Dilepton Results from STAR BES-I

Xiaolong Chen（陈小龙）、Yifei Zhang （张一飞）

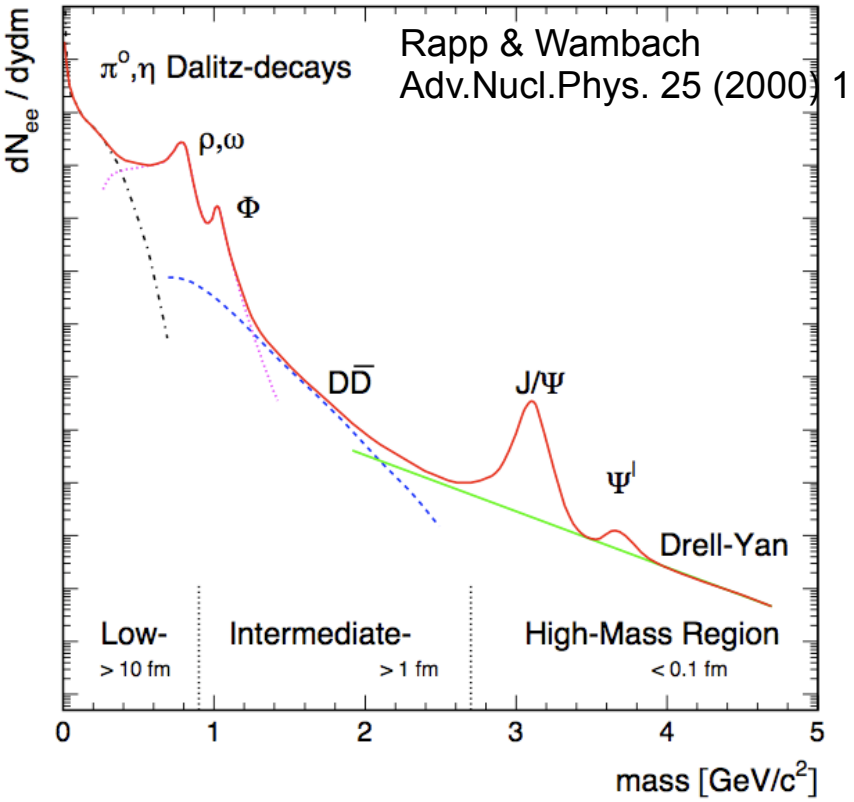
University of Science & Technology of China

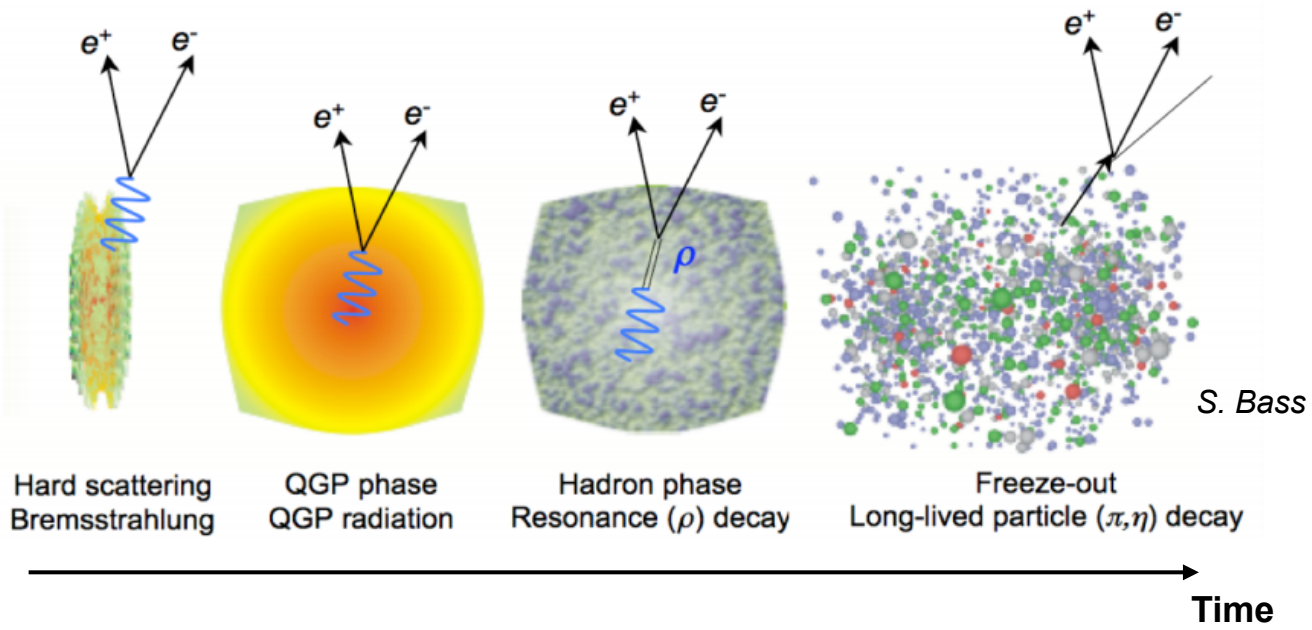
CBM-China Workshop, Yichang
April 16-18, 2018

Outline

- Introduction and motivation
- Dielectron production from RHIC BES-I
- Future prospects
- Summary

Introduction: EM penetrating probes





LMR Chiral symmetry restoration
Vector meson production:
in-medium effect

IMR Heavy quark correlation
QGP thermal radiation

HMR Heavy quarkonia production
Drell-Yan

Electromagnetic probes =>

Do not participate in strong interactions.

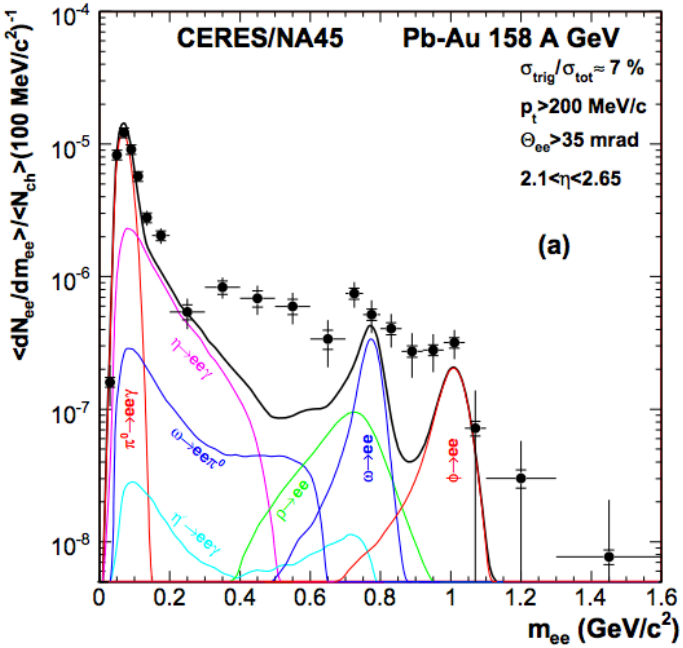
Bring undistorted information as where produced.

Penetrate medium properties.

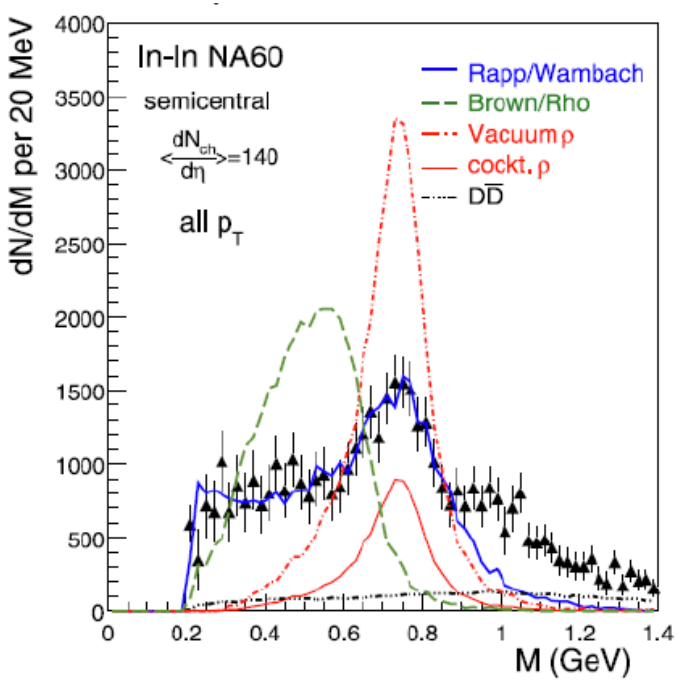
Challenge: Time-space integrated from every stages.

Continuum at IMR.

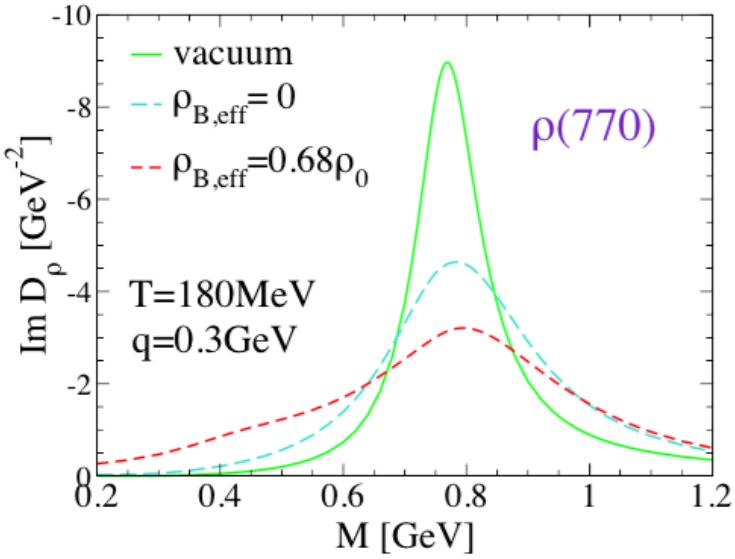
Introduction: in-medium modifications



PLB 666 (2008) 425



EPJ C61 (2009) 711



Rapp, Wambach, van Hees
arXiv:0901.3289

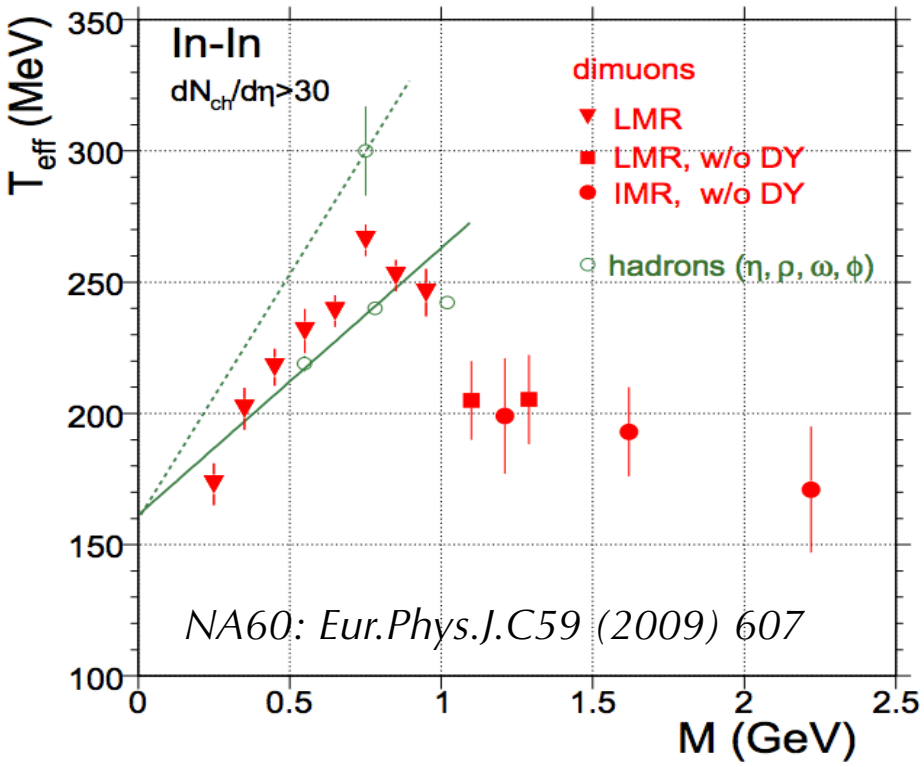
Low mass excess was observed in previous experiments.

