Sensitivity Study of ^{252}Cf(sf) Observables to FREYA Inputs

Ramona Vogt (LLNL & UC Davis)
with P. Talou, T. Kawano & I. Stetcu (LANL) and J. Randrup (LBNL)

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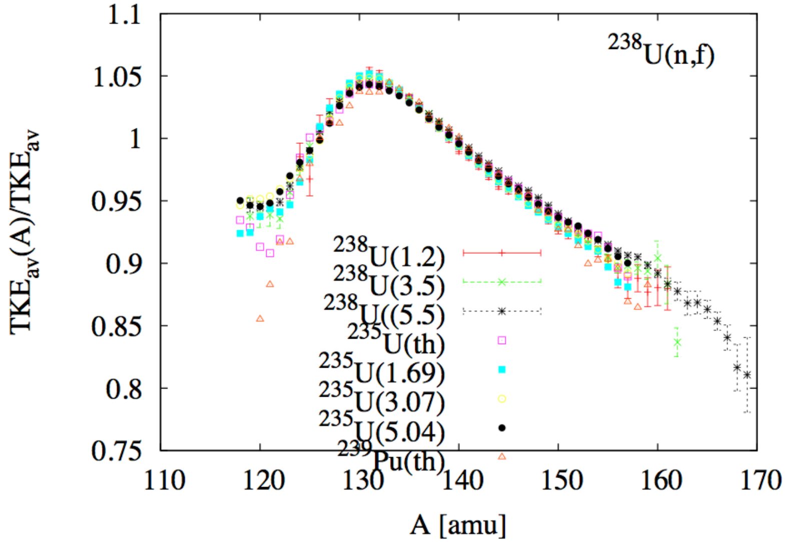
Dependence of Total Kinetic Energy of Fragments with Mass Similar for Many Actinides and Incident Neutron Energies

Average TKE has a huge impact on average neutron multiplicity

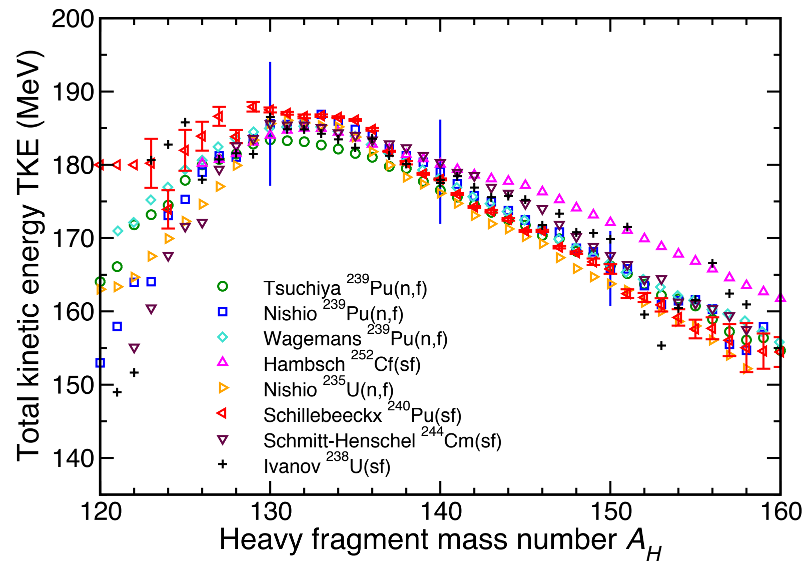
TKE(A)/<TKE> rather similar for different isotopes and different energies

The question we address here is how much changing TKE(A) influences prompt Observables

TKE(A) can change with excitation energy but we focus on ^{252}Cf(sf) here



^{238}U, ^{235}U at different neutron energies and ^{239}Pu fission by thermal neutrons



TKE(A_H) for several isotopes, scaled to ^{239}Pu Nishio value at A_H = 132

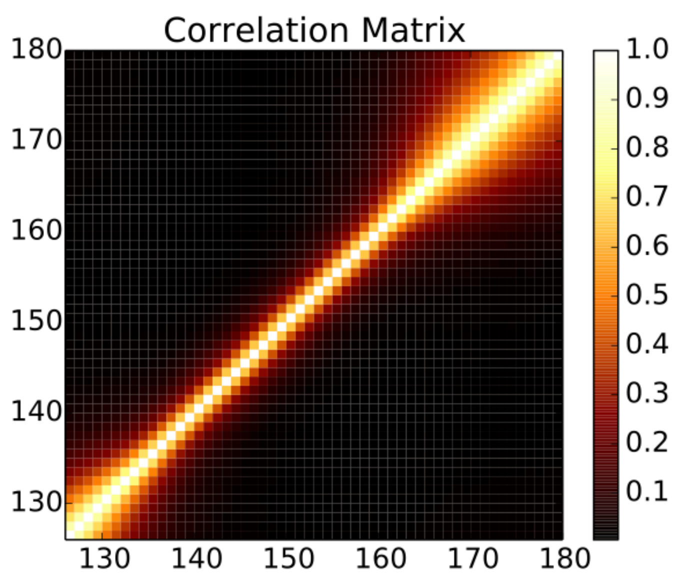
How do uncertainties in TKE propagate to calculated prompt fission observables (neutrons and photons)?

