Fiber-optic fluorescence measurements for PALEOCCENE

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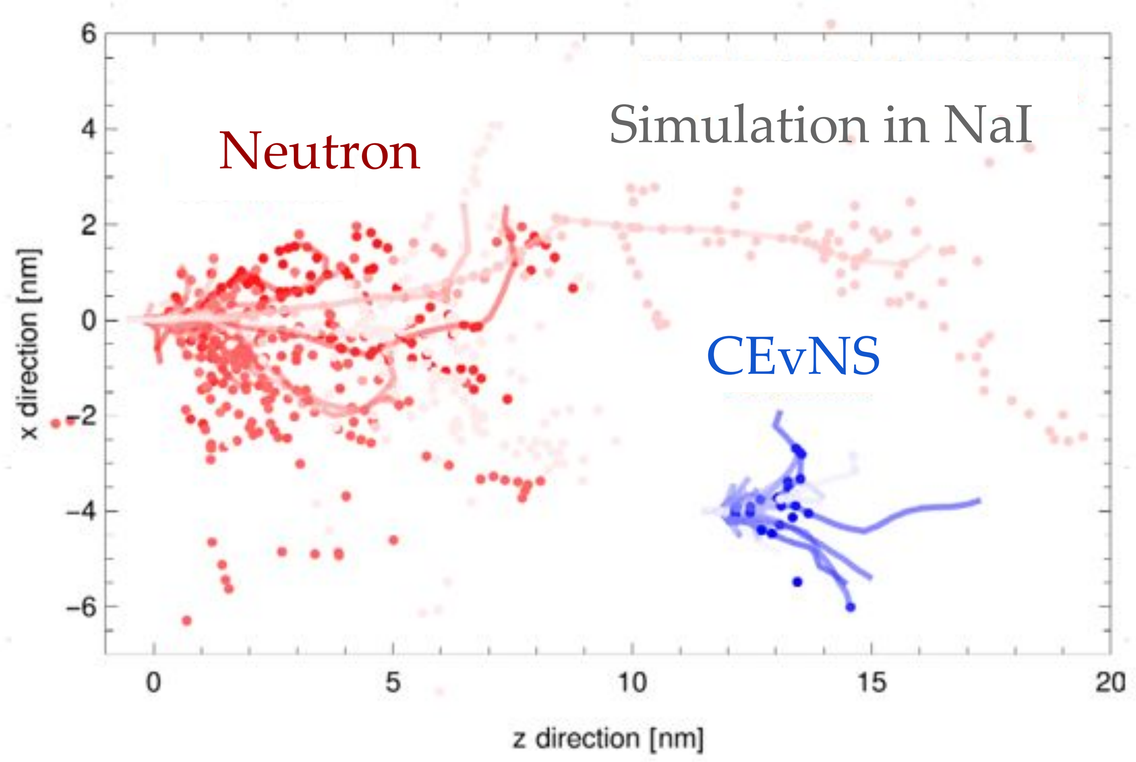
Motivation

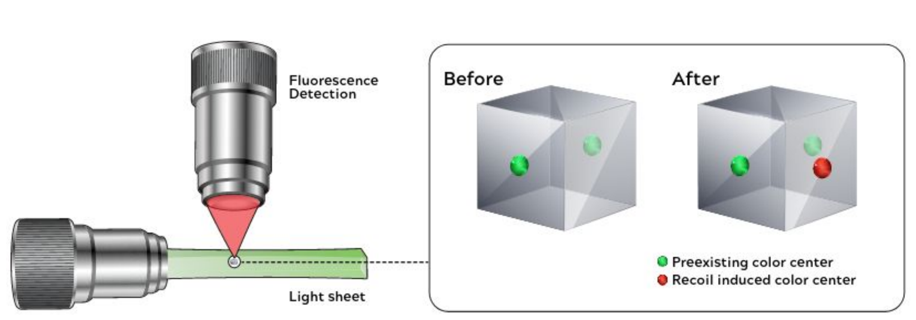
PALEOCCENE

- PAssive Low Energy Optical Color CEnter Nuclear rEcoil (PALEOCCENE)
- Images crystal damage for passive neutron detection
- Fiber-optic setup allows for real-time measurement of crystals during irradiation



Crystal Damage

- Energetic particles may knockout bound atoms and generate color centers
- Color centers can be seen with a 3D scan or by flashing the entire crystal
- In this study of CaF_2 crystals, Samarium (Sm) doping enables fluorescence of the color centers
- Nuclear recoil applications include neutron, neutrino and dark matter detection