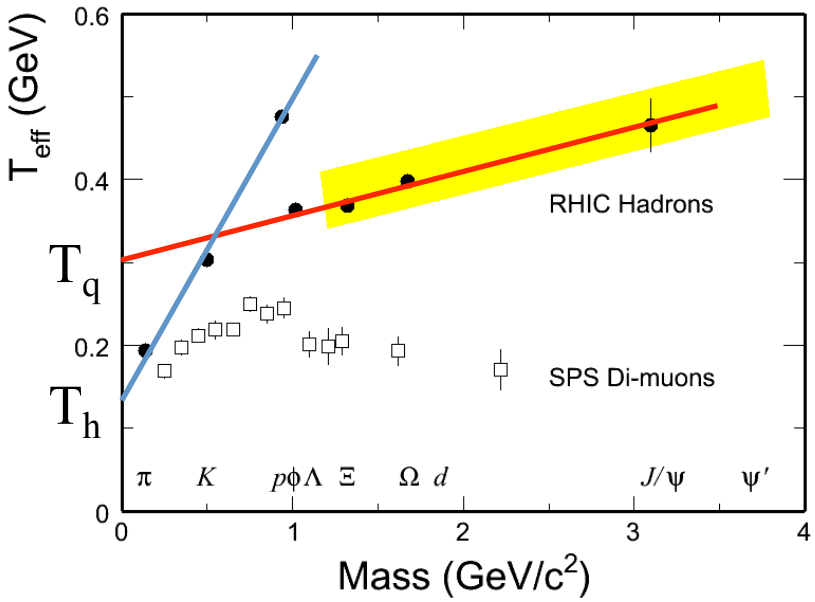
Vacuum ρ unable to describe data.

Rule out Dropping-Mass Scenario (Brown-Rho).

Good agreement with broadening of ρ spectral function (Rapp-Wambach).

Introduction: hadronic vs partonic





RHIC 200 GeV, NPA 757 (2005) 102

$$T_{\rm eff} = T_0 + M v_T^2$$

LMR: inversed slopes show mass dependence

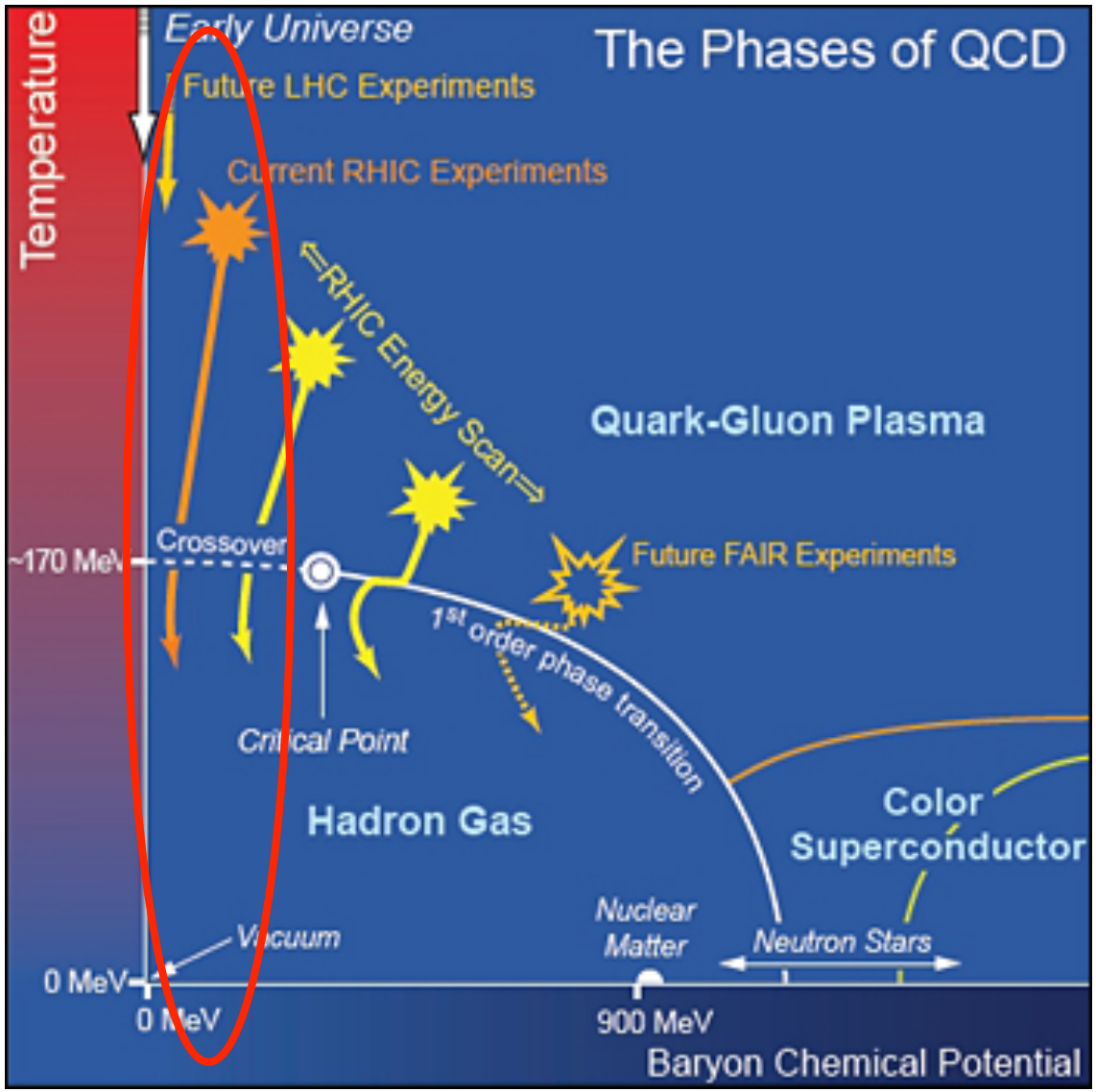
-- hadronic process dominate, radial flow

IMR: no indication of mass dependence

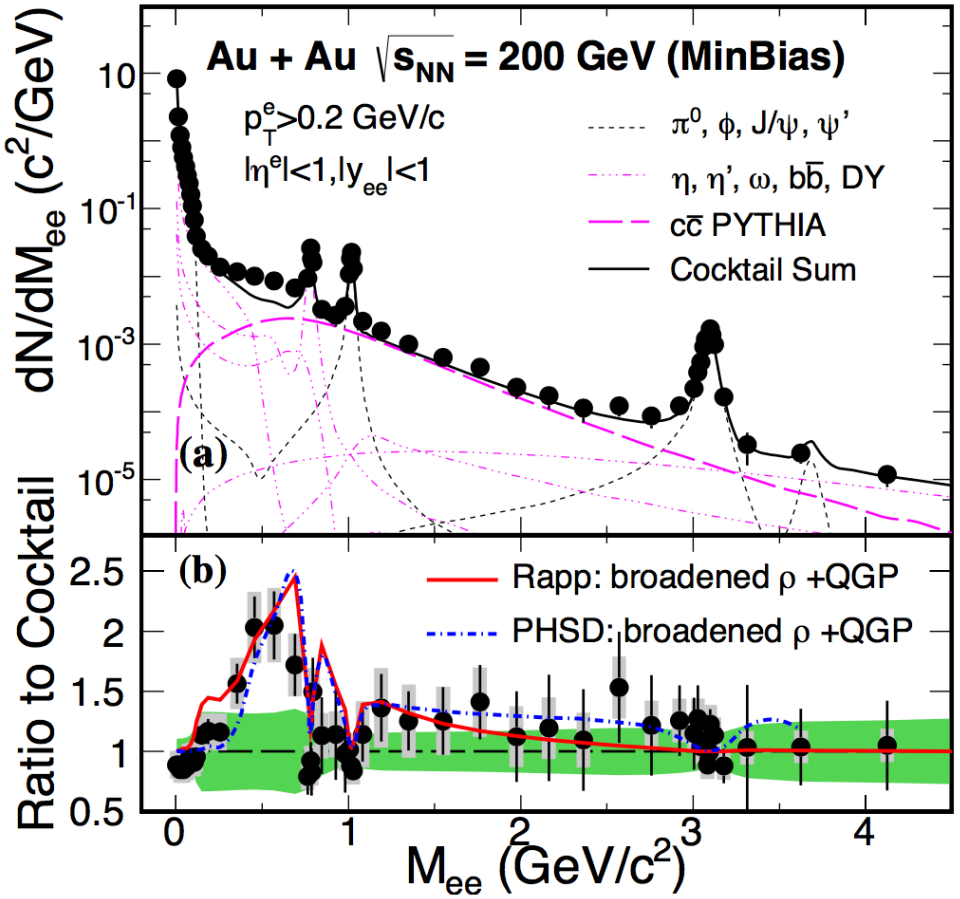
-- thermal radiation from partonic phase

Energy dependence of the slopes could be sensitive to the medium dynamics.

Dilepton at RHIC top energy



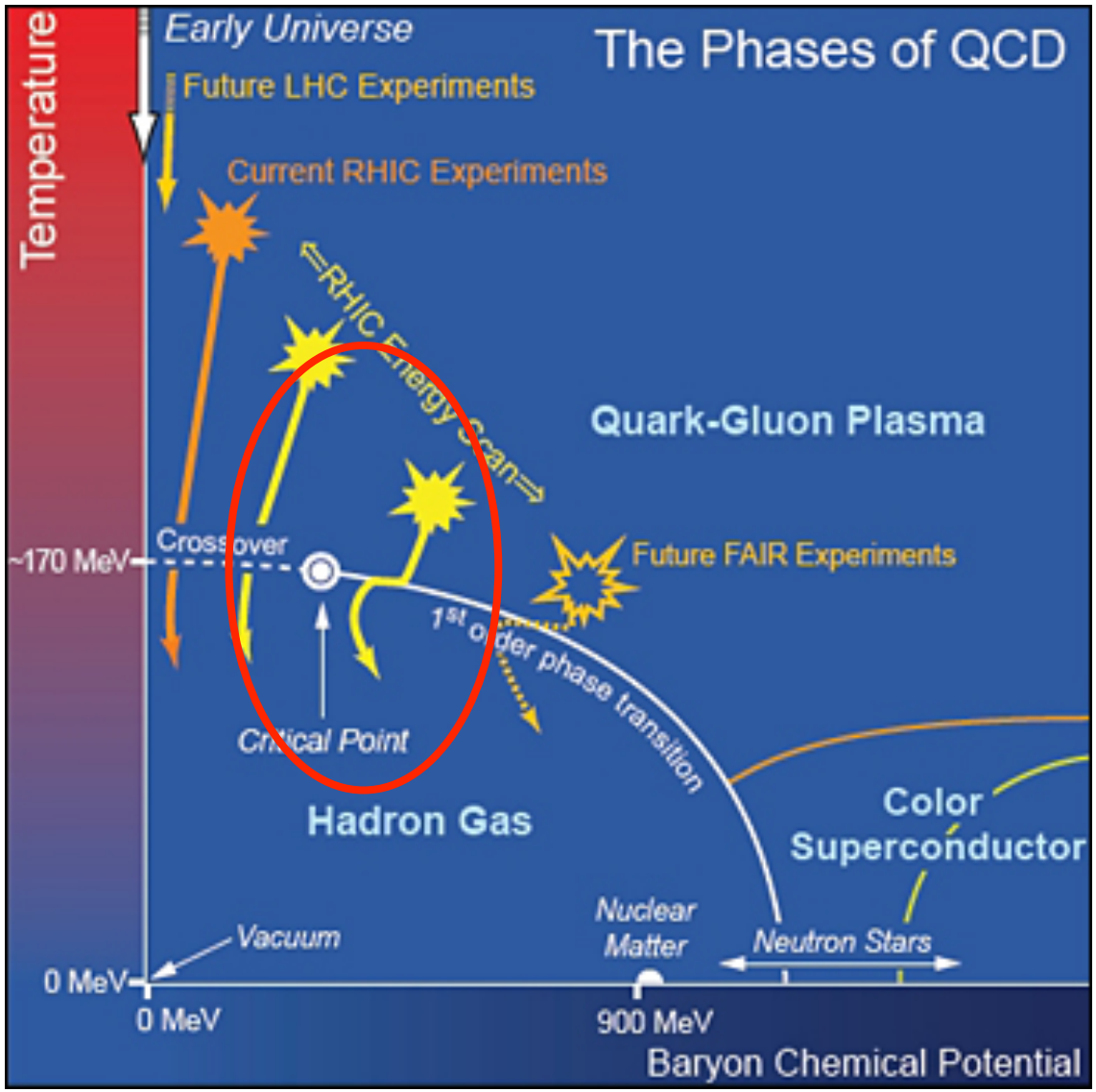
RHIC top energy ($\sqrt{s_{NN}}$ = 200 GeV):
Search for QGP and study its properties



STAR, PRL 113 (2014) 022301

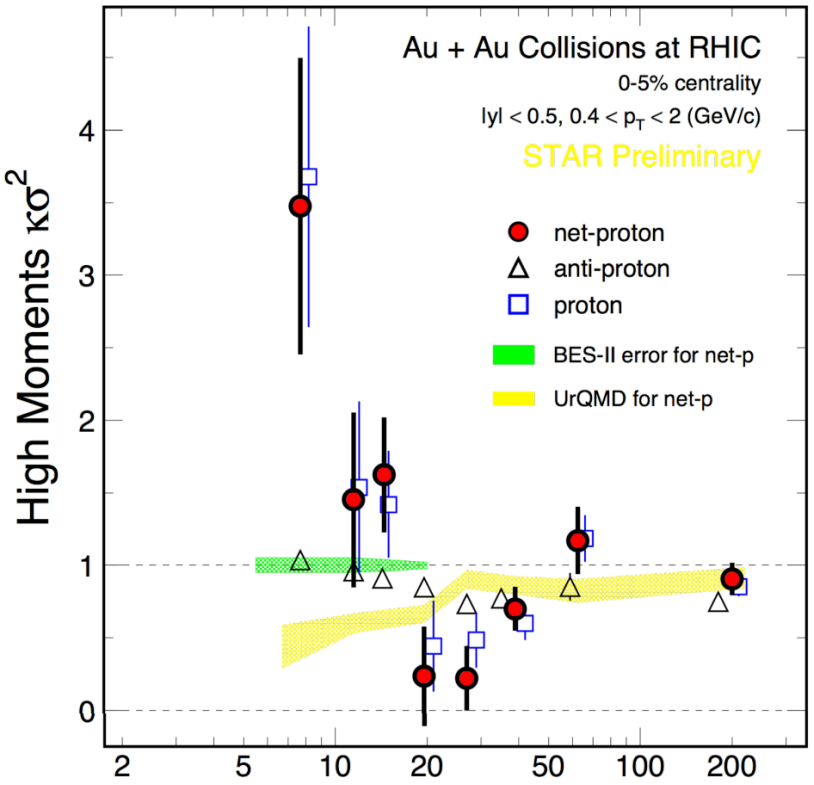
LM excess observed consistent with ρ in-medium modification
- possible link to chiral symmetry restoration.

