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Disruption mitigation by shattered pellet injection on J-TEXT

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ABSTRACT

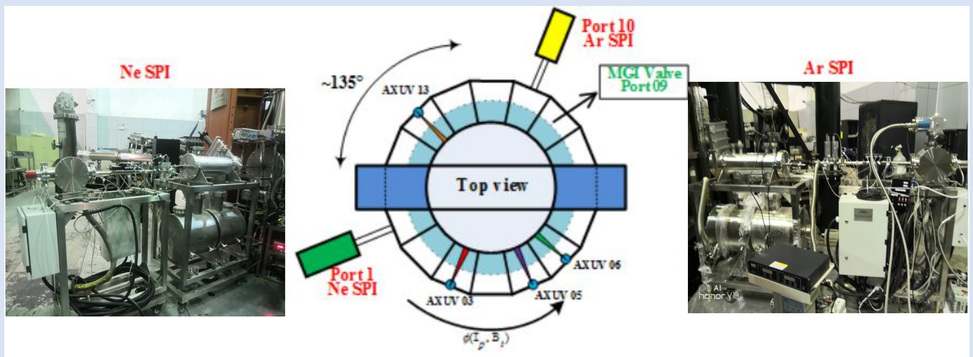
• A dual SPIs system has been developed in J-TEXT. The kind and reaching time of first and second pellets can been determined by pellet penetration time, SXR and fast camera. The experiments about plasma rapid shutdown by dual SPIs shows that dual SPIs can accelerate the plasma current decay at CQ. The CQ rate of dual SPIs can exceed the 70 MA/s. The localized thermal radiation is reduced by dual SPIs. And the toroidal radiation asymmetry has been improved by dual SPIs.

BACKGROUND

- Shattered pellet injection (SPI) has been a primary disruption mitigation method for ITER [1].
- However, single pellet is not enough to increase the electron density for large Tokamak devices [2].
- Dual SPI systems has been developed in J-TEXT to prove the reliability of multi-SPIs [3].

Parameter of dual SPIs

SPI	Ar	Ne
Port	10	1
Propellant gas	Ar	He
Temperature (K)	60	15
Diameter (mm)	5	5
Length (mm)	2-8	2-8
Velocity (m/s)	150-300	150-350



