National Superconducting Cyclotron Laboratory
Proposal Data Form—PAC 31

TITLE: **Evolution of Neutron hole states in N=50 closed shells**

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

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BACKUP SPOKESPERSON: Kate Jones

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OTHER EXPERIMENTERS: (Please spell out first name and indicate Graduate Students (GS), Undergraduate students (UG) and Postdoctoral Associates (PD))

Last name, First name	Organization	Last name, First name	Organization
Bardayan, Daniel	ORNL	Wallace, Mark	LANL
O'Malley, Patrick	Rutgers (GS)	Hatarik, Robert	Rutgers (PD)
Pain, Steve	Rutgers (PD)	Brian Moazen	University of Tennessee
Andy Chae	University of Tennessee	Alisher Sanetullaev	NSCL
Liang, Felix	ORNL	Dan Shapira	ORNL
Bazin,Daniel	NSCL	Lynch, William	NSCL/MSU
Lee, Jenny	NSCL (GS)	Rogers, Andy	NSCL (GS)
Henzl, Vladimir	NSCL (PD)	Hanzelova, Daniela	NSCL (PD)
Desouza, Romualdo	Indiana	Hudan, Sylvie	Indiana
Famiano, Michael	Western Michigan U	Sobotka, Lee	Washington U
Charity, Robert	Washington U		

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	86Kr	100	10	30	144
Beam 2	86Kr	35	0.1	4	52
Beam 3					
Beam 4					

ADDITITIONAL 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:

Total Hours: 34 | 196

TOTAL TIME REQUEST (HOURS): 230

NSCL PAC 31 – 3. Proposal Data Form

(Calculated as per item 4. of the Notes for PAC 31 in the Call for Proposals)

HOURS APPROVED: ________________ HOURS RESERVED: ____________________

		SET UP TIME (before start of beam)	TAKE DOWN TIME
Access to:	Experimental Vault	_____14___ days	____ 7____ days
	Electronics Set-up Area	______5___ days	_____7____ days
	Data Acquisition Computer	______4___ days	_____7____ days

WHEN WILL YOUR EXPERIMENT BE READY TO RUN? _____9_____ / ____25___ / __2007_

DATES EXCLUDED:

EXPERIMENTAL LOCATION:

___ Transfer Hall (in the A1900)
___ N3 vault (with 92” chamber)
___ N4 vault (Gas stopping line)
___ N4 vault (User line)
___ S1 vault (Irradiation line)
_x_ S3 Vault
___ Transfer Hall (downstream of the A1900)
___ N3 vault (92” chamber removed)
___ N4 vault (Sweeper line)
___ S2 vault

EXPERIMENTAL EQUIPMENT:

_x_ A1900
___ 92" Chamber
___ Modular Neutron Array
_x_ High Resolution Array
___ Beta Counting System
___ Sweeper Magnet
___ Neutron Emission Ratio Observer
___ APEX NaI Array
___ Beta-NMR Apparatus
___ Neutron Walls
___ Segmented Ge Array [ ] classic [ ] mini [ ] beta [ ] delta [ ] plunger [ ] barrel [ ] other
_x_ S800 Spectrograph [x] with [ ] without scattering chamber
___ 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): [ ] NONE

TARGETS:
CH_2, C

LIST ALL RESOURCES THAT YOU REQUEST THE NSCL TO PROVIDE FOR YOUR EXPERIMENT BEYOND THE STANDARD RESOURCES OUTLINED IN ITEM 11. OF THE NOTES FOR PAC 31 IN THE CALL FOR PROPOSALS.

SUMMARY (no more than 200 words):

We propose to measure the ^{84}Se(p,d), ^{86}Kr(p,d) reactions in inverse kinematics at E_{beam}~35 MeV/nucleon using the HiRA array and the S800. These measurements, will show the evolution of the single hole state in the N=50 closed shell region with different proton number. In addition, ^{84}Se(p,d), ^{86}Kr(p,d) will clarify the quenching of the spectroscopic factors observed in N=51 particle states.

