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The electron-ion side asymmetry on striated heat flux induced by lower hybrid wave absorption in the SOL on the EAST

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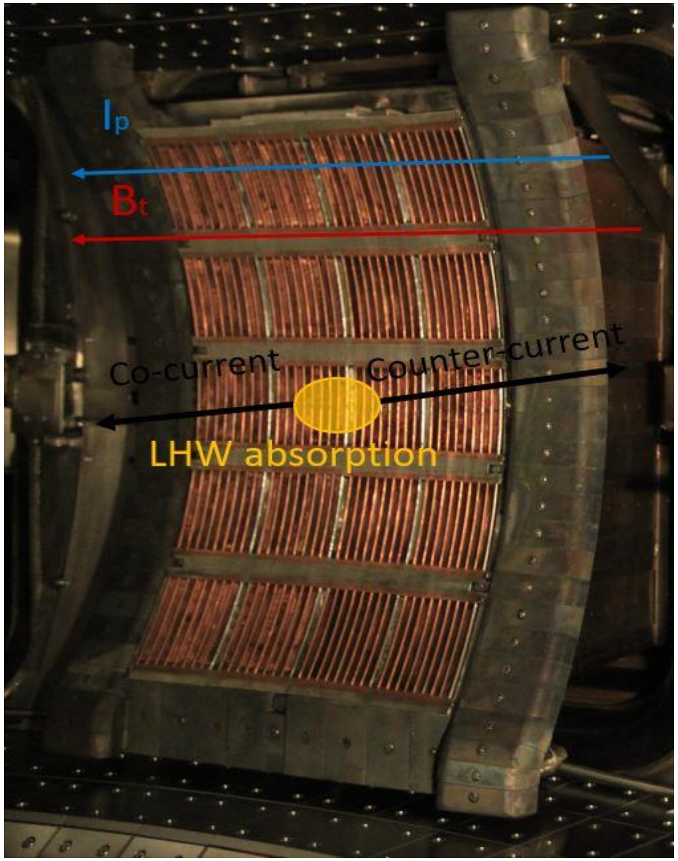
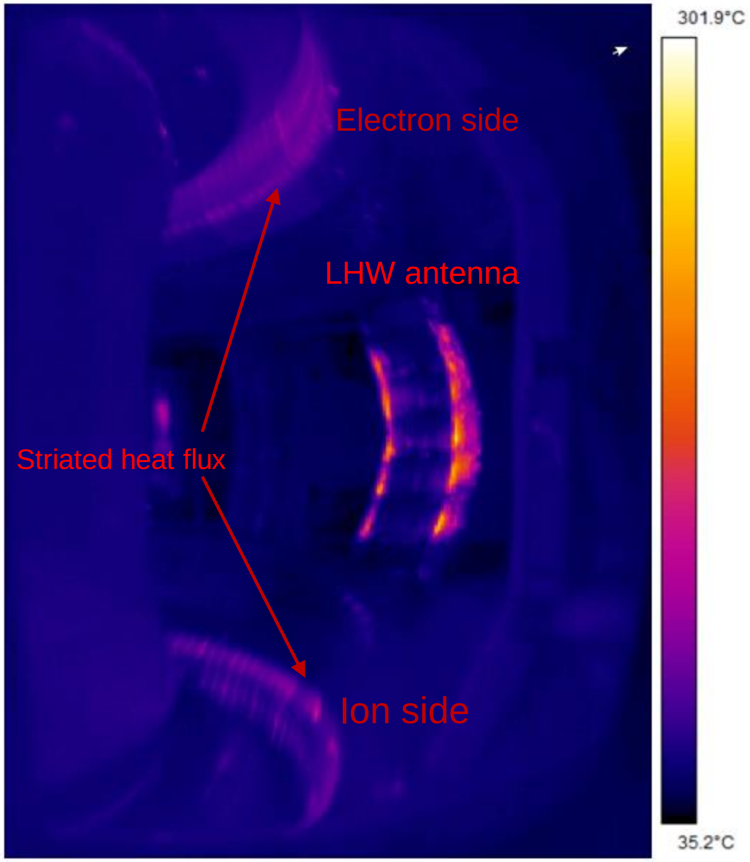
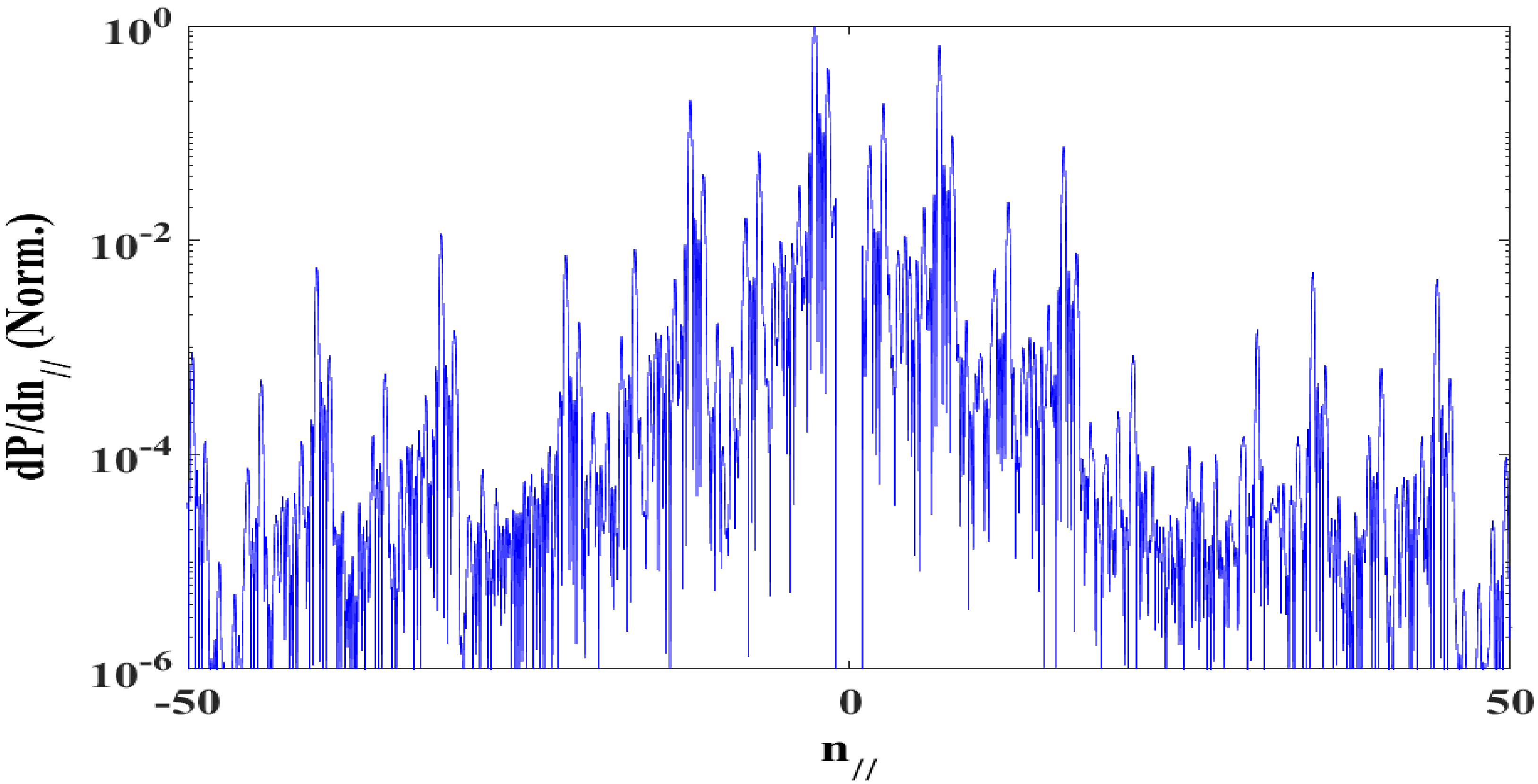
Background





