Branching ratio change in K^- absorption at rest and the nature of the $\Lambda(1405)$

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1. **$\bar{K}N$ interaction $\leftrightarrow$ $\Lambda(1405)$ puzzle**
   - ⋆ **Repulsive**
     $\cdots$ **Experimental data (Scattering & Kaonic Hydrogen)**
   - ⋆ **Attractive**
     $\cdots$ **K^-A optical potential**

   $\cdots$ **Boundstate picture of $\Lambda(1405)$ may solve it.**

2. **Mass shift of $\Lambda(1405)$ in Medium**
   - ⋆ **Boundstate Picture of $\Lambda(1405)$**
   - ⋆ **Mass shift of $\Lambda(1405)$ from Pauli blocking**
   - ⋆ **$I = 0$ ($\Lambda(1405)$ channel) and $I = 1$ interference**
     $\rightarrow$ **Branching Ratio Change**

3. **Comparison of Two Scenarios of $\Lambda(1405)$**
   - ⋆ **Stopped K^- Reaction**
   - ⋆ **(K^-, π^-) and (K^-, π^+) Spectrum**

4. **Summary**

$*$ **Phys. Rev. C, in press; Eprint nucl-th/9706084**

$\bar{K}N$ Interaction: Attractive or Repulsive ?

- **Repulsive (Exp. in $\bar{K}N$)**

  ⋆ **Low Energy Scattering** $\rightarrow a_{K^-p} \simeq -0.15$ **fm**
  (Martin, NP B179 ('81), 33)

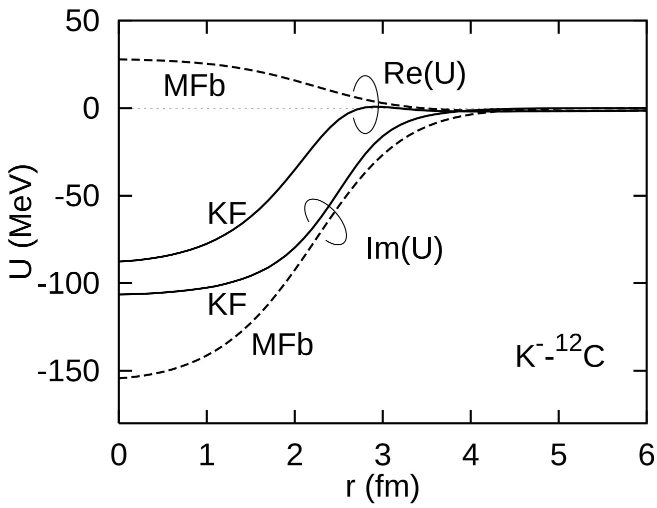
  ⋆ **$1s$ Energy Shift of Kaonic Hydrogen** $\rightarrow -323$ **eV**
  (Iwasaki et al., PRL 78 ('97), 3067)

- **Attractive (Theory, $\bar{K}A$)**

  ⋆ **Kaonic Atom (not hydrogen)**

$$U_N(K^-A) = \alpha\rho + \beta\rho^2 \neq -\frac{2\pi\hbar^2}{\mu_{KN}} a_{K^-N}\ \rho$$

(Friedman et al., PL B308 ('93), 6)



$\cdots$ **How can we solve this problem ?**
$\rightarrow$ Boundstate Picture of $\Lambda(1405)$ May Help it.

