Status of ARIES-CS Power Core and Divertor Design and Structural Analysis

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ARIES Meeting

PPPL

September 15-16, 2005

UCSD

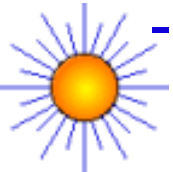
Major Focus of Engineering Effort During Phase II
(from before)

1. **Divertor design and analysis**

2. **Detailed design and analysis of dual coolant concept with a self-cooled Pb-17Li zone and He-cooled RAFS structure:**
   - **Modular concept first for port-based maintenance**
   - **Field-period based maintenance concept next (can use modular concept also)**

3. **Coil design and analysis (including structural support)**

4. **Design integration with credible details for both maintenance schemes.**
   - **power core components,**
   - **maintenance**
   - **ancillary equipment**

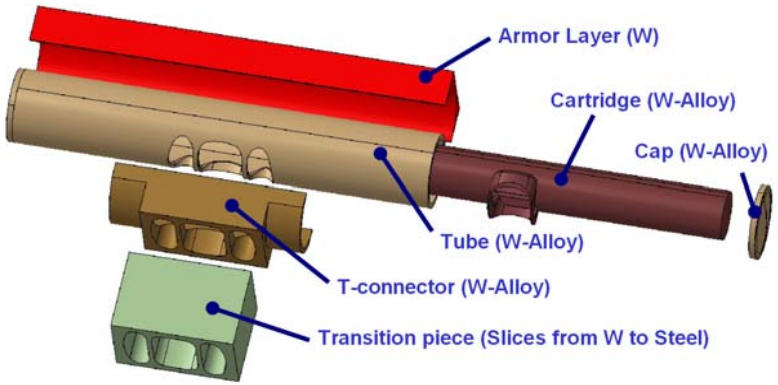


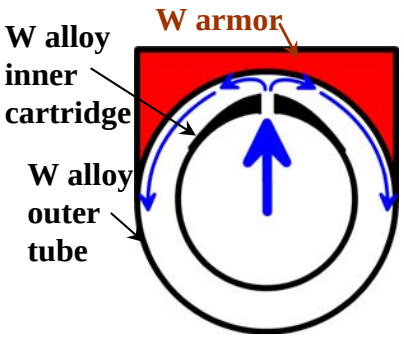
Action Items for Phase II (from before)

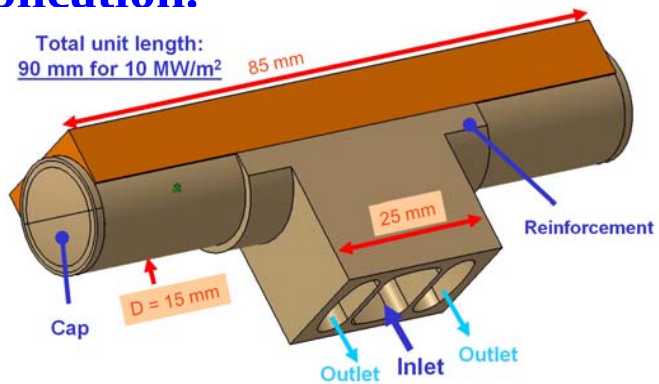
1. Run LOCA/LOFA case with low contact resistance between blanket and hot shield (UW) Done
2. Check effect of local radial conductance in blanket and between shield and vacuum vessel (UW) Done
3. Do we need to consider any other accident scenario? (INEL/UW) LOVA ??
4. Structural analysis of coil support to have a better definition of required thickness for cases with separate coil structure for each field period (MIT/UCSD/UW) In progress
5. Details of module attachment and replacement (choice between "single" module maintenance or "series" module maintenance) (FNTC/UCSD) Done
6. Port maintenance including all pipes and lines (realistic 3-D layout including accommodation of all penetrations) (UCSD) Phase III
   Details of module design and thermal-hydraulic analysis for dual coolant design coupled to Brayton power cycle(FNTC/UCSD) Done
7. Coolant lines coupling to the heat exchanger (choice of HX material, e.g. W-coated FS vs. refractory alloy such as niobium alloy) (FNTC/UCSD/INEL) In progress
8. Tritium extraction system for Pb-17Li + tritium inventories (FNTC/UCSD/INEL) In progress
9. How high can we push the Pb-17Li/FS interface temperature based on corrosion limits? (FNTC/UCSD) Done
10. External vacuum vessel design (thickness and configuration)(FNTC/UCSD) Phase III
11. Divertor design and analysis (T. Ihli/UCSD/GTech) Done, integration in progress
12. Divertor physics (RPI/UCSD) In progress

