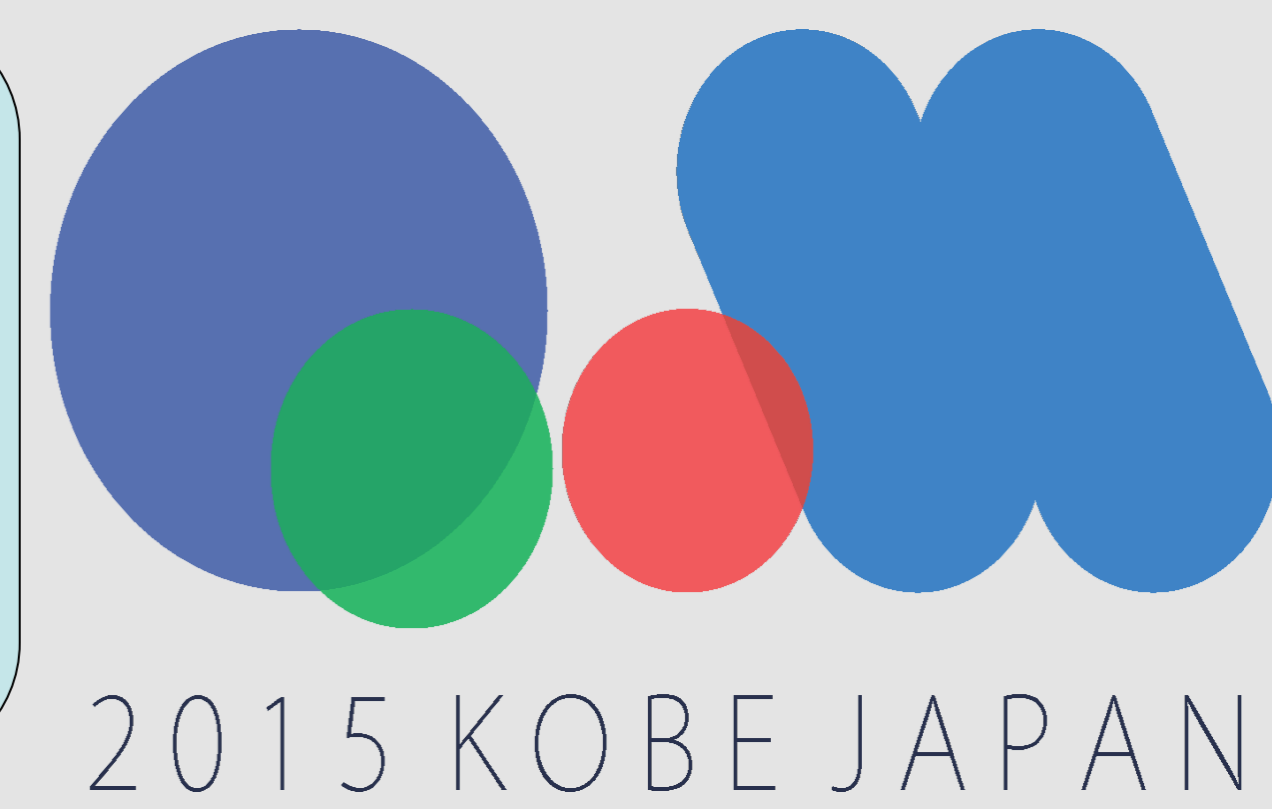




Non-Prompt J/ψ Measurements at STAR

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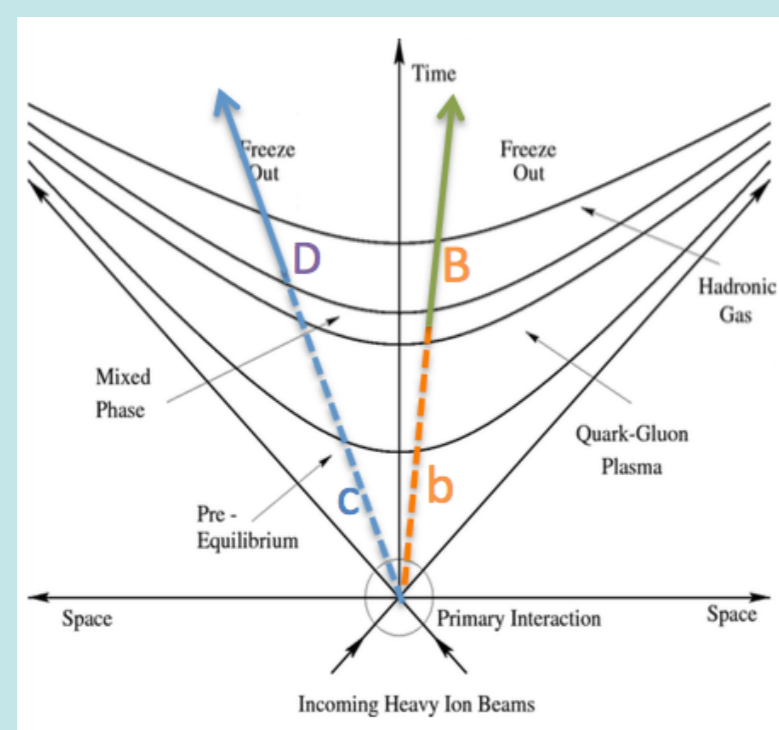


