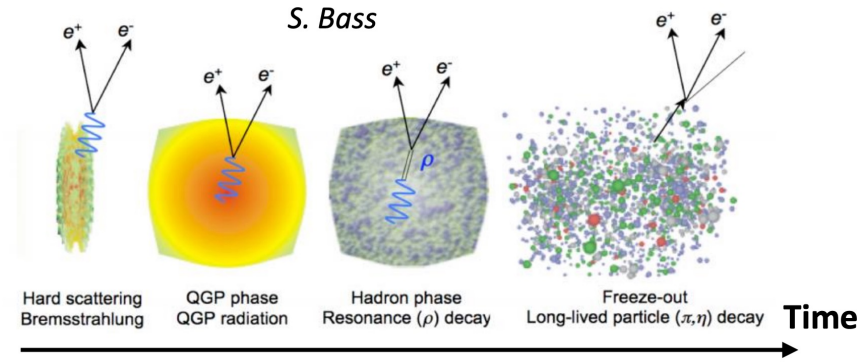
Measurements of dielectron production in Au+Au collisions at 27 and 54.4 GeV with the STAR experiment

Zhen Wang (王 桢)
Shandong University

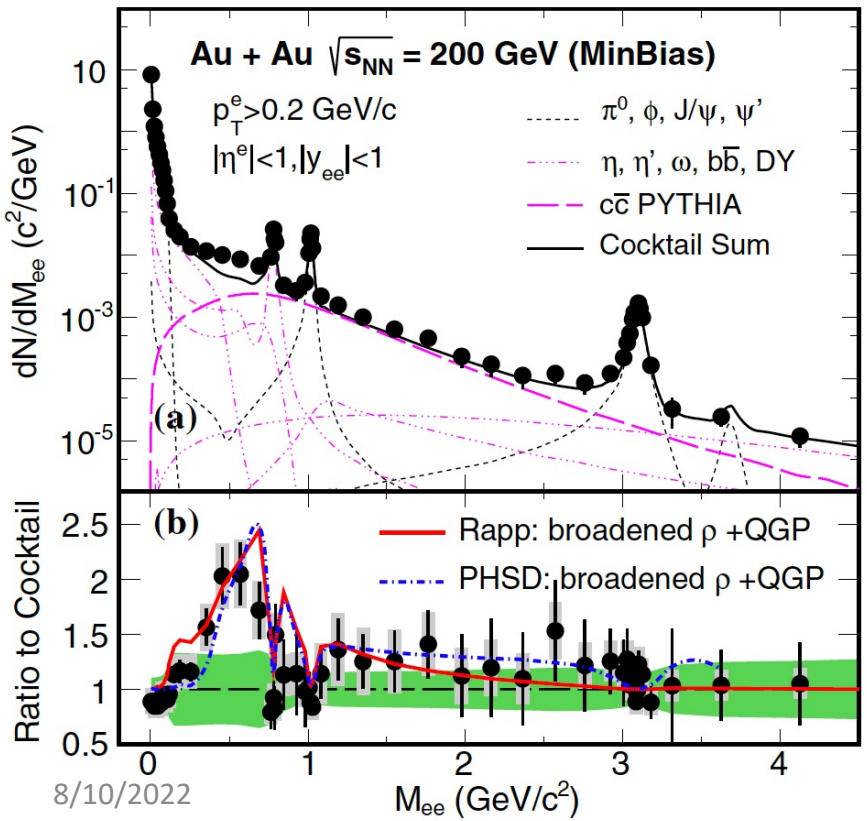
山东大学
SHANDONG UNIVERSITY

中国物理学会高能物理分会
HIGH ENERGY PHYSICS BRANCH OF CPS

Dielectron production



STAR, PRL. 113 (2014) 22301



Dielectrons – an excellent probe

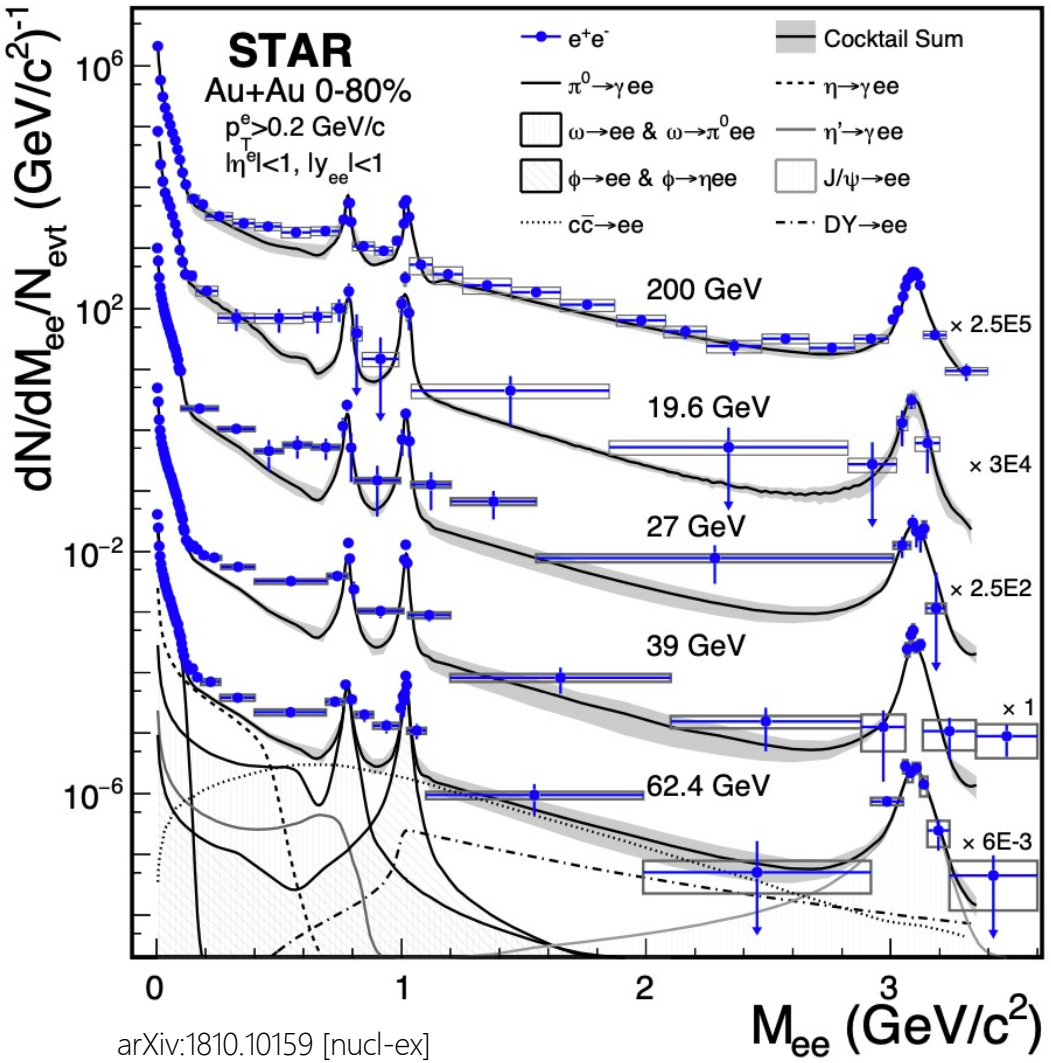
- Minimal interaction with the medium
- Carries information from the initial stage to the final stage of a collision

Different physics of interest

- Low Mass Region (LMR, $M_{ee} < M_{\phi}$)
  - Vector meson in-medium modifications
  - Possible link to chiral symmetry restoration
- Intermediate mass region (IMR, $M_{\phi} < M_{ee} < M_{J/\psi}$)
  - QGP thermal radiation is predicted as a QGP thermometer

