Beam Energy Dependence of Dielectron Production in Au+Au Collisions from STAR at RHIC

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Deutscher Akademischer Austausch Dienst
German Academic Exchange Service

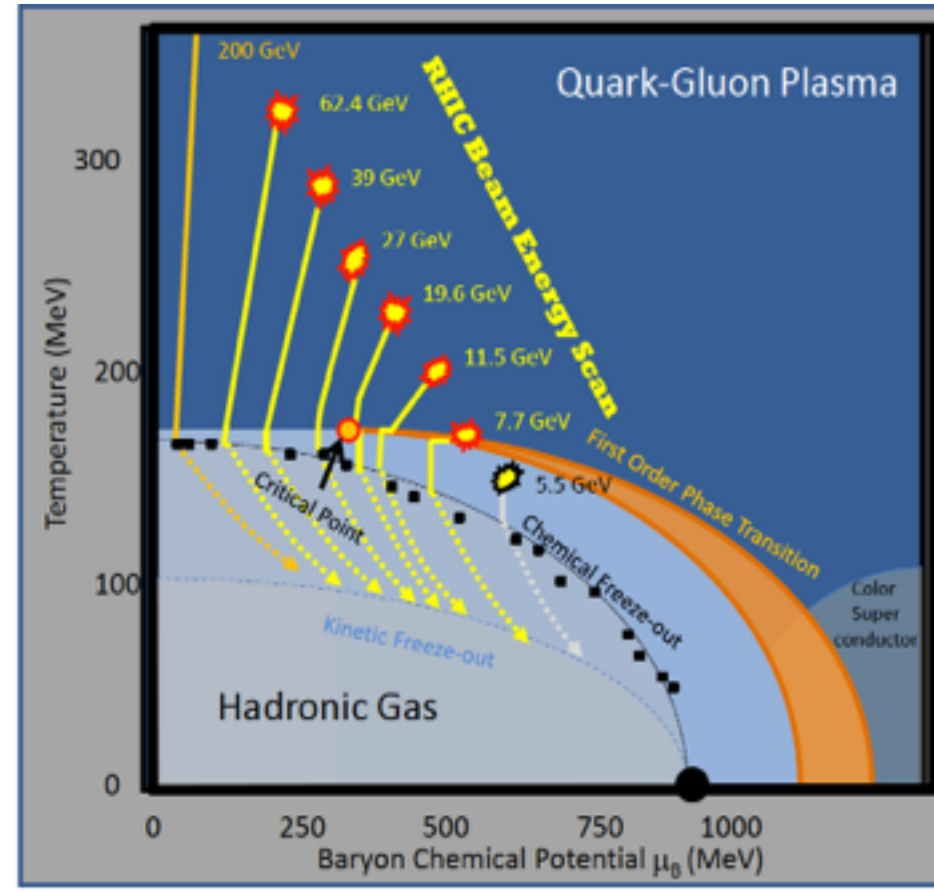
Study the QCD Phase Diagram

Fundamental Questions for HICs

1) thermal equilibrium?
   characterize medium by bulk thermodynamic variables

2) distinctive footprint of partons?
   collectively expanding partonic source (v_2 NCQ scaling)
   QGP radiation (via electromagnetic probes)

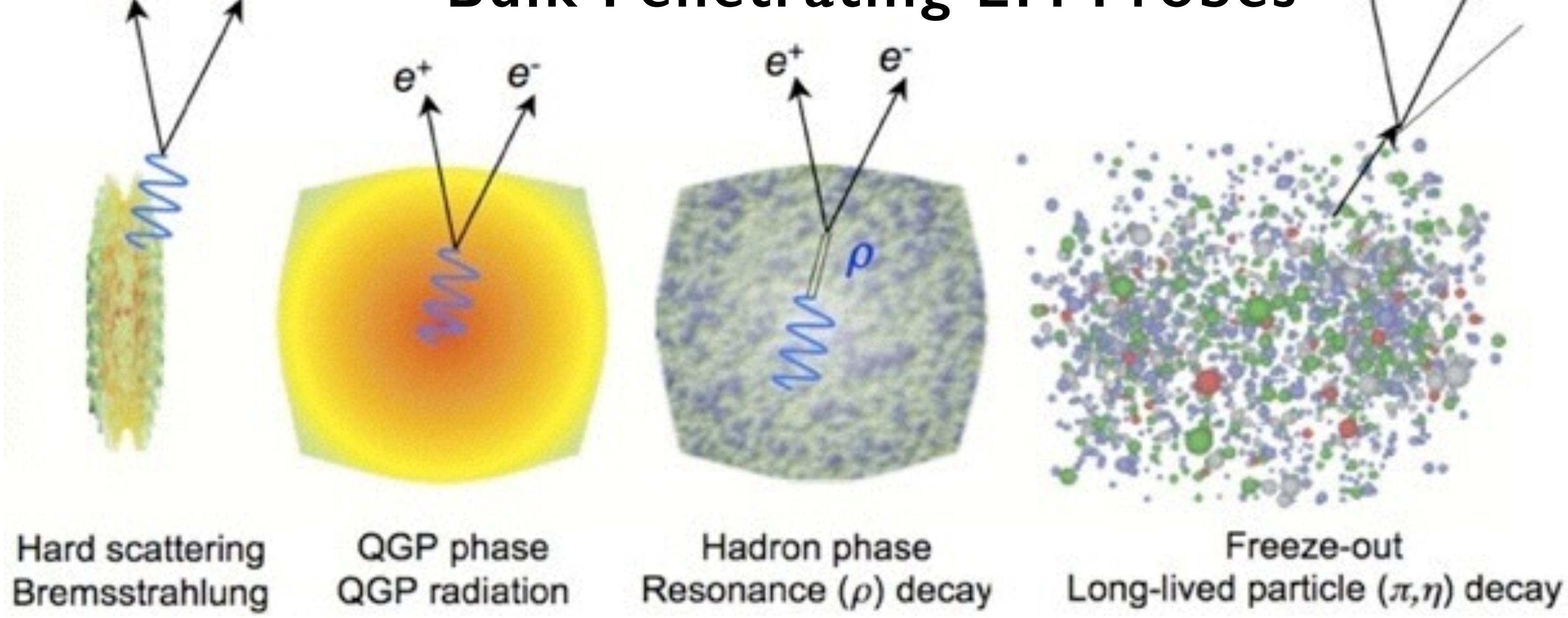
3) deconfinement? chiral symmetry restoration?
   spectroscopy via short-lived resonances
   medium modifications of spectral functions



Beam Energy Scan Program

consistently combine various signatures over a wide range of beam energies
esp. changes in
spectral function modifications & QGP radiation

Bulk Penetrating EM Probes



Spectroscopy:

- access hadronic spectral functions via EM probes w/ negligible FSI
- additional dynamic information about HIC stages encoded in M_{ee} & p_T

