中国ALICE实验学术研讨会

贵阳，7月30日–8月2日，2021

ALICE实验夸克物质强相互作用动力学研究

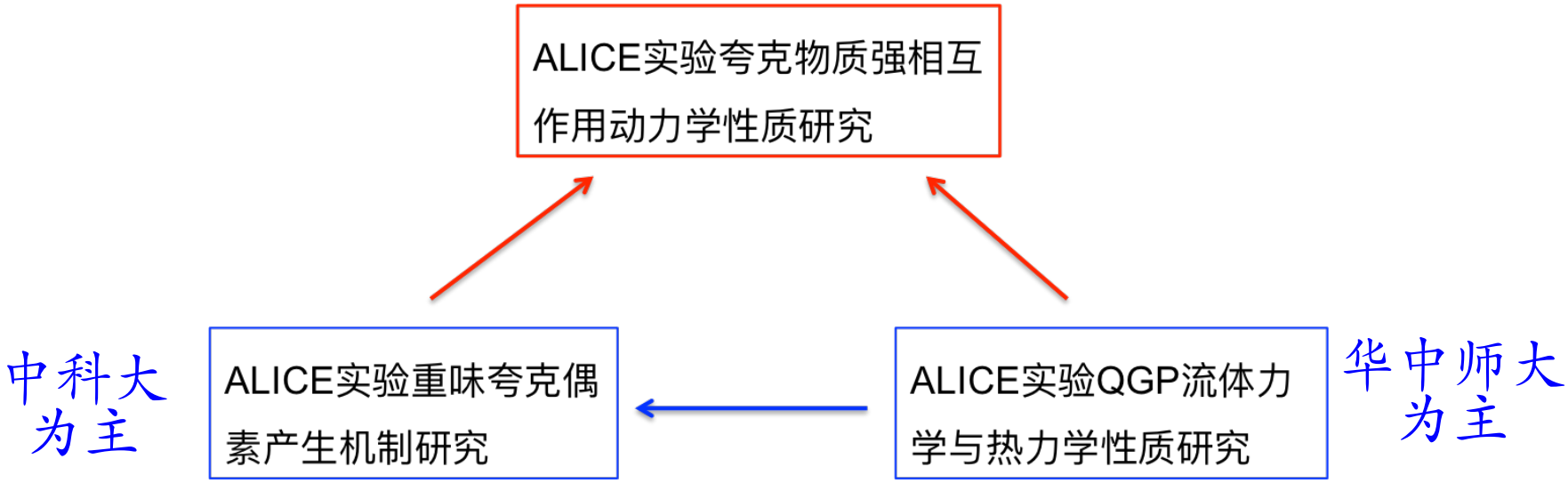
Zebo Tang （唐泽波）

University of Science and Technology of China

State Key Laboratory of Particle Detection and Electronics

项目基本情况

政府间国际科技创新合作重点专项　　2019.08–2024.07



唐泽波
查王妹
李昕 → 白晓智

裴骅

科大该方面数据分析情况

吴奕涛，博士研究生 (2016.9 –)

- J/ψ and D_s in jets in pp@13 TeV, Quark Matter 2019 poster
- 2019.11 visit Strasbourg via CSC，Off–campus supervisor: Boris
- Service task: ITS2 installation & ITS3 WP3

白晓智，特任副研究员

- 2021.02, GSI → USTC
- Inclusive J/ψ production in PbPb@5.02 TeV, preparing for paper
- 2021.06, Jpsi2ee PAG coordinator

卢鹏忠，博士研究生（2018.9 – ）

- Non–prompt J/ψ production in PbPb@5.02 TeV
- Awarded CSC, will visit GSI for two years

熊圳君，硕士研究生 (2021.9 –)

- Will be prepared for quarkonium analysis with Run3 data

J/ψ and D_s in jets in pp@13 TeV

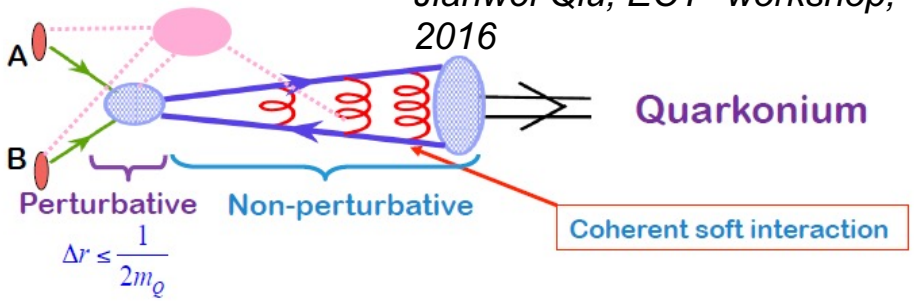
See Yitao Wu's talk for detail

J/ψ production mechanism

Quarkonium is a test ground of QCD

– Test of QCD at the boundary of the perturbative and non–perturbative regimes

Jianwei Qiu, ECT workshop, 2016*



Approximation: on-shell pair + hadronization

$$\sigma_{AB\to J/\psi}(P_{J/\psi}) \approx \sum_n \int dq^2 \left[\sigma_{AB\to[Q\bar{Q}](n)}(q^2)\right] F_{[Q\bar{Q}(n)]\to J/\psi}(P_{J/\psi}, q^2)$$

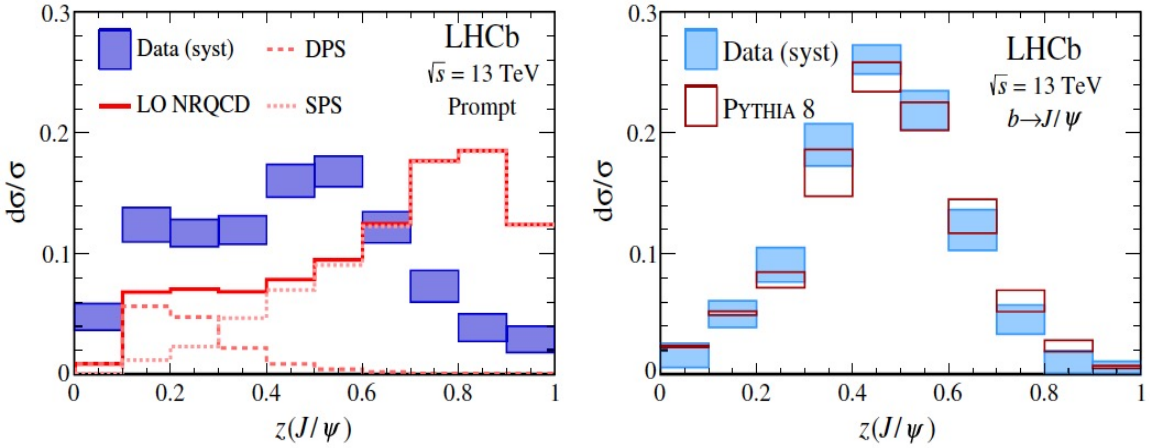
Hadronization:

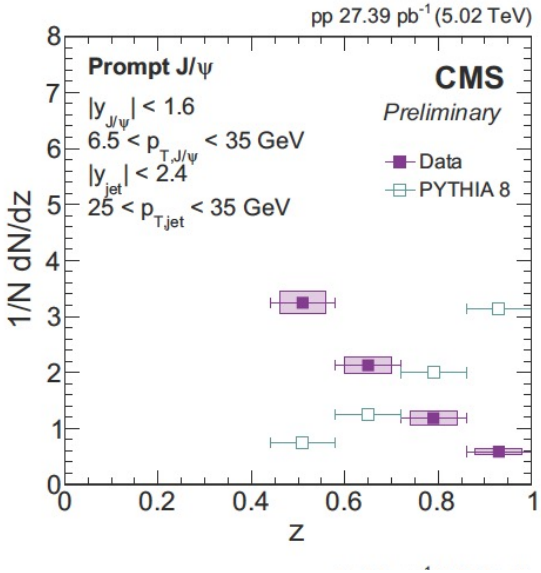
- Color Singlet Model (CSM): 1975 –
  Only the pair with right quantum numbers
- Color Evaporation Model (CEM): 1977 –
  All pairs with mass less than open heavy flavor threshold
- Nonrelativistic QCD (NRQCD): 1986 –
  All pairs with various probabilities: LDMEs

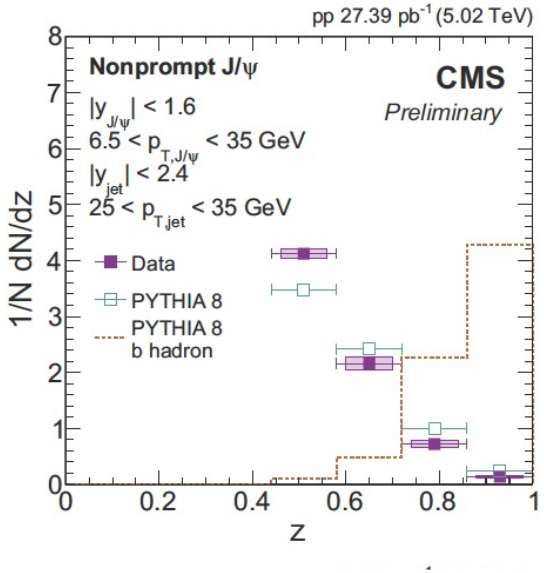
J/ψ production in pp is not fully understood to date

J/ψ production in jets : a novel probe

$20 < p_{T,jet} < 30$ GeV, $2.0 < |\eta_{J/\psi}| < 4.0$







LHCb, PRL118, 192001 (2017)

