106° CONGRESSO NAZIONALE
SOCIETÀ ITALIANA DI FISICA
14-18 settembre 2020

Risultati recenti e prospettive dell'esperimento ALICE

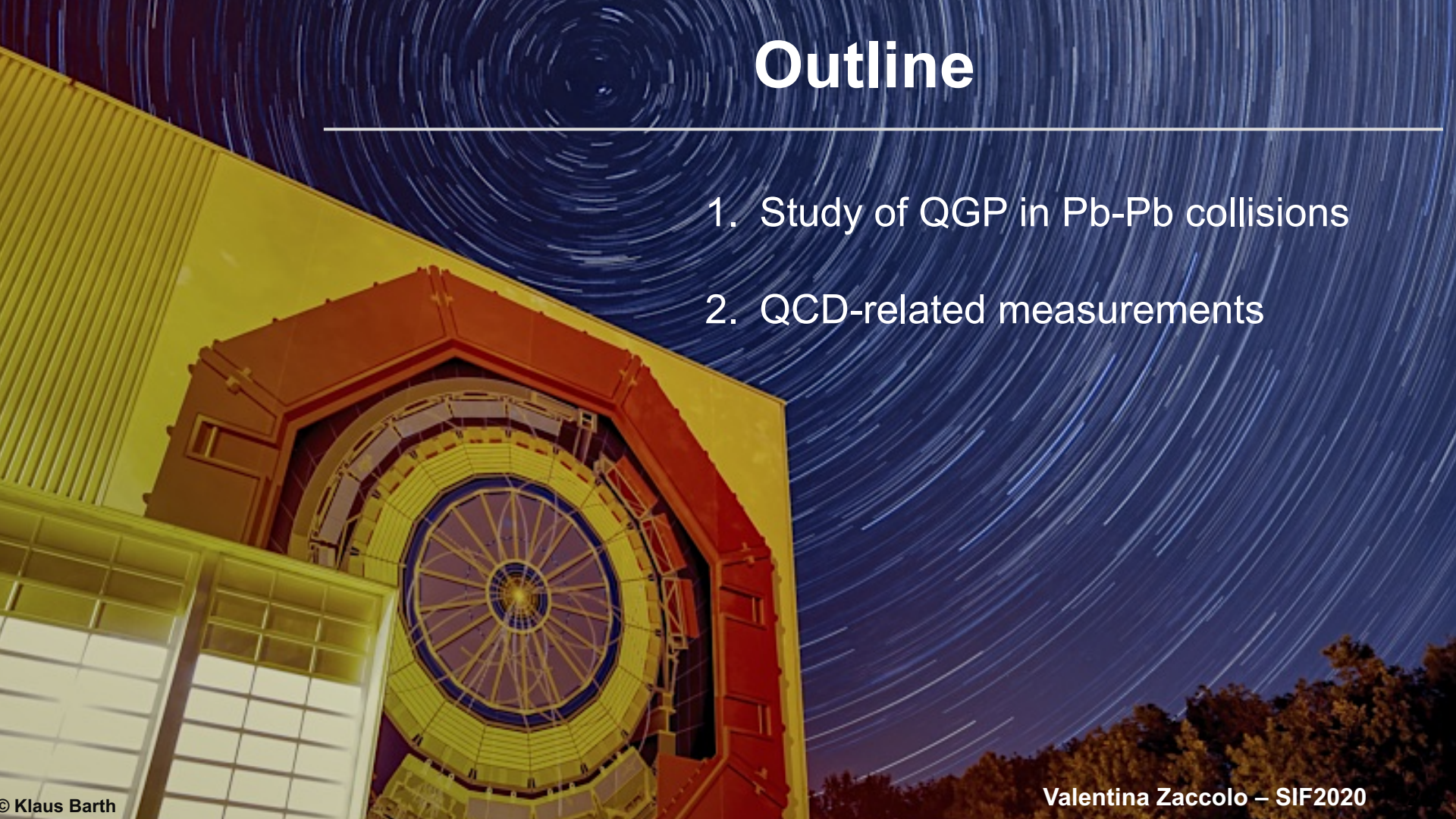
Valentina Zaccolo
Università e INFN – Trieste

INFN TRIESTE

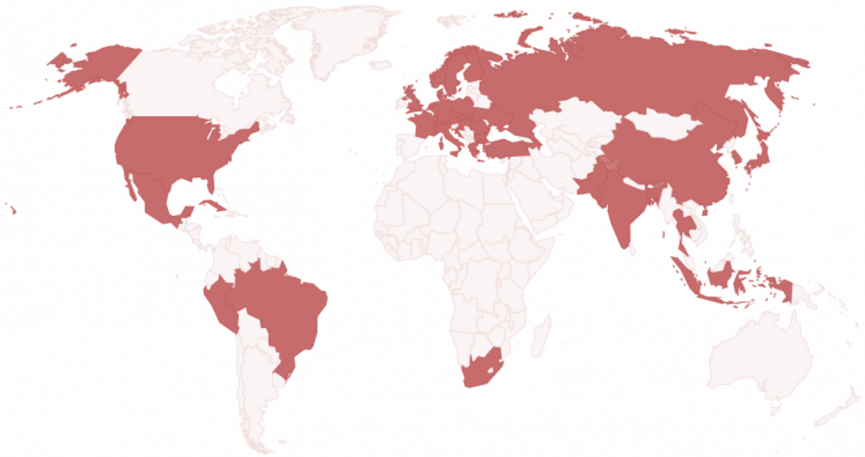
BENEFICENTIA STIFTUNG

Outline

1. Study of QGP in Pb-Pb collisions
2. QCD-related measurements



The ALICE Collaboration

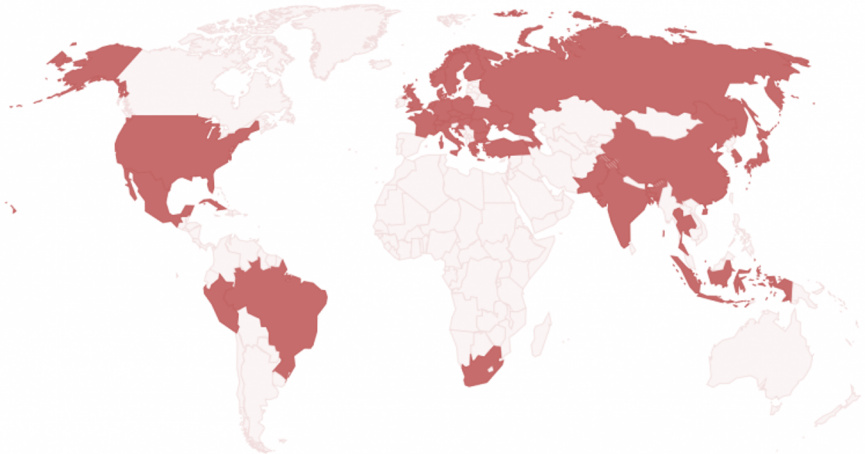


- 1025 Authors
- 174 Institutes
- 39 Countries

Data taking

System	Year(s)	$\sqrt{s_{NN}}$ (TeV)	L_{int}
Pb-Pb	2010, 2011 2015, 2018	2.76 5.02	75 μb^{-1} 800 μb^{-1}
Xe-Xe	2017	5.44	0.3 μb^{-1}
p-Pb	2013 2016	5.02 5.02, 8.16	15 nb^{-1} 3 nb^{-1}, 25 nb^{-1}
pp	2009-2013 2015, 2017 2015-2018	0.9, 2.76, 7, 8 5.02 13	200 μb^{-1}, 100 nb^{-1} 1.5 pb^{-1}, 2.5 pb^{-1} 1.3 pb^{-1} 36 pb^{-1}

The ALICE Collaboration



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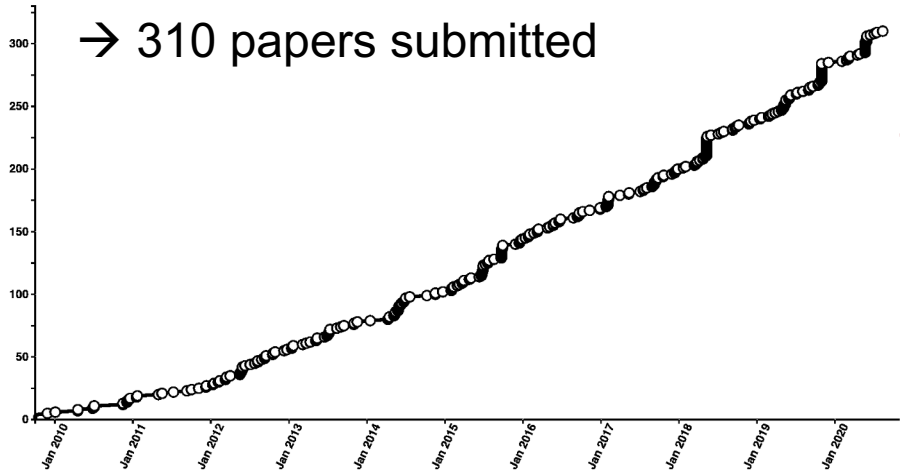
→ 310 papers submitted



