Astrophysics Task Force

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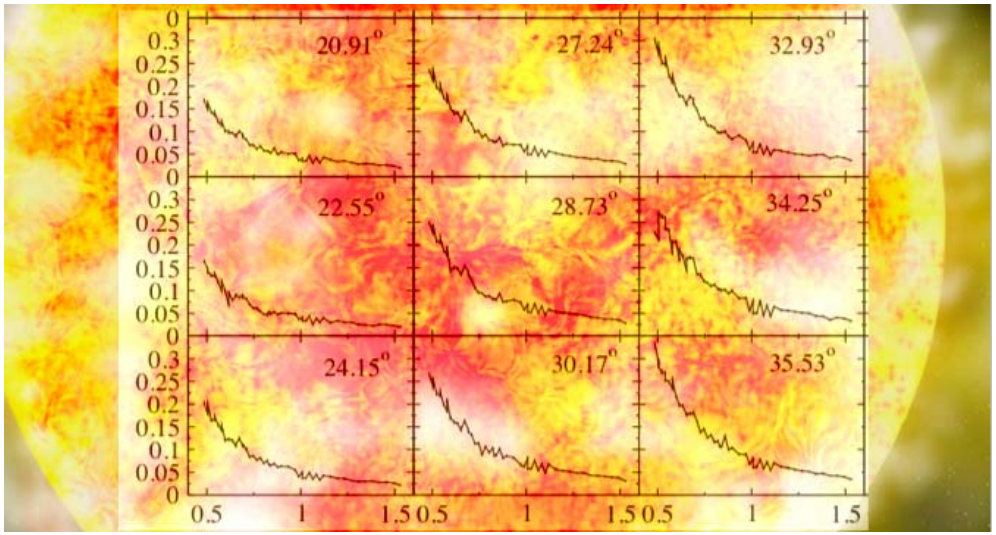
ORNL Physics Division

