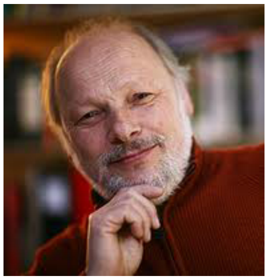
Spring 2013

Joint Institute for Nuclear Astrophysics
An NSF Physics Frontier Center



From the Director, Michael Wiescher

In this Spring issue of the newsletter, we reflect on the past, present, and future status of JINA, and the field of Nuclear Astrophysics at large. What are our roots? What is our status? What lies ahead for us in the future? As we near the end of the current JINA grant, we must examine our past to determine where to focus our efforts in the proposal for our future endeavors. As researchers, we have made great strides in astronomical observations, simulations, theoretical models, and experimental techiniques in nuclear physics. As a scientific community, we have forged strong collaborations across field boundaries and created an inclusive environment for young researchers to grow within. As a collective member of society, we have created an outreach program that serves a variety of populations and enables the sustainability of our field. We have come a long way in the last decade, but there is still more work to do.

In This Issue

WWW.JINAWEB.ORG

Providing an intellectual center with the goal of enabling swift communication and stimulating collaborations across field boundaries, while at the same time providing a focus point in a rapidly growing and diversifying field

Where are They Now?

Charge Exchange Group 2009

led by Remco Zegers

Christoph Caesar – Postdoc at Technische Universität Darmstadt

Arthur Cole – Assistant Professor of Physics at Kalamazoo College

George Hitt – Assistant Professor of Physics at Khalifa University

George Perdikakis – Assistant Professor of Physics at Central Michigan University

Rhiannon Meharchand – Director's Postdoc Fellow, Los Alamos National Laboratory (Read more on pg 6)

Shawna Valdez – Physics Teachers at Orange High School, Orange NJ

Carol Guess – Postdoctoral Researcher and Adjunct Professor at University of Massachusetts Lowell (Read more on pg 6)

Upcoming Events

May 30-31, 2013
NSF Site Visit at the University of Notre Dame.

June 24-28, 2013
20 High school students will particpate in PAN at Notre Dame.

July 8-12, 2013
JINA will co-sponsor a Mad Scientist Camp at St. Patrick's Park in South Bend, IN.

July 15-19, 2013
120 students ages 8-13 will participate in the 3rd annual Art 2 Science Camp at Notre Dame.

July 15-27, 2013
Middle school students will learn nuclear astrophysics from JINA scientists during the Math, Science and Technology Camp at MSU.

July 22-26, 2013
A JINA supported meeting "The Third International Symposium on Nuclear Symmetry Energy (NuSYM13)" will be organized at NSCL/FRIB, East Lansing, MI.

July 29- Aug 9, 2013
The 20th annual PAN will host 20 teachers and 24 students from across the nation at MSU.

October 7-11, 2013
The ECT*-JINA Workshop "Reactions Involving 12C: Nucleosynthesis and Stellar Evolution" will be held at the ECT*, Trento, Italy.

