SNe Workshop
26-28th, Dec, 2011, YITP, Kyoto, JAPAN

An approach to the construction of EOS Database

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with
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Research History

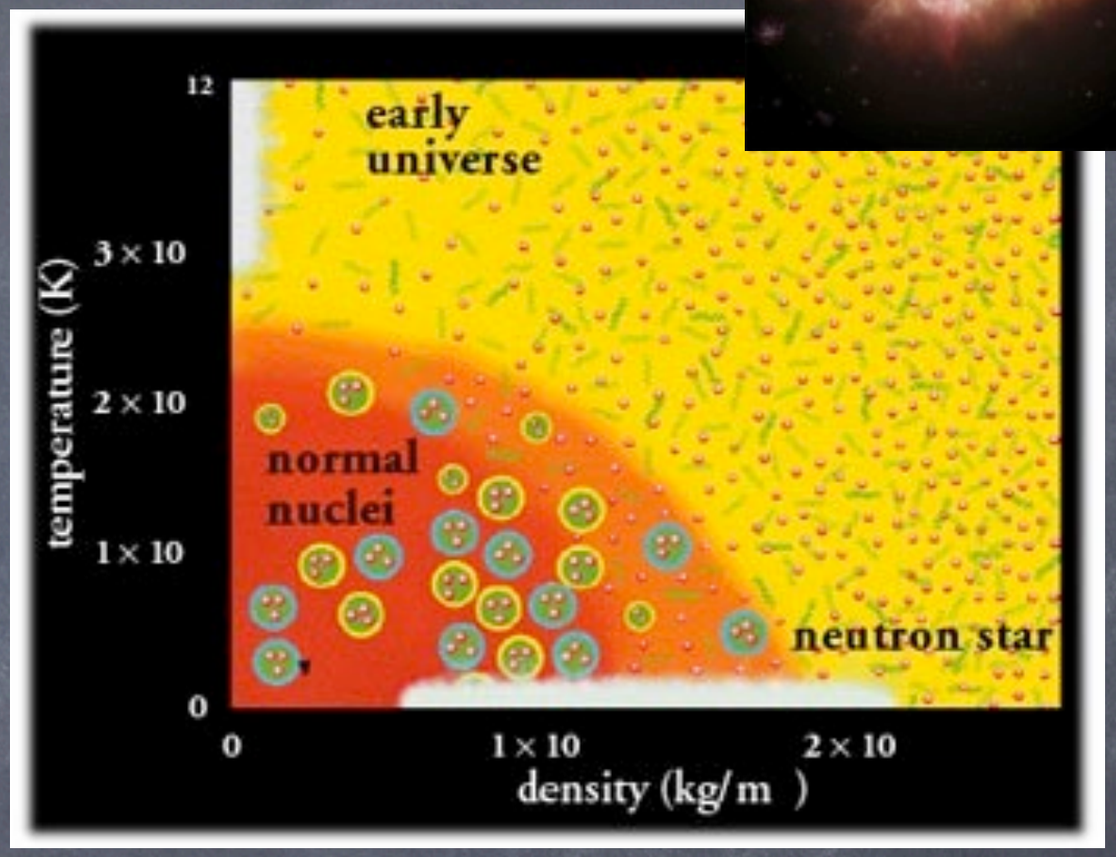
1. Liquid-Gas Phase Transition in SN environment
2. Hyperon EOS Table for SNe
3. Database for Metal Poor Star Observations (SAGA)

Outline of Today's Talk

Introduction: a brief review of nuclear EoS
Motivation: Why do we construct EoS Database?
Method: How to make the database....
Application of SAGA database system
Report: What are we doing now?
Summary

A brief review of nuclear EoS

SN: dynamics,
chemical evolution,
nucleosynthesis....



EoS of nuclear matter:

There are lots of theoretical model to investigate various aspects of nuclear matter but it's still difficult to describe a single model, there is not so much strong connection between researchers who study each phase:-(

EoSs for Compact Objects

- **Takahara-Sato:** an idealized one so as to treat phase transition in general form
- **Baron-Cooperstein-Kahana:** the compressible liquid drop model + a variant of the polytropic form
- **Helmholtz EOS:** wo nucl. force, ideal gas+Coulomb
- **Wolff-Hillebrandt EOS:** 3D Skyrme Hartree-Fock calculation, stiff one
- **Lattimer-Swesty EOS:** compressible liquid drop
- **Sumiyoshi-Shen EOS:** relativistic mean field
- **Recent progress in EOS:** Ishizuka, Nakazato, Furusawa, Togashi, G. Shen, Hempel, Newton, etc.

A brief review of nuclear EoS

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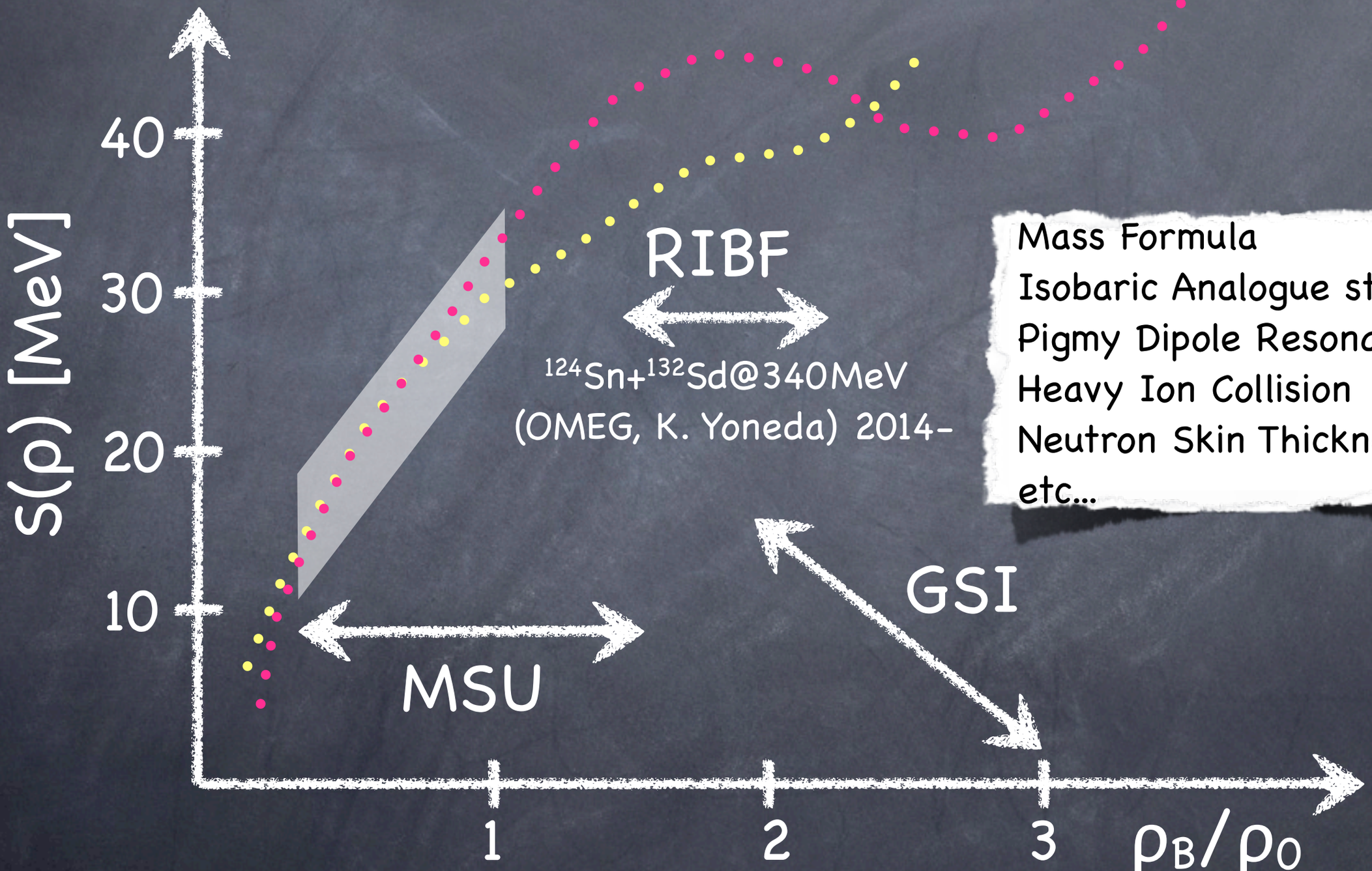
Constraints on EOS from nuclear physics



Mass Formula
Isobaric Analogue states
Pigmy Dipole Resonance
Heavy Ion Collision
Neutron Skin Thickness
etc...

