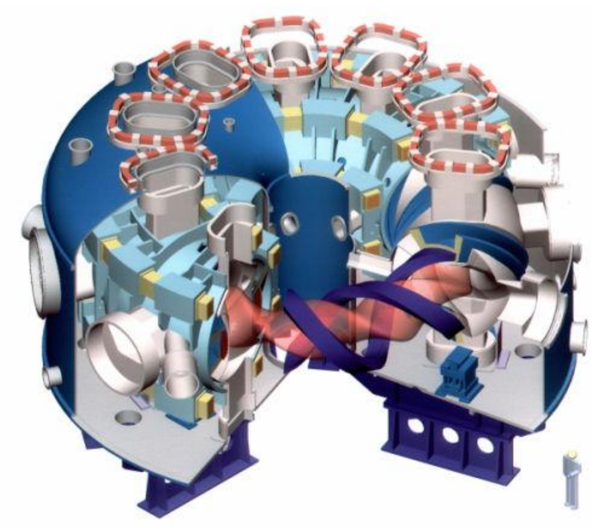
Impurity transport study by means of TESPEL in LHD

N. Tamura for the LHD team

National Institutes of Natural Sciences, Japan



3rd Coordinated Working Group Meeting
Toki, Japan

23-24 October 2007

Outline

- ✓ Introduction
- ✓ About TESPEL
- ✓ Experimental results with TESPEL in LHD
- ✓ Summary

Introduction

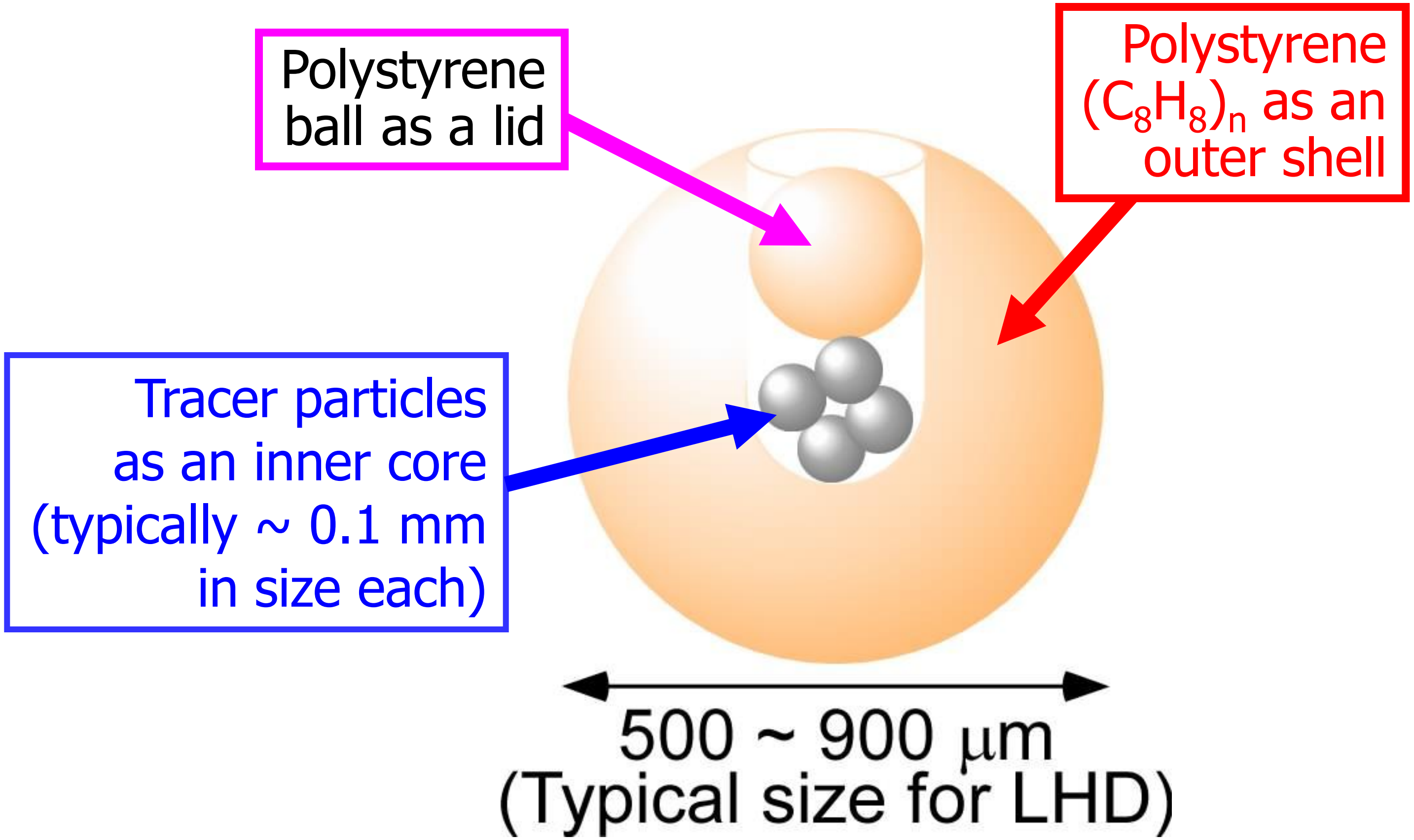
- ✓ Many physics issues, which must be solved for achieving reasonable and cost-effective fusion reactor, remain before us
  - Particle (including impurity) and heat transport
  - Divertor heat load

