International Workshop on "Direct reactions with Exotic Beams" (Jun 30-Jul 2, 2007 at RIKEN)

New complex G-matrix interactions and application to proton-nucleus scattering

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Introduction

We have tried to apply to **nucleus-nucleus reactions**
 - by **the microscopic complex double folding model**
 with **complex G-matrix interaction**.
⇒ the **unstable nucleus** reactions

But, it is not appropriate to use the complex G-matrix interactions published so far
 - the problem of **local density approximation**
 in the microscopic double folding model.
⇒ we make the **new complex G-matrix interaction**

First step
we introduce to apply to the proton-nucleus elastic scattering
with **new complex G-matrix interaction**.

New complex G-matrix interaction

「**CEG2007**」 (tentative)

new complex G-matrix interaction

ESC (Extended Soft-Core)

N-N potential **(modern)**

- up to higher density region
- Three body repulsive force
- up to *g*-wave ($\ell \leq 4$)

「**(old) CEG**」

one of the most reliable complex G-matrix interaction published so far

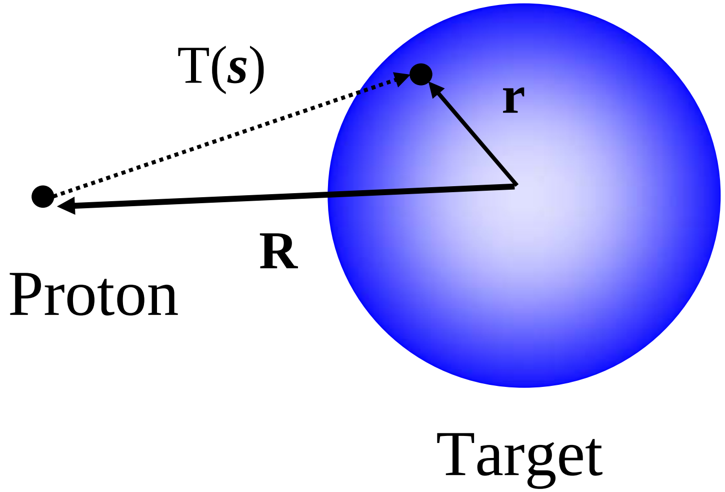
HJ N-N potential

- up to normal density
- no three body force
- up to *d*-wave ($\ell \leq 2$)

N.Yamaguchi, S.Nagata, T.Matsuda, *Prog.Theor.Phys.*70, 459 (1983)

N.Yamaguchi, S.Nagata, J.Michiyama, *Prog.Theor.Phys.*76, 1289 (1986)

Single folding Potential
(Central part)



$$U(\mathbf{R}) = V(\mathbf{R}) + iW(\mathbf{R})$$

$$U(\mathbf{R}) = \int \rho(\mathbf{r}) T_D(\mathbf{R}, \mathbf{r}; k_F, E) d\mathbf{r}$$

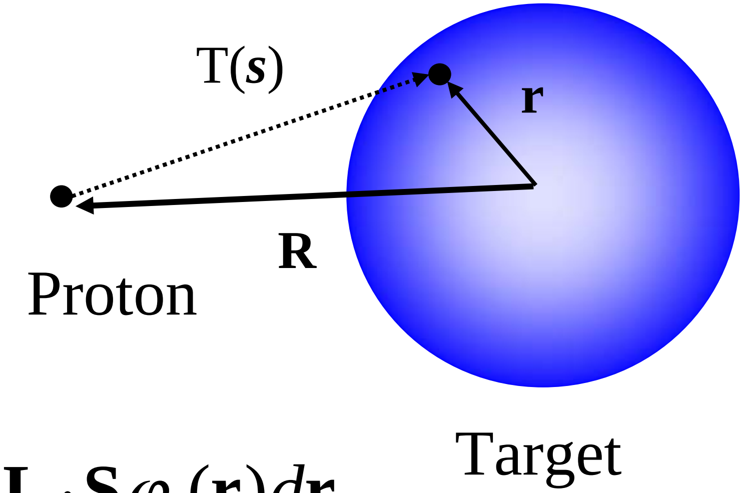
$$+ \int \rho(\mathbf{R}, \mathbf{r}') T_{EX}(\mathbf{R}, \mathbf{r}'; k_F, E) \exp(i\mathbf{k}_0 \cdot \mathbf{s}) d\mathbf{r}'$$

$$\begin{cases} T^{ST}_{D,EX} = \dfrac{1}{4}\left(t^{01} \pm 3t^{11}\right) & ;(\mathrm{p-p}) \\ T^{ST}_{D,EX} = \dfrac{1}{8}\left(\pm t^{00} + t^{01} + 3t^{10} \pm 3t^{11}\right) & ;(\mathrm{p-n}) \end{cases}$$

