

# ALICE project within FCPPL

## Study of QCD matter with the ALICE detector

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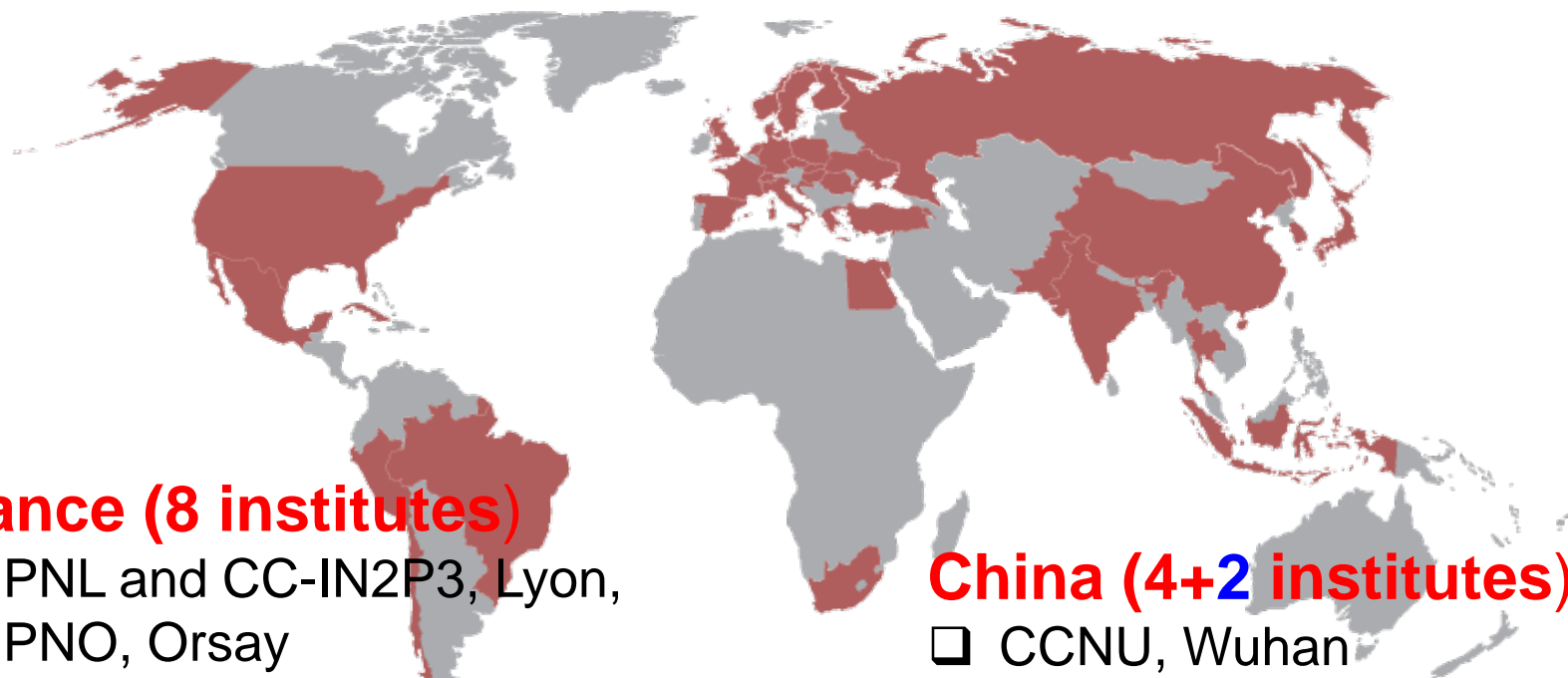
For the France-China team (CCNU, CIAE, IPNO, IHPC, IRFU, HBUT, HUST, LPC, LPSC, Saclay, SINAP, Subatech, USTC)

9<sup>th</sup> FCPPL workshop, Strasbourg, France, March 30—April 1st, 2016

### Outline

- ❑ France and China in ALICE and FCPPL
- ❑ FCPPL ALICE report (2015)
- ❑ FCPPL ALICE project (2016)
- ❑ Conclusion