$\Lambda(1405)$ Puzzle

- $\Lambda(1405)$ **Resonance**

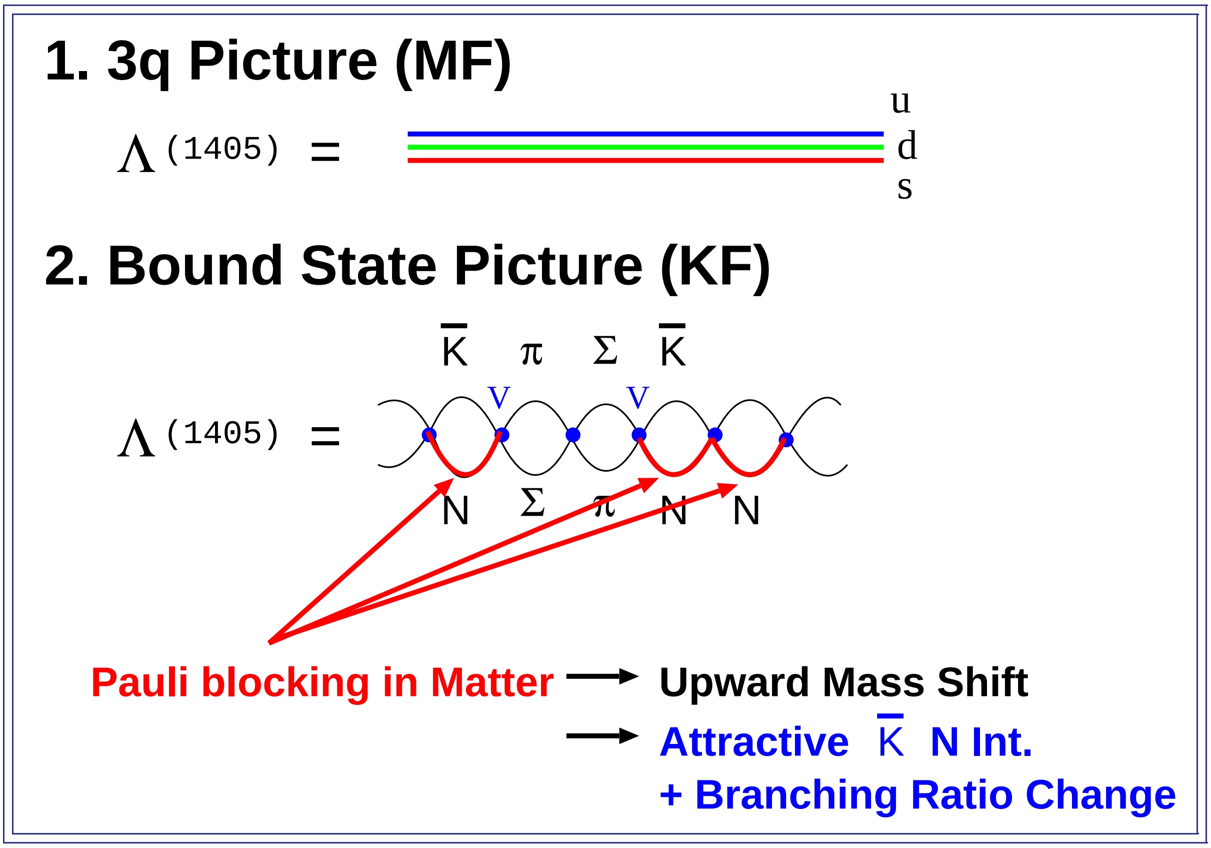
  $\star$ $I = 0, J^\pi = 1/2^-$ **(S-wave)**

  $\star$ **Just below $\bar{K}N$ threshold (1432 MeV)**
  $\rightarrow$ **Repulsive contribution to Scattering Length**