Complex G-matrix interaction

$$t^{ST}(s; k_F, E) = t^{ST}_{real}(s; k_F, E) + it^{ST}_{imag}(s; k_F, E)$$

Single folding Potential
(LS part)



$$U_{LS}(\mathbf{R}) = V_{LS}(\mathbf{R}) + iW_{LS}(\mathbf{R})$$

$$U_{LS}(\mathbf{R})\ell\cdot\sigma = \sum_i \int \varphi_i^*(\mathbf{r}) T_D(\mathbf{R},\mathbf{r};k_F,E)\mathbf{L}\cdot\mathbf{S}\varphi_i(\mathbf{r})d\mathbf{r}$$

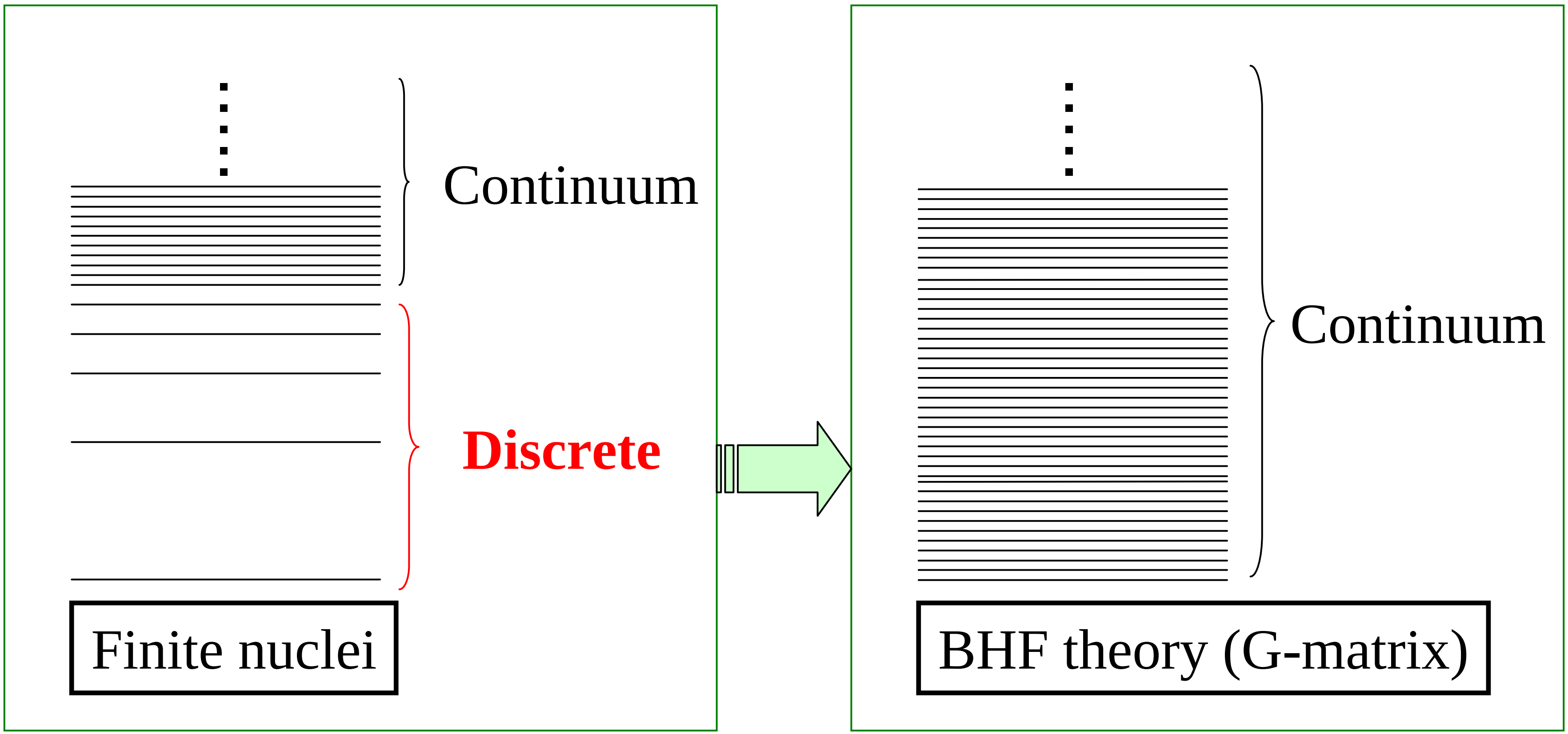
$$+\sum_i \int \varphi_i^*(\mathbf{r}')T_{EX}(\mathbf{R},\mathbf{r}';k_F,E)\mathbf{L}\cdot\mathbf{S}\varphi_i(\mathbf{R})\exp(i\mathbf{k}_0\cdot\mathbf{s})d\mathbf{r}'$$

