Can Extended Duality Uniquely Explain All Dilepton Data in HICs at SPS?

B. Kämpfer[a]

Forschungszentrum Rossendorf/Dresden

Ingredients: (hypotheses)

1. HICs @ CERN-SPS $\Longrightarrow$ fireball $V, T, \mu_i; \tau$: $\langle T \rangle \approx T_c \sim \mathcal{O}(m_\pi)$

2. extended duality $\Longrightarrow$ $\frac{dN_{l\bar{l}}(T,\cdots)}{d^4Q\, d^4x}\Big|_{\mathrm{matter}} \approx \frac{dN_{l\bar{l}}(T,\cdots)}{d^4Q\, d^4x}\Big|_{\mathrm{q\bar{q}}}$

3. all non-thermal sources are known:

$$\frac{dN_{l\bar{l}}}{d\cdots}\Big|_{\mathrm{data}} = \left\{ \frac{dN_{l\bar{l}}(T,\cdots)}{d\cdots}\Big|^{V(t),T(t)}_{\mathrm{matter}} + \sum\nolimits_{\mathrm{b.g.}} \frac{dN_{l\bar{l}}}{d\cdots}\Big|_{\mathrm{b.g.}} \right\}_{\mathrm{filter}}$$

b.g. $=$ hadronic cocktail, charm, Drell-Yan $\longrightarrow$ M

(CERES) (PYTHIA)$_{pp \to AB}$

4. data $+$ filter are correctly dealt with

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

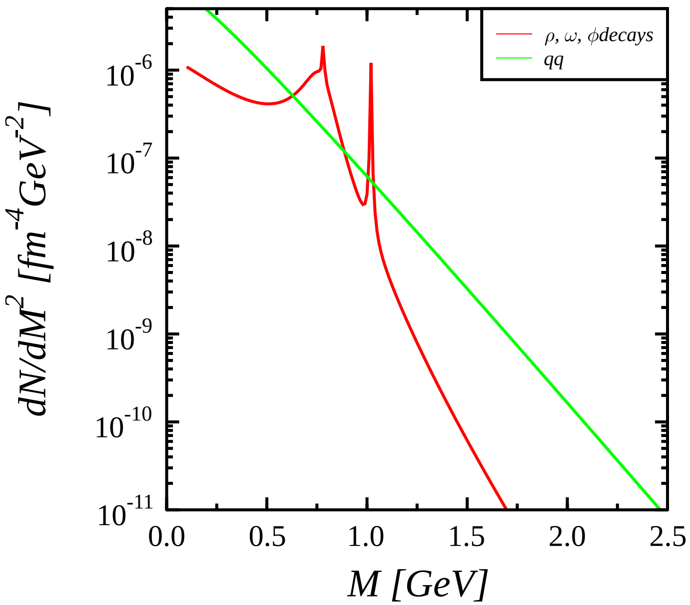
Extended Duality

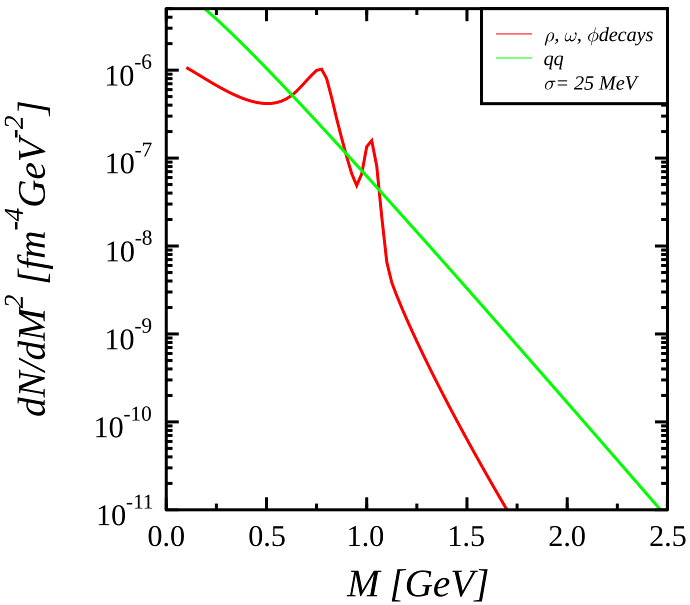
$=$ reshuffling of strength $=$ disappearence of vector mesons / vector meson signals

. *"no hadrons in matter"*

reason: $\langle T \rangle \sim T_c$: chiral symmetry restoration: $\langle \bar{\psi} \psi \rangle \to 0$

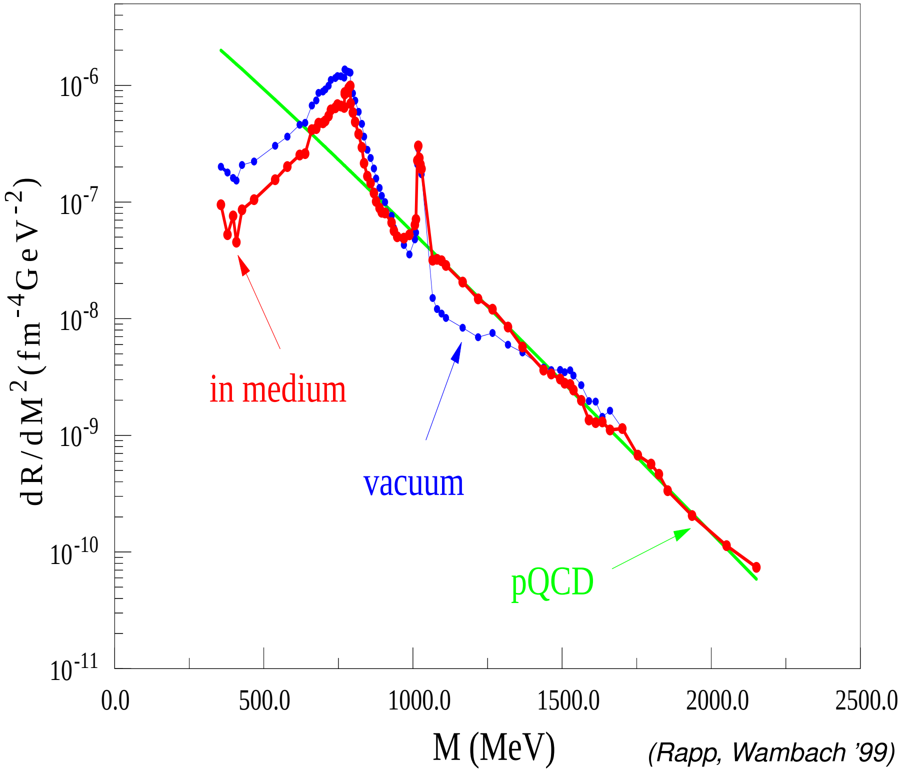
$\Longrightarrow$ reshaping of low-lying hadron spectrum