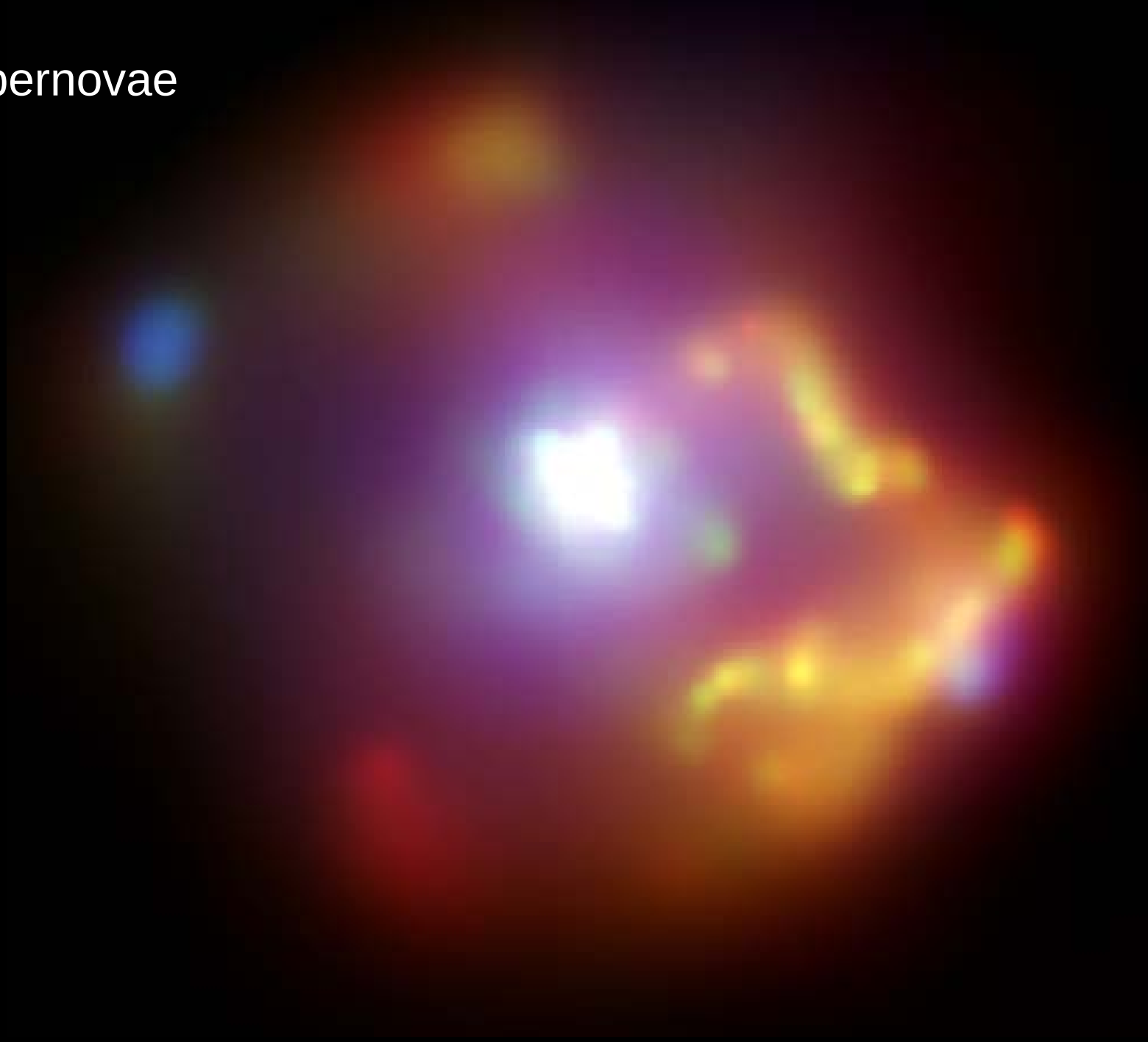
USNDP Contributors to this report

- Argonne National Laboratory
- Los Alamos National Laboratory
- Oak Ridge National Laboratory
- McMaster University
- Brookhaven National Laboratory



National Nuclear Data Center

supernovae



Argonne National Laboratory -- C. Nair, Filip Kondev
[with USNA, LANL]

Project: Electron Capture Delayed Fission of ^{180}Tl

Background:

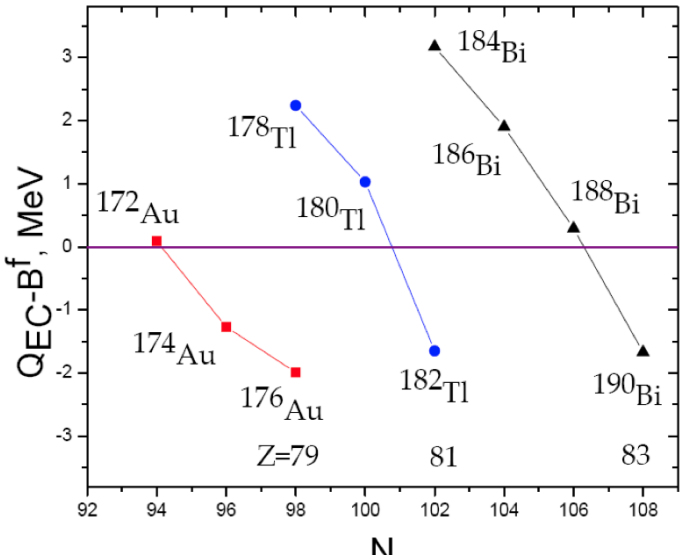
experimental information on Fission Barriers (FB) for nuclei far from stability is scarce

accurate knowledge of FBs is particularly important for neutron-rich nuclei that are located on the path of *r*-process nucleosynthesis

fission of these nuclei determines the termination of the *r*-process and impacts final abundances synthesized in supernovae

beta-delayed fission is an unique tool to investigate FBs – proton-rich

this experiment will investigate p-rich nuclei to develop the technique



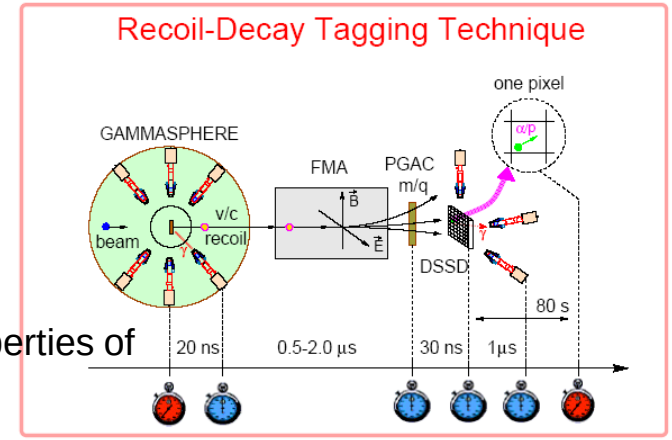
This study:

Measure Electron Capture Delayed Fission properties (ECDF) of ^{180}Tl at ANL-ATLAS

use the ^{92}Mo(^{89}Y,1n) reaction at energies near the Coulomb barrier and a recoil – decay tagging technique

prompt gamma-rays detected by Gammasphere will elucidate the structure of the parent ^{180}Tl nucleus

decay spectroscopy at the FMA focal plane will enable to study properties of the daughter ^{180}Hg nuclide populated following EC on ^{180}Tl



Status:

data analysis is in progress – a talk by C. Nair at the DNP meeting (Thursday afternoon)

Los Alamos National Laboratory -- Peter Möller [with Jorge Randrup]

Project: New 5D Dynamical Model of Fission Yields

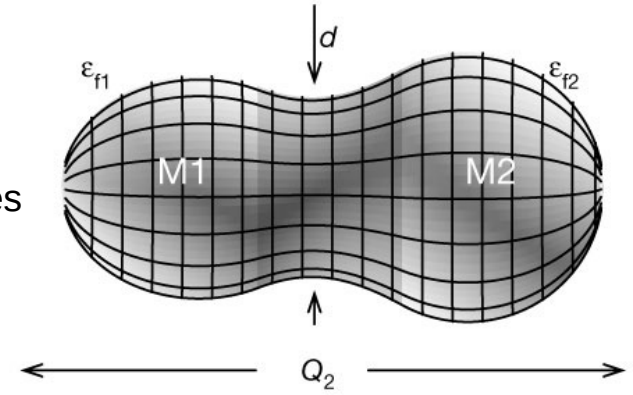
Background:

fission is crucial for studies of element creation in supernovae, determining the heaviest elements formed as well as final abundances

since fission of all heavy nuclei will never be measured, global fission models are essential

previous work has involved a 5-dimensional parameterization of potential energy surface for fission studies

potential energy surfaces are essential component for fission yield calculations, as is the nuclear model used to describe fission



