National Superconducting Cyclotron Laboratory
Proposal Form - PAC 37

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

TITLE: Measurement of Gamow-Teller strength distributions via the (t,3He+gamma) reaction on 45Sc and 46Ti

SPOKESPERSON:	Remco Zegers
ADDRESS:	National Superconducting Cyclotron Laboratory , Michigan State University , 640 S. Shaw Lane, , East Lansing, Michigan 48824-1321
PHONE:	517-908-7473
FAX:	517-353-5967
EMAIL:	zegers@nscl.msu.edu
ORGANIZATION:	NSCL
POSITION:	SR

BACKUP SPOKESPERSON:	Shumpei Noji
ADDRESS:	National Superconducting Cyclotron Laboratory , Michigan State University , 640 S. Shaw Lane, , East Lansing, Michigan 48824-1321
PHONE:	N/A
FAX:	517-353-5967
EMAIL:	nojis@nscl.msu.edu
ORGANIZATION:	NSCL
POSITION:	PD

Other Experimeters:

Name	**Organization**	**Position**
Sam Austin	NSCL	SR
Daniel Bazin	NSCL	SR
Arthur Cole	Kalamazoo College	SR
Justin Browne	NSCL/MSU	GS
George Hitt	KUSTAR	SR
Carol Guess	U. Mass. Lowell	PD
Partha Chowdury	U. Mass. Lowell	SR
Amanda Prinke	NSCL/MSU	GS
Zach Meisel	NSCL/MSU	GS
George Perdikakis	NSCL	SR
Hendrik Schatz	NSCL/MSU	SR
Jared Doster	NSCL/MSU	GS
Alicia Schooley	Kalamazoo College	UG
Alexandra Gade	NSCL/MSU	SR
Rhiannon Meharchand	LANL	PD
Dirk Weisshaar	NSCL	SR

Request for primary beam sequence including tuning, test runs, and in-beam calibrations:

	Isotope	**Energy**	**Minimum Intensity**
Beam 1	16O	150 MeV/Nucleon	175 pnA

Sum of Beam Preparation Times	17 hours
Sum of Beam-On-Target Times	184 hours
Additional CCF Use Time	hours
Total Time	201 hours

EXPERIMENTAL LOCATION: S3 Vault
EXPERIMENTAL EQUIPMENT: A1900
GRETINA
S800 spectrograph without scattering chamber

	Setup Time (Days)	Take Down Time (Days)
Access to Experimental Vault:	2	1
Access to Electronic Setup:	2	2
Access to Data Acquisition Computer:	2	2

Date when experiment will be ready to run: 2012-08-01
Dates excluded: 28 November - 2 December 2012 21-27 October 2012

Detail any modifications needed to the standard configuration of the device used: none
Requirements that are outside the current NSCL operating envelope: none
Reaction targets at the experimental station: 45Sc, 46Ti, CH2, Melamine (all ~10 mg/cm2)
List any breaks required in the schedule of your experiment: none
Non-standard resources: we might need slightly modified target holders compared to the ones originally designed for use with gretina experiments, as the targets are large (rectangular) for use with dispersion-matching optics.
Other special requirements: none

SUMMARY:

We propose measurements of the Gamow-Teller strength distribution in ^{45}Ca and ^{46}Sc via the ^{45}Sc(t,^{3}He+gamma) and ^{46}Ti(t,^{3}He+gamma) reactions at 115 MeV/nucleon. This information is critical for estimating electron capture rates are input for modeling pre-supernova stellar evolution and neutron star crustal heating. Of particular importance for astrophysical applications is the detailed structure of low-lying Gamow-Teller strength. Large uncertainties that exist for both ^{45}Ca and ^{46}Sc in that respect make it difficult to validate theoretical models. Existing experimental information indicate that shell-model calculations that do well for many stable pf-shell nuclei could have significant deficiencies for these lighter cases.

A similar proposal, but without gamma-detection, was previously submitted and accepted under #09073. In the present version, we propose to include the measurement of decay photons from ^{45}Ca and ^{46}Sc in coincidence with the ^{3}He particles from the (t,^{3}He) reaction. By detecting the photons with GRETINA, precise excitation energies can be extracted for transitions to low-lying states. Also, a successful development of the technique will pave the way for the inclusion of g-detection in charge-exchange experiments in inverse kinematics with rare isotopes beams in which the determination of the excitation energy without the gamma-detection is limited to ~1 MeV.

I. Physics Justification

Electron captures (EC) on nuclei in the pf-shell play a crucial role in the late stellar evolution of pre type-Ia and type-II supernova stars and in the crustal heating of neutron stars[LAN03]. Models of these astrophysical phenomena display clear sensitivity to the details of the Gamow-Teller (GT) strength distribution in the daughter nuclei. Such sensitivity became apparent when EC rates based on GT strength distributions produced in the independent particle model[FFN85] were replaced with rates based on large-scale shell-model calculations [BRO88,CAU99,LAN01]. Further contributions were made with Shell Model Monte-Carlo (SMMC+RPA)[DEA98,JUO10] and QRPA[GUP07,MOL90] calculations. Heger *et al*.[HEG01] found that these improved weak rates produced larger electron fractions and changed the entropy profile of pre-collapse Type II supernovae. Hix *et al*.[HIX03] showed that nuclei ranging from the upper sd-shell to the sdg-shell are important and found substantial changes in the formation of the shock wave and in the neutrino luminosity. In a study of burning processes in the crusts of accreting neutron stars, Gupta *et al.*[GUP07] found that accurate estimates for the excitation energy of the lowest EC daughter states are important for describing the heat release by γ-emission in the crust.

