12th International Conference on Hard and Electromagnetic Probes of High-Energy Nuclear Collisions

ALICE highlights

Xiaozhi Bai (USTC)

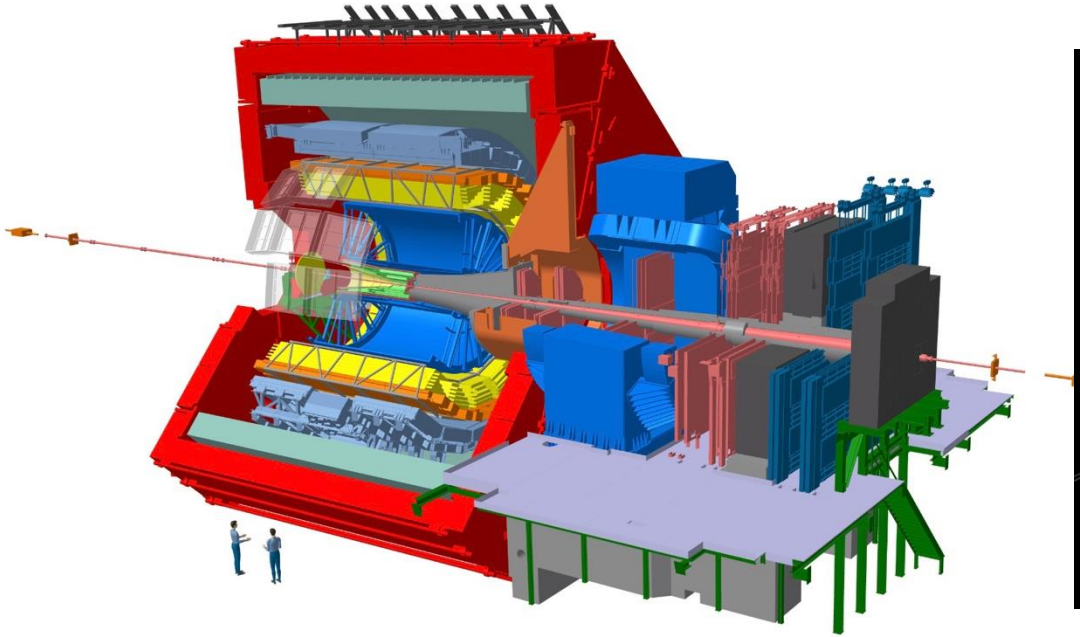
for the ALICE Collaboration

Nagasaki, Japan, 22nd - 27th, Sep. 2024

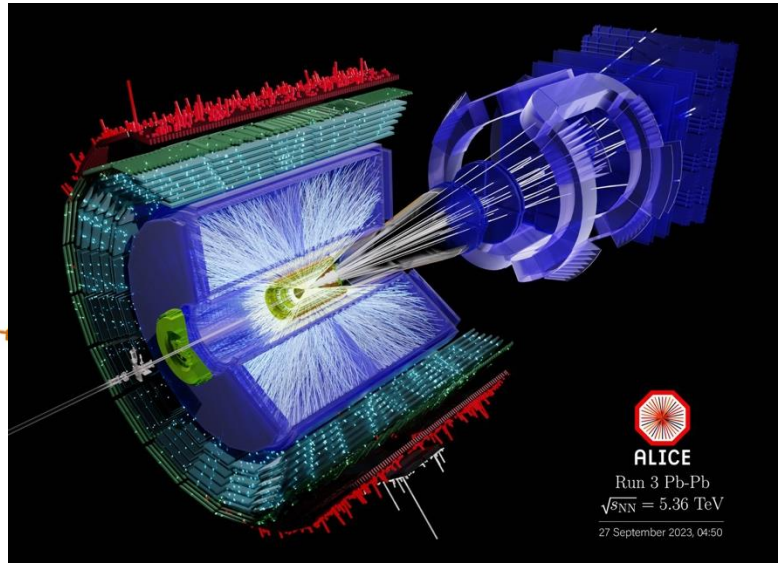
ALICE

HP2024 NAGASAKI

ALICE in Run 3 (Ongoing)

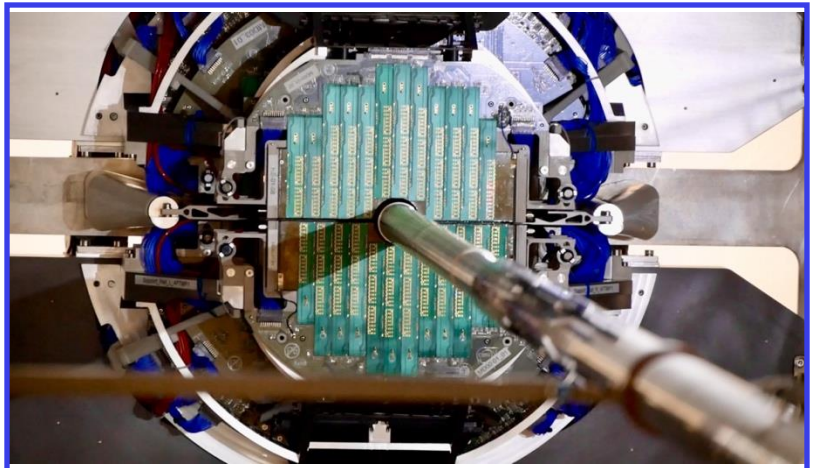


Major upgrades installed in 2019- 2021



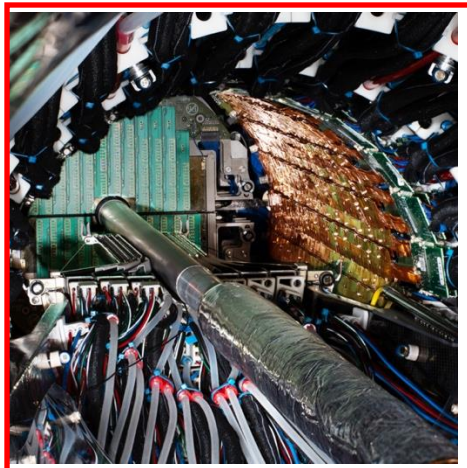
LHC LS2	LHC RUN 3	LHC LS3	LHC RUN 4	LHC LS4	LHC RUN 5 and RUN 6
2019-2021	2022-2025	2026-2028	2029-2032	2033-2034	2035-2041

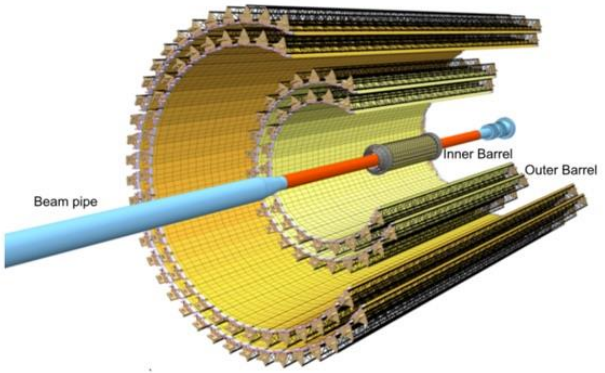
ALICE in Run 3 (MFT and ITS2)



New Muon Forward Tracker MFT CDS LINK

- Monolithic Active Pixel Sensor technology
- Spatial resolution: 5 µm
- Pixel size: 27 µm x 29 µm
- Integration time: 5 µs

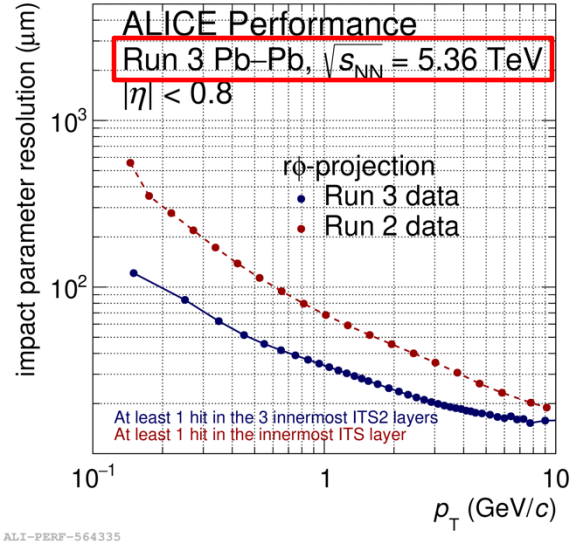


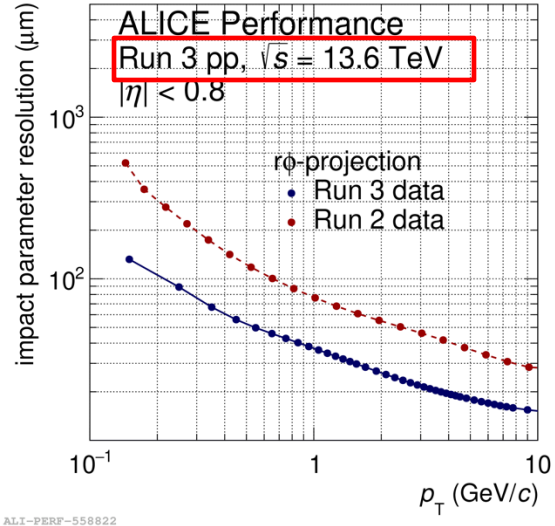


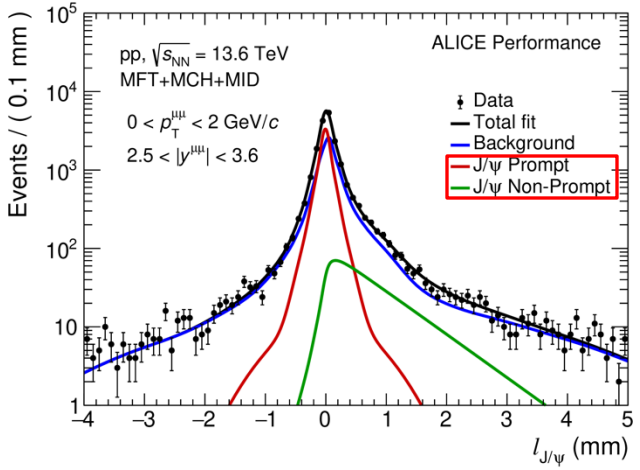
Upgraded Inner Tracking System TDR ITS2 LINK

- 3 layers in inner barrel (IB), 4 in outer barrel (OB)
- Get closer to IP: from 39 mm to 23 mm
- Reduced material budget: from 1.14% X_0 to 0.36% X_0 per layer
- Reduced pixel size: from 50 x 425 µm^2 to 29 x 27 µm^2

Performance of the ITS2 and MFT in Run 3







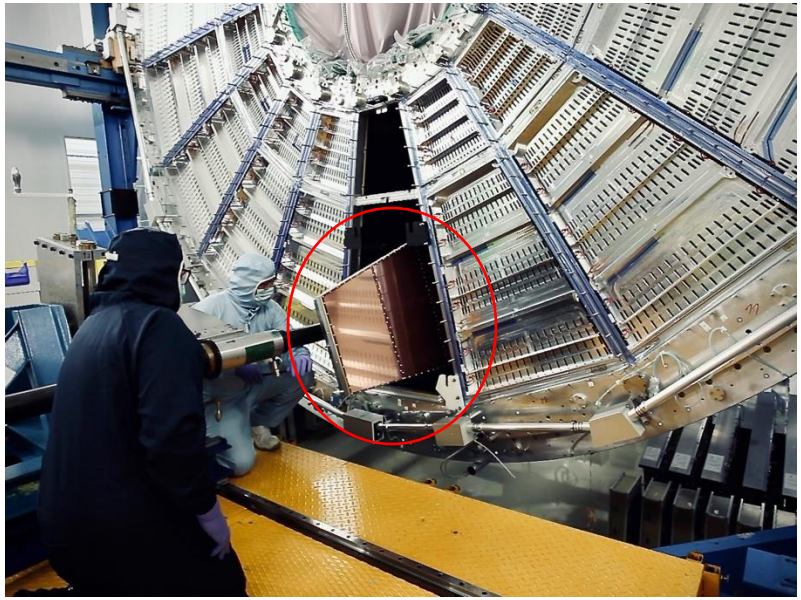
Improved pointing resolution at midrapidity