CMS-PAS-HIN-18-012

B. Diab, NPA982, 186 (2019)

Measurements in ALICE with pp@13TeV

Production of J/ψ meson in jets at mid-rapidity in pp collisions at $\sqrt{s}$ = 13 TeV

Yitao WU[1], Zebo TANG[1], Yaxian MAO[2]

1. University of Science and Techonology of China (USTC, CN)
2. Central China Normal University (CCNU, CN)

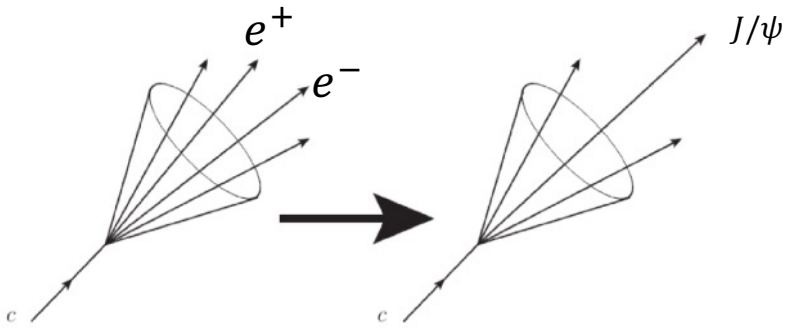
Email: yitao.wu@cern.ch, zebo.tang@cern.ch, yaxian.mao@cern.ch

Abstract

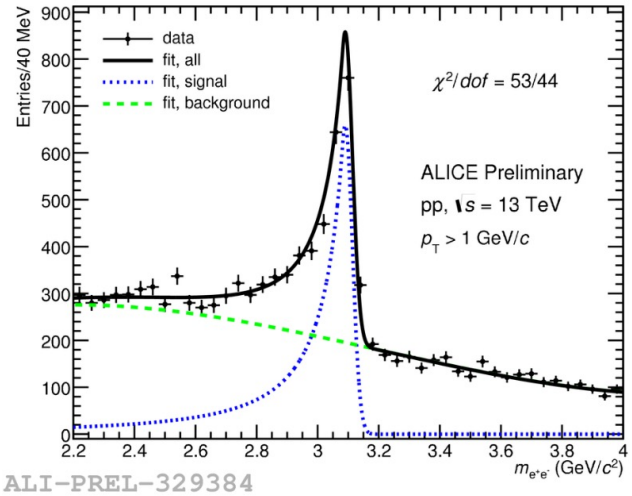
The production of quarkonia in hadron-hadron collisions occurs at the transition between the perturbative and non-perturbative regimes of QCD, resulting in a rich phenomenology that remains far from being fully understood. J/ψ hadronization dynamics can be studied by measuring the p_T fraction, $z \equiv p_{T,J/\psi}/p_{T,jet}$, carried by the J/$\psi$ meson detected inside a jet. The distribution of this quantity, also called fragmentation function, gives us an opportunity to investigate the dominant subprocesses responsible for J/ψ production. In addition, the production of non-prompt J/ψ, coming from b hadron decays, inside a jet should be sensitive to the fragmentation functions of quarks and gluons into b hadrons. The fragmentation of high p_T jets containing a J/ψ meson was measured in pp collisions by LHCb and CMS Collaborations, respectively. The results surprisingly show that non-prompt J/ψ in jets are well described by models, but that prompt J/ψ tend to be produced at much lower z than the model predicted.

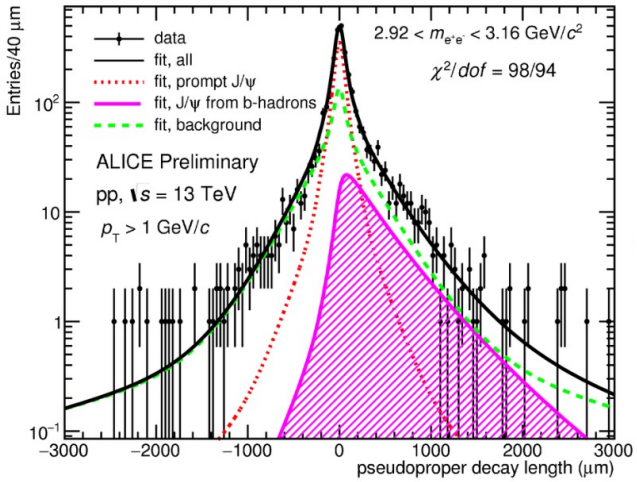
Quark Matter 2019
Poster

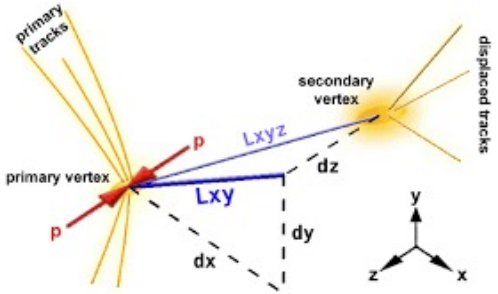
Analysis techniques



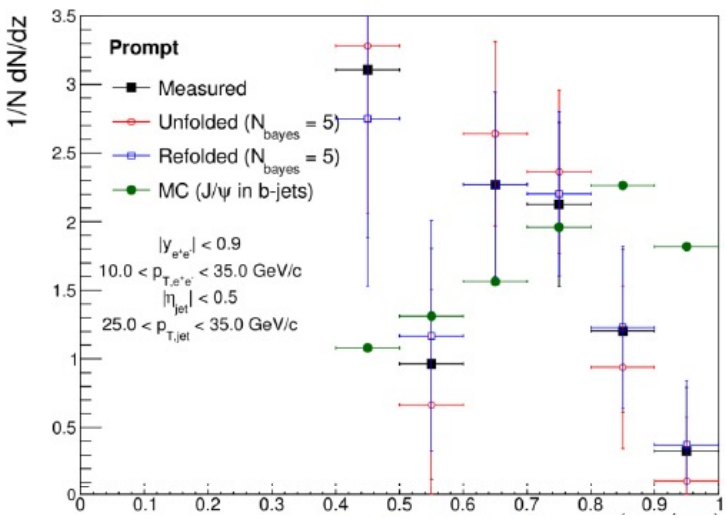
- 13 TeV data taken in 2016–2018
- EMC triggered events for large integrated luminosity
- Anti–kT charged jet
- Pseudo–proper decay length to separate prompt and non–prompt J/ψ

