Simulation of a Burning Plasma Experiment

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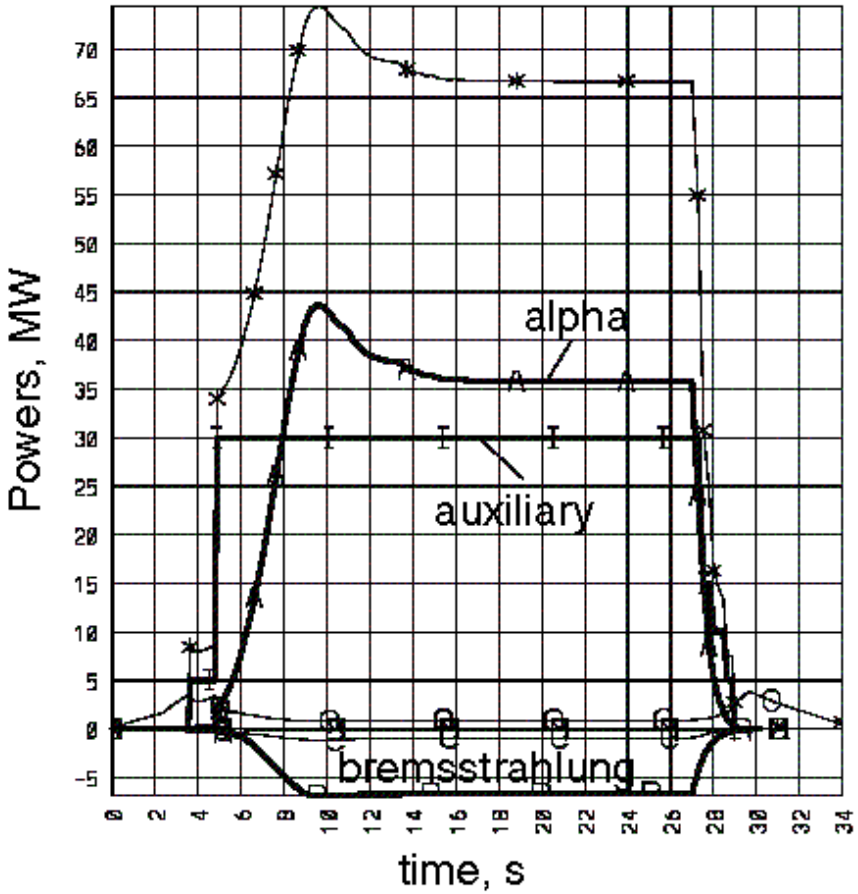
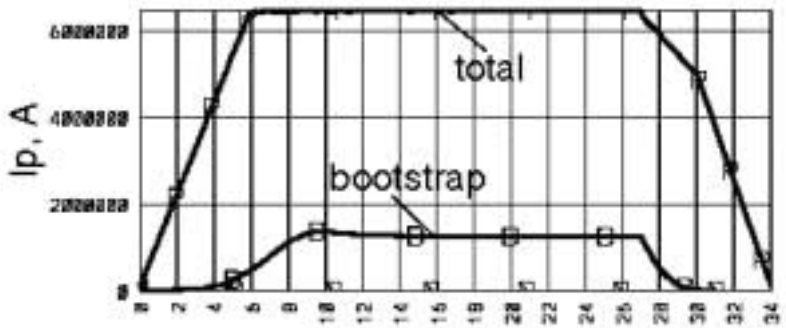
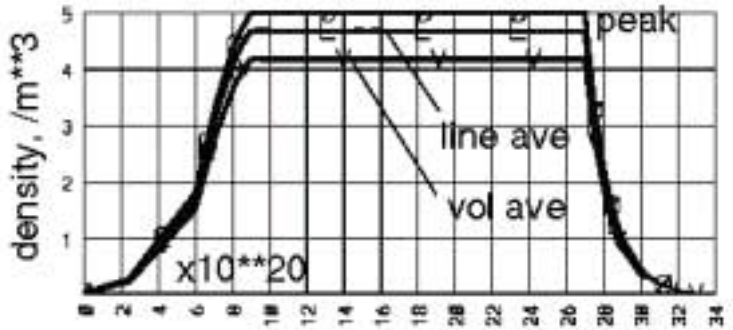
FIRE Burning Plasma Discharge Simulation with TSC

