Open-charm enhancement at FAIR?

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SQM06

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Motivation

- Ψ' and J/Ψ suppression
- D-mesic nuclei
- Open-charm enhancement

m=495.67 MeV

$$\bar{K} = \begin{pmatrix} \bar{K}^0 \\ -K^- \end{pmatrix} \begin{matrix} \bar{d}\,s \\ \bar{u}\,s \end{matrix} \quad s=-1$$

$I(J^P)=1/2\ (0^-)$

m=1866.9 MeV

$$D = \begin{pmatrix} D^+ \\ D^0 \end{pmatrix} \begin{matrix} \bar{d}\,c \\ \bar{u}\,c \end{matrix} \quad c=1$$

$I(J^P)=1/2\ (0^-)$

Predictions for the D-meson potential

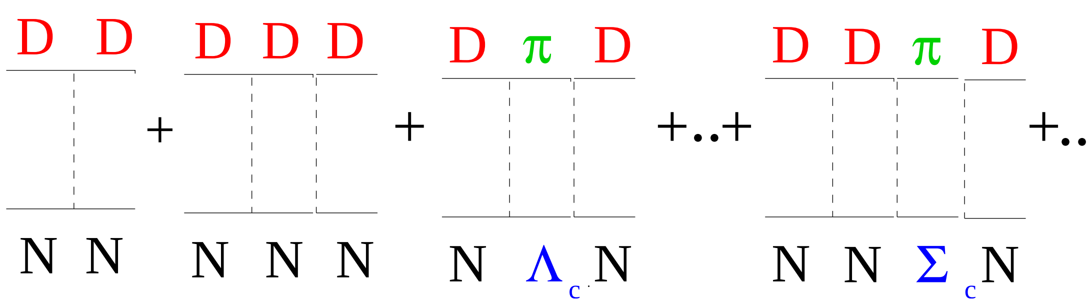
(QSR, QMC, chiral model): -50 to -140 MeV at $\rho = \rho_0$

Coupled-channel approach: $\Lambda_c(2593)$ resonance

The s-wave DN amplitude obtained via *Lippman-Schwinger equation*

$$T_{if}(k_i, k_f; \sqrt{s}) = V_{if}(k_i, k_f) + \sum_l \int \frac{d^3 k_l}{(2\pi)^3} \frac{V_{il}(k_i, k_l)\; T_{lf}(k_l, k_f; \sqrt{s})}{\sqrt{s} - E_l(k_l) - \omega_l(k_l) + i\epsilon}$$

in *coupled channels* ($\pi\Lambda_c$, $\pi\Sigma_c$, DN, $\eta\Lambda_c$ and $\eta\Sigma_c$)

