Dielectron Production in Au+Au Collisions at $\sqrt{s_{NN}} = 39$ GeV at STAR

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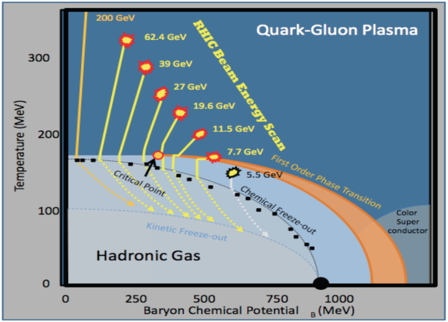
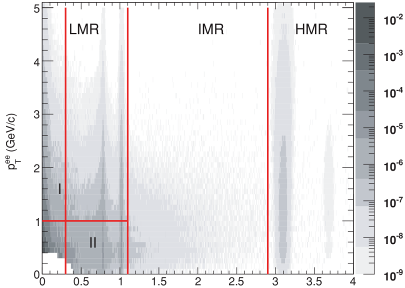
Mapping the Phase Diagram of Nuclear Matter

- **Beam Energy Scan**: Identify QGP properties & explore QCD phases over wide energy range
- usual means are R_{CP} or v_2 of hadrons
- **dielectrons** can serve as an alternate probe
  - → no strong interaction while traveling through matter
  - → probe for the medium created in the early stage of a HI collision



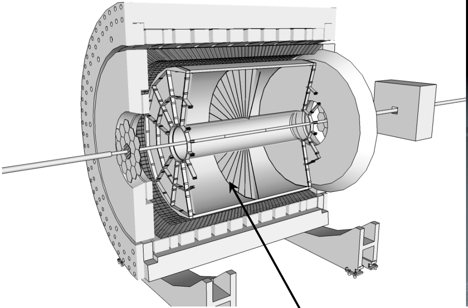
[arXiv:1007.2613]

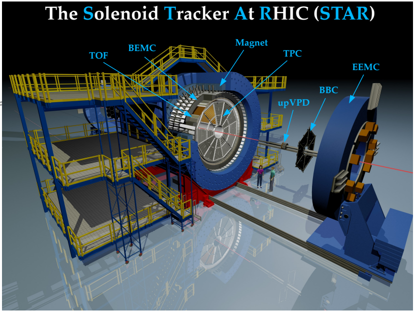


[PRC 81, 034911]

- compare to models by simulation of known dielectron sources (cocktail)
- LMR: vector meson modifications
- IMR: thermal radiation from deconfined phase → initial QGP temperature
- **p_T-dependence of IMR continuum**

STAR Detector





Time-Of-Flight Det.

Large Acceptance

$|\eta| < 0.9 \quad 0 < \phi < 2\pi$

Enables pure electron identification due to effective hadron rejection

$\pi, K : p_T < 1.6\ GeV/c$

$p : p_T < 3.0\ GeV/c$

Time Projection Chamber

Large Acceptance

$|\eta| < 1 \quad 0 < \phi < 2\pi$

Tracking: Momentum & Trajectory

PID: Ionization Energy Loss (dE/dx)

$\pi, K : p_T < 0.7\ GeV/c$

$p : p_T < 1.0\ GeV/c$

Run10 BES Data

- unique capabilities
- low material budget
- high statistics
- favorable for the physics of rare probes

Datasets & Electron Candidates

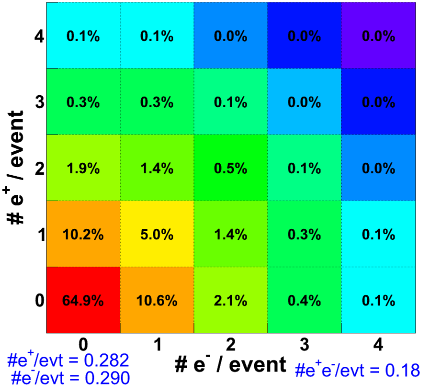
Run10 Dataset for $\sqrt{s_{NN}} = 39\ GeV$ best suitable for the analysis of rare dielectrons

