Project goals and plans
Revisit ARIES Designs with a focus on detailed analysis edge plasma physics and plasma-material interaction, high heat flux components and off-normal events in a fusion power plant.

- What would ARIES designs look like if we use current predictions on heat/particles fluxes?
- What would be the maximum fluxes that can be handled by in-vessel components in a power plant?
- What level of off-normal events are acceptable in a commercial power plant?
- Can the current physics predictions (ITER rules, others) be accommodated and/or new solutions have to be found?
Frame the “parameter space for attractive power plants” by considering the “four corners” of parameter space.
Study is divided into Two Phases:

- **Phase 1:**
  - Examination of power-plant parameter space with the systems code to understand trade-offs.
  - Examination of capabilities of in-vessel components (heat and particle fluxes) in both steady-state and off-normal events, e.g., ELM, disruption (thermal).

- **Phase 2:**
  - Detailed design
    - To verify systems code predictions
    - To develop an integrated design
    - To document trade-offs and R&D needs.
Progress Since Last year (1):

- Most of the work has been concentrated on advanced physics scenario and Sic Blanket concept.
  - Plant parameters are NOT optimized yet, rather we have focused on bench-marking system code as well as updating engineering design.
  - Preliminary work both on DCLL blanket as well as modeling conservative plasma.

- Examination of power-plant parameter space with the systems code to understand trade-offs. (Lane Carlson. Presentation)
  - Many improvements in systems models for engineering components.
  - “Strawman” design point was developed and is used for initial, integrated design bench-mark.
  - Extensive documentation of system code models, algorithms, etc.
ASC Homepage

- **History**
- **Documentation**
  - Modifications
  - Equations
  - Code Modules
  - Input & outputs
  - Examples
  - Flow of calculations
  - Power flow diagram
  - Reference documents
  - Old documentation
- **Strawmen Points**
- **VASST**
Progress Since Last year:

- Detailed Physics Analysis of strawman (Alan Turnbull’ presentation)
- Integrated modeling of discharge scenarios
  - TSC
  - GA integrated modeling (including detailed transport code calculations)
- TSC Modeling of Off-normal events to develop loads on in-vessel components.
  - VDE
  - Disruptions
ARIES ACT1 (aggr phys) operating point

*the case shown is not the latest, we have done better

Ip = 11.25 MA
R = 5.5 m
a = 1.375 m
κ = 2.2
δ = 0.7
I_{BS} = 9 MA (9.4 MA*)
I_{LH} = 0.75 MA (0.8 MA*)
I_{FW} = 125 kA

q(0) ~ 2
q_{min} ~ 2
q_{95} = 3.3

li(1) = 0.5
β = 10%
n/n_{Gr} = 1.0
W_{th} = 600 MJ (625 MJ*)
n(0) = 2.2 \times 10^{20} /m^3
n(0)/<n> = 1.3

\beta_N = 5.5
T_{e,i}(0) \sim 38 \text{ keV}
T(0)/<T> = 2.25

P_\alpha = 340 MW
P_{LH} = 40 MW
P_{IC} = 15 MW
P_{brem} = 60 MW
P_{line} = 42 MW
P_{cyc} = 17 MW

Z_{eff} = 2.18
T_{ped} = 4 \text{ keV (4.7 keV*)}
H_{98} = 1.6

Use Coppi-Tang L-mode χ model adjusting for pedestal and global τ_E
Vertical Displacement Event (VDE)

Turn off vertical position control at 1055s

Plasma contacts wall at 1059 s

Plasma goes from H-mode to L-mode from 1059-1060s

$q_{95}$ drops during this phase as plasma scrapes off on wall reaching 1.5-2 by 1060 s

Thermal quench is from 1 ms long starting at 1060 s

Current quench begins, but does not finish in this simulation
Revisiting ARIES-AT engineering Design
Substantial Detailed Engineering analysis is being performed.

- A He-cooled W-alloy divertor was adopted.
  - ARIES-AT used a LibPb cooled divertor because the divertor heat flux was predicted to be low at the time.

- We have adopted a He-cooled steel hot-shield which includes a structural ring for sector integration.
  - Support for various forces (including off-normal events).
  - Eliminates 3-D MHD issues.
  - Contributes to power cycle.
Substantial Detailed Engineering analysis is being performed.

- 3D MHD is the dominant force acting upon the coolant in insulated channel blankets. Issues can arise in bends, inlet/outlets, flow distribution systems, etc.

- Example: Flow stagnation can occur in the first wall.
Blanket system and coolant manifolds are redesigned to account for 3D MHD and gravity (LiPb weight) forces.

Stress analysis of blanket modules (X. Wang presentation)

Pressure drops in the blanket system

(outboard $\Delta p_{\text{mid}}$ will be lower)

$\Delta p = 0.25$ MPa

$p > 0$

$\Delta p_{\text{top}} = 0.1$ MPa

$\Delta p_{\text{bulk}} = 0$

$\Delta p_{\text{out}} = 0.2$ MPa

$\Delta p_{\text{in}} = 0.45$ MPa

1.2 MPa pump

Heat exchanger

0.25

0.45

2.4

2.8

4 m (0.4 MPa)

8 m (0.8 MPa)

4 m (0.4 MPa)
In Summary…

- ARIES studies is focusing on revisiting ARIES design with a major focus on detailed plasma analysis, edge physics, and off-normal events in a fusion power plant.

- During the last year, we have focused on ARIES-AT type plants (advanced physics/SiC blankets).
  - Inelastic analysis of high-heat flux components allows for substantially higher heat fluxes (discussed last year).
  - 3-D MHD effects in the insulated first wall and blanket are important and should be accounted for.
  - Other analysis (not reported in this workshop) includes detailed safety modeling, vacuum vessel design and revisiting the radial build, etc.
Thank you
Any Questions?