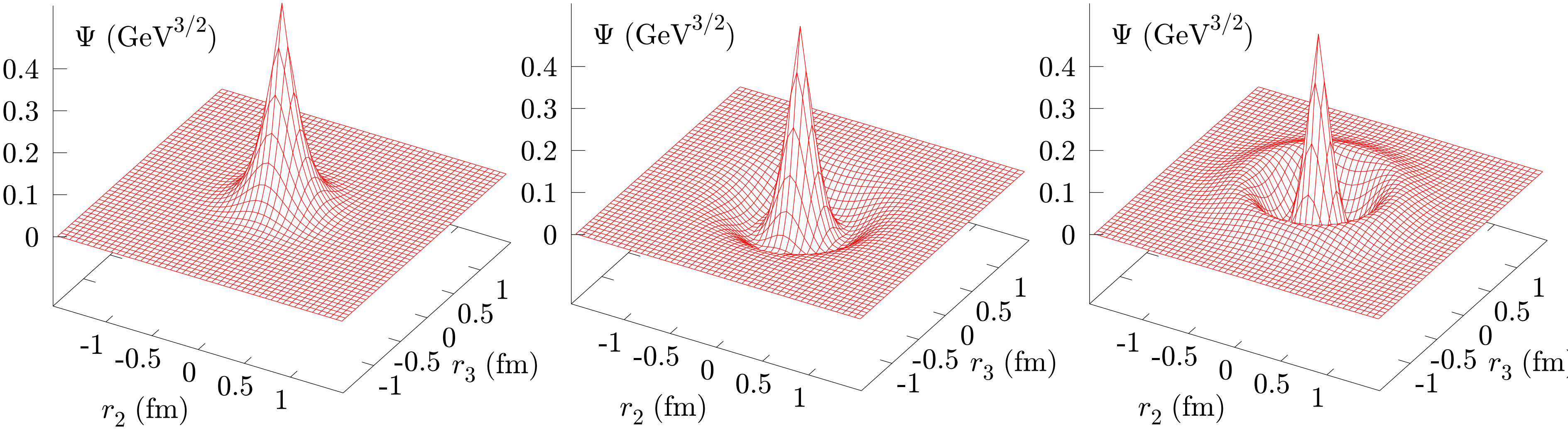
Extended Meson Operators

$O_i(\mathbf{x},t) = \sum_{\mathbf{r}} \Psi_i(\mathbf{r})\bar{q}(\mathbf{x}+\mathbf{r},t)\Gamma q(\mathbf{x},t)\,.$ $\Psi_i(\mathbf{r})$ from potential model with Cornell potential



