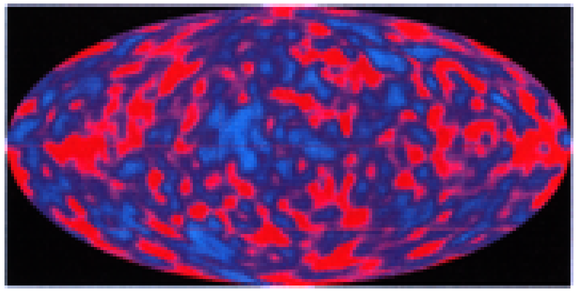
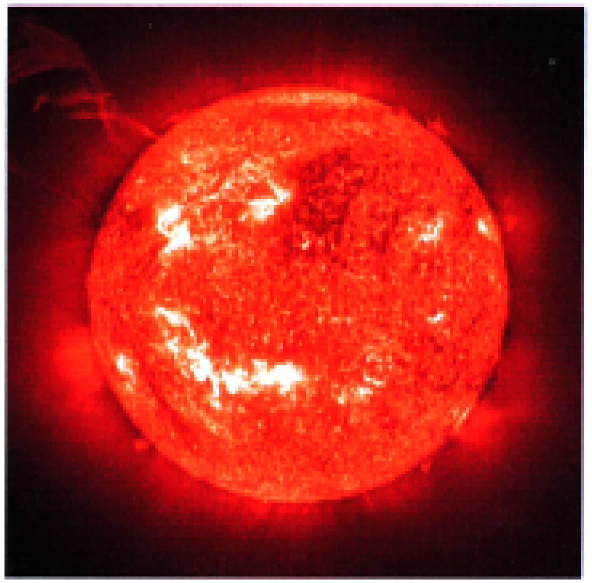
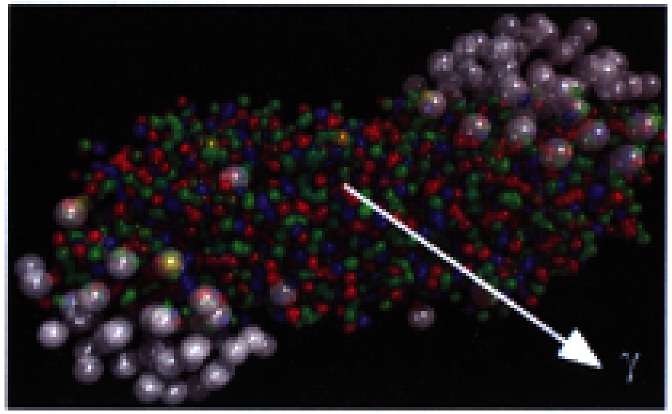
Photons and Dileptons in HICs at CERN-SPS

B. Kämpfer[a]
Forschungszentrum Rossendorf/Dresden

Universe	Sun	Heavy-Ion Collisions
$T = 2.7277$ K	$T_{\mathrm{surface}} = 6000$ K	$\langle T \rangle = 170$ MeV



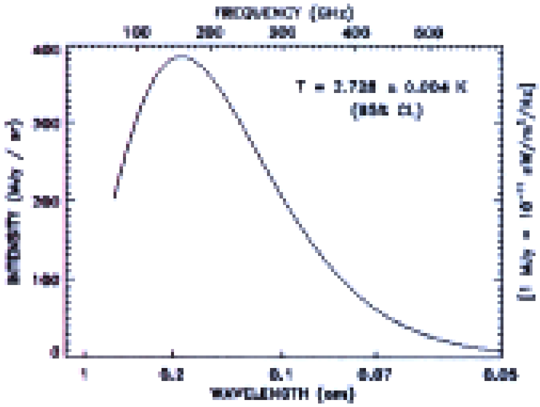


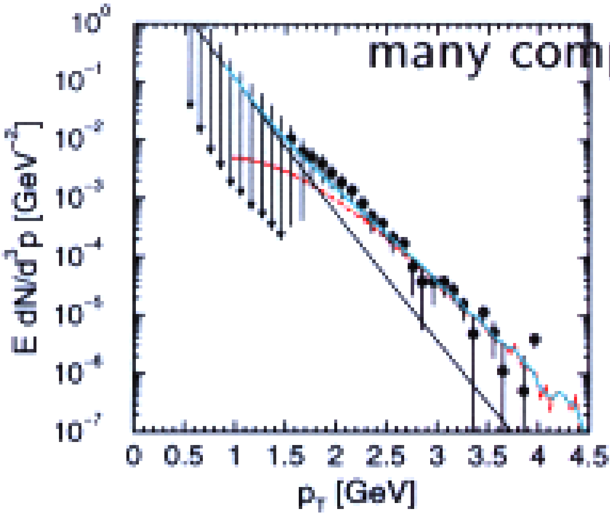


[a]supported by BMBF, with K. Gallmeister, O.P. Pavlenko, C. Gale

blackbody radiation

COBE





Goal

unique parametrization of the shape
of all secondary (= thermal) photon & dilepton spectra
in central HICs at CERN-SPS

