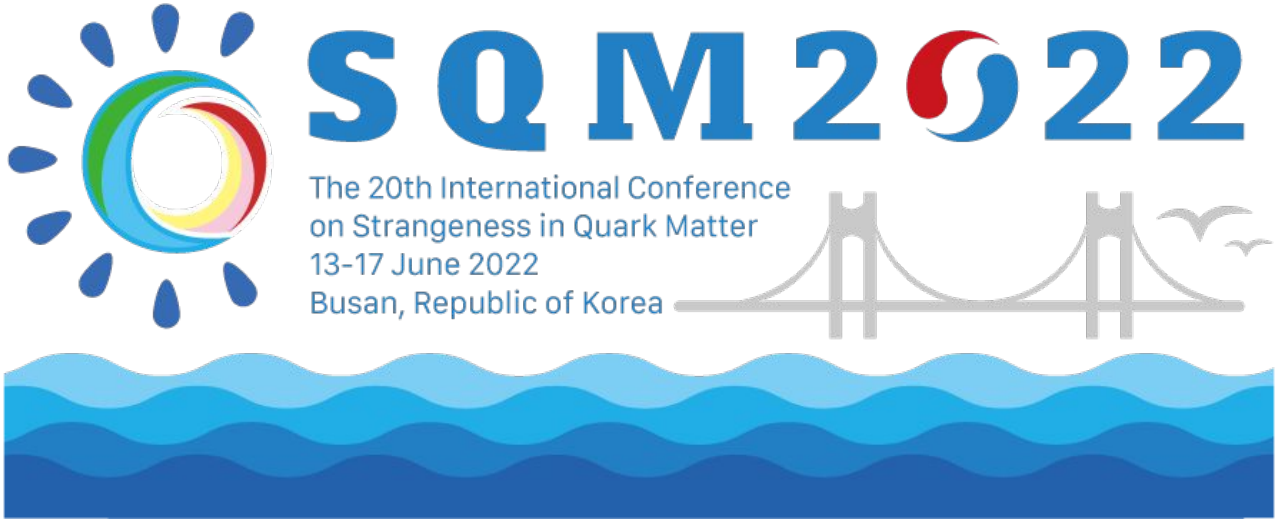

ALICE

Heavy-flavour jet properties and correlations from small to large systems

Antonio Silva for the ALICE Collaboration
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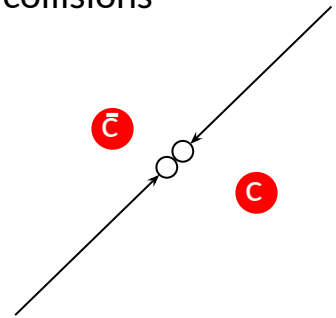
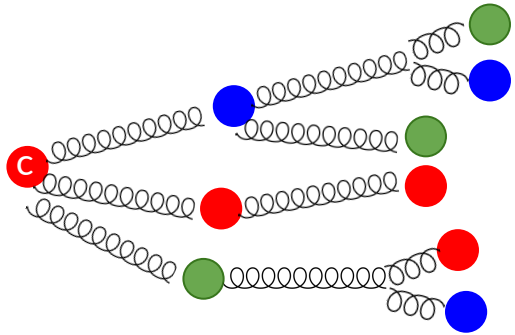
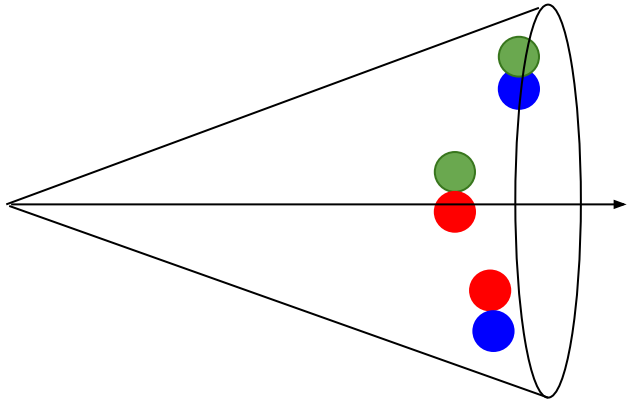
THE UNIVERSITY OF TENNESSEE KNOXVILLE

Physics Motivation

pp collisions







Heavy flavour quarks are produced in **hard scattering** in the **early stage** of the collision

Due to their relatively **large mass**, their production is well **described by pQCD**

The parton shower is affected by **dead-cone effect** → depends on the mass of the initial parton

Heavy flavour quark is **conserved** in the shower → **tagging** of heavy-flavour production

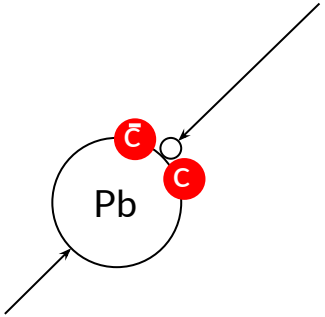
Hadronization

How much of the initial parton energy is carried by the final heavy-flavour hadron?

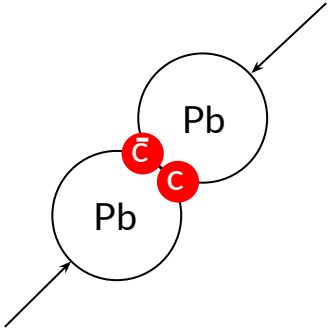
Mesons vs baryons: different hadronization mechanisms?

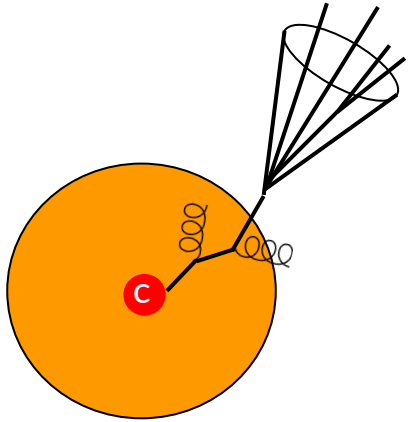
Physics Motivation

p–Pb collisions



Pb–Pb collisions





How heavy flavour is affected by **cold nuclear matter** effects?

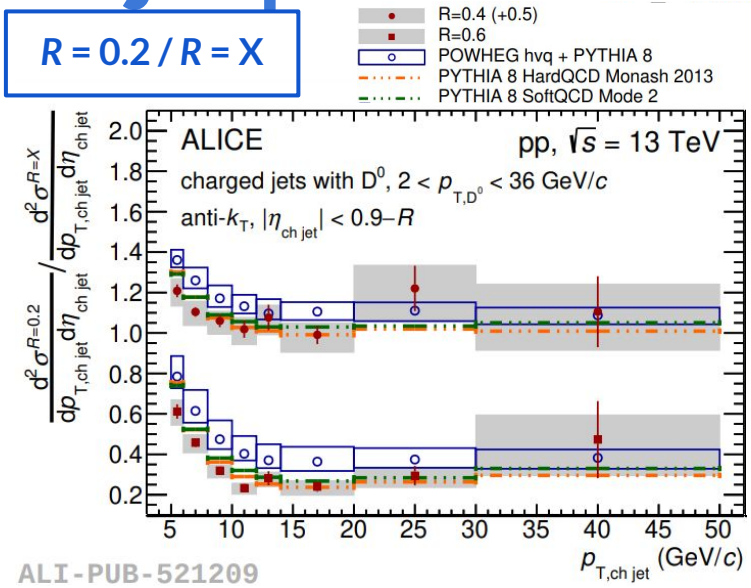
Heavy flavour are ideal probes for the quark-gluon plasma (QGP):

Are charm **fragmentation** mechanisms modified in QGP with respect to pp collisions?

