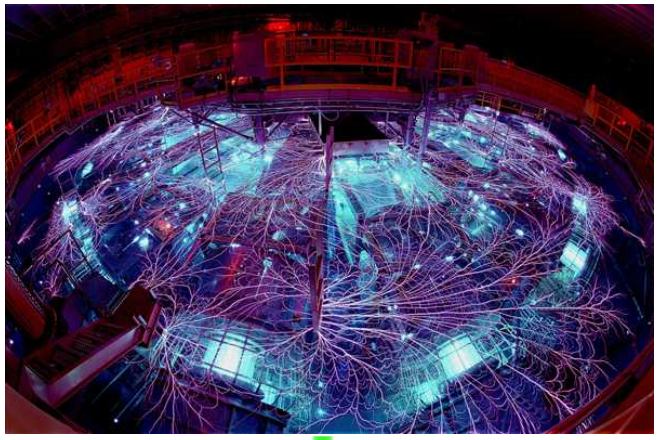
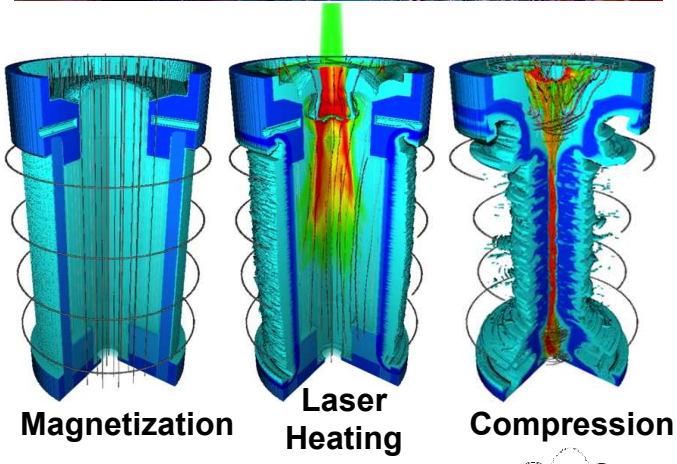
SAND2014-16761PE

Exceptional service in the national interest

Sandia National Laboratories





Monte Carlo Modeling of Secondary Nuclear Reaction Spectra in Fusion Plasmas

Brandon Lahmann

SEERI: End of Summer Presentation

August 13, 2014

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration | SEERI

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND NO. 2011-XXXXP

Outline

Sandia National Laboratories

- MonteBurns
- Secondary DD Reactions
- Tertiary DT Reactions
- Neutron Scattering in MagLif Liner

What is MonteBurns?

Sandia National Laboratories

- Monte Carlo MATLAB script
  - Written by Patrick Knapp in 2012 to study the effects of varying ion distributions on fusion neutron spectra
  - Expanded in 2013 to include transport capabilities
- Tracks source particles through fusion plasmas to calculate product spectra and determine what fraction of source particles would have reacted
- Primarily used to determine diagnostically interesting neutron spectra dependencies

What Makes MonteBurns Unique?

Sandia National Laboratories

- Mediums are defined by arbitrary particle distributions (two particles are sampled for each interaction)
- Tracks particles of arbitrary mass and charge
- Includes methodology to “force” product particles to travel in direction of interest
  - Simulate anisotropic spectra a real detector might see

Added Functionality

Sandia National Laboratories

Before	Now
▪ Hard-coded parameterized cross section representations	▪ Cross sections are parsed from ENDF
▪ Supports 4 hard coded nuclear reactions	▪ Supports any nuclear reaction defined in “valid” ENDF formats
▪ Returns energy spectra of hard-coded product of interest	▪ Returns energy spectra of both products
▪ Direction of the products **must** be specified	▪ Direction of the products **can** be specified

Added Functionality (cont…)

Sandia National Laboratories

Before

- Tracks particles through plasma of deuterium
- Designed to be ran once

Now

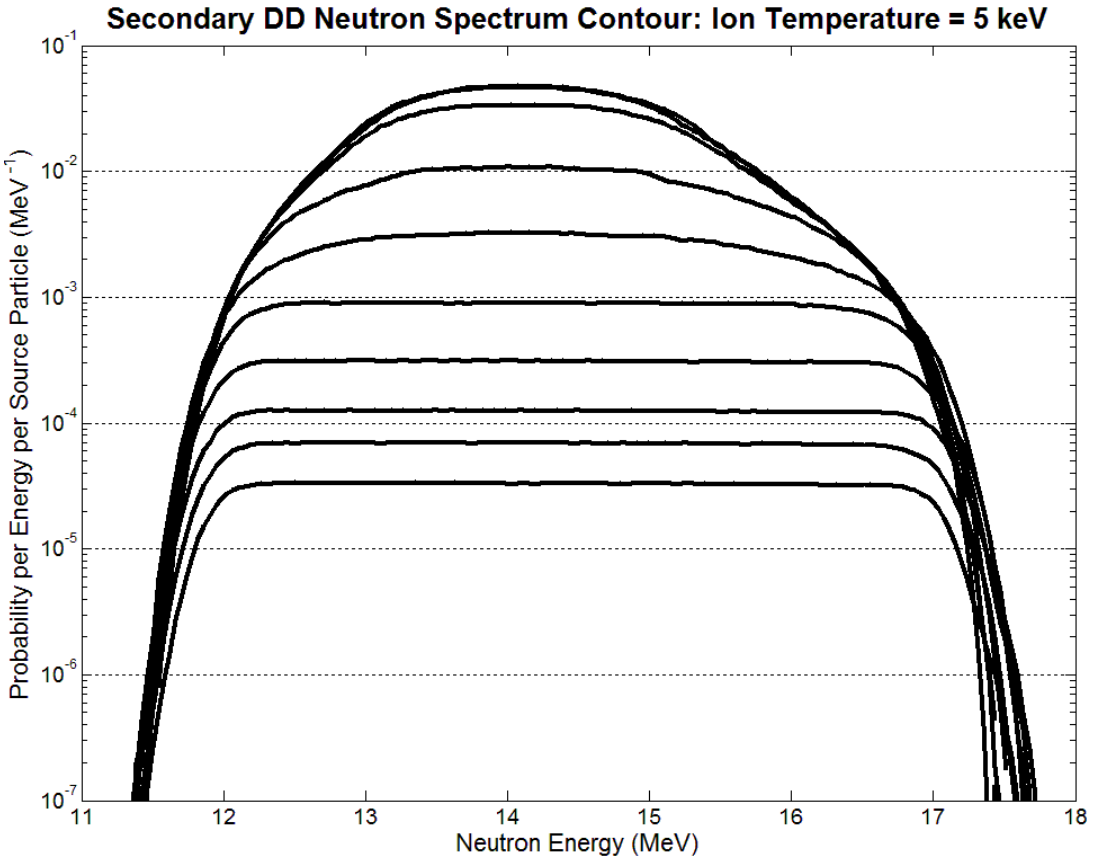
- Tracks particles through an arbitrary number of user defined materials
- Supports “chaining” calls (Used to model n^{th} generation reactions)
- Restructured to be more Object Oriented

