Inclusive J/ψ production in Pb-Pb and pp collisions at $\sqrt{s_{NN}} = 5$ TeV with ALICE at the LHC

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PHEN/ALICE

PHENIICS Fest
LAL Orsay
https://indico.cern.ch/event/801637/

Content

Physics motivation

- Quark-Gluon Plasma
- J/ψ production mechanism in heavy-ion collisions

LHC and ALICE detector

Data samples: Pb-Pb 2015+2018 and proton-proton (pp) 2017

Analysis of inclusive J/ψ production in Pb-Pb and pp collisions

- J/ψ signal extraction
- Acceptance x Efficiency correction
- Reference cross section measurement in pp
- J/ψ yield extraction in Pb-Pb and comparison to J/ψ production in pp

Conclusion and to do

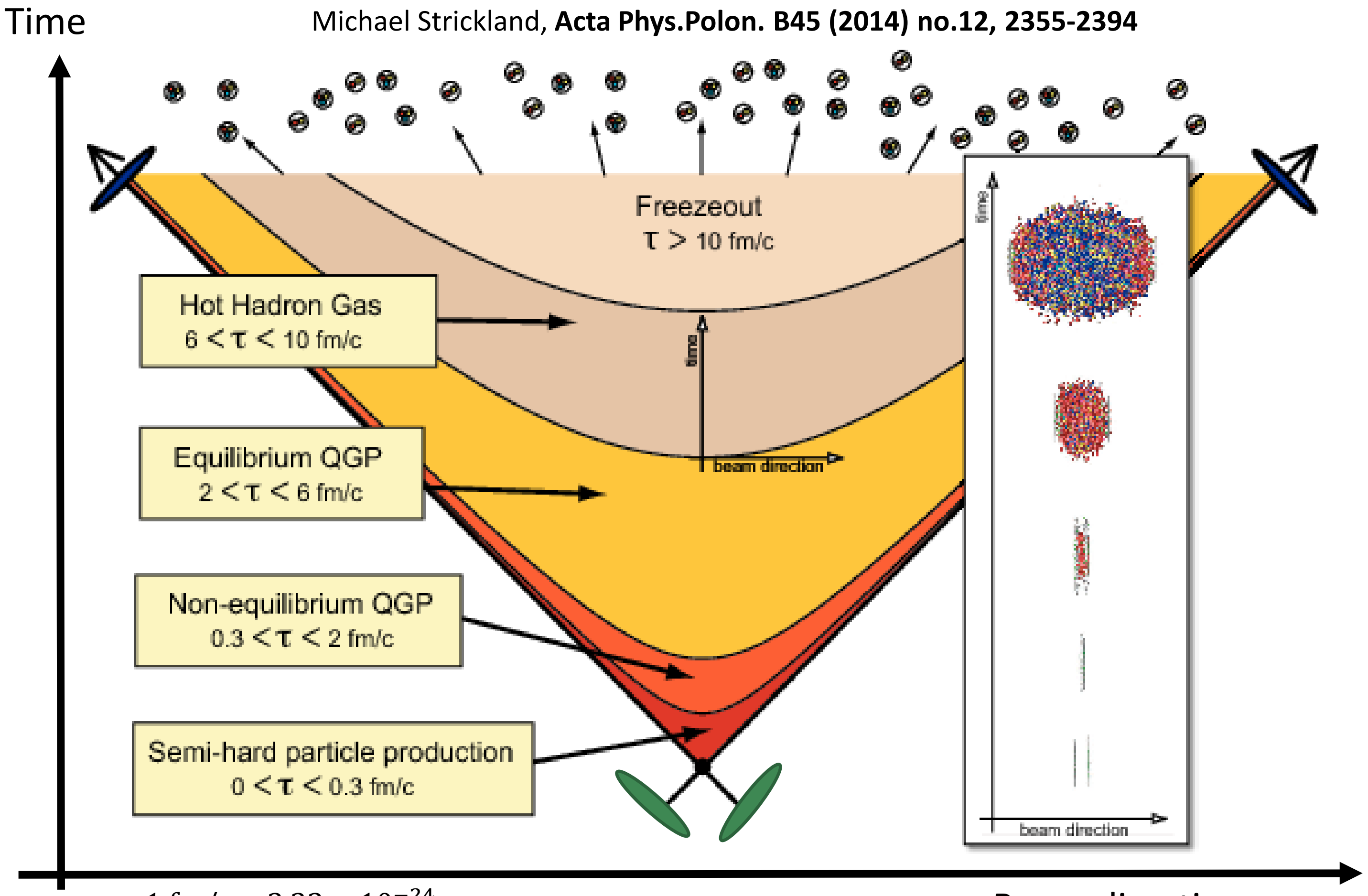
Quark-gluon plasma (QGP) and heavy-ion collisions

QGP is a special state of nuclear matter at high temperature and/or density, which consists of deconfined quarks and gluons

QGP can be created in laboratory with heavy-ion collisions at high energy

The space-time history of heavy-ion collision at LHC energies (Pb-Pb)

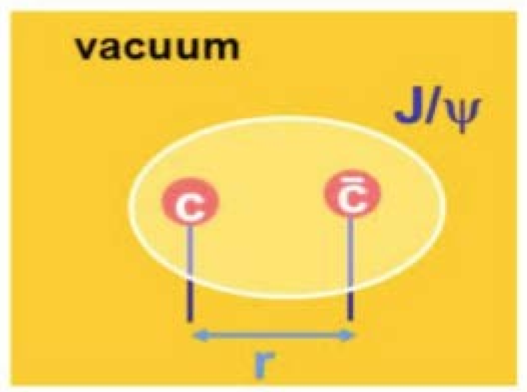
Michael Strickland, **Acta Phys.Polon. B45 (2014) no.12, 2355-2394**



$1\ \mathrm{fm/c} \sim 3.33 \times 10^{-24} s$

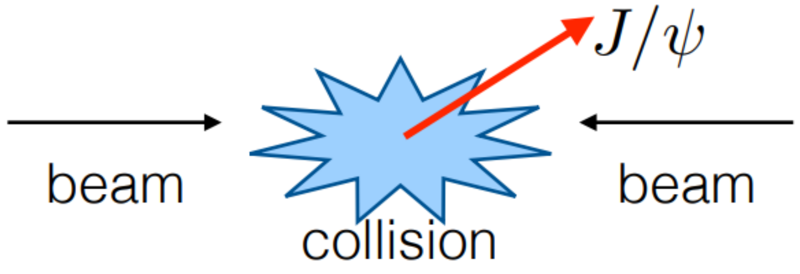
J/ψ particle

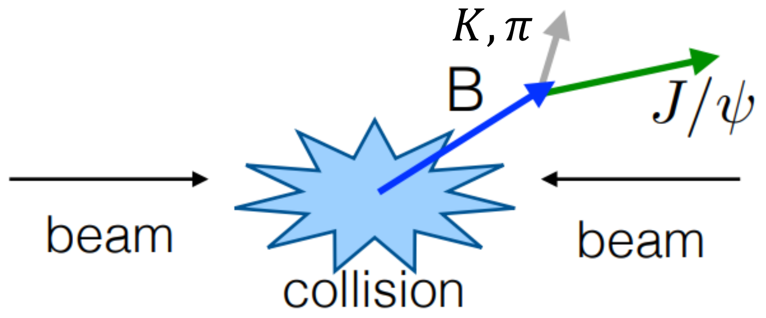
- J/ψ particle is a bound state of charm (c) and anti-charm ($\bar{c}$) quark pair
- J/ψ lifetime is 7.2×10^{-21} s (= $2162\ \mathrm{fm/c}$)
- J/ψ leptonic decay mode:
  - o $\mu^+ \mu^-$, $(5.93 \pm 0.06)\%$



- Inclusive J/ψ:
  - Prompt J/ψ (~85%):
    - o direct J/ψ production (75%)
    - o J/ψ feed-down from decays of charmonium excited states (25%)
  - Non-Prompt J/ψ (~15%):
    - J/ψ from beauty (B) mesons

e.g. Eur.Phys.J. C76 (2016) no.3,107





J/ψ as a probe of QGP

J/ψ production can probe the QGP

Prompt J/ψ suppression by color screening in QGP

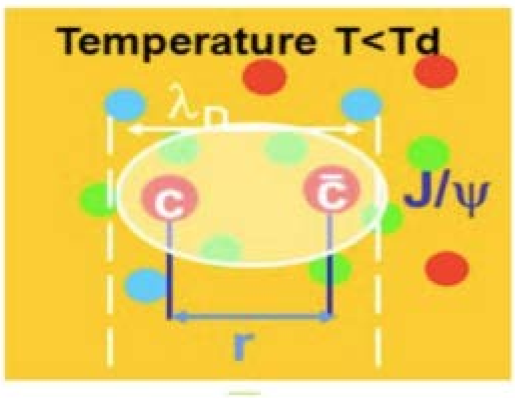
Satz, Matsui. Phys.Lett. B178(1986) 416-422

$\lambda_D(T)$: screening radius.

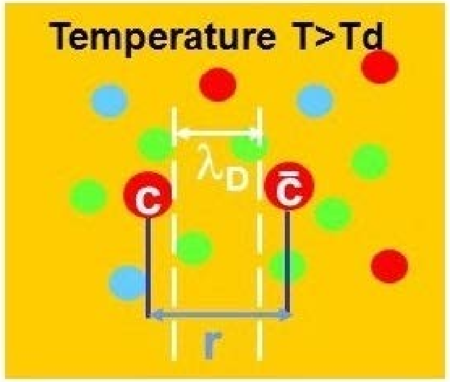
$\mathbf{T_d}$: dissociation temperature.

r: binding radius

Prompt J/ψ produced in the early stage of the collision



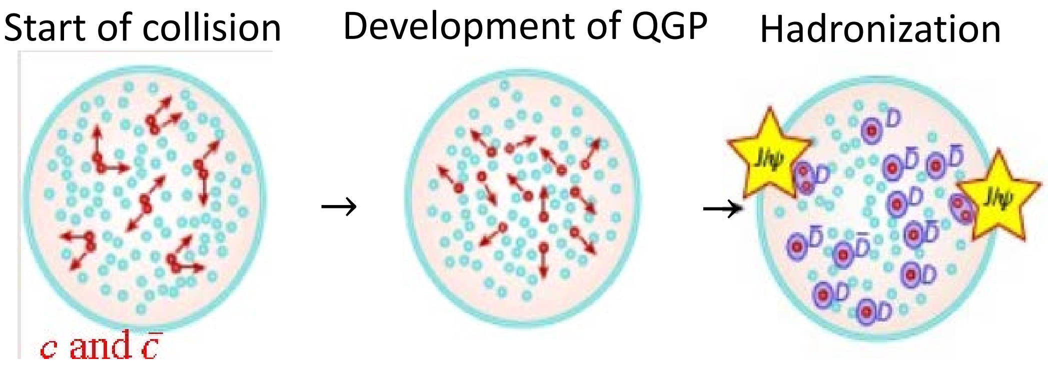
$r < \lambda_D \rightarrow$ J/ψ can be formed



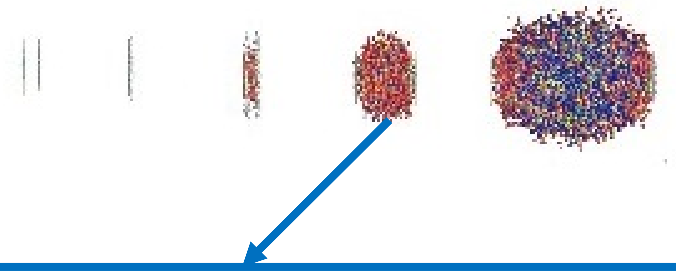
$r > \lambda_D \rightarrow$ J/ψ melt $\rightarrow$ J/ψ suppression

J/ψ as a probe of QGP

At the LHC energy, $c\bar{c}$ **pair production increases**



P. Braun-Munzinger and J. Stachel, Phys. Lett. B 490 (2000) 196
R.L. Thews, M. Schroedter, and J. Rafelski, Phys. Rev. C 63 (2001) 054905

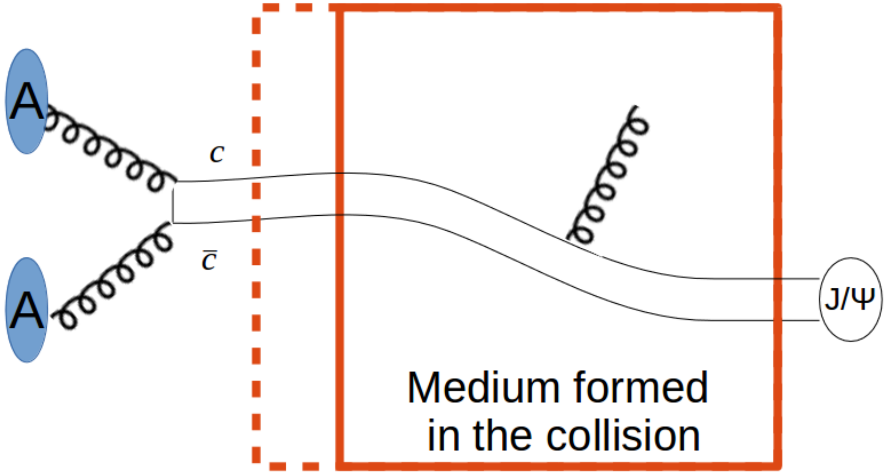


J/ψ (re)generated either during QGP phase and/or at the hadronization stage

- **J/ψ (re)generation in QGP → J/ψ enhancement**
- Regenerated J/ψ are expected at low p_T (transverse momentum)

Energy loss effect

- Parton energy loss by multiple scattering of the parton in the medium and gluon radiation



M. Spousta, Phys. Lett. B 767 (2017) 10
F. Arleo, PRL 119 (2017) 062302

Hard probes produced in the early stage of collision

- Energy loss expected as the main mechanism at large p_T
- Energy loss by quarks, gluons or $c\bar{c}$ pairs?

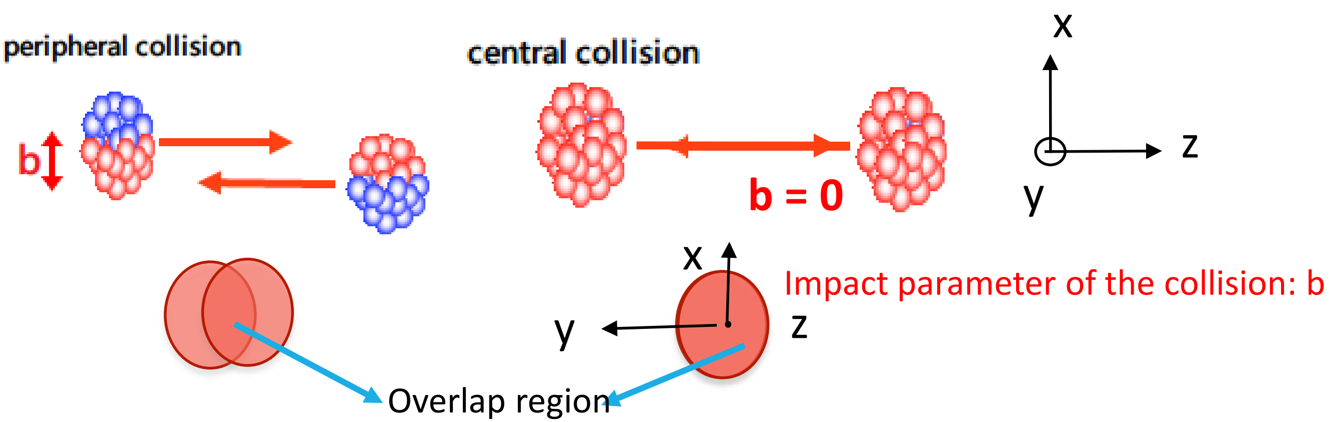
Observable: nuclear modification factor R_{AA}

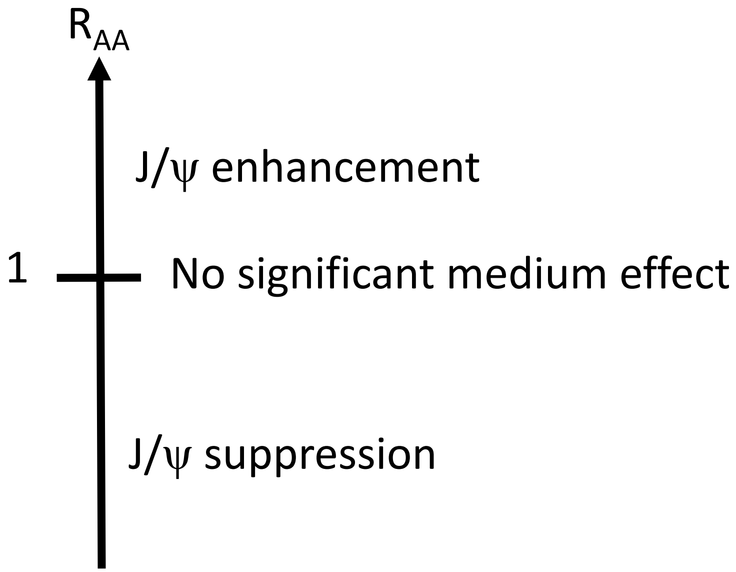
$$R_{AA} = \frac{Y_{AA}^{J/\psi}}{<T_{AA}>\cdot\sigma_{J/\psi}^{pp}}$$

$Y_{AA}^{J/\psi}$ is the J/ψ invariant yield in nucleus-nucleus collisions (AA)

$\sigma_{J/\psi}^{pp}$ is the J/ψ production cross section in proton-proton (pp) collision at the same energy

$< T_{AA} >$ is the nuclear overlap function which quantifies the average nucleon-nucleon luminosity per AA collision

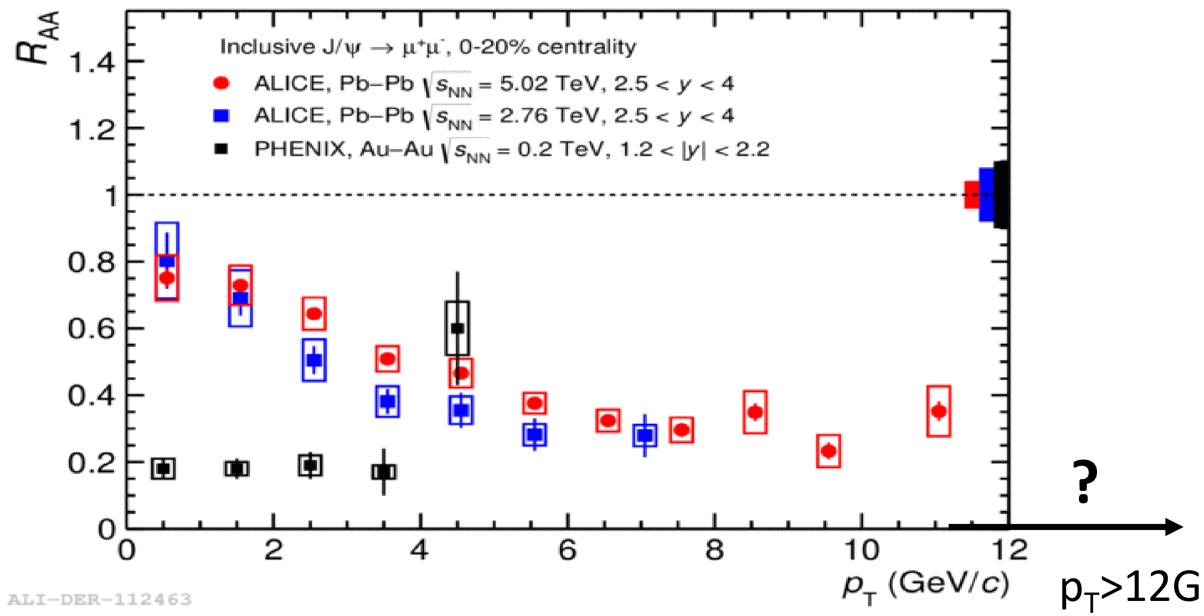




- Centrality describes how large the overlap area is
- Centrality (in %) can be mapped into $<T_{AA}>$ by Glauber model*
- $< T_{AA} >$ is higher if the overlap area is large

