

Developments of Spray and Ambient Gas Flow at the High-pressure Swirl Spray for GDI Engine.

IEA Collaborative Task “Sprays in Combustion”.,
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Background

- To obtain desired mixture formation of direct injection gasoline engines, behavior of a spray and its ambient air flow must be understood.
- Although some groups have investigated the behavior experimentally, most of them have used PIV which can't treat the spray as group of droplets.
- For the better understanding of the spray, individual motions of each droplets should be measured.

Objective

- To investigate sprays and its ambient air flows initiated from two types of injectors for direct injection gasoline engines.

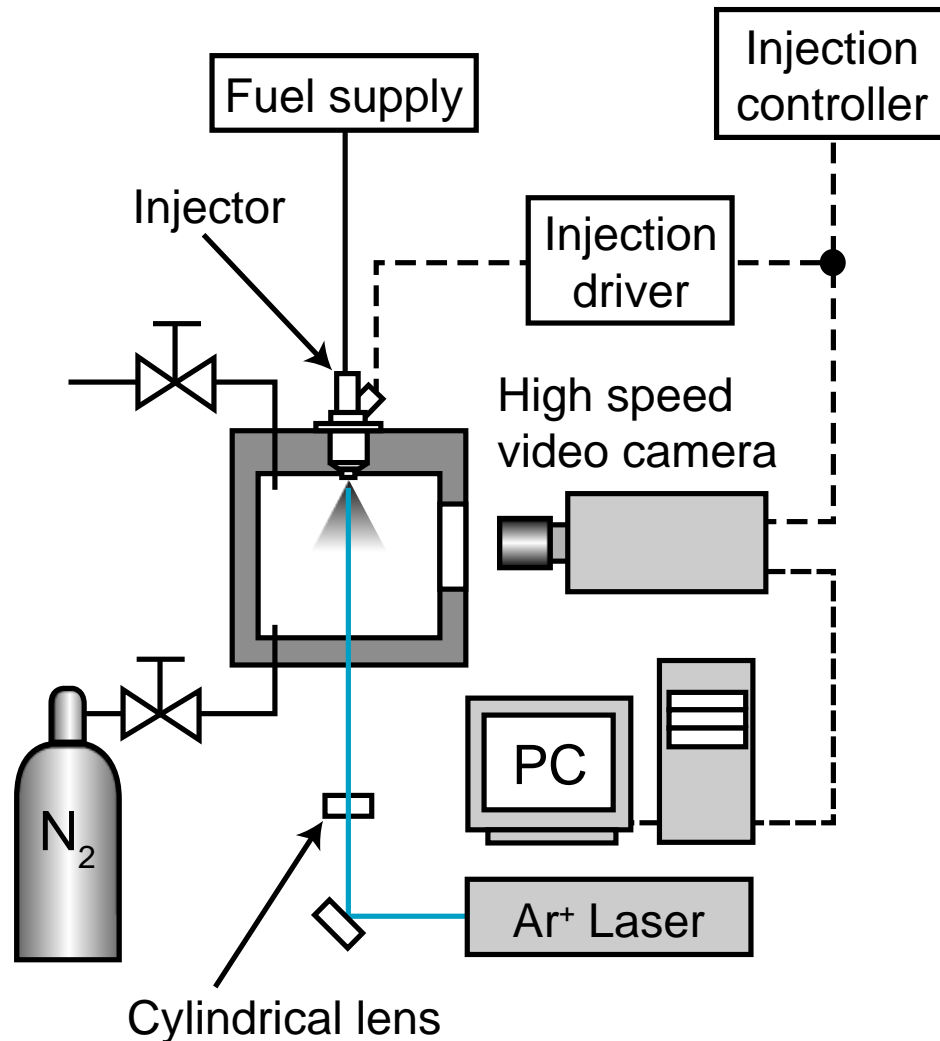
| | |
|--------------|--|
| Spray | 2-D LDA measurement |
| Ambient flow | PIV-based measurement by using high speed video camera |

Employed injectors:

- Swirl type one
- Outwardly opening type one

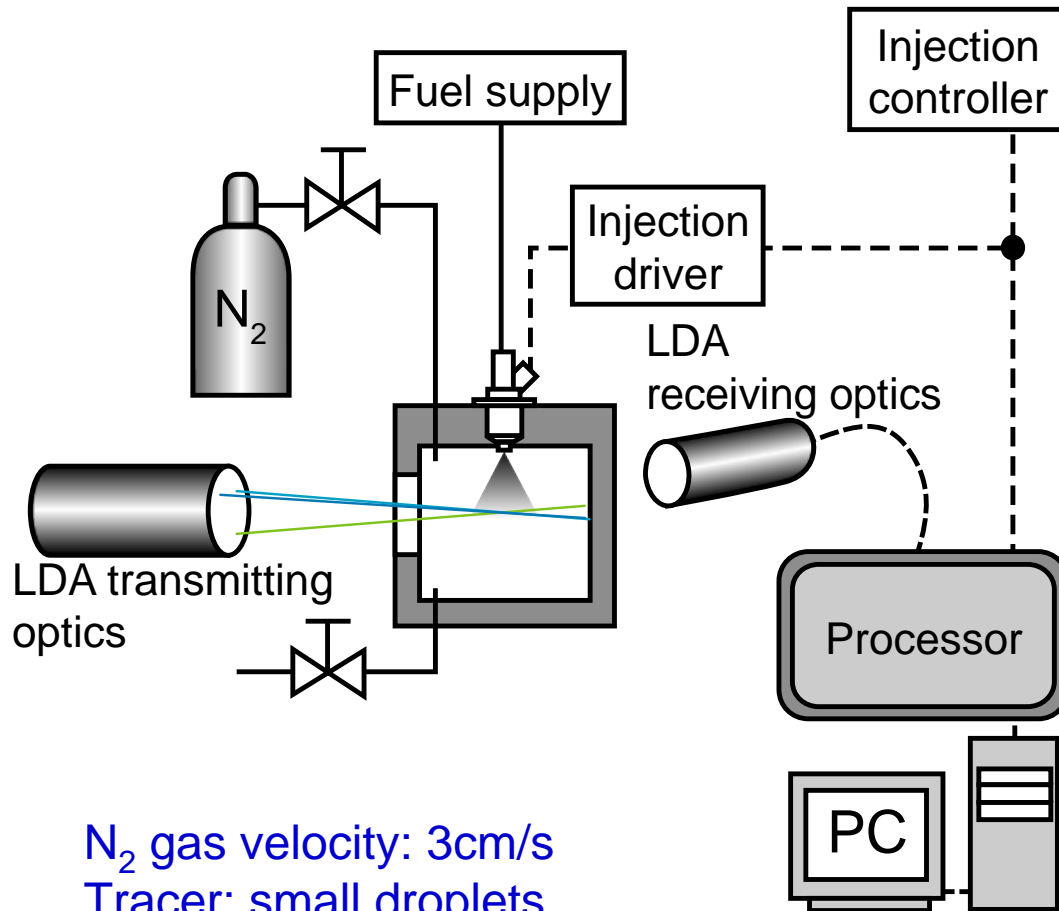
Injection Frequency: 1Hz, Fuel: n-heptane