ALICE today: 41 countries, 159 institutes, 1665 members



## France (8 institutes)

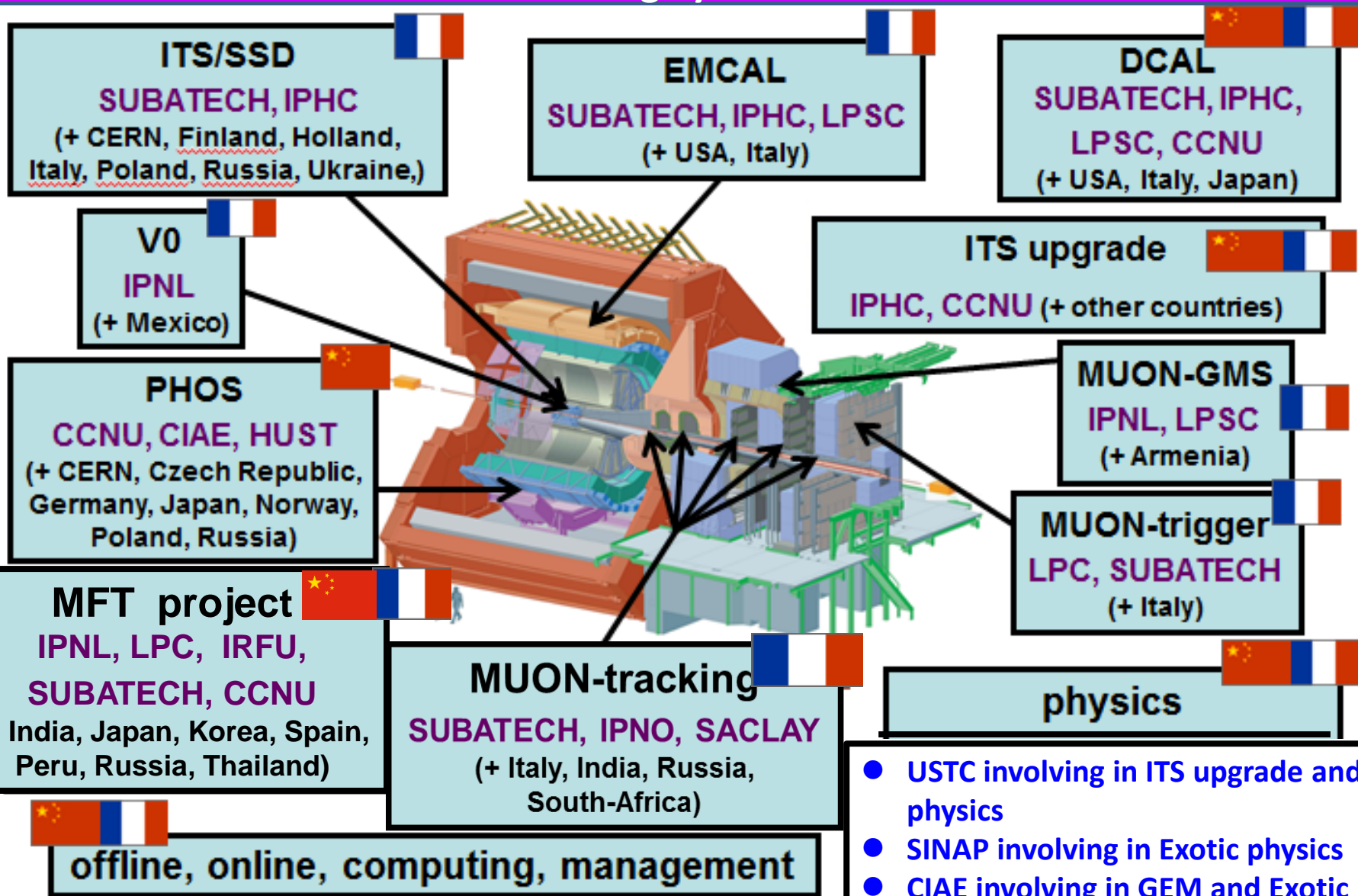
- ☐ IPNL and CC-IN2P3, Lyon,
  - ☐ IPNO, Orsay
  - ☐ IPHC, Strasbourg
  - ☐ LPC, Clermont-Ferrand
  - ☐ LPSC, Grenoble
  - ☐ Subatech, Nantes
  - ☐ IRFU-CEA, Saclay
- 45 physicists, 59 technical staff,  
17 PhDs & post-docs

## China (4+2 institutes)

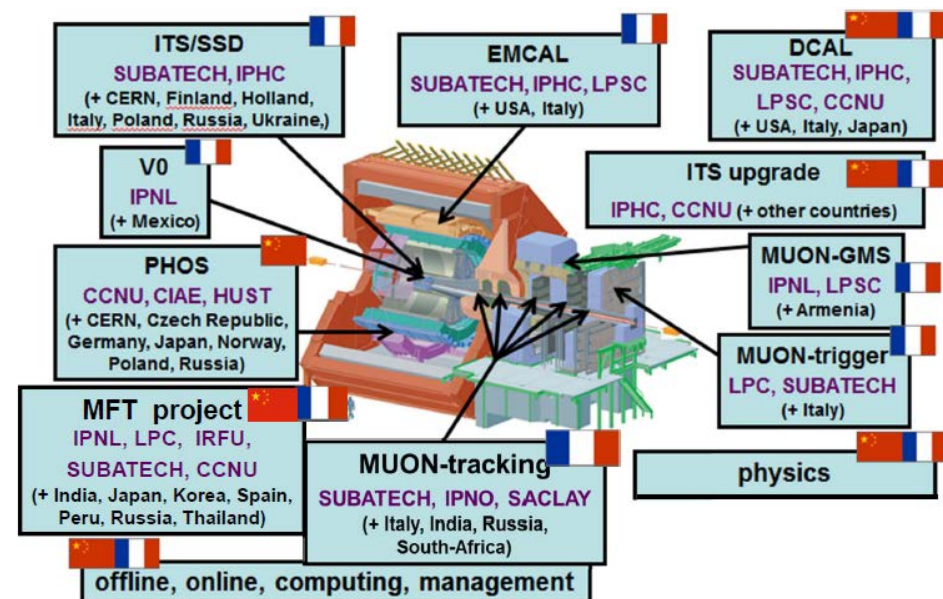
- ☐ CCNU, Wuhan
  - ☐ CIAE, Beijing
  - ☐ HBUT, Wuhan
  - ☐ HUST, Wuhan
  - ☐ SINAP of CAS, Shanghai
  - ☐ USTC, Hefei
- 8+6 physicists, 6+2 tech staff,  
14 PhDs students & Post-docs



**Detector involvement: Muon Spectrometer, Electromagnetic Calorimeter, Inner Tracking System and V0**



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



### □ Data analysis

- Open heavy-flavour measurements via muons
- W-boson production via muons
- Low mass resonances via dimuons
- $\gamma$  and  $\pi^0$  production & correlations with hadrons
- Jet measurements

### □ Performance studies

- Open heavy-flavour measurements with MUON and MFT
- $\gamma(\pi^0)$  & jets with EMCAL, DCAL & PHOS

### □ Data taking

- 3 □ Offline, online, computing, management
- R&D, detector installation and operation
- Upgrade projects: ITS-MFT



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



- ❑ Co-PhD students: **7** since 2008
  - 4 co-PhD defended: Y. Mao (2011), R. Wan (2011), X. Zhang (2012) , S. Li(2015)
  - 2 co-PhD in preparation: M. Wang (2015), J. Zhu (2016)
  - **1 co-PhD CSC application ongoing: 2016-2018, 2 years, CCNU/LPC, Z. Zhang**
- ❑ Post-doctors: **2** since 2009 (Xiaoming Zhang and Liang Sun)
- ❑ Master students: **8** since 2007
- ❑ Many visits of senior physicists & engineers/technicians: data analysis & detector related activities
- ❑ 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-Wuhan),  
**7<sup>th</sup>** FCPPL workshop (LPC Clermont-Ferrand) and  
co-organization of **9<sup>th</sup>** FCPPL workshop (Strasbourg)