Secondary DD Reactions

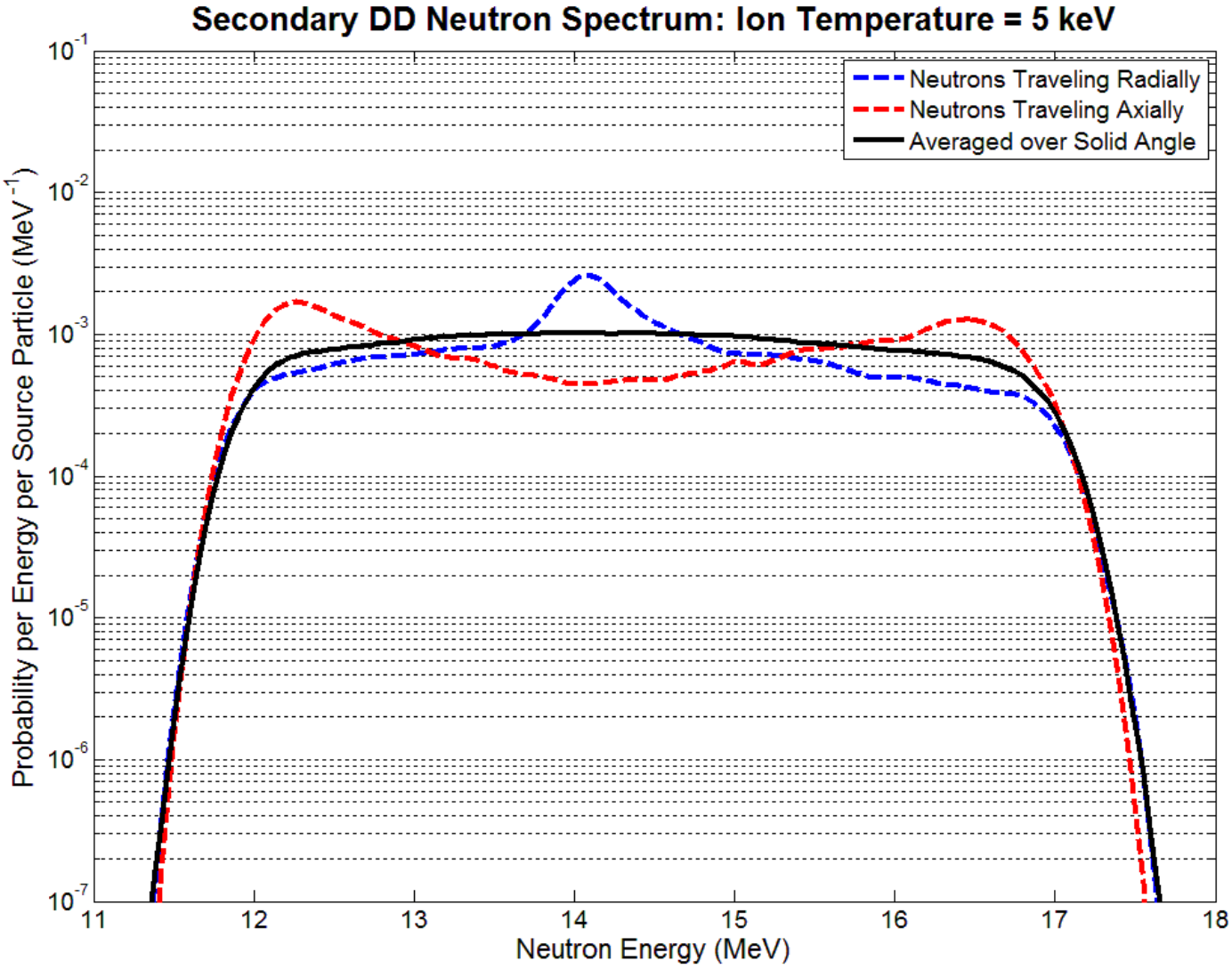
- Neutrons from secondary DD reactions act as a useful diagnostic of plasma conditions