Good overlap with bottomonium states but

$G_{ij}(t) = \langle O_i(t) O_j^\dagger(0)\rangle \neq 0$ for $i \neq j$

$O_i \to \tilde{O}_\alpha = \Omega_{\alpha j} O_j$ such that

$O_\alpha(t)\tilde{O}^\dagger_\beta(0)\rangle \propto \delta_{\alpha,\beta}$

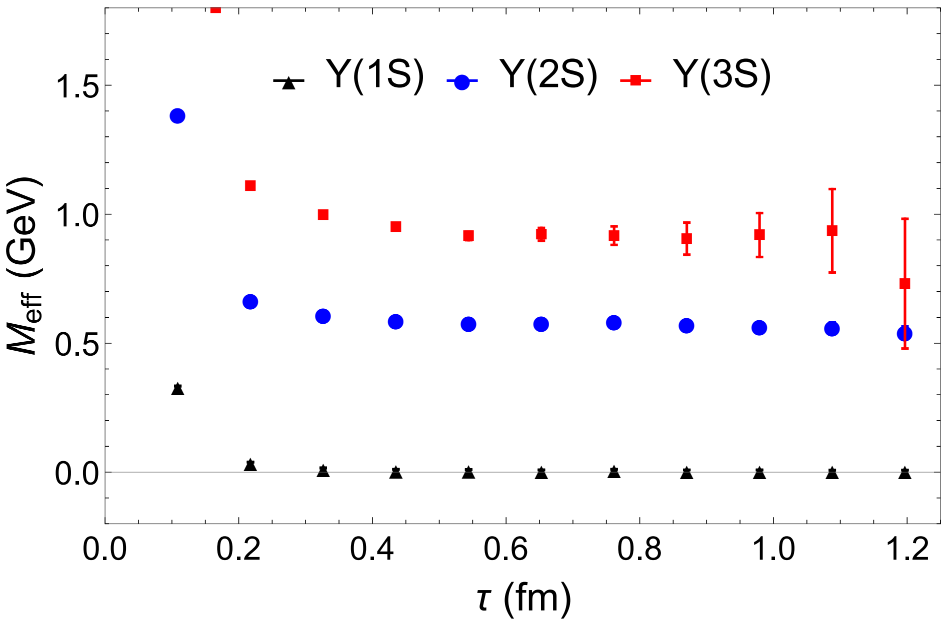
$\Omega_{\alpha j}$ can be obtained as

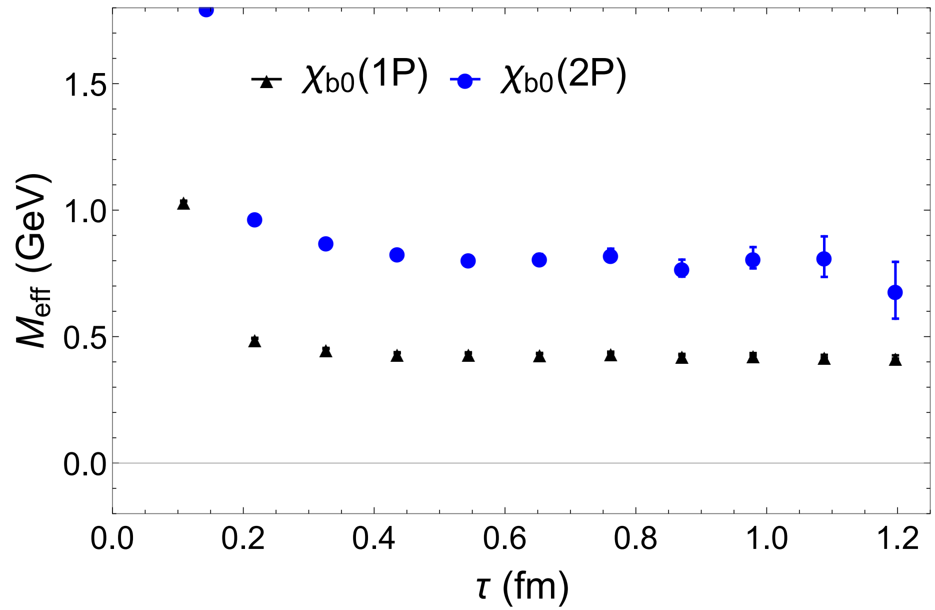
$G_{ij}(t)\Omega_{\alpha j} = \lambda_\alpha(t,t_0) G_{ij}(t_0)\Omega_{\alpha j}.$

Larsen, Meinel, Mukherjee, PP, PRD100 (2019) 074506; PLB800 (2020) 135119

Correlators of Extended Meson Operators at T=0

$$aM_{\text{eff}}(t) = \ln[C_\alpha(t)/C_\alpha(t+1)]$$





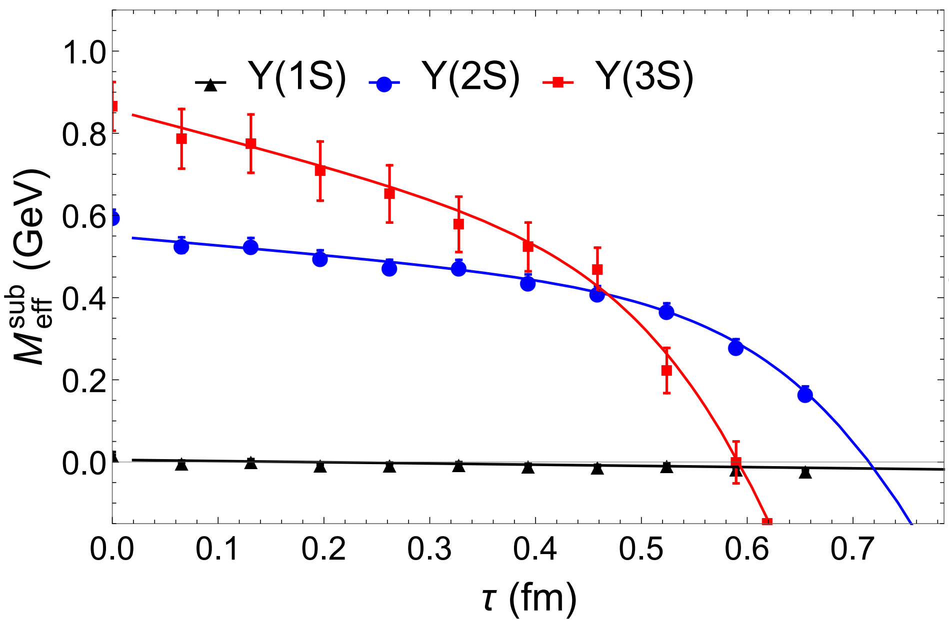
$$C_\alpha(\tau, T) = \int_{-\infty}^{\infty} d\omega \rho_\alpha(\omega, T) e^{-\omega\tau} \qquad \rho_\alpha(\omega, T) = \rho_\alpha^{\text{med}}(\omega, T) + \rho_\alpha^{\text{high}}(\omega)$$