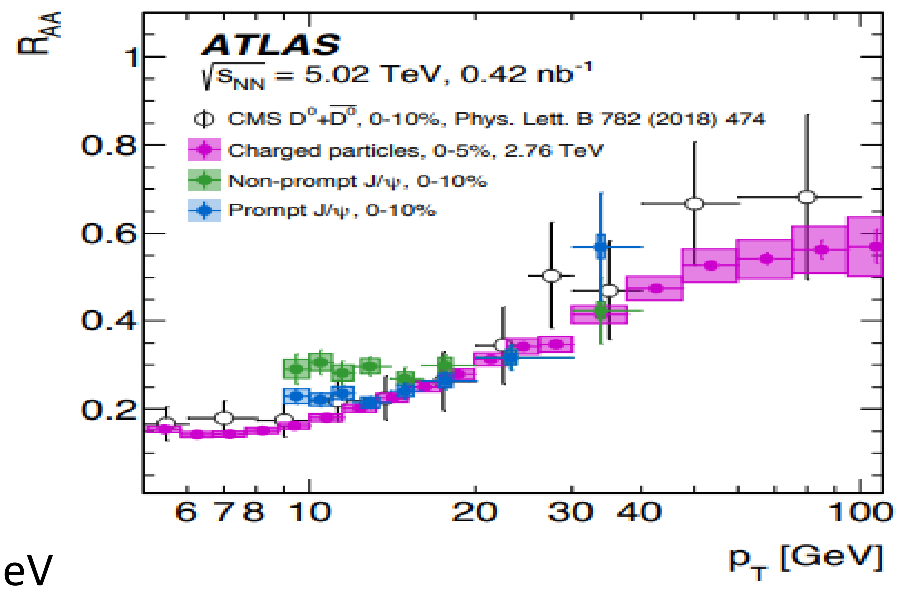
*:https://alice-notes.web.cern.ch/system/files/notes/public/711/2018-06-18-ALICE_public_note.pdf

J/ψ $R_{AA}(p_T)$ at RHIC (PHENIX) and LHC (ALICE, ATLAS, CMS)



?

p_T>12GeV

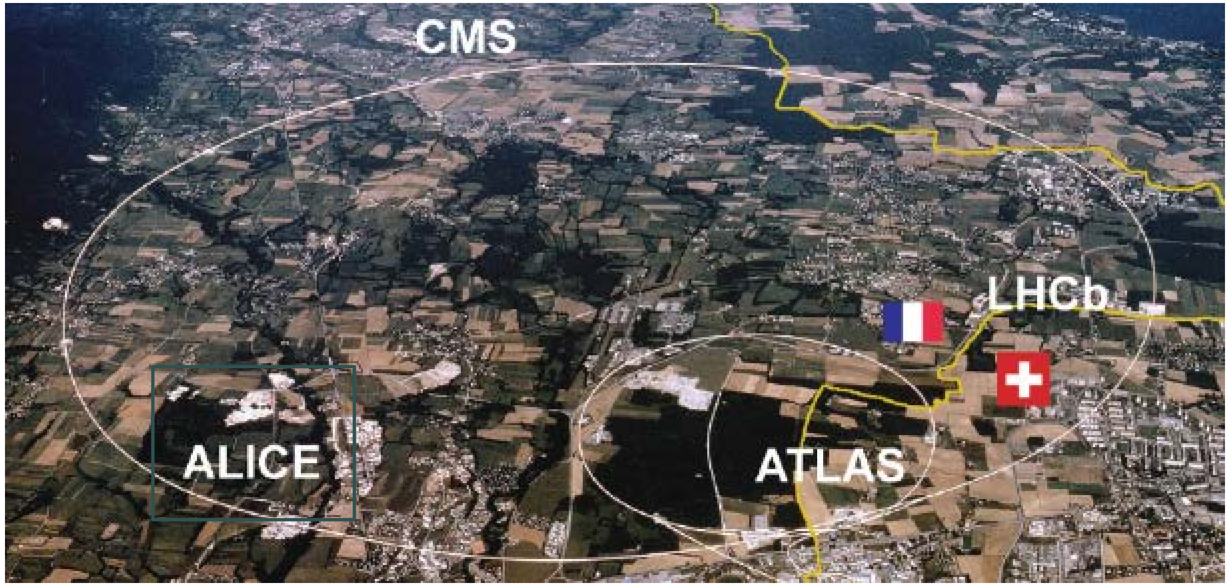


EPJC 78 (2018) 762

- $p_T < 6\ GeV$: R_{AA} increases towards low p_T: hint of regeneration. Interplay between color screening and regeneration
- $6 < p_T < 20\ GeV$: $R_{AA} \sim 0.2 - 0.3$ and increases slightly at larger p_T but suppress strongly. Color screening mostly
- $p_T > 20\ GeV$: $R_{AA}^{J/\psi} \sim R_{AA}^{charged}$: energy loss signature. Interplay between color screening and energy loss

The Large Hadron Collider (LHC)

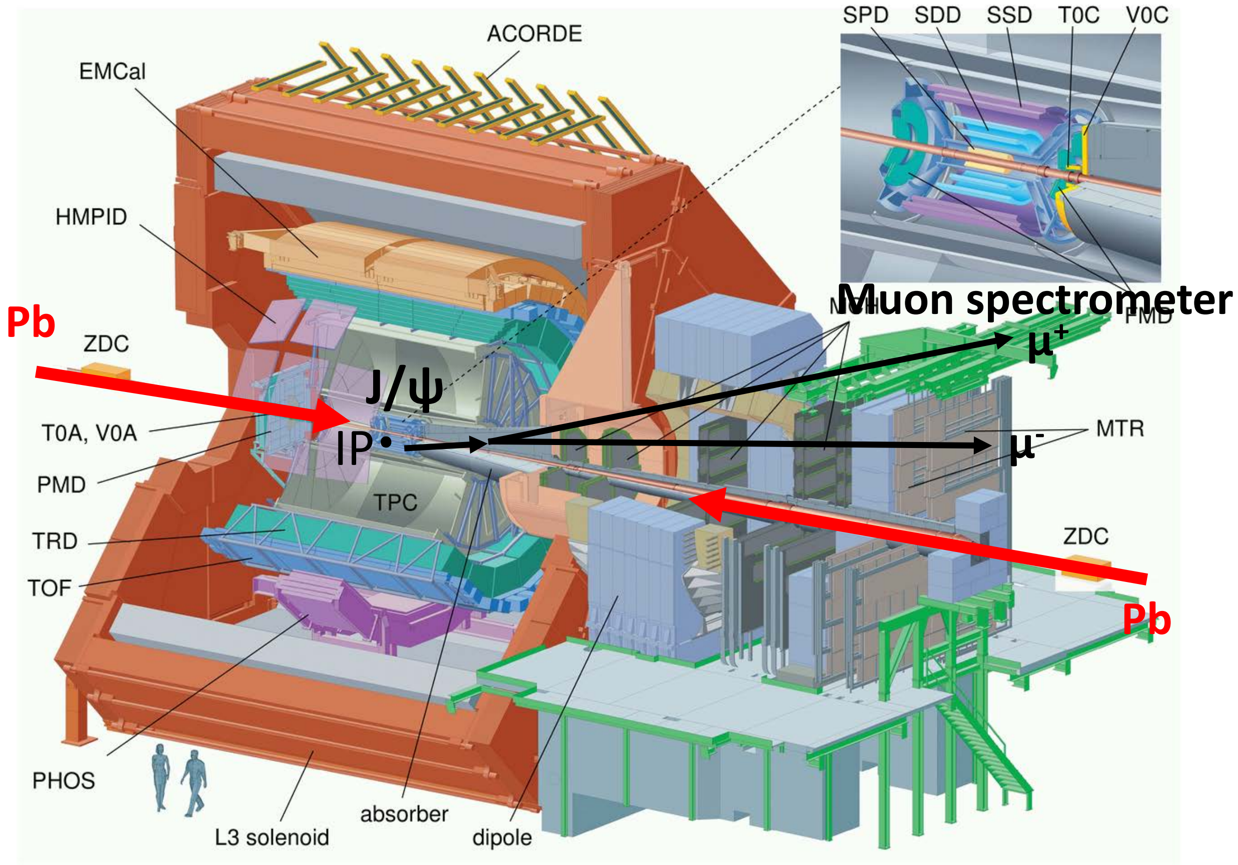
- LHC at CERN (Geneva) is the largest and most powerful particle collider for pp (currently up to $\sqrt{s}$ = 13 TeV) p-Pb (currently up to $\sqrt{s_{NN}}$ = 8.1 TeV) and Pb-Pb (currently up to $\sqrt{s_{NN}}$ = 5 TeV)
- Types of collisions:
  - pp: investigate the quarkonium production mechanism
  - p-Pb: explore the cold nuclear matter effect
  - Pb-Pb: study the properties of quark-gluon plasma



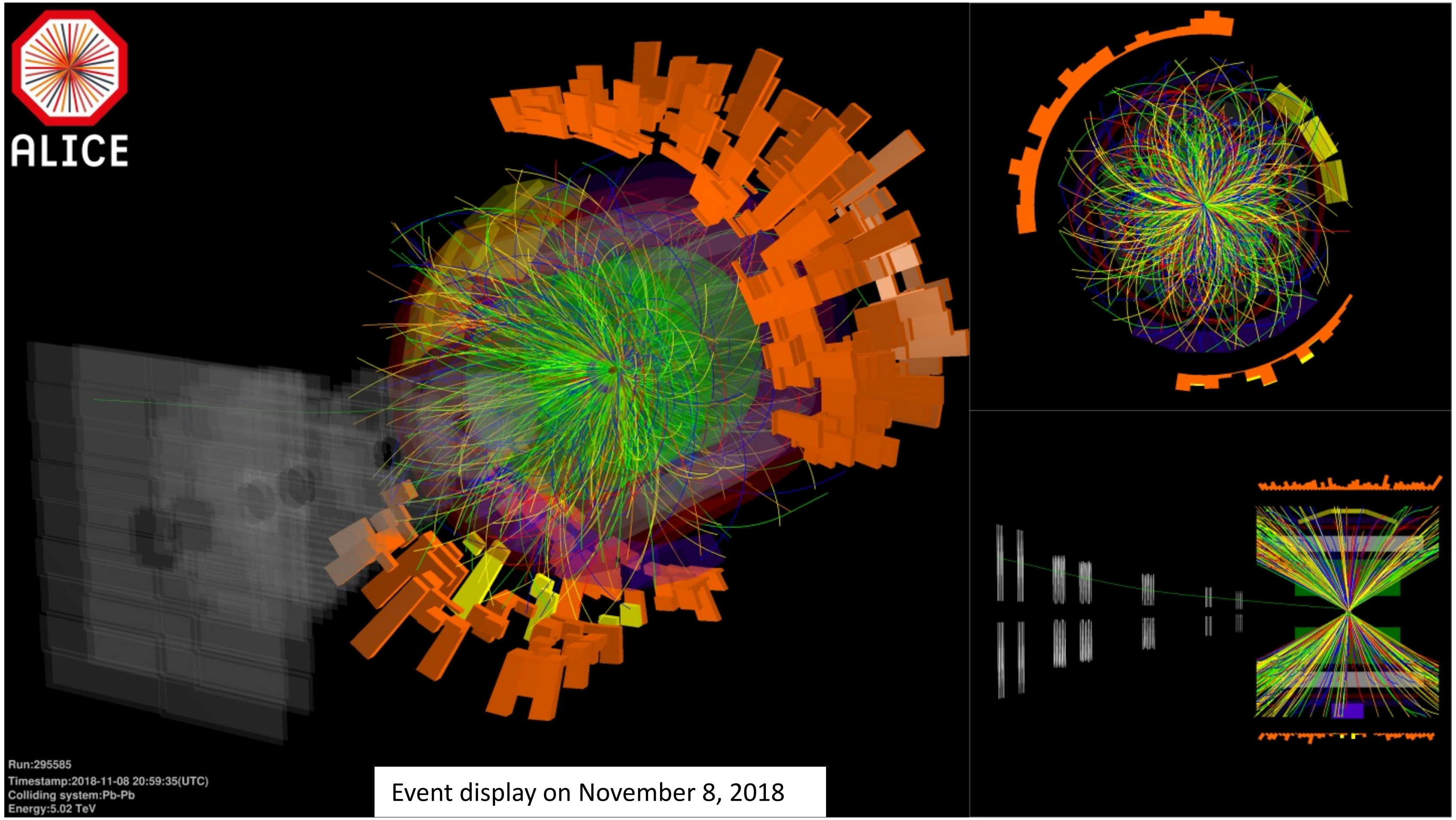
27 km

ALICE detector

- ALICE (A Large Ion Collider Experiment) detector is designed to study QGP in heavy-ion collisions
- Muon spectrometer
  - Absorber system: stop π, k and low momentum μ particles
  - Tracking system: provide the 3D position information of particles
  - Dipole magnet: bend particles to obtain momenta and charges (3 Tm)
  - Trigger system: trigger on dimuon and identify the single muon (2 trigger p_T thresholds: 0.5 & 1 GeV/c or 1 & 4 GeV/c)
- Other ALICE detector used for muon analysis
  - SPD: vertex determination
  - V0 (V0A & V0C): centrality estimator, minimum bias trigger and background event rejection
  - ZDC (≈ 100m before / after IP): background event rejection



Data taking in 2018 Pb-Pb collisions



Event display on November 8, 2018

Data samples: pp 2017 and Pb-Pb 2015+2018

	Pb-Pb 2015	**pp 2017**	**Pb-Pb 2018**
Luminosity	$\approx 225\ \mu b^{-1}$	$\approx 1223\ nb^{-1}$	$\approx 537\ \mu b^{-1}$
Data sample	137 runs	51 runs	232 runs

$L_{int}^{2018,Pb-Pb} \approx 2.4 \times L_{int}^{2015,Pb-Pb}$

Run is basic unit of data taking

pp 2017:

- Extract the J/ψ signal in p_T (and y intervals)
- Acceptance times efficiency in detector
- Measure the J/ψ cross section vs p_T (and y)

Pb-Pb 2015:

- Extract the J/ψ signal and systematic uncertainty
- Acceptance times efficiency in detector

Pb-Pb 2018:

- Extend the 2015 analysis to higher p_T by summing the two data samples
- Measure the R_{AA} versus p_T

Nuclear modification factor R_{AA}

$$R_{AA} = \frac{Y_{AA}^{J/\psi}}{< T_{AA} > \cdot \sigma_{J/\psi}^{pp}} = \frac{N_{AA}^{J/\psi}(p_T)}{< T_{AA} > \cdot \frac{d^2\sigma_{J/\psi}^{pp}}{dp_T dy} \cdot BR \cdot A\varepsilon(p_T) \cdot N_{MB} \cdot \Delta p \cdot \Delta y}$$

$N_{AA}^{J/\psi}(p_T)$: raw number of J/ψ as a function of p_T

BR: branching ratio of J/ψ decaying into dimuon

$A\varepsilon(p_T)$: detector acceptance times efficiency

N_{MB}: number of minimum bias events, computed from the number of dimuon triggered events

Differential J/ψ cross-section in pp: $\frac{d^2\sigma_{J/\psi}^{pp}}{dp_T dy} = \frac{N_{J/\psi}(p_T)}{BR \cdot L_{int}^{pp} \cdot A\varepsilon(p_T) \cdot \Delta p_T \cdot \Delta y}$

L_{int}^{pp}: luminosity in pp collisions at $\sqrt{s}$ = 5 TeV

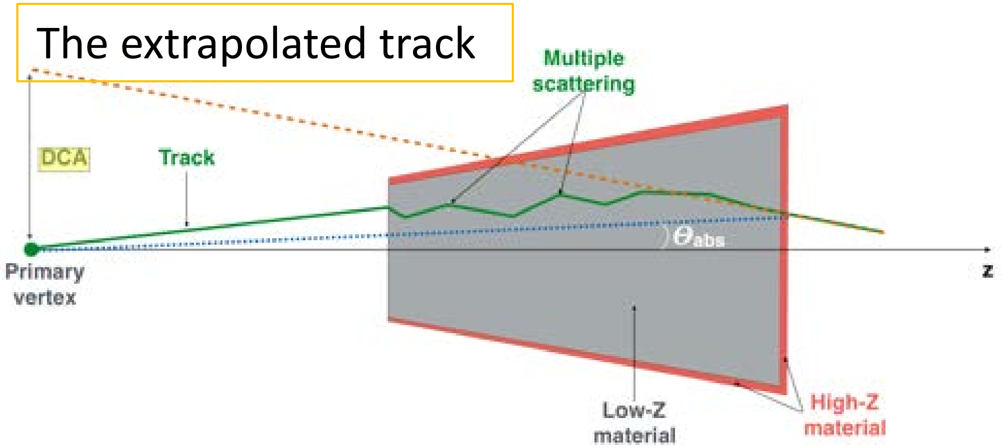
J/ψ differential cross sections in pp

$$\frac{d^2\sigma_{J/\psi}^{pp}}{dp_T dy} = \frac{N_{J/\psi}(p_T)}{BR \cdot L_{int}^{pp} \cdot A\varepsilon(p_T) \cdot \Delta p_T \cdot \Delta y}$$

pp Data samples: event and track selections

Data samples:

- Quality assurance checked runs



Event selections:

- Trigger selection: opposite sign dimuon trigger
- Physics selection: to reject the background events
- Centrality selection: with V0A and V0C (for Pb-Pb only)

Track selections:

- θ_{abs}: 2-10 degree
- p*DCA cut: to reject beam gas tracks
- Pseudo-rapidity η: 2.5 – 4.0: the geometrical acceptance of the muon spectrometer
- Matching of tracking tracks with trigger tracks with p_T threshold of 0.5 GeV/c or 1 GeV/c

Dimuon selection:

- Rapidity: 2.5 < **y** < 4.0
- Opposite charge muons

The same cuts are applied in Monte Carlo & data samples

J/ψ signal extraction in pp

Signal functions (for invariant mass of dimuons $M_{\mu^+\mu^-}$):

- Extended Crystal Ball (CB2), tails from MC (Geant3 & Geant4) and 13 TeV pp data
- NA60 function, tails from MC (Geant3 & Geant4)

Background functions:

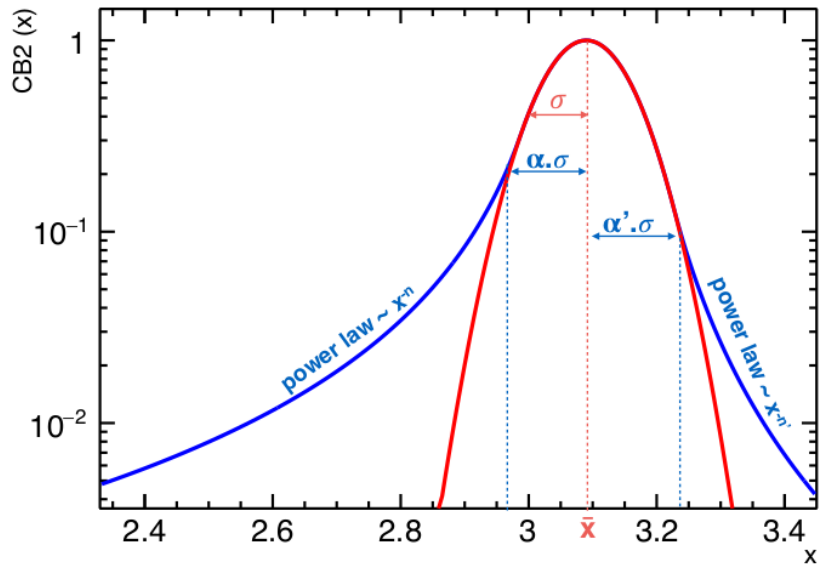
- Variable Width Gaussian (VWG1)
- Polynomial ratios (Pol1/Pol2)

Fitting ranges of invariant mass:

- pp: [2.0, 4.8], [2.2, 4.4] GeV/c^2

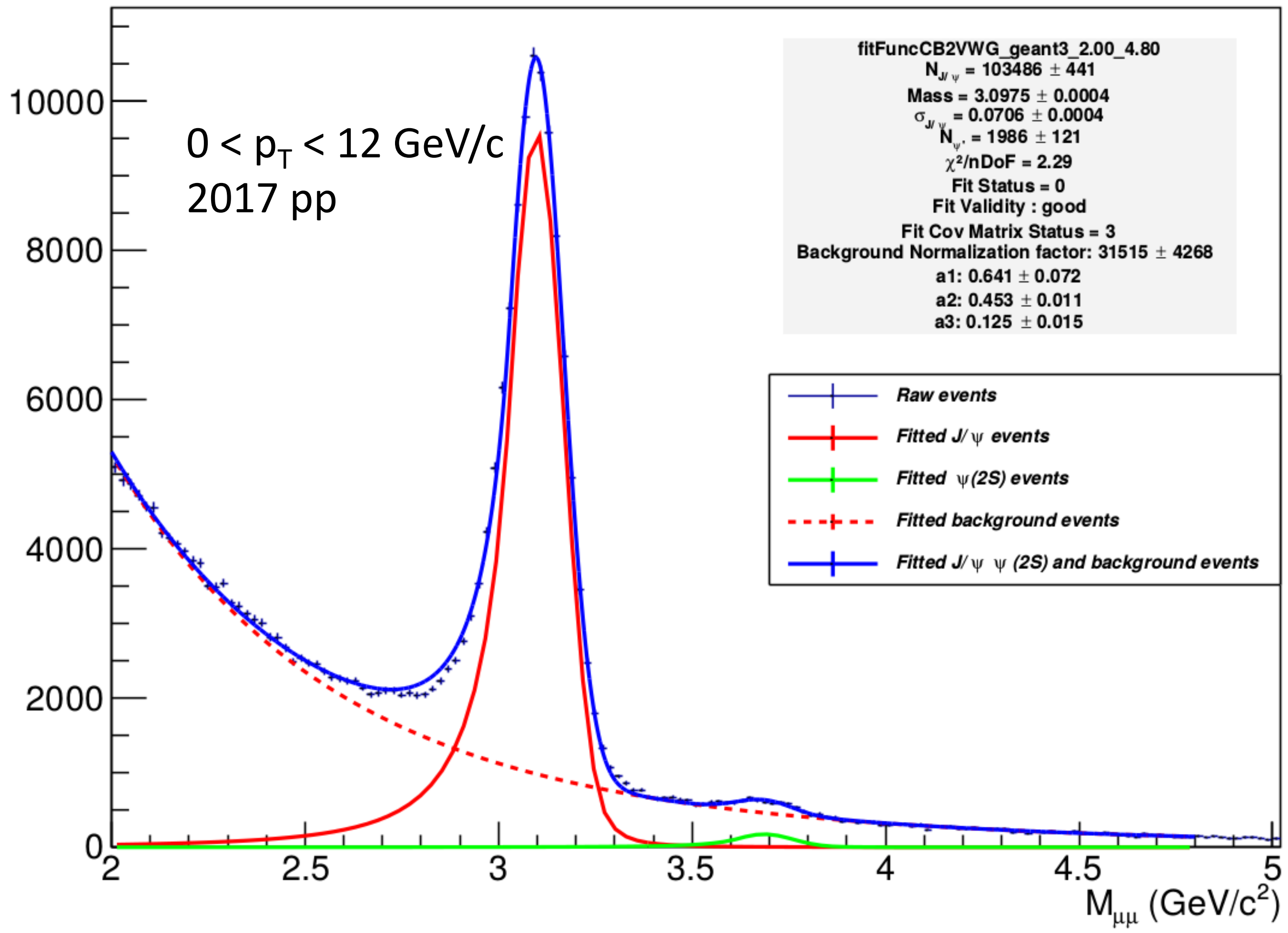
Total methods in pp: $(3+2)\times 2\times 2 = 20$

Extended Crystal-Ball (CB2)



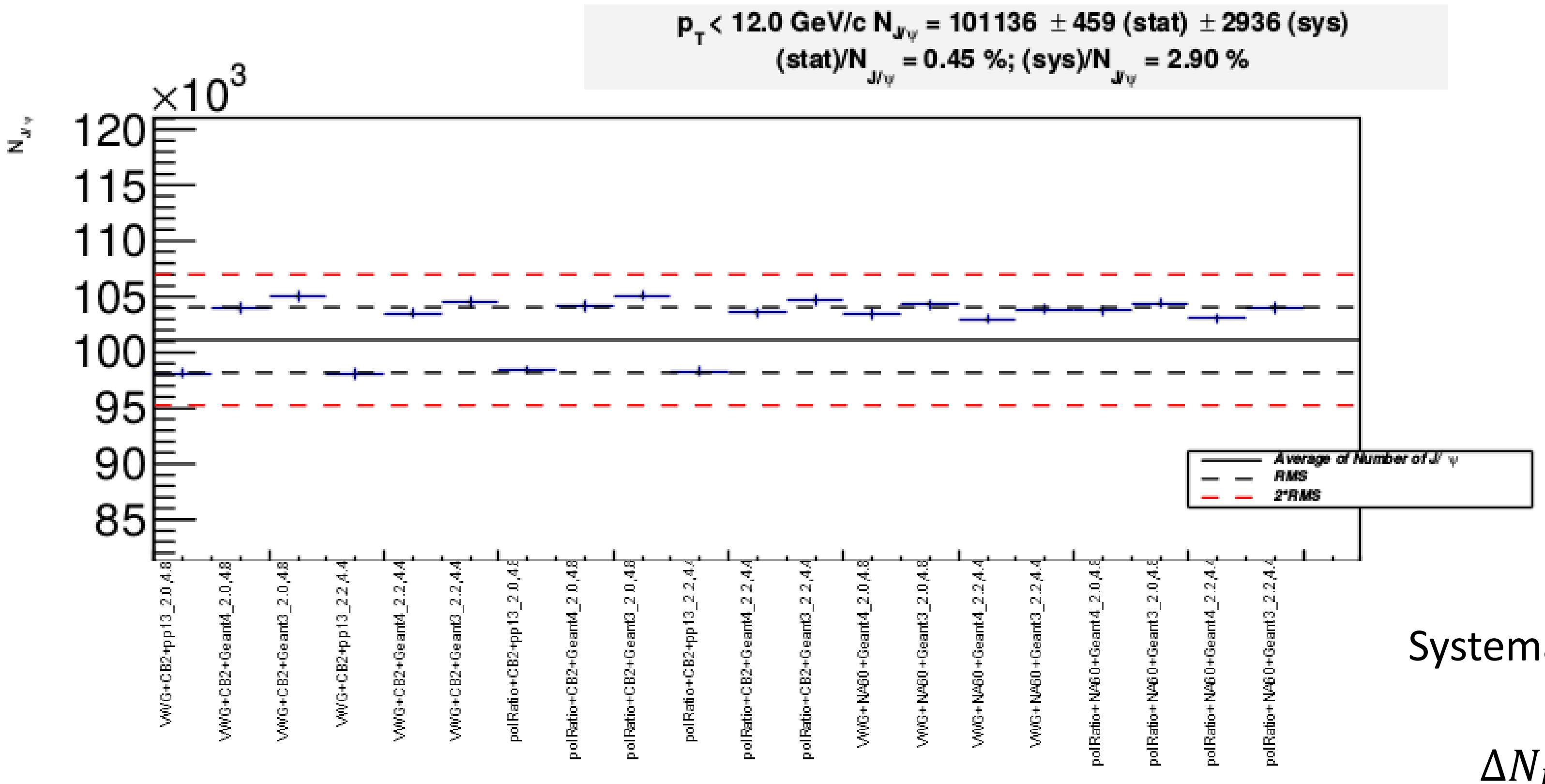
$\bar{x}$: the mean. σ: the width. (α, n, α', n'): 4 tail parameters fixed from MC simulation and from free tails fit to large statistics pp data

J/ψ signal extraction in pp



$$M_{\mu^+\mu^-} = \sqrt{m_{\mu+}^2 + m_{\mu-}^2 + 2(E_{\mu+}E_{\mu-} - \boldsymbol{p}_{\mu+} \cdot \boldsymbol{p}_{\mu-})}$$

J/ψ signal: extraction and systematic uncertainty



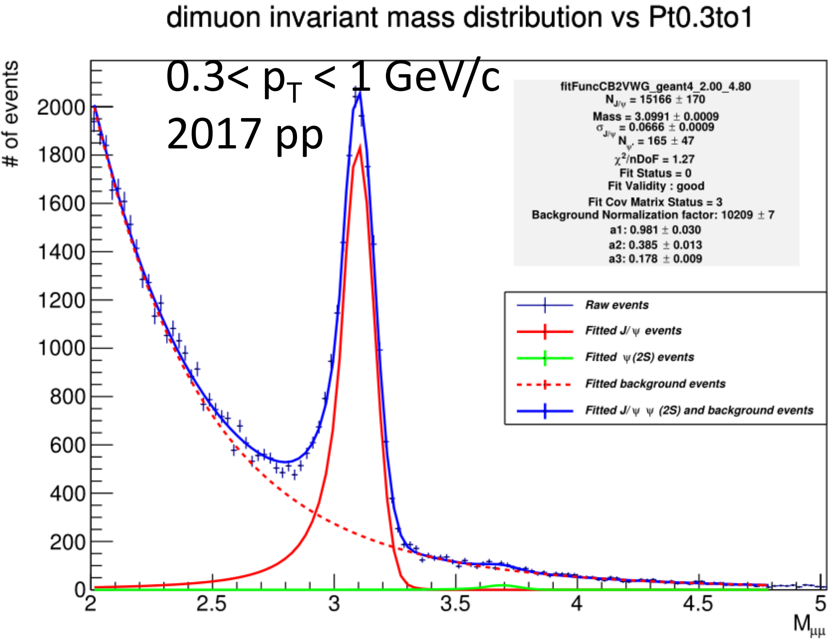
$\langle N_{J/\psi} \rangle$ = 101136 +/- 459 (stat) +/- 2936 (sys)

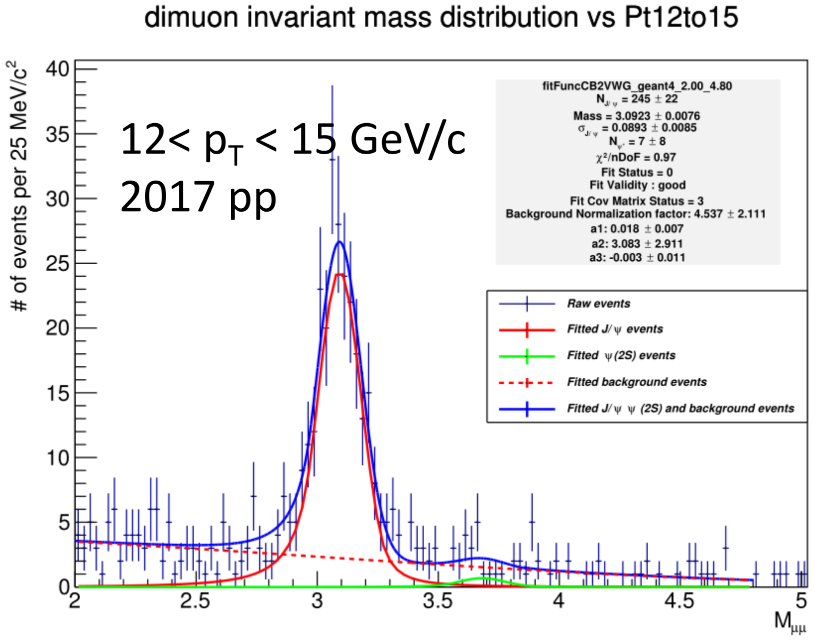
$\langle N_{J/\psi} \rangle = \frac{\sum_i w_i N^i_{J/\psi}}{\sum_i w_i}$, w_i is to account for the fact that there are less tests with pp data tails than with pp MC tails. Dominant source of uncertainty from the tail choices

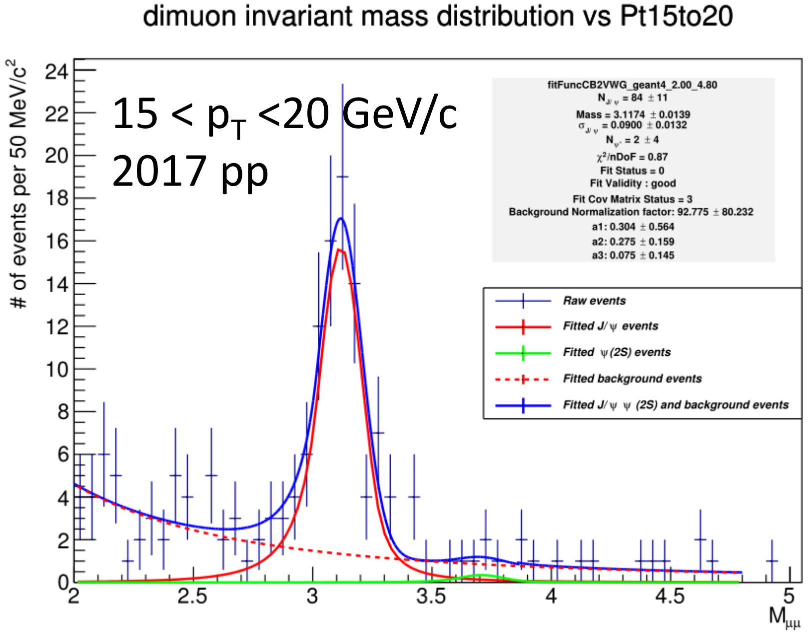
Systematic uncertainty:

$$\Delta N_{J/\psi} = \sqrt{\frac{\sum_i w_i \times N^2_{i,J/\psi}}{\sum_i w_i} - \left[\frac{\sum_i w_i \times N_{i,J/\psi}}{\sum_i w_i}\right]^2}$$

J/ψ signal extraction in different p_T bins in pp





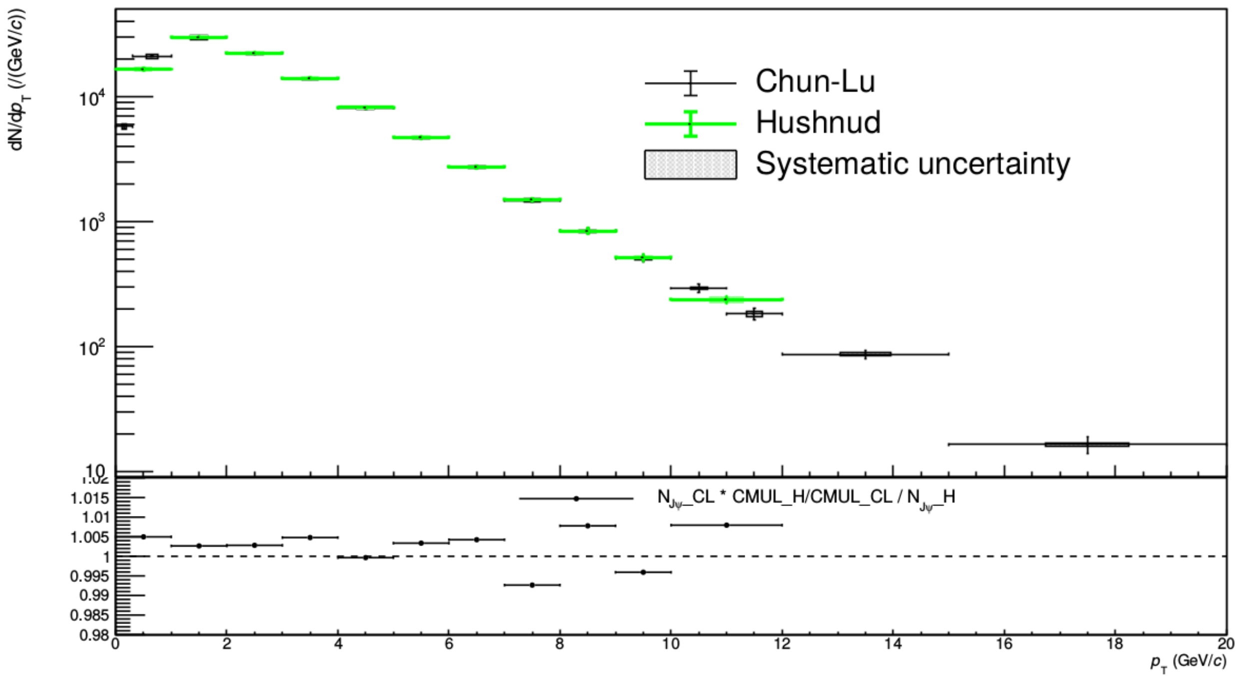


$N_{J/\psi}$ = 84 +/- 11

Statistical precision is around 13%

J/ψ yield: dN/dp_T as a function of p_T

- Cross-check with another independent analyzer up to 12 GeV/c: good agreement within 1%
- p_T reach in pp defines the p_T reach in Pb-Pb as well

