### ALICE project within FCPPL Study of QCD matter with the ALICE detector

### Outline

China and France in ALICE and FCPPL
 FCPPL ALICE report (2016)
 FCPPL ALICE project (2017)
 Conclusion

Nicole Bastid, LPC, Clermont-Ferrand, France Daicui Zhou, CCNU, Wuhan, China 10<sup>th</sup> FCPPL workshop Tsinghua University, Beijing, China March 27-30, 2017



### **China and France in ALICE**



### ALICE today: 42 countries, 174 institutes, 1800 members

### France (8 institutes)

- □ IPNL and CC-IN2P3, Lyon,
- □ IPNO, Orsay
- □ IPHC, Strasbourg
- □ LPC, Clermont-Ferrand
- □ LPSC, Grenoble
- □ Subatech, Nantes
- □ IRFU, Saclay
- 39 physicists, 55 technical staff, 16 PhDs & post-docs

### China (6 institutes)

- IOPP-CCNU, Wuhan
- CIAE, Beijing
- HUST\*, Wuhan
- HBUT\*, Hubei
- □ USTC, Hefei (from end 2016)
- SINAP, Shanghai (from end 2016)
- 17 physicists, 11 technical staff, 11 PhDs



FCPP

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## **Detector involvements**: MUON, V0, ITS, Electromagnetic Calorimeters, ITS & MFT upgrades





### China and France in ALICE Involvements within FCPPL



# Very strong cooperation program between the ALICE groups from CCNU-Wuhan (China) and IN2P3/CEA (France) since several years



Data analysis

- Open heavy flavours & W bosons via  $\mu$
- Quarkonia via (di)µ
- $\gamma/\pi^0$  & correlations with hadrons
- Jets

Performance studies

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

#### Data taking

- □ Offline, online, computing, management
- Detector: R&D, installation, operation
- □ Upgrade projects: ITS-MFT
- Present responsibilities:
  - Management Board, Conference Committee, Physics Analysis Group, detectors & upgrades

### Future: extend the collaboration between French & Chinese institutes

LHC Run-2 analyses, detector upgrade & preparation of physics program beyond 2021 (Run-3 & Run-4)

### ALICE within FCPPL: a brief history of our collaboration



- Co-PhD students: 7 since 2008, main funding from China (CSC, French embassy)
  - 6 co-PhD defended or about to be defended: Y. Mao (LPSC, 2011), R. Wan (IPHC, 2011), X. Zhang (LPC, 2012), S. Li (LPC, 2015), M. Wang (Subatech, 2016), J. Zhu (Subatech, 2017)
  - 1 co-PhD in preparation: Z. Zhang (LPC, 2015-2018)
  - 1 co-PhD CSC application submitted (1.5 years, IPNL/CCNU, no candidate yet)
- Dest-docs: 3 since 2009
- Master students: 10 since 2007 + several ongoing demands for 2017 for the analysis of large amount of Run-2 data
- Several visits of senior physicists & engineers/technicians: data analysis & detector related activities (upgrades)
- □ Numerous presentations in international conferences, ALICE meetings
- □ Numerous conference proceedings, internal/analysis ALICE notes
- Direct contribution in several publications
- Organization of the 2<sup>nd</sup> FCPPL workshop (CCNU) & 7<sup>th</sup> FCPPL workshop (LPC) and co-organization of the 9<sup>th</sup> FCPPL workshop (IPHC)



