# *Lambda-Lambda correlation in high-energy heavy-ion collisions*

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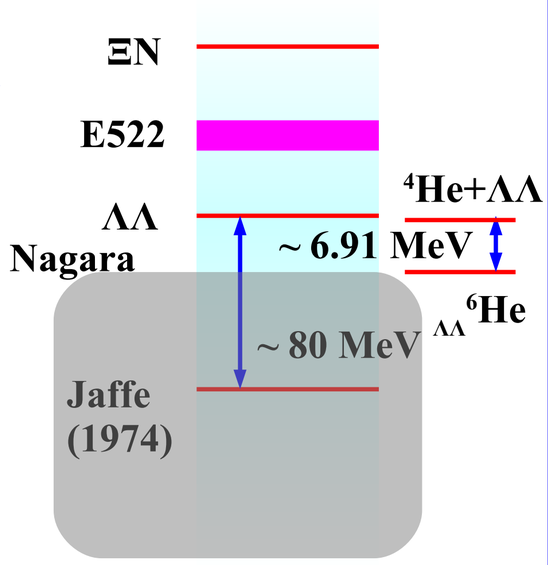
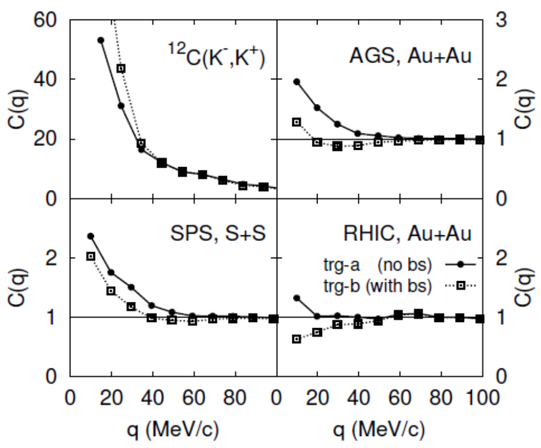
**[to be submitted]**

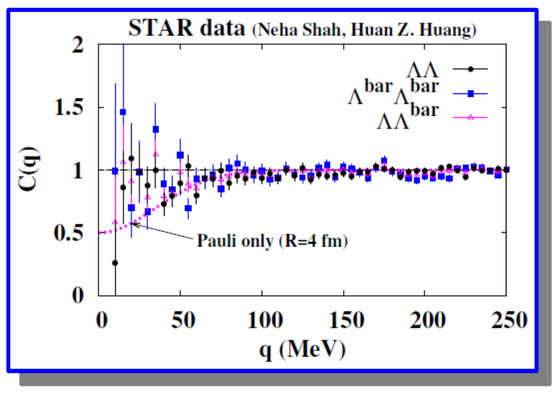
## *Introduction*

- **Where is the S=-2 dibaryon (uuddss) "H" ?**
  - **MIT bag Jaffe, 1977**
    **→ ~ 80 MeV below ΛΛ**
  - **Quark model Oka, Takeuchi, 1991**
    **→ KMI Det. int. may make "H" a resonance above ΛΛ**
  - **Nagara Event $_{\Lambda\Lambda}{}^{6}$He (2001)**
    **→ No deeply bound "H"**
  - **KEK-E522 Yoon et al., 2007**
    **→ "bump" at $E_{\Lambda\Lambda}$ ~ 15 MeV**
    **(Resonance "H" ?)**
  - **Lattice QCD**
    **HAL QCD & NPLQCD**
    **→ bound H at large quark mass**




- **How about HIC ?**
  - **RHIC & LHC = Hadron Factory including Exotics**
  - **"H" would be formed as frequently as stat. model predicts.**
    **Cho et al. (ExHIC Collab.), PRL('11)212001; arXiv:1107.1302**
  - **Precitions of ΛΛ Correlation in HIC**
    **C. Greiner, M. Muller (1989); A.Ohnishi et al., (2000)**
    **→ We can guess the strength of ΛΛ interaction**
  - **Recent observation of ΛΛ correlation at RHIC**
    **Neha Shah et al., (STAR Collab.),**
    **Acta Phys.Polon.Supp. 5 (2012) 593; arXiv:1112.0590.**

