Heavy Quark Dynamics at the FCC

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Implications for:

- Transport/Modeling
- Thermalization/Hadronization
- Collective Flow & Fluctuations

all statements in this presentation regarding HQ Dynamics at the FCC are pure speculation and not based on any quantitative calculation

Transport Models for HQ in Medium

Choice of transport approach allows for study of HQ-medium interactions:

- Langevin+vRFD: sQGP + strong (non-perturbative) HQ-medium interaction
- linearized Boltzmann+vRFD: sQGP + pQCD driven HQ-medium interaction

(viscous) relativistic fluid dynamics:

- transport of macroscopic degrees of freedom
- based on conservation laws:

$$\partial_\mu T^{\mu\nu} = 0$$

$$\begin{aligned} T_{ik} &= \varepsilon u_i u_k + P\left(\delta_{ik} + u_i u_k\right) \\ &- \eta \left(\nabla_i u_k + \nabla_k u_i - \frac{2}{3}\delta_{ik}\nabla \cdot u\right) \\ &+ \varsigma\, \delta_{ik} \nabla \cdot u \end{aligned}$$

(plus an additional 9 eqns. for dissipative flows)

hybrid transport models:

- combine microscopic & macroscopic degrees of freedom
- current state of the art for RHIC modeling

diffusive transport models based on the **Langevin Equation**:

- transport of a system of microscopic particles in a thermal medium
- interactions contain a drag term related to the properties of the medium and a noise term representing random collisions

$$\vec{p}(t+\Delta t) = \vec{p}(t) - \frac{\kappa}{2T}\vec{v}\cdot\Delta t + \vec{\xi}(t)\Delta t$$

microscopic transport models based on the **Boltzmann Equation**:

- transport of a system of microscopic particles
- all interactions are based on binary scattering

$$\left[\frac{\partial}{\partial t} + \frac{\vec{p}}{E} \times \frac{\partial}{\partial \vec{r}}\right] f_1(\vec{p},\vec{r},t) = \sum_{processes} C(\vec{p},\vec{r},t)$$

Modeling HQ Dynamics at the FCC

- will the HQ multiplicity be large enough to influence bulk evolution?
  - if yes, no clear separation anymore between probe and medium
  - are Langevin calculations still viable in such a scenario?
  - if we assume HQ thermalization, then vRFD with a chemical potential for charm/bottom may provide a viable approach
  - full Boltzmann transport should always work...

Recombination+Fragmentation Model

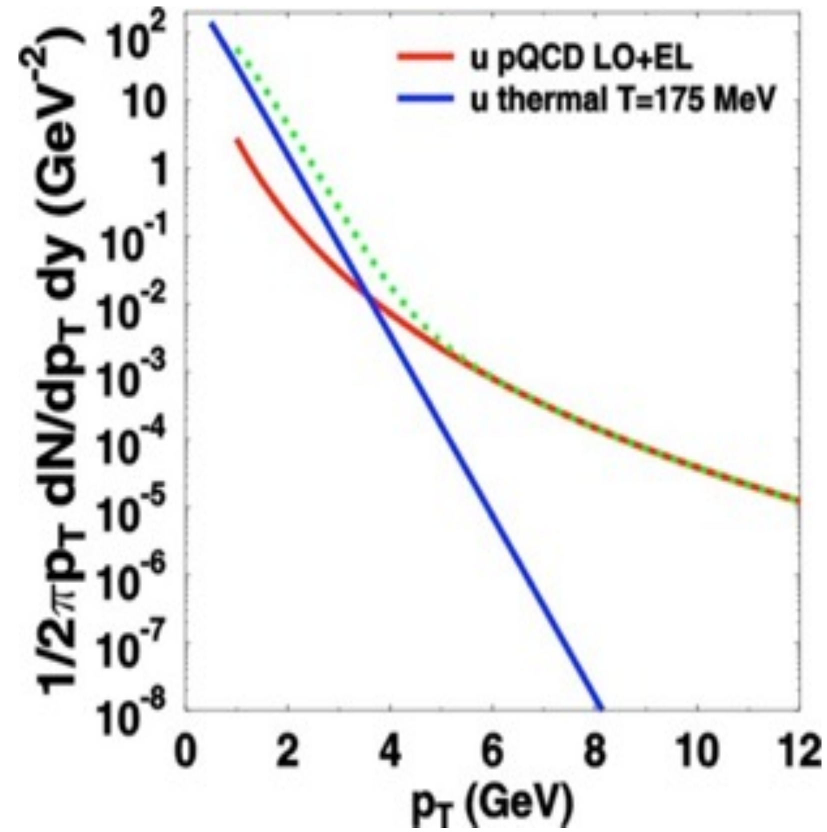
basic assumptions:

- at low p_t, the parton spectrum is thermal and HQs recombine with light quarks into hadrons locally "at an instant":

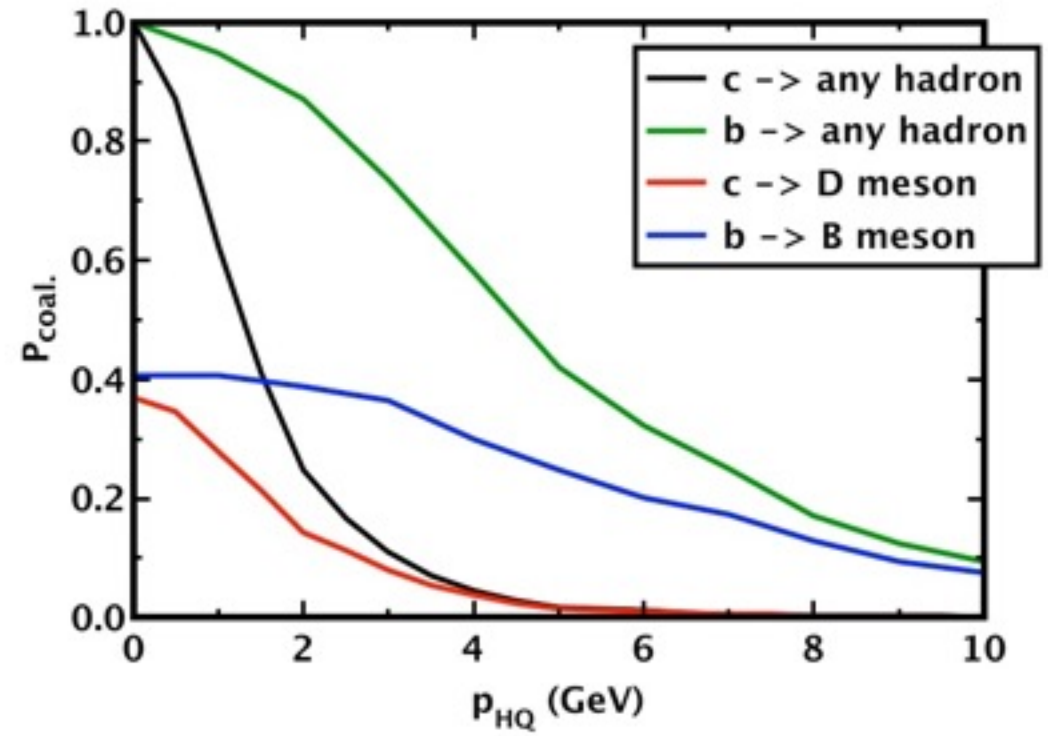
$$\frac{dN_M}{d^3P} = C_M \frac{V}{(2\pi)^3} \int \frac{d^3q}{(2\pi)^3} w\left(\tfrac{1}{2}P - q\right) w\left(\tfrac{1}{2}P + q\right) \left|\hat{\varphi}_M(q)\right|^2$$

- at high p_t, the parton spectrum is given by a pQCD power law, HQs suffer radiative energy loss and hadrons are formed via fragmentation of HQs:

$$E\frac{dN_h}{d^3P} = \int d\Sigma \frac{P\cdot u}{(2\pi)^3} \int_0^1 \frac{dz}{z^2} \sum_\alpha w_\alpha(R, \tfrac{1}{z}P) D_{\alpha\to h}(z)$$



- shape of spectrum determines if reco or fragmentation is more effective:
  - for thermal distribution recombination yield dominates fragmentation yield
  - vice versa for pQCD power law distribution



