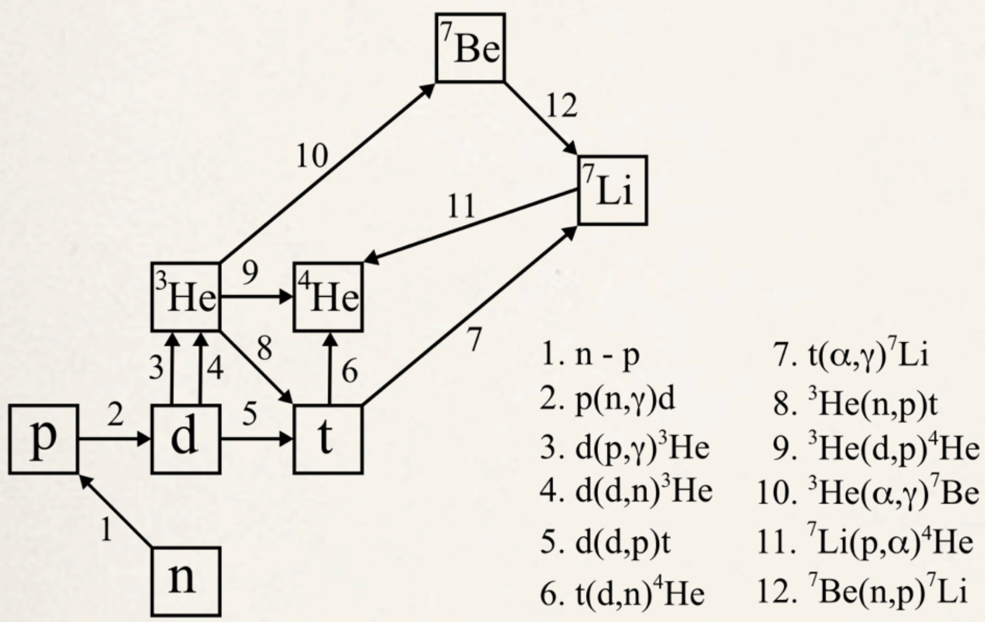
The $^3He(\alpha,\gamma)^7Be$ cross-section at astrophysical relevant energies

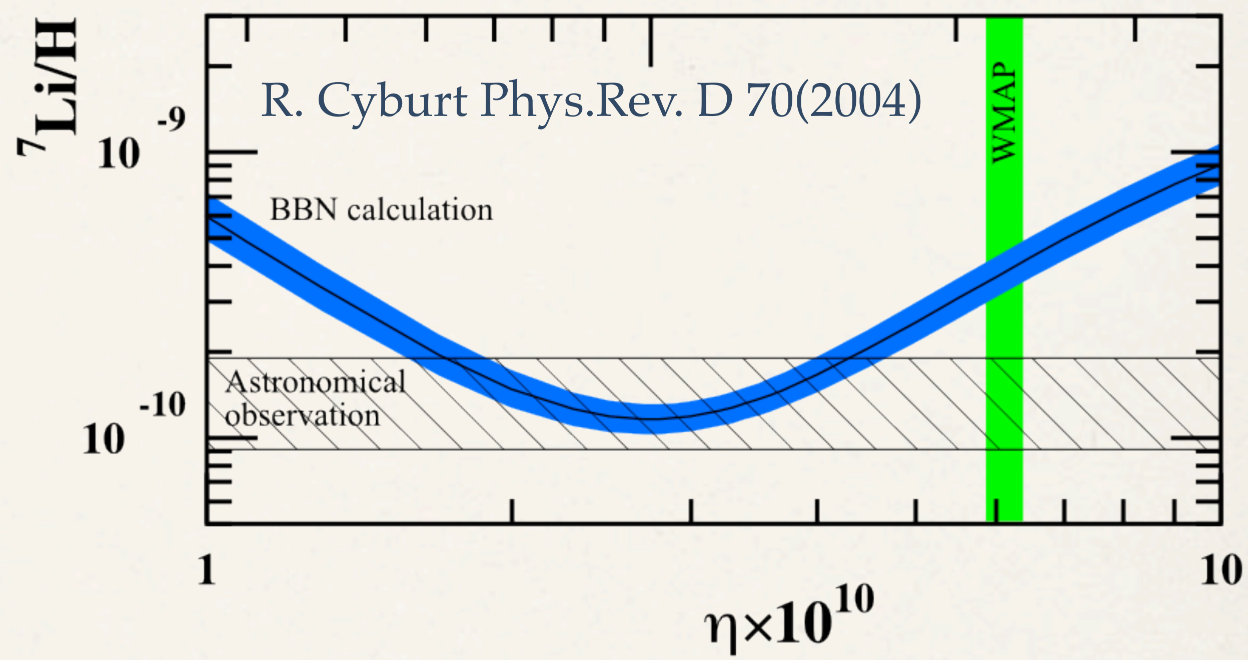
Antonino Di Leva

University of Naples and INFN Naples

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

BBN nuclear reaction network





^{3}He(α,γ)^{7}Be and astrophysics

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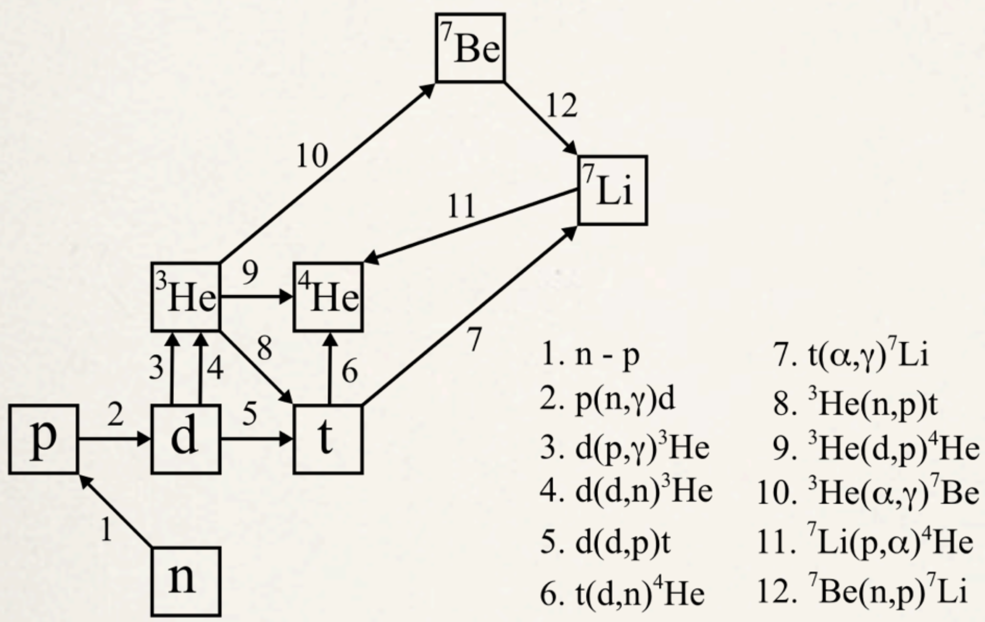
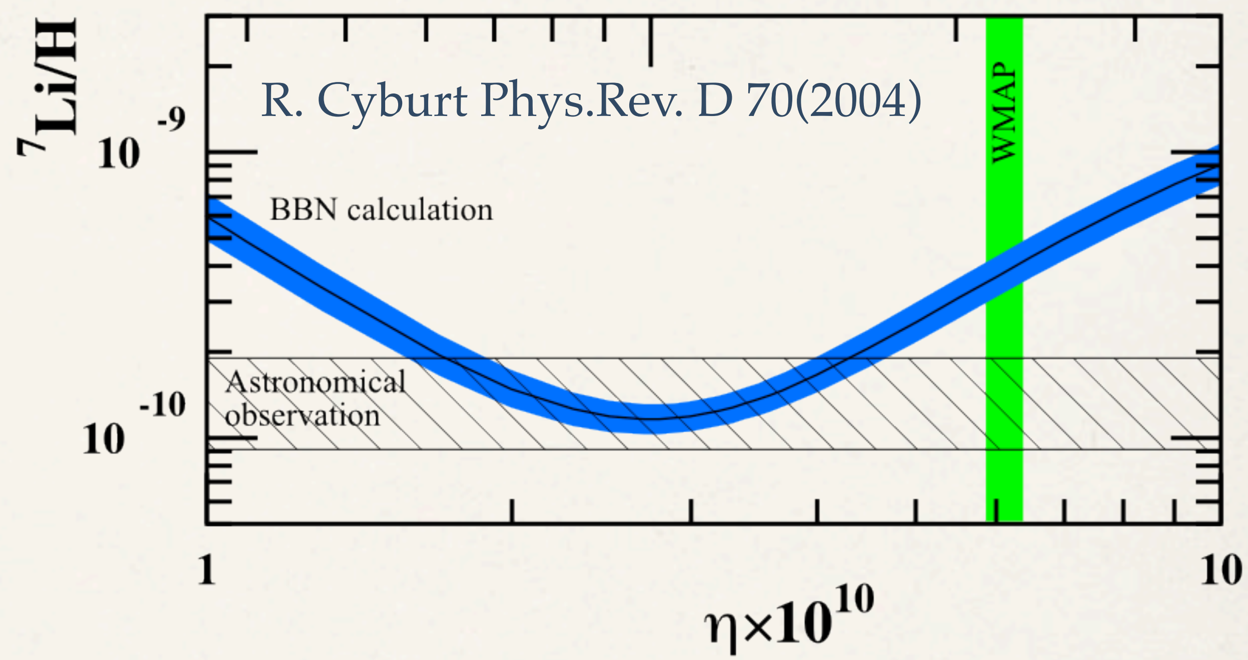
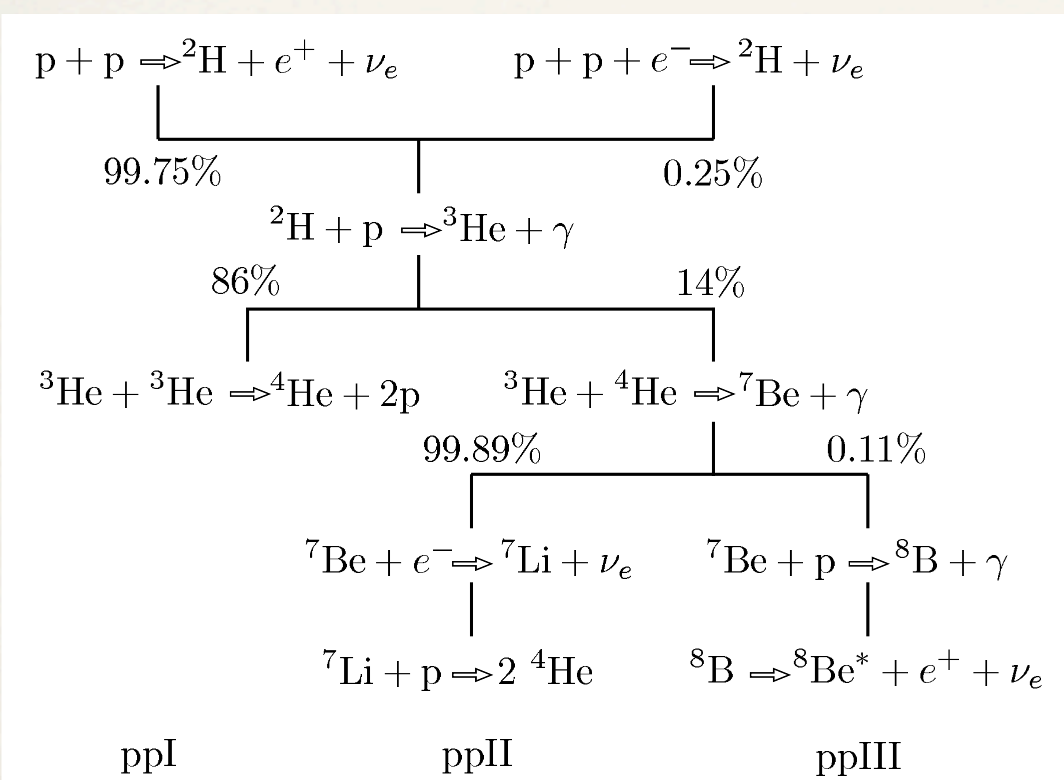
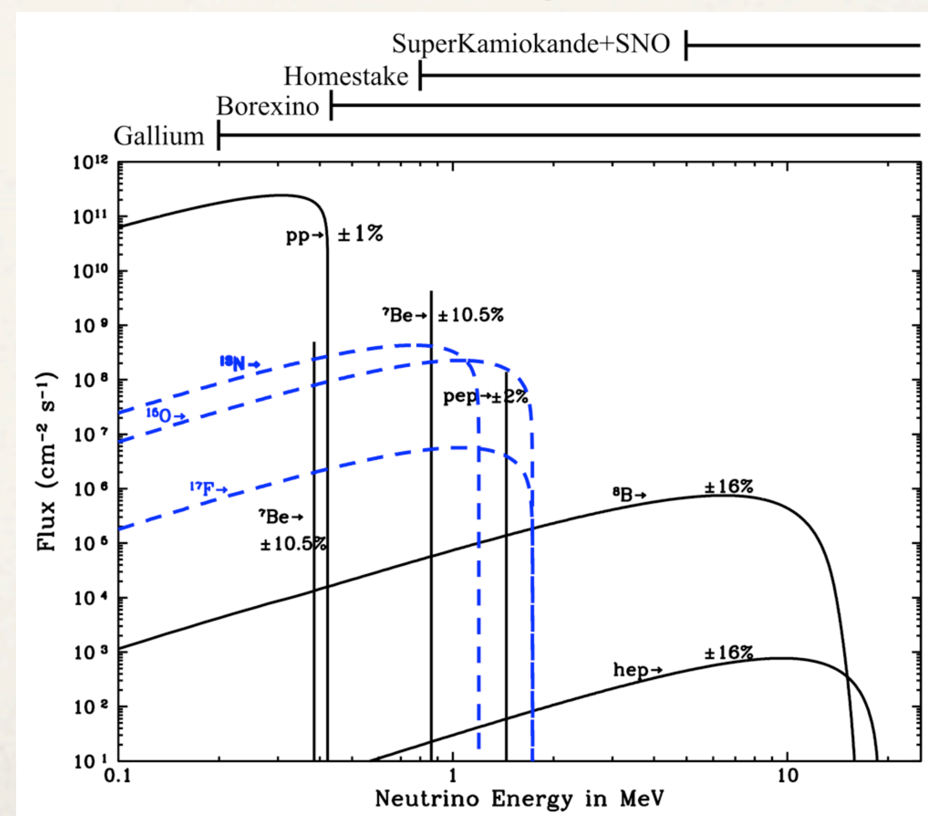


