Neutron Wall Loading Profile Using CAD/MCNP Interface

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ARIES Meeting

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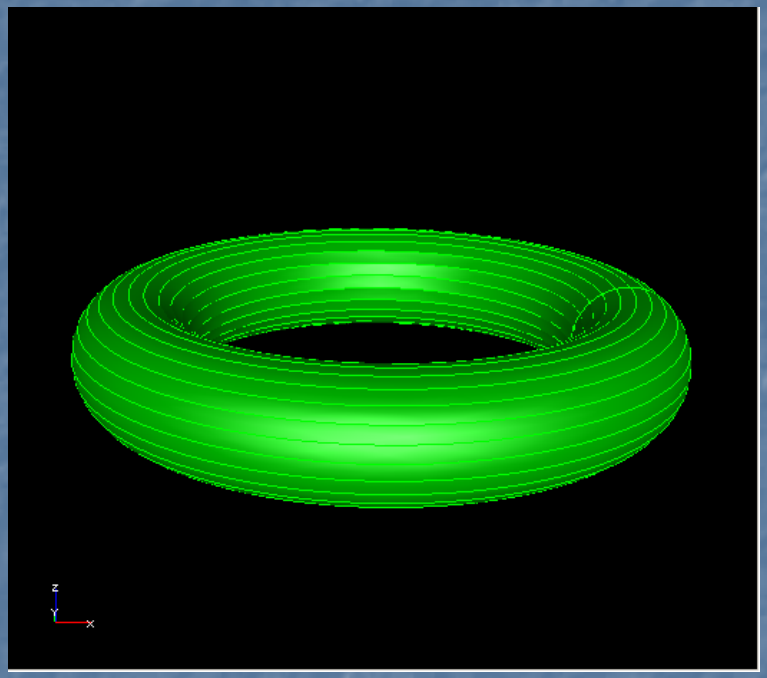
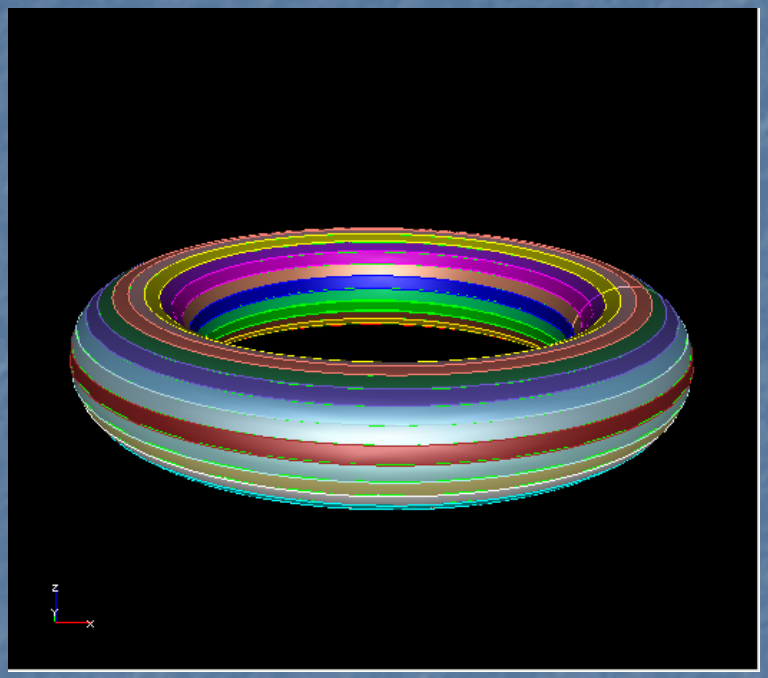
University of Wisconsin - Madison

