A possible breakthrough of power handling by plasma shaping in tokamak

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Recently, we proposed a tokamak with negative triangularity as an innovative concept for a fusion reactor configuration in order to reduce transient ELM heat load and quasi steady-state heat load. Fig.1 shows a comparison of standard D shaped configuration and tokamak with negative triangularity. The power handling area in the divertor plates is essentially wider since the divertor is placed in the large major radius side in this configuration. Since the magnetic field is low, it is possible to use NbTi superconductor for the divertor coils, by which on-site manufacturing is much easier because of the large strain allowance of the NbTi superconductor. Interlinked divertor coils allow the snowflake and flux-expanded divertor with acceptable coil current and provide robust control of divertor configuration. In addition to the major radius difference of 2-2.5, we can expect flux expansion by 1.5-3. Our target is to enhance power handling area by ~7.

The original idea of tokamak with the negative triangularity is late T. Ohkawa's proposal in 1988, called the comet configuration to stabilize trapped particle mode with negative triangularity and horizontal elongation. The experimental proof of improved confinement in negative triangularity is shown by TCV in the limiter configuration and the gyrokinetic simulation shows strongly tilted TEM eigenmode structure in the negative triangularity. Since we want to have low pedestal pressure, it becomes important to break the profile resilience and/or increase critical temperature gradient. Further understanding of mode structure related to profile de-stiffening is necessary. Recent TCV show core turbulence (δT_e) is reduced with edge negative triangularity. Subsonic SOL flow $u_{//}$~0.5Cs has been a key mystery and plays an essential role in narrow SOL heat channel scaling. Particle simulation by Takizuka clarifies role of neoclassical orbiting effect in explaining this phenomena. SOL flow may be influenced by the strong negative triangular plasma shaping. Experimental and numerical studies of flow characteristics for tokamak with negative triangularity is required.

The toroidal field coil design for tokamak with negative triangularity needs some careful analysis since high field region is similar to the circular coil. *Nb3Al* superconductor having lower degradation of *Jc* with strain than those for *Nb3Sn* and the radial plate are preferable. Development of 16T level *Nb3Al* TF conductor is an important research subject.CS coils may be formed by *Nb3Sn* to have higher flux swing. The divertor pumping is much easier by wide and short pumping ducts.

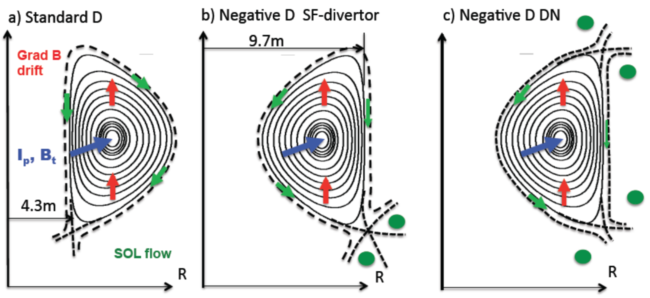

Fig.1. Cross-sectional comparison of standard and tokamak with negative triangularity.