Computational Infrastructure for Nuclear Astrophysics

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overview

- to get the latest nuclear evaluations into astro simulations, evaluation, processing, & dissemination work is needed

- we have launched a new computational infrastructure online at **nucastrodata.org** to help

- one feature we wish to expand (with your advice) is a **nuclear data evaluator's toolkit** to help with evaluations

- the suite also enables Users to process evaluations into reaction rates, create libraries of rates for astro models, and run & visualize element synthesis calculations

- the suite can give **expose** a **new audience** - astrophysicists - to codes, datasets, and techniques from the nuclear reaction community

motivation
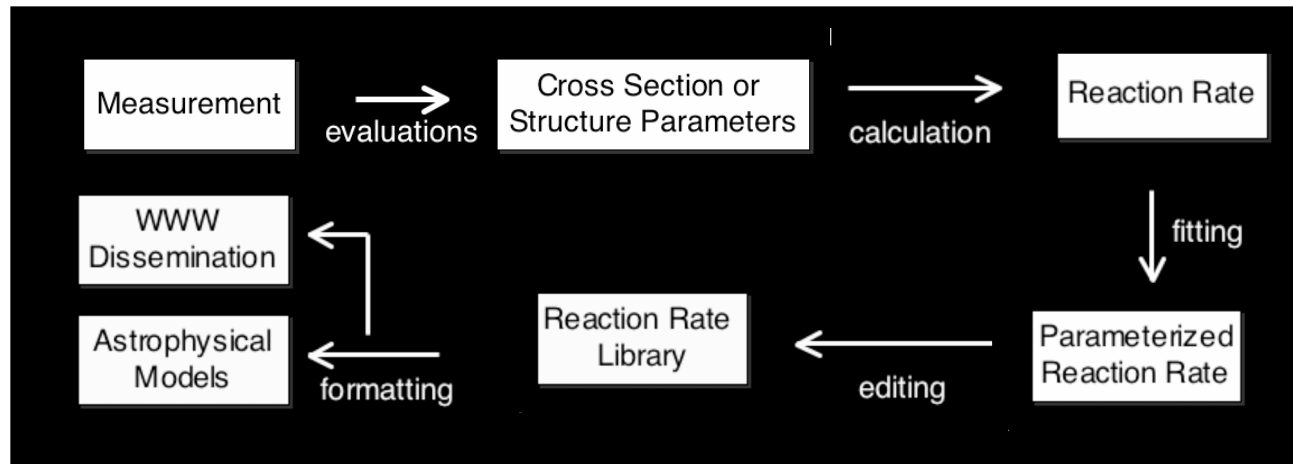
- Problem: **no quick, easy way** to insert latest nuclear physics evaluations into databases used in astro simulations

- The multiple steps were carried out with numerous incompatible codes often by many different researchers

motivation
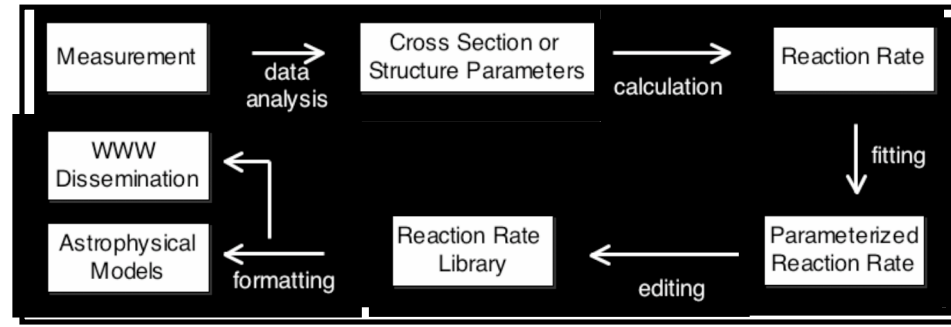
- Bottlenecks:

    - **multiple, incompatible codes**

    - **multiple researchers**

    - **no consistency or convenience**

⟶ Consequences

    - **long delays** in this processing of evaluations into astro models

    - different researchers obtain **inconsistent** results

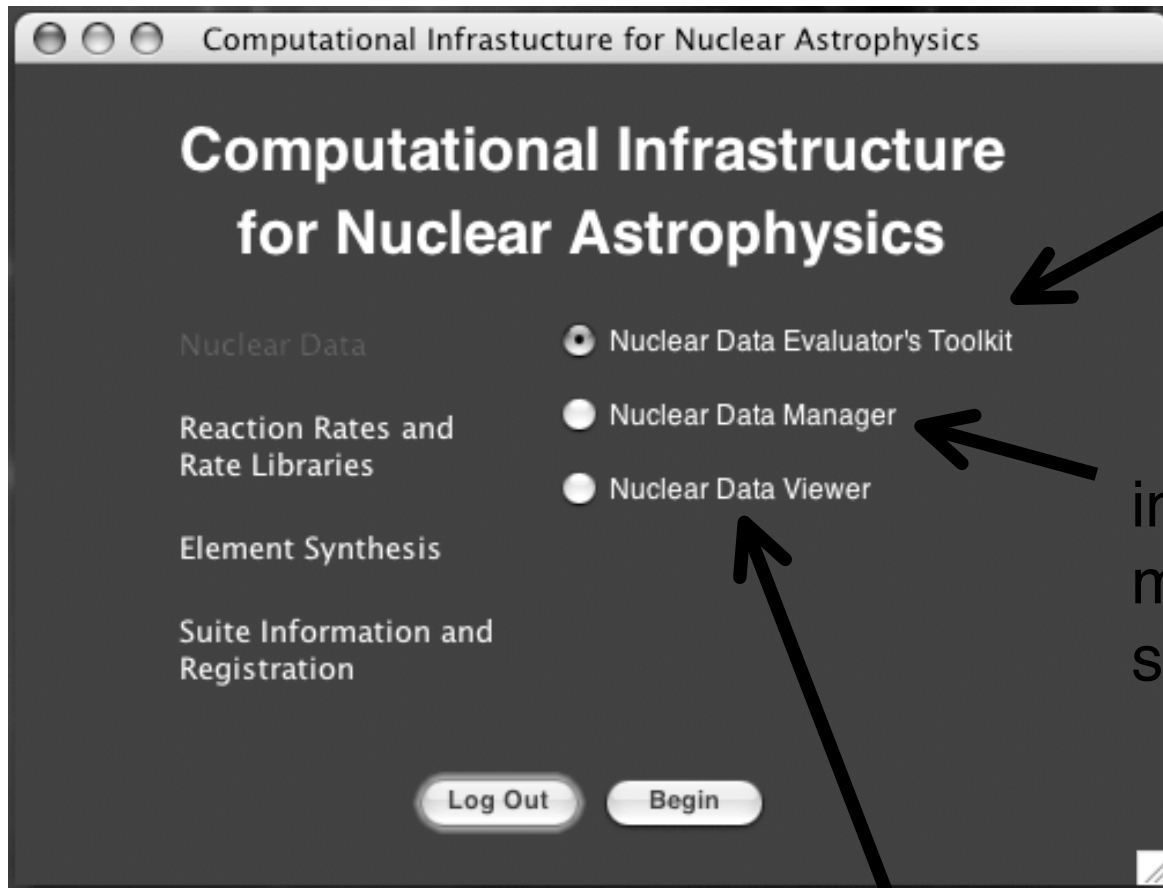   - so difficult to create custom libraries that they are **not shared**

approach

- design an easy-to-use, tightly integrated suite of codes enabling calculations, file management, & data visualization all related to nuclear astrophysics data needs

- empower the community to make their own datasets instead of waiting for someone else to do it!

