

Medium Modifications of the $\Delta(1232)$



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Motivation

- Main features of **low-energy** QCD:
 - **confinement**: relevant degrees of freedom **hadrons**
 - **spontaneously broken chiral Symmetry**



Motivation

- Main features of **low-energy** QCD:
 - **confinement**: relevant degrees of freedom **hadrons**
 - **spontaneously broken chiral Symmetry**
- Lattice: At $T_c \sim 150\text{-}200$ MeV phase transition/crossover
 - **deconfined partonic matter (“Quark-Gluon Plasma”)**
 - **restored chiral symmetry**



Motivation

- Medium modifications of hadrons
 - Heavy-Ion Collisions: dilepton spectra direct probe to hot/dense phase
 - enhancement of dilepton yield $\lesssim \rho$ peak (SpS)
 - baryons important for in-medium modification of vector mesons
 - more detailed treatment of in-medium baryon spectrum desirable
 - Δ accessible through πN invariant-mass spectra preliminary measurements from STAR

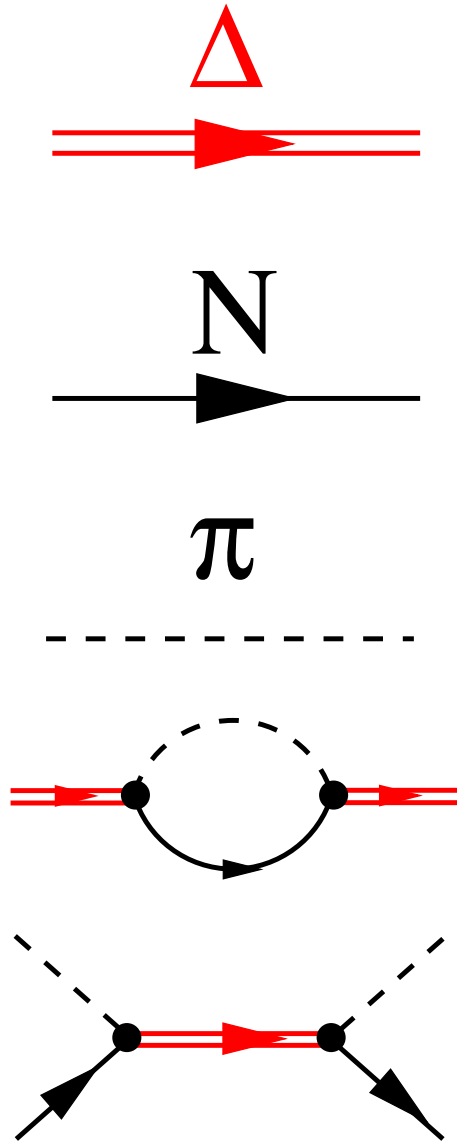


Hadronic model in the vacuum

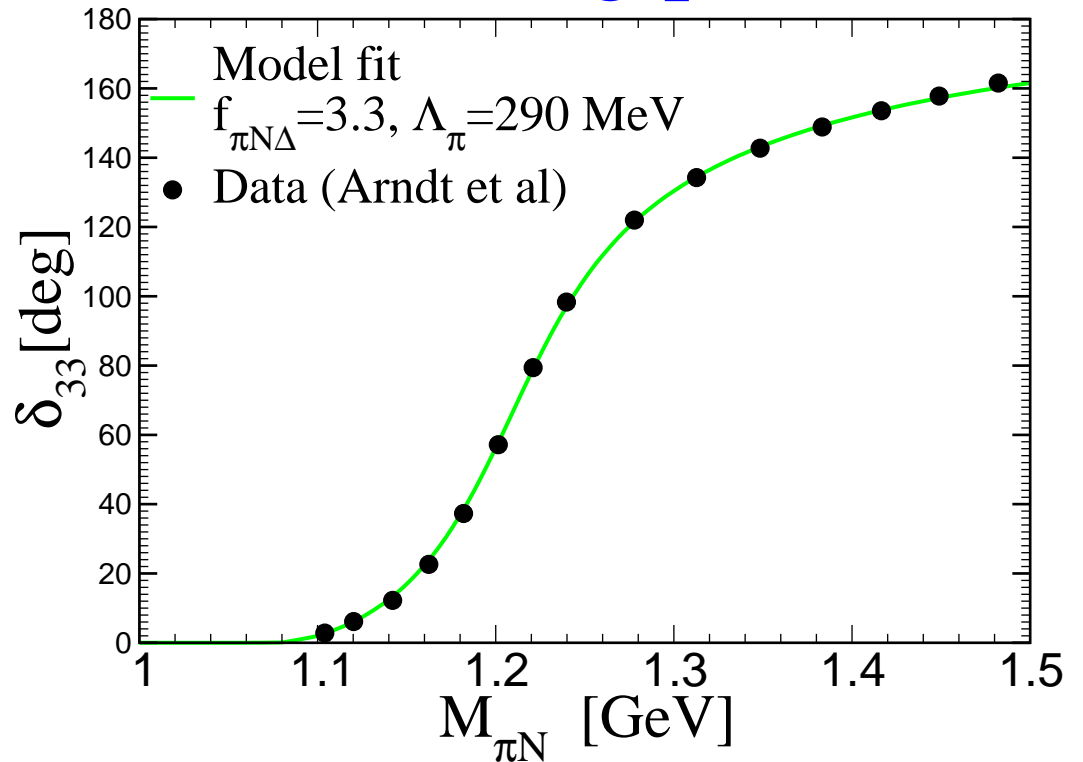
- hadronic fields: nucleons, pions, $\Delta(1232)$
- pions fully relativistic
- baryons: anti-particle poles neglected
- $\pi N \Delta$ vertex: p wave
- form factor $F_{\text{mono}}(|\vec{k}|) = \Lambda^2 / (\Lambda^2 + \vec{k}^2)$



