

Medium Modifications of the $\Delta(1232)$



Hendrik van Hees
Ralf Rapp



2004 Fall Meeting Division of Nuclear Physics APS

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nucl-th/0407050 (to be published in Phys. Lett. B)

nucl-th/0409026 (to be published on Jour. Phys. G)

Motivation

Medium modifications of baryons

- role of **baryons** for dilepton spectra (**in-medium modification** of vector mesons)
- chiral phase transition
- here: Nucleon and Δ in hot/dense matter
- Connection **JLAB/RHIC** physics: **photo absorption on nuclei** vs. **πN invariant-mass spectra**

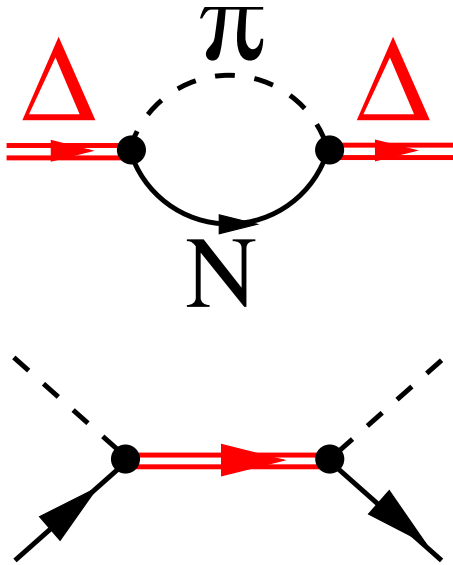
Hadronic model in the vacuum

- hadronic fields: N , π , $\Delta(1232)$, higher resonances
- pions fully relativistic
- baryons: anti-particle poles neglected
- $\pi N \Delta$ vertex: p wave
- $\pi N B^*$ vertices: usually Lowest angular momentum
- form factors

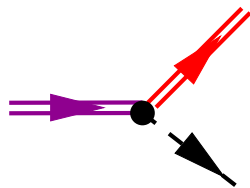
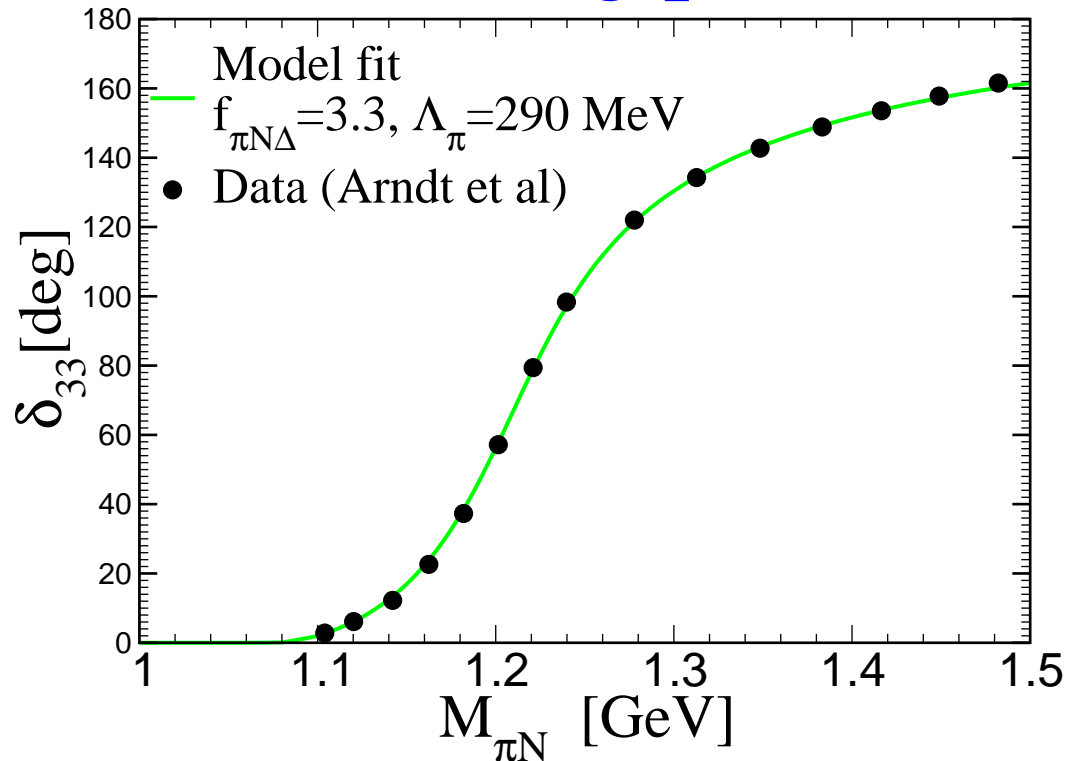
$$F_{\text{mono}}(|\vec{k}|) = \Lambda^2 / (\Lambda^2 + \vec{k}^2) \quad (s\text{- and } p\text{-waves})$$