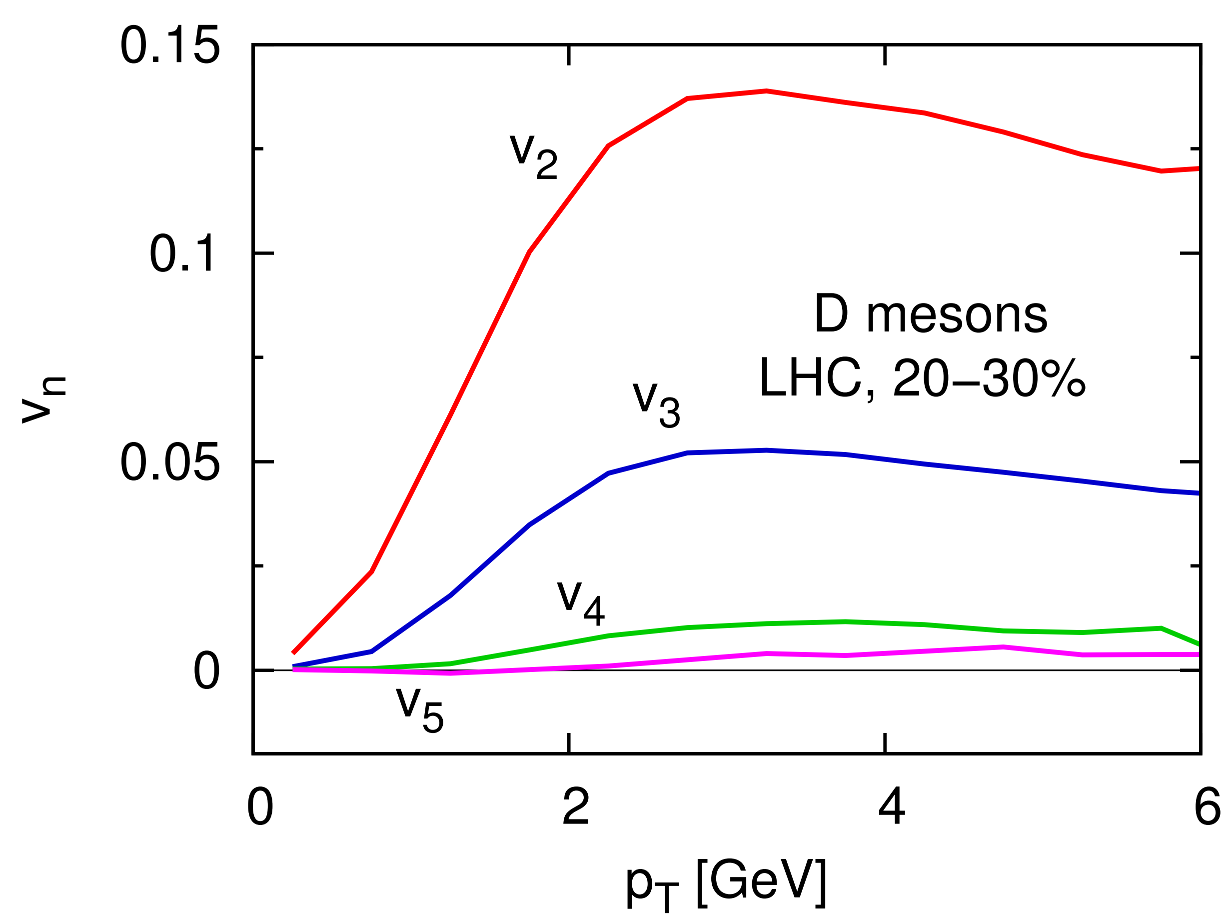
HQ Thermalization & Hadronization at the FCC

