National Superconducting Cyclotron Laboratory
Proposal Form—PAC 35

TITLE: Proton radioactivity of 73Rb and its effects on the astrophysical rp process

By submitting this proposal, the spokesperson certifies that all collaborators listed have read the proposal and have agreed to participate in the experiment.

SPOKESPERSON: Andrew M. Rogers

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OTHER EXPERIMENTERS: (Please spell out first name and indicate Graduate Students (GS), Undergraduate students (UG) and Postdoctoral Associates (PD); include a separate sheet if necessary)

Last name, First name	**Organization**	**Last name, First name**	**Organization**
Lynch, Bill	NSCL	Kilburn, Micha	NSCL (GS)
Tsang, Betty	NSCL	Sobotka, Lee	WashU
Chajecki, Zbigniew	NSCL (PD)	Charity, Robert	WashU
Coupland, Daniel	NSCL (GS)	de Souza, Romualdo	IU
Micheal, Youngs	NSCL (GS)	Hudan, Sylvie	IU
Hodges, Rachel	NSCL (GS)	Hoffman, Calem	ANL (PD)
Winkelbauer, Jack	NSCL (GS)	Deibel, Catherine	ANL/JINA (PD)
Sanetullaev, Alisher	NSCL(GS)	Wuosmaa, Alan	WMU

REQUEST FOR PRIMARY BEAM SEQUENCE INCLUDING TUNING, TEST RUNS, AND IN-BEAM CALIBRATIONS: (Summary of information provided on Beam Request Worksheet(s). Make separate entries for repeat occurrences of the same primary beam arising from user-requested interruptions to the experiment.)

	Isotope	Energy (MeV/nucl.)	Minimum Intensity (particle-nanoampere)	Sum of Beam Preparation Times (Hours)	Sum of Beam-On-Target Times (Hours)
Beam 1	78Kr	150	25	31	209
Beam 2					
Beam 3					
Beam 4					

ADDITIONAL TIME REQUIREMENTS THAT REQUIRE USE OF THE CCF (e.g. modification of the A1900 standard configuration, development of optics, … Obtain estimates from the A1900 Device Contact.)

Additional CCF use time: 0

Total Hours: 31 | 209

TOTAL TIME REQUEST (HOURS): 240
(Calculated as per item 5. of the Notes for PAC 35 in the Call for Proposals)

Access to:		SET UP TIME (before start of beam)	TAKE DOWN TIME
	Experimental Vault	14 days	4 days
	Electronics Set-up Area	12 days	4 days
	Data Acquisition Computer	14 days	4 days

National Superconducting Cyclotron Laboratory
Proposal Form—PAC 35

HOURS APPROVED: ________________ HOURS RESERVED: ____________________

WHEN WILL YOUR EXPERIMENT BE READY TO RUN? ____05_______ / ___01___ / __2011___

DATES EXCLUDED: __06/01/2011 - 08/01/2011__________________________________

EXPERIMENTAL LOCATION:

___ Transfer Hall (in the A1900) ___ Transfer Hall (downstream of the A1900)
___ N2 vault ___ N2 vault (with Sweeper line)
___ S2 vault (Irradiation line) ___ S2 vault
_X_ S3 vault

EXPERIMENTAL EQUIPMENT:

_X_ A1900 ___ Beta Counting System ___ Beta-NMR Apparatus
___ Sweeper Magnet ___ Neutron Walls ___ LENDA
___ Modular Neutron Array ___ Neutron Emission Ratio Observer
_X_ High Resolution Array ___ 53" Chamber ___ CsI(Na) Scintillator Array
___ Segmented Ge Array: [ ] classic; [ ] mini; [ ] beta; [ ] delta; [ ] barrel; [ ] other
_X_ S800 Spectrograph: [X] with; [ ] without scattering chamber
___ Radio Frequency Fragment Separator ___ DDAS ___ Other (give details)

DETAIL ANY MODIFICATION TO THE STANDARD CONFIGURATION OF THE DEVICE USED, OR CHECK NONE: [X] NONE

DETAIL ANY REQUIREMENTS THAT ARE OUTSIDE THE CURRENT NSCL OPERATING ENVELOPE, OR CHECK NONE (Examples: vault reconfiguration, new primary beam, primary beam intensities above what is presently offered, special optics, operation at unusually high or low rigidities): [X] NONE

REACTION TARGETS AT EXPERIMENTAL STATION:

__$(C_3H_6)_n$ and ^{197}Au

LIST ALL RESOURCES THAT YOU REQUEST THE NSCL TO PROVIDE FOR YOUR EXPERIMENT BEYOND THE STANDARD RESOURCES OUTLINED IN ITEM 12 OF THE NOTES FOR PAC 35 IN THE CALL FOR PROPOSALS. [X] NONE