- features database creation, storage, documentation, and sharing to enable researchers to easily compare simulations

- software solution to the problems of proprietary datasets and lack of timely updates

software suite

- Users download a 2.5 MB JAVA applet onto their computer

- requirements: JAVA and an internet connection

- applet provides an easy-to-use graphical interface to a set
of FORTRAN codes running on remote workstation

- Registered Users get access to all functions, private storage space

- Major functions divided into three areas:
  - Nuclear Data
  - Nuclear Reaction Rates & Rate Libraries
 - Element Synthesis Calculations

nuclear data functionality

Computational Infrastructure for Nuclear Astrophysics

Computational Infrastructure for Nuclear Astrophysics

Nuclear Data

Reaction Rates and Rate Libraries

Element Synthesis

Suite Information and Registration

○ Nuclear Data Evaluator's Toolkit

○ Nuclear Data Manager

○ Nuclear Data Viewer

Log Out   Begin

renormalize, extrapolate, merge cross sections & s-factors

input, store, manipulate, modify cross sections & s-factors

plot cross sections & s-factors, access information

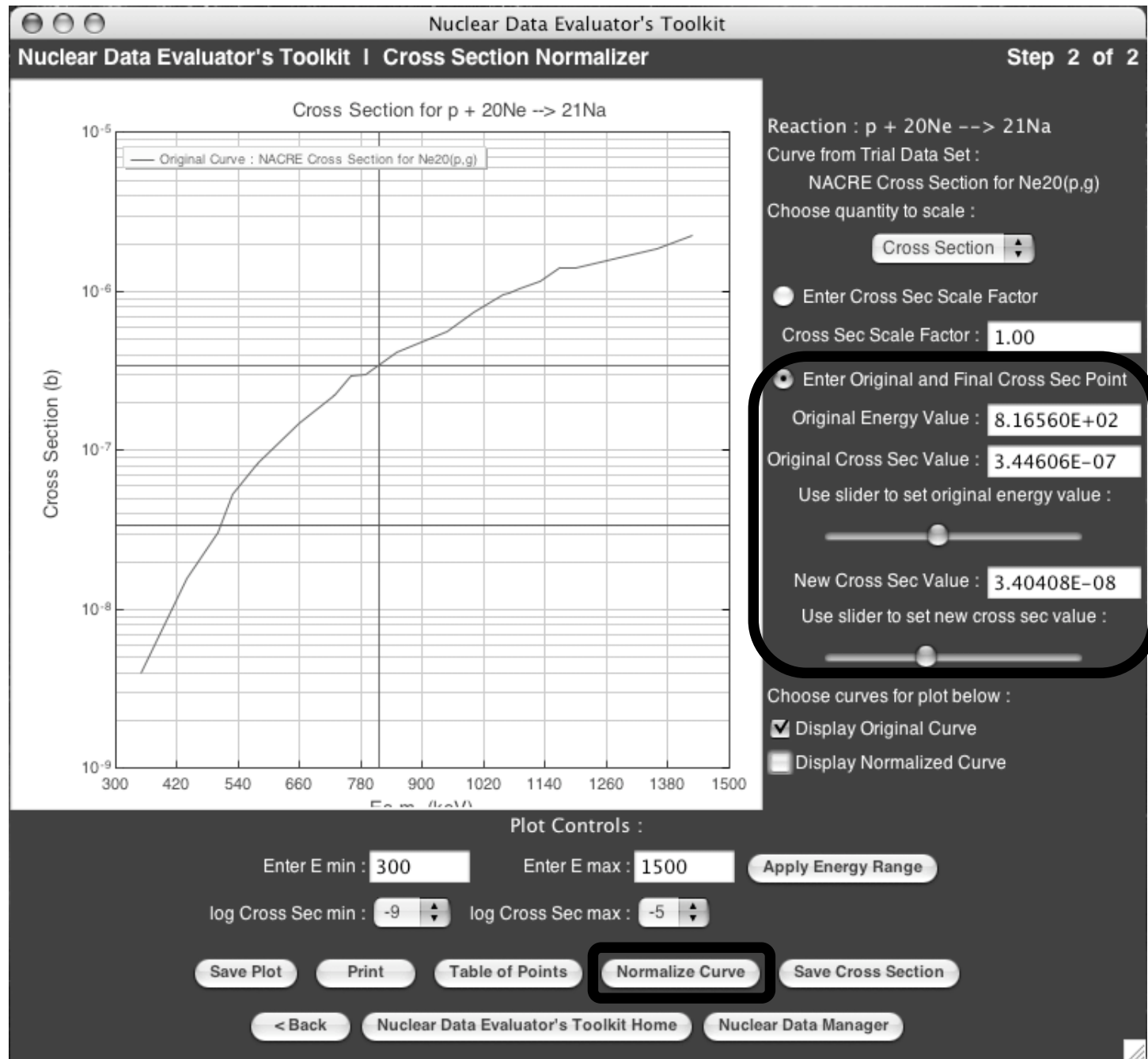# screenshot: extrapolator
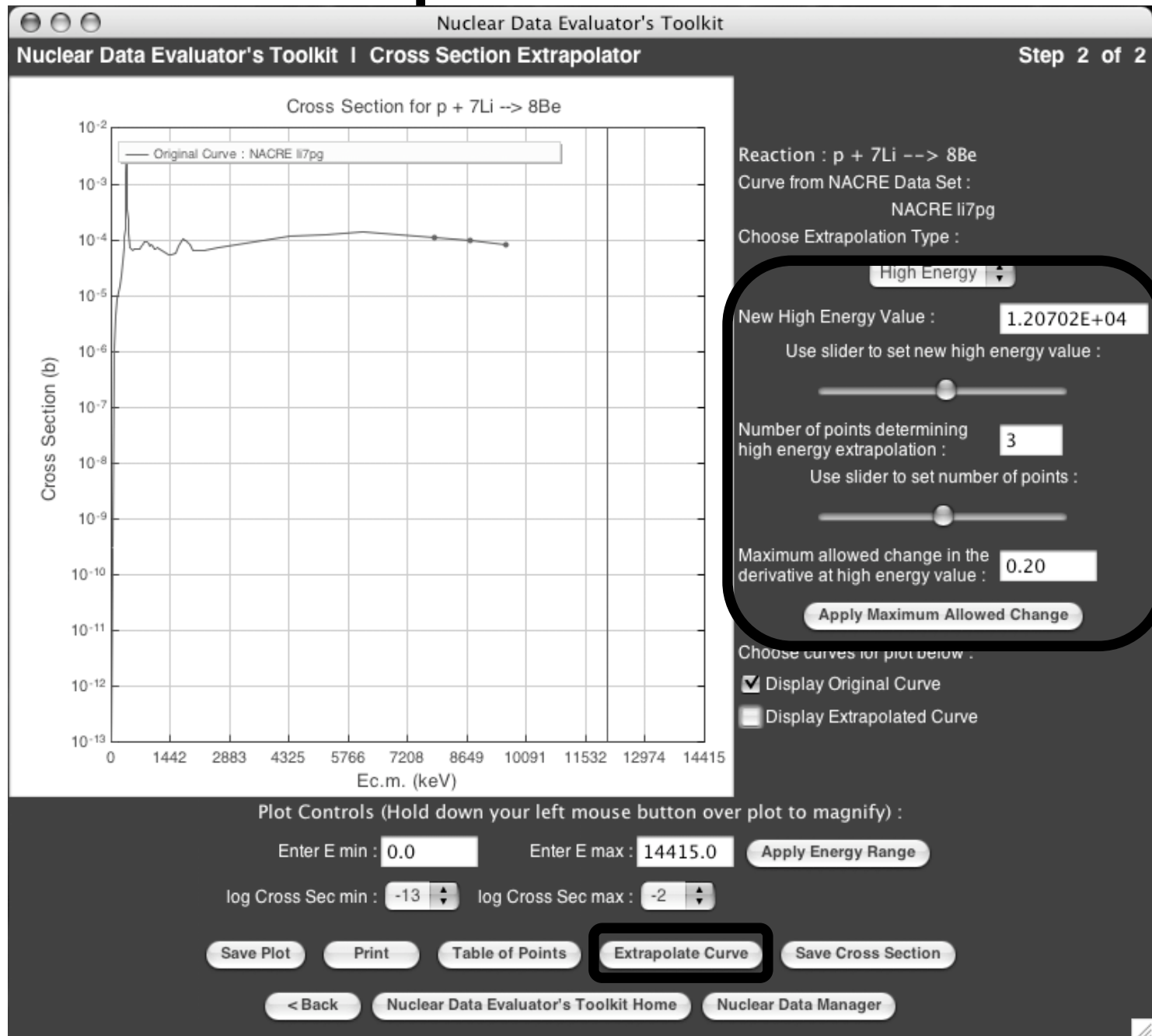
screenshot: extrapolator
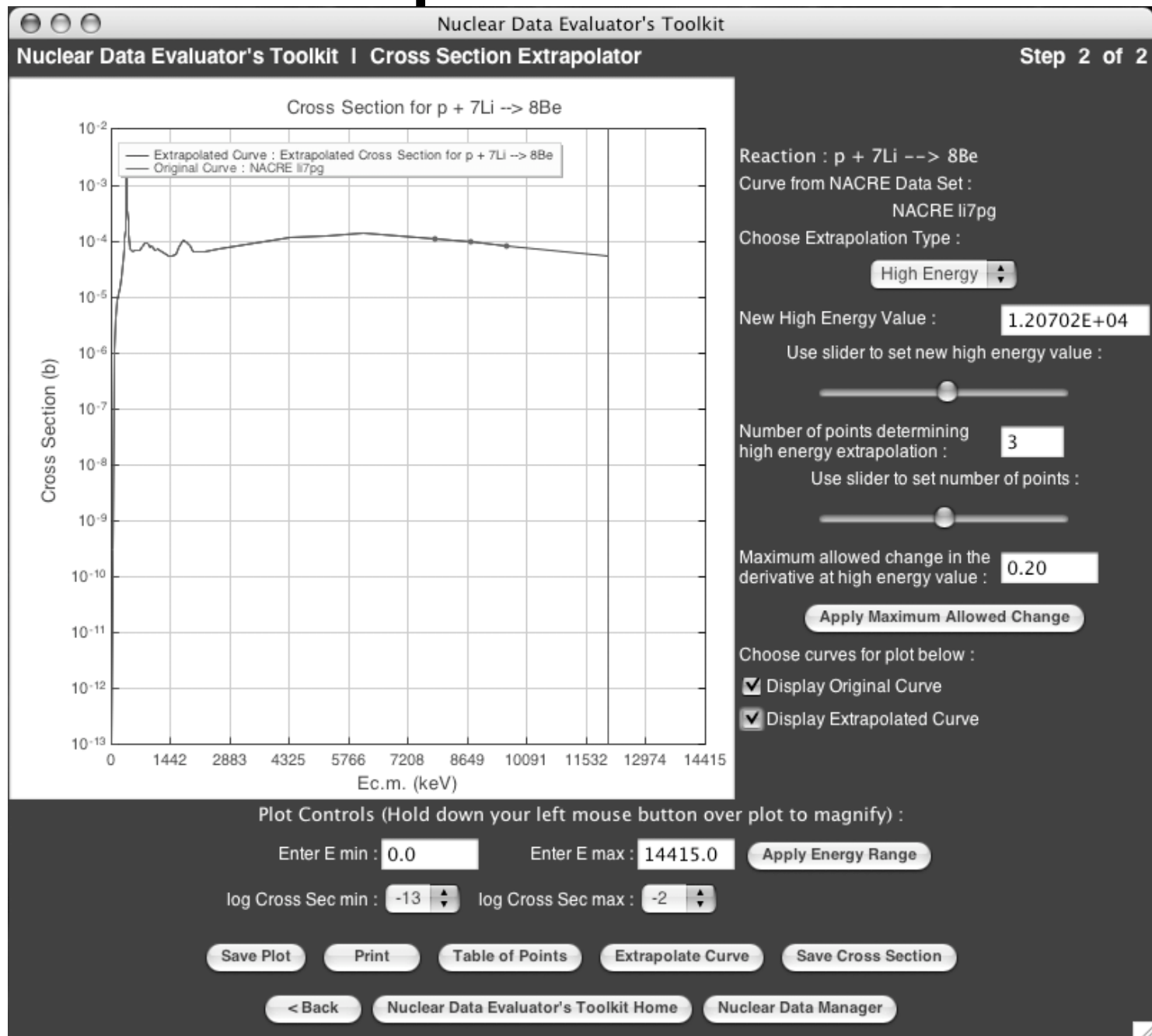
screenshot: cross section fuser
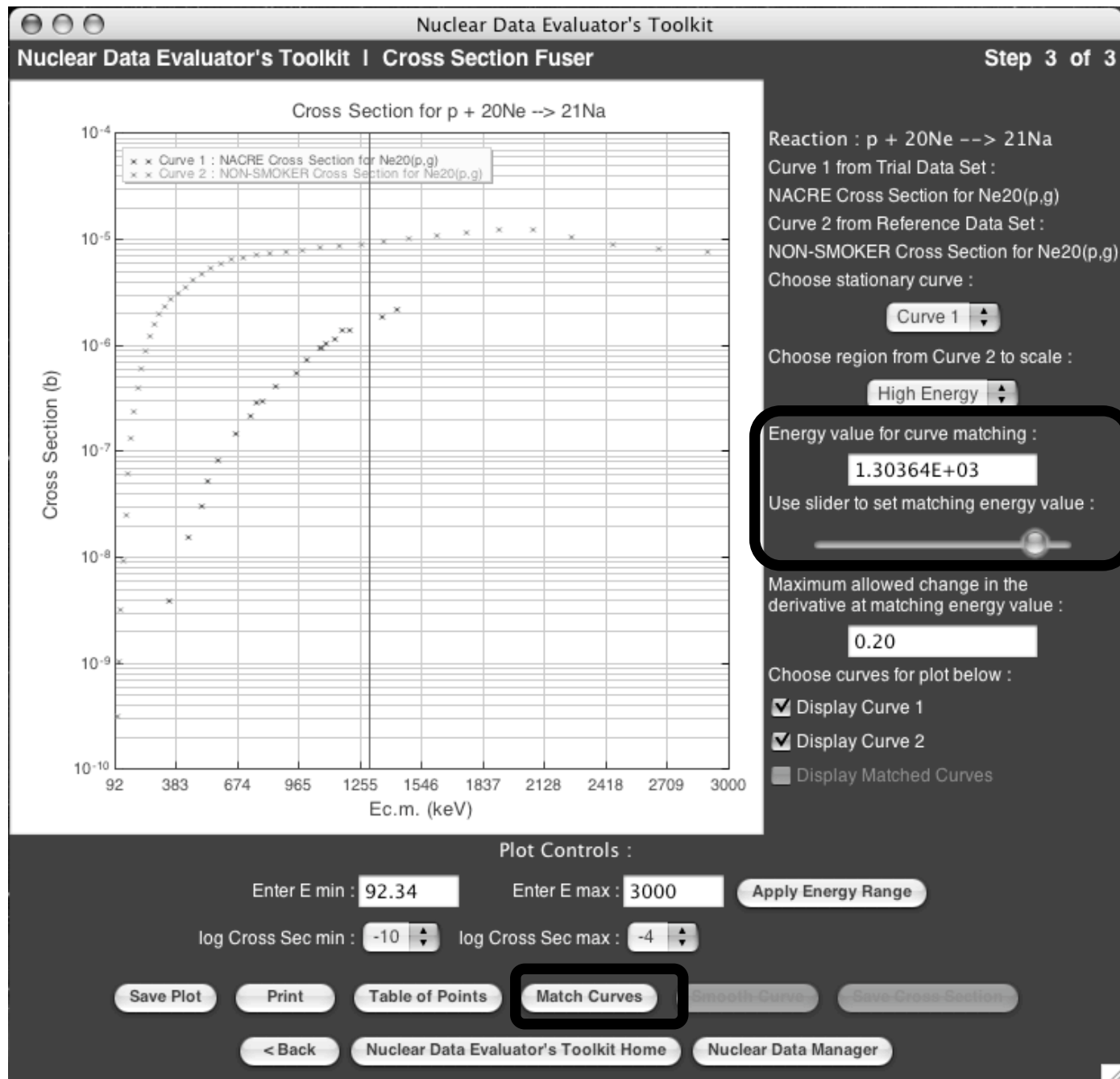
screenshot: cross section fuser
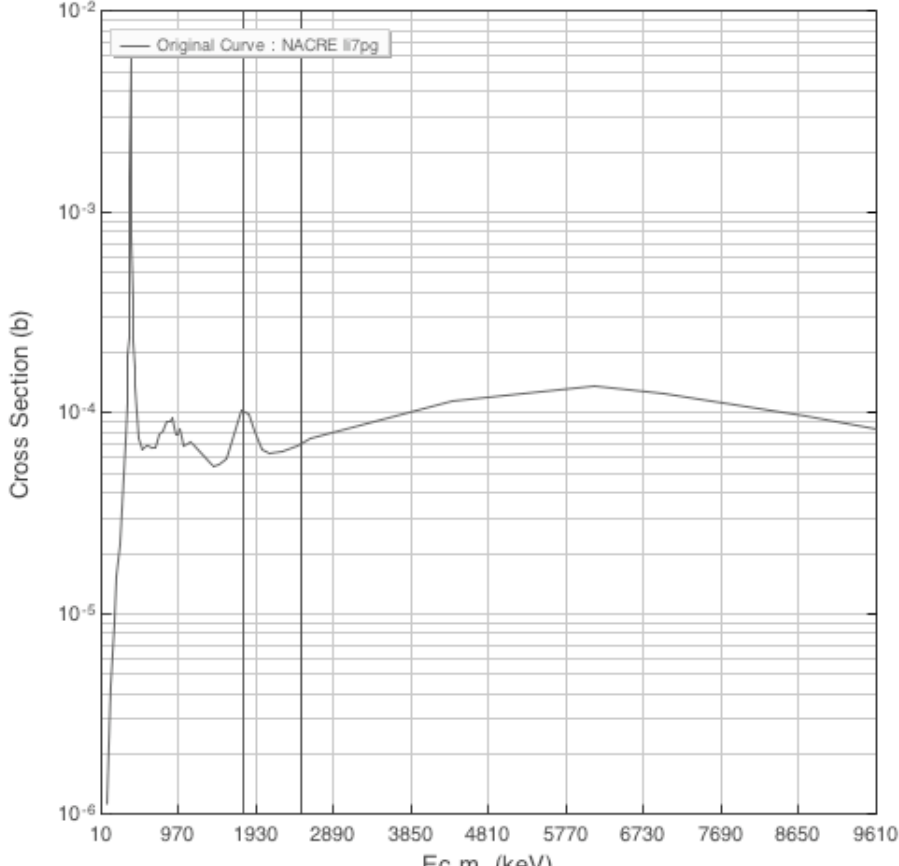
screenshot: normalizer