What about low energies?



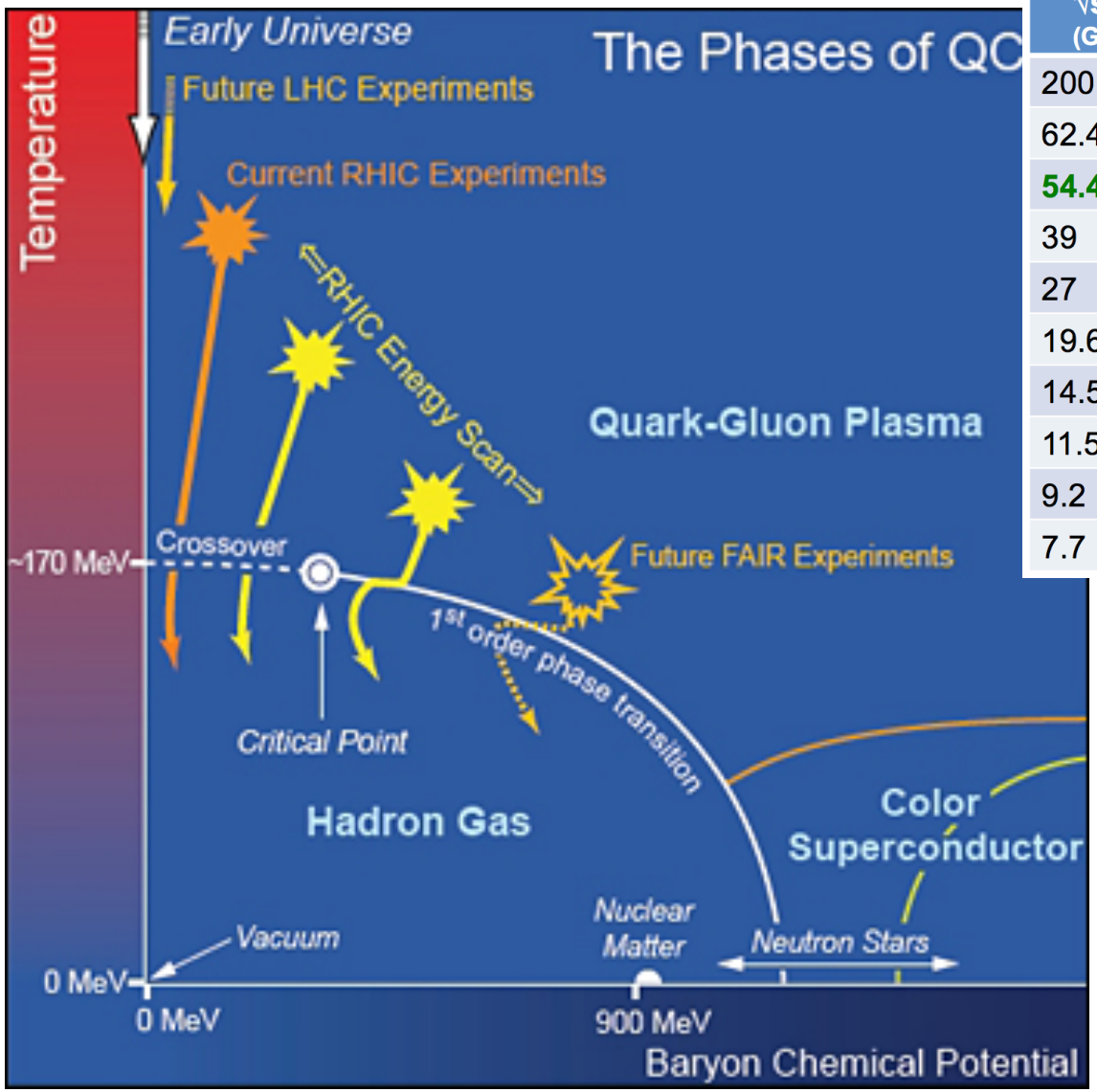
RHIC BES program (7.7 – 62.4 GeV):
Mapping QCD phase structure, search for the phase transition / critical point.

- Multiplicity fluctuations
- Dilepton ?



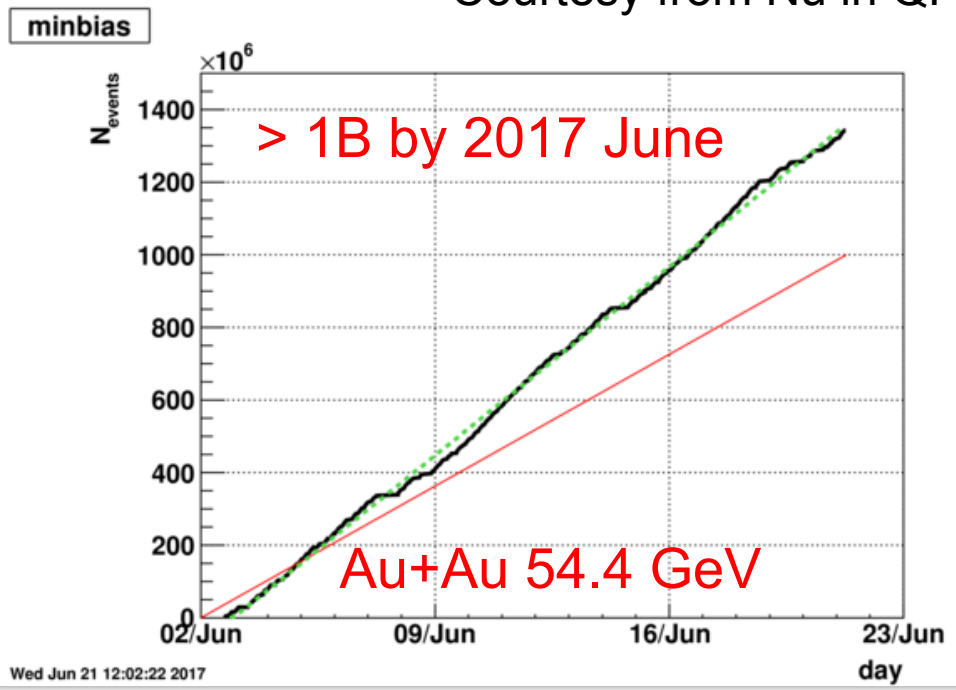
X. Luo, N. Xu, NST 28 (2017) 112

RHIC BES program

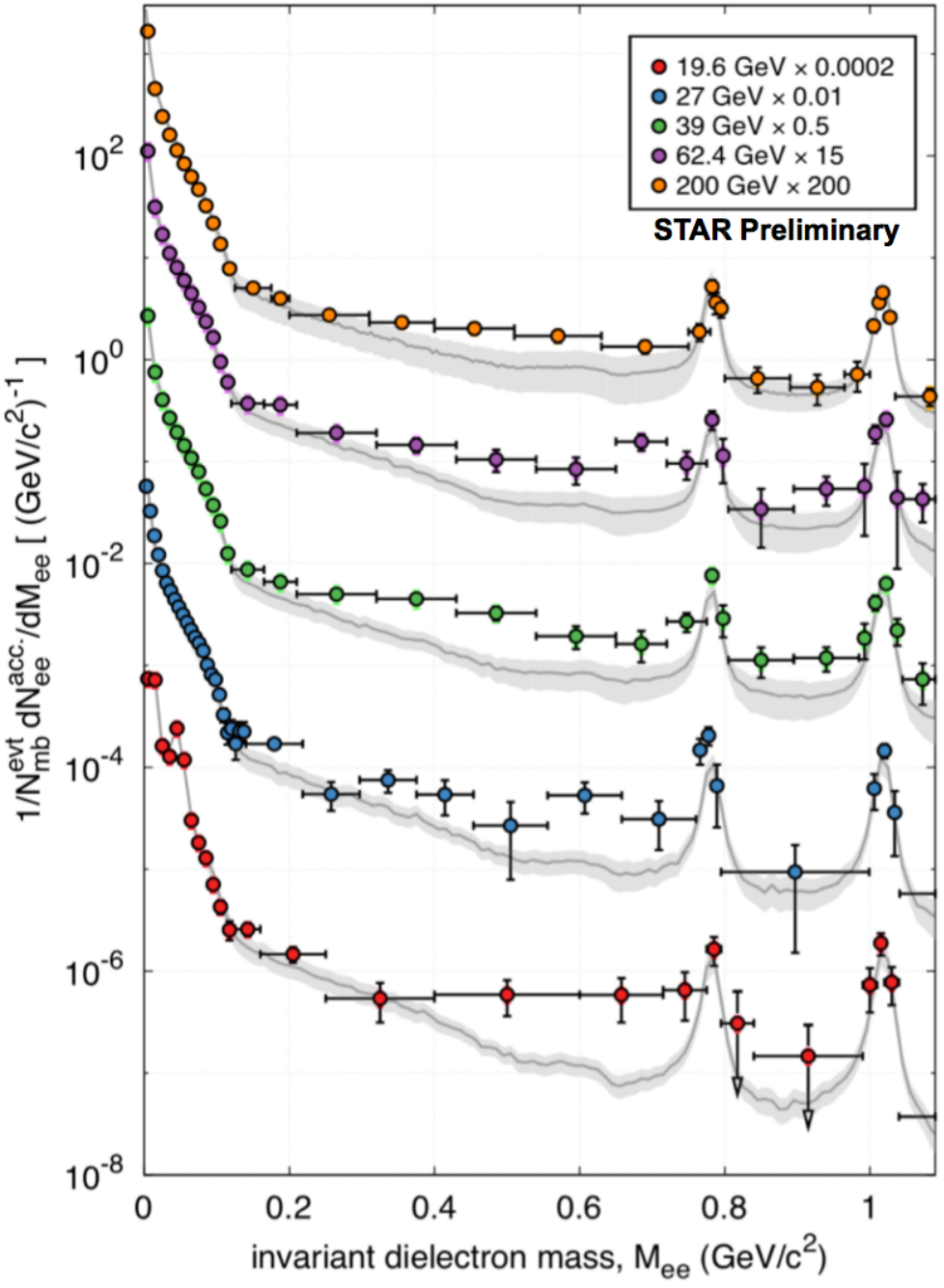


$\sqrt{s_{NN}}$ (GeV)	Events (10^6)	BES II / BES I	Weeks	μ_B (MeV)	T_{CH} (MeV)
200	350	2010		25	166
62.4	67	2010		73	165
54.4	1000	**2017**			
39	39	2010		112	164
27	70	2011		156	162
19.6	**400** / 36	**2019-20** / 2011	**3**	206	160
14.5	**300** / 20	**2019-20** / 2014	**2.5**	264	156
11.5	**230** / 12	**2019-20** / 2010	**5**	315	152
9.2	**160** / 0.3	**2019-20** / 2008	**9.5**	355	140
7.7	**100** / 4	**2019-20** / 2010	**14**	420	140

