Evaluation of W-184 using the Nuclear data Evaluation Pipeline of Uppsala (NEPU)

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Overview

The goal of this project is to develop a pipeline for nuclear data evaluation, that implements methodology to treat model defects and inconsistent experimental data.

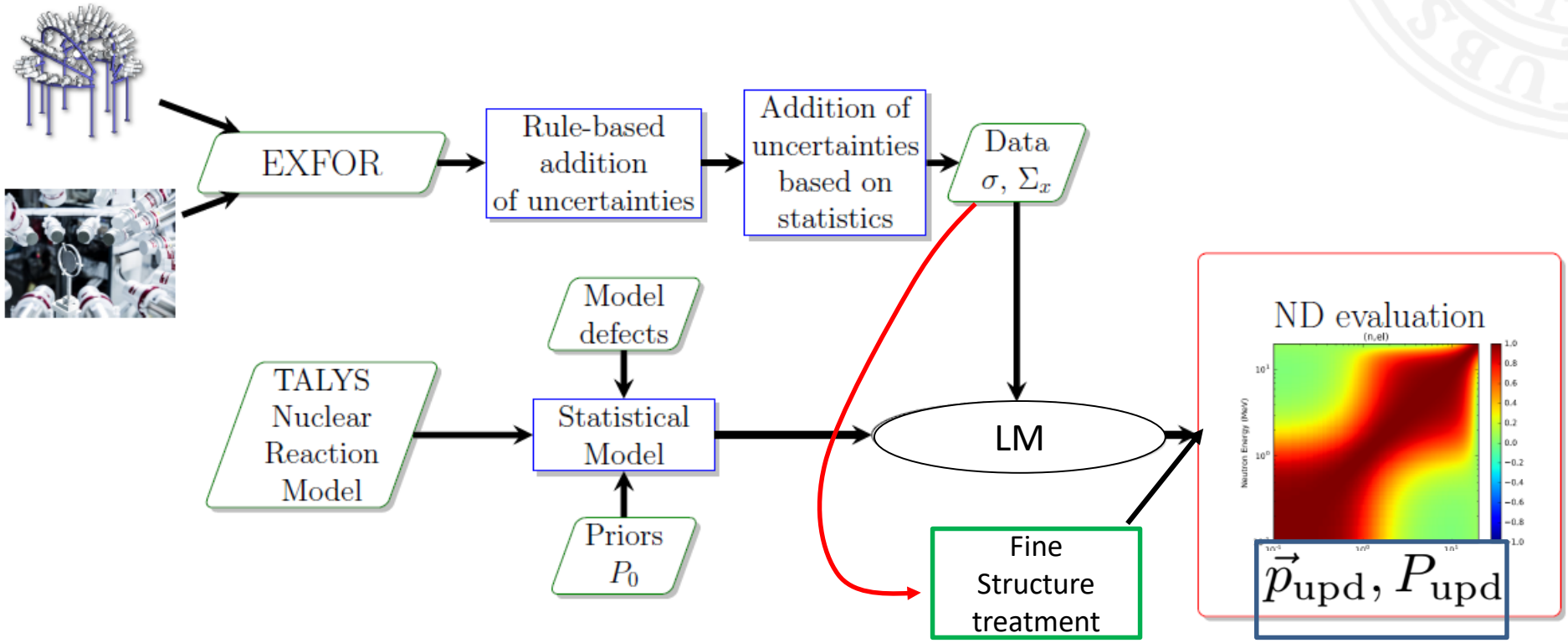
In addition, the pipeline should

- **automatize** as much as possible the steps involved in an evaluation
- produce fully **reproducible** ND evaluations
- focus on providing well-founded uncertainties

The Nuclear data Evaluation Pipeline of Uppsala university (NEPU)

G. Schnabel, et al., “Conception and Software Implementation of a Nuclear Data Evaluation Pipeline,” *Nuclear Data Sheets*, vol. 173, pp. 239–284, Mar. 2021.

A. Göök, et al., “A Nuclear Data Evaluation Pipeline for the Fast Neutron Energy Range – using heteroscedastic Gaussian processes to treat model defects,” EPJ Web of Conf., vol. 294, p. 04005, 2024, doi: 10.1051/epjconf/202429404005.



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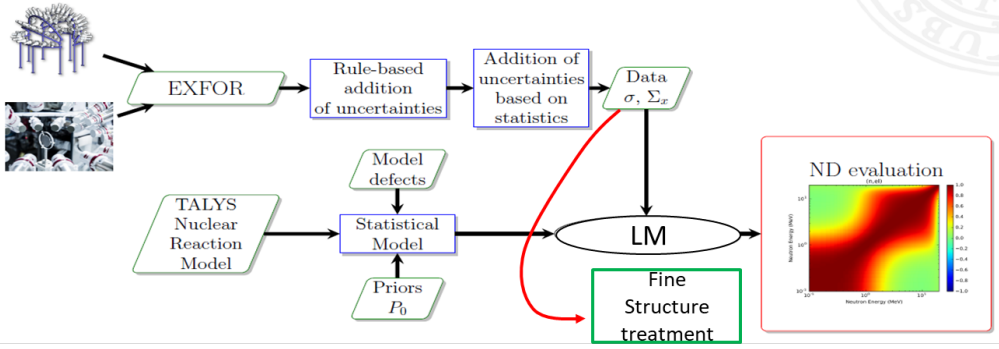
Workflow in the Pipeline

1. Data is retrieved from EXFOR → Mapped to TALYS predictions
2. Rule-based correction of uncertainties in data
3. Correction of uncertainties based on statistics
4. Talys parameter sensitivity evaluation
5. Setup of GP for energy dependence of parameters
6. Parameter optimization using the LM algorithm
7. Setup of GP in the observable domain
8. Re-optimization using the LM algorithm
9. Calculation of MVN approximation of the posterior pdf
10. Generation of random files
11. Addition of fine structures (under development – not for W-184)
12. Creation of ENDF



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Workflow in the Pipeline

is divided into a number of steps, each represented by an R-script.

1. Data is retrieved from EXFOR → Mapped to TALYS predictions
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Random uncertainties

- TALYS models the average cross-section, while experiments observe (unresolved) resonance structure. Therefore, the variance of the data around the mean cross-section is much larger than their reported random (statistical) uncertainties.

- This is modelled by using a heteroscedastic GP, where the varying nugget parameter describes the variation in the data.