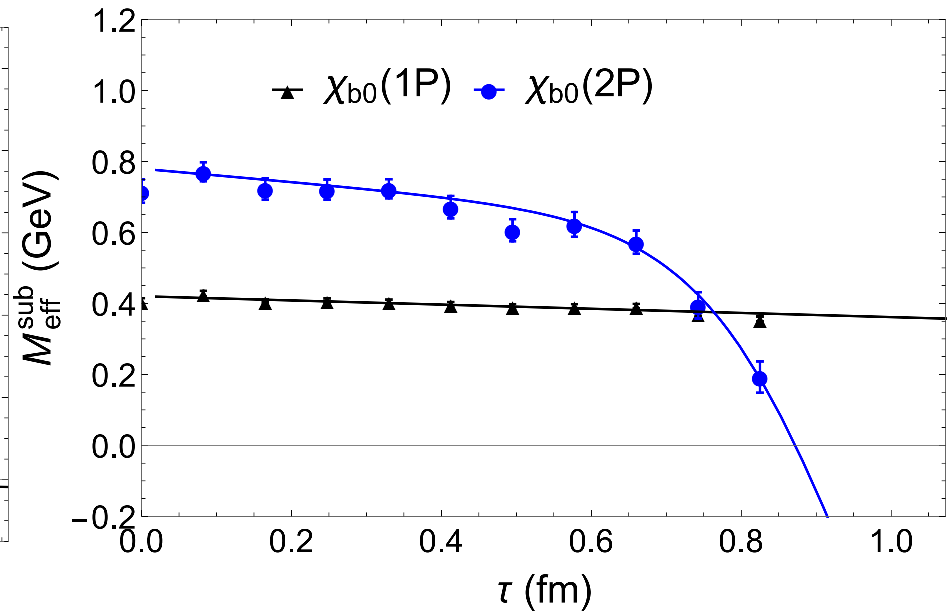
$$\rho_\alpha^{\text{med}}(\omega, T=0) = A_\alpha \delta(\omega - M_\alpha) \Rightarrow C_\alpha(\tau, T=0) = A_\alpha e^{-M_\alpha \tau} + C_\alpha^{\text{high}}(\tau)$$

Determine A_α,M_α from single exponential fit for $\tau > 0.6\text{fm}$ and then $C_\alpha^{\text{high}}(\tau)$

Correlators of Extended Meson Operators at T>0

$$C_\alpha^{\rm sub}(\tau,T) = C_\alpha(\tau,T) - C_\alpha^{\rm high}(\tau) \Rightarrow aM_{\rm eff}^{\rm sub}(\tau,T) = \ln\left(C_\alpha^{\rm sub}(\tau,T)/C_\alpha^{\rm sub}(\tau+a,T)\right)$$





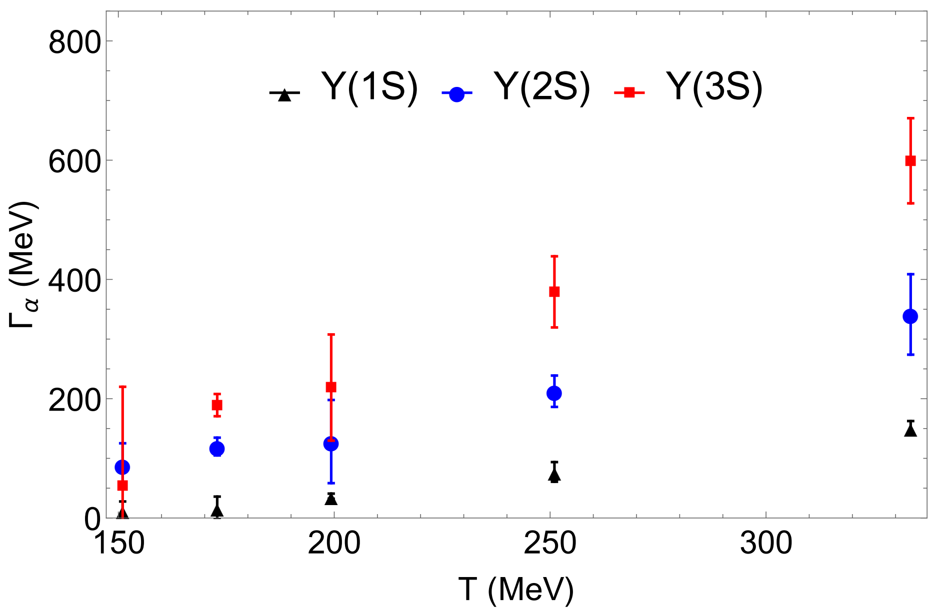
Fit $M_{\rm eff}^{\rm sub}(\tau,T)$ using a simple Ansatz:

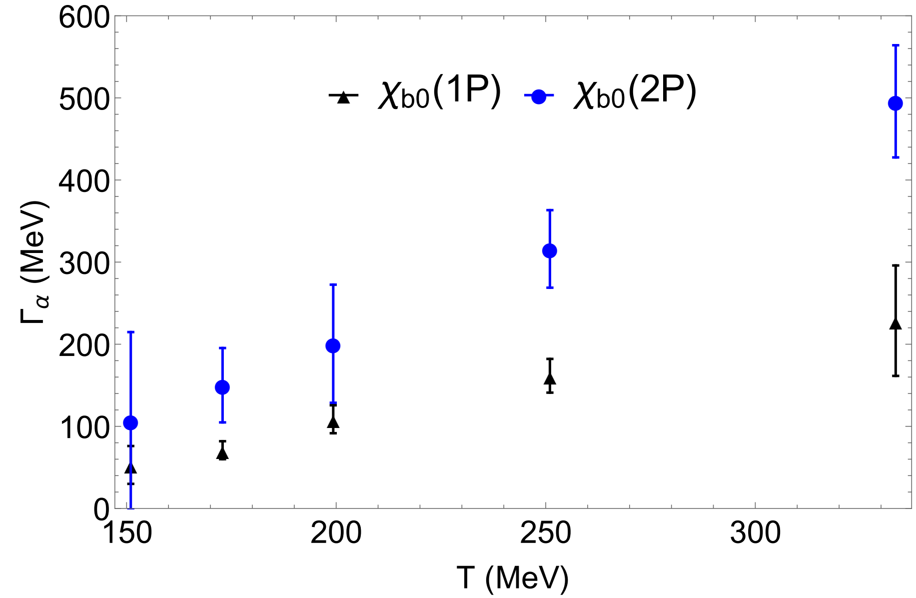
$$\rho_\alpha^{\rm med}(\omega,T) = A_\alpha^{\rm cut}(T)\,\delta\left(\omega-\omega_\alpha^{\rm cut}(T)\right) + A_\alpha(T)\exp\left(-\frac{[\omega-M_\alpha(T)]^2}{2\Gamma_\alpha^2(T)}\right)$$

