
Brookhaven
National Laboratory
U.S. DEPARTMENT OF
ENERGY
FY activities at BNL
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J. Henry, N. Joseph, P. De-Sosoo
@BrookhavenLab
Not Export Controlled
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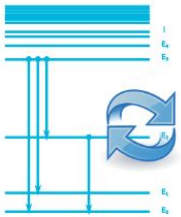
Compilation of FYs

- Fission product yields compilation
- Isomeric yield ratios compilation / evaluation
- FYdb interface
- Revisiting E_n

Fission Yield Compilation

NUCLEAR SCIENCE REFERENCES

The NSR database is used as the starting point of the compilation to collect bib information on all experiments measuring Fission Yields.



UPDATED NUCLEAR DATA

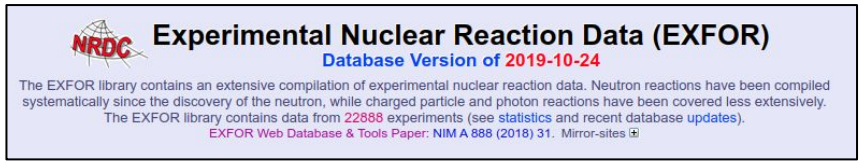
All experimental data that used decay data have been updated to reflect the most current values available

FY-JSON: A NEW WORKING FORMAT FOR FISSION YIELDS

V. Zerkin developed an EXFOR-to-JSON conversion tool (online). We developed a working format based on this

A working format for experimental FY data

- Adapting the format of experimental files to the needs of FY compilation (simpler, lighter, more intuitive)
- Make it easier to access, plot, verify and update experimental values currently stored in EXFOR
- Standardized units & uncertainties



V. Zerkin

Brookhaven National Laboratory

National Nuclear Data Center

Not Export Controlled

A new working format for FY data

FY-JSON: A NEW WORKING FORMAT FOR FISSION YIELDS

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```
    "author1": "H.N.Erten+",
    "reaction": "98-CF-252(0,F)ELEM/MASS,CUM,FY",
    "dataType": "CUM_FY",
    "dataUnits": "PART/FIS",
    "incEnergy": 0.0,
    "NSR": [
        "1978ER01"
    ],
    "flags": [
        "DD",
        "DDC"
    ],
    "history": [
        {
            "date": "2024-06-12T13:43:40.000Z",
            "event": "created from file X4full.json. Format = JSON.FY-0.1.5"
        },
        {
            "date": "2024-09-04T12:51:45.468430Z",
            "event": "Filled decay intensity from NDS 103, 1 (2004)"
        },
        {
            "date": "2024-09-04T12:51:46.661236Z",
            "event": "FY corrected using new Decay Data -- factor = 2.5031"
        }
    ],
    "Z": 52,
    "A": 134,
    "Nucl": "Te-134",
    "Data": 0.0776,
    "dData": 0.01,
    "t12sec": 2520.0,
    "Rad.Type": "DG",
    "Rad.Energy": 79.0,
    "Rad.Intensity": 0.53,
    "correction": {
        "decayPath": "/home/andrea/Documents/BNL/ENSDF/NuDat/decays/134TE BM DECAY.json",
        "bib": "NDS 103, 1 (2004)",
```

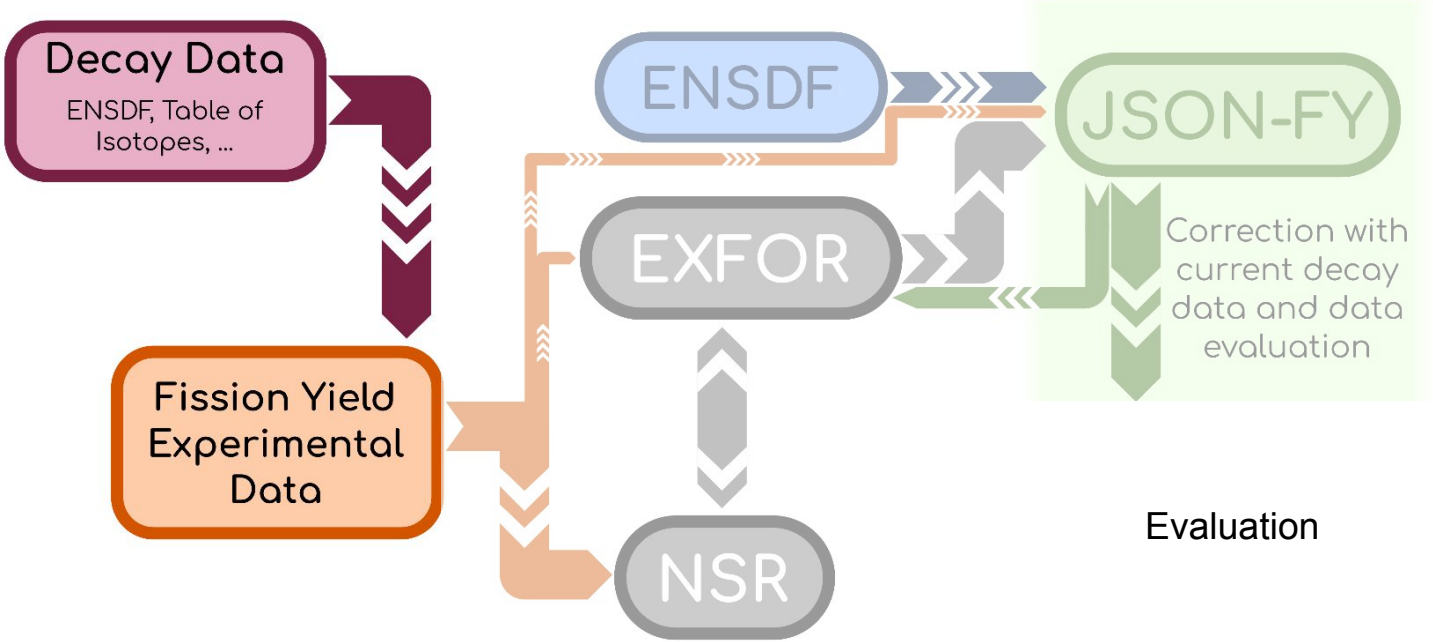

1. Simpler data:
   a. less information! (not a substitute for EXFOR)
   b. uniform units & uncertainties
   c. uniform nuclide ID
   d. decay data easier to access
2. modern *DB-ready* format
3. can store additional information
4. keeps history of changes

JSON_FY python package

- reads and cleans JSON from EXFOR
- implements checks and corrections:
  - values (outliers / wrong units)
  - uncertainties (too low / not reported / …)
  - corrections for decay data
- produce plots to study, check and correct data

