Recent Results from ALICE(-China)

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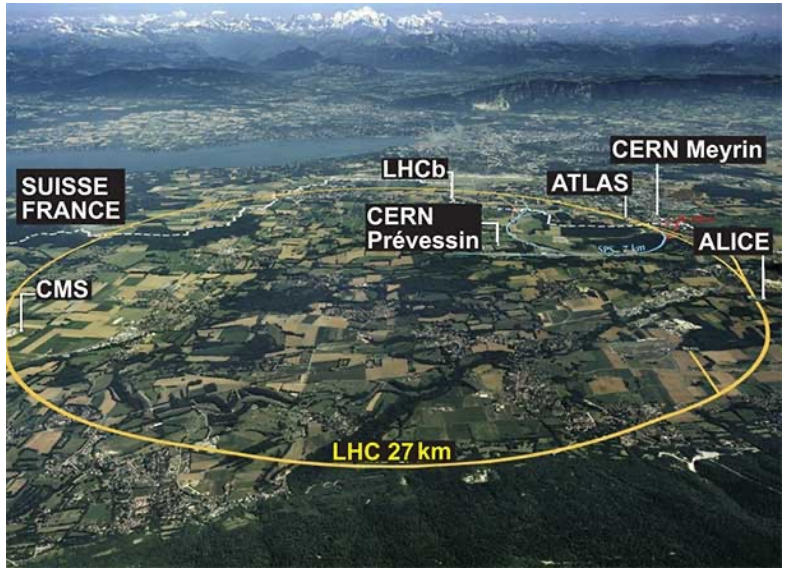
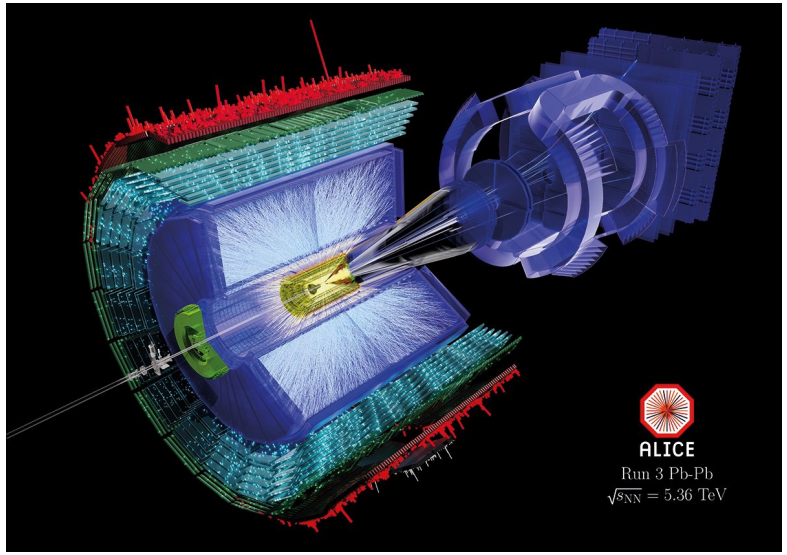
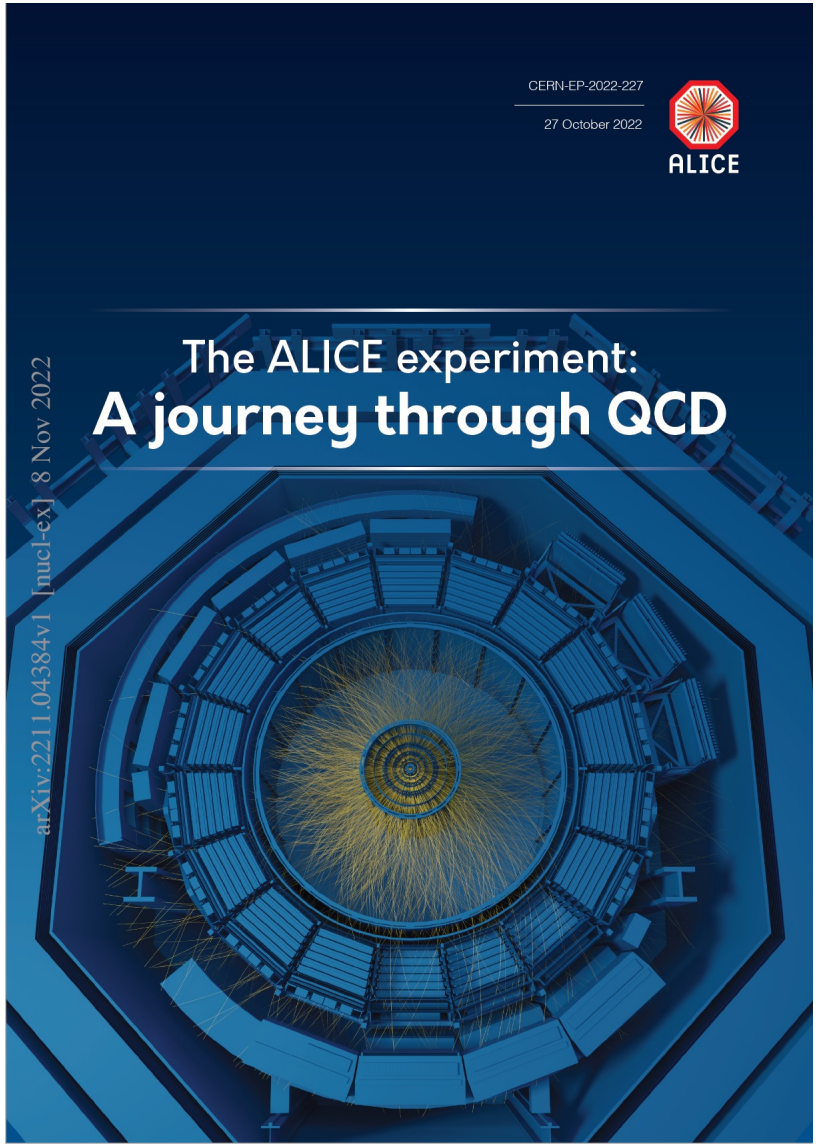
LHC and ALICE



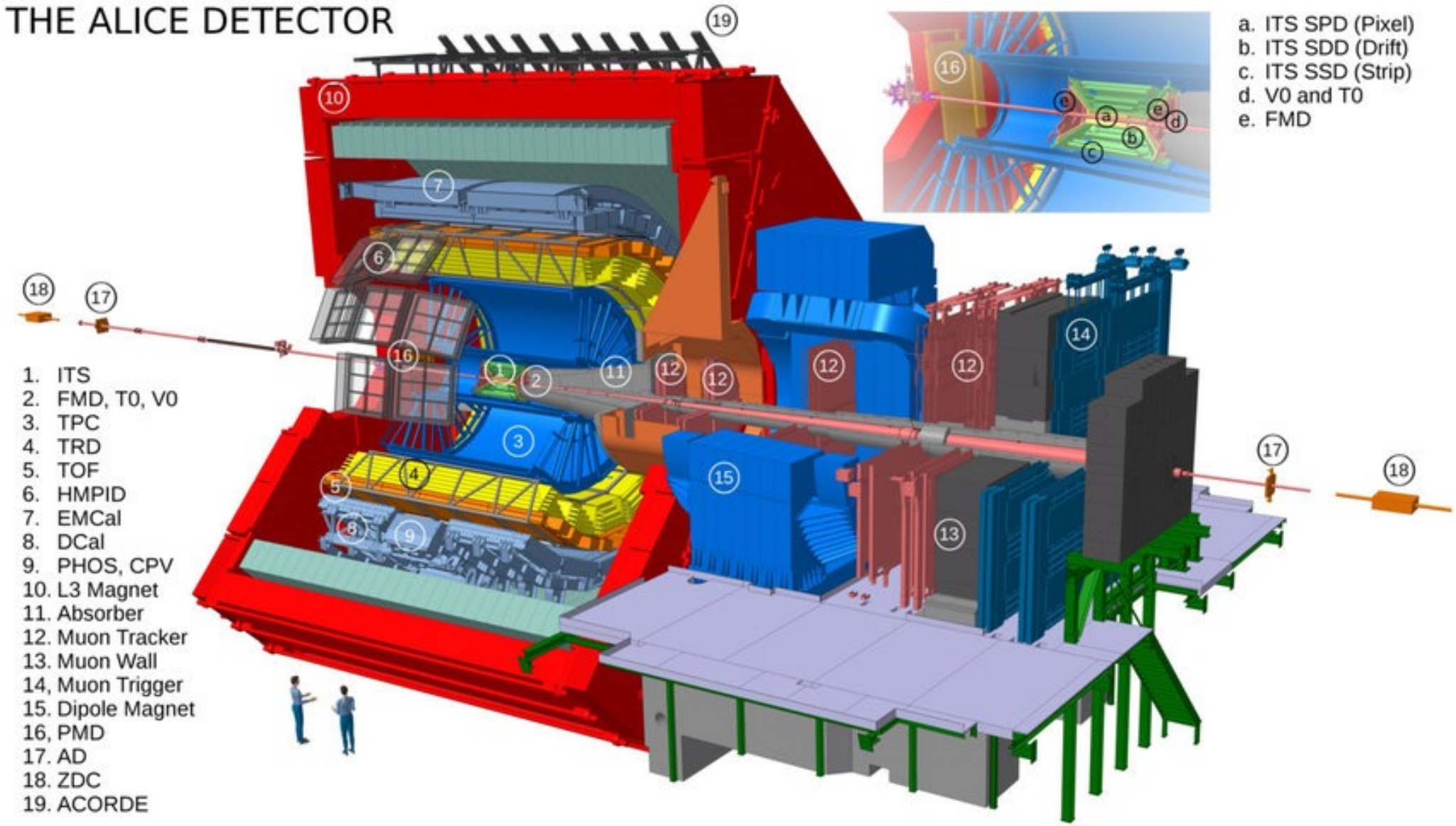




ALICE-China:

- 华中师范大学
  (CCNU, Wuhan)
- 中国原子能科学研究院
  (CIAE, Beijing)
- 中国地质大学（武汉）
  (CUG, Wuhan)
- 复旦大学
  (FDU, Shanghai)
- 中国科学技术大学
  (USTC, Hefei)

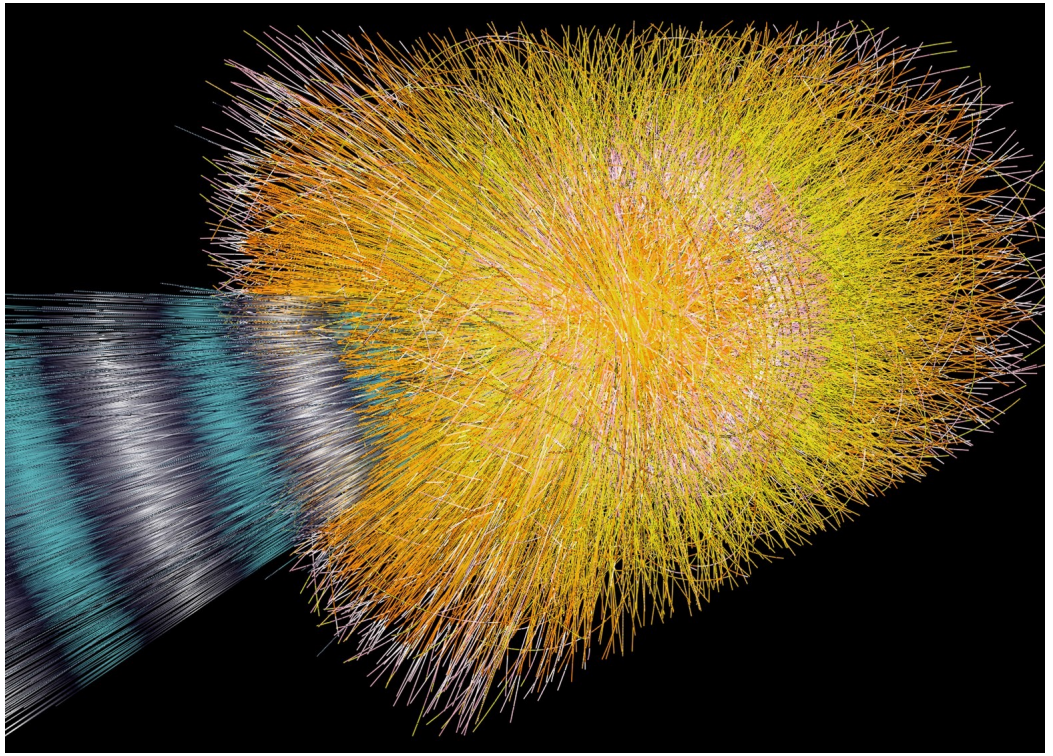
The ALICE Detector in Run2



Heavy Ion Collisions at TeV

- High initial temperature
- Large entropy
- Long lifetime

Complementary between RHIC and LHC

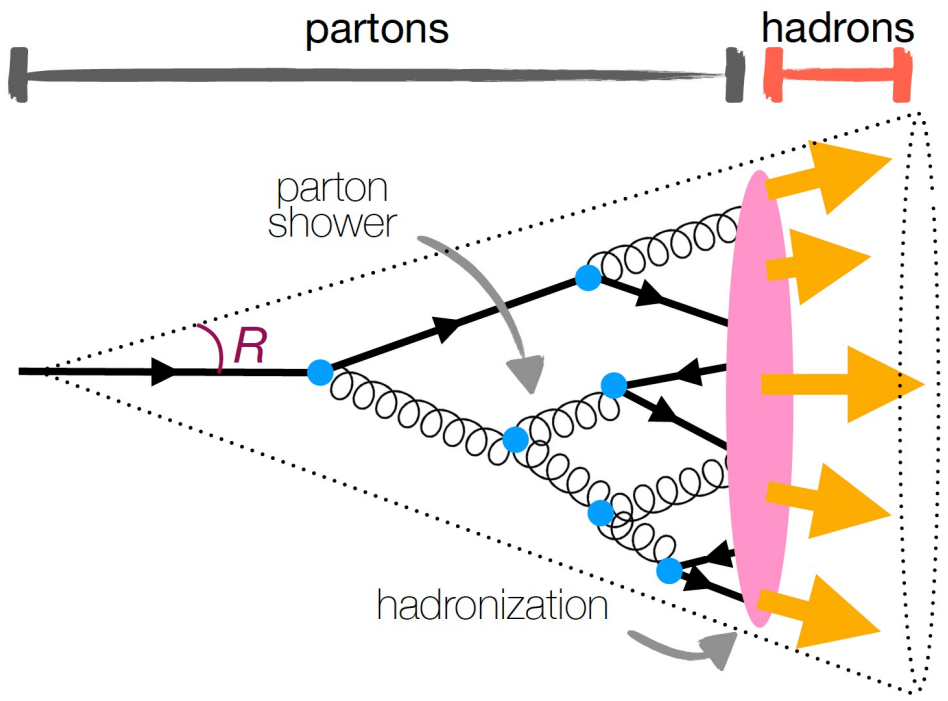


- Large cross-section for hard probes (jets, heavy flavor, quarkonium etc)

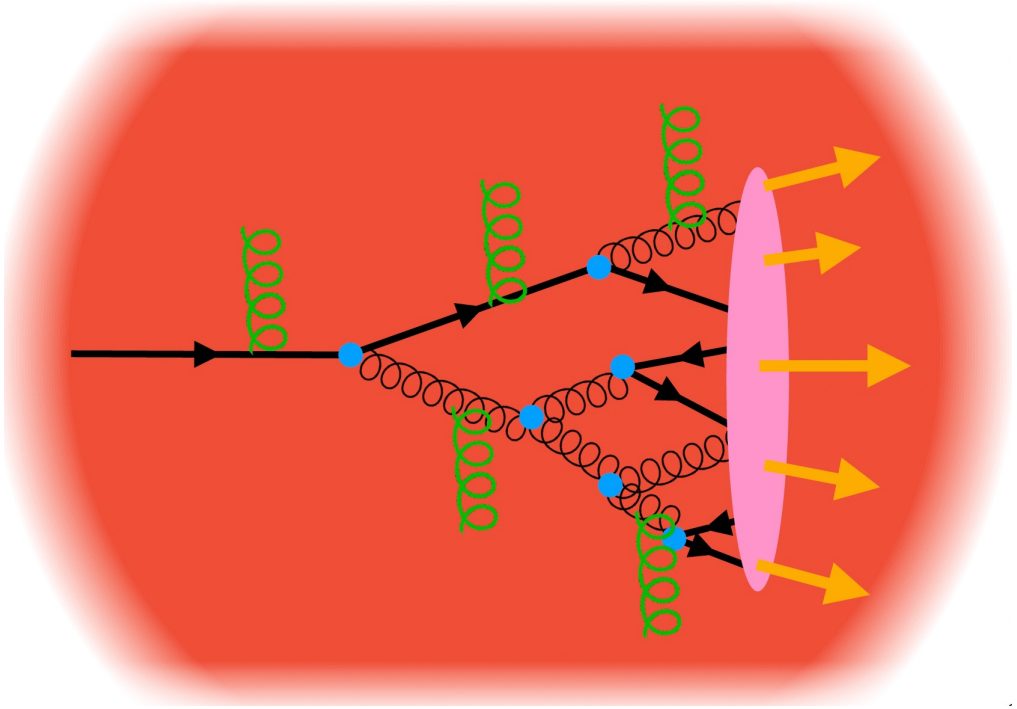
Unique opportunity for hard probes measurements

