Progress in Aries AT Physics Modeling

- New Aries AT,with R=6.5m, non inductive,steady state,self consistent transport,mhd,current drive and stability is sought.
- Currently requires manual iteration and data manipulation between transport, equilibrium and stability codes using EFIT,ONETWO,GCNMP and ELITE.
- New multimode (Nov 2012) model is used for energy confinement
- Density and rotation speed profiles are not evolved.

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Aries new base case results - first iteration

Minor radius a (cm): 156.3	b/a: 2.19
R at mag. axis (cm): 678.4	Z at mag. axis (cm): 0.0
Volume (cm**3): 5.51E+08	Pol. circum. (cm): 1601.1
Bt (G): 5.99E+04	Ip (A): 1.06E+07
L-avg den (1/cm**3): 1.31E+14	Tau-particle-dt (s): 2.000
profiles ucenter	uedge
elec. den. (1/cm**3): 1.59E+14	7.95E+13
elec. temp. (keV): 38.12	0.02
ion temp. (keV): 26.53	0.02
current (A/cm**2): 42.1	0.5
Zeff: 1.29	1.44
q: 6.03	14.1
Brems prim ions (W): 2.15E+07	imp ions : 6.23E+07
beta 4.7	β_n 4.2
β_{nped} 0.68	
pfuse totl 986 MW	paux(rf) = 2.5MW

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Density scaling

- Density profile shape is crucial in obtaining reasonable performance parameters using only fusion heating.
- Current iteration is based on scaled down version of Efit free boundary(including coils) equilibrium calculation (Does not include recent PPPL eqdsk)
- Required scaling to lower density to avoid $\beta_n = 9.3$

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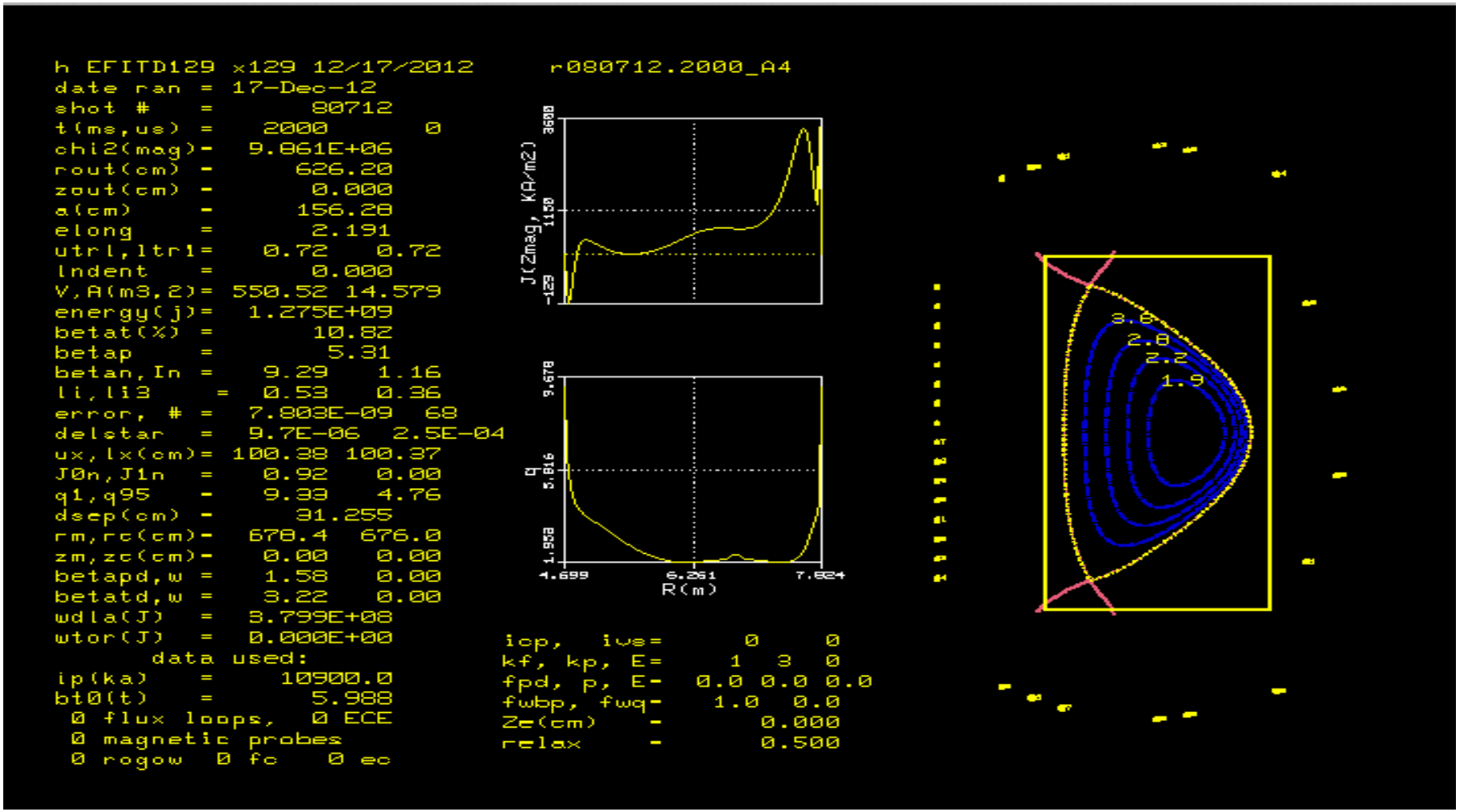
EFIT ARIES R=6.5m with coils