NNSA Mission

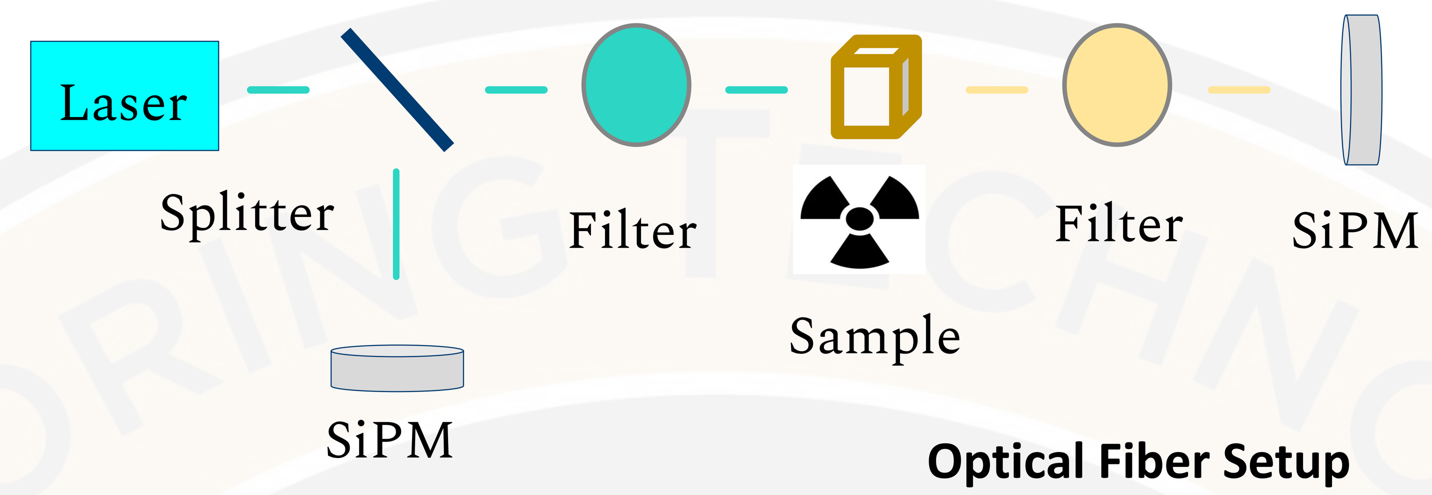
Neutron Monitoring

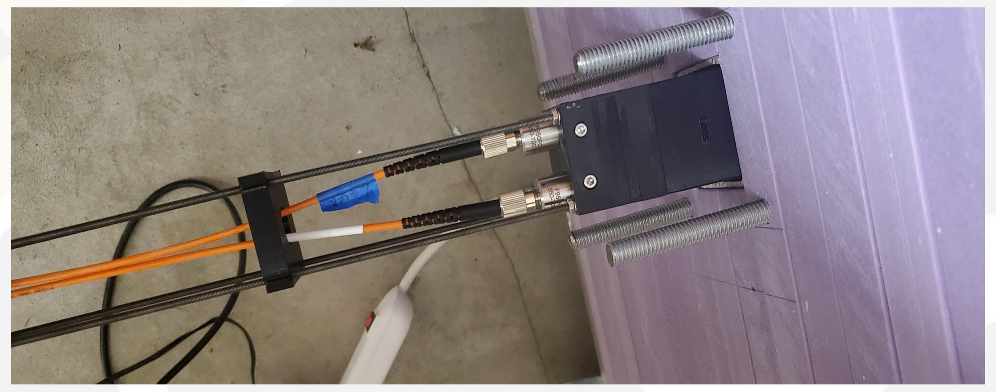
- Passive neutron monitoring is useful for:
  - Personal dosimetry
  - Reactor instrumentation
  - Nonproliferation

Neutrino Safeguards

- Neutrinos provide unique, unblockable reactor information about:
  - Existence
  - Power output
  - Isotopic content