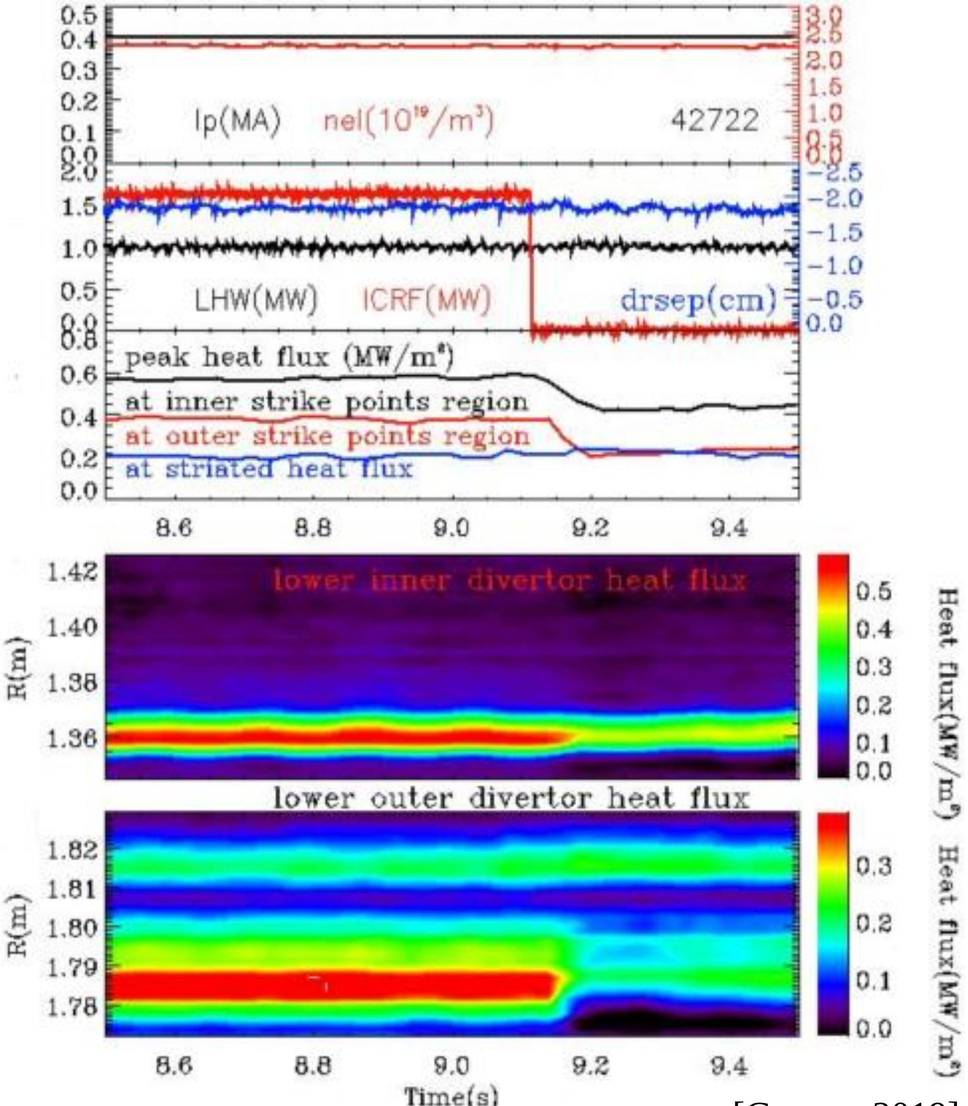
In EAST, lower hybrid waves (LHW) are absorbed in the scrape-off layer (SOL), and then the fast electrons follow the magnetic field lines in the co-current and counter current directions, which intercepts the LHW antenna limiter and divertor plate and induces the striated heat flux on the divertor at the ion and electron side.

Power spectrum of the EAST 2.45 GHz LHW system



- Since the low plasma temperature in SOL, only high $n_{//}$ (>20) can generate the fast electrons in the front of LHW antenna with the landau damping, and deposit on the first wall at the ion side, high $n_{//}$ (<-20) generate the fast electrons and deposit on the first wall at the electron side.
- The power content in the modes with $n_{//}$ >20 is ~0.5%, 0.9% for the $n_{//}$ <-20

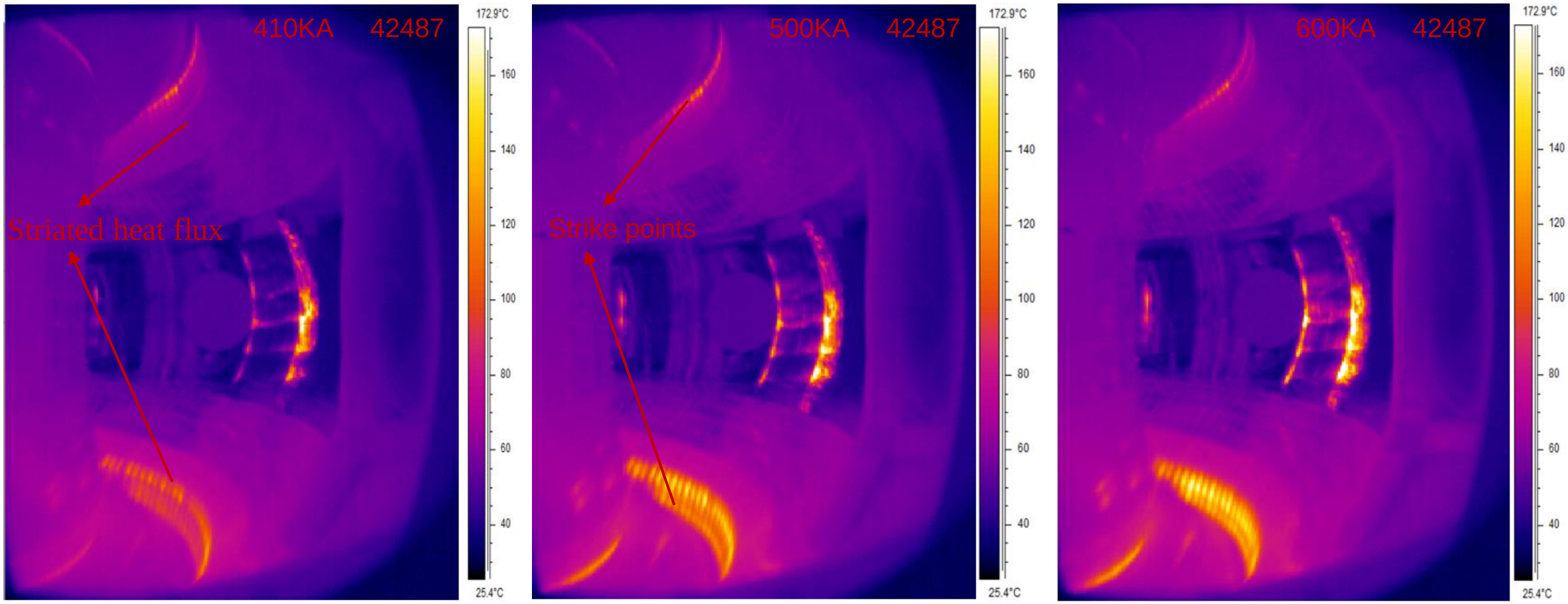
Evidence: the heat source of striated heat flux is from the SOL



