Nuclear data libraries up to 600 MeV? (WP4)

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Introduction

- For high-energy applications, intranuclear cascade codes take over from data libraries at some energy:
  - Up to year 1998: 20 MeV
  - After 1998: 150 MeV (LA-150=ENDFB/VII) or 200 MeV (JEFF, TENDL)
  - The combination data libraries + INC codes is then used in codes like MCNPX
- Some medical applications require data up to 250 MeV
- MYHRRA requires data up to 600 MeV
- Can we provide these customers more than 1 choice? (after which they can choose the best)
- Investigate possibility of nuclear data libraries up to 600 MeV

Comparison

Libraries:

- Can in principle take into account the best of all worlds, i.e. experimental data and (one or more) theoretical models
- Can take into account uncertainties (i.e. our limitations in knowing the true cross section)
- Are well-defined sets of numbers (e.g. JEFF-3.1.2) which can be used in many different codes

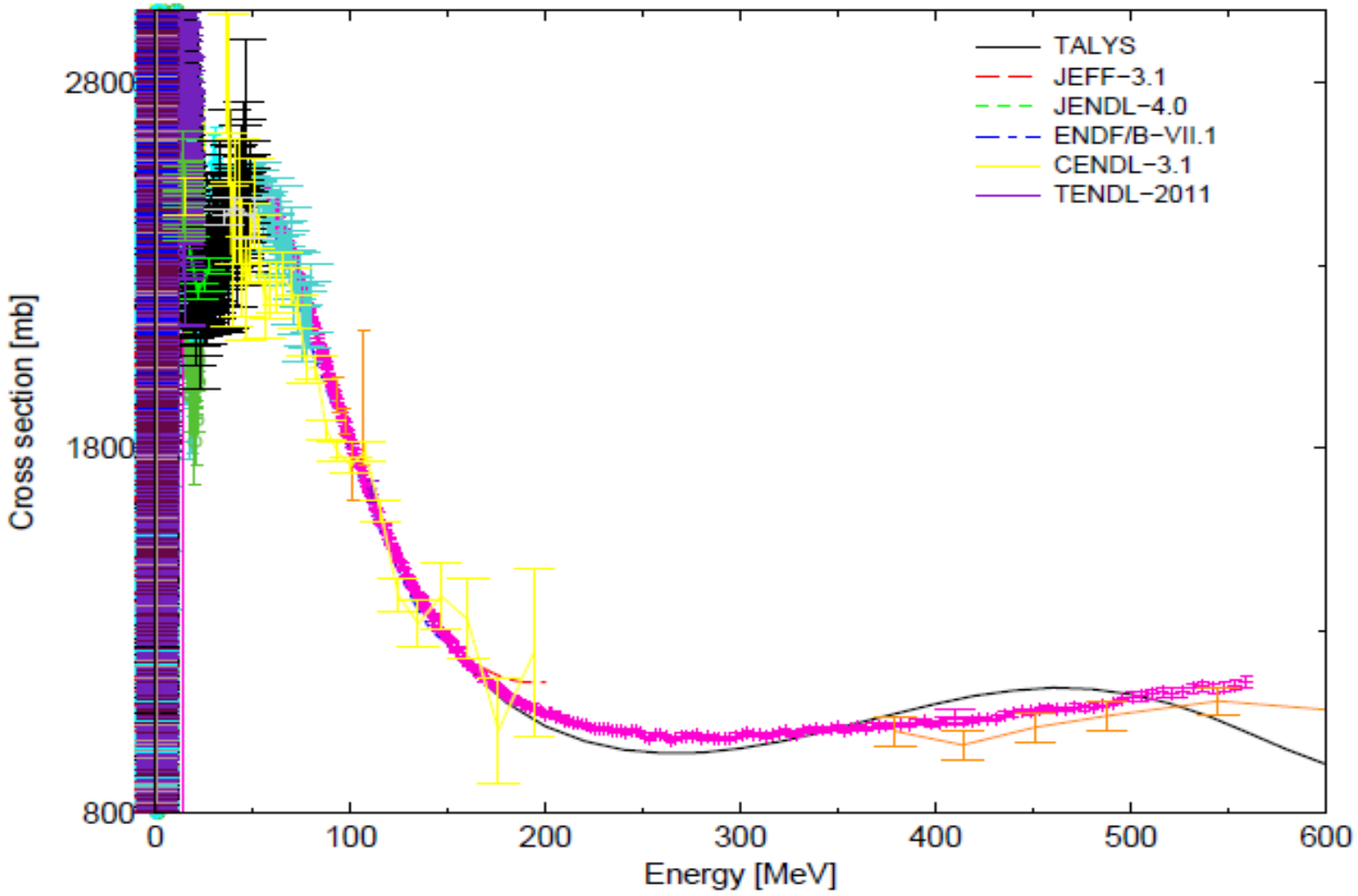
INC codes:

- Take into account every possible secondary energy, angle, etc. from any reaction product (including recoils)
- Include correlations
- Do not require processing steps, generate data on the fly

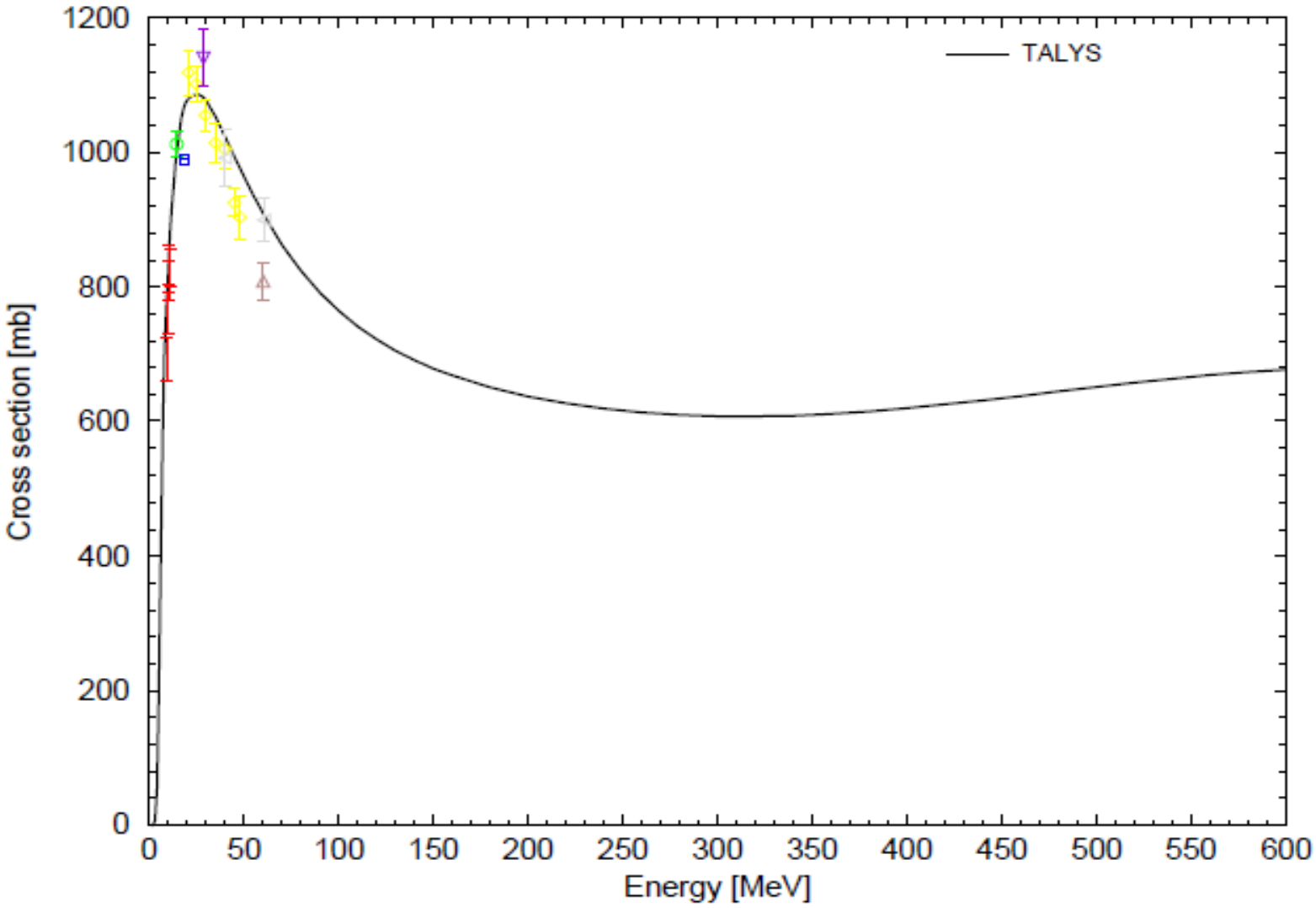
TALYS up to 600 MeV?