Physics interest : Adv. Nucl. Phys. 25 (2000) 1
Rapp: PoS CPOD2013, 008 (2013)
PHSD: Phys. Rev. C 85, 024910 (2012);

STAR previous dielectron spectra results



arXiv:1810.10159 [nucl-ex]

- Hard to extract the temperature in the intermediate mass region
  - 200 GeV: High yield of heavy flavor quark semi-leptonic decay
  - 62.4 - 19.6 GeV: lack of statistics

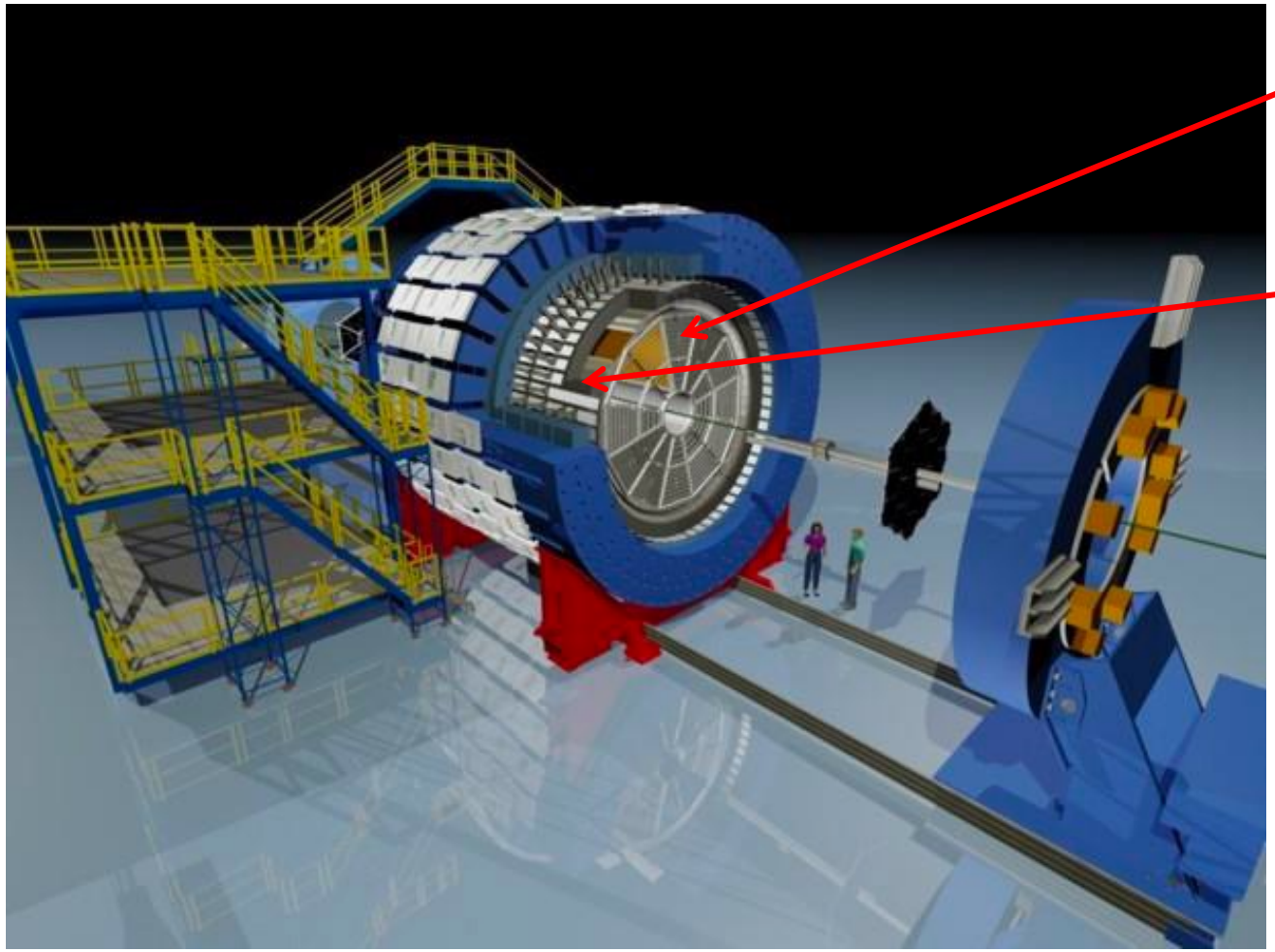
Higher precision measurements now possible with new datasets at 27 and 54.4 GeV

- High statistics compared to 27, 39 and 62.4 GeV datasets in BES-I program

Year	Energy	Used events
2018	27 GeV	500M
2017	54.4 GeV	875M
2011	27 GeV	68M
2010	39 GeV	132M
2010	62.4 GeV	62M

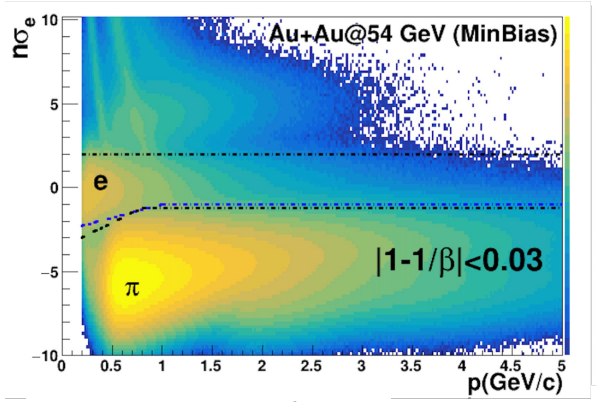
The STAR experiment

Key detectors used in this analysis

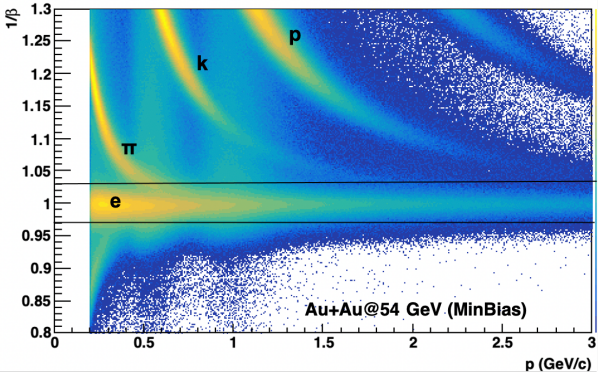


Time Projection Chamber
- $|\eta| < 1, 0 < \phi < 2\pi$
- Tracking, particle momenta, eID

Time of Flight
- $|\eta| < 0.9, 0 < \phi < 2\pi$
- Rejection of slow hadrons
- Improve electron purity