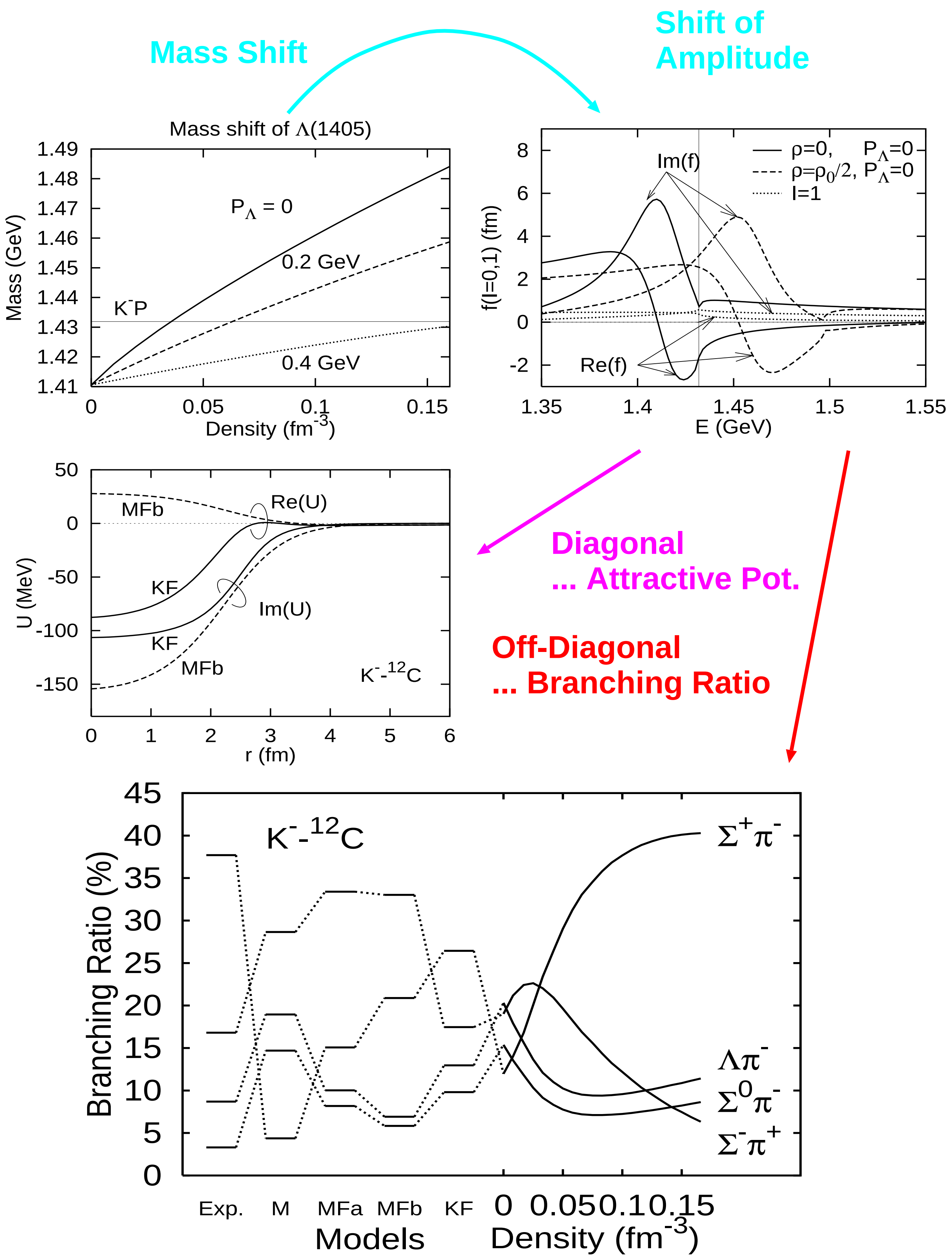
- **Two Pictures of** $\Lambda(1405)$

1. $\Lambda(1405) \simeq 3q$

2. $|\Lambda(1405) >= |\bar{K}N > + |\Sigma\pi >=$ **Boundstate of** $\bar{K}N$
(Dalitz et al., PR 153 ('67),617, Siegel and Weise, PR C38 ('88),2221)
$\leftrightarrow$ **Difficulty in "pure" quark model for** $\Lambda(1405)$
(c.f. Hamaie,Arima,Masutani, NP A591 ('95), 675)



Branching Ratio Change in Medium



Two Scenarios of $\Lambda(1405)$

1. **Model MF:** $\Lambda(1405) \simeq 3q$
   - $\star$ **Martin's Amp. w. Fermi ave.+B.E. Corr.**
   - $\star$ **No Medium Effects on** $\Lambda(1405)$
   - $\star$ **Br. Rat. in** ^{12}**C(Stopped** K^-, π**):** $\Sigma^-\pi^+ > \Sigma^+\pi^-$
2. **Model KF:** $\Lambda(1405) \simeq$ **Bound State of** $\bar{K}N$
   - $\star$ **Koch's Amp. with Pauli blocking in** $\Lambda(1405)$
     (Koch, PL B337 ('94), 7, Waas et al., PL B365 ('94), 12
     Staronski et al., J.Phys.G13('87),1361, Masutani, NPA483('88),565)
   - $\star$ **Density Dependent** $\Lambda(1405)$ **Mass**
   - $\star$ **Br. Rat. in** ^{12}**C(Stopped** K^-, π**):** $\Sigma^-\pi^+ < \Sigma^+\pi^-$

Stopped K^- Reaction

(Exp: Tamura et al., PR C40('89),R479, Kubota et al. NP A602('96),327
Theor: Nara et al., PL B346('95), 217; INS 23,
Staronski et al., J.Phys.G13('87),1361, Masutani, NPA483('88),565)

- **Advantages**

1. $I = 0$ **Branches are dominant** $\cdots$ $\Lambda(1405)$ **Tail**
2. **A lot of Exp. Data**
   $(K^-, \pi^\pm)$ **on various nuclear targets**
3. **Spectrum is sensitive to B.R.**
4. **Slow** $\Lambda(1405)$ **is produced.**