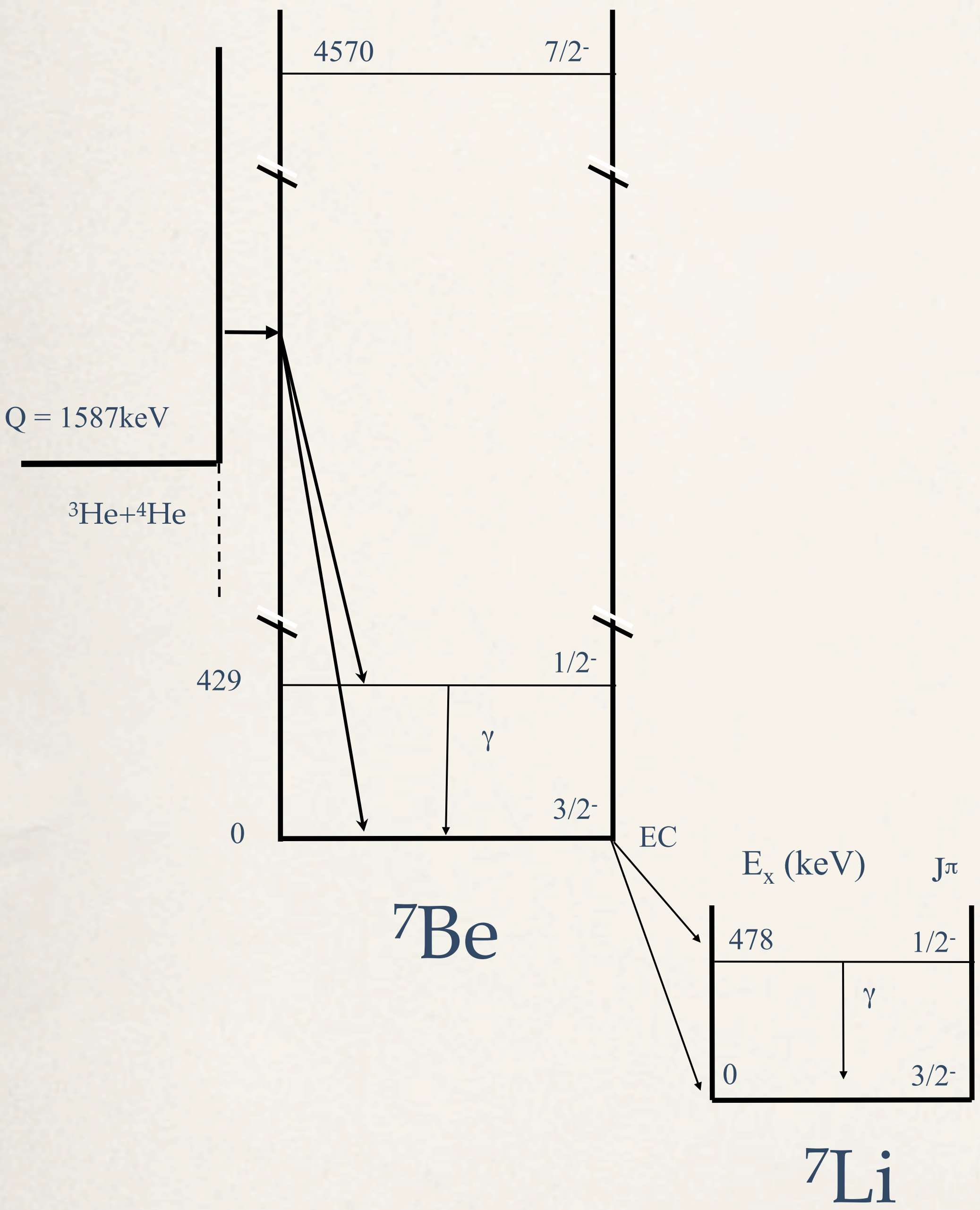




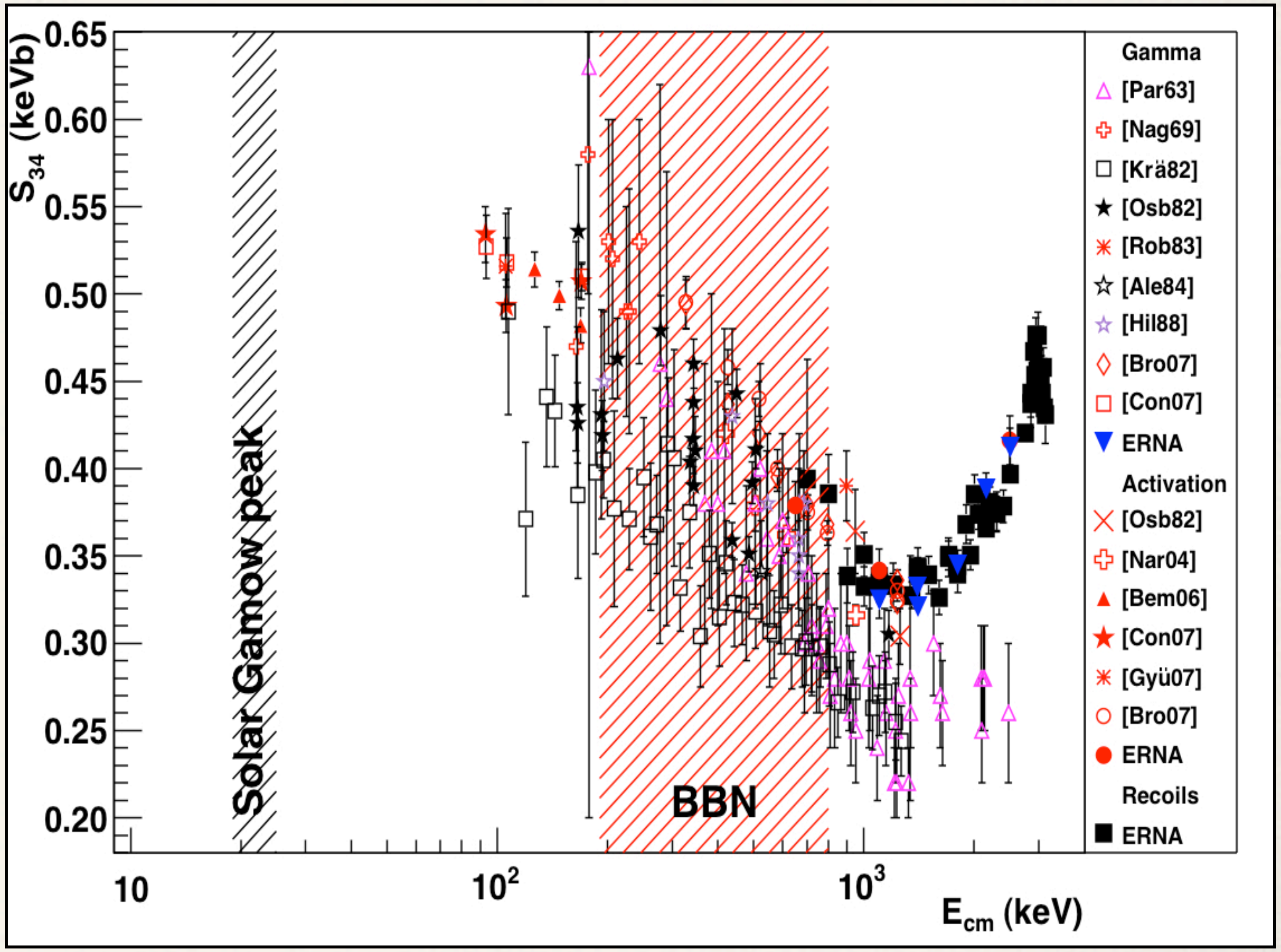


J.N. Bahcall et al ApJL 621(2005)L85

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



$^{3}He(\alpha,\gamma)^{7}Be(e,\nu)^{7}Li^{*}(\gamma)^{7}Li$