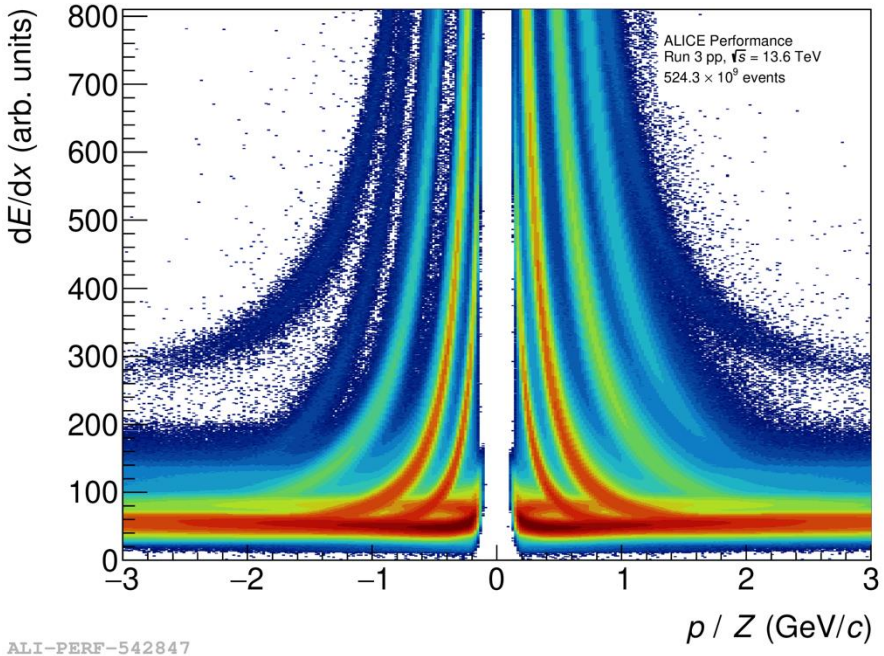
already now by factors of 2 and 6 in the transverse plane and beam-line direction, respectively

Secondary vertex reconstruction enabled at forward rapidity

separation of J/ψ contributions from beauty-hadron decays

ALICE in Run 3 (TPC)



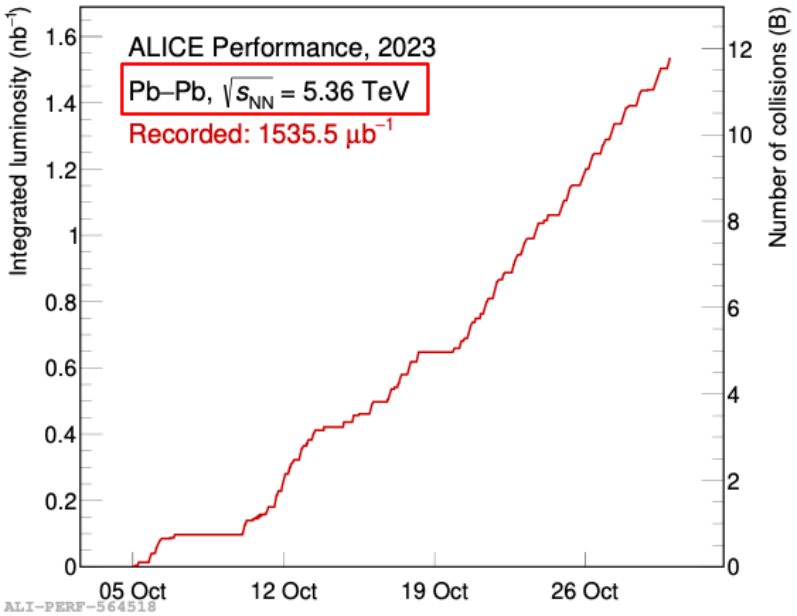


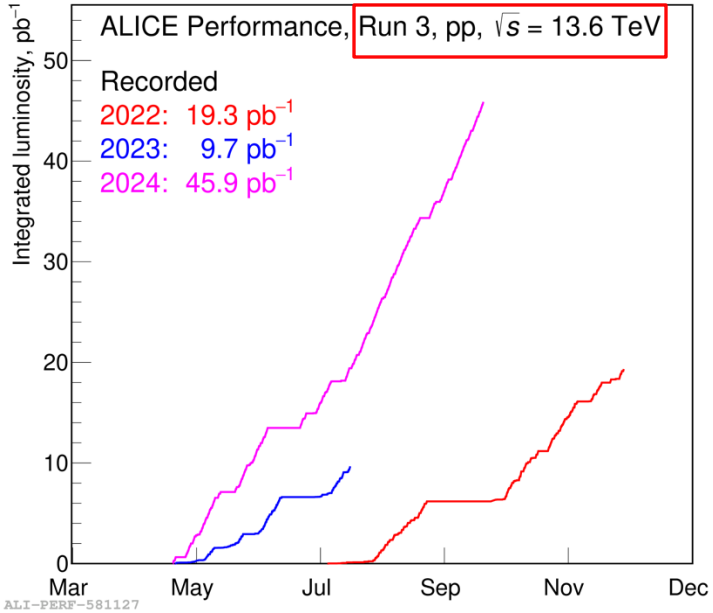
Upgraded Time Projection Chamber -> **GEM, continuous readout**

TPC UPGRADE CDS LINK

- pp data taking at 500 kHz
- Pb-Pb data taking at 50 kHz

Run 3 data taking

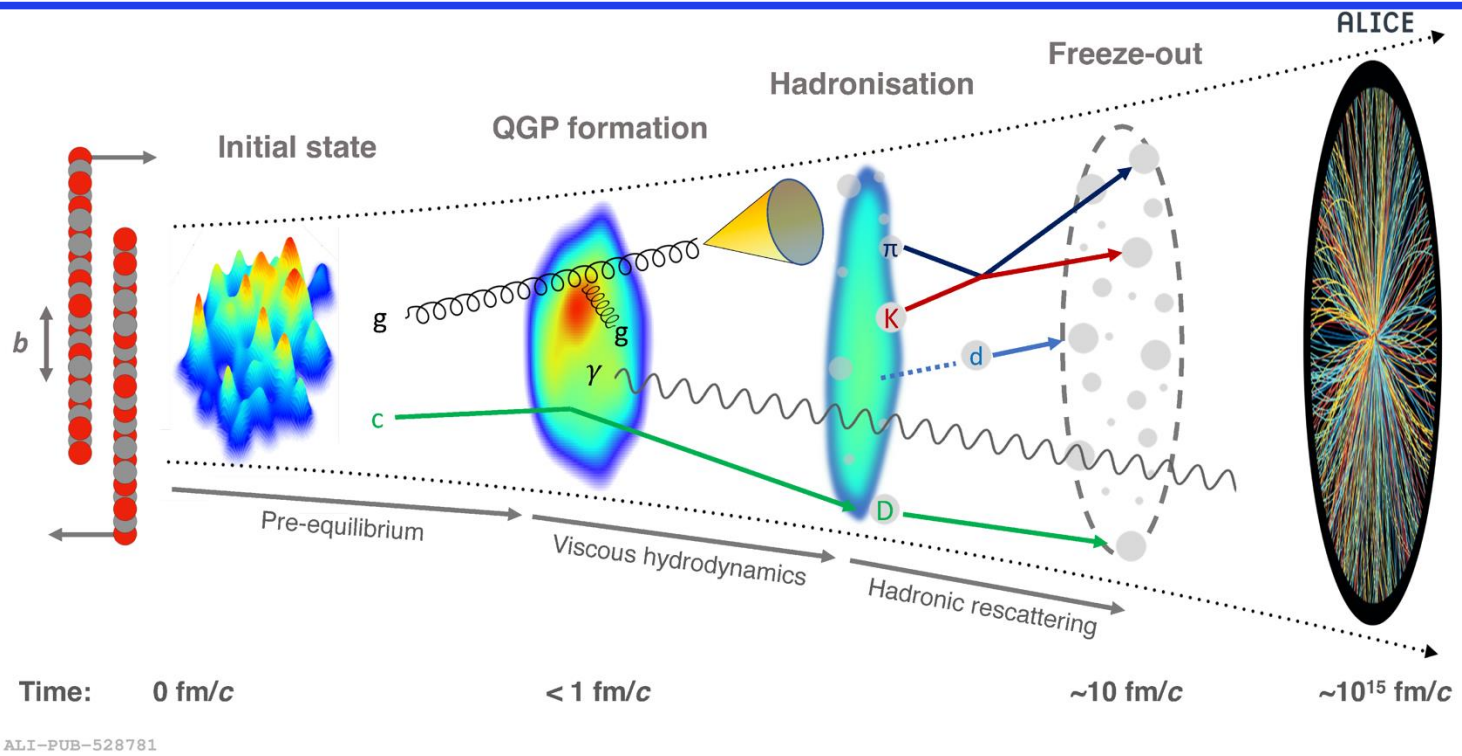




- Pb−Pb data taking at **50 kHz**
- Collected approx. 12 B minimum bias events

- pp data taking at **500 kHz**
- 75 pb^{-1} minimum bias events are currently recorded

Evolution of the heavy-ion collisions



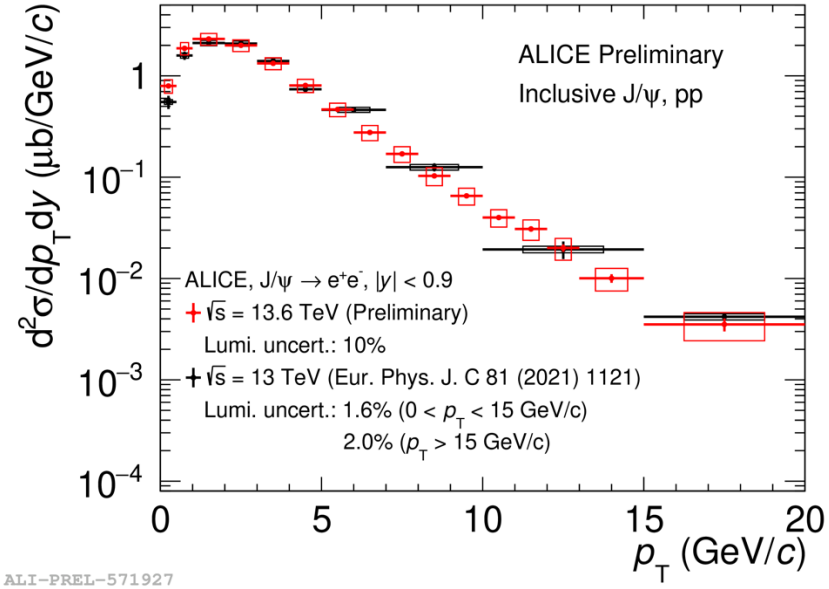
Heavy flavor, quarkonium and jets, are excellent **hard probes** to study the **initial state**, **QGP properties** and **hadronisation mechanisms in heavy-ion collisions**