41 ⊗	Q_2	Elongation (fission direction)
20 ⊗	α_g	(M1–M2)/(M1+M2) Mass asymmetry
15 ⊗	ε_{f1}	Left fragment deformation
15 ⊗	ε_{f2}	Right fragment deformation
15	d	Neck

This study:

combines potential energy surfaces from P. Moller et al. with 5-dimensional dynamical model from J. Randrup

Nuclear fission modes and fragment mass asymmetries in a five-dimensional deformation space
P. Möller, D. G. Madland, A. J. Sierk & A. Iwamoto
Nature **409**, 785-790(15 February 2001)

Status:

will be submitted for publication in November 2010

then will be utilized to calculate fission yields for thousands of nuclei from beta stability to the r-process line

Oak Ridge National Laboratory – Kate Jones (Univ. Tennessee) et al.

Project: Confirmation of Magicity of ^{132}Sn

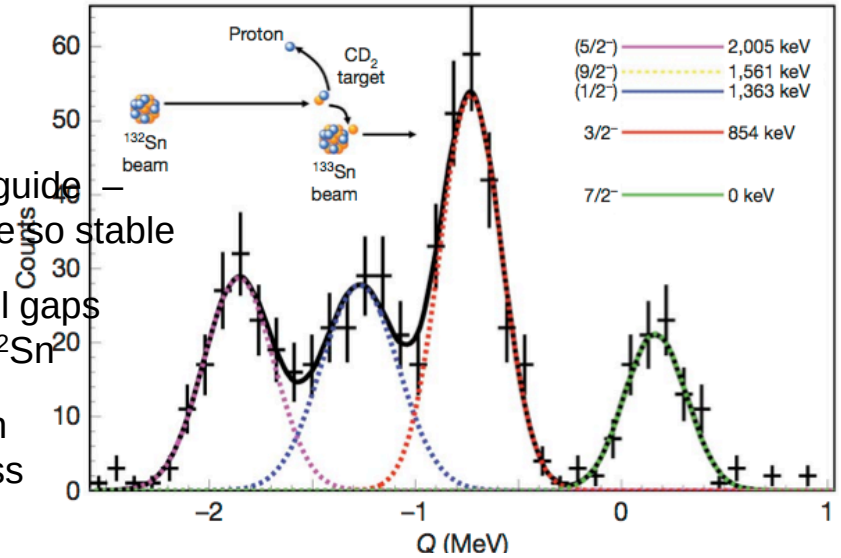
Nature **465**, 7297 (2010) 454

Background:

nuclear shell model -- built in 1950s with stable nuclei as a guide – describes why some nuclei with "magic number" of nuclei are so stable

only 10 doubly-magic nuclei known, and suppression of shell gaps in unstable nuclei may prevent magicity of candidates like ^{132}Sn

properties of single particle levels outside of shell closures in exotic neutron-rich nuclei can influence neutron capture cross sections important for element creation in supernovae



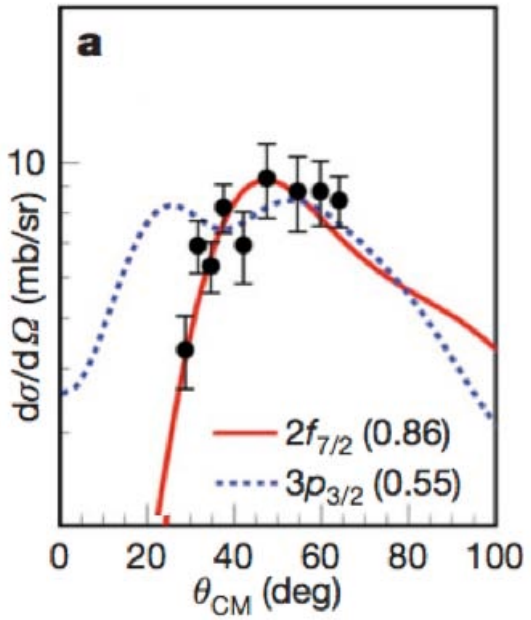
This study:

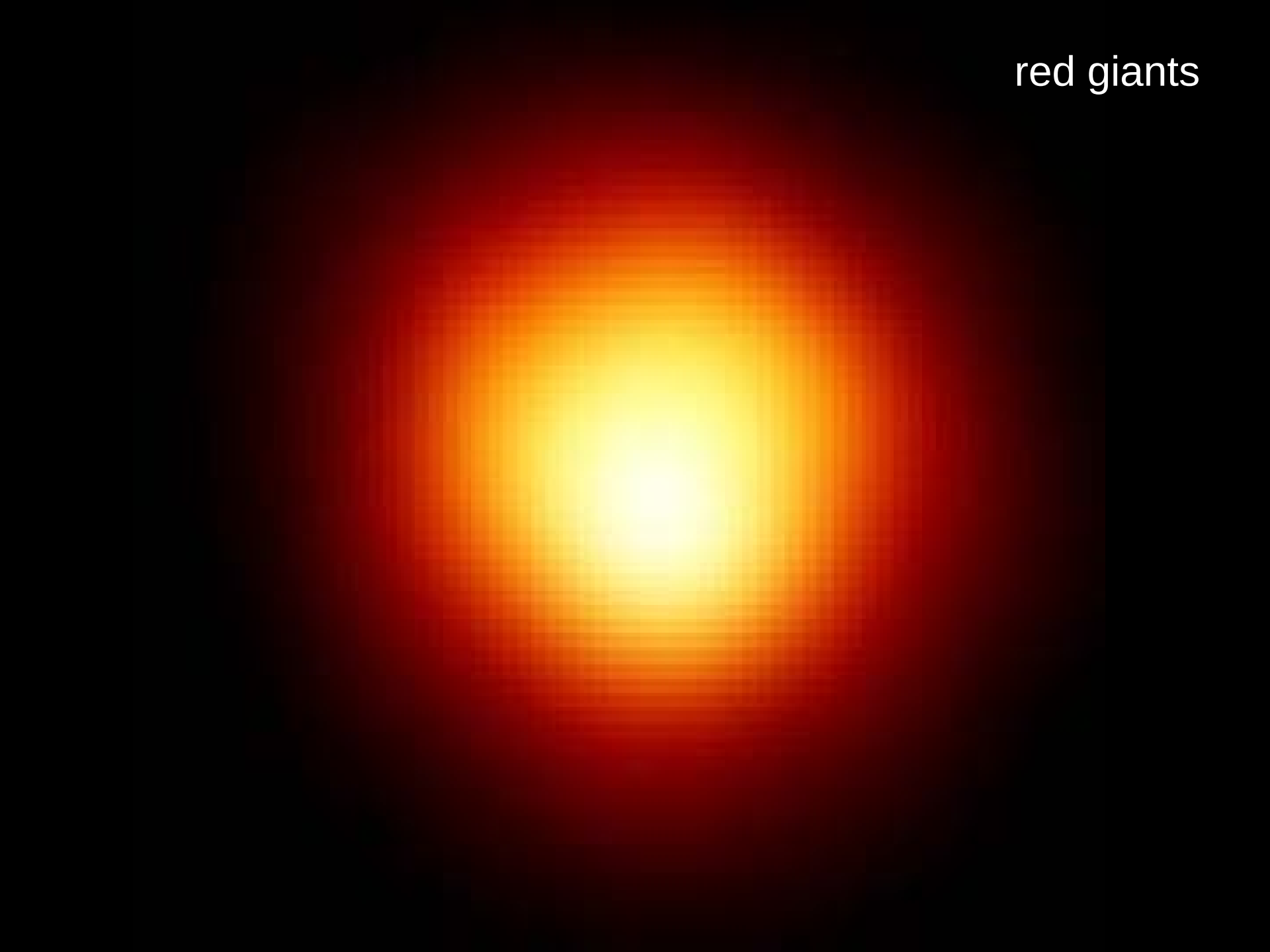
measured ^{132}Sn(d,p)^{133}Sn with radioactive ^{132}Sn beam at ORNL's HRIBF

Results:

determined "pure" single particle nature of levels in ^{133}Sn and confirmed doubly magic status of ^{132}Sn

results will be used for new neutron capture calculations and as basis to extrapolate nuclear structure models to nuclei farther from stability




red giants

Brookhaven National Laboratory -- Boris Pritychenko et al.

National Nuclear Data Center
BROOKHAVEN NATIONAL LABORATORY

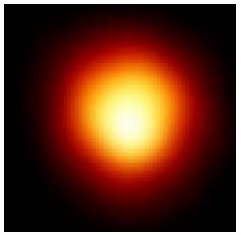
Project: Maxwellian-Averaged Cross Sections from JENDL-4.0, CENDL-3.1, ROSFOND 2010

Background:

In FY09, reaction rates / maxwellian-averaged cross sections (MACS) were calculated from ENDF (and JEFF, JENDL…) and compared to Bao & Kaeppeler collection traditionally used by nuclear astro community

