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Nuclear data research activity and a perspective of JCPRG and NRDC

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Symposium: Nuclear Reaction Data for Astrophysics

Naohiko Otuka

Nuclear Data Center, Japan Atomic Energy Agency (JAEA)

Nuclear Reaction Data Centre, Hokkaido University (JCPRG)

ohtsuka@nucl.sci.hokudai.ac.jp
http://www.jcprg.org/

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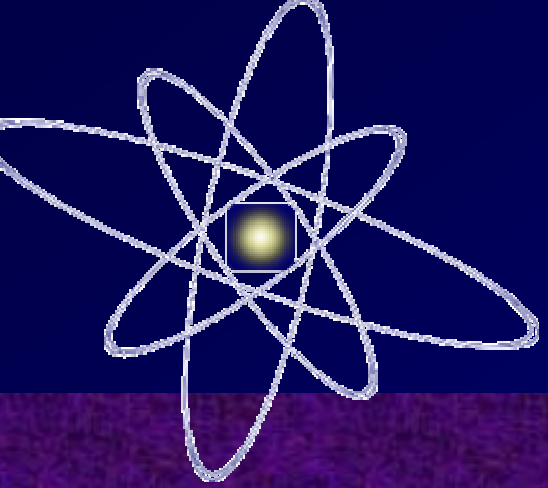


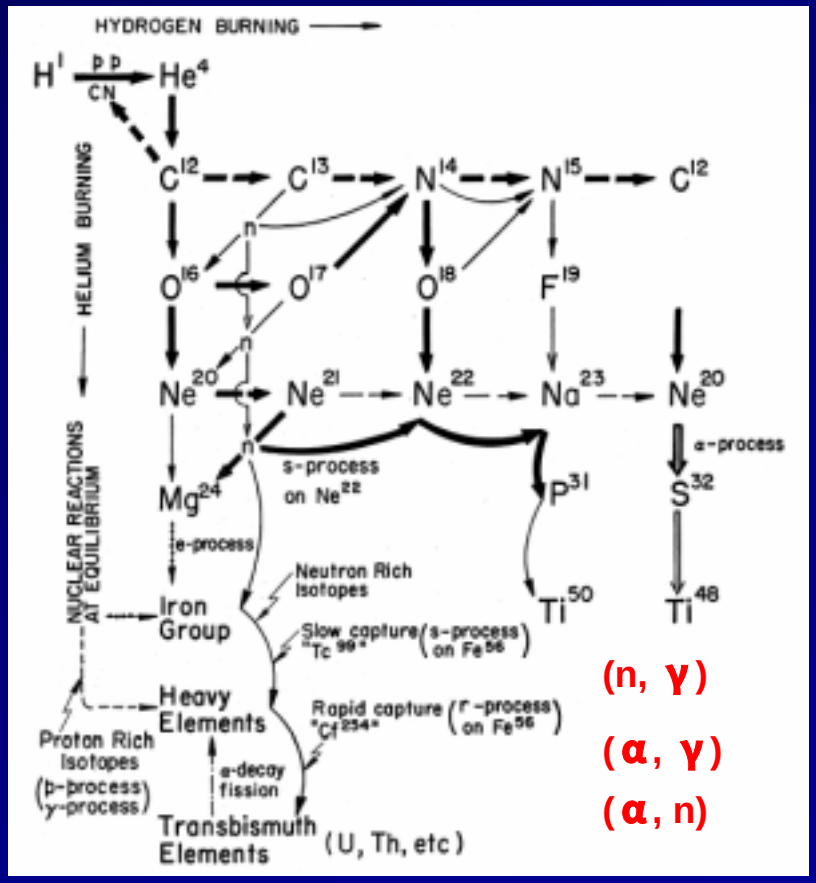
1. Nuclear data

Nuclear Data

- ***describe*** properties of atomic nuclei and the fundamental physical relationships governing their interactions
- ***characterize*** physical processes underlying all nuclear technologies