Hadronic model in the vacuum

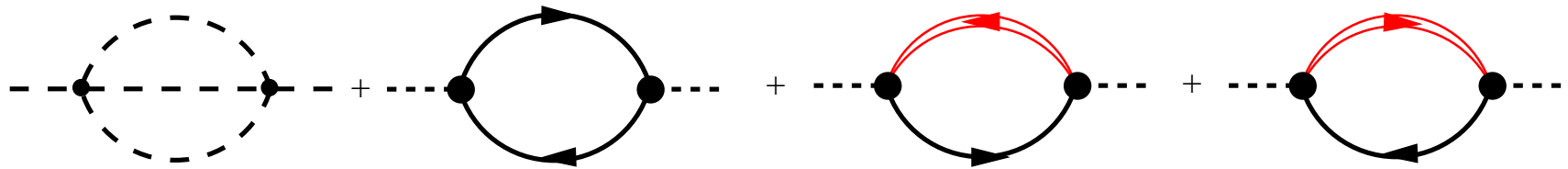


π N scattering phase shift

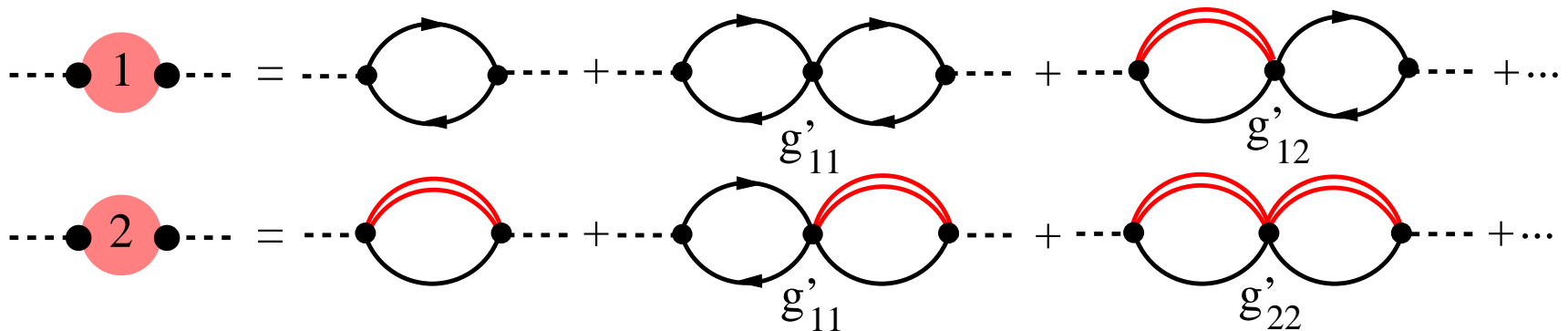


Medium Modifications of pions

- pions: nucleon and Δ -hole excitations