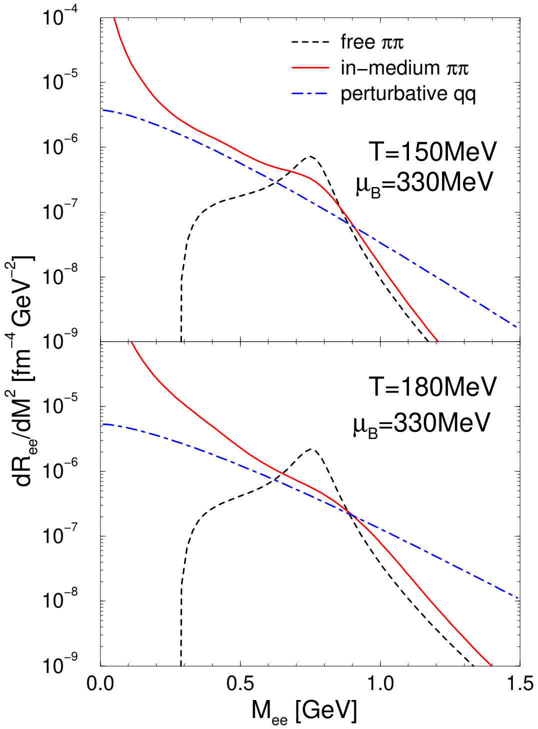
Duality & χ symmetry restoration

1.: mixing of V and A :



(Rapp, Wambach '99)

2.: change of ρ Propagator :



(Rapp, Wambach '99)

use $q\bar{q}$ down to $\sim$ 0.2 GeV

Unique Description of Lead Beam Dilepton Data

no space-time resolution $\to$ parametrize thermal source by a flash:

$$\frac{dN}{p_{\perp 1}\, dp_{\perp 1}\, p_{\perp 2}\, dp_{\perp 2} dy_1\, dy_2\, d\phi_1\, d\phi_2} = \frac{5\alpha^2}{72\pi^5} N_{\rm eff} \exp\left\{ - \frac{M_\perp \cosh(Y - Y_{cms})}{T_{\rm eff}} \right\}$$

$$\equiv \frac{dN}{d\cdots}\Big|_{q\bar{q}}$$

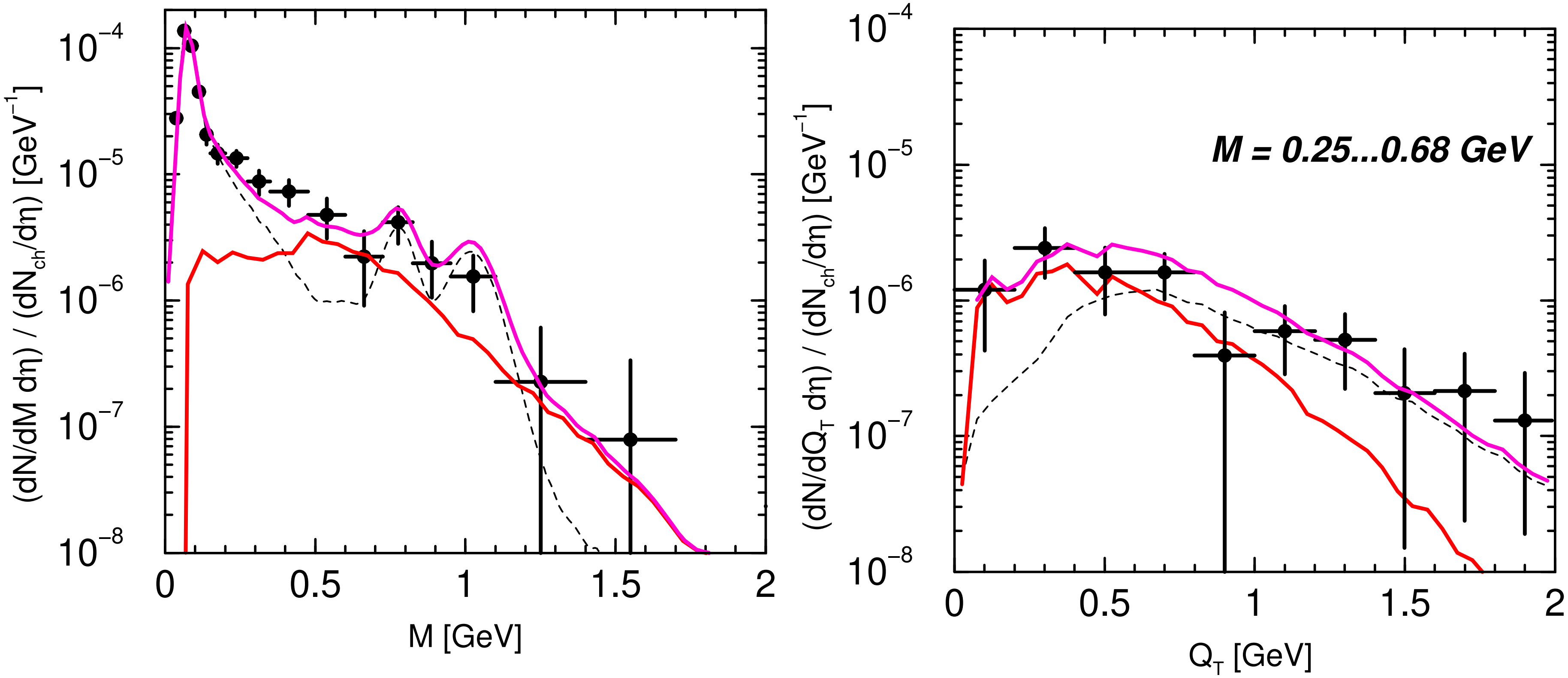
$$\{M, M_\perp, Q_\perp, Y\}(p_{\perp 1,2}, y_{1,2}, \phi_{1,2})$$