### **FCPPL-ALICE project: members**



NameTitleAffiliation (Institute)NameTitleLeaderLeaderLeaderZHOU DaicuiPRBASTID NicolePRINaP3Cai XuPRAphectche LaurentCRINaP3Cai XuPRBaldisseri AlbertoPhysicienIRPUYang ChunbinPRBaldisseri AlbertoPRINaP3Yin ZhongbaoPRBelikov IgorDRINaP3Bartalini PaoloPRCheshkov CvetanCRINaP3Bartalini PaoloPRCheshkov CvetanCRINaP3Liu FumininPRConessa-BalbastreCRINaP3Liu FumininPRGustavoCrochet PhilippeDRINaP3Zhou DaimeiPRDucroxu LaurentCRINaP3Zhong PainingAss. PRFaivre JulienMCINaP3Zhang YainaAss. PRFaivre JulienMCINaP3Zhang YainaAss. PRFeuillard VictorPhD studentIRP3Zhang YainaAss. PRFeuillard VictorPhD studentIRP3Zhang YainaEngineerGermain MarieCRINaP3Cao ChaosongEngineerGuerin CyrilIRINaP3Zhou JaininEngineerGuerna RachidCRINaP3Zhu JaininEngineerGuerna RachidCRINaP3Zhu GaongHongPD studentGuerna RachidCRINaP3Zhang Yang HongPD studentGuerna RachidCRINaP3Zhang Yan		ninese Group	C		ch Group	Fren
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Estienne Magali     CR     INaP3     Mao Yaxian     Ass. PR       Paivre Julien     MC     INaP3     Zhang Xiaoming     Ass. PR       Peuillard Victor     PhD student     IRFU     Zhang Xiaoming     Ass. PR       Purget Christophe     PR     INaP3     Wang Dong     Engineer       Germain Marie     CR     INaP3     Liu Ju     Engineer       Guernane Rachid     CR     INaP3     Gao Chaosong     Engineer       Hippolyte Boris     MC     INaP3     Gao Chaosong     Engineer       Kox Serge     DR     INaP3     Shou-Qi-Ye     Post-doc       Kuhn Christian     DR     INaP3     Gao Chaosong     Engineer       Kuh Christian     DR     INaP3     Shou-Qi-Ye     Post-doc       Lopez Xavier     MC     INaP3     Zha Mongsheng     PhD studer       Maire Antonin     CR     INaP3     Zhu Hongsheng     PhD studer       Rami Fouad     CR     INaP3     Zhu Hongsheng     PhD studer       Rami Fouad     CR     INaP3     Zhu Hongsheng     PhD studer       Schutztrves     DR     INaP3     Ran Xiaowen     PhD studer       Stocco Diego     CR     INaP3     Pang Xiangy     PhD studer       Student and	CCNU	Ass. PR	Pei Hya	IN2P3	DR	Erazmus Barbara
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Maire Antonin         CR         IN2P3         Wang Mengliang         Post-doc           Martinez-Gárcia Ginés         DR         IN2P3         Zhang YongHong         PhD studer           Pillot Philippe         CR         IN2P3         Zhu Hongsheng         PhD studer           Rom Foudd         CR         IN2P3         Zhu Hongsheng         PhD studer           Rog Ami Foudd         CR         IN2P3         Zhu Jianhui         PhD studer           Roy Christelle         DR         IN2P3         Ran Xiaowen         PhD studer           Schutzzves         DR         IN2P3         Ran Xiaowen         PhD studer           Schutzzves         DR         IN2P3         Ran Xu         PhD studer           Silvestre Tello         CR         IN2P3         Ran Xu         PhD studer           Catherine         CR         IN2P3         Ding Yanchun         Master           Stocco Diego         CR         IN2P3         Zhu Ya         Master           Student ann         IE         IN2P3         Zhu Ya         Master           Student ann         Jean Sébastien         IE         IN2P3         Chang Wan         Master           Student and         Student and         Student and	CCNU	Post-doc	Li Shuano	IN2P2	MC	Lopez Xavier
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Silvestre Tello Catherine     CR     IN±P3     Ding Yanchun     Master student and PhD studen from Sept.       Stocco Diego     CR     IN±P3     Zhu Ya     Master student and PhD studen from Sept.       Stotco Diego     CR     IN±P3     Zhu Ya     Master student and PhD studen from Sept.       Stotzmann Jean Sebastien     IE     IN±P3     Chang Wan     Master student and PhD studen from Sept.       Teyssier Boris     PhD student     IN±P3     Zhu Guangpu     Wäster student	CCNU	PhD student	Ran Xu	IN2P3	CR	Shabeita Alexandre
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	CCNU	Master student	Zhu Guangpu	IN2P3	PhD student	Teyssier Boris
Uras Antonio CR IN2P3 Yan Li Master student	CCNU	Master student	Yan Li	IN2P3	CR	Uras Antonio
Tang Shu Master student and PhD studen from Sept.	CCNU	Master student and PhD student from Sept.	Tangslyy	i		
2017		2017				