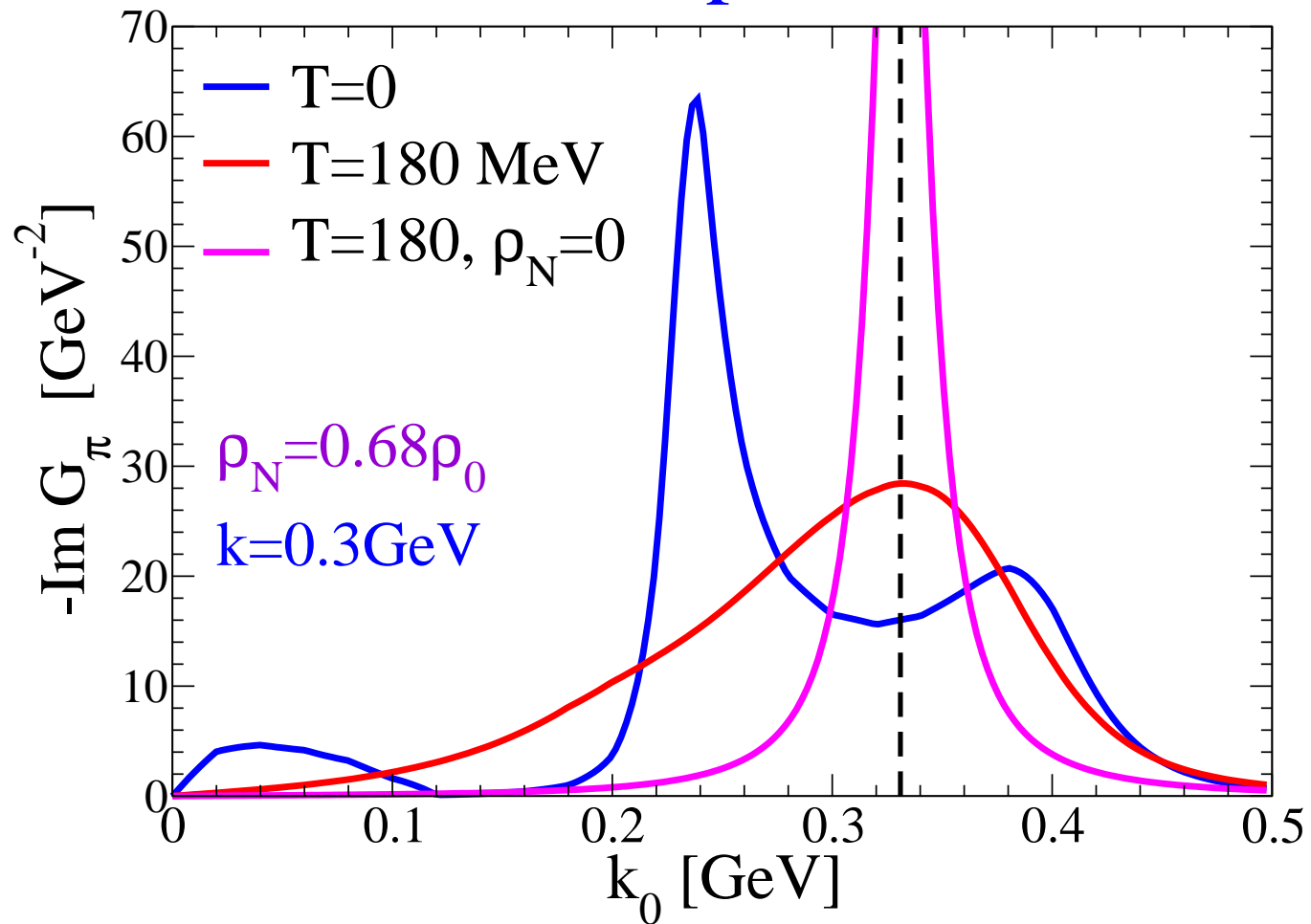


- short-range correlations: Migdal resummation



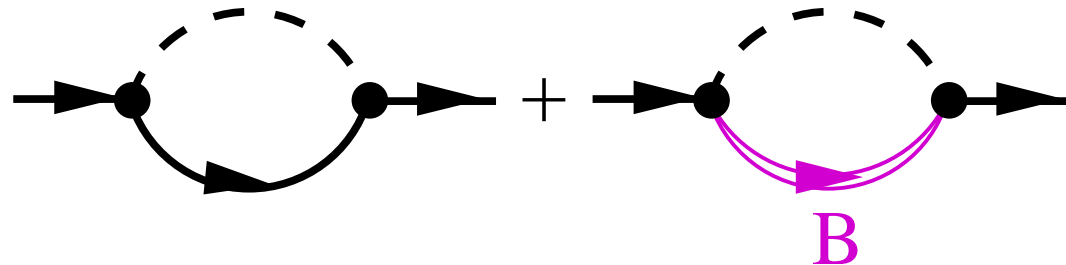
Medium Modifications of Pions

In-Medium π Spectral Function



