Astrophysics Task Force

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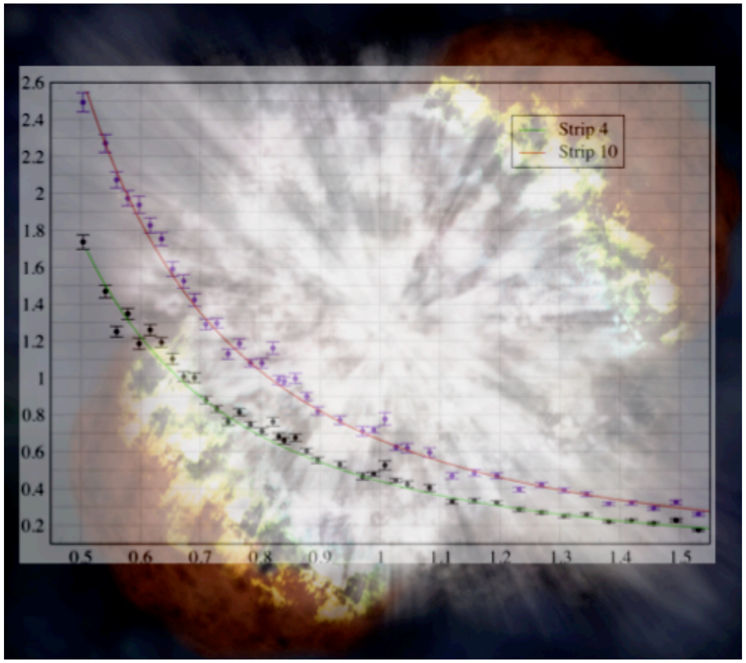
Why have a USNDP Astrophysics Task Force ?



Numerous USNDP institutions are pursuing projects that are beneficial for studies in nuclear astrophysics

Other USNDP institutions have expertise that can greatly benefit astro-related projects

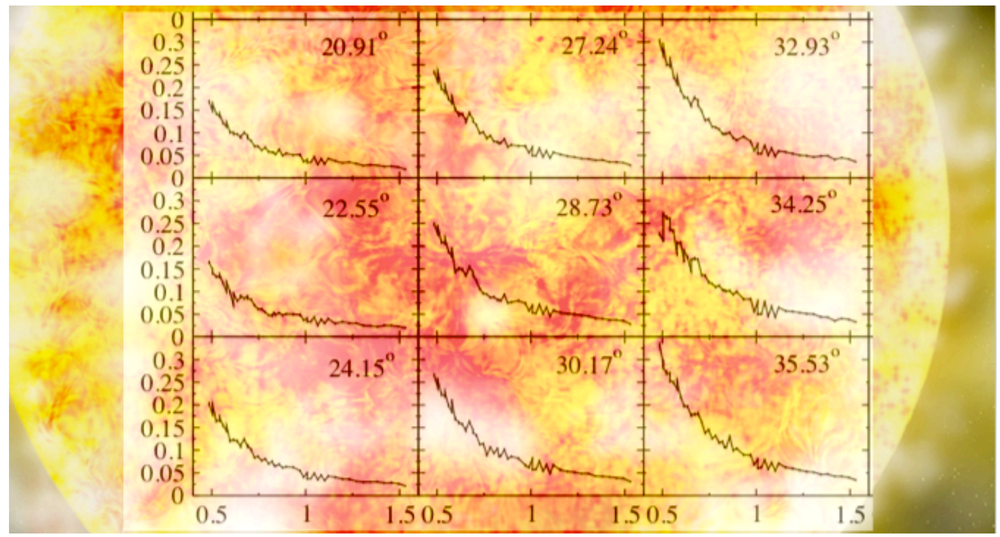
Better communication *can* bring these groups together, facilitate collaboration building, reduce duplication of efforts …

This work does not fit solely in the Nuclear Reaction or Nuclear Structure Working Group – hence the need for the Astro Task Force

Astrophysics Task Force

USNDP Contributors to this report

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



Argonne NATIONAL LABORATORY

Los Alamos NATIONAL LABORATORY EST.1943

National Nuclear Data Center

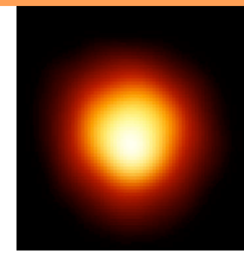
BROOKHAVEN NATIONAL LABORATORY

McMaster University Inspiring Innovation and Discovery

OAK RIDGE National Laboratory

Argonne National Laboratory -- Filip Kondev [with UNC]

Project: Studies of thermal equilibrium of ^{176}Lu via K-mixing PRC 80 (2009) 105806



Background:

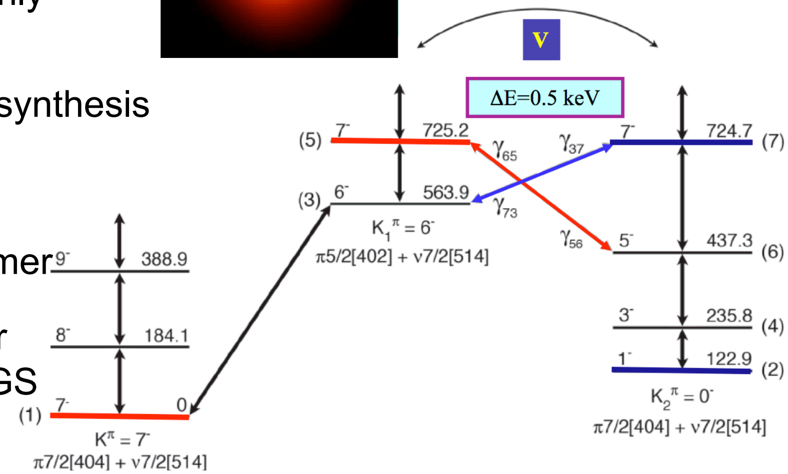
^{176}Lu ground state has 37.6 Gyr lifetime, made by s-process only

potentially useful as chronometer of galactic s-process nucleosynthesis

low-lying (123 keV), short-lifetime (3.6 hr) isomeric state
complicates this IF thermal equilibrium between GS and isomer

detailed studies of capture reactions producing GS and isomer
conflict with ratios of abundances in the region -- not enough GS

suggests a non-capture mechanism to produce the GS –
intermediate state(s) that connect GS and isomer