Abstract

Because of their large masses and long lifetimes, heavy quarks are dominantly produced in initial hard parton scattering processes and can experience the whole evolution of the Quark Gluon Plasma (QGP) created in high-energy heavy-ion collisions. Therefore heavy quarks have been suggested as excellent probes to study the properties of the QGP. Measurements of non-prompt J/ψ produced from B hadron decays are very interesting because they may provide an opportunity to access bottom quark production in heavy-ion collisions at the Relativistic Heavy Ion Collider (RHIC). Such measurements have become possible with the installation of the Heavy Flavor Tracker (HFT) and Muon Telescope Detector (MTD) into the STAR experiment in 2014. The HFT can precisely measure track impact parameters, and thus allows a separation between prompt and non-prompt J/ψ through their decay lengths. The MTD enables J/ψ reconstruction in the dimuon channel at STAR for the first time, which is important for J/ψ measurements at transverse momentum $p_T < 5$ GeV/c and complementary to the dielectron channel at higher p_T . In this poster, we will present an updated measurement of non-prompt J/ψ production via J/ψ -hadron azimuthal correlations in p+p collisions at $\sqrt{s}=200$ GeV. The new result extends the lower p_T limit down to 1.5 GeV/c from 5 GeV/c in a previous measurement, conforming Fixed-Order-Next-to-Leading-Log(FONLL) and Color Evaporation Model calculations for $1.5 < p_T < 10$ GeV/c. We will also report the first result of J/ψ pseudo-decay length distribution in MinBias Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV measured with the STAR HFT. The observed distribution exhibits an excess with positive pseudo-decay lengths than negative ones, indicating the existence of non-prompt J/ψ in Au+Au collisions at RHIC energies. Finally, we will discuss the prospects of non-prompt J/ψ measurements at STAR using data taken in 2014-2016.

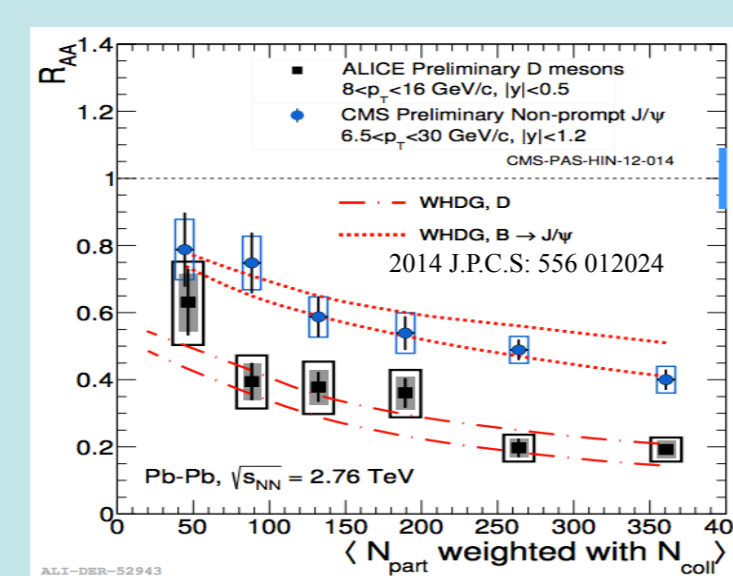
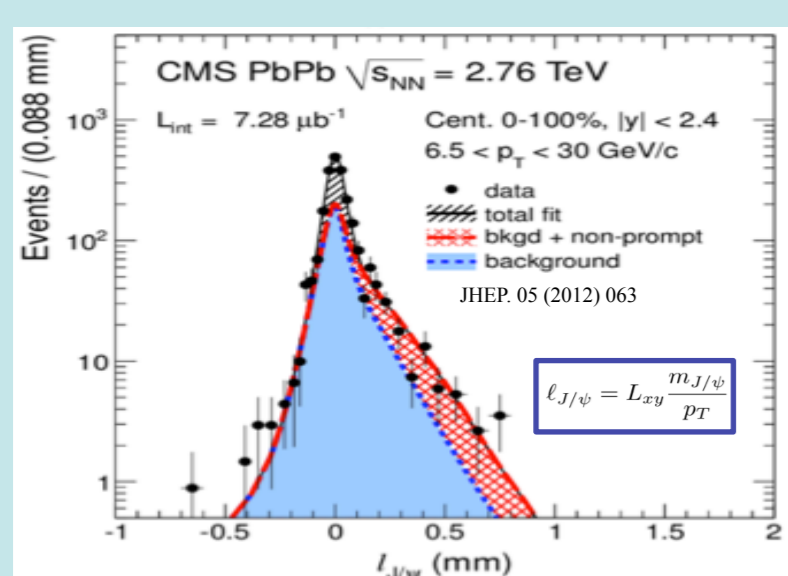
Motivation

- Due to different color charges and masses, parton energy losses within the QGP are expected to be different for gluons, light and heavy flavor quarks:



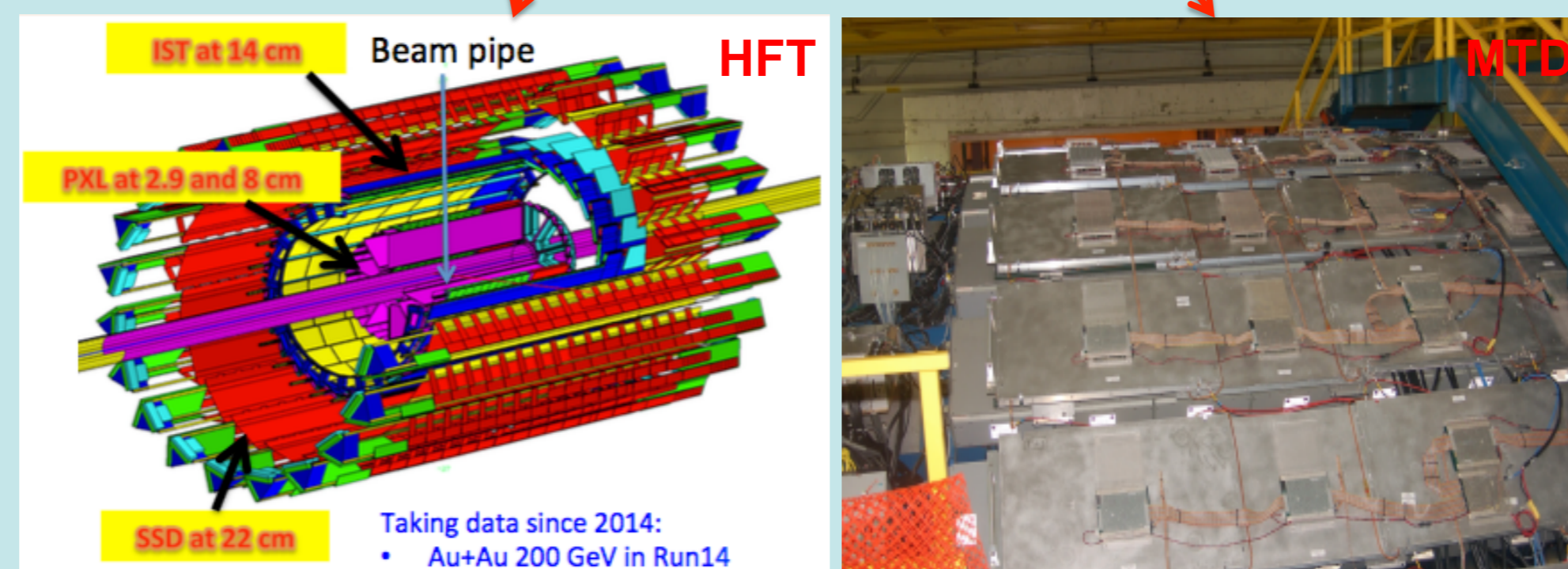
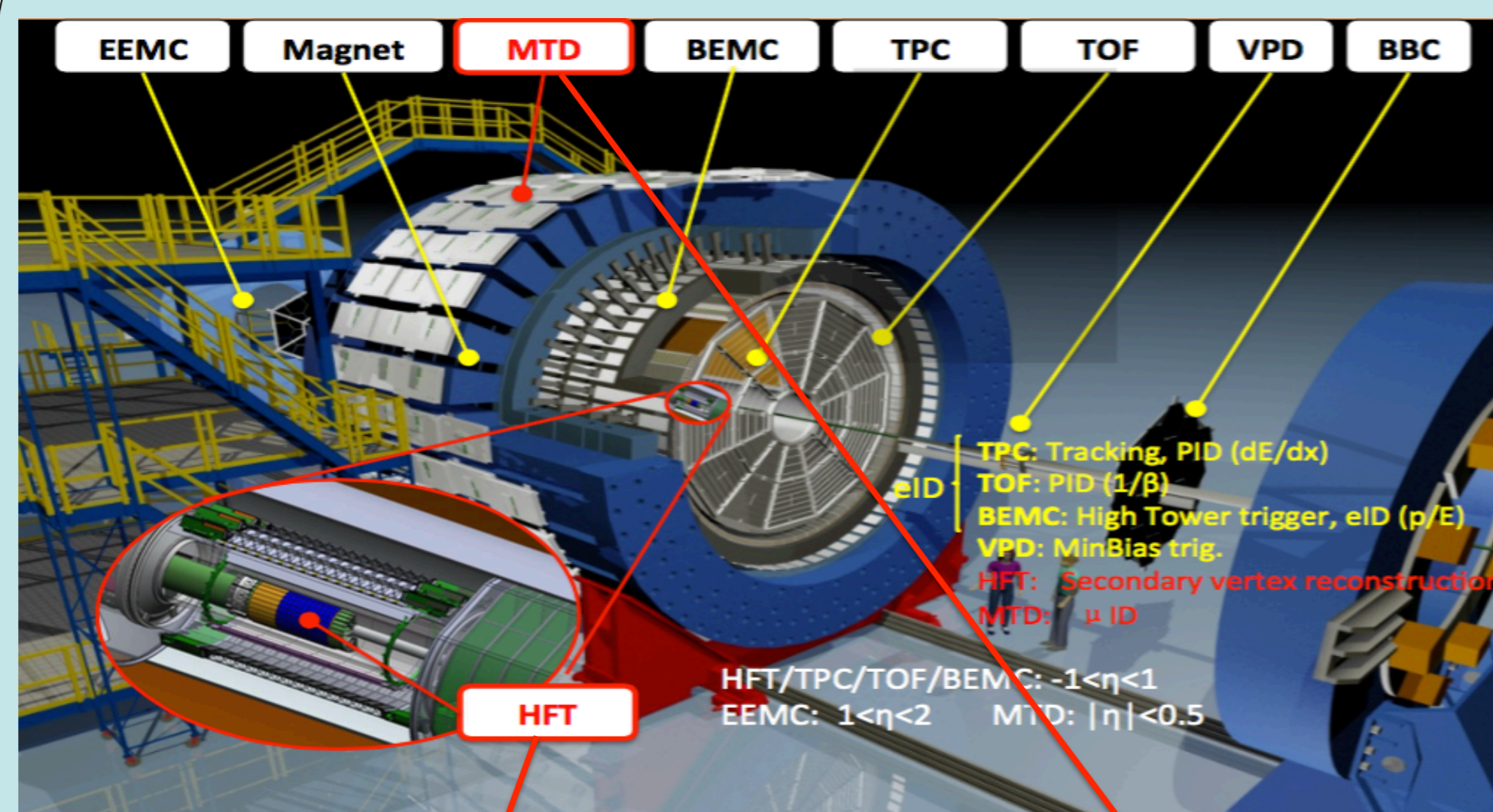
$$\Delta E(g) > \Delta E(u/d/s) > \Delta E(c) > \Delta E(b)$$

- Non-prompt J/ψ from Bottom hadron decays exhibit a strong kinematic correlation with their parent B hadrons due to the large J/ψ mass. Thus measurements of non-prompt J/ψ may provide a more direct access to bottom quark production in heavy-ion collisions to study b quark interactions with the QGP and thus QGP properties.
- At the LHC, CMS and ALICE results indicate that bottom quarks lose less energies than charm quarks in the QGP.



- In order to fully understand the dependences of parton in-medium energy loss on properties of parton (color charge, flavor and mass), and the properties of the medium (energy density, temperature and medium size), it is very crucial to study bottom quark production at RHIC energies.
- Measurements of non-prompt J/ψ at RHIC energies may provide insight into a new knowledge of properties of the b quark in-medium energy loss and the QGP itself.