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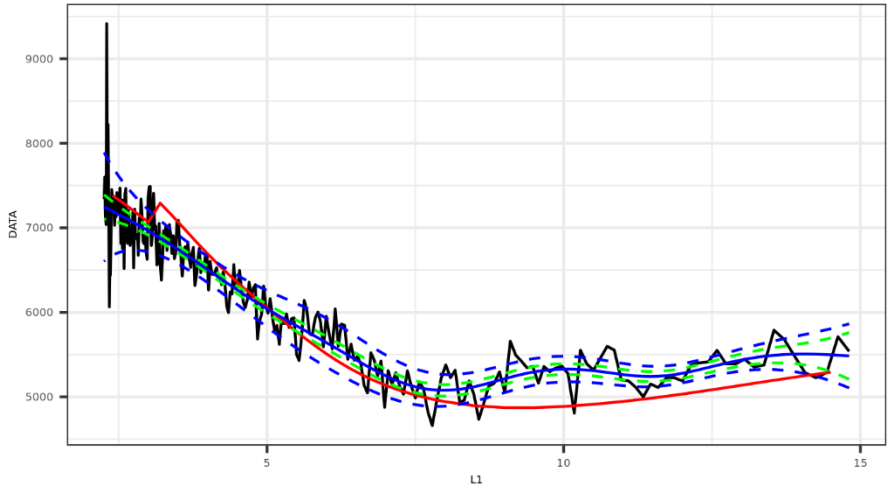
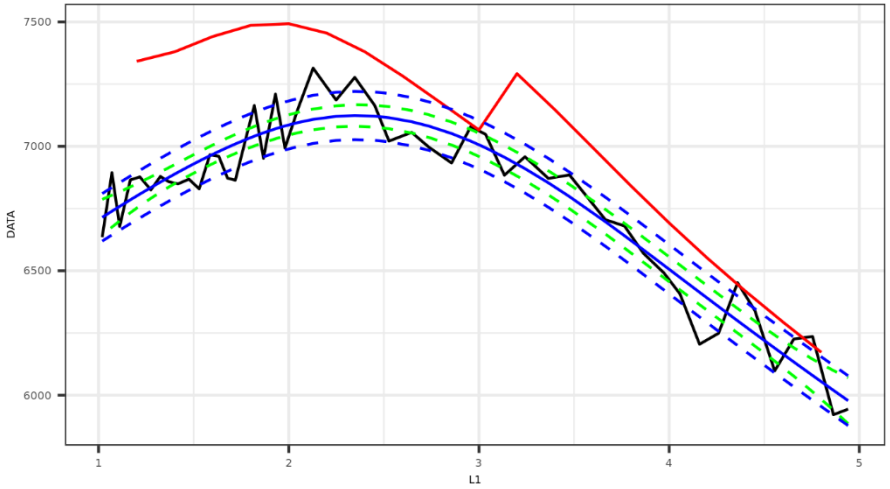
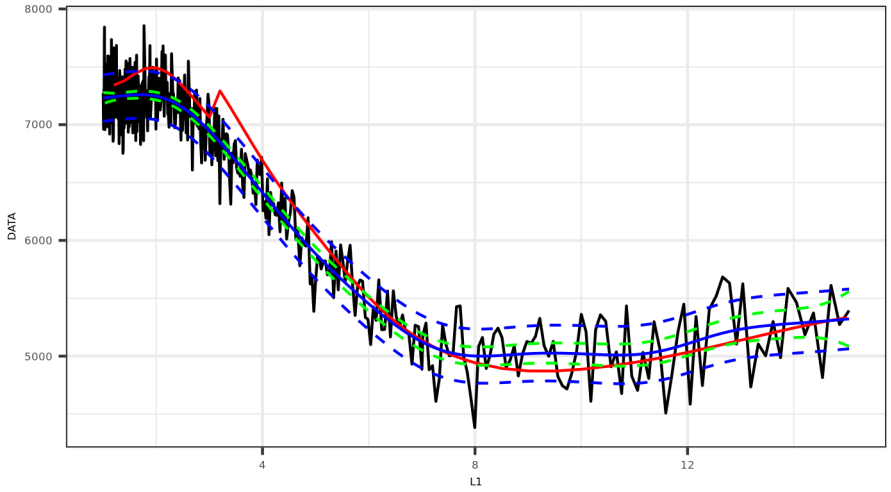
Heteroscedastic fit of individual experiments







- Adding statistical uncertainties to each experiment to account for fine structure and non accounted resonances

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Systematic uncertainties

- Inconsistent data sets are treated using Marginal Likelihood Optimization (MLO)

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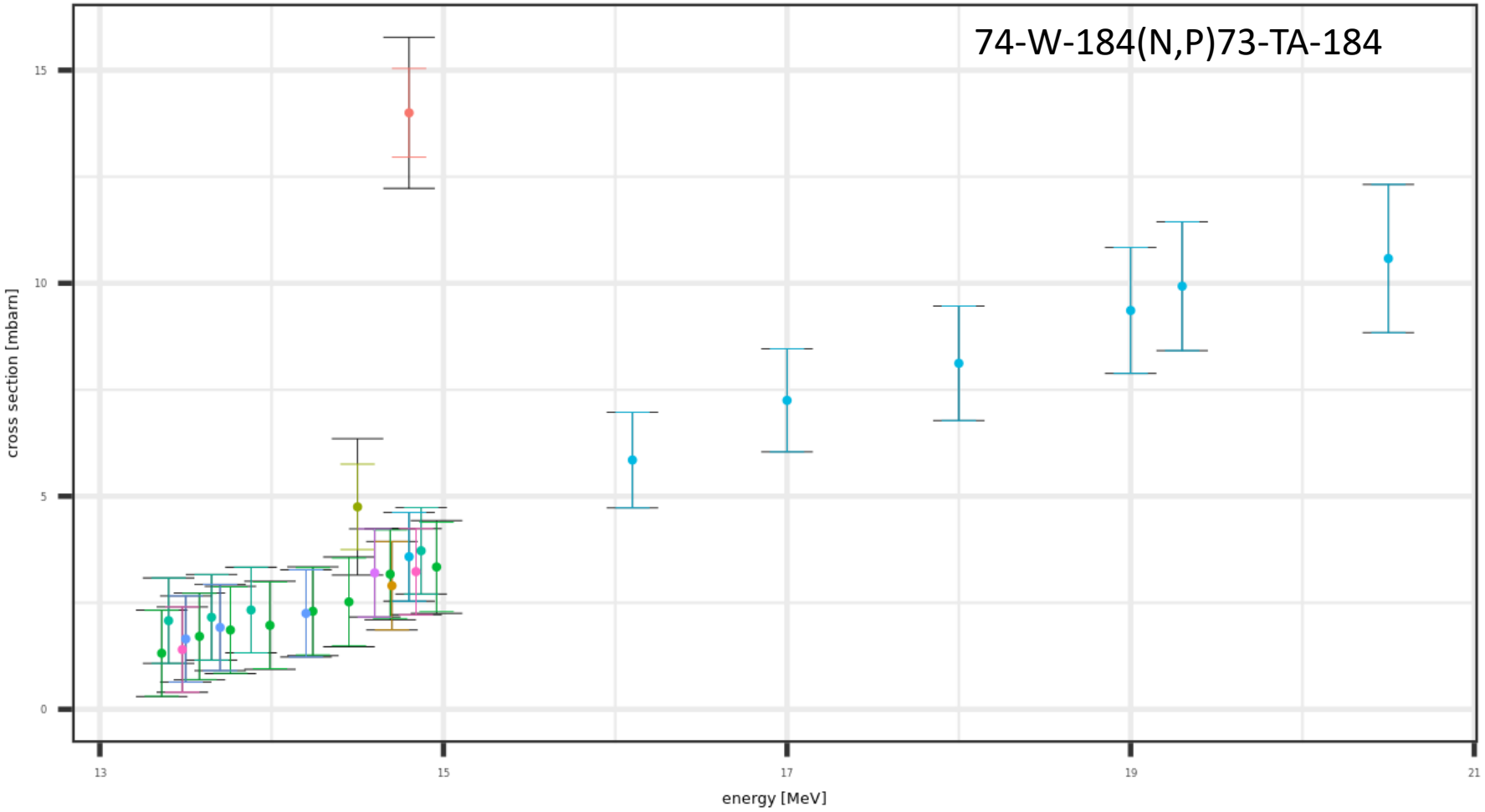
Correcting systematic uncertainties



