



Neutron Capture and Transmission Measurements of ^{54}Fe at the RPI LINAC

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Presented by:

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Project Overview

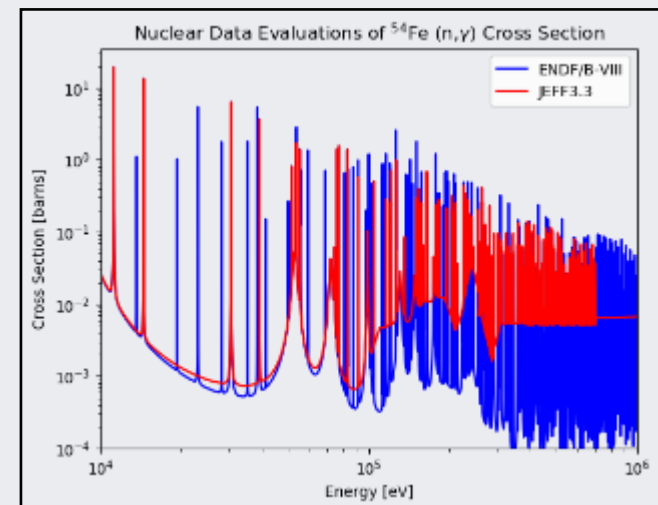
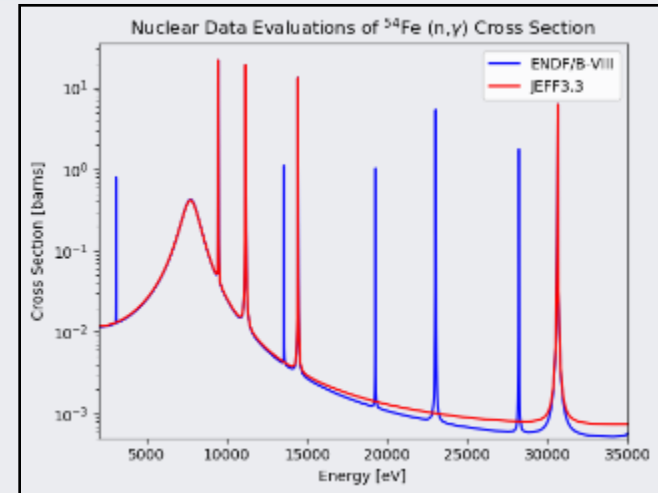


- Motivation:
 - Criticality safety calculations require high accuracy nuclear data to reduce uncertainties
 - Recent evaluation work has found a need for new measurement data of the ^{54}Fe (n, γ) neutron cross section
 - Iron is a part of many structural materials
- Project Goals:
 - Perform radiative capture neutron cross section measurements of ^{54}Fe in the keV energy region
 - Perform total cross section measurement of ^{54}Fe
 - Resolve differences between evaluated nuclear data libraries
 - Perform resonance analysis and fitting for ^{54}Fe cross section in the keV region using RPI nuclear data



