



ALICE

# The France-China Collaboration

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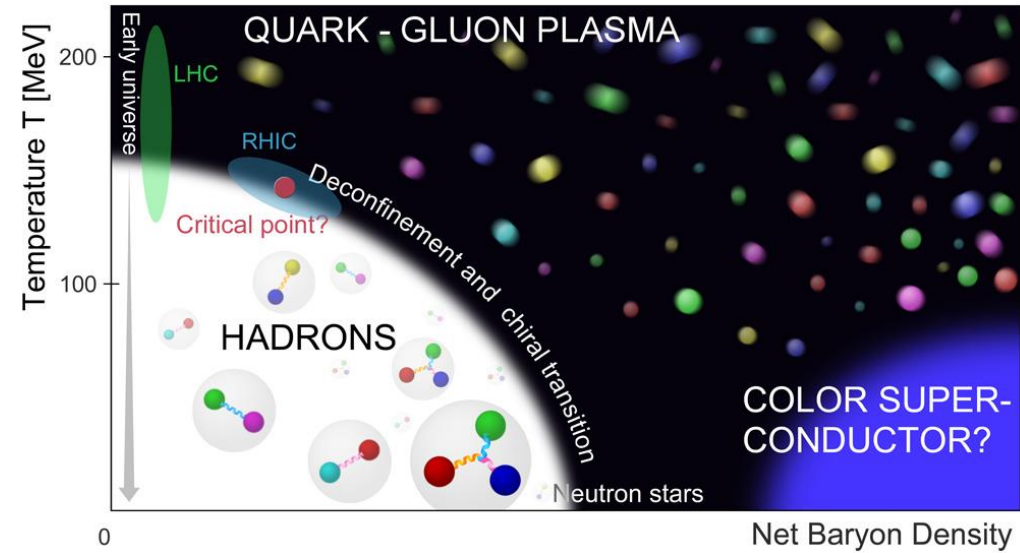
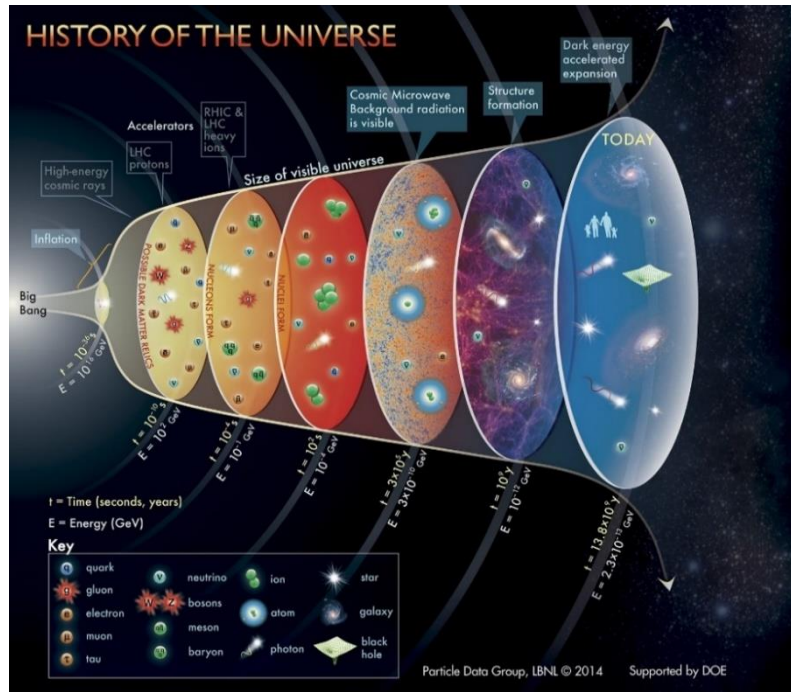
**Main focus:**

- ❖ **Scientific context**
- ❖ **History of the France-China Collaboration within ALICE**
  - **Achievements**
  - **Further collaboration plans**

Workshop on Advances, Innovation, and Future Perspectives In High-Energy Nuclear Physics  
CCNU-Wuhan, October 19-24, 2024



# The QCD phase diagram and the quark-gluon plasma (QGP)

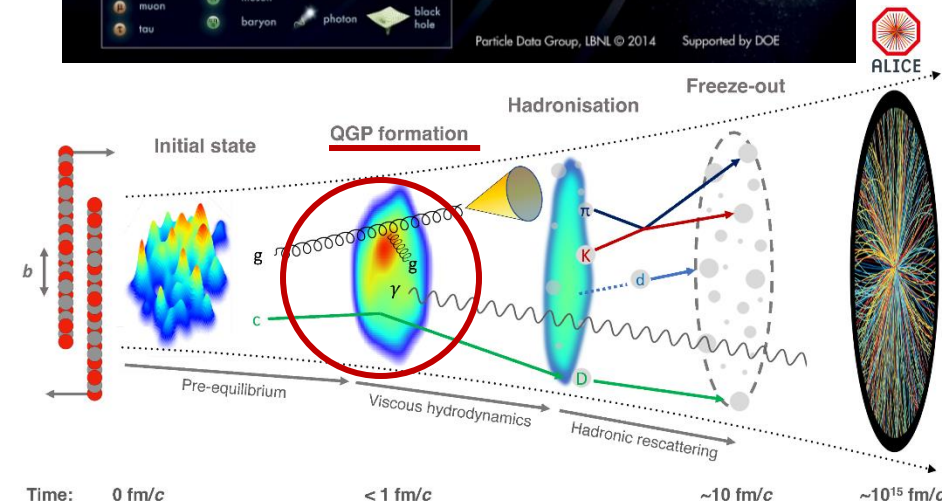


□ Study the properties of nuclear matter at extreme conditions of temperature and energy density

- Deconfined state of matter: **quark-gluon plasma (QGP)**
- Predicted by QCD:  $T_c \sim 155$  MeV,  $\epsilon_c \sim 0.5$  GeV/fm<sup>3</sup>

□ A QGP state can be created using **ultrarelativistic heavy-ion collisions**

□ **ALICE**: dedicated experiment for heavy-ion physics at the LHC



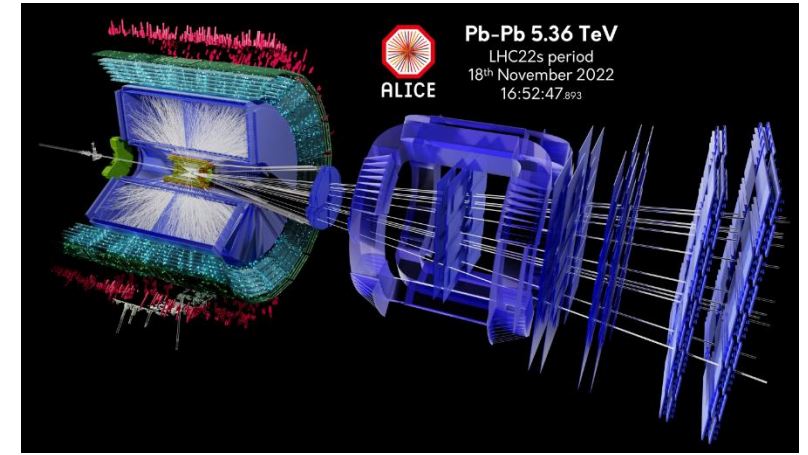
# The ALICE Collaboration in 2024



40 countries, 171 institutes, 1958 members



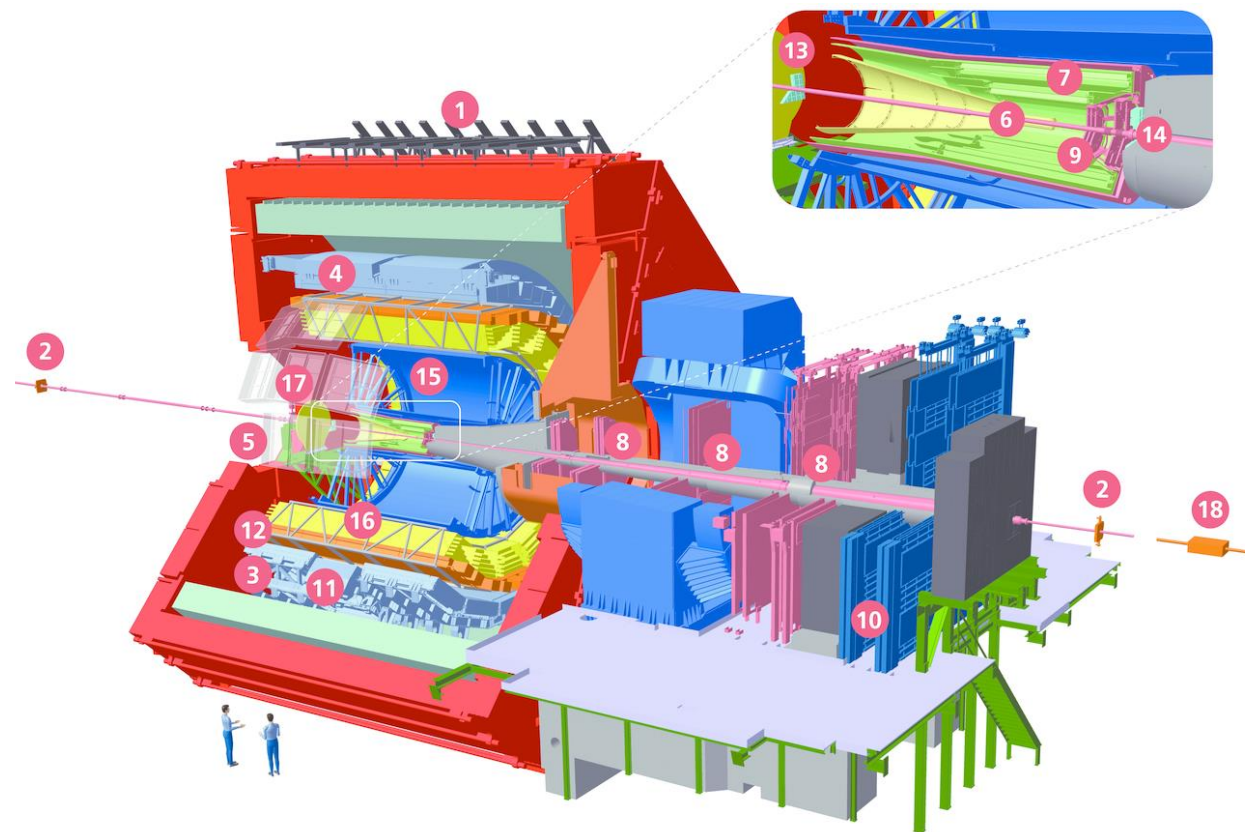
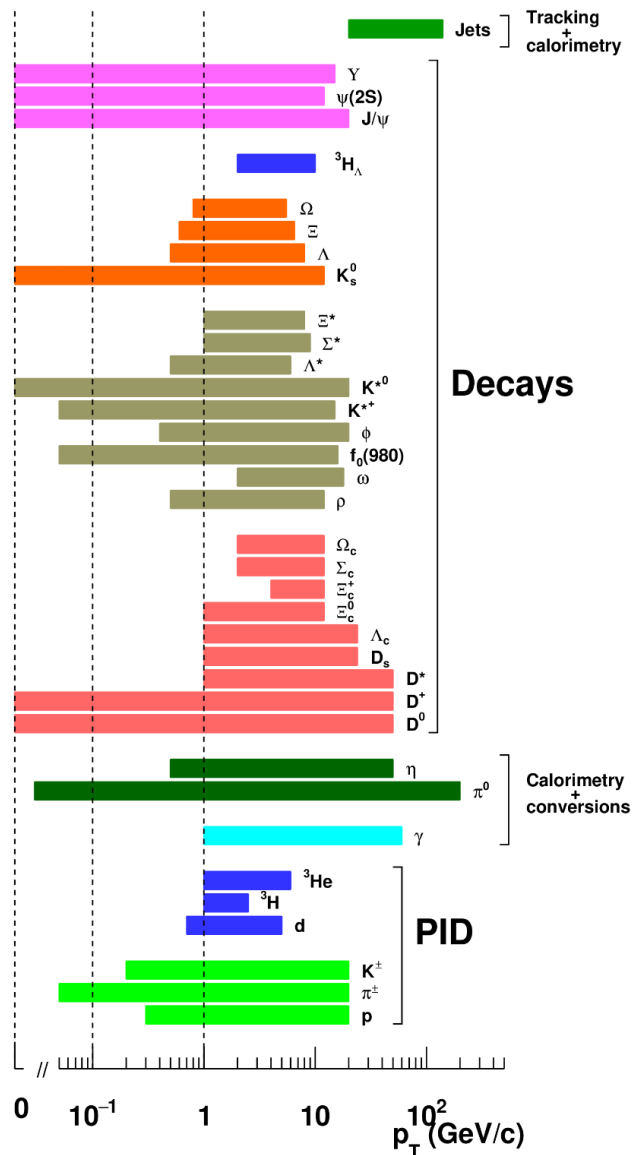
China: 100 members, 5 institutes  
France: 123 members, 8 institutes