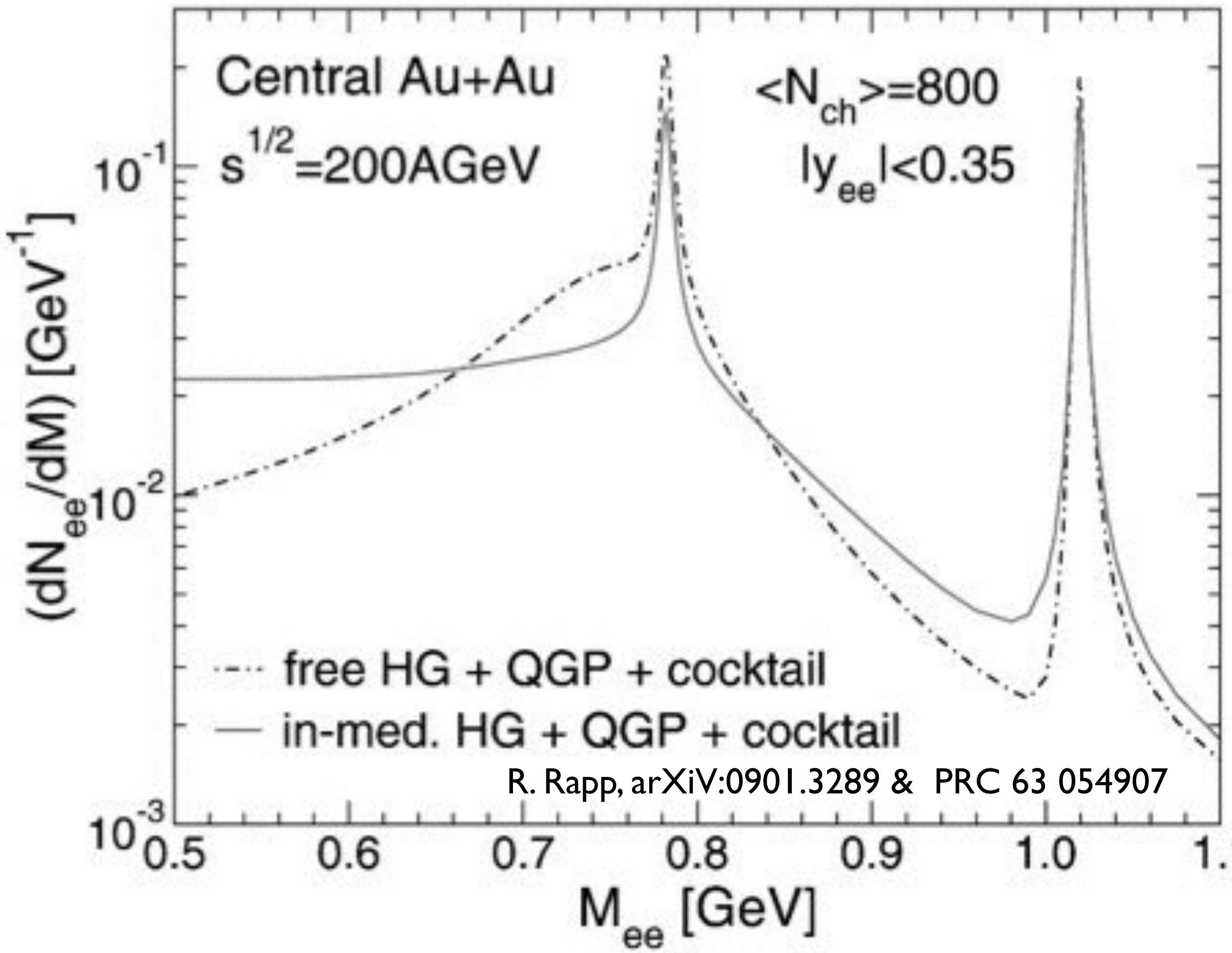
Dielectron Physics @ STAR

Low-Mass Region (LMR, M_{ee} < 1.1 GeV/c²)

- models predict:
  ~2x enhancement at ~0.5 GeV/c²
  ω/ϕ less susceptible
- study modifications to ρ spectral function
  connected to chiral symmetry restoration

Intermediate-Mass Region (IMR, 1.1 < M_{ee} < 3 GeV/c²)

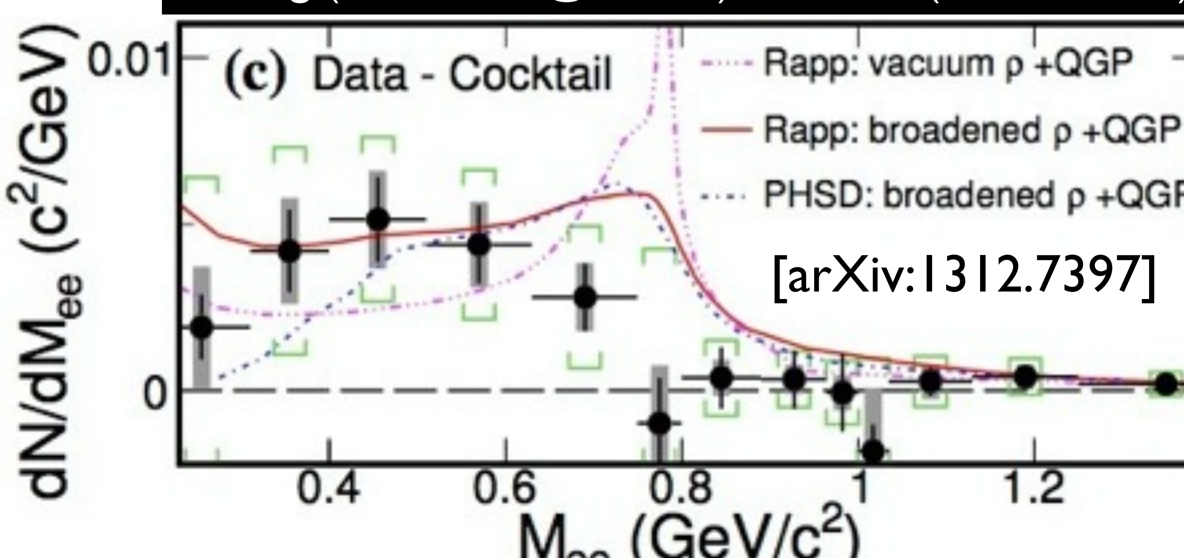
- measure QGP T_{eff}
- compare to yield from correlated charmed decays



R. Rapp, arXiV:0901.3289 & PRC 63 054907

- CERES: discovery of LMR enhancement
  PRL 75 (1995) 1272
- NA60: well established ρ-meson broadening
  EPJ C61 (2009) 711
- STAR @ top RHIC energy:
  consistent w/ in-medium broadened contributions
  spectra & enhancement measured in p T& centrality