- $D + D \rightarrow n_1 + {}^3He$
- $D + D \rightarrow p + T$

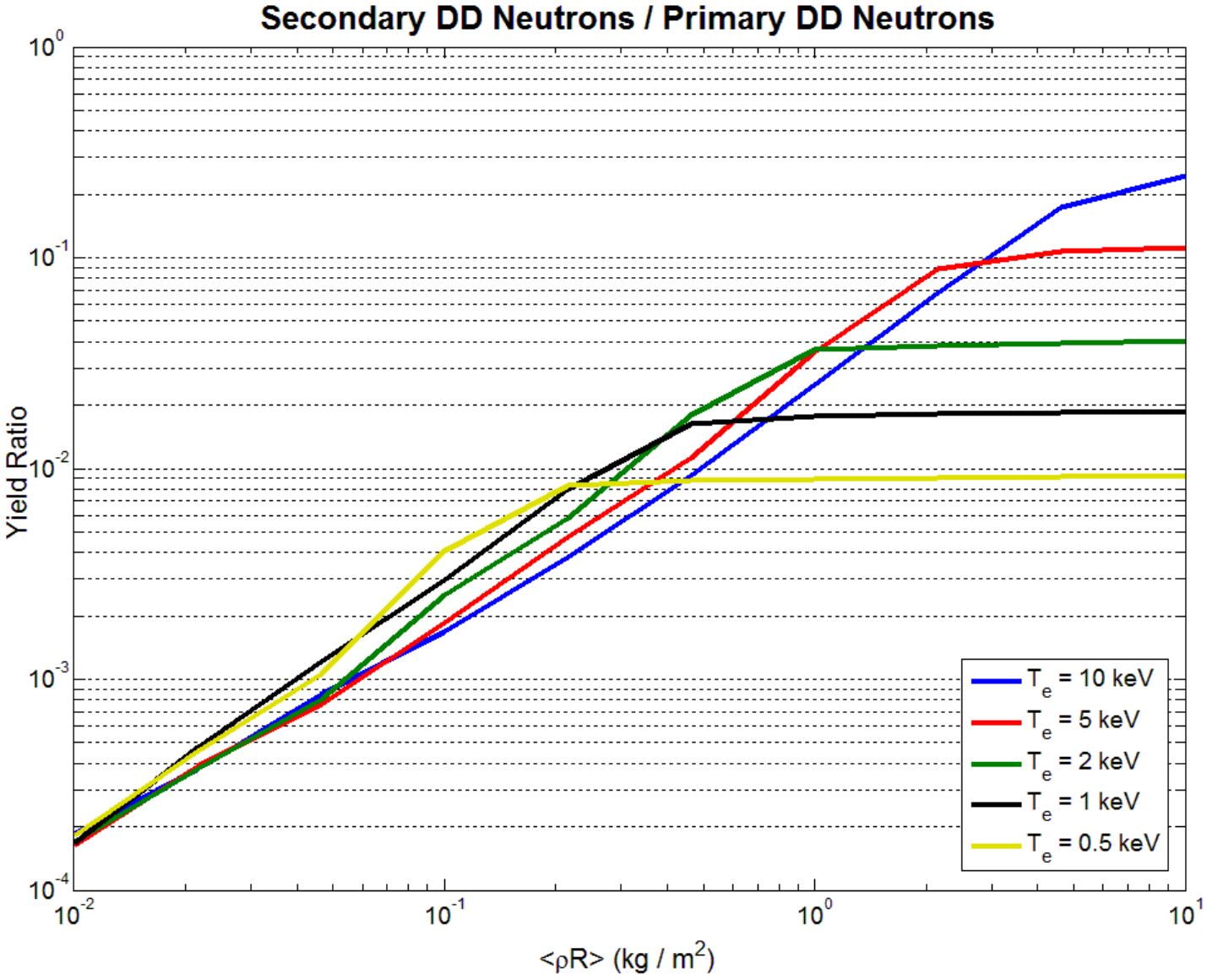
- $D + T \rightarrow n_2 + \alpha$



Spectra From Different Views (Cylindrical Geometry)

