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Direct virtual photon production in Au+Au collision at $\sqrt{s_{\mathrm{NN}}}$ = 27 and 54.4 GeV

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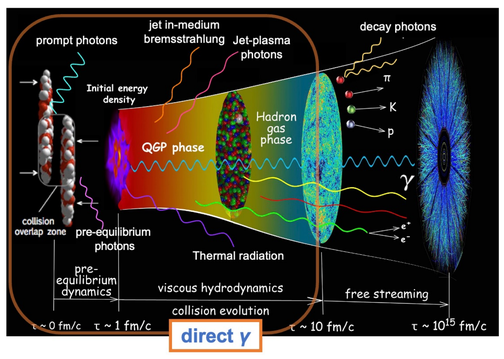
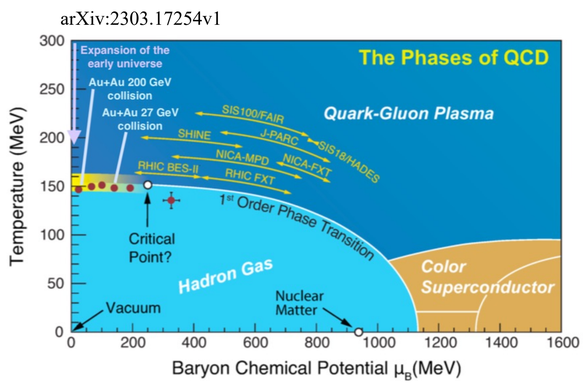
Abstract

As electromagnetic probes, photons have the advantage of escaping from their emission source and do not interact strongly with the QCD medium. Consequently, photons can carry valuable information about the properties and dynamics of the hot QCD medium created in heavy-ion collisions. This poster shows the first measurement of direct virtual photons in Au+Au collisions at $\sqrt{s_{\mathrm{NN}}}$ = 27 and 54.4 GeV. The p_T spectrum and yields of direct virtual photons offer new insights into the understanding of the quark-gluon plasma (QGP)

Motivation



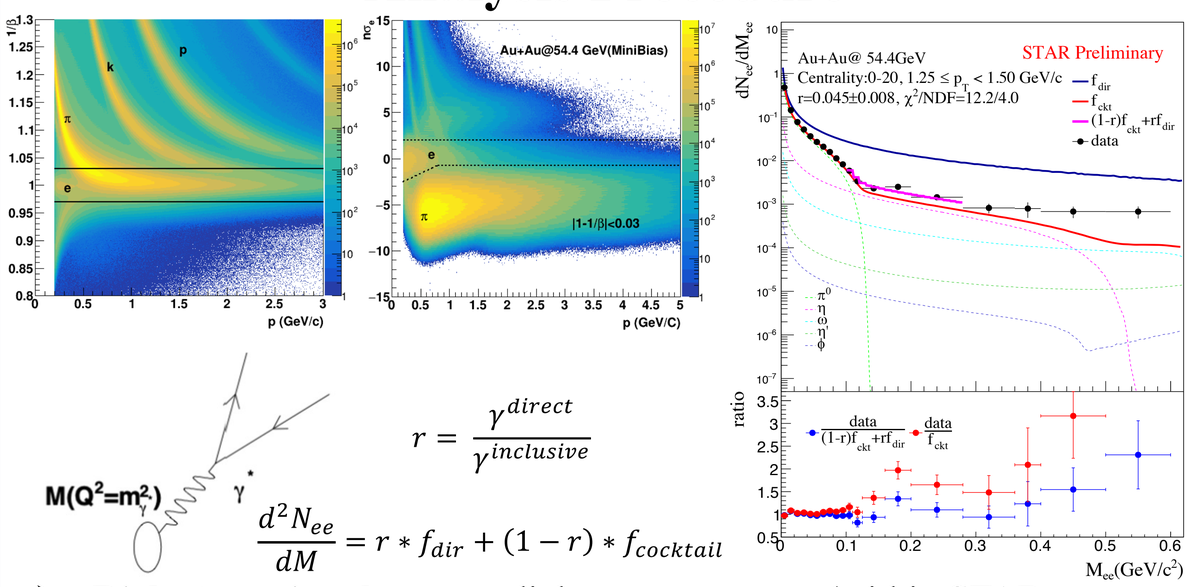


- Measuring direct virtual photons can provide effective temperature of all stages of the collision, including QGP and hadronic phases[1]
  - Do not participate in strong interaction
  - Carry information of QGP (energy density, temperature, and collective motion)
- Direct photon yield is influenced by evolution time, system size, baryon chemical potential and temperature[2]
  - p_T integrated yield→ evolution time
  - $dN_{ch}/d\eta$ → system size
  - Collision energy → μ_B, T

Dataset

- Au+Au collision at $\sqrt{s_{\mathrm{NN}}}$ = 27 and 54.4 GeV (run18 + run17)
- Used events:
  - 27 GeV: ~250M minimum bias events
  - 54.4 GeV: ~430M minimum bias events