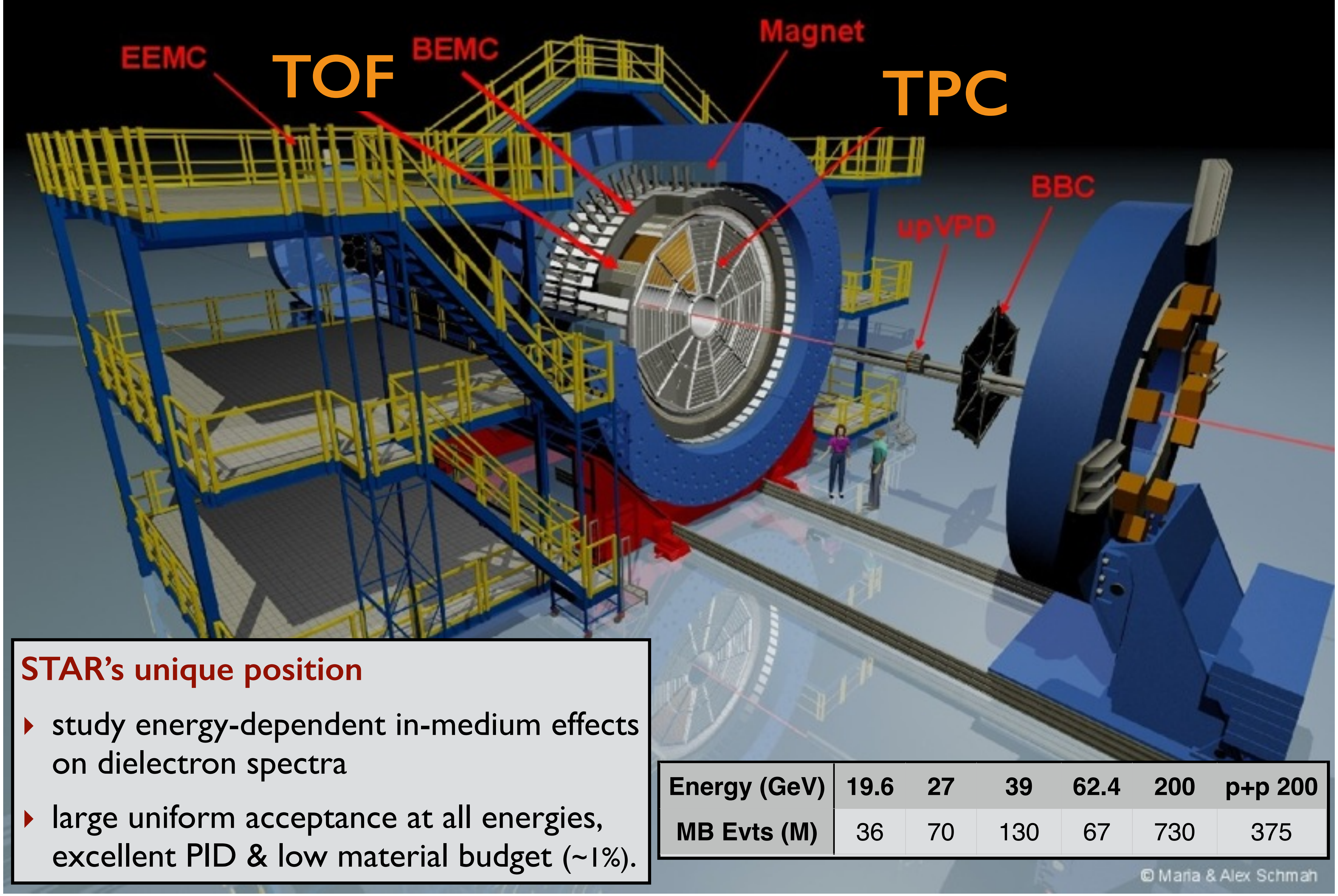
C. Yang (Mo. 14:40 @helium) & Y. Guo (Poster G-13)



[arXiv:1312.7397]