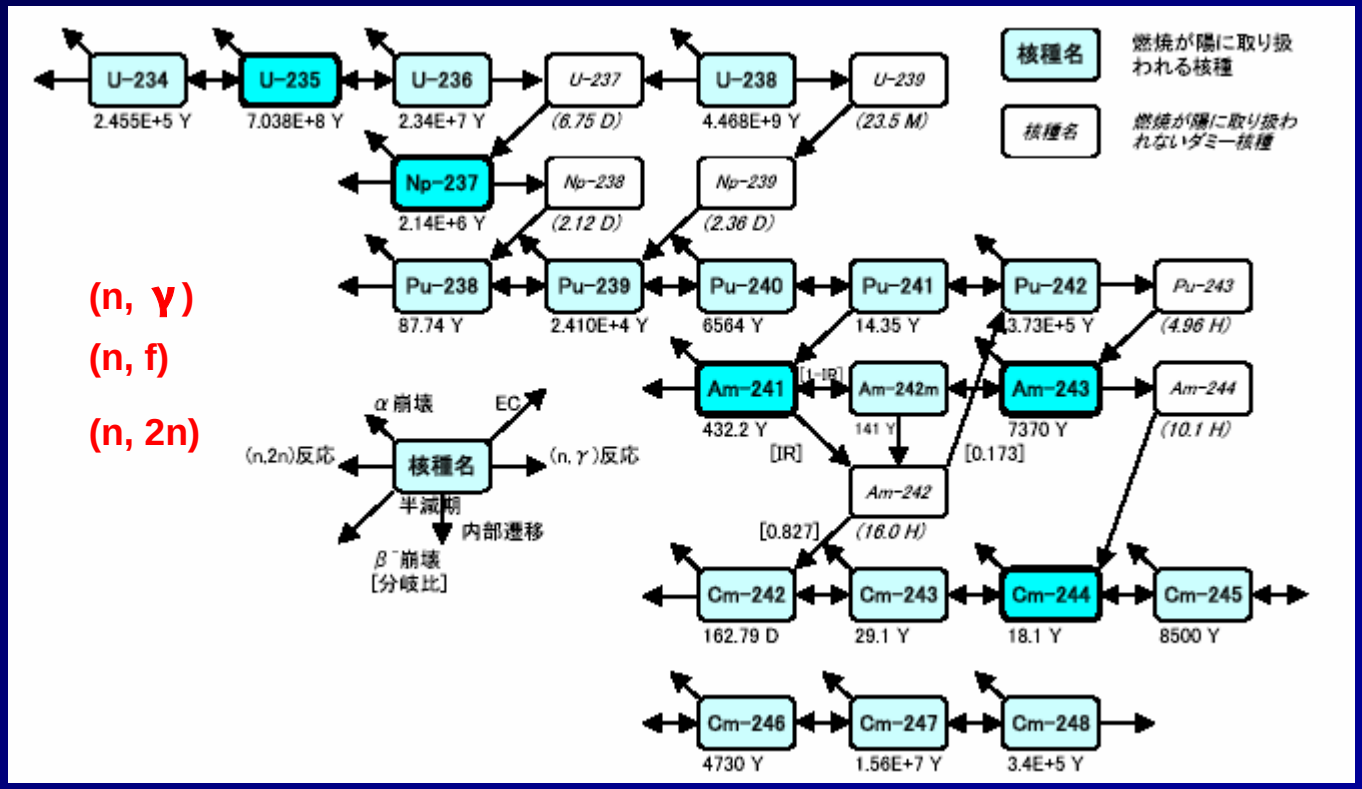
(O. Schwerer, IAEA-NDS 2000)

Network in astrophysics



Schematic diagram of nuclear process in stars - E. M. Burbidge et al., (B^2FH) Rev.Mod.Phys.29(1957

