TRIUMF - EEC SUBMISSION EEC meeting: 200807S *Original Proposal*	TRIUMF	**Exp. No.** S1186 - *Pending (Stage 1)* **Date Submitted:** 2008-06-07 01:16:38

Title of Experiment:

Determination of one neutron separation energy for ^{19}C

Name of group:

Spokesperson(s) for Group

R. Kanungo, J. Dilling

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

R. Kanungo	Saint May\'s University	Assistant Professor	30%
J. Dilling	TRIUMF	Research Scientist	30%
A. Gallant	University of British Columbia	Student (Graduate)	50%
V. Ryjkov	TRIUMF	Research Associate	30%
M. Brodeur	University of British Columbia	Student (Graduate)	20%
R. Ringle	TRIUMF	PDF	20%
P.P.J. Delheij	TRIUMF	Research Scientist	20%
W. Chi	University of Manitoba	PDF	10%
S. Ettenauer	University of British Columbia	Student (PhD)	10%
P. Bricault	TRIUMF	Senior Research	10%
G. Gwinner	University of Manitoba	Professor	10%

Beam Shift Requests:

8 shifts on: TITAN

Basic Information:

Date submitted: 2008-06-07 01:16:38

Date experiment ready: 2009-04-15 12:00:00

Summary:

The halo structure in unstable nuclei has attracted much attention due to their scope to reveal many unknown features of nuclei. The neutron separation energy is a decisive factor in characterizing the nuclear halo. The separation energy guides the extent of the halo. Therefore accurate knowledge of the neutron separation energy is a necessary requisite to understand the halo structure.

In this proposal we aim to determine the one neutron separation energy for the potential one-neutron halo candidate 19C. The existing data on mass measurements of this nucleus has a wide variation making it difficult to determine precisely the one neutron separation energy. This poses to be a major problem in confirming the structure of 19C.

The neutron separation energy depends on both the masses of 18C and 19C. The former has only been measured through a Q-value determination from a multi-nucleon transfer reaction. The measurement is precise but one cannot rule out any uncertainty in the value due to absence of any other data. To achieve an unambiguous determination of the neutron separation energy for 19C we will therefore measure the mass of 18C as well. The measurements will be done using the TITAN trap at ISAC.

Plain Text Summary:

Summary of Experiment Results:

Primary Beamline: TITAN

ISAC Facilities

ISAC Facility:

ISAC-I Facility:

ISAC-II Facility:

Secondary Beam

Energy Units:

Energy spread-maximum:

Time spread-maximum:

Angular Divergence:

Spot Size:

Charge Constraints:

Beam Purity:

Special Characteristics:

Experiment Support

Beam Diagnostics Required:

Signals for Beam Tuning:

DAQ Support:

TRIUMF Support:

NSERC: TITAN facility support

NSERC: TITAN facility support

Other Funding:

Muon Justification:

Safety Issues: TITAN is currently operational. There are no new installations required for this experiment. No major safety hazards are therefore foreseen.

Determination of neutron separation energy for ^{19}C

1. Motivation :

The exotic forms of nuclei such as nuclear halos, existing far from stability are characterized by one or two- weakly bound neutrons coupled to a more strongly bound 'core' nucleus. These halo neutron(s) have separation energy much smaller (typically < 1 MeV) than that for stable nuclei (typically ~ 8MeV). The neutron separation energy (S_n) determines the radial extent of the valence neutron wavefunction, thereby ascertaining the extent of halo formation in a nucleus. Reliable mass measurements are thus crucial for the understanding of nuclear structure. In this proposal, as the first step towards resolving uncertain facts regarding the halo formation in ^{19}C, we intend to accurately determine its one neutron separation energy.

The potential of a halo formation in the ^{19}C nucleus was pointed out from the narrow momentum distribution observed after one-neutron removal from ^{19}C [1-3]. It was suggested that ^{19}C has an abnormal ground state spin of $1/2^+$ with the ^{18}C core mainly in its ground state coupled to the valence neutron in the $2s_{1/2}$ orbital. The unexpectedly large interaction cross section [4] provided further support to this idea as did the large Coulomb dissociation cross section [5]. However a consistent understanding of the structure of ^{19}C from all the existing data is yet to be achieved [6].

