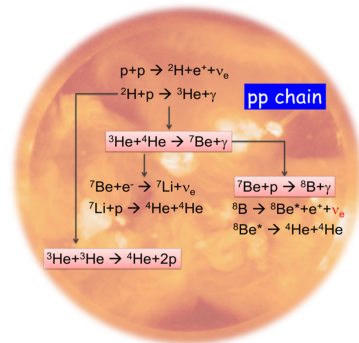


Ab initio calculation of the ${}^3\text{He}(\alpha, \gamma){}^7\text{Be}$ astrophysical S factor

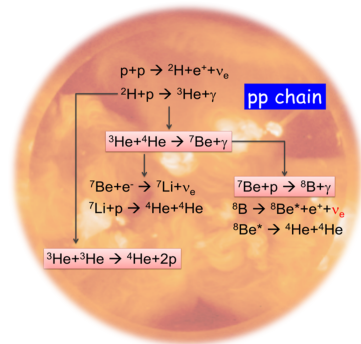
Mack C. Atkinson



${}^3\text{He}(\alpha, \gamma){}^7\text{Be}$ important for solar-model predictions

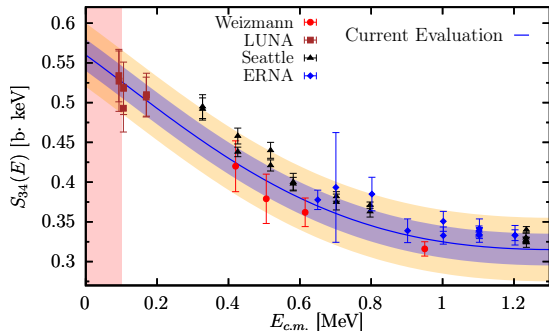


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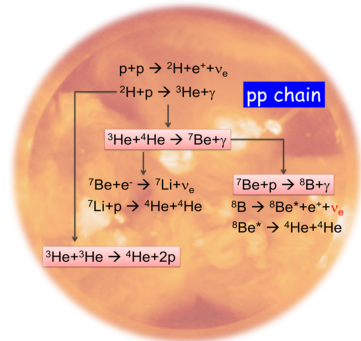
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Adelberger *et al.*, Rev Mod Phys **83** 195 (2011)

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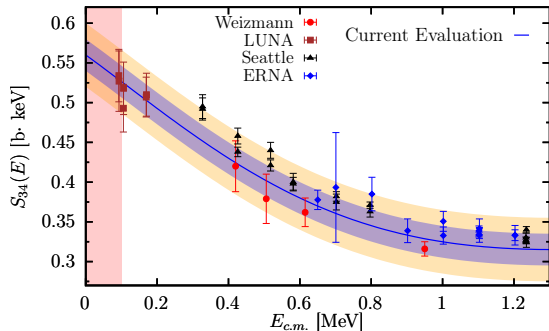
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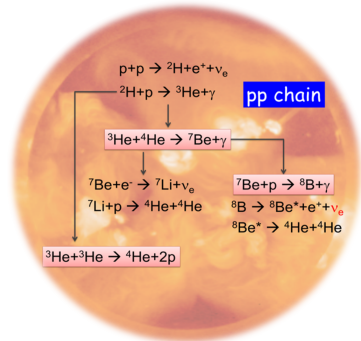
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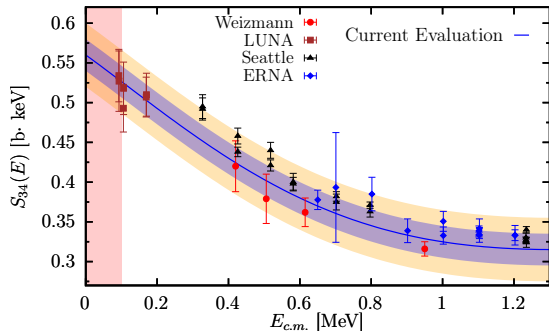
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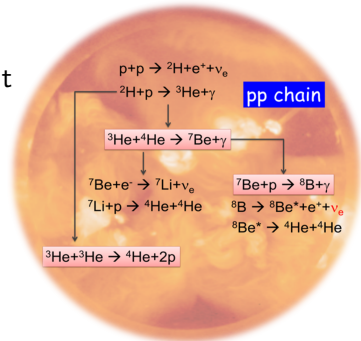
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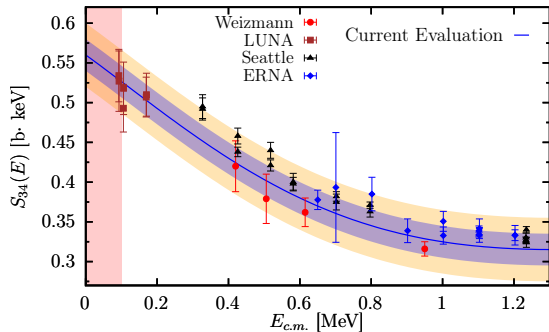
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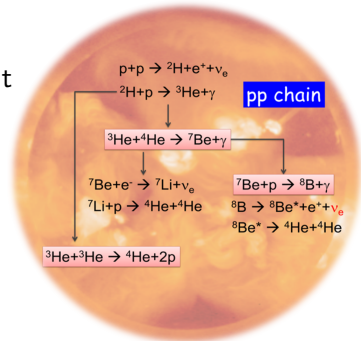
- Reaction rates too low at solar energies in the lab
- Current evaluations depend on both theory and experiment
- Ideally, theory will accurately predict $S_{34}(0)$