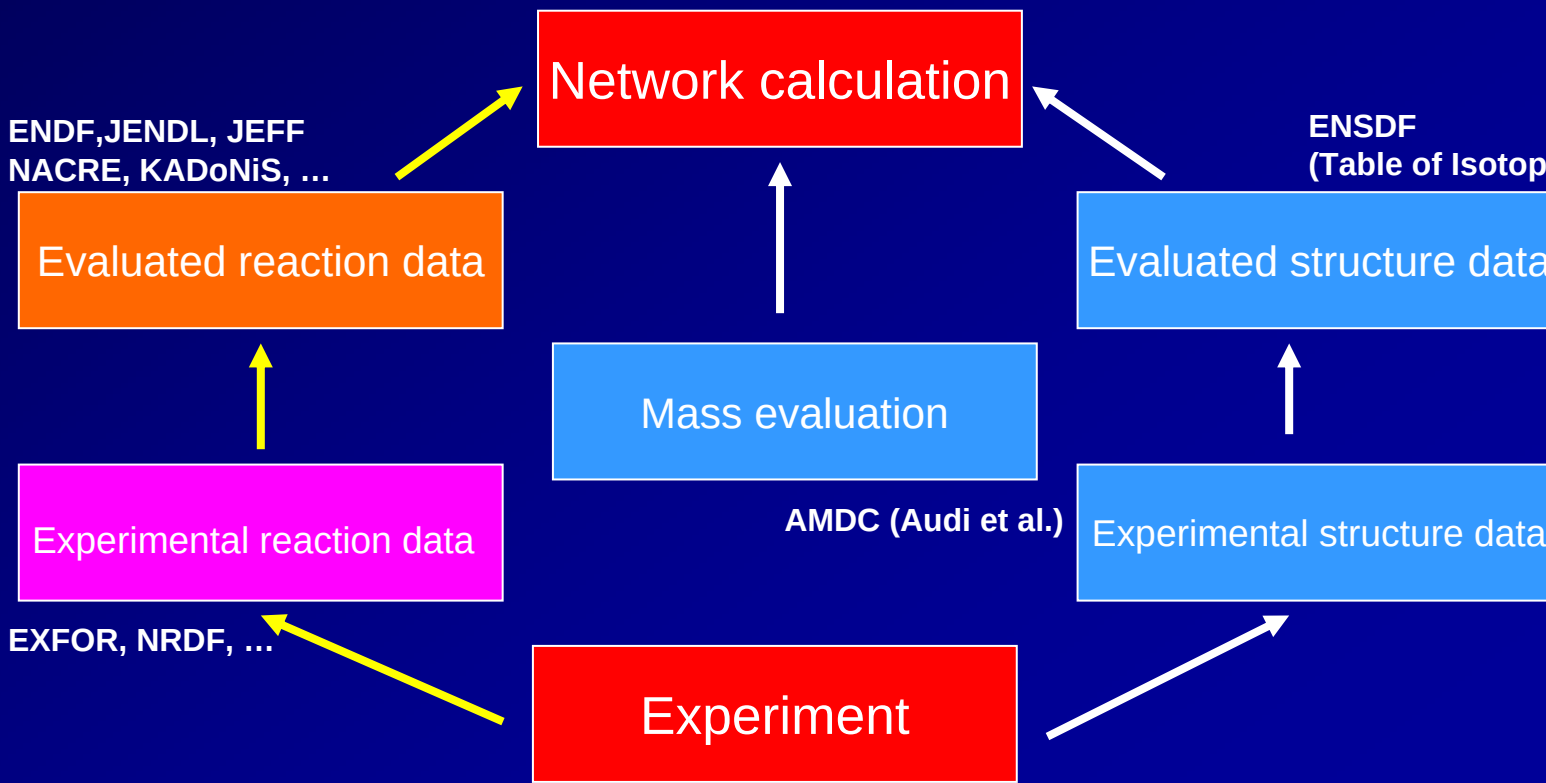
Network in reactor physics

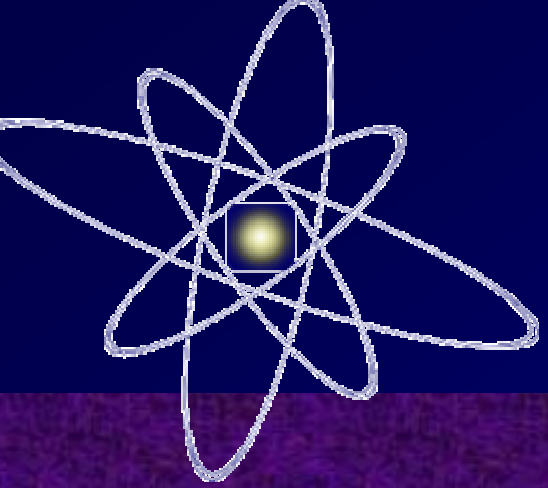


Burning chain in fast reactor *JOYO* - Sugino (2007), private communication

Nuclear Data ➔ Network Calc.

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





2. Activity of JCPRG and NRDC

JCPRG?

Japan Charged-Particle Nuclear Reaction Data Group (JCPRG)
日本荷電粒子核反応データグループ
(1974.4~ founded by H. Tanaka)

Hokkaido University Nuclear Reaction Data Center (JCPRG?)
北海道大学大学院理学研究院附属原子核反応データ研究開発センター
(2007.4~, Head: K. Kato)

- R&D contraction for nuclear data with RIKEN Nishina Center
- Collaborative nuclear data education with JAEA Nuclear Data Center

Poster of JCPRG

barn

Objective of JCPRG

- *Compilation* of charged-particle nuclear data (CPND) and photo-nuclear reaction data (PhND) in NRDF format
- *International exchange* of data files in EXFOR format (coordinated by IAEA)
- JCPRG is responsible to Japanese CPND and PhND compilation.
  (Japanese neutron data →NEA-DB at Paris)
- *Academic oriented* (not atomic energy oriented)

Compilation of Japanese Data

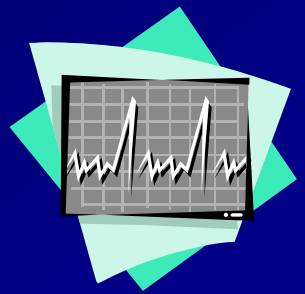
Bibliography
experimental condition
(~1 week)

Compiler

Numerical data from
Experimenters

- Checking
- Author proof

Release
(~6 months)

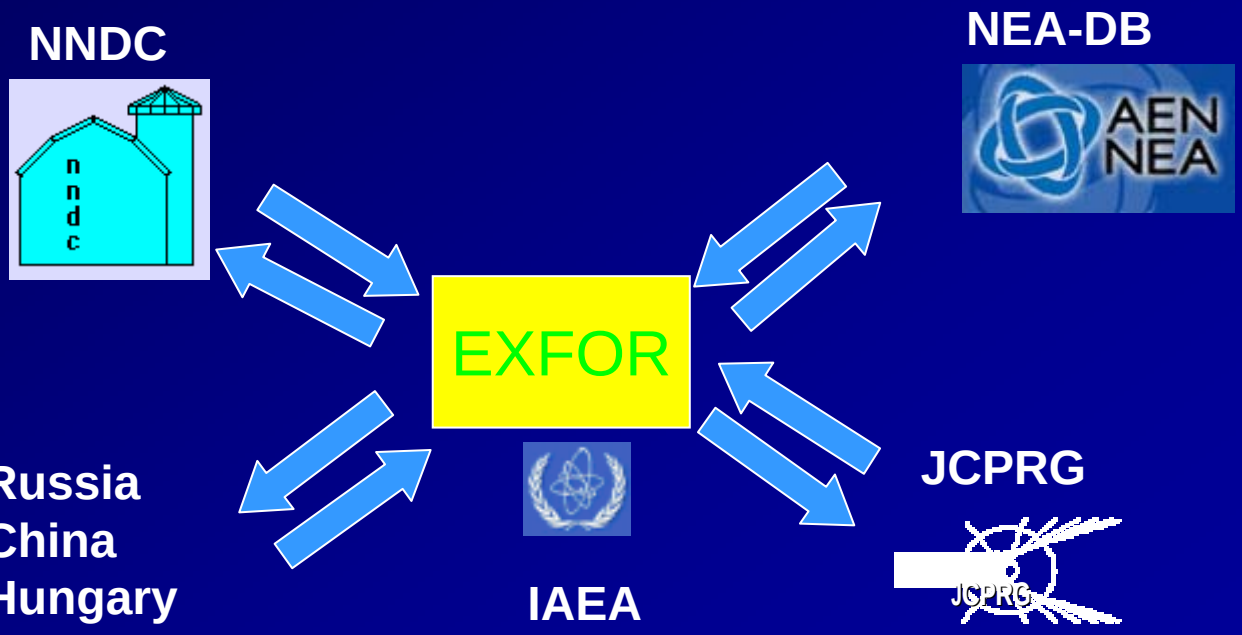


Digitization if data is not available
(old data, silent authors…)