Experimental setup (1 / 2)



| | |
|--------------------|---|
| Laser | Ar ⁺ (Spectra Physics 2017) |
| Output | 5.5W |
| Sheet thickness | 0.2mm |
| Camera | High speed video camera (Photron FASTCAM-APX) |
| Frame rate | 10,000fps |
| Shutter speed | 1/60,000 s |
| Image size | 384x544 and 512x512 pixel |
| Spatial resolution | 0.073 mm/pixel |

Experimental setup (2 / 2)



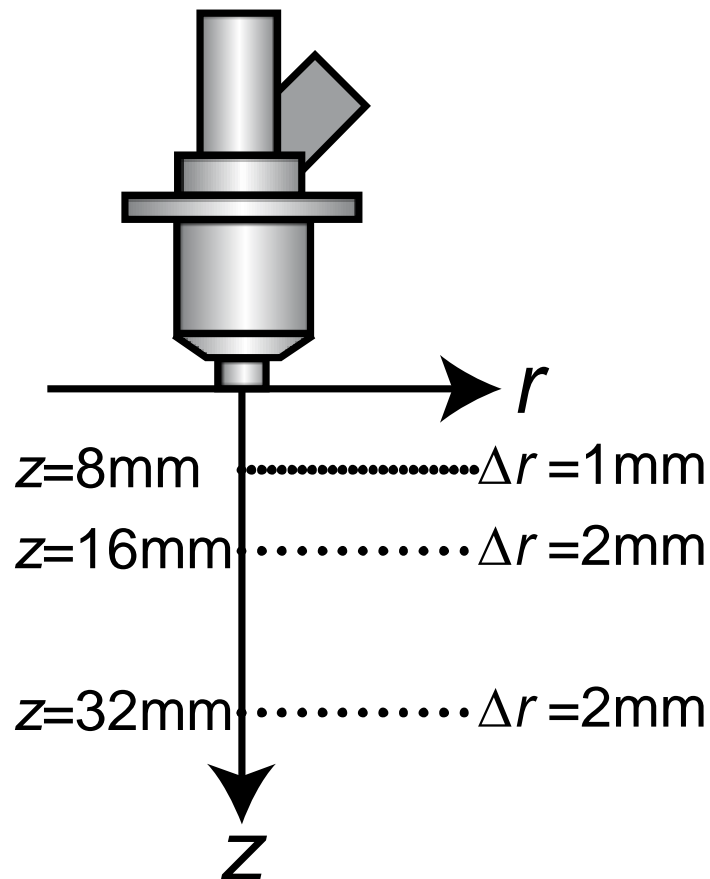
| Measurement direction | Axial | Radial |
|----------------------------|-----------|-----------|
| Wavelength nm | 515 | 488 |
| Beam power mW | 30 | 20 |
| Fringe space μm | 7.8 | 7.5 |
| Velocity range m/s | -58 - 175 | -56 - 168 |

Experimental conditions

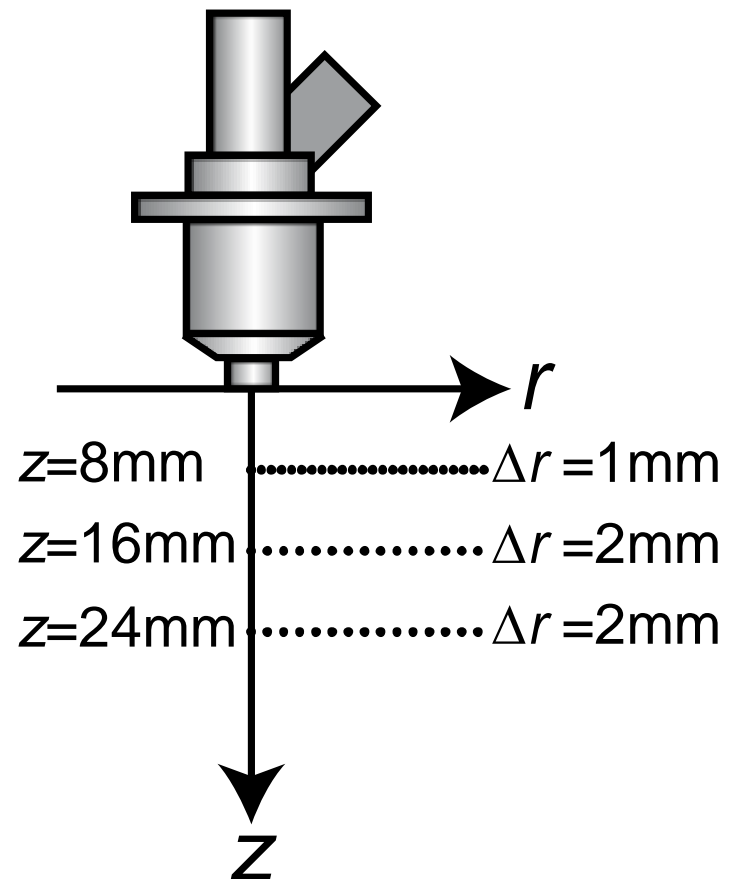
| | |
|---------------------|---------------------------------------|
| Injector | Swirl type and outwardly opening type |
| Fuel pressure | 10MPa |
| Injection duration | 0.7ms |
| Frequency | 1 Hz |
| Ambient temperature | Room temperature |
| Back pressure | 0.1 and 1.1 MPa |