these MACS had no uncertainties, so comparisons were difficult

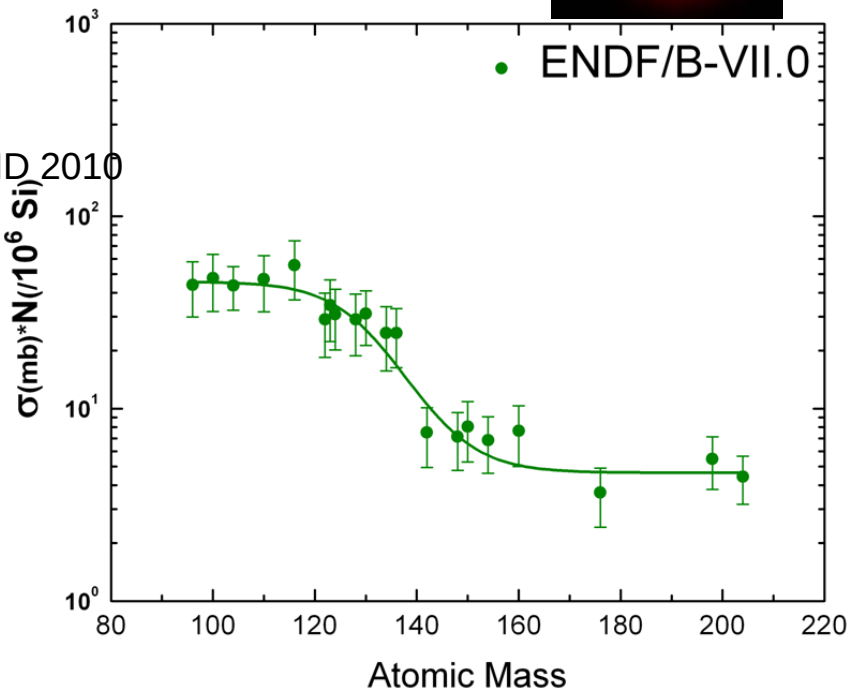
substantial USNDP effort in covariances could provide uncertainties in these rates, which would be useful for modeling nucleosynthesis in red giant stars



This study:

generate MACS from JENDL, CENDL-3.1, ROSFOND 2010 and enable comparisons with Bao & Kaeppeler…

generate **uncertainties** from low-fidelity covariances



Results:

this is the first global determination of uncertainties from evaluated data files for s-process reactions

these can be used in Monte Carlo studies of heavy element creation in red giant stars


nova nucleosynthesis

McMaster University -- K. Setoodehnia, Alan Chen, Jun Chen

Project: Evaluation of Explosive Hydrogen Burning Reactions for Novae Studies

Background:

nucleosynthesis in novae determined by proton-capture reactions on proton-rich unstable nuclei with mass lower than 40

^{23}Mg(p,γ)^{24}Al, ^{25}Al(p,γ)^{26}Si, and ^{29}P(p,γ)^{30}S are three very important reactions with significant uncertainties

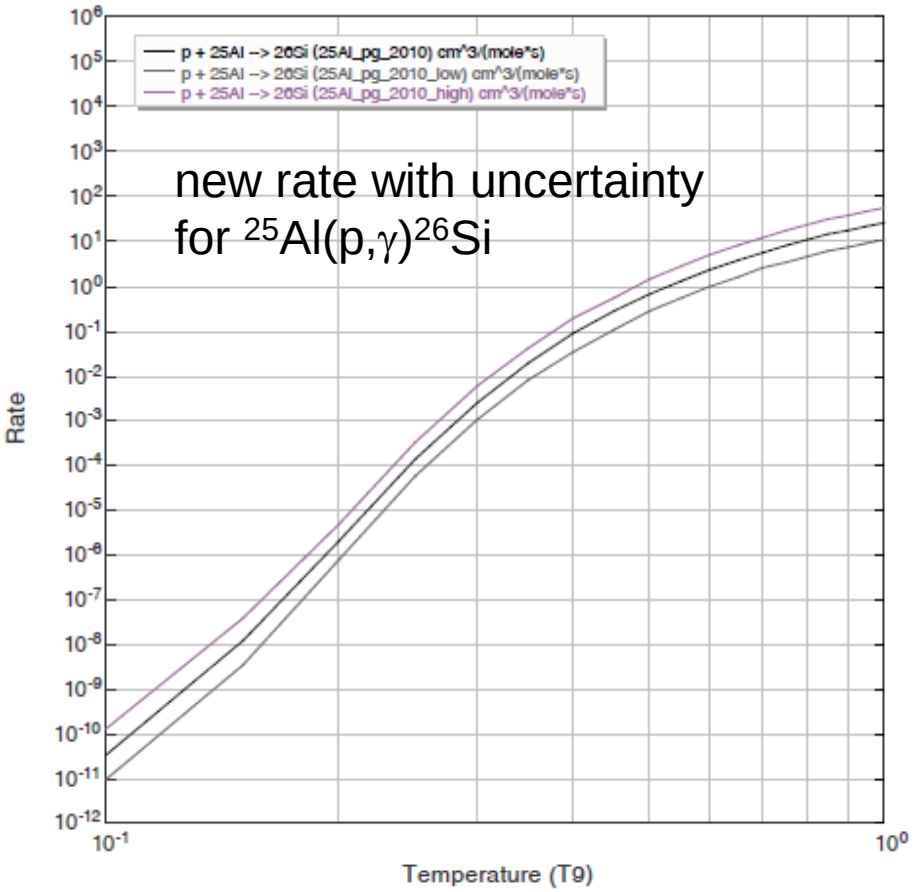
indirect rate determinations from measurements at numerous labs need to be combined

This study:

Evaluations of these three reactions have been made using results from a direct measurement at TRIUMF ISAC [^{23}Mg(p,γ)^{24}Al]; indirect studies at Tsukuba, RIKEN, and NSCL [for ^{25}Al(p,γ)^{26}Si]; and indirect studies at Yale [for ^{29}P(p,γ)^{30}S]

Results:

Rates submitted to Evaluation System at Computational Infrastructure for Nuclear Astrophysics



Further updates expected for for ^{29}P(p,γ)^{30}S based on finalizing (3He,nγ) experiment at Tsukuba

Oak Ridge National Laboratory – Kelly Chipps et al.