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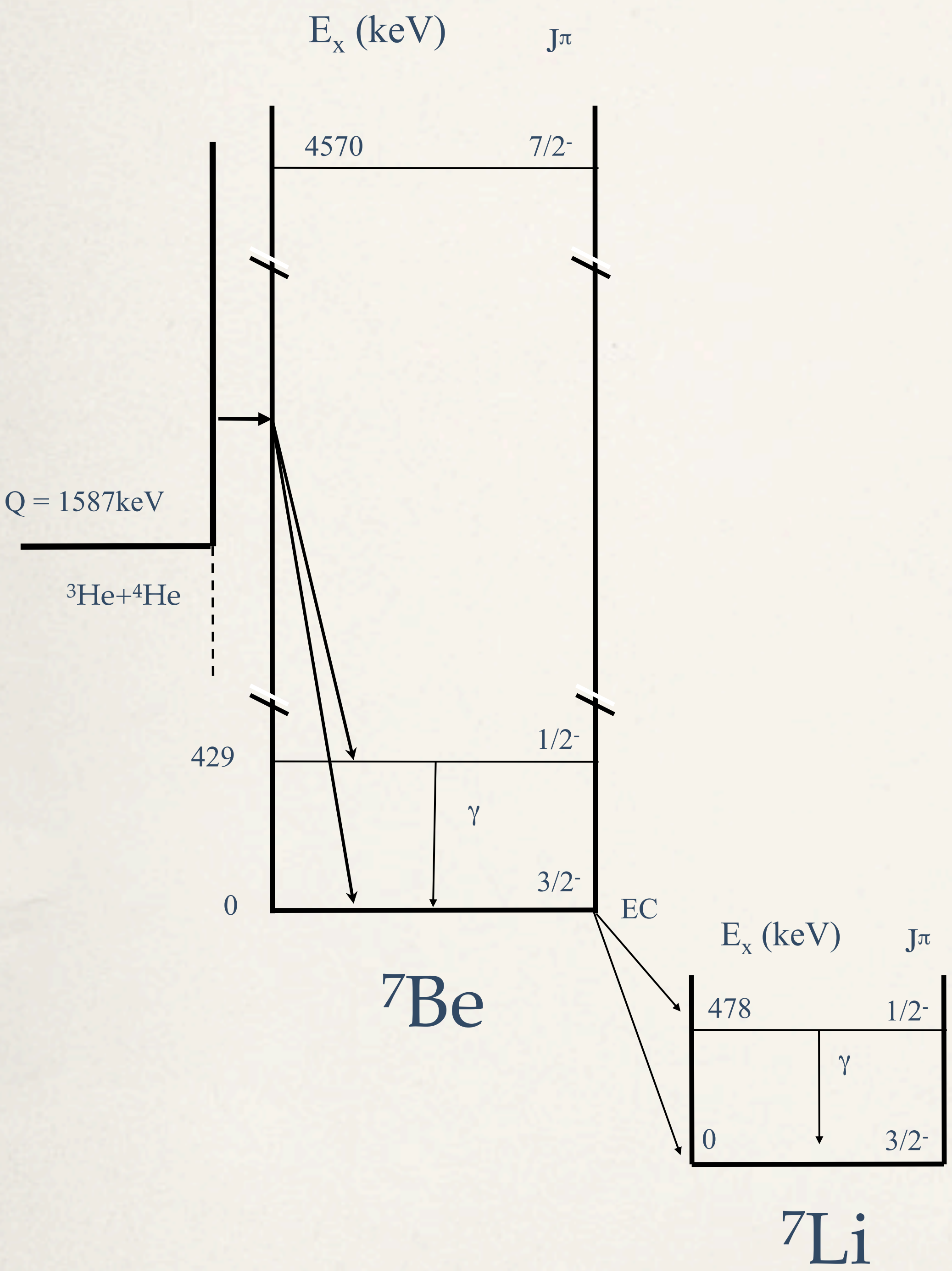

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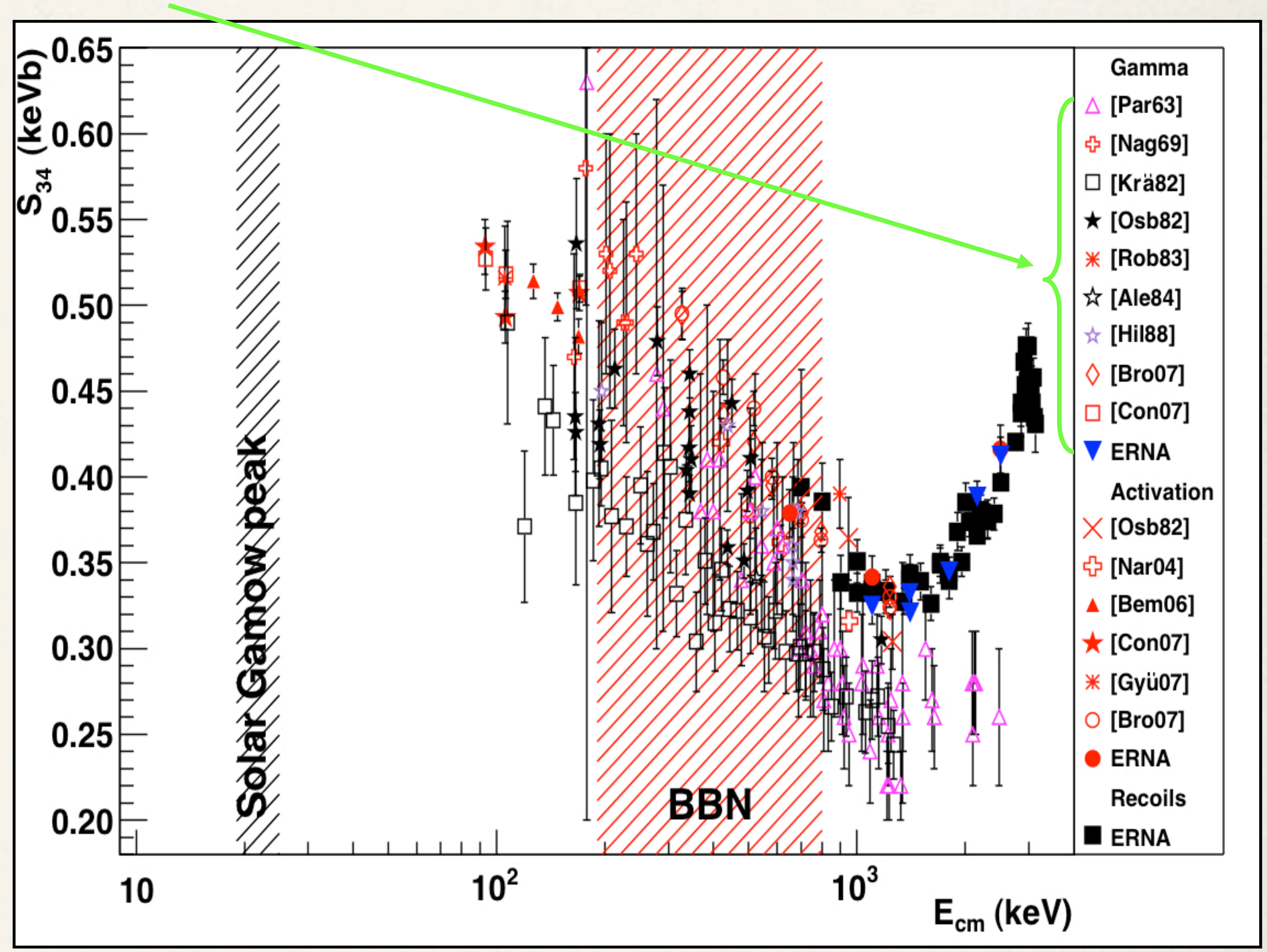

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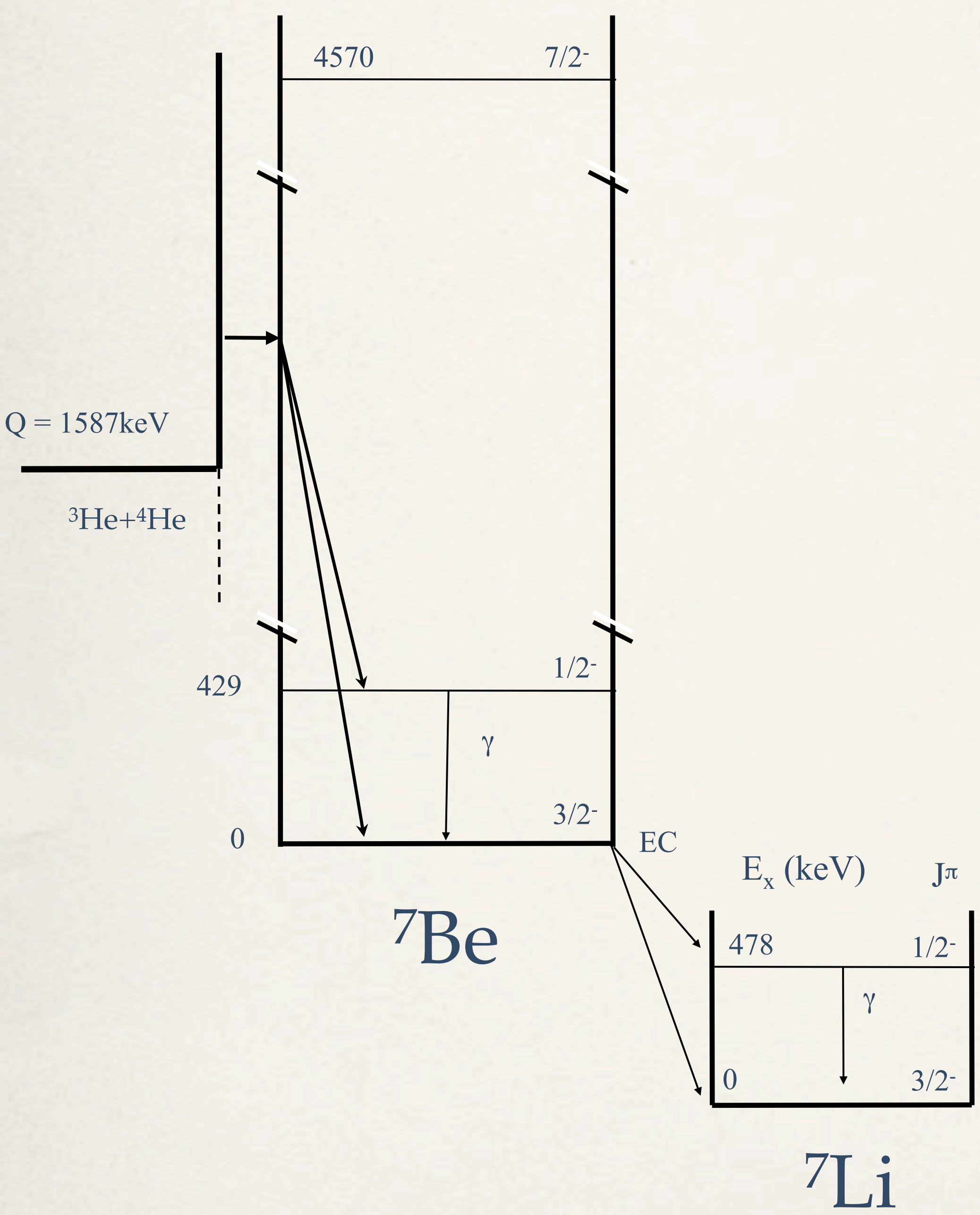