Coordinate system and measurement points

Swirl type injector



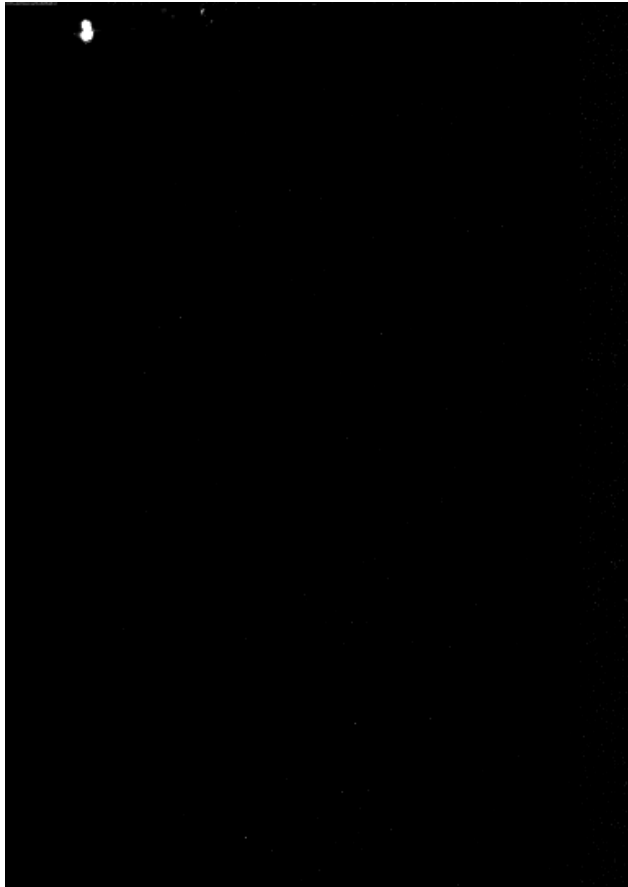
Outwardly opening type injector



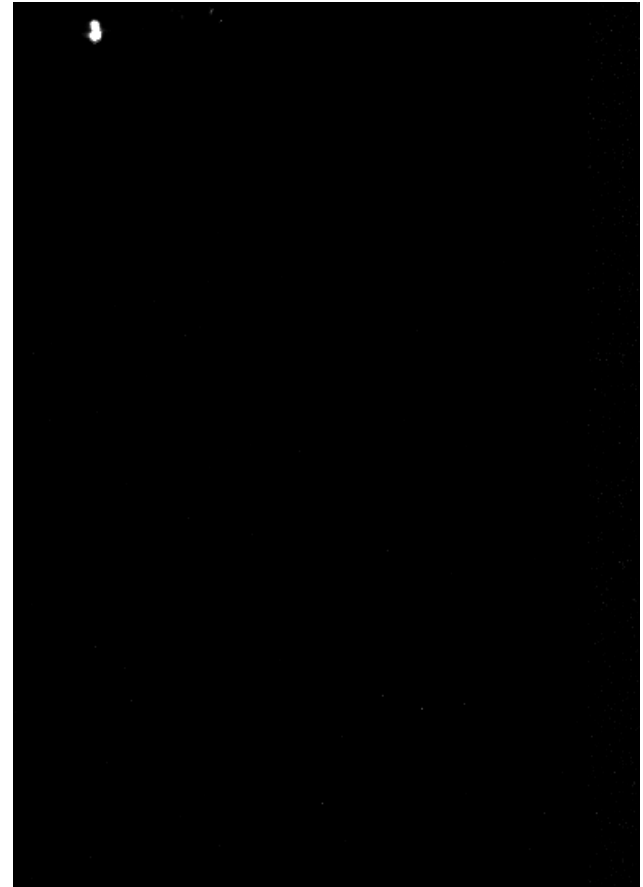
Visualization of developing sprays

Swirl type injector

Back pressure = 0.1MPa



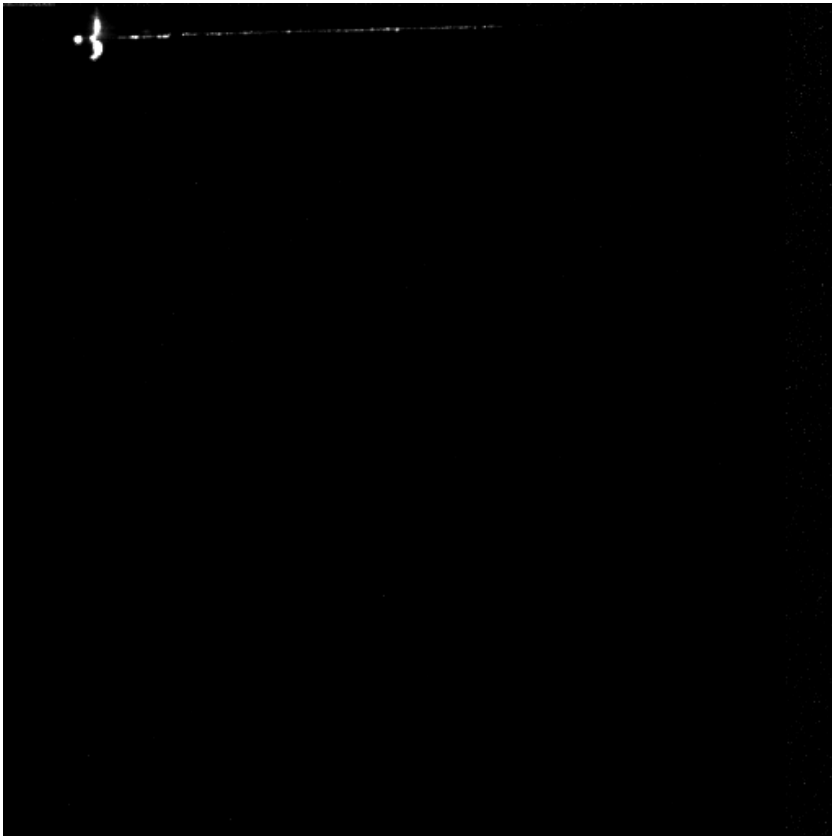
