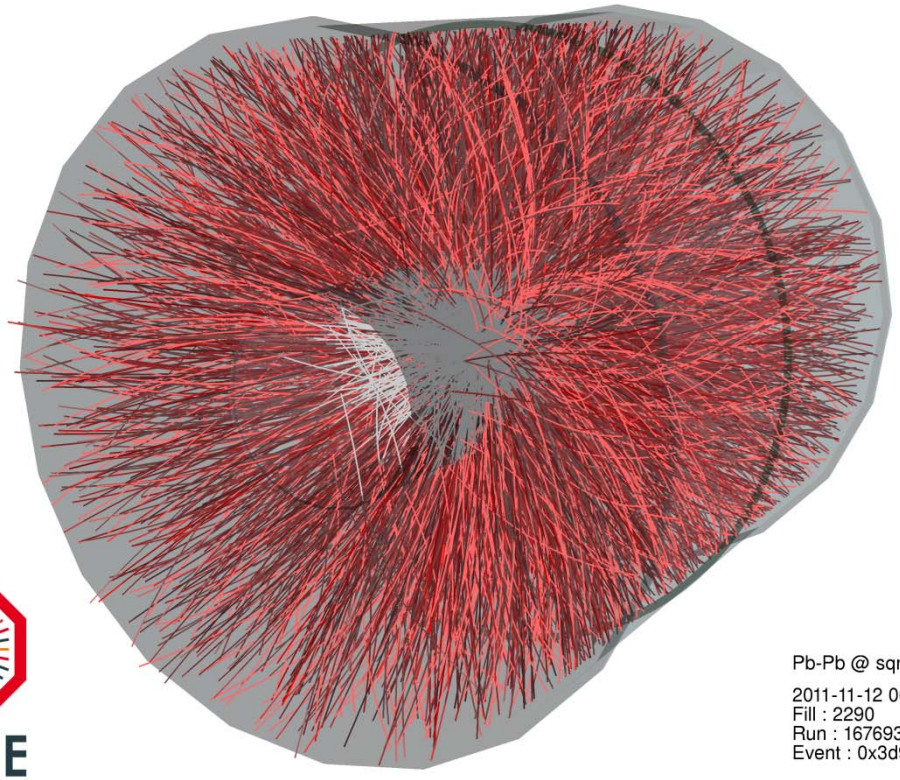
ALICE within FCPPL



Outline

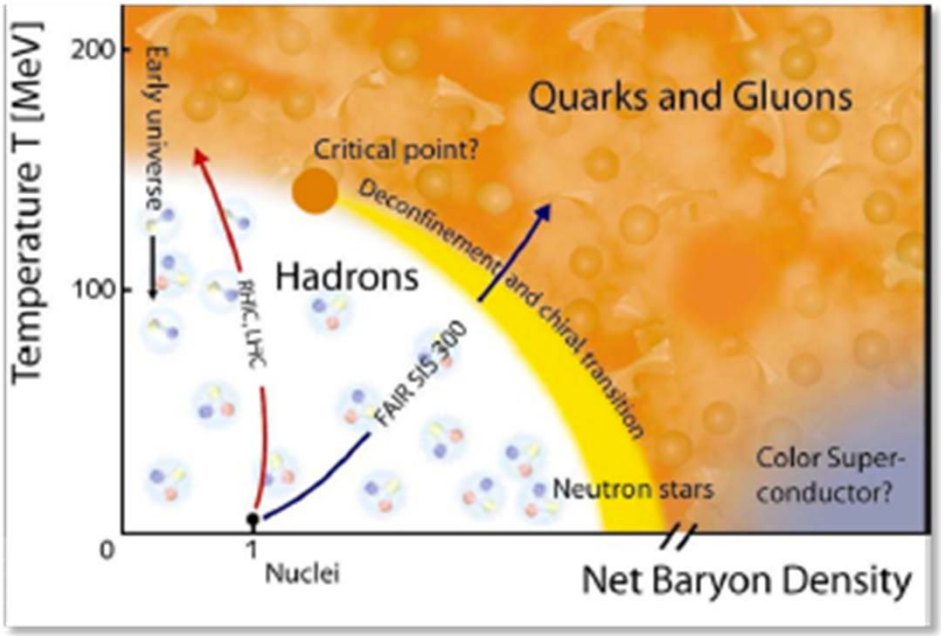
- ALICE
  - short overview
  - selection of recent results
- China and France in ALICE
- FCPPL-ALICE report (2012)
- FCPPL-ALICE project (2013)

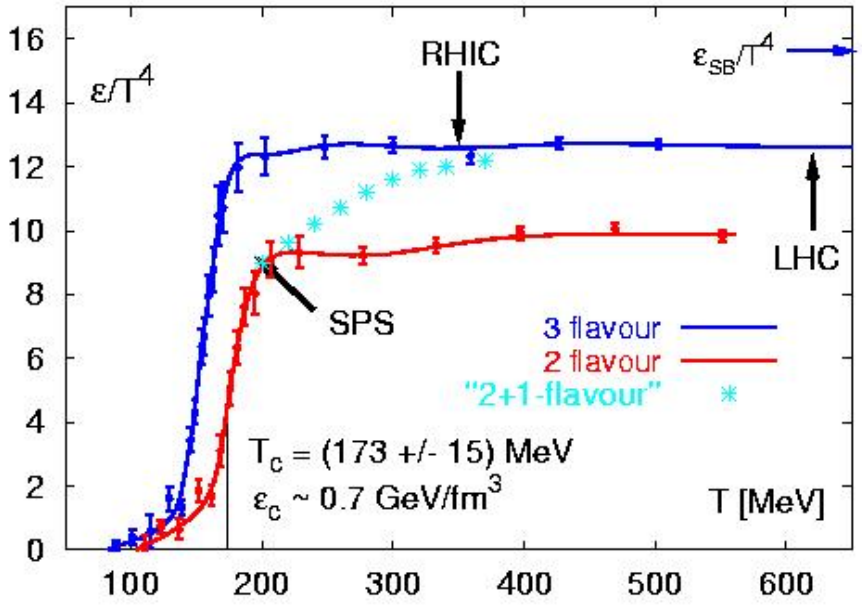
Nicole Bastid, LPC Clermont-Ferrand, France
6th FCPPL workshop, Nanjing, China, March 27-30, 2013

Physics motivations

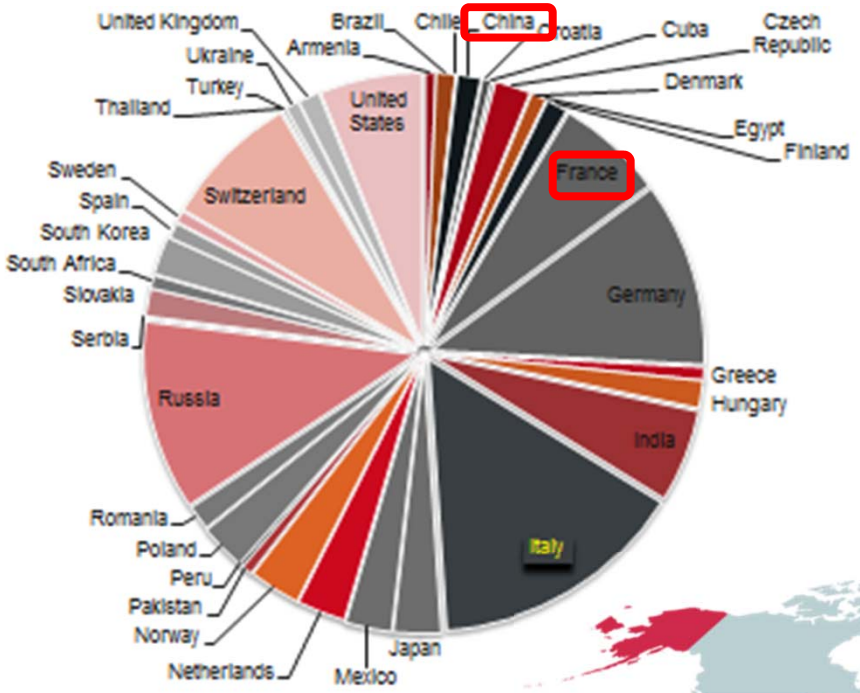
ALICE is the dedicated heavy-ion experiment at the LHC

Systematic study of properties of strongly-interacting matter under extreme conditions of temperature and energy density (Quark Gluon Plasma)