$T_{\rm eff} = \langle T \rangle$, $\quad N_{\rm eff} = \int dt\, V(t) \Longrightarrow$ two-number problem

1. fit CERES'96 data: $N_{\rm eff} = 3.3 \times 10^4$ fm^4, $\quad T_{\rm eff} = 170$ MeV

use $\frac{dN_{ch}}{d\eta} = 250$ + CERES cocktail

CERES: Thermal Source



K. Gallmeister FZ Rossendorf

2. describe NA50 data: same $N_{\mathrm{eff}}, T_{\mathrm{eff}}$, $\quad dN = 31\mathrm{mb}^{-1}\, d\sigma^{pp}_{PYTHIA}$

(i) NA50: "data" $=$ DY $+ 3 \times$ open charm

$q\bar{q} \to l\bar{l}$

$gg \to c\bar{c} \to D\bar{D} \to lX\,\bar{l}X'$

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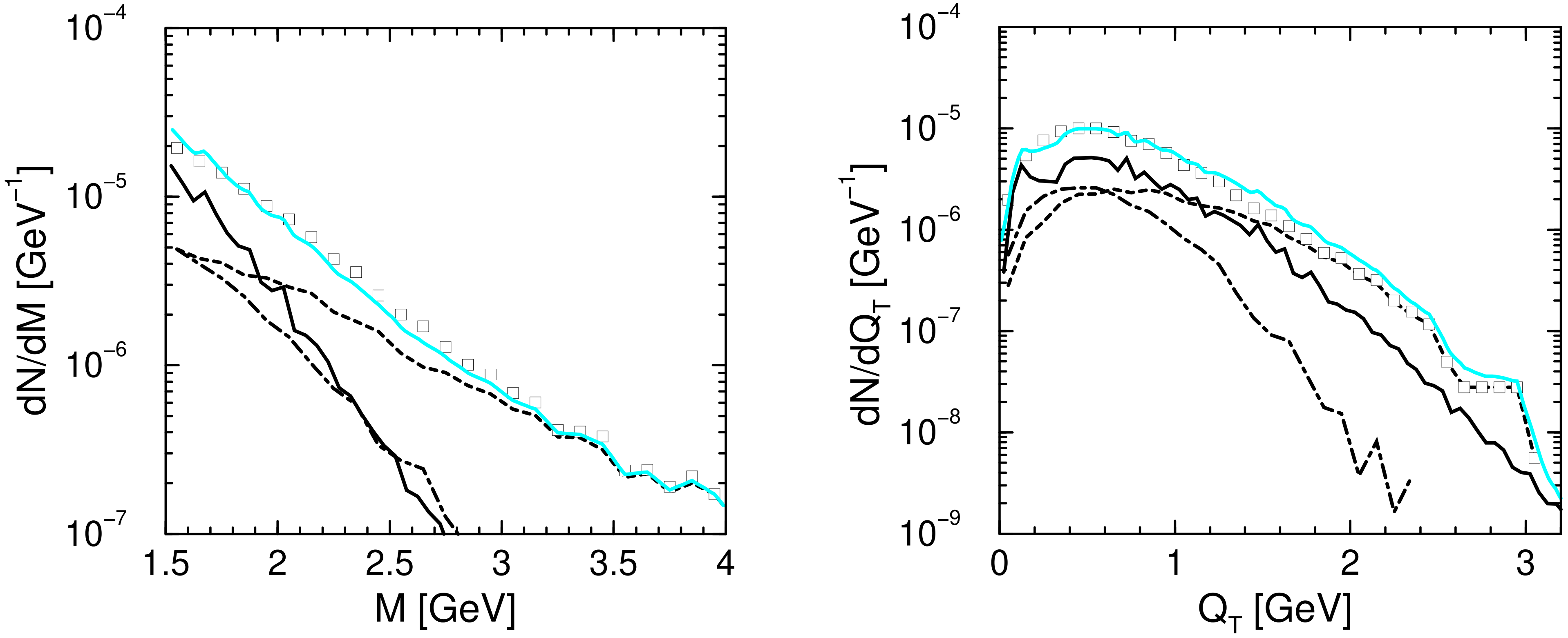
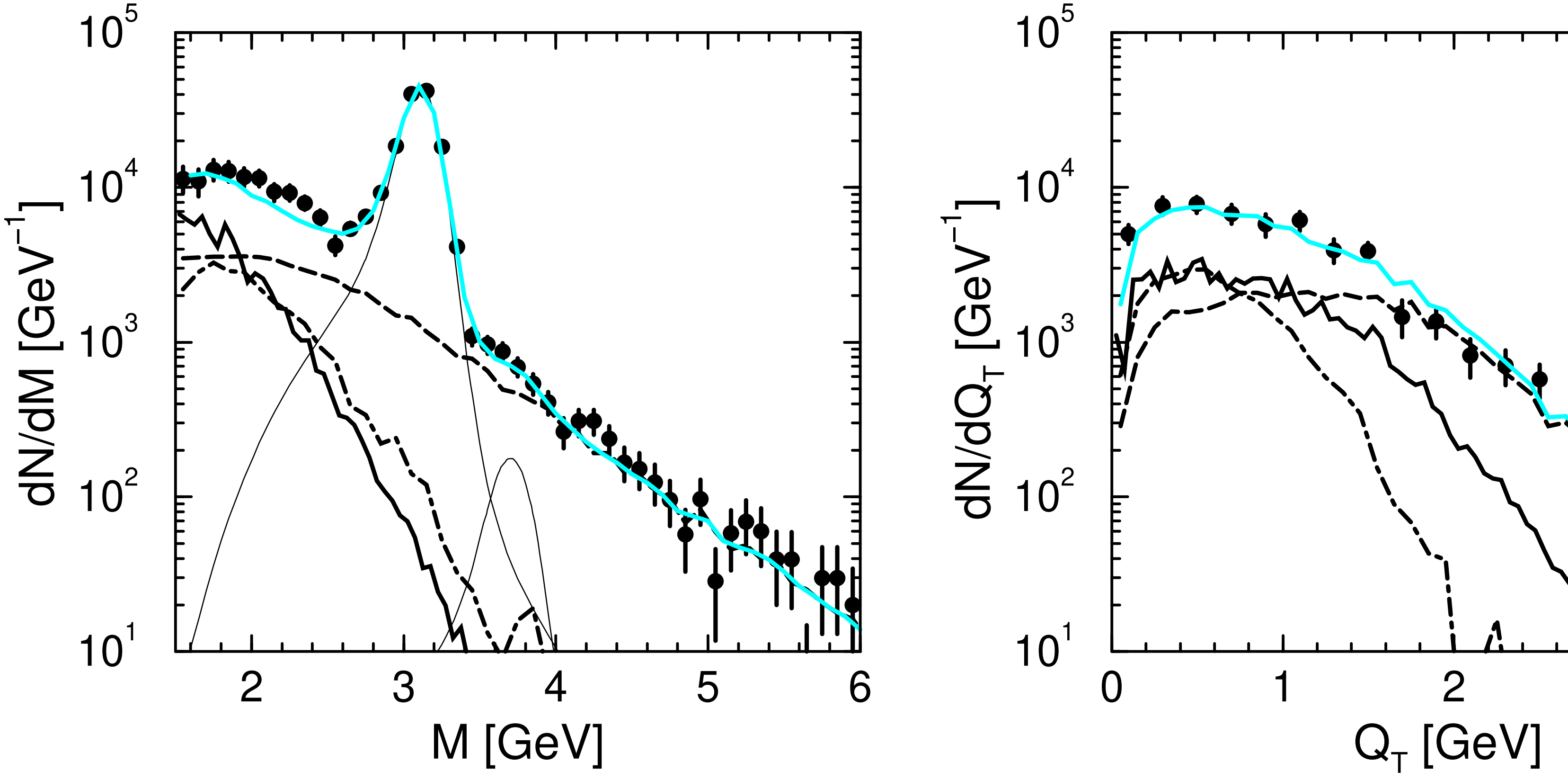
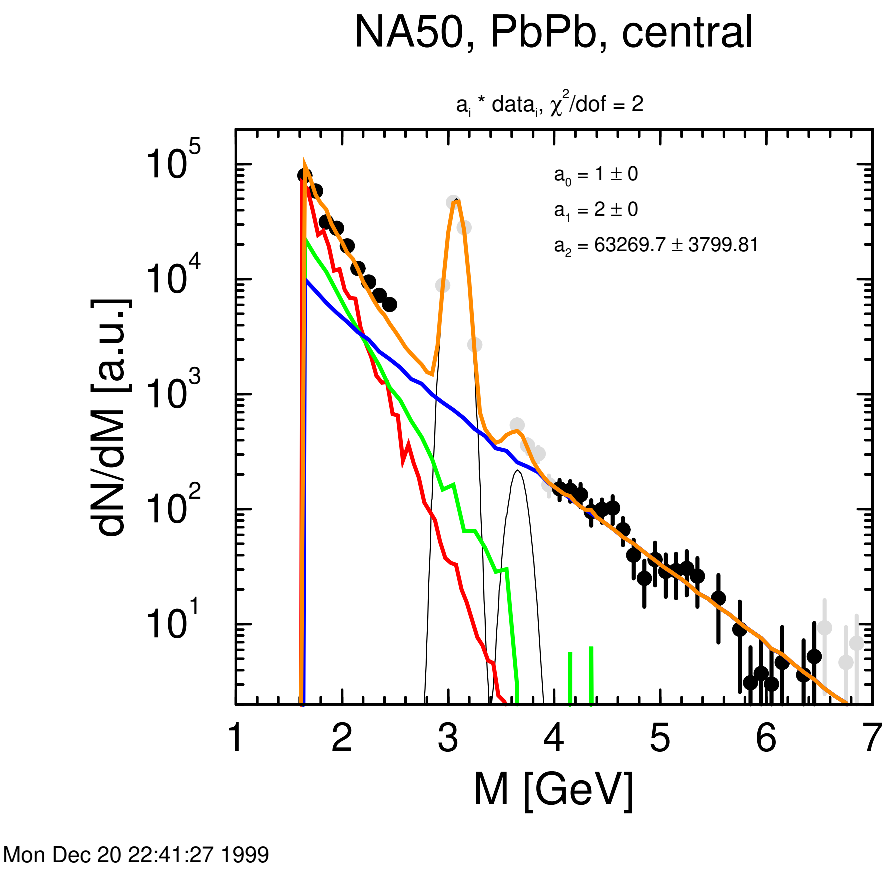
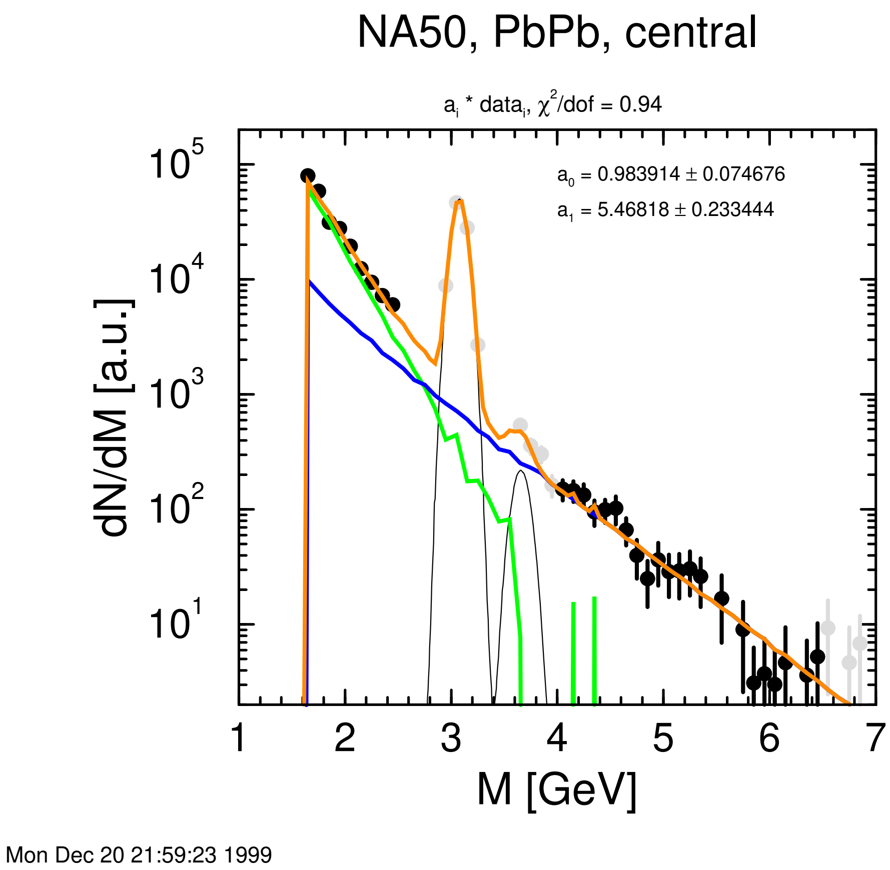


