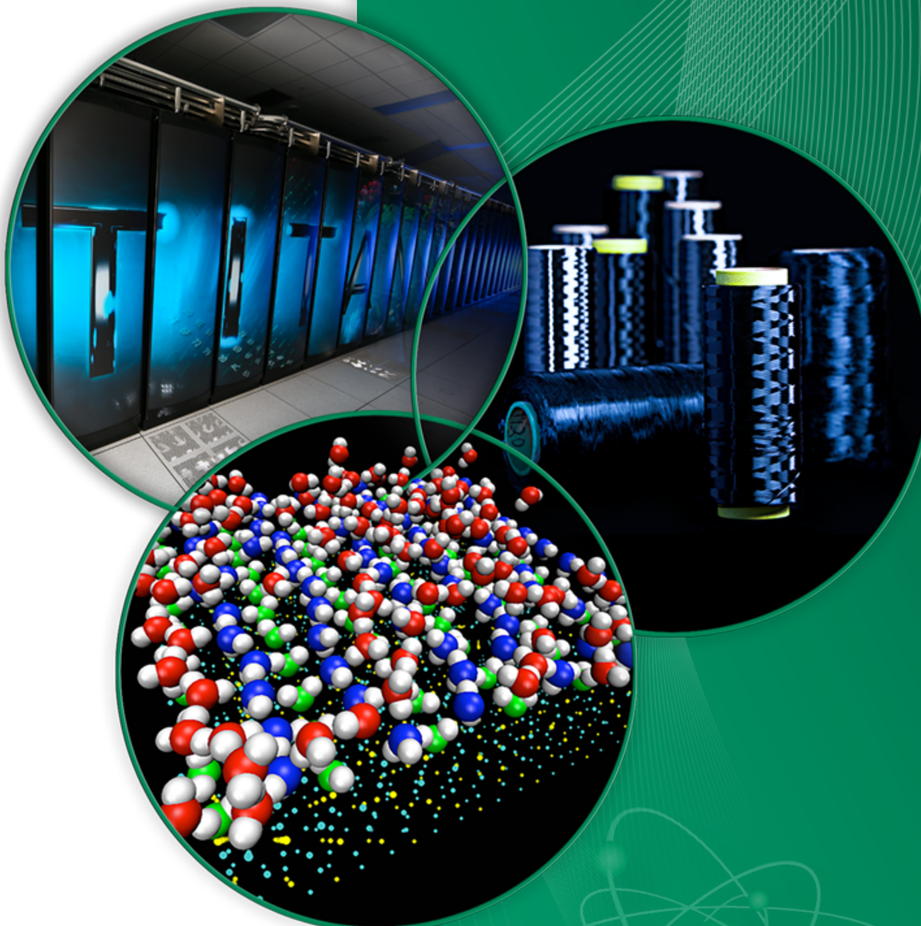
Aspects of Low-Energy Neutron Radiative Capture



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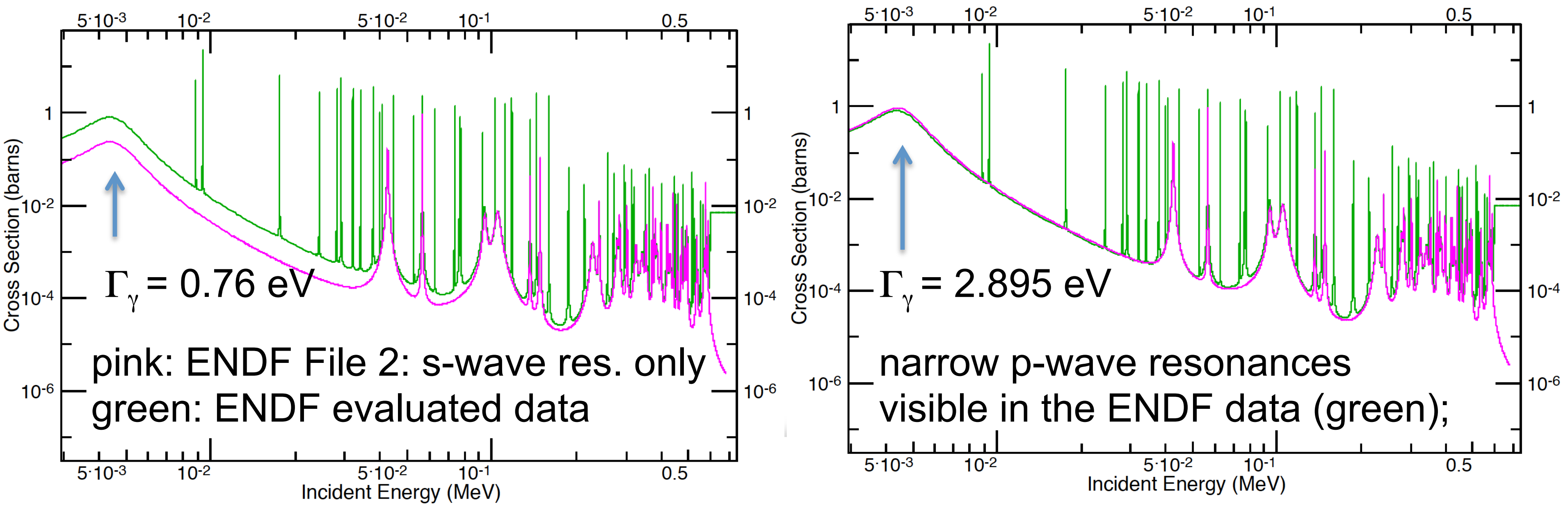
$^{62}Ni(n,\gamma)^{63}Ni$: Direct vs. Resonant capture

