**PAC-37 Report: Core Science Group**

* Experimental plan comprehensive and coherently structured
* Agree with priorities
* Well-aligned with FESAC/FES initiatives, and includes important ITER-relevant research
* Link with Theory strengthens research

Transport and Turbulence

Observations

* Organization around multi-TSG XPs is very effective

Recommendations

* Priority should be given to XPs that can lead to achievement of long-term goals (in context of high-Z walls)
	+ Impact of rotation on relative role of neoclassical and turbulent high-Z transport
	+ Impact of HHFW on high-Z transport (krypton, xenon more appropriate than neon)
		- Xenon/Krypton seeding XP idea in ResFor (Reinke) – might want to increase priority of this idea (late-run XMP?) – inform decisions about future high-Z upgrades
		- Prioritize ideas according to diagnostic availability, auxiliary systems (3D field pacing, pellet pacing), but make it simple initially (change rotation re 3D fields, NB); deeper in FY17
		- Diagnostics needed:
			* Basic core radiation (AXUV from Kevin/Luis) and LLNL spectroscopy for XMP; late FY16
			* More extensive absolute radiation diags (core bolometry, LLNL spectroscopy, JHU TGS and possibly XICS) for comparison to modeling – FY17, combine with LBO

Theory partnership

* Simultaneous application of PPPL and non-PPPL codes (e.g., GTS & GYRO) for validation
	+ Comparison of multiple codes (GTS, GYRO, XGC-1) began in 2014 with residual stress momentum transport calculations (reported in PAC-35). A high priority effort this year will be multi-code gyrokinetic analysis of NSTX-U L-mode plasma for code verification and validation of heat, particle and momentum fluxes and low-k turbulence (2-3 dedicated XP/XMPs). We have also recently started GTS & GYRO simulation efforts for MAST as part of collaborative work with CCFE that is preceding the NSTX-U analysis (Walter, Weixing, C.S.)
* Development of synthetic diagnostics for direct comparison with fluctuation measurements (in particular, low-k: BES, reflectometry)
	+ Diagnosticians work with Theory (Dave Smith/F. Poli/W. Wang)
	+ Synthetic diagnostic for reflectometer has been done in EP (Crocker, Belova, Fredrickson, et al.)
	+ High-k (ETG) synthetic diagnostic development of FP being passed onto A. White grad student

Macrostability

Observations

* NSTX-U remains at forefront of Macro studies
* Flexibility in MGI is world leading: should be given highest priority within TSG due to near-term timescales for providing input to ITER

Recommendations

* Add more run time to MGI experiments
	+ TSG to relook at day allocation, work with RC to adjust
		- XMP will help, maybe additional reserve days
		- Piggybacking once the XP is run? Effect on next shot, etc. needs to be considered
	+ Radiation measurements for MGI needed (a la C-Mod); radiation asymmetry, etc.
		- Not in plans concretely, so probably not show up before FY17-18; need planning now even for that
* Add word “stability” to R16-1 or R16-3 to acknowledge and justify large fraction of run time for this TSG
	+ Passed unanimously
* Consider formation of Working Group to assess stability at wide range of rotation; includes development of modeling capability for equilibrium and stability at high flow
	+ Ian Chapman interest
	+ Rotation in equilibrium calcs (ISOLVER, EFIT, LRDFIT), in stability (MISK, etc);
	+ Many experiments testing effects of rotation
	+ Modeling capability development (Park, Ferraro, Jardin, ZWang,…) an opportunity – to discuss and coordinate
	+ Probably do not need a formal WG
* Think in advance about how high-Z walls will affect Macro program in future
	+ Incorporate high-Z impurity measurements into DECAF
		- Need to show some progress in algorithm development coupled to experimental plans
		- Can show correlation between disruptions and radiation power levels; can do in one year (SAS), assuming diagnostics available
		- Diagnostic availability will drive DECAF algorithms
		- Need LLNL spectroscopy + AXUV diodes (& bolometers) needed for this
	+ Access to high-beta w/o mode control when islands can lead to impurity accumulation
		- Need to assess importance of NTM in NSTX-U through expt (LaHaye), and go from there (rotation control)?
		- Delgado XP (Priority 1) – “Stabilization of radiated-induced tearing modes (RiTMs) using off-axis-heating”
		- Use resistive DCON when ready – new capability