Mass dependent **energy loss**?

D⁰-jet production in pp collisions

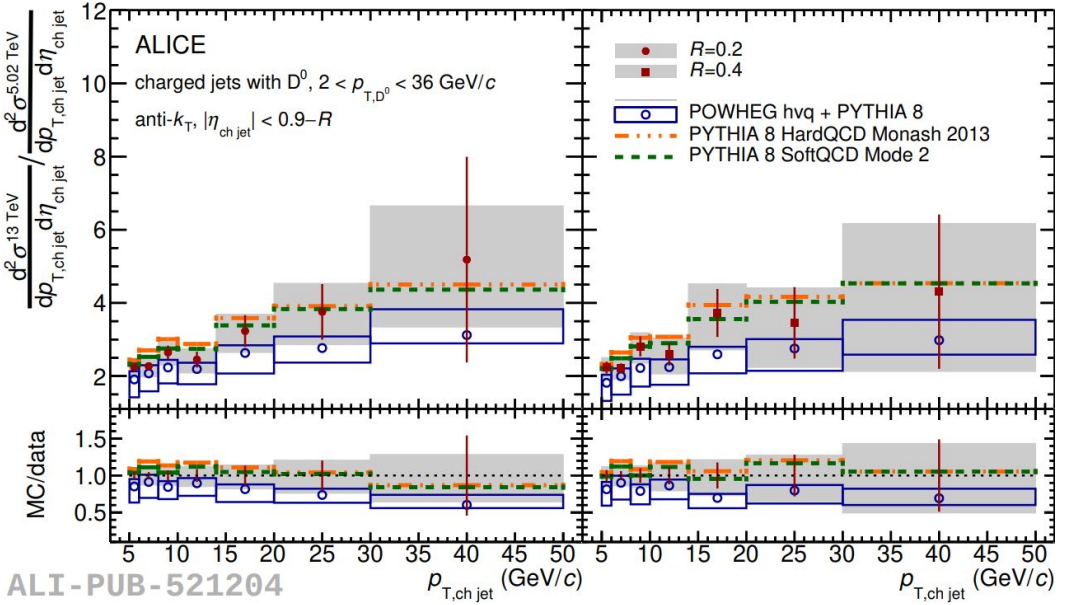
R = 0.2 / R = X



Exploration of the **particle shower**

Interplay between **perturbative** and **non-perturbative** effects

13 TeV / 5 TeV



Hardening of the D⁰-jet transverse momentum with **increasing center-of-mass energy**

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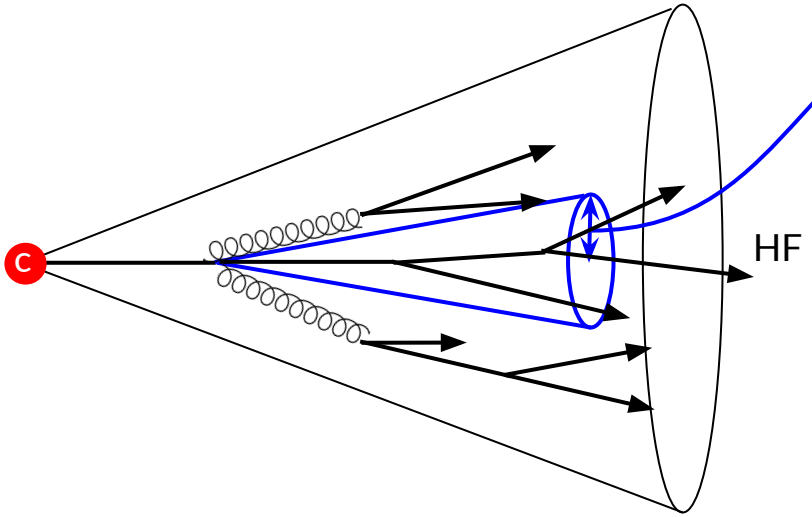
PYTHIA 8: JHEP 1508 (2015) 003

POWHEG: JHEP 06 (2010) 043

Parton shower: dead-cone effect



~ $\theta < m_q/E_q$ gluon radiation suppressed

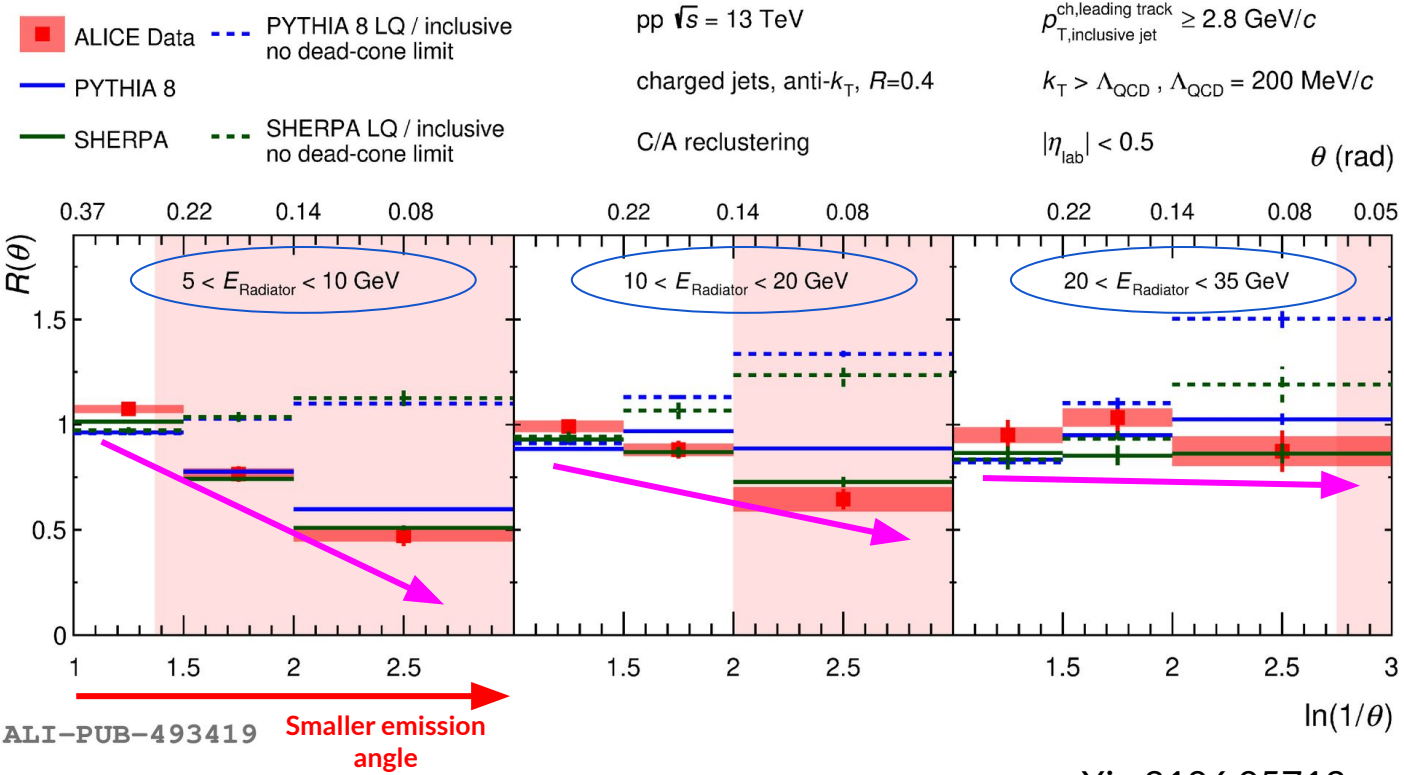
HF hadron → heavy quark survives the parton shower