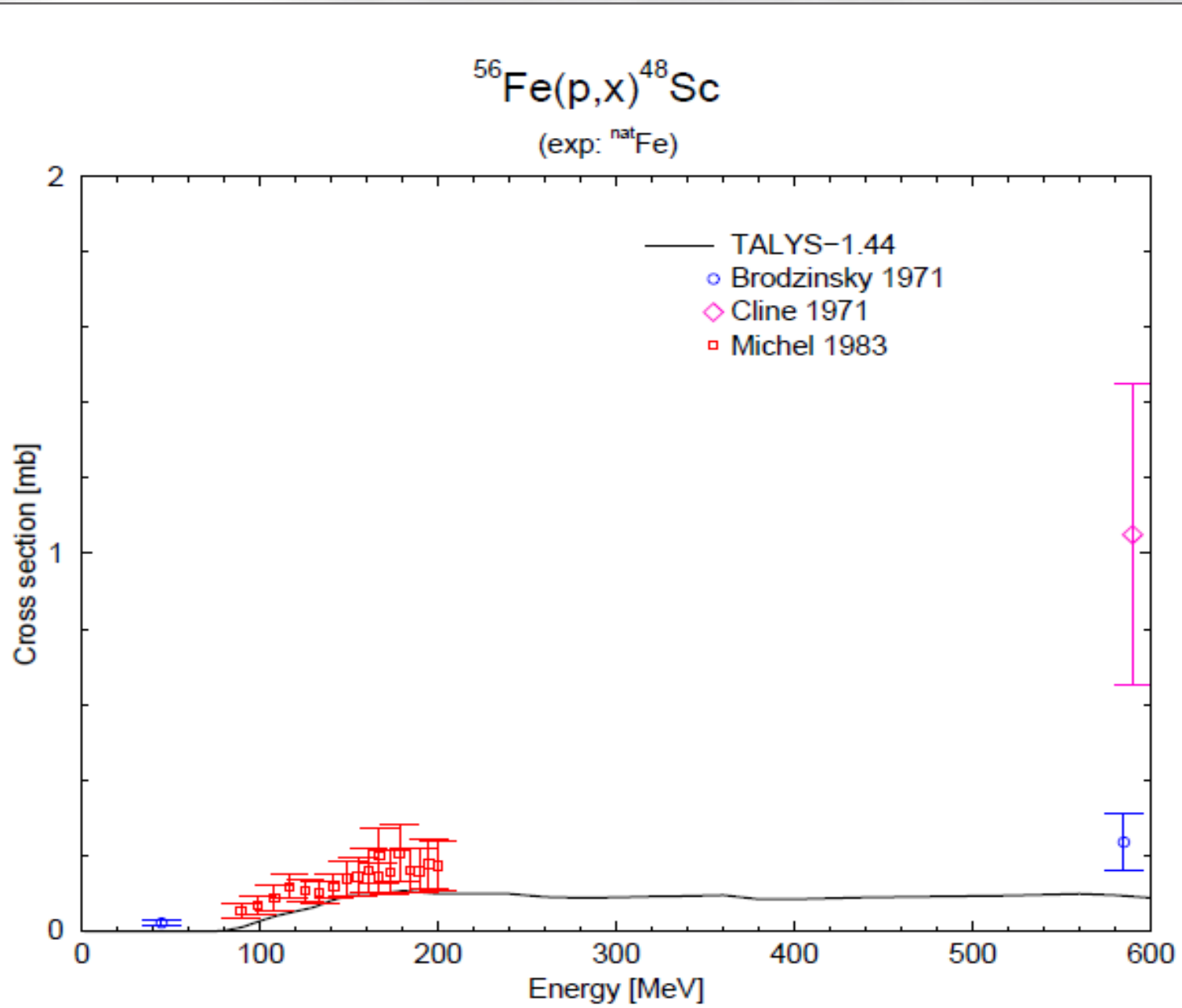
- Koning-Delaroche OMP (E < 200 MeV) can be extended up to 600 MeV (so far only tested for total and reaction cross sections) using additional terms for V and Wv
- Logarithmic excitation energy binning introduced in TALYS: equal (or even larger!) precision in the few MeV neutron range while maintaining good precision at high energies
- Multiple pre-equilibrium emission (the particle-hole phase-space equivalent of (x,t) coordinates in INC codes) was already taken into account up to any order.
- Quality of pre-equilibrium matrix element above 200 MeV is unknown.
- Kalbach systematics for angular distributions (1988) is supposed to work up to 600 MeV.
- Penalty for omitting pions still small (?)
- Let's give it a try.

