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Effects of Gas-Fueling Control on Plasma Performance in Heliotron J

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Abstract

- **A gas fueling by supersonic molecular beam injection (SMBI) is successfully applied to ECH/NBI plasma in Heliotron J.**
- **Although the optimization of this fueling method for the Heliotron J experiment is in progress, the stored energy reached ~ 4.5 kJ in a combination heating condition of ECH (~ 0.35 MW) and NBI (~ 0.6 MW), which is about 50 % higher than the maximum one achieved so far under the conventional gas-puffing in Heliotron J.**
- **After a SMBI pulse for ECH+NBI plasma, two different propagation types of perturbations caused by SMBI are observed in the radiation profile are also observed. For ECH plasma, increase/decrease of electron temperature is observed, which seems to depend on the target density.**

SMBI experiments in Heliotron J

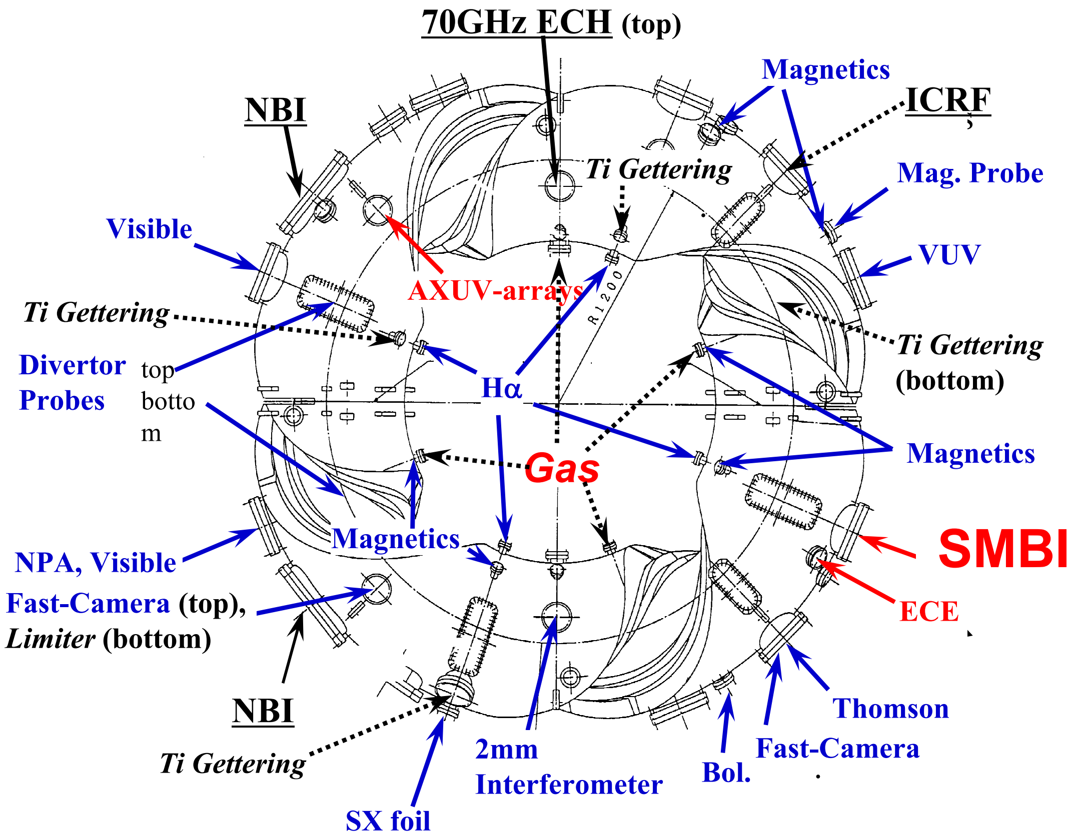
Introduction (1)

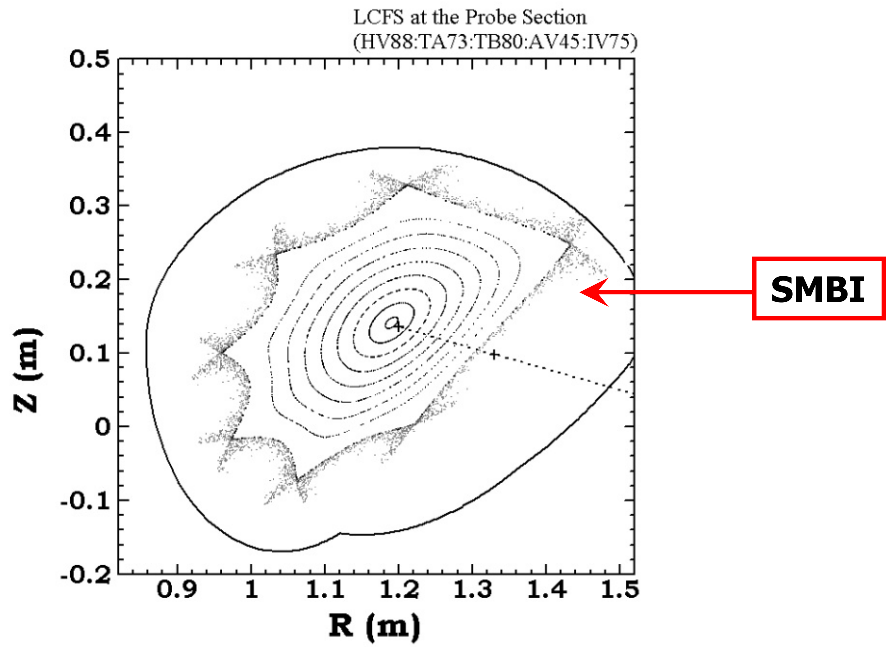
- **The selection of gas fueling method is one of the most important factors to obtain a high density and good performance plasma from two aspects;**
  - **(1) the profile control of the core plasma density through the controlled penetration depth of neutral particles,**
  - **(2) the reduction of neutral particles in the peripheral region.**
- **Although injection of ice pellets is well known as a technique to realize favorable fueling from these aspects and used in several devices, the system is complicated and it is not easy to make a pellet small enough for density control in medium or small sized devices.**