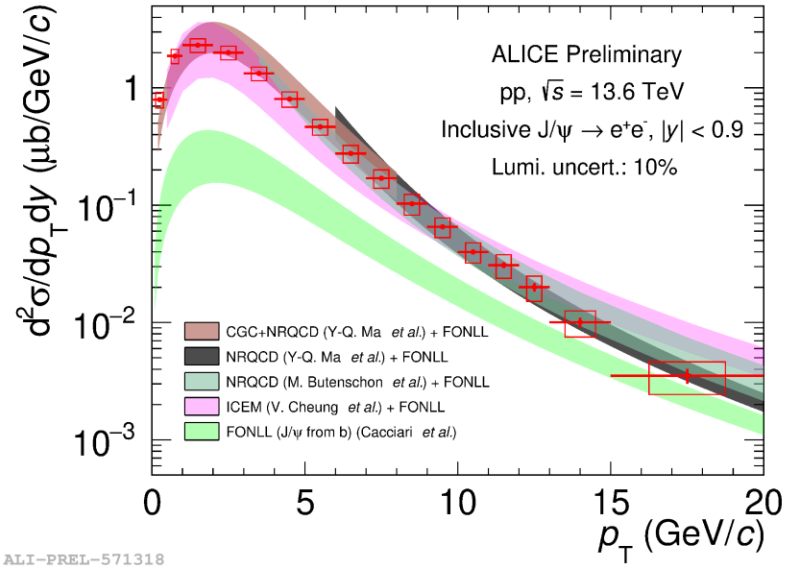
ALICE, Eur. Phys. J. C 84 (2024) 813

Highlights from pp and p-Pb collisions

Charmonia in pp collisions at $\sqrt{s}$ = 13.6 TeV

Run 3 Preliminary



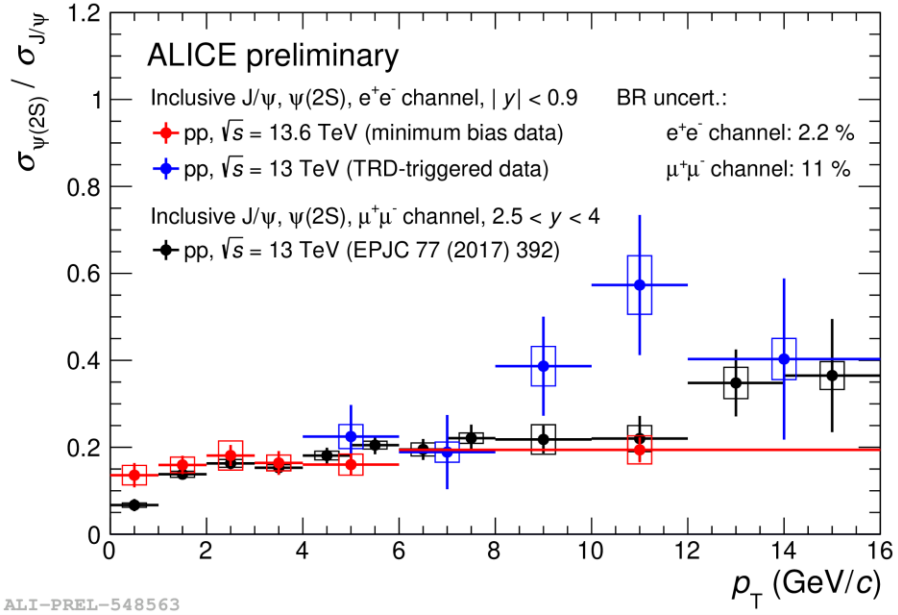


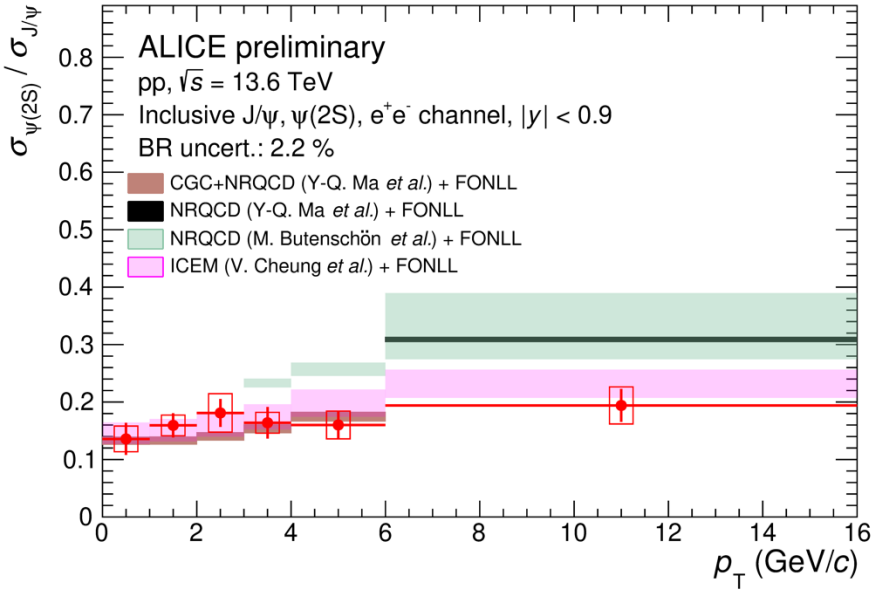
- The new J/ψ cross section is consistent with the Run 2 results
- The data are described by ICEM and NRQCD based models coupled with FONLL to account for the non-prompt J/ψ contribution

Yiping Wang 24/09 09:00

ψ(2S) in pp collisions at √s = 13.6 TeV

Run 3 Preliminary



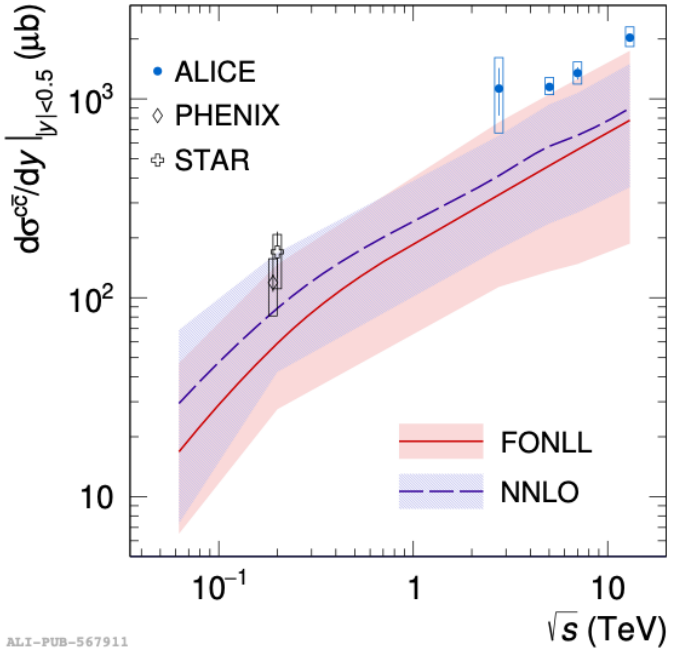


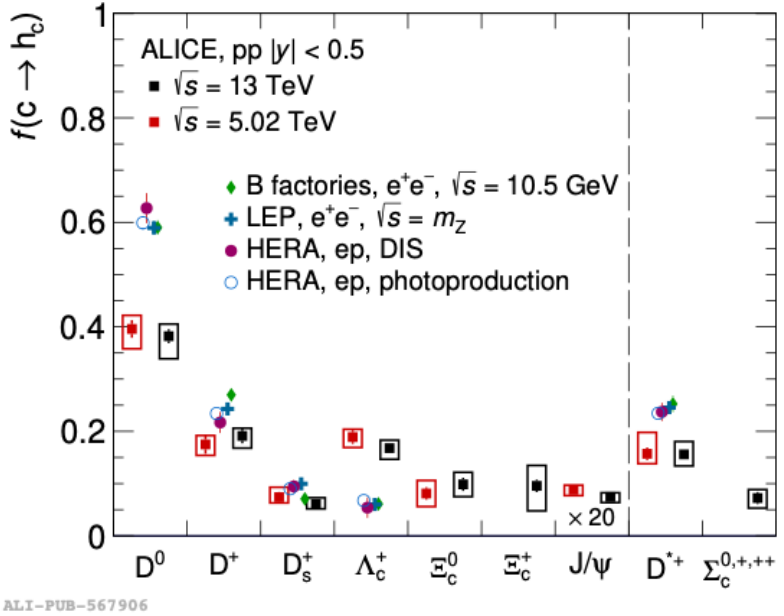
- Run 3 with the significantly increased statistics allow to reconstruct ψ(2S) via dielectron decays
- The CGC + NRQCD and ICEM can describe the data at low p_T

Yiping Wang 24/09 09:00

Charm production and fragmentation fractions

ALICE, JHEP 12 (2023) 086

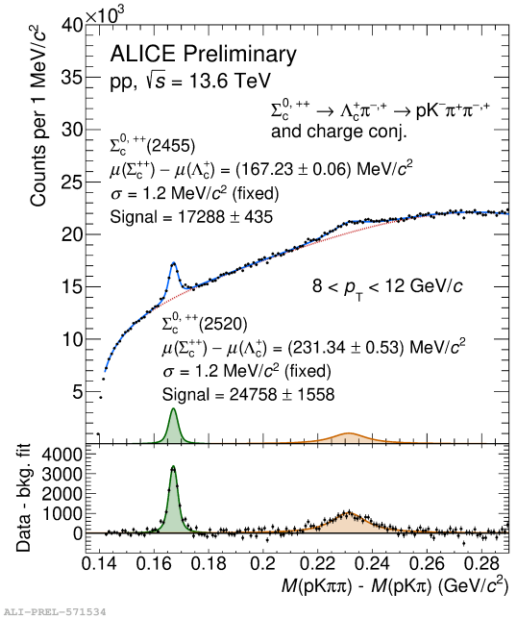




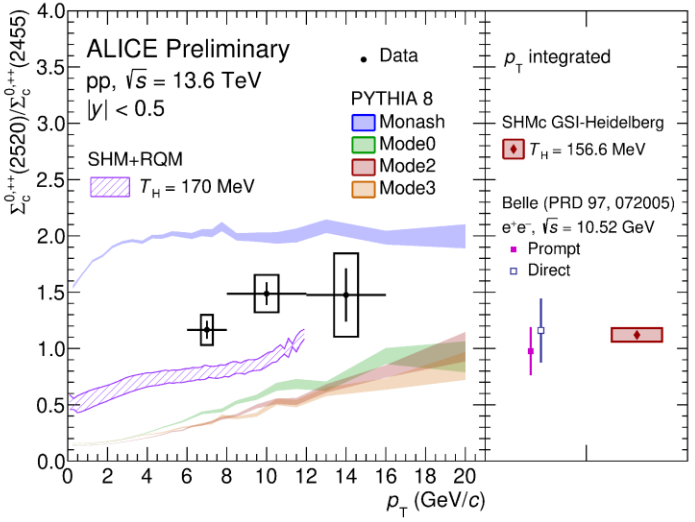
- Total charm production cross section: values on the upper limits of the FONLL prediction at midrapity
- **Charm fragmentation fractions are different** w.r.t ee and ep collisions
- **Baryon production is not fully understood**

Federica Zanone 23/09 17:50

$\Sigma_c^{0,++}$ in pp collisions at $\sqrt{s}$ = 13.6 TeV



Run 3 Preliminary

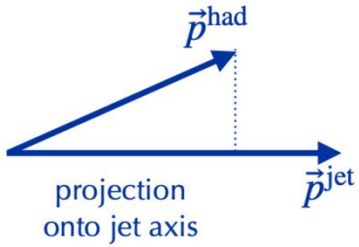


- First measurement of the production of $\Sigma_c^{0,++}(2520)$ relative to $\Sigma_c^{0,++}(2455)$ in pp collisions at $\sqrt{s}$ = 13.6 TeV
- No evidence of difference w.r.t. e^+e^- collisions considering current uncertainties
- PYTHIA 8 Monash (default tune) overestimates the ratio, PYTHIA 8 with with additional color reconnection topologies underestimates the ratio

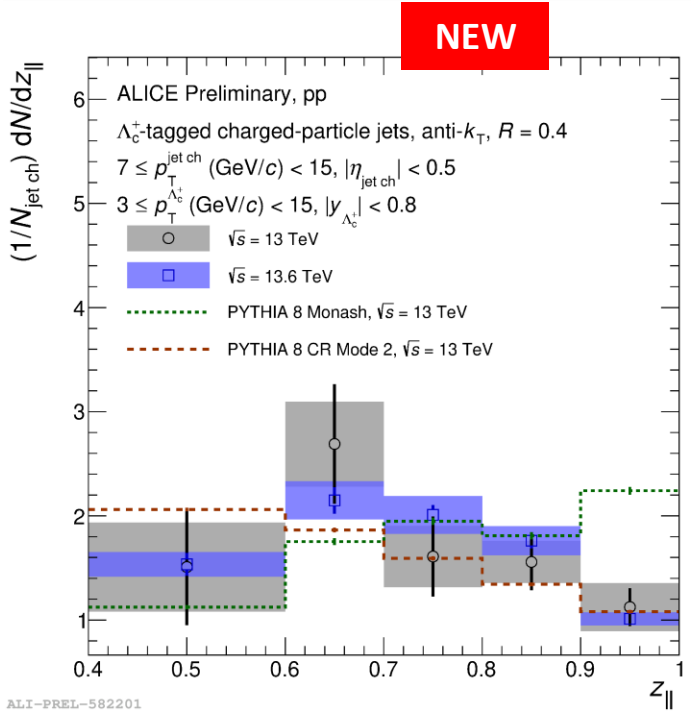
Federica Zanone 23/09 17:50

Probe the charm baron fragmentation function

Run 3 Preliminary



$$z_{\parallel} = \frac{\vec{p}_{\mathrm{jet}} \cdot \vec{p}_{\mathrm{had}}}{\vec{p}_{\mathrm{jet}} \cdot \vec{p}_{\mathrm{jet}}}$$



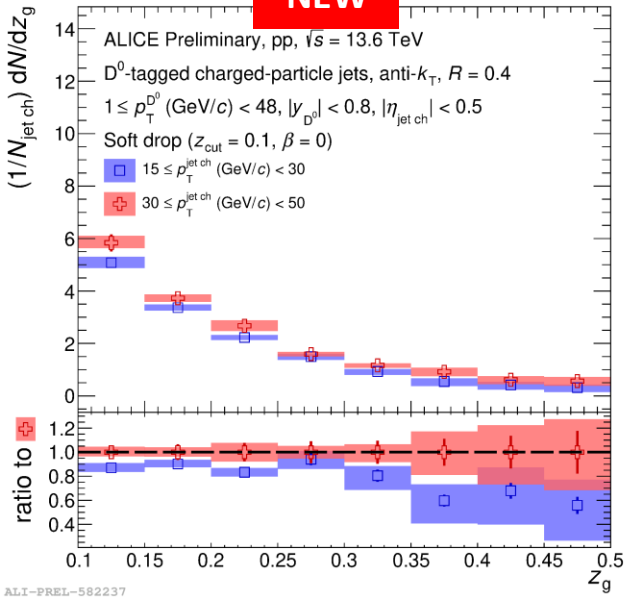
- Λ_C probing the non-universality of charm baryon hadronisation
- The precision of the new results from Run 3 improved significantly

