Direct Photons

Calculations with microscopic+macroscopic hybrid model

Bjørn Bäuchle[1,2] and Marcus Bleicher[1,2]

FIAS Frankfurt Institute for Advanced Studies

Direct Photons

- Small production cross-section: Not many photons produced
- Small rescattering cross-section: Photons, once created, reach detector

⇒ Give insight to all stages of a heavy-ion collision

- Most photons come from hadronic decays, e.g. $\pi^0 \to \gamma\gamma$
- Direct photons are emitted from fireball
- Measurements available from WA 98 and PHENIX

Photons from the model

- Photon emission is calculated perturbatively
- UrQMD: calculate distribution of photons created in each collision
- Hydro: calculate distribution in each fluid cell for every timestep
- Different channels implemented in both models:

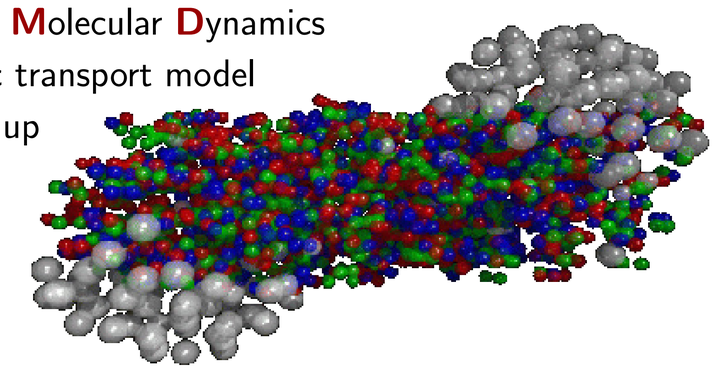
  Common channels: $\pi\pi \to \gamma\rho, \quad \pi\rho \to \gamma\pi$

  Only in UrQMD [5]: $\pi\eta \to \gamma\pi, \quad \pi\pi \to \gamma\eta, \quad \pi\pi \to \gamma\gamma$

  Only in Hydro [4]: $\pi K^* \to \gamma K, \quad \pi K \to \gamma K^*, \quad \rho K \to \gamma K, \quad K K^* \to \gamma\pi$

UrQMD

- **U**ltra-**R**elativistic **Q**uantum **M**olecular **D**ynamics
- Purely hadronic microscopic transport model
- All hadrons and resonances up to $m = 2.2$ GeV included
- No in-medium effects
- Full collision and hadron history known



Hybrid model

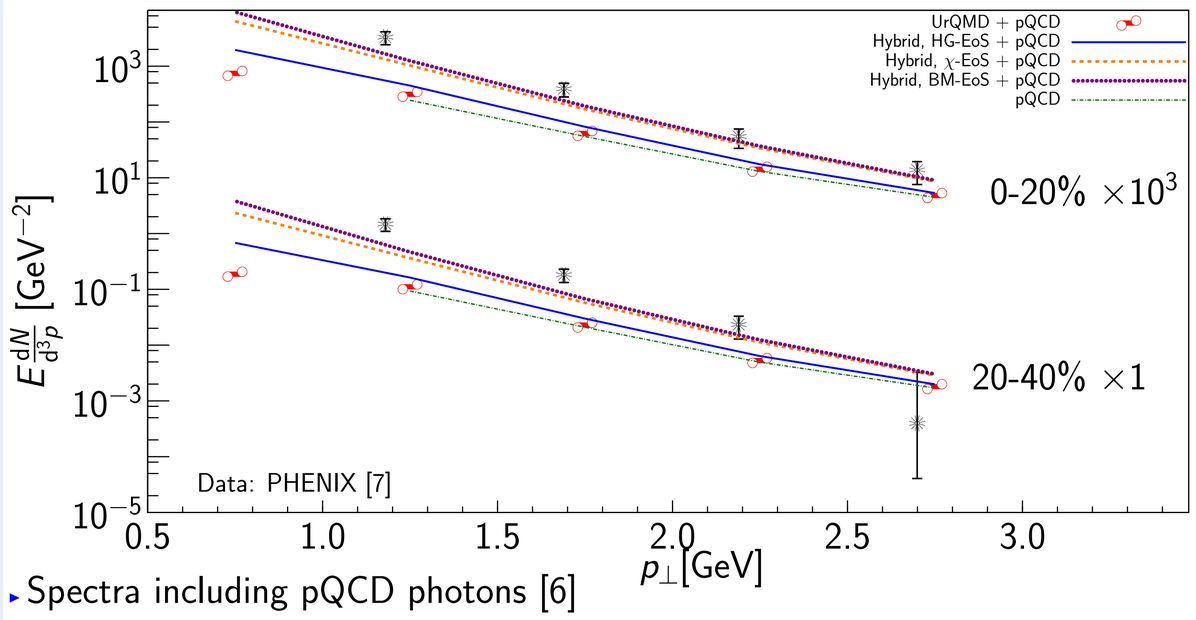
- Transport coupled to hydrodynamics
  - UrQMD until nuclei overlap
  - Hydro for the high-density part
  - UrQMD for low-density rescatterings
- Compare Hadronic EoS to pure UrQMD, compare partonic (Bag Model and χ EoS) & hadronic scenarios.

