Dielectrons as pre-equilibrium probes in heavy ion collisions

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Calculations for pre-equilibrium dileptons

- focusing on dilepton production M > 1 GeV
- initial stage is expected to be highly gluon dominated
- due to rapid longitudinal expansion → momentum distribution of quarks is strongly anisotropic at early times

- using hydrodynamic attractor to calculate pre-equilibrium contributions
- Dilepton production provides Shear viscosity η/s → control the equilibrium time

  → only free parameter in calculation
- Drell-Yan production calculation based on EPPS nPDFs.

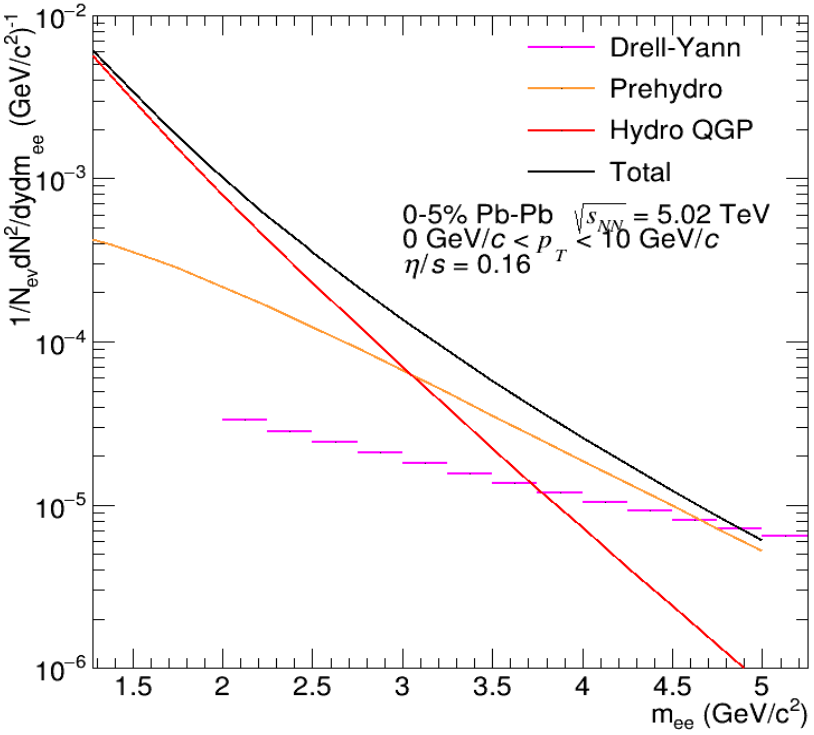
Invariant mass spectrum

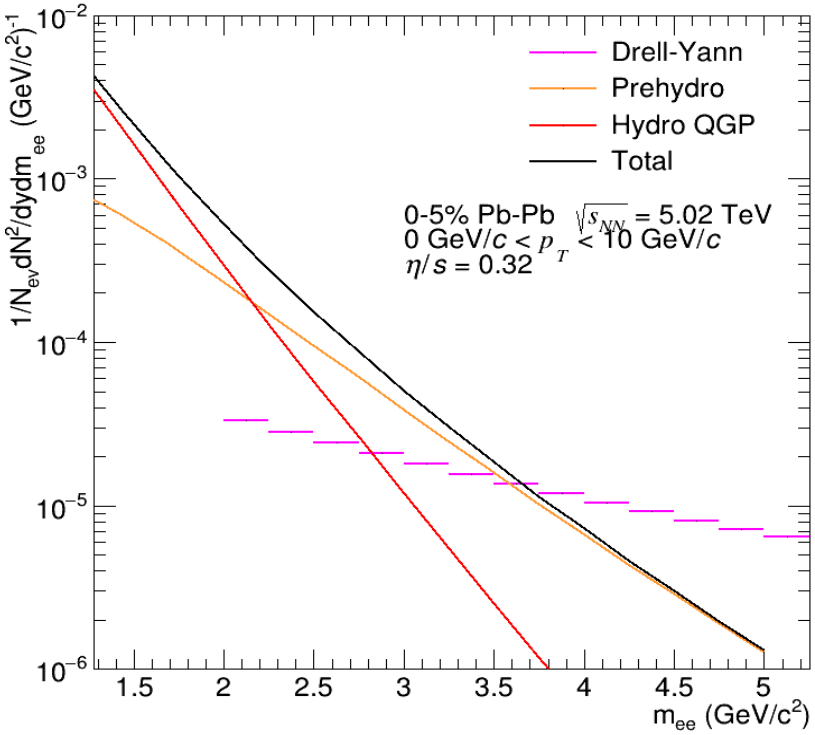
- model is set so that charged-particle multiplicity ($dN_{ch}/d\eta$) reproduced at mid-rapidity
- system is approximately described by viscous hydrodynamics by time $\tau_{hydro} \sim (\eta/s)^{3/2}$
- For lower η/s, system approaches hydro regime faster

- For fixed $dN_{ch}/d\eta$, lower η/s → higher initial energy density & higher temperature through-out the out-of-equilibrium evolution → larger dilepton yields

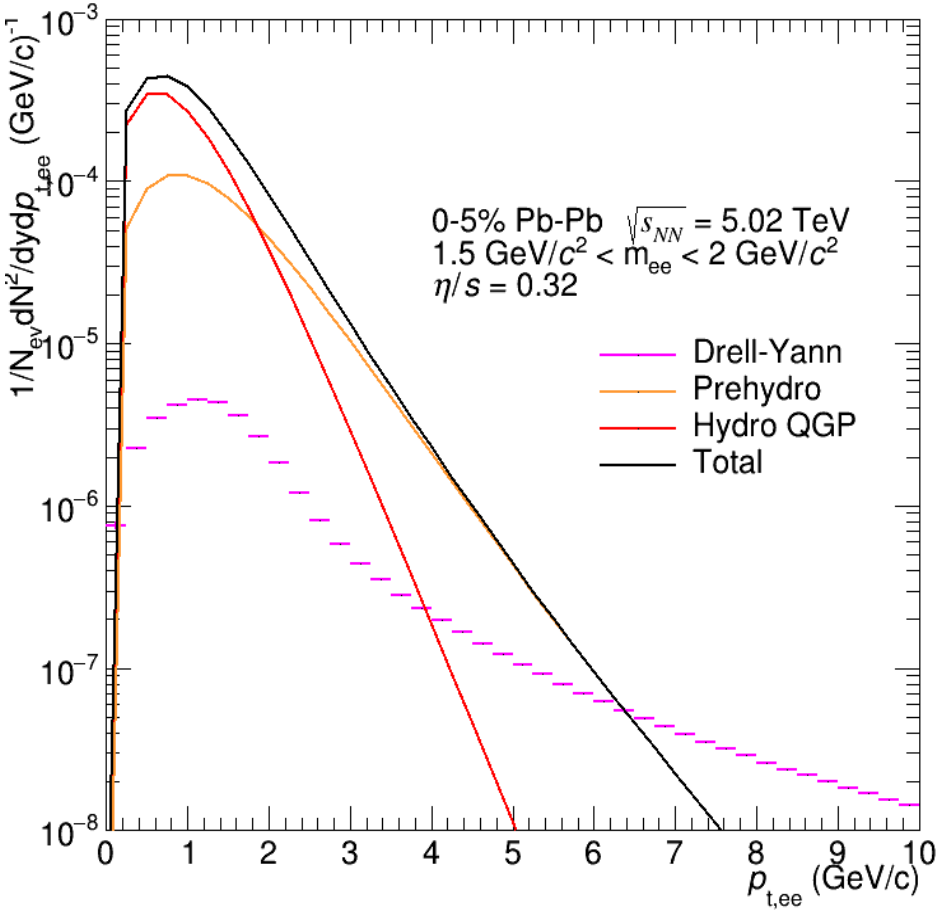
- pre-equilibrium contribution: $\tau < \tau_{hydro}$
- hydrodynamic contribution: $\tau > \tau_{hydro}$

