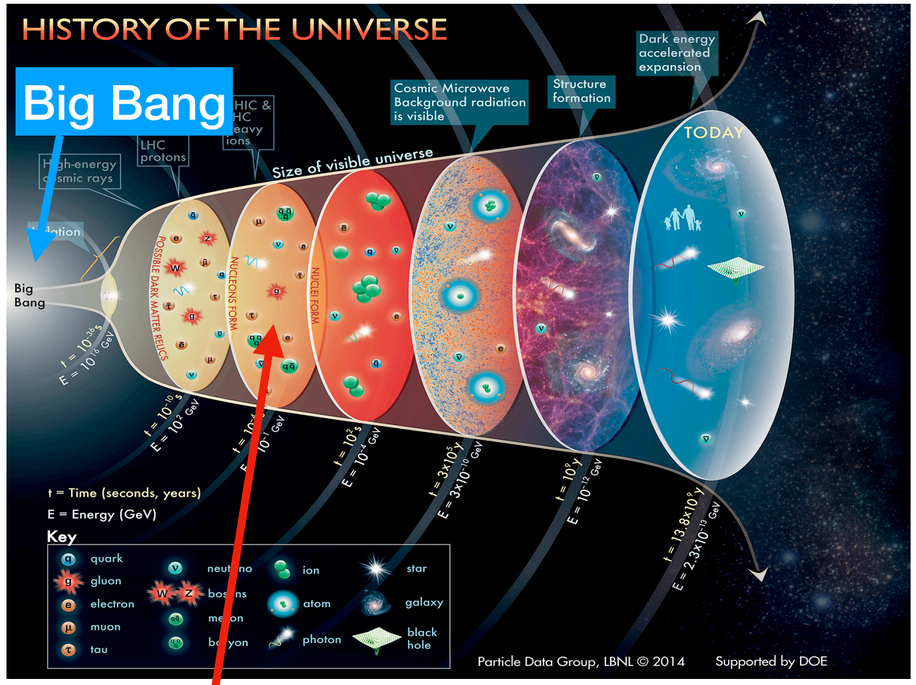
ALICE @ FCPPN/L

“Study of QCD matter with the ALICE detector”

Nicole Bastid (LPC, CNRS-IN2P3, UCA, Clermont-Ferrand, France)
Xiaoming Zhang/Daicui Zhou (IOPP, CCNU, Wuhan, China)

The 15th FCPPN/L workshop
10–14 Jun 2024, Bordeaux, France

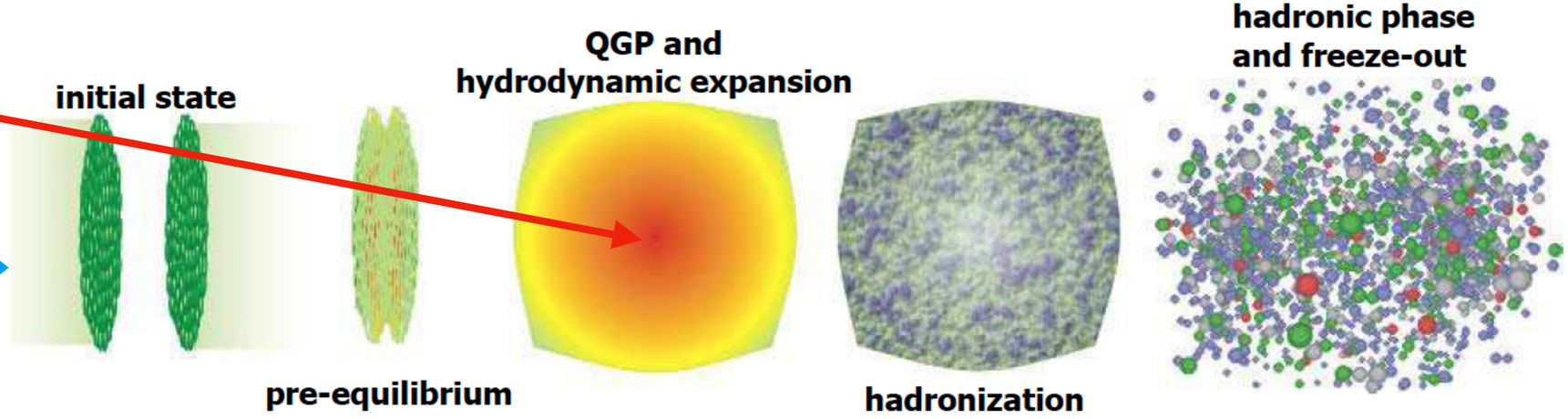
Scientific context: quark-gluon plasma



- Explore properties of the primordial matter state, existed after a few μs of the **Big Bang**
  - ➡ Quark-gluon plasma (QGP)
- Heavy-ion collisions — the QGP factory
  - ➡ Create extreme conditions of temperature and energy density
  - ➡ QGP created at the LHC: $T_{\mathrm{eff}} \approx 340$ MeV

Quark-Gluon Plasma (QGP)

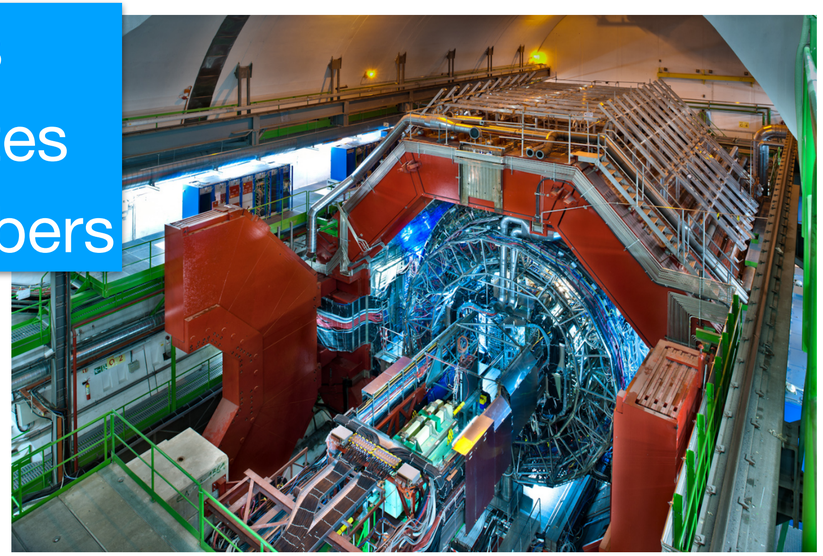
Heavy-ion collisions

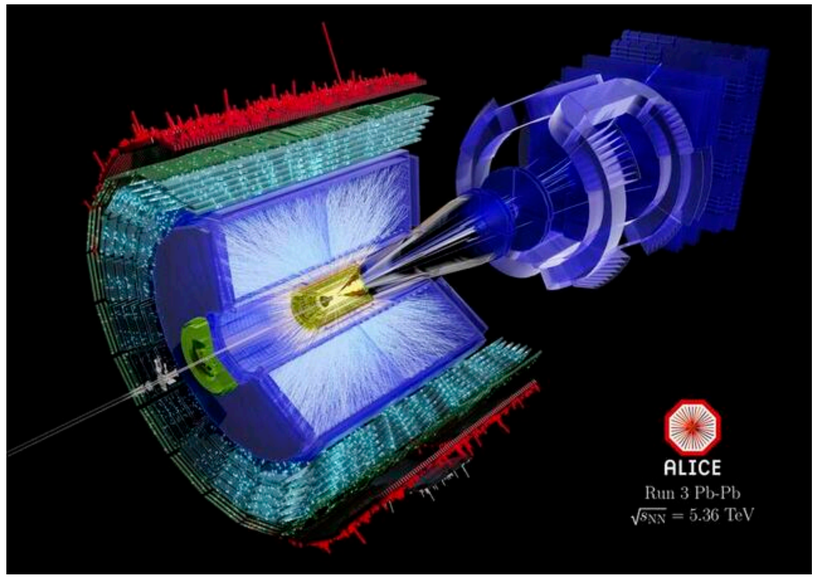


ALICE Collaboration

A large ion collider experiment — ALICE

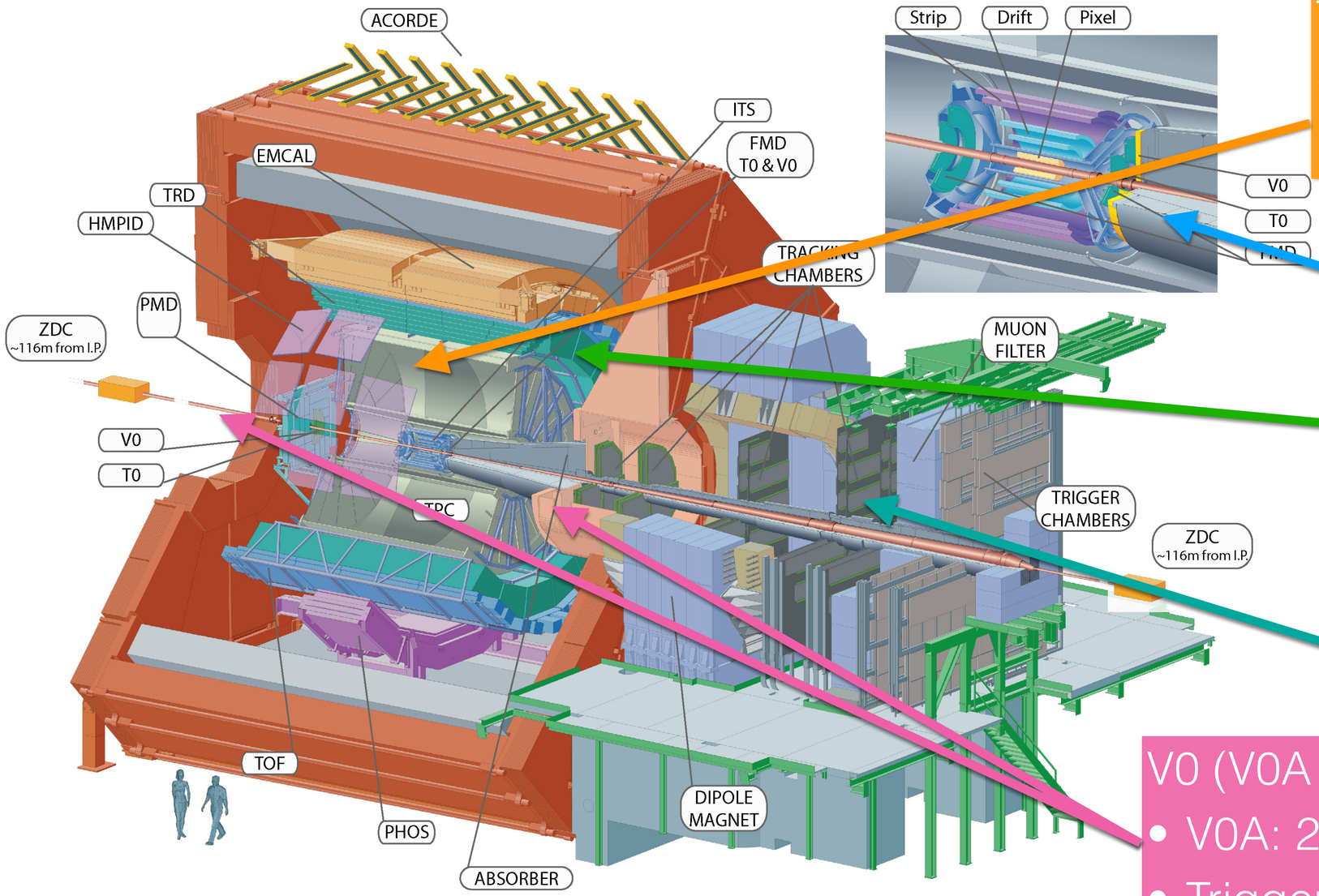
- 40 contries
- 170 institutes
- 1989 members





Study the primordial matter existed after the Big Bang via ultra-relativistic heavy-ion collision “little bang”

