The Tetraneutron

Nucleus in Contention

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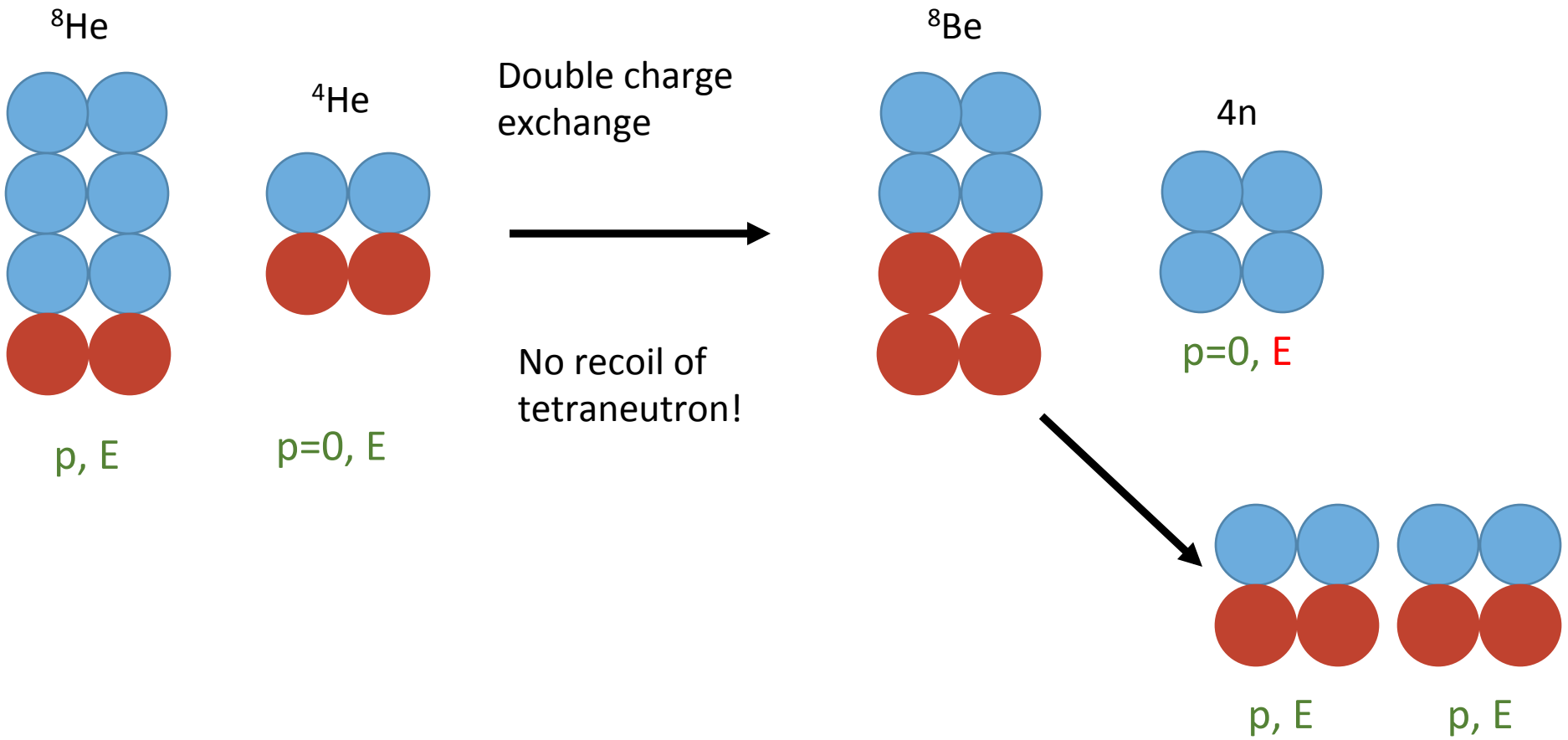
The search for multineutron, zero-proton nuclei has been ongoing for many years. Such multineutron systems could be used to vastly improve our understanding of inter-neutron forces, the structure of larger neutron-rich nuclei, and the behavior of neutron stars. One recent publication has observed a “candidate” tetraneutron (4n) resonant state. However, this claim could not be verified by theoretical calculations. Thus, the existence of a bound or unbound tetraneutron state remains uncertain.