<https://alice-collaboration.web.cern.ch>



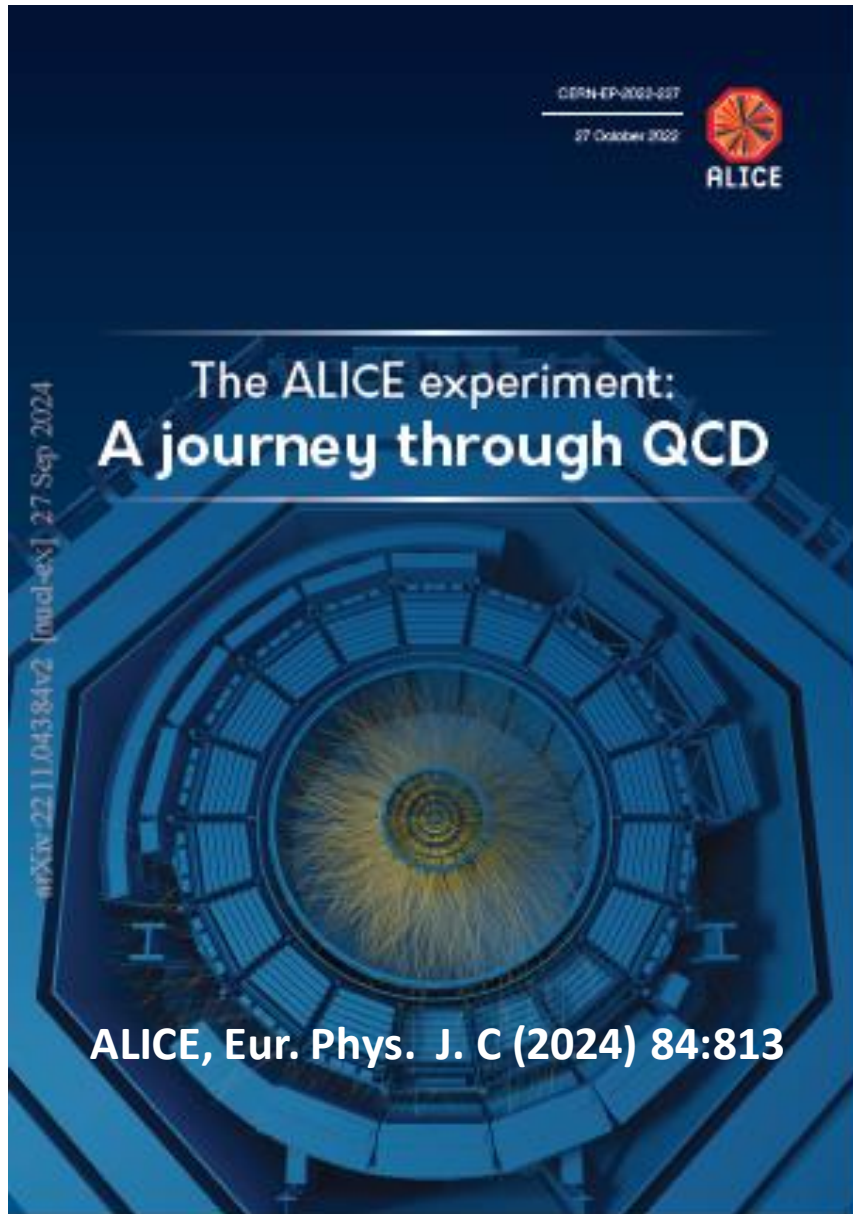
# The ALICE detector



- 1 ACORDE | ALICE Cosmic Rays Detector
- 2 AD | ALICE Diffractive Detector
- 3 DCal | Di-jet Calorimeter
- 4 EMCal | Electromagnetic Calorimeter
- 5 HMPID | High Momentum Particle Identification Detector
- 6 ITS-IB | Inner Tracking System - Inner Barrel
- 7 ITS-OB | Inner Tracking System - Outer Barrel
- 8 MCH | Muon Tracking Chambers
- 9 MFT | Muon Forward Tracker
- 10 MID | Muon Identifier
- 11 PHOS / CPV | Photon Spectrometer
- 12 TOF | Time Of Flight
- 13 T0+A | Tzero + A
- 14 T0+C | Tzero + C
- 15 TPC | Time Projection Chamber
- 16 TRD | Transition Radiation Detector
- 17 V0+ | Vzero + Detector
- 18 ZDC | Zero Degree Calorimeter

ALICE, JINST 19 (2024) 222303

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



**500 ALICE  
papers  
published**

## ❖ Soft physics

- Multiplicity and particle production
- Flow, correlations and fluctuations

## ❖ Hard probes

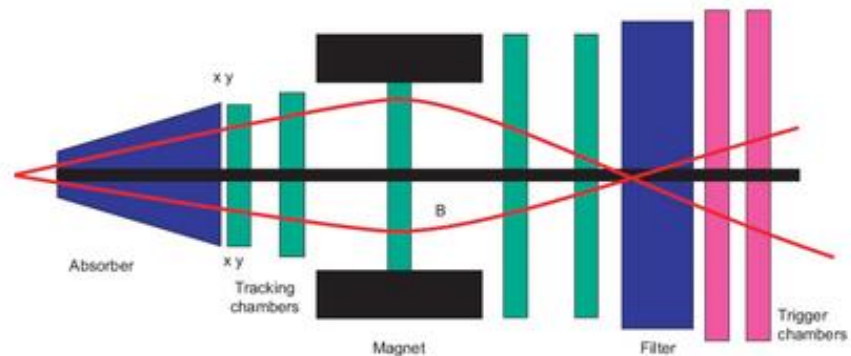
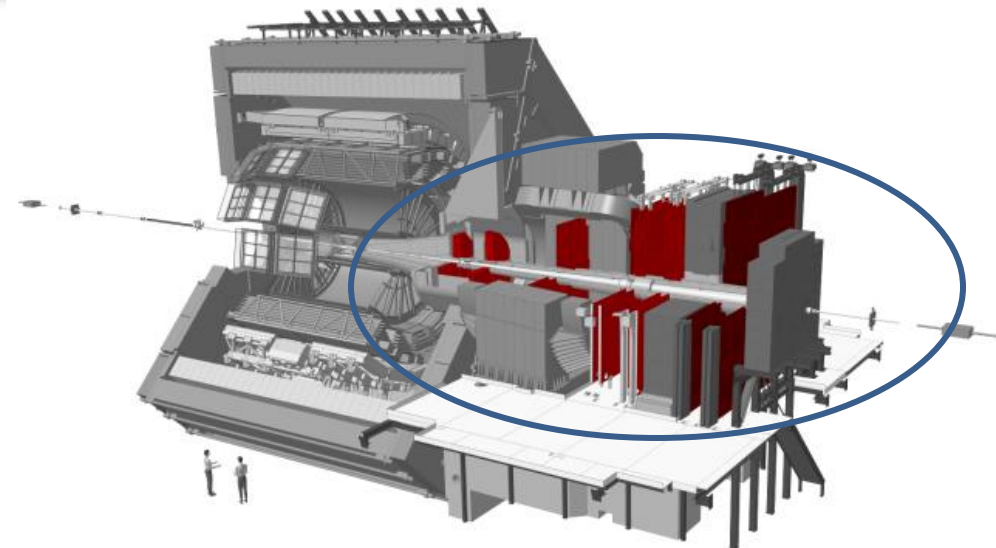
- Heavy quarks
- Jets, high- $p_T$   $\gamma$  and neutral hadrons
- Electroweak bosons W & Z
- Ultra-peripheral collisions

## ❖ New physics

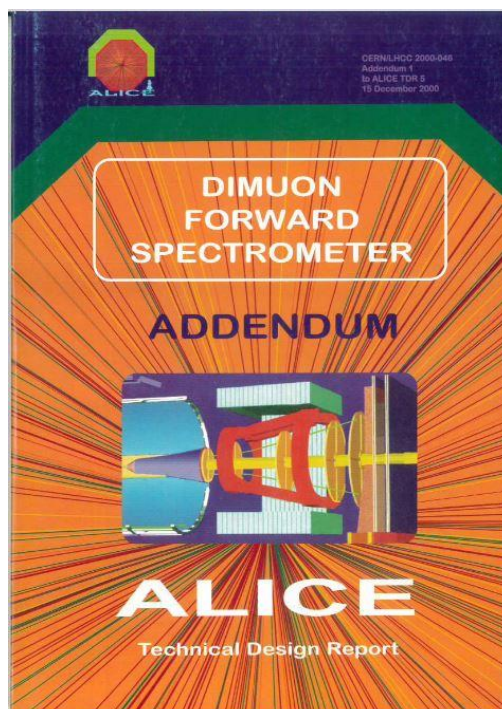
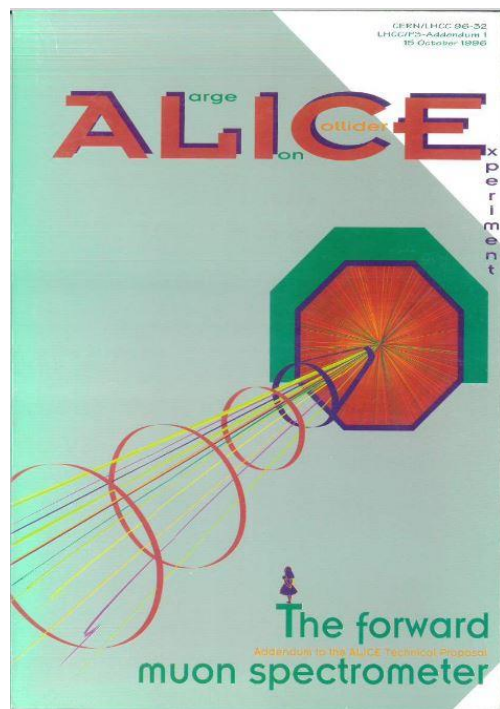
- Magnetic field effects
- Exotic particles, light (anti)nuclei, machine learning...



