Continued progress on the ^{15}N system fit

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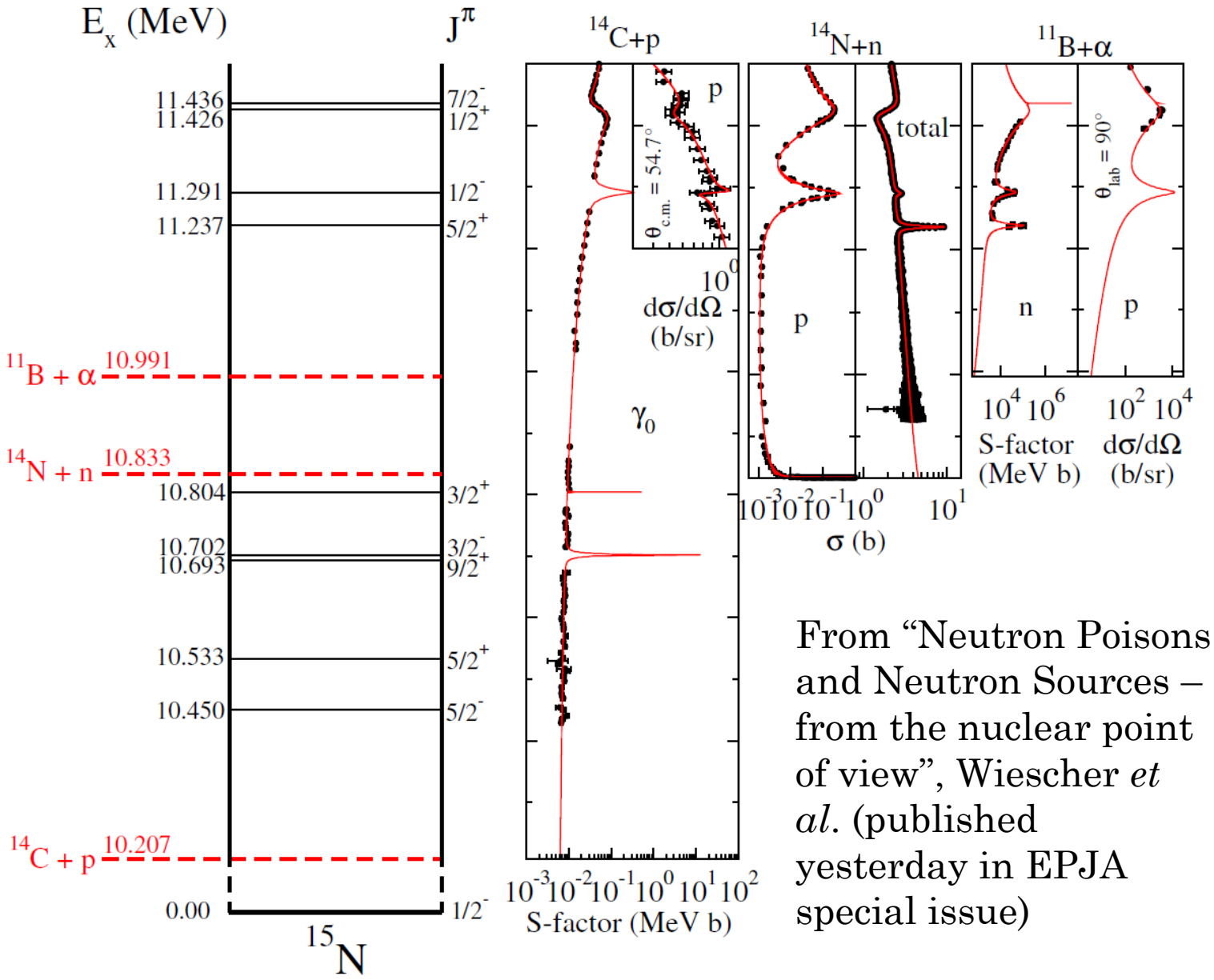
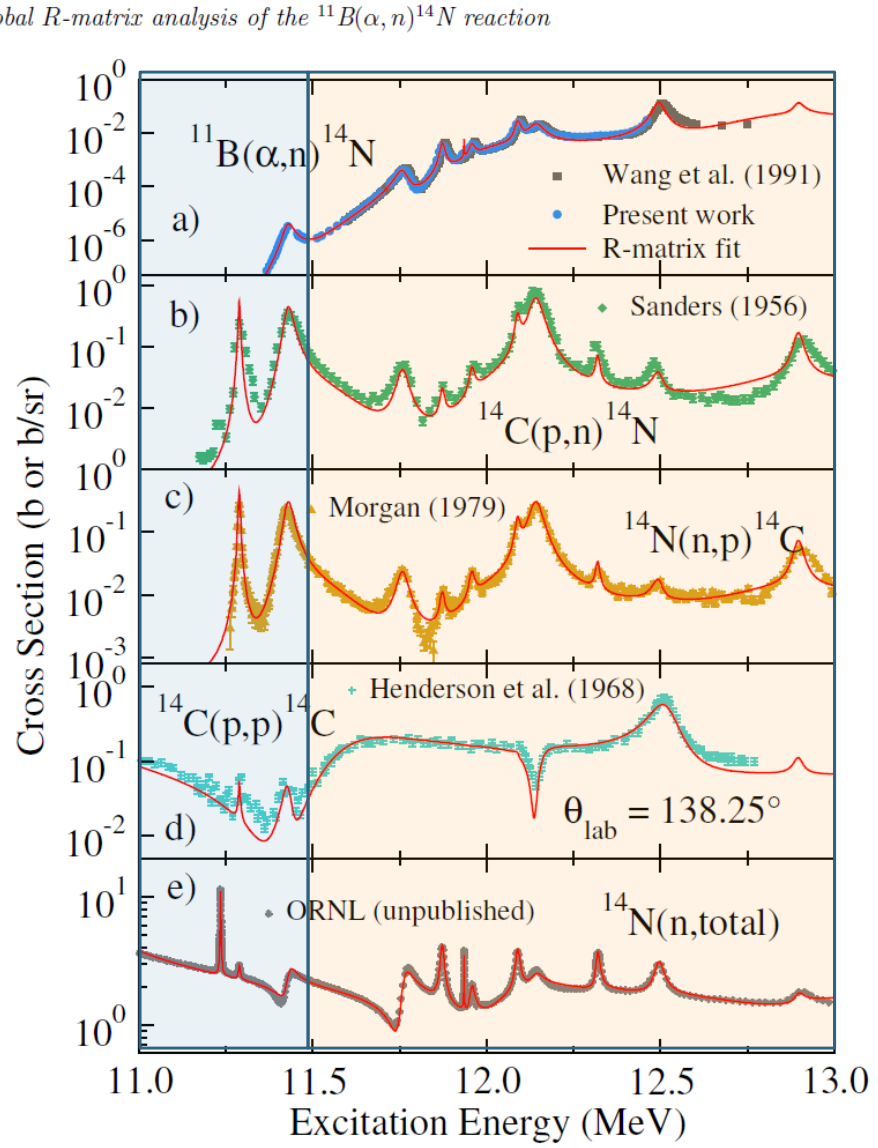
- For nuclear astrophysics applications, I've been focused on the low energy region for the last few years
- I had been stuck with the higher energy part of the fit, unable to get a consistent fit with the different reaction channels