STAR Detector Setup

The Solenoidal Tracker At RHIC



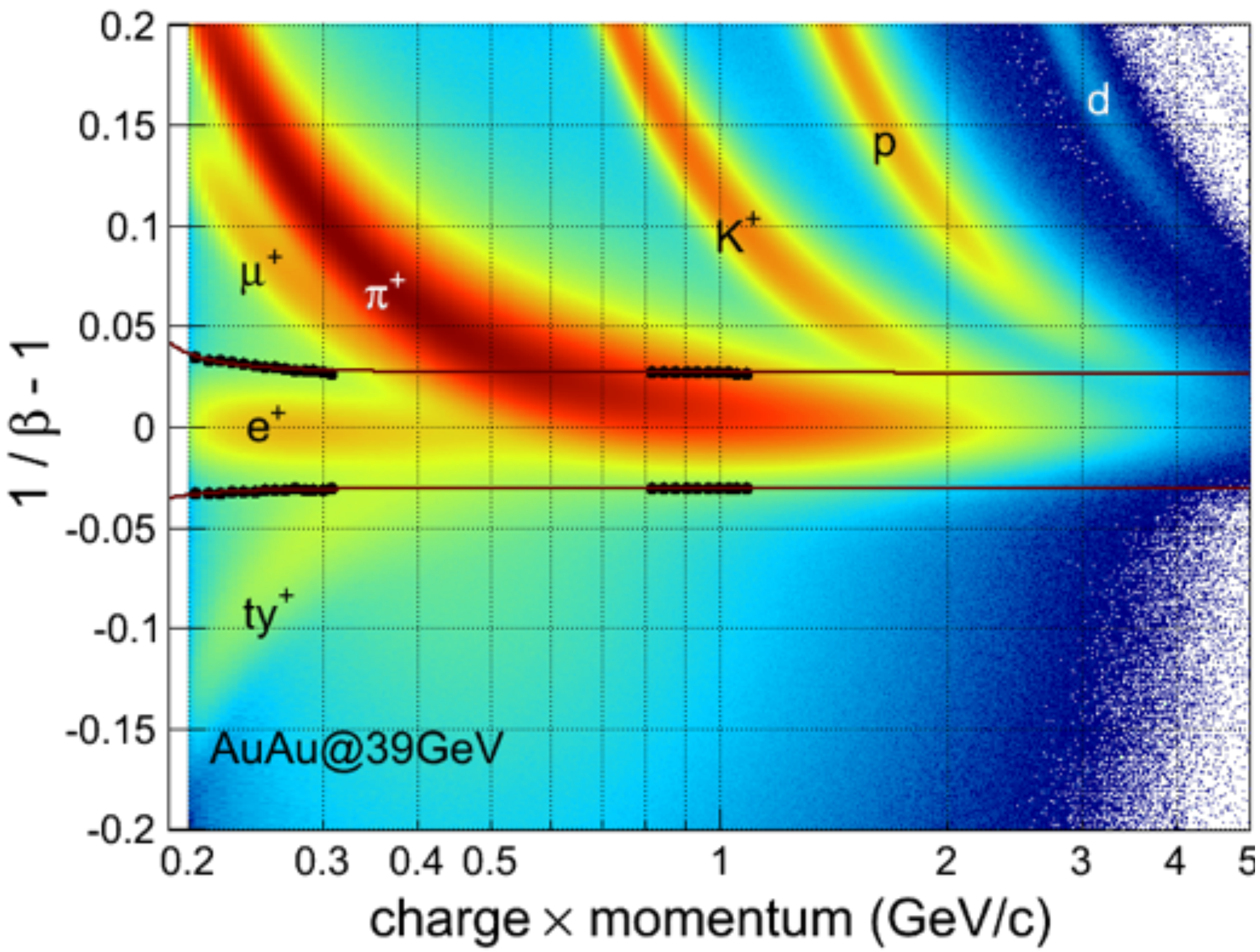
STAR's unique position

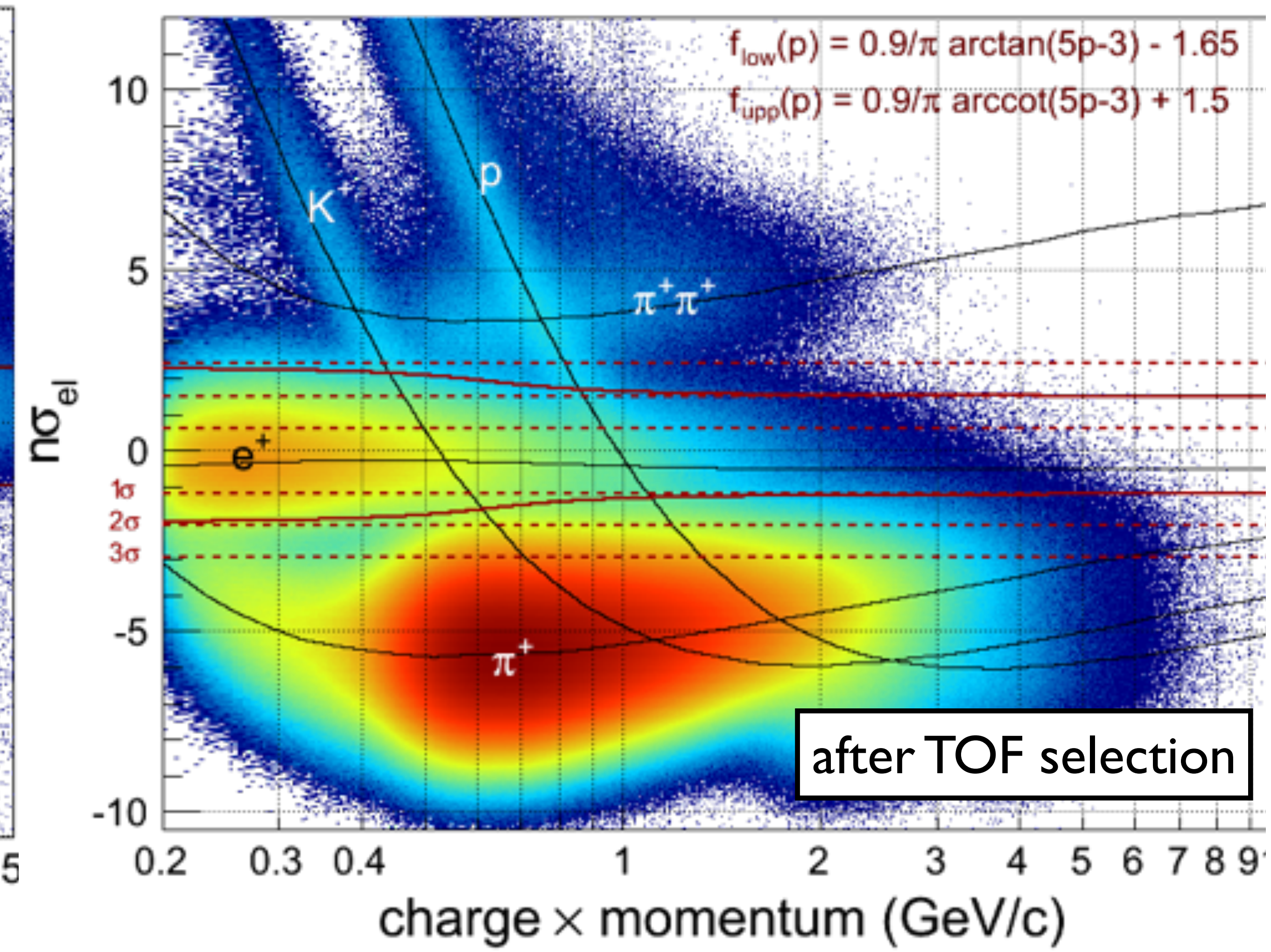
- study energy-dependent in-medium effects on dielectron spectra
- large uniform acceptance at all energies, excellent PID & low material budget (~1%).

Energy (GeV)	19.6	27	39	62.4	200	p+p 200
MB Evts (M)	36	70	130	67	730	375

Particle Identification

- efficient rejection of slow hadrons
- pure eID in combination with TPC dE/dx
- >98% conversion rejection via cut on orientation of dielectron pair w.r.t magnetic field



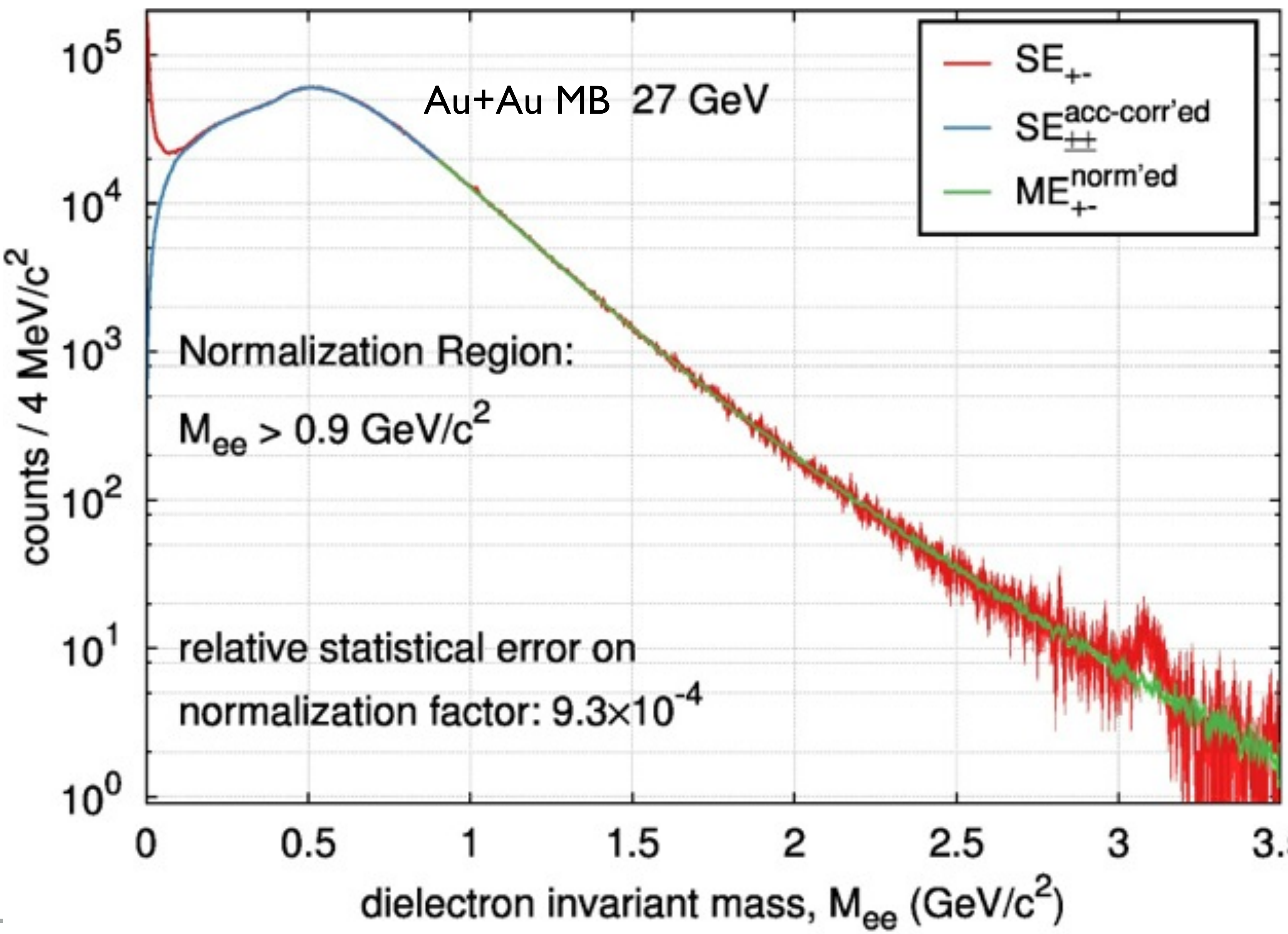


Background Subtraction

e^+/e^- created in pairs ⇒
unlike-sign BG is *geometric mean* of the like-sign BGs independent of primary multiplicity distribution:

$$\langle \mathrm{BG}_{+-}\rangle = 2\sqrt{\langle \mathrm{BG}_{++}\rangle\langle \mathrm{BG}_{--}\rangle}$$