SMBI experiments in Heliotron J
Introduction (2)

- **On the other hand, a supersonic molecular beam injection (SMBI) technique, which has been developed by L. Yao et al., is an alternative method to obtain the deeper penetration of the neutral particles into the core plasma compared to the conventional gas-puffing.**
  - **This technique is considered to be effective especially for a medium or small sized device.**
- **Recently high-pressure SMBI is examined as a fueling method for ECH/NBI plasmas in Heliotron J.**

Application of SMBI in Heliotron J for Fueling Control and Diagnostics



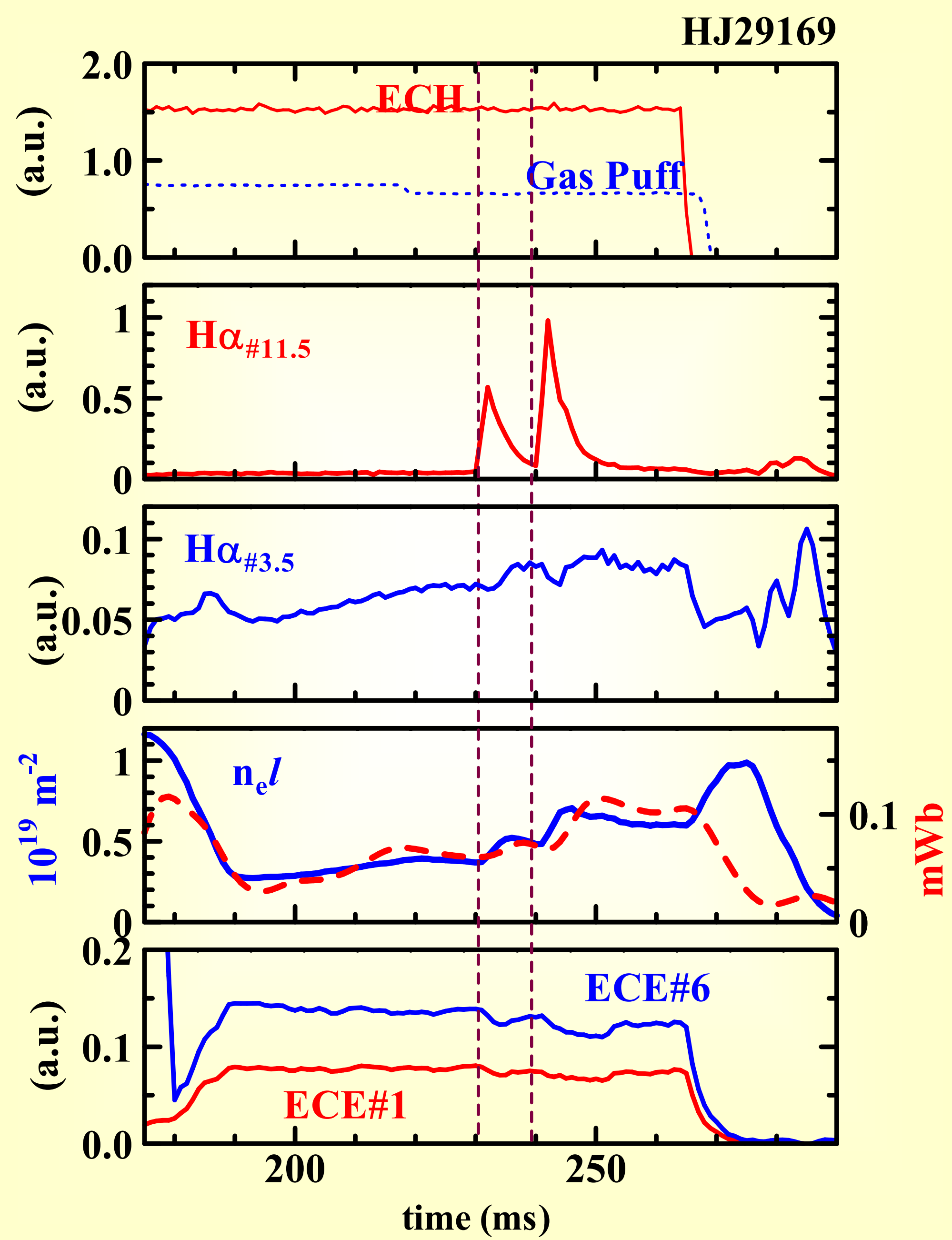


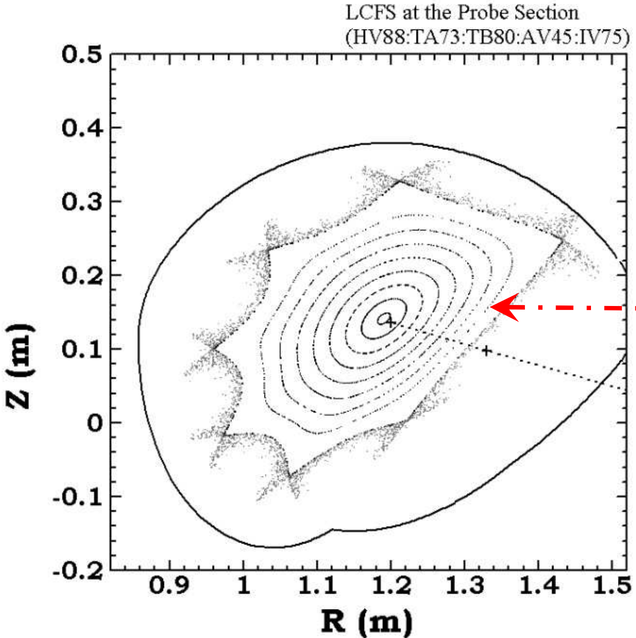
Valve: General Valves with 0.1ϕ orifice with magnetic shield,
Filling pressure: ≤12kg/cm² @room temp

