Astrophysics Task Force

Michael Smith
ORNL Physics Division

Motivation for Astrophysics Data Work

- Improved understanding of many astrophysical phenomena requires significantly improved nuclear data

- Substantial Experimental & Theoretical Programs devoted to this work in the U.S. (ANL, LANL, LBNL, Notre Dame, ORNL, **RIA**, Seattle, SNO, TUNL, Yale) and abroad …

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New measurements and theoretical calculations are not enough …

- New nuclear physics information can change our understanding of the Cosmos **ONLY** if this new information is properly **compiled**, **evaluated, processed**, & **distributed** to the research community
- A Brewing Crisis:
  - More measurements made with fewer evaluations
  - Long time lags between data production & incorporation into astro datasets

→ **Corrective action** needed before datasets are totally outdated

Astrophysics Task Force

Numerous USNDP institutions are addressing these important issues with nuclear astro data projects

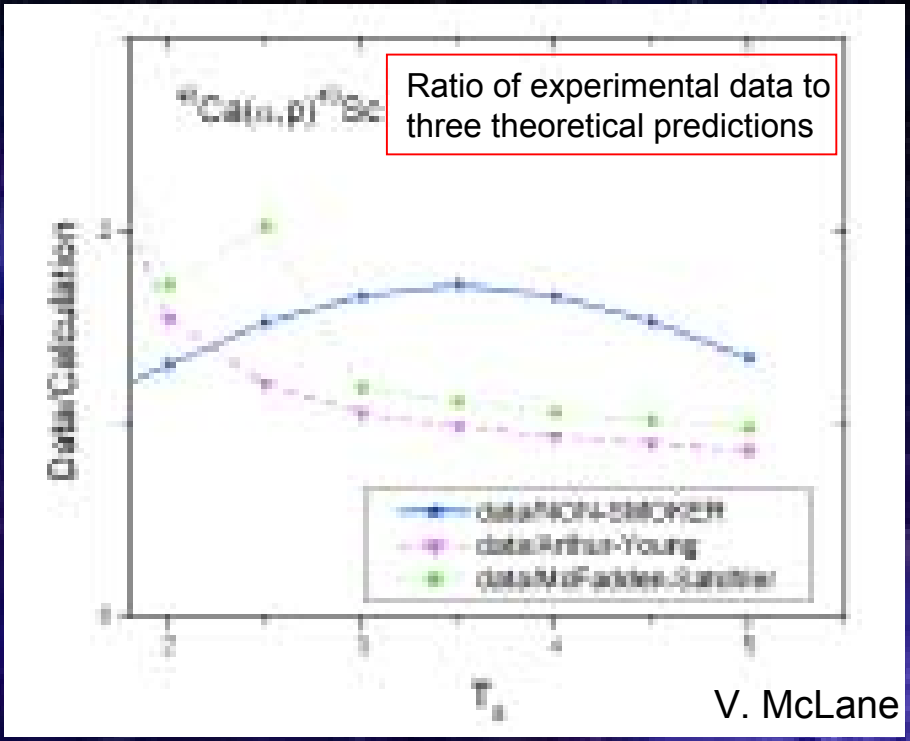
These activities often involve a focus on both nuclear reactions *and* nuclear structure

Recent Activities in

Compilations & Evaluations	BNL, LANL, McMaster, ORNL, TUNL
Development of Evaluation & Processing Tools	ANL, ORNL
Disseminations	ORNL
Nuclear Theory	LANL

Compilations & Evaluations

BNL



V. McLane

Study alpha-induced reaction cross sections on nuclei with Z < 32 [e.g., ^{44}Ca(α,γ) and ^{44}Ti (α,γ)]

