



国防基础项目进展报告

核反应网络方程计算程序的界面 设计和灵敏度计算

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报告内容

1. 引言
2. 核反应网络计算程序界面设计
3. 例子: **CNO**循环
4. 计划
5. 总结

1. 引言 (JINAWeb.org)

- Online Tools
(*Clemson GCE, NSE calculators and nuclear reaction network with easy web interfaces*)
- ✓ Some Astronomy Codes (Arizona State University)
(*Frank Timmes repository of astronomy codes, including reaction networks*)
- Modules for Experiments in Stellar Astrophysics (MESA)
(*Bill Paxton's stellar evolution code*)
- ✓ TYCHO: A Stellar Evolution Code
(*A general, one dimensional stellar evolution code*)
- ✓ Reaction Network & Rates Calculations & Tools
(*Nuastrodata - datasets - infrastructure*)
- Liquid Drop Model of Nuclear Binding Energy
(*The site for you to modify the formula and make your own fit*)

1.1.Cococubed.com:Some astronomy codes (Arizona State University)



Cococubed.com

Some astronomy codes

Home

Teaching materials

Astronomy research

Astronomy codes

... Stellar equation of states

... EOS with ionization

... EOS for supernovae

... Chemical potentials

... Stellar atmospheres

... Voigt Function

... Polytropic stars

... Cold white dwarfs

... Hotter white dwarfs

... Cold neutron stars

... Stellar opacities

... Neutrino energy loss rates

... Ephemeris routines

... Fermi-Dirac functions

... Galactic chemical evolution

... Nuclear reaction networks

... Nuclear statistical equilibrium

... Laminar deflagrations

... CJ detonations

... ZND detonations

Here are some fortran codes, some more complicated than others:

- Stellar equation of states
- Equation of state with ionization
- EOS for core collapse supernovae
- Electron chemical potentials
- Stellar atmospheres
- Voigt Function
- Polytropic stars
- Cold white dwarfs
- Hotter white dwarfs
- Cold neutron stars
- Stellar opacities/conductivities
- Neutrino energy loss rates
- Ephemeris routines
- Fermi-Dirac functions
- Galactic chemical evolution

•Nuclear Reaction Network

- Nuclear reaction networks
- Nuclear statistical equilibrium
- Laminar deflagrations
- Chapman-Jouget detonations
- ZND detonations
- Fitting data to conic sections
- Derivatives on unevenly spaced grids
- An unusual linear equation solver
- A Pentadiagonal solver
- Quadratics, Cubics & Quartics
- Supernova light curves
- Exact Riemann solutions
- 1D PPM hydrodynamics
- Verification Problems
- Volume of Plane-Cube intersection

1.1 (*Frank Timmes repository of astronomy codes*)

Make H and He

- big bang

Burn hydrogen

- pp chains
- cno cycles
- pp + cno
- hotcno + rp
- pp+hotcno+rp
- 8 isotopes

Alpha-chains

- 7 isotopes
- 13 isotopes
- 19 isotopes
- H + He

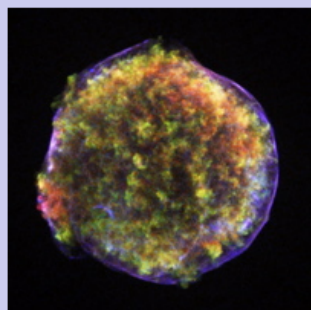
Eat neutrons

- s-process

General network

- torch

1.2 TYCHO: A Stellar Evolution code for the 21st Century



TYCHO: A Stellar Evolution code for the 21st Century

[Tycho Brahe](#) was the first astronomer to determine the distance to a supernova. In November 1572 a new star, or *nova*, appeared in the constellation Cassiopea; in modern terminology this was a supernova in our own Milky Way galaxy. From his own careful observations, this 26-year-old, eccentric Danish nobleman became convinced that this new object (now called Tycho's supernova) was in the supposedly immutable celestial regions. The supernova lay beyond the limits of the solar system as then known, so that the "eternal heavens" were not really unchanging. The medieval cosmology never recovered.

