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***FROM: M. PODESTA and ENERGETIC PARTICLE TSG***

***Subject: impact of potential polar region modifications on research and scenarios for ENERGETIC PARTICLE Topical Science group***

This Memo summarizes physics and diagnostics needs for EP-TSG research on NSTX-U based on the potential modifications of the NSTX-U “polar region”.

*Flat-top duration*

A flat-top duration of ~2 seconds is required for EP research to achieve scenarios with equilibrated current profiles. Stationarity of the current profile is desirable to perform “perturbative” experiments, e.g. through NB modulation or by using 3D fields, starting from a known baseline scenario.

A flat-top duration of 1 second is sufficient for experiments on characterization of instabilities, given the typical time-scales over which instabilities evolve (1-100ms). The availability of diagnostics with good temporal resolution (e.g. Mirnov coils, reflectometers) enables a satisfactory averaging of the mode properties over time windows of a few milliseconds, thus providing good statistics to reconstruct the properties of instabilities as they evolve.

*Magnetic equilibrium*

Planned EP experiments are relatively insensitive to the details of the magnetic equilibrium. One exception is the mapping of Alfvén Eigenmode (AE) stability properties through the AE antenna as a function of triangularity and elongation. However, those studies will be first conducted in ohmic plasmas, and eventually in NB-heated plasmas with low injected NB power (Pnb<2MW).

For this TSG, it is important to retain the capability of 1-second-long discharges in inner-wall-limited configuration (inner gap =0). IWL plasmas provide good, reproducible scenarios for theory/experiment comparison and validation in a simplified geometry. Interpretation of some diagnostics data is also simplified in IWL plasmas (e.g. FIDA: reduced background D-alpha emission from the divertor). A 1-second long IWL scenario is also compatible with NB modulation schemes for CHERS measurements when the 2nd NB source is ON, or for “blips” of source 1A for q-profile measurements. Maximum injected NB power foreseen for IWL plasmas is <4MW during 1 second for L-mode scenarios.

In addition to standard LSN and IWL configurations, USN plasmas are desirable, e.g. to reduce the background on some diagnostics (vertical FIDA) in high-performance discharges that cannot be run as IWL.

*NB power and NBI configuration*

Neutral Beams are one of the main experimental tools for EP-TSG research. All six NB sources need to be reliably available with injection voltage in the 60-90 kV range. Modulation capabilities are also required, with minimum on/off time of 10ms.

Required NB power levels are <4MW for L-mode IWL plasmas and up to 8MW (total) for higher-performance H-mode scenarios. Note: the total 8MW can be either from 4 sources at full 90kV injection voltage, or from a combination of steady/modulated sources at de-rated voltage.

*Toroidal field range and polarity (reversed Bt capability)*

Proposed/foreseen EP experiments require a toroidal field Bt in the range 0.5-1T, with strong desire to decrease Bt down to ~0.35T to establish a connection with previous studies on NSTX.

The possibility of experiments with reversed-Bt is desirable, mainly for diagnostics purposes. For example, validation of FIDA signal modeling would benefit from this. However, alternative schemes can be developed to collect the same data, e.g. by using (a subset of) pCHERS views looking from the top and from the bottom simultaneously.

On the physics side, reversed-Bt scenarios are not expected to bring much new information to EP research. However, operations with reversed Bt *and* Ip are desirable to validate EP transport models for counter-NB injection. Because of the expected higher first orbit loss rate with respect to normal Bt operations, injected NB power and pulse duration can be restricted to <6MW and 1 second, if required.

*Plasma current and polarity (reversed Ip capability)*

The range of plasma current of interest for the EP-TSG is Ip=0.6-1.5MA. The lower limit is useful for experiments with high non-inductive current fraction (ideally near the fully non-inductive operations).

Operations with reversed-Ip are desirable to expand NSTX-U scenarios to study confinement of counter-NB ions and their destabilization of EP-driven instabilities.

*RF heating (HHFW)*

Availability of HHFW heating with up to 4MW of injected power during 0.5 seconds is highly desirable to study the interaction between NB ions and RF waves and validate numerical tools (e.g. “RF kick operator” in TRANSP).

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NSTX-U File