(ii) approximate NA50 acceptance (à la R. Rapp)



(iii) use unfolded data (Dec. 1999)





. thermal source vs. charm enhancement

Understanding of Background

1. cocktail: CERES-given

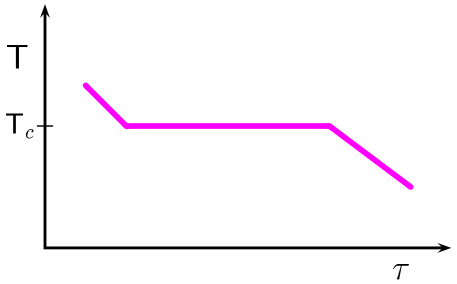
2. Drell-Yan: $\mathcal{K}_{DY} = 1.2$ from dilepton data pN
   $\langle k_\perp^2 \rangle = (0.9\,\mathrm{GeV})^2$ from NA38/50 data

3. open charm: from hadronic channels $\to \bar{\mathcal{K}}_c = 4$
   insensitive against $\langle k_\perp^2 \rangle$
   part. confirmation by NA50 p(450 GeV) + W data $\mu^+\mu^-$
   (increase by factor 1.2?)

Dynamical Models

question: $T_{\rm eff}$, $N_{\rm eff} = \int dt\, V(t) \sim 2V_{Pb} \times 10$ fm/c = reasonable?

1. poor man's model: ($\sim$ bag model EoS)



B.K., O.P. Pavlenko, Phys. Lett. B255 (1991) 503:

spectrum is determined by T_c alone

(contributions from $T > T_c$ and $T < T_c$ are negligible)

rad. exp. fireball: $V(t) = \frac{4\pi}{3}(R_0 + \langle v \rangle\, t)^3$

$$R_0 = 6.4 \text{ fm}, \quad \langle v \rangle = 0.5, \quad \Delta t = 10 \text{ fm/c} \Longrightarrow N_{\rm eff}$$

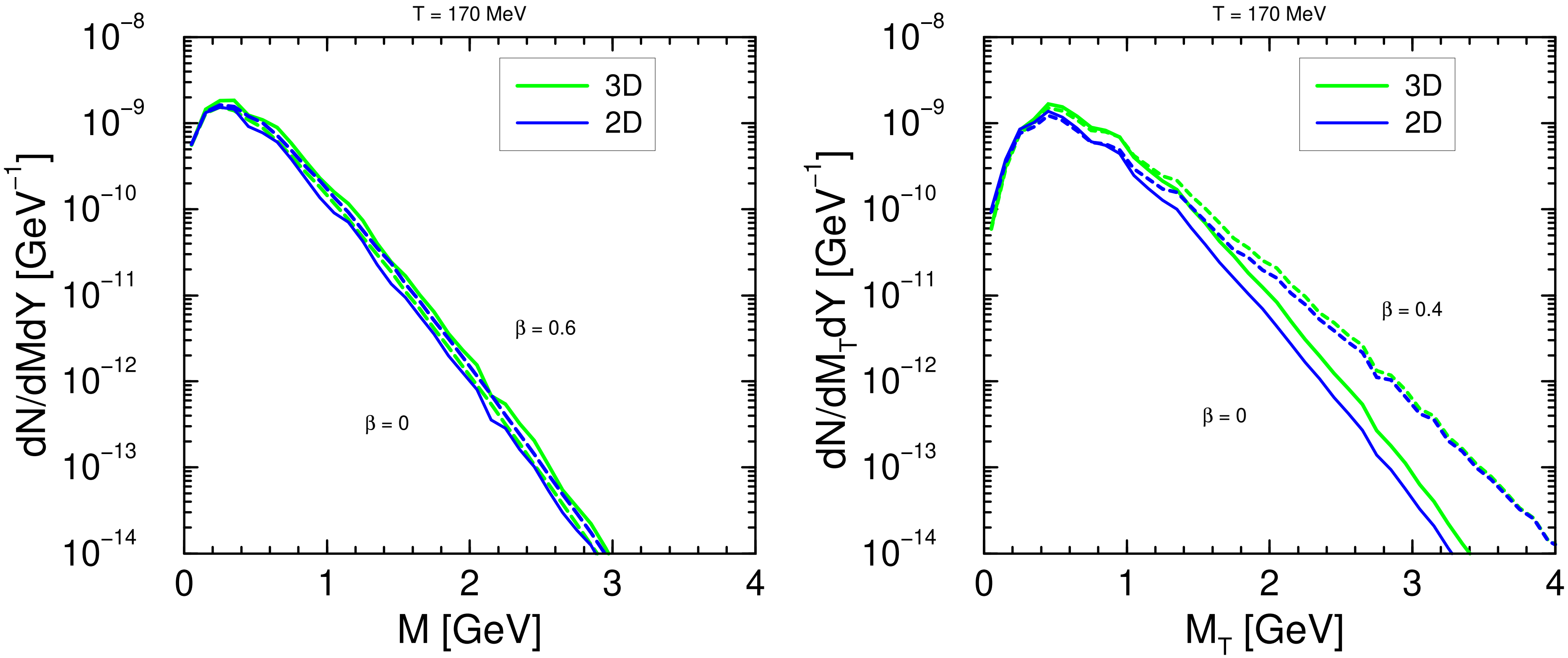
somewhat too large values, but Rapp/Wambach: $\mu_{\pi,K} > 0$ enlarge rate