# France-China Collaboration in ALICE: a long history



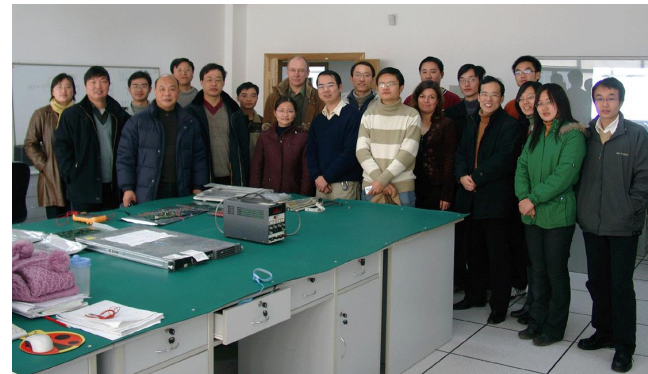
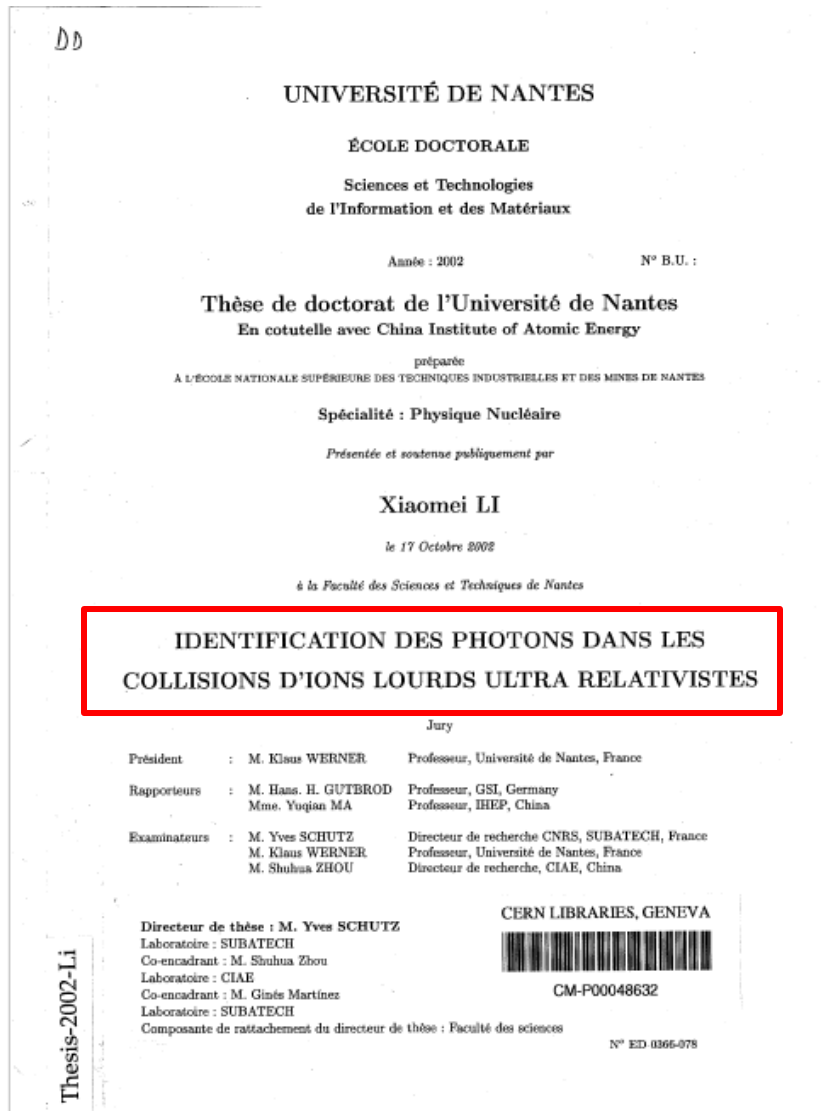
Daicui ZHOU  
(CCNU-Wuhan)  
IPN Orsay  
Oct. 1994-1996  
1998-2001



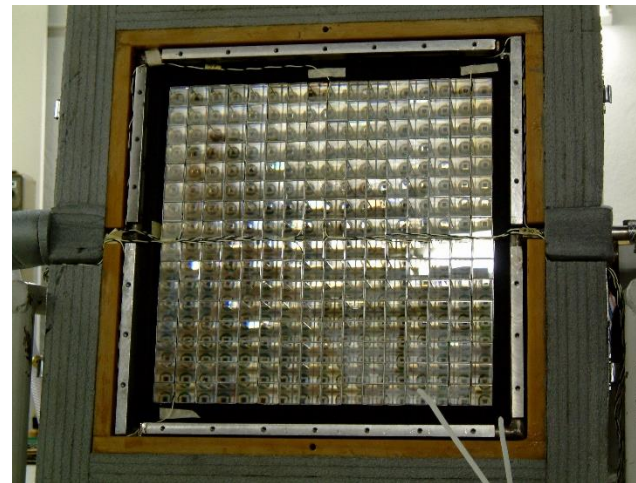
- ❖ Working together with IPN Orsay group on the feasibility study of adding a forward muon spectrometer to ALICE
- ❖ Visiting of French institutes showing interest into the forward muon spectrometer

Addendum to ALICE Technical Proposal: CERN/LHCC 96-32  
Addendum to ALICE TDR: CERN/LHCC 2000-046

# The France-China Collaboration: first joint-PhD



Xiaomei LI  
(CIAE Beijing)  
Cotutorship PhD Subatech-CIAE  
1999-2002  
Supervisor: Yves Schutz



PHOS prototype with  $PbWO_4$  crystals



# The evolution of the France-China cooperation with FCPPL/N



## Signature of Lol to create the "France China Particle Physics Laboratory" (FCPPL)

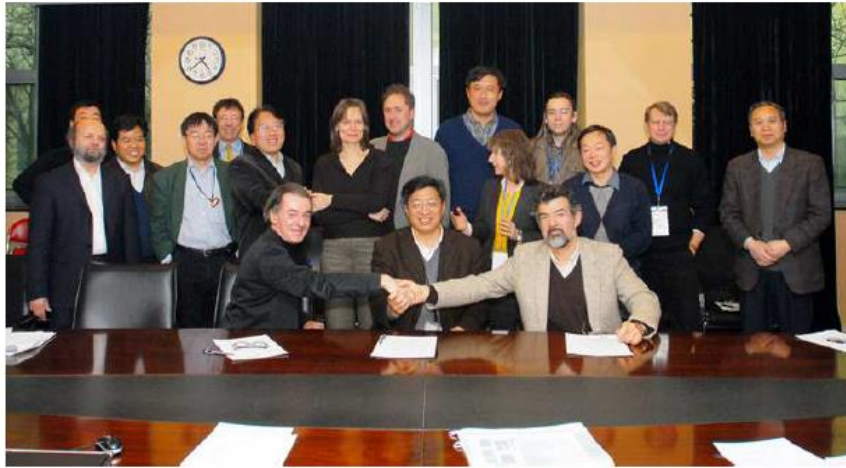


Figure 2 : Signature par François Le Diberder (IN2P3), Chen Hesheng (IHEP), et Bruno Mansoulié (CEA) d'une lettre d'intention pour créer le LIA FCPPL le 14 décembre 2006.  
Signing of the letter of intent to create the LIA FCPPL laboratory.



## "France-China Particle Physics Laboratory" Created

2007-05-15

An Associated International Laboratory (LIA) on particle physics known as "France-China Particle Physics Laboratory (FCPPL) has been just created. The creation marks a new stage for the long cooperation in the field of particle physics between the scientists of both countries and opens broader prospects for the cooperation in the future.

At the invitation of the multi-French Government Agencies, Lu Yongxiang, President of the Chinese Academy of Sciences (CAS) has just rounded up a trip to France. During his trip, he had nice and fruitful discussions with Mr. Catherine Bréchnignac, President of the French National Science Research Institute (CNRS) and Mr. Alain Bugat, Chairman of the French Atomic Energy Agency (CEA), which were culminated by the signature of the three giants on the Agreement to create "France-China Particle Physics Laboratory" in Paris on April 10, 2007. The goals of the FCPPL are to further develop the cooperation between scientists of both countries in the fields of particle physics, astroparticle physics, accelerators and associated technologies. The Agreement defines a basic framework with which the cooperation shall be carried out, overseen and managed. Within this framework of cooperation, the main activities of FCPPL shall be program-oriented with assorted workshops and symposiums and with rich personnel exchanges.

"This is a new starting point, a very important milestone to our cooperation.", commented by Prof. Chen Hesheng, the Director of the Institute of High Energy Physics of the Chinese Academy of Sciences, one of the main sponsors for the cooperation. We have reason to believe that with the efforts of both sides, the tree of Sino-French cooperation in particle physics will bear more fruits.



June 25, 2024: renewal of FCPPL as FCPPN

Signature de l'accord de l'IRN FCPPN au siège de la CAS le 25 juin. De gauche à droite : HOU Jianguo : Président de la CAS, WANG Yifang : Directeur de l'IHEP, Eric KAJFASZ : co-directeur du FCPPN, Antoine PETIT : PDG du CNRS. Image CAS

- ❖ With the creation of the FCPPL/N, the ALICE France China cooperation is becoming stronger and robust via the project "Study of QCD matter with the ALICE"



# ALICE in China



China Institute of Atomic Energy (CIAE)

University of Science and Technology of China (USTC)

Fudan University (FDU)

Central China Normal University (CCNU)

China University of Geosciences (CUG Wuhan)

Huazhong University of science and Technology (HUST)

Hubei University of Technology (HUT)

# ALICE in France



## France (8 institutes)

- IP2i & CC-IN2P3, Lyon
- IJCLab, Orsay
- IPHC, Strasbourg
- LPCA, Clermont-Ferrand
- LPSC, Grenoble
- Subatech, Nantes
  
- IRFU, Saclay



# ALICE within the FCPPL/N



French Group			Chinese Group		
Name	Title	Affiliation (institute)	Name	Title	Affiliation (institute)
<i>Leader</i> <b>BASTID Nicole</b>	PU	IN2P3	<i>Leader</i> 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	<u>Joint-PhD student</u>	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	<u>Joint-PhD student</u>	IOPP/CCNU
Uras Antonio	CR	IN2P3	Wu Yitao	PhD student	USTC Hefei

Xu Lang	<u>Joint-PhD student</u>	IN2P3	Hou Yongzhen	<u>Joint-PhD student</u>	IOPP/CCNU
Xu Ran	<u>Joint-PhD student</u>	IN2P3	Zhang Maolin	<u>Joint-PhD student</u>	IOPP/CCNU
Zhang Maolin	<u>Joint-PhD Student</u>	IN2P3	Xu Lang	<u>Joint-PhD student</u>	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 the 2024 FCPPL application (was 36 members in 2009):
  - Contributions in several physics channels
  - Technical contributions in several ALICE subdetectors
  - Preparation of the future beyond the LHC Run 4 (> 2035)



