

2005年6月28日

CAVE研究会

PIVによる流速場の 3次元および時系列計測

1. SPIVによる速度3成分計測の例

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工学部機械工学科
川橋正昭

流れの実験解析

流速場計測

時系列点計測 空間掃引

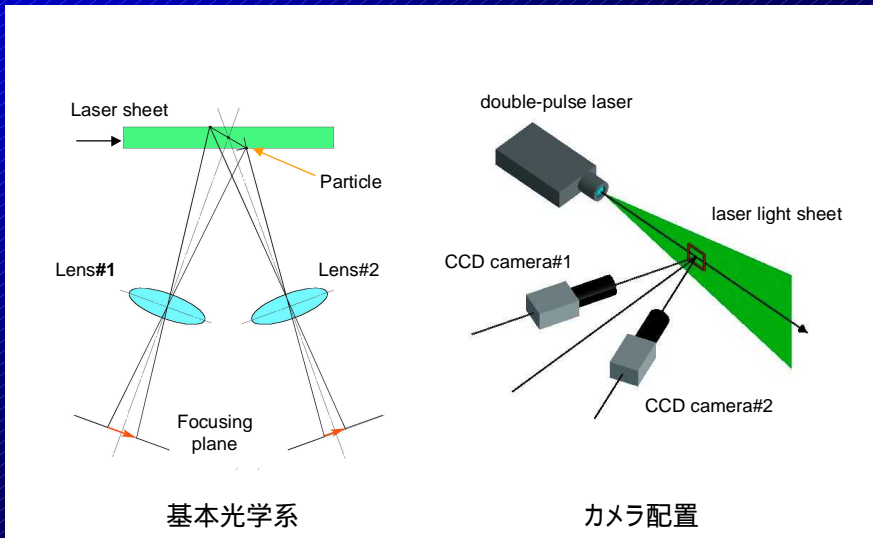
瞬時多次元計測

2次元観測領域	速度2成分	→	PIV、PTV
	速度3成分	→	<u>SPIV</u>
3次元観測領域	速度3成分	→	PTV
		→	HPIV

多次元時系列計測

ダイナミックPIV・SPIV・HPIV

ステレオスコピックPIV(SPIV)基本光学系



計測対象の多翼ファン羽根車およびケーシング



コーン部開口を有する
羽根車



スクロールケーシング

使用したステレオスコピックPIVシステム

照明光源 : ダブルパルスNd:YAGレーザー
(出力 50mJ/pulse)

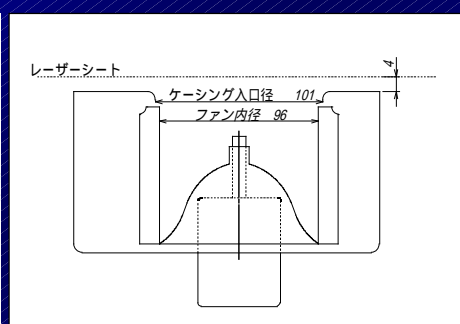
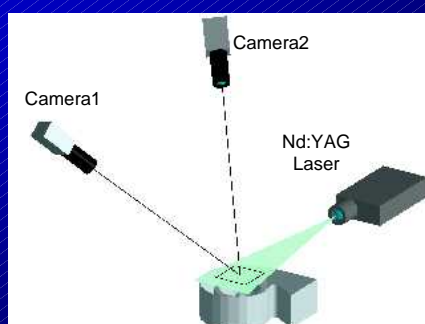
カメラ : CCDカメラ × 2
プログレッシブスキャン
フレームストラドリング
1K × 1K pixels

解析法 : 透視投影アルゴリズム

観察領域 : ~250mm × 250mm

時間分解能 : 15Hz

ベルマウス通過流入流計測光学系 (r-θ面)



