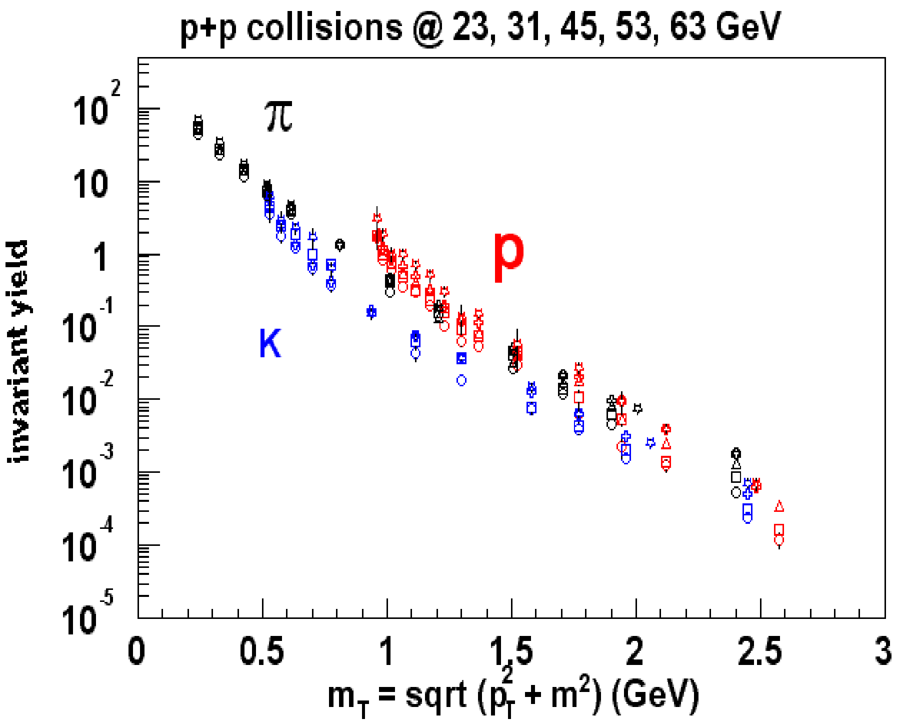
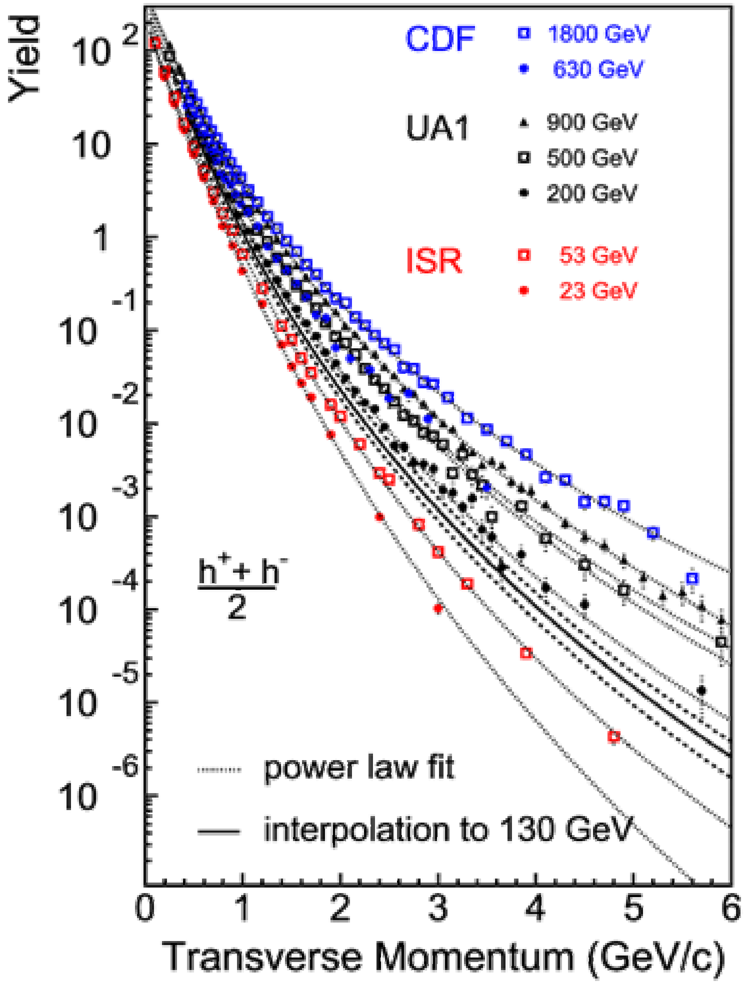
Spectral shapes in pp collisions