(Last time) First step: torus

Plasma Surface

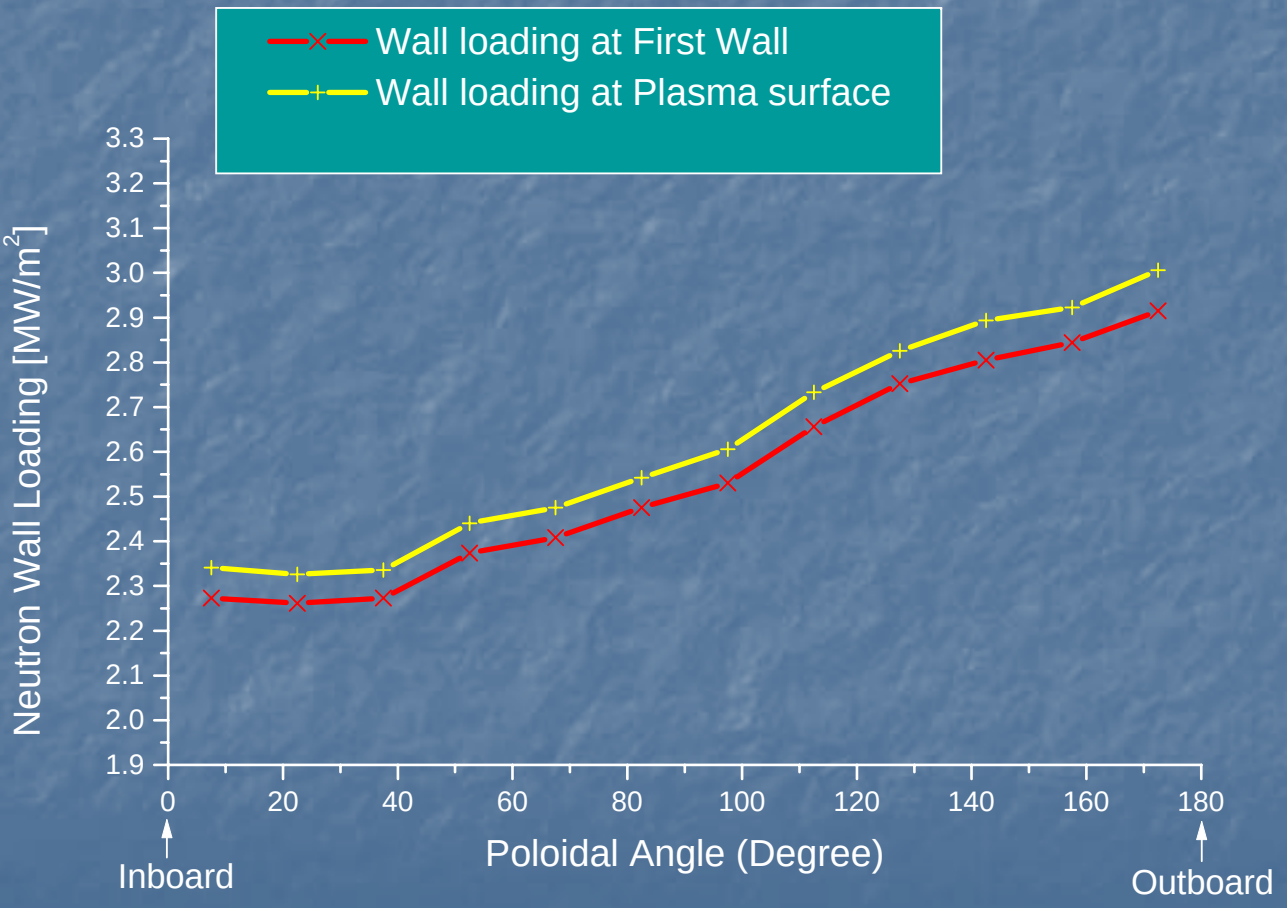


First Wall



First Wall divided poloidally into 15 degree bins

(last time) Result Differ by ~3% for 5cm SOL