$\sqrt{s}$	usable MB events	Event Selection	analyzed Evts	Nr. of Runs
39 GeV	155.8 M	$\lvert V_z \rvert < 30\ cm$ $V_r < 2\ cm$	115.1 M	560

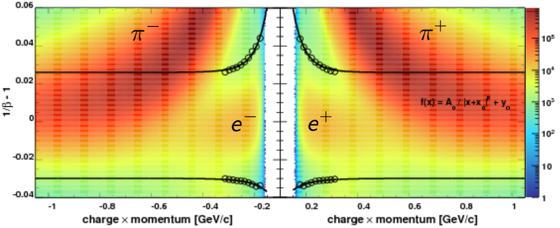
Track Selection

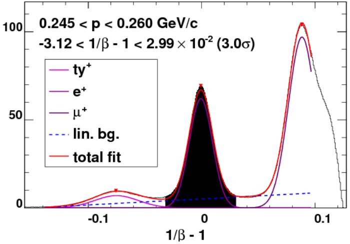
$p_T > 0.2\ GeV/c$	track through TPC
$\beta > 0$	TOF information avail.
$\lvert\eta\rvert < 0.9$	TOF coverage
e^+/e^- dca $< 3\,\mathrm{cm}$	primary tracks
$nHitsdEdx > 14$	TPC dEdx hits used
$nHitsFit > 14$	TPC helix fit points
TPC ratio > 0.52	suppress split tracks

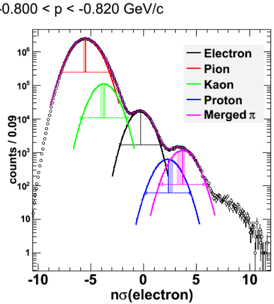
$\Rightarrow$ *only every 5th event has a dielectron pair identified! 50% thereof with only 1 pair!*

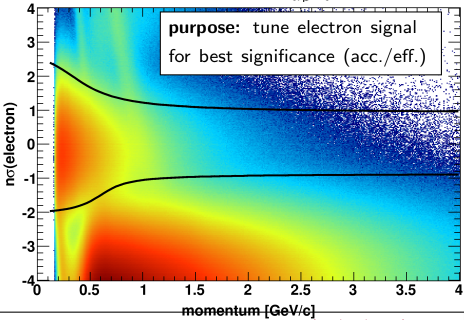


Electron Identification using TOF & TPC









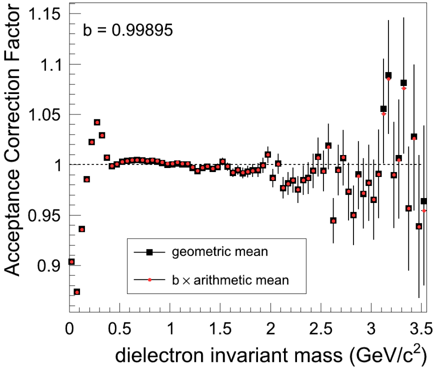
Background Subtraction Methods

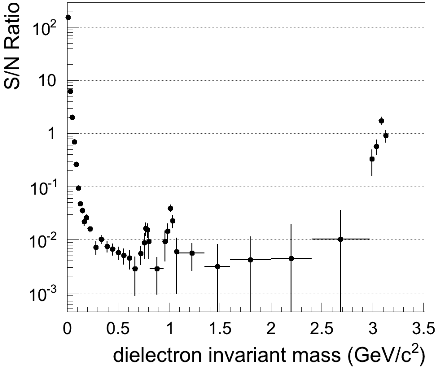
Like Sign Same Event incl. acceptance correction (LS SE)

Geometric Mean	$N_{\pm\pm} = 2\sqrt{N_{++}N_{--}}$	$\cdot ME_{+-} \;/\; 2\sqrt{ME_{++}ME_{--}}$
Arithmetic Mean	$N_{\pm\pm} = a\,(N_{++} + N_{--})$	$\cdot ME_{+-} \;/\; b\,(ME_{++} + ME_{--})$