STAR Experiment

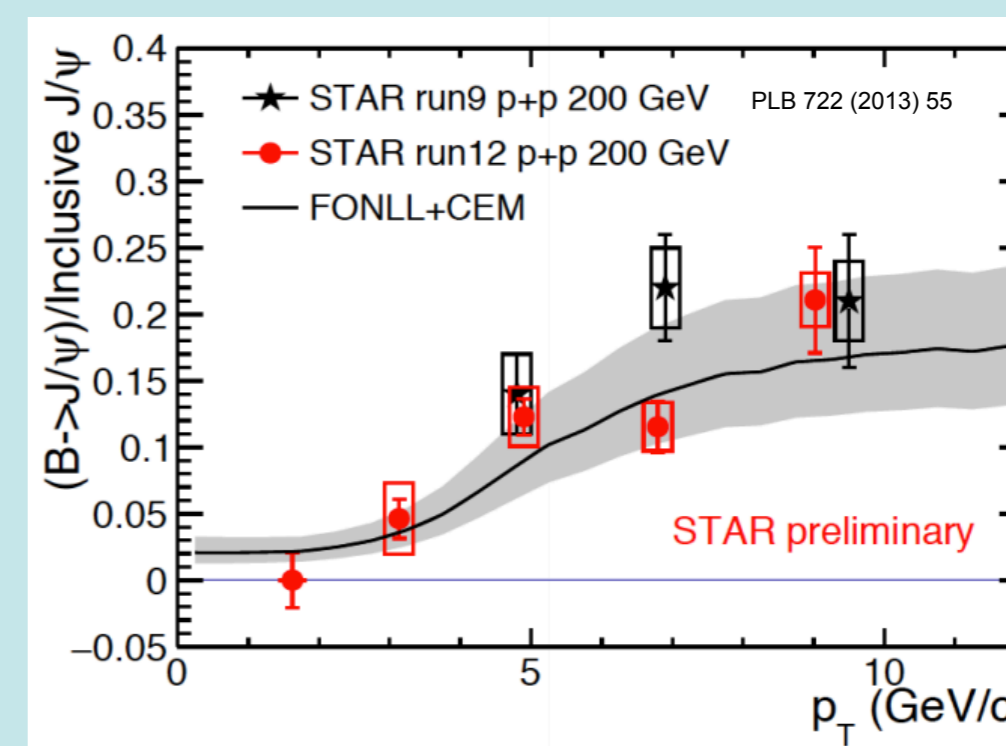
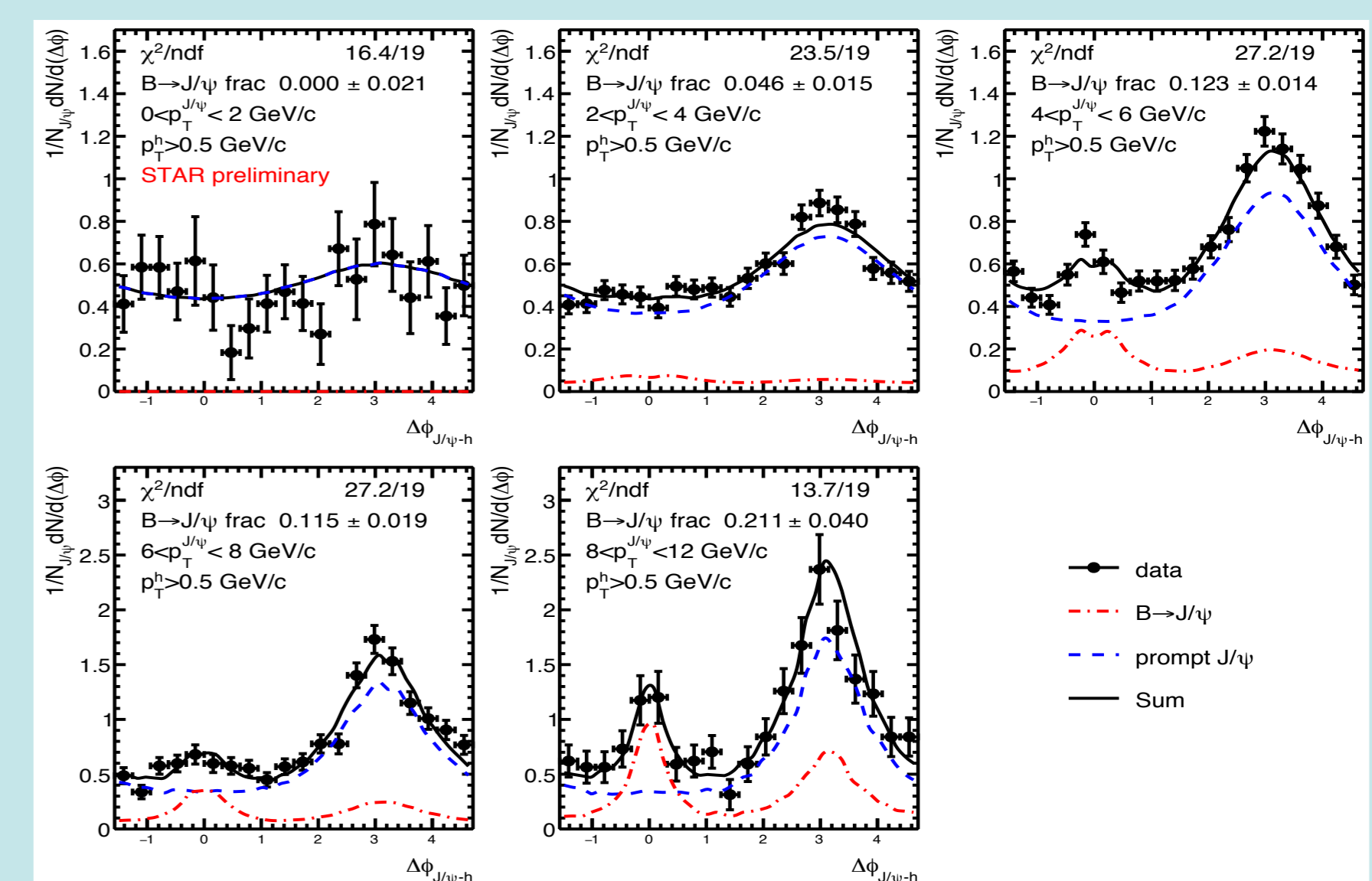


Main detectors for non-prompt J/ψ measurements:

- HFT:** precise Silicon vertex detector, $\sigma_{DCA} < 30 \mu\text{m}$ for $p_T > 1.5$ GeV/c, installed in 2014
- BEMC:** eID and online trigger detector for electron $p > 1.5$ GeV/c
- MTD:** muon ID and online trigger detector, fully installed in 2014
- TOF:** eID for electron $p < 1.5$ GeV/c through $1/\beta$
- TPC:** tracking, electron ID through dE/dx

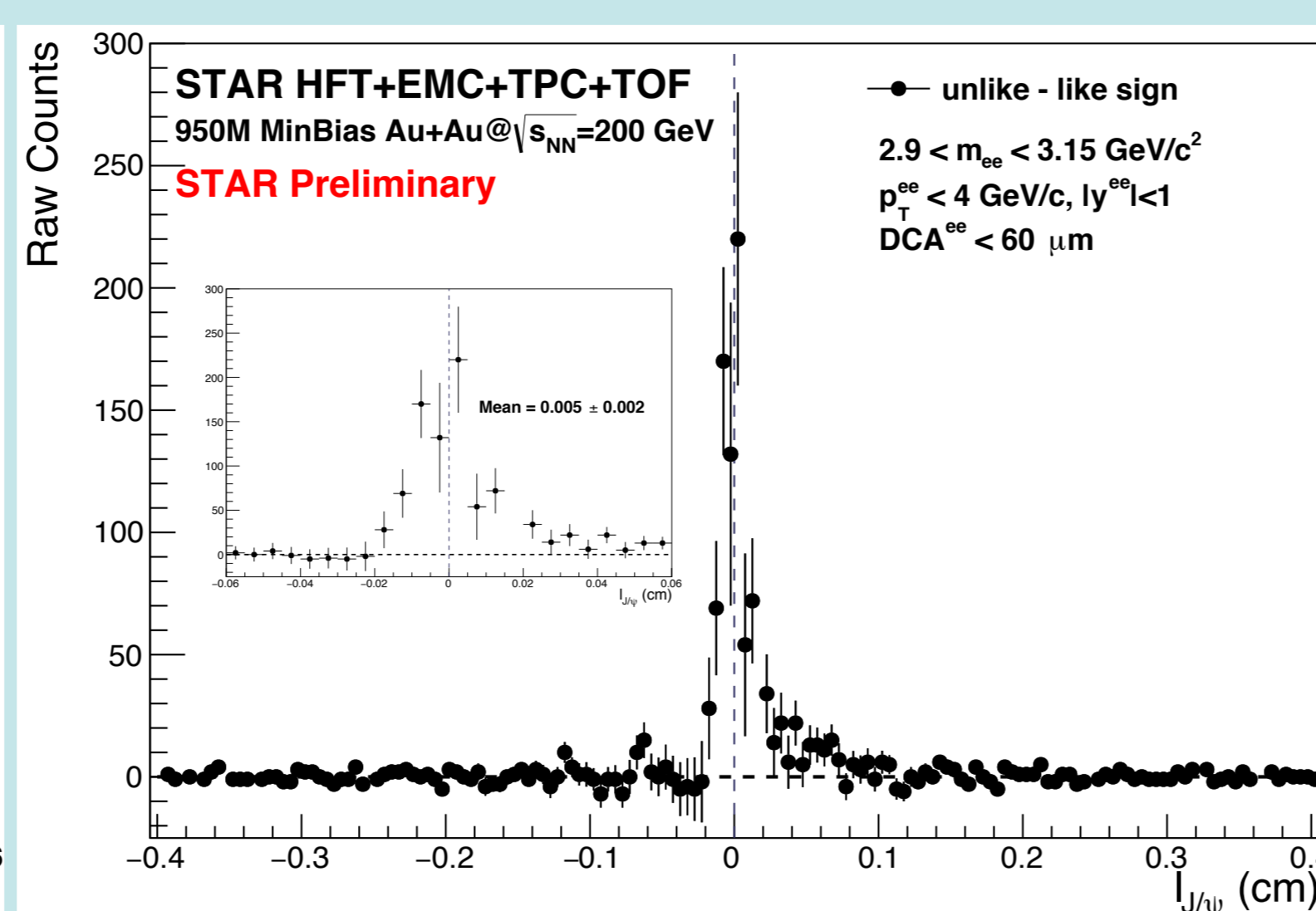
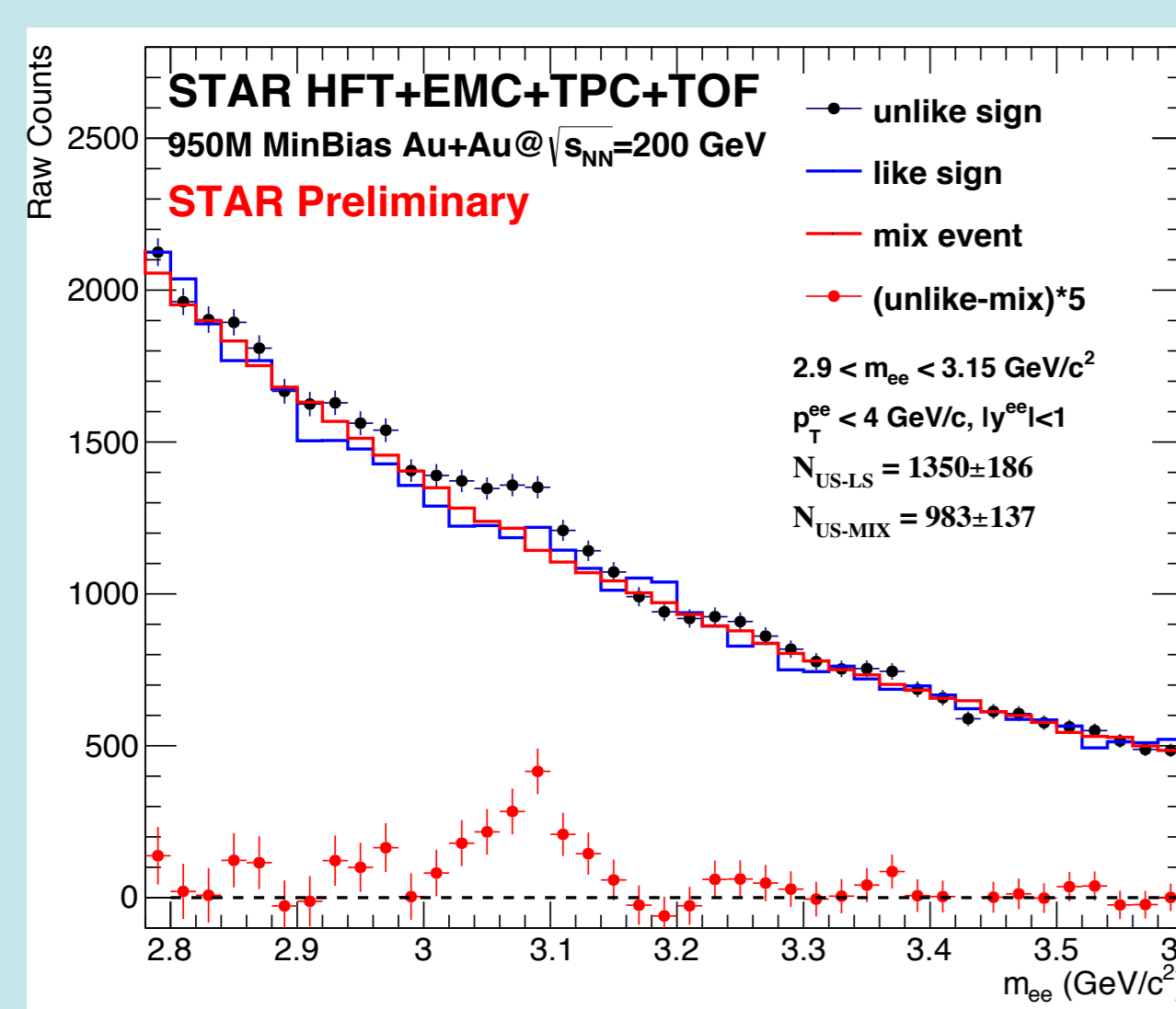
Non-prompt J/ψ in p+p Collisions

