

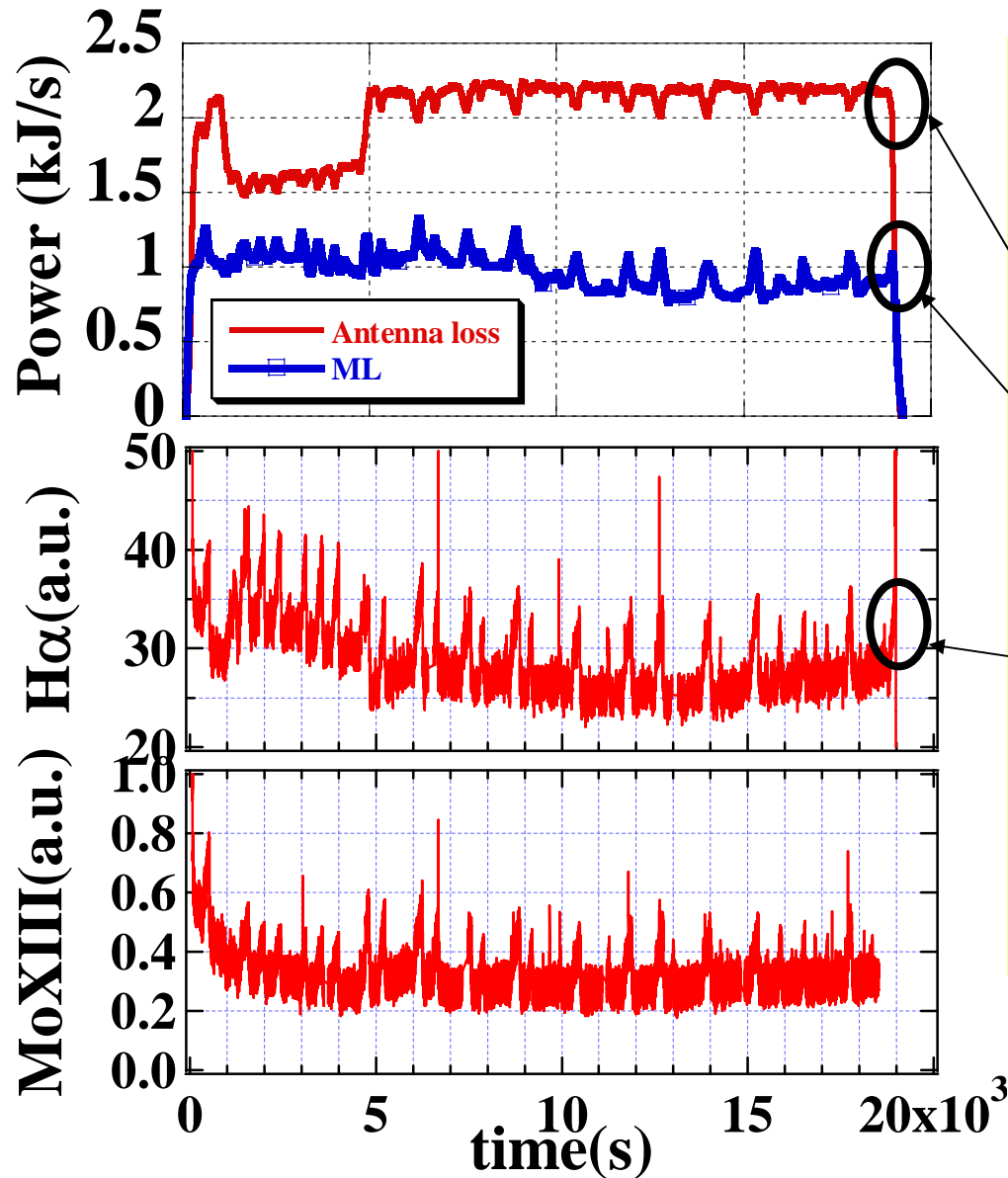
# **Plasma wall interaction induced oscillations and their effects on the global recycling from plasma facing materials in TRIAM-1M**

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- 2. dynamics of recycling**
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# Ultra Low Frequency Events

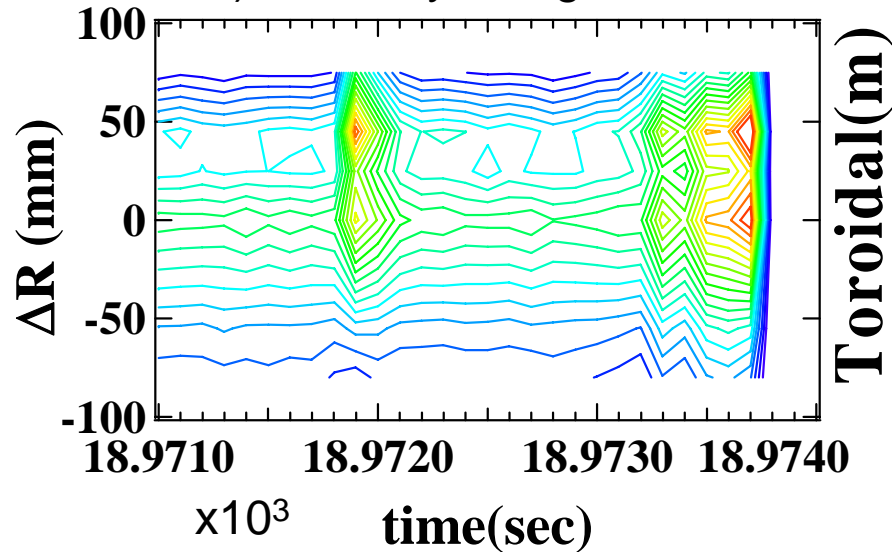


- ◆ Very low frequency semi-regular oscillations are found in signals on heat loads, particle recycling, and impurity influx and contents.
- ◆ Frequency  $\sim 1-2 \times 10^{-3}$  Hz  
amplitude  $\sim$  a few %– 100 %
- ◆ During **the last ULF event**, the five hour discharge terminated.