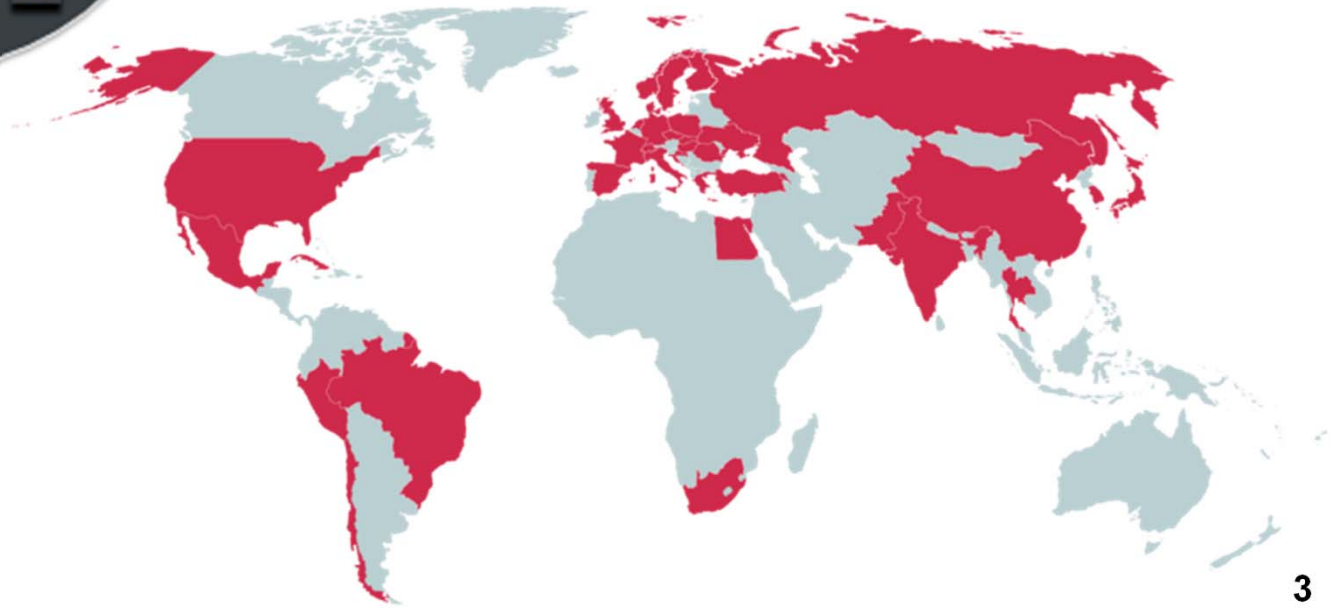




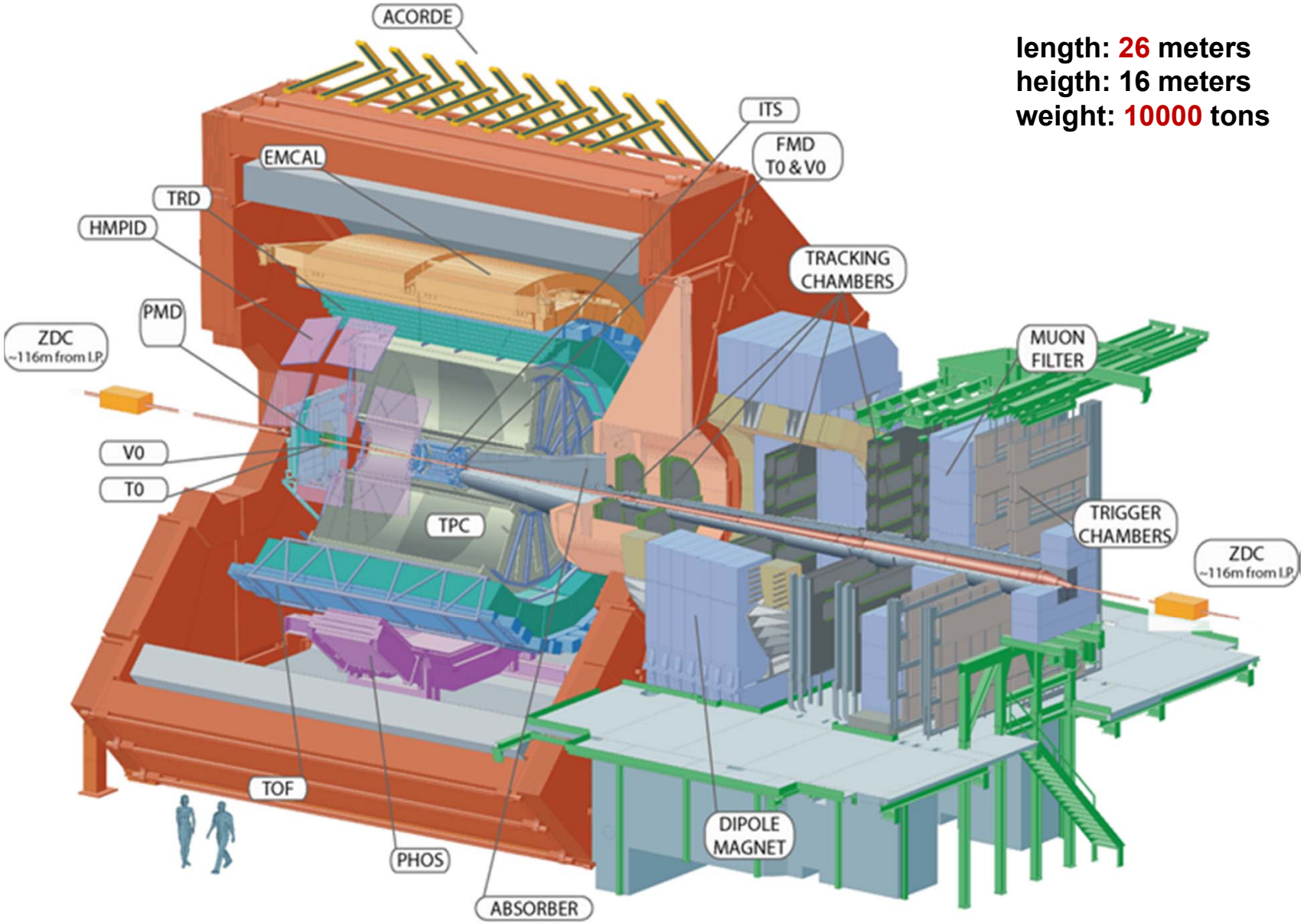
The ALICE Collaboration



~1300 members
132 institutes
37 countries

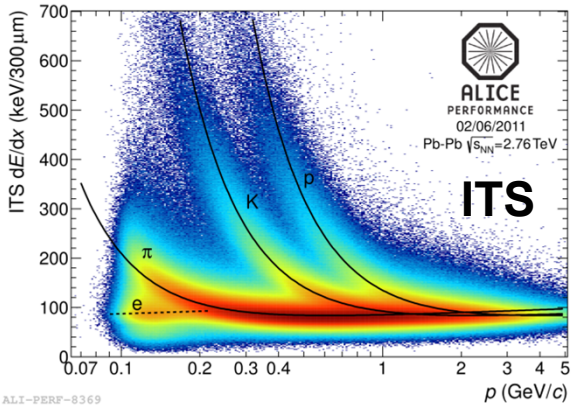


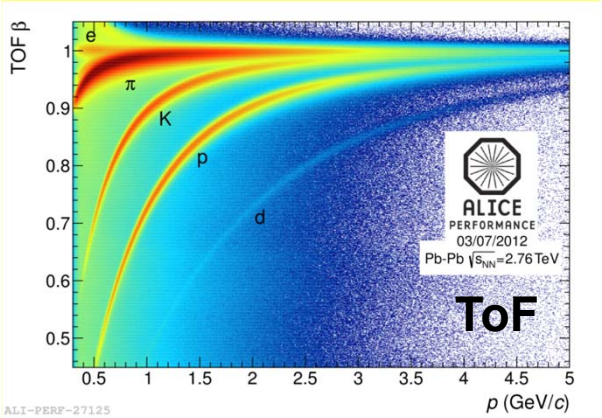
ALICE: A Large Ion Collider Experiment

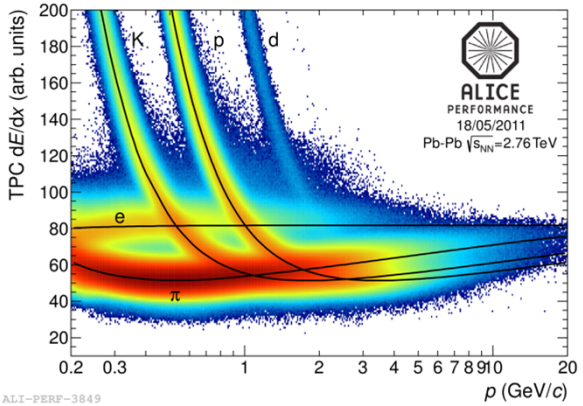


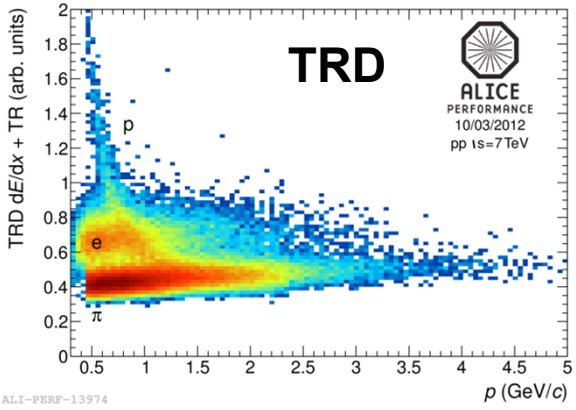
length: 26 meters
heigth: 16 meters
weight: 10000 tons

