Initial Assessment of Maintenance Scheme for 2-Field Period Configuration

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Outline

- Summarize engineering plan of action
- Modular maintenance approach with limited number of ports for 3-field period configuration
- Benefit of larger port sizes: maintenance scheme with ports between each pair of adjacent coils
- 2-field period configuration

Engineering Activities: Year 1

- **Perform Scoping Assessment of Different Maintenance Schemes and Design Configurations**

  - **Three Possible Maintenance Schemes:**

    1. **Sector replacement including disassembly of modular coil system (e.g. SPPS, ASRA-6C)** ***Covered in S. Malang's presentation at this meeting***

    2. **Replacement of blanket modules through maintenance ports arranged between each pair of adjacent modular coils (e.g. HSR)** ***Initial assessment for 2-field period configuration***

    3. **Replacement of blanket modules through small number of designated maintenance ports (using articulated boom)** ***Presented at ARIES project meeting in May 2003***

  - **Each maintenance scheme imposes specific requirements on machine and coil geometry**

Engineering Activities: Year 1

- Scoping analysis of possible blanket/shield/divertor configurations compatible with maintenance scheme and machine geometry, including the following three main classes:
  1. Self-cooled liquid metal blanket(LiPb) (might need He-cooled divertor depending on heat flux)
     Presented at May 2003 ARIES project meeting
     a) with SiC_f/SiC
     b) with insulated ferritic steel and He-cooled structure

     Li or LiPb + He-cooled FW presented at this meeting (S. Malang's presentation)

  2. He-cooled liquid breeder blanket (or solid breeder) with ferritic steel and He-cooled divertor
     To be studied next

  3. Flibe-cooled ferritic steel blanket (might need He-cooled divertor depending on heat flux)
     Presented at Jan. 03 ARIES project meeting

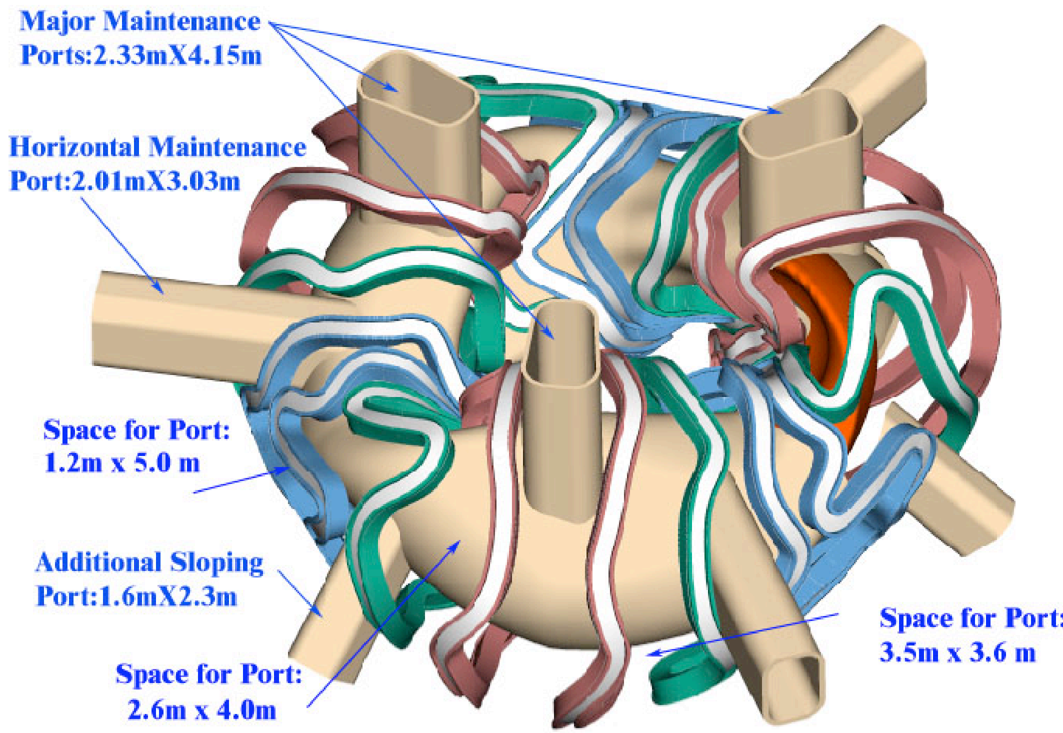
- Evolve coil configuration(s) **(PPPL, MIT)**
  - Material and thicknesses
  - Radius of curvature, shape
  - Space and shielding requirements

Modular Design Approach Using Selected Ports and Articulated Boom Previously Discussed for 3-Field Period Configuration