[Gan pop2019]

- The heat flux at inner strike points and out strike points significantly decreased with ICRF shut-off
- There was almost no change for the striated heat flux after the ICRF shut-off
- The heat source for the striated heat flux should be from the SOL heating generated by LHW absorption in SOL

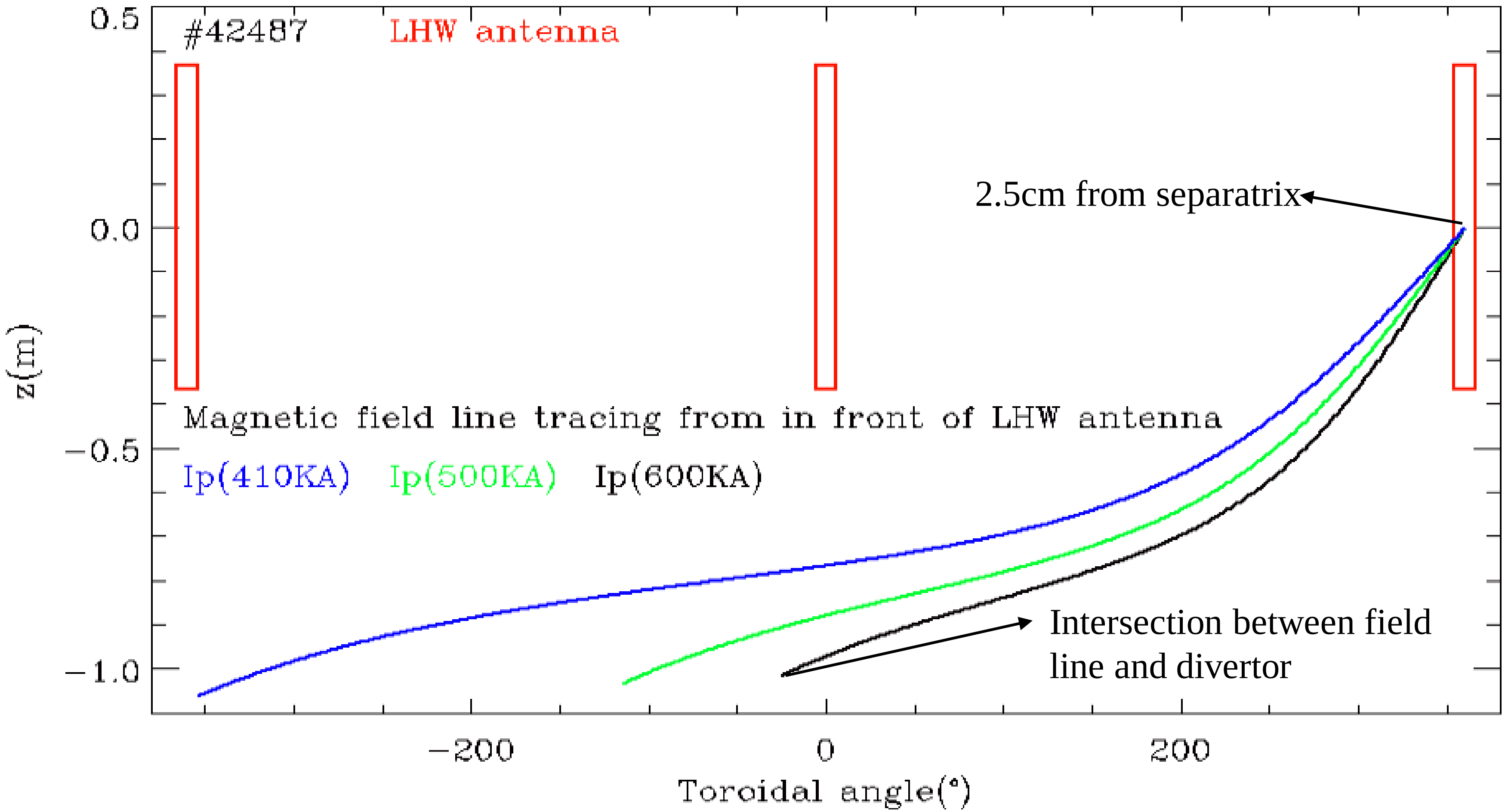
Striated heat flux during plasma current ramp up



- The striated heat flux move toroidally during plasma current ramp up.
- The striated heat flux at the ion side is much stronger than the striated heat flux at the electron side, no matter the current ramp up.

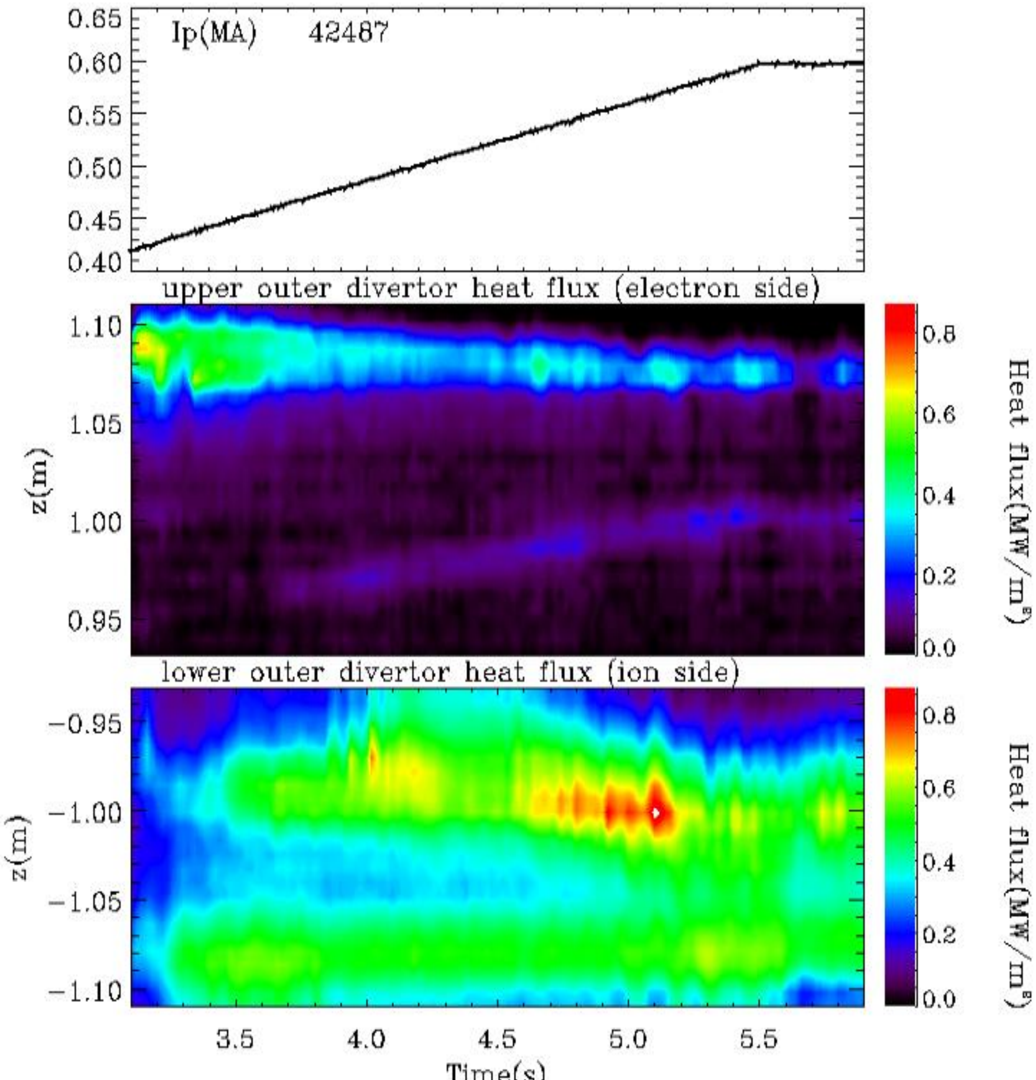
Toroidal movement on the striated heat flux during plasma current ramp up

Magnetic field line tracing from the front of LHW antenna



A rough estimation from field line tracing indicates the striated heat flux can rotate ~300° toroidally during plasma current ramp up from 410KA to 600KA.