The layout of dual SPIs on J-TEXT

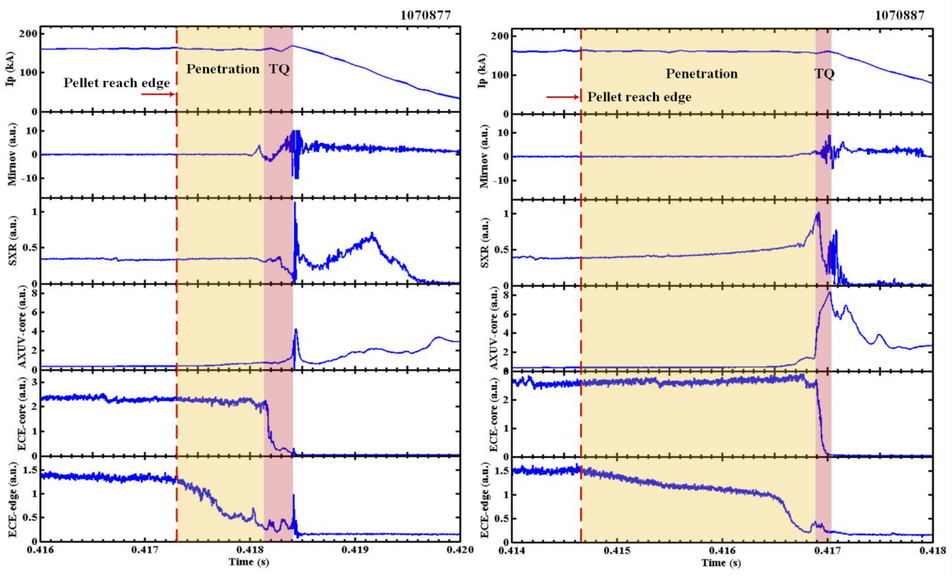
RESULTS

A.Characteristics of single pellet injection

Purpose: confirm the type and arrival time of each pellet

1.Single Ar SPI: L≈7 mm , v_{pellet}=200 m/s ,$t_{trigger}$=0.39 s

2.Single Ne SPI: L≈3 mm , v_{pellet}=250 m/s ,$t_{trigger}$=0.39 s



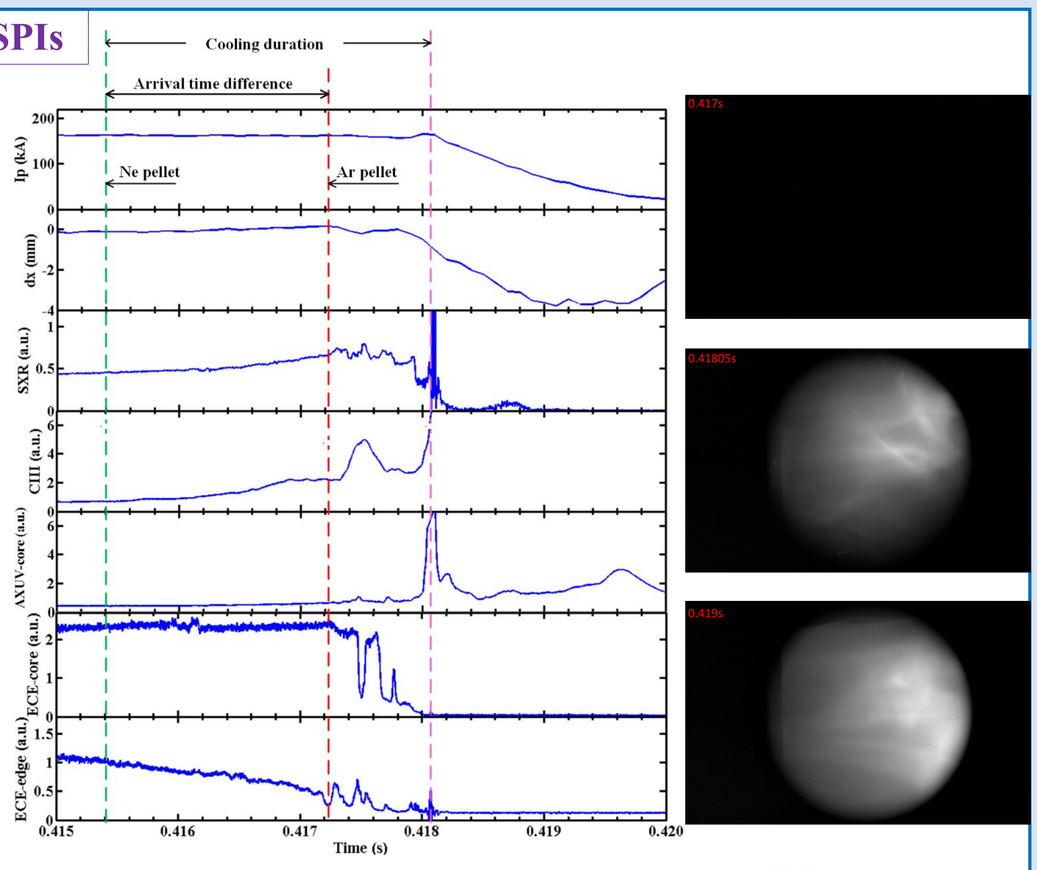
Plasma rapid shutdown by single SPI, (a) Ar SPI; (b) Ne SPI

Difference

- The Ar SPI has shorter penetration time (<1ms);
- The SXR signal will increase when Ne pellet reach the plasma edge.

B. Fast shutdown by dual SPIs

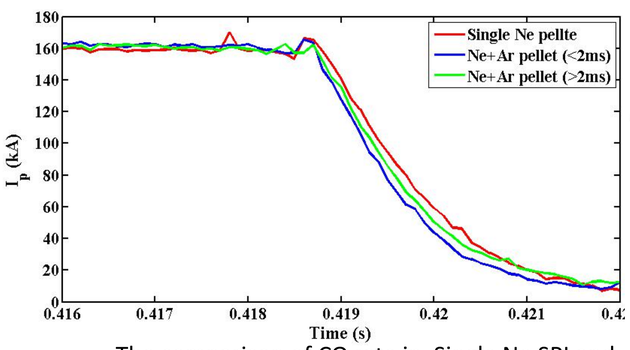
- I_p=160 kA, B_t =1.8 T , n_e=2.0×10^{19} m^{-3}, q_a=3.4
- The plasma is pushed into high field side and the C III increases abruptly when the second pellet strikes.
- The arrival time difference ~ 1.8 ms.
- The photos were taken by fast camera with Ar II filter.



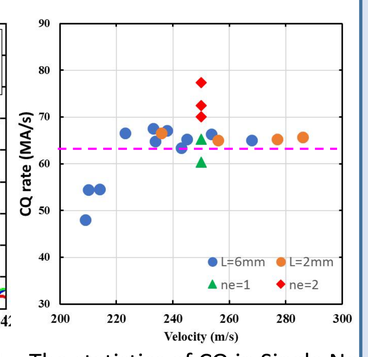
A typical shot of fast shutdown by dual SPIs

C. Influence on CQ and thermal radiation

- Dual SPIs can accelerate the plasma current decay at CQ;
- The influence on CQ is more effective when arrival time difference is less than 2 ms;
- The CQ rate of dual SPIs can exceed the 70 MA/s of single Ne SPI.