  and so on…

- ✓ To promote impurity transport study, an advanced impurity pellet (after-mentioned TESPEL) has been developed at NIFS, Japan and utilized for LHD experiments

Here,
some experimental results with TESPEL injection are presented

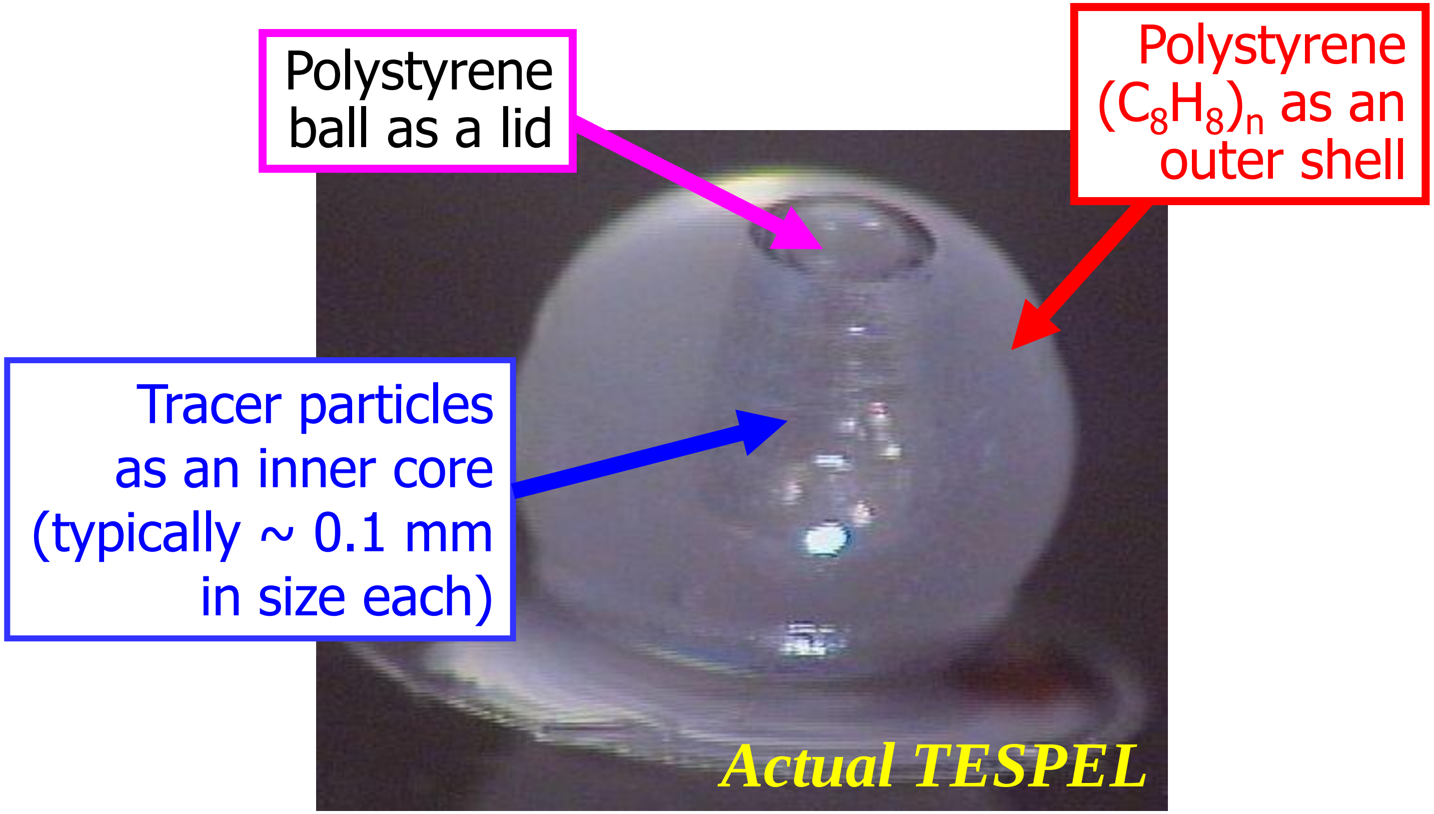
Tracer-Encapsulated Solid Pellet, TESPEL



