Attempts to Constrain the Symmetry Energy Using Light Clusters

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NuSym 13

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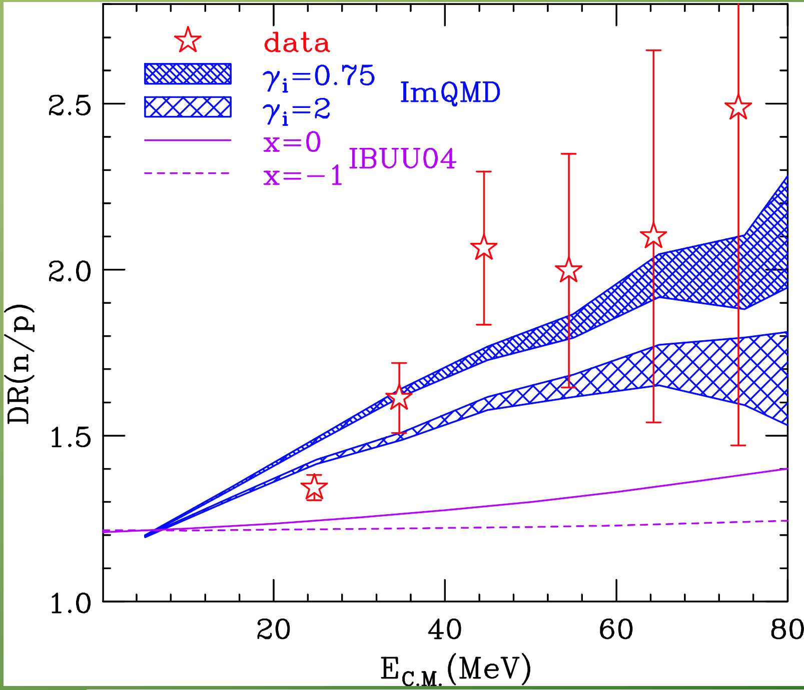
Experimental Details

- Reactions of $^{112}Sn+^{112}Sn$ and $^{124}Sn+^{124}Sn$ at 50 and 120 MeV/A
- Measure neutrons and light charged particles A$\leq$4
- Central Collisions (b<3fm)
- Mid-rapidity region, 70$\leq\theta\leq$110 in C.M.