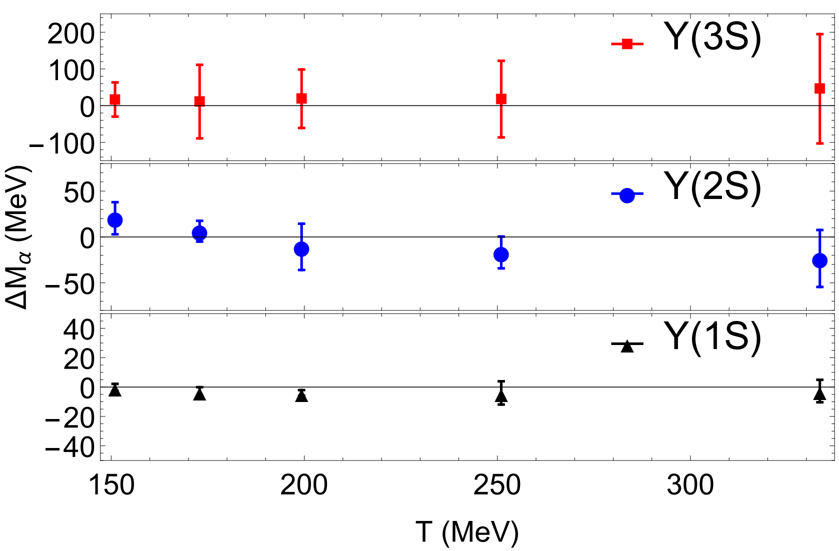
Low energy tail

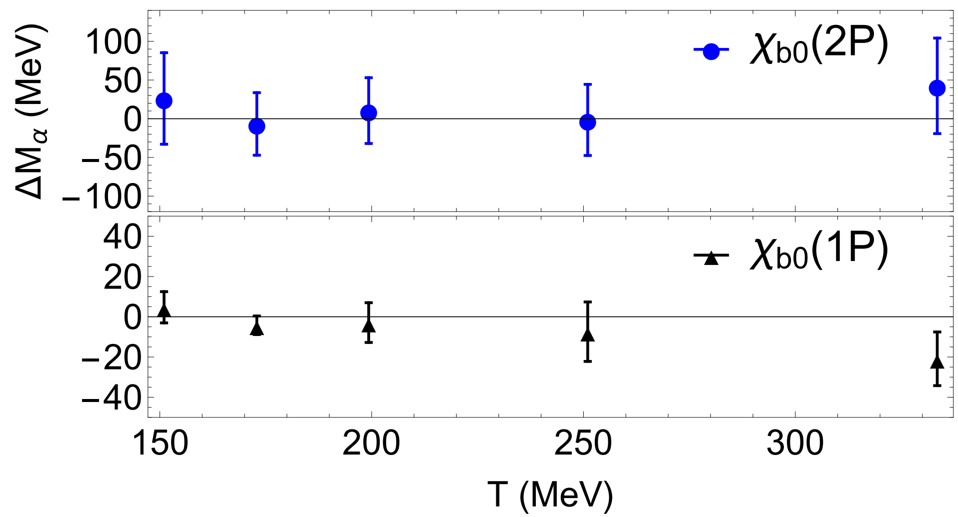
$$\Rightarrow M_\alpha(T), \Gamma_\alpha(T)$$

Thermal width and mass shift of bottomonium









Backup slides

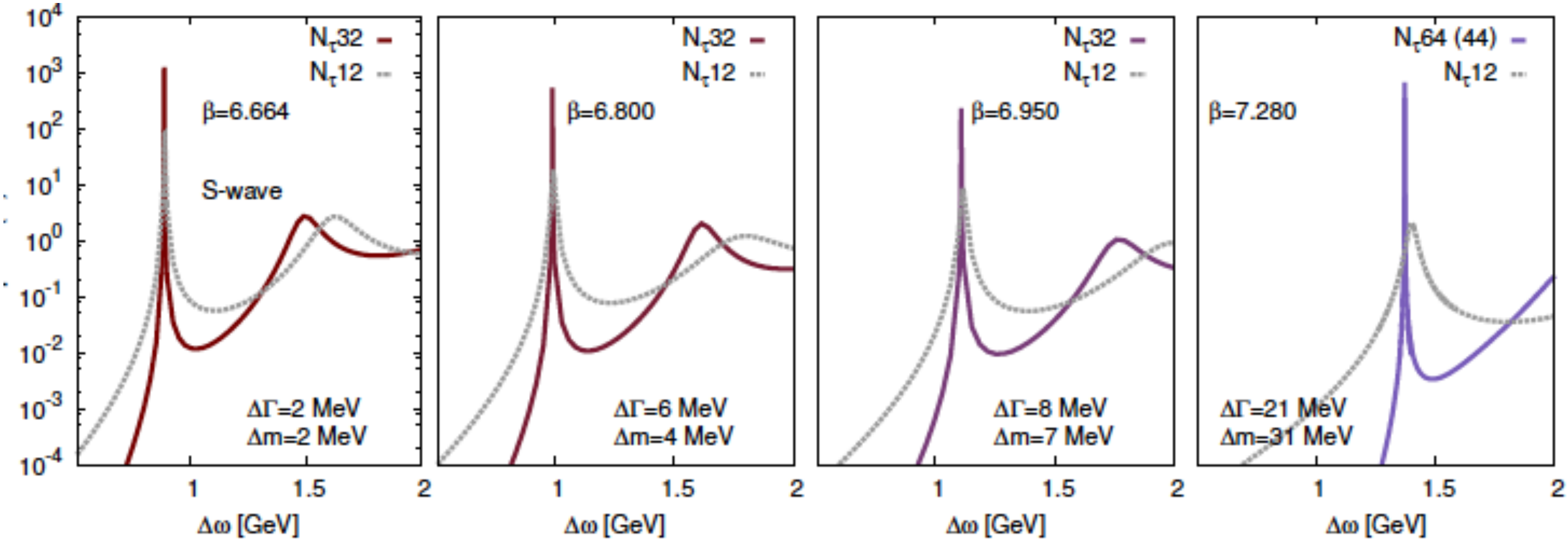
Reconstructing Spectral Functions at T>0