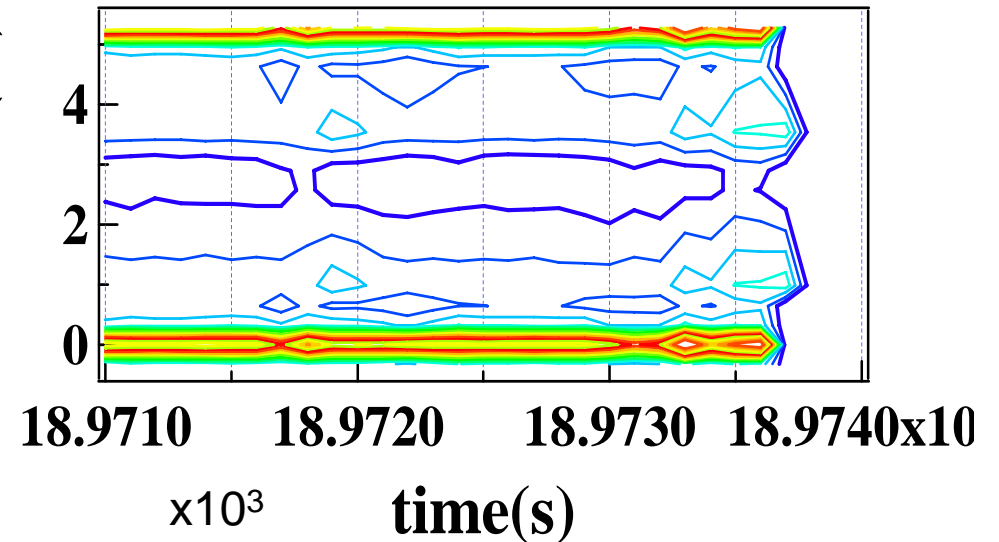
H.Zushi NF (2005)