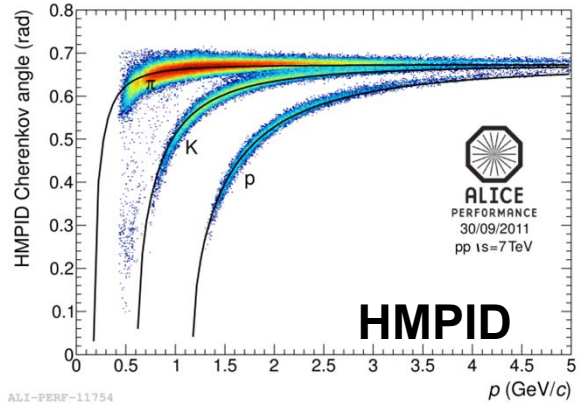
ALICE detector performance

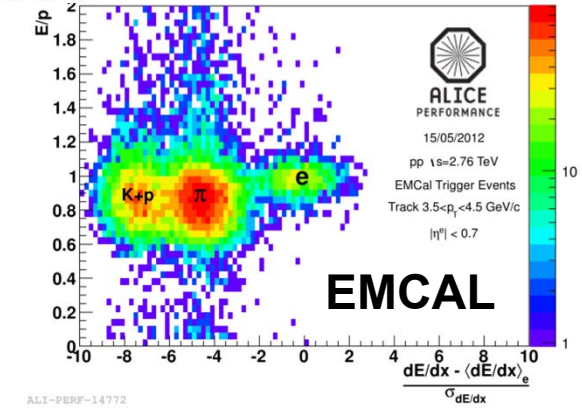


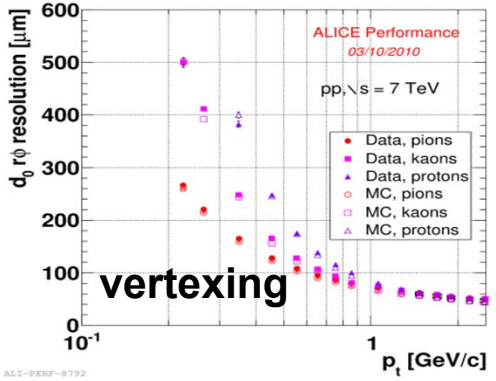








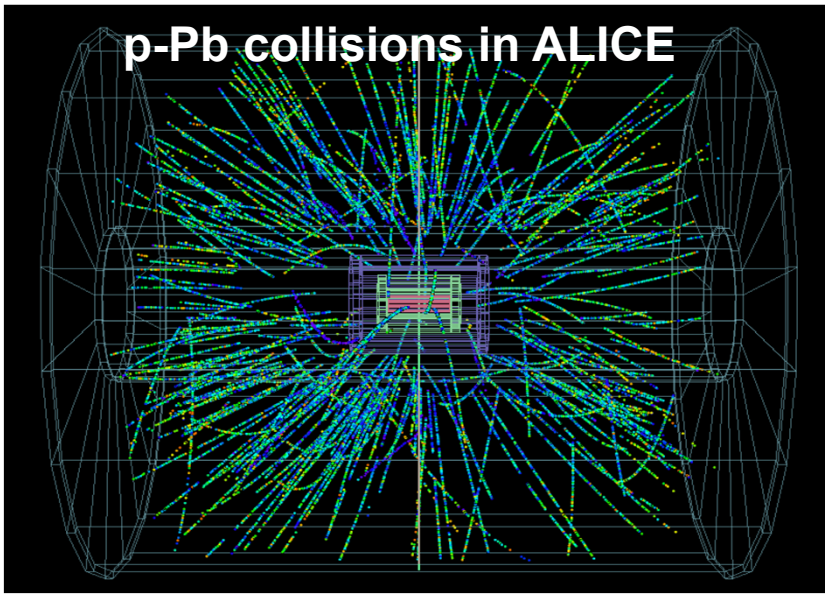




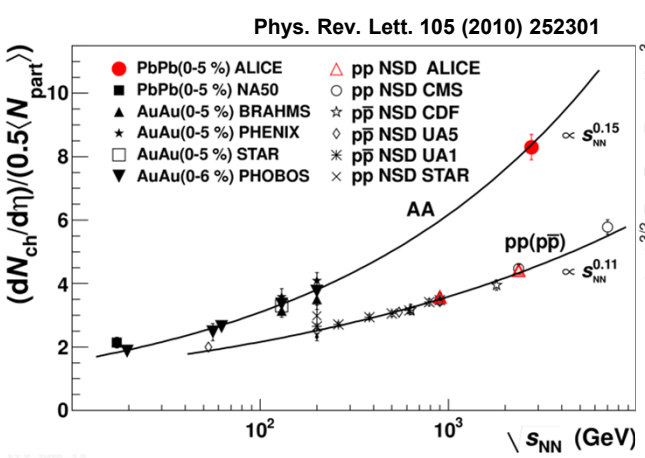
- particle identification over a large rapidity range (almost all known detection techniques)
- excellent tracking down to ~ 100 MeV/c & vertexing
- quarkonium detection down to $p_T = 0$

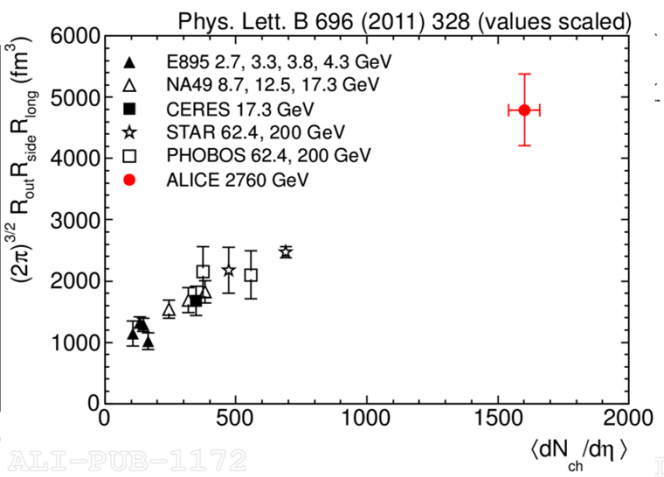
ALICE data taking

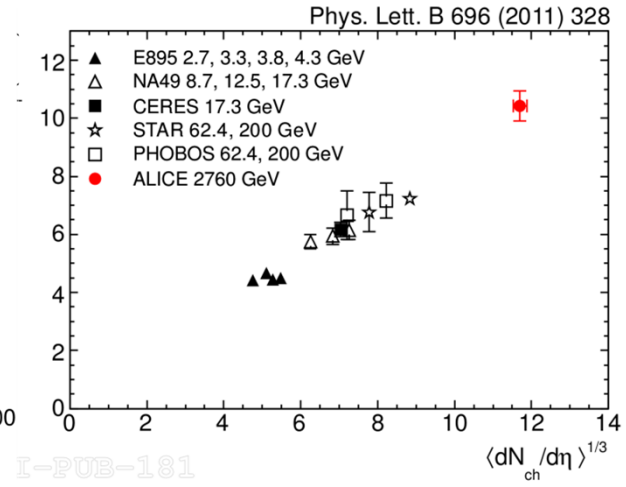
- two Pb-Pb runs at $\sqrt{s_{NN}}$ = 2.76 TeV
  - ✓ 2010: ~10 μb^{-1}, minimum bias
  - ✓ 2011: ~150 μb^{-1}, minimum bias & rare triggers
- p-Pb/Pb-p runs at $\sqrt{s_{NN}}$= 5.02 TeV
  - ✓ 2012 (Sept.): pilot run
  - ✓ 2013 (Jan-Feb. 2013): ~30 nb^{-1}, minimum bias & rare triggers
- 2009-2012: pp runs at $\sqrt{s}$ = 0.9, 2.36, 2.76, 7 and 8 TeV

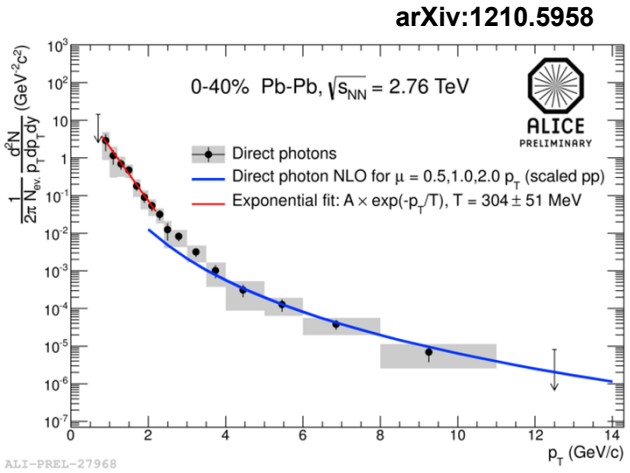


Central Pb-Pb collisions at the LHC





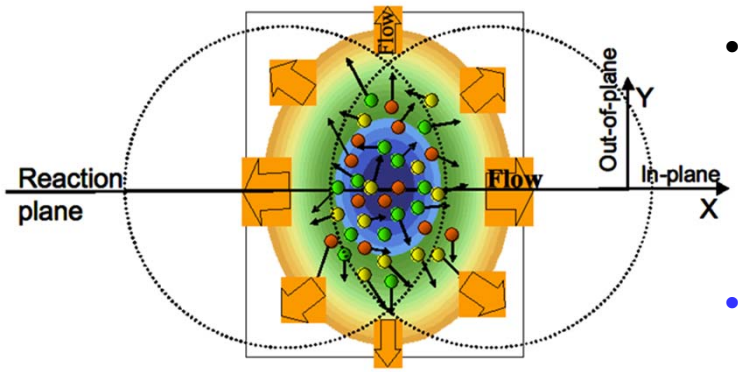




fireball at the LHC is denser, bigger, longer-lived and hotter than at RHIC

	LHC	LHC w.r.t. RHIC
energy density	10 GeV/fm^3	x 3
volume	~5000 fm^3	x 2
lifetime	~10 fm/c	+ 20%
temperature	304 MeV	+ 30%

Anisotropic flow

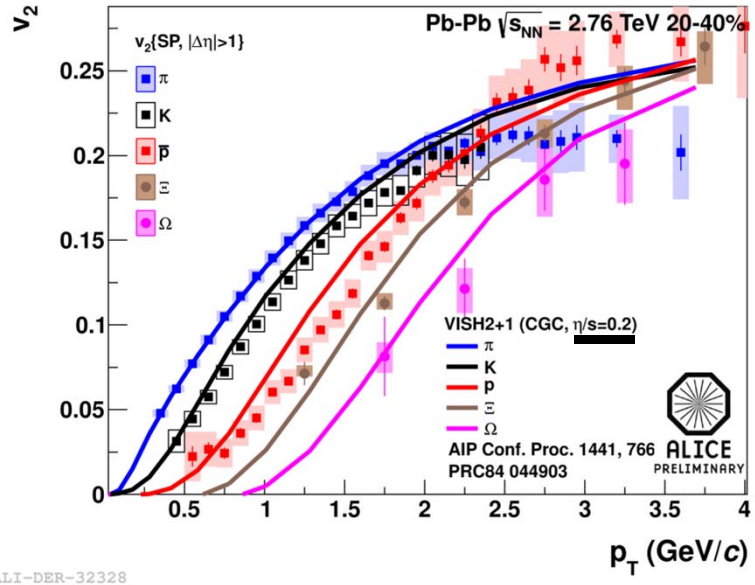


- initial spatial asymmetry → azimuthal anisotropy in momentum space
- quantified by means of Fourier coefficients:

$$\frac{dN}{d\varphi} = \frac{N_0}{2\pi}\left(1 + \sum_{n=1}^{\infty} v_n cos[n(\varphi - \Psi_n)]\right)$$