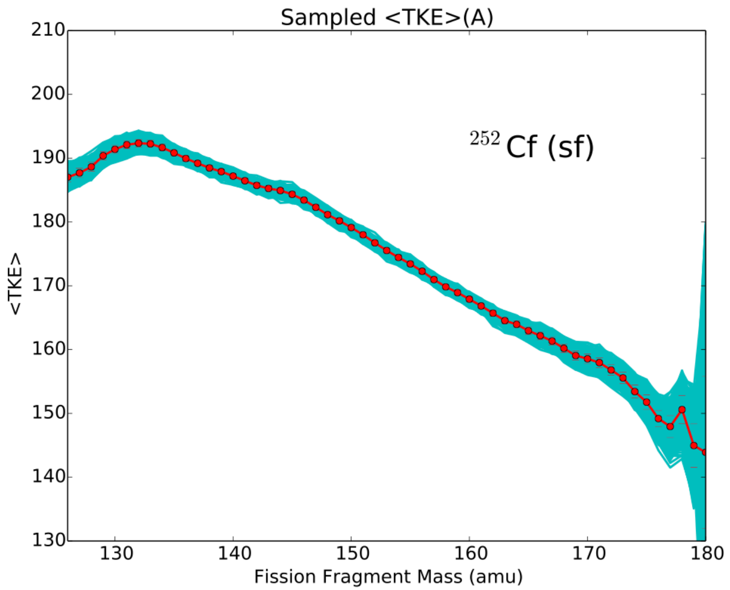
We have so far used FREYA with different input TKE distributions to try to answer this question (FREYA had to be modified to read in sampled yields and produce coherent output

A covariance analysis of TKE(A) data was made

This covariance matrix was sampled to produce 1000 TKE(A) files to use as FREYA input

The following slides show the distribution of the results from the input variations