## 6

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

Members	French Group			Chinese Group		
	Name	Title	Affiliation (Institute)	Name	Title	Affiliation (Institute)
Proton Accelerator Physics Group CCNU	<i>Leader</i>			<i>Leader</i>		
	<b>BASTID Nicole</b>	<b>PR</b>	<b>IN2P3</b>	<b>ZHOU Daicui</b>	<b>PR</b>	<b>CCNU</b>
	Alphécette Laurent	CR	IN2P3	Cai Xu	PR	CCNU
	Baldisseri Alberto	Physicien	IRFU	Yang Chunbin	PR	CCNU
	Batigne Guillaume	MC	IN2P3	Yin Zhongbao	PR	CCNU
	Belikov Igor	DR	IN2P3	Bartalini Paolo	PR	CCNU
	Castillo Castellanos Javier	Physicien	IRFU	Liu Fuming	PR	CCNU
	Cheshkov Cvetan	CR	IN2P3	Zhou Daimei	PR	CCNU
	Cheyins Brigitte	CR	IN2P3	Wang Yaping	Ass. PR	CCNU
	Conessa Balbastre Gustavo	CR	IN2P3	Pei Hua	Ass. PR	CCNU
	Crochet Philippe	DR	IN2P3	Mao Yaxian	Ass. PR	CCNU
	Ducroux Laurent	MC	IN2P3	Zhang Xiaoming	Post-doc	CCNU/CERN
	Dupieux Pascal	DR	IN2P3	Zhang Fan	Lecturer	HBUT
	Erazmus Barbara	DR	IN2P3	Wang Dong	Lecturer	CCNU
	Estienne Magali	CR	IN2P3	Zhu Jianlin	Lecturer	CCNU/SCUBC
	Faivre Julien	MC	IN2P3	Shou Qi-Ye	Post-doc	CCNU
	Furget Christophe	PR	IN2P3	Prabhakar Palni	Post-doc	CCNU
	Gemmau Marie	CR	IN2P3	Li Shuang	Post-doc	CCNU
	Guerin Cyril	IR	IN2P3	Zhang YongHong	PhD student	CCNU
	Gueranne Rachid	CR	IN2P3	Zhu Hongsheng	PhD student	CCNU
	Hippolyte Boris	MC	IN2P3	Wang Mengliang	PhD student	CCNU
	Kox Serge	DR	IN2P3	Zhu Jianhui	PhD student	CCNU
	Kuhn Christian	DR	IN2P3	Zhang Haitao	PhD student	CCNU
	Lopez Xavier	MC	IN2P3	Ran Xiaowen	PhD student	CCNU
	Maire Antonin	CR	IN2P3	Zhang Zuman	PhD student	CCNU
	Martinez-Garcia Gines	DR	IN2P3	Peng Xinye	PhD student	CCNU
	Pereira Hugo	Physicien	IRFU	Yan Li	Master student	CCNU
	Pillot Philippe	CR	IN2P3	Ruan Xu	Master student	CCNU
	Rami Fouad	CR	IN2P3			
	Rosnet Philippe	CR	IN2P3			
	Roy Christelle	DR	IN2P3			
Proton Accelerator Physics Group CCNU	Schutz Yves	DR	IN2P3			
	Shabetov Alexandre	CR	IN2P3			
	Silvestre Tello	CR	IN2P3			
	Catherine					
	Stocco Diego	CR	IN2P3			
	Stutzmann Sébastien	Jean IE	IN2P3			
	Boris Teyssier	PhD student	IN2P3			
	Uras Antonio	CR	IN2P3			



## ❑ Co-PhD program

- Shuang Li: CCNU/LPC, 2012-2015
- Mengliang Wang: CCNU/Subatech, 2012-2016
- Jianhui Zhu: CCNU/Subatech, 2013-2016
- Zuman Zhang: CCNU/LPC at LPC Clermont for 6 months until May 2016 and applying for a 2-year CSC-grant

## ❑ Co-analysis on physics topics

- Heavy flavor measurements: CCNU-LPC
- Electroweak probes: CCNU-Subatech
- Jet and correlation: CCNU-Subatech/Grenoble
- Photon spectra: CCNU-Grenoble

## ❑ Co-silicon pixel detector upgrade program

- Silicon pixel design for ITS upgrade: CCNU-Strasbourg
- Readout electronics for MFT upgrade: CCNU-France groups

## ❑ Participation on 8th FCPPL workshop at USTC, China

- 17 physicists from ALICE in total (8 from IN2P3, 9 from CCNU), 7 talks
- A specific mutual meeting for discussing the cooperation plan and co-PhD prog.
- 3 French physicists on jets attended the “mini-jet workshop” at Wuhan for RUN2 analysis and visited CCNU for 4 days

- ❑ Cold Nuclear Matter effects in p-Pb collisions with  $HF \rightarrow \mu$   
Cooperators: Shuang Li, Xiaoming Zhang, Zuman Zhang, Philippe Crochet, Nicole Bastid and Daicui Zhou
- ❑ Collectivity of  $HF \rightarrow \mu$  in Pb-Pb collisions (published PLB2016)  
Cooperators: Xiaoming Zhang, Philippe Crochet, Nicole Bastid and Daicui Zhou
- ❑ Nuclear suppression factor of  $HF \rightarrow \mu$  in Pb-Pb collisions  
Cooperators: Zuman Zhang, Xiaoming Zhang, Philippe Crochet, Nicole Bastid and Daicui Zhou
- ❑ Electroweak probes: W-boson production (Jianhui Zhu)  
Cooperators: Jianhui Zhu, Diego Stocco, Gines Martinez and D.C.Zhou
- ❑ Jet structure: Fragmentation Function Moment in pp collisions  
Cooperators: Mengliang Wang, Alexandre Shabetai, Magali Estienne, Zhongbao Yin and Daicui Zhou
- ❑  $\gamma$ , jet and  $\gamma$ -jet correlation in pp and Pb-Pb collisions  
Cooperators: H. Zhang, X. Peng, Y. Mao, H. Pei, Y. Li, R. Xu, G. Balbastre, R. Guernane, Z. Yin and D. Zhou
- ❑ Multi-parton interaction (MPI) in pp and p-Pb collisions  
Cooperators: Paolo Bartalini, Prab Palni, Diego Stocco, Rachid Guernane