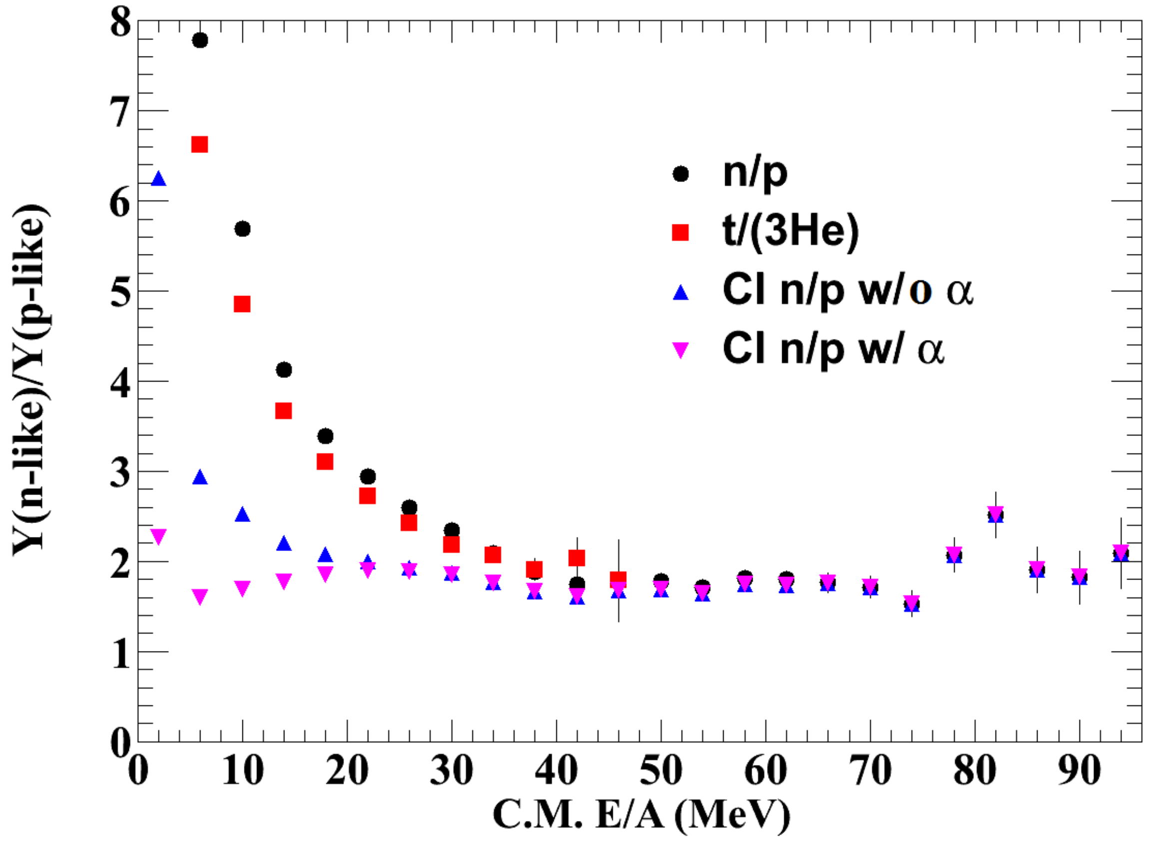


M. A. Famiano et al., PRL 97, 052701 (2006)

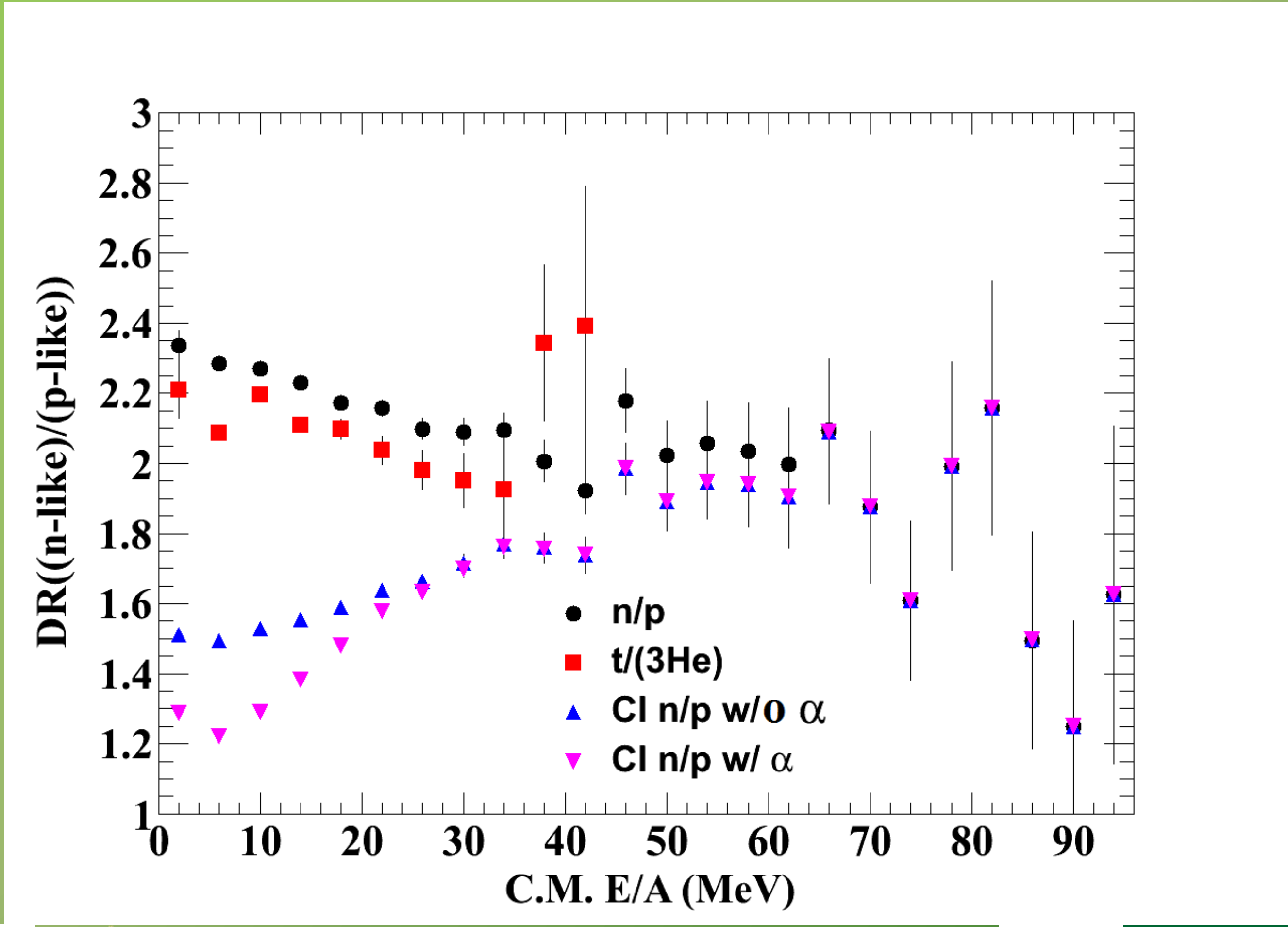
What were we hoping to find?

- Can t/3He ratios be a replacement for n/p ratios (useful for Coalescence Radius, P_0)?
- Can we constrain the symmetry energy using n/p or t/3He ratios?
- In the 120 MeV/A reaction, can we constrain the nucleon effective mass using n/p ratios?

