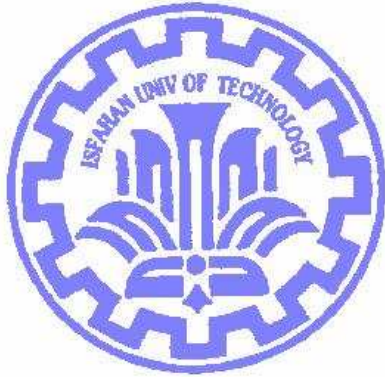




EXA2011
Sep. 07, 2011



A Double-Kaonic Nuclear System, K^-K^-pp to be formed in pp collisions

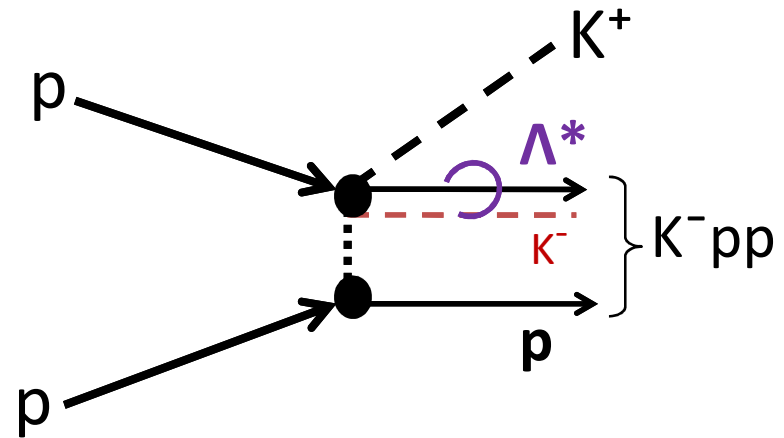
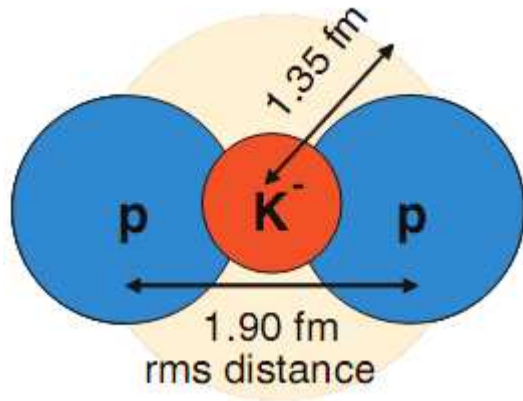
by:

HASSANVAND Maryam, AKAISHI Yoshinori,
YAMAZAKI Toshimitsu



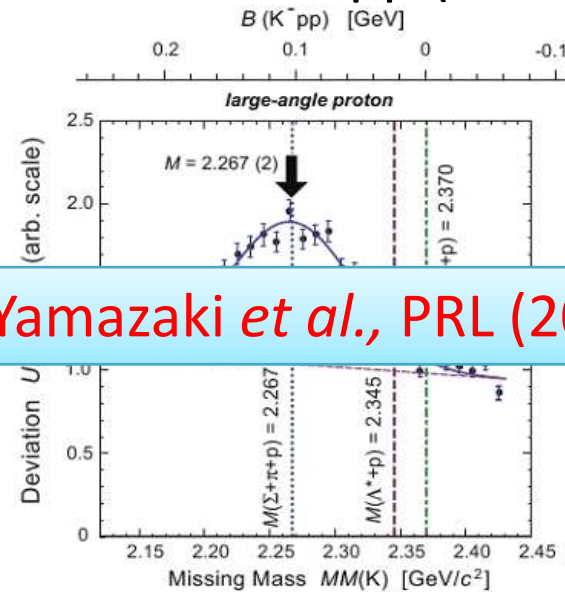
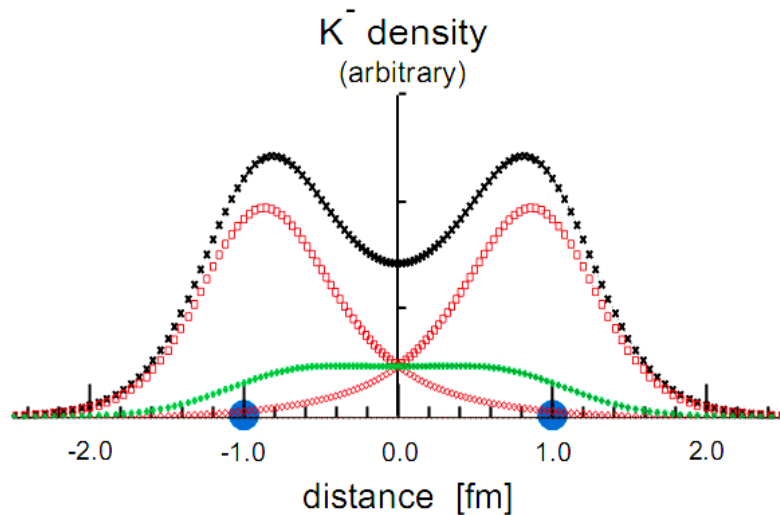
Austrian Academy of Sciences
Österreichische Akademie der Wissenschaften