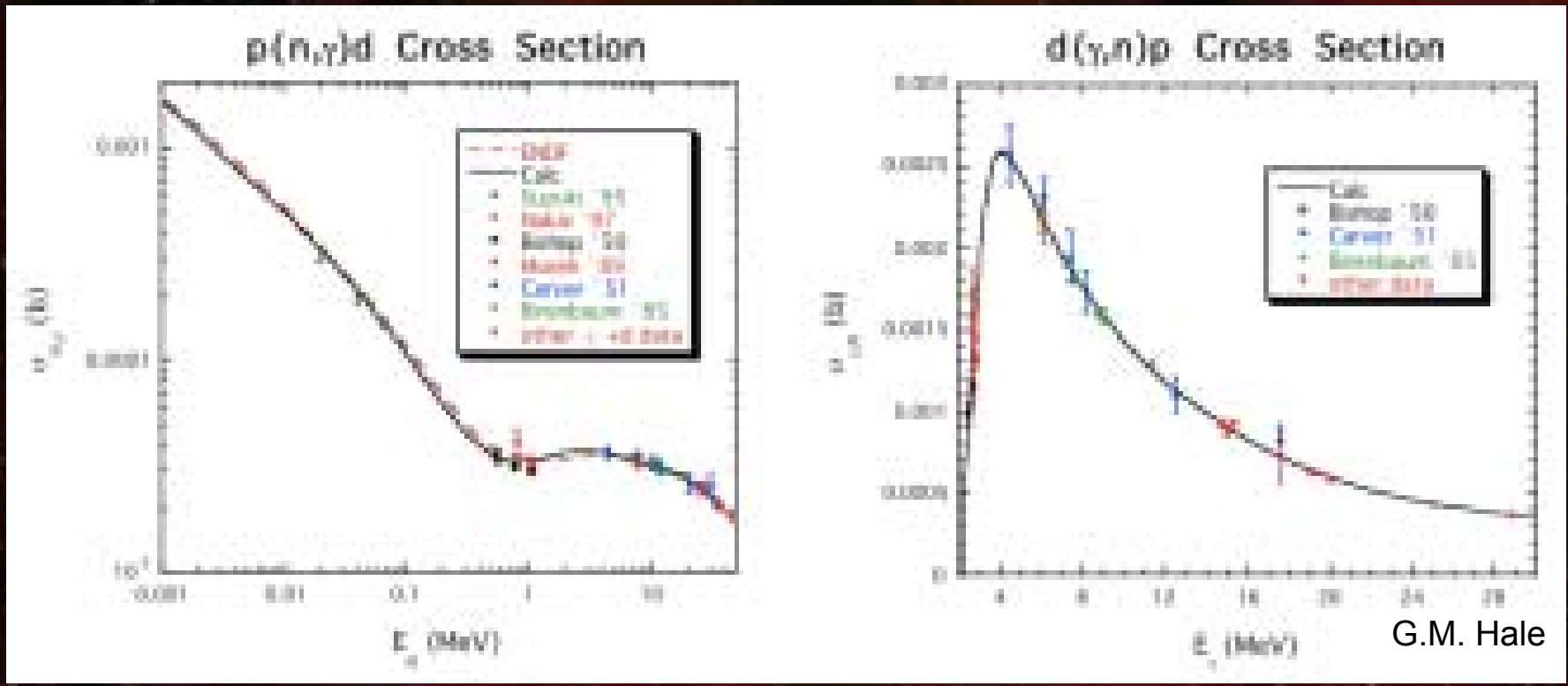
Collaboration with Former Soviet Union scientists (VNIIEF) & ORNL