Comparison of n/p to t/3He



Comparison of n/p to t/3He

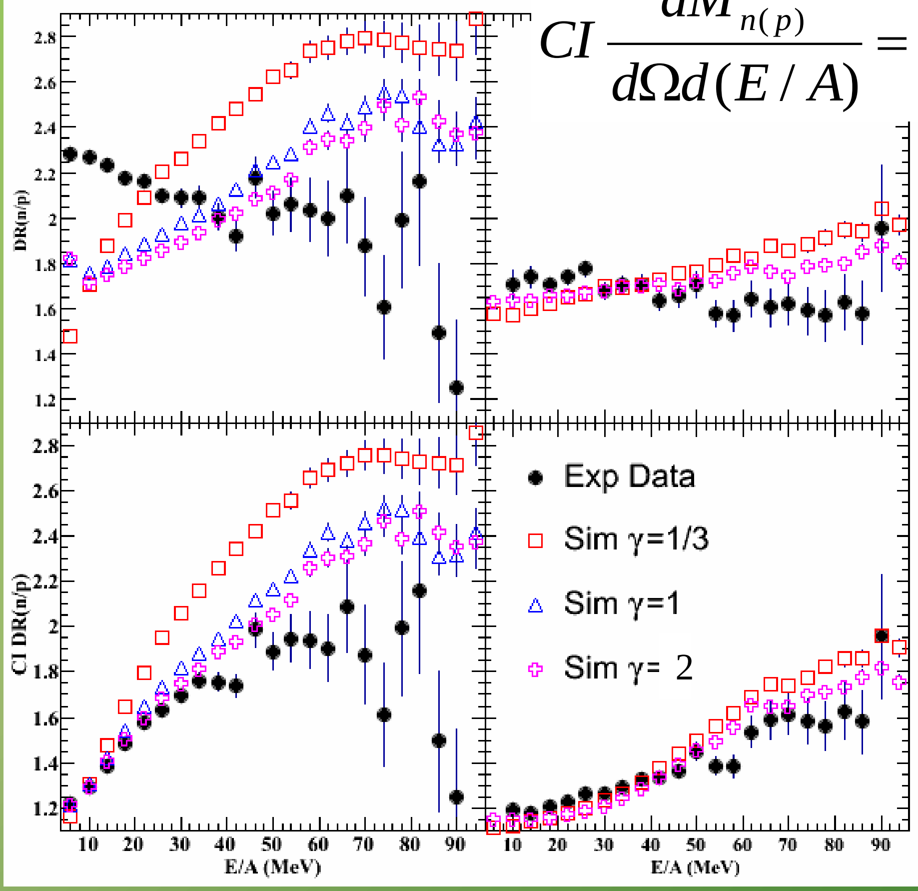


n/p Comparisons to pBUU

$$CI\,\frac{dM_{n(p)}}{d\Omega d(E/A)} = \sum_i \frac{dM_i}{d\Omega d(E/A)} * N_i(Z_i)$$

