

**International Atomic Energy Agency**

# **Contribution of Nuclear Data Section (NDS) and Nuclear Reaction Data Centres (NRDC)**

**IAEA Nuclear Data Section  
Naohiko Otuka**

Second Advanced Workshop on Model Codes for Spallation Reactions  
Saclay, February 8-11, 2010

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## 1. Improvement of EXFOR

- **Completeness**
- **Accessibility**

## 2. Possible Web Service (for future)

- **Code distribution**
- **Upload/Analysis system**

# 1. Improvement of EXFOR (Completeness, Accessibility)



# Improvement of EXFOR (Completeness)

- **EXFOR: Experimental Database**  
(<http://www-nds.iaea.org/exfor/> etc.)
- **Main scope of EXFOR:**  
Target  $A \leq 12$ ,  $E(A?) \leq 1$  GeV  
(EXFOR is originally designed for low-energy neutron physics...)
- **No reason to miss useful data for our benchmark.**  
→ **We are trying to fill gap for data used in our benchmark.**

# Progress in Compilation (Aug. 2009~)

Reaction	Quant.	Emin	Emax	Lab.	Author	Publication	EXFOR
Al,C,Cu,Pb(p,x+pi-, pi+)	DAE	7.30E+02	7.30E+02	1USABRK	D.R.F.Cochran+	J,PR/D,6,3085,1972	C1754 (NNDC)
Ni(p,x+p,d,t,h,a)	DAE	1.80E+02	1.80E+02	2GERJUL	A.Budzanowski+	J,PR/C,80,054604,2009	C1763 (NNDC)
Au(p,x+p,d,t,h,a,Li6,Li7)	DAE	2.50E+03	2.50E+03	2GERJUL	A.Letourneau+	J,NP/A,712,133,2002	D0579 (IAEA NDS)
Ta(p,x+p,d,t,h,a)	DAE	1.20E+03	1.20E+03	2GERGSI	C.-M.Herbach+	J,NP/A,765,426,2006	O1305 Digitized... (NEA DB)
Fe(p,x)nuclide	CS	1.70E+01	2.60E+03	2FR SAT+	R.Michel+	J,NSTS,2,242,2002	In compilation
Fe,Pb(p,x+n)	CSN	8.00E+02	1.60E+03	2FR SAT	S.Leray+	J,PR/C,65,44621,2002	In compilation
Pb(p,x+n)	MLT	1.20E+03	1.20E+03	2GERJUL?	A.Letourneau+	J,NIM/B,170,299,2000	???
Al,Fe,Zr,U(p,x+n)	MLT	1.20E+03	1.20E+03	2GERJUL?	C.-M.Herbach+	R,JUEL-SPEZ	???
Al(p,x+pi-)	DAE	2.20E+03	2.20E+03	2JPNKEK	H.En'yo+	J,PL/B,158,1,1985	Not original

**We have many friendly experimentalists (Michel, Titarenko, Schmidt...)  
But no response from some authors...**

# International Collaboration for EXFOR

International Network of  
Nuclear Reaction Data Centres  
(*NRDC*)