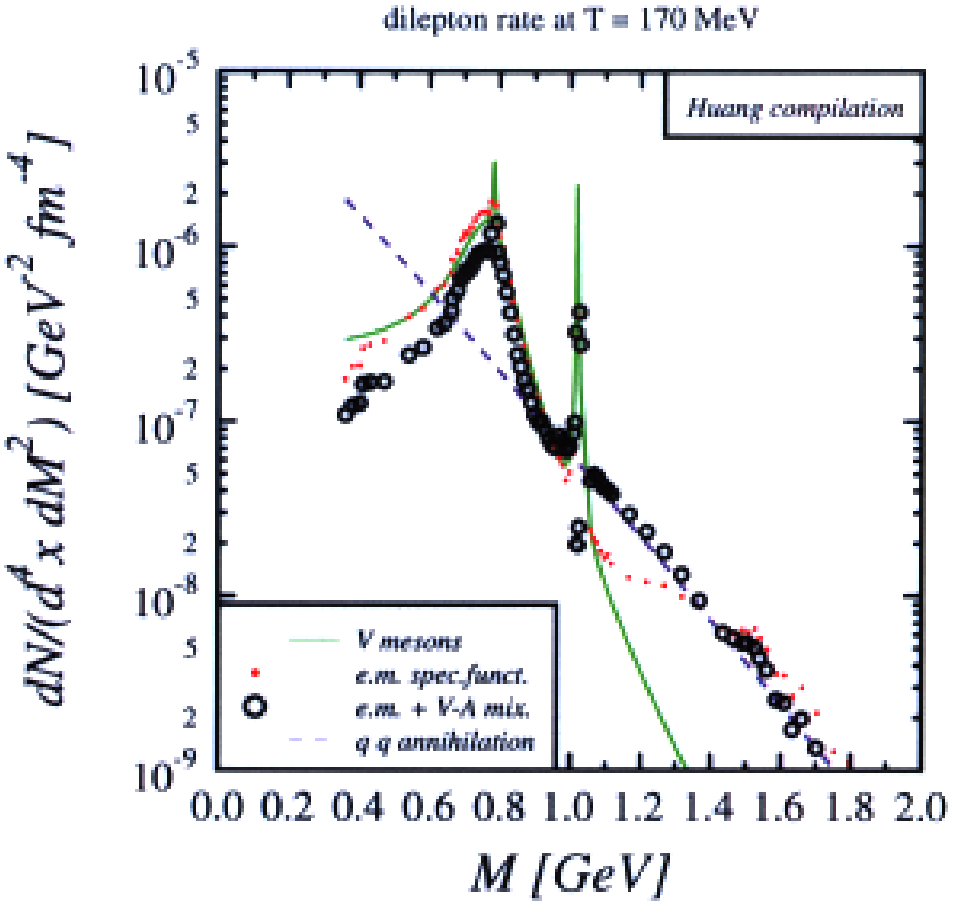
emissivity of matter:

photons: $\frac{dN}{d^4x d^4q}\Big|_{\mathrm{hadrons}} \approx \frac{dN}{d^4x d^4q}\Big|^{l.o.}_{\mathrm{QGP}}$ Kapusta et al. vs. Aurenche, Kobes et al.

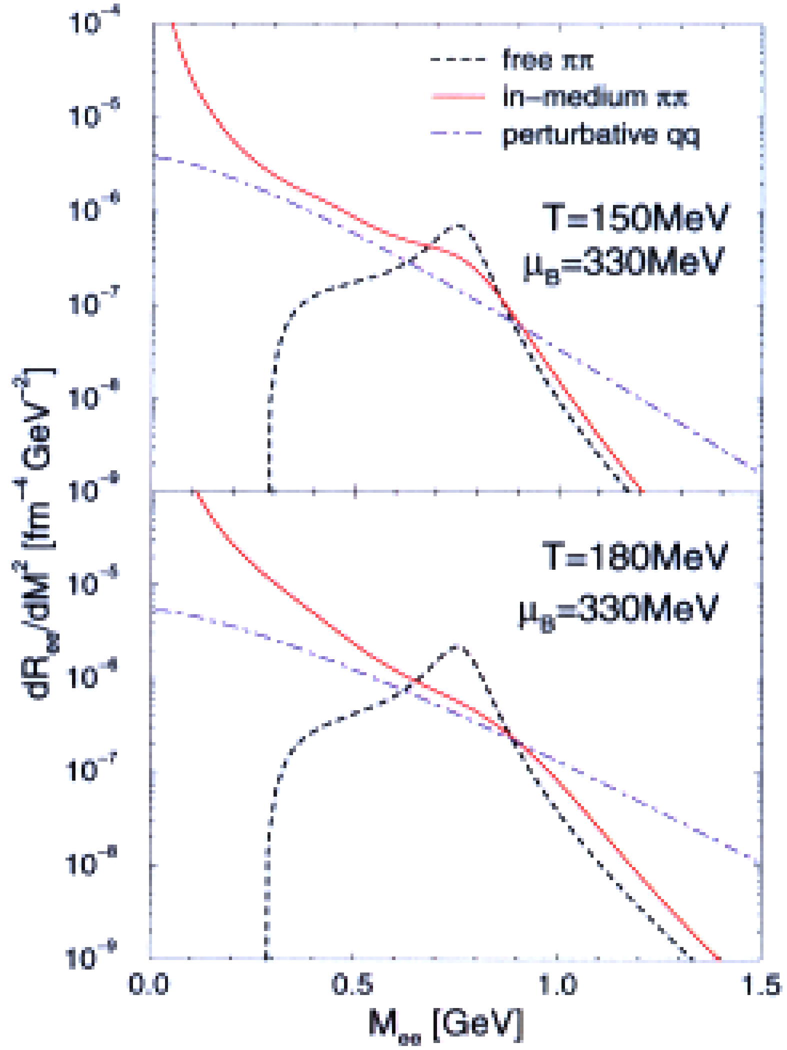
$T \sim 170$ MeV

dileptons: $\frac{dN}{d^4x d^4Q}\Big|_{\mathrm{hadrons}} \approx \frac{dN}{d^4x d^4Q}\Big|^{l.o.}_{\mathrm{QGP}}$ "duality"

