Working Group 7 introduction, theory/fitting aspects

^{3}He$(\alpha,\gamma)^7$Be and ^{3}He$(^3$He$,2p)^4$He

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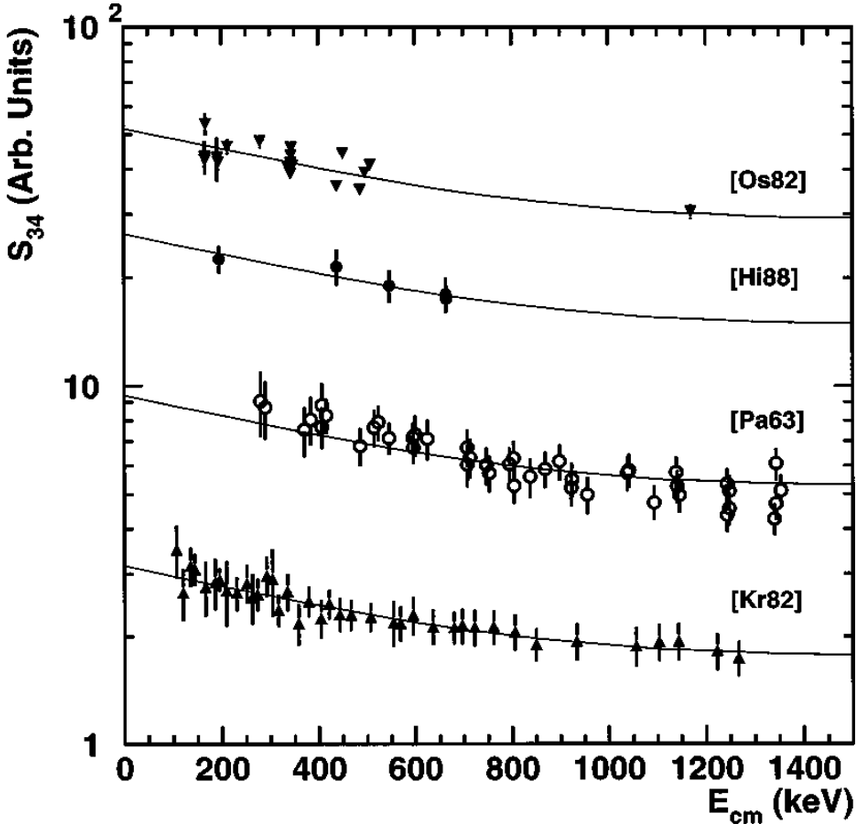
Remembrance of evaluations past

How S_{34} theory was handled before

Solar Fusion I:

Tombrello & Parker 1963 model



Each data set used to fit an overall rescaling of theory curve

Then $S(0)$ values averaged – discrepancy between prompt & activity?

Mistook 2.8 fm hard sphere radius that describes scattering as a good small-radius cutoff

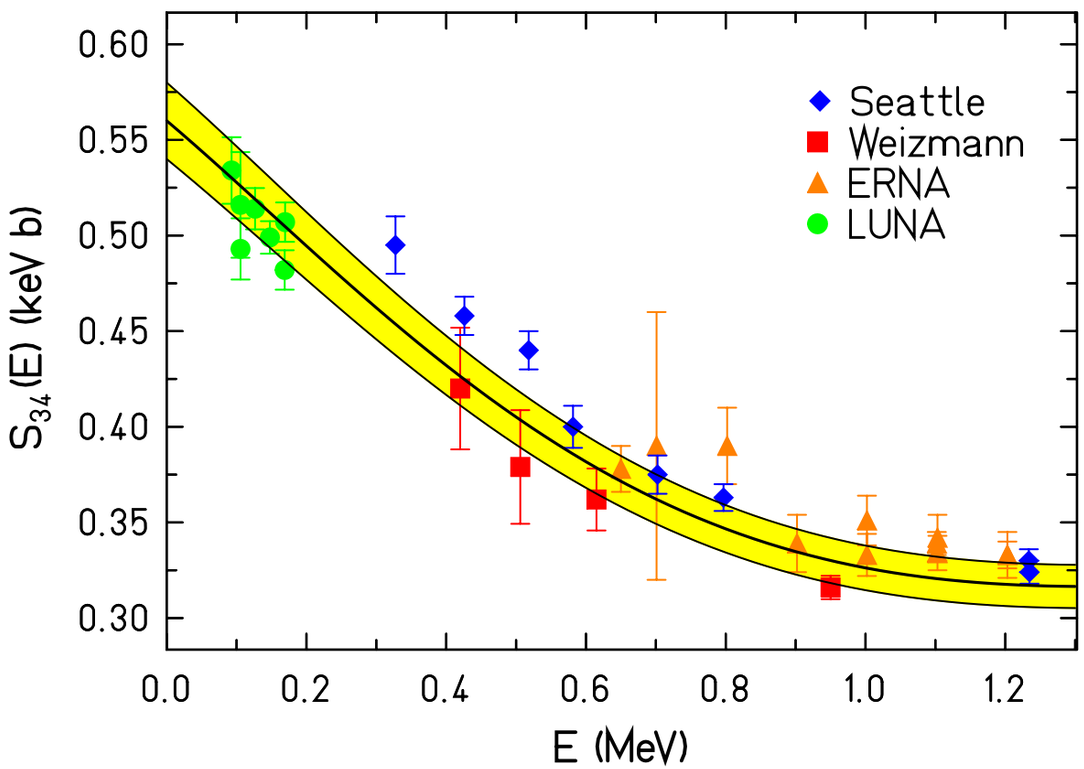
Overestimated s/d-wave ratio, flat at higher E