Jets in QGP

Jet vacuum fragmentation

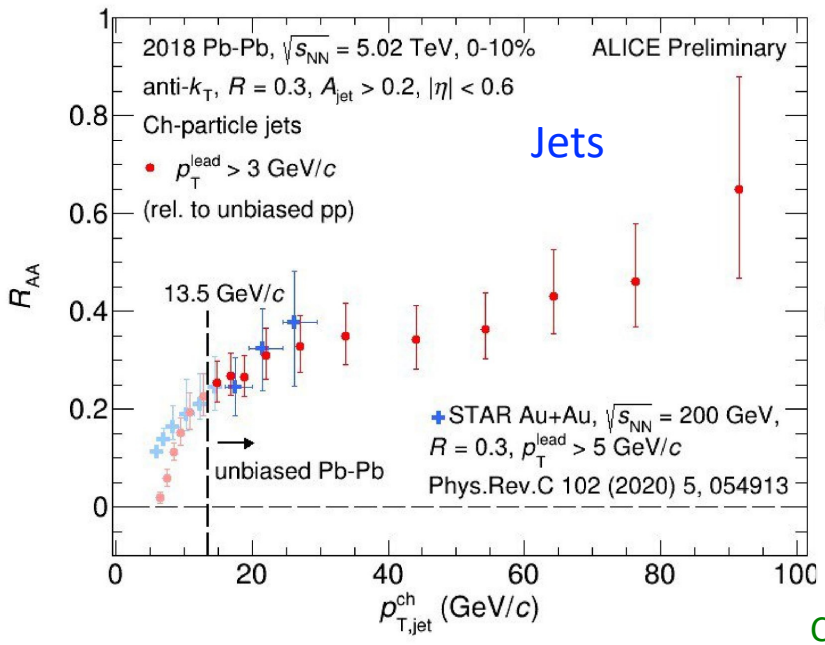


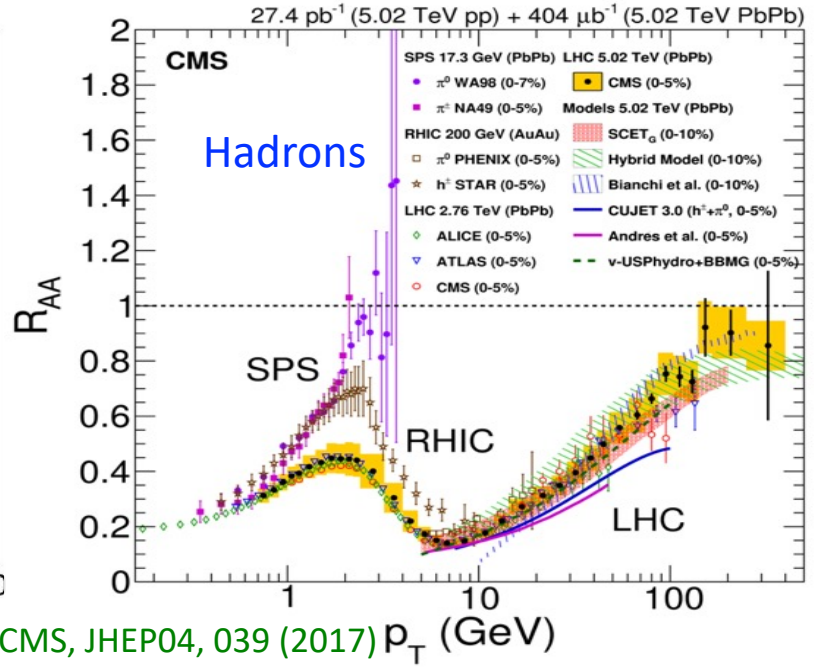
Jet in-medium fragmentation



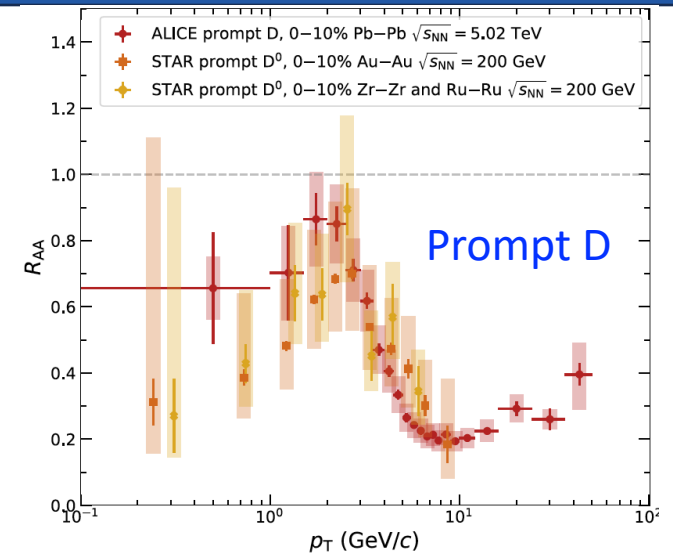
Transport properties of the hot, dense medium

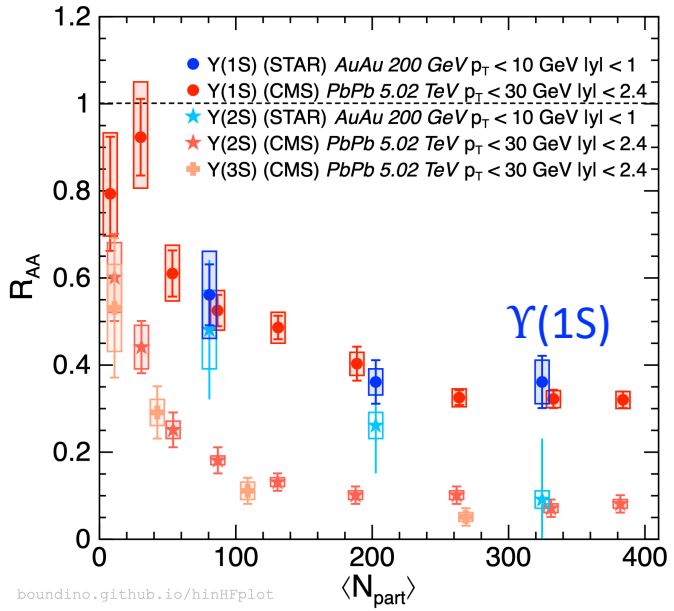
Similarity between LHC and RHIC





CMS, JHEP04, 039 (2017)



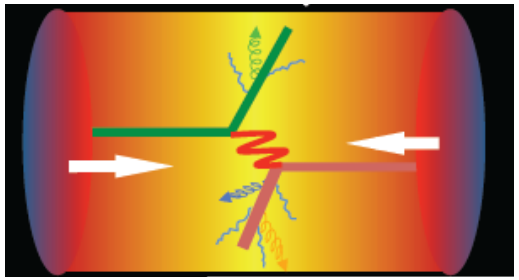


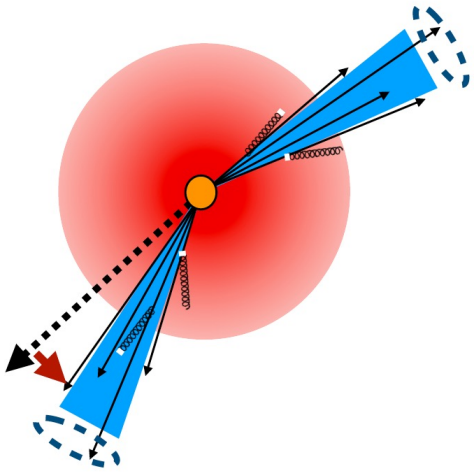
Surprisingly similar suppression at RHIC and LHC for

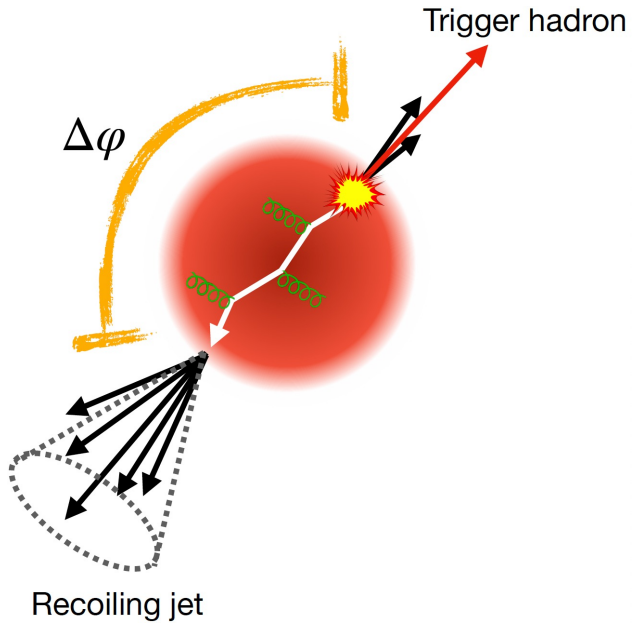
- Jets
- High-p_T light flavor hadrons
- Intermediated p_T charmed mesons
- Ground bottomonium state

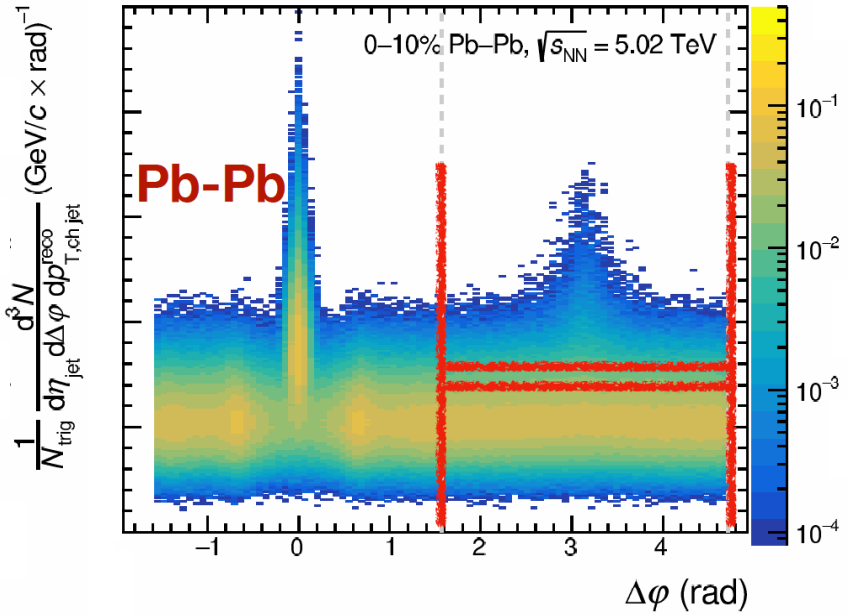
Likely due to interplay of different effects

Hadron-Jet Correlations









Jet energy loss and deflection in QGP

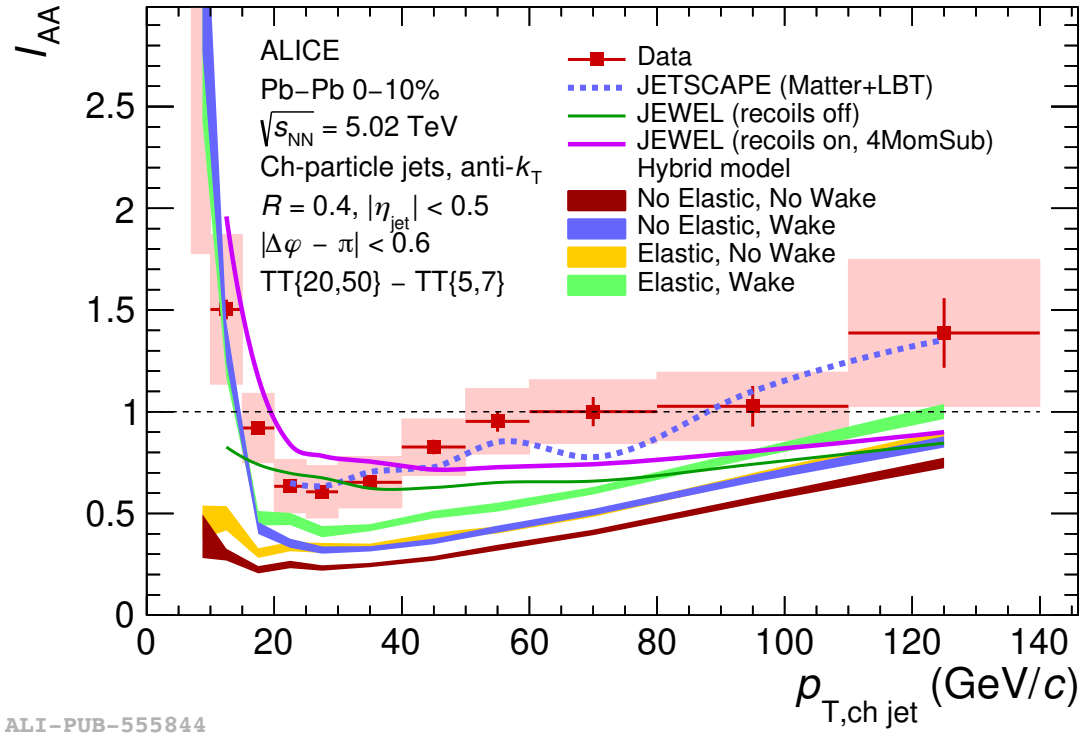
Simultaneously accessed via hadron-jet correlations

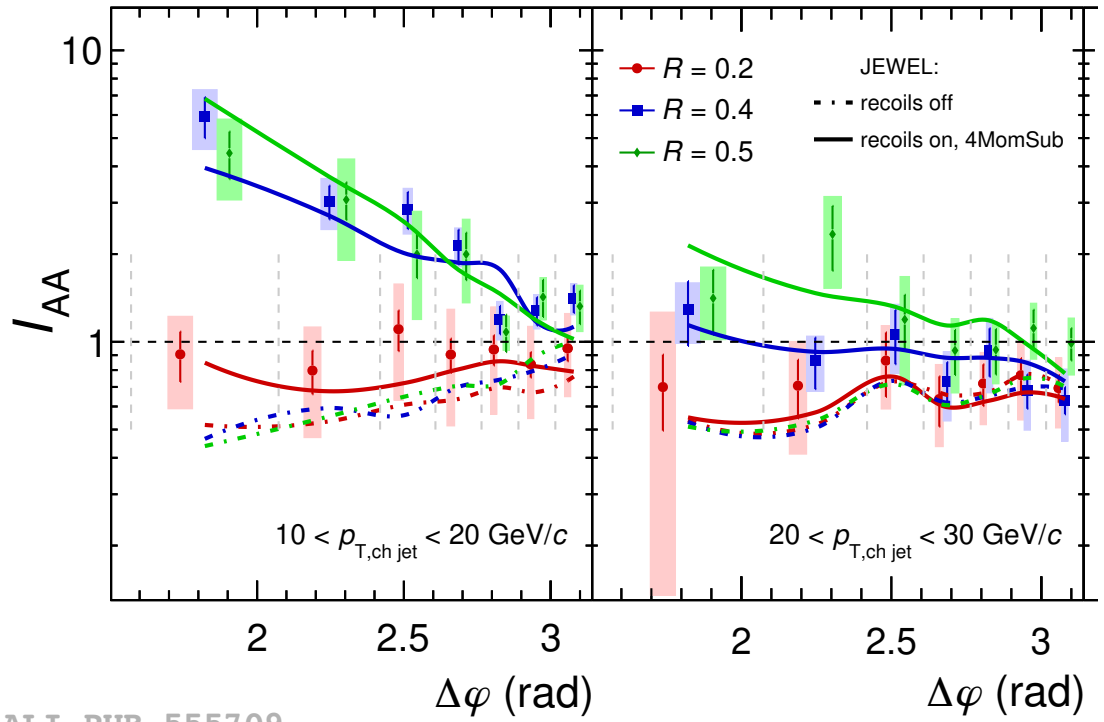
State-of-the-art technology to push down to low p_T

Recoil Jets Results

ALICE, PRL133, 022301 (2024) & PRC110, 014906 (2024)

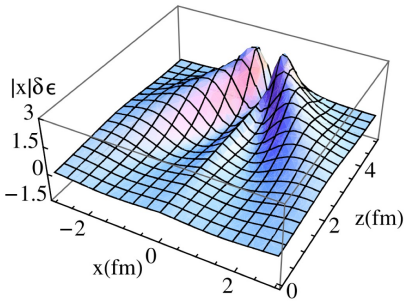
侯永珍（重离子物理，周三5:40 pm）





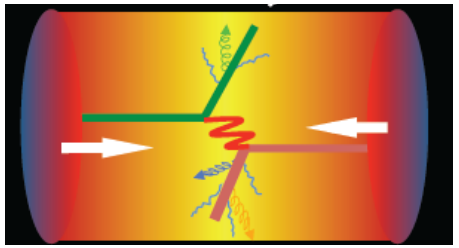
- First observation of recoil jet yield enhancement and medium-induced acoplanarity broadening at low-p_T with ALICE

