Physics Optimization of ARIES-AT

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ARIES Project Meeting
University of California, San Diego
December 1, 1999

DIII-D NATIONAL FUSION FACILITY SAN DIEGO

GENERAL ATOMICS

AGENDA

- Overview and summary (Lao, 5 mins)
- Transport Modeling (Staebler, 15 mins)
- Non-inductive ramp-up (Lao, 5 mins)

FOCUSED AREAS

- Improved β-limit stability calculations to include important non-ideal effects such as resistive wall modes and neo-classical tearing
- Use of physics based transport model for internal transport barrier (ITB) formation and sustainment
- Comparison of current drive and rotational flow drive using fast wave, electron cyclotron waves and negative ion beam
- Improved heat and particle controls
- Integrated modeling of the optimized scenario with self-consistent current and transport profiles to study the robustness of the bootstrap alignment, ITB sustainment, and stable path to high β and high bootstrap fraction operation

SUMMARY OF KEY RESULTS

- **Stability optimization**
  - — **Ideal low *n* modes are stabilized by a conducting wall ~ 1.2 a**
  - — **β limited by high n ideal ballooning modes near the plasma outer region**
  - — **Rotational drive and radially localized off-axis current drive are essential for stabilization against resistive wall modes and neo-classical tearing modes**
- **Transport and current drive modeling**
  - — **The first 13.2 MA, β_N = 5.6 design produces too much alpha heating**
  - — **Physics-based modeling with ITB indicates a smaller device**
  - — **Enhanced confinement and confinement control are essential to reduce non-inductive current rampup power requirement (~ 30 MW with H_{98y1}~ 2)**
- **Divertor heat loading**
  - — **High radiated fraction of the total exhausted power (> 0.5) is essential to keep the peaked heat fluxes at a manageable level (< 10 MW/m^2)**
  - — **Essential to accurately maintain the double-null magnetic balance (~ 0.5 cm)**

NONINDUCTIVE CURRENT RAMPUP

- **Analysis method**
  - — 0-D calculations with fixed profiles (n, T, q) and geometry
  - — J_{BS} computed using Sauter's formula based on kinetic calculations
  - — Assume thermal equilibrium ($\tau_E \ll \tau_{L/R}$) and integrate

$$dI/dt = (I_{BS} + I_{CD} - I) / \tau_{L/R}$$

- **Key results**
  - — ~ 1 hour rampup time
  - — Require minimum current to maintain dI/dt > 0
  - — Base case ($n/n_G = 1.5$, $H_{98y1} = 1.1$) requires 150 MW of P_{NB}
  - — Better confinement and confinement control are important, allowing $H_{98y1} \leq 2$ reduces power requirement to ~ 30 MW

FUTURE PLAN

- **Stability optimization**
  - — **Using exact divertor shape as boundary**
  - — **H-mode pressure and current profiles**
  - — **Reduced size**
- **Transport**
  - — **Further improve bootstrap alignment in the core consistent with ITB**
  - — **Model high confinement scenario for smaller radius device**
- **Current and rotational drives**
  - — **Optimize heating systems for current and rotational profile control**