International Data Exchange

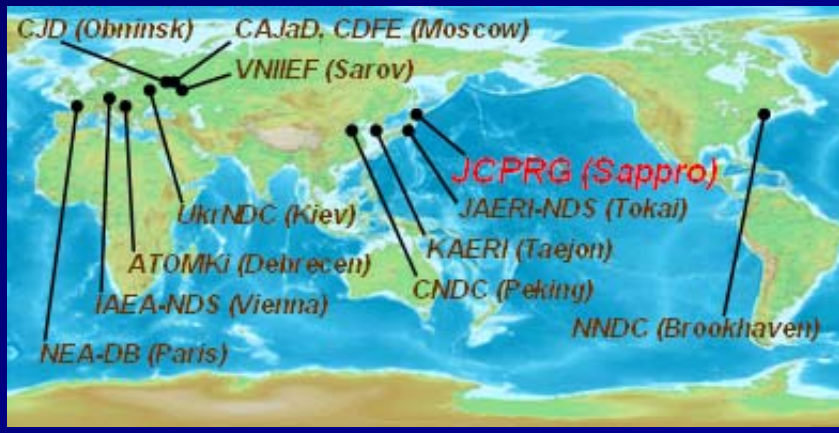
EXFOR:

EXchange FORmat for nuclear reaction data



Nuclear Reaction Data Center Network (NRDC)

- NNDC
- NEA-DB
- IAEA-NDS
- CJD CAJaD CDFE CNPD
- ATOMKI
- CNDC
- JCPRG JAEA-NDC
- KAERI –NDEL
- UkrNDC
- BARC



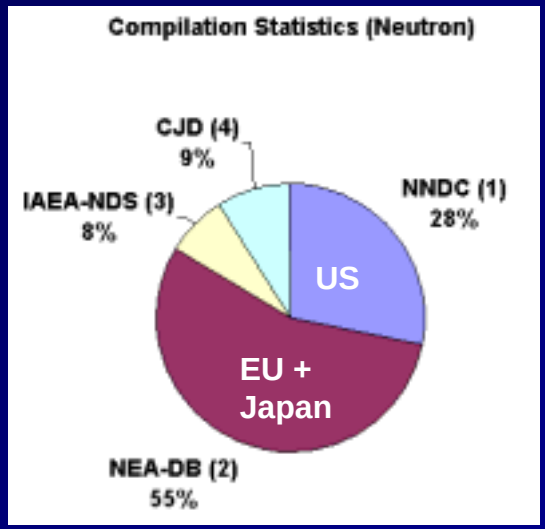
Coordinated by IAEA-NDS (Nuclear Data Section)

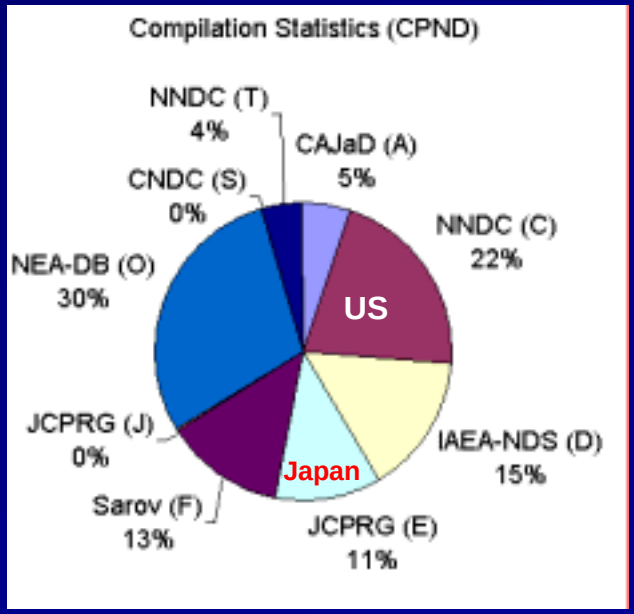
All centres are responsible to compilation of data from their area and/or incident particles (JAEA and KAERI do only evaluation.)

Compiler Workshop (IAEA, 2001)

Compilation Statistics (EXFOR, 2003-2006)

Neutron induced reaction data (1050 works)





Charged-particle induced reaction data (3000 works, of which 10% is from JCPRG)

Photo-nuclear data (138 works)