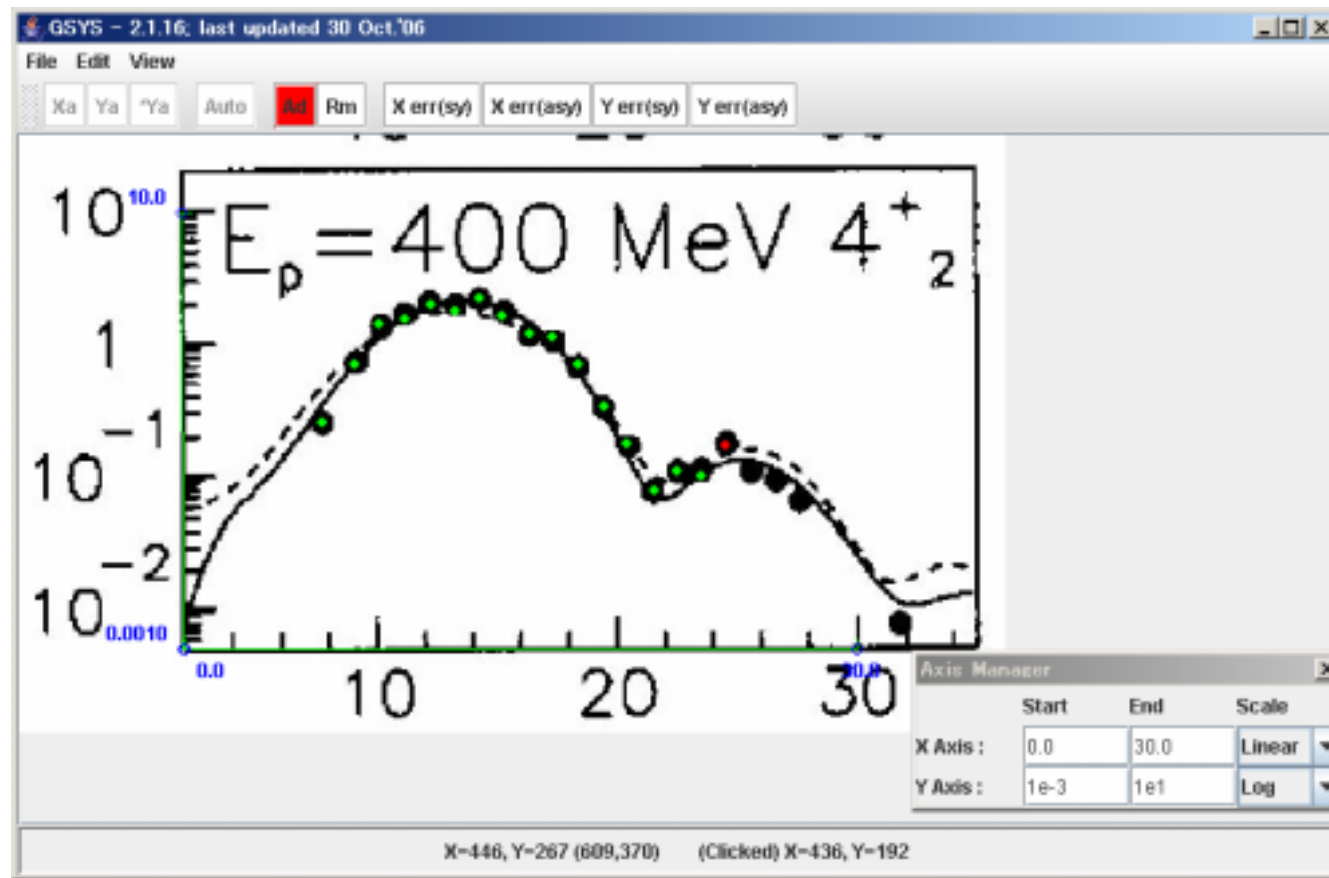


Coordinated by IAEA-NDS

-  **NNDC**
-  **NEA-DB**
-  **CJD, CAJaD, CDFE, CNPD**
-  **ATOMKI**
-  **UkrNDC**
-  **KAERI-NDEL**
-  **JCPRG**
-  **CNDC**
-  **BARC**

**Do not digitize data from figure images! Ask us numerical data!**

, but we also offer a good digitizer...



A java-based digitizer used by EXFOR compilers (GSYS).  
Available at <http://www.jcprg.org/gsys/> (free)

# Database for Elemental Process in INC

## Useful experimental data for inputs to INC

### N-N reaction

$pp \rightarrow pn \pi^+$ ,  $pp \pi^+ \pi^-$ ,  $pp \eta$ , ...