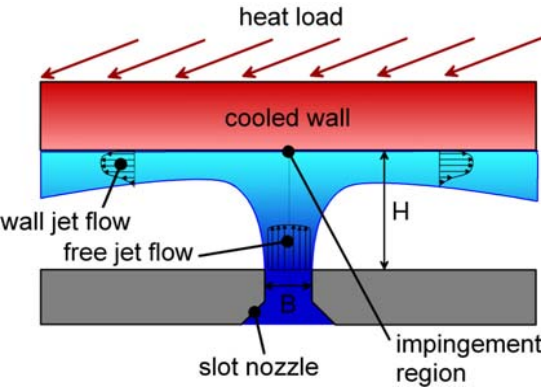
Divertor Study

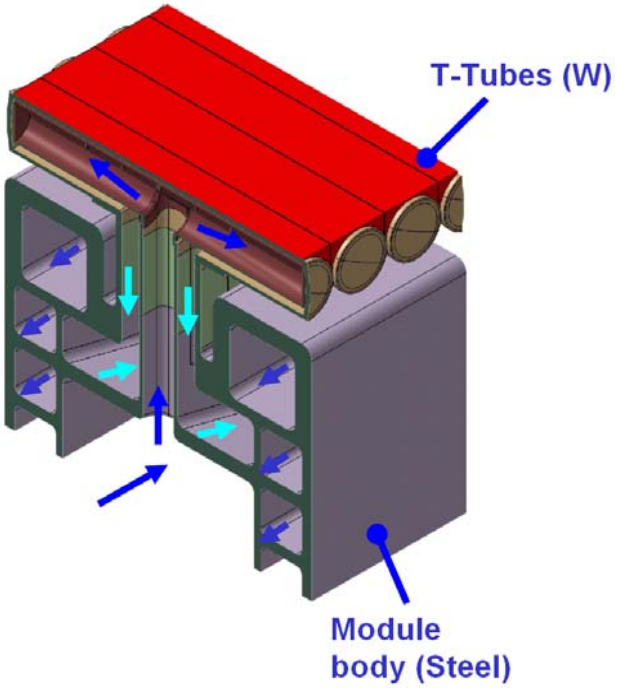
- Good progress (but further progress needed on physics study)
- Design introduced at ISFNT-7, to be described in more detail at SOFE (physics + design presentations) and in journal publication.