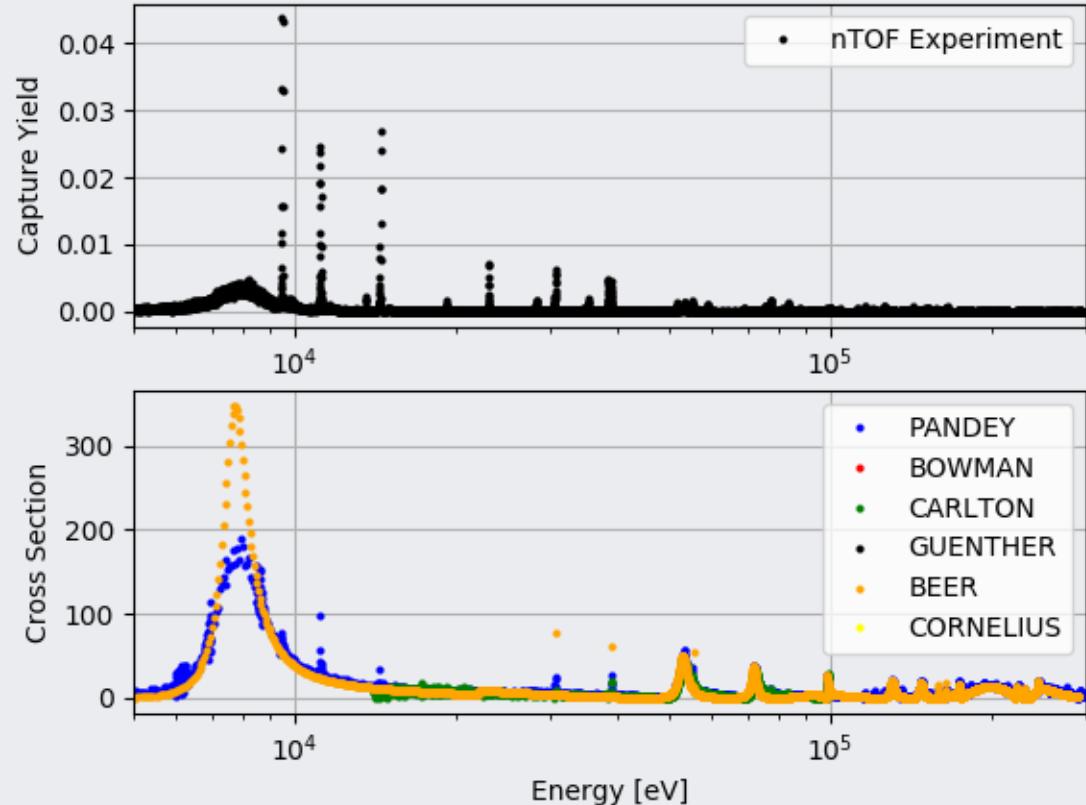
$^{54}\text{Fe} (n, \gamma)$ Measurement Motivation

- Fe is an important constituent of various nuclear systems
 - Reactor, fuel storage, radiation shielding applications
- Natural Fe and ^{56}Fe cross sections have been studied extensively, but there is a lack of data available in EXFOR of the $^{54}\text{Fe}(n, \gamma)$ cross section
 - ^{56}Fe evaluation work has highlighted need for new measurements and evaluation for ^{54}Fe
 - nTOF data from 2014 was added recently to EXFOR after measurements began at the RPI LINAC.
- There are various discrepancies between different evaluated data libraries, where some resonances are present in one evaluation and not the other