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—apparatus (enclose sketch); what is to be measured; feasibility of measurement; count rate estimate (including assumptions); basis of time request (include time for calibration beams, test runs, and beam particle or energy changes); technical assistance or apparatus construction requested from the NSCL.

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

ii. Goals of the proposed experiment

iii. Experimental Details

Physics justification

The properties of low-lying single-particle states in nuclei near the closed shells are key to the reduction of complex many-body physics of nuclei to the much simpler shell model consisting valence nucleons and an inert core. These properties around N=50, 82 and 126 can impact models of nucleosynthesis in explosive scenarios. It is common to tune the nuclear Hamiltonian to the known properties of single-particle or single-hole states in the region. Unfortunately, there is a paucity of knowledge for many of the thousands of nuclei away from stability, particularly on the neutron-rich side where large changes in the shell model are expected.

Direct nuclear reactions provide a tool to understand the details of nuclear shell structure as they probe single-particle states [1,2,3] directly. The study of these orbitals yields information about how the shell structure evolves from stable nuclei to rare isotopes with extreme ratios of protons and neutrons. Aside from understanding the structural properties of these exotic nuclei, the configuration of single particle states governs reaction rates that are important in explosive reaction network calculations in nucleosynthesis of heavy elements. For example, observations of r-process suggest that the familiar shell structure at neutron numbers 50 and 82 is quenched as the standard shell model calculations lead to abundance patterns for the heavy elements with too sharp discontinuities around the magic numbers [4]. Predictions of r-process nucleosynthesis are optimal when nuclei having high level-densities find themselves in an environment where the neutron density is high, such that statistical methods such as Hauser-Reshbach, can be used to calculate neutron-induced reactions. However, close to closed shells at N=50 and 82, the level densities are much lower and the properties of individual states (for direct capture) and resonances need to be included [5]. It is therefore important to elucidate the evolution of the N=50 shell.

Initial measurements of (d,p) reactions on the neutron-rich N=50 isotones ^{82}Ge and ^{84}Se have been performed at HRIBF at ≈ 3.5-4.5 MeV per nucleon beam energies [6]. Together with previous (d,p) measurements on ^{86}Kr, ^{88}Sr , ^{90}Zr, [7,8] the systematics of low energy states for the even Z, N=51 isotones is shown in fig.1. An interesting feature is the trend in the decrease of the spectroscopic factors (SFs) of the neutron-rich ^{83}Ge and ^{85}Se, ^{87}Kr isotopes compared to the spectroscopic factors of ^{89}Sr, ^{91}Zr. Recently, shell model calculations have been performed for these nuclei by David Dean, using an effective two-body interaction derived from the chargedependent version of the Bonn potential [8]. Fig 2 (taken from [8]) shows the comparison of the measured energies and spectroscopic factors with shell model calculations. Generally the trends observed from experiment are reproduced in the calculations, but in the details there are number of significant features which are disparate, namely the energy of the first excited state in ^{83}Ge and ^{87}Kr and the degree of weakening of the spectroscopic factor, most notably in the ground state of ^{85}Se. We see a reduction of the spectroscopic factor values as the nucleus becomes more neutron rich. This observation is just the opposite to the trends established in the knock-out reactions where the quenching of the neutron spectroscopic factors for the light isotopes (A≤57) increase with decreasing neutron separation energy (neutron-richness) [9]. This observation suggests that the fragmentation of the orbital strength for the heavier and more deformed nucleus may be related to the collective effect rather than single particle structure.