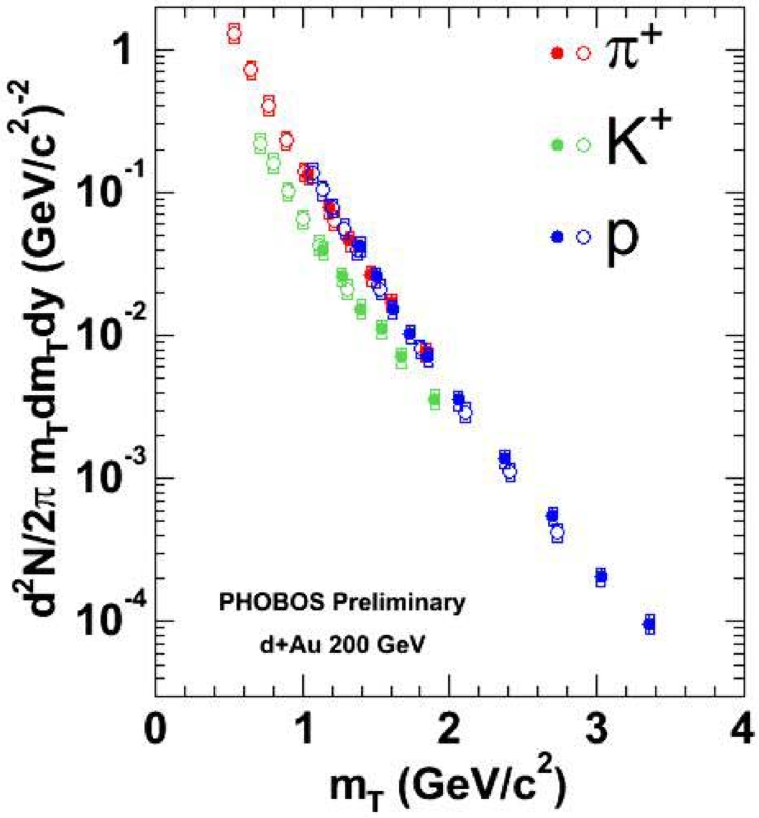


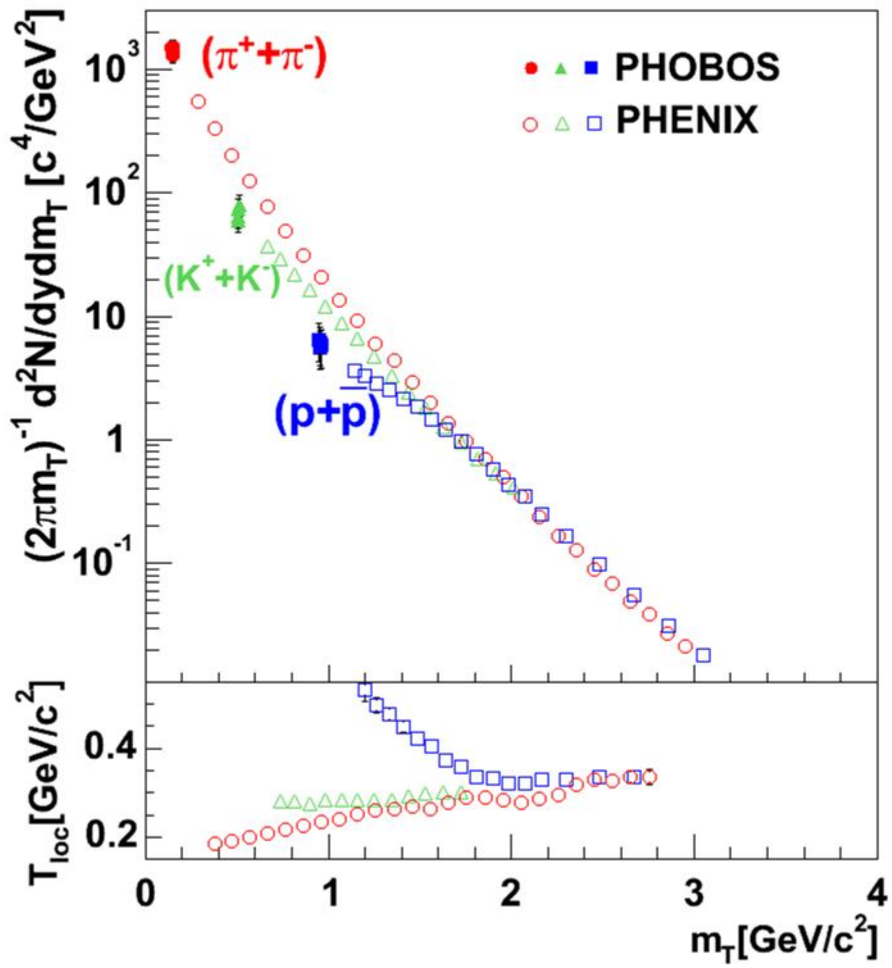


Mt-scaling for soft particles

Power-law tail from hard scattering
Increasing with energy

Scaling of spectra in dA and AA collisions





- m_T scaling in pp and dA, but NOT in AA. Signature of radial flow.

Source is assumed to be:

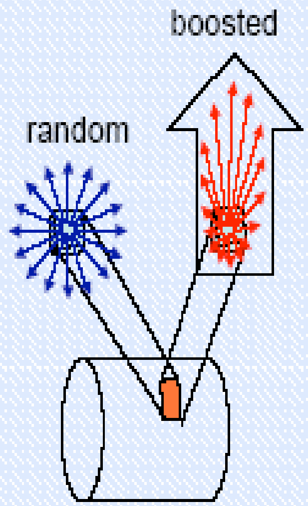
- Locally thermal equilibrated
- Boosted in radial direction

