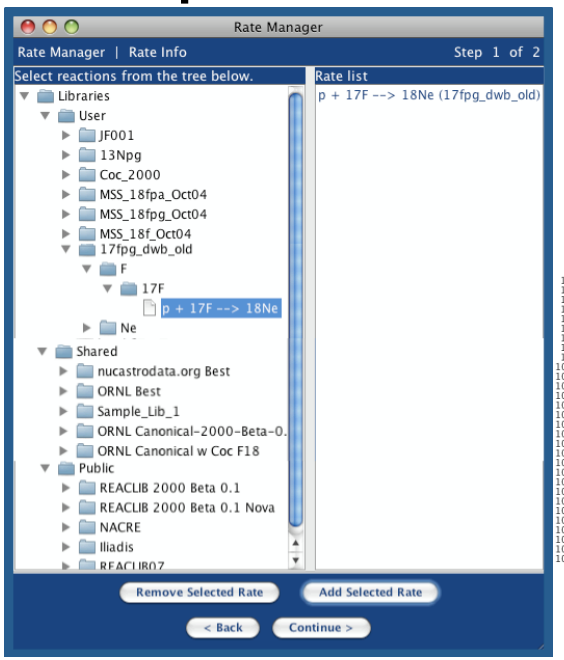
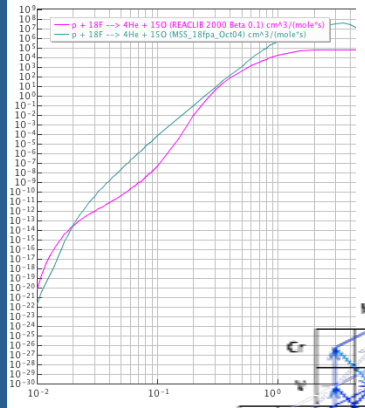
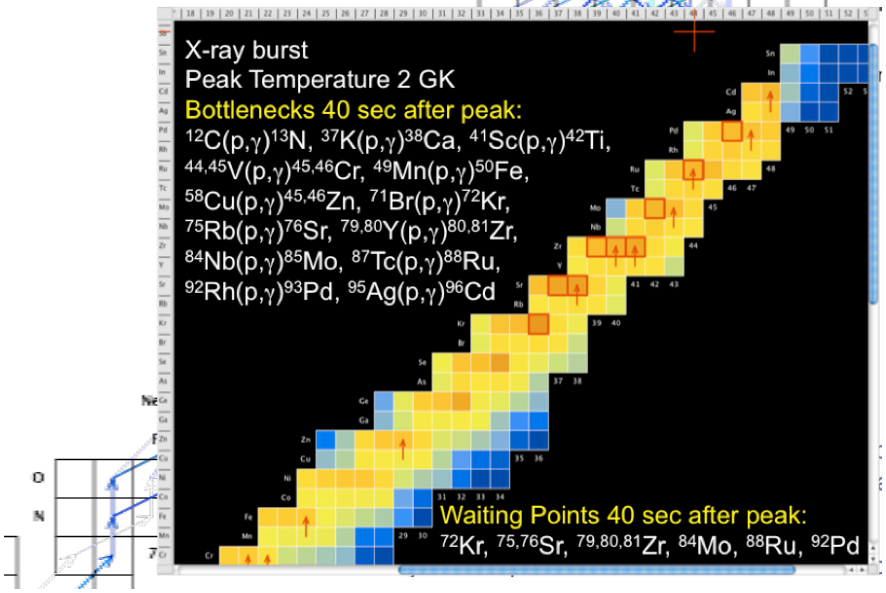
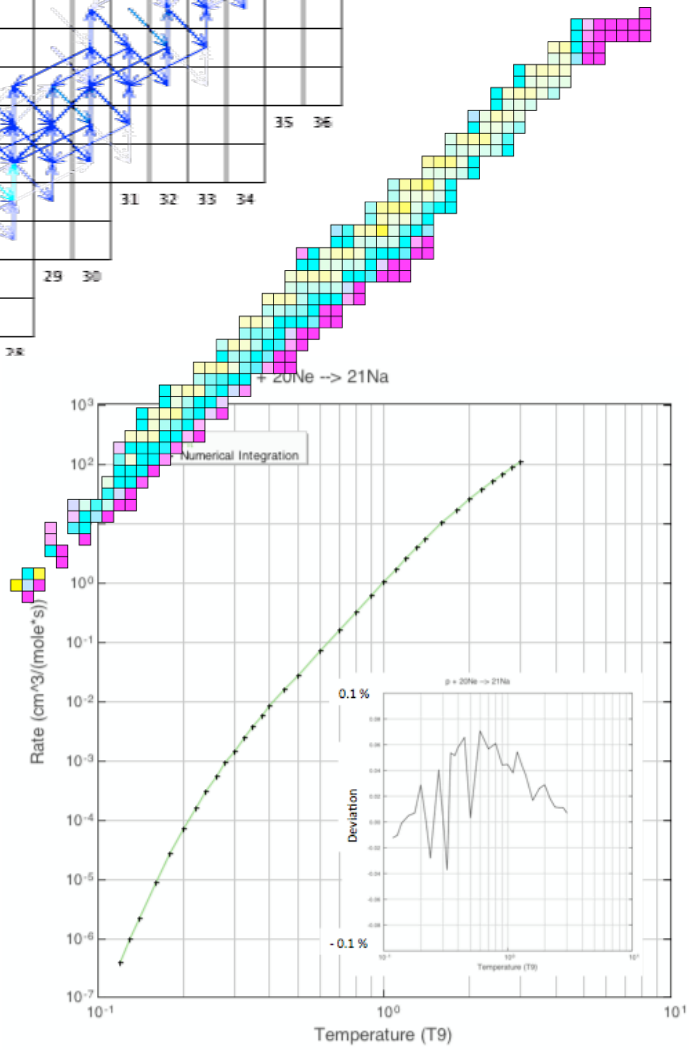
computational infrastructure for nuclear astrophysics



