



International Atomic Energy Agency

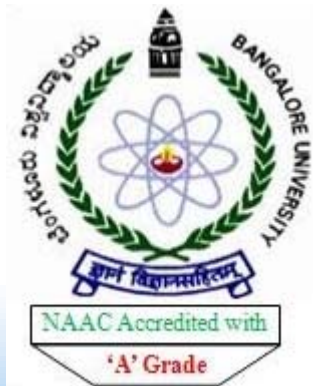
The 6th DAE-BRNS Theme Meeting on

EXFOR Compilation of Nuclear Data

Department of Physics, Bangalore University, Bangalore, India

20–24 January 2015

Goal of the Workshop



Naohiko OTSUKA

Nuclear Data Section

Department of Nuclear Sciences and Applications



Outline of Workshop

- Nuclear Database (General)
- EXFOR/ENDF Search
- EXFOR Compilation I – Bibliography, exp. condition.
- EXFOR Compilation II – Experimental parameters
- EXFOR Compilation III – Data tables
- Digitization tool
- Checking tools

You have to submit your EXFOR entry after clearance by the end of this workshop!

After this Workshop ...

All your EXFOR entries will be stored in the IAEA EXFOR database.
You are responsible to distribute Indian data correctly.

Experimental Nuclear Reaction Data (EXFOR)
Database Version of February 16, 2011
Software Version of 2010.10.13 Old interface is [here]

News

2011/01 Improvements and extensions:
1) Search for recently updated data (Extended mode: Last modified)
2) Display titles of original articles (imported from NSR) when data "Sorted by Publications"
[History]

The EXFOR library contains an extensive compilation of experimental nuclear reaction data. Neutron reactions have been compiled systematically since the discovery of the neutron, while charged particle and photon reactions have been covered less extensively.
The library contains data from 18832 experiments (see [statistics](#) and recent [updates](#)).

Request Examples: 1|2|3|4|5|6|7|...

Submit Reset Help

Target _____ >>>
Reaction _____ >>>
Quantity _____ >>>
Product _____ >>>
Energy from to eV >>>
Author(s) _____ >>>
Publication year _____ >>>
Accession # _____ >>>

Options Tip of the day: video-guide

Exclude superseded data
 No reaction combinations (ratios,...)
 Enhanced search of Products
 Retrieve listing only
 Disable Prompt-Help

Sort by:
 Reaction
 Publication (Entry #)

Ranges (Z,A)
Reaction Sub-Fields
Feedback and User's Input

Submit Reset

Clone Request:
ONDA ENDF

Note:
- all criteria are optional (selected by checking)
- selected criteria are combined for search with logical AND
- criteria separated in a field by ";" are combined with logical OR
- wildcards (*) and intervals are available

Web and Database Design and Programming: Viktor Zerkin, NDS, International Atomic Energy Agency (V.Zerkin@iaea.org) 2010.10.13
Data Source: Network of Nuclear Reaction Data Centres - coordinator: Naohiko Otsuka, NDS, IAEA (N.Otsuka@iaea.org)



Goal of this Workshop

- To understand the idea of “nuclear database”.
- To be able to search and process EXFOR data.
- To be able to prepare EXFOR entries.

The ultimate goal:

Creation of EXFOR entries from your own experiments!



A Successful Workshop Participant – Dr. Chitra Bhatia

PHYSICAL REVIEW C 87, 011601(R) (2013)

$^{136}\text{Xe}(n,2n)^{135}\text{Xe}$ cross section between 9 and 15 MeV

EXFOR 14355
(Jan. 2013)

C. Bhatia,^{1,2,*} S. W. Finch,^{1,2} M. E. Gooden,^{2,3} and W. Tornow^{1,2}

¹Department of Physics, Duke University, Durham, North Carolina 27708, USA

²Triangle Universities System, Durham, North Carolina 27709, USA

³Department of Physics, North Carolina State University, Raleigh, North Carolina 27697, USA
(Received 10/1/12)



SUBENT	14355001	20130125	14355	1	1
BIB	12	23	14355	1	2
TITLE	136Xe(n,2n)135Xe cross section between 9 and 15 MeV		14355	1	3
AUTHOR	(C.Bhatia, S.W.Finch, M.E.Gooden, W.Tornow)		14355	1	4
INSTITUTE	(1USADKE,1USATNL,1USANCS)		14355	1	5
REFERENCE	(J,PR/C,87,011601,2013)		14355	1	6
FACILITY	(VDGT,1USATNL)		14355	1	7
...					
STATUS	(TABLE) Table I of Phys.Rev.C87(2013)011601		14355	1	24
HISTORY	(20130125C) Chitra Bhatia		14355	1	25

TABLE I. Summary of cross-section results. $\Delta\sigma_1$ = statistical uncertainty. $\Delta\sigma_2$ = total uncertainty.

E_n (MeV)	$^{136}\text{Xe}(n,2n)^{135}\text{Xe}$ σ (mb)	$^{136}\text{Xe}(n,2n)^{135}\text{Xe}^m$ $\Delta\sigma_1$	$\Delta\sigma_2$	σ (mb)	$\Delta\sigma_1$	$\Delta\sigma_2$
8.96 ± 0.09	265.09	1.50	12.12	21.71	0.33	0.99
9.46 ± 0.13	558.29	0.94	20.60	198.13	2.10	7.24
9.96 ± 0.13	746.97	1.10	24.90	290.01	3.40	10.48
10.95 ± 0.20	1344.73	1.3	40.01	552.44	3.21	17.64
11.94 ± 0.21	1630.47	3.98	44.50	763.13	2.72	20.26
12.94 ± 0.20	1751.34	3.20	40.95	864.13	2.33	22.04
13.75 ± 0.20	1813.19	2.22	33.11	870.56	1.51	15.05
14.45 ± 0.19	1794.11	2.45	40.02	848.85	1.78	18.70
14.85 ± 0.05	1727.85	2.66	53.15	845.42	1.81	25.58

She compiled data in her
3 PRC articles published in
2012-2013!

A Successful Workshop Participant – Dr. Megha Bhike

PHYSICAL REVIEW C 89, 031602(R) (2014)

EXFOR 14385
(Apr. 2014)

Neutron-capture cross-section measurements of ^{136}Xe between 0.4 and 14.8 MeV

Megha Bhike and W. Tornow

Department of Physics, Duke University, Durham, North Carolina, 27708, USA
and Triangle Universities Nuclear Laboratory, Durham, North Carolina, 27708, USA

(Rec)	SUBENT	14385001	20140404	14385	1	1
	BIB	14	34	14385	1	2
	TITLE	Neutron-capture cross-section measurements of ^{136}Xe between 0.4 and 14.8 MeV		14385	1	3
	AUTHOR	(M.Bhike, W.Tornow)		14385	1	5
	INSTITUTE	(1USADKE,1USATNL)		14385	1	6
	REFERENCE	(J,PR/C,89,031602,2014)				
	FACILITY	(VDGT,1USATNL)				
	...					
	STATUS	(TABLE)Table II of of Phy.				
	HISTORY	(20140404C) compiled by Megha				



She compiled data in her 1 PRC and 1 PLB article published in 2014!
(Also a new PRC article in January '15!)

TABLE II. Neutron energy and energy spread, monitor reaction cross-section values used, and $^{136}\text{Xe}(n,\gamma)^{137}\text{Xe}$ cross-section results obtained in the present work.

Neutron energy $E_n \pm \Delta E_n$ (MeV)	Monitor reactions σ (mb)	$^{136}\text{Xe}(n,\gamma)^{137}\text{Xe}$ σ (mb)
0.37 ± 0.11	170 ± 5.1	0.61 ± 0.08
0.85 ± 0.11	38.93 ± 1.60	0.74 ± 0.08
1.30 ± 0.12	130.23 ± 3.13	1.00 ± 0.12
1.85 ± 0.12	238.71 ± 5.73	0.70 ± 0.07
2.74 ± 0.15	344.40 ± 8.09	0.59 ± 0.08
3.34 ± 0.15	336.66 ± 7.91	0.96 ± 0.22
4.10 ± 0.62	318.20 ± 7.48	1.09 ± 0.11
5.66 ± 0.39	341.90 ± 8.89	0.89 ± 0.09
6.24 ± 0.36	347.62 ± 11.47	0.62 ± 0.09
7.31 ± 0.30	345.04 ± 11.39	0.57 ± 0.16
14.79 ± 0.08	2166.16 ± 23.40	0.73 ± 0.07





No new EXFOR entry from a successful **man** participant in these years... (“successful”=compile data published in his own publication in EXFOR)



International Atomic Energy Agency

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Department of Physics, Bangalore University, Bangalore, India