Why do we construct EoS Database?

"Motivation"

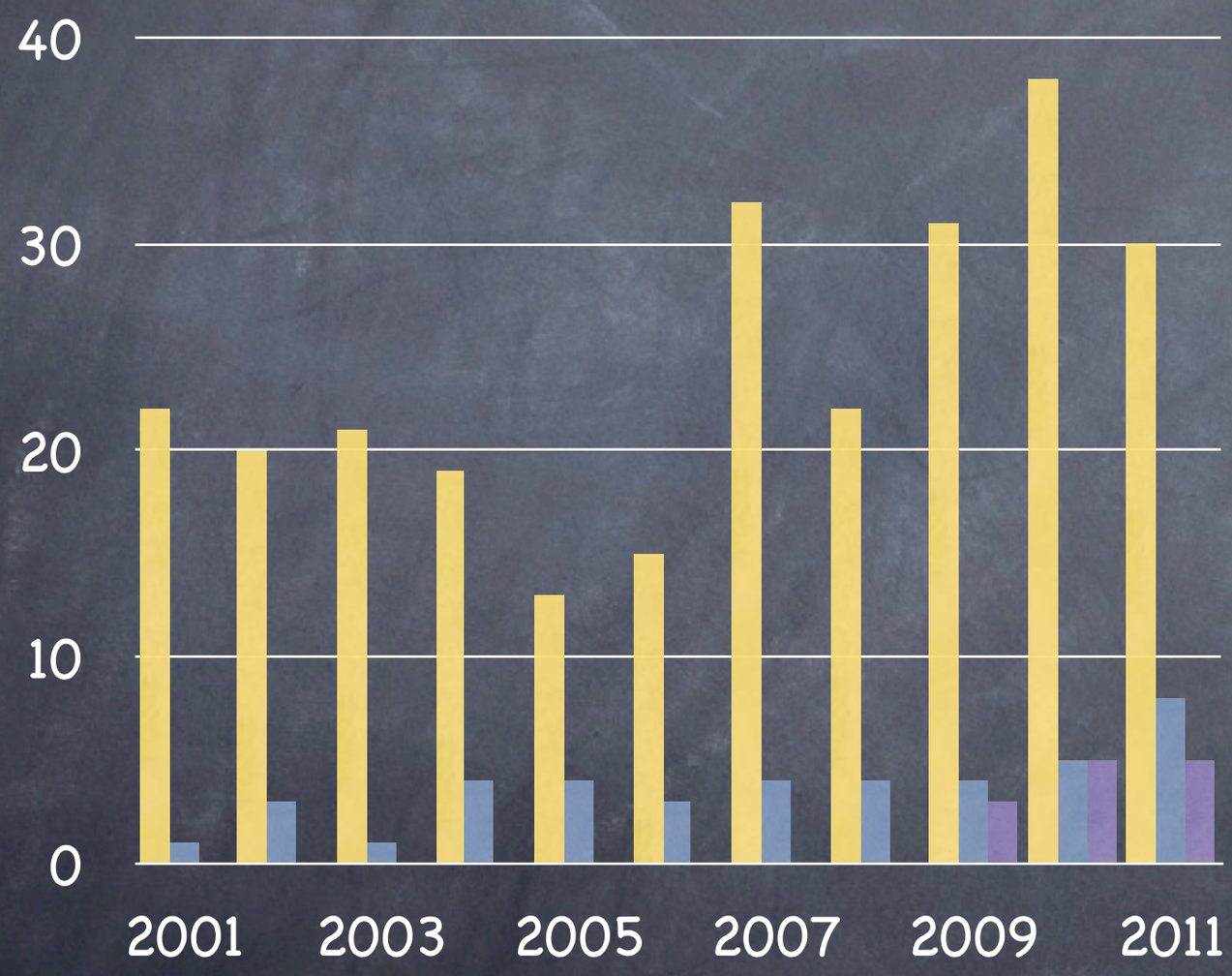
Difficulties in making EOS tables
single model description for various nuclear phase
the EOS within Exp. & Obs.?

What EOS Database can do:

1. Comparison of EOSs by different theo. models
2. Conditions suggested by NS Obs./Nucl. Exp.
3. Evaluation of the most possible EOS in each phase
4. Finding the EOS by statistical method

Why do we construct EoS Database?

Major Published Papers about Nucl. EoS in this decade



APS Journals:263+
Science Direct:41+
IOP Science:52+

Phys. Rev. C
NPA/PLB
J. Phys. G/APJ

Current situation of EOS study

How to make the database....

- An application of SAGA database system -

Compiled Object

Nucl. Theo. EOS/HIC Exp. S0, L/NS Obs.

Method

Database: MySQL+CSV
Search&Plot web system: Perl/cgi (SAGA DB)
Compilation by hand

Data

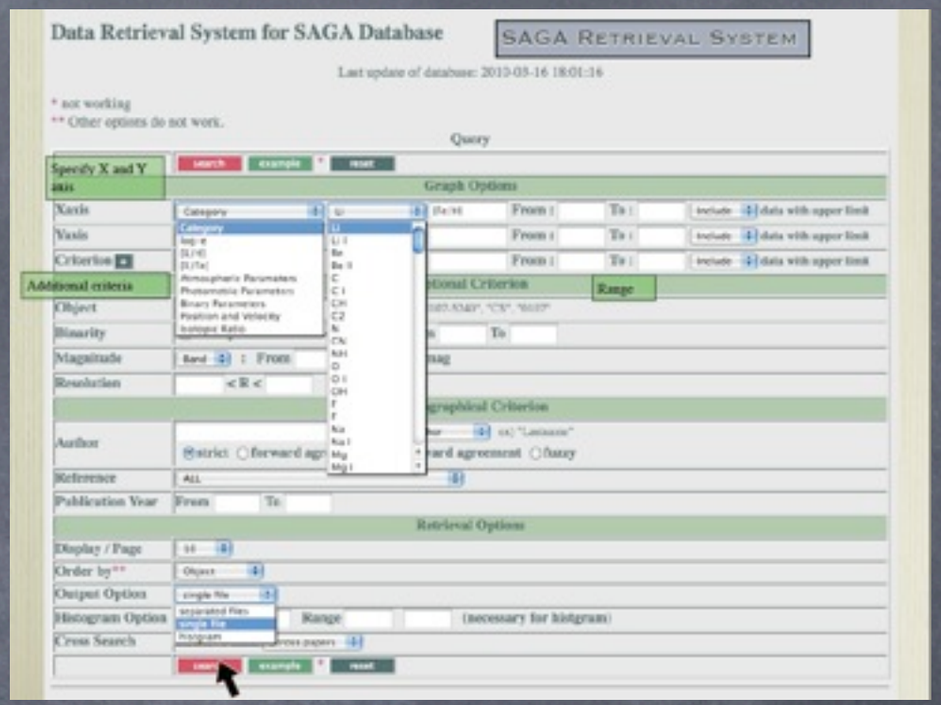
taken from papers (Fig./Tab./sentences)
with graph-read soft at present, however in future
to be provided from the authors of published papers

How to make the database....

- An application of SAGA database system -

The biggest difference between SAGA and EOS DB is the data;

SAGA: EMP observational data basically given by table format in papers, no need to contact directly to the authors.



EOS DB: Most of EOS data given by lines in a figure, we have to contact to the authors or perform calc. if we want to obtain the specific values

What are we doing now?