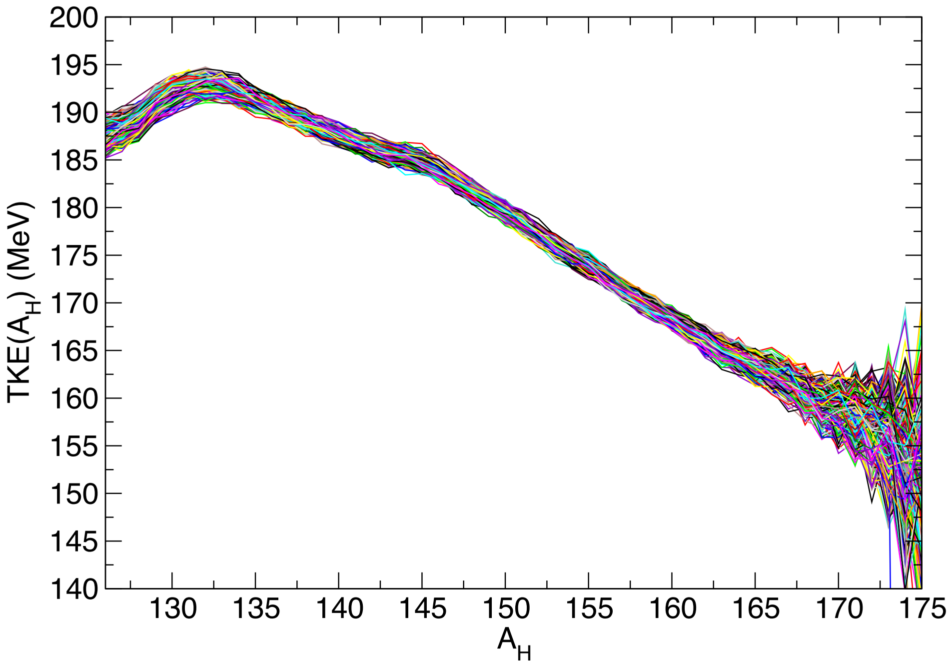


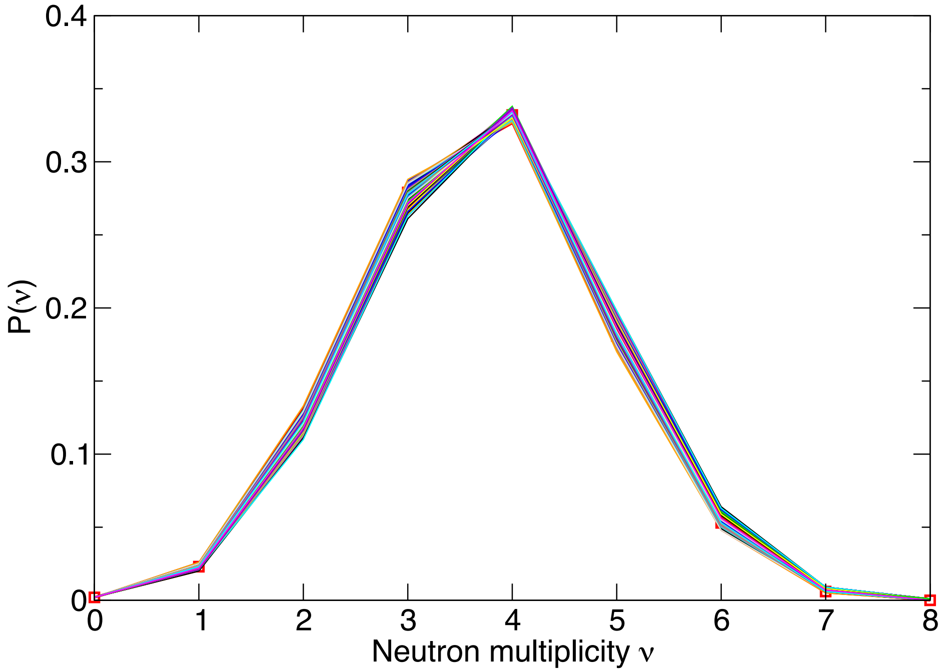


Variations within Covariance Matrix Result in Generally Small Spread in Most Neutron Observables

TKE(AH) after running through FREYA is the same as input (as should be expected)

P(ν) shapes are similar, different choices of TKE(AH) will give different average ν

