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Photon emission in initial and hydrodynamic stages of nuclear collisions

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AM, J. Phys. G 47, 075105 (2020) [arXiv:1907.09266]
AM, PoS 345, 173 (2019) [arXiv:1812.08987]

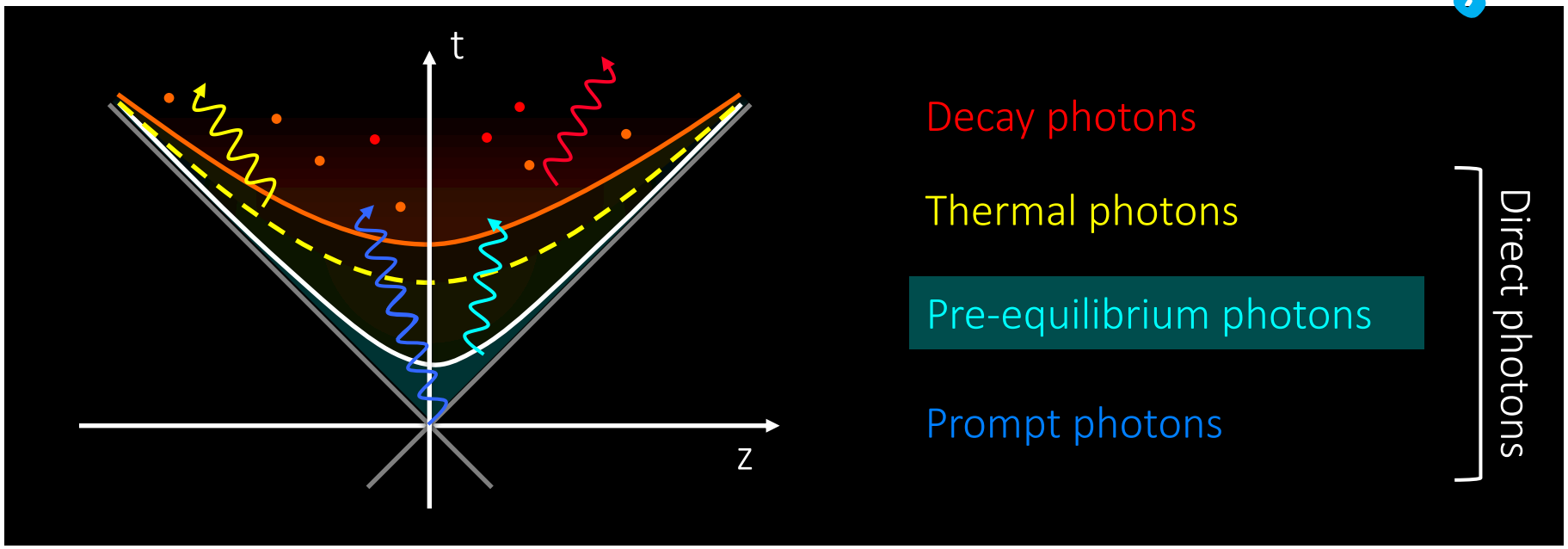
Initial Stages 2021

10 June 2021, Weizmann Institute of Science (Online)

Introduction

Glasma shines

- Key word: **pre-equilibrium photons**



A missing component in direct photon estimation in (most) hydrodynamic models for nuclear collisions

AM, 1812.08987, 1907.09266, Garcia-Montero et al. 1909.12246, 1909.12294
Churchill et al. 2001.11110, 2008.02902, Gale et al. 2002.05191

Direct photons

- Model overview

f_q , f_g : parton distributions

Momentum scale

Time ordering

Prompt photons: N_{coll}-scaled pp results

$$E\frac{dN^{\gamma}_{\rm dir}}{d^3p} = 6745\frac{\sqrt{s}}{(p_T)^5}\frac{N_{\rm coll}}{\sigma^{\rm in}_{pp}[\rm pb]}$$

Turbide, Rapp and Gale, PRC 69, 014903

Pre-equilibrium photons: Turbulent thermlization

$$E\frac{dR^{\gamma}_{a,b}}{d^3p} = \frac{20}{9\pi^2}\alpha_{\rm EM}\alpha_s f_q(p)\log\left(1+\frac{2.919}{g^2}\right)\int\frac{d^3p'}{(2\pi)^3}\frac{1}{p'}[f_g(p')+f_q(p')]$$

Berges et. al., PRC 95, 054904; Tanji and Venugopalan PRD 95, 094009

Thermal photons: Hydrodynamic model

$$E\frac{dR^{\gamma}}{d^3p} = \frac{1}{2}\left(1-\tanh\frac{T-T_c}{\Delta T}\right)E\frac{dR^{\gamma}_{\rm hadron}}{d^3p} + \frac{1}{2}\left(1+\tanh\frac{T-T_c}{\Delta T}\right)E\frac{dR^{\gamma}_{\rm QGP}}{d^3p}$$