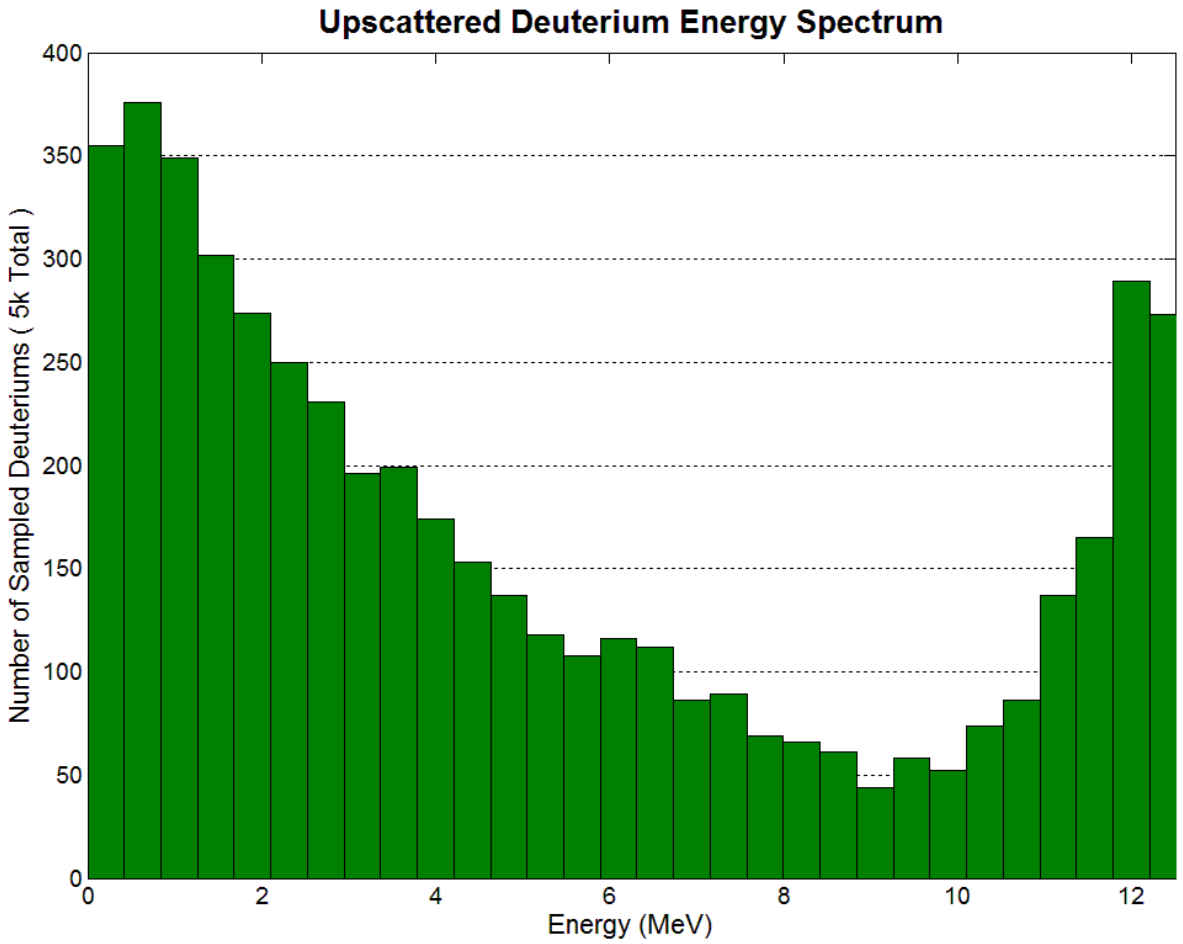


Secondary Neutrons as a Diagnostic

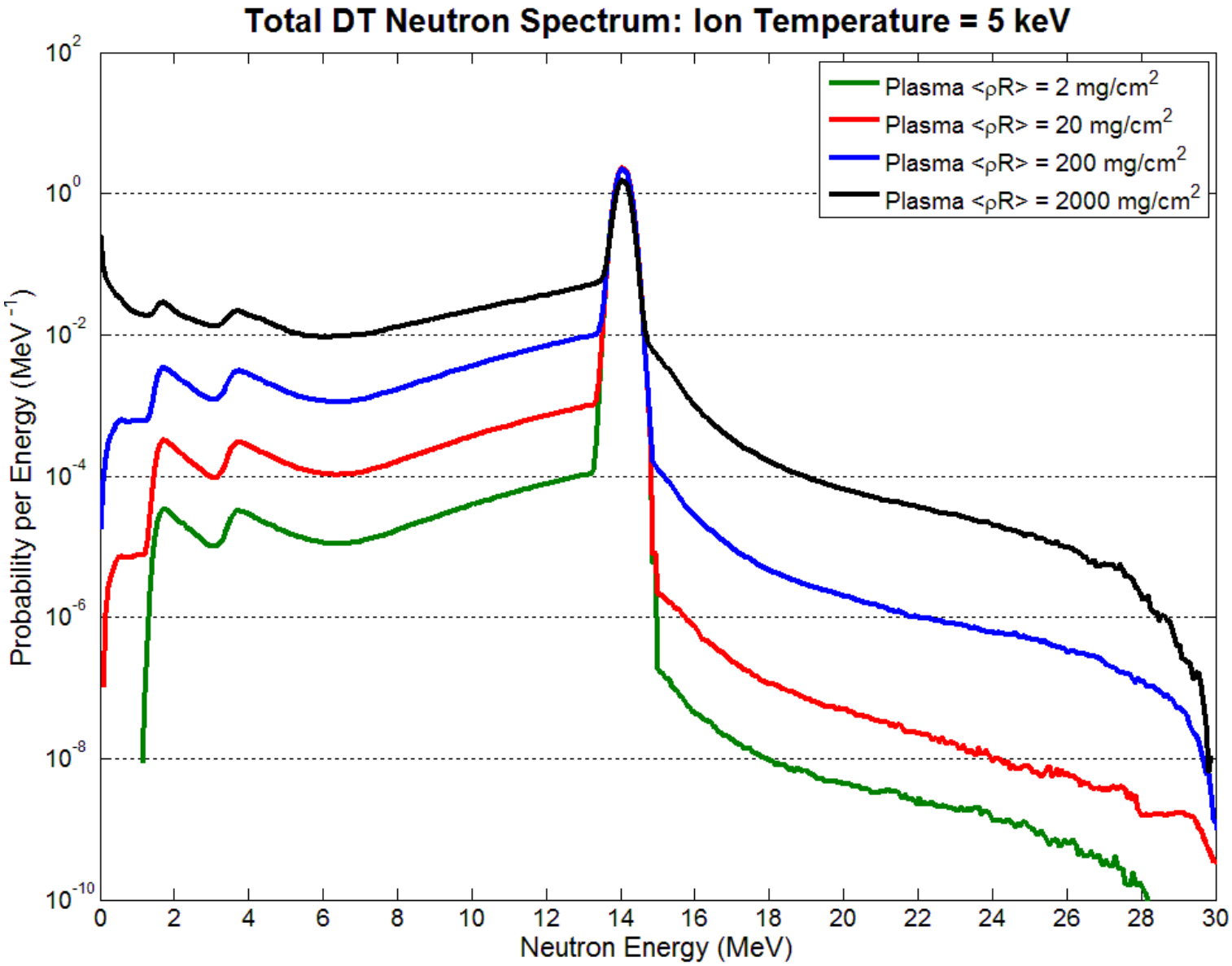


Tertiary DT Neutron Reactions

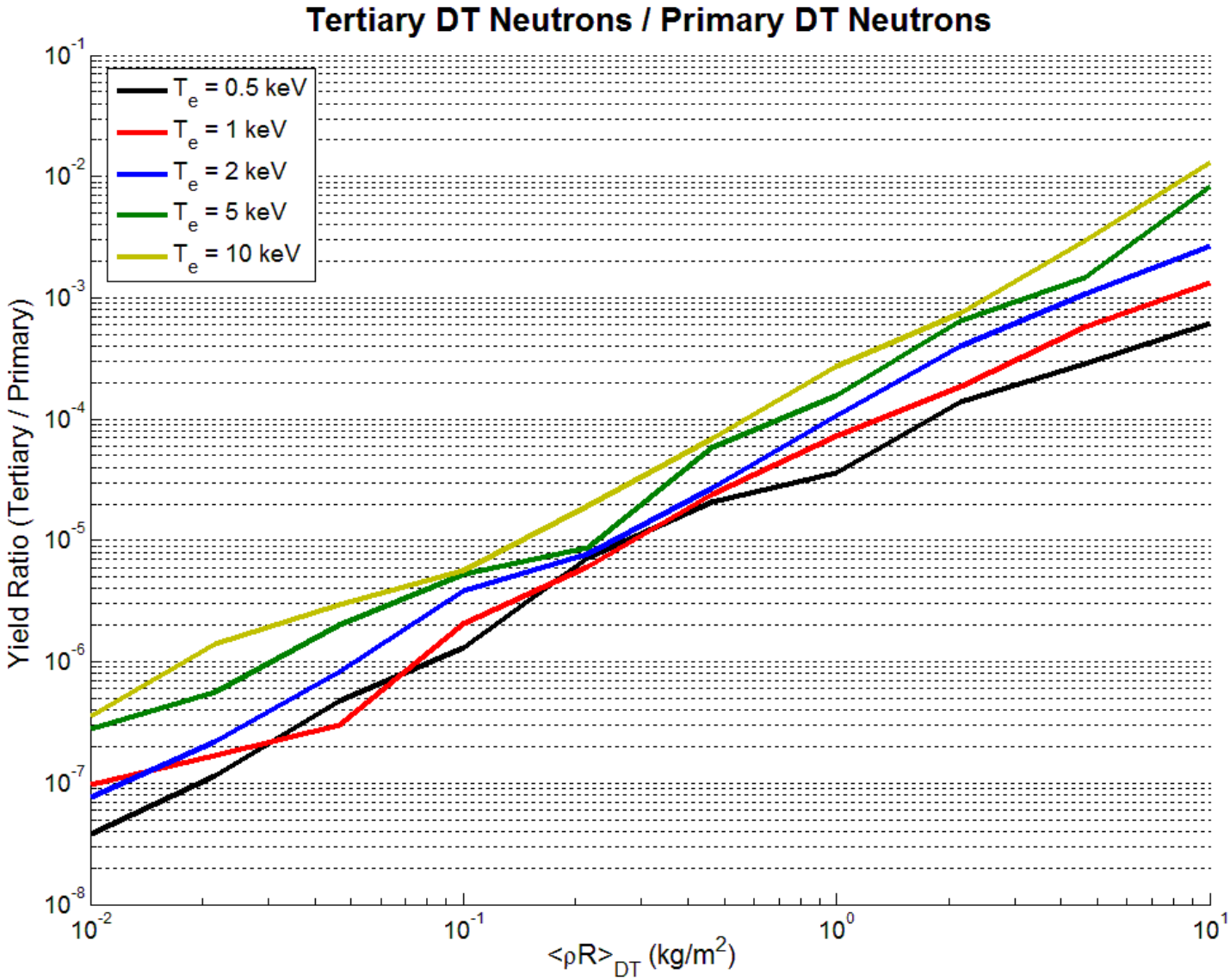
- $D + T \rightarrow n_1 + \alpha$
- $\boldsymbol{D + n_1 \rightarrow D' + n_2}$
- $\boldsymbol{T + n_1 \rightarrow T' + n_2}$
- $D' + T \rightarrow n_3 + \alpha$
- $D + T' \rightarrow n_3 + \alpha$