LIST ANY BREAKS REQUIRED IN THE SCHEDULE YOUR EXPERIMENT, OR CHECK NONE: (Examples of why an experiment might need an interruption: to change the experimental configuration; to complete the design of an experimental component based on an initial measurement.) [X] NONE

OTHER SPECIAL REQUIREMENTS: (Safety related items are listed separately on following pages.) [X] NONE

SUMMARY (no more than 200 words):

We propose to measure the proton separation energy, S_p, for the proton-unbound nucleus ^{73}Rb. A direct measurement with uncertainties <100 keV will further constrain the astrophysical *rp* process and, in particular, the ^{72}Kr waiting point as well as add to our general knowledge of the proton dripline. This measurement builds upon the previous NSCL experiment #02023 for measuring unbound states in proton-rich nuclei where we have successfully performed the first direct measurement with a value of $S_p(^{69}\mathrm{Br})$= -785 (+34)(-40) keV.

Description of Experiment

(no more than 4 pages of text for items 1through 3 - 1 1/2 spaced, 12pt; no limit on figures or tables)

Please organize material under the following headings or their equivalent:

1. Physics justification, including background and references.
2. Goals of proposed experiment
3. Experimental details—what is to be measured; technical feasibility of measurement; count rate estimate; basis of time request; discussion of present state of readiness of the experiment and an estimated earliest date for inclusion in the run schedule; discussion of any technical assistance (design, fabrication, installation, etc.) that may be requested from NSCL; apparatus (including sketch).

Note: Graphics should be such that black-and-white copies will convey the intended information correctly; references to color should be avoided.

I. **Physics Justification**

Properties of nuclei at and beyond the proton dripline are of key importance in defining the limits of particle stability, tests of nuclear models, and for nuclear astrophysics. In particular, the *rp*, or rapid proton-capture, process involves nuclei along the proton dripline where a current lack of knowledge in the nuclear data continues to lead to uncertainties in rp-process calculations [1,2]. Significant uncertainties are due to the so-called "waiting-point" nuclei, where relatively long β-decay half-lifes combined with inhibited proton capture due to photodisintegration or drip-line nuclei with negative proton capture Q values restrict the reaction flow. The sensitivity of the rp process to the properties of these particular isotopes along the rp-process path have prompted studies over the past 25 years [3-10]. Such experiments on nuclei at the dripline, however, are difficult as the cross sections for their production are low and their short lifetimes make measurements on these nuclei a challenge.

The waiting points that occur at ^{64}Ge, ^{68}Se, and ^{72}Kr are of particular significance. Type I x-ray bursts are one of the most promising scenarios for the realization of the rp process in nature [11]. The high temperature, densities, and abundance of hydrogen provide the necessary conditions to trigger the rp process. These bursts are observed to repeat on the order of hours to weeks with a typical burst lasting on the order of 10-100 s. As the β-decay half-life of these three waiting-point isotopes is on the same timescale as the x-ray burst duration they have a strong influence over the reaction path during the burst. For both ^{68}Se and ^{72}Kr, however, proton-capture reactions produce the unbound nuclei ^{69}Br and ^{73}Rb, respectively. The original rp-process calculations ignored contributions from these possible branches [1]. If one includes the possibility of sequential two-proton capture reactions through unbound nuclei, however, as much as ~30% of the flow can bypass the waiting-point. In this case it has been determined that the 2*p*-capture rate depends exponentially on the proton separation energy [1]. Precise measurements of S_p with an uncertainty of ~50 keV or less are required to constrain the models as small uncertainties in S_p produce large uncertainties in the final reaction network. A change by 200 keV in S_p can lead to a change in the effective lifetime by a factor of 5. Figure 1 shows the region around ^{73}Rb and illustrates the possible reaction path as well as the branch around the ^{72}Kr waiting point through two-proton capture reactions.

We propose to measure proton-unbound states, and consequently the proton separation energy, in ^{73}Rb in a similar experiment to that of NSCL experiment #02023 where the proton separation energy of ^{69}Br was successfully measured [12,13]. Previous values have come from both non-observation measurements and predictions taken from mass measurements of $^{72,73}Kr$ together with a Coulomb displacement energy (CDE) calculation. A recent prediction by Rodriguez *et al.* [14] of S_p = -710 (100) keV contains a 100 keV uncertainty originating mostly from the uncertainty in the theoretical CDE. Moreover, such predictions only access the properties of ^{73}Rb indirectly. The experiment being proposed would be the first direct measurement of the ^{73}Rb proton separation energy.

II. <u>Goals of the proposed experiment</u>

There are four main goals of the proposed experiment,

- Detect protons from the ground-state decay of ^{73}Rb and thereby directly determine ^{73}Rb proton separation energy via a full-kinematic reconstruction of the two-body decay energy. In addition measure, if they are populated, higher-lying excited states.
- Place further constraints on the nuclear reaction network through the rp-process ^{72}Kr waiting point, thereby enhancing our understanding of type I x-ray bursts.
- Compare the measured proton separation energy to one that would be obtained through theoretical calculations such as those involving Coulomb displacement energy.
- Improve upon and optimize the techniques utilized in NSCL experiment #02023.