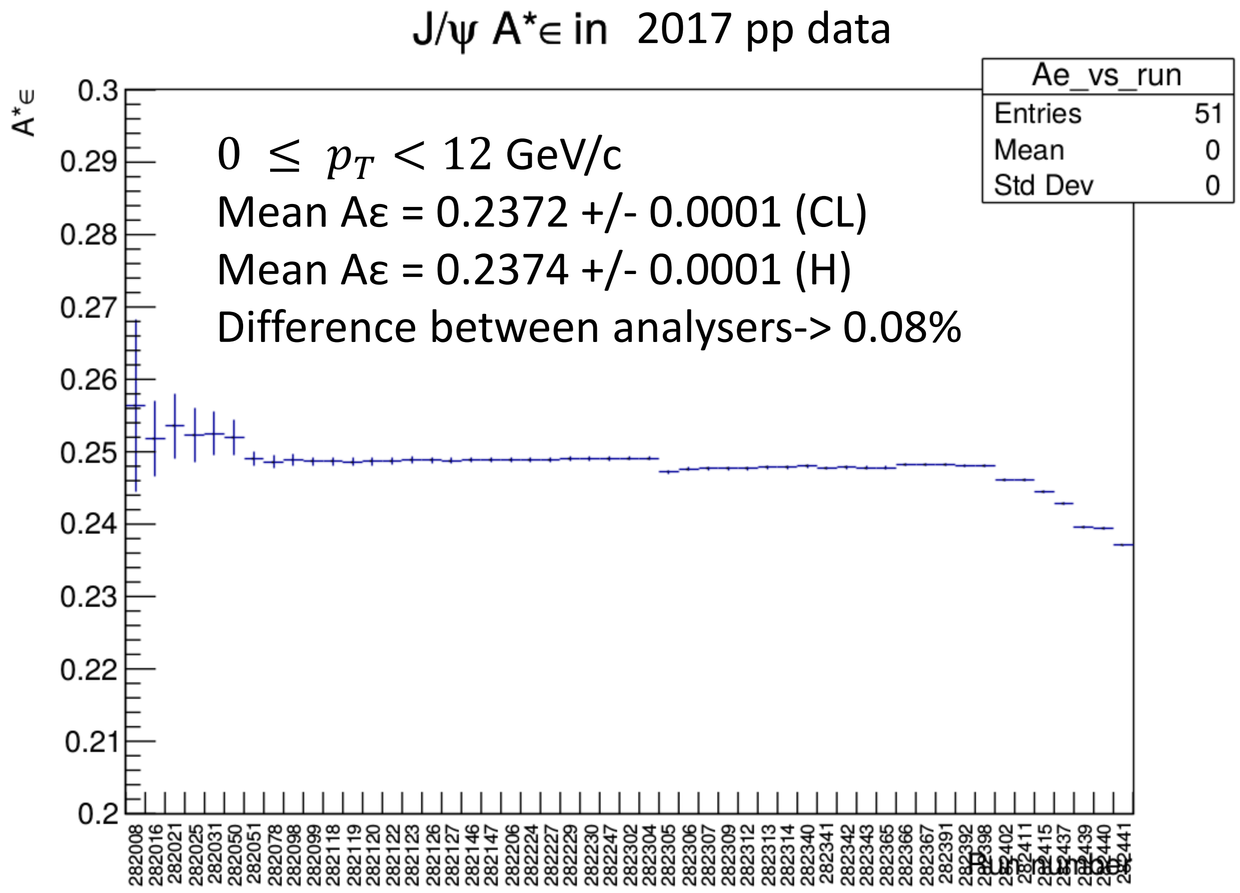


J/ψ Acceptance times Efficiency Aε

To correct for detector effect and geometrical acceptance

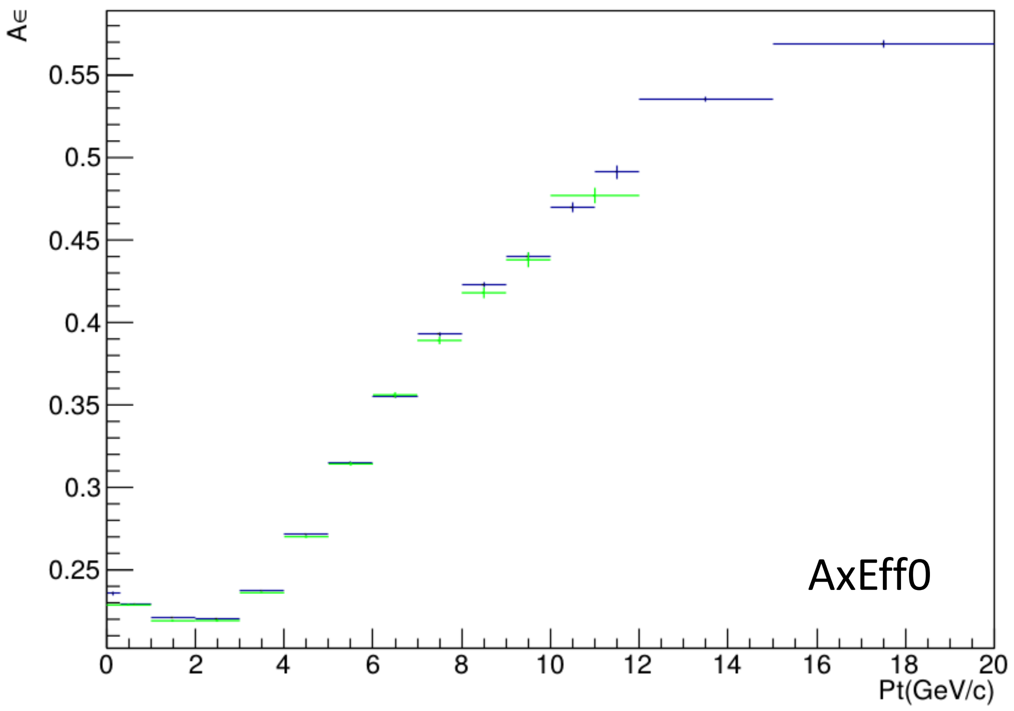
Acceptance x Efficiency $A\epsilon_i(p_T) = \frac{N_i^{rec}(p_T)}{N_i^{gen}(P_T)}$

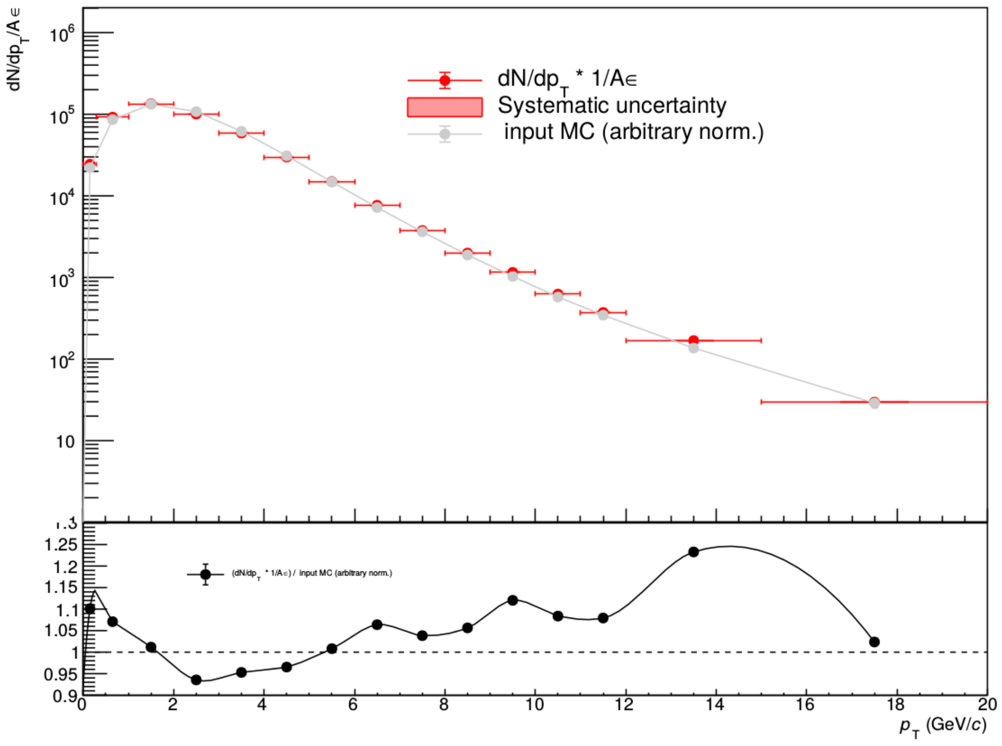
$A\epsilon_i$ may vary run by run



A loss of efficiency is observed at the end of the data taking period because of high voltage trips in tracking chambers

J/ψ Acceptance times Efficiency

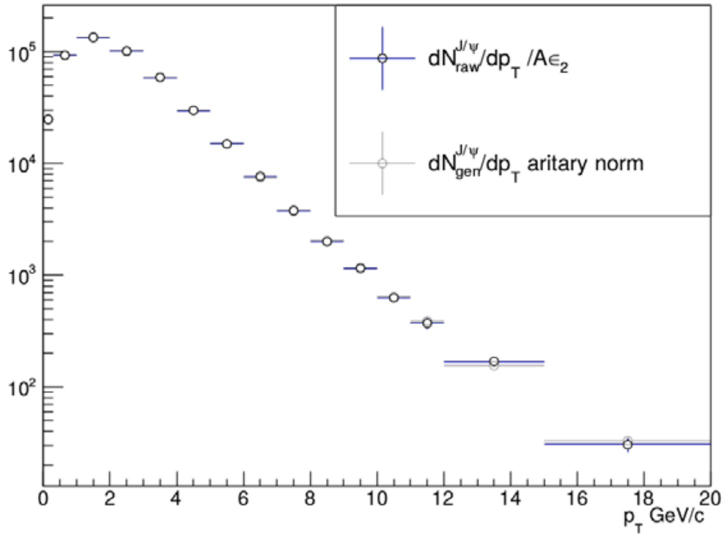


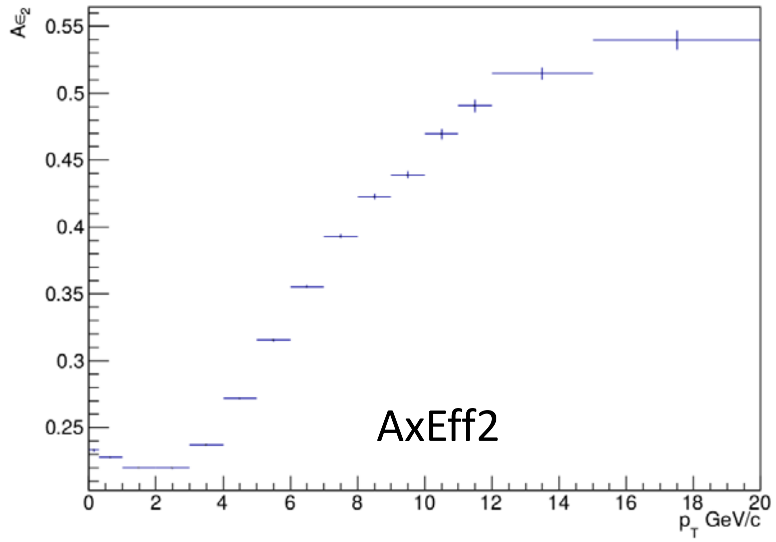


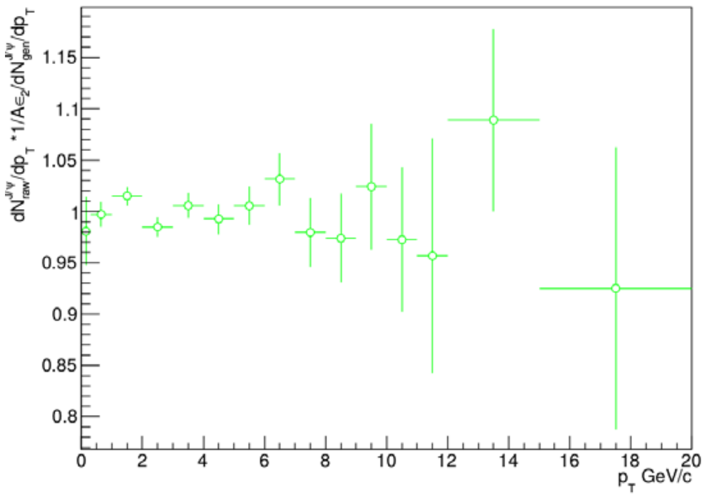
Input MC shape is not consistent with J/ψ yield shape at first

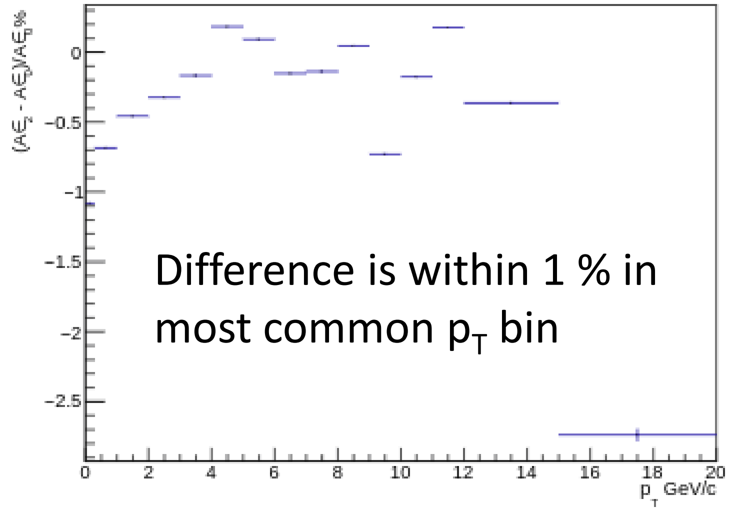
J/ψ Acceptance times Efficiency

Applying the iterative procedure to tune the input MC shape to the J/ψ data corrected by AxEff









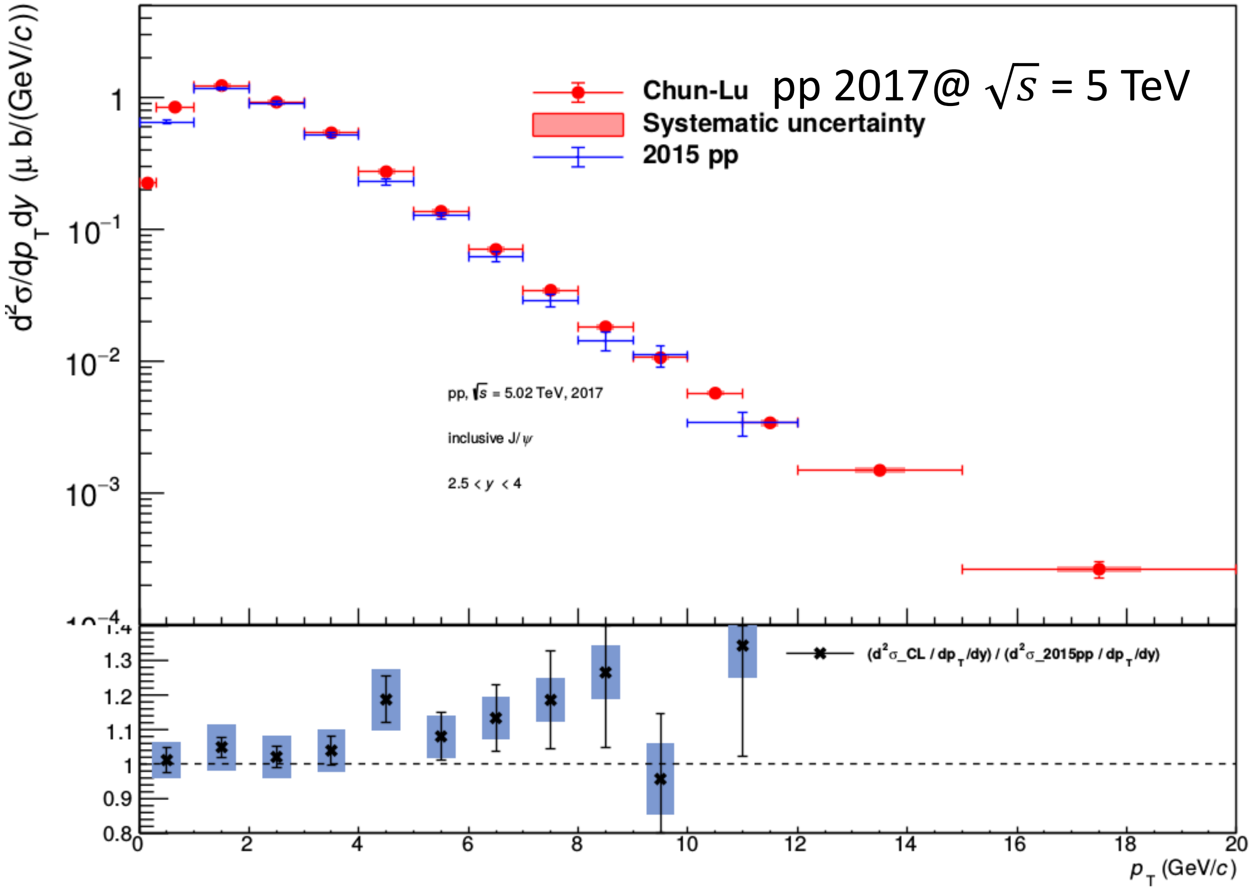
J/ψ cross-section in pp

$$\frac{d^2\sigma^{pp}_{J/\psi}}{dp_T dy} = \frac{N_{J/\psi}(p_T)}{BR \cdot L^{pp}_{int} \cdot A\varepsilon(p_T) \cdot \Delta p_T \cdot \Delta y}$$

Integrated luminosity:

- Chun-Lu: 1220.88 +/- 21.80 nb^{-1}

- Agreement within 1 sigma for the integrated cross section and for the most of p_T and y bins
- Biggest deviation of 1.7 sigma in $4 \leq p_T < 5$ GeV/c

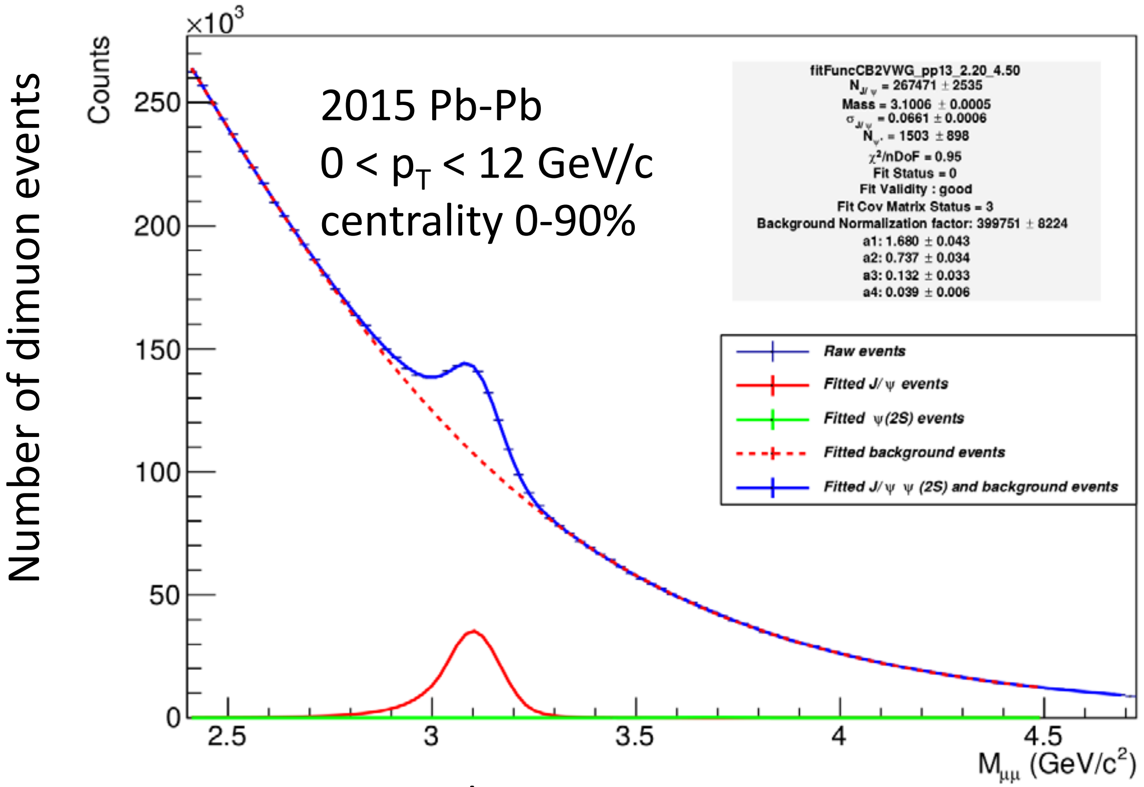


p_T (GeV/c)	$\sigma \pm$ (stat) $\pm$ (syst) (μb) (CL)	$\sigma \pm$ (stat) $\pm$ (syst) (μb) (H)	$\sigma \pm$ (stat) $\pm$ (syst) (μb) (2015)
0–12	$5.8596 \pm 0.0267 \pm 0.2515$	$5.860 \pm 0.025 \pm 0.247$	$5.61 \pm 0.08 \pm 0.28$
0–20	$5.8609 \pm 0.0263 \pm 0.2544$	–	–

