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Neutronic Tuning - Some Thoughts

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DEFINITION

"A *useful* neutron is one heading in the right direction with the correct energy at the right time."

"...uncontaminated and as many as possible!"

Anonymous

I. SUMMARY

The above definition of a ***useful*** neutron offers a real challenge to the designers of spallation target systems for pulsed and steady-state neutron sources. (A spallation target system is the composite of many individual components, which are listed in Table I.) The designer's job is to produce as many useful neutrons as possible. It is an extremely complicated optimization problem.

Neutronically tuning a spallation target system is the process of optimizing the production of useful neutrons. Many variables exist in neutronically tuning a spallation target system (see Table II). Enhancing the neutronic performance of a spallation neutron source by neutronically tuning the target system is much more cost effective and prudent than increasing the output of the accelerator, which feeds the spallation target system. Gains in useful neutron production of 10% are very worthwhile to attain. For LANSCE, a 10% increase in useful neutron production corresponds to 10 μA of proton current in the Proton Storage Ring (PSR), which feeds 800-MeV protons to the Los Alamos Neutron Scattering Center (LANSCE).

In ***neutronic tuning***, the designer should isolate individual components (where possible) to understand the neutronics of that component. However, the designer should take this approach only so far. Because of synergistic effects, the designer must optimize the neutronics of the *entire* target system for useful neutron production. Even with an optimized target system, other variables are also important when looking at the ***total performance*** of a spallation neutron source. Table III shows the main variables affecting total performance.

II. ACKNOWLEDGEMENTS

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Table I

What is a Spallation Target *System*?

- Target(s)
- Moderator(s)
- Reflector(s)
- Poisons/Decouplers/Liners
- Structural Materials
- Cooling Material(s)
- Shielding

Table II

Neutronic Tuning Variables

- Proton Beam
  - *Energy/Beam Profile*
- Target
  - *Material*
    * tantalum
    * tungsten
    * lead
    * lead/bismuth
    * depleted uranium
    * enriched uranium
  - *Geometry/Size*
    * cylinder
    * square
    * slab
    * split
    * composite
- Reflector(s)
  - *Material/Size*
    * beryllium
    * graphite
    * heavy water
    * nickel
    * lead
- Moderator
  - *Material*
    * light water
    * heavy water
    * liquid methane
    * solid methane
    * liquid H_2
    * liquid D_2
  - *Temperature*
  - *Size*
  - *Decoupled*
  - *Poisoned*
  - *Coupled*
  - *Reentrant*
  - *Grooved*
  - *Honeycombed*
  - *Composite*
  - *Field-of-View*
- Poisons/Decouplers/Liners
  - *Material/Thickness*
    * gadolinium
    * cadmium
    * ^{10}B
    * boral
    * ^{6}Li
- Target-Moderator-Reflector-Shield geometry
  - *Coupling*
    * geometric
    * neutronic
  - *Target*
    * solid
    * liquid
    * split
    * composite
  - *Moderator geometry*
    * wing
    * slab
    * flux-trap
    * backscattering
    * composite
- Time
  - *Neutron-pulse shapes*
    * pulse width
    * rise time (leading edge)
    * decay time (pulse tails)
- Synergistic effects