# Termination during the last ULF (Ultra Low Freq. )events

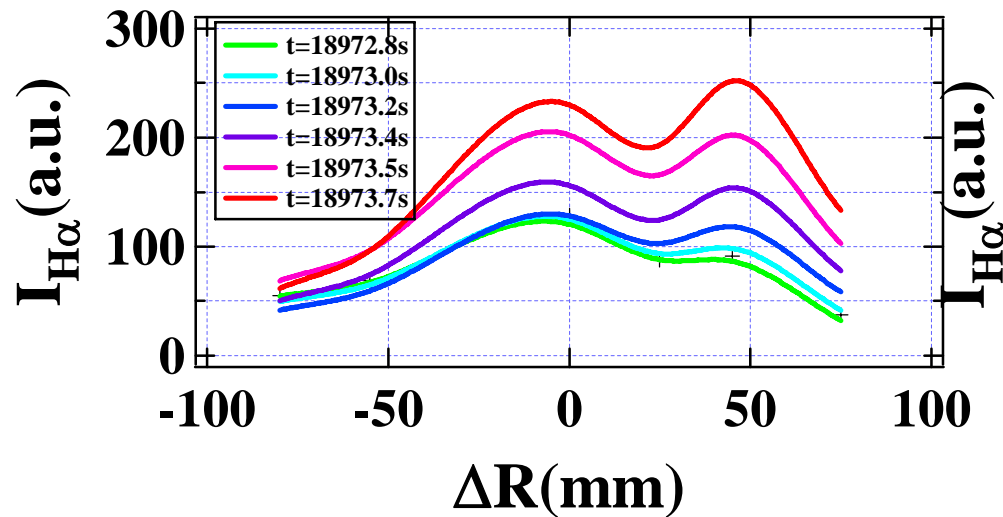
1) H $\alpha$  array along the R



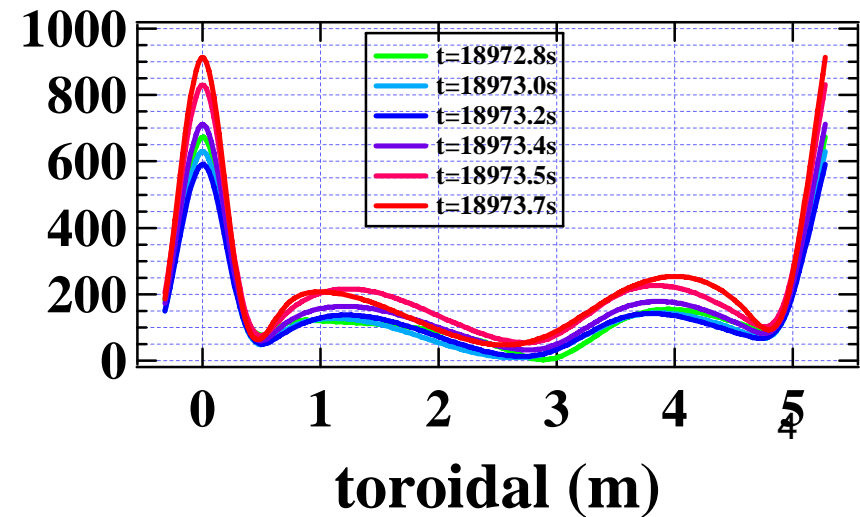
2) H $\alpha$  array at R=R<sub>0</sub>



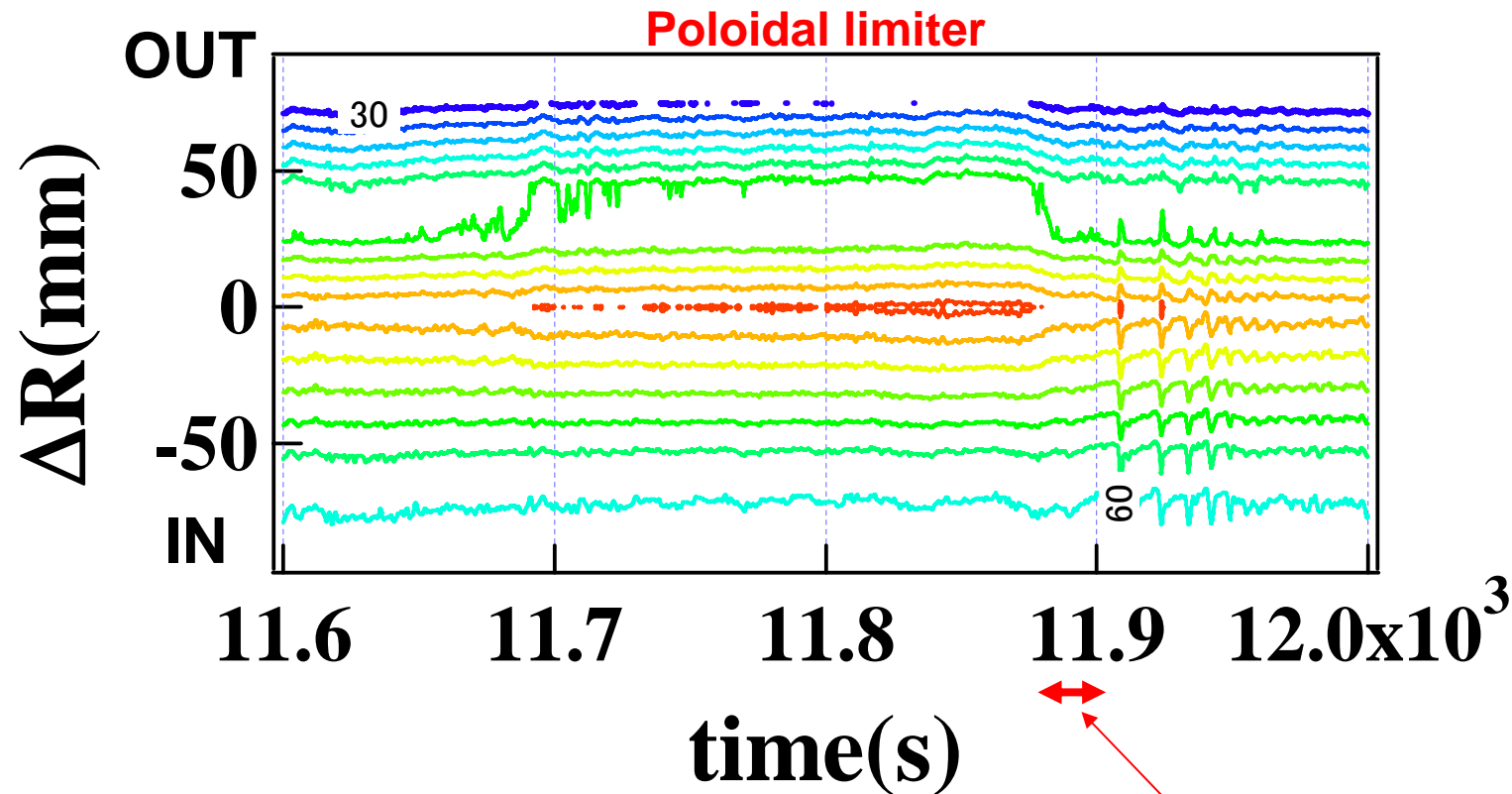
Poloidal limiter



limiter

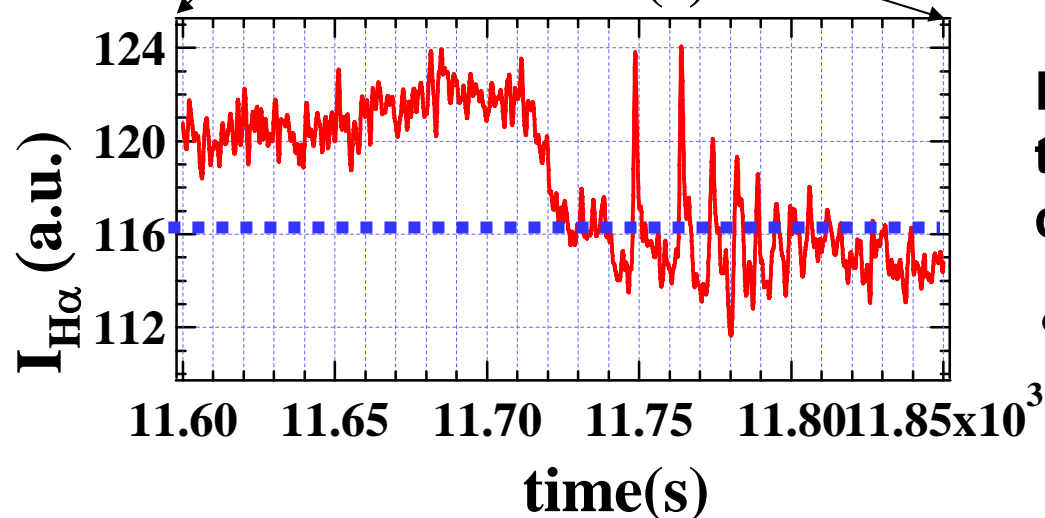
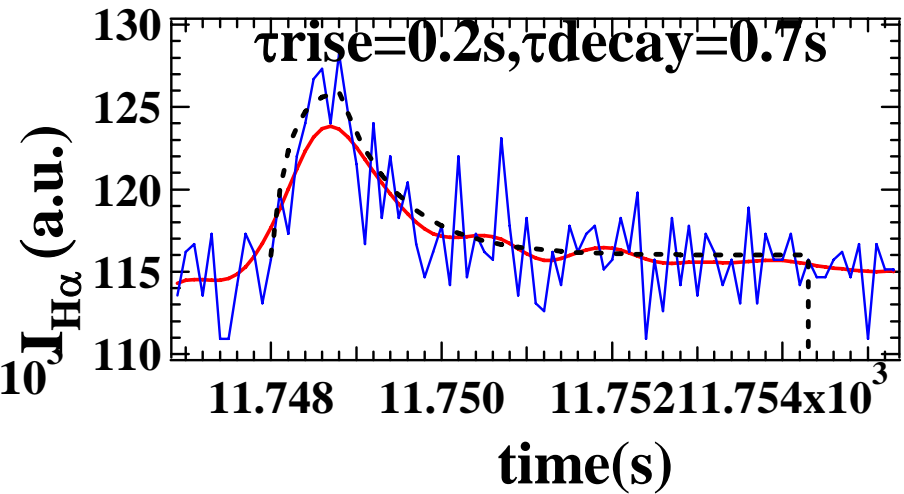
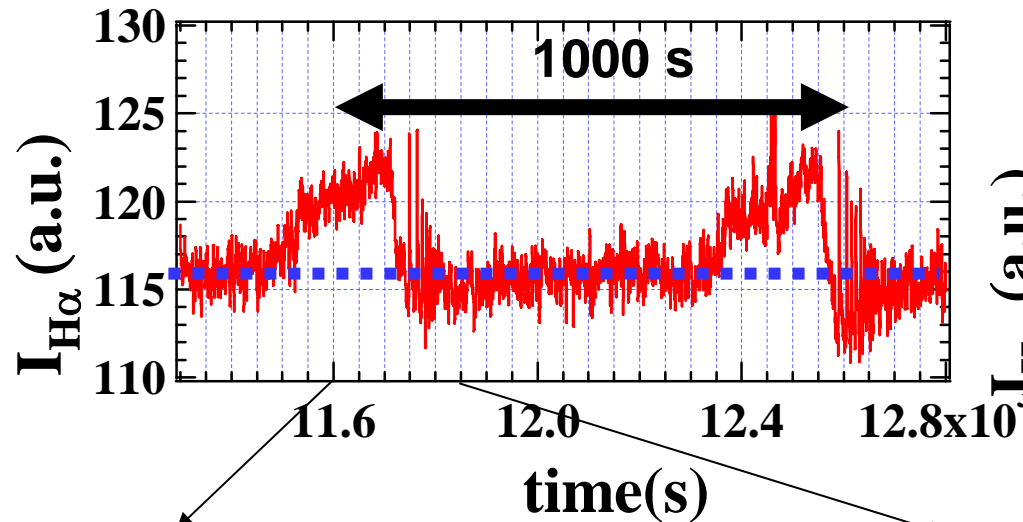


