Workshop for Inelastic and Elastic Neutron Scattering

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1 Examination of C, Be, Mo, ^{238}U, ^{Nat}Fe using the RPI HES Data with Current ENDF, JEFF, and JENDL Evaluations.

Speaker: Dr. Adam Daskalakis (Naval Nuclear Laboratory)

The RPI LINAC has the capability to perform experiments tailored for nuclear data applications. The high energy scattering system has been used in the past to perform quasi-differential neutron scattering measurements on several samples. Comparisons of past measurements have been made to several evaluated nuclear data libraries. Differences are observed between the latest ENDF and JEFF/JENDL evaluations for Molybdenum. ENDF8.1b2 compares poorly to Beryllium data relative to ENDF8.0. JENDL4.0 compares poorly to the Fe data, but better agreement is observed compared to JENDL5. Most evaluations agree well with ^{238}U data.

Discussion:

- Can you elaborate on the issues present with Fe?
  - A general comparison can be made using RPI HES data, and based on Elastic/Inelastic ratios, it appears that JENDL4.0 was not doing well. JENDL5.0 calculates better than 4.0.
    - JENDL5.0 was taken from 4.0, so it is unclear why the two are calculating differently.
- Has there been discussion on turning the RPI HES system into an ICSBEP benchmark?
  - There is interest in this but no current funding.

2 Quasi-Differential Neutron Scattering Measurements of 181Ta and Teflon from 1.75 to 20 MeV

Speaker: Greg Siemers (Rensselaer Polytechnic Institute)

^{181}Ta and Teflon high energy scattering measurements were conducted using the RPI HES scattering system. The system was upgraded from an 8-bit digitizer to a Struck 10-bit SIS-3305 digitizer. The data were reduced to obtain preliminary comparisons to MCNP simulations and it is seen that ENDF8.1b2 performs well when comparing to the preliminary quasi-differential scattering data obtained from RPI. Results obtained are still considered to be very preliminary and further work is underway to improve the pulse shape discrimination methods to see neutrons down to 0.5 MeV.

Discussion:

- Do you know anything about the historical data those evaluations that perform poorly (ENDF8.0 & JEFF3.3) were based on?
  - RPI capture and transmission data were used to constrain the evaluation, but not sure what differential & double-differential data were used to constrain the evaluation.
    - The high energy region is not currently based on any experimental data, it is purely based on calculations.
- Is the detection threshold function important? How do you apply the this detection threshold into MCNP?
  - We apply a conservative A/B P.S.D. cut to be left with only neutrons. A neutron detection efficiency curve is then constructed from in-beam neutron data and these efficiencies are passed into MCNP as a function of neutron energy to be applied as a multiplier on each bin.
    - So it is an experimental threshold function applied?
      - Yes, it is essentially the detector efficiency curve.
- You report a 6% uncertainty, what is this uncertainty coming from and can it be improved?
  - The 6% is for systematic only. It is expected that newly developed experimental techniques will help reduce the systematic uncertainties in the final data.

3 Fast Neutron Inelastic Scattering from ^{7}Li

Speaker: Dr. Arnd Jughans (Helmholtz-Zentrum Dresden Rossendorf)

There is a lot of nuclear data activity occurring in Dresden. An overview was given of nELBE as well as the status and setup for the Li-7 (n, n'γ) measurements. Preliminary results show that the data in the plateau region are about 15% lower than previous GEEL data. A new measurement was conducted, and analysis is underway. Transmission measurements and results were shown for Natural Fe, Zr, N, & Ar.

Discussion:

- Will your final data for ^{7}Li be in the same place as it is now?
  - Yes, hopefully things will not change significantly.

4 On Quantum Entanglement and Neutron Scattering

Speaker: Ron Dagan (Karlsruhe Institute of Technology)

Inclusion of internal level structures of the nucleus impact the scattering process and angular distributions. Both the polar and azimuthal angles are said to contribute to scattering at higher energies, and more experimental work is needed to validate this theory. A set of measurements were conducted at RPI using Uranium to show some sensitivity to this effect, and more measurements are planned at GELINA in the future.