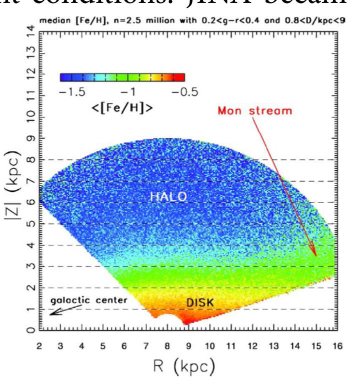
The JINA Vision: An Evolution

by Michael Wiescher

The Joint Institute for Nuclear Astrophysics (JINA) emerged from a collaboration between the University of Notre Dame, Michigan State University, and the University of Chicago with the goal of developing a coherent experimental and theoretical program addressing critical questions in the field of nuclear astrophysics. The collaboration successfully received funding in 2003 through the NSF's Physics Frontier Program (PFC). The goal of JINA is to form a strong community of experimental and theoretical scientists to address the complex interface between nuclear physics as the driving source of astrophysical phenomena and their observational signatures. In that spirit JINA envisions close collaboration between experimentalists and theorists to establish and simulate the nuclear physics data and predict and observe their consequences on stellar environments and phenomena through close communication and joined projects with the astronomy community. To develop this vision JINA established an ambitious conference and workshop program to identify the critical research directions and establish milestones for research accomplishments. These conferences also served as community forum for establishing communication and collaboration bands between JINA groups and the broader nuclear physics and astrophysics communities. A special school program was developed for students and postdocs to provide training in specific experimental or theoretical techniques or methods. These schools served also to establish a strong JINA community feeling between the attending young researchers and led to the formation of new projects and collaborations. JINA Frontier meetings, organized by students and postdocs, helped further strengthening the collaborative spirit in the JINA community. The student education and training program was complemented by an intense outreach effort from K-12 using age appropriate techniques and methods to trigger interest and motivation for scientific thought, ideas, and enterprise.

JINA established a scientific program focusing on critical questions as the origins of the element, nuclear physics phenomena in core collapse supernovae, and the thermonuclear explosions driving X-ray bursts. In this framework experimental collaborations emerged developing new experimental techniques and equipment to expand on the measurement of critical nuclear masses and nuclear reaction rates in stars with stable and radioactive beams of relevance for long-lived quiescent stellar burning scenarios and short-lived explosive burning environments. New theoretical models were developed to describe the reaction flux and transcribe the impact on the stellar environment; this was complemented by the theoretical astrophysics community providing stellar hydrodynamic models to establish temperature density trajectories for the nucleosynthesis models.

The experimental results established by the JINA research during its first funding period indicated that our understanding of stellar nucleosynthesis was far from complete, large uncertainties governed the reactions of relevance for stellar burning that dictated the seed and fuel conditions for subsequent nucleosysnthesis scenarios e.g. in core collapse supernovae. New models for core-collapse supernova were developed and long-lived radioisotopes such as 44Ti, and 60Fe were identified as characteristic signatures for supernova shockfront conditions. JINA became partner in the SDSS-II survey and took responsibility for the SEGUE survey of metal poor stars to establish a statistically broad data base on stellar abundances for mapping the nucleosynthesis history of our universe. The theoretical for-



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Up and Coming Future JINA Researcher

Name: Michael Tripepi

Age: 18

Hometown: Granger, IN

Grade: 12

Favorite Food: Pizza

College Choice: Michael has chosen to attend Hillsdale because of the small size and familiarity with professors. He is looking forward to studying under MSU alumn, Paul Hosmer.

Planned Major: Physics and Mathematics

Q: Which JINA programs have you experienced?

A: Sensing Our World (SOW) two summers, PIXE-PAN at University of Notre Dame, PAN at Michigan State University, and volunteered for JINA Outreach activities

Q: How did those experiences shape your career goals?

A: I would say they gave me the chance to experience what it's like working in a laboratory. Not as much in SOW, but definitely in PIXE-PAN and PAN where I could work with professors and start to do experiments. It solidified my love of science.

Q: When did you know you loved science?

A: Probably since Kindergarten and that was because I was obsessed with space. If it had space on it or NASA on it, I was all over it. It started because I liked the pictures from space, especially nebulas and grew into liking all science.

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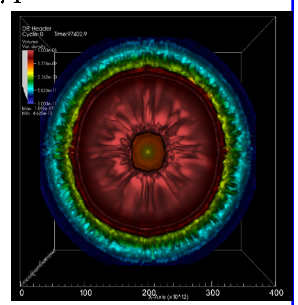
Abstracts from JINA Scientists April APS Meeting

The Most Powerful Stellar Explosions

Ke-Jung Chen – University of Minnesota

We present the results from our 3D simulations of thermonuclear supernovae from the stars with initial masses above 80 solar masses by using CASTRO, a new, massively parallel, multidimensional Eulerian, adaptive mesh refinement (AMR), radiation-hydrodynamics code. We first use Kepler, a one-dimensional spherically-symmetric Lagrangian code to model the possible explosions beyond hypernovae. These extreme explosions include two types of electron/positron production instability supernovae and one type of general relativity instability supernovae. The resulting 1D presupernova profiles are mapped onto 3D grids of CASTRO as initial conditions. We simulate the explosion in 3D and resolve the emergent fluid instabilities. In this talk, we will discuss the energetics, nucleosynthesis, and possible observational signatures of these supernovae.