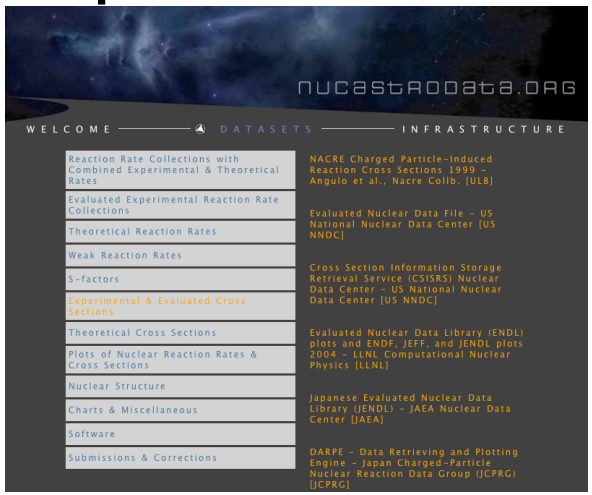


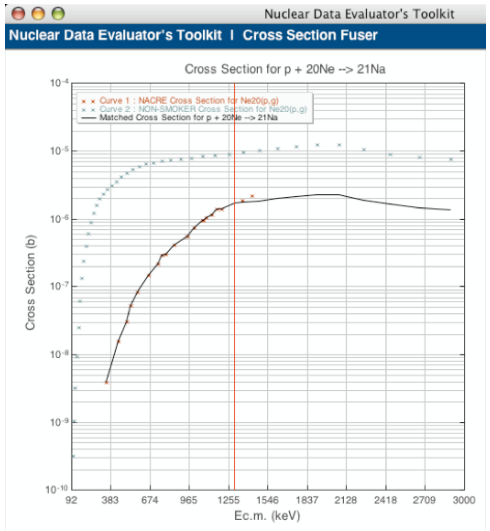


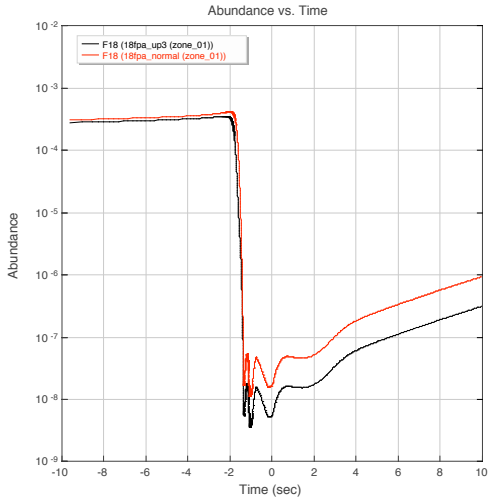


Michael Smith, Physics Division, Oak Ridge National Lab coordinator@nucastrodata.org

computational infrastructure for nuclear astrophysics



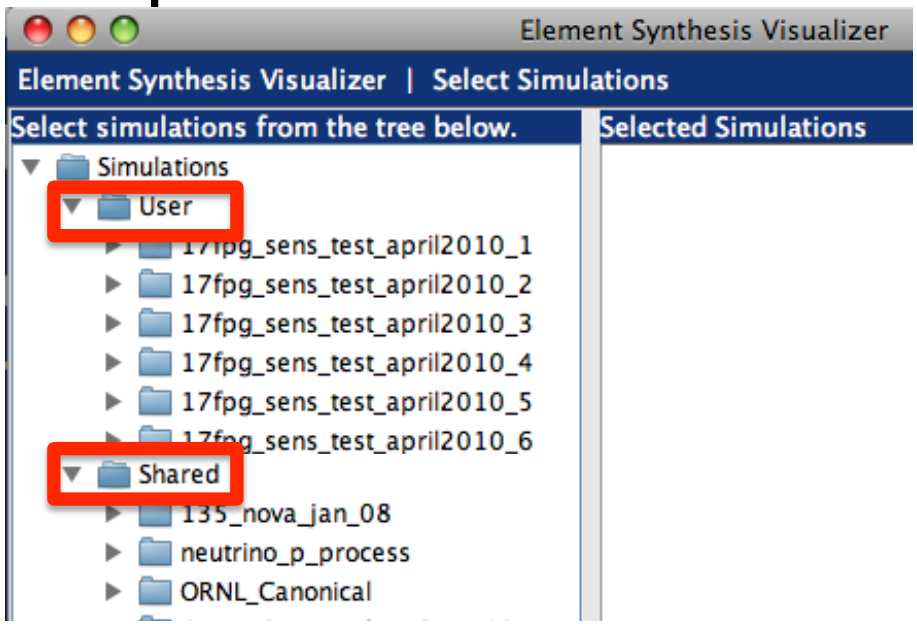


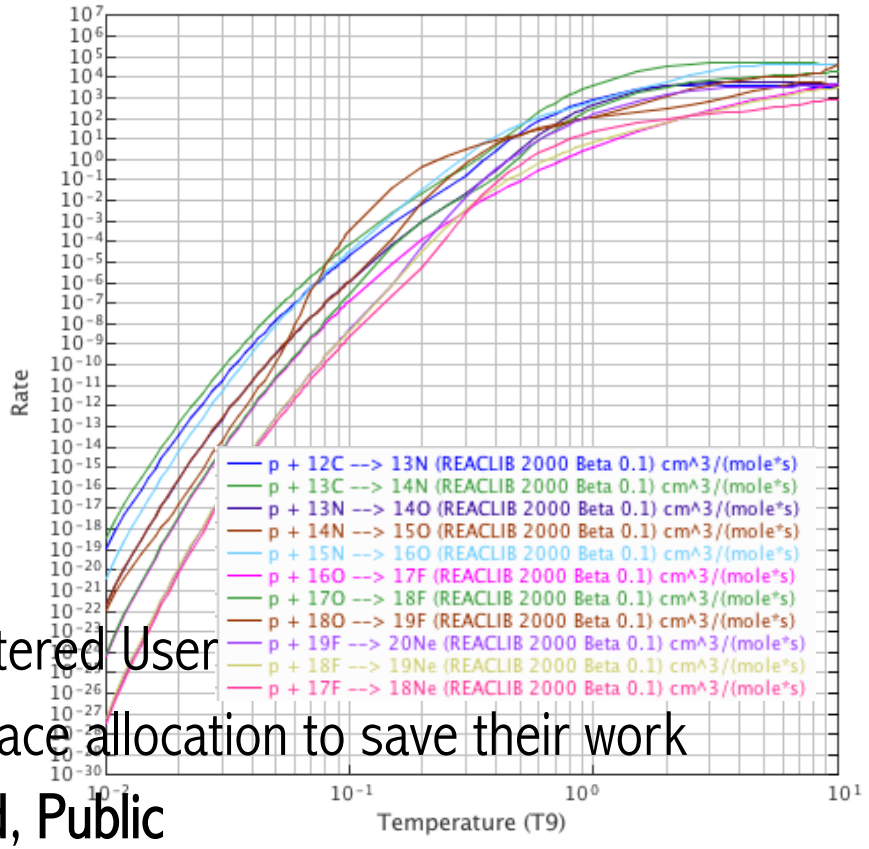


system overview

- work with nuclear information, reaction rates, & simulations
- operates "in the cloud" – you need an internet connection
- platform independent java application
- super easy to follow graphical user interface –
  makes complex manipulations and tasks easy !
- online since 2004; Users from 126 institutions in 29 countries
- new features are always being added at request of Users
- download java program for free at **nucastrodata.org**
- contact coordinator @ nucastrodata.org for help