20–24 January 2015

Introduction to Nuclear Data



Naohiko OTSUKA

Nuclear Data Section

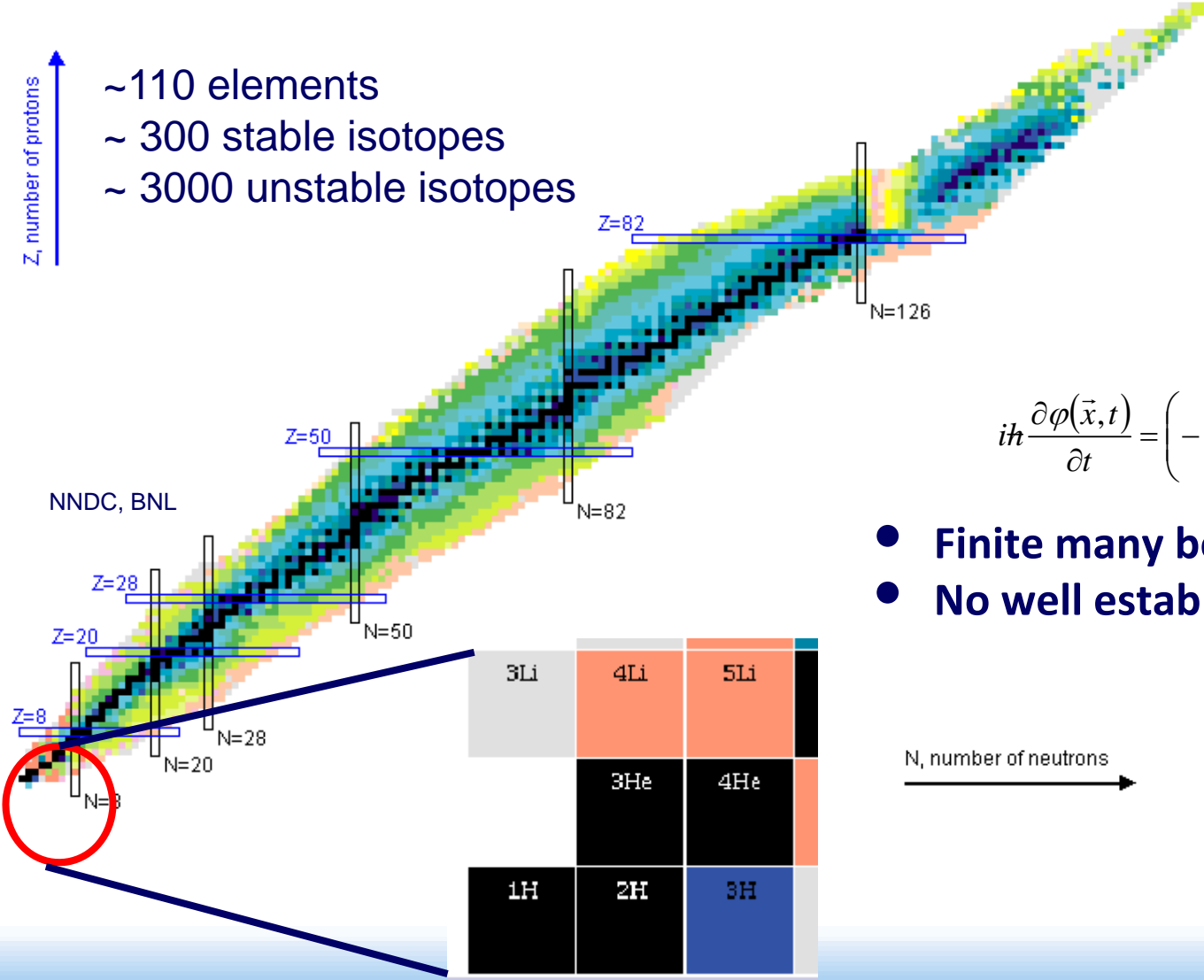
Department of Nuclear Sciences and Applications



Basic Nuclear Physics

Z, number of protons

~110 elements
 ~ 300 stable isotopes
 ~ 3000 unstable isotopes



$$i\hbar \frac{\partial \varphi(\vec{x}, t)}{\partial t} = \left(-\frac{\hbar^2}{2m} \Delta + V(\vec{x}) \right) \varphi(\vec{x}, t) \quad ?$$

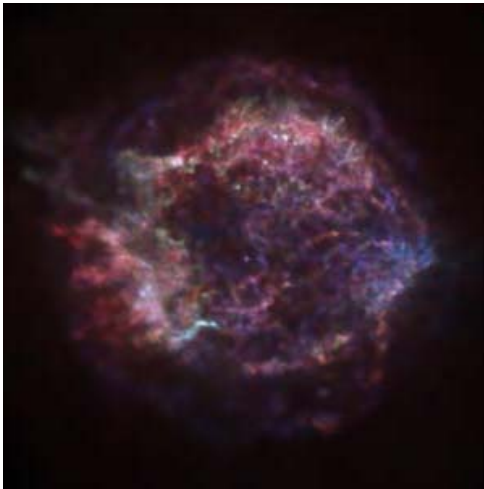
- Finite many body system
- No well established interaction

Nuclear Reaction Network in Science

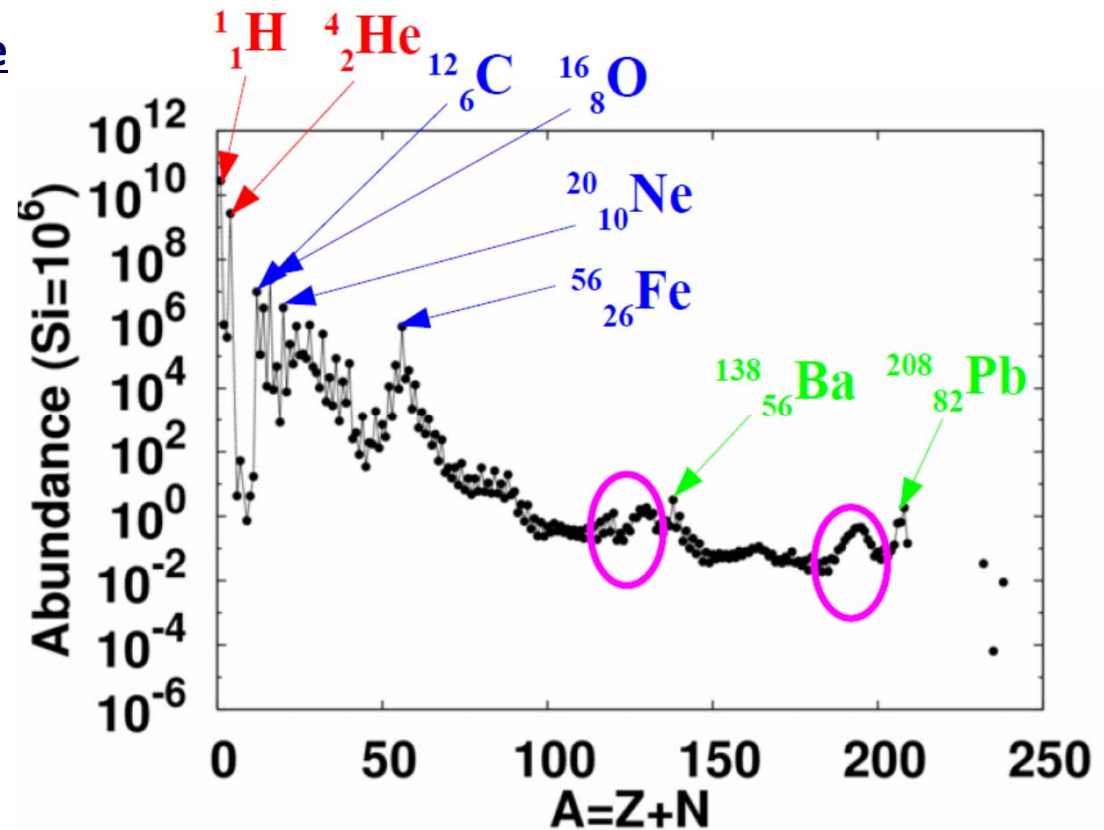
Nucleosynthesis

How do we understand isotopic abundances?

Isotopic abundances in the universe

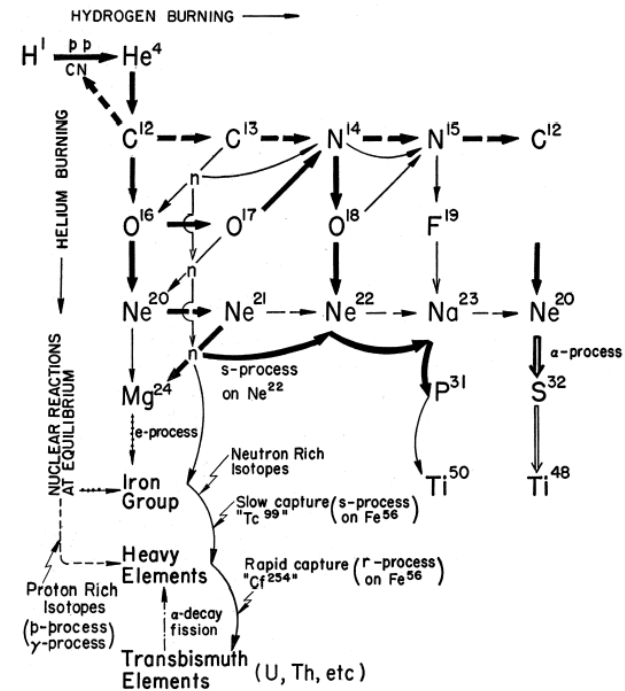
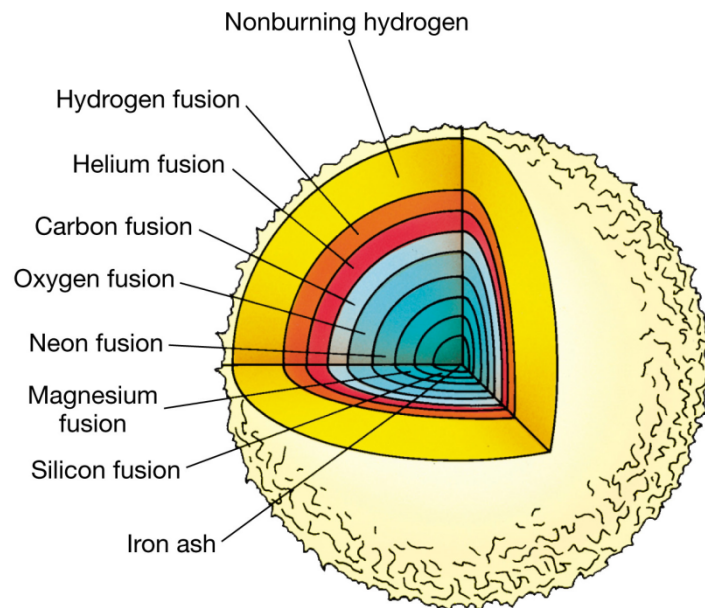