- **Minimum Port Sizes**
  - 1.6 m x 2.3 m and 1.2 m x 5.0 m
  - Quite limiting constraint on size of module
  - Desirable to accommodate ~2 m 2 m x 0.25 m module
  - Better to consider maintenance based on limited number of port

- **Maintenance based on 3 ports (horizontal or vertical) seems possible**
  - half field period length ~ 9 m
  - minor radius =1.85 m (local plasma height varies over about 1.5-3.5 m)
  - Weight of empty module < 1 ton
  - These are comparable to EDITH-system boom*

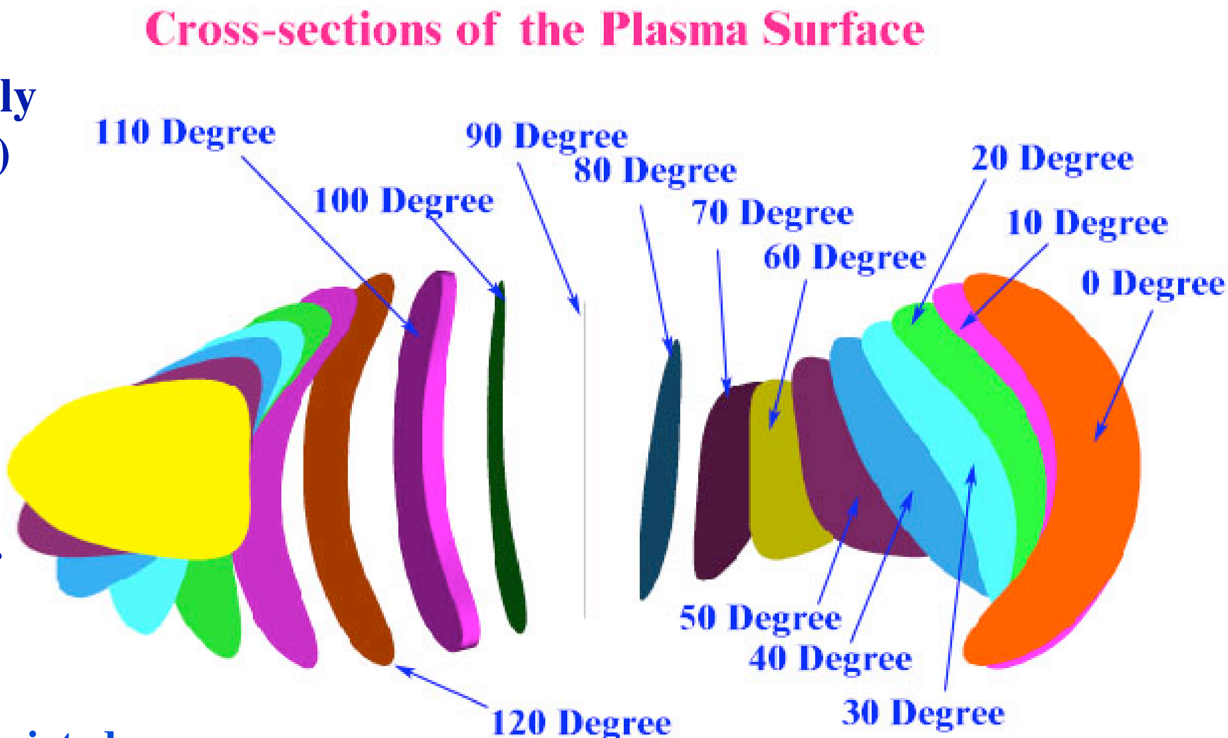
Space Available for Ports for NCSX-Based 3-Field Period Configuration (R=8.25 m)



*Experimental -In-Torus Maintenance System for Fusion Reactors, FZKA-5830, Nov. 1966.

Plasma Access for Articulated Boom Between Ports is a Concern for Modular Maintenance Approach With Limited Number of Ports

- **Final number of ports, largest module size and degree of freedom of articulated boom (probably with at least 3-4 “elbows”) would depend on toroidal access through plasma space between port and furthest serviced region**