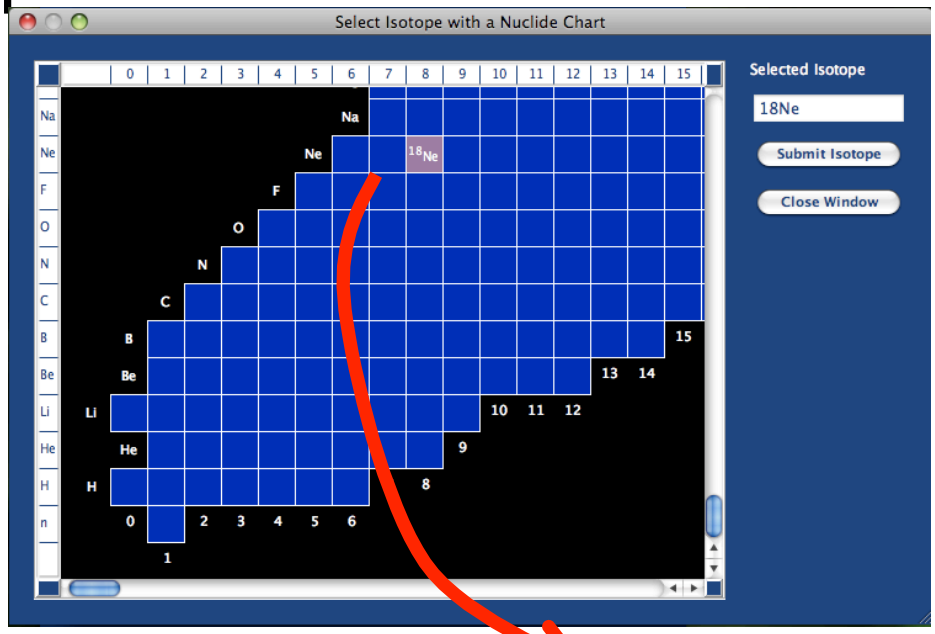
computational infrastructure for nuclear astrophysics

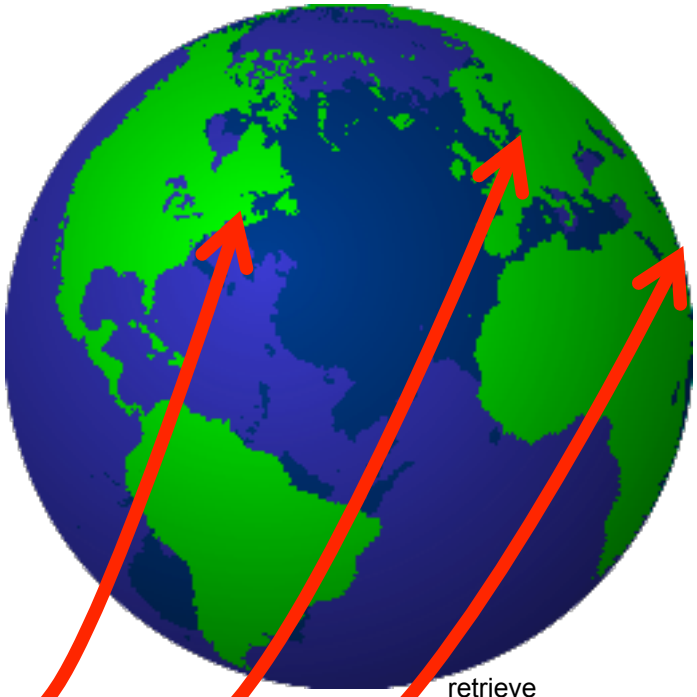




- log in as a Guest or as Registered User
- Registered Users get disk space allocation to save their work
- 3 data volumes: **User**, **Shared**, **Public**
  - **User** space is for your own rates / libraries / simulations
  - **Shared** space allows you to share this with any other User
  - **Public** space contains published rates / libraries / simulations
- enables easy sharing of large datasets between Users forming an online community

computational infrastructure for nuclear astrophysics

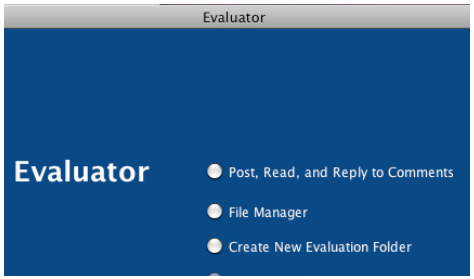




get data

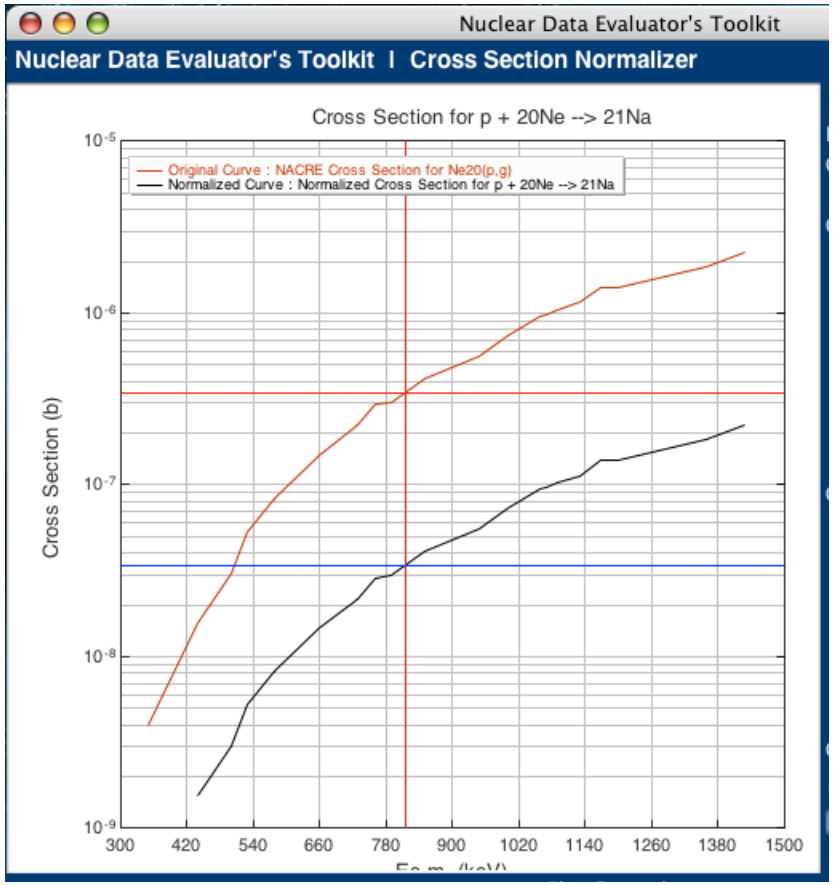
retrieve info from international databases