New experimental evidence!

K. Kisamori *et al.*,PRL **116**, 052501 (2016)

$^{4}He(^{8}He, ^{8}Be)$



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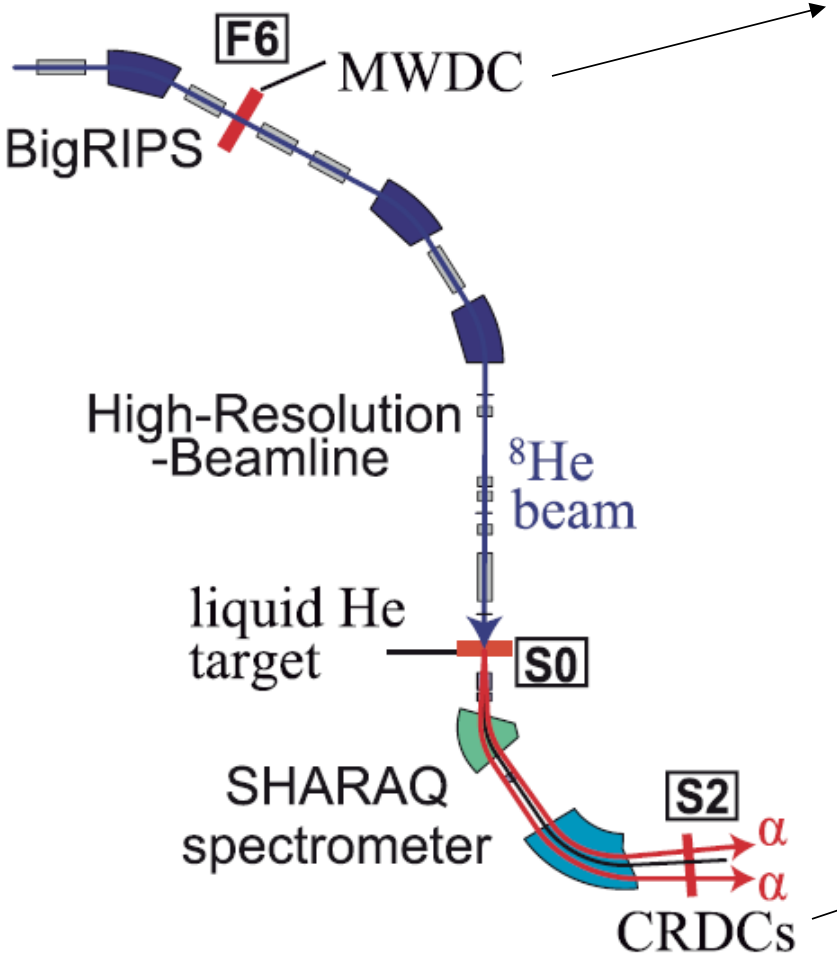
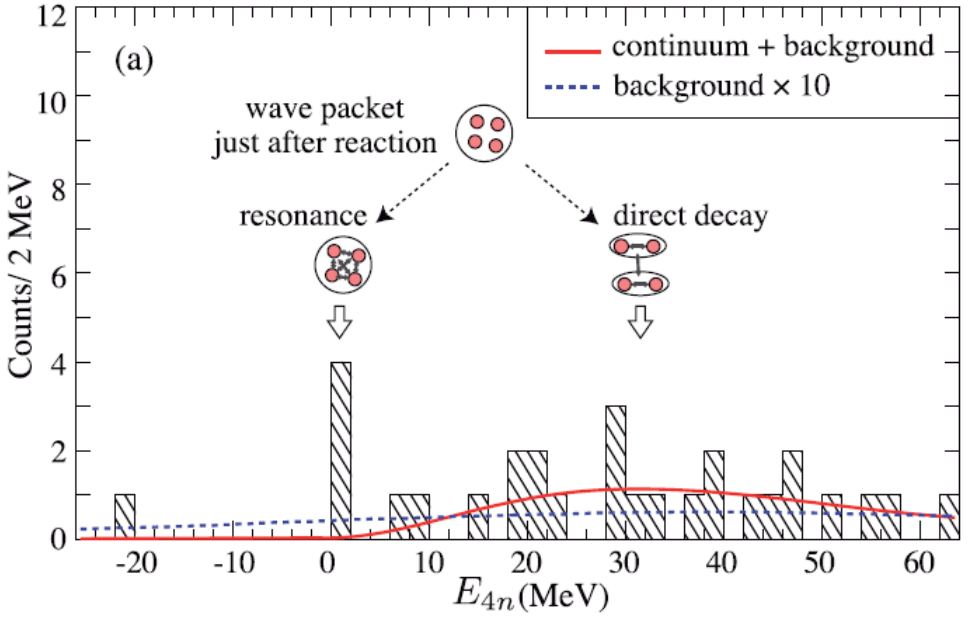
K. Kisamori *et al.*,PRL **116**, 052501 (2016)



