"How Good Are the Internal Conversion Coefficients Now?"

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"How Good Are the ICC's Now?"

- Summary of Analysis Methods
- Evolution of ICC Theory and Experiment
- Results
- Conclusions

"How Good Are the ICC's Now?"

- Principal Tools:
  - BrIccRAINE: Exact calculations of ICC's as a function of energy
  - AveTools:
    - Three weighted average methods
      - Limitation of Relative Statistical Weights (LWM)
      - Normalized Residual Method (NRM)
      - Rajeval Technique (RT)
    - After discrepant data identified and removed (N>3):
      - Adopt arithmetic mean of NRM and RT and the larger of the two uncertainties from NRM and RT for experimental
      - Adopt LWM result for comparison to theory

"How Good Are the ICC's Now?"

- Experimental Data:
  - No dipole or M2. Total, K, and L conversion coefficients and K/L ratios considered.
  - Multipolarity must be assigned independent of α's and (almost) pure.
  - Individual datum must have $\Delta\alpha/\alpha \leq 15\%$. Final average must have $\Delta\alpha/\alpha \leq 5\%$.
  - About 99% of the original papers were obtained and checked.
  - 213 data points satisfied these criteria.

"How Good Are the ICC's Now?"

- Comparison of Experiment to theory:
  - ICC(exp:theory)=100 ×(α(exp)-α(theory))/ α(theory)
  - Three relativistic Dirac-Fock models:
    - BTNTR – "No hole" approximation
    - RNIT(1) – "Self consistent" approximation
    - RNIT(2) – "Frozen orbital" approximation

"How Good Are the ICC's Now?"

– 17 "slices"

Mult.	Shell	Mult.	Shell	Mult.	Shell
All	All	E2	All	M3	All
All	T+K	E2	K	M4	All
All	Total	E2	Total	M4	K
All	K	E3	All	M4	Total
All	K/L	E3	K	$\Delta\alpha/\alpha \leq 1.5\%$	
All	L	E3	Total		

– 188 data points left after exclusion of discrepant data (Compared to 100 in Raman's original study)

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Adopted

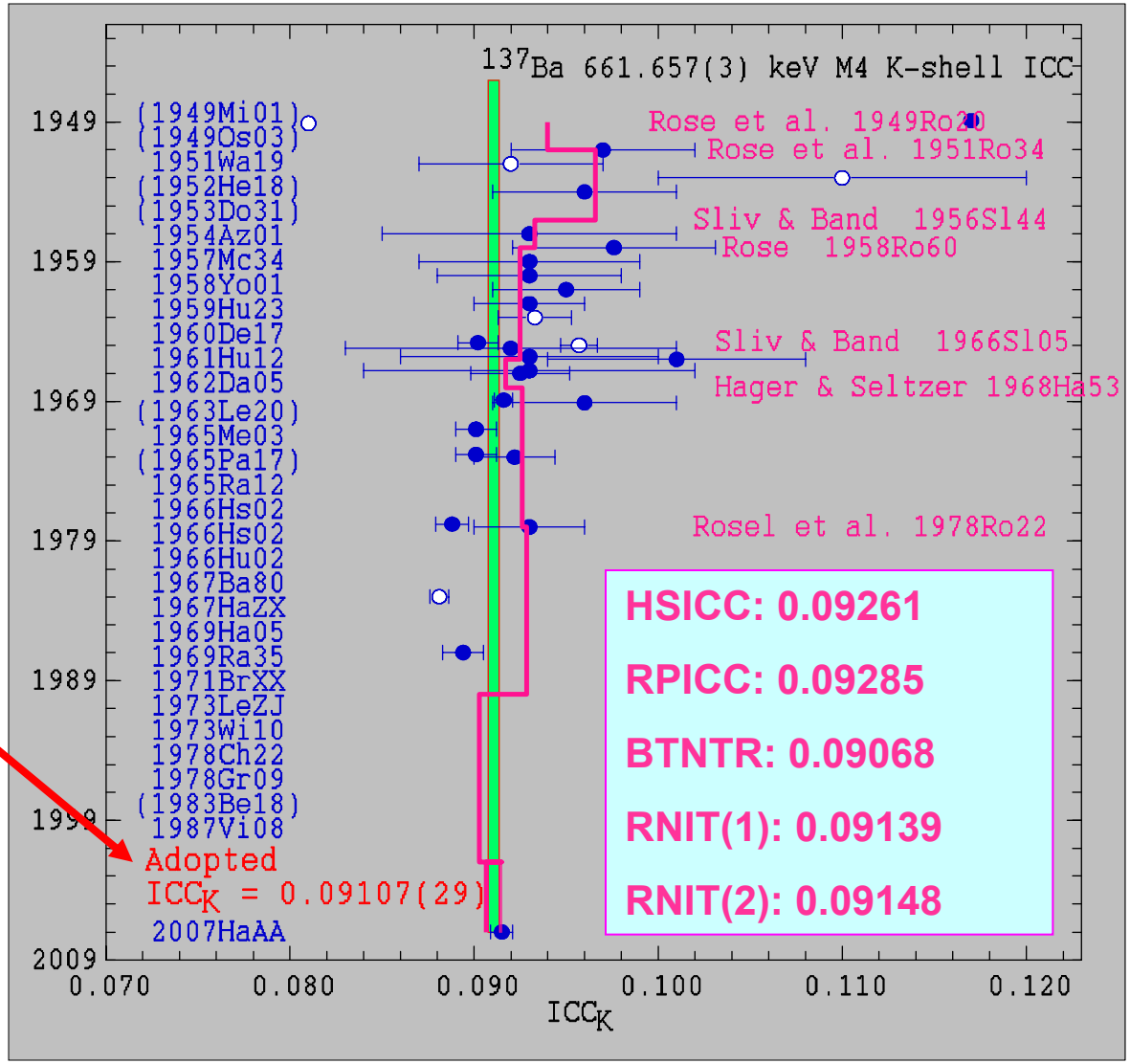
LWM: 0.09103(28)