$$\begin{cases} T_{D,EX}^{ST} = \pm t^{11} & ;(\mathrm{p-p}) \\ T_{D,EX}^{p\text{-}n} = \frac{1}{2}\left(t^{10} \pm t^{11}\right) & ;(\mathrm{p-n}) \end{cases}$$

Complex G-matrix interaction

$$t_{LS}^{ST}(s;k_F,E) = t_{real}^{ST}(s;k_F,E) + it_{imag}^{ST}(s;k_F,E)$$

Renormalization of the imaginary part strength

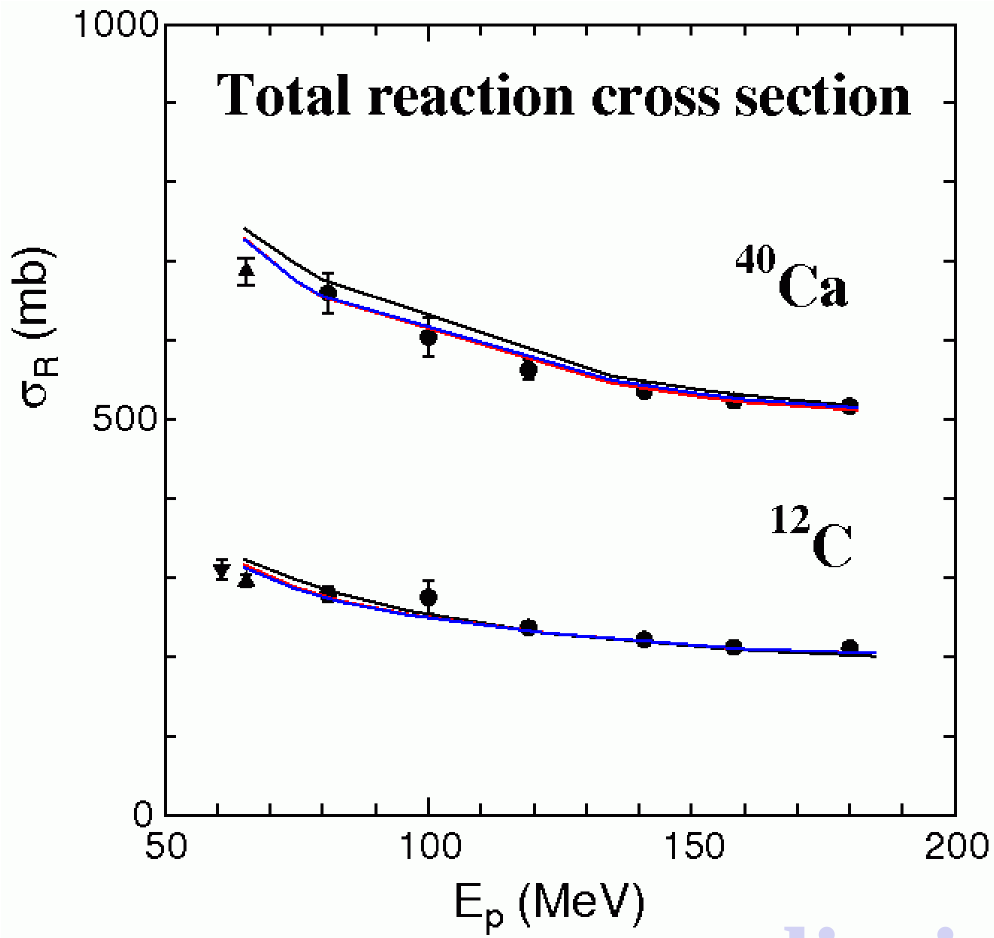


So, we renormalize (suppress) the imaginary part strength

$$V(\mathbf{R}) + \underline{iN_W} W(\mathbf{R}) + \left(V_{LS}(\mathbf{R}) + iW_{LS}(\mathbf{R})\right)\ell \cdot \sigma$$

Renormalized factor N_W is fixed to reproduce measured total reaction cross sections

$$V(\mathbf{R}) + i\underline{N_W} W(\mathbf{R}) + \left(V_{LS}(\mathbf{R}) + iW_{LS}(\mathbf{R})\right)\ell\cdot\sigma$$