ALICE apparatus (till Run2)



Time Projection Chamber (TPC)

- $|\eta| < 0.9$, charged-particle tracking and identification (PID)

Inner Tracking System (ITS)

- $|\eta| < 0.9$, vertexing

Time of Flight (TOF)

- $|\eta| < 0.9$, triggering, pileup rejection, PID

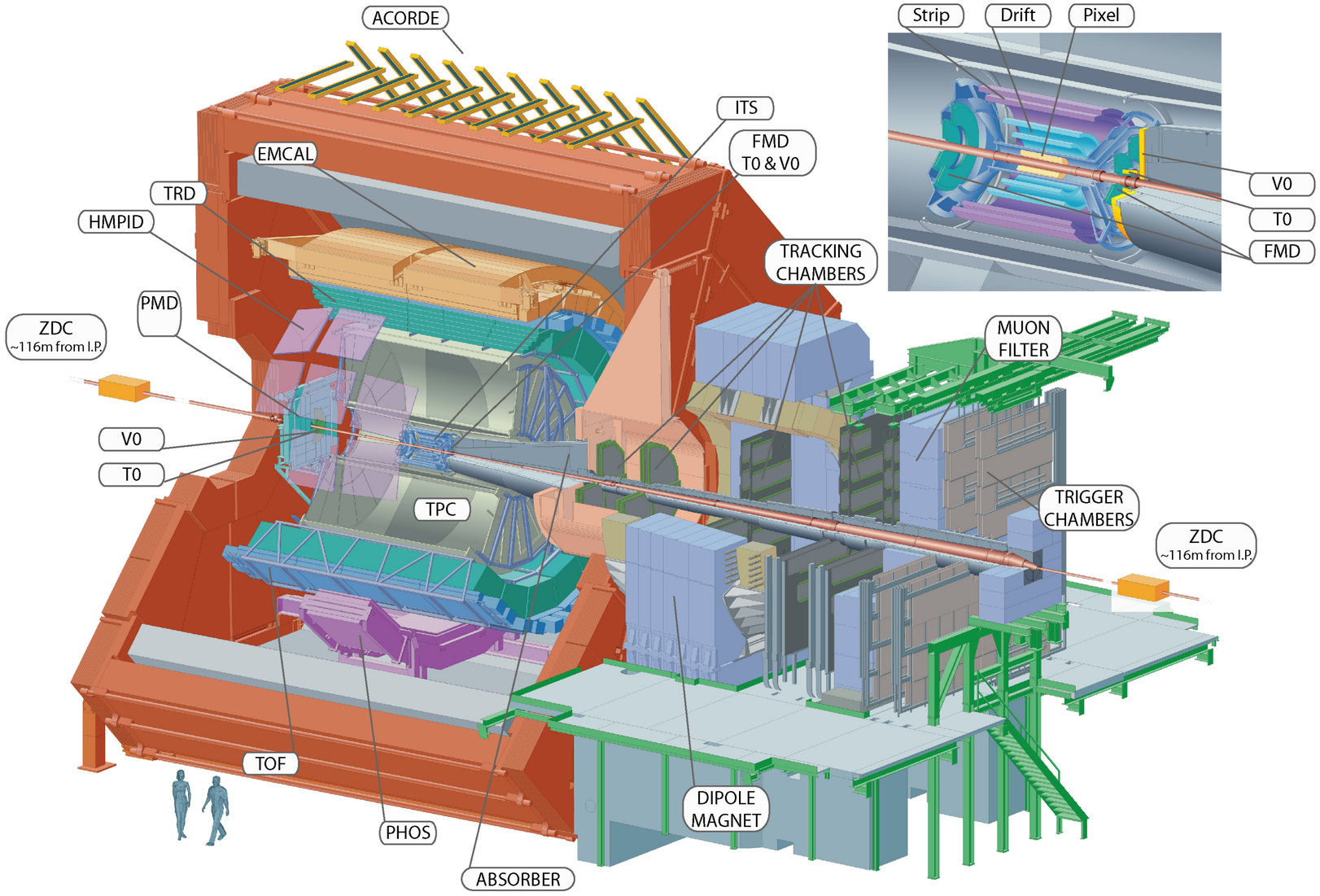
Muon spectrometer

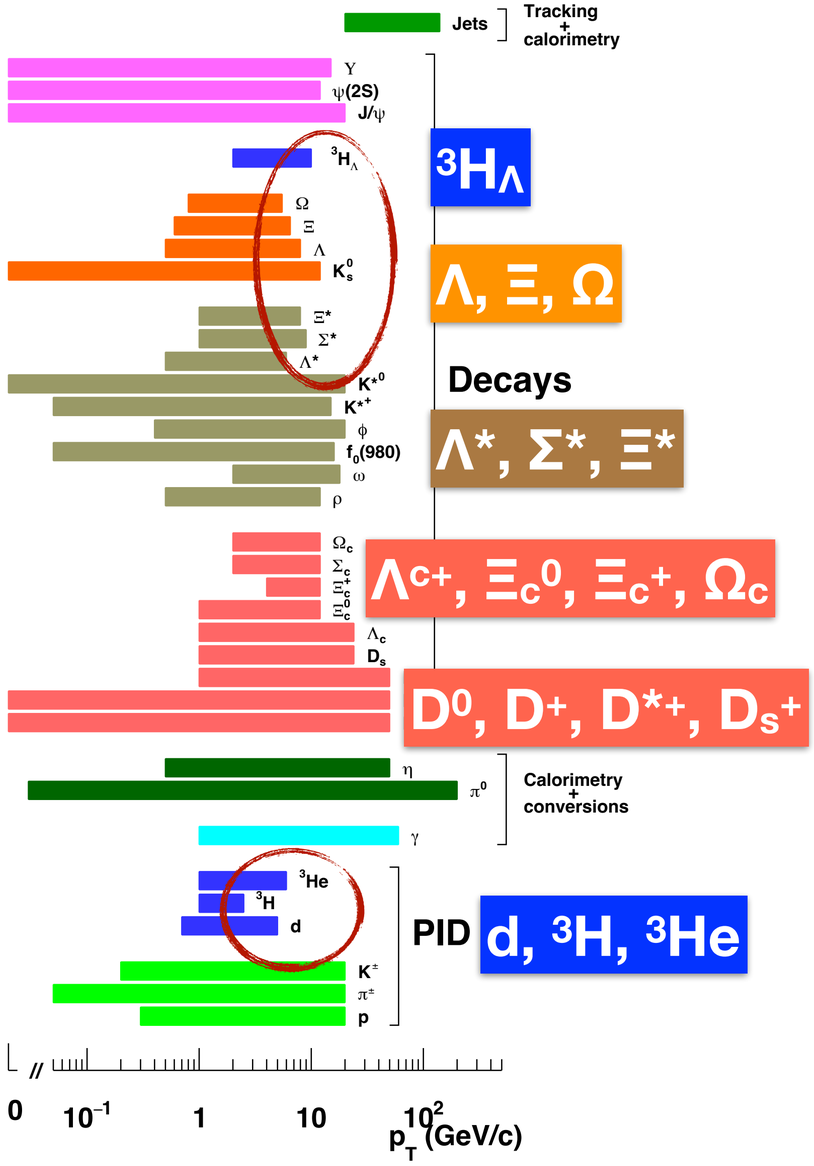
- $2.5 < |\eta| < 4$, $\mu \leftarrow c,b$, $\mu \leftarrow W^{\pm}/Z^{0}$

V0 (V0A and V0C)

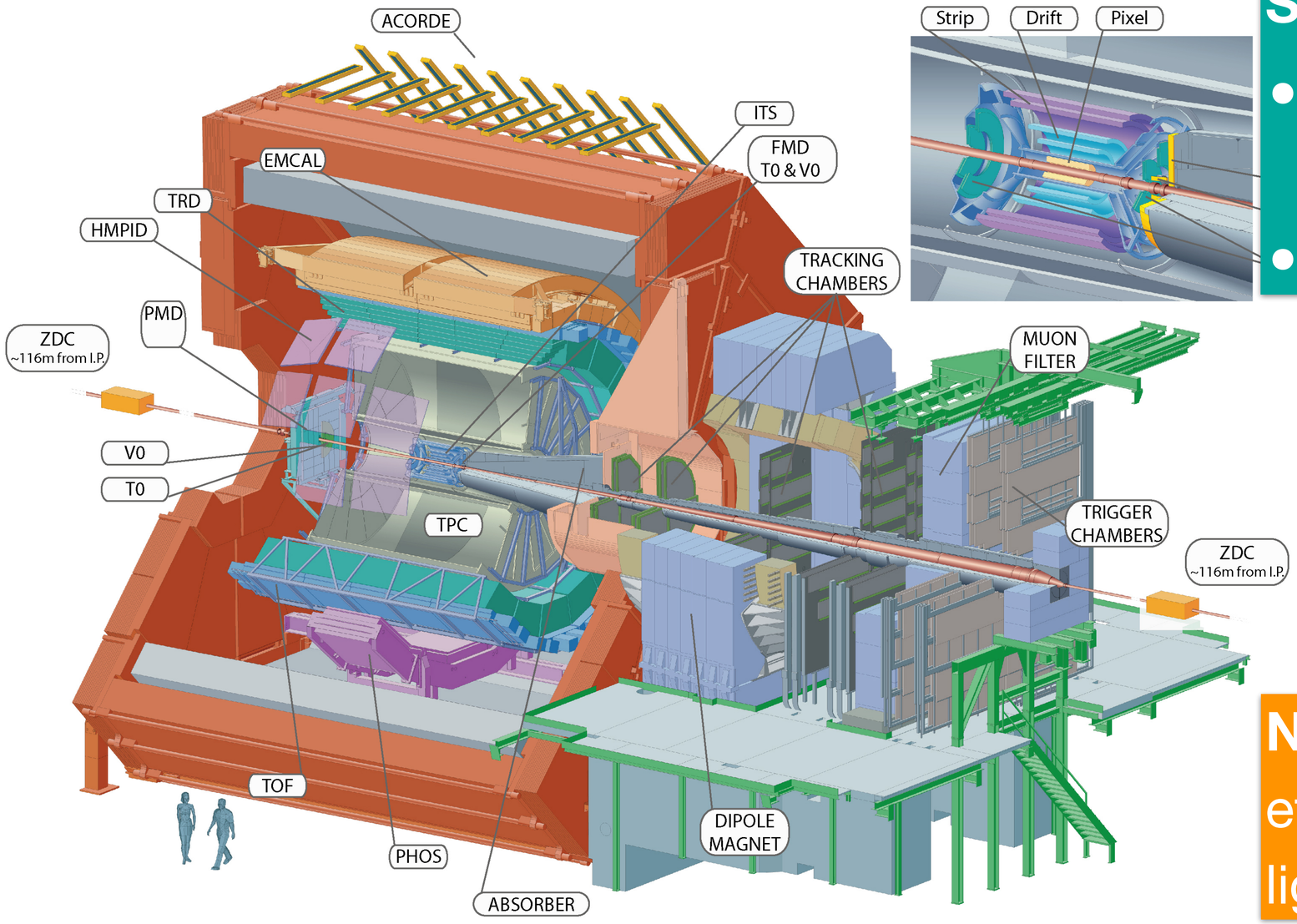
- V0A: $2.8 < \eta < 5.1$, V0C: $-3.7 < \eta < -1.7$
- Triggering and multiplicity determination

ALICE capability of PID





ALICE shopping list



Soft physics

- Event multiplicity and particle production
- Correlations and fluctuations

Hard probes

- Heavy quarks, jets and high-p_T photons
- Ultra-peripheral collisions

New physics: magnetic file effects, exotic particles, light nuclei, antimatter…

ALICE @ FCPPN/L

- 7 Chinese institutes and 8 French institutes
- Cooperation covers a large fraction of ALICE topics

China institutes

- CCNU, Wuhan
- CIAE, Beijing
- CUG, Wuhan
- HUST, Wuhan
- HUT, Wuhan
- USTC, Hefei
- Fudan, Shanghai