## France institutes

- ❑ IP2I & CC-IN2P3, Lyon
- ❑ IJCLab, Orsay
- ❑ IPHC, Strasbourg
- ❑ LPCA, Clermont-Ferrand
- ❑ LPSC, Grenoble
- ❑ Subatech, Nantes
- ❑ IRFU, Saclay

## China institutes

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



### ❖ Data analysis

- Open heavy flavours
- Quarkonia
- Jets
- Electroweak bosons
- Photon and neutral hadrons
- Low mass resonances

### ❖ Performance studies

- Open heavy flavours with MUON & MFT
- D fragmentation function with ITS2
- $\gamma(\pi^0)$  & jets with EMCAL, DCal & PHOS

### ❖ Offline

### ❖ Hardware: R&D, production/installation, commissioning, operation

- Run 2: EMCAL, Dcal, PHOS, ITS
- Run 3: ITS2, MFT

### ❖ Responsibilities at various periods:

- Management Board, Conference Committee, Physics Analysis Group, Physics Working Group, detectors & upgrades



# History and achievements within FCPPL/N: co-PhDs



Renzhuo WAN  
CCNU-IPHC  
(2008-2011)



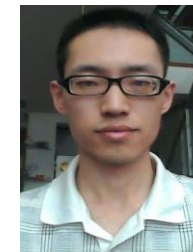
Yaxian MAO  
CCNU-LPSC  
(2008-2011)



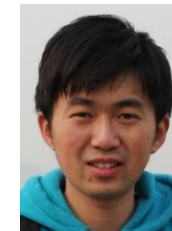
Xiaoming ZHANG  
CCNU-LPCA  
(2009-2012)



Shuang LI  
CCNU-LPCA  
(2012-2015)



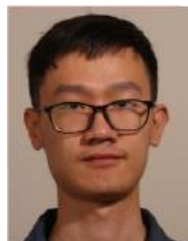
Mengling WANG  
CCNU-Subatech  
(2012-2015)



Jianhui ZHU  
CCNU-Subatech  
(2012-2015)



Zuman ZHANG  
CCNU-LPCA  
(2015-2018)



Siyu TANG  
CCNU-LPCA  
(2018-2022)



Yanchun DING  
CCNU-IP2I  
(2019-2022)



Yitao WU  
CCNU-IPHC  
(2019-2025)



Ran XU  
CCNU-LPSC  
(2020-2025)



Yongzhen HOU  
CCNU-IPHC  
(2021-2024)



Maolin ZHANG  
CCNU-LPCA  
(2024-2026)



Lang XU  
CCNU-IP2I  
(2024-2026)



Yubiao WANG  
CCNU-LPSC  
(2024-2026)

- ❖ Funding: French embassy (Y. Mao, X. Zhang), CSC + additional support from Eiffel, CCNU, FCPPL/IN2P3
- ❖ ~20 Master internships
- ❖ 3 Postdocs
- ❖ Many visits of students, physicists & engineers from France to China and vice-versa
- ❖ After PhD defense: postdocs and/or position at University

# History and achievements within FCPPL/N: postdocs & masters



Postdocs	Affiliations	Period	Funding	Topics
Liang Sun	IP2I	2009	CNRS	Low mass resonances
Hongyan YANG	IRFU Saclay	2011-2012	CEA	Flow of quarkonia
Xiaoming ZHANG	CCNU-LPCA	2012 (3 months)	CNRS	Simulation of MFT performances
Xiaozhi BAI	USTC-LPCA	2024 (visit, Nov.)	FCPPN	Dilepton correlations

Master Students	Affiliations	Period	Funding	Topics
Hengtong DING	CCNU-Subatech	2007	French embassy	Theory: heavy-quark energy loss
Jiebin LUO	CCNU-LPCA	2010, 2011	FCPPL, UCA, IN2P3	Heavy-flavor decay muon production in pp
Xiuxiu LIANG	CCNU-IPHC	2017	FCPPL	$D_s^+$ production in p-Pb
Yuxing DANG	CCNU-IPHC	2019	FCPPL	$D_s^+$ production in pp
Mingrui ZHAO	CIAE-LPCA	2020	FCPPL	W production in Pb-Pb



## ❖ Published peer-viewed papers (8 and 2 submitted)

- Azimuthal anisotropy of jet particles in p-Pb and Pb-Pb collisions, [JHEP 08 \(2024\) 234](#) ([Siyu Tang](#))
- Measurement of inclusive charged-particle jet production in pp and Pb-Pb collisions, [JHEP 05 \(2024\) 041](#) ([Xiaoming Zhang](#))
- Observation of medium-induced yield enhancement and acoplanarity broadening of low-Pt jets in pp and central Pb-Pb collisions, [PRL 133 \(2024\) 022301](#) ([Hongzhen Hou](#))
- Measurements of jet quenching using semi-inclusive hadron+jet distributions in pp and central Pb-Pb collisions, [PRC 110 \(2024\) 014906](#) ([Yongzhen Hou](#))
- Supplement document of “Azimuthal anisotropy of jet particles in p-Pb and Pb-Pb collisions”, [ALICE-PUBLIC-2022-020](#) ([Siyu Tang](#))
- $K^0_S$ ,  $\Lambda$ , ( $\Lambda$ bar),  $\Xi^+$ ,  $\Omega^+$ -production in jets and underlying hadron+jet distributions in pp and central Pb-Pb collisions (5.02 TeV), event in pp and p-Pb, [JHEP 07 \(2023\) 136](#) ([Xiaoming Zhang](#))
- W-boson production in p-Pb and Pb-Pb collisions, [JHEP 05 \(2023\) 036](#) ([Mingrui Zhao](#), [Guillaume Taillepied](#))
- Measurement of the inclusive isolated photon production cross section in pp collisions at 13 TeV, [arXiv:2407.01165](#), [submitted to EPJC](#) ([Ran Xu](#))
- Muon azimuthal anisotropies in high-multiplicity p-Pb collisions, [PLB 846 \(2023\) 137782](#) ([Siyu Tang](#))
- Multiplicity dependence of  $\Upsilon$  Production in pp collisions at 13 TeV, [arXiv:2209.04241](#), [submitted to NPB](#) ([Yanchun Ding](#))

## ❖ Conference proceedings (5):

- Xiaoming Zhang: FPCP2024, Maolin Zhang: SQM2024, Yongzhen HOU: HP2023, Xiaozhi Bai: SPIN2023, QM2023

- Xiaoming ZHANG, “Recent open heavy-flavor highlights from ALICE”, **FPCP2024**, 27-31 May 2024, Bangkok, Thailand
- Maolin ZHANG, “Charm and beauty hadron production in hadronic collisions with ALICE”, **SQM2024**, 3-7 June 2024, Strasbourg, France
- Maolin ZHANG, “Study of charm and beauty production at forward rapidity”, QGP France 2024, Bagnoles de l’Orne, France
- Antonio URAS, “ALICE 3 upgrade project”, QGP France 2024, Bagnoles de l’Orne, France
- Gustavo Conesa Balbastre, “Recent measurements of isolated photon cross sections and their correlation with hadrons with ALICE at the LHC”, QGP France 2024, Bagnoles de l’Orne, France
- Gustavo Conesa Balbastre, “Measuring isolated prompt photon production in small and large collisions systems with ALICE”, **HP2024**, 22-27 September 2024, Nagasaki, Japan
- Mingye LI, “Investigation of charm hadronisation and early magnetic field in ultrarelativistic heavy-ion collisions via  $D^{*+}$ -meson spin alignment with ALICE”, **HP2024**, 22-27 September 2024, Nagasaki, Japan
- Mingyu ZHANG, “Studies of beauty-quark production, hadronisation and cold nuclear matter effects via measurements of non-prompt charm hadron in pp and p-Pb collisions with ALICE”, **ICHEP 2024**, 18-24 July 2024, Prague, Czech Republic and **SQM2024**, 3-7 June 2024, Strasbourg, France (poster)
- Yaxian MAO, “Jets: experimental overview”, **HP2024**, 22-27 September 2024, Nagasaki, Japan
- Zebo TANG, “Heavy flavours and quarkonia” (lecture), **HP2024**, 22-27 September 2024, Nagasaki, Japan
- Xiaozhi BAI, “ALICE highlights”, **HP2024**, 22-27 September 2024, Nagasaki, Japan
- Xiaozhi BAI, “Vector meson polarization measurements in pp and Pb-Pb collisions, SPIN 2023, 24-29 September 2023, Durham, USA
- Mingyu ZHANG, “Probing beauty quark production and transport properties via non-prompt charmed hadrons with ALICE at the LHC”, **QPT 2023**, 15-19 December 2023, Zhuhai, China
- Yaxian MAO, “Study of jet physics”, **QPT 2023**, 15-19 December 2023, Zhuhai, China
- Maolin ZHANG, “Investigate heavy quark production at forward rapidity via semimuonic decays with ALICE at the LHC”, **CLHCP 2023**, 15-20 November 2023, Shanghai, China and **QPT 2023**, 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”, **QPT 2023**, 15-19 December 2023, Zhuhai, China

**18 presentations given by students and FCPPN members in international conferences including SQM 2024, HP 2024, ICHEP 2024, FPCP 2024 and QPT 2023**



# Heavy quark transport properties



Production and flow of muons from heavy-flavor hadron decays at forward rapidity from small to large collision systems

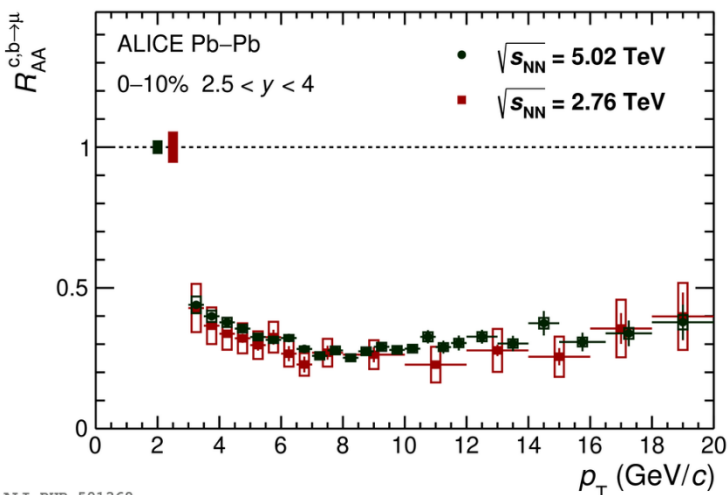


Xiaoming Zhang

Shuang Li

Zuman Zhang

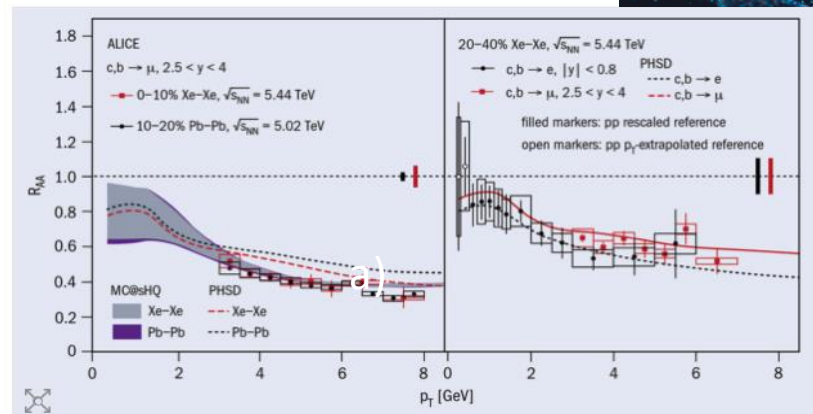
Collaboration: CCNU-LPCA



STRONG INTERACTIONS | NEWS

## Heavy flavours probe QGP geometry

22 January 2021

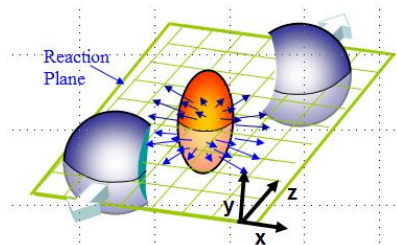


### ❖ High-precision tomography of the QGP

- Similar **strong suppression** at forward rapidity and midrapidity
- No significant dependence on energy
- Similar suppression in Xe-Xe and Pb-Pb (at similar multiplicity)
  - Probe of QGP geometry
- Participation of heavy quarks in the collective expansion of the system
  - New constraints on energy loss mechanisms & model calculations