old CEG
$\rightarrow$ $N_W = 0.8$

CEG2007
$\rightarrow$ $N_W = 0.75$

CEG2007
(No three body force)
$\rightarrow$ $N_W = 0.7$

preliminary

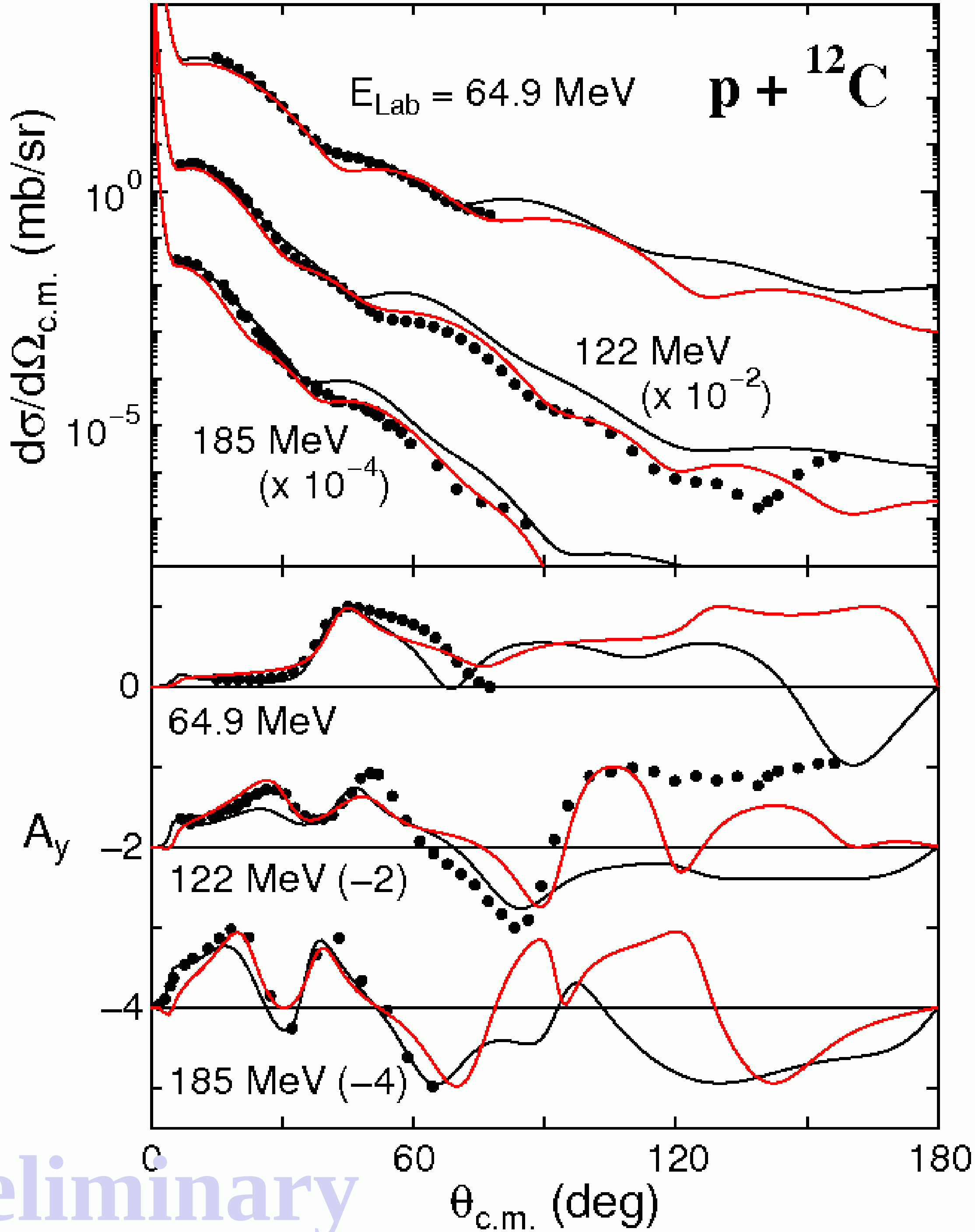
CEG vs. CEG2007

CEG2007

ESC NN potential