β-decay data only provide GT strengths (B(GT)) in a limited Q-value window, if available at all. Therefore, charge-exchange (CE) reactions at intermediate energies have become the preferred way to extract the full B(GT) distribution. The proportionality between GT strength and CE differential cross section at vanishing momentum transfer[TAD87,ZEG07,PER11] allows for model-independent extraction of GT strengths. Due to the large number of nuclei which play a role in stellar evolution, and the significance of transitions from excited states, it is impossible to determine all relevant strengths experimentally. Therefore, data from CE experiments on representative nuclei are critical for validating theoretical approaches. In Fig. 1, an example of such a study is presented for the case of ^{58}Ni[COL06].

In a recently completed study[COL12] of GT strengths and derived EC rates for stable nuclei in the pf shell for which CE data are available from (n,p), (d,^{2}He) and (t,^{3}He) experiments (13 cases, with $45 \leq A \leq 64$), we found that shell-model calculations based on the GXPF1a[HON05] and KB3G[POV01] interactions (calculated with the code NuShellX[RAE10]) do generally well in reproducing experimental GT strengths and derived EC rates (see Fig. 2). Deviations between derived EC rates based on CE data for nuclei for which the excitation energy spectrum at low energies is well-constrained (7 out of the 13 cases studied) and shell-model calculation with the GXPF1a (KB3G) interaction are 31% (47%) and 8% (30%) at stellar densities of 10^7 g/cm^3 and 10^9 g/cm^3, respectively. Possible causes for the slightly better performance of the GXPF1a interaction were recently uncovered on the basis of a ^{56}Ni(p,n) experiment in inverse kinematics[SAS11].

^{45}Sc, for which only low-resolution (n,p) data are available, appears to be an exception (see Fig. 3). Especially at low-excitation energies, where the detailed structure of the GT spectrum is the most critical for estimating accurate EC rates in stellar environments, a large deviation is found between shell-model calculations and the data. Contrarily, shell-model theory and experiment are well-matched for the slightly heavier cases of ^{48}Ti and ^{50,51}V (data from (d,^{2}He) experiments[RAK03,BAU03]). Although no CE data are available for ^{46}Ti, there are concerns about the performance of shell-model calculations for transitions to states at low excitation energies (see below). In addition, ECs on ^{46}Ti were identified as one of the strongest of the shallow heat sources during crustal heating of neutron stars (see Fig. 7 of Ref. [GUP07]) and a measurement of GT strengths would provide direct information on the validity of that prediction.

More generally, uncertainties in the GT strengths from ^{45}Sc and ^{46}Ti raise the question of structural deficiencies in shell-model calculations for the lightest pf-shell nuclei. In early work on ^{44}Ca, it was suggested that mixing between pf and sd configurations is likely for states at low excitation energies[SKO74]. Such mixing is not considered in the shell-model calculations with the GXPF1a and KB3G interactions, but could also impact the GT strengths for nearby ^{45}Sc and ^{46}Ti. Therefore, this proposal is aimed at measuring GT strength distributions from ^{45}Sc and ^{46}Ti, and in particular the details at low excitation energies. Considerations for these cases are summarized next.

^{45}Sc: CE data come from a study of the ^{45}Sc(n,p) reaction[ALF91], which stated a summed GT strength of approximately 0.16 below $E_x(^{45}Ca)$=5 MeV and about 0.5 between 5 and 11 MeV, presumably associated with a single or few states (see Fig. 3). The B(GT) for the g.s. to g.s. transition is known to be $3.9x10^{-3}$ from β-decay measurements[FRE65]. Shell-model calculations using the GXPF1A (KB3G) interaction predict B(GT)=0.014 (0.033) below 5 MeV and B(GT)=0.00023 (0.00019) for the g.s. to g.s. transition, which is much smaller than the experimental values. Above 5 MeV, much better agreement is found (see Fig. 3). The GT distribution from Shell-Model Monte Carlo (SMMC) calculations[DEA98] does about equally well above 5 MeV, but also misses the low-lying strength. QRPA calculations[GUP07,GUP10] predict B(GT)=0.005 for the g.s. to g.s. transition, which is quite close to the experimental value from β-decay. However, these calculations also predict that further GT strength (B(GT)=0.4) is situated just above the ground state, significantly more than seen in the (n,p) experiment. The large differences between the theories and data at low excitation energies result in large differences (nearly 2 orders of magnitude) in derived electron capture rates, as shown in Fig. 4. Unfortunately, possible contaminations in the measured spectrum from reactions on hydrogen in the target may have artificially inflated the low-lying GT strength[ALF91].

^{46}Ti: (n,p)-type charge-exchange data suitable for extracting GT strengths are not available for ^{46}Ti. A 1+ state is reported at 0.991 MeV[BUR08], but it is not clear if this is the lowest-lying 1^+ state. The shell-model calculation with the GXPF1A (KB3G) interaction predicts a 1+ state at 1.78 MeV (1.65 MeV) with a B(GT) of 0.13 (0.045) in ^{46}Sc, and much more strength at energies above 3 MeV. The predicted shell-model B(GT) distributions are shown in see Fig. 5. QRPA calculations[GUP07,GUP10] predict the lowest-lying state at 0.930 MeV (close to the experimentally observed energy) with a B(GT) of 0.34, but the next 1^+ state doesn't appear until 6 MeV.

II. Goals of the proposed experiment

The goals of the experiment are to measure the Gamow-Teller strength distributions in ^{45}Ca and ^{46}Sc via (t,^{3}He+γ) reactions on ^{45}Sc and ^{46}Ti targets. Extracted strength distributions will be compared with shell-model and QRPA calculations, and for the case of ^{45}Sc with the existing (n,p) data. The comparisons will include derived EC rates of astrophysical relevance. The addition of the measurement of γ-decay allows one to much better resolve the location of the relevant final states and to improve the extraction of the GT strength distribution (see details below).