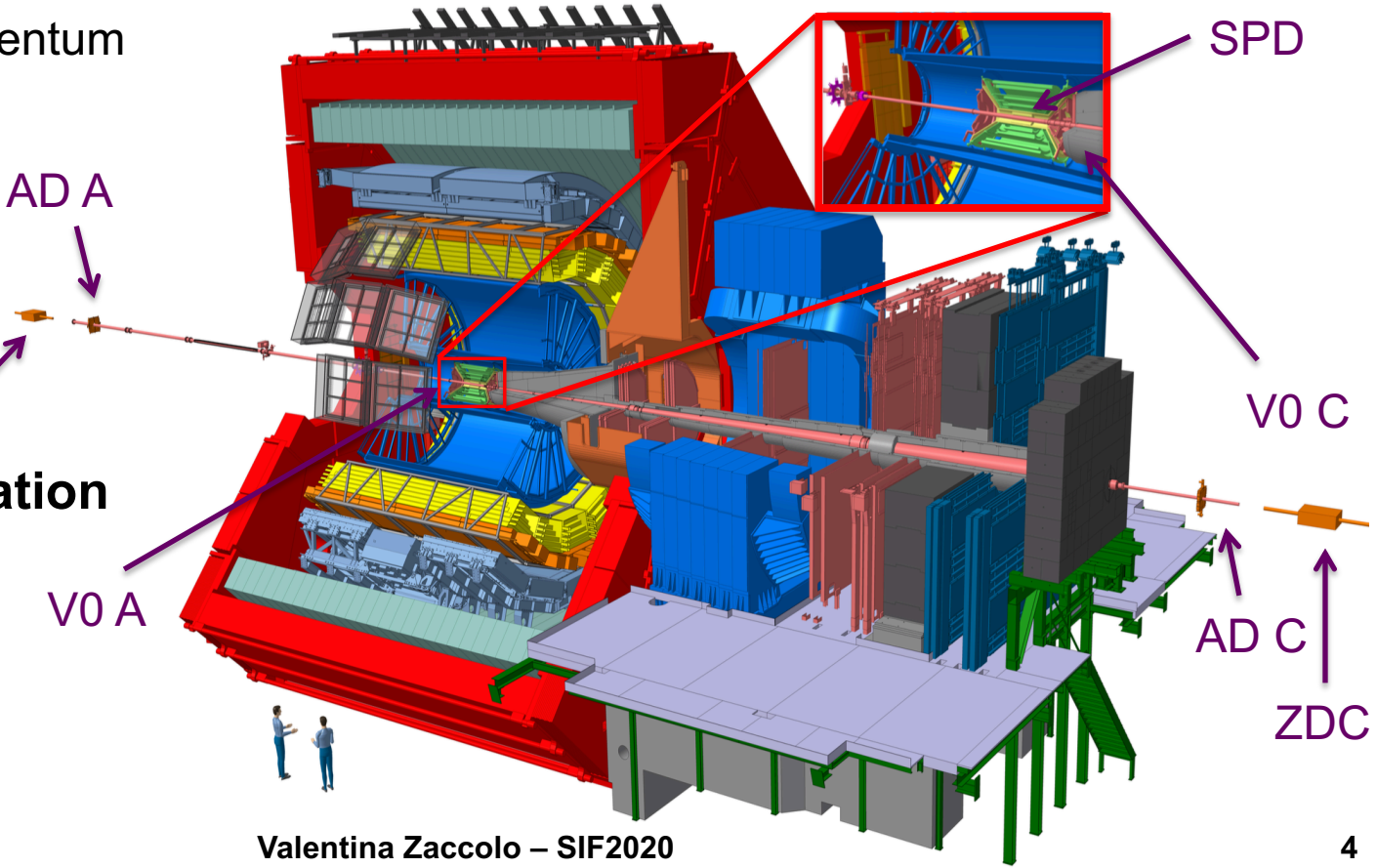
https://alice-publications.web.cern.ch/submitted

A Large Ion Collider Experiment

Excellent track-momentum resolution and PID

solenoidal magnet: 0.5 T

Trigger and event characterisation detectors



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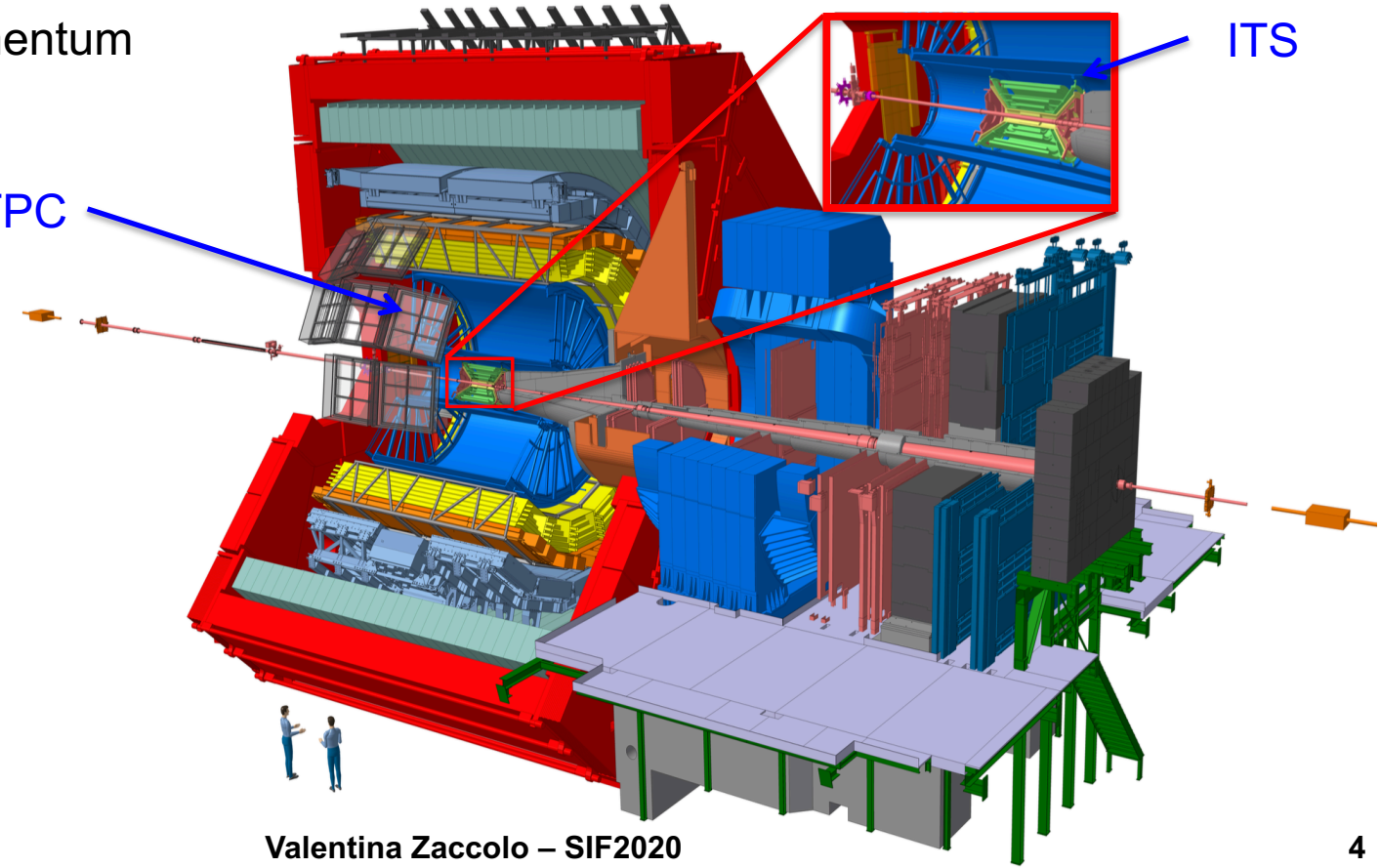
Tracking



A Large Ion Collider Experiment

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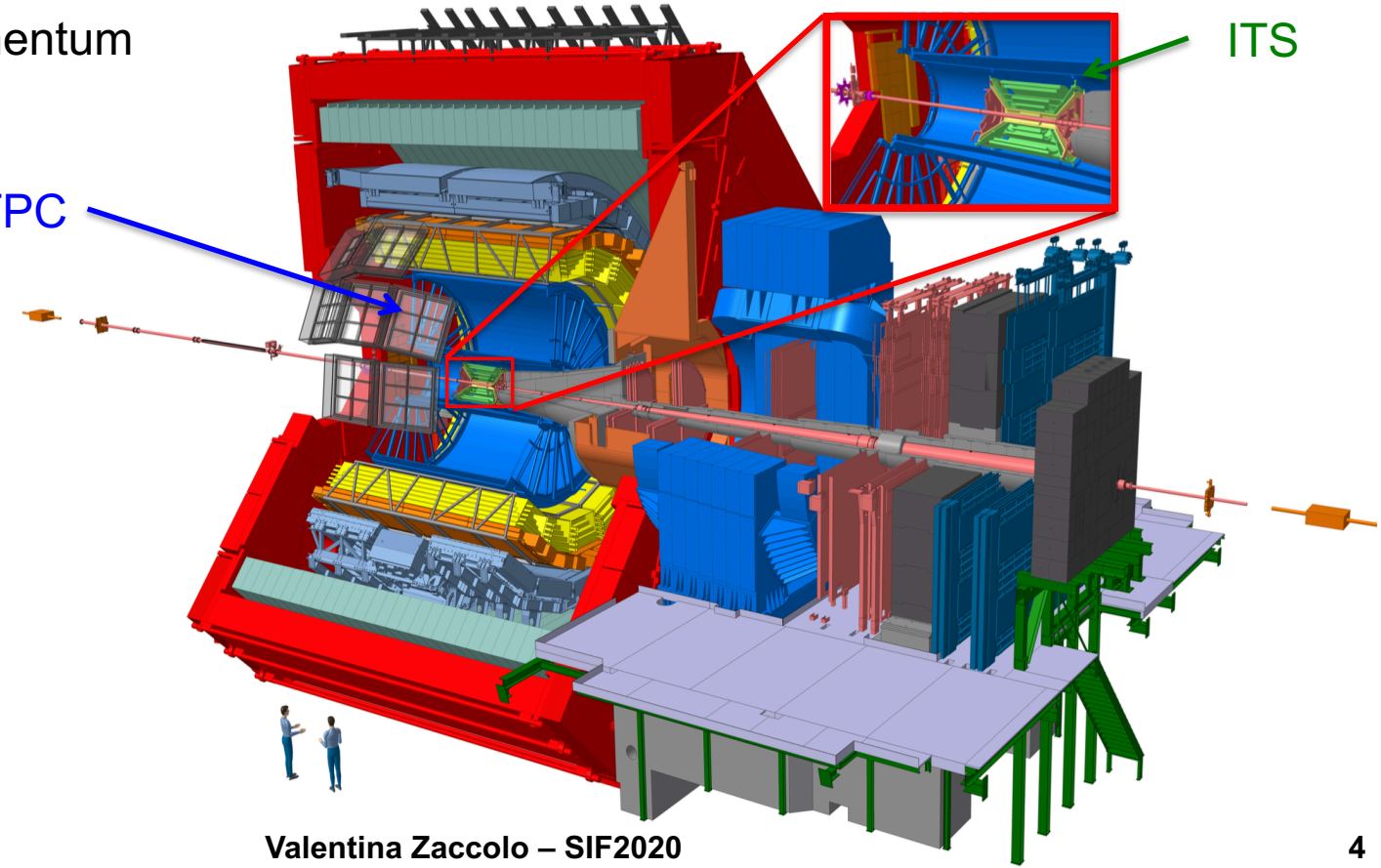
Tracking