# ULF event followed by gas puff FeedBack - oscillations



The horizontally integrated  $H\alpha$  is used as a particle flux indicator  
At the end of ULF events the FB gas was stopped for  $\sim 20$ s and then  
was hunting. This causes oscillations of  $H\alpha$  with a few % around the torus.  
1.A plasma is closed to “the **wall saturation** condition”.

# Hunting oscillations followed by ULF Events



**Long decay time of  $H\alpha$  suggests that the conditions of PFCs are close to be a saturation level.**

$\delta H\alpha/H\alpha$  at the limiters are a few %.

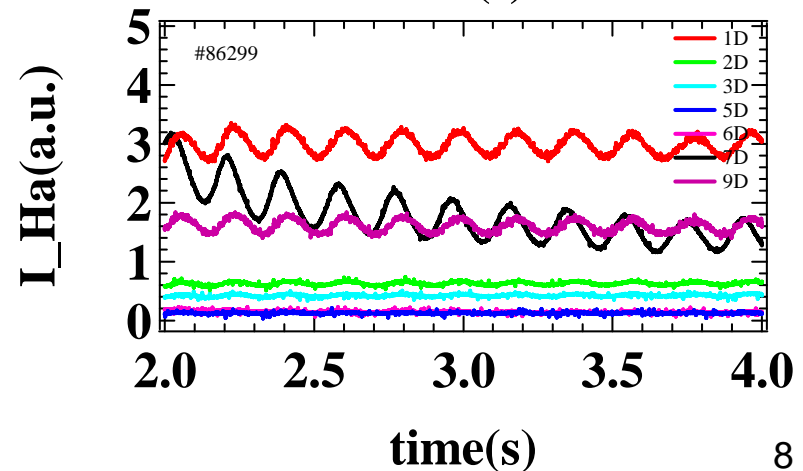
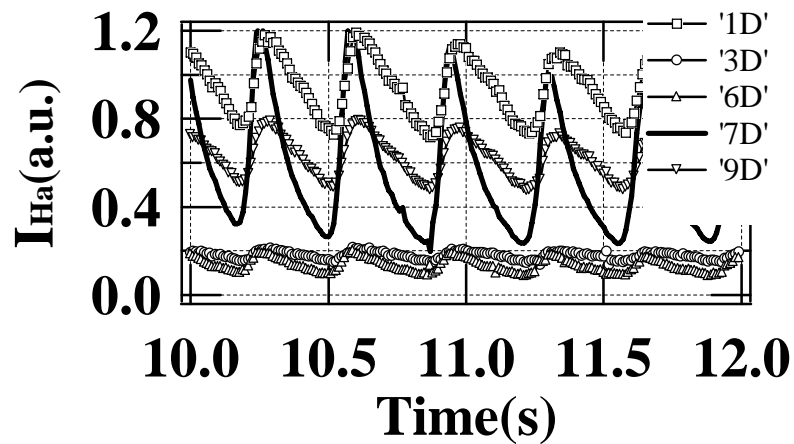
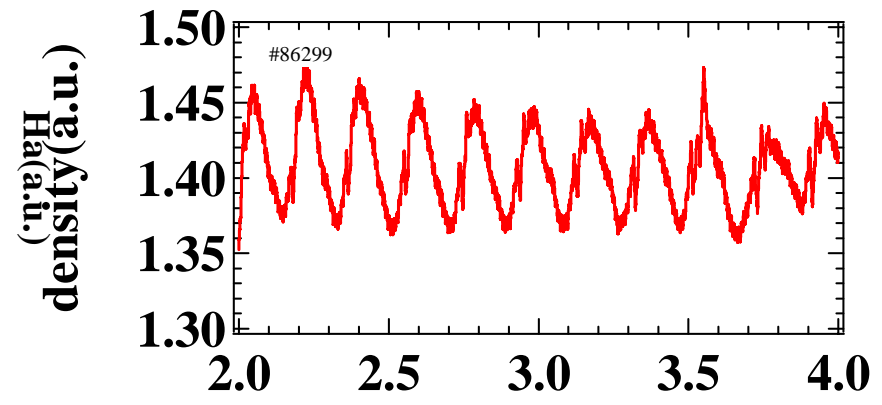
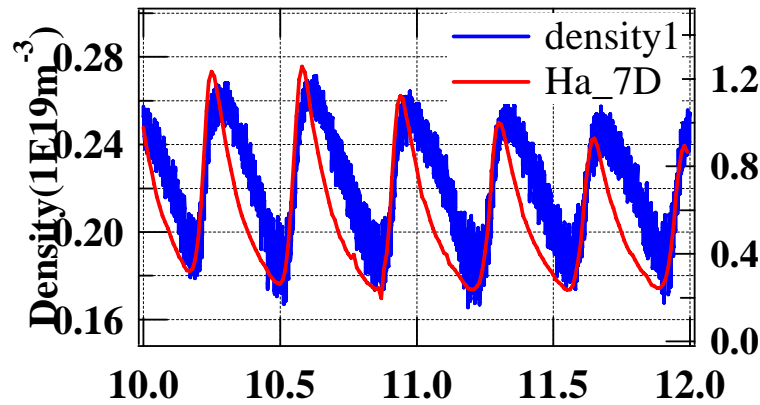
# Experiments

- **How does the perturbations affect on the toroidal recycling structure or does these propagate around the torus?**
  - => correlation phase by FFT analysis**
- **Does this response depend on the localization or uniformity of the particle perturbation?**
  - => local gas injection**
  - => core confinement relaxation oscillation**