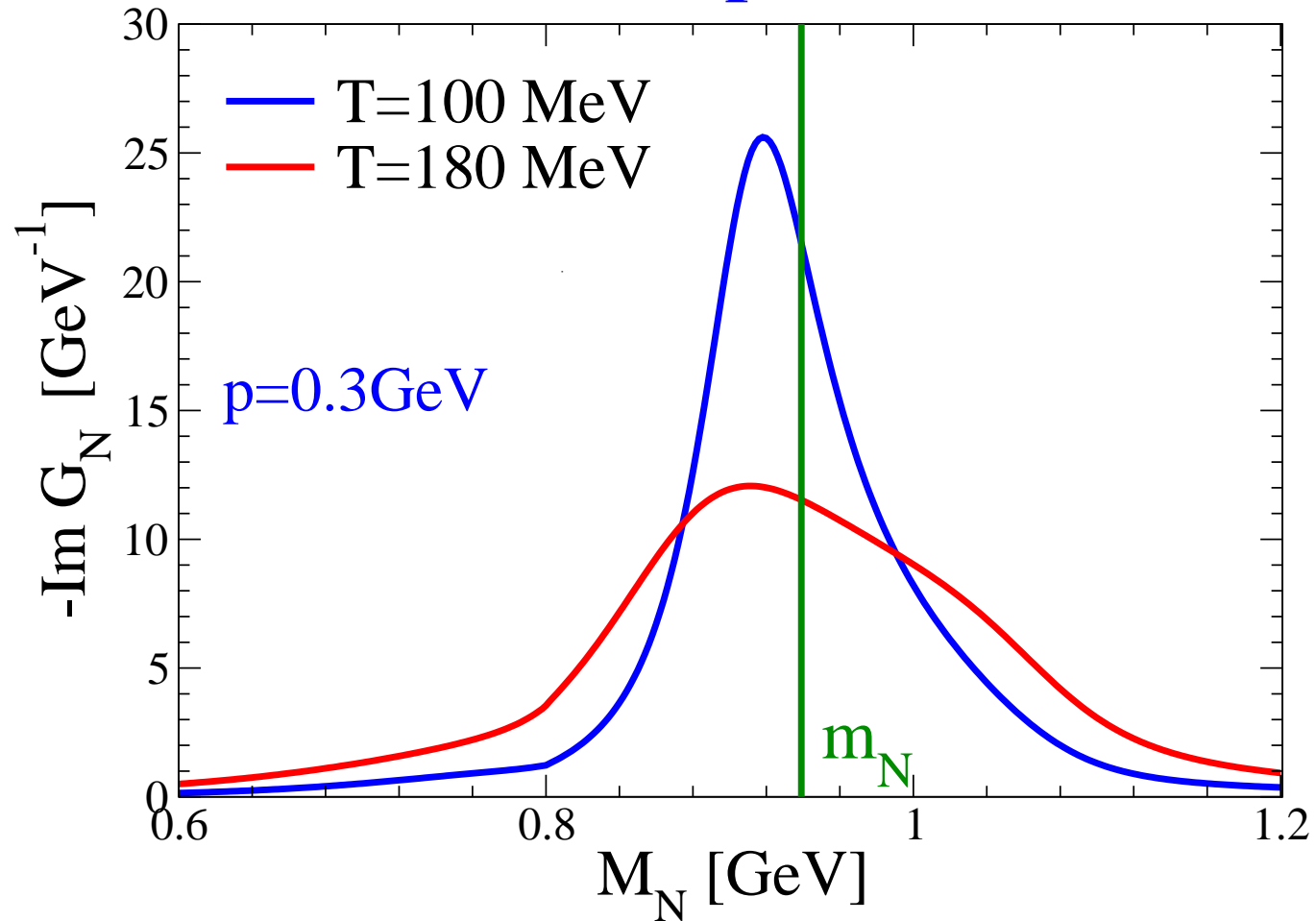
Medium Modifications of Nucleons

- nucleons: πN and πB , $B = \Delta(1232)$, $N^*(1440)$, $N^*(1535)$, $\Delta^*(1600)$, $\Delta^*(1620)$
- coupling constants fitted to partial decay widths