```
106
107     def read_X4(self,filename):
108         with open(filename) as f:
109             self.jData = json.load(f)
110
111         self.format = self.jData["format"]
112         self.date = self.jData["now"]
113         pandasDict = []
114         jj = 0
115
116         for i in self.jData["datasets"]:
117
118             if i["type"] != "FYdata":
119                 continue
120             id = i["entry"]["id"]
121             idd = i["subent"]["id"]
122             author1 = i["author1"]
123             year = i["year"]
124             reaction = i["reaction"]["code"]
125             proj = i["reaction"]["Proj"]
126             target = i["reaction"]["Target"]
127             #reactionType = i["reaction"]["ReactionType"]
128             #dataType = i["reaction"]["DataType"]
129             NSR = getNSR(id,filename[:-5]+"_X42NSR.json",True)
130             if not NSR:
131                 NSR = []
132             #NSRstr = ", ".join(NSR)
133
134             for Ene in i["incEnergies"]:
135                 incEnergy = Ene["incEnergy"]
136                 data = Ene["Data"]
```

Modern tools to update old data



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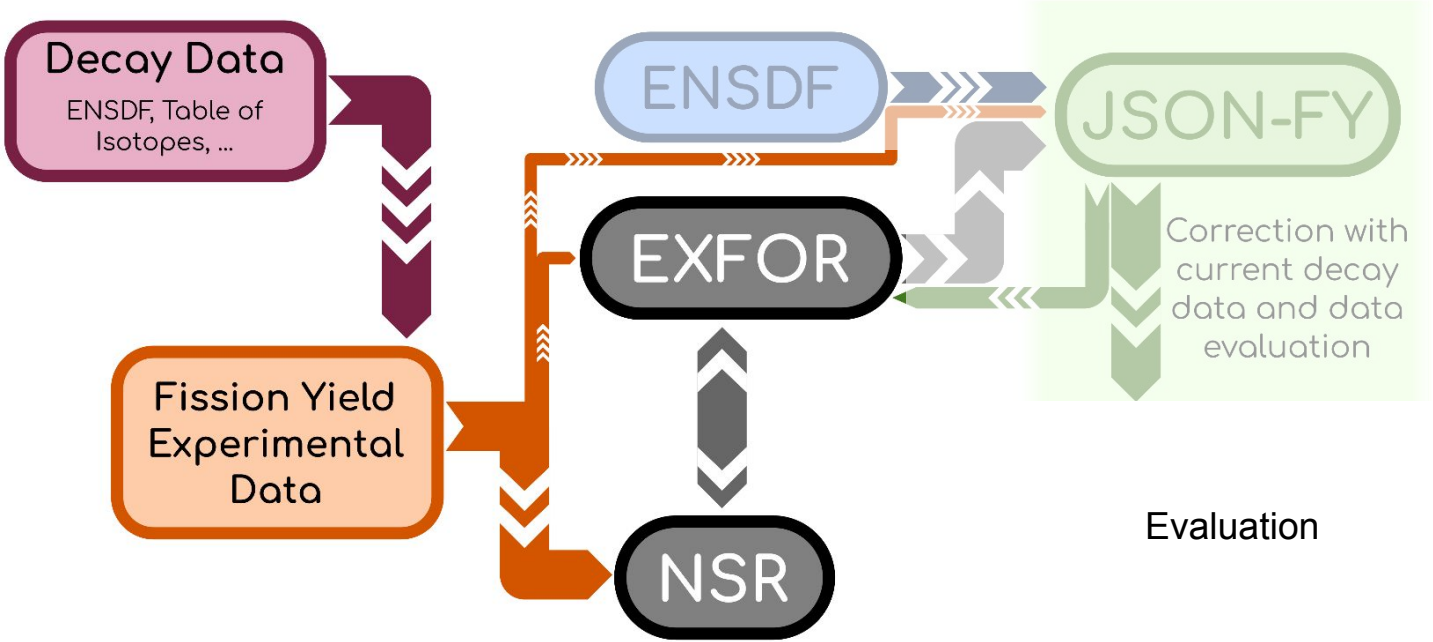

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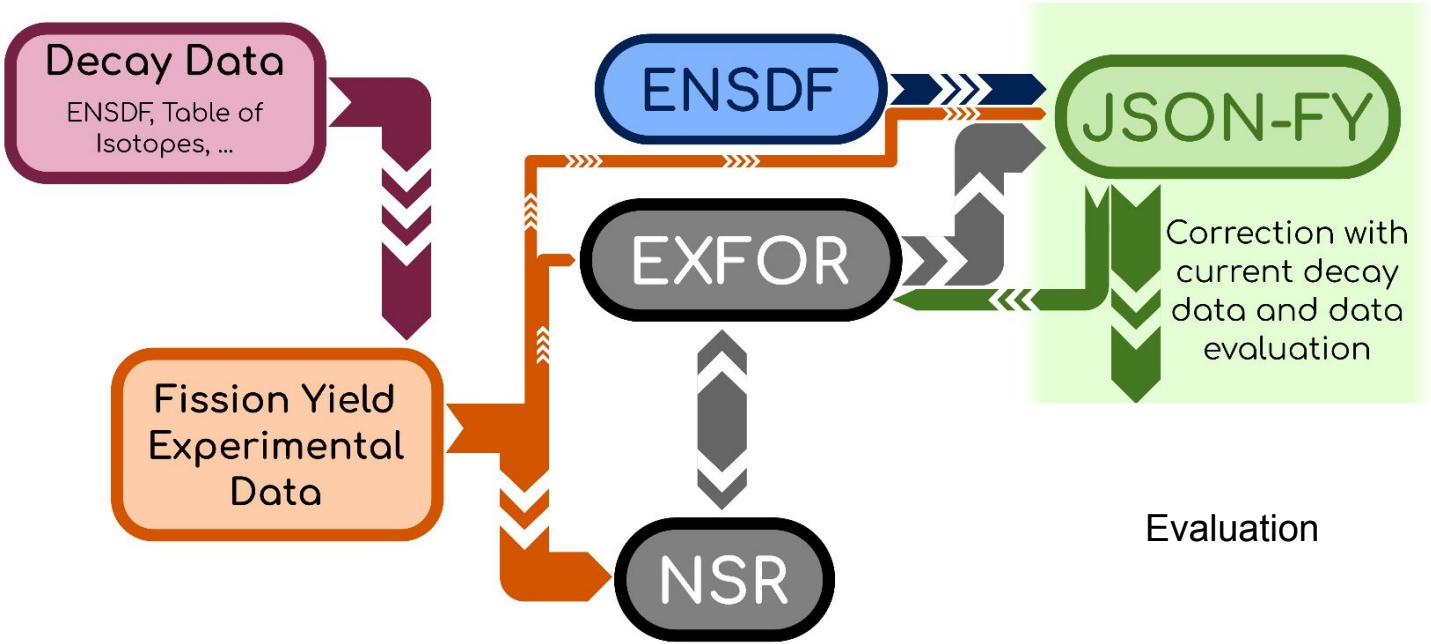


Decay data corrections

X4

ORIGINAL PAPER

Fill JSON_FY class with decay data from NuDat