Jochen Klein 25/09 12:10

Probing the charm splitting function

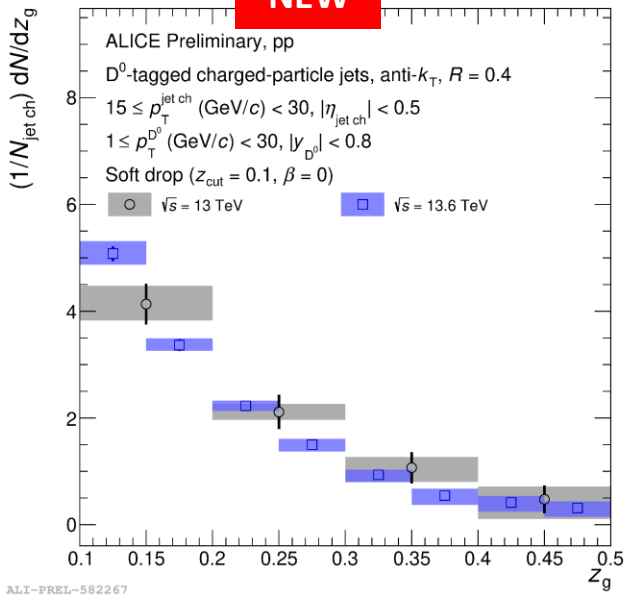
$$z_g = \frac{p_{T,g}}{p_{T,c} + p_{T,g}}$$

NEW



NEW

Run 3 Preliminary

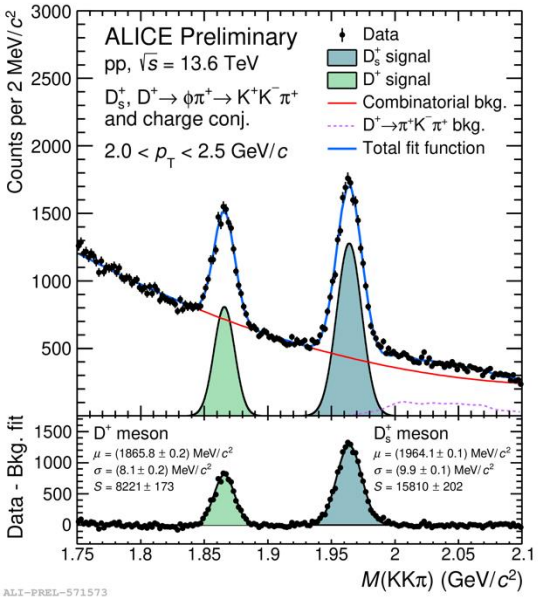


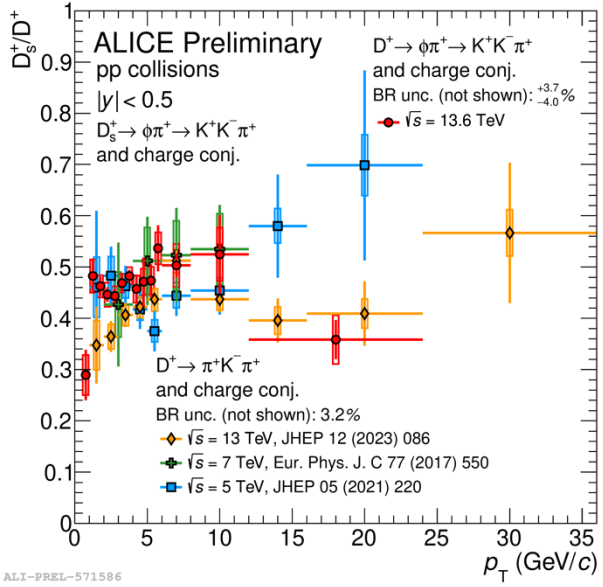
- The momentum fraction of the first splitting in groomed charm jets converges to the charm splitting function(c->cg).
- Run 3 allows us to make differential measurements in jet p_T
- In inclusive jets Zg has no dependence on jet p_T, but in heavy-flavour jets mass effect decreases with increasing p_T ?

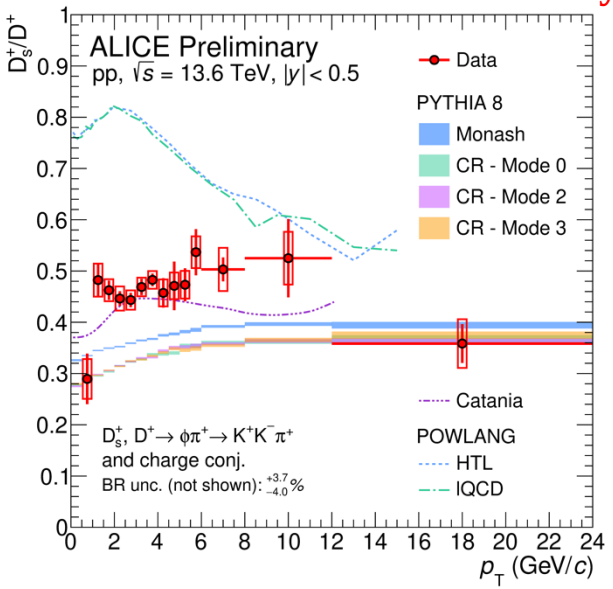
Jochen Klein 25/09 12:10

Prompt D_s^+ and D^+ in pp collisions at $\sqrt{s}$ = 13.6 TeV

Run 3 Preliminary







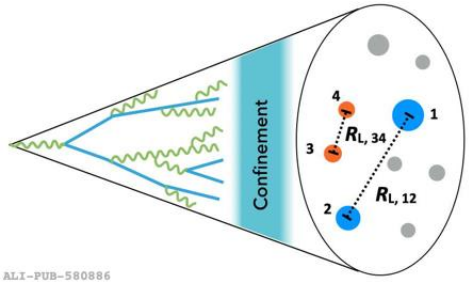
- First measurement of prompt D_s^+ and D^+ ratio in pp collisions at $\sqrt{s}$ = 13.6 TeV, finer granularity, down to p_T = 0
- Provide a better **baseline for Pb-Pb measurements,** tools to investigate the **strangeness enhancement in charm sector**
- Catania (coalescence) gives best description, while POWLANG (local color recombination) and PYTHIA (string fragmentation) can not describe the data

Fabio Catalano 24/09 09:20

Energy-energy correlators in jets in pp and p-Pb collisions

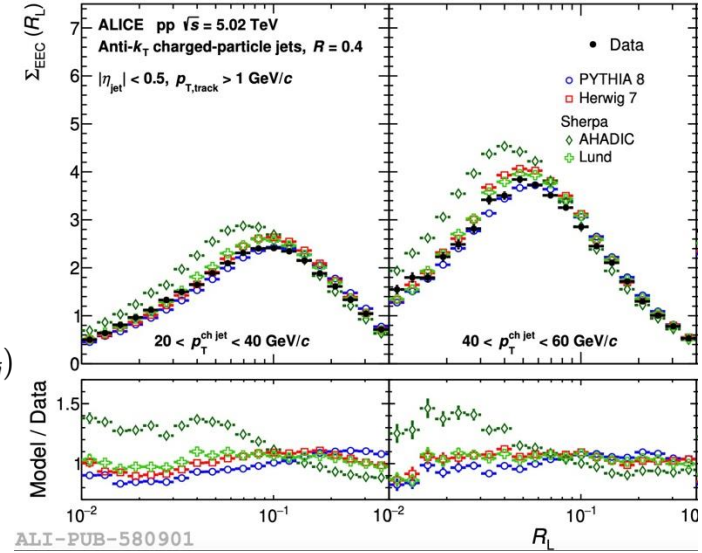
New publication

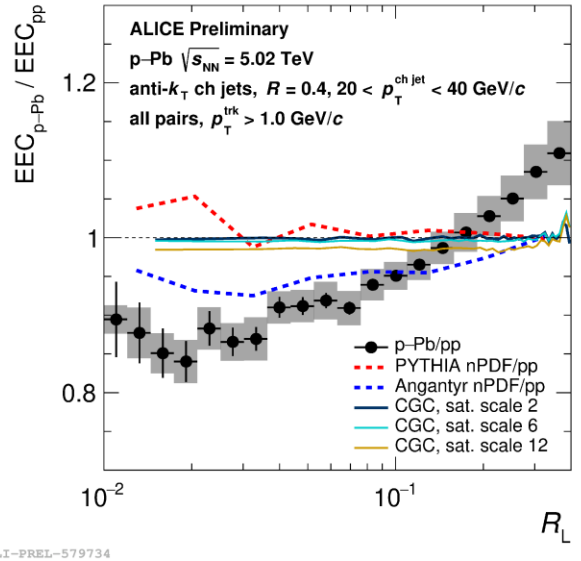
arXiv:2409.12687



$$\frac{d\sigma_{EEC}}{dR_L} = \sum_{i,j} \int d\sigma(R'_L) \frac{p_{T,i} p_{T,j}}{p'^2_{T,jet}} \delta(R'_L - R_{L,ij})$$

$$R_L = \sqrt{\Delta\phi_{ij}^2 + \Delta\eta_{ij}^2}$$





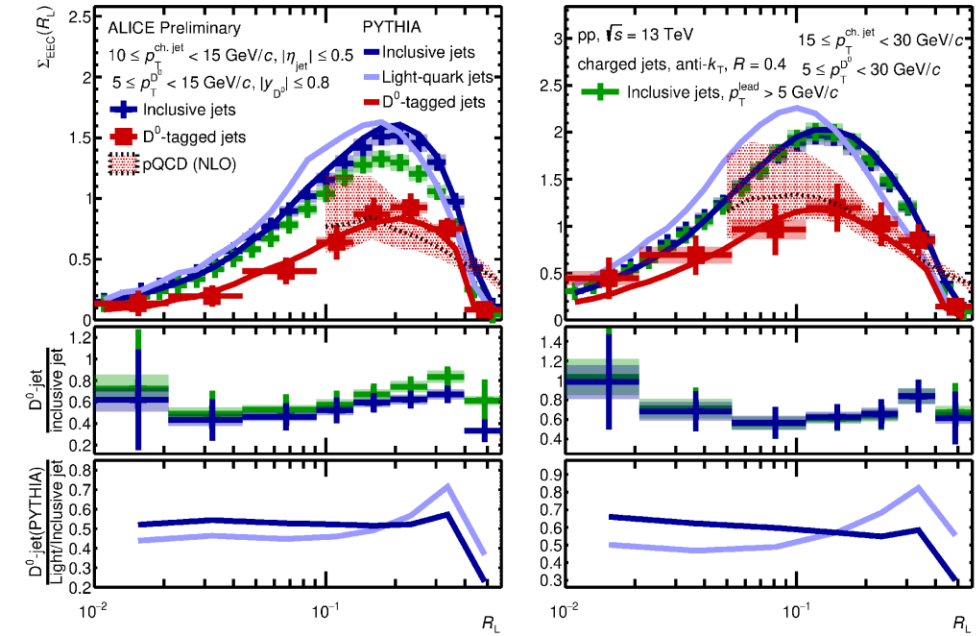
- A novel jet substructure observable describing the energy flow inside jets, can be calculated from first principles in QCD in the perturbative limit
- **Separation of the perturbative and non-perturbative** regimes

Ananya Rai 24/09 12:10

- Modification of the energy-energy correlator (EEC) seen in p-Pb collisions, but not explained by purely initial-state effects