e.m. signals probe e.m. current



Huang compilation



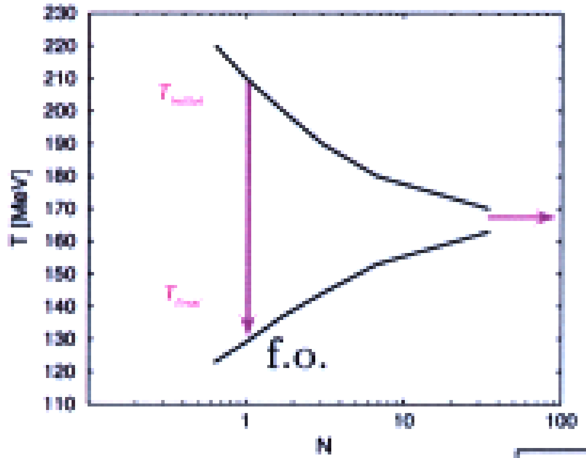
Rapp, Wambach

1. Lead beam experiments at CERN:

Analyses of e^+e^-, $\mu^+\mu^-$, γ spectra

$\frac{dN_{\gamma *}}{d^4x d^4Q} \propto \exp\left\{-\frac{Q\cdot u}{T}\right\}$, $\quad E\frac{dN_\gamma}{d^4x\, d^3q} \propto T^2 \exp\left\{-\frac{q\cdot u}{T}\right\} \log\left[1+\frac{\kappa(q\cdot u)}{\alpha_s T}\right]$, $\quad$ flow!

$T(t)$, $V(t)$ à la Rapp, Chanfray, Wambach & Klingl, Weise:

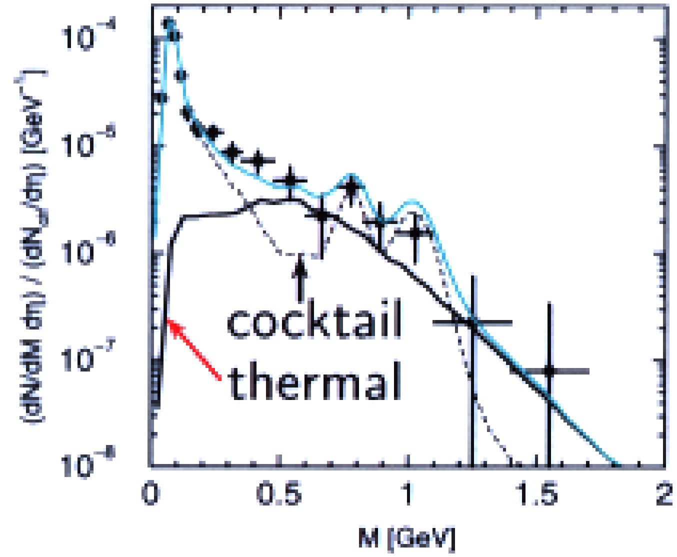


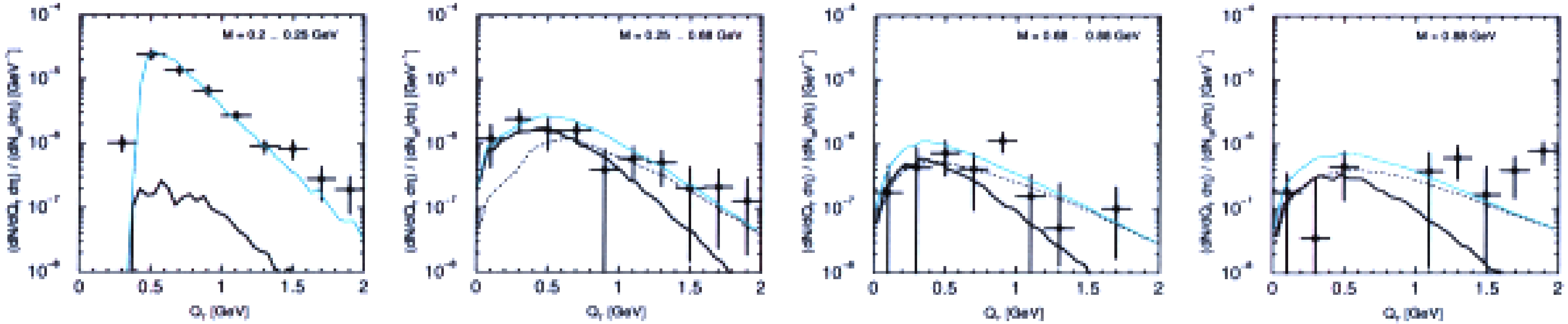
CERES + NA50 data
parametrized by $T_{\rm eff}$, $N_{\rm eff}$
(like hadron spectra)

$u \to \langle u \rangle$, $T \to \langle T \rangle$, $\int dt\, d^3x \to N_{\rm eff}$