Analysis Procedure

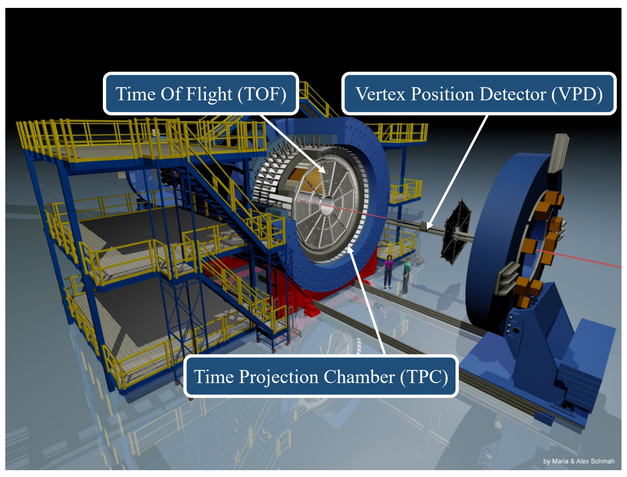


$$r = \frac{\gamma^{direct}}{\gamma^{inclusive}}$$

$$\frac{d^2N_{ee}}{dM} = r * f_{dir} + (1-r) * f_{cocktail}$$

- **Dielectron signal**: extract dielectron spectrum (within STAR acceptance) in different p_T bins and apply efficiency correction
- **Cocktail simulation**: using Monte Carlo simulation to model background (within STAR acceptance)
  - η/π^0 are parametrized using Tsallis blast-wave function, and η/π^0 (p_T = 5 GeV/c) is fixed to 0.470±0.017 obtained from global data[3]
- **Two-component fit**[4]: extract direct virtual photon weight r by fitting cocktail and direct photon templates to the data in M_{ee} range [0.10,0.28]

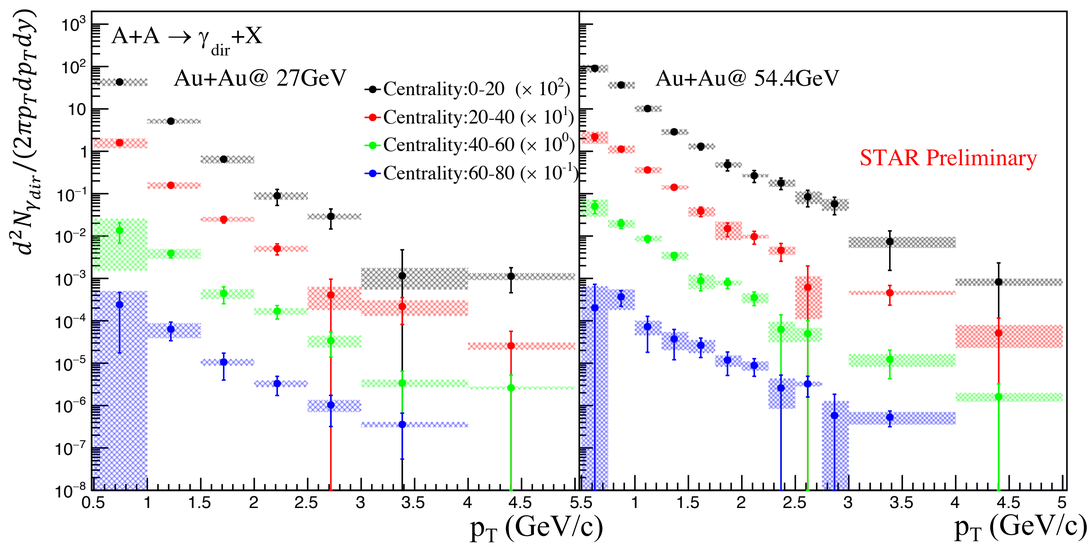
STAR Experiment

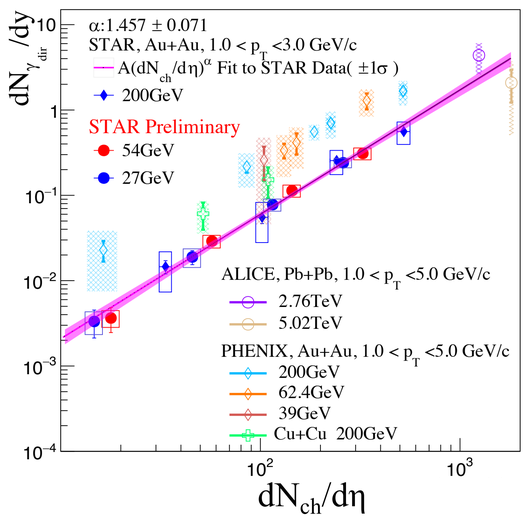


- Large acceptance: $p_T^e > 0.2$ GeV/c, $|\eta| < 1$, $-\pi < \phi < \pi$
- TPC:
  - Momentum
  - Energy loss
- TOF+VPD:
  - Velocity

Results

First measurement of direct virtual photons in Au+Au collisions at $\sqrt{s_{\mathrm{NN}}}$ = 27 and 54.4 GeV in different centrality regions





- Strong $dN_{ch}/d\eta$ dependence
- The yields at $\sqrt{s_{\mathrm{NN}}}$ = 27, 54.4 and 200 GeV measured by STAR follow a common scaling, with $\alpha = 1.457 \pm 0.071$
- The scaling trend is consistent with ALICE measurements[5,6]

Reference

[1]D. Blau, D. Peresunkko, *Particles* 6 (2023) 1, 173-187
[2]PHENIX Collaboration, *Phys.Rev.C* 81 (2010) 034911
[3]Y.J. Ren, *Phys.Rev.C* 104 (2021) 5, 054902
[4]V. Doomra, *Springer Proc.Phys. 304 (2024) 158-161*
[5]ALICE Collaboration, *arXiv: 2308.16704*
[6]ALICE Collaboration, *Phys.Lett.B 754 (2016) 235-248*

Outlook

- Extend the study to the interesting energy region near possible CEP
- Measure direct virtual photons at lower energies ($\sqrt{s_{\mathrm{NN}}}$ = 11.5, 14.6, 19.6 GeV)

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