Turbide, Rapp and Gale, PRC 69, 014903; Arnold, Moore and Yaffe, JHEP 0112, 009

Pre-equilibrium stage

Non-universal parameters

- Parametrize self-similar distributions

$$f_i = (Q_s\tau)^{-2/3} f_i^s(p_T, (Q_s\tau)^{1/3} p_z) \qquad (i = q, g)$$

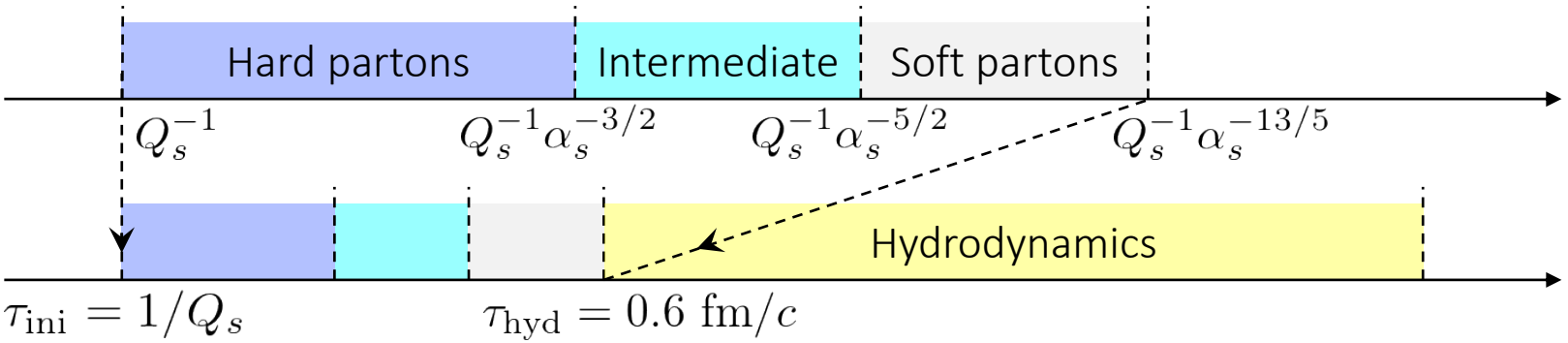
$$f_i^s(p_T, p_z) = A_i p_T^{-1} \exp(-p_z^2/\sigma_z^2) \qquad A_q \sim \alpha_s A_g$$

+ cut-off above $p_T > Q_s$

$$\times \frac{1}{2}\left[1 - \tanh\left(\frac{p_T - Q_s}{\Delta p_T}\right)\right]$$

- A_i : Normalization
- σ_z : Longitudinal momentum scale
- Q_s : Saturation momentum