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Assumed densities and predicted temperatures

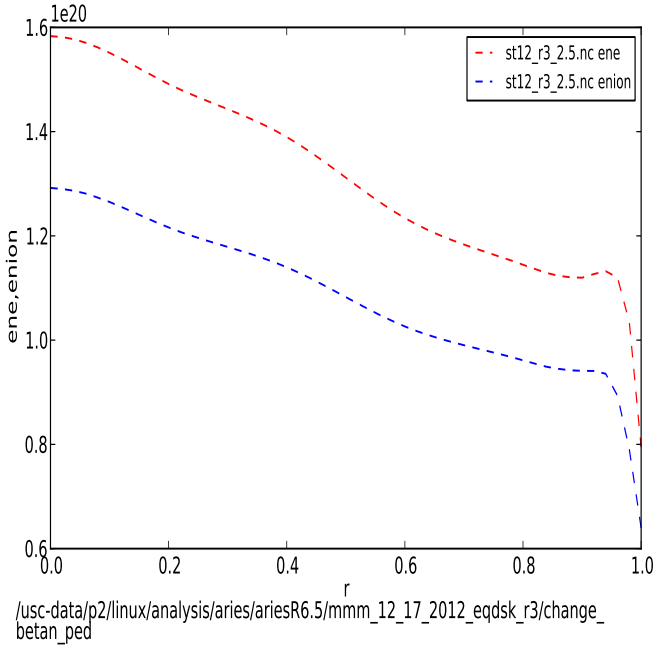

Figure: Scaled down densities for larger Aries

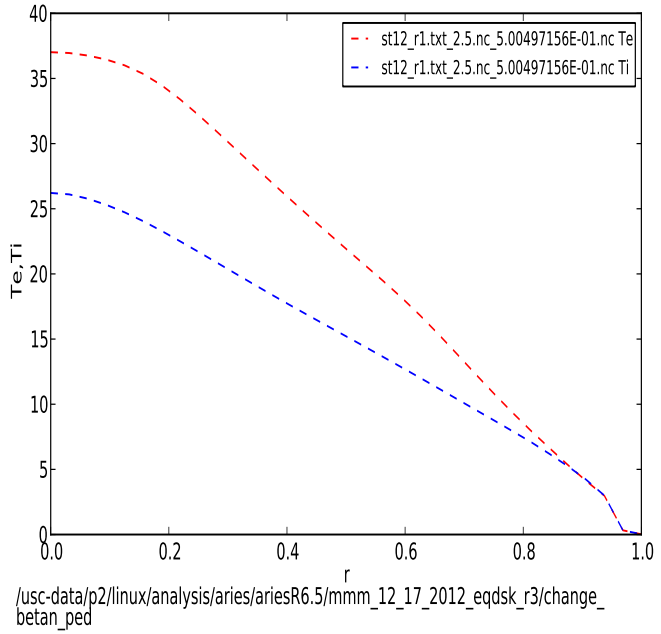

Figure: Multimode predicted steady state Te,Ti

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Multimode electron and ion diffusivities