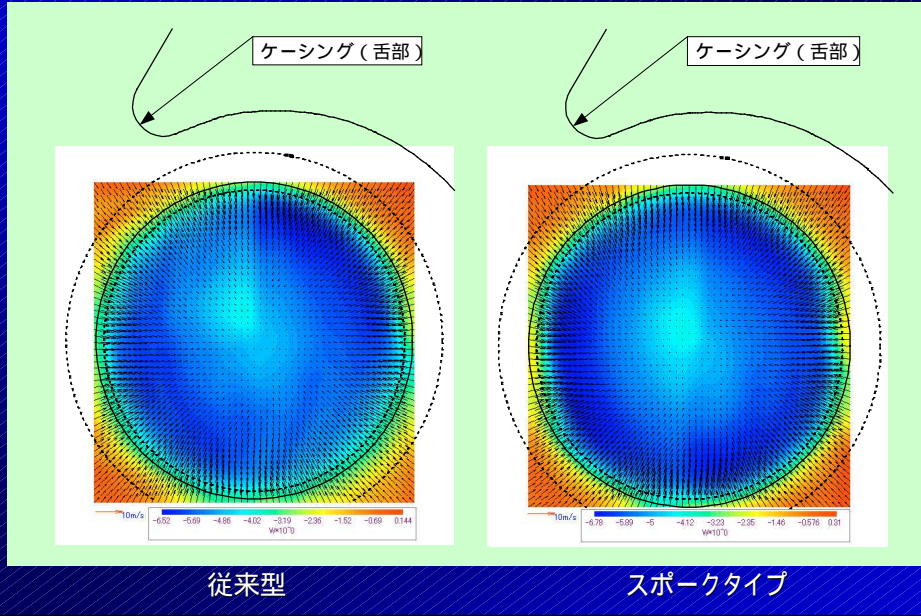
レーザーシート照射位置

実験条件

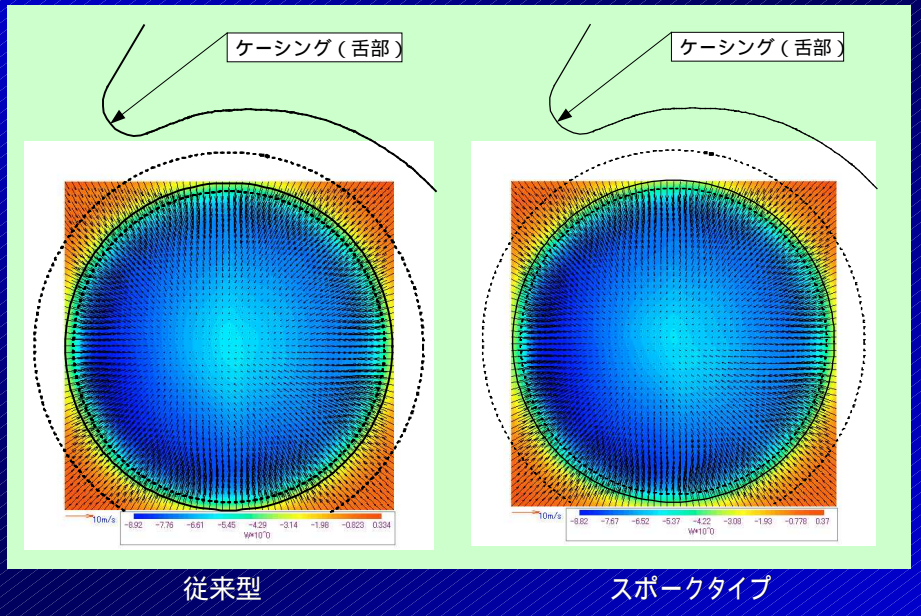
回転数 ; 2000rpm

流量係数 ; =0.20 , 0.25

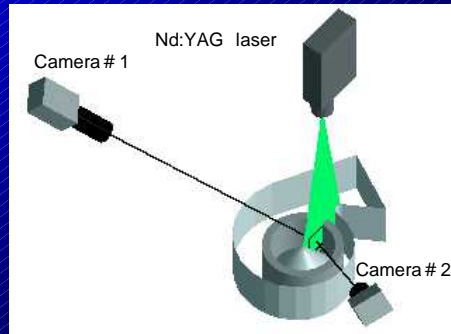
ベルマウス通過流入流速度3成分分布 ($\phi = 0.20$)



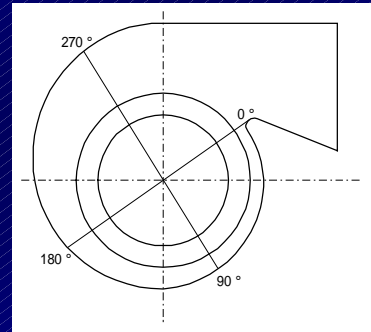
ベルマウス通過流入流速度3成分分布 ($\phi = 0.25$)



羽根車流入流計測光学系 (r-z面)