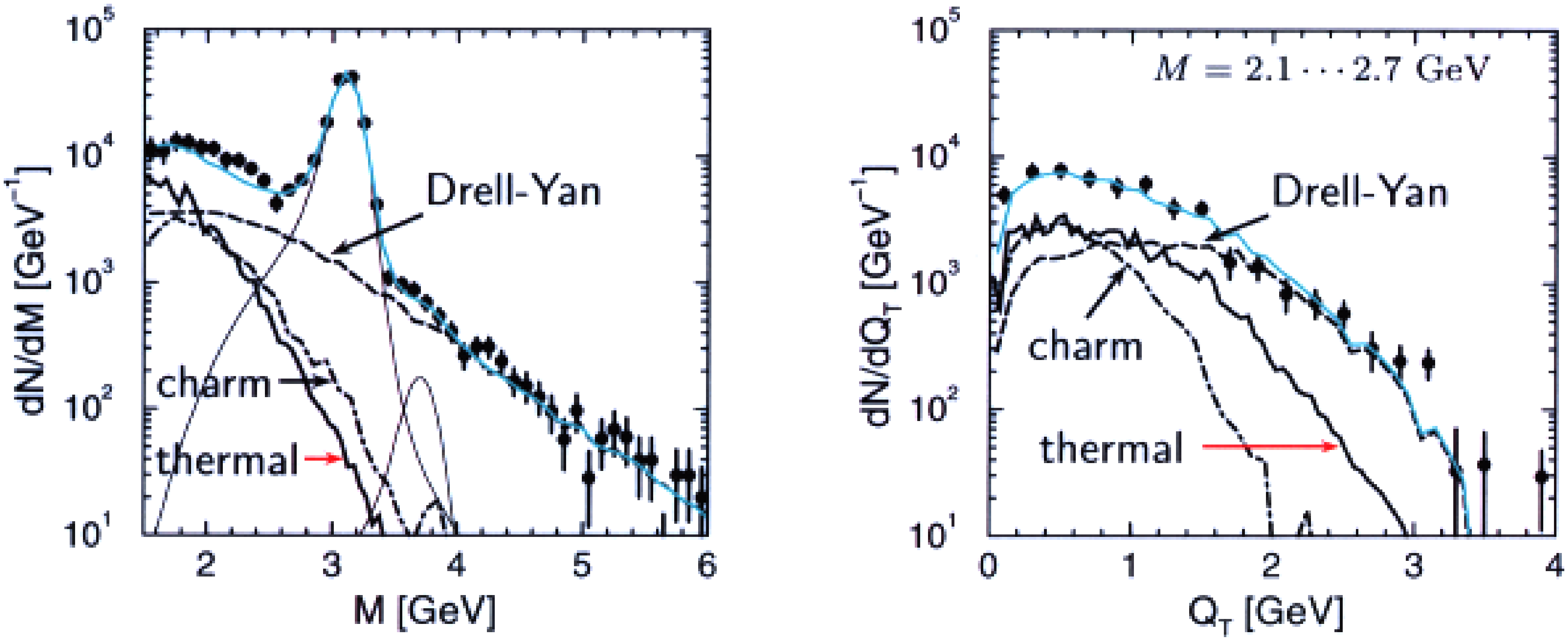
$\frac{dN_{\gamma *}}{d^4Q} \propto N_{\rm eff} \exp\left\{-\frac{M_\perp \cosh(Y-Y_{\rm cms})}{T_{\rm eff}}\right\}$, $\quad E\frac{dN_\gamma}{d^3q} \propto N_{\rm eff}\int \cdots \exp\left\{-\frac{q_\perp \cosh y}{T_{\rm eff}} \ldots\right\}$

CERES: central Pb(158 AGeV) + Au $\to X + e^+e^-$





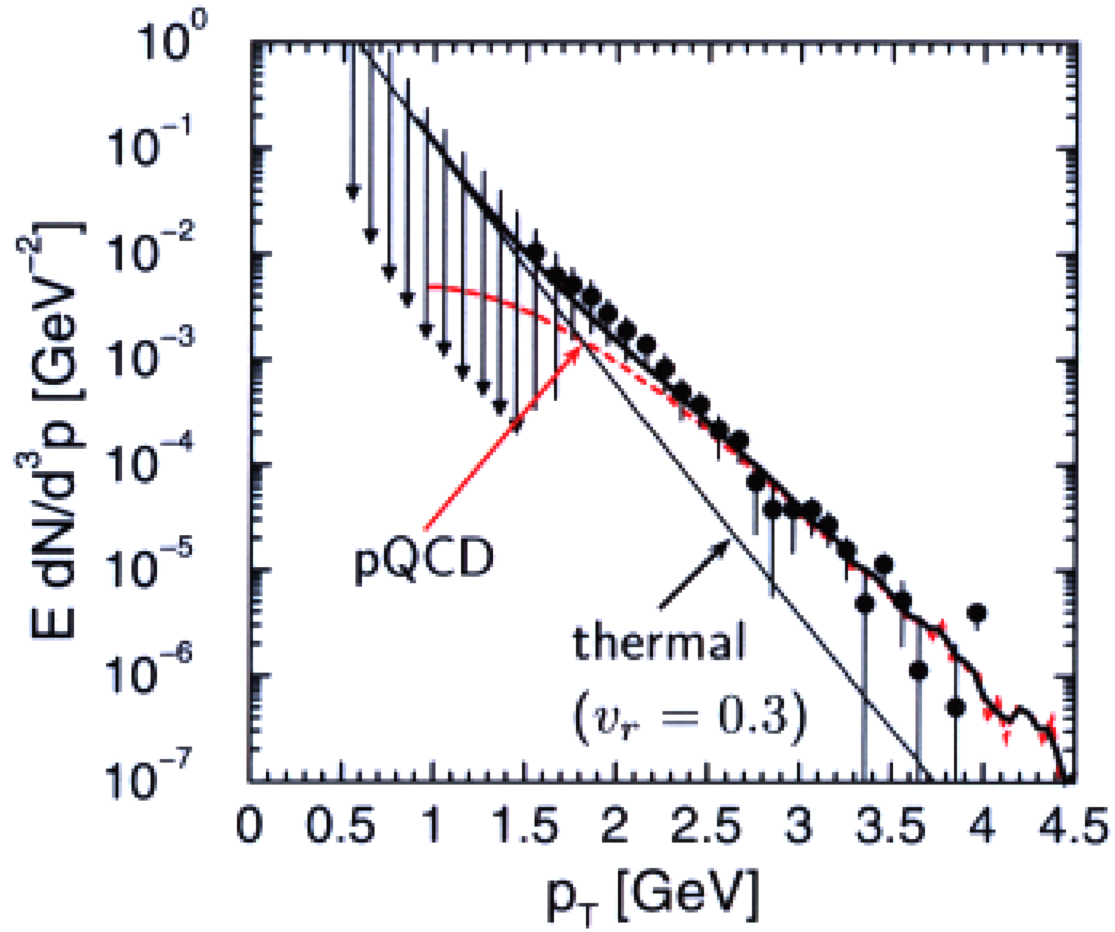
NA50: central Pb(158 AGeV) + Pb $\rightarrow X + \mu^+\mu^-$