The non-prompt J/ψ contribution to inclusive J/ψ in p+p collisions at $\sqrt{s}=200$ GeV has been determined from J/ψ -hadron azimuthal correlations with the data taken in 2012. The new results confirm the STAR published results with $5 < p_T < 10$ GeV/c from 2009 data, and extend the lower p_T limit down to 1.5 GeV/c.

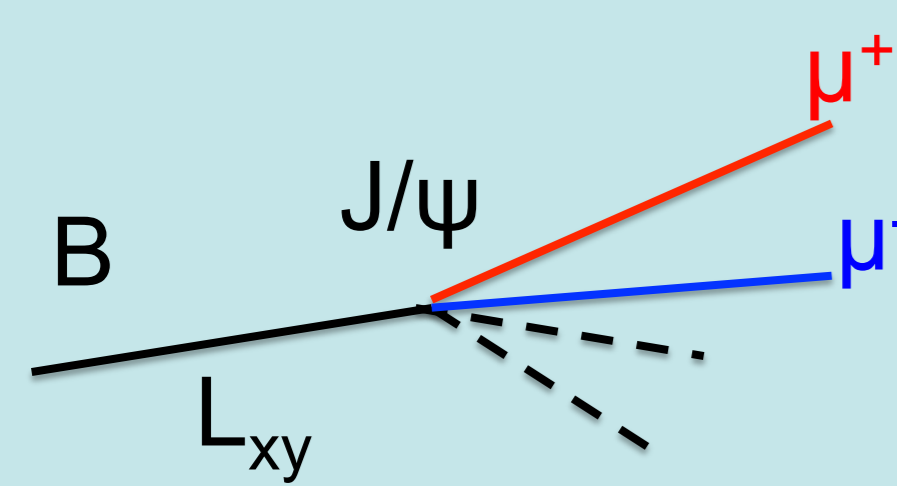


The extracted non-prompt J/ψ fraction as a function of J/ψ p_T are consistent with Fixed-Order-Next-to-Leading-Log (FONLL) calculations based on the Color Evaporation Model (CEM) for prompt J/ψ production.