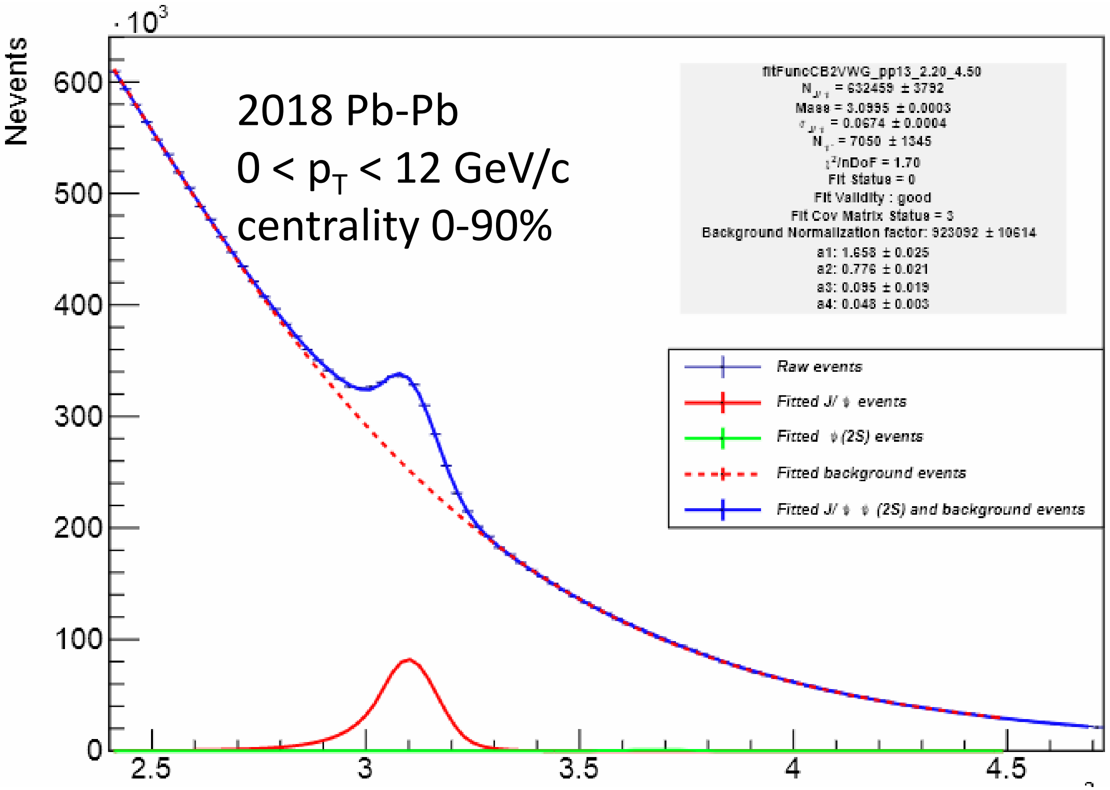
Nuclear modification factor R_{AA} in Pb-Pb collisions

$$R_{AA} = \frac{N_{AA}^{J/\psi}(p_T)}{< T_{AA} > \cdot \frac{d^2\sigma_{J/\psi}^{pp}}{dp_T dy} \cdot BR \cdot A\varepsilon(p_T) \cdot N_{MB} \cdot \Delta p \cdot \Delta y}$$

J/ψ signal extraction in Pb-Pb



$N_{J/\psi}$: 267471 +/- 2535



$N_{J/\psi}$: 632459 +/- 3792

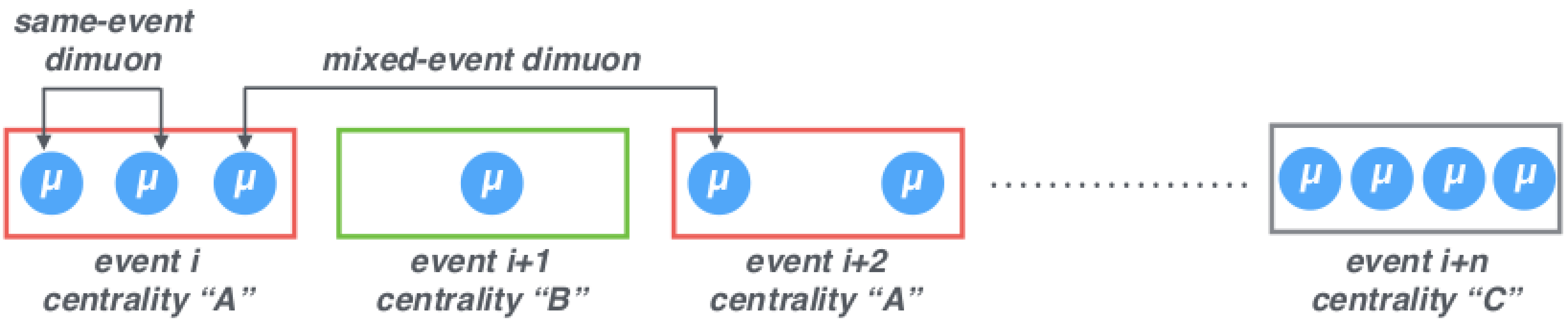
- Fit range [2.2, 4.5] GeV/c^2
- Signal function:
  - Extended crystal-ball (CB2)
- Background function:
  - Variable Width Gaussian (VWG2)

Number of J/ψ ratio: 632459 / 267471 = 2.37
In agreement with the luminosity ratio between 2018 and 2015

J/ψ signal extraction in Pb-Pb: event mixing

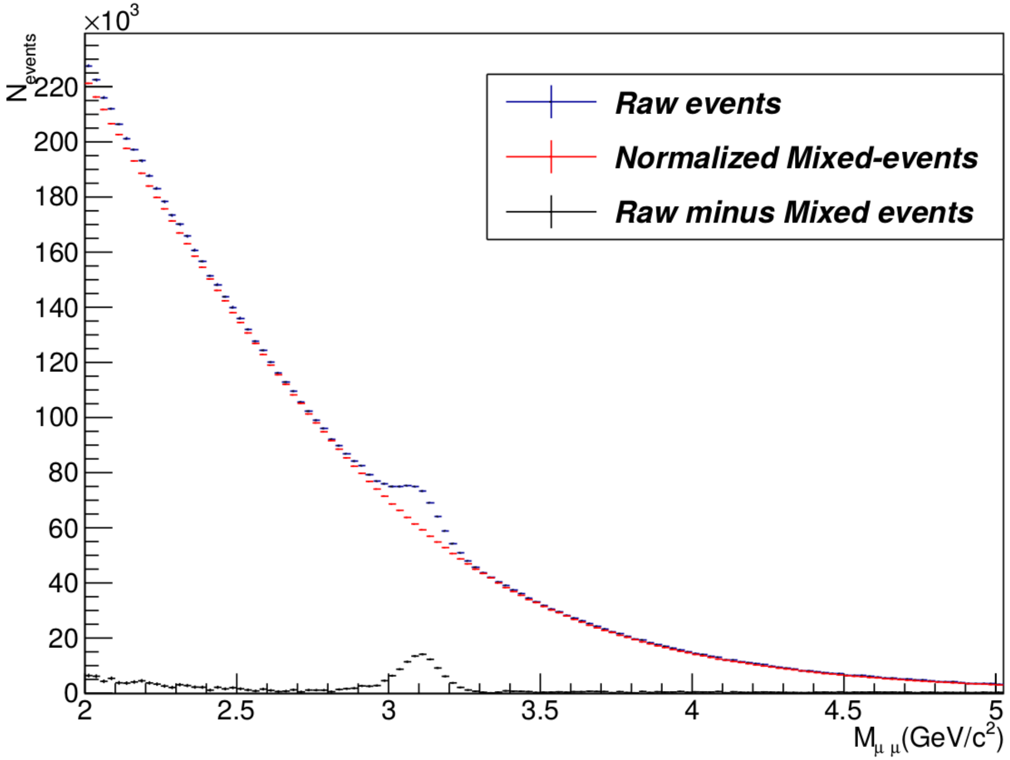
- Dimuon sources populating the invariant mass spectra
- Fully correlated dimuons decayed from charmonium states (J/ψ or ψ(2S))
- Background events:
  - o Correlated dimuons from the decay of heavy quark pairs: $\mathrm{c} \to D \to \mu^+$
  - o Uncorrelated dimuons coming from different physics processes. $\mathrm{K} \to \mu^+$; $\pi \to \mu^-$

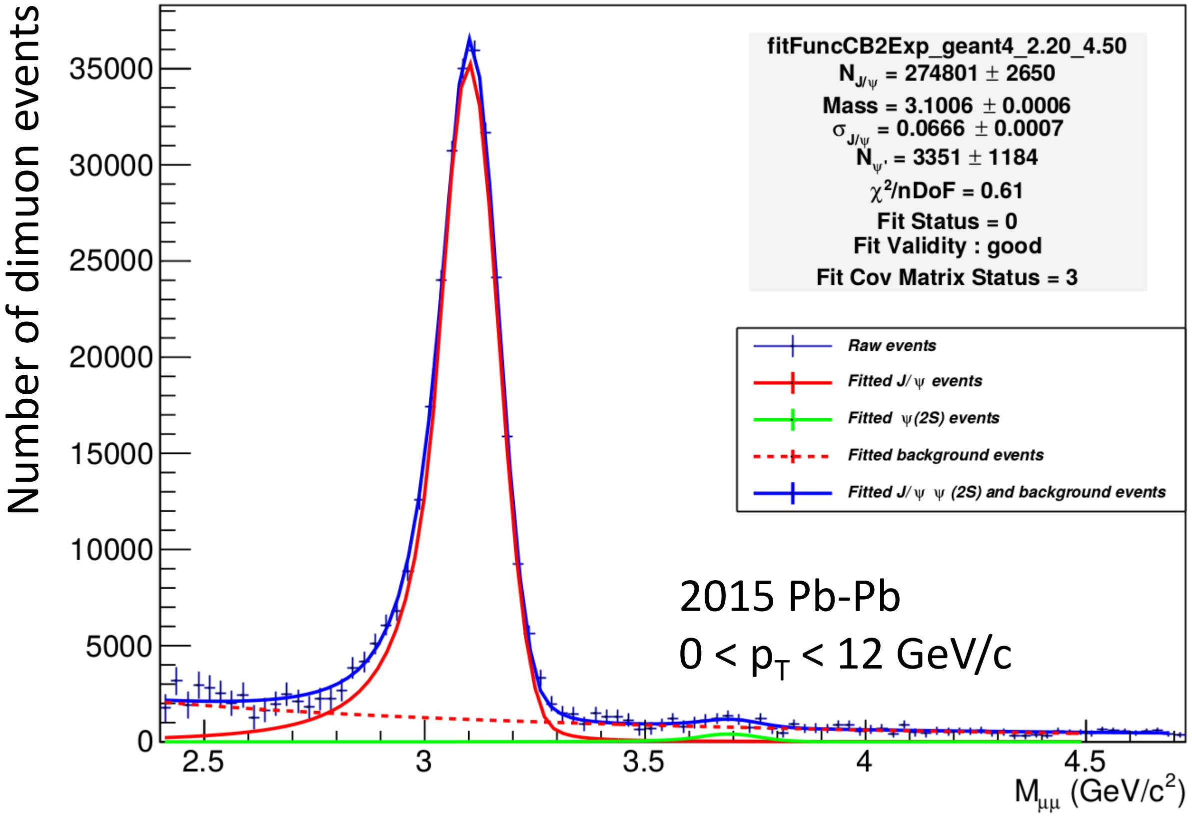
- Remove the uncorrelated dimuon events ⟶ mixed event method



J/ψ signal extraction in Pb-Pb: event mixing

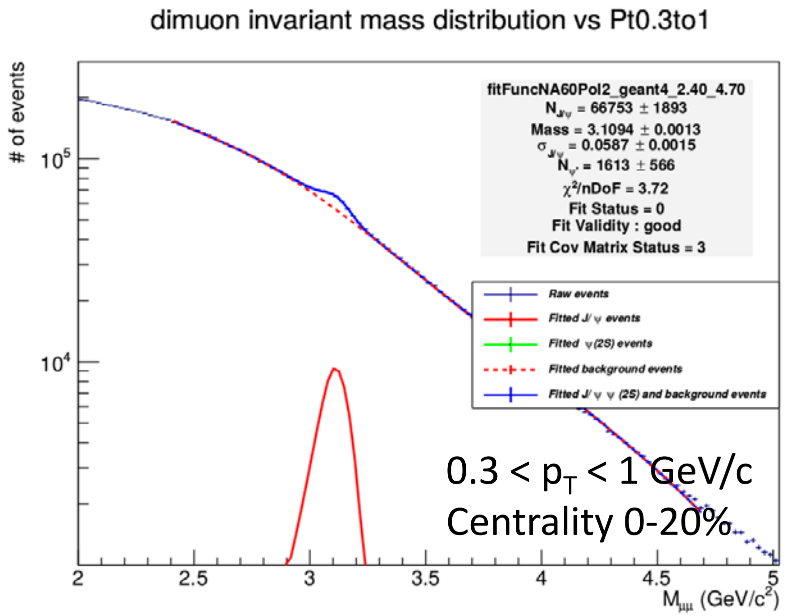
Signal function: CB2 with Geant4 tail
Background function: Exponential function: $f(x) = A \cdot e^{B \cdot x}$
Fit range [2.2, 4.5] $\mathrm{GeV/c^2}$