screenshot: normalizer

screenshot: gain normalizer

screenshot: gain normalizer

expanding our nuclear data functionality

- request feedback from Experts on

    - utility of these tools

    - suggested improvements

    - new tools to add to help Users with evaluations
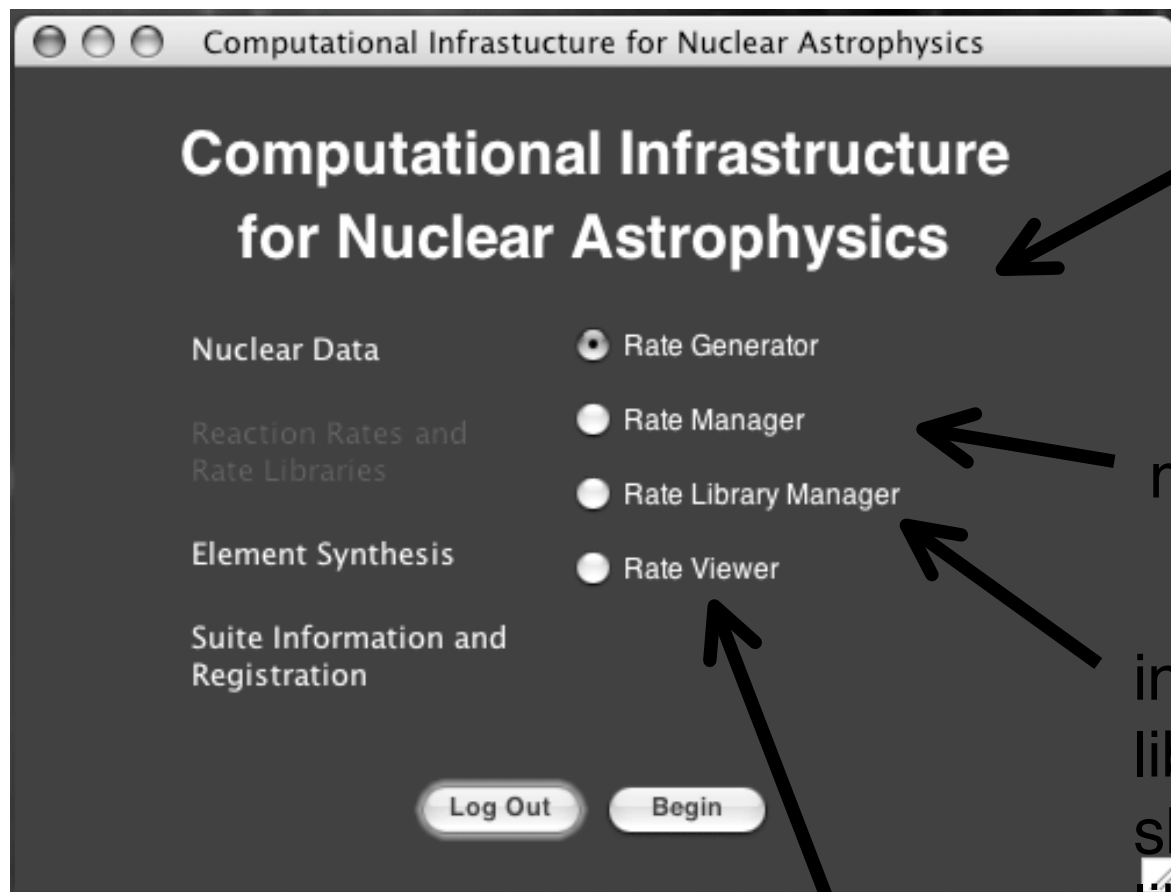
            - R-matrix code