On/Off-line access to database

JCPRG

IAEA-NDS

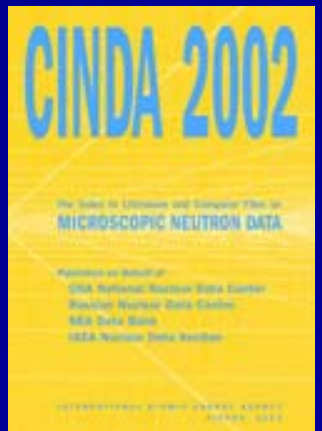
NNDC

NEA-DB

80,000~90,000 searches / year

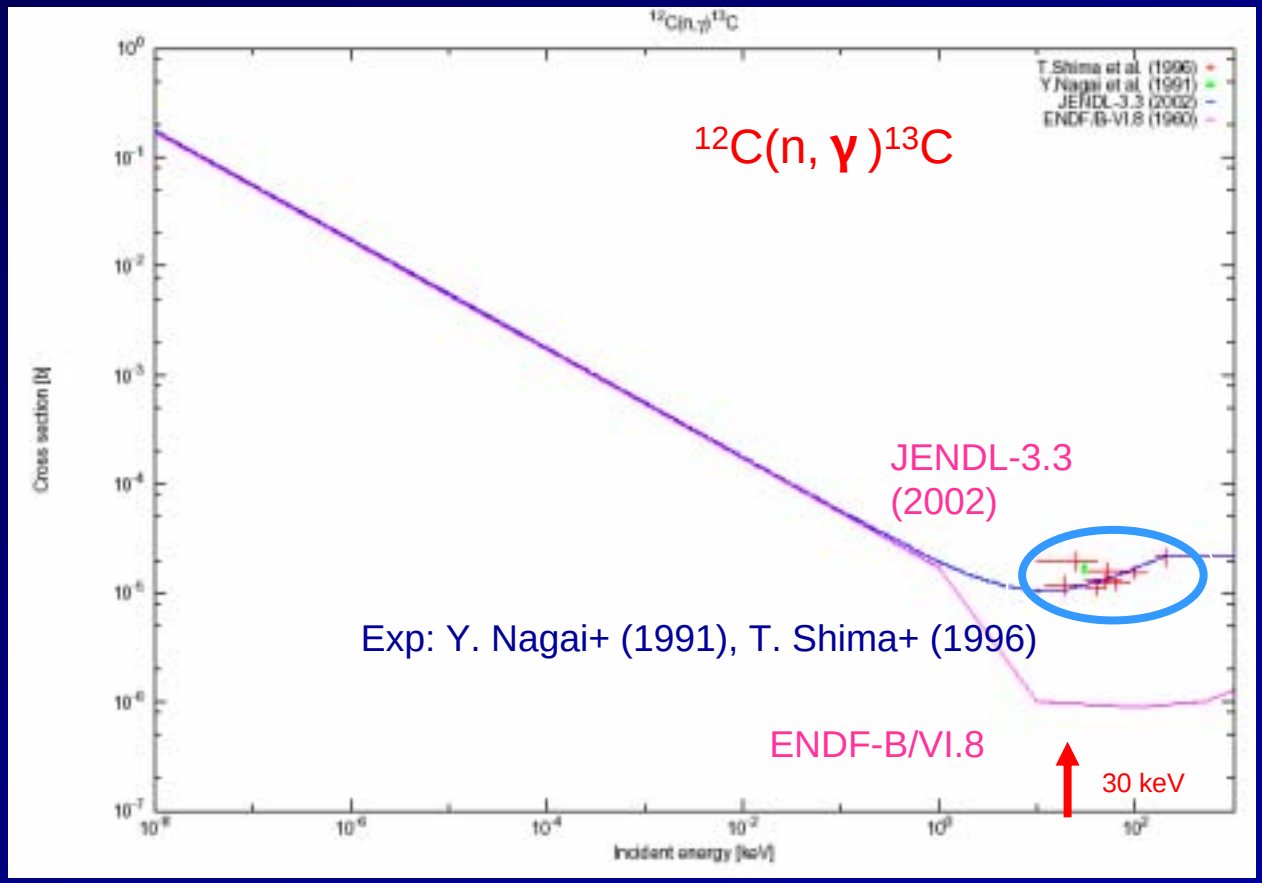
CD and Book are also available.

(CINDA: A Bibliographical data base for nuclear reaction works)



3. Data base and astrophysics

Astro-nuclear data in JENDL-3.3 (JAEA-NDC)



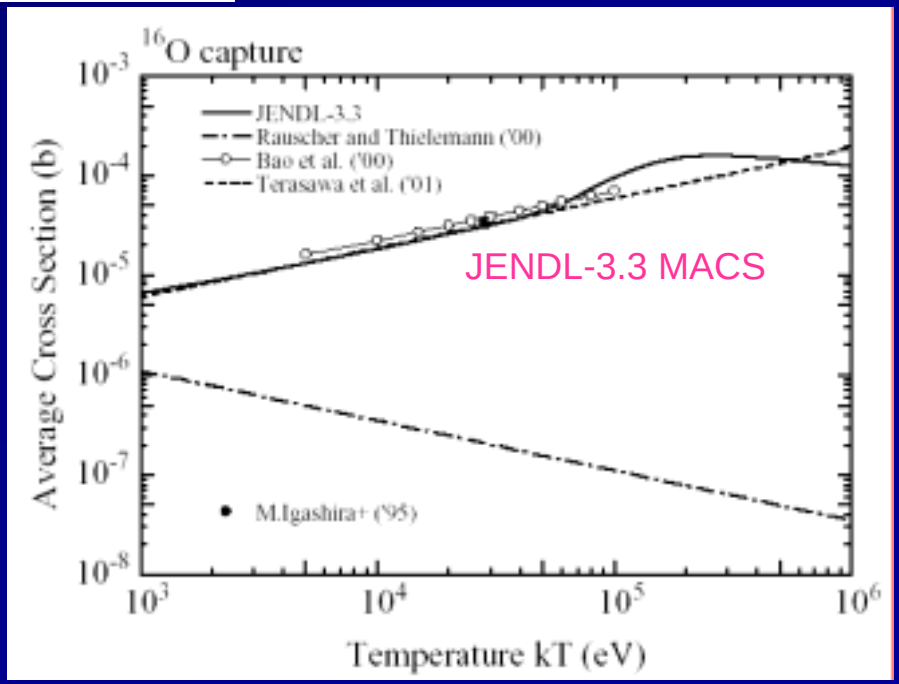
JENDL-3.3 → MACS at 30 keV (JAEA-NDC)

MACS: Maxwellian - Averaged Cross Section $<\sigma v>/v_T$

$$\frac{\langle \sigma \upsilon \rangle}{v_T} = \langle \sigma \rangle_{kT} = \frac{2}{\sqrt{\pi}} \frac{\int_0^\infty \frac{\sigma(E_n)}{NF} E_n e^{-E_n/kT} dE_n}{\int_0^\infty E_n e^{-E_n/kT} dE_n}.$$

