Preliminary study of uncertainties on (alpha,n) cross sections with TALYS

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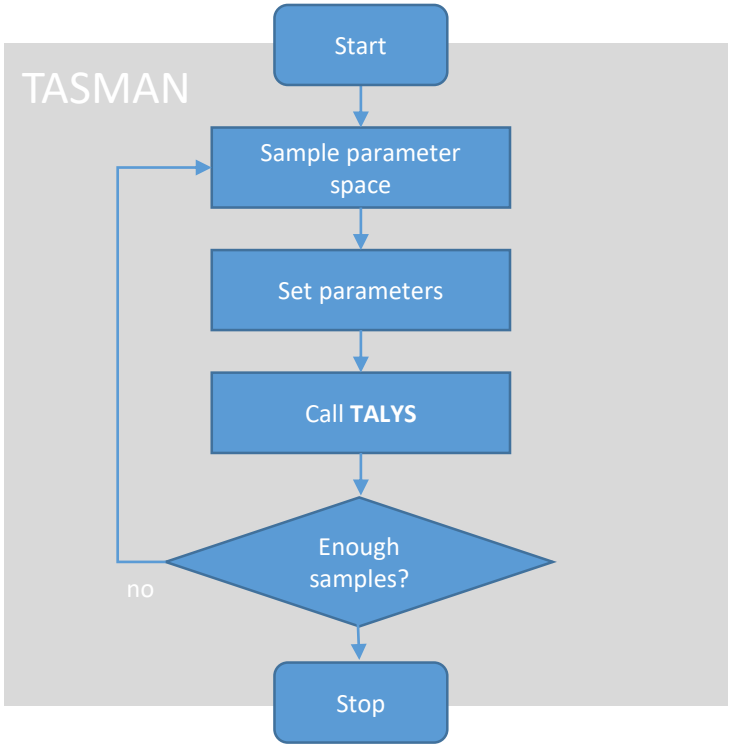
Scope

- What is the uncertainty on (α,n) cross section σ(E) as obtained from nuclear reaction codes? How to propagate uncertainties to background models for rare event searches (e.g. search for dark matter)?
  → Use TALYS/TASMAN [Koning2023] for this study
- Study ***technical*** possibility to extract uncertainties
  - proof of concept, no check yet that physics are meaningful
- Do not change ***physics*** (no parameter fitting, no evaluation, etc.)
- Use ^{40}Ar(α,n) as test case (of interest for Ar-based DM searches – but only one data point in EXFOR [Schwartz1956])

About TALYS and TASMAN



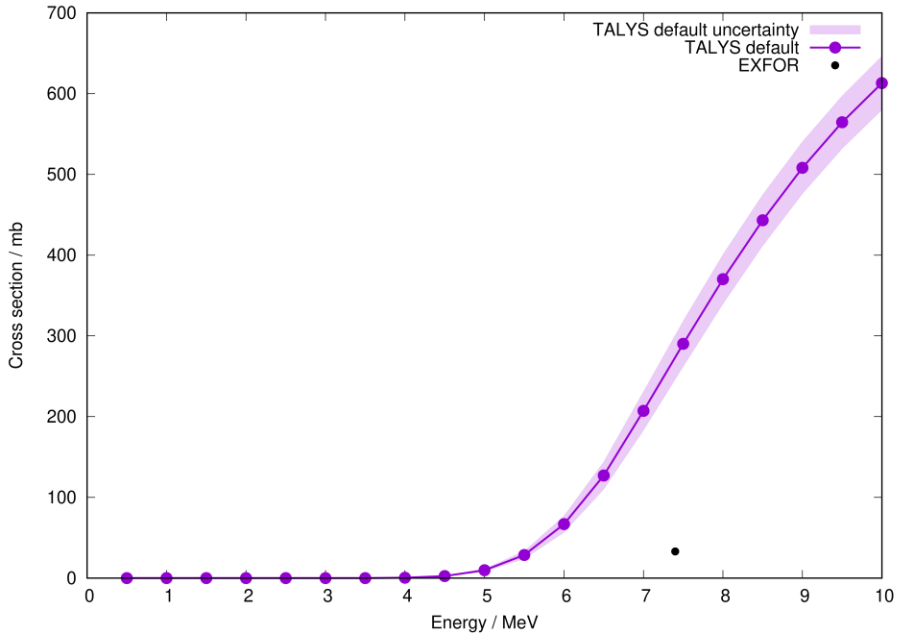
- TALYS and TASMAN were provided – and greatly supported! – by Arjan Koning (IAEA)
- TALYS is a nuclear reaction code
  - publicly available at https://tendl.web.psi.ch/tendl_2019/talys.html
- TASMAN steers TALYS
  - publicly available soon, until them available by A. Koning on request
- TASMAN & TALYS used for
  - fit to experimental data, e.g. EXFOR
  - creation of TENDL
  - ***covariance calculation, e.g. of σ(E)***

Source of uncertainties in (α,n) calculations

Acc. to [Pereira2016] for astrophysical application:

- **α-Optical Model Potential (OMP)**
- **Nucleon OMP**
- Nuclear mass
- Nuclear structure
- Level density
- Photon strength function
- Details of technical implementation (e.g. bin size)