n/p Double Ratio

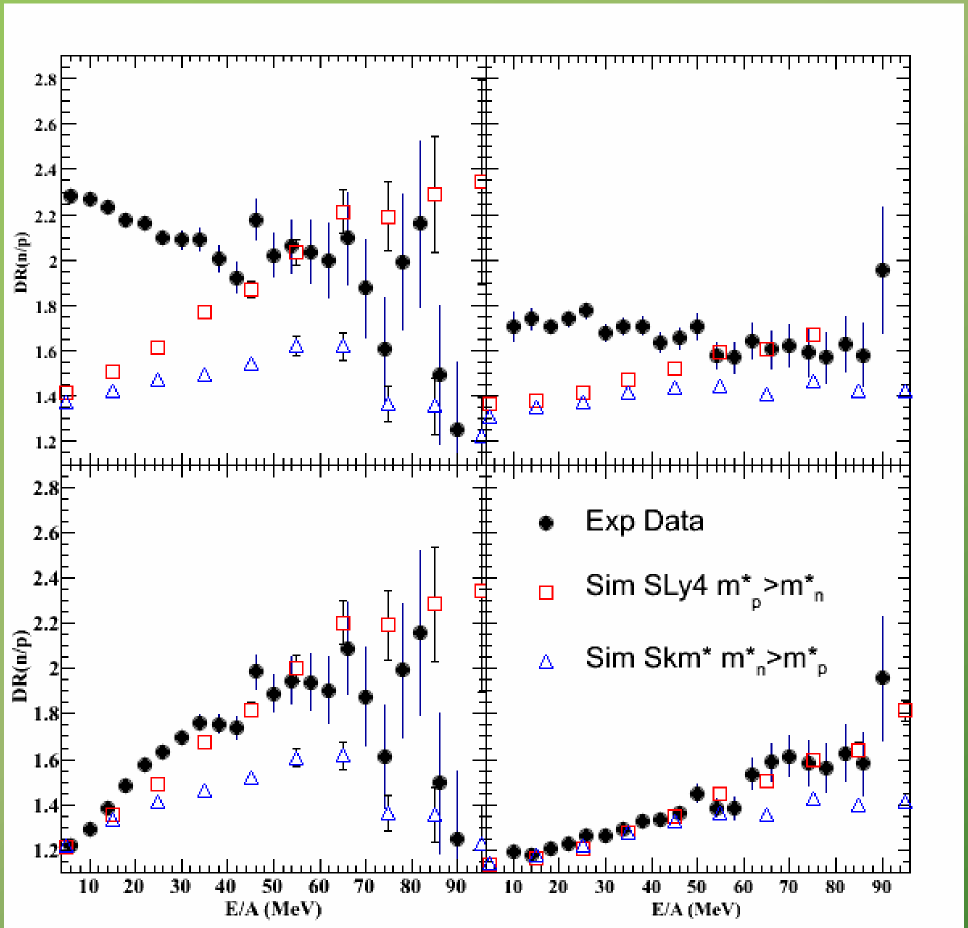
CI n/p Double Ratio



n/p Comparisons to ImQMD-Sky

n/p Double Ratio

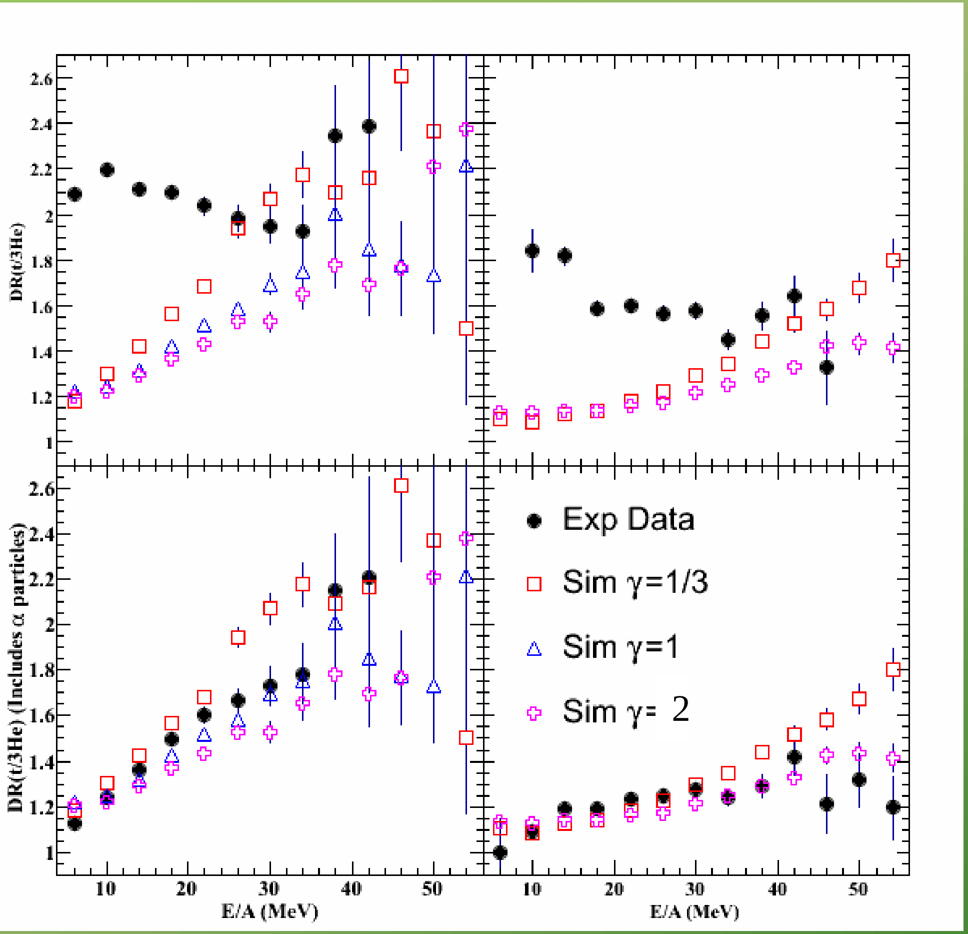
CI n/p Double Ratio



t/3He Comparisons to pBUU