JENDL-3.3 MACS

	nuclides
(n, **γ**)	336
(n, f)	61
(n, p)	40
(n, **α**)	32

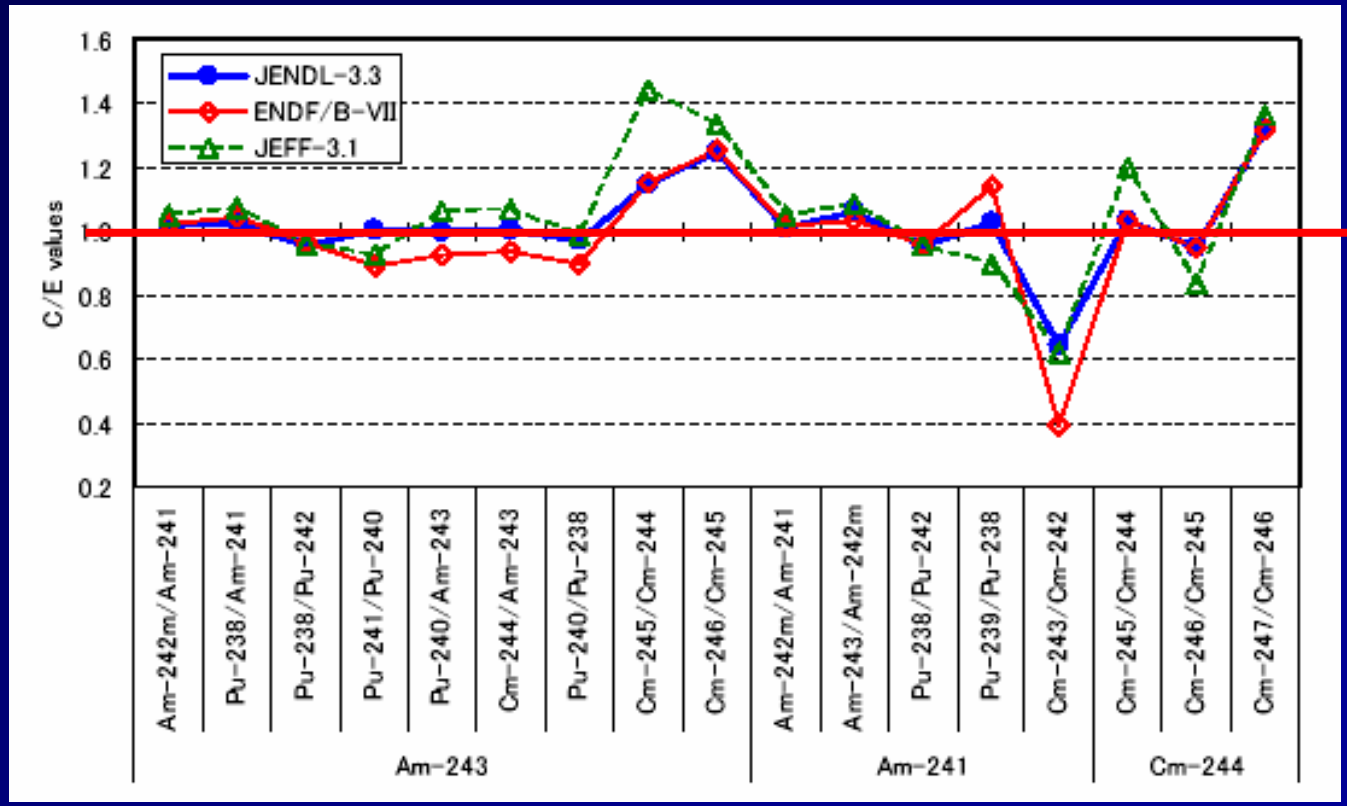


- *T. Nakagawa et al.*（2005）, At. Data Nucl. Data Tables 91(2005)77

Example of deviation in $<\sigma v>/v_T$

^{74}Se	$<\sigma>_{30}$ (mb)	Ratio to JENDL-3.3
Bao *et al*. (2000)	267 (25)	1.28
NON-SMOKER (2001)	207	1.00
MOST (2005)	304	1.46
JENDL-3.3 (2002)	208	1
Dillmann *et al*. (2006)	271 (15)	1.30

Minor actinide yields (reactor)



Experimental Value

Burning chain in experimental reactor JOYO
- Sugino (2007), private communication

Can astrophysics provide benchmark for nuclear data?

Compilation of Astrophysical Data (JCPRG)