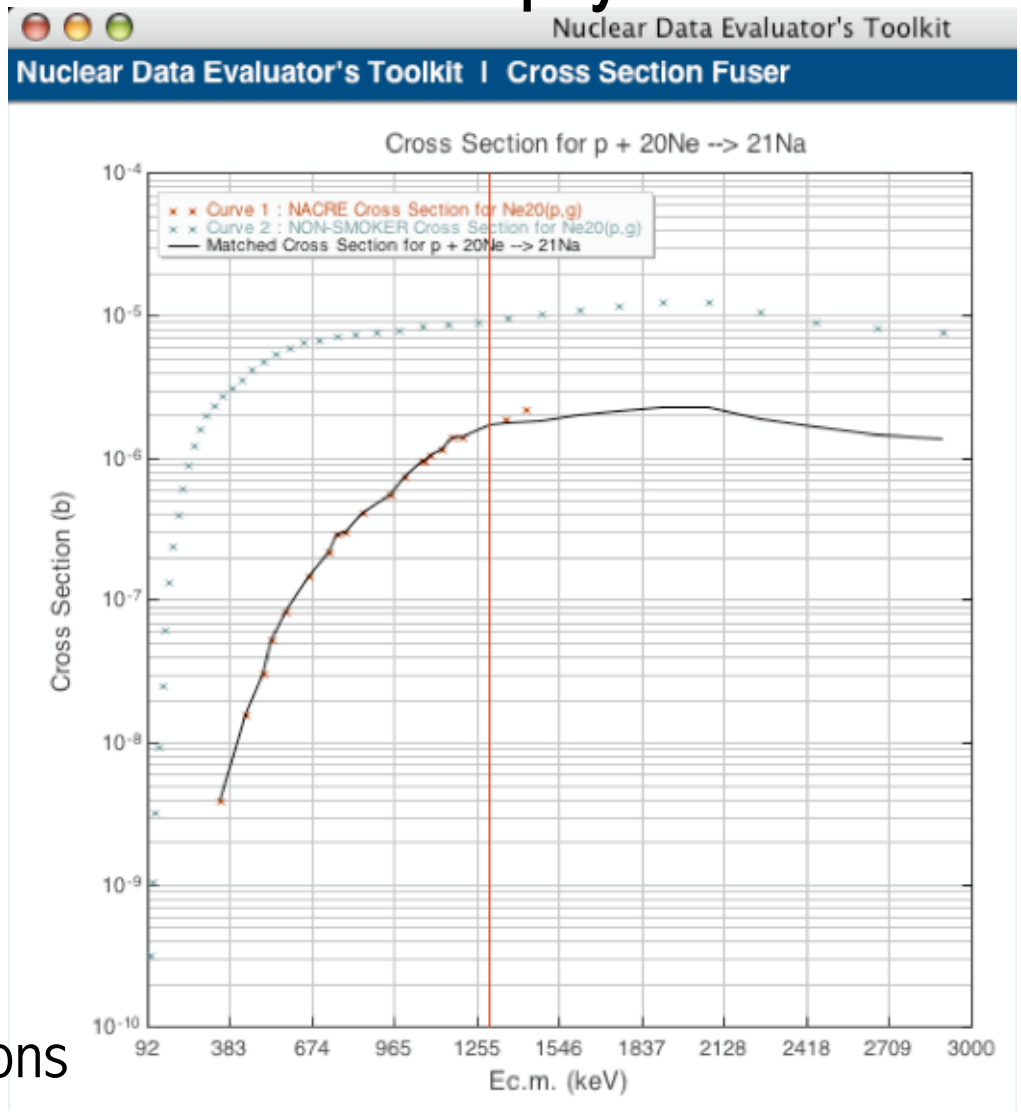
system overview



- new File Repository enables Users to share other types of files
- new "Data Harvester" feature will collects information on chosen nuclei from a number of standard international databases
- extensive workflow tools to streamline reaction evaluations are also online

computational infrastructure for nuclear astrophysics





work with **nuclear information**

- import cross sections
- gain match, normalize, linearly extrapolate cross sections
- extrapolate experimental cross section with theory