This study:

investigate K mixing to enhance transitions between GS & isomer

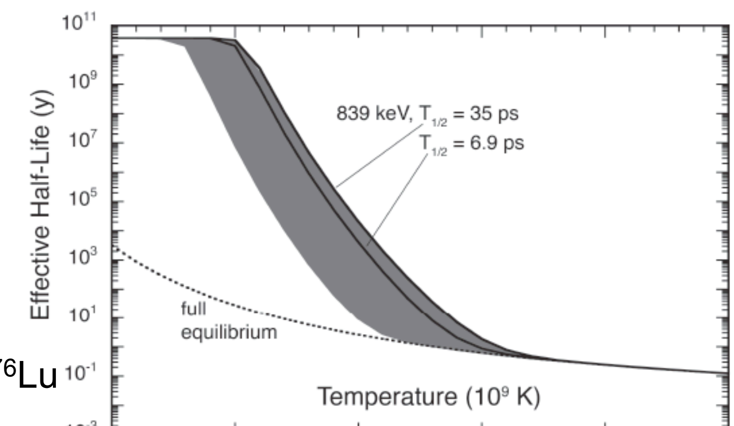
Results:

yes - enhanced transitions between K–bands

so chronometer studies very challenging with ^{176}Lu

PRC 80 (2009) 105806

situation potentially exists for other s- and r-process chronometers



Los Alamos National Laboratory -- Toshihiko Kawano et al.

Project: Coupled-channel calculation of reaction cross sections on excited nuclei

PRC 80 (2009) 024611

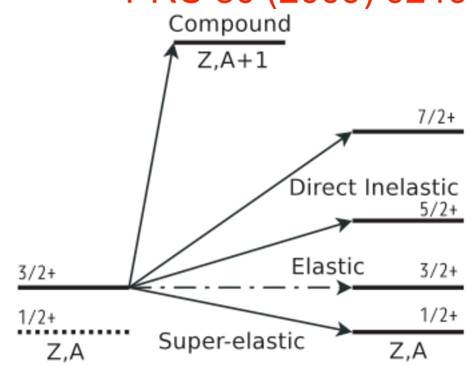


FIG. 1. An example of coupled-channels calculation for the excited state. The target is at the first $(3/2)^+$ state, which is a member of ground-state rotational band. The coupled equations give a set of direct cross sections and the compound formation cross section. In this case the direct transition to the $(3/2)^+$ level is elastic scattering and to other levels is inelastic scattering.

Background:

in astrophysical environments, thermal equilibrium can exist between nuclei in ground and excited states

nuclear reactions on excited states need to be determined – but hard to measure

This study:

use coupled channel (CC) approach to calculate direct reaction component [excited state to final GS or excited state] for n + ^{169}Tm

use statistical model to calculate compound reaction component, with transmission coefficients from CC

Results:

n capture cross sections on excited states can be up to 40 % higher than ground state capture at energies relevant for astrophysics [below 1 MeV]

n-induced fission, n scattering also changed

may suggest revisiting "Stellar Enhancement Factors" based on much older [non-coupled channels] approaches

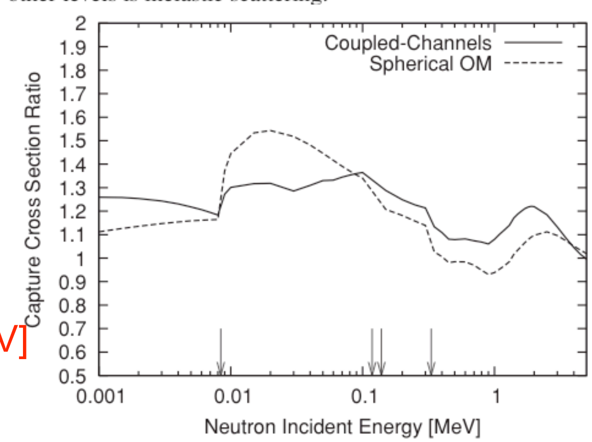


FIG. 6. Ratios of the calculated capture cross sections of excited state to the ground state. The solid line is for the coupled-channels calculation, and the dashed line is for the spherical optical model case. The arrows on the x axis are the inelastic channel threshold energies.

Los Alamos National Laboratory -- Peter Möller

Project: Impact of spin-orbit parameters on nuclear mass models

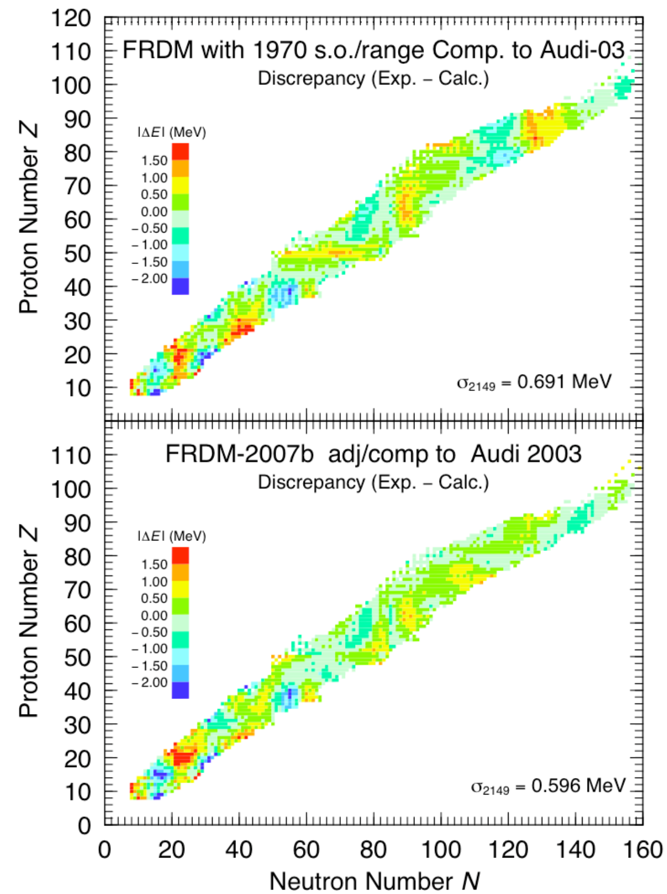
Background:

mass models crucially important for astrophysics studies

spin-orbit & diffuseness parameters appear in nuclear mass models

spin-orbit parameters determined from spectroscopic studies

added automation in his codes has enabled quick calculation of mass tables with new parameter sets



This study:

compare mass models using new spin-orbit & diffuseness parameters with those from ~ 1970

Results:

new spin-orbit & diffuseness parameters give 0.596 MeV RMS deviation from AME2003, while old parameters 0.691 MeV RMS

model with new parameters MUCH better for N> 60

why interesting: new parameters chosen on basis of spectroscopy NOT on basis of mass values … suggests internal consistency of model

a few additional improvements will be made before releasing a “new” mass model

Brookhaven National Laboratory -- Boris Pritychenko, Said Mughaghab, Alejandro Sonzogni

National Nuclear Data Center
BROOKHAVEN NATIONAL LABORATORY

Project: Maxwellian-Averaged Cross Sections from ENDF/B-VII

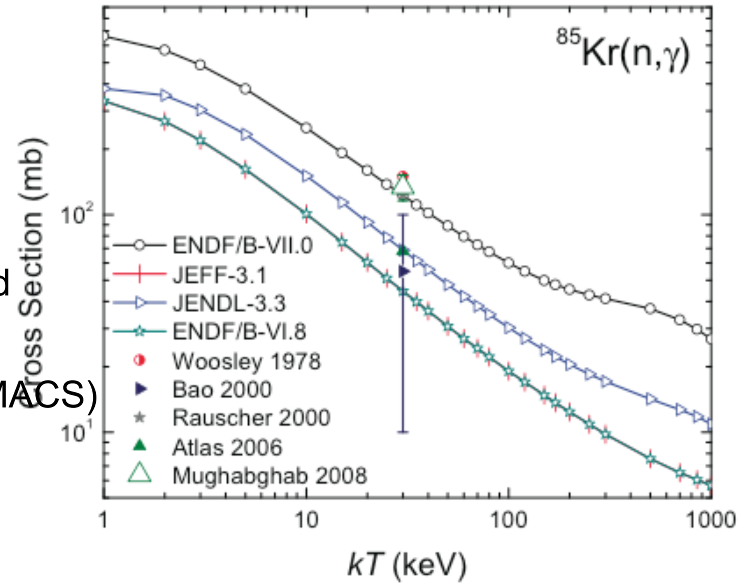
ADNDT in press

Background:

ENDF (and other reaction libraries – JENDL, JEFF …) used by basic and applied nuclear science communities

Bao & Kaeppeler collection of neutron-induced reaction rates used by nuclear astrophysics community (also KADONIS rate library)

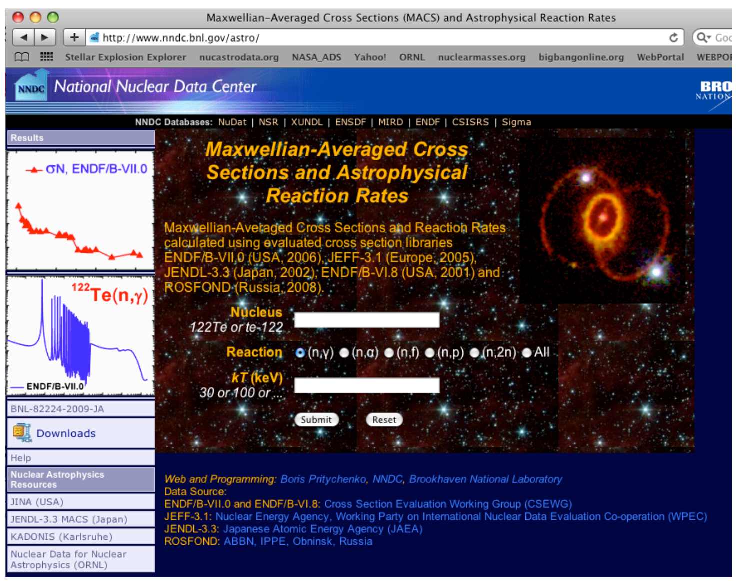
comparing reaction rates / maxwellian-averaged cross sections (MACS) from the two sources is valuable



This study:

generate MACS from ENDF, JENDL, JEFF
and compare with Bao & Kaeppeler, with Mughaghab …

information also posted on NNDC website



Results:

most cases have good agreement

cases with discrepancies are discussed in detail;
no single point of failure of ENDF or other libraries

will lead to improvements in next ENDF release & in rates used for astro studies

National Nuclear Data Center
BROOKHAVEN NATIONAL LABORATORY

Brookhaven National Laboratory -- Boris Pritychenko

Project: Calculation of MACS from ROSFOND

Background:

ROSFOND is a Russian library of neutron-induced reactions optimized for reactors, combining information from ENDF, JENDL, JEFF, BROND …

This study:

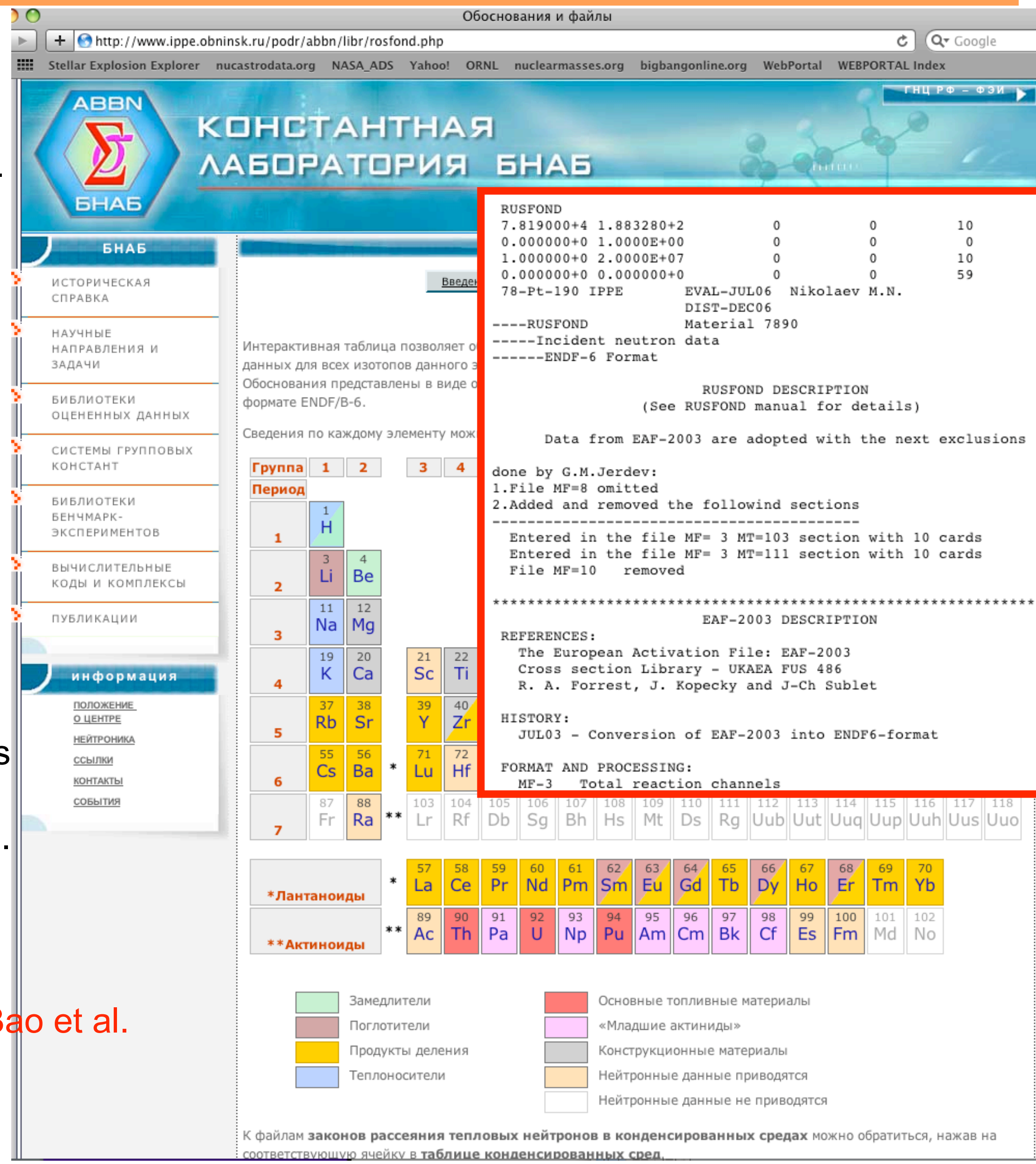
calculate MACS from ROSFOND

Results:

project completed

Follow up: coverage of n-induced reactions by ROSFOND and ENDF
ROSFOND: 96% of isotopes in Bao et al.
ENDF: ~ 80 % of isotopes in Bao et al.

NEW: combining ROSFOND and ENDF gives coverage of 98.3% of isotopes in Bao et al.



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

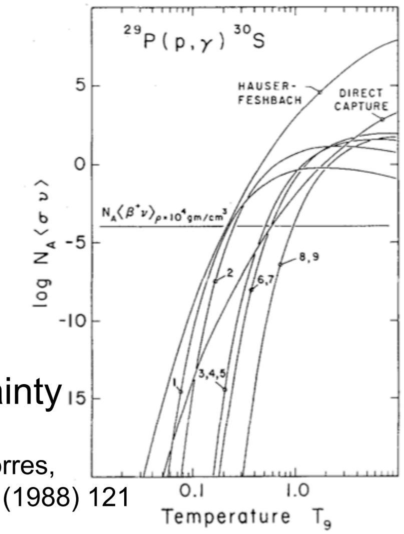
Project: Measurement of $^{32}S(p,t)^{30}S$ to determine $^{29}P(p,\gamma)^{30}S$ rate in novae

Background:

nucleosynthesis of silicon isotopes in novae uncertain by a factor of 1000-10000 *(Iliadis et al. Ap. J. Sup. 134 2001)*

$^{29}P(p,\gamma)^{30}S$ reaction rate crucial in Si isotope production

structure of ^{30}S above proton capture threshold uncertain, giving large rate uncertainty