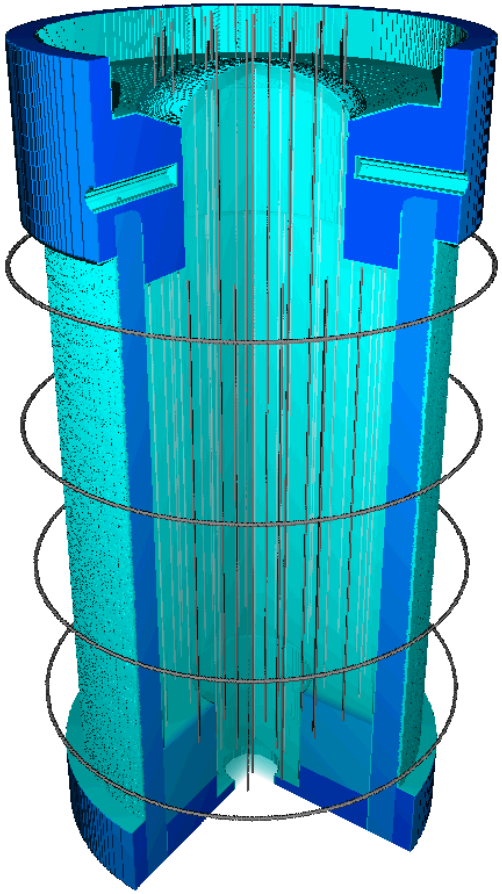
Full DT Neutron Spectra



Tertiary Neutrons as a Diagnostic

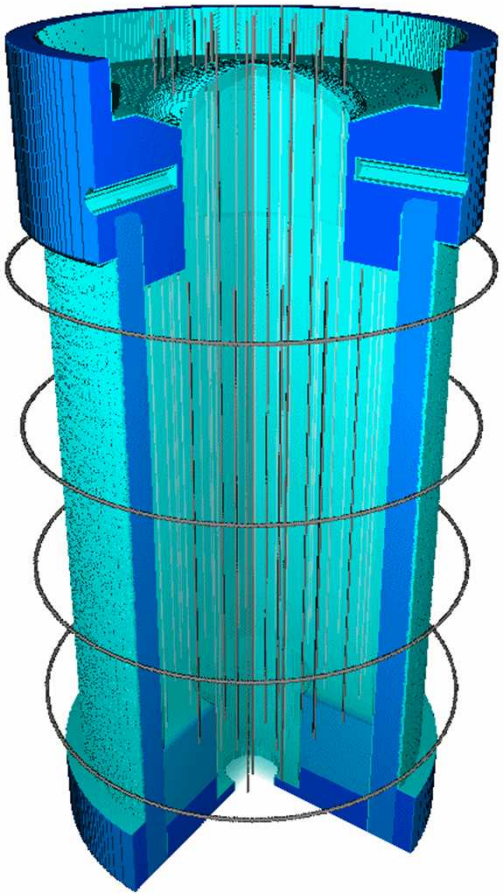


Neutron Scattering in MagLif Liner



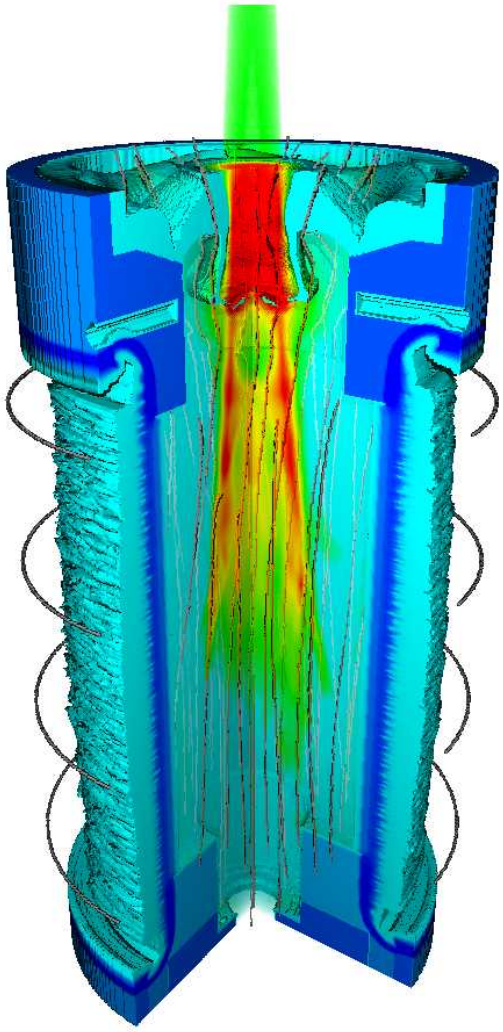
- A majority of neutrons escaping from the plasma will have to travel through a dense lining material
- Neutrons that scatter here can potentially overwhelm plasma scattered neutrons
- Additionally might offer important diagnostic information regarding liner conditions

Neutron Scattering in MagLif Liner



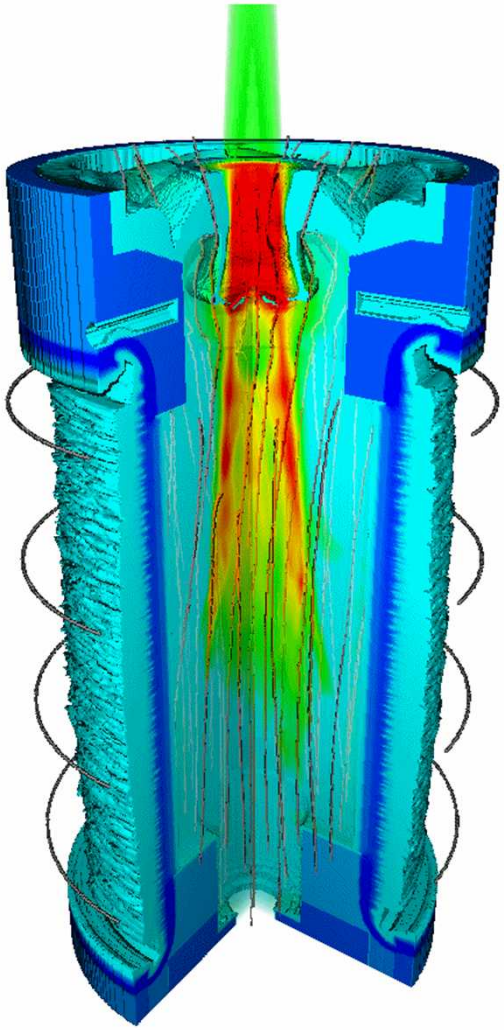
- A majority of neutrons escaping from the plasma will have to travel through a dense lining material
- Neutrons that scatter here can potentially overwhelm plasma scattered neutrons
- Additionally might offer important diagnostic information regarding liner conditions

Neutron Scattering in MagLif Liner



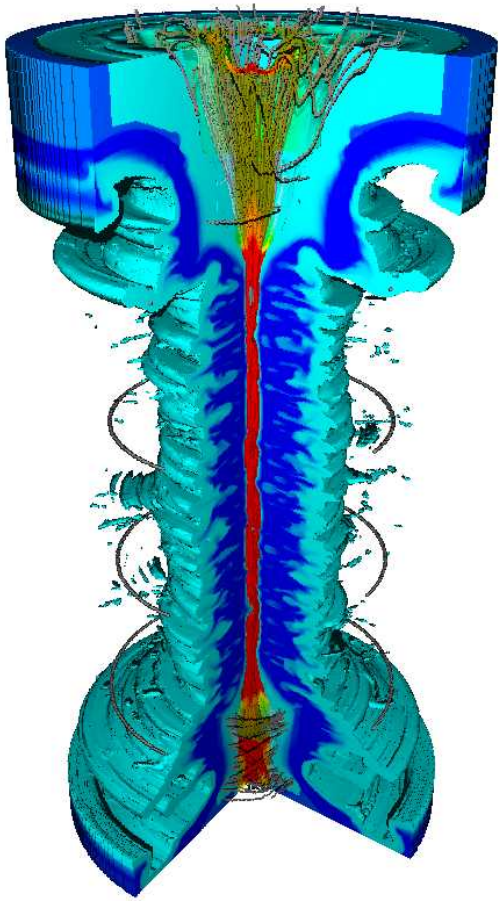
- A majority of neutrons escaping from the plasma will have to travel through a dense lining material
- Neutrons that scatter here can potentially overwhelm plasma scattered neutrons
- Additionally might offer important diagnostic information regarding liner conditions