Courtesy from Nu in QPT17



Dilepton excess spectra in BES-I



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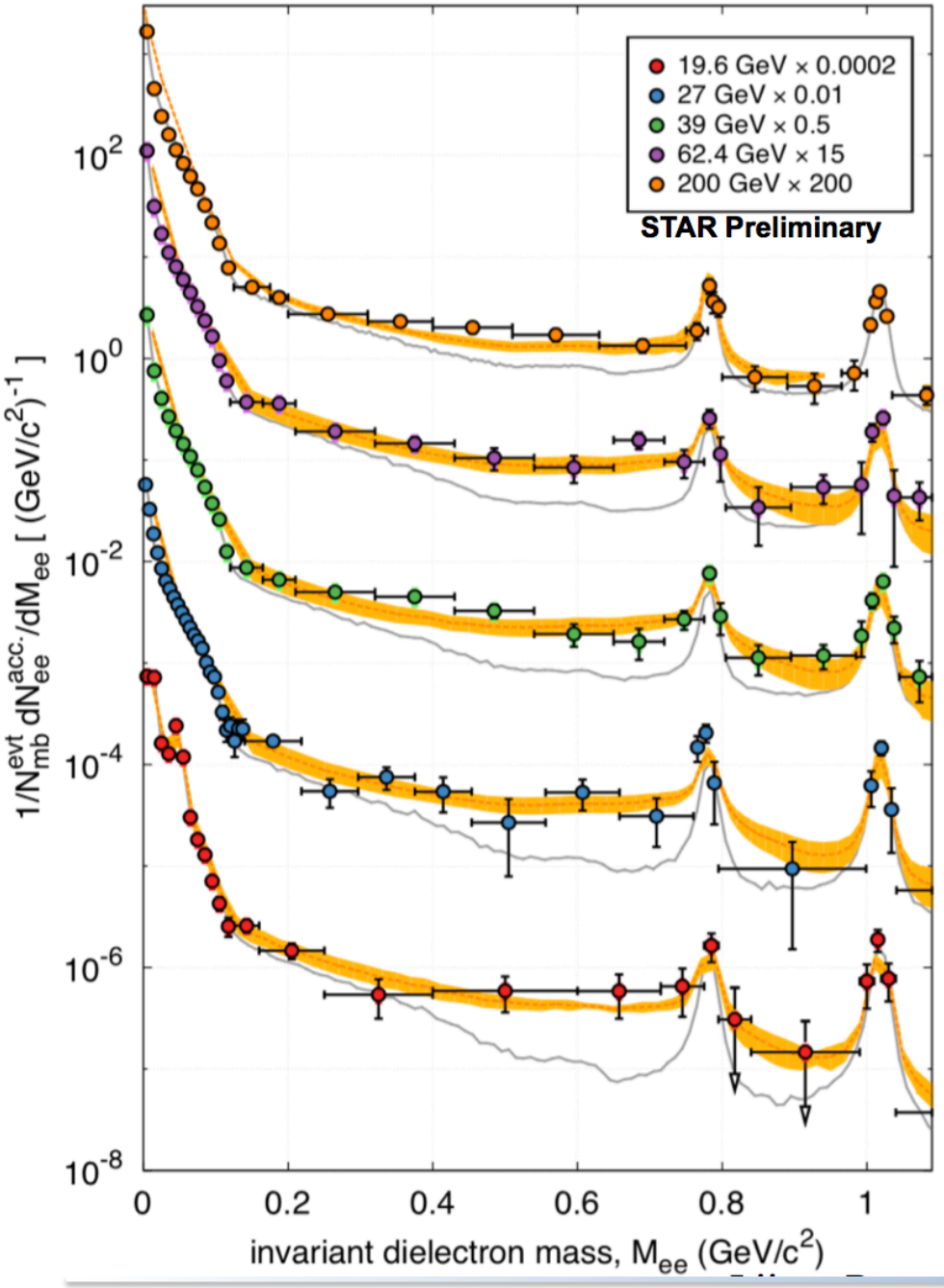
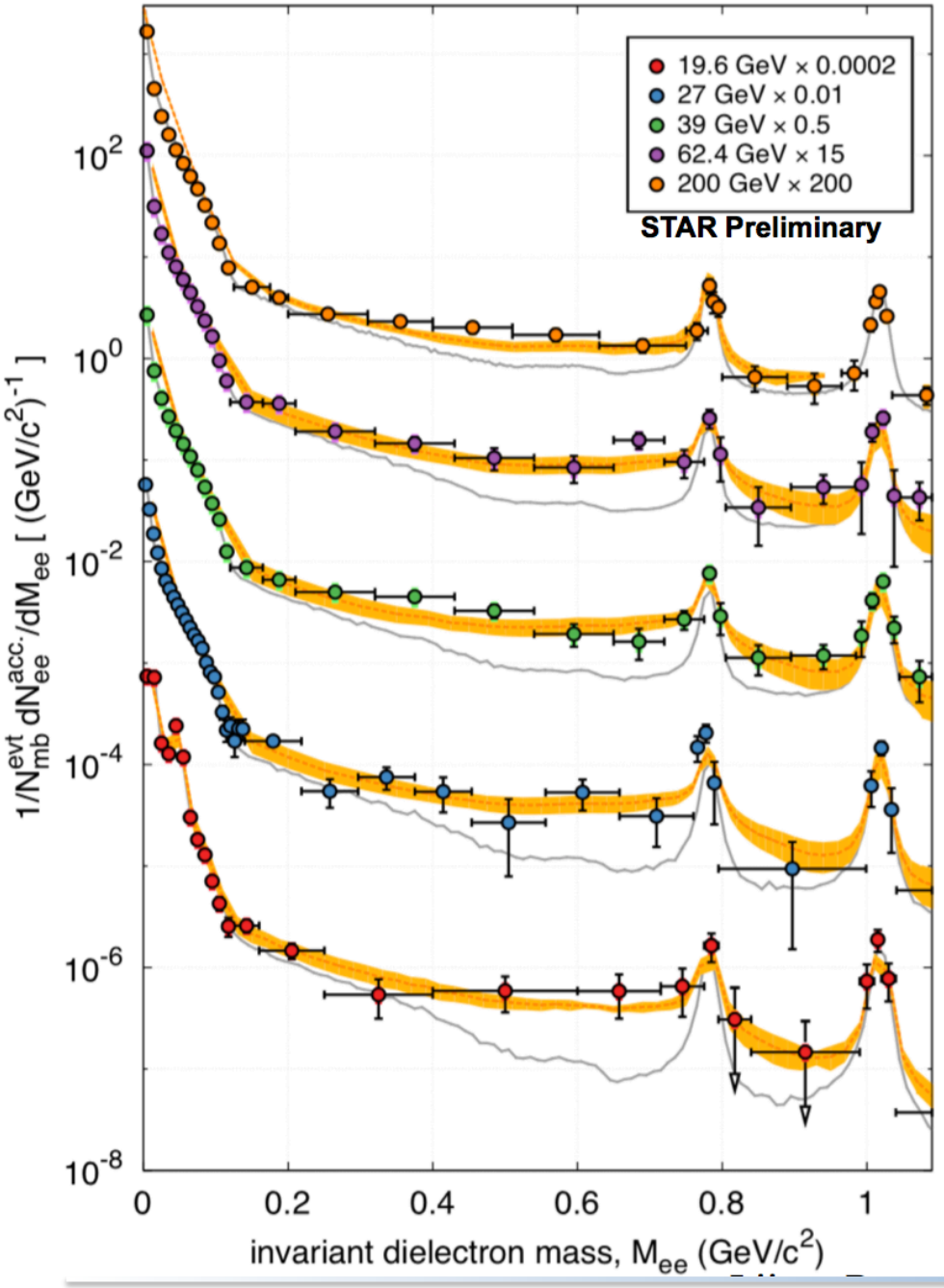
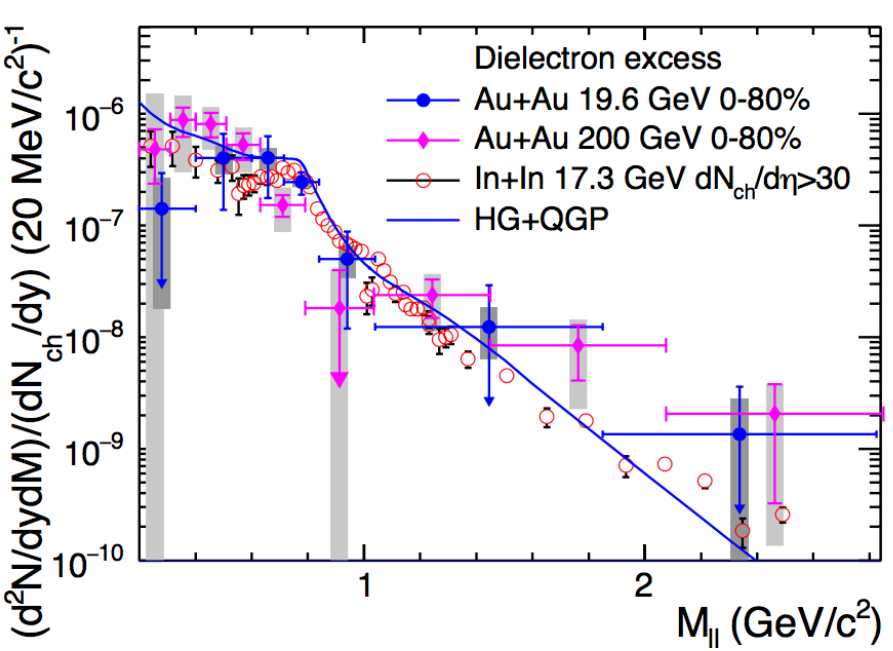


Consistent with ρ in-medium modification.

Dilepton excess spectra in BES-I





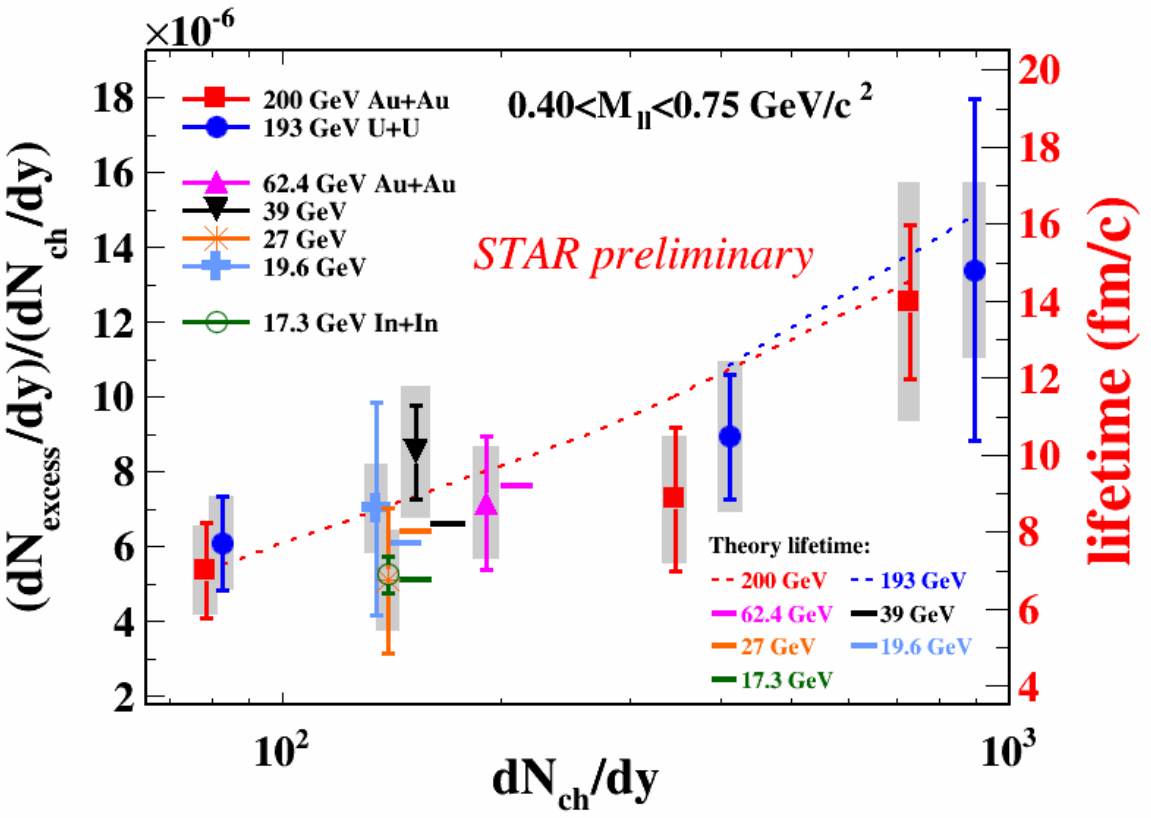
AuAu@19.6,200: STAR, PLB750 64 2015
AuAu@27,39,62&UU@193: S. Yang, Quark Matter 2015
InIn@17.3: NA60, EPJ C59 607 2009
Theory: R. Rapp, PRC 63 (2001) 054907

Consistent with ρ in-medium modification.

