Experience of X4 and C4 in Japan

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Consultant Meeting of SG30

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- Proposals to tabular formats (C4)
  - (1) Isotope production cross section with ELEM/MASS
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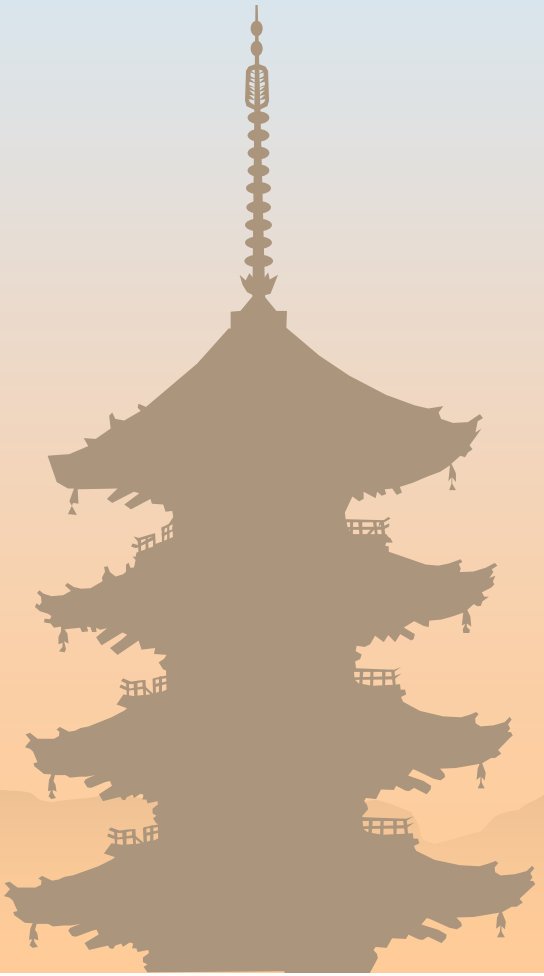
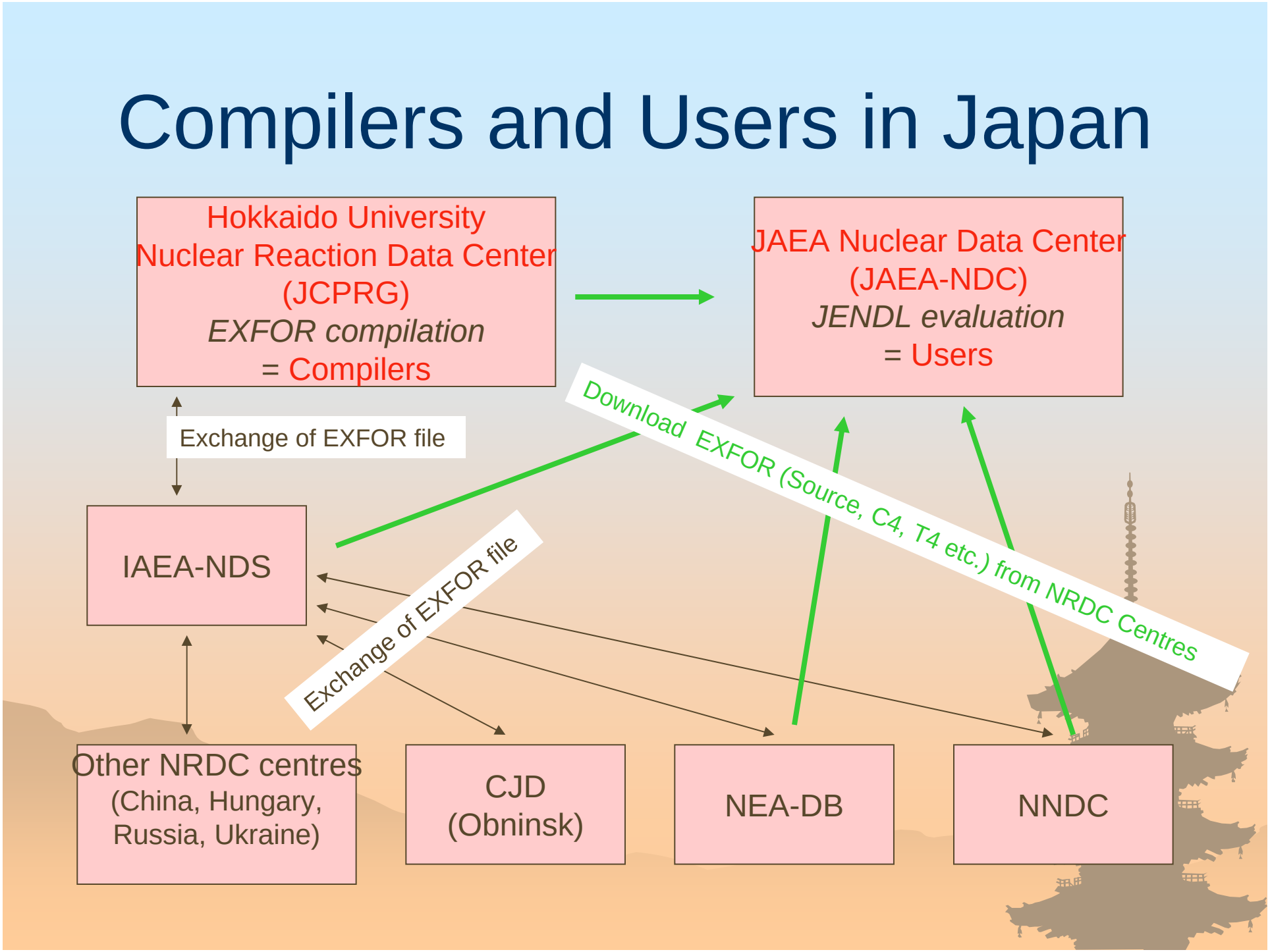
- Mistake reported by Japanese users

