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# FLUOSTAR

***FLUOSTAR® Rhodamine B-"encapsulating" microspheres are seeding particles optimized for Particle Image Velocimetry***

*Technical handbook ver.1, Feb, 2010*

## *CONTENTS*

# 1) Introduction of Fluorescent PIV(fPIV): Overview

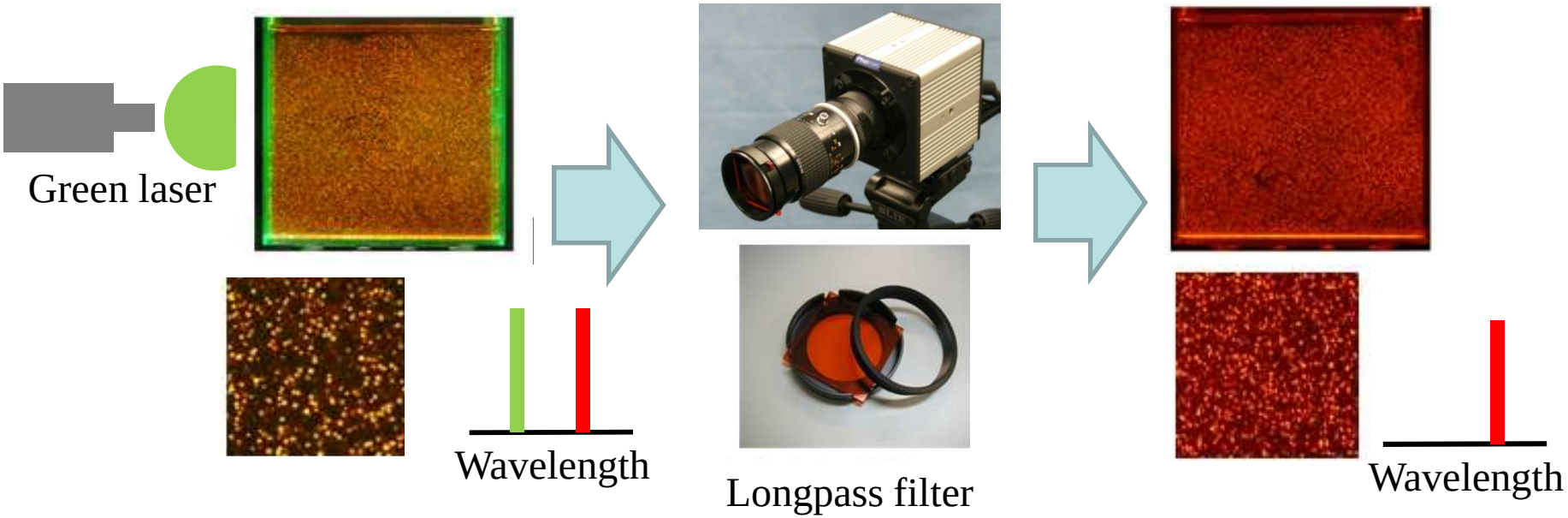
**Fluorescent PIV (fPIV)** is a hands-on advanced PIV liquid measurement using fluorescence-emitting particles rather than conventional non-fluorescent ones, such as glass spheres. When fluorescent particles are illuminated by a light source (Laser, LED etc.) , particles emits fluorescence with a different wavelength (or, color) from that of the light source. By using an **optical filter,** users can **"selectively"** obtain fluorescent particle images without any optical disturbance from the light source, This document explains fPIV and its optimal seeding particles, **FLUOSTAR®**. Users no longer suffer from undesired reflective light. Excellent signal-to-noise ratio can be achieved by using fluorescence, or changing the color.

| | Conventional PIV (Non-fluorescent PIV) | **Fluorescent PIV** |
|---|---|---|
| Seeding particles | • Polystyrene<br>• Glass spheres (GS)<br>• Metal-coated hollow GS etc. | **Fluorescent particles (FLUOSTAR® )** |
| Particle visibility | **Scattering** light | **Fluorescent emission** |
| Wavelength | Same as light source | **Longer than light source** |
| Light source※1 | Laser / LED | **Laser / LED** |
| Camera | CCD (CMOS) sensor | **CCD (CMOS) sensor** |
| Optical filter※2 | No | **Yes** |

※1 We assume a green laser or LED is a typical light source for modern PIV.