III. Experimental Details

A secondary triton beam of 115 MeV/u will be produced from fragmentation of a primary ^{16}O beam at 150 MeV/u on a Be production target[HIT06]. A 195 mg/cm^2 Al wedge will be used to achieve a beam purity in excess of 99% [GUE09]. The triton beam intensity is expected to be ~10^7 pps at a primary ^{16}O beam intensity of 175 pnA (assuming 55% transmission, although maximally 70% has been achieved), based on our previous experiments. ^{3}He ejectiles will be detected in the focal plane of the S800 spectrometer[BAZ03,YUR99]. Positions and angles measured in the CRDCs are used to reconstruct excitation energies and scattering angles. With proposed target thicknesses of 10 mg/cm^2, the expected energy (angular) resolution is ~250 keV (0.5^o) [HOW08]. Differential cross sections will be extracted between 0^o and 5^o, sufficient to separate GT transitions (ΔL=0) from transitions with ΔL≥1 on the basis of their distinct angular distributions[HIT09,GUE09,HOW08,PER11,COL06]. Besides the measurements on ^{45}Sc and ^{46}Ti, we wish to take calibration data on CH_2 and possibly melamine ($C_3H_6N_6$) targets. Based on our extensive studies of the proportionality between B(GT) and differential cross sections[ZEG07,PER11] we expect a cross section of 9.2 mb/sr per unit B(GT) at 0°. We estimate about 6000 (300) singles ^{3}He events per day for B(GT)=1 (0.05). For $\theta<1^{\circ}$, which is most relevant for the GT transitions, we expect 1200 (60) counts per day for B(GT)=1 (0.05). Based on these count rate estimates, we request 3 days of measurement each on the ^{45}Sc and ^{46}Ti targets. We request an additional day for calibration purposes, including measurements with CH_2 and Melamine ($C_3H_6N_6$).

The measurement of decay photons using GRETINA (see fig. 6 for experimental layout) will allow for very detailed spectroscopy as one can gate on a specific excitation energy in the (t,^{3}He) spectrum and study the γ-decay spectrum without ambiguities related to feeding from higher lying states. Since the threshold for decay by particle emission is 7.4 MeV (8.2 MeV) for ^{45}Ca (^{46}Sc) γ-decays can be studied over the full GT region. For example, consider the excitation of the 0.991 MeV 1^+ state in ^{46}Sc via ^{46}Ti(t,^{3}He). With the (t,^{3}He) data only, one obtains a resolution of ~250 keV, and the uncertainty in the extracted GT strength would likely be dominated by the uncertainties in the multipole decompositions analysis since several other states with different J^{π} reside nearby. Since the 0.991 MeV 1^+ state has a branching of 100% for γ-decay of 547 keV, that signature can be used to additionally constrain the extraction of the strength. If the location of a specific low-lying state is not already known from available data, the measurement of coincident γ-rays would lead to a much more accurate determination of the excitation energy than possible from the singles charge-exchange data. The advantage of using GRETINA over other gamma detectors is the high peak-to-total ratio (P/T>0.4 for $E_{\gamma}<2$ MeV, more than a factor of 2 better than achieved for SeGA), in combination with the excellent resolution. The γ-ray photo-peak detection efficiency (see Fig. 7) is better than that of SeGA in the compact Barrel configuration; for $E_{\gamma}=1$ MeV, the efficiency is nearly 11% (compared to 7% for Barrel SeGA), and 600 (30) (t,^{3}He+γ) coincidences are expected for a transition with B(GT)=1 (0.05).

Very few intermediate-energy CE experiments have been performed in which γ-rays were also detected with high-resolution. However, particularly for CE experiments performed in inverse kinematics with RI beams, where the excitation-energy resolution achievable from two-body kinematics is limited to ~1 MeV (see e.g. the case of ^{56}Ni(p,n)[SAS11]) the improvement in accurately pinpointing the location of low-lying final states by measurement of the decay γ-rays is very significant. By developing the technique in forward kinematics, as is proposed here, one can foresee performing (p,nγ) experiments in inverse kinematics.