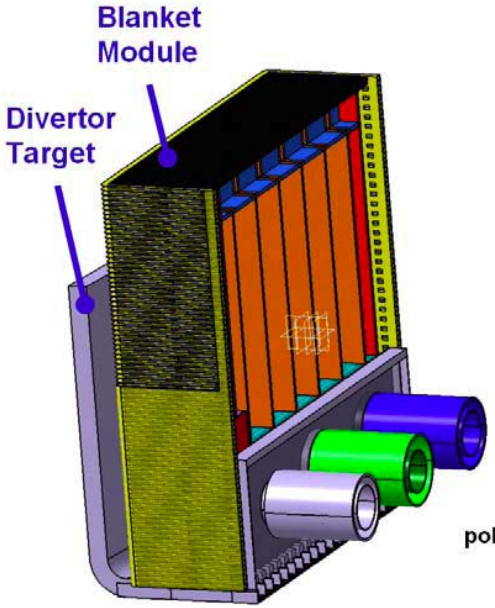


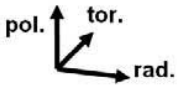








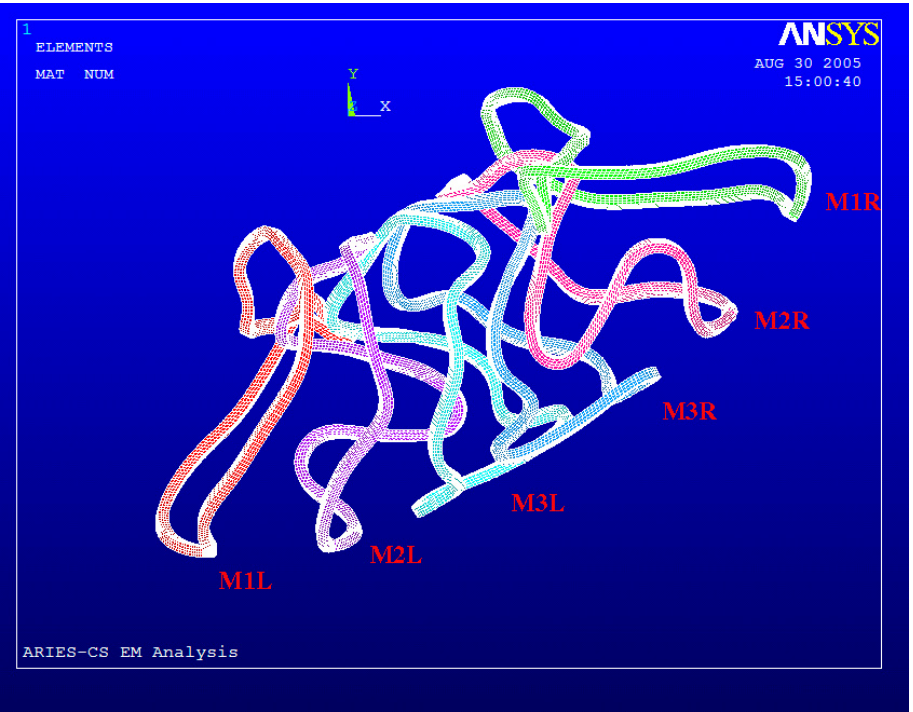


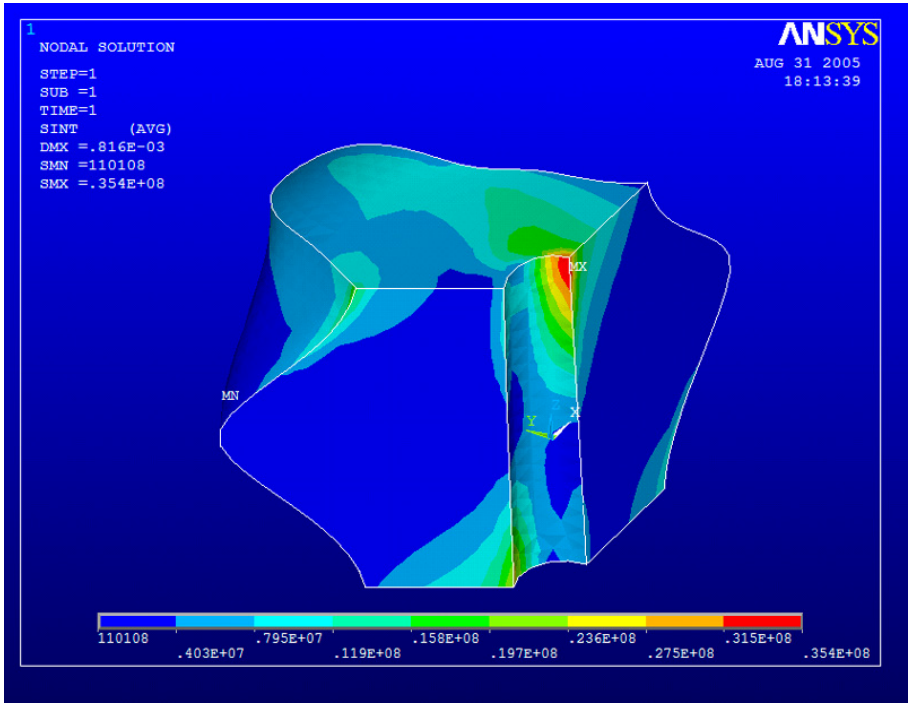


Coil Structural Design and Analysis

- Good progress from UCSD/UW/PPPL
- For given current in coils, maximum magnetic field quite high (~18 T)
- Forces calculated and stress analysis of bucking cylinder performed: structural mass of bucking cylinder can be significantly reduced

- Structural analysis of coil structure to be performed next
- Converge on design of SC (MIT): Nb_3Sn ok for given bend radii?





Ancillary Equipment

- **Tritium extraction and recovery method through permeation prior to HX**
- **Heat exchanger design and material choice**
