

Priorities for AT Thrust

- The AT Thrust is admittedly ambitious in its 5 year goals; we don't apologize for this.
- We recognize that we may not, at first achieve all our goals due to unexpected hardware problems or physics issues.
- It is also conceivable that DOE won't give us all the funding requested. This would delay or cut tools and diagnostics, and, just as importantly, limit runtime to explore the many options available.
- **We agree it is important to identify priority areas, and nearer-term, achievable, goals.**
- For each area, I will:
 - Try to divide into **things we MUST DO** and **those we WANT TO DO**. (quick and subjective. My criterion: Would I consider to have “failed” if we can't do it.)
 - Go through our original ‘intermediate objectives’ table, highlight **near-term** and **science** goals.

Current Profile Control

MUST:

In PHASE I:

- Get LHCD commissioned.
Demonstrate that
 - Power goes in-good coupling
 - Current is driven.
- Establish limits of power and plasma density
- Measure effect:
 - Location of fast electrons.(xrays)
 - Amount of driven current: MSE (at a minimum, show change in $j(r)$ where LH damps).
- Show changes in $j(r)$ with $N_{//}$.
- Compare to various RF models.

By Phase II: Show shear reversal.

WANT TO:

- Demonstrate and understand physics of MCCD.
- Test use of FWCD in some scenarios.
- Measure full $j(r)$ profile, with enough high accuracy for transport, stability calcs. (Polarimetry likely needed for core, ITBs)
- Try many scenarios, combine with ITBs etc.
- Measure energy spectrum of fast electrons. (ECE/ECH?).
- Achieve broad region of reversed shear.

Non-inductive current drive

MUST:

In PHASE I:

- Demonstrate 'substantial' LHCD for 2 secs. (could be L-mode; lower n_e , I_p if we have to.) At least 150 kA; aiming at 300 kA.
- Use cryopump for density control so we can make lower n_e H-modes and ITB edge, compatible with strong LHCD. (Note: present target plasmas are *accessible*; CD may be low).

Phase II:

- Get to 100% CD (possibly at lower n_e , I_p) for 5 secs.
- Get 250 kA LHCD in high conf, higher bootstrap plasmas (H-mode or ITBs).

WANT TO:

- Combine LHCD with MCCD and/or FWCD.
- Get bootstrap fraction to 70%. (Depends on high confinement, pressures not yet proven).
- Expand reversed shear region to $r/a \sim 0.8$
- Combine strong LHCD with highest confinement, bootstrap regimes.

Goal 1: Long Pulse Current Drive

Demonstrate, and develop predictive models for, full non-inductive CD using LH and ICRF waves, in a high n regime ($> 10^{20} \text{ m}^{-3}$) for pulse lengths $\gg t_{\text{CR}}$.

- Produce some optimized targets for LH studies 2003.
- Commission LHCD Phase I, measure coupling, power handling 2003.
- Measure profile of fast electrons with hard X-ray camera 2004.
- Measure LHCD efficiency, localization in L, H, and ITB regimes and determine effective upper density limit. 2005.
- Demonstrate 50% CD, possibly at reduced n_e , for 3 sec pulses. 2005.
- Compare to ACCOME, CQL3D, and full wave models. 2004-06.
- Commission LHCD Phase II, assess CD localization with multiple N_{\parallel} spectra. 2006.
- Maximize and document LH driven current vs target $n_e(r)$. 2006
- Combine LHCD with bootstrap current from ITBs, to maximize total non-inductive CD. 2006-08.
- Extend pulse length to 5 seconds. 2007.

Near term

Science

Transport Control

MUST:

- Produce ITBs. (already doing this)
- Document transport, scalings etc.
- Make ITBs in plasmas with LHCD, modified shear.
- Add more core heating.
- (Re)learn to avoid impurity accumulation and MHD, make steady-state.
- Increase bootstrap fraction. (minimum 30%; at ~15% now.)

WANT TO:

- Combine LHCD with MCCD and/or FWCD.
- Get predictive understanding of thresholds, dynamics of present and future ITBs. (*a tall order, I admit!*)
- GS2 simulations, understand turbulence stabilization.
- Get MC flow shear working, use as a transport control tool.
- Increase bootstrap fraction to 70%. (in 5 years).

Goal 2: Core Transport Barriers

Produce, understand and control core transport barriers in LH and ICRF driven regimes with strongly coupled electrons and ions.

- Measure core χ , D with off and on-axis ICRH, over a range of I_p , B_T , and n_e . (near-term and science) 2003.
- Conduct gyrokinetic simulations of several cases, compare with experiment. (ditto) 2004.
- Assess influence of reduced or reversed shear (produced by LH) on ITB formation, location. 2005.
- Test whether barriers form spontaneously with reversed shear, with on-axis ICRH. Compare χ_e , χ_i and D and assess impurity accumulation. 2005.
- Optimize profiles and transport for steady state, with maximum off-axis bootstrap current (target 70%). 2004-06.

Near term

Science

MHD

MUST:

- Increase W beyond present limits; needs more power + confinement.
- Establish where core MHD limit is. (could lower B and/or I_p if needed).
- Compare type, location of instability with stability calcs.
- By Phase II, get β_N to level where we routinely run into MHD limit. (May be less than 3 initially).

WANT TO:

- Measure MHD growth rate, proximity with active MHD.
- Use active power feedback to avoid instabilities. (*note: I realize we need to think more about feedback control generally*); *won't be in year 1*).
- Optimize current and pressure profiles to increase beta limits.
- Add conformal wall, active stabilization. (only worth doing if we achieve goals on left!)

Goal 3: Increase Beta

Attain and optimize no-wall β limits, with β_n of at least 3, and explore means of achieving higher values.

- Use ICRH power to increase β in inductive discharges, and measure MHD growth rates using active MHD antennas. 2003-04.
 - Compare observed growth rates with stability codes. 2003.
 - Explore MHD properties of reversed shear discharges 2005.
 - Use control of current and pressure profiles to optimize no-wall beta limits, guided by modelling. 2006-07.
 - Conduct feasibility and design studies of conformal wall and active MHD stabilization coils. 2004-05.
 - If studies show feasibility and if warranted by demonstrated high β , fabricate and install MHD control hardware. 2006-08.
- Full exploitation would likely extend to next five-year period.

Near term

Science