Discussion:

- What is the energy region of the experiments that are being proposed at GELINA?
  - Energies of data will go up to 200 keV. How far do you think we need resonance treatment?
    - Some measurements are needed in both resolved and unresolved regions that are all temperature dependent.

5 Neutron Inelastic Cross Sections on ^{40}Ca

Speaker: Marian Alexandru Boromiza (Horia Hulubei National Institute)

^{40}Ca is the dominant isotope and is highly relevant to MSRs. Not a lot of experimental data on inelastic cross sections exist prior to the measurement campaign discussed. For both capture and inelastic channels, one needs, on a target by target basis, a very detailed handling of the CN spin-parity population differences. In the first try, a surrogate based approach was made for an inelastic channel where inference of neutron cross sections was made from proton induced reactions. In the second case, isospin symmetry is taken advantage of. Experiments were done at GELINA with the GAINS spectrometer. The efficiency was extrapolated up to 4 MeV using a Europium source. Gamma spectroscopy was coupled to neutron time of flight to get inelastic neutron cross sections. Results are preliminary so far - multiple scattering corrections are needed. All gamma production cross sections are added for total inelastic. Based on comparisons, large differences are seen between data collected and evaluations. Statistics are limited - 10% uncertainty is reported at minimum.

Discussion:

- Which optical potential is being used?
  - A local potential. From the proton to neutron case the potential is modified.
- With GrapheME data, we see gamma lines from Flourine.
  - Marian was not aware of this.
- Can you comment whether the structure seen in the data is from statistics or real structure?

  - Start to see how well you can resolve, ^{24}Mg. For Calcium low level density resolved to first few MeV.

6 What's "Happ'nin" at Kentucky

Speaker: Jeffrey Vanhoy (US Naval Academy)

Overview given of nuclear data capabilities at Kentucky. ^{19}F was still the devil. 90ns isomer was being missed due to DAQ capabilities at the time, so a new digital DAQ system was developed. Lots of projects are planned and in the pipeline. Kentucky is having major issues with staffing.

Discussion:

- Looking into the fluorine data, LANL agrees that Flourine is evil because we cannot resolve ground state or 1st level.
- What is the average size of a sample?
  - Sample sizes are small to be able to reduce the magnitudes of any corrections required.

7 Using OpenMC to Model Time-of-Flight Quasi-Differential Scattering Experiments

Speaker: Hunter Belanger (Rensselaer Polytechnic Institute)

The RPI HES system was modeled in OpenMC. OpenMC is an open-source software that holds many advantages over MCNP, mainly related to restrictions on distribution of the latter. Using surface current tallies, Graphite and Iron were both modeled at forward and back angles. Some differences were observed between the results between OpenMC and MCNP. Gamma production from neutron scattering with Iron was also studied and exceptional agreement was seen between results between MCNP and OpenMC. Use of OpenMC at the RPI LINAC will expand moving forward.

Discussion:

- Does OpenMC read MCNP input files?
  - It does not but there are translators that are available.
- What kind of tallies were used for the comparisons shown?
  - Surface current tallies for both.
- Can an HDF5 be made from ENDF?

  - Need to make an ACE first, nothing is re-calculated when using a HDF5 files for OpenMC, so the information between MCNP and OpenMC should be the same.

- How much control does one have over OpenMC vs MCNP to see if the codes are in fact doing the same thing?
  - There needs to be some level of trust placed on the manual for the code, but w/o the source code, it is impossible to be 100% certain that things are implemented correctly.

- Benchmarking of both codes can be done by placing a small sample and detectors and very specific angles, and you can reconstruct what is actually put in the ENDF file. The comparison can then be made from the ENDF file to the outputs to both codes.
  - Limited concern as a developer in the differences between OPEN MC results and MCNP. Open MC generates geometries and translates them instead of defining the geometry in a given space in MCNP.
    - There are other projects in progress to compare TRIPOLI and MCNP, maybe some simple test cases would be best to compare codes.