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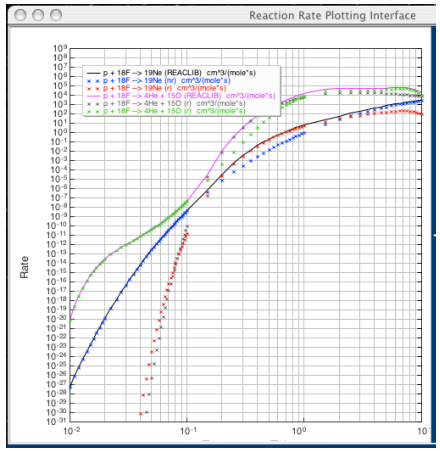
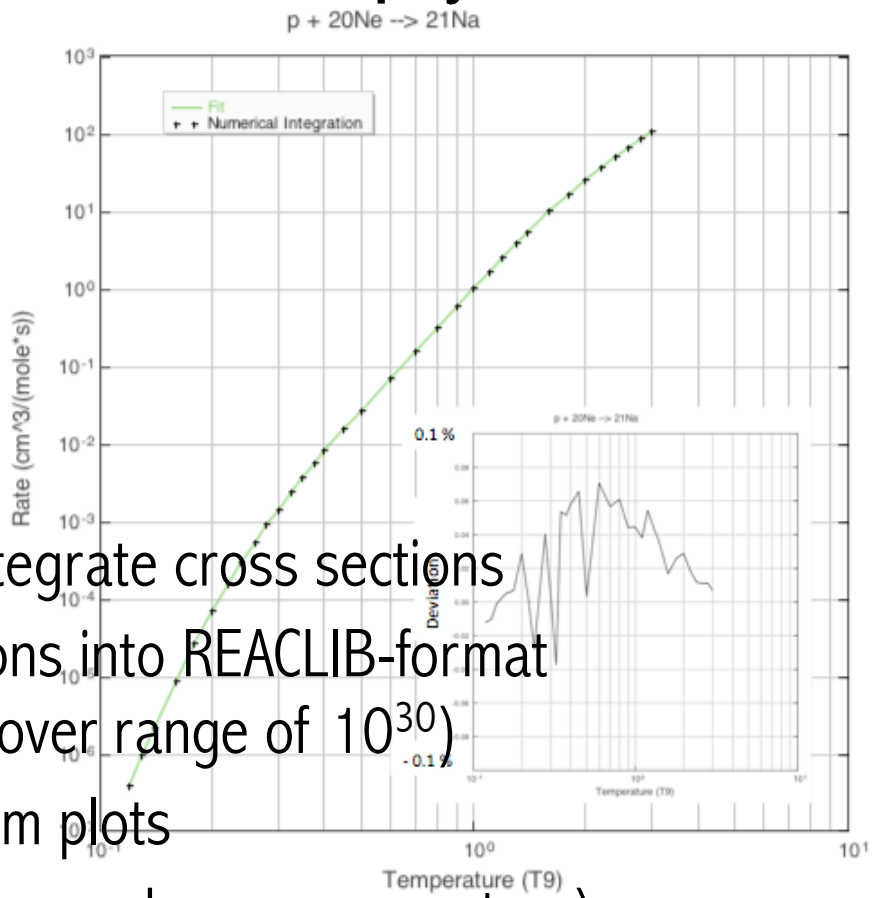
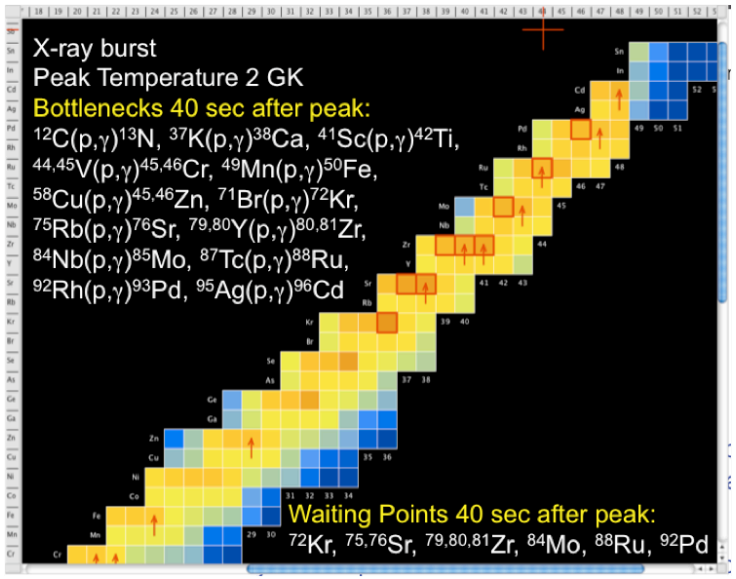


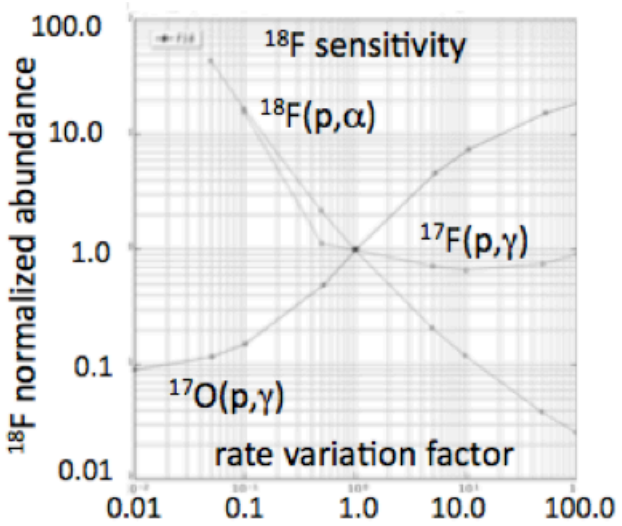


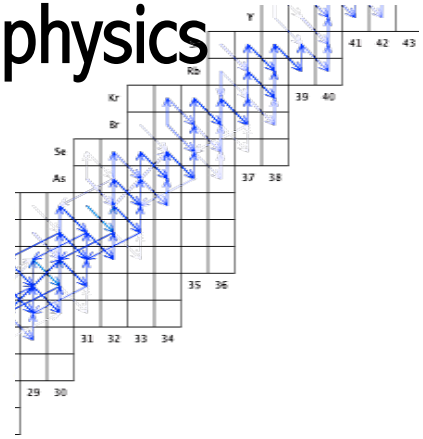
work with **reaction rates**

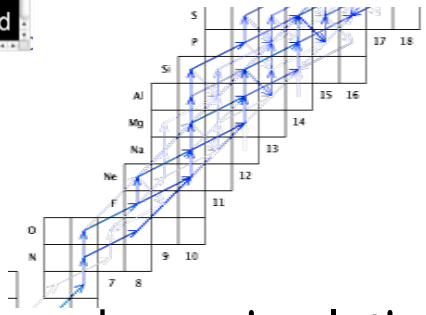
- accurately numerically integrate cross sections
- accurately fit cross sections into REACLIB-format parameterization (2% over range of 10^{30})
- visualize rates with custom plots
- modify rates (scale up, down, change parameters)
- combine rates into rate libraries for input into simulations
- merge libraries together with custom rules
- save libraries and share with colleagues
- **JINA REACLIB v2.0** is the default rate library

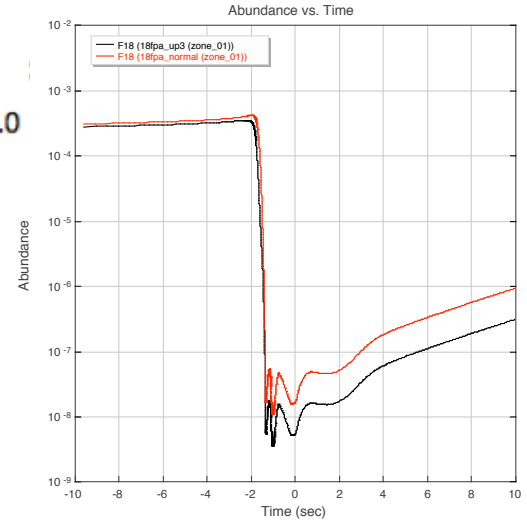
computational infrastructure for nuclear astrophysics







