Neutronics and Activation Results for Samples Irradiated by D-T Neutron Source at LANSCE

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Background

- Fused silica and CaF_2 samples irradiated by neutrons at LANSCE
  - 14 MeV neutrons from D-T source
  - High energy neutron source at the Weapons Neutron Research (WNR) facility with energies up to 600 MeV
- Neutronics and activation calculations performed to determine the amount of activation products and impurities generated in the samples and dose rate during post-irradiation handling
- Results for 14 MeV irradiation reported here. Calculations for WNR irradiation underway

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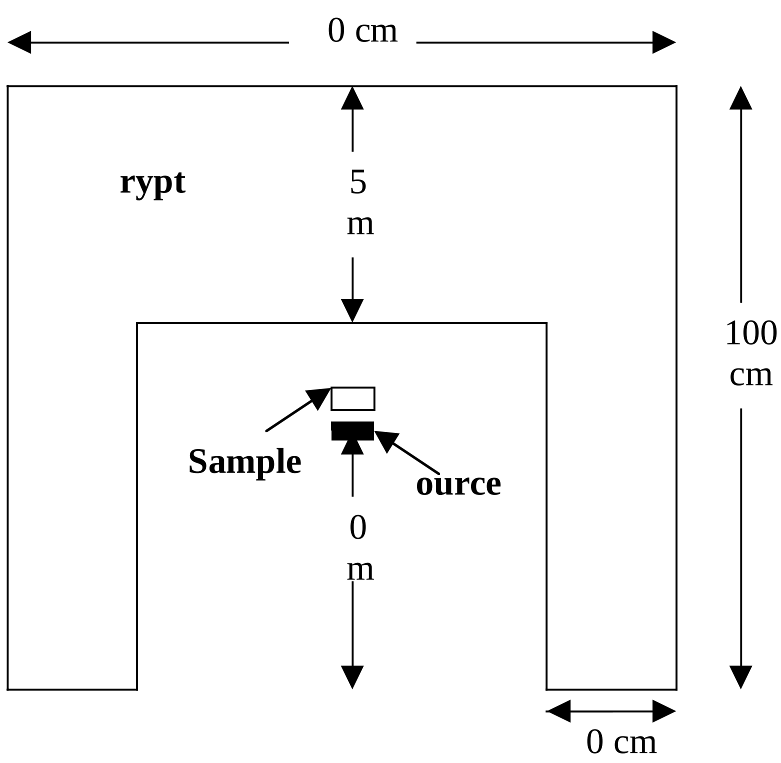
Calculation Procedure

- ❒ Neutronics calculations performed using the 2-D module of the DANTSYS 3.0 particle transport code system
- ❒ Calculated neutron flux used in the activation code ALARA to calculate amount of transmutation products generated in samples following one week irradiation
- ❒ Decay gamma source generated from decay of radioactive transmutation products transported to determine biological dose rate as a function of distance from sample at selected times following irradiation
- ❒ FENDL-2 evaluated nuclear data used in neutronics and activation calculations

Geometrical Model



- Neutron source located at center of five-sided steel crypt
- Neutron source strength is 10^{11} n/s
- 1 mm thick source
- 1 cm^3 sample with 1 cm thickness
- Front surface of sample at 1 cm from source
- Uncollided 14.1 MeV neutron flux at front of sample is $8x10^9$ n/cm^2s
- Surrounding crypt was assumed to be made of SS316L
- Reflected neutrons amount to only 6% of total flux at sample

Transmutation Products

- Detailed tabulated results for transmutation products generated in the SiO_2 and CaF_2 samples after 1 week irradiation were provided to LANL
- Stable nuclides dominate impurities produced
- Impurities in SiO_2 amount to 2.06 appb and include H, He, C, N, F, Mg, Al, and P
- Impurities in CaF_2 amount to 2.34 appb and include H, He, N, O, Ne, Cl, Ar, K, Sc and Ti

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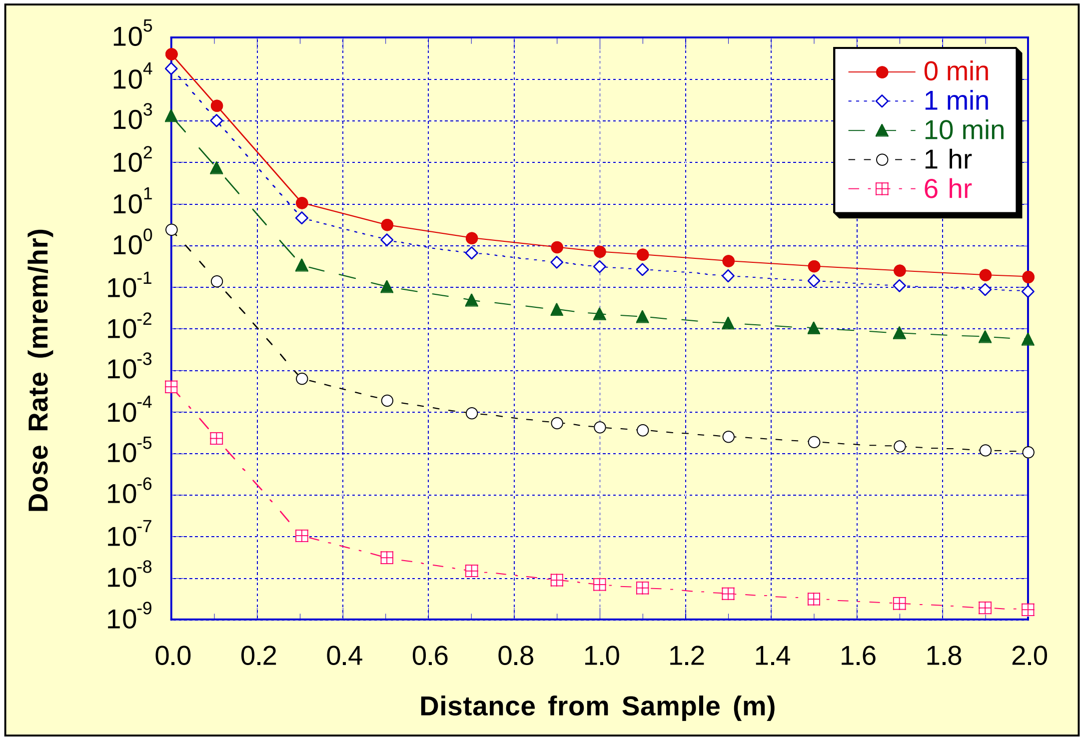
Post Irradiation Handling of Samples