- What kind of difference can be expected between a tally different from F5 such as F2 or F1?
  - Point detectors are very tricky to implement, surface current tallies should be more accurate. Point detectors are used historically due to the efficiency of the simulation.
    - We use F5 tallies because it runs fast, but can be dangerous if you don't know what you are doing.

- Do you use the ring detector in MCNP?
  - Generally no because ring detectors are difficult to rotate and position correctly.

8 GAINS - Twenty Years Later

Speaker: Adina Olacel (Horia Hulubei National Institute)

GAINS (Gamma Array for Inelastic Neutron Scattering) was motivated by nuclear data needs and needs for next-Gen nuclear reactor designs. GAINS has gone through several different configurations and upgrades since its inception in 2000. Now, GAINS has 10 HPGe, 2 $LaBr_2$ detectors. Results were shown for Mg inelastic cross sections, Ti inelastic, which is under investigation to be established as a standard y-ray reference cross section. GAINS provides very low relative uncertainty, with 5% for the strongest transition, and good neutron energy resolution 2000 points for the main transition.

Discussion:

- Can you measure (n,α) gamma and (n, pγ)?

  - Theoretically yes we can measure, but it would take a long time due to statistics due to cross section.
    - In TALYS each of these reactions play a part and are unconstrained if there is no data, and the current way it is usually done is wrong.
      - This is very demanding experimentally, you need very thin targets
      - Shouldn't be an issue of target thickness because you are interested in the gamma, not the charged particle.

- Does Gains have plans to go towards actinides?
  - No.
- Do you have experience with spectrum from $LaBr_2$ detectors?
  - No, we need to process and look at those data, they will likely require background subtraction from the spectrum
- How often do you have to anneal the HPGe after neutron damage?
  - It is done, but unsure about the frequency.
- What is the highest energy photopeak that the efficiency of the germanium is calibrated to?
  - A ^{152}Eu source, an ^{16}O gamma of about 7.1 MeV was observed. Ga can be used for higher energy gammas using a proton beam incident on a Zinc foil.

9 Back on the Iron Throne: A New Measurement of the ^{56}Fe(n, inl) and ^{56}Fe(p,inl) Cross Sections

Speaker: Alexandru Liviu Negret (Horia Hulubei National Institute)

A ^{56}Fe inelastic measurement was performed in 2014 at GELINA, and another CIELO evaluation was made in 2018, INDEN evaluation arrived in 2019 and started to question these data. Performance of these two libraries in iron shielding benchmarks was very poor - an underestimation was made of leakage thru an Fe sphere. INDEN evaluation does not consider the data that were published in 2014. Checks were performed on the old measurement, and the absolute scaling to fission chamber and other issues were checked thoroughly. However, a new measurement was performed anyways - upgrades have been made to GAINS since the last measurement was performed. The new measurement is scheduled for early 2024 using an enriched Fe target - and new normalization technique will be used in tandem with fission chamber normalization. ^{56}Fe(p,pγ) preliminary measurement w/o background corrections was made with several targets, reasonable agreement is shown with TALYS calculations. New measurement of ^{56}Fe(n, el) and ^{56}Fe(n, inl) were performed at GELINA. An array of EJ-301 and C_6D_6 scintillators was used to measure these reactions in tandem using the ELISA array. Some discrepancies observed between results obtained from a detector at the same angle - likely an efficiency correction is needed. Data analysis is ongoing for those data.

