Progress on Optimization Results for Steady-State Plasma Solutions

A.D. Turnbull,
H. St John,

R. Buttery,
L.L Lao,
M. Choi,
S. Smith

General Atomics

ARIES Team Meeting

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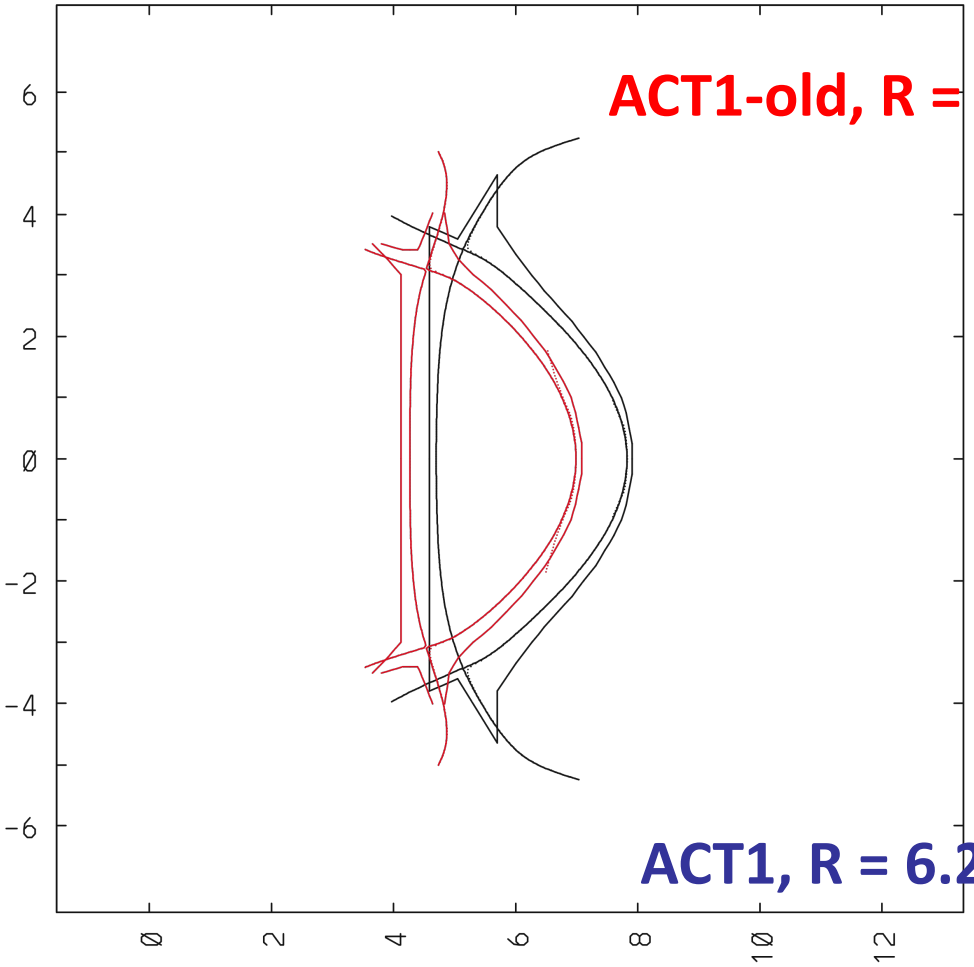
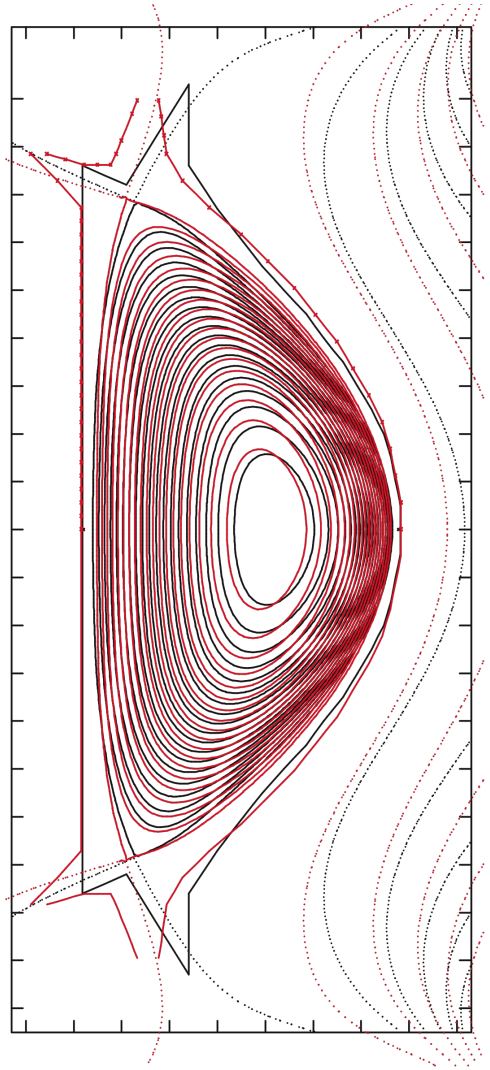
Previous Progress Through June 2012: Successful Simulation Using Multimode Transport Model