France institutes

- IPNL & CC-IN2P3, Lyon
- IPNO, Orsay
- IPHC, Strasbourg
- LPC, Clermont-Fd
- LPSC, Grenoble
- Subatech, Nantes
- IRFU, Saclay

Shopping list (keywords)

- Photons and neutral hadrons
- Low mass vector particles
- Flow and correlations
- Light flavour spectra
- Open heavy flavours
- Electroweak bosons
- Quarkonia
- Jets

FCPPN/L-ALICE members

French Group			Chinese Group		
Name	**Title**	**Affiliation** (institute)	**Name**	**Title**	**Affiliation** (institute)
Leader **BASTID Nicole**	PU	IN2P3	*Leader* ZHANG Xiaoming ZHOU Daicui	PU PU	IOPP/CCNU
Arata Carolina	PhD	IN2P3	Cai Xu	PU	IOPP/CCNU
Baldisseri Alberto	Physicist	IRFU	Huang Guangming	PU	IOPP/CCNU
Belikov Iouri	DR	IN2P3	Liu Fuming	PU	IOPP/CCNU
Castillo Castellanos Javier	Physicist	IRFU	Zhou Daimei	PU	IOPP/CCNU
Cheshkov Cvetan	DR	IN2P3	Yin Zhongbao	PU	IOPP/CCNU
Conesa-Balbastre Gustavo	CR	IN2P3	Ma Yugang	PU	Fudan Univ.
Crochet Philippe	DR	IN2P3	Li Xiaomei	PU	CIAE Beijing
Dupieux Pascal	DR	IN2P3	Wang Yaping	PU	IOPP/CCNU
Erazmus Barbara	DR	IN2P3	Shao Ming	PU	USTC Hefei
Faivre Julien	MC	IN2P3	Zhang Yifei	PU	USTC Hefei
Furget Christophe	PU	IN2P3	Zhang Song	PU	FUDAN Univ.
Germain Marie	CR	IN2P3	Tang Zebo	PU	USTC Hefei
Guernane Rachid	CR	IN2P3	Yan Yuliang	Researcher	CIAE Beijing
Hermann Sarah	PhD student	IN2P3	Mao Yaxian	PU	IOPP/CCNU
Hippolyte Boris	PR	IN2P3	Shou Quiye	Ass. PU	FUDAN Univ.
HOU Yongzhen	Joint-PhD student	IN2P3	Wang Dong	Ass. PU	IOPP/CCNU
Kuhn Christian	DR	IN2P3	Pei Hua	PU	IOPP/CCNU
Landou Aimeric	Postdoc CNRS	IN2P3	Yang Ping	Ass. PU	IOPP/CCNU
Lopez Xavier	PR	IN2P3	Gao Chaosong	Ass. PU	IOPP/CCNU
Maire Antonin	CR	IN2P3	Pen Xinye	Ass. PU	CUG Wuhan
Martinez-Garcia Gines	DR	IN2P3	Tang Siyu	Lecturer	WTU Wuhan
Marchisone Massimiliano	Engineer	IN2P3	Liu Jun	Engineer	IOPP/CCNU
Pillot Philippe	CR	IN2P3	Bai Xiaozhi	Postdoc	USTC Hefei
Ramasubramanian Niveditha	CR	IN2P3	Ding Yanchun	Postdoc	
Schutz Yves	DR Emeritus	IN2P3	Wang Yubiao	PhD student	IOPP/CCNU
Stocco Diego	CR	IN2P3	Xu Ran	Joint-PhD student	IOPP/CCNU
Uras Antonio	CR	IN2P3	Wu Yitao	PhD student	USTC Hefei
Xu Lang	Joint-PhD student	IN2P3	Hou Yongzhen	Joint-PhD student	IOPP/CCNU
Xu Ran	Joint-PhD student	IN2P3	Zhang Maolin	Joint-PhD student	IOPP/CCNU
Zhang Maolin	Joint-PhD Student	IN2P3	Xu Lang	Joint-PhD student	IOPP/CCNU
			Zhou Xinyi	Master	IOPP/CCNU
			Zhang Qiuyue	Master	IOPP/CCNU
			Geng Zhaozheng	Master	IOPP/CCNU
			Feng Wenhui	Master	IOPP/CCNU

- 67 members in 2024 project application
  - ➡ It was 36 members in 2009
  - ➡ Robust, continue growing cooperation!
- Covered activities
  - ➡ MUON spectrometer and new Muon Forward Tracker (MFT)
  - ➡ ITS2 and ITS3 upgrade projects
  - ➡ Calorimeters
  - ➡ ALICE3 upgrade project (under discussion)

History and achievements

- ~6/year bilateral visits of senior physicists and engineers/technicians
- 3 postdoc exchanges since 2009
- 10 defensed joint-PhD theses since 2008
- > 20 mater student trainings since 2007

All former joint-PhDs got permanent or postdoc positions in academic filed

- 2 joint-PhD defenses are scheduled in 2024
- 3 ongoing joint-PhD programmes
- 2 mater student trainings are proposed in 2024

Scientific production (2023 – 2024)

Published peer-viewed paper (6)

- Y. Mao *et al.*, Groomed charm-jet substructure in pp collisions, *Phys. Rev. Lett.* **131** (2023) 192301
- X. Zhang *et al.*, Charged-jet production in pp and p–Pb collisions, *JHEP* **2305** (2024) 041
- X. Zhang *et al.*, (Multi-)strange particle production in jets in pp and p–Pb collisions, *JHEP* **2307** (2023) 136
- M. Zhao, G. Taillepied *et al.*, W-boson production in p–Pb and Pb–Pb collisions, *JHEP* **2305** (2023) 036
- S. Tang *et al.*, Anisotropies flow of muons at forward rapidity in p–Pb collisions, *Phys. Lett.* **B846** (2023) 137782
- S. Tang *et al.*, Supplemental material of jet particle flow, ALICE-PUBLIC-2022-020

Submitted papers (4)

- S. Tang *et al.*, Azimuthal anisotropy of jet particles in p-Pb and Pb-Pb collisions, arXiv:2212.12609, submitted to *Phys. Rev. Lett.*
- Y. Hou *et al.*, Medium-induced low-p_{T} jet modification from pp to Pb-Pb collisions, arXiv:2308.16131, accepted by *Phys. Rev. Lett.*
- Y. Hou *et al.*, Measuring jet quenching using hadron-jet correlations, arXiv:2308.16128, submitted to *Phys. Rev.* **C**
- Y. Ding *et al.*, Y production at forward rapidity in pp collisions, arXiv:2209.04241, submitted to *Phys. Lett.* **B**

Papers under the ALICE review (1)

R. Xu *et al.*, Isolated photon production in pp collisions, tagged journal: *Phys. Lett.* **B**

Conference proceedings (4)

X. Zhang @ FPCP2024, Y. Hou @ HP2023, X. Bai @ HP2023, X. Bai @ SPIN2023

Scientific production (Nov. 2023 – now)

- Xiaoming ZHANG, “Recent open heavy-flavour highlight from ALICE”, FPCP2024, 27–31 May 2024, Bangkok, Thailand
- Maolin ZHNAG, “Charm and beauty hadron production in hadronic collisions with ALICE”, SQM2024, 3–7 Jun 2024, Strasbourg, France
- Maolin ZHANG, “Study of charm and beauty production at forward rapidity”, QGP France 2024, 21–24 May 2024, Bagnoles de l’Orne, France
- Antonio Uras, “ALICE 3 upgrade project”, QGP France 2024, 21–24 May 2024, Bagnoles de l’Orne, France
- Gustavo Conesa Balbastre, “Recent measurements of isolated photons cross section and their correlation with hadrons with ALICE at the LHC”, QGP France 2024, 21–24 May 2024, Bagnoles de l’Orne, France
- Yaxian Mao, “Study of jet physics”, QPT2023, 15-19 December 2023 Zhuhai, China
- Mingze LI, “Investigate dead-cone effect in heavy-ion collisions”, QPT2023, 15-19 December 2023 Zhuhai, China
- Maolin ZHANG, “Investigate heavy quark production at forward rapidity via semi-muonic decays with ALICE at the LHC”, CLHCP2023, 15-20 Nov 2023 Shanghai, China
- Lang XU, “Study of (multi-)strange hadrons production in jets and the underlying event with ALICE”, CLHCP2023, 15-20 Nov 2023 Shanghai, China
- Mingyu ZHANG, “Measurement non-prompt D meson production with ALICE”, CLHCP2023, 15-20 Nov 2023 Shanghai, China
- Maolin ZHANG, “Investigate heavy quark production at forward rapiditywith ALICE at the LHC”, QPT2023, 15-19 December 2023 Zhuhai, China (poster)
- Lang XU, “Study of (multi-)strange hadron production in jets and the underlying event with ALICE at the LHC”, QPT2023, 15-19 December 2023 Zhuhai, China (poster)
- Mingyu ZHANG, “Measurement non-prompt D meson production with ALICE”, QPT2023, 15-19 December 2023 Zhuhai, China (poster)

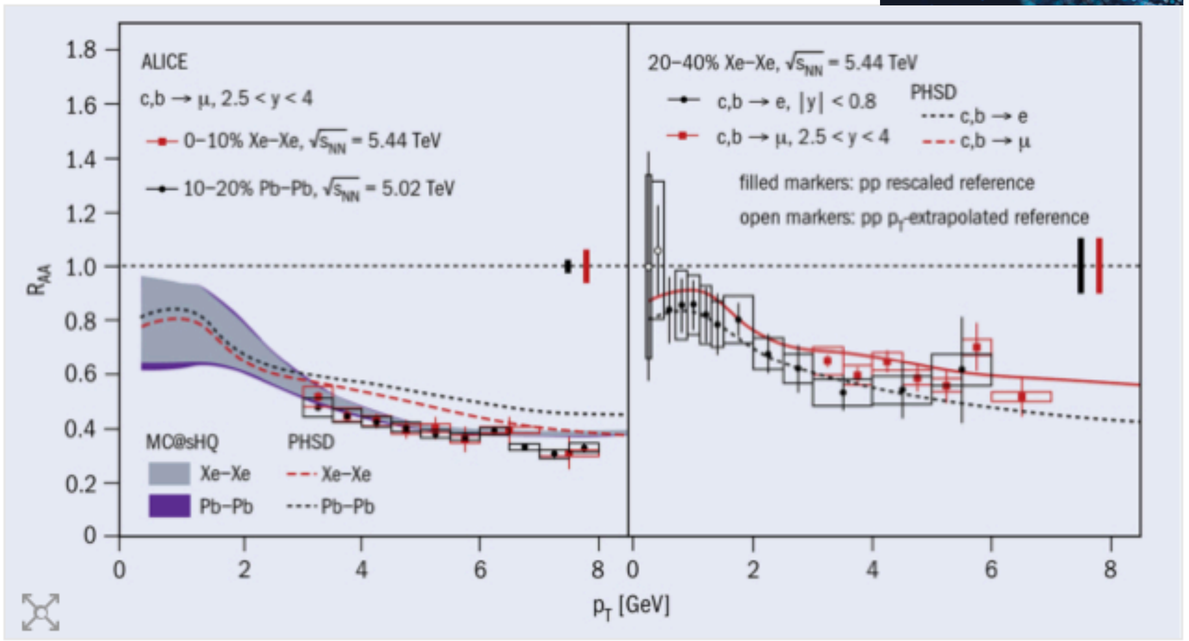
13 presentations given by students and faculties in international conferences and workshops since Nov. 2023, including SQM2024, FPCP2024, and QPT2023