NRDF/A : Compilation for astrophysical data of 31 reactions - (n, γ), (α, γ), (α,n)

```
¥¥BIB;
D#          A0005
DATE        2006-12-09
RCT         13C(A,N)16O
PHQ         SIGMA
REF         [HA2005] S.Harissopulos et al., Phys.Rev.C72(2005)062801
REF         [KE1989] S.E.Kellogg et al., Bull.Am.Phys.Soc.34(1989)1192(E10.5)
REF         [DA1968] C.N.Davids, Nucl.Phys.A110(1968)619
REF         [SE1967] K.K.Sekharan et al., Phys.Rev.156(1967)1187
COM         EXFOR A0613.003 (EN-CM vs SIGMA) should be added.

¥¥DATA;
EN-MIN      EN-MAX      SIGMA       ERR-T       ERR-S       REF
EV          EV          B           B           B
 7.6700E+05 7.6700E+05 2.6000E-06 1.0400E-07 -           HA2005
 7.8600E+05 7.8600E+05 3.3000E-06 1.3200E-07 -           HA2005
 8.0700E+05 8.0700E+05 5.1000E-06 2.0400E-07 -           HA2005
 8.2600E+05 8.2600E+05 7.2000E-06 2.8800E-07 -           HA2005
 8.4600E+05 8.4600E+05 1.0800E-05 4.3200E-07 -           HA2005
 8.6600E+05 8.6600E+05 1.4300E-05 5.7200E-07 -           HA2005
 8.8600E+05 8.8600E+05 2.0200E-05 8.0800E-07 -           HA2005
 9.0600E+05 9.0600E+05 2.8700E-05 1.1480E-06 -           HA2005
 9.2500E+05 9.2500E+05 3.8400E-05 1.5360E-06 -           HA2005
 9.4500E+05 9.4500E+05 5.3200E-05 2.1280E-06 -           HA2005
 9.6500E+05 9.6500E+05 8.0100E-05 3.2040E-06 -           HA2005
 9.7500E+05 9.7500E+05 8.9300E-05 3.5720E-06 -           HA2005
 9.8500E+05 9.8500E+05 1.0100E-04 4.0400E-06 -           HA2005
 9.9400E+05 9.9400E+05 1.1600E-04 4.6400E-06 -           HA2005
 1.0050E+06 1.0050E+06 1.5200E-04 6.0800E-06 -           HA2005
 1.0160E+06 1.0160E+06 1.6400E-04 6.5600E-06 -           HA2005
 1.0250E+06 1.0250E+06 1.8900E-04 7.5600E-06 -           HA2005
 1.0300E+06 1.0300E+06 2.0900E-04 8.3600E-06 -           HA2005
 1.0460E+06 1.0460E+06 4.6100E-04 1.8440E-05 -           HA2005
 1.0500E+06 1.0500E+06 8.5000E-04 3.4000E-05 -           HA2005
 1.0520E+06 1.0520E+06 2.0300E-03 8.1200E-05 -           HA2005
 1.0530E+06 1.0530E+06 4.5300E-03 1.8120E-04 -           HA2005
 1.0540E+06 1.0540E+06 8.7700E-03 3.5080E-04 -           HA2005
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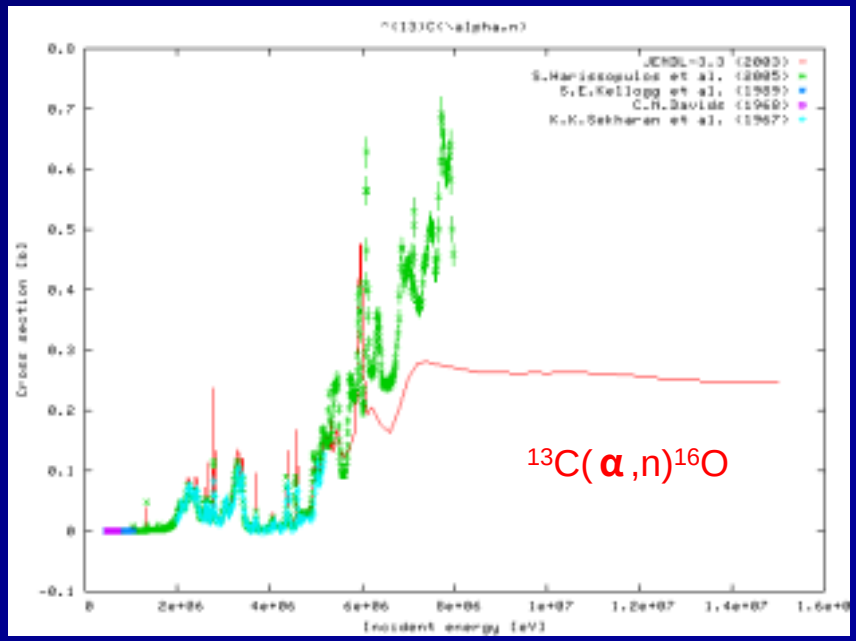
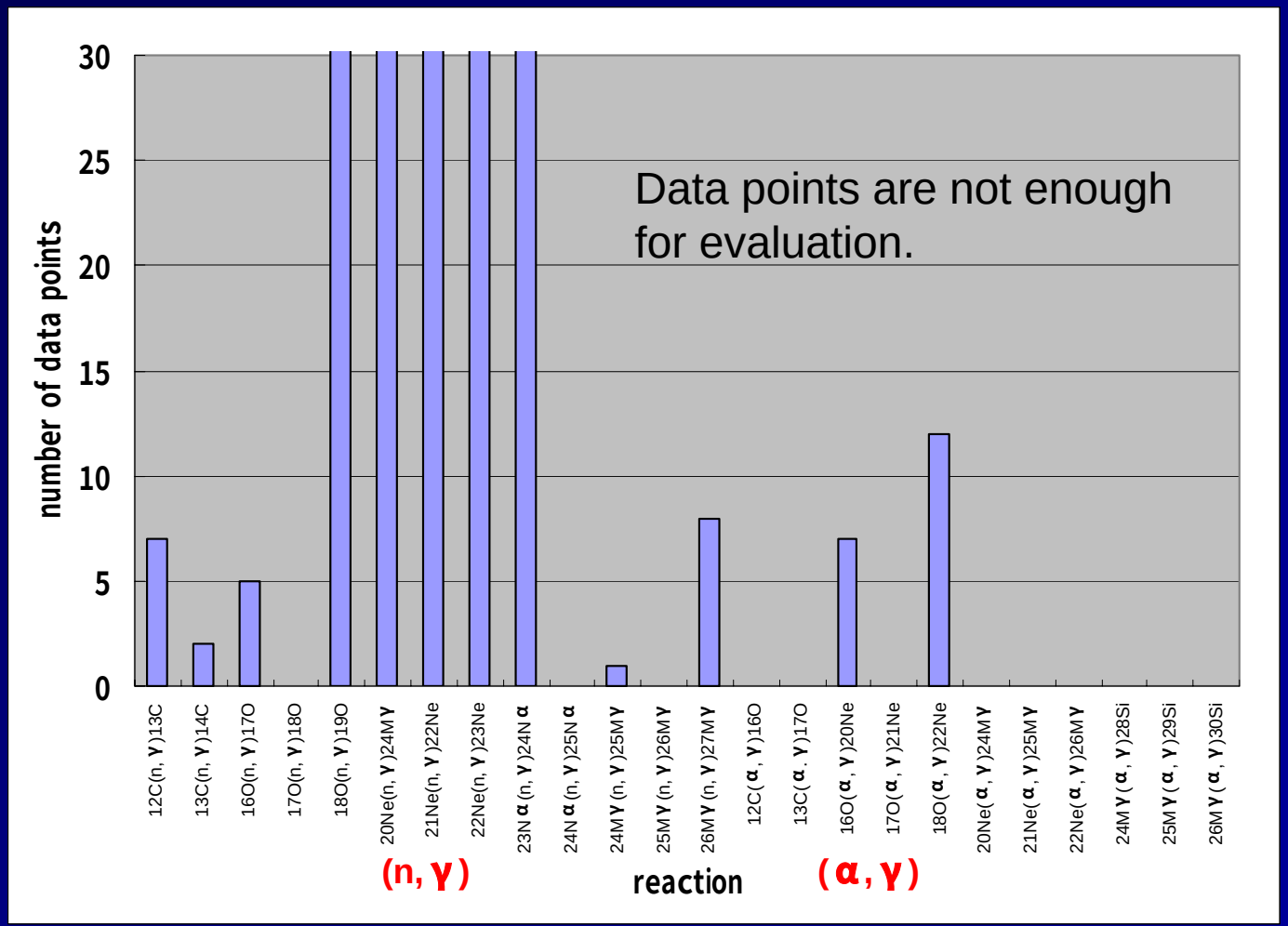