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Current evaluation:

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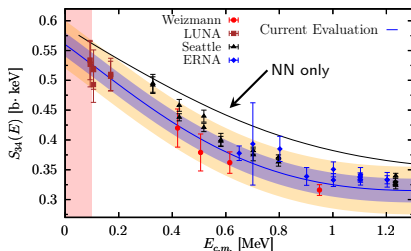
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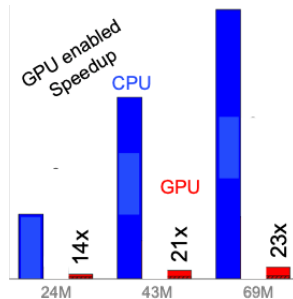
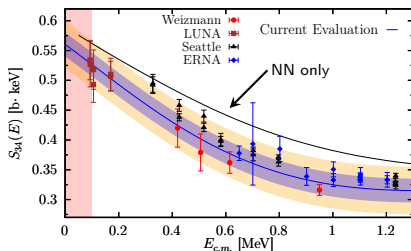


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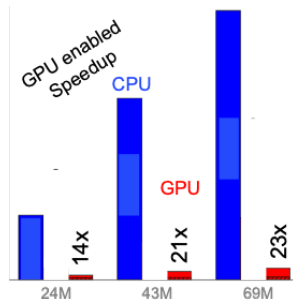
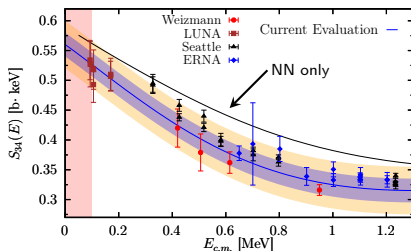


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- GPU speedup \Rightarrow NNN forces are now included

The *ab initio* method: from NCSM to NCSMC

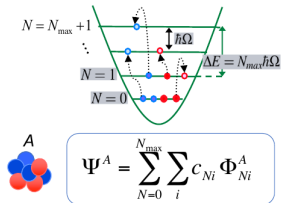
$$\left\langle \Psi_{bs} \left({}^7\text{Be} \right) \left| \hat{\mathcal{M}}_{\text{EM}} \right| \Psi_{sc} \left({}^3\text{He} + \alpha \right) \right\rangle$$

