



Overview of Operation and Experiments in the ADITYA Upgrade Tokamak

OV/5-3

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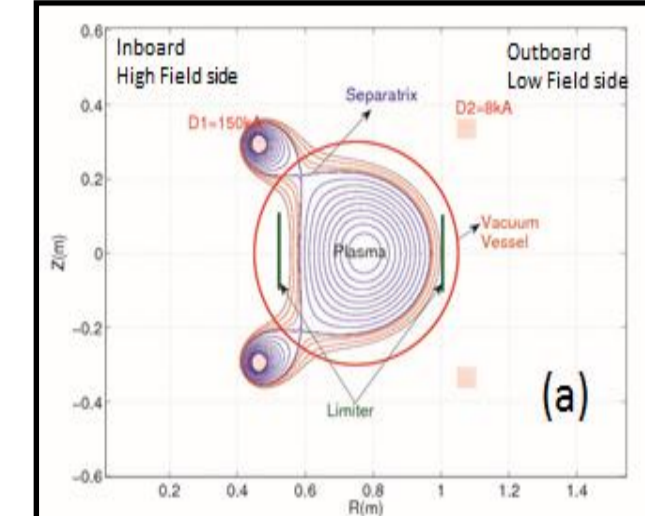
Introduction to ADITYA Upgrade Tokamak

ADITYA-U an Ohmically heated, med. size, toroidal graphite limiter tokamak has been upgraded for carrying out experiments with shaped plasmas in open divertor geometry

AIM: To carry out experiments such as disruption and runaway mitigation studies relevant to future fusion machines

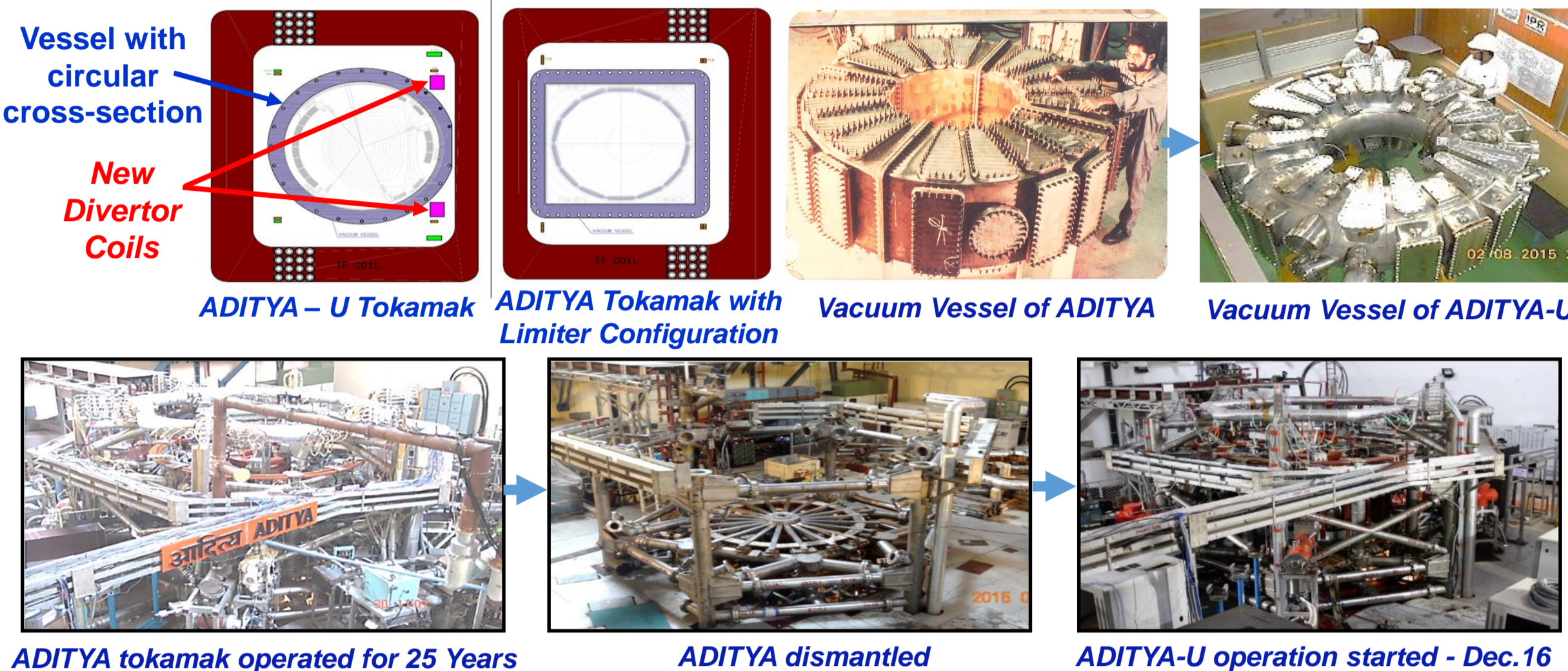
Parameters	Design		Achieved Parameters
	Circular plasma	Shaped plasma	
Major radius (R)	0.75 m	0.75 m	0.75 m
Minor radius (a)	0.25 m	0.18 - 0.22 m	0.25 m
Plasma Shape	Circular-tor. limiter	D shaped	Circular-tor. limiter
Toroidal Field	1.5 T	1.5 T	1.35 T
Plasma Current	250 kA	150 kA	135 kA
Plasma Duration	300 ms	300 ms	190 ms
Electron Density	$4.0 \times 10^{19} \text{ m}^{-3}$	$5.0 \times 10^{19} \text{ m}^{-3}$	$4.0 \times 10^{19} \text{ m}^{-3} \pm 10\%$
Electron Temp.	500 eV	500 eV-1 keV	300 eV \pm 30%
Ion Temp	200 eV	300 eV	140 eV \pm 30%
Elongation	1	1.1-1.2	1
Triangularity	0	0.45	0