            - Hauser-Feshbach codes and results

            - Peak fitting routines

            - General purpose fitting routines

reaction rate & rate library functionality

Computational Infrastructure for Nuclear Astrophysics

Computational Infrastructure for Nuclear Astrophysics

Nuclear Data

Reaction Rates and Rate Libraries

Element Synthesis

Suite Information and Registration

- ◉ Rate Generator
- ○ Rate Manager
- ○ Rate Library Manager
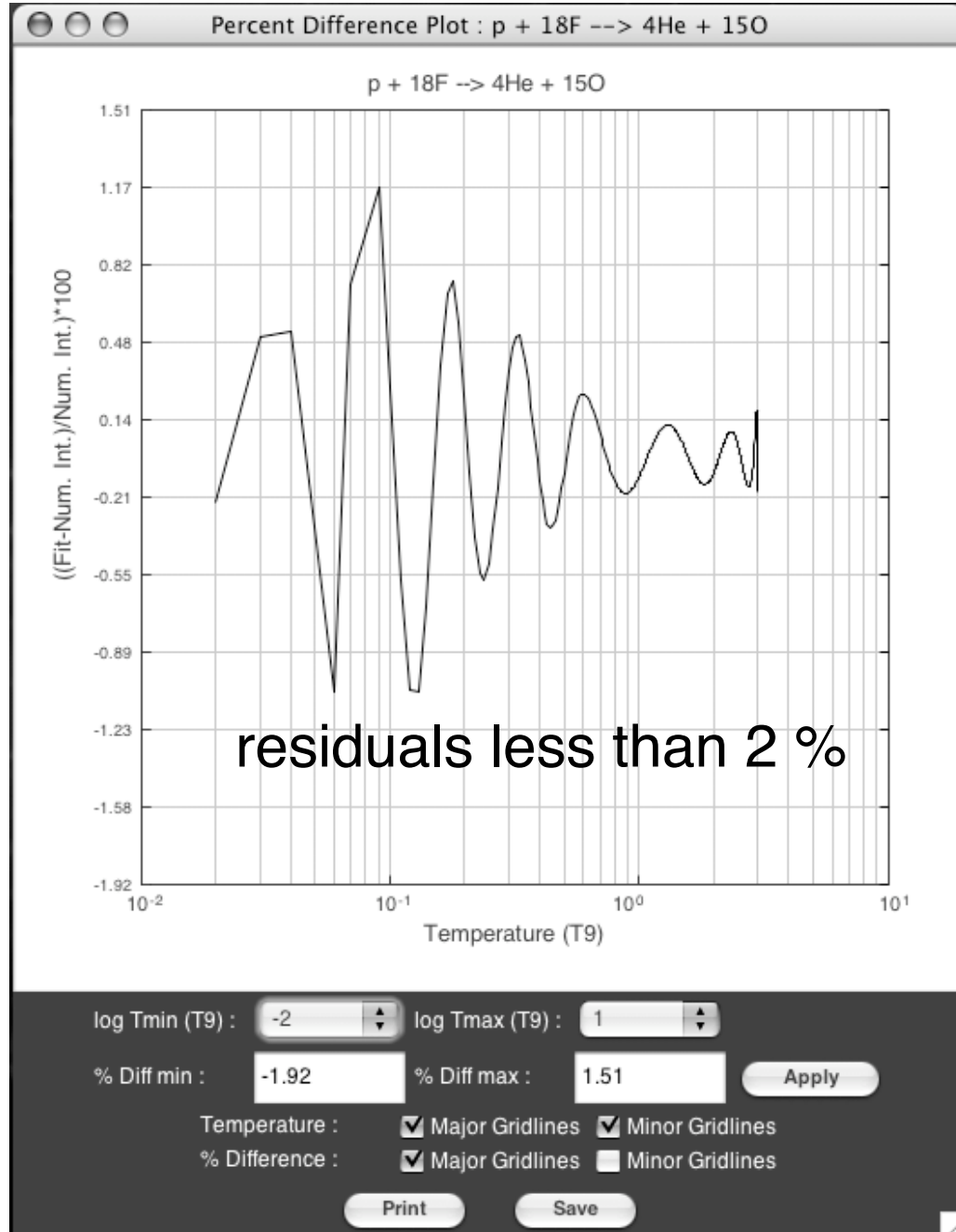- ○ Rate Viewer

Log Out   Begin

step-by-step calculate & parameterize reaction rates from cross sections & s-factors

manipulate & modify rates

insert reaction rates in libraries; modify, merge, share, document rate libraries

plot rates, access information

screenshot: rate parameterizer

Percent Difference Plot : p + 18F --> 4He + 15O

p + 18F --> 4He + 15O

residuals less than 2 %

log Tmin (T9) : -2   log Tmax (T9) : 1

% Diff min : -1.92   % Diff max : 1.51   Apply

Temperature :   ☑ Major Gridlines ☑ Minor Gridlines
% Difference : ☑ Major Gridlines ☐ Minor Gridlines

Print   Save

pointwise reaction rates generated from from cross sections & s-factors

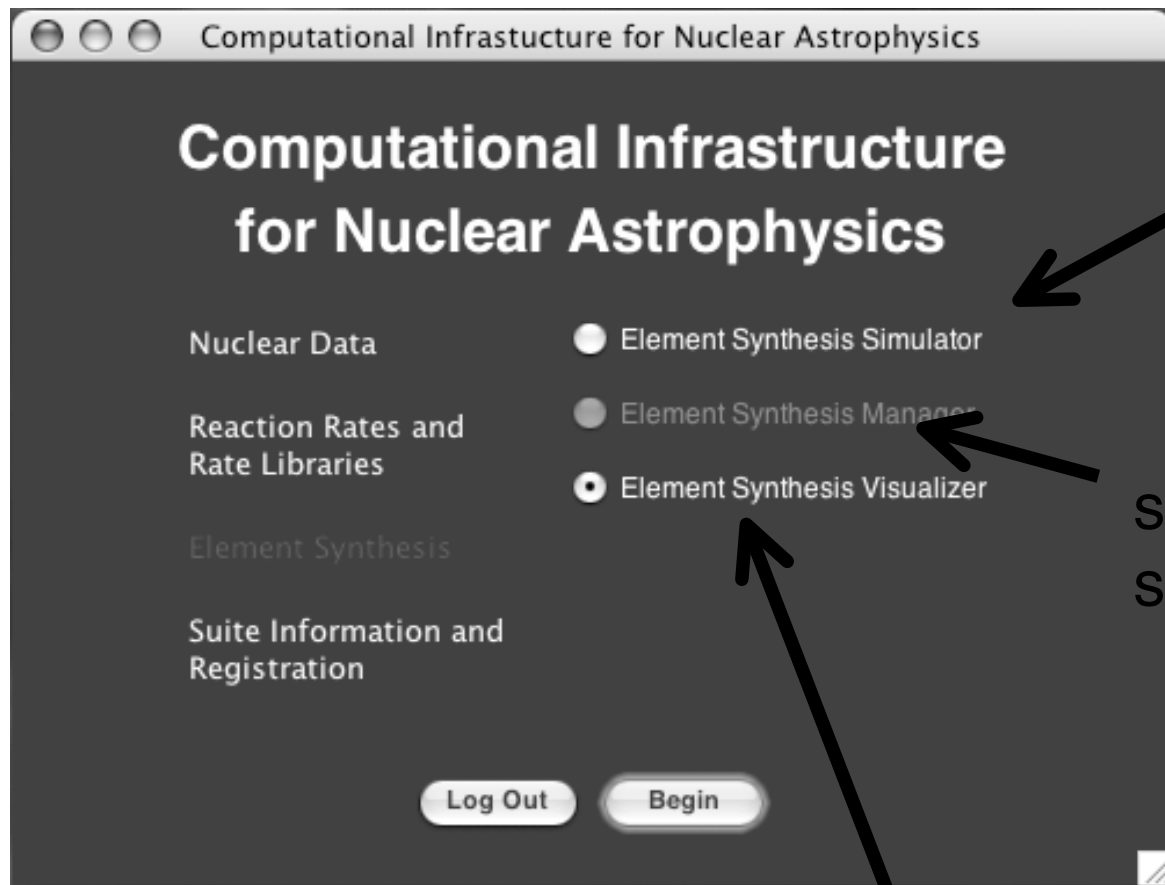then parameterized with one functional form for use in astro simulations