$$v_2: \ elliptic \ flow$$

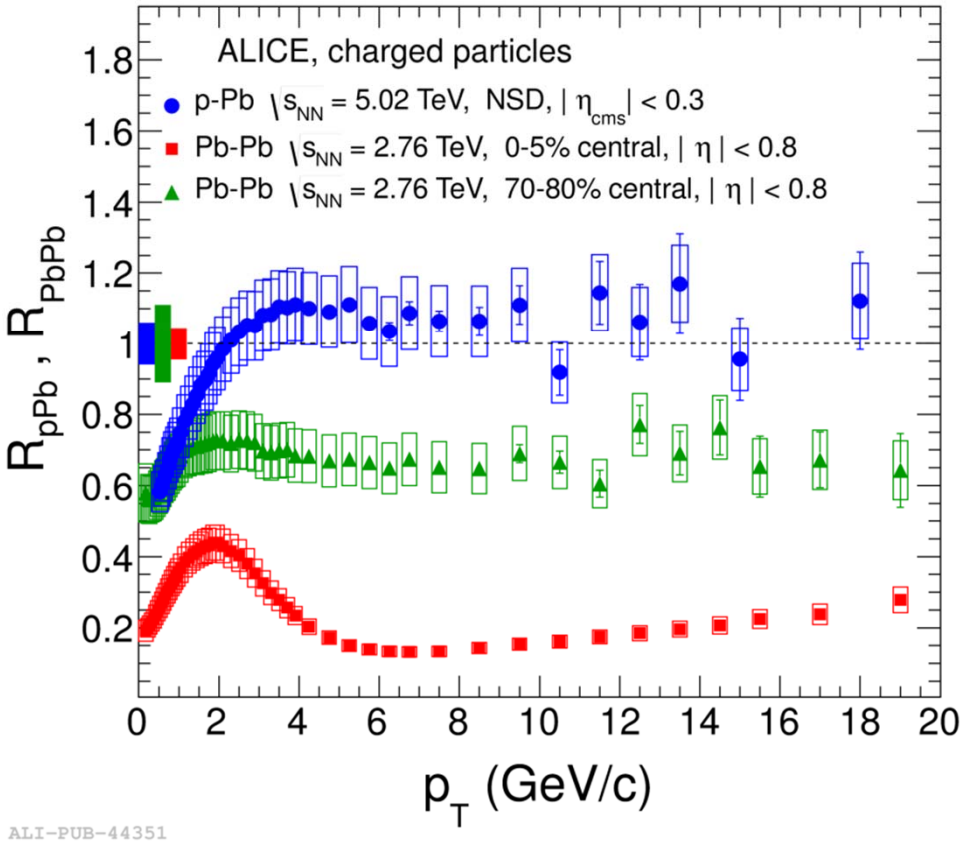
- strength of collective effects & transport medium properties: EoS, η/s (low p_T)
- particle production mechanism (intermediate p_T)
- path length dependence on parton energy loss (high p_T)



- v_2 (p_T) in agreement with hydrodynamical predictions: v_2 built at partonic level from collective expansion
- very low viscosity, almost perfect fluid

Nuclear modification factor of charged particles in p-Pb & Pb-Pb

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



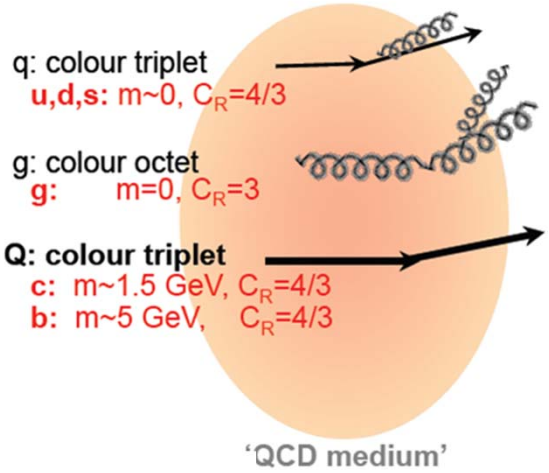
- **strong suppression in central Pb-Pb collisions: up to a factor 6-7**
- **no suppression in p-Pb for p_T > 2 GeV/c**
  → suppression in central Pb-Pb collisions is due to the final state effects

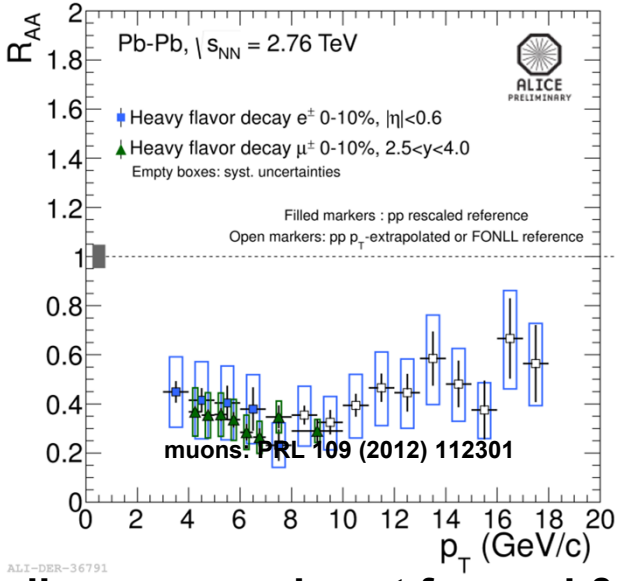
Heavy-flavour production

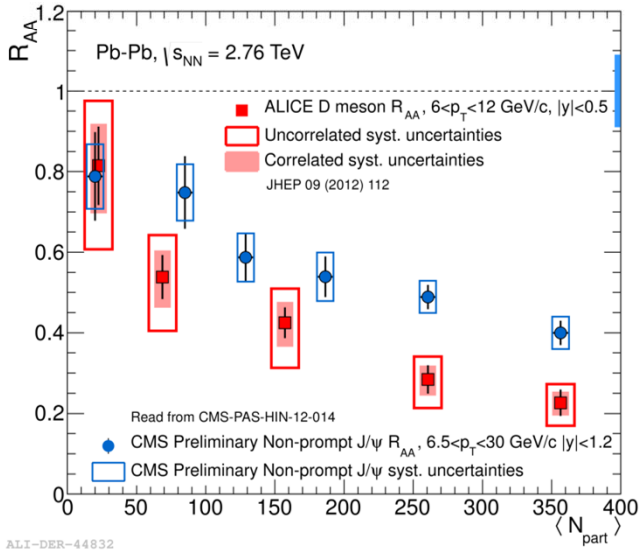
heavy quarks: sensitive probes of the medium properties
parton energy loss via:

- **medium-induced gluon radiation & collisions with partons**
- **proportional to ε, C_R (4/3 (3) for q (g)), m_q, L**
  - ✓ **color-charge, Casimir factor: $\Delta E_g > \Delta E_{u,d,s}$**
  - ✓ **parton mass, dead cone effect: $\Delta E_c > \Delta E_b$**
    (Phys. Lett. B 519 (2001) 1999)

$\rightarrow R_{AA}(\pi) < R_{AA}(D) < R_{AA}(B)$





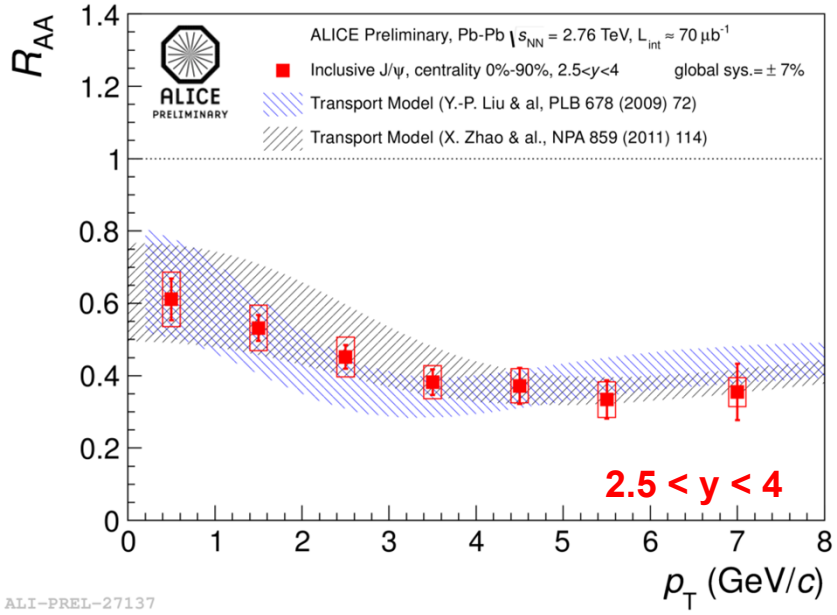


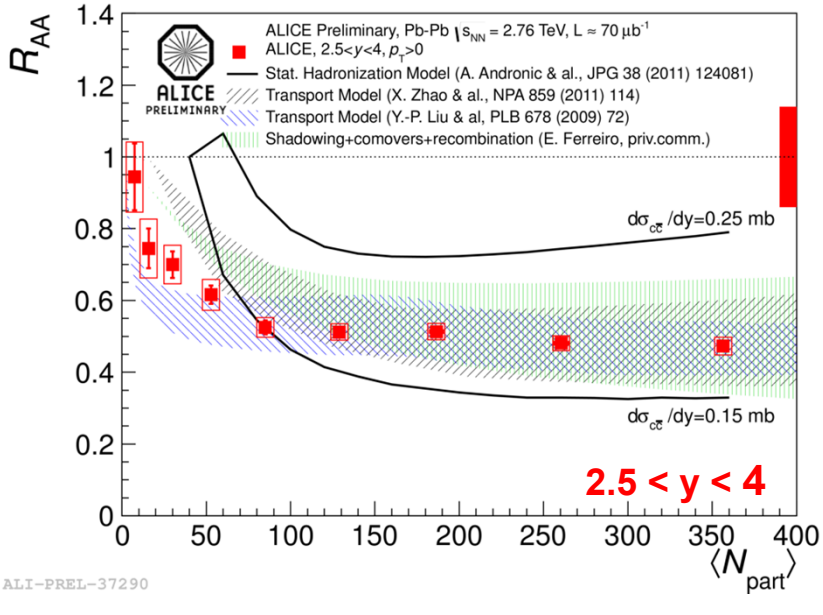
- **similar suppression at forward & central rapidity within uncertainties**
- **first indication of $R_{AA}(D) < R_{AA}(B)$ (not exactely same p_T and y ranges)**

more: see X. Zhang talk

Charmonium production

- **sensitive probe of the deconfined medium**
  - **suppression by colour screening proposed as a signature of deconfinement (Phys. Lett. B 178 (1986) 416)**
- **abundant $c\bar{c}$ production rates at the LHC**
  - **role of regeneration in J/ψ production mechanism?**
  - **do we see a clear signature?**