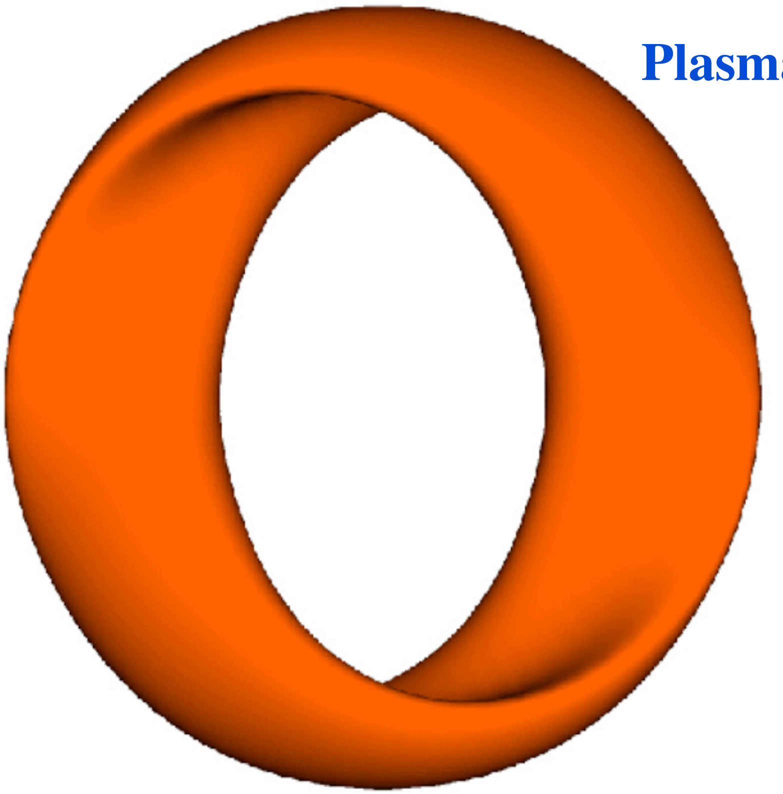


- **Configuration enabling use of additional ports for maintenance would be beneficial**
  - **Plasma access concern alleviated**
  - **Shorter reach would allow for larger boom capacity and larger modules**
  - **Parallel maintenance through ports could speed up process**
  - **Need greater space between coils (~2m x 3 m)**
  - **Larger reactor or 2-field configuration would help**

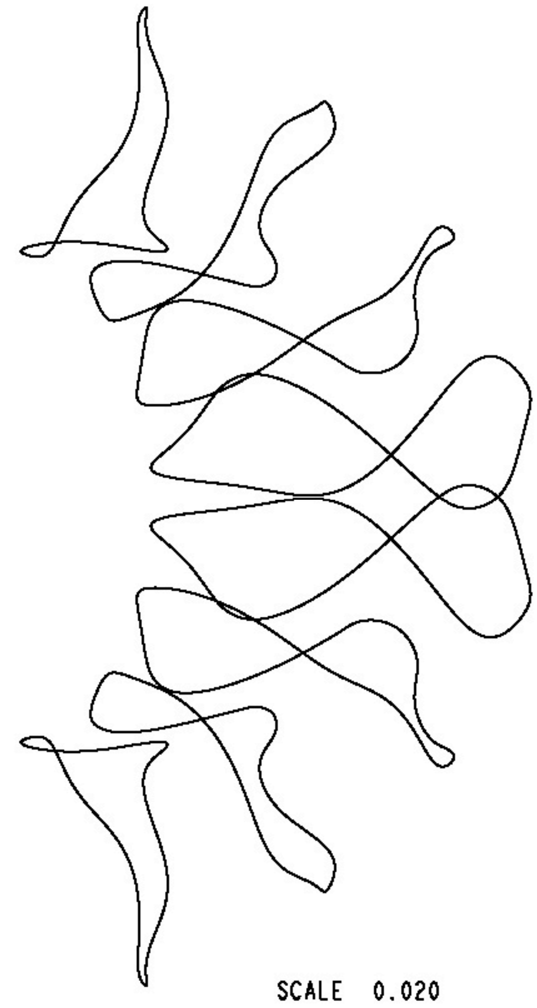
Latest 2-Field Period Configuration from P. Garabedian

R = 8 m
<a> = 2.3 m
A = 3.5
16 coils (8 per period)
Thickness = 57 cm.
Aspect ratio = 2
Coil-plasma min. distance = 1.5 m