Unique features of TESPEL

1. TESPEL can make a both poloidally- and toroidally-isolated impurity particle source as tracer
2. Total quantity of the injected tracer particles can be identified precisely
3. Relatively wide selection of the tracer material is possible

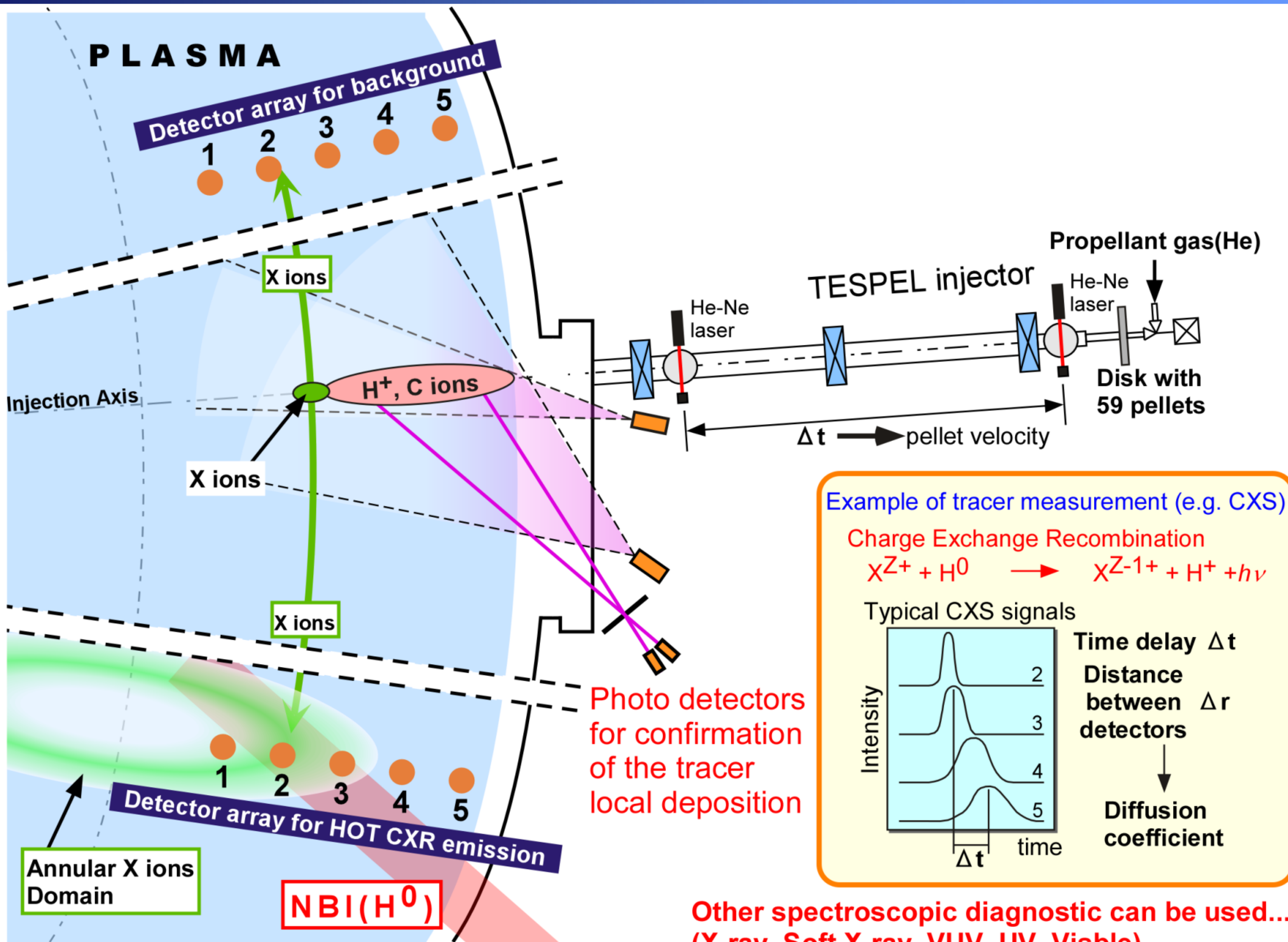
Tracer-Encapsulated Solid Pellet, TESPEL