Start

Checking
& Picking up
papers to compile
(done)

Which info.
will be needed?
(not yet fixed)

Things to do (now doing)

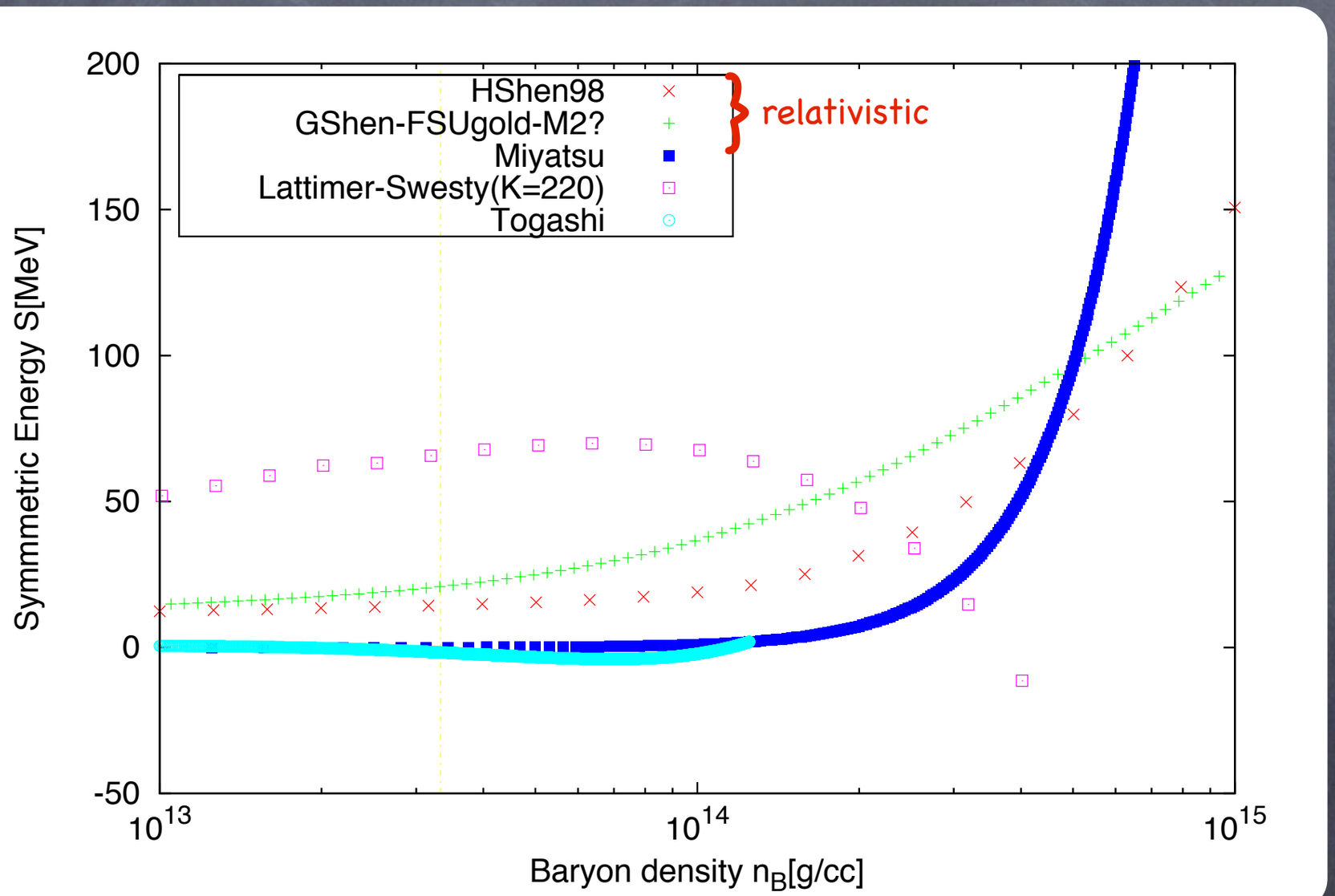
- ✓web platform
- ✓E-mail to authors
- ✓compilation of EoS data
- ✓arrange the data

Looking for the EoS
within the current knowledge
of Theo./Exp./Obs. data

Goal

What are we doing now?

We should check what the word like Energy(E, F, U), $E_{sym}(a_4, S)$ really means by data comparison.
To do that, we should adjust the units, check the reference point, arrange the data format very carefully...



What are we doing now?

In EOS DB, we classify each EOS according to
-their theo. background such as framework
for "high/medium/low" densities and/or temperatures...(1),
-"rel./non-rel."...(2),
-off course their framework such as LDM, HF, RHF etc...(3)

Rel.	Non Rel.
non-linear coupling	Gogny
density dependent	Skyrme
point coupling	
Brown-Rho scaling	
quark-meson coupli	

※Classification of Theo. Approach by J. Zenihiro

Compiled data: Conditions such as Y_p, T, n_B, physics constants, reference point for energy, K etc. from papers, EOS raw data from authors, S/E_{sym} derived from the data

Please tell me what kind of physical values you need to evaluate EOS for astronomical use! Gamma_s ...?

Expected EOS discussion with EOS DB

Using our classifications,
we may find unknown aspects of EOS models
on the web as shown in the previous slide,
besides we can customize EOS for compact objects
within exp./obs. constraints by using EOS DB.

as a tool

(Lattice QCD, HIC exp. and NS Obs.)
+(Bayesian Analysis) = the most probable EOS

The EOS will allow us the following discussions;

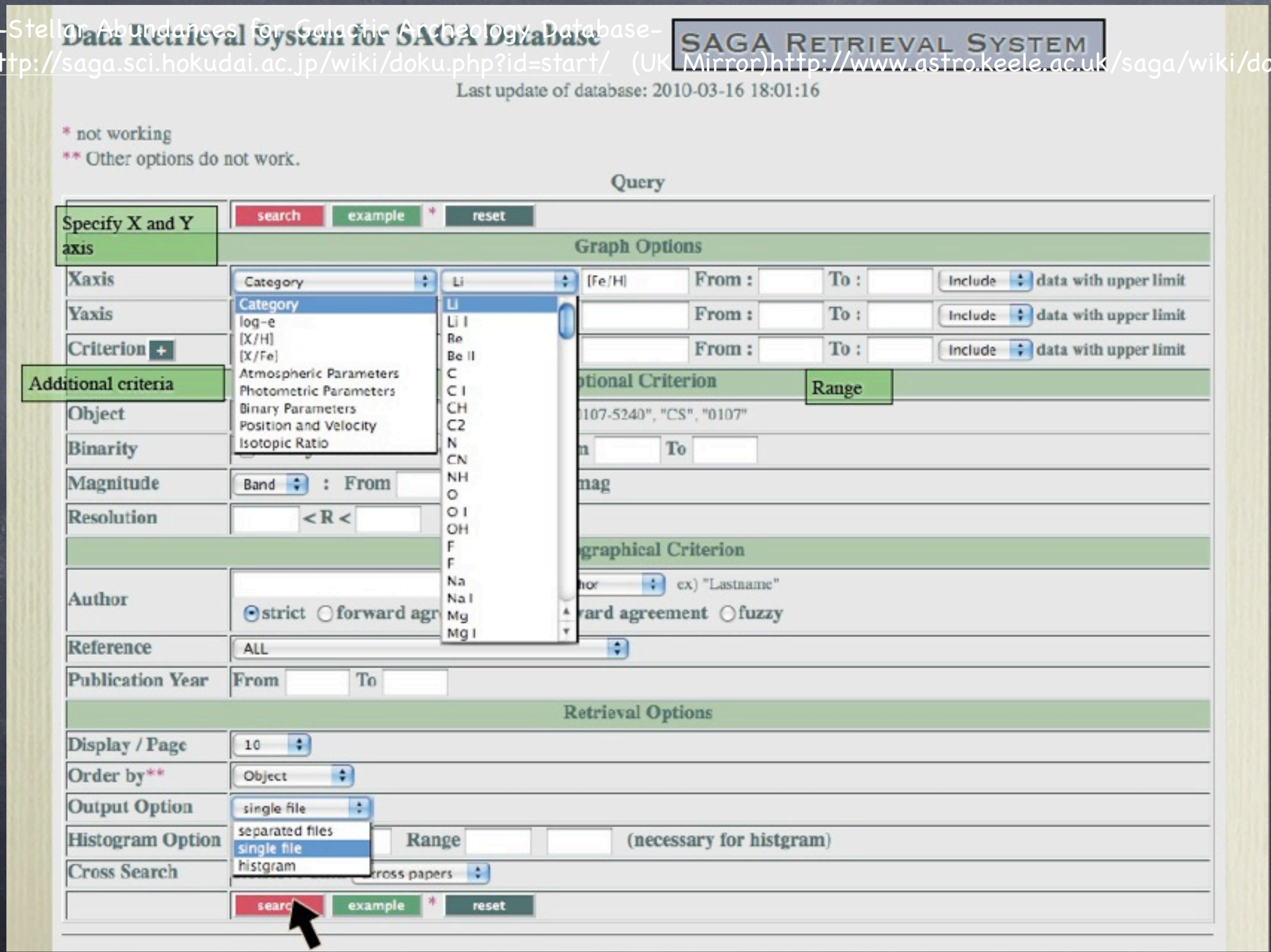
1. Internal structure of NS from phenomenological Lagrangian by fitting the above EOS (missing higher order effects or int. strength)
2. NS radius by OV eqn. and observed NS mass