T. Yamazaki, Y. Akaishi, PRC **76**(2007) 045201

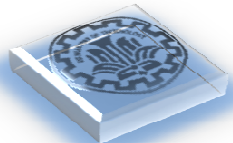


Incident Energy ~ 3 GeV

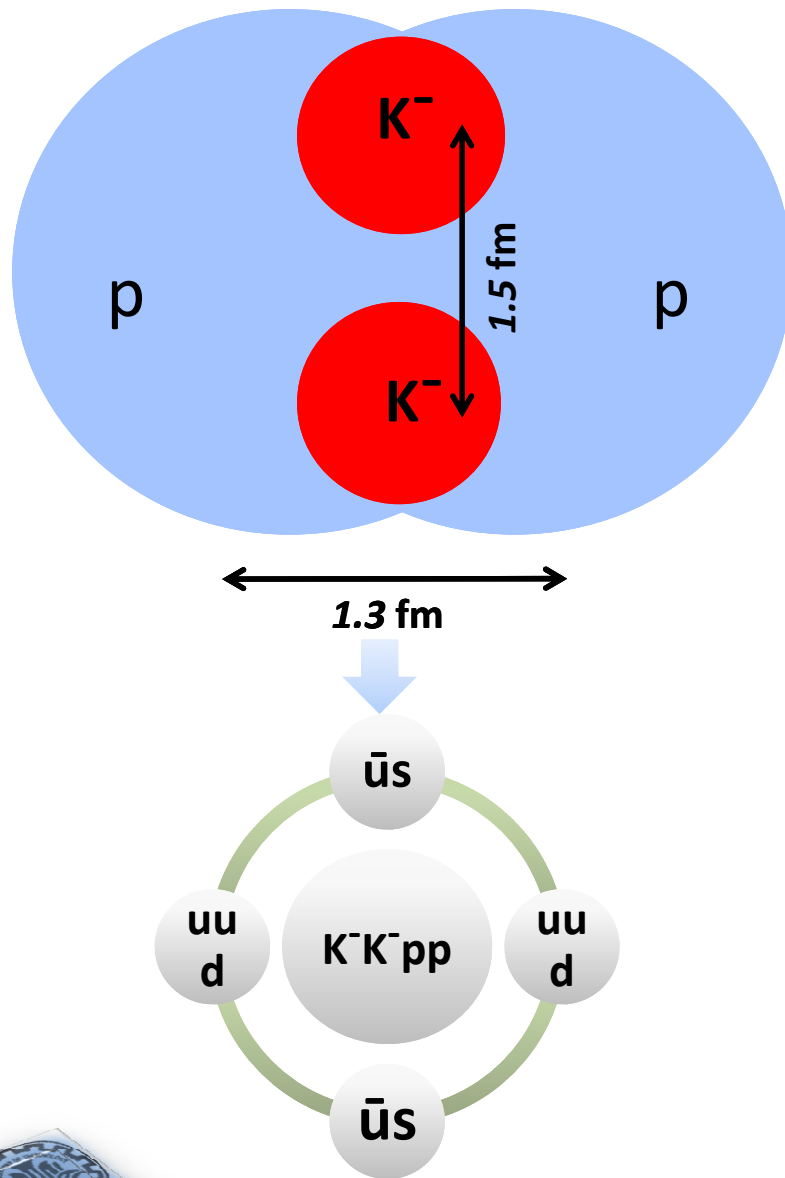
DISTO data on K^-pp (2.85 GeV)



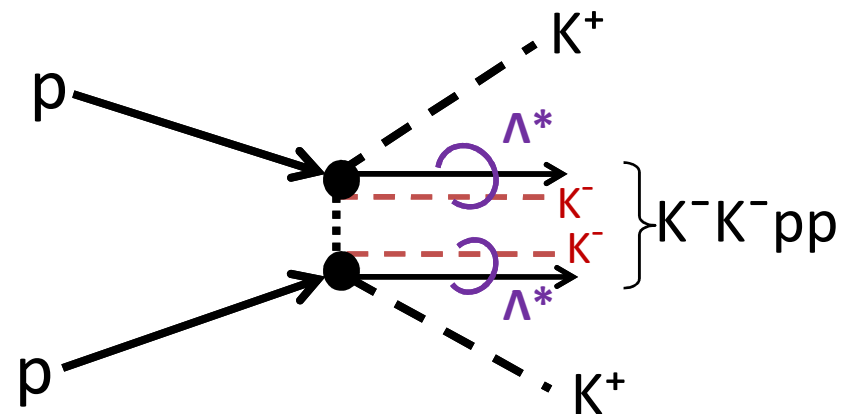
T. Yamazaki *et al.*, PRL (2010)



T. Yamazaki, A. Doté and Y. Akaishi, PLB **587**(2004) 167

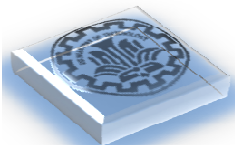


2010; New Idea!



Incident Energy ≥ 6 GeV

$p(p, K^+K^+)K^-K^-pp$



PHYSICAL REVIEW C **84**, 015207 (2011)

Theoretical investigation of the formation of $K^- K^- pp$ in high-energy proton-proton collisions

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¹RIKEN, Nishina Center, Wako, Saitama 351-0198, Japan

²Department of Physics, Isfahan University of Technology, Isfahan 84156-83111, Iran

