



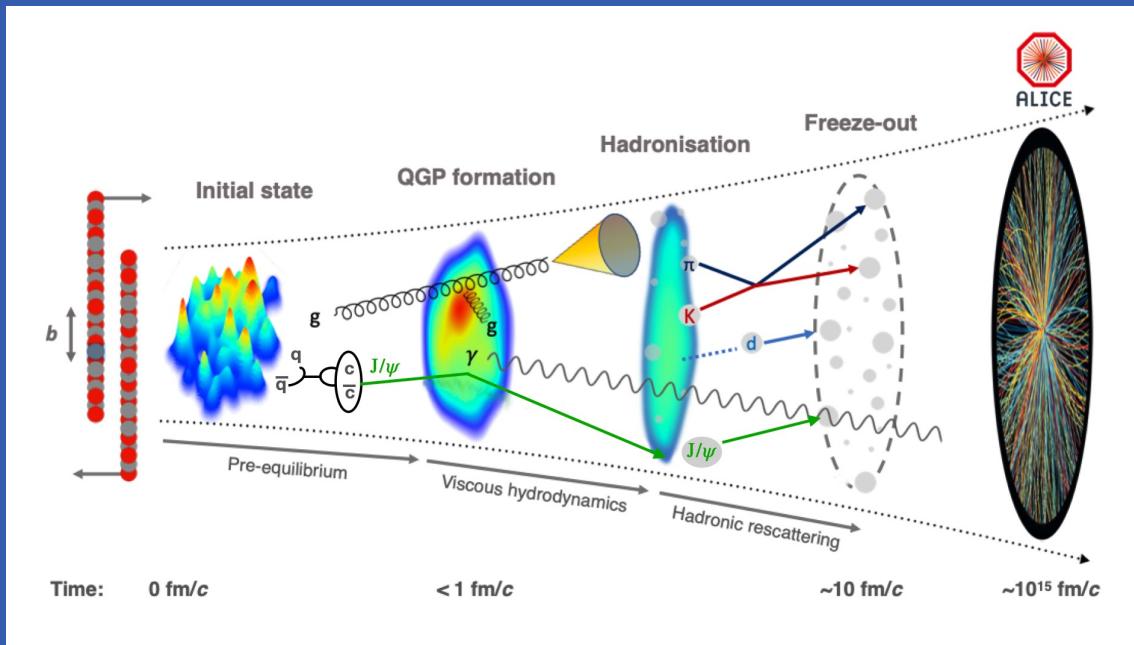
ALICE Highlights

Focus on Hard Probes

Roman Lavička† on behalf of the ALICE Collaboration



Hard probes to explore the evolution of collisions



Hard probes:

Nuclear PDFs:

- What is the gluon distribution in nucleus?

Initial state dynamics:

- How do Multi-Parton Interactions affects hadron production?
- What is the spatial distribution of partons in p and Pb?

Thermalisation:

- What are the origins of flow and energy loss in small systems?

Perturbative QCD:

- How well we understand the fragmentation?

Hadronisation:

- How is the final state connected to initial state?

Initial Stages

Thermalisation

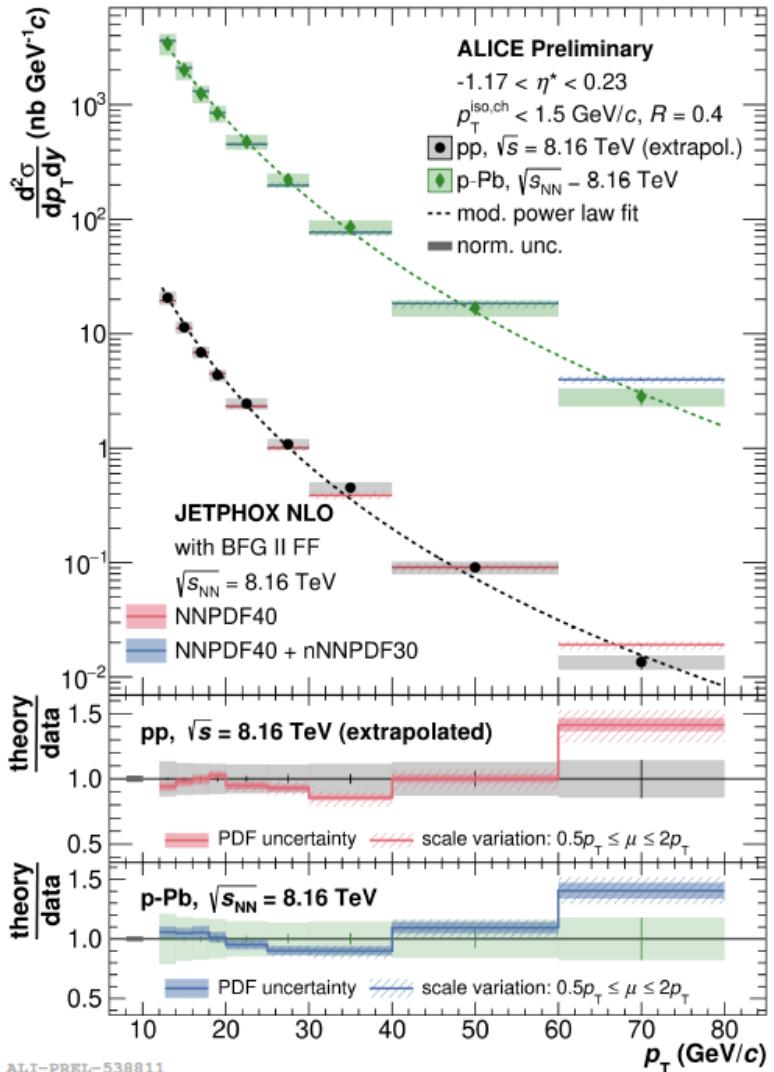
Hadronisation

Initial Stages

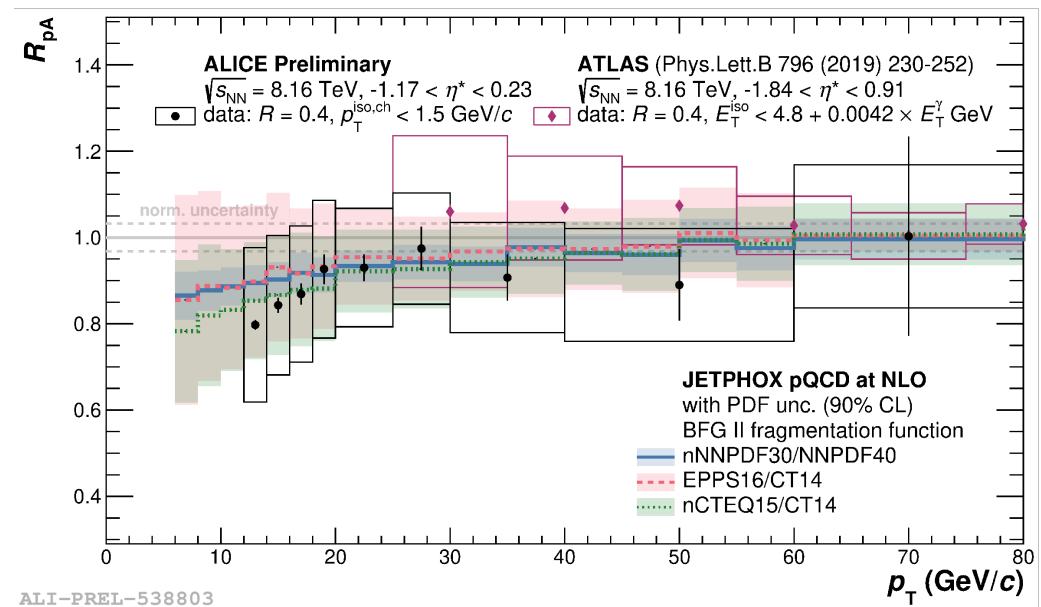
Thermalisation

Hadronisation

Isolated prompt photons



See talk by Barbara Jacak on Wed, 16:10

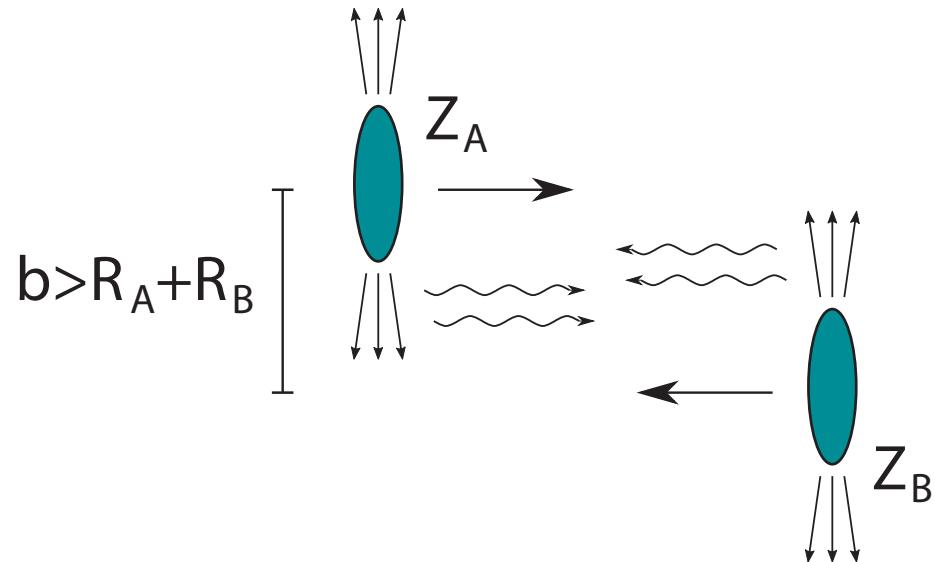


Constrain low-x gluon nPDF

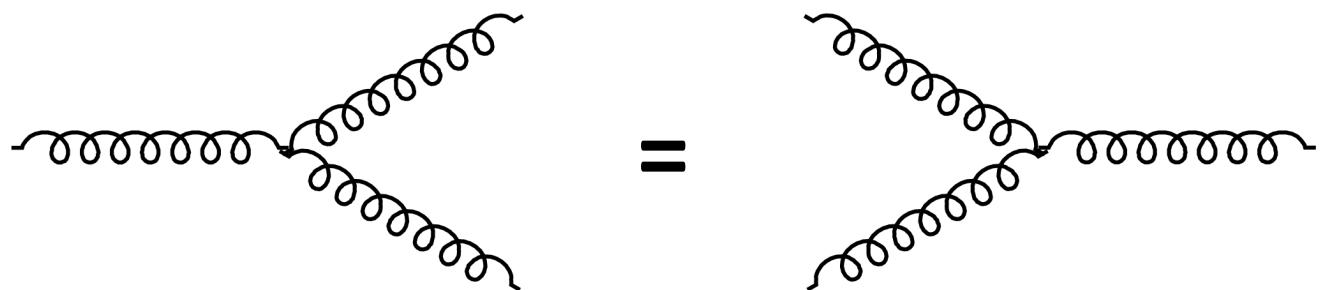
Probing $x \sim 10^{-3}$ gluon shadowing region