E.Schnedermann, J.Sollfrank, and U.Heinz, Phys. Rev. C48, 2462(1993)

$$E\frac{d^3N}{dp^3} \propto \int_\sigma e^{-(u^\mu p_\mu)/T_{fo}} p\, d\sigma_\mu \Rightarrow$$

$$\frac{dN}{m_T dm_T} \propto \int_0^R r\,dr\, m_T K_1\left(\frac{m_T \cosh\rho}{T_{fo}}\right) I_0\left(\frac{p_T \sinh\rho}{T_{fo}}\right)$$

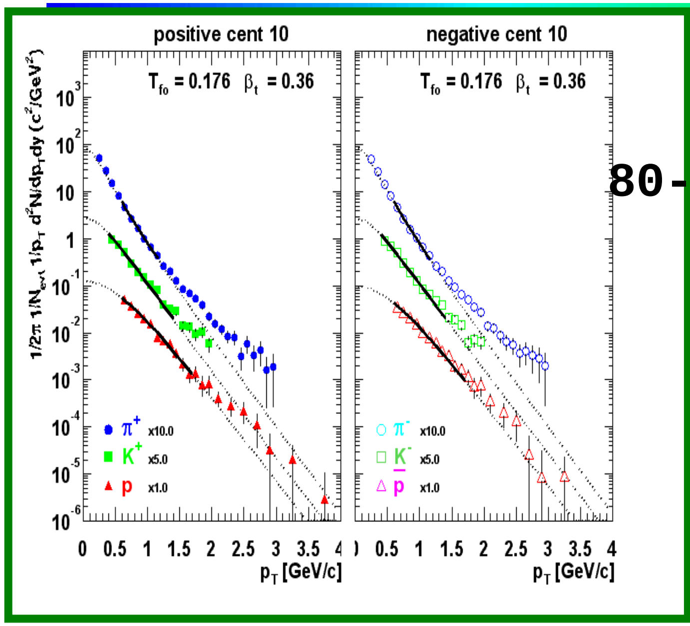
$$\rho = \tanh^{-1}\beta_T \qquad \beta_T = \beta_S\left(\frac{r}{R}\right)^\alpha \qquad \alpha = 0.5,\ 1,\ 2$$