NRM: 0.09103(28)

RT: 0.09110(29)

ENSDF

ICC_K=0.0904(5)



"How Good Are the ICC's Now?"

ML	Shell	N	BTNTR		RNIT(1)		RNIT(2)	
				χ^2/(N-1)		χ^2/(N-1)		χ^2/(N-1)
All	All	188	+0.70 *40*	**1.82**	-0.61 *14*	1.01	-0.93 *14*	0.87

χ^2(critical)=1.25

Both negative;
RNIT(1) out by 4.5σ
RNIT(2) out by 6.9σ

"How Good Are the ICC's Now?"

ML	Shell	N	BTNTR		RNIT(1)		RNIT(2)	
				χ^2/(N-1)		χ^2/(N-1)		χ^2/(N-1)
All	All	188	+0.70 *40*	**1.82**	-0.61 *14*	1.01	-0.93 *14*	0.87
All	Tot	54	+0.32 *25*	0.79	-0.55 *24*	0.76	-0.71 *24*	0.73

χ^2(critical)=1.51

1.3σ 2.3σ 3.0σ

Marginal differences

"How Good Are the ICC's Now?"

ML	Shell	N	BTNTR		RNIT(1)		RNIT(2)	
				χ^2/(N-1)		χ^2/(N-1)		χ^2/(N-1)
All	All	188	+0.70 *40*	**1.82**	-0.61 *14*	1.01	-0.93 *14*	0.87
All	Tot	54	+0.32 *25*	0.79	-0.55 *24*	0.76	-0.71 *24*	0.73
All	K	72	+1.5 *12*	**3.14**	-0.18 *21*	1.09	-0.72 *21*	0.80

χ^2(critical)=1.43
Not favored

"How Good Are the ICC's Now?"

ML	Shell	N	BTNTR		RNIT(1)		RNIT(2)	
				χ^2/(N-1)		χ^2/(N-1)		χ^2/(N-1)
All	All	188	+0.70 *40*	**1.82**	-0.61 *14*	1.01	-0.93 *14*	0.87
Tot	All	54	+0.32 *25*	0.79	-0.55 *24*	0.76	-0.71 *24*	0.73
All	K	72	+1.5 *12*	**3.14**	-0.18 *21*	1.09	-0.72 *21*	0.80
All	K/L	46	+0.00 *31*	0.83	-1.64 *31*	0.96	-1.94 *30*	1.02

RNIT(1) and RNIT(2) out by >5σ
Unexpected

"How Good Are the ICC's Now?"