Ultra-peripheral collisions

Nuclear shadowing

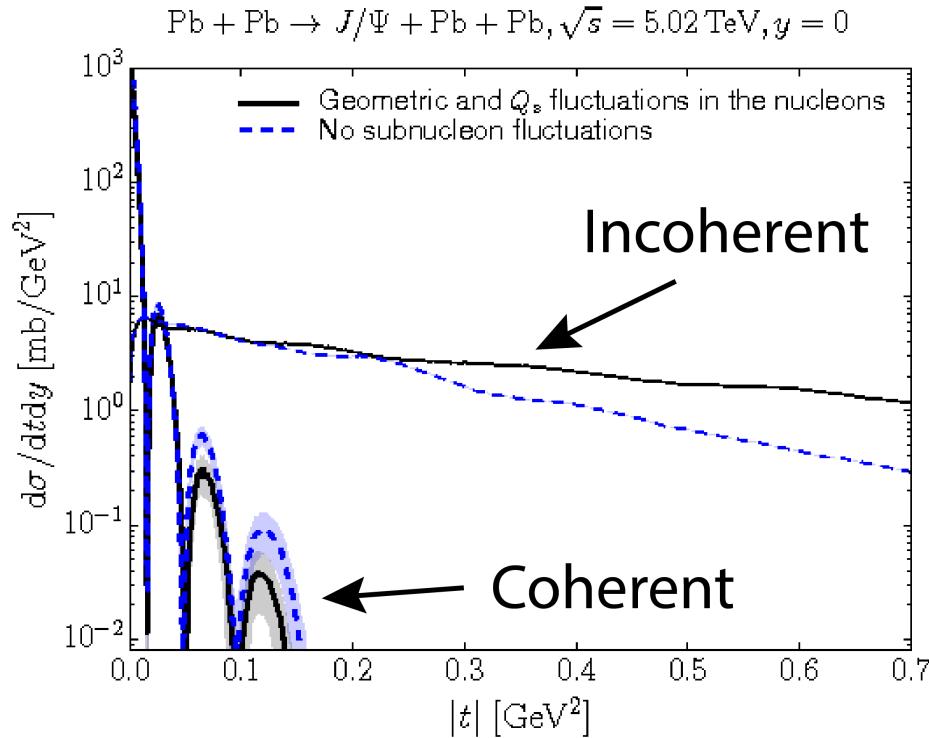


Gluon saturation

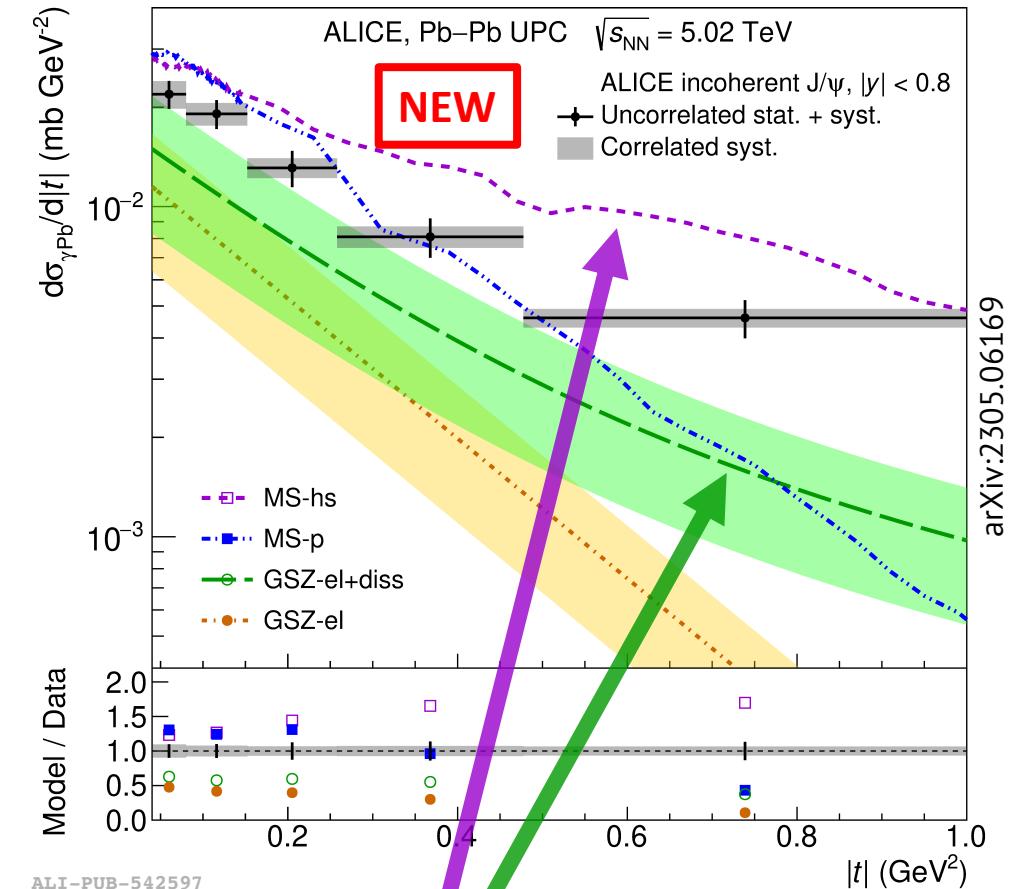


$|t|$ -dependence of incoherent J/ψ in γPb

See poster by David Grund



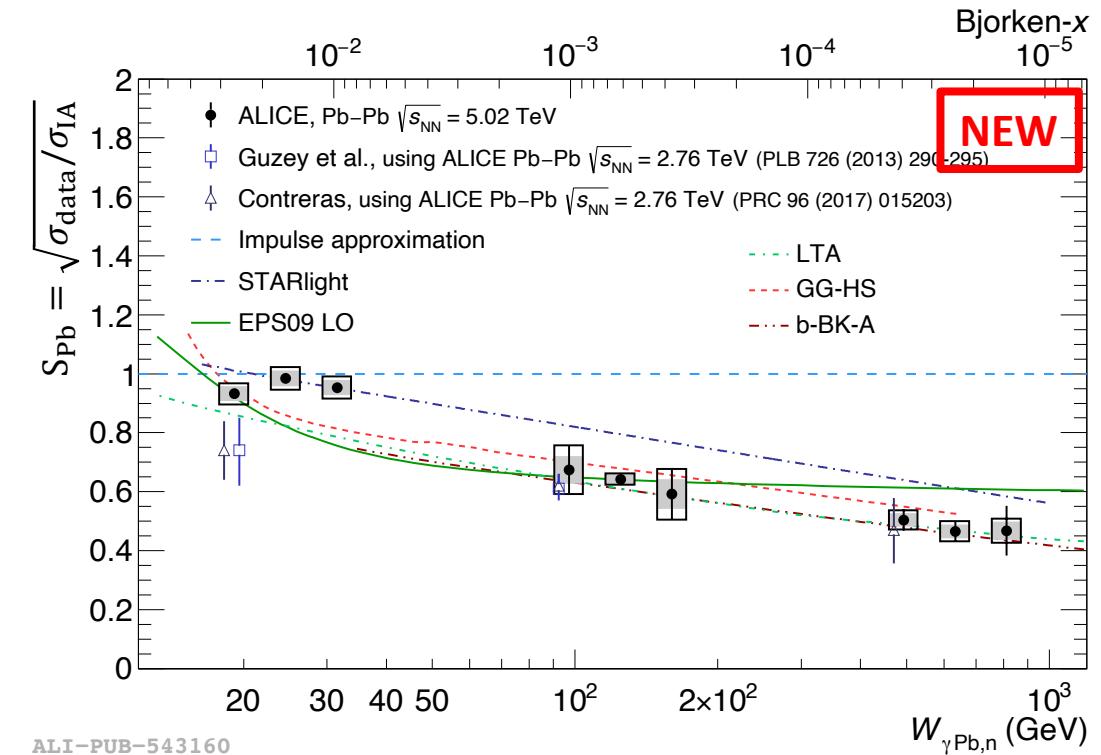
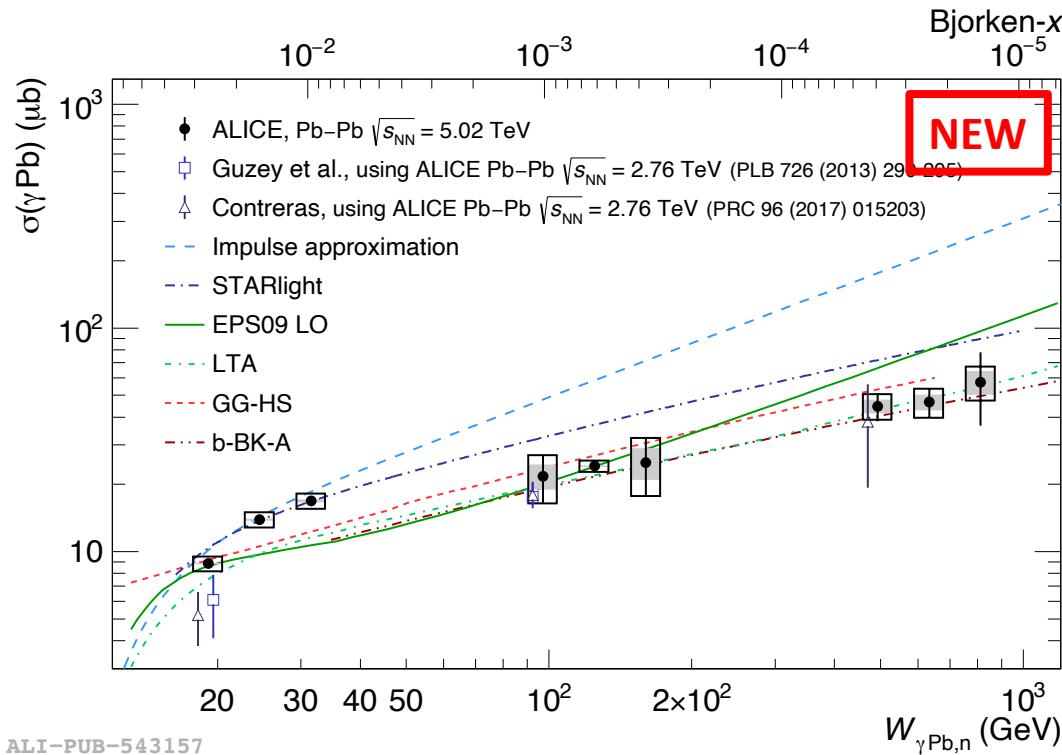
t sensitivity to transverse profile of the target



Consistent with gluonic hotspots fluctuation

W-dependence of coherent J/ ψ in γ Pb

See talk by Joakim Nystrand on Tue, 16:50



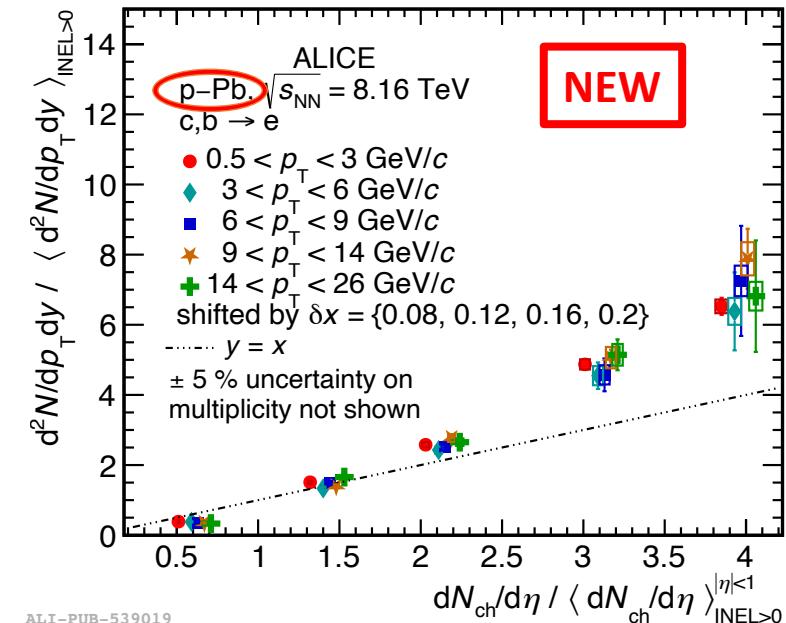
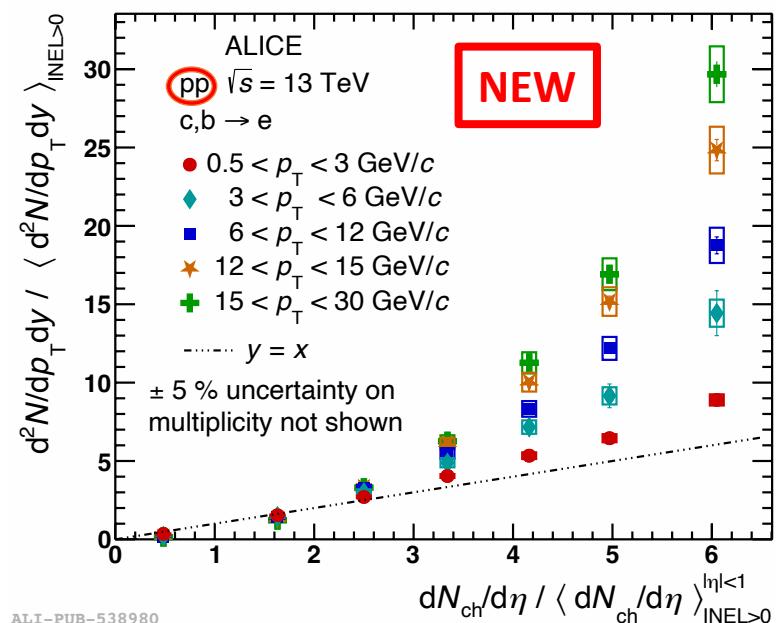
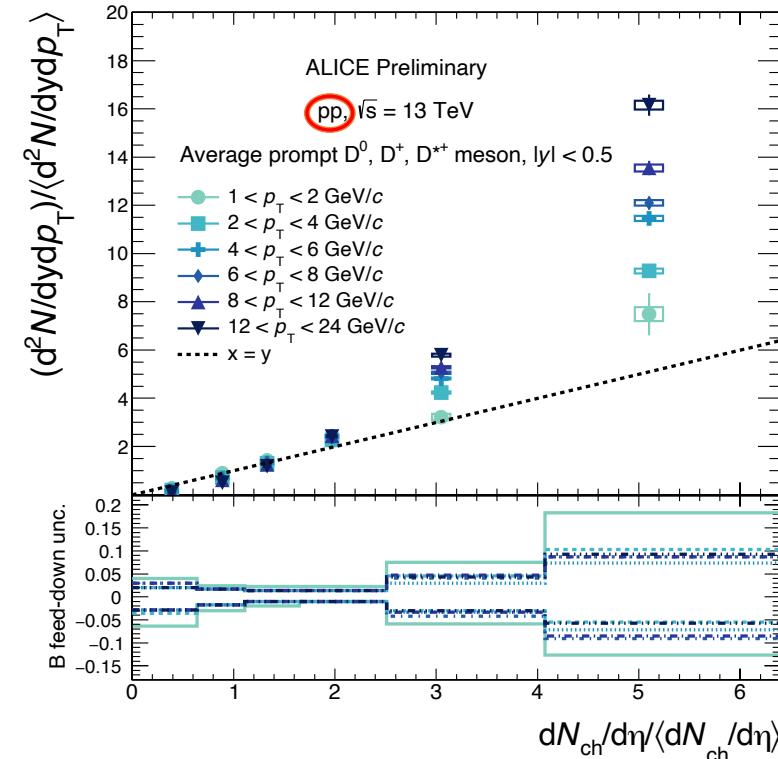
arXiv:2305.19060

Nuclear shadowing/gluon saturation in Pb-Pb

Estimate of strength of nuclear effects
No model can describe the energy dependence

Probe of multi parton interaction in HF

See talk by Shreyasi Acharya on Wed, 17:30



arXiv:2303.13349

Faster than linear trend suggest "harder" MPI
Need to understand auto-correlation effects

Observed p_T dependence in pp but not p-Pb
Different production mechanisms of the electrons?

Initial Stages

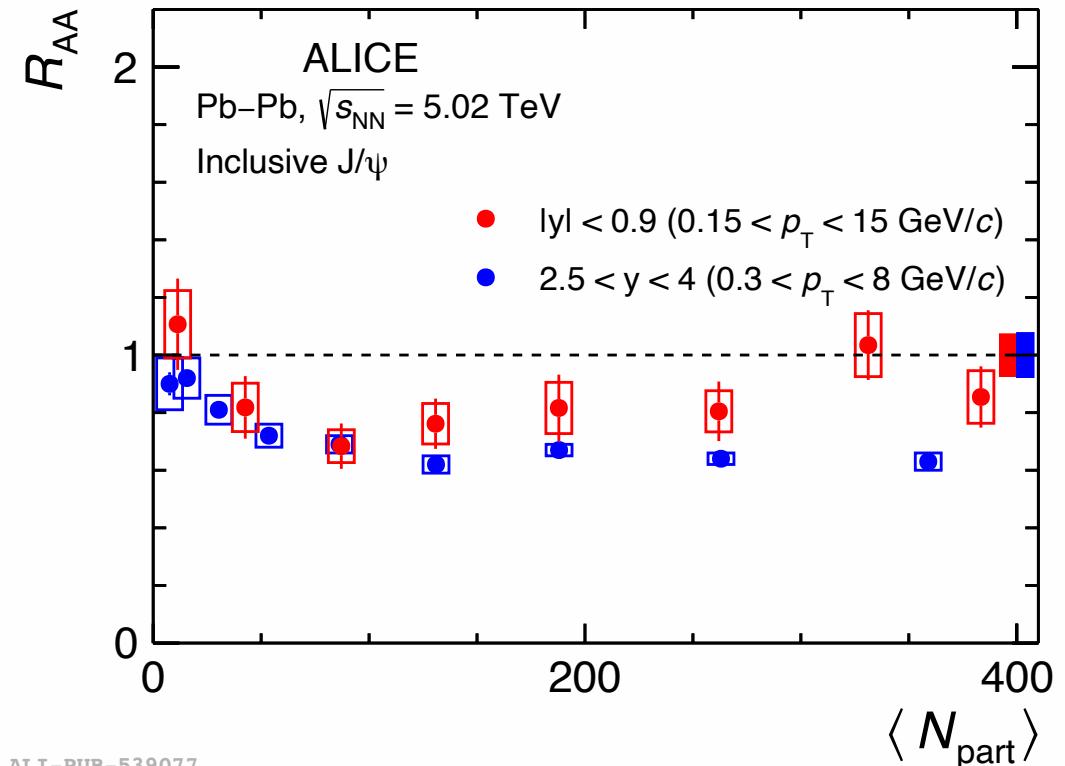
Thermalisation

Hadronisation

Nuclear modification factor

$$R_{AA} \frac{d^2N_{AA}/dn dp_T}{\langle N_{coll} \rangle d^2N_{pp}/dn dp_T}$$

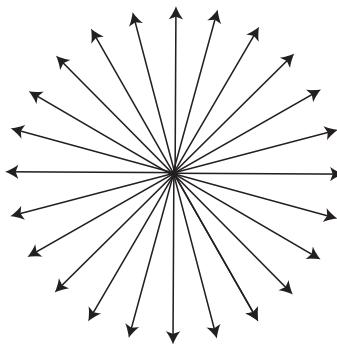
$$R_{pPb} \frac{d^2N_{pPb}/dn dp_T}{\langle N_{coll} \rangle d^2N_{pp}/dn dp_T}$$