Unique features of TESPEL

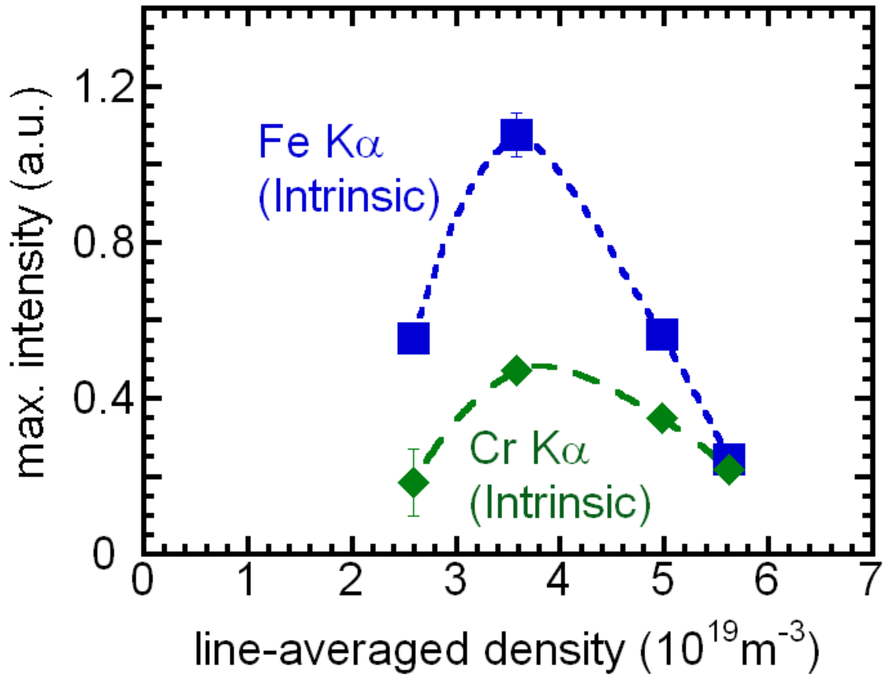
1. TESPEL can make a both poloidally- and toroidally-isolated impurity particle source as tracer
2. Total quantity of the injected tracer particles can be identified precisely
3. Relatively wide selection of the tracer material is possible

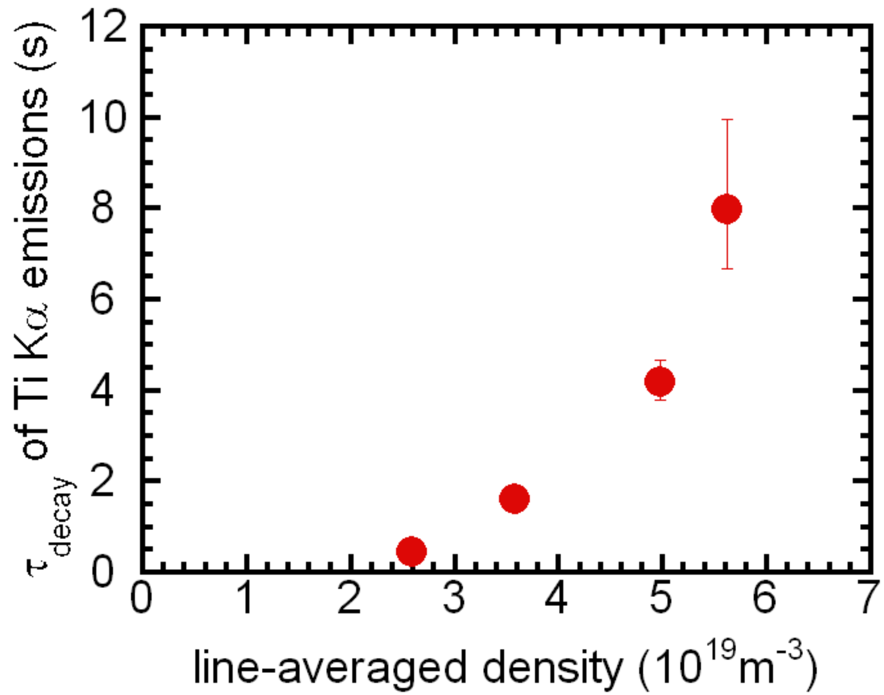
Basic concept of diagnostic for tracer impurity transport by means of TESPEL technique