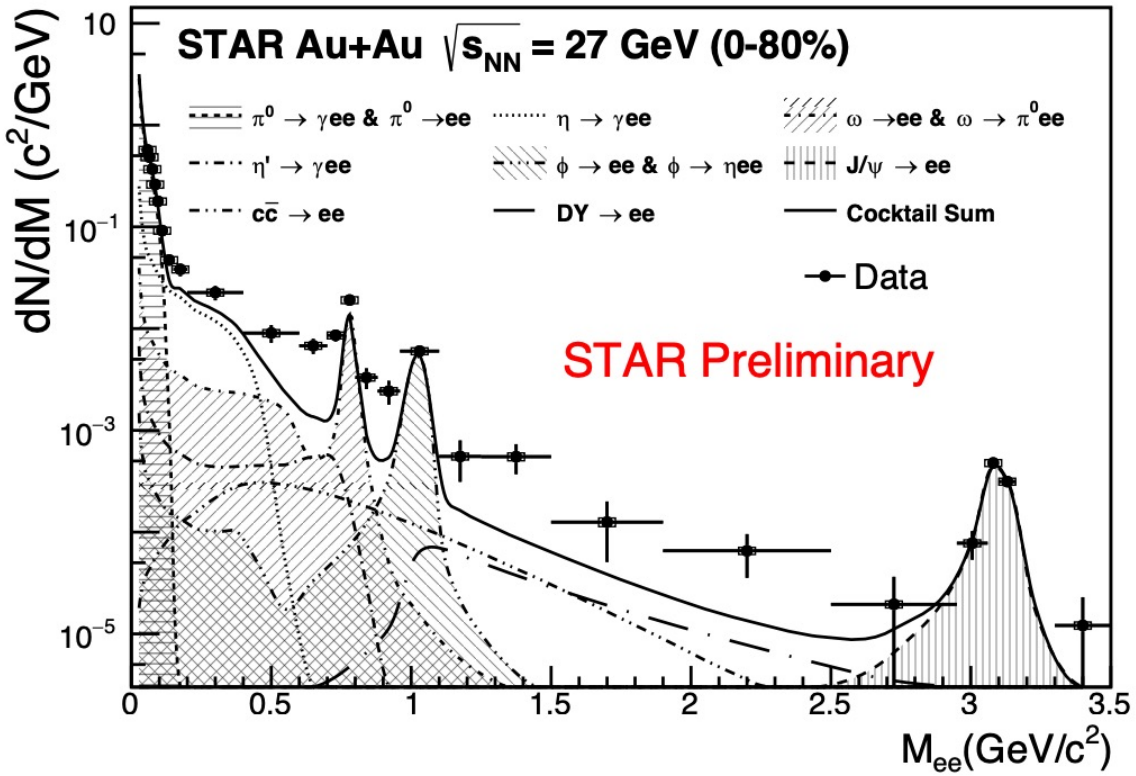


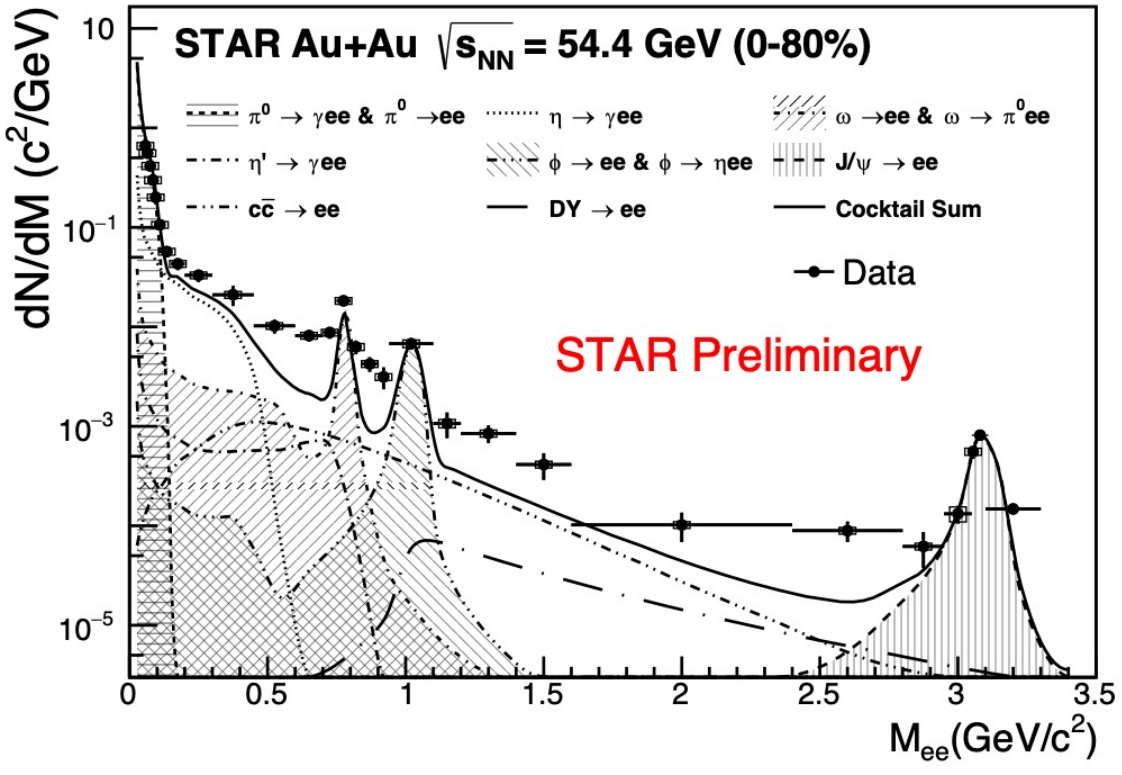
$n\sigma_e$ with $1/\beta$ cut



$1/\beta$ cut

Dielectron spectrum

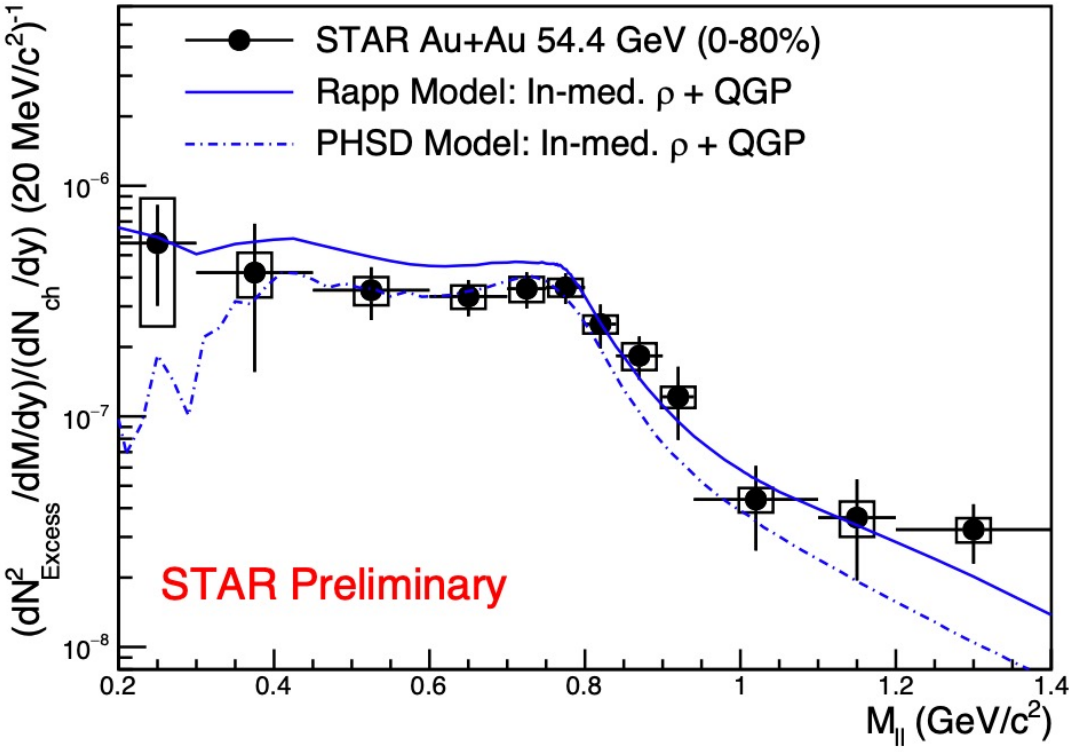


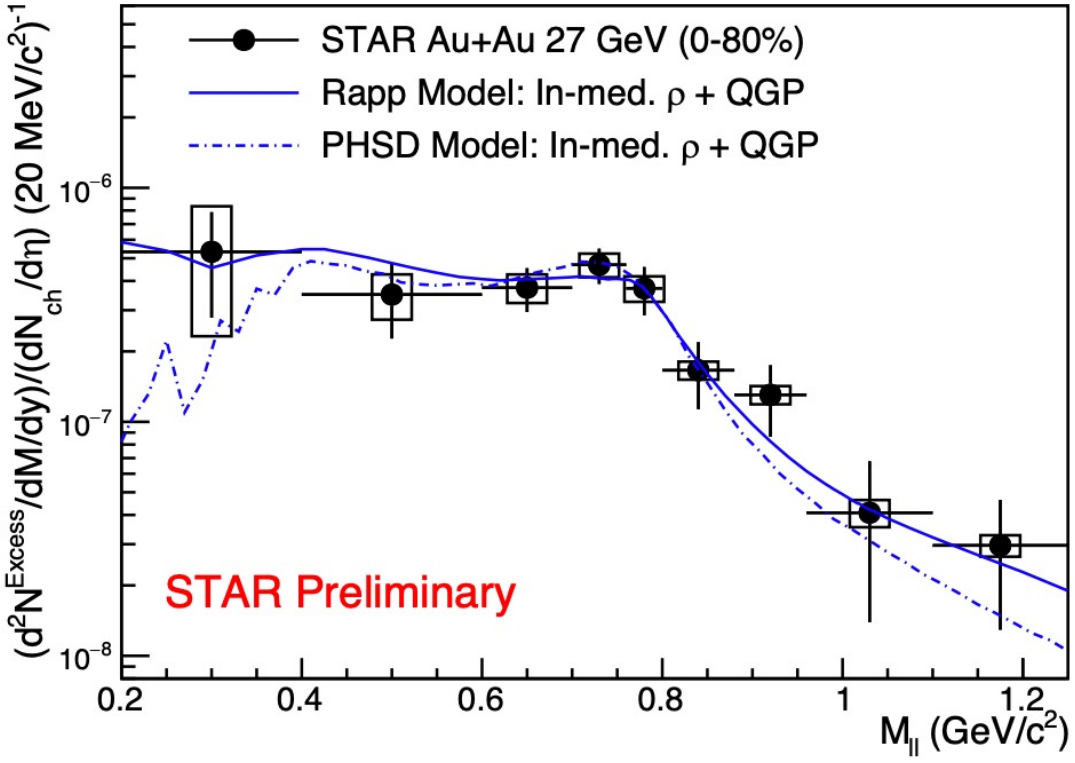


- Clear enhancement compared to ρ excluded cocktail simulation in low mass region
- The excess compared to cocktail simulation observed in intermediate mass region