### PART-CCNU-IN2P3-ALICE Study of QCD matter with the ALICE detector

- Composed of several projects
  - MUON
  - Calorimeters: EMCal/Dcal
  - PHOS
  - ITS-MFT upgrade
- 36 members in 2009, ...,
   64 members in 2016
- □ Now: 73 members
  - China-France Collaboration still increasing

# **FCPPL-ALICE 2016 report: summary**



### Student exchanges (physics analyses):

### Co-PhD

- Mengliang WANG: CCNU/Subatech, 2012-2016 (3 year-CSC grant)
- Jianhui ZHU: CCNU/Subatech, 2013-2016 (2 year-CSC grant)
- Zuman ZHANG: CCNU/LPC, 2015-2018 (2 year-CSC grant)

### Master II training

Ran XU: CCNU/LPSC, Nov.-Dec. 2016 (FCPPL)

### Visits

Several visits of senior physicists/post-docs from France to China and vice-versa for discussions on common activities related to:

- Physics analyses
- Detector upgrades: MFT readout electronics, ITS silicon pixel design
- Participation to the ITS upgrade, MFT and O2 workshop (each 6 months in Asia)
- Future collaboration plans

### 9<sup>th</sup> FCPPL workshop at IPHC (Strasbourg)

- Co-organisation
- 19 physicists/PhDs/Post-docs in total (13 from IN2P3/IRFU, 6 from CCNU) and 7 talks

### **FCPPL-ALICE 2016 report: physics**



ALICE Performance, Pb-Pb 2015, Vs<sub>NN</sub> = 5.02 TeV



Production and flow of open heavy flavours in Pb-Pb collisions (Z. Zhang, X. Zhang, N. Bastid, P. Crochet, D. Zhou) Production of open heavy flavours via muons in p-Pb collisions (S. Li, X. Zhang, N. Bastid, P. Crochet, D. Zhou) Electroweak probes: W-boson production in p-Pb collisions (J. Zhu, D. Stocco, G. Martinez, D. Zhou) □ Jet structure & fragmentation function moments in pp collisions (M. Wang, A. Shabetai, M. Estienne, Z. Yin, D. Zhou) Isolated photons in pp collisions (R. Xu, G. Conesa Balbastre, Y. Mao) New measurements under investigation: double-parton scattering measurements in p-Pb collisions Timestamp:2015-11-25 11:25 (D. Stocco, P. Bartalini, P. Palni)

Run:244918



### Open heavy-flavour production in heavy-ion collisions



Charm and beauty quarks produced in initial hard scatterings with a short formation time, experience the full collision history

Sensitive probes of the medium properties

### **Open heavy flavours in Pb-Pb collisions probe**

- In-medium parton energy loss
- Heavy quark participation in the collective expansion

 $R_{\rm AA}(p_{\rm T}) = 1/\langle N_{\rm coll} \rangle \times \frac{{\rm d}N_{\rm AA}/{\rm d}p_{\rm T}}{{\rm d}N_{\rm pp}/{\rm d}p_{\rm T}}$ 



□ Strong suppression of heavy-flavour hadron decay muons of ~a factor 3 in central Pb-Pb collisions at  $\sqrt{s_{NN}}$  = 5.02 TeV, similar to that at  $\sqrt{s_{NN}}$  = 2.76 TeV

Better precision w.r.t. to LHC Run-1
 Constraints on energy loss models

Results presented at HP2016 & QM2017, publication in preparation

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Zuman Zhang (co-PhD LPC/CCNU),
Xiaoming Zhang (CCNU)
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More: see Zuman Zhang's talk