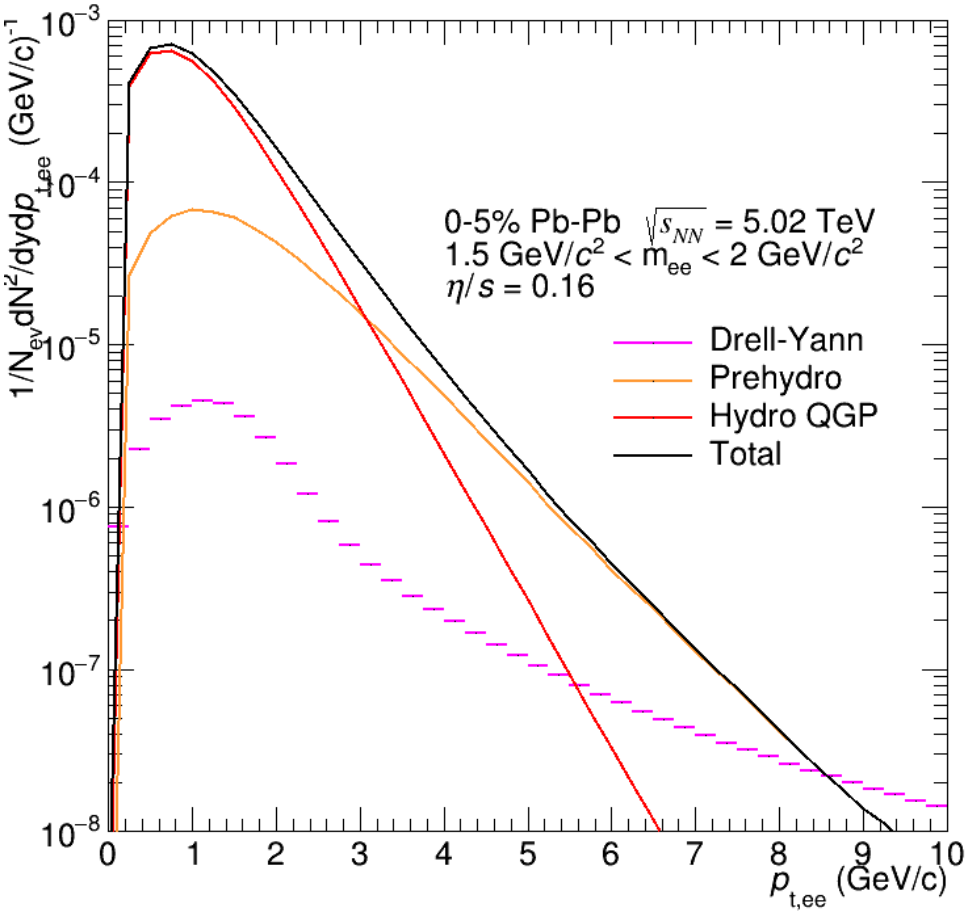
Corresponds to fig.7 Physics Letters B 821 (2021) 136626





p_T -spectrum


0-5% Pb-Pb $\sqrt{s_{NN}}$ = 5.02 TeV
1.5 GeV/c^2 < m_{ee} < 2 GeV/c^2
η/s = 0.32
Drell-Yann
Prehydro
Hydro QGP
Total
$1/N_{ev} dN^2/dy dp_{t,ee}$ (GeV/c)$^{-1}$
$p_{t,ee}$ (GeV/c)

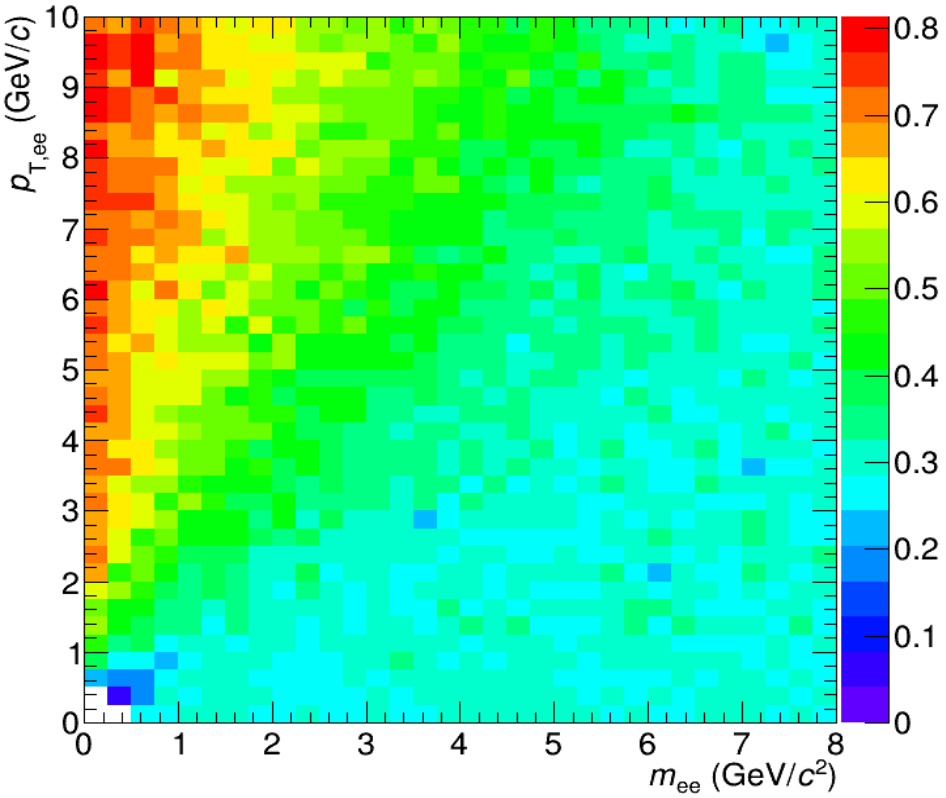

0-5% Pb-Pb $\sqrt{s_{NN}}$ = 5.02 TeV
1.5 GeV/c^2 < m_{ee} < 2 GeV/c^2
η/s = 0.16
Drell-Yann
Prehydro
Hydro QGP
Total
$1/N_{ev} dN^2/dy dp_{t,ee}$ (GeV/c)$^{-1}$
$p_{t,ee}$ (GeV/c)

