Astrophysically Motivated ^{20}Ne(d,p)^{21}Ne

NC STATE UNIVERSITY

TUNL
Triangle Universities Nuclear Laboratory

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Introduction

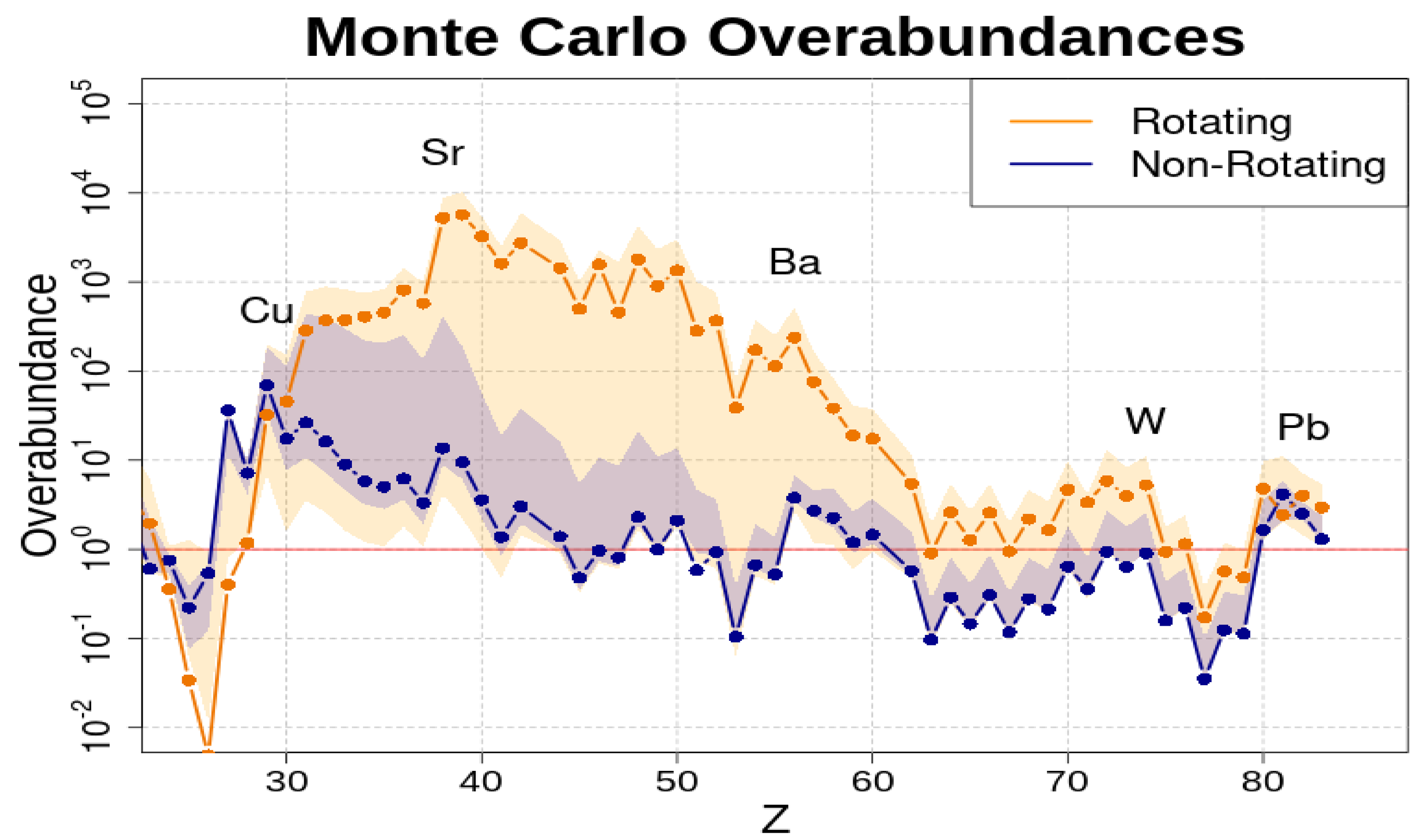

Figure 1: Overabundance for Rotating and Non-rotating Stars with their uncertainties

The s-process in massive starts is found to produce elements up to iron. In simulations the introduction of rotation to these massive stars increases the efficacy of the s-process to produces elements heavier than strontium. These simulations are susceptible to excising data on the nuclear reactions in the nucleosynthesis network.