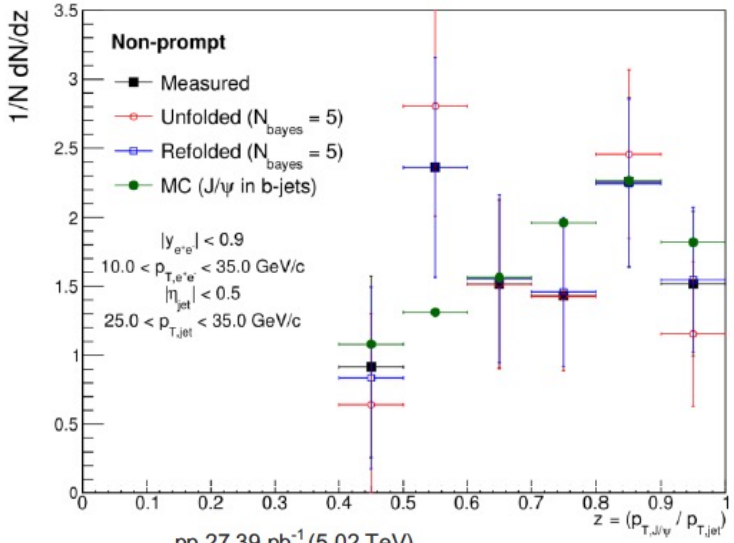


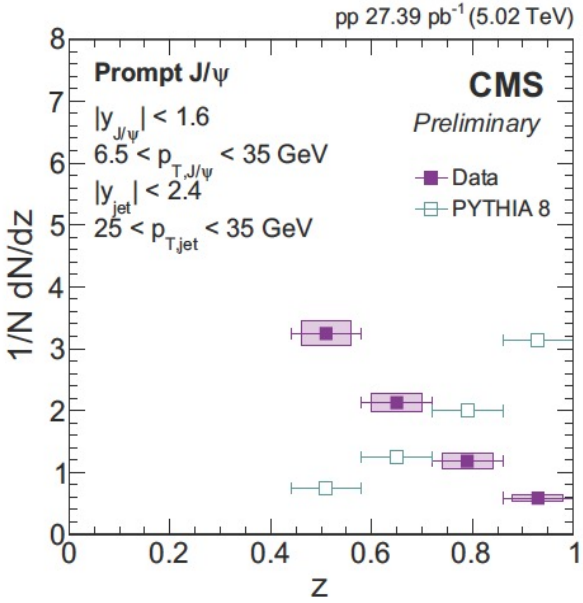


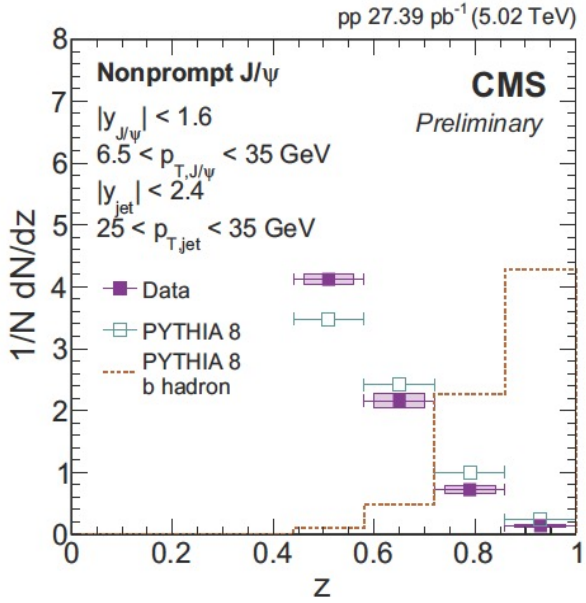


Internal results









Similar trend as CMS prompt

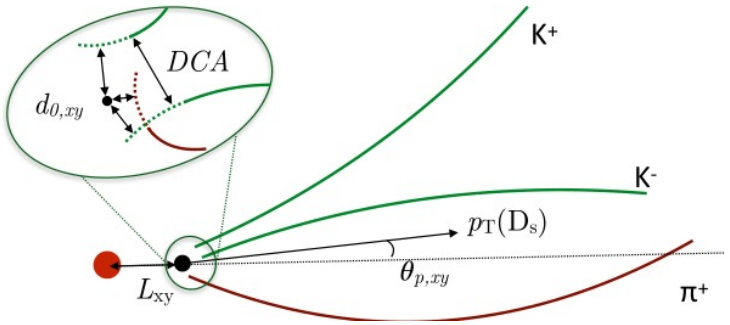
Statistics limited

Suppressed by Johana

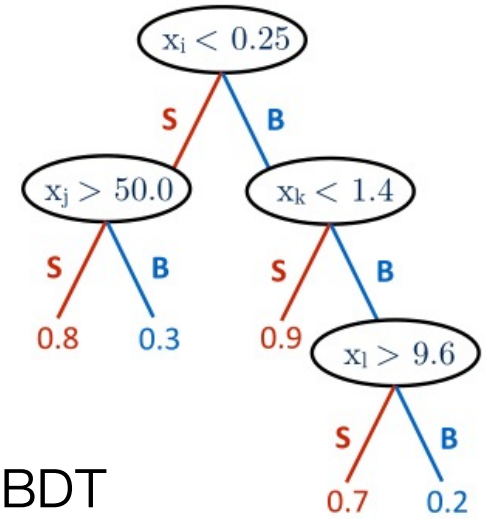
Other groups showed interest

Ds in jets in pp@13 TeV

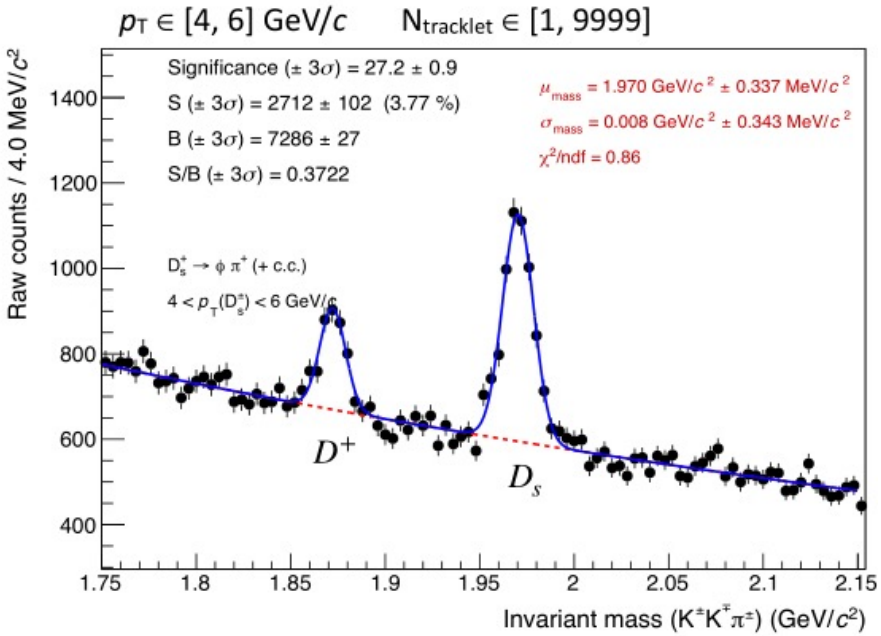
$D_s \to \phi(1020)\pi \to K^+K^-\pi$



Topo. reconstruction



BDT



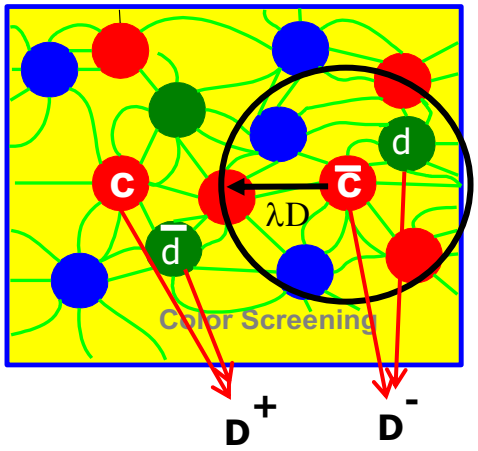
Part of Yitao's PhD Thesis works

J/ψ in PbPb@5 TeV

See Xiaozhi Bai's and Pengzhong Lu's talk for detail

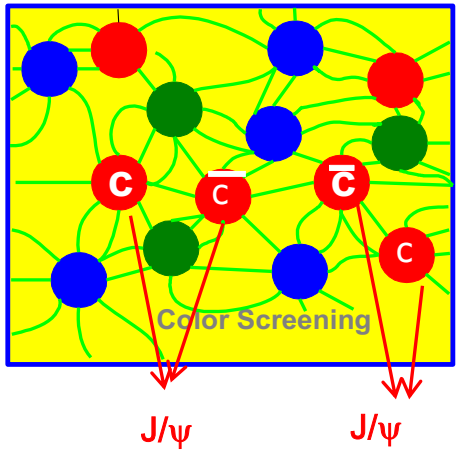
Quarkonium : A probe of deconfinement

Melting in QGP



vs.

Regeneration in QGP

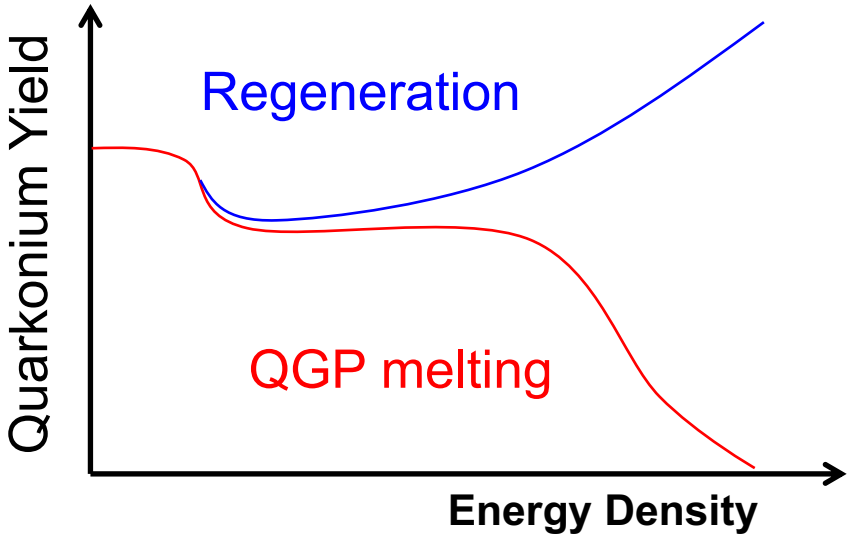


Dissociation due to color–screening

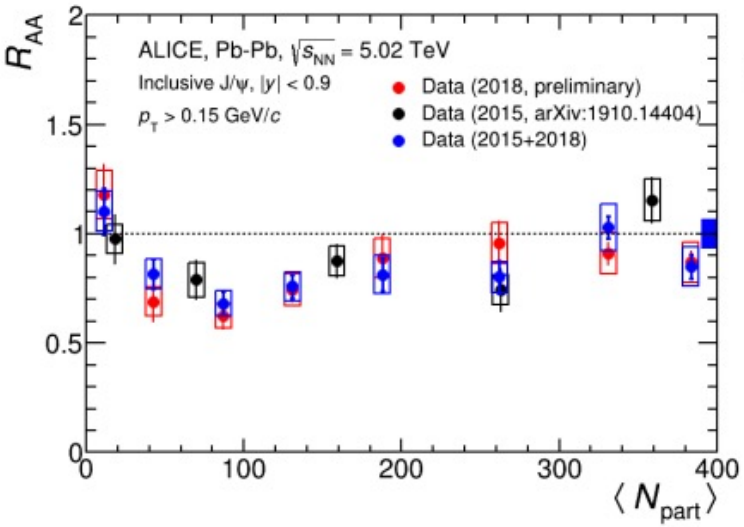
➔ *Signature of QGP formation*

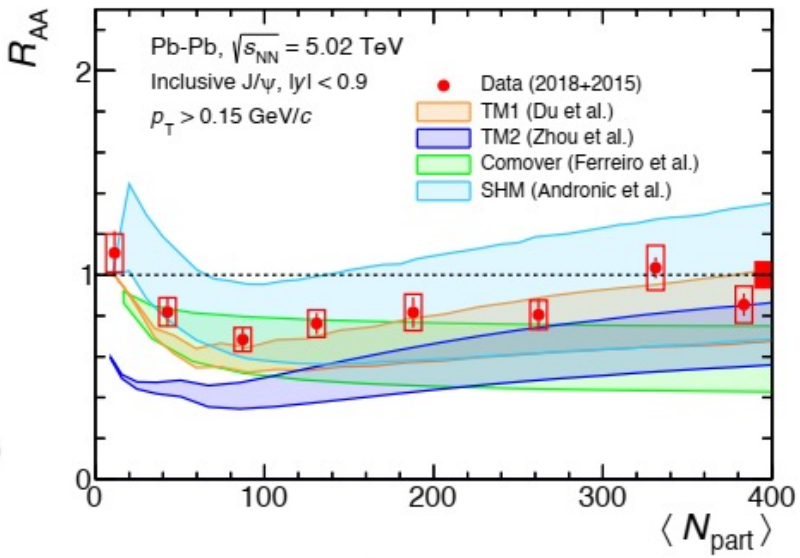
Regeneration due to quark coalescence $\propto N^2_{c\bar{c}}$