In general, a precise measurement of the ^{73}Rb proton separation energy will provide additional limits on the rp process when taken together with the previous results of ^{69}Br [12,13]. If ^{73}Rb is significantly unbound (>700 keV) then this will provide strong evidence against two-proton capture reactions significantly bypassing both the ^{68}Se and ^{72}Kr waiting points to reach nuclei beyond Rb. On the other hand, if ^{73}Rb is only slightly unbound then ^{72}Kr may be less significant of a waiting point than originally assumed. These effects determine the abundances of nuclei that can be processed beyond $A\approx 74$ to heavier masses, altering the light curves, the energy generation, and the isotopic composition of nuclei produced in type I x-ray bursts.

Additionally, a measurement of the ^{73}Rb proton separation energy would allow for tests of Coulomb displacement energy calculations in this region. There exists a discrepancy in the directly measured proton separation energy of ^{69}Br [12,13] compared to that taken from CDE calculations with the mass measurements of ^{68}Se and ^{69}Se [9,10,15]. This comparison showed that ^{69}Br is ~150 keV more unbound than what is predicted. A measurement on ^{73}Rb could help clarify whether this discrepancy is typical in this region of the nuclear chart and provide some guidance regarding the origin of such effects.

III. Experimental Details

We propose to produce ^{73}Rb from a secondary fragmentation beam of ^{74}Kr through an analogous reaction to that in experiment #02023 where a ^{70}Se beam was used to produce ^{69}Br. The decay of $^{73}\text{Rb}\rightarrow p+^{72}\text{Kr}$ will be kinematically reconstructed by measuring decay protons in HiRA [16] and beam-like ^{72}Kr decay product in the S800 spectrograph. The decay energy in the COM system then yields a direct measurement of the ^{73}Rb proton separation energy. A beam tracking system consisting of two micro-channel plates (MCPs) will be used to improve the measurement of the outgoing proton angle and, therefore, an improvement in the resolution of S_p [17,18].

A primary beam of ^{78}Kr at an energy of 150 MeV/u with an intensity of 25 pnA will be used to produce a secondary exotic beam of ^{74}Kr through fragmentation on a 764 mg/cm^2 Be production target. The A1900 combined with a wedge degrader at the intermediate image plane will select the ^{74}Kr fragments to be sent to the target location of the S800 spectrograph. The secondary ^{74}Kr beam will then bombard a polypropylene (C_3H_6) reaction target to produce proton unbound ^{73}Rb nuclei. As ^{73}Rb is expected to be significantly unbound, the decay will occur in the target and dominantly through proton emission as β decay will not compete.

The forward focused decay protons from ^{73}Rb will be detected using eight HiRA ΔE-E telescopes arranged at 50 cm from the reaction target in a similar configuration as that shown in Fig. 2. Each telescope will be configured with a 1.5 mm double-sided silicon-strip detector (DSSD) backed by four 4 cm long CsI(Tl) crystals [16]. Protons are easily resolved as demonstrated in the particle identification (PID) plot from experiment #02023 shown Fig. 3. Minimal modifications to existing mounts can be performed in order to reduce the minimum angle between the telescopes and the beam. This will increase the lowest decay *Q*-value energy to ~ 300 keV (The previous experiment #02023 was sensitive down to only ~500 keV).

The beam-like ^{72}Kr decay products will be measured and tracked in the S800 spectrograph. Figure 4 shows the PID for the reaction products produced during experiment #02023 where ^{68}Se is cleanly resolved in coincidence with particles detected in the HiRA telescopes . The S800 focal plane detectors have since been upgraded and we expect to resolve the reaction products at least as well as that shown in Fig. 4.

Two micro-channel plate detectors (MCPs) will be used for event-by-event beam tracking of the incoming beam. This is required as the beam spot at the target position can be on the order of 2-4 cm. If the point of interaction on the target is not taken into account the uncertainty in the outgoing proton angle can broaden the resolution of the reconstructed decay energy to be greater than 100 keV. In addition, from previous experiments, the MCP tracking system can also be used as a cross check of the ion optics and to optimize the beam tune. It should be noted that the existing HiRA MCP setup is a vast improvement over that used during experiment #02023. An increase in magnetic field strength and return yoke should improve the position resolution by ~25% while upgrades in the electronics will increase the time resolution and, consequently, the particle identification.