The TYCHO stellar evolution code derives from previous work on supernovae, see [Arnett, D., Supernovae and Nucleosynthesis, 1996, Princeton University Press](#), for discussion and references. It is part of an ongoing project to develop computational tools to study the evolution of stars, from birth to death.



The US pronunciation is "tie ko" although the original Danish might have been closer to "two ko".

The photo of the statue of Tycho (right) was taken by W. D. Arnett in Prague CZ, August 2006. The photo of the supernova remnant (left) is a composite taken from observations of the Chandra X-ray Observatory (NASA/CXC/Rutgers/J.Warren & J.Hughes et al.); the purple lines near the edge of the remnant are highly dissipative shocks in which cosmic rays are being accelerated.

Description:

TYCHO is designed to be a stellar evolution code for the 21st Century. It is a general, one dimensional (spherically symmetric) stellar evolution code, designed for hydrostatic and hydrodynamic stages (including mass loss, accretion, pulsations and explosions, using state of the art procedures and microphysics. Mixing and convection algorithms are being based on [3D time-dependent simulations](#)

- It is written in structured FORTRAN (f77).
- It has extensive on-line graphics using [Tim Pearson's PGPLOT](#) with X-windows.
- It is now under version control [Subversion](#).
- It runs effectively on Linux and Mac OS X laptop and desktop computers.
- It is being developed as an open-source, community code. Contributions and feedback are welcome.

TYCHO7 is now (4/2008) in **beta-test**. It is being used in our core graduate course in Stellar Evolution and Nucleosynthesis [ASTRO 535/587](#) at [Steward Observatory](#).

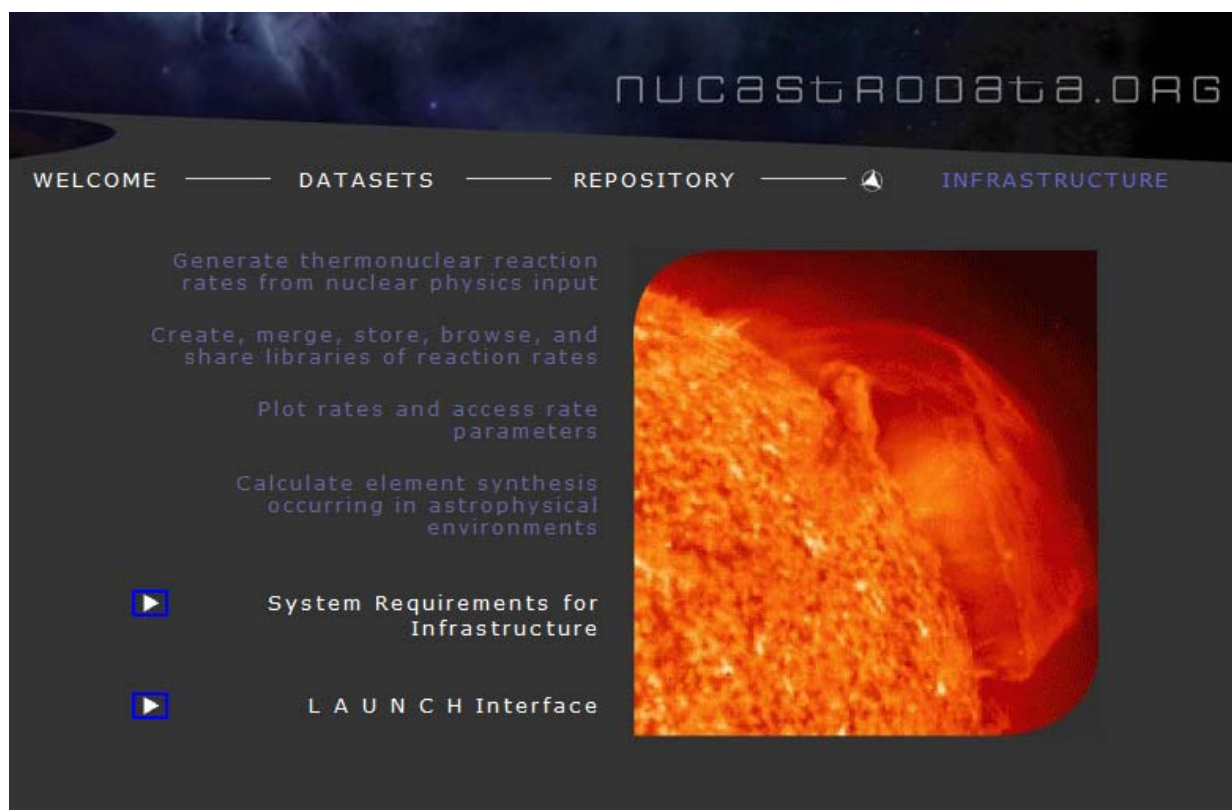
TYCHO is being used for ongoing research in stellar evolution. For recent work, see [Young, et al. 2006, ApJ 640, 891](#). TYCHO provided the initial (low noise) models for [Meakin, C. & Arnett, D., 2007, ApJ 667, 448](#).