$$F_{\text{dip}}(|\vec{k}|) = [2\Lambda^2 / (2\Lambda^2 + \vec{k}^2)]^2 \quad (d \text{ waves})$$

Hadronic model in the vacuum



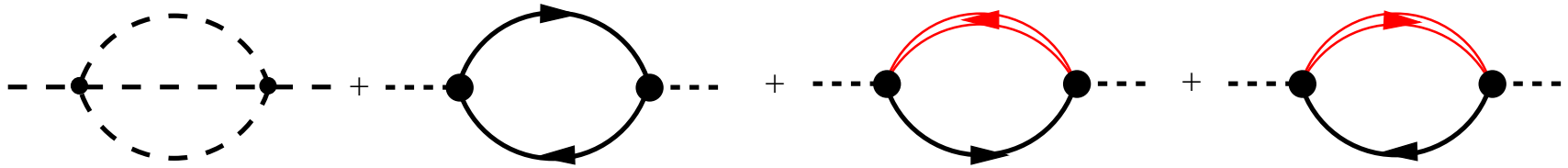
πN scattering phase shift



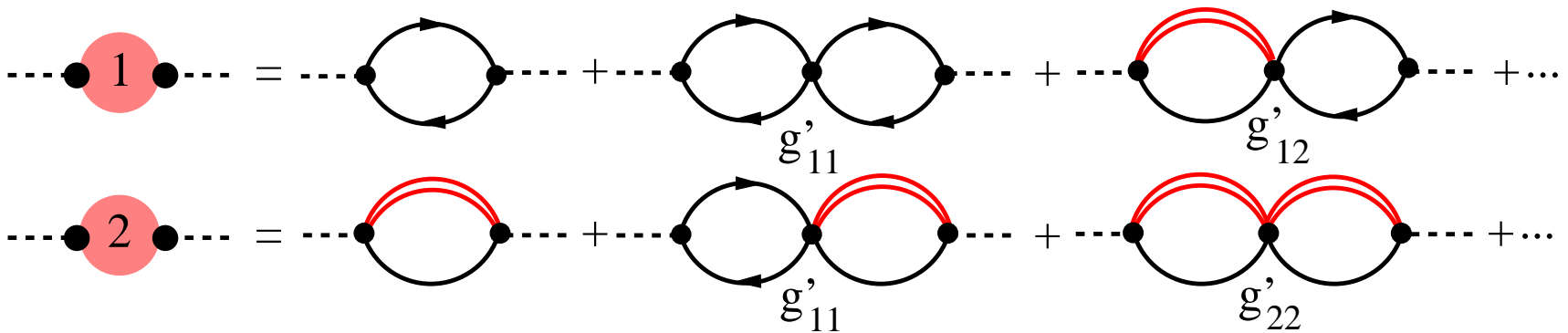
$B^* \Delta / N \pi$ vertex \leftrightarrow partial decay widths
 e.g. $N^*(1440)$ (s wave),
 $N^*(1520)$ (s+d waves), ...