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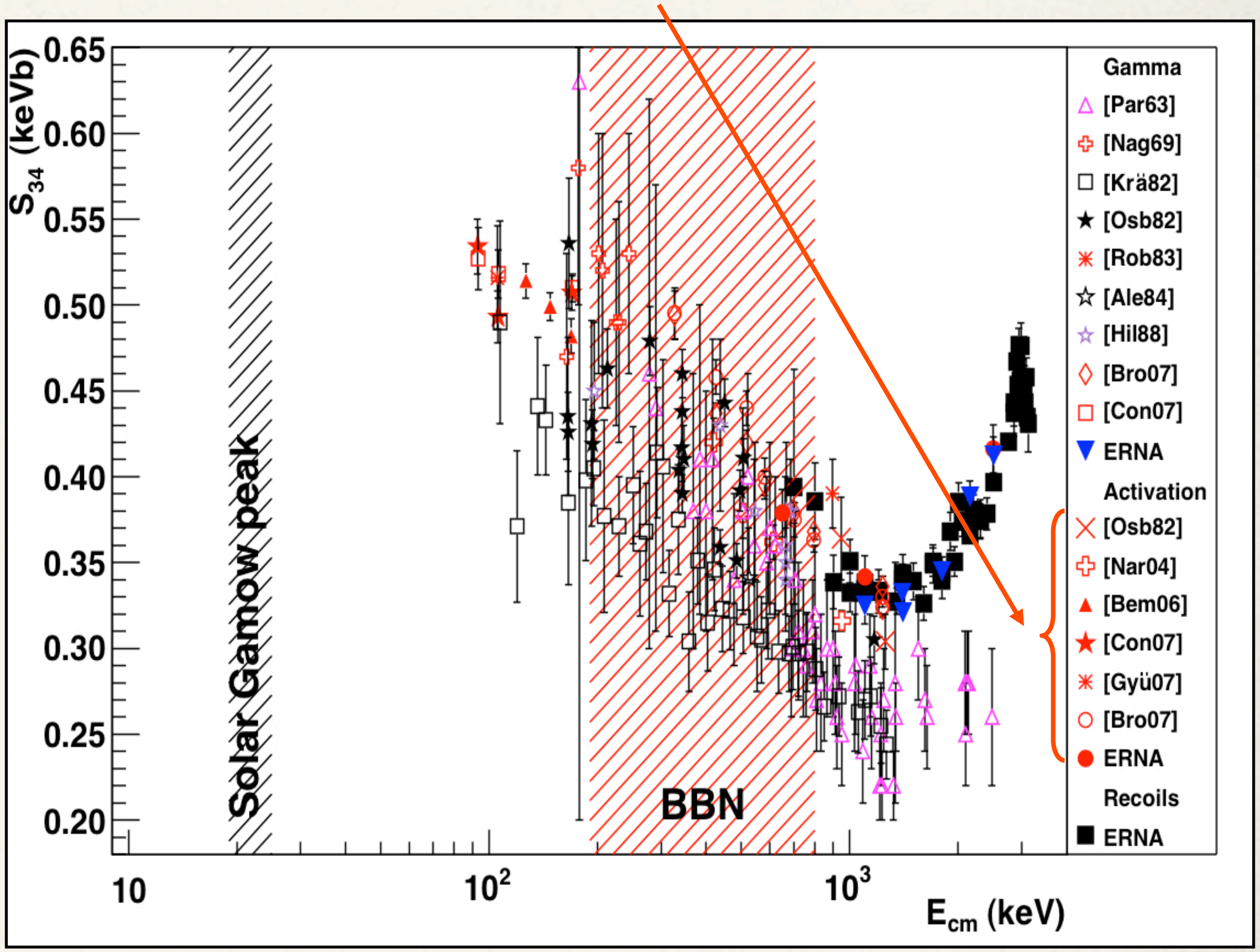

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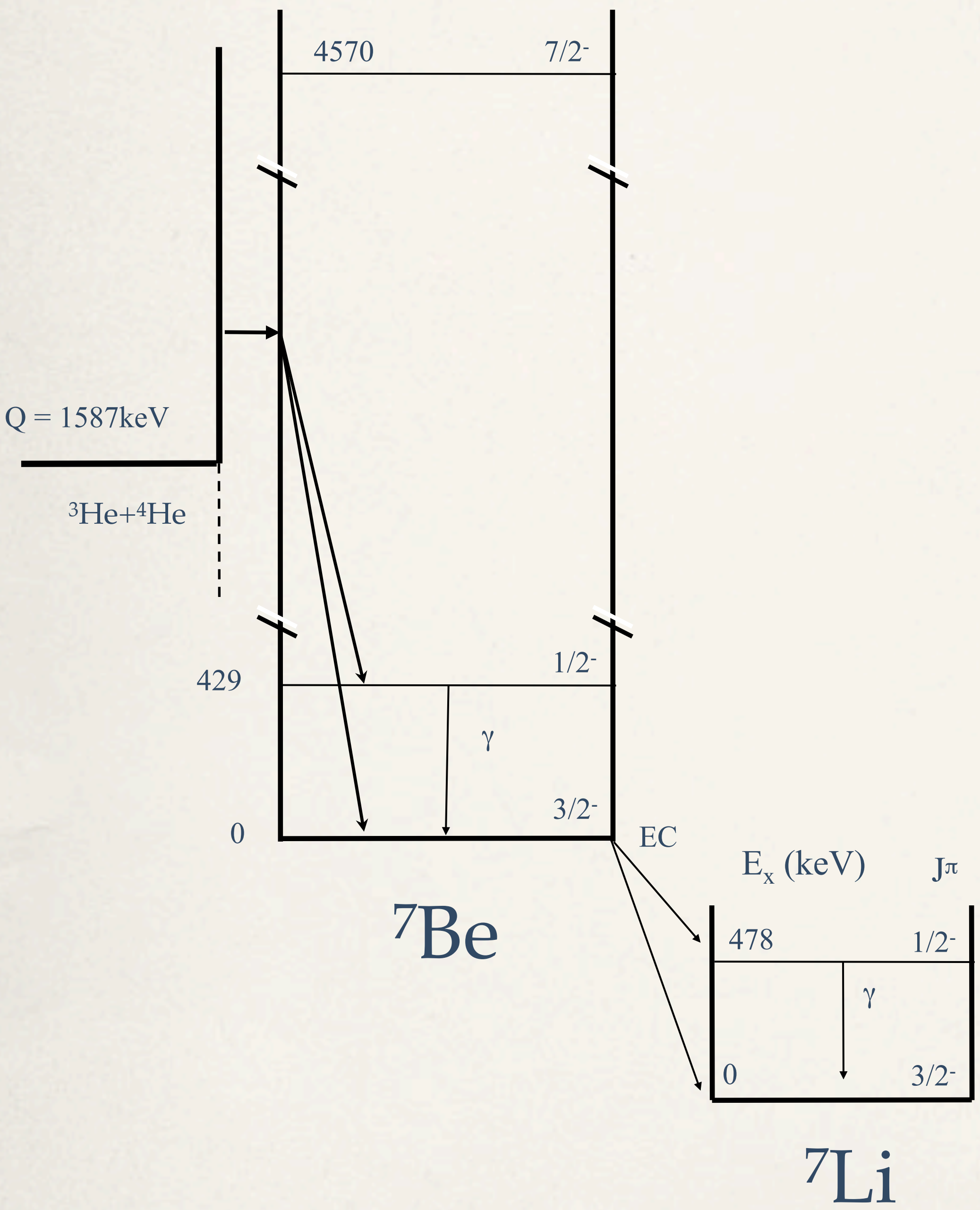

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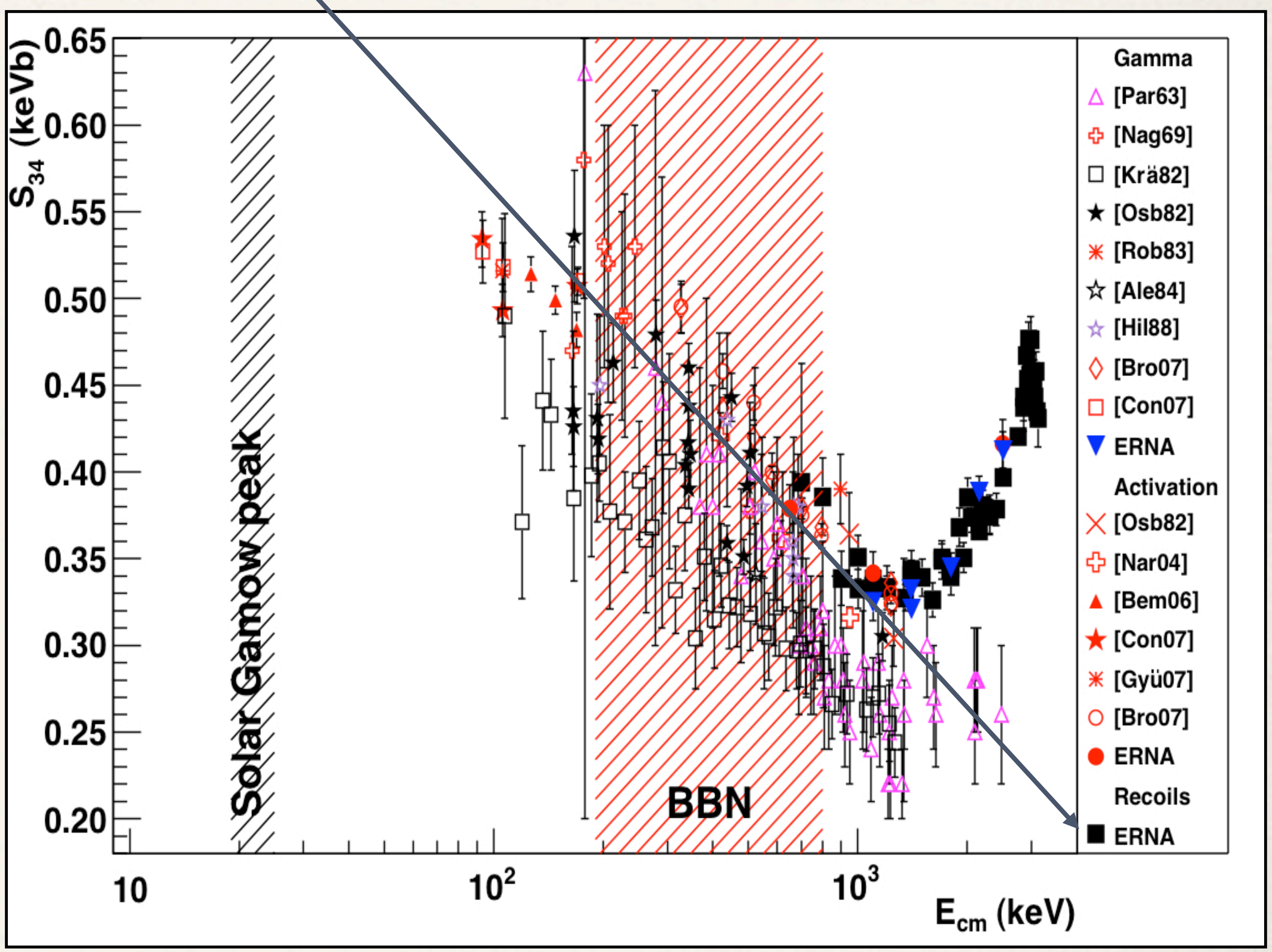

Extrapolation to solar energies

Potential models (global scaling parameter): Tombrello & Parker, Descouvemont (R-matrix based), Mohr

Microscopic models (no global scaling parameter): Csótó & Langanke, Kajino et al., Nollett, etc...

Usually claimed to be valid up to E_{cm}~2.0MeV

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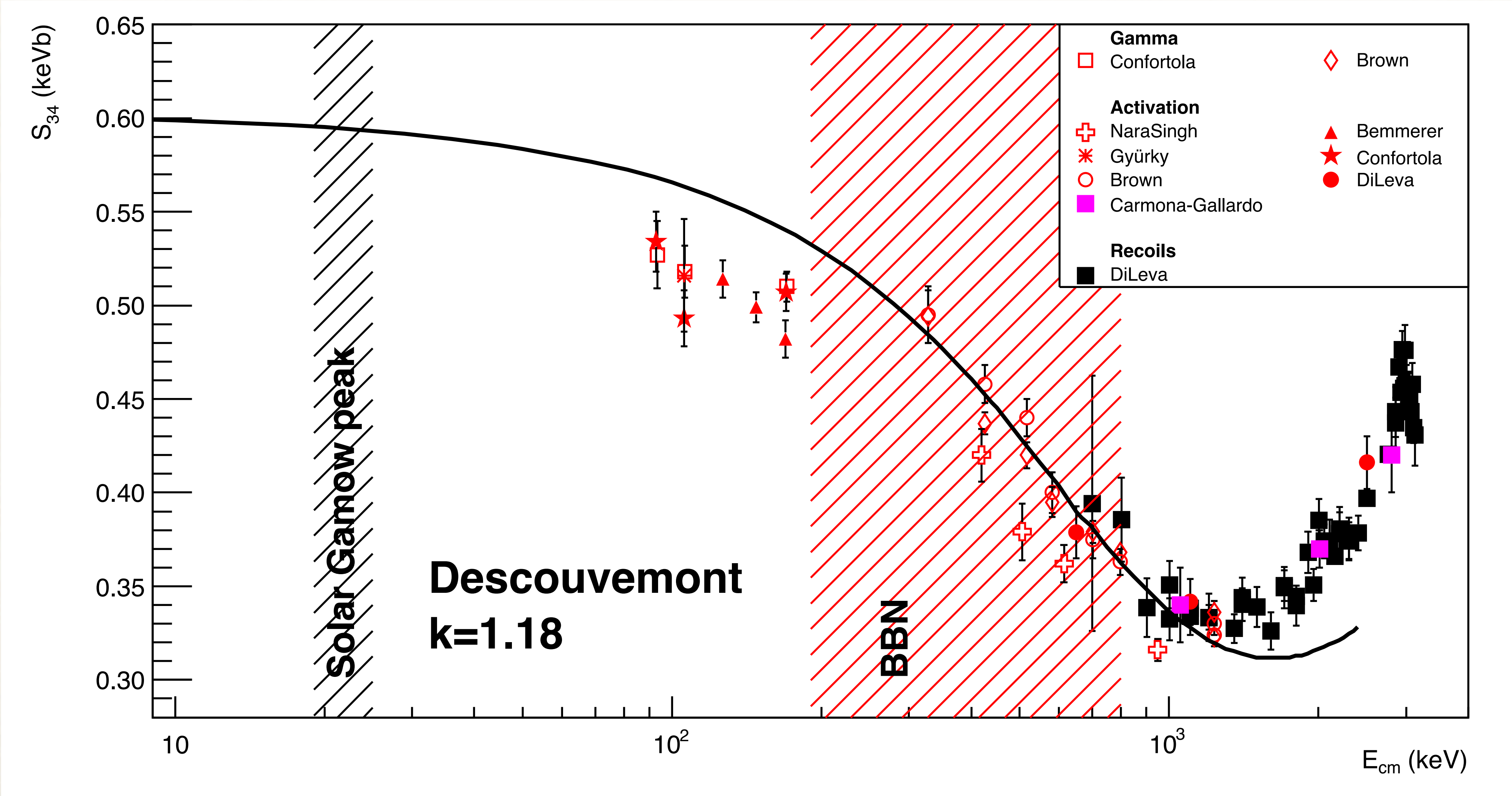