no charm enhancement needed

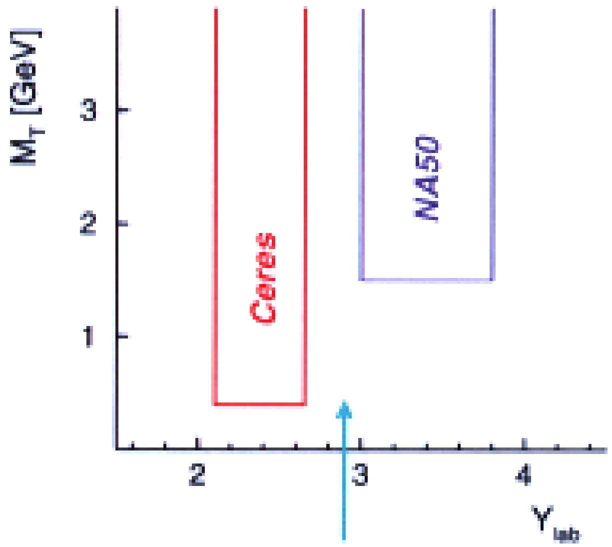
flow

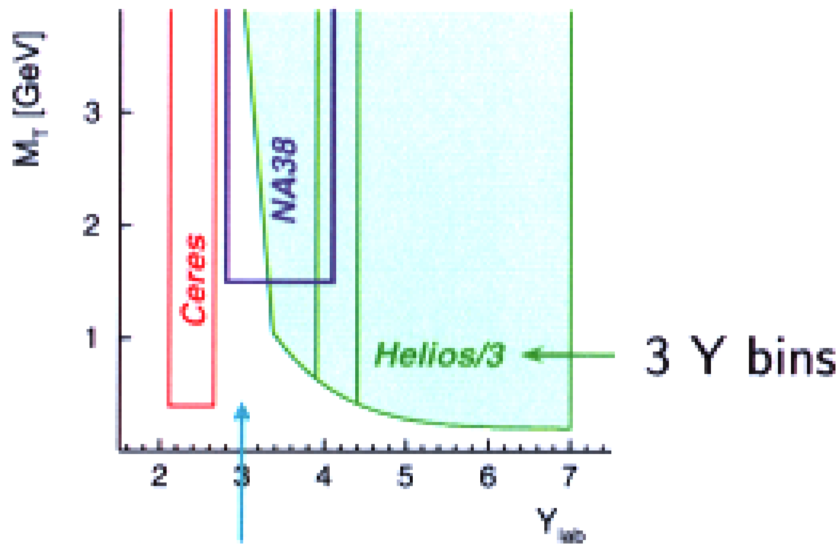
WA98: central Pb(158 AGeV) + Pb $\to X + \gamma$

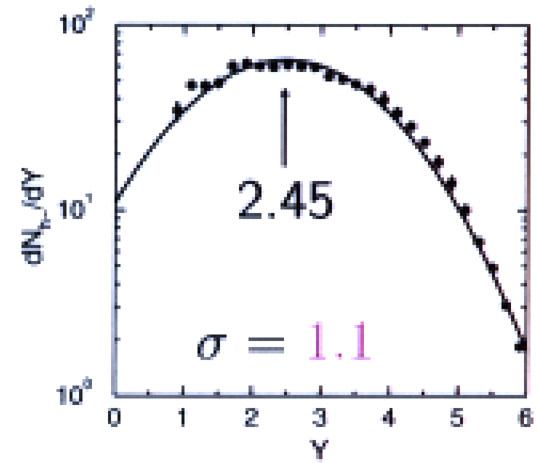


CERES + NA50 + WA98: $\langle T \rangle = 170$ MeV $\quad N_{\rm eff} = \int dt V(t) = 3.3 \times 10^4$ fm^4