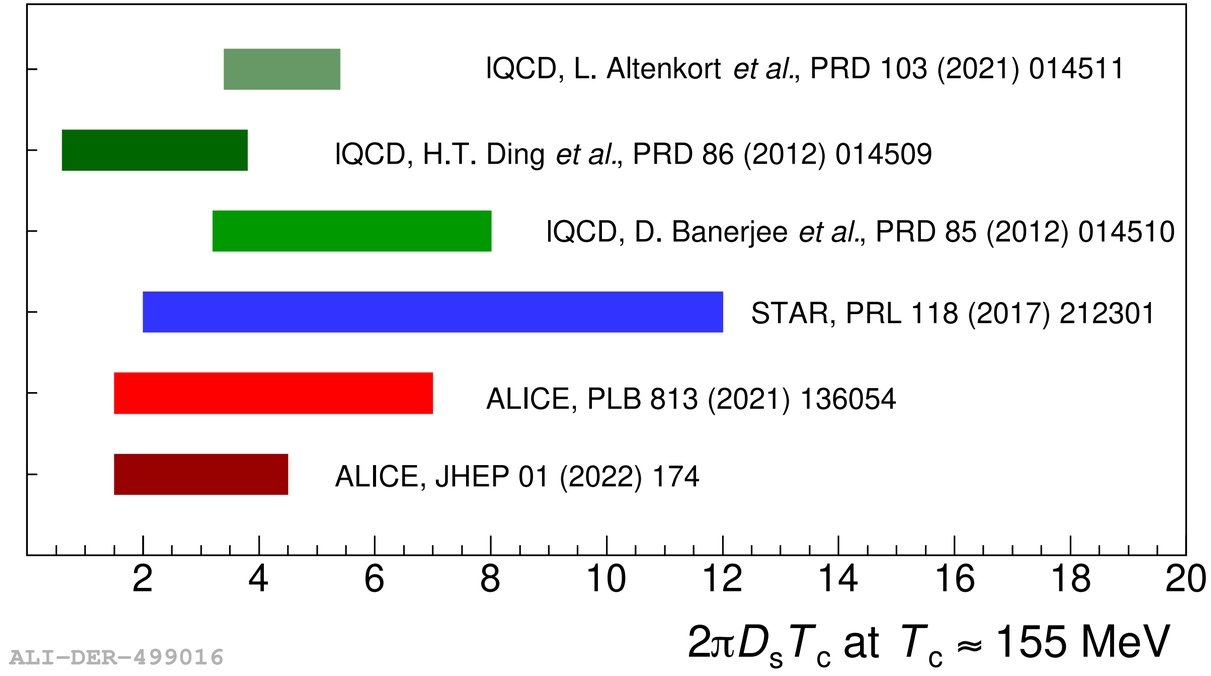
Heavy quark transport properties

STRONG INTERACTIONS | NEWS

Heavy flavours probe QGP geometry

22 January 2021

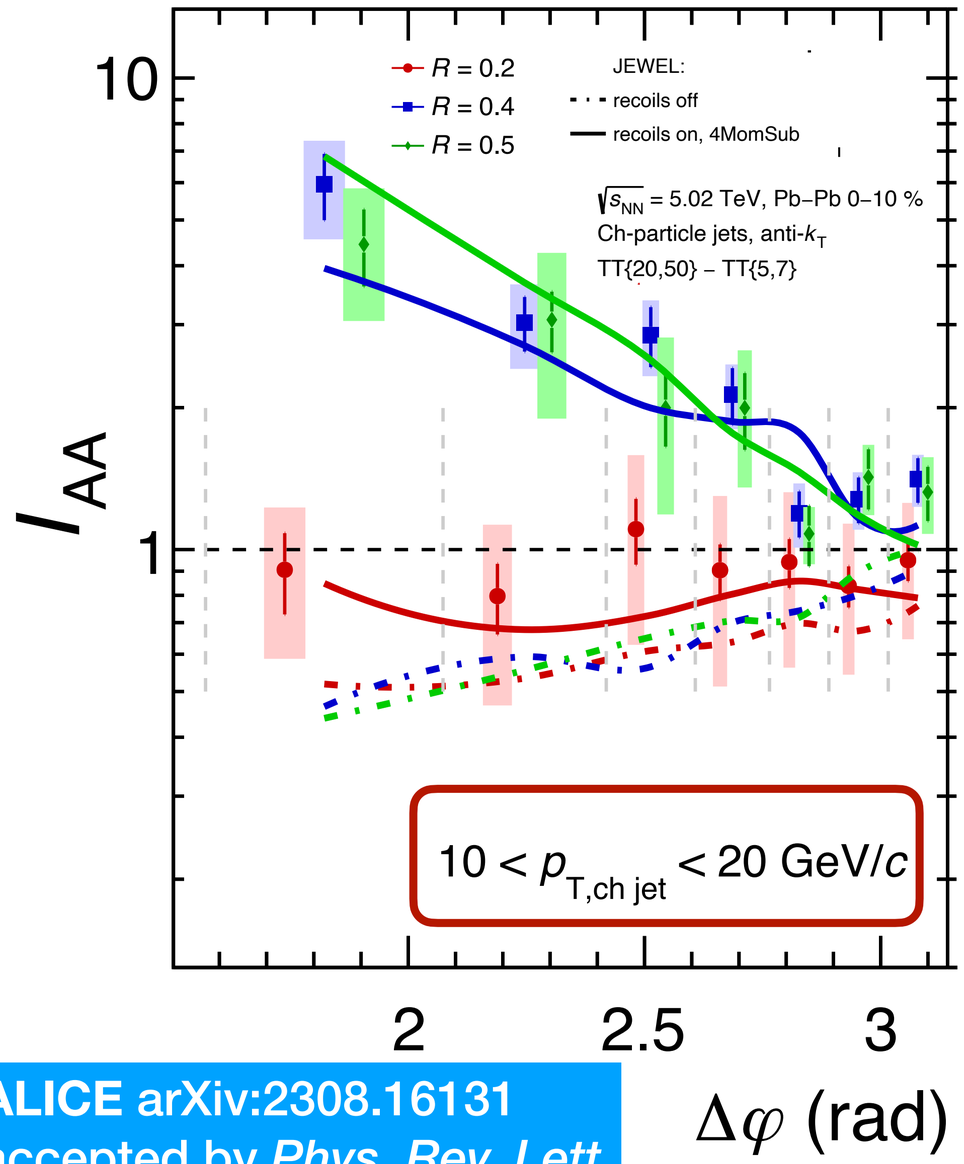




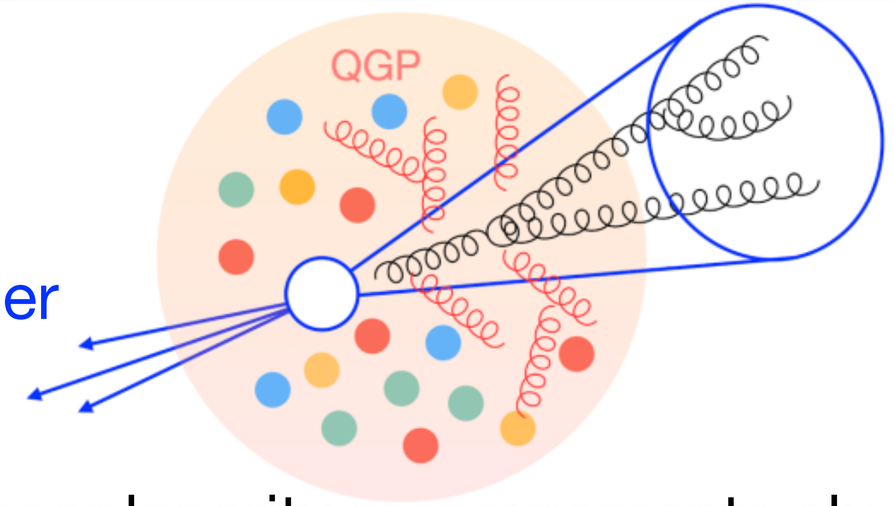
ALICE *Phys. Rev. Lett.* **125** (2020) 022301
ALICE *Phys. Rev. Lett.* **109** (2012) 112301
ALICE *Phys. Lett.* **B819** (2021) 136637
ALICE *Phys. Lett.* **B820** (2021) 136558
ALICE *Phys. Lett.* **B770** (2017) 459
ALICE *Phys. Lett.* **B753** (2016) 41
ALICE *Phys. Lett.* **B708** (2012) 265
ALICE *JHEP* **1909** (2019) 008

- Provide high-precision tomography of the QGP
- Fix the energy loss mechanisms of heavy quarks
- Reveal the thermal degrees of freedom of heavy quarks in the QGP medium

Jet acoplanarity in Pb–Pb collisions



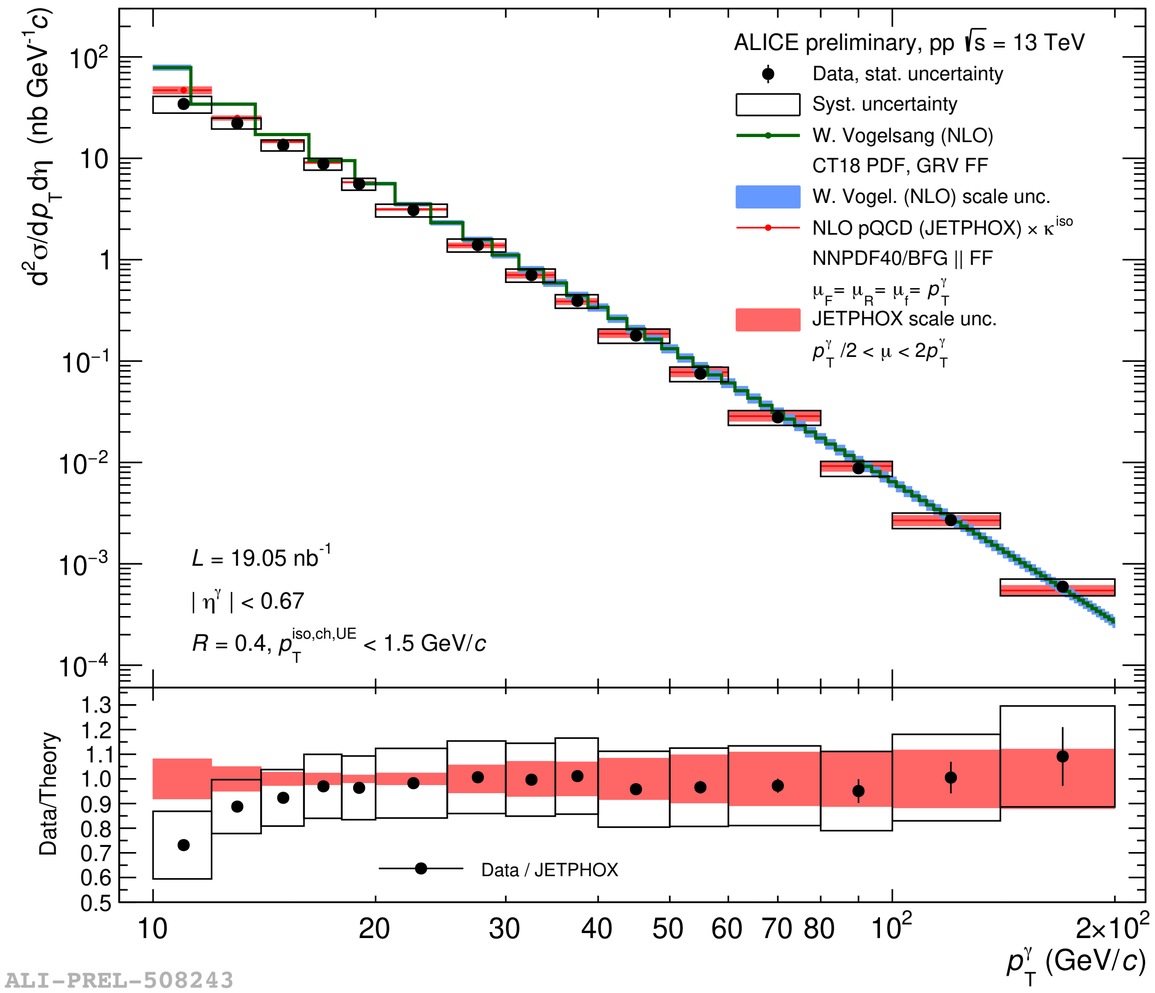
ALICE arXiv:2308.16131
accepted by *Phys. Rev. Lett.*