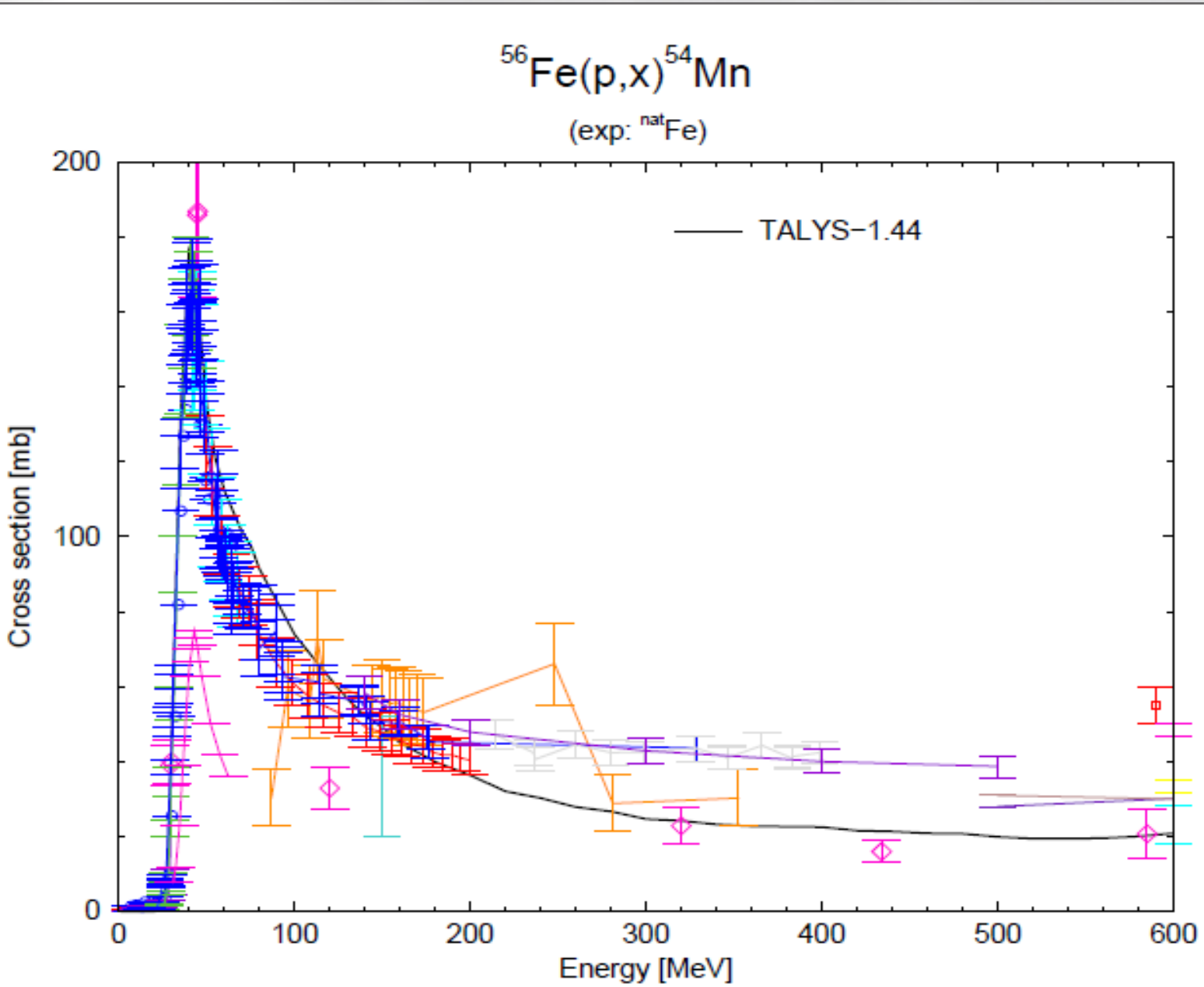
^{0}Fe(n,tot)

