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

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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
  - 2π in ***poloidal*** direction
  - Flux plasma surfaces in ***radial*** direction
- Use Fourier expansion to convert
  - First to (r,z,ϕ)
  - Then to (x,y,z)
- Degenerate hexes along magnetic axis

Mesh Indexing

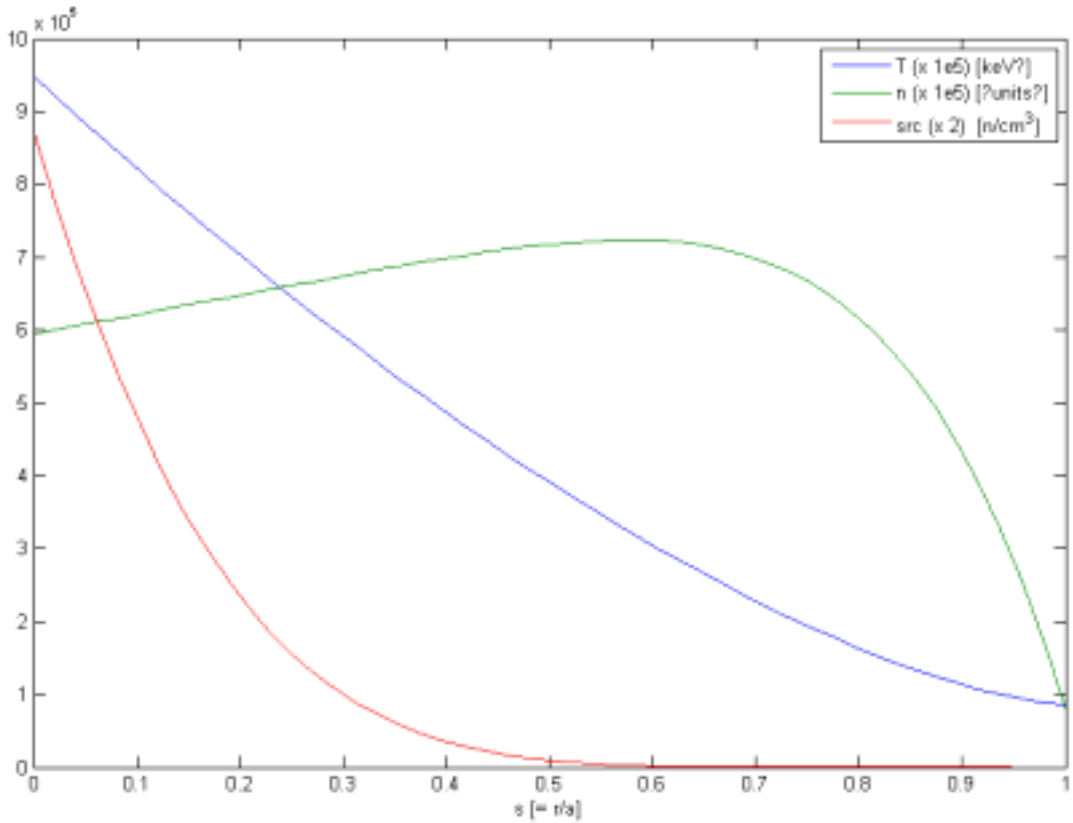
- Mesh vertices are indexed to increase most rapidly in the poloidal direction, then the radial direction and finally in the toroidal direction
- Mesh hexes are numbered to correspond to the lowest numbered vertex that forms that hex

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 intefere with the probabilities