Estimates for the secondary ^{74}Kr beam have been simulated using LISE++ (v9.1.3) with additional estimates taken from our experience with the previous ^{69}Br experiment [19]. Using a 270 mg/cm^2 (1.0 mm) wedge at the A1900 intermediate image plane beam purity can be greatly improved and is expected to be ~84% with the largest contaminant coming from ^{69}Ge (15%). For this reason we request the possibility of installing a timing scintillator at the object plane of the S800 analysis line in order to identify the incoming secondary beam. In principle, the time-of-flight (ToF) information from the MCPs can be used instead. However, the additional timing detector will be useful if the MCP timing resolution proves to be poor. If we assume a transmission efficiency of 80% to the S800 target location then we expect a rate of 3.5e10^5 s^{-1} of ^{74}Kr on target resulting, assuming the production will be similar to that in the ^{69}Br experiment, in 40 events/day for ground-state proton decay. We therefore request 183 hours of ^{74}Kr beam-on-target time resulting in ~300 counts with a resolution of <20 keV in the ground-state decay peak with the possibility of also observing low-lying excited states. In addition we request 16 hours of total beam on target of ^1H, taken as fragmentation products from the ^{78}Kr primary beam, for the energy calibration of the HiRA CsI. We request two energy settings for the ^1H beam at 70

MeV/u and 46 MeV/u with 8 hours of beam-on-target time each. The protons will be elastically scattered from a gold foil providing two high energy points for the CsI calibration.

Given the previous success of experiment #02023 and, due to the fact that all major components of the proposed experiment exist, we have a high expectation for obtaining viable results.

[1] Wallace R K and Woosley S E, Astrophys. J., Suppl. Ser, 45(2), (1981)
[2] Schatz H *et al.,* Physics reports 294 167-263, (1998)
[3] Mohar M F *et al* 1991 Phys. Rev. Lett. 66 1571-1574, (1991)
[4] Blank B *et al,*1995 Phys. Rev. Lett. 74 4611-4614, (1995)
[5] Pfaff *et al,* Phys. Rev. C 53 1753-1758, (1996)
[6] Lima G F *et al,* Phys. Rev. C 65 044618, (2002)
[7] Wohr A *et al*, Nuclear Physics A 742 349 - 362 ISSN 0375-9474, (2004)
[8] Clark J A *et al*, Phys. Rev. Lett. 92 192501, (2004)
[9] Schury P *et al*, Phys. Rev. C 75 055801, (2007)
[10] Savory J *et al*, Phys. Rev. Lett. 102 132501, (2009)
[11]Taam R E *et al*., The Astrophysical Journal 413 324-332, (1993)
[12] Rogers A M, NSCL Thesis, (2009)
[13] Rogers A M *et al.*, ArXiv :1009.2950v1, (2010)
[14] Rodriguez D *et al.*, Phys. Rev. Lett. 93, 161104, (2004)
[15] Brown B A *et al.,* Phys. Rev. C 65 045802, (2002)
[16] Wallace M S *et al*., NIM A 583 302-312, (2007)
[17] Shapira D, Lewis T A, Hulett L D and Ciao Z, NIM A 449 396-407, (2000)
[18] Shapira D, Lewis T A and Hulett L D, NIM A 454 409-420, (2000)
[19] Tarasov, O. & Bazin, D., LISE++ v9.1.3, http://groups.nscl.msu.edu/lise