Transforming ADITYA to ADITYA - U Tokamak



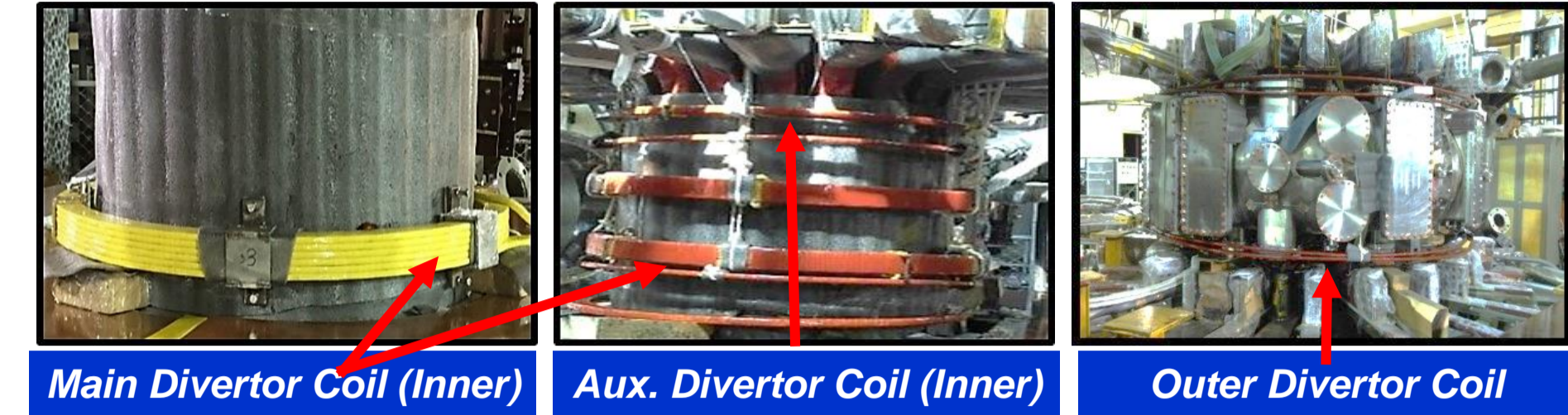
Plasma equilibrium reconstruction with equilibrium code IPREQ
SN and DN configuration in ADITYA-U can be made possible by introducing two sets of new PF coils

Addition of Divertor coils are possible if the Vacuum Vessel of ADITYA Tokamak is modified by circular cross-section