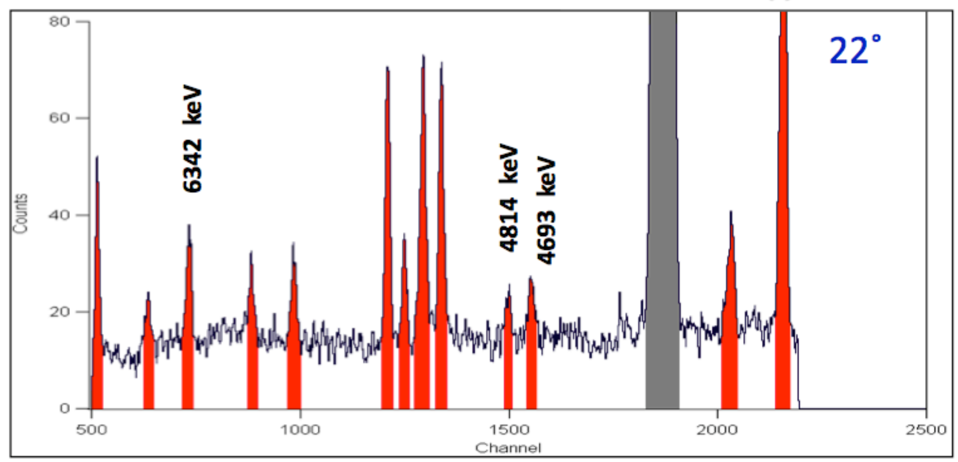


Wiescher & Gorres, Z. Phys. A 329 (1988) 121

Figure 1. Contributions to the reaction rate of $^{29}P(p,\gamma)^{30}S$. Also shown is the Hauser-Feshbach rate of ref. [3].

This study:

use $^{32}S(p,t)^{30}S$ to study level structure of ^{30}S above (p,γ) threshold;
measurement at Yale University



Results:

data under analysis
level assessments to follow

TABLE 10—Continued (Iliadis et al. Ap. J. Sup. 134 2001)

E_x (keV) (1)	E_R^{cm} (keV) (2)	J^π_n (3)	C^2S (4)	l_R (5)	Γ_p (eV) (6)	Γ_γ (eV) (7)	$\omega\gamma$ (eV) (8)
$^{29}P(p,\gamma)$:							
(4733)[n]	333.0	(3_1^+)	0.04[o]	2	9.1×10^{-5}	4.9×10^{-3}	1.5 × 10
(4888)[n]	488.0	(2_3^+)	0.11[o]	2	2.2×10^{-2}	4.2×10^{-3}	4.4 × 10
5145 *10*	745.0	(3_2^+)	0.02[p]	2	2.4×10^{-1}	8.2×10^{-3}	1.4 × 10
5288 *10*	888.0	(3_1^-)	0.36[o]	3	7.5×10^{-1}	9.4×10^{-3}	1.6 × 10
6117 *10*	1717.0	(1_1^-)	0.28[o]	1	1.9×10^{4}	8.2×10^{-1}	6.1×10^{-1}
6233 *10*	1833.0	(4_1^-)	0.35[o]	3	1.9×10^{2}	2.9×10^{-3}	6.5×10^{-3}

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

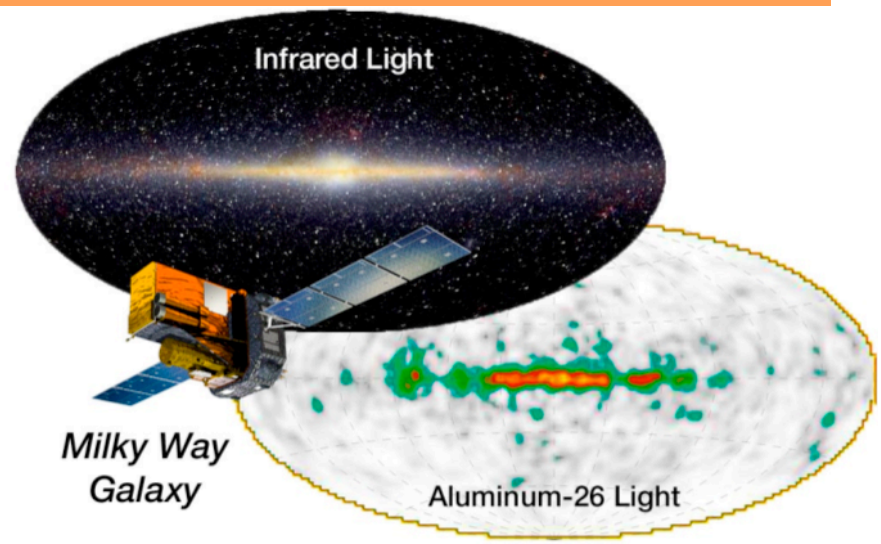
Project: Measurement of p(^{27}Si,^{26}Si*)d to determine ^{25}Al(p,γ)^{26}Si rate in novae

Background:

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

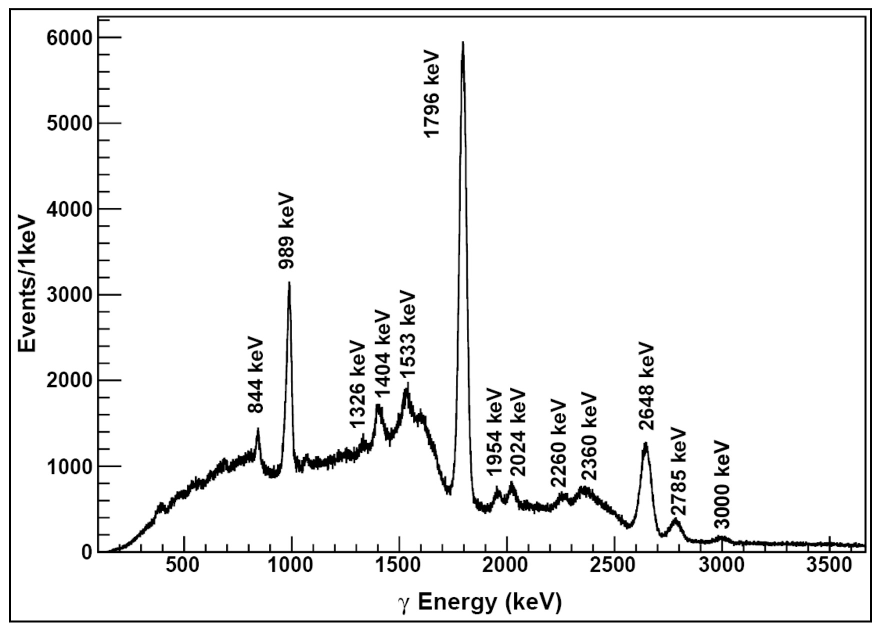
reactions that produce and destroy ^{26}Al are uncertain – including ^{25}Al(p,γ)^{26}Si