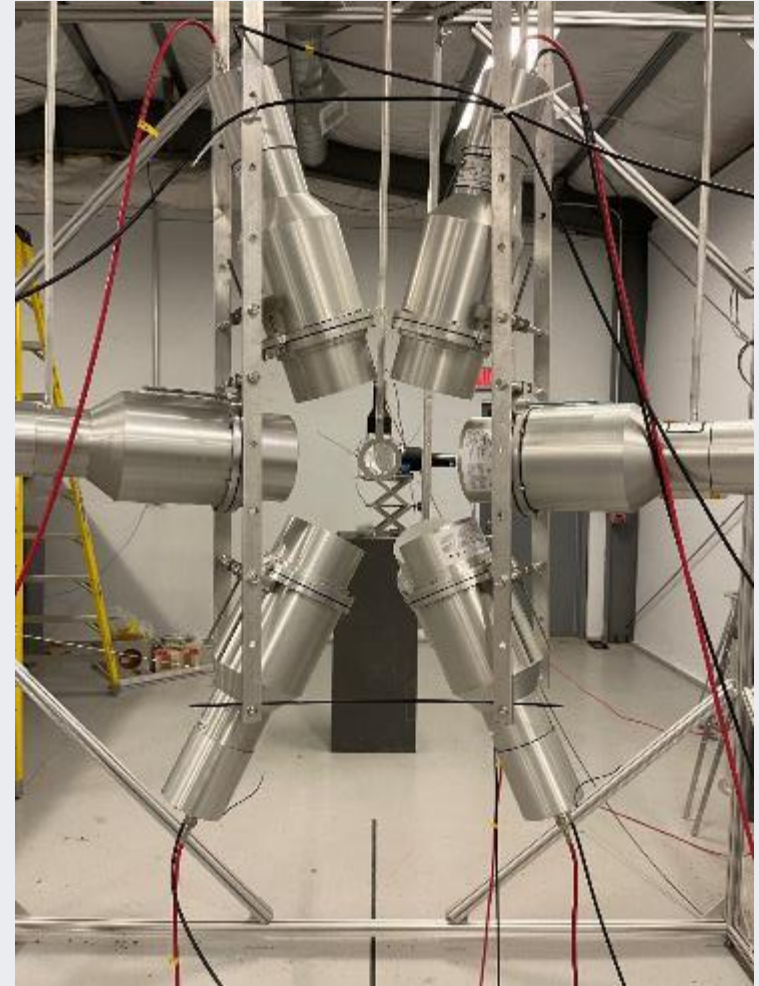
Review of Existing Measurements

- Only a single capture measurement exists on EXFOR
 - Was uploaded following RPI capture measurements
 - High resolution data from nTOF
- Various transmission measurements exist
 - Various energy regions, different sample thicknesses, different grouping



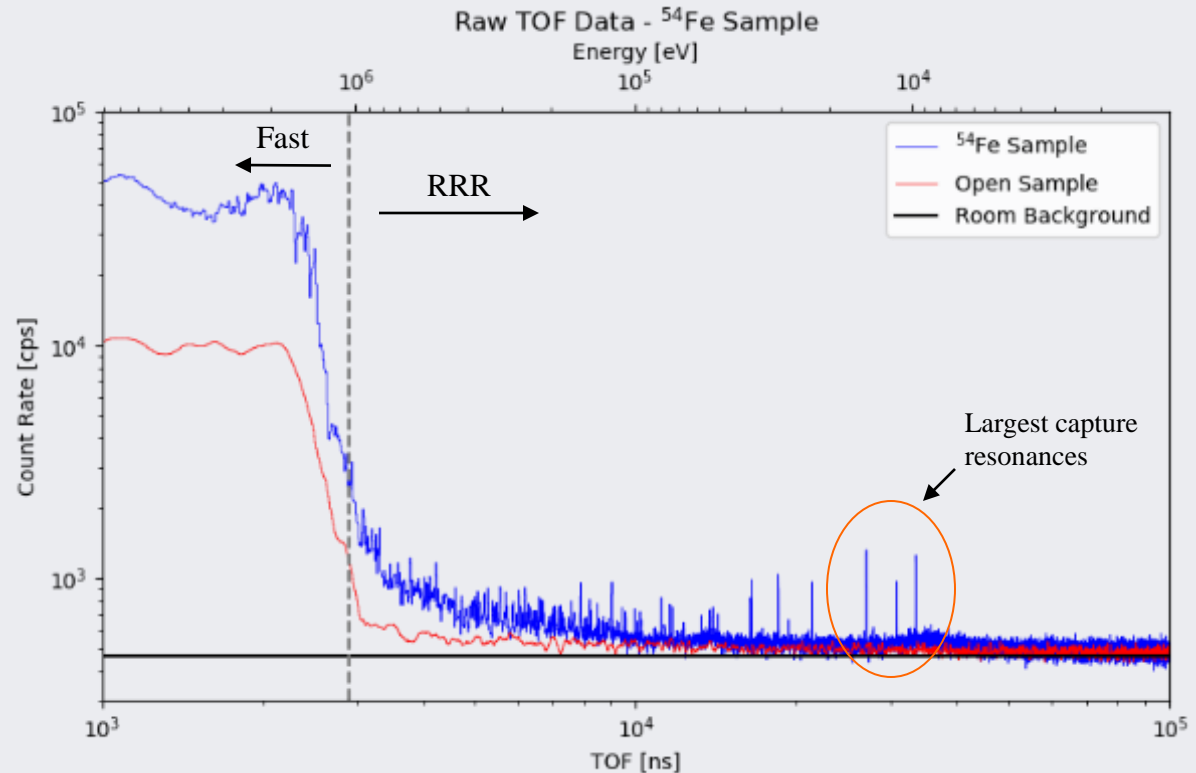
Introduction to C_6D_6 capture system

- An array of seven C_6D_6 liquid scintillators surround the investigated sample at a flight path of $\sim 45m$.
- The system is designed for radiative capture measurements in the mid-energy region (keV-low MeV)
- All structural materials have a low capture cross section to minimize neutron sensitivity
 - Materials are all Al 6061
- System is based on the principle of the total energy method
 - Requires employment of the pulse height weighting technique