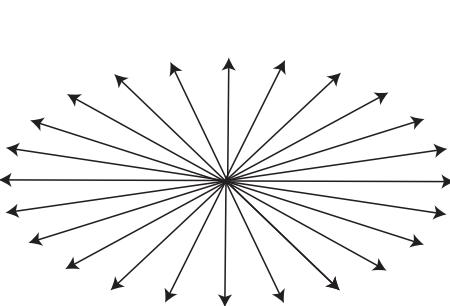
Test the transparency of the medium for different probes and/or their dissociation in the medium

Elliptic flow v_2

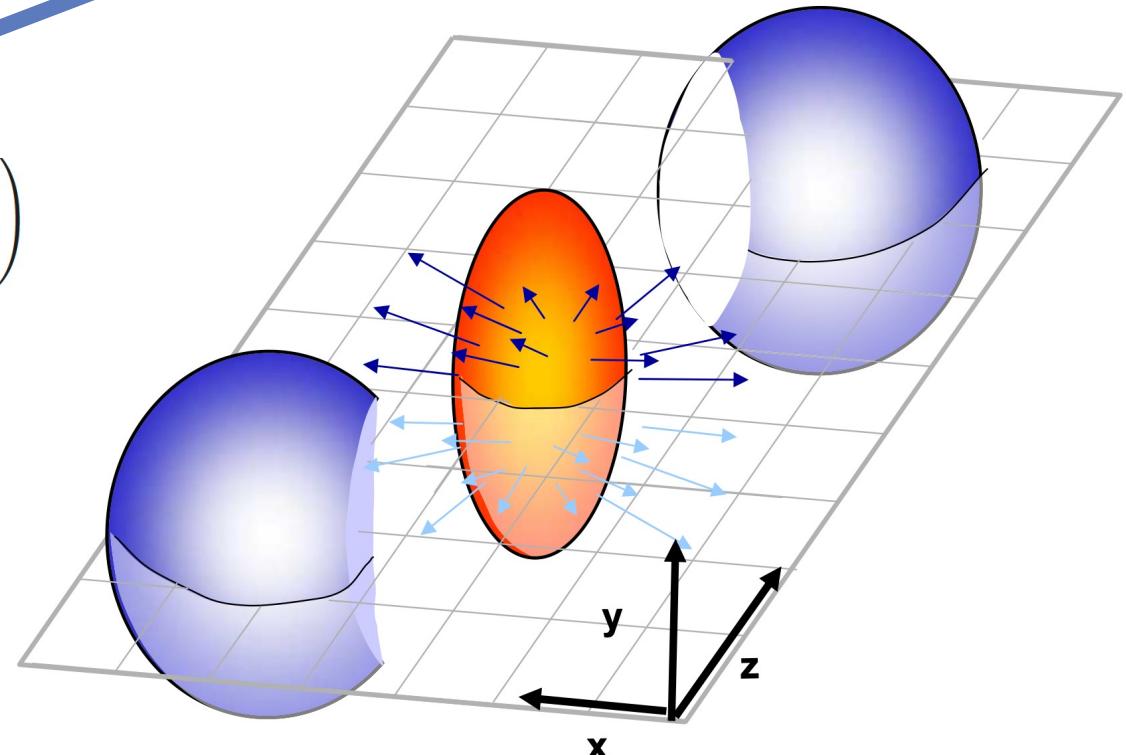
$$E \frac{d^3 N}{dp^3} = \frac{1}{2\pi} \frac{d^2 N}{p_T dp_T dy} \left(1 + \sum_{n=1}^{+\infty} v_n(p_T, y) \cos [n(\phi - \Psi_R)] \right)$$



$$v_2 = 0$$



$$v_2 > 0$$

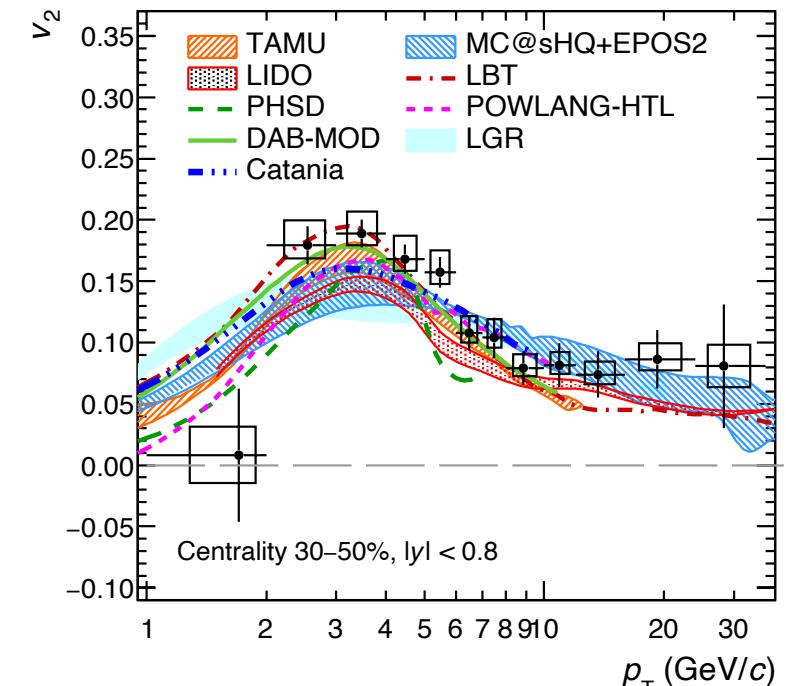
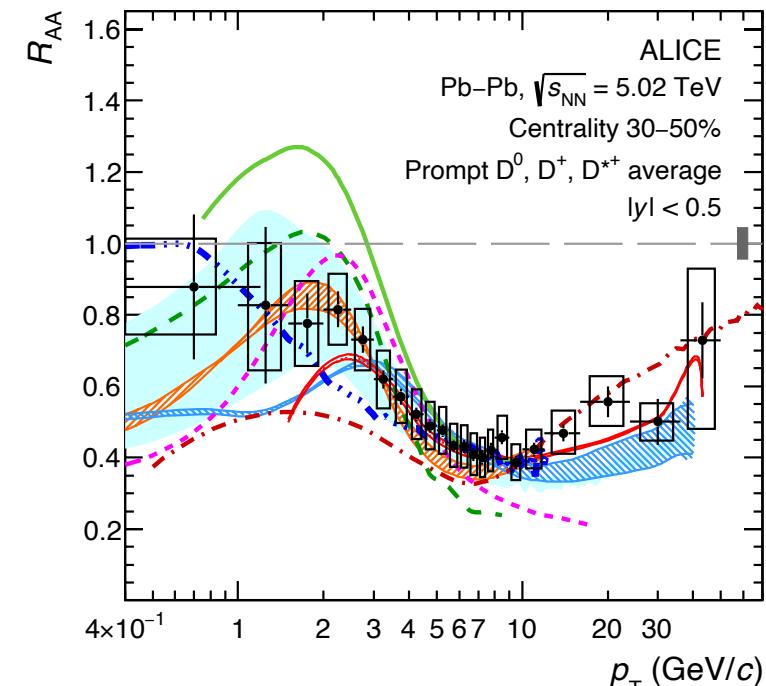


Test the uniformity of the evolution of different probes

Prompt D^0 , D^+ and D^{*+} in Pb-Pb

p_T -differential measurement at different centrality classes of:

- Nuclear modification factor R_{AA}
- +
• Elliptic flow v_2



Prompt D^0 , D^+ and D^{*+} in Pb-Pb

p_T -differential measurement at different centrality classes of:

- Nuclear modification factor R_{AA}

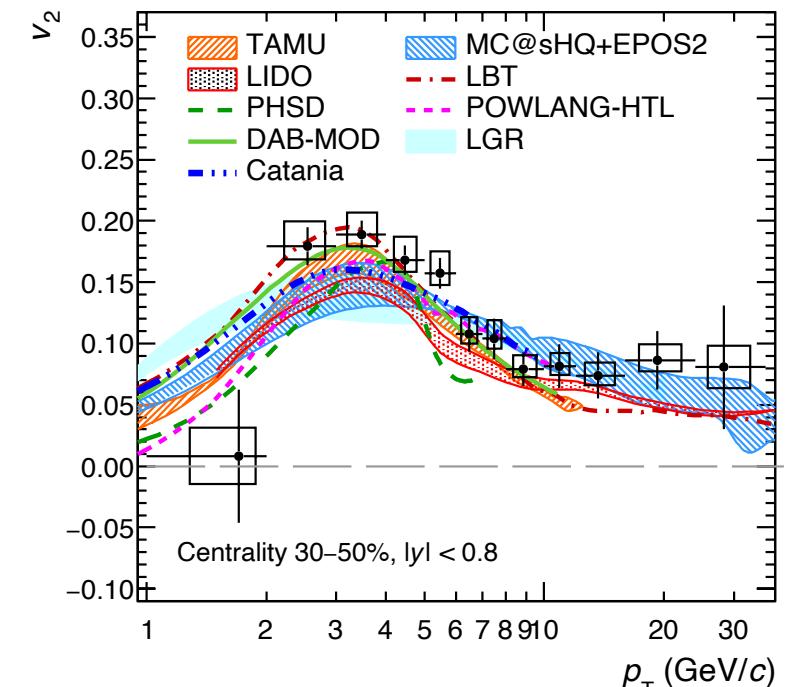
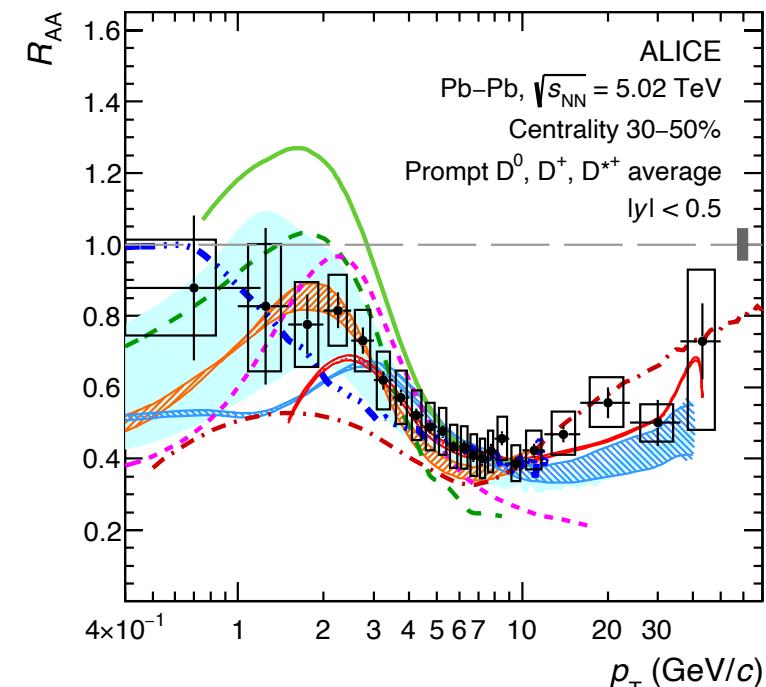


- Elliptic flow v_2



Comparison to models:

- Collisional energy loss
- Radiative loss
- Hadronisation



Prompt D^0 , D^+ and D^{*+} in Pb-Pb

p_T -differential measurement at different centrality classes of:

- Nuclear modification factor R_{AA}
- + • Elliptic flow v_2
- + •

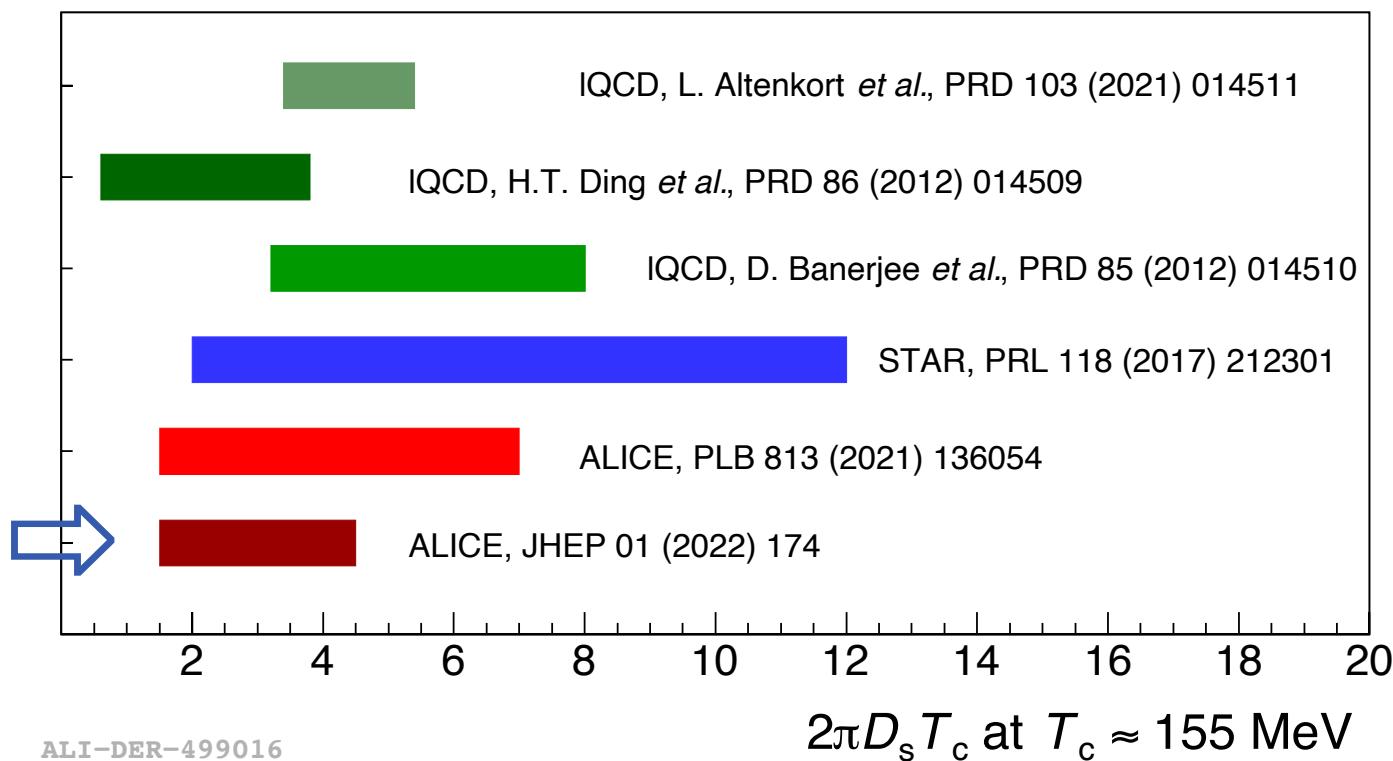
Comparison to models:

- Collisional energy loss
- Radiative loss
- Hadronisation

=

New constrain on spatial diffusion coefficient

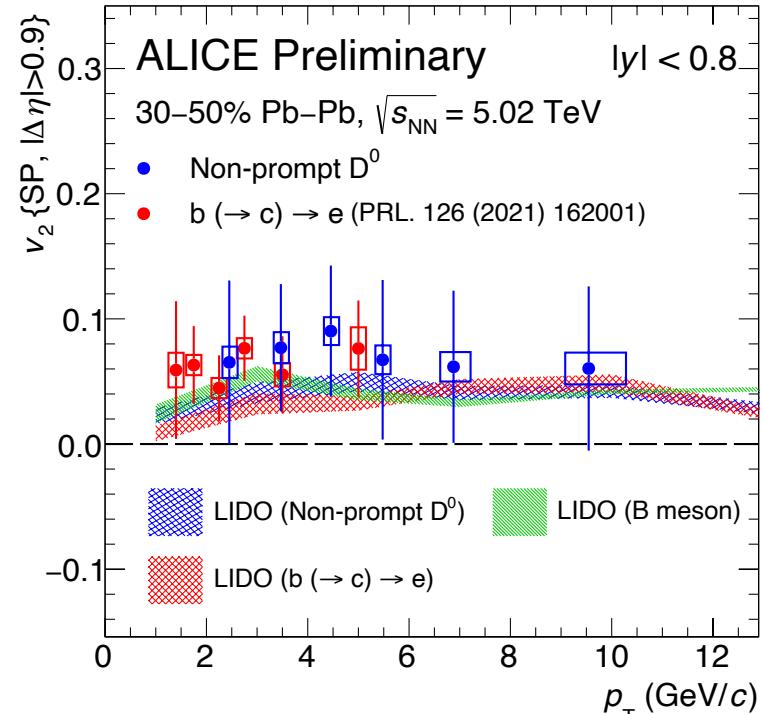
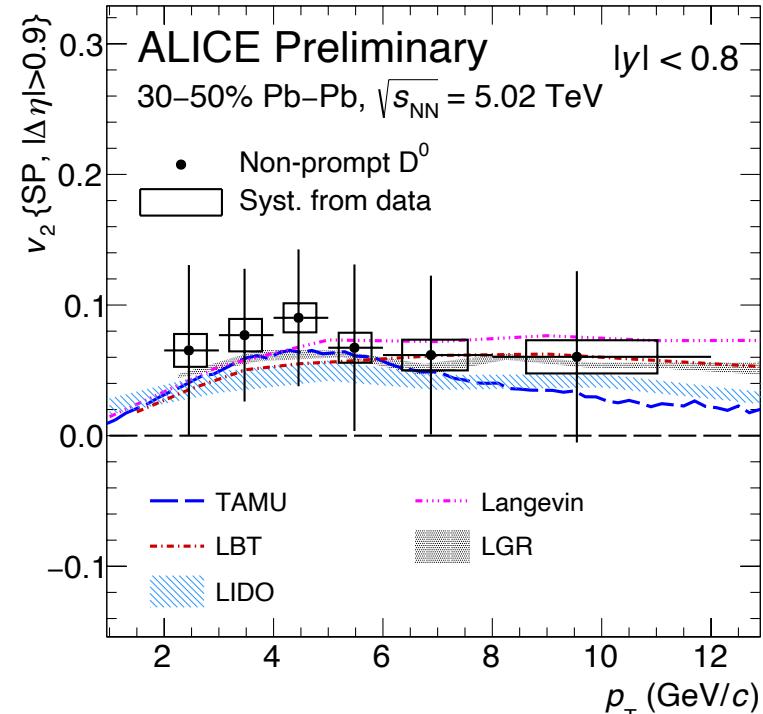
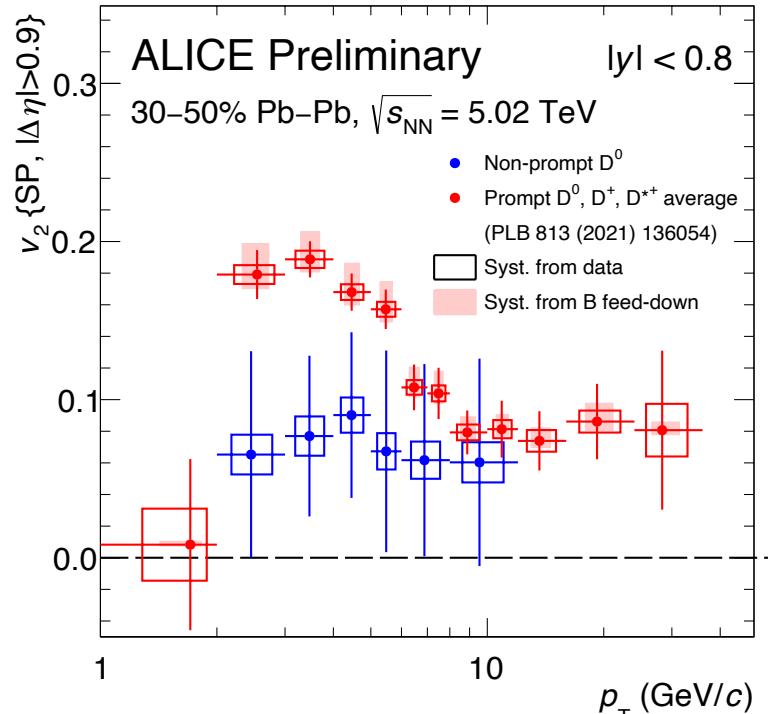
$$1.5 < 2\pi D_s T_c < 4.5$$



See talk by Stefano Trogolo on Wed, 16:30

Probing b quark thermalisation with D^0

See talk by Stefano Trogolo on Wed, 16:30



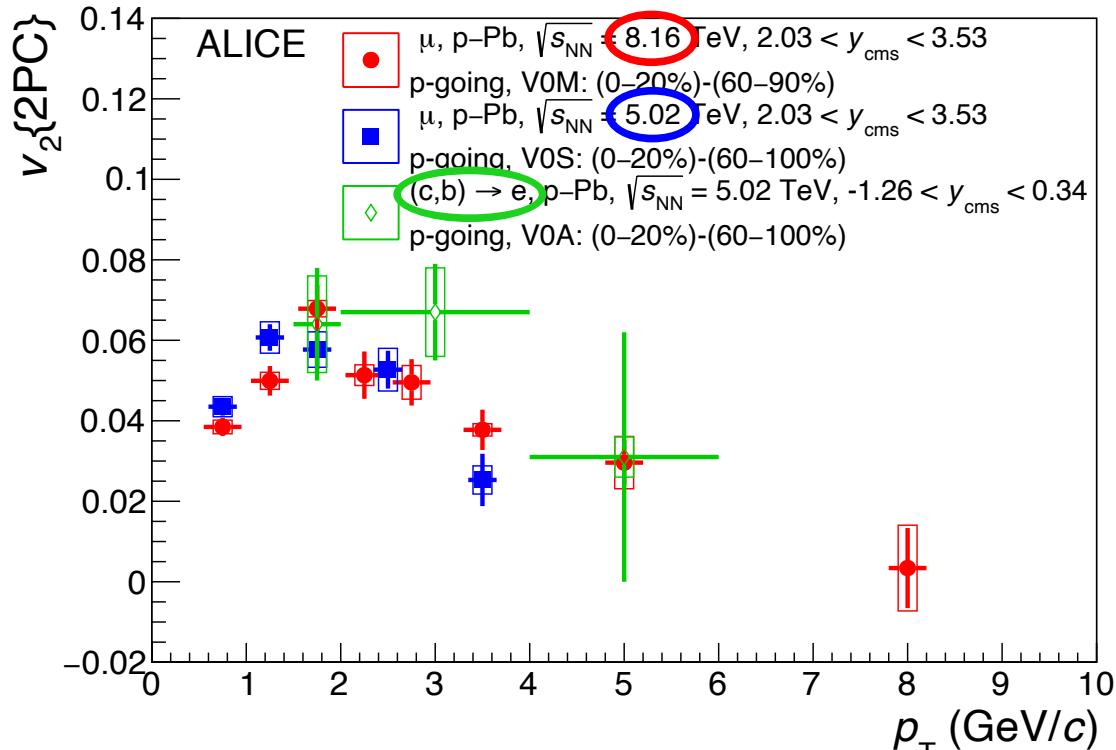
Weaker thermalization of b quark wrt. c quark in QGP

LIDO (diffusion and energy loss) performs well

Heavy flavour v_2 in small systems

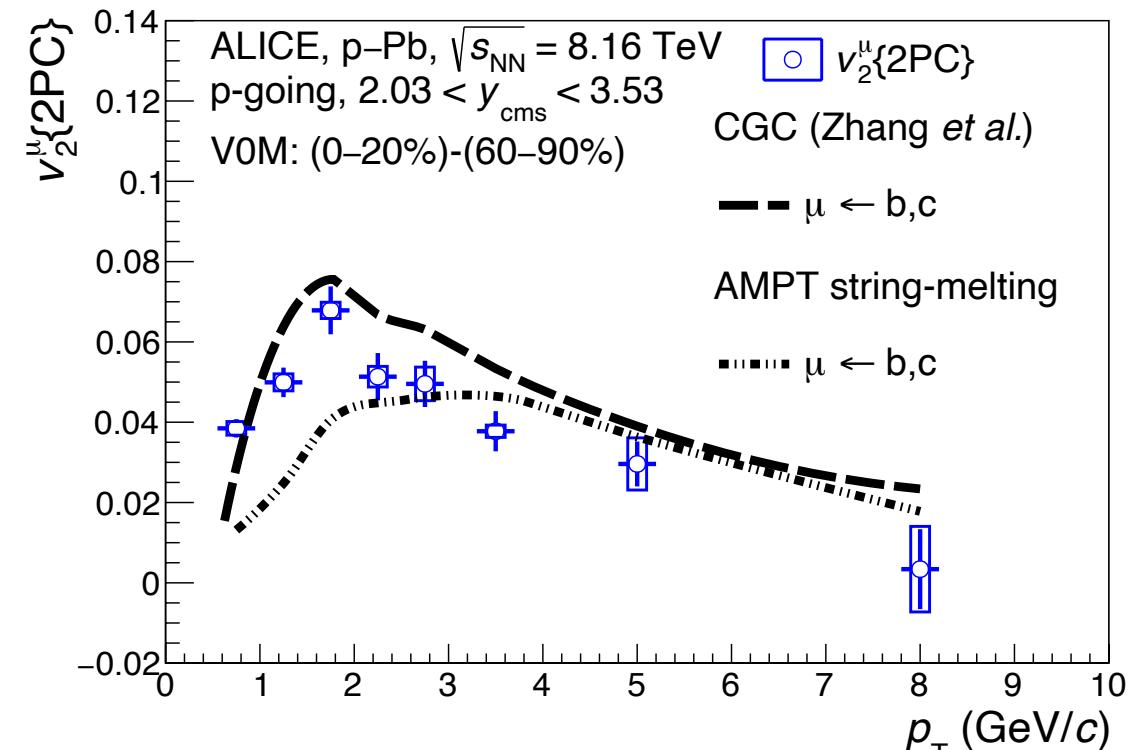
Origin of collective behaviour in small systems