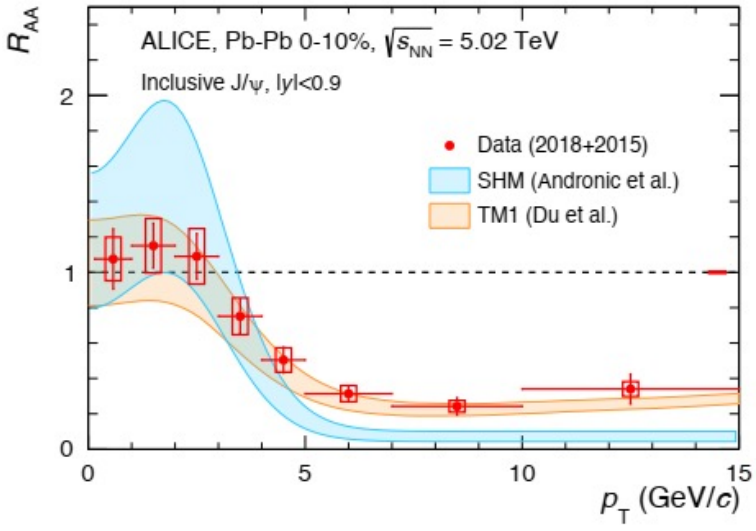
➔ *Deconfinement is a prerequisite*

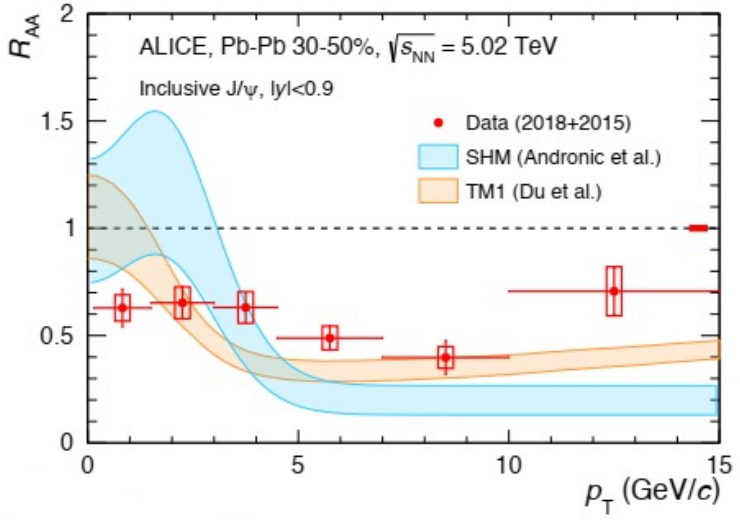


Nuclear Modification Factors

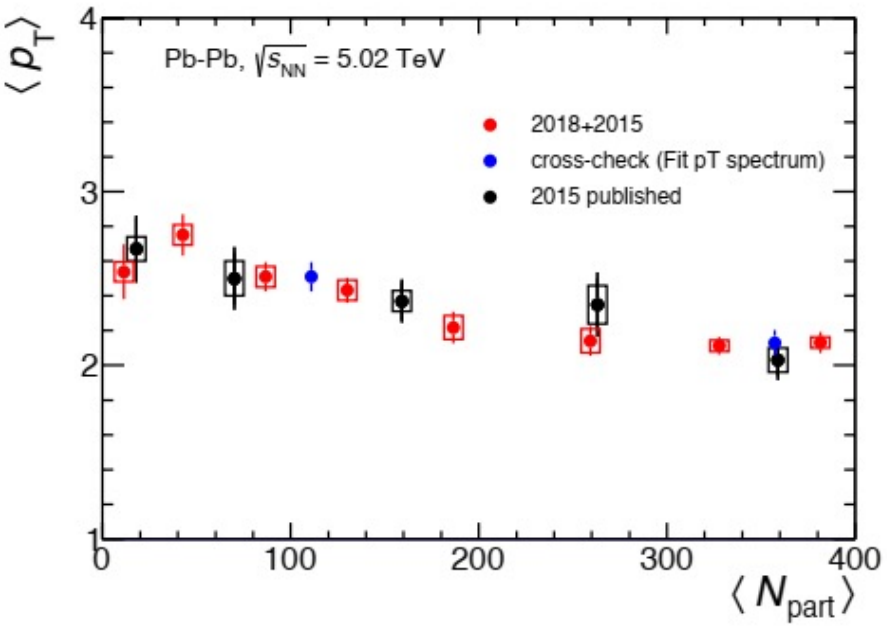








Modification of p_T shape



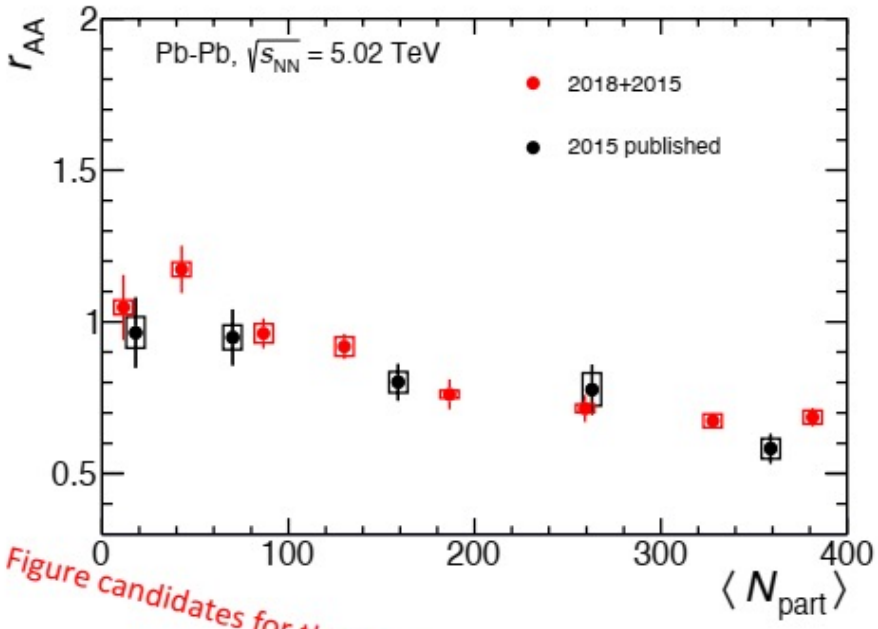


Figure candidates for the paper

<p_T> decreases from peripheral to central

Increasing contribution on regeneration

Paper status

- Paper committee member:
  Xiaozhi Bai, Alena Gromada, Ralf Averbeck, Ionut Arsene

- ARC member:
  Michael Andreas Winn, Cristiane Jahnke

- Analysis Notes:
  https://alice-notes.web.cern.ch/node/953

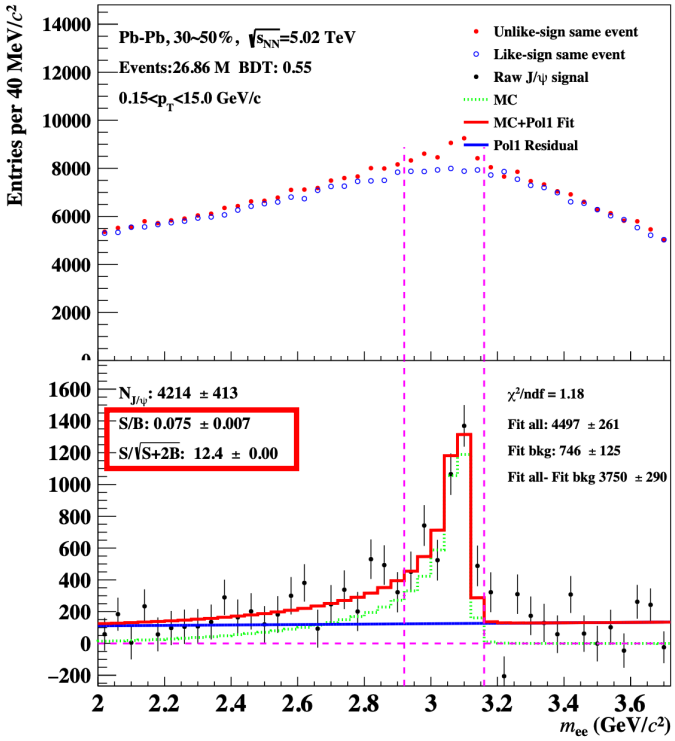
➢ Data and and reconstruction pass (Run 2 Pb-Pb @ 5.02 TeV, 2015 +2018):
  - ✓ LHC18r_pass3
  - ✓ LHC18q_pass3
  - ✓ LHC15o_pass1