Electron-ion side asymmetry on the striated heat flux



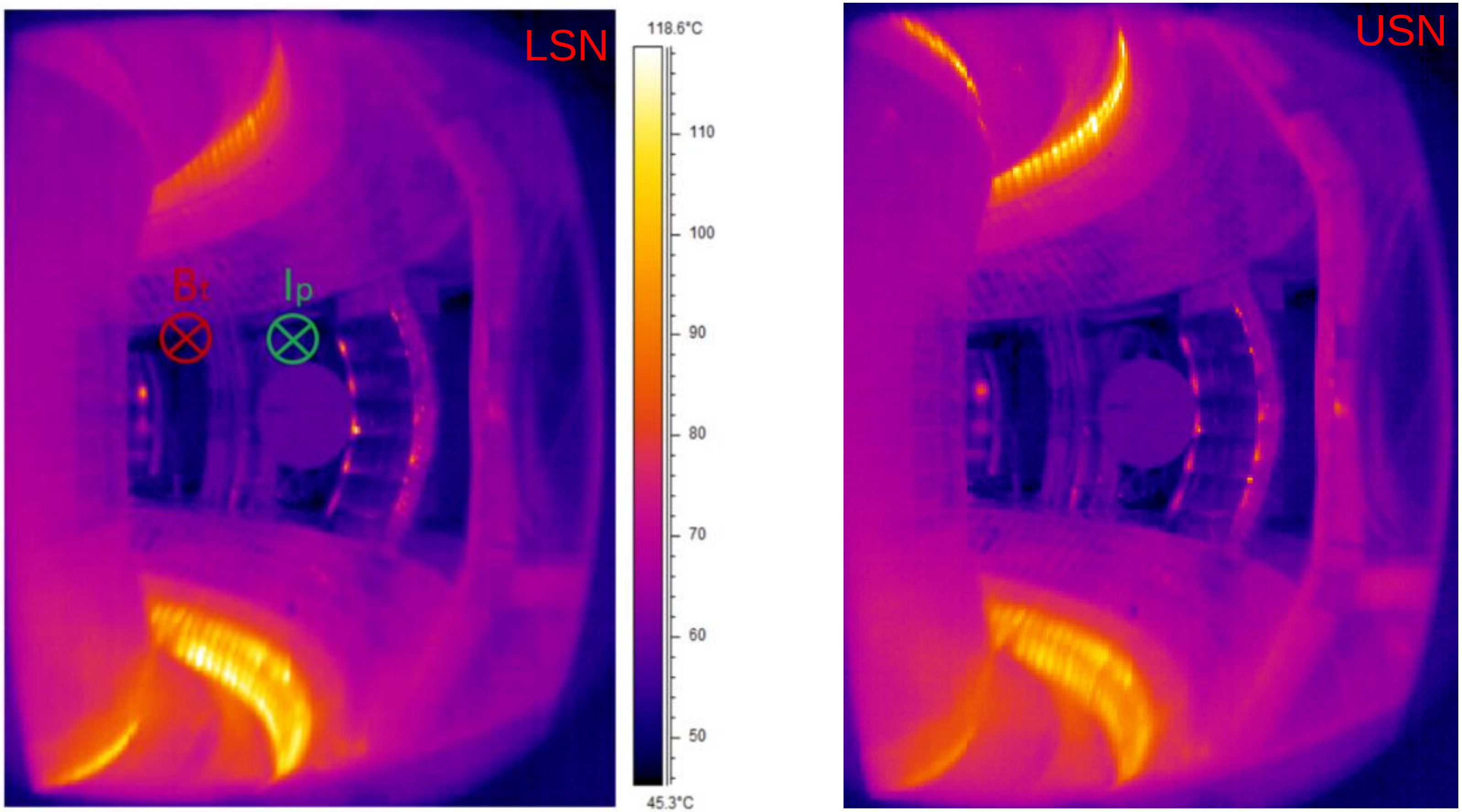
- ➢The striated heat flux at the ion side is ~0.6-0.8MW/m^2 with a wide heat flux width, which is even larger than the heat flux at the strike points

- ➢The striated heat flux at the electron side is < 0.2MW/m^2 with a narrow heat flux width.

- ➢The deposited power for the striated heat flux at the ion side in the IR field of view is ~6% of LHW net power.

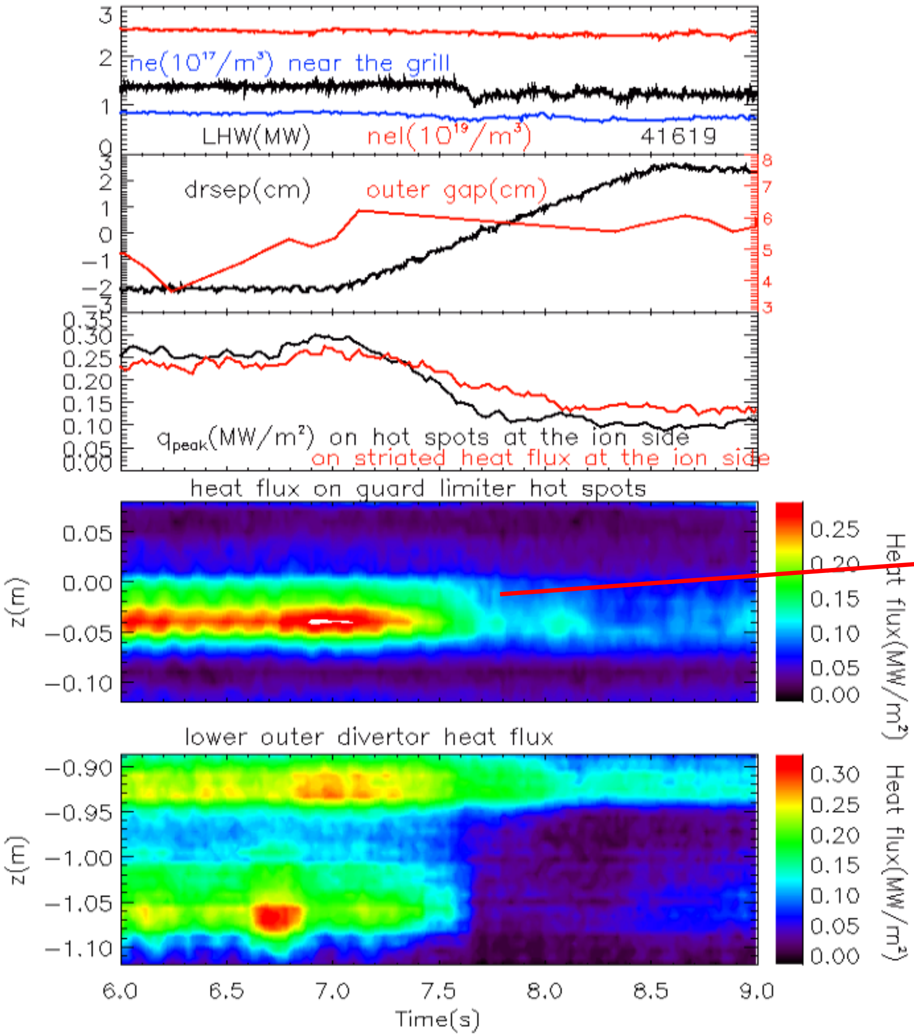
- ➢ The power content in the modes with $n_{//}$ >20 is ~0.5%