See talk by Stefano Trogolo on Wed, 16:30



ALI-PUB-528376

Positive v_2 observed, origin still debated



ALI-PUB-528396

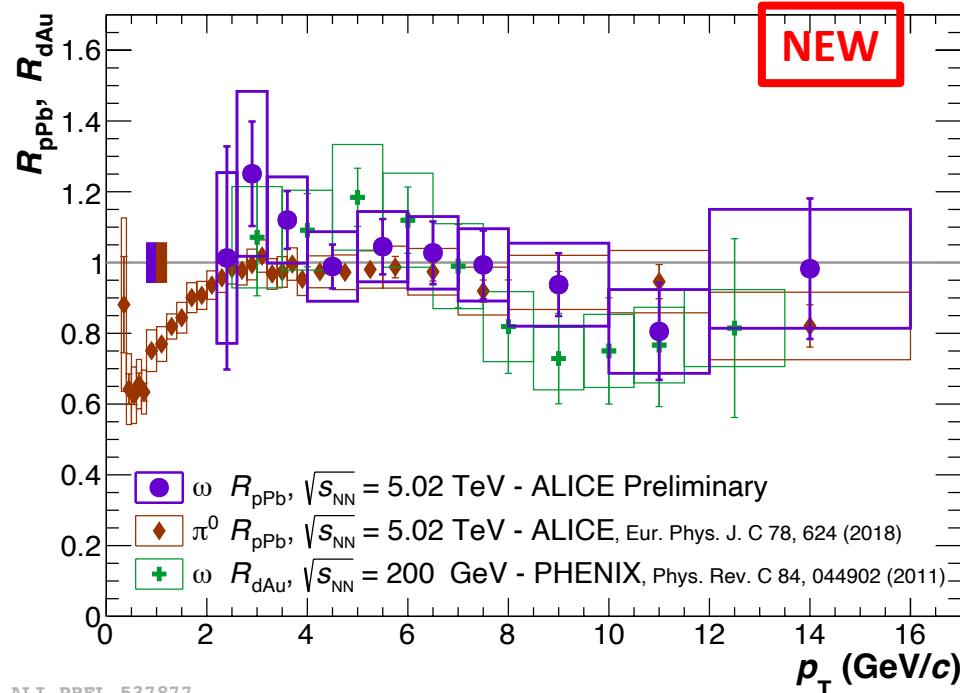
arXiv:2210.08980

Significant contribution to muons at low- p_T from light flavour decays

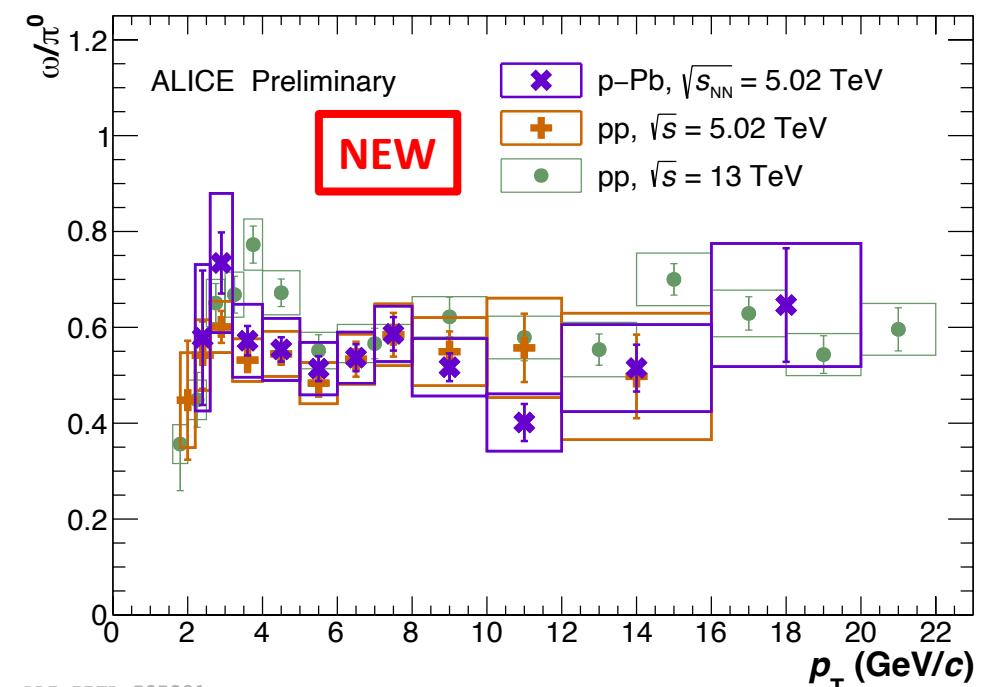
Probing cold nuclear matter with ω

See poster by Marvin Hemmer

Nuclear modification factor in p-Pb



ω/π^0 ratio in pp and p-Pb



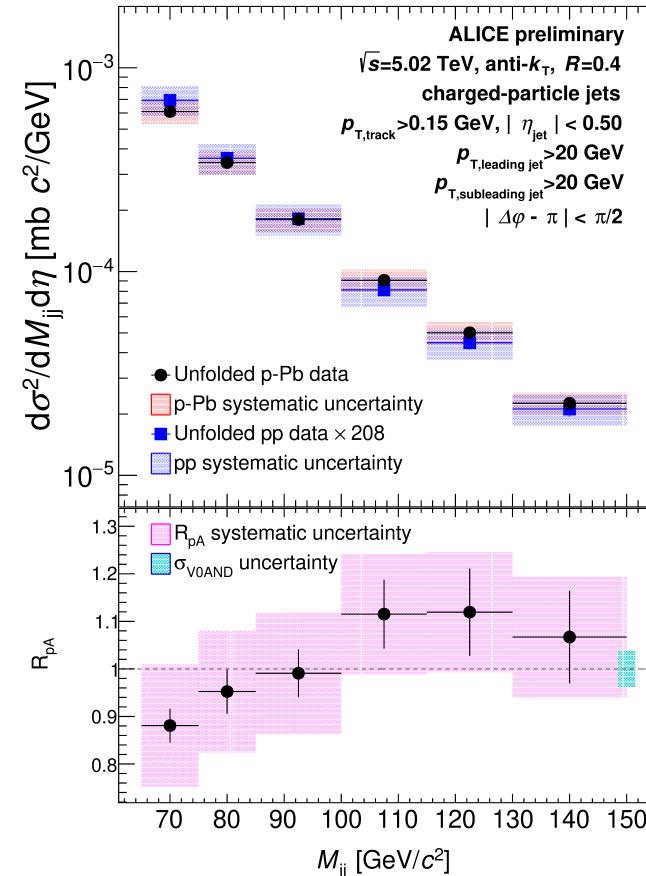
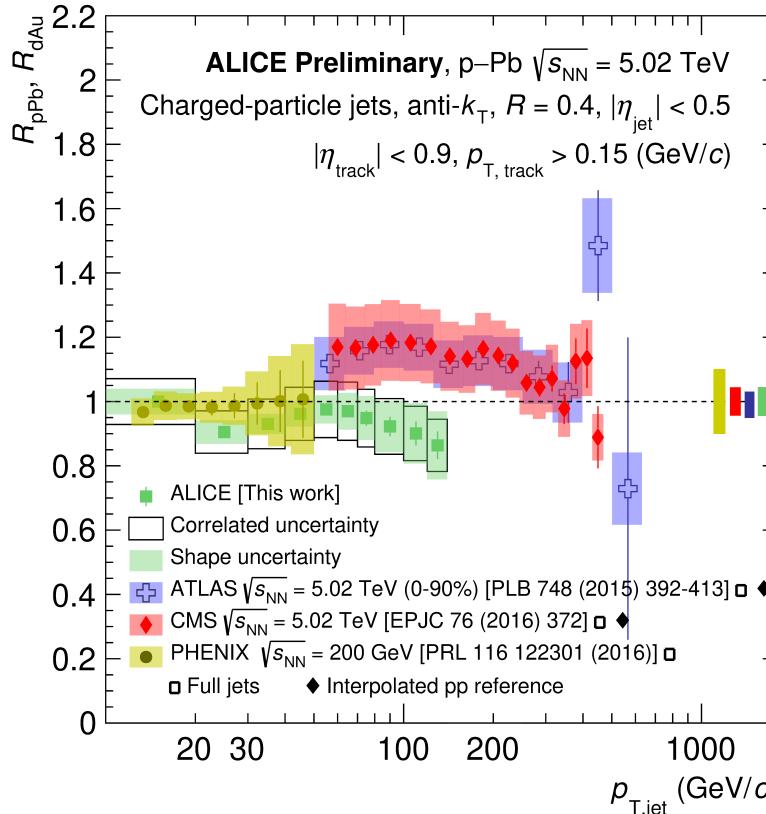
No sign of nuclear modification

Sensitivity to Fragmentation Function of the initial partons

Jets in pp and p-Pb

See poster by Haidar Mas'Ud Alfanda

Inclusive charged jets nuclear modification factor R_{pPb}



$$M_{jj}^2 = 2p_{T,1}p_{T,2}(\cosh(\Delta\eta) - \cosh(\Delta\varphi))$$

No significant cold nuclear matter effects on jet production observed

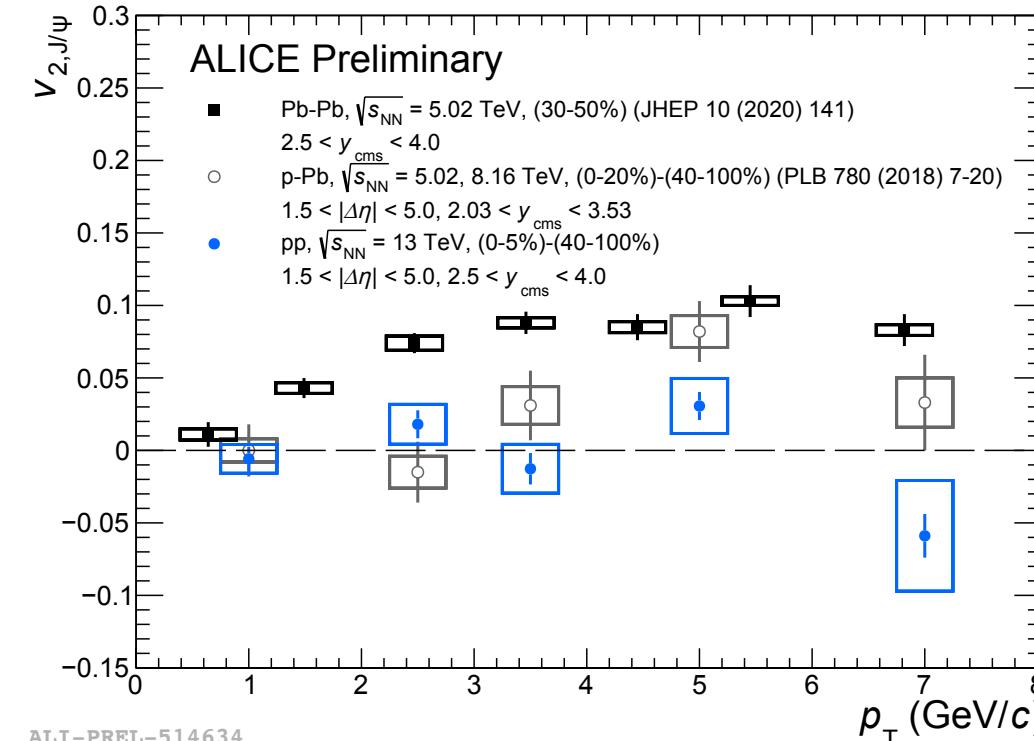
Initial Stages

Thermalisation

Hadronisation

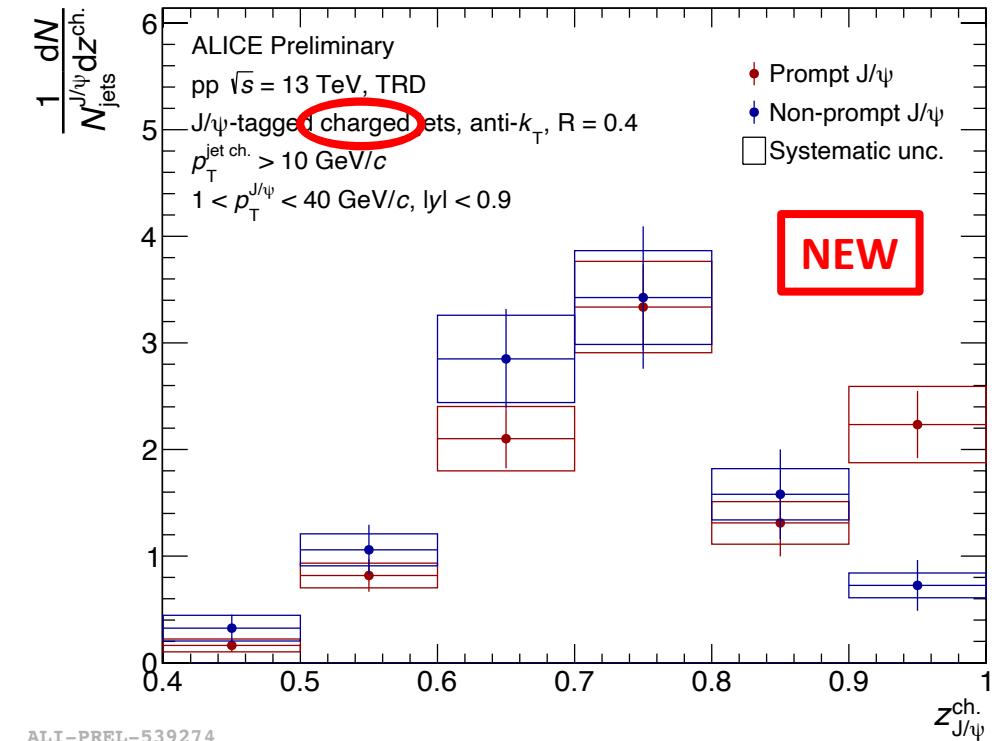
Initial and final state effects with quarkonia

J/ ψ elliptic flow



Collective behaviour in small system at larger p_T
No collective behaviour in pp

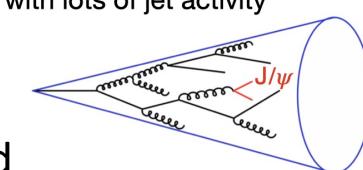
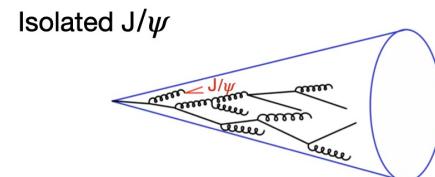
J/ ψ fragmentation



Fragmentation from prompt and non-prompt overlap
Difference for open beauty and hidden charm expected