➢ MC productions: LHC20g5a, LHC20g5b, LHC20g5c, LHC20g5d, LHC16j1

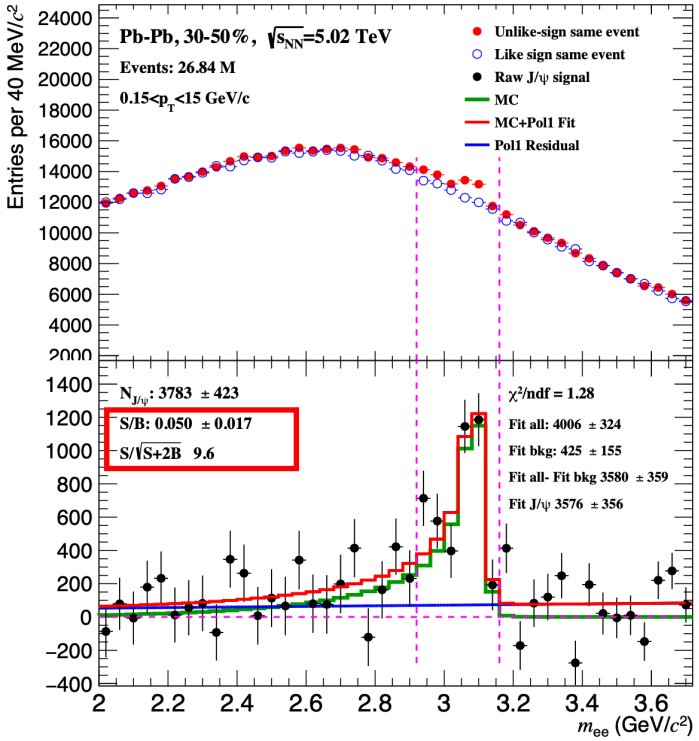
➢ Paper proposal on PF: https://indico.cern.ch/event/1010542

Test machine learning for inclusive J/ψ

Machine learning



Standard method (Xiaozhi etc)

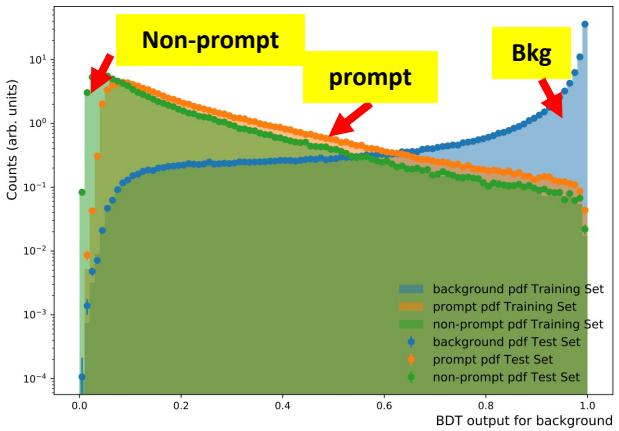


- An example of the performance after BDT cuts and classical cuts.
- Both S/B and Significance Improved obviously w.r.t. the standard method.

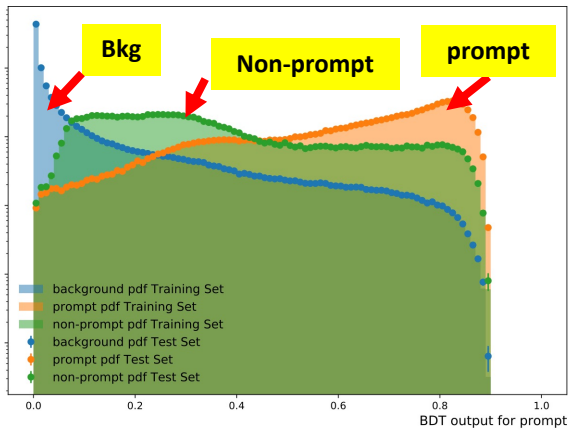
Non–prompt J/ψ measurement

Inclusive input features + pseudo–proper decay length

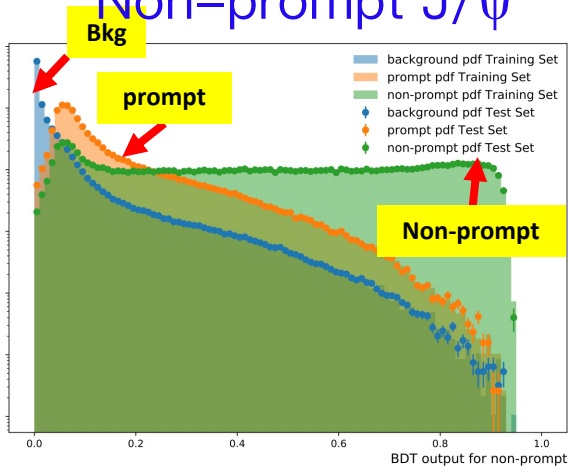
Background

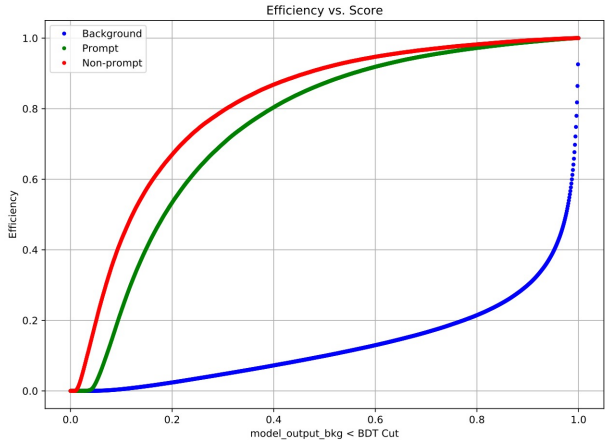


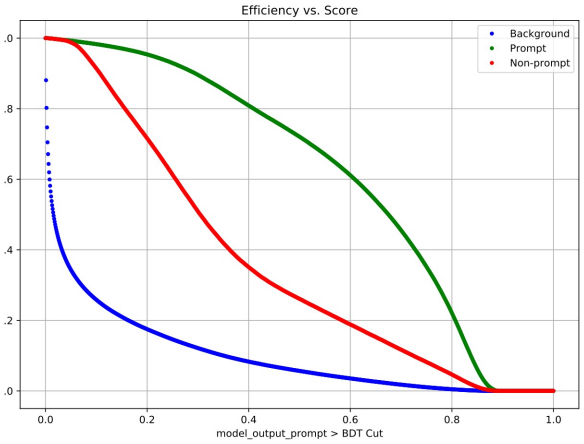
Prompt J/ψ

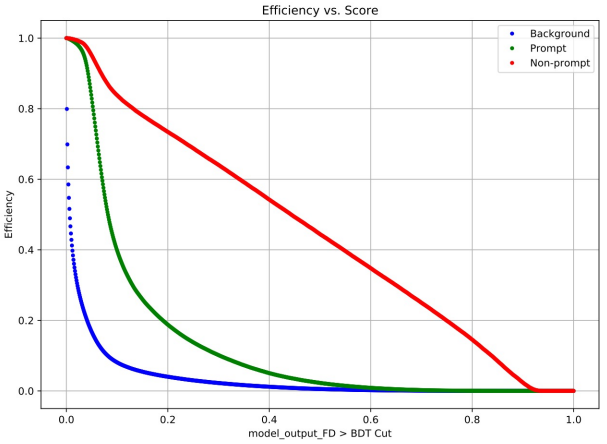


Non–prompt J/ψ









Collaboration with GSI group

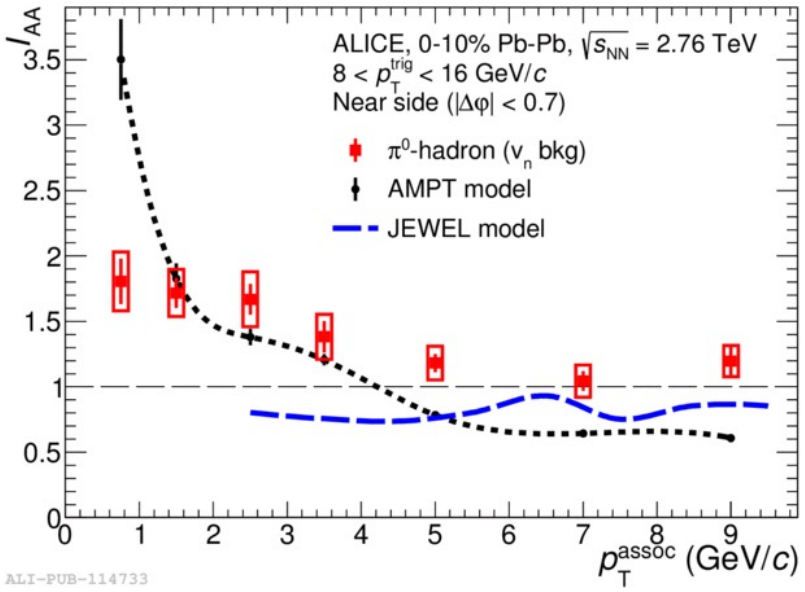
Liuyao from Fudan University will also visit GSI as joint postdoc and will work on quarkonium with ALICE as well

