TRIUMF - EEC SUBMISSION EEC meeting: 200712S *Progress Report*	**Exp. No.** S811 **Date Submitted:** 2007-11-12 12:59:13

Title of Experiment:

A Direct Study of the $^{19}Ne(p,\gamma)^{20}Na$ Reaction with a Recoil Mass Separator

Name of group:

DRAGON

Spokesperson(s) for Group

C. Vockenhuber, U. Greife

Current Members of Group:
(name, institution, status, % of research time devoted to experiment)

C. Vockenhuber	TRIUMF	Research Associate	40%
U. Greife	Colorado School of Mines	Associate Professor	25%
L. Erikson	Colorado School of Mines	Student (Graduate)	50%
C. Ruiz	TRIUMF	Research Scientist	40%
D.A. Hutcheon	TRIUMF	Senior Research	30%
U. Hager	TRIUMF	Research Associate	30%
K. Chipps	Colorado School of Mines	Student (Graduate)	25%
A. Shotter	TRIUMF	Professor	20%
A. Hussein	University of Northern British Columbia	Professor Emeritus	15%
A. Parikh	UPC Barcelona	Research Associate	15%
A.A. Chen	McMaster University	Professor	15%
D. Kahl	McMaster University	Student (Graduate)	15%
J. Chen	McMaster University	Student (Graduate)	15%

J. Clark	Yale University	Research Associate	15%
K. Setoodehnia	McMaster University	Student (Graduate)	15%
A. Wallner	University of Vienna	Research Scientist	10%
A.J. Murphy	University of Edinburgh	Lecturer	10%
A.M. Laird	University of York	Lecturer	10%
D. Ottewell	TRIUMF	Research Scientist	10%
J. Goerres	Notre Dame	Professor	10%
J. Jose	UPC/IEEC Barcelona	Associate Professor	10%
J.M. D#Auria	SFU and ORNL	Professor Emeritus	10%
L. Buchmann	TRIUMF	Senior Research	10%
L. Snyder	Colorado School of Mines	Student (Graduate)	10%
M Couder	Notre Dame	Research Associate	10%
M. Wiescher	Notre Dame	Professor	10%
N. Galinski	Simon Fraser University	Student (Graduate)	10%
B. Davids	TRIUMF	Research Scientist	5%
M. Pavan	TRIUMF	Research Associate	5%

Beam Shifts Used:

Beam Shifts Remaining:

New Beam Requests:

Basic Information:

Date Submitted: 2007-11-12 12:59:13

Date Experiment Ready: 2008-01-01

Summary: The hot CNO cycles an the rp process play an important role in the energy production and nucleosynthesis in a hot and explosive stellar environment. At high temperatures

($T_9 \geq 0.3$, $T_9 = T/10^9$ K) the reaction sequence $^{15}O(\alpha,\gamma)^{19}Ne(p,\gamma)^{20}Na$ may initiate a link between the hot CNO cycles and an element formation up to mass A = 56. This reaction sequence of proton captures and β-decays during explosive hydrogen burning may explain the observed abundance of isotopes between Ne and Al in nova ejecta. However, the reaction flow depends critically on the reaction rates of both capture processes ($^{15}O(\alpha,\gamma)^{19}Ne$ and $^{19}Ne(p,\gamma)^{20}Na$), which are still not well known. Therefore, the actual temperature and density conditions for the breakout of the hot CNO cycles are not sufficiently defined.
In the subsequent text we propose to measure the important resonance parameters in the $^{19}Ne(p,\gamma)^{20}Na$ reaction. In previous experiments four excited states above the proton threshold in ^{20}Na were found in the energy region of interest with a center-of-mass energy of 447,658, 787 and 857 keV, respectively. In most of the astrophysical scenarios the reaction rate is dominated by the resonance at E_{cm} = 447 keV, where a previous direct experiment at Louvain-la-Neuve found an upper limit of $\omega\gamma \leq 26$ meV (90% C.L.). With the increase detection efficiency of the DRAGON setup (gas target and recoil separator) it should be possible to determine the strength of the above mentioned important resonances with sufficient accuracy already with a ^{19}Ne beam current starting at several 10^7 s^{-1}.

Plain Text Summary: The hot CNO cycles an the rp process play an important role in the energy production and nucleosynthesis in a hot and explosive stellar environment. At high temperatures (T9 ≥ 0.3) the reaction sequence 15O(alpha,gamma)19Ne(p,gamma)20Na may initiate a link between the hot CNO cycles and an element formation up to mass A = 56. In most of the astrophysical scenarios the reaction rate of 19Ne(p,gamma)20Na is dominated by the resonance at Ecm = 447 keV. We propose to measure the strength of this resonance with a Ne-19 beam and the DRAGON setup.