Jet algorithms are used to cluster **final state particles** originating from a **scattered parton** into jets

Dead-cone effect:

- Sizeable quark mass dependent effect. Suppression of emission phase space $\theta < \theta_{DC} = m_q/E_q$

Parton shower: dead-cone effect



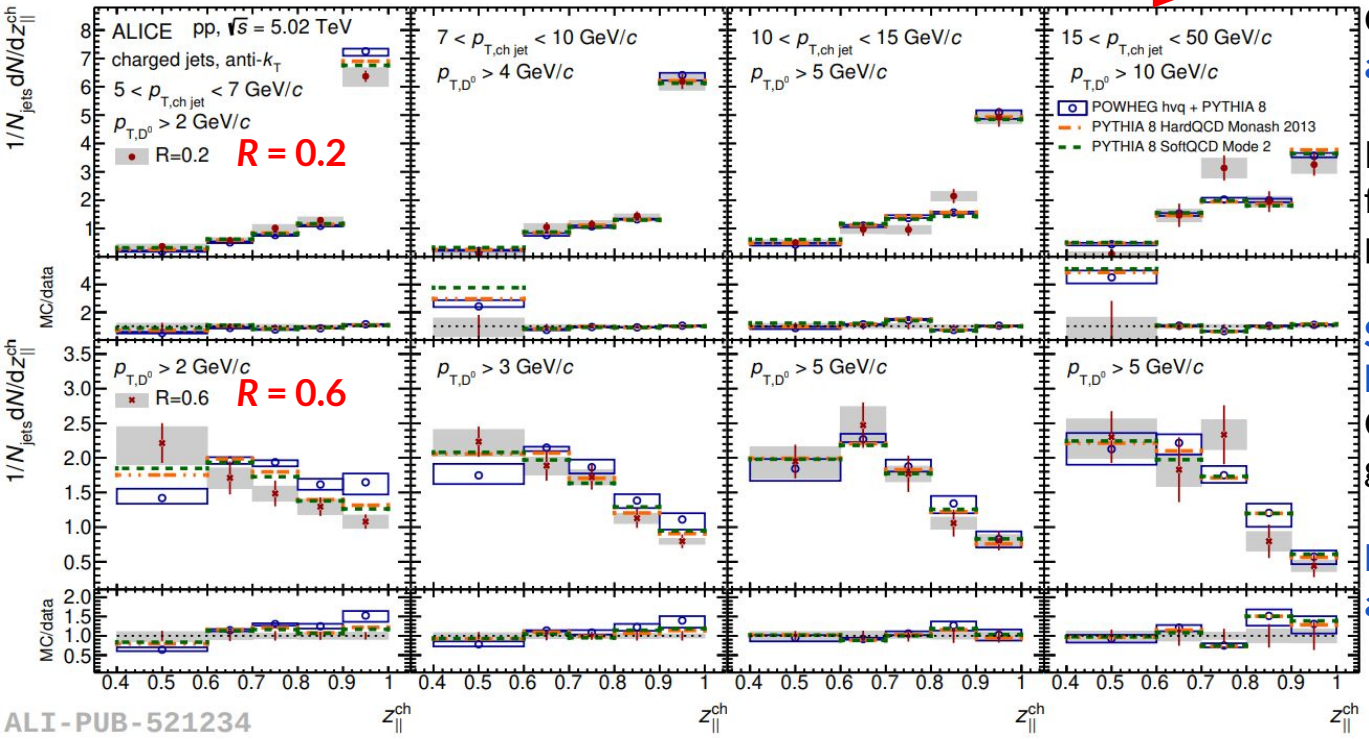
Ratio of emission angle distributions for **charm quark** over **inclusive partons**

Significant suppression of small-θ emissions

arXiv:2106.05713

D⁰-jet momentum fraction

Increasing D and jet p_T



Charm fragmentation gets **softer at higher jet p_T**

Dependence of momentum fraction on resolution parameter:

Smaller *R* → Dominated by **heavy-flavour hadron**. Compatible with **suppression** of gluon emission at **low angles**

Larger *R* → Emissions at **large angles** are **recovered**

$$z_{\parallel}^{ch} = \frac{\vec{p}_{ch\ jet} \cdot \vec{p}_{HF}}{\vec{p}_{ch\ jet} \cdot \vec{p}_{ch\ jet}}$$