[TYCHO Users Manual](#)

2.2 TYCHO: A Stellar Evolution code for the 21st Century

- *TYCHO is designed to be a stellar evolution code for the 21st Century. It is a general, one dimensional (spherically symmetric) stellar evolution code, designed for hydrostatic and hydrodynamic stages (including mass loss, accretion, pulsations and explosions, using state of the art procedures and microphysics. Mixing and convection algorithms are being based on 3D time-dependent simulations*
- *in structured FORTRAN (f77).*
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1.3. Nucastrodata.org



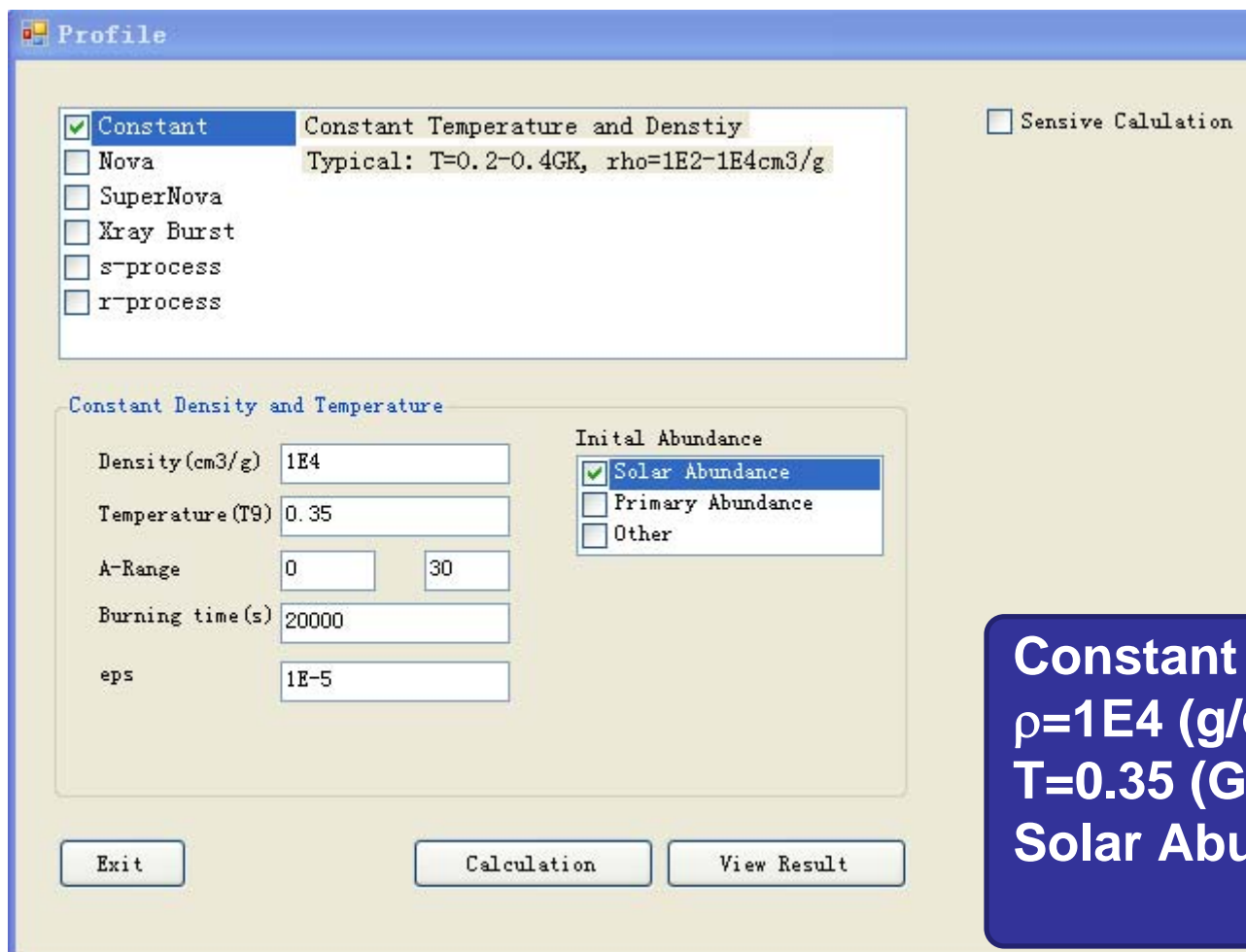
NucAstrodata.org

- ***Generate thermonuclear **reaction rates** from nuclear physics input***
- ***Create, merge, store, browse, and share **libraries** of reaction rates***
- ***Plot rates and access rate parameters***
- ***Calculate element **synthesis** occurring in astrophysical environments***