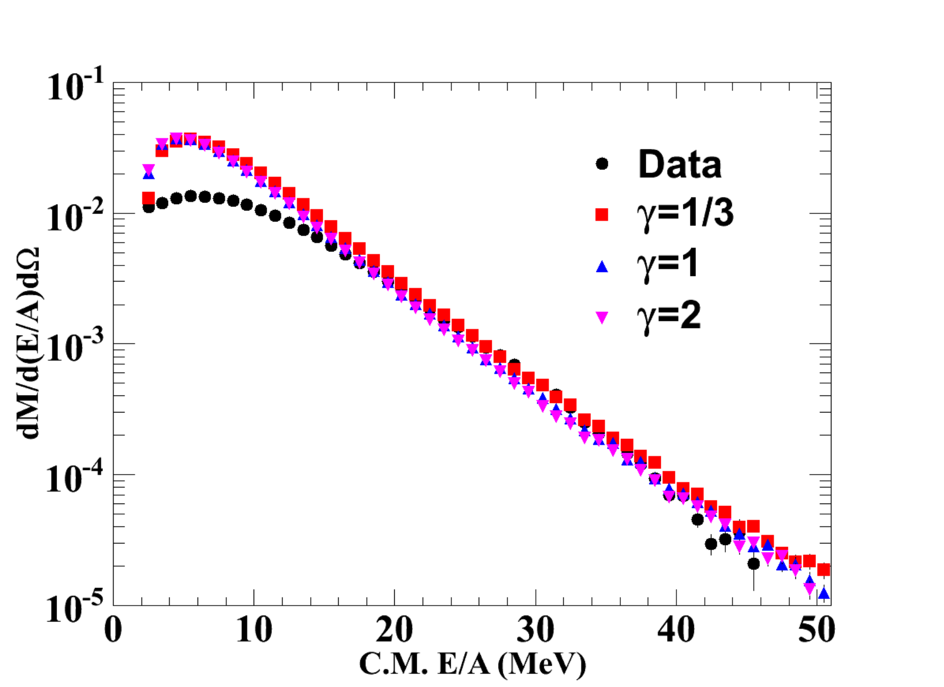
t/3He
Double Ratio

t/3He
Double Ratio
with alphas

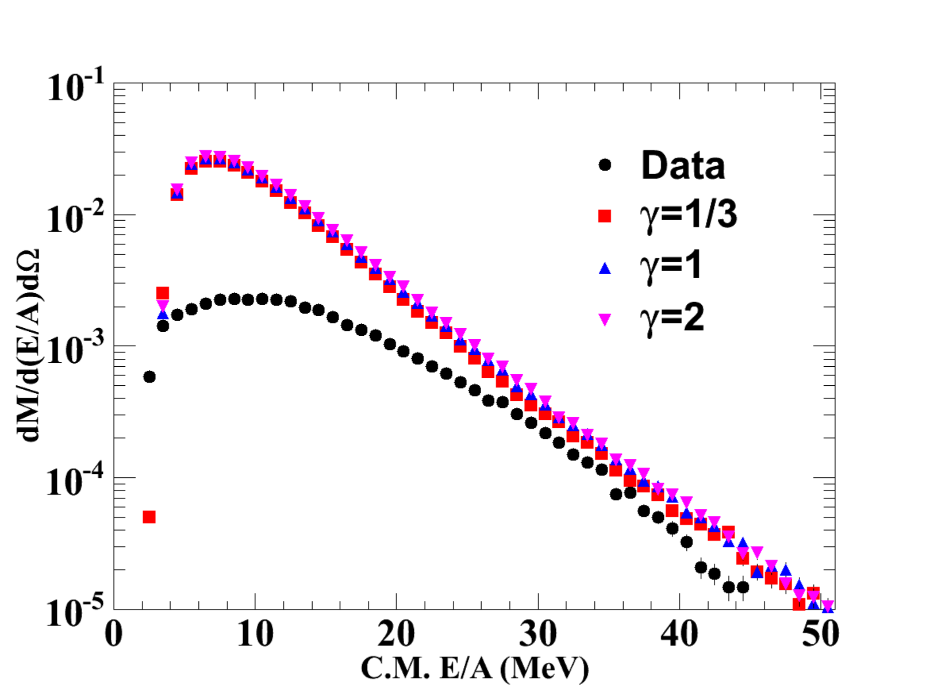


Alpha influence

Tritons

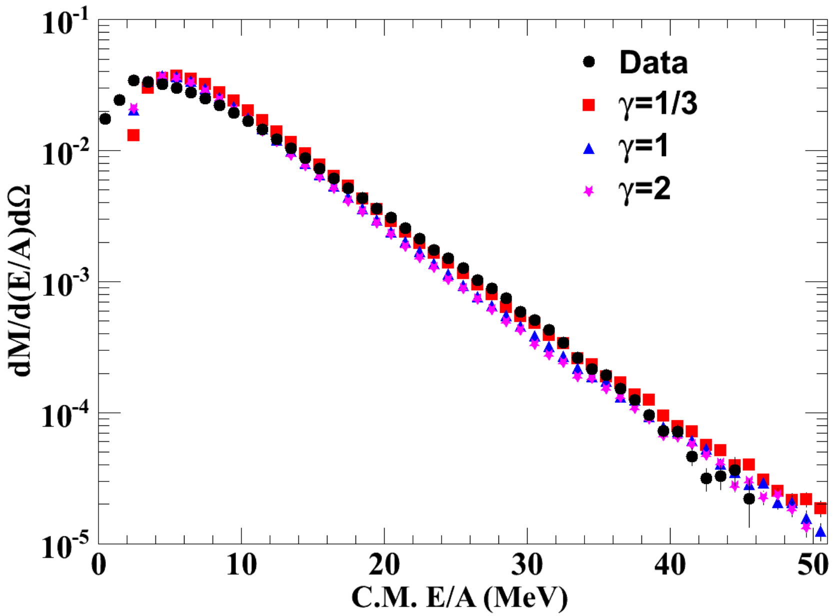