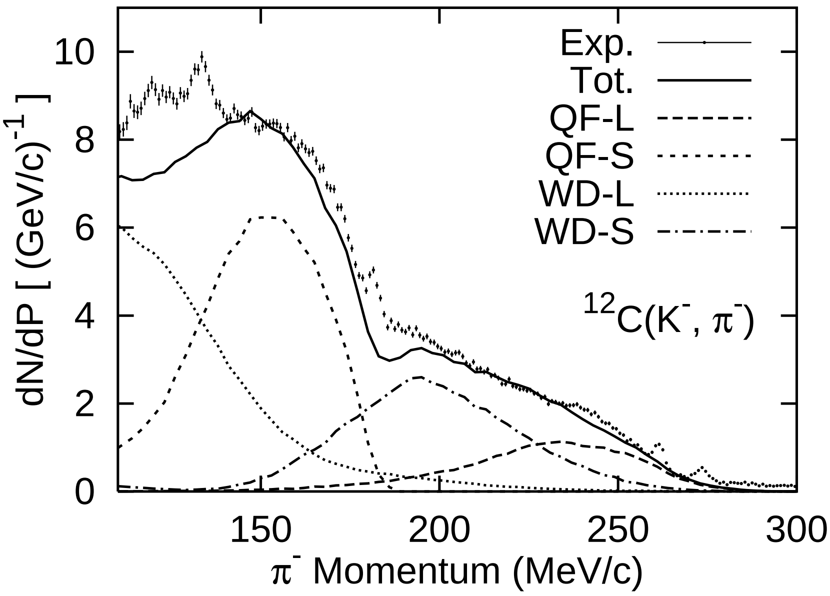
- **Disadvantages**

1. **Reaction processes are complex.**
   Σ **conversion to** Λ, π **rescattering**
   $\rightarrow$ **Monte Carlo Simulation**

• (K^-, π^-) **Spectrum**

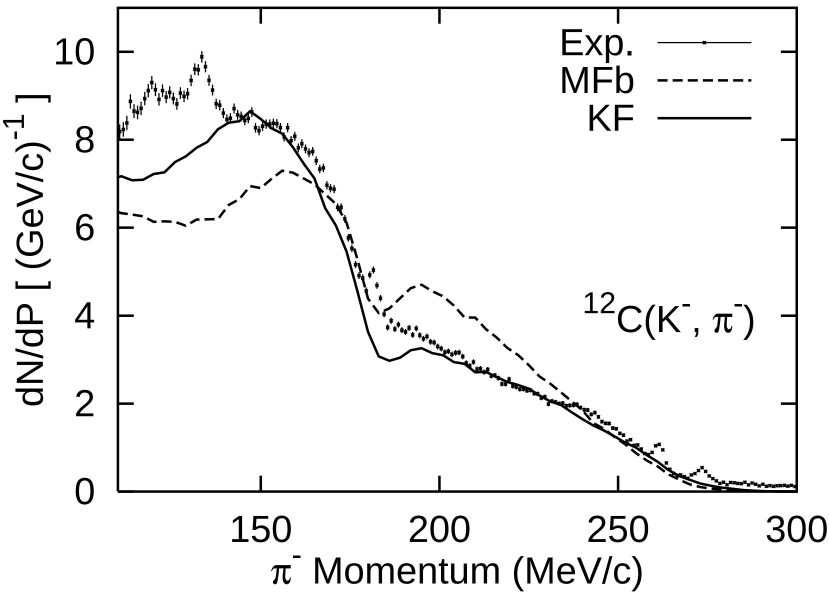
(Exp: Tamura et al., PR C40('89),R479)