From "Neutron Poisons and Neutron Sources – from the nuclear point of view", Wiescher *et al.* (published yesterday in EPJA special issue)

Expanding to higher energy, revisited

- R-matrix fit to higher energies circa 2020
- Ok description but certainly some issues
- In particular the (α,n) wasn't fit well
- Also some issues with (p,n) / (n,p) fits
- (p,p) and (n,total) have always looked pretty good actually

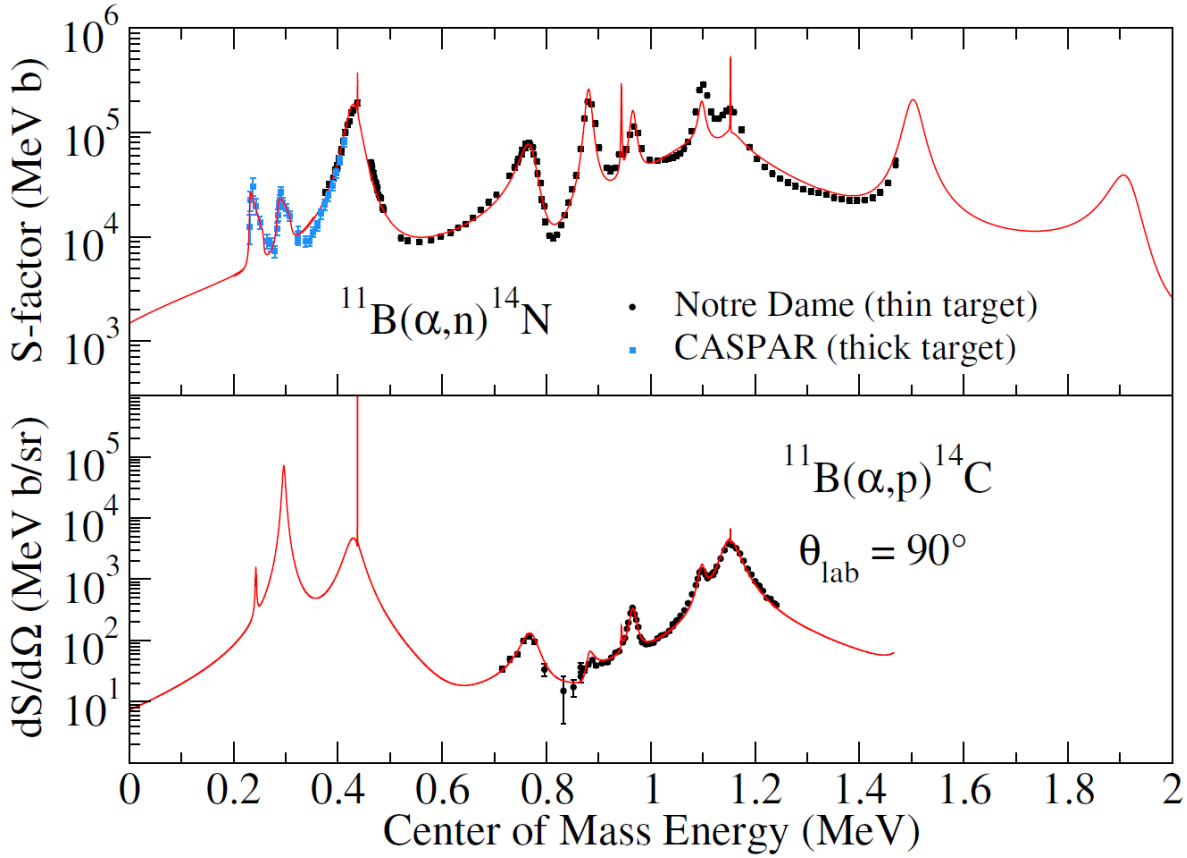


Improvements over the last 6 months

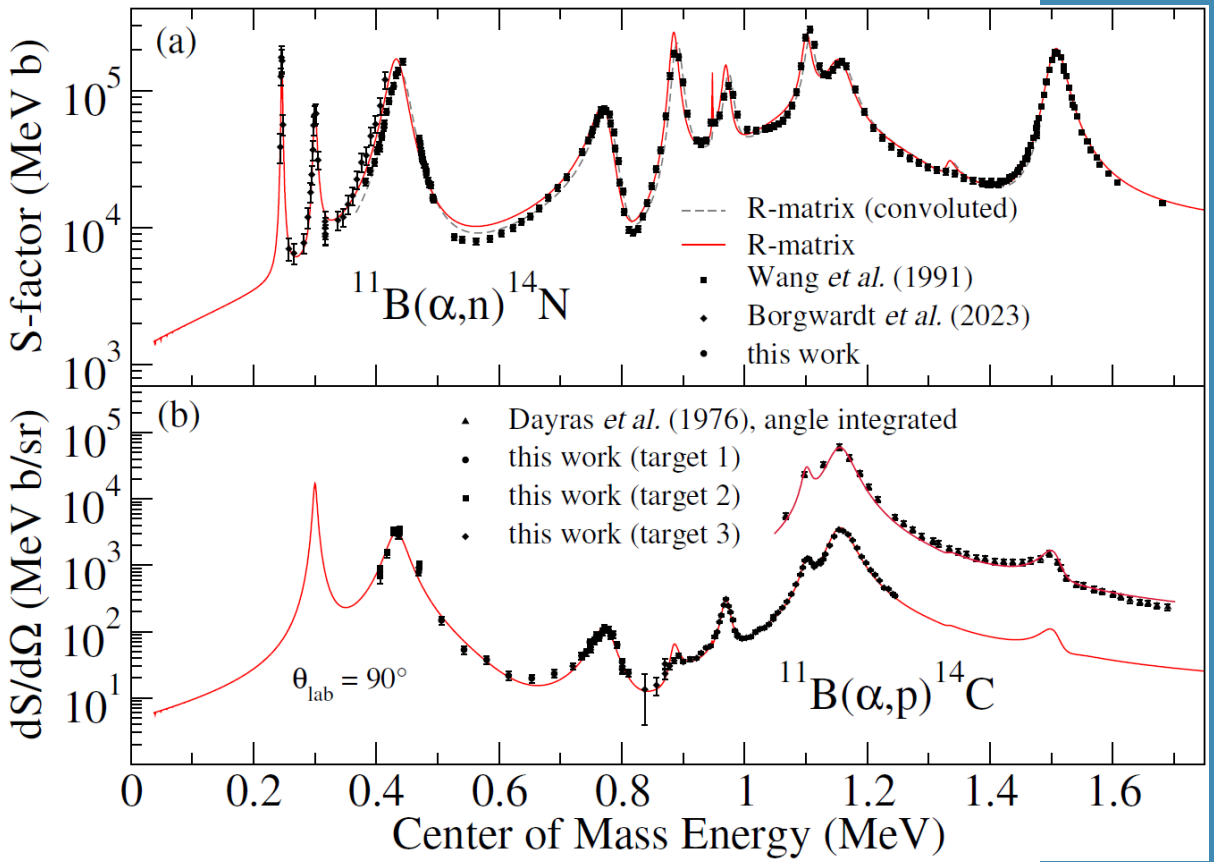
- Implementation of
  - Automated energy shifting of data sets in fitting
  - Energy dependent convolution (for time-of-flight resolution)
  - Built in calculation of total reaction cross section (sum of arbitrary reaction channels
  - Increased speed in calculations
  - Improved handling of Coulomb functions near thresholds (from SAMMY)
    - Thanks to Doro and Marco!