1. EXFOR compilers and users in Japan



Compilers and Users in Japan



Formats used in JENDL evaluation

Evaluator	Data format
T.N.	NESTOR system
K.S.	C4 (but often write small codes for DDX)
T.F.	CONDUCT system
A.I.	C4
O.I	His private system
N.I.	C4
S.K.	C4 + NEA-DB (JANIS?)
N.O.	My system (www.jcprg.org/exfor/)

NESTOR format

```
 922330 NCAPCSAV   G  66HAR20917  2RAERE-M-1709,    F.D.BROOKS+          02 7  0    1
                                                                                0    2
EN G EV    EN L EV    DAT  BARN  ERR  BARN            MON1 BARN  ERR  BARN    0    3
 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00  1    1
 3.5000E-01 4.5000E-01 1.6900E+01 3.0000E+00 0.0000E+00 1.2000E+01 2.0000E+00  1    2
 4.5000E-01 5.0000E-01 1.2500E+01 3.6000E+00 0.0000E+00 1.2000E+01 2.0000E+00  1    3
 5.0000E-01 5.5000E-01 1.3100E+01 4.5000E+00 0.0000E+00 1.2000E+01 2.0000E+00  1    4
 5.5000E-01 7.0000E-01 1.1000E+01 2.3000E+00 0.0000E+00 1.2000E+01 2.0000E+00  1    5
 7.0000E-01 1.0000E+00 8.8000E+00 1.8000E+00 0.0000E+00 1.2000E+01 2.0000E+00  1    6
 1.0000E+00 1.3000E+00 1.7800E+01 2.3000E+00 0.0000E+00 1.2000E+01 2.0000E+00  1    7
 1.3000E+00 1.8000E+00 8.0300E+01 8.9000E+00 0.0000E+00 1.2000E+01 2.0000E+00  1    8
 1.8000E+00 4.5000E+00 4.0000E+01 1.6000E+00 0.0000E+00 1.2000E+01 2.0000E+00  1    9
 4.5000E+00 5.0000E+00 8.9000E+00 1.4000E+00 0.0000E+00 1.2000E+01 2.0000E+00  1   10
 5.0000E+00 1.0000E+01 1.9400E+01 7.3400E+01 0.0000E+00 1.2000E+01 2.0000E+00  1   11
                                                                              199999
                                                                            99999999
 922330 NCAPCSMX   G  46ANL12319  6RCF-3651         W.H.ZINN+            02 7  0    1
                                                                                0    2
EN D EV              DAT  BARN                                                  0    3
 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00  1    1
 2.5300E-02 0.0000E+00 5.8000E+01 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00  1    2
                                                                              199999
                                                                            99999999
 922330 NCAPCSMX   G  61ORL12335  2RORNL-3320,1     J.HALPERIN+          02 7  0    1
                                                                                0    2
EN D EV              DAT  BARN  ERR  %               MON  BARN                  0    3
 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00  1    1
 2.5300E-02 0.0000E+00 5.1700E+01 5.0000E+00 0.0000E+00 3.7000E+01 0.0000E+00  1    2
```