Medium Modifications of pions

- pions: nucleon and Δ -hole excitations

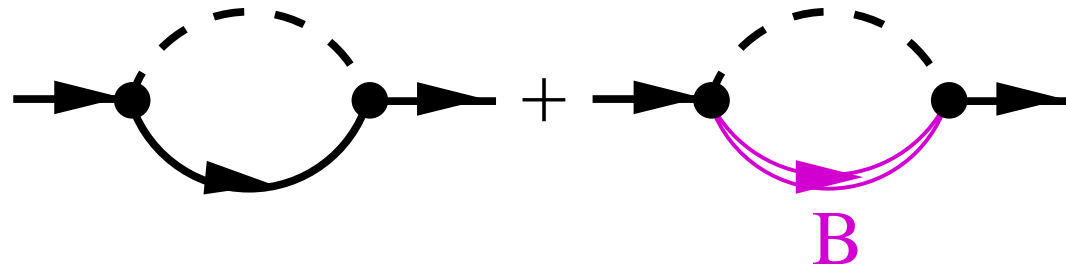


- short-range correlations: Migdal resummation



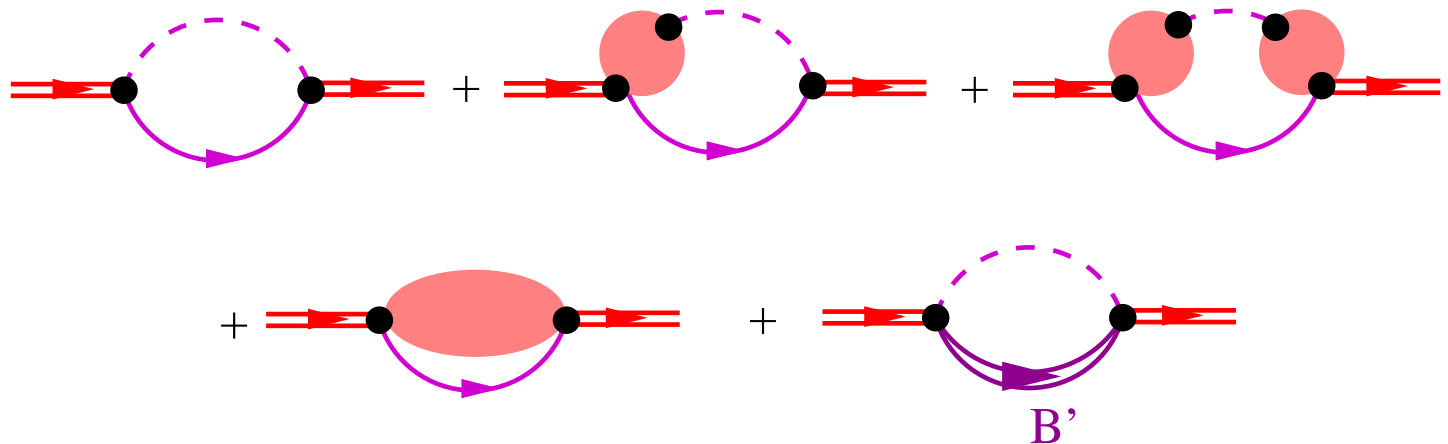
Medium Modifications of Nucleons