# I.(1) Gas modulation exp.

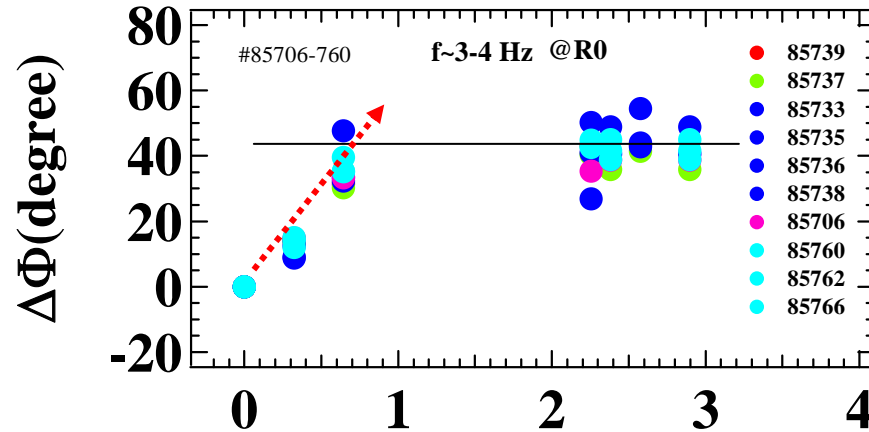
1)  $n_e \sim 0.1-0.2 \times 10^{13} \text{ cm}^{-3}$   
 $\Delta n_e/n_e \sim 18\%$ ,  $\Delta H\alpha/H\alpha \sim 70\%$

2)  $n_e \sim 1.4 \times 10^{13} \text{ cm}^{-3}$   
 $\Delta n_e/n_e \sim 5\%$ ,  $\Delta H\alpha/H\alpha \sim 20\%$



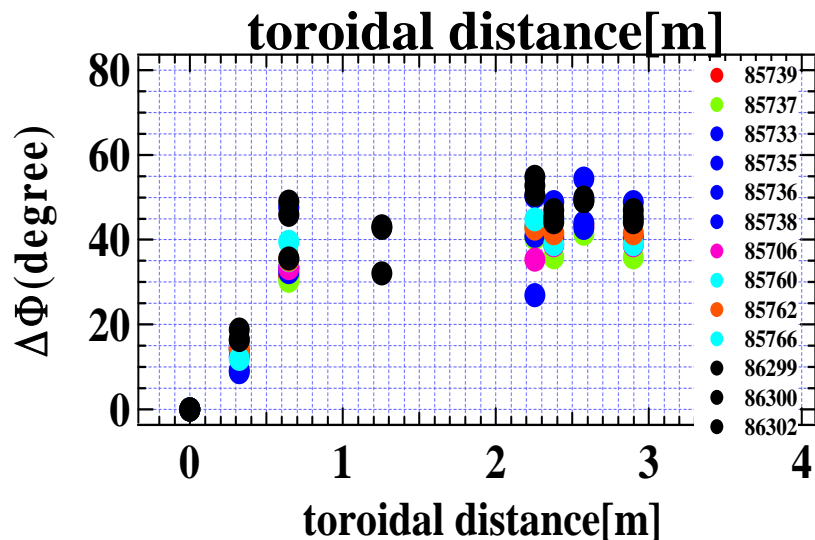


# I. (2) Phase analysis @3-8 Hz ( $1 \times 10^{12} - 1.5 \times 10^{13} \text{ cm}^{-3}$ )



Low ne  
RF power ~10-20 kW  
B=6T

Gas source at 0  
 $V_{\text{Diffusive}} \sim 25 \text{ m/s}$



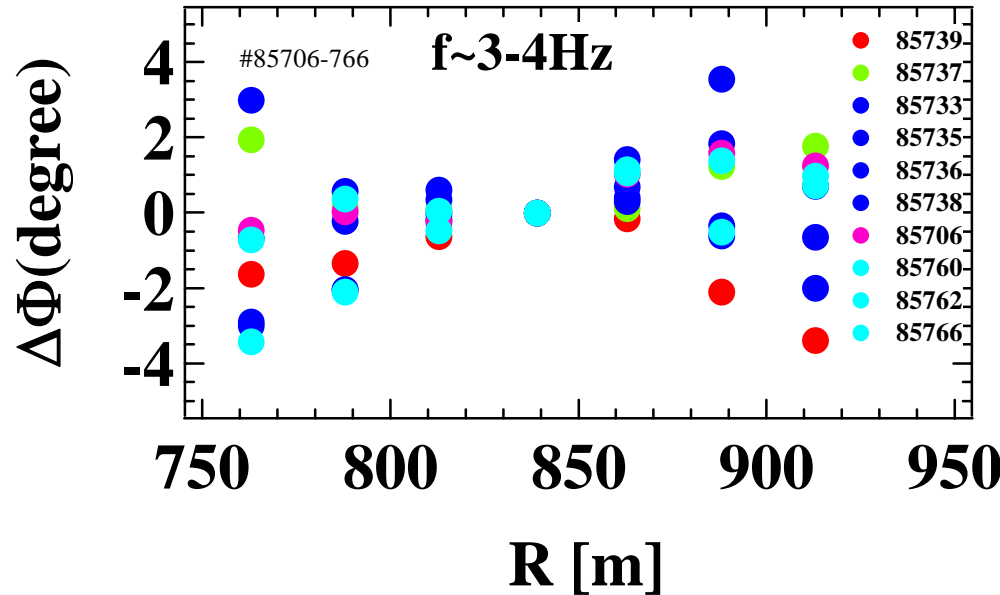
High ne  
RF power ~60 kW  
B=7T  
(Black symbols)