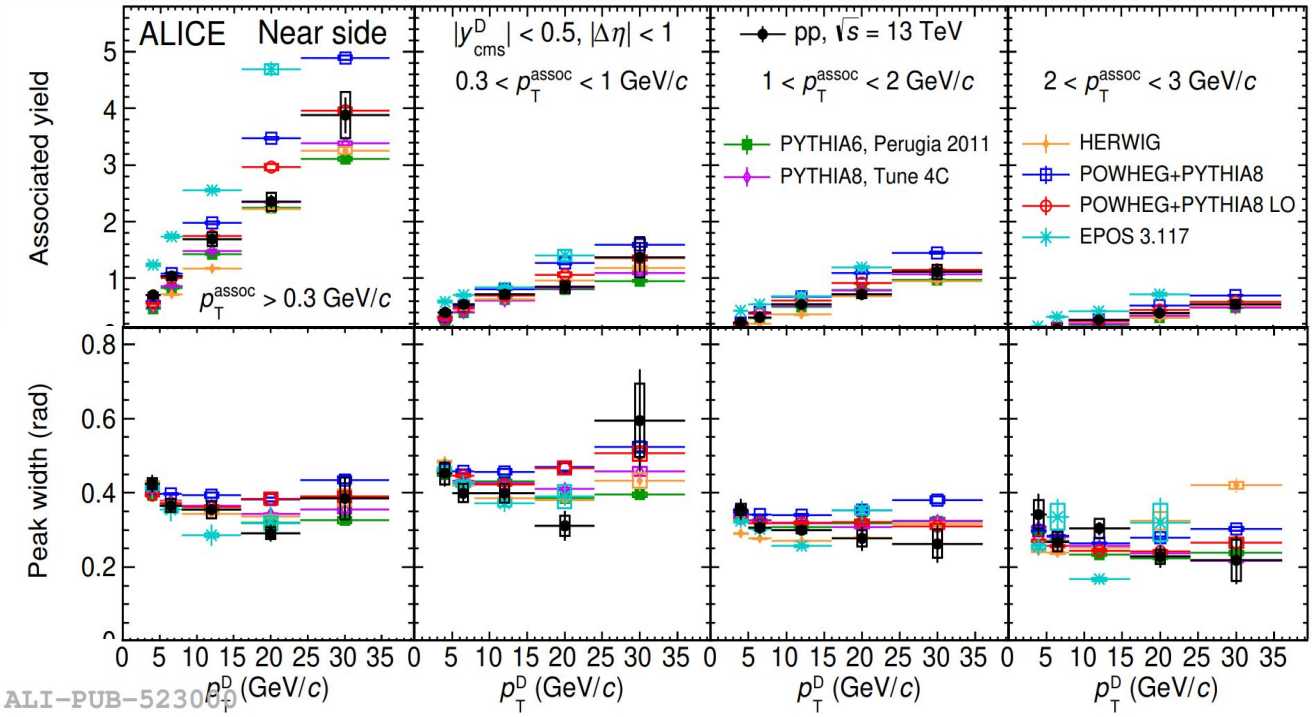
NEW ALICE-PUBLIC-2022-017

PYTHIA 8: JHEP 1508 (2015) 003
POWHEG: JHEP 06 (2010) 043

SQM 2022

D-h correlations

Increasing associated particles p_T



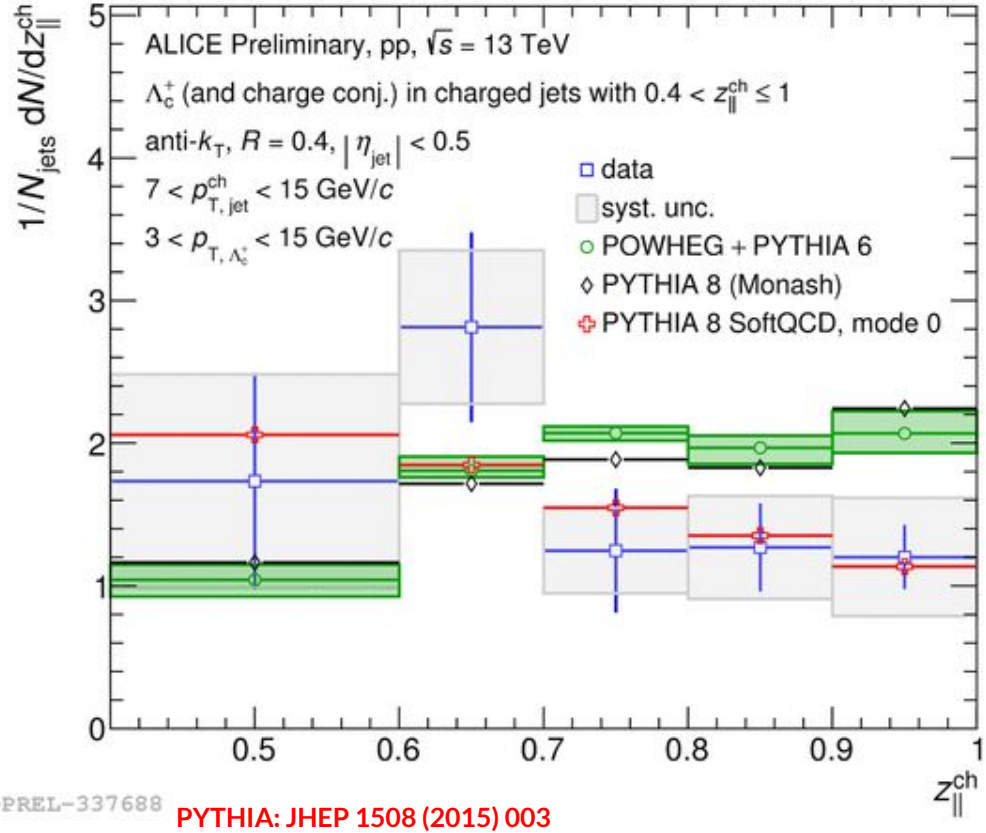
Increase of associated particles with increasing D-meson p_T
→ Characterization of **particle multiplicity** in jets
→ Compatible with **softer fragmentation** for high p_T jets

Decrease of the peak width with increasing D-meson p_T
→ Jet hard core **more collimated**

Eur. Phys. J. C 82 (2022) 335

PYTHIA: JHEP 1508 (2015) 003
POWHEG: JHEP 06 (2010) 043
EPOS 3: Phys.Rev.C 82(2010)044904
HERWIG: Eur.Phys.J C76 (2016) 196

Λ_c-Jet momentum fraction



PYTHIA: JHEP 1508 (2015) 003
POWHEG: JHEP 06 (2010) 043

HF-tagged jets
→ Evolution of **quarks to hadrons**

Heavy-flavour jet tagging using Λ_c

Data indicate **softer fragmentation** with respect to classic in vacuum fragmentation models at **low jet transverse momentum**

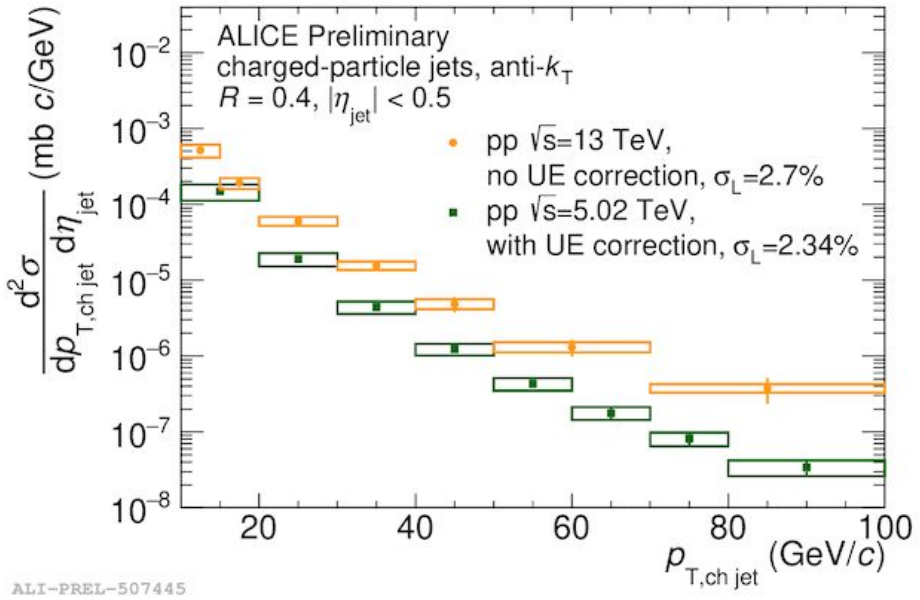
$$z_{\parallel}^{ch} = \frac{\overrightarrow{p}_{ch\ jet} \cdot \overrightarrow{p}_{HF}}{\overrightarrow{p}_{ch\ jet} \cdot \overrightarrow{p}_{ch\ jet}}$$