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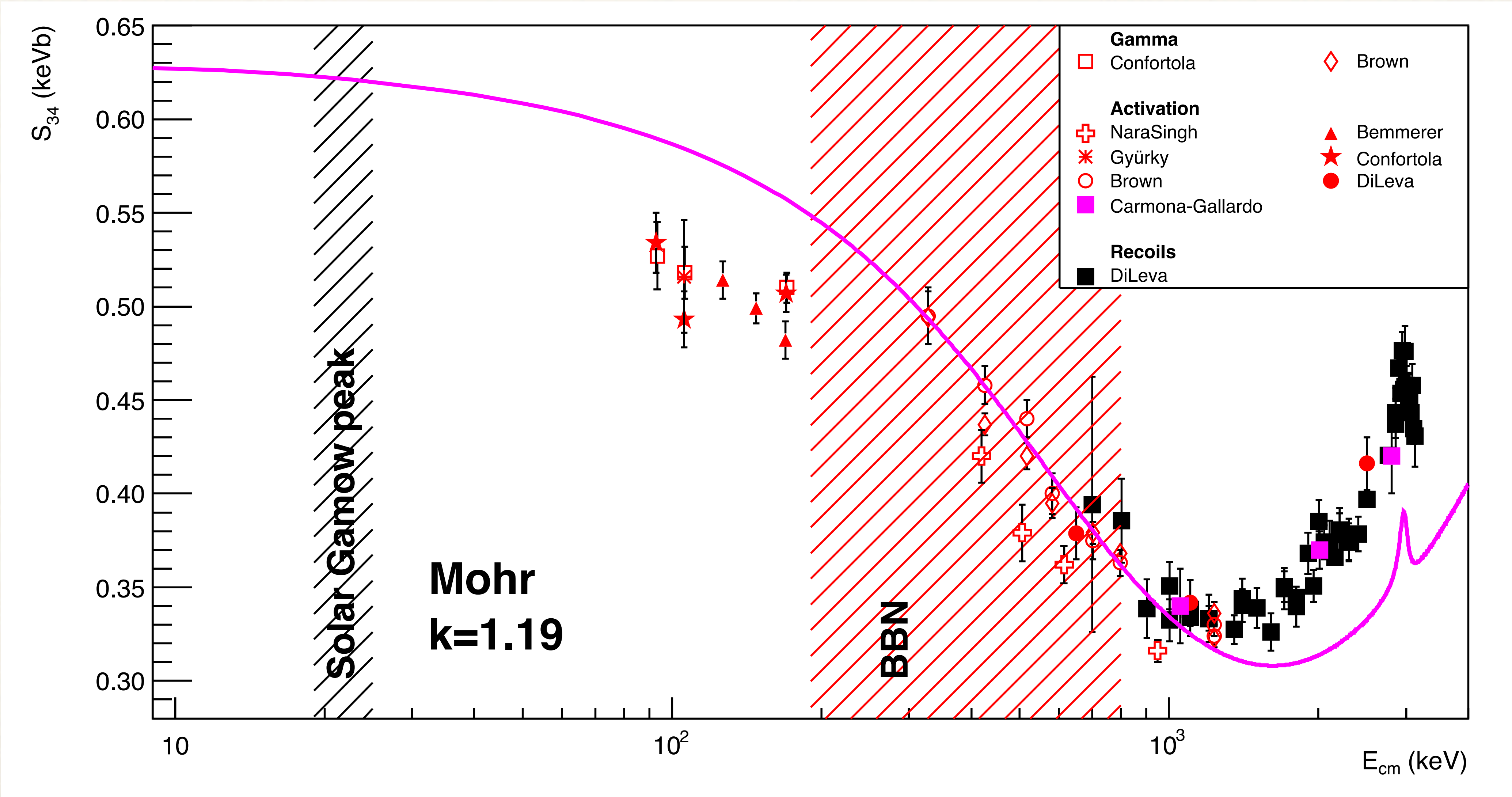

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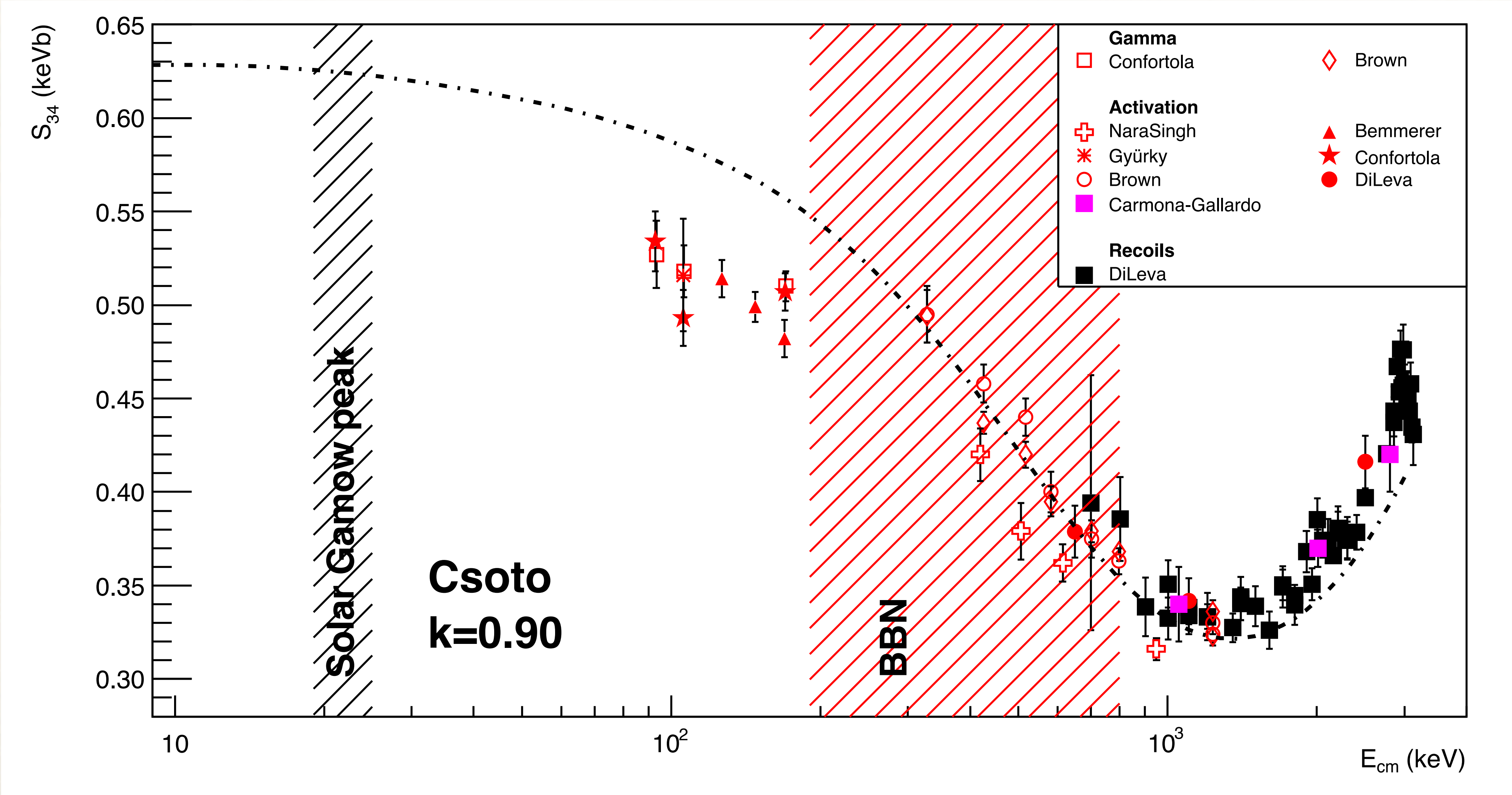

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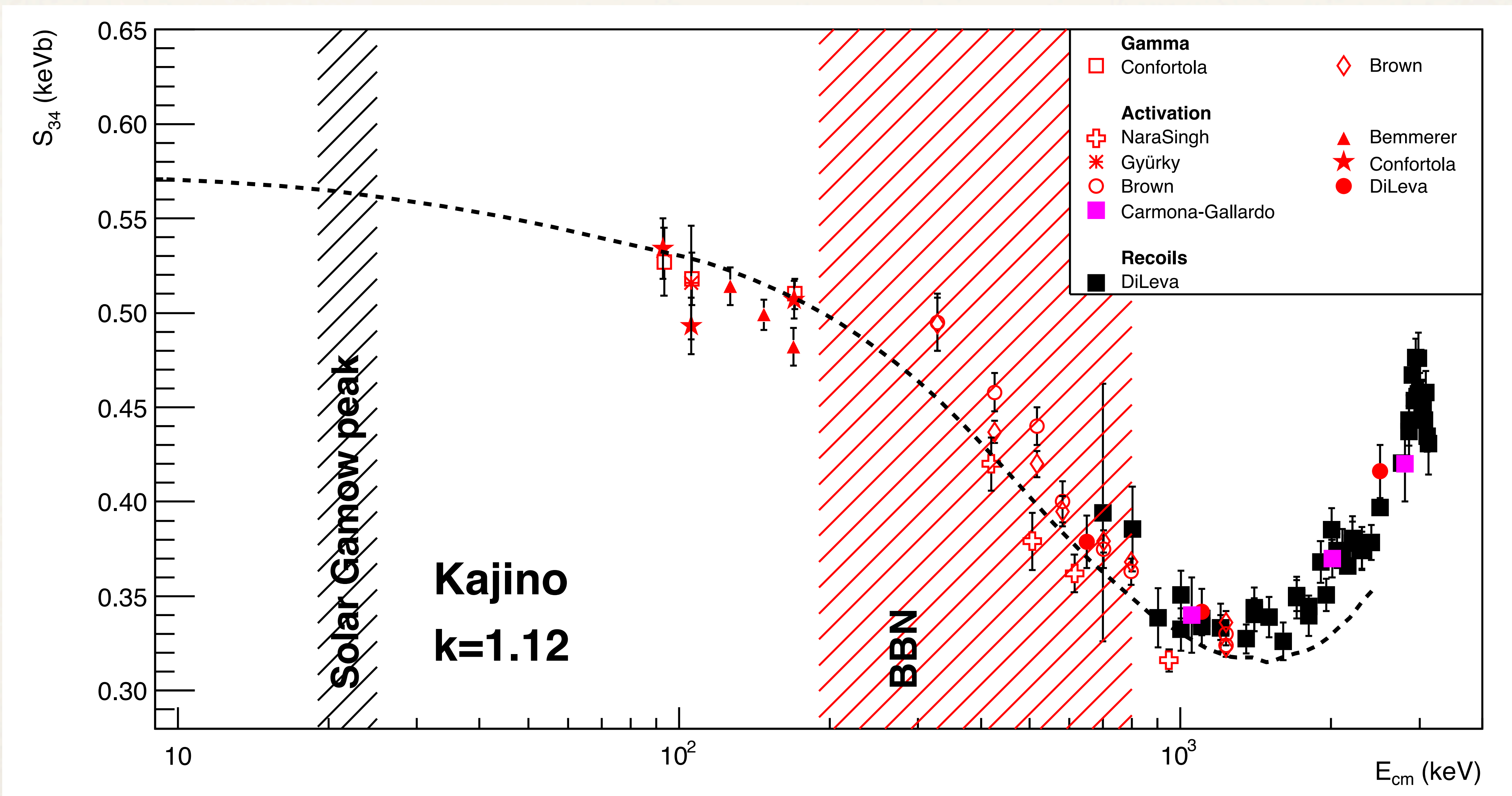