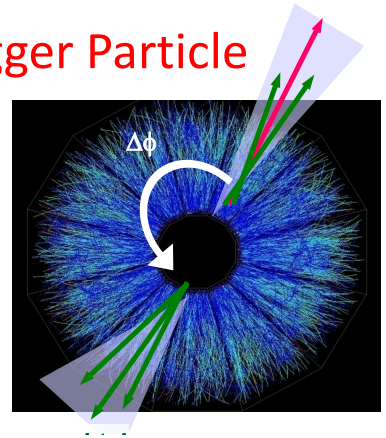
➔ Medium response is favored



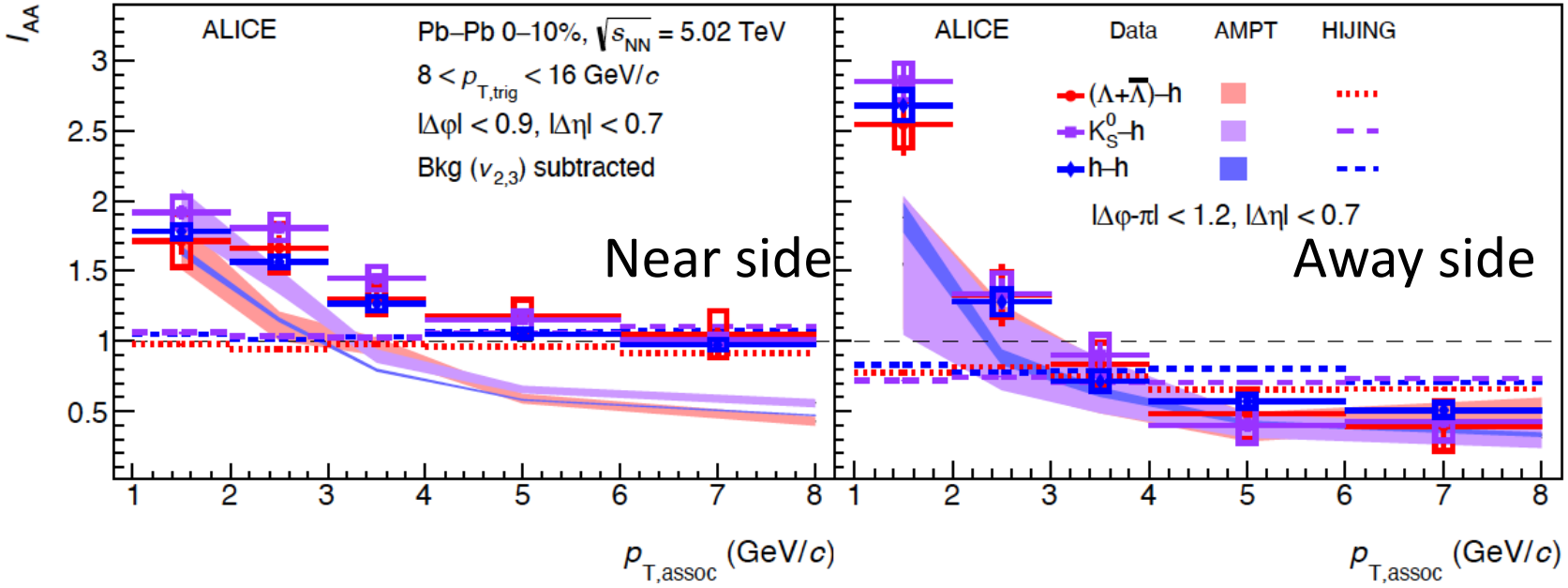
G-Y. Qin et. al, PRL103, 152303 (2009)

Flavor Dependence





ALICE, EPJC83, 497 (2023)



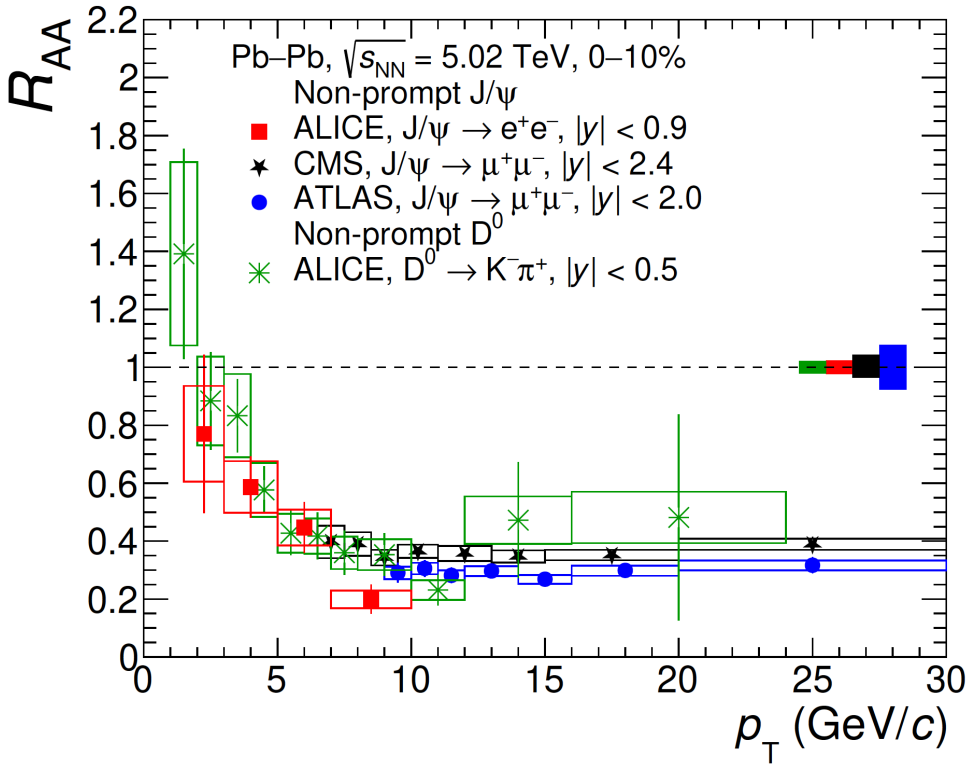
- Jet quenching effects seen in the di-hadron correlations

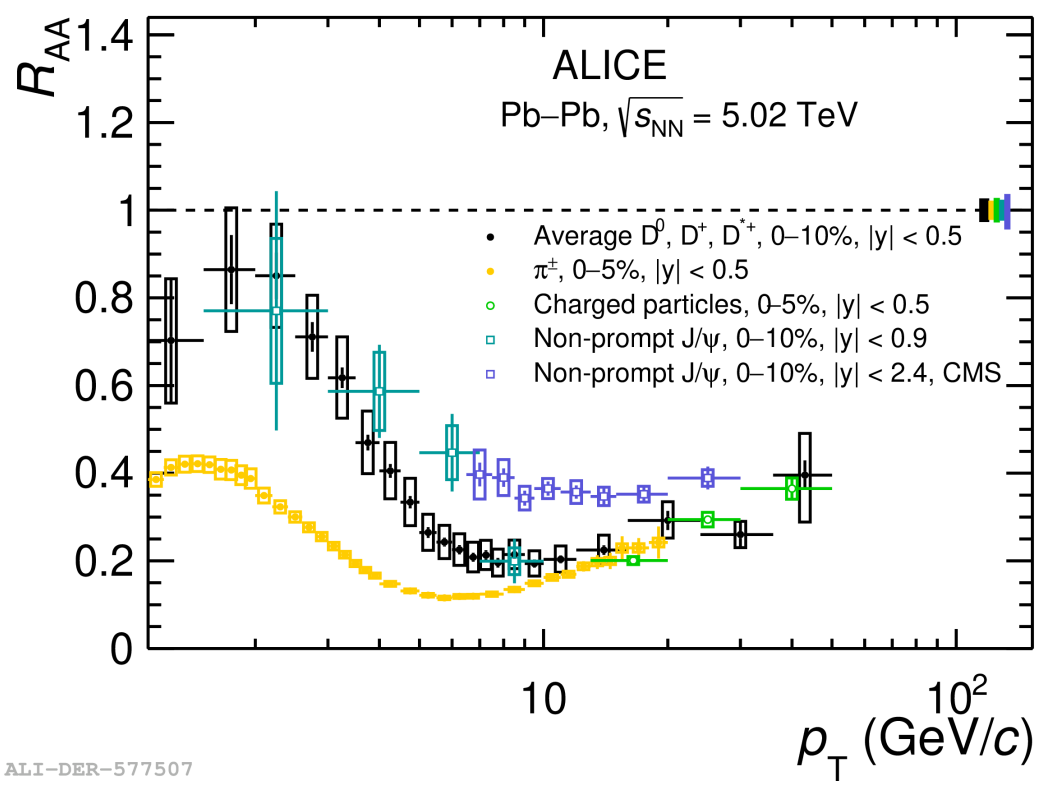
  ➔ Energy loss by high-energy parton recovered in surrounding

- Independent on trigger particle species
- Provide new constraints on jet quenching and medium response

Energy Loss of Bottom

ALICE, JHEP02, 066 (2024)





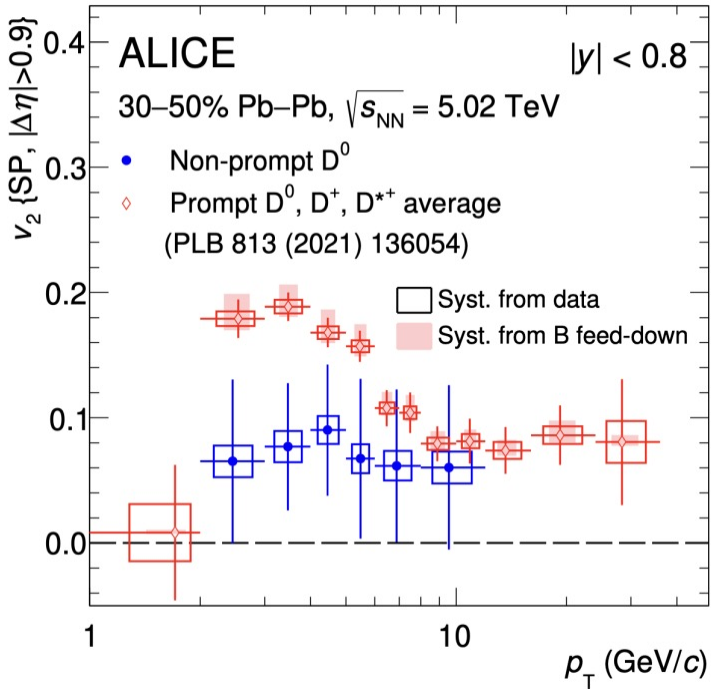
- Pushed to low-p_T via D^0 and J/ψ
  - D^0 has better statistics
  - J/ψ has better kinematics
- Strong suppression of bottom

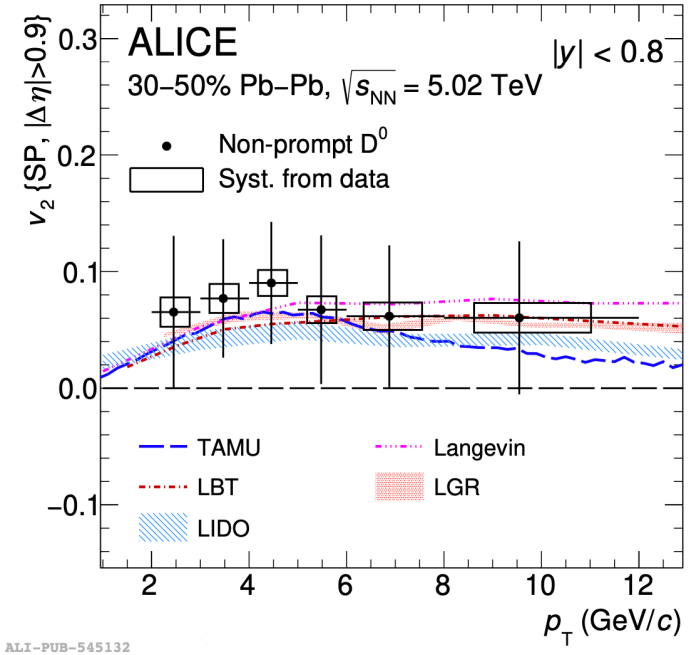
- Clear mass hierarchy at intermediate p_T

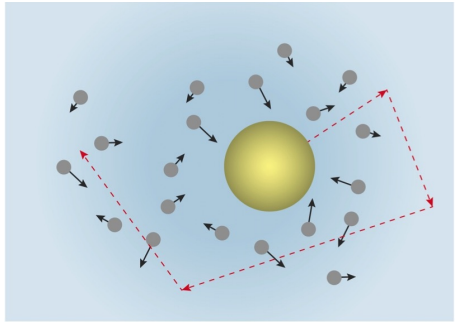
  $R_{AA}(B) > R_{AA}(D) > R_{AA}(\text{light hadrons})$

Elliptic Flow of Bottom

ALICE, EPJC83, 1123 (2023)

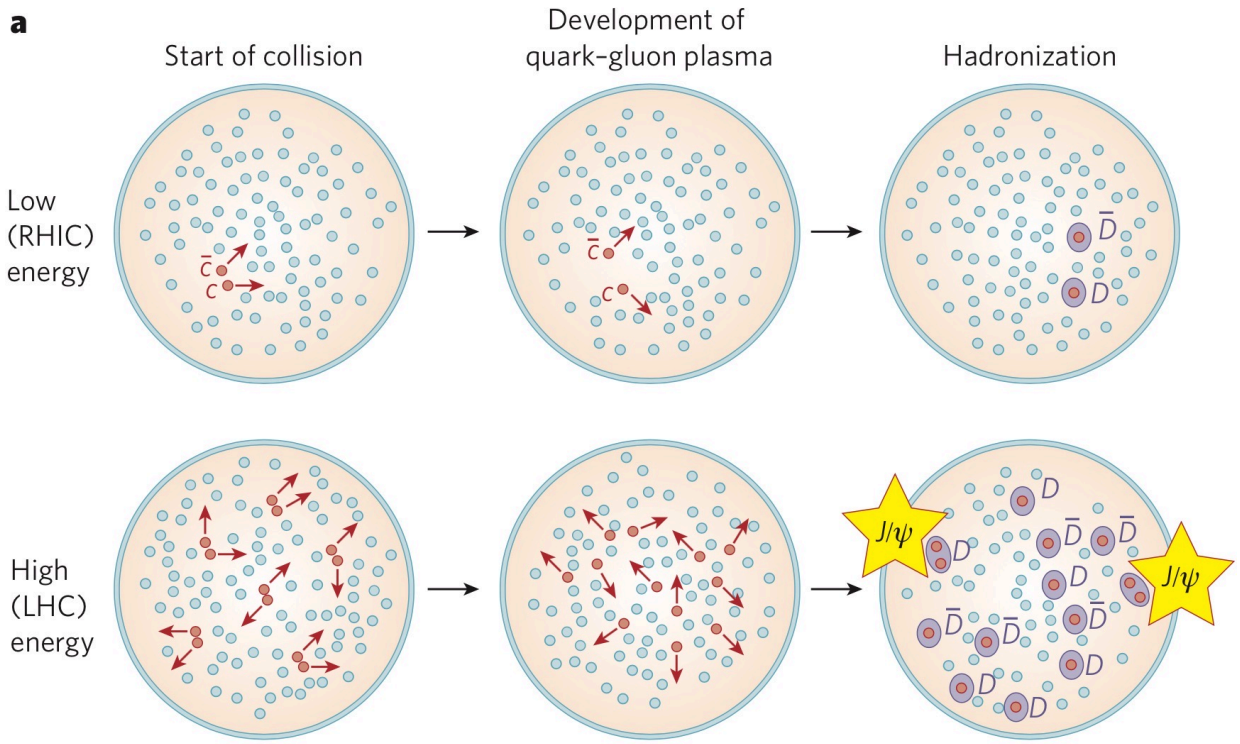






- Positive elliptic flow of D^0 from B-hadons decay
- Lower than that of prompt D^0 for p_T <~ 6 GeV/c
- Described by various models based on bottom quark transport in QGP
- Better precision needed to constrain heavy quark spatial diffusion coefficient

Charmonium in QGP

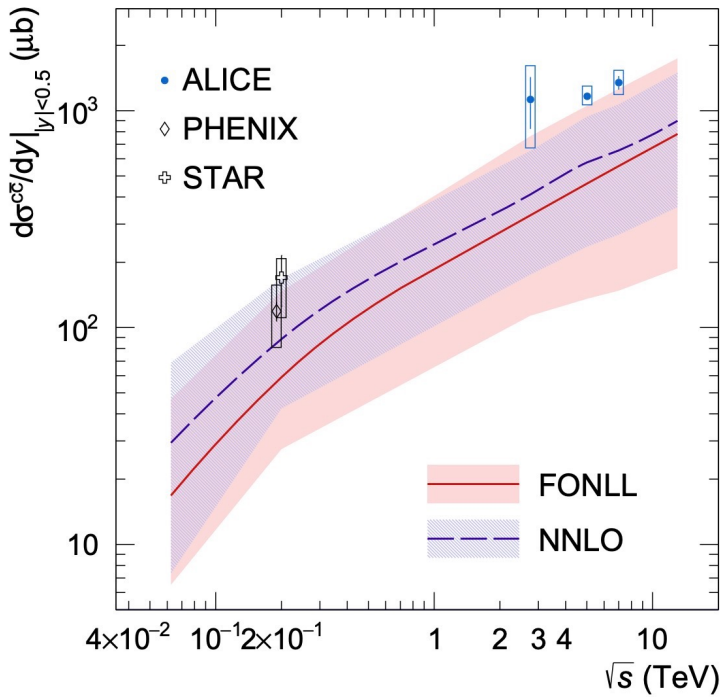


P. Braun-Munzinger, J. Stachel, Nature 448, 302 (2007)

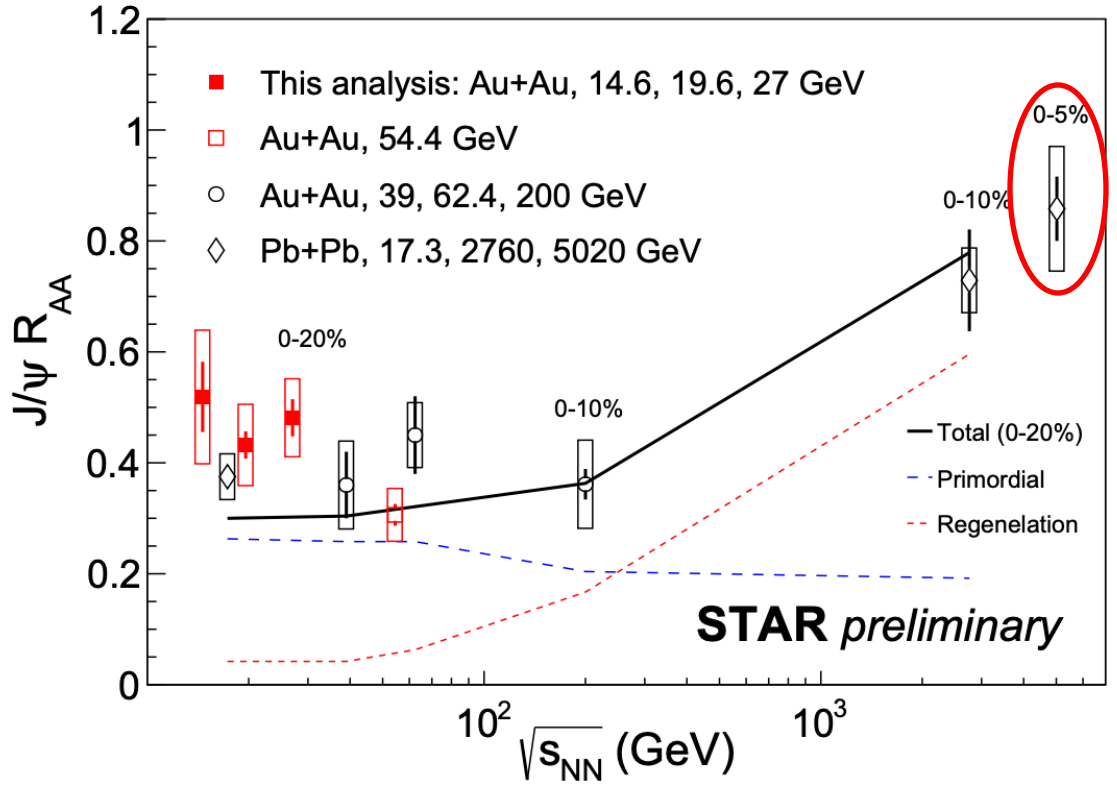
A. Andronic et. al., Nature 561(2018) 321-330

Hot medium effects:

- Melting in QGP
- Regeneration
- Jet quenching?