V0–h correlation in pp+PbPb@5 TeV

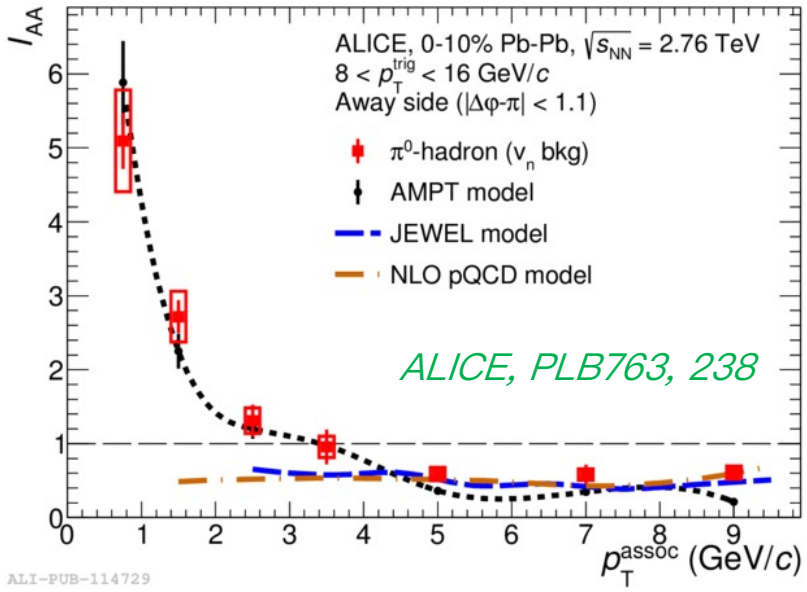
See Mustafa Anaam's talk for detail

Jet–like π^0–h correlation

Near side



Away side

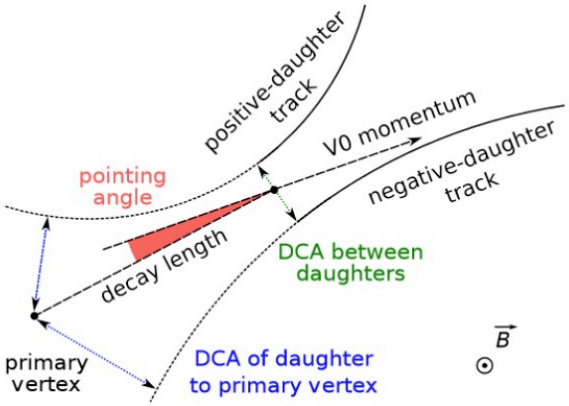


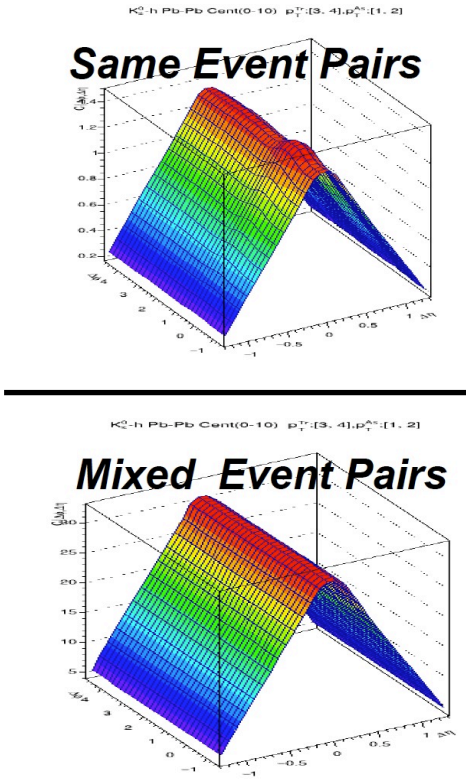
New side: >1 at low pT and approach to 1 at high–pT
medium response or trigger bias

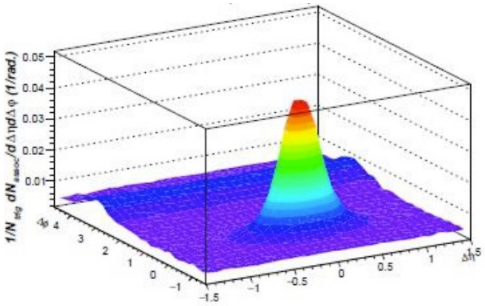
Away side: >1 at low pT and < 1 at high–pT
jet quenching

Favor/mass dependence?