Double-β decay nuclear structure via electron capture on ^{116}In

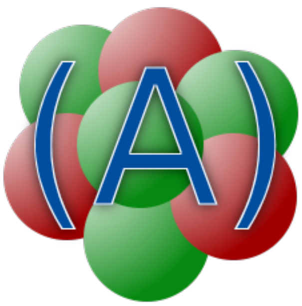
Chris Wrede – NSCL/MSU

The small electron-capture decay branch of ^{116}In has been measured using Penning trap assisted decay spectroscopy. The deduced Gamow-Teller transition strength helps to resolve longstanding differences between scattered charge-exchange reaction values and a previous electron-capture decay value that was less statistically significant than the present one. We argue that this transition can now be used as a reliable benchmark for nuclear-structure calculations of the matrix element for the neutrinoless double-β decay of ^{116}Cd and other nuclides.

Vision (continued from page 3)

mulation of X-ray bursts as thermonuclear runaway on the surface of an accreting n neutron star was expanded, the major nucleosynthesis processes and their most likely reaction path was identified and the final abundance distribution in the ashes of the thermonuclear explosion was established.

These results provided the base for the science program of JINA after the successful renewal for a second funding period. The program on the origin of the elements was re-organized merging the two main sources for the formation of the elements, stars and supernovae, into a single major activity with the research focusing primarily on the development of new experimental techniques and facilities to provide intense stable and radioactive beams for simulating and interpreting critical nuclear reactions and reaction mechanisms. The experimental effort was complemented by the development of the next generation of phenomenological reaction codes based on R-matrix and Hauser Feshbach statistical model techniques, taking into account broad experimental data sets. Parallel to that new theoretical methods were devised in close collaboration between nuclear physicists and astrophysicists to analyze in statistical relevant matter the sensitivity of stellar nucleosynthesis mechanisms to specific nuclear reaction and structure effects. This was complemented by support for the development of NuGRID, which allows stellar evolution simulations for broad star distributions to translate the nuclear reaction data into stellar abundance observables. JINA also started a program to develop a new generation of chemical evolution models capable of integrating the JINA results on individual sources of nucleosynthesis and validating our understanding through comparison with the broad range of JINA observational abundance data in metal poor stars.



A second major activity concentrated on cataclysmic white dwarf binary systems such as novae and type Ia supernovae. A major goal was to explore the ignition

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Up and Coming Future JINA Researcher

Name: Rachel Polus

Age: 16

Hometown: Portage, MI

Grade: 11

Favorite Food: Mac & Cheese

Preferred College: University of Chicago

Planned Major: Physics

Q: Why physics?

A: I really like math, but I like physics since it's a practical application of math.

Q: Which JINA Programs have you experienced?

A: MST at MSU, PAN at MSU, PAN at ND

Q: Which did you like the best?

A: I don't remember MST that well, but I think I liked PAN at ND the best because there was a lot of experimentation.

Q: How did the experiences benefit you?

A: This is my first year taking physics at school and I already understand a lot of it. In the long term, I'm more interested and engaged with the research community on the whole. And I'm less afraid to do things by myself, and don't need the affirmation of someone telling me I'm doing right. I'm also more comfortable using computers for research.

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Where are They Now - Spotlight

Carol Guess

Postdoctoral Researcher and Adjunct Professor at UMass Lowell

JINA funding allowed me to do one of my thesis experiments. The target of metallic 150Sm that I needed was very expensive, and thus access to JINA resources enabled me to complete my degree on time. I am currently a postdoc at UMass Lowell working on a high spin spectroscopy experiment and also teaching introductory physics as an adjunct. I have also been trained to run the 5 MV Van de Graaff in our basement. While I'm not involved in JINA collaborations for nuclear astrophysics at the moment, I do skim through the Virtual Journal at least once a month to try to stay up to date on current results. It is a very helpful resource.