ALICE, PLB 708 (2012) 265  
 ALICE, PRL 109 (2012) 112301  
 ALICE, PLB 753 (2016) 41  
 ALICE, PLB 770 (2017) 459  
 ALICE, JHEP 09 (2019) 008  
 ALICE, PLB 819 (2021) 136637  
 ALICE, PLB 820 (2021) 136558

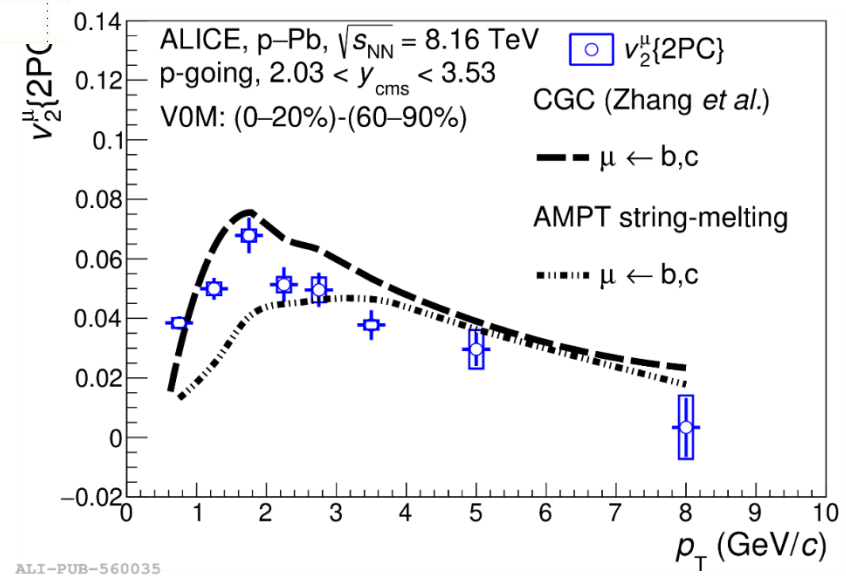
# Collectivity in small collision systems



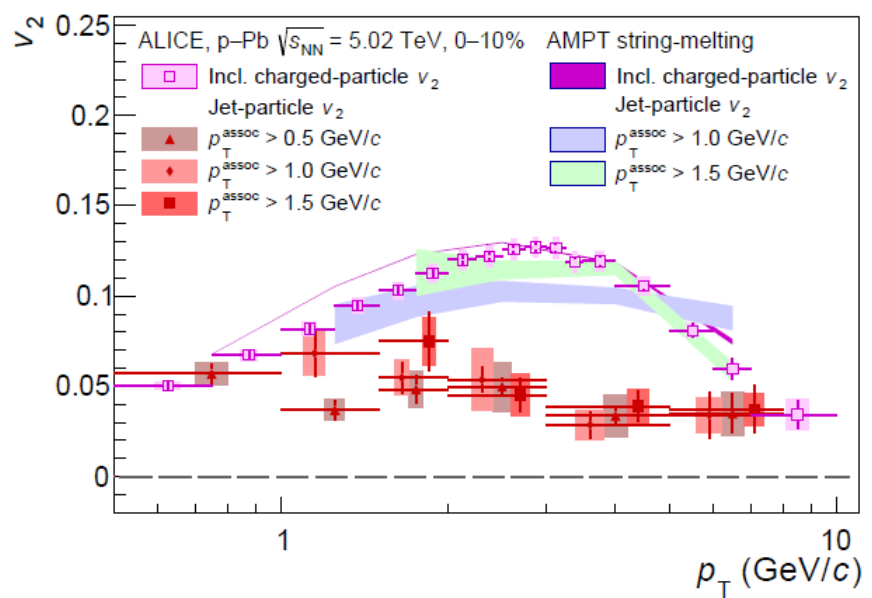
$$\frac{2\pi}{N} \frac{dN}{d\phi} = 1 + \sum_{n=1}^{\infty} 2v_n \cos[n(\phi - \Psi_n)]$$

Xiaoming Zhang  
Siyu Tang

Collaboration: CCNU-LPCA



ALICE, PLB 846 (2023) 137782



ALICE, JHEP 08 (2024) 234

- ❖ **Positive  $v_2$  of inclusive muons** at forward rapidity (dominated by heavy-flavour decays for  $p_T > 2$  GeV/c)
  - Described by AMPT and CGC at high  $p_T$
- ❖ **Positive  $v_2$  of jet particles** with a magnitude smaller than that of inclusive charged particles
  - Non-zero  $v_2$  also predicted by AMPT for jet particles and inclusive charged particles
- ❖ New constraints to understand the origin of collectivity in small collision systems



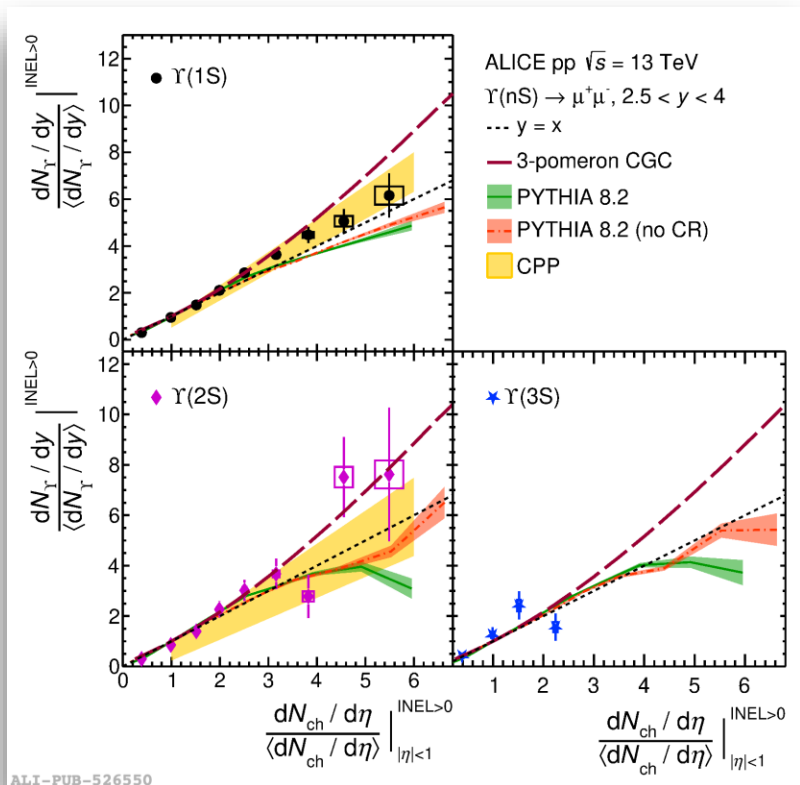
# $\Upsilon$ production vs. multiplicity in pp



Xiaoming Zhang

Yanchun Ding

Collaboration: CCNU-LPCA-IP2I

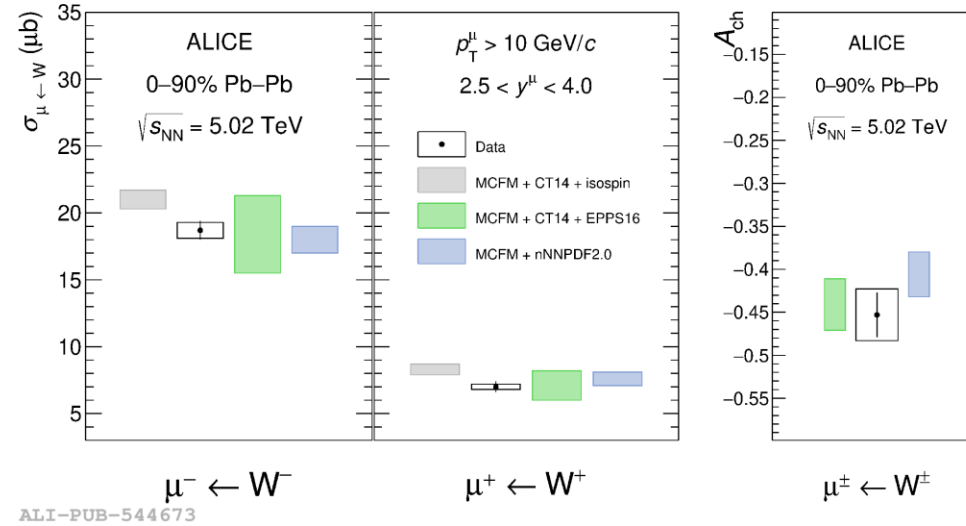
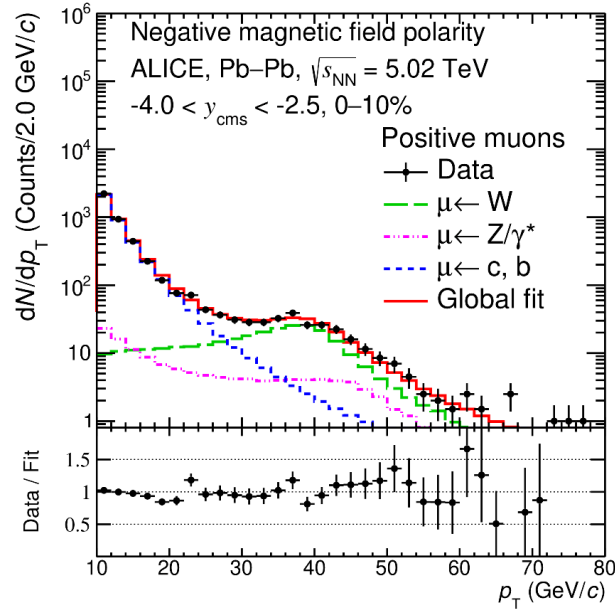


- ❖ Constrain quarkonium production mechanisms
- ❖ Interplay between soft and hard processes
- ❖  $\Upsilon(1S)$ ,  $\Upsilon(2S)$  and  $\Upsilon(3S)$  measured at **forward rapidity** via dimuons
  - **linear increase** of  $\Upsilon(1S)$ ,  $\Upsilon(2S)$   $\Upsilon(3S)$  yields vs. multiplicity
- ❖ Measurements will benefit from the larger statistics collected in Run 3