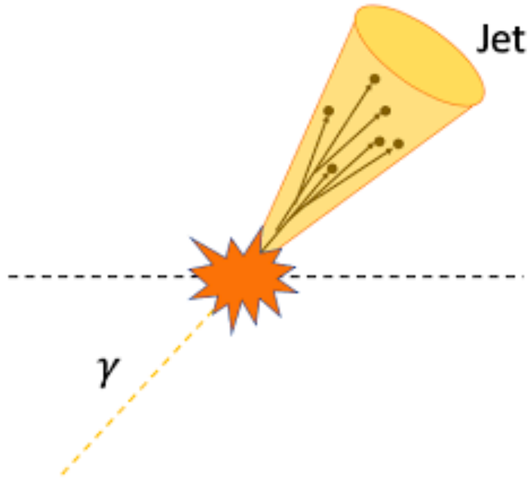
Yongzhen Hou
Co-PhD (2021–24)
CCNU-IPHC

- Jet acoplanarity measurements elucidate the microscopic structure of the QGP
- Semi-inclusive production is immune to complex uncorrelated background in heavy-ion collisions
- Data suggests medium response and medium-induced splitting is important for low p_T and large radial jet production but disfavors the large angular scatting

Isolated direct photon production



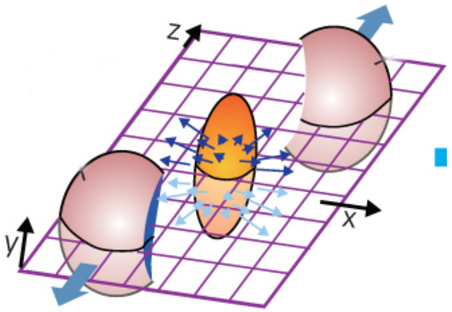
ALI-PREL-508243



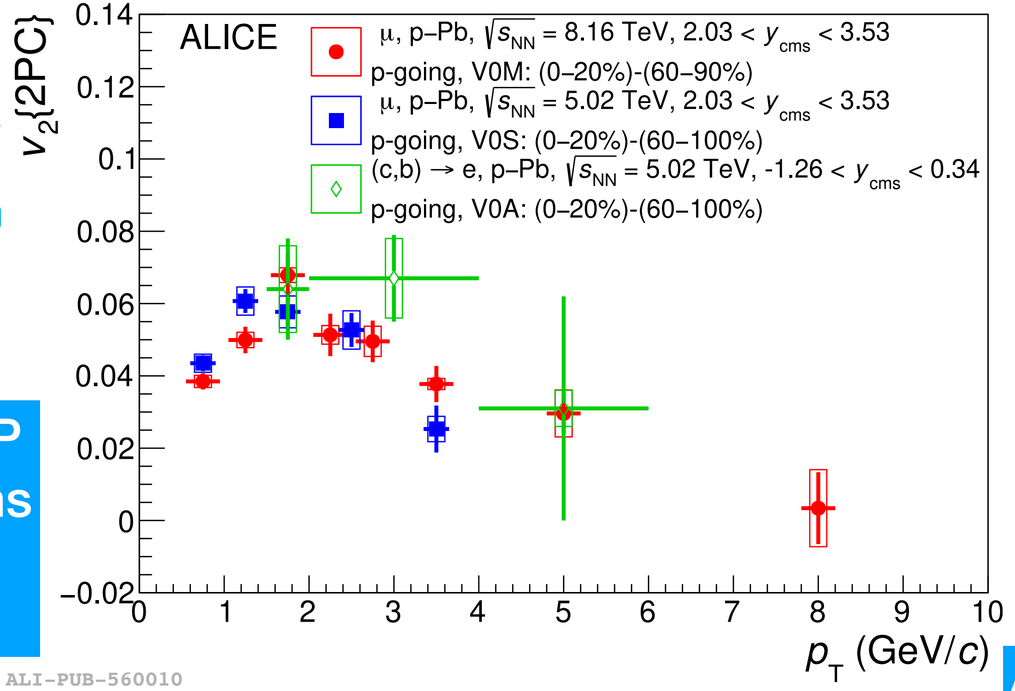
Ran Xu
Co-PhD (2020–24)
CCNU-LPSC

- p_T-differential measurement of the isolated direct photon production cross section in pp collisions in a wide p_T range and down to low p_T
- Well described by theoretical calculations, some tension with JETPHOX at low p_T

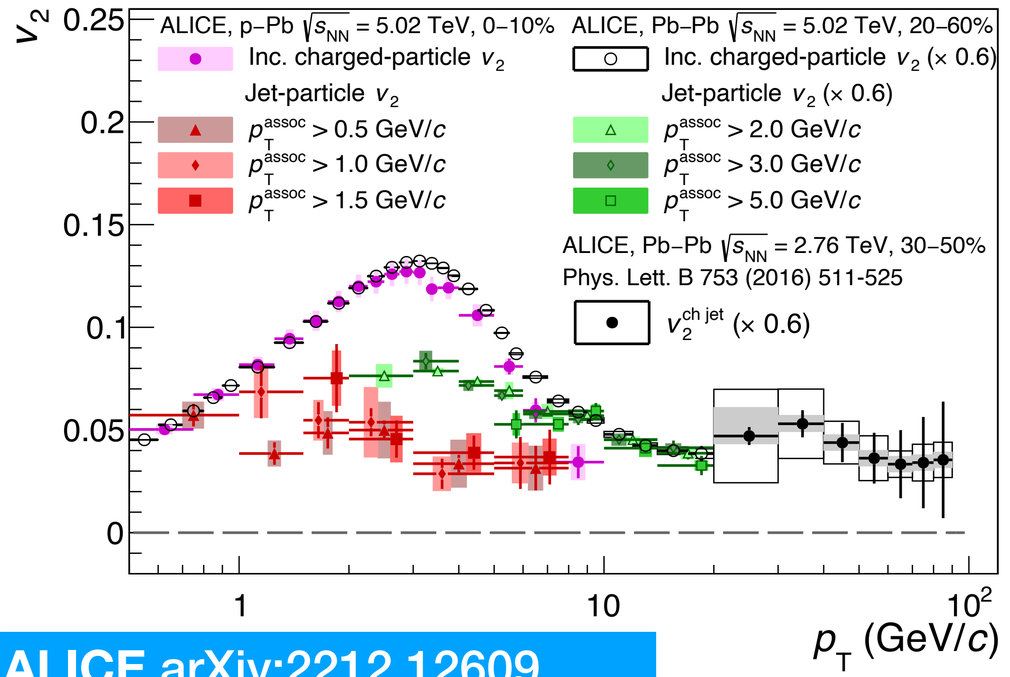
Collectivity in small collision systems



Signature of the QGP in heavy-ion collisions appears in small system collisions

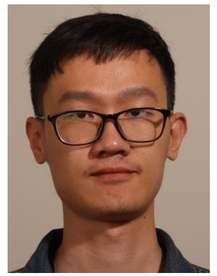


ALICE *Phys. Lett.* **B846 (2023) 137782**



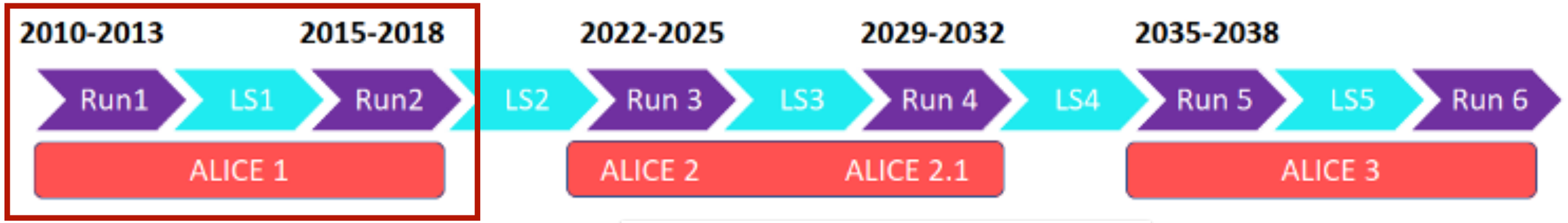
ALICE arXiv:2212.12609
Submitted to *Phys. Rev. Lett.*

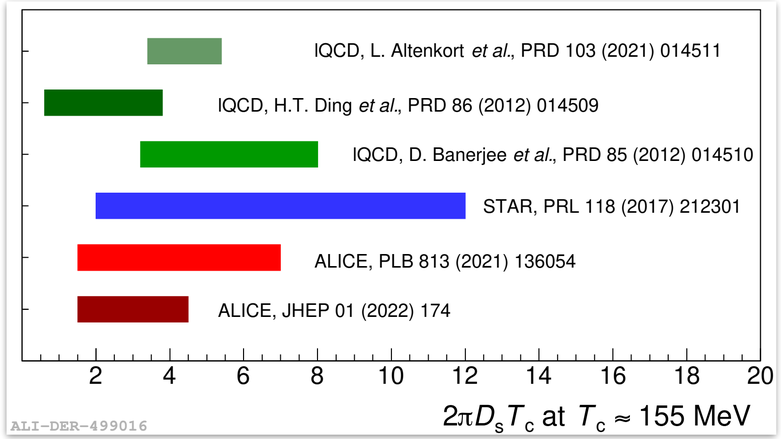
- Positive v_2 of inclusive muons at forward rapidity (dominated by HF decays in p_T > 2 GeV/c) — described by both parton escape (AMPT) and initial stages partons correlations (CGC) mechanisms
- Non-zero v_2 of jet particles in both Pb–Pb and p–Pb collisions, amplitude differs from that of the inclusive particles