```
def fillDecay(self):
    import correctFY
    if not hasAttr(self,"Json"):
        print("The JSON file is not filled yet.\nRun readJson(<FileName>) to import data from the file <FileName>")
        return -1
    countPaths = 0
    countNAN = 0
    for i in self.Json:
        if "flags" not in i:
            i["flags"] = []
        path = self._getPath(i)
        if not path:
            continue
        if not "correction" in i:
            i["correction"] = {}
        i["correction"]["decayPath"] = path
        countPaths += 1
        print("reading decay from path = "+path)
        decayTMP = correctFY.getDecayJson(path)
        i["correction"]["bib"] = decayTMP["citation"]
        t12_txt = decayTMP["parents"][0]["level"]["halflife"]["value"]
        t12_unit = decayTMP["parents"][0]["level"]["halflife"]["unit"]
        t12_new = correctFY.toSeconds(float(t12_txt),t12_unit)
        i["correction"]["t12_new"] = t12_new

        try:
            a,b,c = correctFY.getIntensity(decayTMP,i["Rad.Energy"])
        except ValueError:
```

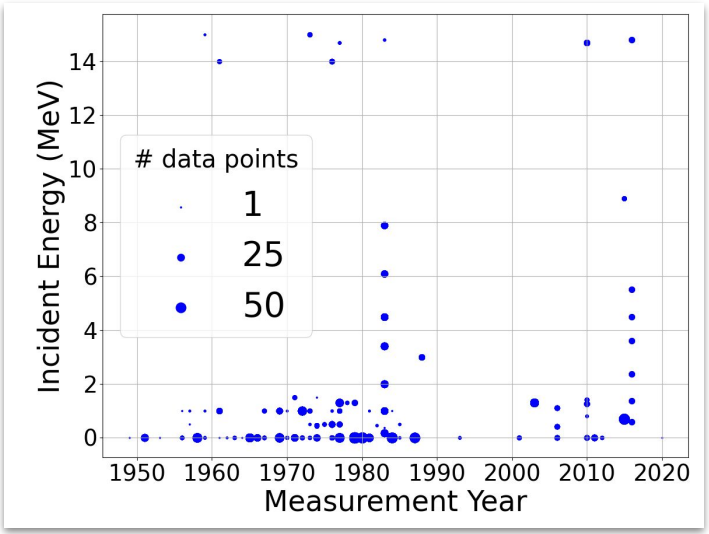
Correction of .json files -- ORG values and new decay data stored in the db entry

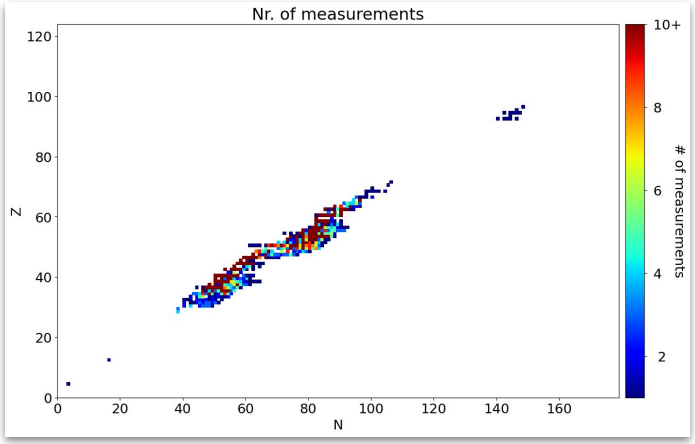
check that uncertainty on the FY is compatible with uncertainty on DD

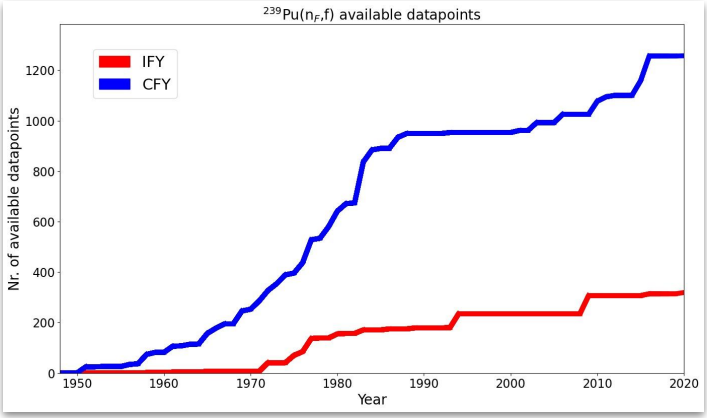
Create FY plots

WITH NO EXPLICIT MENTION OF THE NUCLEAR DATA VALUES IN THE ORIGINAL PAPER, IT IS ALMOST IMPOSSIBLE TO CORRECT AND USE RESULTS FROM DECADES-OLD PAPERS WITH THEIR REPORTED UNCERTAINTY

Data cleanup / annotation / flagging







Aggregate plots for the entire dataset

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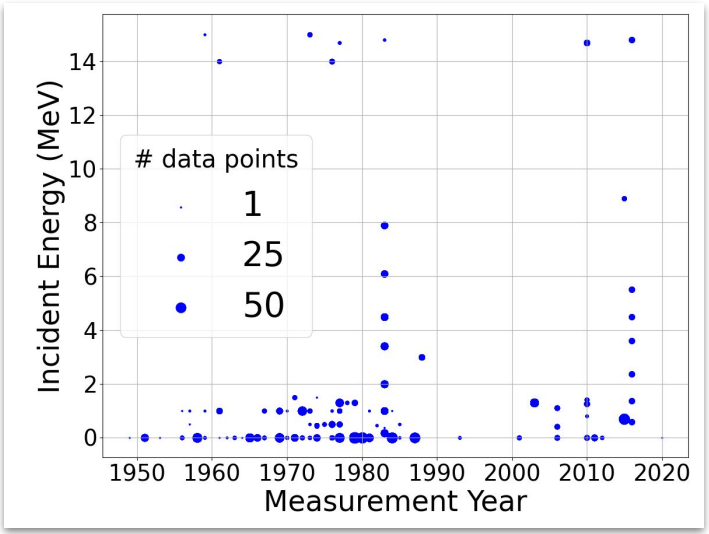
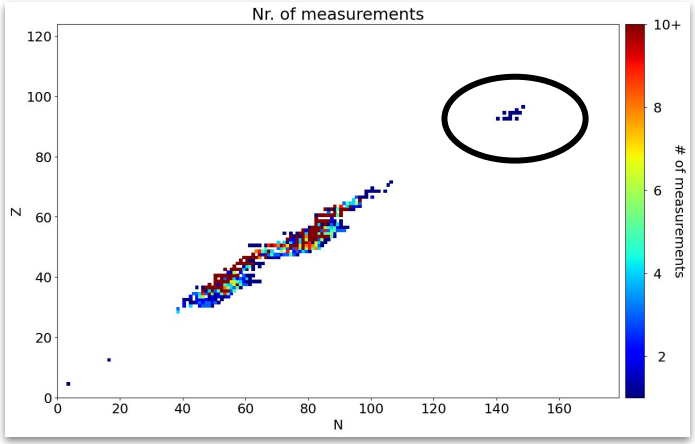
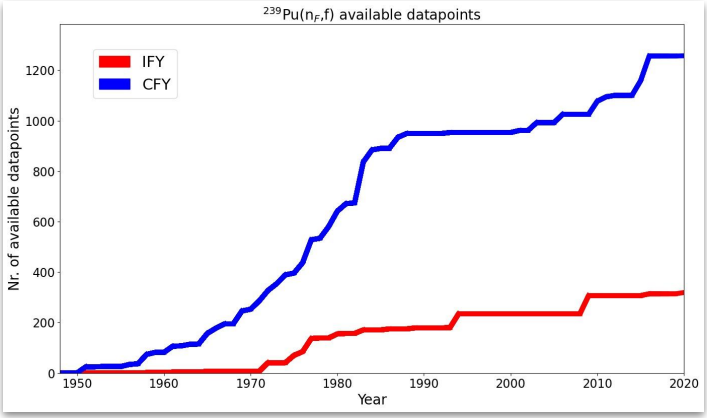
Data cleanup / annotation / flagging







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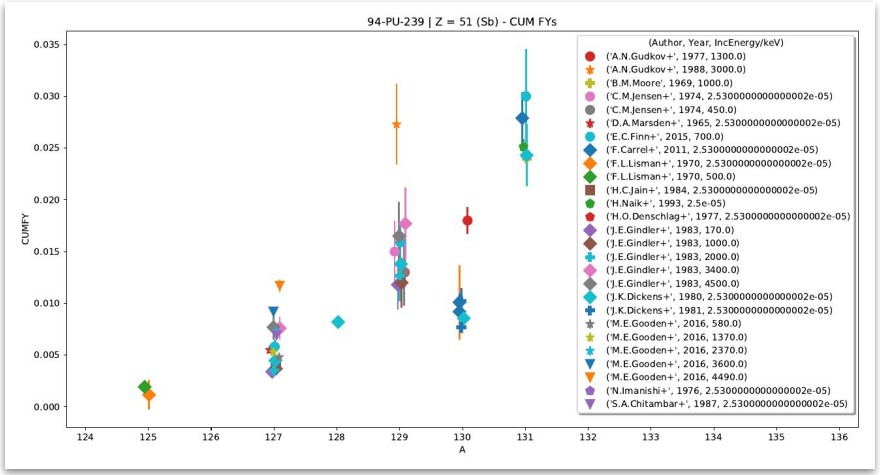