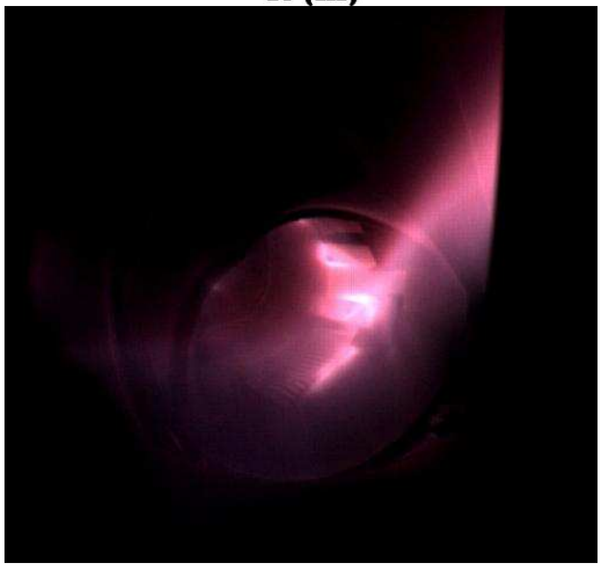
- **The SMBI Fueling technique is introduced to Heliotron J through the international collaborations for**
  - ☞ **Gas-puff imaging with fast video cameras**
  - ☞ **Effective fueling & density profile control**
  - ☞ **n_e, T_e measurement by using spectroscopic technique.**