Vertexing



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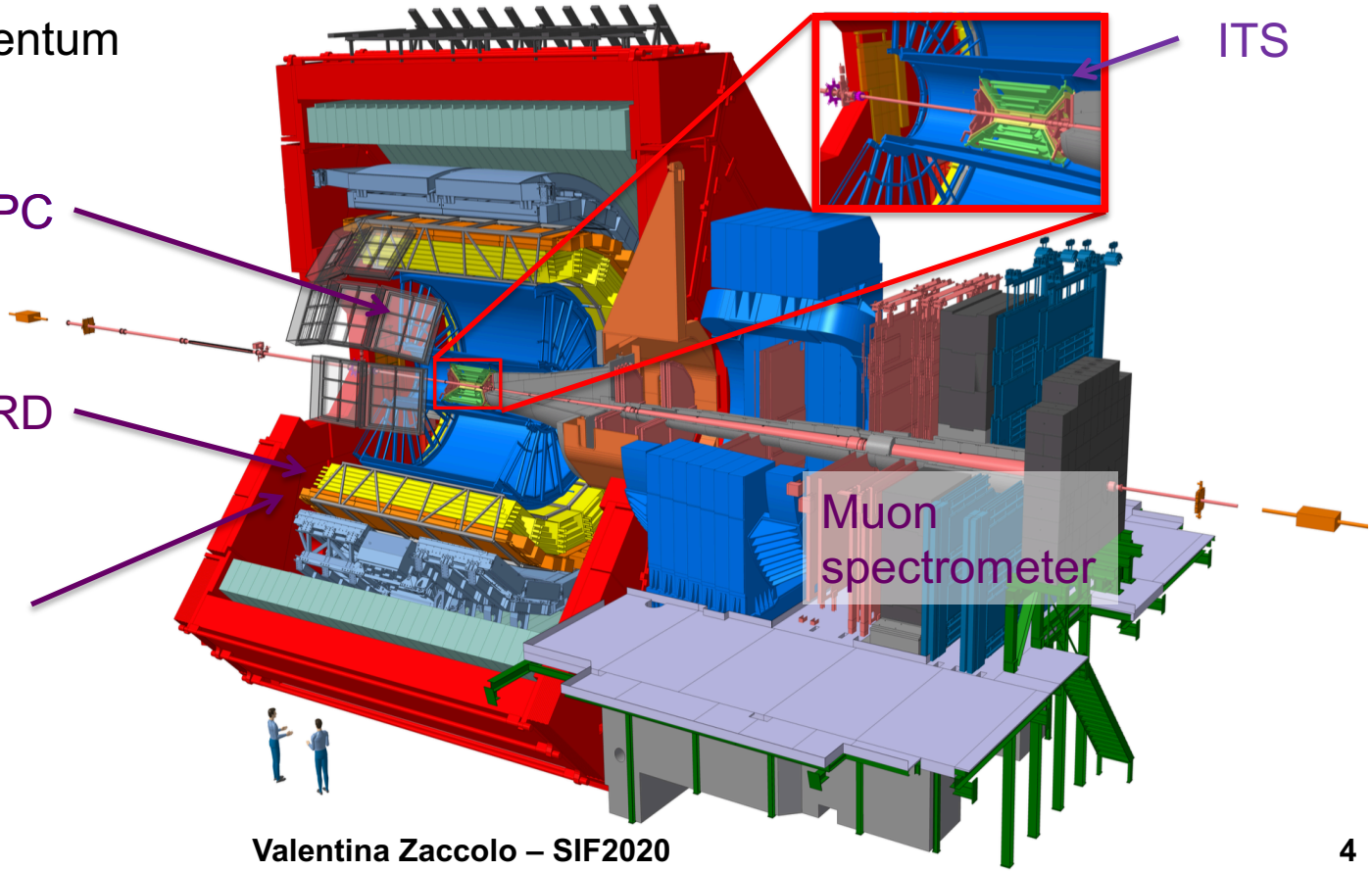

A Large Ion Collider Experiment

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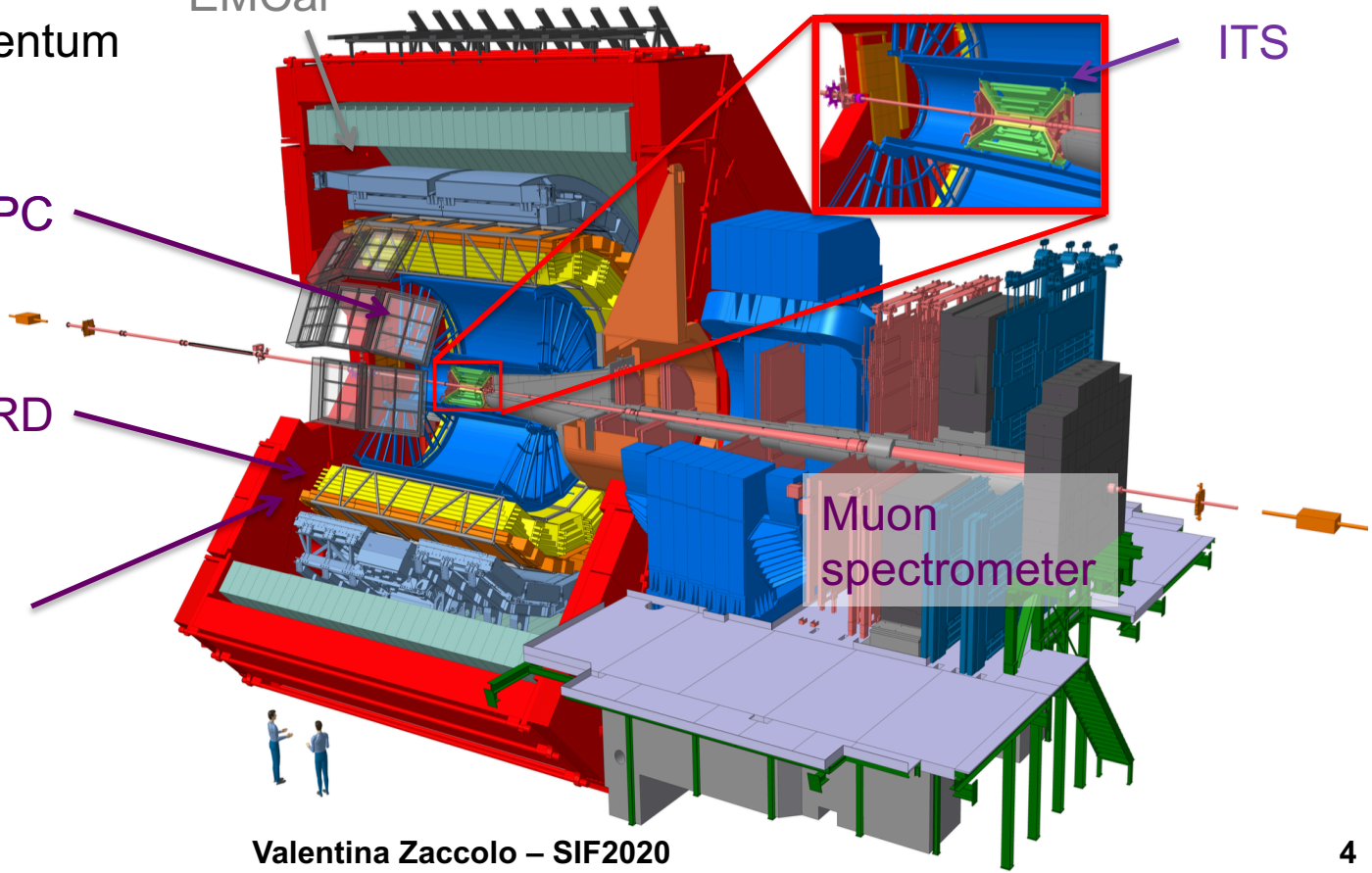
Tracking