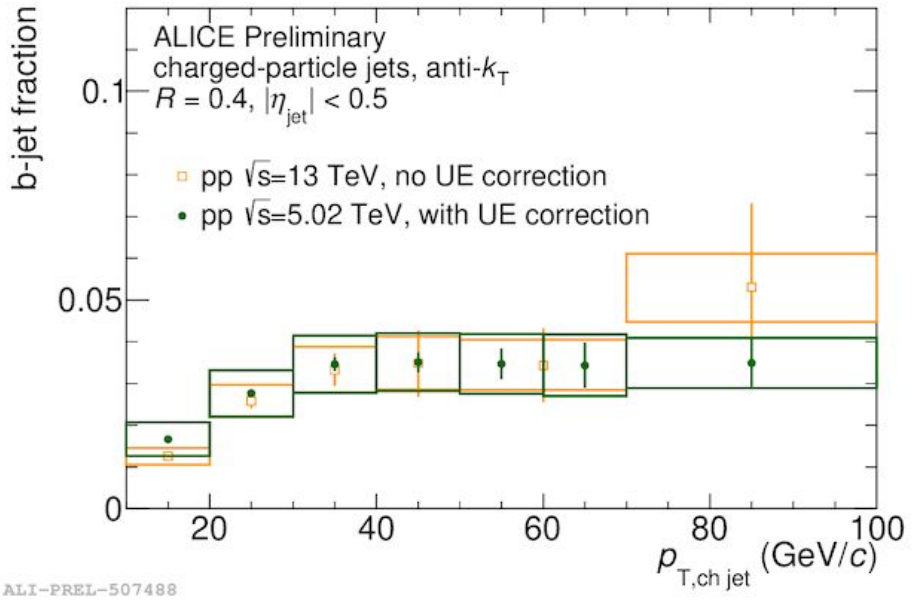
Talk
Jinjoo Seo
14/06 - 12:10

b-jet production in pp collisions

NEW

JHEP 01 (2022) 178

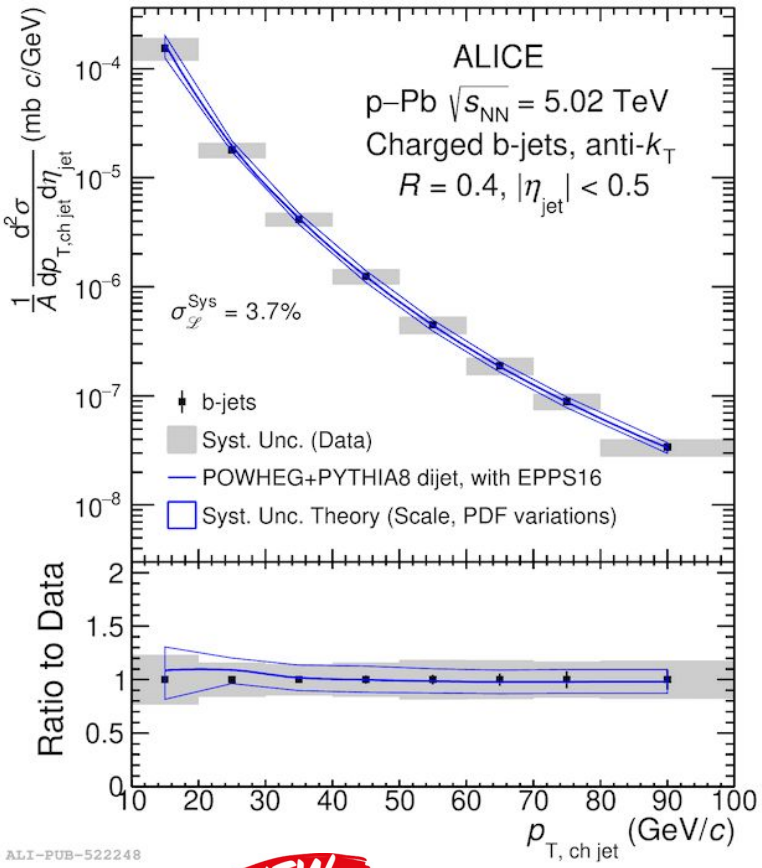


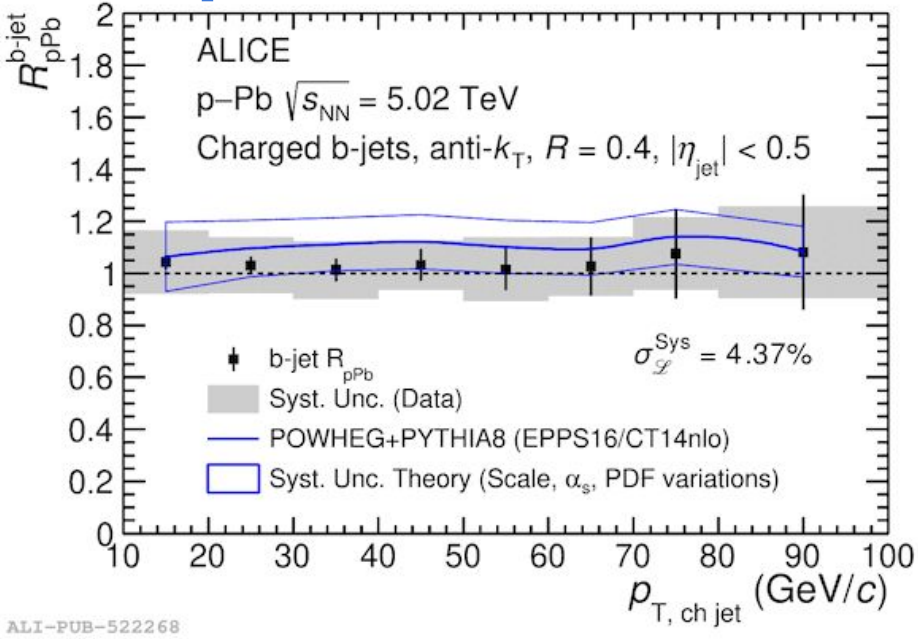


- b-jet identification:
  → Exploits the relatively **long decay length of b-hadrons** using the **impact parameter**
- **Hardening** of the cross section with increasing center-of-mass energy

- Fraction of charged-particle **b-jets over inclusive** charged-particle jets
- **1-2%** in the interval 10 < b-jet p_T < 20 GeV/c
- **3%** above 30 GeV/c

Larger systems: b-jets in p–Pb





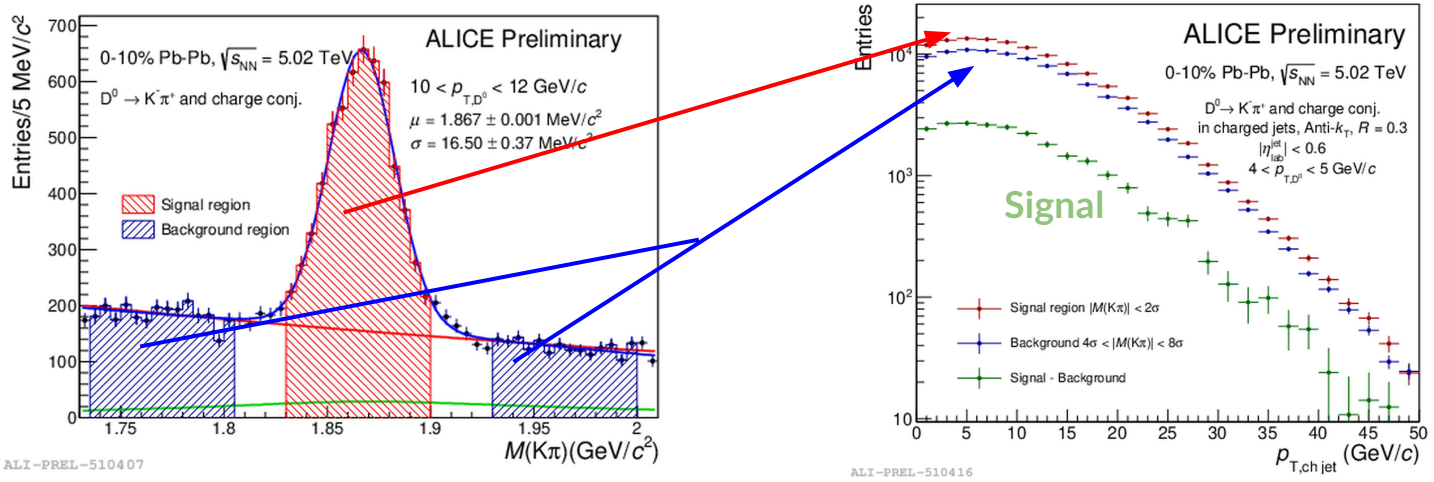
b-jets in p–Pb collisions are **well described by NLO pQCD** calculations (POWHEG+PYTHIA 8)