References

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IV. Figures

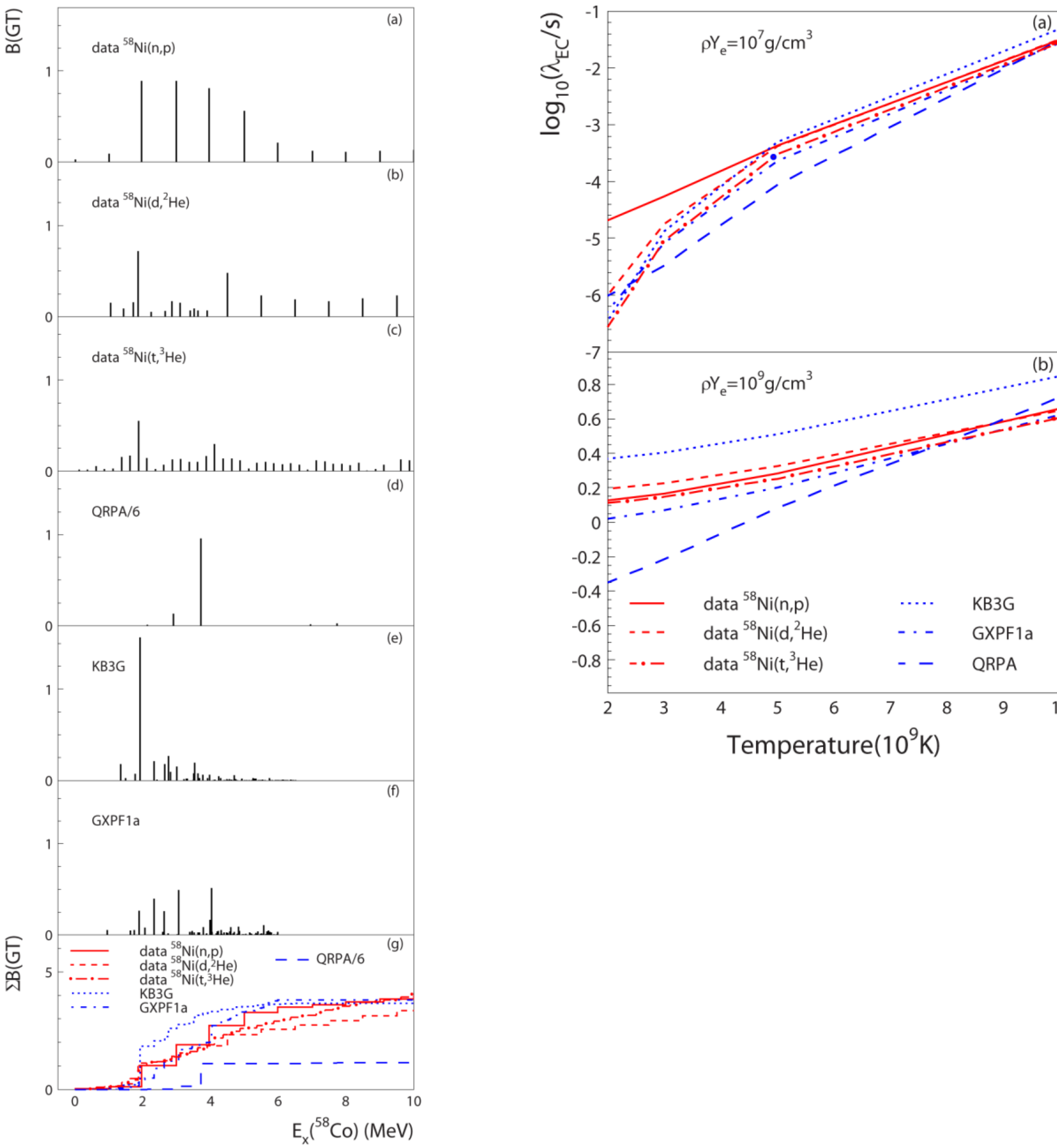

Figure 1 Left: Example of a comparison between experimental and theoretically predicted GT strength distributions for the case of ^{58}Ni. Data are available from a) (n,p), b) (d,^{2}He) and c) (t,^{3}He) experiments (GT strengths are plotted in the center of excitation-energy bins). Shell-model calculations (using the GXPF1a (f) and KB3G interactions (e)) and QRPA calculations (d) are used for comparison. For display purposes, the latter have been divided by a factor of 6. **Right:** Electron-capture rate on ^{58}Ni, plotted as a function of stellar temperature, at an electron density of a) 10^7 g/cm^3 and b) 10^9 g/cm^3. Rates are based on GT strengths displayed in the r.h.s. figure. Plots were taken from Ref. [COL12].

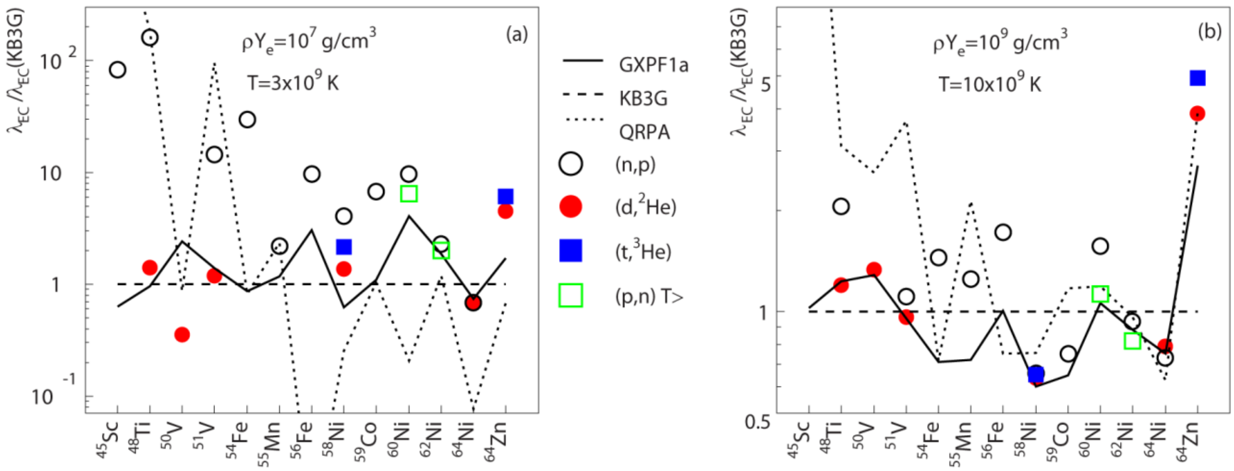

Figure 2. Comparison between electron-capture rates calculated based on Gamow-Teller strengths deduced from experiments and theory, as labeled in the figure. The comparisons are shown for two density-temperature combinations: (a) 10^7 g/cm^3 and 3×10^9 K and (b) 10^9 g/cm^3 and 10^{10} K. Rates are plotted relative to those calculated based on the shell-model calculation with the KB3G interaction. Since the excitation-energy resolution achieved in (n,p) data are relatively poor, some Gamow-Teller strengths are placed at artificially low excitation energies, which results in an unphysical inflation of the electron capture rates. Rates based on high-resolution data [(d,^{2}He), (t,^{3}He) and (p,n) data (T> states)] are quite well reproduced by rates estimated on the basis of shell-model calculations using the KB3G and GXPF1a interactions. The rates based on Gamow-Teller strengths calculated in QRPA generally provide poor estimates. Figure was taken from Ref. [COL12]