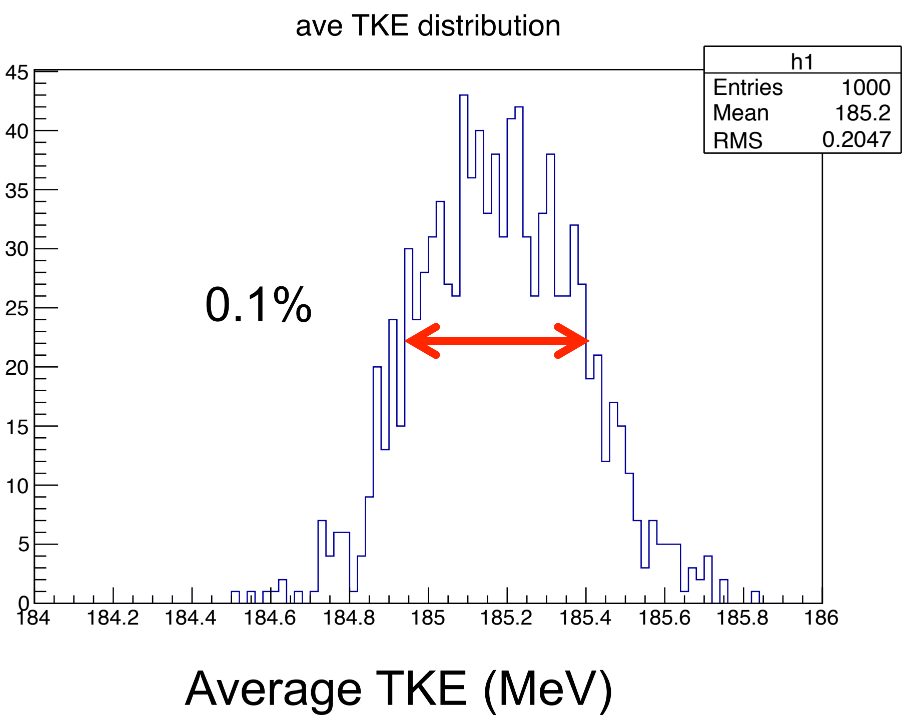


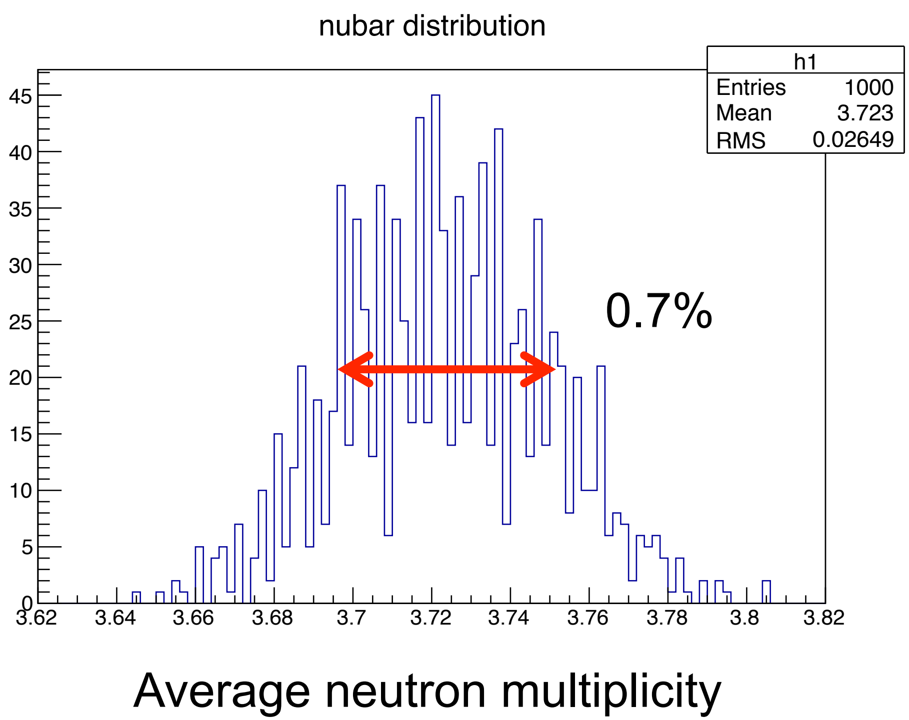


Constraining Average ν Could Place More Stringent Constraints on TKE Spread

The recommended error for <TKE> for ^{252}Cf(sf) is 1.5 MeV

Here we see that varying <TKE> by 0.1% can make the average neutron Multiplicity vary by 0.7%, a huge error on this critical value