Plasma Shape

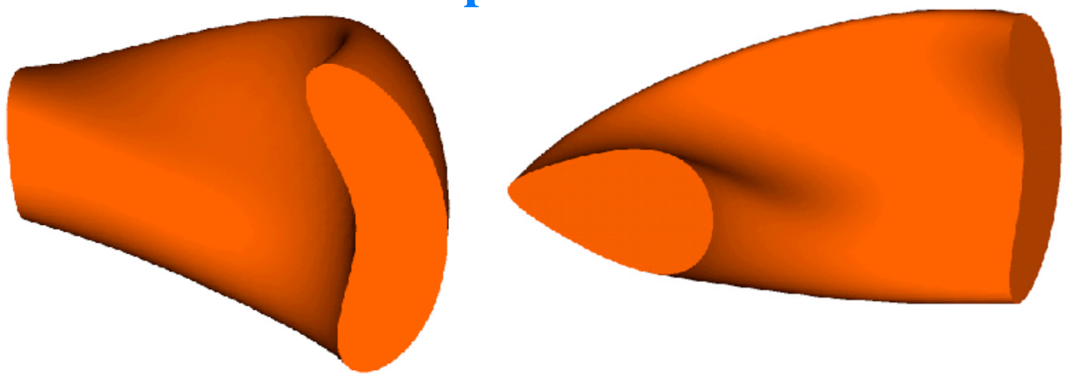


Coil Filament Configuration



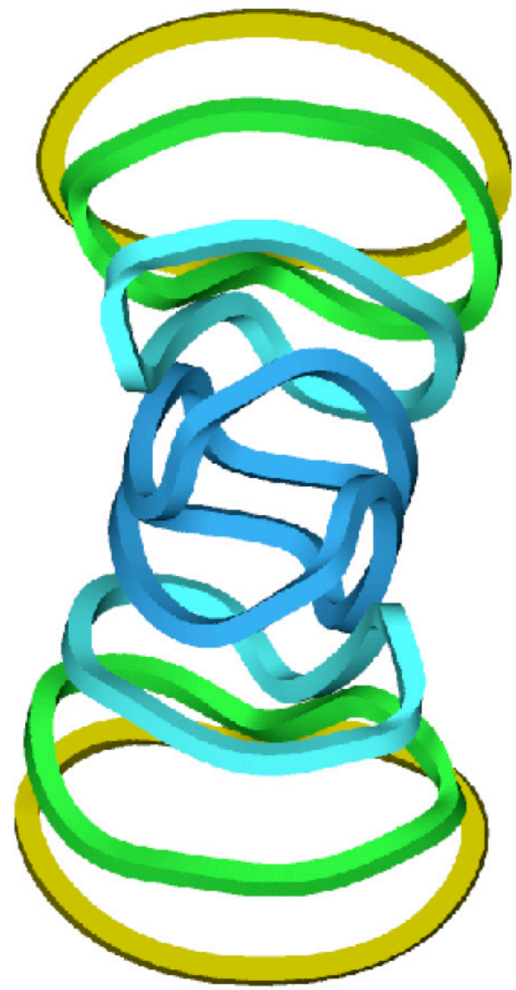
2-Field Period Configuration

Plasma Shape over Half Period



Top View of Coil Configuration

Side View of Coil Configuration



Comparison of Port Access Area Between Adjacent Coils for 3 Different Configurations

Port toroidal dimension x poloidal dimension (m x m)

Configuration \ Port	Port #1	Port #2	Port #3	Port #4	Port #5	Port #6	Port #7	Port #8
NCSX-like 3-field period R=8.25 m	2.6 x 4.0	1.6 x 2.3	1.2 x 5.0	2.0 x 3.0	3.5 x 3.6	2.3 x 4.2		
NCSX-like 3-field period R=9.68 m	3.1 x 4.7	1.9 x 2.7	1.4 x 5.9	2.4 x 3.6	4.1 x 4.2	4.0 x 4.7		
2-field period R=8 m*	3.9 x 10	4.1 x 8.9	4.3 x 5.4	3.8 x 4.6	4.7 x 5.0	3.9 x 7.9	3.9 x 10	4.7 x 10.9

* Assuming a coil cross-section of 0.57 m x 1.15 m

2-Field Configuration Provides Substantially More Space for Ports Between Each Pair of Adjacent Coils

Need further study to confirm dimensions and configuration

- **System study for physics and configuration parameters**
- **Confirmation of coil cross-section**
- **Benefit of larger blanket modules**
- **Details of maintenance scheme**
- **Solid view of plasma shape inside coils to check radial space available for blanket**

Safety/Engineering Discussion Session

1. How many protection barriers are required on a reasonable safety basis?

2. For a He-cooled ceramic breeder blanket with a He/steam heat exchanger (to drive a steam power cycle), a break in the steam generator pipe coupled with a break in the blanket coolant channel can lead to over-pressurization of the module and possible Be/steam reaction. Must the module be designed to take the steam pressure (with the penalty of thicker walls) or do the coolant channels in the blanket provide a sufficient barrier to take the pressure load?

3. Is it acceptable to have a water-cooled shield in combination with a LiPb blanket?

4. Safety issues associated with an external vacuum vessel and mitigating solutions: e.g., for a liquid metal blanket, a rupture would lead to a spill of hot liquid which when touching the coils could lead to over-pressurization as He gets vaporized. Also, Brad has mentioned a possible concern with arcing of the coil.

5. Latest updates on material interactions:
   - compatibility between structural materials and breeder/coolant limits the allowable operating temperature
   - coatings: differentiate between electrical insulation, thermal insulation and material compatibility functions.