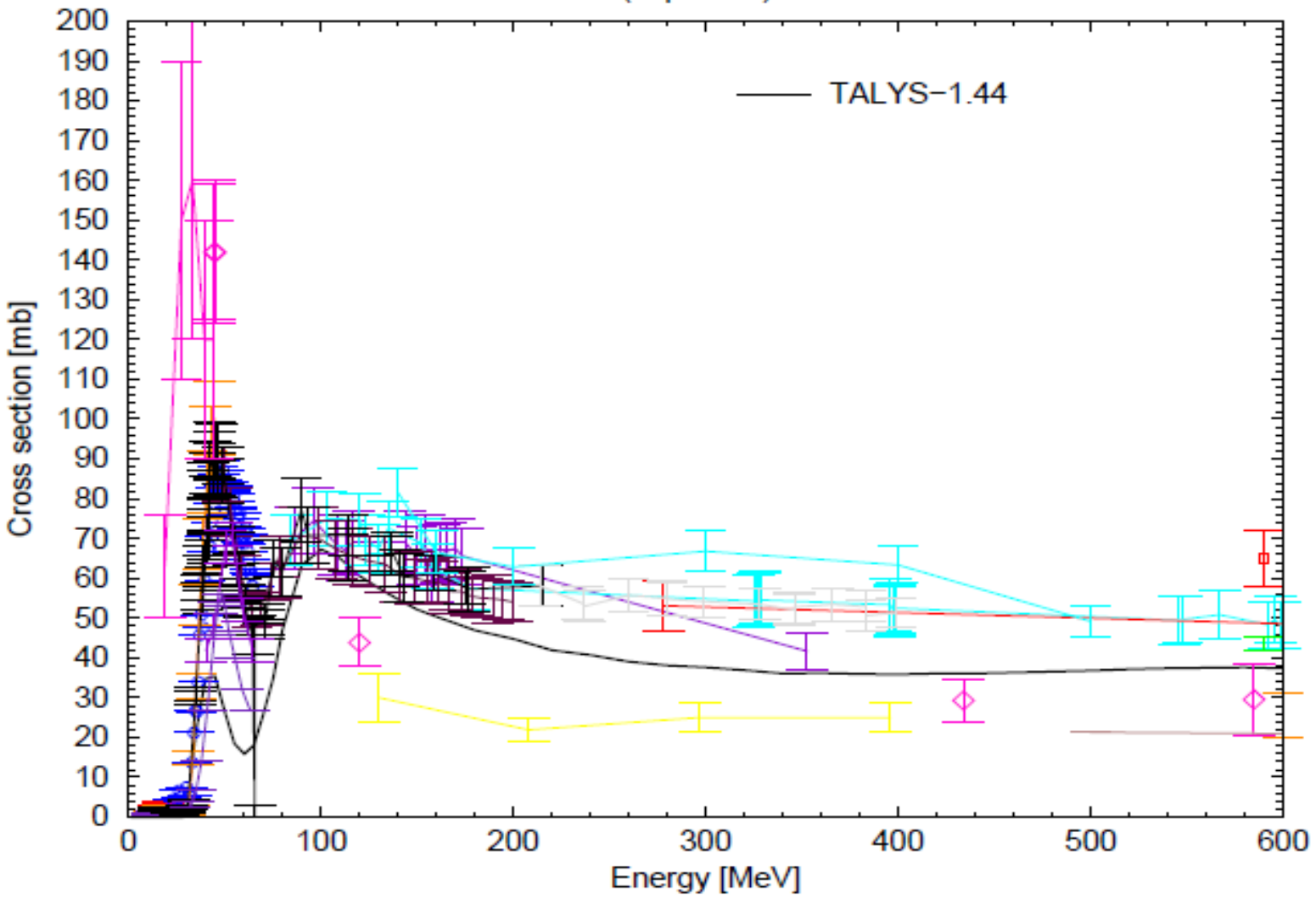

TALYS
JEFF−3.1
JENDL−4.0
ENDF/B−VII.1
CENDL−3.1
TENDL−2011
Cross section [mb]
2800
1800
800
0
100
200
300
400
500
600
Energy [MeV]