- up to higher density region
- Three body repulsive force
- up to *g*-wave ($\ell \leq 4$)

old CEG

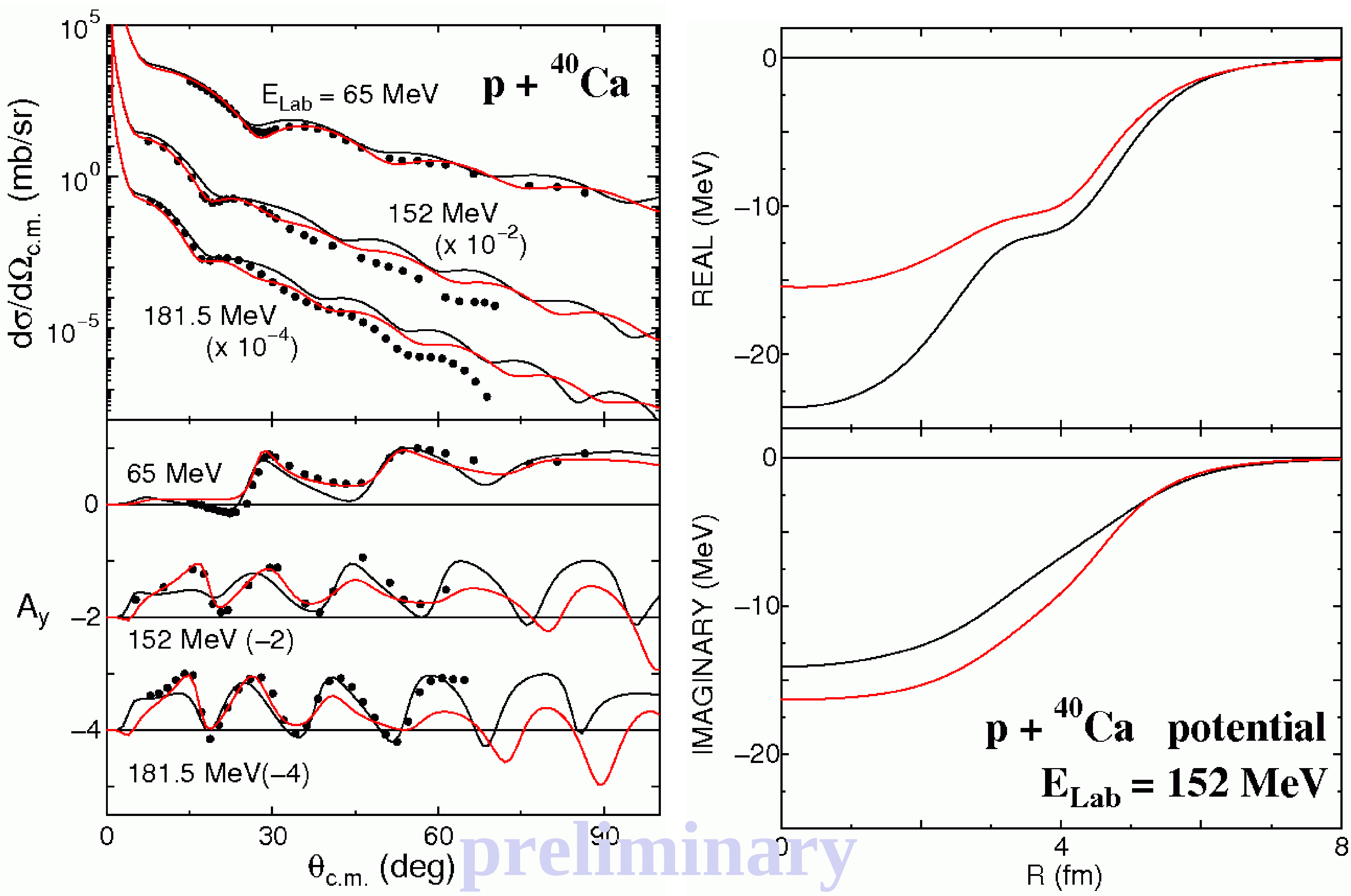
HJ NN potential
- up to normal density
- no three body force
- up to *d*-waves ($\ell \leq 2$)