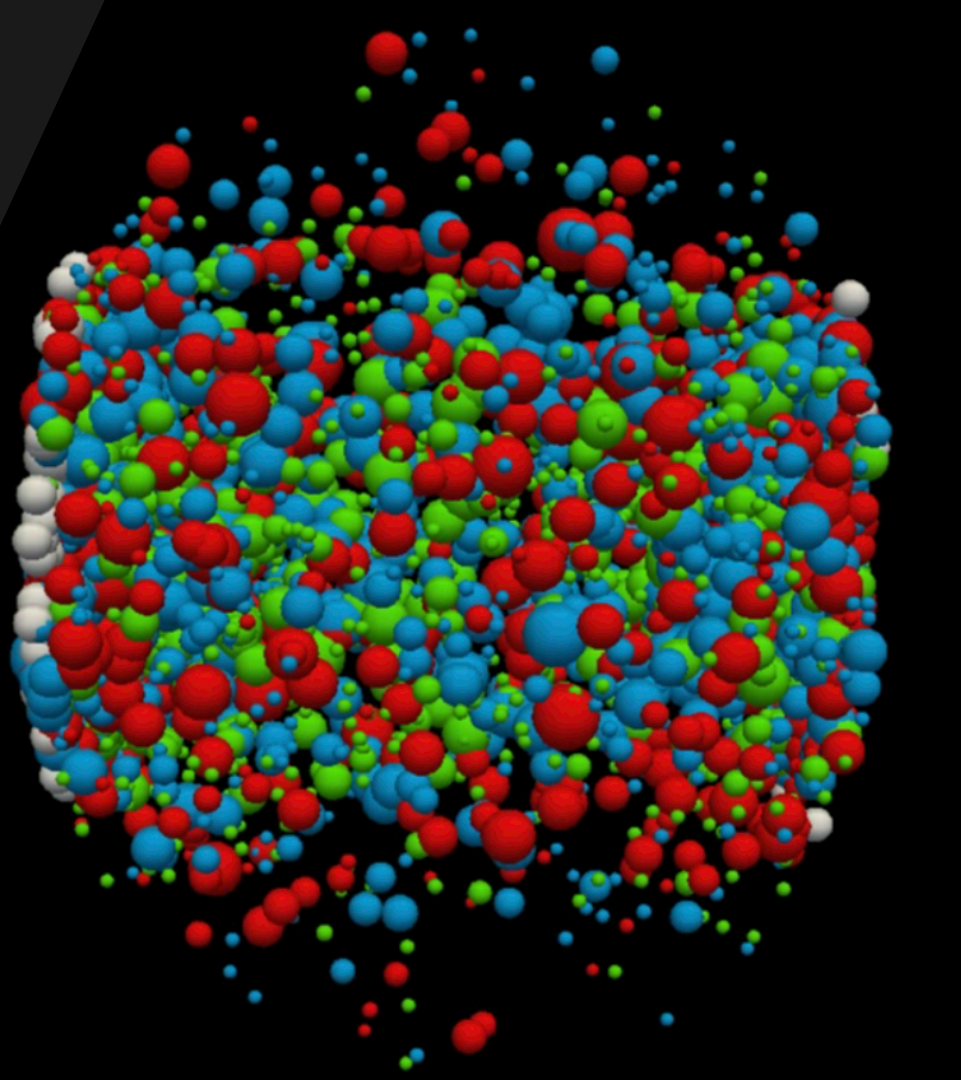
Vertexing

PID

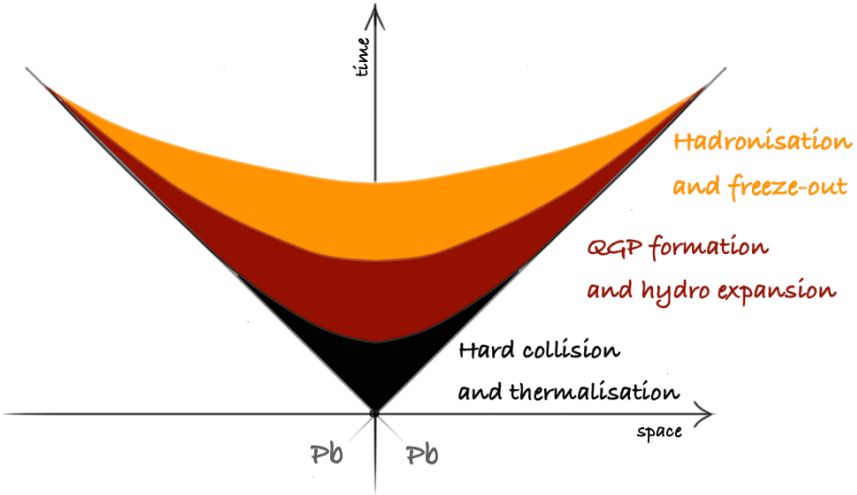
Calorimetry

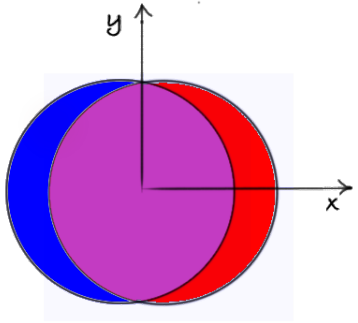


Study of QGP in Pb-Pb collisions



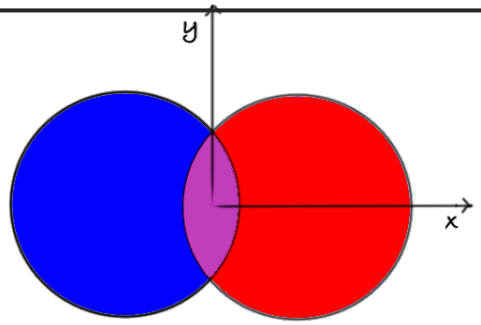
Colliding nuclei





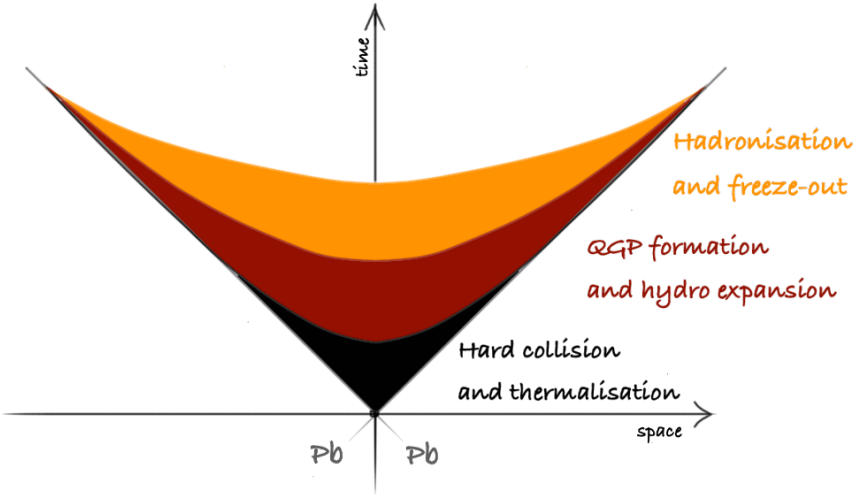
central collision

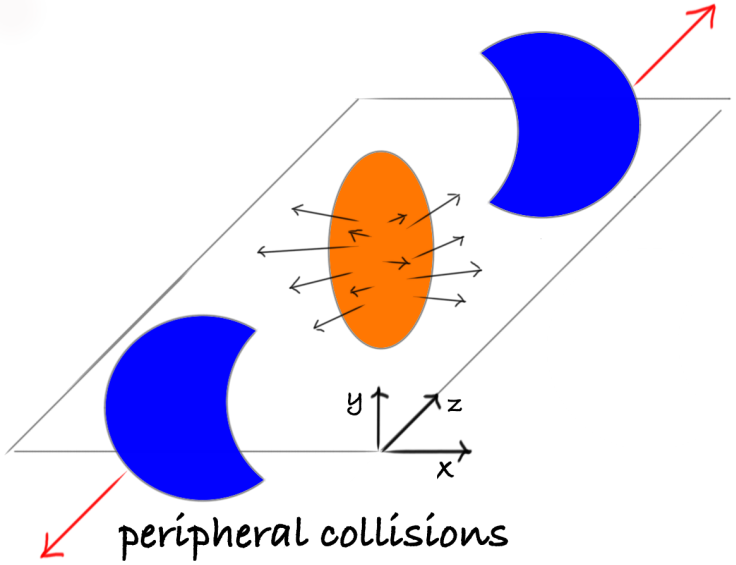
isotropic shape



peripheral collision

Colliding nuclei

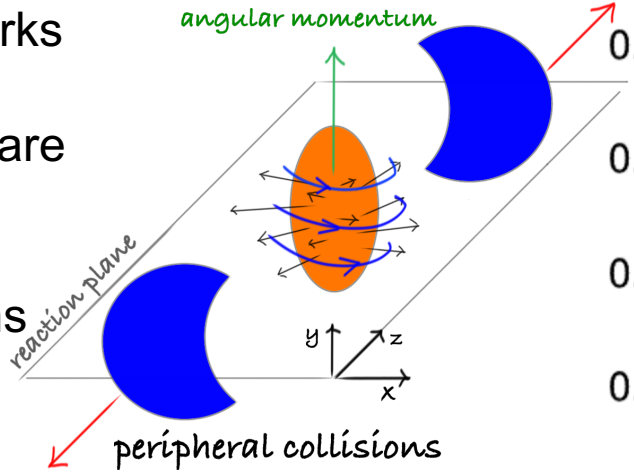


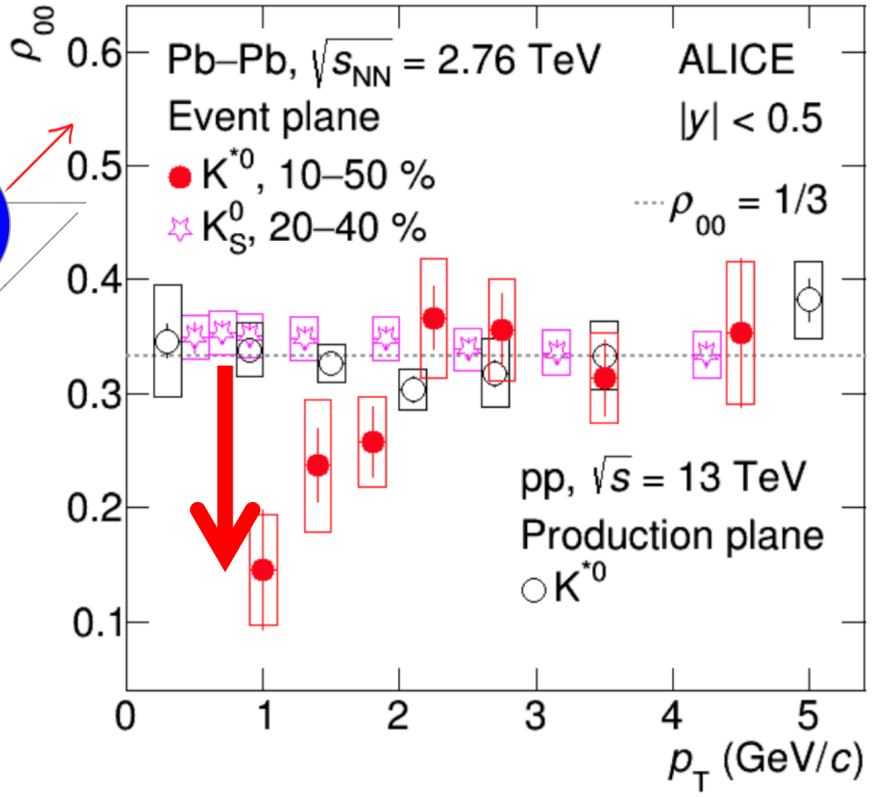


QGP characterisation
Vector mesons spin

QGP in Pb-Pb → high angular momentum equivalent to the order of 10^{21} revolutions/s

- polarises the quarks
- if vector mesons are produced via recombination → their spin aligns $\rho_{00} \neq 1/3$



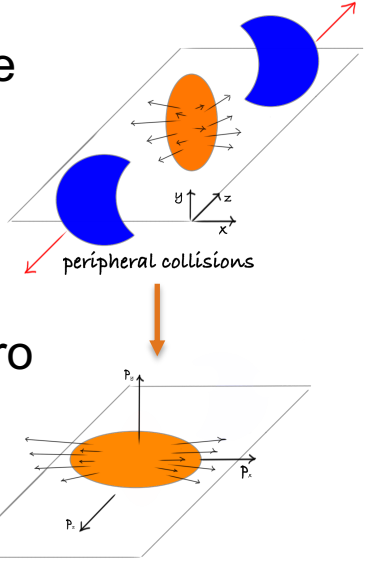


➢ measurement using K^{*0}
→ 3σ effect at low p_T

QGP characterisation

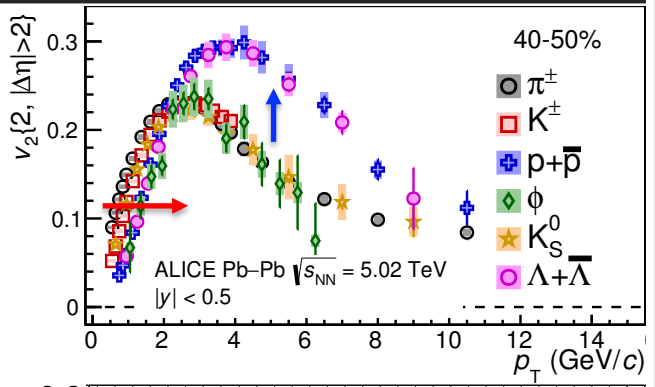
(Almost) all particles flow: light flavours

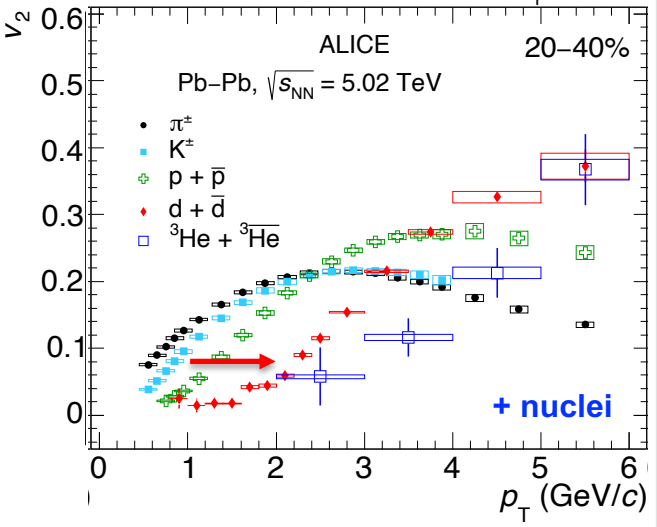
