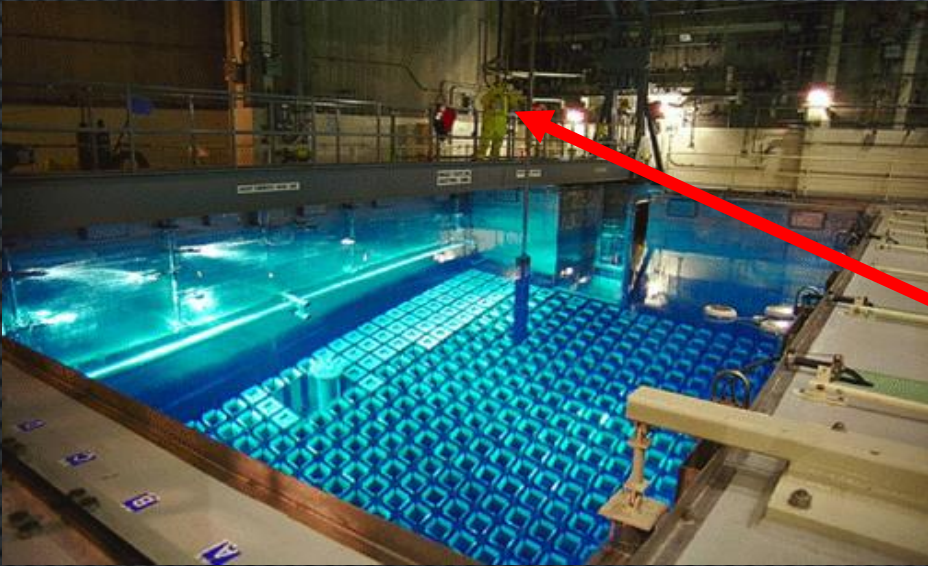


MEASURING SPENT NUCLEAR FUEL USING MUONS

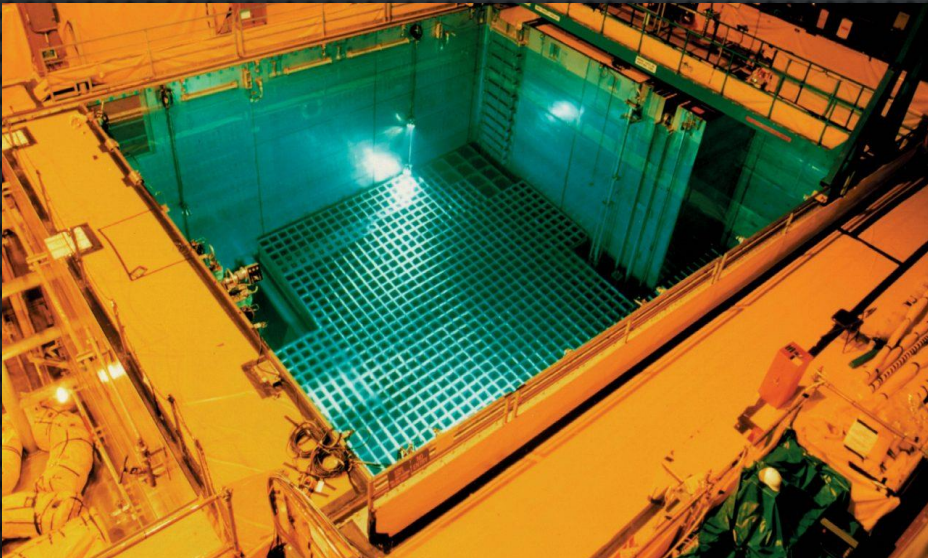
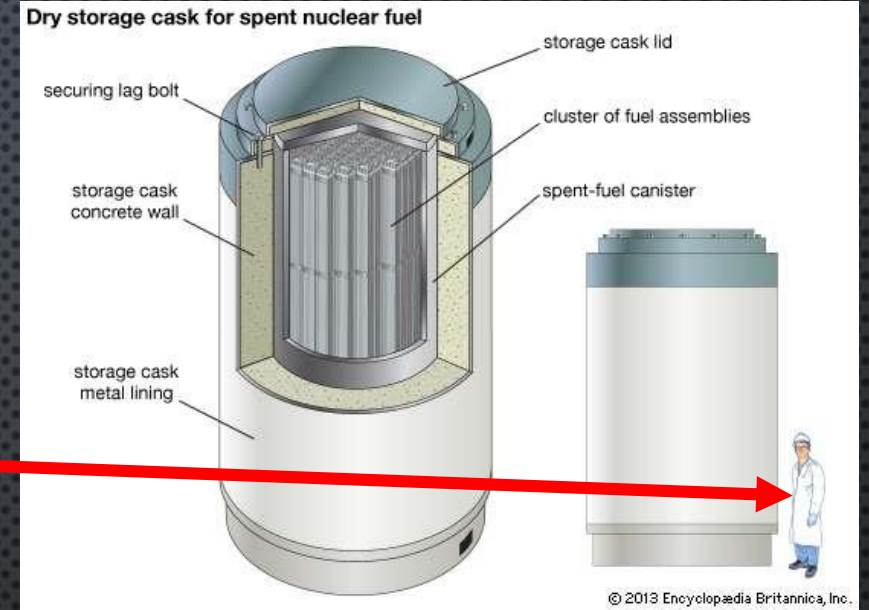
NICK VALVERDE