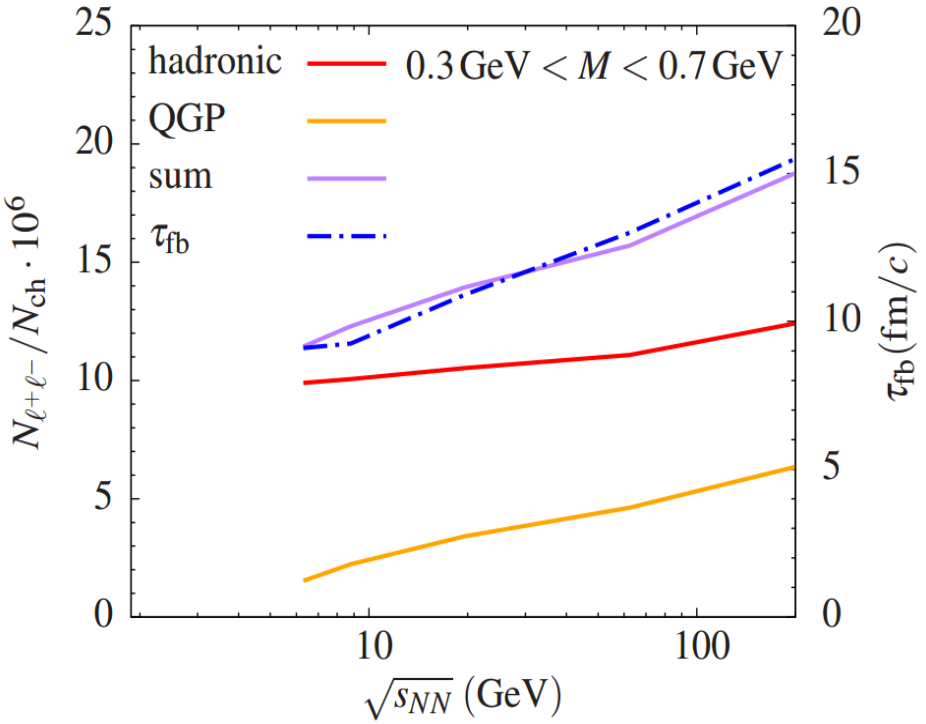
Weak collision energy dependence

=> Leptons are blindly emitted in HG + QGP.

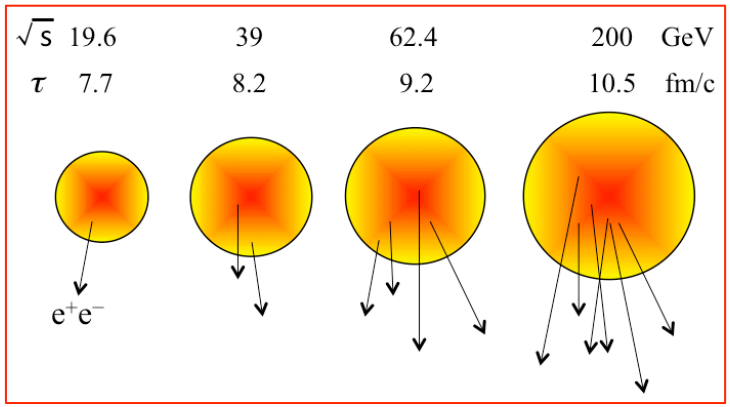
Excess yield and medium life time



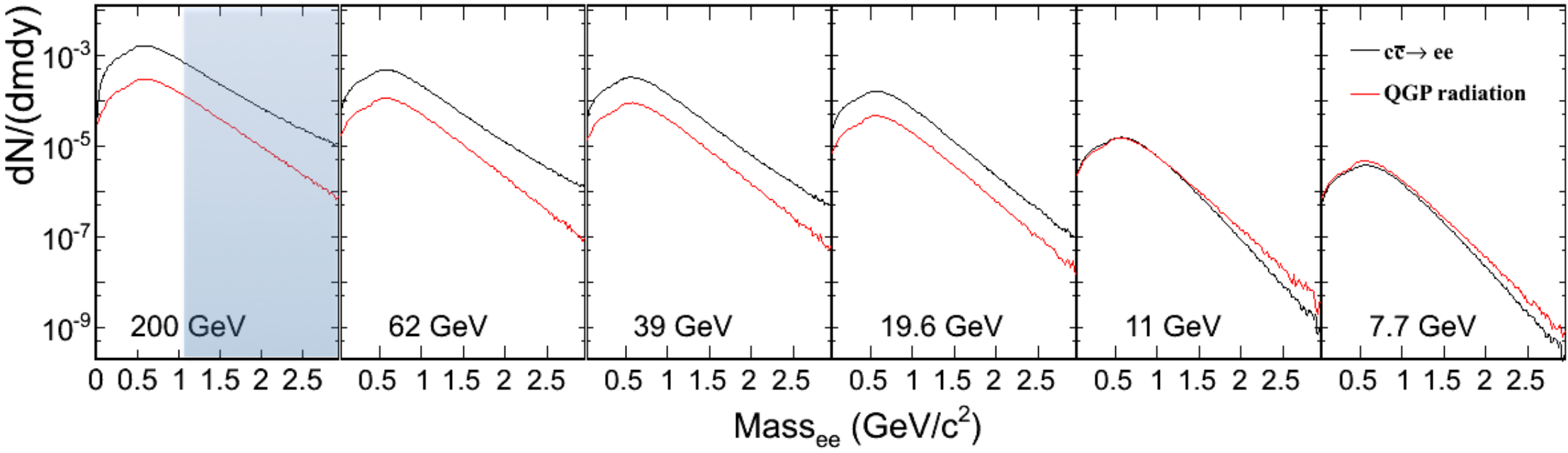
AuAu@200 GeV, 19.6 GeV: *STAR, PLB 750 (2015) 64*
InIn@17.3 GeV: *NA60, Eur. Phys. J. C 59 (2009) 607*
Rapp, van Hees,PLB 753 (2016) 586, arXiv:1411.4612

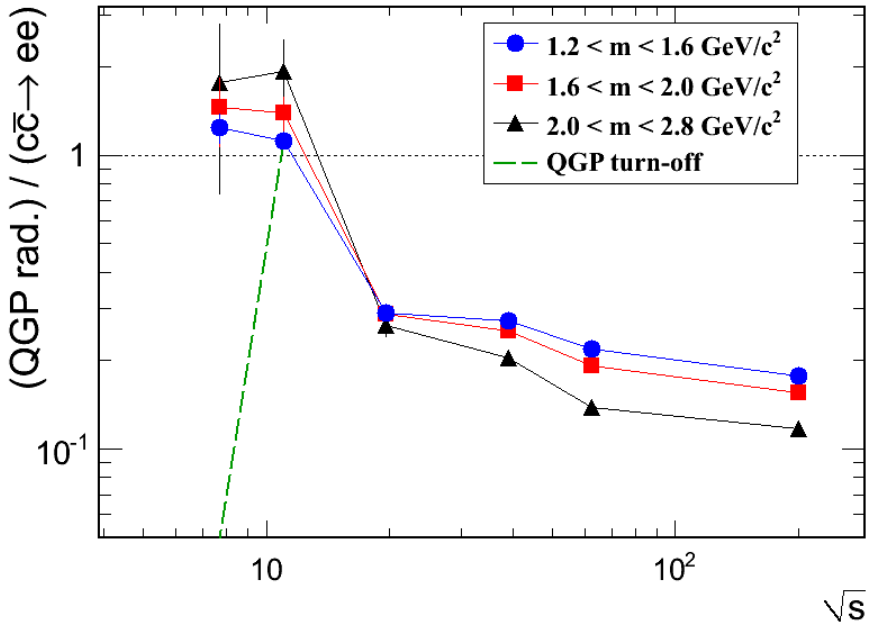


- Data agree with model calculations.
- The normalized excess yield is proportional to the medium life time (HG+QGP) from 17 to 200 GeV.
- Nearly constant total baryon density.



IMR signal / background

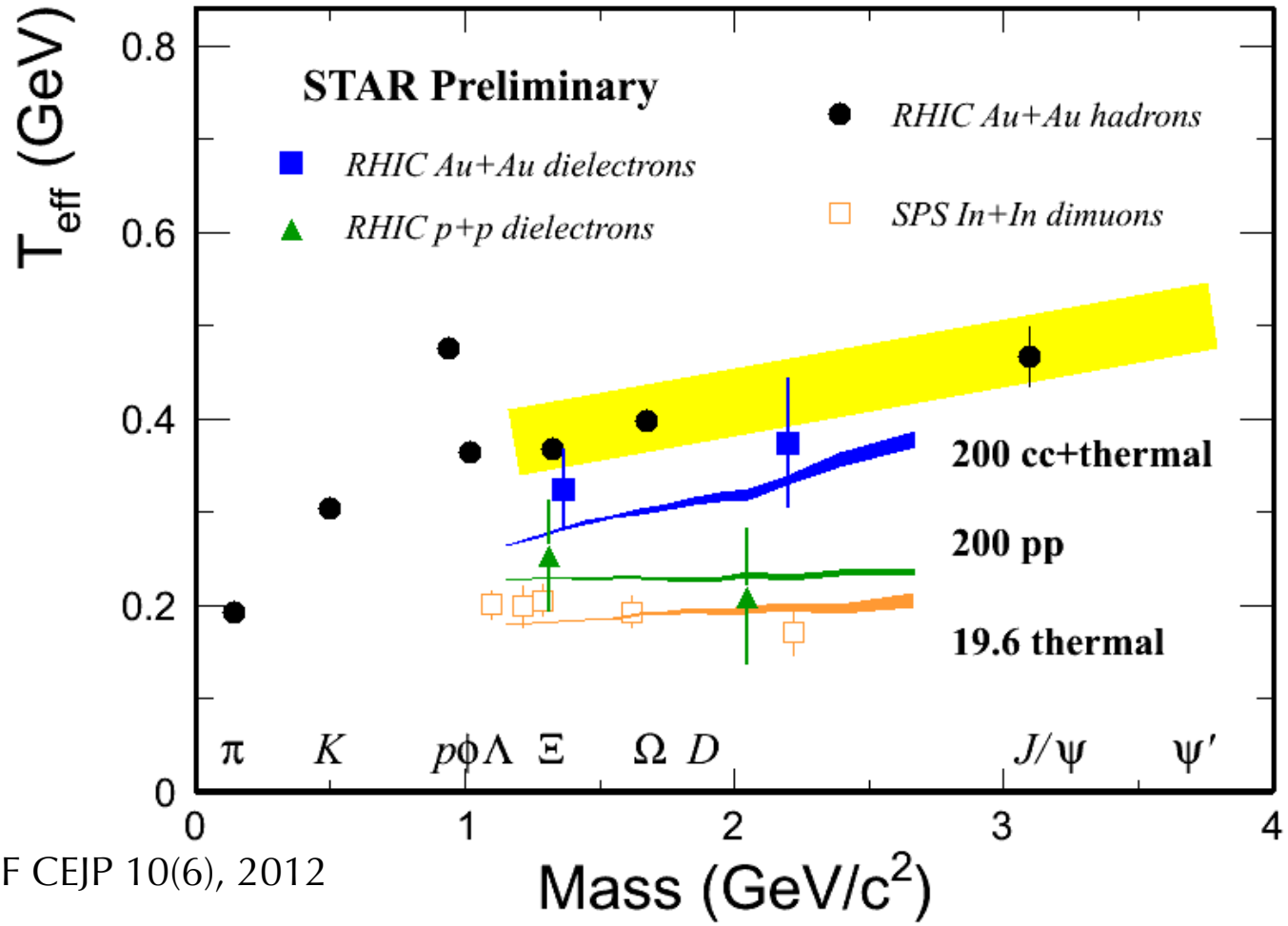




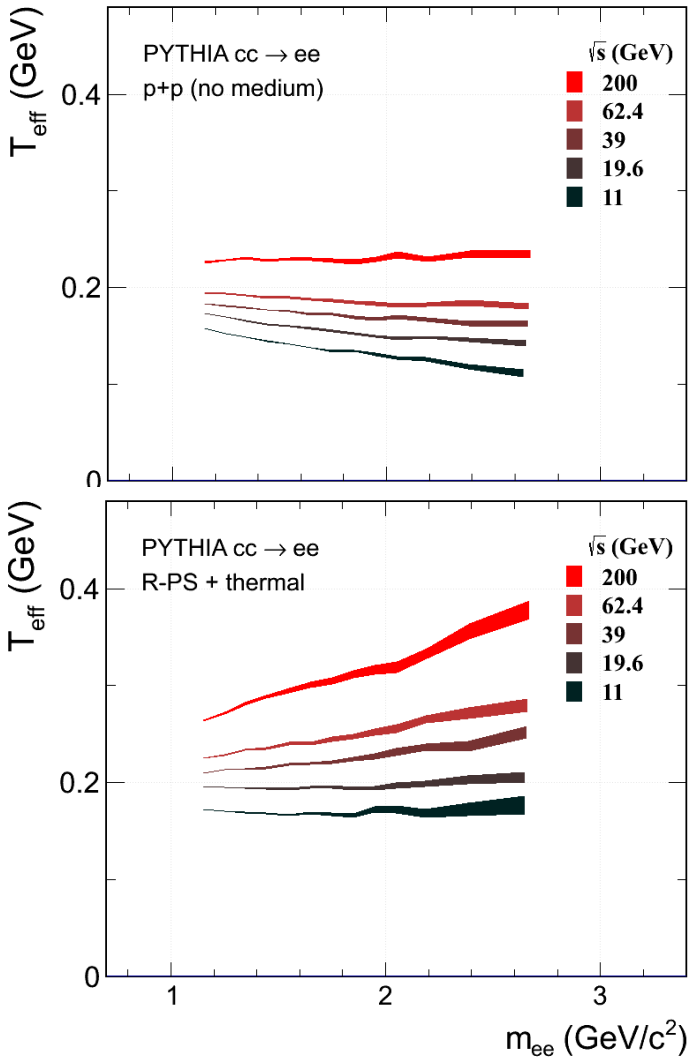
- ✧ s / b ratio is ~ a few percent in higher energies.
- ✧ s / b enhanced in lower energy, relative large emission rate even for a short-lived medium.
- ✧ Test possible phase transition.