### N- $\pi$ reaction

$\pi^- p \rightarrow \pi^0 n$ ,  $\pi^+ p \rightarrow n \pi^+ \pi^+$ ,  $\pi^+ p \rightarrow p \pi^+ \eta$ , ...

**Not in the current EXFOR scope** (boundary between nuclear and hadron physics...). But we may think about it (if it is necessary).



# Improvement of EXFOR (Accessibility)

## “Traditional” EXFOR compilation for GSI experiments

```
SUBENT          01302002      20060526
BIB              3              11
REACTION        (1-H-1(92-U-238,X)ELEM/MASS,,SIG)
...
ENDBIB          11
NOCOMMON
EN
GEV
                238.
ENDCOMMON       3

DATA            5              254
ELEMENT         MASS          DATA          DATA-ERR1  DATA-ERR2
NO-DIM         NO-DIM        MB           PER-CENT   PER-CENT
                7.           15.           1.8         23.         22.
                7.           16.           0.44        22.         21.
```

**Users cannot search this data set as  $p(1\text{ GeV}) + {}^{238}\text{U}$  reaction.**  
(J.-C. David, WPEC SG30 meeting, NEA/NSC/DOC(2007)25)

# New Coding for Inverse Kinematics

```

SUBENT          01302002      20060526
BIB              3             11
REACTION        ((1-H-1(92-U-238,X)ELEM/MASS,,SIG)=
                (92-U-238(P,X)ELEM/MASS,,SIG))
...
ENDBIB          11
NOCOMMON
EN
GEV/A          1.
ENDCOMMON      3

DATA            5             254
ELEMENT         MASS          DATA      DATA-ERR1  DATA-ERR2
NO-DIM         NO-DIM        MB         PER-CENT    PER-CENT
                7.           15.         1.8         23.         22.
                7.           16.         0.44        22.         21.
    
```

Can be searched as  
proton-induced  
reaction data

Incident energy expression  
invariant under  
target projectile

To be proposed in next NRDC meeting (Apr., 2010)

## **2. Possible Web Services (Code Distribution, Web-based Analyzing Tool)**



# An Example of Code Distribution

## OSCAR: Open Standard Codes and Routines

A code distribution website for transport models  
for relativistic heavy-ion collision research (1997~2008)

*“It was established in June of 1997 to address the problem concerning the lack of common standards, documentation, version control, and accessibility in many transport codes at that time. “*

<http://www-cunuke.phys.columbia.edu/OSCAR/>  
(Columbia Univ. etc.)