- **GLF23 Model predicted collapse of standard ARIES ACT1B scenario**
- **TGLF model with real geometry was much more optimistic:**
  - Collapse avoided with small peaking of density:
  - Issue with TGLF is it is extremely slow compared to GLF23
- **Implemented Multi-Mode Gyrofluid transport Model:**
  - Ten times slower than GLF23 but ten times faster than TGLF
- **Main Result from June 2012:**
  - Successful simulation of ARIES base case to steady state
    - No collapse
  - Two cases considered with different density:
    - For $n_e = 1.67 \times 10^{20}$ m^{-3} $P_{DT} = 1.1$ GW and $Q_{DT} = 28.7$
    - For $n_e = 1.78 \times 10^{20}$ m^{-3} $P_{DT} = 1.5$ GW and $Q_{DT} = 39.7$
  - Major issue with considerable evolution of q profile:
    - Axis temperature overheats causing large on-axis current density despite small residual steady-state electric field
    - q_0 drops well below unity and is probably unstable
    - Requires large RF current drive on axis to maintain $q_0 > 1$

Recent Increase in Major Radius of ACT I Design Required New Starting Equilibrium

Equilibrium for NEW ACT1 Operating Point

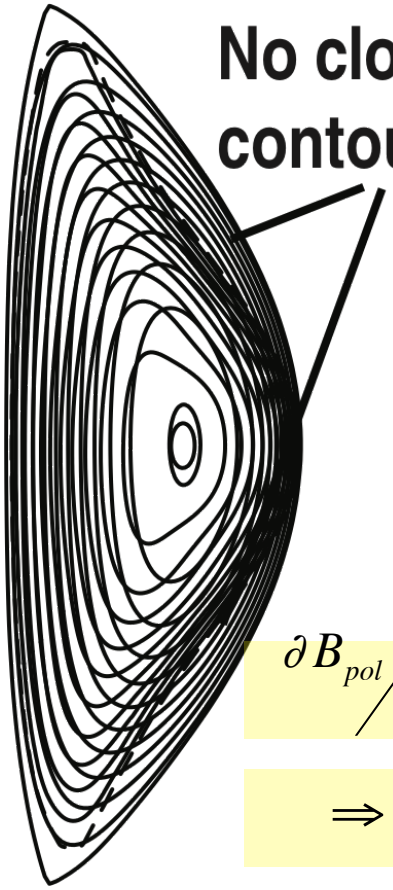




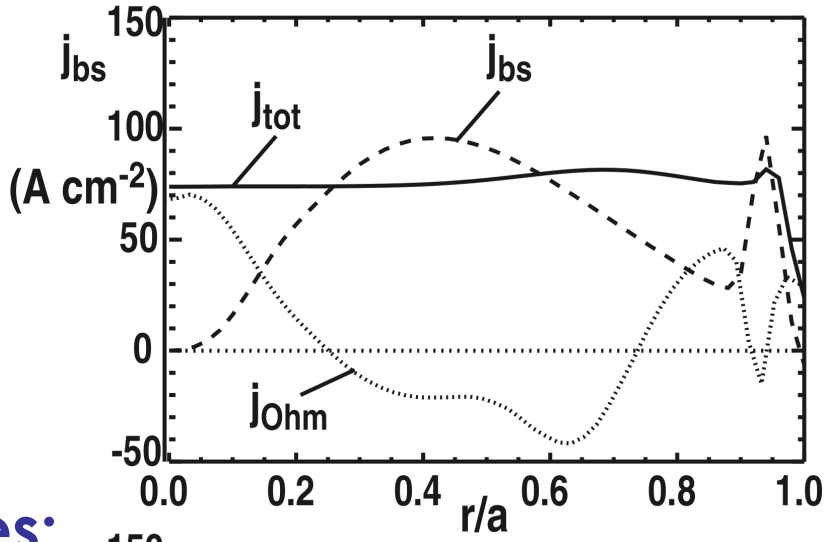
Poor Convergence of Equilibrium Obtained From TSC Results in Problems For Further Transport Evolution

- **Profiles of p(ψ) and f(ψ) inconsistent with dp/dψ and fdf/dψ:**
  - Recalculated p(ψ) and f(ψ) from dp/dψ and fdf/dψ
- **Poor force balance:**
  - Iteration of equilibrium to zero electric field finds very different profiles and non closed flux surfaces
- **Time development to steady state solution requires a better converged initial equilibrium:**
  - Calculation with EFIT requires new Greens Function Table for the new coils
  - Appears to be insufficient vertical field from the coils provided to close the surfaces
- **Current drive calculations were done for the corrected TSC equilibrium:**
  - Combination of Lower Hybrid and small fast wave on axis is successful

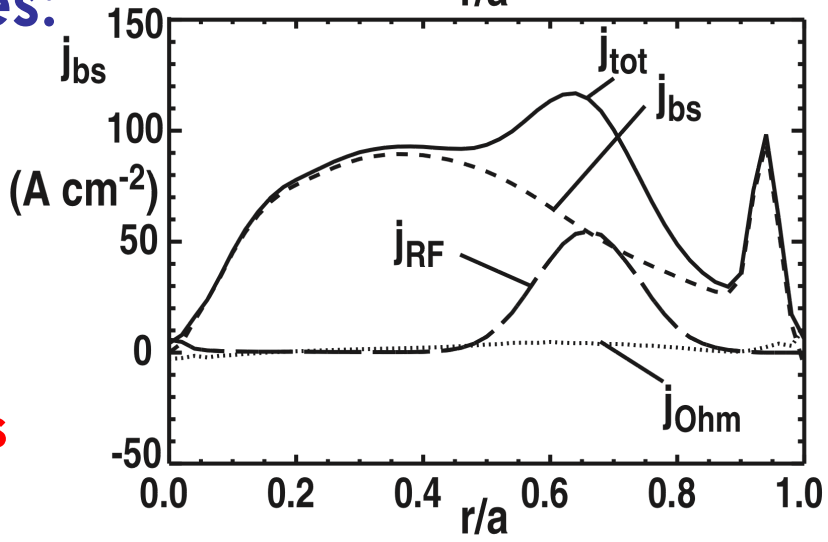
Iteration of Transport Evolution to Steady State Yields Very Different Shape and Profiles



Initial Profiles:



Iterated Profiles:



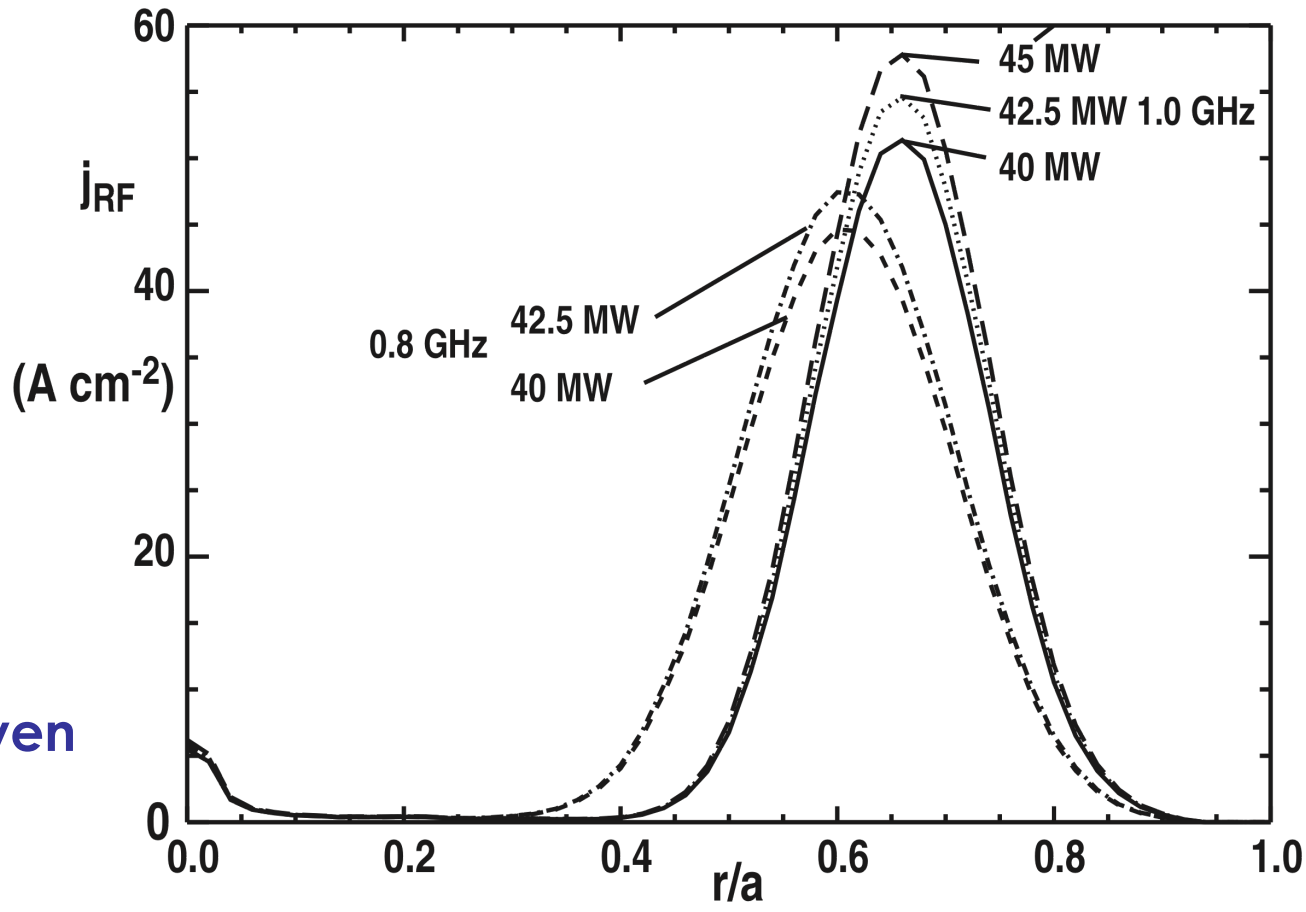
$$\partial B_{pol}/\partial t = \partial E_{tor}/\partial \rho \rightarrow 0$$