- **All of these improvements have been done by Jakub!**

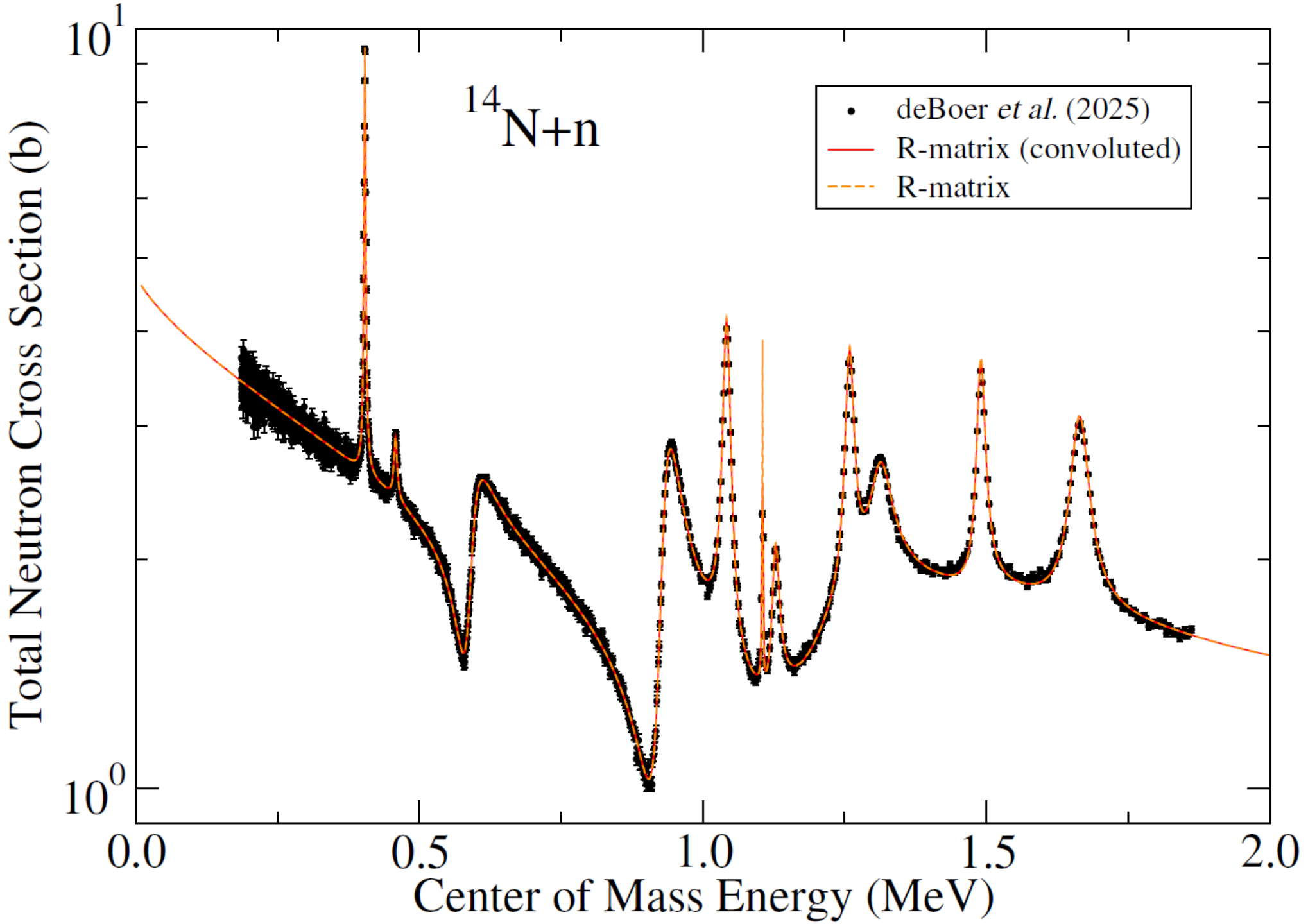
2020



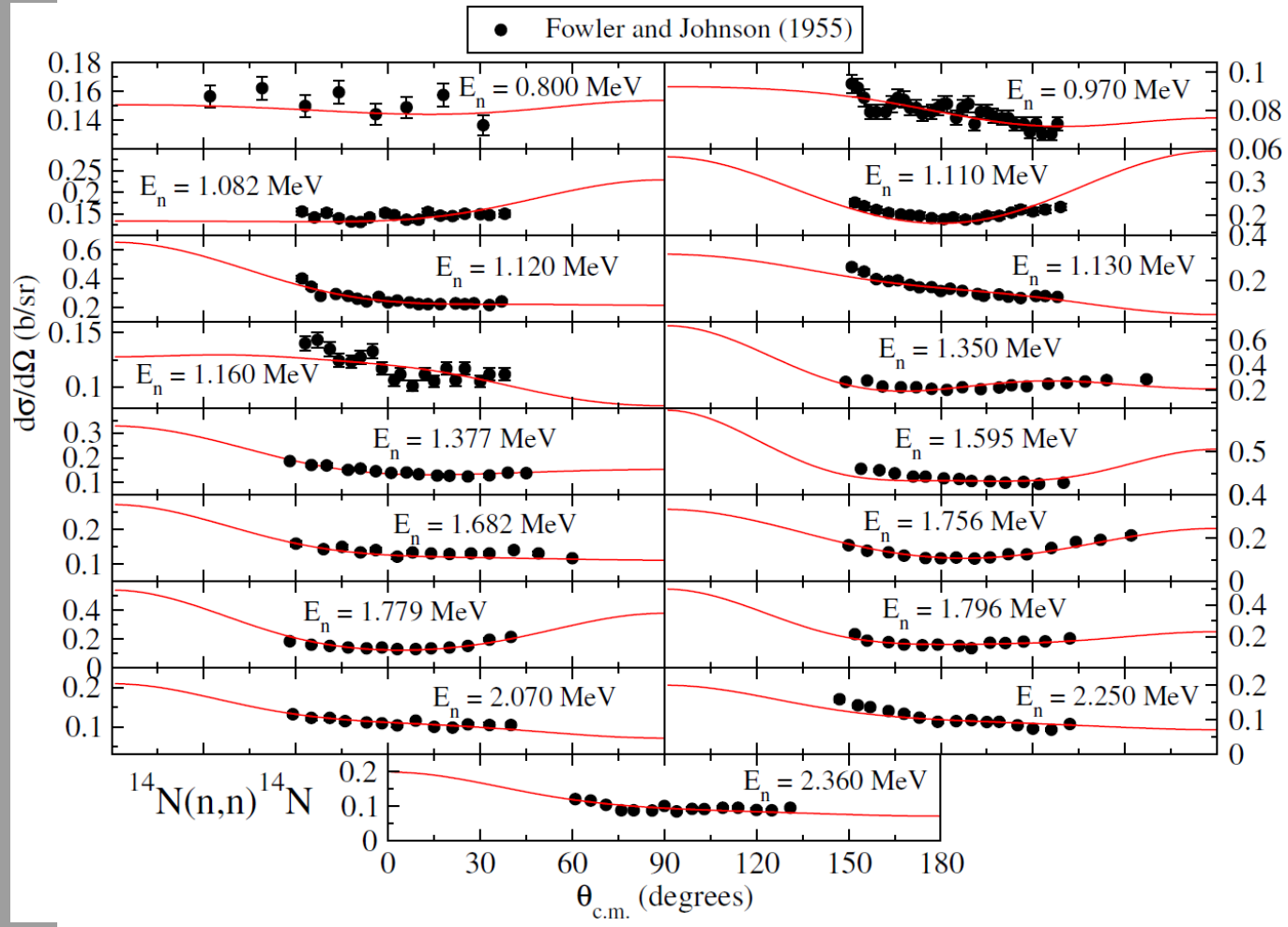
2025

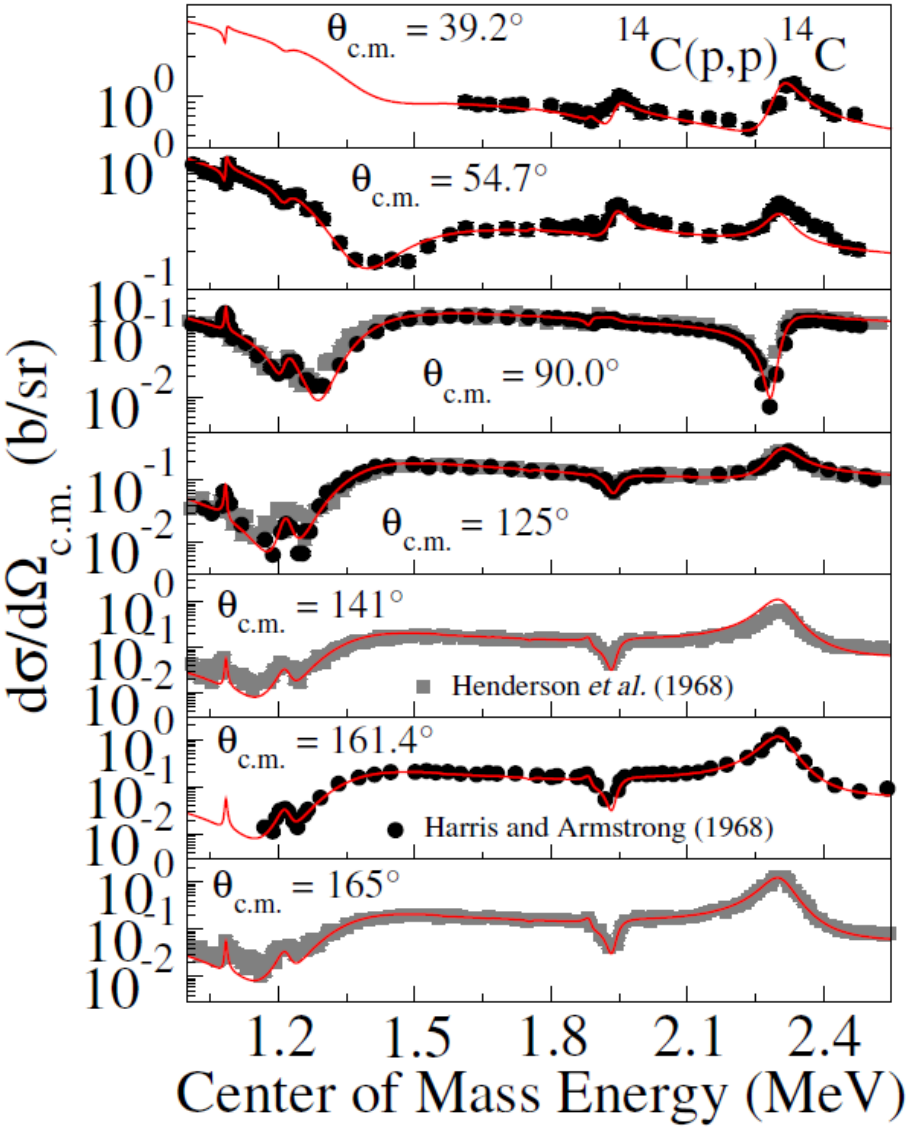


- Much improved fit, but still not as good as I would like it
  - Still some issues with the level structure?
  - Corrections to ^{11}B(α,n)^{14}N data due to detector response and angular distribution of outgoing neutrons?