desired fit accuracy is 2% over rates that vary by up to 10^{20} !

multiple fitting strategies are employed - no one technique works for all rates

screenshot: rateplotter
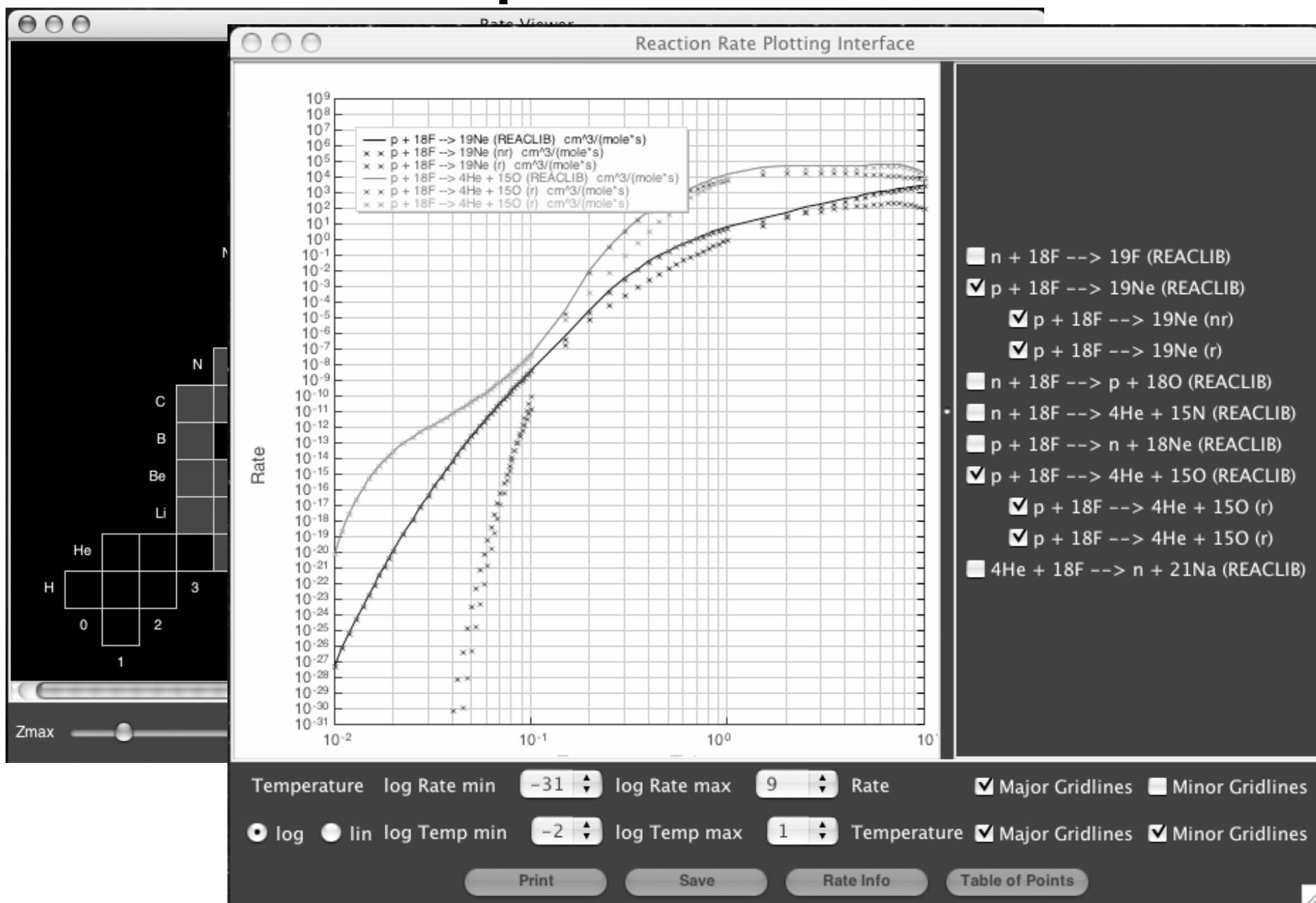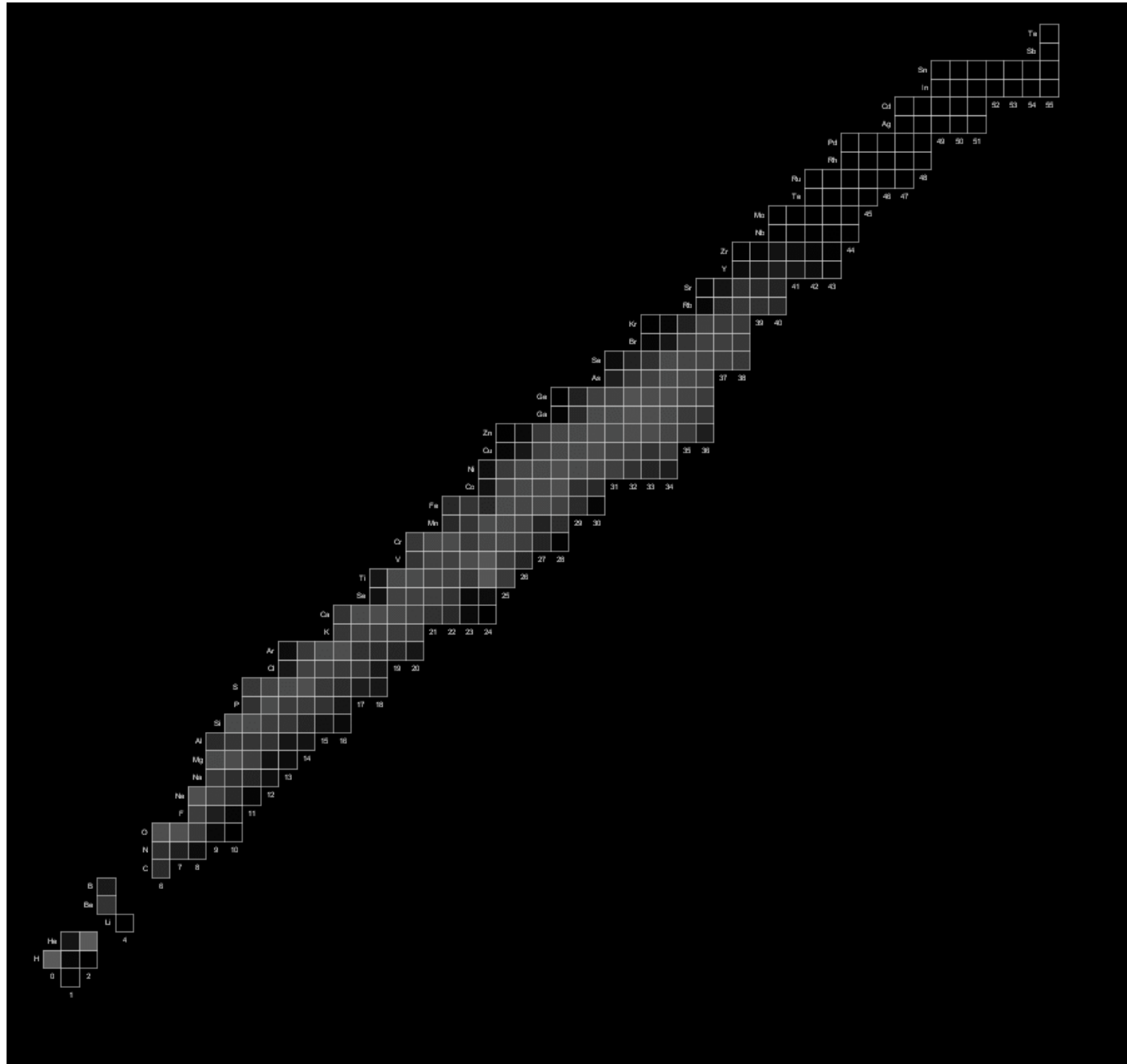
element synthesis functionality