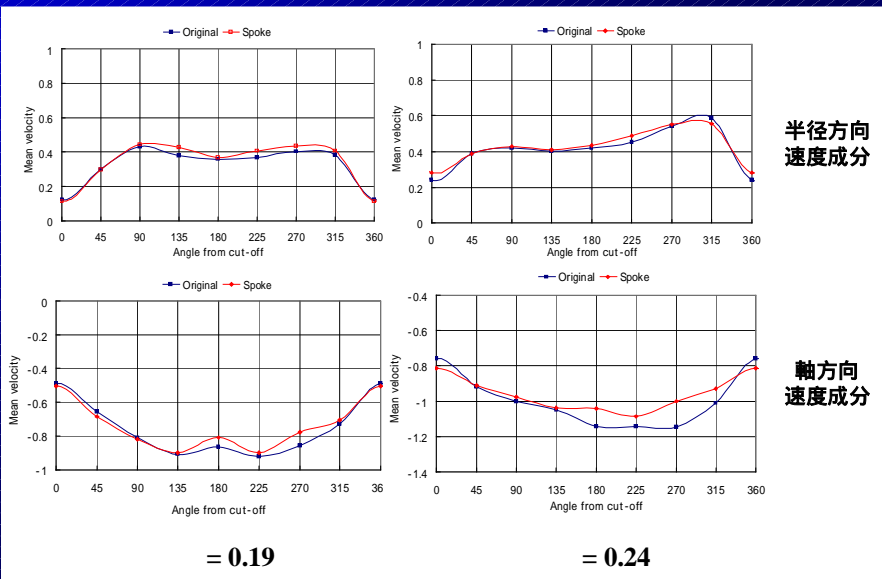


カメラ配置



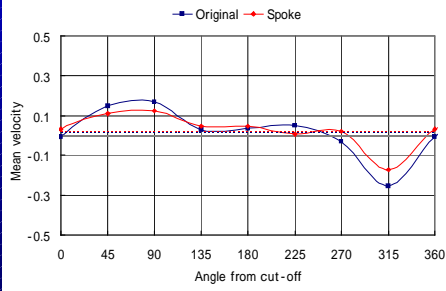
観測面

羽根車流入流速度3成分分布

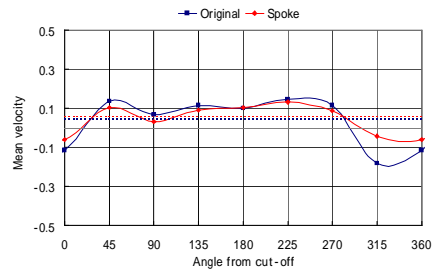


羽根車流入流速3成分分布

回転方向速度成分

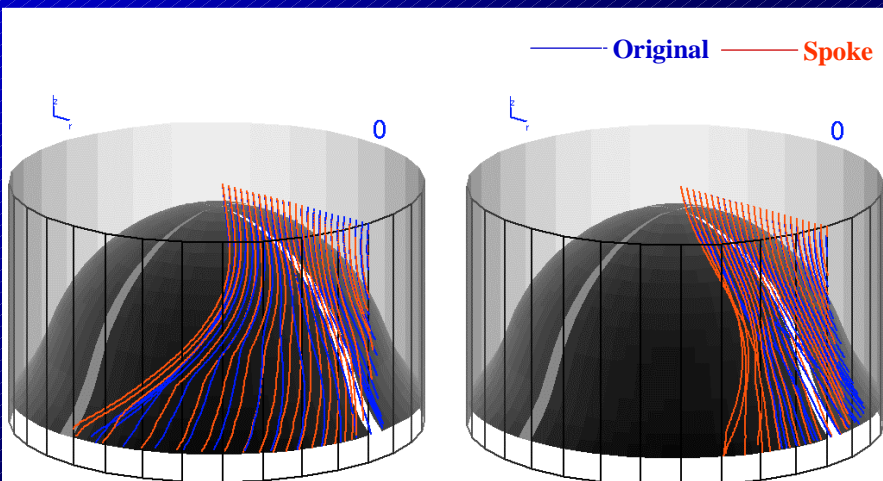


= 0.19



= 0.24