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



This study:

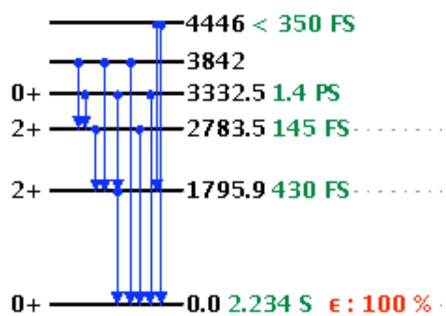
use (p,d) in inverse kinematics with ^{27}Si radioactive beam
to study level structure of ^{26}Si above (p,γ) threshold;
measurement of γ rays & recoils at MSU NSCL



Results:

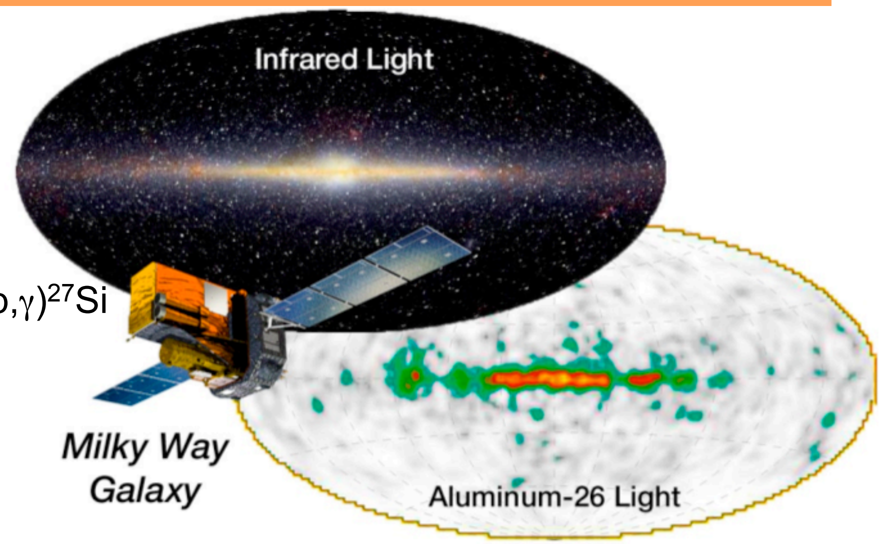
data under analysis

level assessments to follow



Oak Ridge National Laboratory -- Michael Smith, Caroline Nesaraja

Project: Measurement of $p(^{26}Al,^{26}Al)p$ & $d(^{26}Al,^{27}Al)p$ to determine $^{26}Al(p,\gamma)^{27}Si$ rate



Background:

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

reactions that destroy ^{26}Al are uncertain – especially $^{26}Al(p,\gamma)^{27}Si$

structure of ^{27}Si above proton capture threshold uncertain

This study:

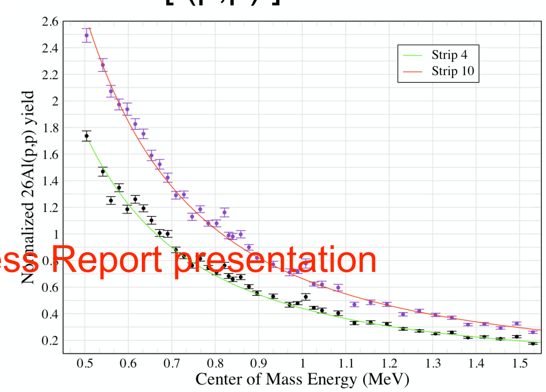
use radioactive ^{26}Al beam at ORNL HRIBF to measure (p,p) and (d,p) in inverse kinematics

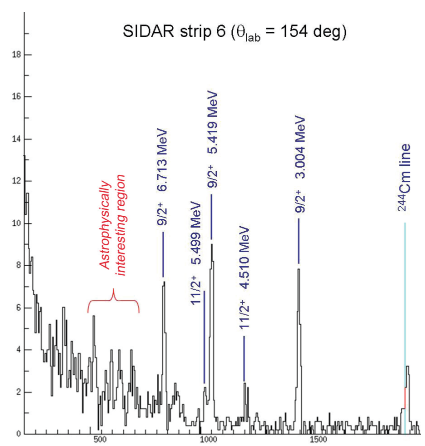
Results:

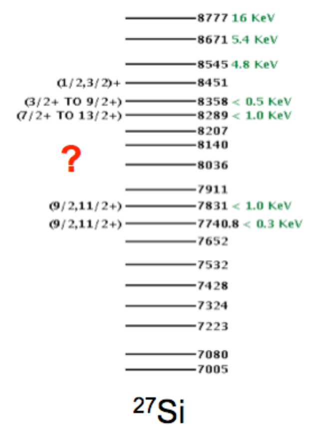
data under analysis – S. Pittman et al. [(p,p)] and S. Pain et al. [(d,p)]

