Quark Matter '01
Long Island, NY, Jan 15–20, 2001

Is there flow without flow at RHIC?

a.k.a.

Is there elliptic flow without radial flow at RHIC?

a.k.a.

Is there elliptic anisotropy without radial flow at RHIC?

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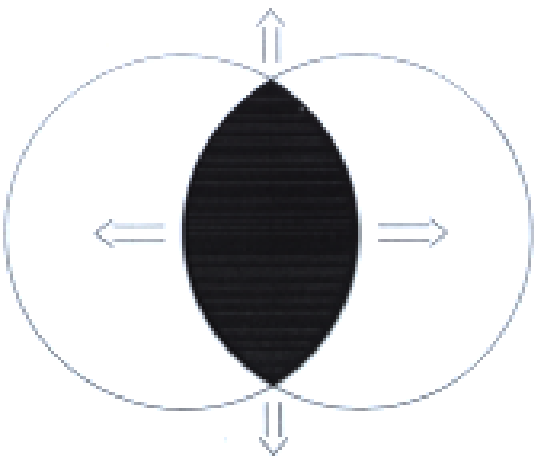
Anisotropic particle distribution

Non-central collision:



Anisotropy in configuration space

$\Downarrow$

Anisotropy in particle distributions
i.e. in momentum space

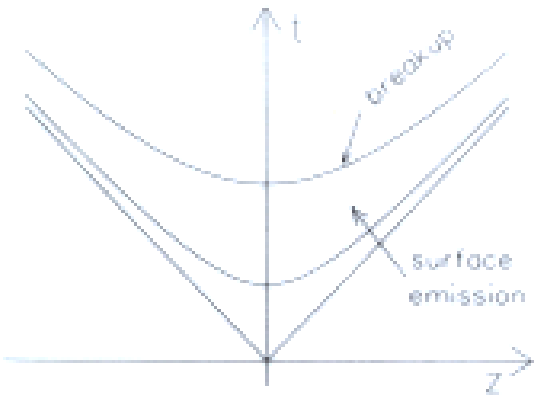
Characterized by Fourier coefficients:

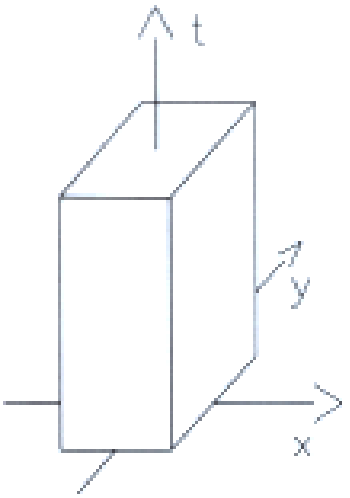
$$E\frac{dN}{d^3p} = \frac{dN}{2\pi p_t dp_t dy} \times [1 + 2v_1(p_t)\cos(\phi) + 2v_2(p_t)\cos(2\phi) + \cdots]$$

or as averaged over p_t:

$$\frac{dN}{dyd\phi} = \frac{dN}{2\pi dy} \times [1 + 2v_1\cos(\phi) + 2v_2\cos(2\phi) + \cdots]$$