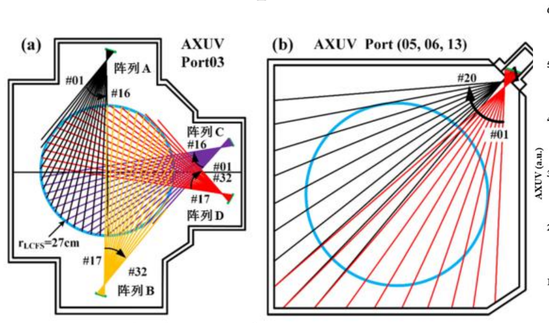
The comparison of CQ rate in dual SPI



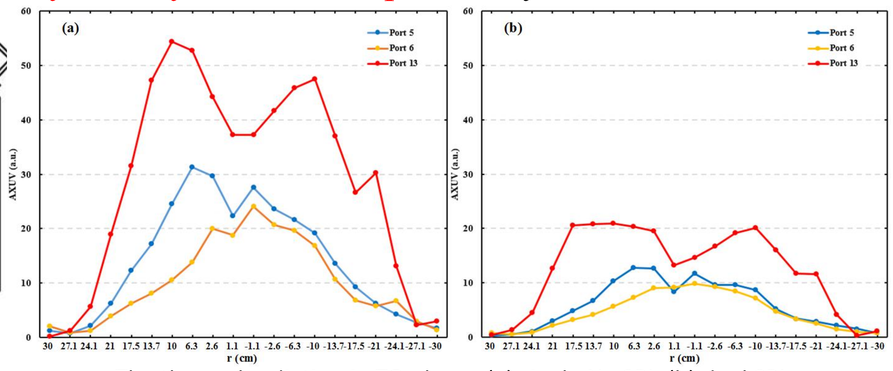
Single Ne SPI and dual SPI

The statistics of CQ in Single Ne SPI and dual SPI

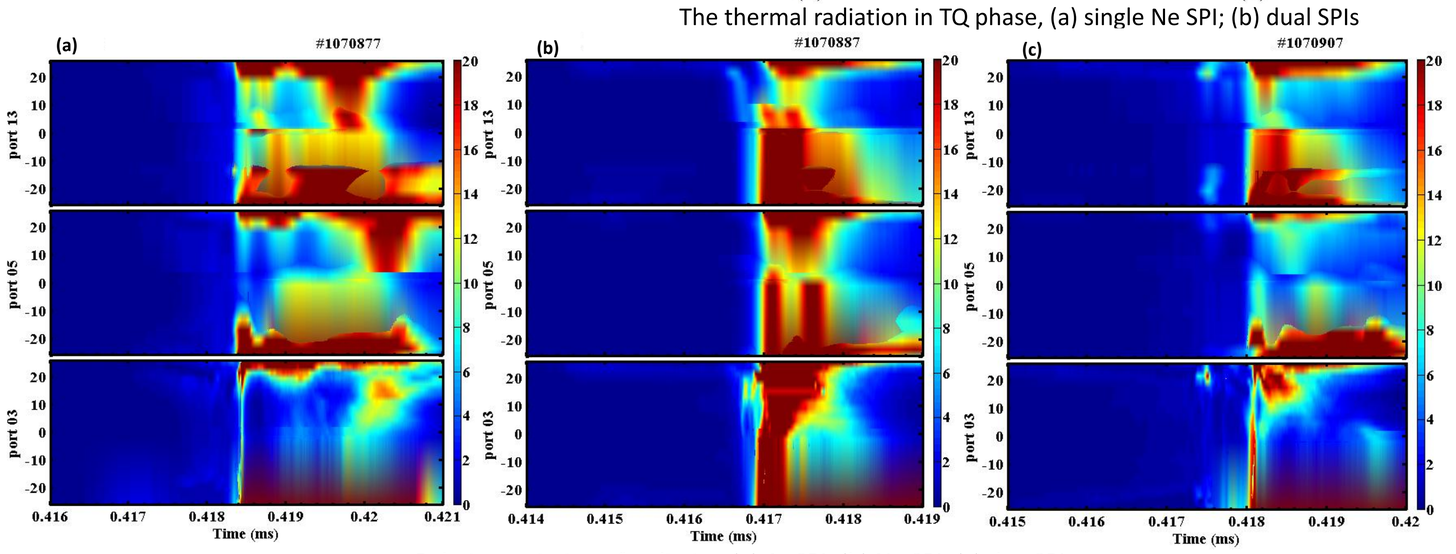
- The localized thermal radiation is reduced by dual SPIs.
- The toroidal and poloidal radiation asymmetry has been improved by dual SPIs.



The layout of AXUV arrays



The thermal radiation in TQ phase, (a) single Ne SPI; (b) dual SPIs



Relative variation of radiation (a) Ar SPI; (b) Ne SPI; (c) dua SPIs

CONCLUSION

- The dual SPIs system has been developed on J-TEXT.
- The dual SPIs can accelerate the plasma current decay at CQ, and the CQ rate exceeds the 70 MA/s of Ne SPI.
- The dual SPIs can reduce the localized thermal radiation and improve the radiation asymmetry.

REFERENCES

[1] Baylor, L. R. , et al. IEEE Transactions on Plasma Science 44.9(2016):1489-1495.
[2] Herfindal, Jeffrey L., et al. Nuclear Fusion 59.10 (2019): 106034.
[3] Li, Y., et al. Review of Scientific Instruments 89.10 (2018): 10K116.