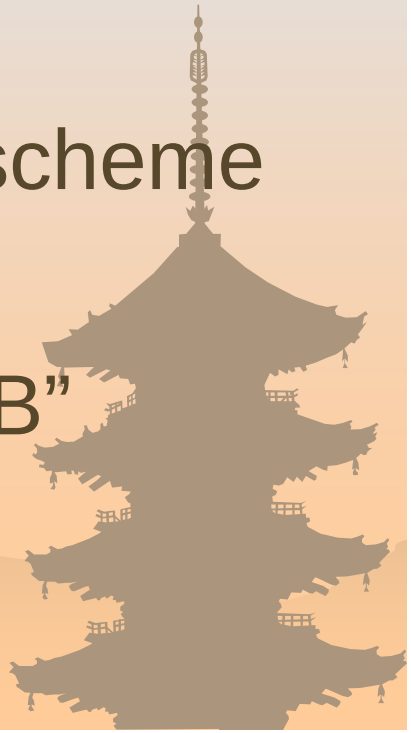
JCPRG format

```
# Reference: K.Merla et al.  91JUELIC,,510,1991
# Data ID  : 22304006
#             EN            EN          DATA        +ERR-T        -ERR-T
#             EV            EV             B             B             B
    2.600000E+06  2.600000E+06  1.240000E+00  2.405600E-02  2.405600E-02
    1.470000E+07  1.470000E+07  2.096000E+00  2.389440E-02  2.389440E-02


# Reference: K.Merla et al.  91JUELIC,,510,1991
# Data ID  : 22304002
#             EN            EN          DATA        +ERR-T        -ERR-T        +ERR-S        -ERR-S
#             EV            EV             B             B             B             B             B
    4.450000E+06  4.450000E+06  1.094000E+00  2.352100E-02  2.352100E-02  1.378440E-02  1.378440E-02
    8.460000E+06  8.460000E+06  1.855000E+00  4.433450E-02  4.433450E-02  2.819600E-02  2.819600E-02
    1.880000E+07  1.880000E+07  2.068000E+00  5.025240E-02  5.025240E-02  2.088680E-02  2.088680E-02


# Reference: P.W.Lisowski et al.  91UPPSAL,,177,1991
# Data ID  : 14016002
#             EN            EN          DATA     +DATA-ERR     -DATA-ERR
#             EV            EV             B             B             B
    3.020000E+07  3.020000E+07  2.050000E+00  3.050000E-02  3.050000E-02
    3.110000E+07  3.110000E+07  2.020000E+00  3.450000E-02  3.450000E-02
    3.210000E+07  3.210000E+07  2.130000E+00  3.250000E-02  3.250000E-02
```

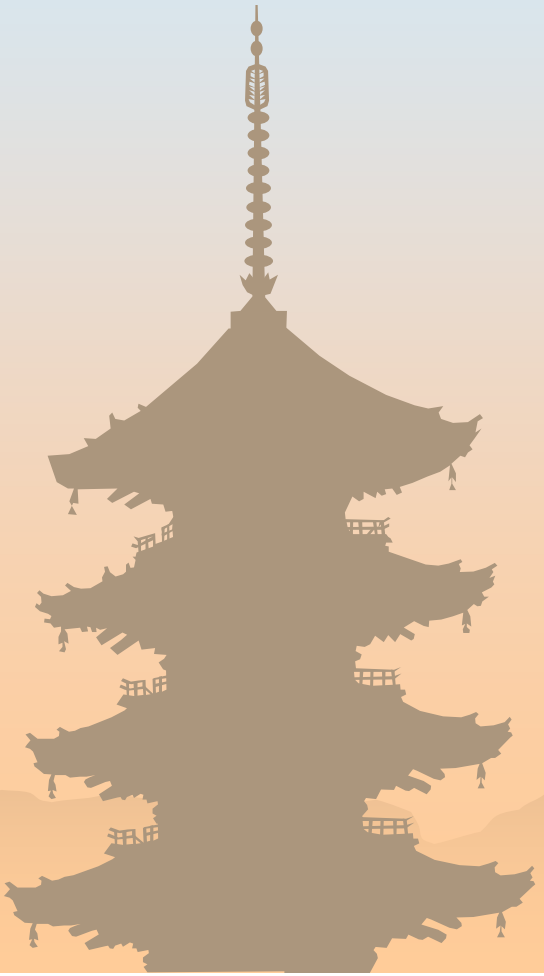
Requests to tabular format from JAEA

- Isotope production coded with ELEM/MASS
- Error information for covariance evaluation
- Charged-particle induced reaction
- Quantities not defined in (MF,MT) scheme

  e.g. analyzing power,…
- Cross section coded with “MICRO-B”



2. 2 Proposals to tabular formats (C4 etc.)



Isotope production cross section with "ELEM/MASS"

- High energy isotope production cross section data:

  - ADS application
  - Reaction mechanism: evaporation v.s. fission
  - RI beam production for unstable nuclear physics