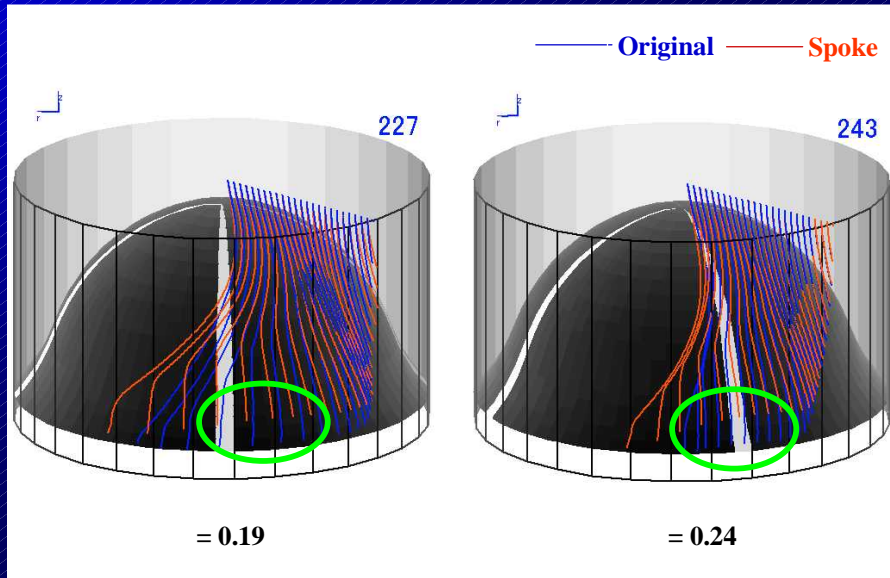
羽根車流入流のStreamline



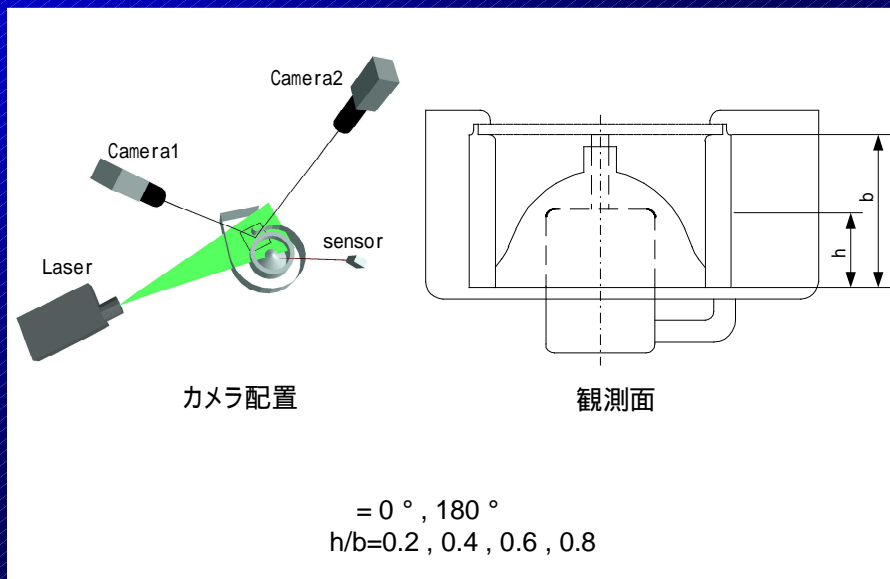
= 0.19

= 0.24

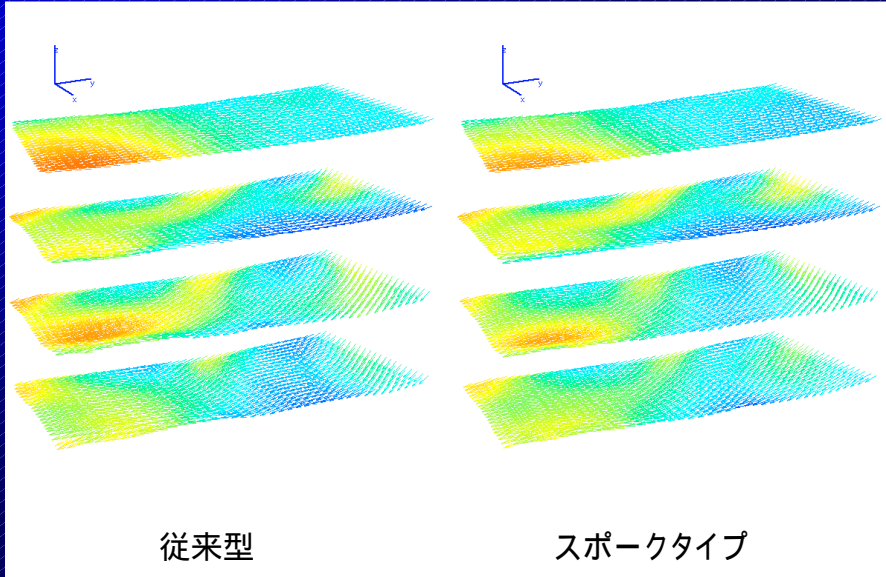
コーンを通過する流入流れ



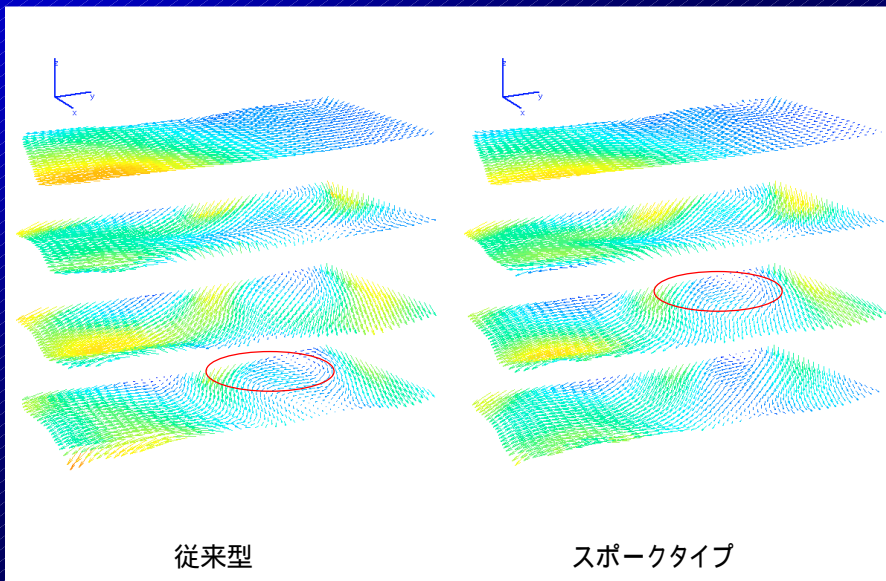
羽根車流出流計測光学系 (r- 面)