#### Open heavy-flavour measurements in p-Pb collisions

- □ Reference for Pb-Pb measurements
- □ Investigation of cold nuclear matter effects



#### arXiv: 1702.01479, Accepted in Phys. Lett. B

More: see Zuman Zhang's talk

- R<sub>pPb</sub> compatible with unity: cold nuclear matter effects small
- $\square R_{\rm pPb} \text{ in agreement with models including cold} \\ \text{nuclear matter effects}$
- R<sub>pPb</sub> being consistent with unity, the strong suppression measured in central Pb-Pb collisions is due to the hot and dense medium
- ✓ Final results, presented at QM2017

**Shuang Li** (co-PhD LPC/CCNU (2012-2015), now at three Gorges University), **Xiaoming Zhang** (CCNU)

Next: extend the analysis to p-Pb collisions at  $\sqrt{s_{NN}} = 8.16$  TeV:  $R_{pPb}$  & elliptic flow (*Siyu Tang*, Master training at LPC)

### Open heavy-flavour elliptic flow in heavy-ion collisions





initial spatial anisotropy  $\rightarrow$  momentum anisotropy

$$\frac{2\pi}{N} \frac{\mathrm{d}N}{\mathrm{d}\varphi} = 1 + \sum_{n=1}^{\infty} 2\nu_n \cos[n(\varphi - \Psi_n)] \qquad v_2 = \text{elliptic flow}$$



Phys. Lett. B 753 (2016) 41

- Complements R<sub>AA</sub> measurements
   Positive v<sub>2</sub> at intermediate p<sub>T</sub> and semi-central collisions: a 4σ effect for 3 < p<sub>T</sub> < 5 GeV/c in 20-40% centrality class</li>
   Participation of heavy quarks in the collective expansion of the system
- ✓ Final results, presented at HP2016 & QM2017

Xiaoming Zhang (CCNU)



### W-boson production via muons in p-Pb collisions



W bosons in heavy-ion collisions: produced in initial hard scatterings, unaffected by

- the strong interaction
- Sensitive to the nuclear modification of the PDFs
- Reference for hard-probe measurements
  - First measurement at forward & backward rapidity in p-Pb collisions
  - In agreement with model predictions with and without including nPDFs
  - Calculations with nPDFs describe ALICE & CMS data over the full rapidity range
  - ✓ Presented at BEACH2016 & QM2017
  - ✓ Published in *JHEP 02 (2017) 077*

Jianhui Zhu (co-PhD Subatech/CCNU) PhD defense: April 1<sup>st</sup>, 2017

More: see Jianhui Zhu's talk



# Jet fragmentation functions and moments in pp collisions



Measurements in pp collisions: test pQCD & reference for Pb-Pb measurements
 Jet fragmentation function moments: new observable less sensitive to background fluctuations than jet fragmentation functions.



□ First measurement of jet Fragmentation Function Moments (FFM) in pp collisions at  $\sqrt{s} = 2.76$  TeV

- □ Strong dependence on resolution parameter *R*: harder fragmentation for R = 0.2
- □ Dependence of FFM on *R* decreases with increasing  $p_T$  jet: indication that high  $p_T$  jets are more collimated
- ✓ Analysis approved for QM2017
- ✓ Paper proposal to come

Mengliang Wang (co-PhD Subatech/CCNU) PhD defense: December 10<sup>th</sup>, 2016, Yaxian Mao (CCNU)

# Isolated photon production in pp collisions





 $\Box$  Training to the different steps in the measurement of the production cross section of isolated  $\gamma$  in pp collisions

- Tuning of MC parameters to improve the description of the EMCal shower shape
- Purity of the identified photon sample vs. E<sub>T</sub>

□ Next: measurement of isolated photons in pp collisions at  $\sqrt{s}$  = 13 TeV