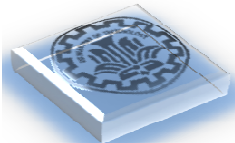
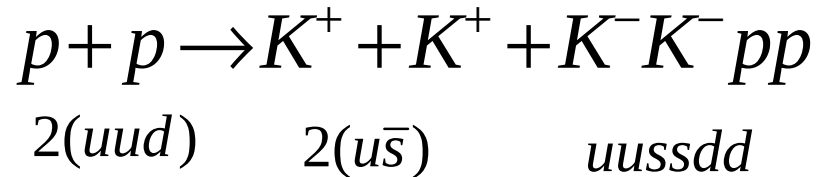
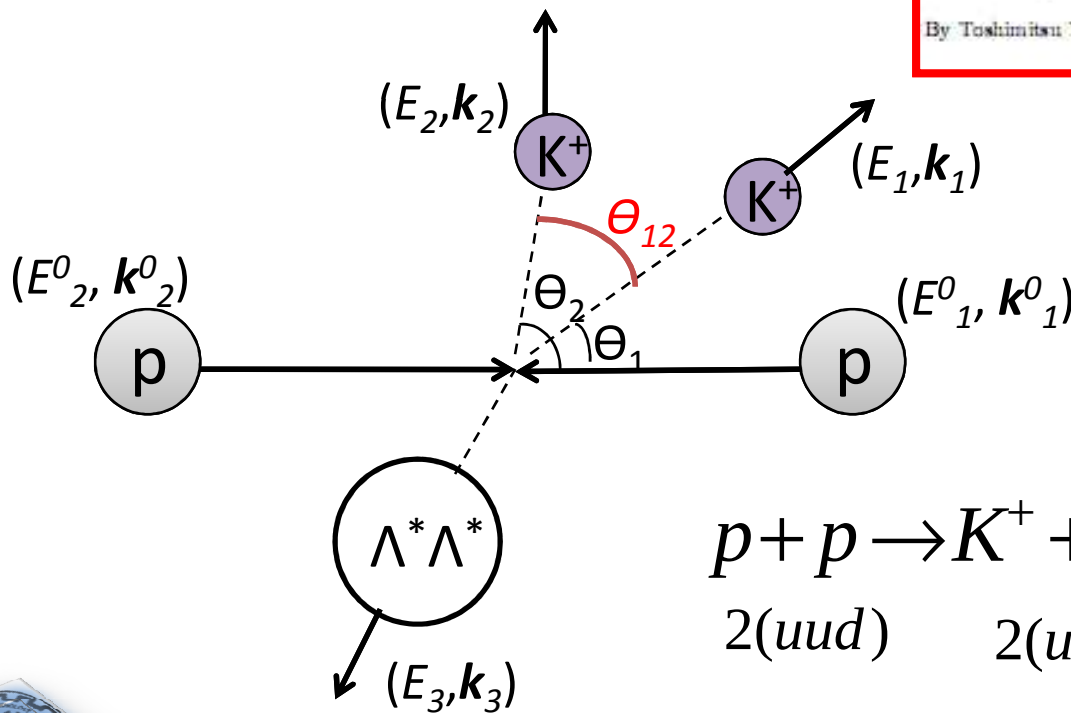
³College of Science and Technology, Nihon University, Funabashi, Chiba 274-8501, Japan

⁴Department of Physics, University of Tokyo, Bunkyo-ku, Tokyo 113-0033, Japan

Proc. Jpn. Acad., Ser. B **87** (2011)

New way to produce dense double-antikaonic dibaryon system,
 $\bar{K} \bar{K} NN$, through $\Lambda(1405)$ -doorway sticking in $p + p$ collisions

By Toshimitsu YAMAZAKI,^{*1,*2,†} Yoshinori AKAISHI^{*1,*3} and Maryam HASSANVAND^{*1,*4}



Reaction formula by Green's Function method

$$\frac{d^6 \sigma}{d^2 \Omega_1 d^2 \Omega_2 dE dE_1} = \beta(k_1) \frac{d^4 \sigma^{elem}}{d^2 \Omega_1 d^2 \Omega_2} S(E)$$

Spectral function
Strength function

$$S(E) = \frac{-1}{\pi} \text{Im} \left[\int d\vec{r} \int d\vec{r}' f^*(\vec{r}) \langle \vec{r} | \frac{1}{E - H_{\Lambda^* \Lambda^*} + i\varepsilon} | \vec{r}' \rangle f(\vec{r}') \right]$$

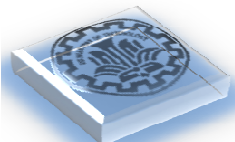
$$f(\vec{r}) = \frac{1}{r} \exp(-r/\beta) \exp(i\vec{Q}\vec{r}),$$

$$\beta(k) = \frac{k_1 k_2}{k_0} \left[1 + \frac{E_2}{E_3} \left(\frac{k_2 + k_1 \cos \theta_{12}}{k_2} \right) \right]^{-1}$$

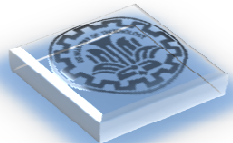
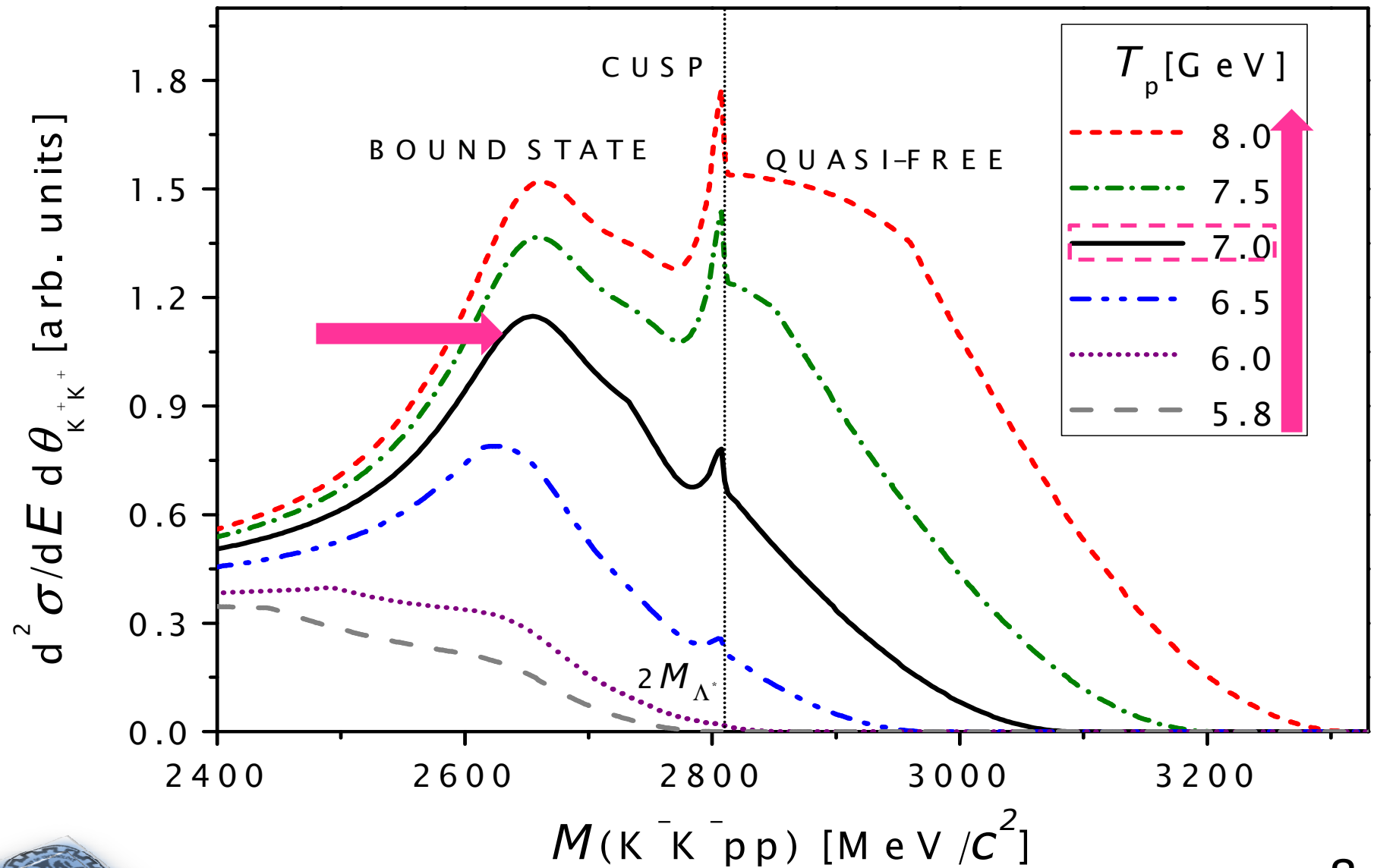
Kinematical
factor