Cassiopeia A (Cas A).
Source: Chandra X-ray Observatory,
NASA/CXC/SAO/Rutgers/J.Hughes



Nuclear Reaction Network in Science (cont)

Nuclear reaction network in high mass stars



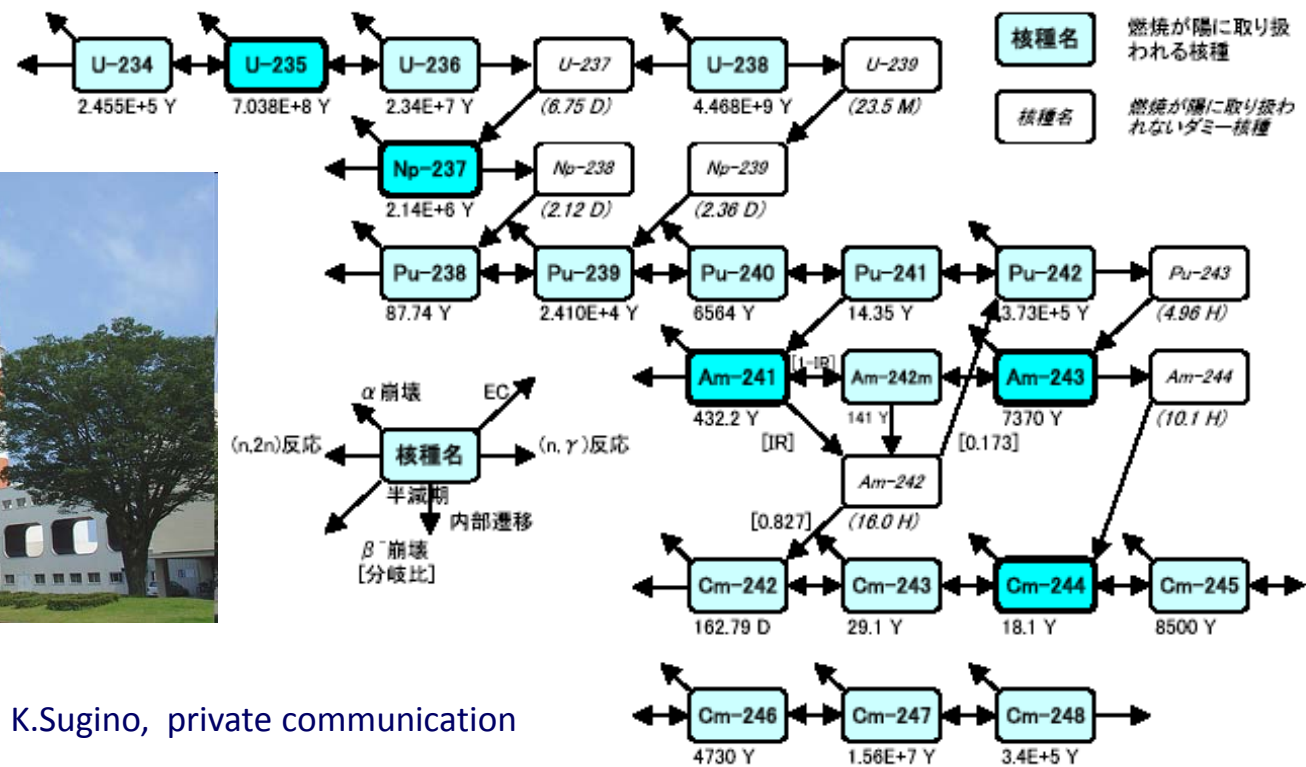
E. M. Burbidge et al., (B²FH) Rev.Mod.Phys.29(1957)



Nuclear Reaction Network in Application

Another example of reaction network:

Burning chain model in a fast reactor (*JOYO*, Japan)

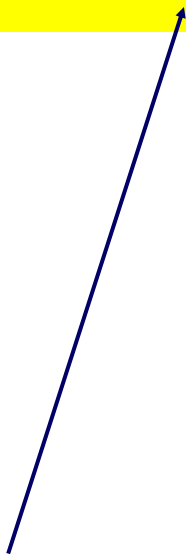


K.Sugino, private communication

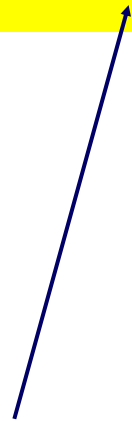
Nuclear Data in Nuclear System

Growth of the number of the i -th isotope per unit time/volume $N_i(t)$

$$\frac{dN_i(t)}{dt} = -\lambda_i N_i(t) - \sigma_i \phi N_i(t) + \sum_j \underline{f_{j \rightarrow i}} \lambda_j N_j(t) + \sum_k \underline{g_{k \rightarrow i}} \sigma_k N_k(t)$$



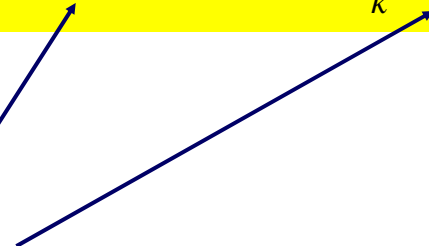
Decrease by decay of the i -th isotope



Decrease by reaction from the i -th isotope



Increase by decay into the i -th isotope

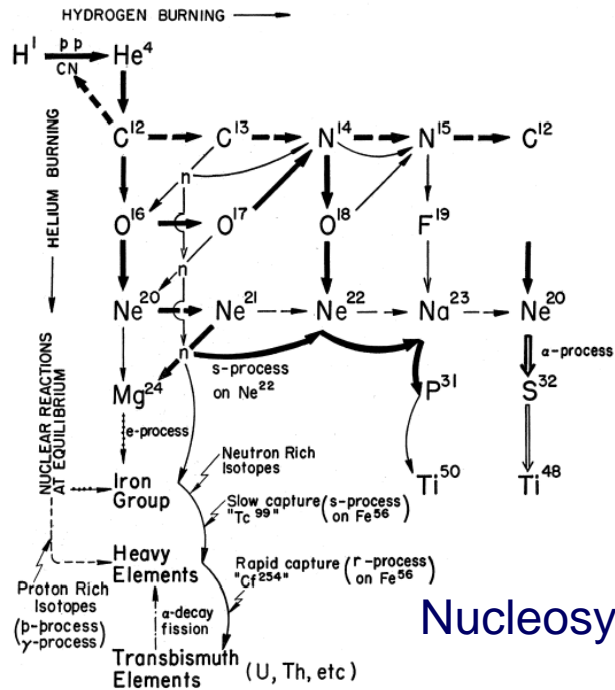


Increase by reaction from the i -th isotope

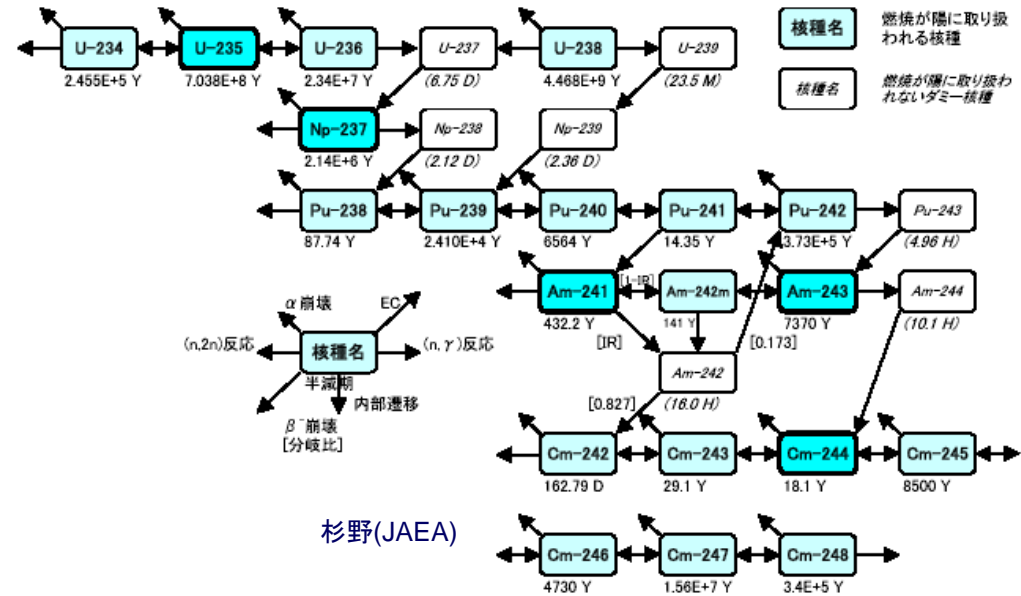
Various nuclear data (λ , σ) for each isotope as input parameters!