Example of SMBI Experiment in Heliotron J

two pulses of SMBI in to ECH Plasma

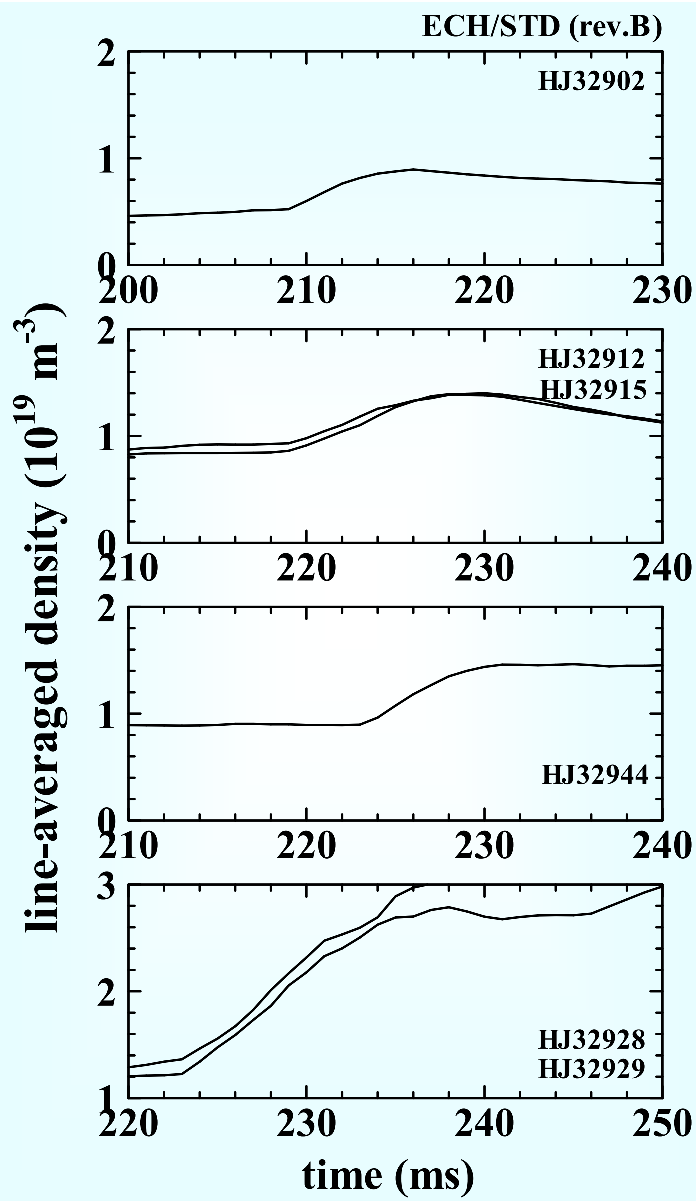


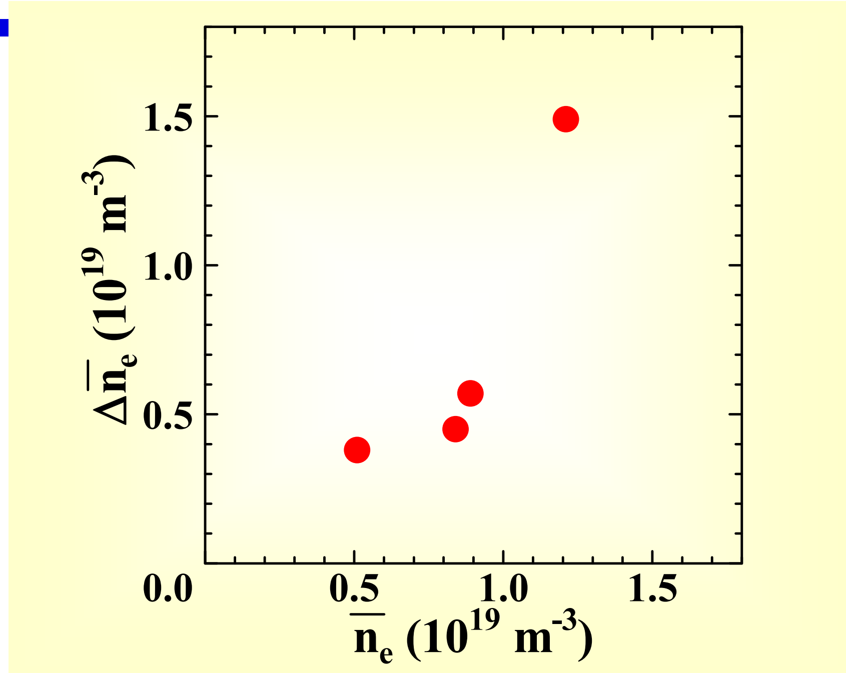




Tangential view of the injection section
(250FPS, 1/5000)

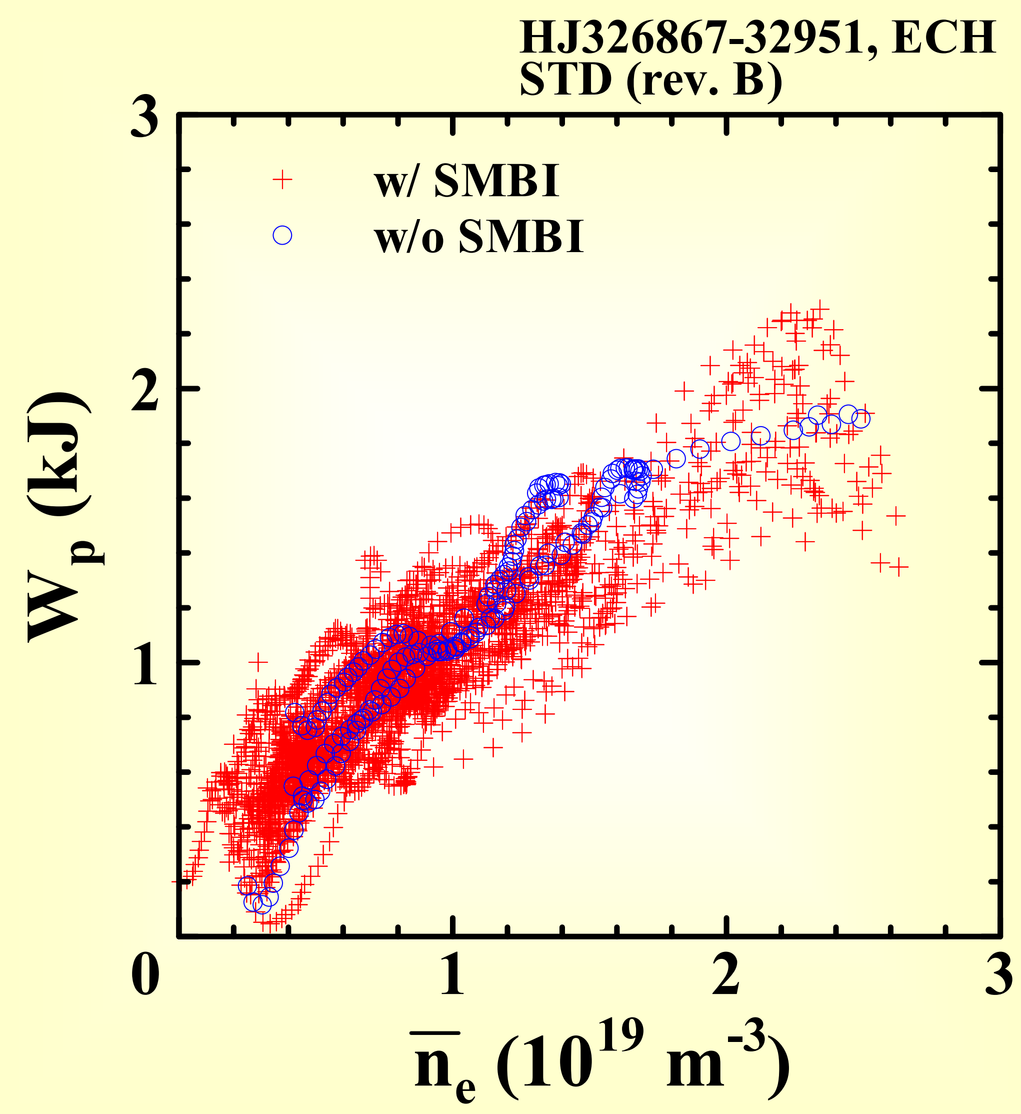
Dependence of the density increase on the target density (ECH plasmas)