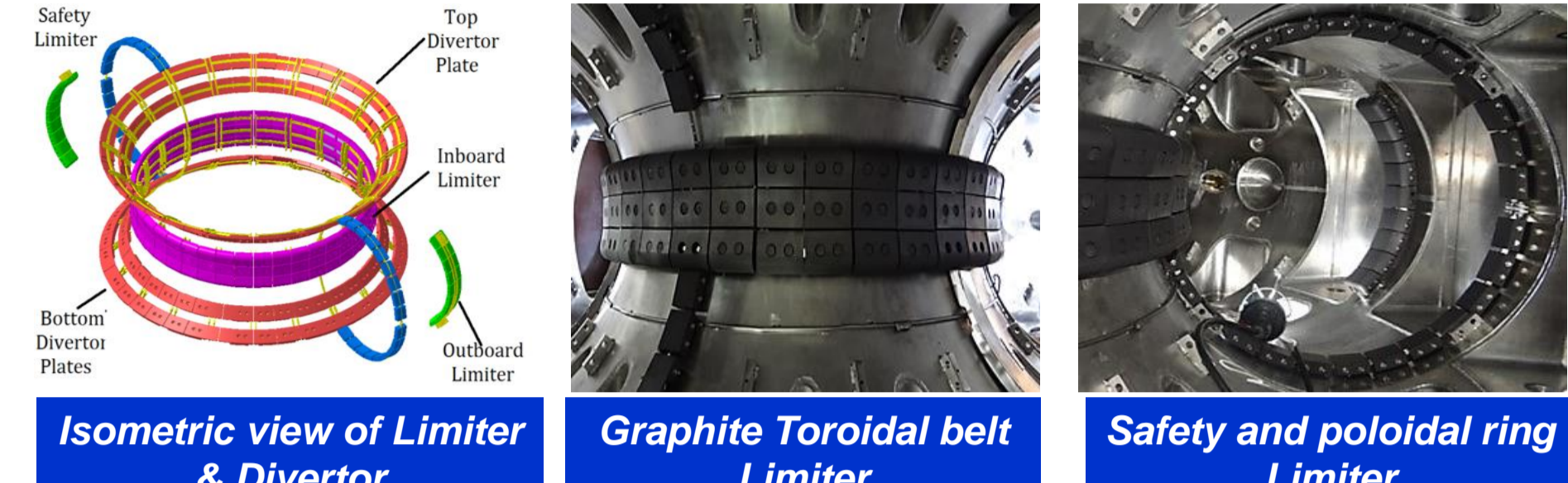


New Inclusions in ADITYA - U Tokamak

Three sets of divertor coils

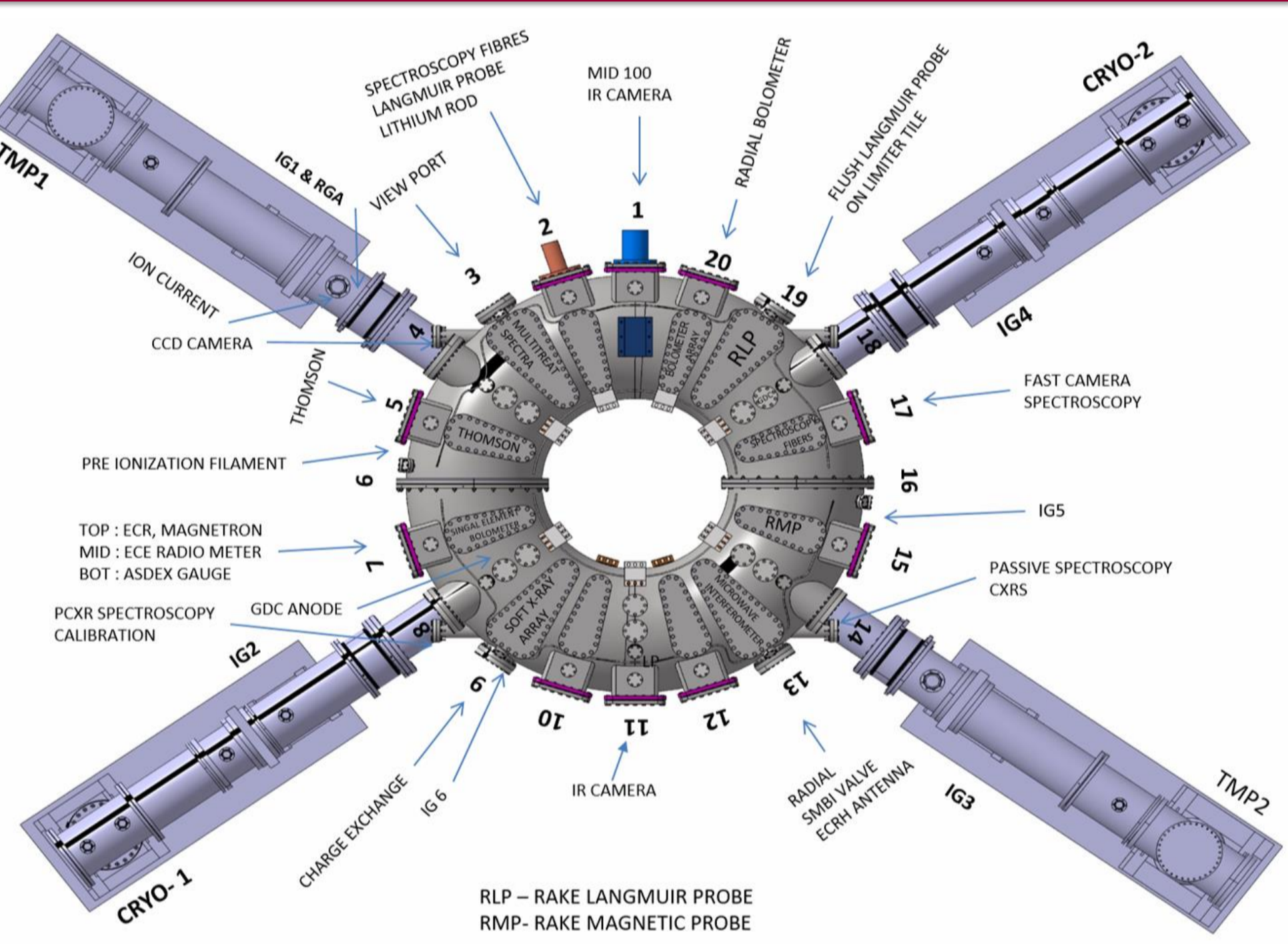


Plasma Facing Components (PFC)

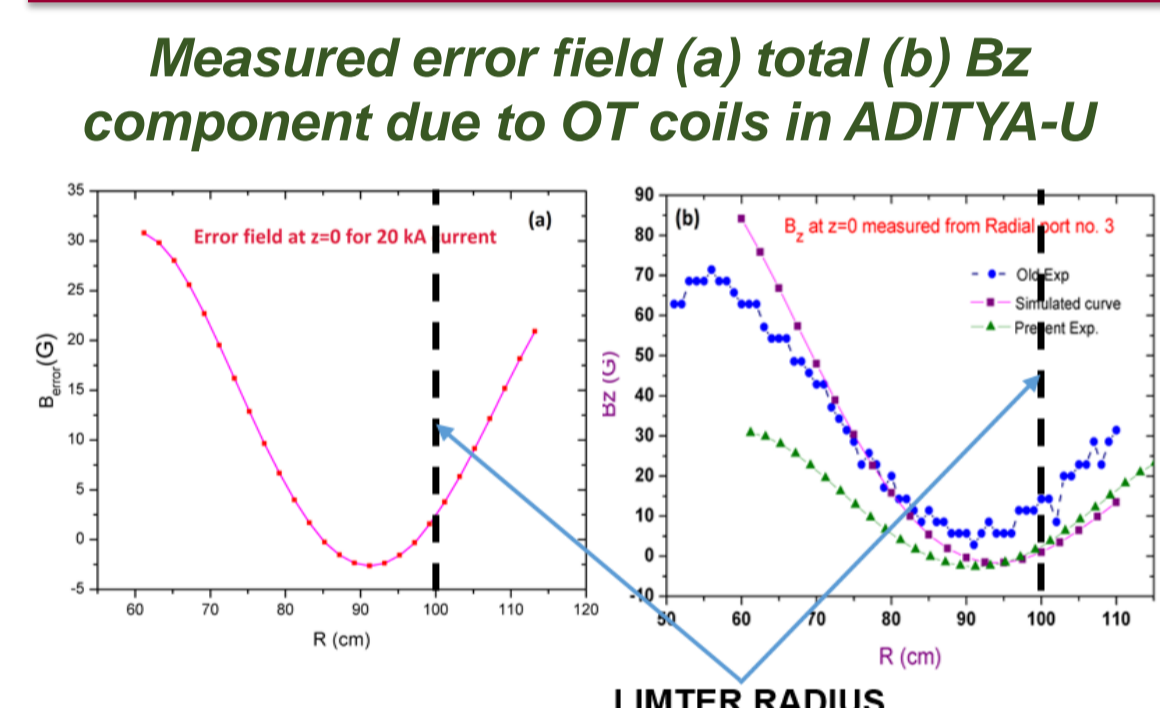


- Major Diagnostics installation
- Calibration of in-vessel magnetic diagnostics
- Baking heaters installation and vacuum vessel baking