ML	Shell	N	BTNTR		RNIT(1)		RNIT(2)	
				χ^2/(N-1)		χ^2/(N-1)		χ^2/(N-1)
All	All	188	+0.70 *40*	**1.82**	-0.61 *14*	1.01	-0.93 14	0.87
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All	K	72	+1.5 *12*	**3.14**	-0.18 *21*	1.09	-0.72 *21*	0.80
All	K/L	46	+0.00 *31*	0.83	-1.64 *31*	0.96	-1.94 *30*	1.02
E2	All	103	+0.21 *23*	1.01	-0.77 *23*	0.89	-0.93 *23*	0.90

BTNTR consistent

RNIT(1) and RNIT(2) out by >3σ
RNIT(2) "follows the trend" being around -0.9

"How Good Are the ICC's Now?"

ML	Shell	N	BTNTR		RNIT(1)		RNIT(2)	
				χ^2/(N-1)		χ^2/(N-1)		χ^2/(N-1)
All	All	188	+0.70 *40*	**1.82**	-0.61 *14*	1.01	-0.93 *14*	0.87
All	Tot	54	+0.32 *25*	0.79	-0.55 *24*	0.76	-0.71 *24*	0.73
All	K	72	+1.5 *12*	**3.14**	-0.18 *21*	1.09	-0.72 *21*	0.80
All	K/L	46	+0.00 *31*	0.83	-1.64 *31*	0.96	-1.94 *30*	1.02
E2	All	103	+0.21 *23*	1.01	-0.77 *23*	0.89	-0.93 *23*	0.90
M4	All	50	+0.98 *68*	**3.87**	-0.51 *20*	1.29	-0.93 *20*	0.72

χ^2(critical)=1.53
Not favored

RT adjusted ^{193}Ir K
Δ from 3.4% *8* to 3.4% *17*
Problems with ^{207}Pb K/L

Problems with
^{207}Pb K/L

"How Good Are the ICC's Now?"