⋆ **Components of** (K^-, π^-) **Spectrum**



⋆ **Comparison of Two Scenarios**

⋯ **Model KF is slightly better.**



- (K^-, π^+) **Spectrum**

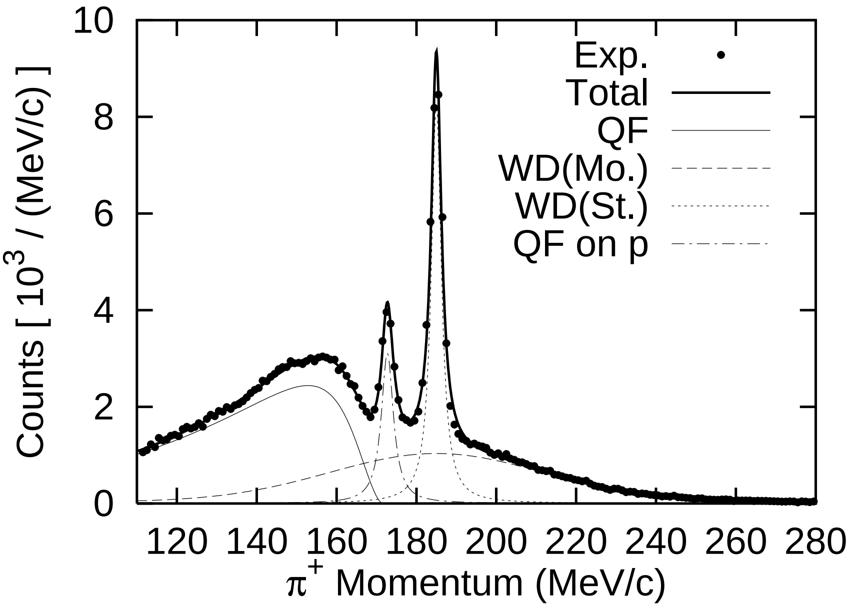
(Exp: Kubota et al. NP A602('96),327)

π^+ **comes from**

QF $(K^- p \to \Sigma^- \pi^+)$

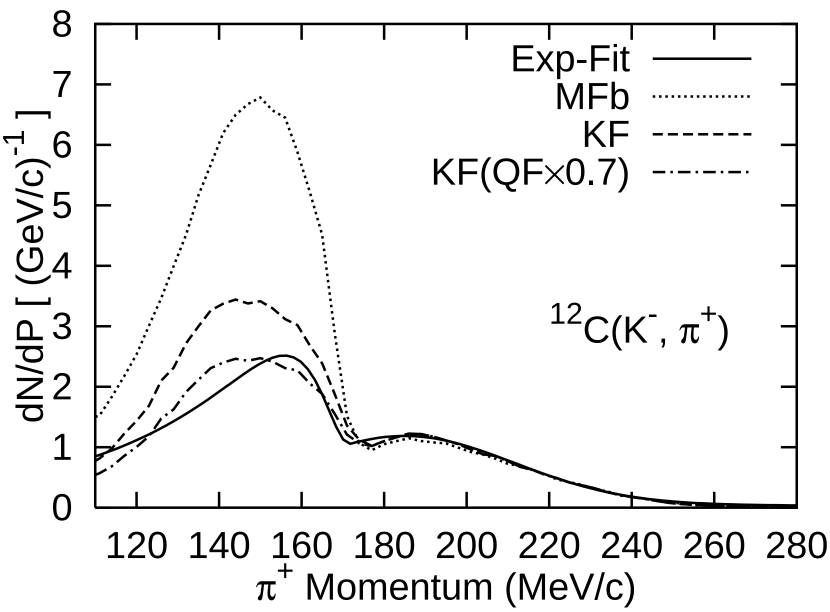
or **WD** $(K^- p \to \Sigma^+ \pi^-, \Sigma^+ \to \pi^+ n)$

⋆ **Components of** (K^-, π^-) **Spectrum**



⋆ **Comparison of Two Scenarios**

⋯ **Model KF is much better.**



Summary and Future Work

- **Summary**

1. **$\Lambda(1405)$ mass shift induces**
   LARGE Branching Ratio Change
   at finite ρ ($\Sigma^+\pi^- \leftrightarrow \Sigma^-\pi^+$).

2. **Stopped K^- Reaction**

   ⋆ (K^-, π^-);
   Various QF ($K^-N \to Y\pi^-$)
   + Various WD ($K^-N \to Y\pi, Y \to \pi^-N$)

   ⋆ (K^-, π^+); **Clean Reaction**
   QF ($K^-p \to \Sigma^-\pi^+$)
   + WD ($K^-p \to \Sigma^+\pi^-, \Sigma^+ \to \pi^+n$)

3. **Boundstate picture gives better description,**
   especially of (K^-, π^+) spectrum.

- **Future Work**

1. **Remaining differences from data**

   ⋆ **Final state interaction ?**
   $\cdots$ **Σ conversion, π absorption ?**

   ⋆ **More mass shift ?**

   ⋆ **B. E. corr., or $\Lambda(1405)$ potential ?**

2. **Direct measurement of mass shift**
   $K^-A \to \pi\Lambda(1405)$ (Magic momentum)