J.M. Durham et.al, Physical Review Applied 044013, 9 (2018).

HOW FUEL IS STORED



Paul



Stored in pool for several years until it is transferred into a large canister for long term storage. The canister is then transferred to a holding site.



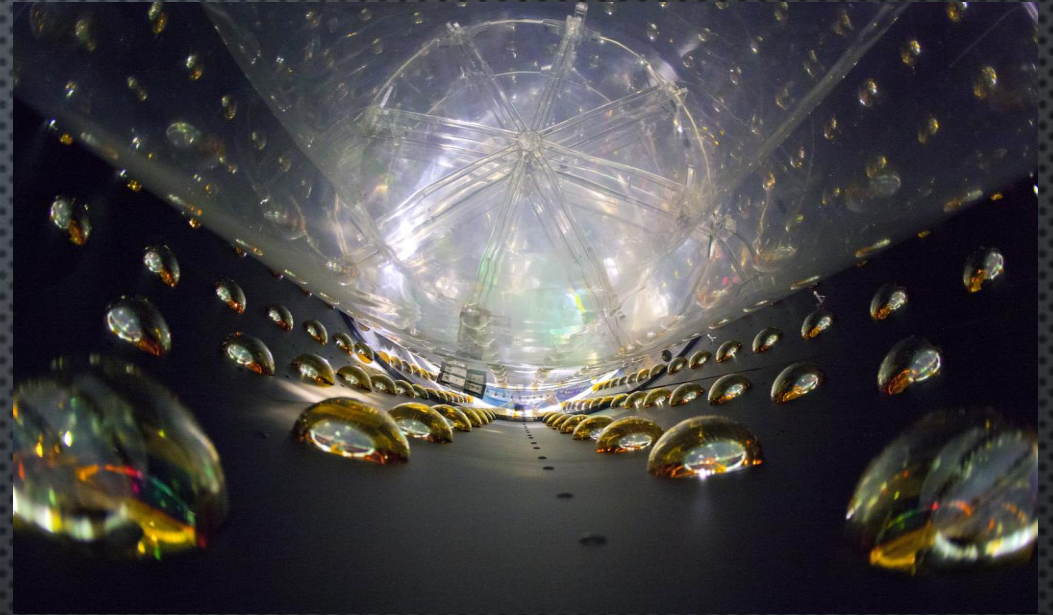
2xPaul

Hmm, I think
it's been
tampered
with.