- Direct Capture (DC) issues:
  - 3s1/2 zero-energy "resonance" of real (e.g. Woods-Saxon) pot. for A~55-60
  - May yield unrealistic (too large) DC cross section (Frank's talk)
- Resonant capture (RC) issues:
  - γ-ray width of the 4.6 keV resonance underestimated:
    - (0.76 vs. 2.895) eV (plotted below)→ 30 keV MACS: (5.2 vs. 14.2) mb; 9 mb too small!
  - *p*-wave resonances were omitted from MACS: another 10 mb missing!



$^{62}Ni(n,\gamma)^{63}Ni$: Direct vs. Resonant capture

\ MACS 30 keV	Rauscher [mb]	This work	Measured
Resonant (RC)	5.2 ± (5%)	24.2 ± (5%)	n/a
Direct (DC)	5.5 ± 0.8	0.4 ± (20%)	n/a
Total	10.5 ± 0.8	24.8± (>5%)	25.8±1.8(stat)±1.9(sys)

- DC in this work computed by CUPIDO (Dietrich, LLNL):
  - for the real part of the Koning-Delaroche optical potential
    - Its s-wave "resonance" occurs near A~55, so possibly safer than Rauscher's potential
  - Analogous computation of MACS on 58,60Ni supported by high-res. data
    - Guber et al., Phys. Rev. C 82, 057601 (2010) (DC computation by Arbanas/CUPIDO)
    - A decreasing trend of DC for {58,60,62}Ni {1.36, 0.54 0.4} mb observed:
      - Expected from a general formula for E1 s-wave neutron capture:
      - SF*($BE+E_n$)^3 ← both SF and BE slowly decreasing as neutron number increases
    - The above may boost confidence into our DC computations.
- RC in this work: corrected Γ_γ of 4.6 keV res. + p-wave resonances

"Rauscher": Rauscher and Guber, Phys. Rev. C **71**, 059903(E) (2005)
"Measured": Alpizar-Vicente et al., Phys. Rev. C 77, 015806 (2008)

Estimating errors of Hauser-Feshbach (HF)

- HF uses optical potential transmission coefficients
  - Yields energy-averaged cross-sections (*gross* structure)
    - Energy-averaging interval is on the order of 1 MeV
- What if we had an *intermediate* structure theory?
  - s.t. yields energy-averaged cross sections averaged over ~0.1 MeV
    - Corresponding to the width of nominal doorway states; e.g. 2p-1h states
- Performed a numerical estimate by energy-averaging ^{62}Ni(n,γ) data
  - Followed by Maxwellian averging for KT= 30 keV; cf. TALYS HF MACS

E-avg. interval [MeV]	MACS [mb] kT=30 keV
0.0	24.2
0.1	24.7
0.2	20.3
0.5	8.8
1.0	7.0

Preliminary

TALYS Γ_γ-strength	renormalized	unrenor.
Kopecky-Uhl Lorentz.	31	8
Brink-Axel Lorentzian	29	35
Hartree-Fock BCS	n/a	13
Hartree-Fock-Bogol.	n/a	13
Goriely's hybrid model	30	12

  - The improvement in accuracy may be appreciable in this case

DC vs RC near closed shell nuclei

- Motivated by our computation of $^{130,132}Sn(n,\gamma)$ Direct Capture (DC)
  - $^{132}Sn(n,\gamma)$: DC >> RC is generally accepted
  - $^{130}Sn(n,\gamma)$: DC << RC is estimated by Hauser-Feshbach models
    - But not confirmed experimentally
    - For ^{48}Ca and ^{208}Pb data suggest DC >> RC (in support of 132Sn DC >> RC above)
    - For ^{46}Ca and ^{206}Pb data suggest DC << RC; does this imply $^{130}Sn(n,\gamma)$ DC<<RC too?
    - $^{124}Sn(n,\gamma)$ (the heaviest stable tin) plotted; shows many compound resonances
      - Its kT=30keV MACS is ~10 mb
      - consistent with some HF models
      - but still inconclusive Re: $^{130}Sn(n,\gamma)$
  - Could an intermediate structure model give answer?
    - Arthur's new model?