Helions



Alpha influence

Tritons



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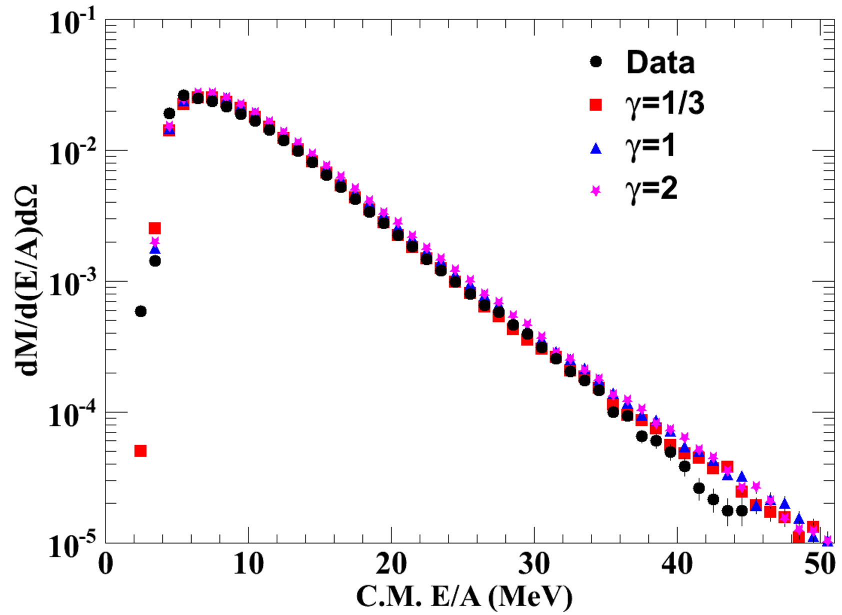
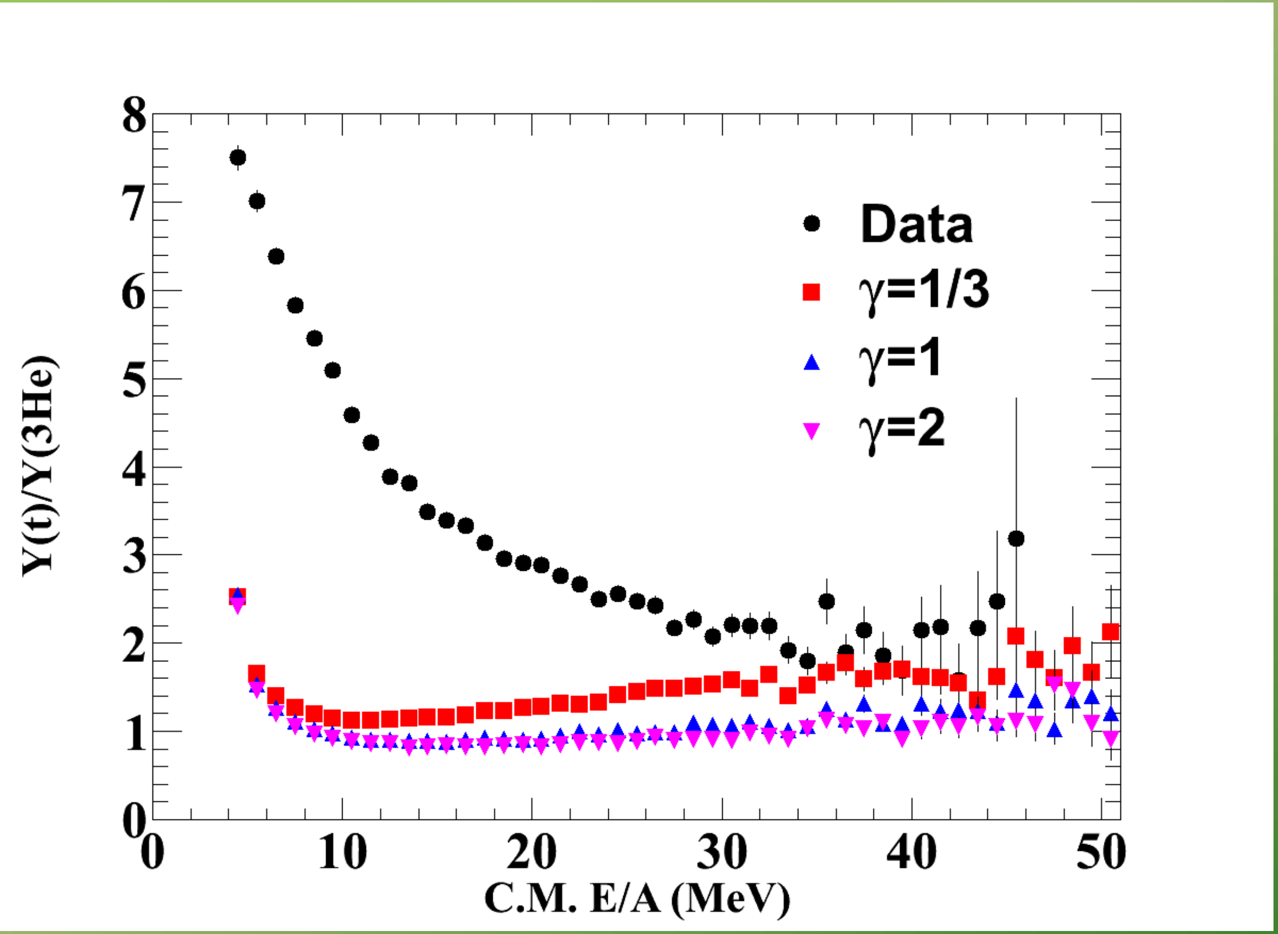
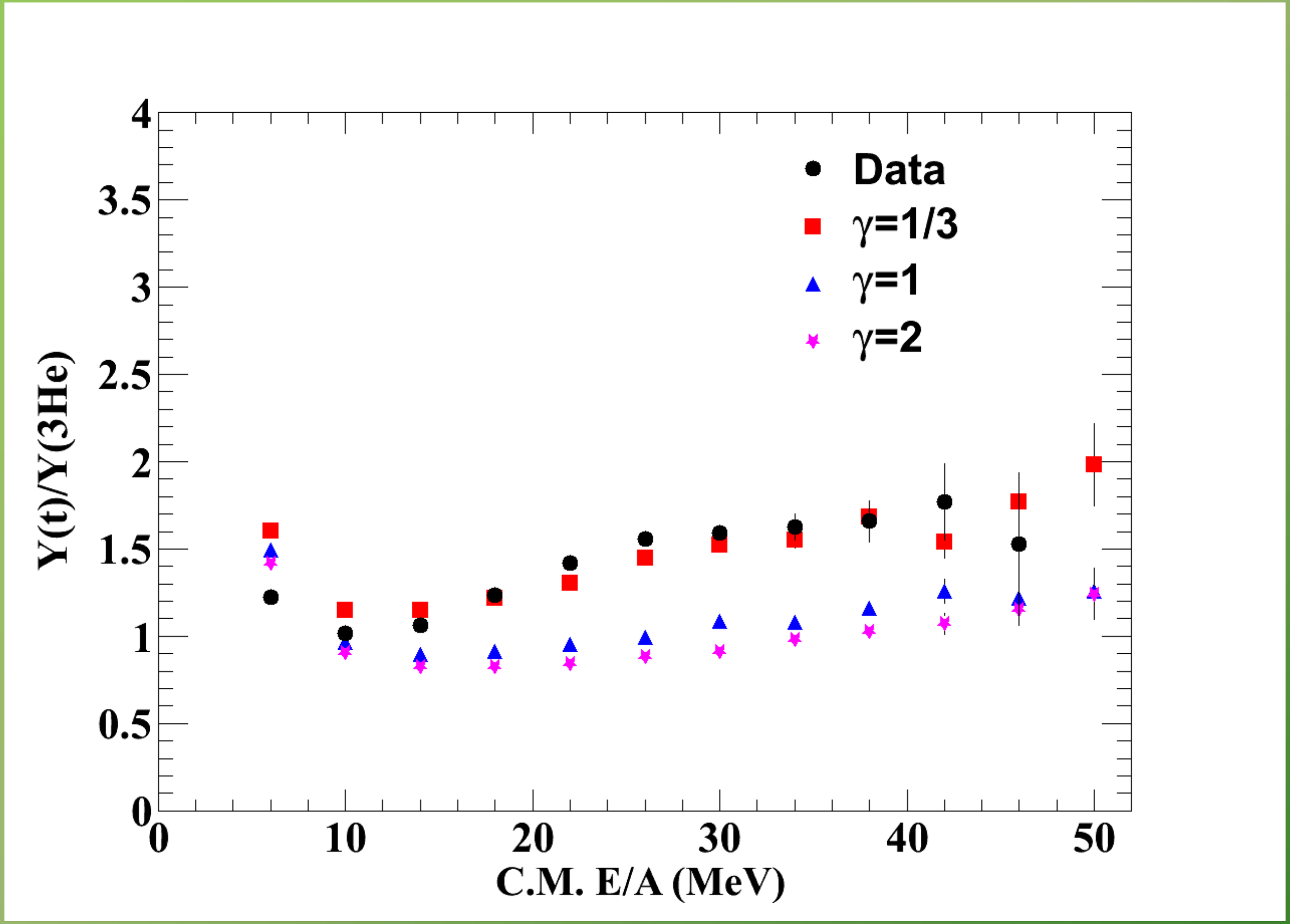