2. Sulfur beam experiments at CERN:



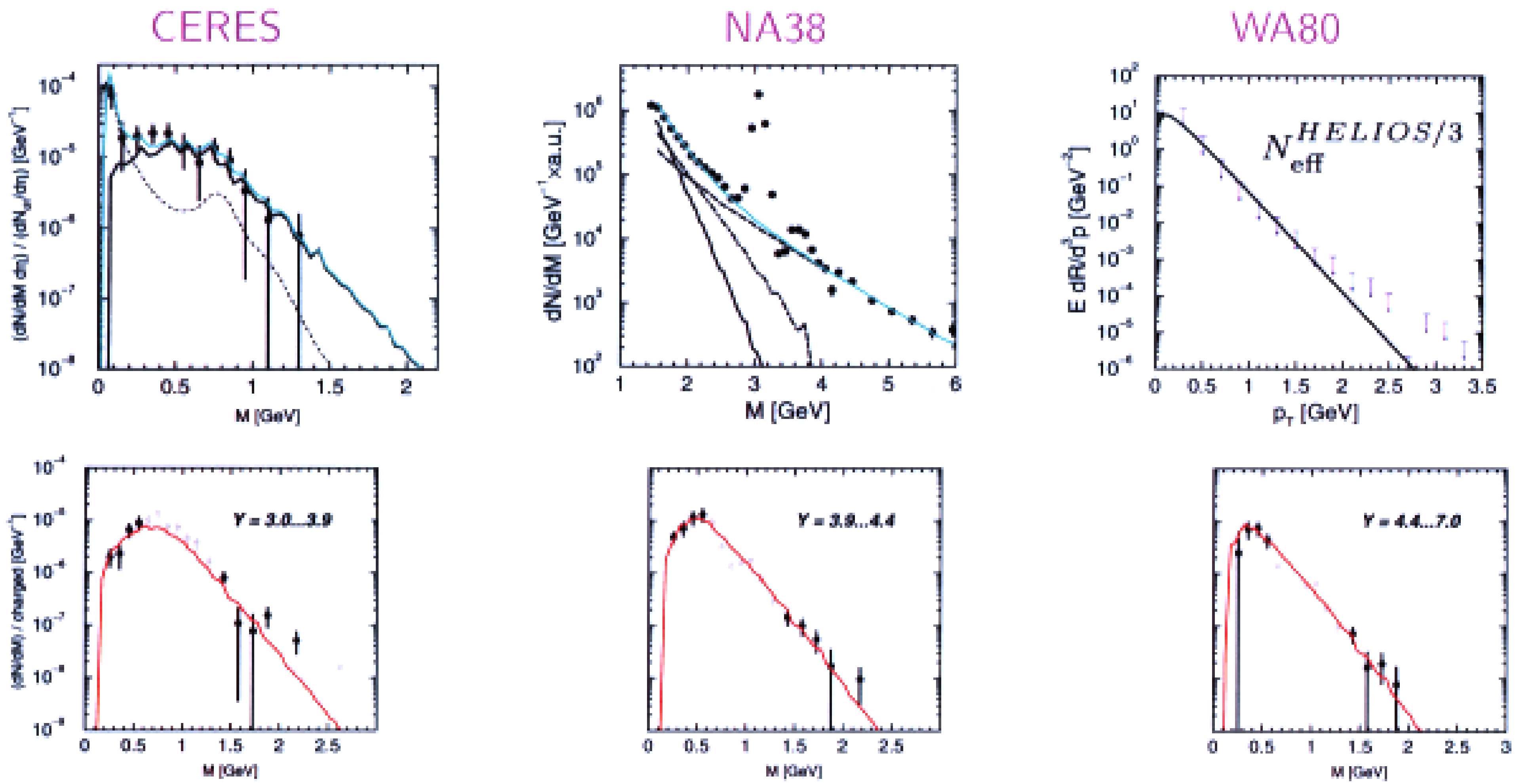




NA35, h^-

Gaussian smearing of thermal source: $\sigma = 0.8$

Analyses of e^+e^-, $\mu^+\mu^-$, γ spectra

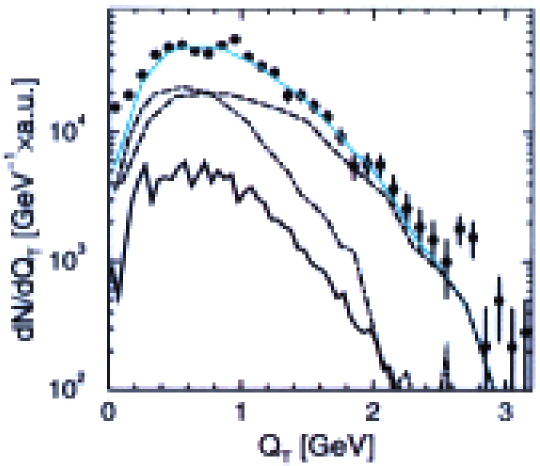


3 × HELIOS/3 ([S + W] - [p + W])