Energy Dependence of J/ψ Suppression



NA50, PLB 477, 28 (2000)
Wei Zhang, QM 2023
STAR, PLB 771, 13 (2017)
Kaifeng Shen, SQM 2021
ALICE, PLB 734, 314 (2014)
ALICE, PLB 849, 138451 (2024)

SPS → RHIC → LHC

CNM domain

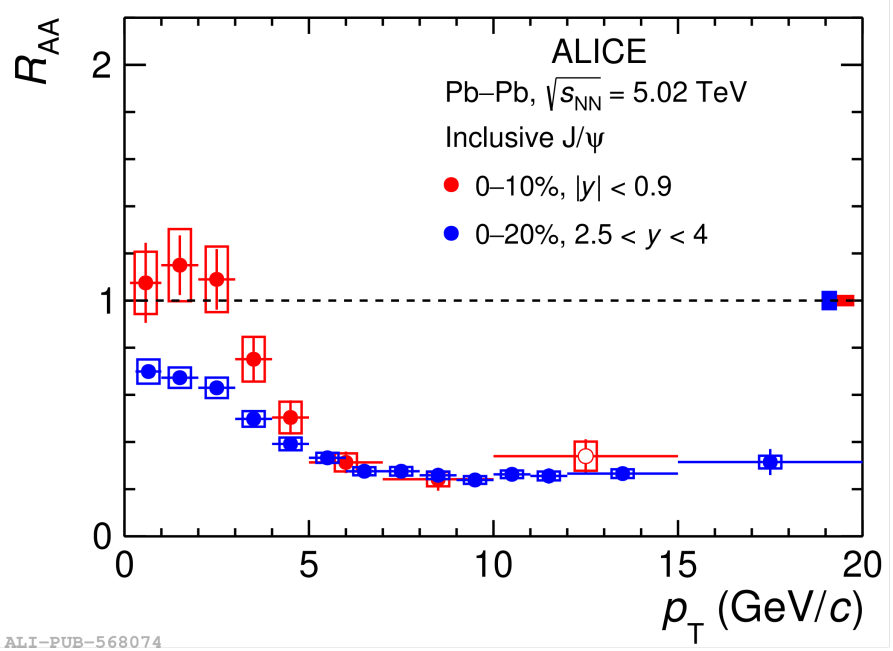
CNM + Melting + regeneration

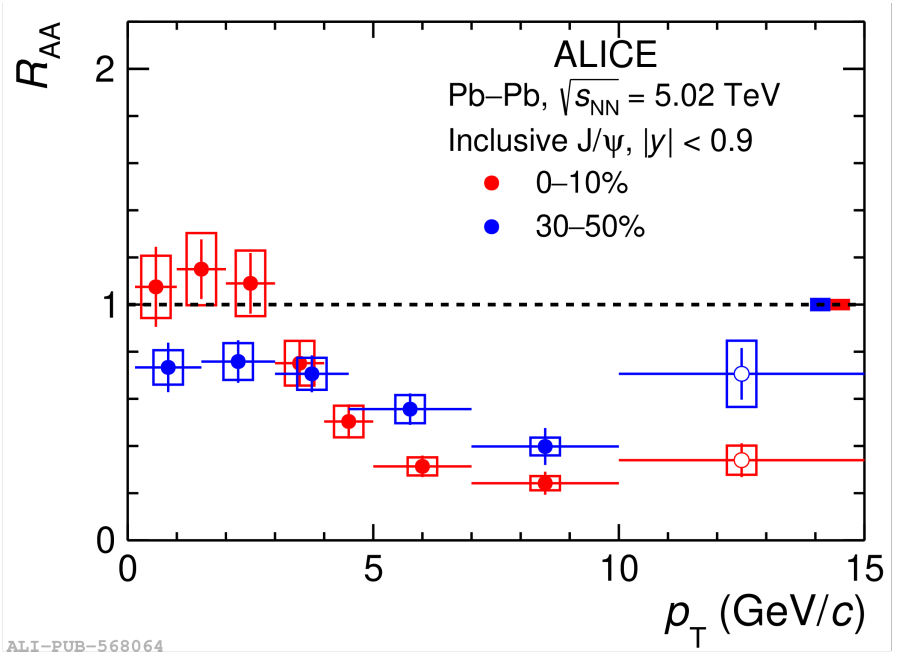
Regeneration domain

20 years efforts at STAR and the LHC

Differential Measurements at ALICE

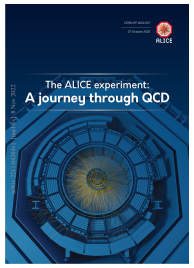
ALICE, PLB 849, 138451 (2024)





- Clear rapidity dependence at low-p_T
- Similar suppression at high-p_T

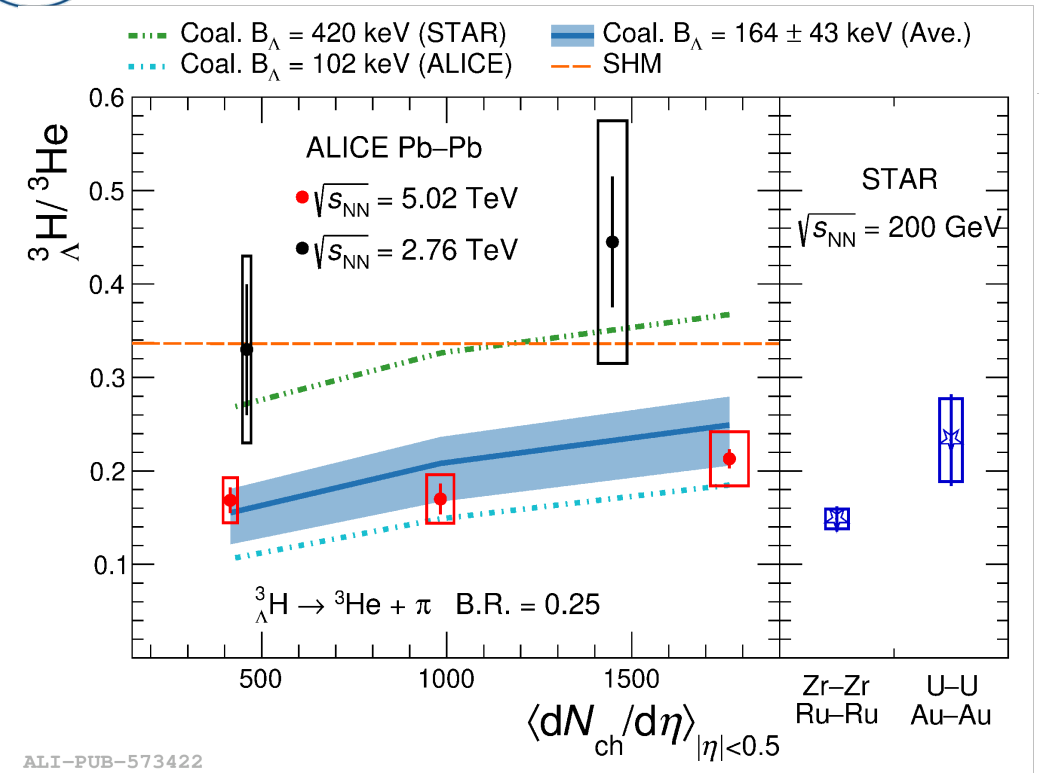
- Clear centrality dependence
- Opposite at low and high p_T region



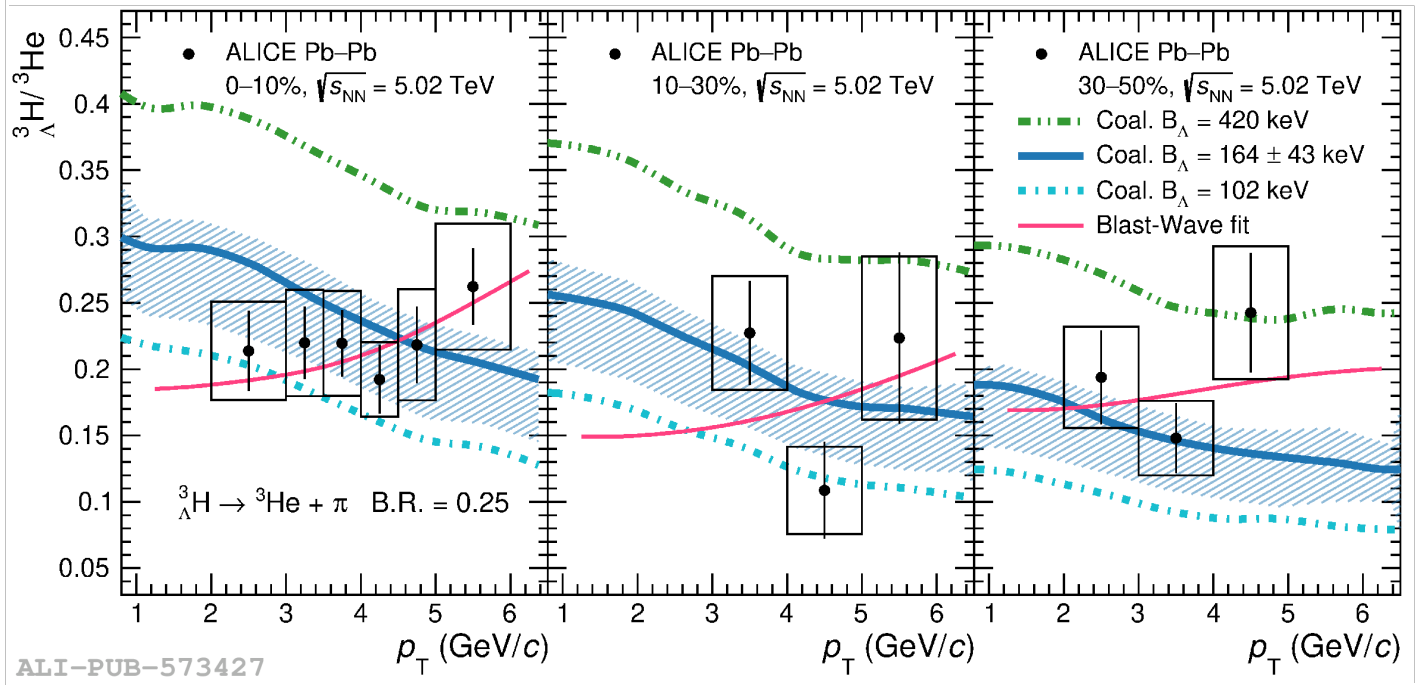
2.5.1 Study of the charmonium ground state: evidence for the (re)generation and demonstration of deconfinement at LHC energies

*Energy loss may play import role at high p_T

Hypertriton Production



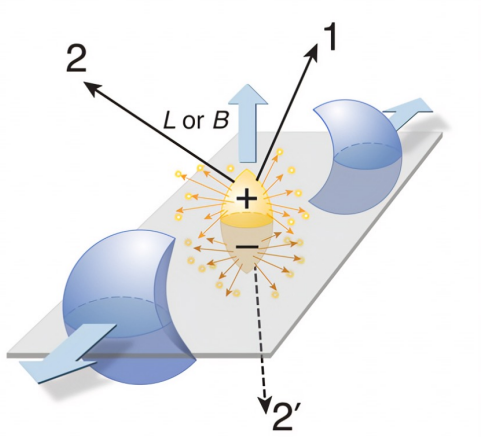
ALICE, arXiv:2405.19839

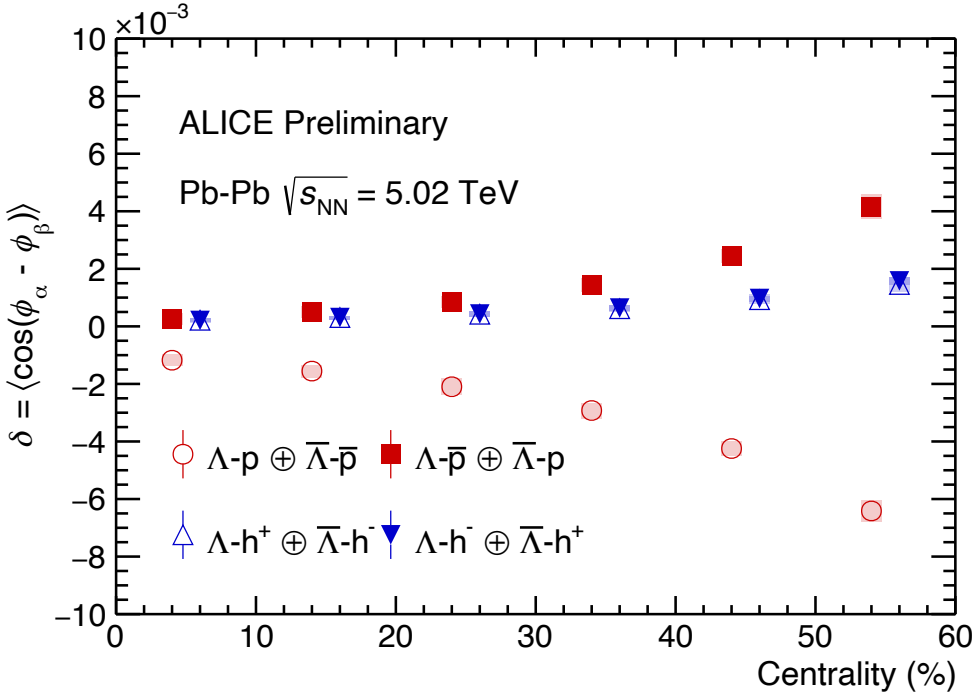


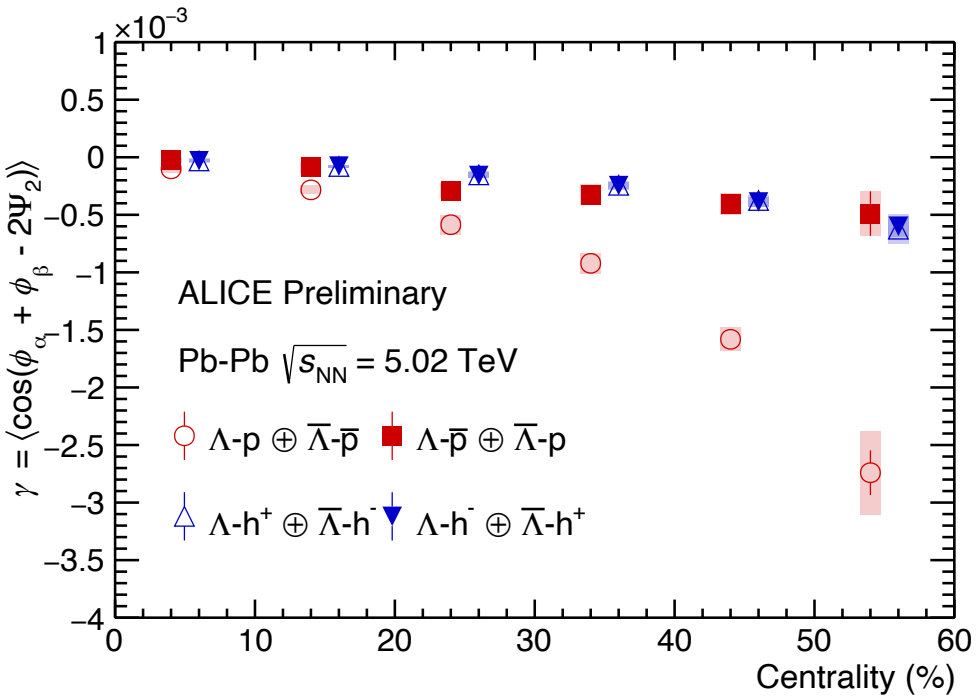
- Hypertriton ($^3_\Lambda H$) is a unique probe to study Y-N interactions
- Hypertriton production is precisely measured via machine learning
- Extracted ratio described by the coalescence model with the world average binding energy (B_Λ)