Goal of Nuclear Data

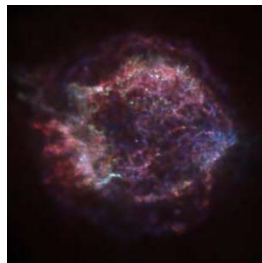


Nucleosynthesis



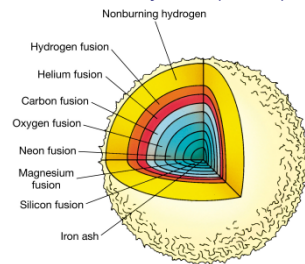
Burning chain in reactors

E. M. Burbidge et al., (B²FH) Rev.Mod.Phys.29(1957)



Cassiopeia A (Cas A).

Source: Chandra X-ray Observatory,
NASA/CXC/SAO/Rutgers/J.Hughes



$$\frac{dN_i(t)}{dt} = -\lambda_i N_i(t) - \sigma_i \phi N_i(t) + \sum_j f_{j \rightarrow i} \lambda_j N_j(t) + \sum_k g_{k \rightarrow i} \sigma_k N_k(t)$$

Nuclear Data:

Comprehensive set of nuclear structure and reaction data to solve various nuclear systems

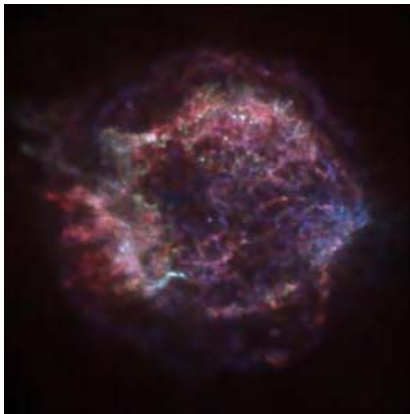
International Atomic Energy Agency



Nuclear Data in Science and Technology

Science

- Nuclear physics
 - Astrophysics
- etc.



Technology

- Fission and fusion energies
 - Material analysis
 - Medical application
- etc.



Structure Data and Reaction Data

Nuclear Data:

Data which *characterize properties and phenomena of nucleus* (e.g., mass, spin-parity, half-life, cross section)

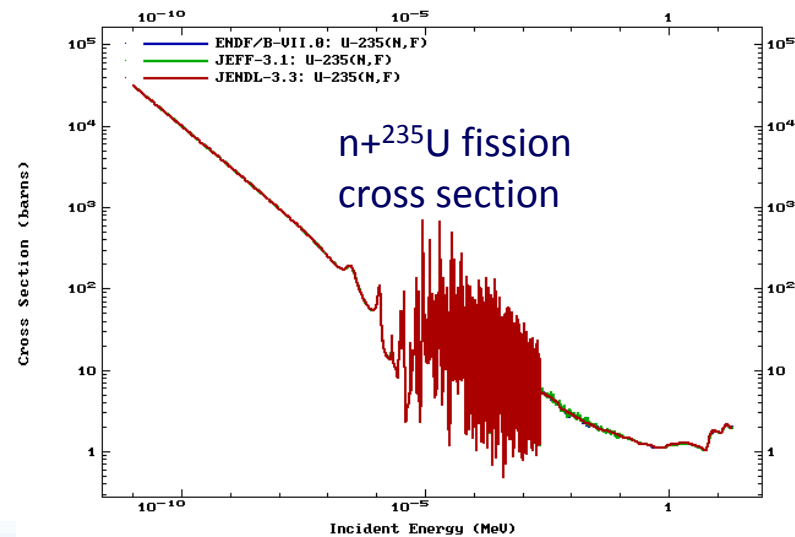
Example: Uranium-235

Mass: 218 942 MeV/c²

Structure

Level energy (MeV)	Spin	Parity	Half-life
0.0	7/2	-1	7.0x10 ⁸ y
0.0765	1/2	+1	~26 min
13.04	3/2	+1	0.50 ns
...

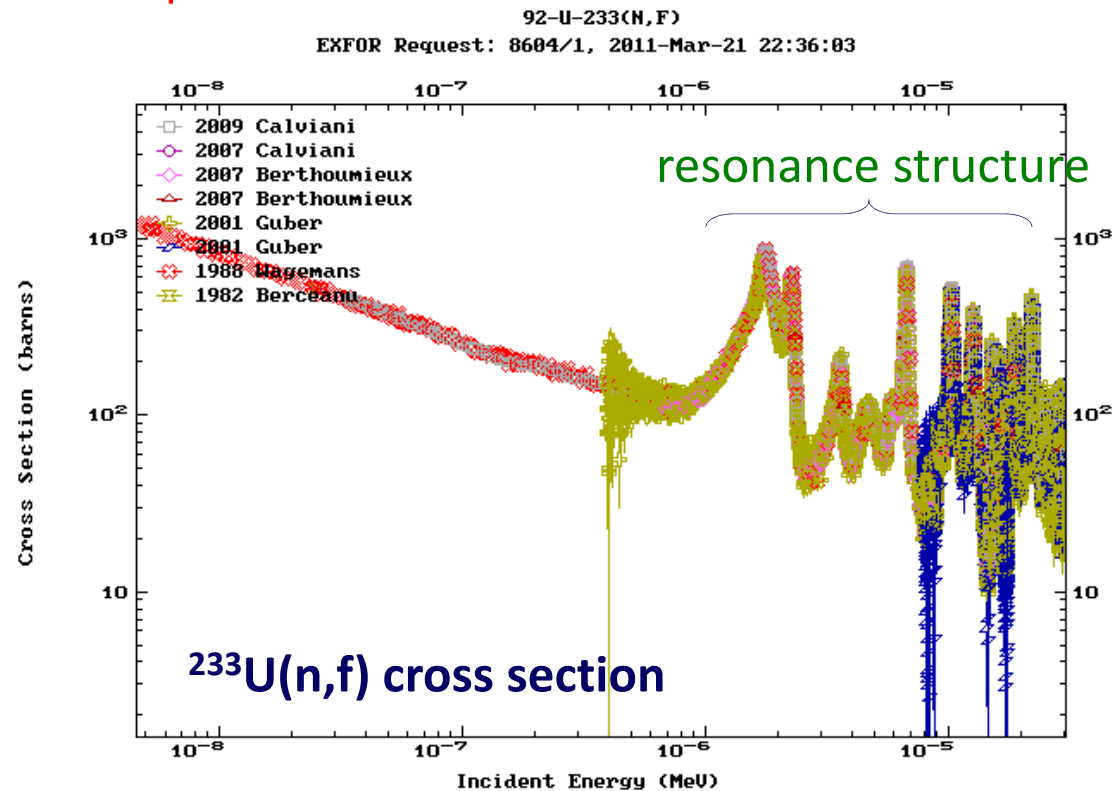
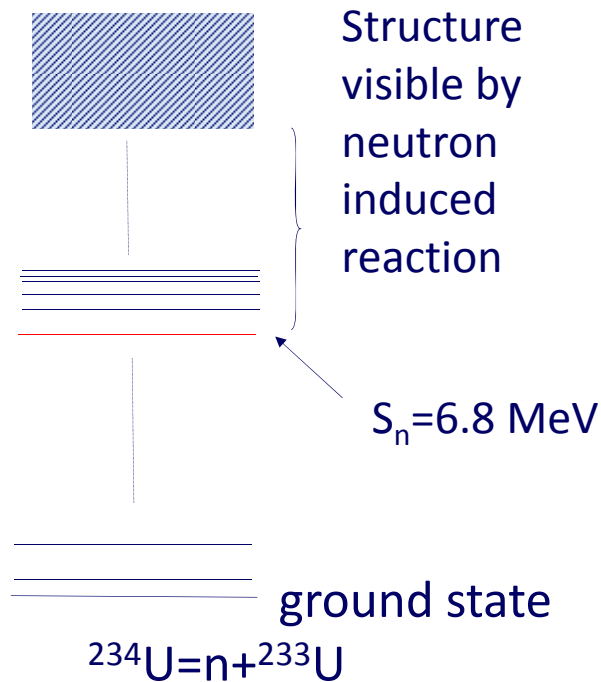
Reaction (incl. EXFOR)