- ρ/ω region S/B ~ 1/100 - 1/250
- background subtraction crucial



Like-Sign Same Event (SE) Method

- combine & average like-sign pairs in an event
- reproduces BG from correlated sources i.e. cross pairs from pion double conversion
- correct acceptance difference of like-sign to unlike-sign pairs using ME technique.

Unlike-Sign Mixed Event (ME) Method

- combine charges from two different events within same event class (V_z / centrality / ψ_2^{EP}).
- describes uncorrelated BG only.

BES Cocktails & Dielectron Spectra

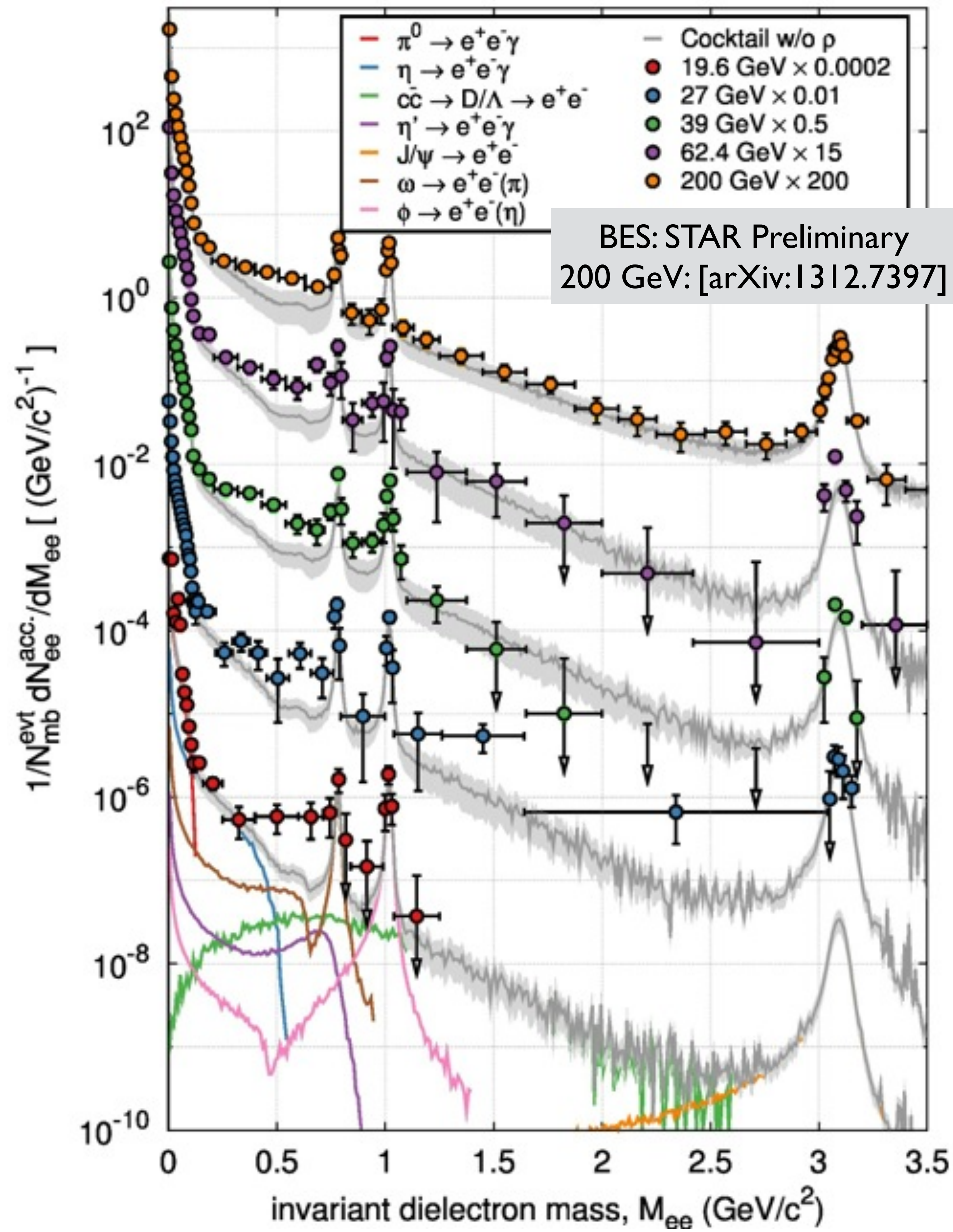
- flat input η [-1,1] & ϕ [0,2π]
  Kroll-Wada for Dalitz w/ PDG form-factors

Hadron Input

- Tsallis-Blast-Wave fits to STAR BES-I data
- meson/π^0 ratio from SPS w/ STAR π^0 yield