Two main problems:

1) $\tau < 1/T \Rightarrow$ limited temporal extent at high T

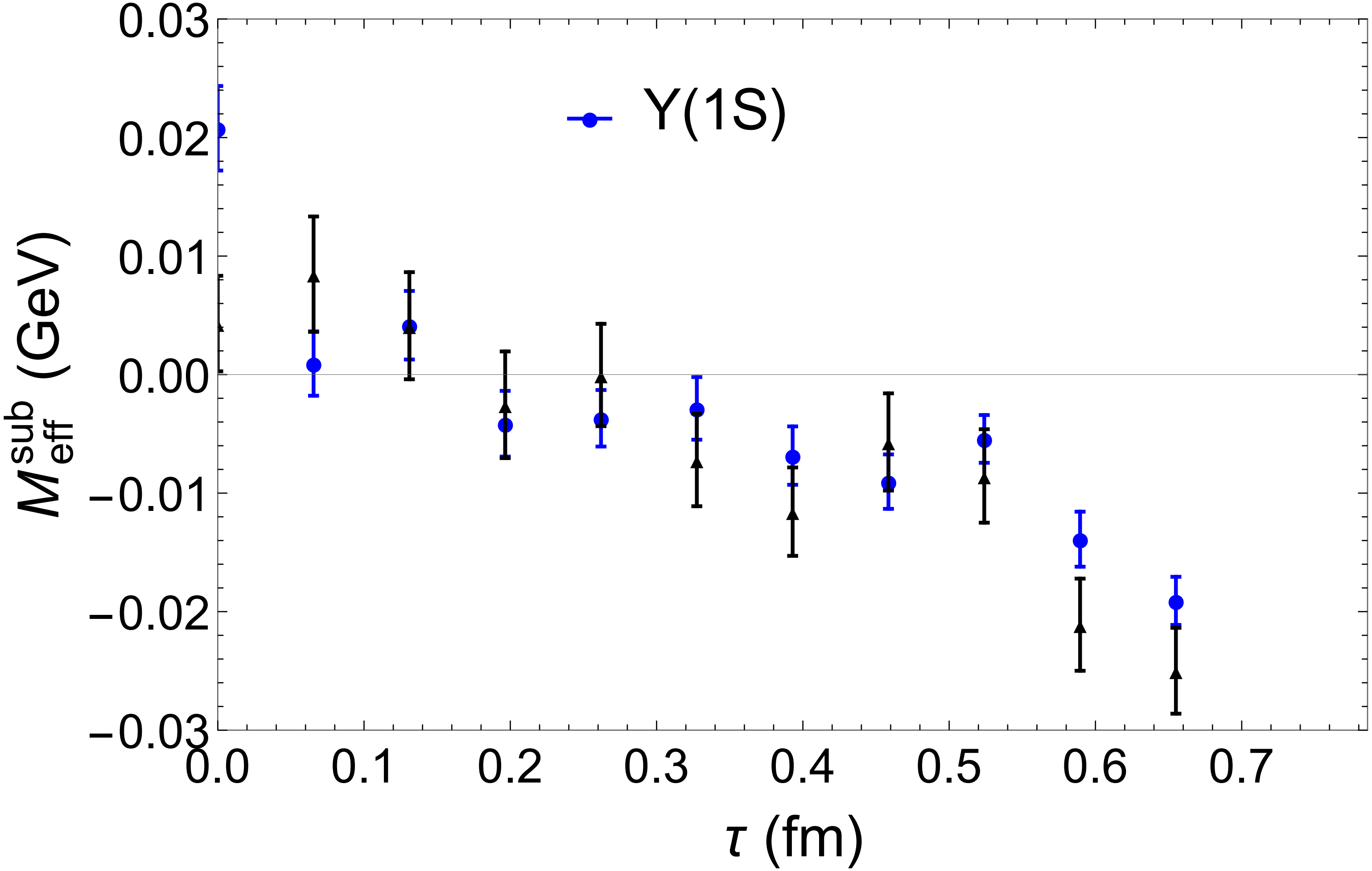
2) relatively small number of time slices ($N_\tau = 12$ in our study)