Remembrance of evaluations past

How S_{34} theory was handled before

Solar Fusion II:

Kajino 1986 & Nollett 2001 models



Similar fitting procedure (but parameterizing models was bad)

This time models were more physical

Models with even a little microscopic content cut off short-range s-wave capture at $\gtrsim$ 5 fm

Nice demonstration of that in Neff 2011 calculation

Substantially same results for Kajino/Nollett/Neff (cf. Iliadis et al. 2016)

Theory error:

Spread among RGM models + Snover/Nollett negotiation

Theory work since Solar Fusion II

Additional *ab initio* models:

Neff 2011, Dohet-Eraly 2016 (Vorabbi 2019)

RGM models:

Solovyev 2017, 2019 (looks unconverged at low energy – $S(E)$ flattens)

Potential models:

Tursunov 2018, 2021, Dubovichenko 2019

Halo EFT:

Higa 2018, Premarathna 2020, Zhang 2020

Fit/extrapolation work since Solar Fusion II

Model rescaling:

Iliadis 2016 (Bayesian)

Tursunov 2018, 2021, Dubovichenko 2019, Kiss 2020 (potential model, range of parameters)

R-matrix:

deBoer 2014 (frequentist), Odell 2022 (Bayesian)

Halo EFT:

Higa 2018, Premarathna 2020, Zhang 2020 (Bayesian, ~ 6 parameters + floated norms)

^{3}He$(\alpha,\gamma)^7$Be questions to be answered

Previous Solar Fusion:

- Very conservative
- Only capture data
- Only direct data
- Avoid correlations between datasets
- One model is a fixed shape
- Two models estimate theory error
- No new or complicated methods

Choices to make:

- Model with more adjustable parameters?
  (R-matrix? Halo EFT? Potential model?)
- Use scattering constraints directly? As test of models? Not at all?
- Fit multiple ways & compare?
- ANC on same footing as capture data?
  (Need to use in consistent model)
- How to improve theory error estimate?
  (More models? Adjustable-parameter models?)

Worth noticing:S' and S'' are different things for model derivatives at $E = 0$ & for fits over some range

Remembrance of evaluations past

Several old RGM models of $^3\mathrm{He}(^3\mathrm{He}, 2p)^4\mathrm{He}$ exist (reviewed in SF I, not much action since)

All kind of incomplete, but all predict very gentle $S(E)$, so polynomial fit isn't completely stupid

Model used for Solar Fusion I/II is $S(E) = S(0) + S'(0)E + \frac{1}{2}S''(0)E^2$, plus $\exp(\pi\eta U_e/E)$ lab screening

SFI assumed $U_e = 240$ eV

SFII fit $U_e = 305 \pm 90$ eV simultaneously with polynomial

Iliadis 2016: Bayesian fit to similar model with floating norms & possible "outlier" status, $U_e = 325^{+47}_{-48}$ eV
(different slope from different E range)

Whither ^{3}He(^{3}He, $2p$)^{4}He?