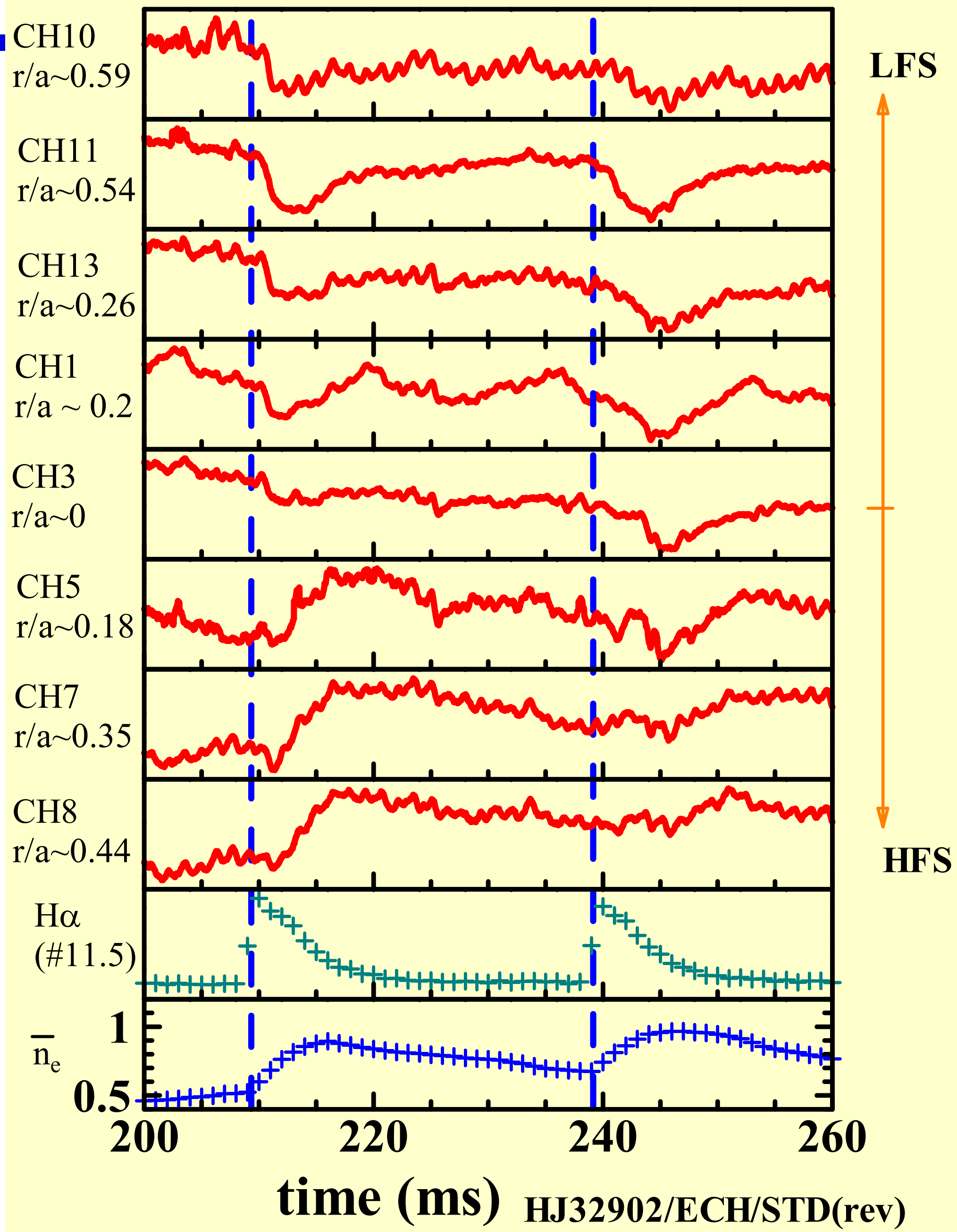
- For the same SMBI condition (the pulse width and the plenum pressure), the increase of the line-averaged density seems to depend on the target density.
  - Enhance the penetration of neutrals outside the plasma through the edge cooling by SMBI?
  - Above a critical density, the H-mode transition occurs and the density uncontrollably increases in this experiment.