$$\Rightarrow B_{pol} \Rightarrow \Psi(r,z)$$

Subsequent current drive calculations utilized only the initial equilibrium

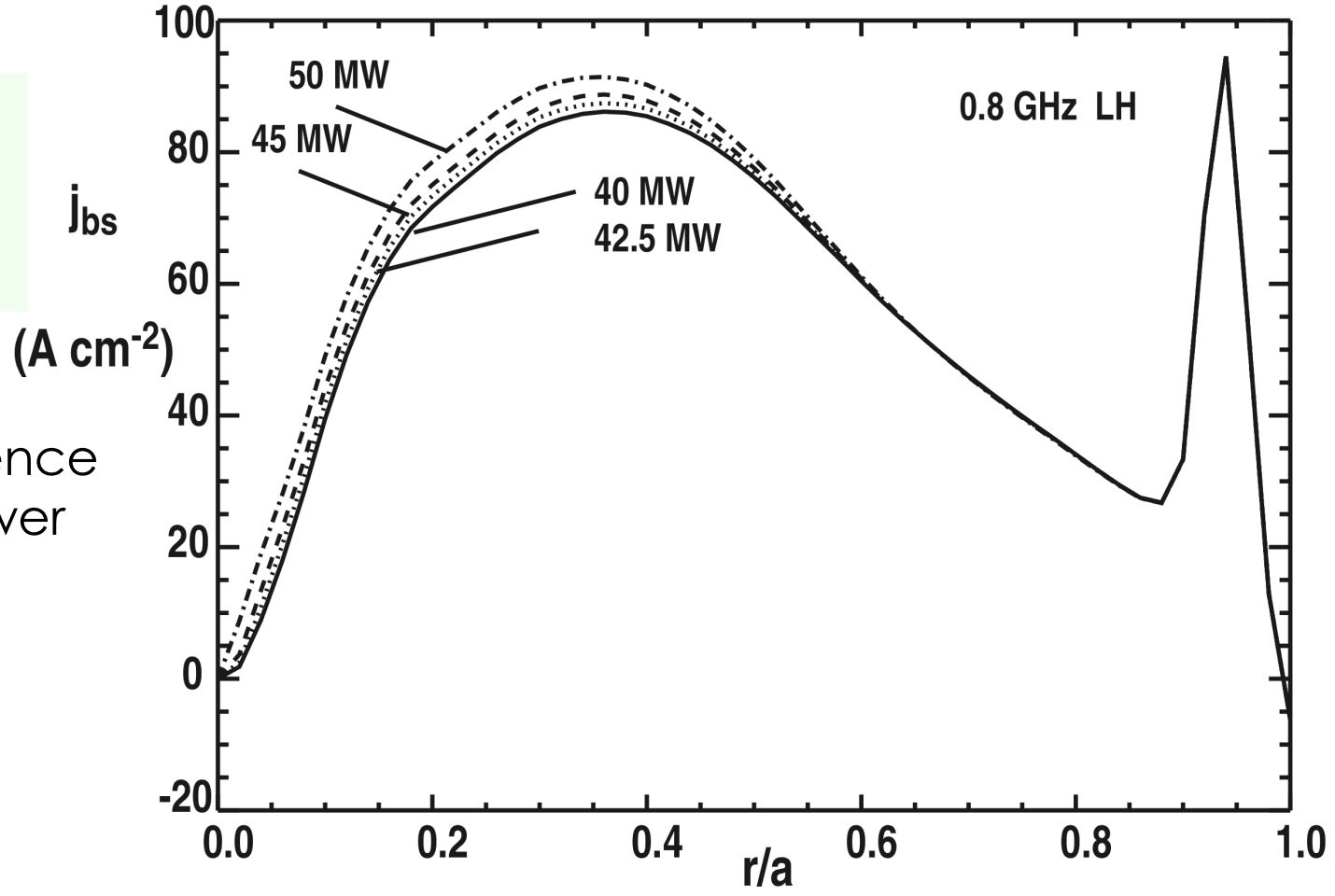
Combination of Lower Hybrid and ICRF Can Drive Most of Current Not Provided by Bootstrap Current

- **Lower Hybrid at 0.8 GHz and 1.0G Hz with varying power:**
  - Fast wave on axis is used to drive current on axis to maintain q_0 sufficiently low
  - Ratio of Lower Hybrid to Fast Wave power is 60
- **Current can be driven between r/a = 0.55 and 0.8**