N=49	**E(1/2$^-$)**	**SF(gs)**	**SF/IPM**		**N=51**	**E(1/2$^+$)**	**SF(gs)**	**SF/IPM**
81Ge					83Ge		0.50	0.50
83Se	0.228				85Se		0.35	0.35
85Kr	0.304				87Kr	0.532	0.43	0.43
87Sr	0.388	8.15	0.82		89Sr	1.032	0.74	0.74
89Zr	0.588	6.80	0.68		91Zr	1.204	0.71	0.71
91Mo	0.654	7.84	0.78		93Mo	0.943		

Table I Neutron hole spectroscopic factors extracted from literature for the N=49 and neutron particle SF extracted from N=51 isotones with even Z compared to the independent particle model. No neutron SF's have been measured for the neutron rich isotopes of ^{86}Kr, ^{84}Se and ^{82}Ge.

To simplify the discussions on the hole states which have no shell model calculations, we assume theoretical predictions to be that of the independent particle model (IPM) which should be reasonable in the vicinity of good closed shells. For the N=51 isotones, the single valence neutron is in the $g_{9/2}$ orbital and the spectroscopic factor predicted by the IPM model is 1. These values are comparable to the theoretical predictions in Fig. 2. The corresponding neutron hole states in N=50 should experience the same nuclear environment as in the particle states with the same proton numbers. Searching the literature yields the neutron spectroscopic factors for ^{88}Sr , ^{90}Zr and ^{92}Mo. Table 1 lists the energy of the first excited hole state as well as the measured spectroscopic factors for the N=49 (left side) and N=51 (right side) isotones. The valence neutrons are in the $g_{9/2}$ orbital and the IPM predicts spectroscopic factors of 10 for the filled $g_{9/2}$ orbital. The ratios of the spectroscopic factors are about 70% of the IPM values for the ^{88}Sr , ^{90}Zr and ^{92}Mo. Due to lack of data in the more neutron rich nuclei of ^{86}Kr and ^{84}Se, it is not clear how the single hole state evolves with decreasing the proton number or with increasing the neutron richness of the nucleus. Moreover, as shown in Table I, the energy of the first excited hole states for the N=49 isotones is about half of the energy for the corresponding particle states in the N=51 isotones. The proposed measurement would yield information about the role of the collective effect on the evolution of the neutron hole states for the N=50 isotopes with proton number.

Experimental Details

A secondary beam of ^{84}Se will be produced from the fragmentation of a primary beam of ^{86}Kr at 100 MeV/u, on a 300mg/cm^2 thick Be production target, at the entrance to the A1900 separator. Calculations using the LISE++ software indicate that a beam of ^{84}Se at 35 MeV/u with an intensity of 4x10^4 pps is obtainable, employing a 300 mg/cm^2 thick Al wedge degrader at the Image 2 position of the A1900 spectrometer. The experimental setup is shown in Figure 3. The HiRA consists of 20 Silicon-Silicon-CsI(Tl) telescopes, each composed of a 65 μm thick silicon strip detector (E1), a 1.5 mm thick silicon strip detector (E2), and a 4 cm thick CsI(Tl) scintillator (E) read out by a PIN diode. These thicknesses are sufficient to isotopically resolve the deuterons and stop them in the 1.5 mm Si detectors. Energetic particles that punch through both Si detectors will be vetoed by the CsI(Tl) detectors. For this experiment the 20 telescopes will be arranged to cover $6°\leq\theta\leq37°$. Due to the kinematics and forward focusing of the reaction this covers the total solid angle in the center of mass frame. The HiRA measures the energy and angle of the deuteron created in the CH_2 target. Similar setups with 16 telescopes has been used successfully in experiments 02018, 02019 and 02023. We will need tracking of the beam particles in order to obtain good angular information of the emitted deuterons as well as good particle identification in the S800 to identify the heavy residue. Energy resolution of about 100 keV is expected. This is sufficient to resolve the low lying states of ^{83}Se. Due to the low beam rate of ^{84}Se, we request 24 hour of the degraded primary ^{86}Kr beam to shake down the experimental setup including tuning the HiRA detector array. In addition, 24 hours of ^{86}Kr beam is needed to calibrate by measuring the Q-value and the resolution of the experimental set up. The data taken from ^{86}Kr(p,d) reaction will provide the neutron hole state of ^{86}Kr which is part of the physics goal in this experiment. Thus for the ^{86}Kr degraded to 35 MeV/u, we request a total of 24+24=48 hours beam time on target.