Tamper indicating seals help. If broken must transport back to pool to reverify.

CURRENT METHODS



Antineutrino detectors pose transport problem and large counting time (~1yr).

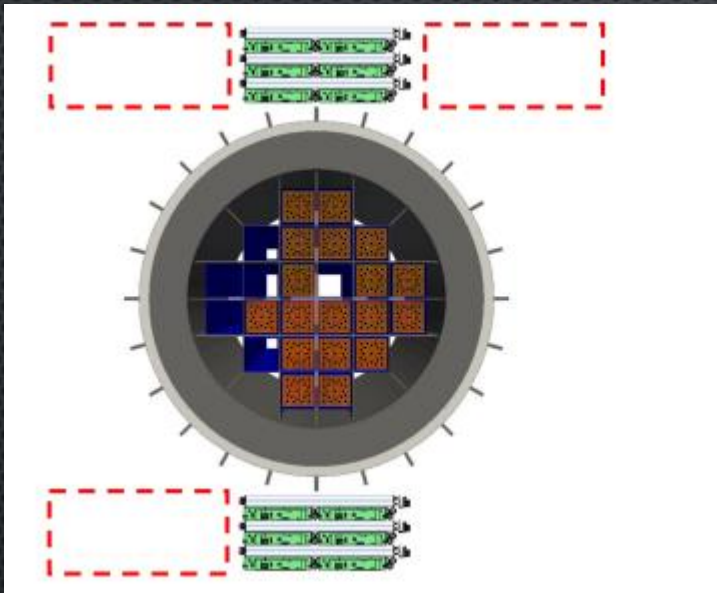
Conventional radiography using neutrons and photons wont work due to this cask shielding + fuel rod shielding.

WHY MUONS?

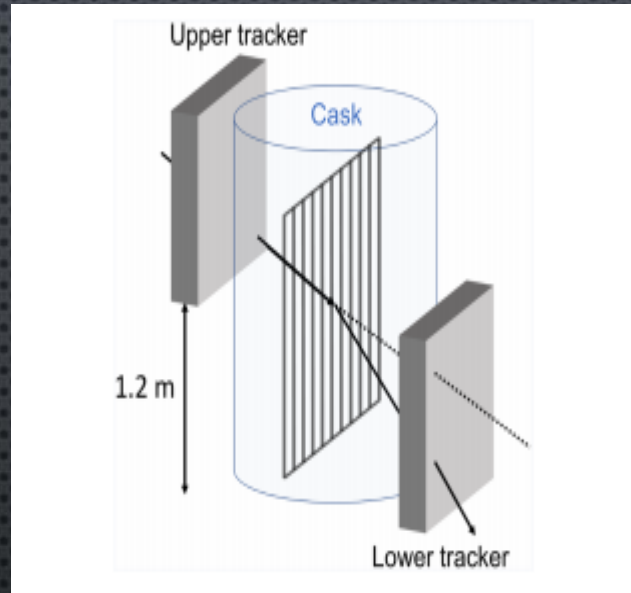


- Most abundant charged particle found on Earth.
- Large mass prevents radiative energy loss from bremsstrahlung photons.
- Muon scattering sensitive to high-Z materials so it can pass through low-Z shield and interact with high-Z spent fuel.