$$E = M_{\Lambda^* \Lambda^*} - 2M_{\Lambda^*} = \sqrt{(E_{in} - E_1 - E_2)^2 - K_3^2} - 2M_{\Lambda^*}$$

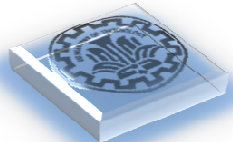
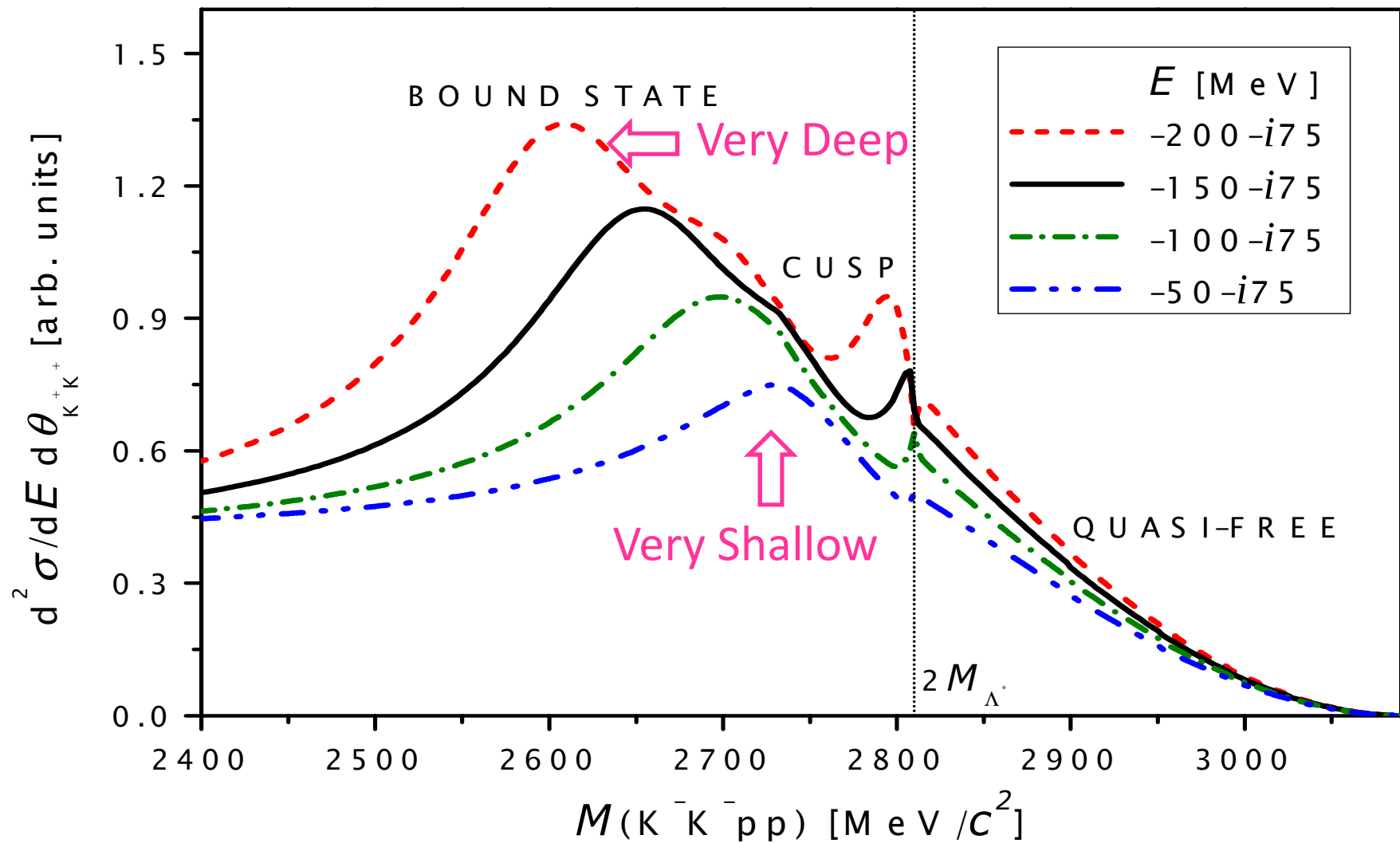
$$E_i = \sqrt{m_K^2 + k_i^2},$$