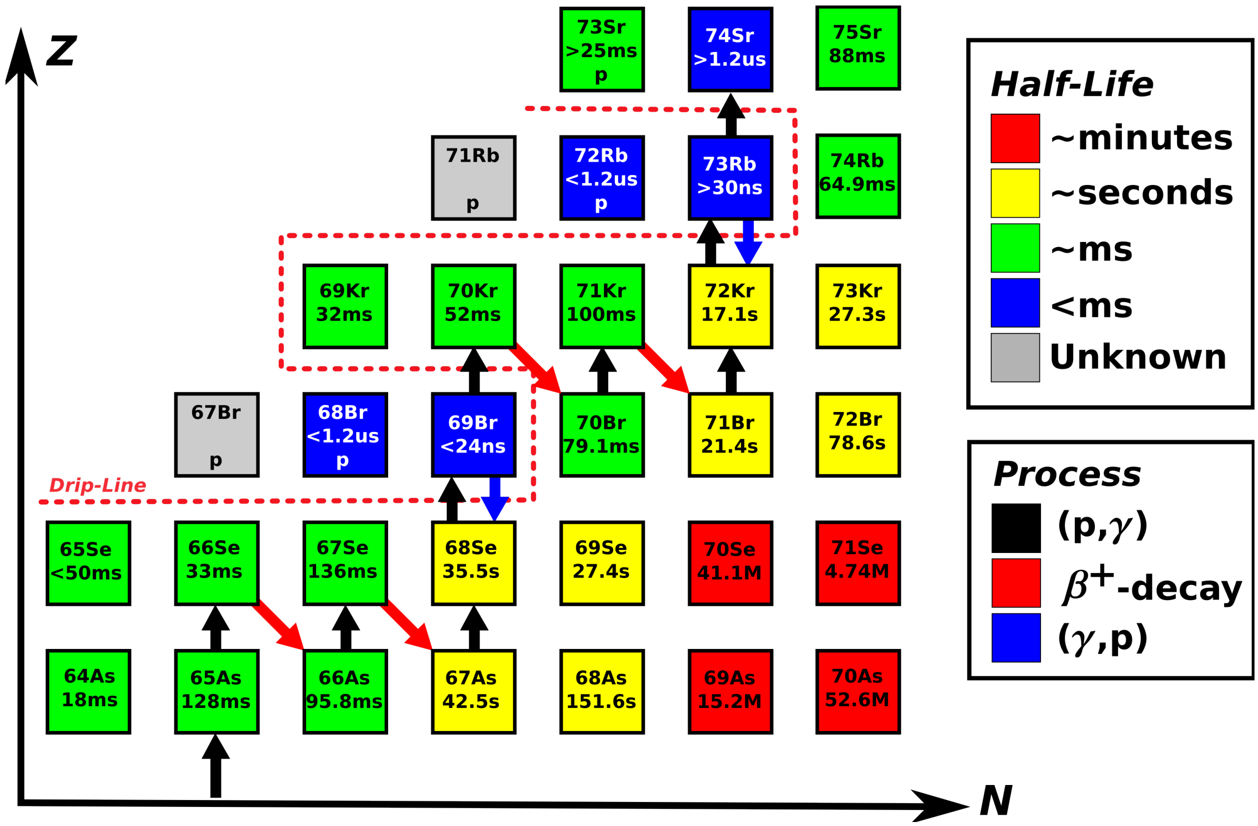

Fig. 1 Illustration of the possible rp-process path near the ^{72}Kr and ^{68}Se waiting-points. During a type I x-ray burst the rp process must wait for the long β decay ($T_{1/2}$ = 17.1 s) of ^{72}Kr in order for the process to continue to heavier nuclei. If part of the reaction flow can proceed through two-proton capture reactions as show in the figure then the waiting point can be bypassed.

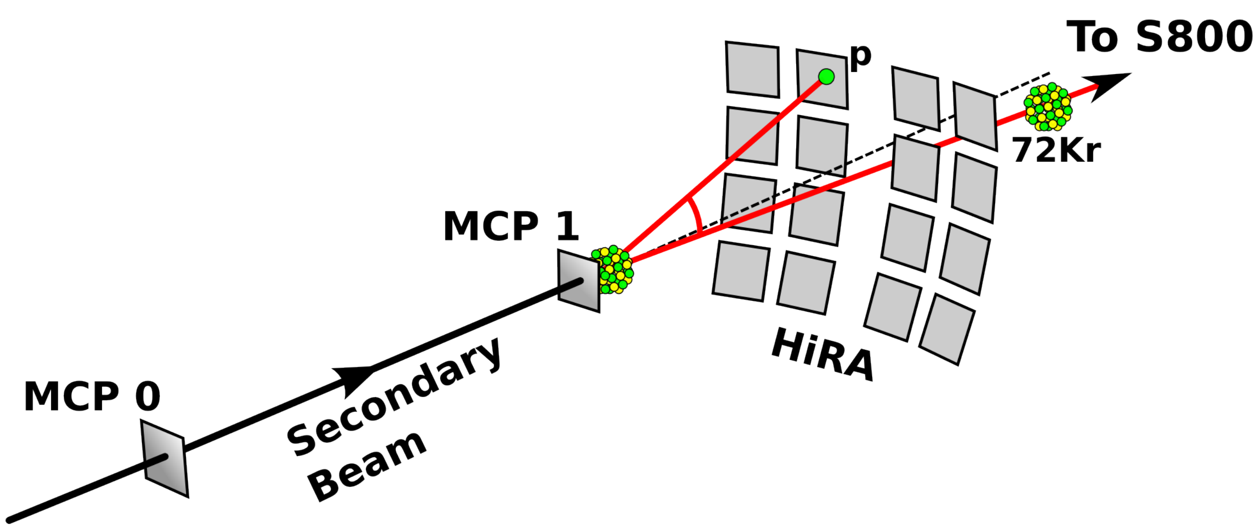

Fig. 2 Sketch of the proposed experimental setup and method. The HiRA configuration shown is from experiment #02023. For the current proposal the configuration will be modified to improve the efficiency and angular coverage.