ML	Shell	N	BTNTR		*RNIT(1)*		RNIT(2)	
				χ^2/(N-1)		χ^2/(N-1)		χ^2/(N-1)
All	All	188	+0.70 *40*	**1.82**	-0.61 *14*	1.01	-0.93 *14*	0.87
Tot	All	54	+0.32 *25*	0.79	-0.55 *24*	0.76	-0.71 *24*	0.73
K	All	72	+1.5 *120*	**3.14**	-0.18 *21*	1.09	-0.72 *21*	0.80
K/L	All	46	+0.00 *31*	0.83	-1.64 *31*	0.96	-1.94 *30*	1.02
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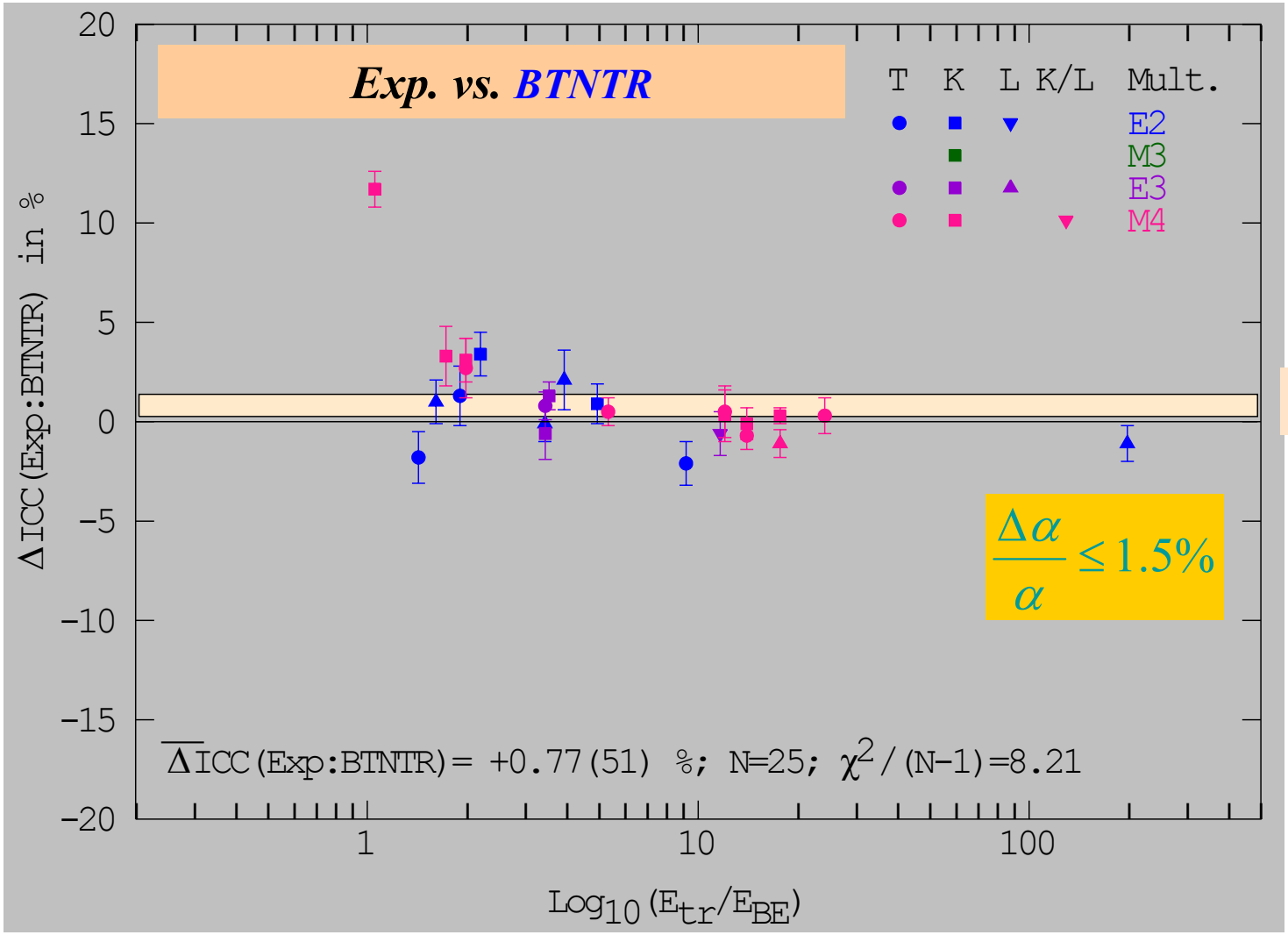
M4	All	50	+0.98 *68*	**3.87**	-0.51 *20*	1.29	-0.93 *20*	0.72
ICC's known to better than 1.5% relative uncertainty								
All	All	25	+0.77 *51*	**8.21**	-0.56 *26*	2.12	-0.95 *17*	1.06

χ^2(critical)=1.79
Not favored

Marginally larger than χ^2(critical)