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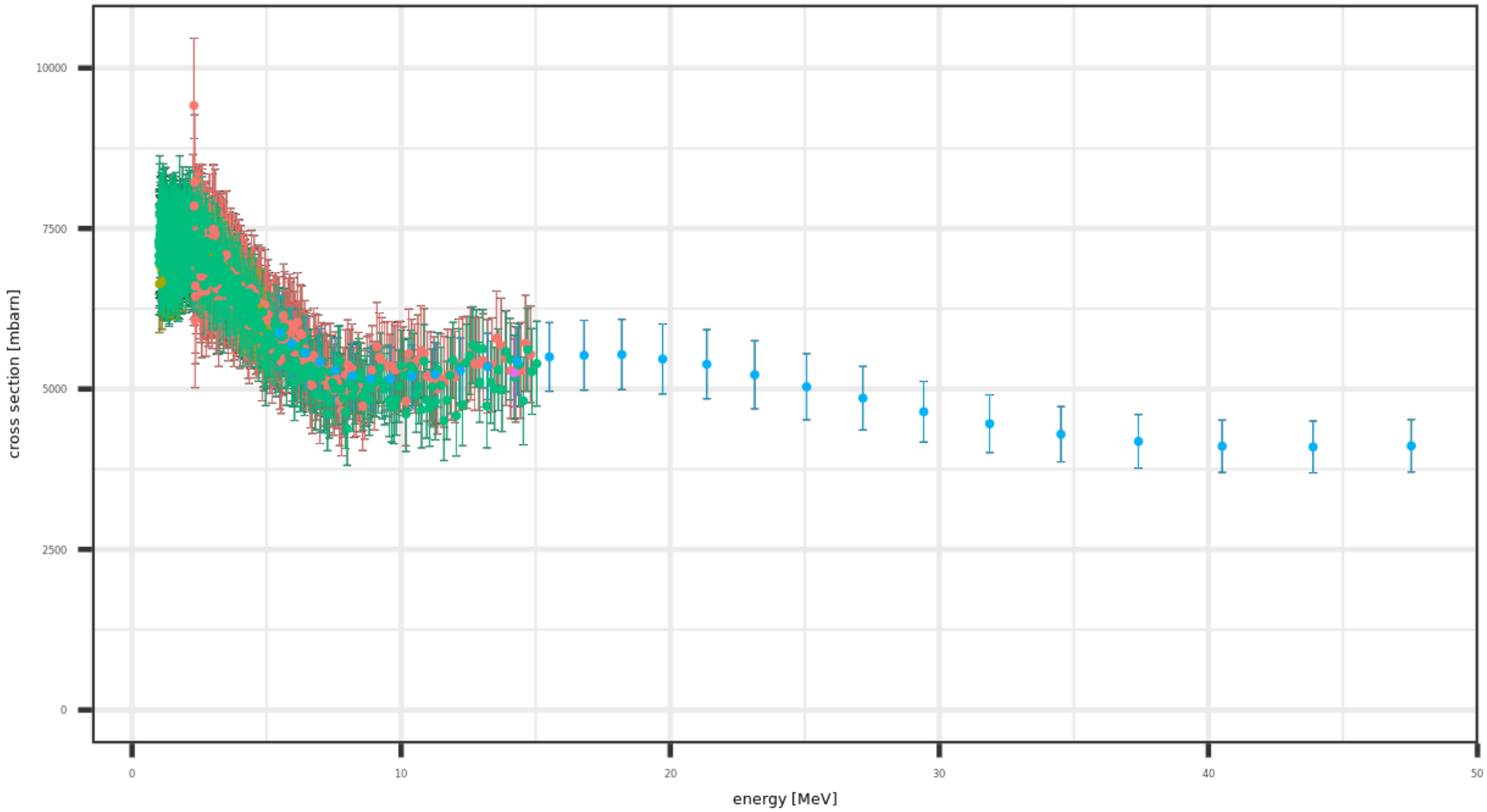
74-W-184(N,TOT)



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Workflow in the Pipeline

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1. Data is retrieved from EXFOR → Mapped to TALYS predictions
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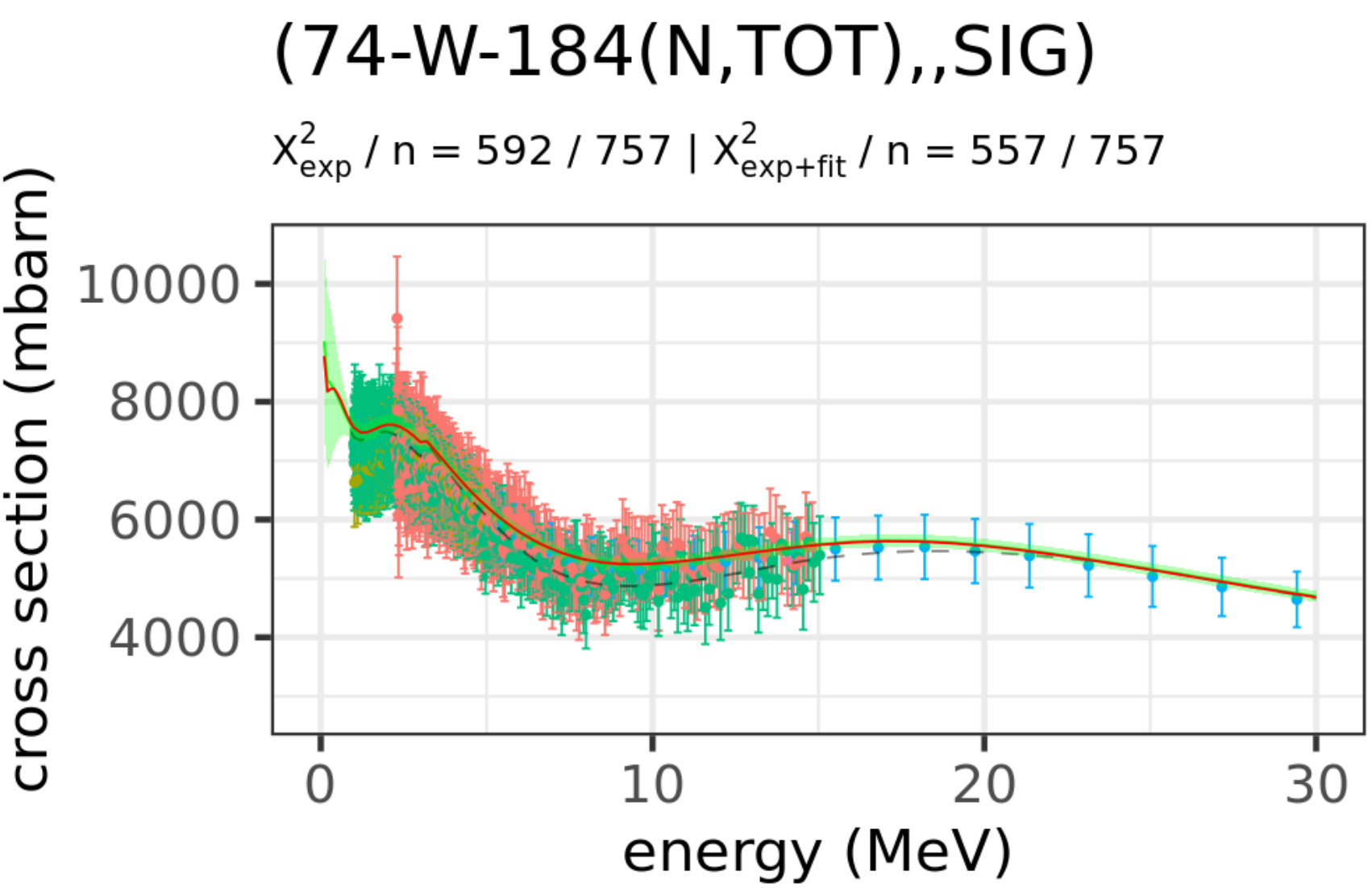
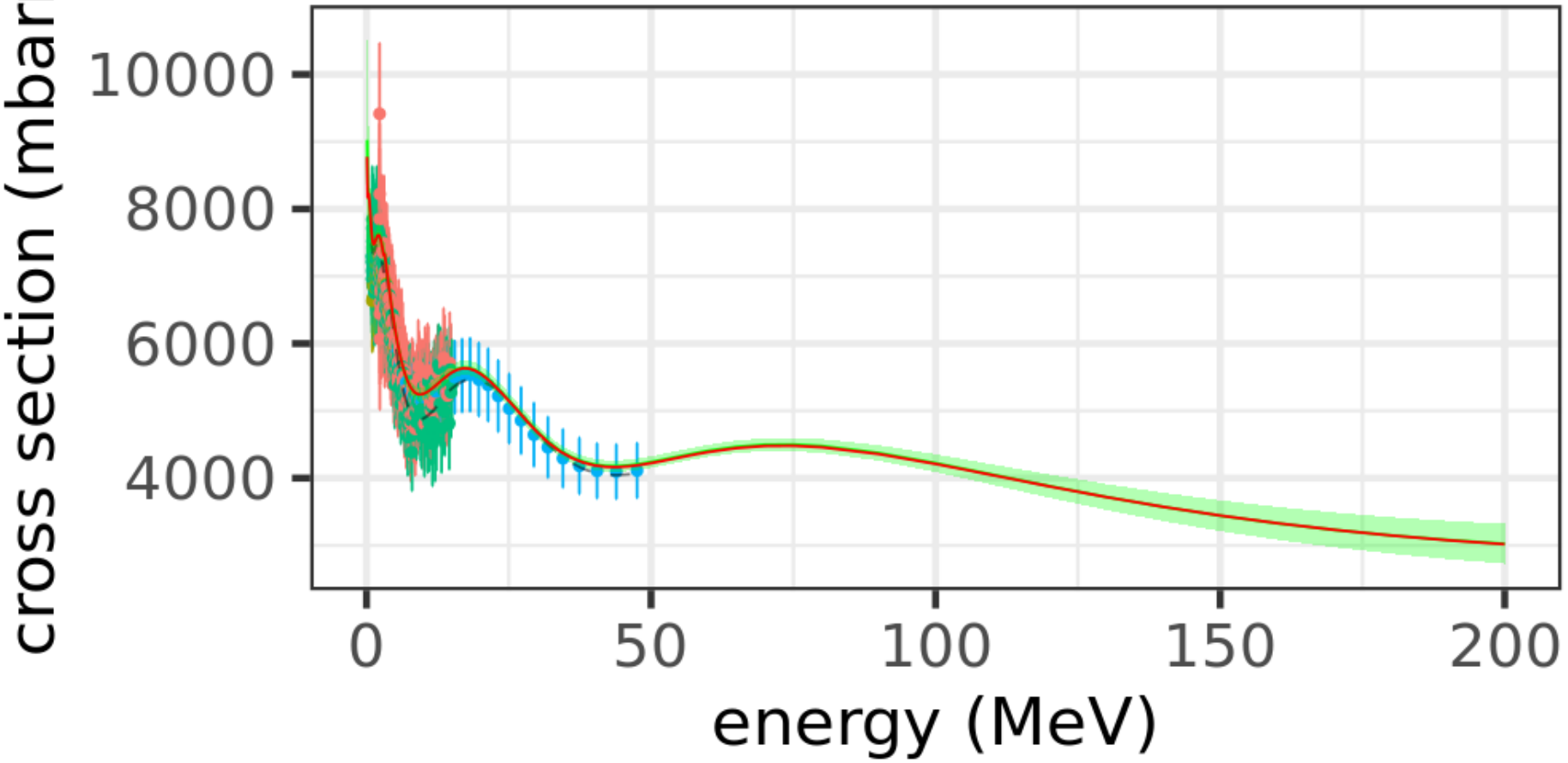
Some preliminary results