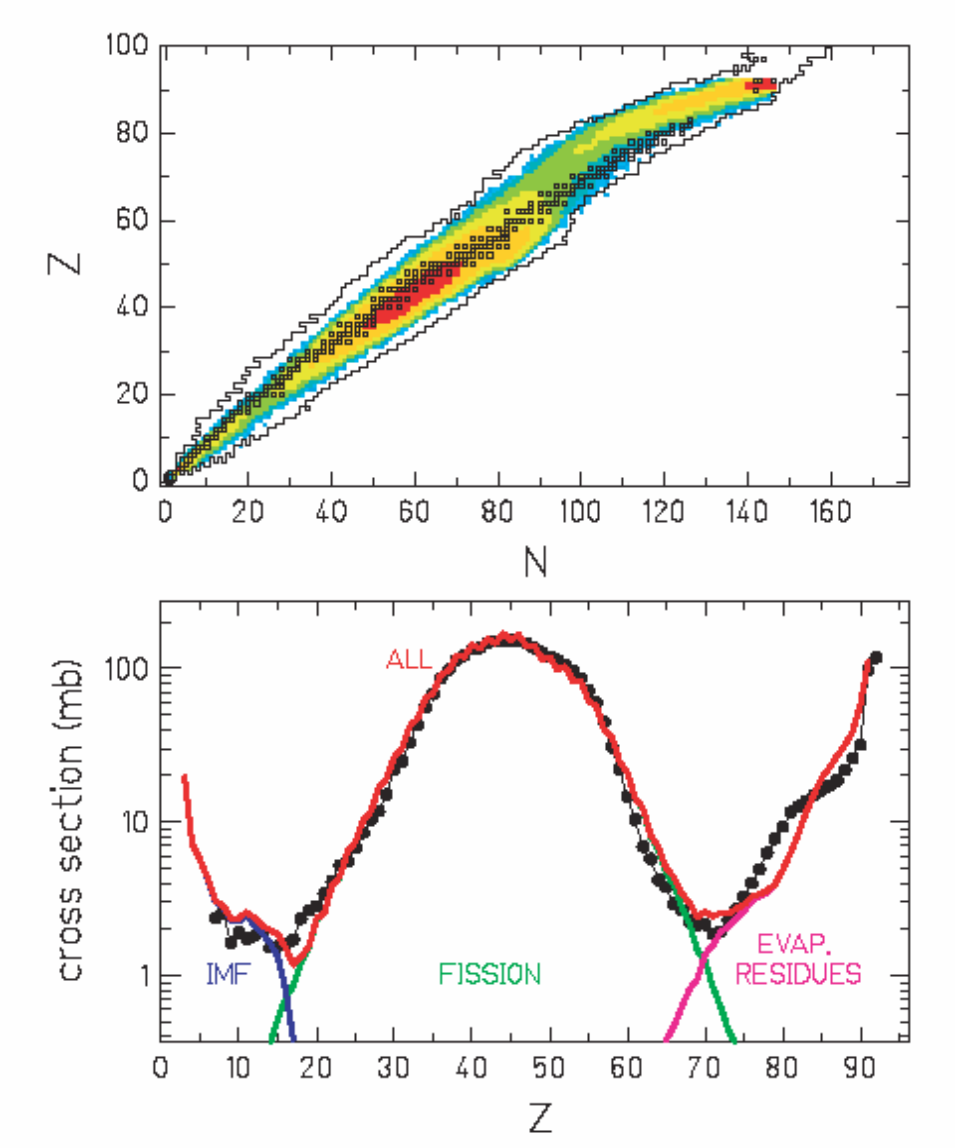
etc.

Major facilities: GSI (Darmstadt), ITEP (Moscow) …

→ JENDL High-Energy file (coordinator: T. Fukahori)

Example (GSI $^{238}U+^{1}H$ @ 1GeV)

- M. V. Ricciardi, Phys.Rev.C73(2006)014607
- 254 isotopes (6<Z<38) are identified by fragment separator GSI-FRS



Two options of EXFOR coding

1. Isotope codes in SF4

(92-U-238(P,X)**7-N-15**,,SIG)

(92-U-238(P,X)**7-N-16**,,SIG)

…

→ *254* subentries

2. ELEM/MASS in SF4

(92-U-238(P,X)**ELEM/MASS**,,SIG)

→ *1* subentries

APPENDIX

TABLE A1. Measured fission cross sections for the spallation of 1 *A* GeV ^{238}U on hydrogen.[a] The last two columns represent the upper and lower relative uncertainties (expressed in percentage). Both statistical and systematic errors are considered. The cross section of those isotopes which either could not be measured or the measurement was rejected for technical reason (see text) are marked with the notation "==".

Z	N	σ/mb	$\varepsilon_{\mathrm{rel}}^{\mathrm{up}}$	$\varepsilon_{\mathrm{rel}}^{\mathrm{dw}}$
7	8	1.8	23	22
7	9	0.44	22	21
7	10	0.14	67	44
8	8	0.52	33	29
8	9	0.8	28	28

……

Continued for 254 isotopes…

Advantage and disadvantage

- For compilers:

  ELEM/MASS reduces workload of compilation and checking

- For evaluators:
  1. ELEM/MASS shortens the list of subentries.
  2. But cannot see the list of all possible combinations of (*Z*,*A*) of products in EXFOR.
  3. Current C4 does not include ELEM/MASS entries

Example of search result (NDS)

