We investigated the ps intense laser pulse propagation into homogeneous critical density plasma at EFLIE laser facility, LULI-Ecole Polytechnique, France. A critical density plasma was created by the ionization of low-density plastic foam filled in a small polyimide tube (300µmφ x 300µmL), that prevents the plasma free expansion during the interactions by a ns laser beam. We use two different density foams, 5 and 10 mg/cc, corresponding to \( n_c \) and \( 2n_c \) which was verified with a X-ray transmission measurement [1]. Ultra intense laser light irradiated the plasma from one open side of the tube. The laser propagation inside the plasma was investigated with Doppler shift of back-scattered light spectroscopy as well as the proton radiography technique. We also observed the angular dependence of accelerated electrons with multi-channel magnet spectrometer and imaging plate.

We observed about 10% of reflected laser energy with significant red shift in the spectrum. The spectral peak was about 1.65 µm for 5 mg/cc foam and 1.55 µm for 10 mg/cc foam for laser intensity of \( 3 \times 10^{19} \) W/cm\(^2\). These Doppler peaks well agree with the estimated shift for each density from the recession velocities of channel front determined by the power balance between laser ponderomotive force and excited electrical potential at the channel front [2]. Our PIC calculation also reproduced a similar peak position in the back-scattered spectrum. We also observed significantly collimated electron beam toward laser axis, whose beam divergence was around 15° in FWHM, whereas the divergence from a simple flat foil target recorded over 40°. Our PIC and analytical calculations reveal that the strong magnetic field around the plasma channel brings the electron beam toward the channel direction [1]. In addition a strong X-ray signal was observed at 16° from the laser axis in the laser polarization direction, which may correspond to synchrotron radiations from the electron beam. The interaction with long critical density plasma can provide unique and interesting experimental platform not only for fast ignition study but also for particle accelerations.