Discussion:

- For the first inelastic state, do you need to use a known branching ratio to get the cross section? How much trust do you have in this number? Additionally, how can you be so sure of the calibration of the HPGe detector?
  - There is an uncertainty on the branching ratio, all uncertainties are propagated into the final reported uncertainty. For calibration, a calibrated source is used, and that uncertainty is also being propagated into the final results.
- Is there noticeable cross-talk between the detectors?
  - We do detector-by-detector multiple scattering corrections.
    - It is important to see the amount of neutron scattering background per incident neutron.
- What is the black object in one of the images?
  - These are Be windows around the detectors used to filter x-rays and low energy gammas.
- What material is the sample holder?
  - The beam is smaller than the sample, so we did not take the sample holder into account.

10 Cross Sections for Inelastic Scattering of Neutrons on ^{14}N using the GAINS Spectrometer

Speaker: Andreea Oprea (Joint Research Center (JRC) (BE))

An overview given of different detection systems present at GELINA. ^{14}N is important due to its presence as part of fuels for liquid metal fast breeders. Measured first two transitions from ^{14}N and cross validated with Si. Future data analysis is required, including angle-integrating cross sections at 110 and 150 degrees, multiple scattering corrections, and submitting the data to EXFOR and writing a paper.

Discussion:

- An alternative approach for level schemes would be more reasonable.
- Flight path for ELISA is 30m
- Any plan to put a nitrogen sample thru ELISA?
  - No, we do not have enough manpower

  - Gammas for N are all above Eu, are there any below?
    - No, but there is one immediately after in energy.

- Are you measuring energy via pulse height or total time of flight?
  - Energy comes from total time of flight, but the pulse height is used for n/g discrimination. There are tricky corrections needed for inelastic vs elastic scattering since a neutron will fly the additional length to the detector.

11 Recent Results from CoGNAC Neutron Scattering Measurements at LANL

Speaker: Keegan Kelly (LANL)

An overview of the LANSCE facility was given. CoGNAC consists of CLYC and EJ-309 detectors. 72 CLYC now in detector array - goal to measure n and gammas from scattering. 6 detectors at each theta at various phi angles - 1 ns time resolution. Random coincidence background is subtracted. Spectrum unfolding is used to correct for n scattering effects and extract full strength of each excited state. Covariance matrices are included and generated for all results. Fe56 data shows good agreement with ENDF evaluation. γ-rays can be gated and correlated to first inelastic state. New LANSCE data with this γ-only analysis highlights structure seen in C(n,n'γ). Work is being done for γ-only analysis of ^{16}O(n,n'γ). Si measurements with high-purity target are planned, high purity ^{56}Fe, ^{9}Be(n,n) and (n,2n) and expand CoGNAC broadly include (n, 2n) and (n, 3n).

Discussion:

- Are you sensitive to the gamma angular distributions?
  - No, since we are integrating over the gamma distribution we are not sensitive.
- How do you decide when to stop iterations for the unfolding?
  - There is no great answer, unfolding methods say hundreds/thousands without any convergence criteria. We have seen 1 to 2 is sufficient, with statistical noise being added with additional iterations.
- You show new correlation information that has not been present before in slides 10/11. This data may be very important for transport calculations.
  - Not able to get funding for this, even though it is very interesting to the nuclear data community.
  - This is fundamental information that is not present or used in transport codes, there is no data format to accommodate this information.
    - Data formats are nice, but to have measurements of this is a very interesting start.

12 Zirconium Scattering Sensitivity in Neutron Transport Calculations of Multiplying Systems

Speaker: Greg Siemers (RPI)

Comparisons of evaluations are made to RPI scattering data of Zr. A tool was presented that allows for in-depth analysis of sensitivities of multiplying systems to different nuclear reaction channels. Based on this information, it is recommended that new measurements (double differential (n, el) below 1.5 MeV) and evaluations efforts be made by the larger nuclear data community to improve Zr, where eigenvalue prediction using ICSBEP benchmarks can reach 600 PCM differences between major evaluated libraries. Preliminary work was also presented in designing a Zr-sensitive critical benchmark.