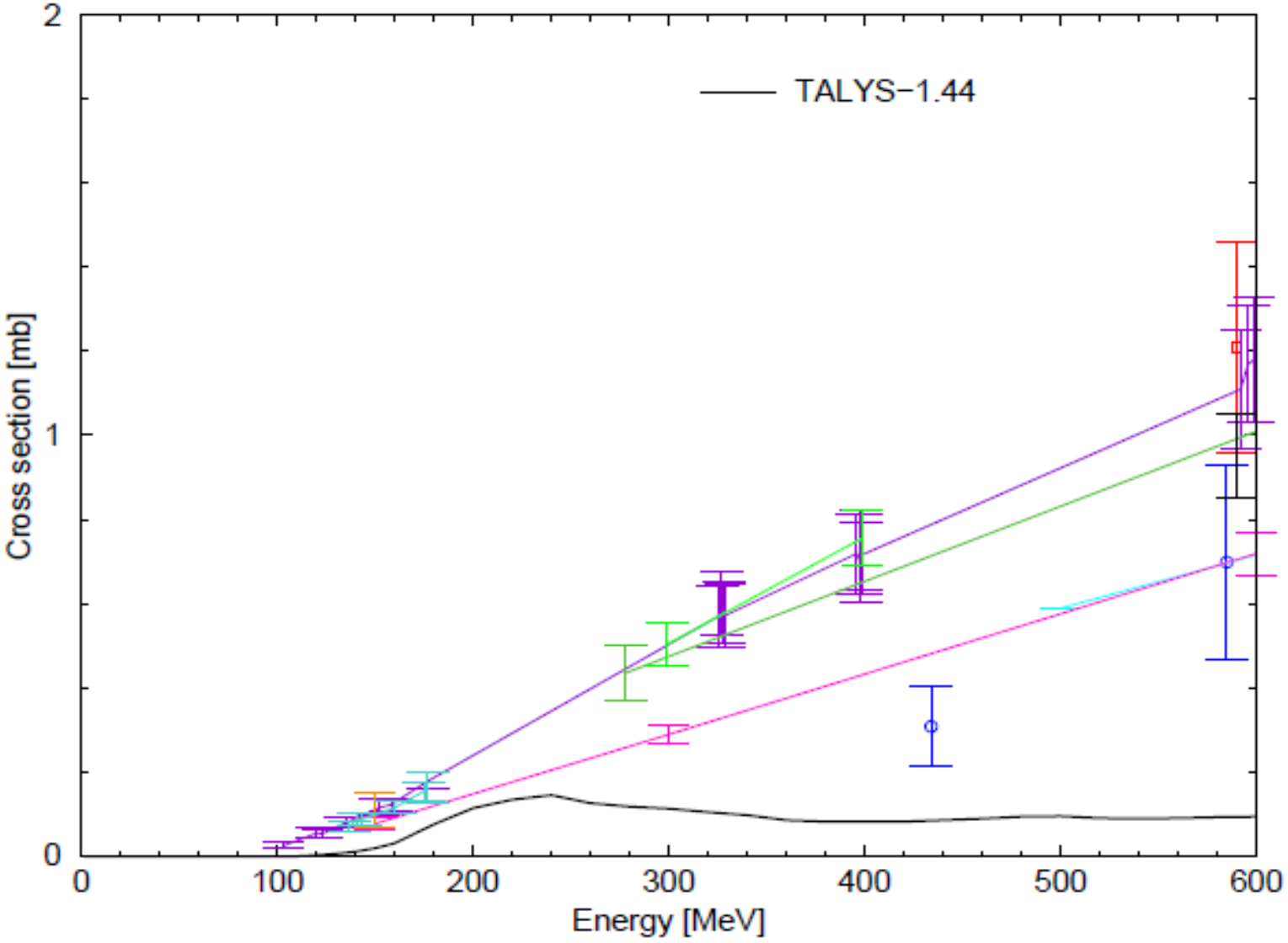
^{56}Fe(p,non)


TALYS
Cross section [mb]
Energy [MeV]
0
200
400
600
800
1000
1200
0
50
100
150
200
250
300
350
400
450
500
550
600