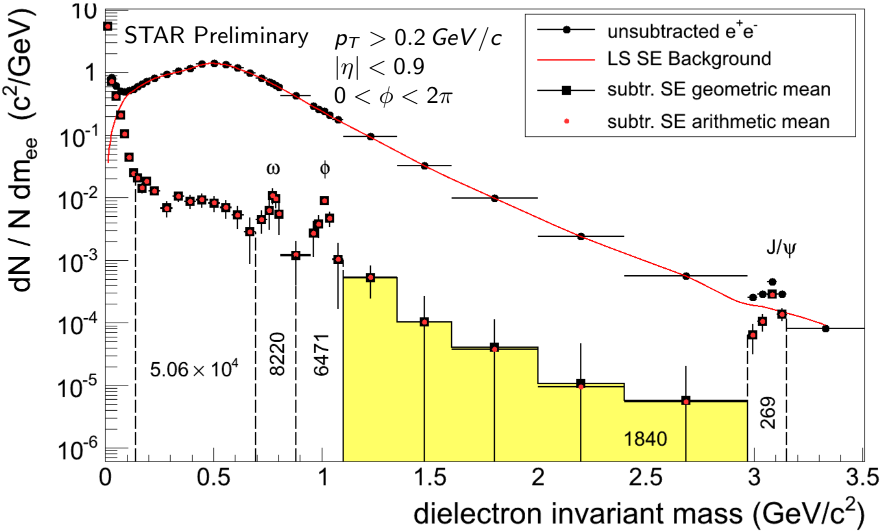
(a,b correct for the respective difference to the geometric mean)

N_i, ME_i = # counts in each bin i (m_{ee}, [p_T]) [PRC 81, 034911]