Example of Experimental Data in Library

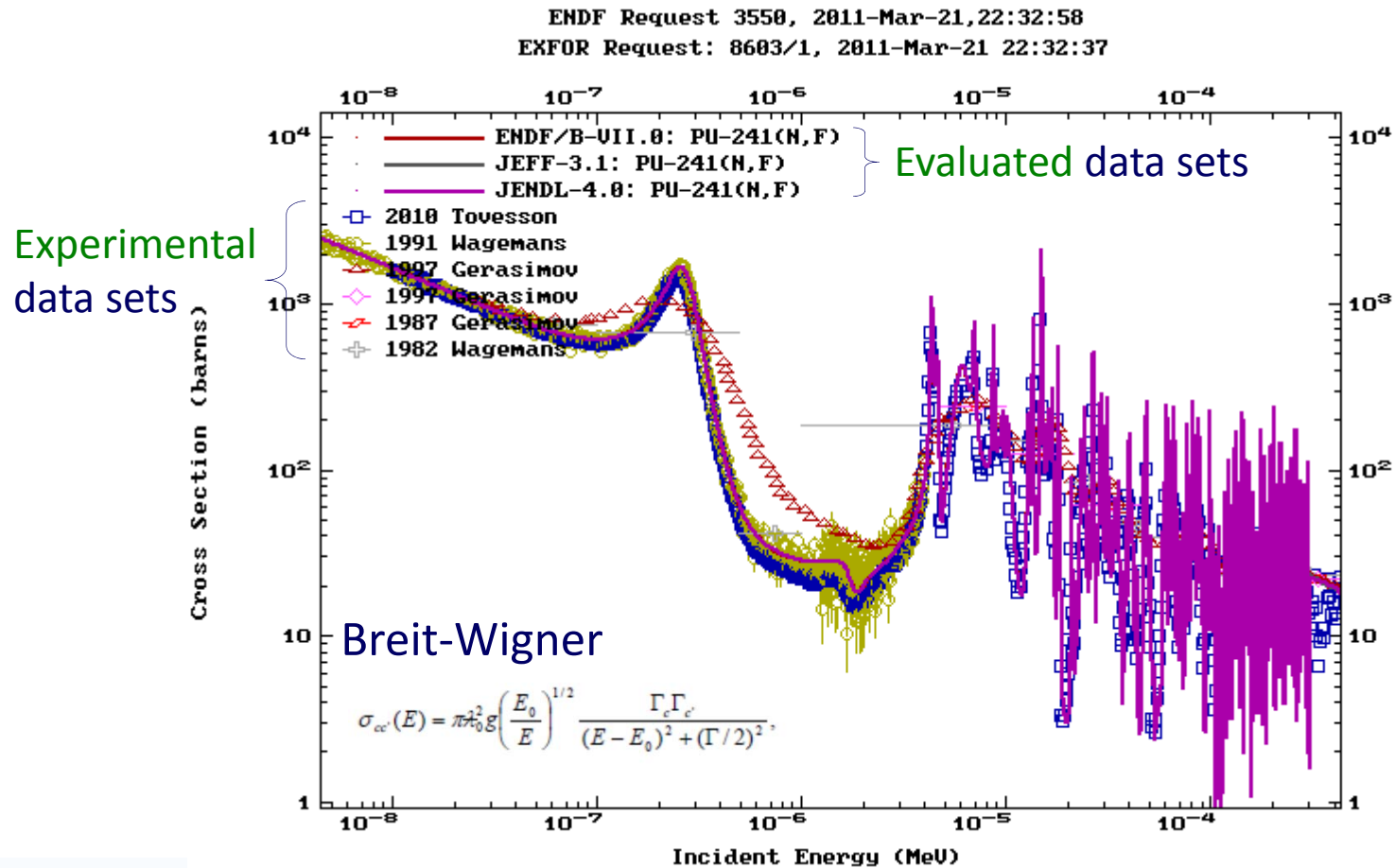
Fission cross section in resonance region

Important for application, theory is not very powerful, but a lot of experimental data points are available.

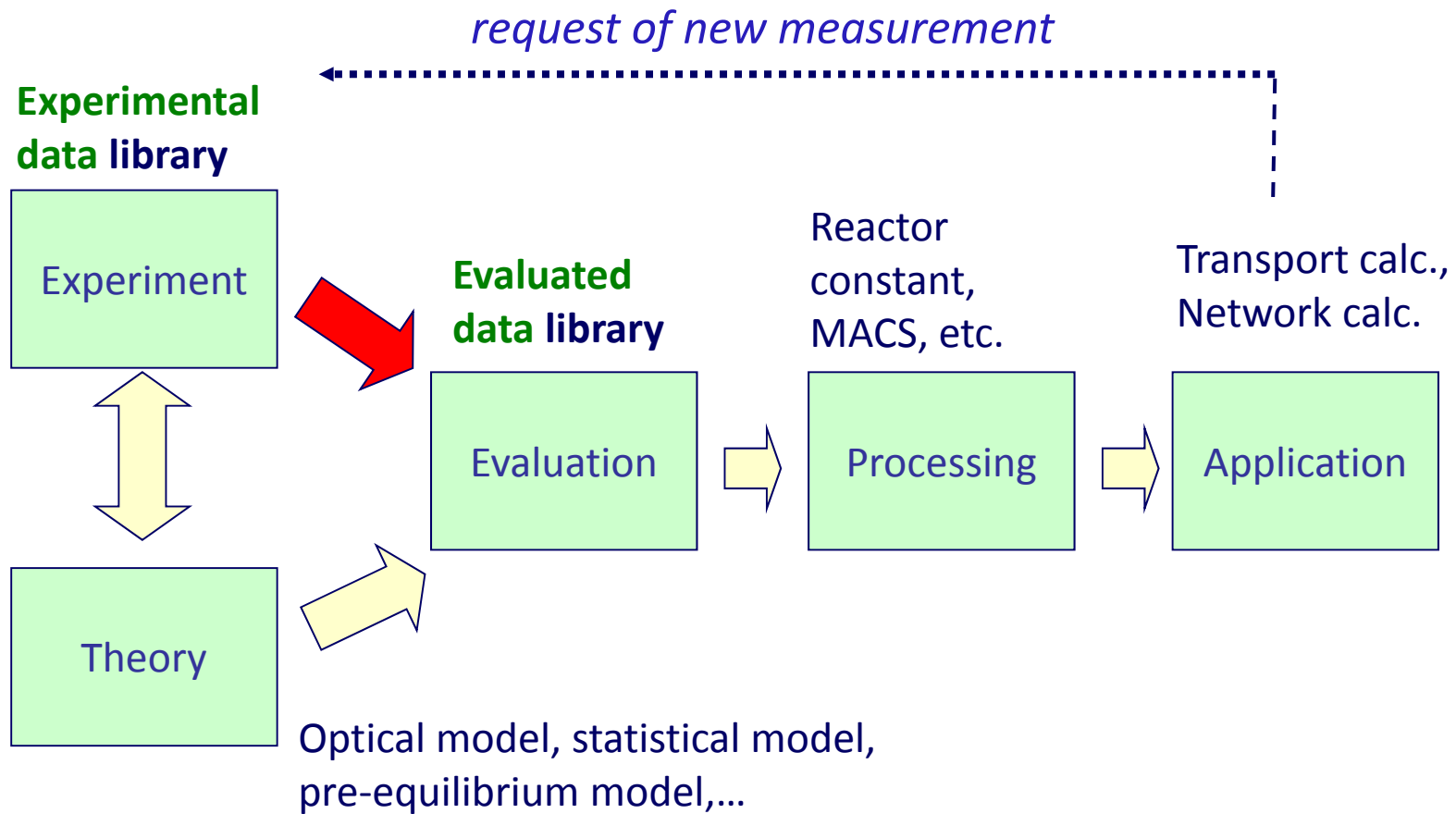


Experimental and Evaluated Data Libraries

Evaluated data derived from **experimental data** are used as an input for applications (Breit-Wigner, R-matrix).



From Microscopic Experiment to Application





International Atomic Energy Agency

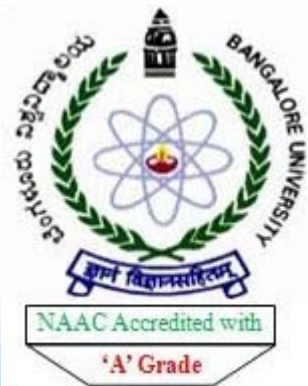
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Department of Physics, Bangalore University, Bangalore, India

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Introduction to IAEA Nuclear Data Services



Naohiko OTSUKA

Nuclear Data Section

Department of Nuclear Sciences and Applications



IAEA Nuclear Data Services

EXFOR (experimental reaction data)

ENDF (evaluated reaction data)

→ We will discuss them later.

IAEA.org | NDS Mission | About Us | Mirrors: India | China

Search Go

June 2014

IRDF - International Reactor Dosimetry and Fusion File v1.03 [page] [archive] [retrieve]
CD/DVD-ROMs available for on-line downloading [page]
Portable Empire-3.2.2 for Windows - nuclear reaction model code system for data evaluation [page] [download]

Quick Links

- ADS-Lib
- Atomic Mass Data Centre
- CINDA
- Charged particle reference cross section
- DROSG-2000
- EMPIRE-3.2

Main | All | Reaction Data | Structure & Decay | by Applications | Doc & Codes | NDS-Internal | Index | Events | Links | News

EXFOR Experimental nuclear reaction data

LiveChart of Nuclides Interactive Chart of Nuclides

ENDF Evaluated nuclear reaction libraries

CINDA Nuclear reaction bibliography

NSR Nuclear Science References

Charged particle reference cross section
Beam monitor reactions

IRDF International Reactor Dosimetry and Fusion File

Partners

- NNDC
- International Nuclear Data Centre, Brookhaven, USA
- NEA

*Database at the IAEA, Vienna **Database at the US NNDC

LiveChart of Nuclides
(evaluated structure and decay data)

NSR (Bibliography)

<http://www-nds.iaea.org/> : primary server (Vienna)

<http://www-nds.indcentre.org.in/>: mirror server (India)

NSR (Nuclear Science References)

Nuclear Science References (NSR)

NSR Reference Paper NIM A 640, 213 (2011)

Database version of January 14, 2015

The NSR database is a bibliography of nuclear physics articles, indexed according to content and spanning more than 100 years of research. Over 80 journals are checked on a regular basis for articles to be included. For more information, see the help page. The of the NSR Web

- ~200,000 references (~150,000 from journals)
- Database maintained at NNDC.
- Compiled at NNDC and McMaster Univ. (Canada).