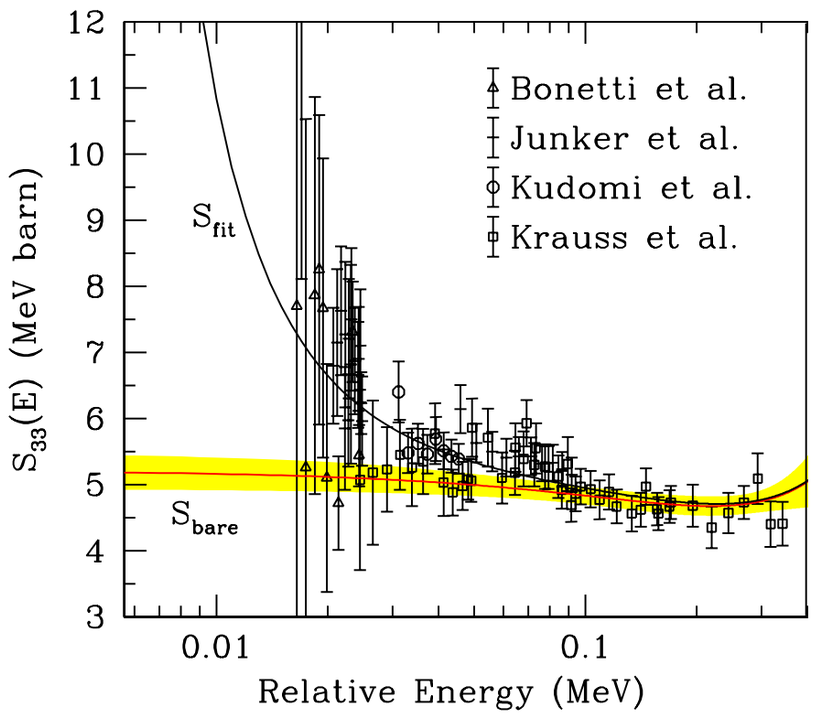
There are no new data to fit, & I didn't find any new theory developments

Main question is then: Can we improve on procedure? If yes, is there a consensus on how?

Not obvious to me how correlated errors were handled in SF II

Remove single-event data á la Iliadis 2016?

Anything we should recommend?
(Revisit theory? Inertial confinement for different screening?)



SLIDES FROM PRELIMINARY ZOOM MEETING

$^3\mathrm{He}(\alpha,\gamma)^7\mathrm{Be}$

New *ab initio*:

Neff (2011); Dohet-Eraly (2016); Vorabbi (2019)

New microsopic/RGM:

Solovyev (2017); Solovyev (2019)

New potential model:

Tursunov (2018); Dubovichenko (2019); Tursunov (2021)

Halo EFT, R-matrix, Bayesian, etc.:

Higa (2018); Premarathna (2020); Zhang (2020); Odell (2022); deBoer (2014); Iliadis (2016); [Poudel (2022)]

$^3\mathrm{He}(\alpha,\gamma)^7\mathrm{Be}$: Issues for fitting

Model selection (feasible to fit multiparameter model?)

- SF I&II just rescaled theory models
- Scaling found for each data set, then averaged
- Understanding of model determines E range of fit