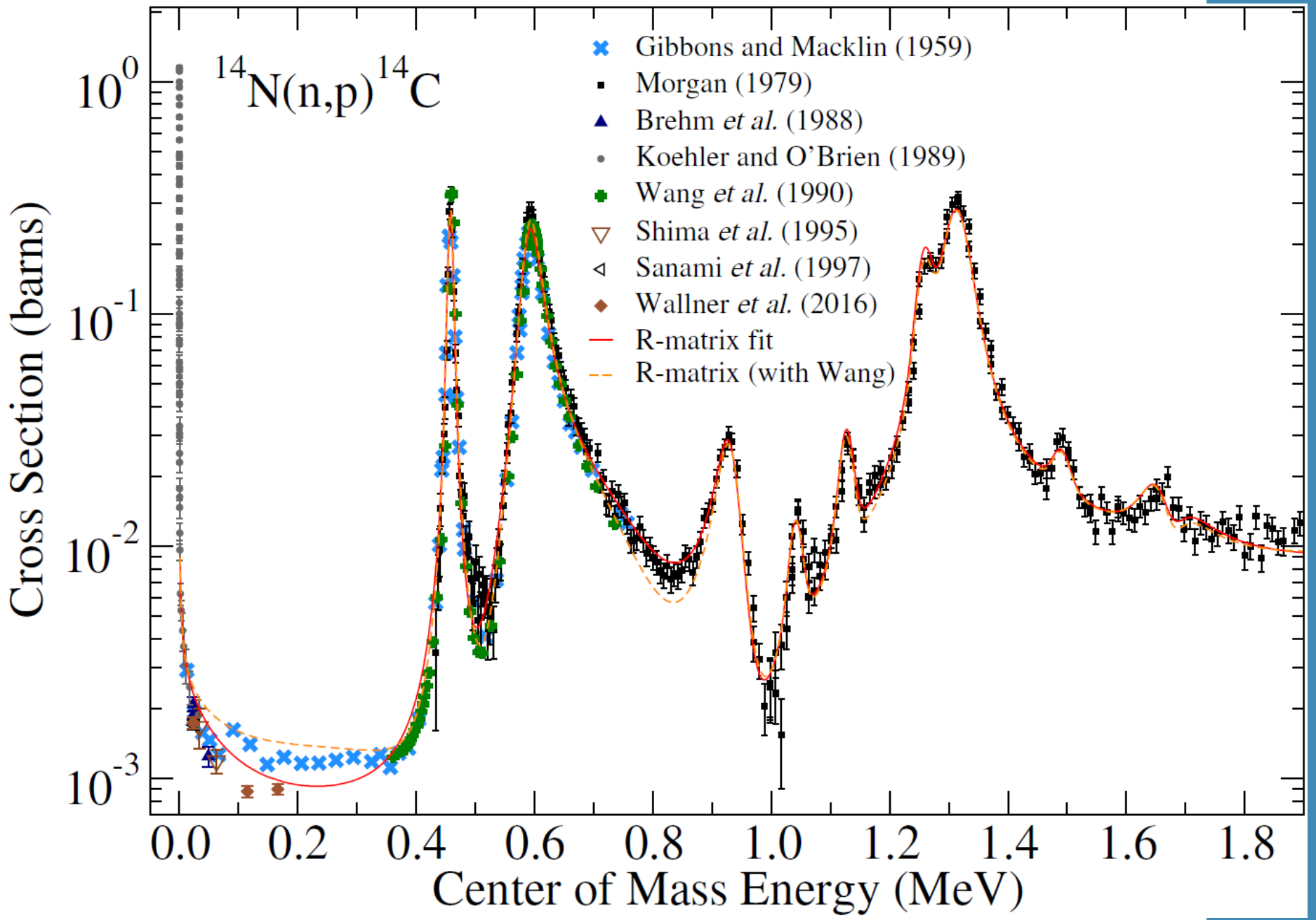

^{14}N+n
deBoer *et al.* (2025)
R-matrix (convoluted)
R-matrix
Total Neutron Cross Section (b)
Center of Mass Energy (MeV)
10^1
10^0
0.0
0.5
1.0
1.5
2.0