  - **Connection to blanket structural material**
  - **Compatibility with Pb-17Li at a temperature of up to ~700-800°C**
  - **Niobium?**
- **Can benefit from effort on ITER test module, which can be updated and applied to our blanket configuration (B. Merrill)**

Dual Coolant Module Design

- **Design and cooling configuration for dual-coolant blanket modular concept applicable to field-period based maintenance**

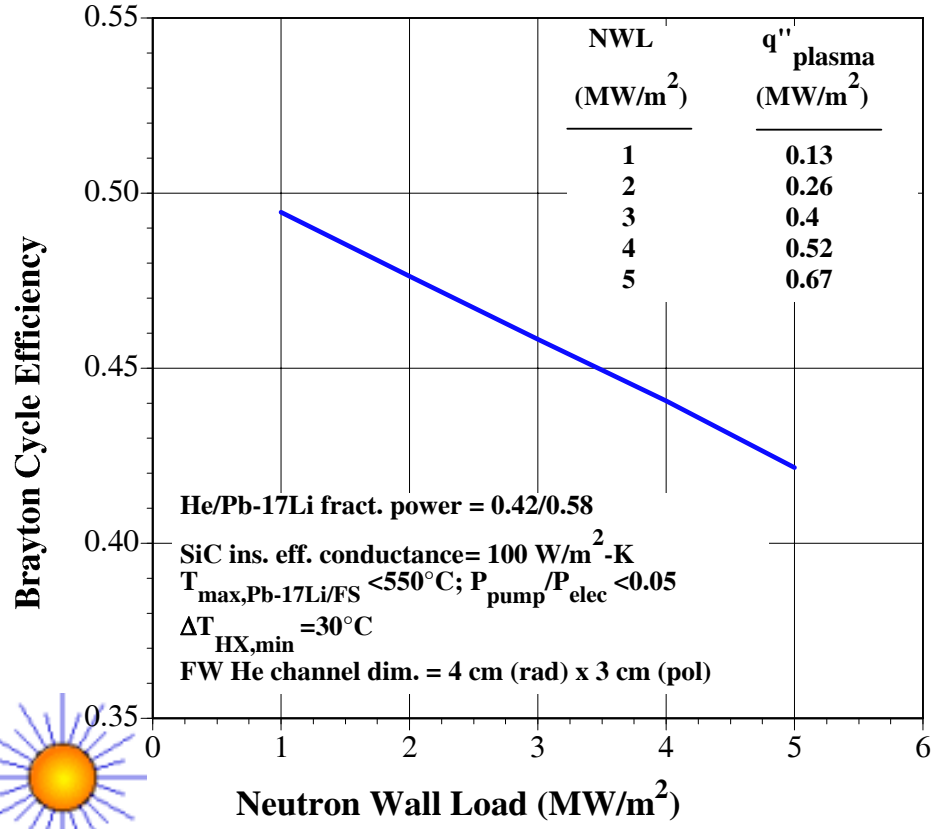
- **Maintenance of DC concept requires pipe cutting behind module.**
  - **Outside access for pipe cutting and rewelding**
  - **Neutron streaming a concern, but insertion of shield disk is a possible solution**
  - **Neutronics calculations to confirm thickness of blanket/shield required for reweldability of piping**