Rhiannon Meharchand

Director's Postdoc Fellow, Los Alamos National Laboratory

In a lot of ways, what I do now isn't that different from what I did while at NSCL/MSU. I'm still running beam experiments, only now they last 4-6 months instead of one week. I'm still studying nuclear physics, but focused on fission rather than structure. And I'm still working as part of a team, but on a slightly larger scale. As a member of the Neutron Induced Fission Fragment Tracking Experiment (NIFFTE) collaboration, I am working with approximately 30 people from 4 national laboratories and 7 universities to develop a Time Projection Chamber (TPC) that can measure neutron-induced fission cross sections with unprecedented precision. As a postdoc in the Neutron and Nuclear Science group at Los Alamos National Laboratory, I facilitate the in-beam tests and production data collection of the NIFFTE TPC. I am also responsible for delivering the TPC measurement of the 238U/235U (n,f) cross-section ratio, which will be used to benchmark TPC performance and improve the nuclear data evaluations used by modelers in defense and energy applications. Looking back, even though my Ph.D. research was only peripherally related to nuclear astrophysics, I'm very grateful for my past experience with JINA. In addition to providing valuable scientific breadth, JINA was a great introduction to large, multi-institutional collaborations. Thanks in part to JINA support, I was given several opportunities to speak at conferences and workshops, and make valuable connections with leaders in nuclear physics and astrophysics. I'm not sure yet where on the nuclear landscape I'll end up, but I'm sure that the knowledge and experience provided by JINA will help me on my way.

Up and Coming Future JINA Researcher

Name: Stephanie Brown, but many call her by her pen name, Alex

Age: 16

Hometown: Lansing, MI

Grade: 11

Favorite Food: Ice Cream

Preferred College: Princeton

Planned Major: Astrophysics

Q: Why astrophysics?

A: Well, physics is my favorite subject in high school, and I like astrophysics because everything in space is so much beyond what we experience on Earth.

Q: What do you want to do after college?

A: I want to earn my Ph.D. and maybe work at GSI, which means I need to learn German in college.

Q: Where would you like to go for graduate school?

A: Hopefully at MSU because they'll have FRIB by then and it's already one of the best in the world.

Q: Which JINA Programs have you experienced?

A: MST, PAN at MSU, PAN at ND, Counselor at Art 2 Science Camp

Q: Which did you like the best?

A: I don't know because they're all really different. I liked MST because everything was new and it was "woah" because it was the first time I was learning about nuclear astrophysics. I like work-

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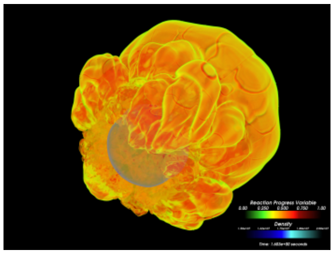
Vision (continued from page 5)



conditions and the timescale of the explosive event. For type Ia supernovae the most critical reaction, the 12C+12C fusion process that drives ignition was investigated, 22Ne(α,n) was identified to be critical for the speed of the deflagration front initiating the explosion. Another significant effort went into experimentally determining weak interaction strength to benchmark shell model effective interactions used to calculate stellar electron capture and beta decay rates in supernovae. After extensive measurements of charge exchange reactions, the optimum effective interaction was identified and the resulting uncertainty for the stellar rates quantified for the first time. Both for type Ia supernovae as well as for novae 3d models were employed to more reliably investigate the explosion mechanism.

The third major activity concentrated on the fate of the ashes of the thermonuclear runaway at the surface of neutron stars. It was shown that electron capture and a balance of neutron emission and neutron capture at highly degenerate conditions drives the abundance distribution in the ashes towards neutron rich light ion species. At extreme densities near nuclear densities pycnonuclear fusion provide a new energy source deep in the neutron star crust. New models for pycnonuclear fusion in a lattice of light ions were developed and triggered additional theoretical efforts outside the JINA collaboration.