Discussion:

- In an example where you have benchmarks that are not performing well, fixing Zr does not appear like it will solve the overall problem. What is happening in those benchmarks?
  - There is a large overprediction of keff, and there are several working theories as far as why that could be the case.
- You show 75% of difference due to ESADs. Did you properly account for the correlations between the ESADs and integrated cross sections?
  - Validation work was done to make sure this was taken into account.
- We studied ESADs of Zr and generated ESADs from resonance parameters. Currently k might be overpredicted due to calculation of the p1 moment. You can get the ESADs from resonance parameters using B.B.
  - This is only possible with a proper resonance evaluation to reconstruct the angular distributions. We need proper spin assignments and resonances that are visible as well, and a lot of structure in Zr breaks down.
- Scattering ESADs are garbage because ENDF7.1 had a time crunch on the evaluation, which was done using a broken version of the EMPIRE code. Mughabghab also messed up the resonances.
  - EMPIRE now agrees with CoH so it should be good. There should be enough data to get B.B. with existing nuclear data.
- Will there be an additional report or paper, as this is a good justificiation for more differential experiments.
  - Yes this will be published in some form.
- WPEC subgroup potentially being formed on Zr evaluations w/ Dave Brown and Greg Siemers

13 Problem with Gradual Absorption in MSD/MSC Calculations

Speaker: Toshihiko Kawano (LANL)

Multistep direct and compound reactions have had two major theories proposed. The impact of MSD/MSC on fission calculations was shown using the EMPIRE code. If MSC is ignored, the fission cross section was shown to be larger - suggesting MSC is more important than previously thought. MSC is underestimated, and various options exist to increase MSC in EMPIRE. There is no good explanation why calculations currently disagree with experimental data. More work is needed to study MSD/MSC because experiments suggest higher MSC but there may not be enough space in theory. Therefore, a microscopic approach to coupling P and Q chains is suggested to be incorporated into the MSD/MSC framework.

Discussion:

- Is there influence from other parameters?
  - This is a population distribution parameterized by a spin, but this is a question for Mike. There are also various modeling effects accounting for differences.

14 Gaussian Orthogonal Ensemble Model for Low-Energy Neutron-Induced Reaction to Excite Weakly Overlapped Compound Nucleus States

Speaker: Toshihiko Kawano (LANL)

There exist gaps between RRR and URR, and a smooth transition is not always fully guaranteed. Conventional H.F. calculations are very simple, and CC and HF calculations are often decoupled. H.F. equation assumption of average widths being replaced by transmission coefficients is called into question because of a correlation that appears in the width fluctuation correction factor. LANL code CoH is used to perform these calculations. Differences were shown between CoH, TALYS, and EMPIRE calculations, CoH is higher when comparing ^{238}U inelastic cross section ratios. A unified approach was shown for coupled channel optical model and H.F. theory and applied to deformed nuclei, which is incorporated into CoH_3

Discussion:

- For the URR step in ENDF, should the cross sections match when stepping from low to high or vice versa?
  - This is a real step change, there is missing degrees of freedom coming from the higher energy.
- Isn't there the issue that you are not able to measure all resonances?

  - Higher energy has missing resonances, can be seen by statistics. Stops resonance analysis.
- Degrees of freedom factor not change per channel?
  - Tiny gamma channels are different, lump them all into 1 have continuous distribution, which does not produce actual average. Neutron channel degree of freedom is "Good Enough"

15 Validation and Evaluation Uses for Quasi-Differential High Energy Scattering Data

Speaker: Peter Brain (RPI)

There are several uses of Quasi-Differential High Energy Scattering Data, as shown for the Pb evaluation recently done at RPI. Quasi-differential data shows large differences between experiments and evaluations. The scattering data was then used to constrain the spins of resonances since it was shown to be very spin-sensitive. After changing elastic and inelastic channels, large improvements are observed in the comparison of quasi-differential experimental data and the RPI evaluation. Quasi-differential scattering data can also be used to scale and understand covariances for secondary neutron distributions. These experiments are preferred over integral experiments for validation purposes as well.