- **J/ψ suppression smaller at low p_T, low p_T region accessible only by ALICE at the LHC**
- **R_{AA} flattens for $< N_{part} >$ larger than 70**
- **transport models including a large fraction of regenerated J/Ψ (> 50% in central collisions) & statistical hadronization model with all J/ψ produced at hadronization describe J/ψ R_{AA} within uncertainties**

France and China in ALICE

China (3 laboratories)

- China Institute of Atomic Energy (CIAE), Beijing
- Central China Normal University (CCNU), Wuhan
- Huazhong University of Science and Technology (HUST), Wuhan

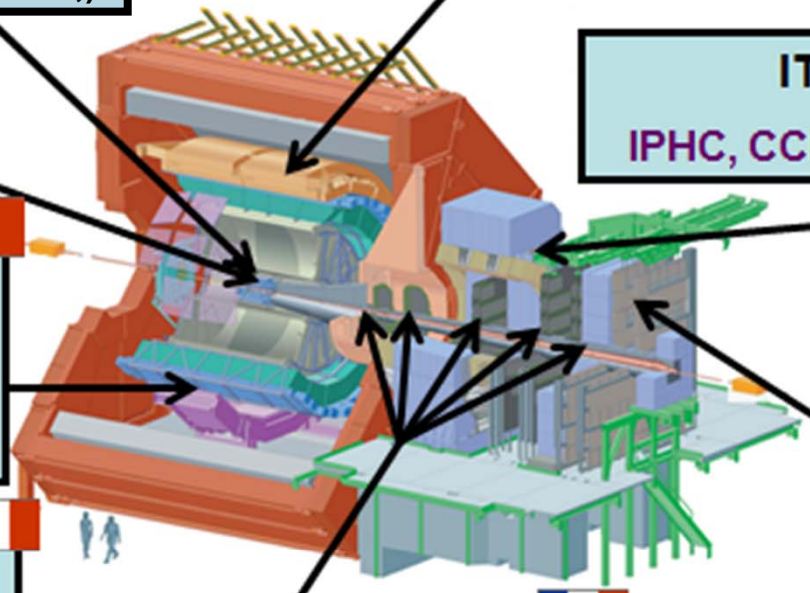
10 physicists (permanent)
10 tech. staff (permanent)
10 PhD students

France (8 laboratories)

- LPC, Clermont-Ferrand
- LPSC, Grenoble
- IPNL and CC-IN2P3, Lyon
- Subatech, Nantes
- IPNO, Orsay
- CEA-IRFU, Saclay
- IPHC, Strasbourg

45 physicists (permanent)
13 tech. staff (permanent, FTE)
20 PhD students & post-docs

Contributions from China and France in ALICE



ITS/SSD
SUBATECH, IPHC
(+ CERN, Finland, Holland, Italy, Poland, Russia, Ukraine,)

V0
IPNL
(+ Mexico)

PHOS
CCNU, CIAE, HUST
(+ CERN, Czech Republic, Germany, Japan, Norway, Poland, Russia)

MFT project
IPNL, LPC, IPNO, SACLAY, SUBATECH
(+ Russia, India, Armenia, South-Africa, Italy (sim.))

EMCAL
SUBATECH, IPHC, LPSC
(+ USA, Italy)

DCAL
SUBATECH, IPHC, LPSC, CCNU
(+ USA, Italy, Japan)

ITS upgrade
IPHC, CCNU (+ other countries)

MUON-GMS
IPNL, LPSC
(+ Armenia)

MUON-trigger
LPC, SUBATECH
(+ Italy)

MUON-tracking
SUBATECH, IPNO, SACLAY
(+ Italy, India, Russia)

physics
- quarkonia & heavy flavours
- soft physics & strangeness
- jets & photons

offline, online, computing, management

The FCPPL-ALICE project

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)
	Leader			*Leader*		
	Bastid Nicole	Pr	IN2P3	Zhou Daicui	Pr	CCNU
	Aphecetche Laurent	CR	IN2P3	Cai Xu	Pr	CCNU
	Baldisseri Alberto	Physicien	IRFU	Yang Chunbin	Pr	CCNU
	Batigne Guillaume	MC	IN2P3	Yin Zhongbao	Pr	CCNU
	Cheshkov Cvetan	CR	IN2P3	Liu Fuming	Pr	CCNU
	Cheynis Brigitte	CR	IN2P3	Zhou Daimei	Pr	CCNU
	Conesa-Balbastre Gustavo	CR	IN2P3	Wang Yaping	Ass. Pr	CCNU
	Crochet Philippe	DR	IN2P3	Pei Hua	Ass. Pr	CCNU
	Delagrange Hugues	DR	IN2P3	Wang Dong	Lecturer	CCNU
	Dupieux Pascal	DR	IN2P3	Zhang Xiaoming	Post-doc	CCNU
	Estienne Magali	CR	IN2P3	Mao Yaxian	Post-doc	CCNU/VU
	Faivre Julien	MC	IN2P3	Zhu Jianlin	PhD student	CCNU
	Furget Christophe	PR	IN2P3	Xiang Changzhou	PhD student	CCNU
	Germain Marie	CR	IN2P3	Zhang Fan	PhD student	CCNU
	Guernane Rachid	CR	IN2P3	Zhou Fengchou	PhD student	CCNU
	Kox Serge	DR	IN2P3	Wang Mengliang	PhD student	CCNU
	Martinez-Garcia Gines	DR	IN2P3	Zhu Xiangrong	PhD student	CCNU
	Massacrier Laure	Post-doc	IN2P3	Li Shuang	PhD student	CCNU
	Pillot Philippe	CR	IN2P3	Zhu Jianhui	PhD student	CCNU
	Réal Jean Sébastien	DR	IN2P3	Zhang Haitao	PhD student	CCNU
	Rosnet Philippe	PR	IN2P3	Zhu Hongsheng	PhD student	CCNU
	Roy Christelle	DR	IN2P3	Hu Peng	Mast. student	CCNU
	Schutz Yves	DR	IN2P3	Dang Ruina	PhD student	CCNU
	Shabetai Alexandre	CR	IN2P3	Zhang Yonghong	PhD student	CCNU
	Silvestre Tello Catherine	CR	IN2P3			
	Stocco Diego	CR	IN2P3			
	Stutzmann Jean Sébastien	IE	IN2P3			
	Tieulent Raphaël	CR	IN2P3			
	Uras Antonio	Post-doc	IN2P3			

- **53 members (CEA-Saclay joined the projet in 2013)**

- **activities**
  - ✓ physics (muons, jets, photons)
  - ✓ computing
  - ✓ detector construction & operation
  - ✓ upgrade projects
  - ✓ management

- **38 members in 2010**
- **46 members in 2012**

FCPPL-ALICE report (2012): activities

Students

- **Co-tutorship PhD theses**
  - ✓ Xiaoming Zhang (CCNU) at LPC Clermont-Ferrand (2009-2012)
  - ✓ Shuang Li (CCNU) at LPC Clermont-Ferrand (2012-2015)
  - ✓ Mengliang Wang (CCNU) at Subatech Nantes (2012-2015)
- **PhD theses**
  - ✓ Jianhui Zhu (CCNU), in collaboration with LPC Clermont-Ferrand & Subatech
- **Master III**
  - ✓ Jiebin Luo (CCNU), in collaboration with LPC Clermont-Ferrand

Visits

- **visit of four physicists (N. Bastid (LPC), P. Crochet (LPC), B. Erazmus (CERN), G. Martinez-Garcia (Subatech)) at CCNU-Wuhan (May 2012)**
  - ✓ PhD defense of Xiaoming Zhang & Master defense of Jiebin Luo
  - ✓ define PhD work of Shuang Li & Jianhui Zhu and discuss further collaboration
  - ✓ seminar at SINAP in Shanghai (G. Martinez-Garcia)
- **visit of F. Zhang (CCNU) & K. Wang (CCNU) at Subatech**
  - ✓ assembly of DCAL strip modules

5th FCPPL workshop at LAL-Orsay & Irfu-Saclay

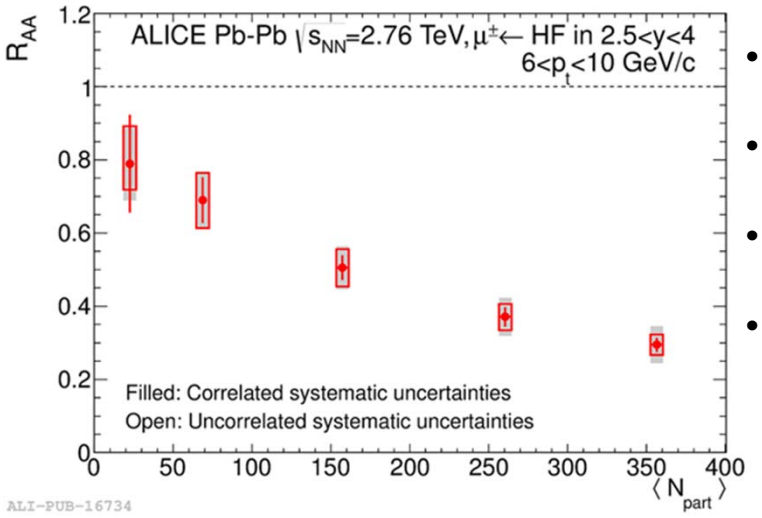
- nine physicists (six from IN2P3/IRFU and three from CCNU)

Xiaoming Zhang
(CCNU Wuhan & LPC Clermont-Ferrand)