Mass dependence of the energy-energy correlators

New Preliminary

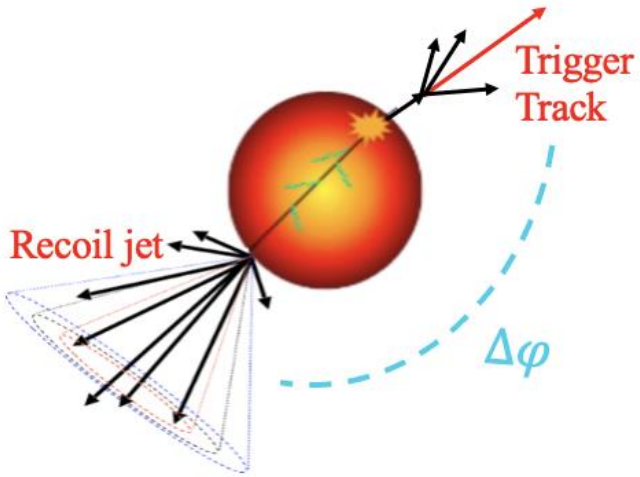


- First heavy flavor energy-energy correlator measurement

Anjali Nambrath 24/09 09:00

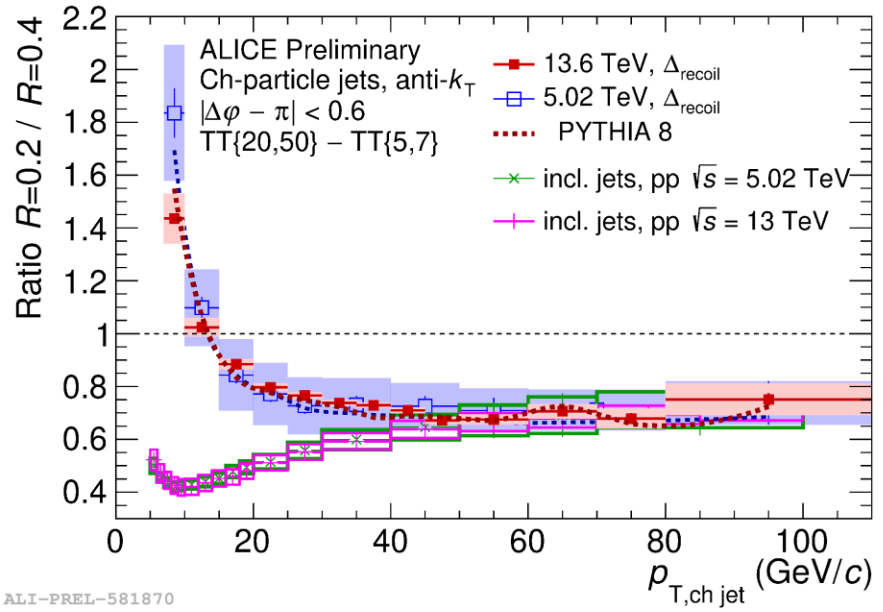
- Flavour effect is seen as a decrease in the EEC amplitude, peak position is not significantly shifted compared to inclusive jets

Jet measurements in Run 3



NEW

Run 3 Preliminary



- The jet measurements in Run 3 by ALICE

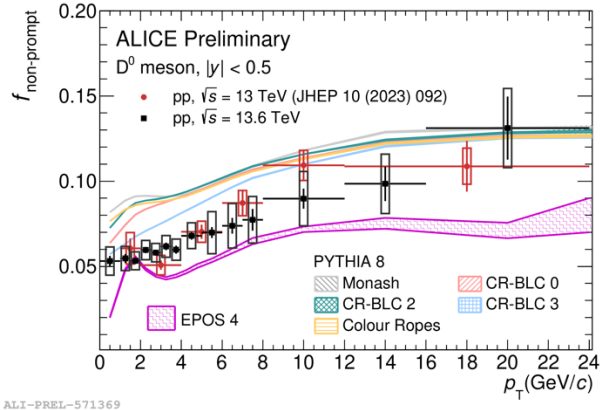
Daniel Matthew Jones 24/09 14:40

- The **statistical precision of the jet measurements is improved significantly in the Run 3**

Open beauty production in Run 3

Run 3 Preliminary

NEW



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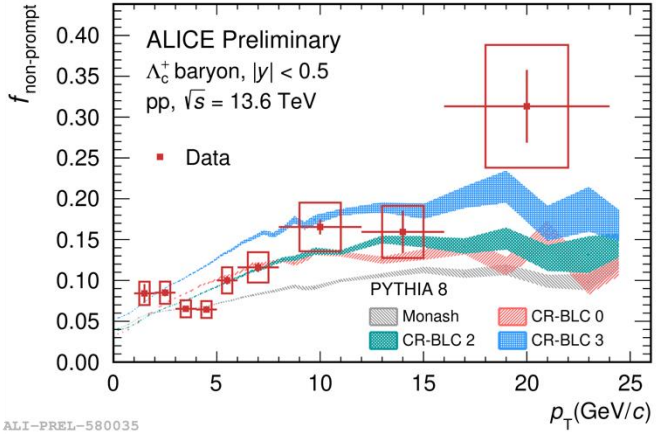
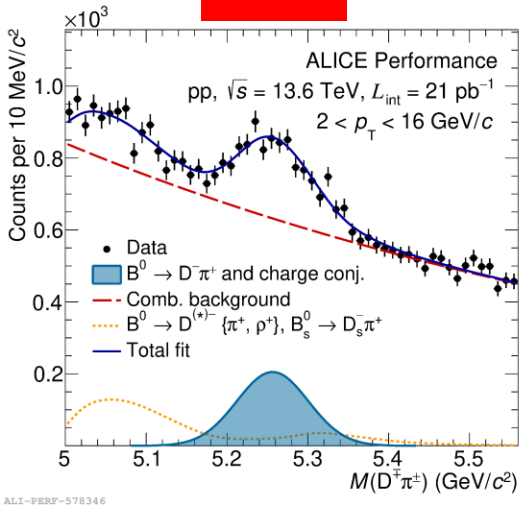
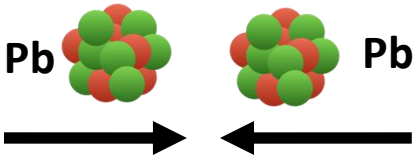




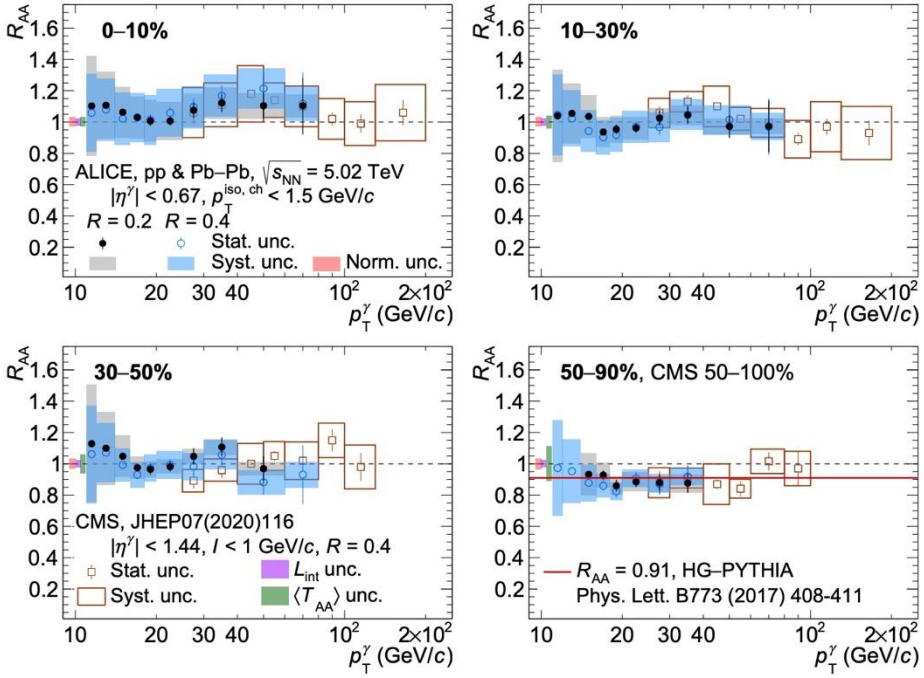
- Non-prompt D⁰ fraction measured in Run 3: improved precision compared to Run 2 results and extended down to $p_T = 0$
- Non-prompt Λ_c^+ measured p_T down to 1 GeV/c
- **First direct observation of B⁰ meson in ALICE**, measured down to $p_T = 2$ GeV/c
  - Better constraint of the open beauty production

Andrea Tavira Garcia 23/09 14:40



Highlights from Pb–Pb collisions

Isolated photon nuclear modification factor R_{AA}



New publication

arXiv:2409.12641

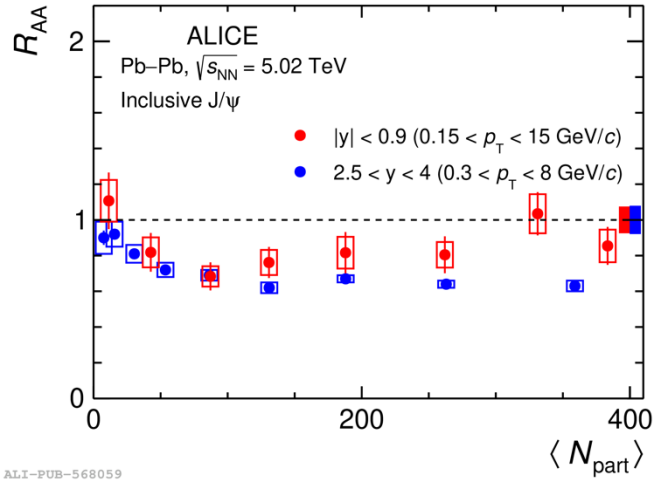
Gustavo Conesa Balbastre 25/09 09:00

- R_{AA} **consistent with unity** within the uncertainties for both R= 0.2 and 0.4, **no radiation from QGP at these** p_T
- Peripheral collision in agreement with PYTHIA prediction including bias on centrality estimation

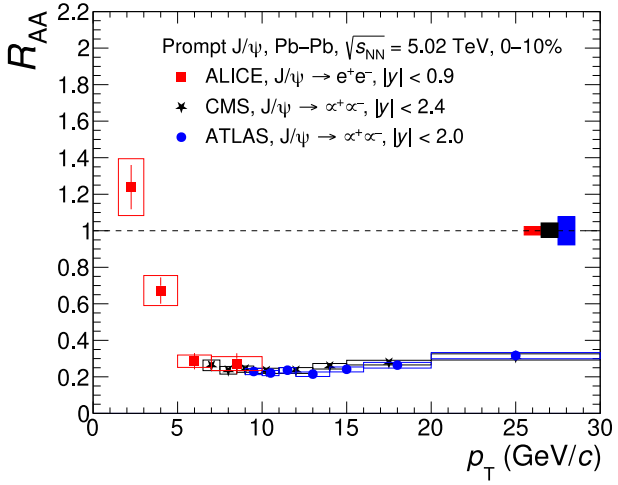
J/ψ (re-)generation Pb–Pb collisions

ALICE, PLB 849 (2024) 138451, JHEP 02 (2024) 066

Inclusive J/ψ



Prompt J/ψ

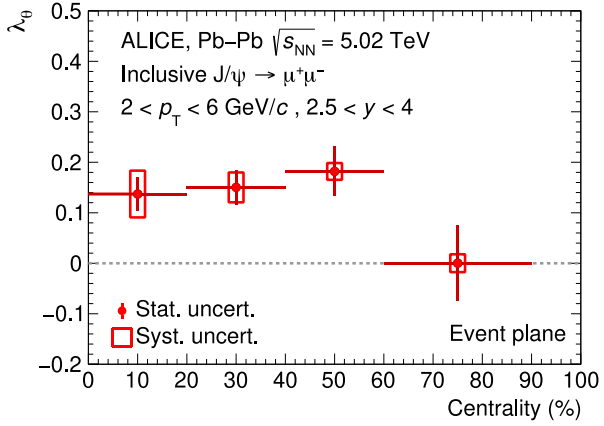


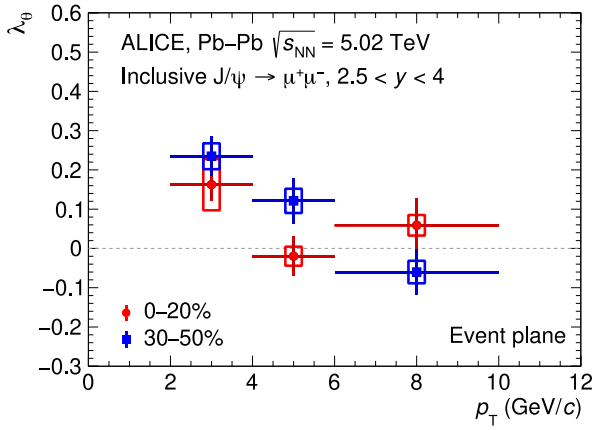
- **Evidence for J/ψ (re-)generation in central collisions, with a larger contribution at low p_T, and at midrapidity**
- R_{AA} extended down to p_T = 1.5 GeV/c and compatible within uncertainties with ATLAS and CMS measurements in the common p_T range