Technical Approach



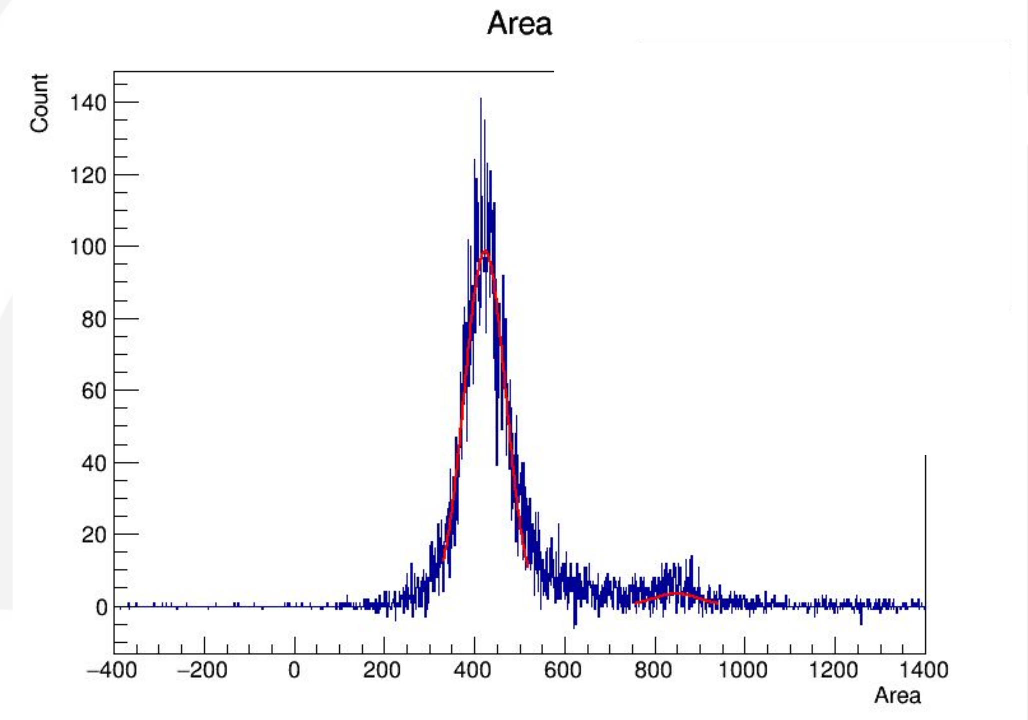


Optical Fiber Setup

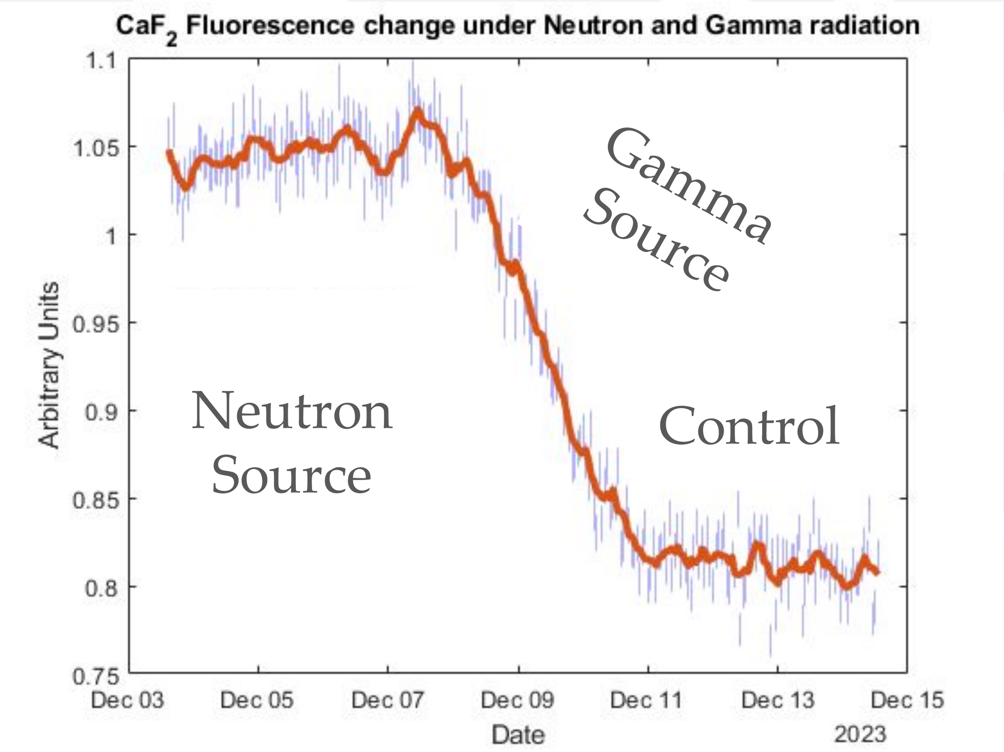
- A 488 nm laser is piped through an optical fiber to a sample in radiation
- A series of filters and optical baffles are used to ensure only color center induced fluorescence is seen

Data Analysis

- The fluorescence signal is weak
- Data is taken with the laser on and off in 3 minute intervals to allow for on-off noise subtraction



Results



- Exposure to a gamma source reduces light output
- A confocal microscope saw changes induced by neutron damage
- There is evidence that this disagreement may be caused by different Sm ionization between crystal batches

Impacts

- Verification that color centers increase proportionally with dosage for low-dose applications
- Selection of crystal compositions that are well-behaved in gamma radiation
- Collaboration with Lawrence Livermore National Lab under MTV to look at LiF samples as a promising composition

Future Work

Conclusion

- The fiber optic setup is able to see fluorescence changes during irradiation
- Further development is needed to reduce systematic differences and uncertainties

Future improvements

- Will use a commercial spectrophotometer to measure the entire emission spectrum
- Will switch the laser monitoring channel into a Sm^{3+} peak measurement channel

PALEOCCENE Collaborators

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Universität Zürich
University of Michigan

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