Neutron Scattering in MagLif Liner



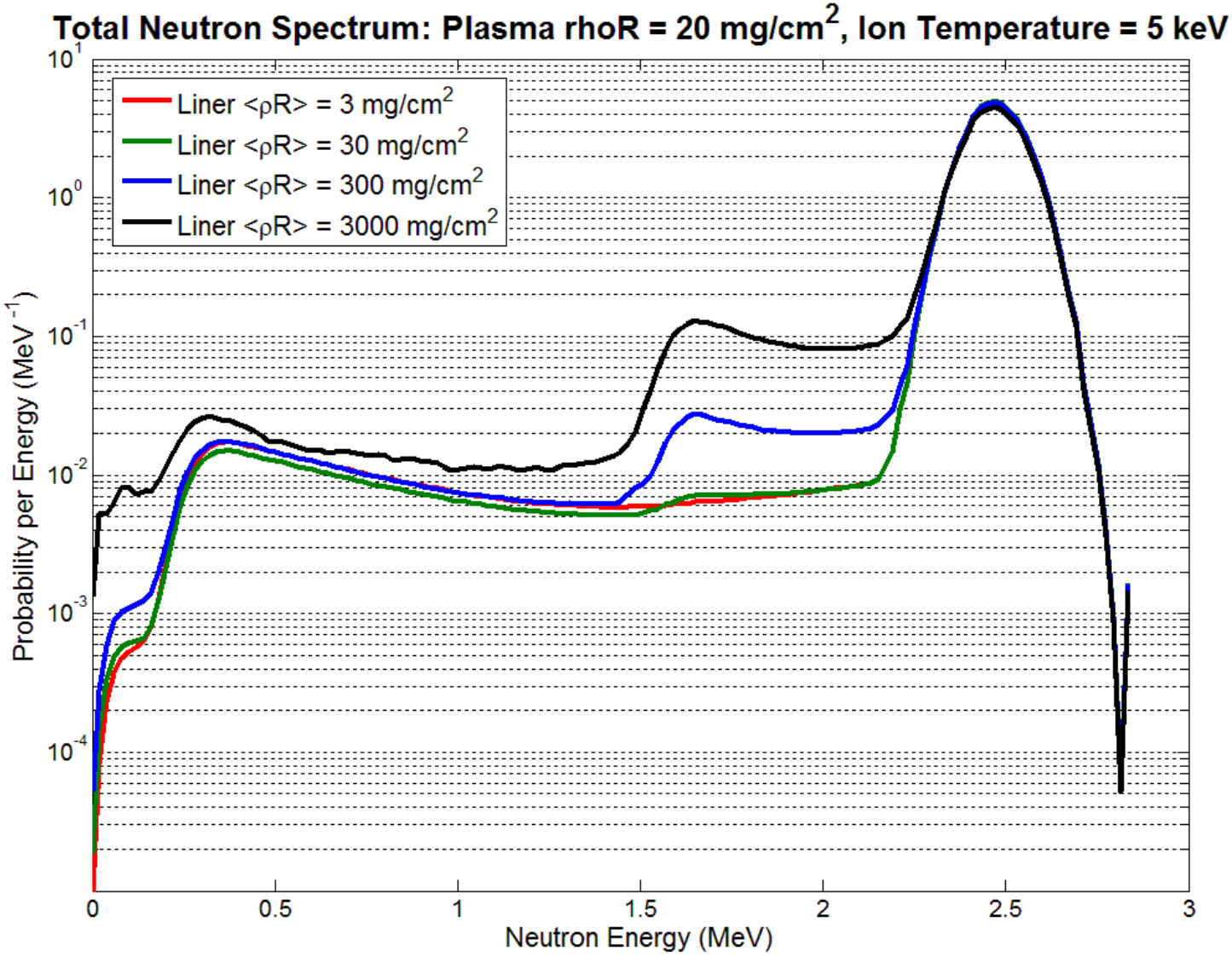
- A majority of neutrons escaping from the plasma will have to travel through a dense lining material
- Neutrons that scatter here can potentially overwhelm plasma scattered neutrons
- Additionally might offer important diagnostic information regarding liner conditions