Compilations, optical model fitting, and evaluations

Useful for producing improved alpha-nucleus potentials & reaction rates

Compilations & Evaluations

LANL



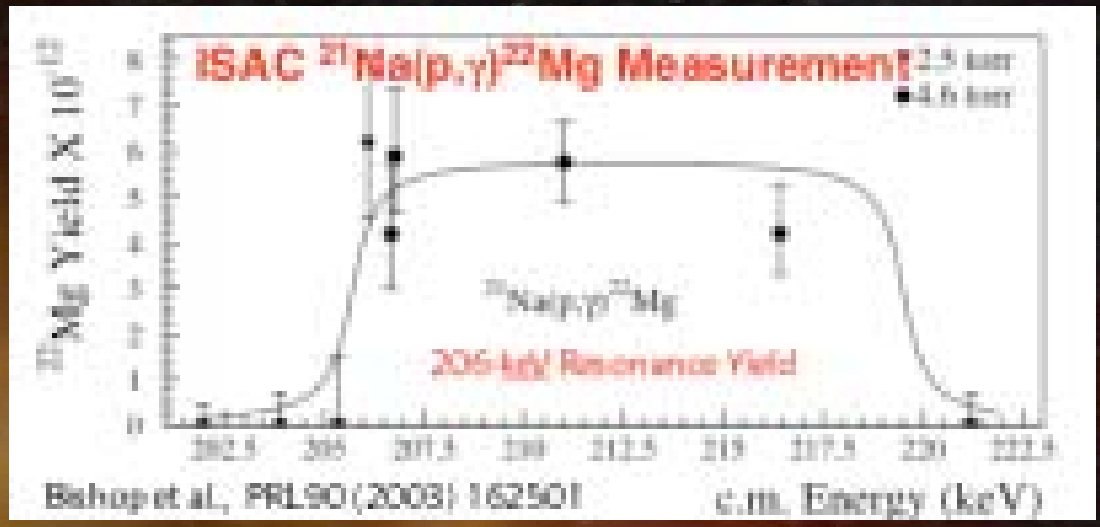
G.M. Hale

Evaluation of p(n,γ)d relevant for the Early Universe - folding in capture, deuteron disintegration, & NN scattering; uncertainties 0.2 - 2.5 %

In collaboration with ORNL, evaluation of $^{14}O(\alpha,p)^{17}F$ (from analysis of HRIBF $^{17}F+p$ data) for Novae & X-ray bursts

Compilations & Evaluations

McMaster University



Brand New Effort (Summer 2003) with Alan Chen

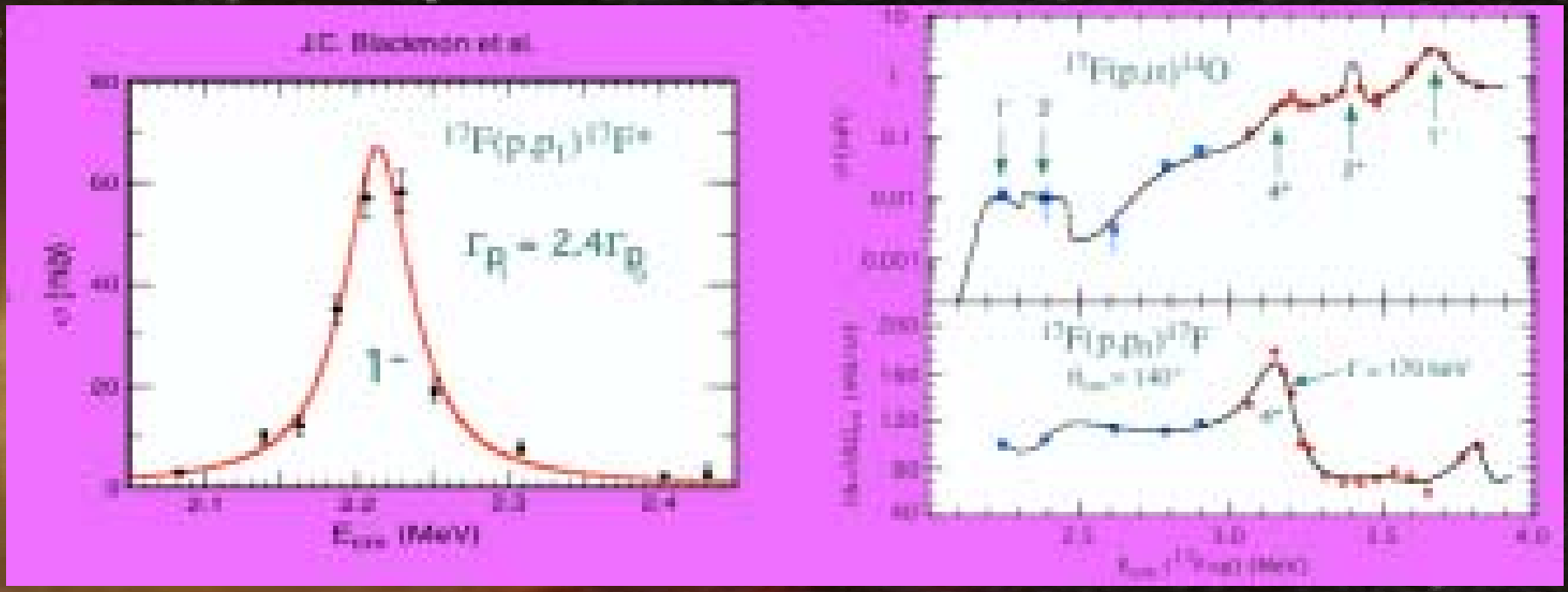
Focus on reactions involving radioactive nuclei important for stellar explosions - coupled to TRIUMF ISAC measurements

Reaction evaluations planned:

- Hot CNO cycle - $^{13}N(p,\gamma)^{14}O$
- Hot CNO Breakout - $^{15}O(\alpha,\gamma)^{19}Ne$, $^{19}Ne(p,\gamma)^{20}Na$, $^{18}Ne(\alpha,p)^{21}Na$
- Radionuclide production in novae - $^{21}Na(p,\gamma)^{22}Mg$ and $^{25}Al(p,\gamma)^{26}Si$

Compilations & Evaluations

ORNL



Explosive Nucleosynthesis Reactions in Novae & X-ray Bursts

- $^{14}O(\alpha,p)^{17}F$ reaction & ^{18}Ne level structure
- $^{18}F(p,\alpha)^{15}O$ & $^{18}F(p,\gamma)^{15}O$ reactions & ^{19}Ne level structure
- $^{30}P(p,\gamma)^{31}S$ reaction & ^{31}S level structure
- $^{33,34}Cl(p,\gamma)^{34,35}Ar$ reactions & $^{34,35}Ar$ level structure

Also: $^{17}O(p,\alpha)^{14}N$ & $^{17}O(p,\gamma)^{18}F$ evaluations for Red Giants & Novae

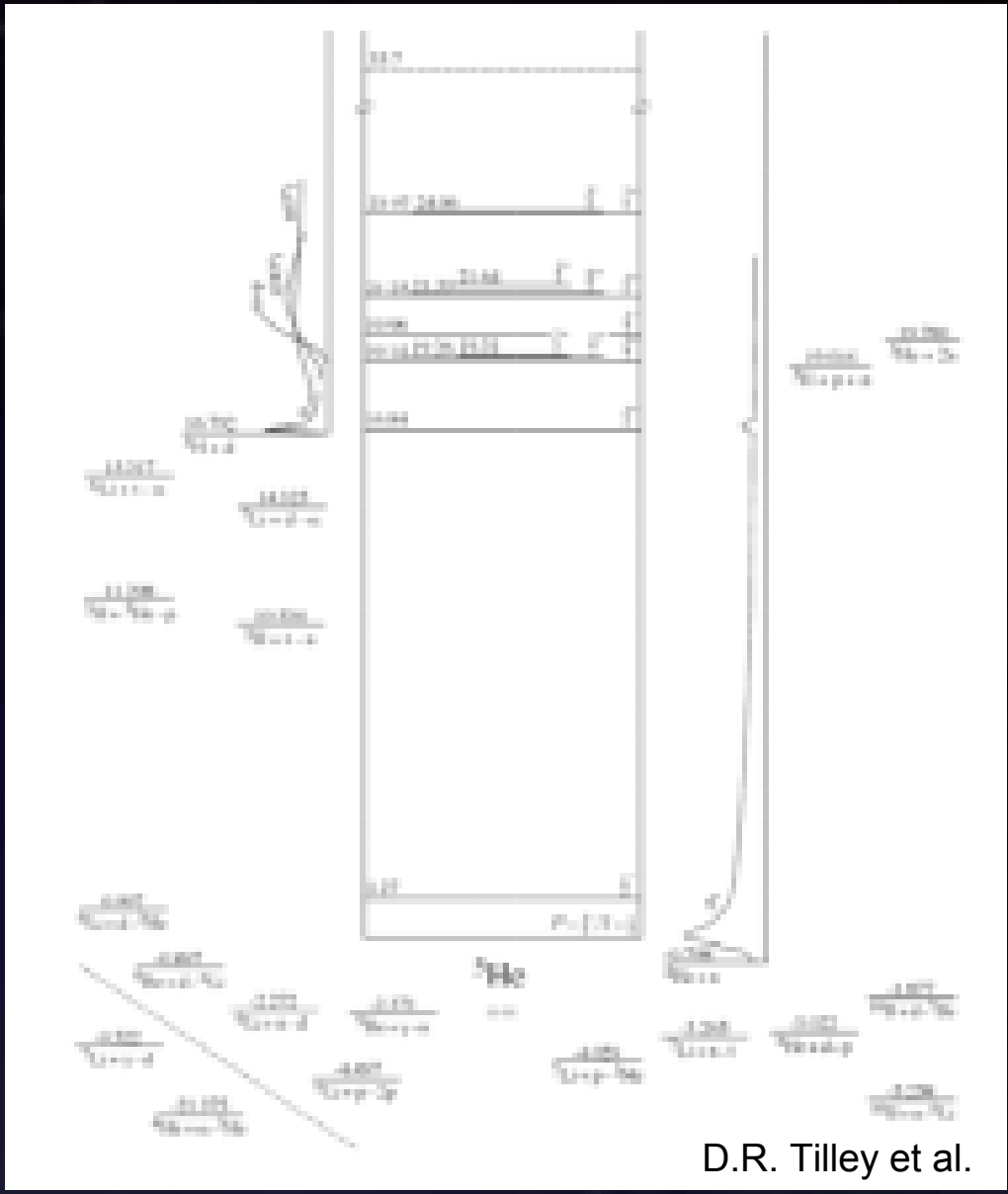
Compilations & Evaluations

TUNL