setup and run element synthesis calculation

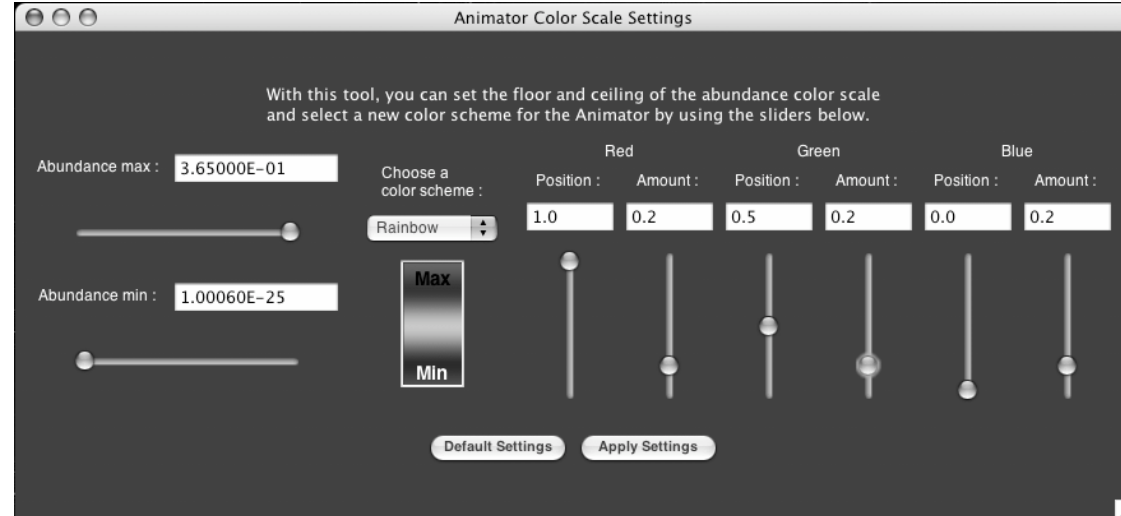store & share element synthesis results

plot simulation results, quickly compare two simulations, generate animations of simulation results
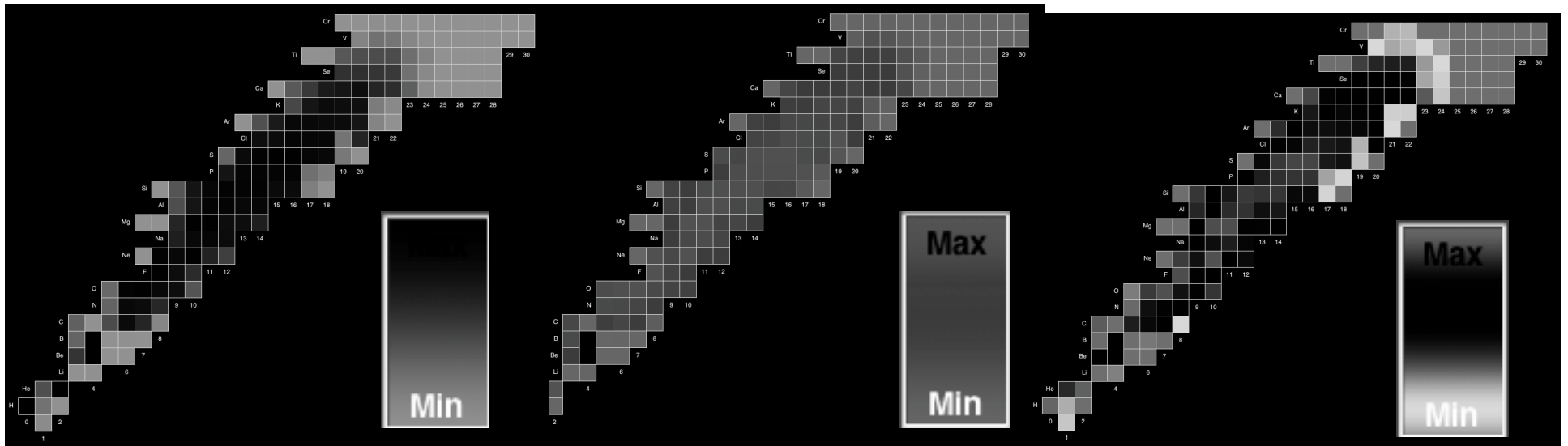
screenshot: element synthesis animator
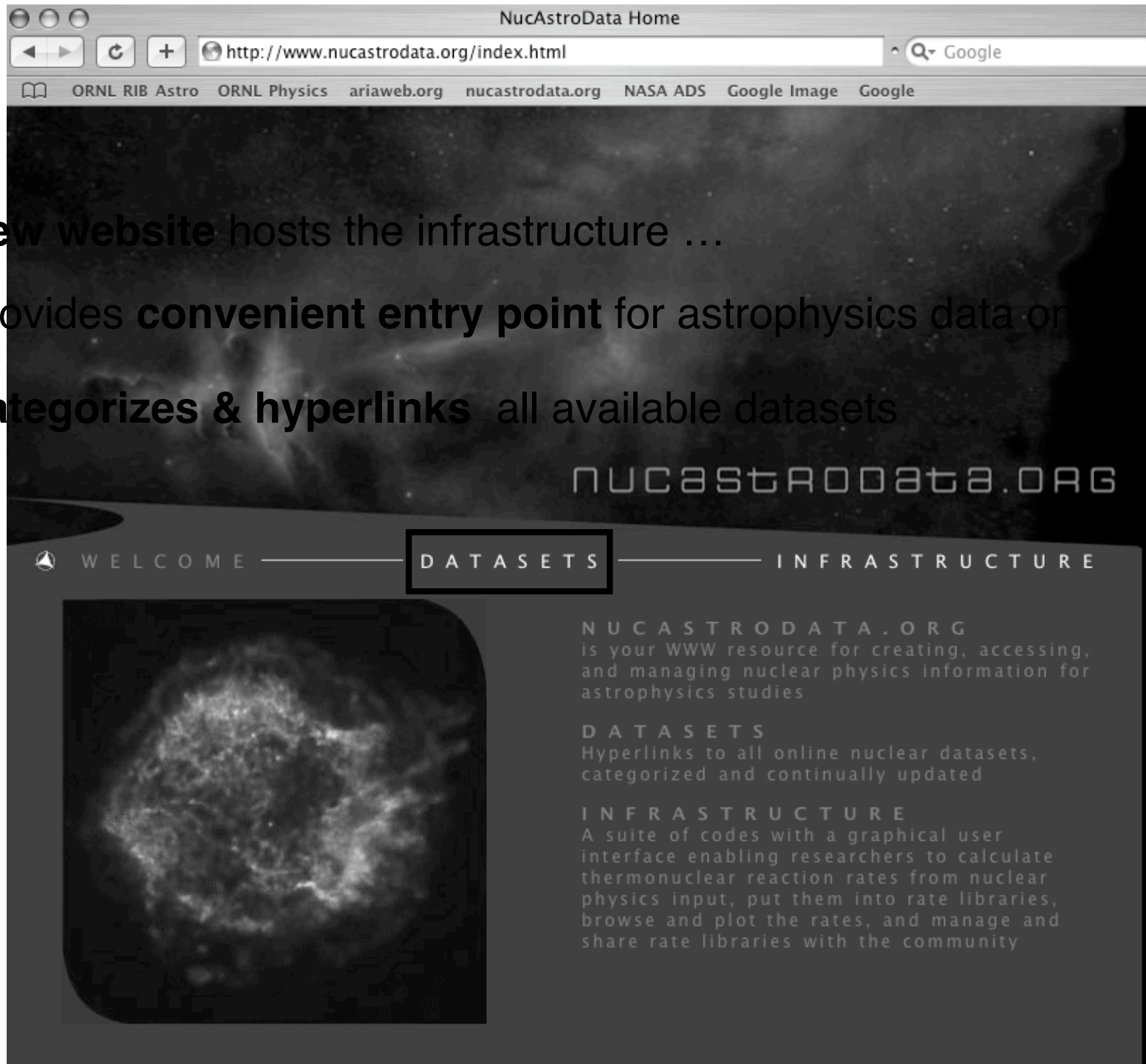