Effect on the Single Ratios



Effect on the Single Ratios



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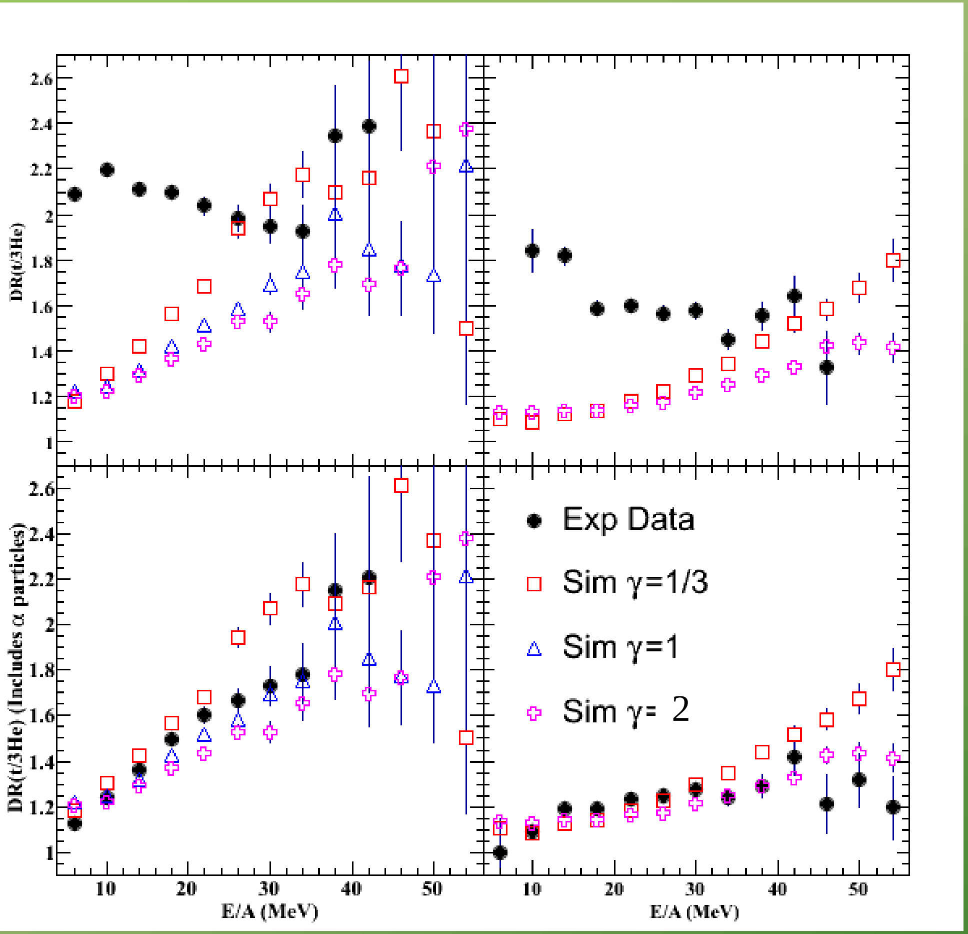
t/3He Comparisons to pBUU