2. flow: expansion $\longleftrightarrow$ flow

Lorentz - inv. $\Longrightarrow \frac{dN}{d^4Q\, d^4x} \propto \exp\left\{ -\frac{u(x)\cdot Q}{T(x)} \right\} \neq \exp\left\{ -\frac{Q_0}{T(x)} \right\}$

Jüttner Boltzmann (Bose/Dirac)

$\perp$ flow is constrained by hadron $m_\perp$ spectra



$\sum$: luckely, a "static" source is enough: $V(t)$, $T(t)$

3. certain parametrizations: from transport/hydro codes, e.g.

$$
\begin{aligned}
T &= (T_i - T_\infty) \exp\left\{ -\frac{t}{t_2} \right\} + T_\infty , \\
V &= \frac{A+B}{2.5 n_0} \exp\left\{ \frac{t}{t_1} \right\} .
\end{aligned}
$$

T_i	T_∞	T_f	t_1	t_2	n_0
210 MeV	110 MeV	130 MeV	5 fm/c	8 fm/c	0.17 fm^{-3}

EoS, entropy?

or: ansatz for $V(t)$ + entropy, baryon, pion/kaon number conservation
$\rightarrow$ Rapp/Wambach/Shuryak (check flow & consistency with hadron spectra!)

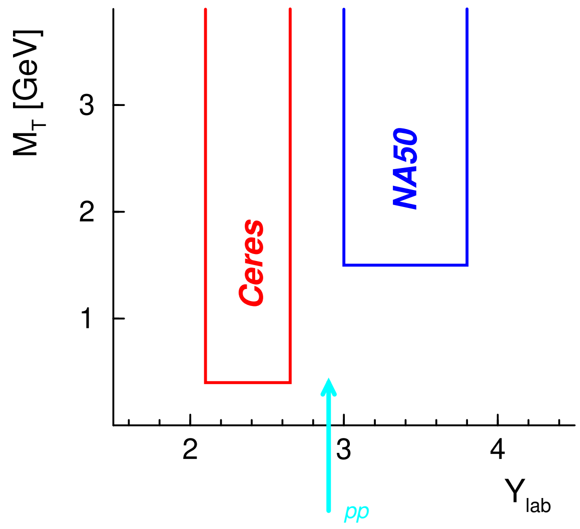
$\rightarrow$ no improvement of data description, but understanding of parameters

future plans: E_T dependence of the thermal source/open charm (NA50 data)

Phase Space Coverage

lead beam:

158 AGeV



CERES & NA50

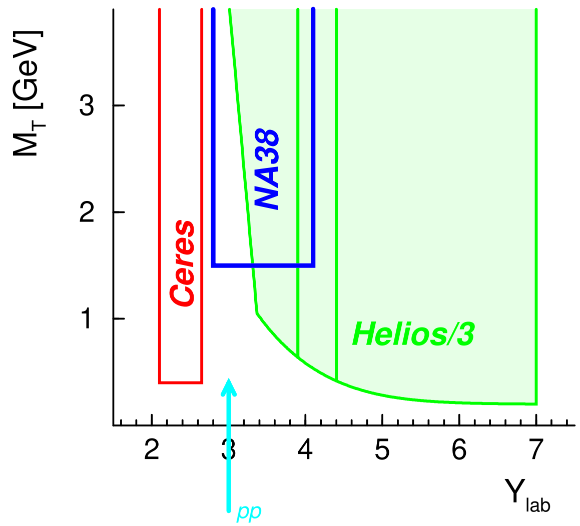
$\approx$ symmetric around y_{cms}^{pp}

Pb + Au, Pb $\approx$ symmetric around y_{cms}^{pp}

$\rightarrow$ fireball centered at y_{cms}^{pp}

sulfur beam:

200 AGeV



CERES & NA38 & HELIOS-3_1

$\approx$ symmetric around y_{cms}^{pp}

S + Au, Pb = asymmetric around y_{cms}^{pp}

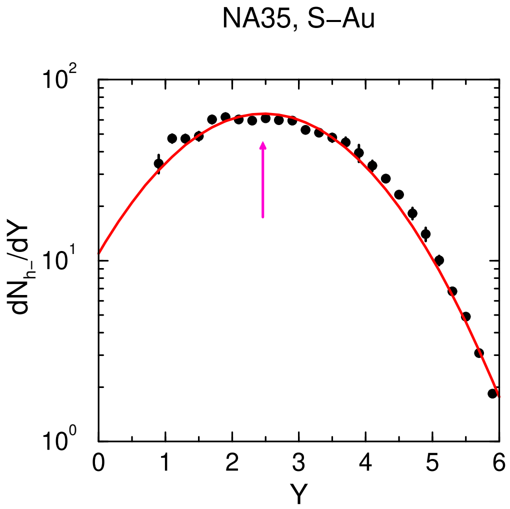
$\rightarrow$ fireball centered at ?