physics

APPENDIX

What Database can do is ....

SAGA -Stellar Abundances for Galactic Archeology Database-
(URL)http://saga.sci.hokudai.ac.jp/wiki/doku.php?id=start/ (UK Mirror)http://www.astro.keele.ac.uk/saga/wiki/doku.php



What Database can do is ....

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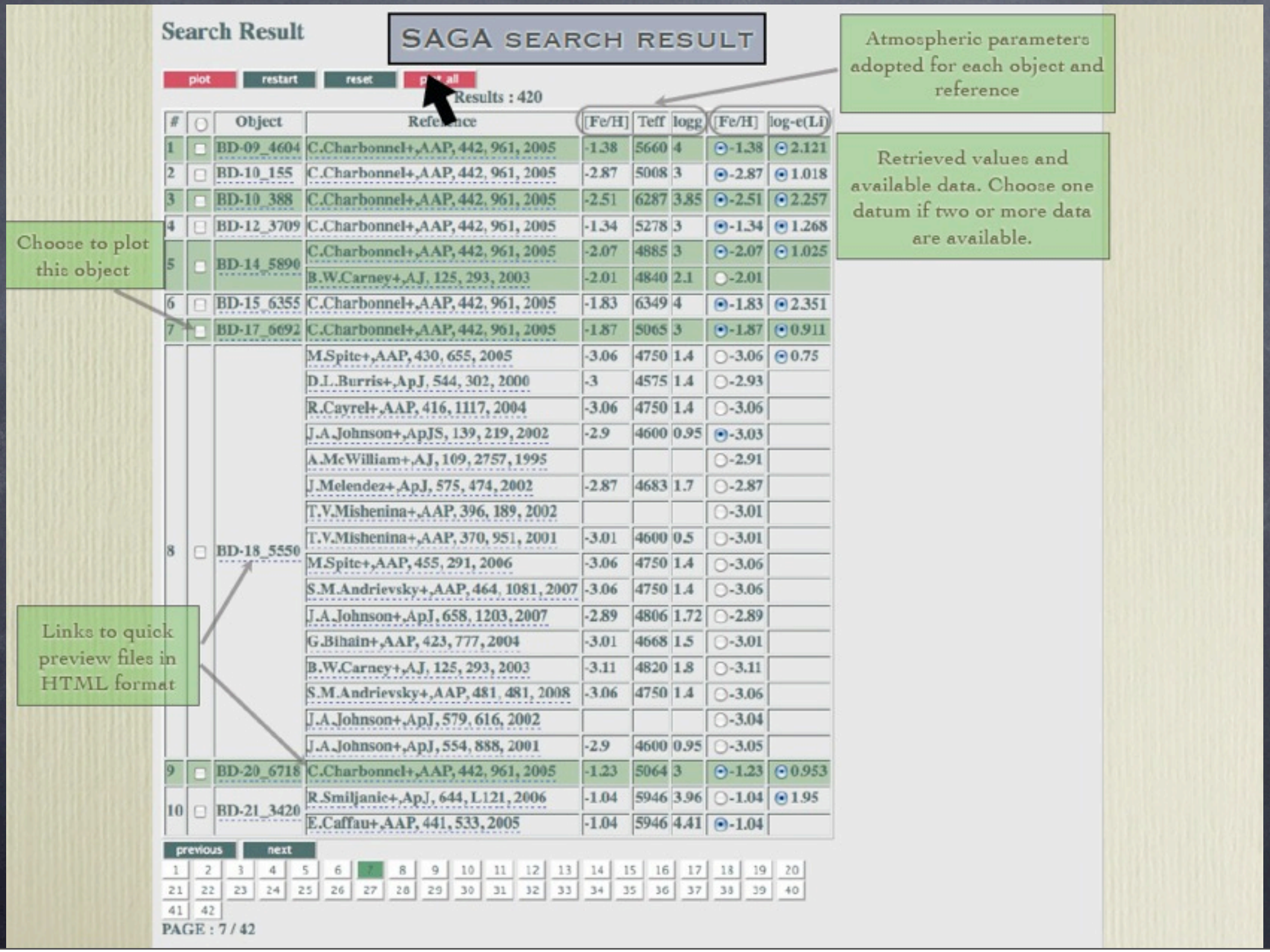
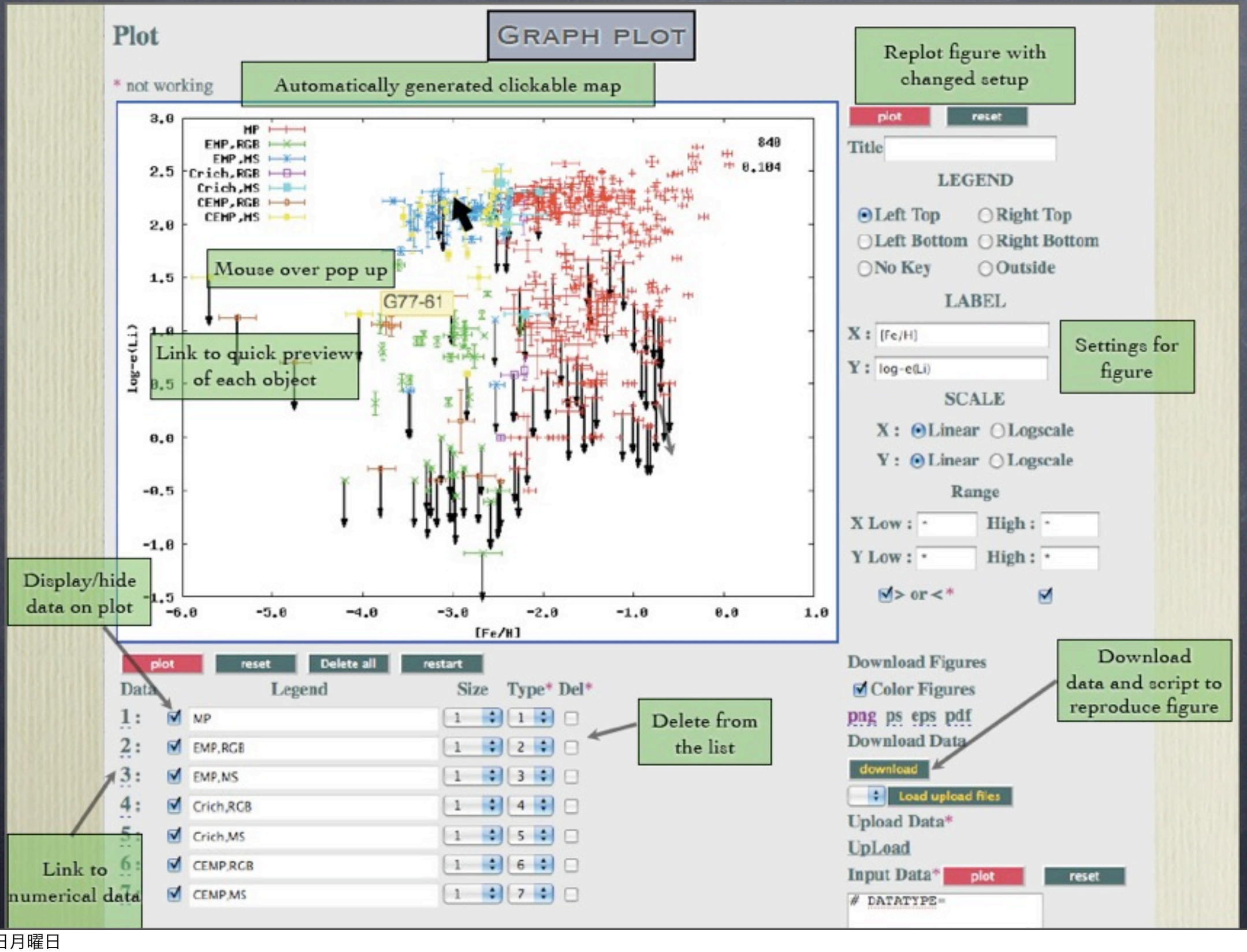