First Look at Non-prompt J/ψ in Au+Au Collisions at RHIC



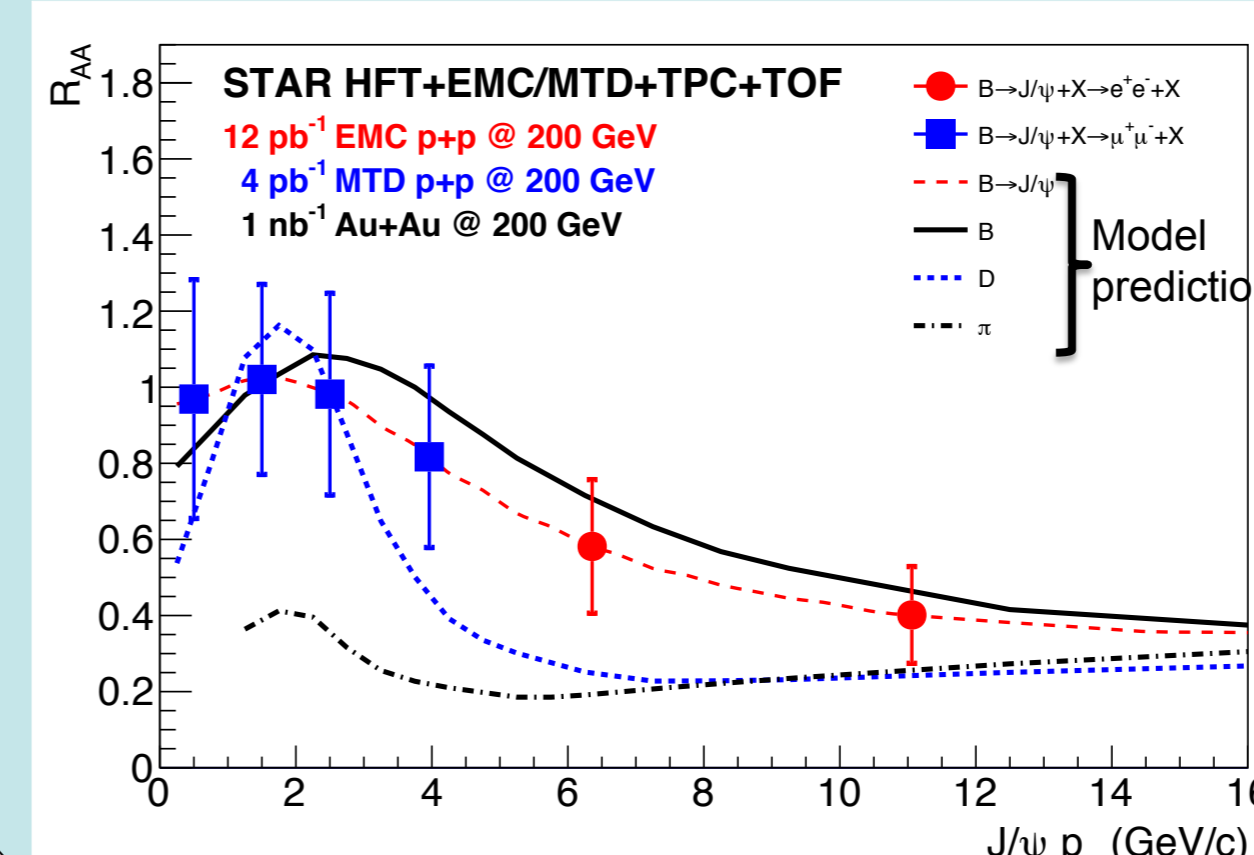
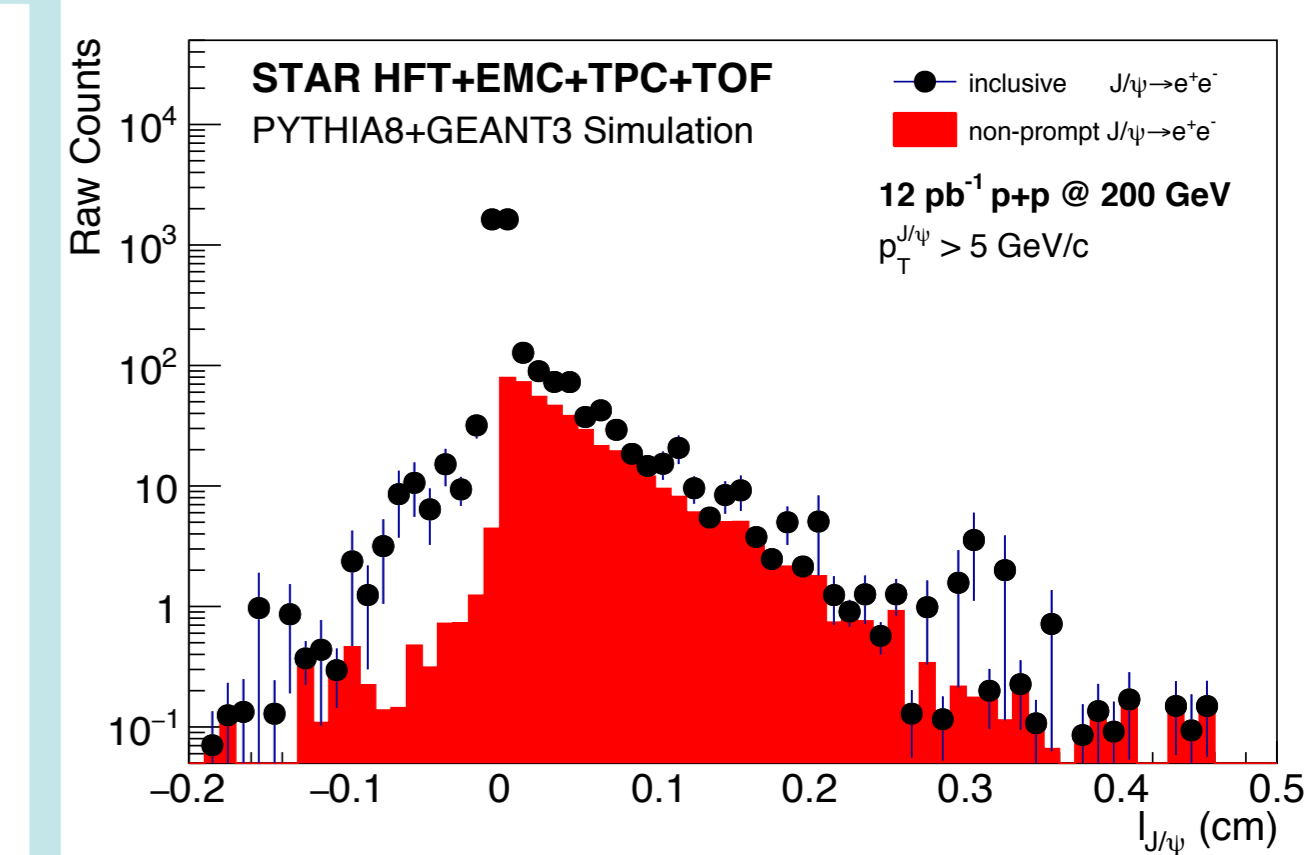
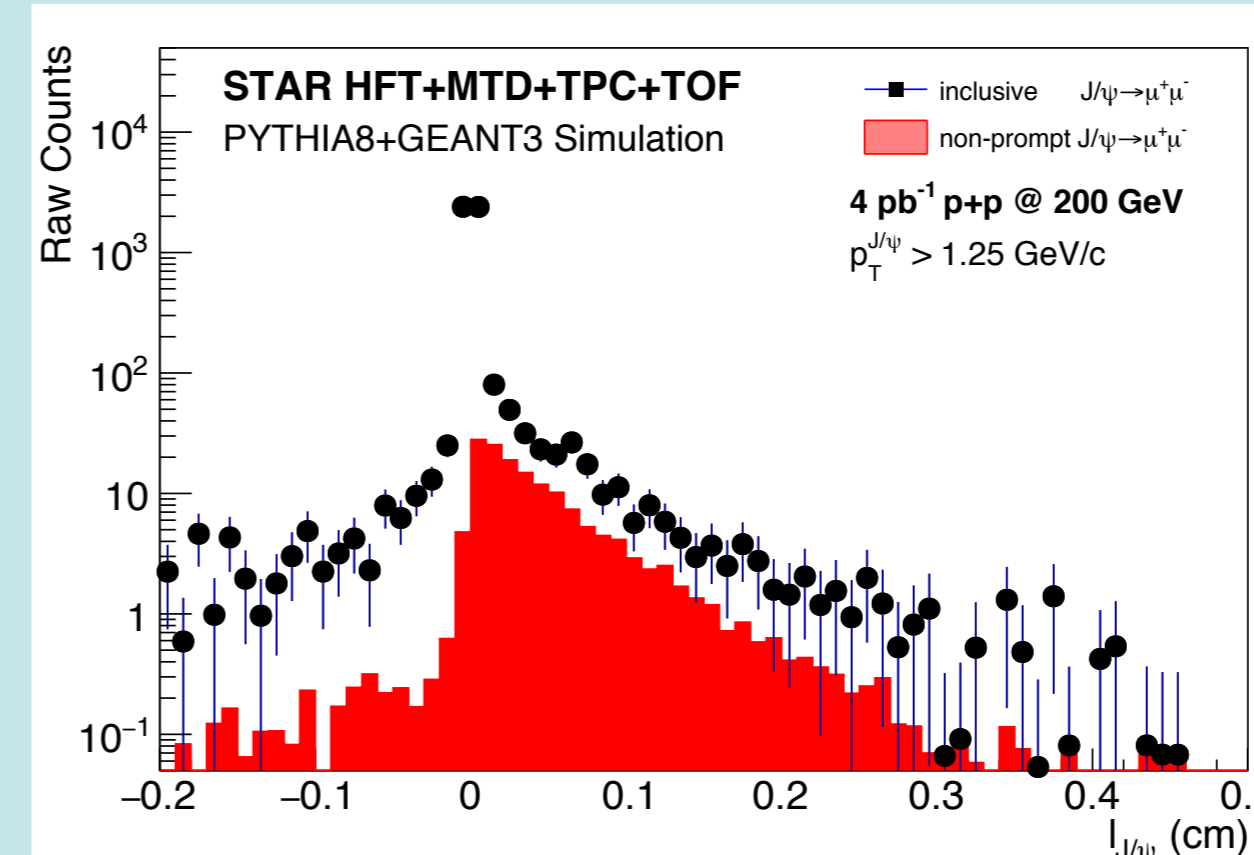
- STAR took data in Au+Au collisions in 2014 and p+p and p+Au collisions in 2015 at $\sqrt{s_{NN}} = 200$ GeV, and expect to increase the Au+Au statistics by a factor of two in 2016.
- From about 75% of 2014 Au+Au MB data in the dielectron channel, STAR has found about 1000 J/ψ candidates after eID and HFT matching requirements (top-left figure), and studied their pseudo-decay length l_{xy} distribution (top-right figure).
- We have observed an excess of J/ψ candidates with positive pseudo-decay lengths than those with negative ones, indicating for the existence of non-prompt J/ψ . If it is confirmed, it will be the first direct experimental evidence of non-prompt J/ψ in heavy-ion collisions at RHIC energies.
- Detailed data analyses with the full Run14 data in both the dielectron and dimuon channels are on-going.