With the current precision, R_{pPb} consistent with unity
→ **no cold nuclear matter effects were observed**

NEW **JHEP 01 (2022) 178**

Antonio Silva

Hot nuclear matter: D⁰-Jet in central Pb–Pb



Signal D^0-jet p_T obtained from the signal region with normalized side-bands region subtraction

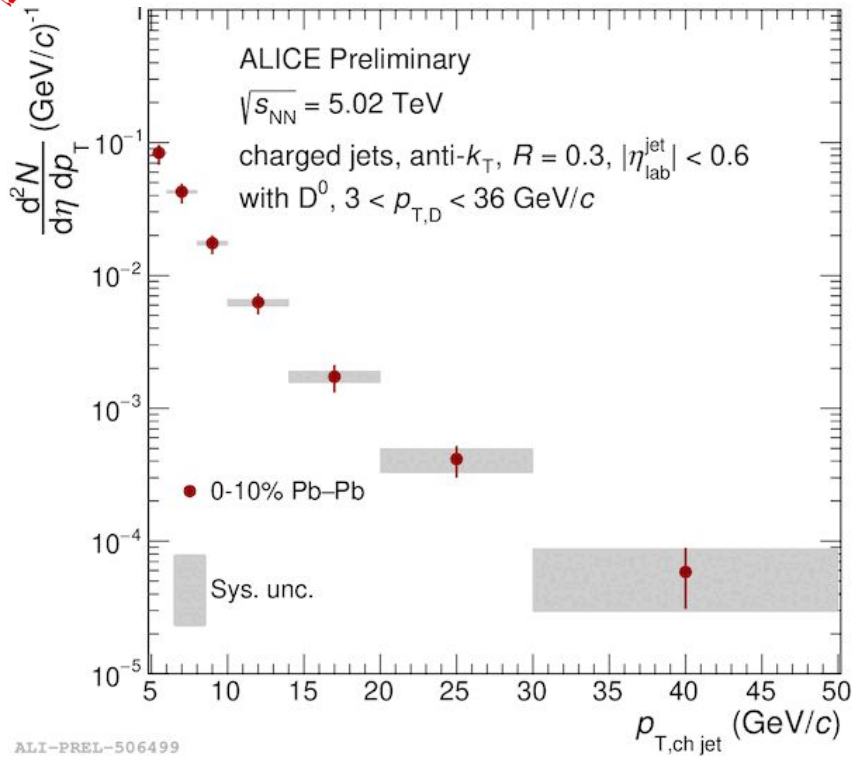
Corrected by D^0-jet reconstruction efficiency

Removed feed-down contribution from bottom quarks
→ POWHEG simulation and non-prompt D^0 R_{AA} measurement (CERN-EP-2022-015)

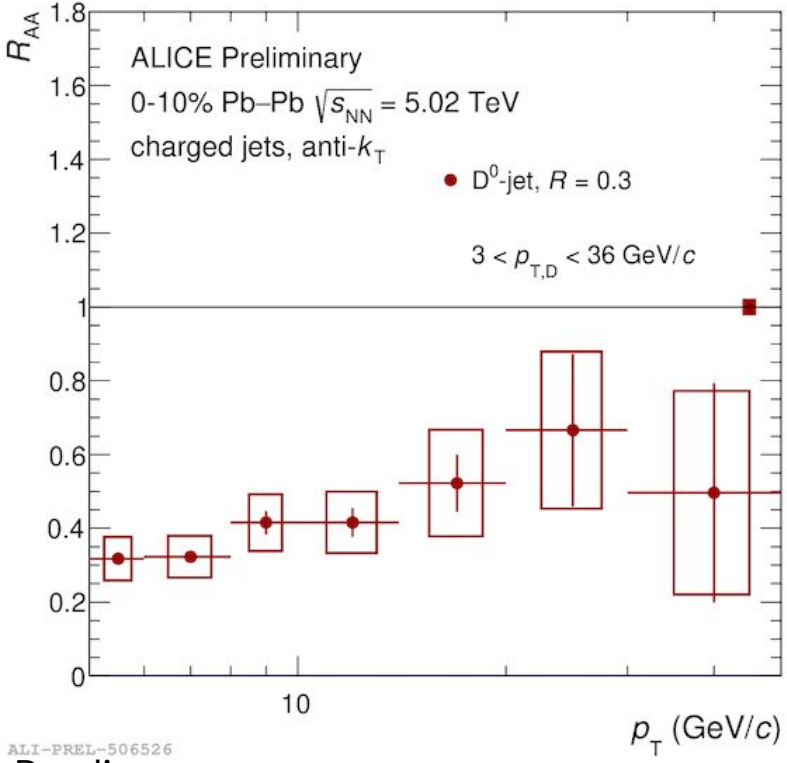
D^0-jet p_T corrected for detector effects using Bayesian unfolding

Hot nuclear matter effects: D⁰-Jet in Pb–Pb

NEW

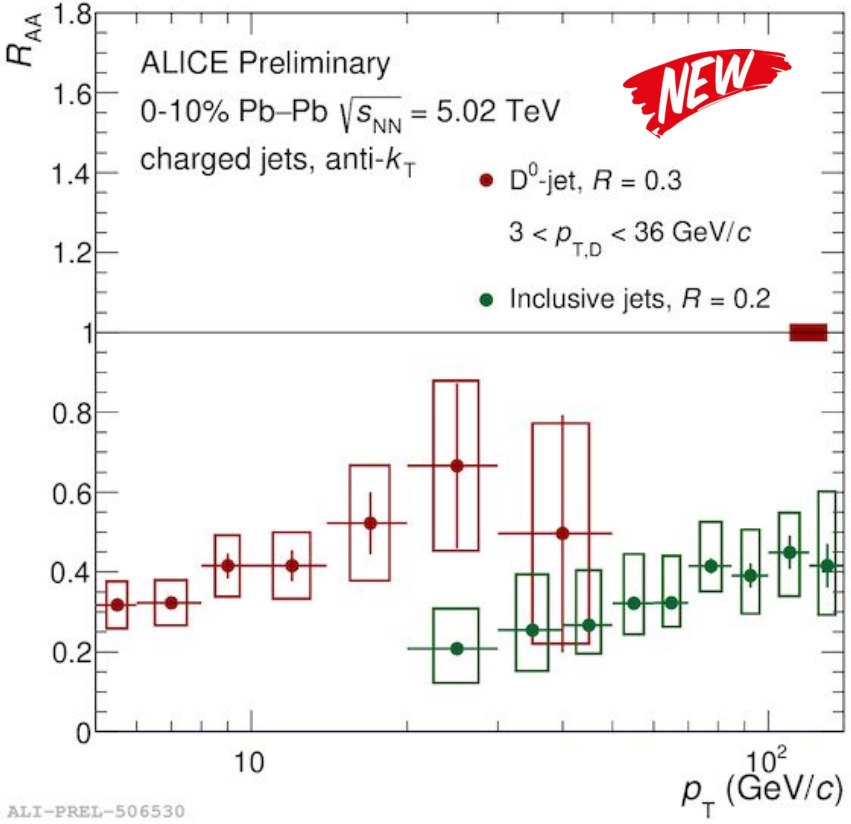


p_T-differential yields in central 0-10% Pb–Pb collisions



Baseline:
D⁰-jet cross section in pp collisions at 5.02 TeV
Same jet reconstruction and D⁰ p_T intervals