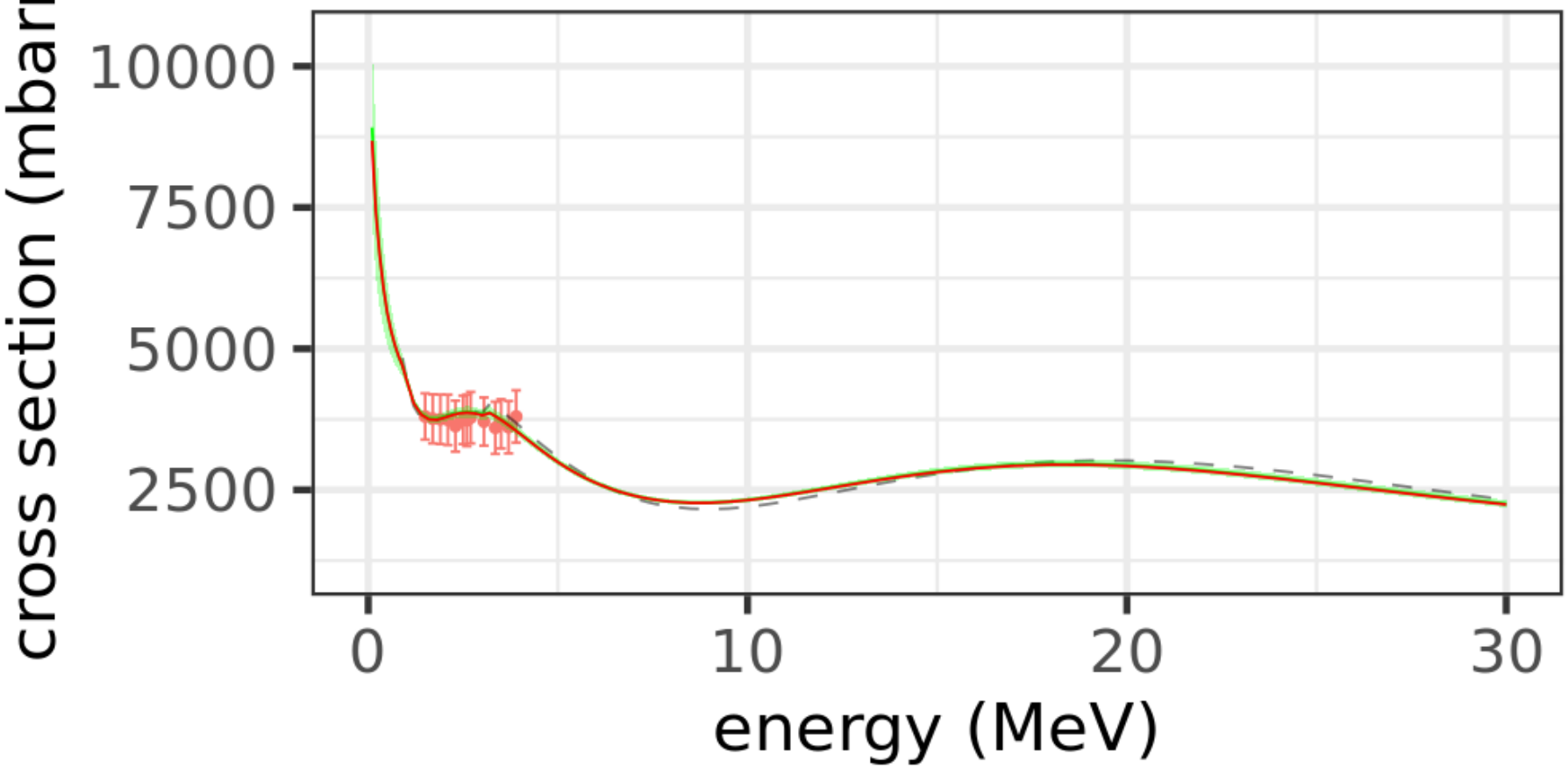
(74-W-184(N,TOT),,SIG)