3 x 6 months at LPC Clermont-Ferrand
funding: French embassy

- **2009-2012: co-tutorship PhD CCNU-Wuhan & LPC Clermont-ferrand**
  - ✓ **topic: production and elliptic flow of muons from heavy-flavour decays**
  - ✓ **defended on May 23rd, 2012 at CCNU, two diplomas**
- **Sept.-Dec. 2012: CDD-CNRS at LPC Clermont-Ferrand**
  - ✓ **Muon Forward Tracker (MFT) upgrade projet in ALICE: performance studies**
- **Since Jan. 2013: post-doctoral position at LNBL (Berkeley, USA) in ALICE**

PRL 109 (2012) 112301



- **differential production cross sections in pp:**
  - ✓ **Phys. Lett. B 708 (2012) 265 (PC member)**
- **nuclear modification factor in Pb-Pb:**
  - ✓ **Phys. Rev. Lett. 109 (2012) 112301 (PC member)**
- **heavy-flavour decay muon elliptic flow in Pb-Pb:**
  - ✓ **letter in preparation**
- **performance of MFT for open charm & beauty measurement in Pb-Pb:**
  - ✓ **a section in the Letter of Intent (LoI)**

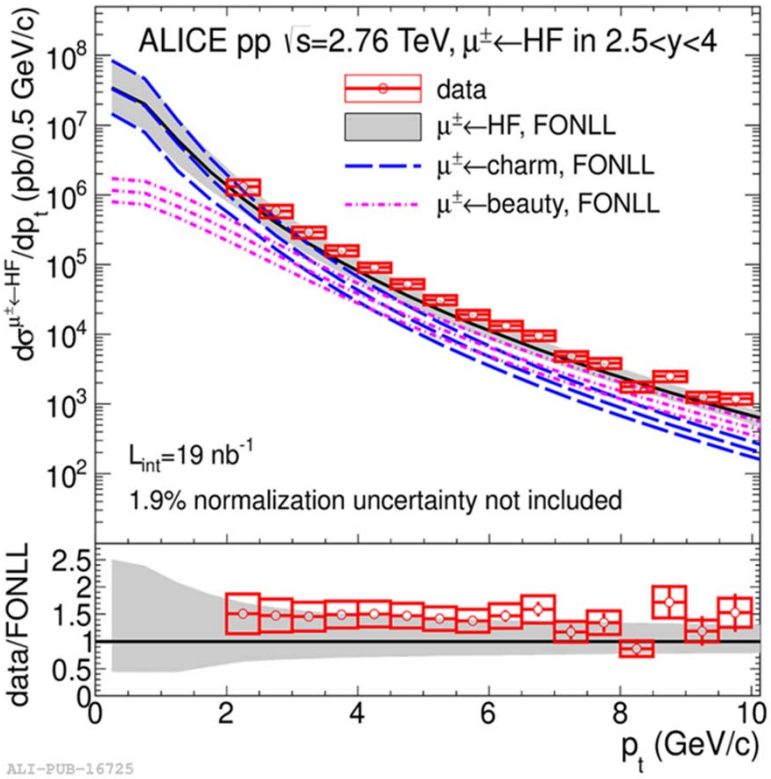
more: see X. Zhang & J. Zhu talks

Jiebin Luo (CCNU Wuhan)

3 months (6 months) at LPC Clermont-Ferrand in 2010 (2011)
funding: CCNU, FCPPL, IN2P3 & UBP

- **2010-2012: master student at CCNU, in collaboration with LPC Clermont-Ferrand**
  - ✓ **topic: production of muons from heavy-flavour decays in pp & Pb-Pb**
  - ✓ **defended on May 23rd, 2012 at CCNU**

Phys. Rev. Lett. 109 (2012) 112301



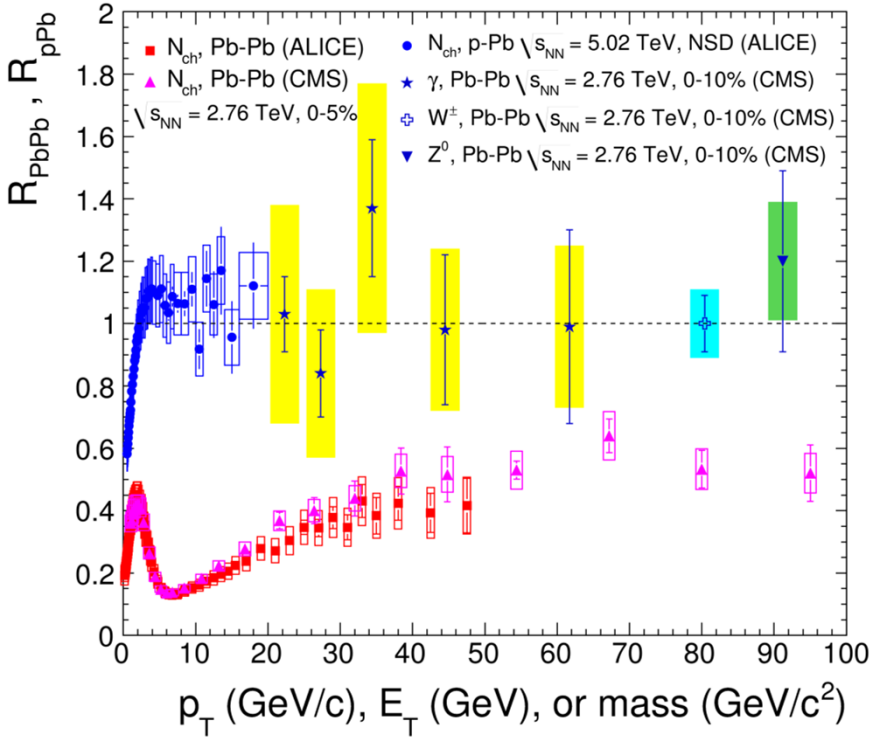
- **contributions to the measurement of the heavy-flavour decay muon production in pp & Pb-Pb (in collaboration with Xiaoming Zhang)**
  - ✓ **measurement of the p_T-differential cross-section in pp collisions at $\sqrt{s}$ = 2.76 TeV**
  - ✓ **development of a complementary method for the background subtraction in pp**
  - ✓ **production of acceptance x efficiency matrices based on MC productions**
- **detailed comparisons Geant3/Geant4**

more: see X. Zhang & J. Zhu talks

Jianhui Zhu (CCNU Wuhan)

2011: 5 months at LPC Clermont-Ferrand, funding: CCNU & UBP
application for a CSC PhD grant (2 years at Subatech)
requested (FCPPL): ~3 months at LPC Clermont-Ferrand in 2013

- **2012-2015: PhD student at CCNU, works in collaboration with LPC Clermont-Ferrand**
  - ✓ **topic: $W^{\pm}$ production in the muon channel in pp and Pb-Pb**



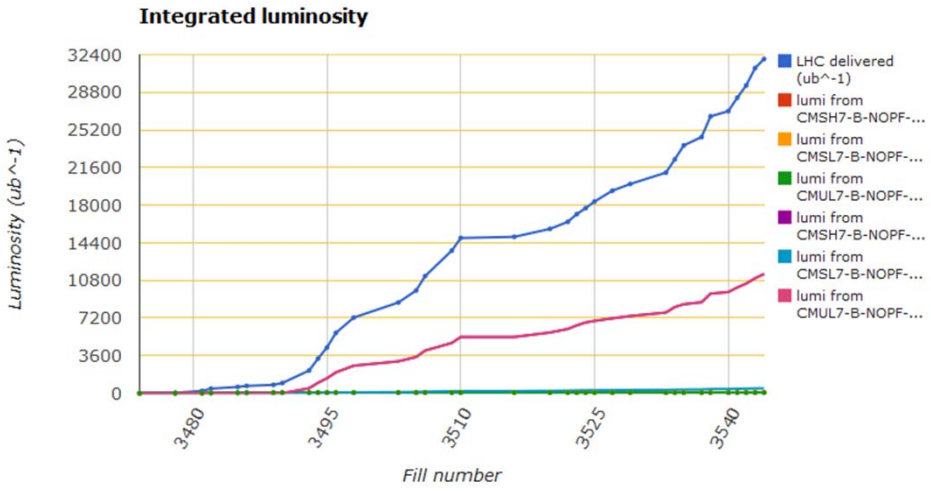
- **hint of a $W^{\pm}$ signal in the muon channel at forward rapidity in Pb-Pb**
  - ✓ **estimation of systematics with realistic MC simulation & efficiency matrix ongoing**
  - ✓ **analysis of pp data ongoing**

ALICE (p-Pb): arXiv:1210.4520
ALICE (Pb-Pb): arXiv: 1208.2711
CMS (W): Phys. Lett. B 715 (2012) 66
CMS (Z^0): Phys. Rev. Lett. 106 (2011) 212301
CMS (ɣ): Phys. Lett. B 710 (2012) 256
CMS (Nch): Eur. Phys. C 72 (2012) 1945

Shuang Li
(CCNU Wuhan & LPC Clermont-Ferrand)

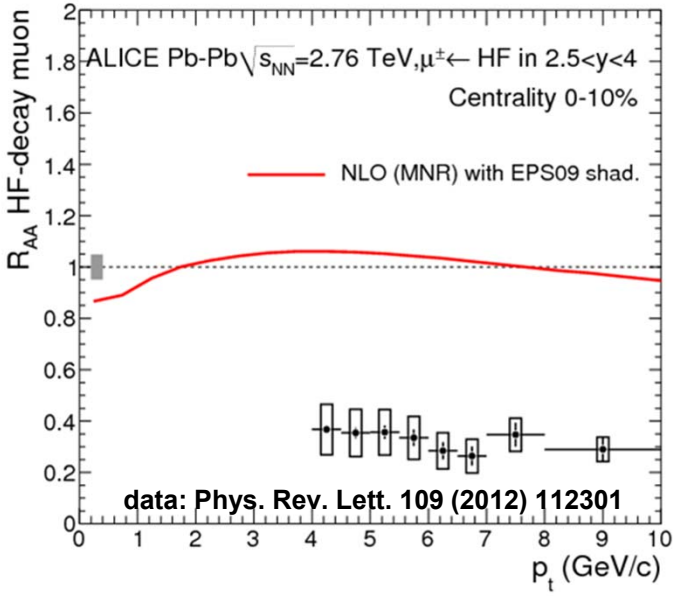
2 years at LPC Clermont-Ferrand, starting in Dec. 2012
funding: CSC PhD-grant