Bjorken brick



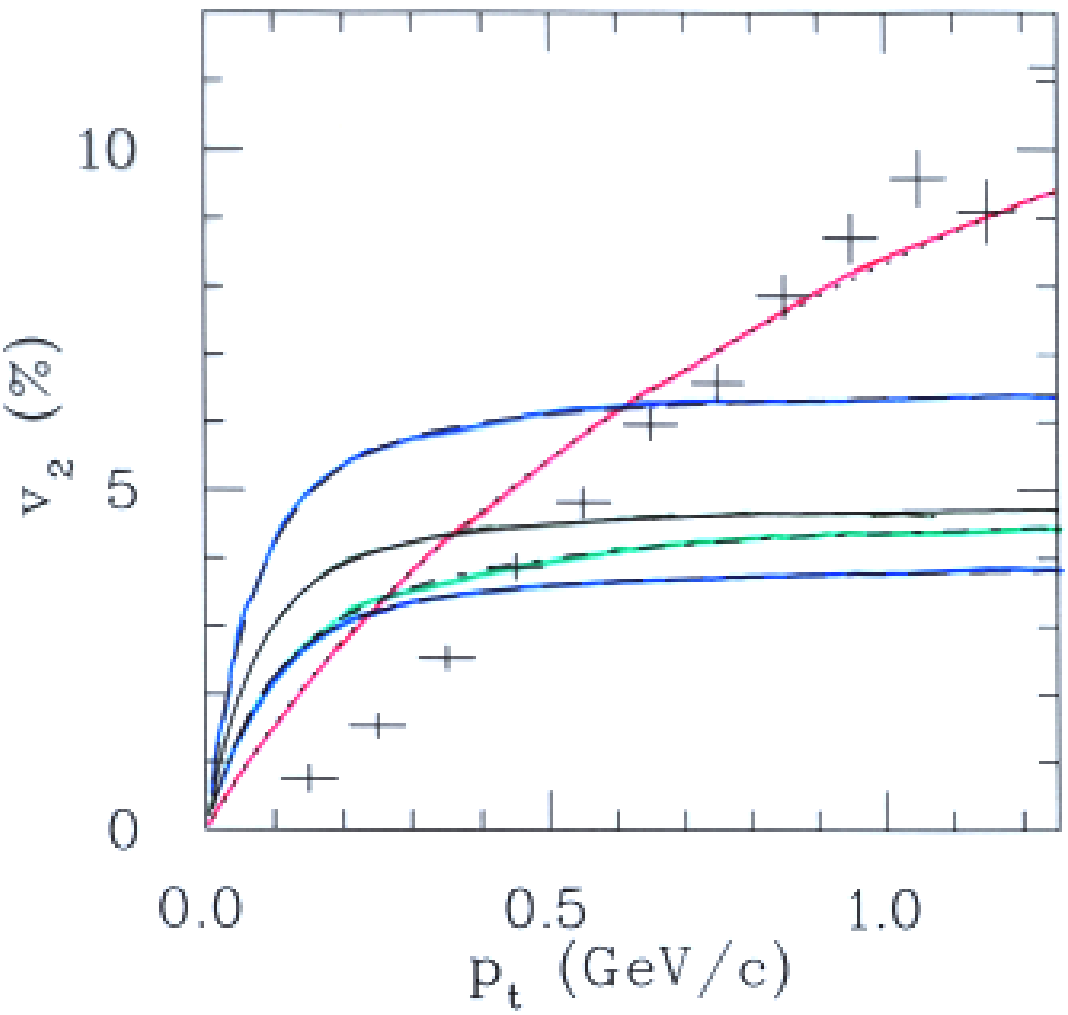


- boost invariant
- rectangular in transverse plane
- opaque
- emission
  - on surface
  - at final breakup
- parameters: R_y/R_x, τ/R_x, v_x, v_y, T

Modified Cooper-Frye:

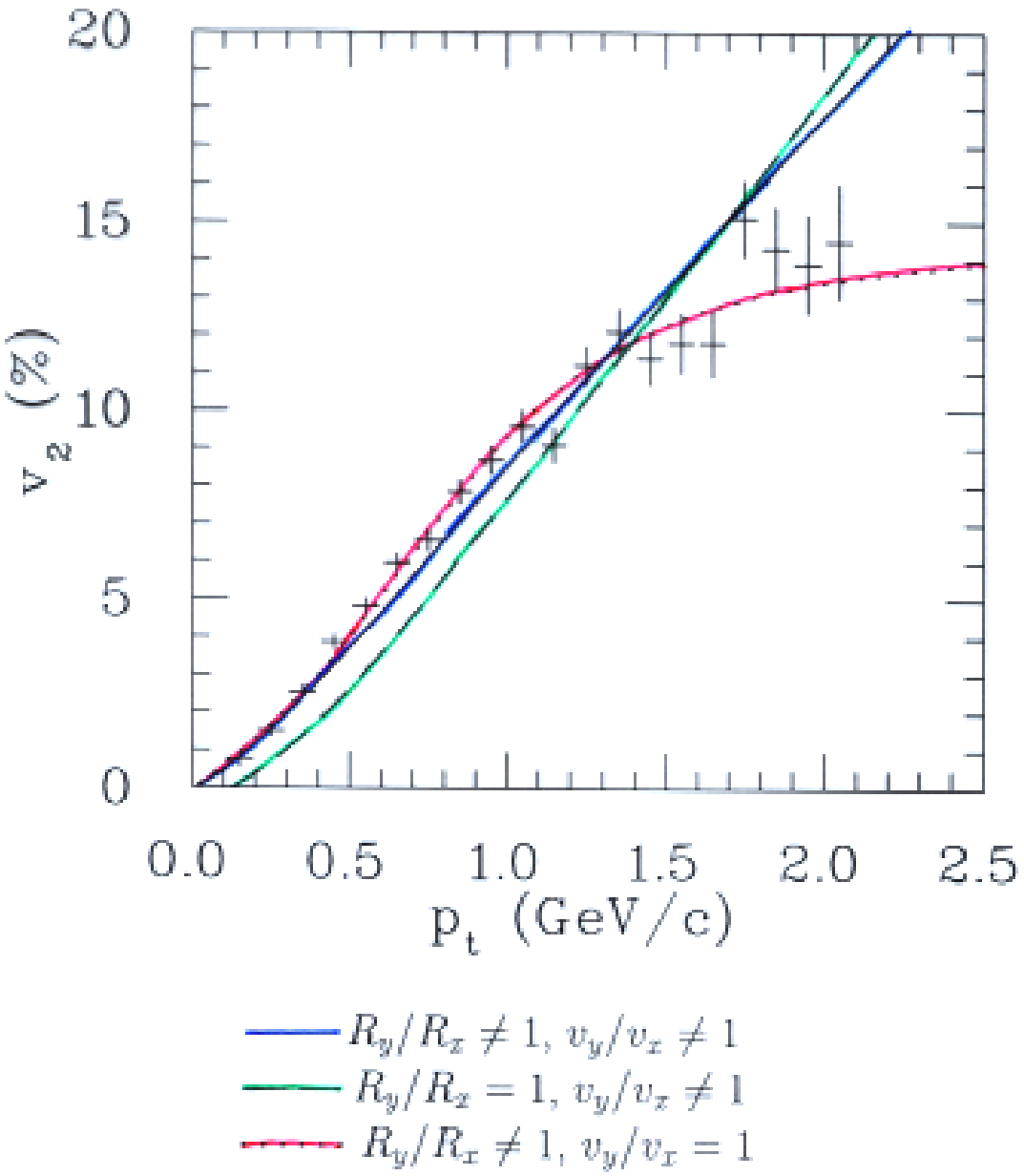
$$E\frac{dN}{d^3p} = \int d\sigma_\mu p^\mu \, f(p \cdot u, T)\, \theta(d\sigma_\mu p^\mu)$$