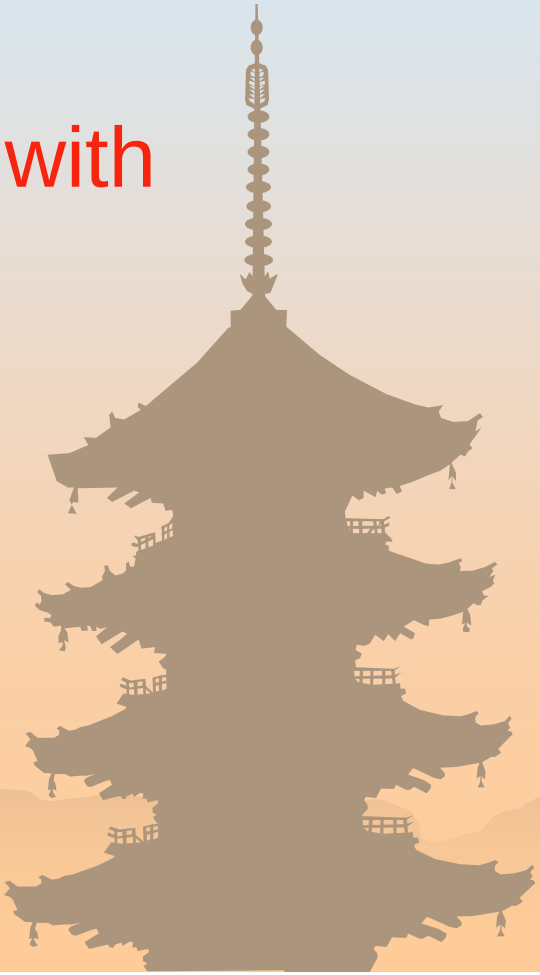
Isotopes from $^{208}Pb+^{1}H$ are listed in search result.

Only one line for all isotopes.
→ We must see EXFOR source to know the list of isotopes.

Request -1

Conversion of subentries with ELEM/MASS

to C4



Information of Partial Error

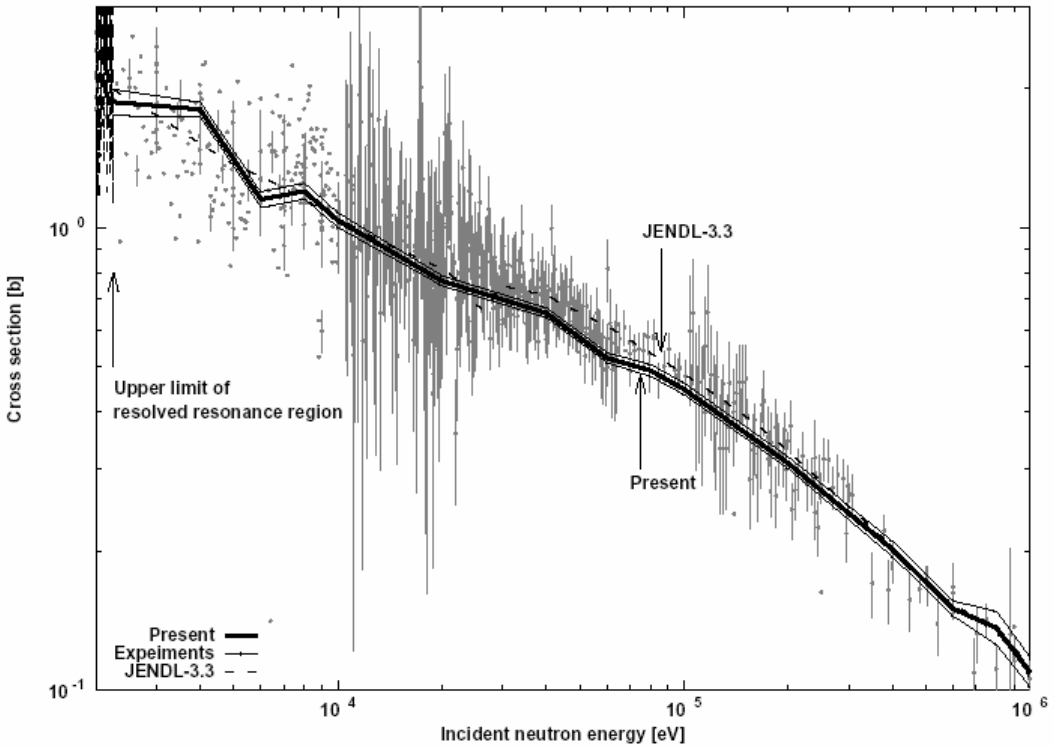
- Least-squares method:

  Useful when many data points are available at EXFOR (e.g., Fission / capture cross section above resolved resonance region)

Example: $^{235}U(n,\gamma)$ @ fast region)

- N. Otuka et al.,
  J. Nucl.Sci.Technol. 44(2007)815
  analyzed by GMA

- Join SG**29** if you are interested in ^{235}U capture cross section problem



Input for least-squares method

- $\boldsymbol{x}=(C^t V^{-1} C)^{-1} C^t V^{-1} \boldsymbol{y}$

  $\boldsymbol{x}$: least-squares solution vector (evaluated data)