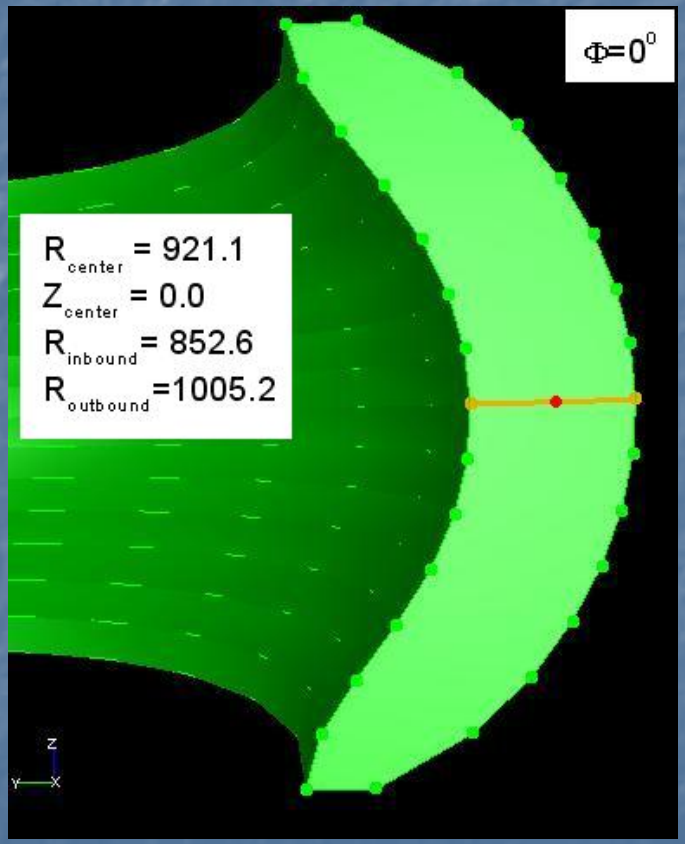
(last time)Wall subtract Plasma Surface

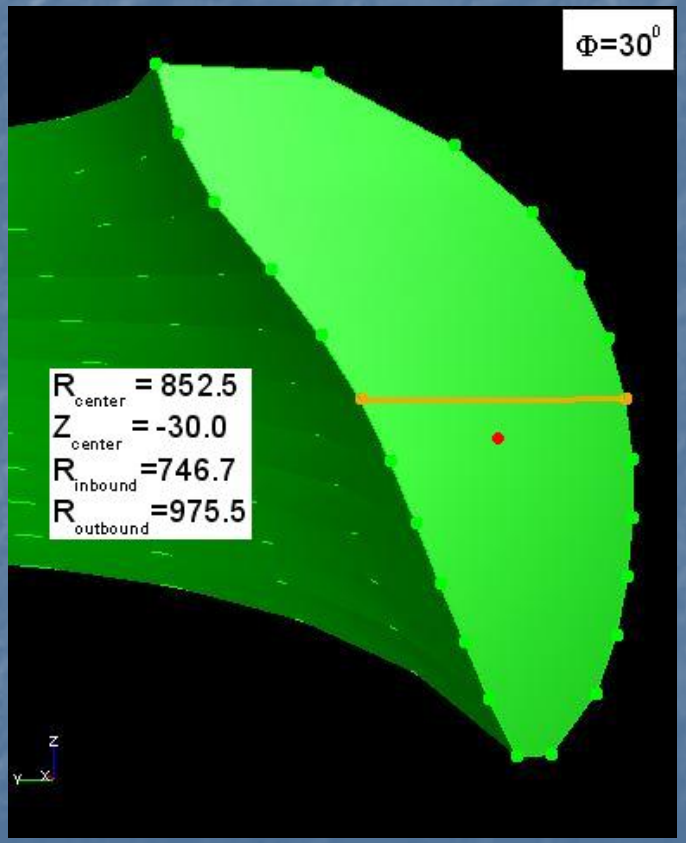
Second step: Cross Section Sweep Object

Φ=0°

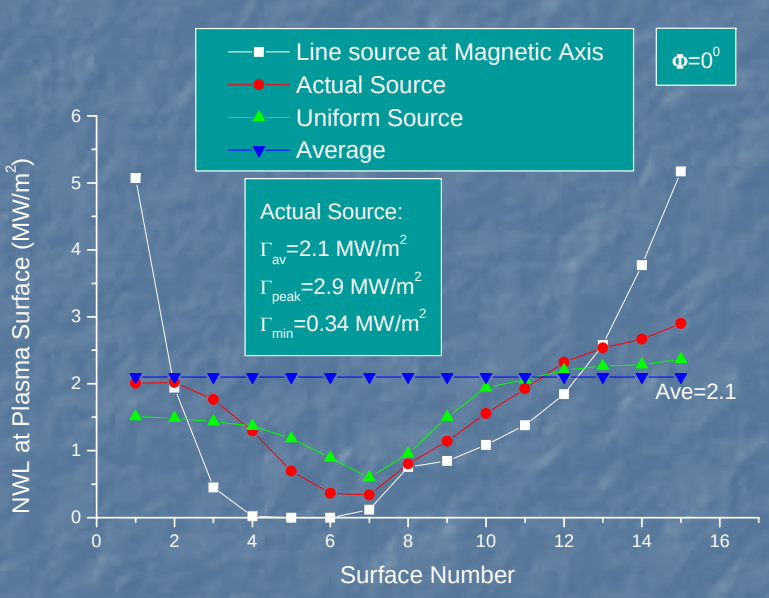
and