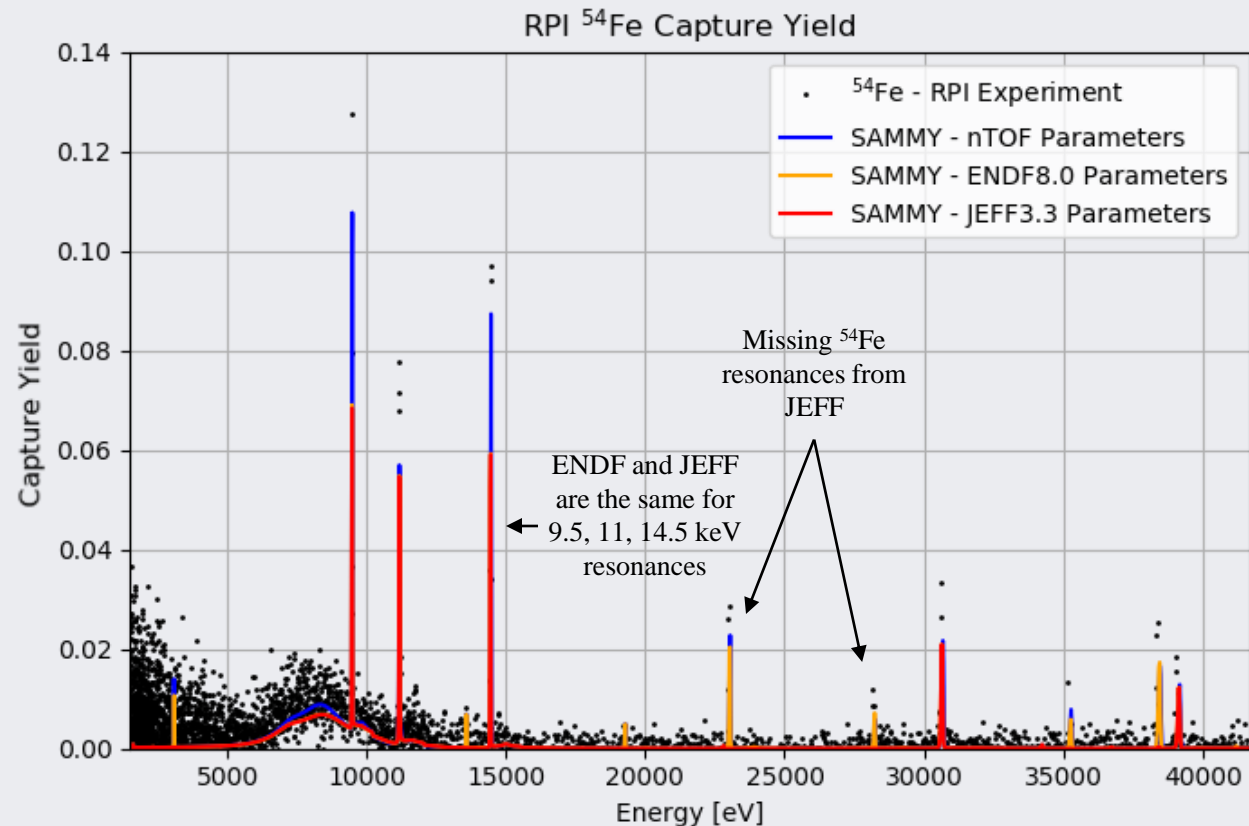
^{54}Fe (n, γ) Measurement – Raw Data

- Resonance structure clearly observed in RRR
- Data analysis at higher energies still in progress, data should be useful until ~2 MeV
- Room background rate remains a challenge with mid-energy measurements