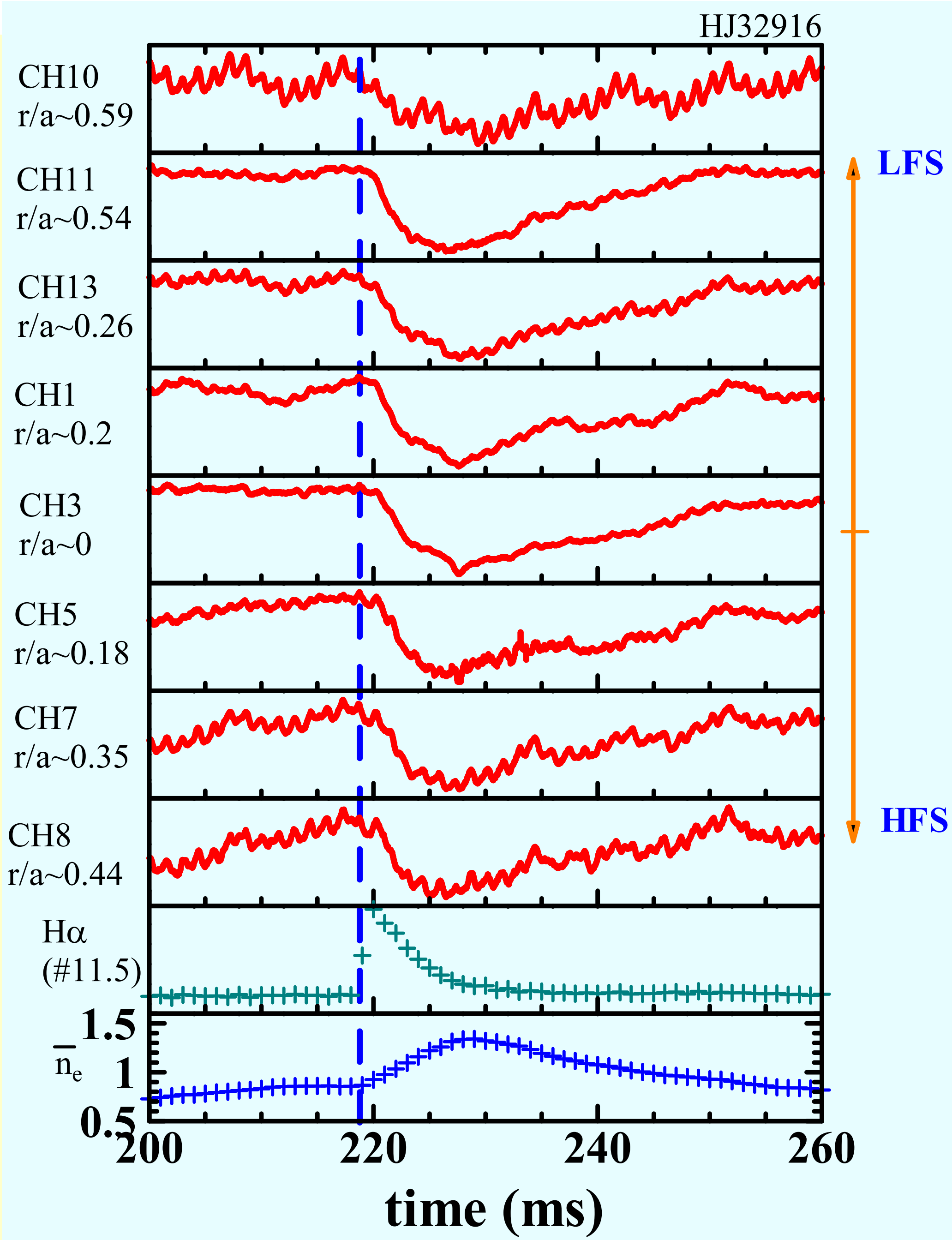
SMBI makes it easy to produce higher density and higher W_p plasmas. (ECH plasmas)



- **ECH: 70 GHz, ~ 0.35 MW**
  the second harmonic X-mode
  non-focusing Gaussian beam
- **In this experiment,**
  - **the difference in the $\bar{n}_e$-W_p relation between the conventional gas-puff and the SMBI was not clear for ECH plasmas well below the cut-off density.**
  - **Near the cut-off density, the SMBI fueling seems better than the conventional gas-puff from the view point of operation.**
  - **An over-dense plasma with high enough W_p could not be produced up to now.**

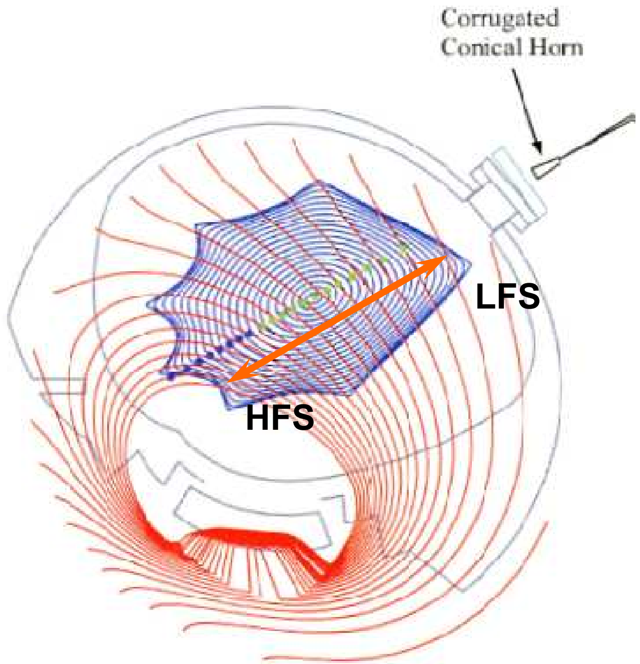
Time responses of I_{ECE} after SMBI depends on the target density. (ECH plasma)