  $\boldsymbol{y}$: experimental data vector (DATA in EXFOR)

  V: covariance matrix of experimental data

  $$V_{ij} = \delta_{ij} \Delta_{\mathrm{sta}}(E_i) \Delta_{\mathrm{sta}}(E_j) + \sum_k \Delta^k_{\mathrm{sys}}(E_i) \Delta^k_{\mathrm{sys}}(E_j) c^k_{ij}$$

  (c^k_{ij} =1 is often assumed – long range correlation)

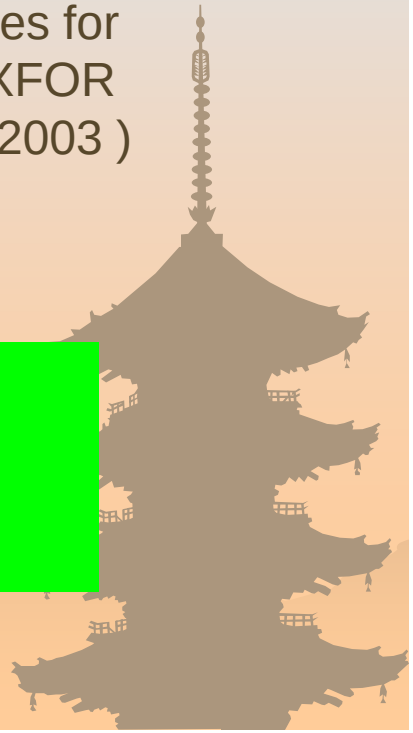
  Separation of statistical (random) and systematic (correlated) error is essential, but not implemented in the C4 format.

Request to X4 compilers

… This requires that all partial components contributing to the total error and their correlative properties (if they are provided by the authors) should be compiled. These partial components (if they vary with energy) should be given at each data point.

(V. Pronyaev: Introduction to the workshop “Relational Databases for Nuclear Data Development, Dissemination and Processing: EXFOR Implementation, Maintenance and Compilation”, December 1, 2003)

Request to compilers:
DATA-ERR →ERR-T, ERR-S, ERR-SYS,…
if detailed information is available



Old entries must be improved…

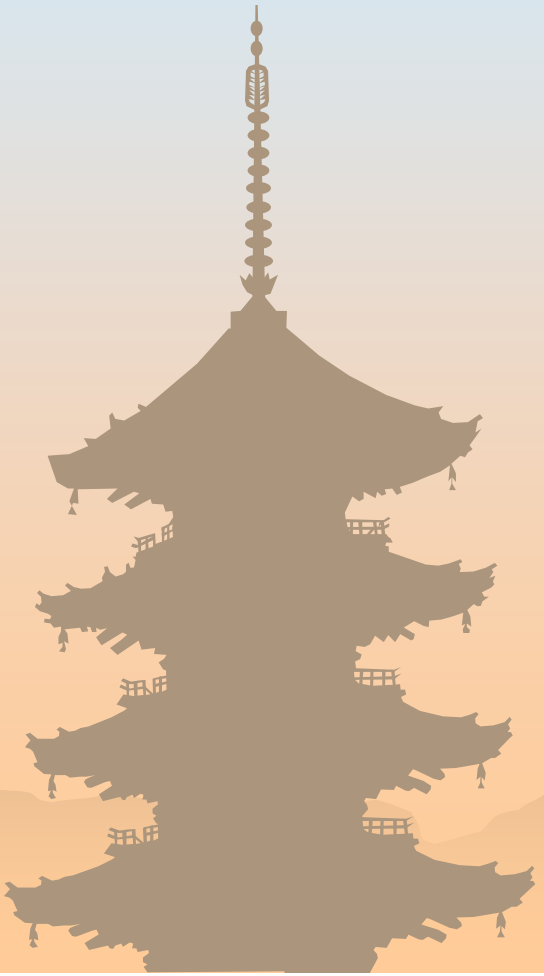
```
SUBENT        12316010     860512
BIB                  6         24
REACTION   (92-U-235(N,F),,SIG)
DETECTOR   (IOCH) PARALLEL PLATE IONIZATION CHAMBER.
MONITOR    (1-H-1(N,EL)1-H-1,,SIG)
CORRECTION CORRECTED FOR D(D,NP)D NEUTRONS IN THE ENERGY RANGE
            BETWEEN 8 AND 10 MEV.
ERR-ANALYS (DATA-ERR1)STATISTICAL UNCERTAINTY.
           (DATA-ERR2) TO THE STATISTICAL UNCERTAINTY ALSO ADD
             - 30 PERCENT UNCERTAINTY DUE TO SCATTERING CORRECTION
             - 30 PERCENT UNCERTAINTY IN SECOND-GROUP NEUTRON
…
HISTORY    (800331C) REVISED DATA RECEIVED FROM G.E.HANSEN, 80/2.
           (860512A) ERROR UNITS CORRECTED.
ENDBIB              24
NOCOMMON             0          0
DATA                 4         27
EN         DATA       DATA-ERR1  DATA-ERR2
MEV        B          PER-CENT   PER-CENT
   2.22       1.301      0.021+02 .060   +02
   2.50       1.250      0.006+02 .057   +02
   3.00       1.192      0.006+02 .055   +02
   4.00       1.128      0.013+02 .054   +02
   5.00       1.078      0.015+02 .051   +02
   5.46       1.083      0.007+02 .049   +02
   6.00       1.101      0.009+02 .049   +02
   6.41       1.278      0.011+02 .048   +02
```