The one neutron separation energy of ^{19}C is poorly determined experimentally. The uncertainty of the measured masses for the nucleus ^{19}C, at LOS Alamos [7,8] and GANIL [9,10] using the method of time-of-flight, spans nearly two orders of magnitude thereby causing similar uncertainty in its one-neutron separation energy as shown in Fig.1. This poses as a severe limitation to draw a conclusive picture on the possible neutron halo in ^{19}C.

The weighted average of the existing mass measurements yields a value of S_n = 293±94keV. This value of separation energy is unable to successfully explain the Coulomb dissociation cross section assuming the dominant structure of $^{19}C = {}^{18}C_{gs} + n(2s_{1/2})$. Based on the location of the peak from relative energy distribution in Coulomb dissociation as well as the angular distribution, the separation energy of S_n = 530±130 keV was put forward in Ref.[5]. A later analysis of the ^{19}C momentum distribution suggests S_n = 650±150 keV [11]. The currently adopted value in the Atomic Mass Evaluation(AME) table is therefore, 580±90 keV [12]. The lower limit on S_n can be set from the observation of a bound excited state at 200keV in ^{19}C [13,14]. It should be noted that if the ^{18}C 'core' inside ^{19}C resides in its excited state, then the separation energy reflected in the reaction observables is the effective separation energy, which is larger than S_n. Therefore, the unambiguous direct precise determination of masses of $^{18,19}C$ at TITAN will allow us to settle all uncertainties regarding S_n in ^{19}C.

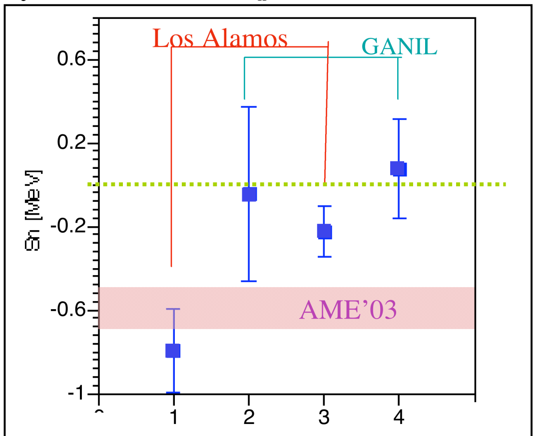

Fig.1 Summary of S_n for ^{19}C from existing mass measurements.

2. Experiment :

The half-life of ^{19}C is 49ms which is suitable for measurement with TITAN, hence with a Penning trap excitation time of T_{RF} = 100 ms and a statistic of N=10 000 ions a relative mass precision of $\Delta m/m = 2 \bullet 10^{-8}$ can be reached, corresponding to an absolute mass uncertainty of $\Delta m \approx 400$ eV. This measurement would be carried out with the ions in a single charge state. With higher charge states better precision would be possible, however not needed, or lower statistic (factor of 6) could be used. The capability of TITAN for precision mass measurements of extremely short-lived neutron-rich nuclei has been successfully demonstrated by the measurements of ^{8}He, ^{11}Li and ^{11}Be masses.

The one neutron separation energy of ^{19}C involves the masses of both ^{18}C and ^{19}C. The mass of ^{18}C is known precisely but from one measurement only involving measuring the reaction Q-value [15]. We will therefore perform a direct measurement of ^{18}C mass at TITAN.

3. Beamtime :

Measurement/Job	**Shifts** *(1shift = 12 hrs.)*
Tune of TITAN with OLIS beam	2
$^{18,19}C$ mass measurements	6
Total	**= 8 shifts**

4. Student thesis:

This is intended to be part of the thesis project of A. Gallant. Therefore we request that the $^{18,19}C$ yields be reported to us as soon as possible. The measurement of mass will be followed by reaction studies on ^{19}C in order to draw a conclusive picture on the nuclear halo for this nucleus.

5. Readiness :

The TITAN facility is presently operational and no new major developments are required for the proposed experiment. The $^{18,19}C$ beams need to be developed at ISAC. These beams can be produced from an oxide target. Tests of an oxide target are under consideration.