In general, all calculations suggest that the nucleon transfer cross-sections are around 1 mb/sr as shown in Figure 4 where the angular distributions of ^{84}Se(p,d)^{83}Se for ground and first excited states are plotted. The calculations were performed with TWOFNR. The valley is about a factor of 10 lower. As we need good statistics of the peak, we aim to get 100 counts in the valley and use this a guide for our count rate estimates. Our beam purity requirement is not very stringent. In contrast to (d,p) reactions, the spectroscopic factors for (p,d) reactions are rather large (~7) for the cases we study, even with a proposed quenching factor of 0.3, the low beam intensity of the ^{84}Se (40,000 pps) is partly compensated by the large SF. We assume 40000 pps of beam particles at the S800 scattering chamber and a spectroscopic factor of 2.4. Two deg in the lab corresponds to about five deg in the center of mass frame. All the calculations show that at 35 MeV per nucleon incident energy, the minima occur within the full acceptance of HiRA, thus we can assume a solid angle of ~100 msr. If we use 2. mg/cm^2 CH_2 target, the calculated count rate is $2x10^{-4}$/sec at the valley of the distributions and 100 counts will require 140 hr of ^{84}Se beam on target. The peak region will have about 10 times statistics. This should allow good extraction of the l value from the angular distributions as well as the spectroscopic factors.

References

[1] A. Bohr and B.R. Mottelson, *Nuclear Structure* (Benjamin, New York, 1975), Vol.I.

[2] G.R. Satchler, *Direct Nuclear Reactions* (Oxford University, Oxford, 1983).

[3] H. Feshbach, *Theoretical Nuclear Physics: Nuclear Reactions* (J. Wiley and Sons, 1992).

[4] C. Freiburghaus et al., Astrophys. J. **516**, 381 (1999).

[5] T. A. Rauscher et al., Nucl. Phys. **A621**, 327c (1997)

[6] J.S. Thomas et al., *Phys. Rev.* **C 71**, 021302R (2005); J.S. Thomas et al., to be published; and J.S. Thomas, Ph.D. dissertation, Rutgers University (unpublished 2005).

[7] K. Haravu, et al., Phys. Rev. C **1**, 938 (1970)

[8] K.L Jones et al., Acta Physica Polonica B (in press).

[9] A. Gade, et al., Phys. Rev. Lett. **93**, 042501 (2004).

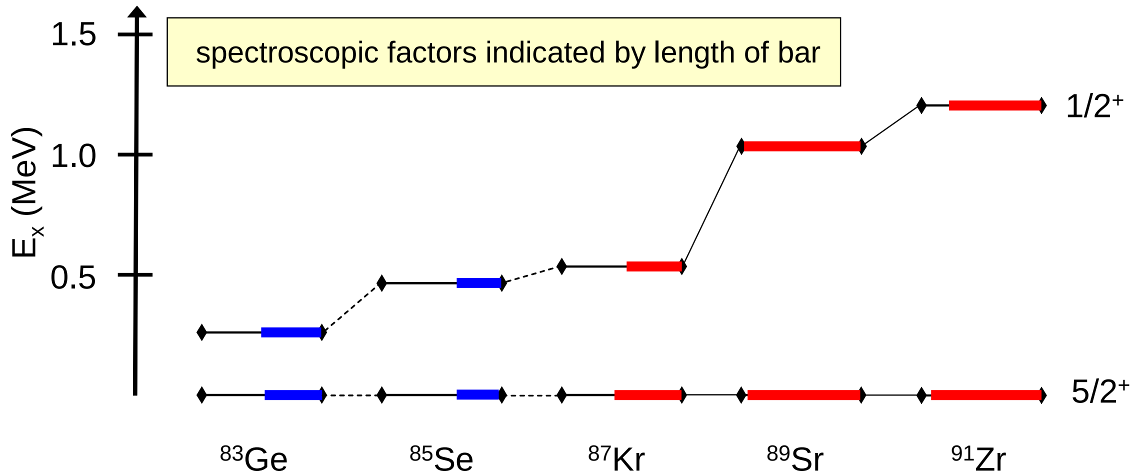

Figure 1 Systematics for the first two states in the even Z, N=51 isotones. Data for ^{83}Ge is from [6], ^{85}Se [6], ^{87}Kr [7], ^{89}Sr [8] and ^{91}Zr [8].