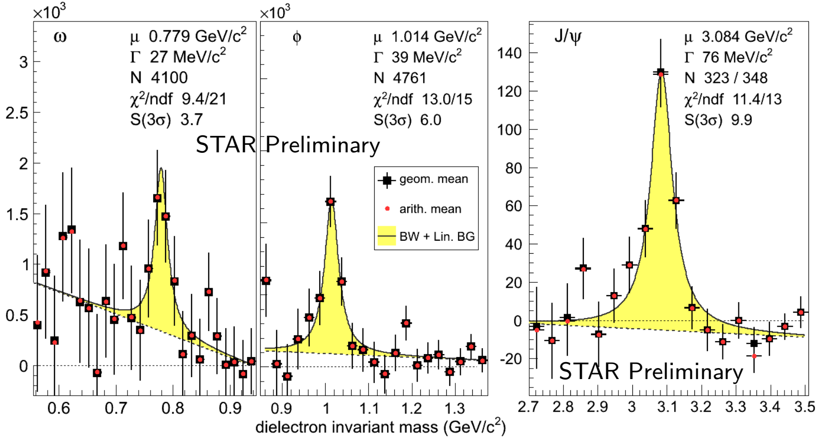




Raw Invariant Mass Spectra

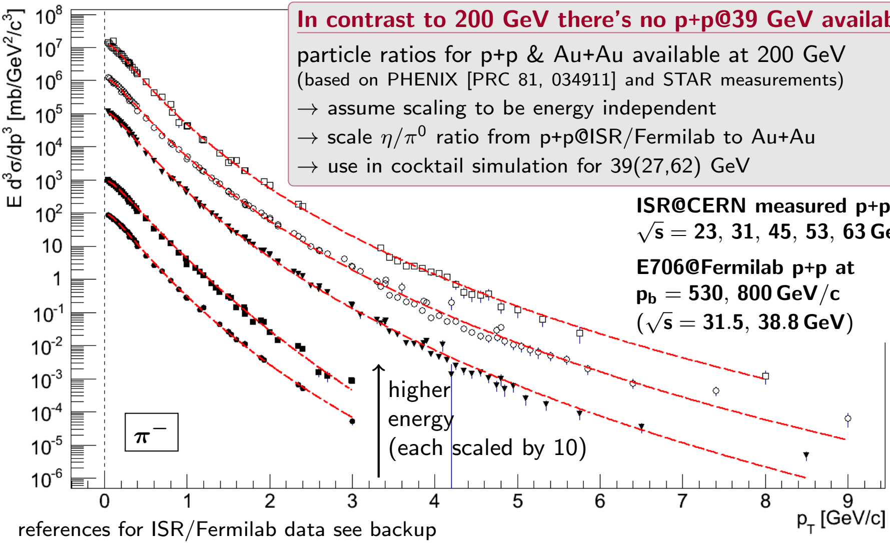


BG Subtraction Comparison on Linear Scale



Vector meson resonances are reconstructed with good or even high significance!

Bypassing the missing p+p Measurement



In contrast to 200 GeV there's no p+p@39 GeV available

particle ratios for p+p & Au+Au available at 200 GeV
(based on PHENIX [PRC 81, 034911] and STAR measurements)

→ assume scaling to be energy independent

→ scale η/π^0 ratio from p+p@ISR/Fermilab to Au+Au

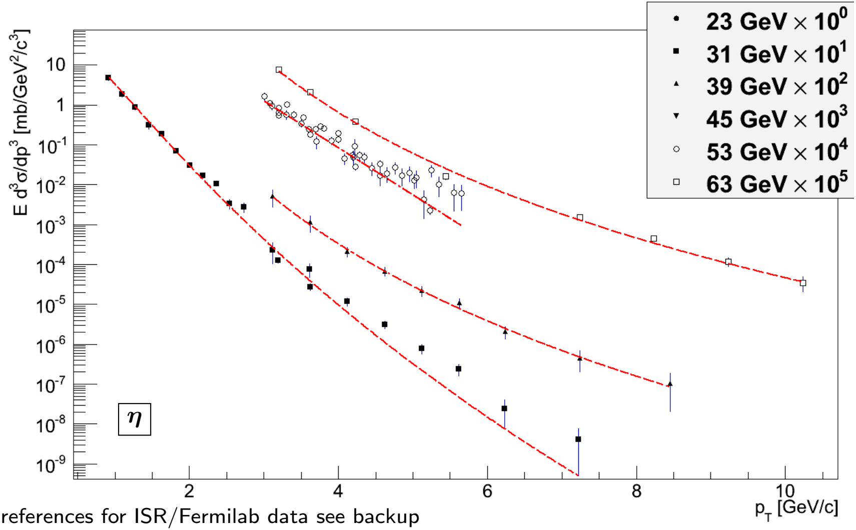
→ use in cocktail simulation for 39(27,62) GeV

ISR@CERN measured p+p at $\sqrt{s} = 23, 31, 45, 53, 63\,\text{GeV}$

E706@Fermilab p+p at $p_b = 530, 800\,\text{GeV}/c$ ($\sqrt{s} = 31.5, 38.8\,\text{GeV}$)