Other spectroscopic diagnostic can be used...
(X-ray, Soft X-ray, VUV, UV, Visble)

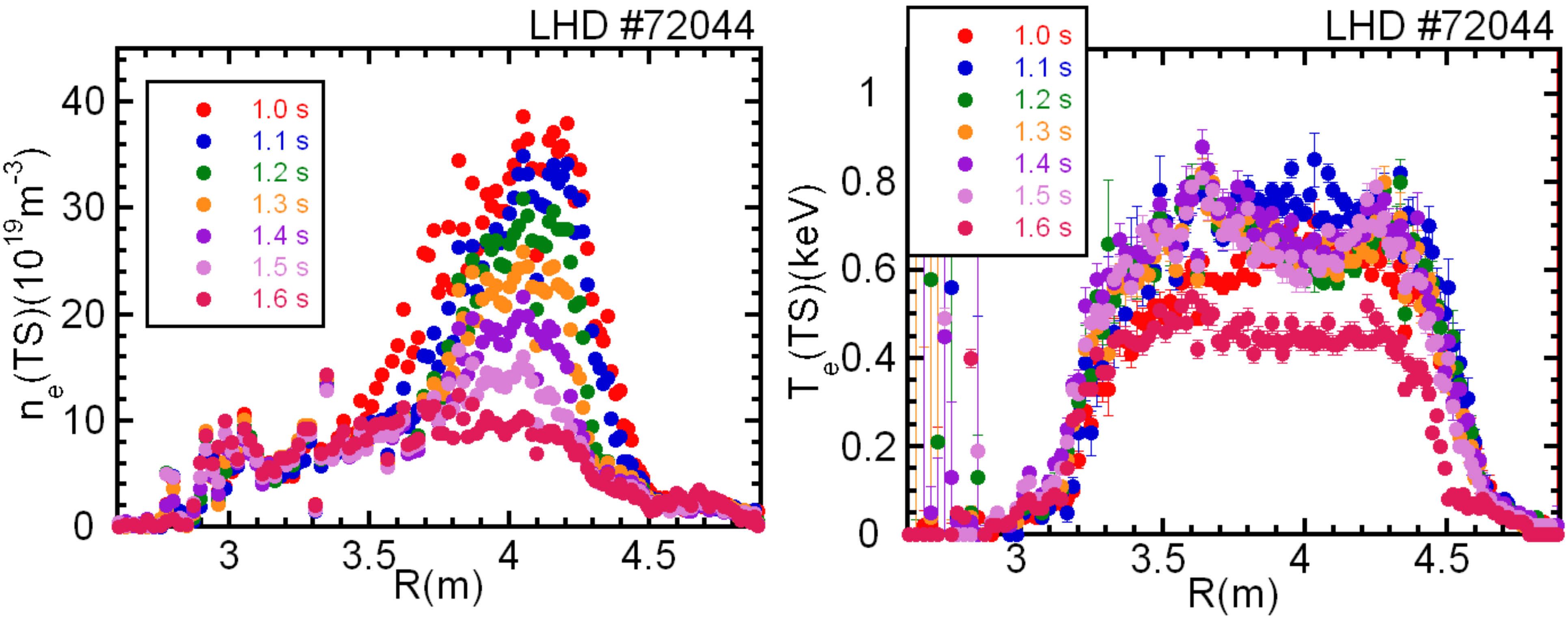
TESPEL can show clearly screening effect in plasma edge for impurity influx from the wall