X^2_{exp} / n = 592 / 757 | $X^2_{exp+fit}$ / n = 557 / 757



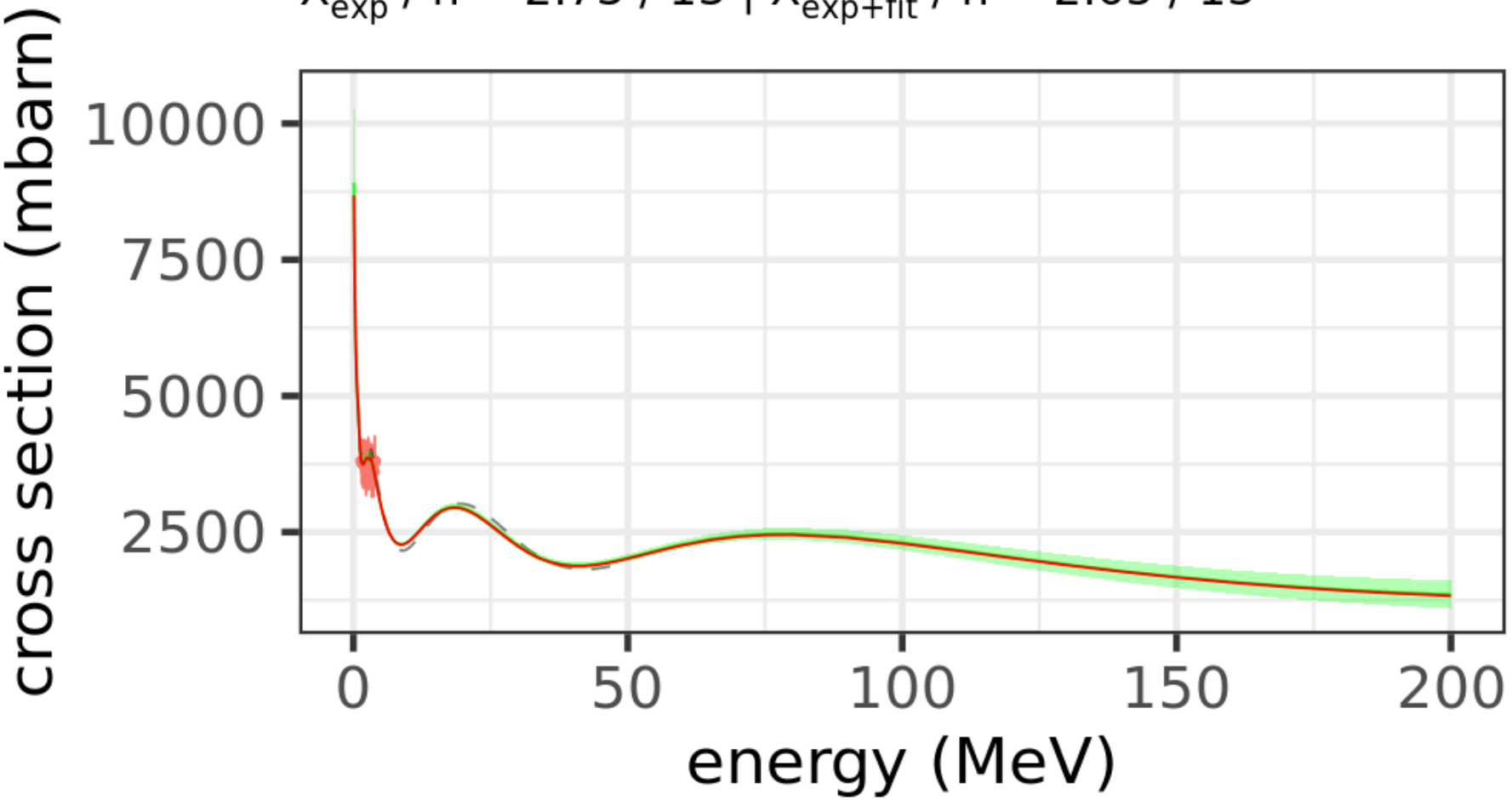
(74-W-184(N,EL)74-W-184,,SIG)

X^2_{exp} / n = 2.73 / 13 | $X^2_{exp+fit}$ / n = 2.65 / 13



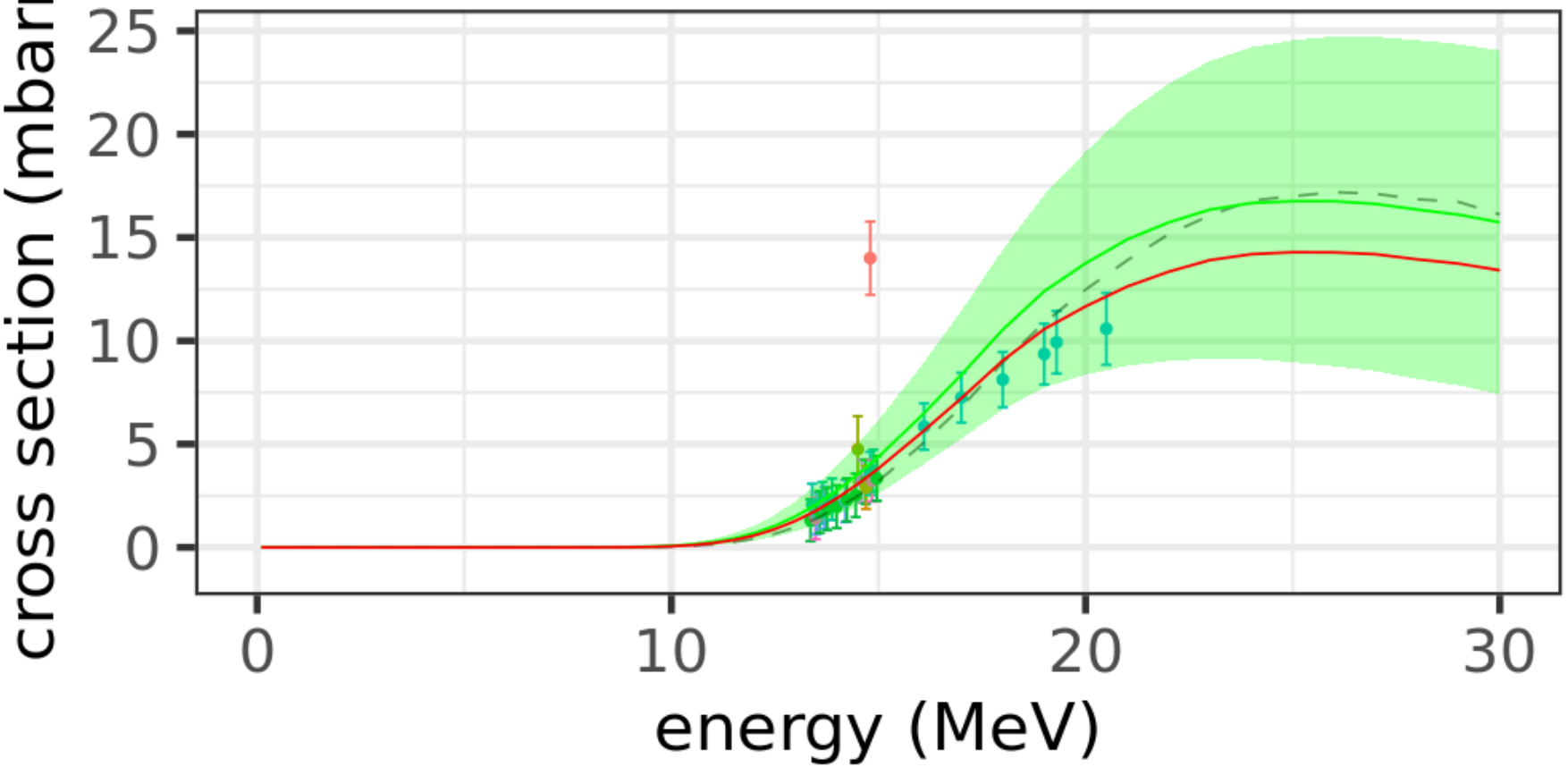
(74-W-184(N,EL)74-W-184,,SIG)