# OSCAR – List of Codes

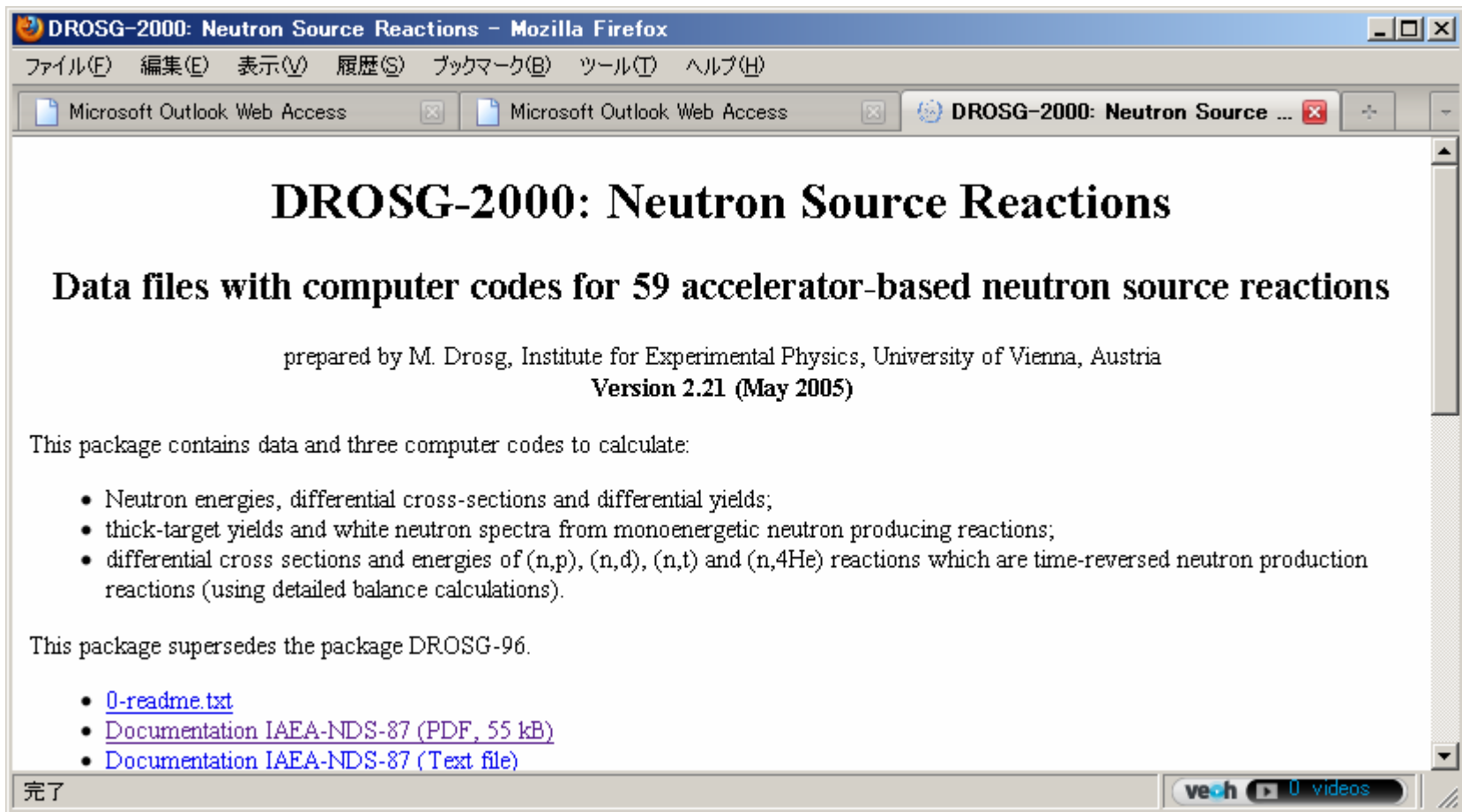
**List of Codes**

1. Partonic/String Transport  
[AMPT](#) [HIJING](#) [HIJING/B-anti-B](#) [MPC](#) [neXus](#) [PCPC](#) [PSM](#) [VNI](#) [VNIb](#) [ZPC](#)
2. String/Hadronic Transport  
[AMPT](#) [ART](#) [BEM](#) [BNC](#) [HSD](#) [JAM](#) [JPCIAE](#) [LEXUS](#) [LUCIAE](#) [RQMD](#) [UrQMD](#)
3. Transport Tools  
[GCP](#)
4. Correlation Builders  
[CRAB](#)
5. Hydrodynamics  
[AZHYDRO](#) [BJ\\_HYDRO](#)

Code Name: **AMPT** – *A Multi-Phase Transport*  
Authors: *Che-Ming Ko, Bao-An Li, Zi-Wei Lin, Subrata Pal, and Bin Zhang*  
Description: AMPT is a Monte Carlo transport model for heavy ion collisions at relativistic energies. It uses the Heavy Ion Jet

完了

# Example of Distribution from NDS



**DROSG-2000: Neutron Source Reactions**

**Data files with computer codes for 59 accelerator-based neutron source reactions**

prepared by M. Drosig, Institute for Experimental Physics, University of Vienna, Austria  
**Version 2.21 (May 2005)**

This package contains data and three computer codes to calculate:

- Neutron energies, differential cross-sections and differential yields;
- thick-target yields and white neutron spectra from monoenergetic neutron producing reactions;
- differential cross sections and energies of (n,p), (n,d), (n,t) and (n,4He) reactions which are time-reversed neutron production reactions (using detailed balance calculations).