V0–h correlation analysis method



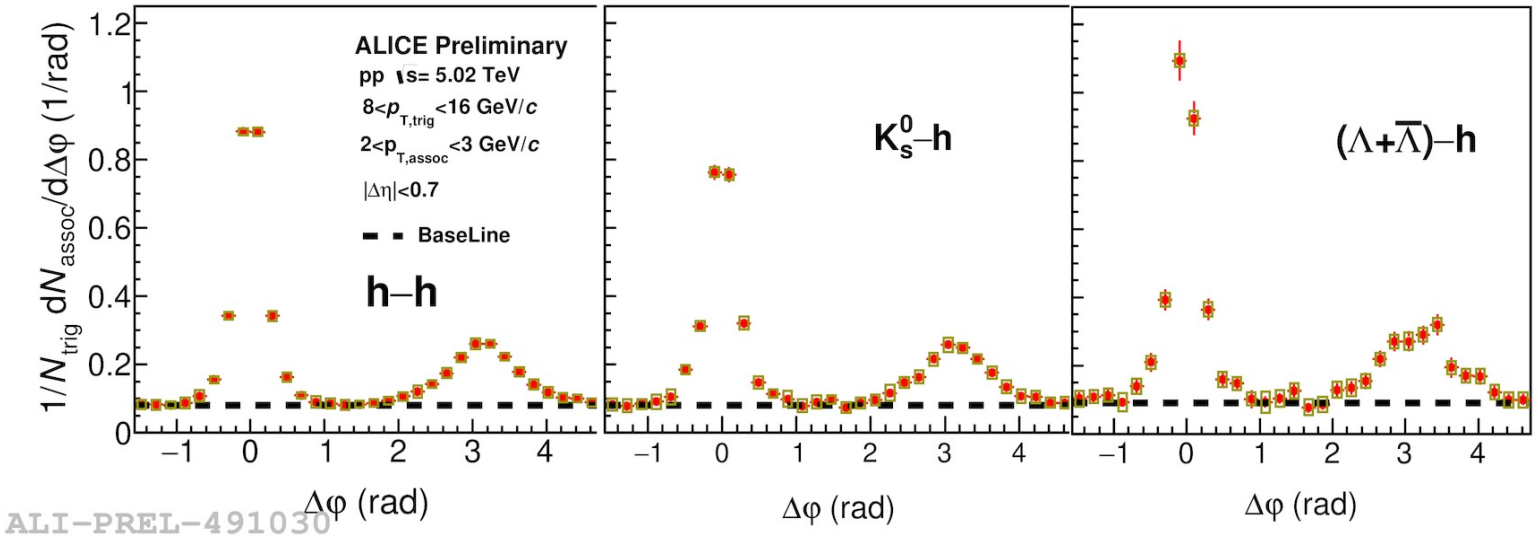




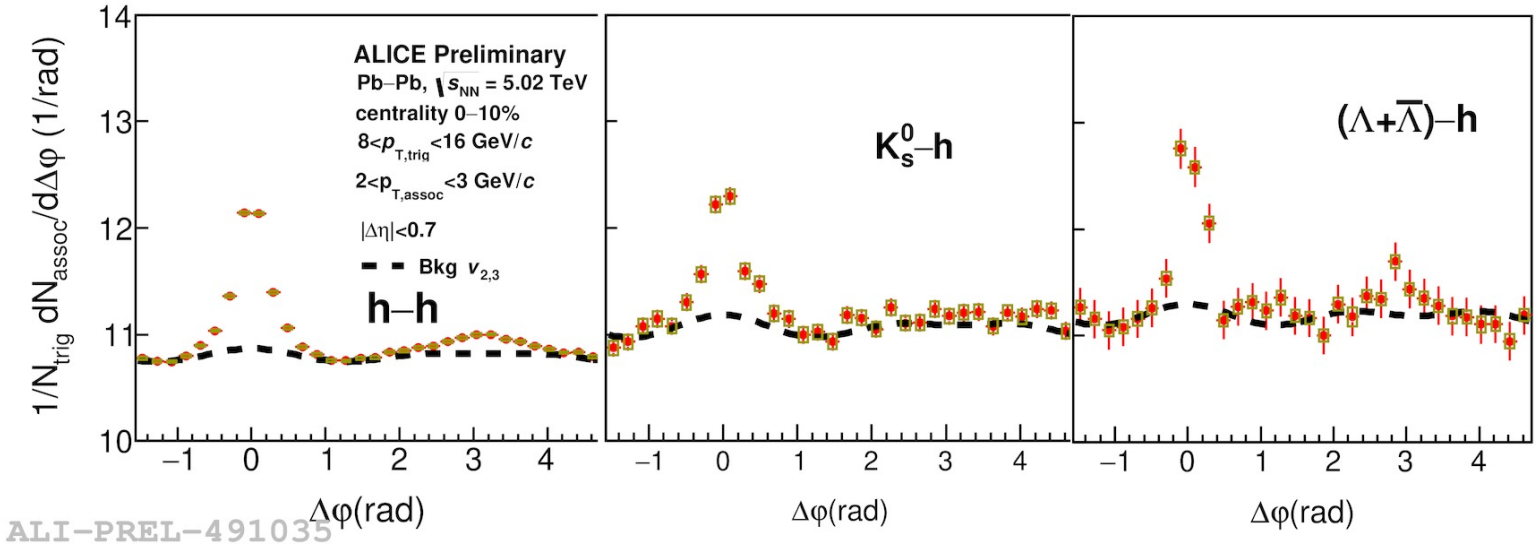
$K^0_S \rightarrow \pi^+ + \pi^-$

$\Lambda \rightarrow$ proton + π^-

Correlation functions



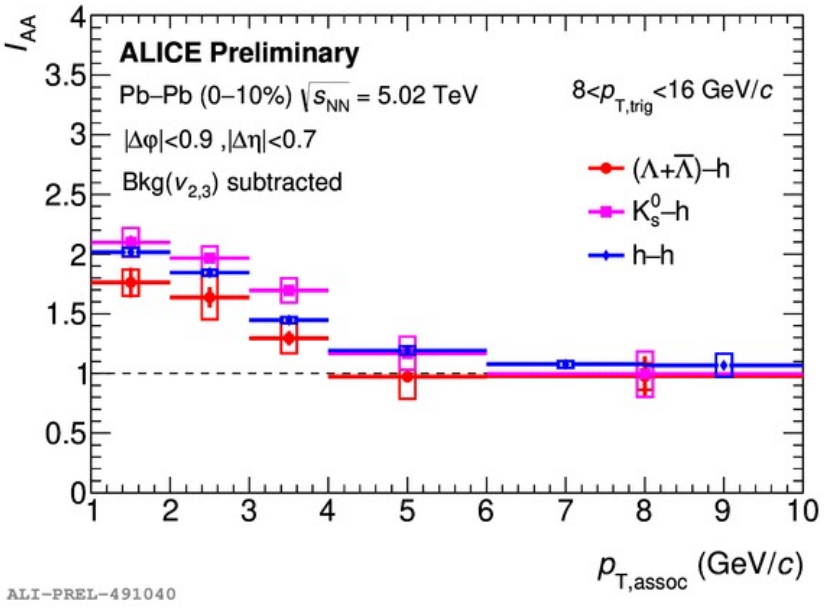
pp



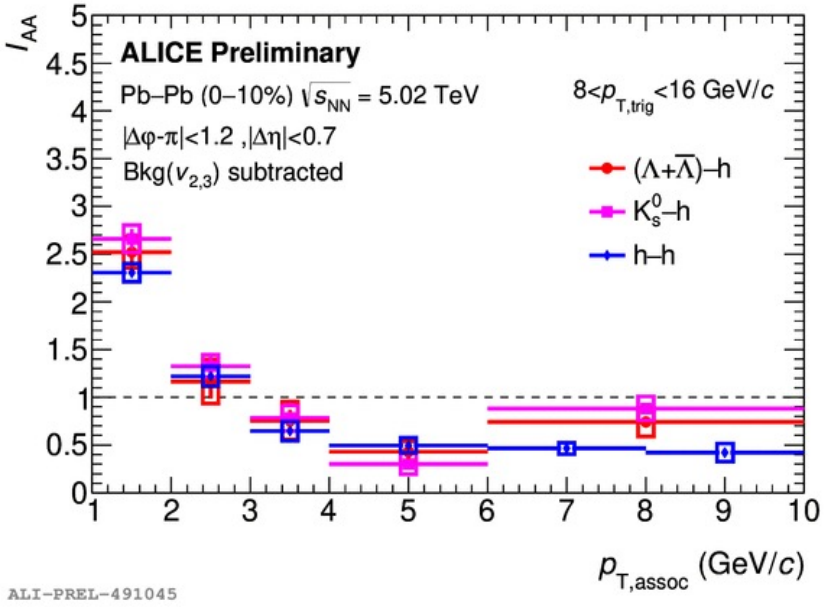
PbPb

h–h, K_S–h and Λ–h

Near side



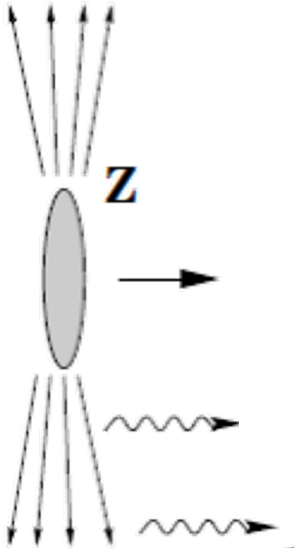
Away side



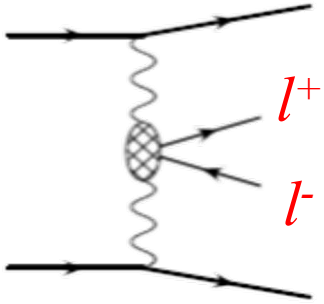
- At most central Pb–Pb (0–10%) and highest trigger p_T, the flow subtracted yields are qualitatively close between K^0_S, Λ and inclusive charged hadron triggers
- While K^0_S–h I_{AA} usually stay closely with inclusive h–h, the Λ –h CF are quantitatively different

Photo-production

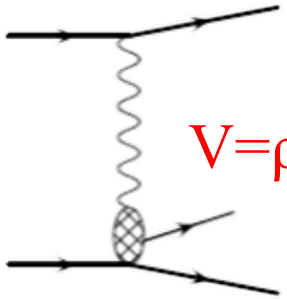
Extremely strong EM field in HIC



$\gamma + \gamma$



$\gamma + A$



$V=\rho, \omega, \phi, J/\psi \ldots$

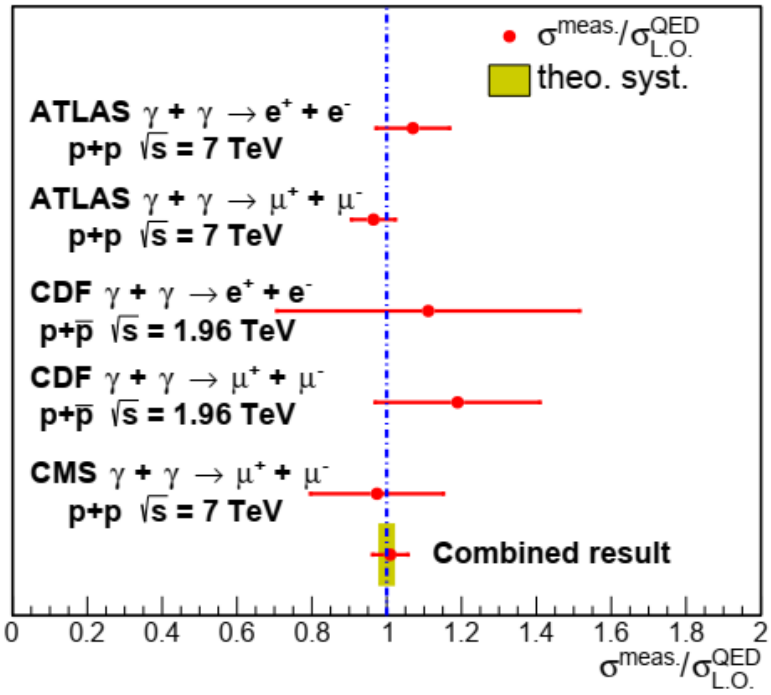
- Strong EM field accompanies the nuclei in relativistic heavy–ion collisions
- The Lorentz contracted EM field can be expressed in terms of equivalent photon flux
- Quasi–real photon induces dilepton and vector meson production

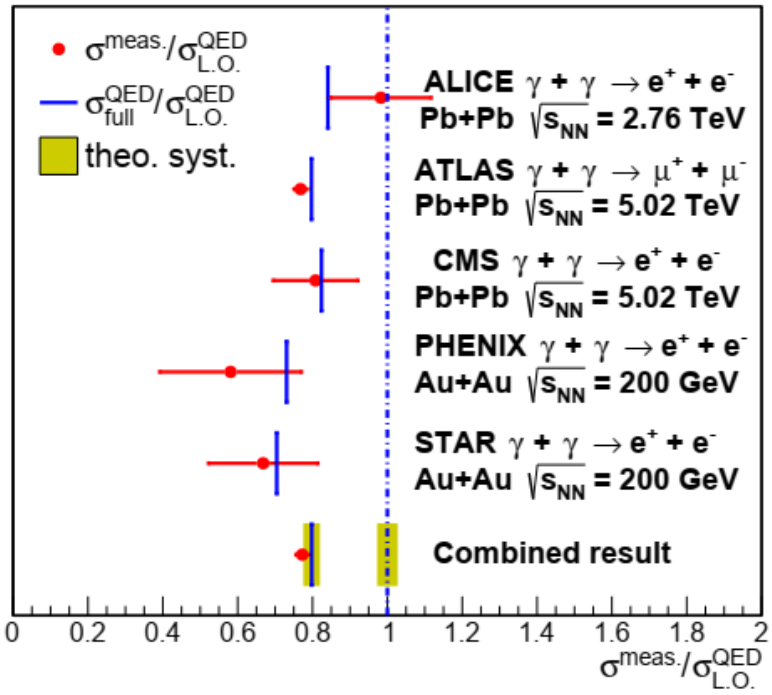
Discovery high order QED with e^+e^-

Discovery of higher order quantum electrodynamics effect for the vacuum pair production

Wangmei Zha[1,*] and Zebo Tang[1,†]
[1] *University of Science and Technology of China, Hefei, China*
(Dated: March 9, 2021)

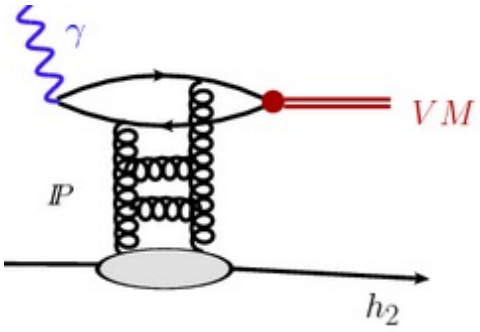
useful discussions. This work was funded by the National Natural Science Foundation of China under Grant Nos. 11775213 and 11720101001, and MOST under Grant No. 2018YFE0104900.