 $B \rightarrow \pi N$



Medium Modifications of Nucleons

In Medium N-spectral function



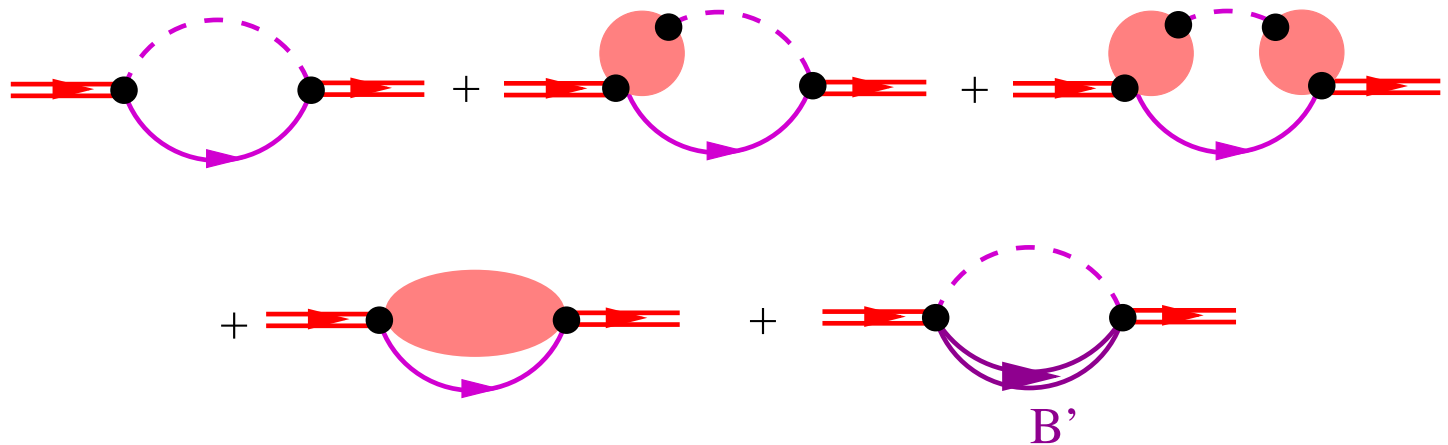
$T=100\text{ MeV}, \rho_N=0.12\rho_0, \mu_\pi=96\text{ MeV}$