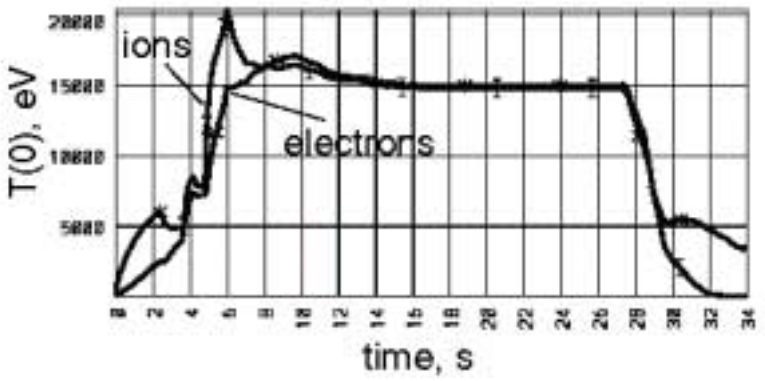
ELMy H-mode, βN<2.0, Q=6

Bt=10 T, R=2.0 m, Ip=6.5 MA







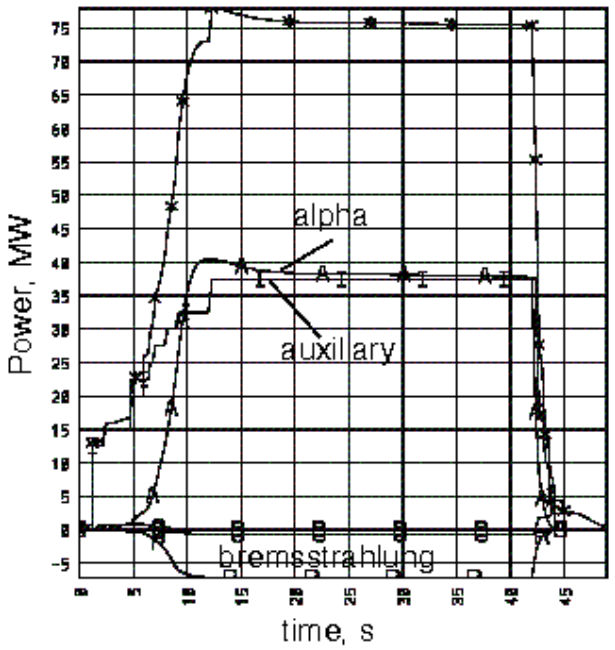


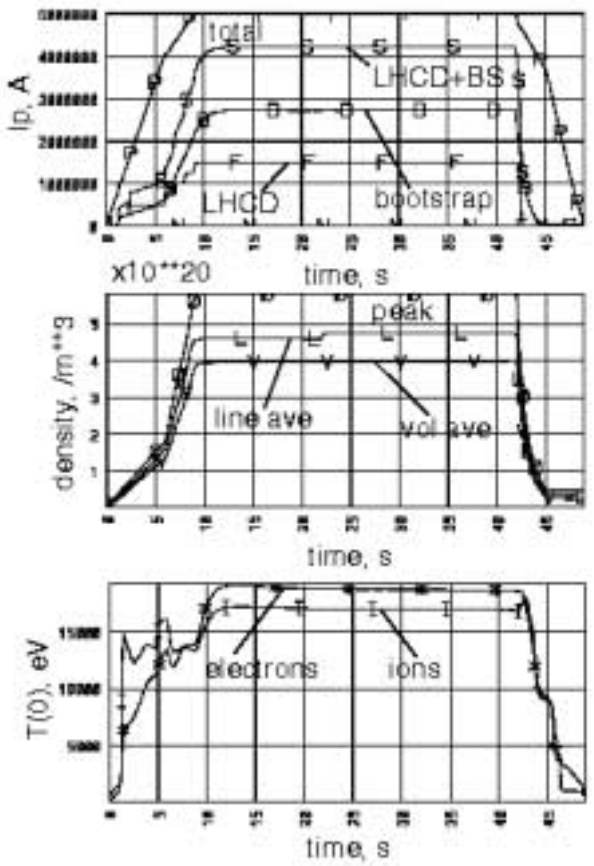
Burning Plasma Experiment Simultaneously Needs

- L-H mode transition
- Non-disruptive sawtooth
- Energy confinement close to scaling
- Low Zeff (impurities)
- Effective helium confinement around 5-10 x τE
- Alpha particles are not lost before slowing down
- Good control of density and fuel mixture
- The βN low so NTMs don't affect confinement
- Operating far from density limit for confinement
- Alpha heating remains peaked in plasma core
- Divertor can pump with large heat flux and ELMs

FIRE AT Burning Plasma Discharge Simulation with TSC

Ip=5.0 MA, Bt=8.5 T, βN=3.0, li=0.4, n/nGr=0.7,
H(y,2)=1.1, n(0)/<n>=1.45, P(LH)=20 MW, P(IC)=18 MW





(In Addition) Burning AT Modes Would Simultaneously Need

- CD sources are not perturbed by alphas
- Higher safety factors don't lead to excessive alpha losses
- NTMs are stabilized or have weak effects
- ITBs can be relaxed to some degree (control)
- Density control can be maintained with ITBs
- Plasma edge/SOL/divertor particle and power solutions
- Auxiliary power must be reasonable to get Q>5
- Current profile control with large bootstrap fraction
- Kink stabilization above βN of 3-3.5 (RWMs)

Simultaneous Achievement of Several Plasma Features is Difficult Science

- A burning plasma experiment requires the successful combination of several plasma physics features that have been studied in isolation on tokamak experiments
- These plasma physics issues all have some degree of coupling to each other making the system complex
- We can not theorize/simulate all the effects of these plasma physics issues on a computer without the guidance of an experiment (who would believe it?)
- A burning tokamak experiment can provide the basis for burning plasma physics and advanced tokamak physics by
  - Addressing the simultaneity problem head-on
  - Guiding theory/simulations to the most critical issues

What if…..

- The money to build a burning experiment was separated from the base program
- Both the long pulse DD and burning plasma objectives could be met in the same device (FIRE at 4T has >200 s pulse length, ITER-FEAT)
- In the next five years we were given the opportunity to build a burning class experiment, how would we respond