Excess in low mass region

Excess = data - cocktail

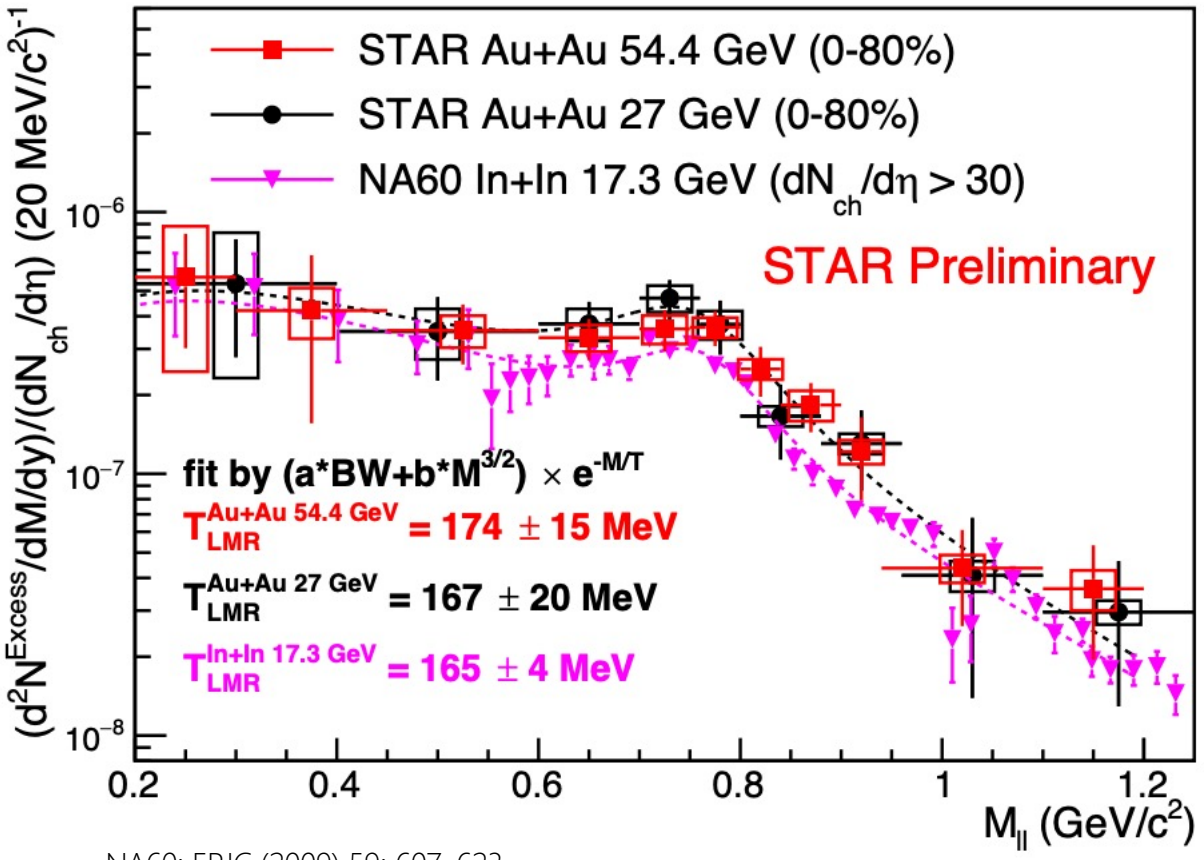




- Both models can well describe 27 GeV in ρ mass region
- Rapp model describes data well but overestimate 54.4 GeV for 0.5< M_{ee} <0.9 GeV/c^2
- PHSD model describes data well but underestimate 54.4 GeV for M_{ee} > 0.9 GeV/c^2