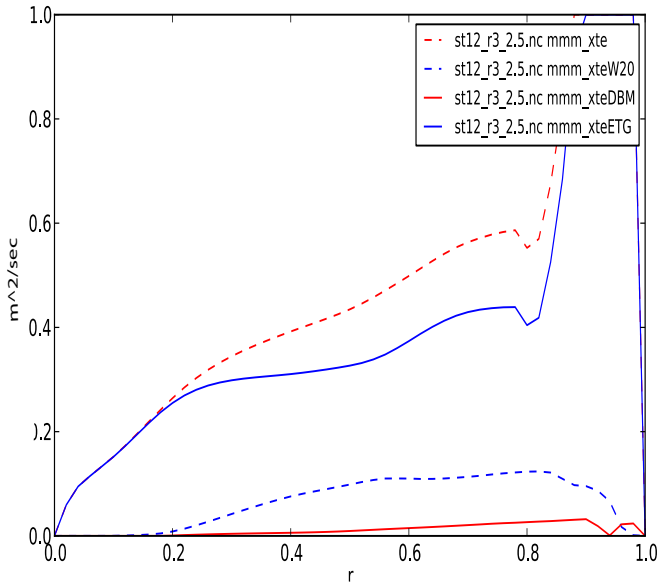

Figure: Electrons

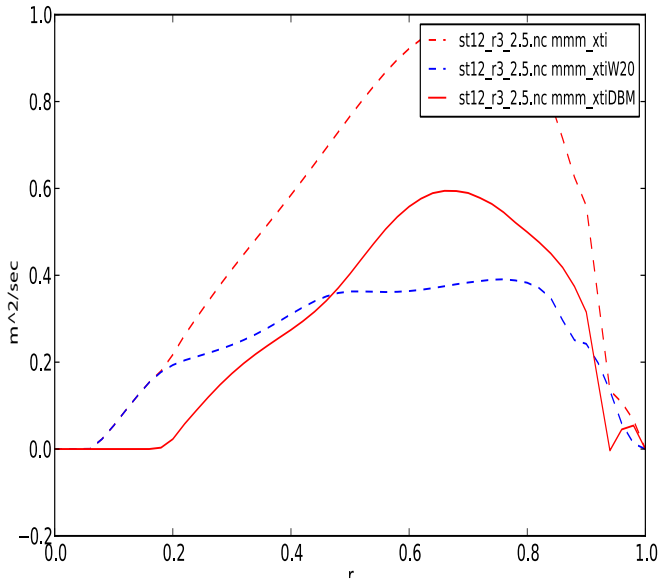

Figure: ions

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Steady state current drive

- Non inductive AT type discharges depend on minimizing the parallel electric field E_0 in Faraday's law:

$$\frac{1}{FG(H\rho)^2}\frac{\partial(FGH\rho B_{p0})}{\partial t} = \frac{1}{H\rho}\frac{\partial E_0}{\partial \rho} \tag{1}$$

- Inductive current is proportional to inverse of resistivity:

$$E_0 \equiv H\left\langle \frac{\vec{E}\cdot\vec{B}}{B_{T_0}} \right\rangle = \eta_{\|} H\left\langle \frac{\vec{J_{ohm}}\cdot\vec{B}}{B_{T_0}} \right\rangle . \tag{2}$$

- Minimization achieved manually by scanning rf power input.