Quick Search

Nuclide
31Na or ca-38

Reaction
n,g or (n,g) or (16O,16O)

Publication Year from to

Reference Type All Experiment Theory

Output Format HTML BibTex Text

Search Reset

<http://www.nndc.bnl.gov/nsr/>



NSR (cont.)

Nuclear Science References (NSR)

NSR Reference Paper NIM A 640, 213 (2011)

Database version of December 18, 2014

Very easy to use!

Just provide

- Author and/or
- Nuclide (Target) and/or
- Reaction

and search.

ysics articles, indexed according to content and spanning more than 1
ided. For more information, see the [help page](#). The NSR database sche
f the NSR Web Interface.

Number Search | Combine View | Recent References

Author
Brown or B.A.Brown

Nuclide
³¹Na or ca-38

Reaction
n,g or (n,g) or (16O,16O)

Publication Year from to

Reference Type All Experiment Theory

Output Format HTML BibTex Text



NSR – Exercise 1

Nuclear Science References (NSR)

NSR Reference Paper [NIM A 640, 213 \(2011\)](#)

Database version of December 18, 2014

Question

Search articles where
“Ganesan” is an author.

Physics articles, indexed according to content and spanning more than 100 years. For more information, see the [help page](#). The NSR database schema is available in the NSR Web Interface.

Number Search

Combine View

Recent References

Author

Brown or B.A.Brown

Ganesan

Nuclide

³¹Na or ca-38

Reaction

n,g or (n,g) or (16O,16O)

Publication Year

from 1896

to

2015

Reference Type

All

Experiment

Theory

Output Format

HTML

BibTex

Text

Search

Reset



NSR – Exercise 2

Nuclear Science References (NSR)

NSR Reference Paper NIM A 640, 213 (2011)

Database version of December 18, 2014

Question

Search articles reporting experimental results of $^{78}\text{Se}(n,p)^{78}\text{As}$.

Physics articles, indexed according to content and spanning more than 100 years. For more information, see the [help page](#). The NSR database schema is available in the NSR Web Interface.

Number Search | Combine View | Recent References

Author
Brown or B.A.Brown

Nuclide
 ^{31}Na or $^{ca-38}$

Reaction
 n,g or (n,g) or $(16O,16O)$

Publication Year from to

Reference Type All Experiment Theory

Output Format HTML BibTex Text



NSR – Exercise 2 (cont)

Not all articles report the $^{78}\text{Se}(n,p)$ reaction.

1995BI16 Phys.Rev. C52, 2546 (1995)

I.-G.Birn, B.Strohmaier, H.Freiesleben, S.M.Qaim

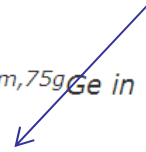
Isomeric Cross Section Ratios for the Formation of $^{75m,75g}\text{Ge}$ in (n, p) , (n, α) , and $(n, 2n)$ Reactions from 6 to 15 MeV

NUCLEAR REACTIONS $^{75}\text{As}(n, p)$, $^{78}\text{Se}(n, \alpha)$, $^{76}\text{Ge}(n, 2n)$, $E=6-15$ MeV; measured $\sigma(E)$; deduced isomeric cross-section ratio. Activation technique, hyperpure Ge detector. Statistical, precompound model analyses.

doi: [10.1103/PhysRevC.52.2546](https://doi.org/10.1103/PhysRevC.52.2546)

Data from this article have been entered in the **EXFOR** database. For more information, access X4 [dataset22291](#).

No $^{78}\text{Se}(n,p)$ in keywords



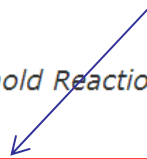
1994BI01 Nucl.Sci.Eng. 116, 125 (1994)

I.Birn, S.M.Qaim

Excitation Functions of Neutron Threshold Reactions on Some Isotopes of Germanium, Arsenic, and Selenium in the 6.3- to 14.7-MeV Energy Range

NUCLEAR REACTIONS ^{75}As , $^{74,76,78}\text{Se}$, $^{72,73,74}\text{Ge}(n, p)$, ^{75}As , $^{78,80}\text{Se}(\alpha, \alpha)$, ^{75}As , $^{70,76}\text{Ge}(n, 2n)$, $E=6.3-14.7$ MeV; measured $\sigma(E)$. Activation technique, high resolution γ -spectroscopy. Statistical multi-step model analysis.

$^{78}\text{Se}(n,p)$ in keywords!



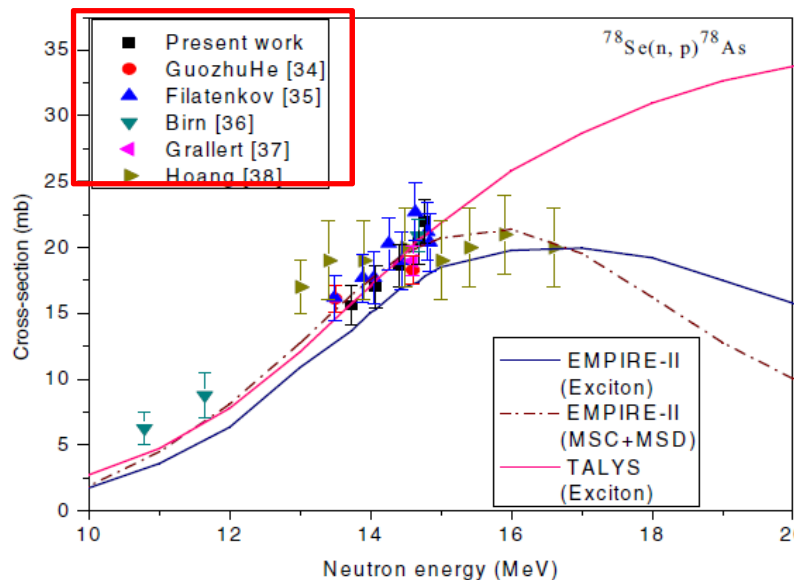
NSR – Exercise 2 (cont)

Compare NSR output for

“Nuclide = ^{78}Se and Reaction = n,p reaction”
with Fig.3 of [the 33080 article](#).

Five past experiments plotted in Fig.3.

Are they also in the NSR output?



[34] Guozhu He, Zhongjie Liu, Junhua Luo, and Xiangzhong Kong, Indian J. Pure Appl. Phys. **43**, 729 (2005).

Not in NSR

[35] A. A. Filatenkov and S. V. Chuvaev, Khlopin Radiev. Inst., Leningrad Reports No. 258 (2001).

Not in NSR

[36] I. Birn, S. M. Qaim, B. Strohmaier, and H. Freiesleben, Nucl. Sci. Eng. **116**, 125 (1994).

in NSR

[37] A. Grallert, J. Csikai, Cs. M. Buczko, and I. Shaddad, IAEA Nucl. Data Section report to the I.N.D. C. No.286, 131 (1993).