1.4.本程序特点:

- 基于给定模型的温度、密度profile;
- 计算核合成的丰度随时间的变化;
- 计算反应路径;
- 计算特定核素对于某个反应率的灵敏度;
- 窗口界面。

2.核反应网络计算程序界面设计



Profile

☒ **Constant** Constant Temperature and Denstiy
☐ Nova Typical: T=0.2-0.4GK, rho=1E2-1E4cm3/g
☐ SuperNova
☐ Xray Burst
☐ s-process
☐ r-process

☐ Sensive Calculation

Constant Density and Temperature

Density (cm3/g) 1E4
 Temperature (T9) 0.35
 A-Range 0 30
 Burning time (s) 20000
 eps 1E-5

Initial Abundance

☒ Solar Abundance
☐ Primary Abundance
☐ Other

Exit Calculation View Result

Constant
 $\rho=1E4$ (g/cm3)
 $T=0.35$ (GK)
 Solar Abundance

2.核反应网络计算程序界面设计

☒ **Sensitivity calculation**

Source Reaction

F18 (H1, G)NE19
 F18 (H1, HE4)O15

<==
 ==>

F17 (N, H1)O17
 F17 (N, G)F18
 F17 (H1, G)NE18
 F18 (N, G)F19
 F18 (H1, G)NE19
F18 (H1, HE4)O15
 F18 (N, H1)O18
 F18 (N, HE4)N15
 F19 (H1, HE4)O16
 F19 (N, G)F20
 F19 (H1, G)NE20
 F19 (HE4, H1)NE22
 F20 (H1, HE4)O17