^{17}O(α,n)^{20}Ne vs ^{17}O(α,γ)^{21}Ne

Reaction	Spearman Coeff.
$^{17}O(\alpha,\gamma)^{21}Ne$	0.4925819
$^{17}O(\alpha,n)^{20}Ne$	-0.4551983
$^{21}Ne(\alpha,\gamma)^{24}Mg$	-0.3371195
$^{22}Ne(\alpha,n)^{25}Mg$	-0.1801521
$^{22}Ne(\alpha,\gamma)^{26}Mg$	0.1609411

Table 1: Spearmen Coefficients for ^{128}Ba

^{17}O(α,n)^{20}Ne and ^{17}O(α,γ)^{21}Ne are competing key reactions for s-process nucleosynthesis of elements heavier than iron. Unfortunately, the cross sections for these reactions have not been measured directly, so their uncertainties are large.

^{20}Ne(d,p)^{21}Ne

E_x [keV]	Previous E_x [keV]	$E_{r,\alpha}$ [keV]	$2J^\pi$	ℓ_α	ℓ_n	Γ_α [eV]	Γ_n [eV]
7420.4(15)*	7420.3(10)	72.5(15)	$(5,7)^-$	1	3	1.2×10^{-33}	**14(1), 11(1)**
7470(2)	7465(10)	122(2)	$(1,3)^-$	3,1	1	7.9×10^{-24}, 3.9×10^{-22}	200(140)
7559.1(15)	7547(10)	211.2(15)	$(3,5)^+$	2,0	2,2	2.4×10^{-14}, 2.5×10^{-13}	**570(30), 420(20)**
7602.0(15)	7600(5)	254.1(15)	$(5,7)^-$	1	3	2.6×10^{-11}	**8(2), 6(2)**
			$(7,9)^+$	2	4	5.6×10^{-12}	**0.4(1), 0.3(1)**
7619.9(10)	7628(10)	272.0(10)	3^{-f}	1	1	1.7×10^{-10}	**8000(1000)**
7655.7(22)	7648(2)	307.8(22)	7^{+h}	2	4	9.8×10^{-10}	0.10(7)
7748.8(17)	7740(10)	400.9(17)	5^{+a}	0	2	5.2×10^{-6}	200(140)
7820.1(15)	7810(10)	472.2(15)	$(3,5)^+$	2,0	2	1.8×10^{-5}, 1.7×10^{-4}	**560(90), 400(60)**
7960(2)	7960.9(13)	612(2)	11^{-g}	3	5	5.3×10^{-8}	0.10(7)
7981(2)	7980(10)	633(2)	3^{-f}	1	1	1.9×10^{-2}	**14000(5000)**
7982.1(7)	7982.1(6)	634.2(7)				$7.5(15) \times 10^{-6}$	
8008(2)	8009(10)	660(2)	1^{-f}	3	1	1.2×10^{-3}	0.20(14)
8069(1)*	8069(2)	721(1)	3^{+a}	2	2	**$46.2(46) \times 10^{-3}$**	**1600(200)**
8146(1)	8146(2)	798(1)	3^{+a}	2,0	2	**$54.7(55) \times 10^{-3}$**	**550(150), 400(100)**
8159(2)^b	8155.0(10)	811(2)	9^{+g}	2	4		
8160(2)	8160(2)	812(2)	5^{+a}	0	2	**$1.6(2) \times 10^{-3}$**	**23000(2300)**

Table 2: Frost-Schenk ^{21}Ne Excited States Table

One viable reaction is the neutron transfer reaction between ^{20}Ne and ^{21}Ne. Previous work has found the excited states for ^{21}Ne (7749 and 7820 keV) are the most important for the s-process in these MRS; however, these states were not resolved. Physical targets are needed for this reaction, but the nature of Neon leave only two options, for target creation.