2+1D hydro:
B. Schenke, *et. al.*, PRC82, 014903 (2010)
H. Xu, *et al.*, PRC 85 024906 (2012)

M_T slope at IMR



YF CEJP 10(6), 2012

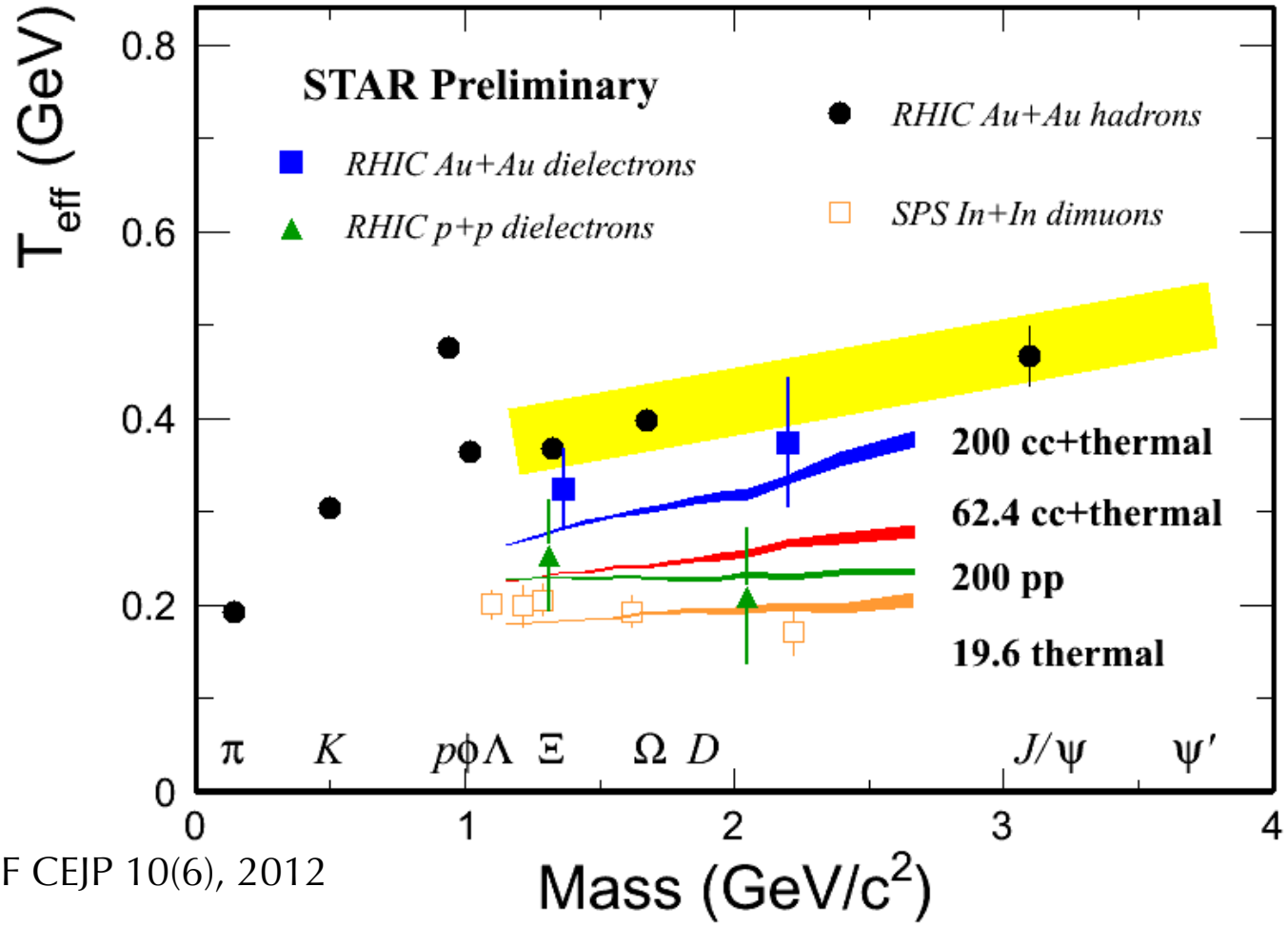


Correlated charm (Pythia) describes p+p data.

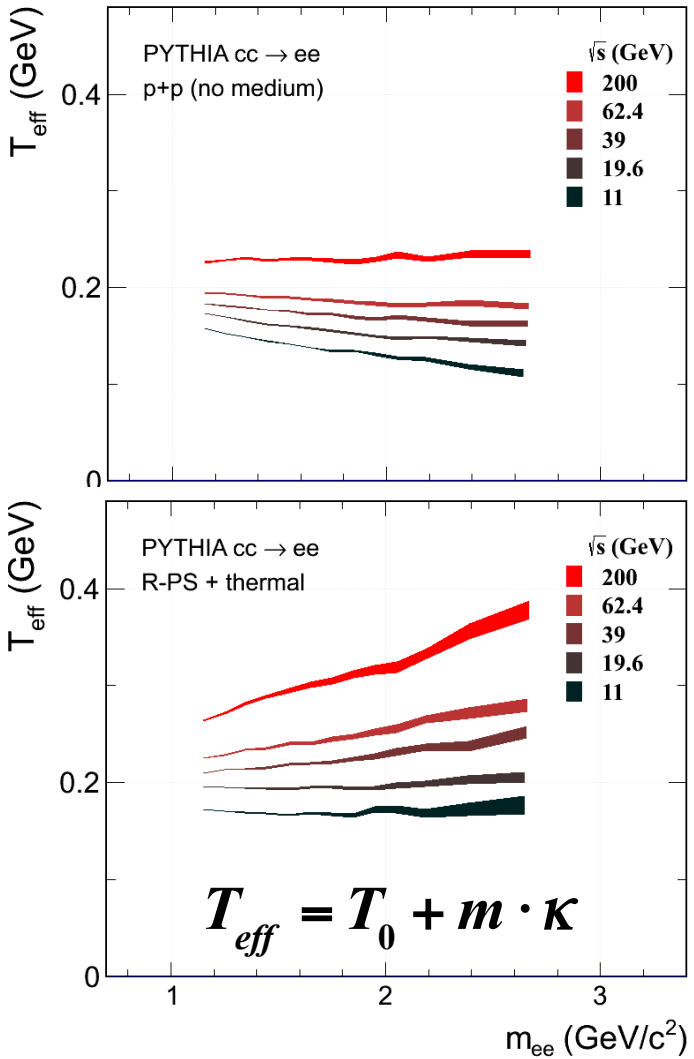
Correlated charm + thermal (2+1D hydro) describe A+A data as well.

Dynamic evolution with system-size / collision-energies is expected.

M_T slope at IMR



YF CEJP 10(6), 2012



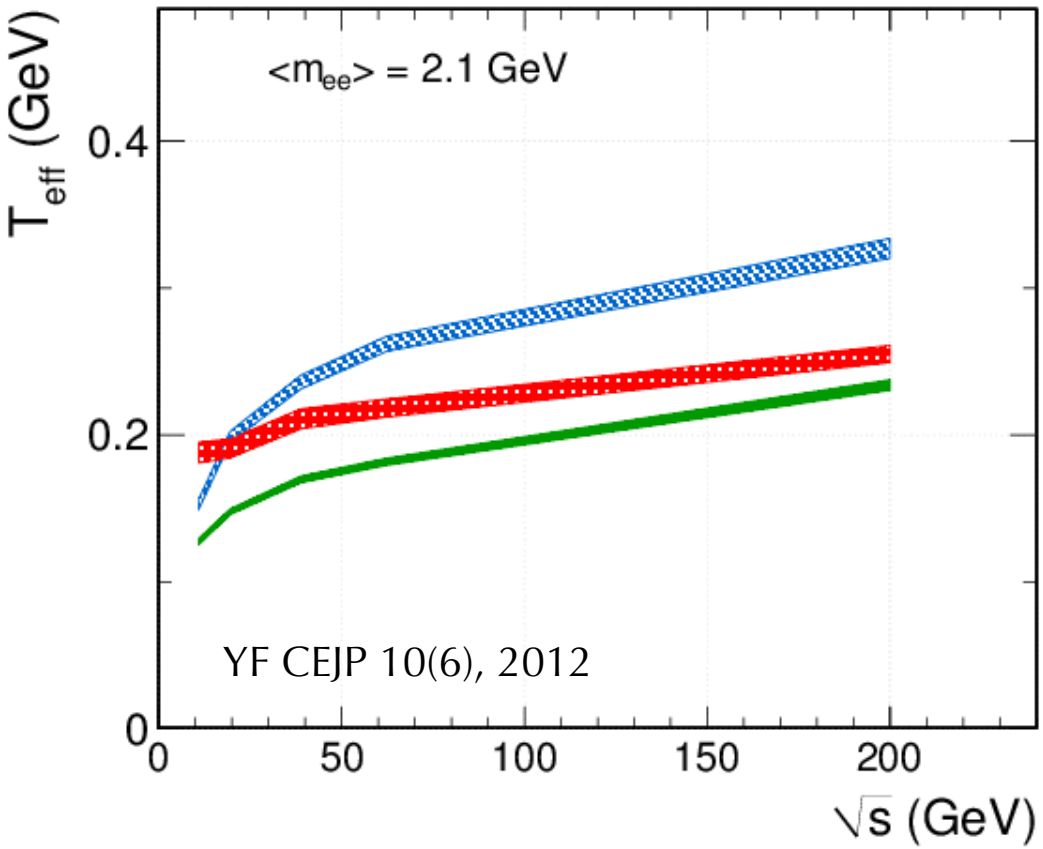
Correlated charm (Pythia) describes p+p data.

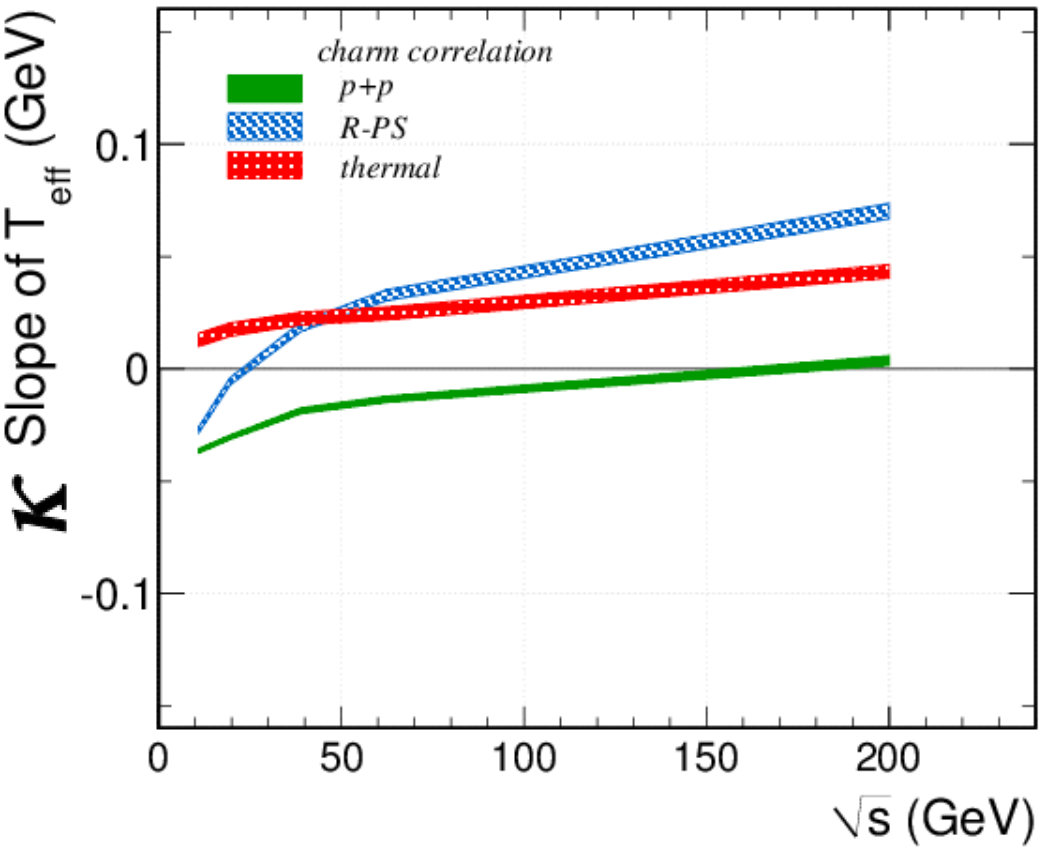
Correlated charm + thermal (2+1D hydro) describe A+A data as well.

Dynamic evolution with system-size / collision-energies is expected.

Precision measurement at 54 GeV is crucial to test the model.

Possible observation at phase transition?