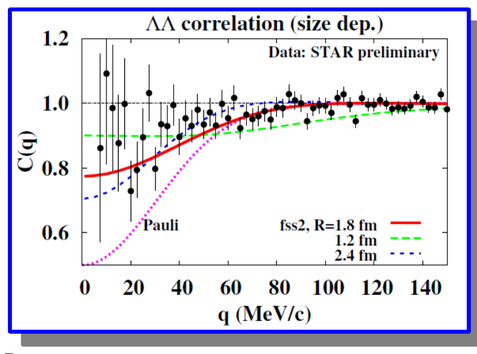


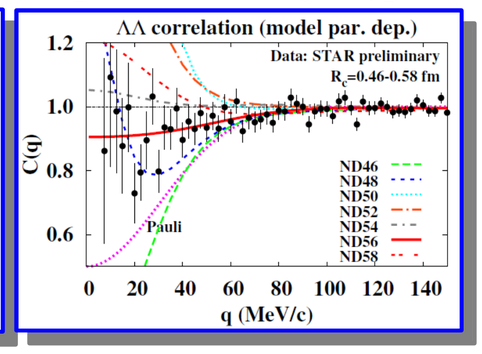




***This work:***
***Λ Λ correlation data → Λ Λ interaction***
***How far can we constrain it ?***

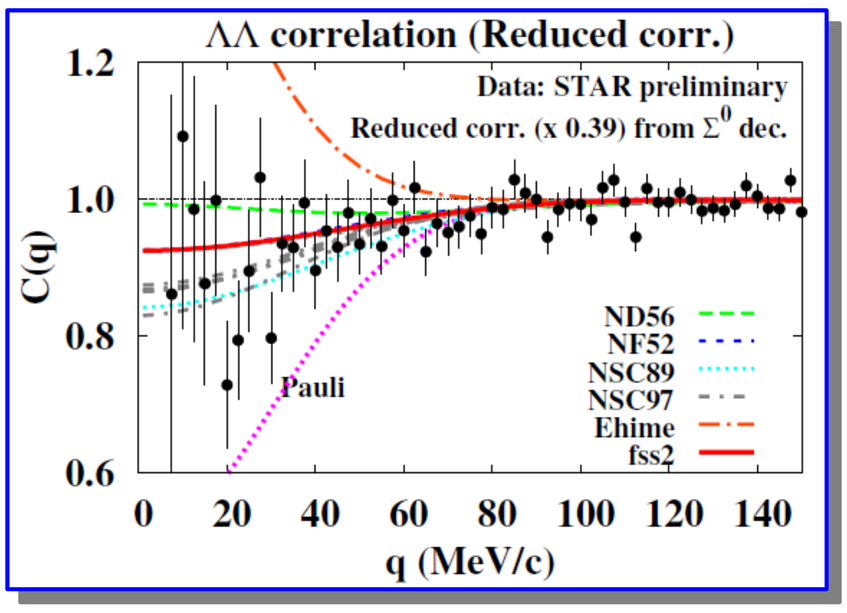
## *Results*

- **How can we determine ΛΛ interaction ?**
  - **1st step: Fix (guess) source size from C(q) at large q**
  - **2nd step: Fix undetermined model parameters by C(q)**

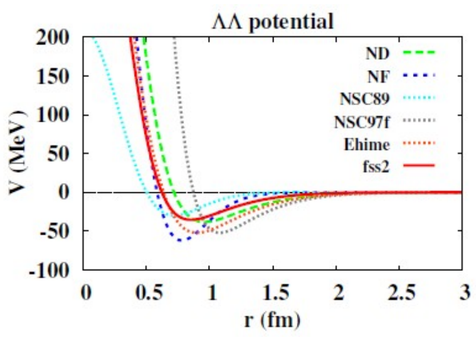


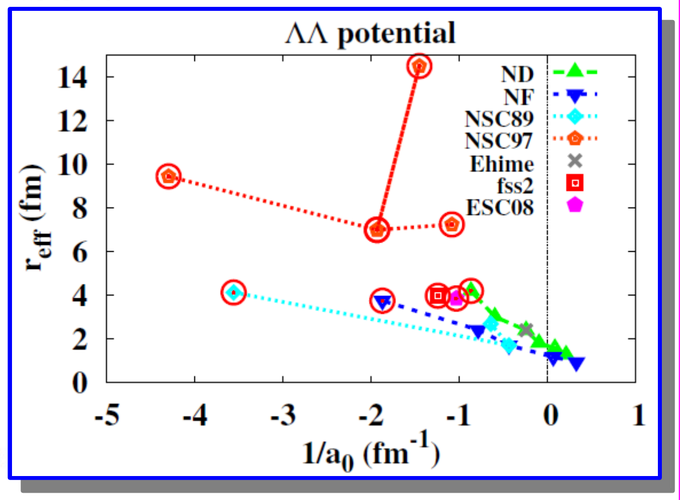




- **Results**
  - **Feeddown effects from $\Sigma^0$ is included via red. of C(q)-1.**