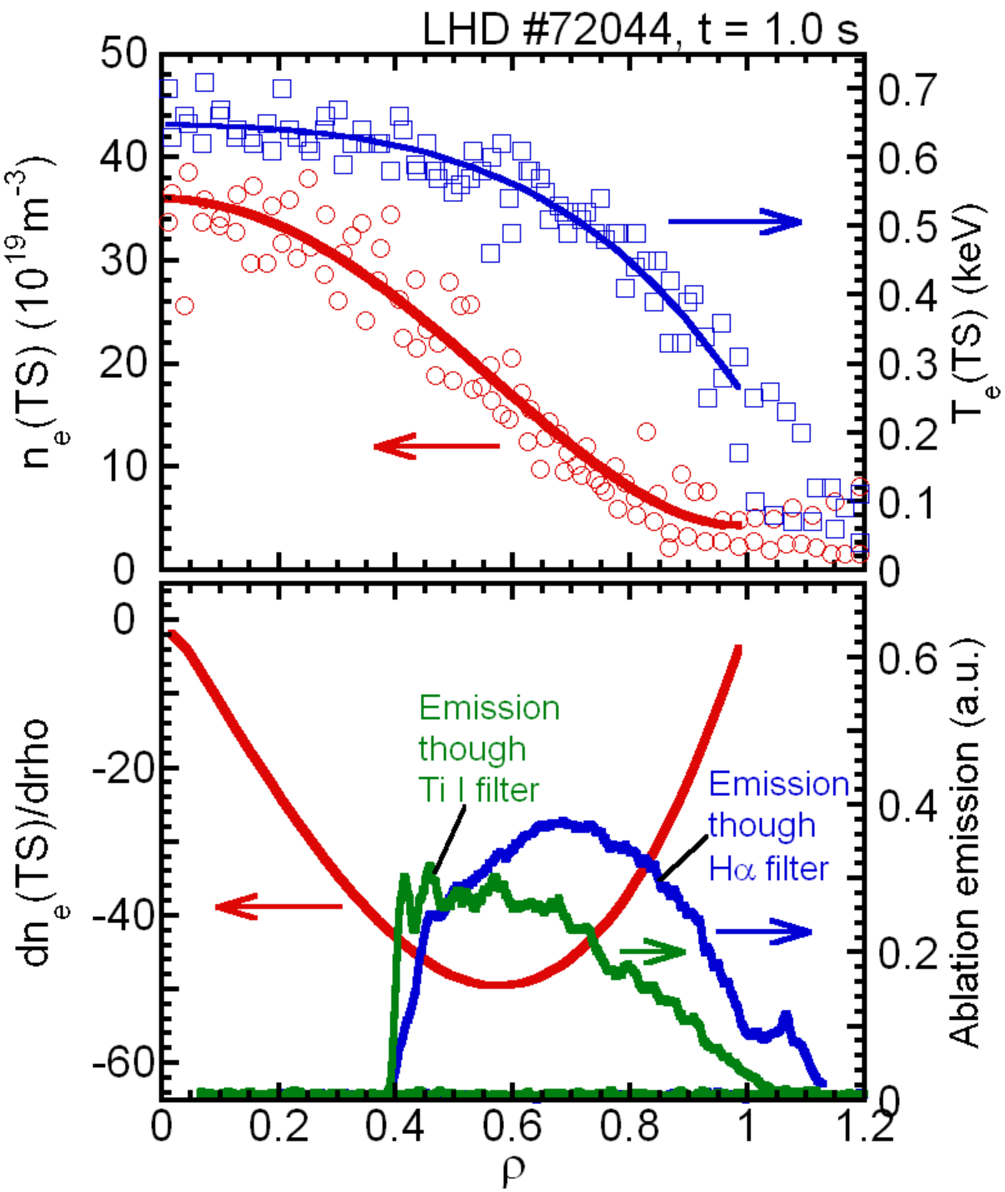
- ✓ Intrinsic (Fe, Cr) impurity from the wall has a density window for accumulation
- ✓ Decay time of Ti Kα emission from tracer impurity introduced by TESPEL shows a monotonic increase with density
  - Tracer impurity has been deposited at ρ = 0.7~0.8
- ✓ Therefore, a plasma edge (ρ > 0.8) can be a screen for extraneous impurity, not be a exhaust for interior (i.e. He ash) impurity
- ✓ Characteristics over 1 x 10^{20} m^{-3} (tracer still accumulate?) under investigation

To investigate impurity transport inside an IDB, TESPEL injection into the IDB plasma has been done