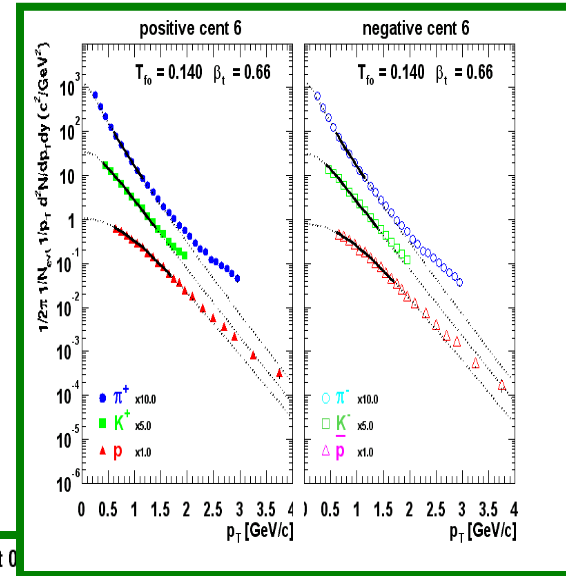
Extract thermal temperature T_{fo} and velocity parameter $\langle\beta_T\rangle$

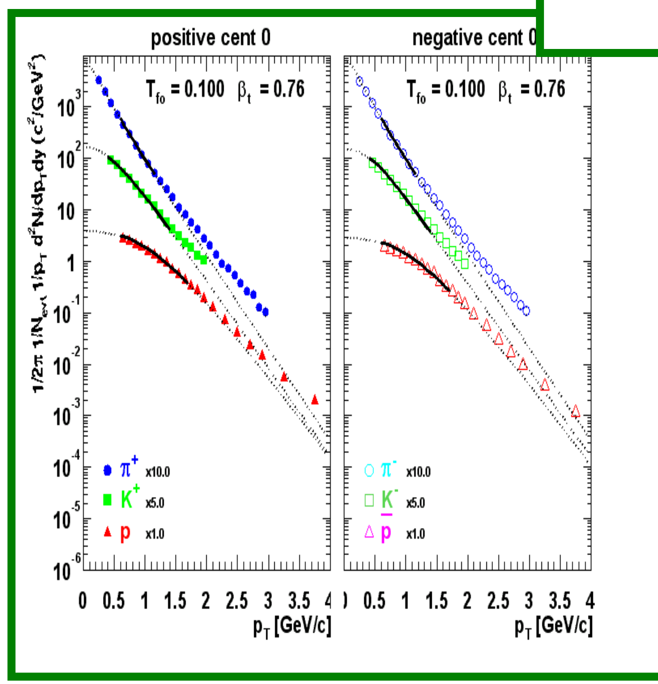
Fitting π,K,p with hydrodynamics model

80-92%



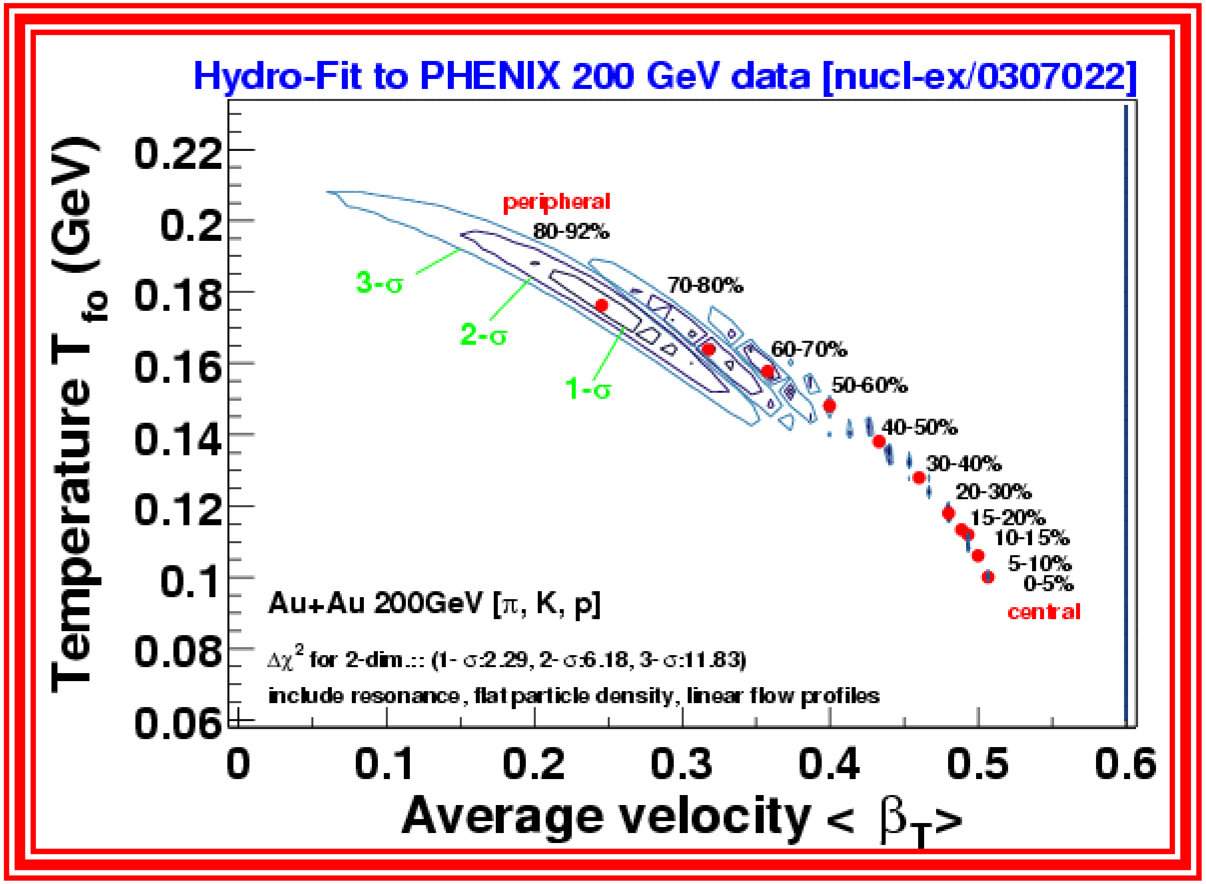
40-50%



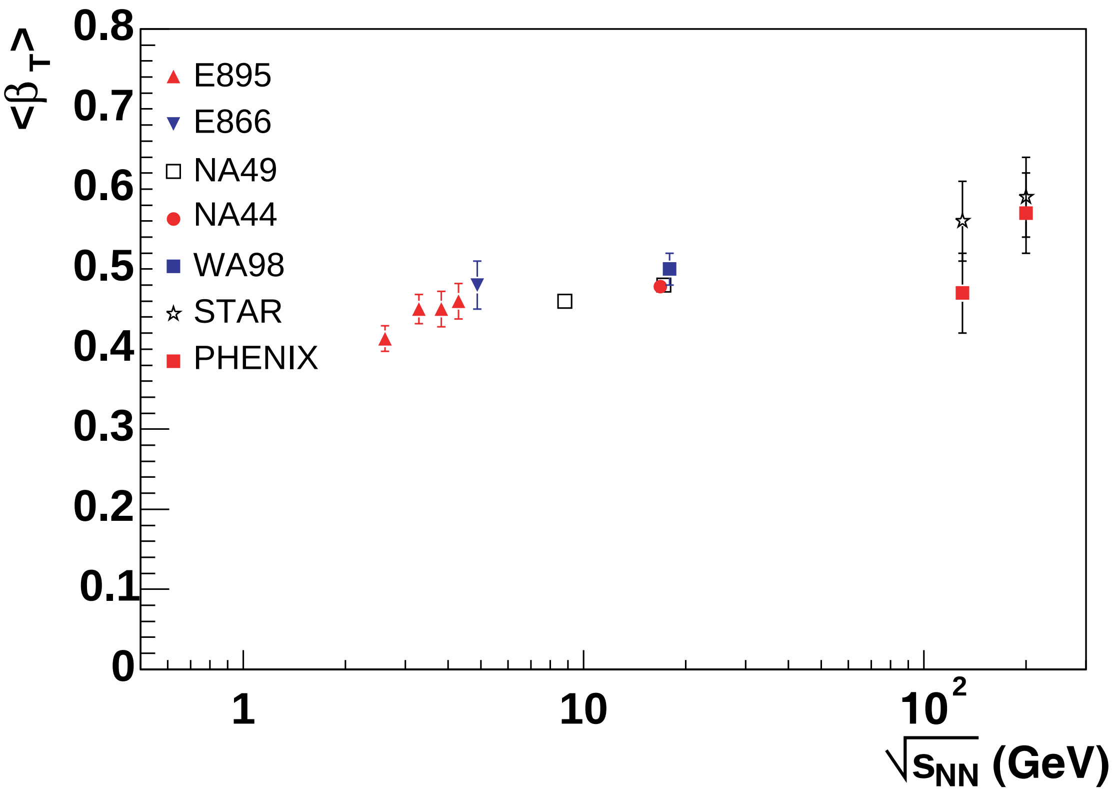


0-5%

Blast wave fits: T_{fo} and flow velocity



Flow velocity vs energy



$< \beta_T >$ **slowly increasing from AGS to SPS to RHIC**

Basics of Hydrodynamics

Hydrodynamic Equations

$$\partial_\mu T^{\mu\nu} = 0,$$ Energy-momentum conservation