Theory partnership

* Maintain close relationship with Theory
	+ Great idea

Energetic Particles

Observations

* Flexibility in NBI will enable a broad capability for tailoring the fast ion distribution
* Alfvén Eigenmode control potentially very high impact for ITER
	+ Source 2 injection, even if degraded, suppresses CAE/GAEs – observation
	+ Need to study stability boundaries, effects of RF and 3D in Upgrade

Recommendations

* Want update and status of TAEA at next PAC
	+ Eric will make it work, once we get engineers and techs, etc. If not, next year we will be where we are this year. Not good if so

Theory partnership

* Provide vision to fully model AE evolution to validate against NSTX-U data and reliably extrapolate to ITER and FNSF-ST
	+ Short-term: Improvements to ORBIT (saturation levels of modes – new feature, along with drive. Still needs NOVA input), improvements to NOVA (estimate parameter range for chirping vs stationary modes, other mode behavior), kick/CGM in TRANSP, new model by Gorelenkov w/o NOVA, CAE/GAE: HYM/reflectometer validation and modeling
	+ Want also to develop longer-term plan
* Can M3D-K capture nonlinear WPI, collisional damping or fast ion orbit widths?
	+ Response from Fu
		- Yes, M3D-K can capture nonlinear WPI and fast ion orbit (via gyrokinetic model). We plan to update M3D-K to full beam ion orbit in order to be more accurate for NSTX parameters.
		- Right now M3D-K has damping mechanisms of continuum damping and thermal ion Landau damping, but not collisional damping or radiative damping. These two dampings can be added if there is sufficient manpower
		- Thus M3D-K can model nonlinear physics of beam-driven AE, but the damping physics needs to be improved in order to model stability threshold more accurately.
		- Physics of damping in ST parameter range in NOVA also need improvement
	+ In addition to Fu contribution two longer-term directions are being pursued (Gorelenkov):
		- GTS is being adopted to EP needs via MPP-PPPL center (Wange, Schneller) with short-term task to model eGAMs
		- Reduced models to be incorporated into NOVA-K/LBQ framework. In the short-term a 1D version of LBQ is being developed for future integration into TRANSP code with further detailed validation goals on various machines.
		- Both directions are long-term projects.
		- In general theory plans are correlated with the NSTX program and depend on it for validations and motivations.

Long-Term Upgrades/Plan (Core)

Observations

* Plan to control high-Z with ELMS may be insufficient (consider in terms of present HHFW and future RF capability)
* NCC significant for Macro (and other) research: finalize design asap
	+ Design almost complete
	+ Reduction in rotation may help with impurities, but negatively impact confinement
		- Fine control of 3D spectrum (with comprehensive set of coils) can lead to “fine” control of rotation and effects on turbulence and transport, MHD?

Recommendations

* Consider how long-term program requires capabilities by each of the proposed facility enhancements
	+ NCC clear, high-Z not clear (NCC controllable, high-Z is not)
		- Issues are: how can high-Z help research, but also, how can we live with high-Z
		- Initially, we will assess high-Z effects, as well as specific areas
			* High-Z influence on disruptions, NTMs
			* High-Z impurity transport
			* Plans for mitigation follow assessment
		- Program issue, not just Core

Theory partnership

* A 5/10 year plan for how the Partnership will develop to ensure future impact on the NSTX-U program would be beneficial
	+ SK to work with AB
	+ Consider meeting of Core Group with relevant PPPL Theory and others to develop long-term plan for theory work, coordinated among all theory efforts
		- How is PPPL Theory plans impacted or complemented by non-PPPL theory work? Want to coordinate