Acceptance

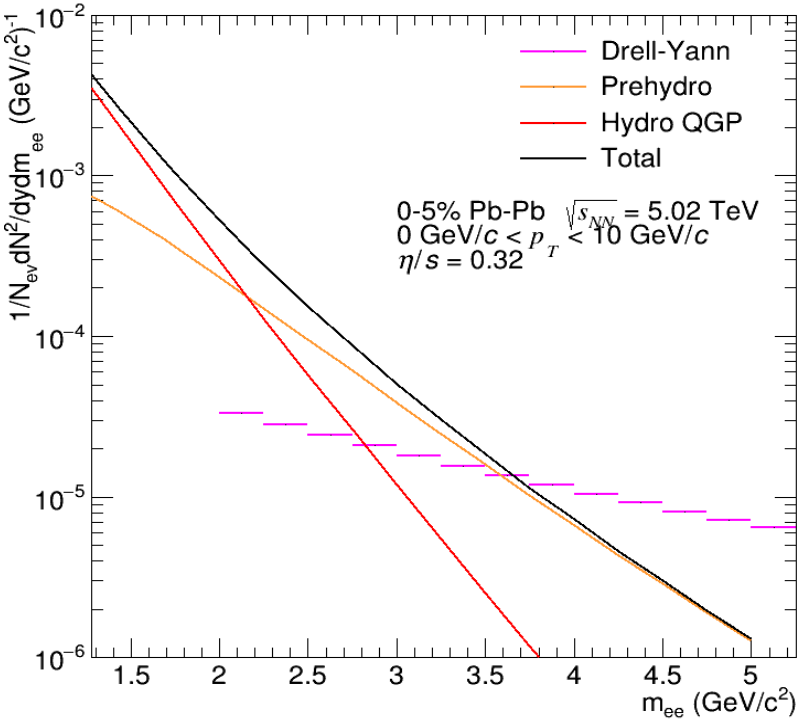
- Calculate acceptance for $|\eta_e| < 0.8$, $0.2 < p_{T,e} < 10$ GeV/c with $-1 < y_{ee} < 1$

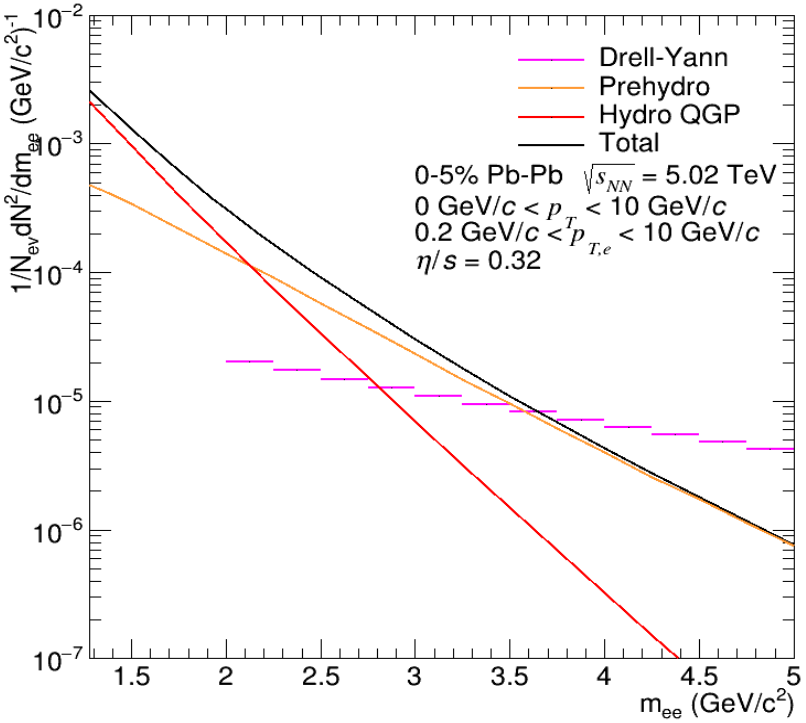
- Flat y_{ee} distribution around [-1,1] rapidity range and in Φ_{ee}