v_2 of pions without flow



No satisfactory fit with any realistic parameters

v_2 of pions with flow



Data: $v_2(p_t)$ of charged particles, *not* pions

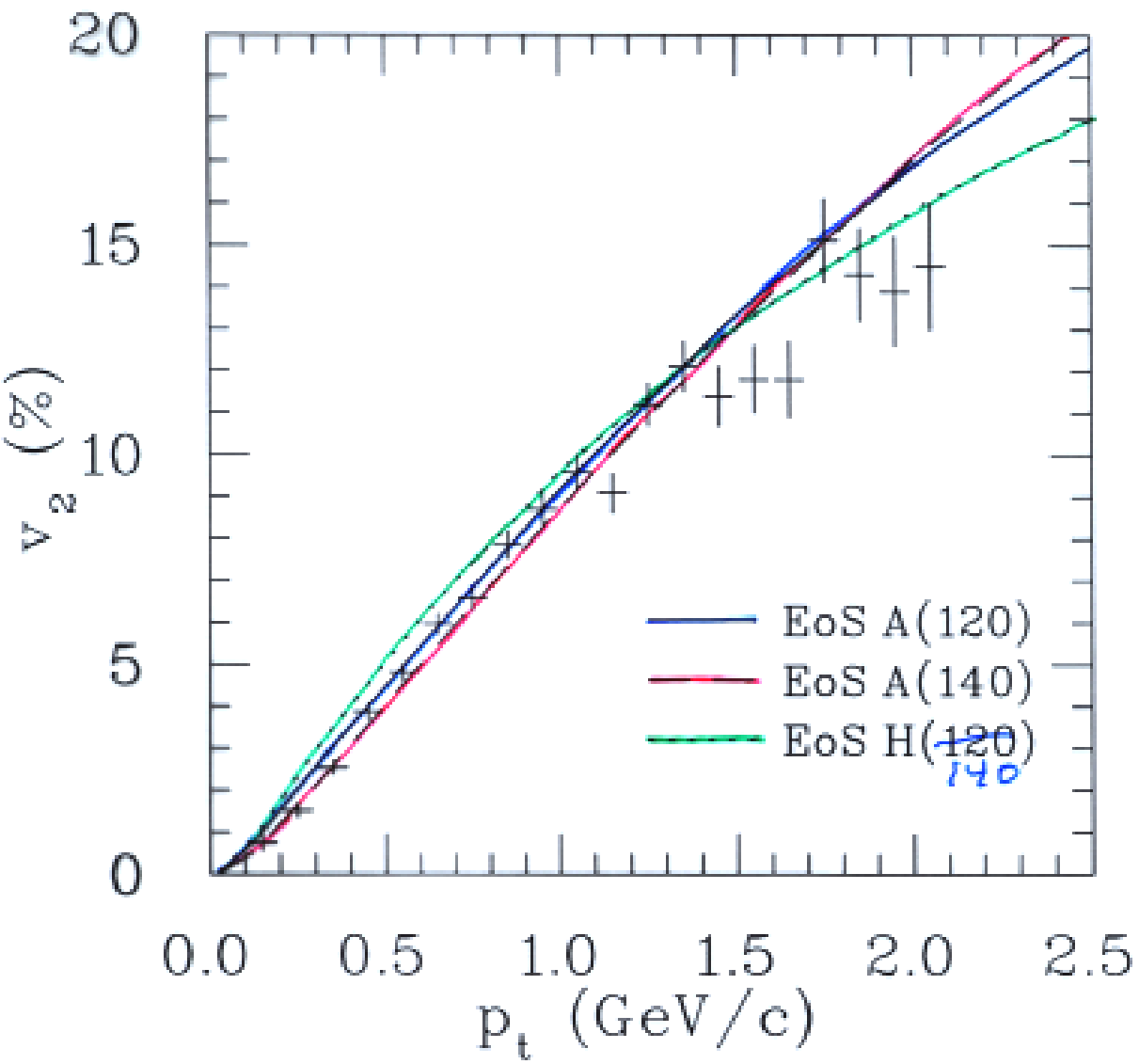
Hydrodynamical model

- Boost-invariant 2+1 dim. model
- Initial spatial distributions based on wounded nucleon model
- Tuned to reproduce charged particle multiplicity in central collisions measured by Phobos collaboration
  - $\frac{dN}{d\eta}|_{\eta<1} = 545$
  - $\frac{\bar{p}}{p} = 0.65$
- Decoupling temperature unknown
  - use $T_f \approx 140$ MeV and $T_f \approx 120$ MeV
- Equations of state with
  - $T_c = 165$ MeV
  - $T_c = \infty$
- Initial parameters at b=0 collision
  - $\epsilon_0 = 23.0$ or 22.3 GeV/fm^3
  - $n_{b,0} = 0.12$ or 0.25 fm^{-3}
  - $\tau_0 = 0.6$ fm
  - $T_0 = 330$ or 270 MeV
- See Peter Kolb's poster