Project: Measurement of $^{28}Si(p,t)^{26}Si^{*}(p)^{25}Al$ to determine $^{25}Al(p,\gamma)^{26}Si$ rate

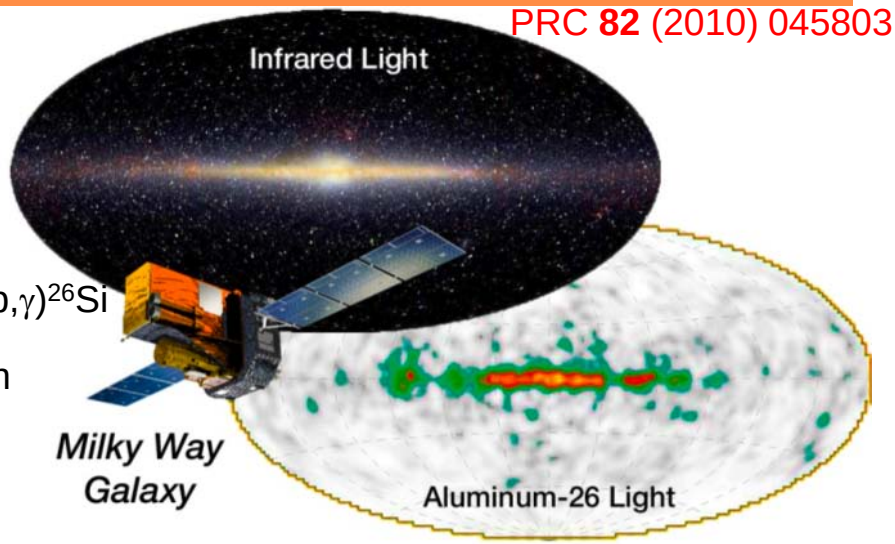
PRC **82** (2010) 045803

Background:

nucleosynthesis of ^{26}Al in stellar explosions
needed to explain maps of ^{26}Al in our Galaxy

reactions that create ^{26}Al are uncertain – especially $^{25}Al(p,\gamma)^{26}Si$

structure of ^{26}Si above proton capture threshold uncertain



This study:

measure $^{28}Si(p,t)^{26}Si^{*}(p)^{25}Al$ at ORNL HRIBF

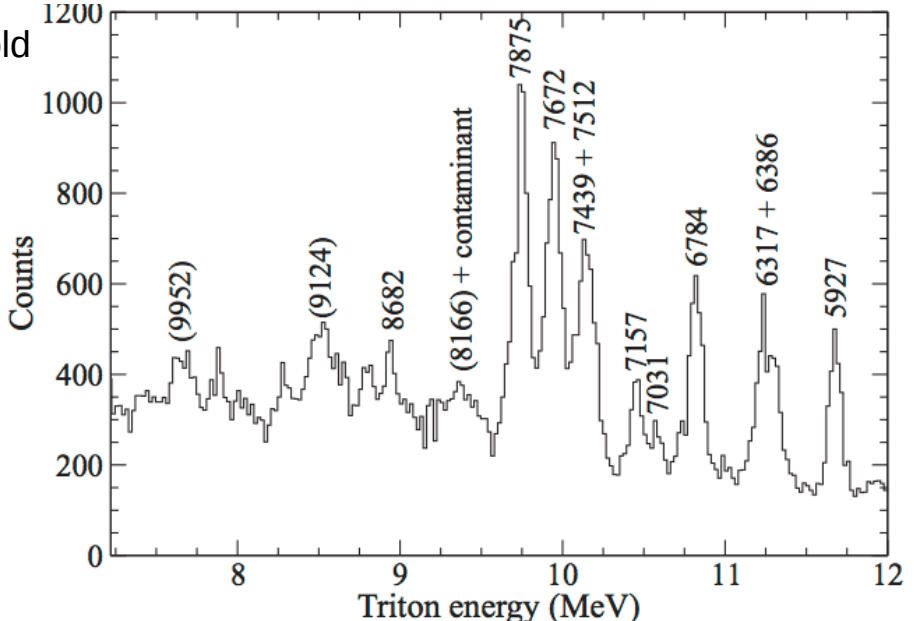
determine level structure of ^{26}Si above ^{25}Al + p threshold