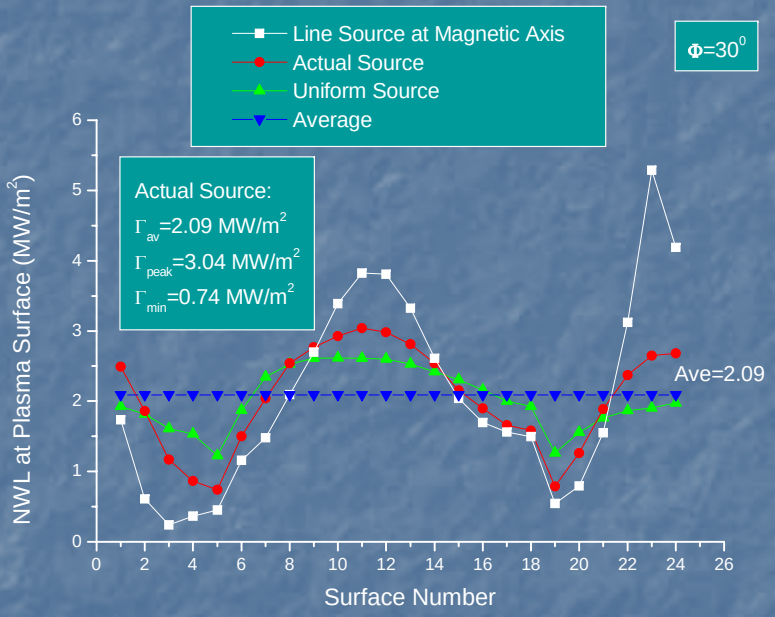
Φ=30°





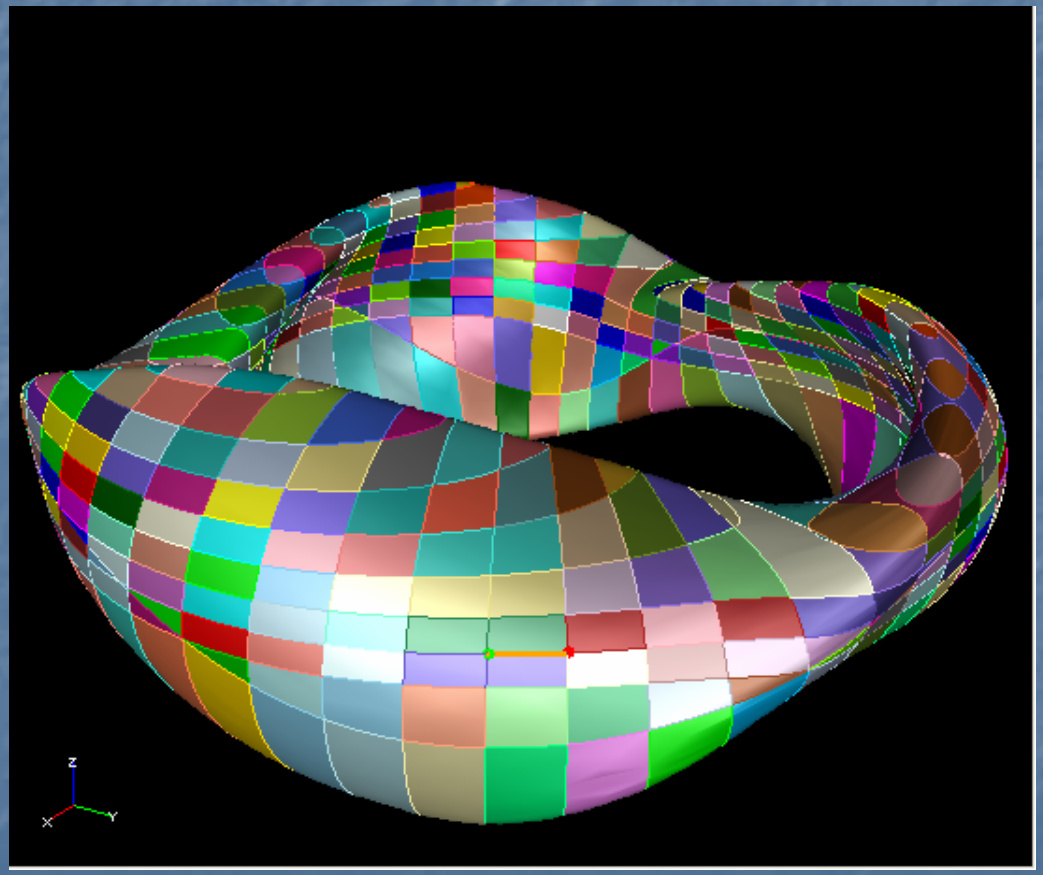
Cross Section Sweep Object (cont)





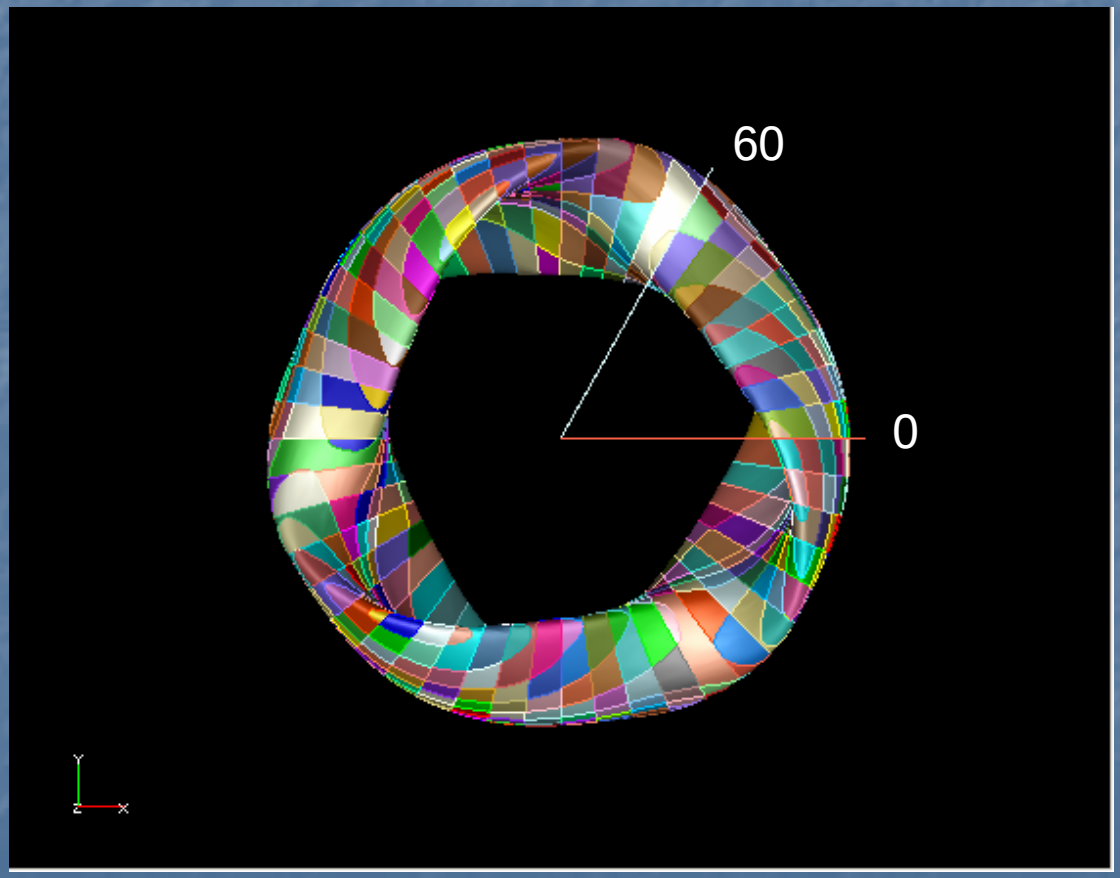
Third step: Computation model of stellerator