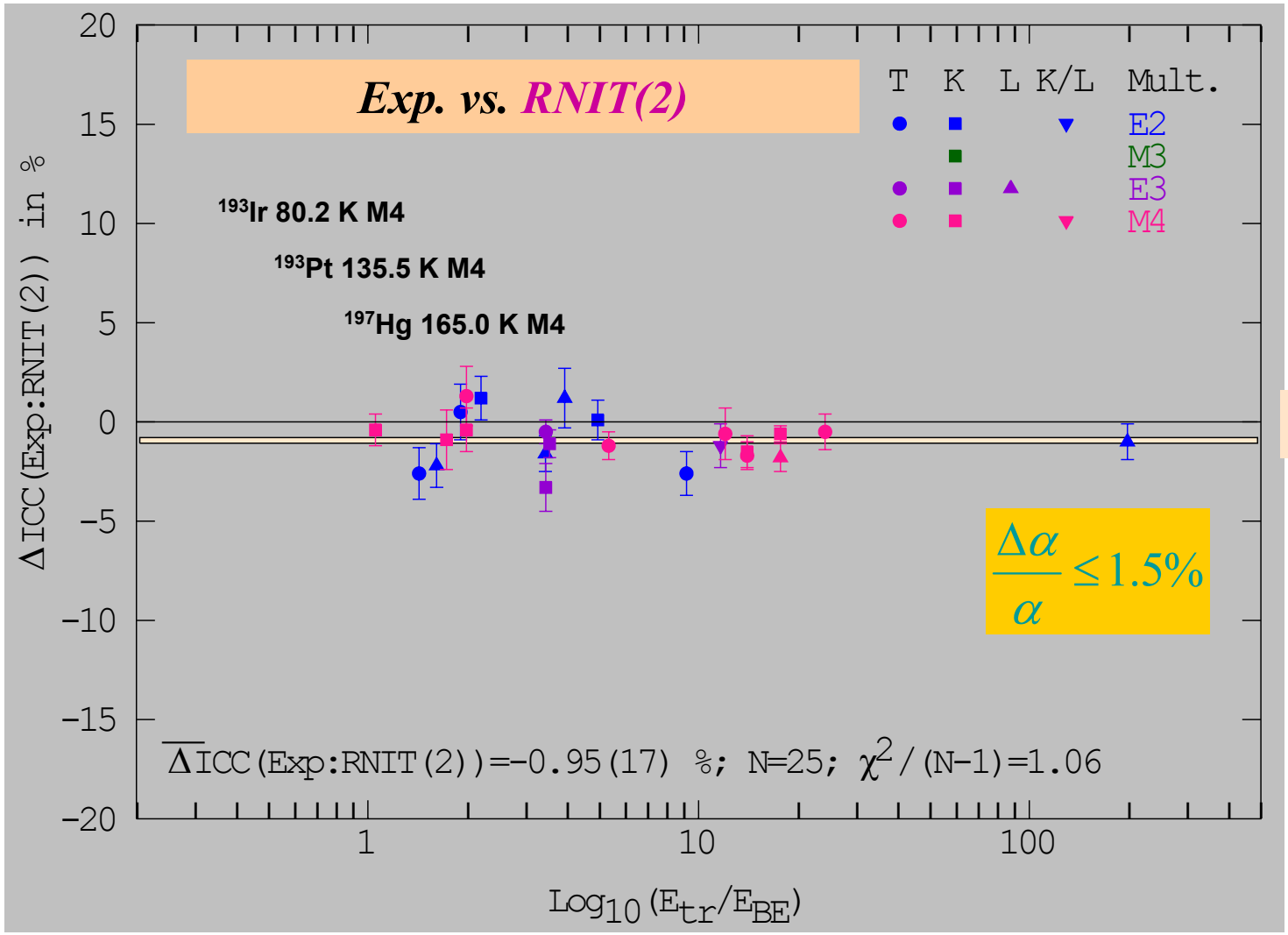
Favored

"How Good Are the ICC's Now?"



+0.77 (51) %

"How Good Are the ICC's Now?"



-0.95 (17) %

"How Good Are the ICC's Now?"

- BTNTR is definitely not favored
  - $\chi^2/(N-1) > \chi^2(\text{critical})$ for six cases (All/All, All/Tot+K, All/K, M4/All, **M4/K**, and $\Delta\alpha/\alpha \leq$ **1.5%**)
  - Exceptions: BTNTR seems to be favored for All/K/L and E2/Tot.

"How Good Are the ICC's Now?"

- RNIT(2) seems to be somewhat favored over RNIT(1)
  - $\chi^2/(N-1) > \chi^2$(critical) for $\Delta\alpha/\alpha \leq 1.5\%$. Also, ^{193}Ir M4 K marked as outlier in LWM and adjusted in NRM and RT.
  - Rajeval Technique adjusts the RNIT(1) ^{193}Ir M4 K uncertainty, from 0.8% to between 1.4% and 1.8%, in four cases

"How Good Are the ICC's Now?"

- As a function of R where $R=\log_{10}(E_{tr}/BE_K)$
  - $<\Delta Icc(Exp:RNIT(2))>$ is relatively independent of R
  - $<\Delta Icc(Exp:BTNTR)>$ shows a very strong systematic trend downward until converging with RNIT(1) and RNIT(2) results at $R\approx2$
  - $<\Delta Icc(Exp:RNIT(1))>$ shows a weaker but still definite downward trend until converging with BTNTR and RNIT(2) results at $R\approx2$

“How Good Are the ICC’s Now?”