Back pressure = 1.1MPa



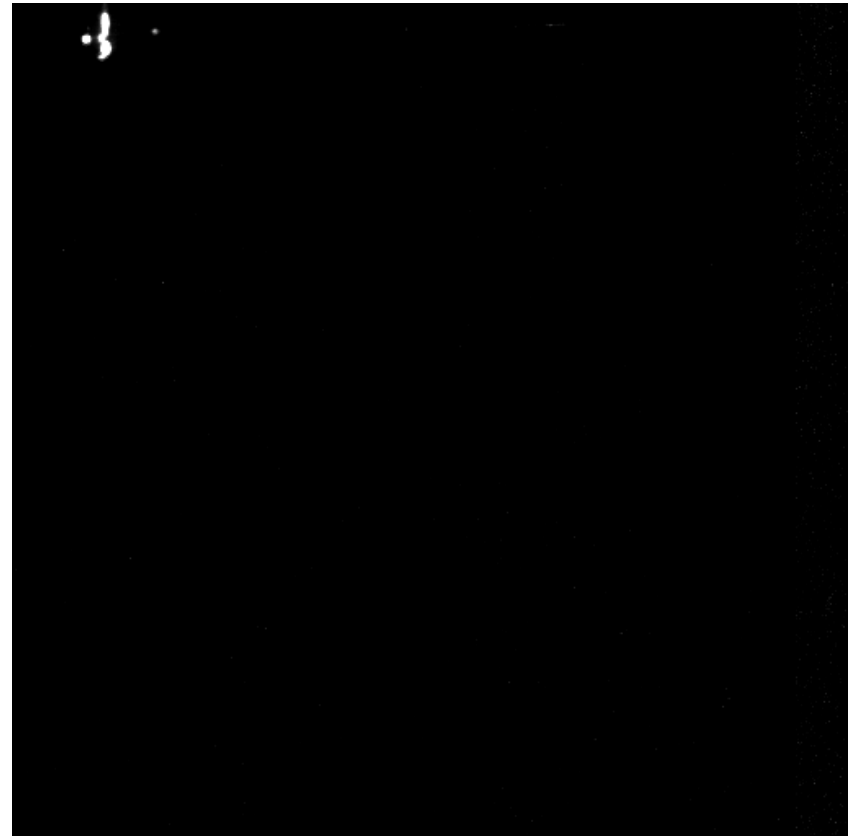
Visualization of developing sprays

Outwardly opening type injector

Back pressure = 0.1MPa

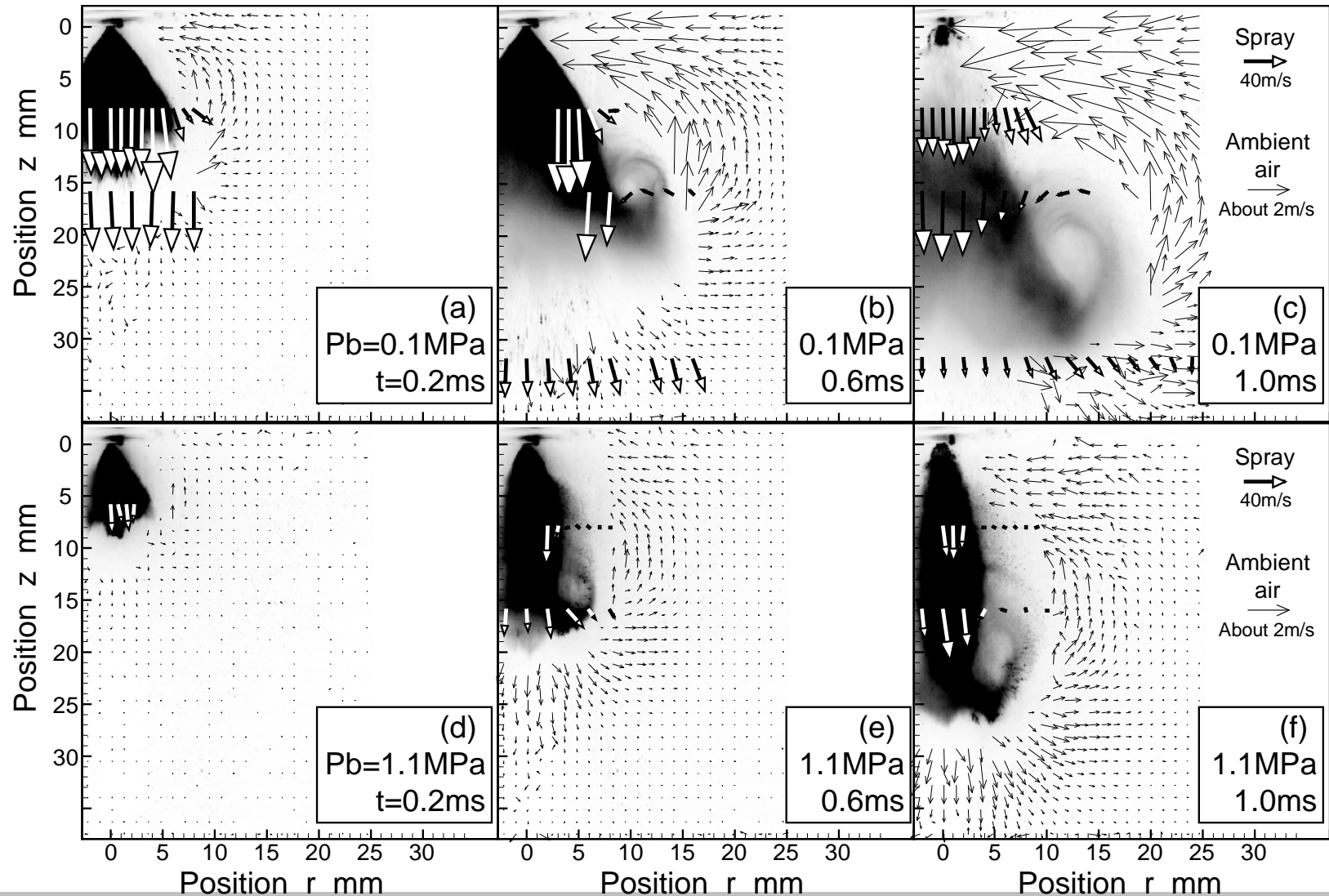


Back pressure = 1.1MPa



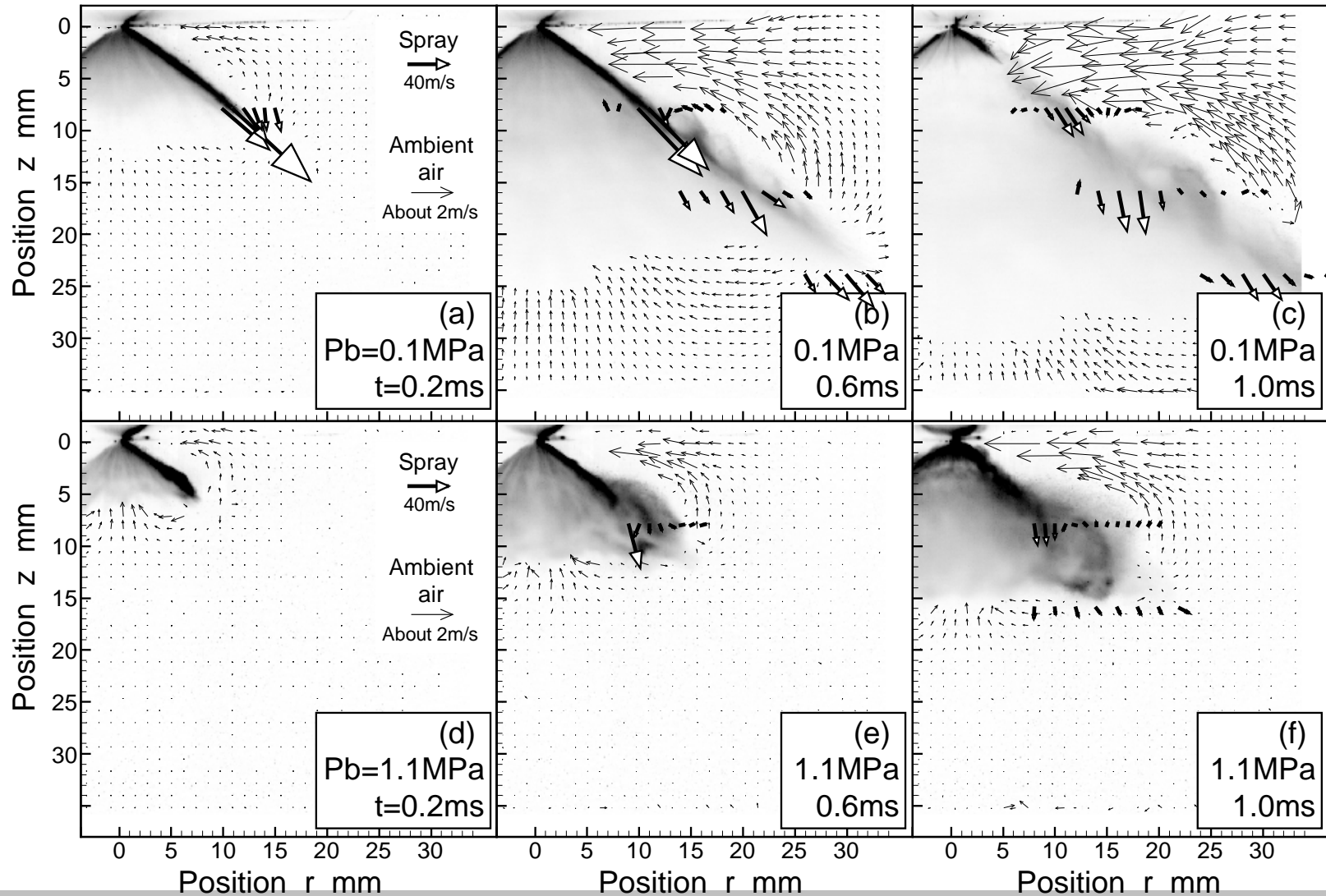
Behavior of spray and its ambient air flow