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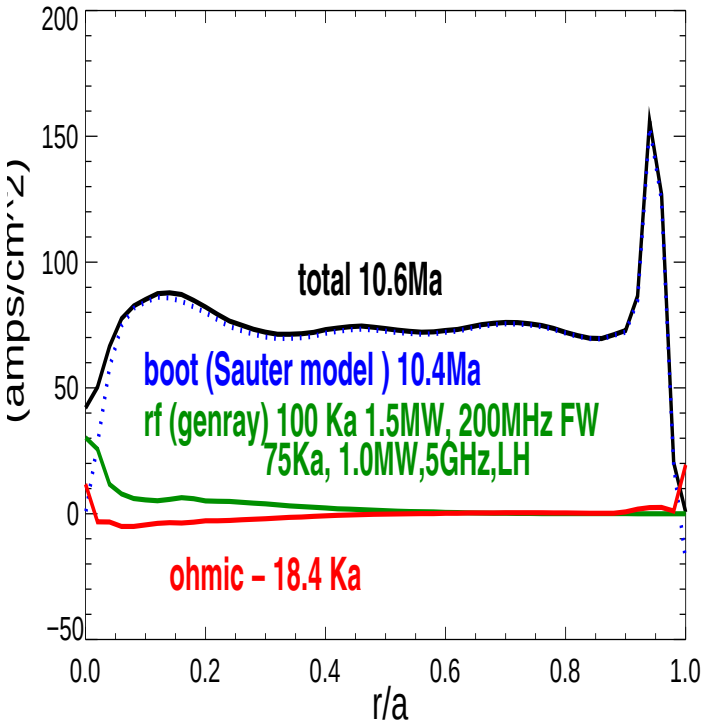
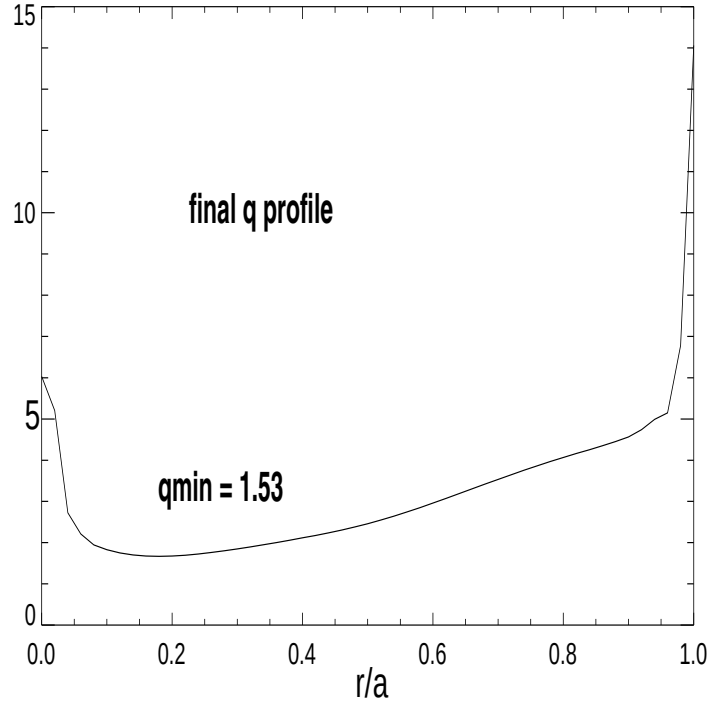
Steady state current and safety factor





Results based on 10.6 MA plasma current

Excellent alignment with bootstrap

Need to iterate

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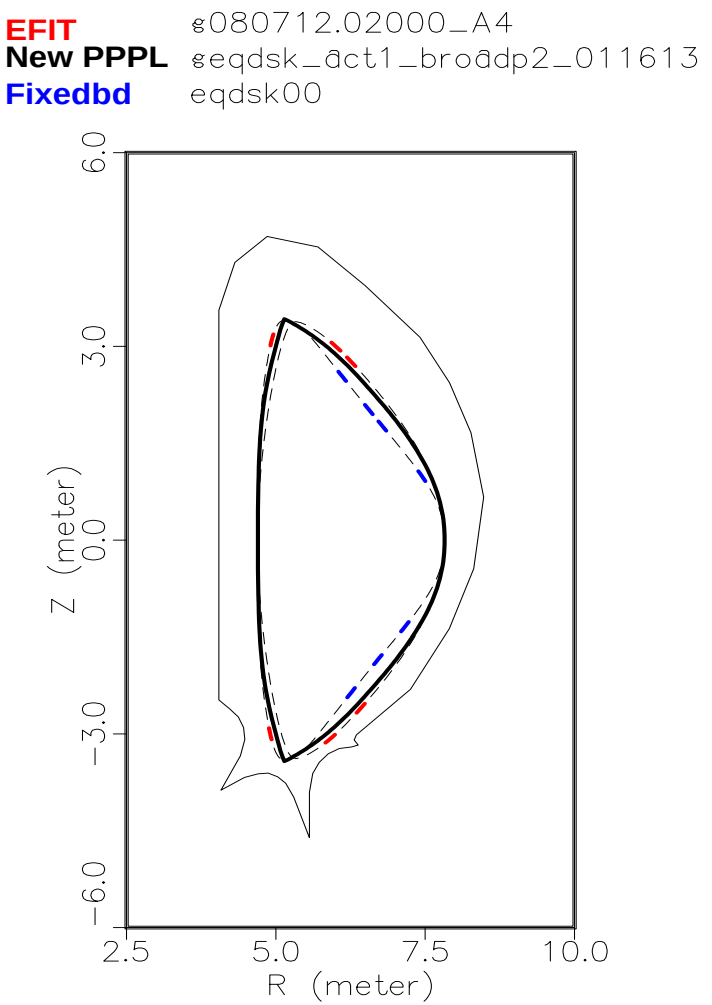
Mhd equilibrium issues