Neutron Source Strength

- Using plasma fusion density function from J. Lyon



Source Strength on Mesh

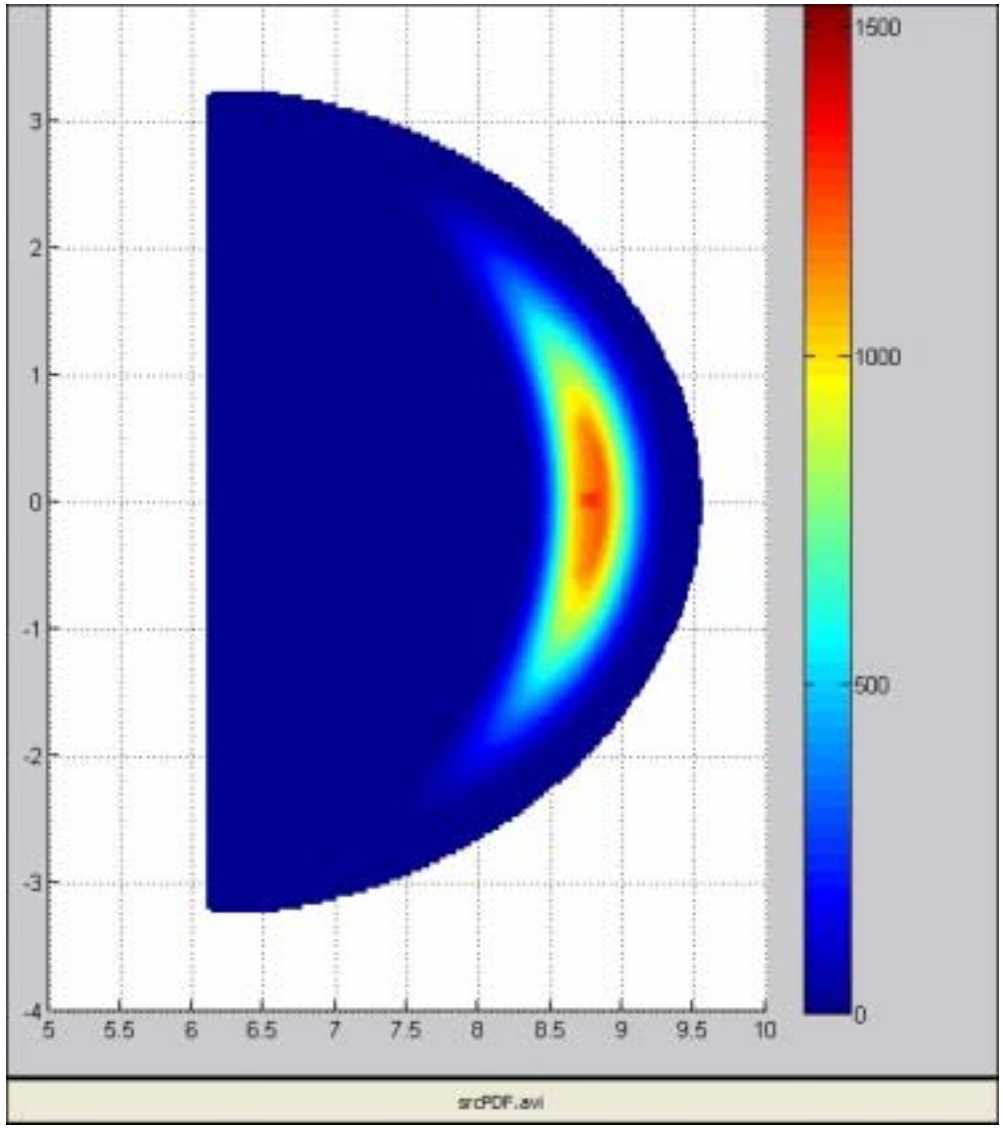
- Evaluate source density at each mesh vertex, s_{vi}
- Define mesh cell source strength as simple mean of associated mesh vertex source densities
- Define mesh cell probability as normalized source strength
- Evaluate CDF for this discrete PDF