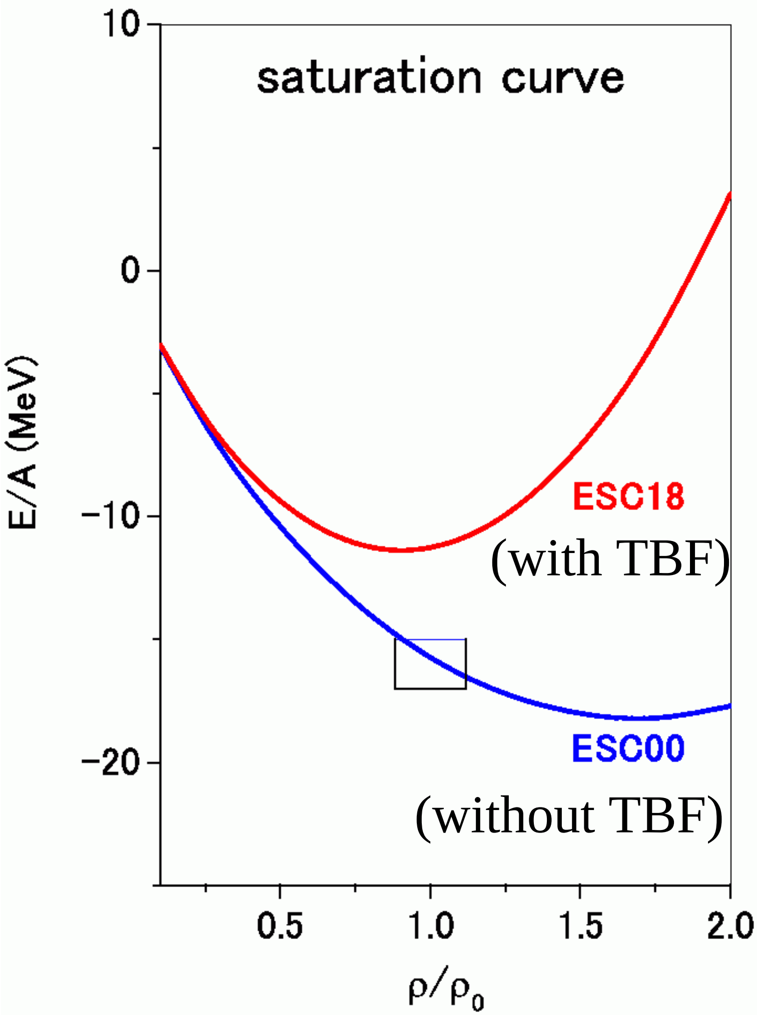
preliminary