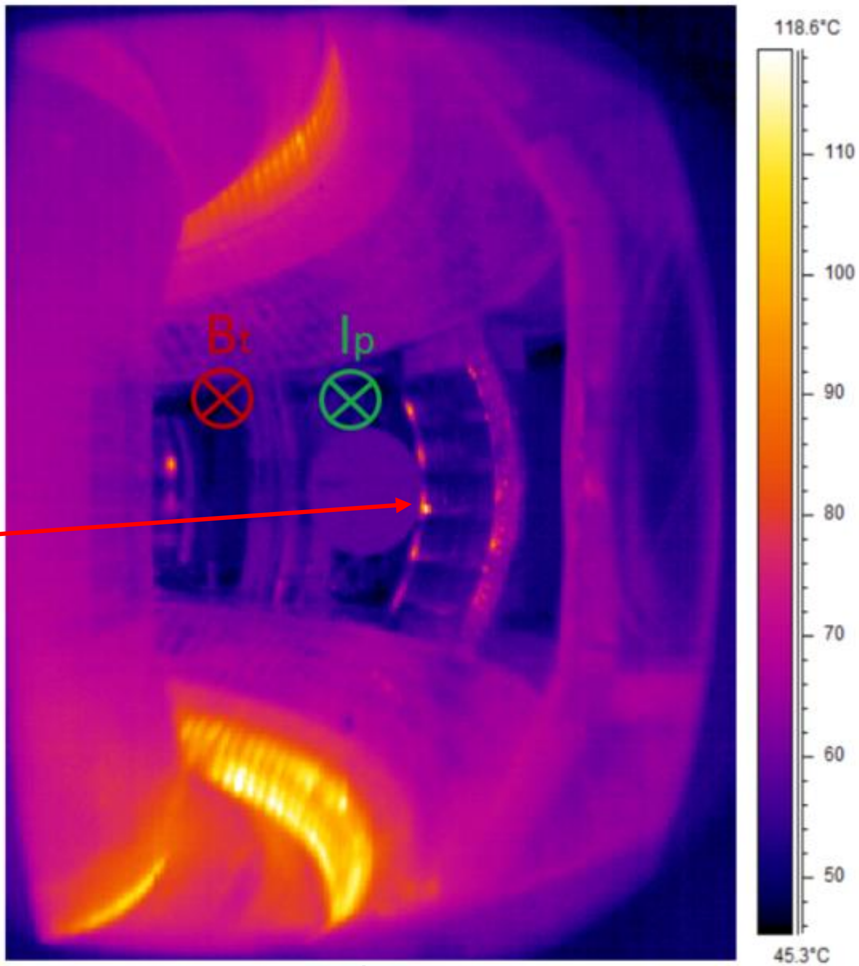
Electron-ion side asymmetry on the striated heat flux at low plasma density



The striated heat flux on the electron side was not observed at low plasma density ($2.5\times10^{19}/m^3$).