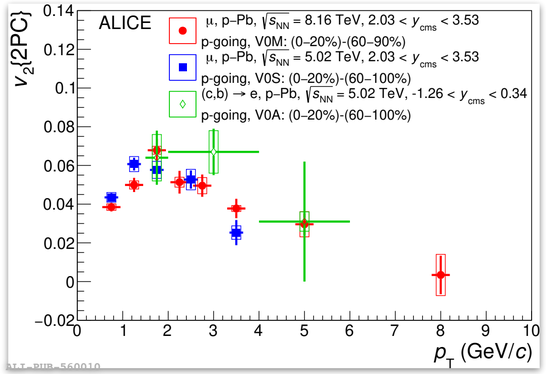


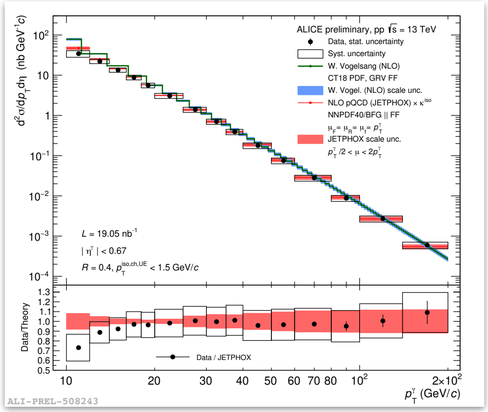
Siyu Tang
Co-PhD (2018–22)
CCNU-LPC

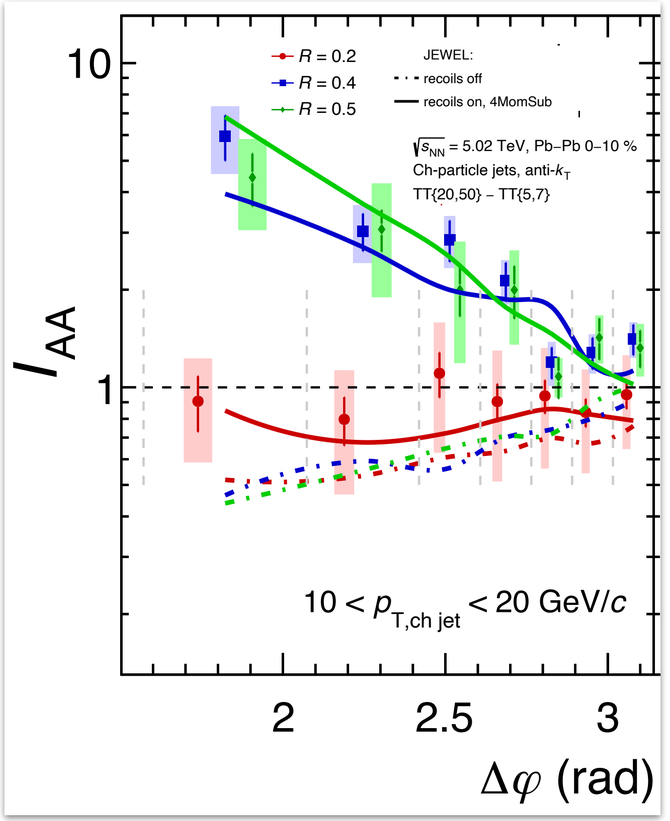
A journey through QCD





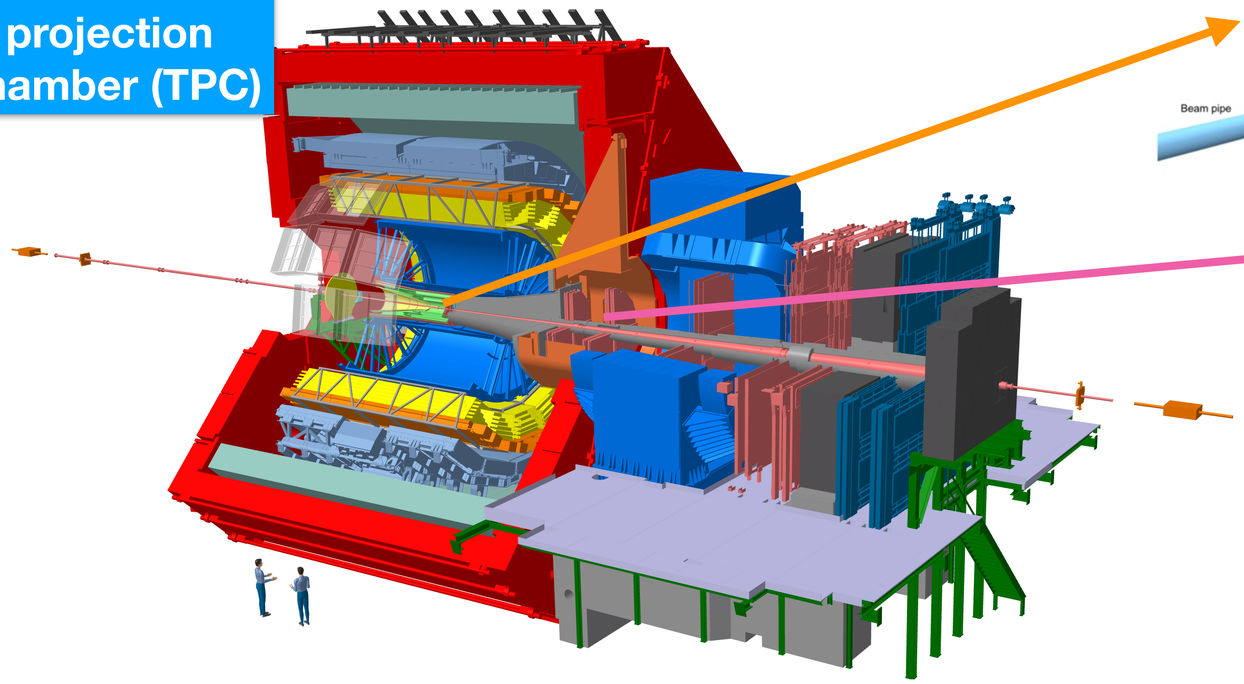




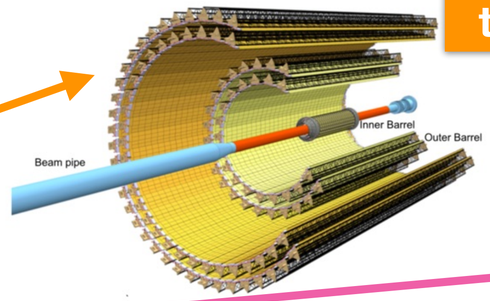


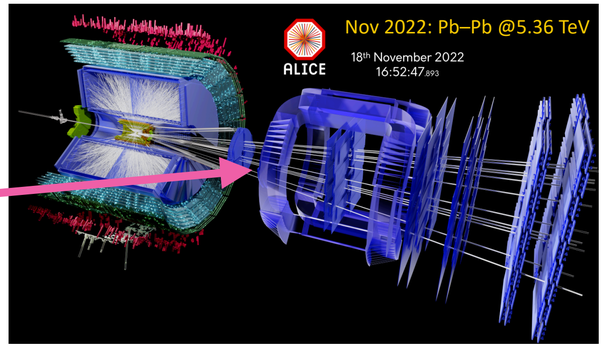
A journey through QCD

Upgraded readout of time projection chamber (TPC)

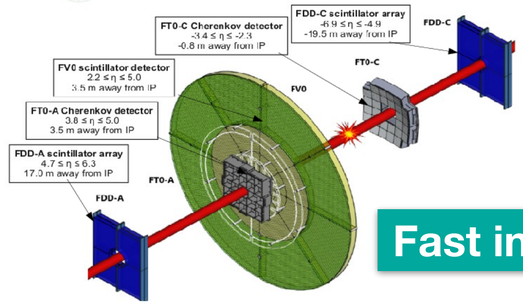


The 2nd generation inner tracking system (ITS2)



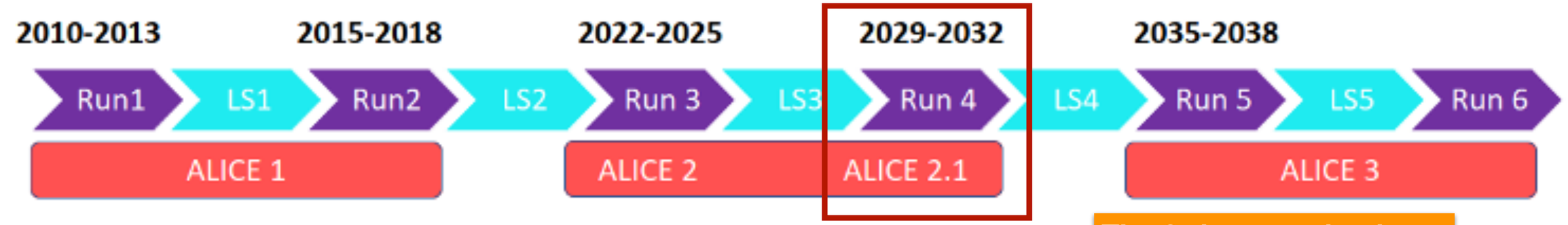


Muon forward tracker (MFT)

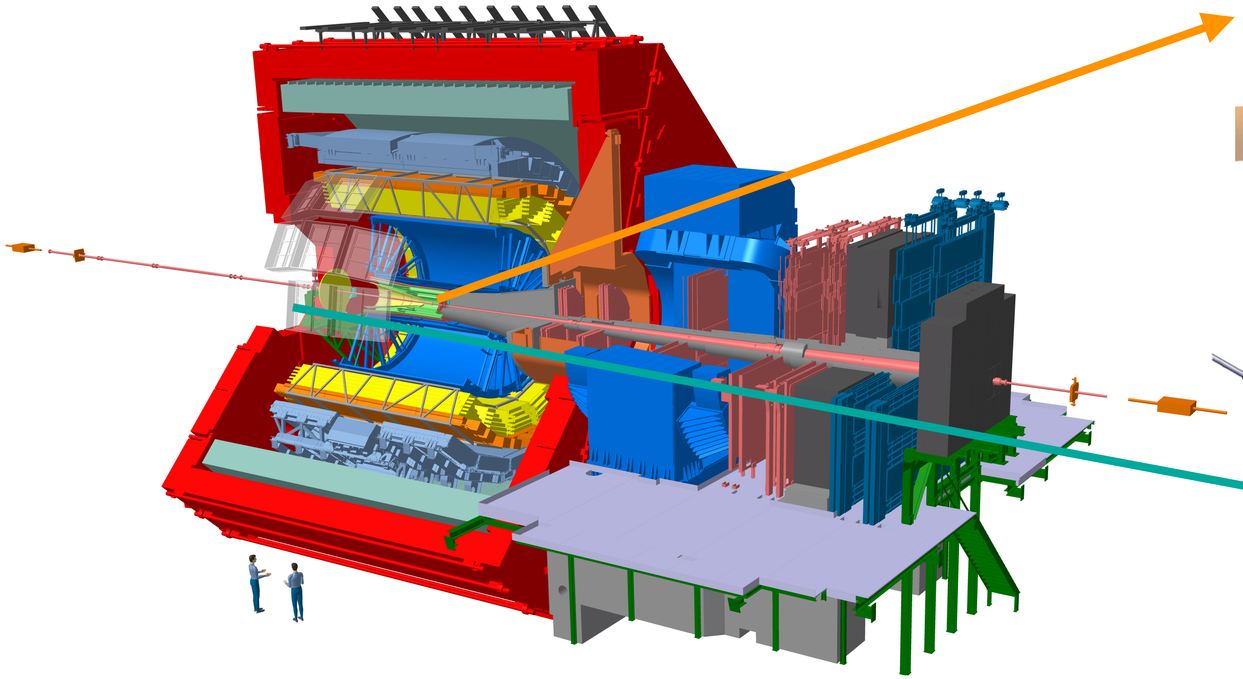


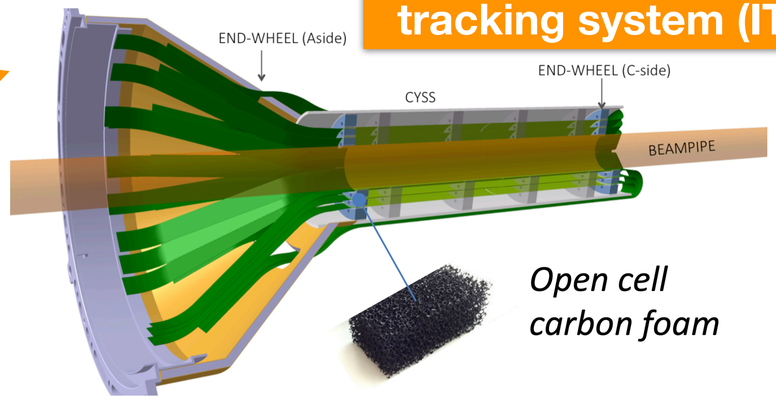
Fast integrated trigger (FIT)

A journey through QCD



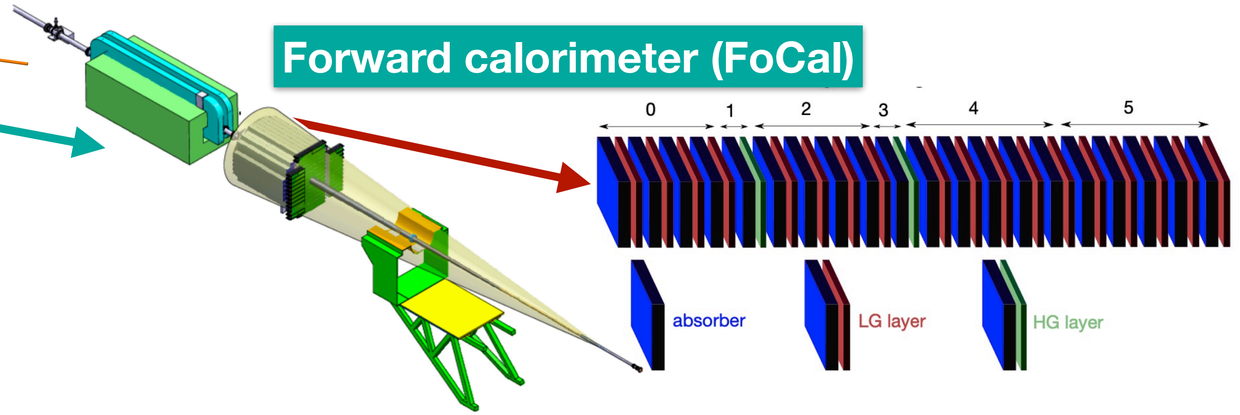
The 3rd generation inner tracking system (ITS3)