Temperature extract from low mass region

Excess = data - cocktail

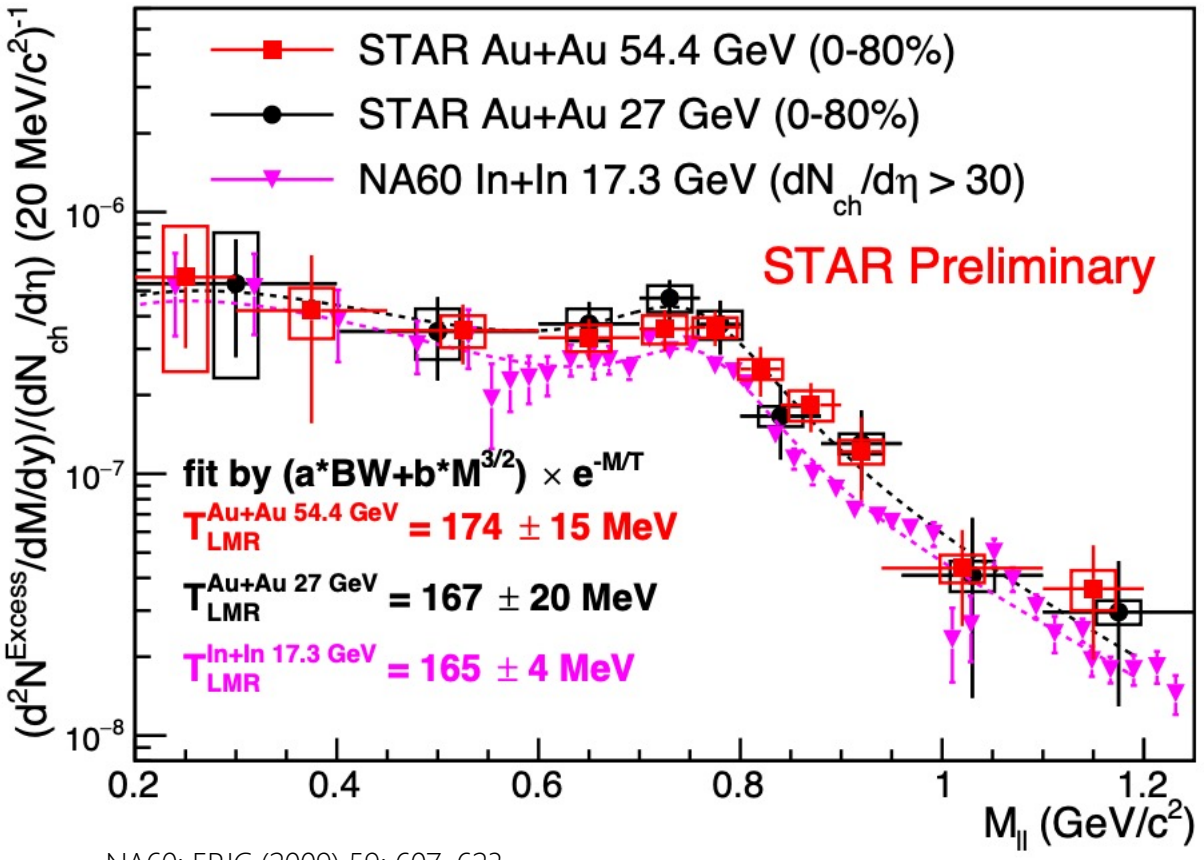


NA60: EPJC (2009) 59: 607–623

- Excess dielectron spectra of 27 and 54.4 GeV Au+Au collisions and NA60 In+In collisions are similar

Temperature extract from low mass region

Excess = data - cocktail

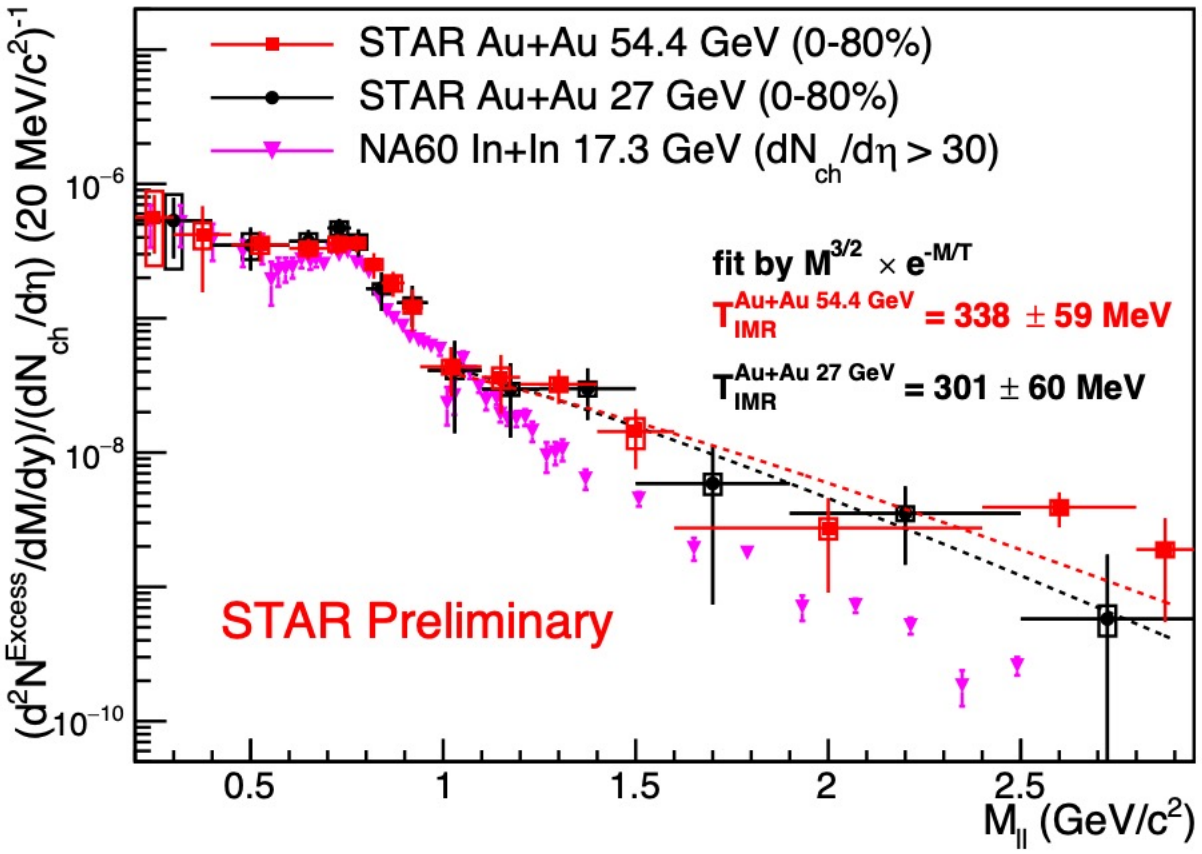


NA60: EPJC (2009) 59: 607–623
HotQCD: PLB 795 (2019) 15-21

fitting function: $(a*BW+b*M^{3/2})*e^{-M/T}$

- Excess dielectron spectra of 27 and 54.4 GeV Au+Au collisions and NA60 In+In collisions are similar
- T is similar despite significant differences in collision energy and system size
- T extract from low mass region around the pseudo critical temperature T_{pc} (156 MeV)

Temperature extract from intermediate mass region



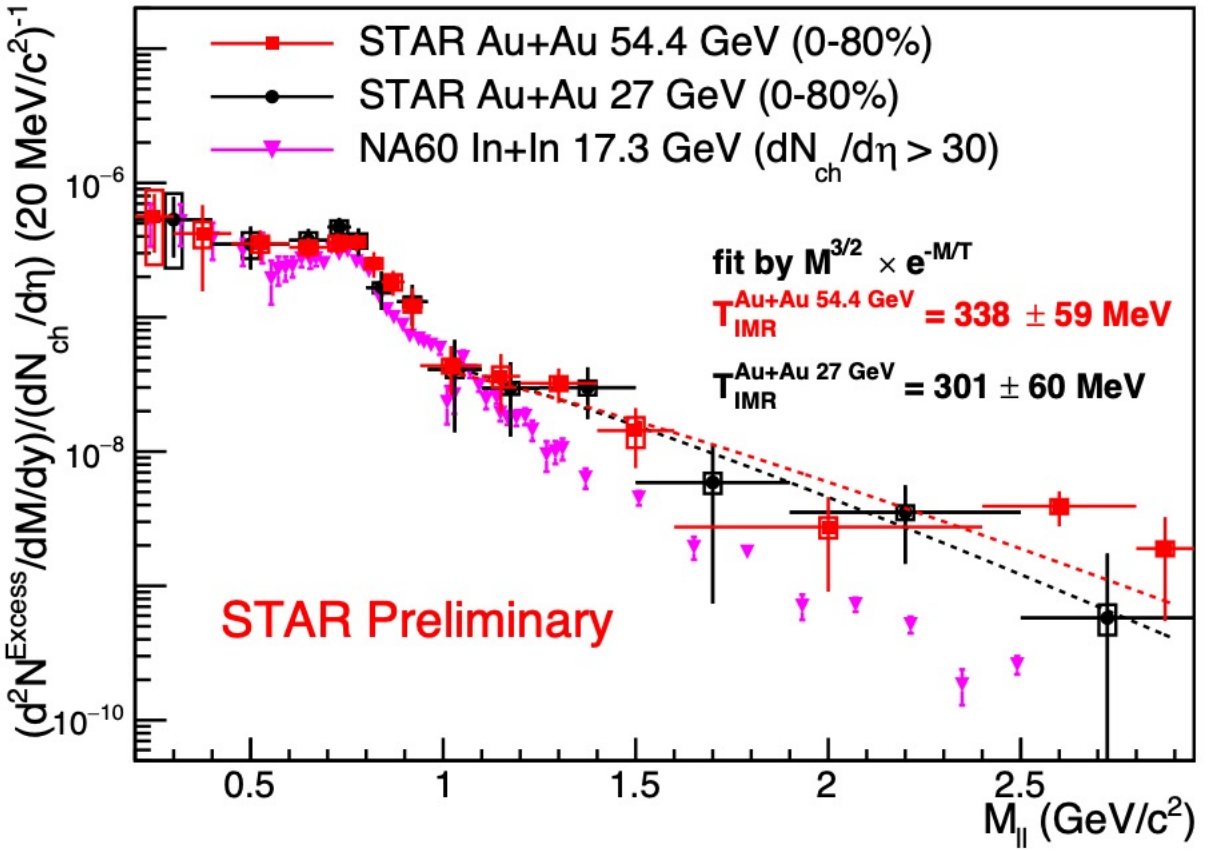
HotQCD: PLB 795 (2019) 15-21
NA60: EPJC (2009) 59: 607–623