A = 5 - 7 Evaluation from the TUNL Nuclear Data Evaluation Project [Nucl. Phys. **A708** (2002) 3]

Implications for light element formation in the Early Universe & in Stars - via reactions such as $^{3}He(d,p)^{4}He$, $t(d,n)^{4}He$ …

In Collaboration with Gerry Hale at LANL



D.R. Tilley et al.

A = 10 evaluation released August 2003 (preliminary version)

Development of Evaluation & Processing Tools

ANL

$$p_{log-normal}(x) = \frac{1}{\sqrt{2}\,\pi\beta x}\exp\left(-\frac{(\ln x-\alpha)^2}{2\beta^2}\right)$$

D.L. Smith et al.

Developed **lognormal techniques** to represent quantities (such as reaction rates) with large uncertainties that are manifestly positive

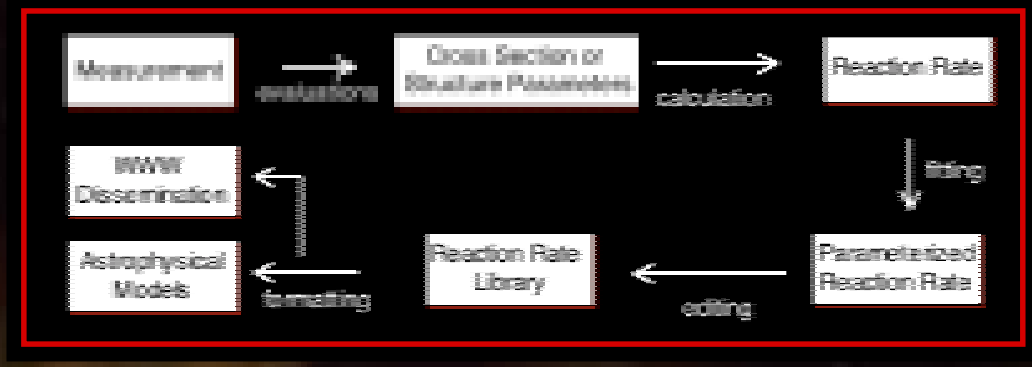
Focuses on using **confidence intervals** to represent uncertain data rather than mean values & standard deviations