Striated heat flux at the ion side decreasing from LSN to USN

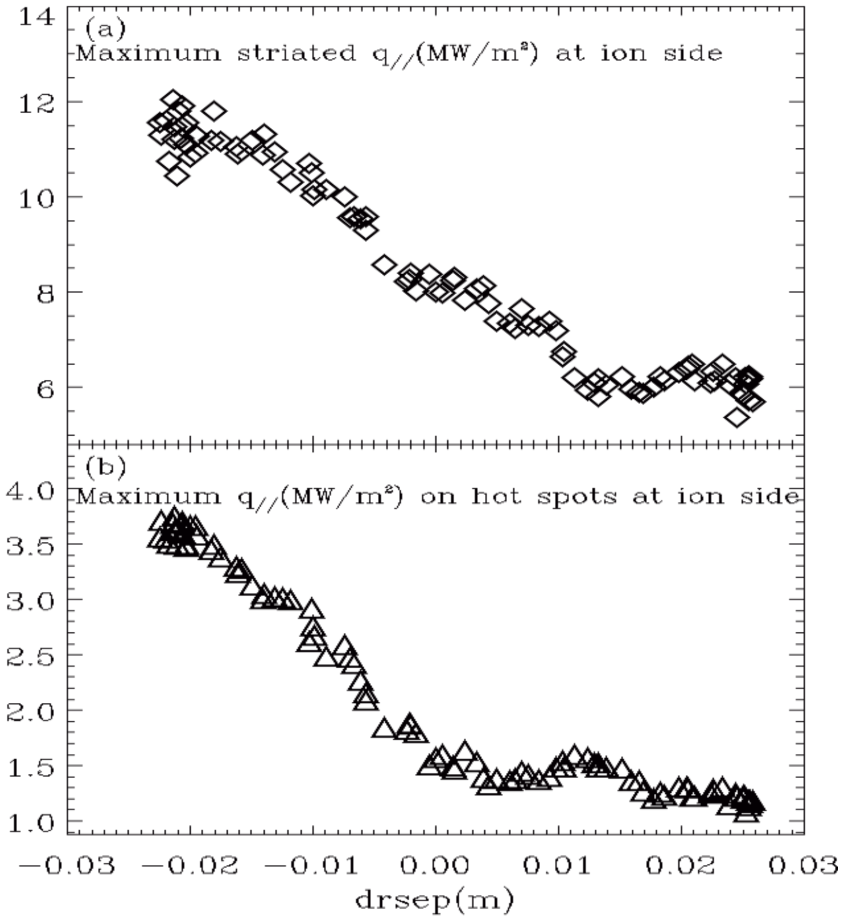




IR image

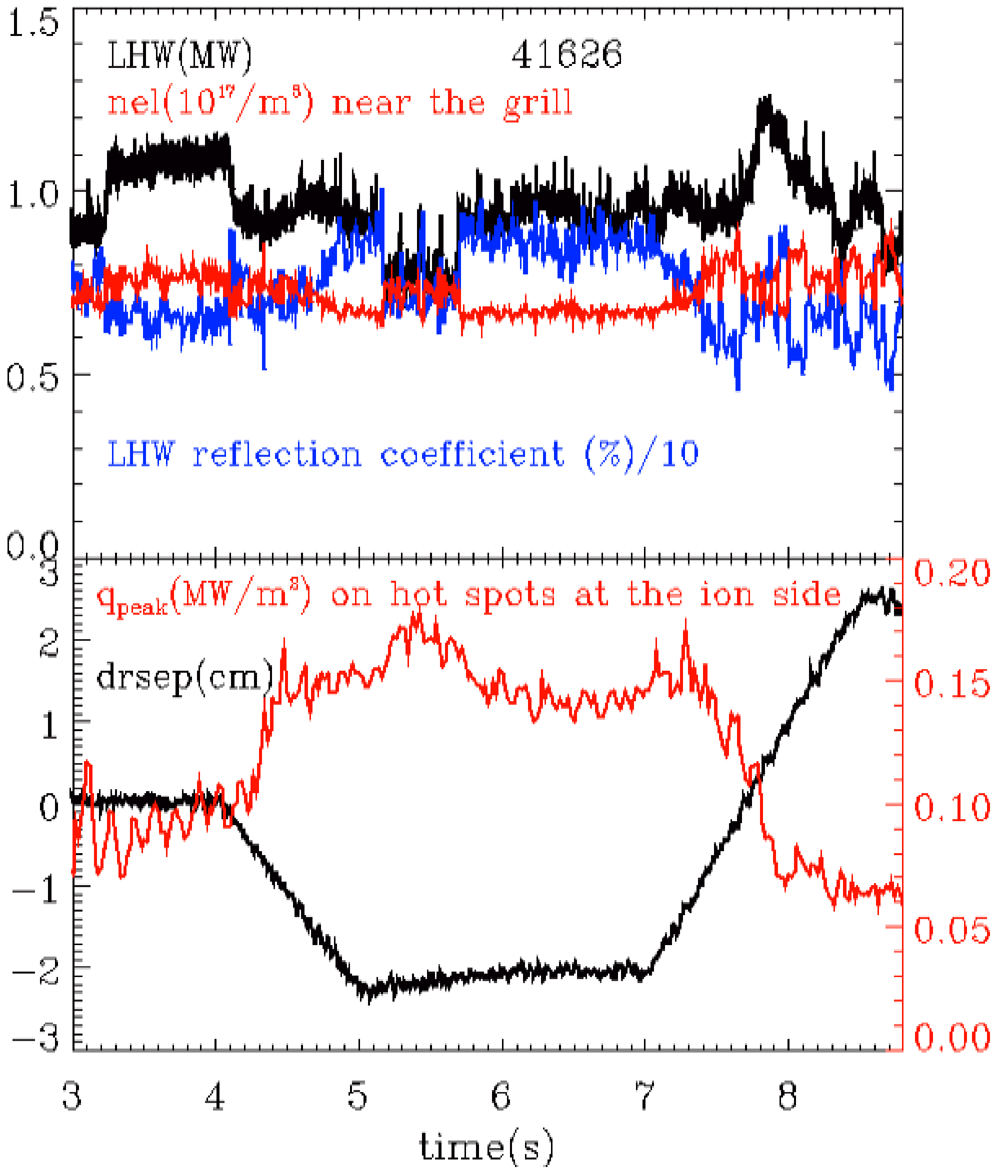
The heat flux on guard limiter hot spots and striated heat flux at the ion side decreased from LSN to USN.

Relationship between parallel striated heat flux at the ion side and drsep



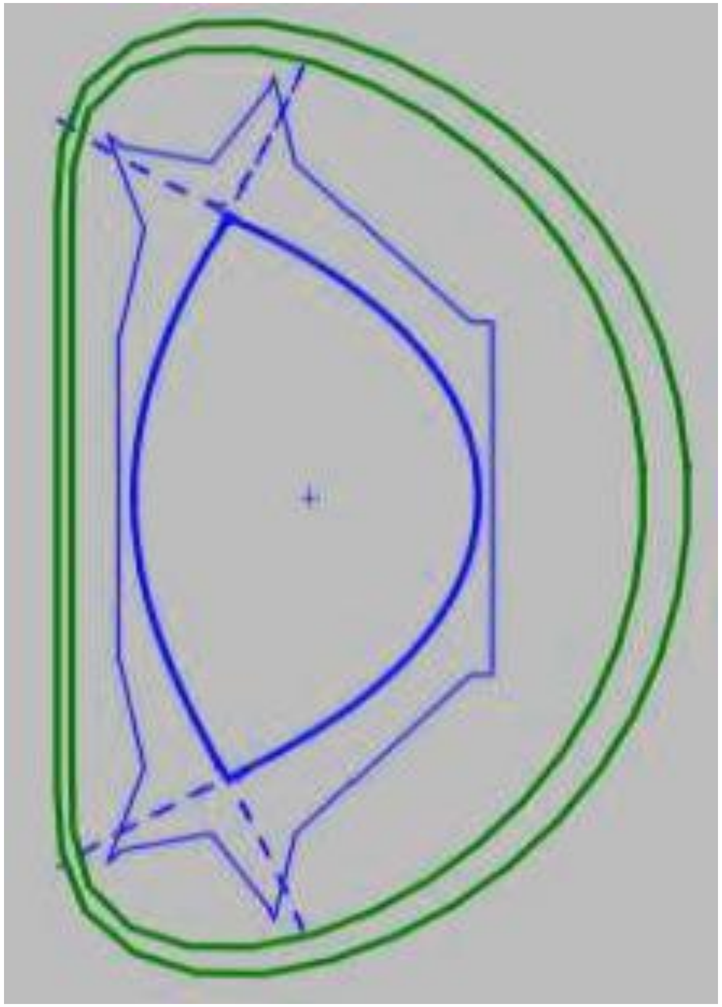
- From The maximum striated $q_{//}$ on the ion side decreased from 11MW/m^2 to 6MW/m^2 when the drsep changed from -2cm to 2cm.
- the $q_{//}$ on the hot spots at the ion side decreased by 2.5MW/m^2 when drsep changed from -2cm to 0cm.

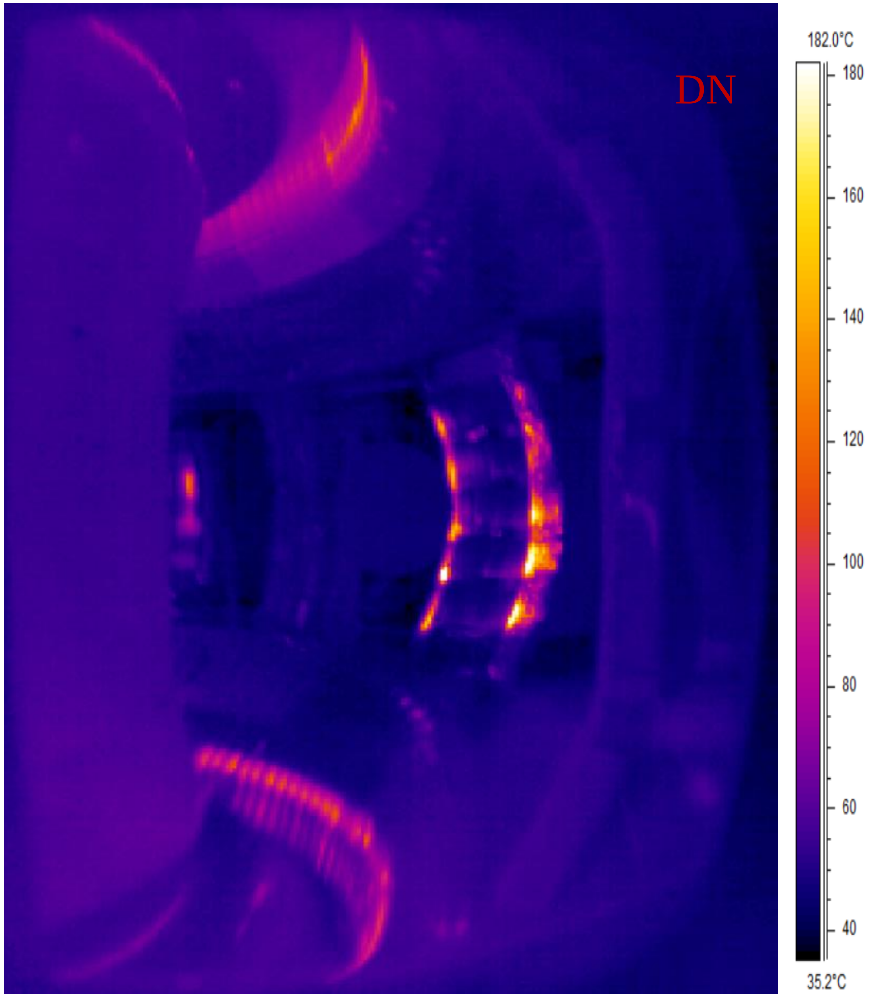
More evidence: heat flux on hot spots at the ion side decrease from LSN to USN



- The changing of the divertor shape will change the magnetic field line from the front of LHW antenna to the divertor, but can not change the magnetic field line from the front of LHW antenna to the guard limiter.
- The heat flux on the hot spots at the ion side even decrease with increasing electron density near the grill from LSN to USN, increase with decreasing electron density near the grill from DN to LSN.