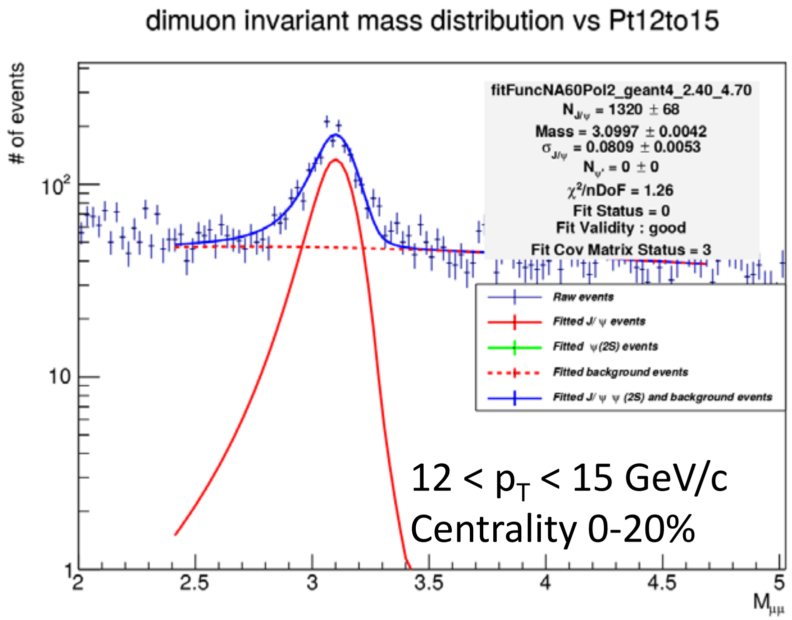


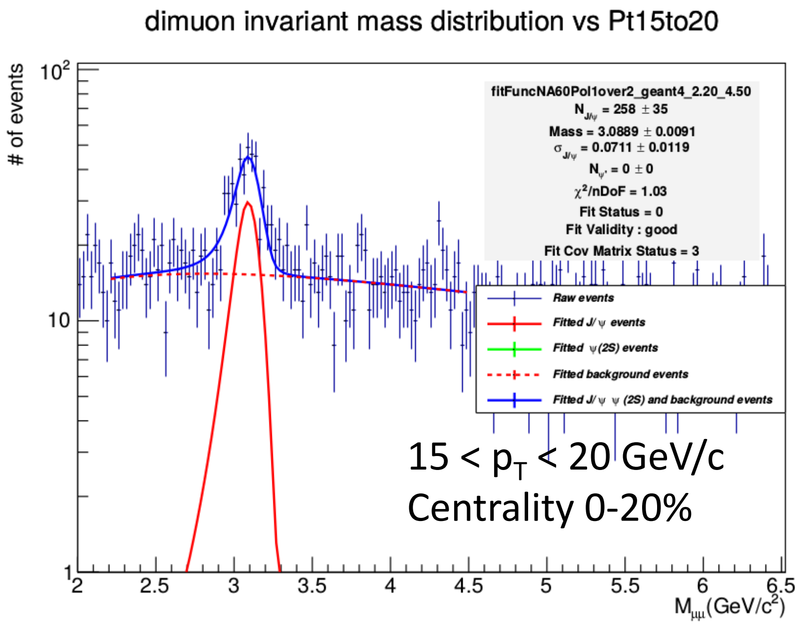


Signal is clear. Correlated background is estimated with an exponential

Number of J/ψ in 2018 Pb-Pb



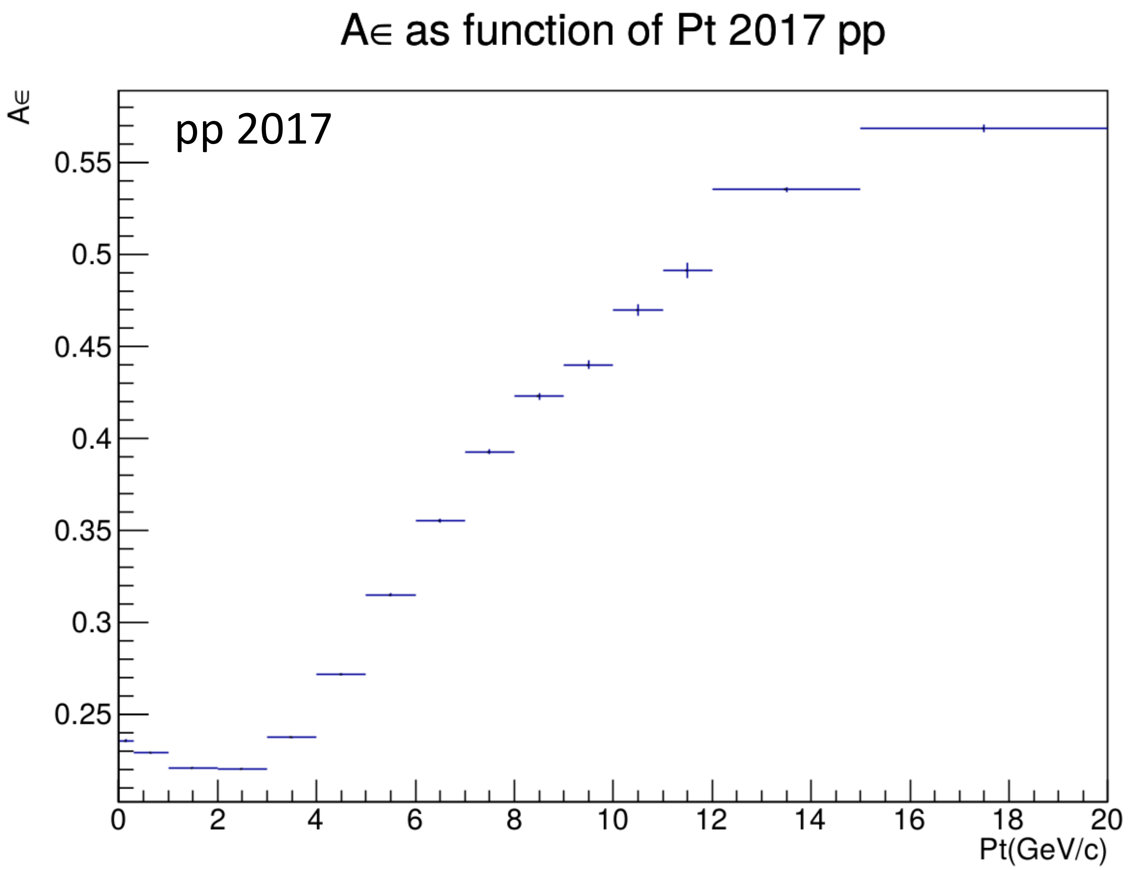


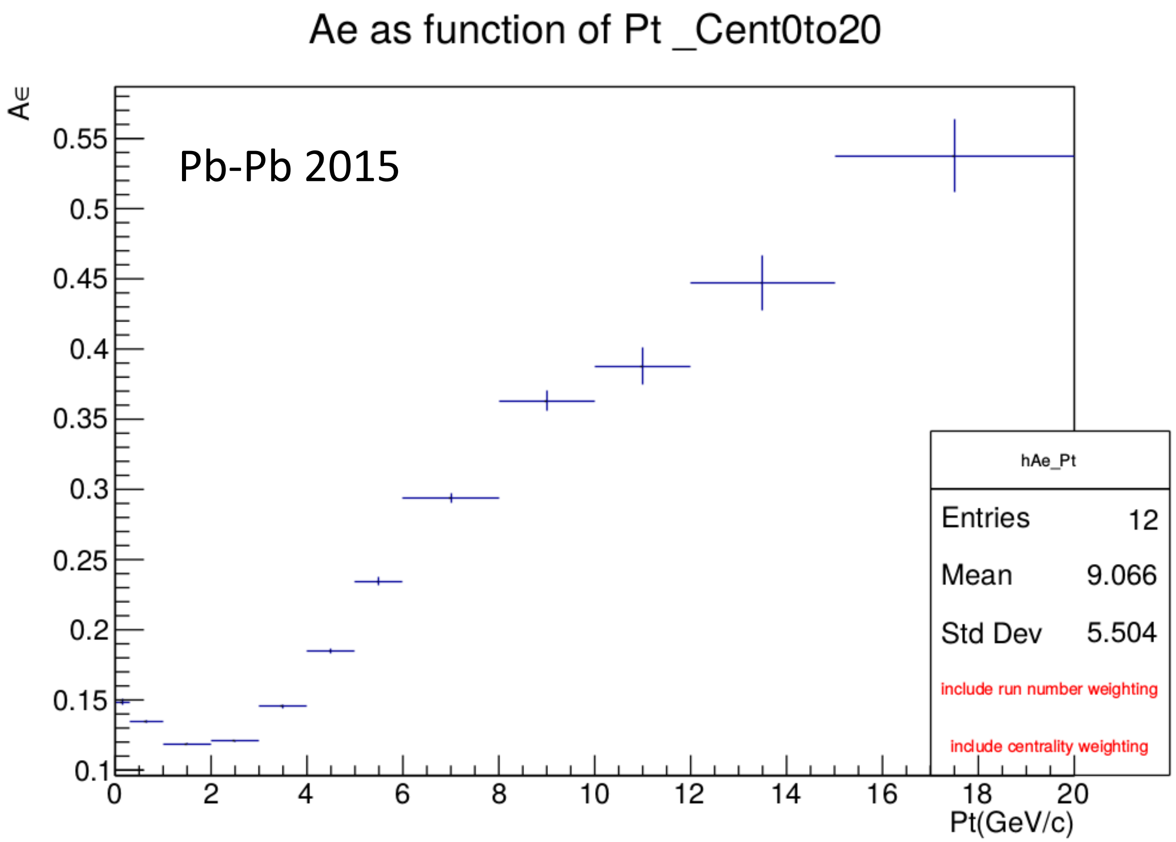


Signal function: NA60 (The same Geant4 tail as in 2015 Pb-Pb). Background function: pol2/pol3, pol1/pol2 (for high p_T region)

$N^{J/\psi}$ = 258 +/- 35 in p_T [15, 20] GeV/c → the statistical precision on the J/ψ yield is ~13.5%

Acceptance times efficiency vs p_T





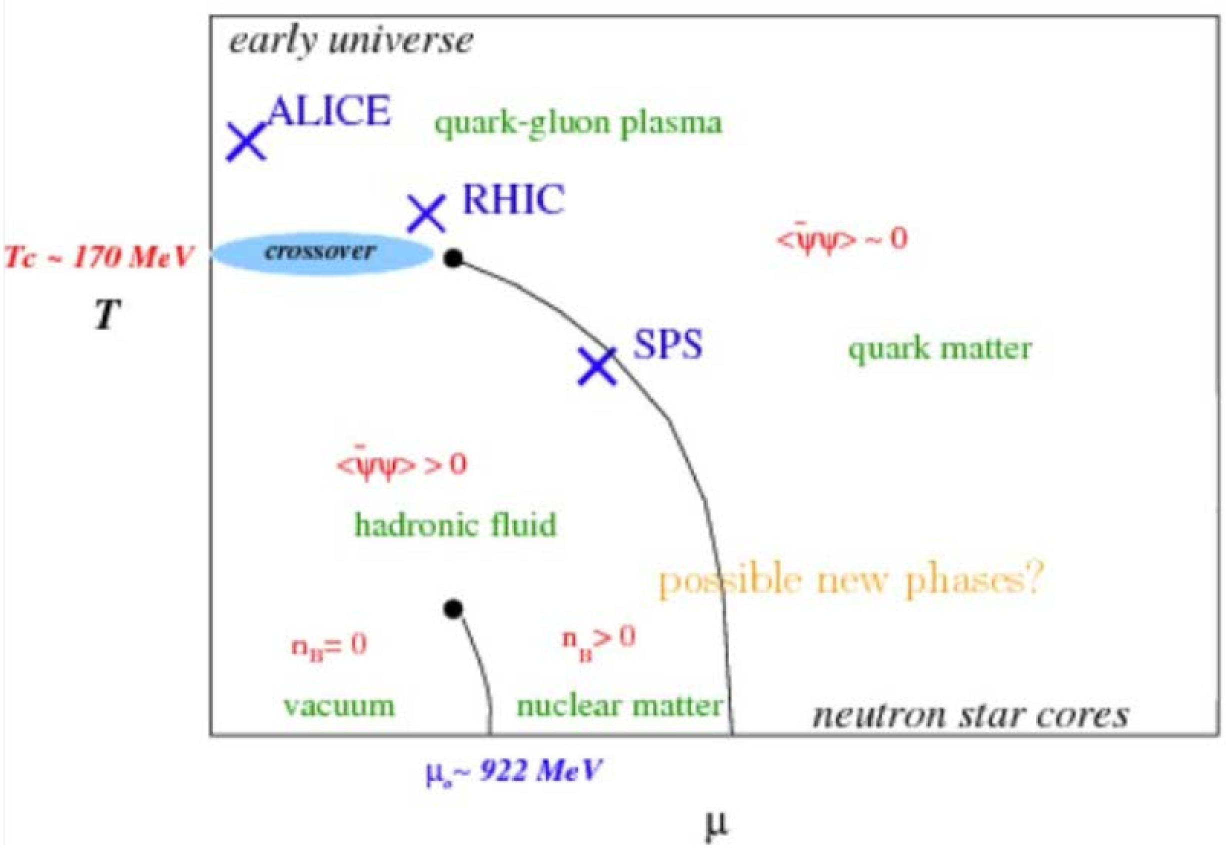
Efficiency is lower in Pb-Pb due to the higher trigger p_T threshold and high occupancy in detectors

Conclusion and to do

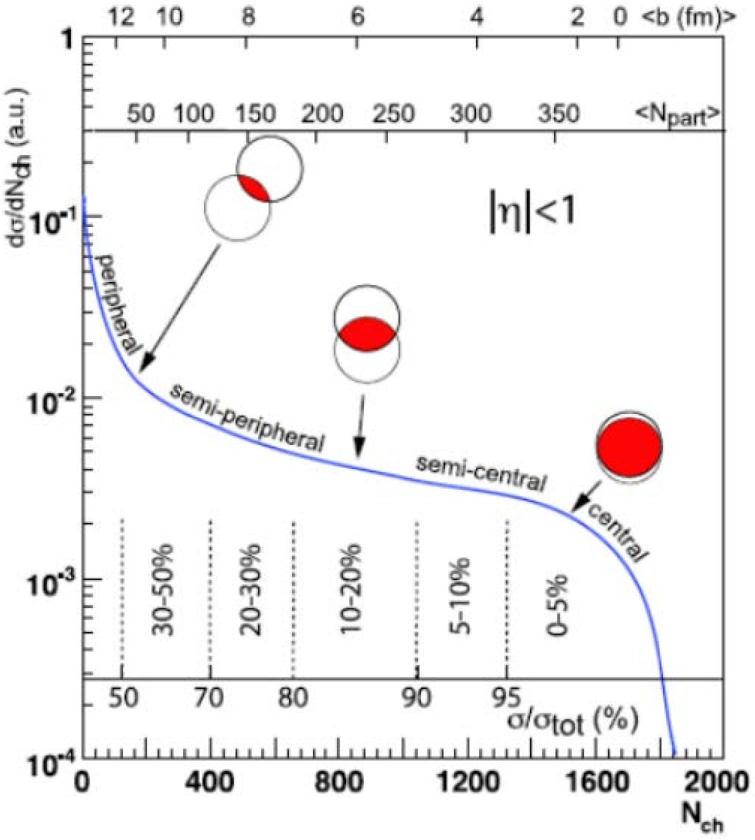
- Measuring J/ψ production cross section in pp collisions at various energy is important to study J/ψ production mechanism
- It is also an important reference for the new J/ψ R_{AA} measurement in Pb-Pb with 2015 + 2018 data which allow one to reach larger p_T and perform double differential analysis in p_T / y
- J/ψ is a probe of the QGP by measuring its R_{AA} observable
- Different medium effects can explain the yield suppression / enhancement in Pb-Pb w.r.t pp collisions:
  - color screening (low to large p_T)
  - regeneration (low p_T mainly)
  - energy loss (large p_T)
- Combined analysis of several datasets is on the way to compute J/ψ R_{AA} up to p_T = 20 GeV/c
- To measure J/ψ R_{AA} accumulating 2015+2018 Pb-Pb data
  - Compute Aε vs p_T in 2018 PbPb
  - Extract J/ψ signal with full statistics in p_T intervals until 20 GeV/c
  - Apply the mixed-event method to subtract the background events in 2018