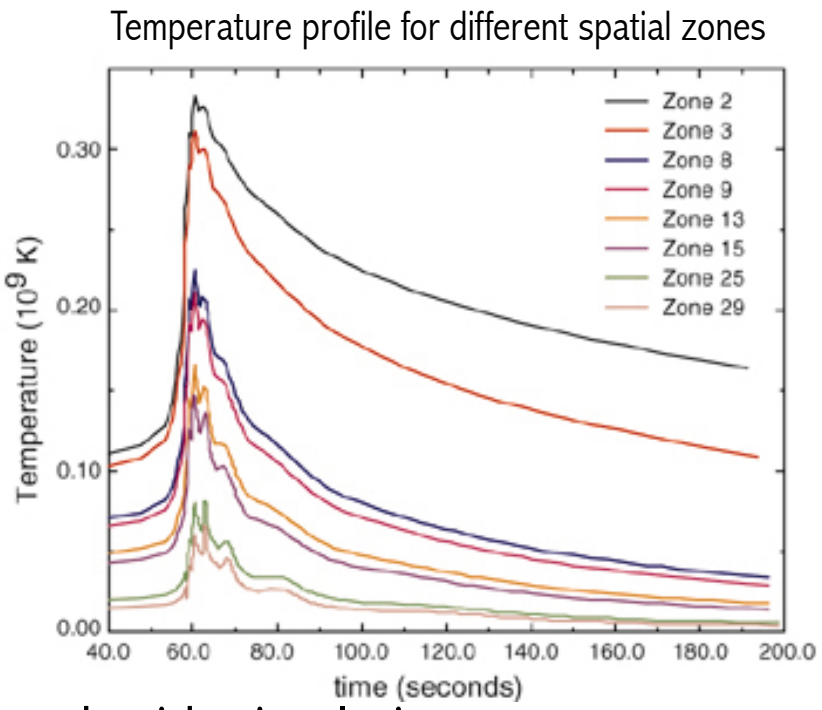


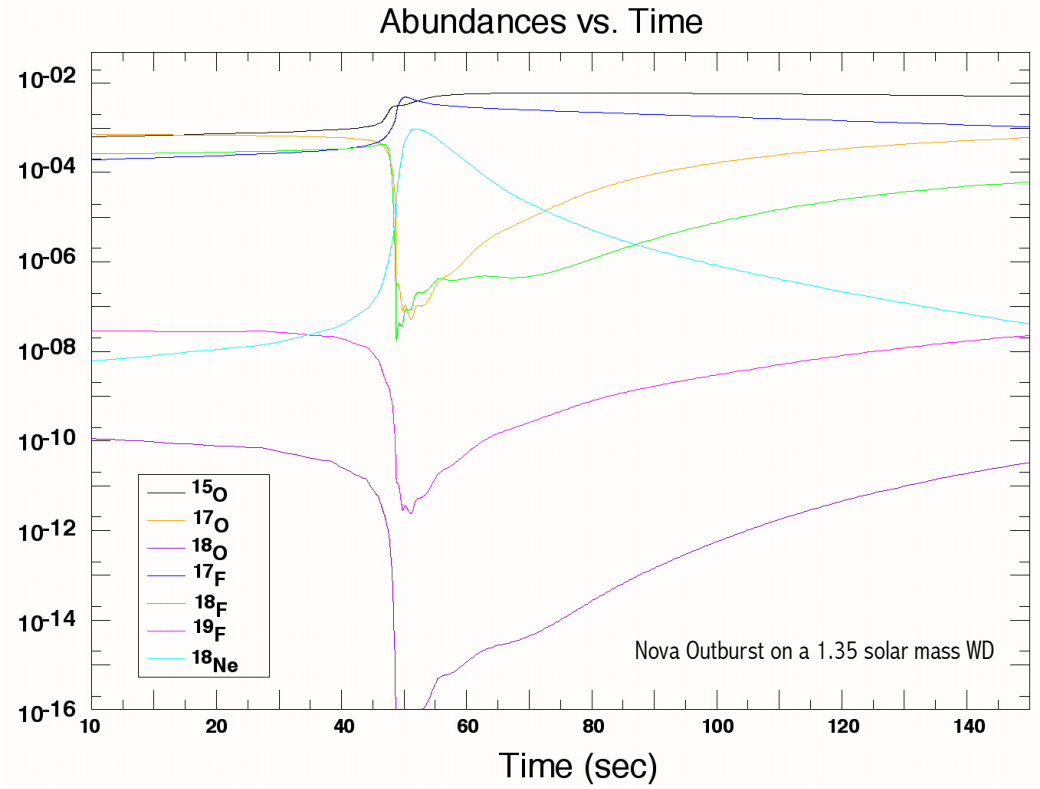


work with simulations

- easily set up and run simulations
- visualize simulations with 1D, 2D plots and animations
- quickly compare simulations with different input
- run **automated sensitivity studies** (changing input rates)
- analyze simulation results – find **bottlenecks**, **waiting points**

computational infrastructure for nuclear astrophysics





work with simulations

- post-processing code XNET from Raph Hix [ORNL / UTK]
- simulation types: novae, X-ray bursts, solar, CNO, Hot CNO
- single zone and multi-zone simulations
- some simulations with tracer particle temperature/density profiles
- coming soon (1 week): **core collapse supernova r-process**

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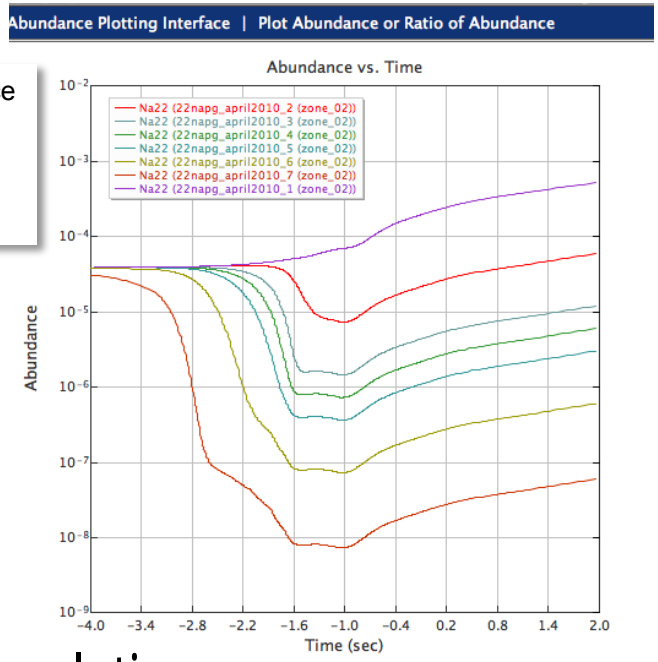
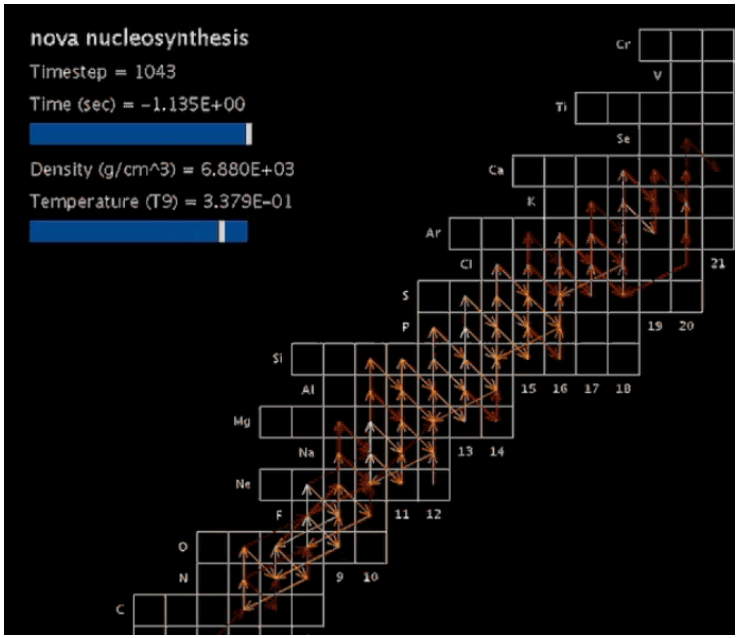
^{22}Na abundance vs. time in Nova outburst with different ^{22}Na(p,γ) rates