- Scale bottom-up thermalization into the hydro model timeline

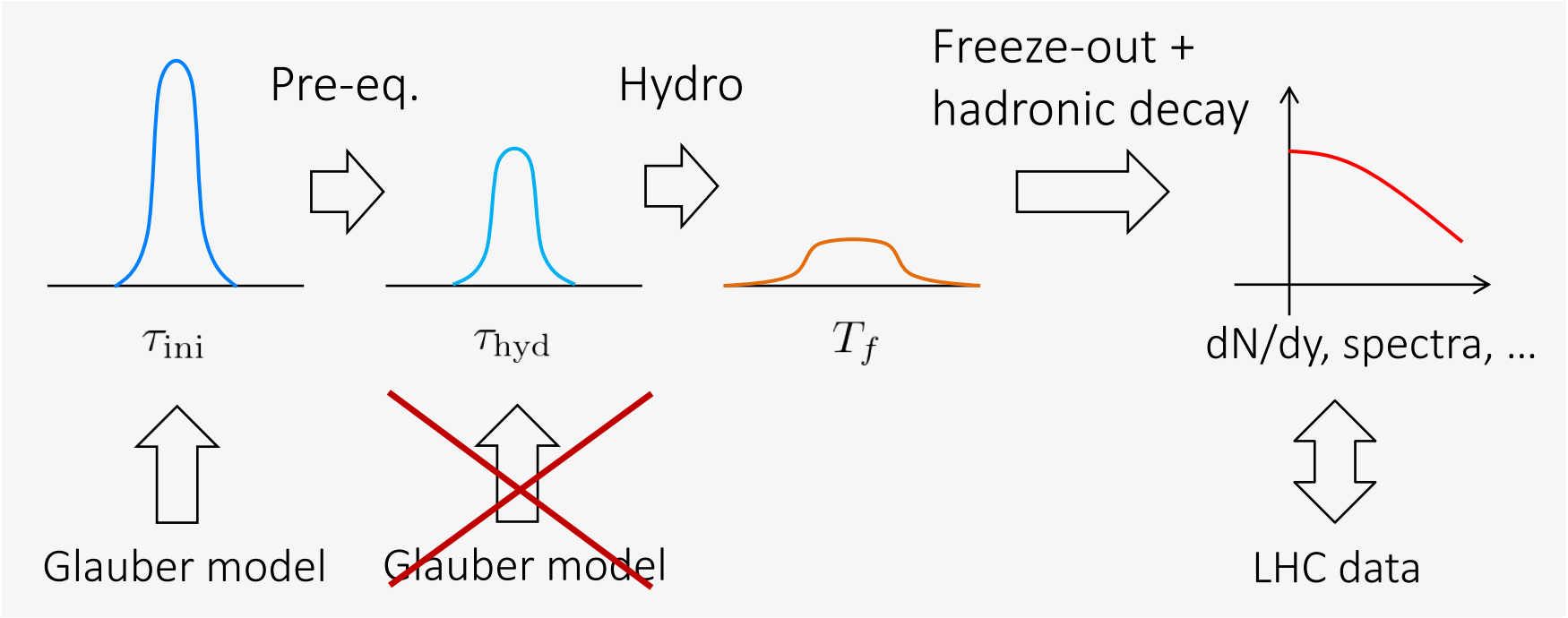


QCD matter

A_i : Normalization

- Initial energy density distribution for the pre-equilibrium stage

Event-averaged MC Glauber model at b = 4.6 fm
normalized by $\sqrt{s_{NN}}$ =2.76 TeV Pb+Pb data at LHC