Yuan Zhang 24/09 10:00

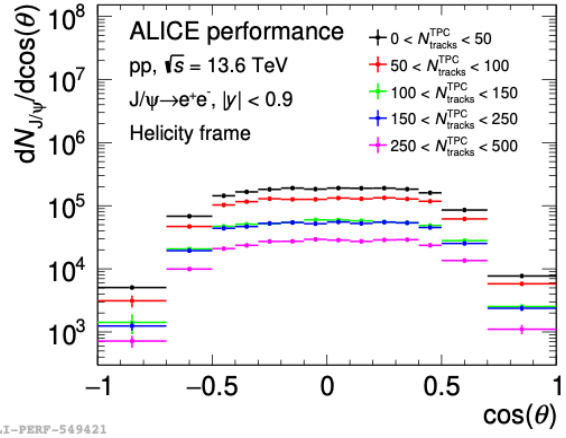
Charmonium Polarization

ALICE, PRL 131 (2023) 4, 042303





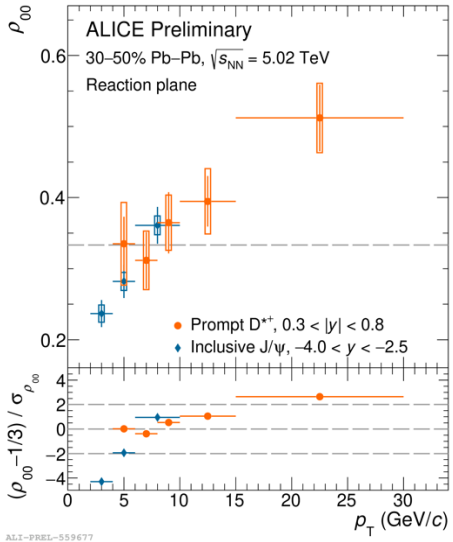
New performance



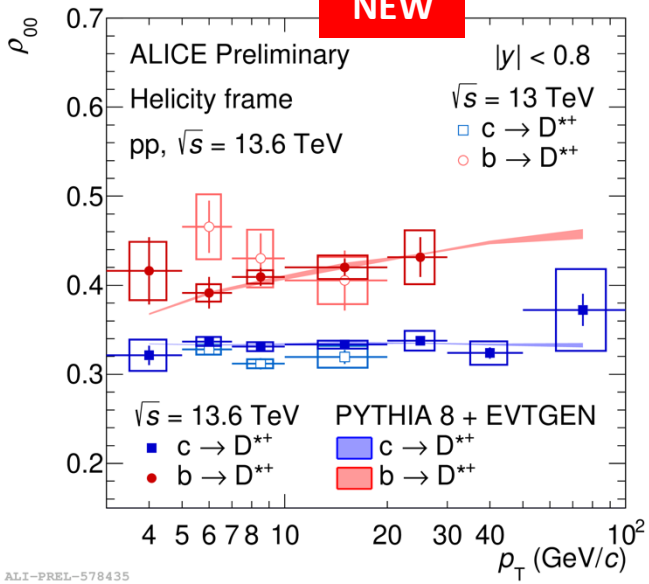
- First measurement of quarkonium polarization **w.r.t the event plane**
- Significant polarization (~**3**.9σ) observed in semicentral collisions
- Polarization measurements are ongoing at midrapidity with Run 3 data

Zhenjun Xiong 24/09 11:30

D*+ spin alignment in pp and Pb-Pb collision



NEW



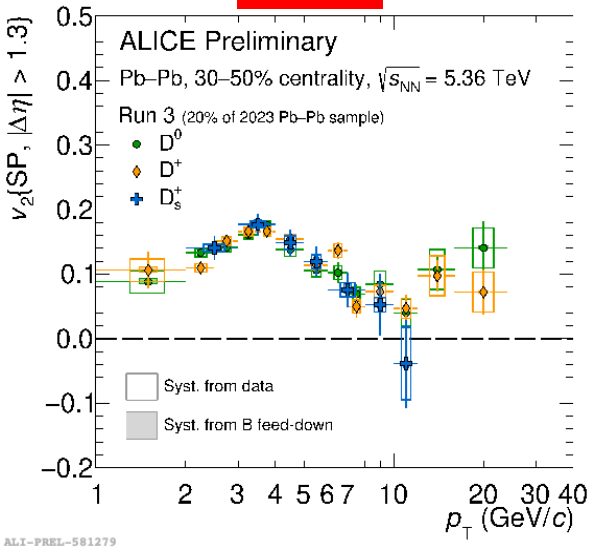
Run 3 Preliminary

- In Pb-Pb collisions:
  - Spin density matrix $\rho_{00} > ⅓$ for D*+ at high p_T ⇒ quark fragmentation scenario
- In pp collisions:
  - $\rho_{00} = ⅓$ for prompt **D**$^{*+}$, ρ00 larger than ⅓ for non-prompt **D**$^{*+}$, due to the helicity conservation in weak decays
  - New measurement in pp collisions provides an important baseline for Pb-Pb collisions

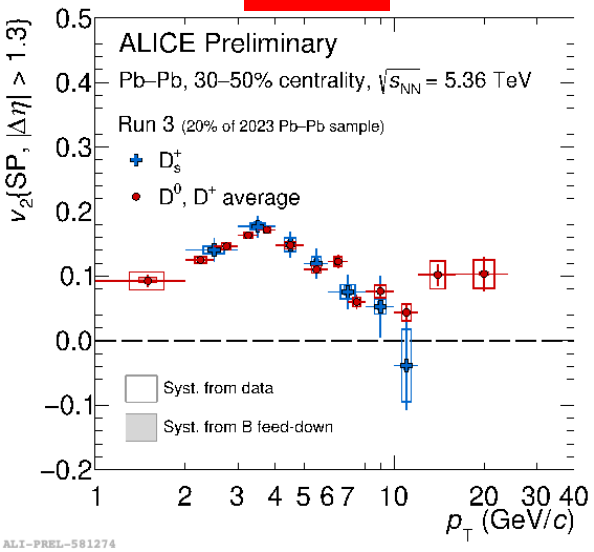
Mingze Li 24/09 11:50

Strange and non-strange D-mesons elliptic flow

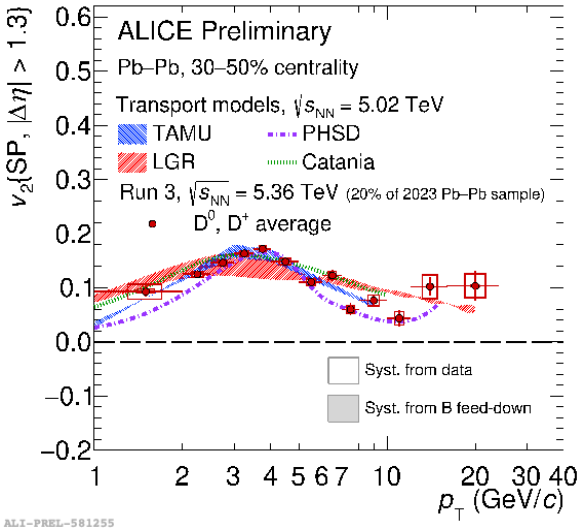
NEW



NEW



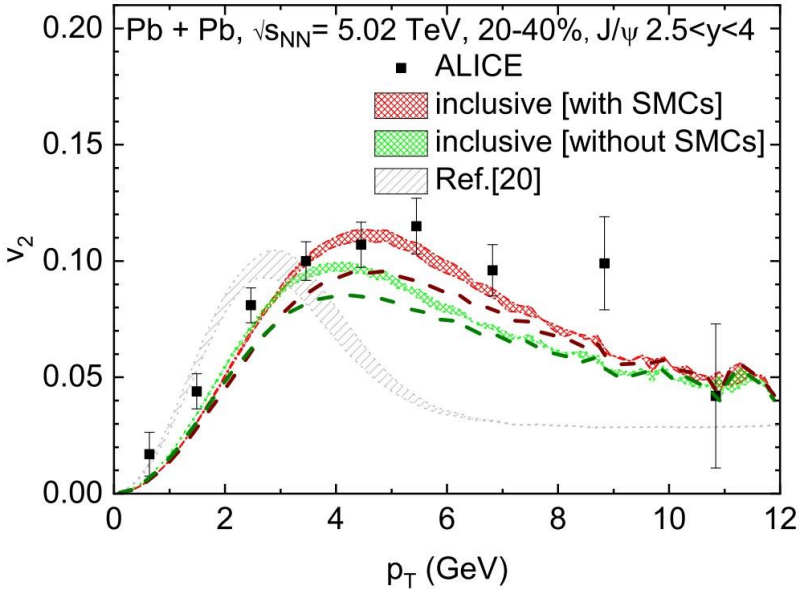
NEW **Run 3 preliminary**



- Prompt D-meson v_2 measured using Run 3 Pb–Pb data sample
  - No significant difference between strange and non-strange D mesons
  - Strange D-meson elliptic flow reproduced by the transport models
- About x4 larger statistics more than Run 2 one, x5 more statistics will come soon

Biao Zhang 23/09 16:50

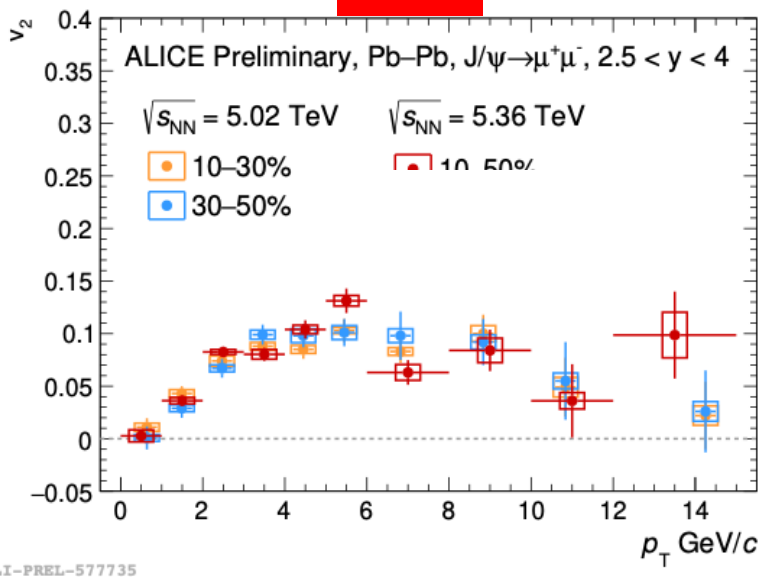
Charmonium elliptic flow in Run 3



M. He, et al., PRL.128, 162301 (2022)

NEW

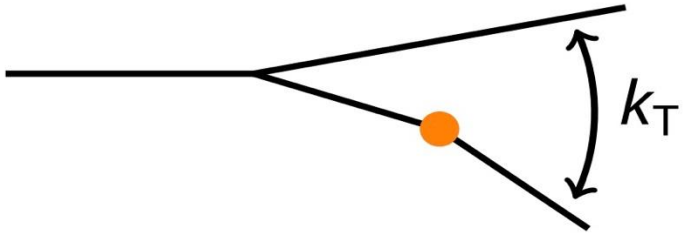
Run 3 Preliminary



Yiping Wang 24/09 09:00
Poster by Chi Zhang 24/09

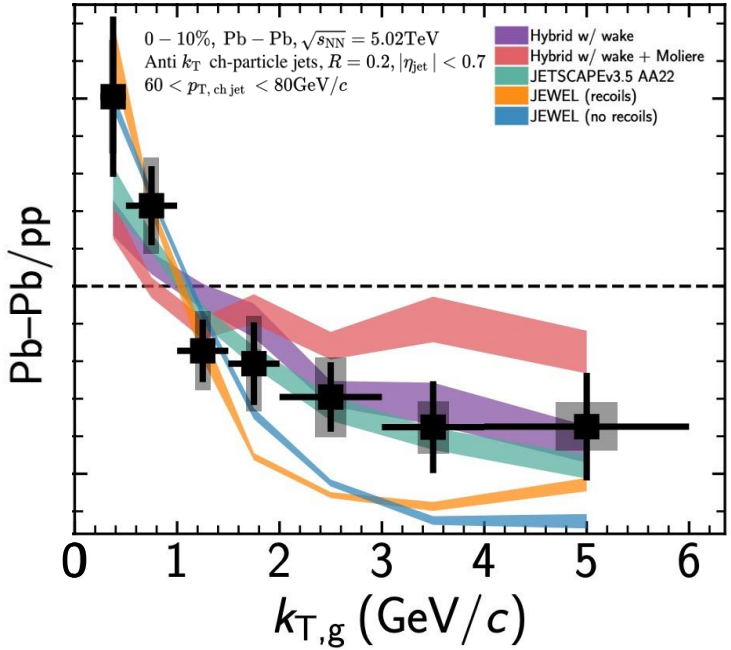
- The new result is consistent with Run 2, with statistical precision improved at low p_T at forward rapidity
- A significant J/ψ v_2 is observed at forward rapidity, consistent with the charm quark thermalization