# Relevance of open heavy-flavour measurements

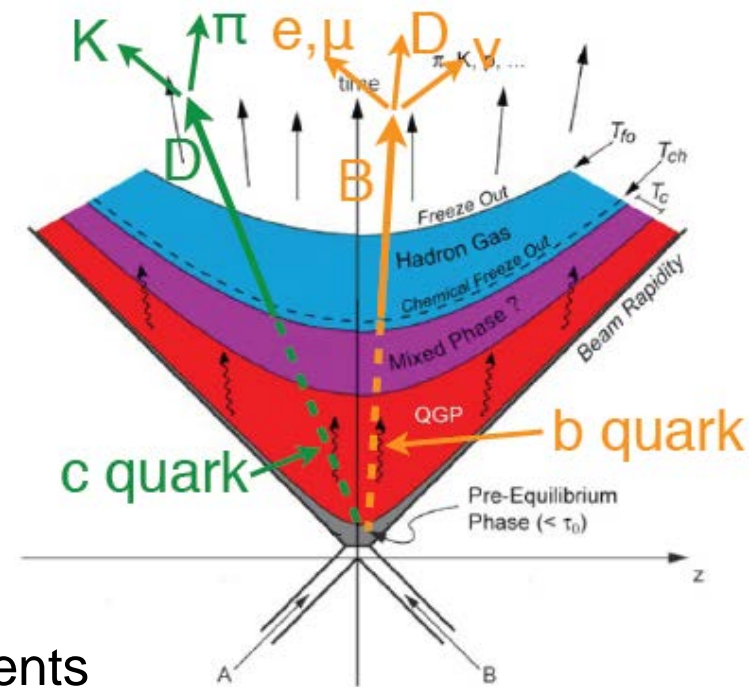
- ❑ Charm and beauty quarks produced in **initial hard scatterings** with a short formation time  $\tau_f \sim 1/2m_{c/b} \sim 0.02-0.1 \text{ fm}/c < \tau_0 \ll \tau_{\text{QGP}} \sim 5-10 \text{ fm}/c$
- ❑ Experience the **full collision history**
  - Sensitive probes of the medium properties

Open heavy flavours in Pb-Pb collisions probe

- ❑ Parton energy loss
- ❑ Heavy quark participation in the collective expansion

A meaningful interpretation of Pb-Pb data needs data from

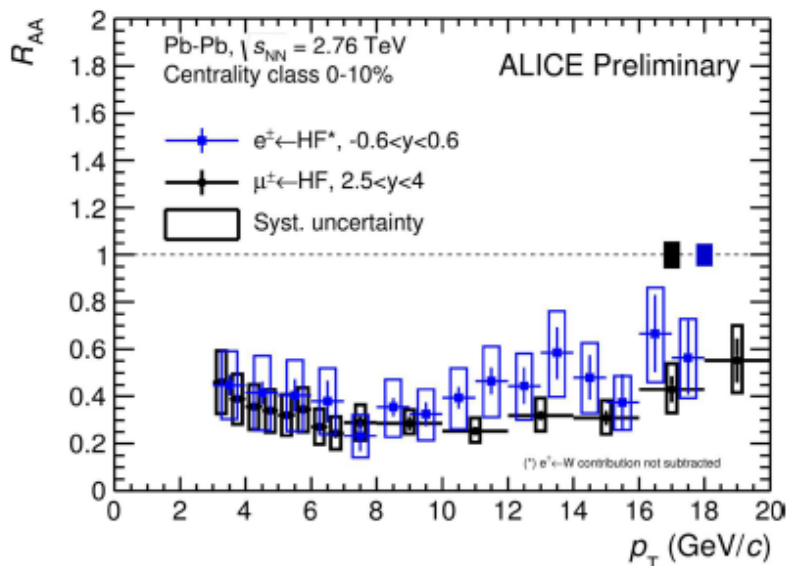
- ❑ **p-Pb collisions**
  - Address cold nuclear matter effects
  - Control experiment for Pb-Pb measurements
- ❑ **pp collisions**
  - Reference for p-Pb and Pb-Pb collisions
  - Test perturbative QCD calculations



# Heavy-flavour decay muon production in Pb-Pb collisions (Zuman Zhang)

- ❑ 2015: PhD student, 6 months at LPC Clermont-Ferrand from Nov. 2015-May 2016
- ❑ Funding: FCPPL(50%), CCNU(50%)
- ❑ 2016-2018: co-PhD LPC/CCNU at LPC, 2-year CSC grant requested,
- topic: open heavy-flavor measurements via muons with run 1 and run 2 data in pp and Pb-Pb collisions)

$$R_{AA}(p_T) = 1 / \langle N_{\text{coll}} \rangle \times \frac{dN_{AA}/dp_T}{dN_{pp}/dp_T}$$



- ❑ Extend published  $R_{AA}$  results for heavy-flavour decay muons (X. Zhang PhD, PRL 109 (2012) 112301) to higher  $p_T$  to constrain energy loss models (in collaboration with X. Zhang)
- ❑ Results presented in PAG-HFM and PWG-HF
- ❑ Analysis being finalized and **paper proposal to the Collaboration for approval soon**
- ❑ Focusing on RUN2 data analysis in pp and Pb-Pb with aim to get approved results for HP2016.
- ❑ Contribution to p-Pb analysis (in collaboration with S. Li)