JINA has emerged after ten years of funding as an international center for nuclear astrophysics. Multiple groups and institutions have joined JINA through agreements of exchange and collaboration. Most of the JINA projects are pursued on a broad international basis. JINA initiated experiments take place at laboratories in the Americas, Europe, and Asia, the observational program uses US, European, and Australian facilities. The JINA conference and workshop program is international, but organized by local groups associated with JINA. The JINA postdoc and student community has grown substantially; the first generation has already reached faculty level and

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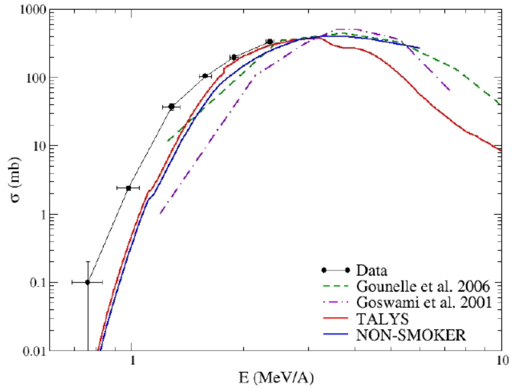
Abstract from JINA Scientist April APS Meeting

Experimental Results of the 33S(α,p)36Cl Cross Sections: Implications on 36Cl Production in the Early Solar System

Matthew Bowers – University of Notre Dame

Isotopic measurements of primitive solids in meteorites provide insight into the origins of the Solar System, the chemical evolution of the elements, and nucleosynthetic processes. Identifying the origins of now-extinct short-lived radionuclides (SLRs) is important for both Early Solar System chronology and nuclear astrophysics. The origin of extinct 36Cl in the early Solar System is thought to have been produced by irradiation of gas and dust by solar energetic particles emitted by the young Sun. Attempts to recreate the production of 36Cl in the early Solar System using the x-wind model lack experimental data for the nuclear reactions considered. We measured the cross sections for the 33S(α,p)36Cl reaction, an important reaction in the production of 36Cl, at six energies that ranged from 0.70-2.42 MeV/A. The cross section measurement was performed by bombarding a target and collecting the recoiled 36Cl atoms produced in the reaction, chemically processing the samples, and measuring the 36Cl/Cl concentration with AMS. The experimental procedure, results, and comparison with predicted Hauser-Feshbach predictions will be discussed.



Up and Coming - Tripepi

(continued)

Q: What other programs have you experienced, and how did they compare to the JINA programs?

A: In the PAN programs, the research was more guided and the professors expected a certain outcome. During the QuarkNet summer research, you were on the front line doing research with the professors, and working back and forth with them to solve the problems. I liked them both, but they were like taking steps, with first learning what it takes to do research, and then starting to do it yourself, and taking on a little bit of the role yourself. PAN prepared me for the research at QuarkNet.

Q: Where do you see yourself in 5 years?

A: Hopefully, graduated from college. I would expect myself to be in graduate school, although I don't know where. Probably either Notre Dame or MSU, doing research in a theoretical field of physics.

Q: Where do you see yourself in 20 years?

A: I see myself working either in a national laboratory or a company's laboratory doing research.

Q: Is there anything else you'd like the readers to know about you?

A: As someone that likes to do scientific research, I hated science fairs when I was younger. I couldn't decide which topic to study, or what to use for a project. I eventually began to like it as an extension of my research.

Q: And now you're headed to ISEF with your science fair project. What's it about?

A: It's based on my work at QuarkNet over the summer and fall, which was working with optical mixers for use in particle detectors.

Up and Coming - Brown

(continued)

ing with MoNA at MSU, but I also like the variety of experiments at Notre Dame. So I liked them all, but for different reasons.

Q: How did the experiences benefit you?

A: It helps to see what you would be doing as a scientist because you get to see the machines you would be working with and meet the types of people you'd be working with and see what they do. You're also learning about it. It's one thing to hear about nuclear astrophysics and think that it sounds cool, but it's a something completely different to know actually what it is, what it requires, and the types of careers available.

Q: What other programs have you experienced?

A: Dimensions, a forensics science camp, a theater Shakespeare camp

Q: Where do you see yourself in 5 years?

A: Hopefully graduating with my Bachelor's, but I might double major and spend an additional year.

Q: Where do you see yourself in 20 years?

A: I might be working as an astrophysicist, because I really liked what the lecturer at Notre Dame said about different uses of computers, including defense work with satellites as well as astrophysics research. However, I also think that using the GSI or FRIB facilities to do research would be really cool.

Q: Is there anything else you'd like the readers to know?

A: I'd also like to be a novelist. I'd like to write science fiction because it bothers me when sci fi writers get the science wrong.

Up and Coming - Polus

(continued)

Q: Are you involved with other science activities?