Search for Chiral Vortical Effect

ALICE, Quark Matter 2023



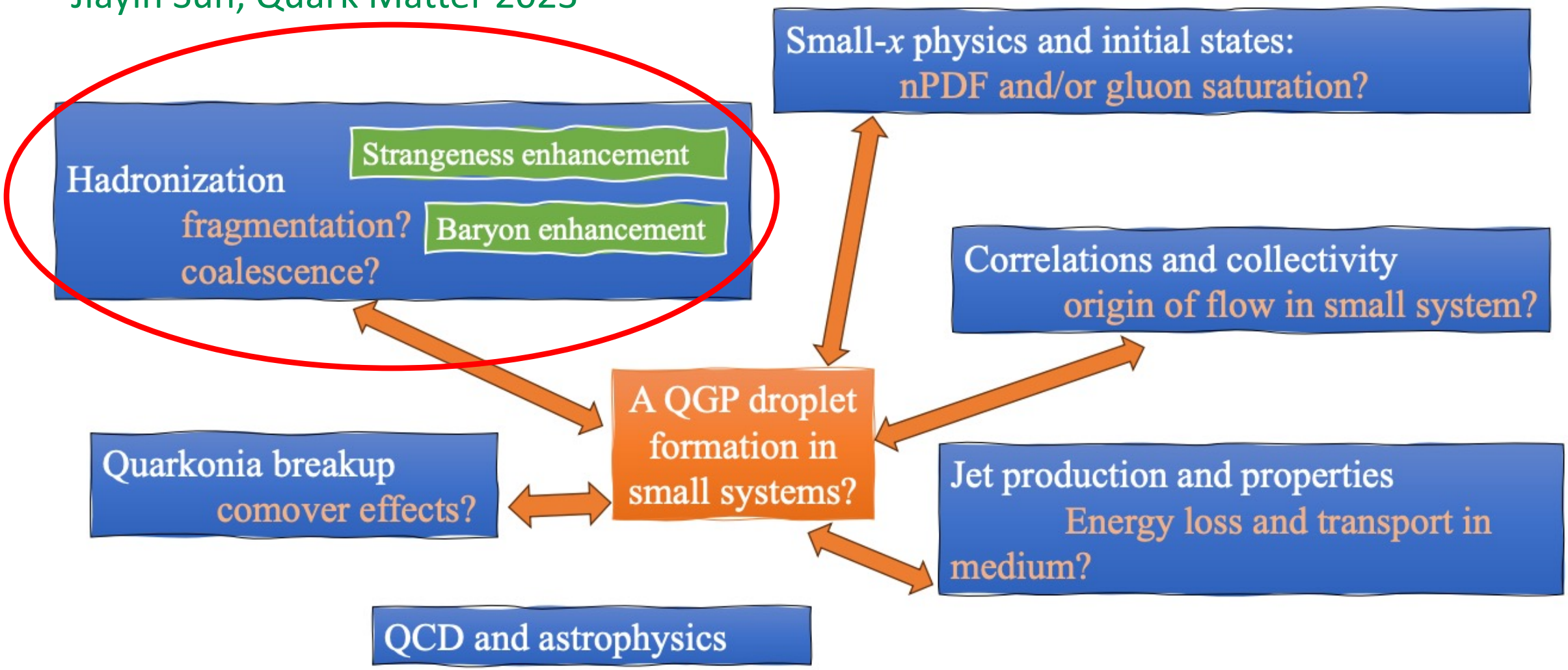




- The interplay between the strong vortical field and chiral anomaly could give rise to the Chiral Vortical Effect (CVE) --- remains unexplored
- CVE has been measured with Λ-p azimuthal correlations for the first time
- Non-trivial behaviors are observed. Interpretation ongoing

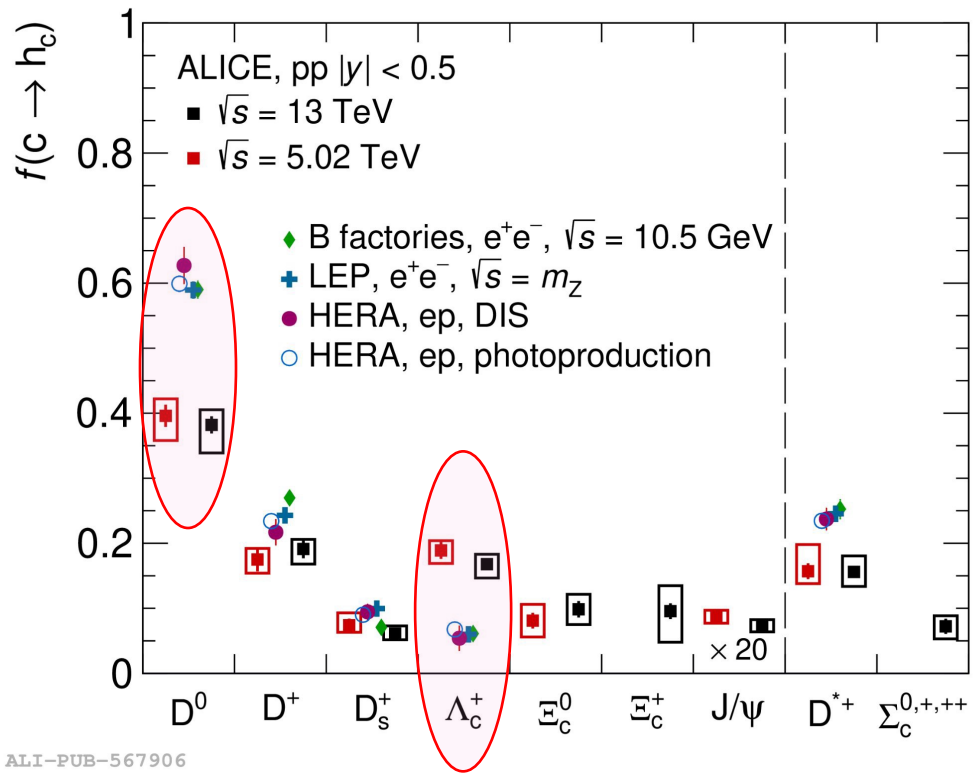
Small System – QGP Droplet?

Jiayin Sun, Quark Matter 2023

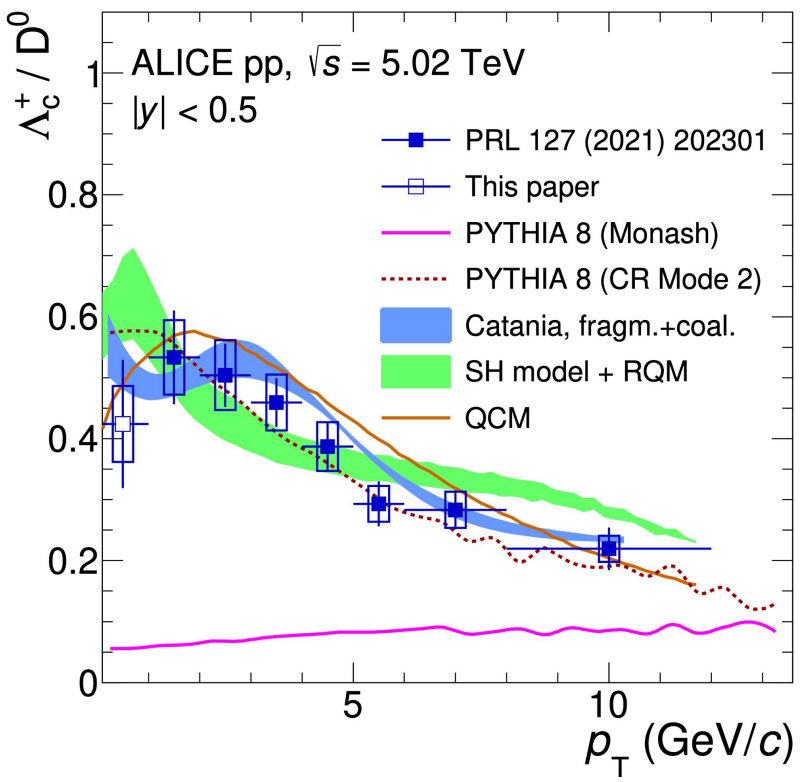


Charm Hadronization

ALICE, JHEP12, 086 (2023)



ALICE, PRC107, 064901 (2023)



程甜甜（重离子物理，周三3:40 pm）

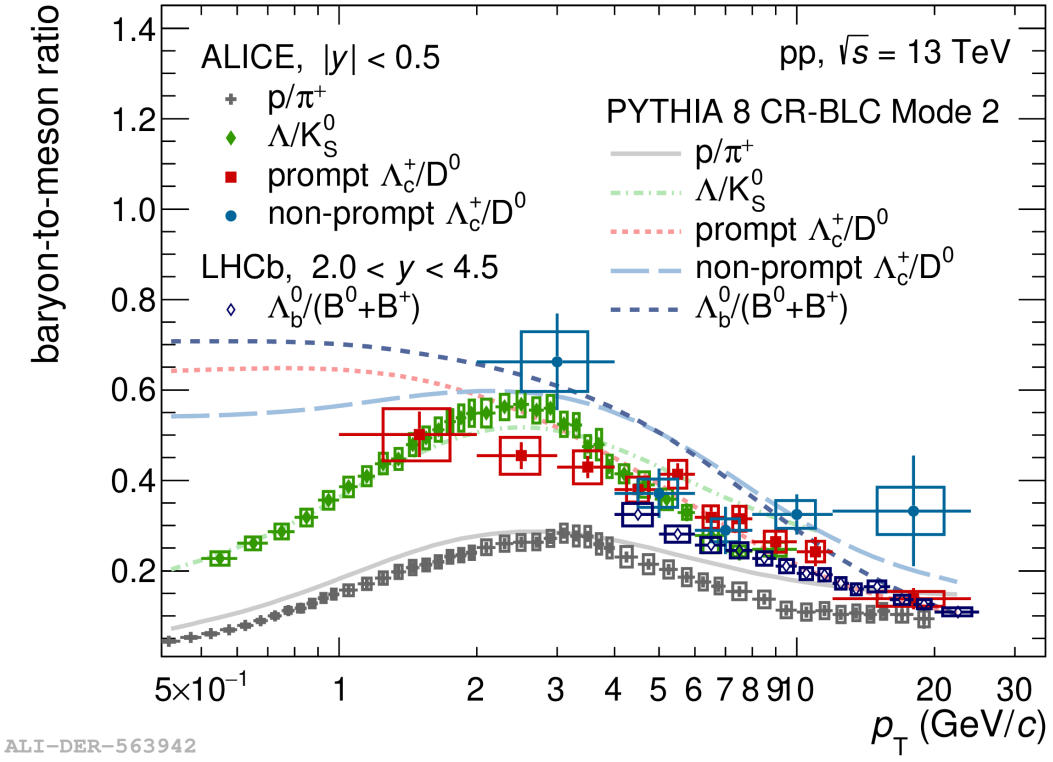
- Charm quarks redistributed even in pp collisions at the LHC

➔ Modification of hadronization in pp

- Measurements pushed down to $p_T = 0$
- Significantly larger than default PYTHIA
- Qualitatively described by models

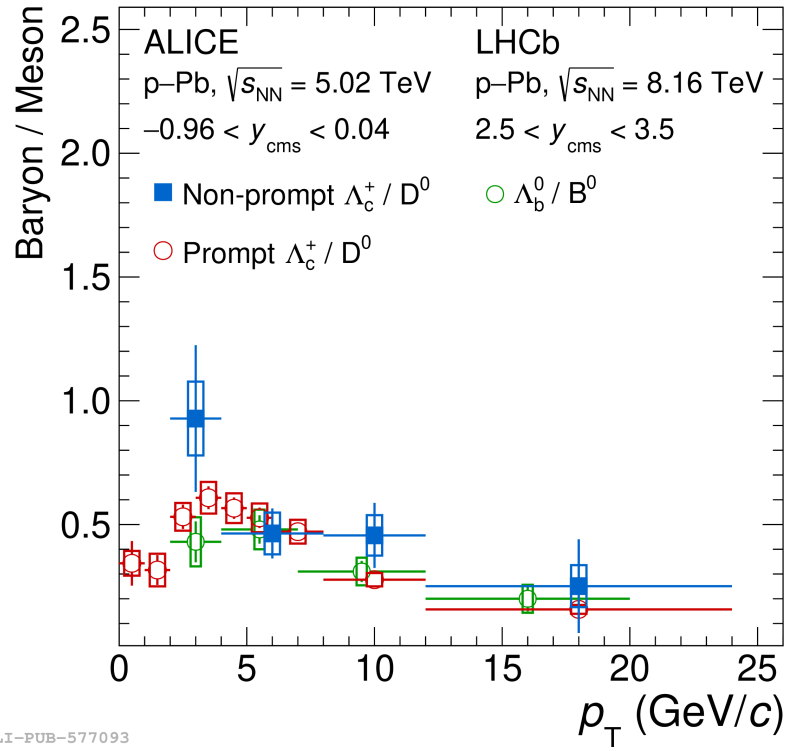
Bottom Hadronization

ALICE, PRD108, 112003 (2023)



ALICE, arXiv:2407.10593

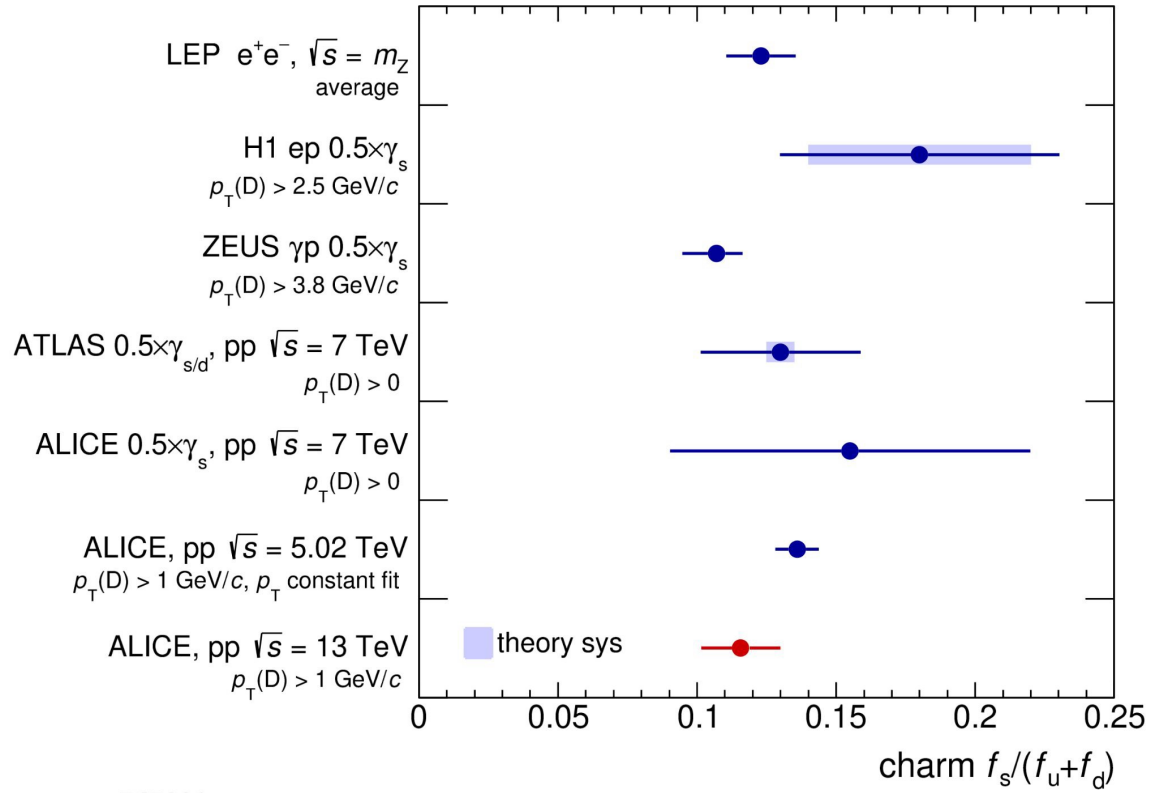
卢鹏忠（强子物理与味物理，周四5:15 pm）



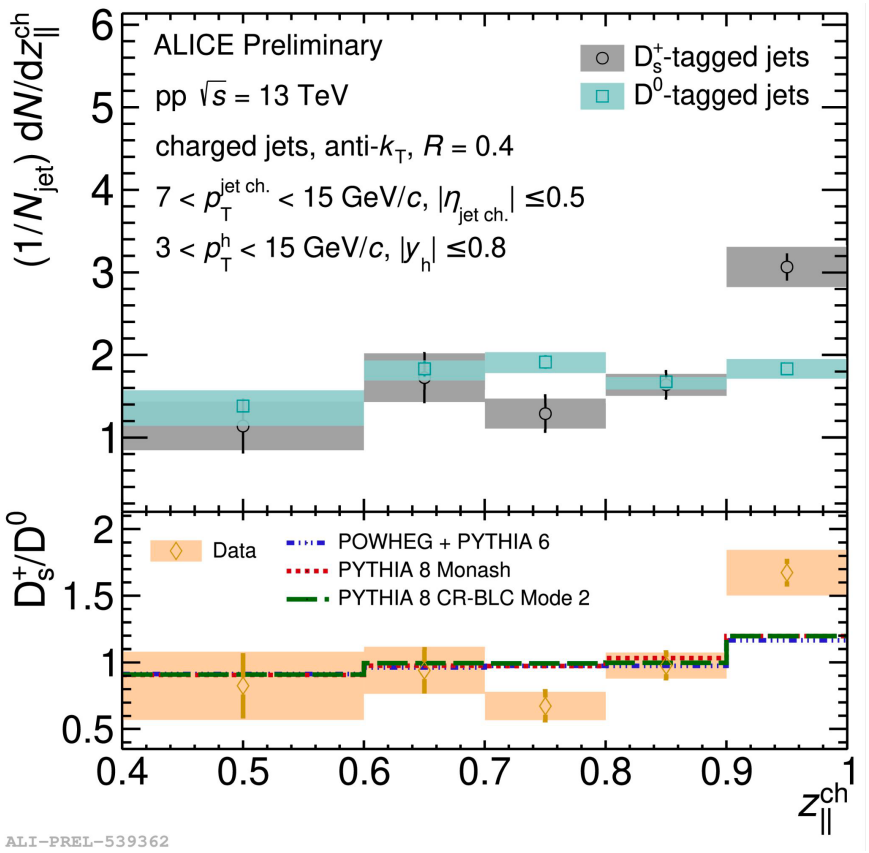
- Bottom baryon-to-meson ratios show similar enhancement as charm and strange hadrons in both pp and pPb collisions at LHC

➔ Mass doesn’t play a significant role

Strangeness Enhancement?