- Decay with TGenPhasespace

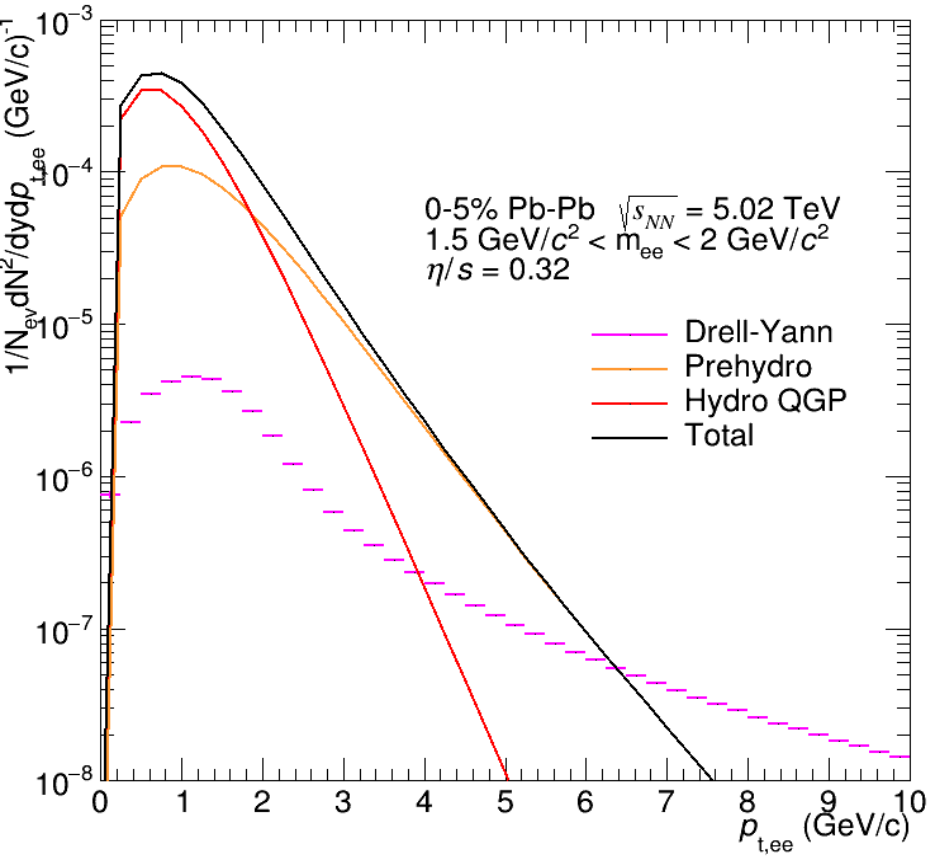


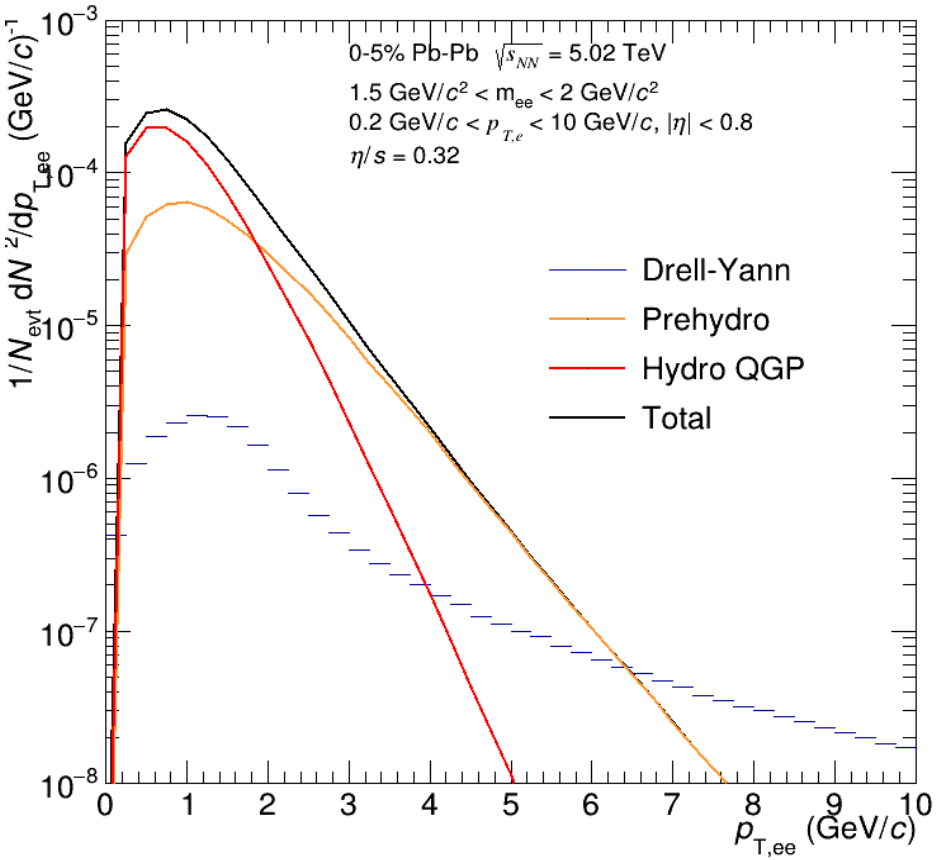
Acceptance (m_{ee})





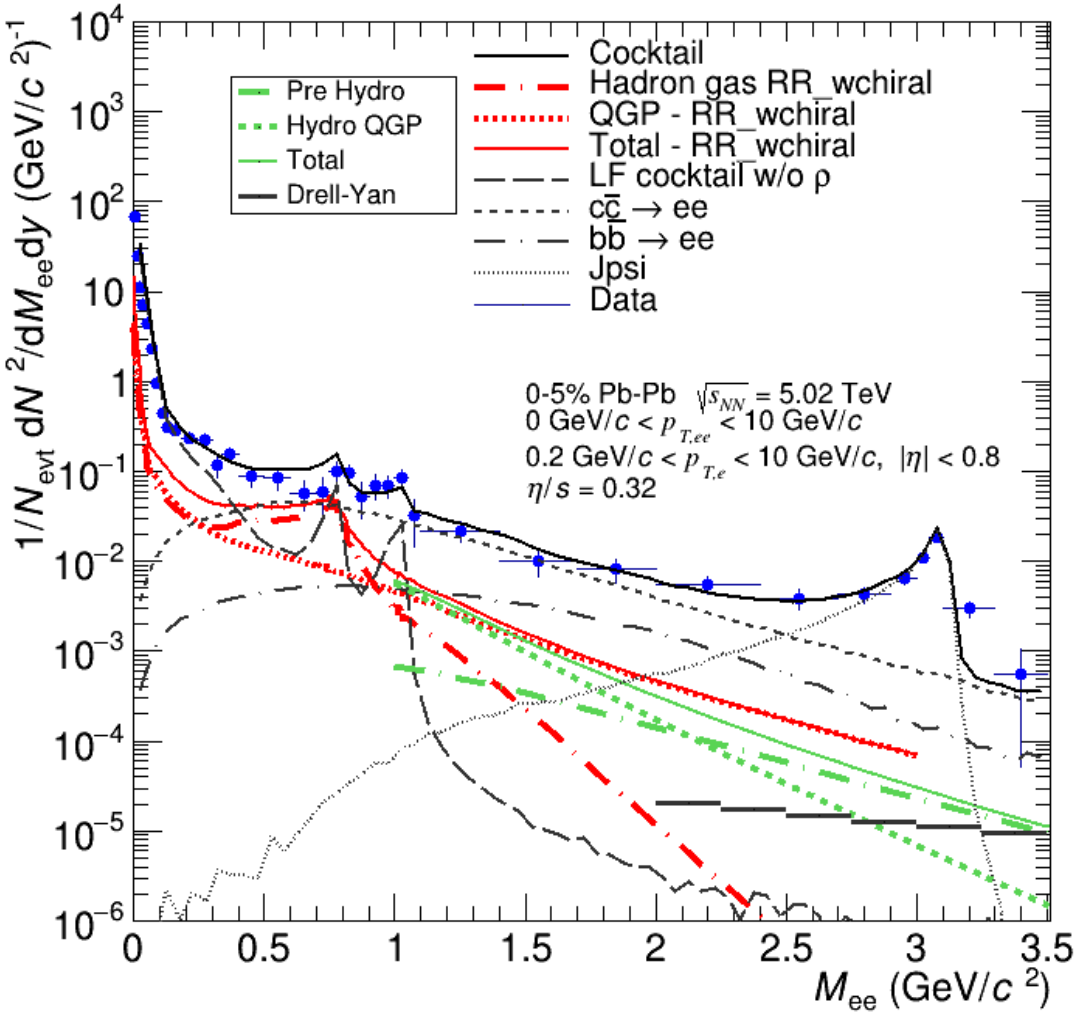
Acceptance ($p_{t,ee}$)





Comparison data and RalfRapp-Model (m_{ee})

- Data from Daiki preliminary
- RalfRapp:
  R. Rapp, Adv. High Energy Phys. 2013 (2013) 148253
  P.M. Hohler and R. Rapp, Phys. Lett. B 731 (2014) 103
- Preequilibrium-calculations:
  M. Coquet, X. Du, J-Y Ollitrault, S. Schlichting, M. Winn, Physics Letters B 821 å(2021) 136626
- 0-5% centrality for the pre-equilibrium calculations, rest 0-10% centrality