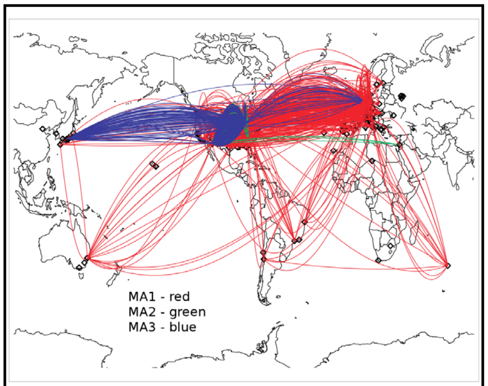
A: I'm heavily involved with Science Olympiad, and I do all of the physics events. I also do a lot of programming for the robots, underwater vehicle competition, and an RC car that we built.

Q: Where do you see yourself in 5 years?

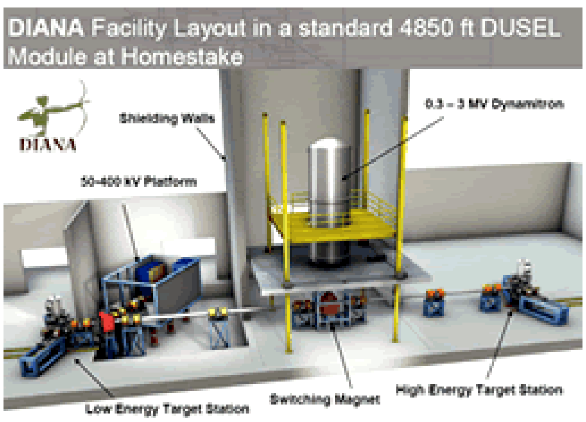
A: Studying physics, graduating college, and getting ready to go to graduate school at MSU to work with FRIB.

Q: Where do you see yourself in 20 years?

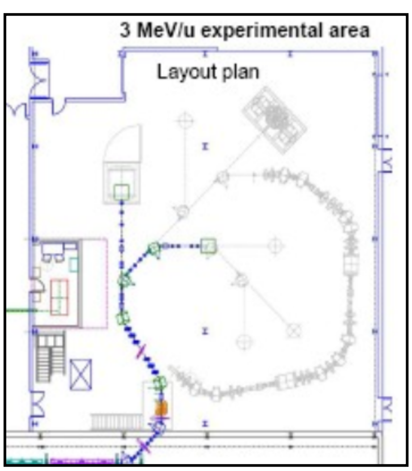
A: I'd like to be working in a lab, researching either astrophysics or nuclear physics. I would also enjoy a career working with optics.



Lines represent connections between institutions of co-authors on JINA publications.



Above: *Possible DIANA layout*
Below: *Proposed SECAR layout with ReA3*



Vision (continued from page 7)

assumed positions at the University of Alabama, Caltech, Michigan State University, the University of North Carolina, and the University of Notre Dame in the US and at many Universities abroad. This reflects the national and international recognition of JINA science and science achievements.

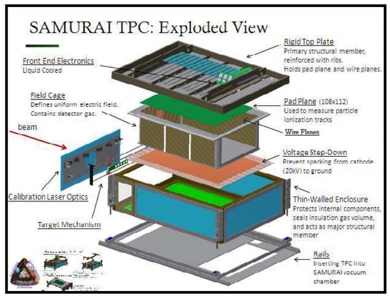
JINA envisions to continue its work in the next funding round, building upon the previous accomplishments. New technical developments such as the Notre Dame heavy ion accelerator and the St. George recoil separator provide new opportunities for inverse kinematics measurements of alpha capture reactions that are crucial for stellar helium and carbon burning. The plans for the development of an intense beam underground accelerator facility DIANA at Homestake mine, opens new opportunities for direct proton and alpha capture measurements in nearly background free environment. The construction of the new ReA3 reaccelerated beam facility at NSCL also opens new and unique opportunities for JINA researchers who were involved in the planning and design of new instrumentation for the development of a nuclear astrophysics program. Additionally, specific nuclei have been identified whose masses have a substantial impact on final r-process abundances. These masses can be measured using radioactive ion beams at facilities such as CARIBU at Argonne National Laboratory and next-generation facilities. The new science agenda will take advantage of these technical capabilities and other accomplishments of the last years for a more focused, but also more comprehensive approach on key frontiers in nuclear astrophysics.