IMR: 1.1 - 2.8 GeV

fitting function: $M^{3/2} * e^{-M/T}$

- Dielectrons from thermal radiation is the major source in intermediate mass region
- T extract from 27 and 54.4 GeV are consistant with each other

Temperature extract from intermediate mass region



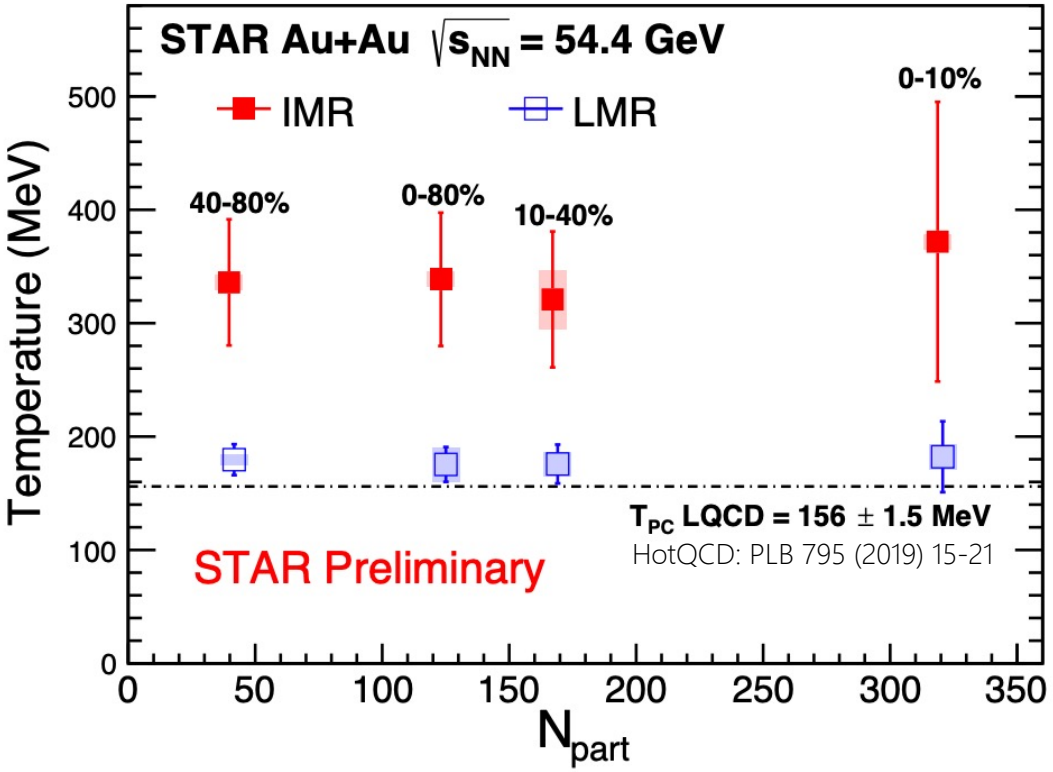
HotQCD: PLB 795 (2019) 15-21
NA60: EPJC (2009) 59: 607–623

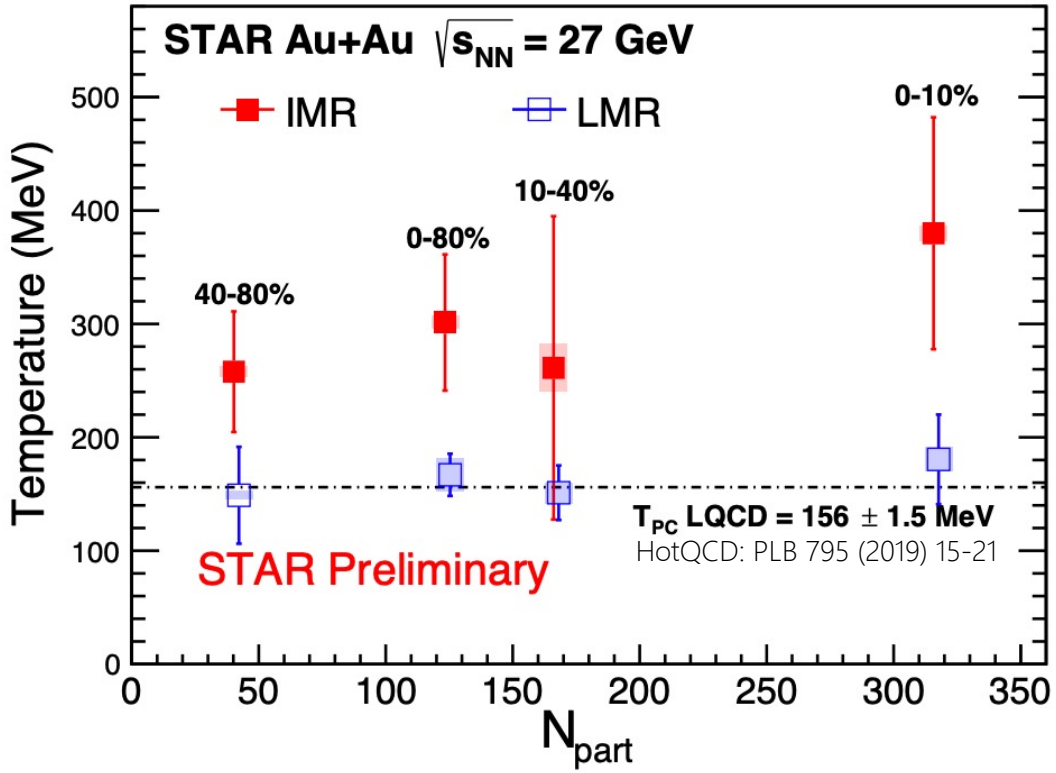
IMR: 1.1 - 2.8 GeV

fitting function: $M^{3/2} * e^{-M/T}$

- Dielectrons from thermal radiation is the major source in intermediate mass region
- T extract from 27 and 54.4 GeV are consistant with each other
- T at RHIC is higher than NA60 result (205+/-12 MeV)
- T is higher than pseudo critical temperature T_{pc} (156 MeV), indicating that the emission is predominantly from deconfined partonic phase - QGP