$$\partial_\mu n_i^\mu = 0$$ Charge conservations (baryon, strangeness, etc…)

For perfect fluids (neglecting viscosity),

$$T^{\mu\nu} = (e + P)u^\mu u^\nu - P g^{\mu\nu}$$

Energy density | Pressure | 4-velocity

Need equation of state (EoS)

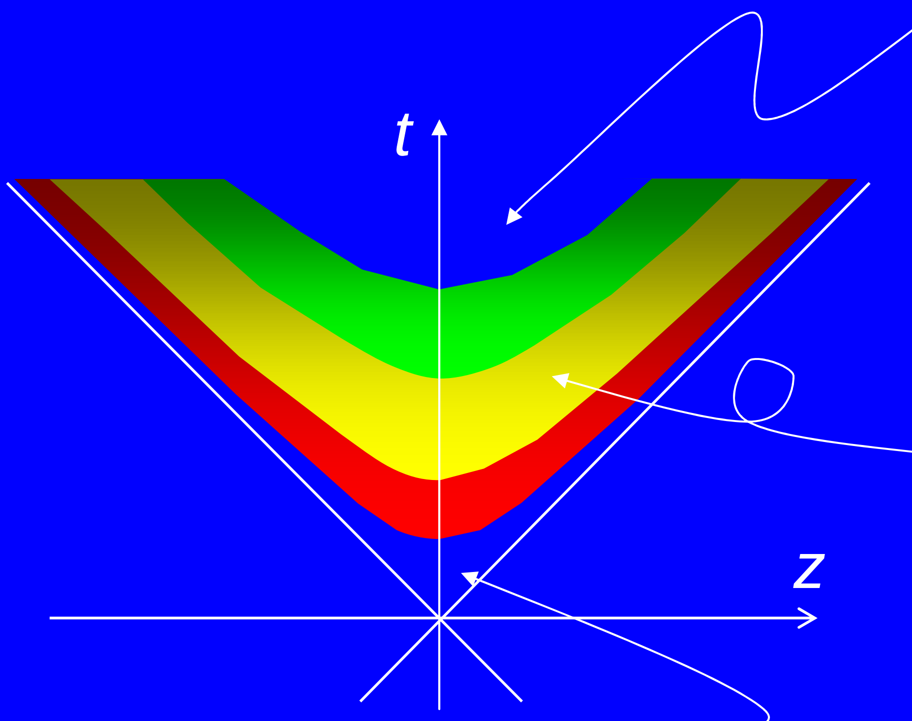
$P(e, n_B)$

to close the system of eqs.
→ Hydro can be connected directly with lattice QCD

Within ideal hydrodynamics, pressure gradient *dP/dx* is the driving force of collective flow.
→ Collective flow is believed to reflect information about EoS!
→ Phenomenon which connects 1st principle with experiment

Caveat: Thermalization, λ << (typical system size)

Inputs to Hydrodynamics



Final stage:
Free streaming particles
→ Need decoupling prescription

Intermediate stage:
Hydrodynamics can be valid if thermalization is achieved.
→ Need EoS

Initial stage:
Particle production and pre-thermalization beyond hydrodynamics
→Instead, initial conditions for hydro simulations

Need modeling
(1) EoS, (2) Initial cond., and (3) Decoupling