- **2012-2015: co-tutorship PhD CCNU-Wuhan & LPC Clermont-Ferrand**
  - ✓ **topic: production of muons from heavy-flavour decays in p-Pb/Pb-p with ALICE**



rare muon triggers

L_{int} (nb^{-1})	Low p_T	High p_T
p-Pb	0.213	5.386
Pb-p	0.266	6.028

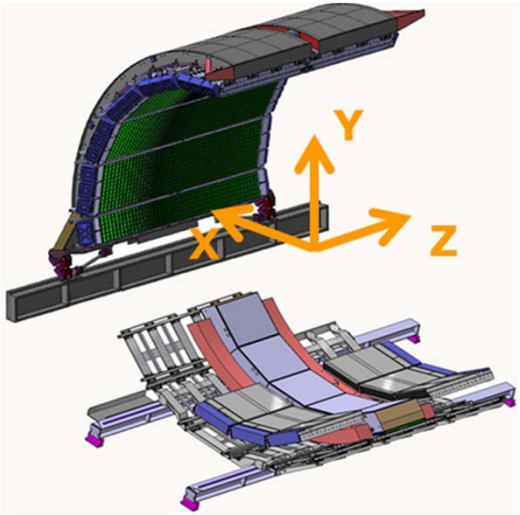


ongoing measurement of $R_{p\text{-}Pb}$ & $R_{Pb\text{-}p}$ for muons from heavy-flavour decays crucial to quantify initial state effects

Mengliang Wang
(CCNU Wuhan & Subatech Nantes)

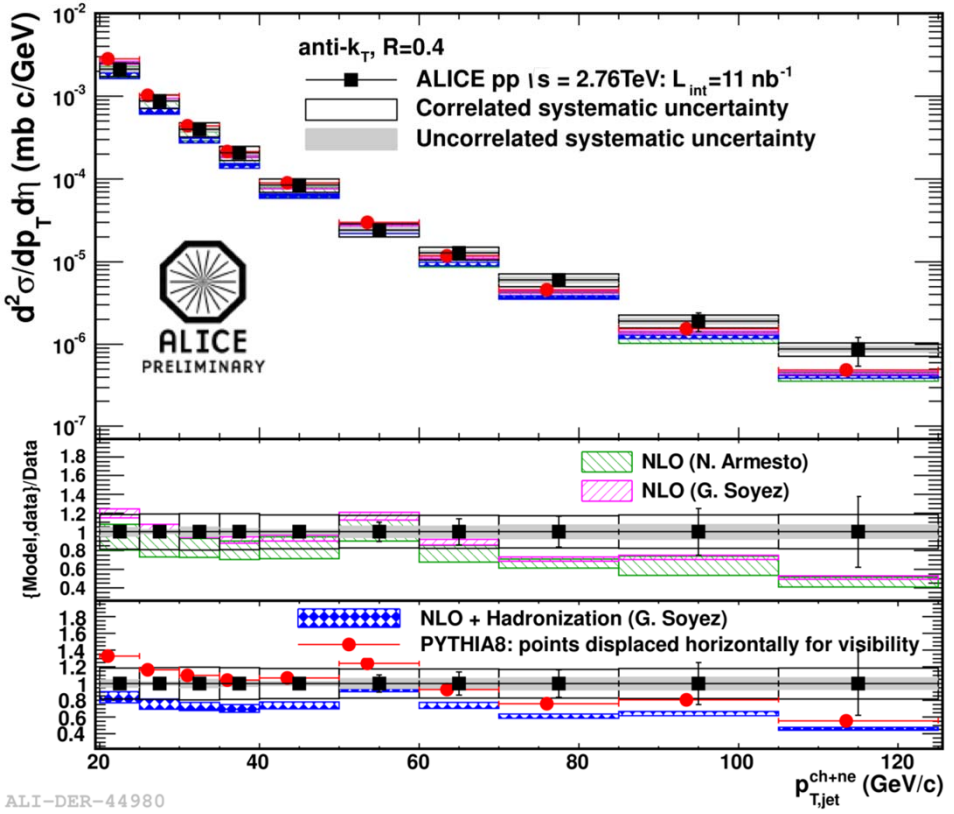
3 years at Subatech, starting in Sept. 2012
funding: CSC PhD-grant

- **2012-2015: co-tutorship PhD CCNU-Wuhan & Subatech Nantes**
  - ✓ **topic: measurement of the jet fragmentation function and jet structure in Pb-Pb**



- **implementation of DCal geometry in the official ALICE analysis software**
- **data analysis**

arXiv: 1301.3475



inclusive jet p_T distribution

Publications/Conferences (students, 2012)

- **2 publications with direct contributions**
  - ✓ Phys. Rev. Lett 109 (2012) 112301: "Production of Muons from Heavy Flavor Decays at Forward Rapidity in pp and Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV"
  - ✓ Phys. Lett. B 608 (2012) 265: "Heavy flavour decay muon production at forward rapidity in proton-proton collisions at $\sqrt{s}$ = 7 TeV"

- **8 talks in international conferences & workshops**
  - ✓ X. Zhang, QM2012, Washington, USA, Aug. 13-18, 2012
  - ✓ X. Zhang, X. Zhu, 8th International Workshop on high p_T physics at the LHC, Wuhan, China, October 21-24, 2012,
  - ✓ J. Zhu, The 4th Asian Triangle Heavy Ion Conference, Pusan, South Korea, Nov. 14-17, 2012
  - ✓ X. Zhang, 5th FCPPL workshop, LAL-Orsay and Irfu-Saclay, France, March 21-24, 2012
  - ✓ S. Li, International MUON Workshop, Cape Town, South-Africa, April 30-May 4, 2012
  - ✓ X. Zhang, Rencontres QGP-France 2012, Sept. 2012
  - ✓ J. Zhu, Alice Physics Week 2012, Puebla, Mexico, Nov. 28-Dec. 1, 2012

- **1 poster in international conference**
  - ✓ X. Zhu, QM2012, Washington, USA, Aug. 13-18, 2012

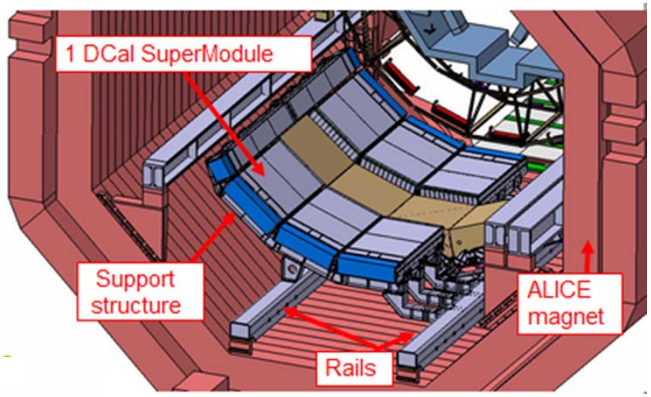
- **2 seminars**
  - ✓ X. Zhang: LBNL, Berkeley, USA, Oct. 2012
  - ✓ X. Zhang: LPC Clermont-Ferrand, France, May 2012

- **many presentations in weekly ALICE Physics Analysis Group meetings and monthly ALICE Physics Working Group meetings**

Hardware activities with DCal (Subatech Nantes, LPSC Grenoble, Wuhan)

DCal: upgrade of EMCal

measurement of di-jet & ɣ-jet correlations
6 super-modules ½ built at Subatech, 1 built at CCNU
Subatech responsible for inserting tools, support structure & and DCal installation
installation in 2013-2014 back-to-back to EMCal



visit of F. Zhang (CCNU) & K. Wang (CCNU) at Subatech in 2012

- equipment of strip modules with optic fibers
- strip module assembly for several super-modules

assembly in super-modules & calibration at LPSC, insertion test at CERN in April 2013


shipping to Nantes


load testing of support structure at CERN


SM assemby at LPSC with strip modules from Subatech

FCPPL-ALICE project for 2013

Funding from France: request of 22600 Euros in total

- stay costs for 2 Chinese physicists at LPSC Grenoble
- stay costs for a Chinese physicist at Subatech Nantes
- stay costs for a Chinese PhD student (J. Zhu) at LPC Clermont-Ferrand
- travel costs for French physicists to the 6th FCPPL workshop
- travel costs for French physicists to CCNU

Funding from China: request of 170,310 Yuan in total

- stay and travel costs for 2 Chinese physicists at LPSC Grenoble
- travel costs for a Chinese physicist at Subatech Nantes
- stay and travel costs a Chinese PhD student (J. Zhu) at LPC Clermont-Ferrand
- stay costs for French physicists for the 6th FCPPL workshop
- stay costs for French physicists at CCNU

Other fundings

- 2 CSC-PhD grants (approved in 2012)
  - ✓ Co-PhD CCNU & LPC Clermont-Ferrand (2 years)
  - ✓ Co-PhD CCNU & Subatech Nantes, EMCal/Dcal group (3 years)
- 1 new demand for CSC-PhD grants ongoing
  - ✓ Co-PhD CCNU & Subatech Nantes, Muon group (2 years)