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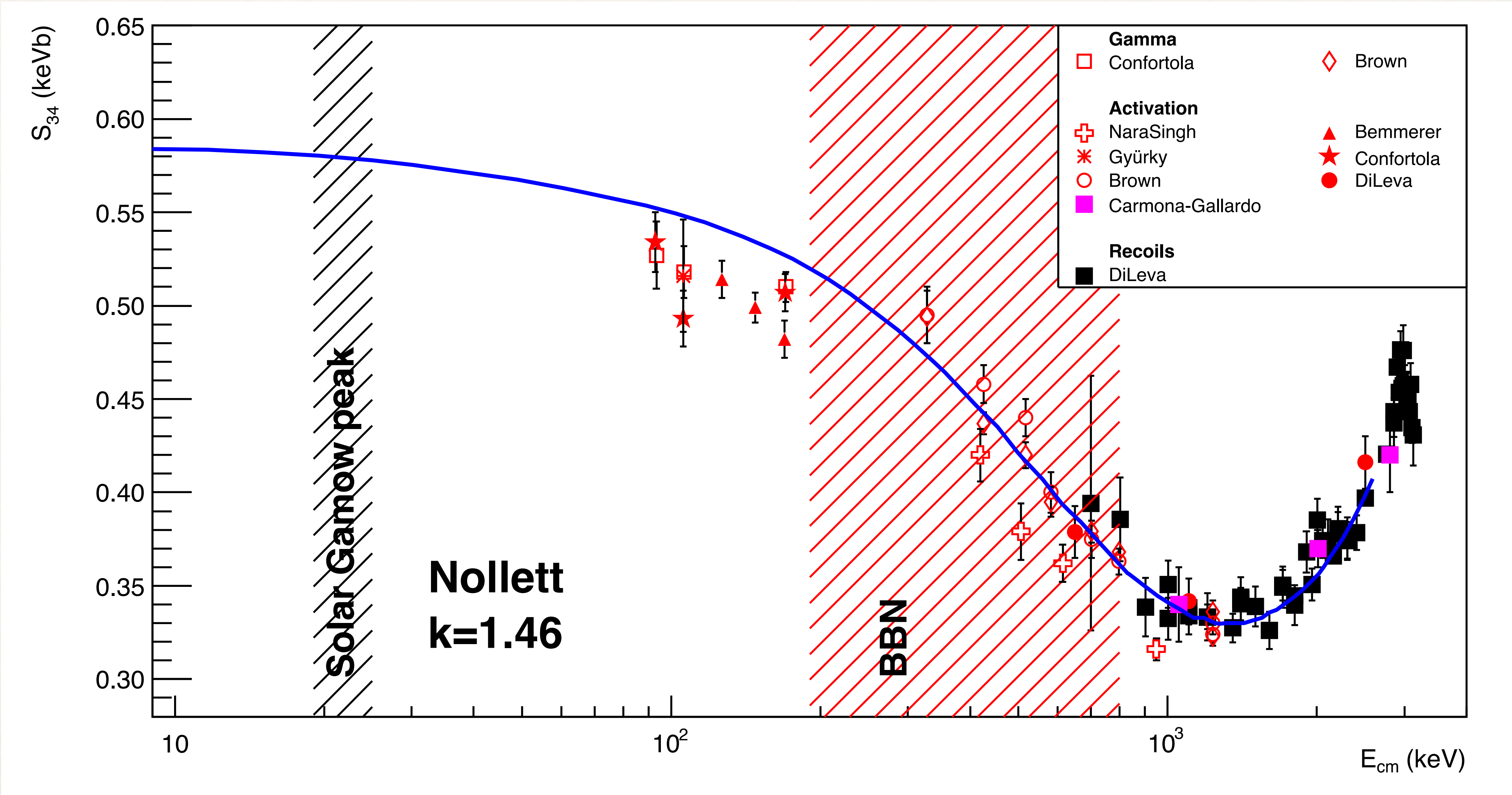

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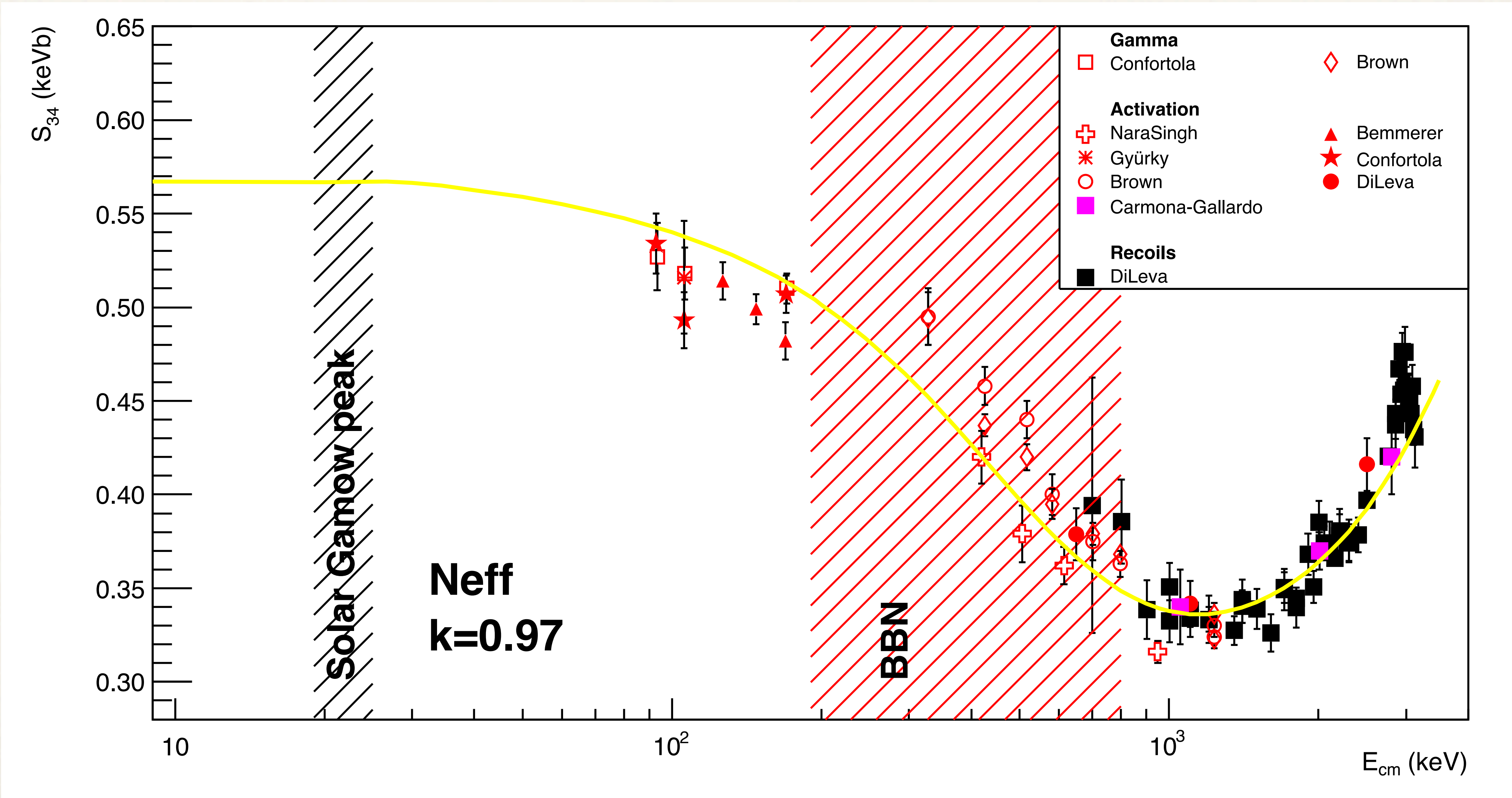

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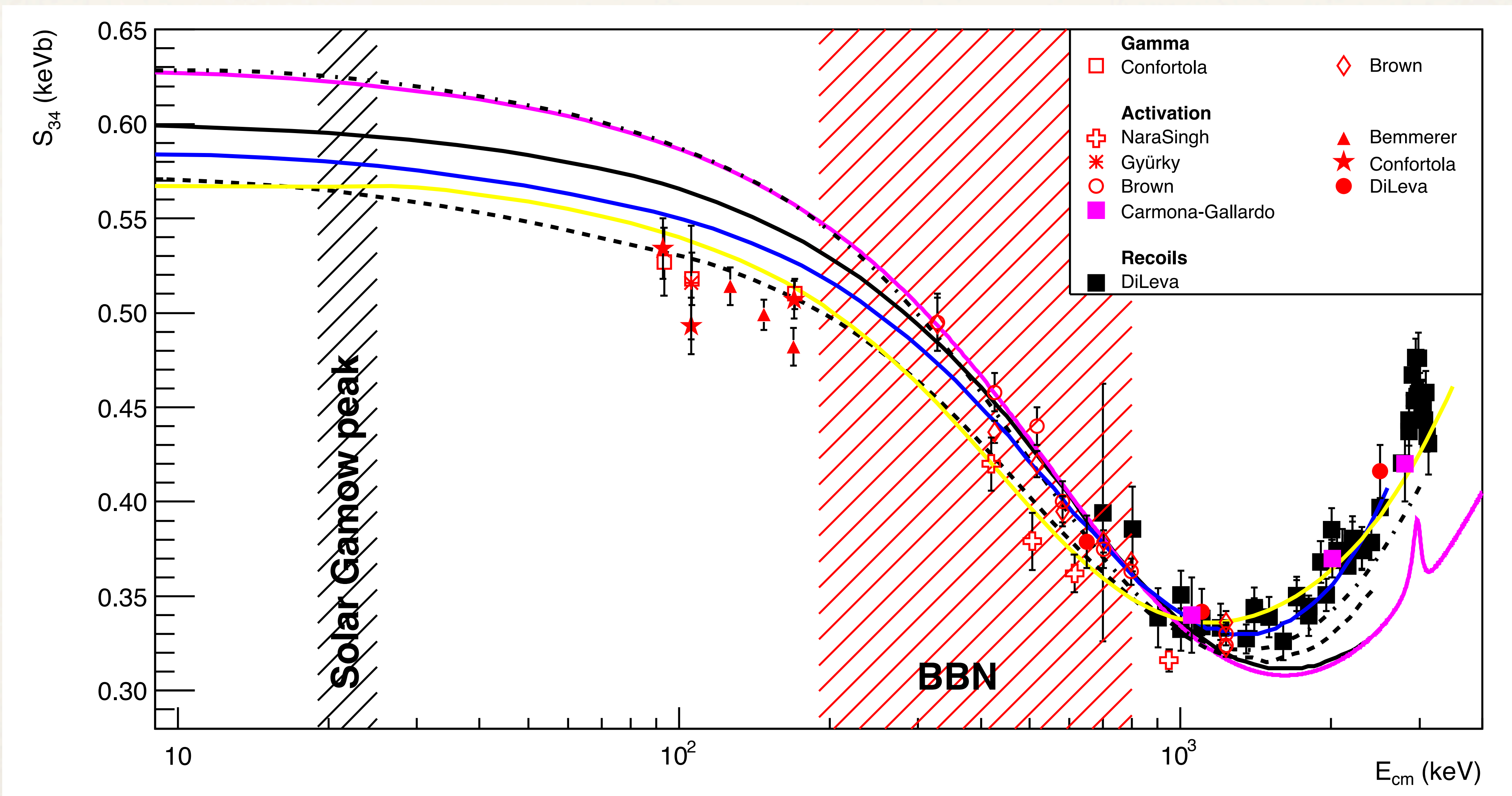

Extrapolation to solar energies

- Use as much of experimental information as possible
- Choose the model that best describes all of the experimental datasets
- Treat data in statistical robust way (no arbitrary inflation of errors)
- Take into account combined systematic errors
- Determine best estimate of $S_{34}(0)$

Datasets and models selection

The least square function is a χ^2 variable only under the conditions:

- model is adequate to describe the data;
- fitted measurements are independent;
- measured quantities have a gaussian distribution, whose standard deviations must be correctly evaluated.