Searching for the quasi-particle in QGP



$$k_T = p_{T,\text{subleading}} \sin \Delta R$$

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



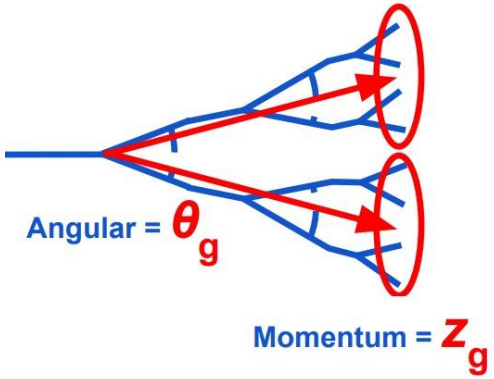
New publication

arXiv:2409.12837

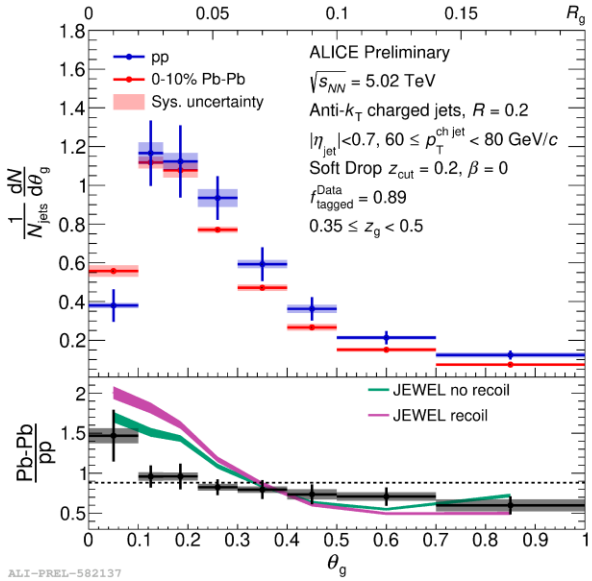
Bas Hofman 23/09 14:40

- First measurement of the hardest relative transverse jet splitting
- **Need well-controlled models baseline** from theory to investigate Moliere effects to search quasi-particle in QGP
- Provide new constrain on the microscopic structure and dynamics of the quark–gluon plasma

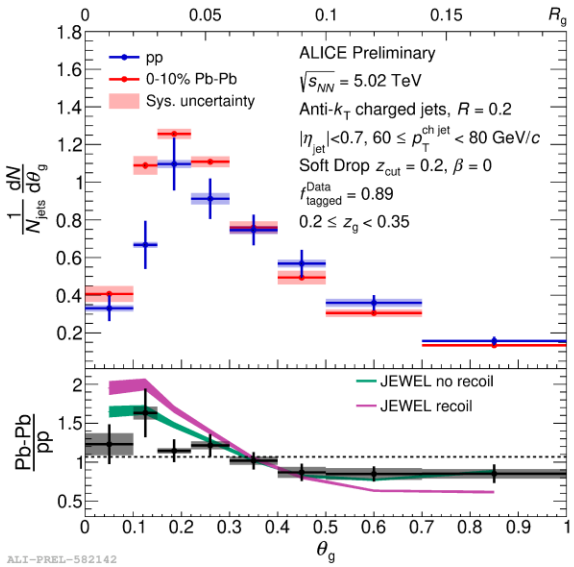
Quenching with correlated jet substructure



balance



unbalance



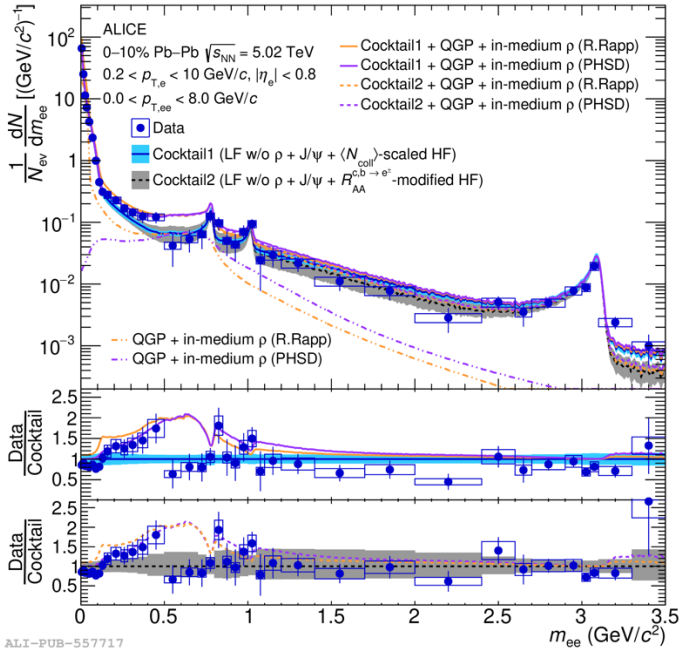
- Multidimensional measurement to disentangle jet survival bias from medium modifications
- Allow disentangling modifications to the substructure of jets from energy loss effects arising from migration of the jet momentum

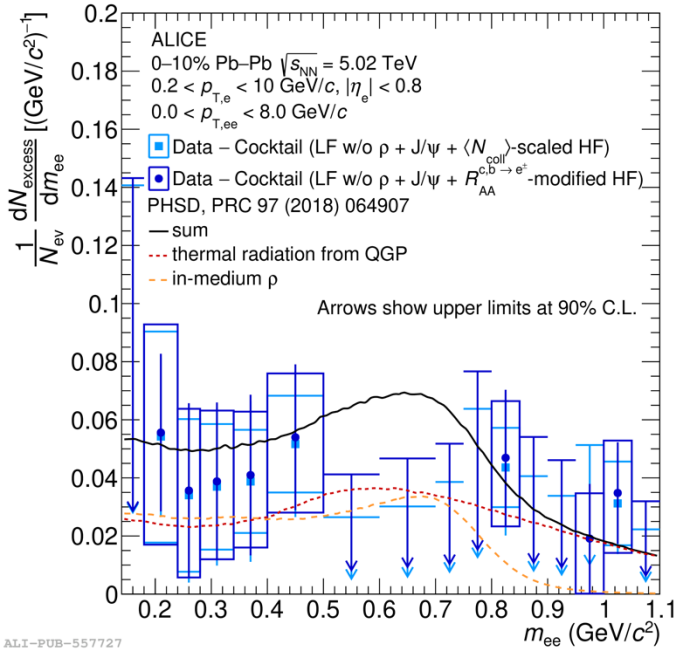
Bas Hofman 23/09 14:40

Dielectron production in Pb–Pb collisions

arXiv:2308.16704

Jerome Jung 24/09 12:10

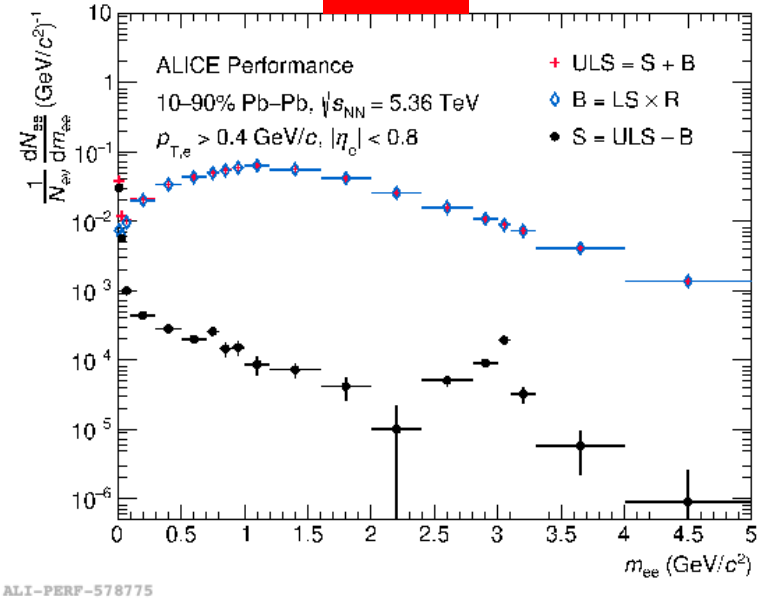




- Dielectron yield is consistent with hadronic cocktail within uncertainty, the excess in the low-mass region is 1.3σ
- More statistics and better control of HF background are needed to quantify the excess: full statistics from Run 3

Di-electron performance in Run 3

NEW



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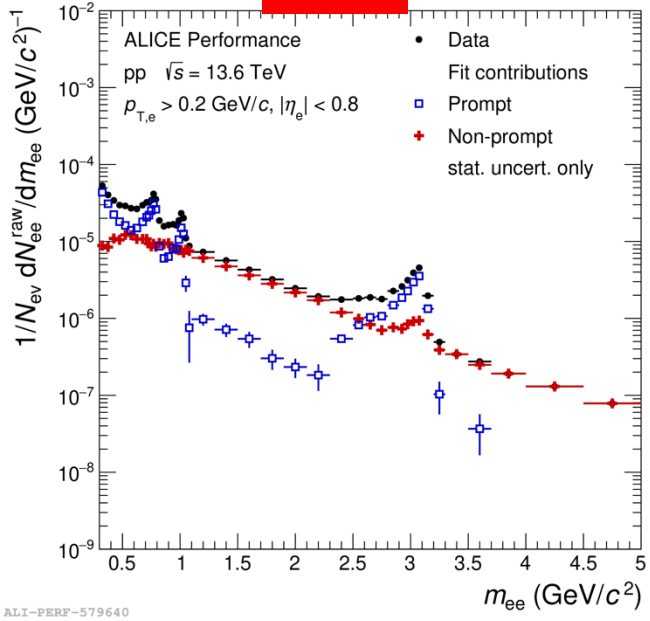


Run 3 performance

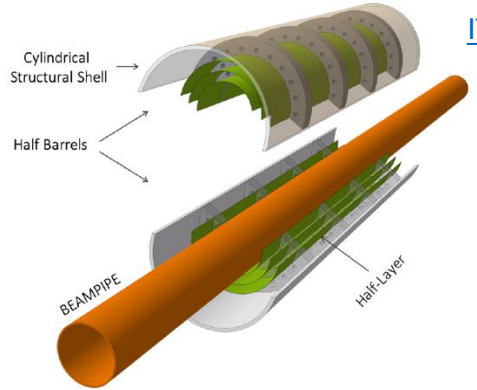
- More statistics and better-pointing resolution thanks to MFT and ITS upgraded in Run 3
- Improved DCA enable the separation of prompt (e.g. thermal) and non-prompt (HF background)

Poster by **Emma Charlotte Ege** 24/09
Poster by **Florian Eisenhut** 24/09

Upgrading the ALICE detector (RUN 4)

ITS3: TDR approved

ITS3 CDS LINK

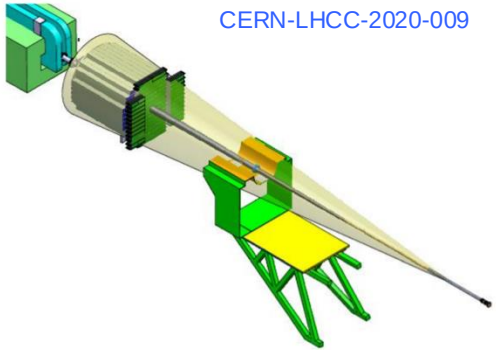


- Replacing the ITS2 inner layers by "silicon-only"
- Inner-most radius 19 mm, x 2 improvement in pointing resolution
- **Improve the measurements of heavy flavor and dielectrons at midrapidity**

Bong-Hwi Lim 24/09 15:55

FoCal: TDR approved

CERN-LHCC-2020-009



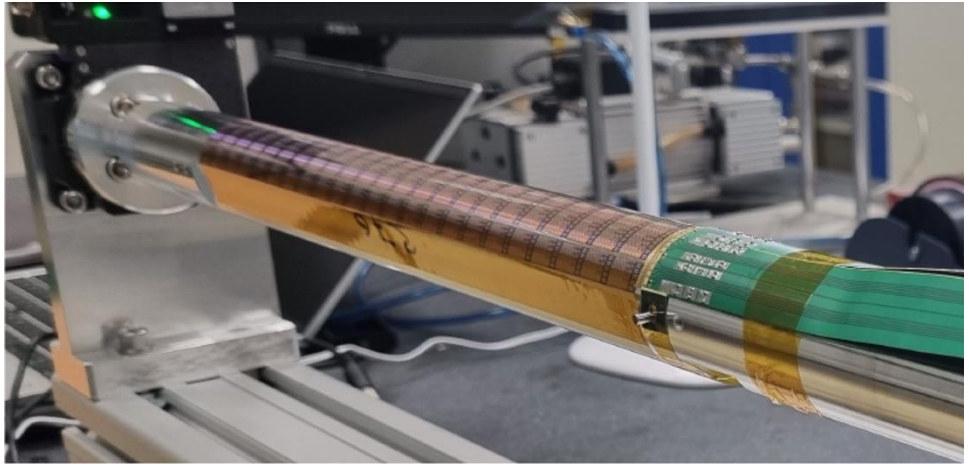
- FoCal-E calorimeter: High-granularity Si-W
- FoCal-H: Cu-scintillator
- Direct photons, π^0, jets at forward rapidity
- **Unexplored regions of small-x and low Q^2 gluons**