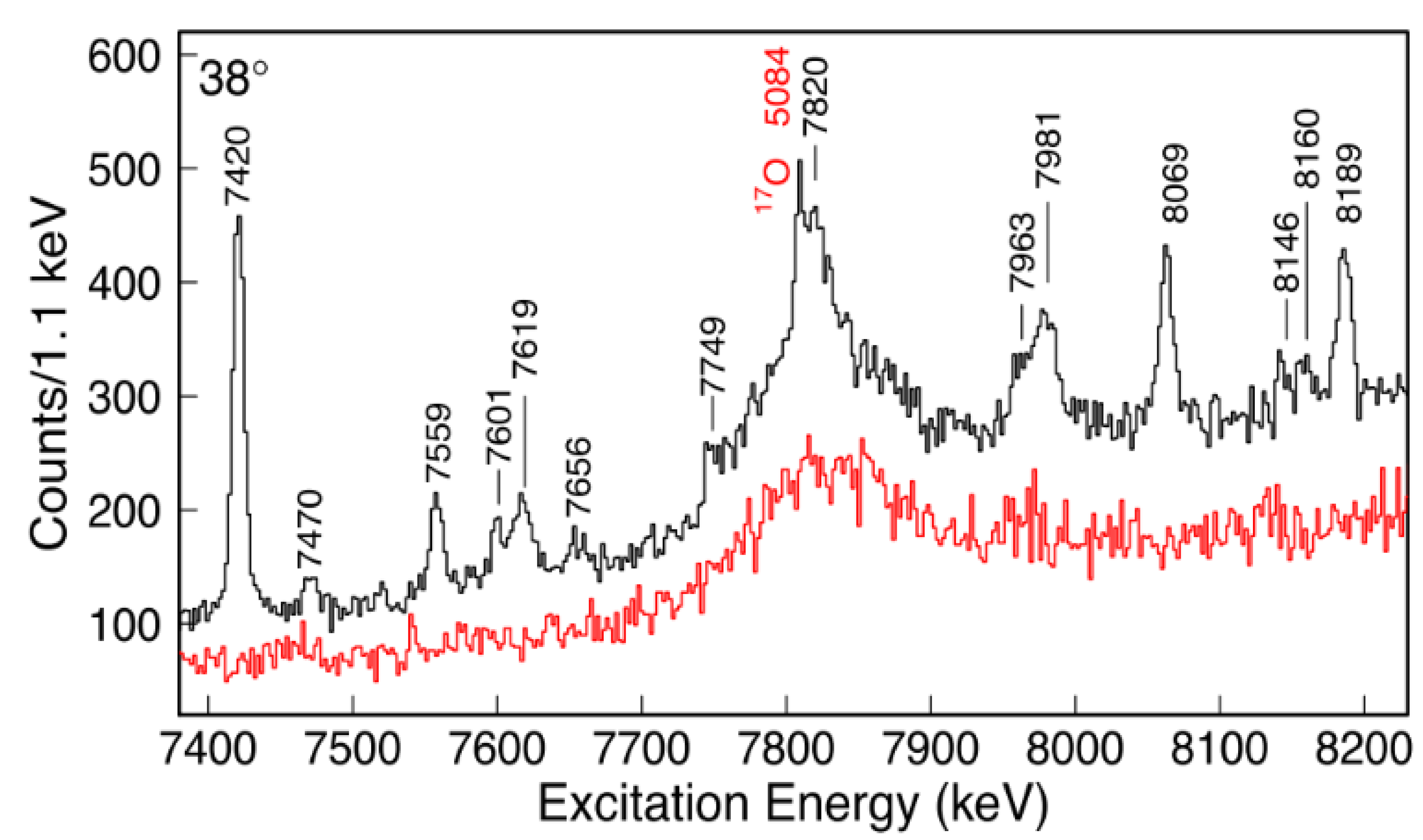

Figure 2: Frost-Schenk Spectrum for ^{20}Ne(d,p)^{21}Ne

References

[1]J. Frost-Schenk et al.2022, [2]L.K Fifield and N.A. Orr 1990

Improved ^{20}Ne Targets

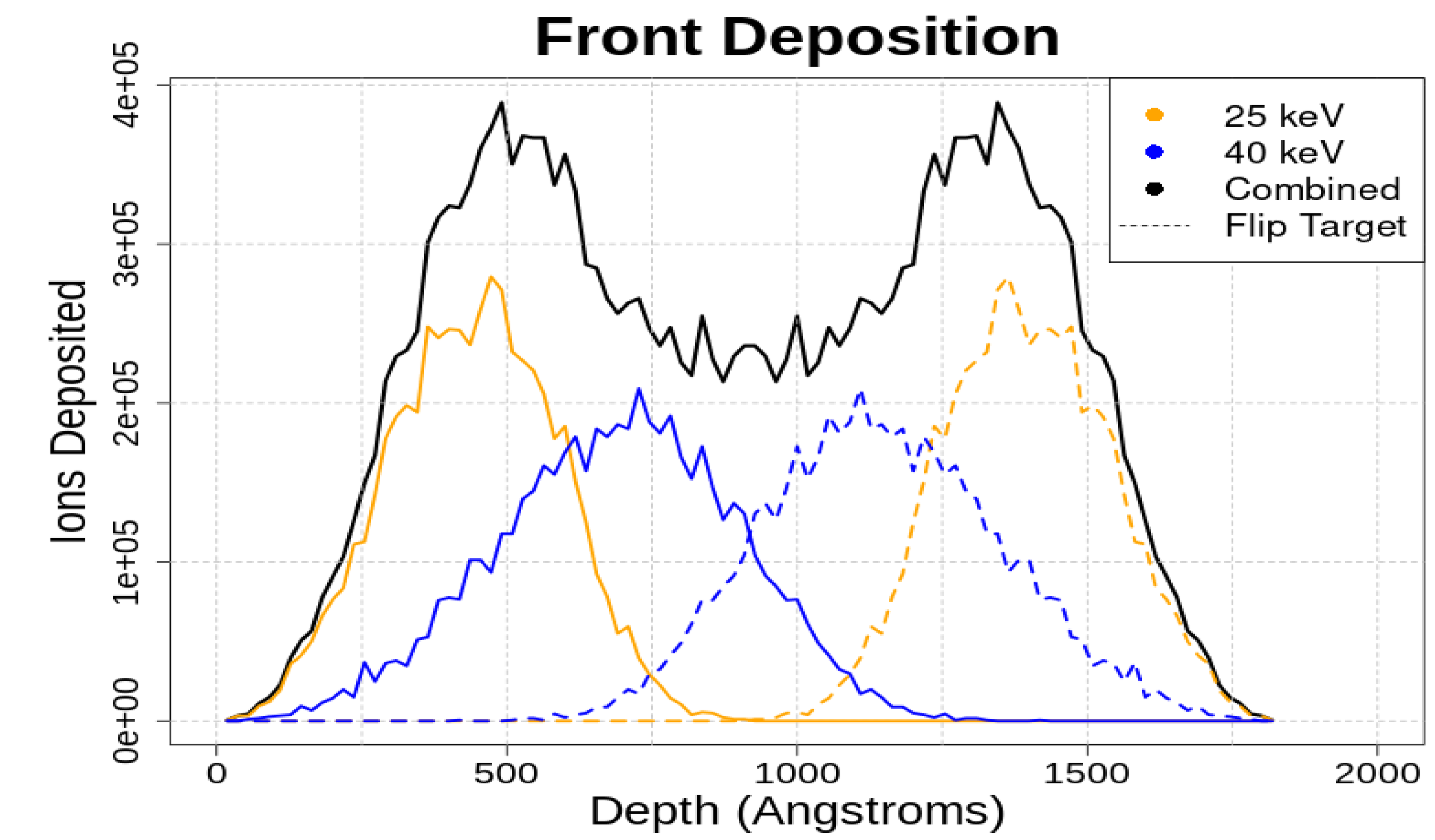

Figure 3: TRIM Calculation for Front Deposition

Frost-Schnek used implanted ^{20}Ne targets on 44 μg/cm^2 carbon foil with a roughly 4% Ne:C abundance ratio. By increasing the Ne available and using thinner carbon we should see improved resolution of the indicated excited states. Multiple Implantation methods were devised to give the most isotropic distribution of ion through the foil.

Future Analysis

- With the installation of the new TORVIS source at TUNL we expect to increased statistics from higher data collections.
- During the experiments we plan to characterize the targets with Rutherford Back Scattering experiments to monitor target degradation over each run.
- Further implanting runs to standardize the foil implanting procedure for future users at TUNL.