

## Isotopic Evaluations for <sup>12,13</sup>C Based on R-matrix Analyses

G. M. Hale and M. W. Paris T-2 Los Alamos National Laboratory



LA-UR-16-22418

## Outline

- n+<sup>12</sup>C evaluation
  - Three-channel R-matrix analysis for E < 6.5 MeV</li>
  - Fits to the cross sections
  - Extension of the evaluation to higher energies
- n+<sup>13</sup>C evaluation
  - Single-channel R-matrix analysis for  $E \le 5 \text{ MeV}$
  - Fits to the total cross section
  - Capture cross section
- Elastic cross section for natural carbon (standard)
- Summary and outlook





# Analysis of Reactions in the <sup>13</sup>C System

	channel	l a <sub>c</sub> (fr		I <sub>max</sub>	
	n+ <sup>12</sup> C(0 <sup>+</sup> )	4.6		4	
	n+ <sup>12</sup> C*(2+)	5.0		1	
	γ+ <sup>13</sup> C	50		1	
Reaction	Energies (MeV)		# data points		Data types
<sup>12</sup> C(n,n) <sup>12</sup> C	$E_n = 0 - 6.45$		6940		$σ_{T}, \sigma(\theta), A_{n}(\theta)$
<sup>12</sup> C(n,n') <sup>12</sup> C*	E <sub>n</sub> = 5.3 –	443		$\sigma_{int}$ , $\sigma(\theta)$	
<sup>12</sup> C(n,γ) <sup>13</sup> C	$E_n = 0 - 0.$	7		$\sigma_{int}$	
total	4994	7	390	5	

 $\chi^2$  per degree of freedom = 1.54

## n+12C Total Cross Section



## n+12C Inelastic Cross Section



Operated by Los Alamos National Security, LLC for the U.S. Department of Energy's NNSA Slid

# <sup>12</sup>C(n,γ)<sup>13</sup>C Cross Section





# Analysis of Reactions in the <sup>14</sup>C System

	channel	a <sub>c</sub> (fm)		I <sub>max</sub>		
	n+ <sup>13</sup> C	3.6	5	3		
Reaction	Energies (MeV)		# data points		Data types	
<sup>13</sup> C(n,n) <sup>13</sup> C	$E_{n} = 0 - 5$		2530		σ <sub>T</sub> , σ(θ)	
total	2274		2530		2	

 $\chi^2$  per degree of freedom = 2.34



#### n+<sup>13</sup>C Total Cross Section





#### n+<sup>13</sup>C Cross Sections



#### **Elastic Cross Section for Natural Carbon**





# **Summary and Outlook**

- EDA analysis of the <sup>13</sup>C system includes data from all possible reactions, giving results that are highly constrained by unitarity.
- More channels are being added to the <sup>14</sup>C analysis as we extend it to higher energies (~11 MeV). Above the highest energy of the analysis, we plan to merge with the existing evaluation in the TENDL file.
- The <sup>12,13</sup>C(n,γ) cross sections have been improved, and give better agreement with the MACS in the KADoNIS data base (J.-C. Sublet).
- The elastic scattering cross section for natural carbon is ≤ 2% larger than in ENDF/B VII.1 below 1.8 MeV. That difference exceeds the maximum estimated uncertainty (0.6%) of the standard cross section at the upper end of its energy range.