hep-ph/0012137

v_2 @ RHIC, $\sqrt{s} = 130$ AGeV

charged hadrons, $|\eta| < 1.3$, minimum bias

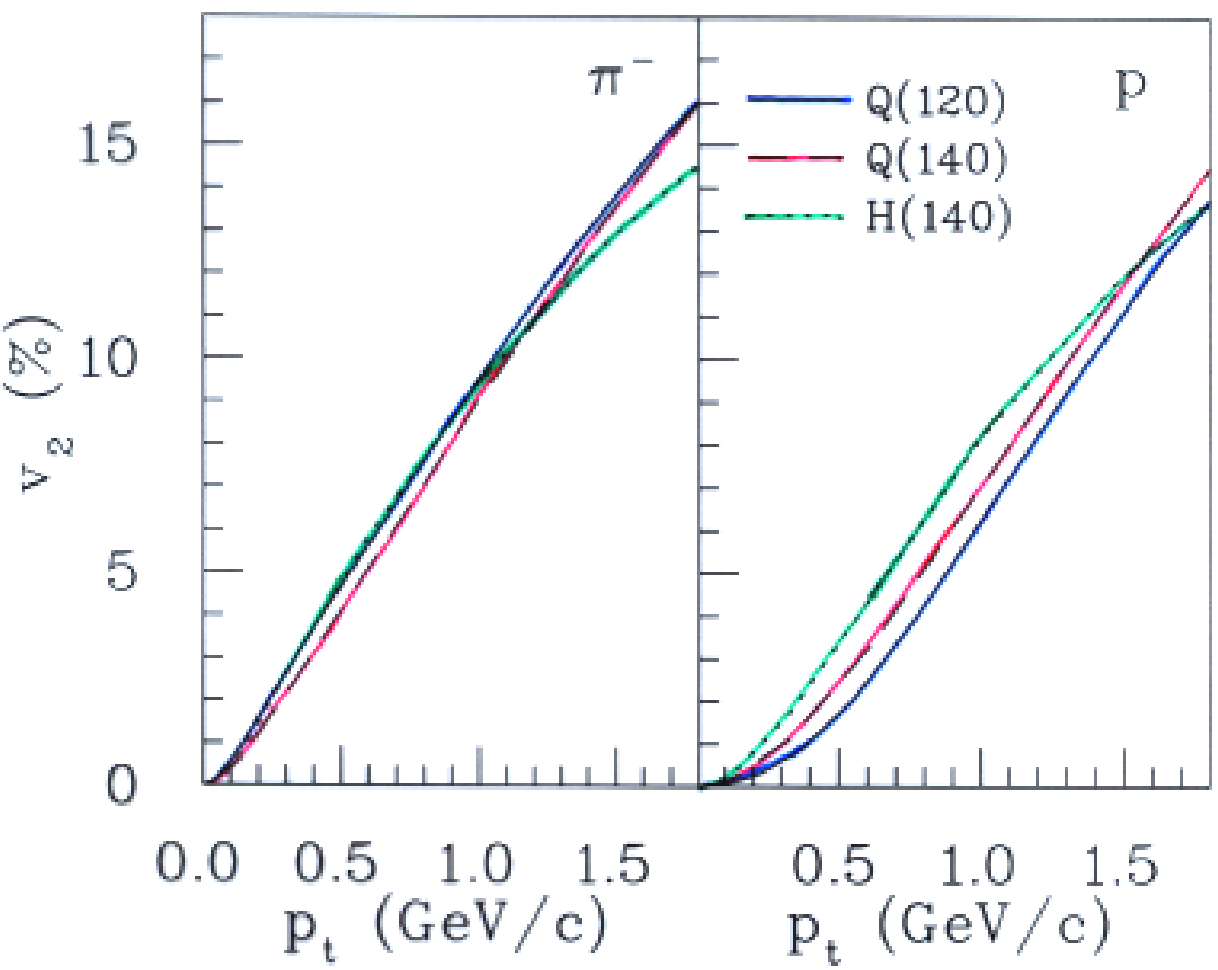


Data: STAR collaboration, nucl-ex/0009011

hep-ph/0101136

v_2 @ RHIC, $\sqrt{s} = 130$ AGeV

pions and protons, $y = 0$, minimum bias



Summary

- Finite v_2 is *not* a signal of flow
- The shape of $v_2(p_t)$ is!
- The data strongly favours existence of collective motion
- Hydrodynamical model gives excellent fit to data
- Collision system behaves like a system which thermalizes rapidly