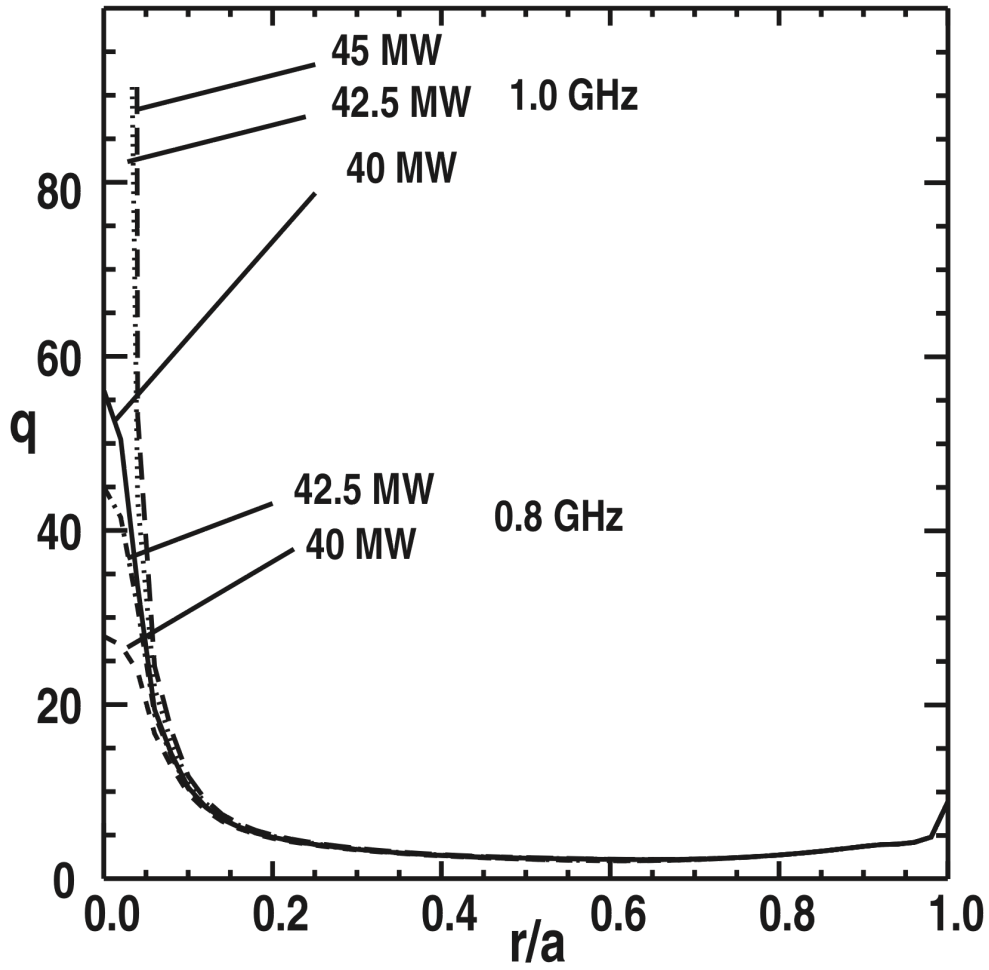
Bootstrap Current Density Actually Increases with RF Power Due to Dependence on B_{pol}

- **Unchanged density and temperature**
  - Dependence on RF Power is weak however