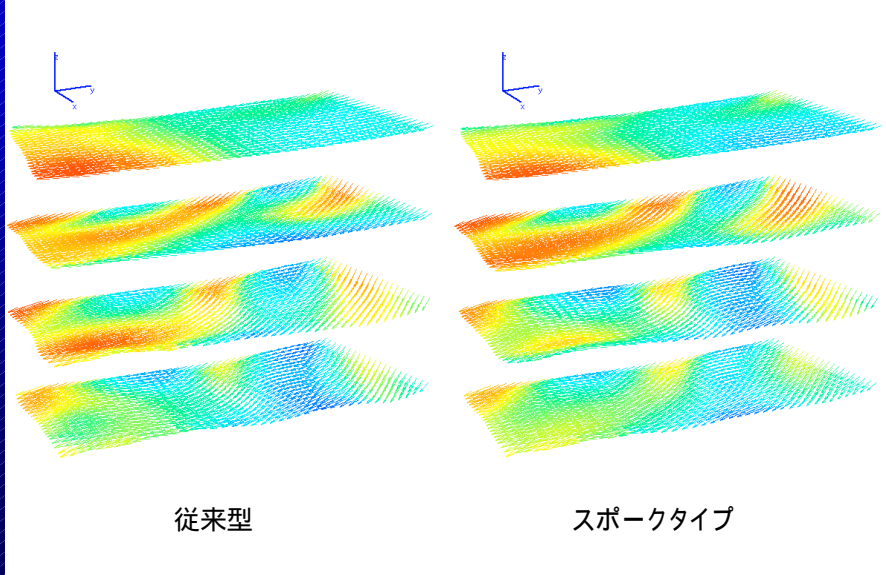
羽根車流出流絶対速度分布($\alpha = 0^\circ$ $U = 0.19$)



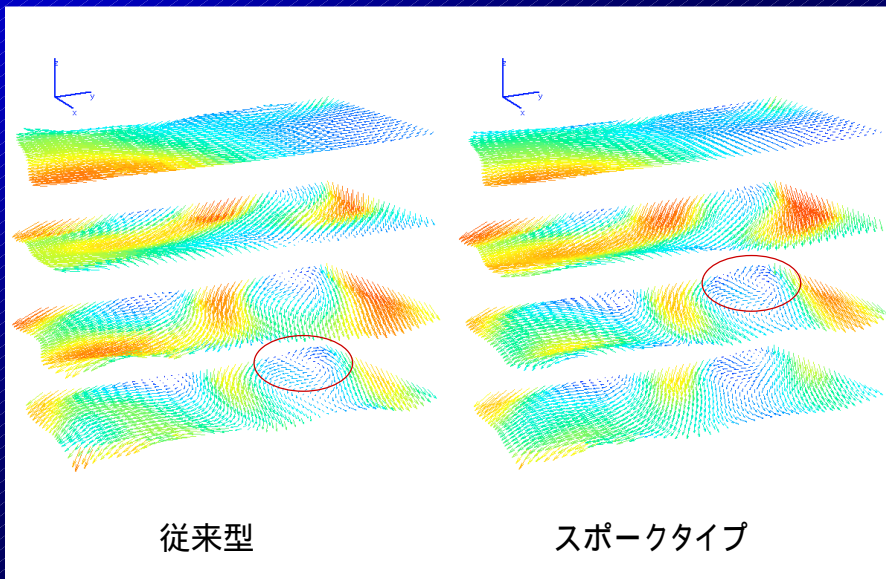
羽根車流出流相対速度分布($\alpha = 0^\circ$ $U = 0.19$)



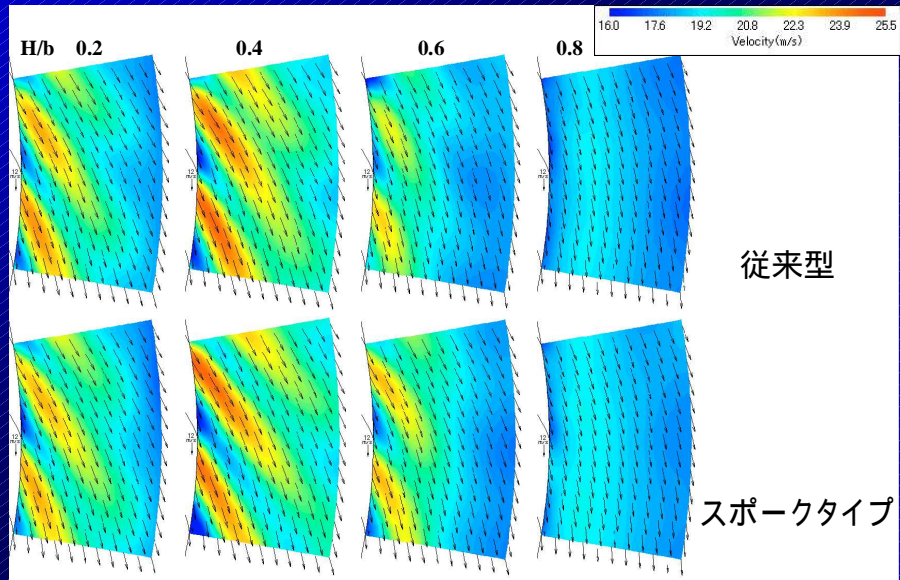
羽根車流出流絶対速度分布($\alpha = 0^\circ$ $U = 0.24$)