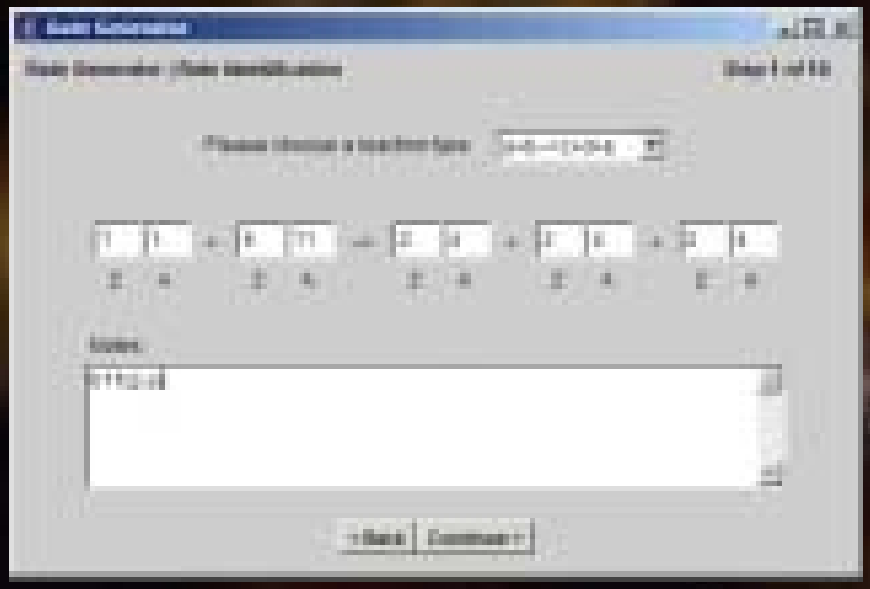
In collaboration with Hiram College

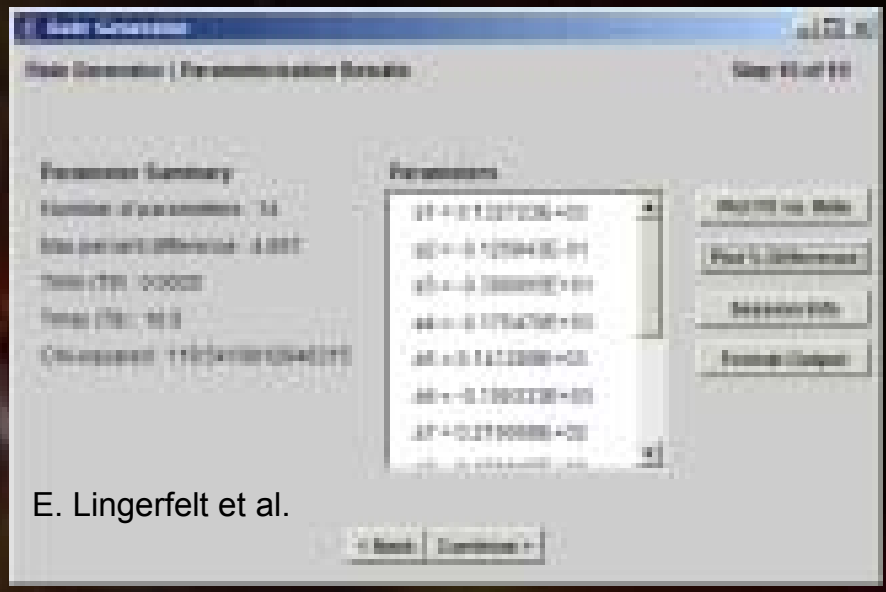
Relevant for ORNL Monte Carlo Nucleosynthesis project

Development of Evaluation & Processing Tools

ORNL







E. Lingerfelt et al.

Development of **new computational infrastructure** to facilitate incorporation of nuclear physics evaluations into astro models

Development of **Monte Carlo element synthesis techniques** to quantitatively determine influence of nuclear reaction rate uncertainties (from data evaluations) on astro predictions