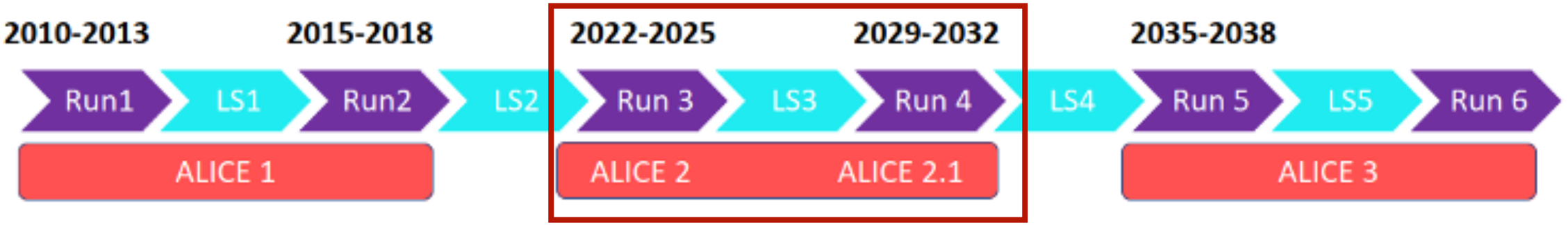


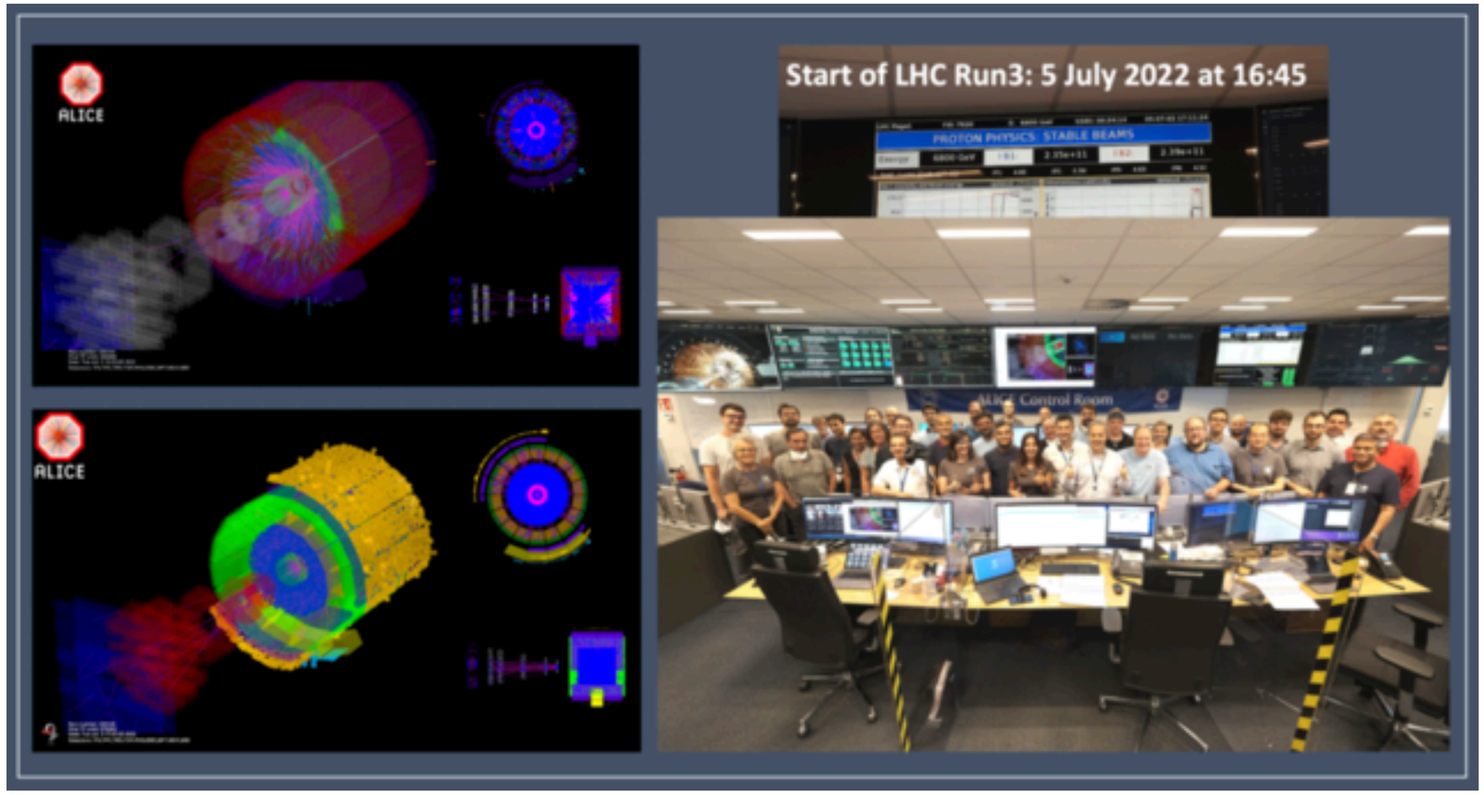
Open cell carbon foam

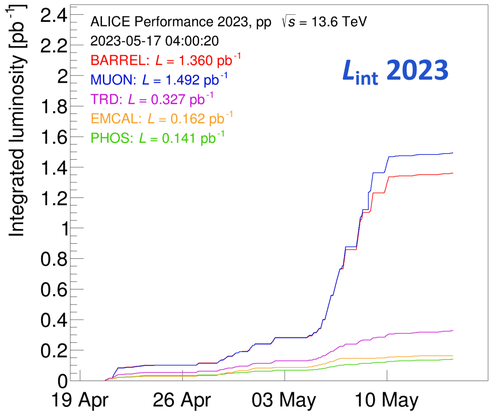
Forward calorimeter (FoCal)