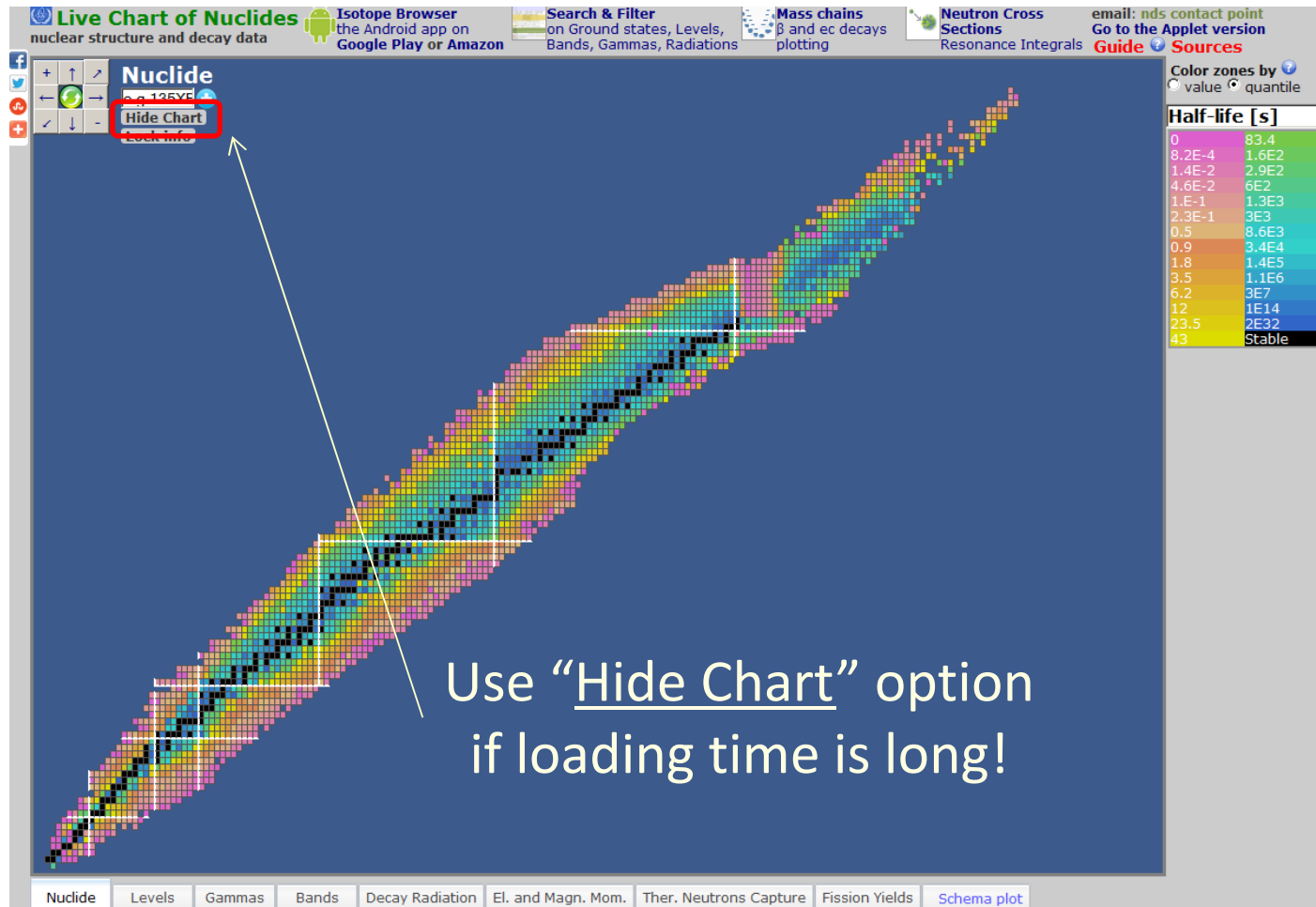
Not in NSR

[38] H. M. Hoang, U. Garuska, A. Marcinkowski, and B. Zwieglinski, Zeitschrift fuer Physik A, Hadrons and Nuclei **334**, 285 (1989).

in NSR

FIG. 3. (Color online) Cross sections for $^{78}\text{Se}(n, p)^{78}\text{As}$ reaction

LiveChart of Nuclides



<http://www-nds.iaea.org/livechart/> (No mirror available)

LiveChart of Nuclides (cont.)

The query page becomes very simple if you select “Hide Chart” option.





The screenshot shows the top navigation bar of the Live Chart of Nuclides website. The main header includes the site name and various navigation links. The 'Go to Nuclide' input field is highlighted with a red circle and contains the text 'e.g. 135XE'. Below the input field is a navigation menu with tabs for 'Nuclide', 'Levels', 'Gamma', 'Bands', 'Decay Radiation', 'El. and Magn. Mom.', 'Ther. Neutrons Capture', 'Fission Yields', and 'Schema plot'. A blue arrow points from the text below to the 'Gamma' tab.


Just type a nuclide symbol
(e.g., 1H, 12C, 238U)


LiveChart of Nuclides – ^{135}Xe

Nuclide tab


Live Chart of Nuclides
 nuclear structure and decay data


Isotope Browser
 the Android app on
[Google Play](#) or [Amazon](#)


Search & Filter
 on Ground states, Levels,
 Bands, Gammas, Radiations


Mass chain
 β and ec de
 plotting

Go to Nuclide: Show Chart

Click on a nuclide symbol to show the level schema and ENSDF dataset

Nuclide	J^π	G.S. $T_{1/2}$ Abundance	G.S. Decays	Q_{β^-} [keV]	Q_{α} [keV]
^{135}Xe 54 81	3/2+	9.14 h 2	β^- 100	1165.048 4070	-3630.67 415

Metastable states

Nuclide	Energy (keV)	J^π_{order}	Band	$T_{1/2}$	$T_{1/2}$ [s]	Decays
$^{135\text{m}}\text{Xe}$ 54 81	526.551 13	11/2-		15.29 min 5	9.17E2	β^- < 0.6 IT > 99.4

ENSDF datasets related to ^{135}Xe

Ground
state

Metastable
state



LiveChart of Nuclides - ^{135}Xe (cont.)

Levels tab

Live Chart of Nuclides
nuclear structure and decay data

Isotope Browser
the Android app on
Google Play or Amazon

Search & Filter
on Ground states, Levels,
Bands, Gammas, Radiations

Mass chains
 β and ec decays
plotting

Neutr
Sectio
Resor

Go to Nuclide: ^{135}Xe Show Chart

Nuclide Levels Gammas Bands Decay Radiation El. and Magn. Mom. Ther. Neutrons Capture Fission Yields Schem

Click on a nuclide symbol to show the level schema and ENSDF dataset

Nuclide	Energy (keV)	J^{π}_{order}	Band	$T_{1/2}$	$T_{1/2}$ [s]	Decays	
^{135}Xe 54 81	0.0	3/2+		9.14 h 2	3.29E4	β^- 100	
^{135}Xe 54 81	288.455 15	1/2+					
^{135}Xe 54 81	526.551 13 m	11/2-		15.29 min 5	9.17E2	β^- < 0.6 IT > 99.4	————— 7/2+
^{135}Xe 54 81	1131.512 11	7/2+					————— 11/2+
^{135}Xe 54 81	1260.416 13	5/2+					————— 1/2+
^{135}Xe 54 81	1448.36 3	(3/2+)					————— 3/2+

————— 7/2+

————— 11/2+

————— 1/2+

————— 3/2+

^{135}Xe

LiveChart of Nuclides - ^{135}Xe (cont.)

Decay Radiation tab

Live Chart of Nuclides nuclear structure and decay data

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Mass chains β and ec decays plotting

Go to Nuclide: Show Chart

Nuclide Levels Gammas Bands Decay Radiation El. and Magn. Mom. Ther. Neutrons Capture Fission Yields

Parent	$T_{1/2}$	Level E [keV]	Jp order	Decay	Q decay note on Q values	Daughter
^{135}Xe 54 81	9.14 h 2	0.0	3/2+	β^- 100 %	1165.048 4070	^{135}Cs 55 80

see the ENSDF source

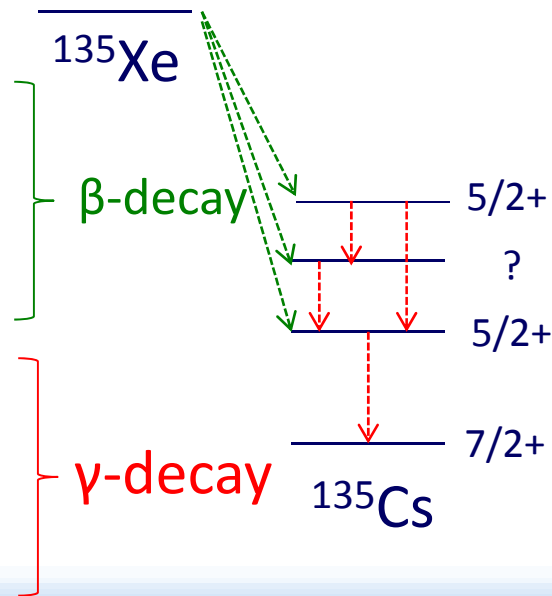
Note: Q-value used in ENSDF to determine displayed decay data is: 1165.4 keV - see note on Q values

Beta -

Fed level [keV]	Jp	End Point [keV]	Avg Energy [keV]	Intens. per decay [%]
1062.420 14		103 4	26.9 11	0.123 6
981.315 22		184 4	50.0 12	0.075 5
608.186 14	5/2+	557 4	173.3 15	3.11 14
407.989 13		757 4	248.1 16	0.59 3
249.793 12	5/2+	915 4	310.2 16	96 4

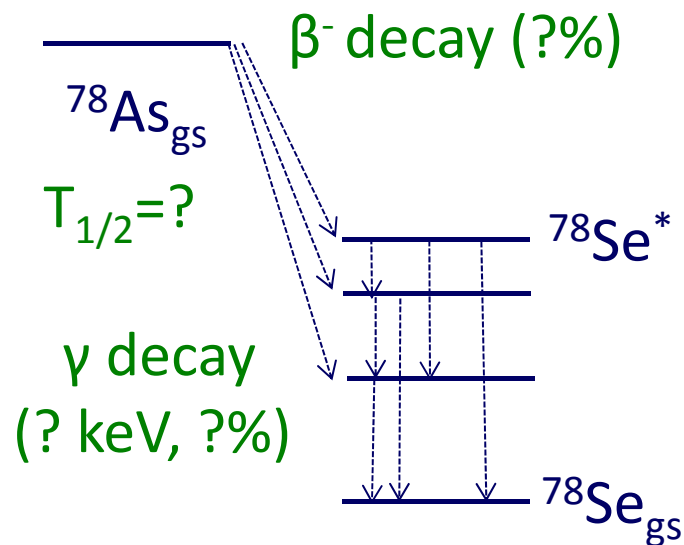
Gamma

Start level [keV]	Jp	Final Level [keV]	Jp	γ Energy [keV]	Intens. per decay [%]
407.989 13		249.793 12	5/2+	158.197 18	0.289 14
608.186 14	5/2+	407.989 13		200.19 10	0.012 5
249.793 12	5/2+	0.0	7/2+	249.794 15	90 3
608.186 14	5/2+	249.793 12	5/2+	358.39 3	0.221 11
981.315 22		608.186 14	5/2+	373.13 10	0.015 3



LiveChart of Nuclides - Exercise

One determined the $^{78}\text{Se}(n,p)^{78}\text{As}$ cross section by detection of γ from $^{78}\text{As} - \beta^- \text{ decay} \rightarrow ^{78}\text{Se}^* - \gamma \text{ decay} \rightarrow ^{78}\text{Se}_{\text{gs}}$.