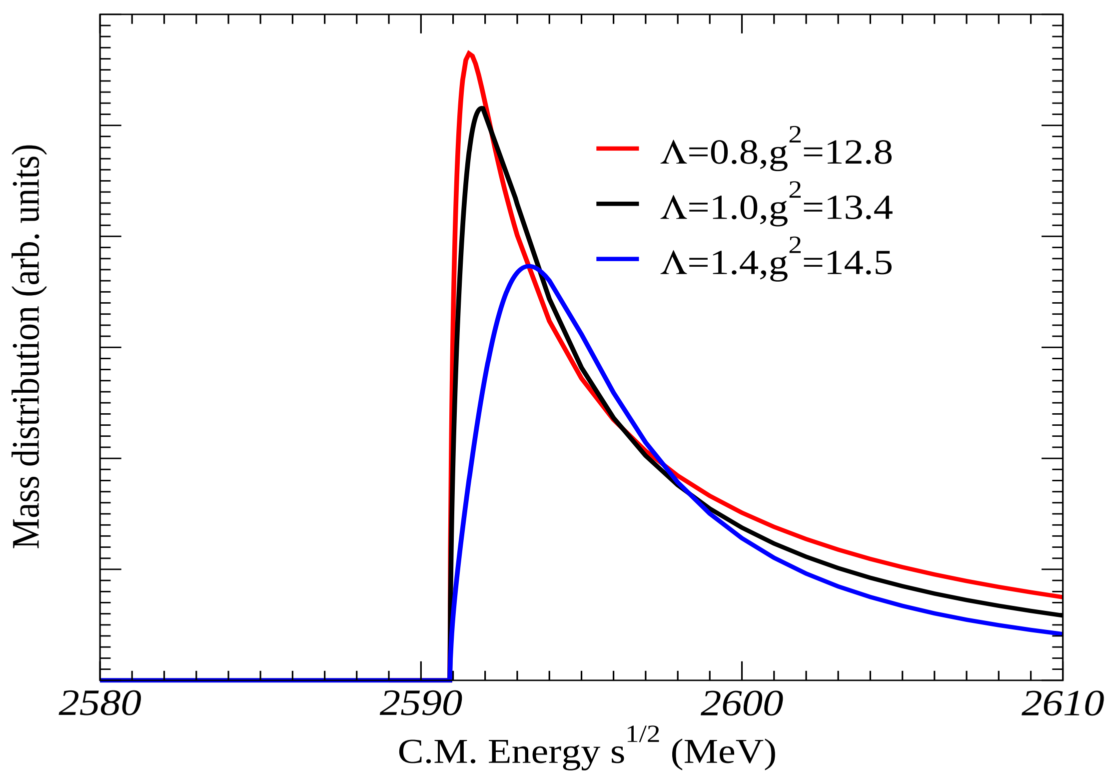


using a separable potential as bare interaction

$$V_{i,j}(k, k') = \frac{g^2}{\Lambda^2} C_{i,j} \Theta(\Lambda - k)\Theta(\Lambda - k')$$

g(coupling constant), Λ(cutoff), $C_{i,j}$(SU(3) matrix with u,d,c)

$\Lambda(2593)_c$ resonance



$I = 0,\ J^P = (1/2)^-$ with $\Gamma = 3.6^{+2.0}_{-1.3}$ MeV

$$\frac{d\sigma}{dm_{\pi\Sigma_c}} \propto \left|T^{I=0}_{\pi\Sigma_c\to\pi\Sigma_c}\right|^2 p_{cm}$$

The D-meson in hot and dense matter

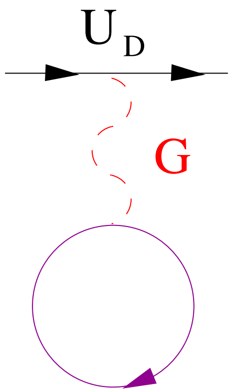
Brueckner-Hartree-Fock approach

for the in-medium DN interaction

$$G = V + V\frac{Q}{\omega - H}V + V\frac{Q}{\omega - H}V\frac{Q}{\omega - H}V + \ldots$$

$$G = V + V\frac{Q}{\omega - H}G$$

Bethe−Goldstone equation



Q Pauli blocking

H Particle dressing

$$U_D(k, E_D^{qp}) = \sum_{N \leq F} \langle DN \mid G_{DN \to DN}(\Omega = E_N^{qp} + E_D^{qp}) \mid DN \rangle$$

Self-consistently!!

After self-consistency for the on-shell $U_D(k, E_D^{qp})$,

the D-meson self-energy is

$$\Pi_D(k_D, \omega) = 2\sqrt{k_D^2 + m_D^2}\, U_D(k_D, \omega) \ ,$$

the D-meson single-particle propagator is

$$D_D(k_D, \omega) = \frac{1}{\omega^2 - k_D^2 - m_D^2 - \Pi_D(k_D, \omega)} \ ,$$

and the D-meson spectral density is

$$S_D(k_D, \omega) = -\frac{1}{\pi} \mathrm{Im}\, D_D(k_D, \omega) \ .$$

Finite temperature effects:

G-matrix at finite temperature obtained by replacing

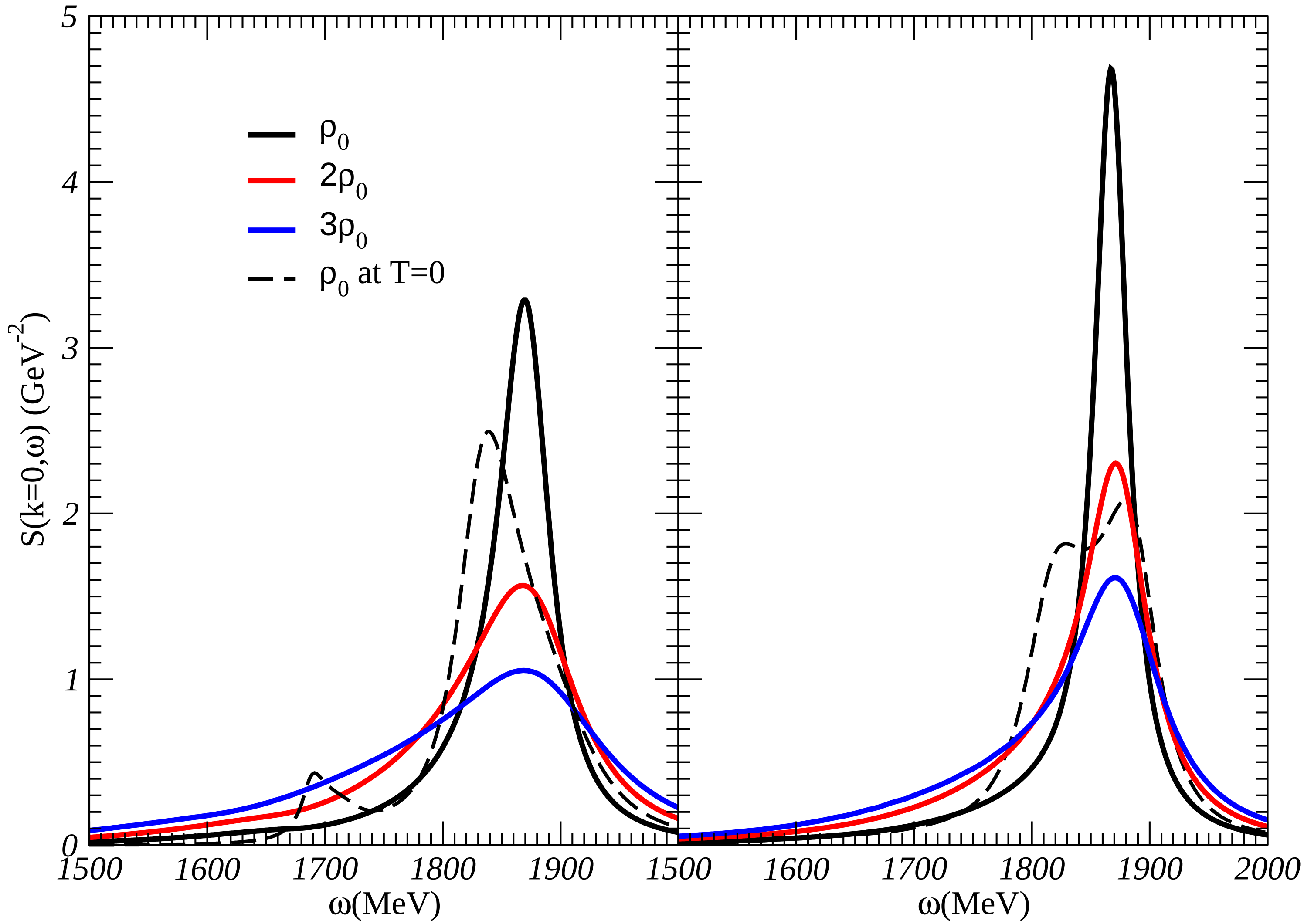
$$Q_{MB} \rightarrow Q_{MB}(T)$$
$$E_M \, , E_B \rightarrow E_M(T) \, , E_B(T)$$
$$G(\Omega) \rightarrow G(\Omega, T)$$