X^2_{exp} / n = 2.73 / 13 | $X^2_{exp+fit}$ / n = 2.65 / 13



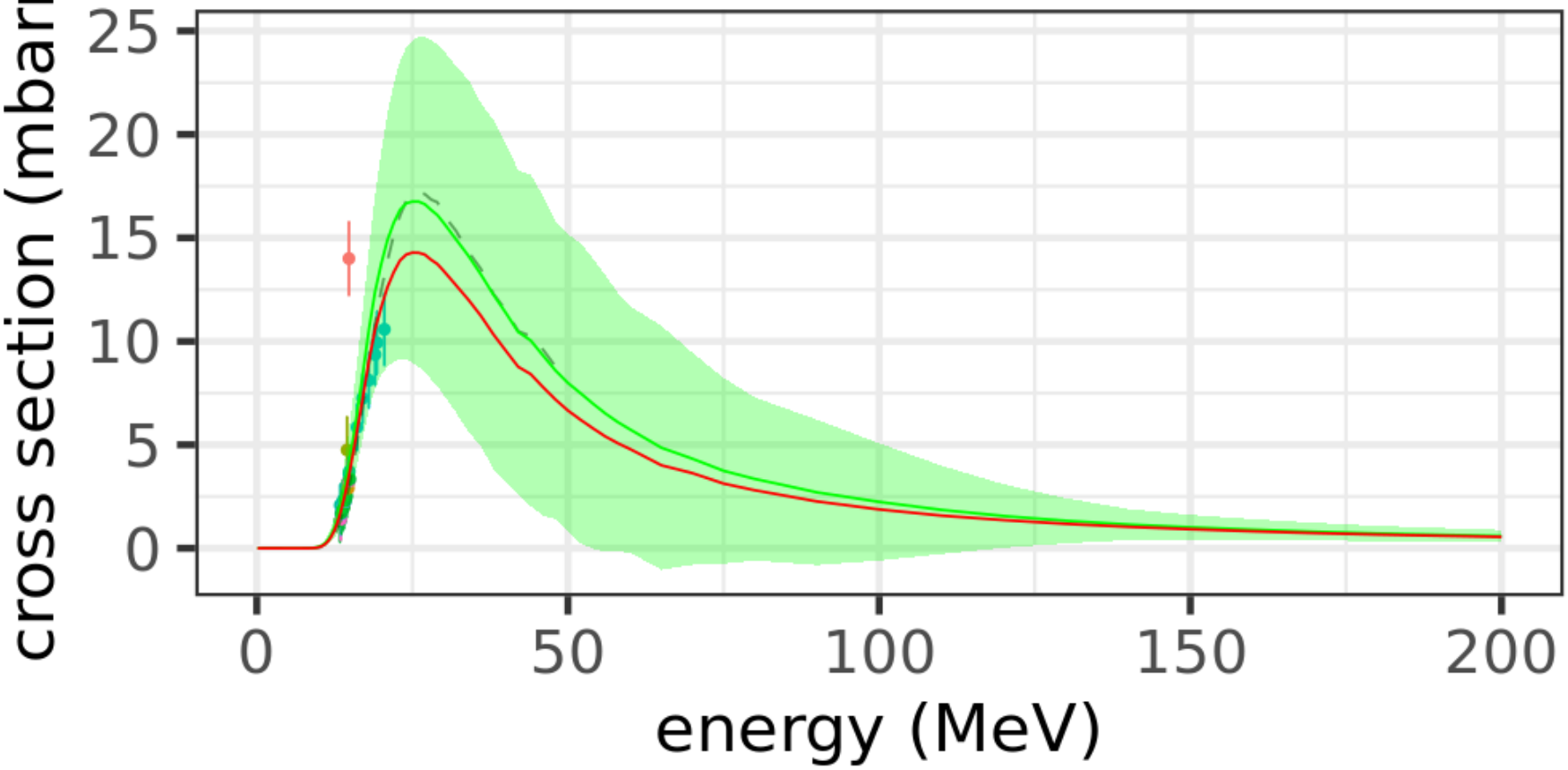
(74-W-184(N,P)73-TA-184,,SIG)

X^2_{exp} / n = 44.8 / 28 | $X^2_{exp+fit}$ / n = 38.2 / 28



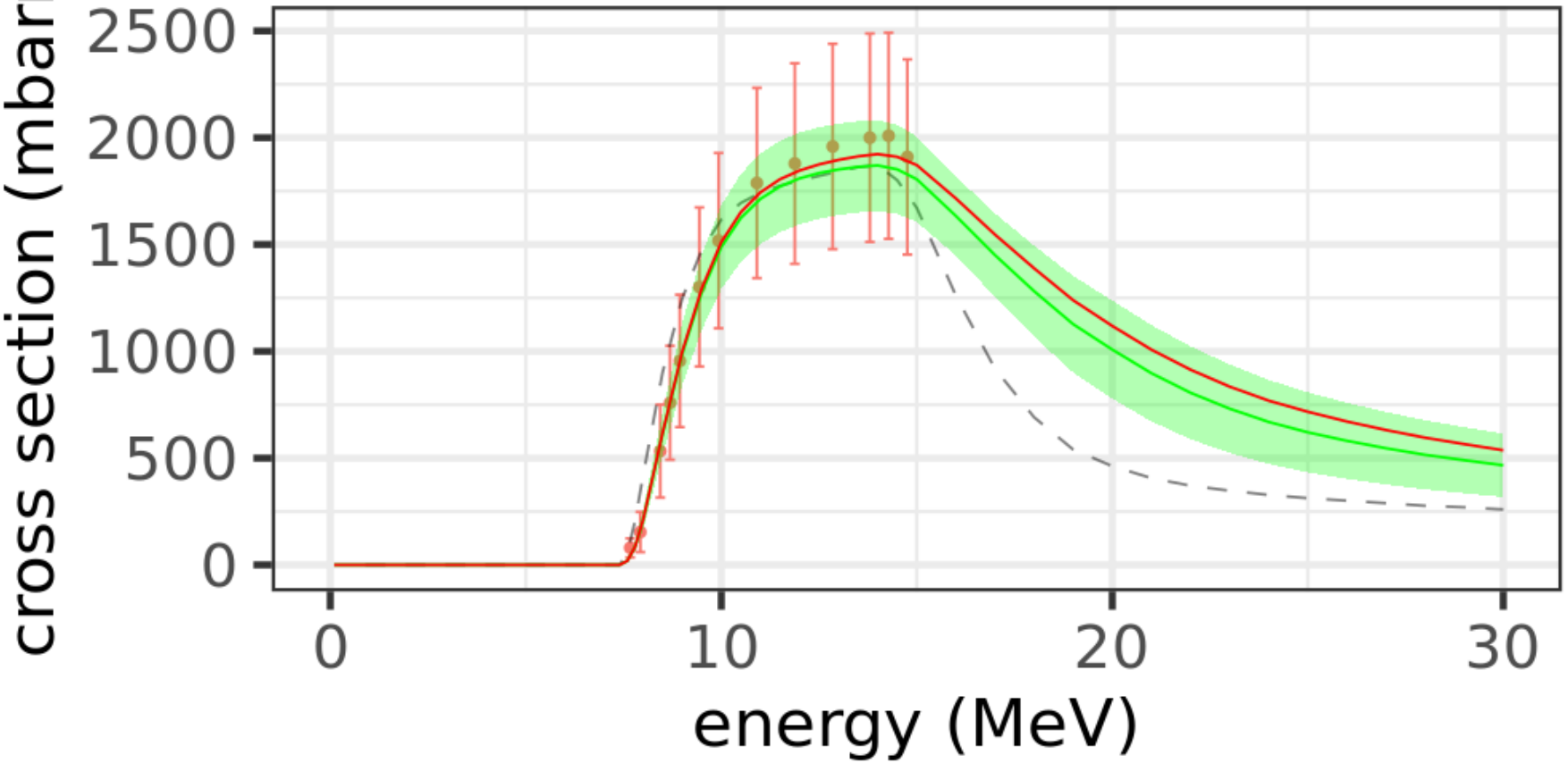
(74-W-184(N,P)73-TA-184,,SIG)