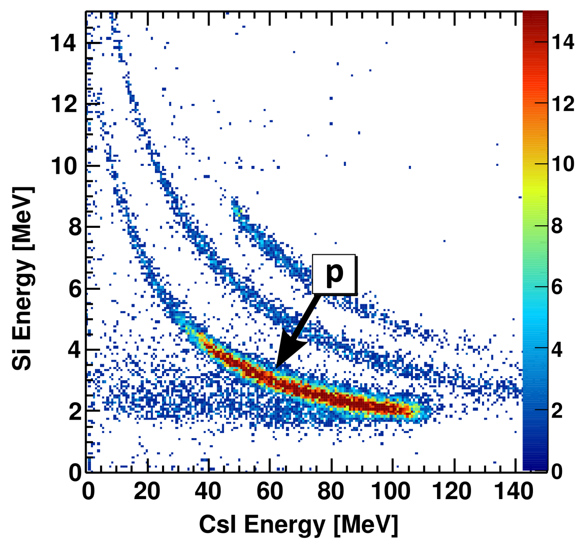

Fig. 3 Particle identification for ^{69}Br decay protons detected in HiRA. For the ^{73}Rb decay the measured protons will be nearly identical and should not be an issue.

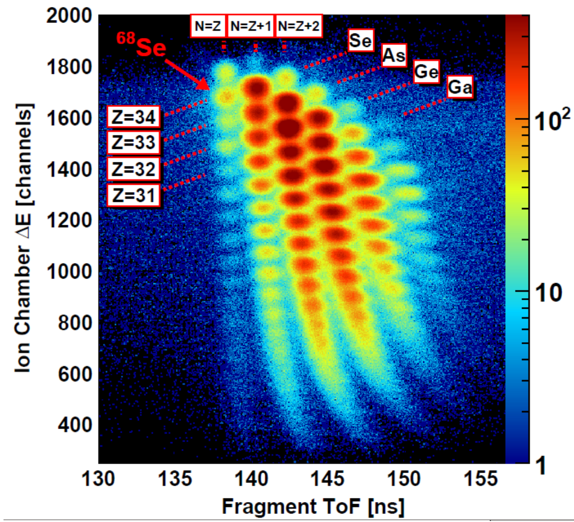

Fig. 4 Particle identification for beam-like reaction products from experiment #02023 detected in the S800 spectrograph. In this case, ^{68}Se could be cleanly resolved. We expect similar or even improved identification for the proposed ^{73}Rb experiment.

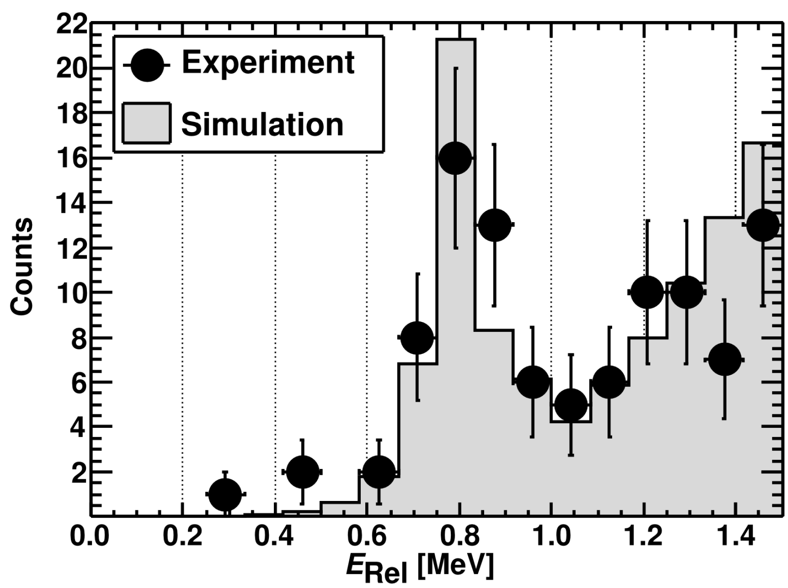

Fig. 5 Relative energy of proton decays from ^{69}Br measured in experiment #02023. The observed proton decay peak with S_p = -785 keV is compared to simulated data that accounts for know properties in the ^{69}Se mirror nucleus.

Status of Previous Experiments

Results from, or status of analysis of, previous experiments at the CCF listed by experiment number. Please indicate publications, invited talks, Ph.D.s awarded, Master's degrees awarded, undergraduate theses completed.

Experiment #02023:

The previous experiment #02023 on the decay of 69Br has led to the first direct measurement of 69Br proton separation energy of $S_p(^{69}Br)$= -785 (+34)(-40) keV. A Ph.D. was awarded to Andrew Rogers for this work. Currently, a proceeding for INPC2010 has been submitted for this work and a PRL is in preparation.

Educational Impact of Proposed Experiment

If the experiment will be part of a thesis project, please include how many years the student has been in school, what other experiments the student has participated in at the NSCL and elsewhere (explicitly identify the experiments done as part of thesis work), and whether the proposed measurement will complete the thesis work.