$$S_{hi} = \frac{1}{8}\sum_{vj} S_{vj}$$

$$p_{hi} = \frac{S_{hi}}{\sum S_{hi}}$$

$$P_{hi} = \sum_{hj=1}^{hi} p_{hj}$$

Source Density Map



Sampling Source CDF

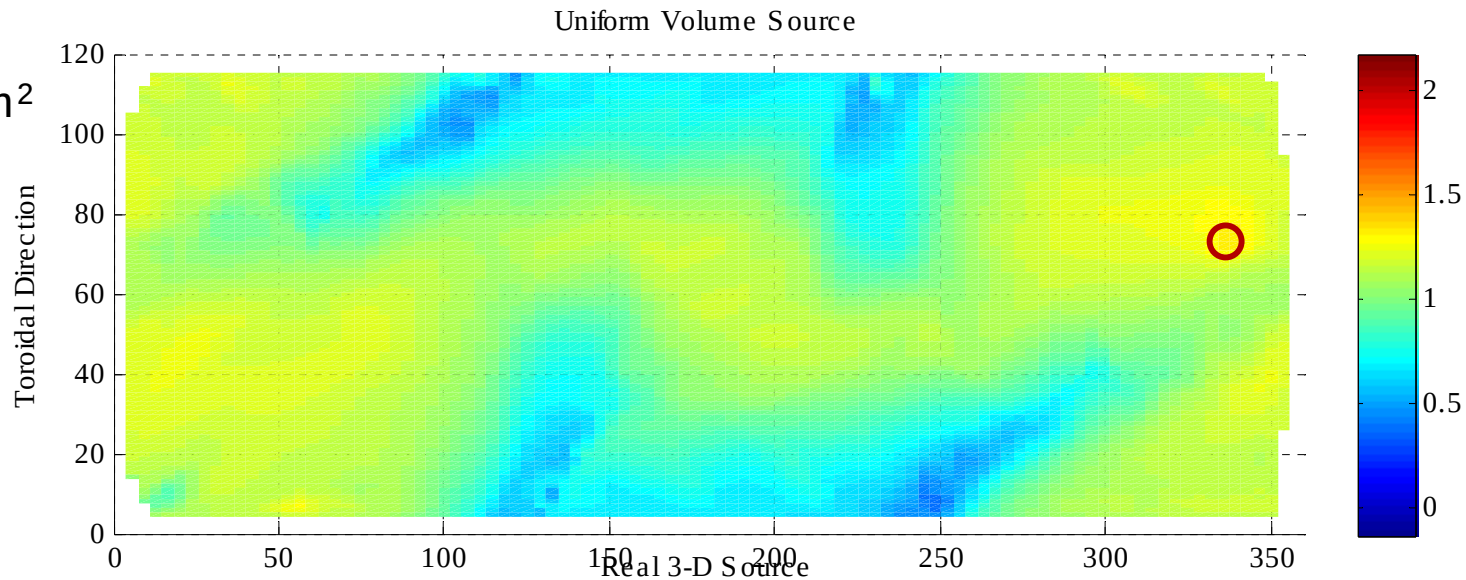
- Know vertex coordinates and CDF of source strength
- Find hi such that for random variable ξ

$$P_{hi-1} < \xi < P_{hi}$$

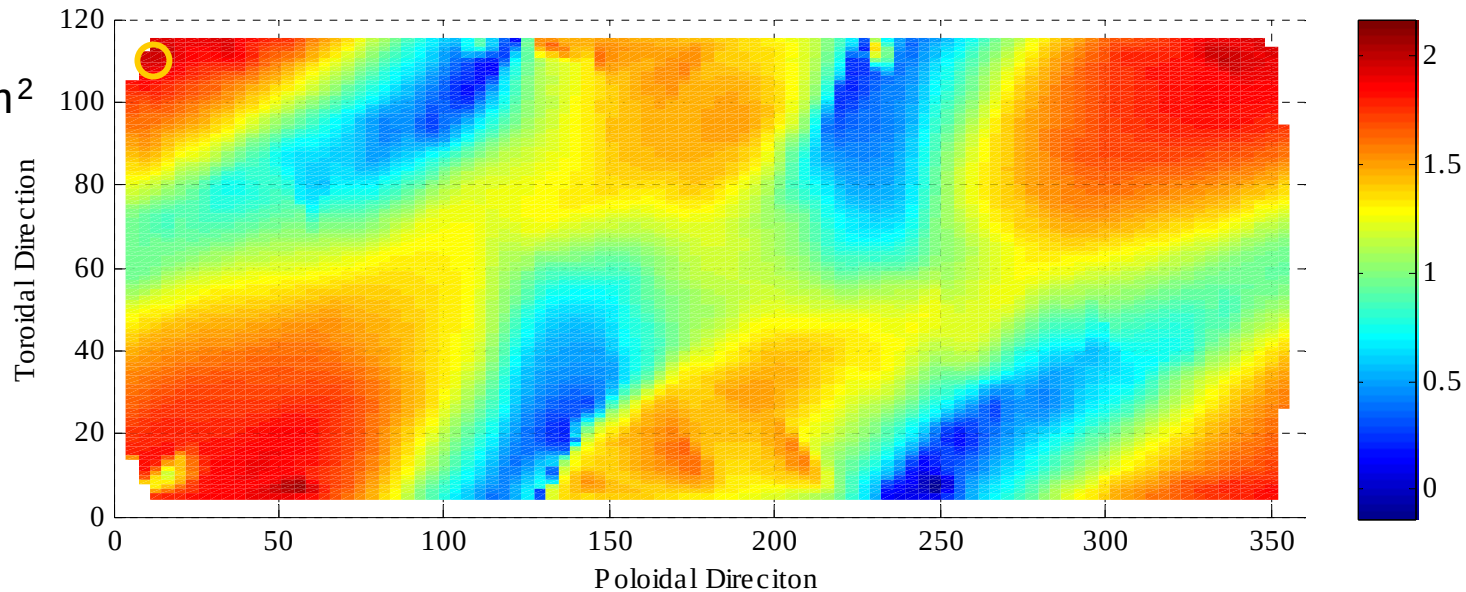
- Sample trilinear coordinate system of mesh cell hi uniformly
- Map trilinear coordinates to real coordinates for origin

