These VGs plus the FIRE Summary VG Presentation at http://fire.pppl.gov were the basis for the talk to the PPPL Transport and Turbulence Science Focus Group.

Issues to be Addressed on a Next Step MFE Burning Plasma Experiment

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Statement Endorsed by Burning Plasma and Energy-B Subgroups at Snowmass

1. Burning plasma experiments are essential for the development of fusion.

2. The tokamak is technically ready for a high-gain burning plasma experiment.

3. The US should actively seek* opportunities to explore burning plasma physics by:

   Pursuing burning plasma physics through collaboration on potential international facilities (e.g., JET Upgrade, IGNITOR, and ITER-RC).

   Seeking a partnership position, should ITER construction proceed.

   Continued design studies of moderate cost Burning Plasma (BP) Experiments (e.g., FIRE) capable of exploring advanced regimes.

   Exploiting the capability of existing and upgraded tokamaks to explore and develop advanced operating regimes suitable for BP experiments.

   * one group in MFE endorsed “has exciting” rather than “actively seek”.

VG from MFE Transport subgroup at Snowmass Thursday evening

What did we do in the MFE Transport Group?

We attempted to craft a vision for transport research in MFE and succeeded in reaching a broad consensus on this theme.

- We did **not** evaluate point designs of particular burning plasma proposals.

- We did reach a consensus that empirical scaling is not a sufficient basis for transport prediction.

- Particular areas of concern were raised, which affect our ability to project to a tokamak burning plasma with high confidence.

VG from MFE Transport subgroup at Snowmass Thursday evening discussion

Uncertainties in Projecting Conventional Tokamaks to Ignition Regimes

- Accuracy of Empirical Confinement Extrapolations, Particularly at High Density
- Lack of Definitive Physics or Scaling of H-Mode Threshold and Pedestal
- Sufficient Confinement with Acceptably Small Elms

ALL of these Issues are the subject of active research at **ALL** major experimental facilities and by numerous theory groups.

The lack of resolution for these issues introduces an element of risk into burning plasma initiatives. The level of acceptable risk is clearly a matter of personal judgement.

Confinement Issues for Burning Plasma Experiments

- Quantify extrapolation/uncertainty in projections from the statistical data base
  - dimensional parameter extension
  - dimensionless parameter extension (include edge and alpha parameters)

- Confinement as a function of density relative to Greenwald density

- Confinement as a function of power relative to L to H Power Threshold
  - hysteresis
  - single null vs double null
  - density relative to Greenwald density

- Consistency of HH98 $\approx$ 1 and detached divertor operation.

- H-mode pedestal scaling versus B, a, δ, n/n_{GW}

- ρ^* scaling of confinement (e.g., flow shear, isotope effect, etc.)

- Prototype discharges for potential next step experiments.

Confinement Issues Needs

H-Mode Regime

- A model (comparable to the Bohr model) that explains (predicts) the statistical confinement scaling(s).
- A model that explains (predicts) the deterioration of confinement at high Greenwald densities.
- A model that explains (predicts) the H-mode power threshold.

Internal Transport Barrier

- The tokamak needs only modest HH98 enhancements $\leq$ 50% to access interesting AT regimes with $\beta_N \sim 4$.
- What are the possibilities for testing techniques for modest confinement enhancements in existing and potential next step experiments?

Summary for Transport and Turbulence SFG

- There are physics issues for next step MFE experiments that cause uncertainties in the performance projections.
- Some progress can be made in the near term by exploiting the capability of existing experiments and improving simulations.
- A major objective of a next step experiment(s) is to resolve these physics issues, and to reduce uncertainty in the projections of MFE fusion plasma performance.

Recommendation: Establish the Snowmass MFC Working Subgroups (Science Focus Groups) as an ongoing structure to:

1. Facilitate the general development of magnetic fusion science.
2. Identify and address issues associated with next step MFE experiments.