- Horizon and toroidal subdivision, each patch as tally surface
  - 7.5 degree toroidal subdivision
  - 0.5 m horizontal subdivision
- Combine the symmetry patch to reduce relative error
- 5 days on a 2.4GHz linux station
- 9% ~ 10% relative error

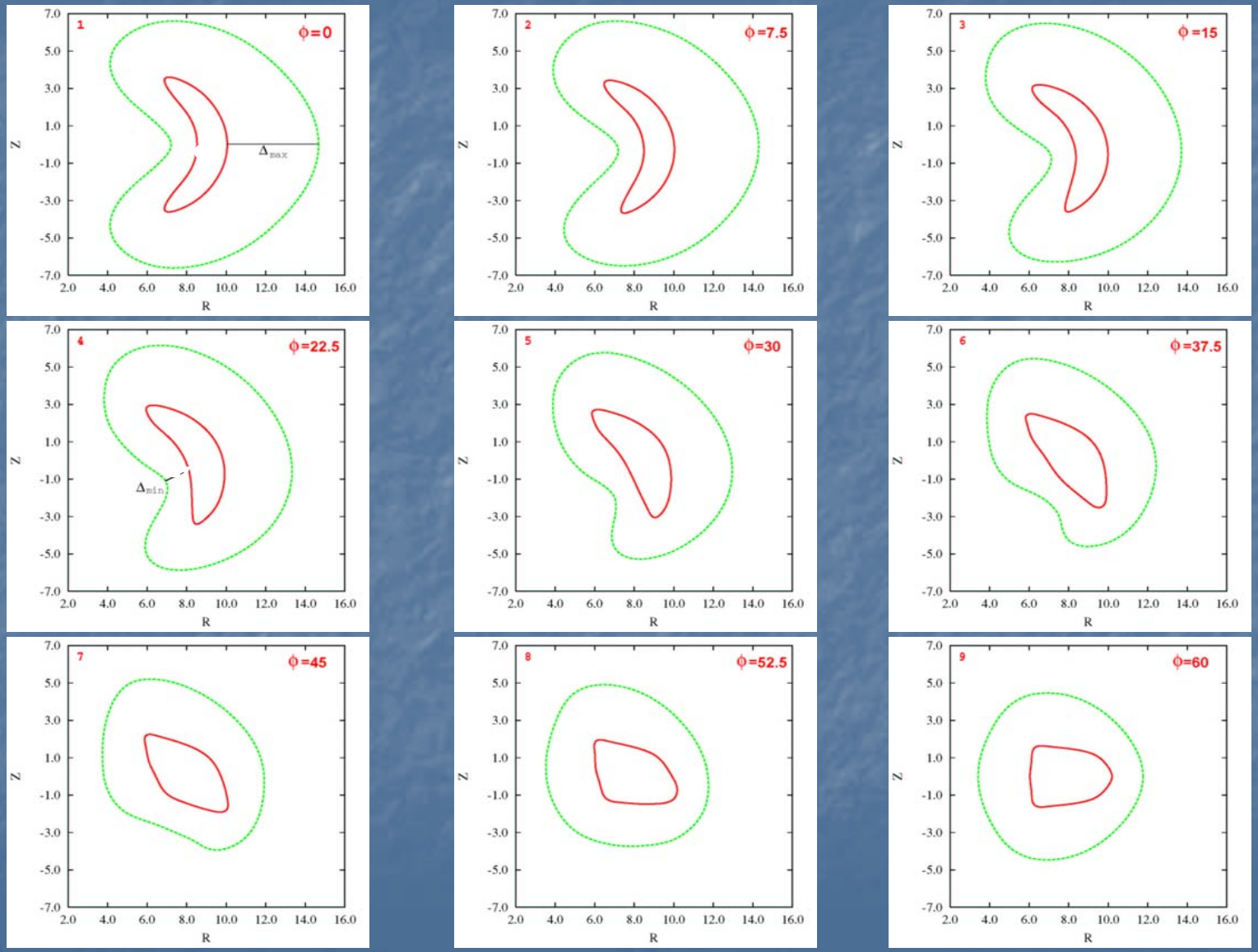


Computation model of stellerator

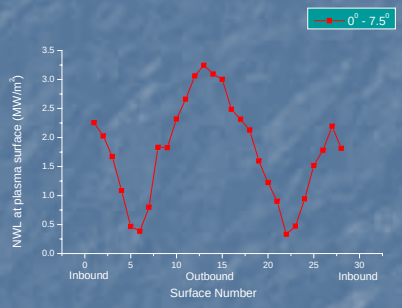
- By the symmetry, select portion from 0 to 60 degree
- 9 cross sections
- 8 neutron wall load profiles