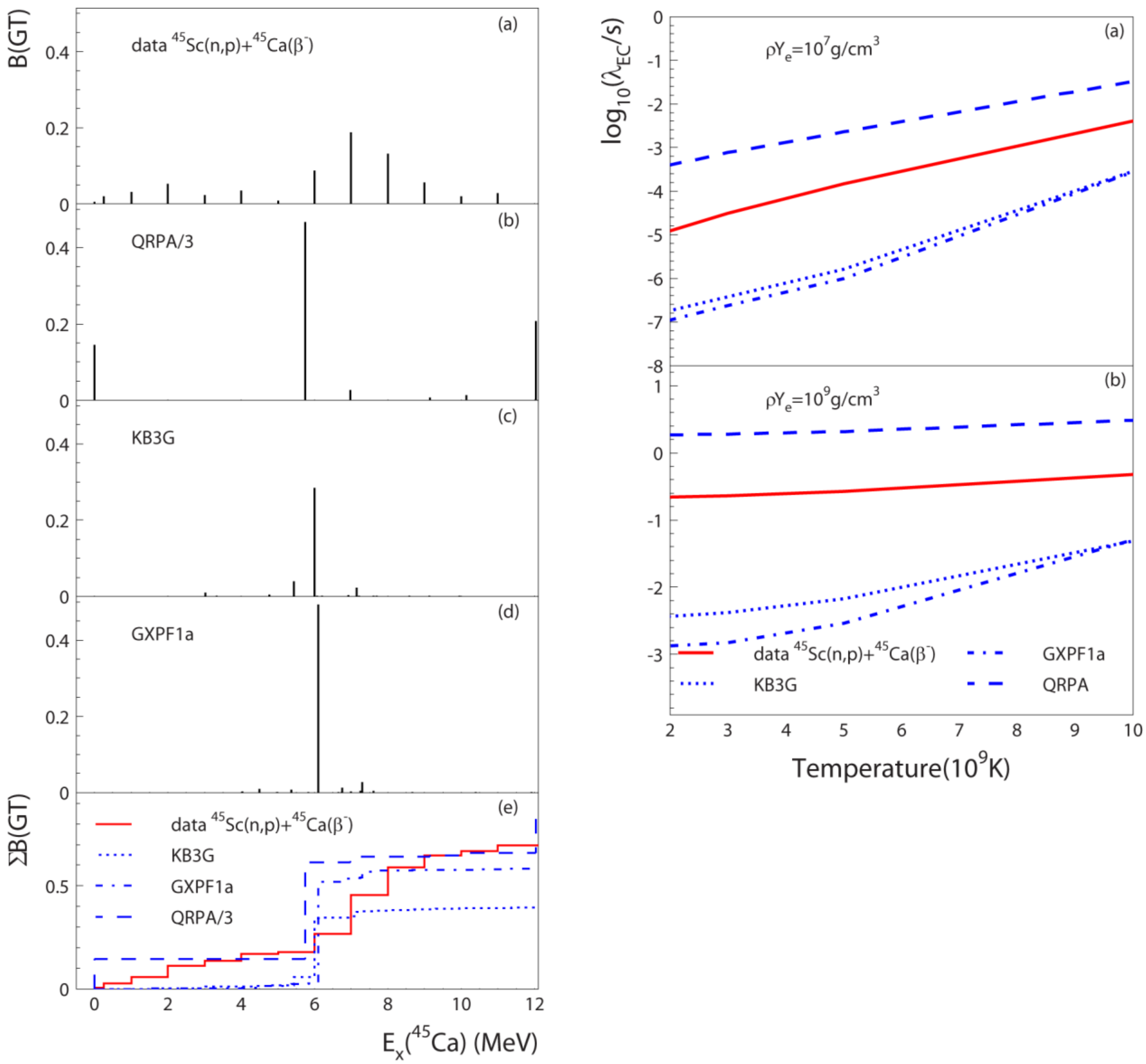

Figure 4. Left: Experimental results from the ^{45}Sc(n,p)^{45}Ca experiment are compared with shell-model calculation using the GXPF1A and KB3G interactions. While the calculations predict the strong state near 7 MeV rather well, the low-lying strength seen in the data is not predicted in the theory. Strengths calculated in QRPA are also shown (divided by a factor of 3 for display purposes only), but strongly over predict the experimental strengths. Panel e) shows cumulative strengths.
Right: Electron-capture rates on ^{45}Sc, plotted as a function of stellar temperature, at densities of (a) 10^7 g/cm^3 and (b) 10^9 g/cm^3. Rates based on GT strengths from the (n,p) data, shell-model calculations with the GXPF1A and KB3G interactions, and QRPA calculations are shown. Because the shell-model calculations underestimate the low-lying strength, their rates are too low by roughly a factor of 100. In contrast, the QRPA calculations, which have too much strength at low excitation energies, yield electron capture rates that are much higher than those based on the (n,p) data. Figures were taken from [COL12].