X^2_{exp} / n = 44.8 / 28 | $X^2_{exp+fit}$ / n = 38.2 / 28



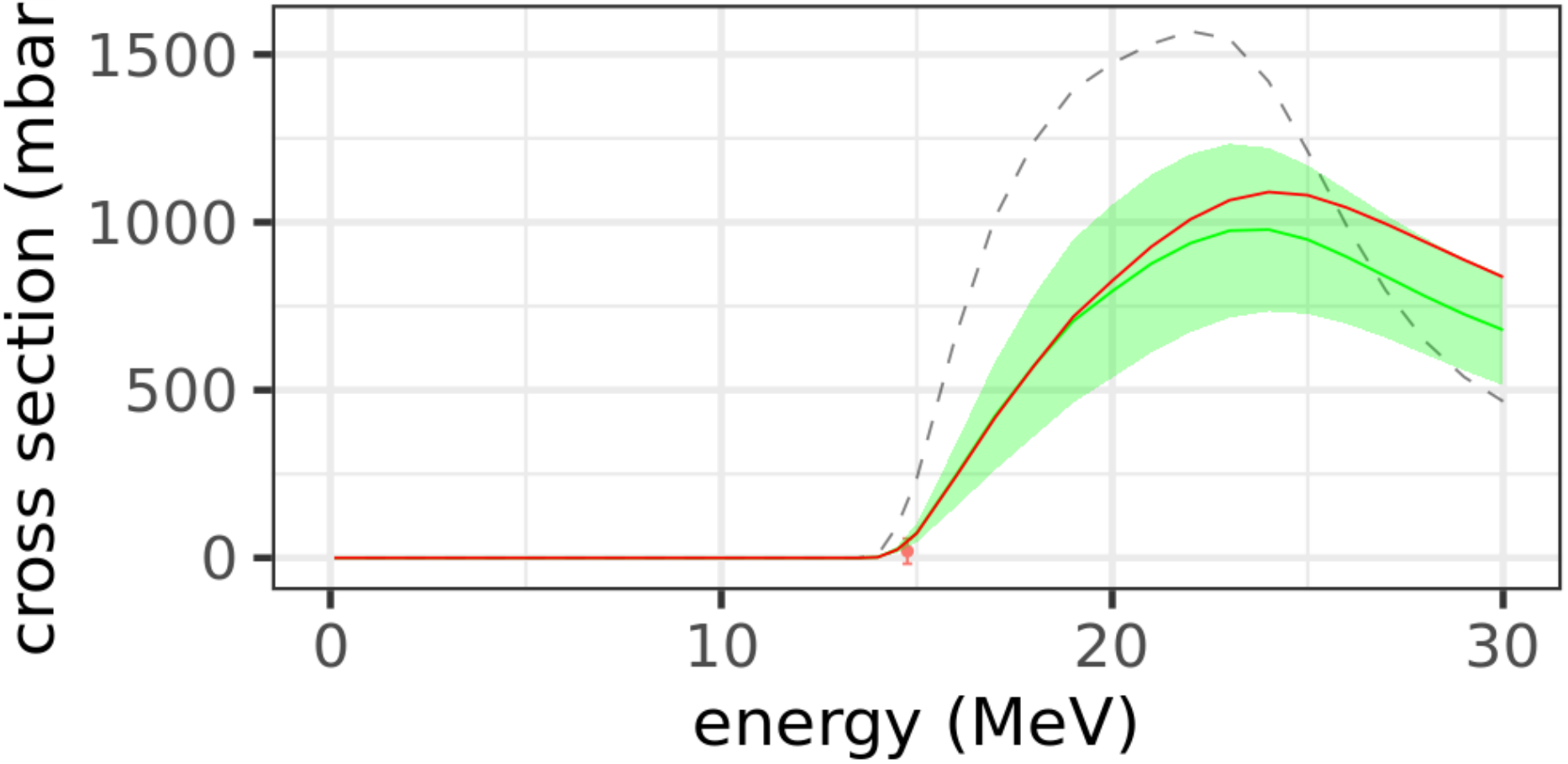
(74-W-184(N,2N)74-W-183,,SIG)

X^2_{exp} / n = 4.75 / 13 | $X^2_{exp+fit}$ / n = 3.05 / 13



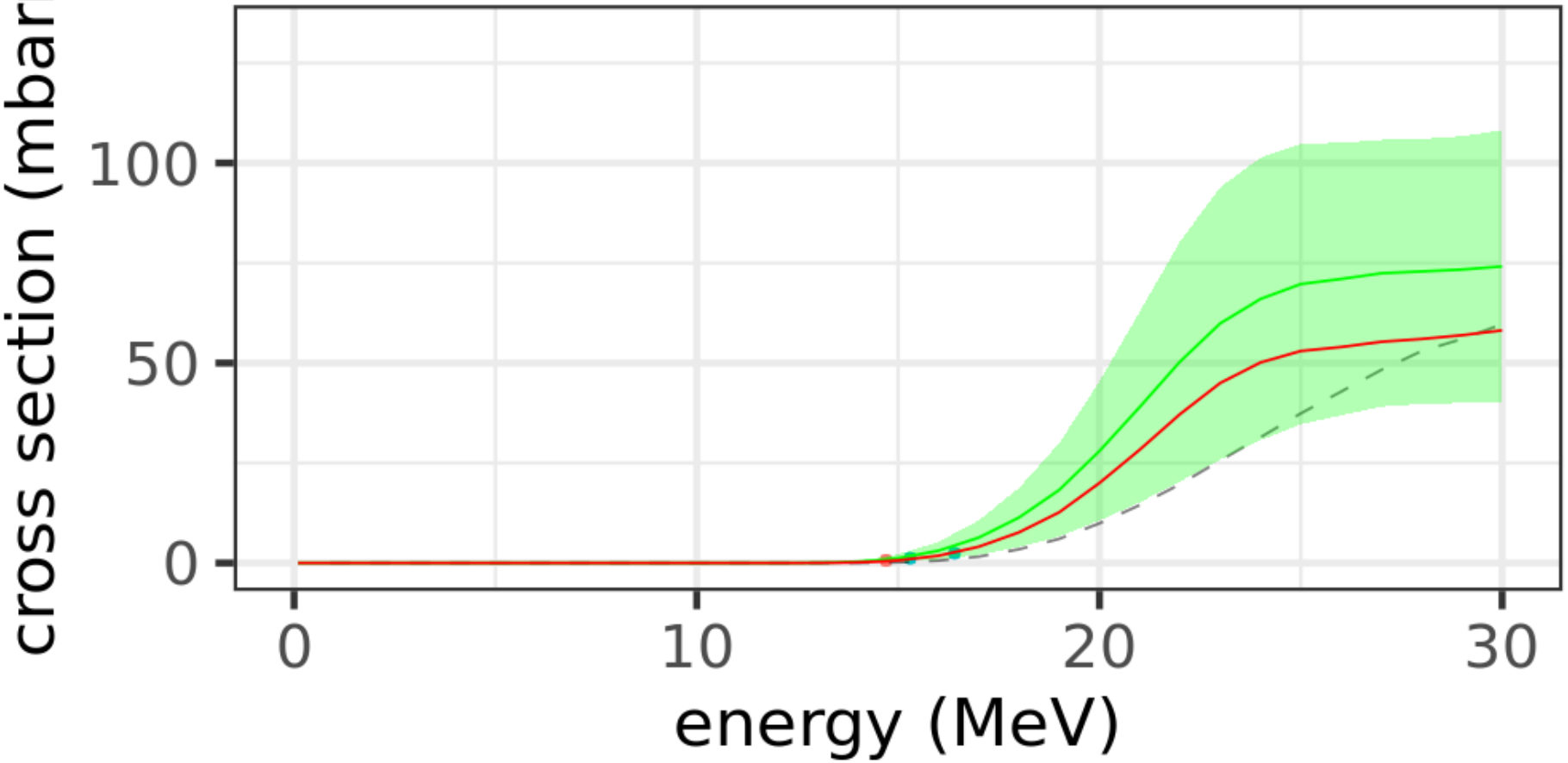
(74-W-184(N,3N)74-W-182,,SIG)