Back up

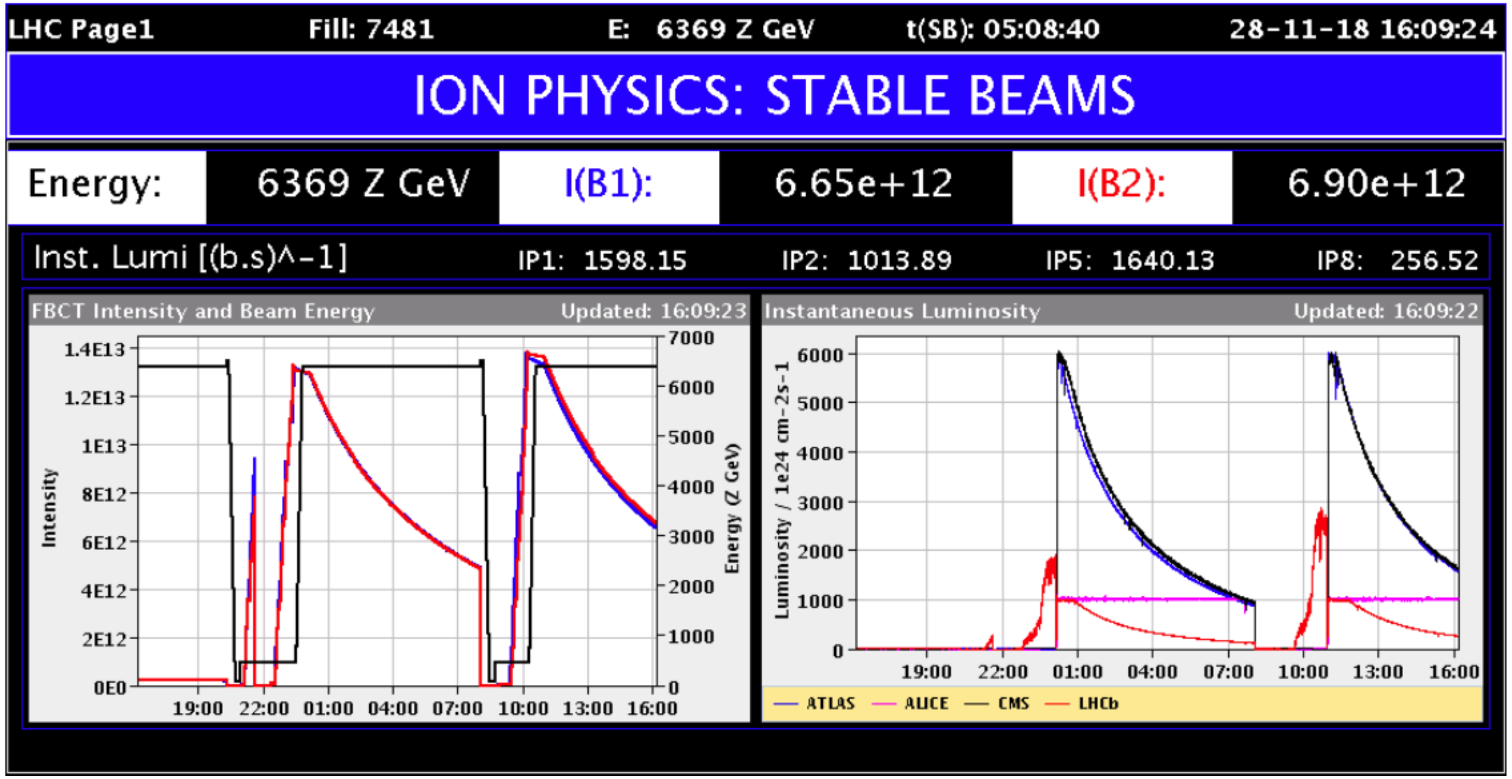
QCD phase diagram

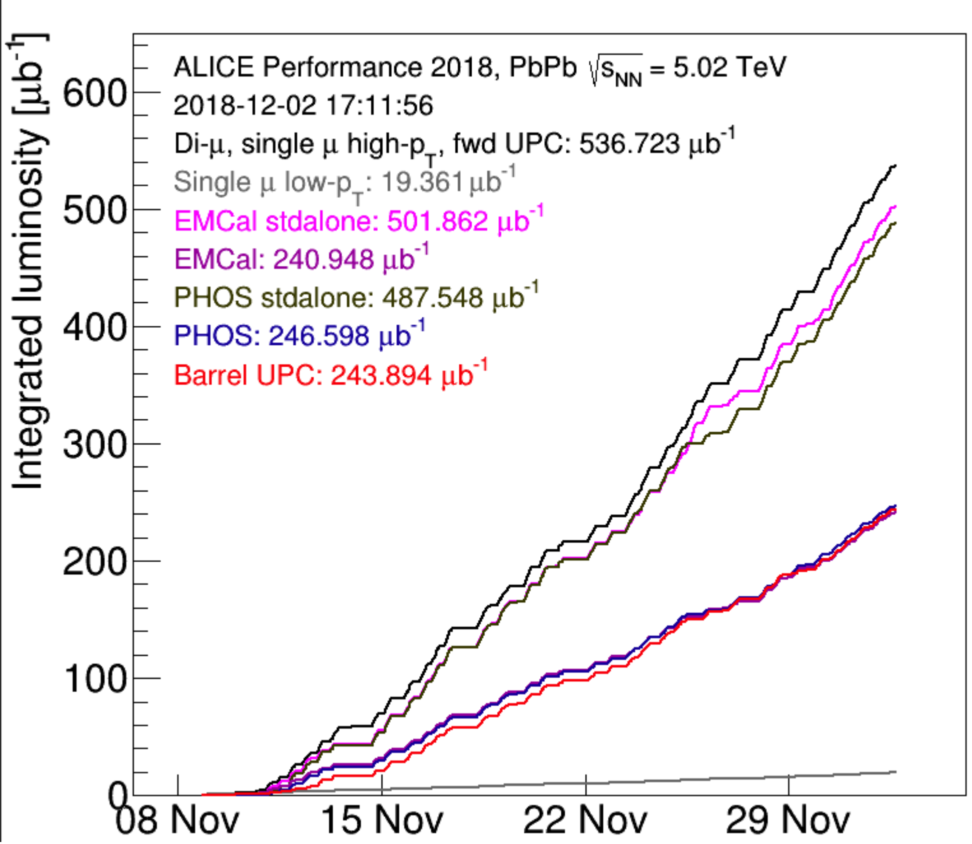


Relating Glauber to real collisions

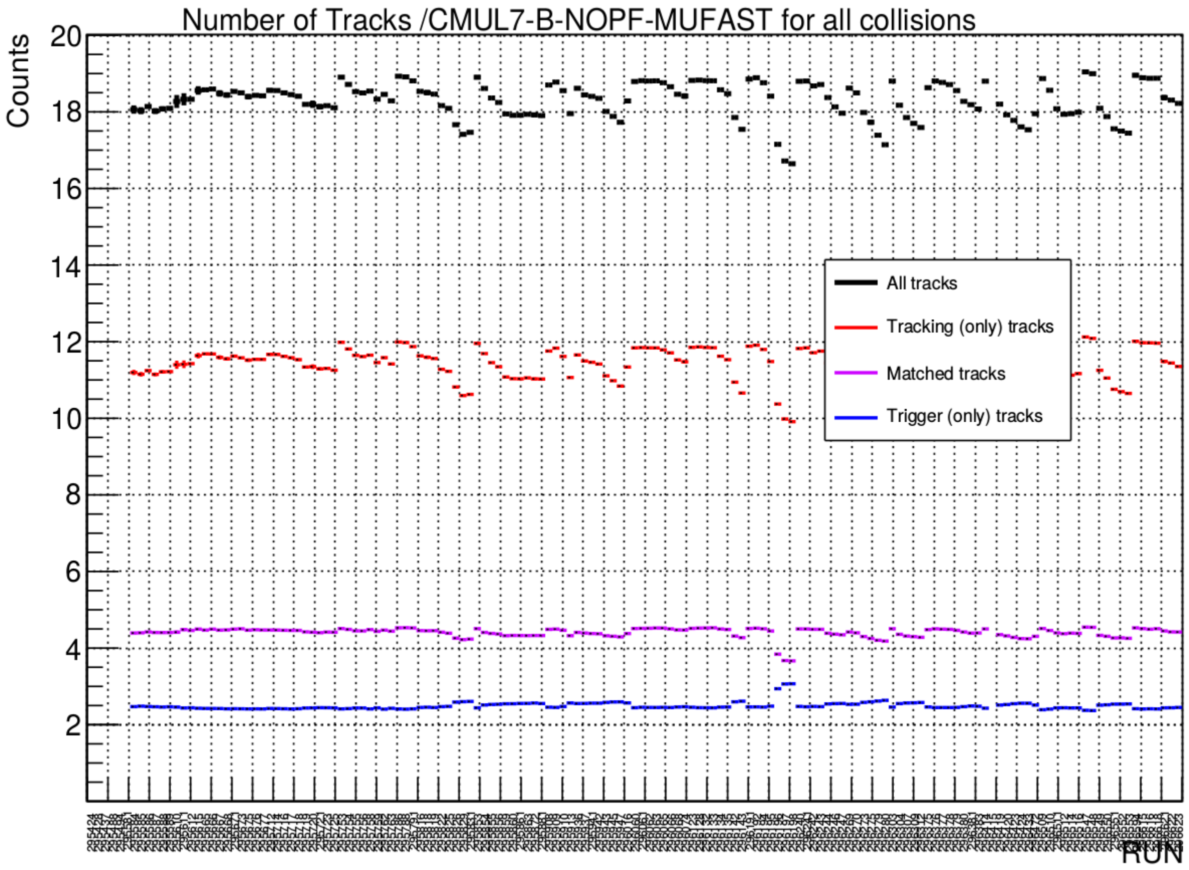


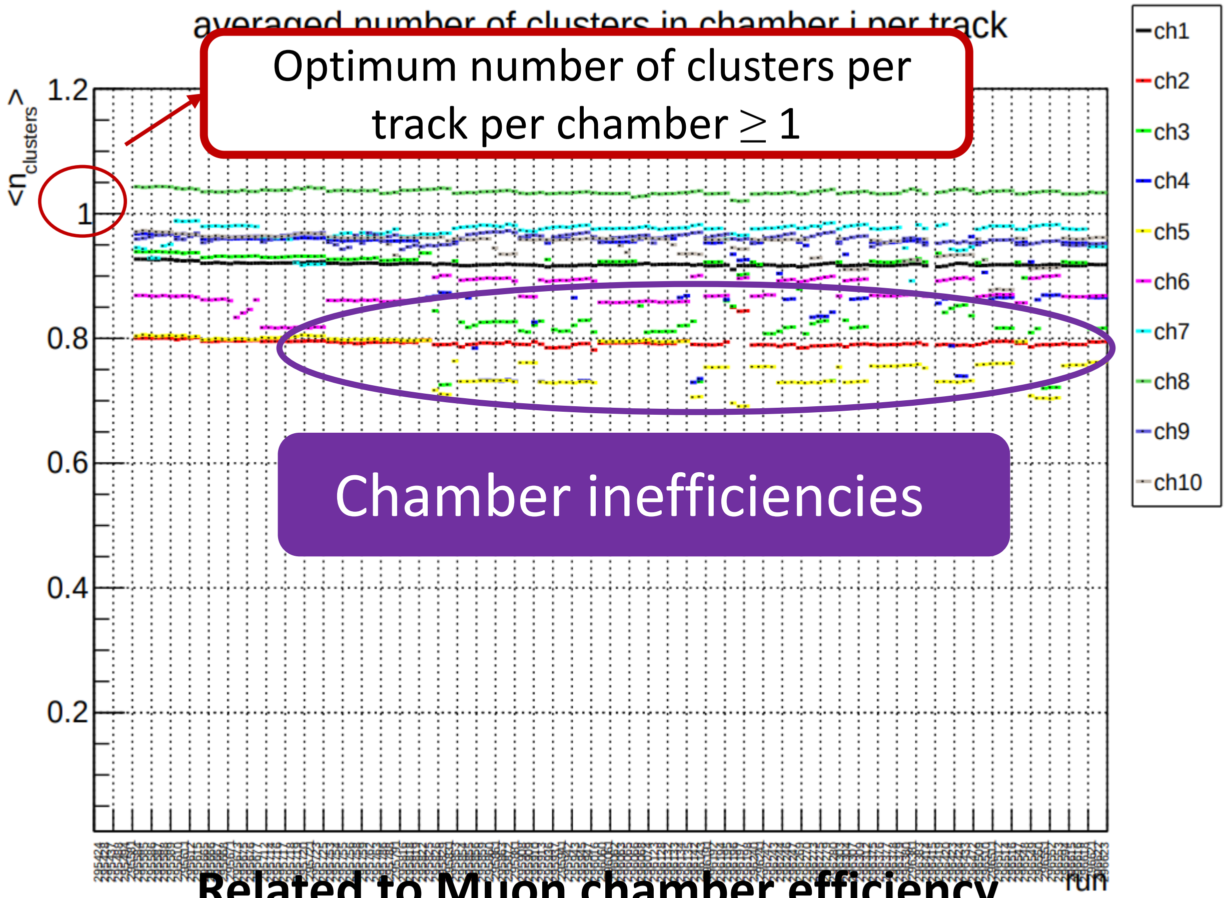
Luminosity at the LHC in 2018





Quality of muon data in 2018 Pb-Pb





Related to Muon chamber efficiency

- Matched tracks: Matching of tracking tracks with trigger tracks with p_T threshold of 1 GeV/c
- Stable trending plots in 2018
- Chamber inefficiencies are reproduced in MC simulation

Analysis of inclusive J/ψ in 2015 and 2018 Pb-Pb data

Data samples

137 QA checked runs (2015)

(110+101)QA checked runs. 2018 data taking reconstruction finished in January,2019

Event selection

- Trigger selection: Dimuon trigger
- Centrality selection: With V0A and V0C
- Physics selection: To reject background events

Track selection (Single muon)

- Pseudo rapidity selection: 2.5-4.0. The geometrical acceptance of the muon spectrometer
- θ_{abs} selection: 2 – 10^{o}
- Matching of tracking tracks with trigger tracks with p_T threshold of 1GeV/c
- $p \times DCA$ (momentum times Distance of Closest Approach) selection: To reject beam gas tracks

Dimuon selection

- Rapidity: 2.5 < **y** < 4.0: The acceptance of the measurement

J/ψ signal extraction in pp & Pb-Pb

Signal functions (for invariant mass of dimuons $M_{\mu^+\mu^-}$):

- Extended Crystal Ball (CB2), tails from MC (Geant3 & Geant4) and 13 TeV pp data
- NA60 function, tails from MC (Geant3 & Geant4)

Background functions:

- Variable Width Gaussian (VWG2 & VWG1)
- Polynomial ratios (Pol2/Pol3 & Pol1/Pol2)
- Exponential function – for mixed-event method only

Fitting ranges of invariant mass:

- Pb-Pb: [2.2, 4.5], [2.4, 4.7] GeV/c^2
- pp: [2.0, 4.8], [2.2, 4.4] GeV/c^2

Total methods in pp: $(3 + 2) \times 2 \times 2 = 20$

Total methods in Pb-Pb: $(3 + 2) \times 2 \times 3 = 30$

Extended Crystal-Ball (CB2)

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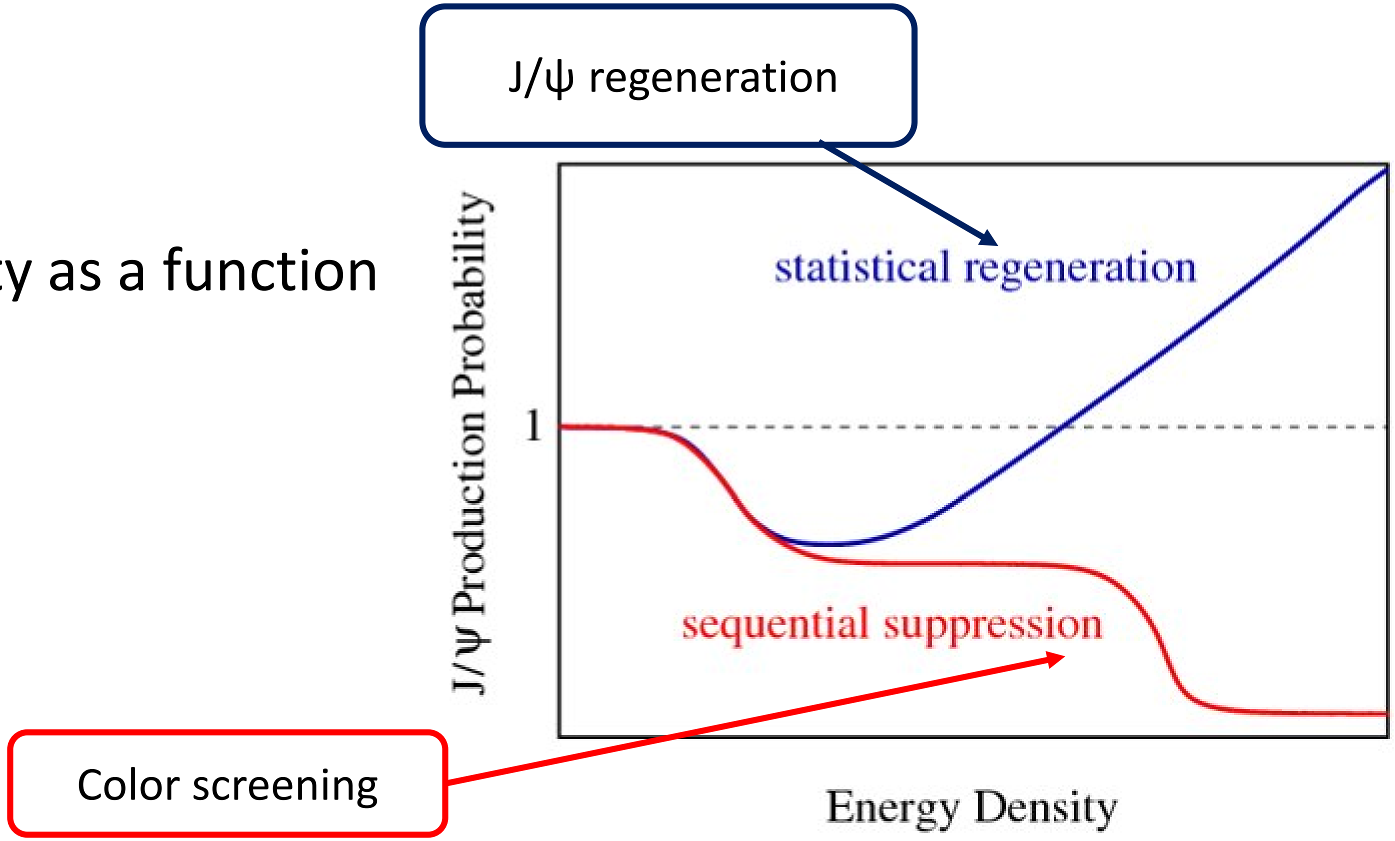
$\bar{x}$: the mean. σ: the width. (α, n, α', n'): 4 tail parameters fixed by MC simulation and data

J/ψ sequential suppression

J/ψ production probability as a function of energy density



Fit functions

Extended Crystal-Ball (CB2)

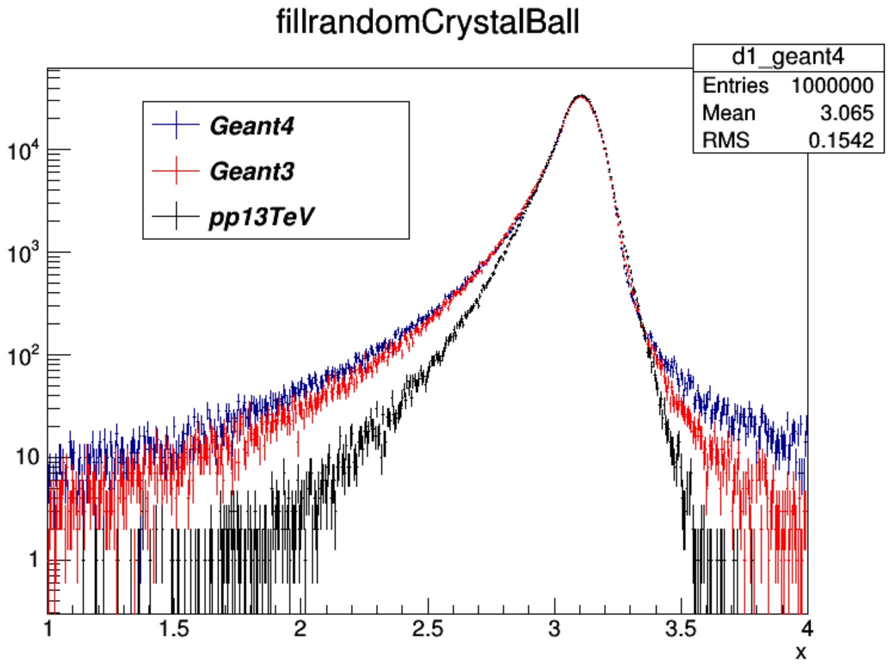
$$CB2(x) = N \cdot \begin{cases} \exp\left(\frac{-(x-\bar{x})^2}{2\sigma^2}\right) & \text{for } \alpha' > \frac{x-\bar{x}}{\sigma} > -\alpha \\ A.\left(B - \frac{x-\bar{x}}{\sigma}\right)^{-n} & \text{for } \frac{x-\bar{x}}{\sigma} \le -\alpha \\ C.\left(D + \frac{x-\bar{x}}{\sigma}\right)^{-n'} & \text{for } \frac{x-\bar{x}}{\sigma} \ge \alpha' \end{cases}$$

with

$$A = \left(\frac{n}{|\alpha|}\right)^{n} \cdot exp\left(-\frac{|\alpha|^2}{2}\right), B = \frac{n}{|\alpha|} - |\alpha|$$

$$C = \left(\frac{n'}{|\alpha'|}\right)^{n'} \cdot exp\left(-\frac{|\alpha'|^2}{2}\right), D = \frac{n'}{|\alpha'|} - |\alpha'|$$

si



$$NA60(x) = N \cdot \exp\left(-0.5\left(\frac{t}{t_0}\right)^2\right)$$

$$t = \frac{x-\bar{x}}{\sigma}$$

$$\begin{cases} t_0 = 1 + p_1^L(\alpha^L - t)^{(p_2^L - p_3^L\sqrt{\alpha^L - t})} & \text{for } t < \alpha^L \\ t_0 = 1 & \text{for } \alpha^L < t < \alpha^R \\ t_0 = 1 + p_1^R(t - \alpha^R)^{(p_2^R - p_3^R\sqrt{t-\alpha^R})} & \text{for } t > \alpha^R \end{cases}$$

›n has a normalization factor N, and four parameters ($\bar{x}$, α, β, γ):

$$VG2(x) = N.exp\left(\frac{-(x-\bar{x})^2}{2\sigma^2}\right), \text{where } \sigma = \alpha + \beta\left(\frac{x-\bar{x}}{\bar{x}}\right) + \gamma\left(\frac{x-\bar{x}}{\bar{x}}\right)^2$$

Polynomials ratio (Pol2/Pol3)

In addition to the normalization factor N, this function has 5 parameters (a_1, a_2, b_1, b_2, b_3) and it is defined by:

$$Pol2/Pol3(x) = N.\frac{1 + a_1 x + a_2 x^2}{b_1 x + b_2 x^2 + b_3 x^3}$$

Weight in calculation of A*ε

Run number Weighting

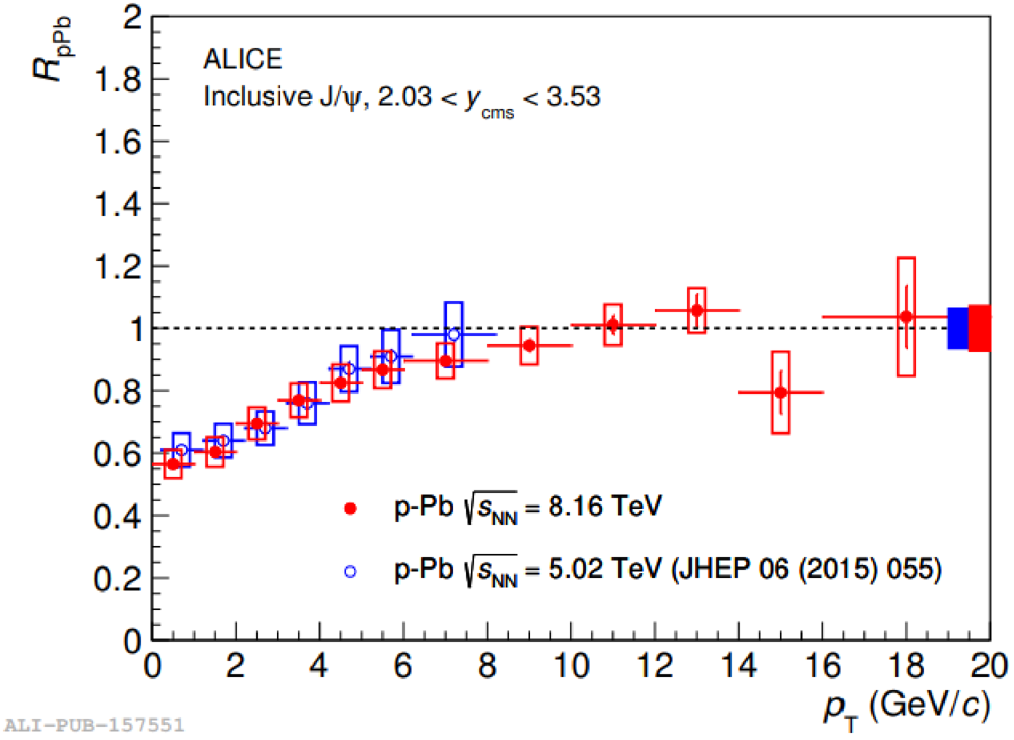
Weighted Acceptance x Efficiency $\overline{A\epsilon_j} = \frac{\sum_i N_{CMUL}^{i,j} \cdot A\epsilon_{i,j}}{\sum_i N_{CMUL}^{i,j}}$,