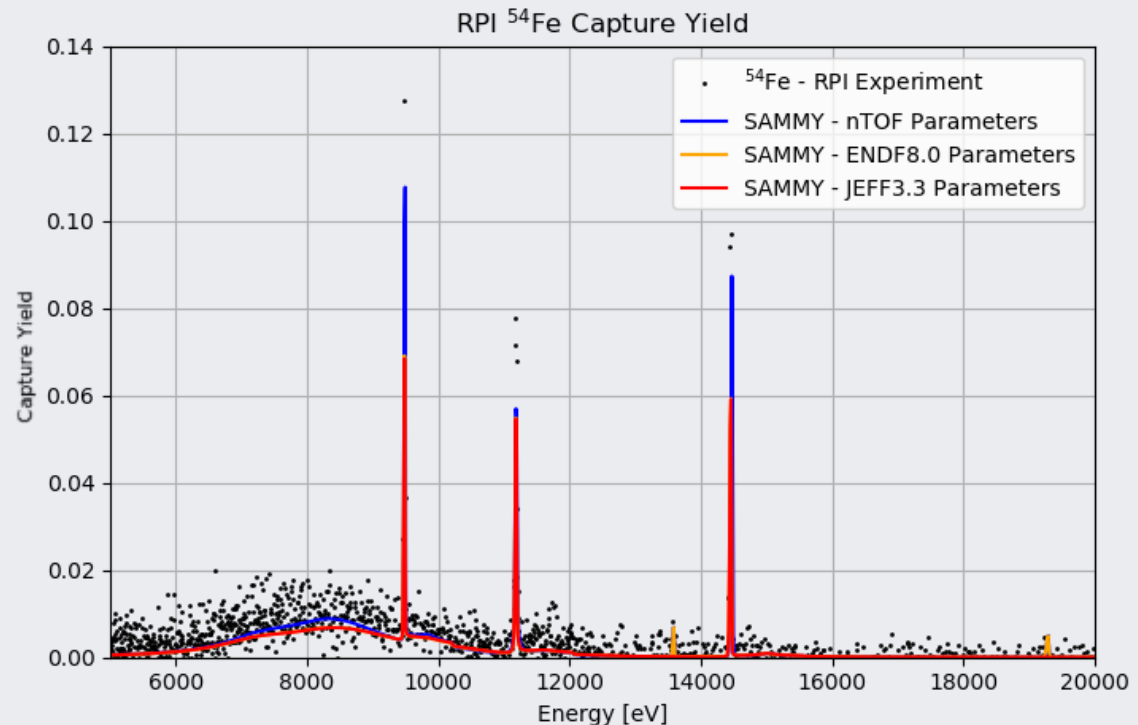
^{54}Fe (n, γ) Measurement – Results

- Three largest capture resonances are discrepant with the 2021 RPI experiment
 - ENDF8 and JEFF3.3 in agreement with each other for three largest capture resonances
 - nTOF resonance parameters seem to provide better agreement to RPI experiment than JEFF or ENDF resonance parameters
 - A new set of resonance parameters will be fit to RPI data
- Some missing resonances from JEFF evaluation can be clearly seen in ENDF evaluation and in RPI and nTOF experiments
- To fit properly, it is necessary to consider multiple datasets



^{54}Fe (n, γ) Measurement – Results

- JEFF3.3 and ENDF8.0 parameters agree for three largest capture resonances shown
- nTOF resonance parameters (both Γ_n and Γ_γ) are very different from existing evaluations
- More data or measurements are needed to justify large changes in resonance parameters
 - Transmission data could be used to constrain Γ_n
- Systematic effects are still under review
 - Impact of weighting functions on final capture yield
- SAMMY resolution functions being verified
- Generation of covariance matrix for data fitting needed