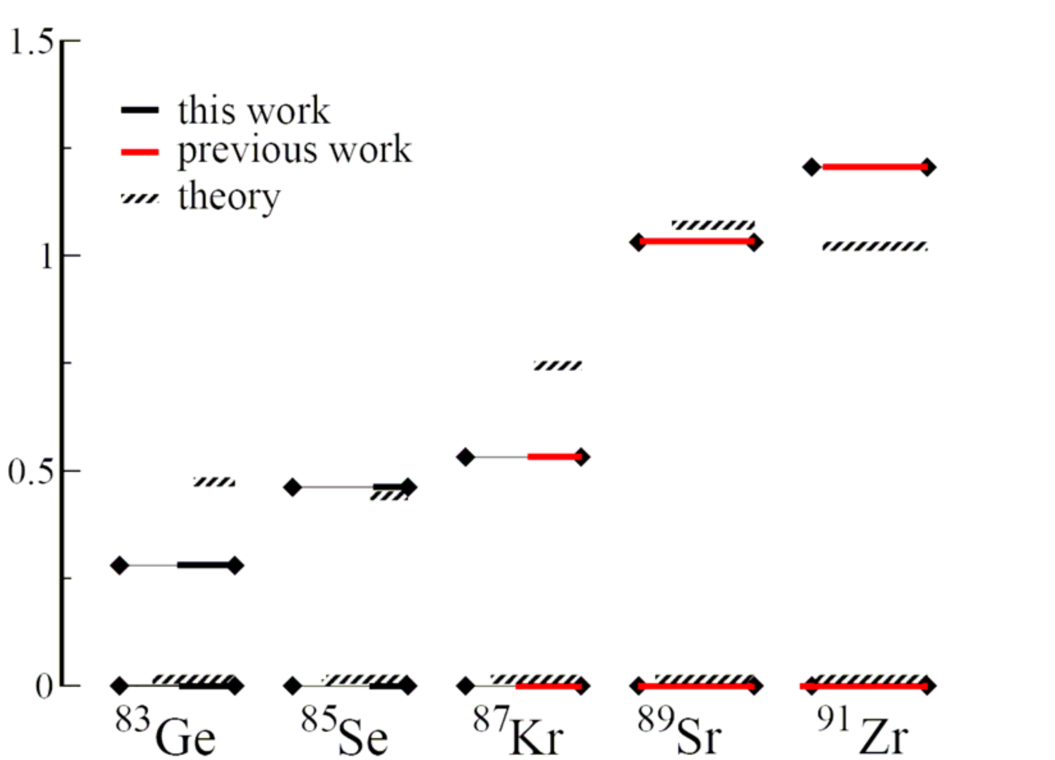

Figure 2. Experimental and theoretical values for the excitation energy of the first excited state and spectroscopic factors for the first two states in the neutron-rich even-Z N=51 systems. The spectroscopic factors are represented by the length of the bars.