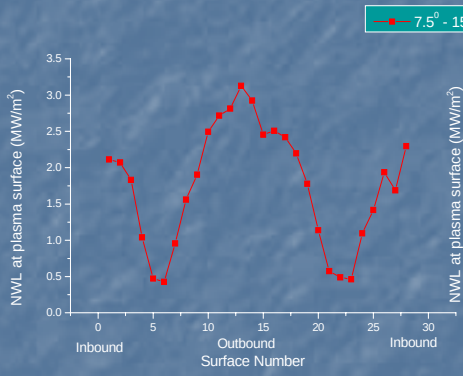


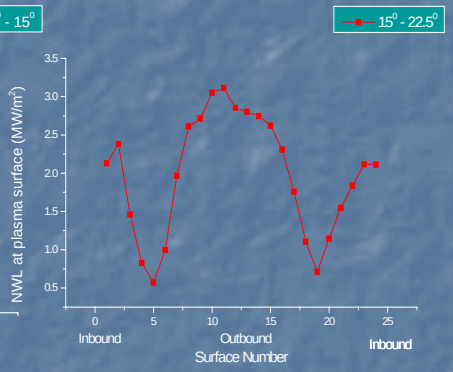
9 Cross Section of Plasma Boundary (red) and WP Center (green)

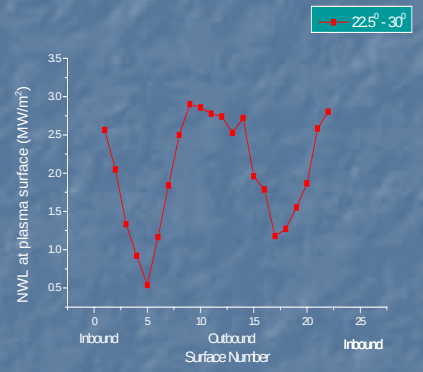


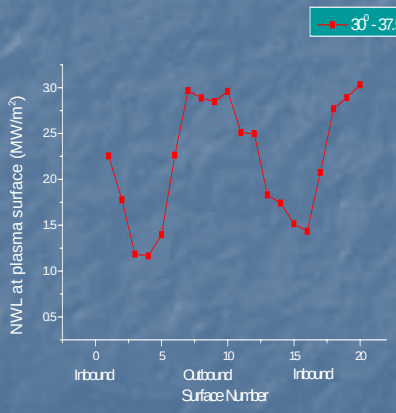
Computation result

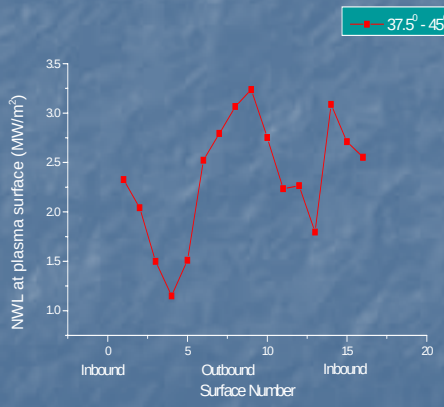


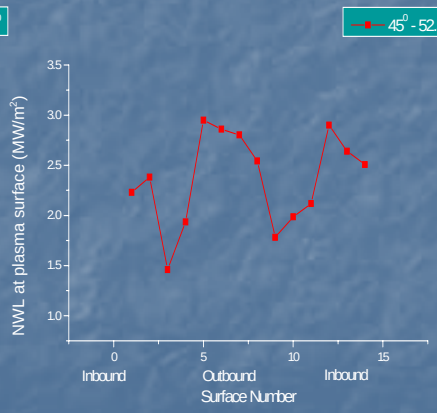


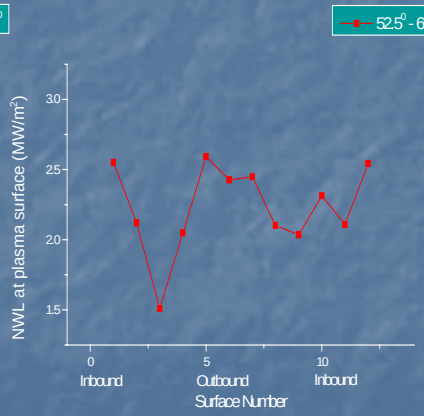










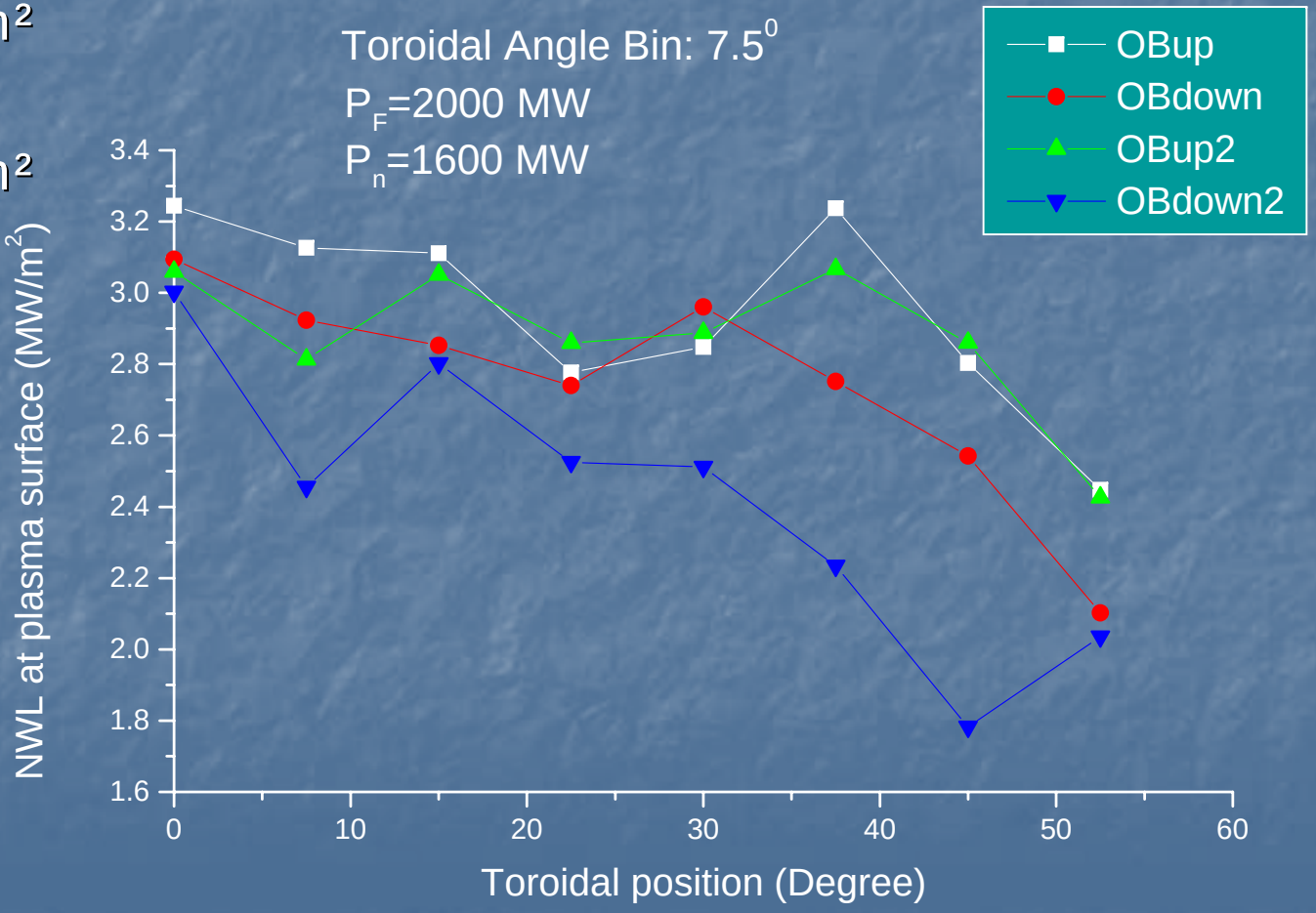


Peak is at Outbound

Γpeak=3.24MW/m²

PSarea=800.6m²

Γave=1.985MW/m²



Problem of CAD based MCNP

- Performance of CGM/MCNP
  - CAD based MCNP is about 10 – 30 times slower than standard MCNP
- Reason
  - CAD function is not optimized for a single function
  - Ray-object intersection function is compatible with all type of geometry
  - Ray-object intersection function also test for vertex and edge