Major Diagnostics Systems of ADITYA Upgrade



Operation Preparation before 1st Plasma in ADITYA - U

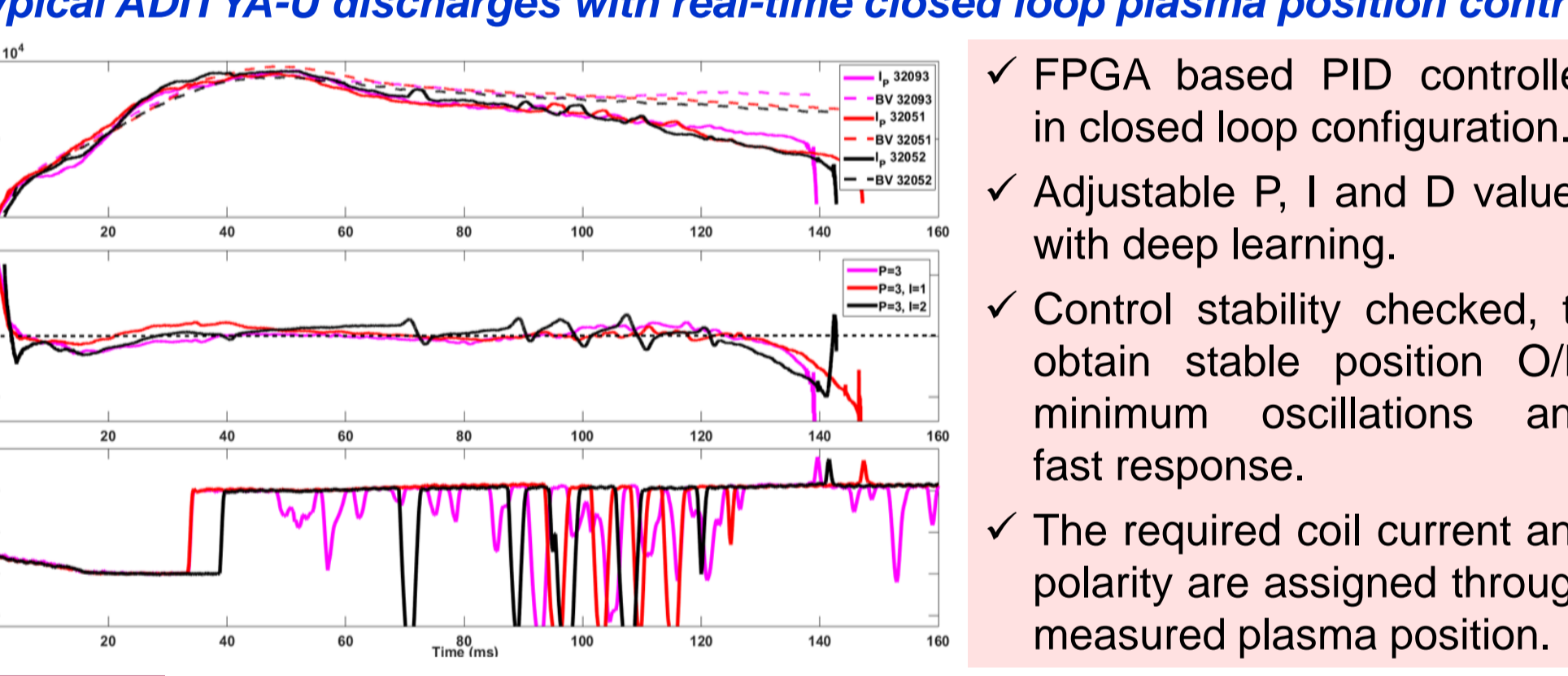
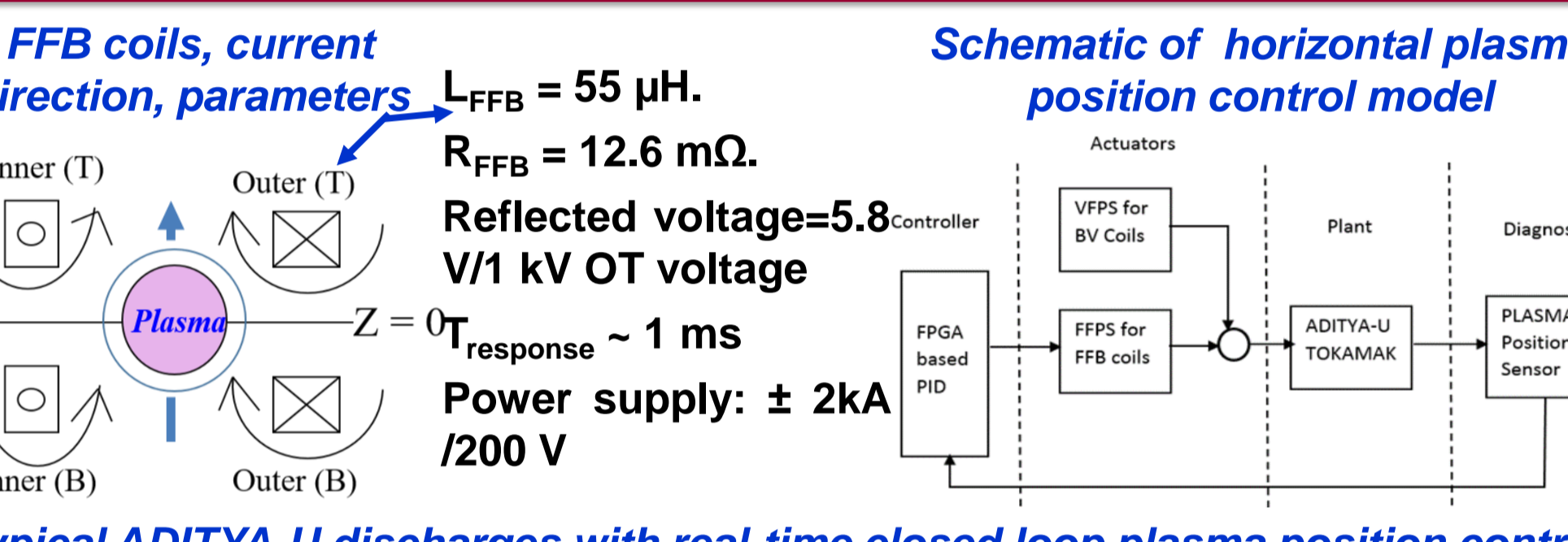


Error Field Measurements:
Magnetic field coils are accurately positioned with a precision tolerances of ± 1 mm during commissioning of ADITYA-U.
Error field: $\frac{B_{err}}{B_T} \sim 5 - 7 \times 10^{-4}$ (nearly $\frac{1}{2}$ to $\frac{1}{3}$ of the error-field values prevailing in ADITYA)

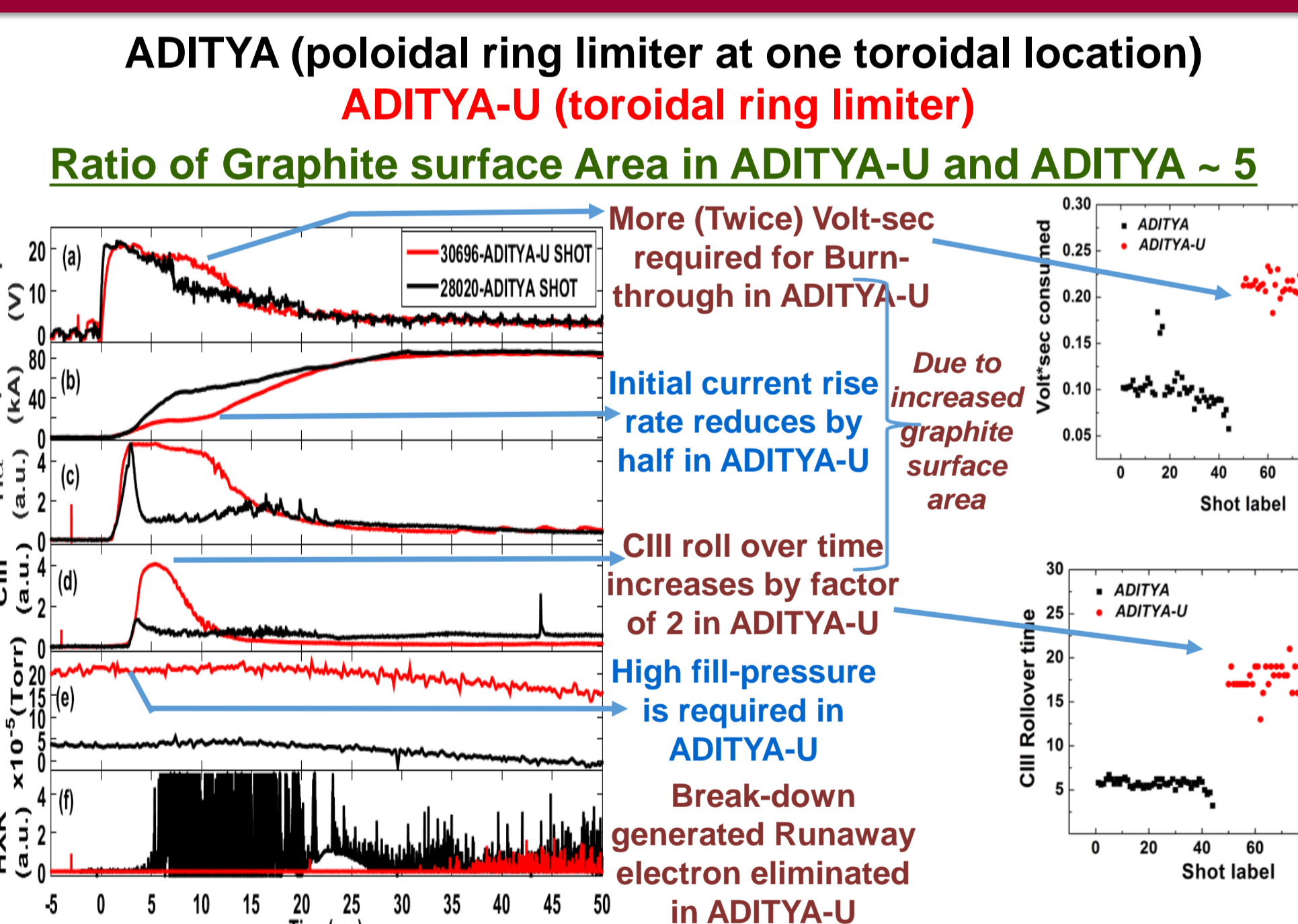
Wall Conditioning:

- Continuous GDC for long hours (~12 h)
- Low parameter discharge pulses in ECR plasma background
- Vessel Baking $\sim 130^\circ\text{C}$
- Base pressure of $\sim 9 \times 10^{-9}$ Torr
- A novel concept of Pulse GDC instead of continuous to reduce H_2 recycling.

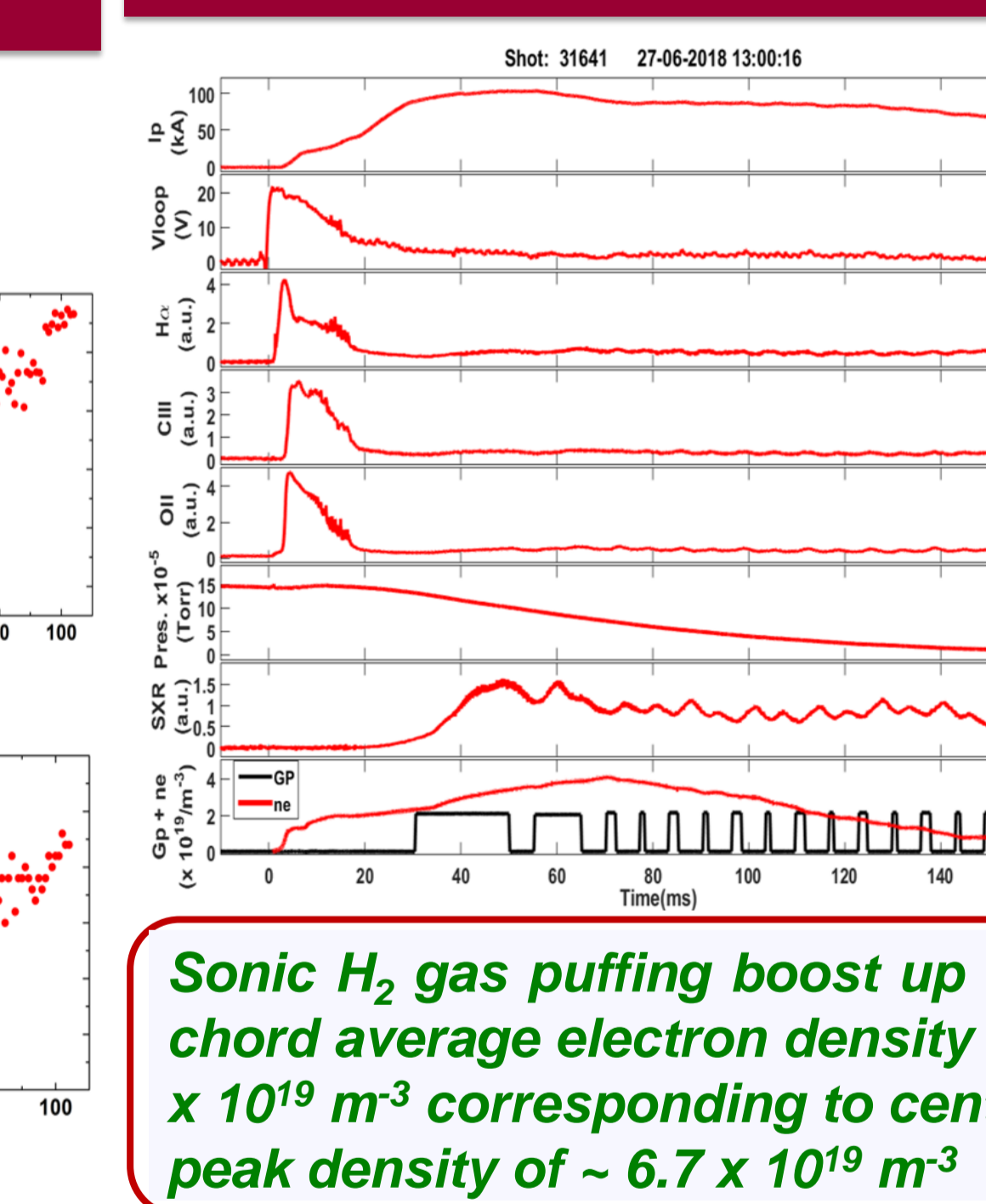
Real Time Horizontal Plasma Position Control