More: see Zuman Zhang presentation

# Heavy-flavour decay muon elliptic flow in Pb-Pb collisions (Xiaoming Zhang)

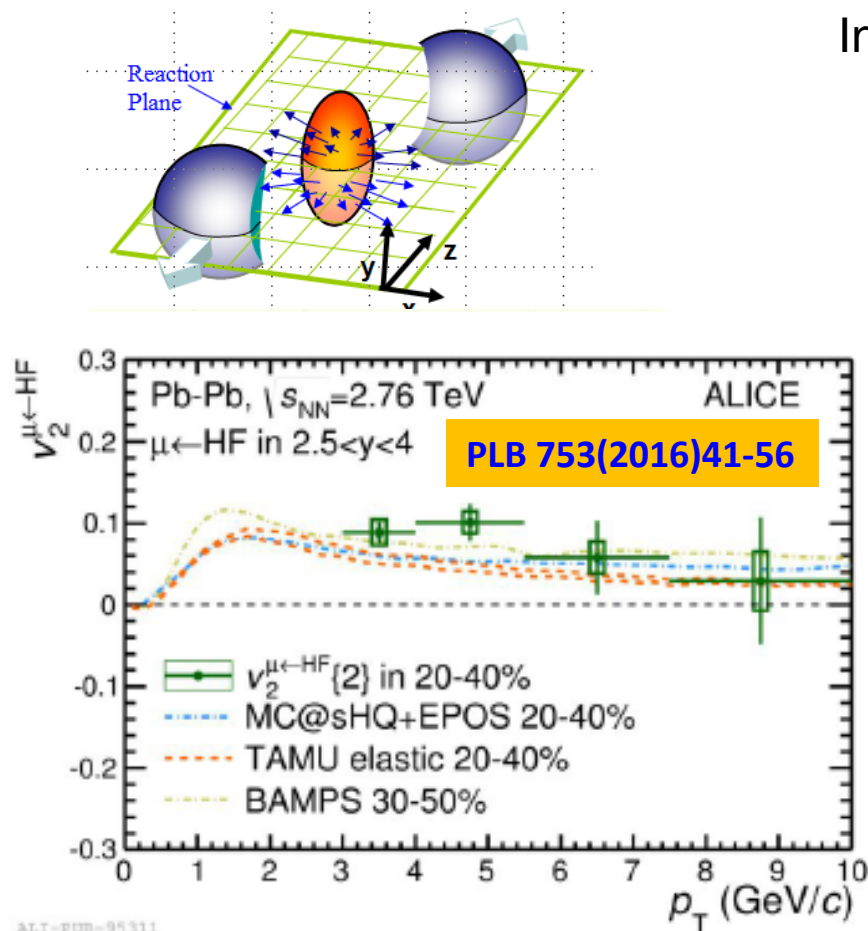
- 2013-2015: post-doctor at LBNL, located at CERN. Project associate at CERN 2016
- Continue to work in close collaboration with LPC and CCNU on heavy-flavour decay muon measurements: data analysis and performance studies

Initial spatial anisotropy  $\rightarrow$  momentum anisotropy

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

$v_2$  = elliptic flow: look for collective motion and path-length dependence of energy loss

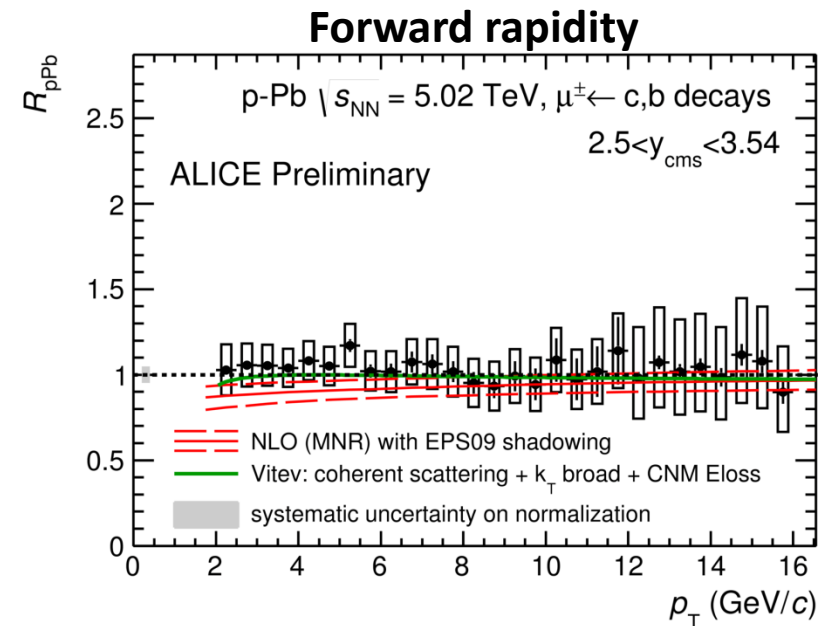
- Complements  $R_{AA}$  measurements
- Positive  $v_2$  at intermediate  $p_T$  and semi-central collisions
- Participation of heavy quarks (charm, mainly) in the collective expansion of the system
- Confirmation of significant interaction of heavy quarks with the medium.



More: see Zuman Zhang presentation

# Heavy-flavour decay muon production in p-Pb collisions (Shuang Li)

- ❑ 2012-2015: co-PhD LPC/CCNU, defense in Oct. 2015 at CCNU
- ❑ Funding: CSC (2 years) and Eiffel (10 months)
- ❑ Topic: heavy-flavour decay muon production in p-Pb collisions