references for ISR/Fermilab data see backup

Bypassing the missing p+p Measurement



references for ISR/Fermilab data see backup

Summary & Outlook

Summary

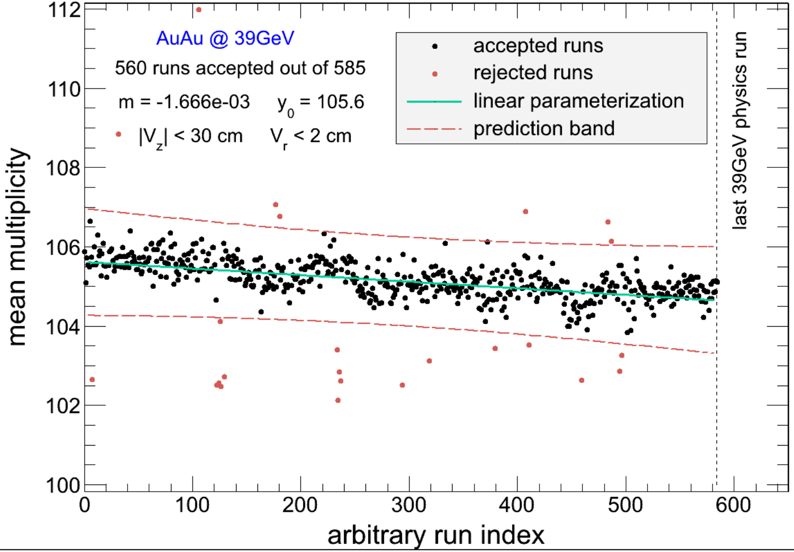
- First study of dielectron production at BES energies in STAR
- Raw invariant mass spectrum presented up to $M_{ee} < 3.5\ GeV/c^2$
- Prominent vector meson signals reconstructed $(\omega, \phi, J/\psi)$
- Data compilation for cocktail simulation at BES energies
- Continuum yield makes study of its p_T-dependence feasible

Outlook

- Equivalent analyses planned for 62 & 27 GeV
- Single electron embedding & efficiency correction ongoing
- Input for simulation & cocktail generation need further investigation
- Finalization of Mixed Event subtraction ongoing

BACKUP

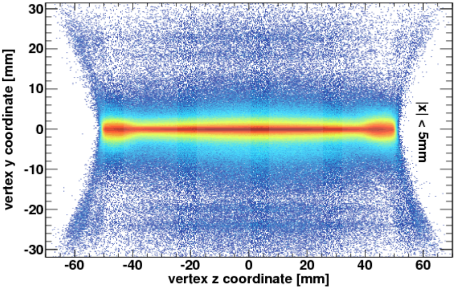
Datasets & Track Selection – Bad Runs



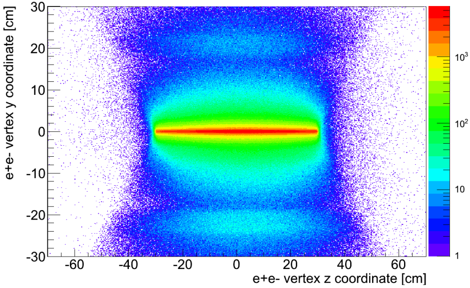
Dielectron Global Vertex & Pair Cuts

Reconstructed e^+e^- vertex using global helices to reduce conversion background and understand material budget.

Quark Matter Analysis
($|Evt - z| < 50\ cm$)

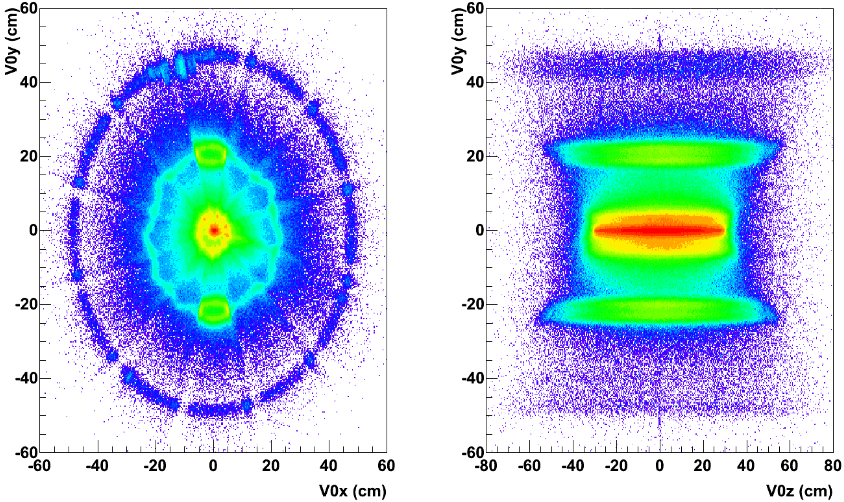


Current Analyses for 39 & 62 GeV
($|Evt - z| < 30\ cm$)