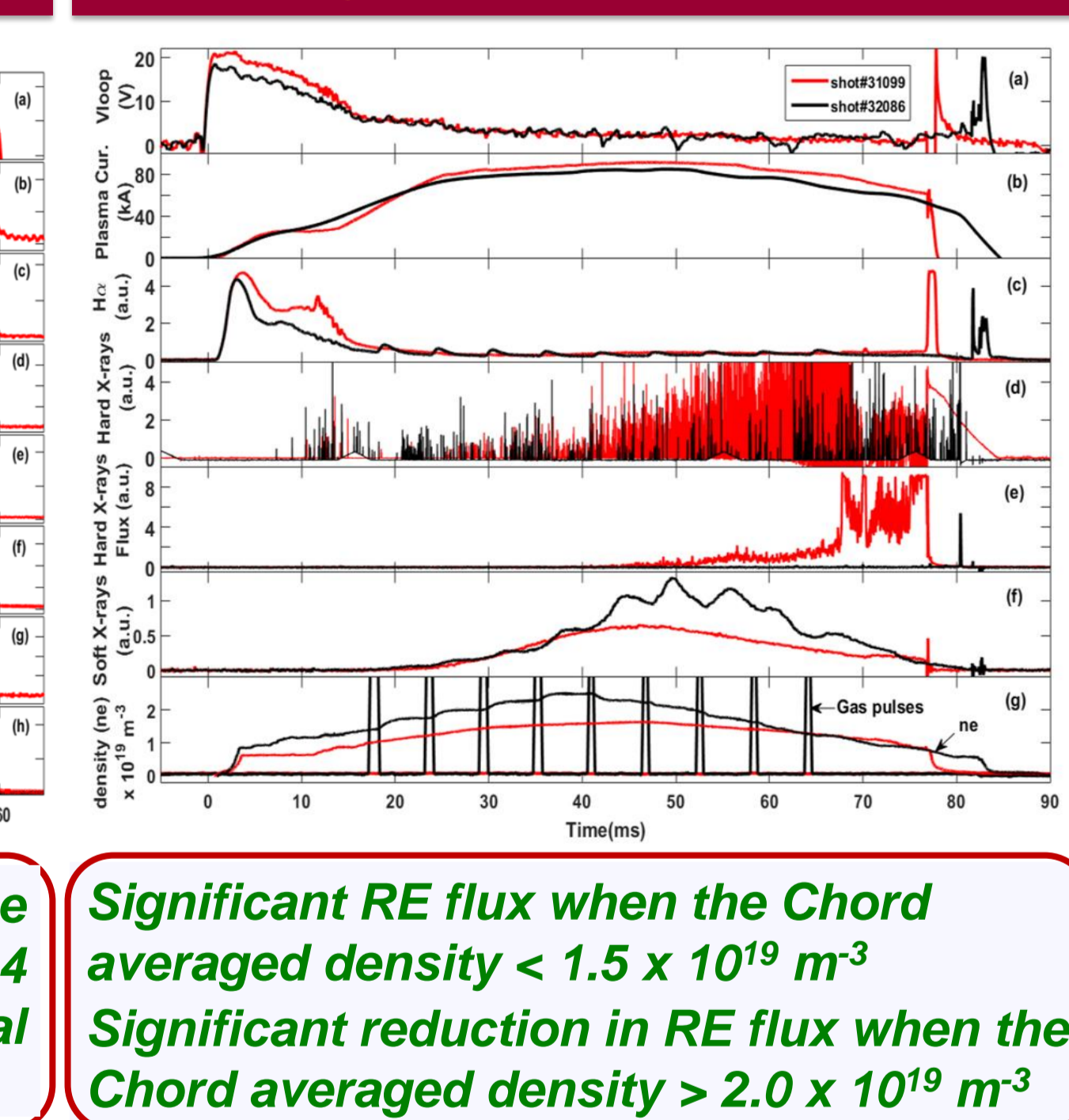
Comparison of Breakdown and Ramp-up phases of ADITYA and ADITYA-U