- 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 the Δ

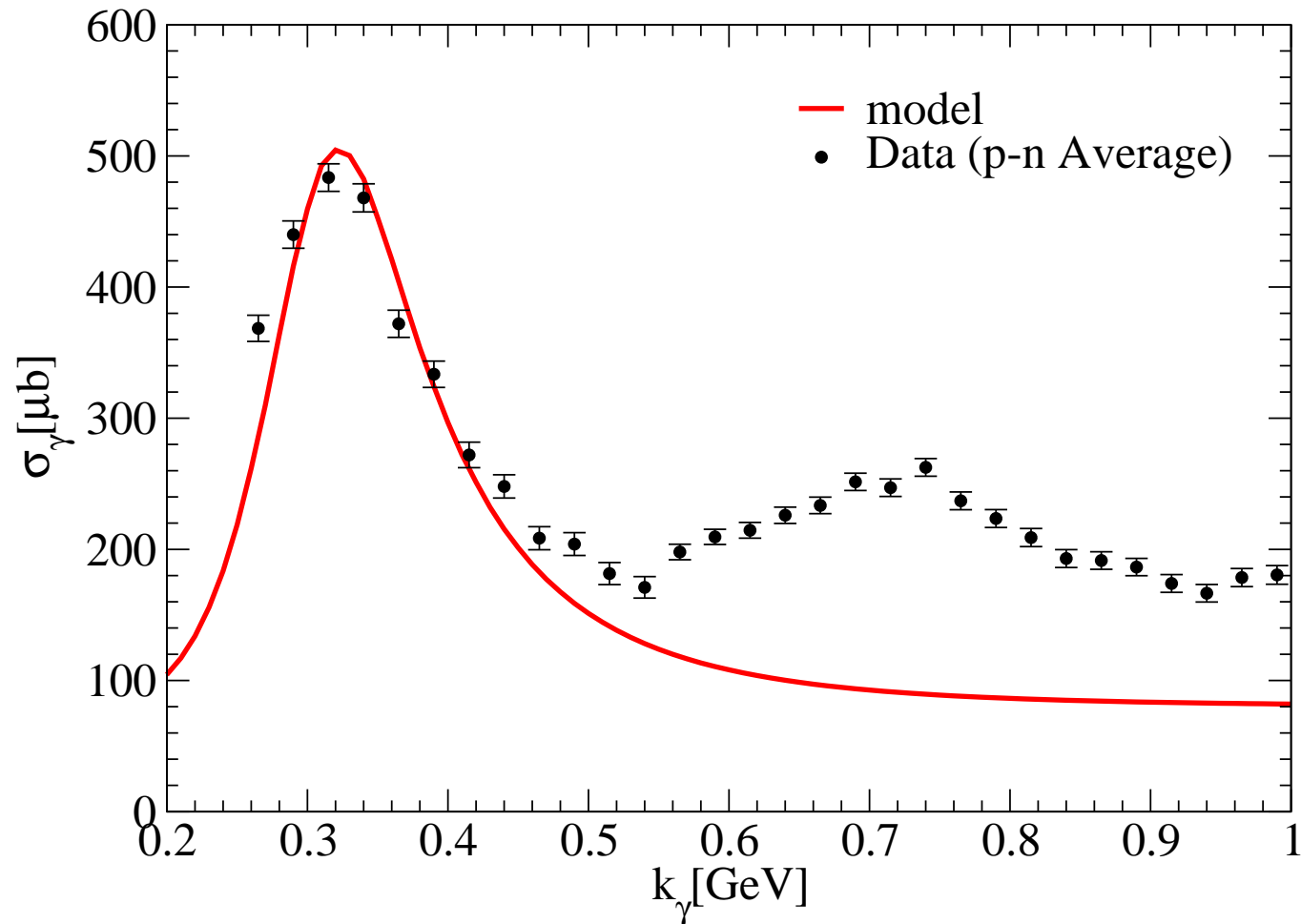
- same diagram as in vacuum with dressed pion- and nucleon propagators
- vertex corrections: same resummed Migdal loops as for the pion
- 4-fermion vertices: same Migdal parameters as for the pion