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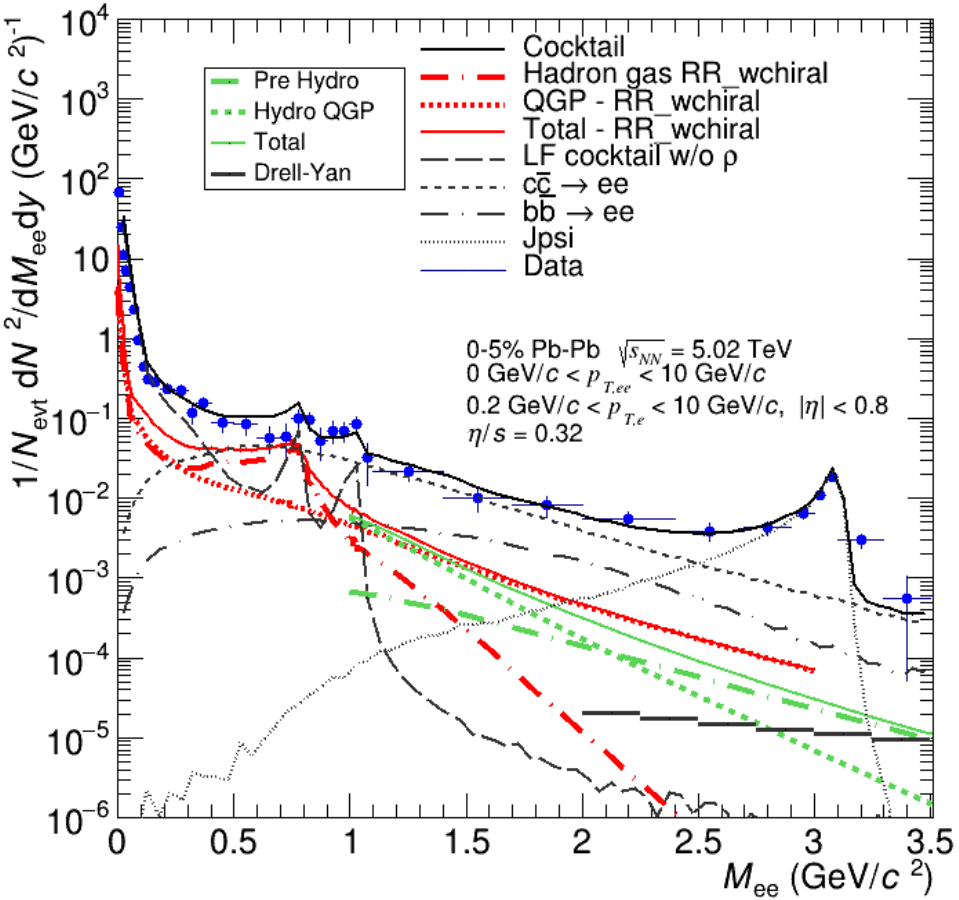