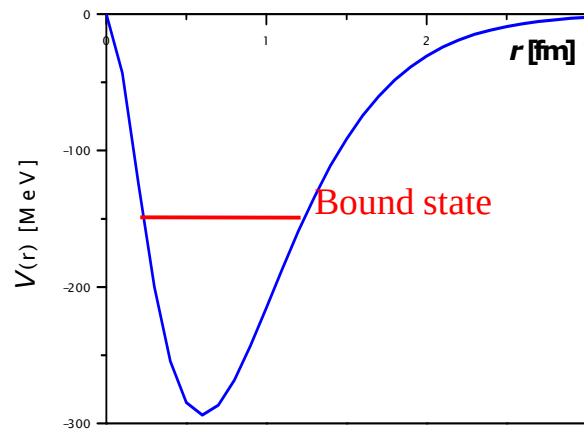
Incident Energy



Strength of the Interaction



$\Lambda^*-\Lambda^*$ model for $K^-K^- pp$

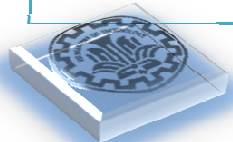


$$V_{\Lambda^*\Lambda^*}(r) = (V_0 + iW_0)\left(\frac{r}{b}\right)^2 \exp(-r/b)$$

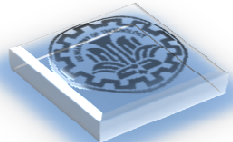
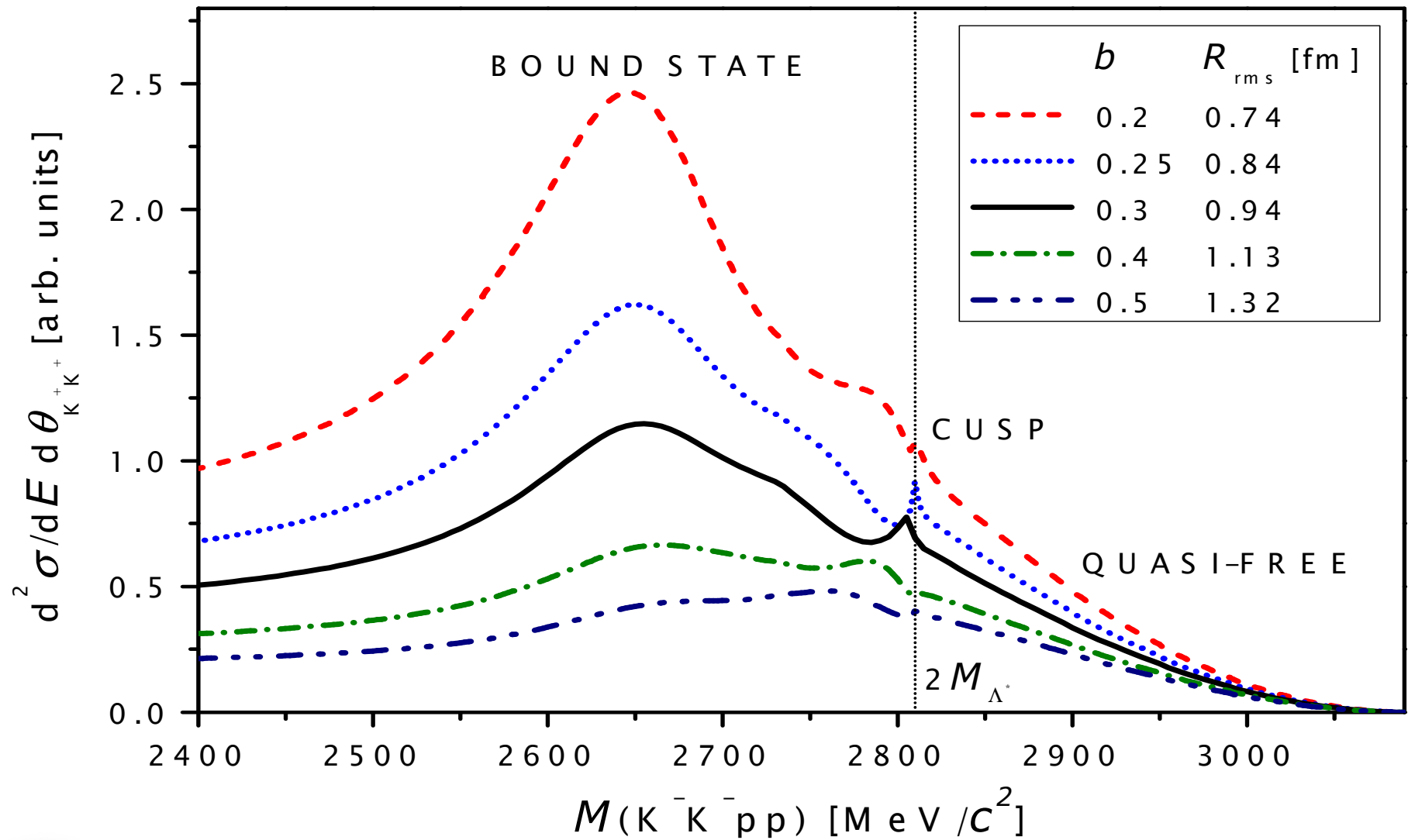
$$b = 0.3 \text{ fm}$$

$$E(K^-pp) = \begin{cases} -115-i34 & \text{FINUDA} \\ -105-i59 & \text{DISTO} \end{cases}$$

V_0+iW_0 [MeV]	$E(\Lambda^*\Lambda^*)$ [MeV]	rms distance [fm]	b [fm]
-298-i205	-50-i75	1.1121	0.3
-422-i190	-100-i75	1.005	0.3
-543-i182	-150-i75	0.94020	0.3
-661-i176	-200-i75	0.89602	0.3