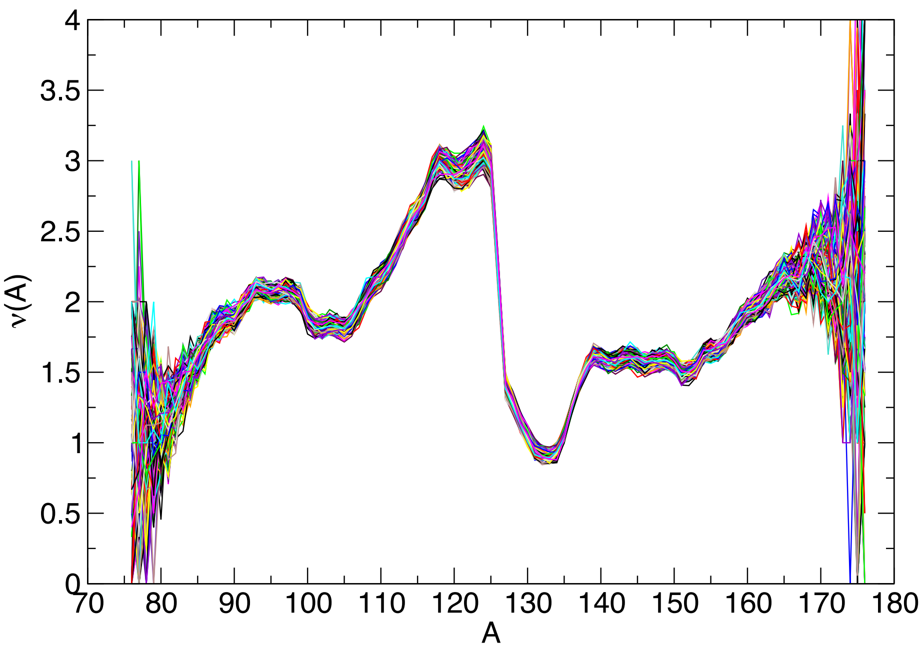


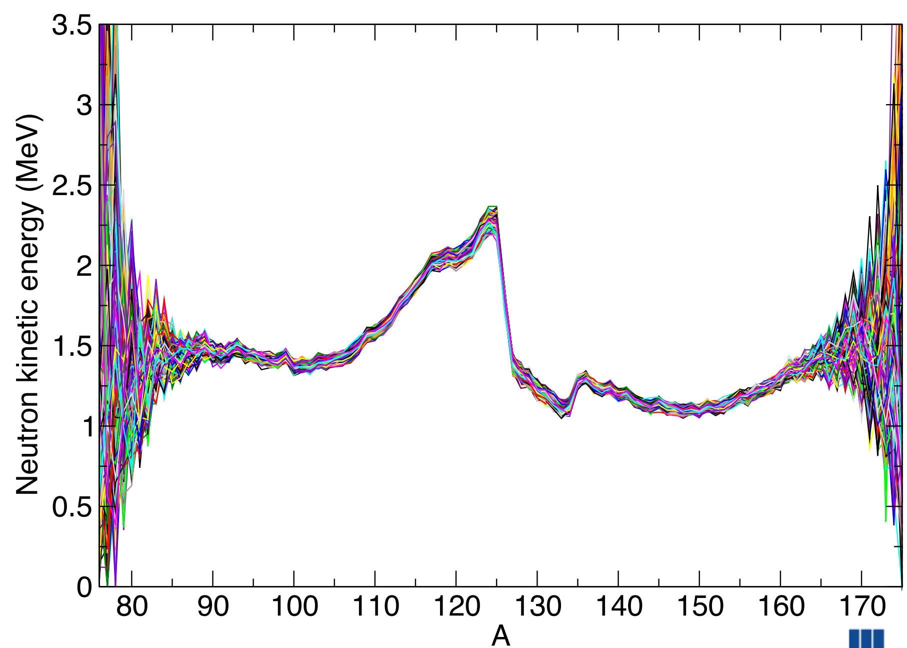


Average Neutron Multiplicity and Energy vs. Fragment Mass

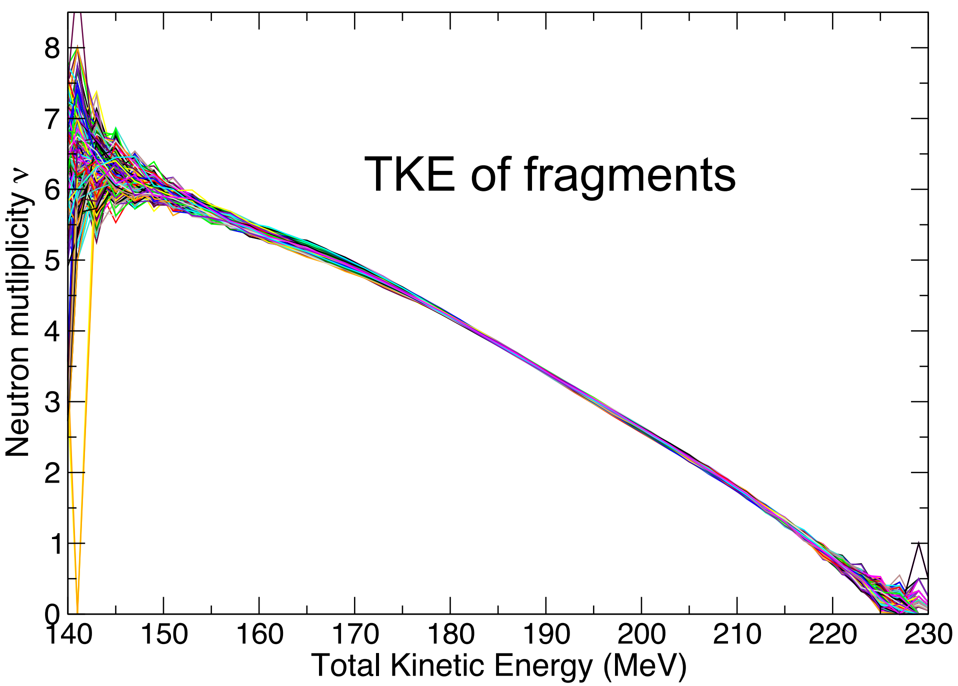
Greatest variation in ν(A) and ε(A) is for A < 90 and A > 160 where TKE(A_H) spread becomes large (Note that ε(A) is not in good agreement with data – not understood)

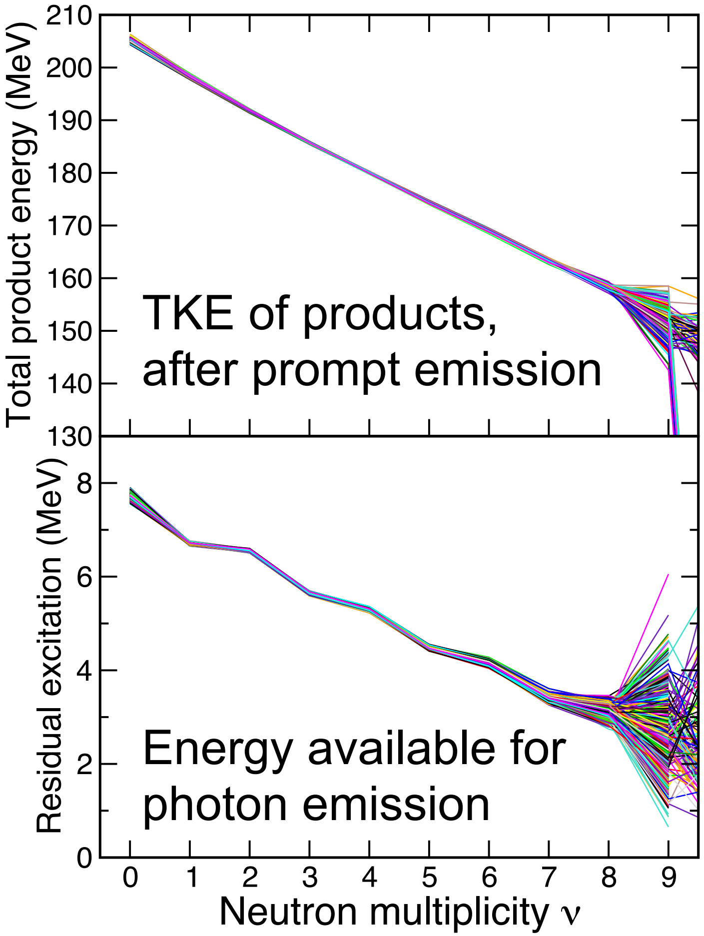
Sensitivity of neutron multiplicity distribution is small near shell closure at A = 132, average energy is also small here where deformation is small; more deformed light fragments near symmetry emit more energetic neutrons