Destination

F18

<--

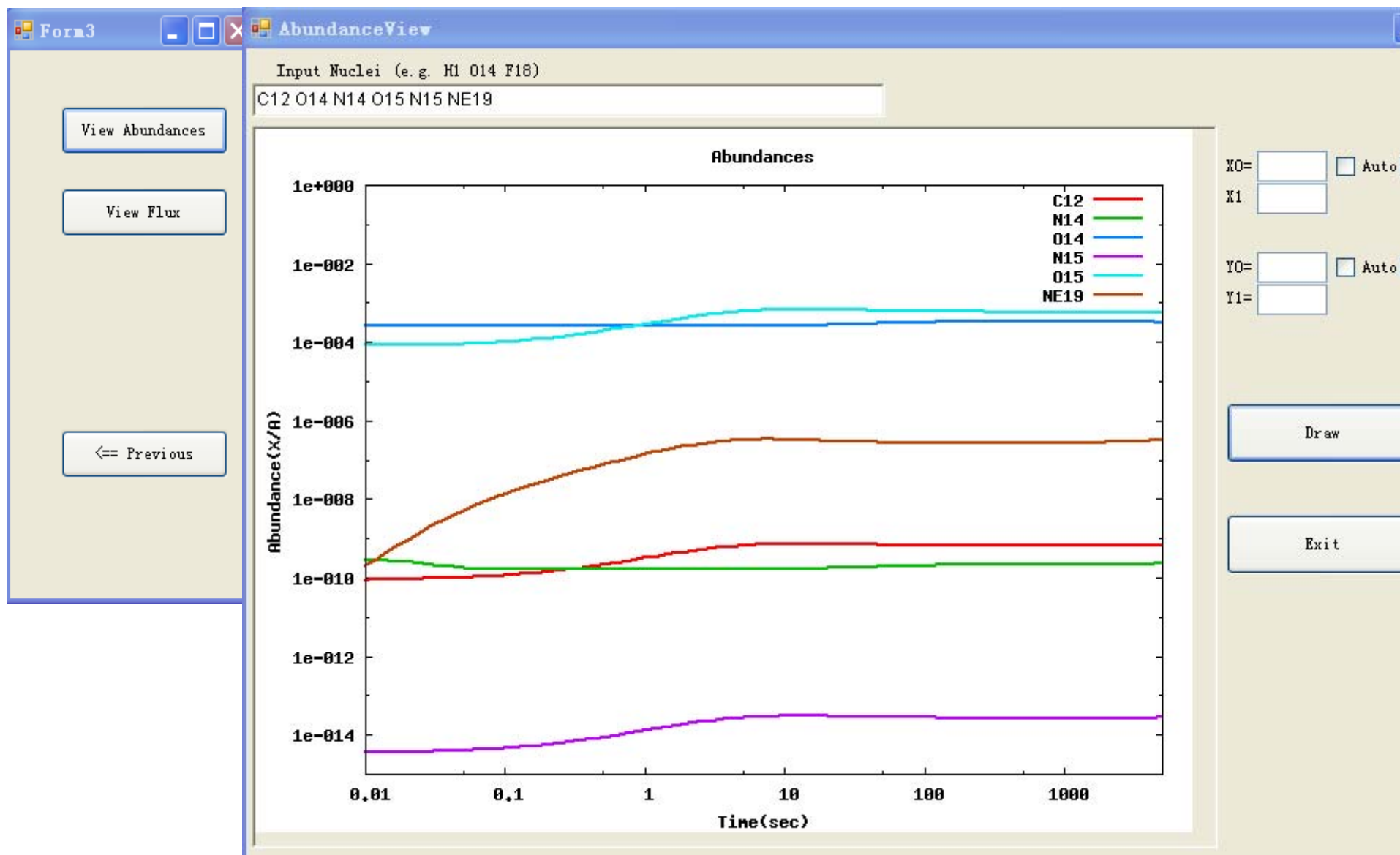
N
 H1
 H2
 H3
 HE3
 HE4
 LI6

Calculation

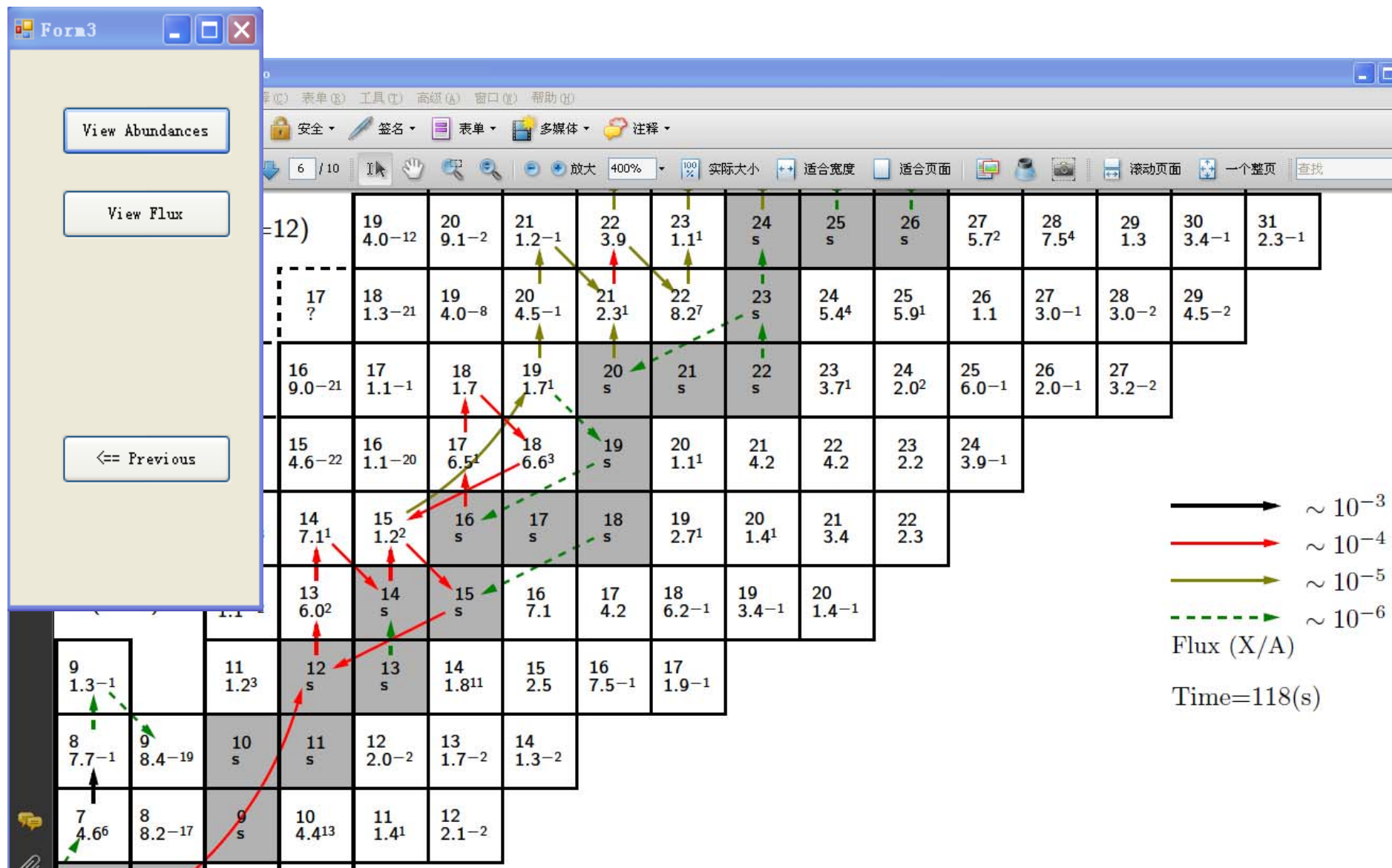