**Ran Xu** (master II student, 2-month training at LPSC Grenoble, now PhD student at CCNU), Yaxian Mao (CCNU)

### Double-parton scattering measurements in p-Pb collisions with ALICE

□ Particle yields vs. charged-particle multiplicity

Key observable to study Multi-Parton Interactions

- Investigate Double Parton Scattering (DPS) in the heavy-flavour sector focusing on p-Pb collisions (enhanced probability of DPS compared to pp collisions)
  - High-p<sub>T</sub> muons at forward rapidity (heavy-flavour decay muons, mainly)
- > search for same-sign high- $p_{T}$  muons □ Feasibility study ongoing with MC

Paolo Bartalini (CCNU), Diego Stocco (Subatech)

More: see Diego Stocco's talk



### ALICE, JHEP 09 (2015) 148



## **CPPL** 2016 scientific production (students)



#### Publications with direct contribution & conference proceedings: 8

- J. Adam et al. (ALICE Collaboration), "Elliptic flow of muons from heavy-flavour hadron decays at forward rapidity in Pb-Pb collisions at  $\sqrt{s_{NN}}$  = 2.76 TeV", Phys. Lett. B 753 (2016) 41
- J. Adam et al.. (ALICE Collaboration), W and Z boson production in p-Pb collisions at  $\sqrt{s_{NN}}$  = 5.02TeV", JHEP 02 (2017) 077
- S. Acharya et al. (ALICE Collaboration), "Production of muons from heavy-flavour decays in p-Pb collisions at  $\sqrt{s_{NN}}$  = 5.02TeV", arXiv:1702.01479, submitted to Phys. Lett. B
- J. Adam et al. (ALICE Collaboration), "Jet-like correlations with neutral pion triggers in pp and central Pb-Pb collisions at 2.76 TeV", Phys. Lett. B 763 (2016) 238
- J. Zhu for the ALICE Collaboration, J. Phys. Conf. Ser. 770 (2016) 012022
- M. Wang for the ALICE Collaboration, EPJ Web Conf. 117 (2016) 03009
- X. Zhang for the ALICE Collaboration, to be published in Nuclear and Particle Physics Proceedings
- Z. Zhang for the ALICE Collaboration, to be published in Nuclear and Particle Physics Proceedings

#### Talks in international conferences & workshops: 13 (+ 1 poster)

- P. Palni, Y. Mao, X. Zhang, J. Zhu, 2<sup>nd</sup> China LHC Physics Workshop, Beijing, China, 16-19 Dec. 2016
- X. Zhang, Y. Mao, International Workshop on "Flow, Jet Quenching and Strong Coupling Physics", Huzhou, China, 17-19 Dec. 2016
- J. Zhu, BEACH 2016, Fairfax, Virginia, USA , 12-18 June 2016
- X. Zhang, Z. Zhang, X. Peng, Qi-Ye Shou (poster), Hard Probes 2016, Wuhan, China, Sept. 23-27, 2016
- Z. Zhang, Rencontres QGP-France, Etretat, France, 10-13 Oct. 2016 : Z. Zhang
- X. Zhang, Z. Zhang, Muon Workshop 2016, Pornichet, France, 23-27 May 2016
- Many presentations in weekly ALICE Physics Analysis Group meetings & monthly ALICE Physics Working Group meetings

Several papers to come (several Run-2 analyses being finalized)





- □ Major upgrade currently in preparation for LHC Run-3 (2021-2023) and beyond
  - New conditions with Run 3: Pb-Pb interaction rate may reach 50kHz (now ~ 8 kHz)
  - Ongoing R&D, some construction already started, installation during the second Long Shutdown

### Goals of ALICE Run-3:

- High precision measurements of rare probes with main focus on the low  $p_T$  region  $\rightarrow x \ 100$  larger minimum-bias sample compared to Run 2 (~10<sup>11</sup> events)
- Increase readout rate to 50 kHz, presently limited to ~1 kHz
- Improvement of pointing resolution at both central and forward rapidity