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

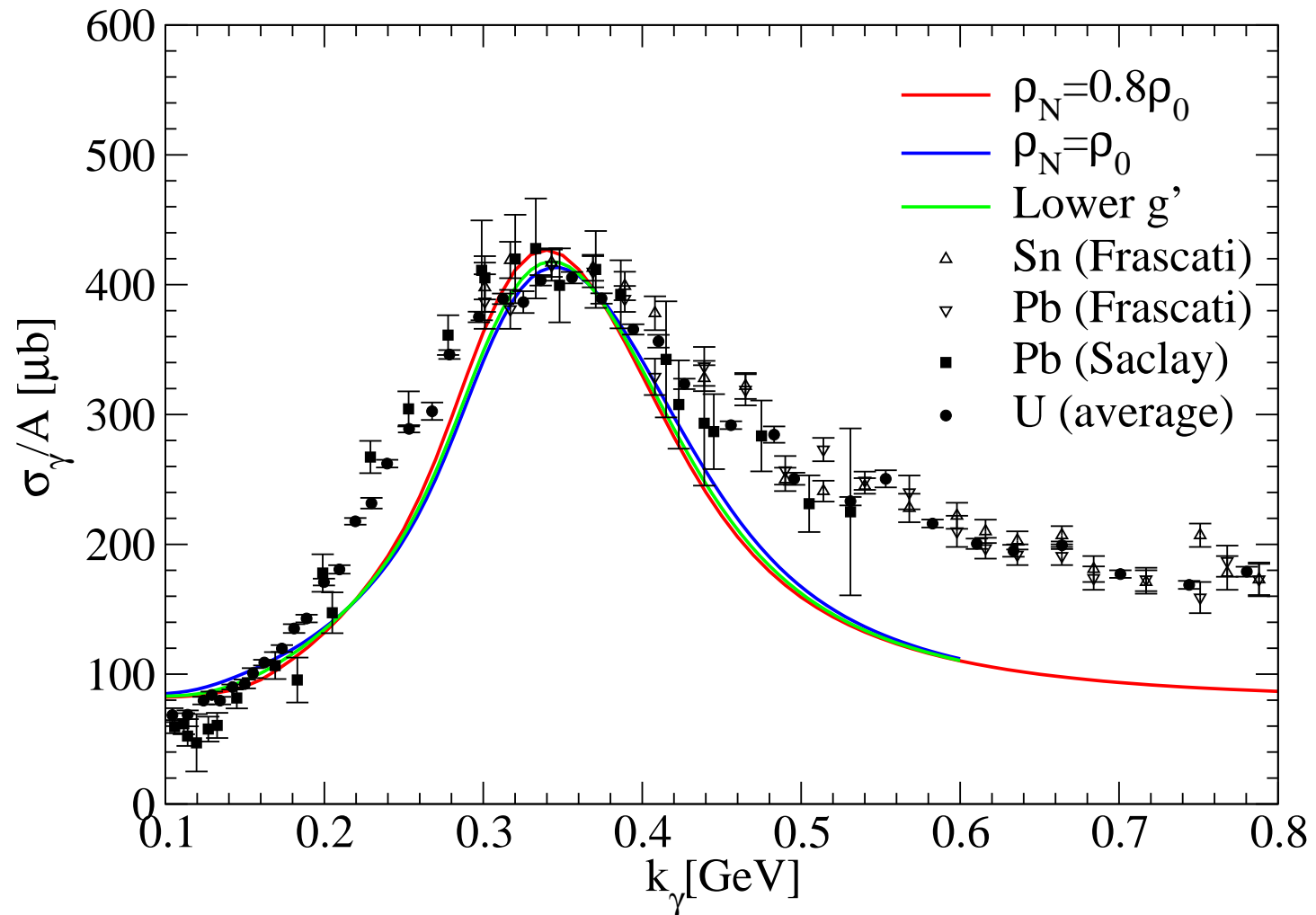
Cold Nuclear Matter

● photo absorption on the nucleon 