Correlated charmed decays

- PYTHIA w/ σ_{NN} + N_{bin} -scaling to Au+Au

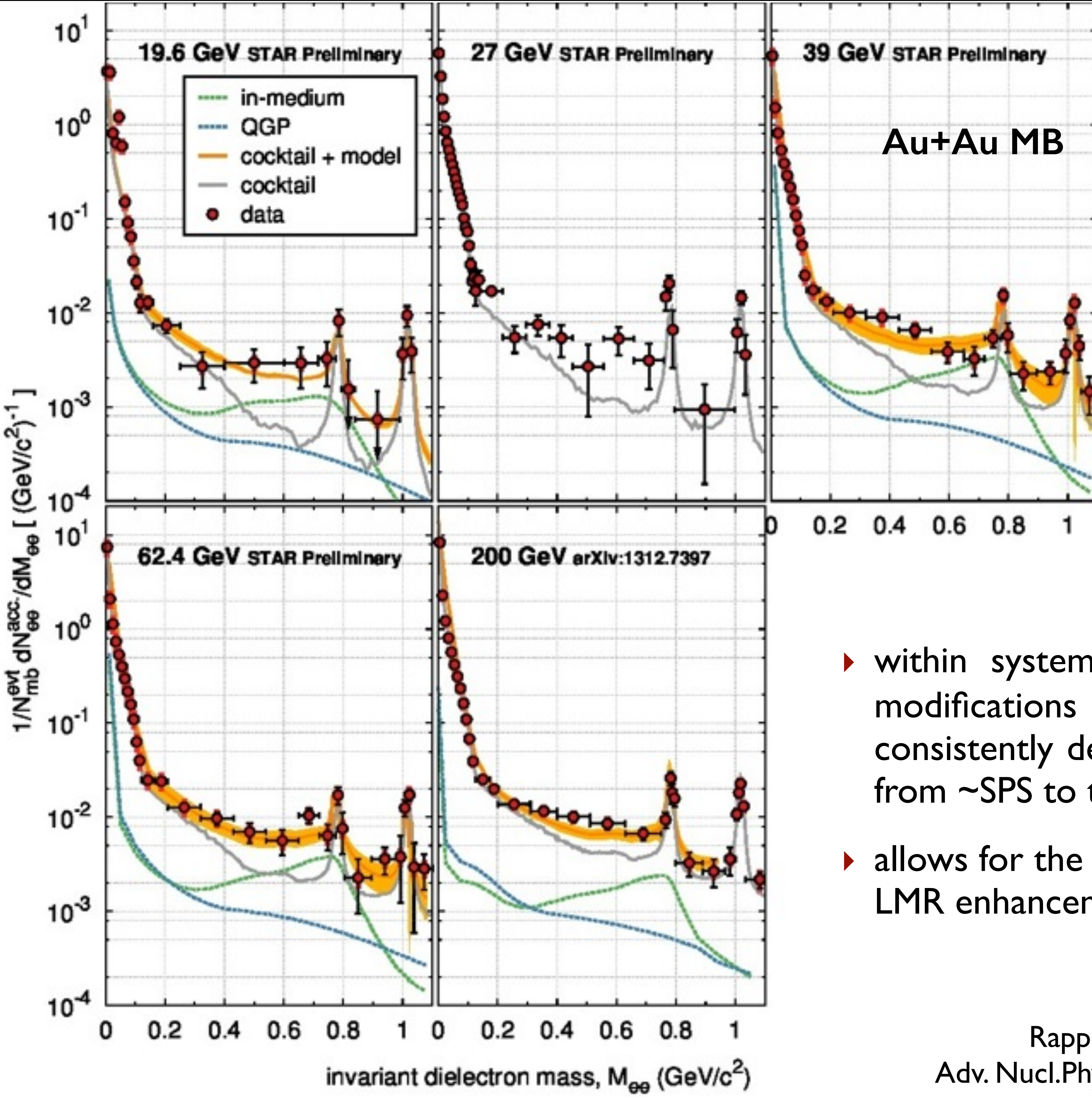


Conclusions BES-I

- systematic study of dielectron production for $\sqrt{s_{NN}}$ = 19.6 - 200 GeV
- LMR excess over cocktail observed at all energies (vacuum-ρ does not account for it)

Poster J. Butterworth G-12

LMR Model Comparison in Invariant Mass

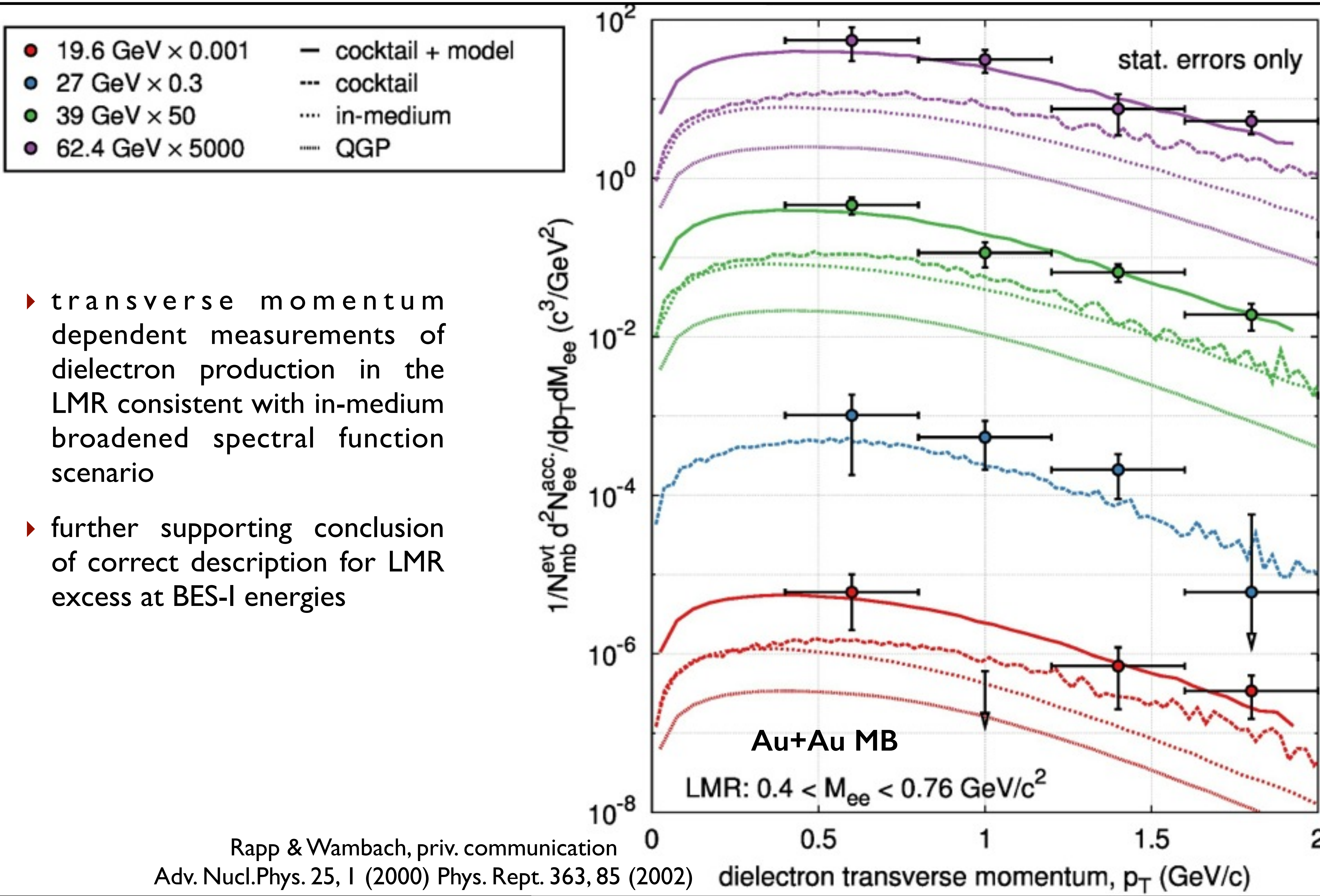


- systematic uncertainties due to cocktail simulation
- model uncertainties not shown

- within systematic uncertainties, in-medium modifications of the ρ spectral function consistently describe the LMR enhancement from ~SPS to top RHIC energies.
- allows for the systematic measurement of LMR enhancement factor and excess yield

Rapp & Wambach, priv. communication
Adv. Nucl.Phys. 25, 1 (2000) Phys. Rept. 363, 85 (2002)