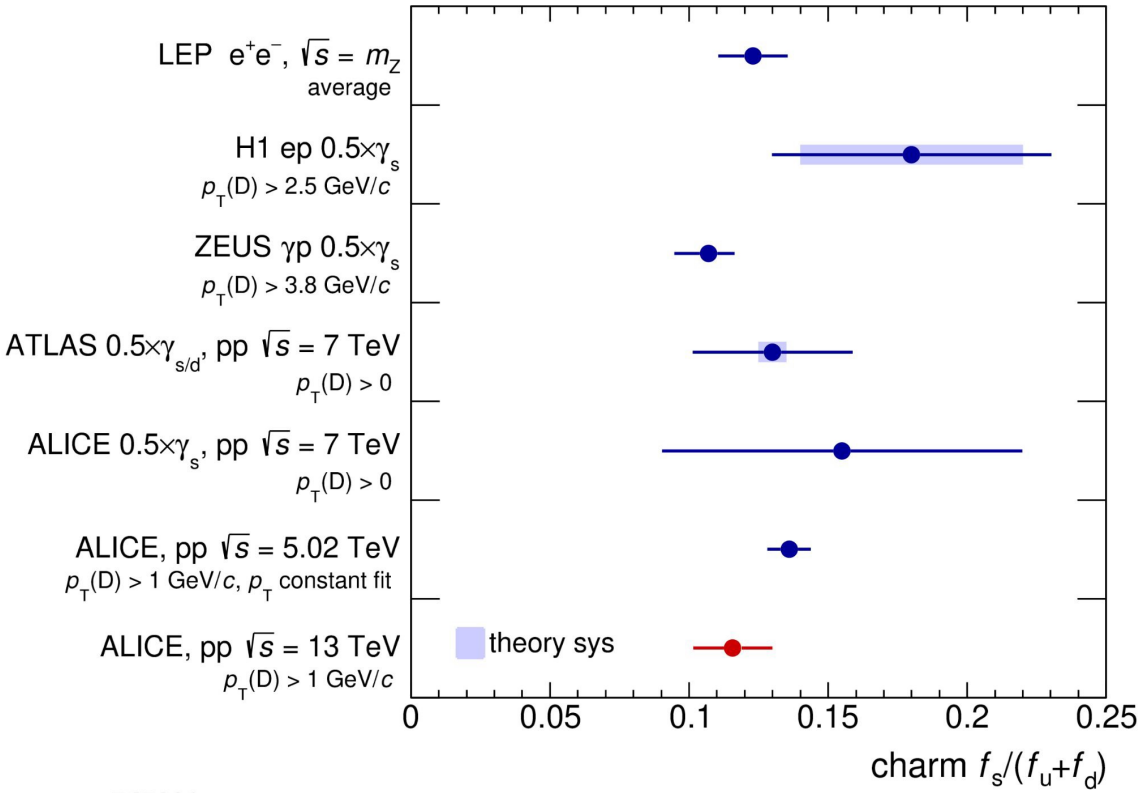


ALICE, Hard Probes 2023

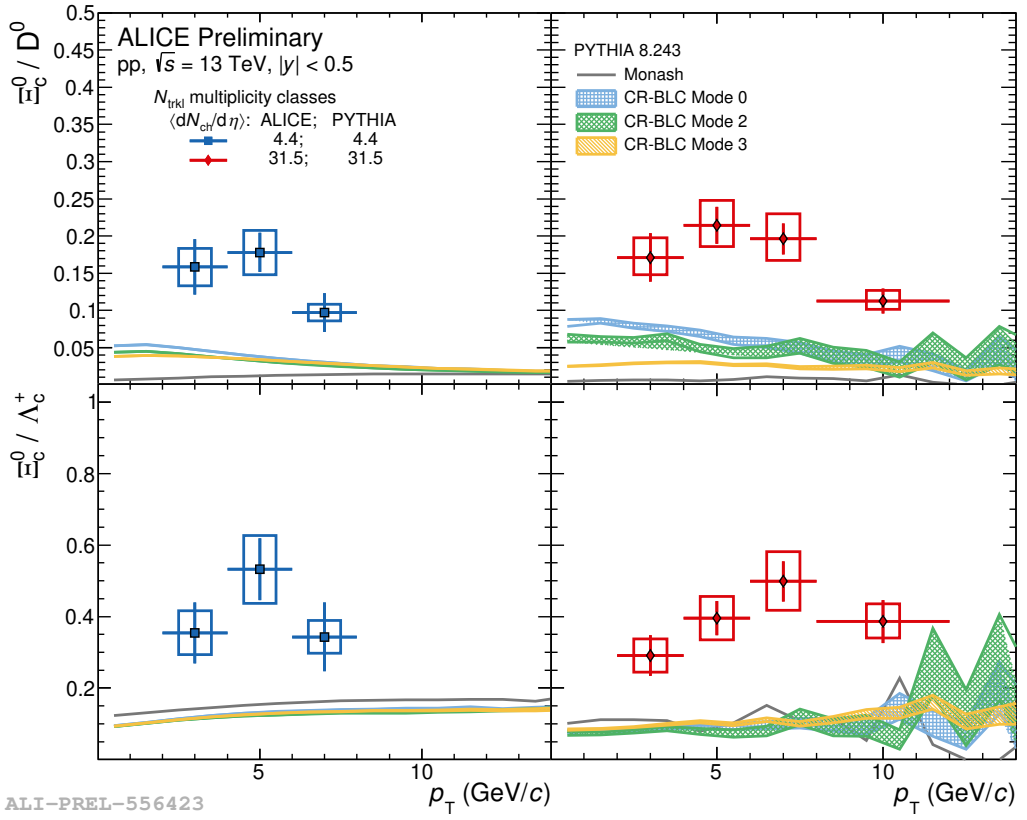


- Ratio of strange and non-strange D mesons compatible between pp and ee collisions
- Hint of harder fragmentation for strange mesons w.r.t non-strange D mesons

Strangeness/Baryon Enhancement?

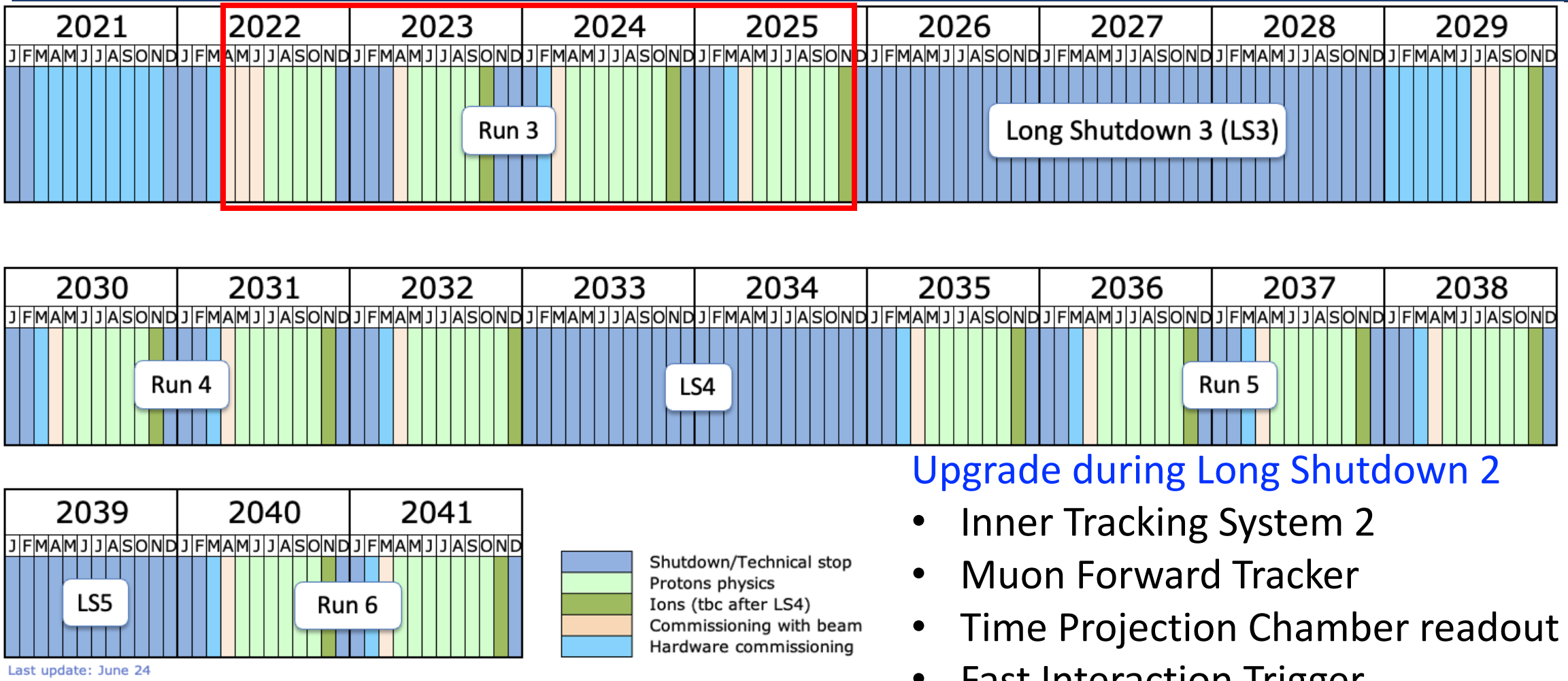


ALICE, Quark Matter 2023



- Ratio of strange and non-strange D mesons compatible between pp and ee collisions
- Indication of enhancement for charm-strange baryons ➔ Puzzling

ALICE Run3



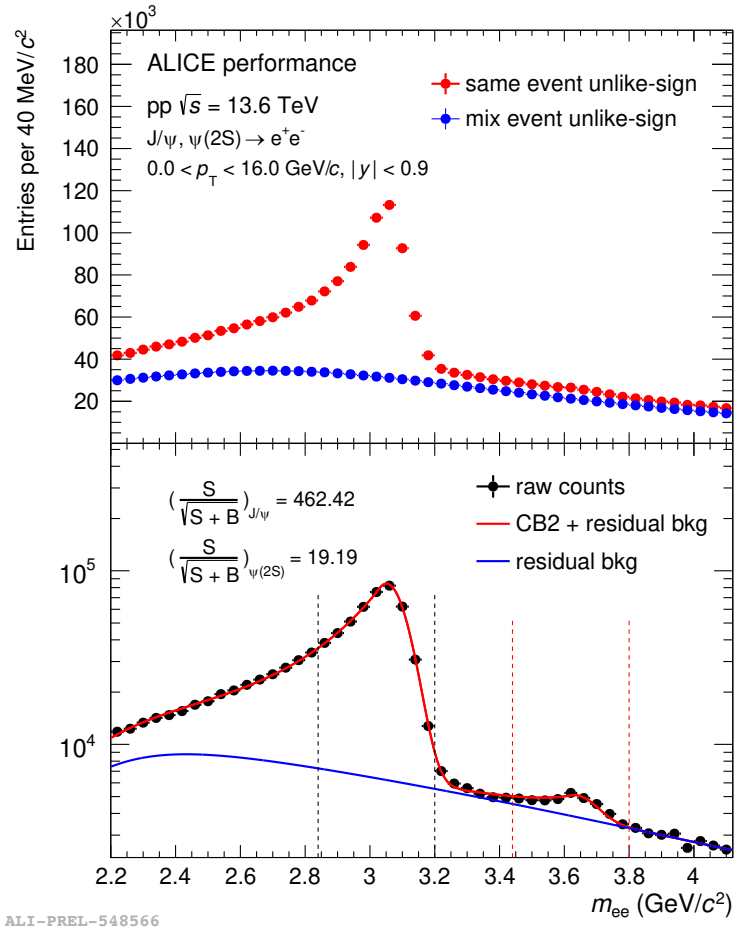
Upgrade during Long Shutdown 2

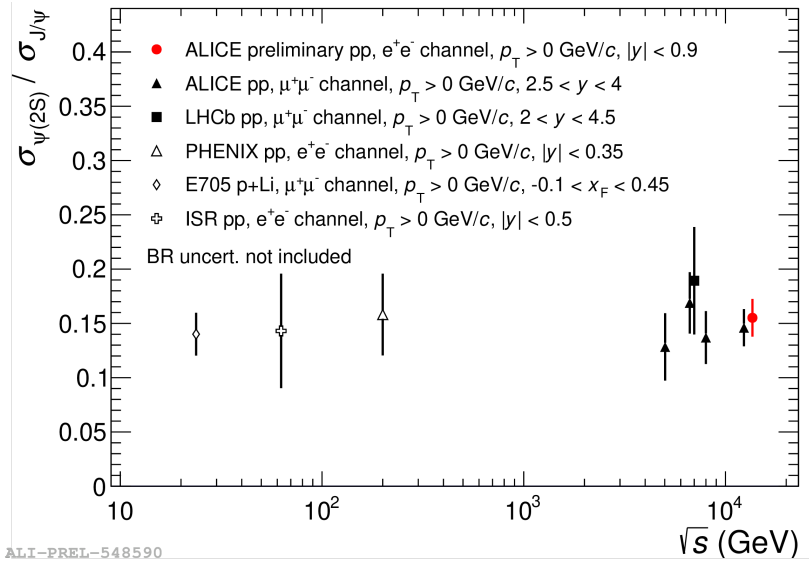
- Inner Tracking System 2
- Muon Forward Tracker
- Time Projection Chamber readout
- Fast Interaction Trigger
- New analysis framework (O^2)

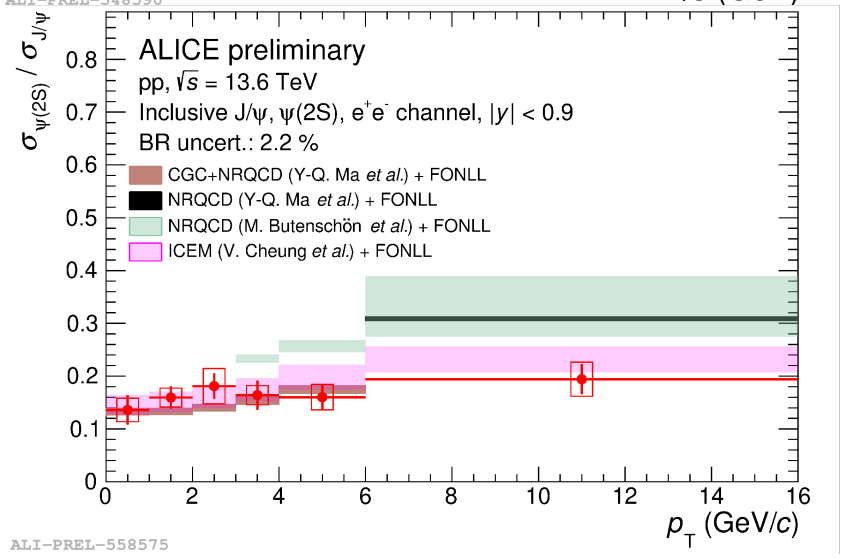
Significantly improved vertex resolution and data acquisition rate