Safety Information

It is an important goal of the NSCL that users perform their experiments safely, as emphasized in the Director's Safety Statement. Your proposal will be reviewed for safety issues by committees at the NSCL and MSU who will provide reviews to the PAC and to you. If your experiment is approved, a more detailed safety review will be required prior to scheduling and you will need to designate a Safety Representative for your experiment.

SAFETY CONTACT FOR THIS PROPOSAL:

____

HAZARD ASSESSMENTS (CHECK ALL ITEMS THAT MAY APPLY TO YOUR EXPERIMENT):

____X_____ Radioactive sources required for checks or calibrations.
__________ Transport or send radioactive materials to or from the NSCL.
__________ Transport or send— to or from the NSCL—chemicals or materials that may be considered hazardous or toxic.
__________ Generate or dispose of chemicals or materials that may be considered hazardous or toxic.
__________ Mixed Waste (RCRA) will be generated and/or will need disposal.
__________ Flammable compressed gases needed.
__________ High-Voltage equipment (Non-standard equipment with > 30 Volts).
__________ User-supplied pressure or vacuum vessels, gas detectors.
__________ Non-ionizing radiation sources (microwave, class III or IV lasers, etc.).
__________ Biohazardous materials.
__________ Lifting or manipulating heavy equipment (>500 lbs)

PLEASE PROVIDE BRIEF DETAIL ABOUT EACH CHECKED ITEM.

A ^{228}Th source will be required to calibrate the DSSDs of the HIRA telescopes.

Spectrograph Worksheet for S800 Spectrograph or Sweeper Magnet

The NSCL web site contains detailed technical information and service level descriptions about the S800 Spectrograph (Service Level Description) and the Sweeper Magnet (Service Level Description).

1. Timing detectors

Is a plastic timing scintillator required (at the object of the S800 or in front of the sweeper magnet)?

[ ] No
[X] Yes

i. What is the desired thickness? [X] 125 μ m [ ] 1 mm [ ] other_____
ii. What maximum rate is expected on this scintillator? _550000_ Hz

2. Tracking detectors

Tracking detectors for incoming beam are available for Z>10. Performance limitations are to be expected at rates exceeding 200 kHz.

Are tracking detectors needed?

[X] No
[ ] Yes

3. Focal-plane rates

a) What detectors are planned to be used? CRDCs, Ion chamber, E1 scintillator
b) What is the maximum rate expected in the focal-plane detection system? 5000 Hz

4. For S800 experiments only: Optics mode and rigidities:

a) Which optics mode is needed?
   [ ] Dispersion matched [X] focused [ ] Other ___________________________
b) What are the maximum and minimum rigidities planned to be used for the analysis beam line?
   _1.0_ Tm minimum, _2.1_ Tm maximum
c) What are the maximum and minimum rigidity planned to be used for the spectrograph?
   _1.5_ Tm minimum, _2.1_ Tm maximum
d) The maximum particle rate in the focal plane is 6 kHz when the CRDC detectors are being used. What is the maximum total particle rate expected in the S800 focal plane?
   5000_ Hz

Beam Request Worksheet Instructions

Please use a separate worksheet for each distinct beam-on-target requested for the experiment. Do not forget to include any beams needed for calibration or testing. This form does not apply for experiments based in the A1900. Note the following:

(a) **Beam Preparation Time** is the time required by the NSCL for beam development and beam delivery. This time is calculated as per item 5. of the Notes for PAC 35 in the Call for Proposals. This time is not part of the time available for performing the experiment.

(b) **Beam-On-Target Time** is the time that the beam is needed by experimenters for the purpose of performing the experiment, including such activities as experimental device tuning (for both supported and non-supported devices), debugging the experimental setup, calibrations, and test runs.

(c) The experimental device tuning time (XDT) for a supported device is calculated as per item 6. of the Notes for PAC 35 in the Call for Proposals. For a non-supported device, the contact person for the device can help in making the estimate. In general, XDT is needed only once per experiment but there are exceptions, e.g. a change of optics for the S800 will require a new XDT. When in doubt, please consult the appropriate contact person.

(d) A **primary beam** can be delivered as an on-target beam for the experiment either at the full beam energy or at a reduced energy by passing it through a degrader of appropriate thickness. The process of reducing the beam energy using a degrader necessarily reduces the quality of the beam. Please use a separate worksheet for each energy request from a single primary beam.

(e) Report the Beam-On-Target **rate** in units of particles per second per particle-nanoampere (pps/pnA) for secondary beams or in units of particle-nanoampere (pnA) for primary or degraded primary beams.

(f) More information about **momentum correction** and **timing start signal** rate limits are given in the A1900 service level description.

(g) For rare-isotope beam experiments, an electronic copy of the LISE++ files used to estimate the rare-isotope beam intensity must be e-mailed to the A1900 Device Contact.