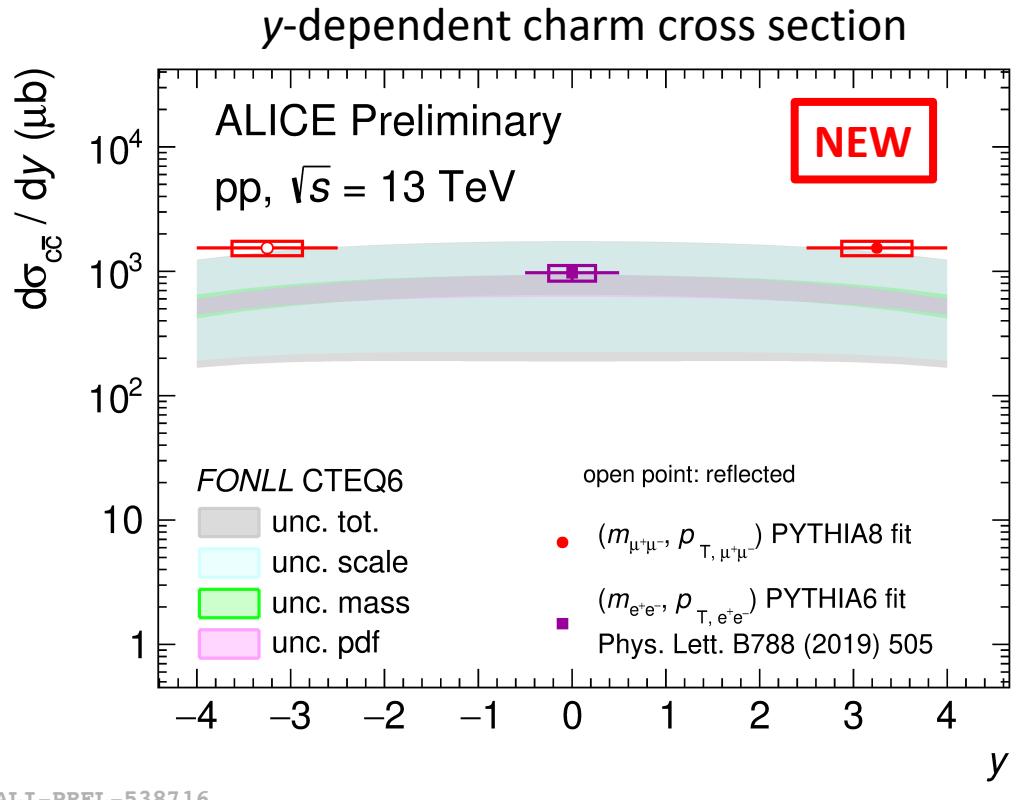
See talk by Ingrid Lofnes on Wed, 16:50

$$z^{ch} = \frac{p_T^{J/\psi}}{p_T^{Jet, ch}}$$

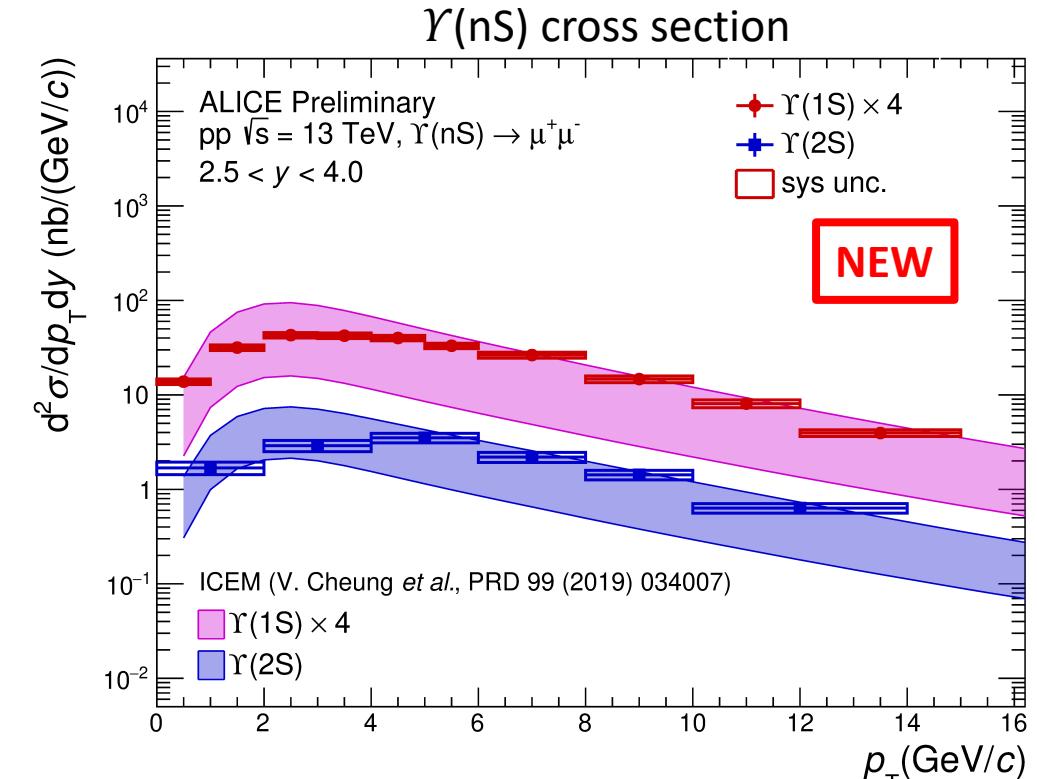


Open and closed heavy flavour production

See talk by Ingrid Lofnes on Wed, 16:50



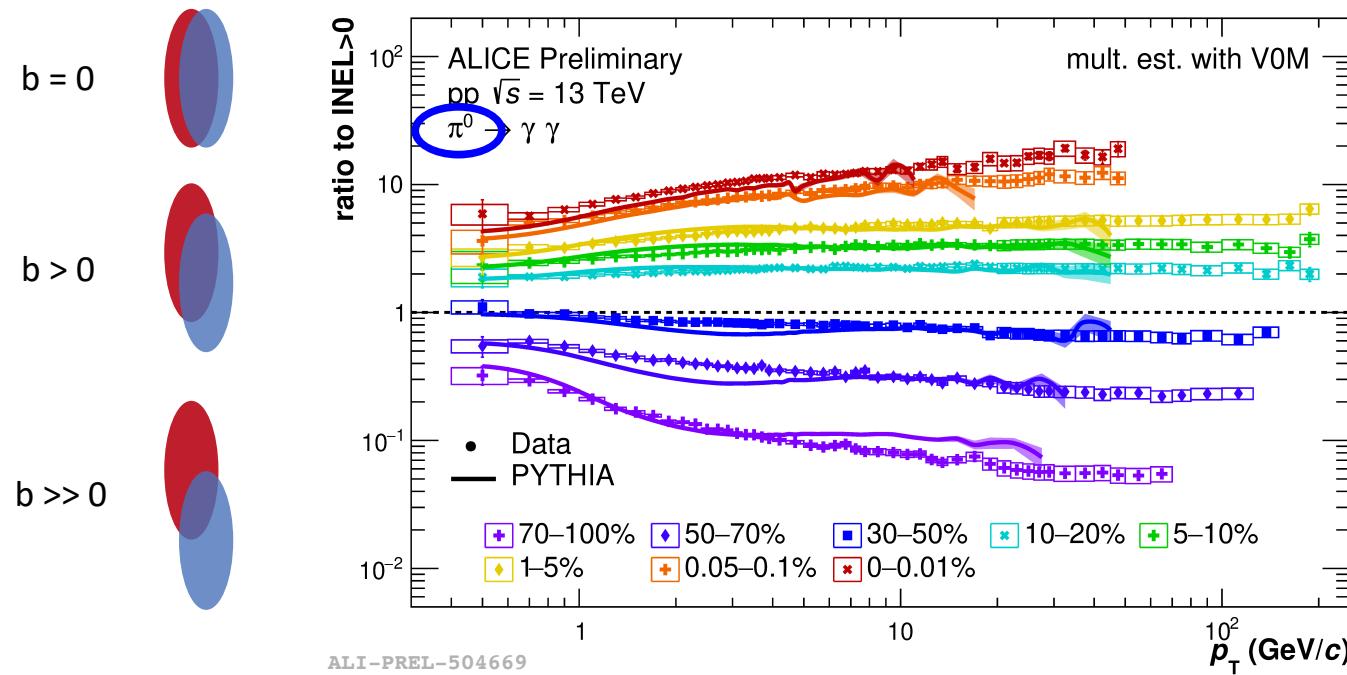
First estimate of charm (and beauty) cross section
now measured also at forward-y



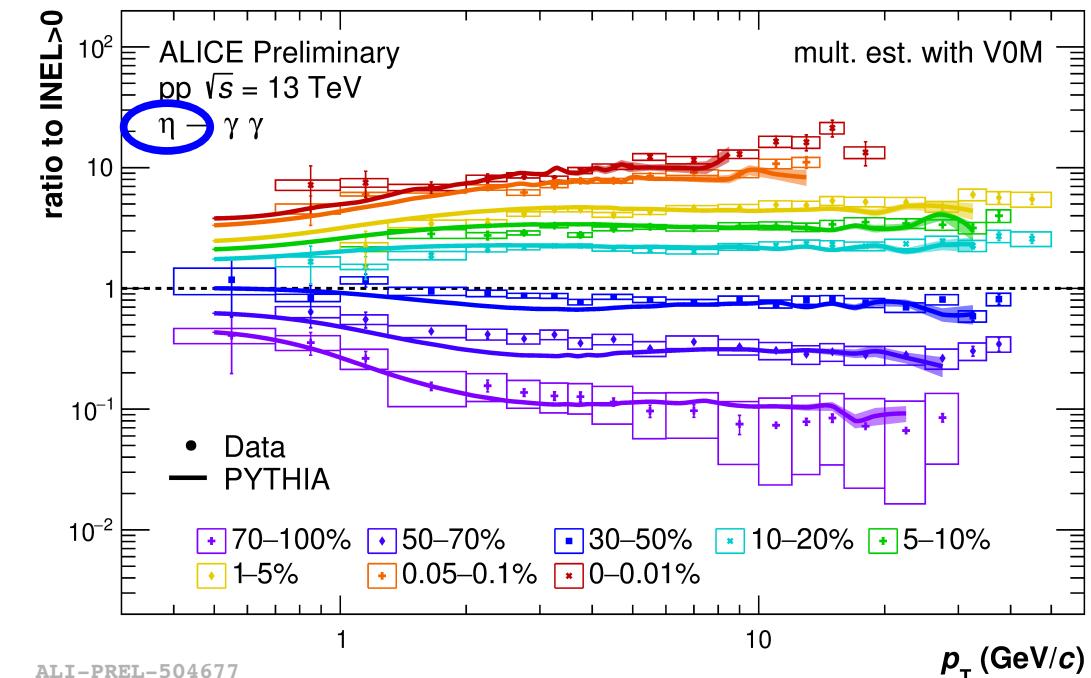
Improved Color Evaporation Model works well

Neutral mesons vs. multiplicity

See poster by Marvin Hemmer



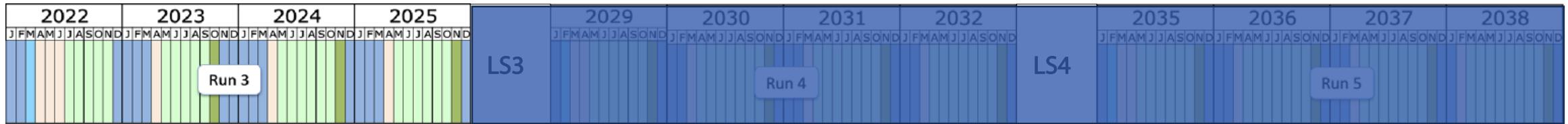
Hardening of p_T spectra with rising multiplicity



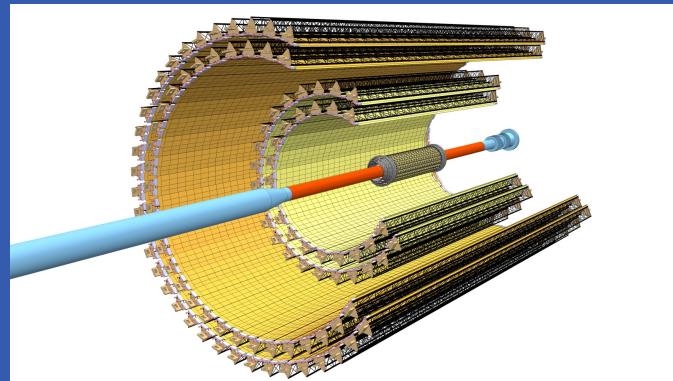
Ordering and magnitude described by PYTHIA