p of ^{8}He



p for α's (^{4}He)

0.85 ± 0.65(stat) ± 1.25(syst)

E. Hiyama, arXiv:1604.04363 (2016)

By considering the 2n and 3n force, can we recreate this resonant tetraneutron state?

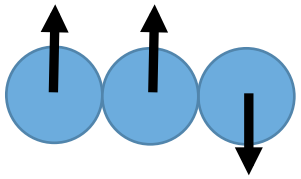
$$H = T + \sum_{i<j} V_{ij}^{NN} + \sum_{i<j<k} V_{ijk}^{3N}$$

AV8' 2n potential from B. D. Pudliner *et al.*, Phys. Rev. C **56**, 1720 (1997)

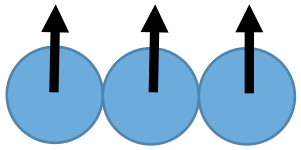
$$V_{ijk}^{3N} = \sum_{T=1/2}^{3/2} \sum_{n=1}^{2} W_n(T) e^{-(r_{ij}^2 + r_{jk}^2 + r_{ki}^2)/b_n^2} \mathcal{P}_{ijk}(T)$$

Recall: T is the total isospin

T=1/2



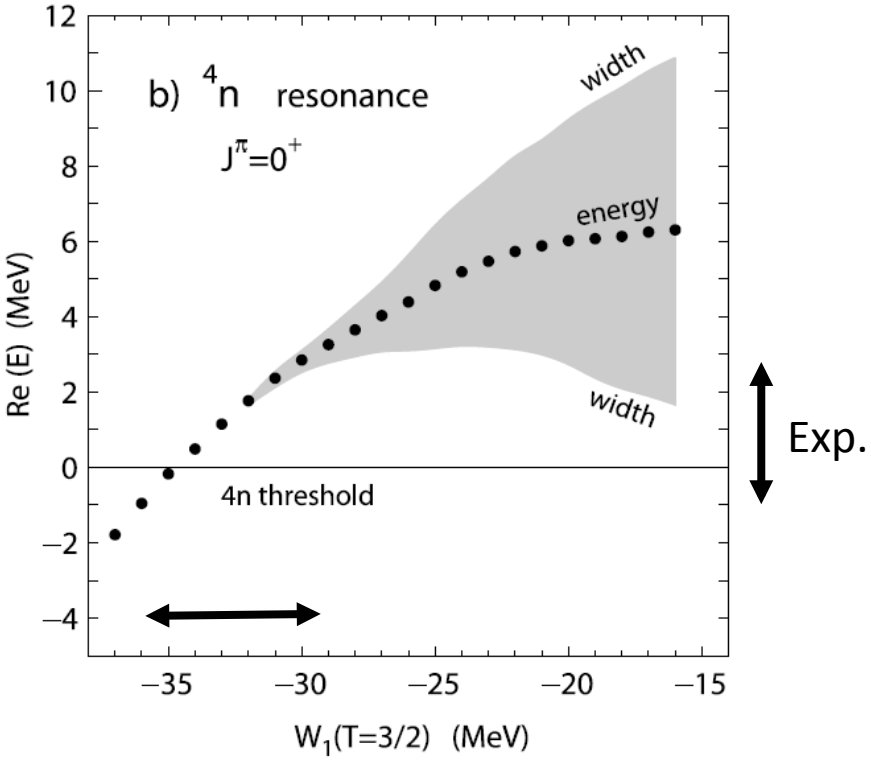
T=3/2



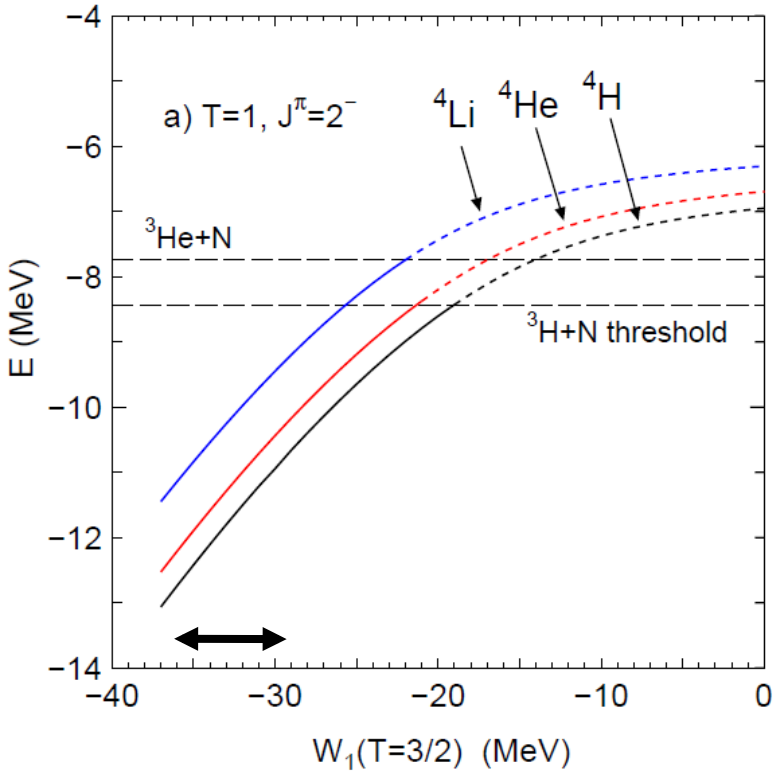
The strengths and ranges, $W_1(T=1/2)$, $W_2(T=1/2)$, $W_2(T=3/2)$, b_1, b_2 are constrained to recreate known properties of light nuclei.

$W_1(T=3/2)$ is a free parameter, varied to try to recreate the reposted resonant tetraneutron state.

K. Kisamori *et al.*,PRL **116**, 052501 (2016)



Exp.



So what next?

Experimentally

- Confirm (or disprove) the measured unbound state with independent measurements.
- Narrow the uncertainty on the energy of the unbound state.
- S. Shimoura *et al.,* K. Kisamori *et al.*, and S. Paschalis *et al.* have proposed to study the tetraneutron.

Theoretically

- Analyze the possibility of an unbound tetraneutron state using 2n, 3n, and 4n forces simultaneously.
- Explore possible causes of the tetraneutron signal due to some unknown phenomenon.