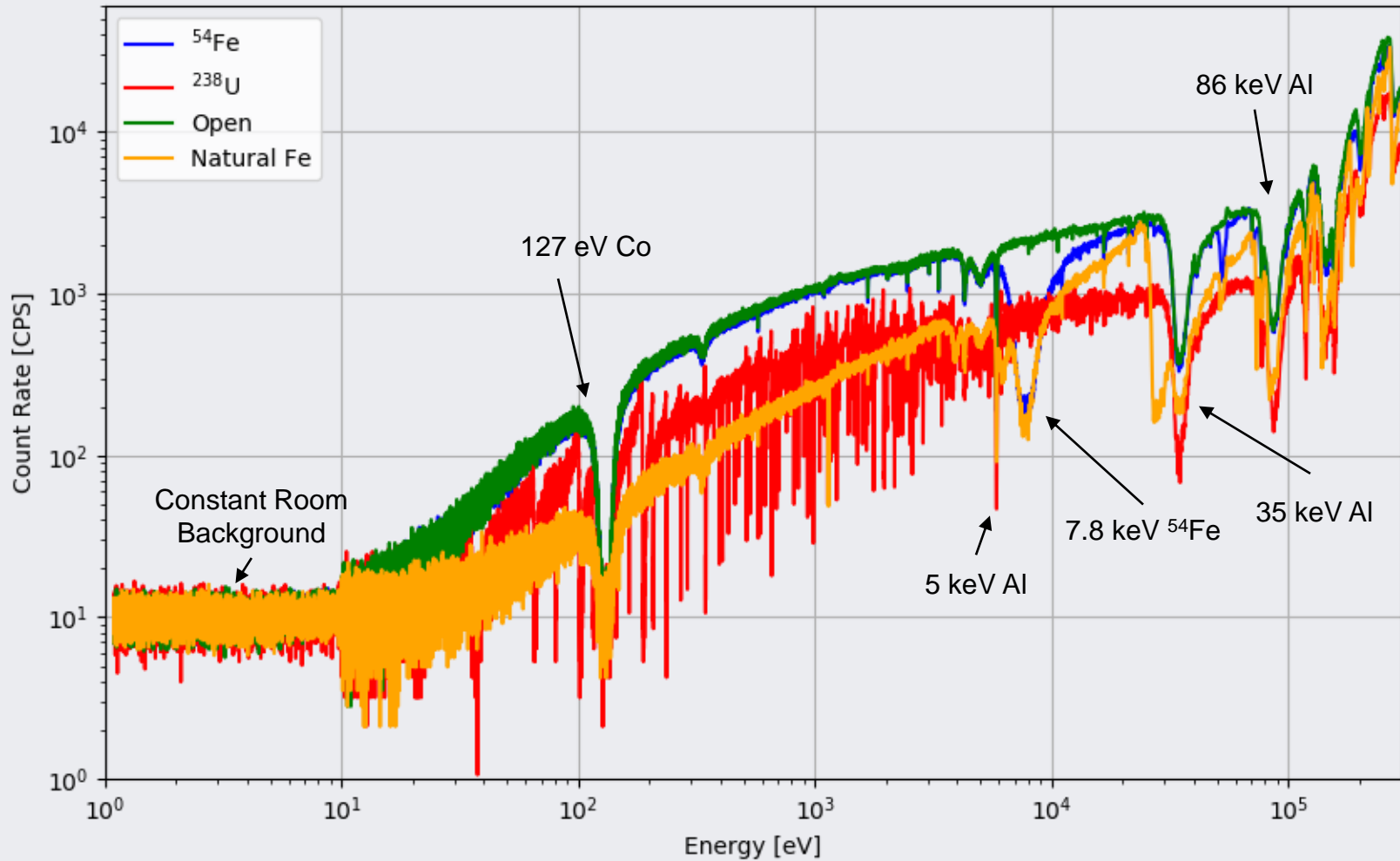
^{54}Fe Transmission Experiment - Overview

- To improve the fitting of the ^{54}Fe capture data, a transmission measurement to obtain total cross section data was conducted
 - Transmission data will help validate RPI capture yield and further justify that changes are needed in resonance parameters
- A Li-Glass detector at 35m was used to collect data, sample placed at 15m flight path
- 2cm of natural Fe, 625 mil of depleted Uranium, 0.25 cm of ^{54}Fe all measured during experiment