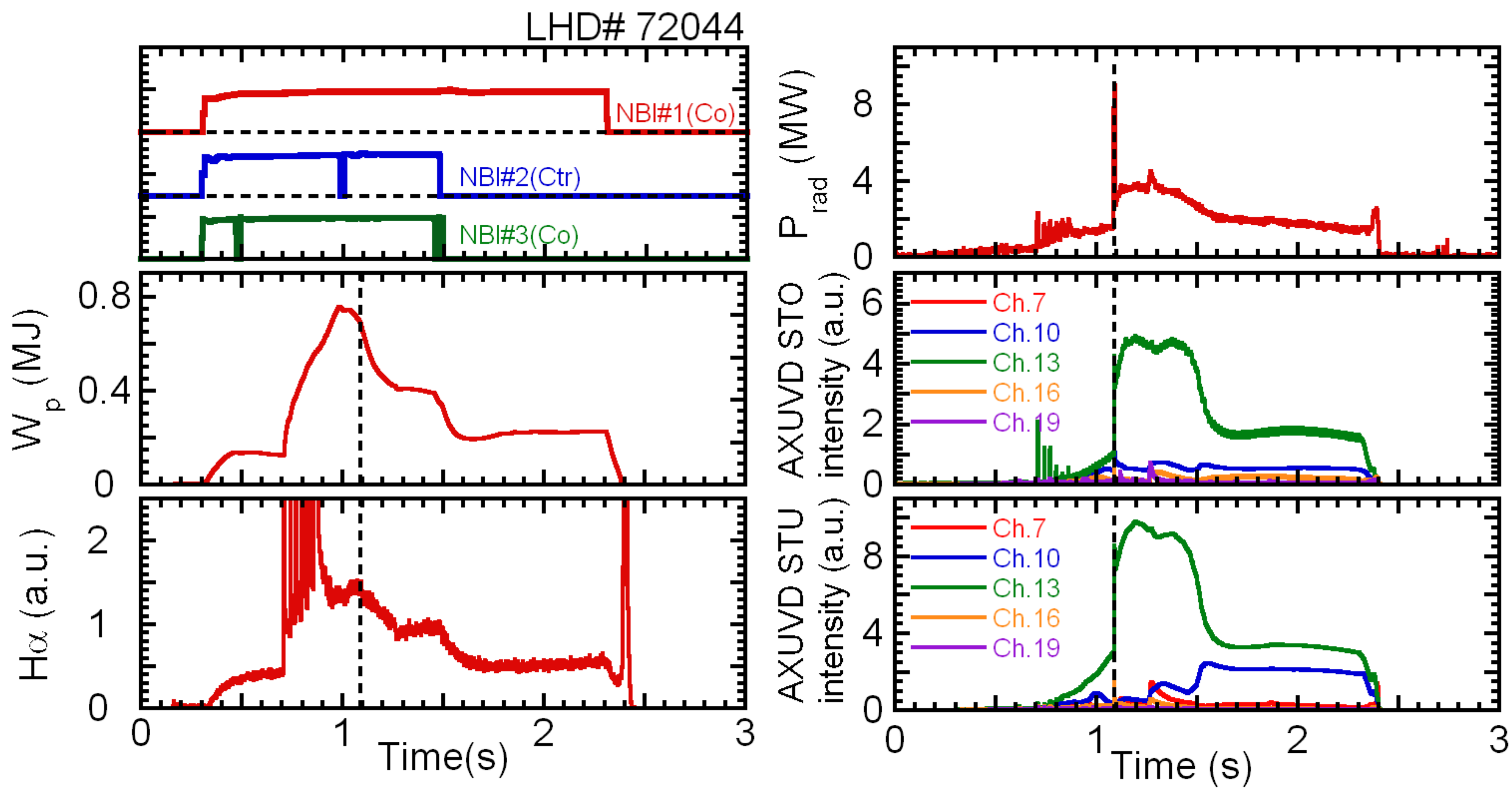
- ✓ Extremely high-density region has already begun to disappear before the TESPEL injection ($t_{injection}$ ~ 1.1 s)
  - TESPEL injection seems to have little impact on IDB
- ✓ T_e profile seems to become a little hollow
  - Due to Ti tracer deposition/accumulation in the core?