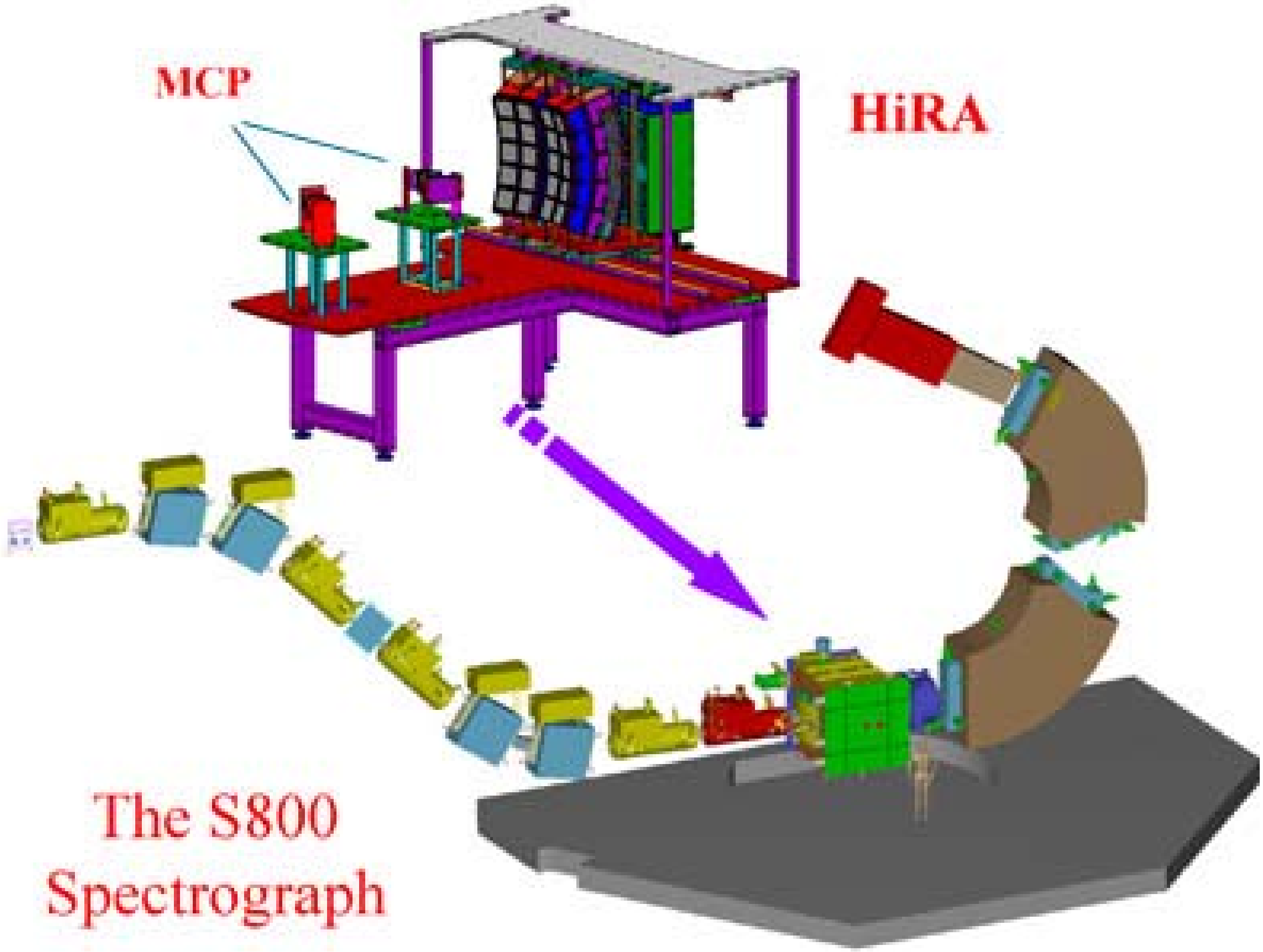

FIGURE 3: Experimental set up. The HiRA array is placed in the S800 chamber. Same setup has been used successfully in NSCL experiments 02023, 02018 and 02019.