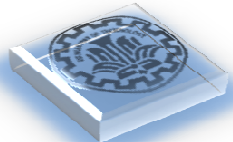
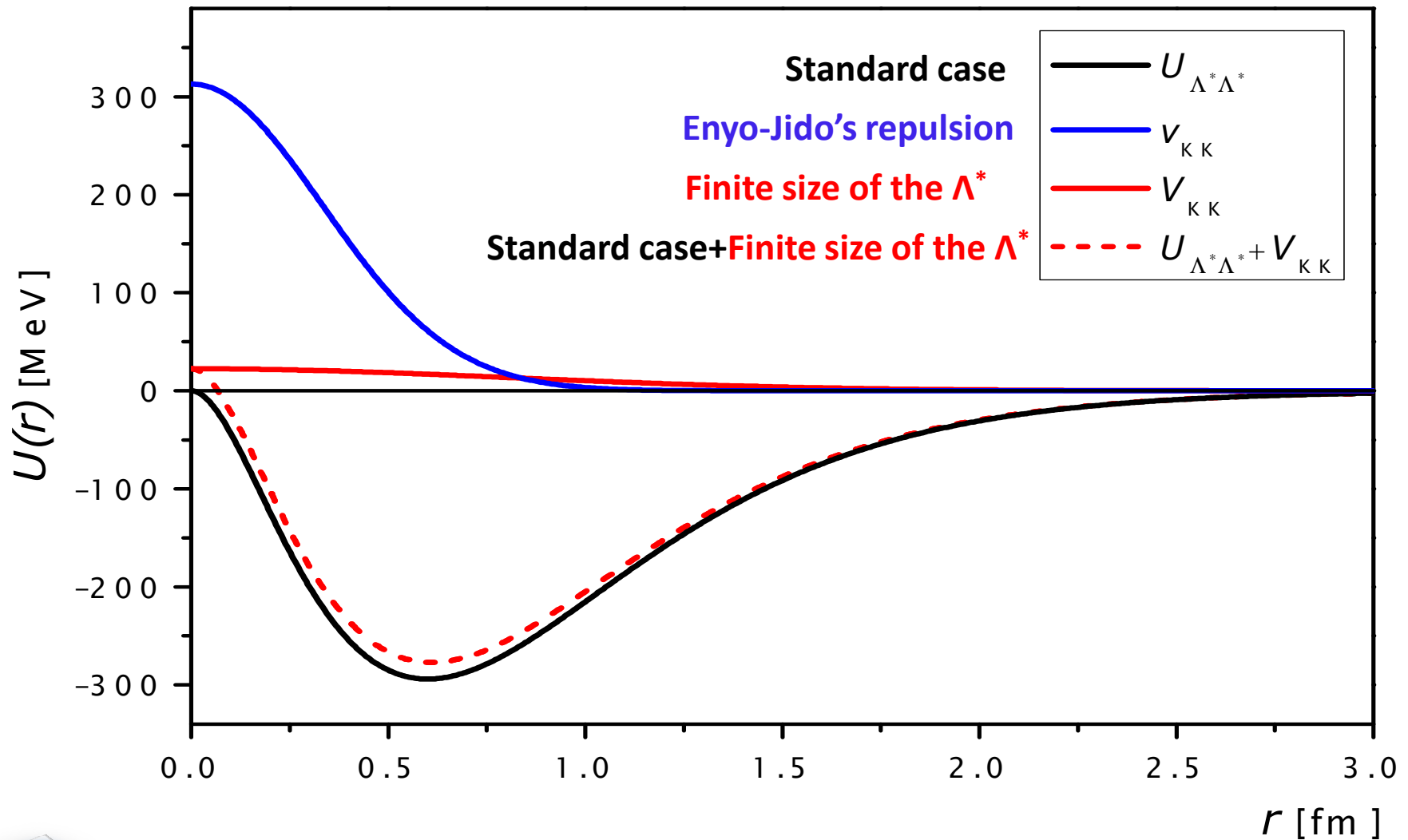


rms distance dependence

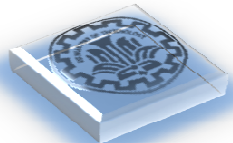
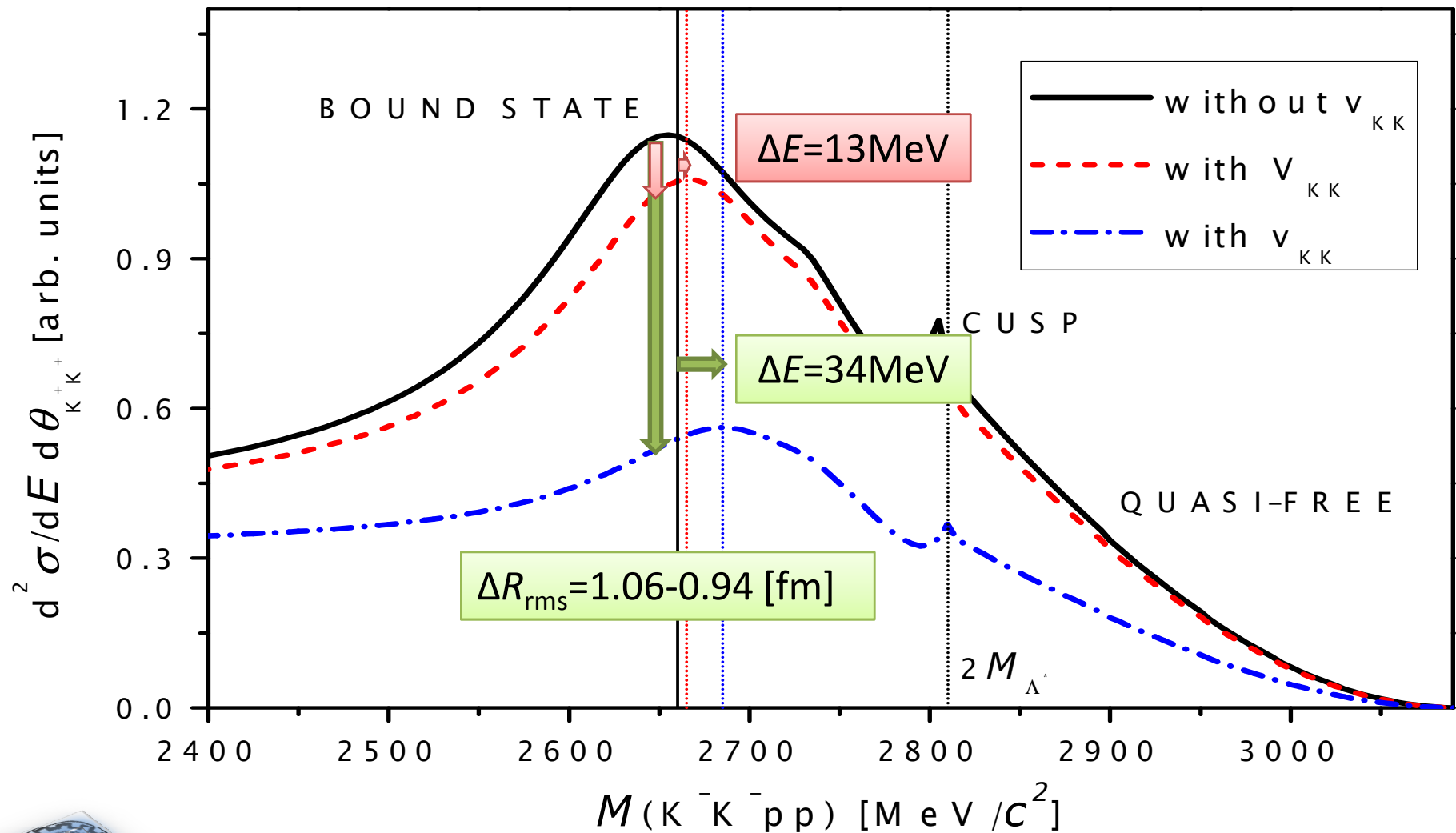