Discussion:

- I didn't get the idea of the optical model potential, did you check it or fit it?
  - Resonances are well-isolated, so optical model is too coarse since you cannot get the reconstruction of differential data. B.B. is better because you get back the resonance structure itself and integral responses are very sensitive to those resonance themselves.

16 Latest News from GRAPhEME @ GELINA and future measurements @ GANIL/SPIRAL2/NFS Facility

Speaker: Maelle Kerveno (IPHC / CNRS)

Work has been done at GRAPhEME on studying actinides over the last few years. Th data, Uranium, Zr, W, Fe, Pu measurements completed or in progress. Measurements uncertainties are from 3-5% below 9 MeV, all data are reported with correlation and covariance matrices. Results were shown for U, but DAQ was upgraded for ^{239}Pu inelastic measurement. Only a few weeks of beam time thus far due to COVID. Future at NFS consists of doing (n, 2n) and (n, 3n) reaction studies. Beamline is being designed and background characteristics are being characterized. GRAPhEME results are being used to constrain (n, inelastic) cross sections for actinides and W isotopes.

Discussion:

- Does your segmented Ge detector use add-back or vetoing between segments?
  - No
- Was the test done with full power at NFS?
  - About half power.
- You mentioned Zr, what is the status of that?
  - We have the data, but it has not been analyzed yet.
- How did you deal with gamma flash in the fission chamber?
  - Gamma flash is determined based on the total gamma transit time and signal transit in cables and electronics.

17 Overview of the Gamma Rays Induced by Neutrons (GRIN) Project

Speaker: David Brown (BNL)

Gamma data in ENDF is woefully deficient. There exist many different use cases of good gamma data - which are used in transport codes, and many isotopes require good gamma data. GNDS format has feature that allows to treat primary gammas using two-body kinematics. GEANT4 implementation of gamma emission is incorrect. To fix GEANT4 - MCGIDI will be used which is open source GNDS flavored collision kernel. ENDF-based event generator is desired (not a reinvention of CGM). Active work is being done to identify strategies to employ fixes for these nuclear data. Large collaborative efforts are being established to begin validation work for tools and evaluations.

Discussion:

- What is MCGIDI?
  - It is a full collision kernel. For the gamma if its decide you do a reaction in a excited state. If data is available it will de-excite that nucleus. Repeats until it lands on the ground state
- You mentioned problems with transport codes like preservation of physics, but the information is not available to the codes. What about issues with other transport codes?
  - It is a transport code dependent issue, where LLNL codes prefer to preserve energy balance over all else. MCNP now uses CGM to preserve some of these physics.
- MF6 was used over other format due to limitations that existed within MCNP.

18 TLYC vs CLYC: Comparison of Fast Neutrons and Gamma-Ray Detector Performance for In-Beam Neutron Scattering Measurements

Speaker: Patrick Copp (LANL)

TLYC detectors replace Cesium with Thallium for a higher efficiency. TLYC has worse resolution than CLYC but a better efficiency. The optimal settings for resolution and efficiency are not identical for the detectors. Optimal settings have a small dynamic range where the spectrum ends at 2.5 to 3.5 MeV. 3.1% resolution is observed at 4.4 MeV for PuBe for CLYC and 2.9% resolution for TLYC. P.S.D performance for TLYC is not as good as CLYC. In-beam characterization of these detectors are underway on a scattering measurement of C. Performance comparison with C^7LYC is also underway.

Discussion:

- How thick are the CLYC crystals?
  - 1.5"RCC.
    - We had an issue where the detectors were very sensitive to gammas where they were dead for linger than our EJ-301. How do you think these will perform in-beam?
      - We will need to test, as we want less than 10 events per macro pulse, but we can reduce the gamma flash intensity by using Pb in the beam.
- Can you save and analyze the full waveform for a detector?
  - There are issues with the throughput of the data - we are limited by how much data we can stream before the DAQ is no longer happy.