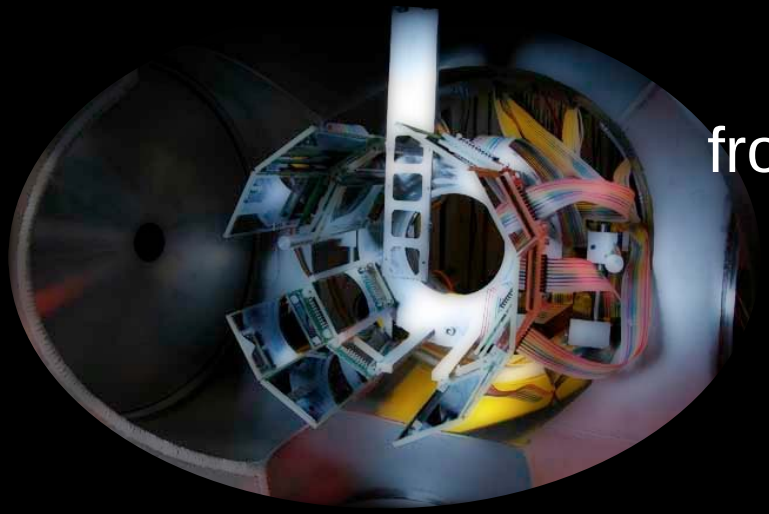
Results:

first measurement of proton decay of ^{26}Si levels

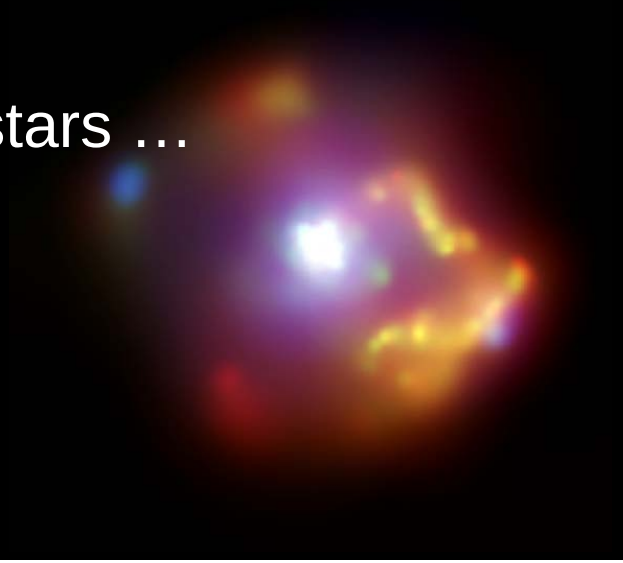
provides evidence that the ^{26}Si level at 5927±4 keV is the lowest energy 3+ (l = 0) resonance above ^{25}Al + p threshold

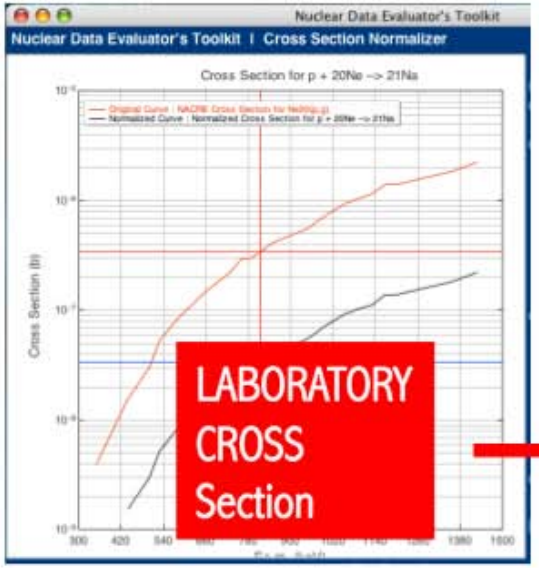
this level dominates the astrophysical reaction rate