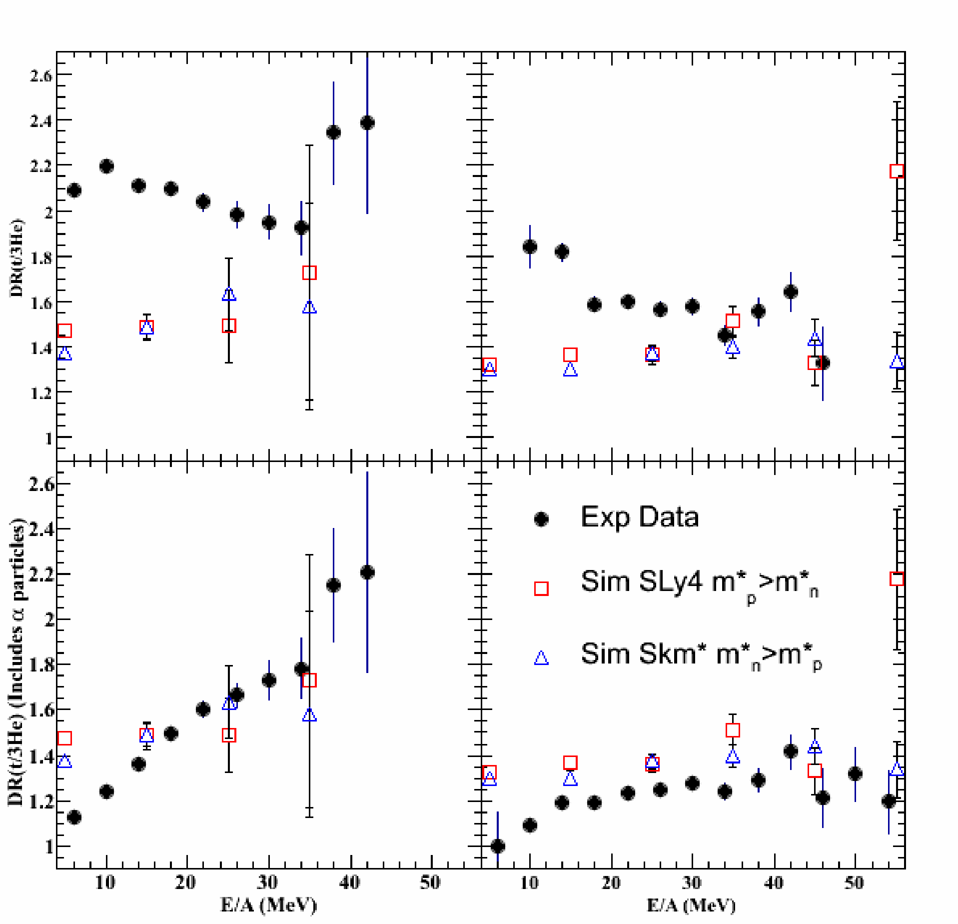
t/3He
Double Ratio



t/3He
Double Ratio
with alphas

t/3He Comparisons to ImQMD-Sky

t/3He
Double Ratio



Conclusions

- n/p ratios can not be directly replaced by t/3He ratios, however they are relatively close and depending on their use is better than several other options
- At present we could make an attempt to constrain the symmetry energy using modified t/3He ratios to better compare to pBUU, however this would have significant systematic uncertainty and would likely not improve on current constraints.
- n/p ratios may be as sensitive to the nucleon effective mass as the symmetry energy at beam energies less than previously anticipated.
- t/3He ratios, while sensitive to the symmetry energy may be significantly less sensitive to the nucleon effective mass. More statistics are needed to verify this in simulation, however this could imply that t/3He ratios are better candidates for constraining the symmetry energy and the n/p ratios for nucleon effective mass once completed.