#	Object	Reference	[Fe/H]	Teff	logg	[Fe/H]	log-e(Li)
1	BD-09_4604	C.Charbonnel+,AAP,442,961,2005	-1.38	5660	4	-1.38	2.121
2	BD-10_155	C.Charbonnel+,AAP,442,961,2005	-2.87	5008	3	-2.87	1.018
3	BD-10_388	C.Charbonnel+,AAP,442,961,2005	-2.51	6287	3.85	-2.51	2.257
4	BD-12_3709	C.Charbonnel+,AAP,442,961,2005	-1.34	5278	3	-1.34	1.268
5	BD-14_5890	C.Charbonnel+,AAP,442,961,2005	-2.07	4885	3	-2.07	1.025
		B.W.Carney+,AJ,125,293,2003	-2.01	4840	2.1	-2.01	
6	BD-15_6355	C.Charbonnel+,AAP,442,961,2005	-1.83	6349	4	-1.83	2.351
7	BD-17_6692	C.Charbonnel+,AAP,442,961,2005	-1.87	5065	3	-1.87	0.911
		M.Spite+,AAP,430,655,2005	-3.06	4750	1.4	-3.06	0.75
		D.L.Burris+,ApJ,544,302,2000	-3	4575	1.4	-2.93	
		R.Cayrel+,AAP,416,1117,2004	-3.06	4750	1.4	-3.06	
		J.A.Johnson+,ApJS,139,219,2002	-2.9	4600	0.95	-3.03	
		A.McWilliam+,AJ,109,2757,1995				-2.91	
		J.Melendez+,ApJ,575,474,2002	-2.87	4683	1.7	-2.87	
		T.V.Mishenina+,AAP,396,189,2002				-3.01	
8	BD-18_5550	T.V.Mishenina+,AAP,370,951,2001	-3.01	4600	0.5	-3.01	
		M.Spite+,AAP,455,291,2006	-3.06	4750	1.4	-3.06	
		S.M.Andrievsky+,AAP,464,1081,2007	-3.06	4750	1.4	-3.06	
		J.A.Johnson+,ApJ,658,1203,2007	-2.89	4806	1.72	-2.89	
		G.Bihain+,AAP,423,777,2004	-3.01	4668	1.5	-3.01	
		B.W.Carney+,AJ,125,293,2003	-3.11	4820	1.8	-3.11	
		S.M.Andrievsky+,AAP,481,481,2008	-3.06	4750	1.4	-3.06	
		J.A.Johnson+,ApJ,579,616,2002				-3.04	
		J.A.Johnson+,ApJ,554,888,2001	-2.9	4600	0.95	-3.05	
9	BD-20_6718	C.Charbonnel+,AAP,442,961,2005	-1.23	5064	3	-1.23	0.953
10	BD-21_3420	R.Smiljanic+,ApJ,644,L121,2006	-1.04	5946	3.96	-1.04	1.95
		E.Caffau+,AAP,441,533,2005	-1.04	5946	4.41	-1.04	

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
41 42

What Database can do is ....

SAGA -Stellar Abundances for Galactic Archeology Database-
(URL)http://saga.sci.hokudai.ac.jp/wiki/doku.php?id=start/ (UK Mirror)http://www.astro.keele.ac.uk/saga/wiki/doku.php



What SAGA can do is ....

SAGA -Stellar Abundances for Galactic Archeology Database-
(URL)http://saga.sci.hokudai.ac.jp/wiki/doku.php?id=start/ (UK Mirror)http://www.astro.keele.ac.uk/saga/wiki/doku.php

BPS CS22892-052: found in 18 paper(s).

QUICK PREVIEW OF DATA

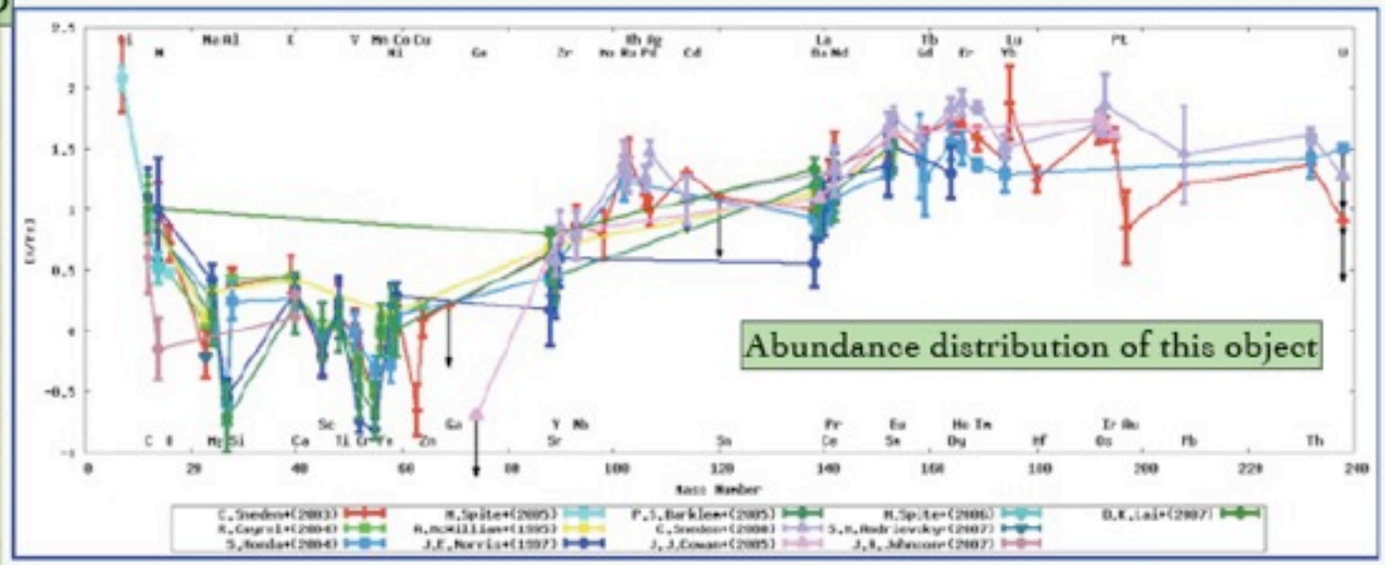
Labels:

/C.Sneden et al.(2003)/ /R.Cayrel et al.(2004)/ /S.Honda et al.(2004)/ /N.Christlieb et al.(2004)/ /M.Spite et al.(2005)/ /A.McWilliam et al.(1995)/ /A.McWilliam et al.(1995)/ /J.E.Norris et al.(1997)/ /G.W.Preston and C. Sneden(2001)/ /P.S.Barklem et al.(2005)/ /C.Sneden et al.(2000)/ /W.Aoki et al.(2003)/ /J.J.Cowan et al.(2005)/ /S.Honda et al.(2004)/ /M.Spite et al.(2006)/ /S.M.Andrievsky et al.(2007)/ /J.A.Johnson et al.(2007)/ /D.K.Lai et al.(2007)/