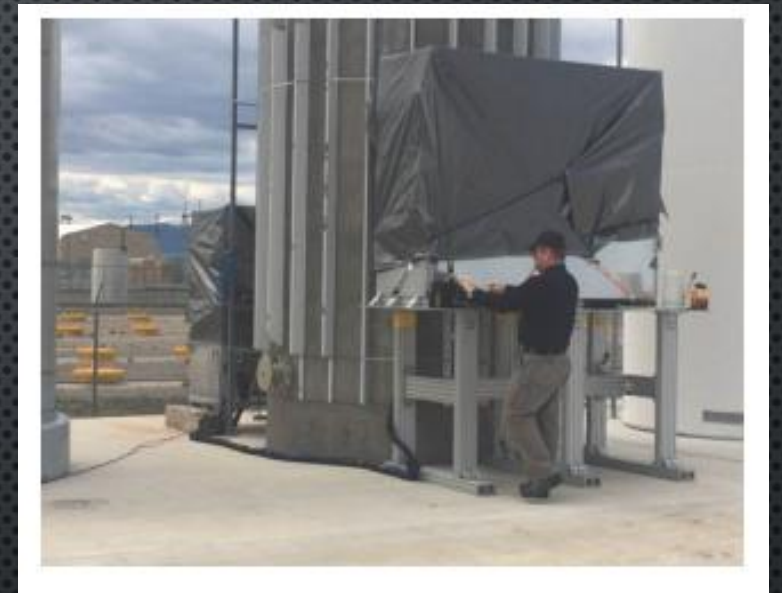
MUON METHOD/SET-UP



Aerial diagram of the test cask. Orange represents spent fuel rods.



Lateral diagram showing two detectors and muon path.

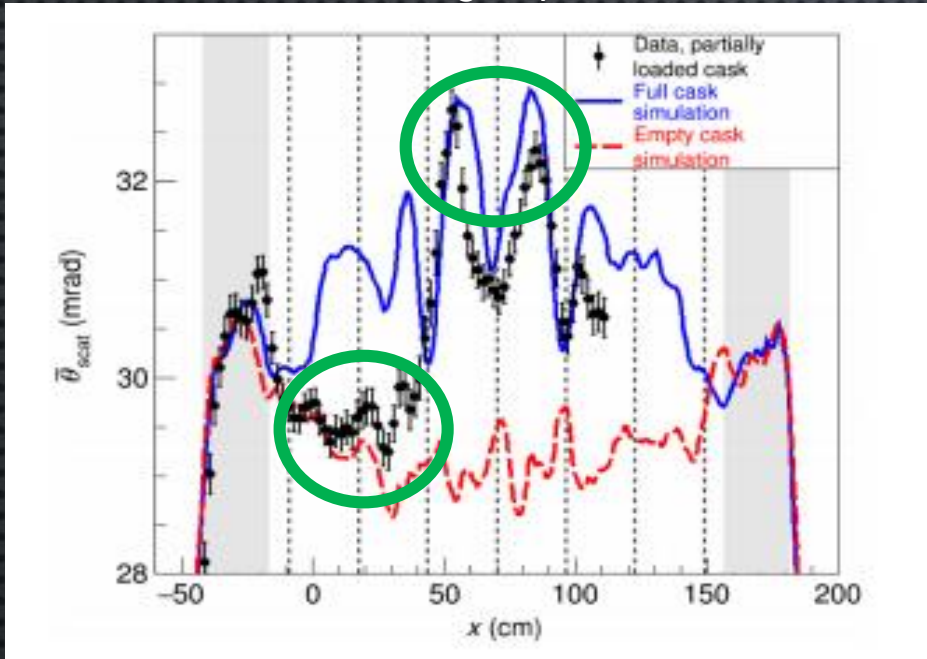


Real time view (sunglasses on cloudy day?)