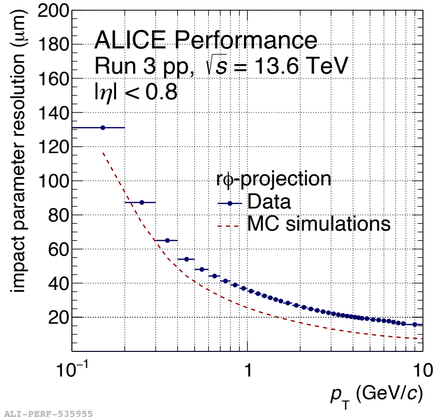


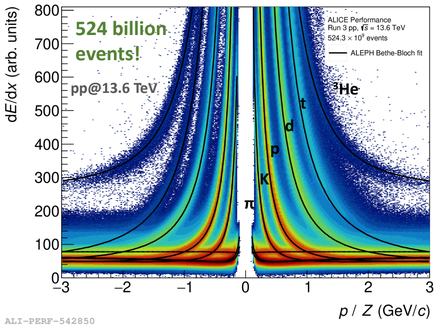
ALICE Run3 data taking

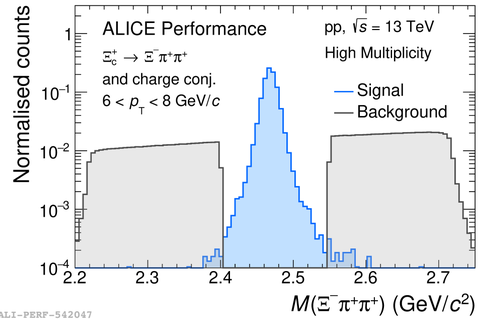






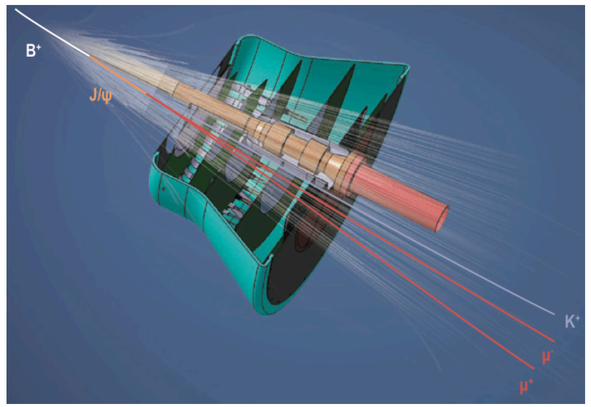


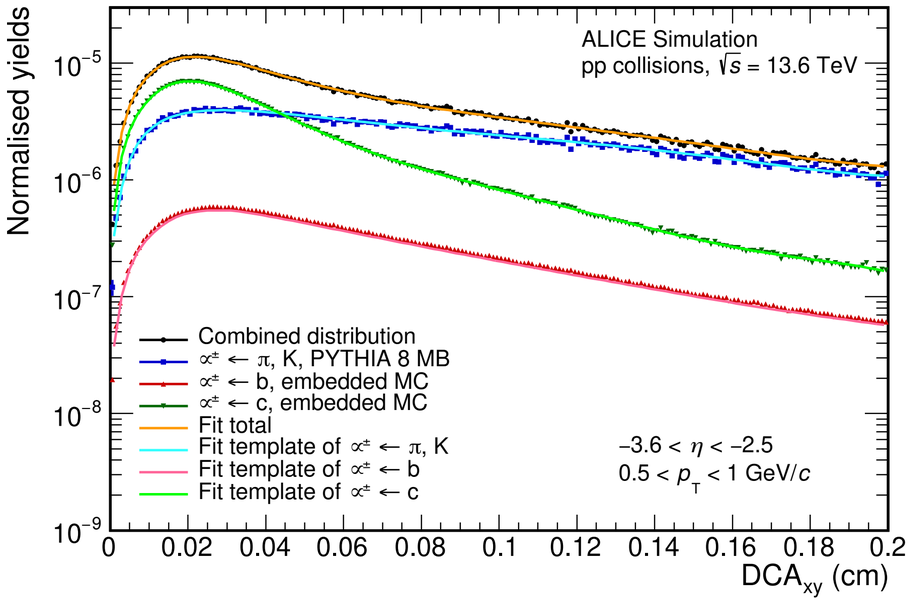


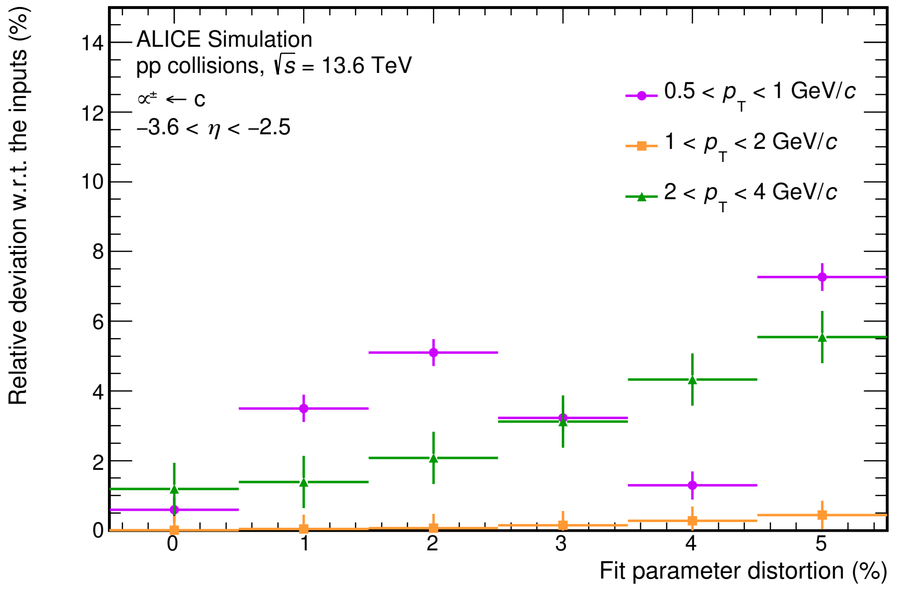


Performance of MFT

Maolin Zhang
Co-PhD (2024–26)
CCNU-LPC

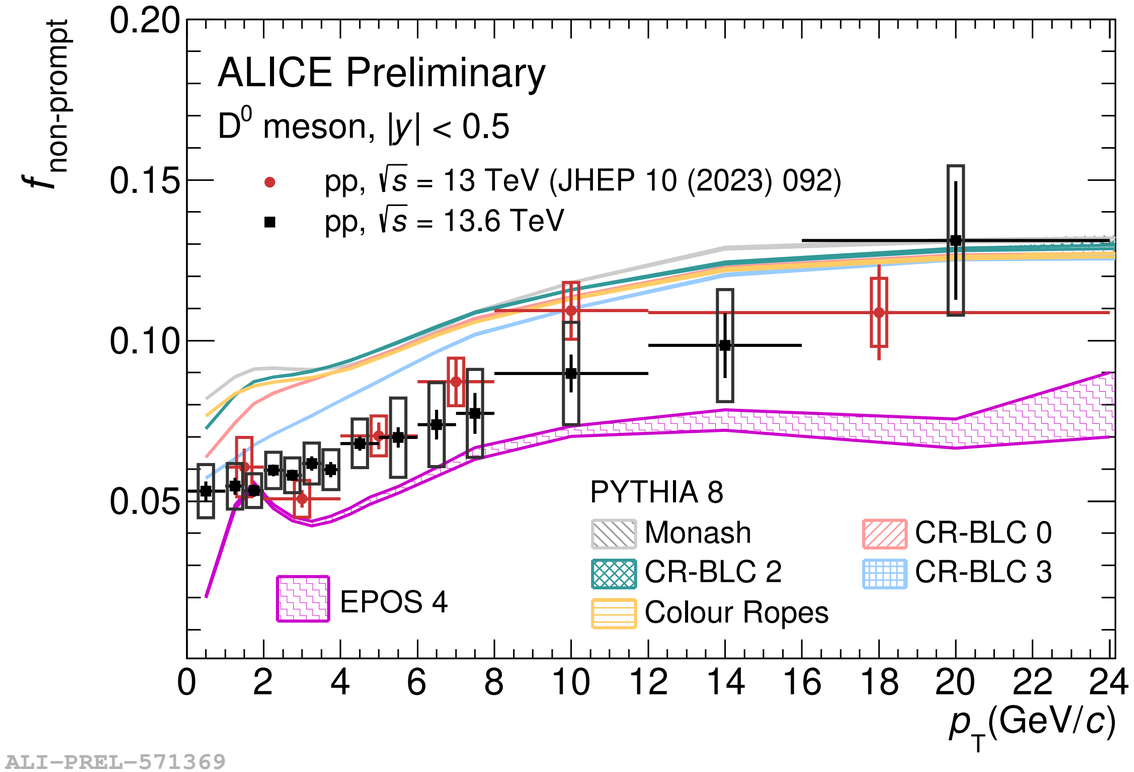




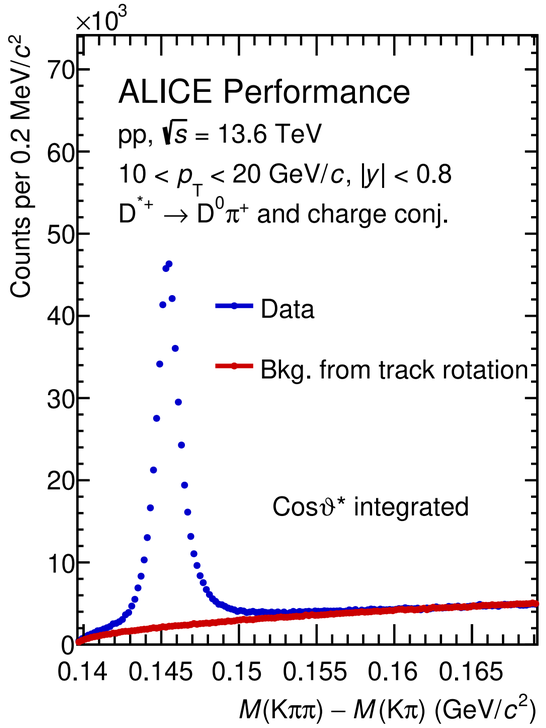


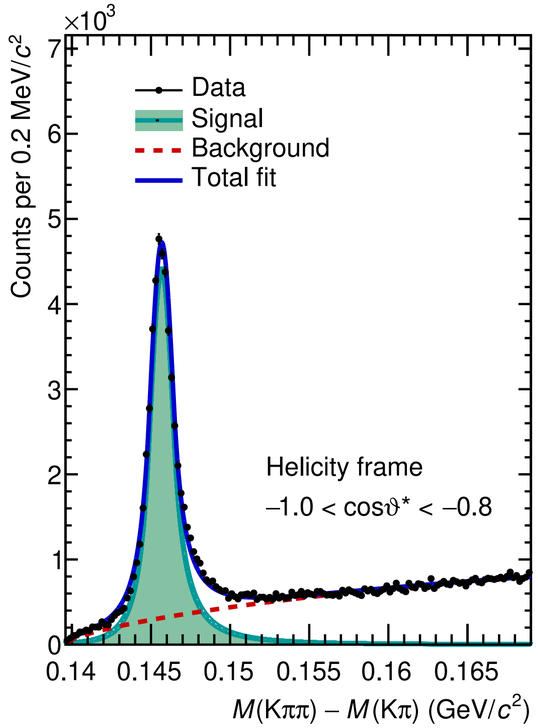
- Different muon sources are well identified based on the displacement from the primary vertex
- Apply fit to the total displacement distribution with distortions up to a given % for each source
- Good compatibility to separation charm and beauty hadron decay muons down to low p_T

D_s^+ and b→D^0 production



ALI-PREL-571369



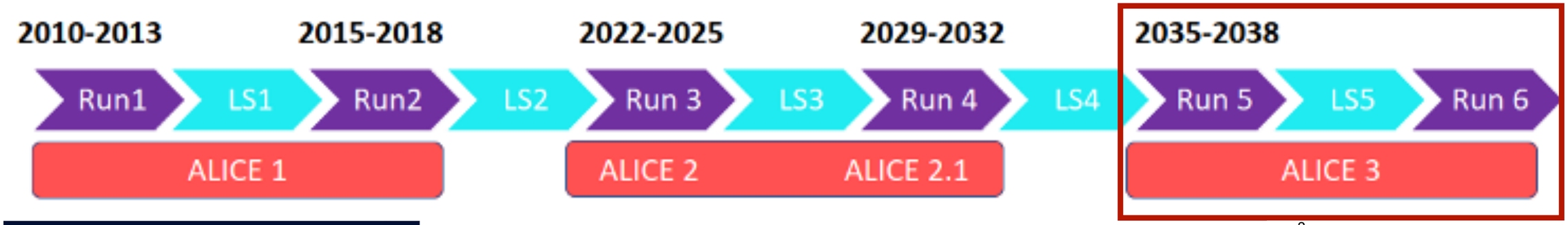


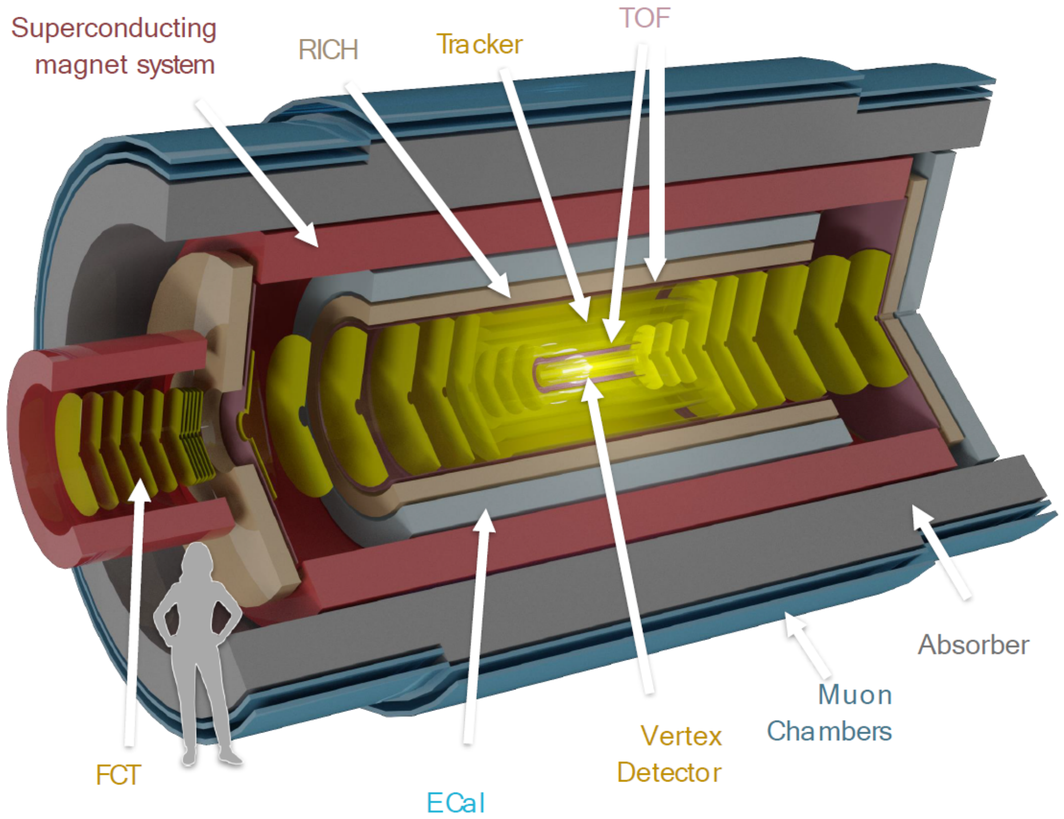
ALI-PERF-571935

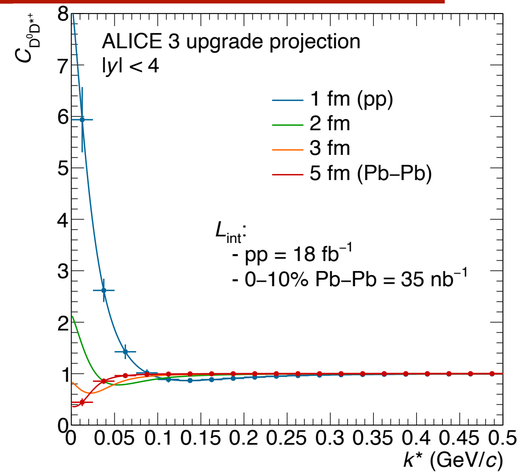
- Measurements are extended to lower p_T and more granular w. r. t. run 2

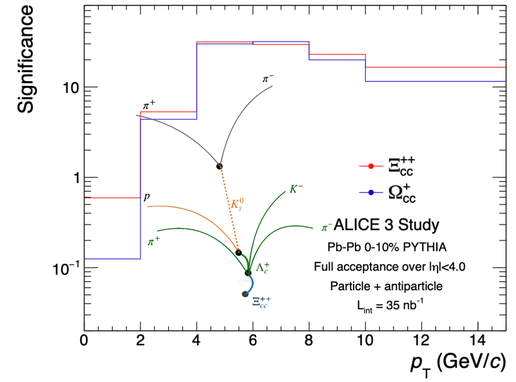
  ➡ Stronger constraints on the modelling of charm-quark hadronization

Next-generation experiment









Next-generation experiment

ALICE @ FCPPN/L should keep much strengthening and closer cooperation for ALICE 3 and even beyond with common interest in next-generation detector upgrade projects and exciting physics exploration