Links to quick preview for this object

Find this object in SIMBAD

Link to SIMBAD



C.Sneden et al.,ApJ, 591, 936, 2003 (A0003,ADS)

Link to ADS

Link to quick preview for this reference

Atmospheric data

T_{eff} : 4800 log g : 1.50 v_{turb} : 1.95

Stellar atmosphere parameters

Chemical Abundances

Element	Nline	[X/H]	[X/Fe]	log-e
Li I	...	-1.01+-0.30	2.09+-0.30	+0.15+-0.30
CH	...	-2.22+-0.10	+0.88+-0.10	+6.30+-0.10
CN	...	-2.09+-0.20	+1.01+-0.20	+5.83+-0.20
O I	...	-2.38+-0.15	+0.72+-0.15	+6.45+-0.15
Na I	...	-3.29+-0.19	-0.19+-0.19	+3.04+-0.19
Mg I	...	-2.87+-0.08	+0.30+-0.08	+4.78+-0.08
Al I	...	-3.68+-0.15	-0.58+-0.15	+2.79+-0.15
Si I		-2.74+-0.15	+0.36+-0.15	+4.81+-0.15

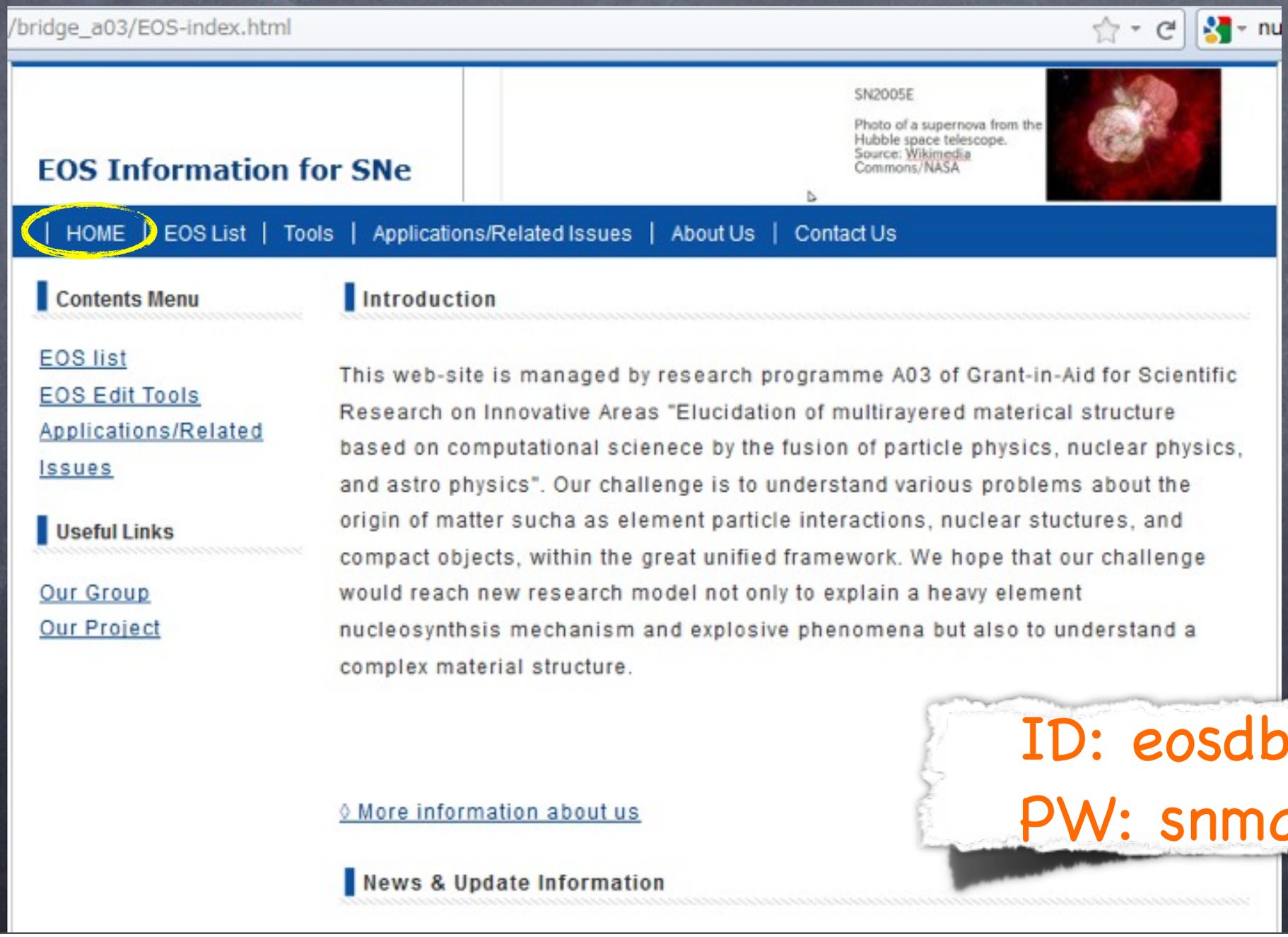
: Data presented in the paper
: Data converted with the solar abundance from Grevesse et al. (1996)

Abundance data

and information on photometry, observing log, and binarity

List up EOSs

Gathering EOS table
Summarising their theoretical background
e.g.) Physics constants, method...



ID: eosdb
PW: snmatter

/eos/EOS-list.html

8 EOS tables (row data & codes)
2 EOS tables coming soon
4 Links to the other EOS tables

EOS Information for SNe

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Our Group
Our Project

Shen EOS and its friends

- ***1998 ver.***

constituents:nucleons, alpha, a heavy nucleus
methods: Relativistic Mean Field Theory
using parameter set TM1+Thomas Fermi calc.
physical constants:
m_u=931.49432[MeV],
hbarc=197.32705[MeVfm],
pi=3.14159265358979323846
ref.) Particle Data Book, PRD 50,3-1(1994) p.1233
comments: Original
articles: Nucl. Phys. A, 637 (1998) 435
manuals:guide for EOS1.pdf
--main table = eos1.tab.gz
--table for zero temperature = eos1.t00.gz
--table for zero proton fraction = eos1.Yp0.gz

constituents,
detailed info. of phys. const.,
ref., EOS table data, manual

comments on the table
e.g.) characteristics
of used potential
and cal. methods etc.