View Result

$$S = \frac{\partial Y_i}{\partial R_j} \square \frac{\delta Y_i}{\delta R_j}$$

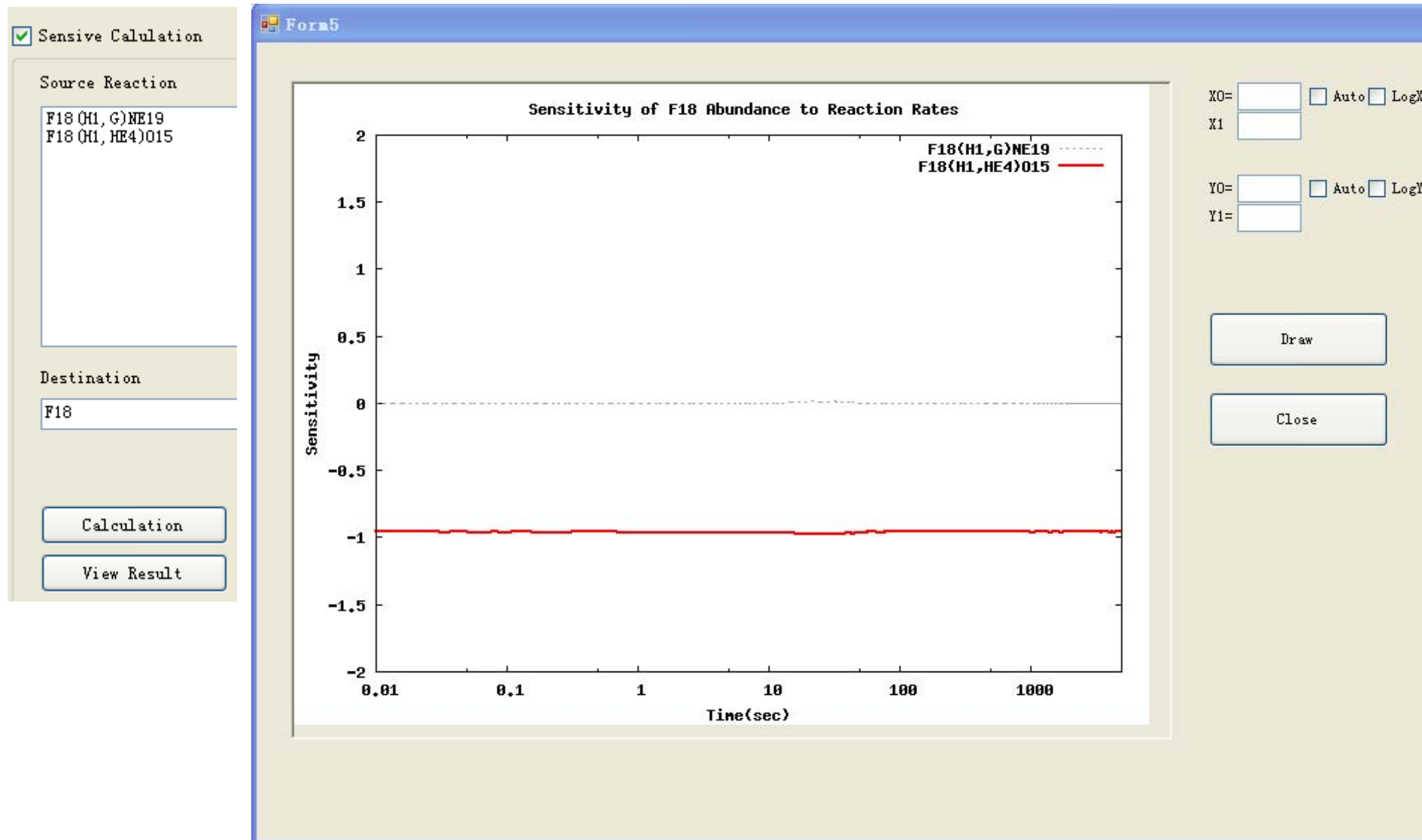
2.核反应网络计算程序界面设计(Result View)



2.核反应网络计算程序界面设计



2.核反应网络计算程序界面设计



4. 计划

- 程序开发:

- 继续程序开发, 完成各模型的计算;
- 增加反应率管理查看功能;
- 开发网络在线平台, 方便使用和管理。

- ***Thanks***