Study these effects at $T = 0$ by using only the first 12 data points:



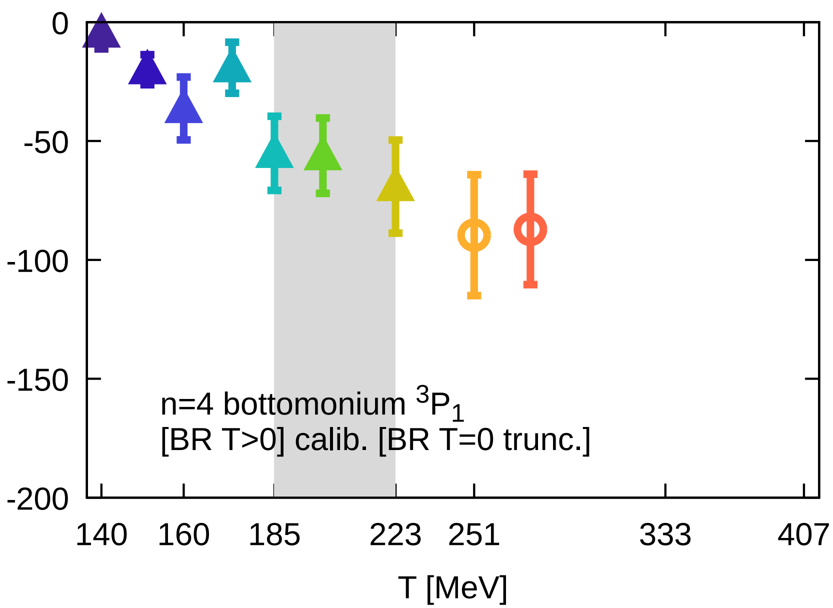
Decreasing $\tau_{max} = 1/T$ leads to broadening of the bound state peak

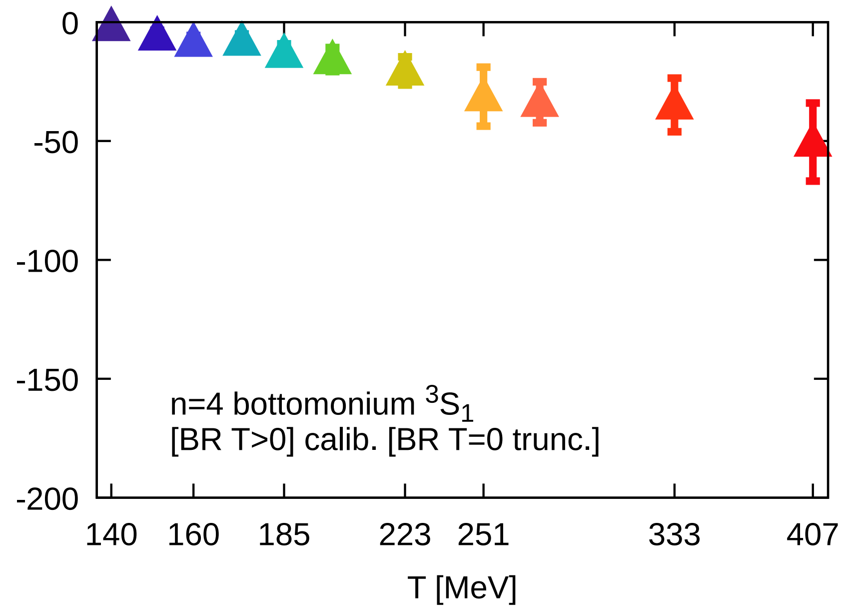
(to be taken into account in comparison $T = 0$ and $T > 0$ spectral functions)