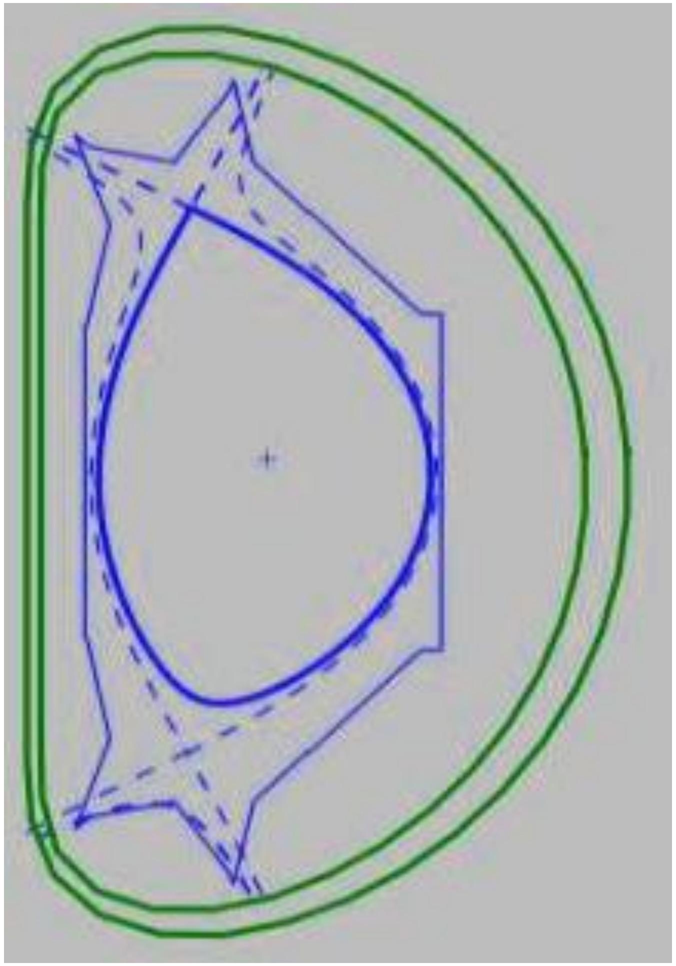
Striated heat flux at the ion side with high plasma density

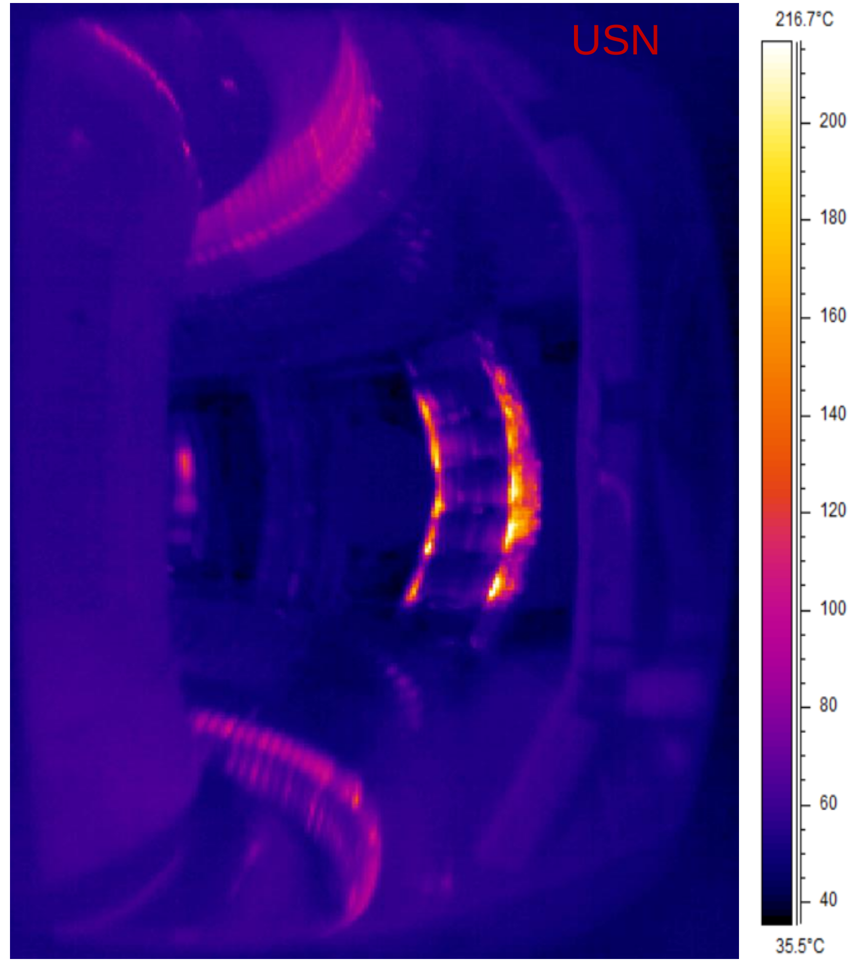




At high plasma density (nel>3.5×$10^{19}/m^3$), the striated heat flux appeared at the upper outer divertor plate (electron side)