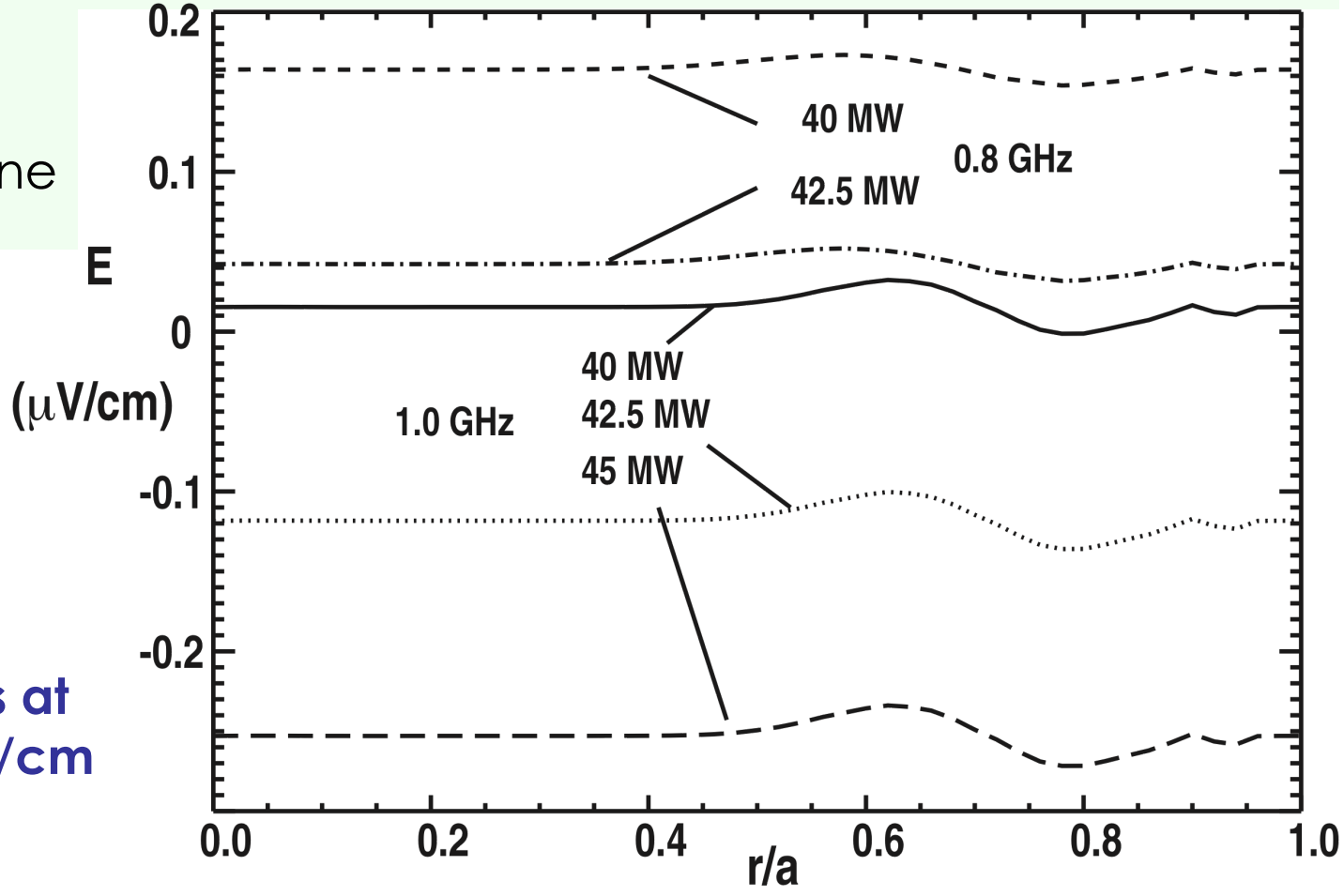
Initial Safety Factor Profile is Maintained Except Right Near Axis

- **Axis value is extremely high as current density almost vanishes there:**
  - Requires additional Fast Wave on axis to lower q_0
  - But this may not be necessary:
    - q_0 is not critical to stability



Total Electric Field is Reduced to Near Zero Implying The Configuration Can Be Maintained in Steady State