Run3 and beyond

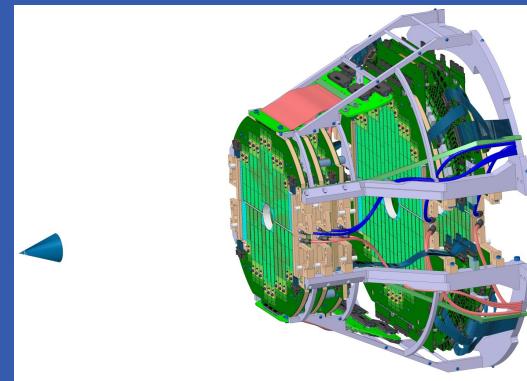




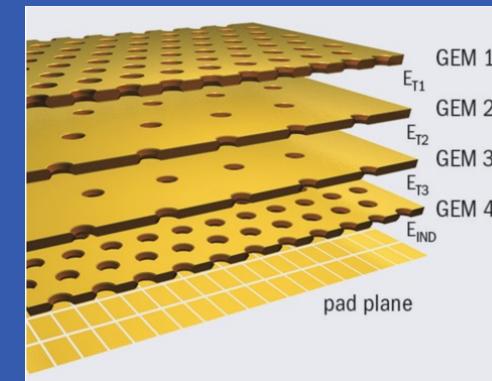
Inner Tracking System 2



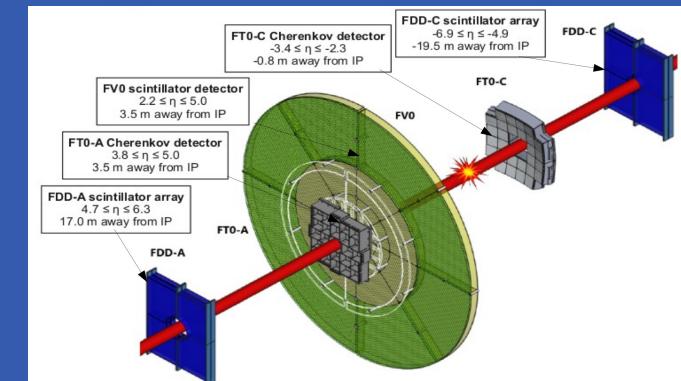
Muon Forward Tracker



Time Projection Chamber



Fast Interaction Trigger



Improved vertex precision 3-6x

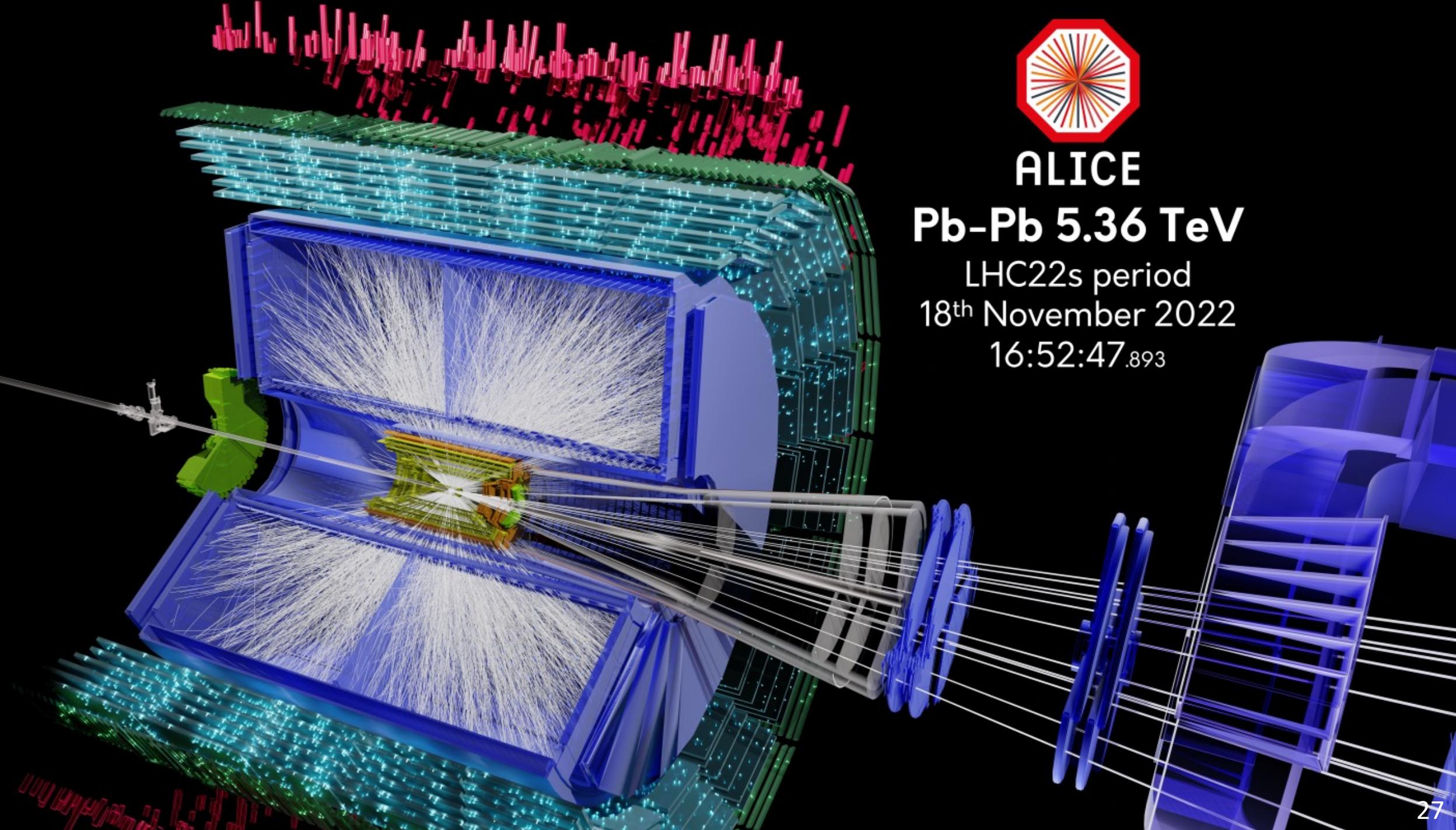
Increased rate capability 50x

Run 3 upgrades Public Note: CERN-EP-2023-009

Successful commissioning and data-taking in pp and Pb-Pb

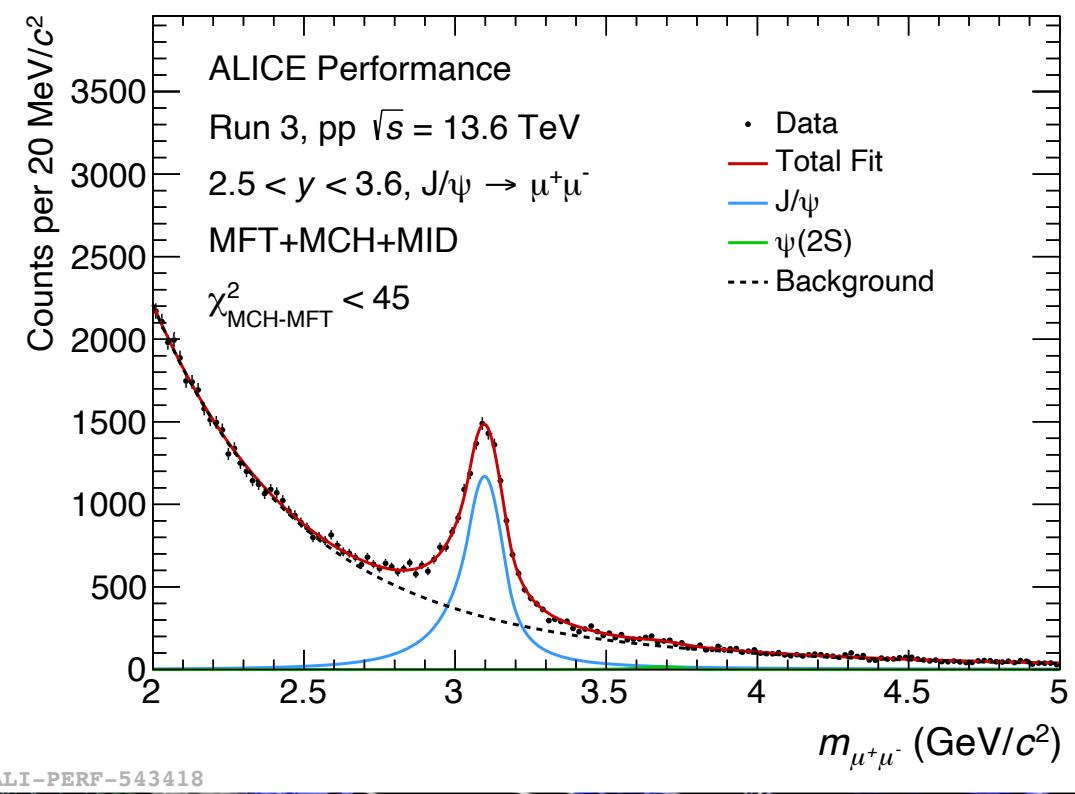
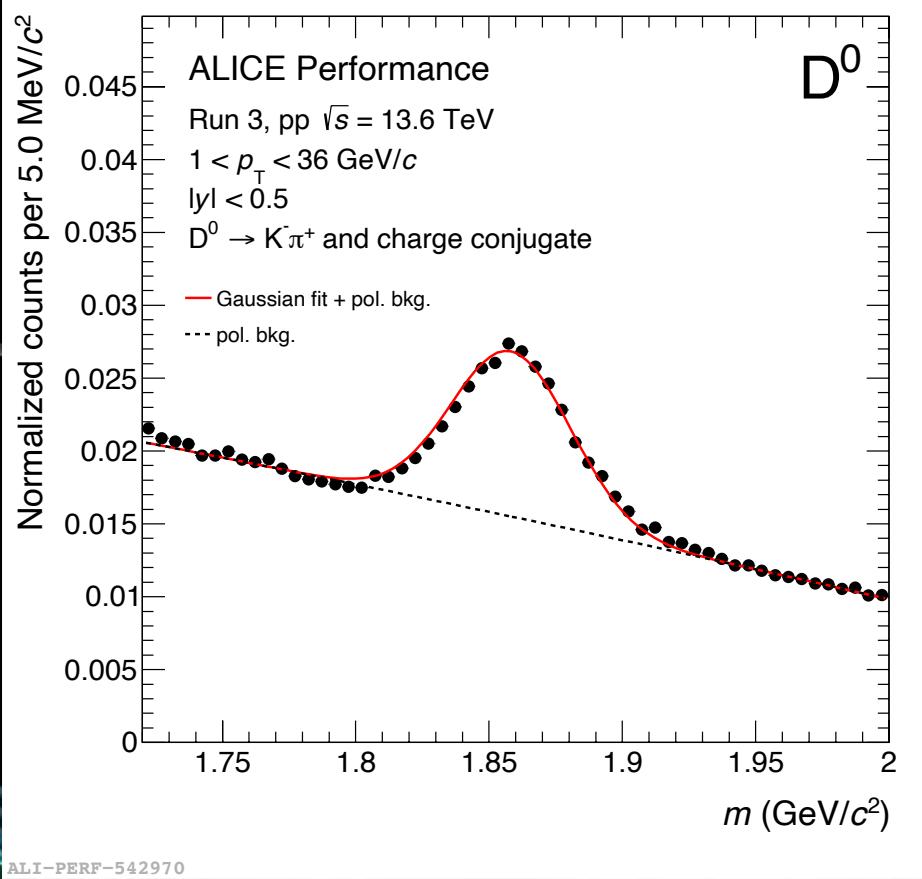


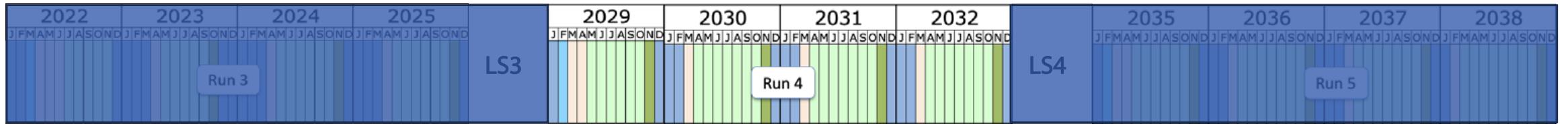
ALICE
Pb-Pb 5.36 TeV
LHC22s period
18th November 2022
16:52:47.893



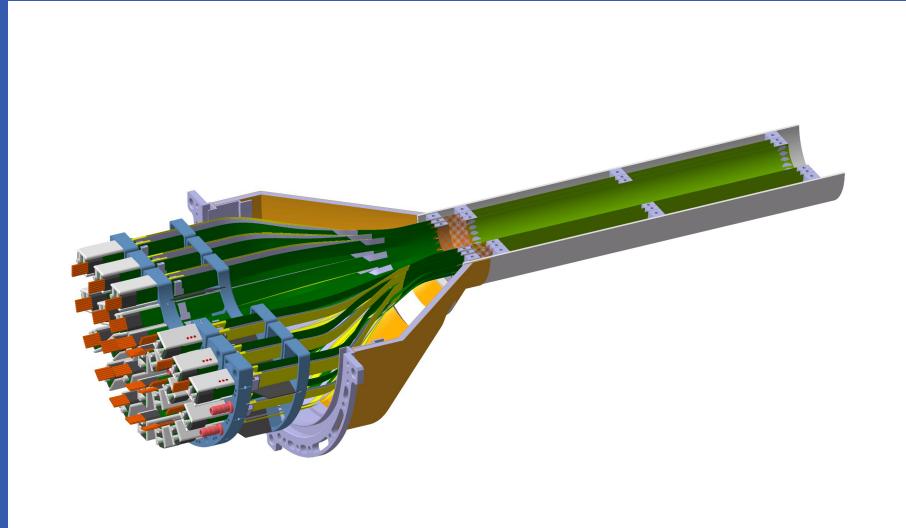


ALICE

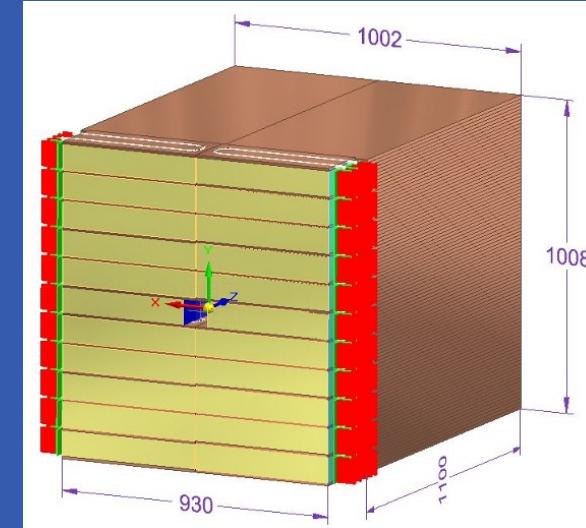




Inner Tracking System 3



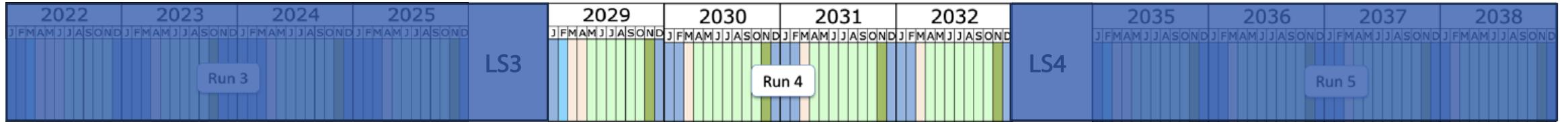
Forward Calorimeter



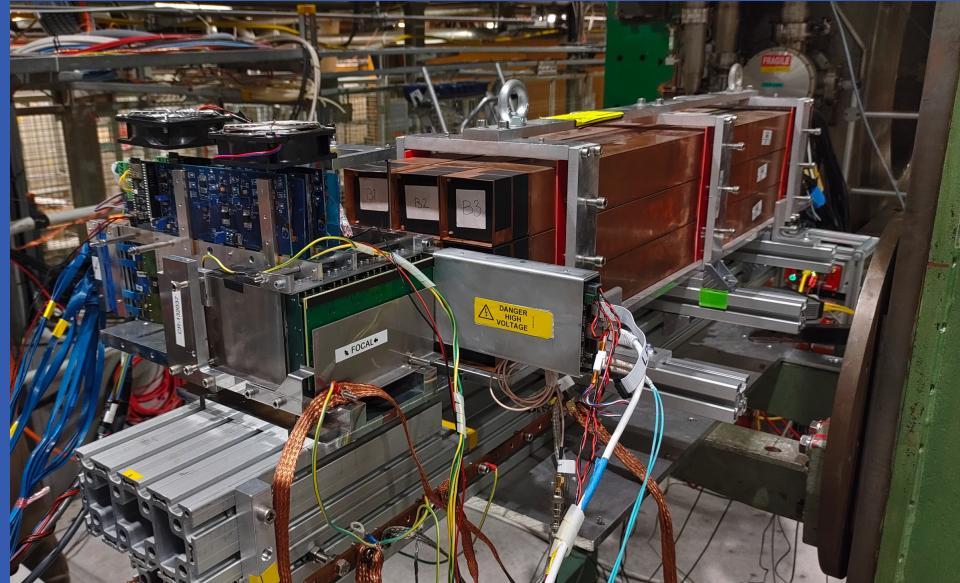
Improved reach for HF and dielectrons

Gluon density at low-x

New opportunity to study hard probes



Forward Calorimeter



EM calorimeter:

- Direct photons, high p_T neutral pions

Hadron calorimeter:

- Dynamics of hadronic matter, good Jet isolation capabilities

$$3.4 < \eta < 5.8$$

Public Note: ALICE-PUBLIC-2023-001

Prototype under test beam: See talk by Max Rauch on Tue, 17:50

Reach low-x down to 10^{-6} and complement EIC

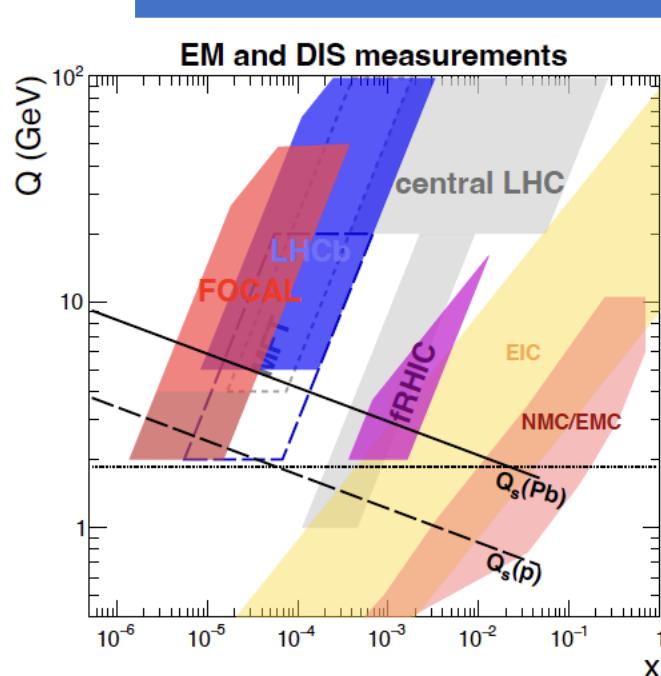
Small-x physics with FoCal upgrade

Connection between forward p-A and e-A DIS

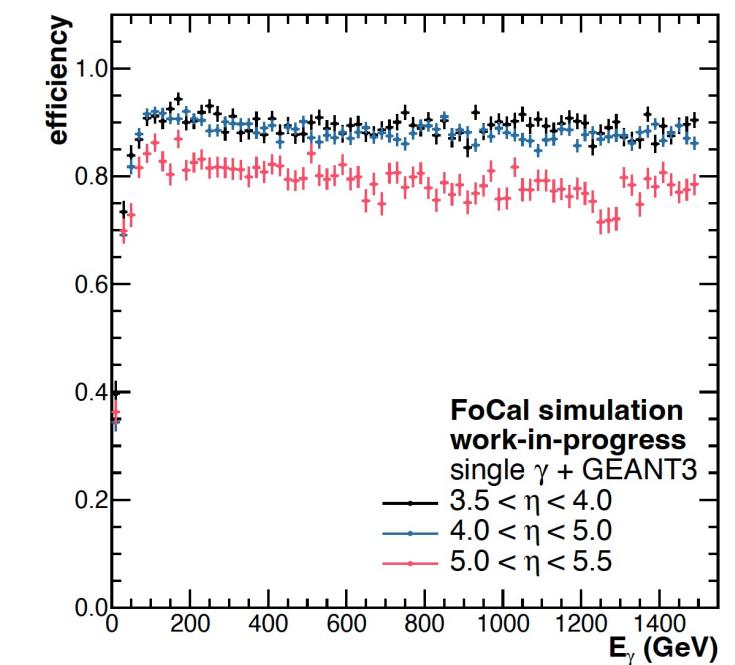
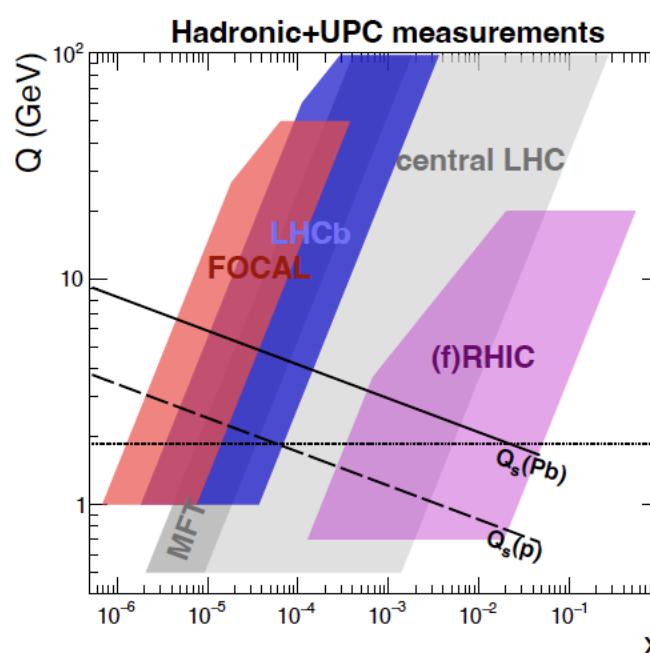
$$\text{e-A: } \sigma_{\text{dipole}}^{\text{LO}}(x, \mathbf{r}_\perp) = 2 \int d^2\mathbf{b} T_{\text{LO}}(\mathbf{b} + \frac{\mathbf{r}_\perp}{2}, \mathbf{b} - \frac{\mathbf{r}_\perp}{2})$$

$$\text{p-A: } |M|_{\text{LO}}^2 \propto \int d^2\mathbf{b} d^2\mathbf{r}_\perp e^{i\mathbf{p}_\perp \cdot \mathbf{r}_\perp} T_{\text{LO}}(\mathbf{b} + \frac{\mathbf{r}_\perp}{2}, \mathbf{b} - \frac{\mathbf{r}_\perp}{2})$$