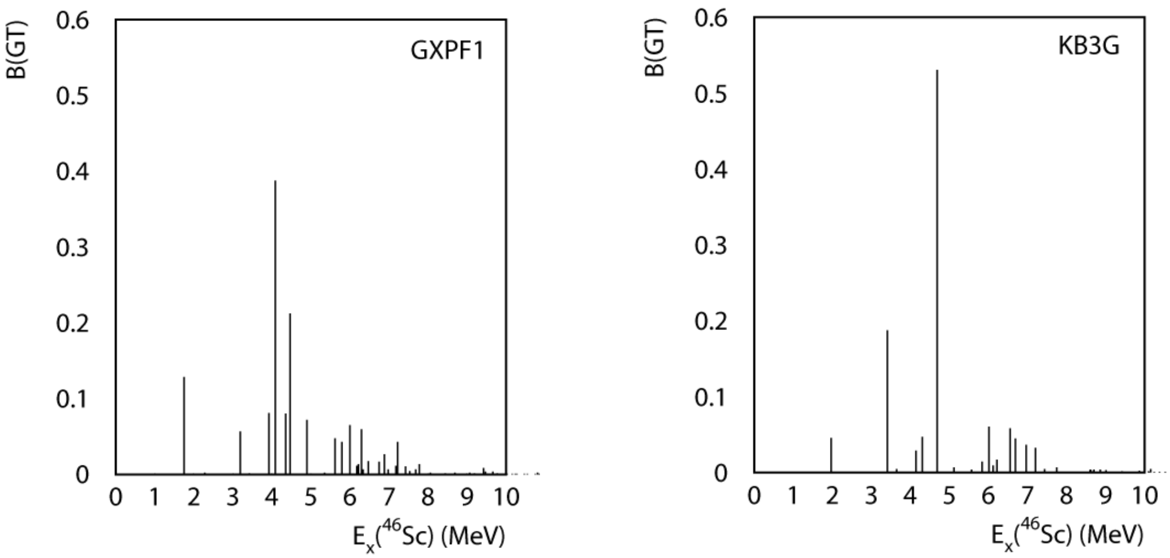

Figure 5. Shell model calculations (unquenched) using the GXPF1a (left) and KB3G (right) interactions for the GT strength distribution in ^{46}Sc populated from the ^{46}Ti ground state. Both calculations predict the first 1^+ state just below 2 MeV. However, a 1^+ state is known to reside at 0.997 MeV, which is missed by the calculations. Based on the available data, it is possible that other 1^+ states may exist below 2 MeV.

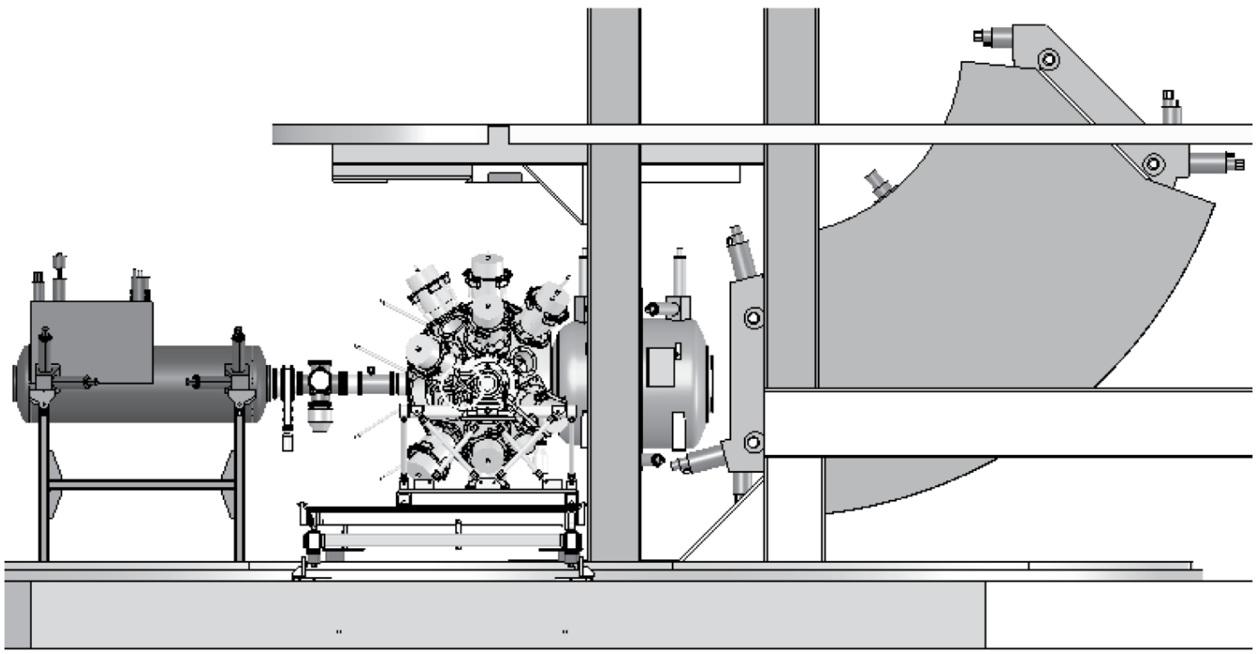

Figure 6. Design layout of Gretina at the S800 spectrometer. For the current proposal, the angular placement of the individual Gretina detectors is more or less arbitrary, since on average the γ-decay will be isotropic. Unreacted tritons are stopped in the first dipole magnet of the S800. In a previous (t,^{3}He) experiment, the neutron yields near the target were measured and found to be insignificant, and certainly far below the yields that could damage the Gretina detectors.