Second order anisotropies in particle momentum arise from asymmetry in the initial almond geometry of the collision



- $p_T < 3$ GeV/c mass ordering
  from collective dynamics during hydro expansion (heavier particles have smaller v_n)

- $3 < p_T < 8$-10 GeV/c baryons flow more than mesons
  from coalescence hadronisation





ALICE
JHEP 09 (2018) 006
arxiv: 2005.14639 [nucl-ex]

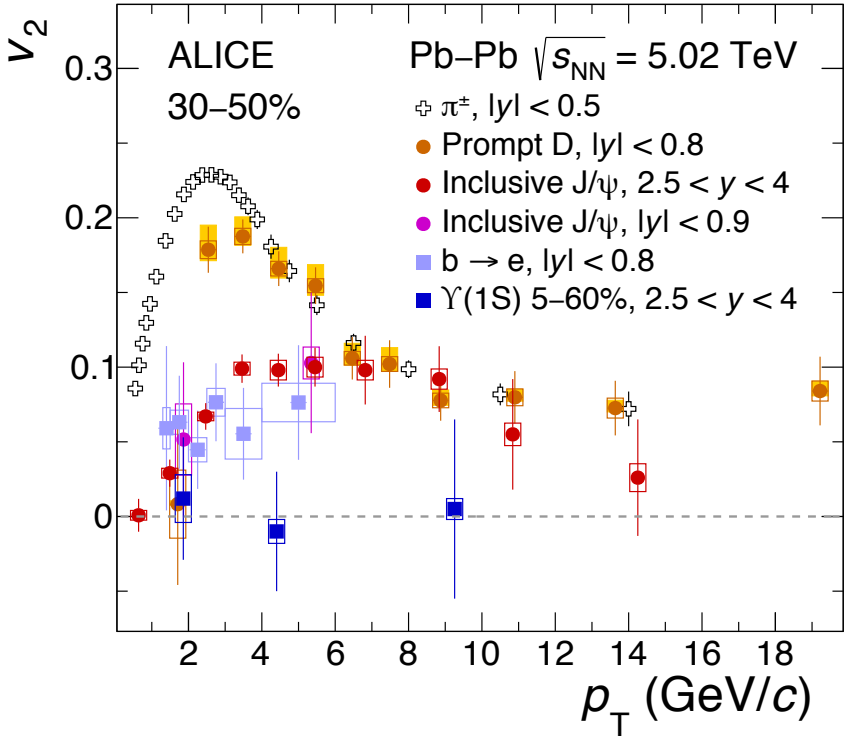
QGP characterisation

(Almost) all particles flow: heavy flavours

Second order anisotropies in particle momentum arise from asymmetry in the initial almond geometry of the collision

Heavy flavours are produced in the hard scattering → travel through the QGP

- D and J/ψ flow
- e from b-hadron decay flow
  → b flow < c flow
- Υ(1S) large mass + small recombination
  → flow consistent with zero



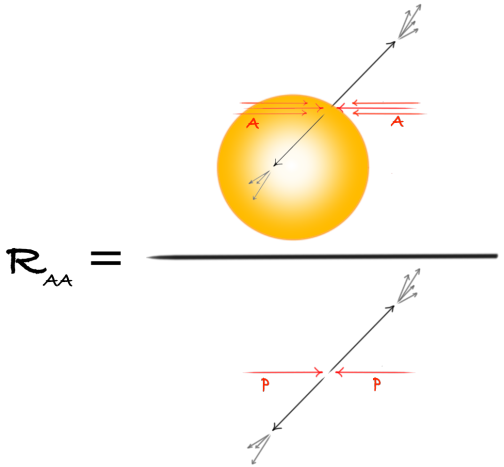
ALICE
Phys. Rev. Lett. 123, 192301 (2019)
arXiv: 2005.11130 [nucl-ex]
arxiv: 2005.14518 [nucl-ex]