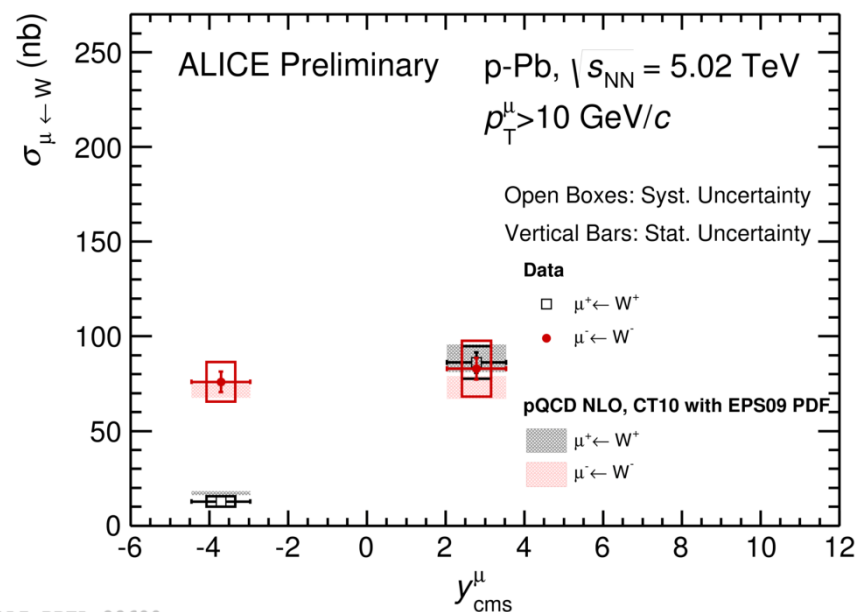
ALI-PREL-90686

- ❑ Heavy-flavour  $R_{pPb}$  consistent with unity
- ❑ Small **cold nuclear matter (CNM) effects**
- ❑ Strong suppression measured in central Pb-Pb collisions is due to the hot and dense medium
- ❑ Talk at QM2014 (Darmstadt, Germany)
- ❑ Paper proposal approved and Letter in preparation, with ALICE Editorial Board
- ❑ Ongoing: heavy-flavour decay muon production vs event activity, to be proposed to the ALICE Collaboration for approval soon



# W-boson production via muons in p-Pb collisions (Jianhui Zhu)

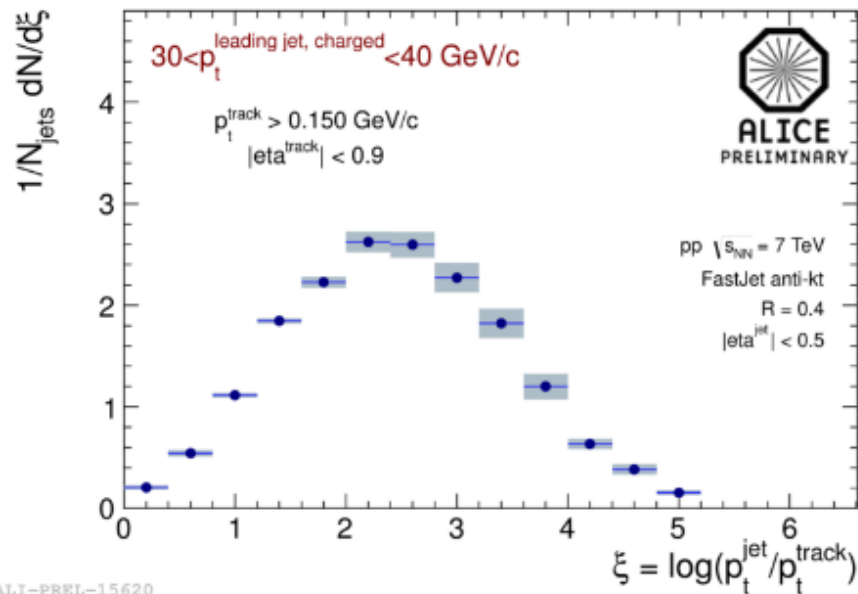
- ❑ 2013-2016: co-PhD Subatech/CCNU, funding: CSC (2 years) extended for 3 months
- ❑ Topic: W-boson production via single muons in p-Pb and pp collisions
- ❑ PhD defense: to be in Nov. 2016 at CCNU
- ❑ pp collisions: test Parton Distribution Functions (PDF)
- ❑ p-Pb collisions: investigate CNM effects and test binary scaling
- ❑ Pb-Pb collisions: reference for medium-induced effects and test binary scaling



- ❑ First measurement at forward & backward rapidity in p-Pb collisions
- ❑ Measurements in agreement with theoretical predictions including nPDF
- ❑ Talk at Hot Quarks (Spain)
- ❑ Talk proposed to be at BEACH2016 (USA)
- ❑ Paper proposal approved and letter in preparation

# Jet structure in pp collisions (Mengliang Wang)

- ❑ 2013-2015: co-PhD Subatech/CCNU, defense before end of 2016
- ❑ Funding: CSC (3 years, until end of August) and extended for 6 months
- ❑ Topic: jet structure and fragmentation function Moment in pp collisions



- ❑ pp collisions: test pQCD calculations, reference for Pb-Pb measurements

- ❑ Differential measurements of jet fragmentation functions in pp collisions
- ❑ Challenging in Pb-Pb collisions (background)

- ❑ **Ongoing**: fragmentation function moments, **less sensitive to background fluctuations**

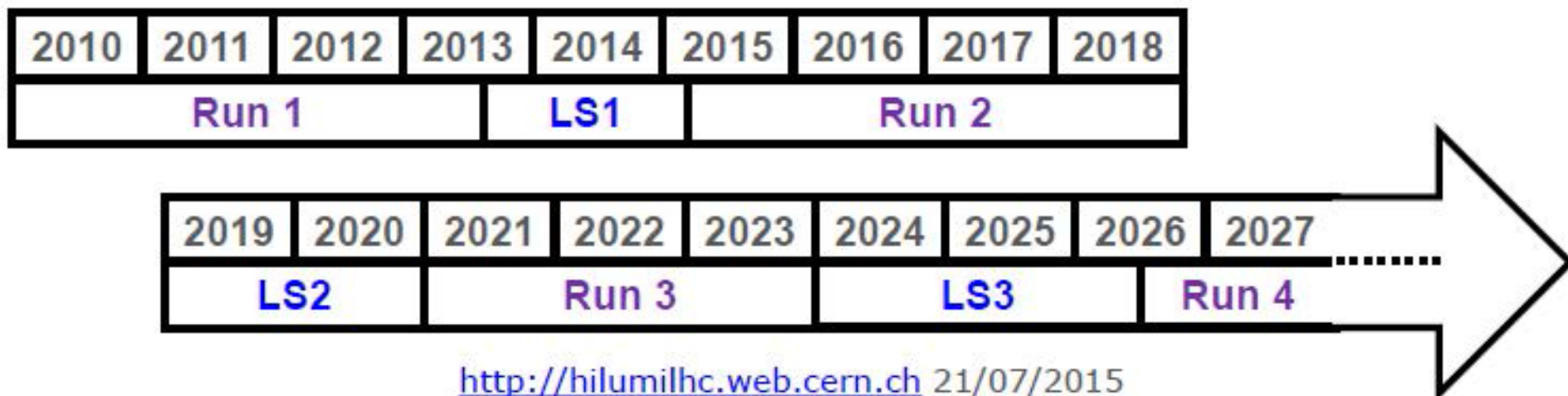
- ❑ DCal geometry implemented in AliRoot