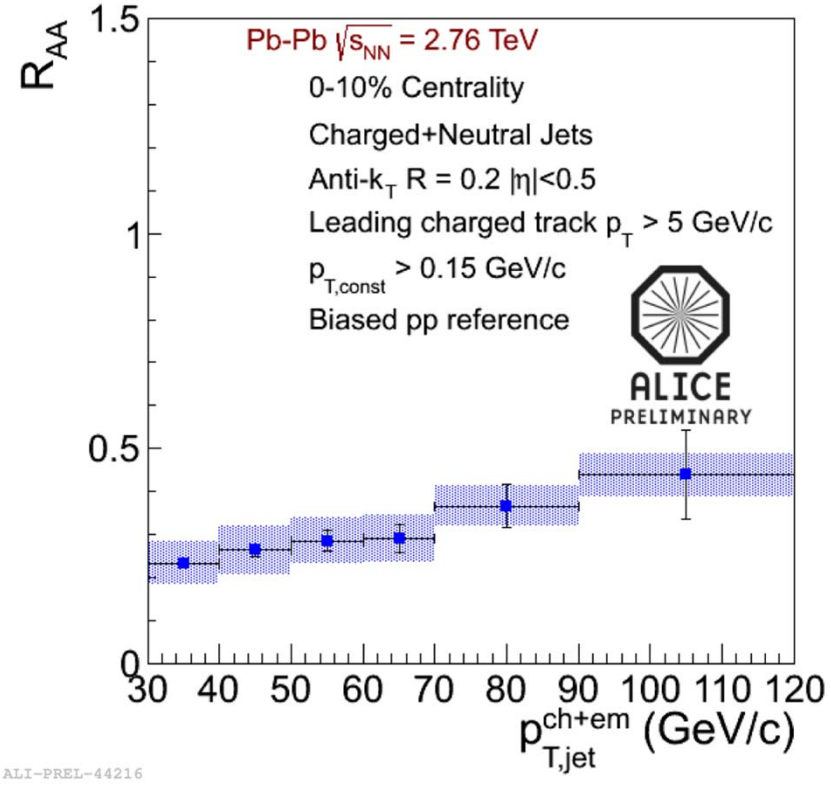
Conclusions

The FCPPL-ALICE Chinese & French collaboration is solid, healthy and very fruitful

- technical contribution to DCal
- contribution to data taking & analysis
  - excellent contributions of students
  - large scientific production

Backup

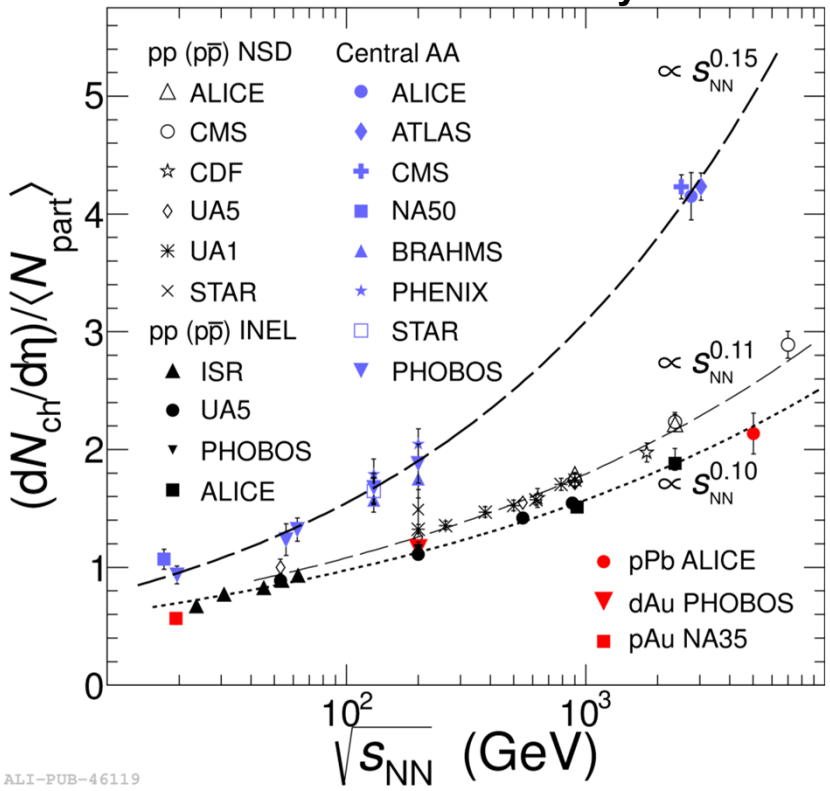
Jet quenching measurement

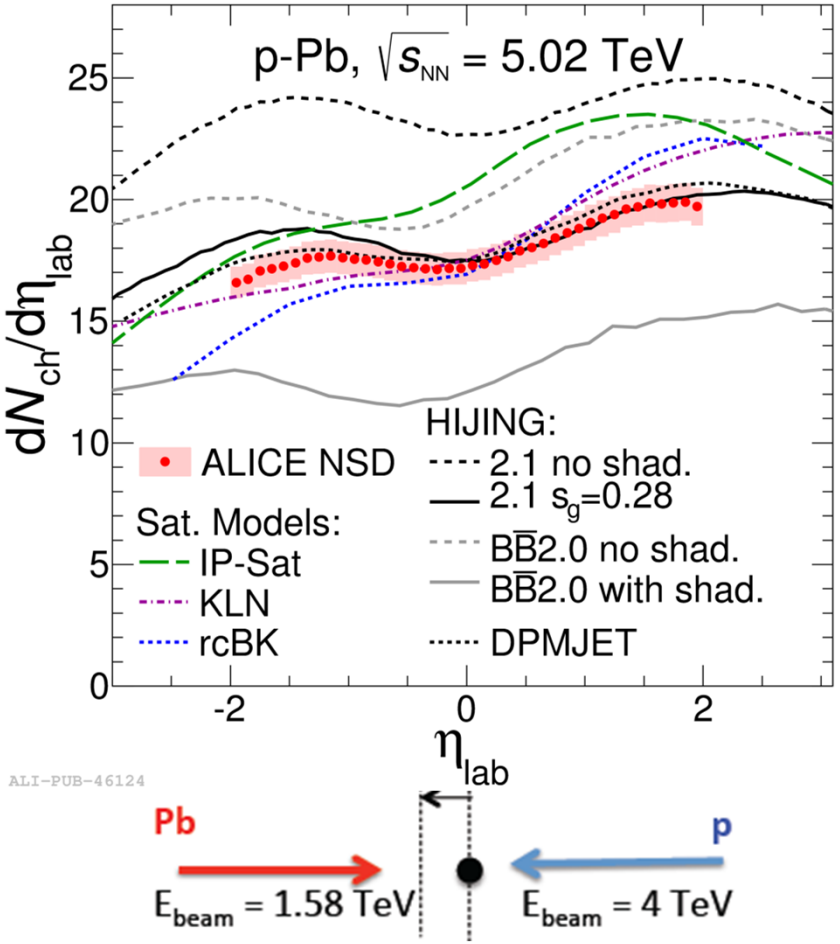


- **jet yield suppressed by a factor 3-4**
  - ✓ **consistent with single particle, taking into account fragmentatiom**
  - ✓ **suggest that the lost energy is radiated at large angles, outside the jet (otherwise would be less suppressed than single particles)**

Particle production in p-Pb collisions

Phys. Rev. Lett. 110 (2013) 032301





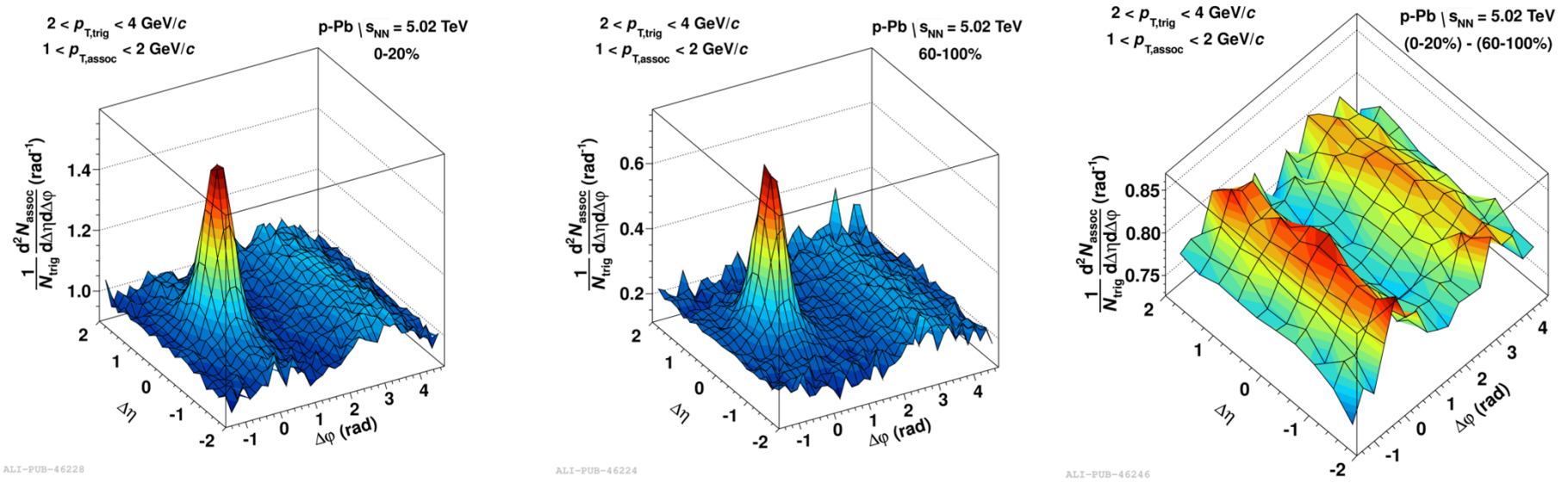
- **multiplicity per participant nucleon follows same energy trend as in pp**
- **new constraints on description of particle production at the LHC: data favour models that incorporate shadowing**

di-hadron correlations in p-Pb collisions

$\Delta\eta\Delta\varphi$ **di-hadron correlation built between a trigger and an associated particle in a given p_T Intervals such as $p_{T,\,assoc} < p_{T,\,trig}$ ($2 < p_{T,\,trig} < 4$ GeV/c & $1 < p_{T,\,assoc} < 2$ GeV/c)**

$$\frac{1}{N_{trig}}\frac{d^2N_{assoc}}{d\Delta\varphi\Delta\eta} = \frac{S(\Delta\varphi,\Delta\eta)}{B(\Delta\varphi,\Delta\eta)}$$

0-20% **60-100%**



- **no near-side ridge in 60-100% (similar to pp collisions)**
- **double ridge observed when subtracting 60-100% to 0-20%**
- **flrst seen by ALICE (Phys. Lett. B 19 (2013) 29) & confirmed by ATLAS (arXiv:1212.5198)**
- **similar observation in Pb-Pb collisions attributed to flow effects**