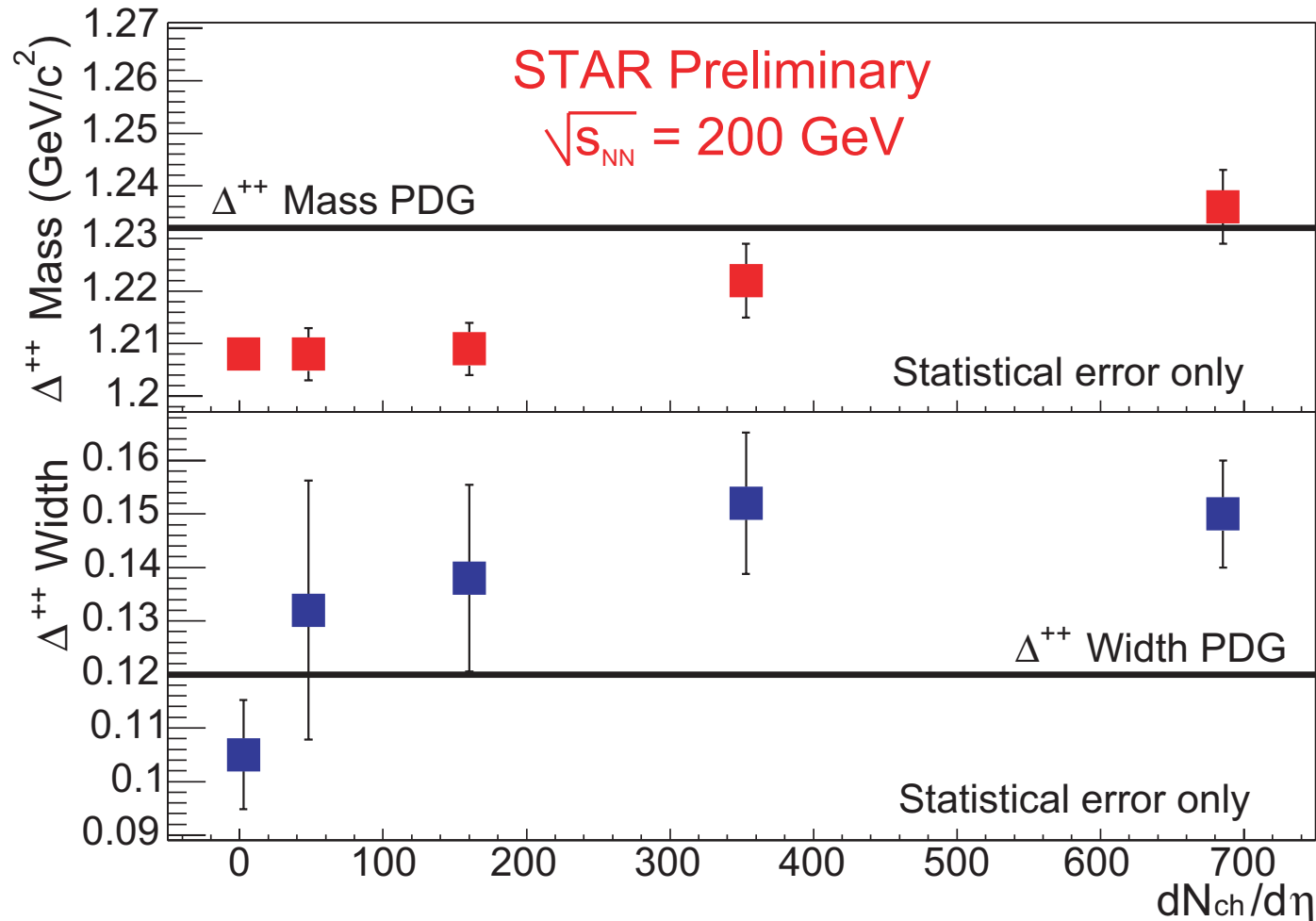


Cold Nuclear Matter

- photo absorption on nuclei



Hot hadronic matter (RHIC)