Swirl type injector

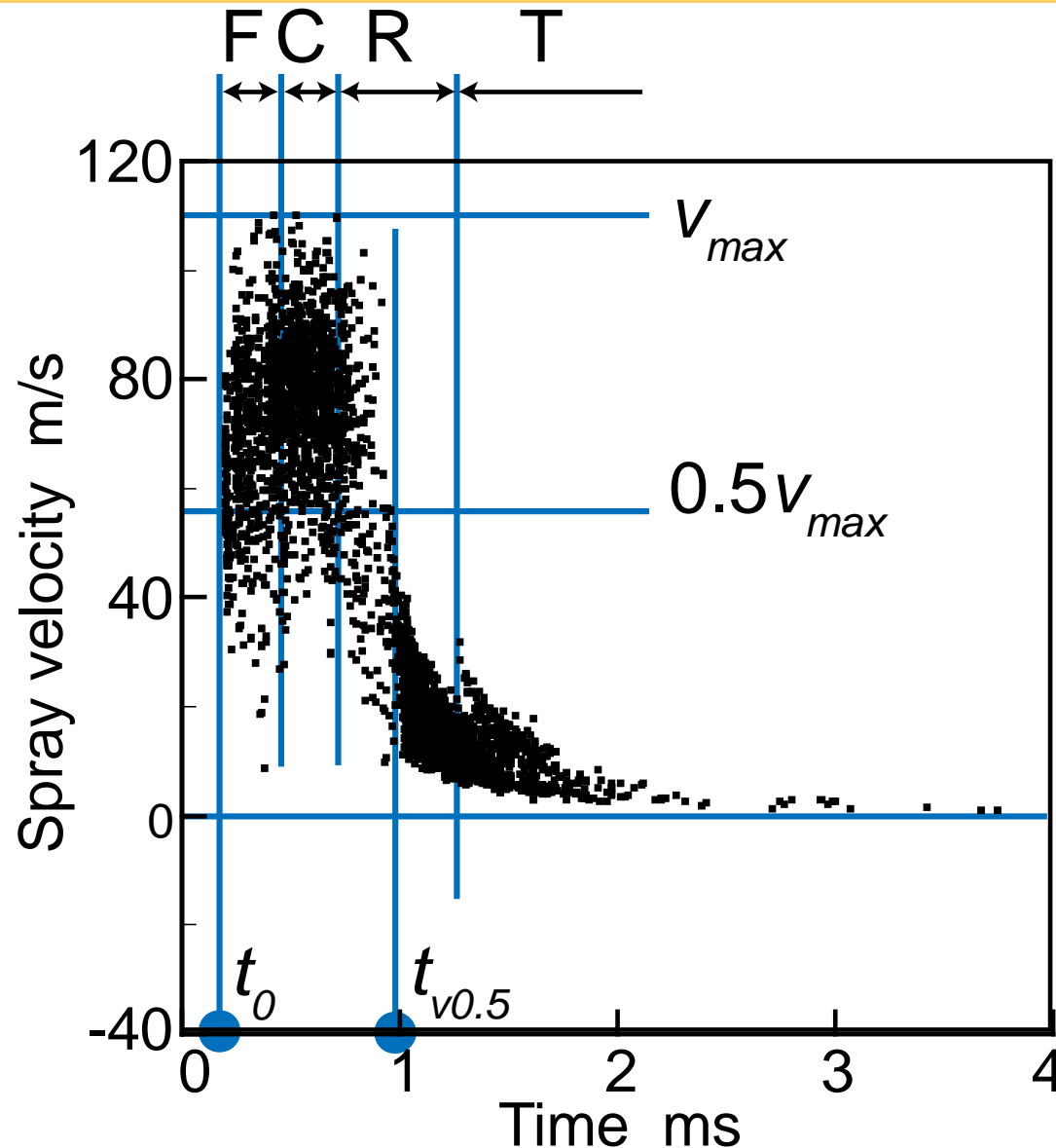


Behavior of spray and its ambient air flow

Outwardly opening type injector



Explanation of time-dividing method



F: Fore part
C: Center part