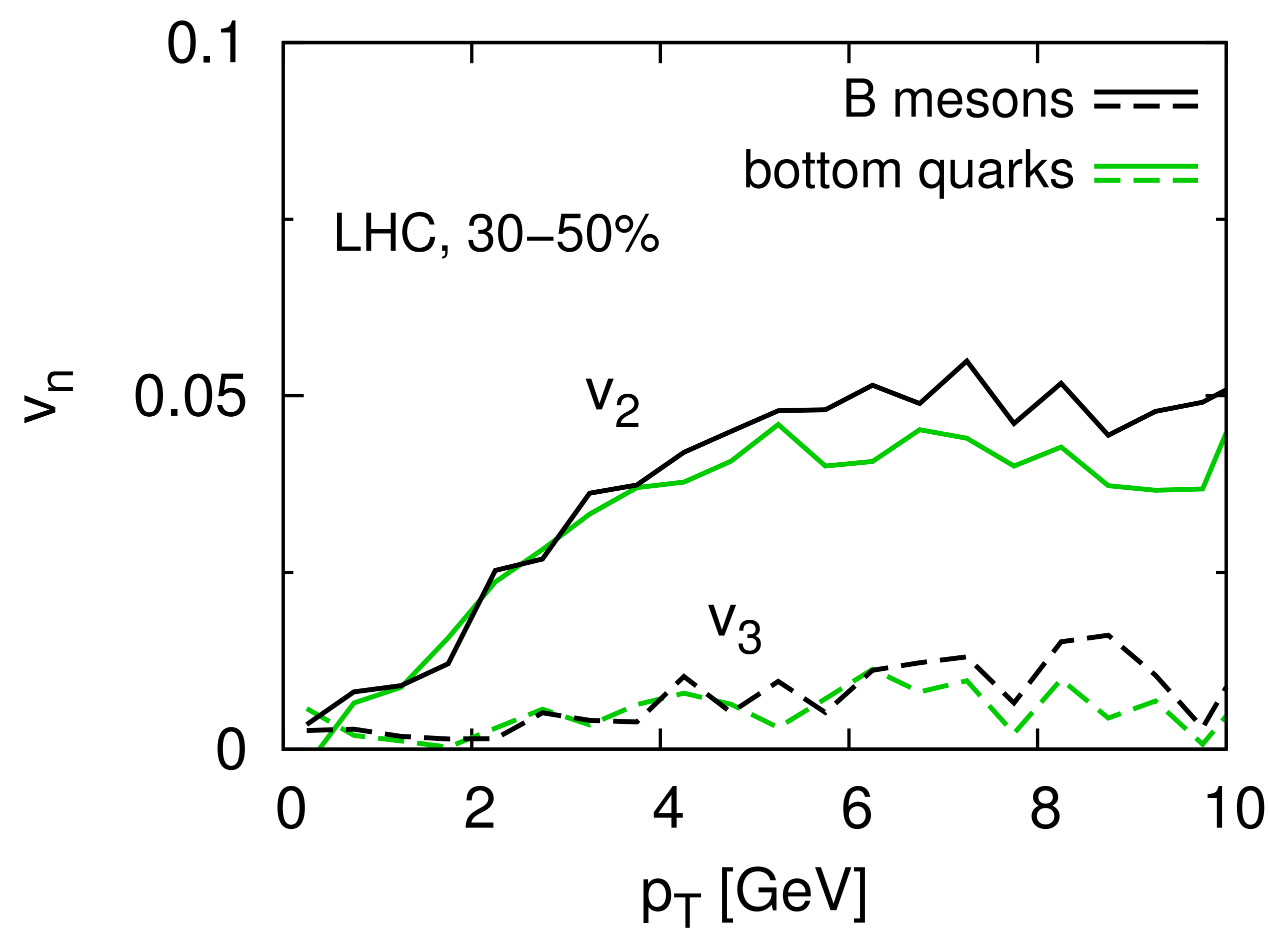
- increased QGP volume & lifetime may help HQ's to thermalize within the medium (or even become part of the medium)
  - this will drive the thermal (exponential) HQ spectrum out to dominate over power law in a wider p_T range
  - increase of the momentum range where recombination dominates over fragmentation
  - observable consequences for R_{AA}, v_2 and D/π ratio as a function of p_T

HQ Flow at the FCC

- increased QGP volume & lifetime as well as HQ multiplicity will result in significant HQ elliptic flow
- triangular flow signal good enough to characterize the spatial fluctuations of the HQ initial state?