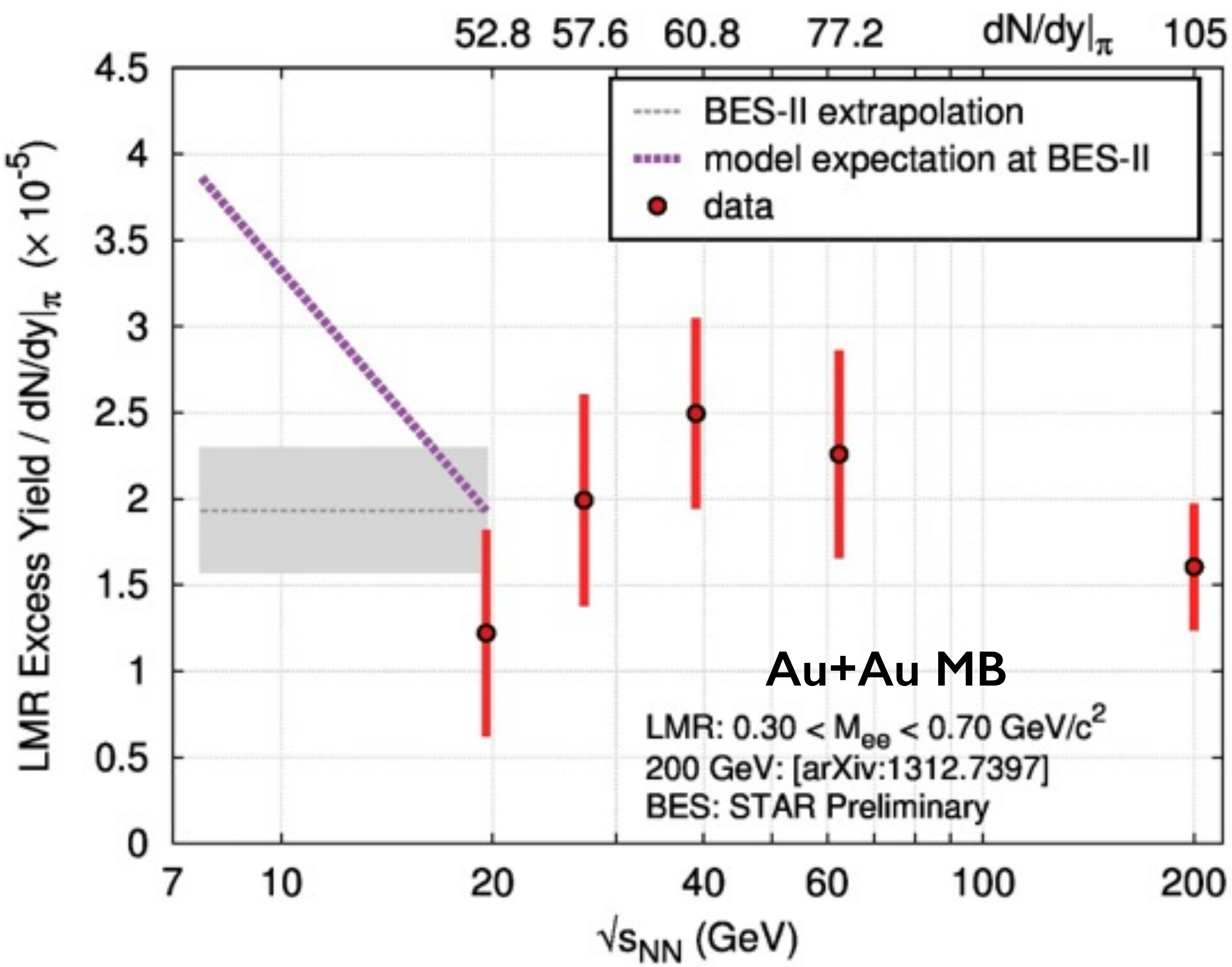
LMR Transverse Momentum Dependence



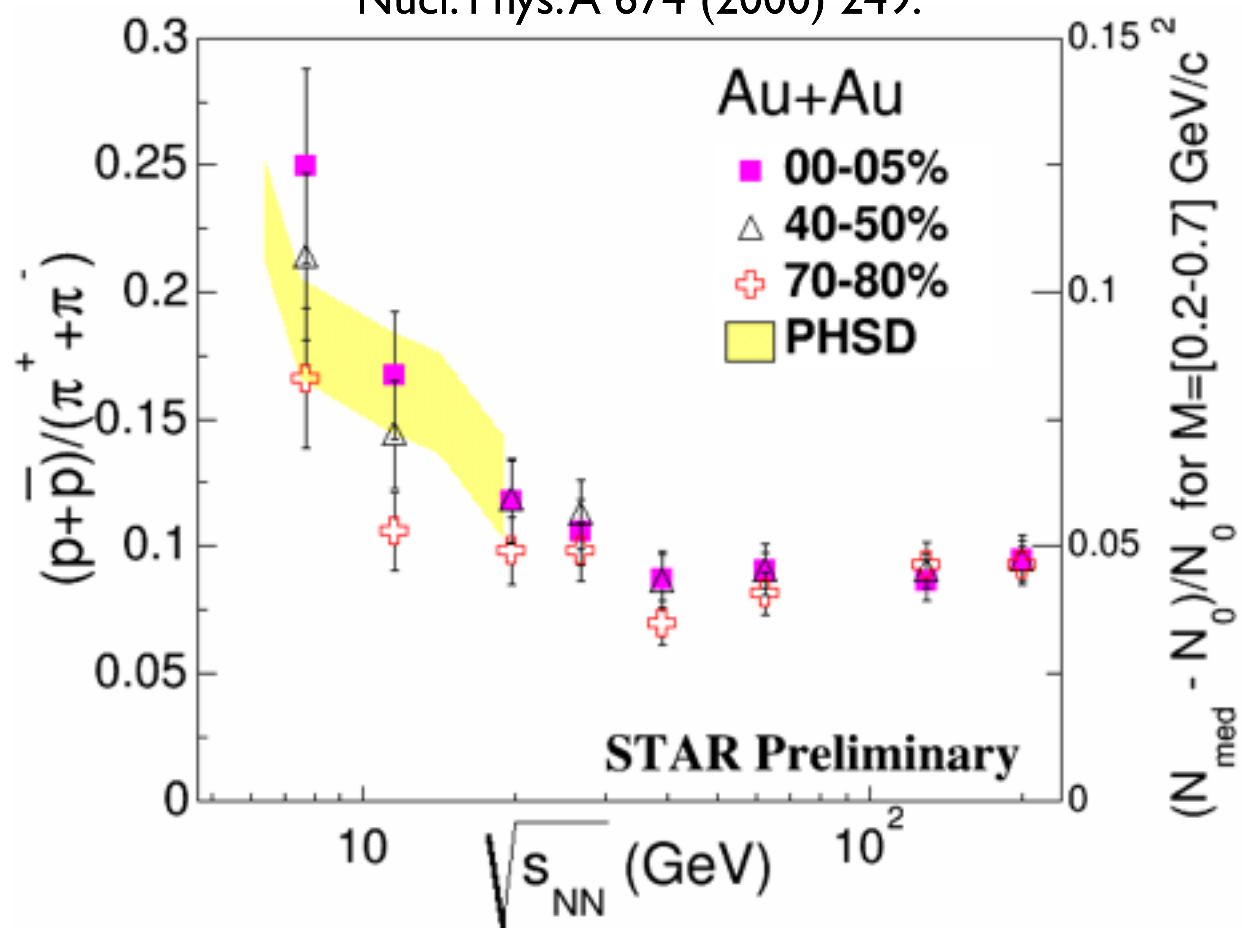
- transverse momentum dependent measurements of dielectron production in the LMR consistent with in-medium broadened spectral function scenario
- further supporting conclusion of correct description for LMR excess at BES-I energies