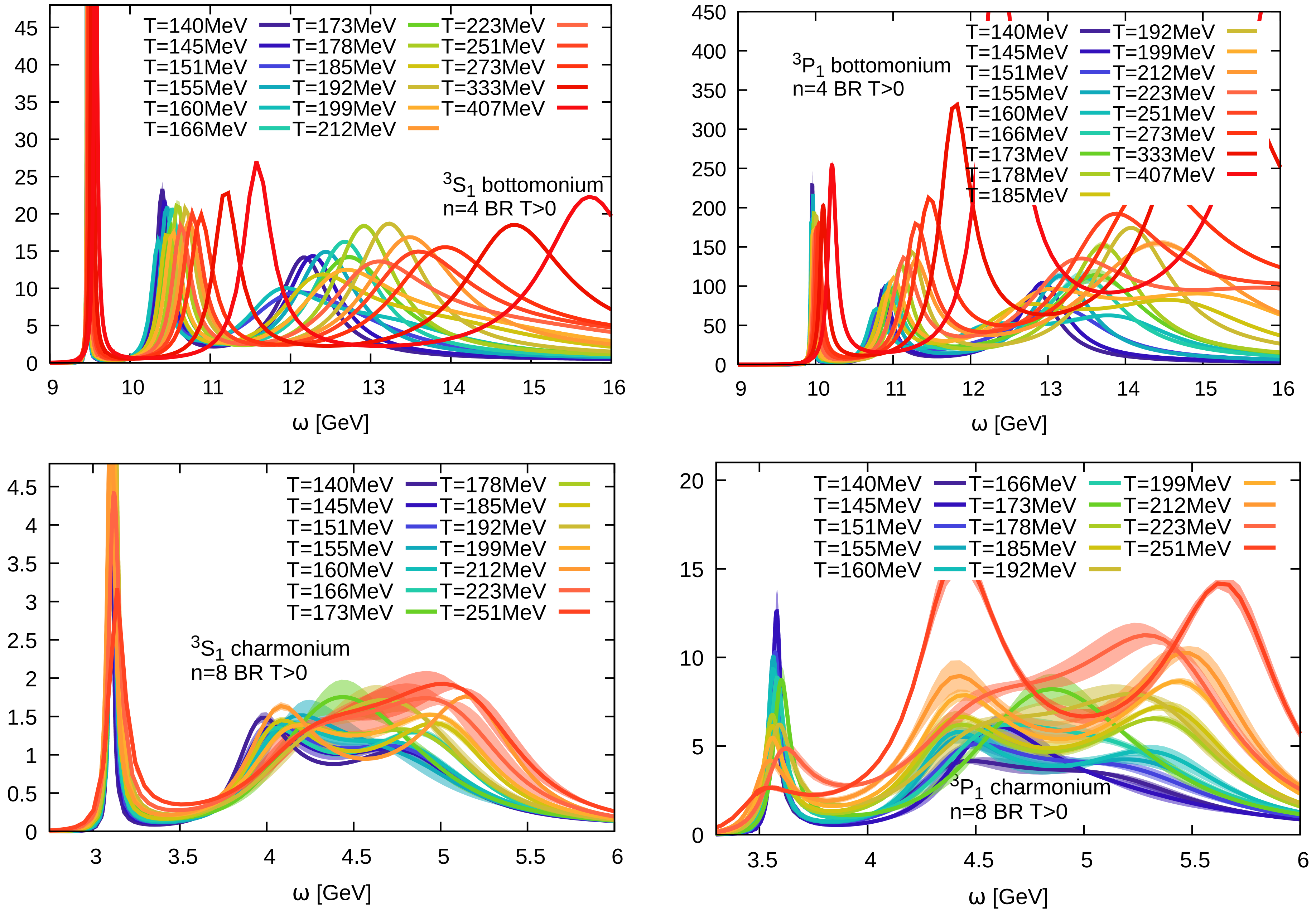
Υ(1S)
$M_{\rm eff}^{\rm sub}$ (GeV)
τ (fm)
0.03
0.02
0.01
0.00
−0.01
−0.02
−0.03
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