- **ΛΛ int. favored by RHIC data**
  - **ND & NF with large hardcore radius**
  - **Some of NSC98, Most of NSC97**
  - **Quark model int. (fss2)**
    **→ $1/a_0 < -0.8$ fm$^{-1}$, $r_{eff} > 3$ fm**

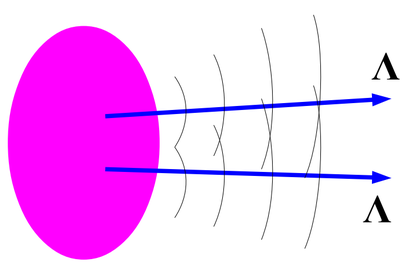



***Even with preliminary data, ΛΛ correlation at RHIC can constrain ΛΛ interaction to some extent !***

## *ΛΛ correlation in HIC*

- **Merit of HIC to measure ΛΛ correlation**
  - **Source is "simple and clean" !**
  - **T, μ, flow, size, … are well-analyzed.**
  - **Source size is big and probes w.f. tail.**
  - **Discovery of "H" and/or Constraint on ΛΛ int.**
- **Model: Gaussian Source + s-wave int.**
  **c.f. Bauer, Gelbke, Pratt (1992)**




$$C_{\Lambda\Lambda}(q)=\frac{\int dx_1 dx_2 S(x_1, p+q) S(x_2, p-q)|\psi^{(-)}(x_{12}, q)|^2}{\int dx_1 dx_2 S(x_1, p+q) S(x_2, p-q)}$$

$$\simeq 1-\frac{1}{2}\exp(-q^2 R^2)+\frac{1}{2}\int dr\, S_{12}(r)\left(|\chi_0(r)|^2-|j_0(qr)|^2\right)$$

**( $\chi_0$ : s-wave wave func., $S_{12}(x)=(R\sqrt{\pi})^{-3}\exp(-r^2/R^2)$ )**

- **ΛΛ interaction**
  - **Meson exchange: Nijmegen model D, F, Soft Core (89, 97)**
    **Nagels, Rijken, de Swart ('77, '79), Maessen, Rijken, de Swart ('89), Rijken, Stoks, Yamamoto ('99)**
  - **Quark cluster model interaction: fss2**
    **Fujiwara, Fujita, Kohno, Nakamoto, Suzuki ('00)**
  - **Phenomenological model: Ehime**
- **Other effects than FSI**
  - **Feeddown effects : $\Sigma^0 \rightarrow \Lambda + \gamma$**
    **Monte-Carlo simulation results suggest Correlation (C-1) is reduced by 0.39.**
  - **Couple channel effects : ΞN - ΛΛ**

## *Summary & Discussion*

- **We studied ΛΛ correlation in heavy-ion collisions at RHIC.**
- **Recent STAR (preliminary) data clearly show enhanced ΛΛ correlation compared to the free fermion correlation.**
- **Effects other than Λ Λ final state interaction may be easily included or small.**
  - **$\Sigma^0$ decay effects are well simulated by multiplying 0.39 to (C-1), if there is no strong correlation in ΛΣ channel.**
  - **Coupled channel effects with ΞN is expected to be minor.**
- **Preferred ΛΛ interactions have $1/a_0 < -0.8$ fm$^{-1}$, $r_{eff} > 3$ fm.**
  **→ Weakly attractive. Consistent with Nagara event.**
- **Higher statistics data**
  **in HIC (RHIC, LHC) and ($K^-$, $K^+$ΛΛ) (J-PARC, proposal)**
  **are desired to pin down ΛΛ interaction.**

**R. L. Jaffe, PRL38 ('77) 195. / H. Takahashi et al., PRL87 ('01) 212502. / M. Oka and S. Takeuchi, NPA524 ('91) 649. / C. J.Yoon et al.(KEK-E522 collab.), PRC75 ('07)022201(R). / S.R. Beane et al. (NPLQCD Collab.), PRL106 ('11) 162001. / T. Inoue et al. (HAL QCD Collab.), PRL106 ('11) 162002. / S. Cho et al. (ExHIC collab.), PRL106('11)212001;PRC 84 ('11) 064910. / C. Greiner, B. Muller, PLB219 ('89) 199. / A. Ohnishi, Y.Hirata, Y.Nara, S.Shinmura, Y.Akaishi, NPA670('00)297c. / R. Lednicky, Phys.Part.Nucl.40('09)307. / A. M. Gasparyan et al. PRC85('12)015204. / Neha Shah et al. (STAR Collab.), APPS 5 ('12) 593.**