$T=180\text{ MeV}, \rho_N=0.68\rho_0, \mu_\pi=0$



Medium Modifications of the Δ

- same diagram as in vacuum with dressed pion- and nucleon propagators
- vertex corrections: same resummed Migdal loops as for the pion
- 4-fermion vertices: same Migdal parameters as for the pion

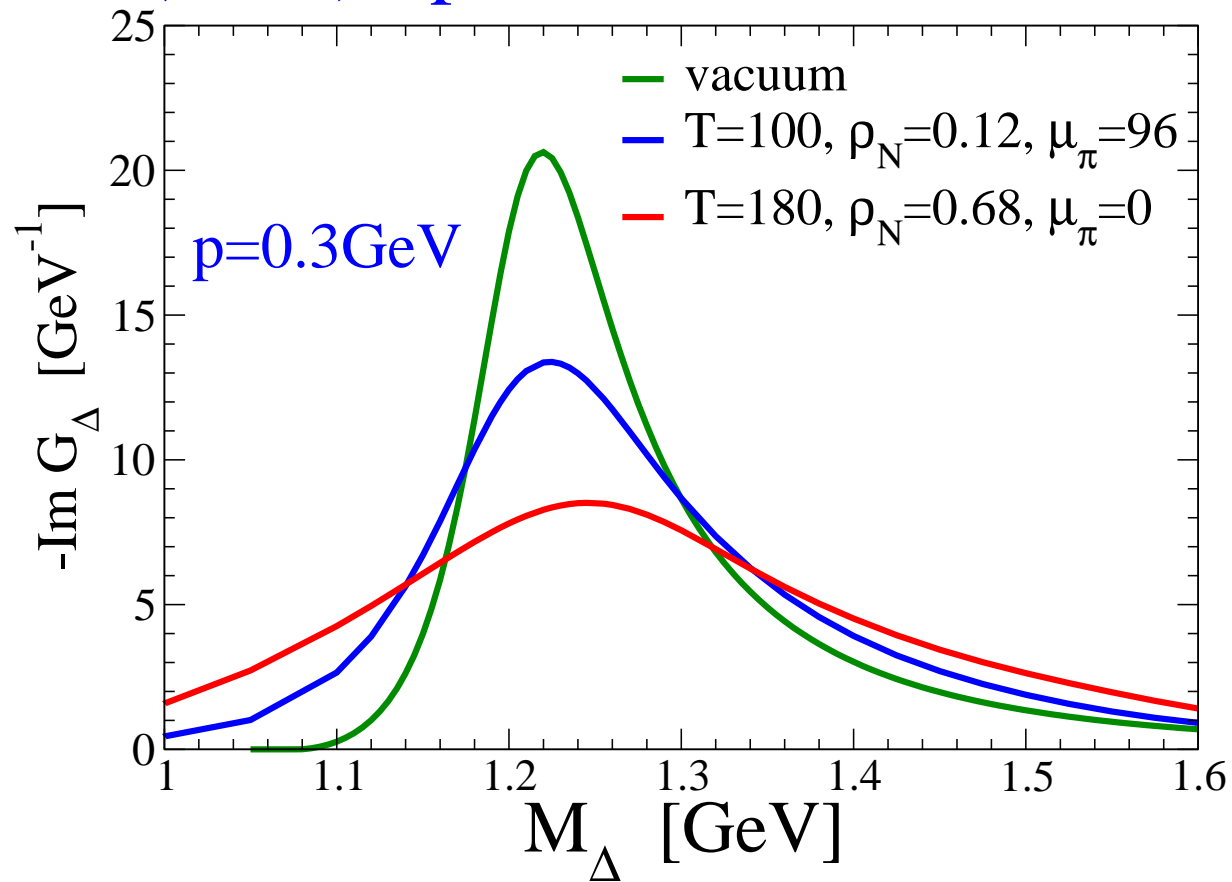


- $B' = \Delta(1232), N^*(1440), N^*(1520), \Delta^*(1600), \Delta^*(1620), N^*(1700), \Delta^*(1700)$



