The interpretation of NSTX divertor particle and heat flux measurements and the planned NSTX divertor probes.

I.D. Kaganovich, S. Zweben, M. Jaworski, and D. P. Stotler, PPPL

What new physics understanding might be obtained with the proposed new capability?

Improved understanding of power loss mechanisms in the SOL and role of electron and ion kinetic effects in SOL. Kinetic effects might change divertor plate heat flux and impurity generation, via changes in the sheath and energy of particles hitting plates.
Sheath voltage and role of secondary electron emission. Sheath breakdown and arcing.

What new experiments or additional diagnostics or facility enhancements are needed to improve validation activities?

Measurements of electron and ion distribution functions resolved in space, current profiles in SOL. Direct measurement of the ratio of heat and particle flux at one location would help with the 'validation' in combination with absolutely calibrated spectroscopic impurity flux from divertor plates. In situ SEE measurements. Introducing active emitting surfaces.

"What upgraded or new analysis/code/algorithm capabilities are needed to support validation activities?

Upgrade of EDIPIC and LSP codes for SOL conditions to perform kinetic simulation of particle and energy fluxes to the divertor plate surfaces. Study of current diffusion across field line and plasma perturbation due to biased electrodes.

Competitors: D. Tskhakaya, A. Chankin, G. Manfredi.

Measurements of kinetic effects in NSTX SOL

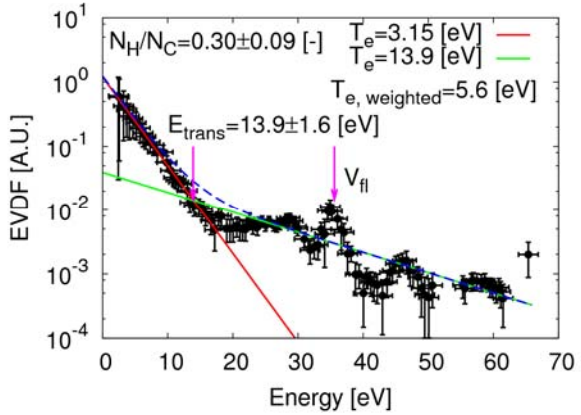
There are a number indications that under some circumstances T_e measured by probes can significantly deviate from the "actual" values. That is the probes need to be interpreted using a non-Maxwellian VDF suggested by theory.

Stationary SOL

ASDEX :
Fussmann JNM 1984
Horacek JNM 2003

$$T_e^{LP} / T_e^{T.Scat} \approx 2$$
$$T_e^{LP} / T_e^{B2} \approx 5$$

Super-thermal electrons
Stangeby PPCF 1995,
Van Rompuy PPCF 2007,
Čerček JPFRS 2009…



ELMy SOL

JET:
Herrmann JNM 2003,
Kallenbach PPCF 2004,
Pitts NF 2007,
Tskhakaya JNM 2009

$$\frac{T_e^{LP}}{T_e^{sim}} \sim 0.5$$

Courtesy of D. Tskhakaya

Langmuir probes with non-local interpretation infer non-Maxwellian features in EVDF

Courtesy of M. Jaworski

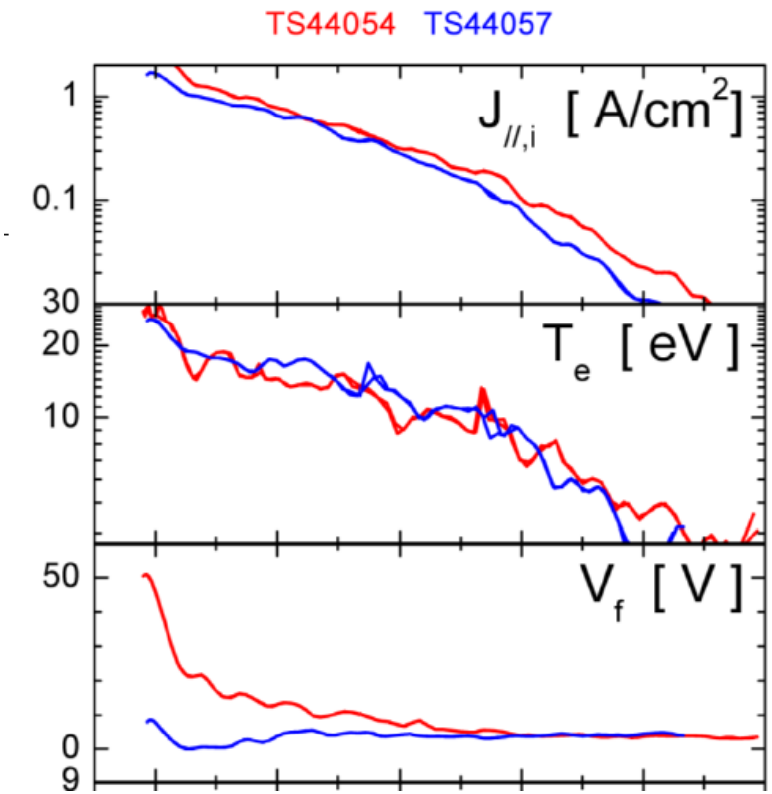
Preliminary fluid code run indicates SOL is at marginal collisionality even for High-recycling PFC