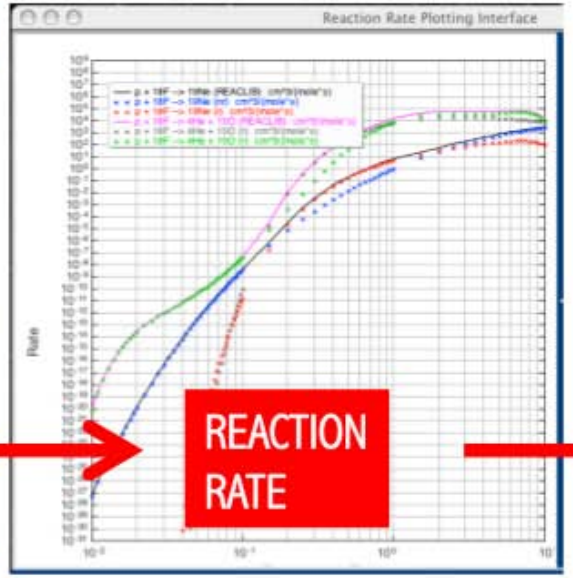


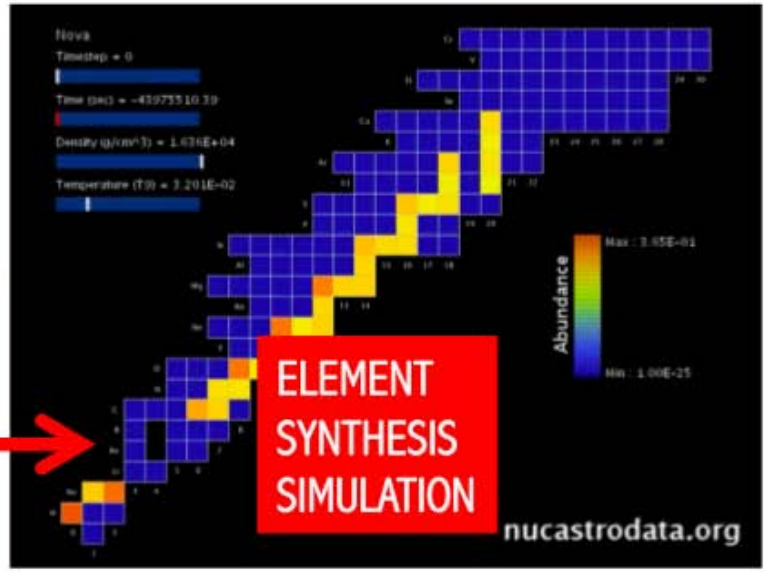


from the lab to the stars …









Oak Ridge National Laboratory -- Michael Smith, Eric Lingerfelt, Caroline Nesaraja

Project: software systems for nuclear astrophysics research

Background:

nuclear information not easy to access, visualize, share, process into astrophysical models

not easy to determine astrophysical impact of new nuclear physics information

This study:

significant improvements in our unique on-line software suites for research in nuclear astrophysics and nuclear science

nucastrodata.org / Computational Infrastructure for Nuclear Astrophysics

nuclearmasses.org

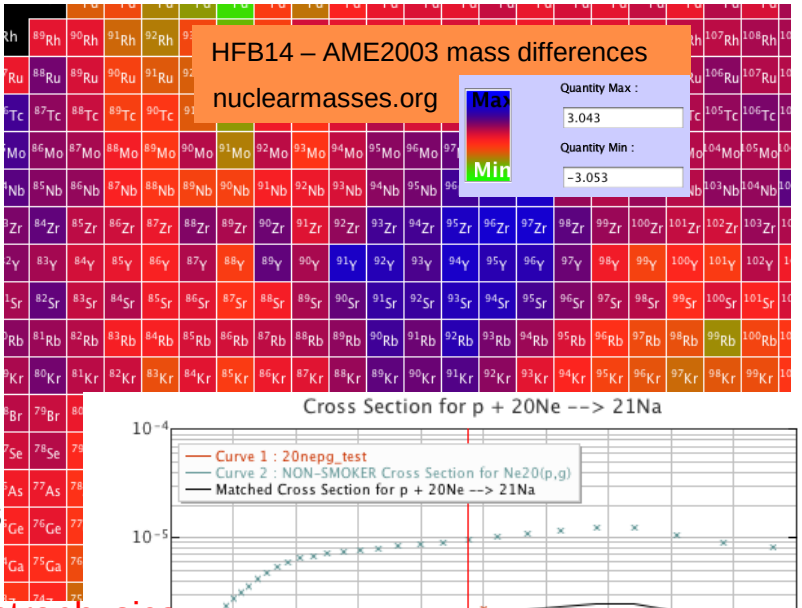
Results:

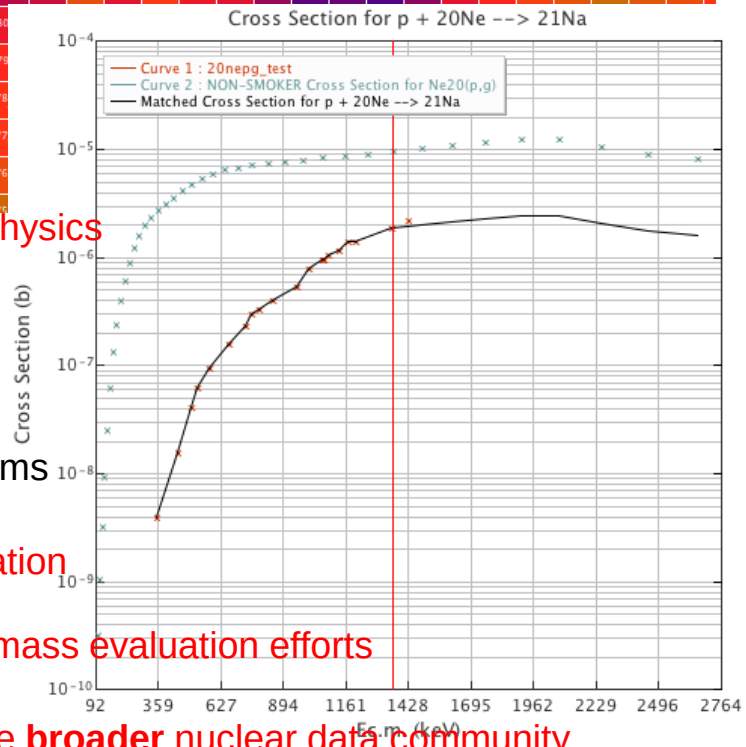
researchers in 100 institutions in 26 countries use our online systems

details of recent improvements in ORNL Progress Report presentation

our nuclear mass software makes an excellent platform for future mass evaluation efforts

some of our workflow management software could be helpful to the **broader** nuclear data community





Closing Comments

there are really interesting astro-related projects carried out by USNDP institutions

some of your projects could possibly be extended or enhanced to have astrophysical implications

we would like to explore such possibilities with you !