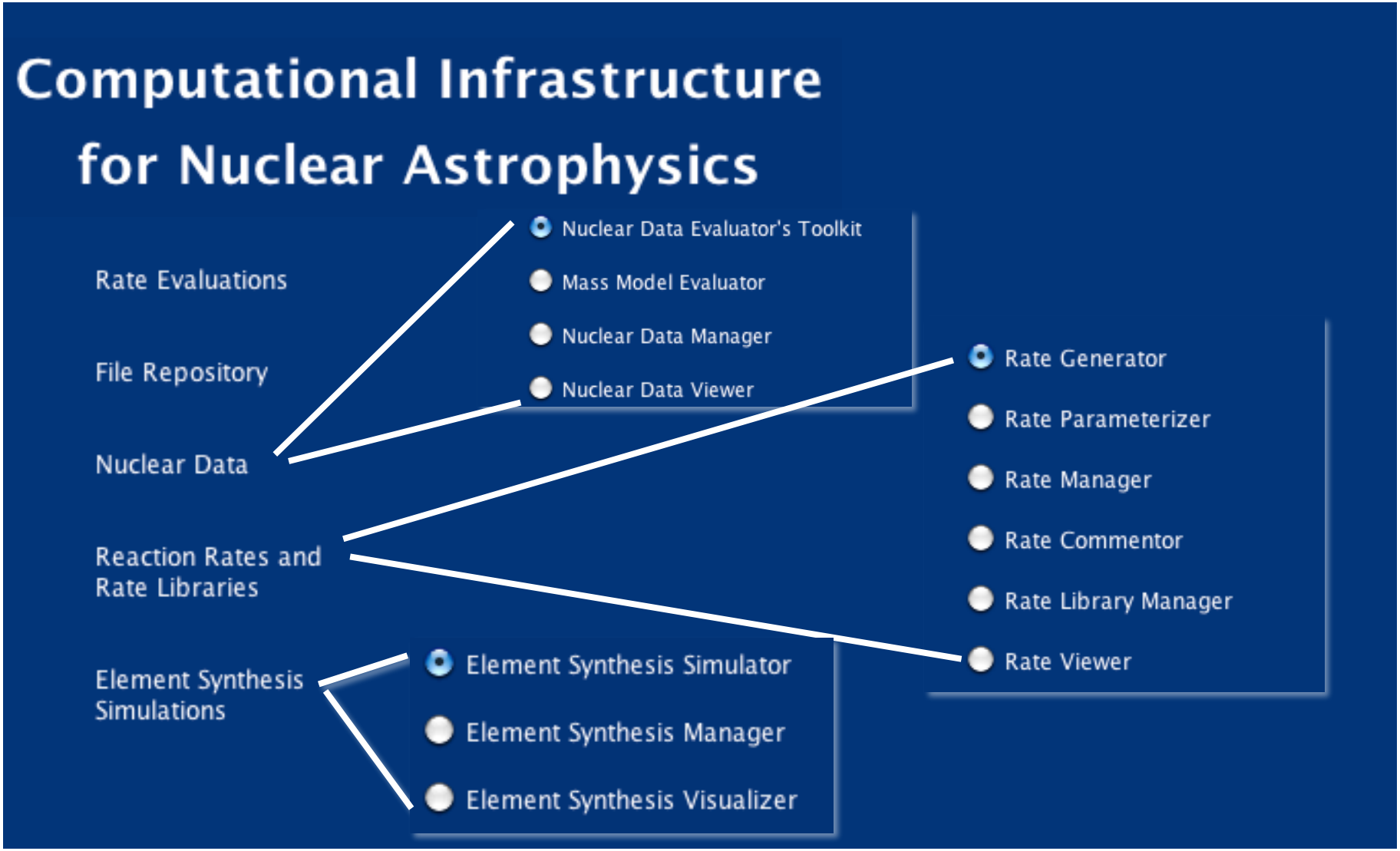




work with simulations

- customized visualization of simulations
- simulations can be saved & shared with colleagues without email or ftp
- you can import your own simulations & use our viz tools
- animation output rendered on our server to your parameters and available for you to download

computational infrastructure for nuclear astrophysics



sample investigations

before & after study: what was the impact of my measurement ?

- assume you just measured a new rate of the $^{18}F(p,\alpha)^{15}O$ reaction
- rate is 10 times lower than previous “best” rate
- how does this impact predictions of ^{18}F production in novae ?

approach

- modify existing $^{18}F(p,\alpha)^{15}O$ rate appropriately, save into new library
- combine with JINA REACLIB v2.0 into full library for a simulation
- choose a novae simulation, run with old rate & new rate
- compare final abundances in the two simulations
- draw your conclusion on the impact of the measurement
- variations: more nova models, different zones or all zones …

sample investigations

sensitivity study: how does one abundance depend on a rate ?