^{56}Fe(p,x)^{48}Sc
(exp: ^{nat}Fe)
TALYS-1.44
Brodzinsky 1971
Cline 1971
Michel 1983
Cross section [mb]
Energy [MeV]
0
1
2
0
100
200
300
400
500
600

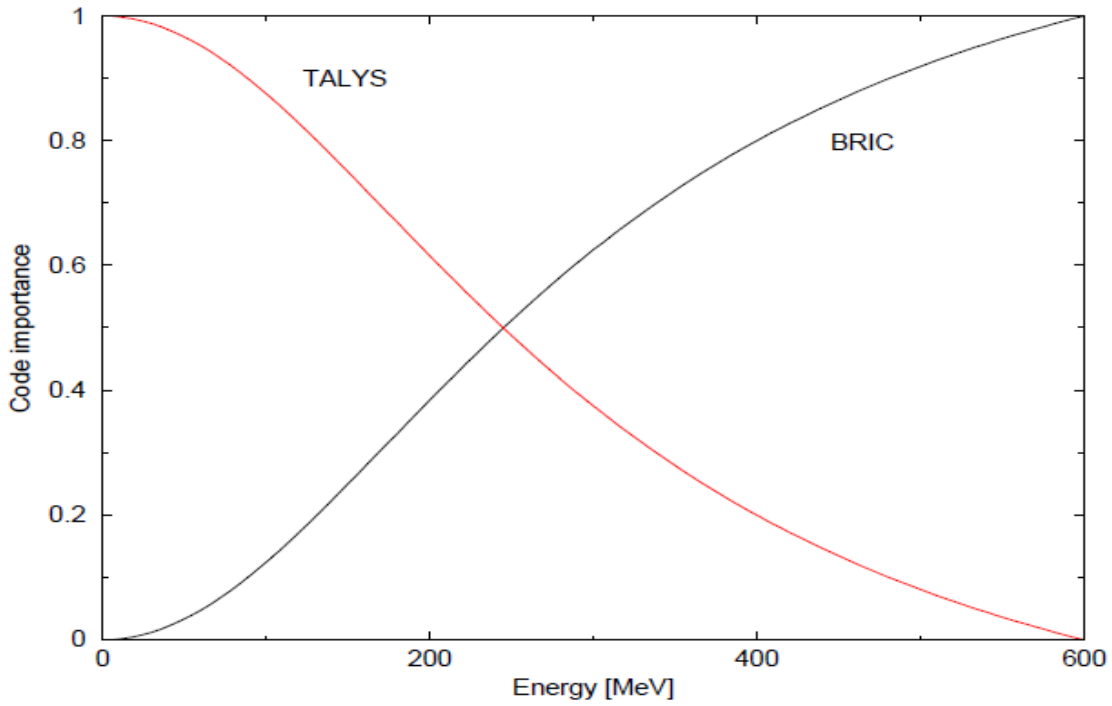

^{56}Fe(p,x)^{54}Mn
(exp: ^{nat}Fe)
TALYS-1.44
Cross section [mb]
Energy [MeV]
0
100
200
300
400
500
600


^{56}Fe(p,x)^{51}Cr
(exp: ^{nat}Fe)
TALYS-1.44
Cross section [mb]
Energy [MeV]
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
0
100
200
300
400
500
600


^{56}Fe(p,x)^{43}K
(exp: ^{nat}Fe)
TALYS-1.44
Cross section [mb]
Energy [MeV]
0
1
2
0
100
200
300
400
500
600

Coupling INC with TALYS

- Problems to connect BRIC to TALYS: too many channels produced by BRIC for standard TALYS version
- Evaluated file should probably consist of weighted contributions from both TALYS and BRIC+TALYS(de-excitation), (i.e. do every calculation twice)



Conclusions

- First results with TALYS up to 600 MeV promising. However,
  - Elastic angular distributions not yet tested
  - (Double-)differential spectra not yet tested
- Extension of data libraries up to 600 MeV: no problems with ENDF6 format encountered so far.
- Further effort depends on
  - Relevance and requests (MYHRRA?)
  - The amount of available experimental data in the 200-600 MeV range for global refitting of a few parameters (such as the exciton model matrix element)
- AK statement (made on 24-4-2012): It is hard to believe that TALYS can outperform INC codes up to 600 MeV, so for the best data libraries a combination with INC codes (BRIC) seems appropriate.