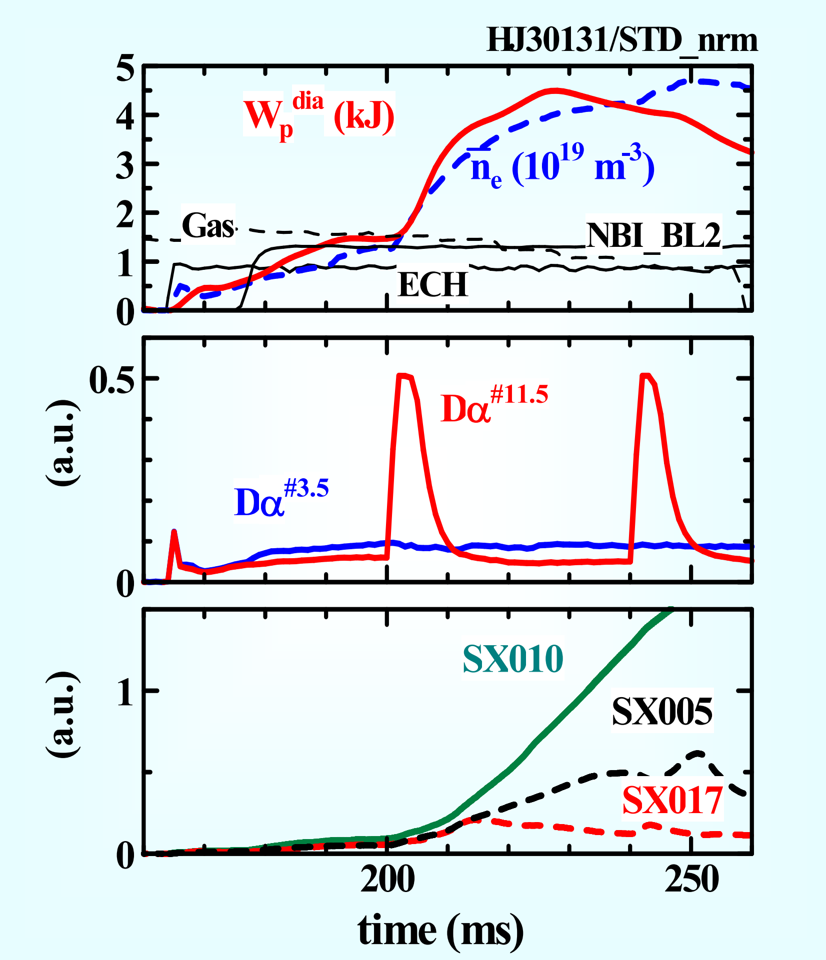


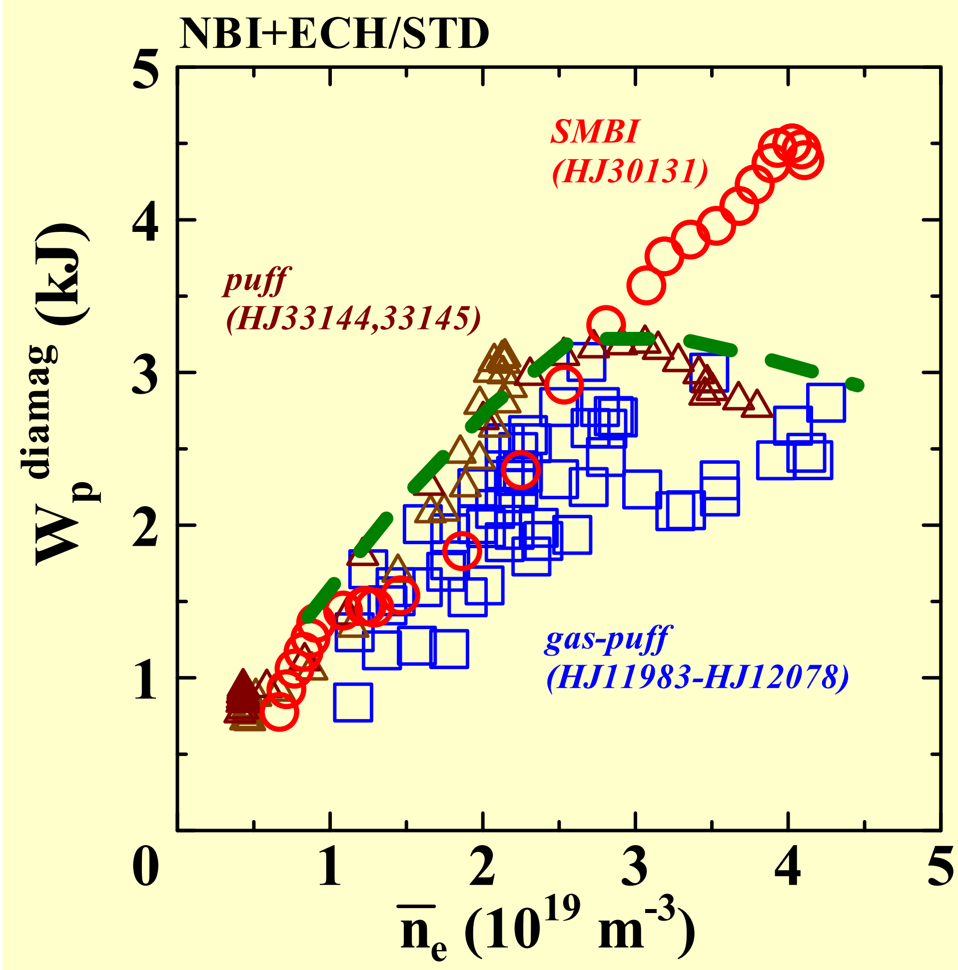
Time responses of I_{ECE} after SMBI depends on the target density. (ECH plasma)

- **For higher target density plasma,**
  - the intensity of ECE signals **DECREASED** after the SMBI pulse,
  - and gradually recover to the level before the SMBI.
- **For lower target density plasma,**
  - the ECE intensity **INCREASES** after the SMBI for the far side of the SMBI,
  - but, the intensity **DECREASES** for the near side of the SMBI.
  - The intensity from r/a ~ 0 shows almost no response.
- **The measurement is necessary at a position toroidally well apart from the SMBI section.**
- **The measurement in more peripheral region is also necessary.**



SMBI can expand the operation region of Heliotron J (ECH+NBI plasma)





- The stored energy reached ~ 4.5 kJ, about 50 % higher than the max. one achieved so far under the normal gas-puff fueling condition in Heliotron J.
  - ECH (~ 0.35 MW) and NBI (~ 0.6 MW)
- The optimization of this fueling method for Heliotron J is in progress.