R: Rear part
T: Tail part

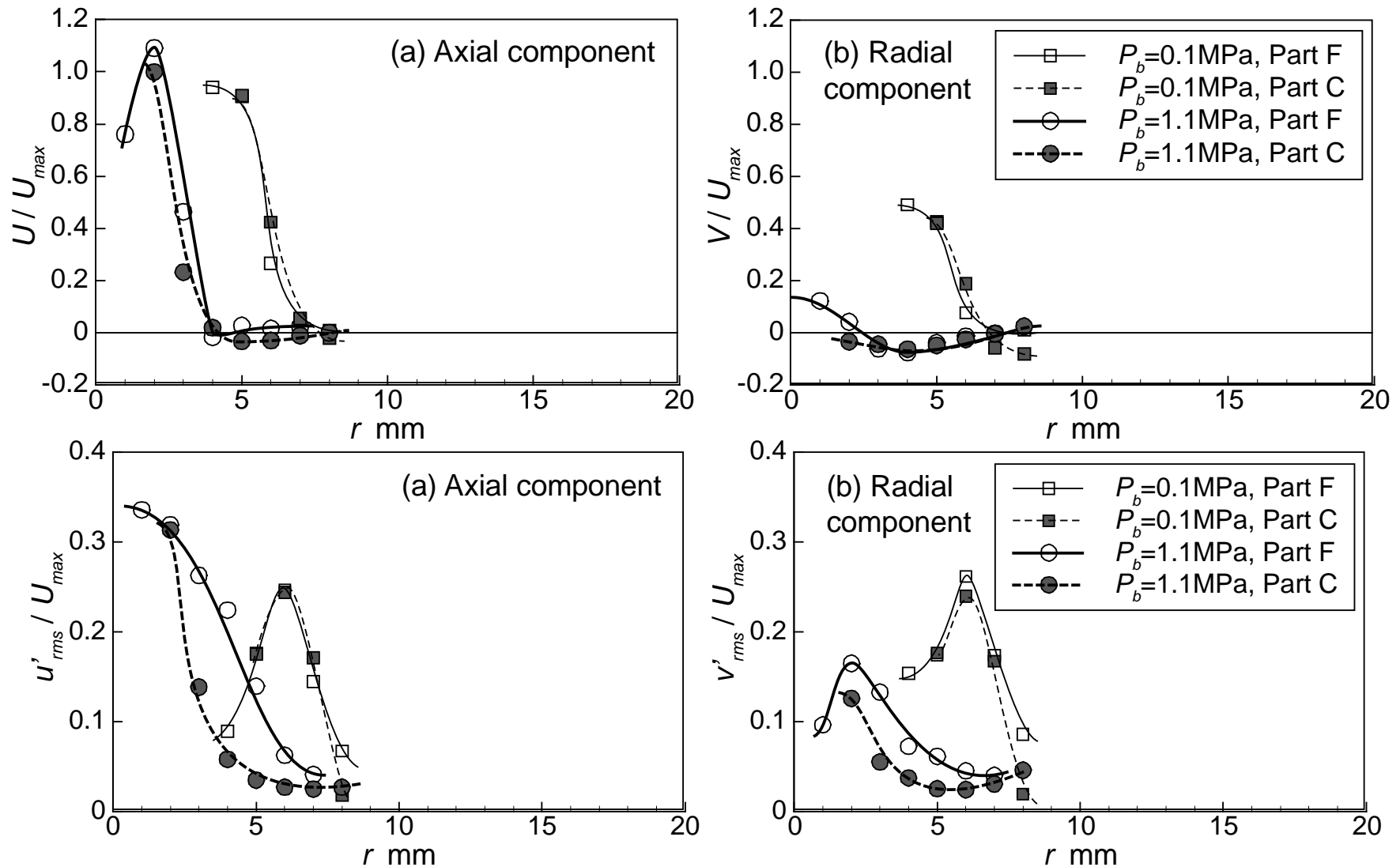
Swirl type injector

$z = 8 \text{ mm}$

$r = 5 \text{ mm}$

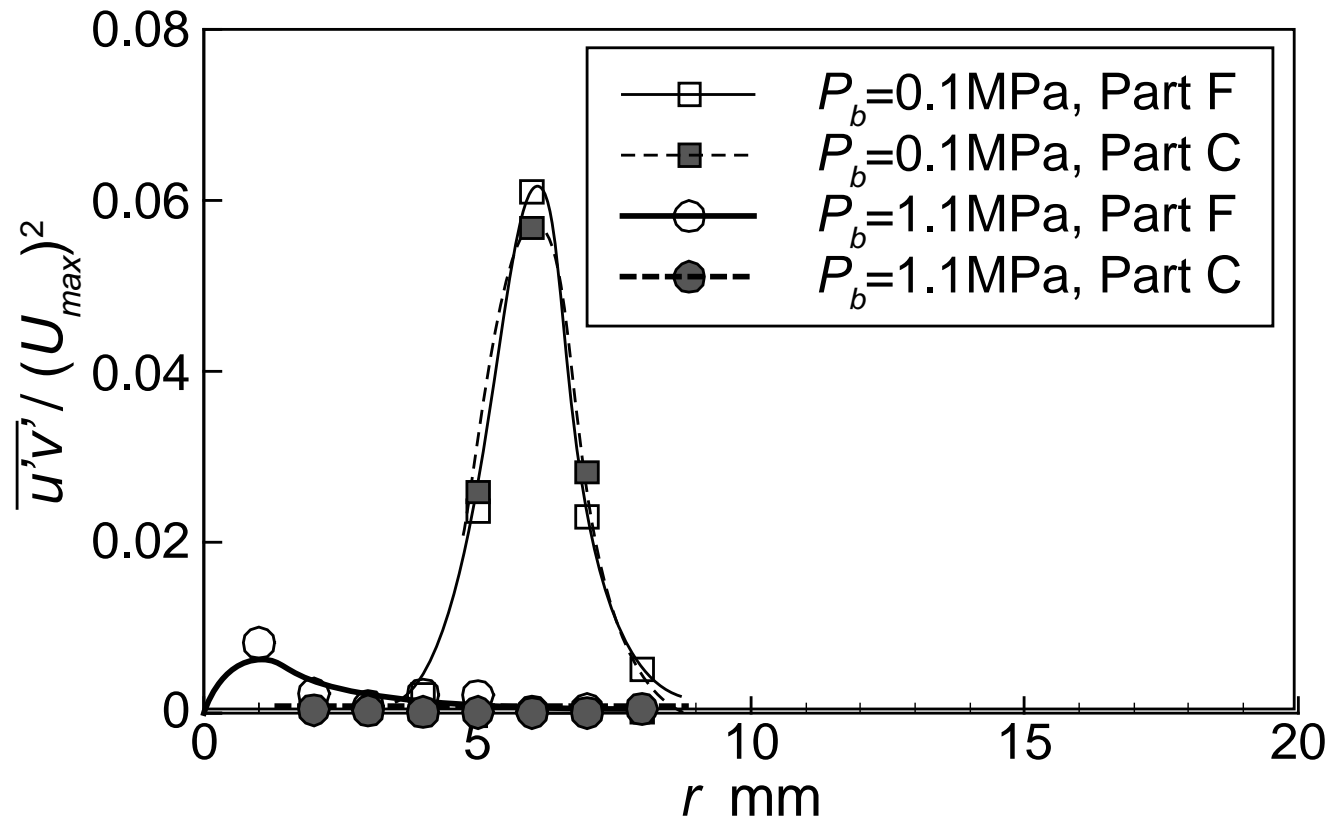
Mean and rms spray velocities