Bag Model: 1st order phase transition, large latent heat

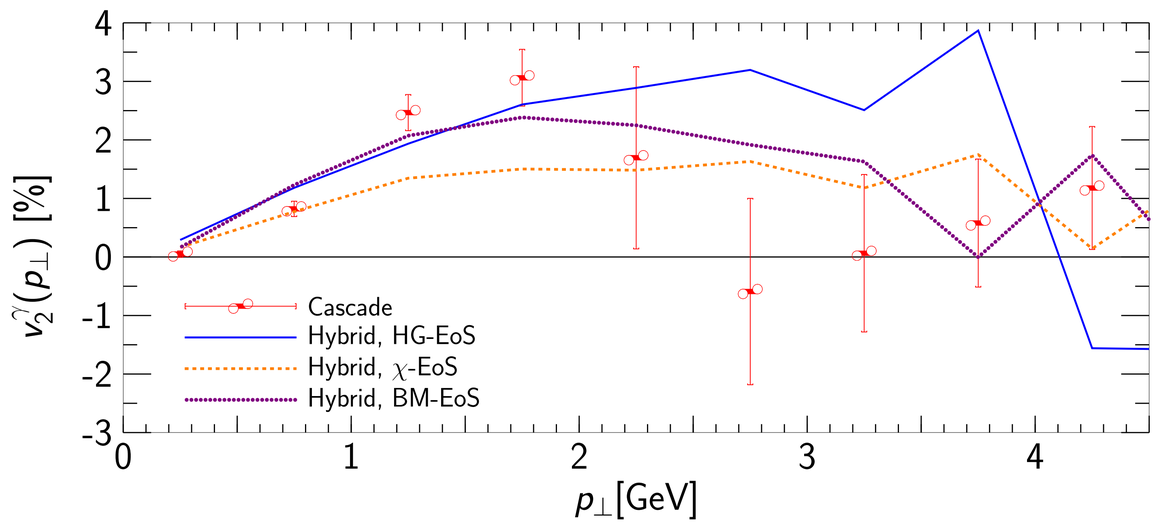
χ EoS: Cross-over phase transition to chirally restored phase