Propagation of perturbations caused by SMBI are observed in a chord-profile of radiation from plasma measured with an AXUV-array. (ECH+NBI plasma)

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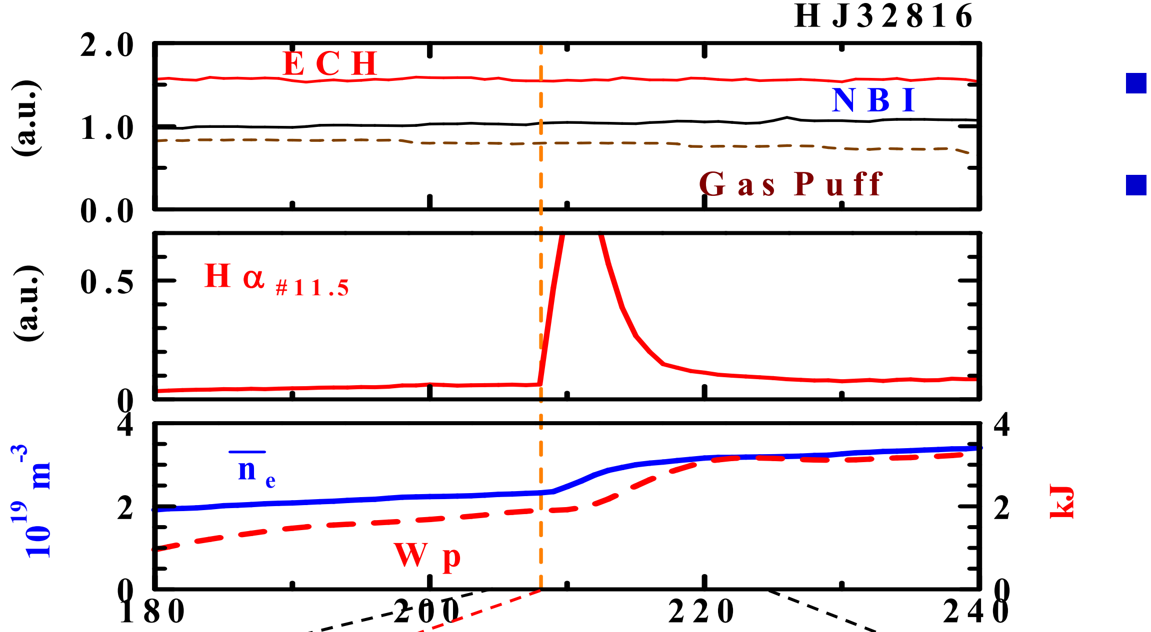
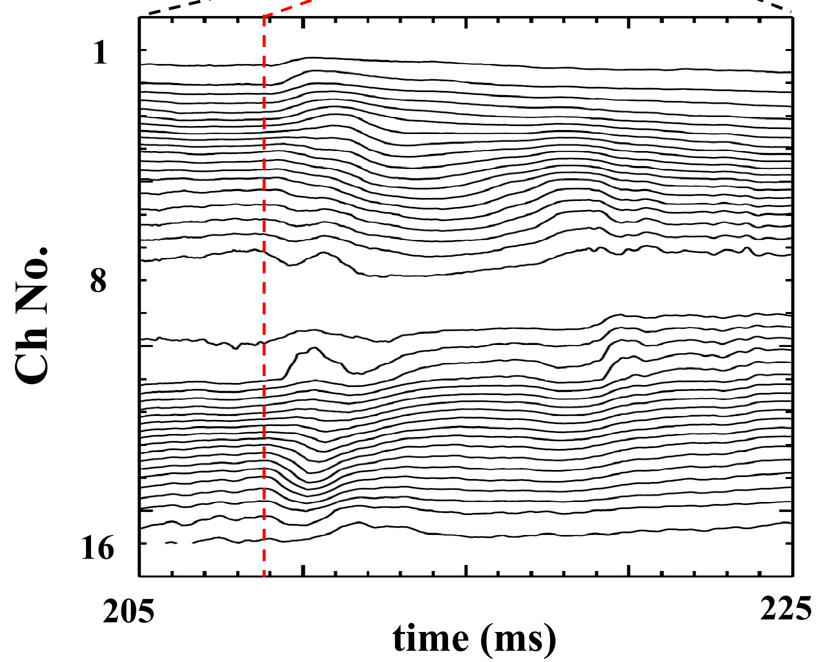
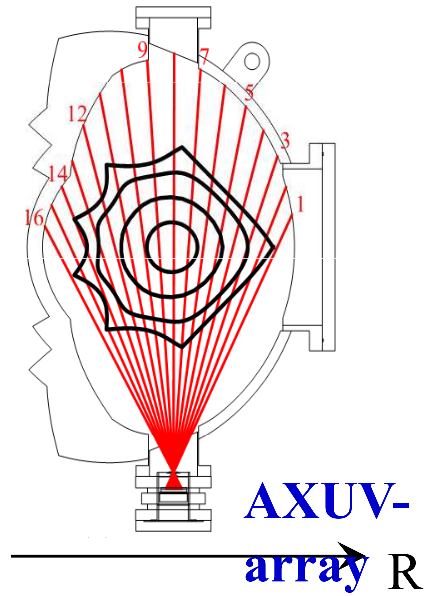


- The AXUV array with 1μmt-Al filter can detect radiation (above ~500eV).
- Two types of propagating perturbations are caused by a SMBI pulse.
  - A pinch-like perturbation near the center and the expansion observed in the peripheral region.
  - Different time response between temperature and density?
  - Direct measurement of the temperature and density is necessary.





Summary

- A gas fueling method by SMBI is successfully applied to ECH/NBI plasma in Heliotron J.
- Interesting time responses caused by SMBI are observed from the transport and heating viewpoints.
- In a combination heating condition of ECH and NBI, the stored energy reached ~ 4.5 kJ, which is about 50 % higher than the maximum one achieved so far under the conventional gas-puff fueling condition in Heliotron J.
- *The optimization of this fueling technique for the Heliotron J experiment is in progress.*

Acknowledgement

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