different $N_{\rm eff}$ for CERES, NA38, HELIOS/3

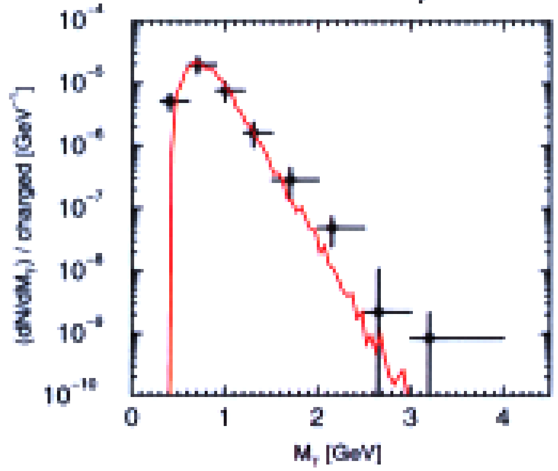
$Q_\perp$, $M_\perp$ spectra

NA38



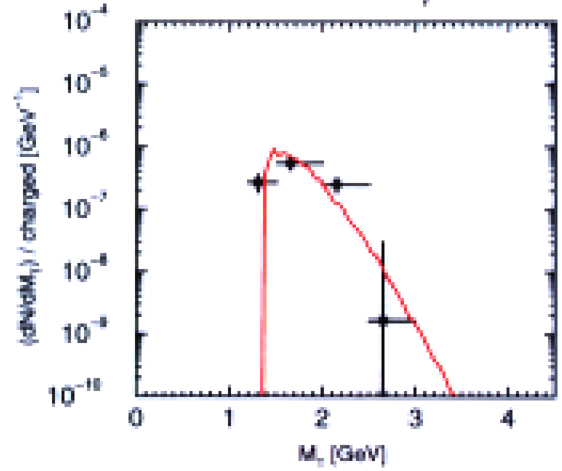
$M = 2.1 - 2.7$ GeV

HELIOS/3



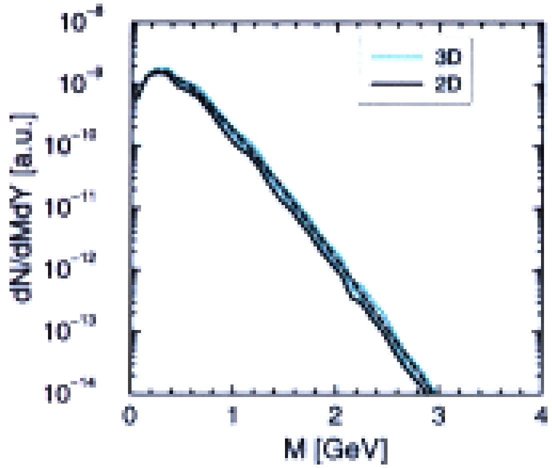
$M = 0.2 - 0.6$ GeV

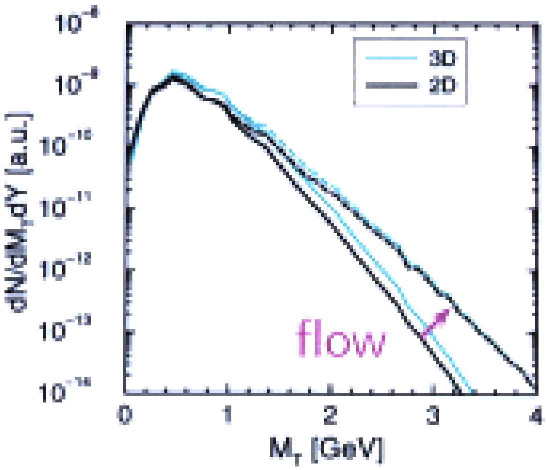
HELIOS/3



$M = 1.35 - 2.2$ GeV

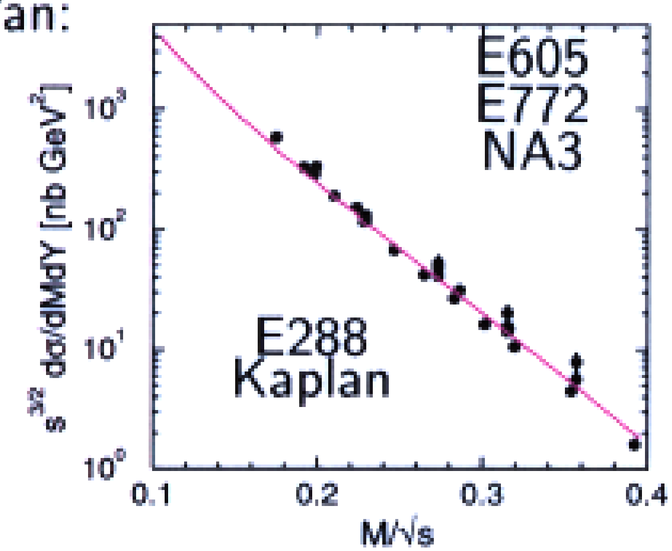
transverse flow effects

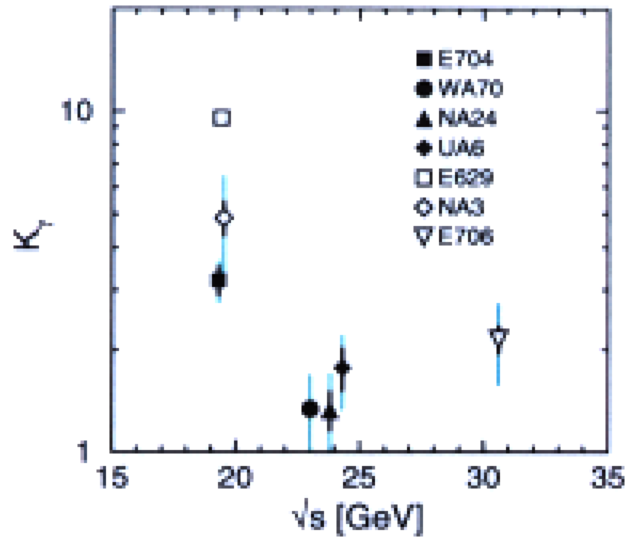




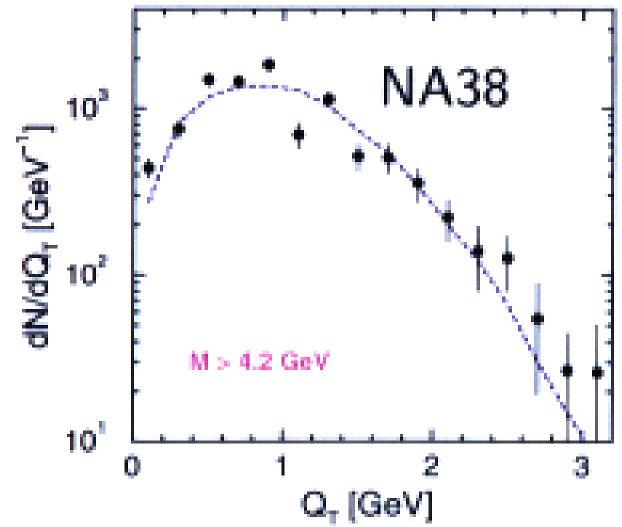
A tragedy: "hard" background from PYTHIA