Abstracts from JINA Scientists April APS Meeting

SAMURAI Time-Projection Chamber: A device for constraining the symmetry energy

Bec Shane – NSCL/MSU

The SAMURAI-TPC is a time-projection chamber to be used in conjunction with the SAMURAI spectrometer at the Radioactive Isotope Beam Facility at RIKEN, Japan. It is designed to detect charged pions as well as light charged particles up to oxygen produced in heavy ion collisions. Design of the TPC is based on the EOS TPC with similar dimensions. However, the TPC will be equipped with the newly designed General Electronics for TPCs (GET). One of the proposed experimental programs using the TPC is to measure pi+/pi- ratios from heavy-ion collisions which should provide constraints on the asymmetry term in the nuclear equation of state at densities about twice saturation density. In this talk, the design and construction of the detector will be discussed.



Art as a Vehicle for Nuclear Astrophysics

Micha Kilburn – University of Notre Dame

One aim of the The Joint Institute for Nuclear Astrophysics (JINA) is to teach K-12 students concepts and ideas related to nuclear astrophysics. For students who have not yet seen the periodic table, this can be daunting, and we often begin with astronomy concepts. The field of astronomy naturally lends itself to an art connection through its beautiful images. Our Art 2 Science programming adopts a hands-on approach by teaching astronomy through student created art projects. This approach engages the students, through tactile means, visually and spatially. For younger students, we also include physics based craft projects that facilitate the assimilation of problem solving skills. The arts can be useful for aural and kinetic learners as well. Our program also includes singing and dancing to songs with lyrics that teach physics and astronomy concepts. The Art 2 Science programming has been successfully used in after-school programs at schools, community centers, and art studios. We have even expanded the program into a popular week long summer camp. I will discuss our methods, projects, specific goals, and survey results for JINA's Art 2 Science programs.

First Lifetime Results from a Systematic Study of Odd-Mass Neutron-Rich Nuclides Near A~110

Brian Bucher – University of Notre Dame

Our understanding of the astrophysical r-process nucleosynthesis path relies strongly on input from nuclear models. The mass region surrounding A~110 is known to exhibit rapid structural evolution, however experimental data is lacking for nuclides away from stability making the prediction of important nuclear properties in the r-process region difficult. In this talk we report new pico-second lifetimes of excited states populated via beta decay of fission fragments produced at IGISOL in Jyvaskyla, Finland. The measurements utilized triple coincidences (βγγ) where two fast scinitillators (plastic for β and LaBr3 for γ) were used in conjunction with a HPGe detector. Details of the experimental technique will be highlighted along with the presentation of eight new lifetimes in 109Pd, which range between 10-1500 ps, representing the first results from a broad experimental campaign.

Member Institutions

NSL / University of Notre Dame
NSCL / Michigan State University
ASC / University of Chicago

Associated Institutions

Arizona State University
EMMI-GSI, Helmholtz Gemeinschaft, Germany
INPP, Ohio University
LANSCE-3 / Los Alamos National Laboratory
MoCA/Monash University, Australia
Physics Division / Argonne National Laboratory
Princeton University
SESE, Arizona State University
The Cluster of Excellence "Origin and Structure of the Universe
Theoretical Astrophysics (T-2) / LANL
University of Minnesota
University of Sao Paulo
University of Victoria, Canada
VISTARS, Helmholtz Society, Germany
Western Michigan University

Participating Institutions

Ball State University, IN
Clark Atlanta University, GA
Hope College, MI
Indiana University South Bend, IN
Southern Indiana University, IN
St. Edwards University, TX
St. Mary's University, TX
SUNY Geneseo, NY
Xavier University, LS

Want to write a feature article? Know a young researcher that would like to be interviewed? Other ideas or tidbits you'd like to share? Contact the JINA Outreach Coordinator for more information.

For questions or comments about:	Contact:
JINA Membership	Michael Wiescher
JINA Science	Hendrik Schatz
JINA Outreach or Newsletter	Micha Kilburn
JINA Administration	Kathy Burgess