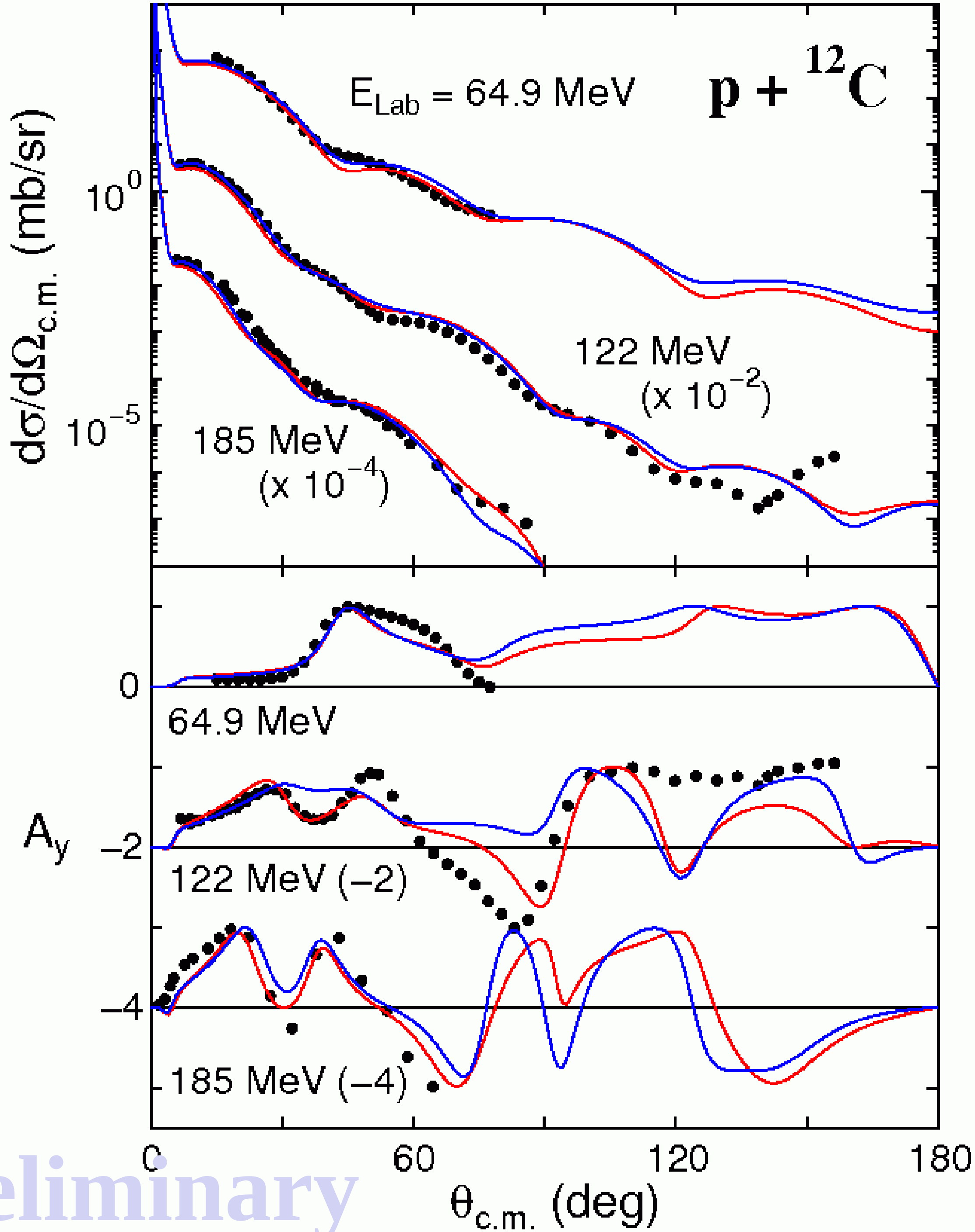
old CEG vs. CEG2007

CEG2007
CEG (old)