Gas source at 0  
 $V_{\text{Diffusive}} \sim 45 \text{ m/s}$

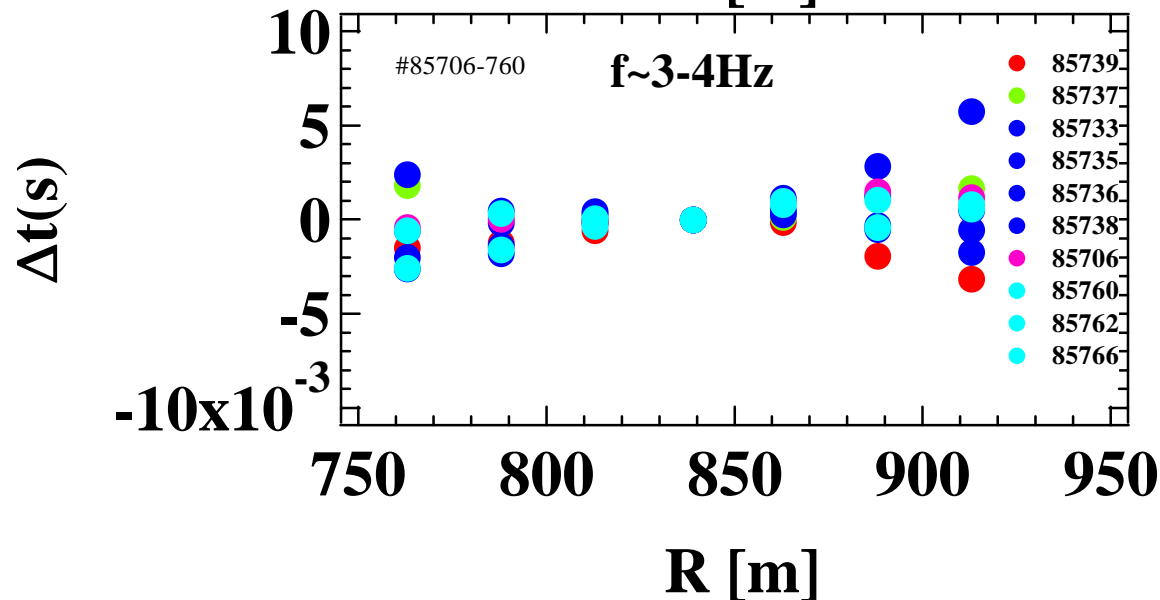
Phase difference of Ha at toroidal array

Shows a particle diffusion near the gas port

# I. (3) poloidal structure

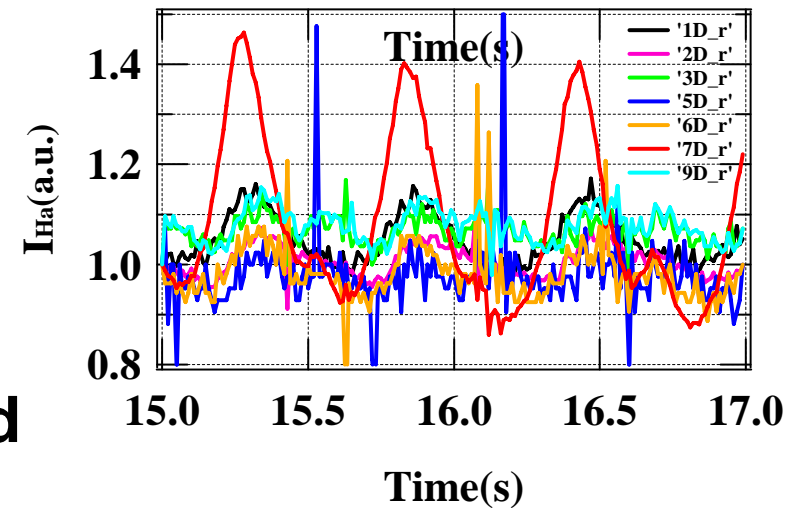
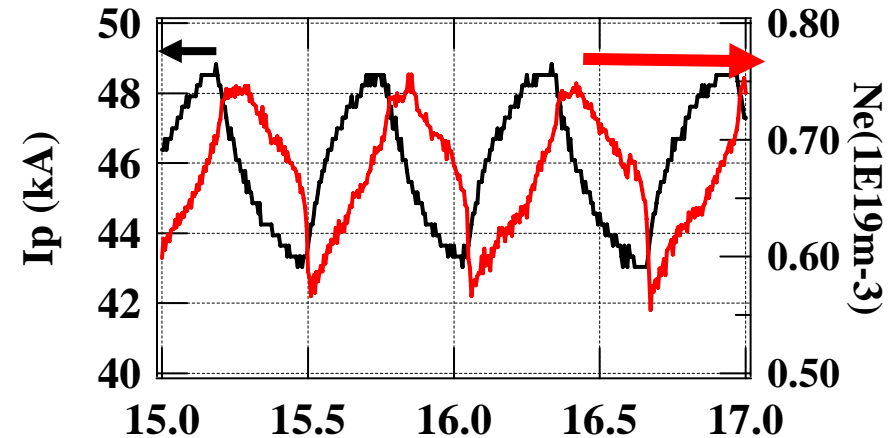
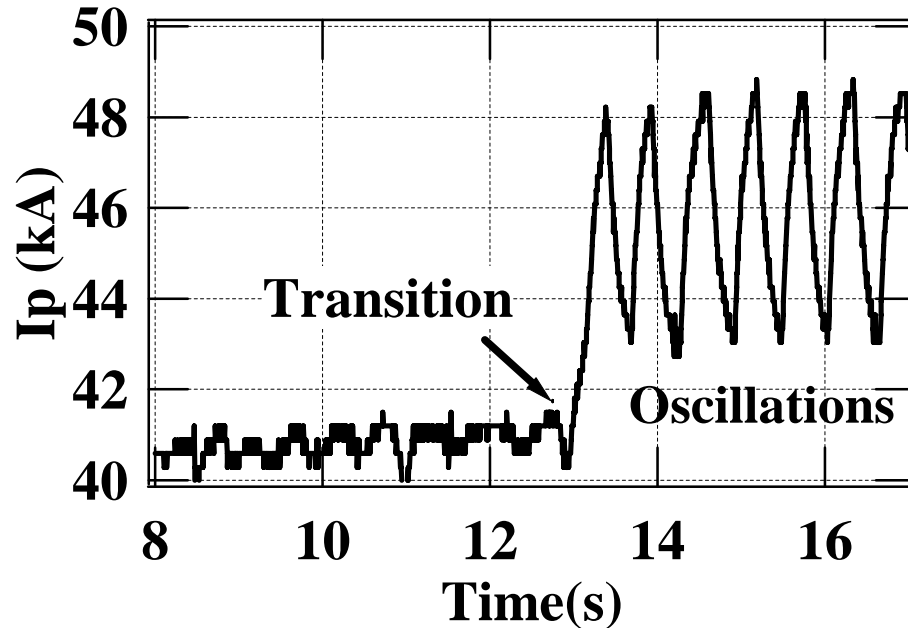


Although the perturbation diffuses from the gas port around the torus, a poloidal structure seems to be established within 5 ms.