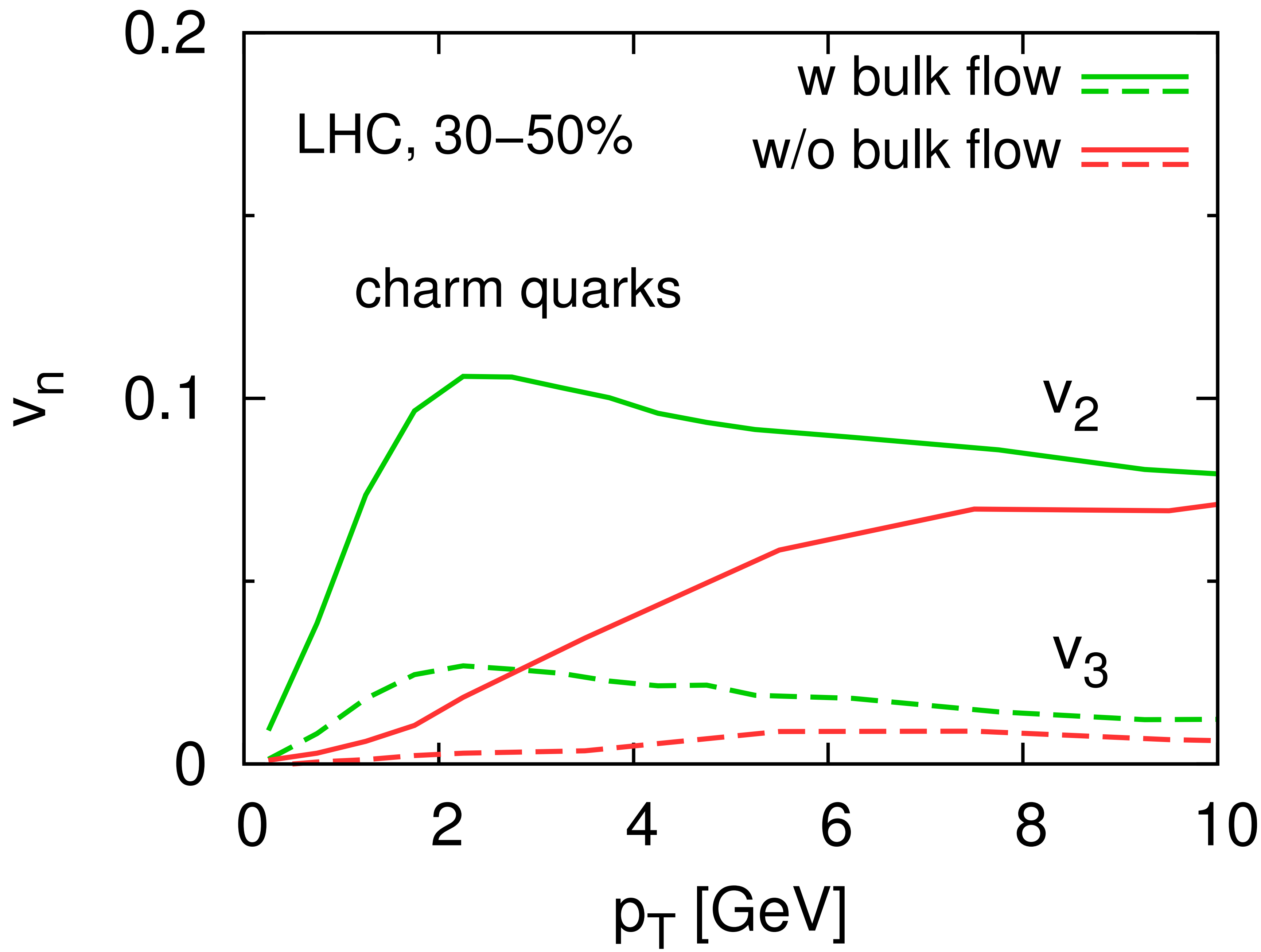
example: LHC calculation of HQ anisotropic flow by
Nahrgang, Aichelin, Bass, Gossiaux & Werner, Phys.Rev. C91 (2015) 1, 014904





precision measurement of HQ v_4 & v_5?

HQ Flow continued...



bulk flow effects at FCC could stretch well beyond 10 GeV!

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