Then, the D-meson optical potential

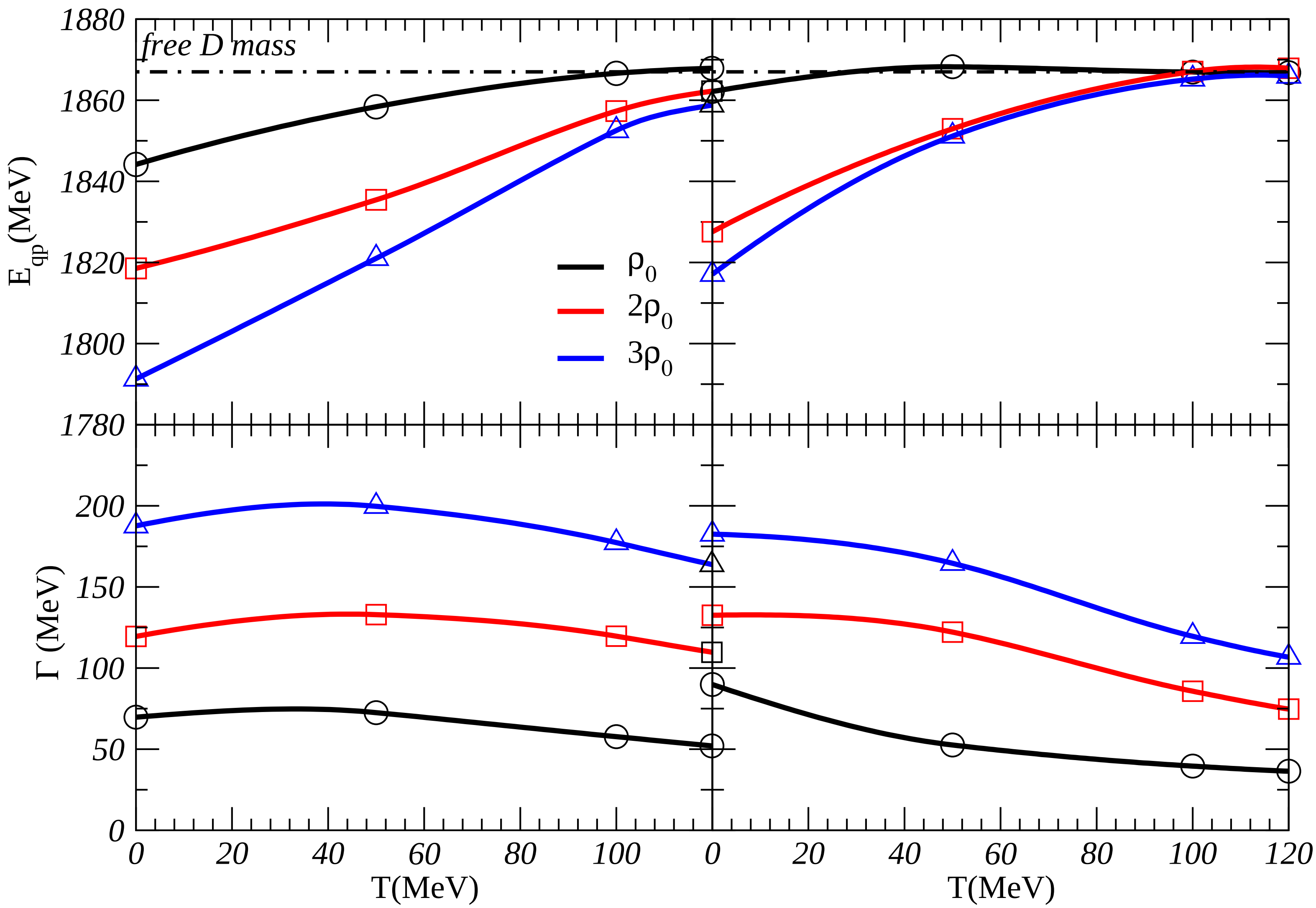
$$U_D(k, E_D^{qp}) = \sum_{N \leq F} \langle DN \mid G_{DN \to DN}(\Omega = E_N + E_D^{qp}) \mid DN \rangle$$

