FROM HYDRO TO HIGH $p_T$

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Hydro at high $p_t$?

Are you out of your mind?''

Jet tomography?

Had better know what your object is radiating!
Thermal parametrizations

- Assume a freeze-out surface i.e. shape and lifetime of a source
- Assume $T(r), \mu(r)$ and $v_r(r)$ on this surface
- Choose the values to fit the data
- Blast wave model (Siemens & Rasmussen)
  - Thin cylindrical shell with constant $T$, $\mu$ and $v_r$.
  - Generalization for non-central collisions:
    elliptical shell with $v_r = v_r(\phi)$

Hydrodynamical calculation

- Assume initial state
- Evolution governed by equation of state and conservation laws
  \[ \partial_\mu T^{\mu\nu} = 0 \]
- Evolves until $T = T_{fo}$ or $\epsilon = \epsilon_{fo}$
- Alternative: use transport model in hadronic phase
Fit using thermal model parameters

W. Broniowski and W. Florkowski: nucl-th/0106050

- $T = 165$ MeV
- $\mu_B = 41$ MeV
- $r = 6.7$ fm
- $v_{r_{\text{max}}} = 0.66$ or $v_r = 0.48$

(b) PHENIX, min. bias
(c) STAR + PHENIX, most central
$p/\pi$ ratio in thermal distributions

$p_t$ spectrum in blast-wave model:

$$\frac{1}{p_t dp_t dy} \propto g m_t e^{\mu/T} I_0 \left( \frac{p_t \gamma r u_r}{T} \right) K_1 \left( \frac{m_t \gamma r}{T} \right)$$

High $p_t$ limit is:

$$\frac{\bar{p}}{\pi} = \frac{g_p e^{\mu_p/T}}{g_\pi e^{\mu_\pi/T}} = 2 e^{(\mu_p-\mu_\pi)/T}$$
Blast-wave fit at $T=120$ MeV

Data: Phenix, preliminary

- $T = 120$ MeV
- $\mu_p - \mu_\pi = 260$ MeV
- $v_r = 0.6$
Hydro+cascade calculation

D. Teaney et al: nucl-th/0110037
Neutral pions at the SPS

Hydro: Räisänen et al; in preparation
Charged particles at RHIC

\[ \frac{1}{2\pi} \frac{1}{p_t} \frac{dN}{dp_t \, dy} \text{ (GeV}^{-2}) \]

- PHENIX
- Hydro
- $\pi^-$
- $K^-$
- $p$–bar

Hydro: Kolb et al; in preparation
$v_2(p_t)$, minimum bias

Negative hadrons

Parametrization of decoupling surface (Blast wave):

- longitudinal boost invariance
- thin elliptic shell: $r(\phi) = r_0 - 2r_2 \cos(2\phi)$
- $r_2 = 0.07$
- $T' = 165$ MeV, $v_r = 0.42$
- But no mass dependence
$v_2(p_t)$, minimum bias

Negative hadrons

Data: STAR, preliminary QM'01
Summary

- $\bar{p}/\pi$ anomaly is no anomaly
- $p/\pi > 1$ at high $p_t$
- The power law shape not hydrodynamical.
- Saturation of $v_2$ above 2 GeV can be parametrized but not dynamically reproduced.