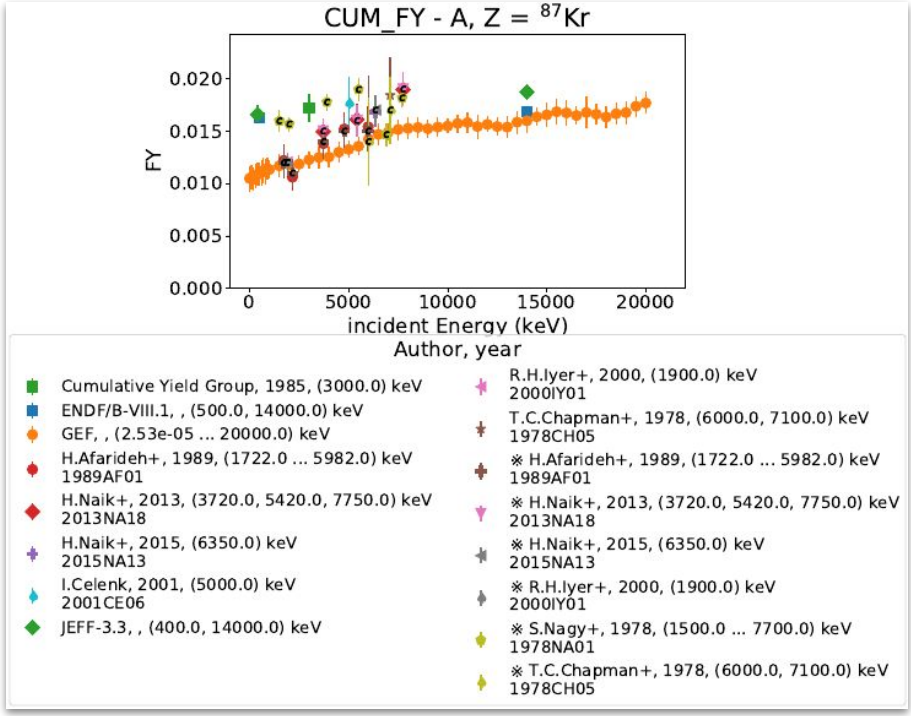


A distributions / Z distributions
FY as a function of incident energy



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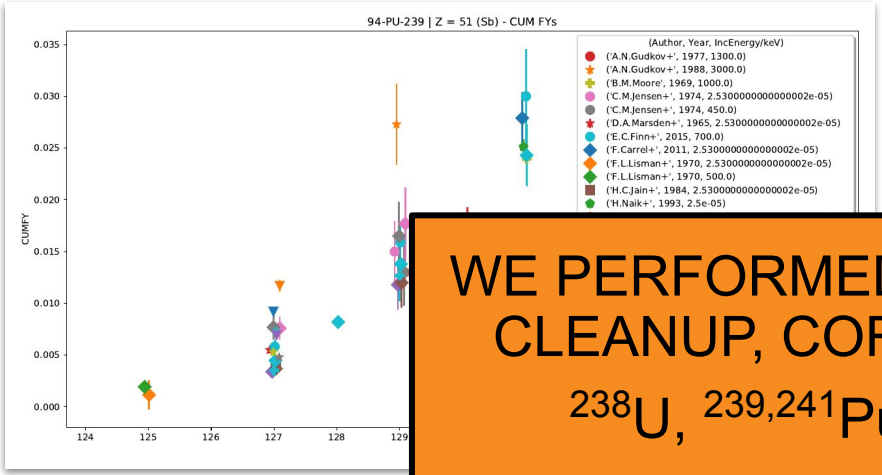

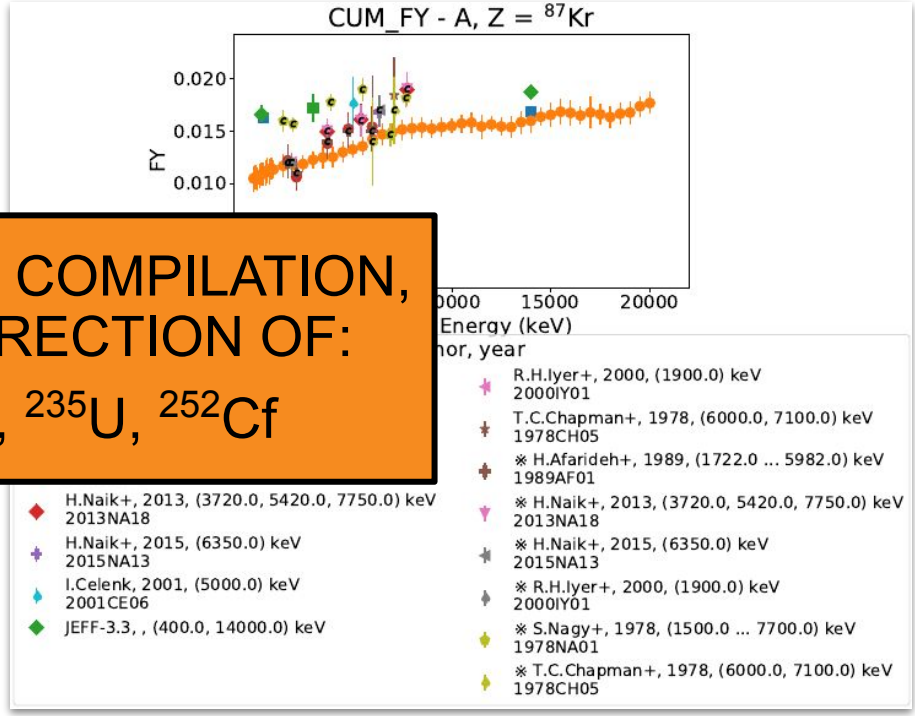

WE PERFORMED COMPILATION, CLEANUP, CORRECTION OF:

^{238}U, $^{239,241}Pu$, ^{235}U, ^{252}Cf

A distributions / Z distributions

FY as a function of incident energy

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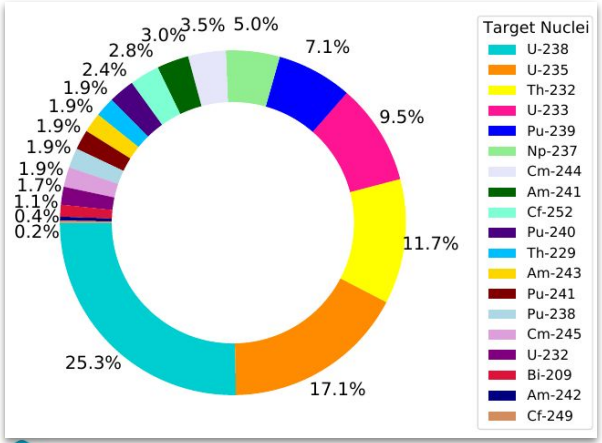
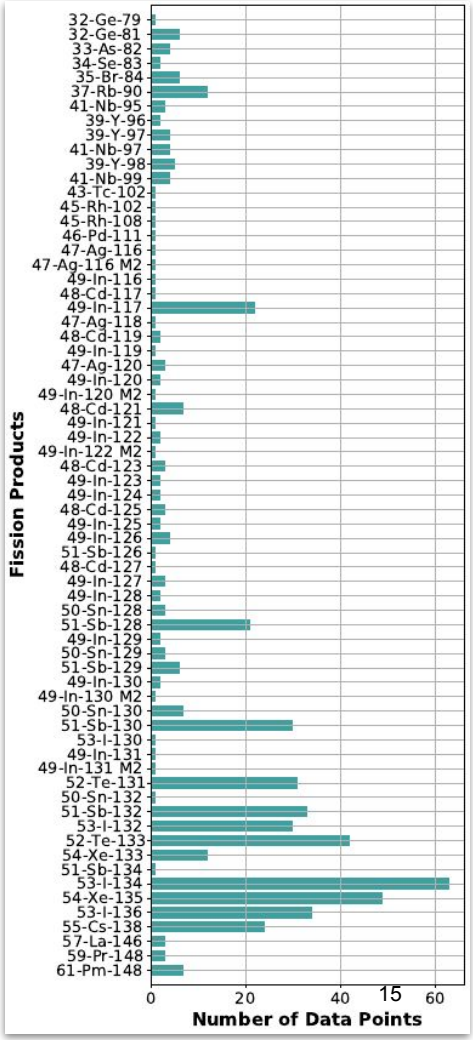
Evaluation of Isomeric Yield Ratios

We retrieved and compiled 538 independent isomeric yield ratios, from 39 compound nuclei, and 62 unique fission products.

5x the amount of data available to Madland & England when they developed the model



Wealth of new data can be used to benchmark new models for the prediction of IYRs



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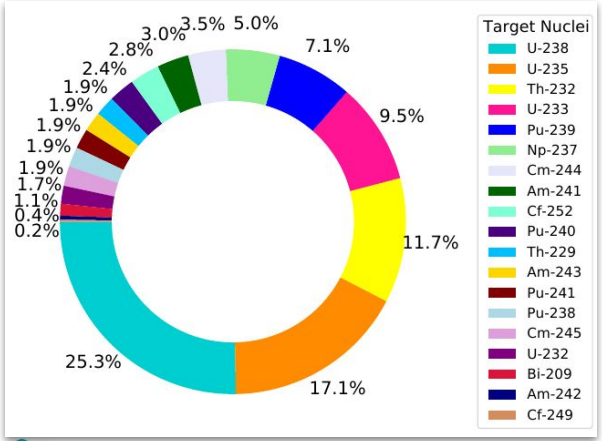

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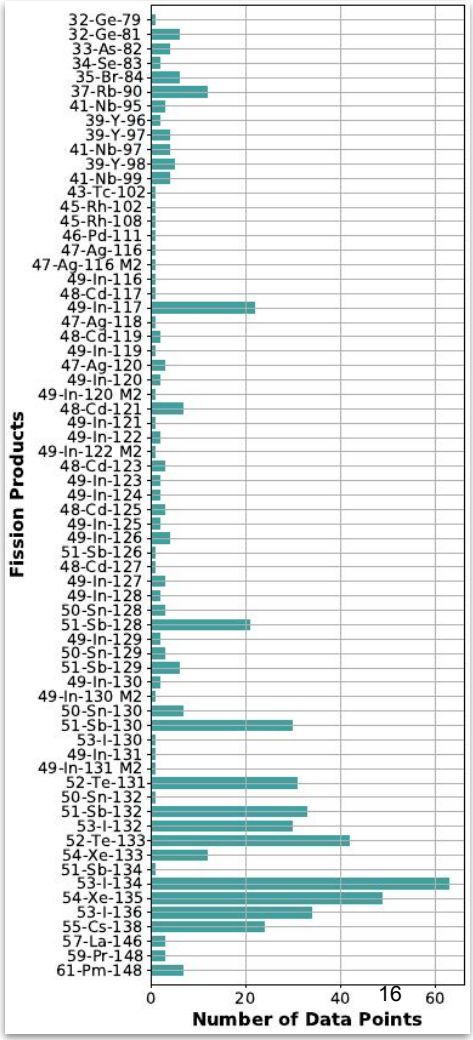
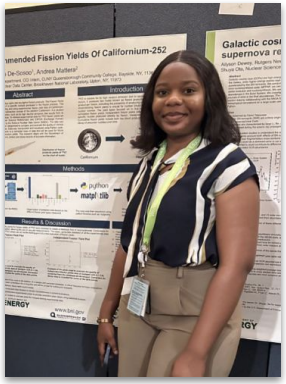
Wealth of new data can be used to benchmark new models for the prediction of IYRs

studying how IYR impact antineutrino spectra

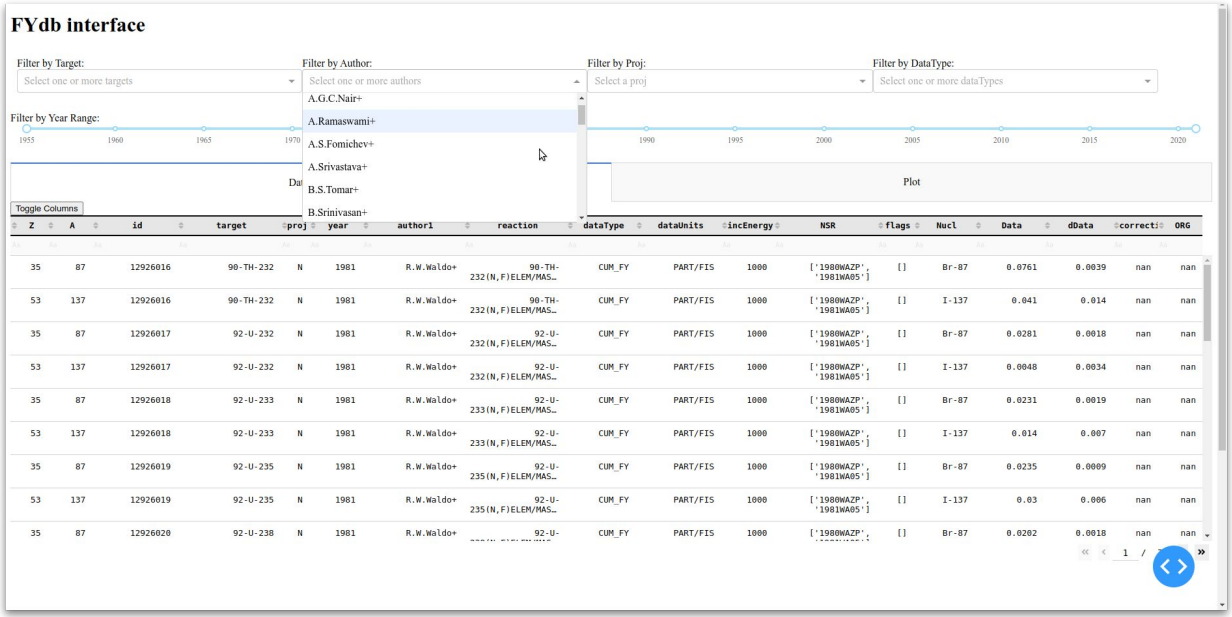


FYdb dashboard

- upload compiled data to NNDC gitlab
- develop a dashboard to access, visualize and edit the FYdb



Pedrocia De-Sosoo



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Revisiting E_n

Tabulated data

Table 1. ^{238}U(n,f) Fission Yields. E_n=[0-20] MeV

A	Z	Nuclide	Eγ keV	Data Type	Old FY	FY (nucl. per fission)	Old dFY	New dFY	Corr Factor	Author	Year	E_n MeV	Ref.
83	34	Se-83-G	356.6	CUM	2.600E-03	2.570E-03	1.300E-02	3.148E-05	0.988	S.Daroczy+	1976	14.4	[17]
83	35	Br-83	529.5	CUM	1.870E-03	1.870E-03	1.309E-04	1.309E-04	1.000	R.H.Iyer+	2000	1.9	[18]
84	33	As-84	1454.5	CUM	4.600E-03	4.600E-03	5.000E-04	4.238E-04	1.000	B.D.Pierson+	2017	14.3	[19]