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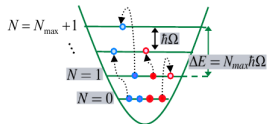
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The *ab initio* method: from NCSM to NCSMC



$$\Psi^A = \sum_{N=0}^{N_{\max}} \sum_i c_{Ni} \Phi_{Ni}^A$$

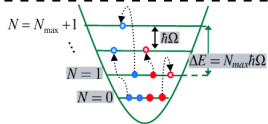
$$\hat{H} = \hat{T} + \hat{V}_{NN} + \hat{V}_{NNN}$$

$$\hat{H} |\Psi^A\rangle = E |\Psi^A\rangle$$

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The *ab initio* method: from NCSM to NCSMC



$N = N_{\max} + 1$
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 $N = 0$
 $\hbar\Omega$
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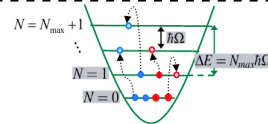
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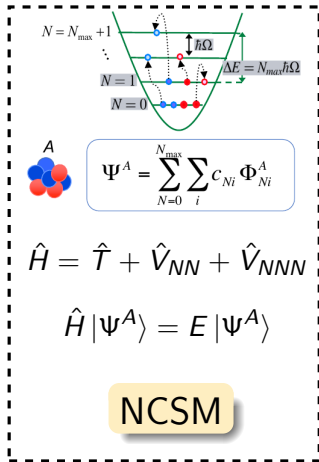
NCSM

$$\Psi^{(A)} = \sum_{\lambda} c_{\lambda} \left| \begin{matrix} (A) \\ \text{cluster} \end{matrix}, \lambda \right\rangle + \sum_{\nu} \int d\vec{r} \gamma_{\nu}(\vec{r}) \hat{A}_{\nu} \left| \begin{matrix} \text{cluster} \\ (A-a) \end{matrix}, \nu \right\rangle$$

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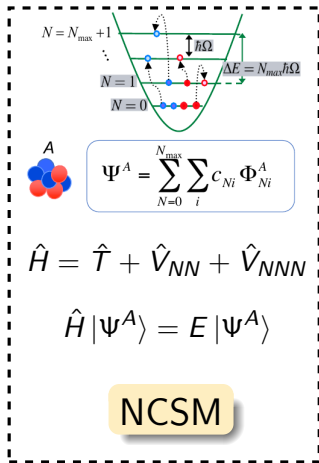
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\uparrow
 $|^7\text{Be}\rangle$