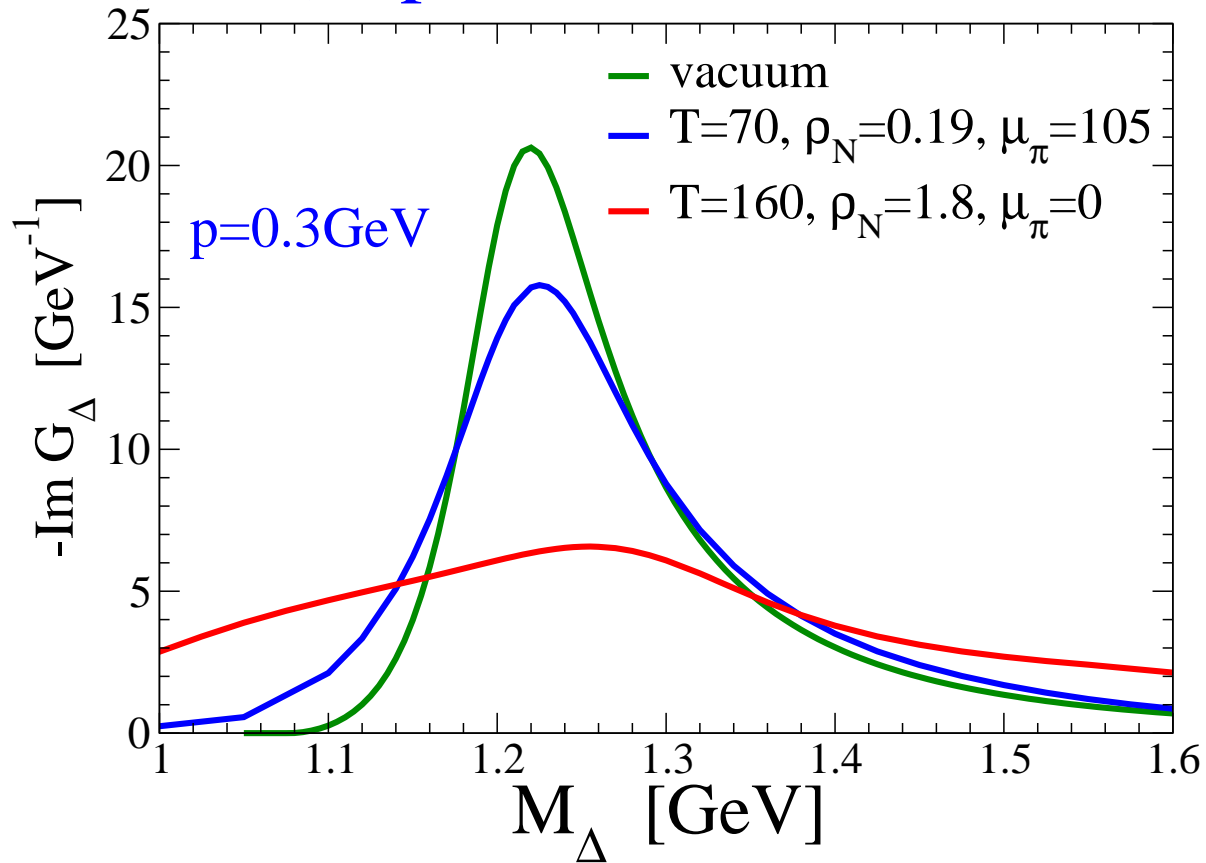
Medium Modifications of the Δ

$\Delta(1232)$ Spectral Function at RHIC



Medium Modifications of the Δ

$\Delta(1232)$ Spectral Function at SIS-06



Conclusions and Outlook

- study of the $\Delta N\pi$ system in hot/dense matter
- results qualitatively in line with preliminary STAR data for πN invariant-mass spectra



Conclusions and Outlook

- study of the $\Delta N\pi$ system in hot/dense matter
- results qualitatively in line with preliminary STAR data for πN invariant-mass spectra
- further developments:
 - medium effects on excited resonances
 - comparison with πN invariant-mass spectra: detailed treatment of freezeout dynamics
 - coupling to vector mesons within chiral framework
 - role of medium modifications of the Δ for electromagnetic emission spectra (soft photons at SpS?)