TESPEL allow us to deposit tracer impurity inside the IDB region



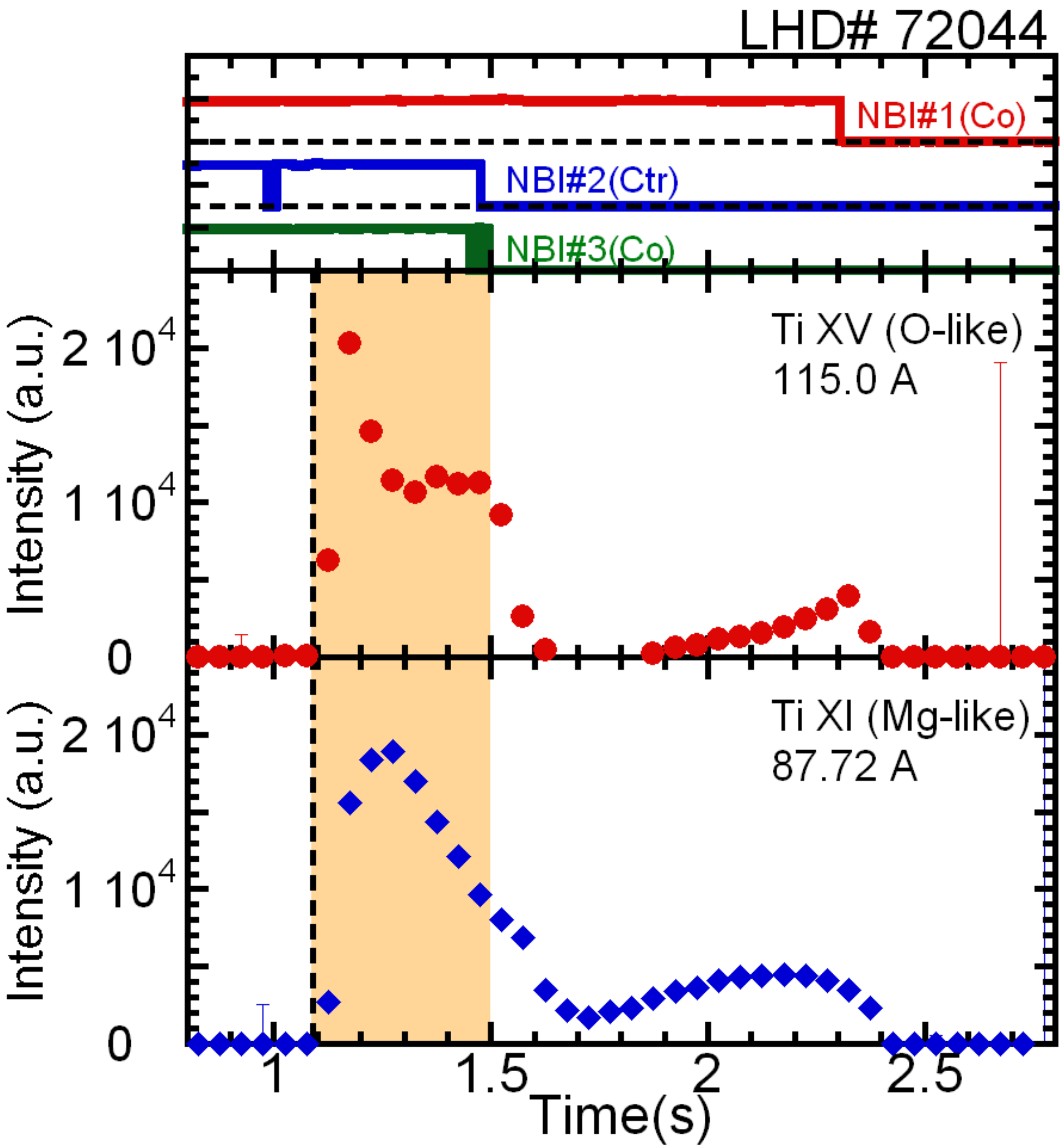
- ✓ Used parameter for VMEC equilibrium reconstruction
  - R_{ax}: 3.85 m, Bq: 100 %, $\langle\beta_{dia}\rangle$: 1.03 %, pressure profile ~ $(1-\rho^{2.0})^{2.0}$
- ✓ Extremely high-density region would be defined as the inner region with $\rho < 0.6$ (see the profile of $dn_e/d\rho$)
- ✓ Ti tracer would be deposited around $\rho = 0.4 \sim 0.5$
  - Thus Ti tracer must be deposited inside the IDB region
- ✓ Emission through a Ti I filter (λ_{ctr} = 400.3 nm, $d\lambda$ = 2.0 nm) does not so clearly show the tracer ablation
  - Due to a high background?

Bolometric detectors indicate that the tracer impurity would be kept in the IDB region



- ✓ After the TESPEL injection, radiated power (measured with a resistive bolometer and AXUVD arrays) is increased and its profile seems to be extremely peaked (moreover sustained)

VUV emissions from tracer impurity inside the IDB also clearly indicates the tracer would be kept in the IDB region



- ✓ Between 1.0 s to 1.5 s, IDB plasma with steady heating has been formed
  - T_e profile at the time of t = 1.0 s ~ 1.5 s remains the same
- ✓ Taking drastic decrease in n_e into account, Ti tracer seems to be accumulated inside IDB
  - To assess inward pinch velocity, transport analysis using a 1-D transport code is being performed

Summary

- ✓ To promote impurity transport study, an advanced impurity pellet (TESPEL) has been developed at NIFS, Japan and utilized for LHD experiments

- ✓ TESPEL experiments clearly show…
  - Screening effect in plasma edge for intrinsic impurity originated from the first wall,
  - Impurity transport property inside the IDB region,

  and so on

- ✓ TESPEL allow us to investigate correctly core impurity transport
  - Because TESPEL make it possible that tracer will be deposited inside the region of interest, such as ergodic region, IDB, etc.
    - When the tracer is deposited in the ergodic region, the tracer impurity can be considered as an intrinsic impurity but with a known amount