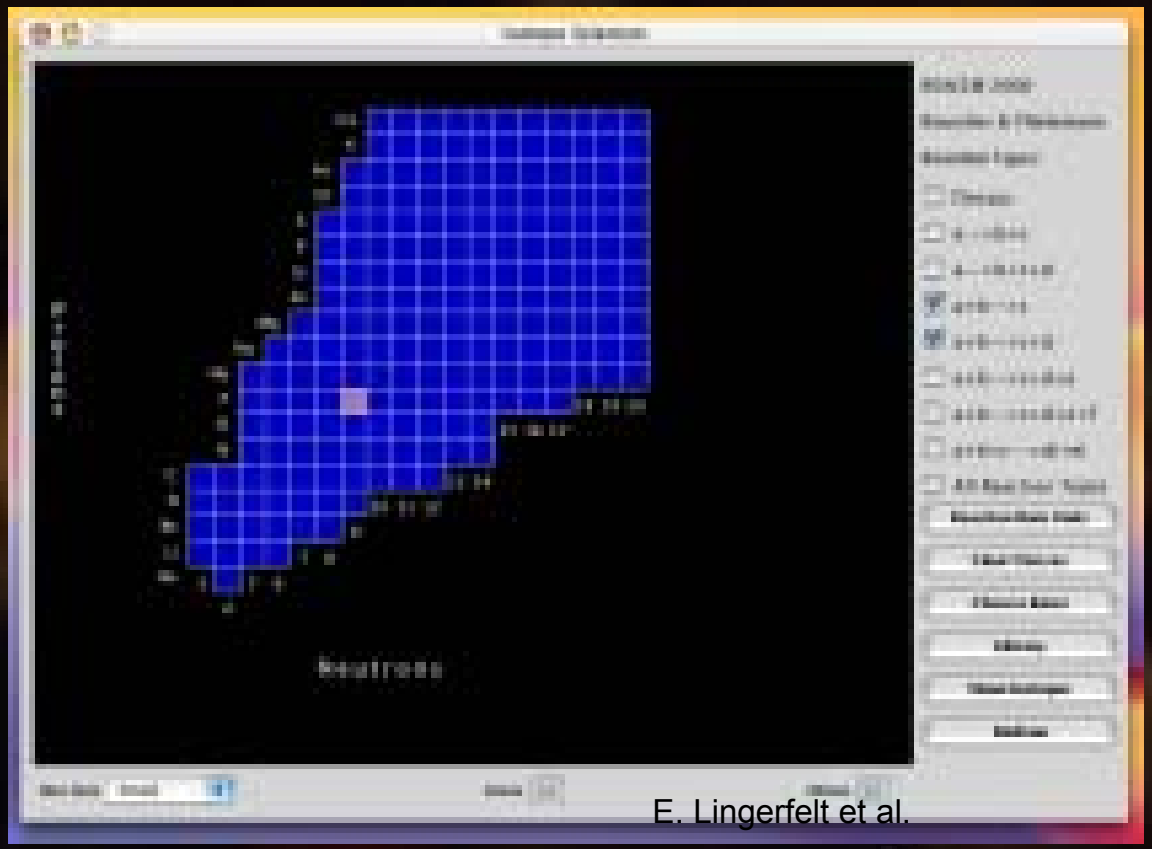
Disseminations

ORNL

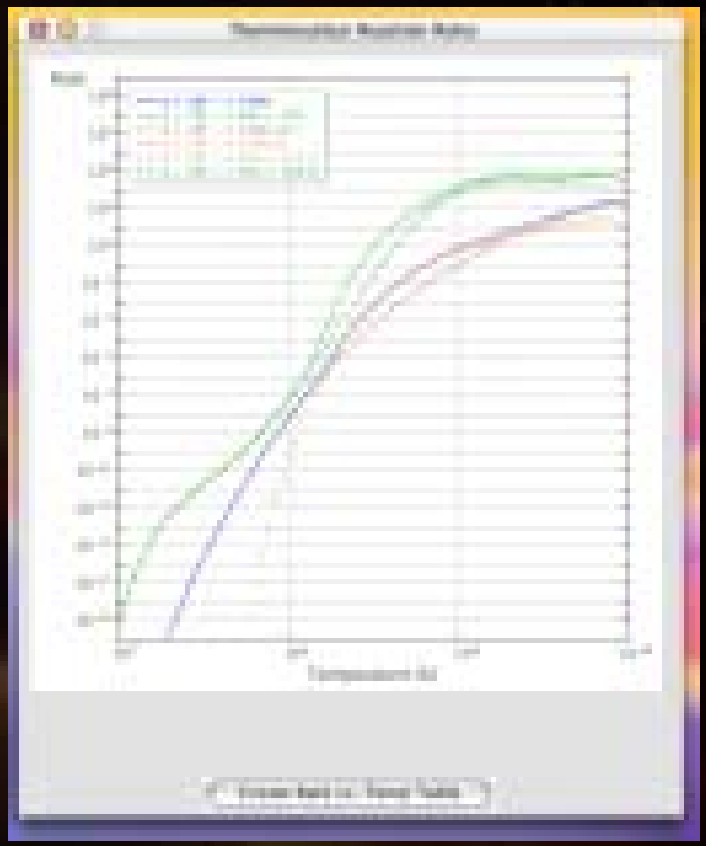
Launched new website **www.nucastrodata.org** to hyperlink all nuclear data sets relevant for nuclear astrophysics studies

Disseminations

ORNL



E. Lingerfelt et al.



Developed **RATEPLOTTER** to give quick, user-friendly access to over 60,000 thermonuclear reaction rates in the REACLIB library via your web browser