6. Data Analysis :

Data analysis will be done using software and computer currently available at TRIUMF.

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Dr. Rituparna Kanungo

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1. Meausrement of two-neutron transfer reaction p(^{11}Li,^{9}Li)t at 3*A* MeV
   I. Tanihata , M.Alcorta, D. Bandyopadhyay, R. Bieri, L.Buchmann, B.Davids, N.Galinski, D.Howell, W.Mills, R.Openshaw, E. Padilla-Rodal, G. Ruprecht, G. Sheffer, A.C.Shotter, S.Mythili, M.Trinczek, P.Walden, H. Savajols, T. Roger, M. Caamano, W.Mittig, P. Roussel-Chomaz, R. Kanungo, A. Gallant, M. Notani, G. Savard, I.J. Thompson
   Phys. Rev. Lett, 100 (2008) 192502

2. Spectroscopic factors for the ^{9}Li ground state and N=6 shell closure
   R. Kanungo, A.N. Andreyev, L. Buchmann, B. Davids, G. Hackman, D. Howell, P. Khalili, B. Mills, E. Padilla-Rodal, Steven C. Pieper, J. Pearson, C. Ruiz, G. Ruprecht, A. Shotter, I. Tanihata, C. Vockenhuber, P. Walden, R.B. Wiringa
   Phys. Lett B 660 (2008) 26

3. Lifetime of states in ^{19}Ne above the ^{15}O+α threshold
   S. Mythili, B. Davids, T. K. Alexander, G.C. Ball, M. Chicoine, R.S.Chakrawarthy, R. Churchman, J.S.Forster, S. Gujrathi, G. Hackman, D.Howell, R. Kanungo, J.Leslie,E.Padilla, C.J.Pearson, C.Ruiz, G.Ruprecht, M.Schumaker, I.Tanihata, C.Vockenhuber, P.Walden,S.Yen
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4. High-precision half-life determination of the superallowed β^{+} emitter ^{62}Ga
   G.F.Grinyer, P.Finlay, C.Svensson, G.C.Ball, J.R.Leslie, R.A.Austin, D.Bandyopadhyay, A.Chaffey, R.S.Chakrawarthy, P.E.Garrett, G.Hackman, B.Hyland, R.Kanungo, K.G.Leach, C.M.Mattoon, A.C.Morton, C.J.Pearson, A.A.Phillips, J.J.Ressler, F.Sarazin, H.Savajols, M.A.Schumaker, J.Wong
   Phys. Rev. C 77 (2008) 015501.

5. Shell closures in the N ad Z=40-60 region for neuron and proton-rich nuclei.
   R. Kanungo,
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6. Examining the exotic structure of the proton-rich nucleus ^{23}Al
   D.Q.Fang, W.Guo, C.W.Ma, K.Wang, T.Z.Yan, Y.G.Ma, X.Z.Cai, W.Q.Shen, Z.Z.Ren, Z.Y.Sun, J.G.Chen, W.D.Tian, C.Zhong, M.Hosoi, T.Izumikawa, R.Kanungo, S.Nakajima, T.Ohnishi, T.Ohtsubo, A.Ozawa, T.Suda, K.Sugawara, T.Suzuki, A.Takisawa, K.Tanaka, T.Yamaguchi, I.Tanihata
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7. TRIUMF-ISAC Gamma-Ray Escape-Suppressed Spectrometer (TIGRESS): a versatile tool for radioactive beam physics
   G.C.Ball, A.Andreyev, R.A.E.Austin, D.Bandyopadhyay, J.A.Becker, A.J.Boston, H.C.Boston, A.Chen, R.Churchman, F.Cifarelli, D.Cline, R.J.Cooper, D.S.Cross, D.Dashdorj, G.Demand, M.R.Dimmock, T.E.Drake, P.Finlay, F.Gagon-Moisan, A.T.Gallant, P.E.Garrett, K.L.Green, A.N.Grint,

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22. Experiment on synthesis of element 113 in the reaction ^{209}Bi(^{70}Zn,n)^{278}113
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