Swirl type injector ($z = 8$ mm)



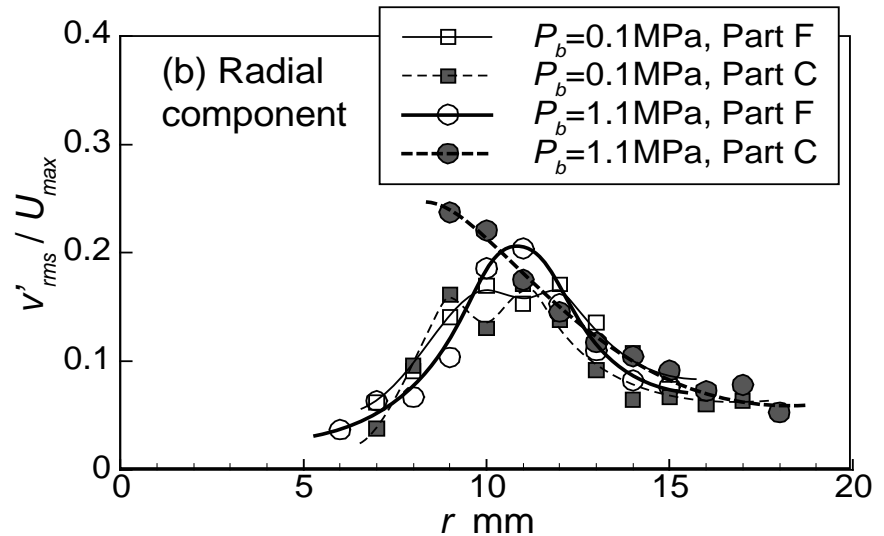
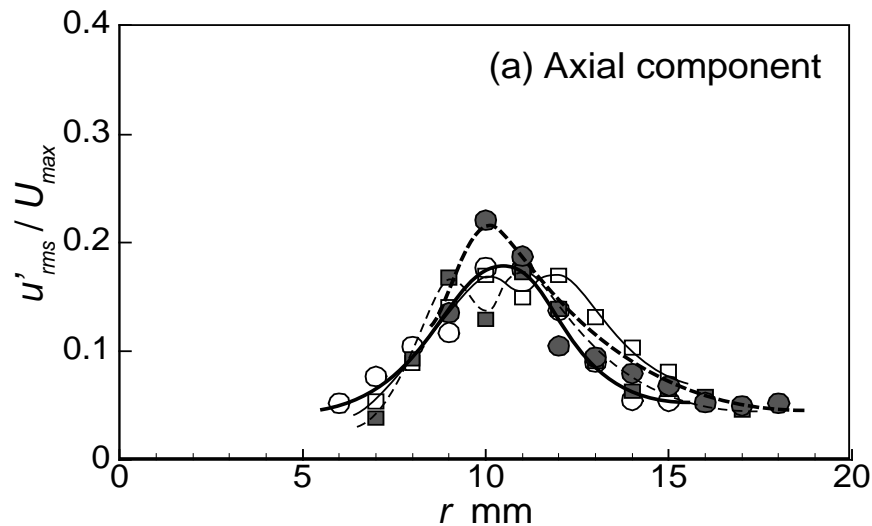
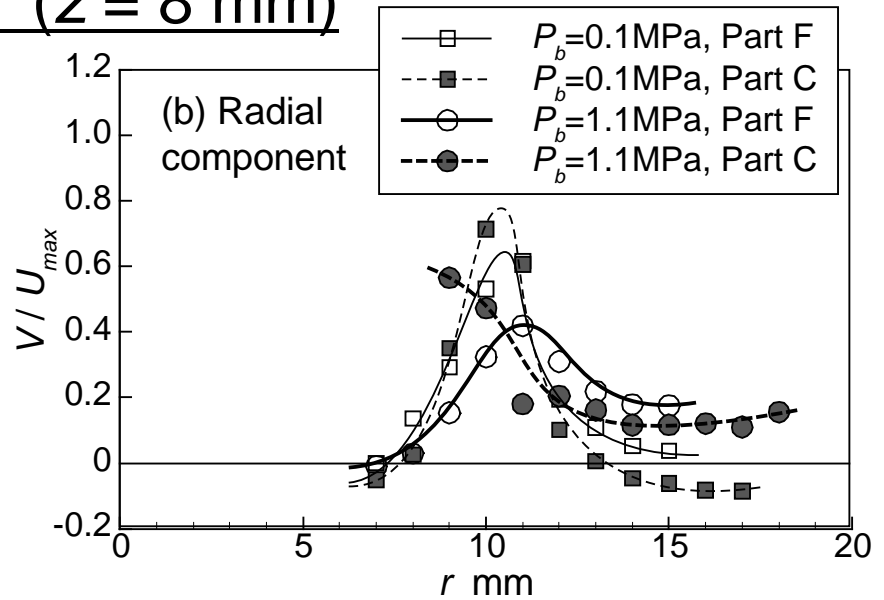
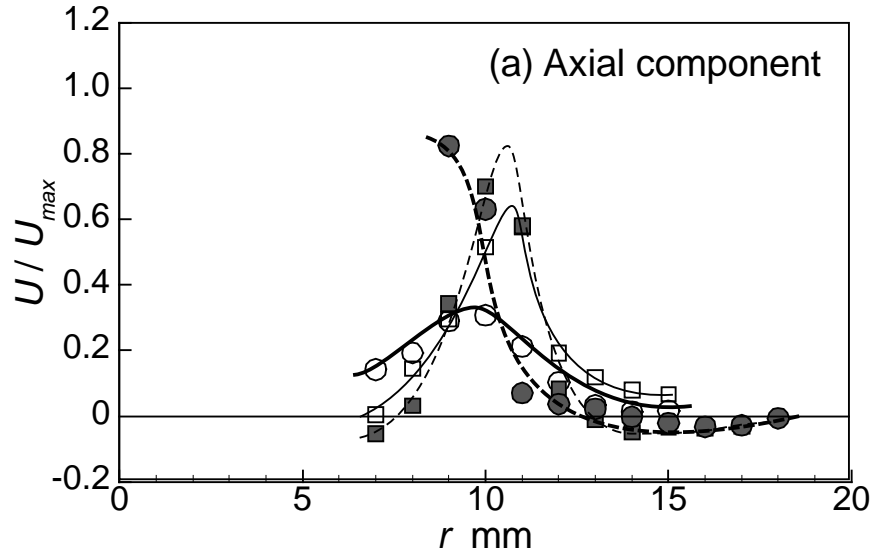
Velocity correlation