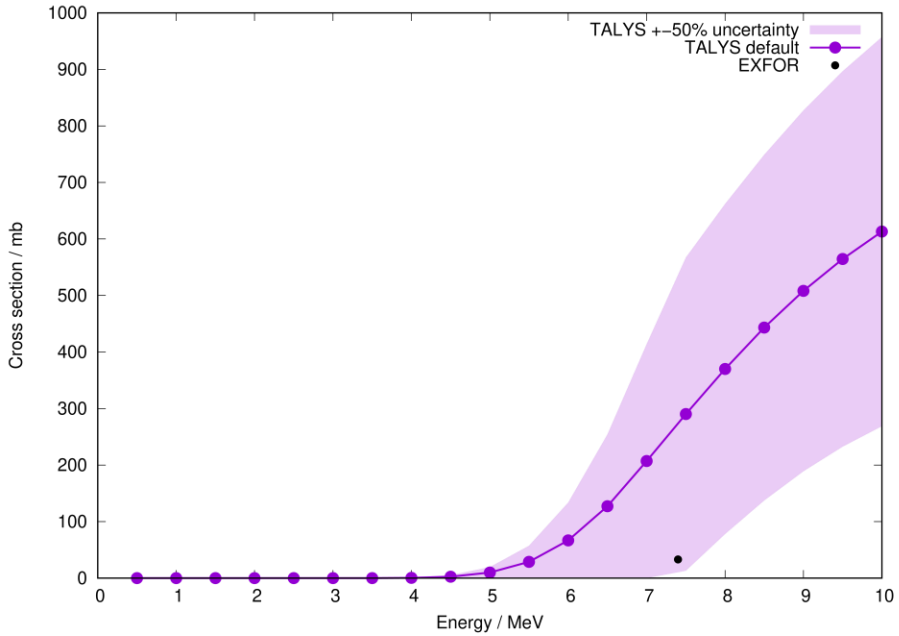
Nucleon OMP



- Use [Koning2003] OMP
- Sample 30 parameters X_i of Optical Model Potential, for each calculate σ(E)
- 2750 samples in 8 CPU.hours
- Uniform sampling within $[\widehat{\boldsymbol{X}}_{\boldsymbol{i}}-\boldsymbol{\delta}_{\boldsymbol{i}}, \widehat{\boldsymbol{X}}_{\boldsymbol{i}}+\boldsymbol{\delta}_{\boldsymbol{i}}]$
- Use TALYS best values $\hat{X}_i$ and default uncertainties δ_i:

  „when these uncertainties are applied to the parameters […], the resulting cross sections, […] display uncertainty bands which on average overlap different experimental data sets. In other words, the default uncertainties have been set to simulate the current discrepancy between measurements and between models and measurements." [TASMAN manual, §5.4]
- No covering of the EXFOR data point

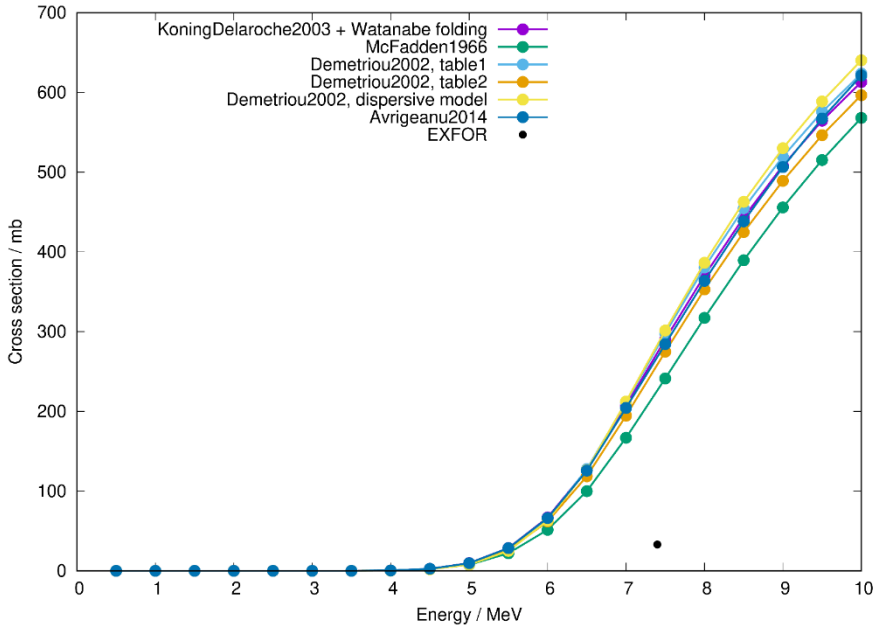
Nucleon OMP



- Use [Koning2003] OMP
- Sample 30 parameters X_i of Optical Model Potential, for each calculate σ(E)
- 2750 samples in 8 CPU.hours
- Uniform sampling within $[\mathbf{0.5} \cdot \widehat{\boldsymbol{X}}_{\boldsymbol{i}}, \mathbf{1.5} \cdot \widehat{\boldsymbol{X}}_{\boldsymbol{i}}]$
- Use TALYS best values $\widehat{X}_i$

→ can ***artificial*** extend uncertainties so that it covers data point – no check (yet) that this is physical meaningful

α-OMPs



- Use the 6 OMPs implemented in TALYS 1.95 that are suitable for ^{40}Ar(α,n)
- TALYS provides also 2 additional, unsuitable OMPs:
  - [Nolte1987] for E>80MeV
  - [Avrigeanu1994] only for α emission
  → exclude them
- Oldest α-OMP [McFadden1966] differs the most
- Default α-OMP [Koning2003+folding] agrees pretty well with newest α-OMP [Avrigeanu2014]
- None covers the EXFOR data point

Summary

- Study technical possibility to propagate uncertainties on (α,n) model parameter to background models for rare event searches
  →It's possible (and easy) with TALYS/TASMAN
- For ^{40}Ar-test case no agreement with data was found

Outlook

- Study also other inputs:
  - Nucleon OMPs other than [Koning2003]
  - Different nuclear mass model
  - Different level (density) model
  - …
- Repeat this study also for other nuclides of interest

Thank you for your attention

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