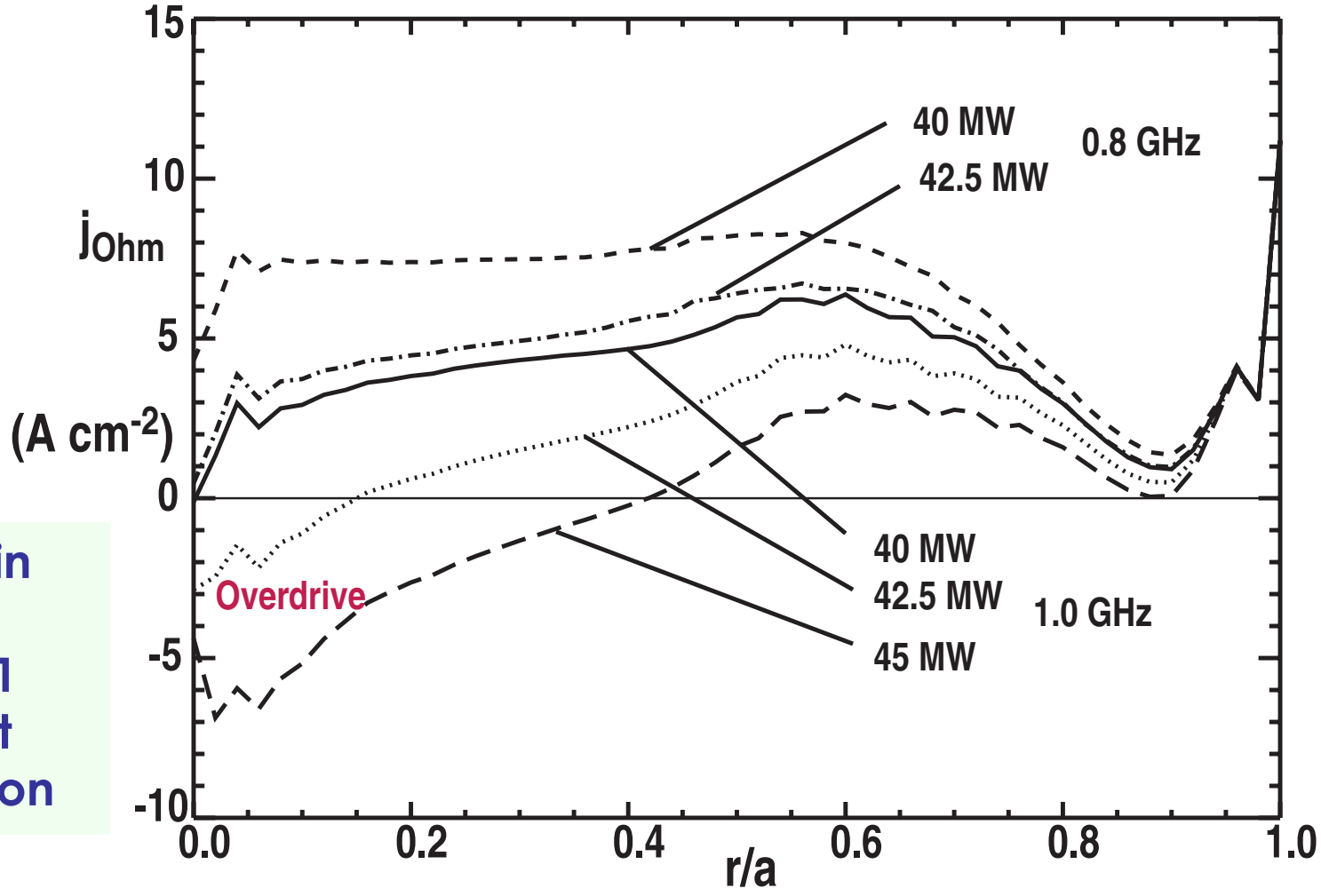
- **Caveat that the profiles do not change**
  - Transport simulation not yet done



- **Electric Field is at sub micro volt/cm in each case**

Ohmic Current Contribution is Small and Relatively Flat

- Overdrive in the core occurs for 1 GHz largest power option



Re-established New Case at Larger Aspect Ratio

- **Equilibrium reconstruction is underway:**
  - Requires some additional work to define appropriate coils
- **Current drive calculations with GENRAY using the TSC equilibrium appear to be promising:**
  - Current profile can be reproduced with 40 MW auxiliary power

Future Steps

- **Complete equilibrium calculation**
- **Evolve to steady state:**
  - Transport calculation to produce density and temperature consistent with steady state
  - GENRAY calculation of current drive needed to maintain profiles
- **Iterate using steady state as new starting equilibrium:**
  - Transport coefficients based on initial equilibrium need to be updated to reflect quite different steady state profiles
  - Then evolved to new steady state