Sulfur Beam Data

flash parametrization by $N_{\rm eff}$, $T_{\rm eff}$

Problems: 1. very asymmetric systems, large y coverage

$\rightarrow$ Gaussian distribution $\sigma = 0.8$ (from h^- distribution)

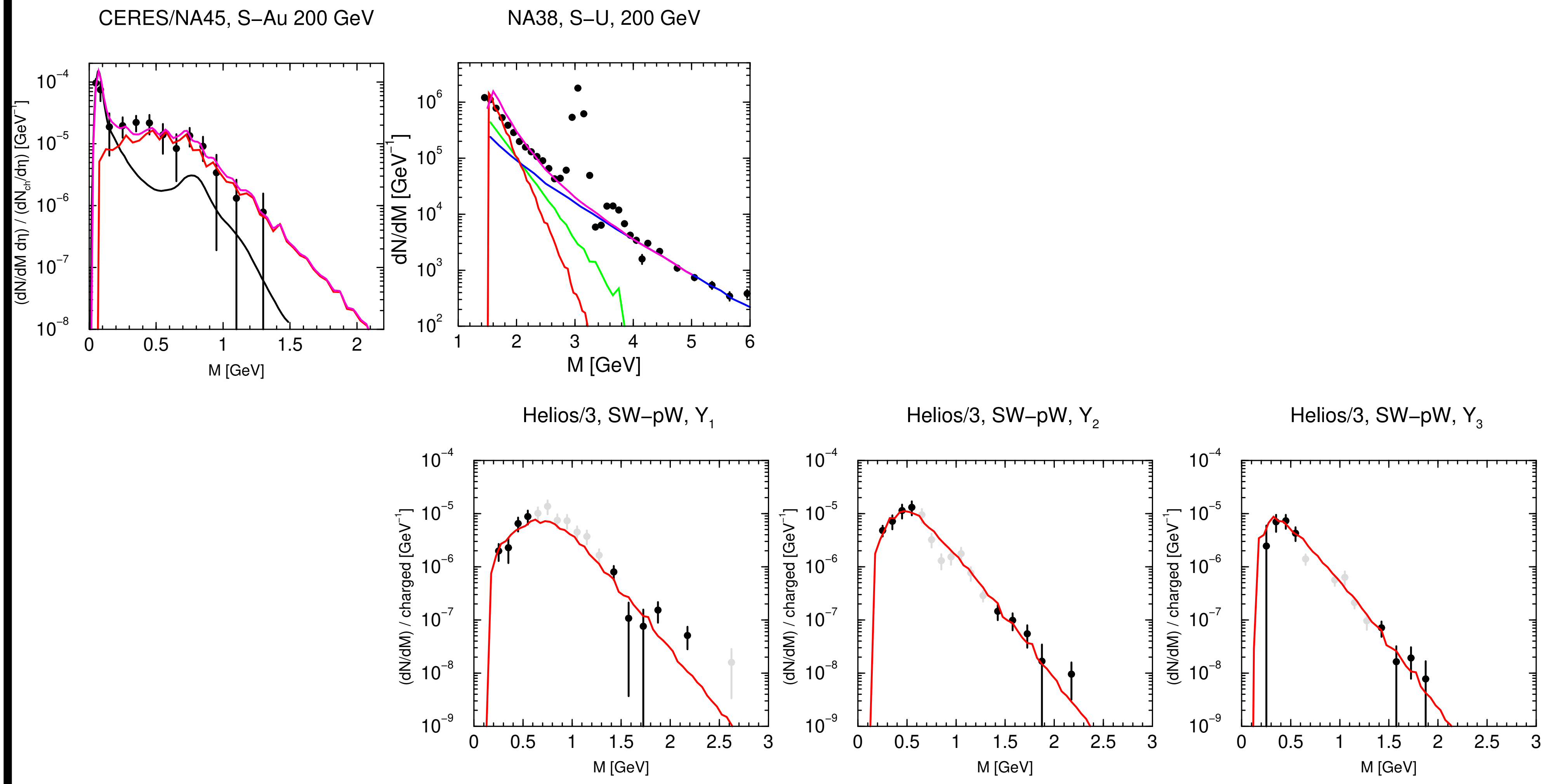


2. background (HELIOS-3_{3-7}: open charms fails, DY $=$ ok)