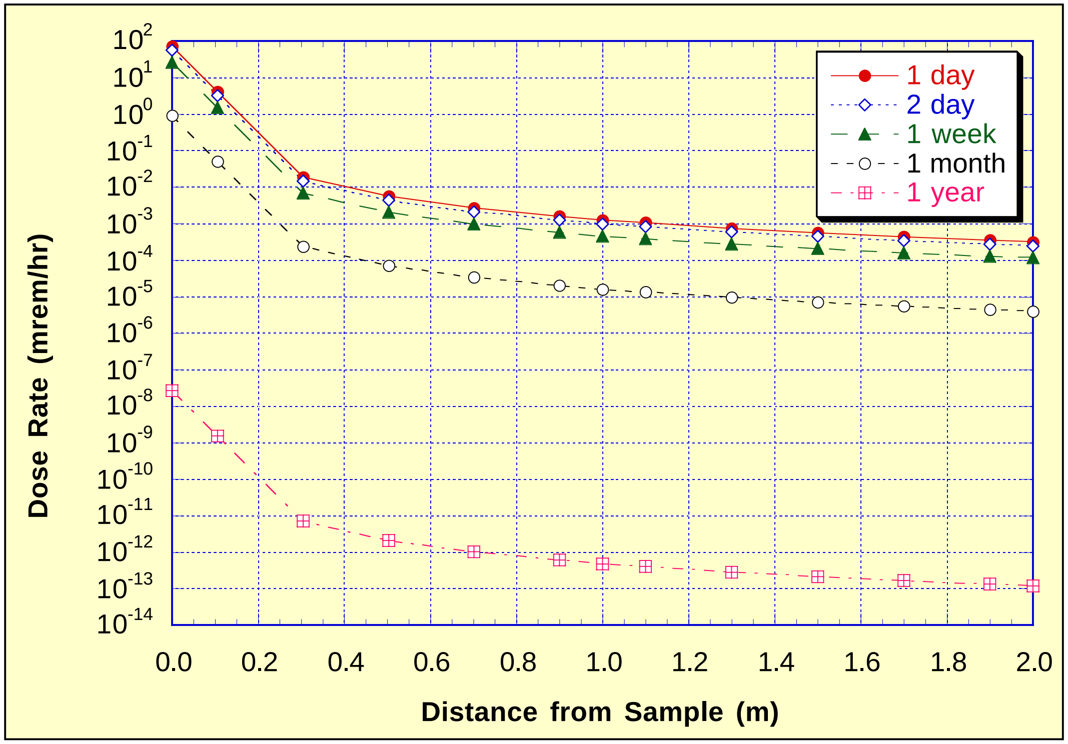
- Dose rates evaluated as function of distance from the sample at different times following a one-week irradiation period
- Results are useful in determining how close to the sample one could get and how long a cooling period is needed to have acceptable dose rates
- The plan is to do the post irradiation analysis in a lab with dose rates from the samples <5 mrem/hr on contact

Dose Rate Around Fused Silica Sample



- ⇨ Immediately after irradiation one should remain at least 0.5 m away from sample
- ⇨ Contact dose for the SiO_2 sample reduces to 2.4 mrem/hr after one hour

Dose Rate Around CaF_2 Sample



- Dose from CaF_2 sample is a factor of ~2 lower than from SiO_2 sample immediately after irradiation but drops much slower with time due to ^{47}Ca ($T_{1/2}$ = 4.5 d)
- Contact dose for the CaF_2 sample reduces to 0.9 mrem/hr after one month

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Extrapolation to Multiple One-Week Irradiation Cycles

- Three one-week irradiation cycles are being considered with one month in between
- While short-lived isotopes decay between irradiation cycles, long-lived and stable isotopes accumulate from one irradiation period to the other
- Results will be higher than those reported for one irradiation period by a factor of 1-3 depending on dominant radionuclides
- Impurities produced are dominated by stable isotopes and total impurities after three one-week irradiation periods will be about a factor of 3 higher

Extrapolation to Multiple One-Week Irradiation Cycles

- We will use the conservative assumption that dose rates after three irradiation cycles will be three times those for one irradiation period
- We recommend using a safety factor of ~3 to account for uncertainties in modeling, calculation method, nuclear data and sample composition
- Therefore, the dose rate results reported here need to be increased by about an order of magnitude for 3 irradiation cycles

Summary

- Low impurity level generated in samples
  - After a single one-week irradiation period
    - 2.06 appb in SiO_2
    - 2.34 appb in CaF_2
  - Impurity level increases linearly with irradiation time
- For post irradiation of samples with <5 mrem/hr contact dose
  - After a single one-week irradiation period
    - ~2 hour cooling period required for SiO_2
    - ~1 month cooling period required for CaF_2
  - After three one-week irradiation cycles
    - ~3 hour cooling period required for SiO_2
    - ~2 month cooling period required for CaF_2

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