Connecting *Ab Initio* Theory to Reaction Data

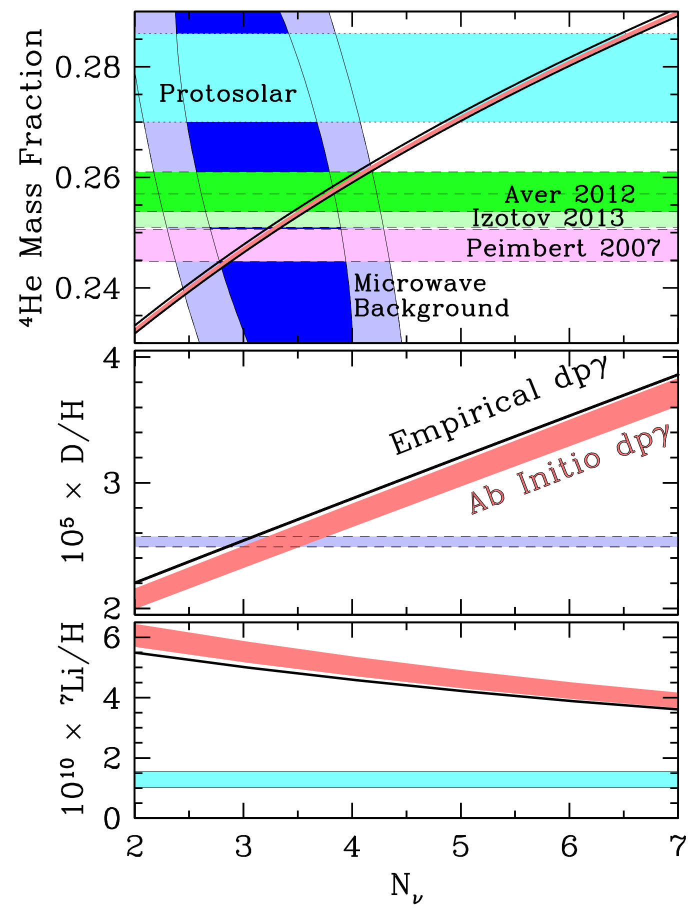
Reaction properties provide different windows on nuclear interaction & structure than discrete-state properties (e.g., "unnatural" parity & small components)

They also determine timescales & nucleosynthetic yields in astrophysics

BOTH understanding AND data-fitting require multiple theoretical methods, not just *ab initio*

Fully *ab initio* reaction models may be inefficient, unnecessarily difficult, hard to use & interpret

"Fewer-body" reaction models can connect irreducibly *ab initio* information to data with less computation



Percent-level precision is needed (e.g. to probe neutrino properties) for big bang & the solar interior, & for strong tests of nuclear models

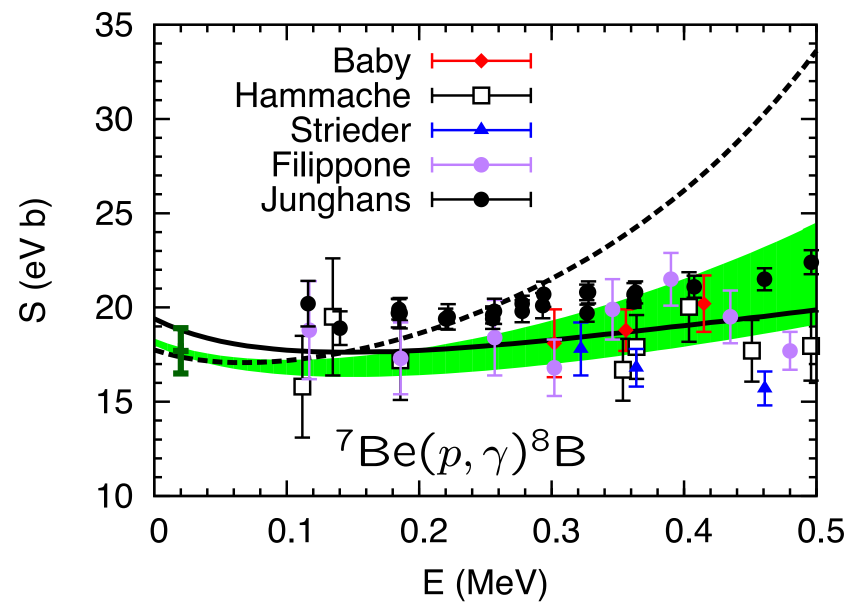
The Situation Today

Astrophysics often settles for poorly constrained “non-models:” polynomial S-factors, δ-function resonances,...

Theory without nucleon-level input can include real physics & interpret data (Woods-Saxon, halo EFT, fitted R-matrix,...); constraints are often weak

Nucleon-level models take much human & computer effort; then data test the method or provide inconsistent fitting constraints (typically rescaling)

Ab initio tests data in at least one case already: $d(p,\gamma)^3$He at big bang energies



Interpretation of transfer reactions so far artificially & inconsistently separates “structure” & “reaction” information

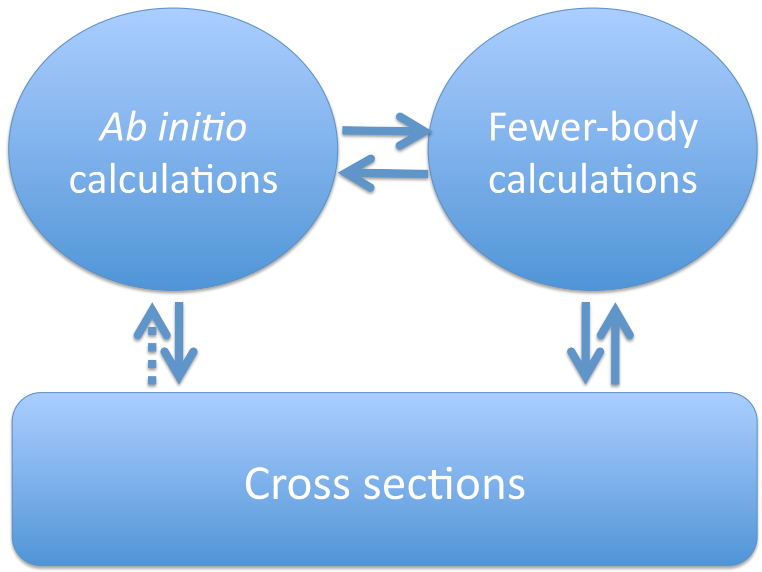
Work has begun to combine data, *ab initio* calculations, & “fewer-body” theory more consistently (e.g., halo EFT with experimental & *ab initio* inputs)

Where Work Is Needed

For **fitting**, new methods must combine the best *ab initio* & empirical information about the same reaction (weighting? tweaking? modified interactions?)

For precise **predictions**, new theory methods must identify crucial, highly constraining inputs (experimental & *ab initio*) & use them self-consistently

Ab initio calculations of “exotic” quantities (ANCs, halo EFT couplings,...) in new reaction models will be needed



Experimental interpretation, interaction constraints, computational efficiency, & astrophysical & fundamental-symmetry applications will all benefit

Students & postdocs need deep exposure to multiple theoretical & experimental methods during education so they can exploit connections later

Collaborations across specializations can help bridge the gaps & train junior researchers to see across them