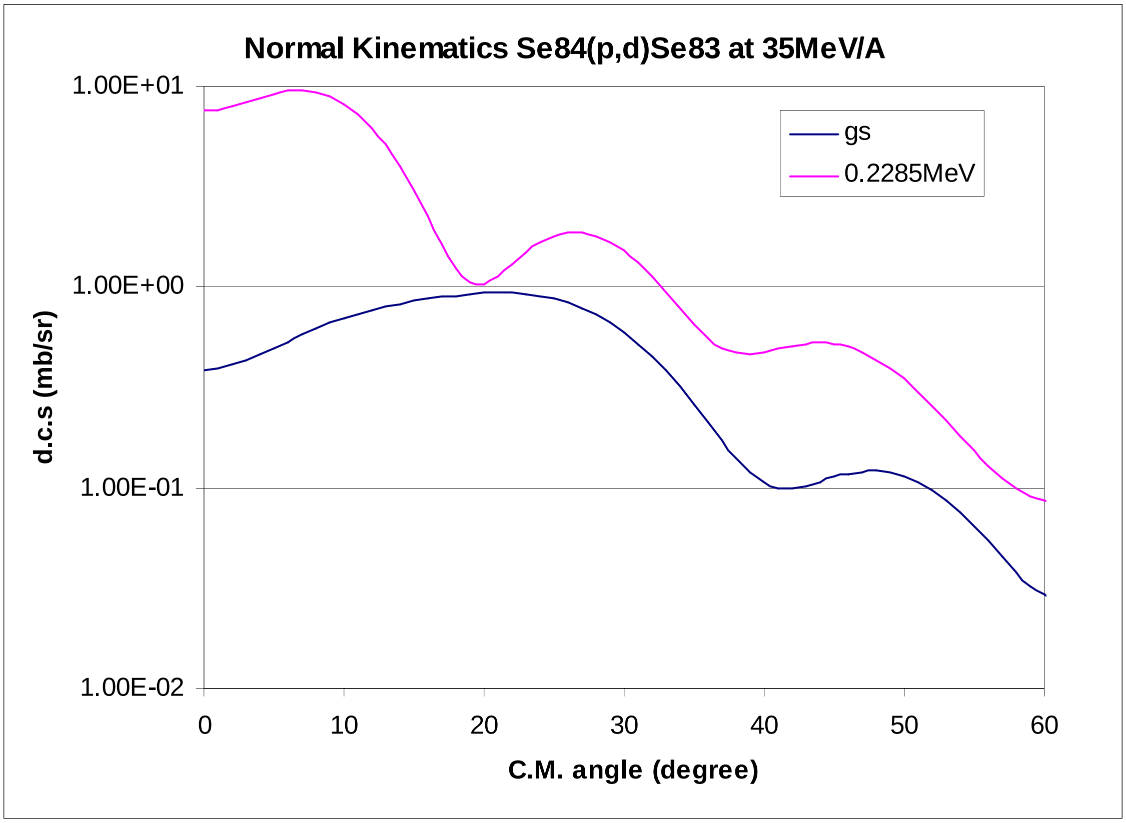

Figure 4 Angular distribution for protons emitted from the 84Se(p,d)83Se reaction in inverse kinematics at E=35 MeV/nucleon for emission from the ground state and the first excited state. The angular coverage of HiRA is 10° - 100° in the center of mass system. The plots are similar for the ground states of 86Kr(p,d)85Kr.

Status of Previous Experiments

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

Experiment 01036, thesis experiment for Michal Mocko, was finished in March 2005. The fragment cross-sections from $^{48,40}Ca$ + Be and Ta, $^{58,64}Ni$ + Be, Ta reactions have been published (Phys. Rev. C 74, 054612 (2006)) and Michal Mocko is currently a postdoc at the Los Alamos National Laboratory. The experimental results have been discussed in many international and national conferences. A second paper on model comparison is being prepared for publication.

Experiment 03031 was run in May, 2005. The data analysis is finished. A paper is under preparation.

The last campaign involving HiRA for Experiment 02018, 02019, 02023 and 05038 were completed at the middle of January, 2006. Calibrations of the HiRA detectors for expt 05038 and 02026 have been finished. The data analysis for 02023, the thesis experiment of Andy Rogers, has started. The data of experiment 02019 is being analyzed by the Washington University group. The HiRA+4pi experiment, 03045 was finished in December last year. It is the thesis experiment for Micha Kilburn and the data are being analyzed by Micha as well as our two postdocs Henzl and Henzlova.