Beam Request Worksheet

Please use a separate sheet for each distinct beam-on-target requested

	Beam Preparation Time	Beam-On-Target Time

Primary Beam (from beam list)

Isotope 78Kr
Energy 150 MeV/nucleon
Minimum intensity 25 particle-nanoampere

Tuning time (12 hrs; 0 hrs if the beam is already listed in an earlier worksheet): 12 hrs

Beam-On-Target

Isotope 74Kr
Energy 43.3 MeV/nucleon
Rate at A1900 focal plane $1.8x10^4$ pps/pnA (secondary beam) or pnA (primary beam)
Total A1900 momentum acceptance 1 % (e.g. 1%, not ± 0.5%)
Minimum Acceptable purity 84 %

Is a plastic timing scintillator required at the A1900 focal plane for providing a timing start signal?
[ ] No
[X] Yes
What is the desired thickness? [X] 125 μm; [ ] 1000 μm
What is the maximum rate expected for this setting? 550000 Hz (1 MHz max)

Is event-by-event momentum correction from position measured at the A1900 Image 2 position required?
[X] No
[ ] Yes
Which detector should be used? [ ] Scintillator; [ ] PPACs
What is the maximum rate expected for this setting? _________Hz (1 MHz max)

Delivery time per table (or 0 hrs for primary/degraded primary beam): 6 hrs

Tuning time to vault: 3 hrs

Total beam preparation time for this beam: 21 hrs

Experimental device tuning time [see note (c) above]: 8 hrs
S800 [X]; SeGA [ ]; Sweeper [ ]; Other [X] HiRA
On-target time excluding device tuning: 185 hrs

Total on-target time for this beam: 193 hrs

Beam Request Worksheet

Please use a separate sheet for each distinct beam-on-target requested

	Beam Preparation Time	Beam-On-Target Time

Primary Beam (from beam list)

Isotope 78Kr
Energy 150 MeV/nucleon
Minimum intensity 25 particle-nanoampere

Tuning time (12 hrs; 0 hrs if the beam is already listed in an earlier worksheet): [0] hrs

Beam-On-Target

Isotope 1H
Energy 70 MeV/nucleon
Rate at A1900 focal plane 25 pps/pnA (secondary beam) or pnA (primary beam)
Total A1900 momentum acceptance 1.4 % (e.g. 1%, not ± 0.5%)
Minimum Acceptable purity 5 %

Is a plastic timing scintillator required at the A1900 focal plane for providing a timing start signal?

[X] No
[ ] Yes
What is the desired thickness? [ ] 125 μm; [ ] 1000 μm
What is the maximum rate expected for this setting? ________Hz (1 MHz max)

Is event-by-event momentum correction from position measured at the A1900 Image 2 position required?

[X] No
[ ] Yes
Which detector should be used? [ ] Scintillator; [ ] PPACs
What is the maximum rate expected for this setting? ________Hz (1 MHz max)

Delivery time per table (or 0 hrs for primary/degraded primary beam): [2] hrs

Tuning time to vault: [3] hrs

Total beam preparation time for this beam: [5] hrs

Experimental device tuning time [see note (c) above]: [0] hrs
S800 [ ]; SeGA [ ]; Sweeper [ ]; Other [ ]
On-target time excluding device tuning: [8] hrs

Total on-target time for this beam: [8] hrs

Beam Request Worksheet

Please use a separate sheet for each distinct beam-on-target requested

	Beam Preparation Time	Beam-On-Target Time

Primary Beam (from beam list)

Isotope	78Kr	
Energy	150	MeV/nucleon
Minimum intensity	25	particle-nanoampere

Tuning time (12 hrs; 0 hrs if the beam is already listed in an earlier worksheet): [0] hrs

Beam-On-Target

Isotope	1H	
Energy	46	MeV/nucleon
Rate at A1900 focal plane	13	pps/pnA (secondary beam) or pnA (primary beam)
Total A1900 momentum acceptance	1.4	% (e.g. 1%, not ± 0.5%)
Minimum Acceptable purity	5	%

Is a plastic timing scintillator required at the A1900 focal plane for providing a timing start signal?

[X] No

[ ] Yes

What is the desired thickness? [ ] 125 μm; [ ] 1000 μm

What is the maximum rate expected for this setting? ________Hz (1 MHz max)

Is event-by-event momentum correction from position measured at the A1900 Image 2 position required?

[X] No

[ ] Yes

Which detector should be used? [ ] Scintillator; [ ] PPACs

What is the maximum rate expected for this setting? ________Hz (1 MHz max)

Delivery time per table (or 0 hrs for primary/degraded primary beam): [2] hrs

Tuning time to vault: [3] hrs

Total beam preparation time for this beam: [**5**] **hrs**

Experimental device tuning time [see note (c) above]: [0] hrs

S800 [ ]; SeGA [ ]; Sweeper [ ]; Other [ ]

On-target time excluding device tuning: [8] hrs

Total on-target time for this beam: [**8**] **hrs**