Charmonium Measurements in pp

ALICE, Quark Matter 2023





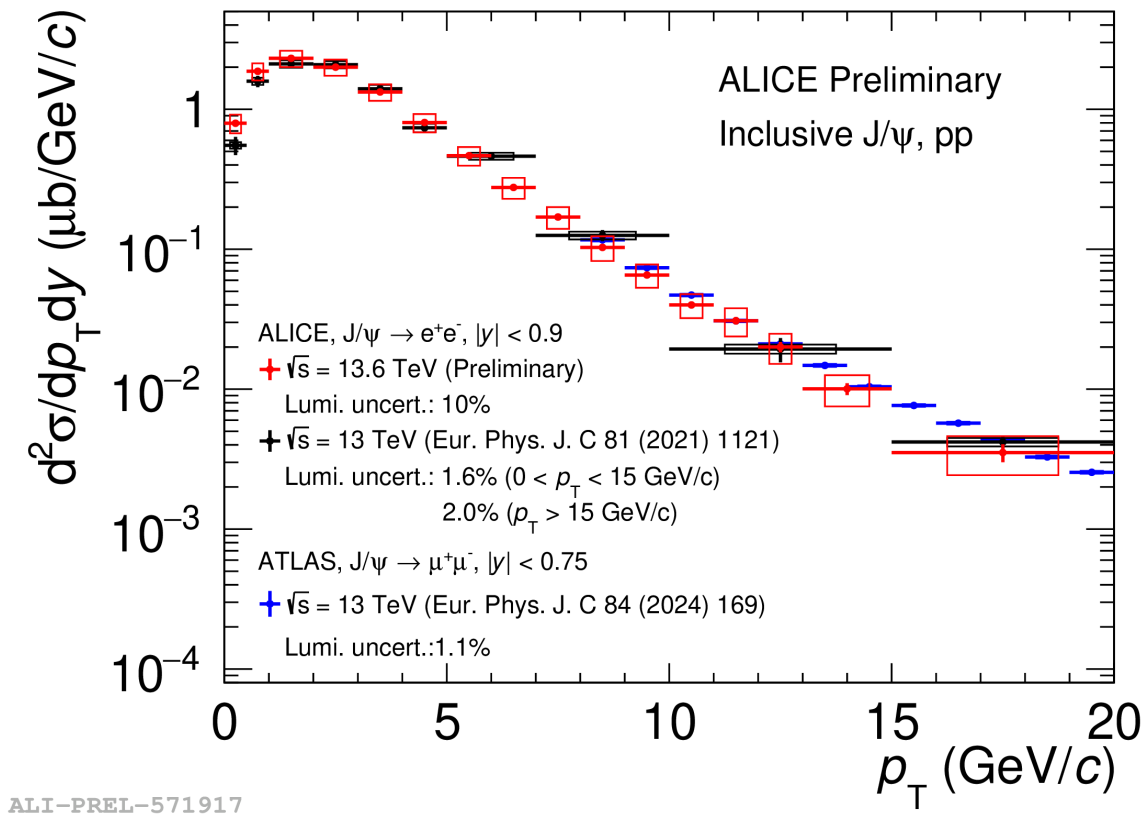


张原（强子物理与味物理，周四 5:00 pm）

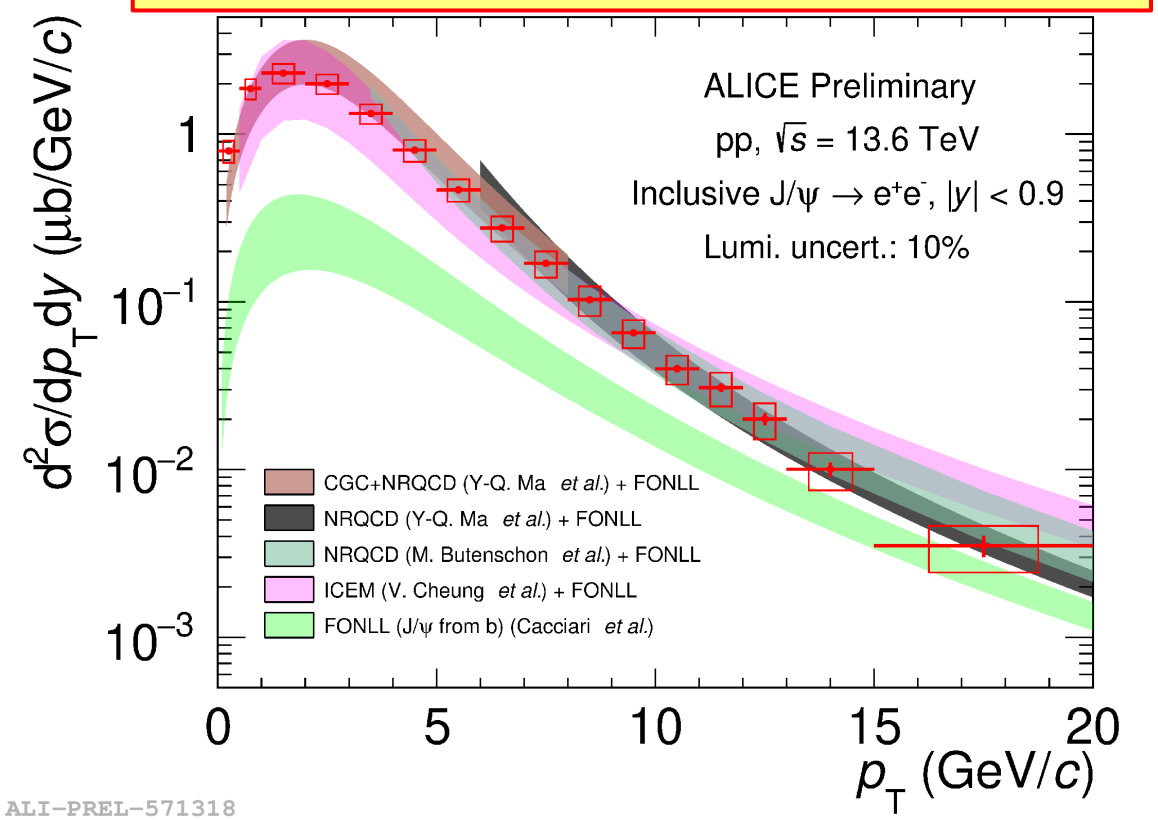
- First physics results from ALICE Run 3
- Significantly improved statistics greatly enhance physics capability

Charmonium Measurements in pp

ALICE, SQM 2024



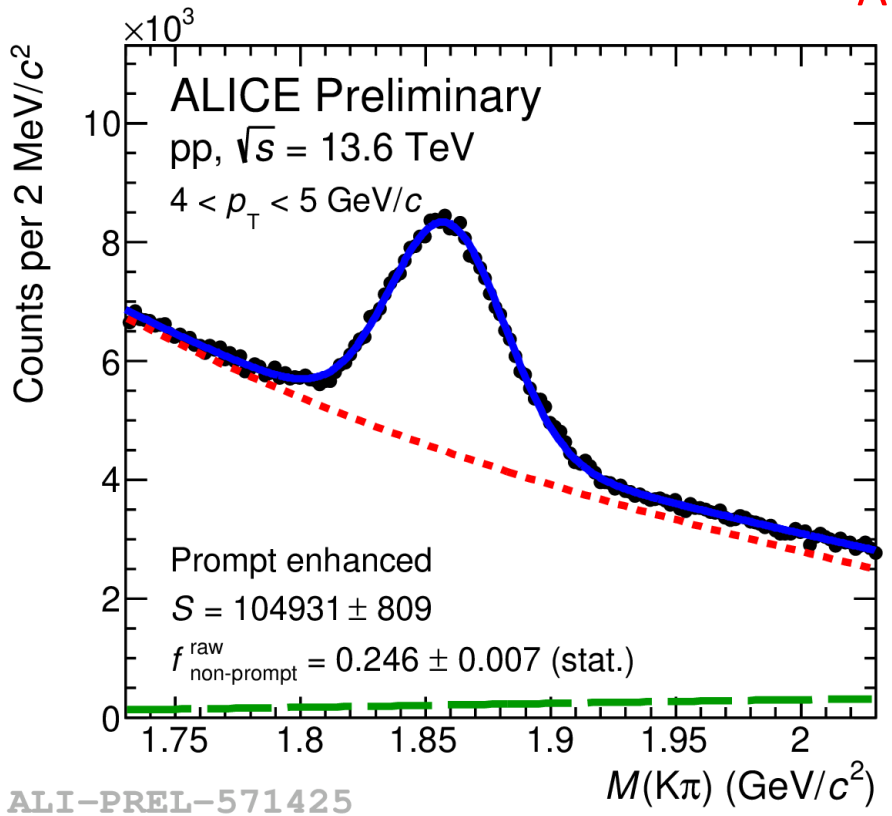
张原（强子物理与味物理，周四5:00 pm）

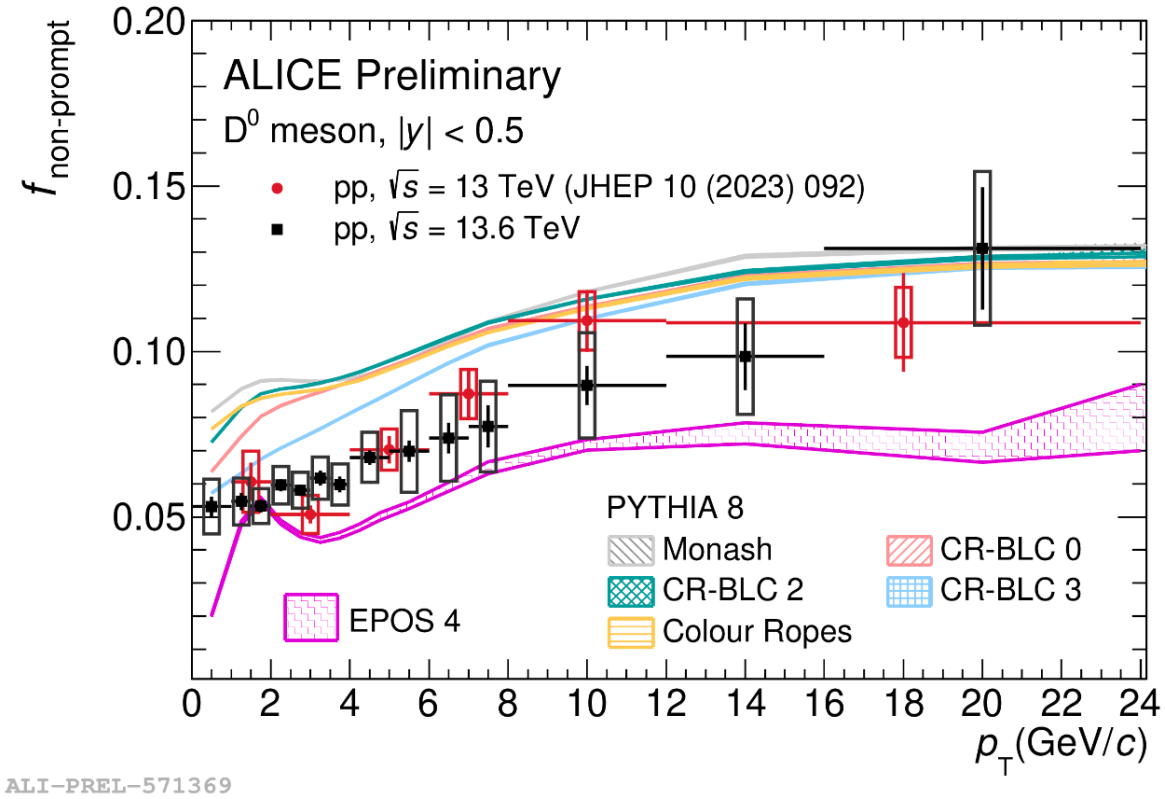


- Run 3 results consistent with Run 2 results with higher granularity
  - Validation of analysis chain with new detectors and frameworks
- Described by NRQCD and ICEM calculations

Non-prompt D-mesons Fraction in pp

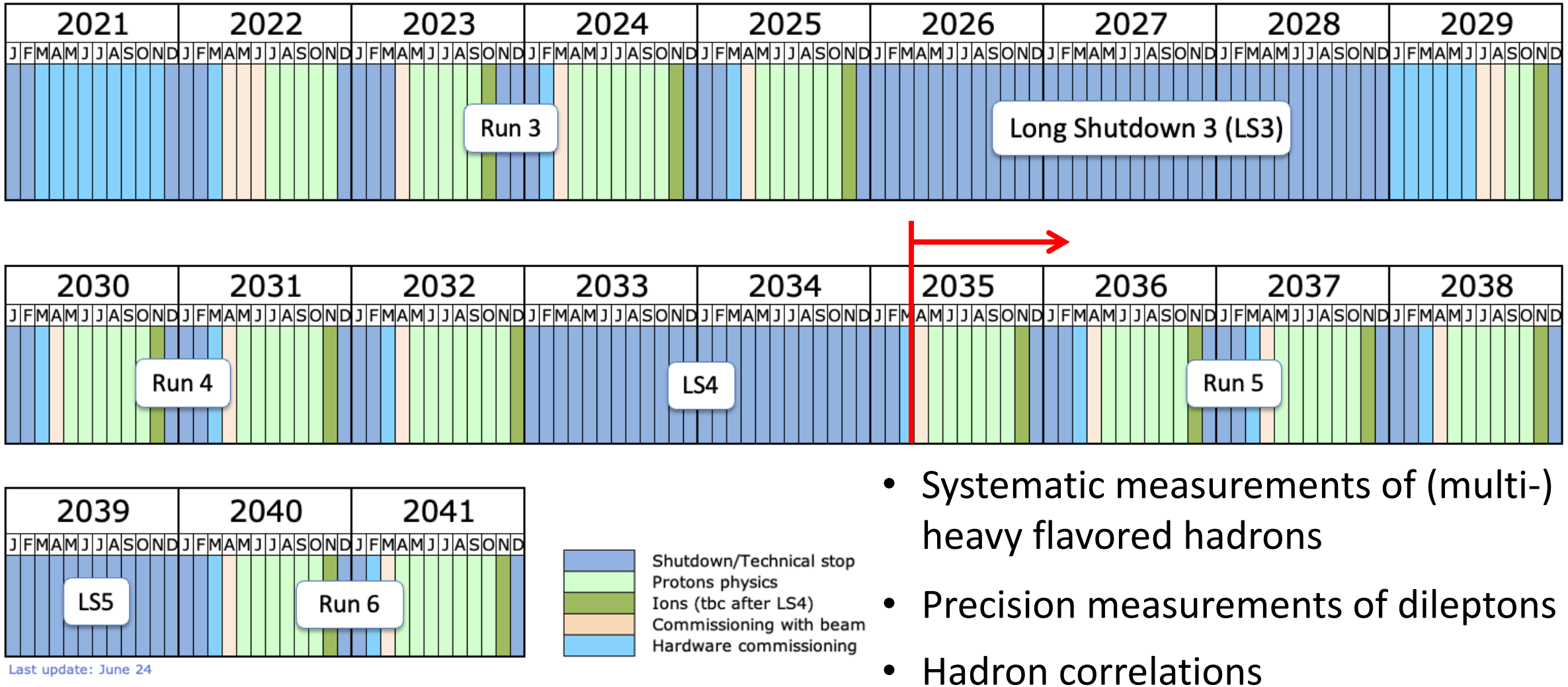
ALICE, SQM 2024





- Run 3 results consistent with Run 2 results with higher granularity
- Models either underestimate or overestimate data

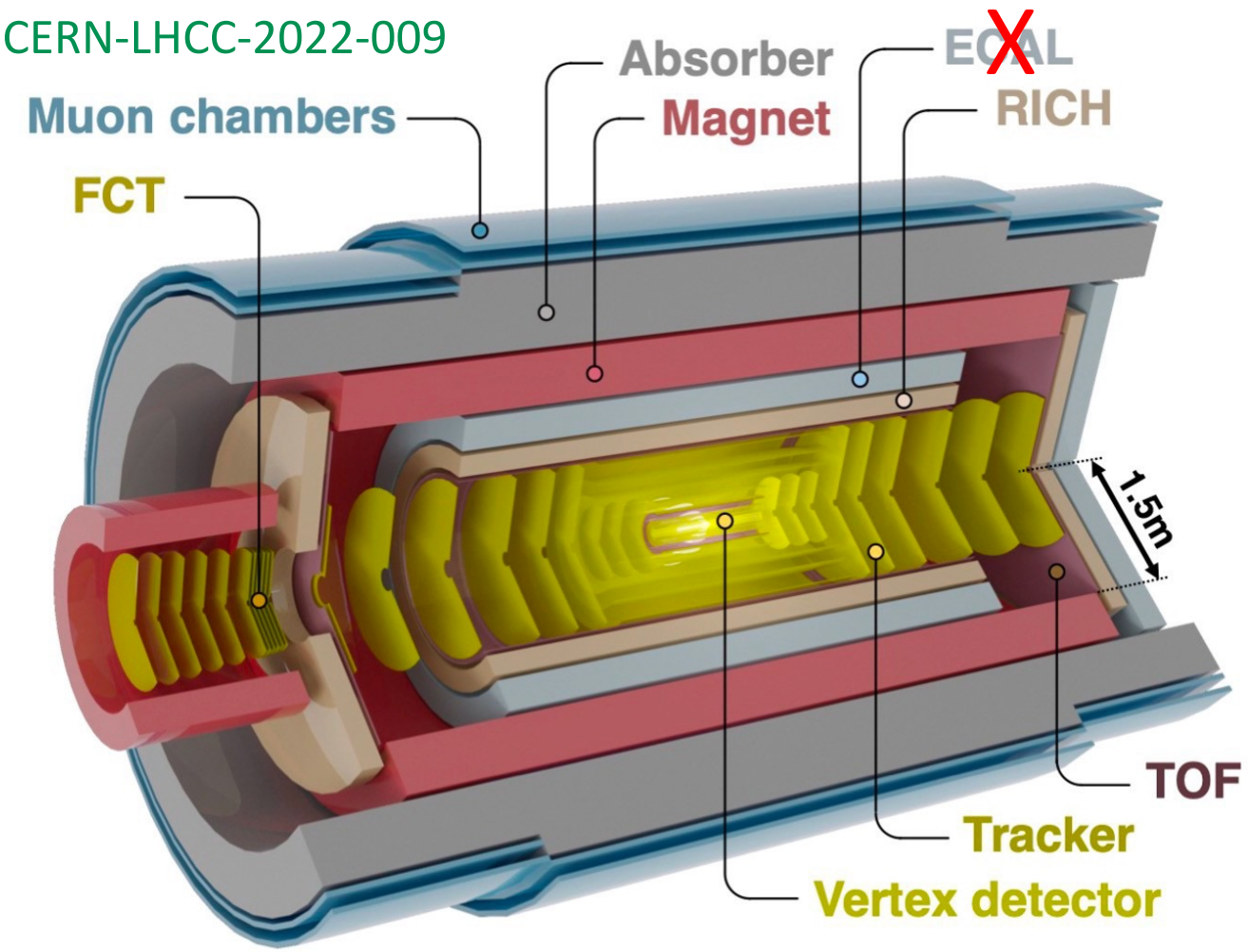
ALICE after LS4 (ALICE 3)