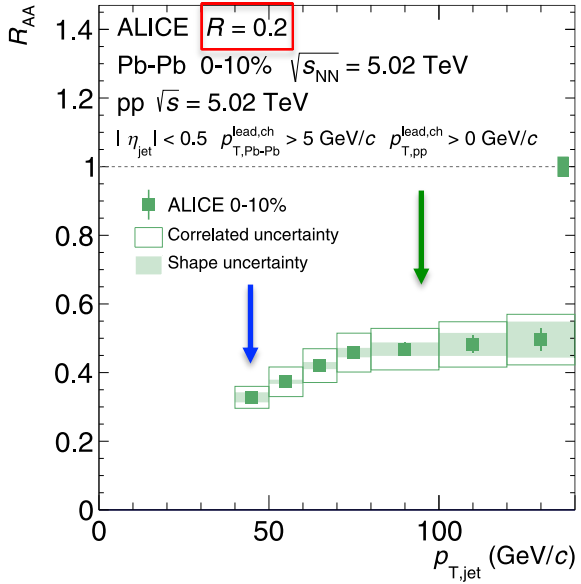
QGP characterisation

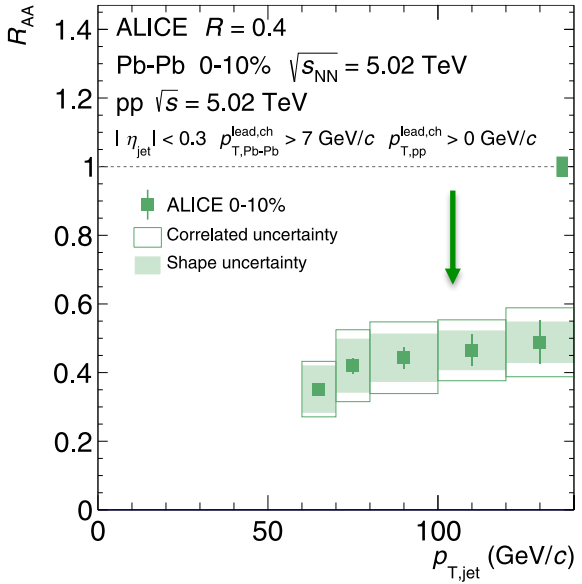
Jets are quenched

The jet R_{AA} exhibits strong suppression

- visible $p_{T,jet}$ dependence in the case of jet angular aperture of $R = 0.2$
- R_{AA} for $R = 0.2$ and 0.4 are consistent → energy loss radiated outside the cone





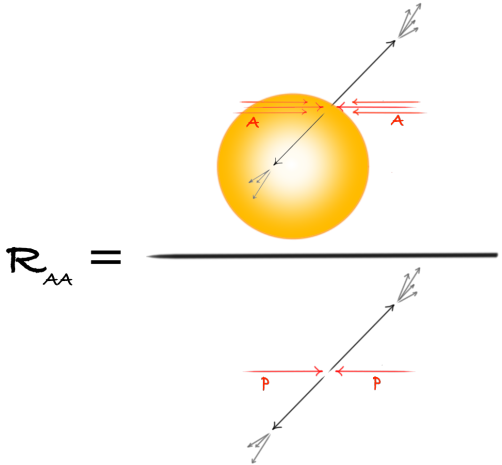


QGP characterisation

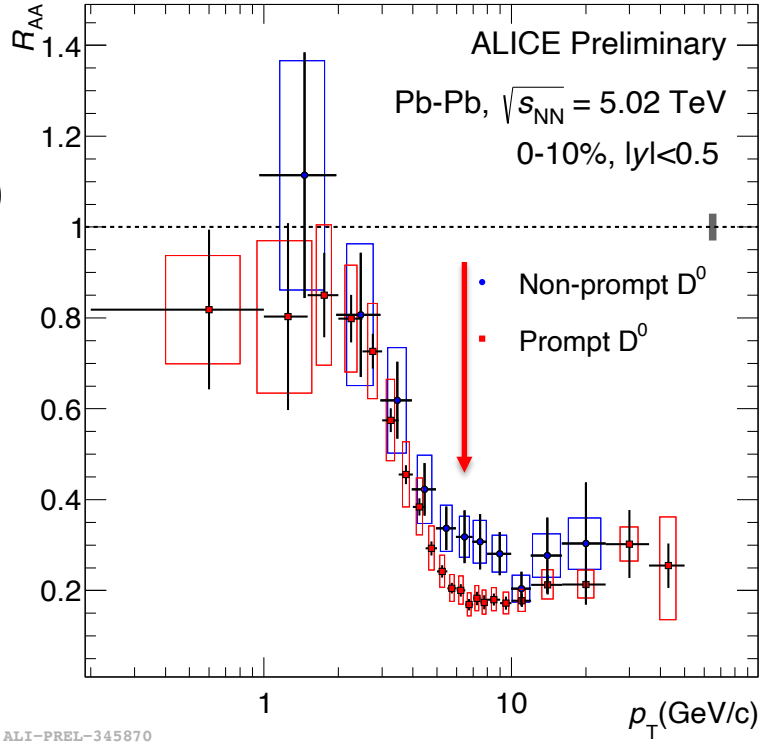
Heavy-flavour jets are quenched

Heavy flavours are produced in the hard scattering → travel through the QGP

Energy loss depends on quark mass
→ prompt D-mesons (from c quarks) more suppressed than non-prompt ones (from b quarks)



$$R_{AA} = \frac{\text{Pb-Pb}}{\text{p-p}}$$



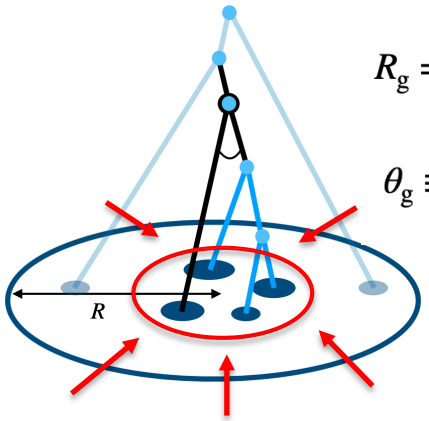
QGP characterisation

Jets have modified angular scale

Groomed jet: removing soft wide-angle radiation

Soft Drop alogorithm

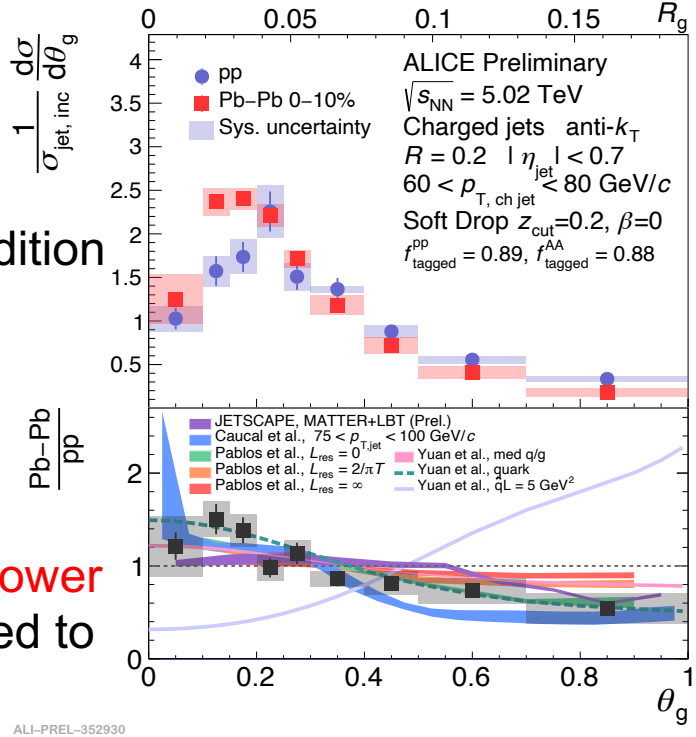
- clustering a jet
- re-clustering the constituents of that jet
- identifying a splitting that satisfies the grooming condition