# II. (1) confinement induced relaxation oscillations

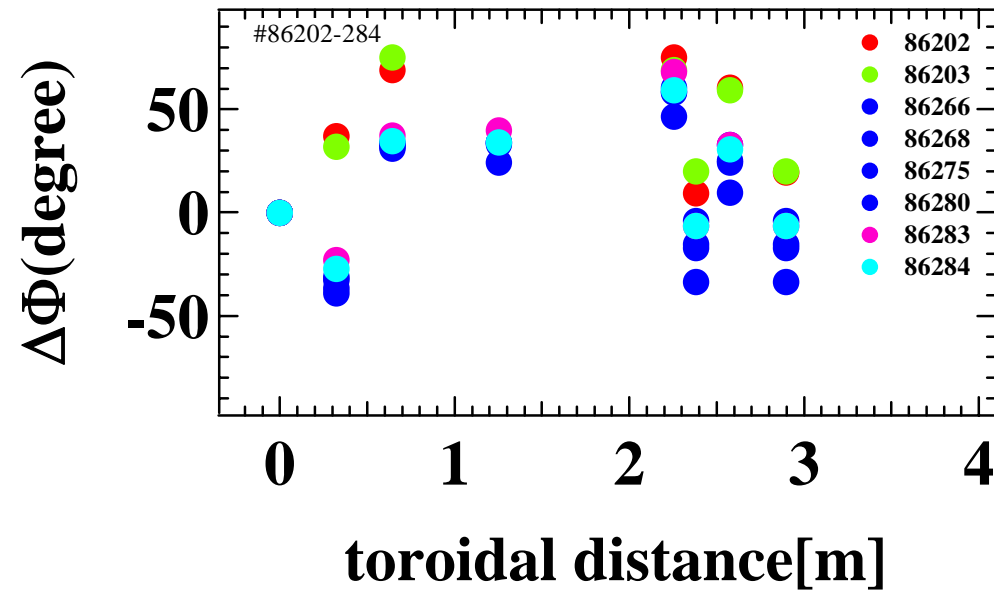
$\Delta n_e/n_e \sim 15\%$ ,  $\Delta H\alpha/H\alpha \sim 10\%$



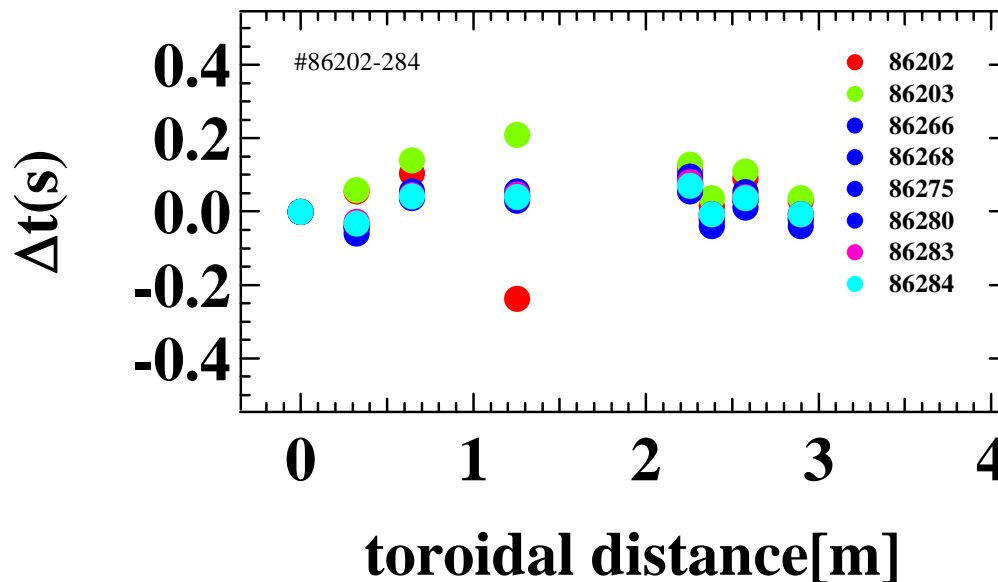
Transition to a mode w/ high current drive efficiency near or below the power threshold of 60 kW @ 7T

$N_e$ -rise precedes  $H\alpha$  @ gas port

## II. (2) weak / no toroidal propagation structure

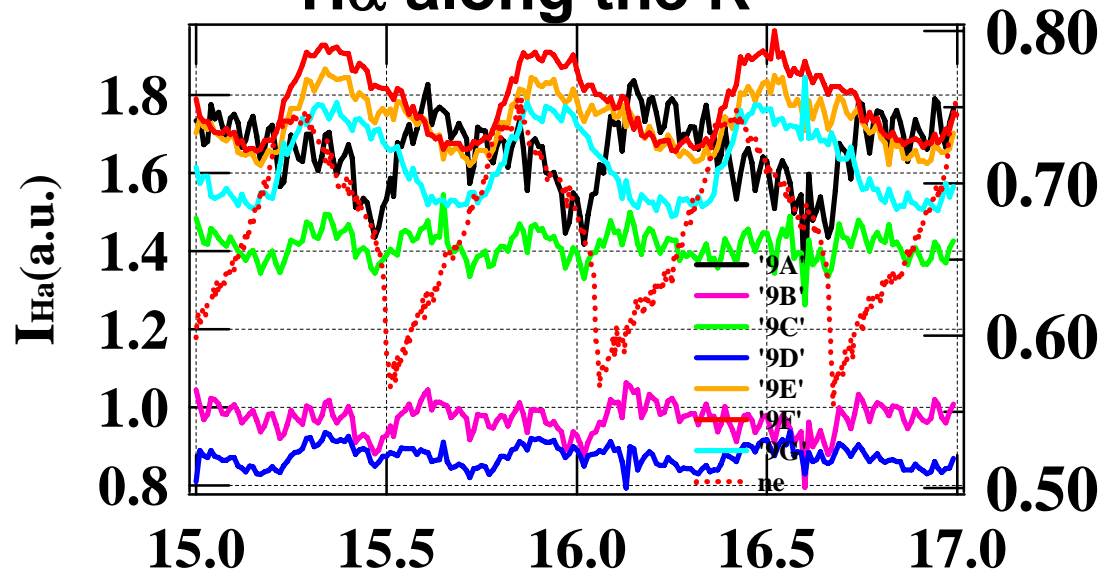


No toroidal propagation is found within  $\pm 50$  degree.