Rapp & Wambach, priv. communication
Adv. Nucl.Phys. 25, 1 (2000) Phys. Rept. 363, 85 (2002)

Energy Dependence of LMR Excess



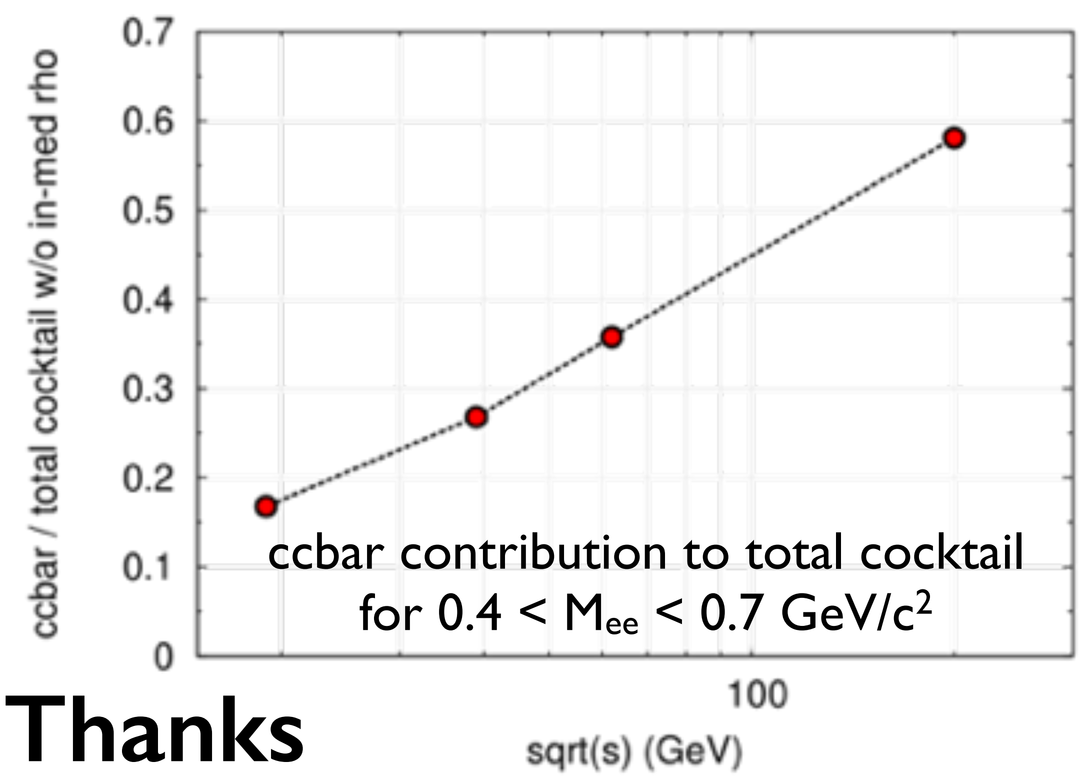
O. Linnyk, private communication;
W. Cassing, E.L. Bratkovskaya, S. Juchem,
Nucl. Phys. A 674 (2000) 249.



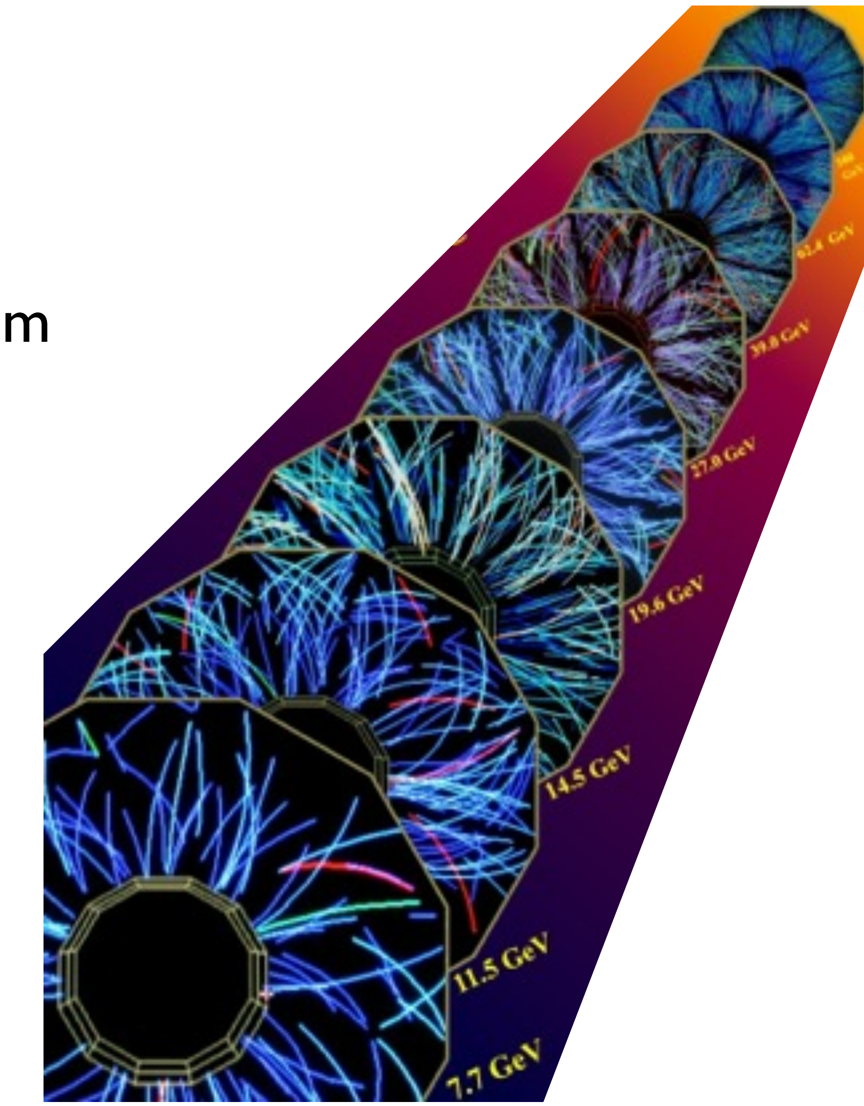
- in-medium modifications to ρ spectral function expected to depend on total baryon density
- energy-dependent enhancement factor might be directly related to dielectrons from earlier creation times due to constant total baryon density
- high-statistics BES-II to check model predictions of x2 gain in excess yield

Summary & Outlook

- STAR BES provides a unique opportunity to address long-standing questions regarding the consequences of in-medium modifications on dielectron spectra
- comprehensive data serves the better understanding of LMR enhancement (p_T & energy dependence)
- LMR excess at all energies consistently in agreement with in-medium modifications to ρ spectral functions in mass and transverse momentum dependence
- no strong energy dependence due to ~const. total baryon density
- high-statistics BES-II below 20 GeV to study trend with total baryon density



STAR Note 0598



Outlook

- BES II [~2018+2019]
  iTPC, Enhanced Statistics, Dimuons
- HFT & MTD upgrades allow for study of
  - possibly medium-modified charm continuum
  - QGP radiation

Thanks