN}}}$
- No clear indication of N_{coll} scaling — N_{ch} production near $\eta = 0$ dominated by soft sector

Back-ups

Quark scaling?



Average $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$ in $|\eta| < 0.5$

- Scaled by $\langle N_{\mathrm{part}} \rangle / 2$
- Scaled by $\langle N_{\mathrm{qp}} \rangle / \mu$
  - N_c: # const. quarks
  - μ: $\langle N_{qp} \rangle$ in pp
- $N_c = 5$ slightly preferred.

ALICE-PUBLIC-2015-008, arXiv:1603.07375