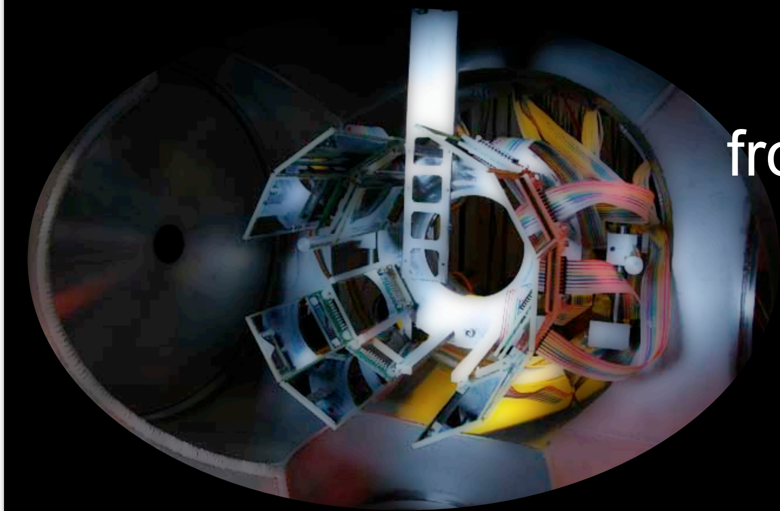
level assessments to follow

more details in ORNL Progress Report presentation

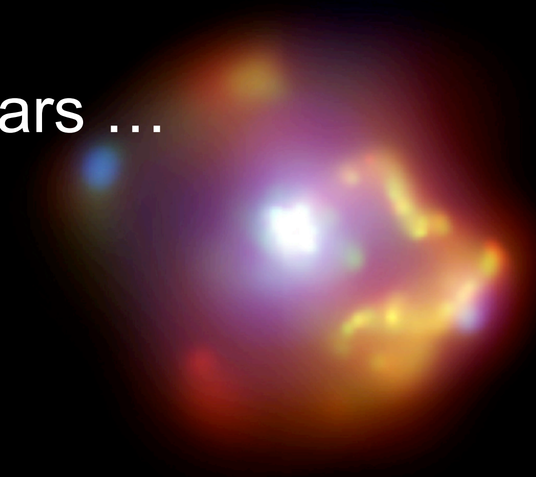






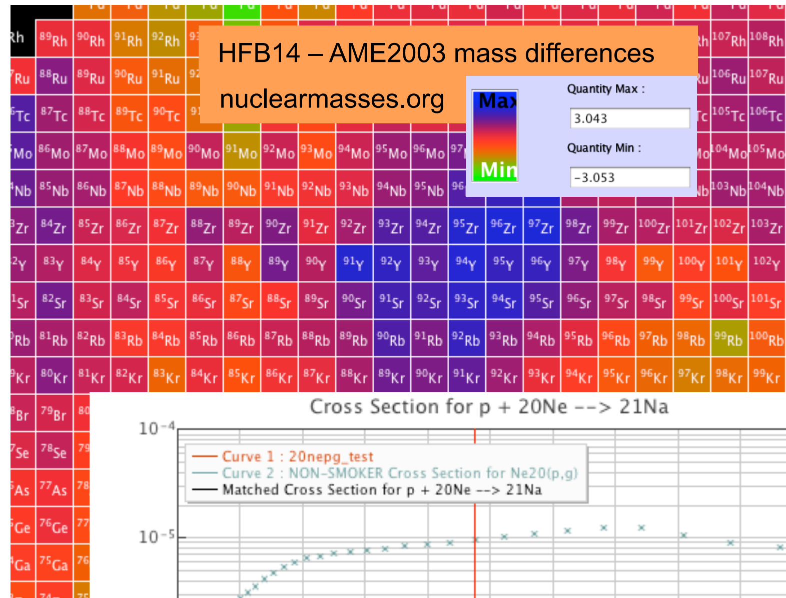


from the lab to the stars …



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

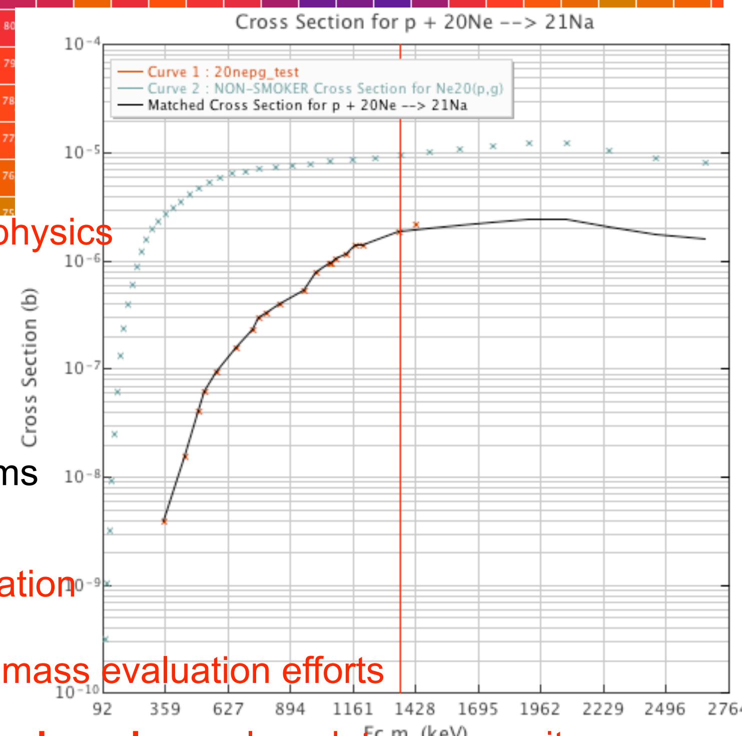
not easy to determine astrophysical impact of new nuclear physics information