Antonio URAS, 22 Oct. 15:15-16:40

ALICE, arXiv:2209.04241, submitted to NPB

# W production at forward rapidity in p-Pb and Pb-Pb



ALI-PUB-544673



Guillaume Taillepied

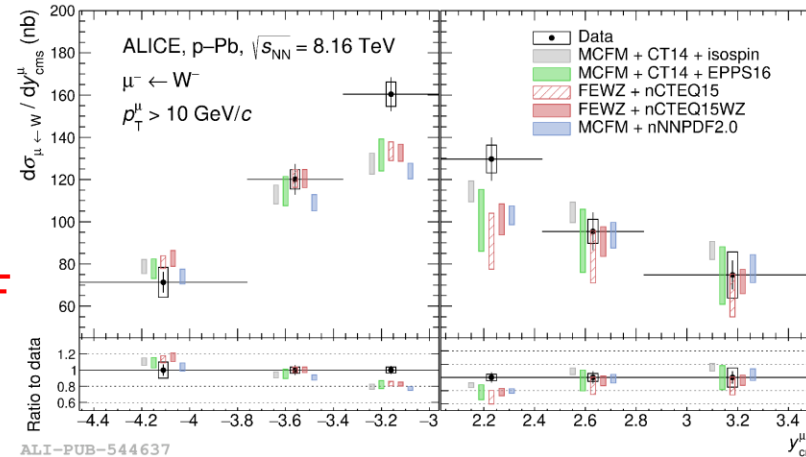
Mingrui Zhao

Jianhui Zhou

Collaboration:

CCNU-CIAE-LPCA-Subatech

ALI-PUB-544633

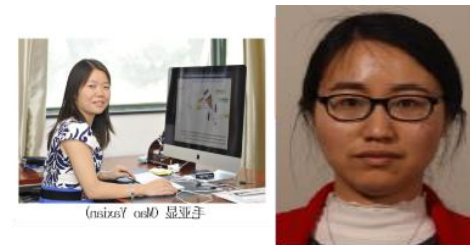
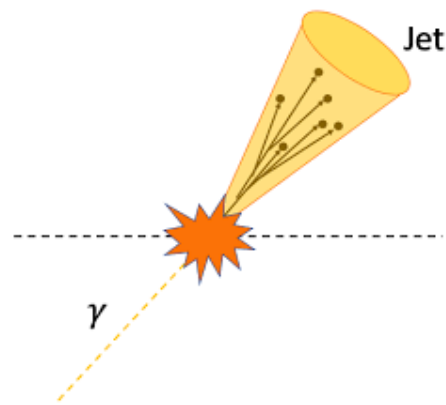
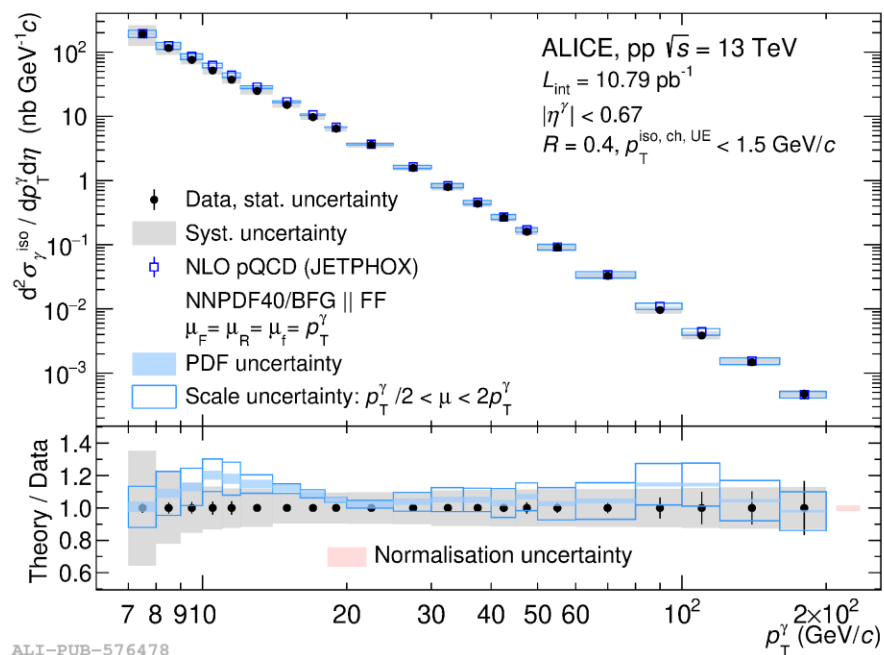


ALI-PUB-544637

- ❖ **First W measurement** at forward rapidity in Pb-Pb collisions
- ❖ Data can provide important constraints to **nPDF** models and **help reducing their uncertainties** in both p-Pb and Pb-Pb collisions

Diego STOCCO, 23 Oct. 15:40-16:05

# Isolated photon production in pp



Yaxian MAO  
Ran XU

Collaboration: CCNU-LPSC

ALICE, arXiv:2407.01165, submitted to EPJC

- ❖  $p_T$ -differential measurement of the isolated direct photon production cross section in pp collisions at 13 TeV in a wide  $p_T$  range and down to low  $p_T$
- ❖ Well described by theoretical calculations within uncertainties

Gustavo Conesa Balbastre , 23 Oct. 9:00-9:25



# Hadron-jet correlations in pp and Pb-Pb



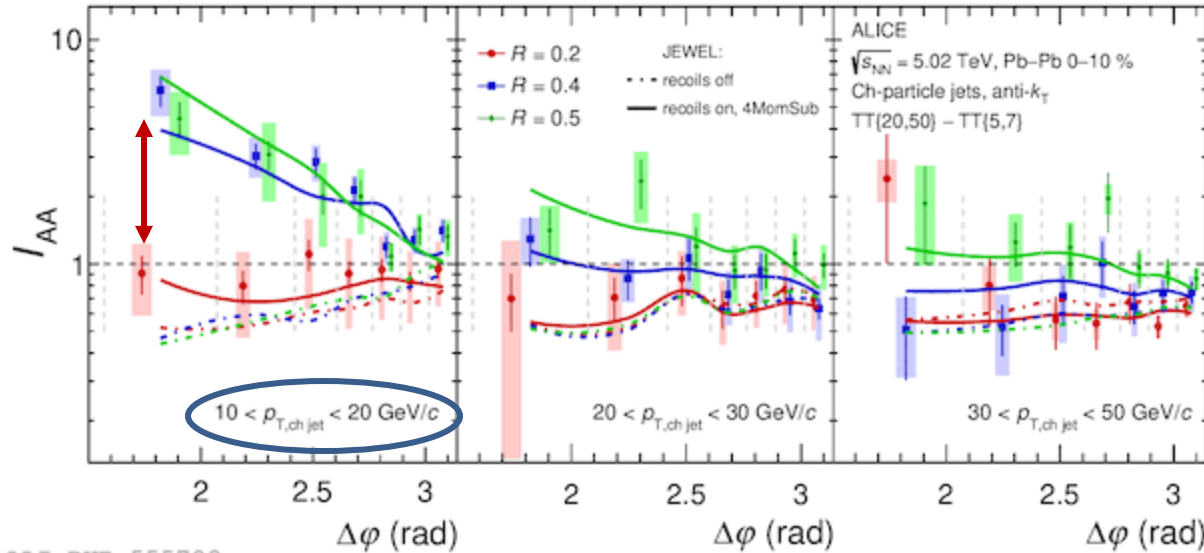
- ❖ Comparison of semi-inclusive distributions of charged-particle jets recoiling from a high- $p_T$  charged hadron in pp and central Pb-Pb collisions via their ratio  $I_{AA}$ 
  - ❑ Probes medium-induced jet energy loss, intra-jet broadening, in-medium jet scattering and medium response
  - ❑ Low- $p_T$  reach: unique space phase for studying interaction of jets with the QGP



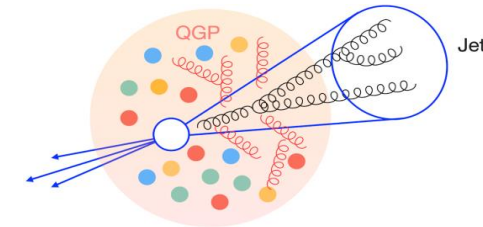
Yaxian Mao

Yongzhen Hou

Collaboration: CCNU-IPHC-LPSC



ALI-PUB-555709



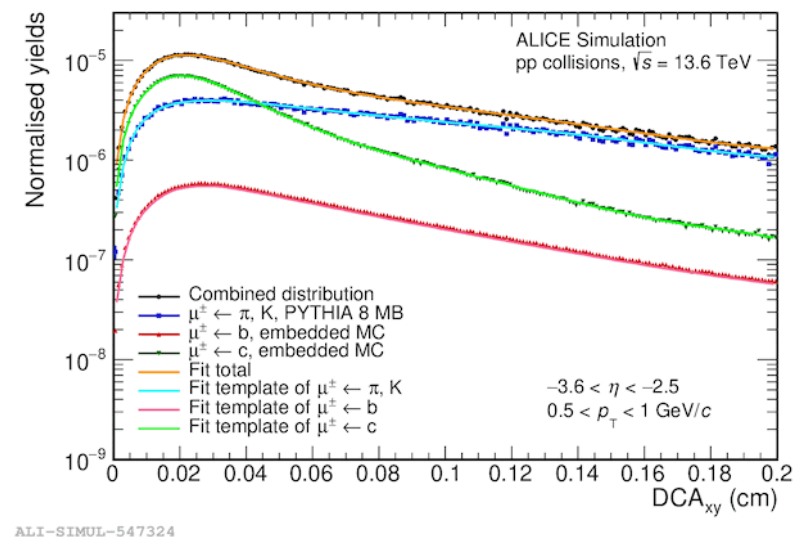
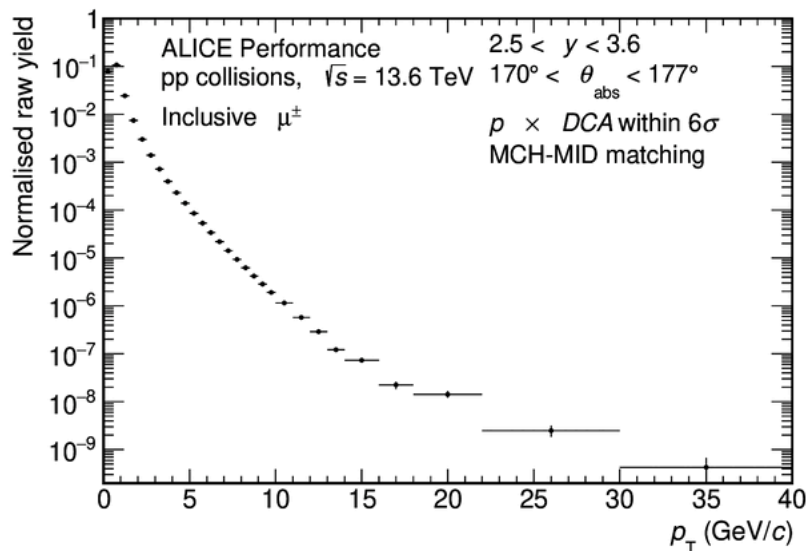
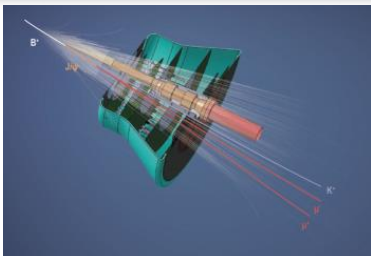
ALICE, PRL 133 (2024) 022301  
ALICE, PRC 110 (2024) 014906