# II(3) In-out asymmetric PWI

H $\alpha$  along the R

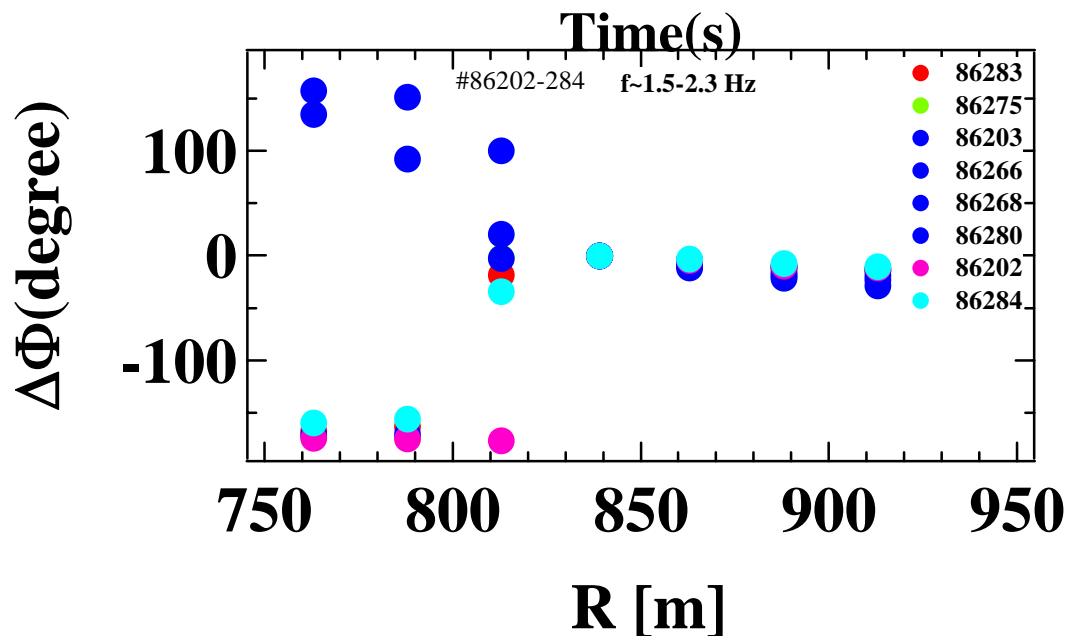


0.80  
0.70  
0.60  
0.50

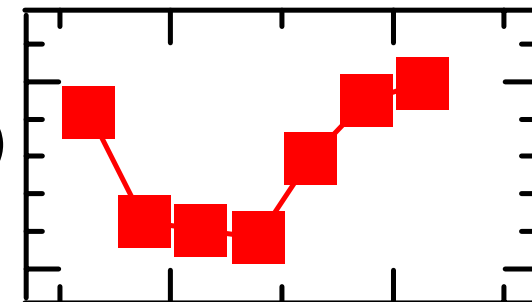
In-board – black  
Out-board- sky blue  
Center-green (2xf)

Relaxation oscillations  
Show an m=1 type  
perturbation structure.

#86203 @1.7142[Hz]



S(f)

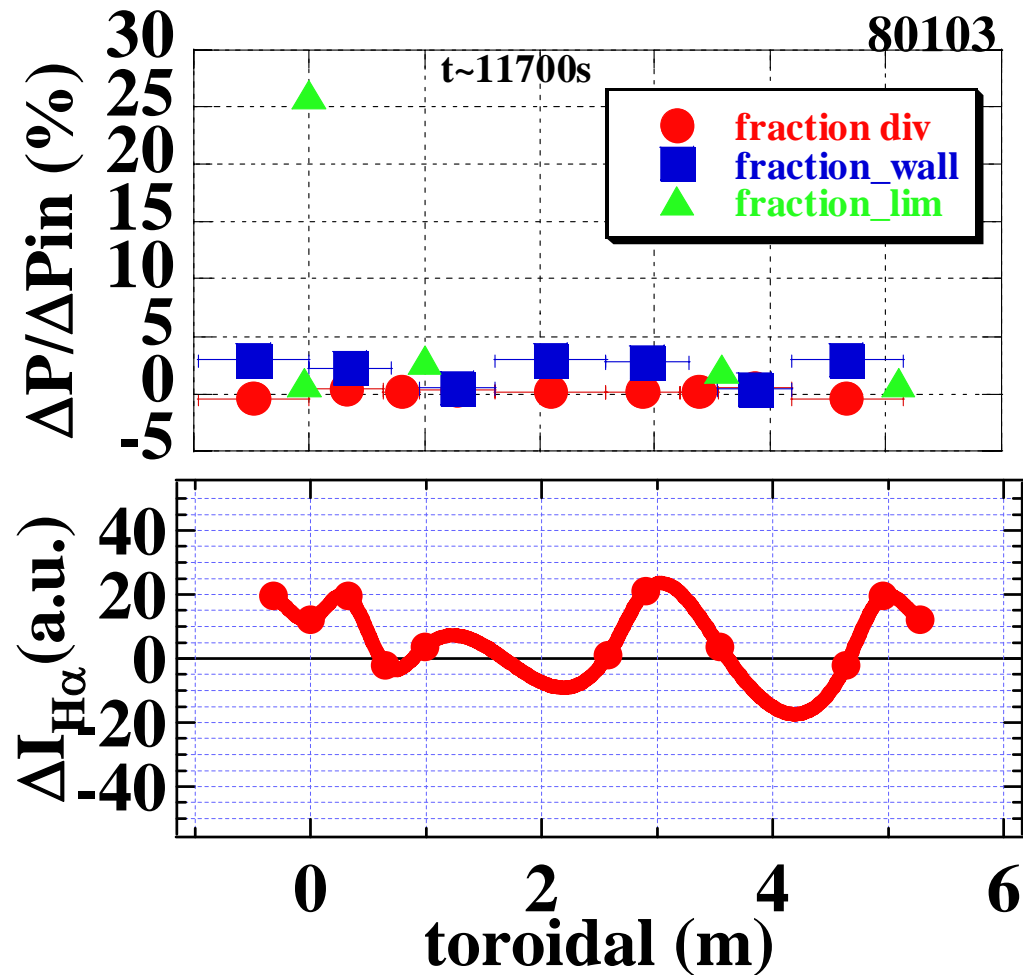


800 900 [mm]

# summary

- **Near the wall saturation conditions, the ULF events have been studied to search a cause of termination of SSTO.**
- **Two particle perturbations, localized and uniform, have been applied to change the recycling Ha.**
- **1) toroidal localized:  
recycling change diffuses w/  $U_{\text{tor}}$  of 20-50 m/s  
within ~0.6m**
- **2) toroidal uniform:  
recycling poloidal structure shows  $m=1$   
perturbation**

# Perturbed Heat load/ recycling profiles during ULF event



- ◆ **Difference** between heat load and recycling on ML
- ◆  $\Delta P$  variation is quite localized on the ML.
- ◆ However,  $\Delta H\alpha$  is not so localized.

# Perturbations & Termination