- Eqdsk corresponding to R=6.5m Aries cases are not well substantiated at this time.
- low fusion power 986 MW (eqdsk00)
- Analysis needs to be iterated

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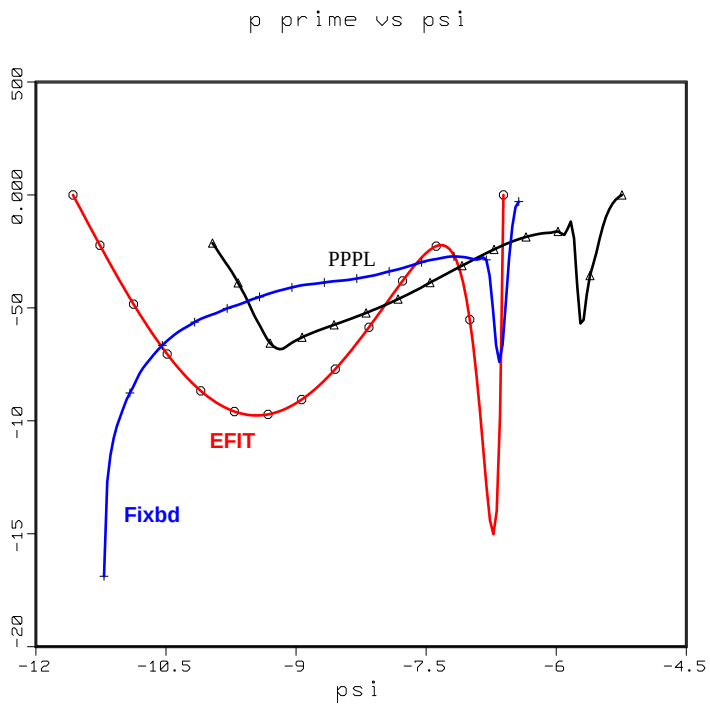
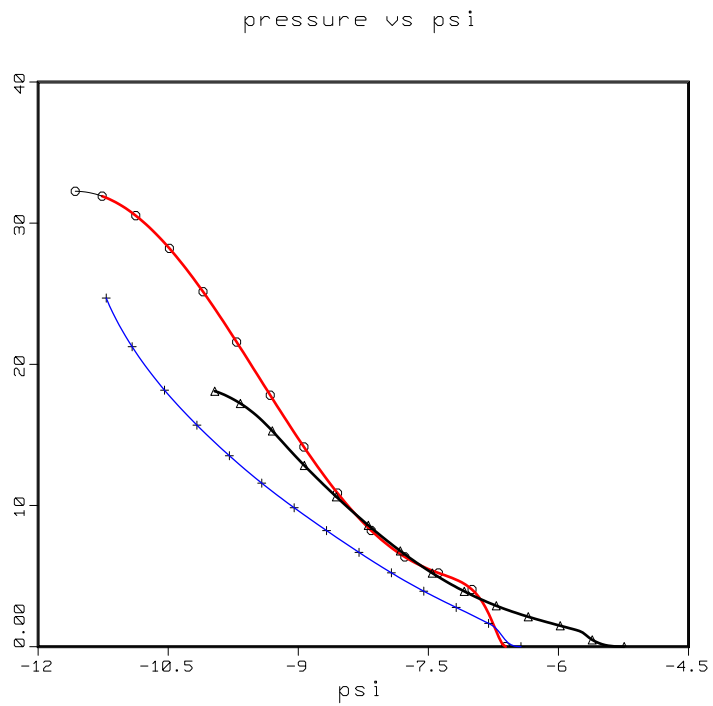
Mhd pprime and pressure





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Summary

- Previous simulations required lower hybrid current to yield near zero ohmic current.
- New simulation, with a corrected mhd equilbrium file, indicates that relatively little rf current drive is required.
- Neoclassical/multimode confinement leads to Te,Ti profiles that give high bootstrap current. Assumed density profiles further enhance this effect.
- Iteration on these results is required to ensure that a self consitent scenario is established.

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