Parker, Nagatani, Kräwinkel, Hilgemeier: include systematic uncertainties.

Robertson, Alexander, Volk: single data point.

	18 osborne	1 osborneAct	3 narasingh	2 LUNAprm	6 LUNAact	7 brownPrm	7 brownAct	16 ERNA	2 carmona
Descouvemont	85.91	1.56	1.15	0.84	6.61	20.23	5.26	31.76	5.65
Kajino	83.33	2.31	1.37	0.66	6.63	9.65	12.28	15.08	1.49
Csoto	94.55	2.49	0.88	1.45	6.72	18.83	3.39	12.81	0.54
LiuKanadaTang	79.23	2.42	2.79	0.15	7.29	16.53	21.46	18.58	1.61
Nollett	82.90	2.45	0.91	0.66	6.62	10.67	10.02	12.15	1.36
Mohr	91.30	1.50	1.98	1.23	6.65	31.11	6.63	35.71	4.97
Neff	87.22	3.92	3.98	1.20	6.65	54.76	46.16	8.95	0.02

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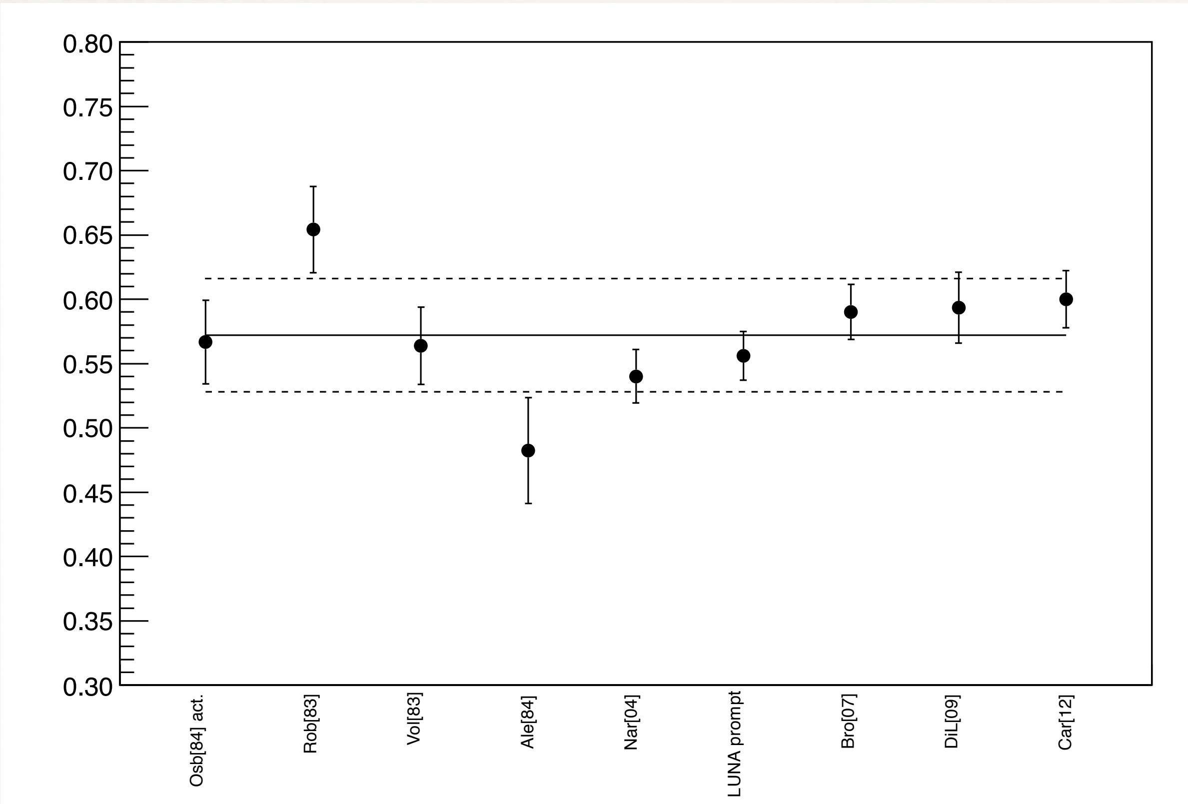
$P(\chi^2 > \chi^2_0)$

green: >15%

15% > yellow: >1%

red: <1%

$S_{34}(0)$



$P(w > w_{ij})$

$$w_{ij} = \frac{\left|S_{34\,i}(0) - S_{34\,j}(0)\right|}{\sqrt{\sigma_i^2 + \sigma_j^2}}$$

Model: Nollett

	osborneAct	robertson	Volk	alexander	narasingh	LUNAprm+Act	brownPrm+Act	ERNA	carmona
osborneAct	1.000	0.061	0.949	0.108	0.514	0.822	0.712	0.749	0.442
robertson		1.000	0.045	0.001	0.004	0.011	0.108	0.163	0.177
Volk			1.000	0.110	0.519	0.831	0.475	0.466	0.337
alexander				1.000	0.210	0.103	0.020	0.024	0.012
narasingh					1.000	0.636	0.278	0.373	0.111
LUNAprm+Act						1.000	0.283	0.346	0.266
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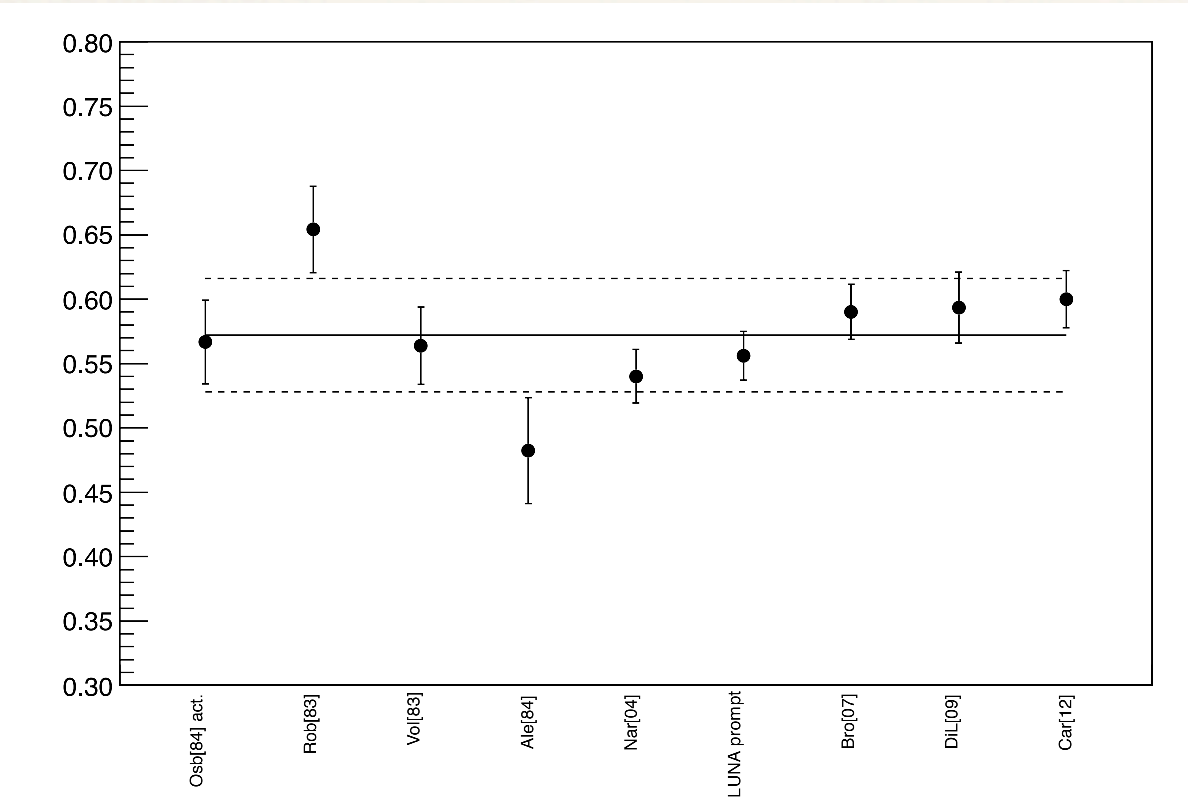

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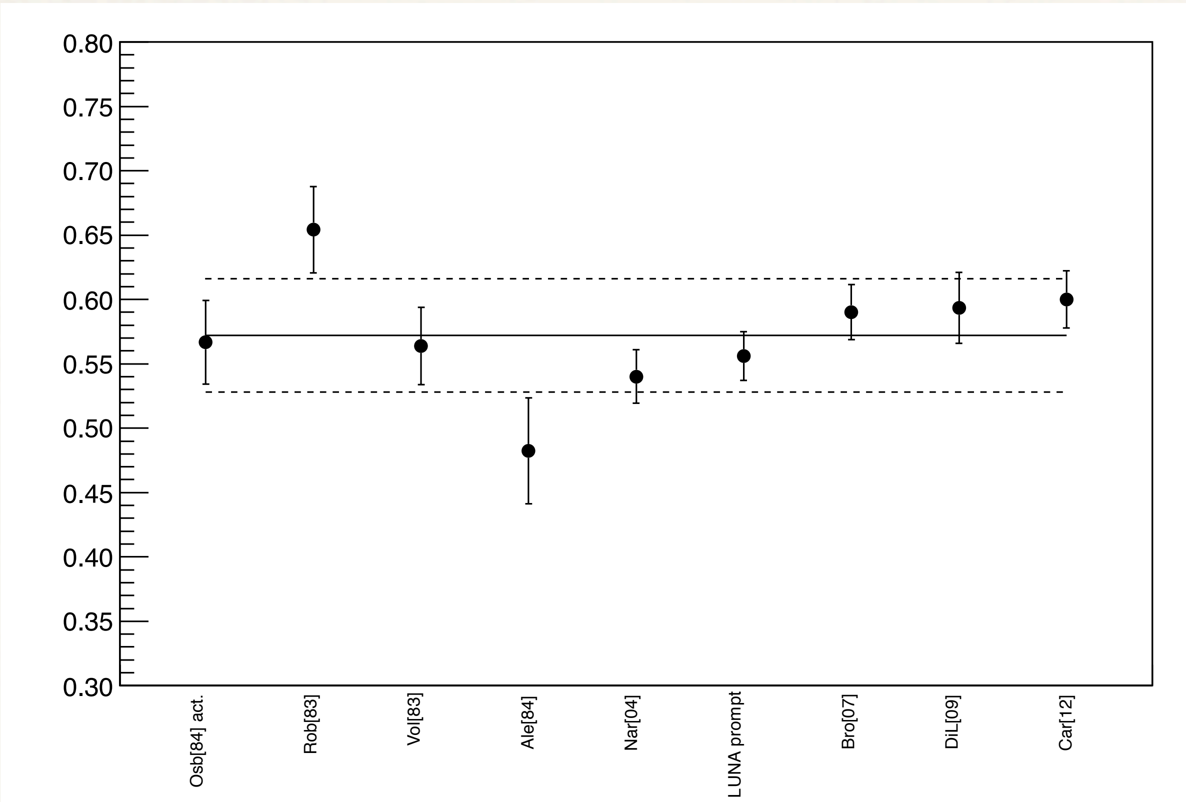
Kajino or Nollet model

