ARIES-CS Neutron Wall Loading with 3-D Source Function

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Sept 6, 2006
Overview

- Methodology
- Source map
- NWL results
Neutron Source Methodology

- Generate hex mesh in real space from uniform mesh in flux coordinate space
- Generate cumulative distribution function for source density in hex mesh
- Sample hex mesh and mesh cells for source position
Generate Hex Mesh

- Uniform spacing in
  - 1 field period in **toroidal** direction
  - $2\pi$ in **poloidal** direction
  - Flux plasma surfaces in **radial** direction

- Use Fourier expansion to convert
  - First to $(r,z,\phi)$
  - Then to $(x,y,z)$

- Degenerate hexes along magnetic axis
Mesh Indexing

• Mesh vertices are indexed to increase most rapidly in the poloidal direction, then the radial direction and finally in the toroidal direction.

• Mesh hexes are numbered to correspond to the lowest numbered vertex that forms that hex.
Mesh Conveniences

• Use extra storage to simplify calculations
• Extra vertices are stored for $\theta=2\pi$ even though these points are redundant with $\theta=0$
• Extra hexes are indexed at the maximum in each dimension even though there is no space there
  – Since they are defined to have 0 volume these hexes won’t interfere with the probabilities
Neutron Source Strength

- Using plasma fusion density function from J. Lyon
Source Strength on Mesh

- Evaluate source density at each mesh vertex, $s_{vi}$
- Define mesh cell source strength as simple mean of associated mesh vertex source densities
- Define mesh cell probability as normalized source strength
- Evaluate CDF for this discrete PDF

\[ S_{hi} = \frac{1}{8} \sum_{vj} S_{vj} \]

\[ P_{hi} = \frac{S_{hi}}{\sum S_{hi}} \]

\[ P_{hi} = \sum_{hj=1}^{hi} p_{hj} \]
Source Density Map
Sampling Source CDF

- Know vertex coordinates and CDF of source strength
- Find $h_i$ such that $P_{hi-1} < \xi < P_{hi}$ for random variable $\xi$
- Sample trilinear coordinate system of mesh cell $h_i$ uniformly
- Map trilinear coordinates to real coordinates for origin
Results

Peak: 3.56 MW/m²
@ $\phi = 71^\circ$
$\theta = 337^\circ$

Peak: 5.26 MW/m²
@ $\phi = 108^\circ$
$\theta = 6.5^\circ$
Toroidal Slices