The effect of
<u>three body force (TBF)</u>

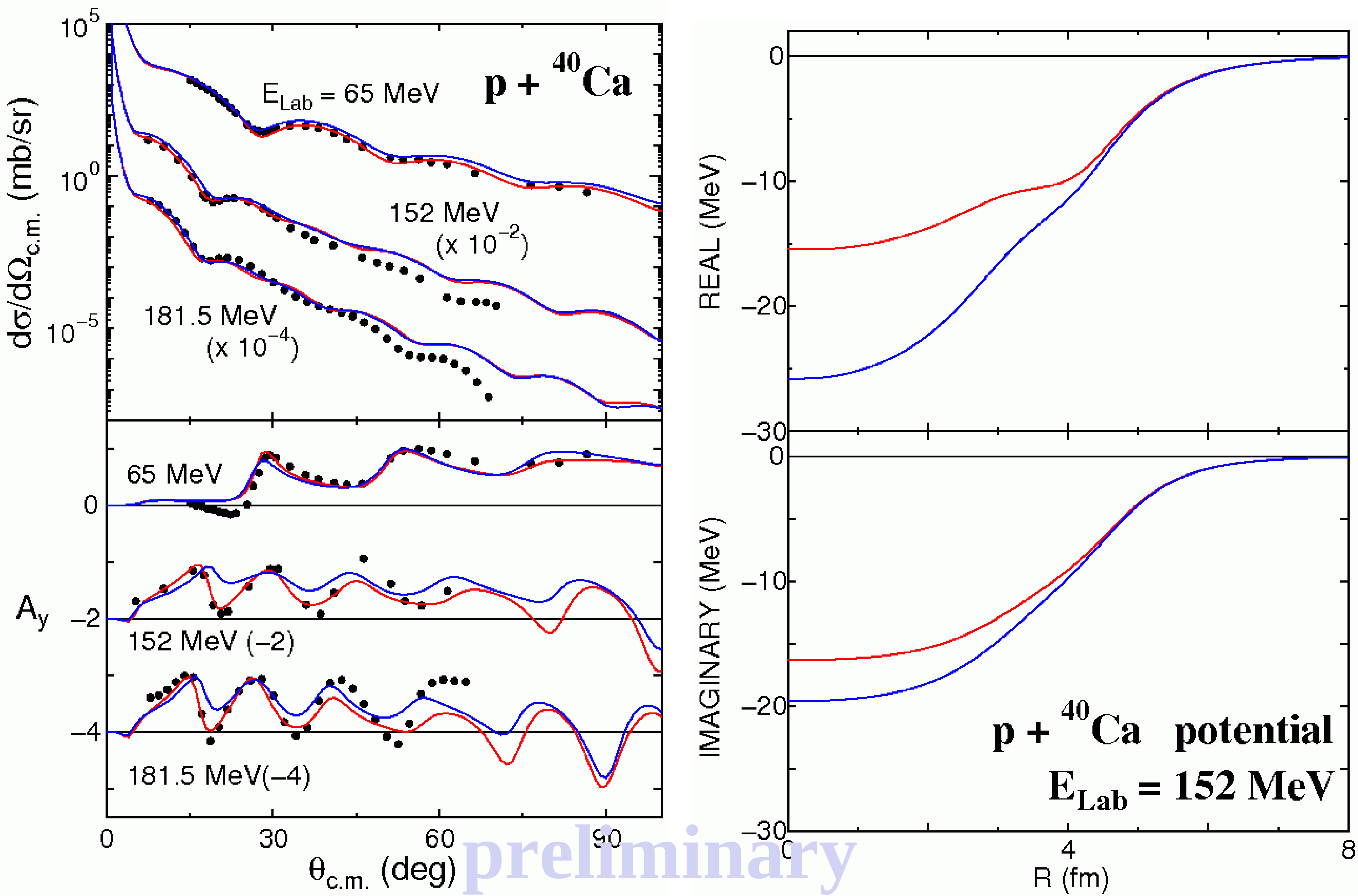




preliminary

The effect of three body force (TBF)

(with TBF)
(without TBF)



Summary : CEG2007 vs. old CEG

- **We have proposed a new complex G-matrix ("CEG2007"),**
  - **use ESC(extended soft-core) NN force**
  - **include three-body force (TBF) effect**
  - & **higher partial wave contribution ($\ell \leq 4$)**

- **CEG2007 is successful for proton-nucleus elastic scattering**
  - reproduce **cross section/analyzing power** data up to the most backward angles.
  - imaginary strength has been renormalized (～25%) and fixed so as to reproduce observed **total reaction cross section** data

- **CEG2007** is apparently better than **old CEG,** mainly due to
  - three-body force effect (particularly in **analyzing power**)
  - higher partial wave contribution (for higher-energy scattering)