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.

This experiment will form part of the thesis for Alisher Sanetullaev, a second year physics graduate student at MSU and a graduate student from Rutgers.

This project would also actively engage undergraduate, REU students, graduate students and postdocs from NSCL, Rutgers University and the University of Tennessee.

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 review will be required prior to scheduling and you will need to designate a Safety Representative for your experiment.

SAFETY CONTACT FOR THIS PROPOSAL: Betty Tsang

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.

PLEASE PROVIDE BRIEF DETAIL ABOUT EACH CHECKED ITEM.

Alpha Sources (^{228}Th) for HiRA Calibration

Spectrograph Worksheet for S800 Spectrograph and 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 μm [ ] 1 mm [ ] other _____
ii. What maximum rate is expected on this scintillator? _10^6__ 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?

[ ] No
[X] Yes

We'll provide our own tracking detectors consisting of two MCPs

3. Focal-plane rates

a) What detectors are planned to be used? Extended focal plane.
b) What is the maximum rate expected in the focal-plane detection system? _10^6_ 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?
   _3.1__ Tm minimum, __2_ Tm maximum
c) What are the maximum and minimum rigidity planned to be used for the spectrograph?
   _2_ Tm minimum, _2.7_ 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?
   _6 k _ 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 4. of the Notes for PAC 31 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 5. of the Notes for PAC 31 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, please remember to send an electronic copy of the LISE++ files used to obtain intensity estimates.

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	86Kr					
Energy	100	MeV/nucleon				
Minimum intensity	10	particle-nanoampere				
Tuning time (14 hrs; 0 hrs if the beam is already listed in an earlier worksheet):			14	hrs		
Beam-On-Target						
Isotope	84Se					
Energy	35	MeV/nucleon				
Rate at A1900 focal plane	4,000	pps/pnA (secondary beam) or pnA (primary beam)				
Total A1900 momentum acceptance	1	% (e.g. 1%, not ±0.5%)				
Minimum Acceptable purity	50	%				
Additional requirements	[ ]	Event-by-event momentum correction from position in A1900 Image 2 measured with [ ] PPAC [ ] Scintillator				
	[X]	Timing start signal from A1900 extended focal plane				
Delivery time per table (or 0 hrs for primary/degraded primary beam):			12	hrs		
Tuning time to vault:			4	hrs		
Total beam preparation time for this beam:			**30**	**hrs**		
Experimental device tuning time [see note (c) above]: S800 [X] SeGA [ ] Sweeper [ ] Other [ ]					4	hrs
On-target time excluding device tuning:					140	hrs
Total on-target time for this beam:					**144**	**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	86Kr	
Energy	100	MeV/nucleon
Minimum intensity	1	particle-nanoampere

Tuning time (14 hrs; 0 hrs if the beam is already listed in an earlier worksheet): 0 hrs

Beam-On-Target

Isotope	86Kr	
Energy	35	MeV/nucleon
Rate at A1900 focal plane	10^6 pps	pps/pnA (secondary beam) or pnA (primary beam)
Total A1900 momentum acceptance	1	% (e.g. 1%, not ±0.5%)
Minimum Acceptable purity	99	%
Additional requirements	[ ]	Event-by-event momentum correction from position in A1900 Image 2 measured with [ ] PPAC [ ] Scintillator
	[ ]	Timing start signal from A1900 extended focal plane

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

Tuning time to vault: 4 hrs

Total beam preparation time for this beam: **4** **hrs**

Experimental device tuning time [see note (c) above]: 4 hrs
S800 [ ] SeGA [ ] Sweeper [ ] Other [X] HiRA
On-target time excluding device tuning: 48 hrs

Total on-target time for this beam: **52** **hrs**