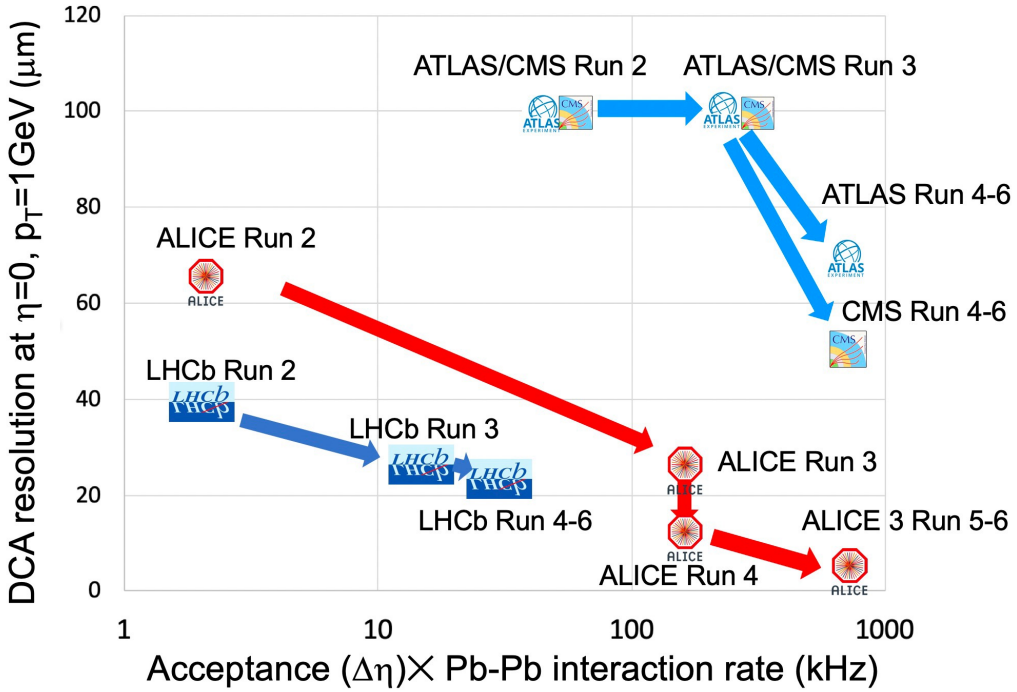


- Systematic measurements of (multi-) heavy flavored hadrons
- Precision measurements of dileptons
- Hadron correlations
- …

ALICE 3 Detector

CERN-LHCC-2022-009



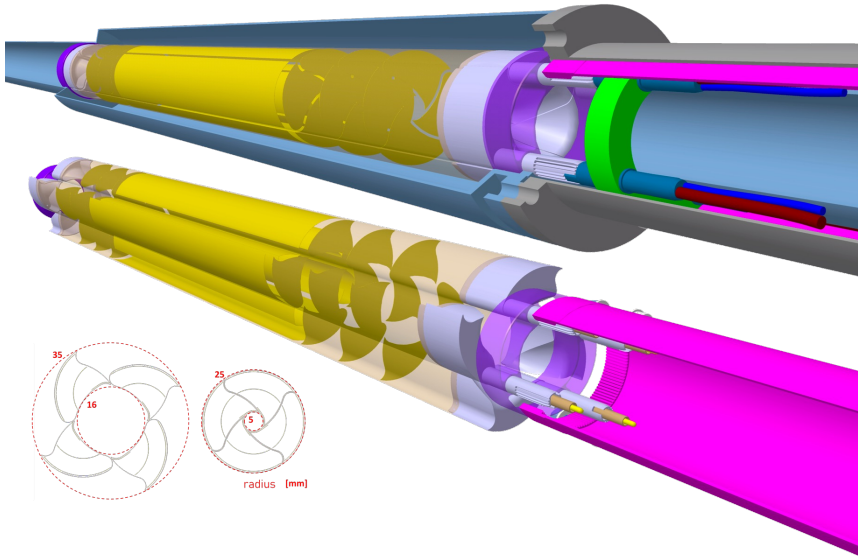


- Compact and lightweight all silicon tracker
- Extensive particle identification
- Large acceptance

ALICE-China interests: Inner tracking system and time-of-flight

Inner Tracking System

	Layer	Material thickness ($\%X_0$)	Intrinsic resolution (μm)	Barrel layers Length ($\pm z$) (cm)	Barrel layers Radius (r) (cm)	Forward discs Position ($\lvert z \rvert$) (cm)	Forward discs R_{in} (cm)	Forward discs R_{out} (cm)
VD	0	0.1	2.5	50	0.50	26	0.50	3
	1	0.1	2.5	50	1.20	30	0.50	3
	2	0.1	2.5	50	2.50	34	0.50	3
ML	3	1	10	124	3.75	77	5	35
	4	1	10	124	7	100	5	35
	5	1	10	124	12	122	5	35
	6	1	10	124	20	150	5	80
OL	7	1	10	124	30	180	5	80
	8	1	10	264	45	220	5	80
	9	1	10	264	60	279	5	80
	10	1	10	264	80	340	5	80
	11	1				400	5	80

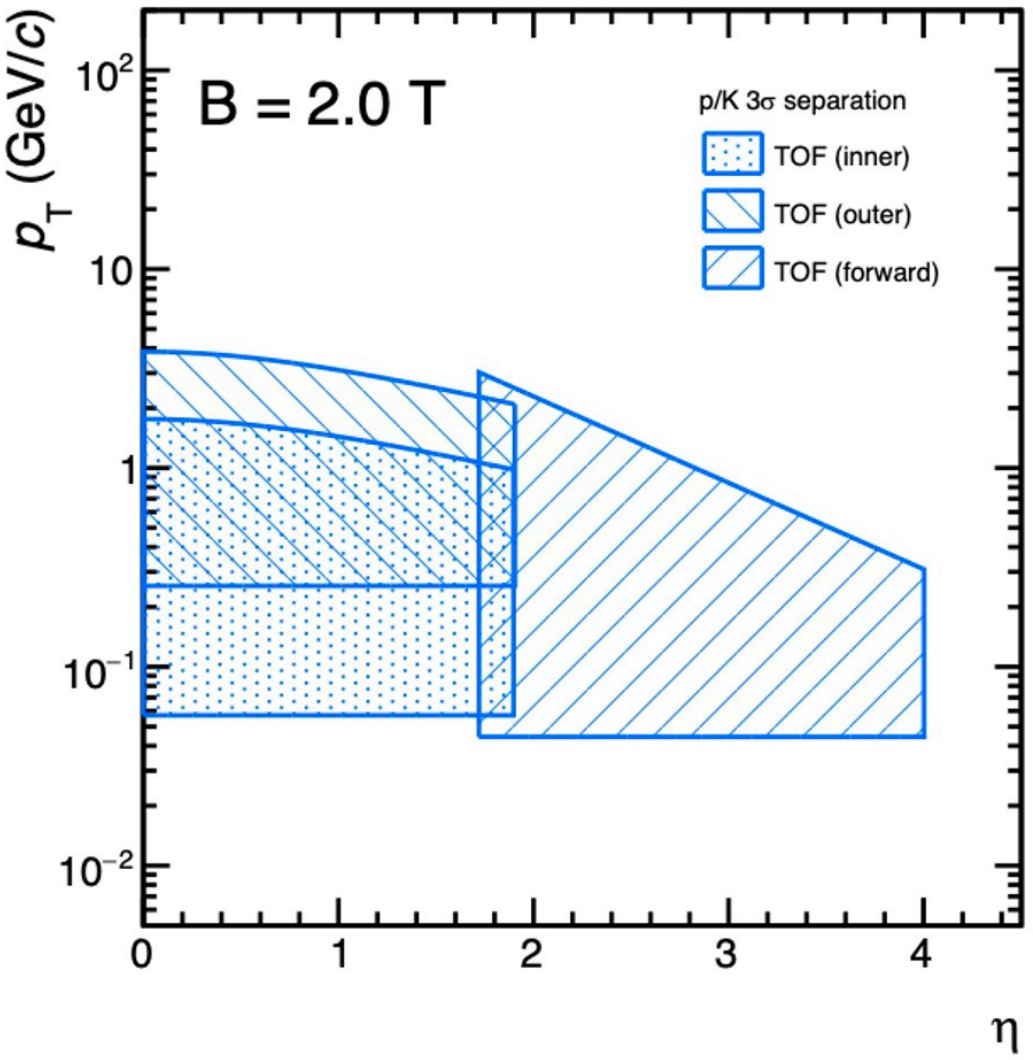


Retractable Vertex Detector

- ALICE-China is interested in vertex detector and middle layer of the ALICE 3 ITS
  - CCNU etc, benefit from the experience on ALICE ITS2 and ITS3

Time-of-Flight

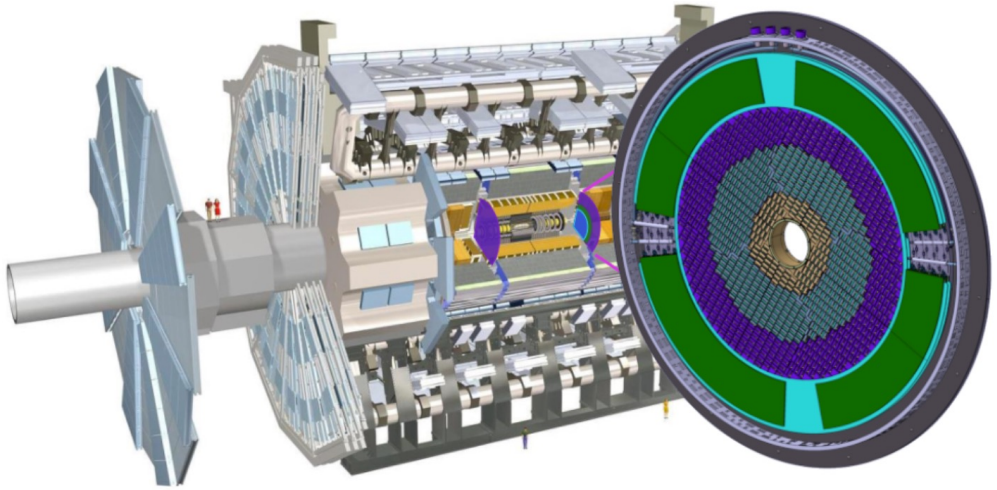
	Inner TOF	Outer TOF	Forward TOF disks
Radius (m)	0.19	0.85	0.15 to 1.0
z range (m)	−0.62 to 0.62	−3.50 to 3.50	±3.70
Area (m^2)	1.5	37	6
Acceptance	$\|\eta\| < 1.9$	$\|\eta\| < 2$	$2 < \|\eta\| < 4$
Granularity (mm^2)	1×1	5×5	1×1 to 5×5
Hit rate (kHz/cm^2)	200	15	280
Material thickness ($\%X_0$)	1 to 3	1 to 3	1 to 3
Power density (mW/cm^2)	50	50	50
Time resolution (ps)	20	20	20



- DAQ rate requires new technique (Silicon)
- Sensor options:
  - MAPS with gain layer (baseline)
  - Low gain avalanche diodes (fallback solution)
  - SiPMs (synergy with RICH R&D)

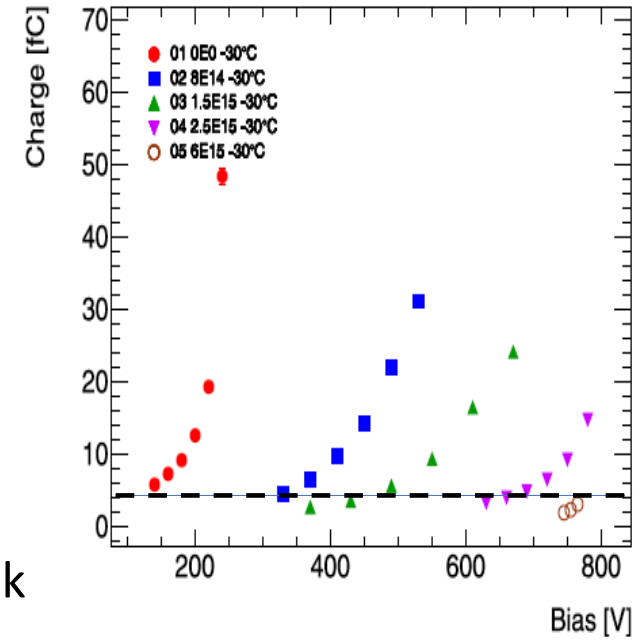
USTC Experience on LGAD

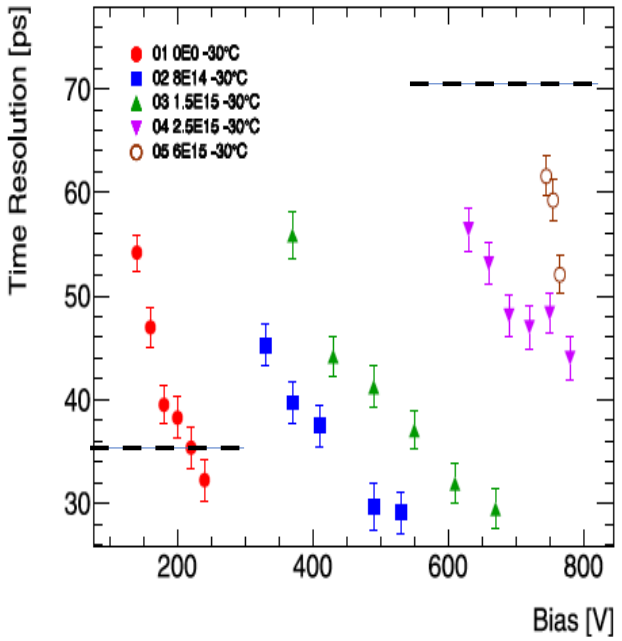
ATLAS High Granularity Timing Detector



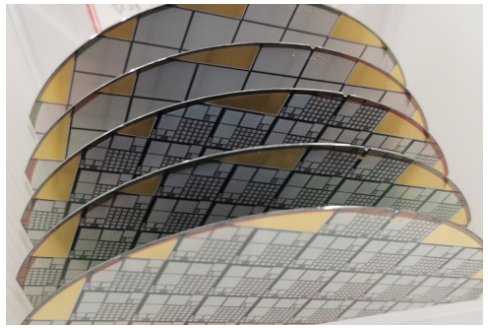
6.4 m^2, ~3.6 M channels, 1.3x1.3 mm^2, 50 μm thick

C. H. Li, X. Yang, J. J. Ge et al., NIMA 1039, 167008 (2022)





- ATLAS-USTC developed LGAD for ATLAS HGTD
  - < 35 ps before irradiation
  - < 70 ps after irradiation up to neq = 2.5x10^{15}/cm^2
  - 28 ps reached, higher bias voltage unexplored



- Need R&D on thinner (and double layers) LGAD to reach 20 ps

Summary

- ALICE-China making significant contributions in various physics topics in PbPb and small systems with ALICE
  - Jets transport in QGP
  - Heavy flavor hadronization, flow and energy loss
  - Quarkonium dissociation and (re)generation
  - Correlations
  - Exotics
  - …
- ALICE-China actively involved in state-of-the-art detector R&D for ALICE upgrades
  - High spatial resolution MAPS for ALICE 3
  - High timing resolution LGAD for ALICE 3

ALICE Talks in this Conference

- Tiantian Cheng, Investigation of charm-quark hadronisation in proton–proton collisions with ALICE, Heavy Ion Physics, Wed. 15:40
- Yongzhen Hou, Measurements of jet quenching using semi-inclusive hadron+jet distributions in pp and central Pb–Pb collisions at 5.02 TeV with ALICE, Heavy Ion Physics, Wed. 17:40
- Kai Cui, h-strangeness correlation in Run 3 with ALICE, Hadron Physics and Flavor Physics, Thu. 16:45
- Yuan Zhang, Measurements of inclusive J/ψ and ψ(2S) production at mid-rapidity at 13.6 TeV with ALICE, Hadron Physics and Flavor Physics, Thu. 17:15
- Pengzhong Lu, Non-prompt Λ_c^+ Production with machine learning in p–Pb Collisions at $\sqrt{s_{NN}}$ = 5.02 TeV with ALICE, Hadron Physics and Flavor Physics, Thu. 17:15

Thanks!