K⁻K⁻ repulsion effect

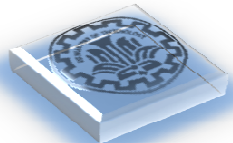
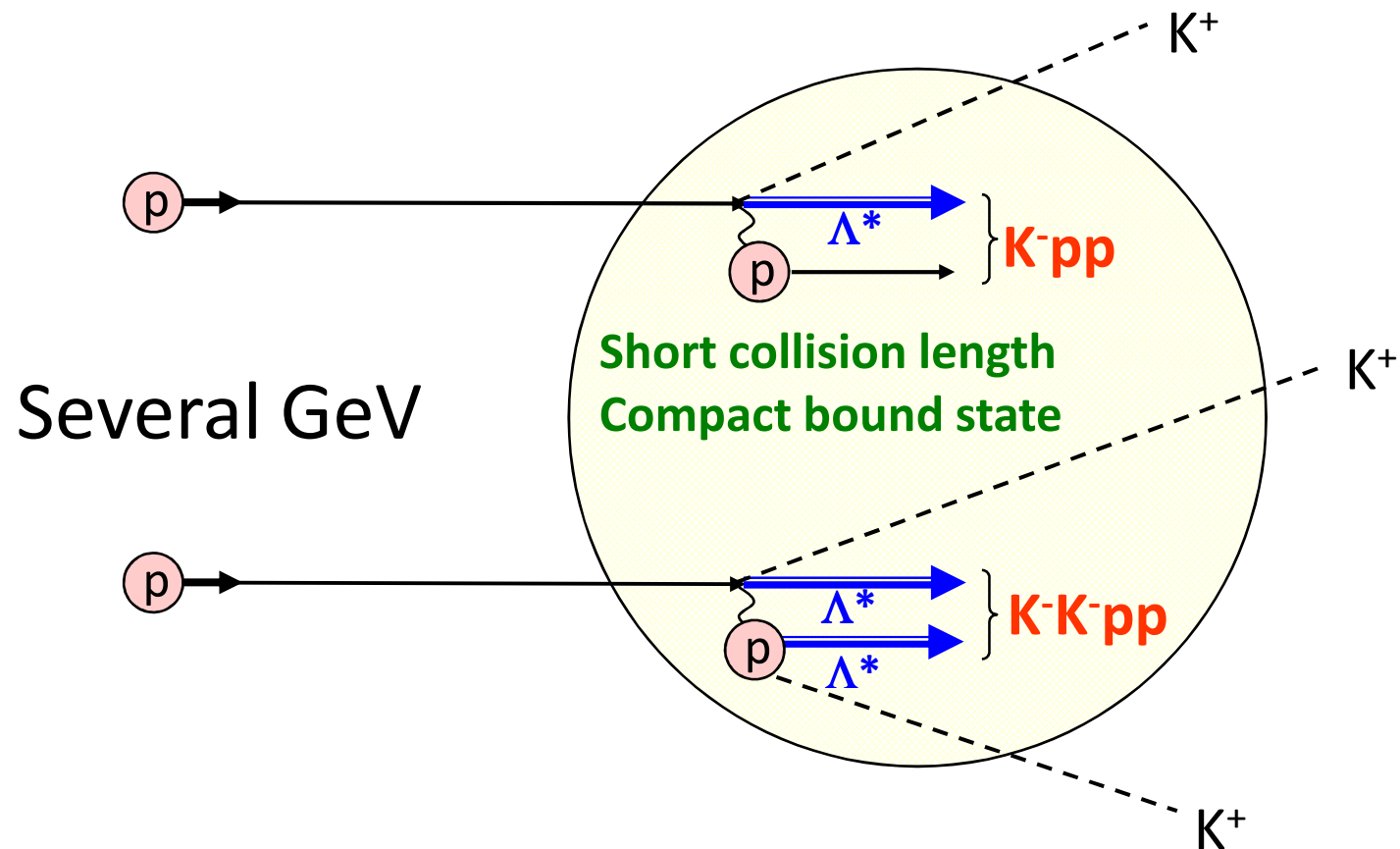
Y. Kanada-En'yo, D. Jido, PRC **78** (2008) 025212



K⁻K⁻ repulsion effect



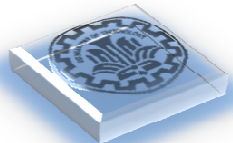
Doorways to “Kaonic Nuclear Clusters”