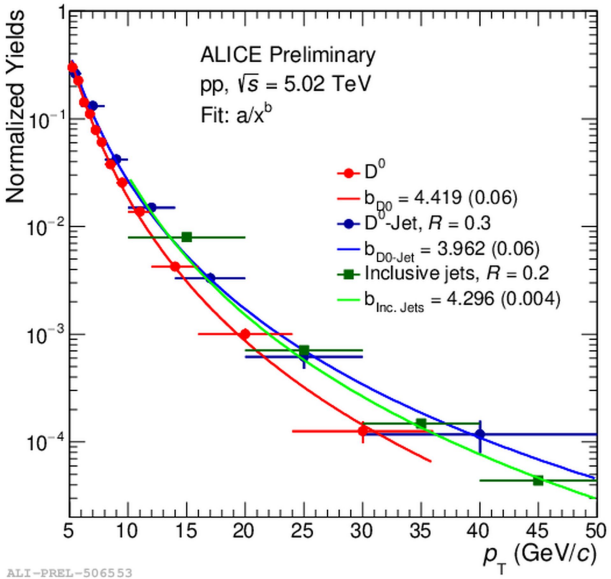
Hot nuclear matter effects: D⁰-Jet in Pb–Pb



ALI-PREL-506530

Is **D⁰-jet R_{AA} higher** than inclusive jets in central Pb–Pb collisions?

- Comparison can be sensitive to different contributions of quarks and gluons energy loss
- Mass-dependent effects, such as dead-cone, could play a role



ALI-PREL-506553

Summary

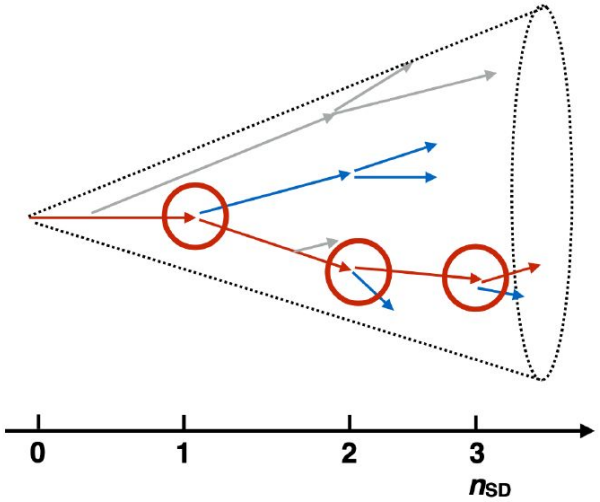
- Heavy-flavour jets → excellent tool to study the process of quarks going into hadrons
  - A deeper insight into jet structure → momentum fraction and D-hadron correlations
  - Heavy-flavour mass influences the parton shower → dead-cone effect
  - Hint of less suppression of D-tagged jets with respect to inclusive jets

What to expect from Runs 3 and 4?

- Higher statistics (x100) and improved DCA resolution
- Expand the successful pp program to explore pQCD and hadronization mechanisms in central heavy-ion collisions
- Study B-tagged jet production and substructure

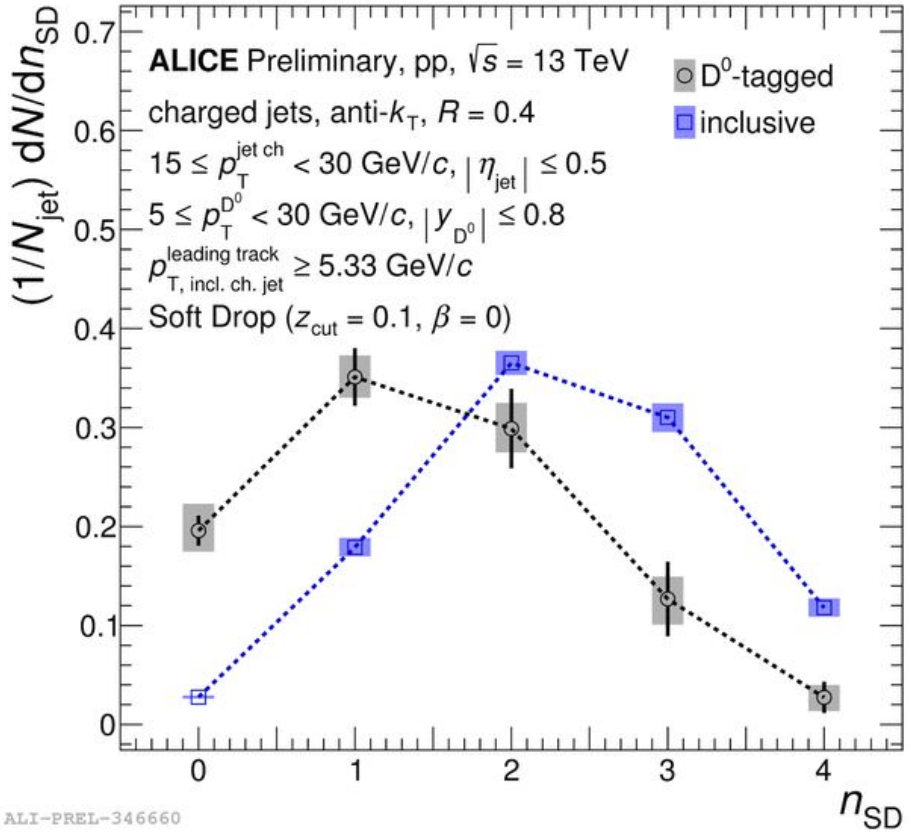
Backup

Parton shower



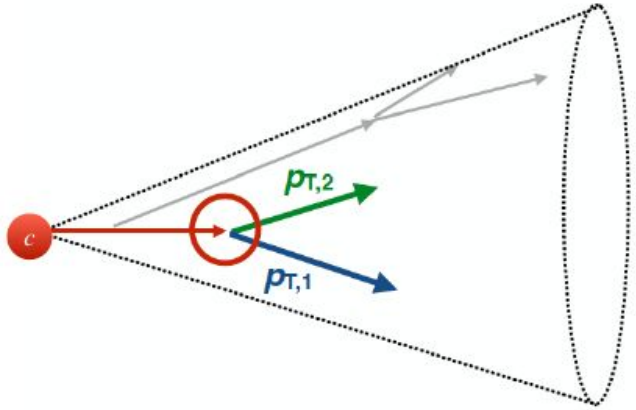
total number of splitting satisfying SD n_{SD}