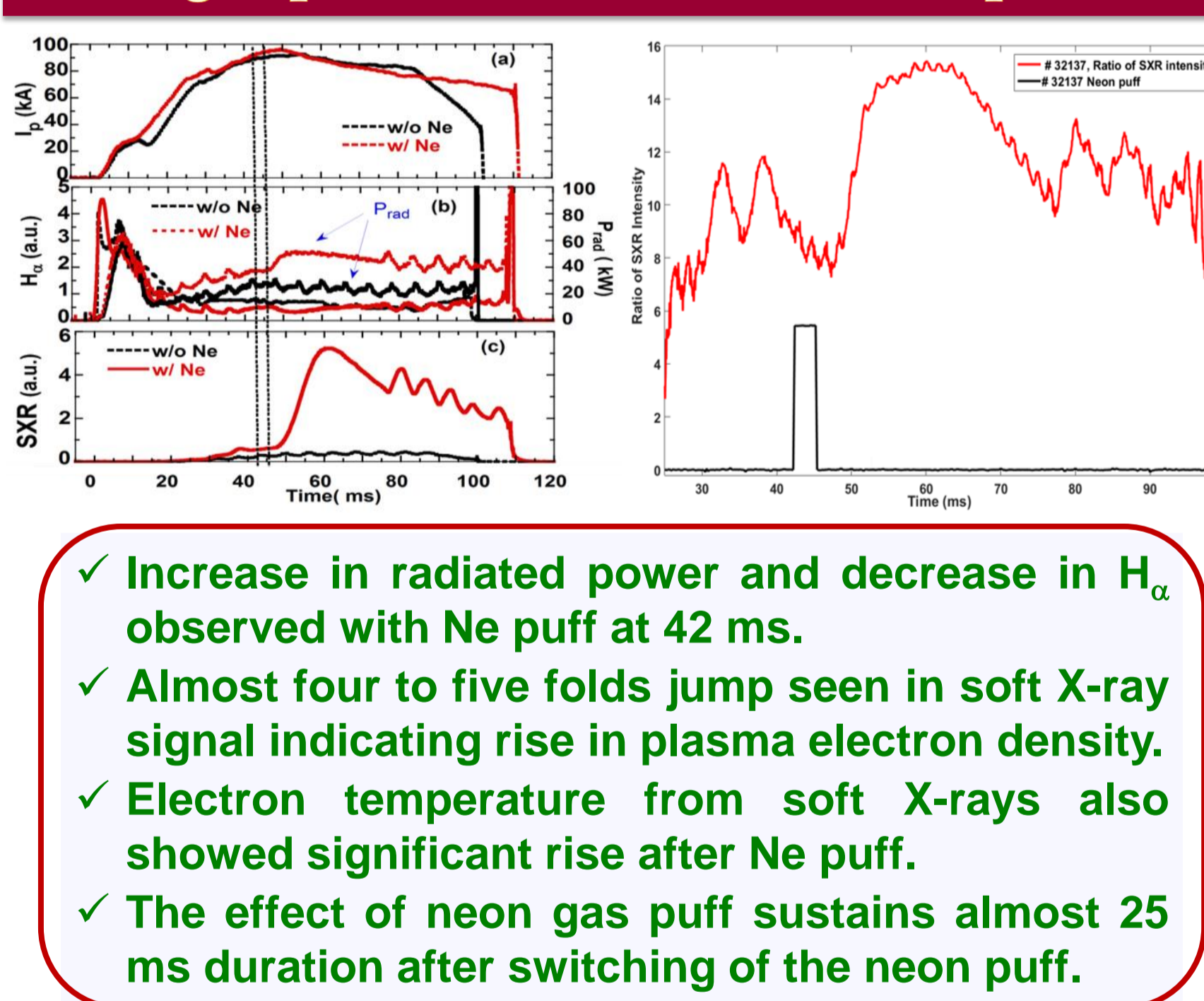
Density Enhancement



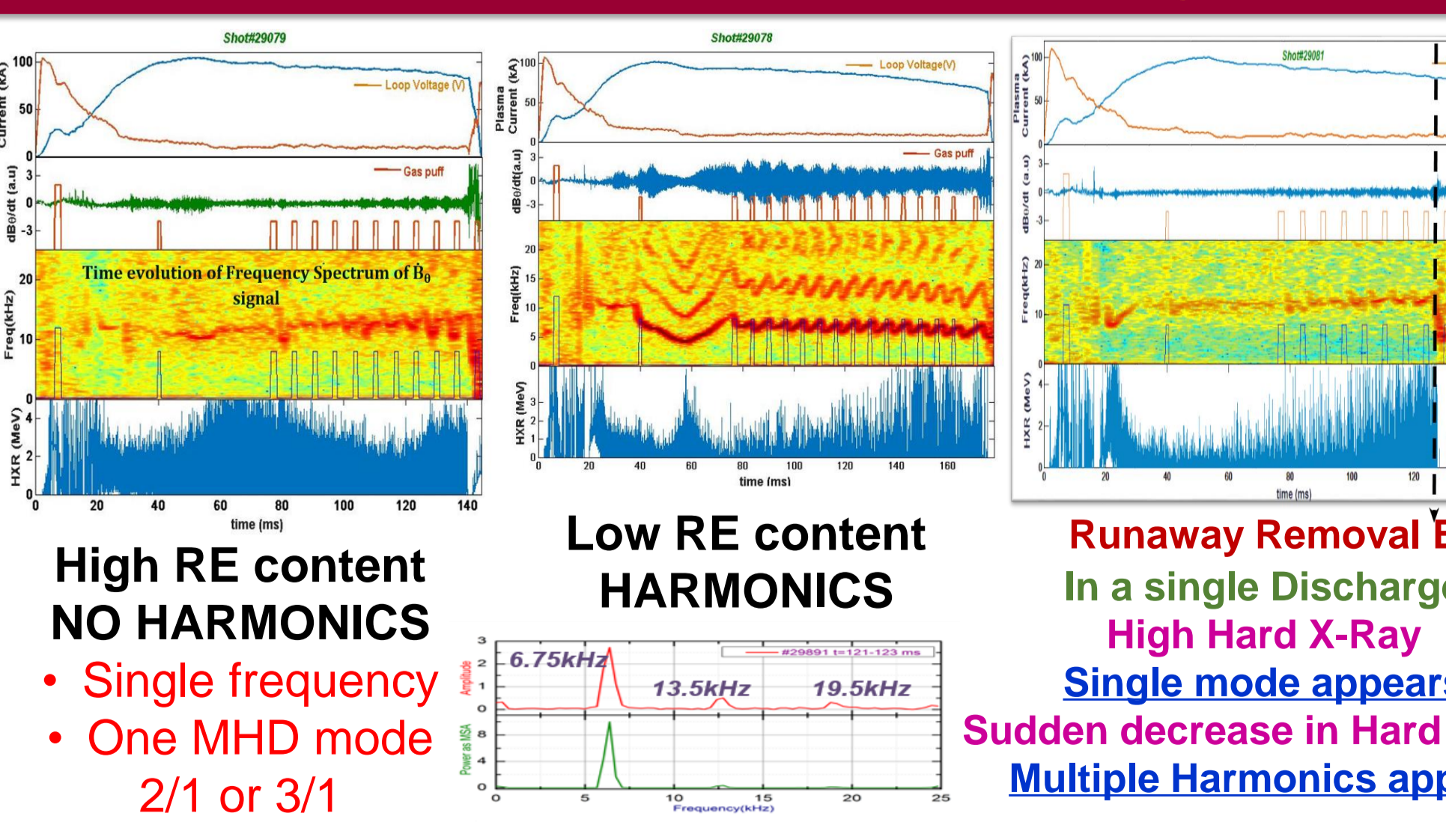
Discharges with & without REs



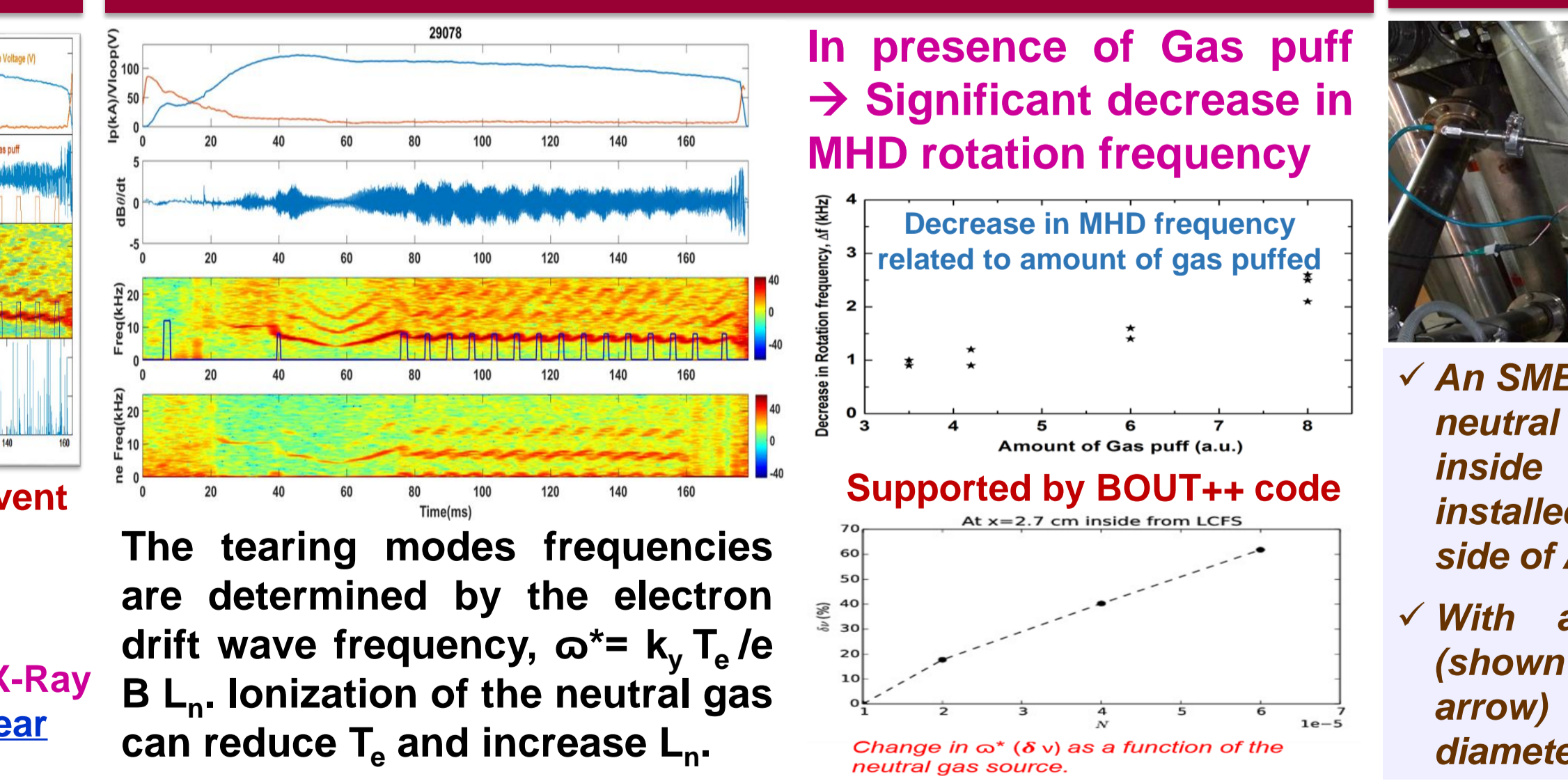
Neon gas puff assisted RI Mode Experiment