See talk by Peter Jacobs on Tue 17:30



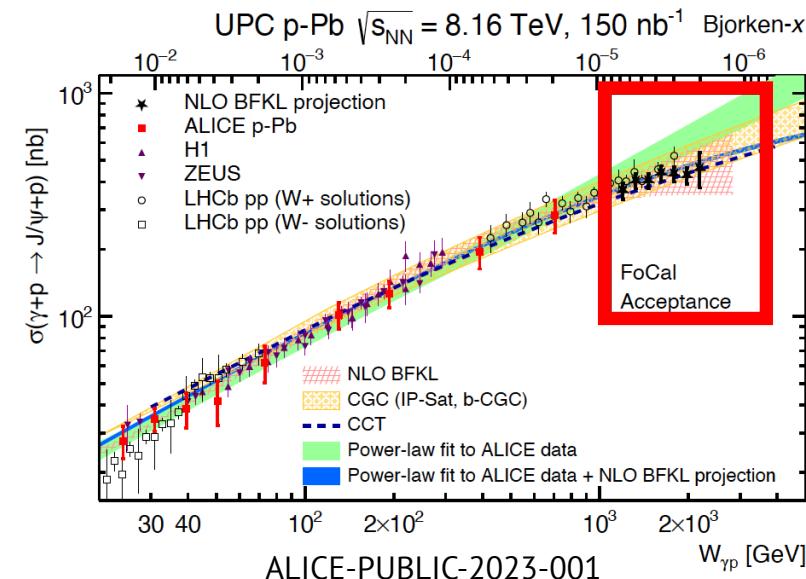
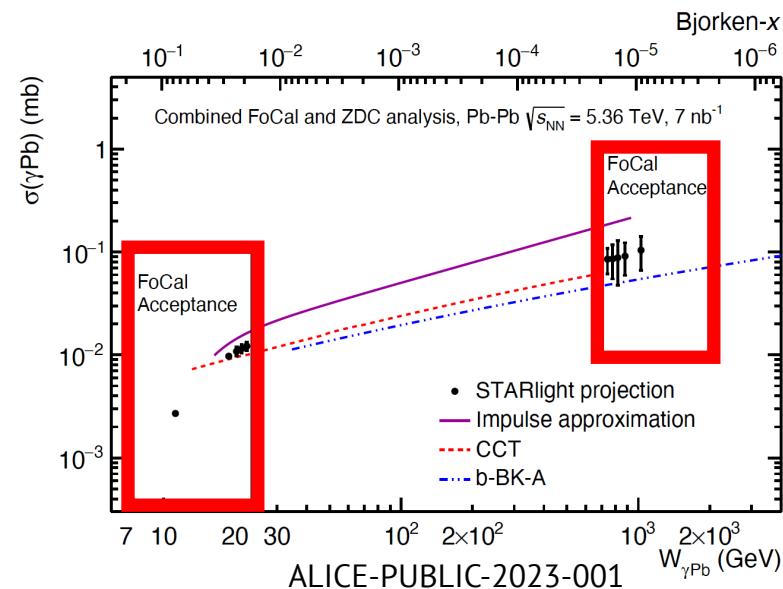
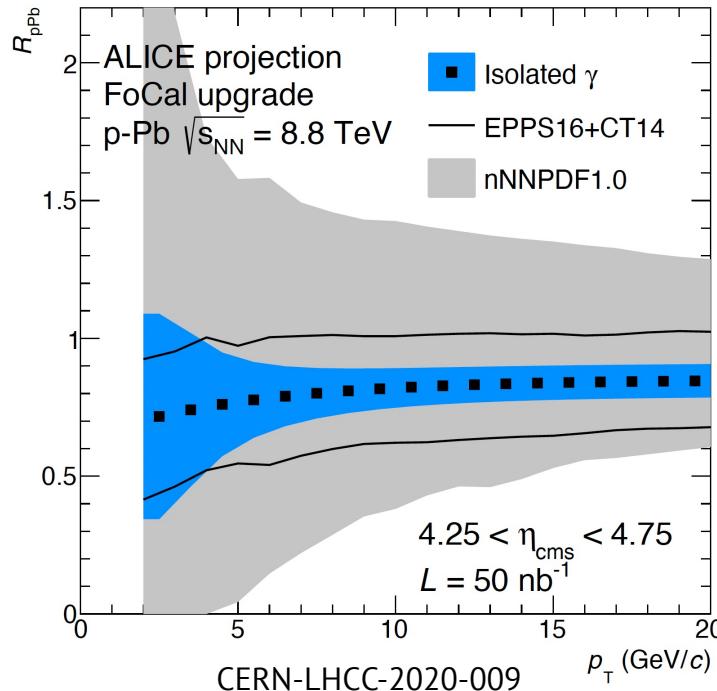
Unique phase-space coverage



High efficiency across large energy range

Probe to very low-x down to 10^{-6}

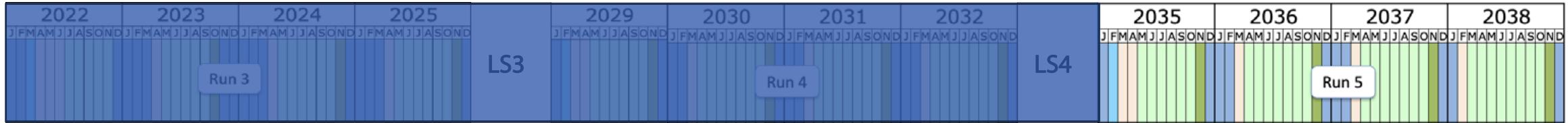
See talk by Peter Jacobs on Tue 17:30



Direct photon production and UPC provide complementary probes of unique small-x range

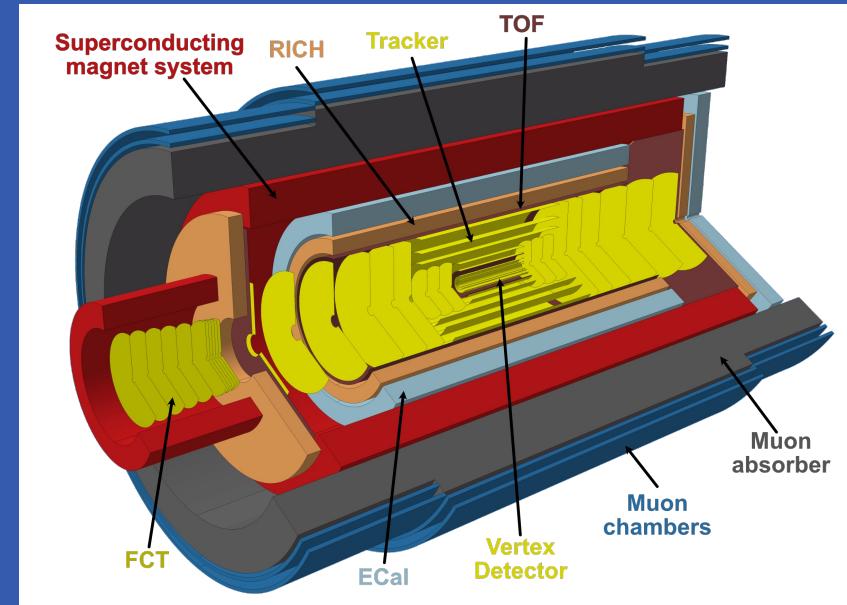
Test beam results: see talk by Max Rauch on Tue, 17:50

More on UPC: see talk by Joakim Nystrand on Tue, 16:50



Physics topics:

- Multi-charm hadrons
- Charm-charm correlations
- Thermal dielectrons, time evolution
- UPCs with very broad η coverage



Letter of Intent: arXiv:2211.02491

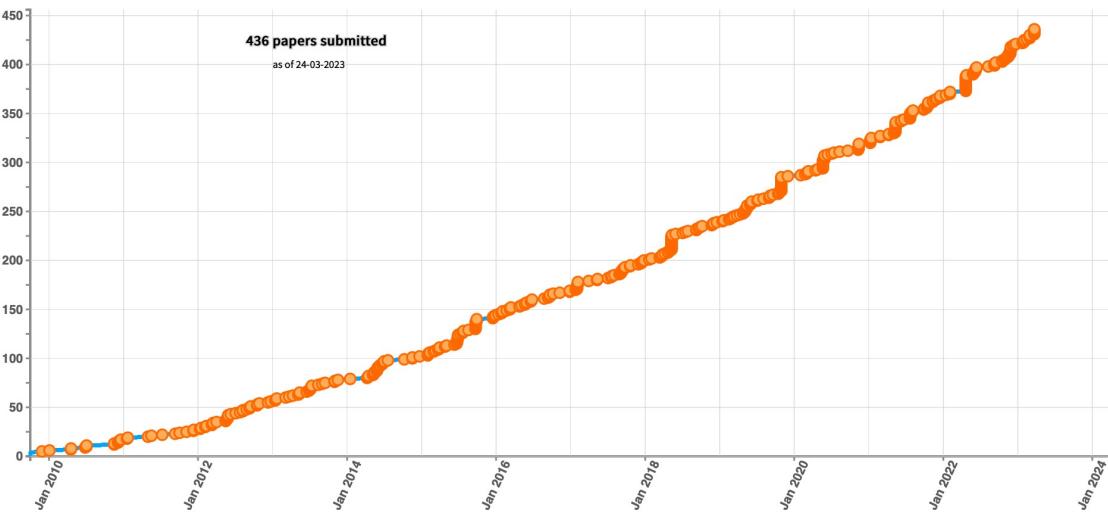
Specifications:

- Large acceptance: $|\eta| < 4$, $p_T > 50$ MeV/c
- Hadron and electron ID
- Muons at midrapidity
- Pointing resolution <10 microns
- Target integrated \mathcal{L}_{int} : 35/nb in Pb-Pb

A next-generation heavy-ion detector
to fully exploit the LHC heavy-ion programme

ALICE results

Publications



alice-publications.web.cern.ch

Public figures

alice-figure.web.cern.ch

Review paper



arXiv:2211.04384

Summary

ALICE results from Run 1-2 have allowed us to move forward
in understanding the evolution of the collisions

Hard probes play a significant role since they allow us to access
the initial stages, the thermalisation and the hadronisation phases

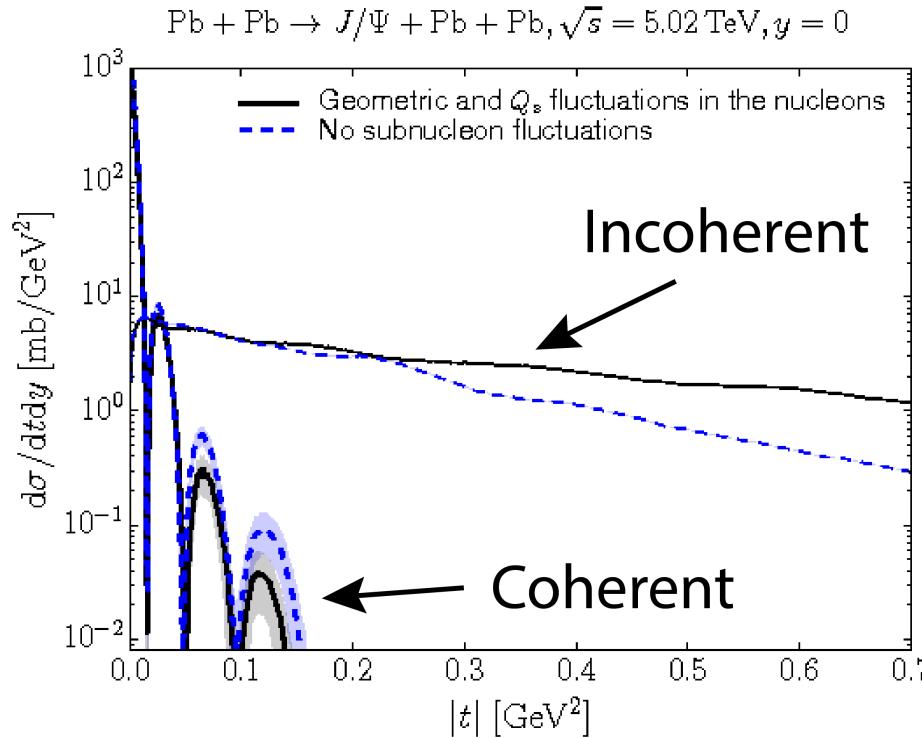
We now look forward to the high-precision Run 3 data
which will help to move ever further

A clear path in the future of this physics is now being shaped

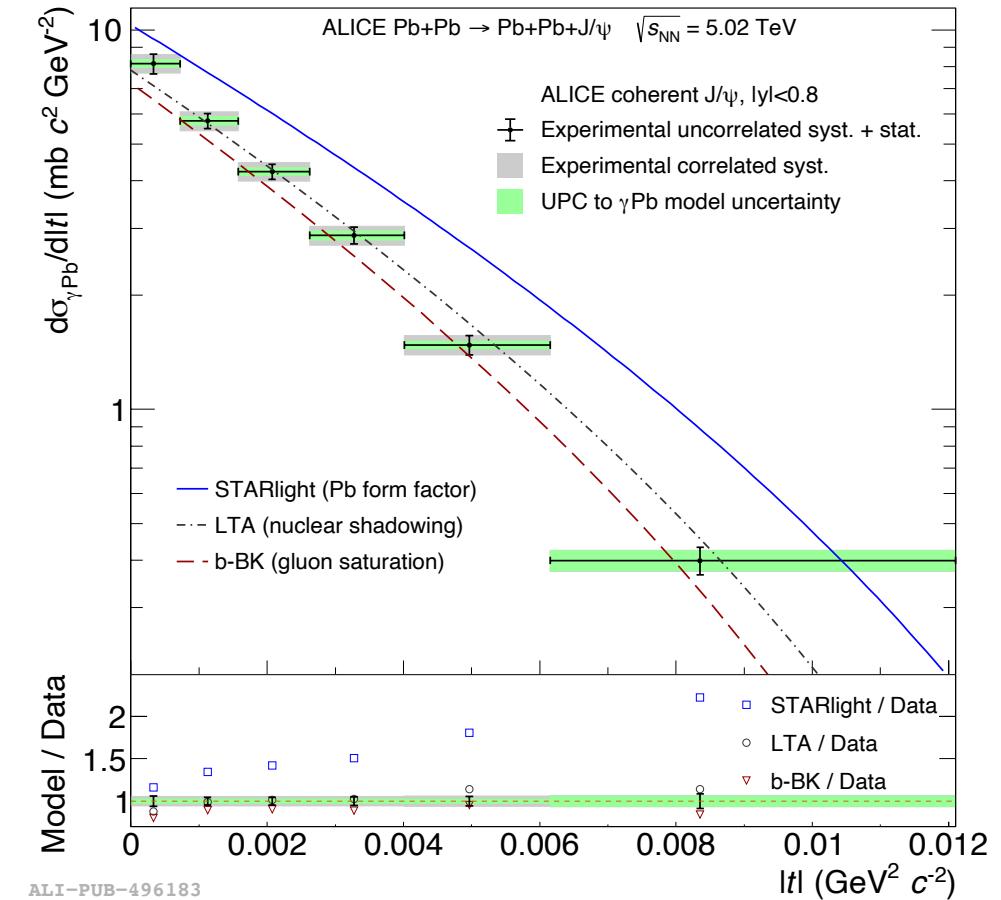
Back up

$|t|$ -dependence of coherent J/ψ in γPb

See poster by David Grund



Phys. Lett. B 772 (2017) 832-838



PLB 817 (2021) 136280

W-dependence of coherent J/ ψ in γ Pb

Derived plots

See talk by Joakim Nystrand on Tue, 16:50