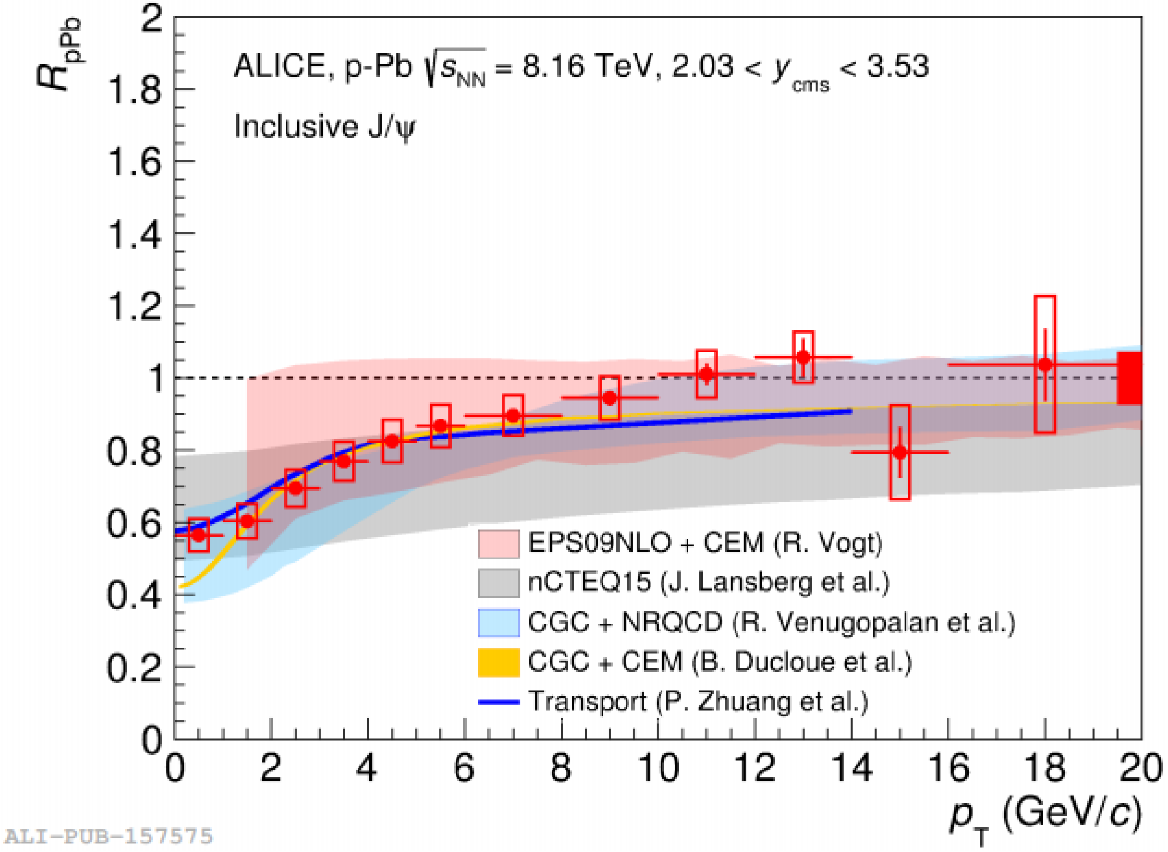
the weighted uncertainty $\sigma_{\epsilon,j} = \sqrt{\frac{\sum_i (N_{CMUL}^{i,j})^2 * \sigma_{\epsilon,i,j}^2}{(\sum_i N_{CMUL}^{i,j})^2}}$,

Centrality Weighting

Weighted Acceptance x Efficiency $\overline{A\epsilon} = \frac{\sum_j N_{CMUL}^{j} \overline{A\epsilon_j}}{\sum_j N_{CMUL}^{j}}$

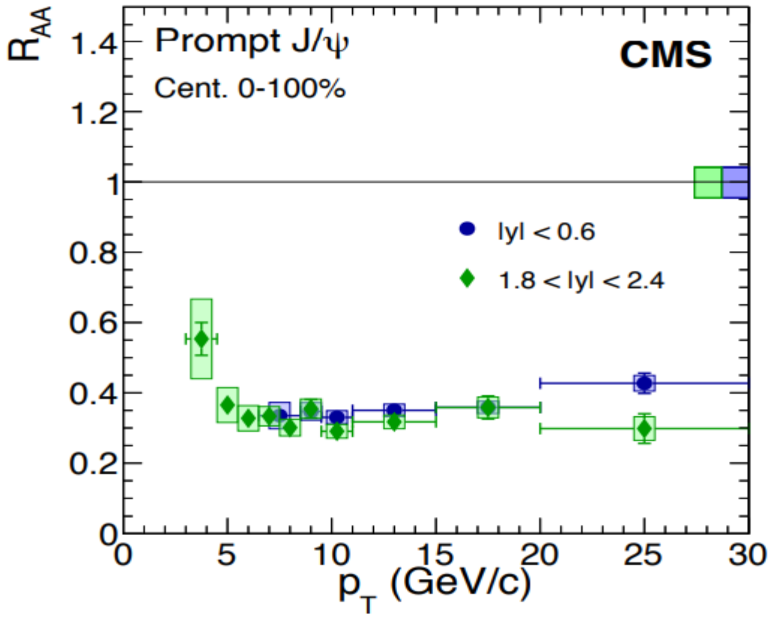
where $N_{CMUL}^{i,j}$ is the number of events in run number i in centrality bin j for CMUL trigger from real data.

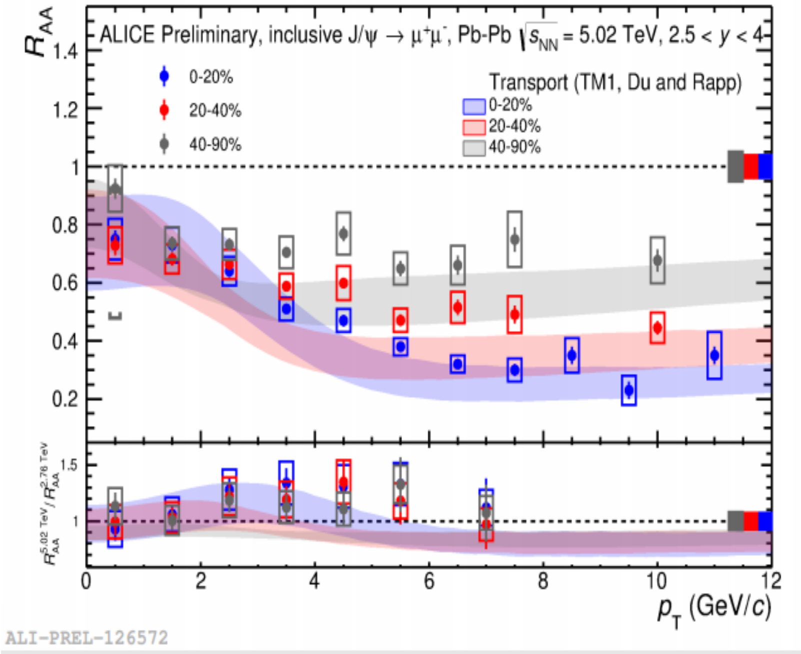


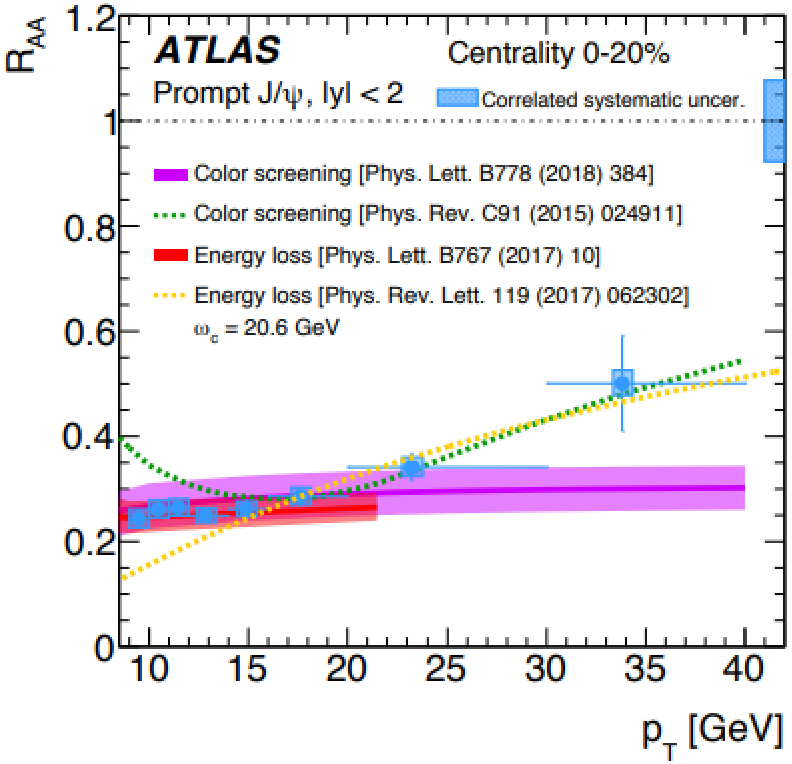


CNM effects (shadowing, gluon saturation, energy loss, ...) studied by measuring the nuclear modification factor R_{AB} in light systems

Newest R_{AA} vs p_T in LHC and models



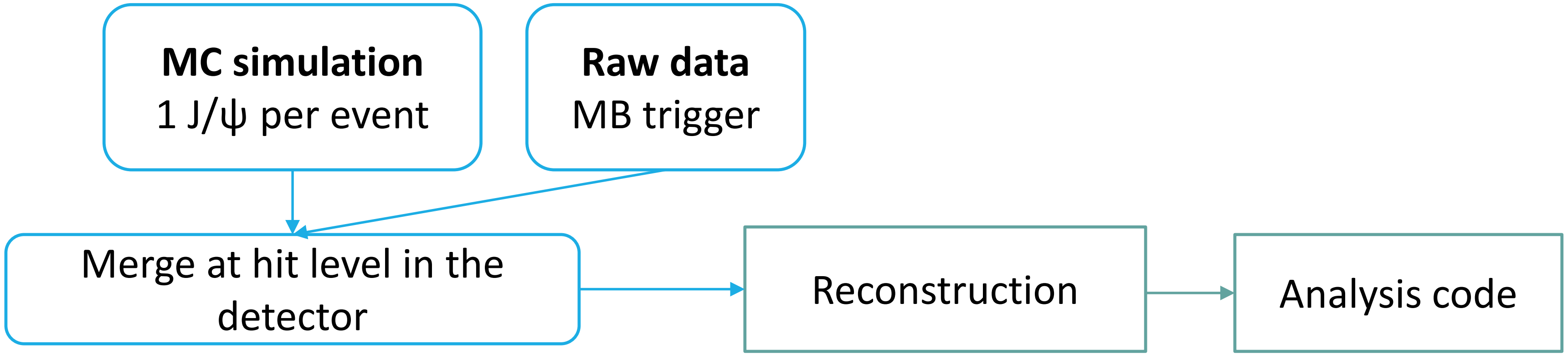




Monte-Carlo(MC) simulation of 2015 Pb-Pb collisions

- High occupancy of the detectors in Pb-Pb collisions -> decrease of the detector resolution and efficiency

Principle of an embedding MC simulation

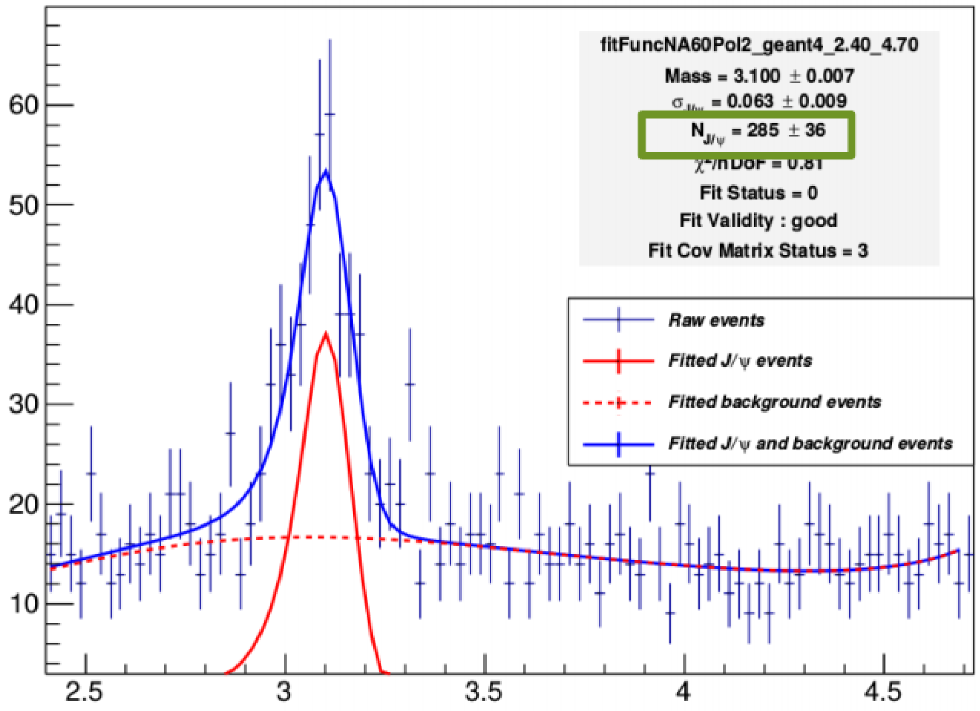


Embedding simulation: merge at hit level raw data and pure signal -> allow to simulate the high occupancy of the detectors

Estimation number of J/ψ in 2015 Pb-Pb collisions

Centrality 0-20%, J/ψ p_T range: 0-20 GeV/c

pT: 12-15 GeV/c

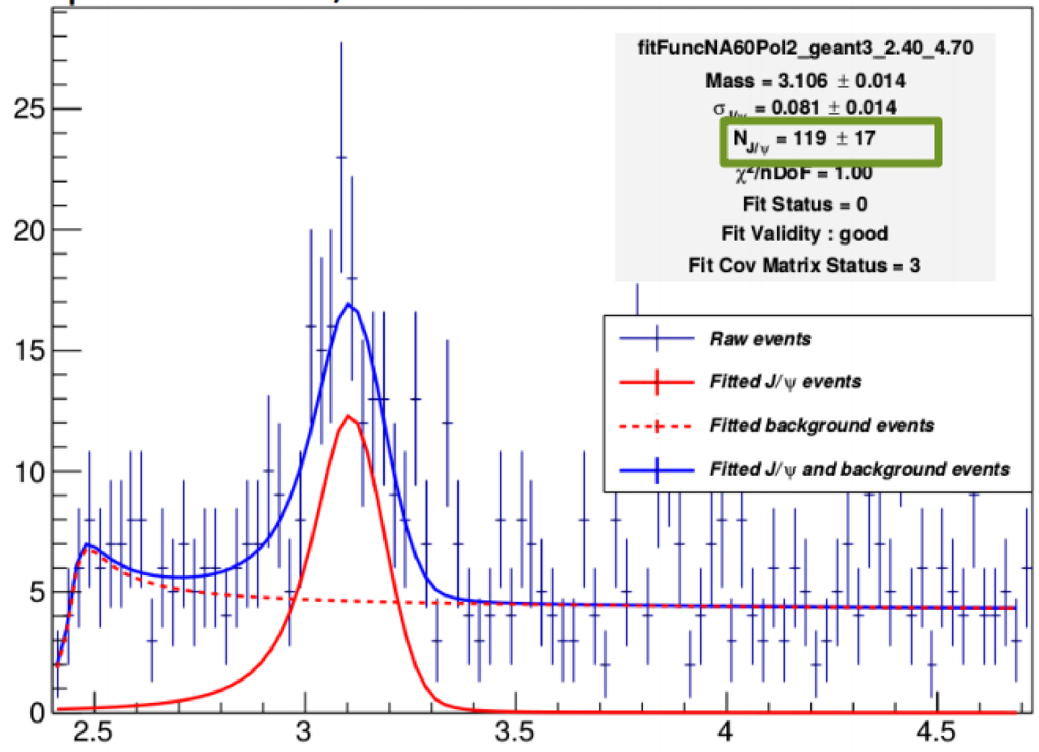


Signal function: NA60

(Signal tails integrated over p_T: Geant 4 and Geant 3)

Background function: pol2/pol3

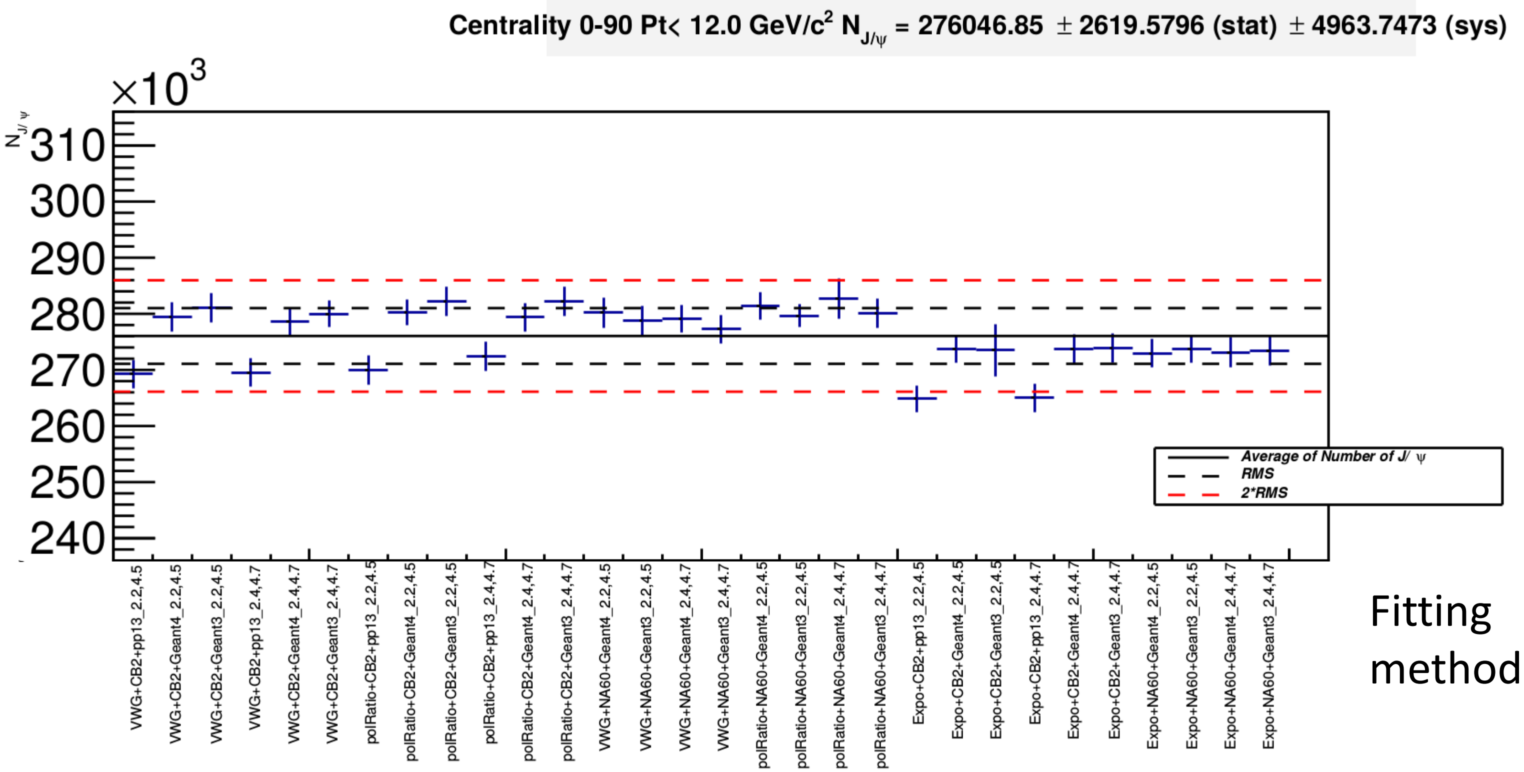
pT: 15-20 GeV/c



The statistical precision on the J/ψ yield is ~14% in p_T 15-20 GeV/c -> p_T reach = 20 Gev/c

J/ψ signal extraction in 2015 PbPb

The systematic uncertainty on J/ψ signal extraction in 2015 Pb-Pb



Fitting methods

$N_{J/\psi} = 277007 \pm 2434(stat) \pm 4806(sys)$*

*: Phys. Lett. B 766(2017) 212-224

The relative difference: $-0.3\% \pm 7.6\%(stat) \pm 3.3\%(sys)$

J/ψ signal extraction in 2018 PbPb

2018 (30 runs/ (130 runs + 118 runs to be checked QA)) Dimuon invariant mass with all centrality and p_T integrated

Signal function: CB2
Background function: VWG

Estimated number of J/ψ events in this year : 276k*2.4~ 662k according the luminosity