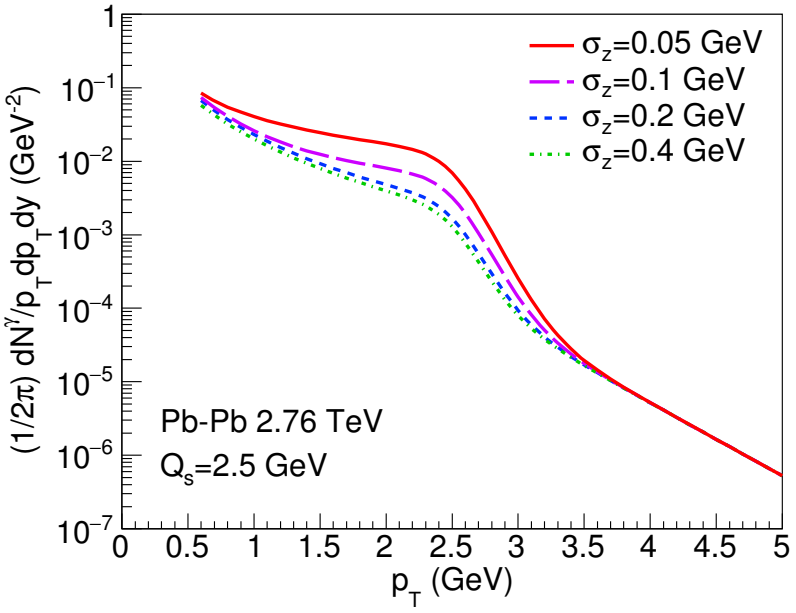


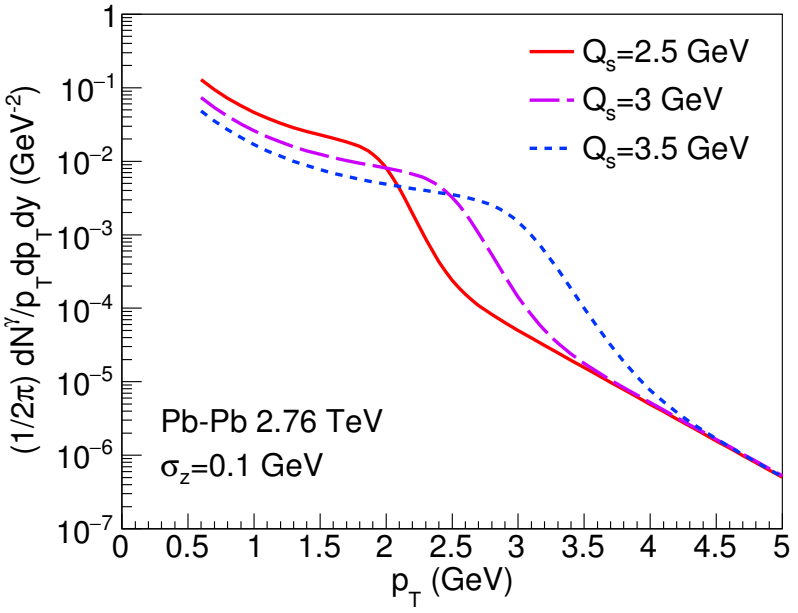
Results and conclusion

σ_z : Longitudinal momentum scale

Q_s : Saturation momentum

- Pre-equilibrium photons





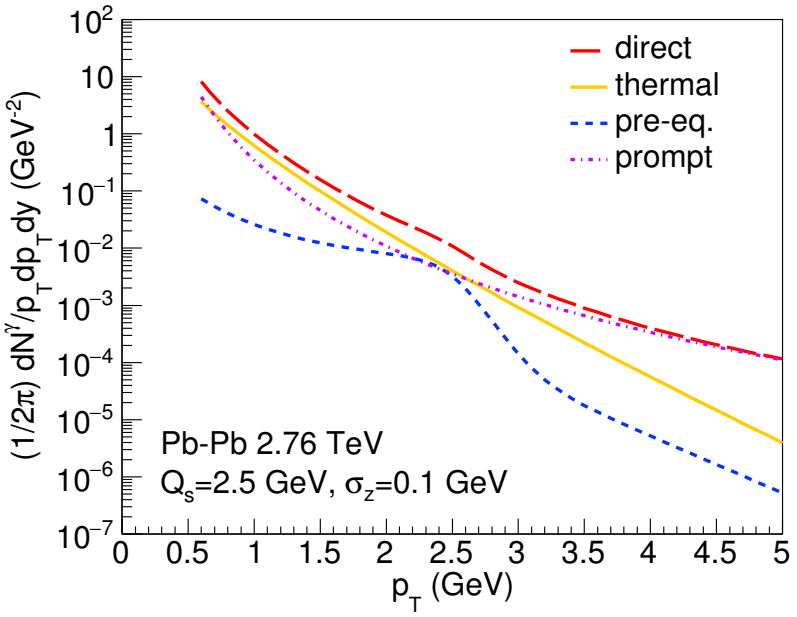
Smaller σ_z → Higher peak in p_T spectra

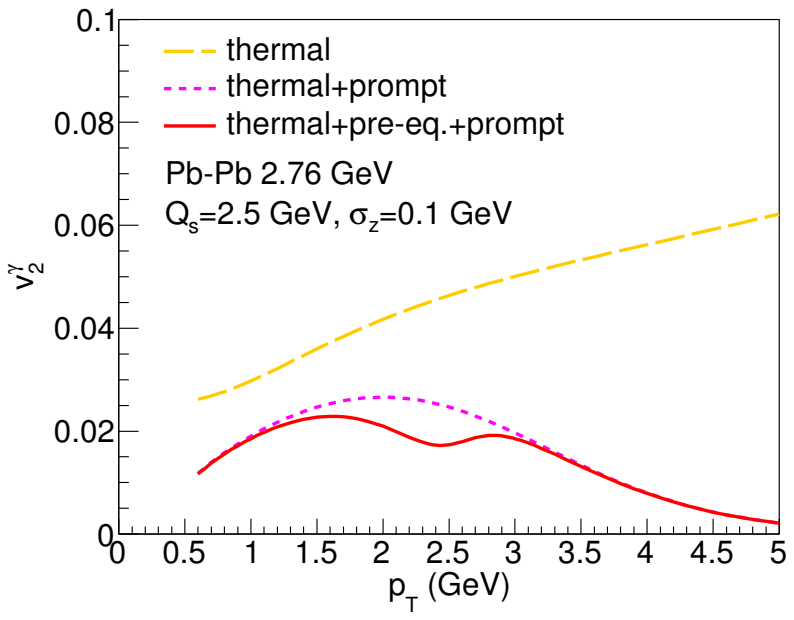
Larger Q_s → Lower peak at larger p_T in spectra

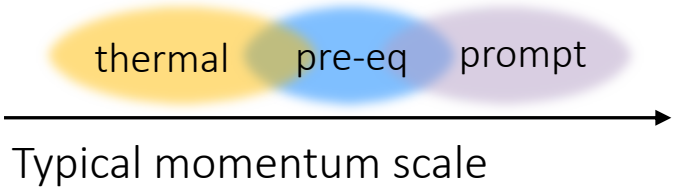
*Phase space volume is constrained by normalization

Results and conclusion

- Thermal + pre-equilibrium + prompt photons







p_T spectra: enhanced around Q_S

v_2: reduced around Q_S

Pre-equilibrium photons can be important near $p_T \sim Q_S$

The end

- Thank you for listening!

- If you have further questions, contact me at:
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