## ☐ Publications with direct contribution & conference proceedings& in preparation: 8

- X. Zhang (J. Adam et al.,ALICE Collaboration), Phys. Lett. B 753 (2016) 41
- J. Zhu for the ALICE Collaboration, J. Phys. Conf. Ser. 612 (2015) 012009
- Z. Yin (J. Adam et al.,ALICE Collaboration), JHEP 06 (2015) 190
- J. Adam et al., ALICE Collaboration, Production of muons from heavy-flavour hadron decays in p-Pb collisions at  $\sqrt{s_{NN}} = 5.02$  TeV. In preparation, target journal: Letter
- J. Adam et al., ALICE Collaboration, Measurement of W- and Z-boson production in p-Pb collisions with ALICE at the LHC. In preparation, target journal: Letter
- J. Adam et al., ALICE Collaboration, K<sup>0</sup>S and Lambda production in jets and the underlying event in p-Pb collisions at  $\sqrt{s_{NN}} = 5.02$  TeV. In preparation, target journal: Letter
- J. Adam et al., ALICE Collaboration,  $\pi^0$ -hadron correlations in Pb-Pb collisions at  $\sqrt{s_{NN}} = 2.76$  TeV. In preparation, target journal: E.P.J. C
- J. Adam et al., ALICE Collaboration, Measurement of neutral pion production at high  $p_T$  in pp collisions at  $\sqrt{s} = 2.76$  TeV. In preparation, target journal: Letter

## ☐ Talks and posters at international conferences & workshops : 12

- Z. Zhang “ALICE Muon Meeting 2015”, Chia, Sardinia, Italy, May 25-29, 2015
- Z. Zhang “Quark Matter 2015” Conference, Kobe, Japan, Sep. 27-Oct. 3, 2015
- Z. Zhang S. Li “8th FCPPL workshop”, Hefei, China, April 8-10, 2015 ☐
- Z. Zhang 11th workshop on QCD phase transition and relativistic HI physics”, Harbin, China, Aug. 17-19, 2015
- J. Zhu “ALICE Muon Meeting 2015”, Chia, Sardinia, Italy, May 25-29, 2015
- J. Zhu “Quark Matter 2015” Conference, Kobe, Japan, Sep. 27-Oct. 3, 2015
- J. Zhu t “8th FCPPL workshop”, Hefei, China, April 8-10, 2015
- M. Wang “Nucleus-Nucleus 2015” Conference, Catania, Italy, 21-26 June, 2015
- M. Wang “8th FCPPL workshop”, Hefei, China, April 8-10, 2015
- X. Zhang et al., “Quark Matter 2015”, Kobe, Japan, Sep. 27-Oct. 3, 2015. Proceedings: arXiv:1512.09255
- H. Zhang for the ALICE Collaboration, High  $p_T$   $\pi^0$  identification in pp collisions at the LHC measured with EMCal
- Poster at “Quark Matter 2015” Conference, Kobe, Japan, Sep. 27-Oct. 3, 2015



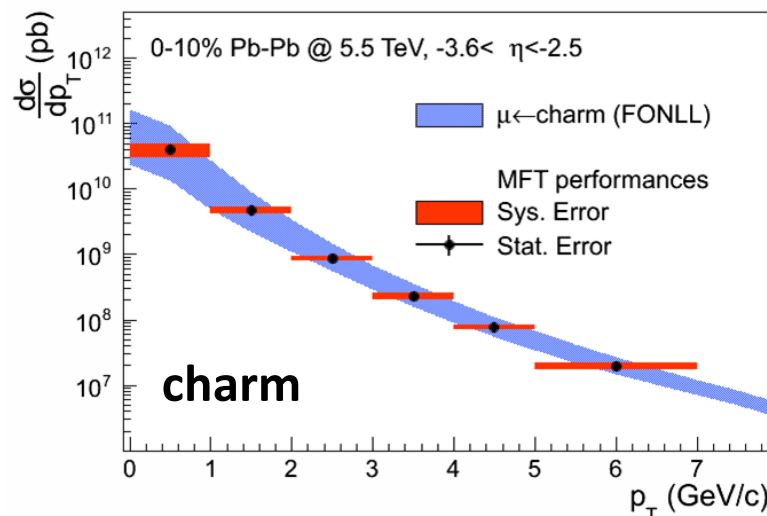
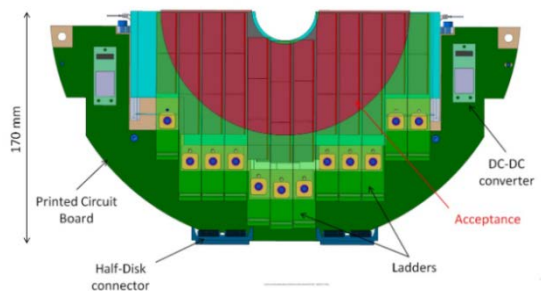
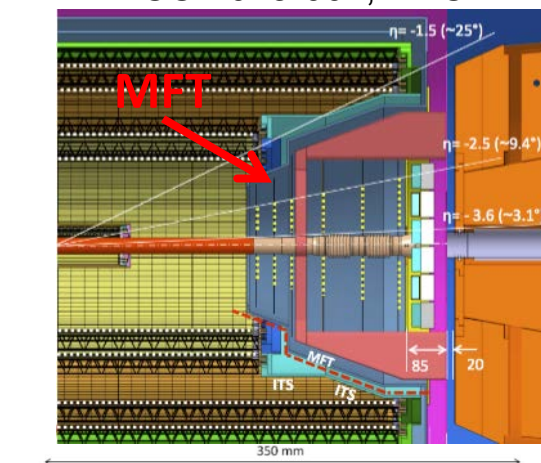
- ❑ The LHC heavy-ion program will be extended to run 3 and run 4
- ❑ High interaction rate: 50 kHz
- ❑ Expected integrated luminosity:  $> 10 \text{ nb}^{-1}$  (factor 10 compared to approved program until LS2)
- ❑ Major detector upgrade:
  - **ITS**, TPC chambers, online-offline ( $O^2$ ), **Muon Forward Tracker (MFT)**
  - Upgrade of readout electronics of MUON, TOF, PHOS, EMCAL, TRD
  - Upgrade of forward/trigger detectors