84	35	Br-84	1616.2	CUM	7.430E-03	7.406E-03	9.800E-04	9.168E-04	0.997	H.Naik+	2013	3.7	[20]
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84	35	Br-84-G	881.5	CUM	7.671E-03	7.671E-03	5.792E-03	5.479E-04	1.000	T.C.Chapman+	1978	6.0	[21]
84	35	Br-84	1616.2	CUM	6.420E-03	6.399E-03	4.400E-04	4.386E-04	0.997	H.Naik+	2015	6.3	[22]
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compiled ^{238}U data -- we
alth of energy-dependent data

Brookhaven National Laboratory

Revisiting E_n

how do we get the En for non-thermal fission?

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compiled ^{238}U data -- we
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Rao and Iyer measured at the same facility, but reported energy is different

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84	35	Br-84	1616.2	CUM	7.430E-03	7.406E-03	9.800E-04	9.168E-04	0.997	H.Naik+	2013	7.8	[20]
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									0.997	H.Naik+	2015	8.5	[22]
									1.000	T.C.Chapman+	1978	9.1	[21]
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									0.997	H.Naik+	2013	10.1	[20]
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Brookhaven National Laboratory

Revisiting E_n

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ENDBIB              17
COMMON               2          3
EN-DUMMY   MONIT
MEV        PC/FIS
 1.0000E+00 6.2000E+00
ENDCOMMON           3
DATA                6         15
ELEMENT    MASS       DATA       DATA-ERR   DATA-MAX   FLAG
NO-DIM     NO-DIM     PC/FIS     PC/FIS     PC/FIS     NO-DIM
 2.8000E+01 6.6000E+01 4.0100E-06 1.6000E-06            1.0000E+00
 2.9000E+01 6.7000E+01 2.3200E-05 9.3000E-06            1.0000E+00
 3.0000E+01 7.2000E+01 6.5400E-05 2.5000E-05            1.0000E+00
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COMMON               2          3
EN-DUMMY   MONIT