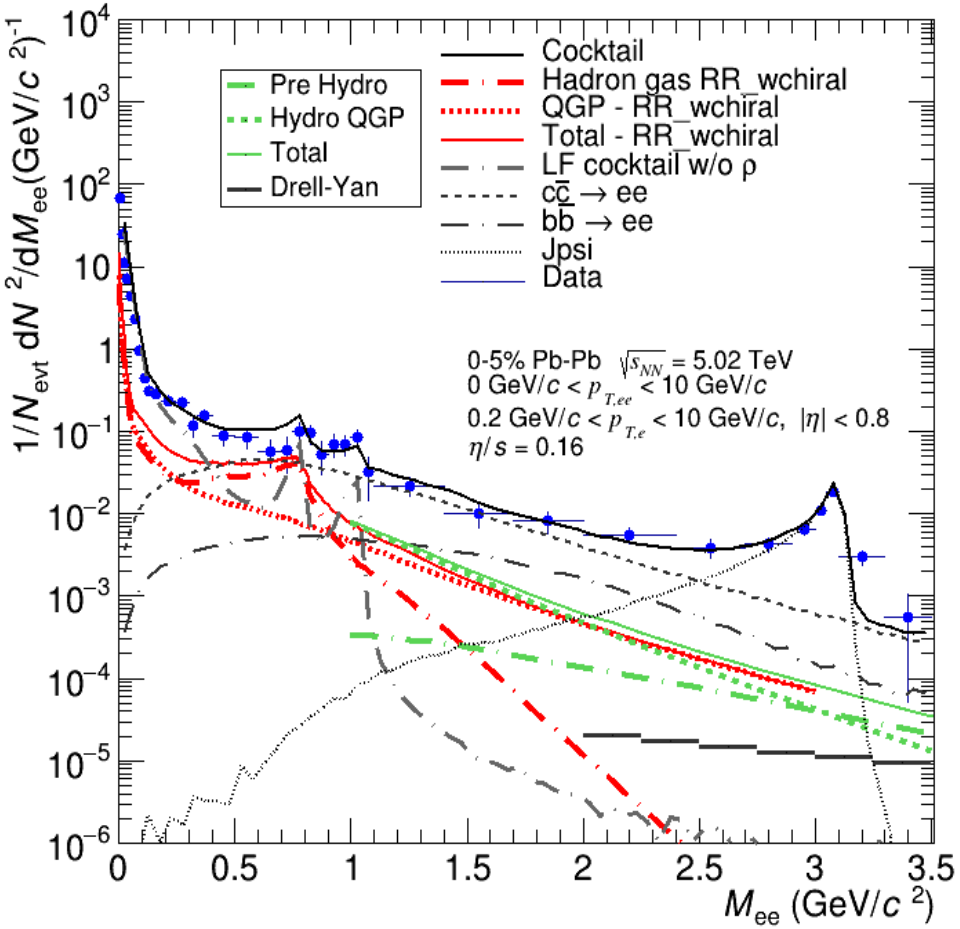

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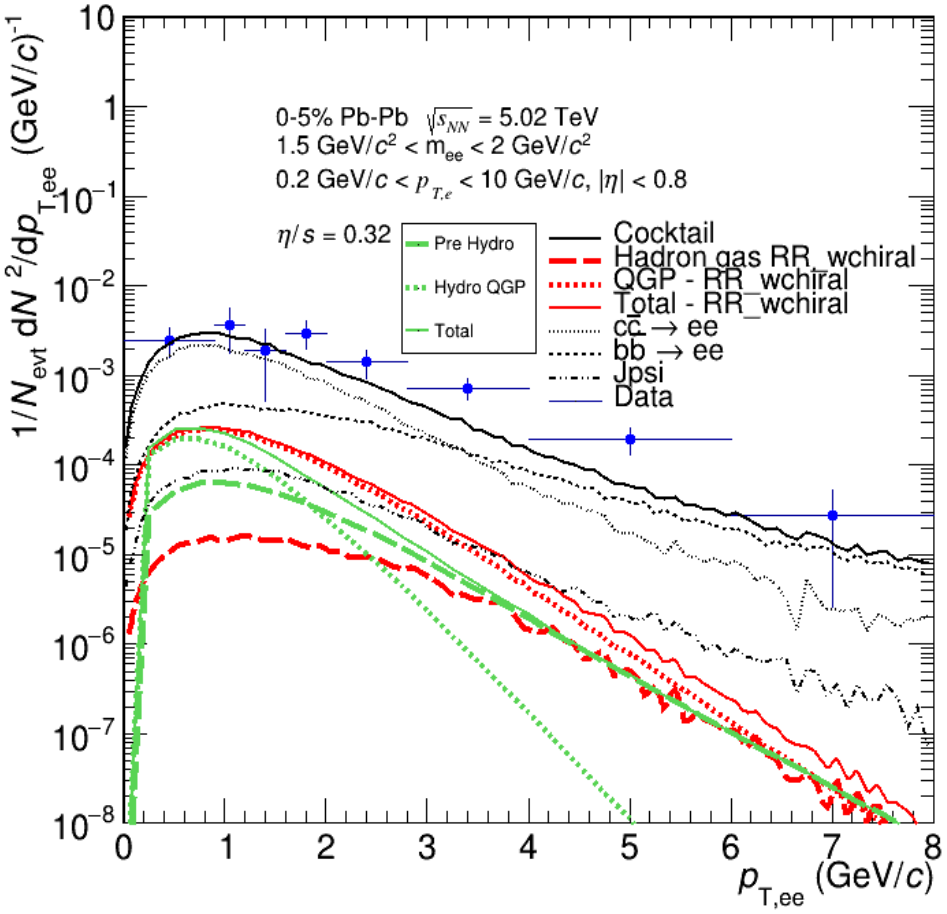
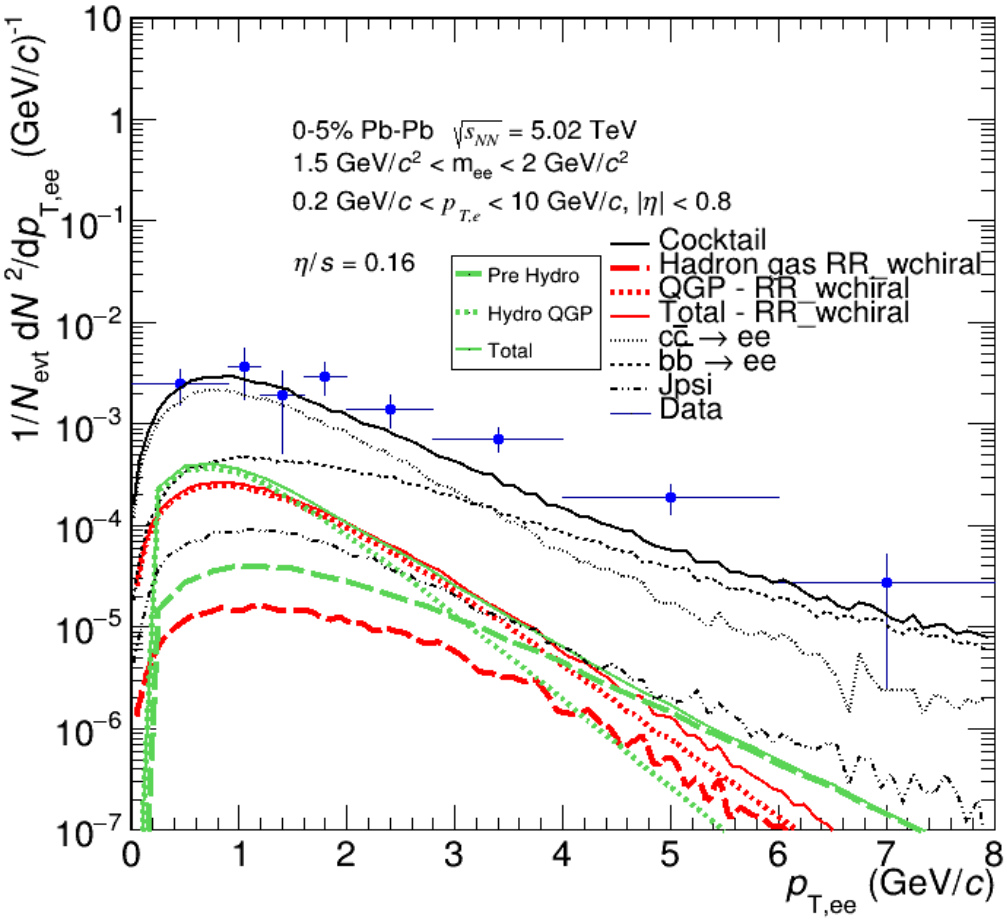
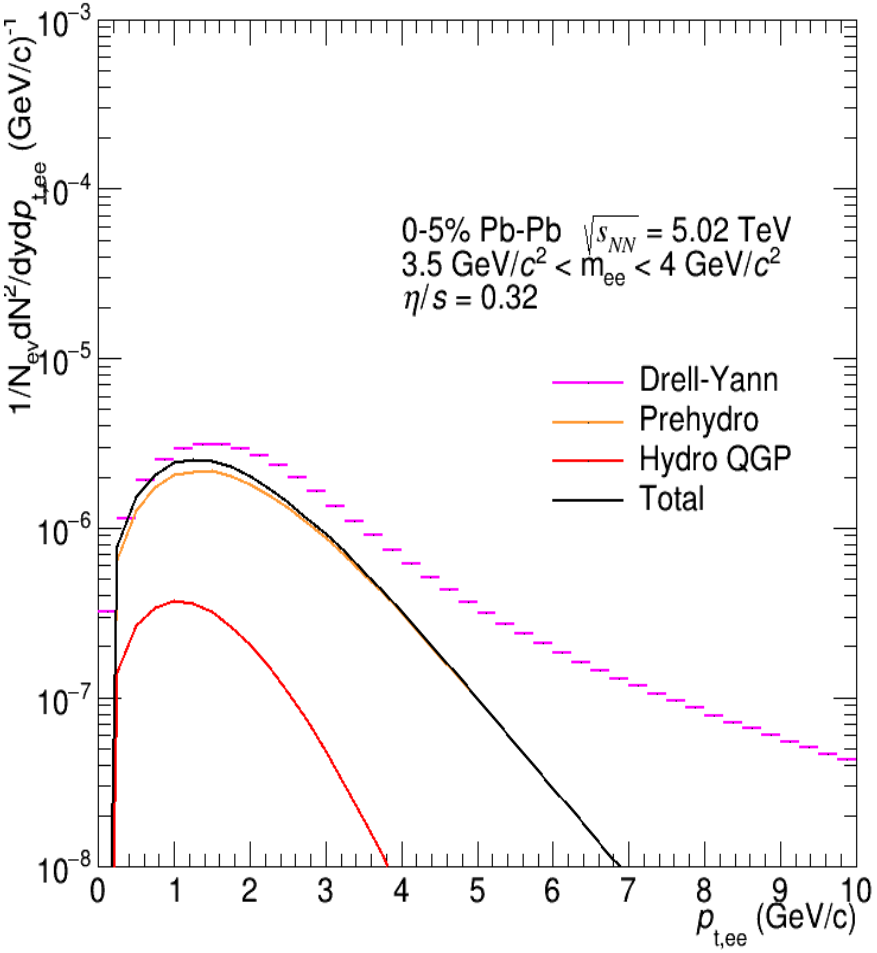