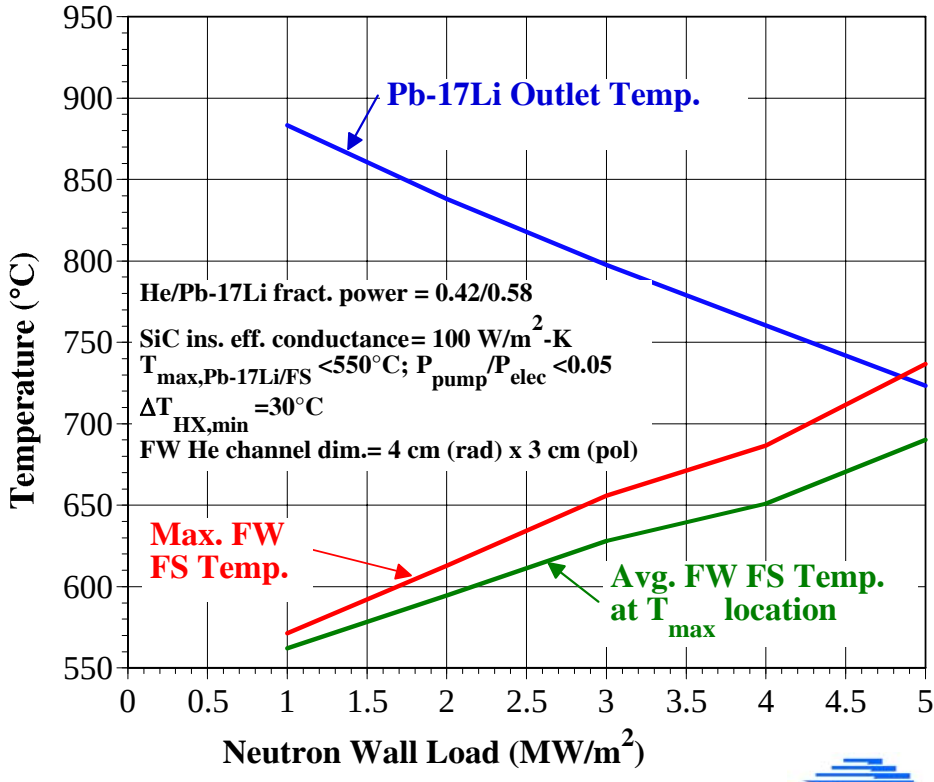
- **Motion study for removing power core replacement unit for field based maintenance schem indicates possible interference**
  - **Solutions include local shaving of blanket, local increase of cold shield and/or local displacement of coil**

- **Latest progress on maintenance to be presented at SOFE.**

Optimization of DC Blanket Coupled to Brayton Cycle Assuming a Higher FS/Pb-17Li Compatibility Limit of 550°C and ODS FS for FW

- Are optimized parameter values reasonable?
- Some advantage at reducing wall load: higher cycle eff., higher Pb-17Li temp.
- Cycle eff. dependency on wall load should be considered in system study (update values previously provided to Jim)





Selection of Blanket Concept and Maintenance Scheme for Phase III Detailed Design Study

Blanket

1. **Dual Coolant concept with a self-cooled Pb-17Li zone and He-cooled RAFS structure with SiC-composite as electrical (and thermal) insulator between flowing LM and steel structure.**
2. **Self-cooled Pb-17Li blanket with SiC/SiC_f composite as structural material.**

Maintenance Scheme

1. **field-period-based maintenance scheme**
2. **port-based maintenance scheme**

Suggested procedure

- **Summary write-up of advantages and issues for each option**
- **Individual and group discussion before next meeting**
- **Decision on selection at next ARIES meeting (December 2005) based on combination of quantitative parameters and engineering judgement**