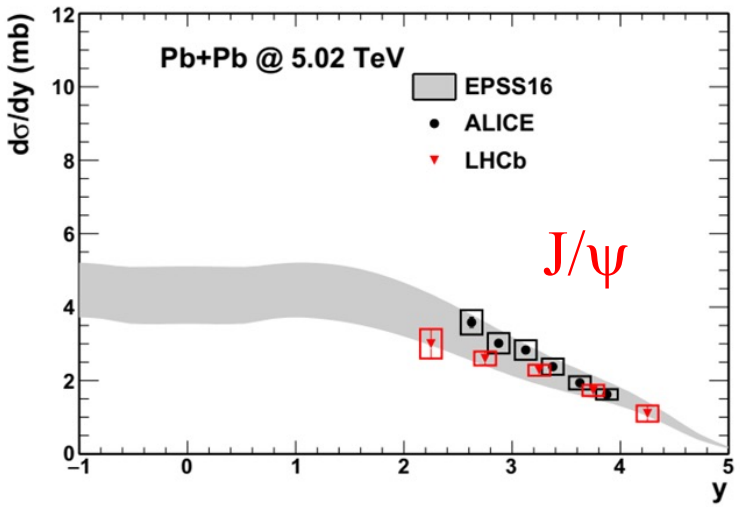


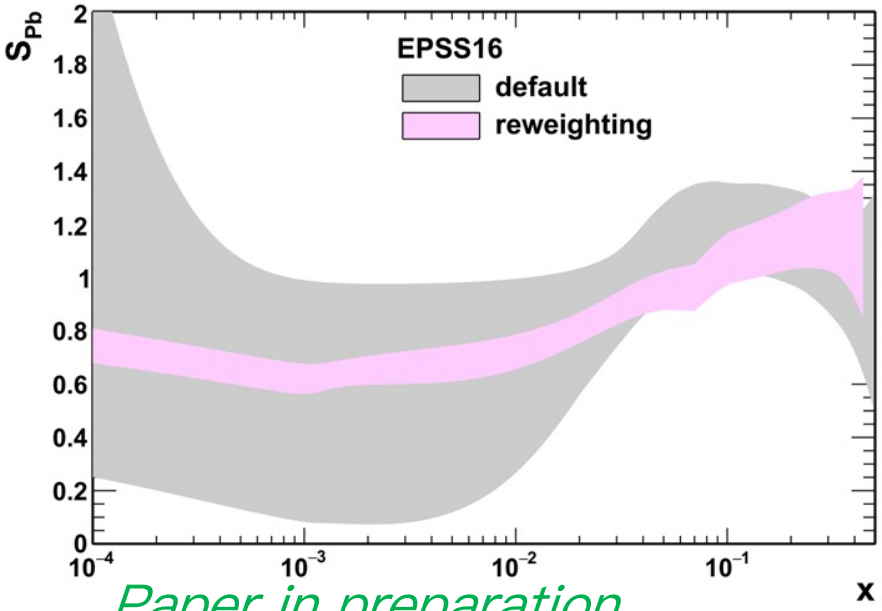
Accepted by JHEP

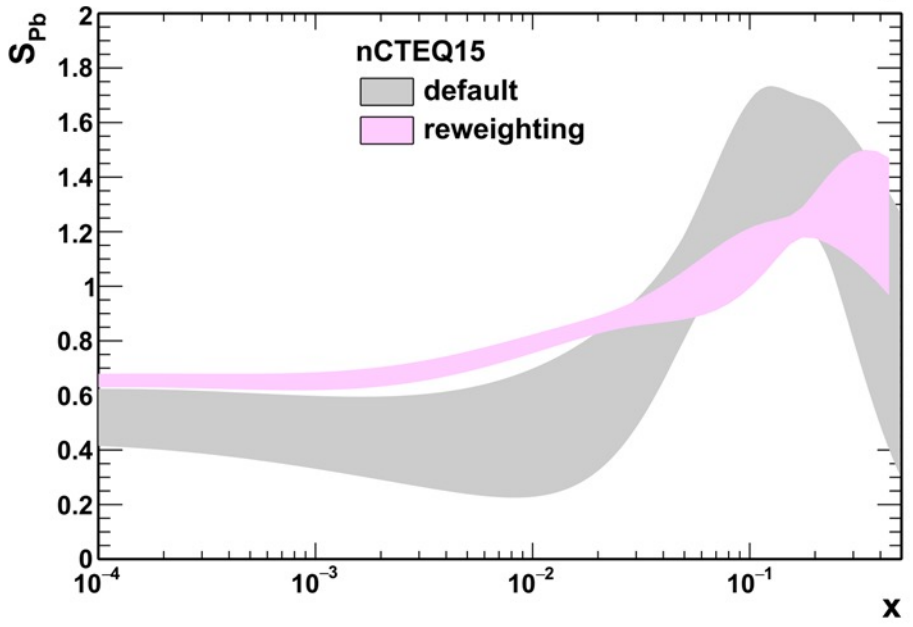
Constraint gluon nPDF with J/ψ



$$\left.\frac{d\sigma(\gamma A \to V A)}{dt}\right|_{t=0} = \frac{\alpha_s^2 \Gamma_{ee}}{3\alpha M_V^5} 16\pi^3 \left[xG_A\left(x, Q^2\right)\right]^2$$

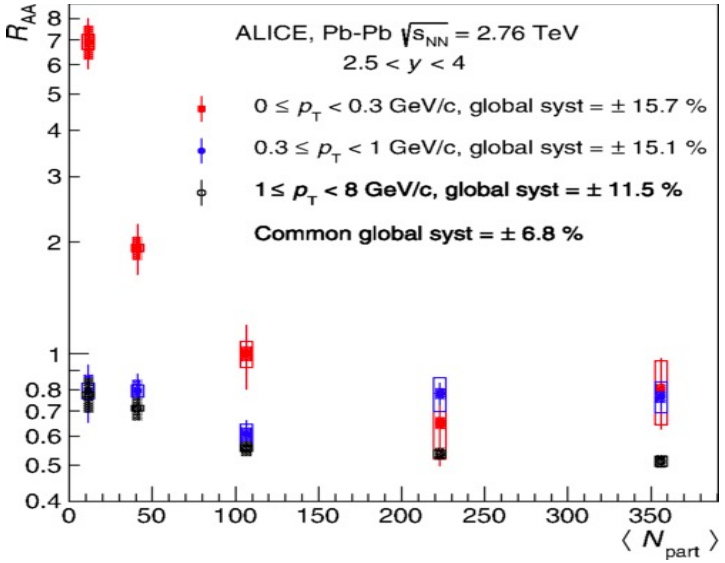




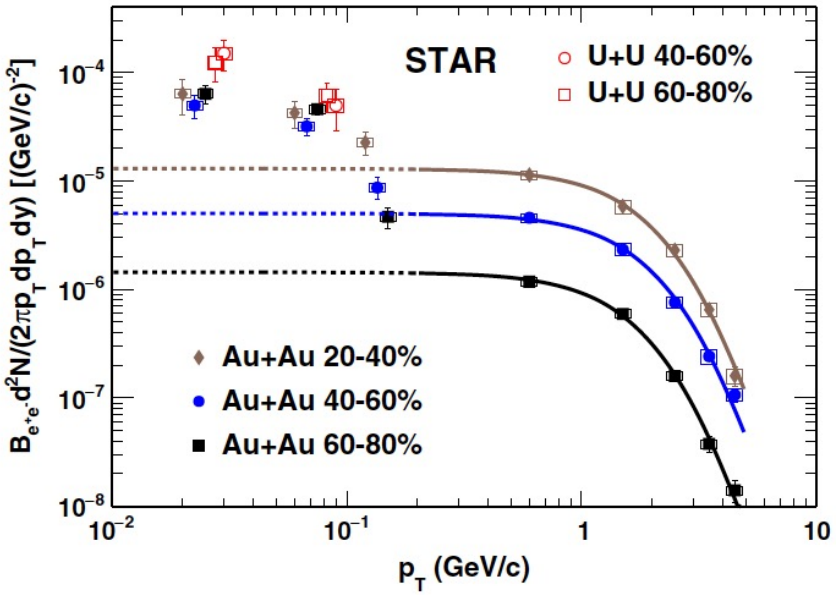


Paper in preparation

Measurement of J/ψ photoproduction?



ALICE, PRL116, 222301 (2016)



STAR, PRL123, 132302 (2019)

Precise measurement of J/ψ photoproduction in peripheral Pb+Pb collisions with Run2/3 data?

Summary

- Several analyses started
  - J/ψ in jets in pp
  - D_s in jets in pp
  - Inclusive J/ψ in PbPb
  - Non-prompt J/ψ in PbPb
  - Jet-like V0-h correlation in pp and PbPb

- Possible phenomenological works related to ALICE

- Looking forward to preliminary results and publication in the upcoming year

Thanks