Available Energies Before and After Prompt Emission vs. ν

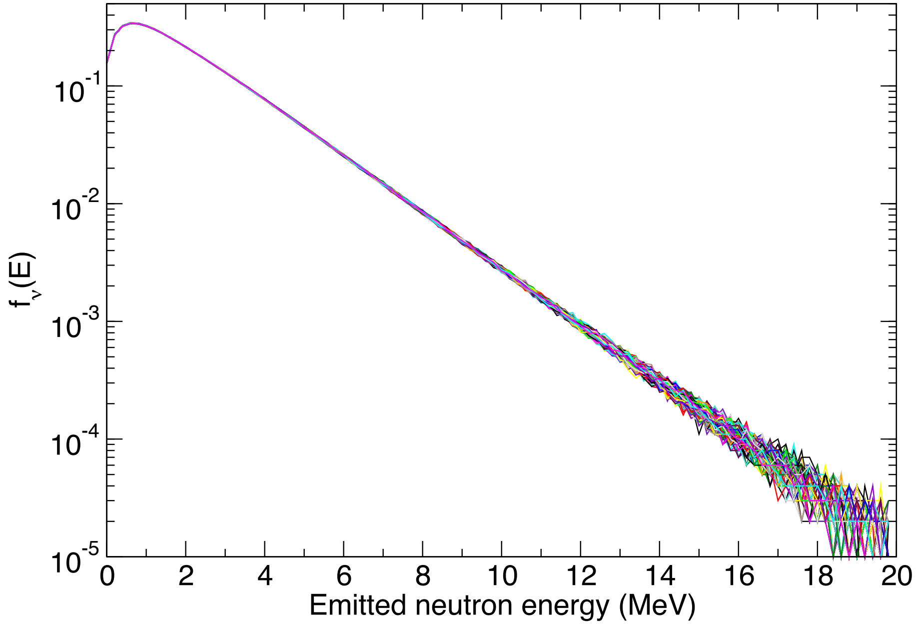


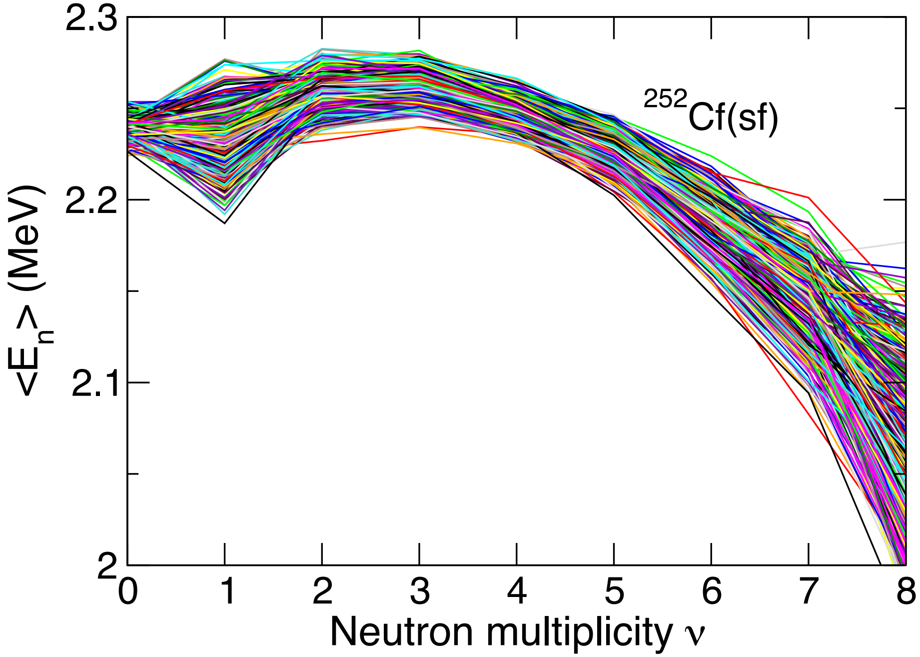


Sensitivity of Spectral Shapes and Average Energies

Spectral shape (divided by average neutron multiplicity to normalize) shows Little variation (on a log scale) at low outgoing neutron energy but the high Energy tail is broadened