In Medium Bottomonium Mass Shifts From Bayesian analysis

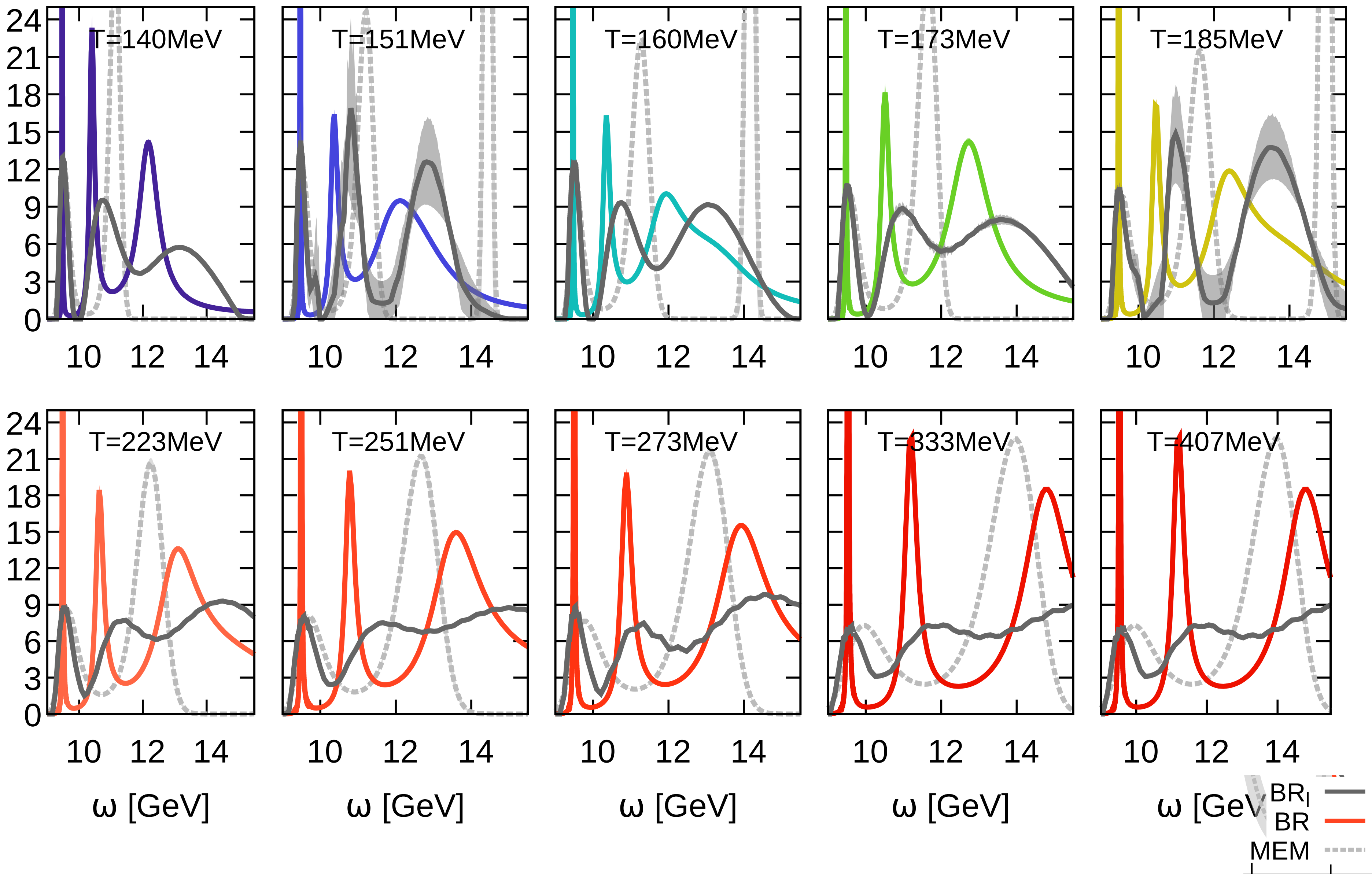




Quarkonium Spectral Functions at T>0

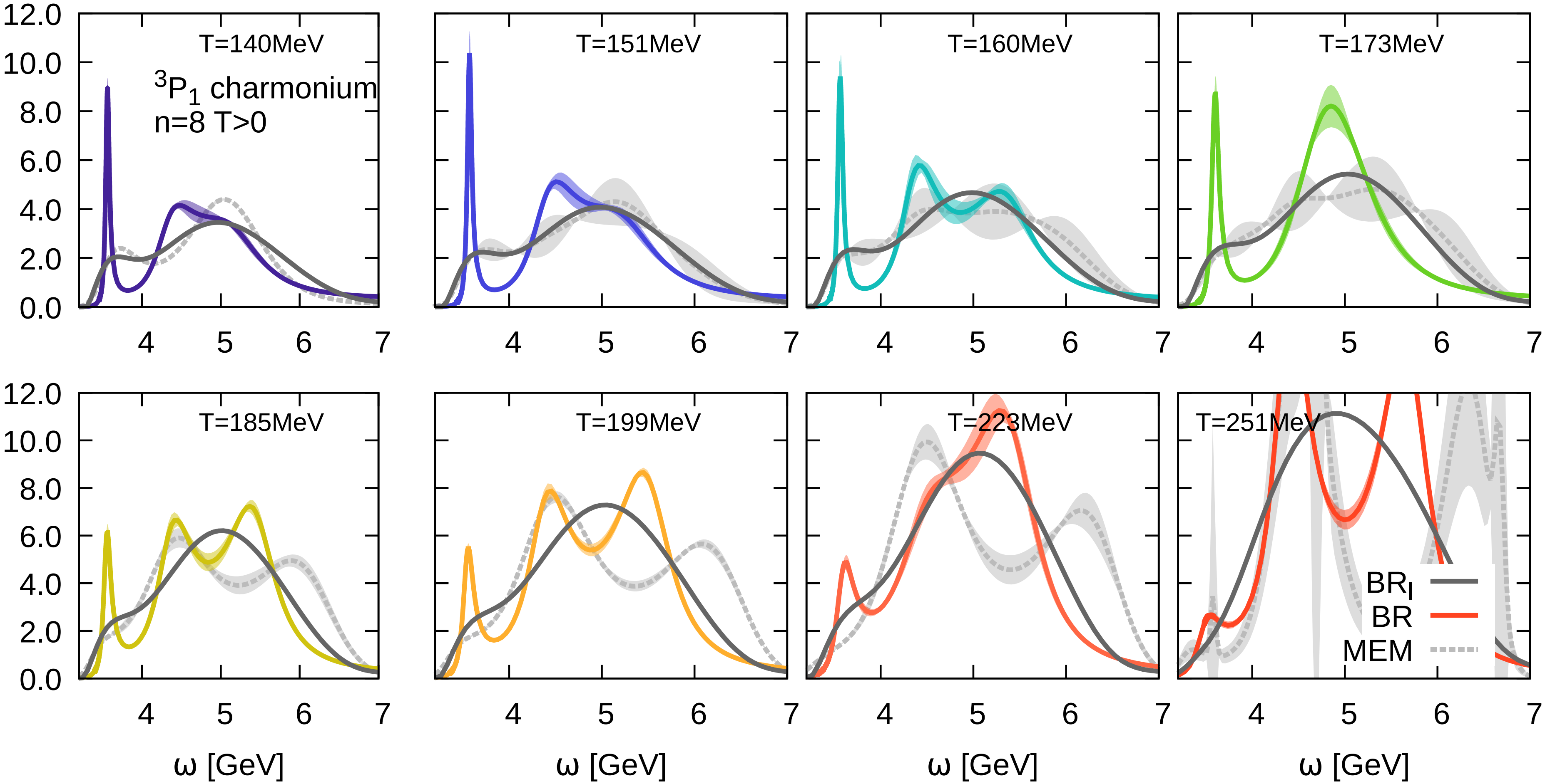


Bottomonium Spectral Functions with Different Methods



Υ spectral functions

Charmonium Spectral Functions with Different Methods



χ_c spectral functions