Backup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η/s = 0.32
Drell-Yann
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Hydro QGP
Total
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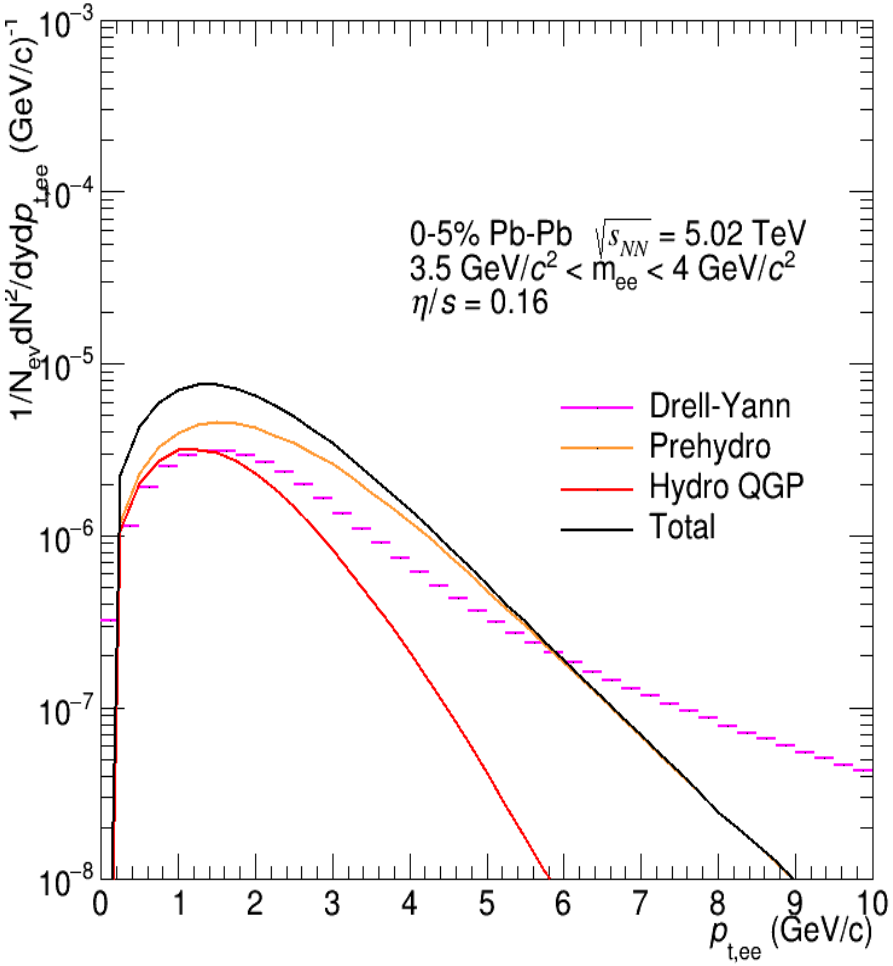
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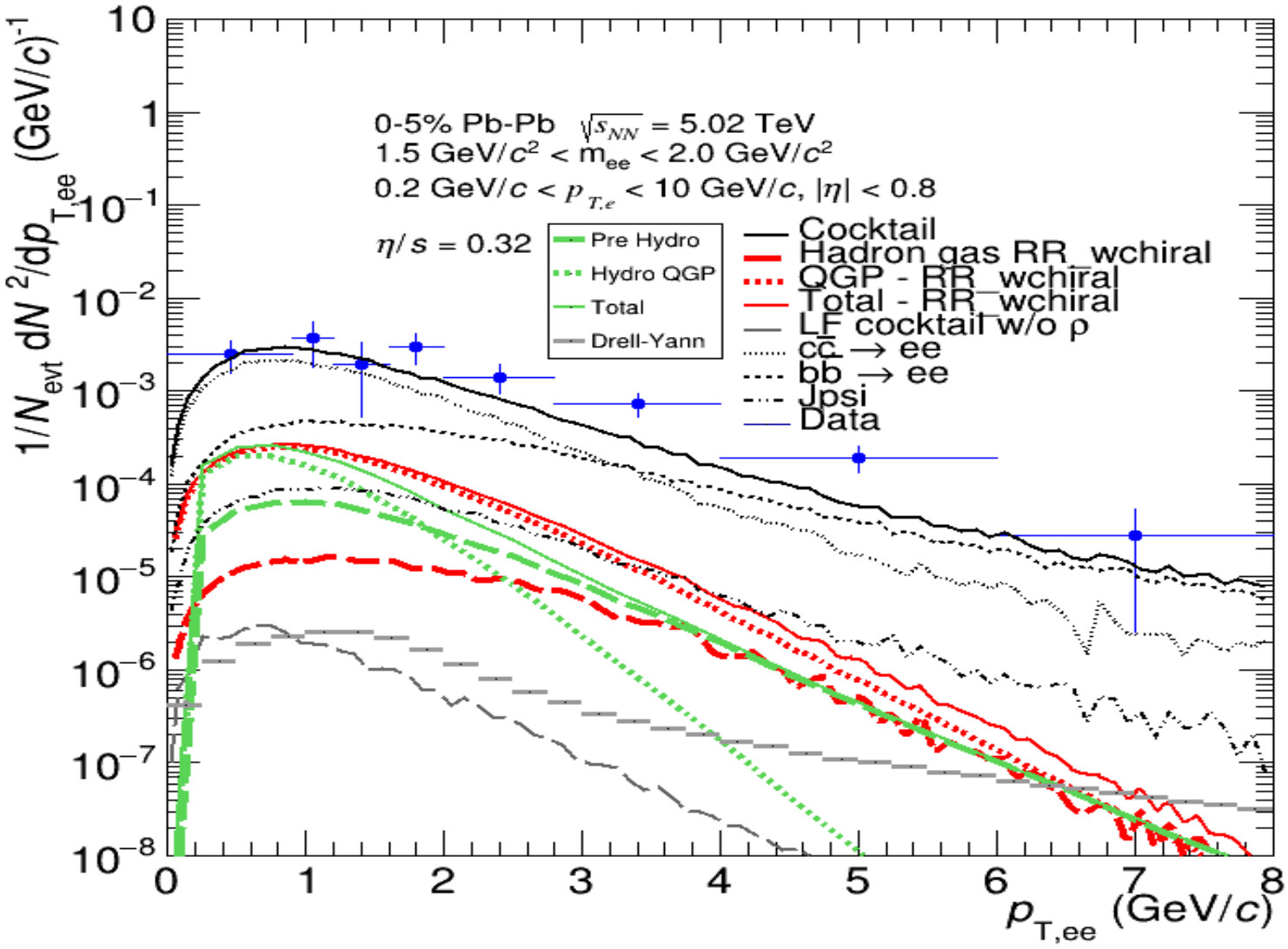
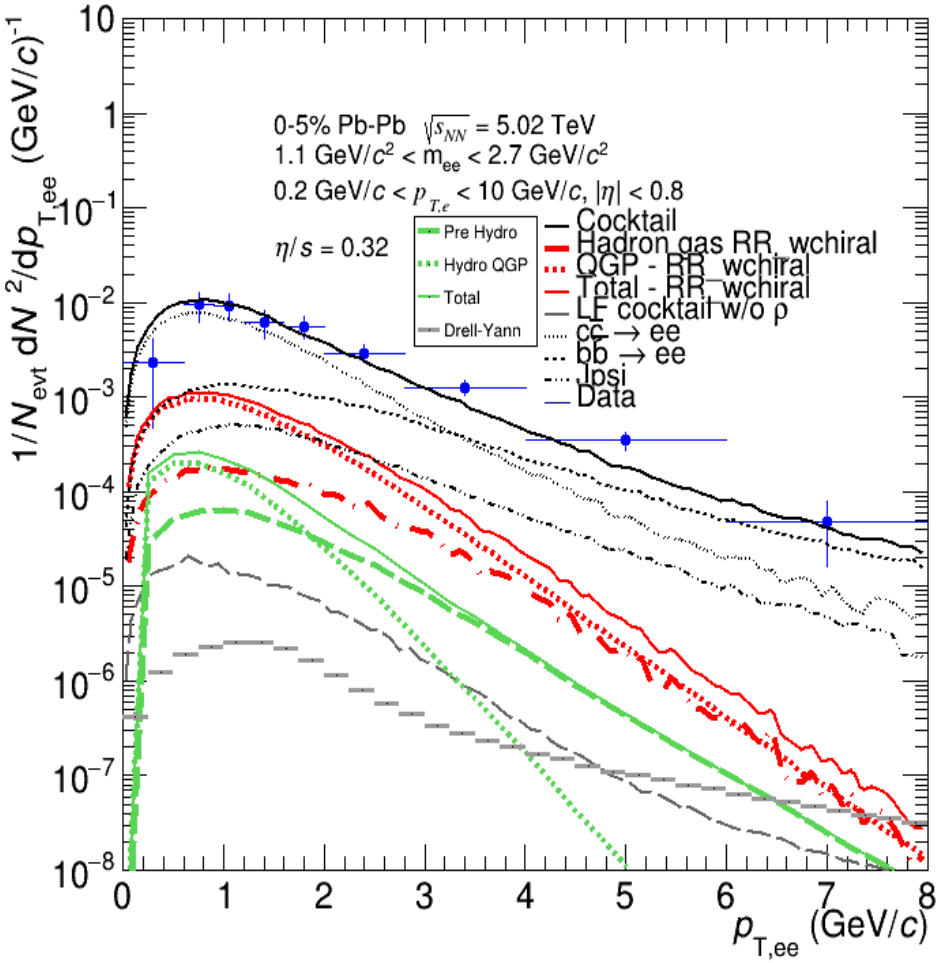
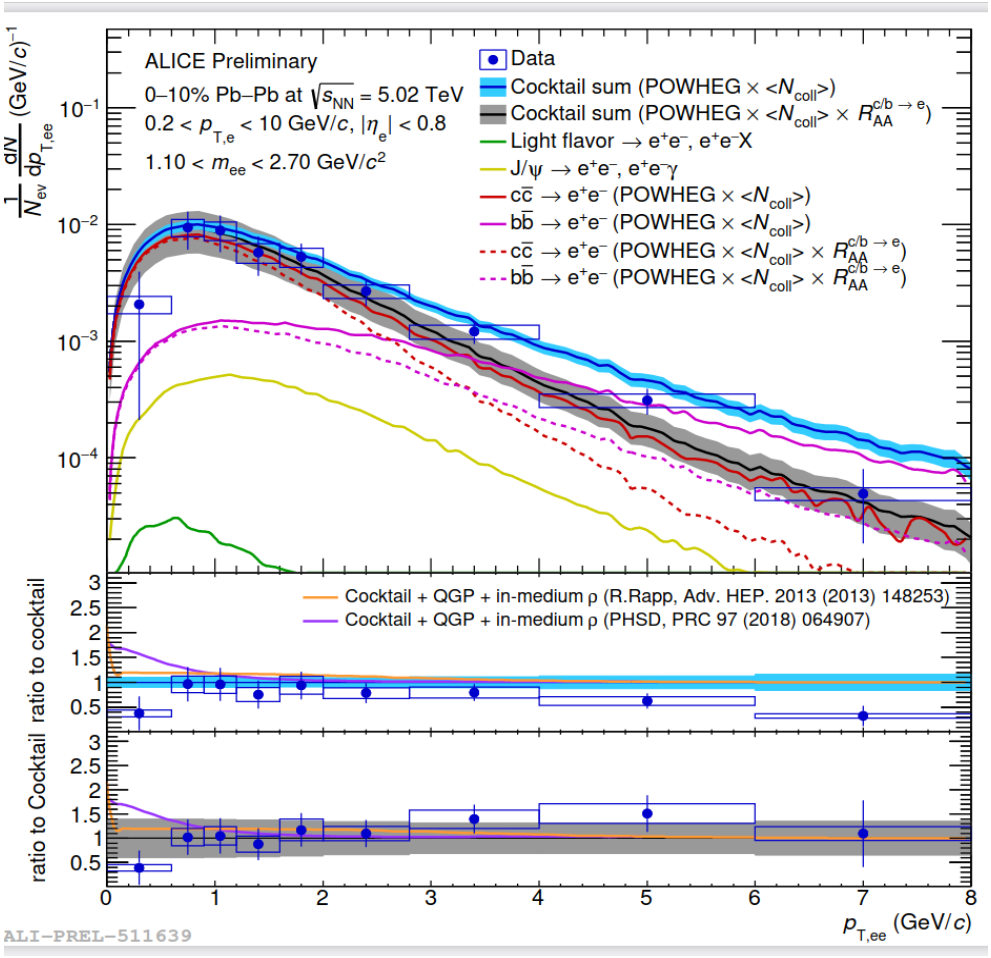