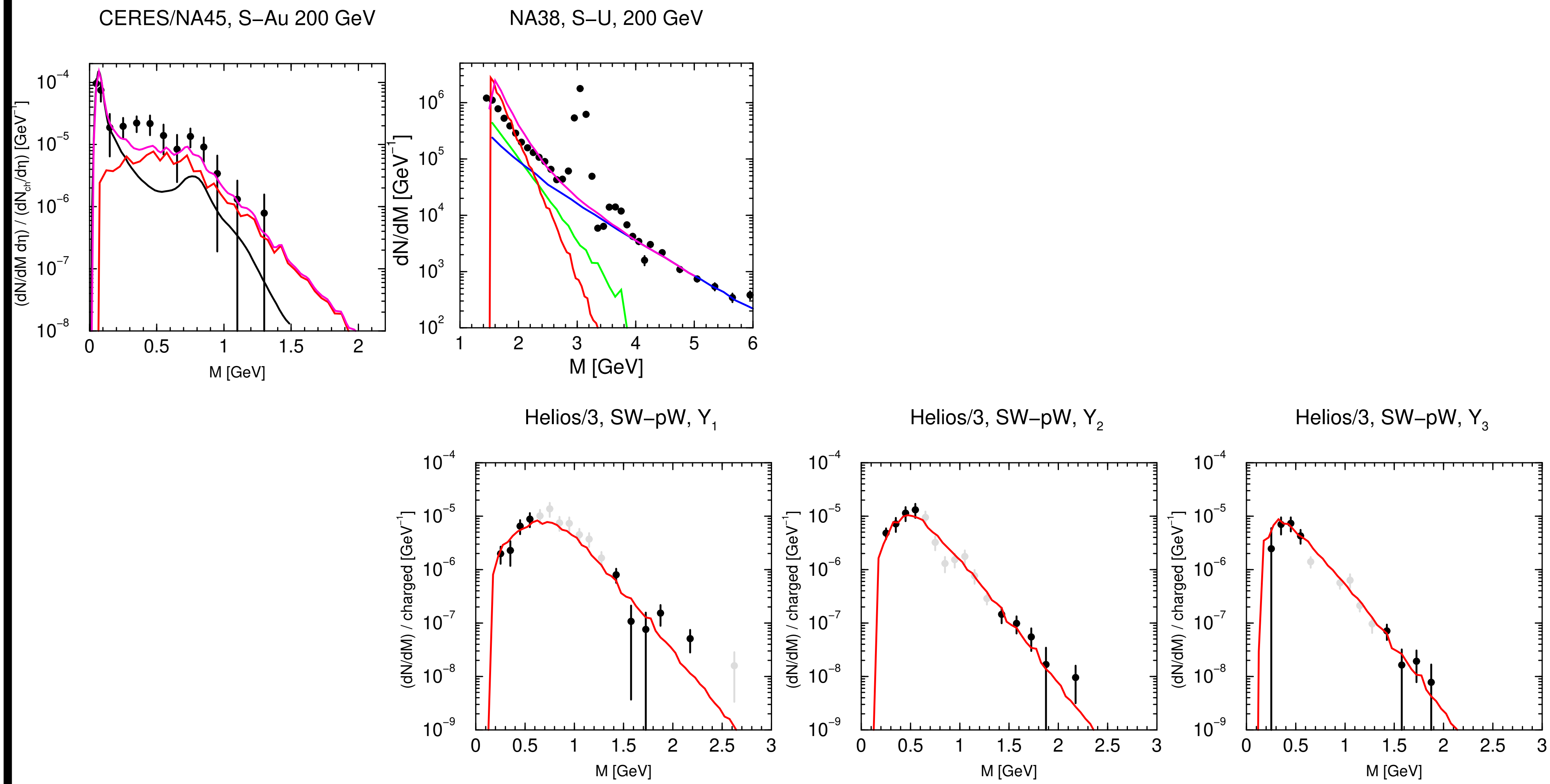
$\rightarrow$ use difference spectra

3. compatibility with photon upper limits

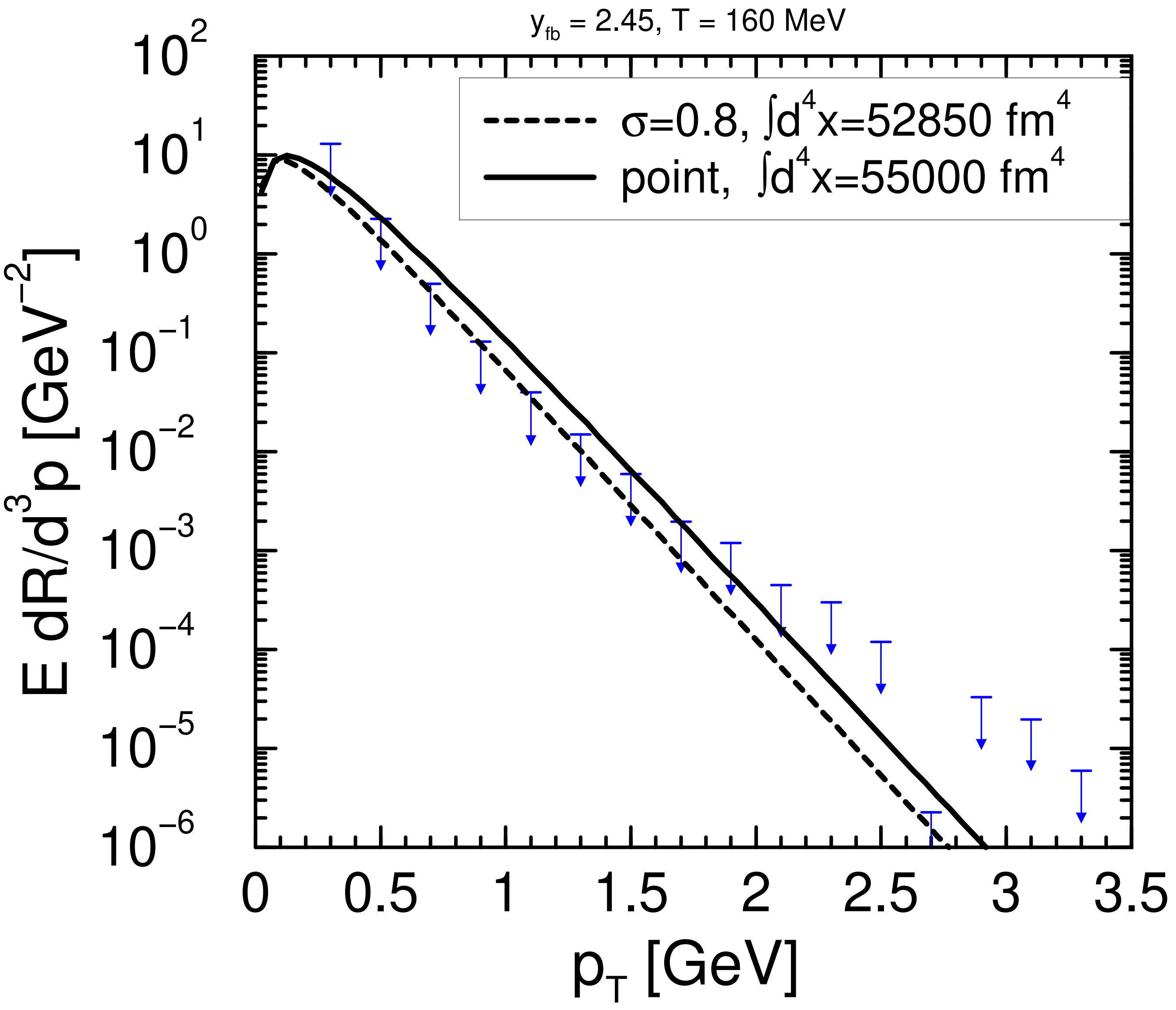
$T = 160$ MeV, $\sigma = 0.8$, $y_{f.b.} = 2.45$, free normalization



$T = 160$ MeV, $\sigma = 0.8$, $y_{f.b.} = 2.45$, fixed normalization to HELIOS-3



WA80, S–Au



adjusted
to
CERES

Conclusions

attempt to explain all CERN-SPS HIC dilepton data by extended duality

(=reshuffled strength + strong in-medium effects):

- Pb + Au, Pb = (ok): or charm enhancement???
- S + Au, W, U = failure: good shapes & bad normalizations

  violates photon boundary slightly

- future: NA50/38 $E_\perp$ dependence