1. Drell-Yan:





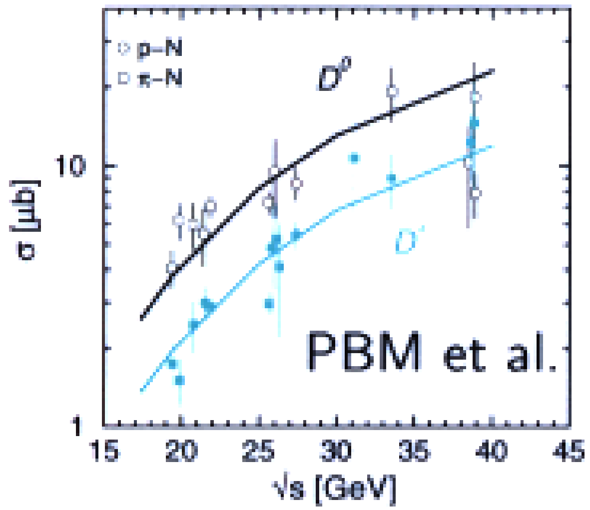
$\mathcal{K} = 1.5$

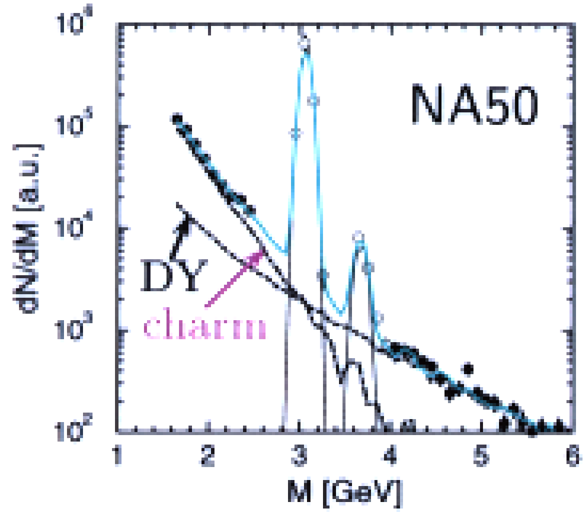


$\sqrt{\langle k_\perp^2 \rangle} = 0.8$ GeV

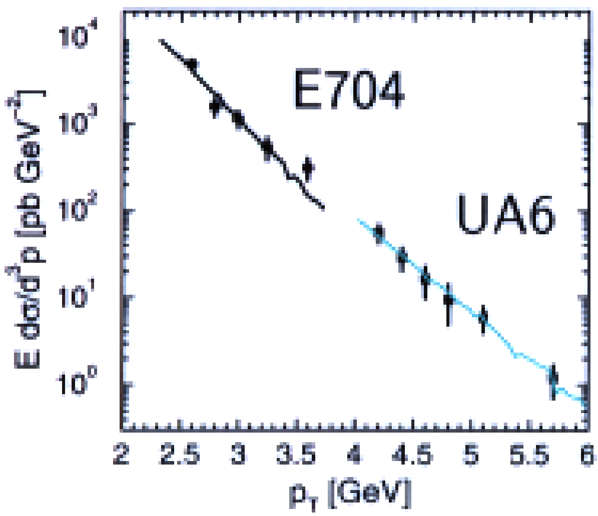
2. open charm: $\mathcal{K} = 5.7$

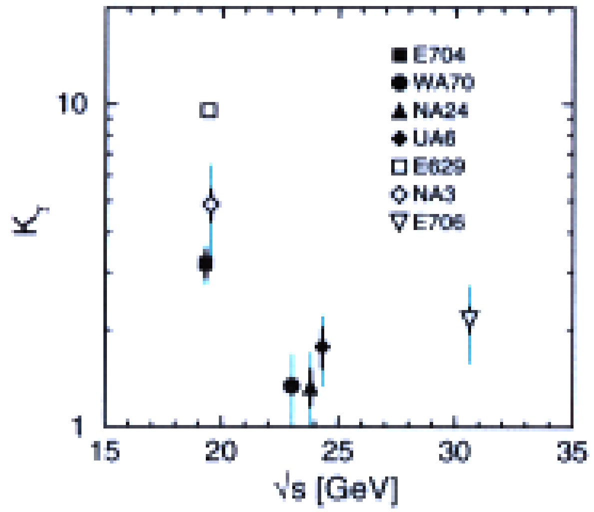
$p(450\ \mathrm{GeV}) + W \rightarrow X + \mu^+\mu^-$





3. direct photons: $\mathcal{K} = ?$





Conclusions

1. $q\bar{q}$ annihilation spectrum is enough for shape of thermal dilepton source
2. l.o. rates also enough for shape of thermal photon source
3. $\langle T \rangle = 170$ MeV for CERES$_{\mathrm{Pb,S}}$, NA50, NA38, HELIOS/3, WA98, WA80
   $\Longrightarrow$ we are at phase boundary, $\langle T \rangle = T_{\mathrm{hadro-chemistry}}$
4. model for $T(t)$, $V(t) \Longrightarrow T_i \approx 210$ MeV
   $\Longrightarrow$ we are beyond phase boundary
5. N_{eff} : unique large & long living thermal source for CERES$_{\mathrm{Pb}}$, NA50, WA98
6. different N_{eff} for CERES$_{\mathrm{S}}$, NA38, HELIOS/3, WA80
   $\Longrightarrow$ different rapidity distribution?
7. background estimates = ? $\Longleftarrow$ NA60 charm
8. no substitute of detailed dynamical models (hydro, transport)