DATA-ERR1
must be ERR-S
DATA-ERR2
must be ERR-SYS

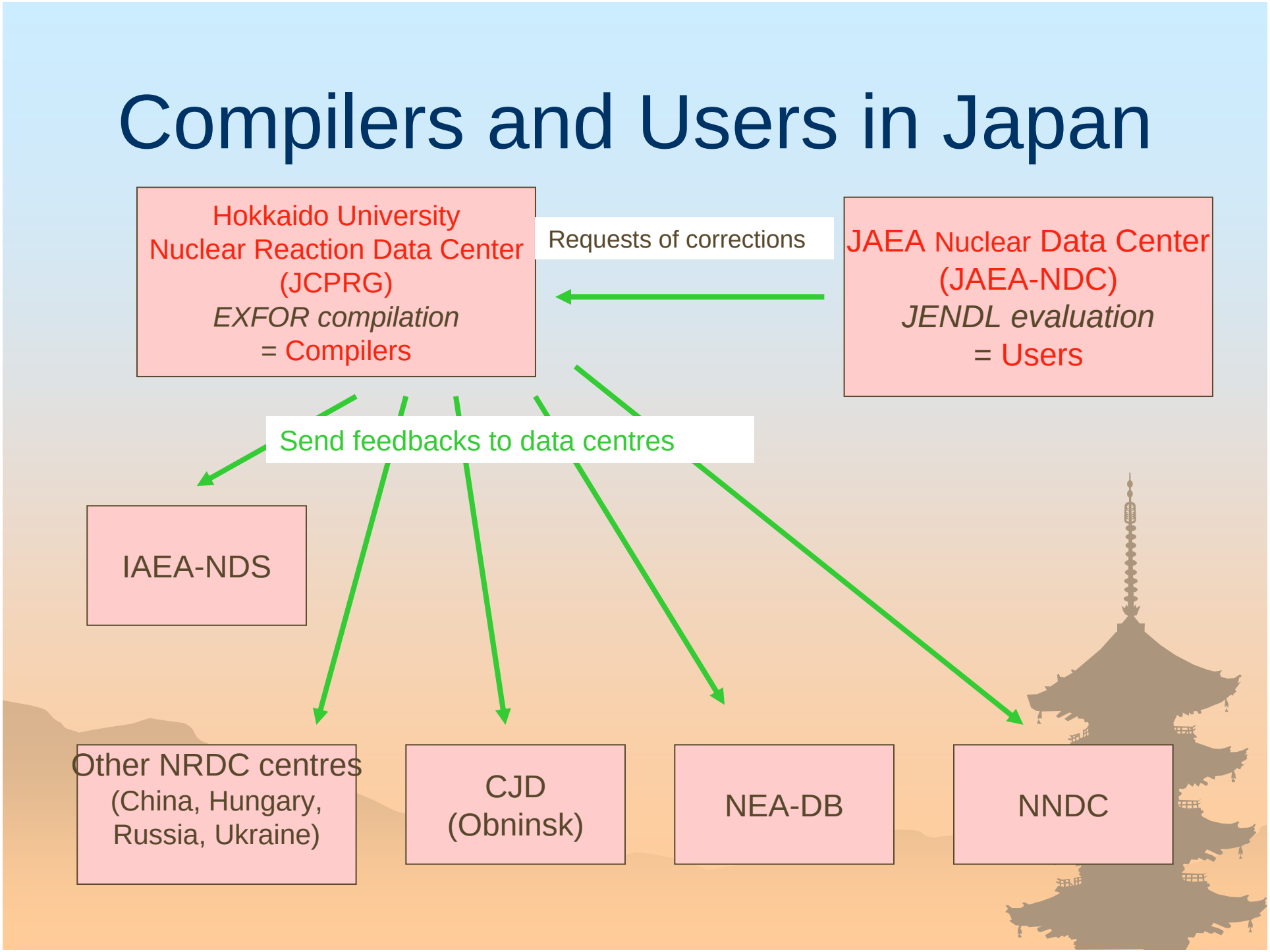
Proposal to C4 (2)