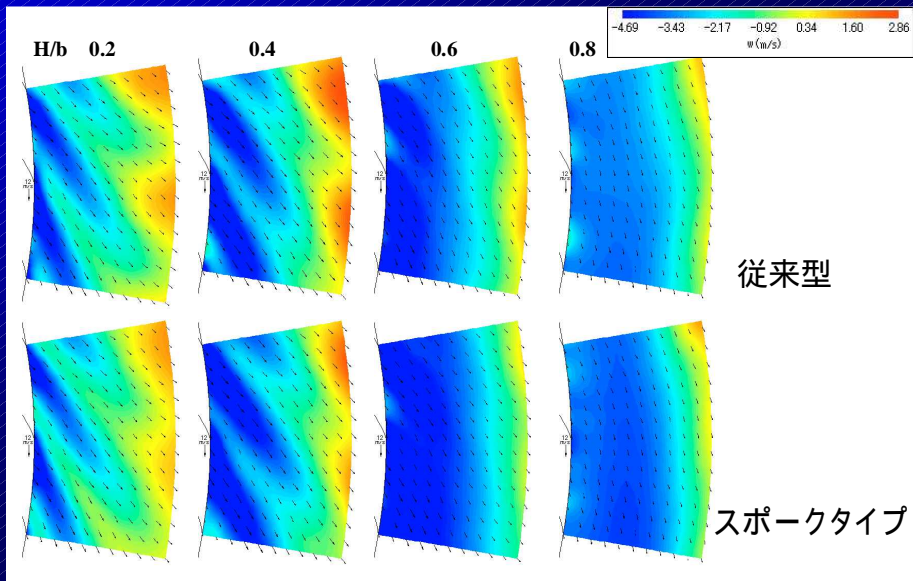
羽根車流出流相対速度分布($\alpha = 0^\circ$ $U = 0.24$)



羽根車流出流の絶対速度($\alpha = 180^\circ$ $\beta = 0.19$)



羽根車流出流の速度3成分($\alpha = 180^\circ$ $\beta = 0.24$)



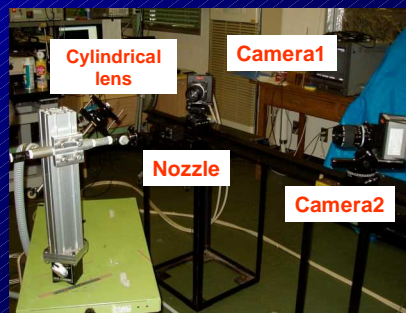
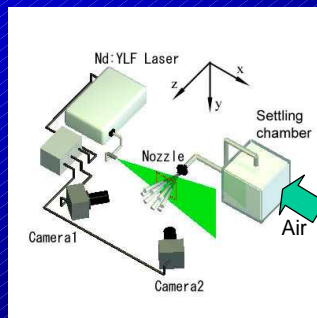
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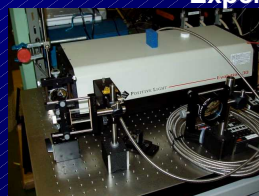
PIVによる流速場の3次元および時系列計測

2. ダイナミックSPIVによる時系列計測の例

Optical arrangement of dynamic SPIV



Experimental set-up

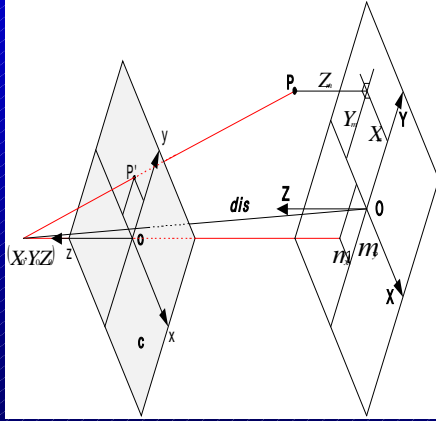


Nd:YLF Laser
Positive light : Evolution-30
Out put : 20mJ/pulse at 1kHz
Wavelength : 527nm