$$l_{J/\psi} = L_{xy} \frac{m_{J/\psi}}{p_T}$$

Prospects for Non-prompt J/ψ from 2014-2016 Data

Non-prompt J/ψ measurements with the HFT have been studied in Monte Carlo simulations. Prompt and non-prompt J/ψ are produced and decayed by PYTHIA8, and are relatively normalized according to the FONLL+CEM prediction. Suppression in Au+Au collisions are taken into account. STAR detector responses are then obtained from GEANT3 detector simulation and reconstructed in the same way as real data.



- The reconstructed pseudo-decay length distributions for non-prompt and inclusive J/ψ in the dimuon and dielectron channel are shown in the two figures at the top.
- The expected non-prompt J/ψ R_{AA} from direct measurements with the HFT (bottom-left figure) indicates that differences to D^0 R_{AA} with two standard deviation significance may be achieved from STAR 2014-2016 data. The uncertainties which are dominated by the p+p statistics, can be reduced by a factor of two from J/ψ -hadron azimuthal correlations.

Summary and Outlook

- Non-prompt J/ψ from B hadron decays can provide an access to the bottom quark production in high-energy p+p and heavy-ion collisions. Measurements of non-prompt J/ψ at RHIC energies will improve our knowledge of bottom quark interactions with the QGP and thus QGP properties.
- Non-prompt J/ψ in p+p collisions have been studied in the dielectron channel at STAR via J/ψ -hadron azimuthal correlations. A new measurement has been completed using data taken in 2012 in p+p collisions at $\sqrt{s}=200$ GeV. The new results have substantially better uncertainties than STAR published ones, extending the p_T range down to ~ 1.5 GeV/c, and confirm FONLL theoretical predictions based on the Color Evaporation Model.
- With the newly installed Heavy Flavor Tracker, STAR can now measure non-prompt J/ψ through their decay lengths in heavy-ion collisions. The new Muon Telescope Detector and existing detectors allow the study of J/ψ in both the dielectron and dimuon channels, covering nicely $p_T > 5$ GeV/c and $p_T < 5$ GeV/c, respectively.
- STAR has recorded 1.2B MinBias events and 0.4 nb⁻¹ EMC and MTD triggered data in Au+Au collisions at $\sqrt{s_{NN}}=200$ GeV in 2014. From about 75% of the MB data sample, an excess with positively reconstructed J/ψ pseudo-decay lengths has been found, indicating for the existence of non-prompt J/ψ in Au+Au collisions at RHIC.
- With the data taken already in p+p and p+Au collisions in 2015 and planned data taking in Au+Au collisions in 2016, STAR will be able to make the first measurement of non-prompt J/ψ nuclear modification factors at RHIC.