color
indicates
time-
dependent
abundance

screenshot: element synthesis animator

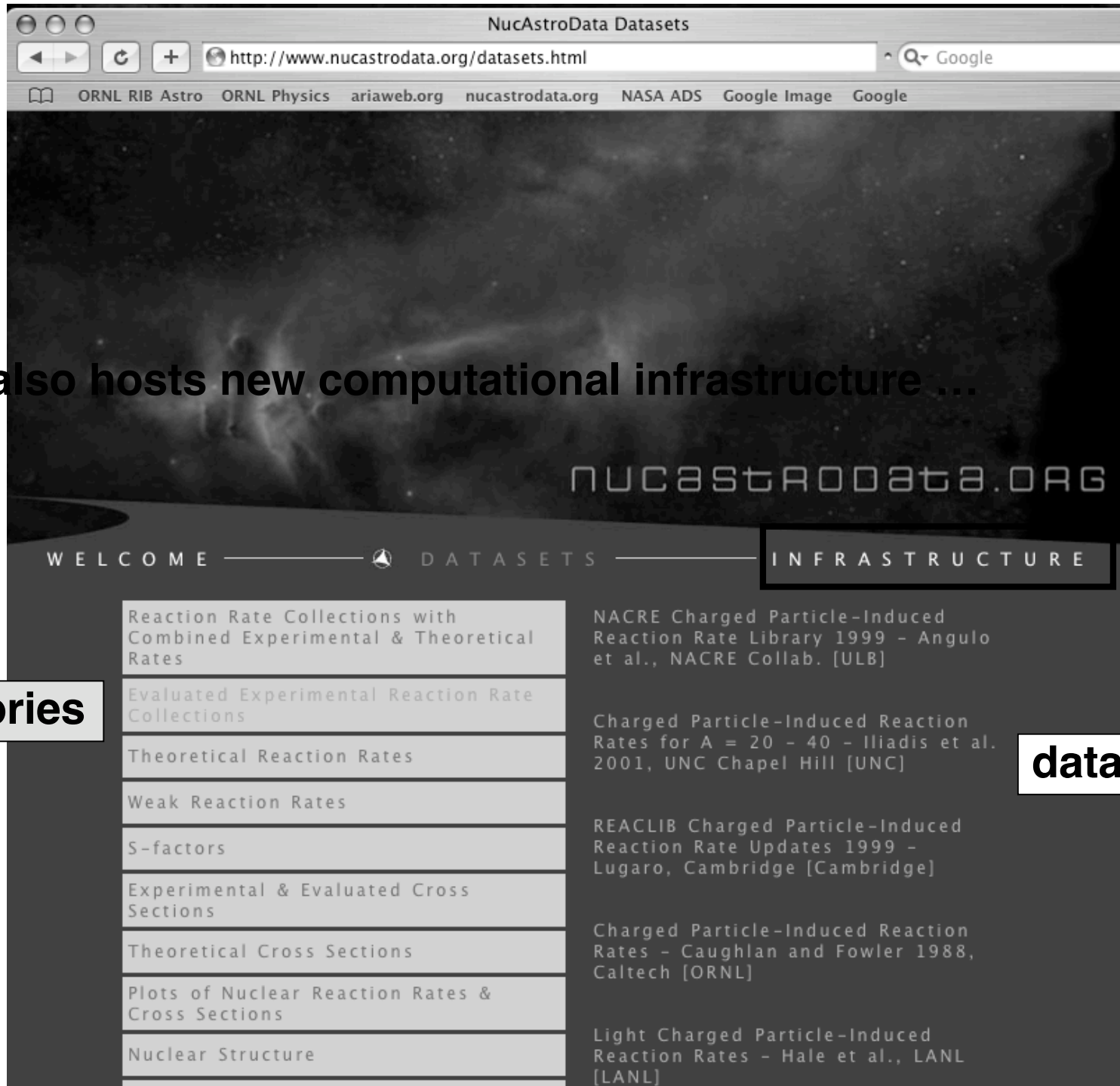- User-defined color schemes & abundance ranges
- can be utilized to emphasize low- or high-abundance nuclides

- 1d plots available to help compare results of different simulations

- **new website** hosts the infrastructure …

- provides **convenient entry point** for astrophysics data on the web

- **categorizes & hyperlinks** all available datasets

• **site also hosts new computational infrastructure ...**

uncertainties

nuclear data evaluations determine uncertainties
(e.g., in cross sections, resonance parameters)

this information, in standard databases, is generally **not utilized** when
- converting nuclear data into thermonuclear reaction rates
- running astrophysics simulation codes

we propose to develop the science and interface tools to seamlessly
integrate uncertainties into our suite

translate nuclear physics uncertainties into uncertainties in
thermonuclear reaction rates

translate uncertainties in rates into astrophysical model
prediction uncertainties

develop user-friendly graphical user interface to automate this process

we need collaborations with, & advice from, **experts** on uncertainties

summary

- evaluations, processing, & disseminations are needed to get the latest nuclear evaluations into astro simulations

- we have launched a new computational infrastructure online at **nucastrodata.org** to help

- the suite can **expose** astrophysicists to codes, datasets, and techniques from the nuclear reaction community

- we are looking for expert advice on
  - how to best expand our nuclear data toolkit to facilitate evaluations
  - how to best incorporate **uncertainties** into the suite
  - how to make this suite a complete work environment for nuclear astro