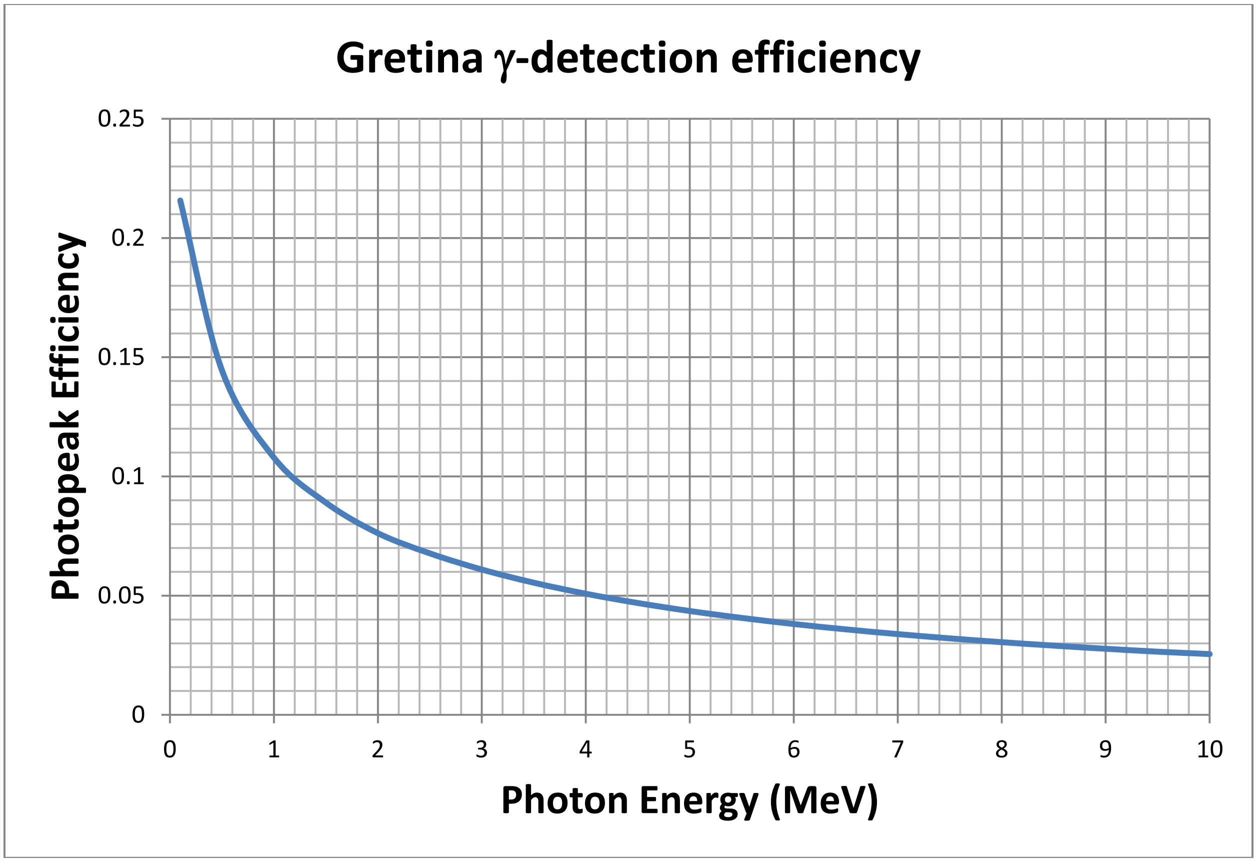

Figure 7. Estimated photo-peak efficiency of Gretina as a function of γ-ray energy, calculated using the online simulation tool for Gretina[GRE12] . The photopeak efficiency (~11% at 1 MeV) is significantly better than for Barrel SeGA (~7% at 1 MeV).

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.

Overview of NSCL experiments by the charge-exchange group (completed and accepted)

- (t,^{3}He) experiments
  - 96031: ^{26}Mg(t,^{3}He) and ^{58}Ni(t,^{3}He) – nuclear structure and astrophysics/weak reaction rates
    - Completed & published 2 papers.
  - 03017: Development of a secondary triton beam from ^{16}O.
    - completed & published
  - 03018: ^{24}Mg(t,^{3}He) reaction – nuclear structure, proof of principle experiment
    - completed, published (thesis M. Howard)
  - 03500: Test experiment for momentum compression of the triton beam
    - completed
  - 05504: ^{64}Zn(t,^{3}He) reaction – astrophysics/weak reaction rates
    - completed & published (thesis of G.W. Hitt)
  - 06032: ^{13}C(t,^{3}He) and ^{150}Sm(t,^{3}He) – nuclear structure and double beta decay.
    - completed, ^{13}C(t,^{3}He) data published, ^{150}Sm(t,^{3}He) data published (thesis of C. Guess).
  - 09073: ^{45}Sc, ^{46}Ti(t,^{3}He) – nuclear structure and astrophysics/weak rates
    - Experiment accepted by NSCL PAC
  - As part of 09053: ^{19}F(t,^{3}He) – nuclear structure and astrophysics – under analysis (thesis of Amanda Prinke)
- (^{7}Li,^{7}Be) experiments in inverse kinematics
  - 01038: ^{56}Ni(^{7}Li,^{7}Be) experiment in inverse kinematics (spokesperson B. Sherrill)
    - Analysis stopped (was project of Arthur Cole)
  - 05027: ^{34}Si(^{7}Li,^{7}Be) experiment in inverse kinematics
    - Completed and Published
  - 08017: ^{12}B(^{7}Li,^{7}Be) experiment in inverse kinematics
    - Completed (thesis of Rhiannon Meharchand) and published.
- (p,n) reaction in inverse kinematics
  - 09014: Gamow-Teller Transitions from ^{56}Ni
    - Experiment completed, 1 paper published, another in preparation.
  - 10003: Study of the giant resonances in ^{16}N
    - Accepted
- 11021: Search for the Isovector Giant Monopole Resonance via the ^{28}Si(^{10}Be,^{10}B+γ) reaction at 100 MeV/u.
    - Accepted Proposal by NSCL PAC (thesis work of Michael Scott)

Papers Published based on NSCL experiments by the Charge-Exchange group.