This package supersedes the package DROSG-96.

- [0-readme.txt](#)
- [Documentation IAEA-NDS-87 \(PDF, 55 kB\)](#)
- [Documentation IAEA-NDS-87 \(Text file\)](#)

完了

**Purpose of the code, Links to package and manual,  
How to run (short manual).**

# Manual as an IAEA-NDS report



INTERNATIONAL ATOMIC ENERGY AGENCY  
**NUCLEAR DATA SERVICES**  
DOCUMENTATION SERIES OF THE IAEA NUCLEAR DATA SECTION

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IAEA-NDS-87  
Rev. 9, May 2005

## **DROSG-2000: Neutron Source Reactions**

**Data files with computer codes  
for 59 monoenergetic neutron source reactions**

**Version 2.21**

prepared by

M. Drosg  
Institute of Experimental Physics  
University of Vienna

Summary documentation

**Note: Code distribution is not the main task of NDS. If you need additional services (e.g. validation), codes should go to NEA.**

# Future update of calc./exp. data

Benchmark-CalculRes - Spallations - Mozilla Firefox

ファイル(F) 編集(E) 表示(V) 履歴(S) ブックマーク(B) ツール(T) ヘルプ(H)

Microsoft Outlook Web Access Microsoft Outlook Web Access Benchmark-CalculRes - Spall...

neutron-prod

### Neutron production

Double-differential Cross Sections

Energy	Target	Element	Reaction	MC module	calc2002	calc2003	calc2004	phs2001	phs2002	phs2003	calc2001	calc2002	calc2003	calc2004	calc2005	calc2006	calc2007	calc2008	calc2009	calc2010
0	Fe	48	neutron	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01
0	Fe	300	neutron	FF 40.01FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01
0	Fe	300	neutron	FF 40.01FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01
0	Fe	3000	neutron	FF 40.01FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01
0	Fe	3000	neutron	FF 40.01FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01
1%	Fe	48	neutron	FF 40.01FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01
1%	Fe	300	neutron	FF 40.01FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01
1%	Fe	300	neutron	FF 40.01FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01
1%	Fe	3000	neutron	FF 40.01FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01
1%	Fe	3000	neutron	FF 40.01FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01

Multiplicity Distribution

Neutron multiplicity data was listed by the participants using a common efficiency formula given [here](#).

Energy	Target	Element	Reaction	MC module	calc2002	calc2003	calc2004	phs2001	phs2002	phs2003	calc2001	calc2002	calc2003	calc2004	calc2005	calc2006	calc2007	calc2008	calc2009	calc2010
0	Fe	3000	neutron	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01
1%	Fe	3000	neutron	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01

Average Multiplicity:

Calculated from the energy and angle integrated cross-sections using the formula given [here](#).

Energy	Target	Element	Reaction	MC module	calc2002	calc2003	calc2004	phs2001	phs2002	phs2003	calc2001	calc2002	calc2003	calc2004	calc2005	calc2006	calc2007	calc2008	calc2009	calc2010
0	Fe	3000-3000	2 - 2n	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01	FF 40.01