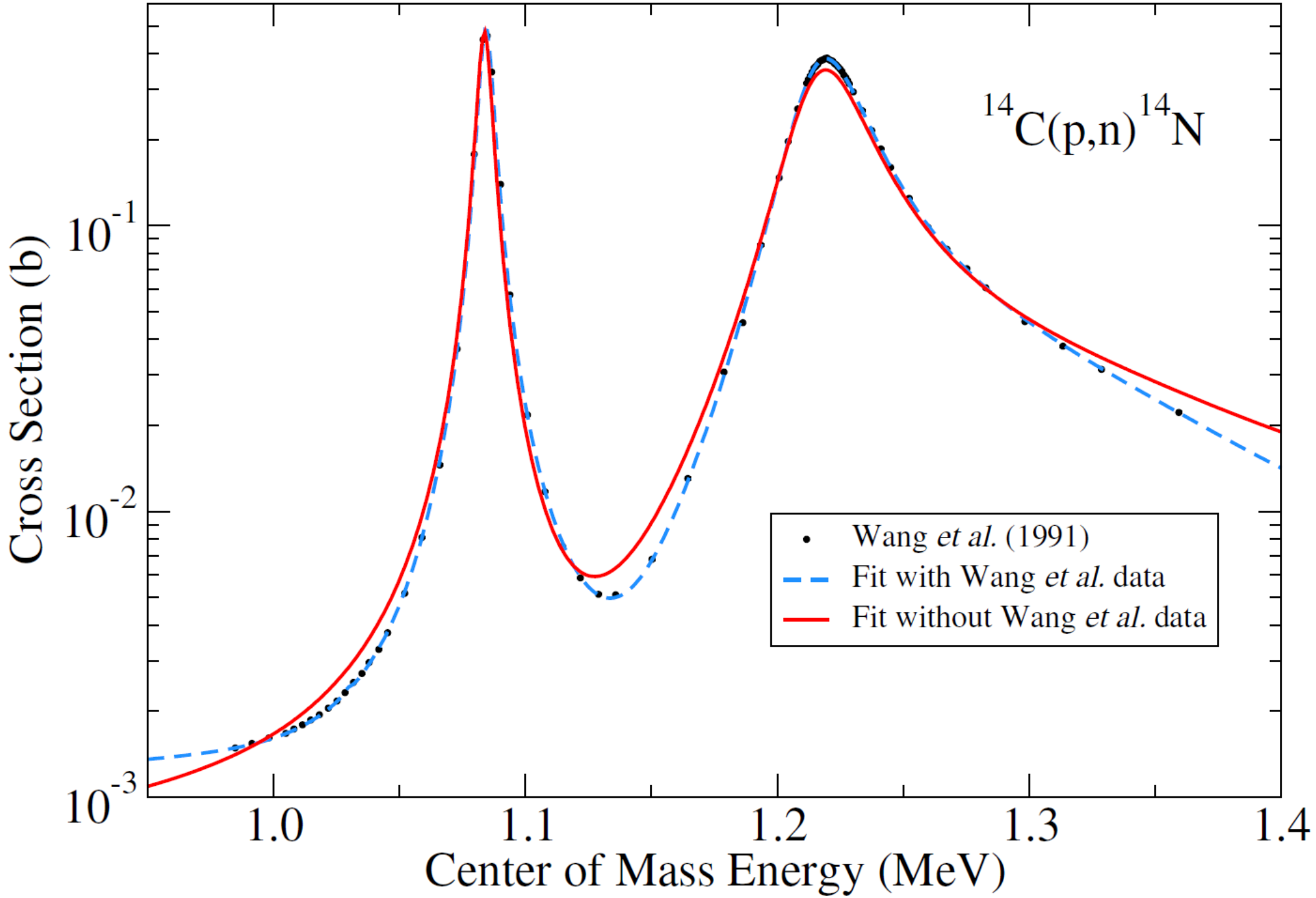
Other reaction channels



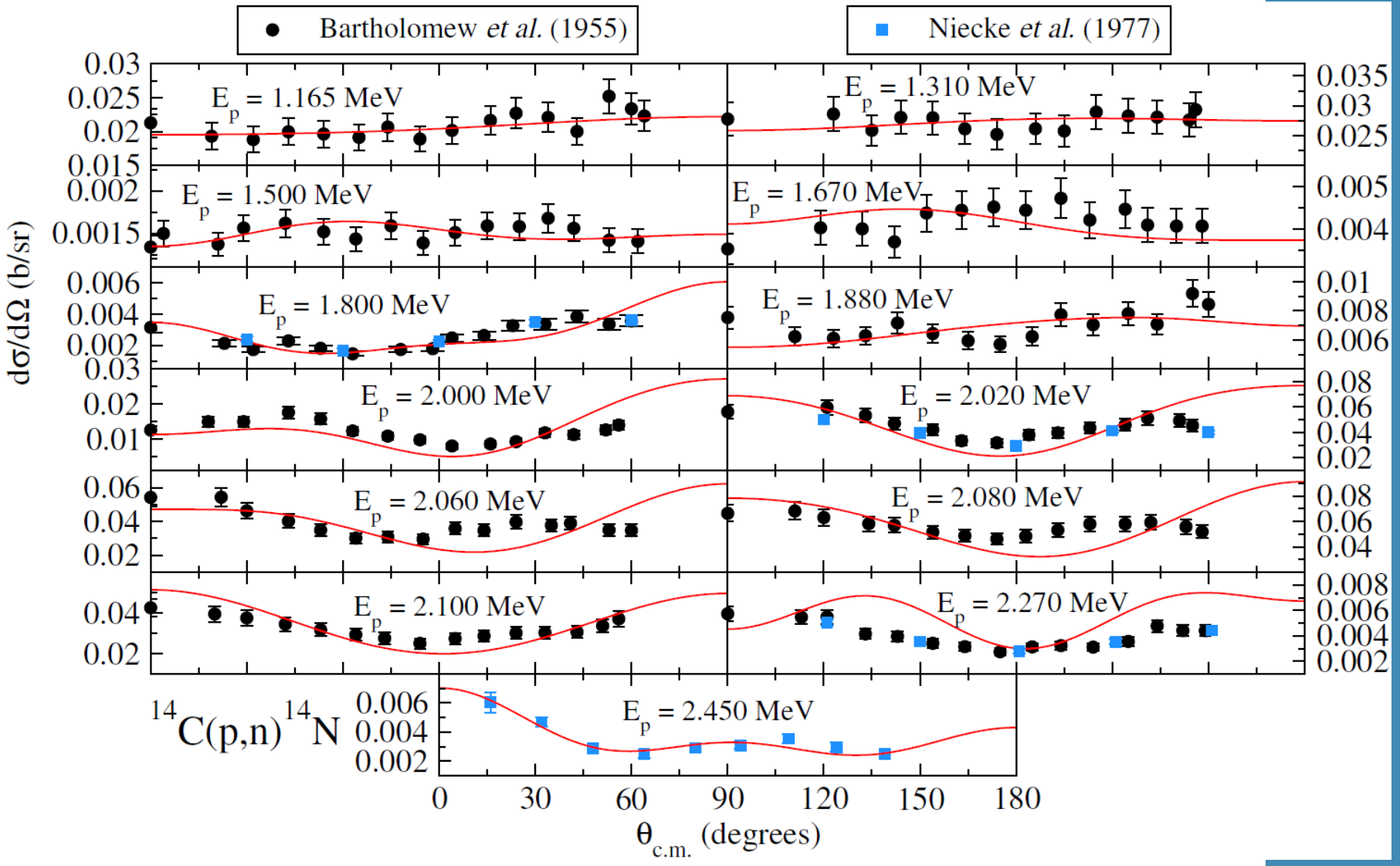


- Low energy issue with the fit
  - Red solid line is with all data except Wang's (p,n) data
  - Orange dashed line is with Wang's data