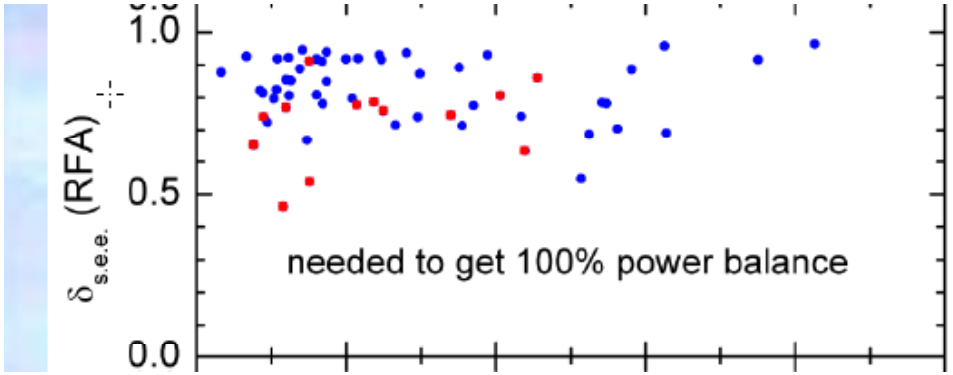
Tore Supra Results indicate large influence of secondary electron emission and kinetic effects

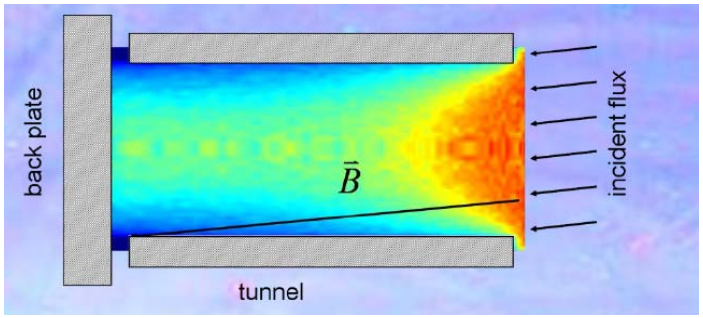
Measured with tunnel probe large secondary electron emission coefficient on CFC, δ_e => several times (~5 times) increased electron power loss calculated with local T_e.

Local T_e is too low to explain SEE yield δ_e =0.8 => high-energy electron tail.

$$\gamma = 2.5\frac{T_i}{T_e} + \frac{2}{1-\delta_e} - 0.5\ln\left[\left(2\pi\frac{m_e}{m_i}\right)\left(1+\frac{T_i}{T_e}\right)\frac{2}{(1-\delta_e)^2}\right]$$

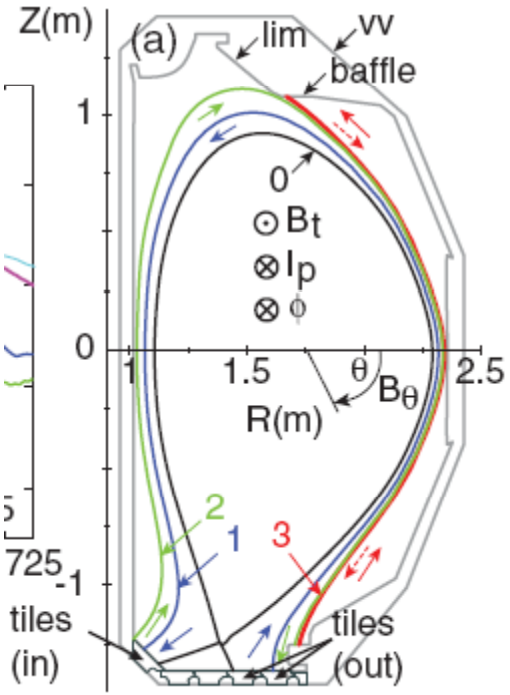






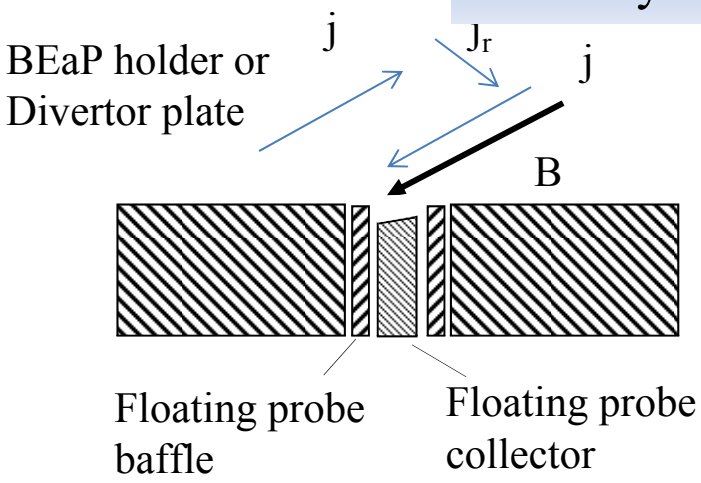
Courtesy of J. P. Gunn

Modeling of current flow patterns for biased electrodes and sheath breakdown during disruptions



SOL currents.
Poloidal cross sections are shown of plasma separatrix
H. Takahashi, PRL **100,** 205001 (2008)

Courtesy of Y. Raitses



Hot spots, unipolar arcs are common on the outer stainless steel wall of NSTX (tracks are very visible), but poorly understood.