Neutron Scattering in MagLif Liner

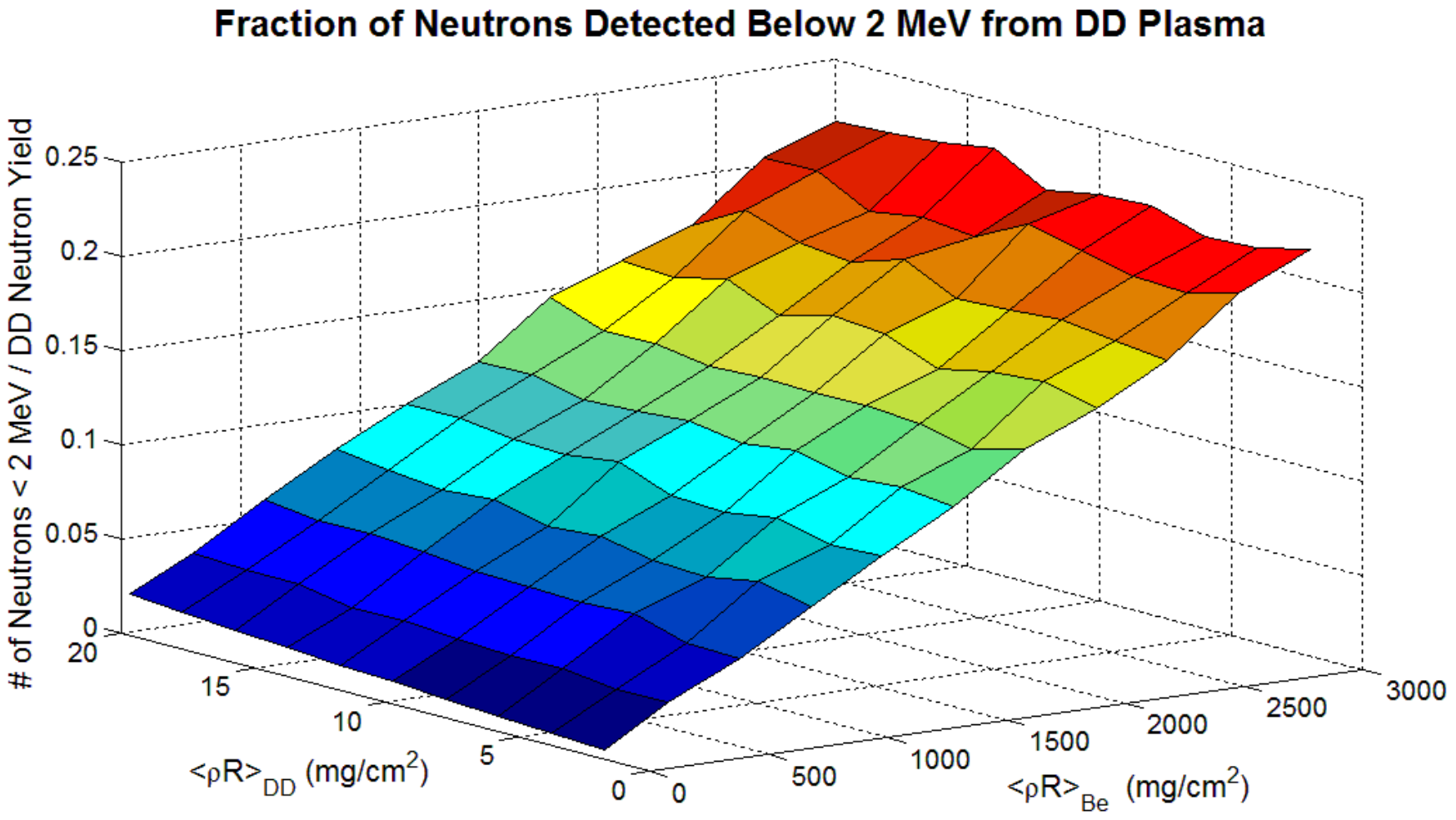


- A majority of neutrons escaping from the plasma will have to travel through a dense lining material
- Neutrons that scatter here can potentially overwhelm plasma scattered neutrons
- Additionally might offer important diagnostic information regarding liner conditions

Neutron Scattering in MagLif Liner

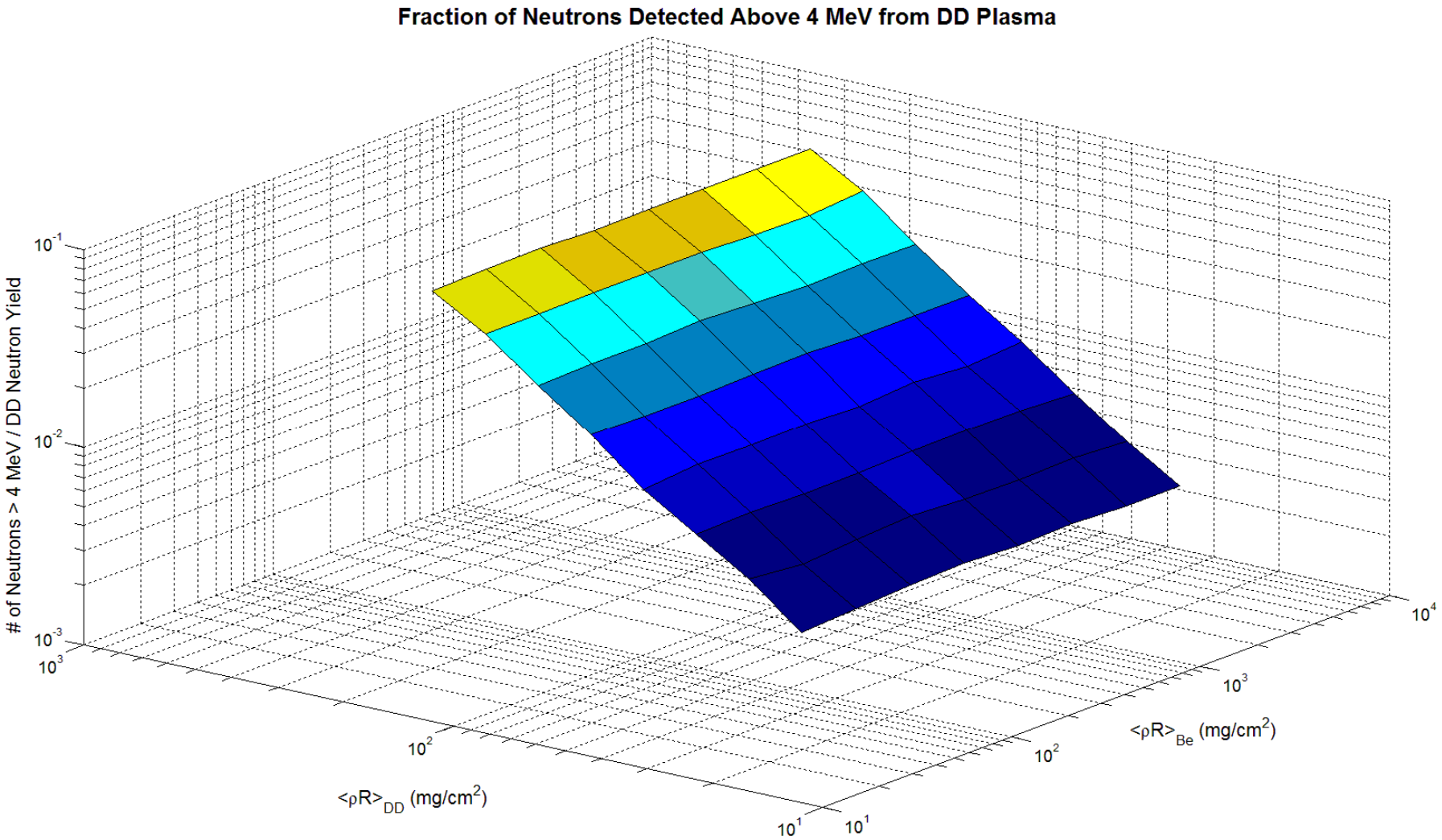


Scattered Neutrons as a Diagnostic



Scattered Neutrons as a Diagnostic

Sandia National Laboratories



Sandia National Laboratories

QUESTIONS?