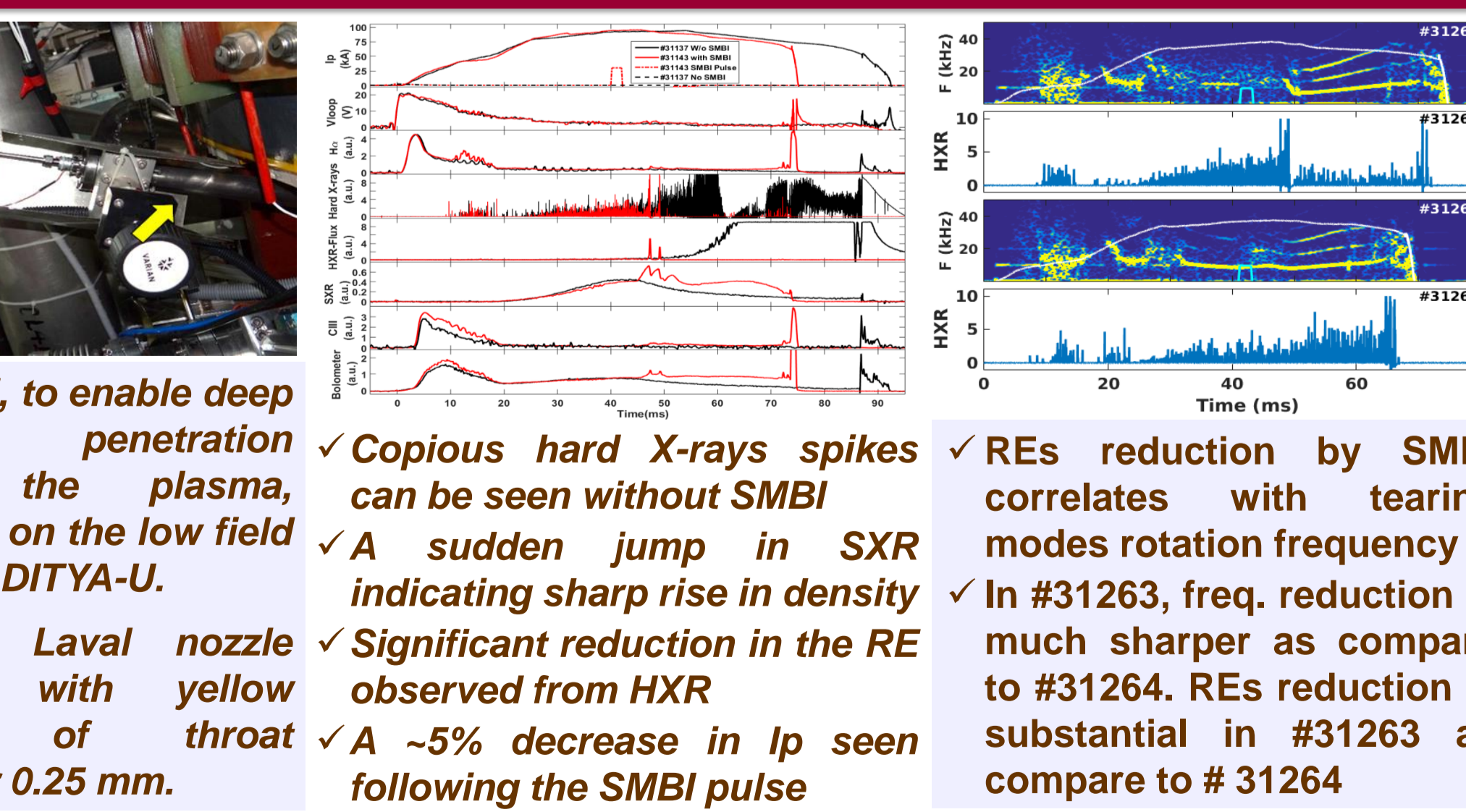
Multiple Harmonics of Drift-Tearing Modes



Modulation with Periodic Gas Puffs



Effect of SMBI on RE Suppression in ADITYA - U



SUMMARY:
The first Indian tokamak ADITYA (a=25 cm, R=75 cm) with limiter configuration, has been upgraded to ADITYA-U with divertor configuration and an additional graphite toroidal belt limiter. After successful commissioning of ADITYA-U, hydrogen gas breakdown has been achieved in more than 2000 discharges without a single failure.
Successful development and implementation of real time position control. Achieved wider pressure window and significant reduction in runaway electrons (REs) in ADITYA-U tokamak as compared to ADITYA tokamak.
The chord average electron density boost up $\sim 4 \times 10^{19} \text{ m}^{-3}$ corresponding to central peak density of $\sim 6.7 \times 10^{19} \text{ m}^{-3}$ has been achieved for the first time in ADITYA-U.
Analysis of drift tearing mode dominated discharges reveals presence of multiple harmonics. Observation of MHD frequency and amplitude modulation by periodic gas puffs. Evidence of dominant role of MHD in REs loss in experiments with MHD amplitude modulated by periodic gas puffs.
Significant reduction of REs by application of SMBI has been observed. Radiative improved modes with Neon gas injection has been achieved and studied in ADITYA-U.