$S_{34}(0) = 0.57 \pm (0.02)_{\mathrm{exp}} \pm (?)_{\mathrm{model}}$ keVb

$S_{34}(0)$



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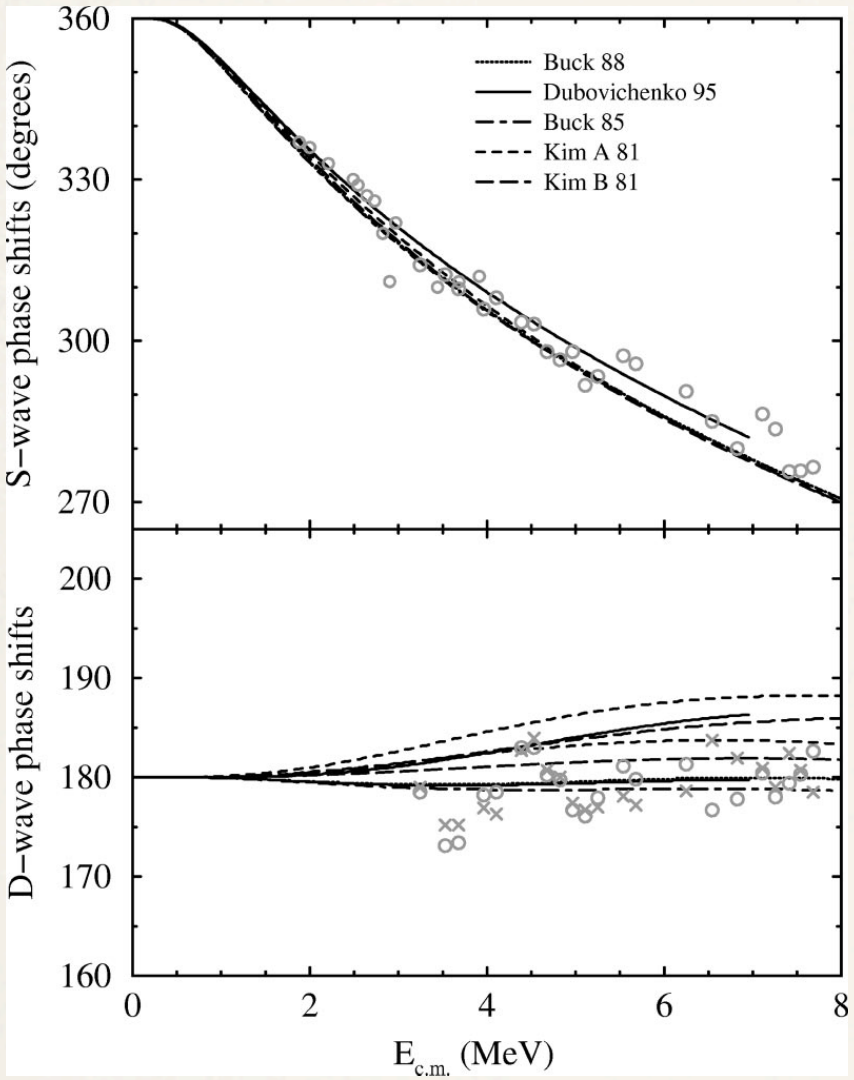
$\sigma_{\mathrm{model}} = 0.02$ keVb

Adelberger et al.

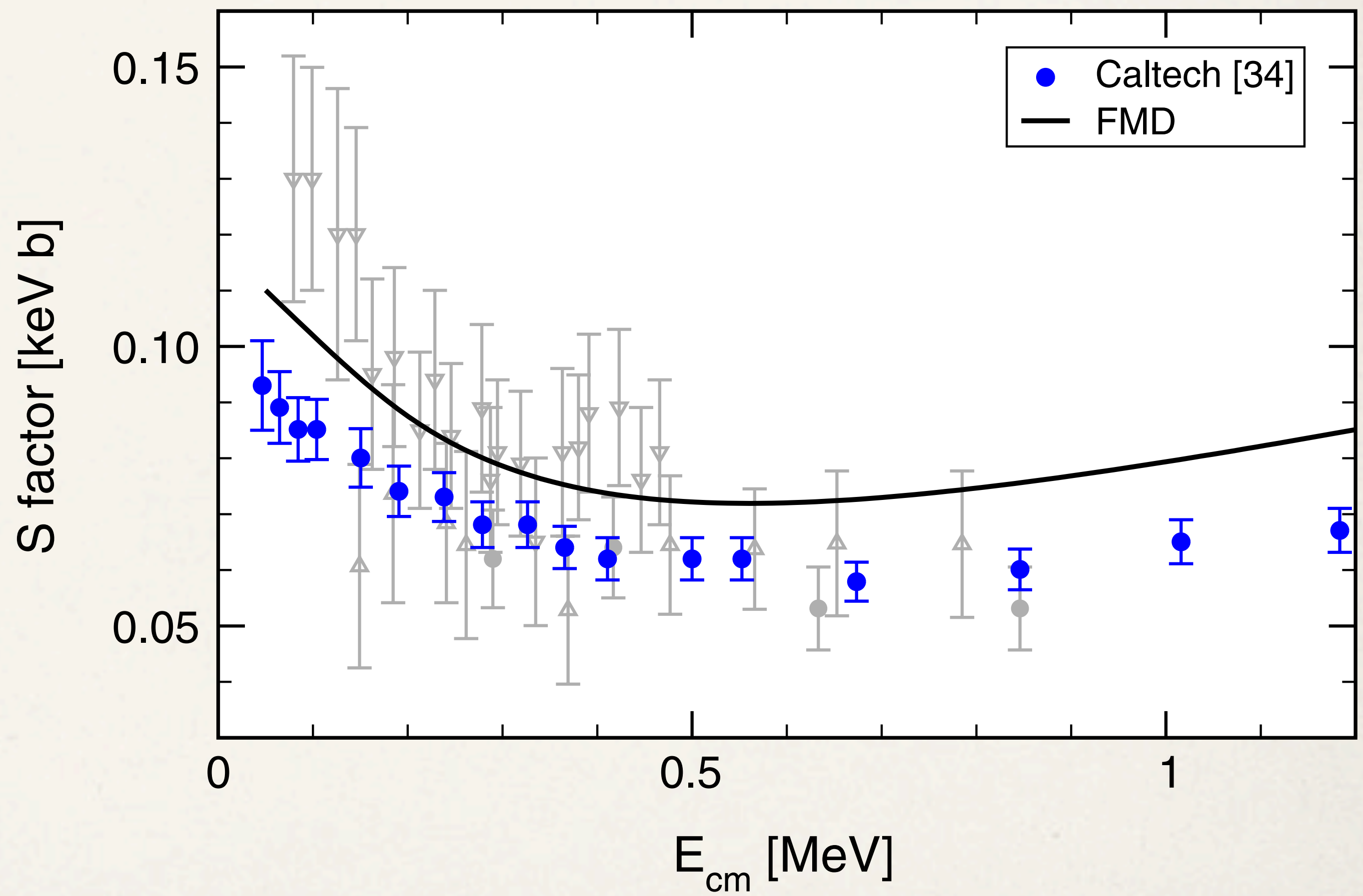
RevModPhys 83(2011)195

Improved model?

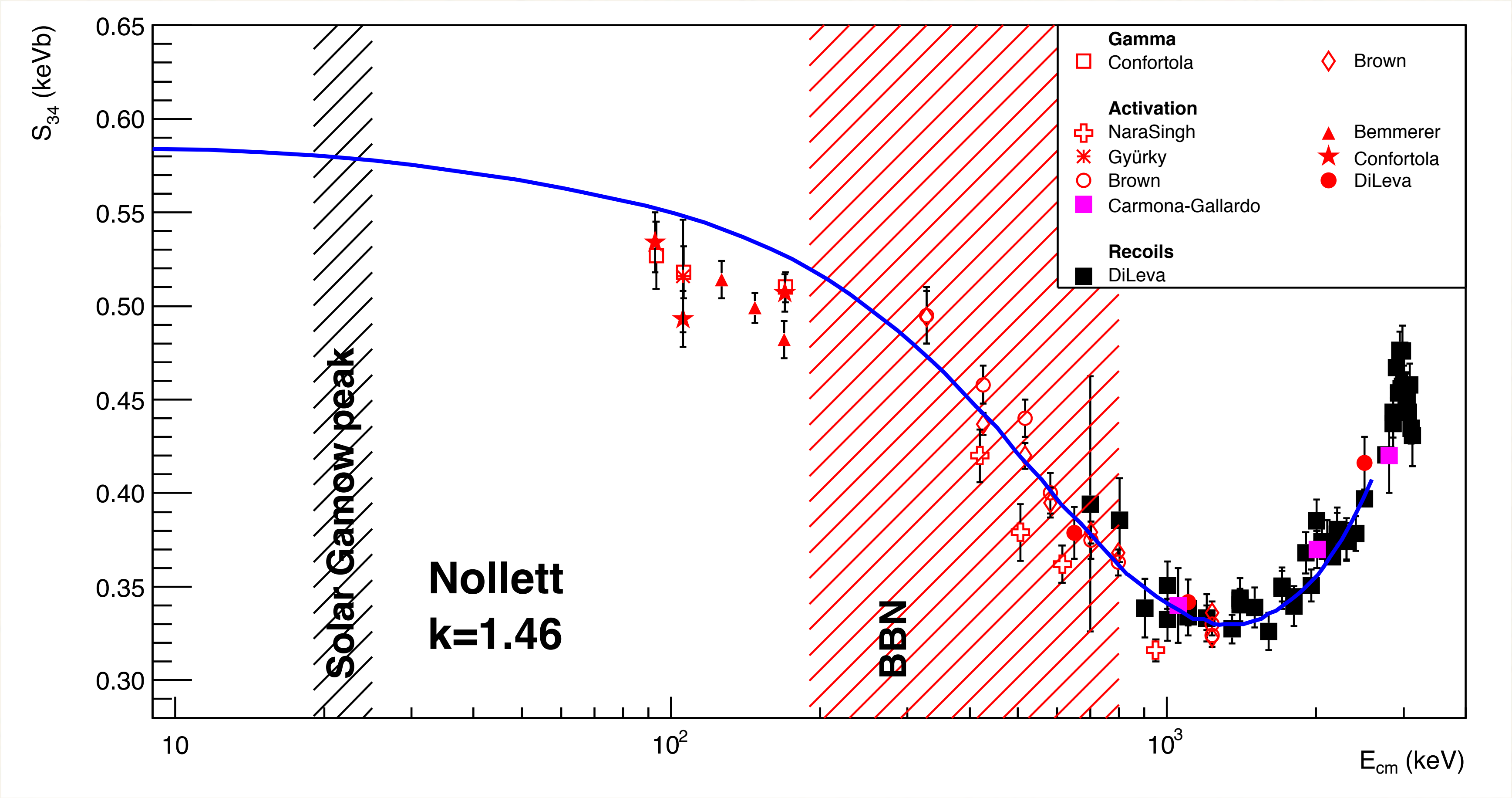


Nollett, Phys. Rev. C63(2001)054002

T. Neff, PRL106(2010)042502



Summary



$$S_{34}(0) = 0.57\pm(0.02)_{\mathrm{exp}}\pm(0.02)_{\mathrm{model}}\ \mathrm{keVb}$$

using Kajino or Nollet model

- Improved models are needed to assess the low energy slope of $S_{34}(E)$
- Additional experimental information to better constrain the models will help to reduce the uncertainty