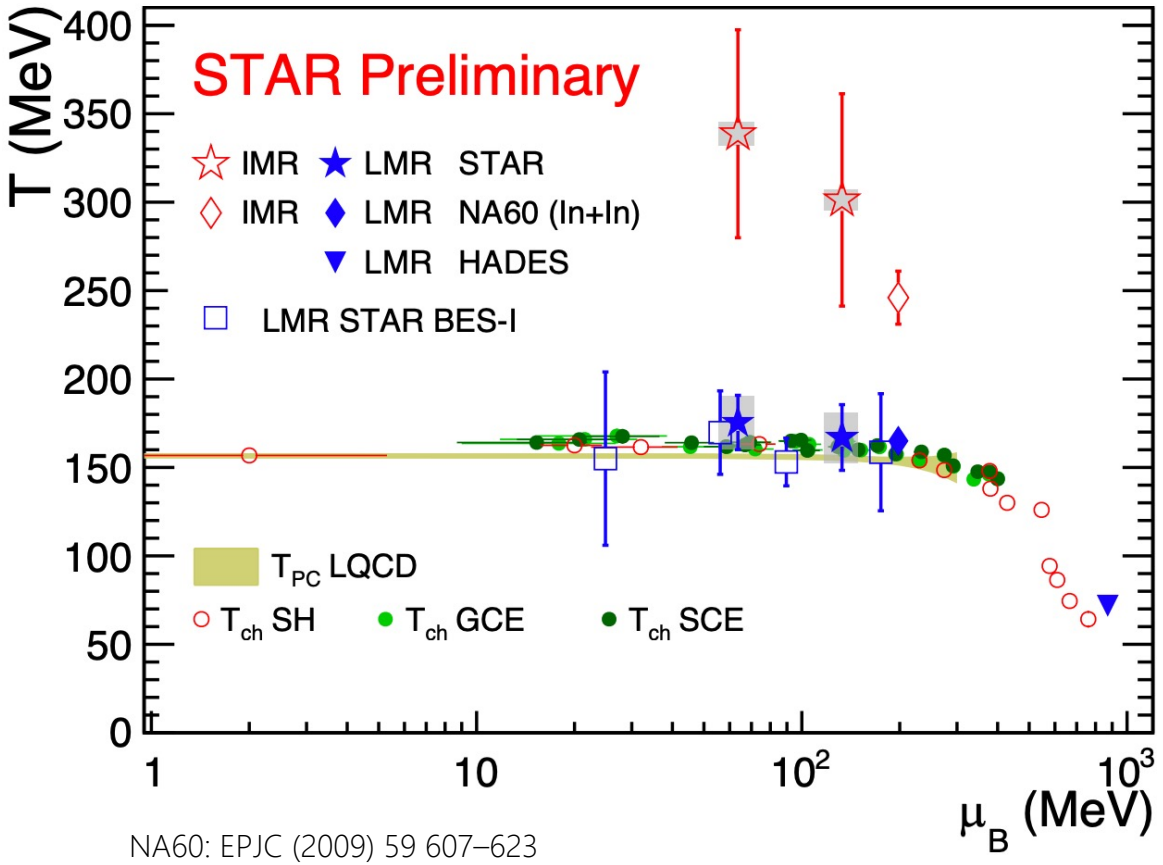
Temperature v.s. N_{part}





- Temperatures have no clear centrality dependence in both mass region
- Temperature from low mass region around phase transition temperature
- Temperature from intermediate mass region is higher than that in low mass region

Temperature v.s. μ_B

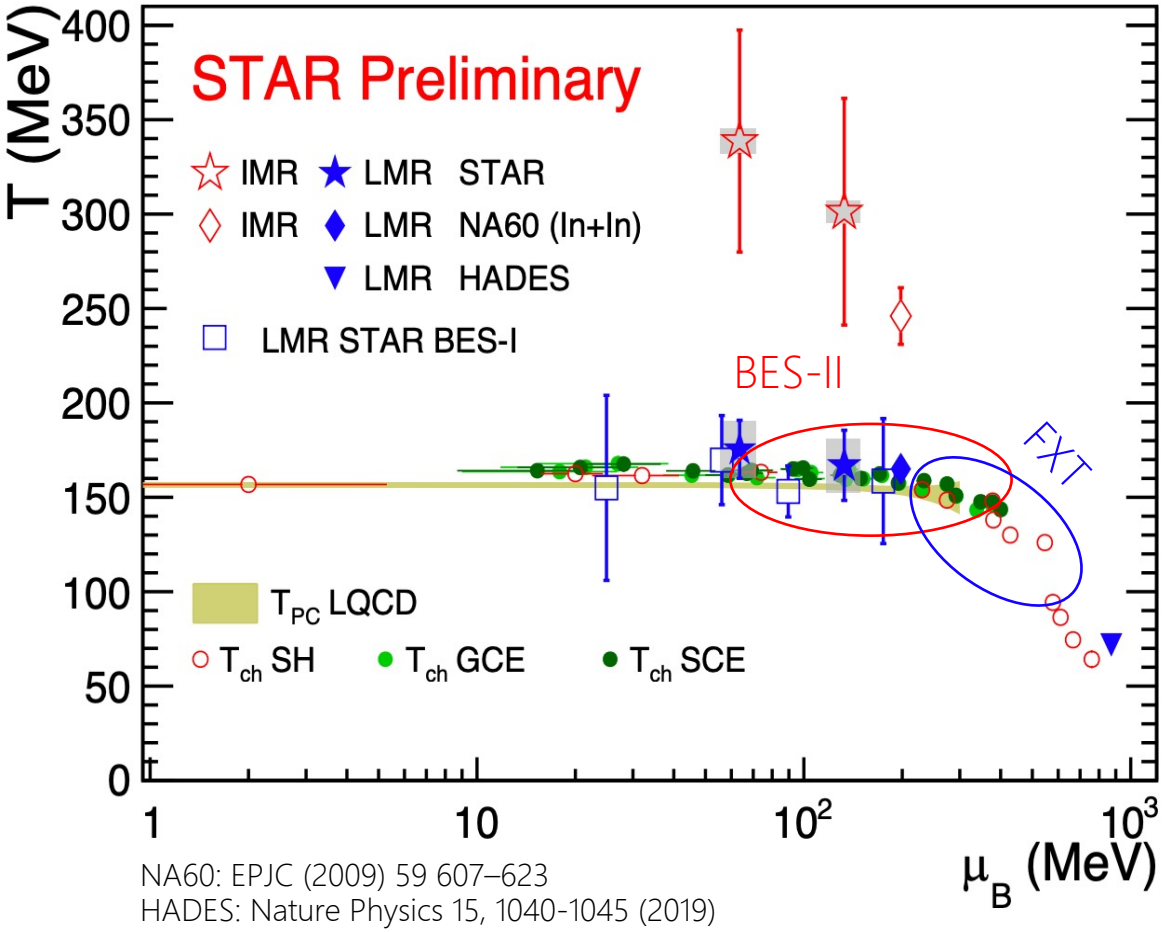


NA60: EPJC (2009) 59 607–623
HADES: Nature Physics 15, 1040-1045 (2019)
Tch SH: P. Braun-Munzinger et al. Nature 561, 321-330 (2018)
Tch GCE/SCE: STAR PRC 96, 044904 (2017) c

- In low mass region, T_{LMR} is close to T_{ch} and T_{pc} , indicate that dielectrons dominantly emitted around phase transition
- In intermediate mass region, T_{IMR} is higher than T_{LMR}, T_{ch} and T_{pc} , indicate that dielectrons dominantly emitted from QGP phase