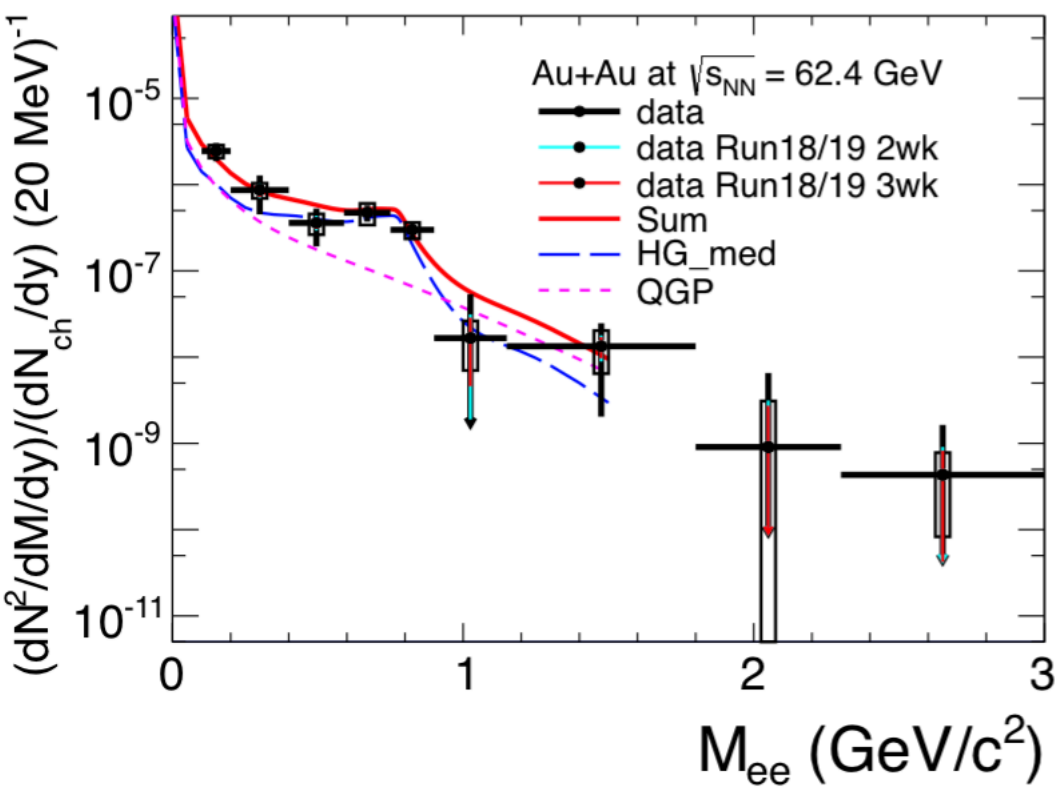


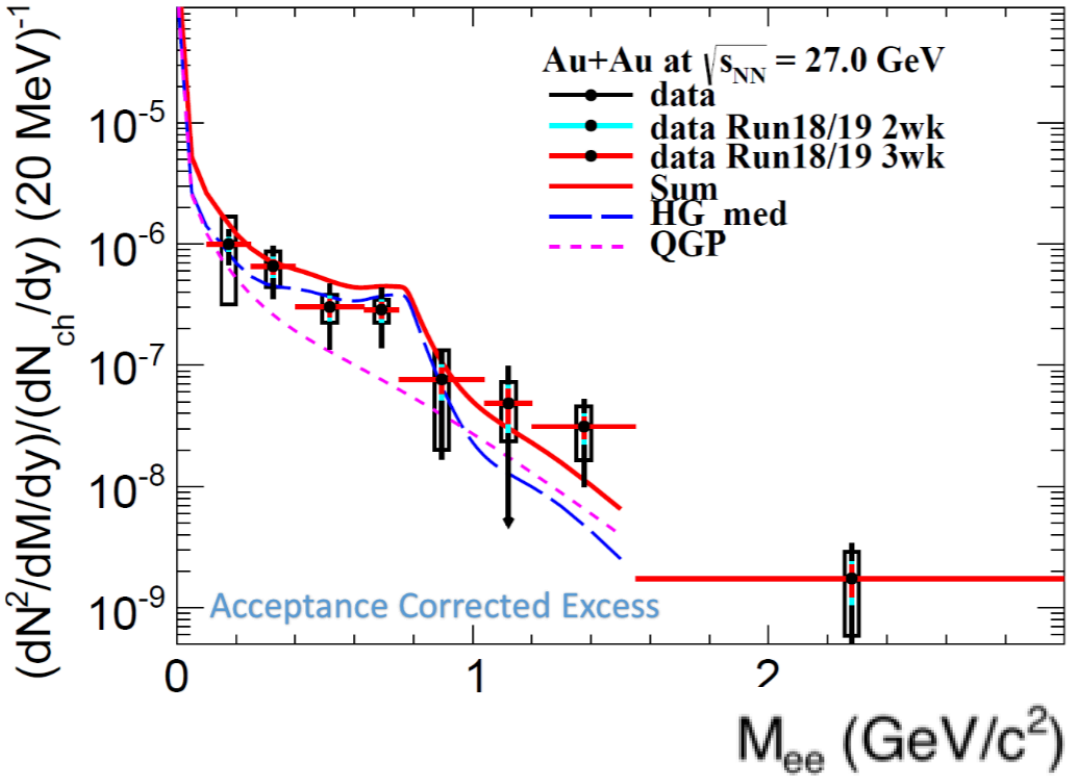


Both T_{eff} and its slope κ in medium are significant higher than the system w/o medium.

Phase transition could happen if the T_{eff} increases dramatically or the sign of its slope κ changes from negative to positive.

Projection of Run 18&19





- With 2-3 weeks data taken, the low mass statistics will be significantly improved.
- Possible access for QGP radiation component at IMR.

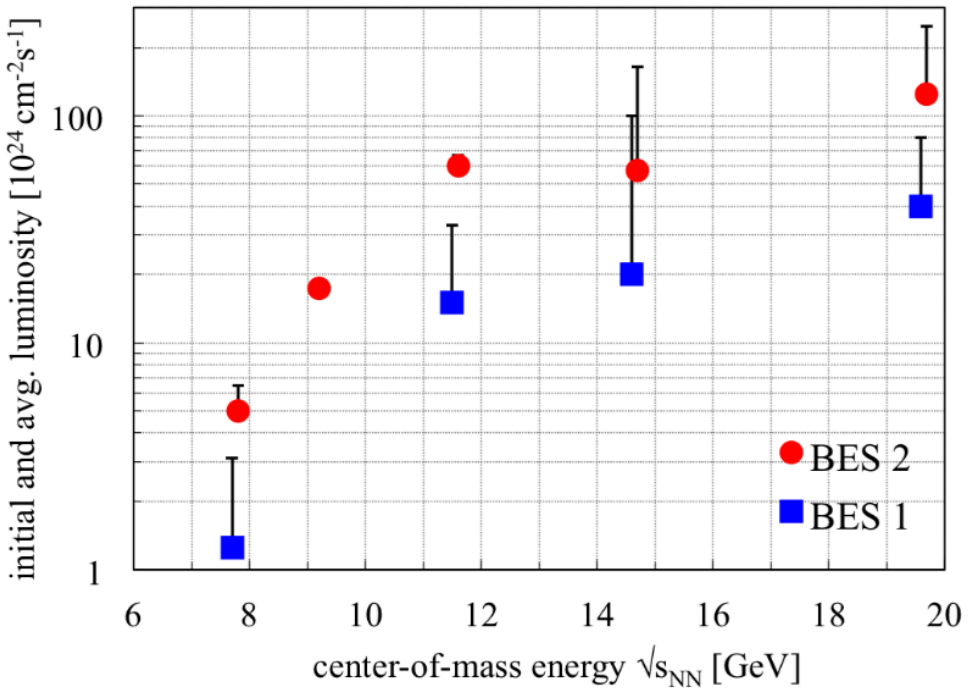
BES Phase II

✧ Electron cooling will provide increased luminosity.

✧ iTPC + HFT + MTD upgrades

✧ Enables increased statistics for the BES energies

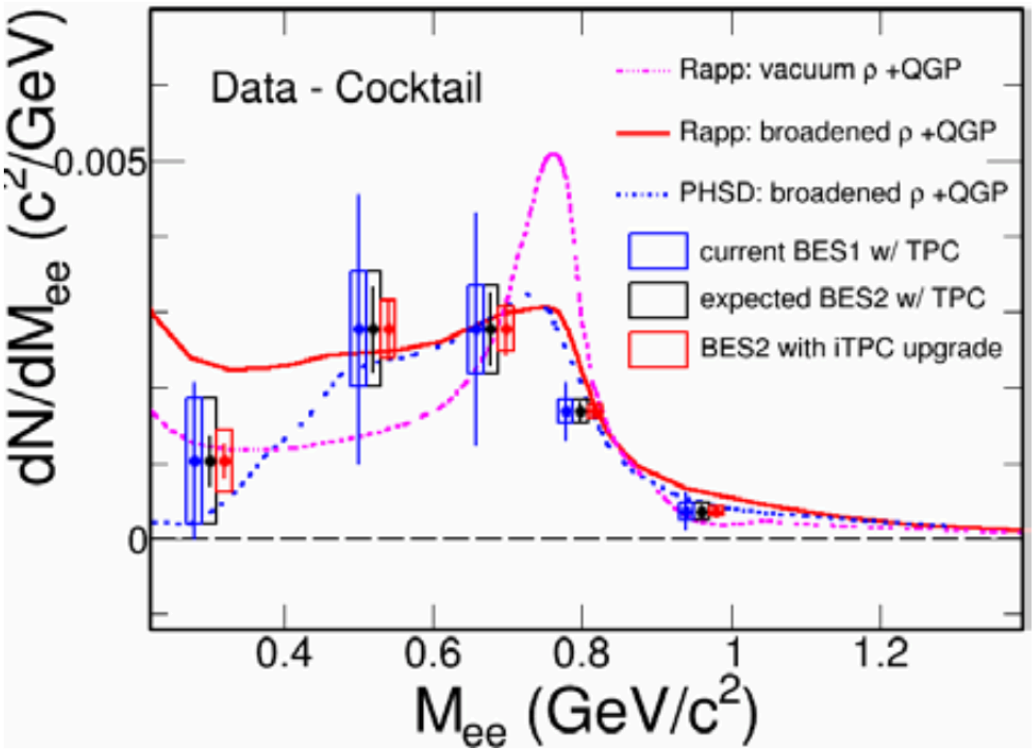
✧ Statistics enriched data for rare probes, especially for dilepton measurements.

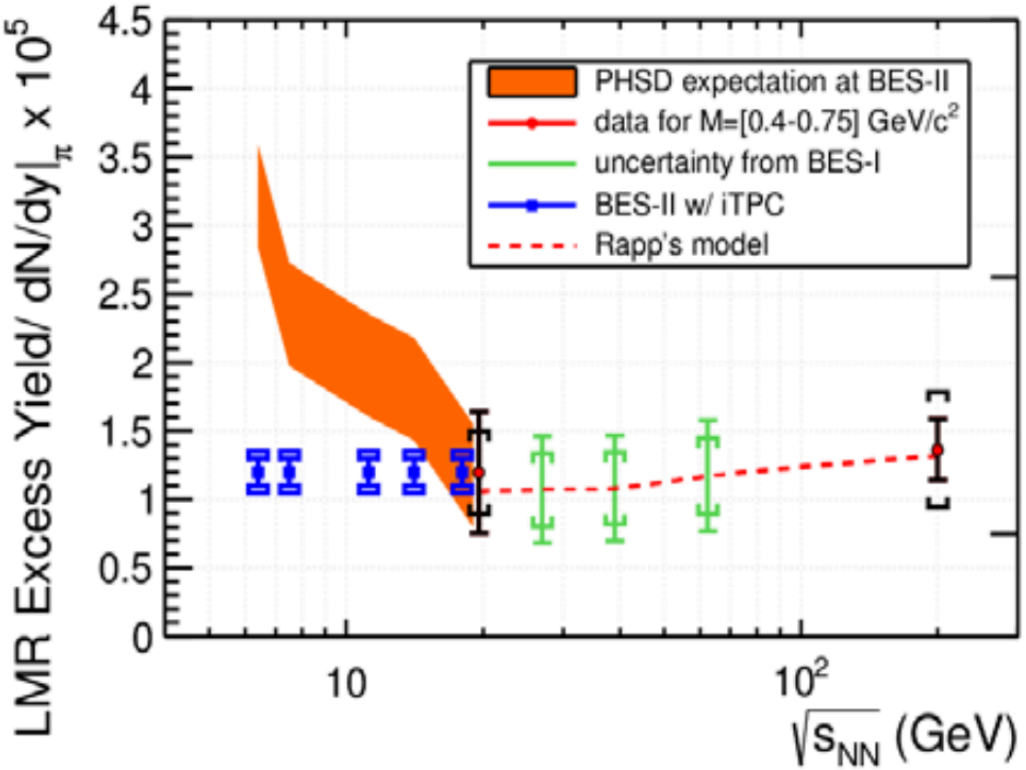


Proposed energies for BES-II (Years 2019-2020):