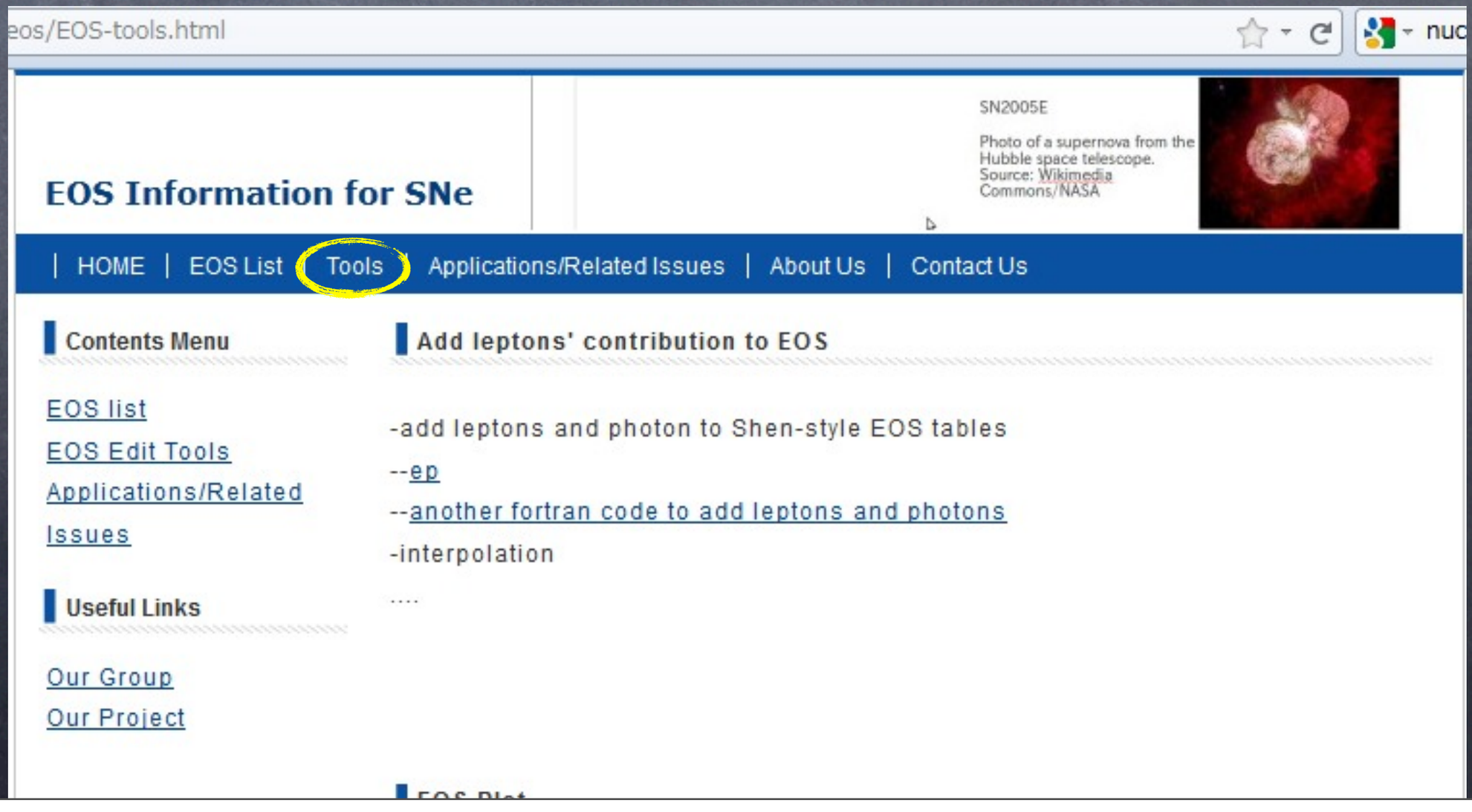
- ***2011 ver.***

constituencts:nucleons, alpha, a heavy nucleus
methods: Relativistic Mean Field Theory
using parameter set TM1+Thomas Fermi calc.
physical constants:
m_u=931.49[4MeV],
hbarc=197.327[MeVfm],

List up EOSs

Tools for SN simulations

- Add lepton contributions, interpolate EOS tables
- Figure out EOSs coming soon
- Thomas-Fermi config. of inhomo. phase (S. Yamamuro)
- Transform EOS tables from (Ye, rhoB, T) to (Ye, S, T)



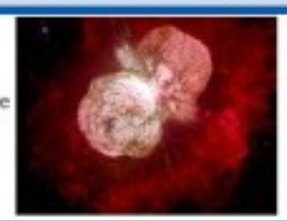
List up EOSs

eos/EOS-appendix.html

EOS Information for SNe

SN2005E

Photo of a supernova from the Hubble space telescope. Source: Wikimedia Commons/NASA



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Our Group
Our Project

Nucleosynthesis during SNe

Nucleosynthsis during SNe

Still under construction

Progenitor Models

We also provide you some progenior models for supernovae. These models are calculated by Umeda Group at Univ. of Tokyo.

This page is maintained by Chikako Ishizuka.
Last updated at 22nd, Sep., 2011

Notations for symmetry energy

$$E(\rho,\delta) = E(\rho,0) + E_{sym}(\rho)\delta^2 + o(\delta^4)$$

$$E(\rho,0) = E(\rho_0,0) + \frac{K_0}{2}\varepsilon^2 + o(\varepsilon^3)$$

$$E_{sym}(\rho) = E_{sym}(\rho_0) + L\varepsilon + \frac{K_{sym}}{2}\varepsilon^2 + o(\varepsilon^3)$$

$$K_0 = 9\rho_0^2 \left.\frac{\partial^2 E(\rho,0)}{\partial\rho^2}\right|_{\rho=\rho_0}$$

$$\delta = (\rho_n - \rho_p)/\rho$$

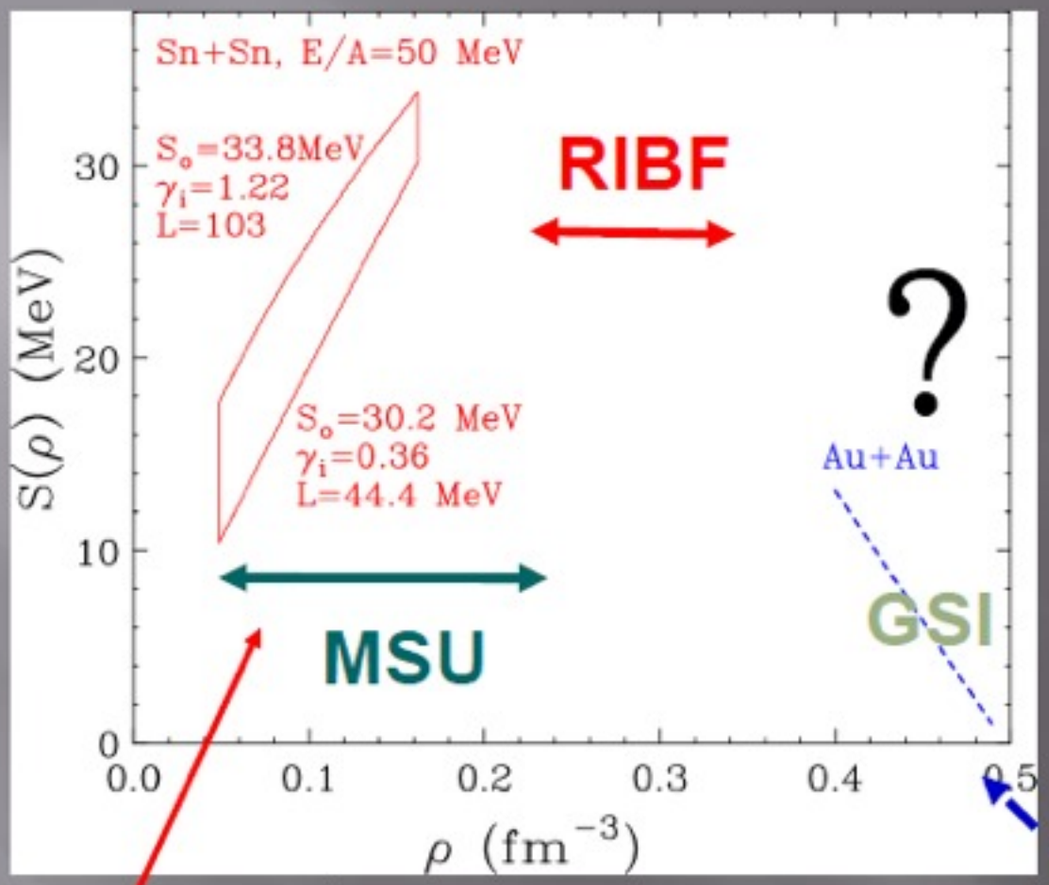
$$\varepsilon = (\rho - \rho_0)/3\rho_0$$