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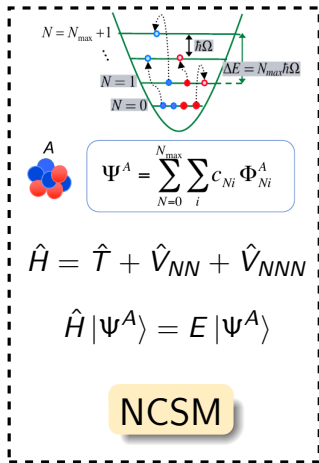
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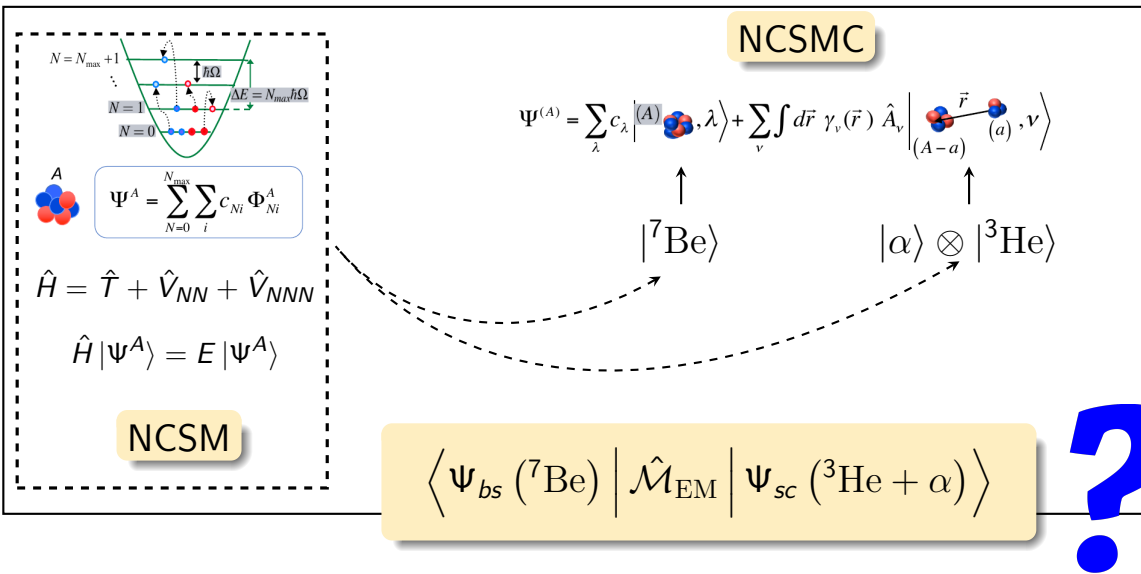
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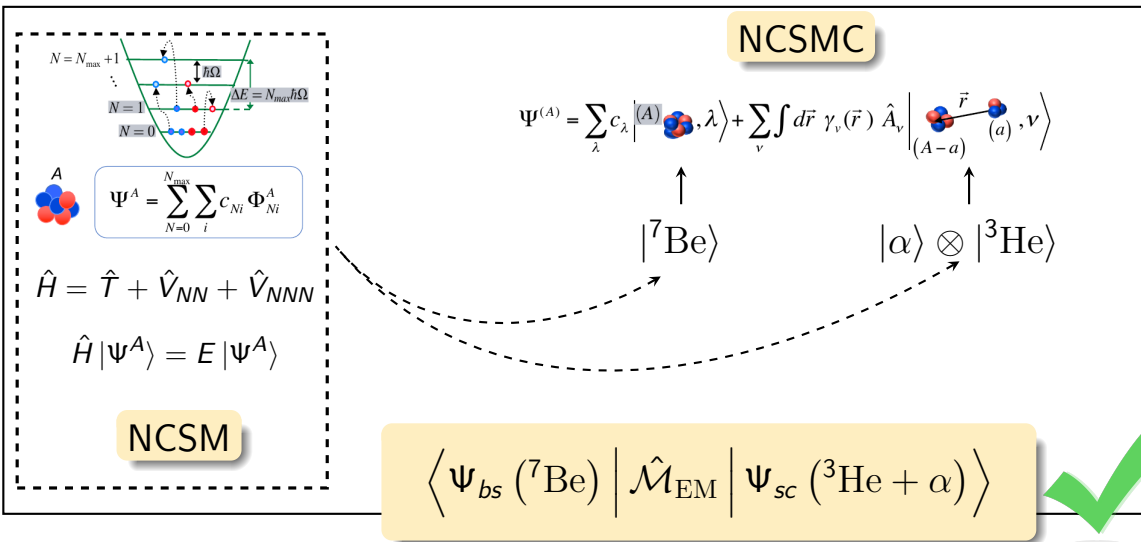
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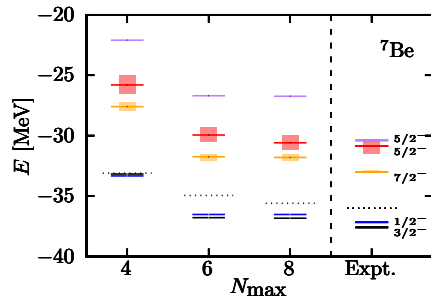
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NCSMC Calculation of ${}^3\text{He}+{}^4\text{He}$ shows reasonable agreement with data