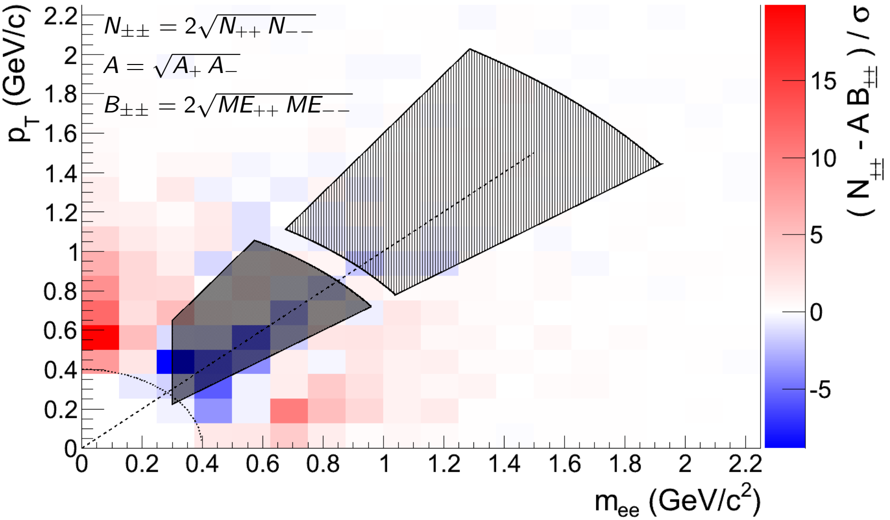
- kept cut on e^+e^- g-vertex: $r < 10\,cm$ $|z| < 38\,cm$
- e^+e^- dca $< 2\,cm$ no $\delta(\phi_V)$ cut for now (less conversion bg-rejection)

Conversion Pair Vertizes for global inv. Mass Cut



structures of inner field cage, SVT support and beam pipe can be identified.

S/N Ratio, ME Normalization Region, 1D Ratio



ISR/Fermilab Data for Particle Ratios in BES

ISR@CERN measured p+p at $\sqrt{s} = 23, 31, 45, 53, 63\,\mathrm{GeV}$

Phys. Lett. B 194 (1987) 4
Nucl. Phys. B 209 (1982) 309-320
Nucl. Phys. B 158 (1979) 1-10
Phys. Lett. B 79 (1978)
Nucl. Phys. B 124 (1977) 1-11
Phys. Lett. B 64 (1976)
Nucl. Phys. B 116 (1976) 77-98
Phys. Rev. Lett 40 (1978) 684
Phys. Rev. Lett. 38 (1977) 112
Nucl. Phys. B 106 (1976) 1-30
Nucl. Phys. B 100 (1975) 237-290
Nucl. Phys. B 98 (1975) 49-72
Phys. Lett. B 55 (1975) 232
Nucl. Phys. B 87 (1975) 19-40
Phys. Lett. B 47 (1973) 75
Phys. Lett. B 47 (1973) 275
Phys. Lett. B 46 (1973) 471
Phys. Rev. Lett. 31 (1973) 413
Phys. Lett. 44B (1973) 521

E706@Fermilab p+p at $E_{\mathrm{kin}} = 530, 800\,\mathrm{GeV}/c$.
Corresponds to $\sqrt{s} = \mathbf{31.5, 38.8\,GeV}$!

Phys. Rev. D 68 (2003) 052001

$\Rightarrow$ ca. 90 datasets for π, K, η with $|\eta| < 1$
(mostly small windows around midrapidity)

Levy Fit Function [PRC 71, 064902]
best description over entire p_T range

$$\frac{1}{2\pi p_T}\frac{d^2N}{dy\,dp_T} = \frac{dN}{dy}\frac{(n-1)(n-2)}{2\pi nT(nT+m_0(n-2))}\left(1+\frac{\sqrt{p_T^2+m_0^2}-m_0}{nT}\right)^{-n}$$

all rapidities plotted independently
$\rightarrow$ average each energy over rapidity range!