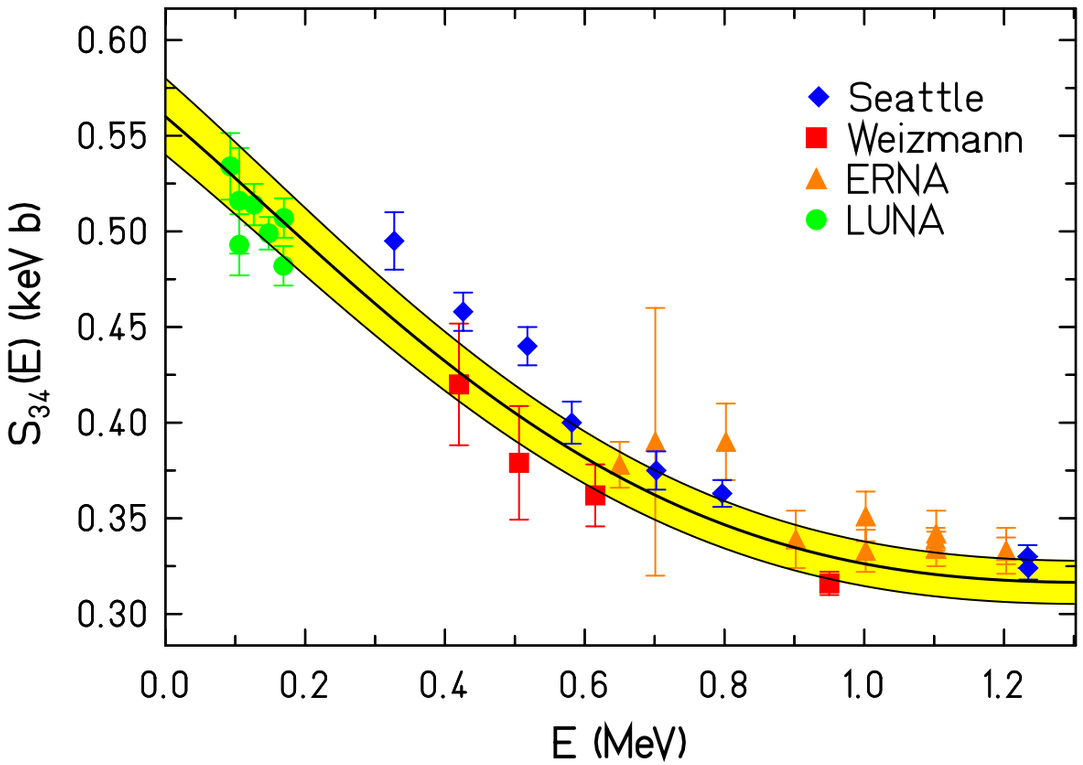
(How) should *ab initio* inputs be used?

Role of scattering data?

- "Must be this tall" test?
- Needs a formalism that can use them
- Barnard data appear to have problems (at least in error quantification)

How to use ANCs from transfer & scattering?

- Any role for mirror symmetry?



Personal prejudice: I would like to see see a less crude approach, and better quantification of theory error, this time

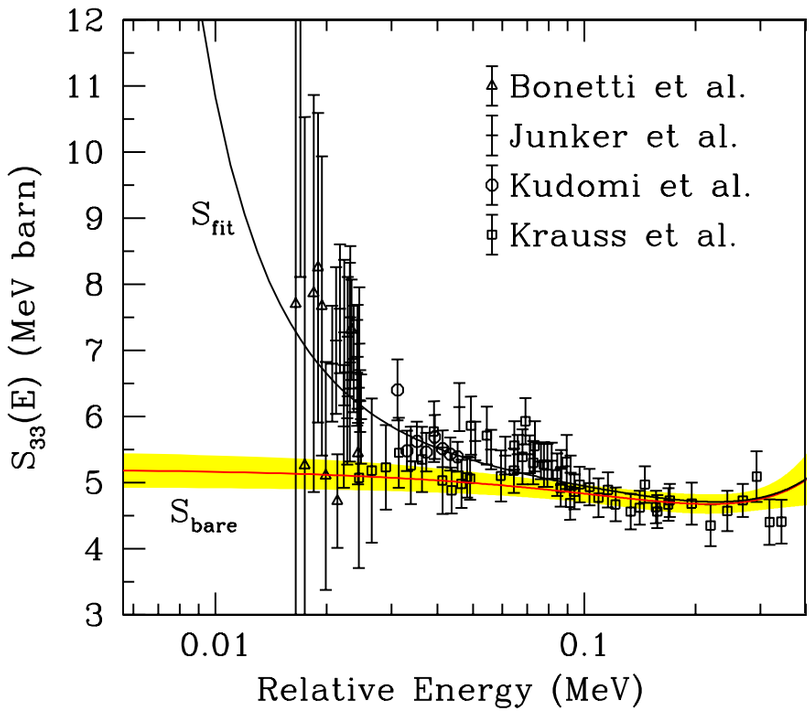
$^3\mathrm{He}(^3\mathrm{He}, 2p)^4\mathrm{He}$

Last time: Fitted $S(0)$, S', S'', U_{eff}

Only models are Typel (1991) RGM

New theory & fitting:

Nesterov (2010) 3-cluster RGM; Iliadis (2016) (adding 5 floating norms); anything else?



^{3}He(^{3}He, $2p$)^{4}He: Issues for fitting

Any progress on lab screening?

Should we aim to encourage ICF experiments?