19 Study of the (n, xnγ) Reactions on Tungsten Isotopes: Retrospective and Perspectives

Speaker: Greg Henning (IPHC / CNRS)

Results for W have been collected and presented in the past along with some data covariances. Transitions from high spin states in the rotational ground state band are overestimated by calculations. Large discrepancy observed between TALYS and more recent experimental results of ^{183}W inelastic. There is an understanding on where to look for issues with data analysis including pileup and gamma efficiency. ^{184}W(n,2nγ) data analysis in the pipeline as well.

Discussion:

- Can you say something about your experimental energy resolution?

  - On slide 17, there is overlap because of time resolution loss due to the CFD. The resolution is included in calculations, but shows very little effect. The CFD threshold is also hardware based, so there is no flexibility to reanalyze the data with a different value.
- LANL always calculated the cross section too high, but the discrepancy was never found or explained further.
  - The cause is unknown, perhaps there is a long-lived isomer.
- How many gamma rays do you get per isotope and are they consistent with ENDSF?
  - About 15 for most of the isotopes. The branching ratios are within uncertainties (which are large), so it hard to make a conclusion on agreement with ENDSF.

20 Examining and Modeling Gamma Emission from Quasi-Differential High Energy Scattering Measurements

Speaker: Adam Daskalakis (Naval Nuclear Laboratory)

Quasi differential high energy scattering data can be used to examine gamma emission data. Corrections were made to analyze the gamma data, and reasonable agreement was seen. There is more work to do in order to flesh out the method and corrections needed on the quasi-differential scattering data. ^{238}U appeared problematic.

Discussion:

- I am measuring every gamma event depositing 200 keV to 1 MeV.
- What about neutrons being misclassified as gammas?
  - The correction factor is likely compensating for this effect.

21 Using Neural Networks for Inelastic Neutron Scattering Cross-Sections Interpretation

Speaker: Greg Henning (IPHC / CNRS)

There are many experimental limitations in inferring total inelastic cross sections, so can we find some neural network that takes training data and predict different quantities including total inelastic cross section. A neural network was trained on TALYS calculation. NN prediction is below TALYS calculations, which is not suprising because similar issues are seen experimentally. NNs show some promise, but are still far away from evaluating nuclear data.

Discussion:

- There is interesting structure in your data, but it is not in the neural network prediction.
  - We were more interested in the higher energy.
- Is using ML to generate evaluations not an example of trying to push it too far? M.L. is non-physical and doesn't understand the structure of the nuclei.
  - It is highly dependent how the neural network is trained. If you train it on TALYS calculations, it will give you TALYS calculations. This neural network approach is more attractive when you have no starting basis.
  - Having nothing and understanding that is better than having nothing and trying to create something.
    * Try training N.N. on different models and see what will happen.
    * The N.N. is a garbage-in garbage-out where if we have to be careful of treating this all like a black box.

22 Deployment of Gaussian Surrogate Model for Ad-Hoc Adjustments to Elastic Scattering Angular Distributions

Speaker: Peter Brain (Rensselaer Polytechnic Institute)

The deployment of Gaussian surrogate model for ad-hoc adjustments for ESADs was investigated. If you dont have the option for B.B. - how can you get ESADs? Brute force, fit data directly, or define an objective function based on scattering simulation or data and legendre polynomials. Objective function being used is a chi-square comparison of a simulation and experiment. Sampling of scattering coefficients was done using latin hypercube sampling to generate ESADs. The method was validated on ^{208}Pb data, and was applied to ^{9}Be data. Not all angles are improved in the ^{9}Be, but better agreement is shown in a majority of the back-angles. Future work involves expanding to multiple energies and isotopes.

Discussion:

- Usually, we all use Legendre up to order 5, in RRR Uranium has required up to 15. RPI data may not be as sensitive to order based on angles.
- Can the surrogate model be used for materials w/o resonances?
  - It is likely very possible.