Conversion of partial errors to C4

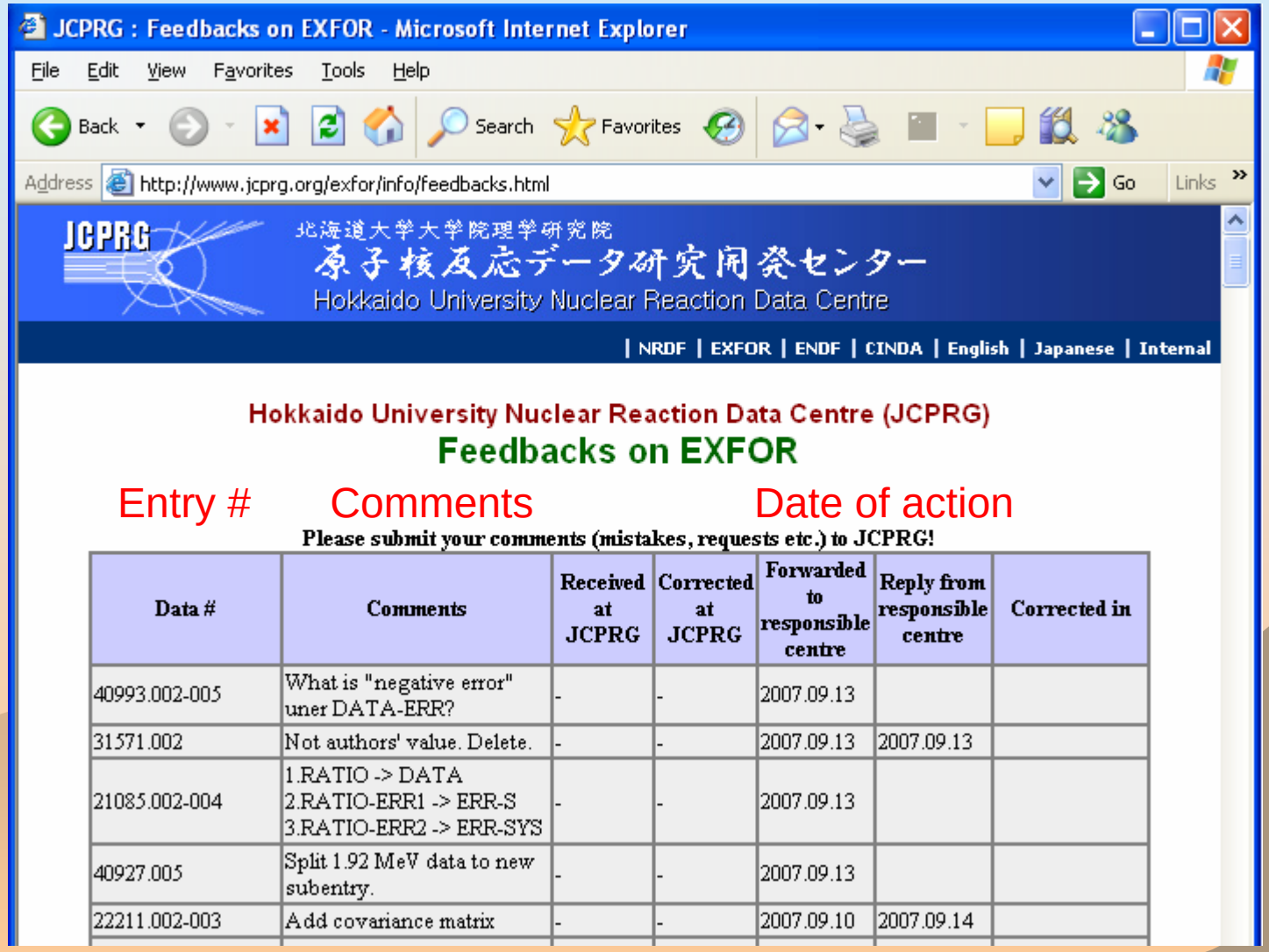
3. Feedbacks from Japanese users



Compilers and Users in Japan



List of Feedbacks at JCPRG



Data #	Comments	Received at JCPRG	Corrected at JCPRG	Forwarded to responsible centre	Reply from responsible centre	Corrected in
40993.002-005	What is "negative error" uner DATA-ERR?	-	-	2007.09.13		
31571.002	Not authors' value. Delete.	-	-	2007.09.13	2007.09.13	
21085.002-004	1.RATIO -> DATA 2.RATIO-ERR1 -> ERR-S 3.RATIO-ERR2 -> ERR-SYS	-	-	2007.09.13		
40927.005	Split 1.92 MeV data to new subentry.	-	-	2007.09.13		
22211.002-003	Add covariance matrix	-	-	2007.09.10	2007.09.14	

Summary

- We have mutual communication between compilation centre (JCPRG) and evaluation centre (JAEA-NDC).

- Conversion from X4 to C4 is requested by Japanese evaluators (e.g. ELEM/MASS formalism and partial errors).