MEV        PC/FIS
 1.0000E+00 6.2000E+00
ENDCOMMON           3
DATA                6         15
ELEMENT    MASS       DATA       DATA-ERR   DATA-MAX   FLAG
NO-DIM     NO-DIM     PC/FIS     PC/FIS     PC/FIS     NO-DIM
 2.8000E+01 6.6000E+01 4.0100E-06 1.6000E-06            1.0000E+00
 2.9000E+01 6.7000E+01 2.3200E-05 9.3000E-06            1.0000E+00
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```
ENDBIB              142
COMMON                3
EN-DUMMY    ERR-SYS     DATA-ERR
MEV         PER-CENT    PER-CENT
  1.          4.0         7.0
ENDCOMMON             3
ENDSUBENT           149
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DATA                 6         15
ELEMENT    MASS       DATA       DATA-ERR   DATA-MAX   FLAG
NO-DIM     NO-DIM     PC/FIS     PC/FIS     PC/FIS     NO-DIM
 2.8000E+01 6.6000E+01 4.0100E-06 1.6000E-06           1.0000E+00
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ENDBIB                142
COMMON                  3
EN-DUMMY    ERR-SYS     DATA-ERR
MEV         PER-CENT    PER-CENT
  1.          4.0         7.0
ENDCOMMON               3
ENDSUBENT             149
```

```
                (20080826A) SD,NO. Energy
                and in Subents 002-014 a
ENDBIB              149             0
COMMON                3             3
EN-DUMMY    ERR-SYS     DATA-ERR
MEV         PER-CENT    PER-CENT
  1.9         4.0         7.0
ENDCOMMON             3             0
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EN-DUMMY   MONIT
MEV        PC/FIS
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ENDCOMMON            3
DATA                 6         15
ELEMENT    MASS       DATA       DATA-ERR   DATA-MAX   FLAG
NO-DIM     NO-DIM     PC/FIS     PC/FIS     PC/FIS     NO-DIM
 2.8000E+01 6.6000E+01 4.0100E-06 1.6000E-06            1.0000E+00
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ENDCOMMON               3
ENDSUBENT             149
```