Primary Beam Line: isac2a

ISAC Facilities

ISAC Facility:

ISAC-I Facility: DRAGON

ISAC-II Facility:

Secondary Beam

Isotope(s): Ne-19

Energy: 400 - 700

Energy Units: keVA

Energy spread - maximum : 1-2 keV, FWHM

Time spread - maximum : 1-2 ns, FWHM

Angular Divergence : 2 mr, FWHM

Spot Size: 2 mm, FWHM

Intensity Requested: 1e8 pps

Minimum Intensity: 1e7 pps

Maximum Intensity: 1e12 pps

Charge Constraints: 4+ or 5+ which ever is more intense

Beam Purity:

Special Characteristics:

Experiment Support

Beam Diagnostics Required: Faraday cup, slits, wire scanner, DRAGON CCD camera, ion chamber

Signals for Beam Tuning: Faraday cup, mass slit current, beta monitor, ion chamber

DAQ Support (Summary of Requirements): standard DAQ support for DRAGON experiments

TRIUMF Support (Resources Needed): Ne-19 beam production with FEBIAD ion source.

NSERC: DRAGON NSERC grant

Other Funding:

Safety Issues: Standard DRAGON saftey procedures for operation the H_2 gas target and the ion chamber. No long-lived activities are expected at A=19; slit boxes where most of the beam is dumped is surrounded by 5 cm Pb shielding; a fence/gate exclusion system prevents access closer than 1 m to the beam line at DRAGON

TRIUMF EEC Re-Submission

E811: A direct study of the ^{19}Ne(p,g)^{20}Na reaction with a recoil mass separator (DRAGON)

P.I.'s: Uwe Greife / Christof Vockenhuber

This experiment was first proposed by the DRAGON collaboration in June 1997 as part of the motivational push to build the DRAGON recoil separator experiment. The proton capture on ^{19}Ne is part of two possible chains of reactions that can provide a bridge from the hot-CNO cycles to the rp-process in novae and X-ray burst nucleosynthesis. All chains start with ^{18}F: ^{18}F(p,α)^{15}O(α,γ)^{19}Ne(p,γ)^{20}Na, or ^{18}F(p,γ)^{19}Ne(p,γ)^{20}Na, or ^{18}F(β^+)^{18}Ne(α,p)^{21}Na. In the relevant astrophysical temperature ranges the reaction rate of ^{19}Ne(p,γ)^{20}Na is believed to be dominated by a resonance at 447 keV corresponding to an excited state in ^{20}Na at 2.646 MeV.

The 1997 EEC noted that: "a convincing case (was) made that the results are of considerable astrophysical interest." We additionally presented a progress report to the EEC in December 2000 and the committee expressed their satisfaction with status of our preparations and the performance of our detector systems. It therefore stated: The committee reiterates its high priority rating for this experiment and allocates the requested 60 shifts to allow data-taking to start in the fall 2001".

Since this last assessment only one additional experiment was performed. The nuclear astrophysics group at the Louvain-la-Neuve cyclotron lowered the upper limit on the important 448 keV resonance (theoretically predicted strength 6-7 meV) from 18 meV down to 15.6 meV employing a solid target and a recoil separator [M.Couder et al., Phys. Rev. C 69 (2004) 022801(R)]. The experiment enjoyed a ^{19}Ne beam of 1×10^8 s^{-1} on target, however the unavailability of a gas target (higher yield) and a low rejection factor of the ARES separator (5×10^{-6}) limited the sensitivity to an upper limit result. Therefore, to our knowledge no additional experimental information exists that would change the scientific case compared to what was presented in our original proposal.

When the EEC received this experiment in 1997 it considered it together with E810 (Proton capture on ^{23}Mg). Their comment read: "The committee considered that the ^{19}Ne experiment should be done first since the beam is easily produced, something is already known about the reaction, and it is of higher astrophysical interest". However, the beam development at TRIUMF proved more complicated than anticipated by the EEC. The 2000 allocation of beam time (60 shifts) was based on the anticipated success of an ECR ion source development, which however did not come to fruition. Recent beam developments with the FEBIAD source show however promise that a sufficient ^{19}Ne beam current at the DRAGON experiment could be achieved in the near future. So far the tests achieved a beam intensity of $\sim7\times10^7$ s^{-1} at the yield station. This is allows already to start work on the ^{19}Ne(p,γ)^{20}Na project. With this beam intensity (1×10^7 s^{-1} at the DRAGON experiment) the event rates at the higher energy resonances (658 and 787 keV) are

expected to be about 30 per day, while the astrophysically important resonance at 447 keV would give about 5 events per day. A factor of 4 increase would allow an experiment in a realistic time frame (see requirements of beam time below).
Our recent tests with the ionization chamber in the DRAGON focal plane have shown the capability of the IC to separate beam and recoil ions at the relevant energies. Stable ^{20}Ne and ^{23}Na beams will be used for IC calibration and charge state distribution measurements.
Over the years, naturally, the composition of the collaboration has changed somewhat as reflected in our updated coversheet.

As the demonstrated ^{19}Ne intensity allows already to measure resonance strengths of the higher energy resonances and a first look at the 447 keV resoance, we request stage 2 approval for this experiment.

Our requirements of beam time are (under the assumption of 4×10^7 s^{-1} ^{19}Ne on target):

^{20}Ne	4 shifts	IC calibration and charge state distributions
^{23}Na	4 shifts	IC calibration and charge state distributions
^{19}F	4 shifts	pilot beam for tuning and IC calibration
^{19}Ne	8 shifts	On and off resonance measurements at 700 keV/u
^{19}Ne	50 shifts	On and off resonance measurements at 480 keV/u

The number of required ^{19}Ne shifts can be reduced as the beam intensity goes up.