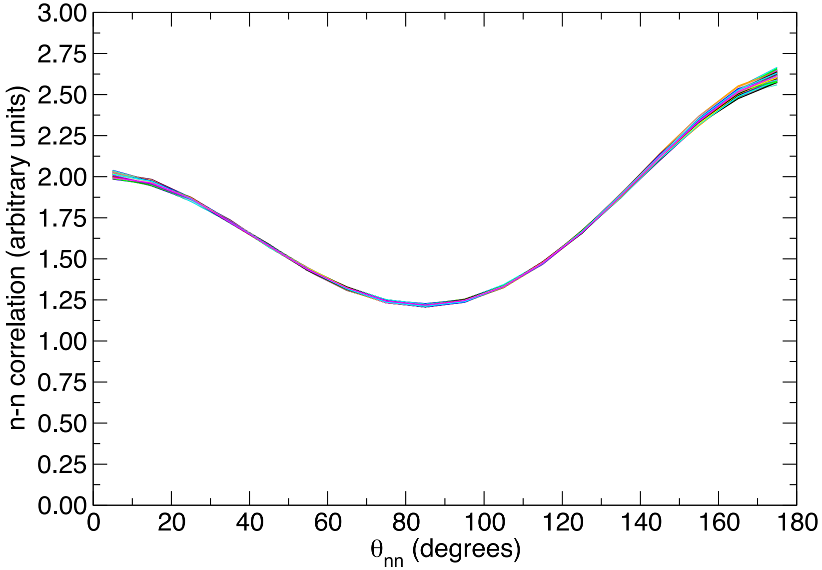
Average emitted energy decreases overall for higher neutron multiplicity (ν = 0 value corresponds to integral over all ν, as on left-hand side)

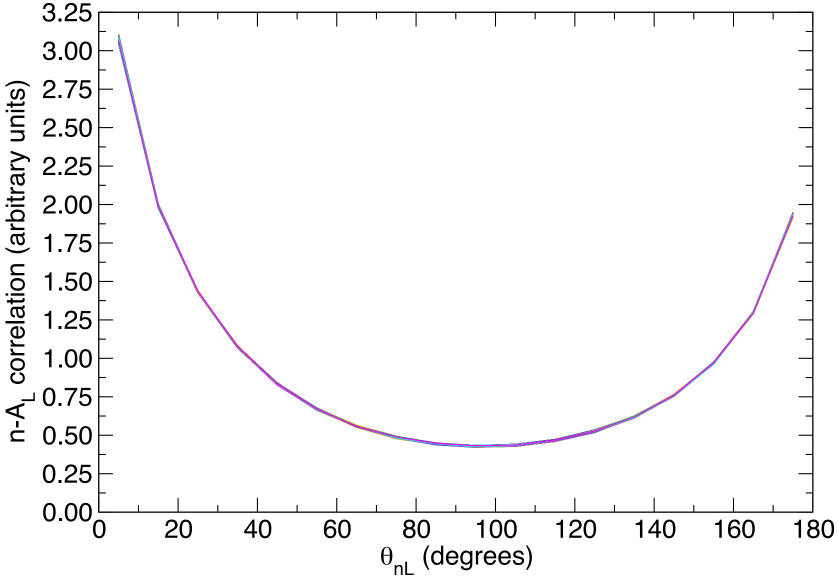




Correlations Relatively Insensitive to TKE(A_H)