High-speed C-MOS camera
Photoron Fastcam Max
Pixels size : 1024 x 1024 at 2kHz

Algorithm of Stereoscopic PIV



Relationship of camera coordinates and object coordinates

$$x = c_x \frac{X_m - m_x}{\sqrt{dis^2 - m_x^2 - m_y^2 - Z_m^2}} + \Delta x$$

$$y = c_y \frac{Y_m - m_y}{\sqrt{dis^2 - m_x^2 - m_y^2 - Z_m^2}} + \Delta y$$

$$\Delta x = \frac{x}{r} (k_1 r^2 + k_2 r^4)$$

$$\Delta y = \frac{y}{r} (k_1 r^2 + k_2 r^4)$$

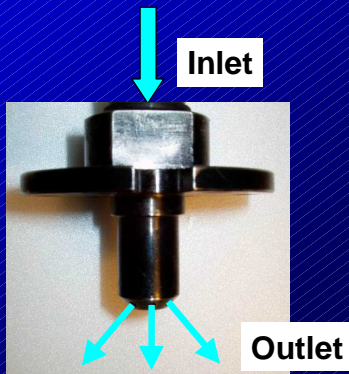
$$r = \sqrt{x^2 + y^2}$$

Doh.H.D et al. (2000)

Perspective relationship for particle position

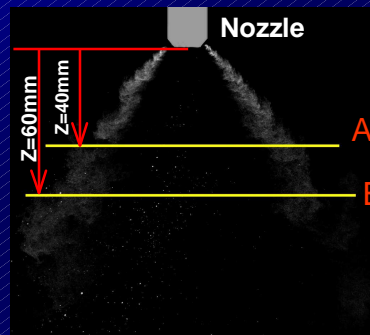
Saitama University Fluid Dynamics Lab.

Experimental condition



Injection pressure: 18.0 [kPa]
 Flow rate : 153[l/min]
 Spray Angle : 45°
 Number of holes : 8

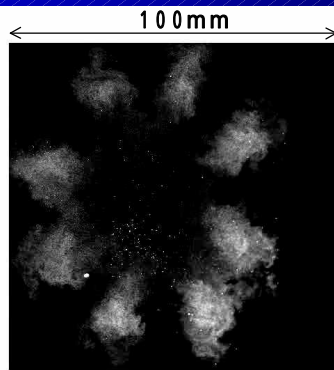
Test nozzle



Injection pressure : 18.0[kPa]
 Injection condition : continuous
 Observation : A 100(H)mm × 80 (V) mm area
 : B 200(H)mm × 150 (V) mm
 Stereo view angle : 45°
 Thickness of Laser light sheet : 3mm
 Seeding particle : Oil vapor (dp=1μm)

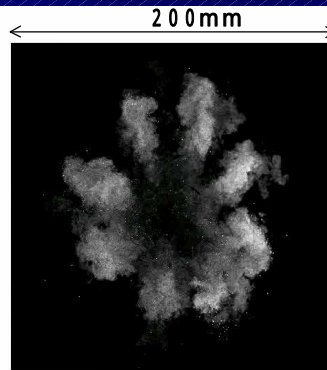
Saitama University Fluid Dynamics Lab.

Raw images of gas jets in time series



T+0[ms]

Test section A (Z=40mm)



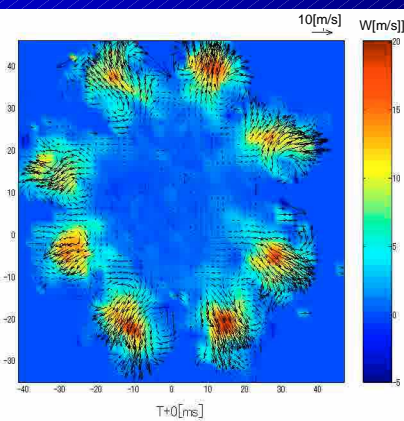
T+0[ms]

Test section B (Z=60mm)

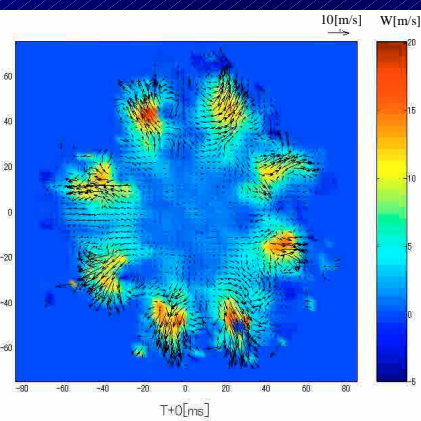
Flame rate : 2000 f.p.s

Saitama University Fluid
Dynamics Lab.

Three-components of velocity in time series



Test section A (Z=40mm)

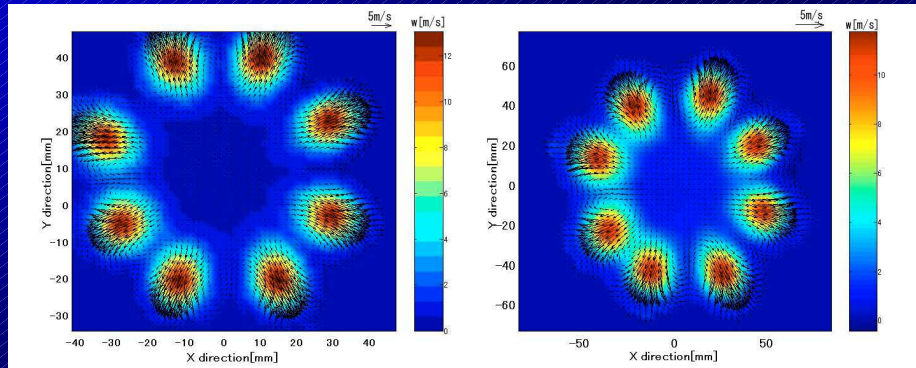


Test section B (Z=60mm)

Flame rate : 2000 f.p.s

Saitama University Fluid
Dynamics Lab.