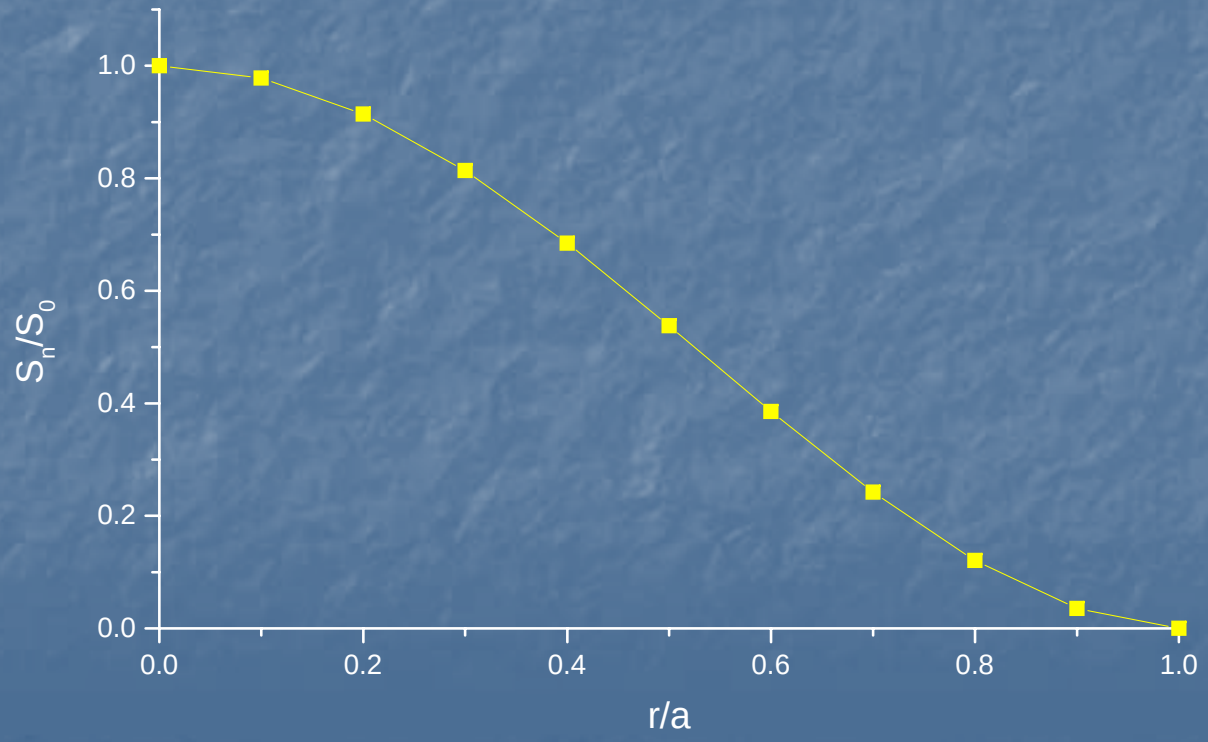
Future Plan

- Speed up calculations
  - Bounding box
  - Spatial subdivision
  - Direction techniques

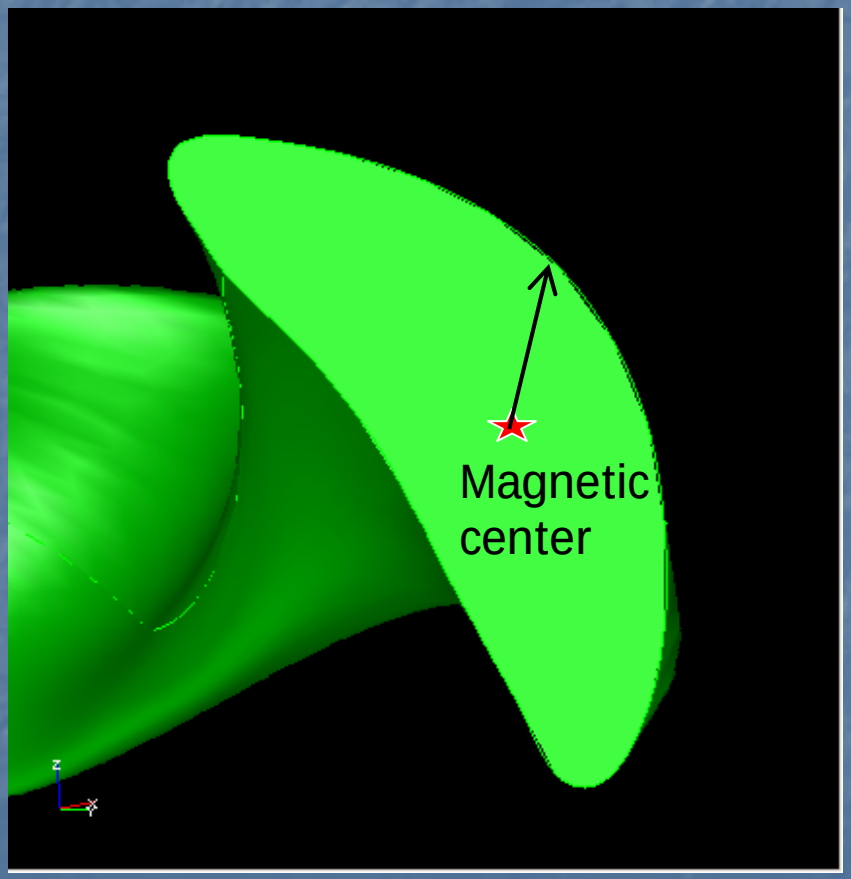
Neutron Source Profile

- the neutron production rate (in $cm^{-3}s^{-1}$)

$$S_n(r/a) = S_0[1-0.2(r/a)^2]^2[1-(r/a)^2]^{1.8}$$



Plasma Cross Section



- ‘a’ is calculated by CAD ray-fire function
  - Start from magnetic center
  - Direction is determined by sampling toroidal and poloidal direction

Neutron Source Profile

- ‘r’ is from magnetic center
  - Center position is computed by a constant table and two formula.
  - Constant Table

n	rmag	zmag
0	8.5672E+00	0.0000E+00
1	6.0678E-01	-2.9852E-01
2	4.1392E-02	-1.8349E-02
3	-2.2776E-03	1.2718E-03
4	-1.1638E-03	7.3849E-04
5	-9.5859E-04	-9.9194E-06
6	-6.2693E-05	6.6409E-05

  - in the following formula;

    $R=\mathrm{sum}\{ \mathrm{rmag}(n)*\cos(np*n*phi)\}$

    $Z=\mathrm{sum}\{ \mathrm{zmag}(n)*\sin(np*n*phi)\}$
- ‘a’ is from magnetic center to plasma surface
  - Use a CAD ray-fire function obtain ‘a’.