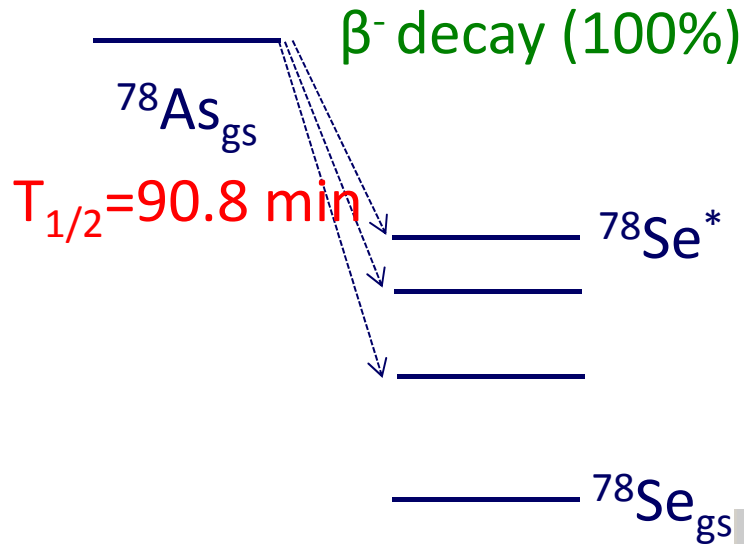


Questions:

1. Half-life of ^{78}As
2. Branching ratio of $^{78}\text{As} \beta^-$ decay
3. Energy of strongest decay γ radiation and its intensity



LiveChart of Nuclides – Exercise (cont)



Questions:

1. Half-life of ^{78}As
2. Branching ratio of ^{78}As β^- decay
3. Energy of strongest decay γ radiation and its intensity

Live Chart of Nuclides
 nuclear structure and decay data

Go to Nuclide: Show Chart

Isotope Browser the Android app on Google Play or Amazon

Search & Filter on Ground states, Levels, Bands, Gammas, Radiations

Mass chain β and α plotting

Nuclide Levels Gammas Bands Decay Radiation El. and Magn. Mom. Ther. Neutrons Capture Fiss

Click on a nuclide symbol to show the level schema and ENSDF dataset

Nuclide	J π	G.S. $T_{1/2}$ Abundance	G.S. Decays	Q_{β^-} [keV]	Q_{α} [keV]
^{78}As 33 45	2-	90.7 min 2	β^- 100	4208.949 9813	-7192.26 1026

ENSDF datasets related to 78AS
 Evaluated Nuclear Structure Data File

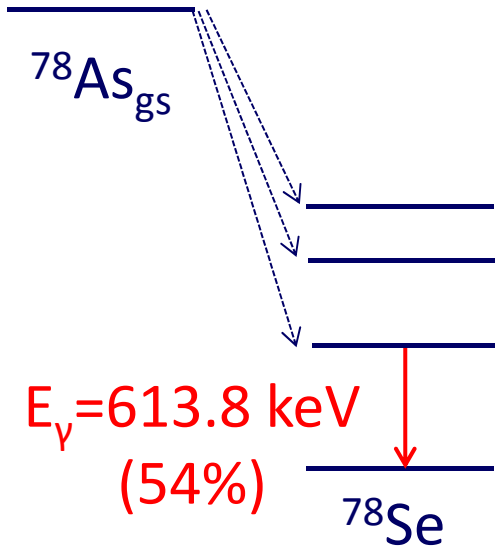
- ADOPTED LEVELS, GAMMAS
- 78GE B- DECAY (88 M)
- 76GE(A,PNG)

XUNDL datasets related to 78AS
 Experimental Unevaluated Nuclear Data List

- 76GE(A,PNG):XUNDL-1
- 78AS B- DECAY (90.7 M)
- 78SE(T,3HE)
- 80SE(D,A)



LiveChart of Nuclides – Exercise (cont)



Questions:

1. Half-life of ^{78}As
2. Branching ratio of ^{78}As β^- decay
3. Energy of strongest decay γ radiation and its intensity

Live Chart of Nuclides
nuclear structure and decay data

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Mass chains
 β and ec decays plotting

Go to Nuclide: Show Chart

Nuclide Levels Gammas Bands Decay Radiation El. and Magn. Mom. Ther. Neutrons Capture Fission Yields S

Start level [keV]	Jp	Final Level [keV]	Jp	γ Energy [keV]	Intens. per de
2838.58 9	(2+)	2682.09 9	4+	156.6 3	0.092 24
2682.09 9	4+	2507.72 10	3-	174.2 3	0.18 4
1854.00 9	3+	1502.64 11	4+	351.1 2	0.162 24
2682.09 9	4+	2327.34 13	2+	354.3 2	1.9 3
1758.91 11	0+	1308.66 7	2+	449.8 4	0.08 3
3144.52 13	3-	2682.09 9	4+	462.2 2	0.59 9
1995.78 10	2+	1498.76 18	0+	497.0 3	0.18 3
2838.58 9	(2+)	2334.87 19	0+	503.7 2	0.42 6
1854.00 9	3+	1308.66 7	2+	545.3 1	3.0 4
613.84 7	2+	0.0	0+	613.8 1	54 6
3144.52 13	3-	2507.72 10	3-	637.1 2	0.21 3



LiveChart of Nuclides – Exercise (cont)

Half-lives and decay gamma intensities are important inputs to derive Activation cross sections.

Extractions from the 33080 article ($\lambda = \ln 2 / T_{1/2}$, f_d : decay γ intensity)

$$\sigma = \sigma_M \frac{A \varepsilon_M f_{dM} \lambda}{A_M \varepsilon f_d \lambda M} \frac{N_M (1 - e^{-\lambda M t_1}) e^{-\lambda M t_2} (1 - e^{-\lambda M t_3})}{N (1 - e^{-\lambda t_1}) e^{-\lambda t_2} (1 - e^{-\lambda t_3})}$$

We extracted these data from LiveChart.

TABLE I. The decay data of the radioisotopes produced

Nuclear Reaction	Abundance (%)	Half life	E_γ (MeV)	f_d (%)
$^{78}\text{Se}(n, p)^{78}\text{As}$	23.77 ± 0.28	90.7 ± 0.2 m	0.614	54 ± 0.6
$^{80}\text{Se}(n, p)^{80}\text{As}$	49.61 ± 0.41	15.2 ± 0.2 s	0.666	42 ± 0.5
$^{56}\text{Fe}(n, p)^{56}\text{Mn}$	91.75 ± 0.36	2.578 ± 0.0001 hr	0.847	99 ± 0.3
$^{19}\text{F}(n, p)^{19}\text{O}$	100	26.91 ± 0.08 s	0.197	96 ± 2.1
			1.357	50.4 ± 1.1

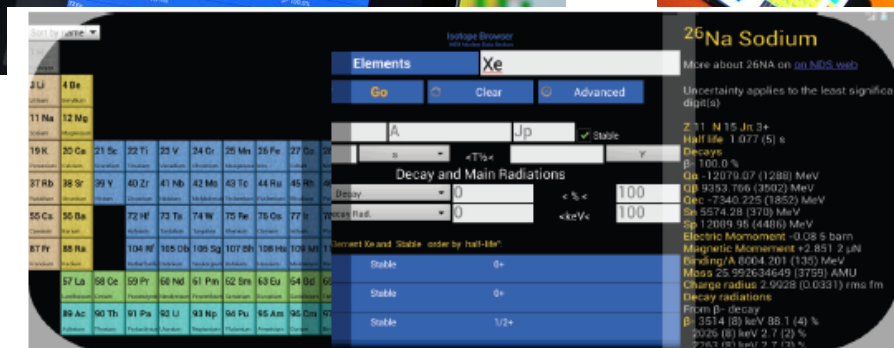
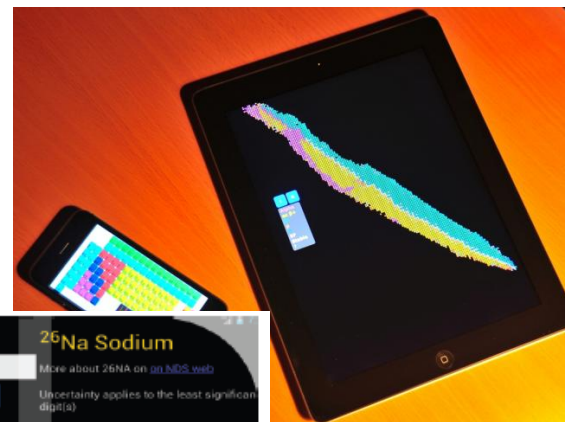


LiveChart of Nuclides – Data Source

- **Q-value, S-value, atomic masses:** 2012 Atomic Mass Evaluation (G. Audi et al., Chin.Phys.C**36**(2012)1287; M. Wang et al., Chin.Phys.C**36**(2012)1603)
- **Natural isotopic abundances:** M.Berglund and M.E.Wieser, Pure.Appl.Chem.**83**(2011)397.
- Other data are mainly from the **ENSDF library** which evaluation results are also published in “Nuclear Data Sheets” which is good for citation.
- Similar data can be also available through **NuDat (NNDC)**.



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