$$\Downarrow T \text{ effects}$$

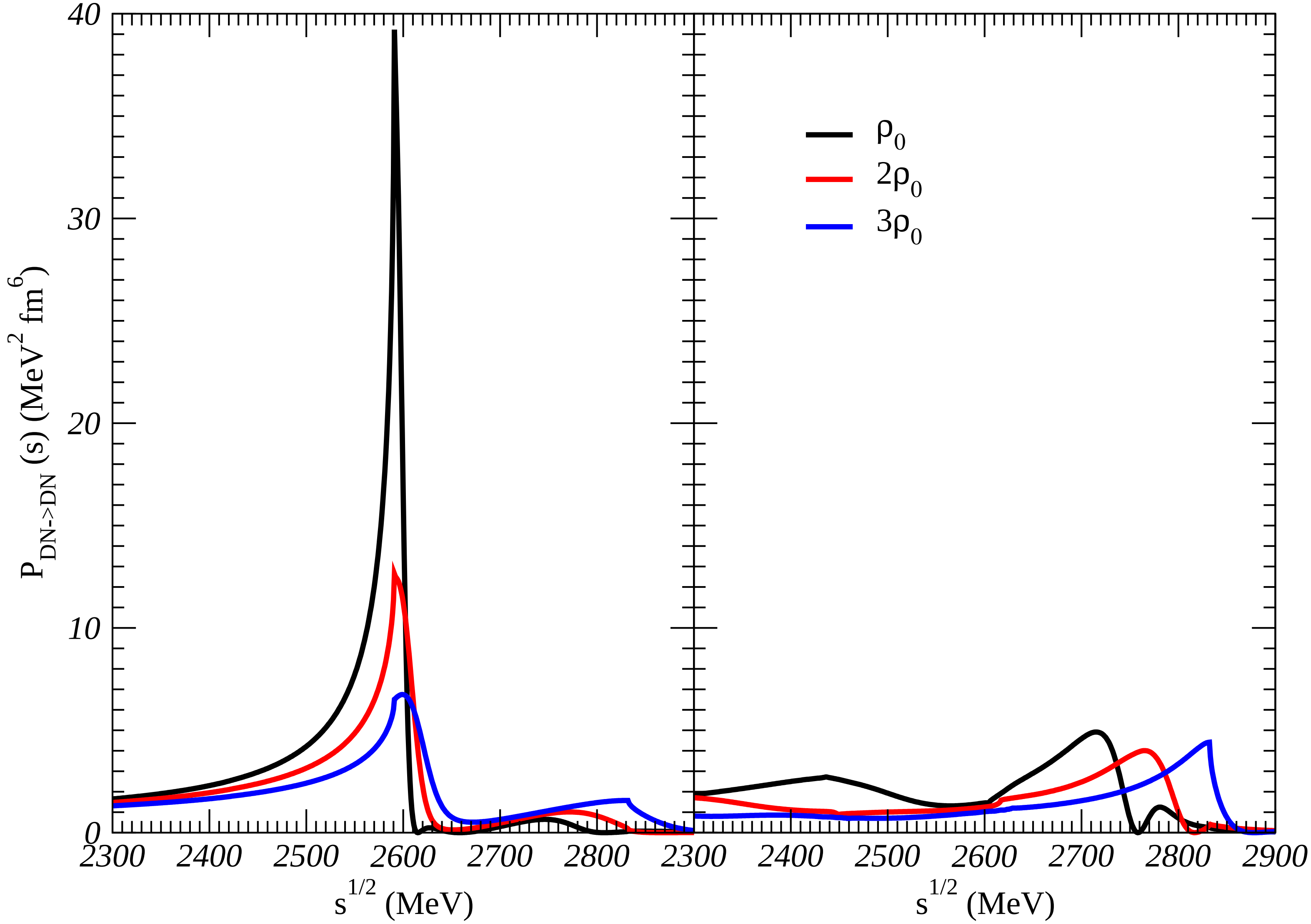
$$U_D(k, E_D^{qp}, T) = \int n(k,T) \; d^3k \; \langle DN \mid G_{DN \to DN}(\Omega, T) \mid DN \rangle$$



The D-meson spectral density for T=120 MeV



Open-charm enhancement?



$D^+n(D^0p)$ transition rates for T=120 MeV

Conclusions & Future

OBJECTIVE: The D-meson spectral density in hot nuclear matter to address open-charm enhancement

METHOD: To solve the DN coupled-channel Bethe-Goldstone equation self-consistently at finite temperature taking as bare DN interaction a separable potential

- $\Lambda_c(2593)$ resonance generated dynamically for (g^2,Λ)
- The quasiparticle peak stays close to its free position (self-consistent coupled-channel effects result in a overall reduction of the in-medium modifications) BUT the D-meson develops a considerable width

CONCLUSION: The medium modifications to the D-mesons in A+A collisions will be dominantly on the width and not on the mass.

Open-charm enhancement??

FUTURE:

- Improve bare interaction by extension to SU(4) for u-,d-,s- and c-quark content. Some recent work by Hofman, Lutz and Korpa.
- CBM experiment at FAIR (GSI)

More details:

L.Tolos, J.Schaffner-Bielich and A.Mishra, PRC 70 (2004) 025203

L.Tolos, J.Schaffner-Bielich and H.Stoecker, PLB 635 (2006) 85