- Probing configuration mixing in ^{12}Be with Gamow-Teller transition strengths, R. Meharchand, R.G.T. Zegers, B.A. Brown, Sam M. Austin, T. Baugher, D. Bazin, J. Deaven, A. Gade, G.F. Grinyer, C.J. Guess, M.E. Howard, H. Iwasaki, S. McDaniel, K. Meierbachtol, G. Perdikakis, J. Pereira, A.M. Prinke, A. Ratkiewicz, A. Signoracci, S. Stroberg, L. Valdez, P. Voss, K.A. Walsh, D. Weisshaar, and R. Winkler, Phys. Rev. Lett. 108, 122501 (2012).
- Gamow-Teller Transition Strengths from ^{56}Ni, M. Sasano, G. Perdikakis, R. G. T. Zegers, Sam M. Austin, D. Bazin, B. A. Brown, C. Caesar, A. L. Cole, J. M. Deaven, N. Ferrante, C. J. Guess, G. W.

Hitt, R. Meharchand, F. Montes, J. Palardy, A. Prinke, L. A. Riley, H. Sakai, M. Scott, A. Stolz, L. Valdez, and K. Yako, Phys. Rev. Lett. 107, 202501 (2011) (Editors' suggestion).
Related publications:

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- Study of Gamow-Teller transition strengths from 56Ni and 55Co via the (p, n) reaction at 110 and 106 MeV/u with rare isotope beams, M. Sasano, G. Perdikakis, R. G. T. Zegers, Sam M. Austin, D. Bazin, B. A. Brown, C. Caesar, A. L. Cole, J. M. Deaven, N. Ferrante, C. J. Guess, G. W. Hitt, R. Meharchand, F. Montes, J. Palardy, A. Prinke, L. A. Riley, H. Sakai, M. Scott, A. Stolz, L. Valdez, and K. Yako, in preparation for submission to Phys. Rev. C
- Gamow-Teller transitions in the A = 40 isoquintent, M. Karakoc, B. A. Brown, Y. Fujita, and R.G.T. Zegers, in preparation for Phys. Rev. C.
- Determination of Gamow-Teller strength distributions and electron-capture rates for pf-shell nuclei in pre-supernova stars, A.L. Cole, T.S. Anderson, Sam Austin, B.A. Brown, O. Fawwaz , S. Gupta, G.W. Hitt, L. Valdez and R.G.T. Zegers, http://arxiv.org/abs/1204.1994v1, and submitted to Physical Review C.

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.

Shumpei Noji (postdoctoral researcher) will be the primary person responsible for the analysis of the data of the proposed experiment. He will work closely with Michael Scott (GS), who will take the lead experiment #11021 with Gretina. Both are expected to be heavily involved in the setup of Gretina in the S3 vault and in developing analysis tools.

Other graduate students in the charge-exchange group will play an active role in the preparation and running of the experiments. As in previous experiments by the charge-exchange group, junior graduate students are also involved in the analysis to gain experience.

NSCL PAC 37 – Safety Information

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: __Remco Zegers__________________________

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.

STANDARD GAMMA-RAY SOURCES FOR CALIBRATING THE GRETINA ARRAY WILL BE USED.

NSCL PAC 37– Spectrograph Worksheet

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

a) 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? [ ] 125 μm [x] 1 mm [ ] other _____
ii. What maximum rate is expected on this scintillator? 10^7 Hz

*** scintillator is only needed for measuring triton beam intensities and is not used in regular runs.**

b) Do you plan to use a different type of timing detector (at the object of the S800 or in front of the sweeper magnet)?

[x] No
[ ] Yes

If "Yes," please give details.

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, scintillator (thick))
b) What is the maximum rate expected in the focal-plane detection system? 100 Hz

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

a) Which optics mode is needed?
[x] Dispersion matched [ ] focused [ ] Other _________________________
b) What are the maximum and minimum rigidities planned to be used for the analysis beam line?
_3.5__ Tm minimum, _4.8__ Tm maximum
c) What are the maximum and minimum rigidity planned to be used for the spectrograph?
_2.1_ Tm minimum, _2.5_ 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?
__100_ Hz

NSCL PAC 37– Beam Request Worksheet

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 37 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 37 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.

NSCL PAC 37– Beam Request Worksheet

Beam Request Worksheet 1 of 1.

(Please number the sheets and use a separate sheet for each distinct beam-on-target requested.)

	Beam Preparation Time		Beam-On-Target Time
Primary Beam (from beam list)			
Isotope: 16O			
Energy: 150 MeV/nucleon			
Minimum intensity: 175 particle-nanoampere (pnA)			
Tuning time (12 hrs; 0 hrs if the beam is already listed in an earlier worksheet):	12	hrs	2

Beam-On-Target

Isotope: 3H

Energy: 115 MeV/nucleon

Rate at A1900 focal plane: 10^5 pps/pnA (secondary beam) or pnA (primary beam)

Total A1900 momentum acceptance: 0.5% % (e.g. 1%, not ±0.5%)

Purity at A1900 focal plane: 99 %

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)

	Beam Preparation Time		Beam-On-Target Time	
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:	**17**	**hrs**		
Experimental device tuning time [see note (c) above]: S800 [x]; SeGA [ ]; Sweeper [ ]; Other [x] Gretina – 2 hrs			14	hrs
On-target time excluding device tuning:			168	hrs
Total on-target time for this beam:			**184**	**hrs**