Swirl type injector ($z = 8$ mm)



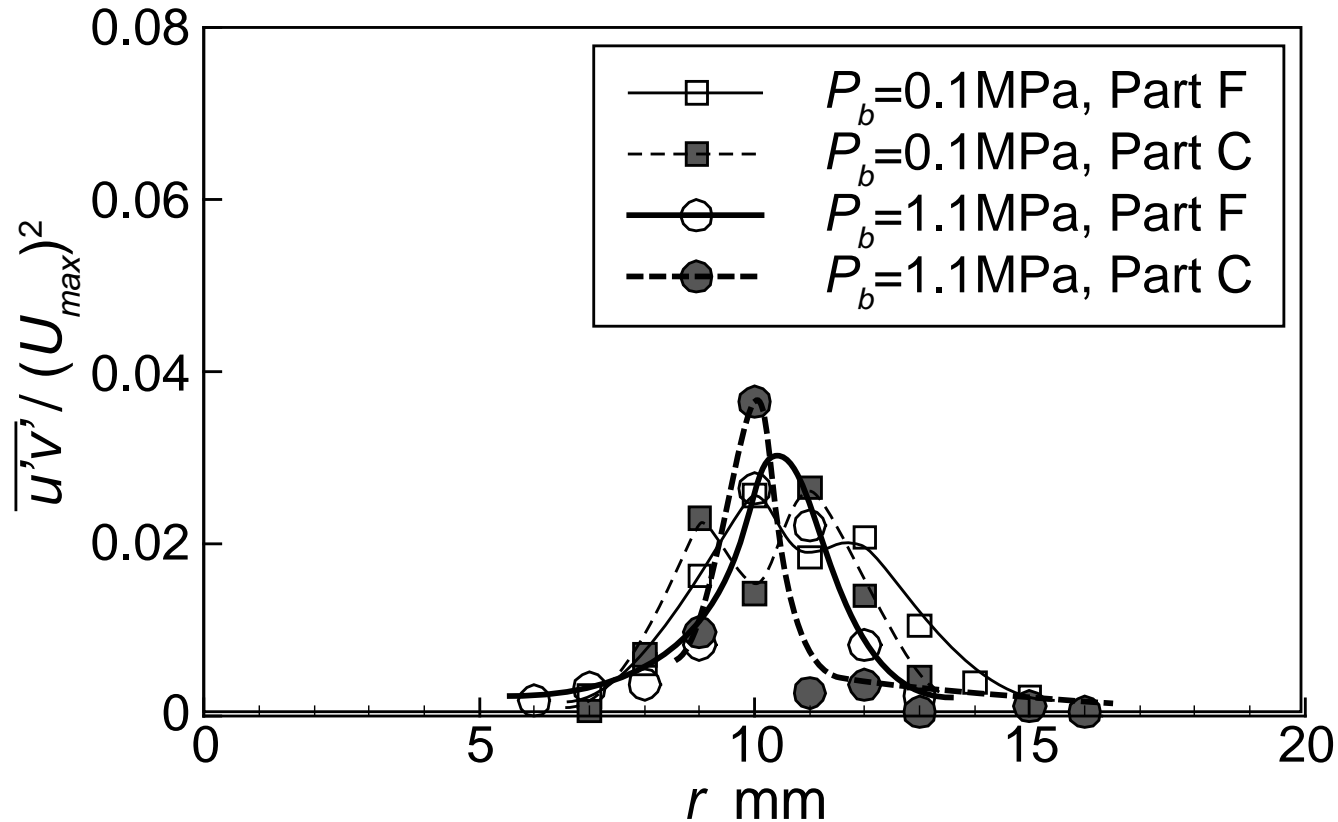
Mean and rms spray velocities

Outwardly opening type injector ($z = 8$ mm)



Velocity correlation

Outwardly opening type injector ($z = 8$ mm)



Conclusion (1)

- Ambient air flow is visualized by time-series images of high speed video camera.
- The mean velocities of spray and ambient flow for high back pressure are smaller than those for normal back pressure.
- Time - dividing method is performed for spray velocity data measured by LDA. At dense region, the radial spray velocity in fore part (part F) is larger than those in center part (part C).

Conclusion (2)

- By using 2-D LDA, two-component mean and rms velocities are measured.
- Two-component rms velocity and velocity correlation is useful for evaluation of the spray characteristics.

Thank you for your attention.