This study:

continual improvements of 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 85 institutions in 22 countries use our online systems

details of recent improvements in ORNL Progress Report presentation

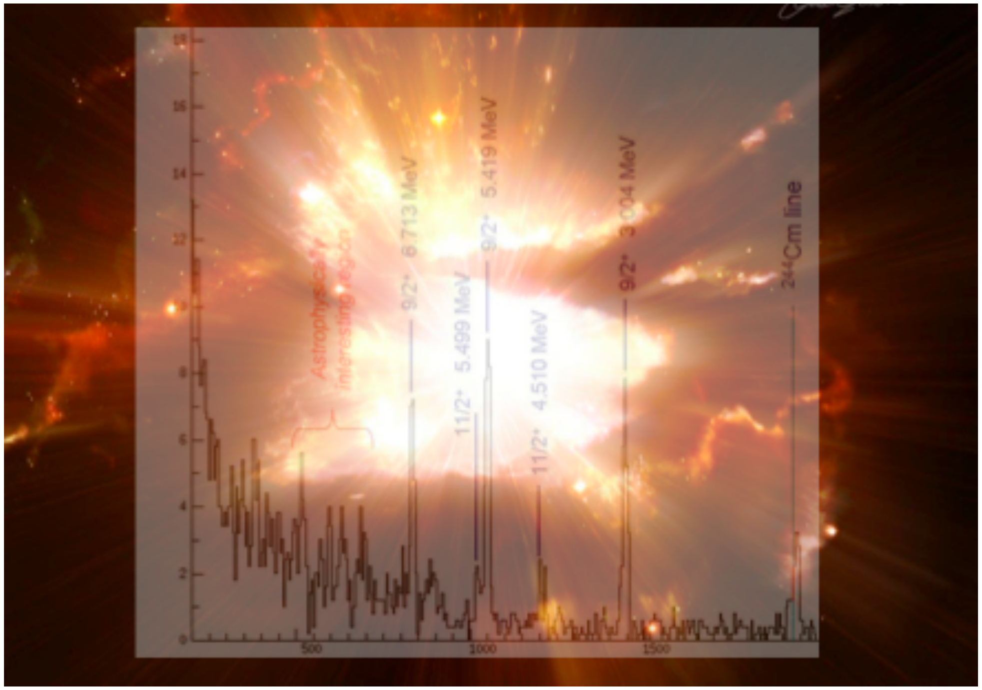
our nuclear mass software makes an excellent platform for future mass evaluation efforts

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

Task Force Activities

Early Years:

- Submitted proposal to DOE for supplemental effort
- Wrote survey of resources in nuclear data community relevant for nuclear astrophysics



Recent years:

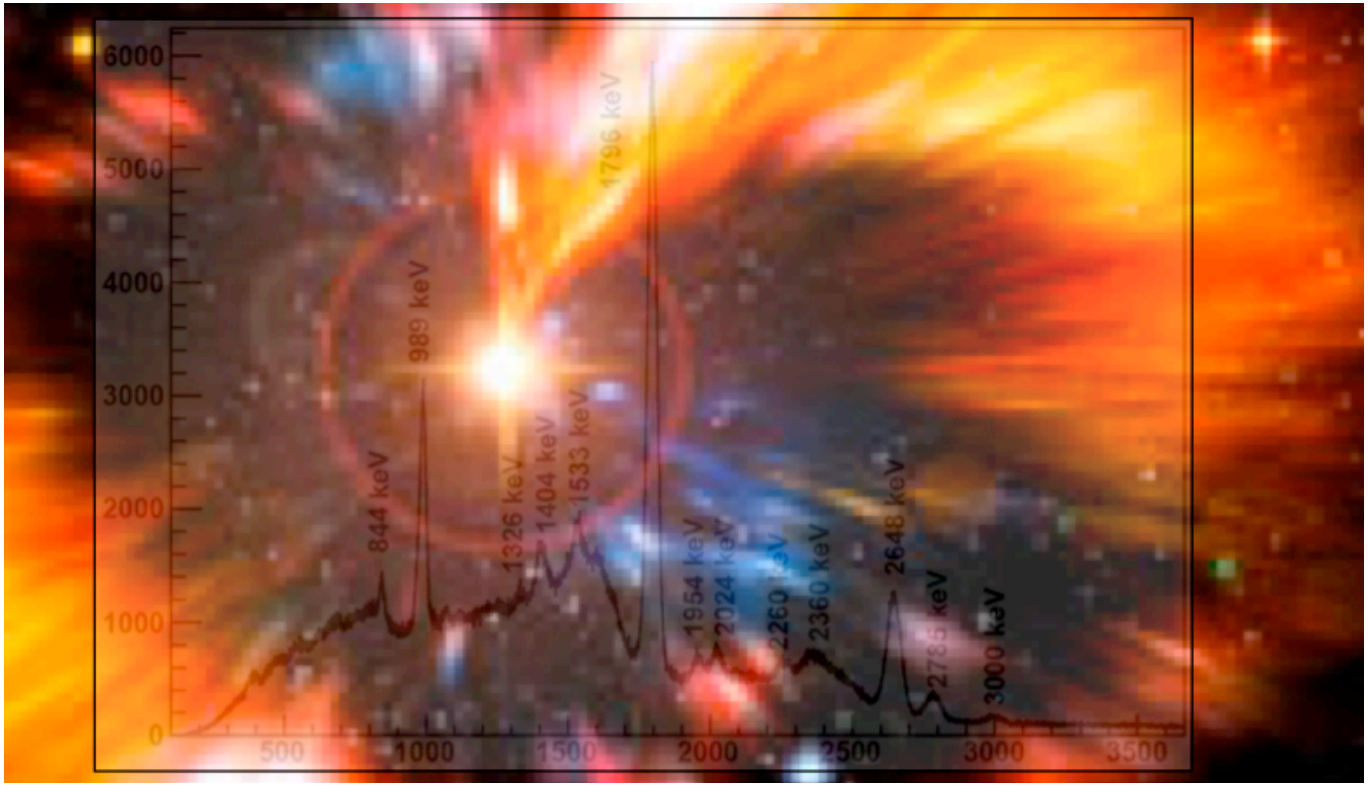
- Annual Summary of USNDP work relevant for astrophysics

This year:

- Add a mid-year update of astro projects
- Post summaries on USNDP web page
- Advertise projects on other online astro data services

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 !