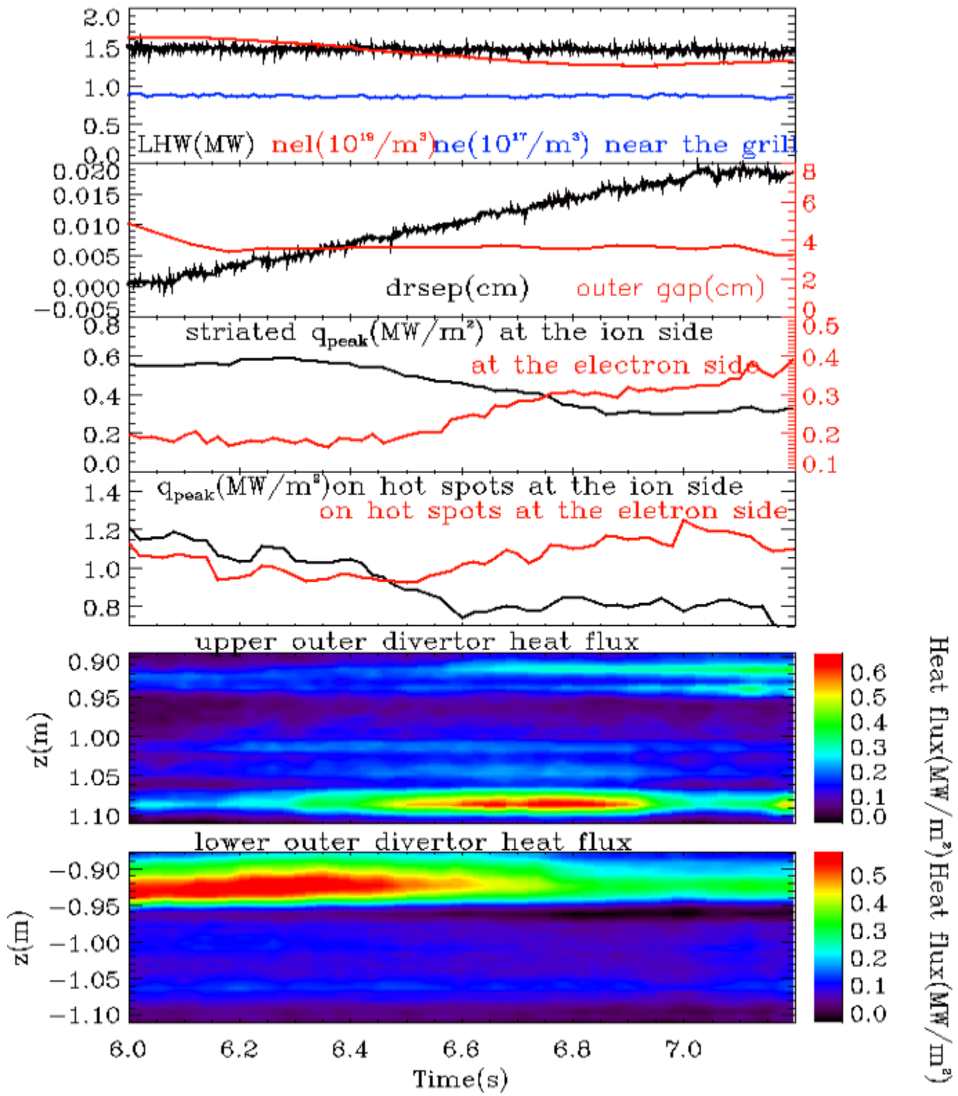
Striated heat flux at the ion side with high plasma density during LSN discharge





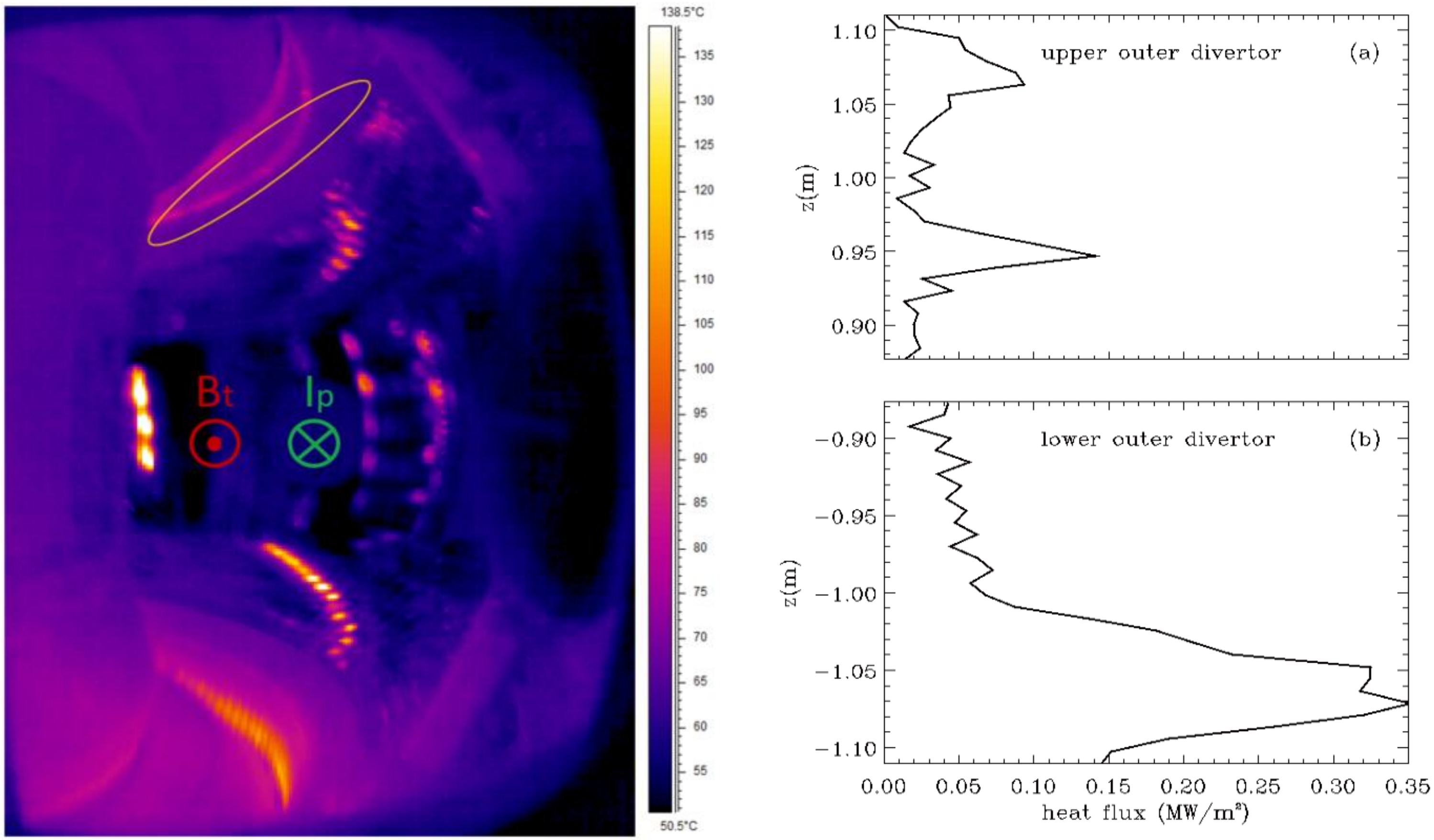
At the USN discharge, the striated heat flux at the electron side is more obvious than at the DN discharge.

Variation of striated heat flux on upper and lower divertor From DN to USN



- The q_{peak} on the guard limiter hot spots and striated heat flux at the electron side increased when the divertor geometry changed from DN to USN
- The q_{peak} on the guard limiter hot spots and striated heat flux at the ion side decreased from DN to USN.
- The electron-ion side asymmetry on striated heat flux changes with the divertor geometry.

Striated heat flux at the ion side with standard Bt



With the standard Bt, the ion side is located at the upper outer divertor plate, the striated heat flux was also observed at the ion side on the upper outer divertor, There was no striated heat flux at the electron side on lower outer divertor

Summary

- It was found there was strong electron-ion side asymmetry on striated heat flux during plasma current ramp up, the deposited power for the striated heat flux at the ion side is 10 times larger at least than the power content in the modes with $n_{//}$ >20 .
- At low plasma density (nel~$2.5\times10^{19}/m^3$) and LSN, the striated heat flux only appeared on the lower outer divertor (ion side) with reversed Bt and on the upper outer divertor (ion side) with standard Bt.
- The peak striated heat flux at the ion side decreased from LSN to USN, which is consistent with the decreasing q_{peak} on the guard limiter hot spots at the ion side
- At high plasma density (nel>$3.5\times10^{19}/m^3$), the striated heat flux appeared on the electron side. From DN to USN, the q_{peak} on the guard limiter hot spots and striated heat flux at the ion side decreased, while the q_{peak} on the guard limiter hot spots and striated heat flux at the electron side increased.
- The electron-ion side asymmetry on striated heat flux changes with the divertor geometry.