Nuclear Theory

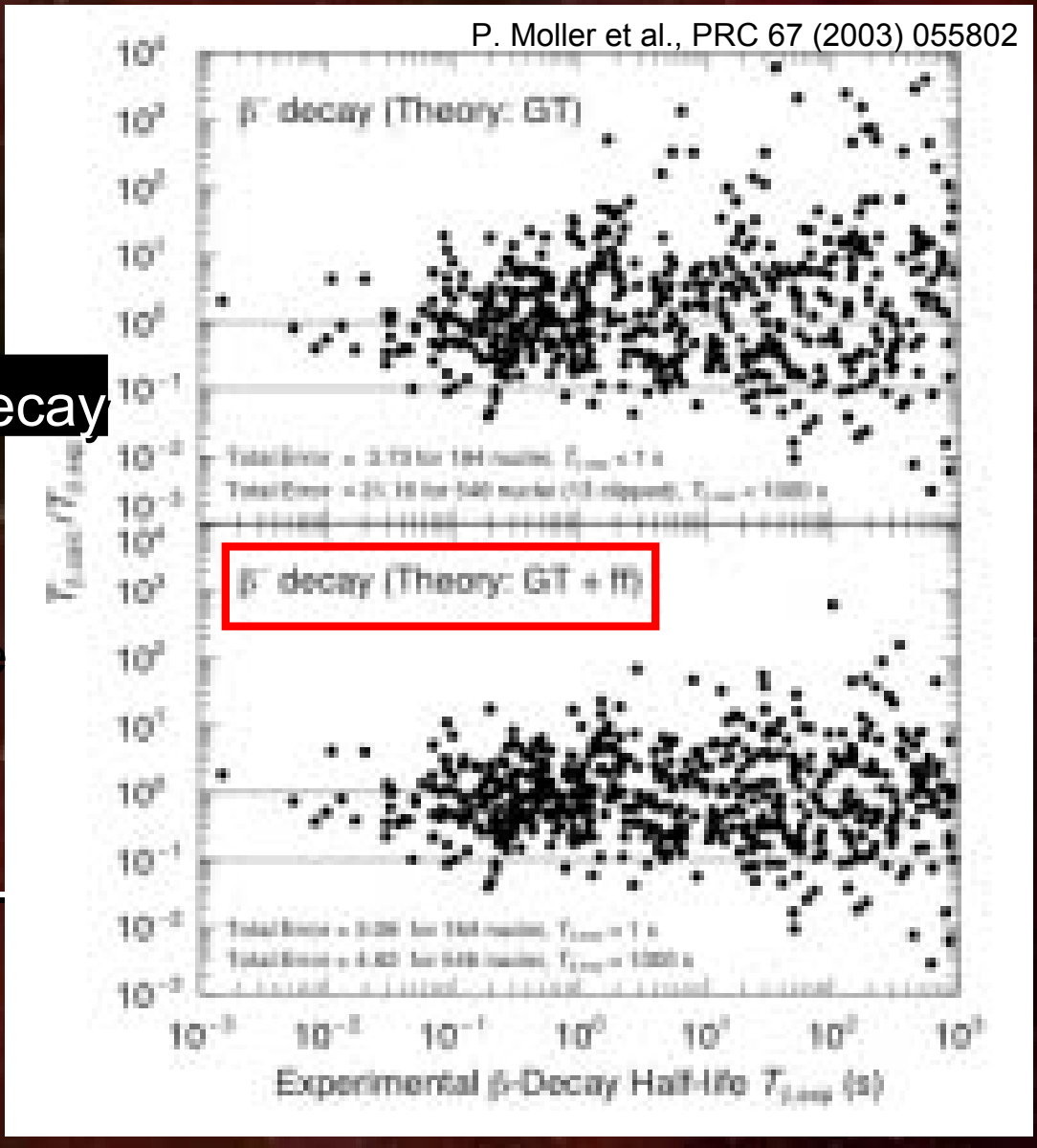
LANL

Improved global microscopic - macroscopic predictions of β decay with 1st forbidden transitions

Influences the time scale of r-process burning in supernovae (speeds it up)

Calculated β-decays of neutron-rich unstable nuclei $^{94\text{-}99}$Kr, $^{142\text{-}147}$Xe

P. Moller et al., PRC 67 (2003) 055802



New β-decay model & new study of fission barriers far from stability (multimillion grid point 5-D deformation spaces) may be used in cosmochronometer studies to estimate the age of the Universe

Summary

- Progress in understanding many astrophysical phenomena requires improved nuclear data

- Interesting, Important Astrophysics Projects involving
  - Structure & Reaction work
  - Compilations, Evaluations, Disseminations, Tool development, Theory
  - Multiple laboratories ANL, BNL, LANL, ORNL, & TUNL
  - Brand New Effort at McMaster

- New computational infrastructure project started at ORNL to ensure timely incorporation of evaluations in astro models