Results

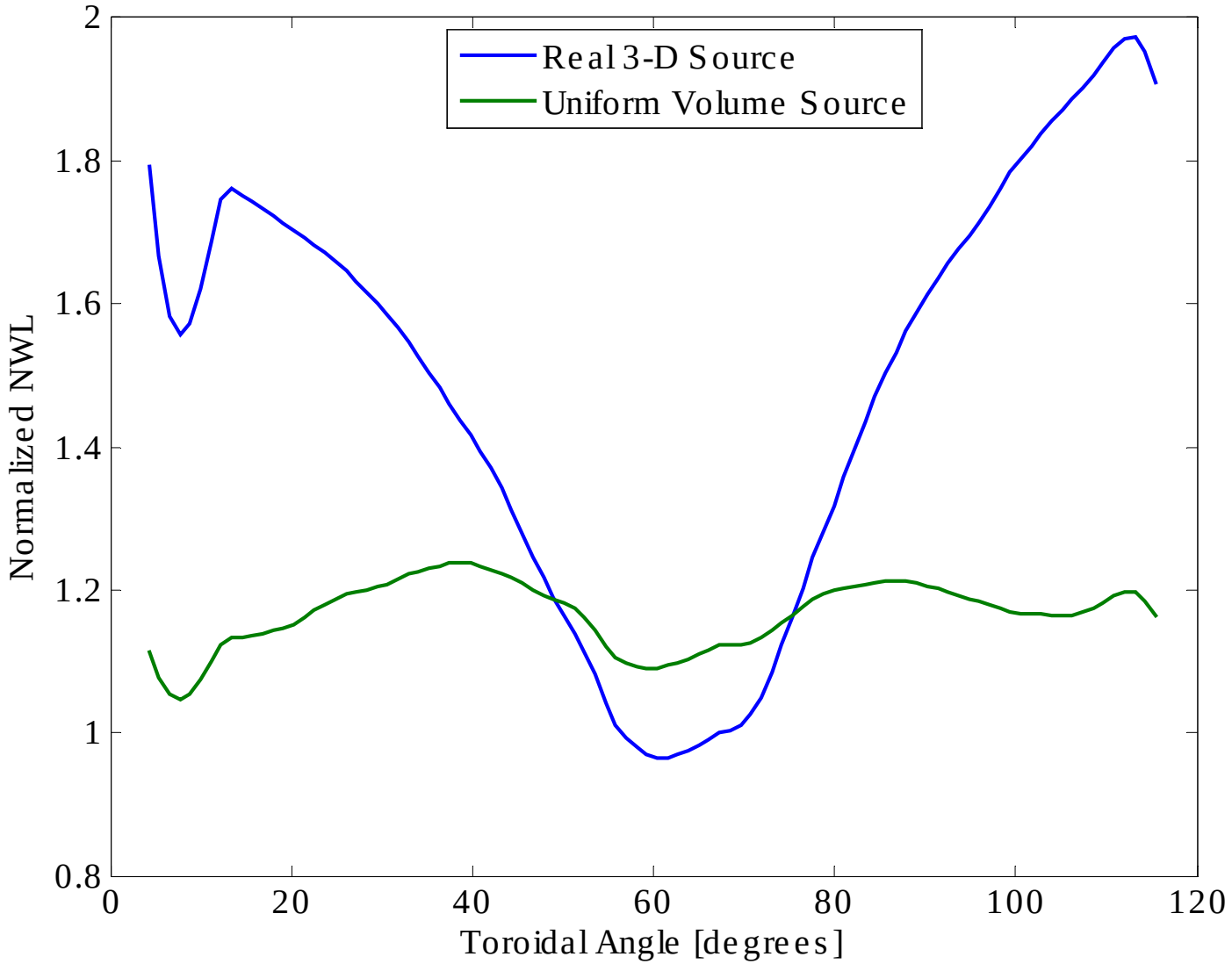
Peak: 3.56 MW/m^2
@ ϕ = 71°
θ = 337°



Peak: 5.26 MW/m^2
@ ϕ = 108°
θ = 6.5°



Midplane NWL Profile



Toroidal Slices