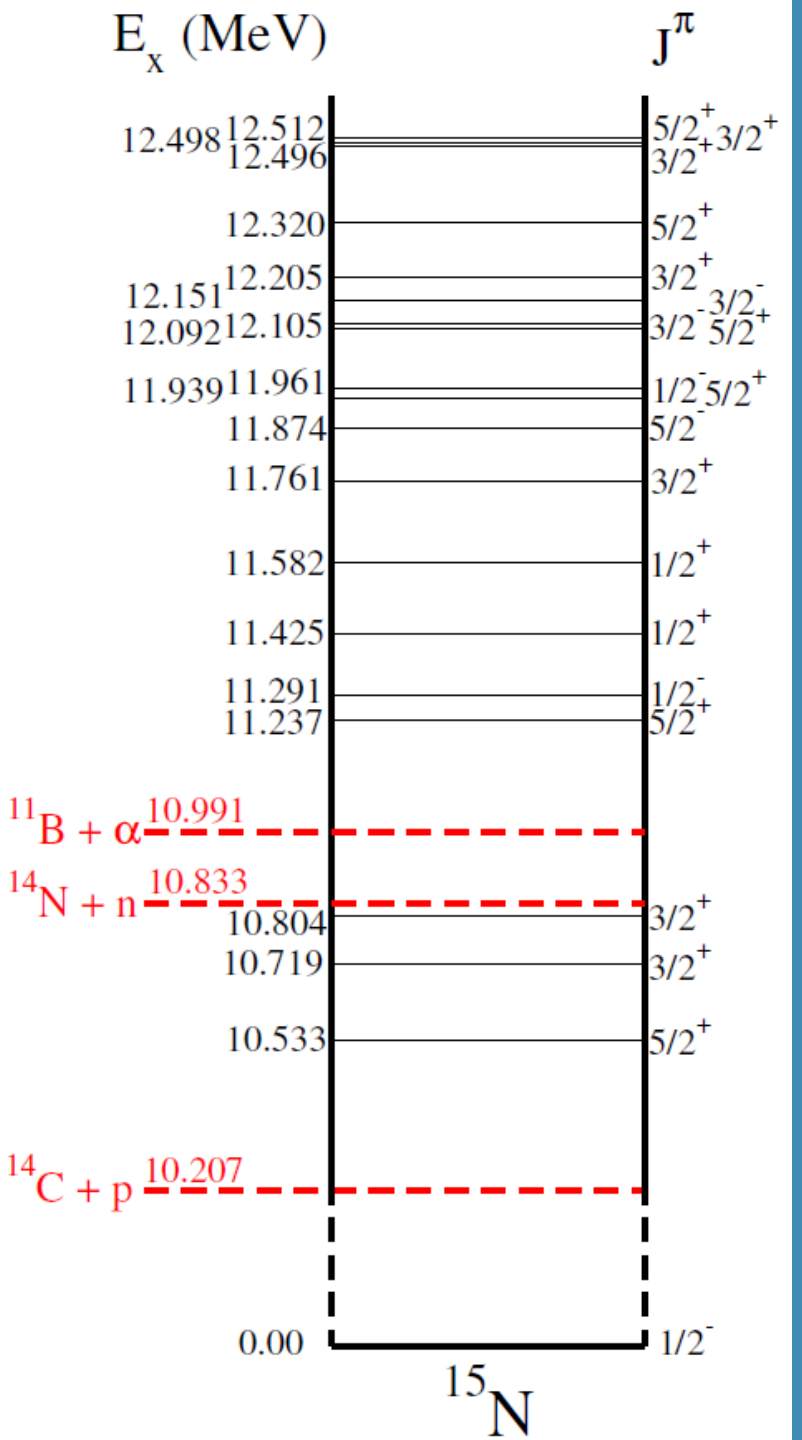

$^{14}C(p,n)^{14}N$
Cross Section (b)
10^{-1}
10^{-2}
10^{-3}
1.0
1.1
1.2
1.3
1.4
Center of Mass Energy (MeV)
Wang *et al.* (1991)
Fit with Wang *et al.* data
Fit without Wang *et al.* data

- Fits to (p,n) angular distributions are OK, but not great
- Not sure what the reason for these issues are yet



Expanded energy range

- Mostly dominated by narrow(ish) resolved resonances, but there seem to be at least 2 broad (100's of keV width) levels
- One is a 1/2+ level at 11.582 MeV that is easy to see in the 14C(p,p) data and is also crucial for fitting the low energy 14C(p,n)14N data, the other is a 5/2+ at 12.320, although the energies are somewhat different than in Hale



Summary of improvements

- Fixing issue with Coulomb functions causing AZURE2 crashes near threshold made it much easier to implement target resolution functions (Jakub)
- Increase in code speed made implementing target resolution functions doable (Jakub). Implementing experimental resolutions resulted in a much more consistent fit overall
- Energy shifts implemented for each data set (Jakub)
- Can now include total cross sections directly (Jakub)
- Had a mistake in the spin-parity of one of the levels with a large width (Gerry's paper has it correct)

Issues still to investigate

- Normalizations are discrepant in some cases
  - (n,p) and (p,n)
    - Morgan: 1.20
    - Gibbons and Macklin: 1.61
    - Wang: 1.31
  - (α,n) and (n,α)
    - Wang: 1 (fixed)
    - ND: 0.75
    - Gabbard: 0.88
    - Van der Zwan (0 degrees): 0.77
    - Borgwardt: 1.56
  - (α,p)
    - Dayras: 1 (fixed)
    - ND: normalized to Dayras
  - (n,total)
    - deBoer: 1 (fixed)

Experimental collaborators on previous ND measurements

Writing up draft of paper now…

Low energy measurement of the $^{11}B(\alpha,n)^{14}N$ and $^{11}B(\alpha,p)^{14}C$ cross sections and multichannel R-matrix analysis