$\sqrt{S_{NN}}$ (GeV)	7.7	9.1	11.5	14.5	19.6
μ_B (MeV)	420	370	315	250	205
BES II (MEvts)	100	160	230	300	400

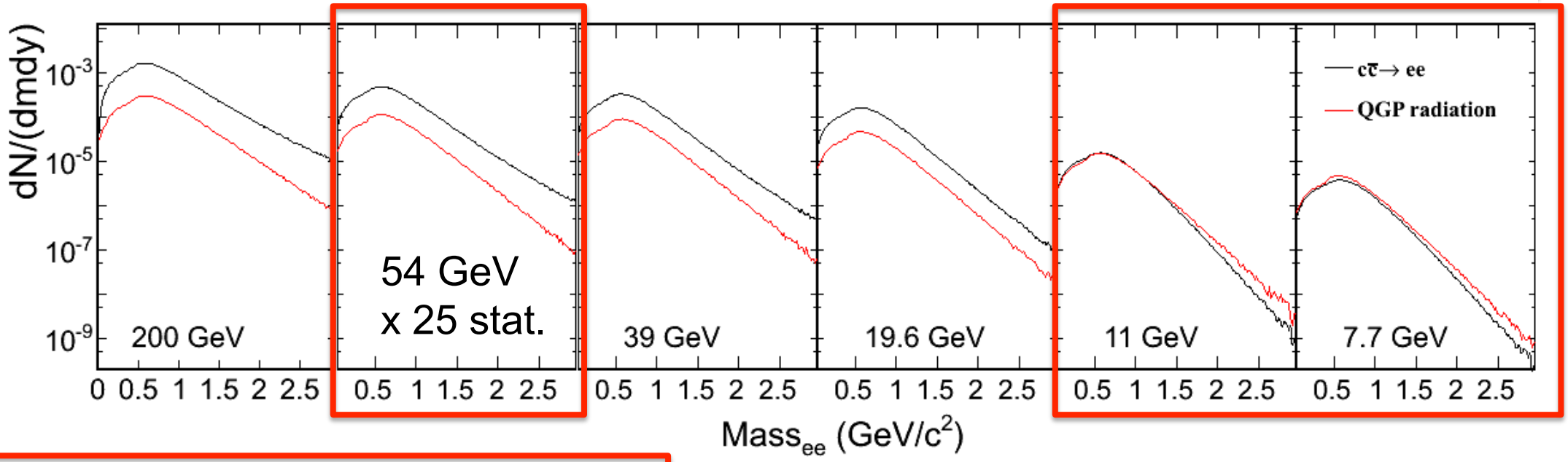
Projection with iTPC for BES-II

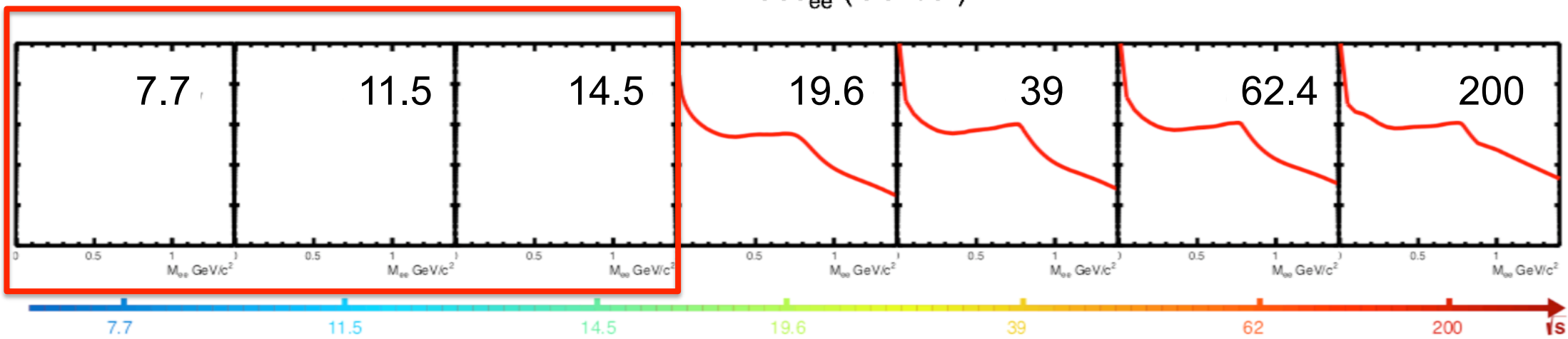




- Systematically study dielectron continuum from 7.7 – 19.6 GeV.
- Inner Time Projection Chamber (iTPC) upgrade: reduce uncertainties.
- Quantify different models.
- Study total baryon density effect at lower energies from BES-II.

Opportunity at BES-II

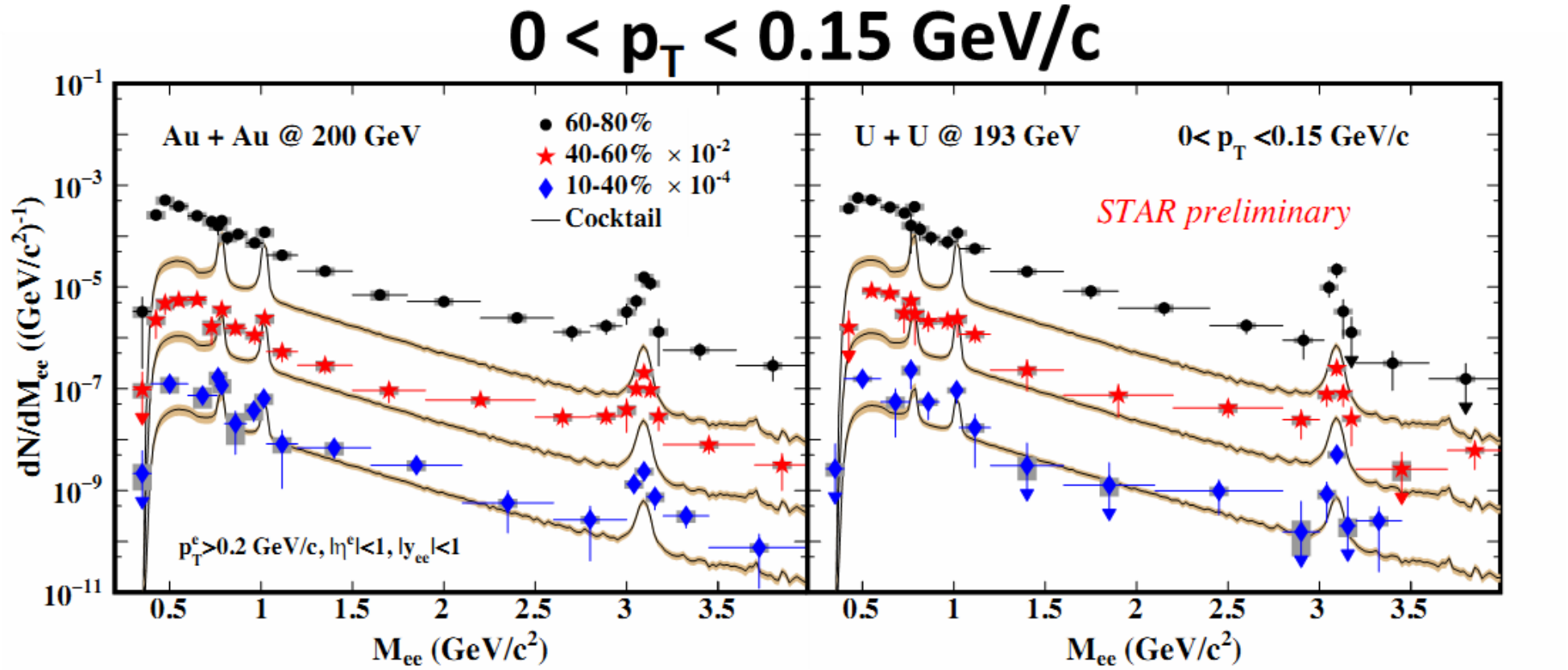




- Possible chance for QGP radiation at IMR.
- Phase transition, QGP turn-off signature, baryon density dependence.

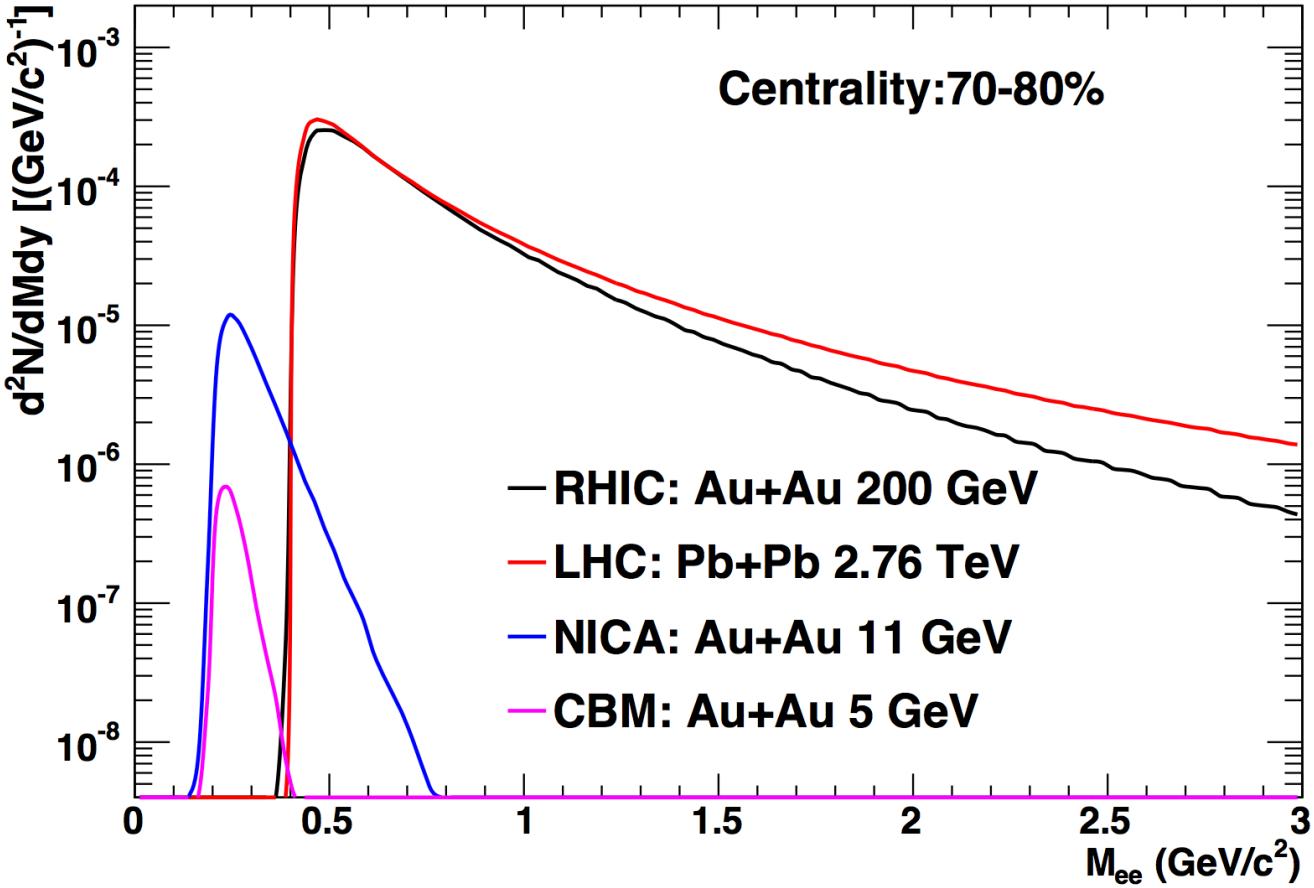
…

Excess of dielectron at very low p_T at RHIC STAR



- Significant excess with respect to hadronic cocktail in peripheral Au + Au and U + U collisions!
- Excess observed over the whole measured mass region!

Excess of dielectron at NICA & CBM



Acceptance:

RHIC: $p_T > 0.2$, $|\eta| < 1$, $|y_{ee}| < 1$

LHC: $p_T > 0.2$, $|\eta| < 0.8$, $|y_{ee}| < 0.8$

NICA: $p_T > 0.1$, $|\eta| < 2$, $|y_{ee}| < 2$

CBM: $p_T > 0.1$, $|\eta| < 1$, $|y_{ee}| < 1$

by Wangmei Zha

- Considerable production rate and softer mass spectrum at NICA & CBM

Summary

✧ Dielectron mass spectra in 19.6 - 200 GeV Au+Au were measured by RHIC-STAR.

✧ Low mass enhancement was observed and can be well described by model calculations with broadening ρ mass spectra function for all collision energies and systems at RHIC and SPS.

✧ The normalized excess yield is proportional to the medium life time from 17.3 to 200 GeV Au+Au collisions and 193 GeV U+U collisions.

✧ STAR future Runs and upgrades enable further exploration of the dilepton continuum.

-- QGP thermal radiation

-- Correlated charm modifications

Thank you!