#### □ New Inner Tracking System (UITS)

- Improved pointing resolution, reduced material budget, faster readout
- □ Forward Muon Tracker (MFT)
  - New Silicon tracker, heavy-flavour vertices also at forward rapidity
- □ New TPC readout chambers based on GEM
- Upgraded readout for many detectors
- □ Integrated Online-Offline (O<sup>2</sup>) system
- □ New Fast Integration Trigger detector (FIT)





#### More: see Antonio Uras's talk



### □ DCal installed and PHOS completed before Run-2, operated in Run-2

### □ Involvement of CCNU in the ITS-MFT project:

 Performance studies for both UITS & MFT: charm & beauty measurements via single muons with MFT-MUON and D-meson fragmentation function with UITS

motherboard

 Contribution to the global readout electronics design of MFT (PCB design, motherboards to interface disks)



- 10 half-disks, 2 detection plane each in the muon spectrometer acceptance, between absorber & interaction point
- 920 silicon pixel sensors in 280 ladders



FireFly connector (SAMTEC)





- Continue the involvement in data analysis: analysis of large samples of Run-2 data (pp, p-Pb and Pb-Pb collisions)
  - Open heavy-flavour measurements: production and flow LPC/CCNU Collaboration: Zuman Zhang (co-PhD), Siyu Tang (Master), Xiaoming Zhang (physicist)
  - Charmonium (J/ $\psi$ ,  $\psi$ (2S)) production at high multiplicity in small systems Subatech/CCNU Collaboration: **Yanchun Ding (Master)**, **Xiaoming Zhang**
  - Double-parton scattering measurements in the heavy-flavour sector Subatech/CCNU Collaboration: Paolo Bartalini
  - Jets and γ/π<sup>0</sup> production
     LPSC/CCNU Collaboration: Ran Xu (PhD)/Guangpu Zhu (Master), Yaxian Mao

#### Continue to strengthen the involvements in the ALICE upgrade projects

- Technical involvements (UITS-MFT): Collaboration with all French institutes
- Software developments (UITS with O<sup>2</sup> framework): IHPC/CCNU Collaboration: Peipei Zheng (Master)
- Physics program with Run-3 & Run-4: co-PhD demand (IPN Lyon)

# FCPPL support for student, senior physicist & technician/engineer exchanges between China-France





#### □ Funding from France: request of 29.5 kEuros

- Travel costs for French physicists for the 10<sup>th</sup> FCPPL workshop (Beijing)
- Travel costs for members of the committee of Jianhui Zhu's PhD defense (CCNU Wuhan)
- Stay costs a Master training (Guangpu Zhu, 1 month) and a PhD (Ran Xu, 1 month) at LPSC Grenoble
- Stay costs for a Master training (Siyu Tang, 2 months) and a physicist (Xiaoming Zhang, 1 month) at LPC Clermont-Ferrand
- Stay costs for a Master training (Yanchun Ding, 2 months) at Subatech Nantes
- Stay costs for a Master training (Peipei Zheng, 2 months) at IPHC Strasbourg
- Stay costs for a senior physicist (Paolo Bartalini) at Subatech Nantes
- Stay costs for a engineer & student (1 month) in French institutes involved in MFT readout electronics

### □ Funding from China: request of 211700 Yuans

- Stay/travel for ALICE Chinese members for the 10<sup>th</sup> FCPPL workshop (Beijing)
- Stay costs for members of the committee for Jianhui Zhu's PhD defense
- Travel cost for 9 students/senior physicists/engineers in French institutes
- Additional stay costs for 2 students at LPSC Grenoble
- Additional stay costs for one student at LPC Clermont-Ferrand

### Other fundings

Ongoing CSC demand (1.5 years) for a PhD student at IPN Lyon (no candidate yet)





### Solid China-France cooperation in the ALICE scientific program with a recognized visibility within ALICE

□ Strong contribution to data taking, data analysis and performance studies

- Excellent contributions of students
- Significant contributions to scientific production
- Many talks in conferences
- □ Contributions to ALICE upgrades: detector and software developments
- Preparation of the Run-3 & Run-4 physics program

# Continue to extend the collaboration in more and more common activities