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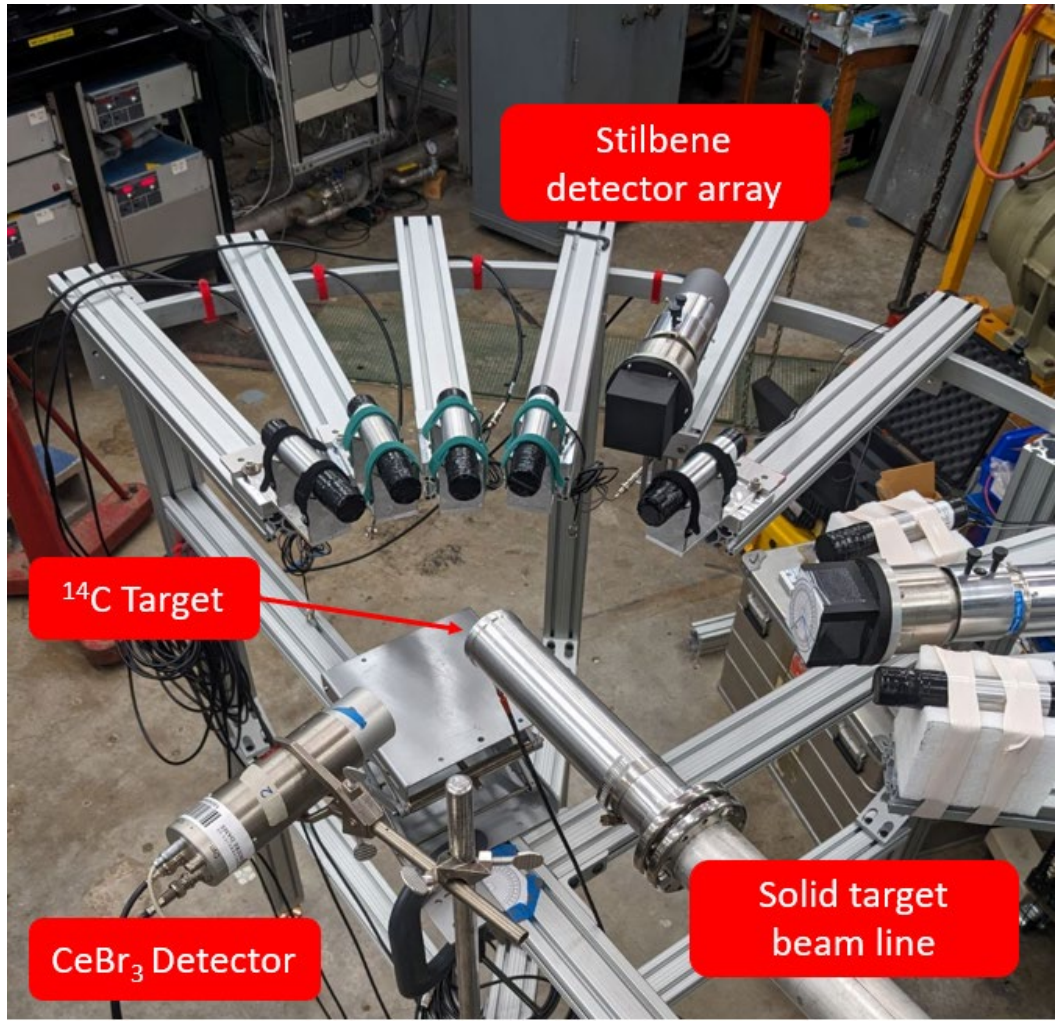
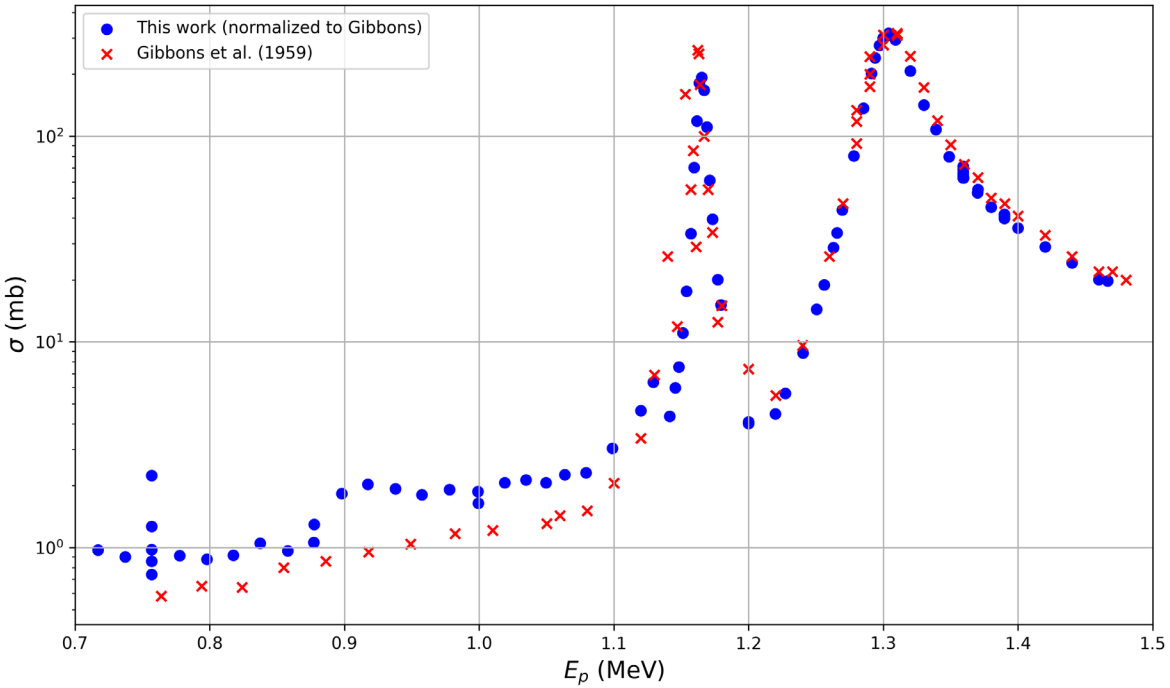
New $^{14}C(p,n)^{14}N$ measurements!



PhD project of Javier Rufino

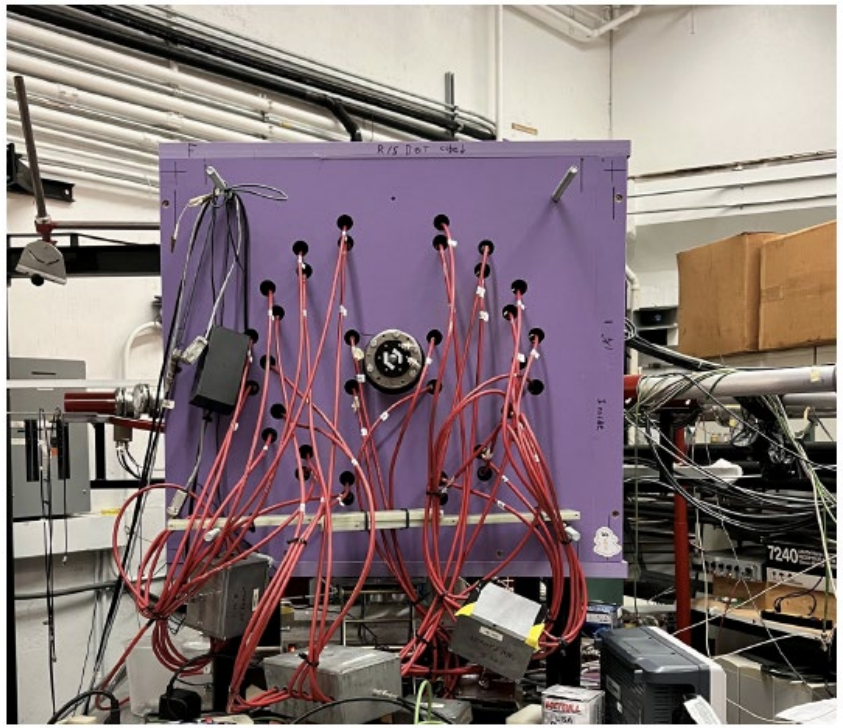
- Some online yields at zero degrees (several corrections needed to get to cross section still)
- At each energy point there are 9 angle differential cross sections



New $^{14}C(p,n)^{14}N$ measurements!

Postdoc project of Joseph Derkin

Measurements at Ohio University



(b) A picture of the HeBGB detector on the R65 beamline [5].

- Some online yields (several corrections needed to get to cross section still)
- Angle integrated cross section