Simultaneous Measurement of Proton Ratio and Beam Divergence of Positive-ion-based Neutral Beam in the Large Helical Device

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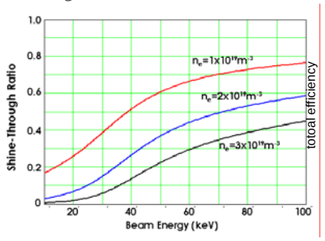
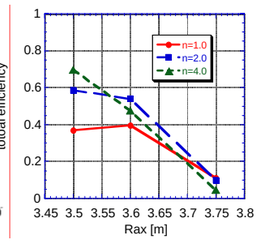
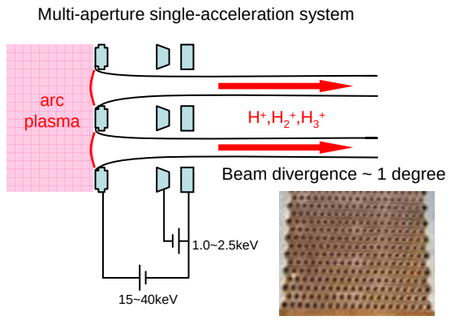
Introduction

Positive-ion-based neutral beam injector (P-NBI) was installed in the Large Helical Device (LHD) at 9th experimental campaign (2005-2006). The neutral hydrogen beam with energy of 40keV and power of 6MW was injected into LHD plasmas, and was utilized as a diagnostic neutral beam (DNB) for a charge-exchange spectroscopy measurement. The low energy beam has a higher efficiency of ion heating than that of high energy beam (180keV) produced by negative-ion-based neutral beam injectors (N-NBIs) installed in LHD, so ion heating experiments were also performed using the P-NBI. In order to evaluate heating efficiency, it is necessary to know proton ratio of the beam because half and one-third energy components are included in the beam produced by P-NBI, and they affect beam deposition and heating efficiency. On the other hand, monitoring of the beam divergence is important for stable beam operation and accurate estimation of port-through power of the beam. Thus, we developed a simultaneous measuring system of the proton ratio and the beam divergence.





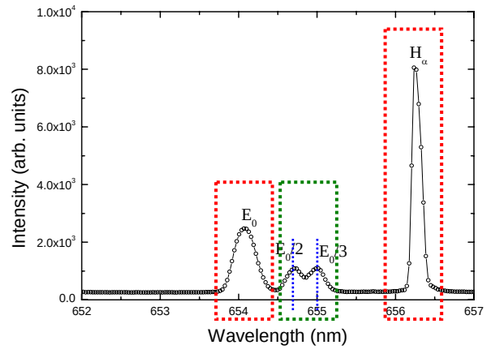
Beam extraction



Specification of P-NBI in LHD

- Beam energy; 40keV
- Beam power; 6MW (1.5MW x 4 IS)
- Beam duration; 10s
- Species; positive hydrogen
- Injection angle; 87.24 degree
- Location; 5-O @LHD
- Focal length; 8.3m
- Neutralizer; gas cell (L=2.5m)
- Vacuum pump; cryo-sorption (2200m^{-3}/s)
- Power supply; ACC:2, Dec:2(2.5kV) Arc PS:4, Filament PS:4
- Acc PS; 40kV, 180A, 10s
- DC switch; IGBT switch
- Dec PS; 1~2.5kV, 30A, 10s
- Arc PS; 100V, 1800A, 20s (UA, LA) 120V, 1500A, 20s (UB, LB)
- Filament PS; 15V, 2520A, 30s

Proton ratio and beam divergence



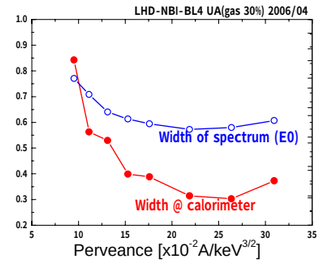
①Gaussian fitting of background and full energy lines; peak wavelength, 1/e width

②Calculation of peak wavelength of $E_0/2$ and $E_0/3$ emission

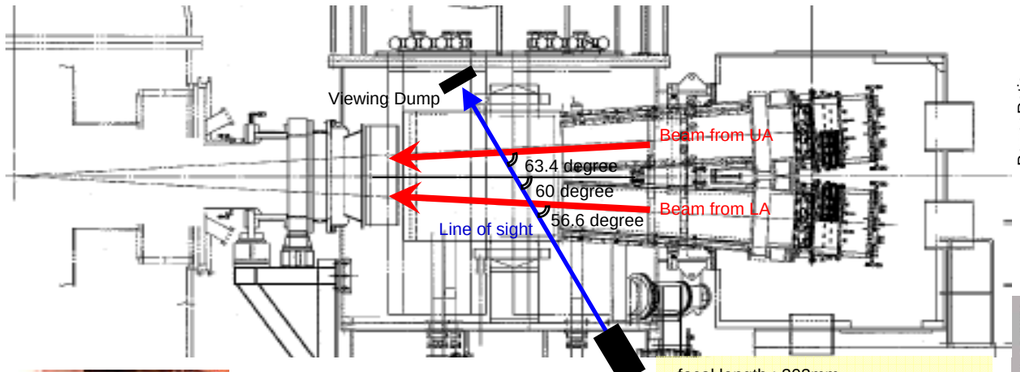
③Double Gaussian fitting of $E_0/2$ and $E_0/3$ emission lines using the calculated peak wavelength as initial conditions.

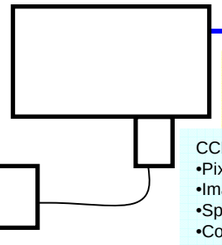
Summary and future plan

- The beam emission Ha line measurement was performed for proton ratio measurement and monitor of beam divergence.
- The proton ratio with minimum beam divergence was almost 90%.
- The width of Ha line emitted from the beam corresponds to the beam width measured by the calorimeter at L=***.
- The perveance dependences of Ha line width emitted from E_0, $E_0/2$ and $E_0/3$components show same tendency.
- In near future, the proton ratio will be calculated automatically and can be utilized for the power estimation of P-NB.



Schematic





PC

Spectrometer (ANDOR Shamrock)

- focal length : 303mm
- Dispersion : 1.7nm/mm
- Focal area : 28mm x 14 mm
- Shutter speed : 10 Hz
- Grating : 1800L/mm (Holo 350-900nm) 1200L/mm (Ruled 500nm) 150L/mm (Ruled 500nm)

CCD(ANDOR DV420)
- Pixel : 1024 x 255
- Image area : 26.6mm x 6.7mm
- Speed : 3.3 f/s
- Coolong : -55 degree (air)

Experimental Results