Important result for applications interested in correlations



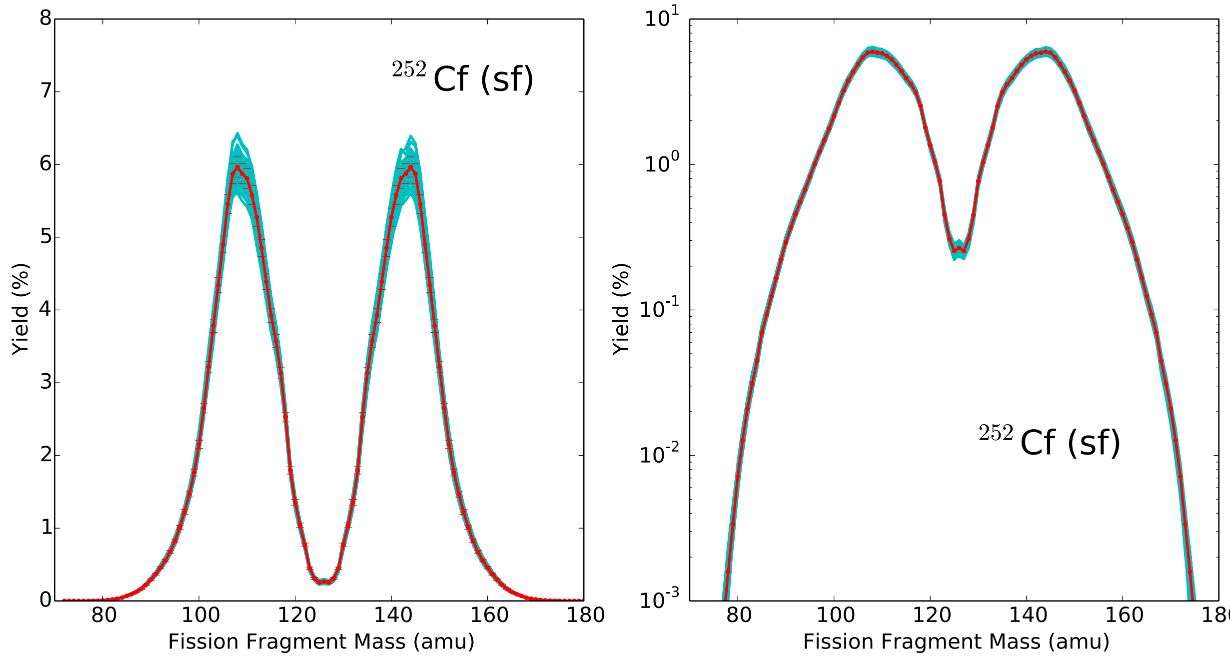


Next Step: Variation of Yields and TKE Simultaneously – Y(A,Z,TKE)

Steps toward making Y(A,Z,TKE):

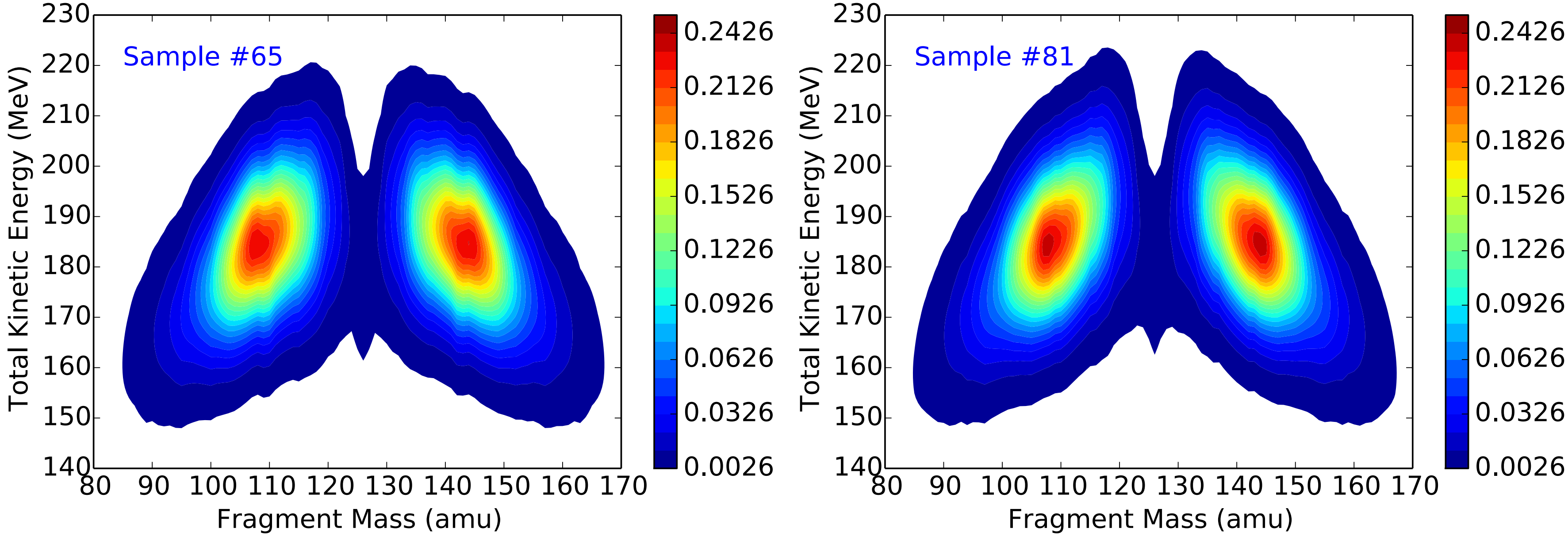
1. Make covariance analysis of Y(A)
2. Sample covariance matrix to get 1,000 samples $Y_i(A)$
3. Combine $Y_i(A)$ and $TKE_j(A)$ to produce $Y_{ij}(A,TKE)$
4. Complement the Z distribution from Wahl systematics to obtain Y(A,Z,TKE) samples
5. Run FREYA and CGMF with these inputs

Sampled Mass Yields Y(A)



Next Step: Variation of Yields and TKE Simultaneously – Example of Countours

Contours of Y(A,TKE) for two different sampled yields



Other New Developments with FREYA

- Version 1.0 of FREYA published in Comp. Phys. Comm. 191 (2015) 178.
- Photon emission augmented by GDR strength functions and RIPL lines, improving agreement with photon spectral data (not part of study but nice result)