Results

RHIC: Au+Au @ $\sqrt{s_{NN}} = 200$ GeV

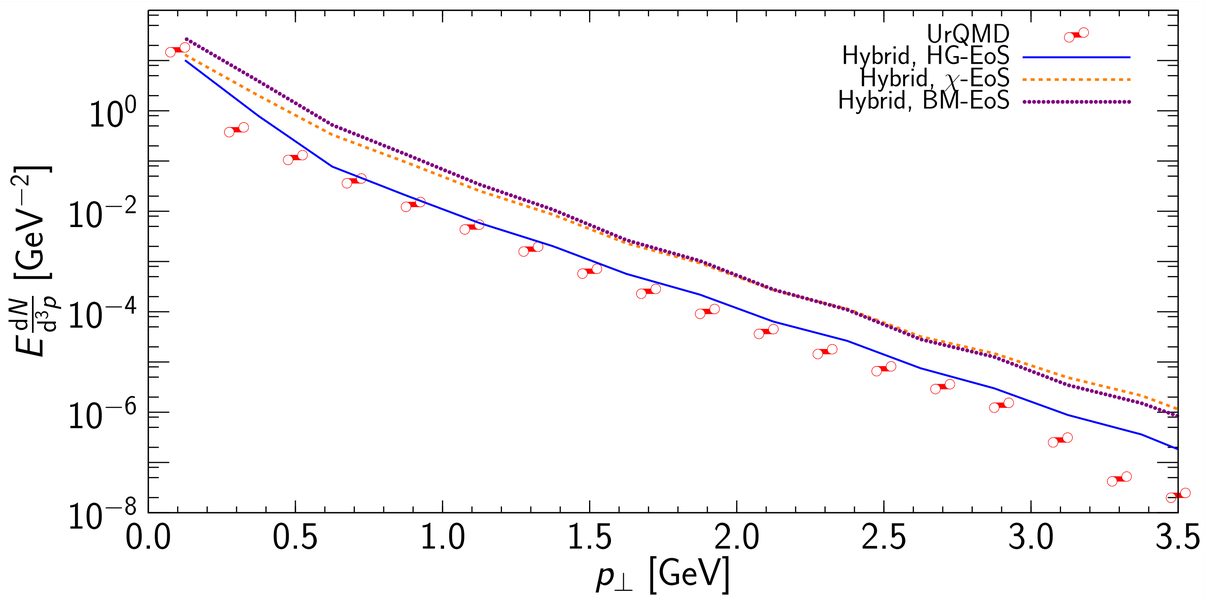


- Spectra including pQCD photons [6]
- Pure hadronic scenario disfavoured
- Large $\tau_0 \approx 1$ fm: lack of signal from very early QGP

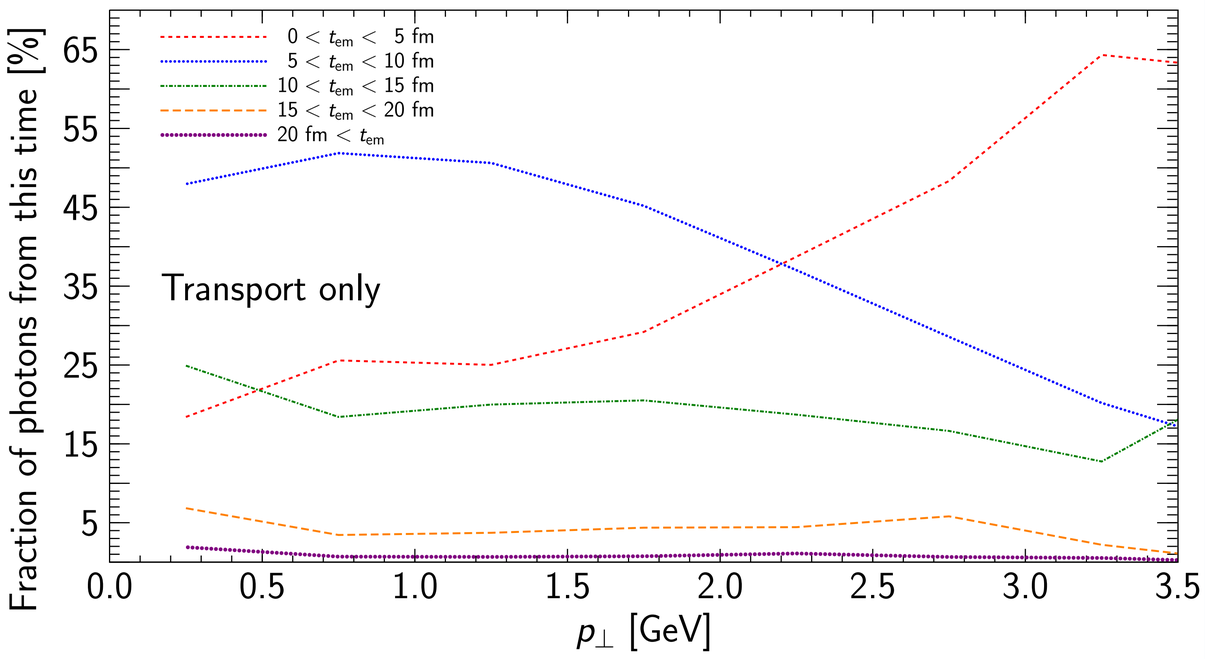


- Elliptic flow of direct photons significantly > 0 in all scenarios
- Addition of prompt photons (symmetrical emission) would lower signal

FAIR: U+U @ $E_{lab} = 35$ AGeV



- At FAIR, pQCD photons do not contribute to spectrum
- Therefore, distinction between partonic and hadronic scenarios possible



- Small $p_\perp$: Most photons from $5 < t_{em} < 10$ fm
- High $p_\perp$: Early times dominate

Summary

- Reasonable agreement at RHIC even with late equilibration times
- Large elliptic flow of direct photons
- FAIR perfect for distinction between partonic and hadronic scenarios
- Early time signal at FAIR visible at $p_\perp > 2$ GeV

Outlook

- Number of implemented channels will be extended
- Add photons from hard pQCD-scatterings and hadronic decays
- Comparison of experimental analysis techniques

References

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GOETHE UNIVERSITÄT FRANKFURT AM MAIN

FIAS Frankfurt Institute for Advanced Studies

baeuchle@fias.uni-frankfurt.de

[1]: Frankfurt Institute for Advanced Studies, Ruth-Moufang-Straße 1, 60438 Frankfurt am Main, Germany; [2]: Institut für Theoretische Physik Frankfurt am Main, Germany