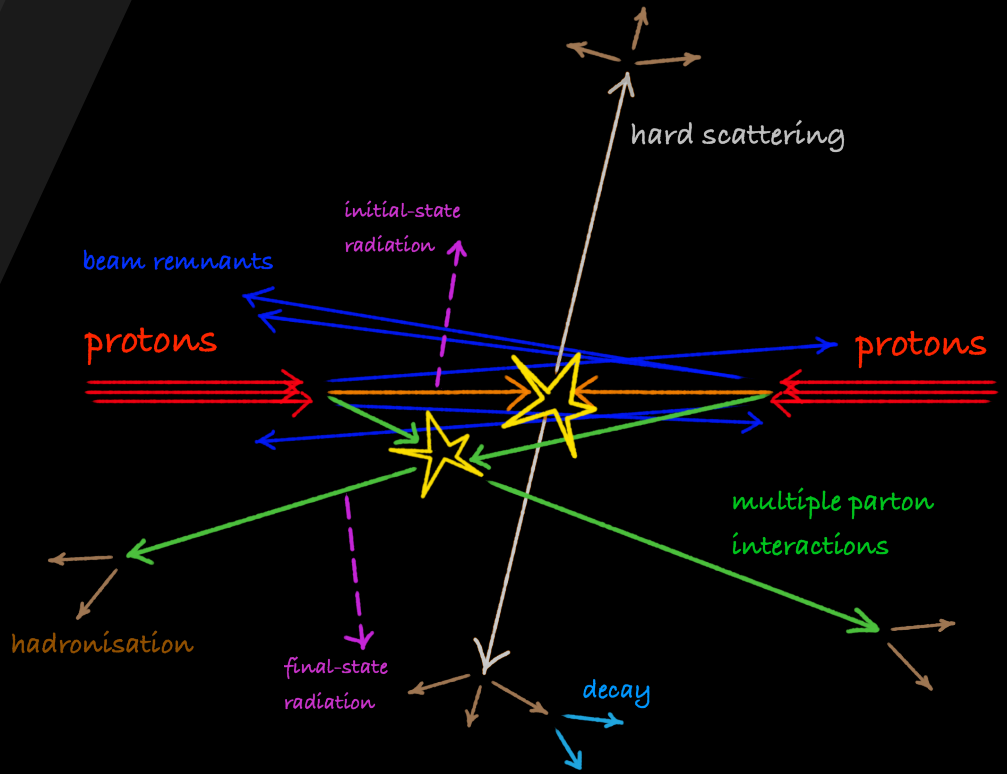
$$R_g = \sqrt{\Delta y^2 + \Delta \varphi^2}$$

$$\theta_g \equiv \frac{R_g}{R}$$

The θ_g distributions are narrower in Pb–Pb collisions compared to pp collisions



QCD-related measurements



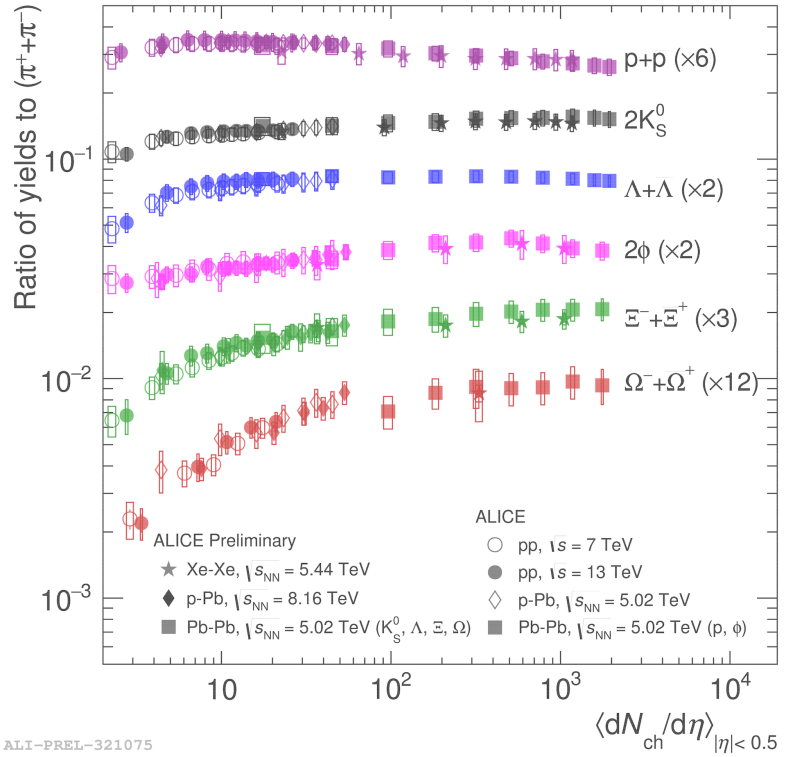
QCD properties in pp and AA

Strangeness enhancement

- In pp, the production of strange hadrons is suppressed relative to hadrons containing only light quarks due to quark s mass

- In AA particle ratios are described by a grand-canonical approach within the statistical hadronsation model

➢ What is the microscopic mechanism that explains strangeness enhancement?



QCD properties in pp and AA

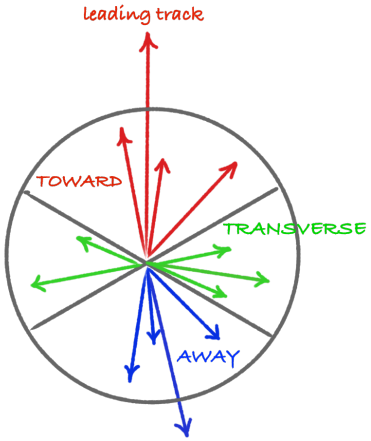
Strangeness enhancement

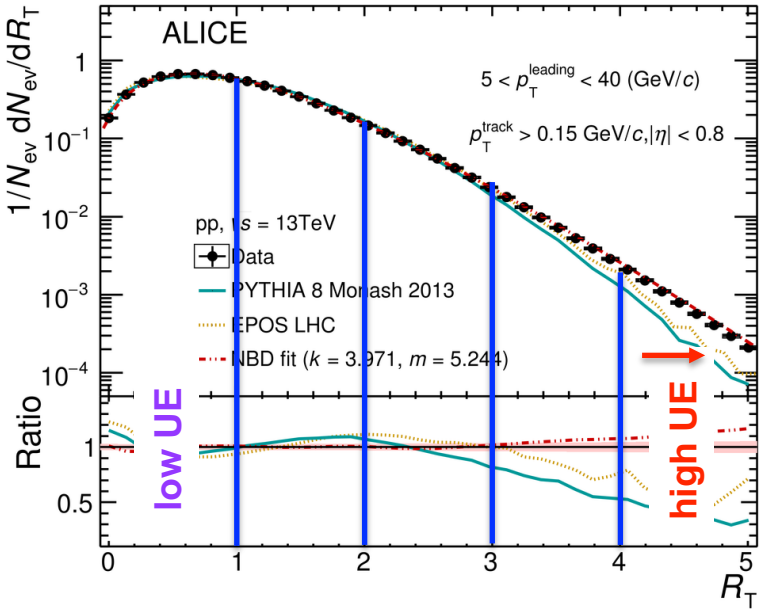
Define relative transverse activity classifier in the plateau region

$5 < p_T^{\text{leading}} < 40$ GeV/c

Martin, Skands, Farrington
Eur.Phys.J.C 76 (2016) 5, 299

$$R_T = \frac{N_{ch}^{transverse}}{\langle N_{ch}^{transverse} \rangle}$$





(almost) jet–free multiplicity estimator

➢ use it as tool for particle-production studies

QCD properties in pp and AA

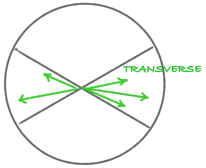
Strangeness enhancement

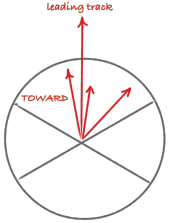
Particle production vs R_T

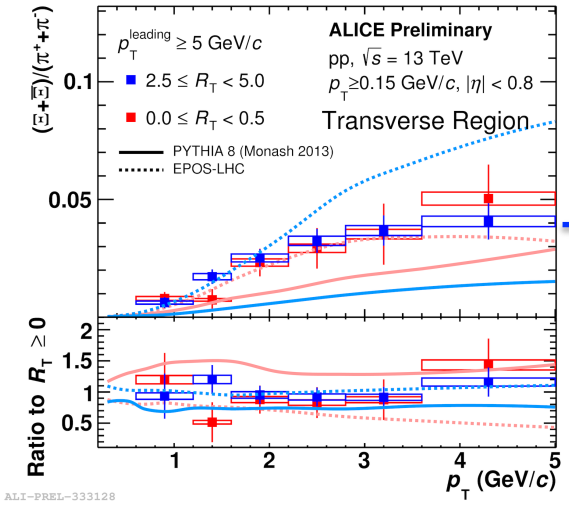
$$R_T = \frac{N_{ch}^{transverse}}{\langle N_{ch}^{transverse} \rangle}$$

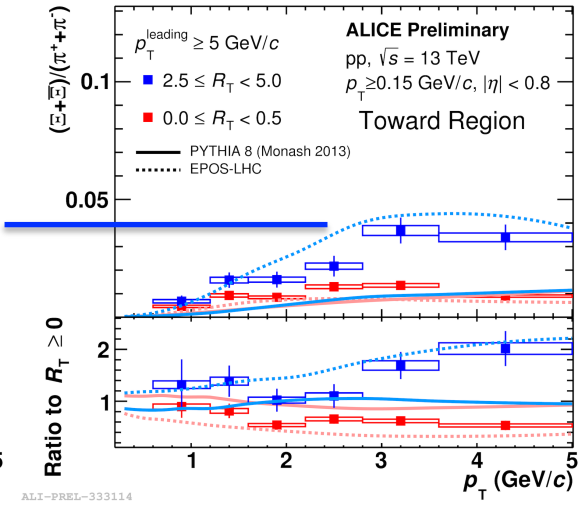
- transverse
  - no enhancement
- toward
  - enhancement
  - for high R_T values
    → same ratio yields as transverse