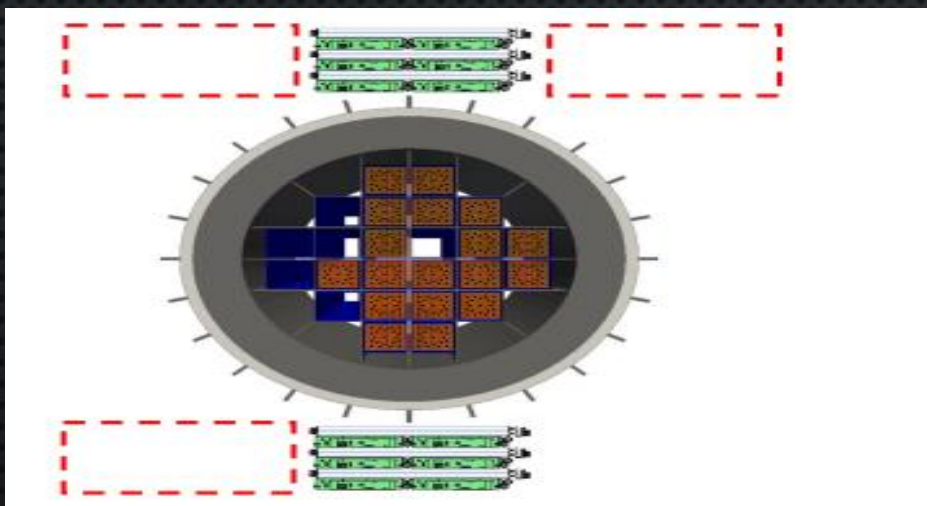
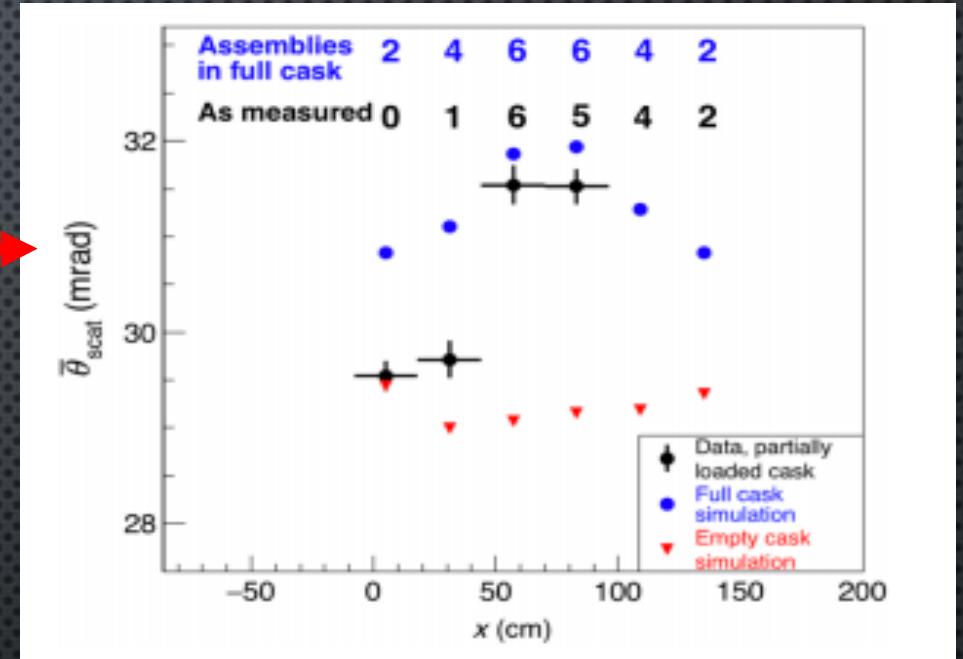
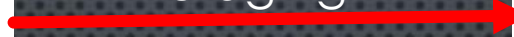
Muon scattering through cask will depend on the length of shielding and the amount of fuel they encounter. Tubes in detectors filled with gas that are ionized by muons creating an avalanche effect which produces a measurement.

RESULTS

1 2 3 4 5



Averaging



Data collected matched cask configuration. 5th column data was dismissed since detectors were not properly secured against the wind.

CONCLUSION AND NEXT STEPS



- Count times from several weeks to months can provide sufficient data on fuel content which fits IAEA's timeliness goals.
- Increasing detector area with more efficient gamma ray detection can decrease time by a factor 4 allowing for multiple cask measurements.
- Further work being done to understand sensitivity of muon radiography to handle more complicated cases (portion removal, dummy canister, etc).

See you in your nightmares.

muon

m