**More: see Gines Martinez presentation**



- ❑ Installation of DCal and PHOS completed before Run2 and data taking now
- ❑ A part of involvements from CCNU in the MFT project on readout electronics
  - Performance studies: charm & beauty measurements via single muons (Xiaoming Zhang (LPC/CNNU), contribution to LoI, CERN-LHCC-2013-014)
  - Contribution in the Readout Electronics: Circuit Boards design and production on going well (ALICE-Asia O2-MFT-ITS Workshop at CCNU, June 7-9, 2015)

CERN-LHCC-2015-001, ALICE-TDR-018



- 10 half-disks of silicon pixels in the acceptance of the muon spectrometer, between absorber & interaction point
- Vertexing for the muon spectrometer:
- Improvement of physics reach: separation of charm and beauty signals, ...

## □ Continue the strong involvement in data analysis

- Finalization and publication of ongoing analyses with run 1 data (5 papers)
- Analysis of run 2 data: pp ( $\sqrt{s} = 13$  TeV) & Pb-Pb ( $\sqrt{s_{NN}} = 5.1$  TeV)
  - Open heavy-flavour measurements
    - Production & flow:  $p_T$  &  $y$ -differential cross sections in pp and Pb-Pb collisions, nuclear modification factor & elliptic flow (CCNU/LPC: **a 2-year CSC of Zuman**)
    - Yields vs charged particle multiplicity in pp and p-Pb collisions to investigate Multi-Parton Interactions (CCNU/LPSC/Subatech)
  - Jets structure and  $\gamma/\pi^0$  -jet correlation (CCNU/LPSC/Subatech)
  - Electroweak probes: W (CCNU/Subatech)
  - High  $p_T$  neutral spectrum in small system and Pb-Pb collisions (CCNU/LPSC)

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

- Technical involvements (MFT project and ITS)
- Physics performance

**➡ FCPPL is a very successful collaboration platform for student, senior physicist & technician/Engineer exchanges between France-China**

## ❑ Funding from France: request of ~33 kEuros in total

Travel costs for committee members of Mengliang Wang PhD defense at CCNU

Travel costs for committee members of Jianhui ZHU PhD defense at CCNU

Stay costs for 2 students from IOPP/CCNU at LPSC Grenoble (2 months each)

Stay costs for 2 students from IOPP/CCNU at IPHC Strasbourg (1month each)

Stay costs for 1 student from IOPP/CCNU at LPC Clermont-Ferrand (3 months)

Stay costs for Dong WANG and a student at Subatch Nantes and IPN Lyon (1 week each)

Travel cost for one physicist from Subatech Nantes at IOPP/CCNU

Travel costs for 7 physicists to IOPP/CCNU Wuhan to attend HP2016 and ALICE meetings on ongoing activities, run-2 analyses and upgrades, who are from LPC (2 physicists), IPN Lyon (2 physicists), IRFU Saclay (2 physicists), IPHC Strasbourg (1 physicist)

Travel and stay costs for participants from French institutes to attend the 9<sup>th</sup> FCPPL workshop at IPHC Strasbourg

## ❑ Funding from China: request of ~210,000 Yuans in total

Travel costs for 8 participants from CCNU-Wuhan to attend the 9<sup>th</sup> FCPPL workshop at IPHC Strasbourg

Costs for an extended stay of 2 months (Jan.-Feb. 2016) for Mengliang WANG at Subatech Nantes (co-tutorship PhD)

Costs for an extended stay of 2 months (Jan.-Feb. 2016) for Jianhui ZHU at Subatech Nantes (co-tutorship PhD)

Stay costs for 5 committee members who will participate to the PhD defense of M. WANG (May 2016) and J. ZHU (Nov. 2016)

Stay costs for Zuman ZHANG PhD training at LPC Clermont-Ferrand (mid. Feb.- mid. May 2016)

Travel costs for two Master II students, Yan Li and Ruan Xu from CCNU to LPSC Grenoble for master training ( $\gamma$  and jet physics )

Travel costs for two Master II students from CCNU Wuhan to IPHC Strasbourg for master training

Travel costs for one Master student from CCNU Wuhan to LPC Clermont-Ferrand for master training

Travel costs for D. WANG and a student from CCNU to Subatech Nantes and IPN Lyon for MFT activities (readout electronics)

Stay costs for physicists from Subatech at CCNU Wuhan

## ❑ CSC fundings (52,000 Yuan for 2016)

- Ongoing demand for a 2-year CSC grant for Zuman Zhang at LPC Clermont-Ferrand

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

- ❑ **Strong contribution to data taking & data analysis and performance studies**
  - Excellent contributions of students and staff
  - Significant contributions to ALICE scientific production
  - Many talks in conferences and workshops
- ❑ **Contributions to ALICE upgrades**

**Continue to extend the collaboration in more and more common activities  
related to run 2 physics, ALICE upgrade, run3-4 physics program  
preparation**



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**Thank you for  
your attention**