Ensemble mean velocity field

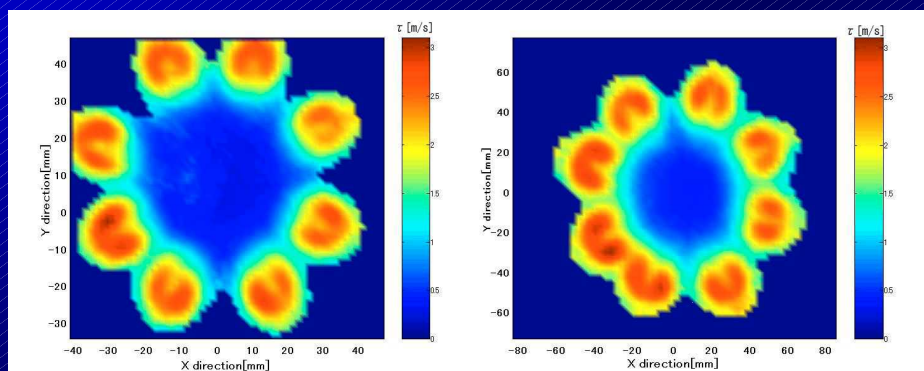


Z=40mm

Z=60mm

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Dynamics Lab.*

Distribution of turbulent intensity

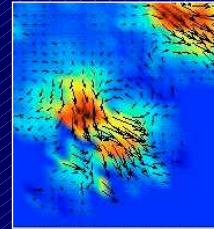
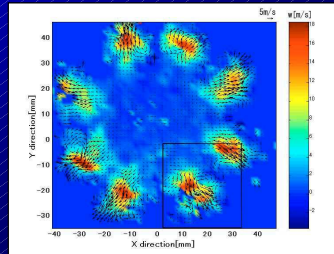
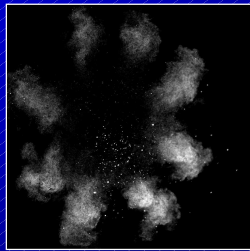


Z=40mm

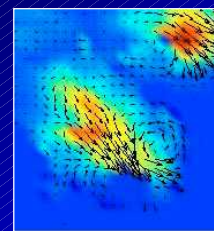
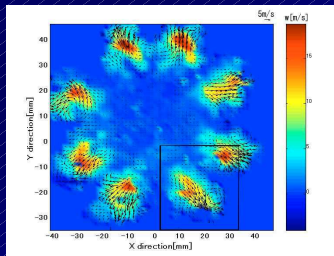
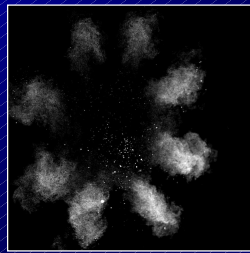
Z=60mm

*Saitama University Fluid
Dynamics Lab.*

Instantaneous velocity field in time series measurements

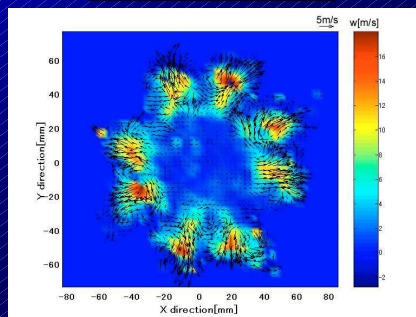
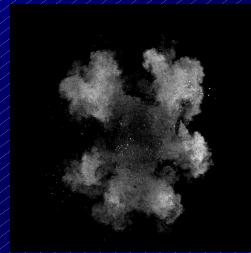
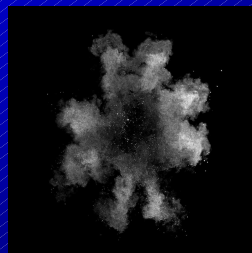


T=t [ms] Z=40mm

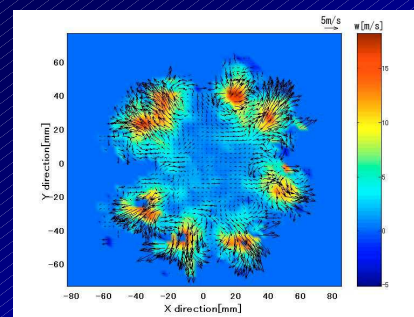


T=t+1.0 [ms] Z=40mm

Instantaneous velocity field in time series measurements



T=t [ms] Z=60mm



T=t+120 [ms] Z=60mm