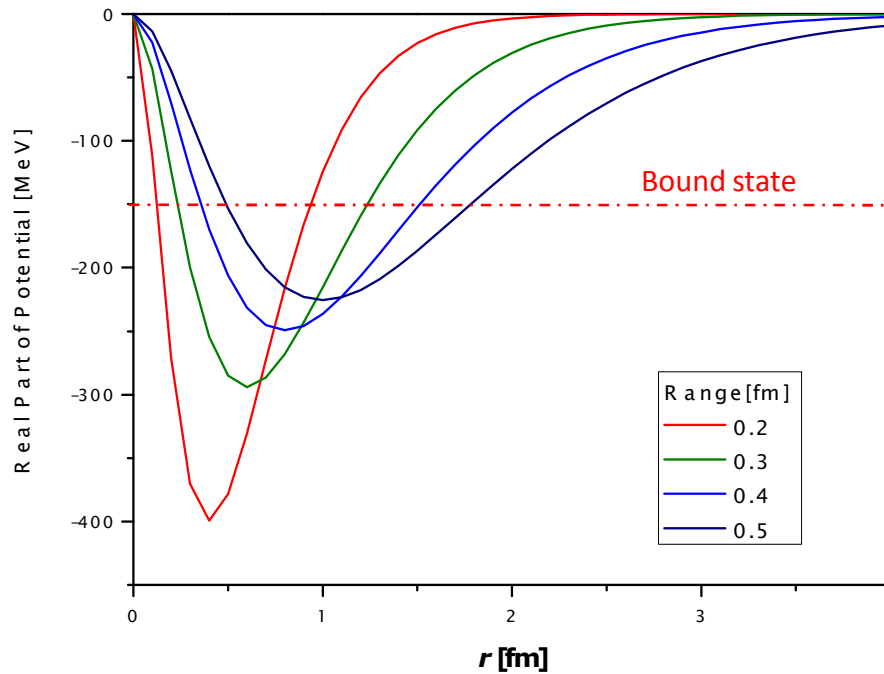


CONCLUSION

- In spite of very large momentum transfer, a large bound-state peak has clearly been predicted.
- Compactness of the system is essentially important. For a more compact K^-K^-pp , larger production is expected.
- Deeper binding is more favorable. Adding K^-K^- repulsion causes an energy shift to lower binding and a reduction in the cross section.

Experiment is highly awaited!





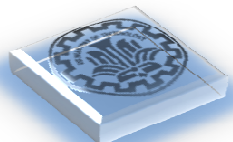
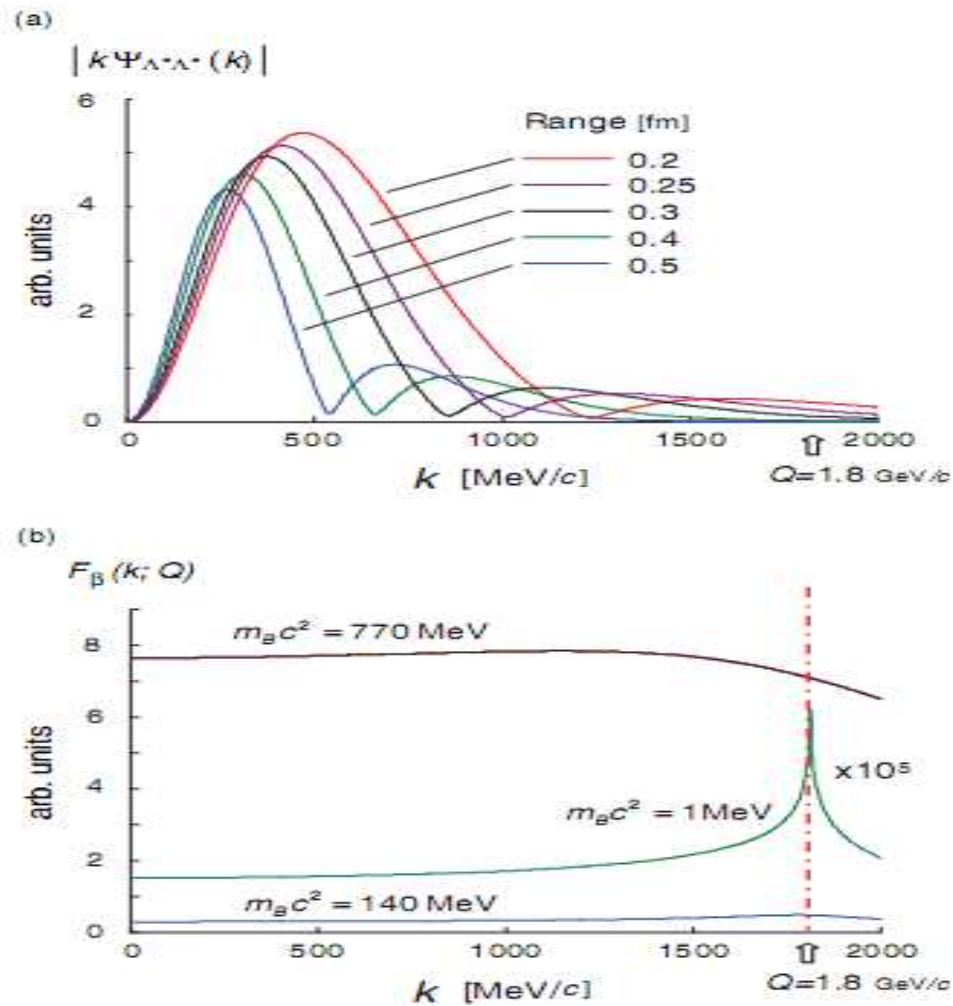
$$V_{\Lambda^* \Lambda^*}(r) = (V_0 + iW_0) \left(\frac{r}{b}\right)^2 \exp(-r/b)$$

b is the **range** of interaction

$$E(K^- K^- pp) = -(150 + 2 \times 27) - i75 \\ = -204 - i75 \text{ MeV}$$

$V_0 + iW_0$ [MeV]	b [fm]	$E(\Lambda^* \Lambda^*)$ [MeV]	rms distance [fm]
-738-i205	0.2	-150-i75	0.74
-617-i191	0.25	-150-i75	0.84
-543-i182	0.3	-150-i75	0.94
-461-i171	0.4	-150-i75	1.13
-417-i165	0.5	-150-i75	1.32

Momentum Window



Determination of Angle