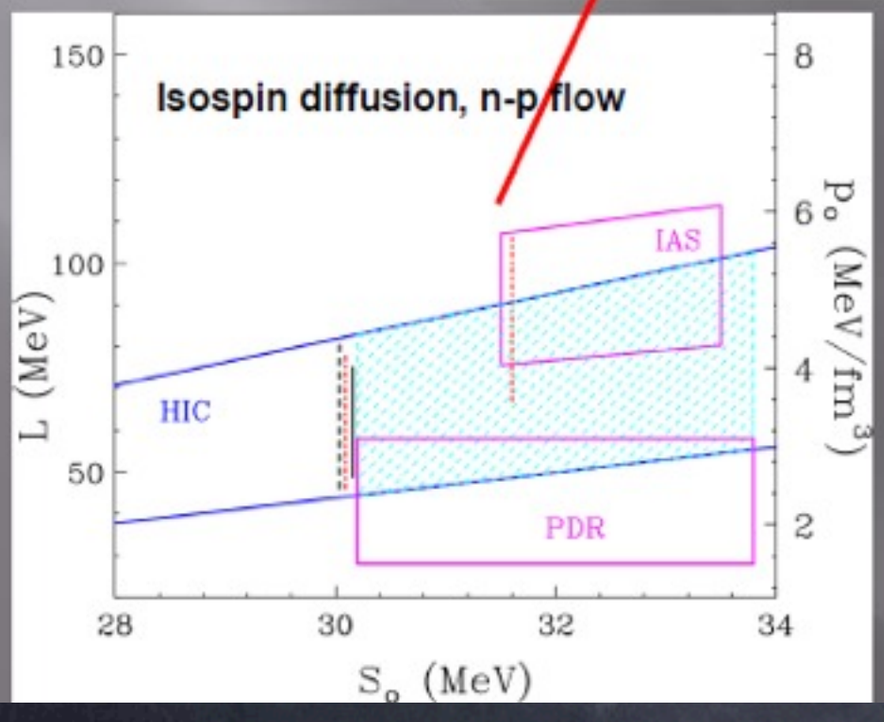
$$S_0 = E_{sym}(\rho_0)$$

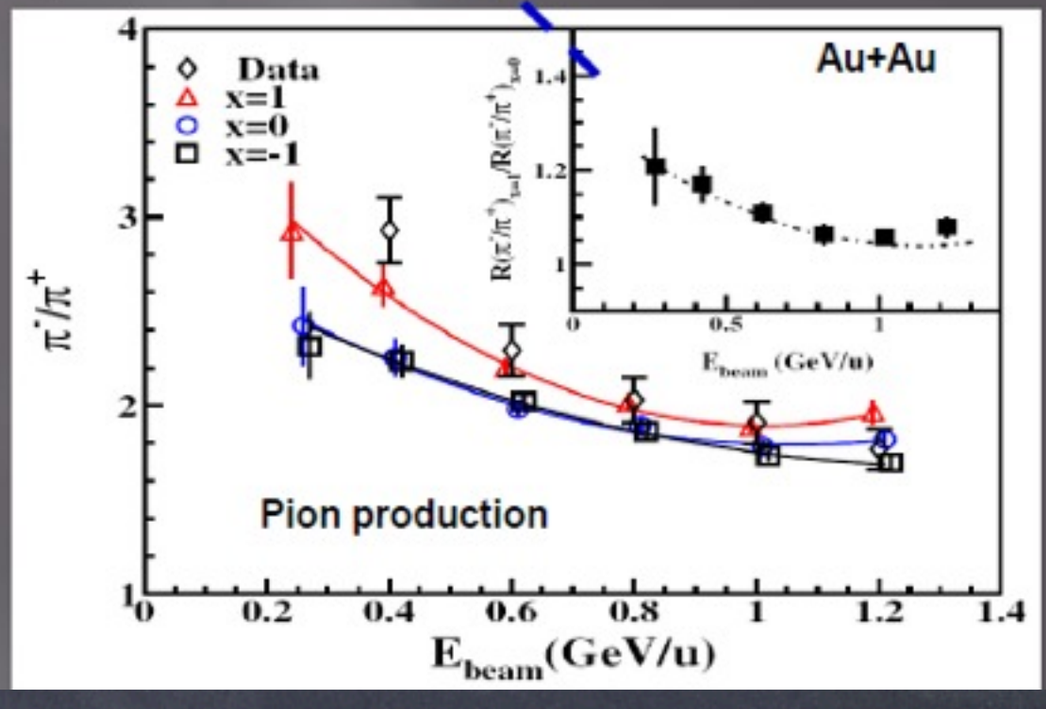
$$L = 3\rho_0 \left.\frac{\partial E_{sym}(\rho)}{\partial\rho}\right|_{\rho=\rho_0} = (3/\rho_0)P_0$$

$$K_{sym} = 9\rho_0^2 \left.\frac{\partial^2 E_{sym}(\rho)}{\partial\rho^2}\right|_{\rho=\rho_0}$$

$$K_\tau \approx K_{sym} - 6L$$

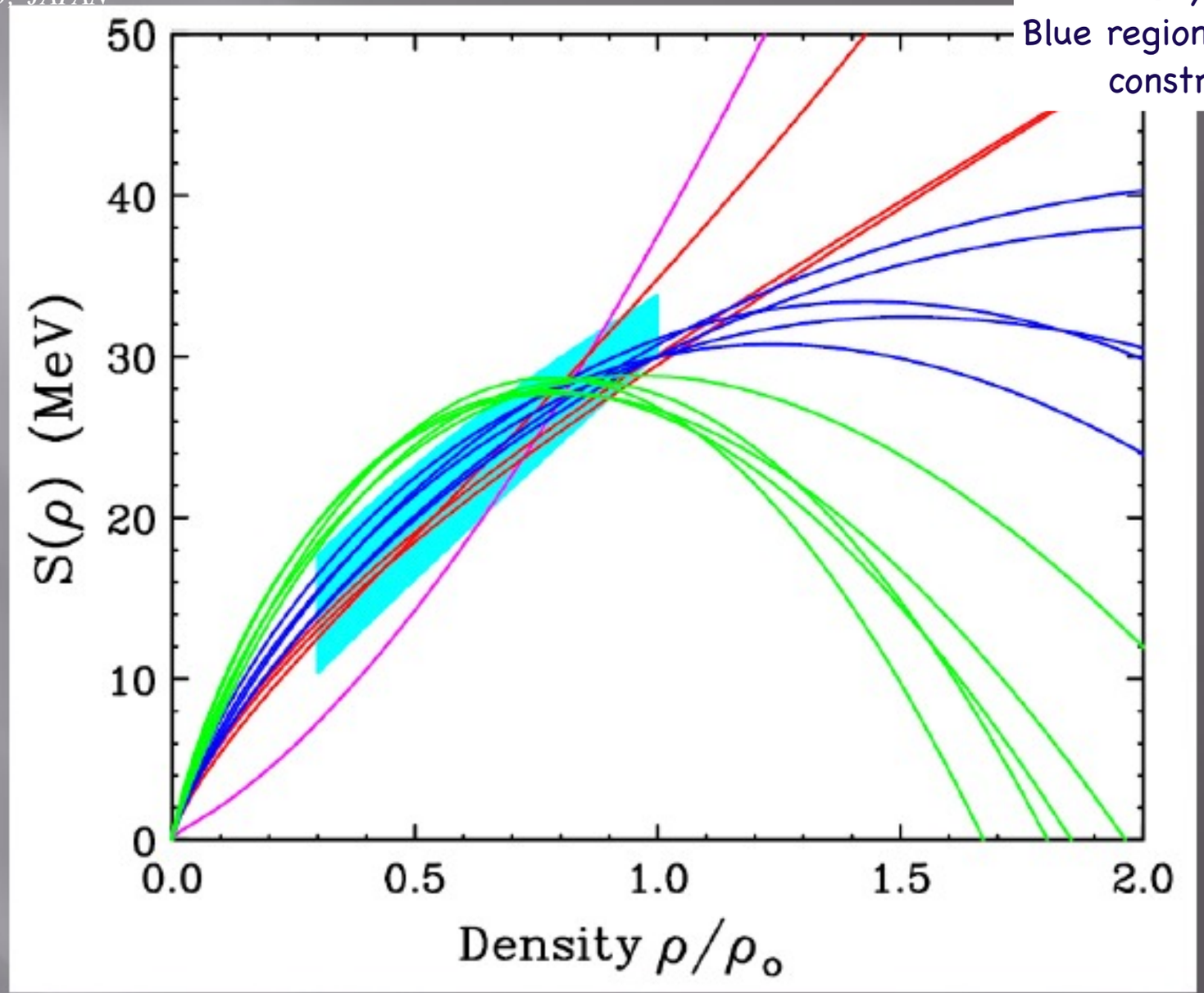






Xiao, et al., arXiv:0808.0186 (2008)
Reisdorf, et al., NPA 781 (2007) 459.

Lines : Skyrme HF Calc
Blue region:: Murakami's exp.
constraints on S_0 and L



Our consensus is S_0=31-34 MeV and L=50-110 MeV

Now preparing a summary article on outcomes of NuSYM11.