- ❖ **First observation** of significant **medium-induced yield enhancement** and **acoplanarity broadening** of low- $p_T$  jets
- ❖ Set important constraints for models

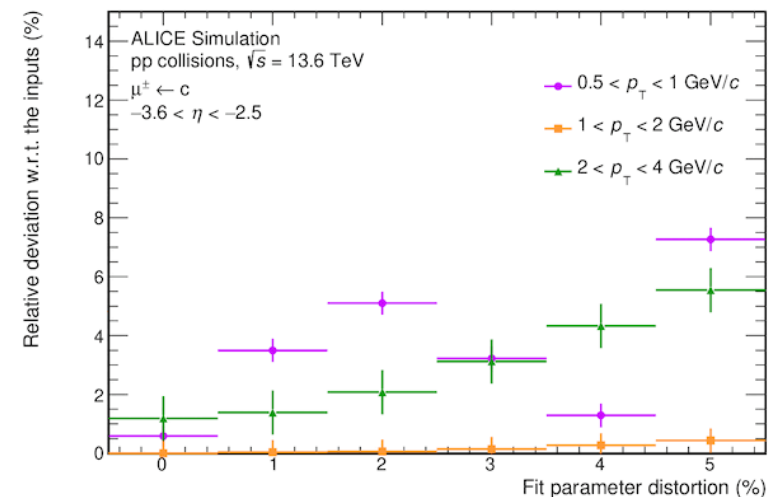
# Charm and beauty production with muons in Run 3



Xiaoming Zhang  
Maolin Zhang  
Collaboration:  
CCNU-LPCA



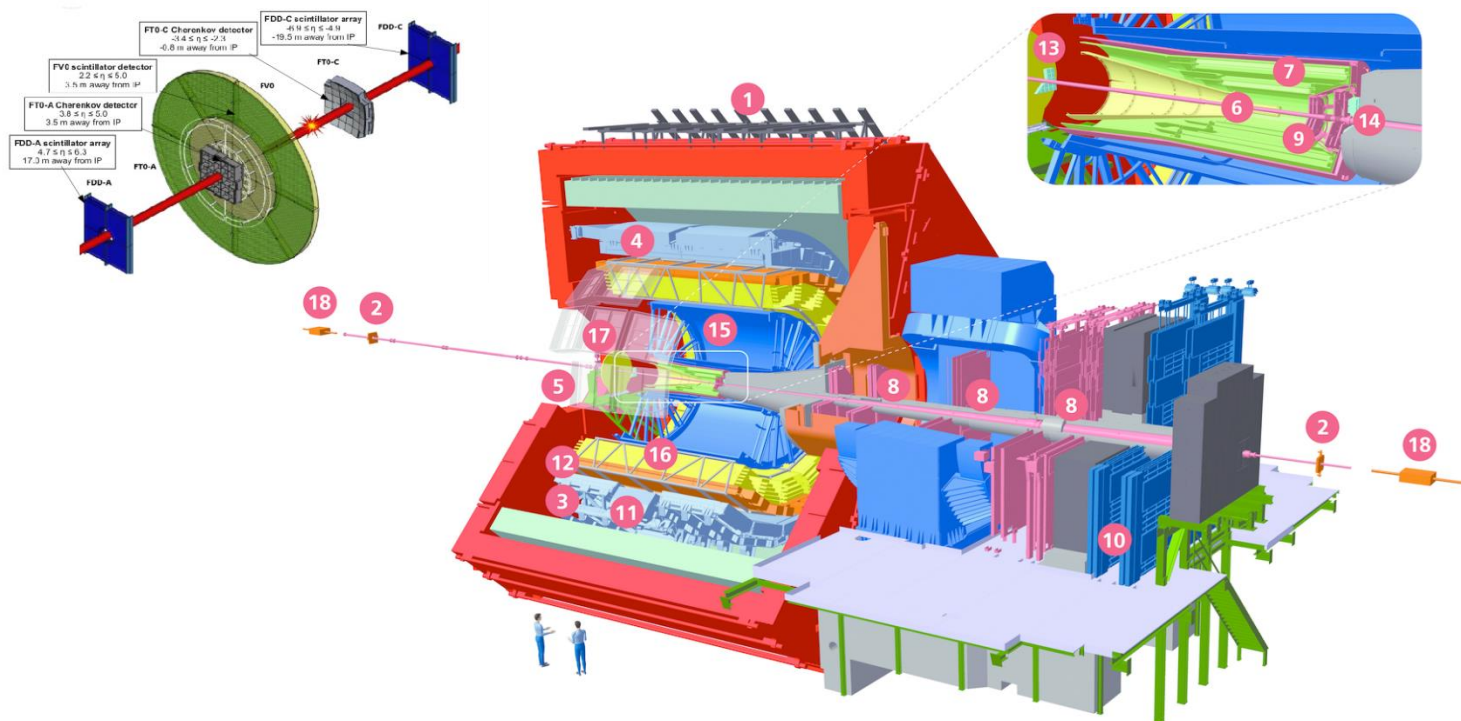
- ❖ Vertexing capabilities at forward rapidity with the Muon Forward Tracker (MFT) coupled with the muon spectrometer in the Run 3
- ❖ Different sources well separated based on the displacement from the primary vertex
- ❖ Charm and beauty hadron decay muons can be well separated down to the low  $p_T$  region



More to come soon: method currently being applied to data



# France-China technical contributions



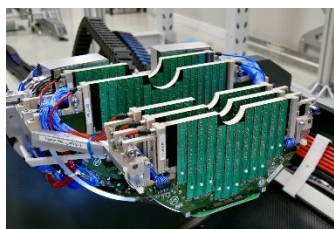
- 1 ACORDE | ALICE Cosmic Rays Detector
- 2 AD | ALICE Diffractive Detector
- 3 DCal | Di-jet Calorimeter
- 4 EMCal | Electromagnetic Calorimeter
- 5 HMPID | High Momentum Particle Identification Detector
- 6 ITS-IB | Inner Tracking System - Inner Barrel
- 7 ITS-OB | Inner Tracking System - Outer Barrel
- 8 MCH | Muon Tracking Chambers
- 9 MFT | Muon Forward Tracker
- 10 MID | Muon Identifier
- 11 PHOS / CPV | Photon Spectrometer
- 12 TOF | Time Of Flight
- 13 T0+A | Tzero + A
- 14 T0+C | Tzero + C
- 15 TPC | Time Projection Chamber
- 16 TRD | Transition Radiation Detector
- 17 V0+ | Vzero + Detector
- 18 ZDC | Zero Degree Calorimeter



ITS2:

MFT: global readout electronics (with IP2I)

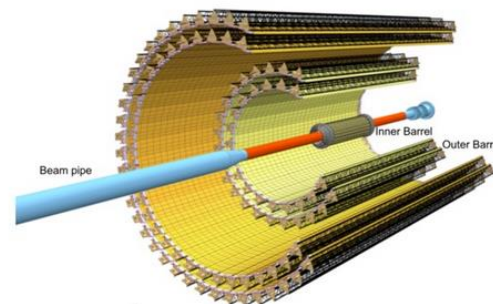
- Printed Circuit Boards: design, test, production



Half MFT cone



ITS2: participation to the installation in 2021 (IPHC, CCNU, USTC)



# ALICE upgrade plans

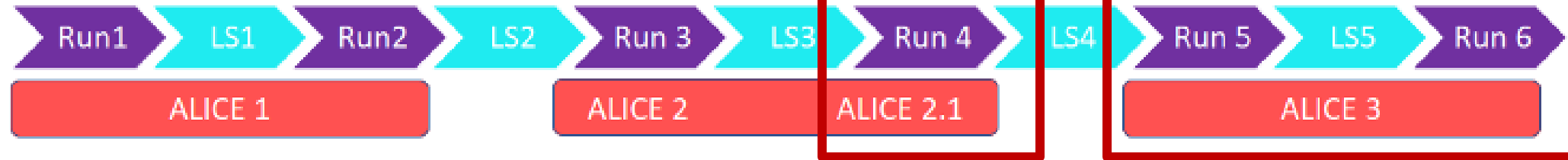
2009 – 2013

2025-2018

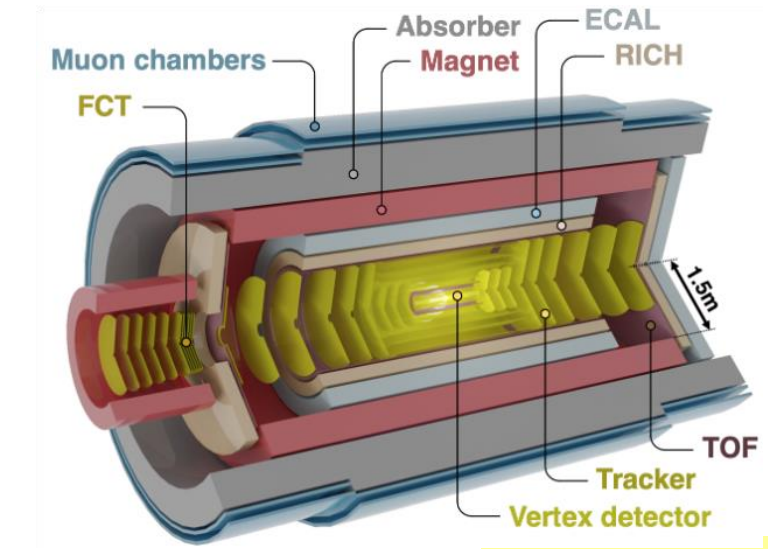
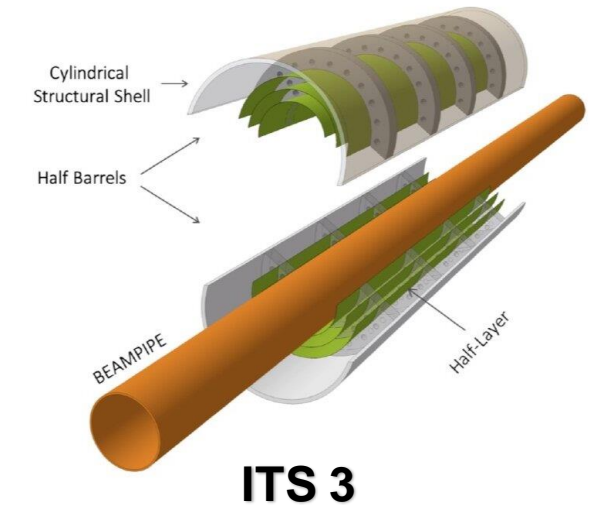
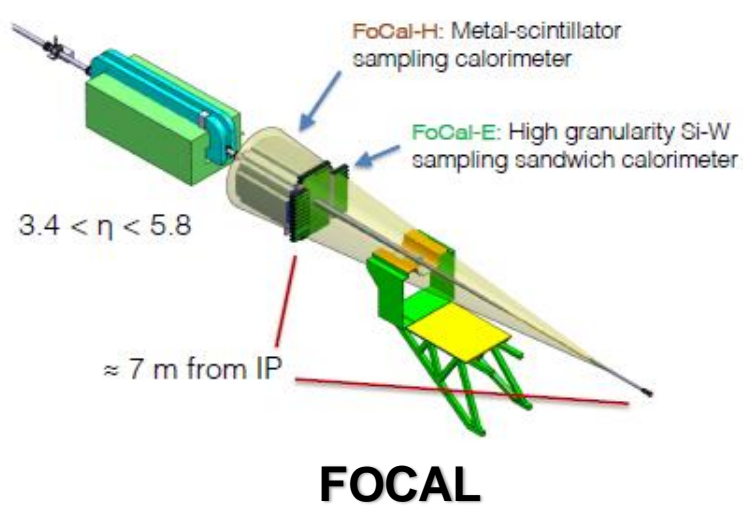
2022 – 2026