Jacek Tomasz Otwinowski 24/09 16:15

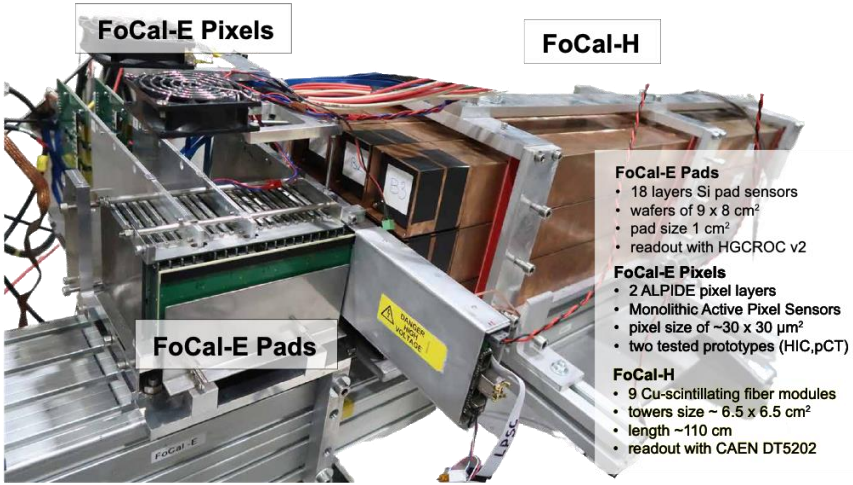
LHC LS2	LHC RUN 3	LHC LS3	LHC RUN 4	LHC LS4	LHC RUN 5 and RUN 6
2019-2021	2022-2025	2026-2028	2029-2032	2033-2034	2035-2041

Upgrading the ALICE detector (RUN 4)

ITS3: Prototype



FoCal: Prototype



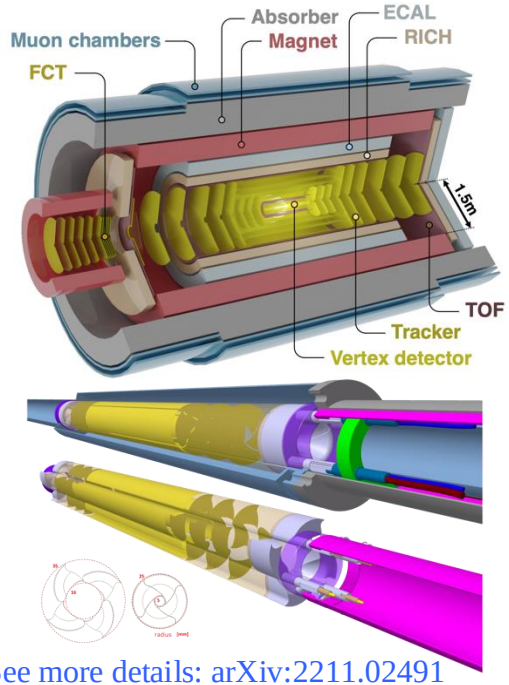
Prototypes constructed to test assembly methods and verify performance

Bong-Hwi Lim 24/09 15:55

Jacek Tomasz Otwinowski 24/09 16:15

LHC LS2	LHC RUN 3	LHC LS3	LHC RUN 4	LHC LS4	LHC RUN 5 and RUN 6
2019-2021	2022-2025	2026-2028	2029-2032	2033-2034	2035-2041

Upgrading the detector (ALICE 3)



See more details: arXiv:2211.02491

Detector concept:

- Compact **all-silicon tracker** with high-resolution vertex detector
- **Particle Identification** over large acceptance, identification of muons, electrons, hadrons, photons
- Fast read-out and online processing

Physics programs:

- High-precision **beauty** measurements
- **Multi-charm** baryons, **exotic hadrons**, **ultra-soft photons**
- **Time-dependence and flow of thermal radiation**
- D-$\overline{\text{D}}$ and D-D* $\Delta\phi$ correlations

Cas Van Veen 24/09 15:35

LHC LS2	LHC RUN 3	LHC LS3	LHC RUN 4	LHC LS4	LHC RUN 5 and RUN 6
2019-2021	2022-2025	2026-2028	2029-2032	2033-2034	2035-2041

The ALICE contribution (parallel session)

JETs (7)

- Jet fragmentation and substructure correlations in pp and Pb-Pb at $\sqrt{s_{NN}}$ = 5.02 TeV with ALICE, **Bas Hofman 23/09 14:40**
- Energy-energy correlators of inclusive jets from small to large collision systems with the ALICE experiment, **Anjali Nambrath 24/09 09:00**
- Probing jet hadrochemistry and charged-particle jet radial profile modifications in pp and Pb--Pb collisions with ALICE, **Sierra Lisa Weyhmiller 24/09 11:10**
- Extracting the anomalous dimensions of energy-correlators in charged jets in pp collisions at 13 TeV with ALICE, **Ananya Rai 24/09 12:10**
- Measurements of jet quenching using hadron-jet observables at ALICE **Daniel Matthew Jones 24/09 14:40**
- New measurements of inclusive jet suppression and jet v_2 in Pb-Pb collisions with ALICE **Aimeric Landou** 24/09 15:00
- Measuring isolated prompt photon production in small and large collision systems with ALICE **Gustavo Conesa Balbastre** 25/09 09:00

Heavy Flavor (8)

- Measurements of production of charm-hadron pairs in pp collisions with ALICE **Pengzhong Lu 23/09 14:20**
- Studies of beauty-quark production, hadronisation and cold nuclear matter effects in pp and p-Pb collisions with ALICE **Andrea Tavira Garcia** 23/09 14:40
- Characterisation of heavy-quark propagation and thermalisation in QGP with ALICE **Biao Zhang** 23/09 16:50
- Investigating of charm-quark hadronisation into baryons and its collision-system dependence with ALICE **Federica Zanone** 23/09 17:50
- The role of strangeness in heavy quark hadronisation from small to large collision systems with ALICE **Fabio Catalano** 24/09 09:20
- Investigation of charm hadronisation and early magnetic field in ultrarelativistic heavy-ion collisions via D^{*+}-meson spin alignment with ALICE **Mingze Li** 24/09 11:50
- Electroweak vector-boson production in hadronic collisions with ALICE **Shingo Sakai** 25/09 09:20
- Differential measurements of in-jet fragmentation of charmed mesons and baryons in pp collisions with ALICE **Jochen Klein** 25/09 12:10

Quarkonia (5)

- Charm and beauty production at forward rapidity with ALICE **Michele Pennisi** 23/09 15:20
- Quarkonia production in proton-proton and Pb-Pb collisions with ALICE **Yiping Wang** 24/09 09:00
- Prompt/Non-prompt J/ψ production in proton-proton and Pb-Pb collisions with ALICE **Yuan Zhang** 24/09 10:00
- Quarkonium polarization in hadronic collisions with ALICE **Zhenjun Xiong** 24/09 11:30
- J/ψ photoproduction and polarization in peripheral Pb-Pb collisions with ALICE **Ionut Cristian Arsene** 24/09 12:10

Soft Probes Detector Upgrades (11)

- Exploring jet quenching effects via di-hadron correlations in 13 TeV proton-proton collisions with ALICE **Maxim Virta** 23/09 15:00
- Studying the interaction between charm and light-flavor mesons with ALICE **Emma Chizzali** 25/09 11:50
- Exploring light flavor hadronization in hard and soft events with event shape classifiers in small collision systems at the LHC with ALICE **Feng Fan** 23/09 15:20
- Probing light nuclei production mechanism by measuring nuclei production in and out of jets with ALICE at the LHC **Chiara Pinto** 25/09 10:50
- Direct photon production and correlations at low pT in Pb-Pb collisions with ALICE **Dmitri Peresunko** 24/09 10:50
- Direct photon measurement in small systems and thermal radiation from QGP with ALICE **Jerome Jung** 24/09 12:10
- Probing the nucleus and nucleons with vector mesons in ultra-peripheral collisions in ALICE **Minjung Kim** 25/09 09:40
- A new class of ultra-peripheral collisions in ALICE: inelastic photonuclear interactions and open charm photoproduction **Sigurd Nese** 25/09 10:00
- ALICE 3 physics programme and detector R&D **Cas Van Veen** 24/09 15:35
- Design and expected performance of the ALICE ITS3 tracker upgrade **Bong-Hwi Lim** 24/09 15:55
- ALICE Forward Calorimeter upgrade (FoCal): physics program and expected performance **Jacek Tomasz Otwinowski** 24/09 16:15

The ALICE contribution (poster session)

• Probing the shower properties of charm quarks using energy-energy correlators with ALICE **Preeti Dhankher** • Testing the flavour dependence of QCD parton showers using heavy-flavour jet substructure with ALICE **Vit Kucera** • Energy-energy correlators in p-Pb collisions at 5 TeV with the ALICE experiment **Anjali Ila Nambrath** • Monte Carlo studies of energy-energy correlators for D0-tagged jets in in pp collisions **Beatrice Eva Liang-Gilman** • Measurement of the transverse momentum(jT) distributions of charged-particle jet fragments in pp collisions at √s = 5.02 TeV with ALICE **Jaehyeok Ryu** • b-jet measurement using heavy flavour tagging with secondary vertex method in pp collisions at 13.6 TeV with ALICE **Hanseo Park** • Energy-energy correlators of jets in pp and PbPb collisions with the ALICE experiment **Wenqing Fan** • Charged beauty-tagged jet measurement with impact parameter method in proton--proton collisions in Run3 **Hyungjun Lee** • First Measurements of Charged-Particle Jet Production in pp Collisions at √s =13.6 TeV with ALICE **Joonsuk Bae** • Jet spectra evolution as a function of center of mass energy in pp collisions with ALICE **Archita Rani Dash** • Study of background effects for jet analyses with Run 3 data in ALICE **Wenhui Feng** • Probing medium response by measuring proton to pion ratio and charged particles radial profile with jet in Pb-Pb and pp collisions at 5.02 TeV with ALICE **Taketo Yokoo**	**JETs (12)**
• b-jet tagging in pp collision using graph neural network for the ALICE experiment **Changhwan Choi** • First D0-tagged jet axes difference measurement in pp collisions at √s =5.02 TeV with ALICE **Emma Rose Yeats** • First study for azimuthal correlations of electron-muon pairs from heavy flavor decays in proton-proton collisions with ALICE Shunsuke Kurita • Measurement of multiplicity dependent Xic0 via semileptonic decay in collisions of pp at 13 TeV with ALICE **Chong Kim** • Production of electrons from open beauty-hadron decays in pp collisions at 13 TeV with ALICE Jonghan Park	**Heavy Flavor (5)**
• Quarkonia collectivity in proton-proton and Pb-Pb collisions with ALICE **Chi Zhang** • Dimuon measurement in low and intermediate mass region in √s = 13.6TeV pp collisions at ALICE **Motomi Oya** • Charmonium production at midrapidity using TRD-triggered data measured in ALICE **Jin Joo Seo** • Measurements of inclusive J/ψ and ψ(2S) production at midrapidity in pp collisions at √s = 13.6 TeV with ALICE **Yuan Zhang**	**Quarkonia (4)**
• Correlation of strangeness production with charged hadrons in proton-proton collisions **Kai Cui** • Event-by-event mean transverse momentum fluctuations in pp collisions at√s = 13 TeV using ALICE detector **Bushra Ali** • Production of omega mesons in pp collisions at sqrt(s) = 5.02TeV with ALICE **Merle Luisa Walde** • Performance of the dielectron analysis in Pb-Pb collisions in Run 3 with ALICE **Emma Charlotte Ege** • Dielectron production and topological separation of dielectron sources with ALICE in Run 3 **Florian Eisenhut** • Beam test results for the new prototype ITS3 sensor design **Minyoung Chris Hwang**	**Soft Probes Detector Upgrades (6)**

Summary

- **ALICE is successfully taking data after the significant detector upgrades in Run 3**
  - Many results from the new data are shown
- **Detector upgrades are progressing smoothly for the future Run 4 and ALICE 3**
- **ALICE presents 31 talks and 27 posters at Hard Probes 2024**

Enjoy the conference!