- you just read an article on ^{22}Na observations in nova ejecta
- you wonder if measurements of ^{21}Na(p,γ)^{22}Mg and ^{21}Ne(p,γ)^{22}Na reaction would help clarify the nuclear uncertainties in ^{22}Na abundance predictions
- what are the sensitivities of these predictions on these rates ?

approach

- choose a reference rate library and a novae simulation
- choose a set of variations of these the reactions of interest (e.g., 0.01, 0.1, 1.0, 10, 100 …)
- use automated sensitivity study tool to vary rate and run simulations
- use tools to plot out abundance vs. rate, look for strong correlations
- variations: more nova models, different rate variations, change other rates on neighboring nuclei …

sample investigations

uncertainty analysis: what is the uncertainty of this predicted abundance ?

- you have just made a new measurement of the $^{14}O(\alpha,p)^{17}F$ reaction with an uncertainty that ranges from a factor of 2 higher to a factor of 20 lower
- what are the implications of this uncertainty for final abundance predictions in novae ?

approach

- modify $^{14}O(\alpha,p)^{17}F$ rate to have “max” and “min” values
- save each into library, merge with JINA REACLIB v2.0 library
- choose a novae simulation, run with reference, max, & min rates
- compare final abundances, the spread gives the uncertainty
- draw your conclusion on the impact of the uncertainty on ^{16}O / ^{18}O and $^{17}O/^{18}O$ abundance ratios, on ^{18}F and ^{22}Na abundances …
- variations: examine different abundances; different nova models …

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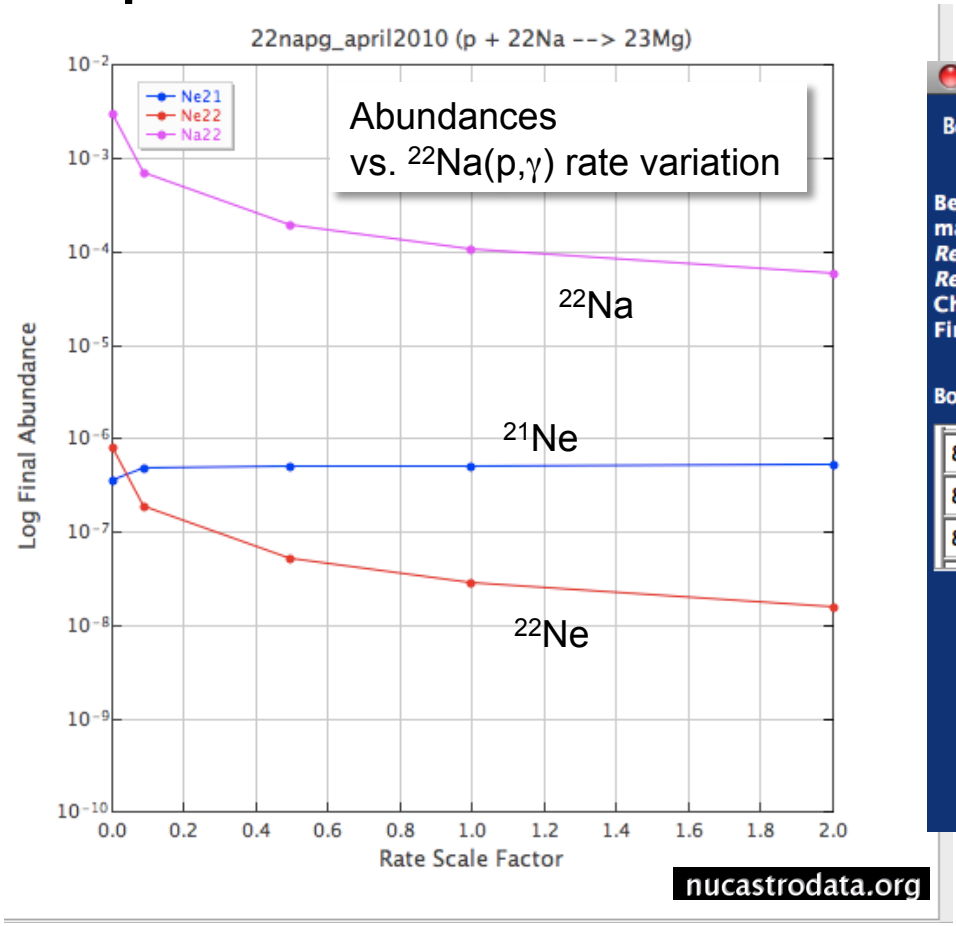

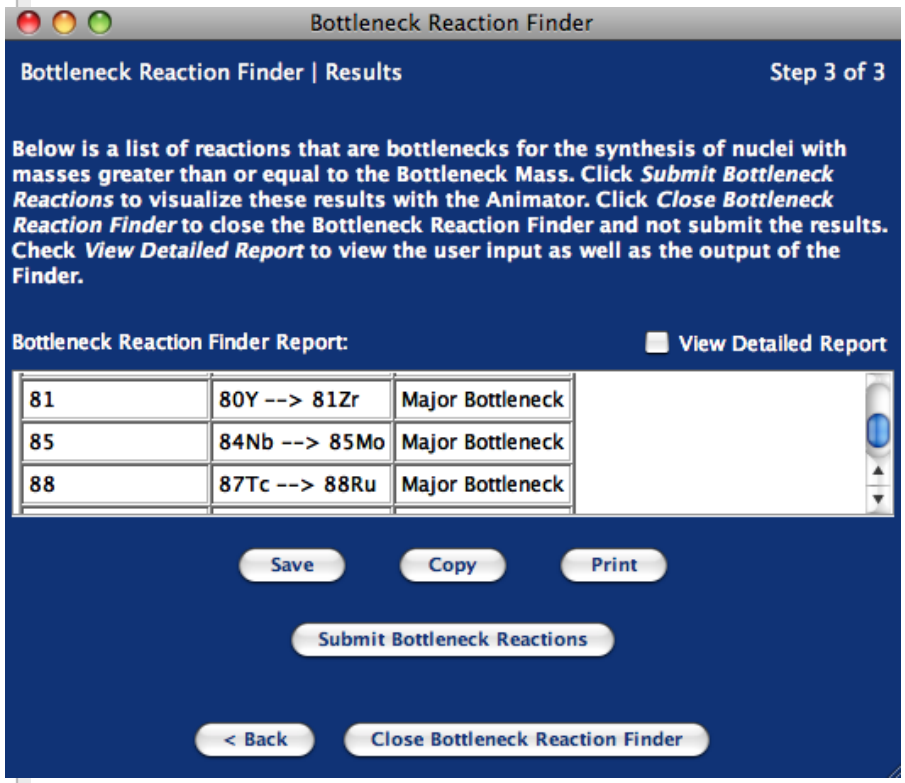

- download java program for free at **nucastrodata.org**
- contact coordinator @ nucastrodata.org for help
- suggest new features for nuclear data / rates / libraries / simulations / visualization / analysis and we will work with you !