2030 – 2033

2036 - 2041



FOCAL & ITS3



ALICE, arXiv: 2211.02491

- ❖ France and China are involved in the R&D of the ITS3 which will be operated in the Run 4
- ❖ France and China show interest for ALICE 3
  - In discussion, not yet approved by the funding agencies

Marco van Leeuwen, Oct. 21, 14:00-14:30  
 Alessandra Fantoni, Oct. 21, 17:00-17:30  
 Antonin Maire, Oct. 21, 17:30-18:00

# Conclusion

## **Solid China-France cooperation in the ALICE scientific program with a recognised visibility within ALICE and at international level**

- ❖ Strong contribution to data taking, data analysis and performance studies
  - Excellent contributions of students
  - Significant contributions to scientific production: joint-PhD theses, publications
  - Many talks in conferences
- ❖ Important contributions to various ALICE upgrades: detector and software developments
- ❖ Analyses of Run 3 ongoing
  
- ❖ **Continue to strengthen the collaboration in more and more common activities within the France-China Particle Physics Network**
  - Huge statistics already collected for pp and Pb-Pb collisions and interesting opportunities beyond Run 4 with ALICE 3 project

**More to come soon: stay tuned!**





Thank you for your attention  
Merci pour votre attention

感谢您的聆听

*Thanks to Daicui Zhou, Xiaoming Zhang, Eric Kajfasz, Gang Chen,  
Maxime Feraille, Shanshan Li, Xavier Antoine*



**ALICE**

Run 3 Pb-Pb  
 $\sqrt{s_{NN}} = 5.36 \text{ TeV}$

27 September 2023, 04:50

# backup





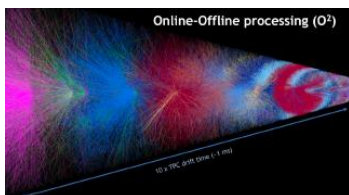
# The ALICE detector: Run 3 setup

- ❖ Major upgrades installed in 2019-2021
- ❖ Taking data since **mid 2022**

## New GEM-based TPC



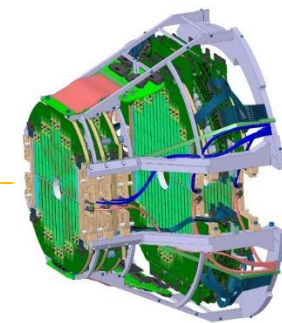
Upgraded readout for most subdetectors



Integrated Online-Offline system (O<sup>2</sup>)

## New Inner Tracking System (ITS2)

Improved pointing resolution at midrapidity

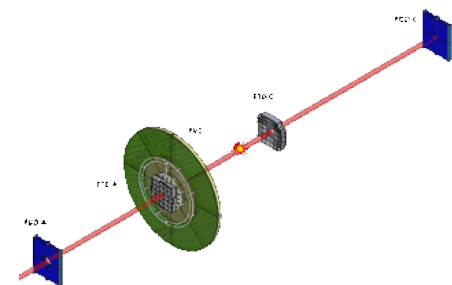


## New Muon Forward Tracker (MFT)

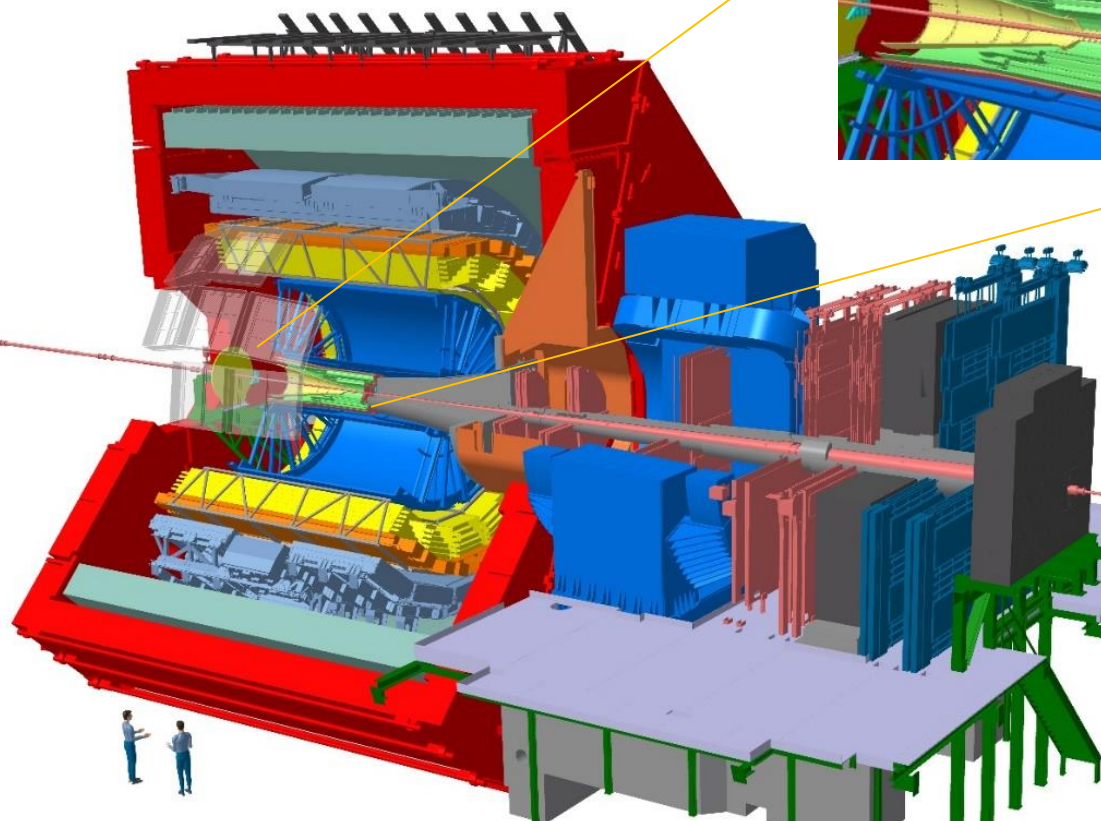
Vertexing at forward rapidity

MFT: global readout electronics (with

- Printed Circuit Boards: design, test, pro



## New Fast Integration Trigger



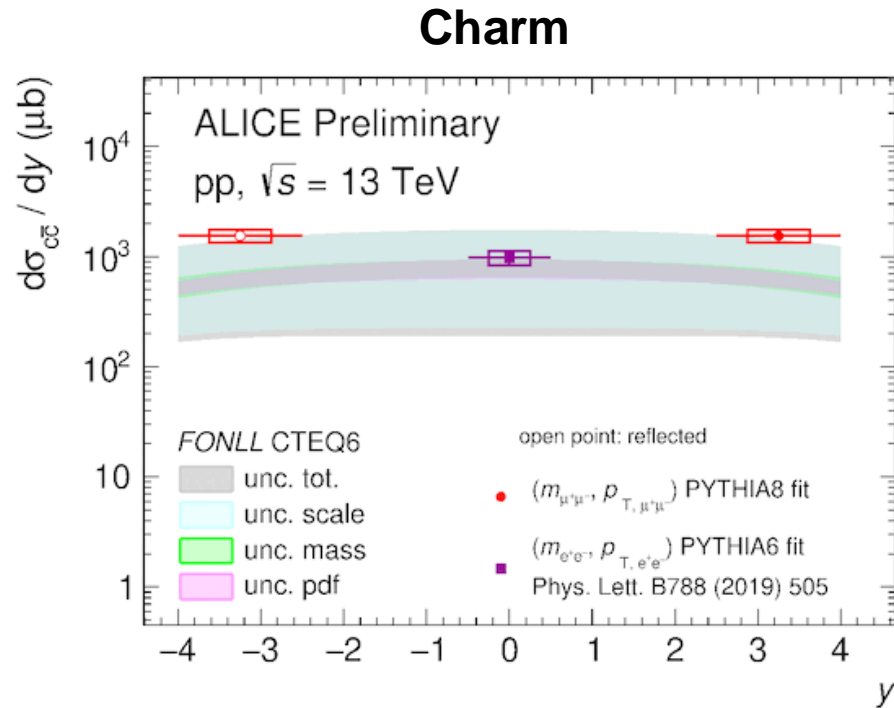
## New beam pipe



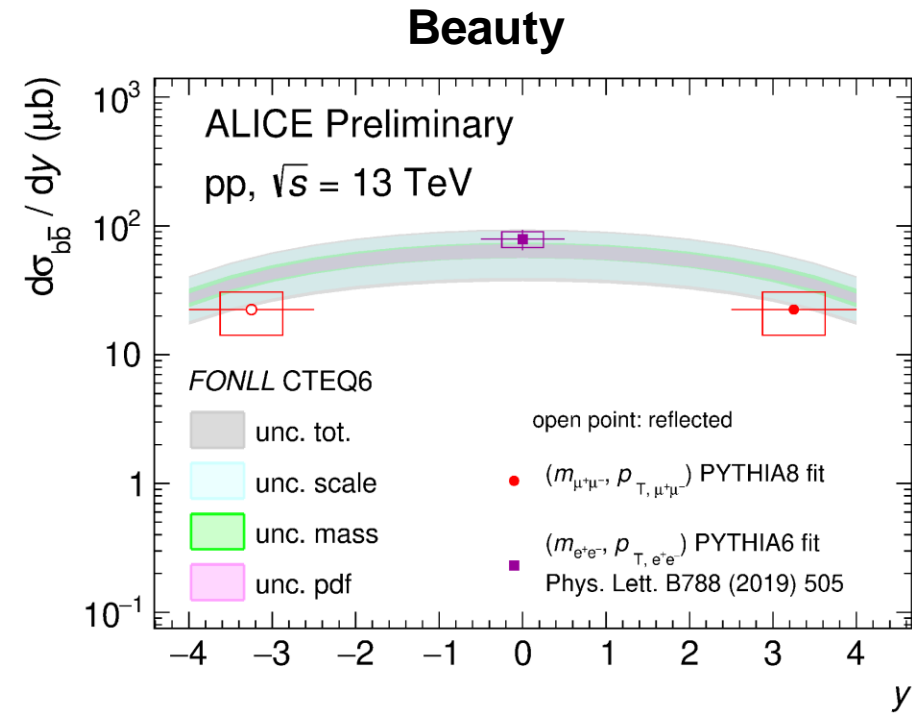
JINST 19 (2024) 222303



# Charm and beauty production cross sections at forward $y$ in pp collisions at $\sqrt{s} = 13$ TeV



ALI-PREL-538716



ALI-PREL-538708

- ❖  $p_T$ -integrated charm and beauty production cross sections measured separately at forward rapidity via the dimuon continuum
- ❖ Results in agreement with FONLL predictions within uncertainties
  - lie in the upper and lower limit of the calculations for charm and beauty production cross section, respectively
- ❖ Complement the previously published results at midrapidity in the dielectron channel