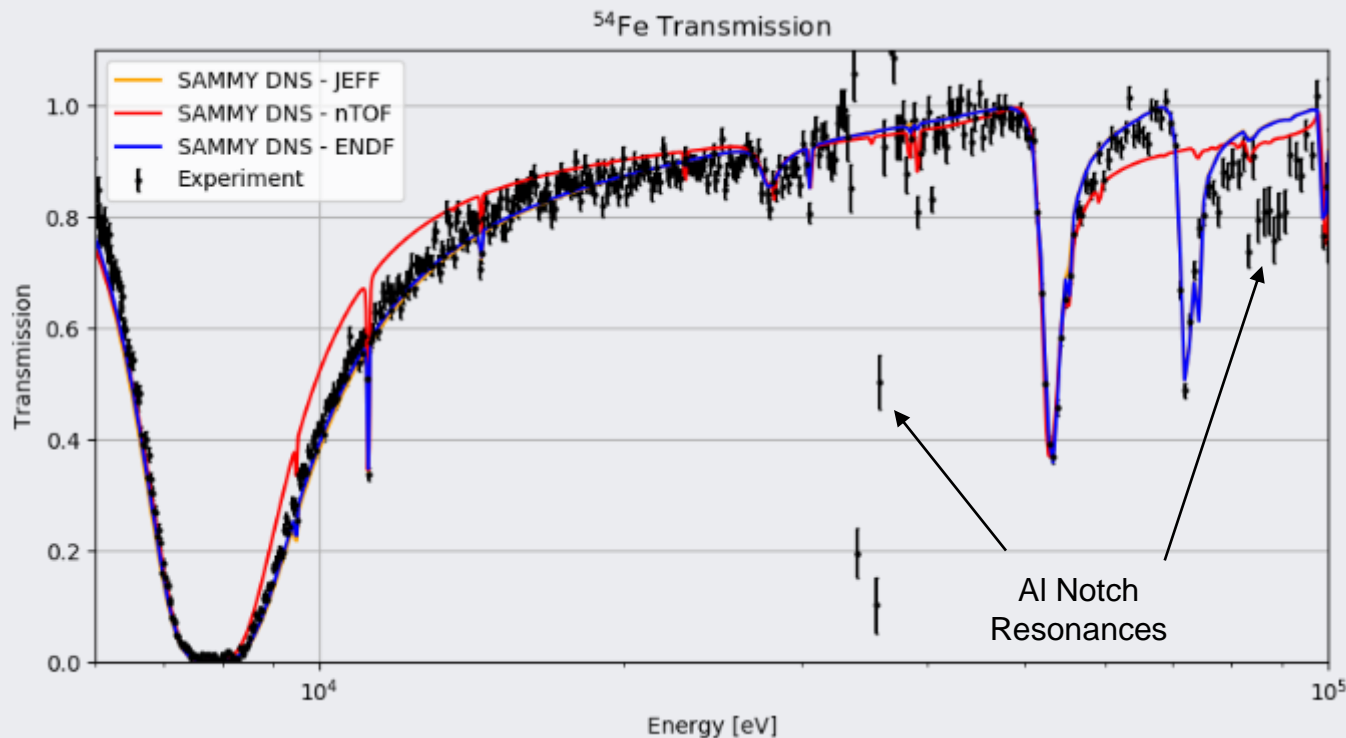
^{54}Fe Transmission Experiment – Raw Data

Transmission Raw Data



^{54}Fe Transmission Experiment - Results

- nTOF resonance parameters do not perform well when looking at transmission data in SAMMY
- Moving forward, RPI's combination of capture and transmission data will enable a more wholistic approach to resonance evaluation and fitting for ^{54}Fe



Accomplishments and Future Work



- Conclusions
 - ^{54}Fe data has been taken in both transmission and capture, with the goal to fit datasets simultaneously in SAMMY
 - Experiments show that further work is needed on resonance parameters for Fe
- Future Work
 - Full fitting of resonance parameters is currently underway in SAMMY
 - Generation of implicit covariance matrices for use by SAMMY is in progress
 - Generation of user-defined resolution functions in progress
 - Neutron beam mapping system in development to improve capture measurement normalization

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