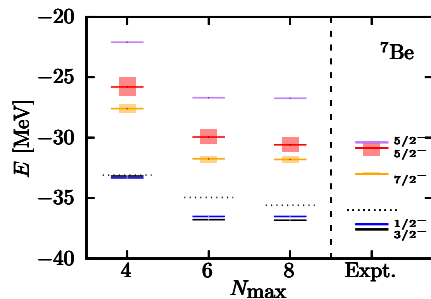
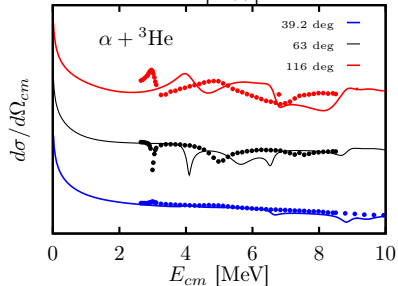
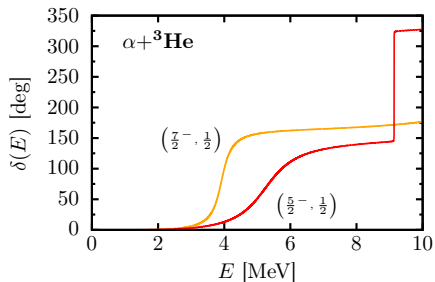
NN-N3LO+3Nlnl

$\hbar\Omega = 20$ MeV

$\lambda_{\text{SRG}} = 2.0 \text{ fm}^{-1}$

D.R. Entem and R. Machleidt, PRC **68**, 041001 (2003)
P. Navratil, Few Body Systems **41**, 117 (2007)

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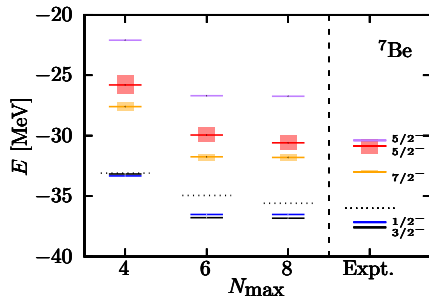
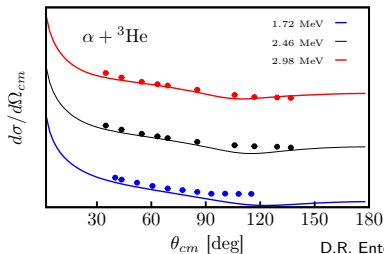
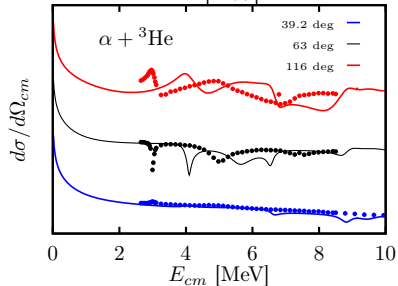
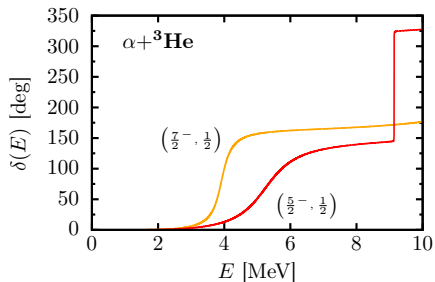
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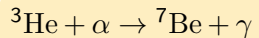
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Results are promising but convergence needs to be explored

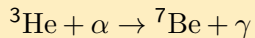
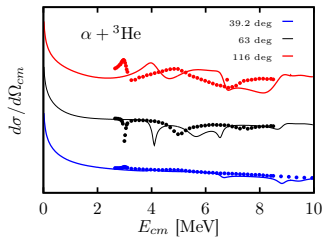


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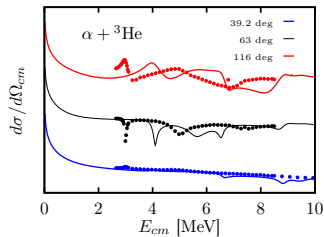


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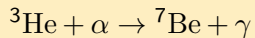
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+