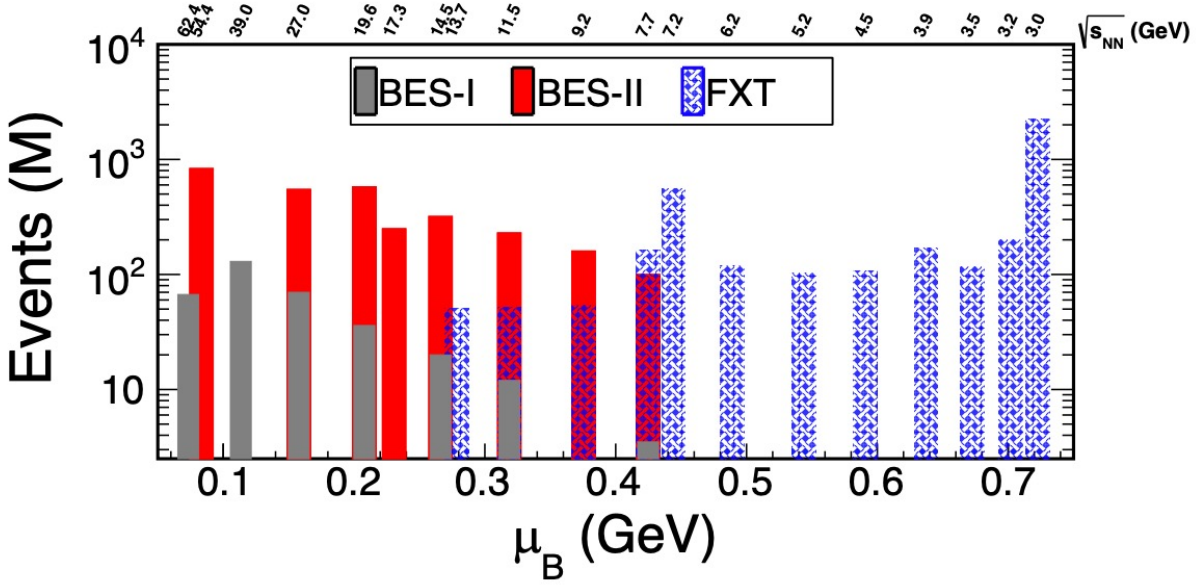
T_{ch} : Chemical freeze-out temperature
T_{pc} : Pseudo critical temperature

STAR BES-II program



NA60: EPJC (2009) 59 607–623
HADES: Nature Physics 15, 1040-1045 (2019)
Tch SH: P. Braun-Munzinger et al. Nature 561, 321-330 (2018)
Tch GCE/SCE: STAR PRC 96, 044904 (2017)

- Measurement of dielectron spectra with high statistic data sample between 7.7 GeV and 19.6 GeV will be possible with STAR BES-II data
- Enhanced tracking and particle identification capabilities with iTPC and eTOF upgrades



Summary

Dielectron spectra in Au+Au collisions at 27 and 54.4 GeV in BES-II has been measured

Low mass region:

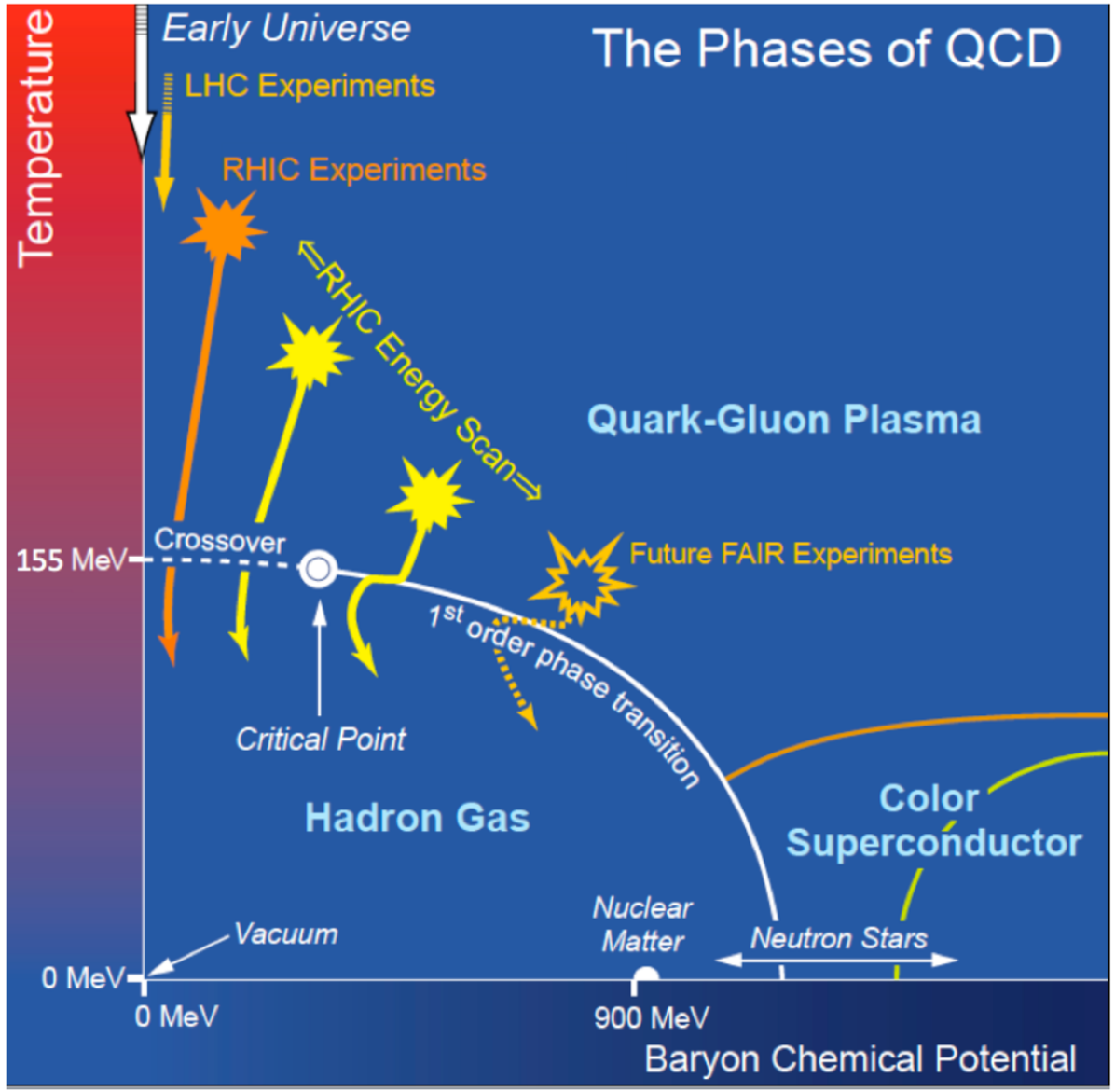
- T_{LMR} ~ 170 MeV, first experimental evidence that in-medium ρ are dominantly produced around phase transition

Intermediate mass region:

- T_{IMR} ~ 320 MeV, first QGP temperature measurement at RHIC without distortion by medium flow
- $T > T_{pc}$, radiation source is QGP thermal radiation

Thanks for your attention!

backup


The Phases of QCD
Temperature
Early Universe
LHC Experiments
RHIC Experiments
RHIC Energy Scan
Quark-Gluon Plasma
Crossover
155 MeV
Future FAIR Experiments
1st order phase transition
Critical Point
Hadron Gas
Color Superconductor
Nuclear Matter
Neutron Stars
Vacuum
0 MeV
0 MeV
900 MeV
Baryon Chemical Potential