Splitting function of groomed D^0-tagged and inclusive jets

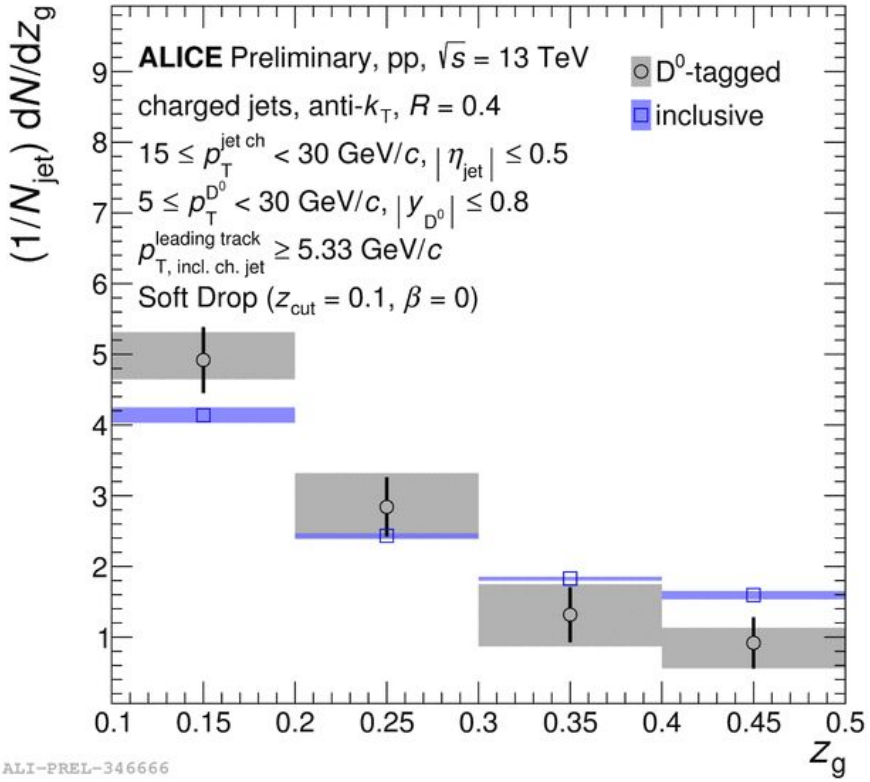


Parton shower

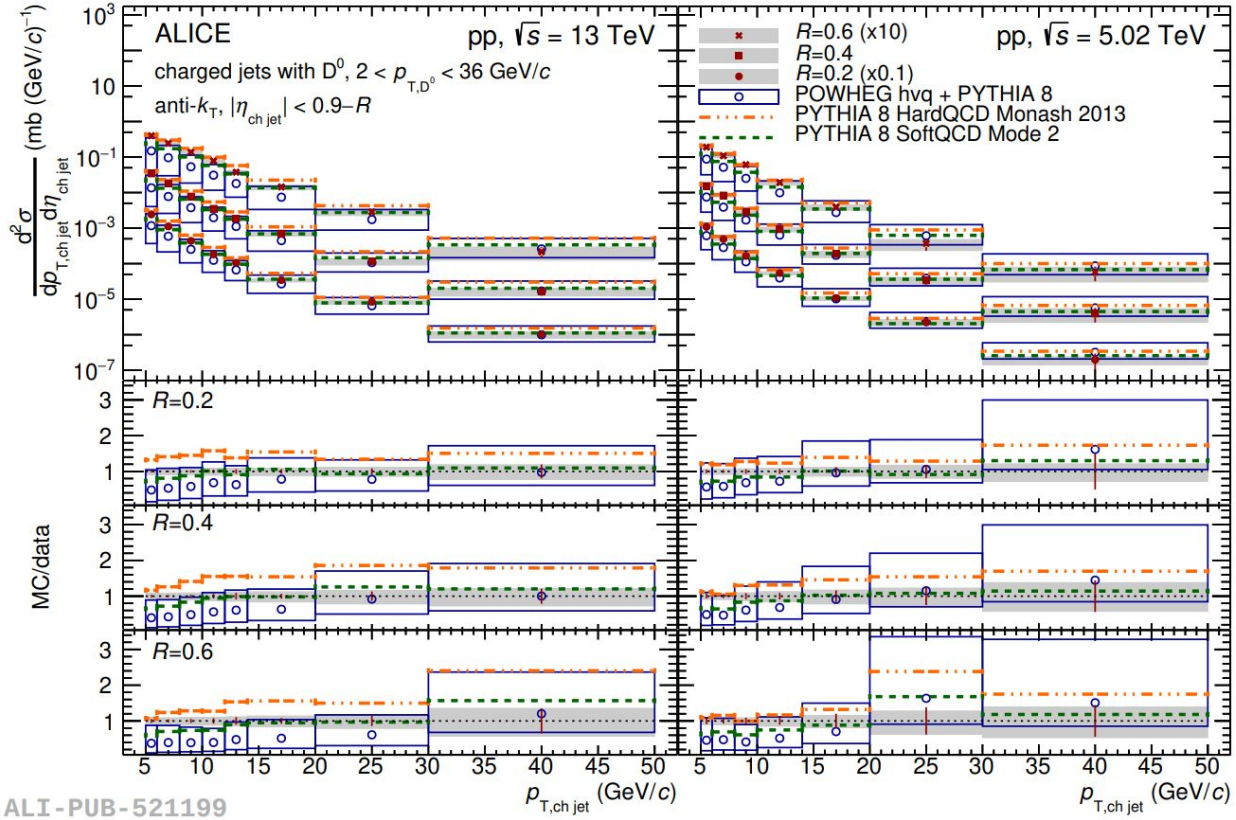
Probes c→cg splitting function
Isolate hard structures inside the jet



p_T balance between prongs $z_g = \dfrac{p_{T,2}}{p_{T,2} + p_{T,1}}$

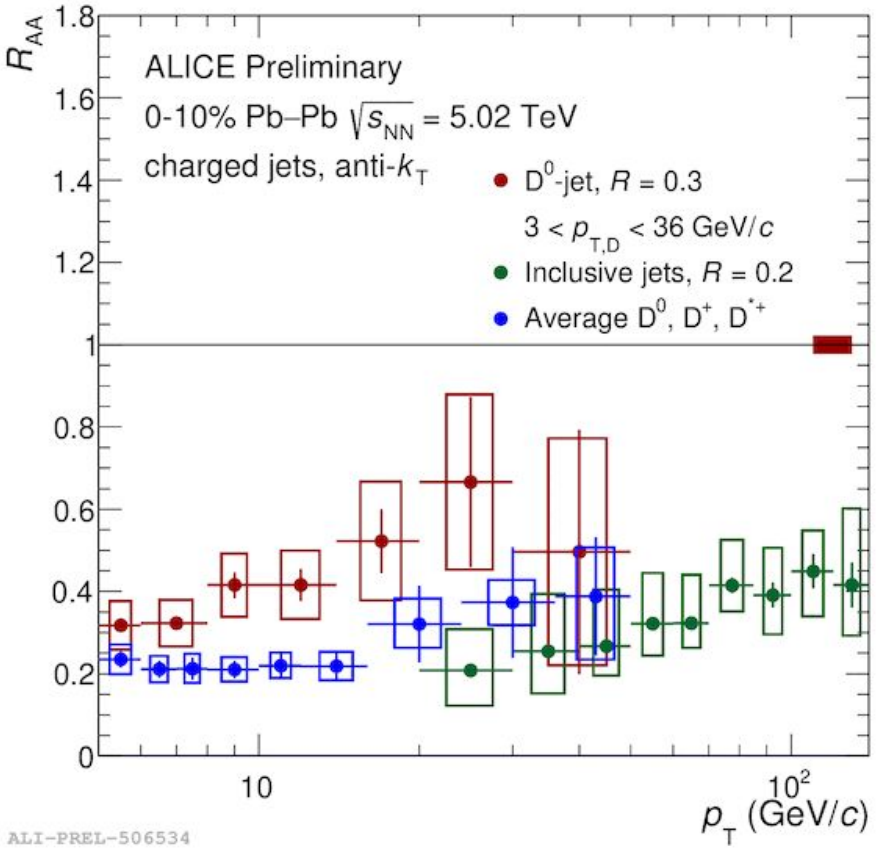


D^0-Jet in pp at 13 TeV



D^0-tagged jet cross section

Hot nuclear matter effects: D⁰-Jet in Pb-Pb



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