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                (20080826A) SD,NO. Energy
                and in Subents 002-014 a
ENDBIB                149             0
COMMON                  3             3
EN-DUMMY    ERR-SYS     DATA-ERR
MEV         PER-CENT    PER-CENT
  1.9         4.0         7.0
ENDCOMMON               3             0
                Subent 008 was deleted.
(20210923A) VS. EN-DUMMY=1.9 MeV -> EN-MIN=0.5 eV and
        SF8:FIS->EPI and ERR-S -> DARA-ERR in 002-014;
 ERR-ANALYS corrected and moved from 001 to 002-008
 and added in 009-014.
```

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 2.8000E+01 6.6000E+01 4.0100E-06 1.6000E-06           1.0000E+00
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83	34	Se-83-G	356.6	CUM	2.600E-03	2.570E-03	1.300E-02	3.148E-05	0.988	S.Daroczy+	1976	14.4	[17]
83	35	Br-83	529.5	CUM	1.870E-03	1.870E-03	1.309E-04	1.309E-04	1.000	R.H.Iyer+	2000	1.9	[18]
84	33	As-84	1454.5	CUM	4.600E-03	4.600E-03	5.000E-04	4.238E-04	1.000	B.D.Pierson+	2017	14.3	[19]
84	35	Br-84	1616.2	CUM	7.430E-03	7.406E-03	9.800E-04	9.168E-04	0.997	H.Naik+	2013	3.7	[20]
84	35	Br-84	1616.2	CUM	7.430E-03	7.406E-03	9.800E-04	9.168E-04	0.997	H.Naik+	2013	5.4	[20]
84	35	Br-84-G	881.5	CUM	7.671E-03	7.671E-03	5.792E-03	5.479E-04	1.000	T.C.Chapman+	1978	6.0	[21]
84	35	Br-84	1616.2	CUM	6.420E-03	6.399E-03	4.400E-04	4.386E-04	0.997	H.Naik+	2015	6.3	[22]
84	35	Br-84	881.5	CUM	1.070E-02	1.070E-02	5.662E-03	7.643E-04	1.000	T.C.Chapman+	1978	7.1	[21]
84	35	Br-84	1616.2	CUM	7.430E-03	7.406E-03	9.800E-04	9.168E-04	0.997	H.Naik+	2013	7.8	[20]
84	35	Br-84	881.5	CUM	1.070E-02	1.070E-02	5.662E-03	7.643E-04	1.000	T.C.Chapman+	1978	8.1	[21]
									0.997	H.Naik+	2015	8.5	[22]
									1.000	T.C.Chapman+	1978	9.1	[21]
									0.997	H.Naik+	2015	9.3	[22]
									0.997	H.Naik+	2013	10.1	[20]
									0.997	H.Naik+	2015	12.5	[22]
									1.040	Chien Chung+	1987	1.0	[23]
									1.048	H.Afarideh+	1989	1.7	[16]

V.K.Rao+	1974	1	[16]
V.K.Rao+	1974	1	[16]
S.Daroczy+	1976	14.4	[17]
R.H.Iyer+	2000	1.9	[18]

J data -- we
alth of energy-dependent data