0-5% Pb-Pb $\sqrt{s_{NN}}$ = 5.02 TeV
1.5 GeV/c^2 < m_{ee} < 2.0 GeV/c^2
0.2 GeV/c < $p_{T,e}$ < 10 GeV/c, |η| < 0.8
η/s = 0.32
Pre Hydro
Hydro QGP
Total
Drell-Yann
Cocktail
Hadron gas RR_wchiral
QGP - RR_wchiral
Total - RR_wchiral
LF cocktail w/o ρ
$c\bar{c} \rightarrow ee$
$b\bar{b} \rightarrow ee$
Jpsi
Data
$1/N_{evt}\, dN^2/dp_{T,ee}$ (GeV/c)$^{-1}$
$p_{T,ee}$ (GeV/c)


0-5% Pb-Pb $\sqrt{s_{NN}}$ = 5.02 TeV
1.1 GeV/c^2 < m_{ee} < 2.7 GeV/c^2
0.2 GeV/c < $p_{T,e}$ < 10 GeV/c, |η| < 0.8
η/s = 0.32
Pre Hydro
Hydro QGP
Total
Drell-Yann
Cocktail
Hadron gas RR, wchiral
QGP - RR, wchiral
Total - RR, wchiral
LF cocktail w/o ρ
cc̄ → ee
bb̄ → ee
Jpsi
Data
$1/N_{evt}\ dN^2/dp_{T,ee}$ (GeV/c)$^{-1}$
$p_{T,ee}$ (GeV/c)


ALICE Preliminary
0–10% Pb–Pb at $\sqrt{s_{NN}}$ = 5.02 TeV
0.2 < $p_{T,e}$ < 10 GeV/c, |η_e| < 0.8
1.10 < m_{ee} < 2.70 GeV/c^2
Data
Cocktail sum (POWHEG × <N_{coll}>)
Cocktail sum (POWHEG × <N_{coll}> × $R_{AA}^{c/b \to e}$)
Light flavor → e⁺e⁻, e⁺e⁻X
J/ψ → e⁺e⁻, e⁺e⁻γ
cc̄ → e⁺e⁻ (POWHEG × <N_{coll}>)
bb̄ → e⁺e⁻ (POWHEG × <N_{coll}>)
cc̄ → e⁺e⁻ (POWHEG × <N_{coll}> × $R_{AA}^{c/b \to e}$)
bb̄ → e⁺e⁻ (POWHEG × <N_{coll}> × $R_{AA}^{c/b \to e}$)
Cocktail + QGP + in-medium ρ (R.Rapp, Adv. HEP. 2013 (2013) 148253)
Cocktail + QGP + in-medium ρ (PHSD, PRC 97 (2018) 064907)
ratio to Cocktail
$\frac{1}{N_{ev}} \frac{dN}{dp_{T,ee}}$ (GeV/c)$^{-1}$
$p_{T,ee}$ (GeV/c)
ALI-PREL-511639