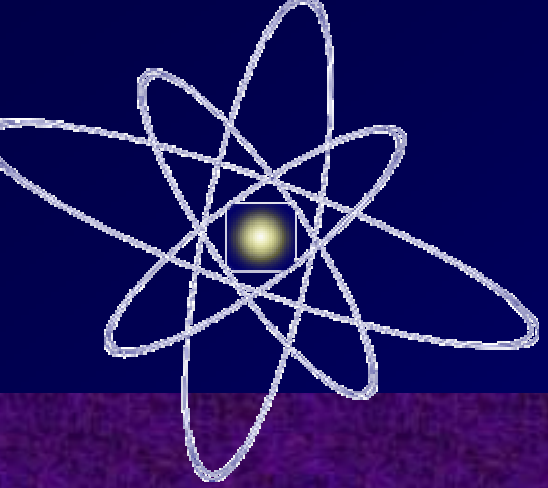


Data point number in NRDF/A





5.Conclusion

Conclusions

- Nuclear reaction data base:
  Basic infrastructure in physics and engineering
- JCPRG: Accumulate all experimental data points in database
  (We do not know which reaction data will be useful in future)
- Financial and human resource for compilation are unstable.
  (Nuclear data services are free of charge.)
- Citation and acknowledgement to the database are appreciated.
- Scope is very wide:
  Collab. between experimenters-compilers-evaluators-users
- Thank you for all experimentalists who provide us numerical data!!

Members of JCPRG and NRDC

- **Hokkaido University Nuclear Reaction Data Centre (JCPRG)**

NRDF Advisory Committee:

Y. Abe (RCNP), Y. Akaishi (RIKEN), Y. Aoki (Tsukuba), M. Baba (Sendai), J. Chiba (TUS), A. Hasegawa (NEA-DB), K. Hatanaka (RCNP)), M. Ishihara (RIKEN), K. Kato (Sapporo), J. Katakura (JAEA), M. Kawai (Fukuoka), S. Kubono (CNS), S. Morinobu (RCNP), T. Noro (Fukuoka), T. Motobayashi (RIKEN), T. Nagae (Kyoto), K. Okamoto (JAIF), H. Ohnuma (TIT), H. Orihara (Sendai), T. Saito (Sendai), H. Sakurai (RIKEN), H. Tanaka (Sapporo), H. Utsunomiya (Konan)

NRDF Steering Committee:

K. Kato (Hokkaodo U.), S. Aoyama (Niigata U.), M. Chiba (Sapporo Gakuin U.), Y. Hirabayashi (Hokkaodo U.), T. Katayama (Hokusei Gakuen U.), H. Masui (Kitami Inst. Tech.), H. Noto (Hokusei Gakuen U.), A. Ohnishi (Hokkaido U.), S. Okabe (Hokkaido U.)

Compilation, Digitization, System development:

T. Ashizawa (Hokkaido U.), H. Matsumiya (Hokkaido U.), T. Murakami (Hokkaido U.), R. Suzuki (Hokkaido U.) T. Togashi (Hokkaido U.), K. Tsubakihara (Hokkaido U.), H. Yoshida (Hokkaido U.)

- **Nuclear Reaction Data Centers Network (NRDC)**

Compilers:

O. Schwerer (IAEA-NDS), S. Dunaeva (IAEA-NDS), D. Rochman (BNL-NNDC), S.Y. Babykina (Moscow), S. Maev (Obninsk), M. Mikhaylyukova (Obninsk), N.Otuka (JAEA/JCPRG), S. Takacs (ATOMKI), H. Henriksson (OECD-NEA), N.Klimova (Kiev)

More information?

- Experimental nuclear data base (NRDF, EXFOR):
  http://www.jcprg.org/ (JCPRG)
- Evaluated nuclear data base (JENDL):
  http://wwwndc.tokai-sc.jaea.go.jp/ (JAEA-NDC)

JCPRG – Monthly meeting