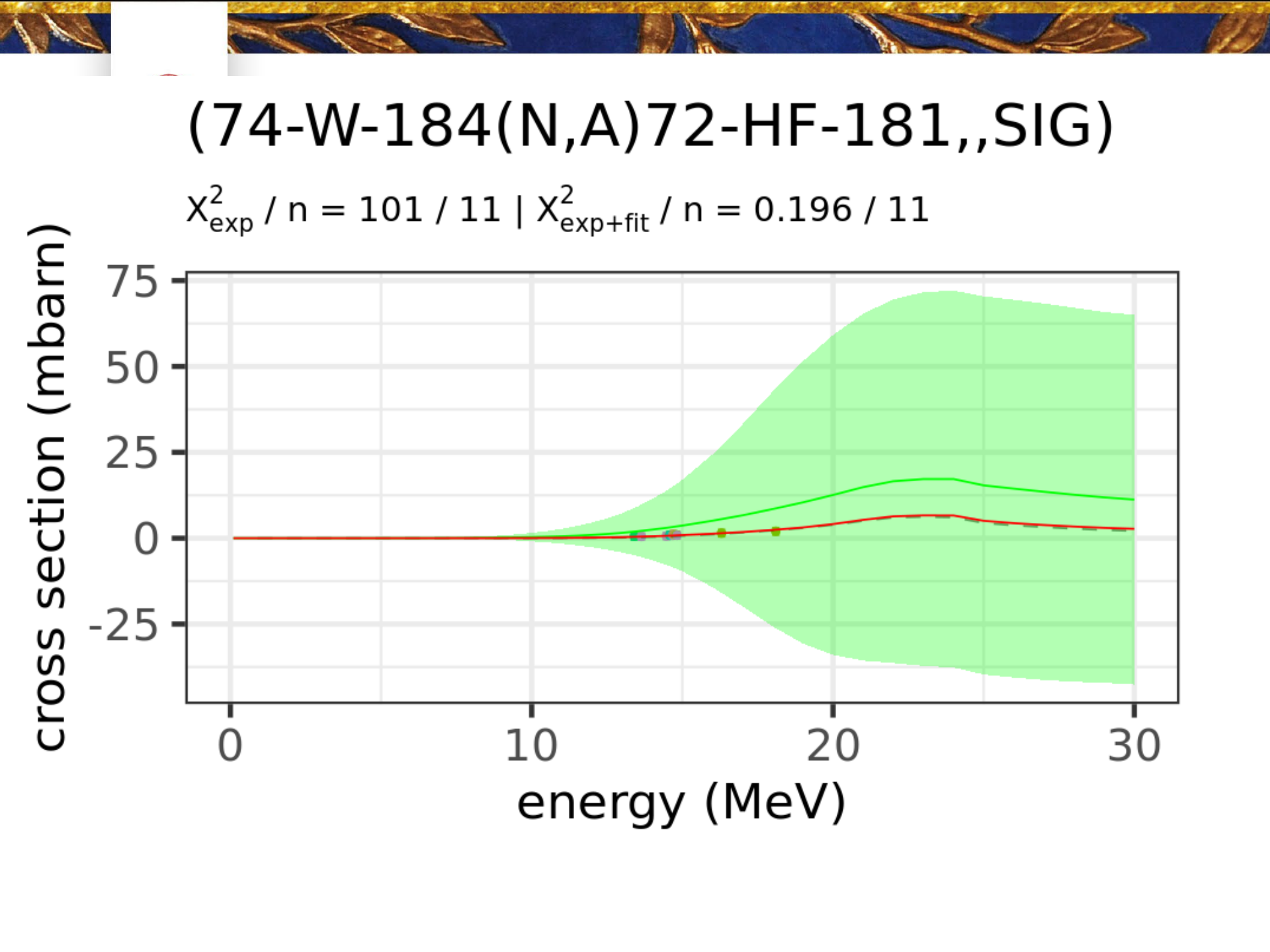
X^2_{exp} / n = 0.669 / 1 | $X^2_{exp+fit}$ / n = 0.532 / 1



(74-W-184(N,X)73-TA-183,,SIG)

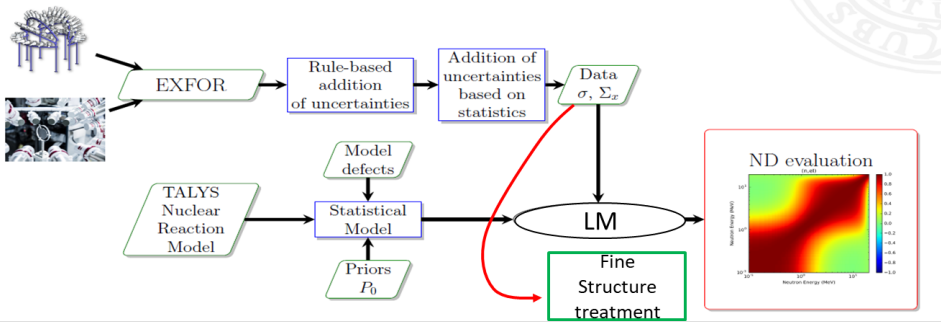
X^2_{exp} / n = 4 / 3 | $X^2_{exp+fit}$ / n = 0.399 / 3




(74-W-184(N,A)72-HF-181,,SIG)
X^2_{exp} / n = 101 / 11 | $X^2_{exp+fit}$ / n = 0.196 / 11
cross section (mbarn)
75
50
25
0
-25
0
10
20
30
energy (MeV)

Workflow in the Pipeline

1. Data is retrieved from EXFOR → Mapped to TALYS predictions –done
   A. Behavior of TALYS at 3 MeV
2. Rule-based correction of uncertainties in data –done
3. Correction of uncertainties based on statistics –done, but further investigation needed
4. Talys parameter sensitivity evaluation -done
5. Setup of GP for energy dependence of parameters –done
6. Parameter optimization using the LM algorithm
7. Setup of GP in the observable domain –done
8. Re-optimization using the LM algorithm -done
9. Calculation of MVN approximation of the posterior pdf – done
   A. Further investigation of behavior in some channels.
10. Generation of random files – to do
11. Addition of fine structures (under development – not for WP-184)
12. Creation of ENDF –to do



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Conclusions

- Nuclear data Evaluation Pipeline of Uppsala (NEPU) addresses model defects and data inconsistencies.
- Work has started on W-184.
- The NEPU produces mostly reasonable results, but there are still aspects that need to be addressed.

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Questions