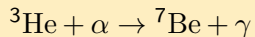


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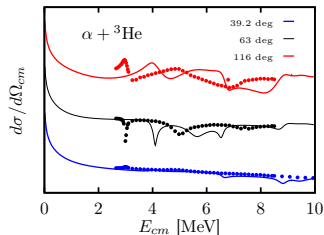
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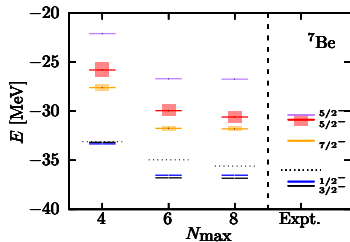
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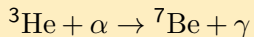
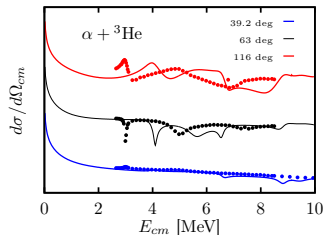
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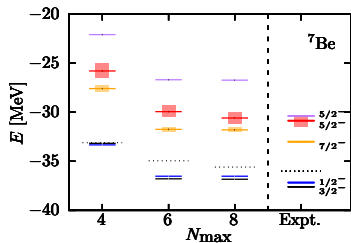
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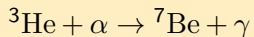
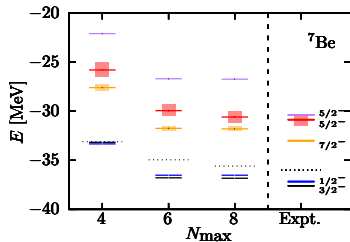
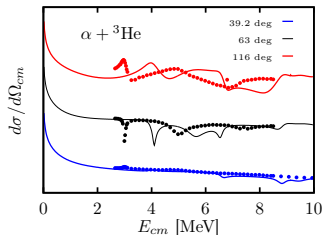
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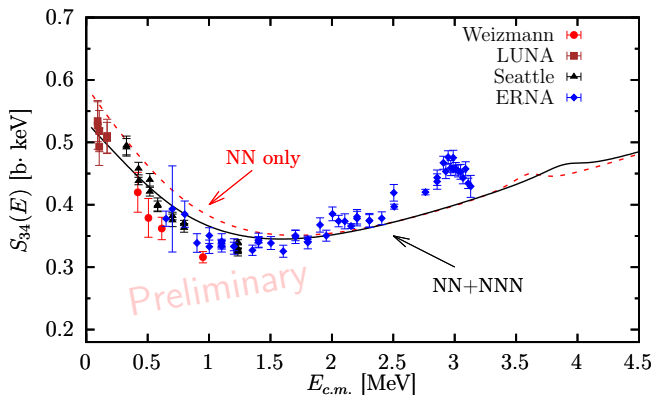
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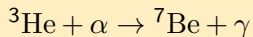
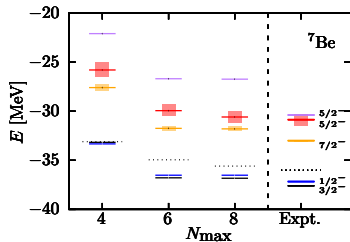
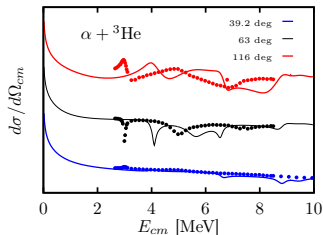
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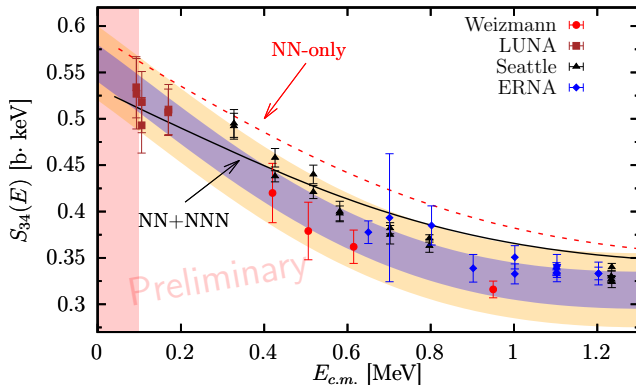
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Thanks



Sofia Quaglioni

(LLNL)



Kostas Kravvaris



Guillaume Hupin

(IN2P3)



Petr Navratil

(TRIUMF)