```
ENDBIB                142
COMMON                  3
EN-DUMMY    ERR-SYS     DATA-ERR
MEV         PER-CENT    PER-CENT
  1.          4.0         7.0
ENDCOMMON               3
ENDSUBENT             149
```

```
                (20080826A) SD,NO. Energy
                and in Subents 002-014 a
ENDBIB                149             0
COMMON                  3             3
EN-DUMMY    ERR-SYS     DATA-ERR
MEV         PER-CENT    PER-CENT
  1.9         4.0         7.0
ENDCOMMON               3             0
                Subent 008 was deleted.
(20210923A) VS. EN-DUMMY=1.9 MeV -> EN-MIN=0.5 eV and
     SF8:FIS->EPI and ERR-S -> DARA-ERR in 002-014;
 ERR-ANALYS corrected and moved from 001 to 002-008
 and added in 009-014.
```

```
          (2.) Same data as in phys.rev. C9,1506, but uncertain-
               ty reduced to 20pc.
STATUS    Data taken from table 1 of Phys.Rev. C19,1372.
ERR-ANALYS In view of the higher activities of the products 73Ga,
          77As,161Tb, 167Ho, the uncertainties for these yields
          are estimated to be =20pc. The other yields are
          assigned an uncertainty of 40pc.
ENDBIB              17
COMMON               2          3
EN-DUMMY   MONIT
MEV        PC/FIS
 1.0000E+00 6.2000E+00
ENDCOMMON           3
DATA                6         15
ELEMENT    MASS       DATA       DATA-ERR   DATA-MAX   FLAG
NO-DIM     NO-DIM     PC/FIS     PC/FIS     PC/FIS     NO-DIM
 2.8000E+01 6.6000E+01 4.0100E-06 1.6000E-06           1.0000E+00
 2.9000E+01 6.7000E+01 2.3200E-05 9.3000E-06           1.0000E+00
 3.0000E+01 7.2000E+01 6.5400E-05 2.5000E-05           1.0000E+00
```

EN-DUMMY

checking all EN-DUMMY in EXFOR FYs, group by facility and include the energy spectrum and an average energy as En

Summary

- compilation of Fission Yields for ^{238}U $^{239,241}Pu$, ^{235}U, ^{252}Cf
- API / editor to interact with database
- Studying the En for EXFOR / FYdb compiled data
- bypass EXFOR-JSON step through implementation of FY data in x4i