➢ Strangeness enhacement observed in
- jet+UE
- high UE activity









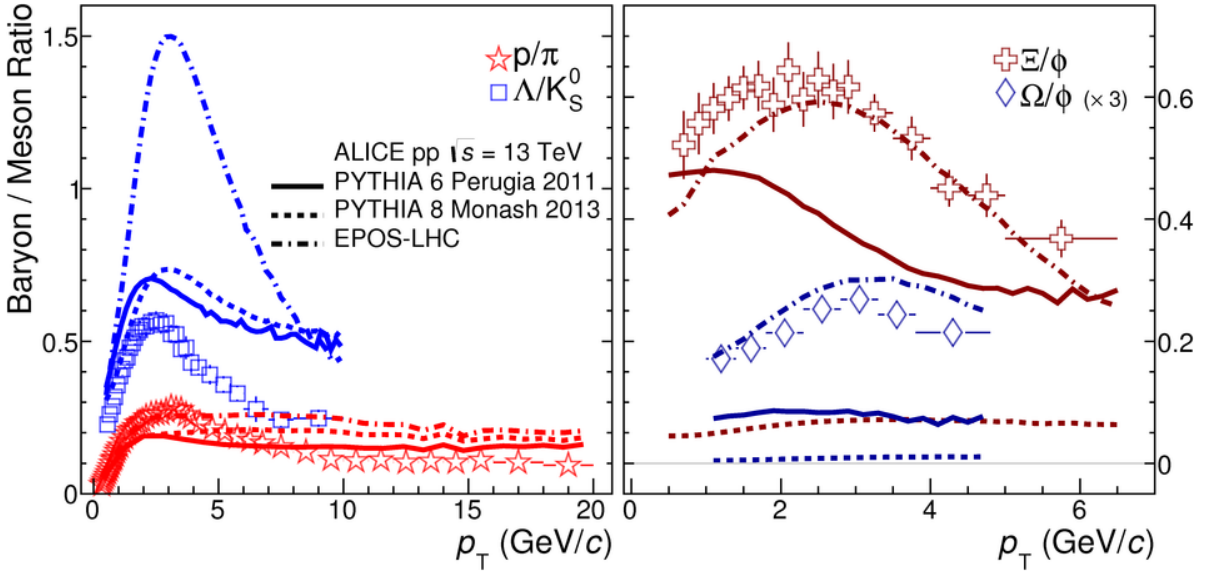
QCD properties in pp

Baryon-hadronisation studies

Modelling baryons is difficult due to their colour topology

➢ are not included in leading-colour approximations → interesting probes!

- p/π^0 (|S|=0)
  - models are flatter than data
- Λ/K^0_S (|S|=1)
  - EPOS LHC off
  - PYTHIA overestimates data by factor 3
- Ξ/ϕ (|S|=2) and Ω/ϕ (|S|=3, all s)
  - EPOS LHC good
  - PYTHIA off



QCD properties in pp

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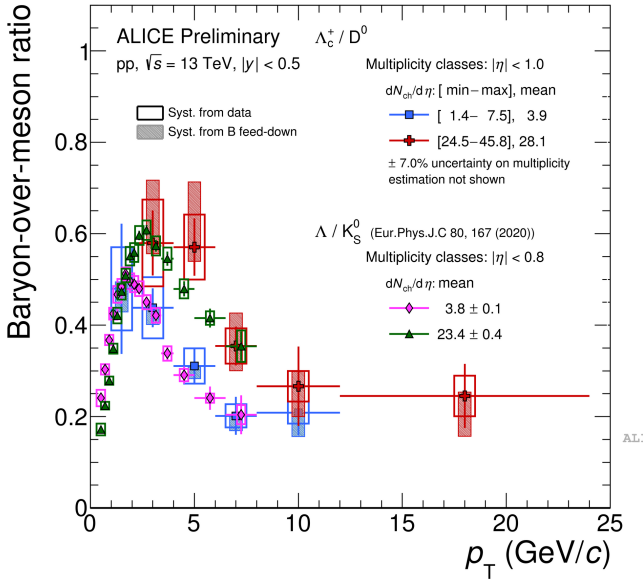
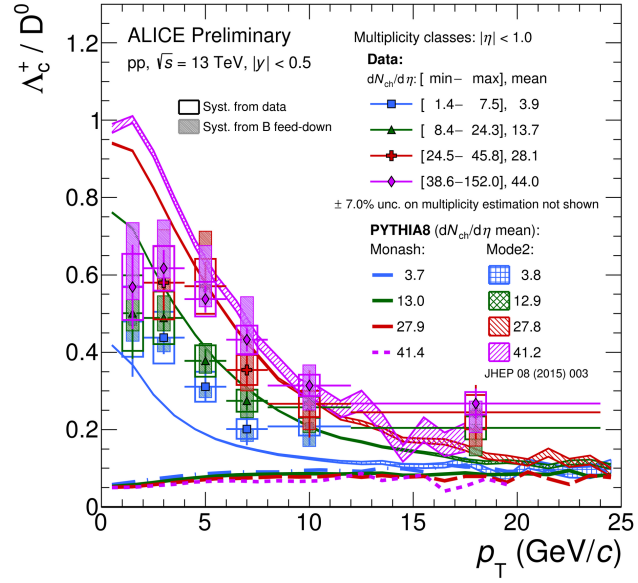
Same trend for Λ_c/D^0 (|C|=1)

- is mid-p_T enhancement a baryon/meson feature?
- PYTHIA Mode2 (QCD-CR) works for Λ_c/D^0…





QCD properties in pp

Baryon-hadronisation studies

Modelling baryons is difficult due to their colour topology

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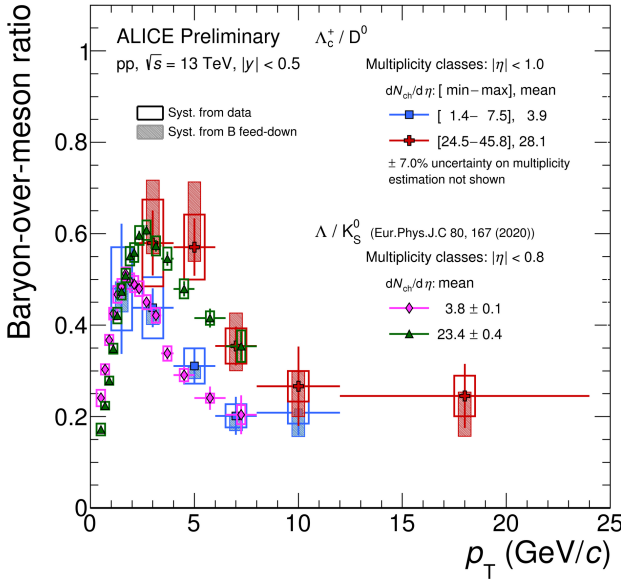
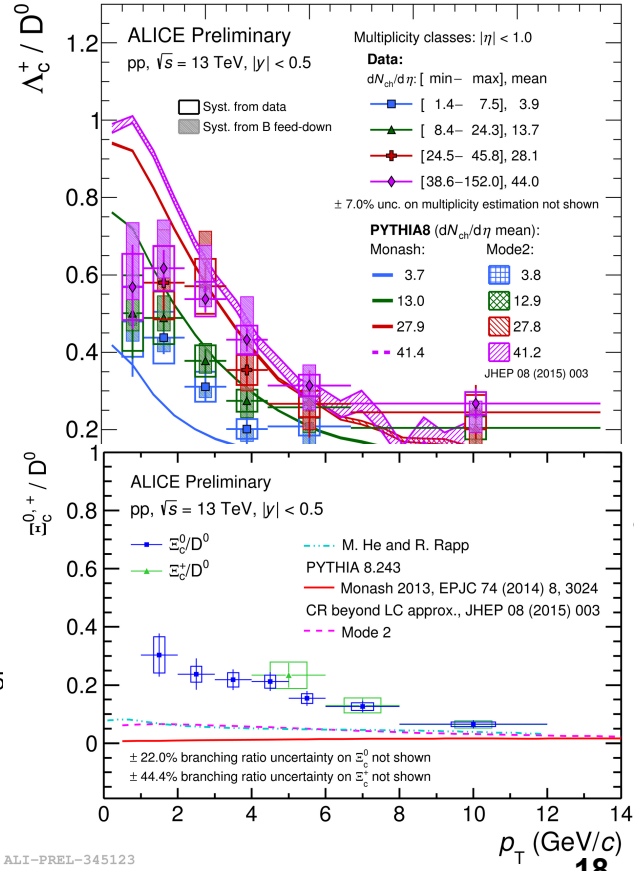
Same trend for Λ_c/D^0 (|C|=1)

- is mid-p_T enhancement a baryon/meson feature?
- PYTHIA Mode2 (QCD-CR) works for Λ_c/D^0…
- …but not for Ξ_c/D^0!





Conclusions and outlook

Extensive results for LHC Run 1 and 2:

- detailed QGP characterisation (spin, flow, jet quenching…)
- advanced QCD studies (strangeness, baryons and mesons hadronisation…)

Looking forward to Run 3!

…see next talk by Domenico

Comunicazioni

https://agenda.infn.it/event/23656/contributions

1. Measurement of (anti-)^{3}He absorption cross-section with ALICE – P. Larionov
2. Measurement of charmed baryon production with ALICE experiment at LHC – M. Faggin
3. Azimuthal correlations of D mesons with charged particles in pp collisions at 13TeV13TeV with ALICE – A. Palasciano
4. Produzione di D*+ in collisioni pp con ALICE a √s=13 TeV in LHC – M. Giacalone
5. Hunting hypertritons in heavy ion collisions with the ALICE experiment using a machine learning approach – P. Fecchio
6. Measurement of light (anti-)nuclei production with ALICE – A. Balbino
7. Measurement of quarkonium polsarization in Pb--Pb collisions at the LHC with ALICE – L. Micheletti
8. Studio delle anisotropie azimutali del charm con l'esperimento ALICE a LHC – S. Trogolo
9. Electroweak bosons production in heavy ion collisions with ALICE – N. Valle
10. Measurements of hadronic resonance production with ALICE – A. Rosano