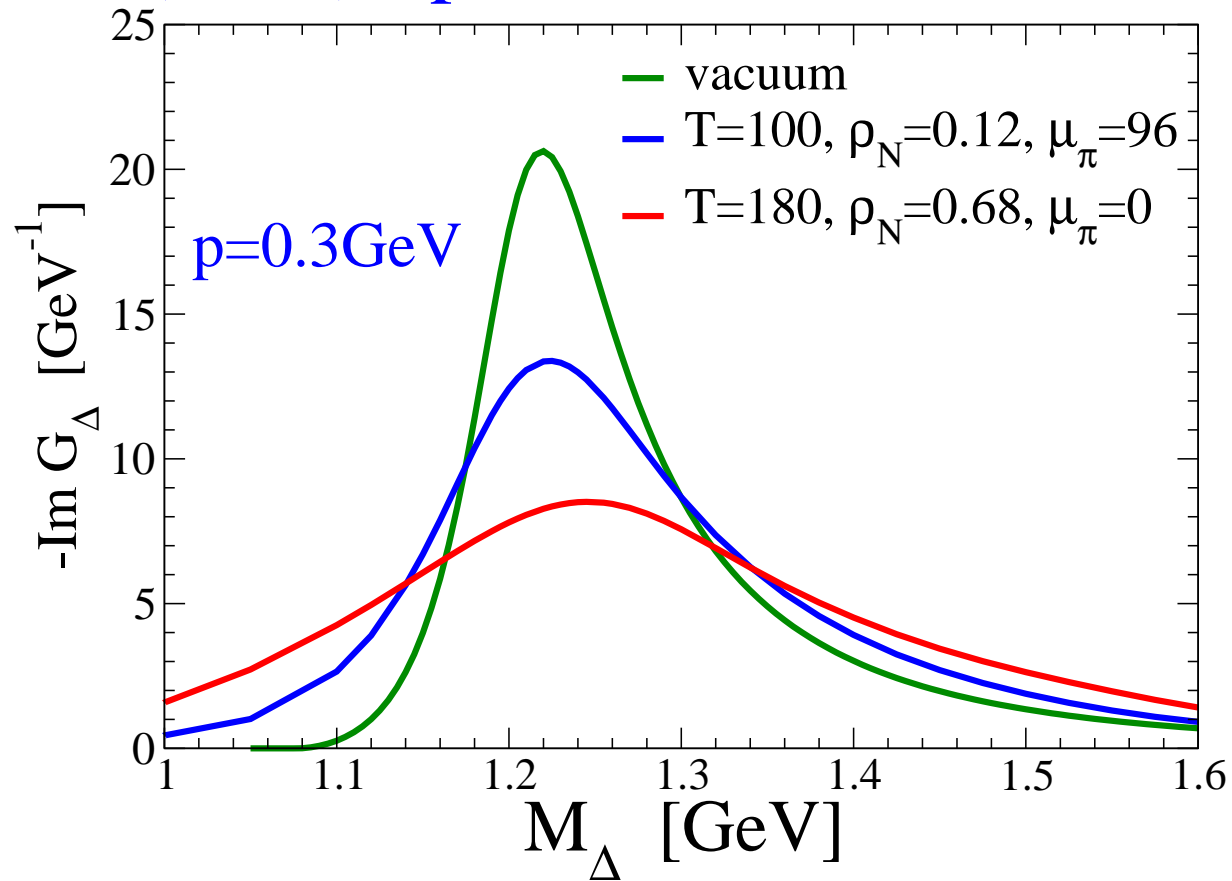


Courtesy: Patricia Fachini

$$\Delta m \sim (17 \pm 7) \text{ MeV}, \Delta \Gamma \sim (45 \pm 14) \text{ MeV}$$

Hot hadronic matter (RHIC)

$\Delta(1232)$ Spectral Function at RHIC



$$\Delta m \sim 7 \text{ MeV}, \Delta \Gamma \sim 67 \text{ MeV}$$

Conclusions and Outlook

- photo absorption on **nuclei/ πN spectra** \leftrightarrow connection of JLab and RHIC physics
- results qualitatively in line with preliminary STAR data for πN invariant-mass spectra

Conclusions and Outlook

- photo absorption on **nuclei/ πN spectra** \leftrightarrow connection of JLab and RHIC physics
- results qualitatively in line with preliminary STAR data for πN invariant-mass spectra
- further developments:
 - medium effects on **excited resonances**
 - πN invariant-mass spectra \leftrightarrow detailed treatment of **freezeout dynamics**
 - implication for **vector mesons** \leftrightarrow **chiral framework**
 - Equation of State of **interacting** Hadron gas/chemical freeze-out