完了

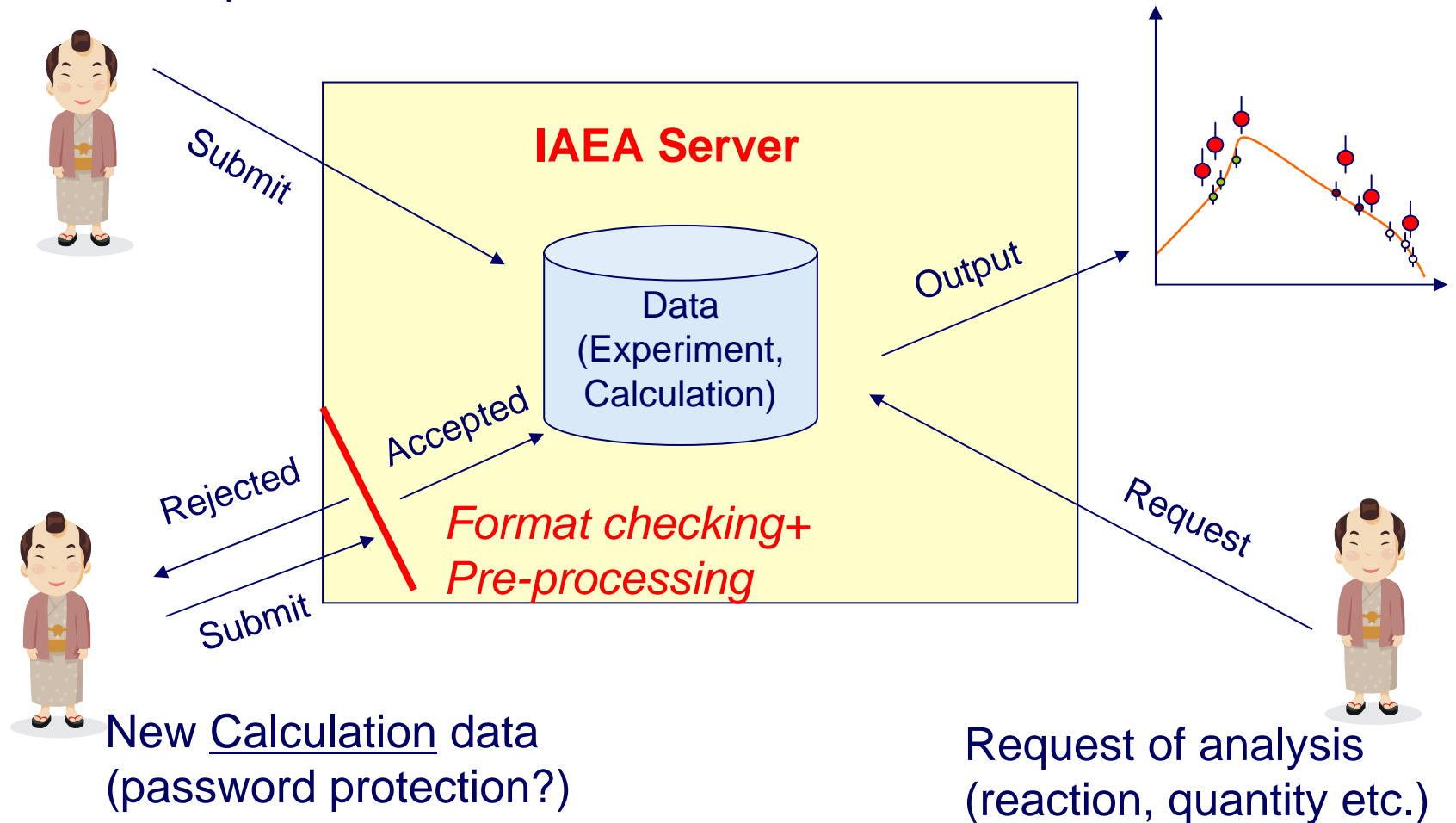
A lot of manual work by M. U. Khandaker (+J.-C. David and NO)





# Upload / Analysis System (~1 year?)

New Experimental data



# Summary

## 1. Improvement of EXFOR

**Completeness – Effort by NRDC data centres**

**Accessibility – New coding for inverse kinematics**

## 2. Web Services (if necessary)

- **Code distribution**
- **Upload / Analysis system (short-term plan)**
- **Web calculation? (No enough CPU in NDS)**



# Best regards from Alberto in Japan !



**Alberto's last working day at IAEA-NDS (2009-06-30)**