※2 A standard longpass filter is necessary for fPIV. In the case of FLUOSTAR ®, the filter should have a sharp cutoff wavelength at 550nm. Upon request, EBM Corp. recommends a suitable filter and attachment (see p3).

# 1) Introduction of Fluorescent PIV(fPIV): illustration

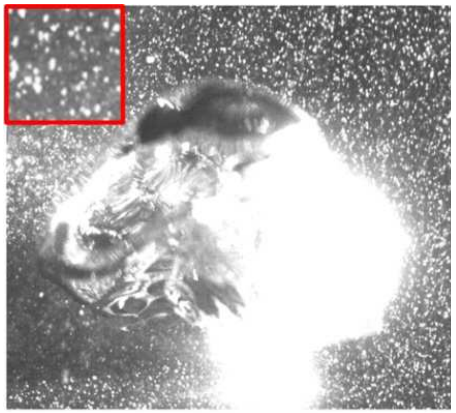



For clarity, FLUOSTAR® images were taken by a color CCD sensor.
Particles were seeded in water within a Perspex-made container and illuminated by a Nd:YLF laser (527nm)

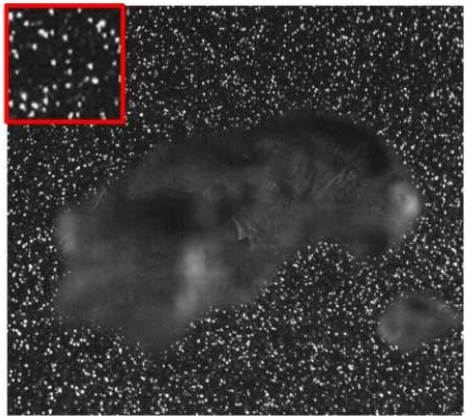
# 1) Introduction of Fluorescent PIV(fPIV): applications

## Bubbly flow meas.

Hardware setup
- Nd:YLF laser (527nm, Photonics Industries)
- 5 mJ-energy high-rep. pulsed green laser
- Standard CMOS camera, Fastcam 1024 (Photron)
- 1Kfps time-resolved measurement



Non-fluorescent particles

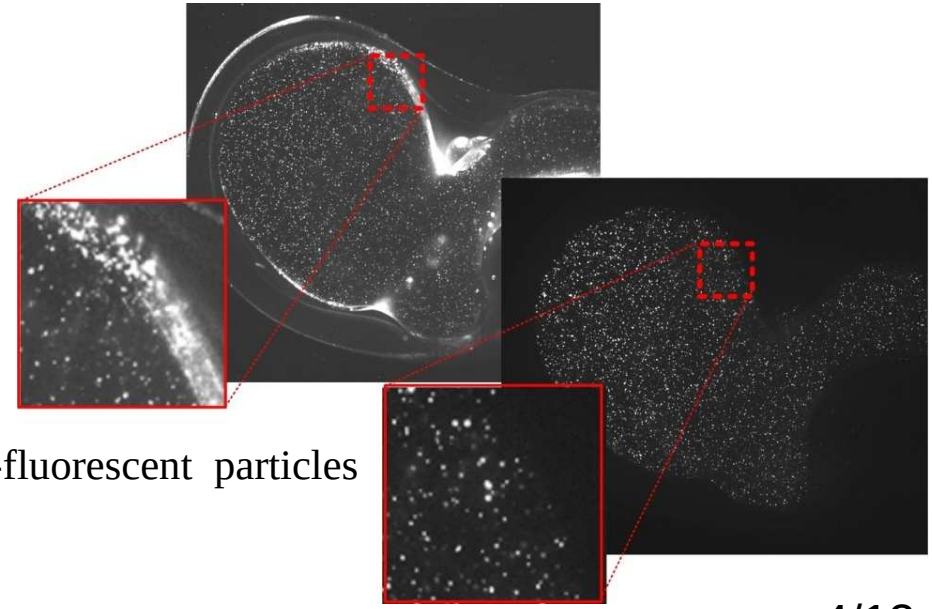


FLUOSTAR® microspheres

## Near-wall flow meas.

Similar as above

**Excellent particle visibility!**

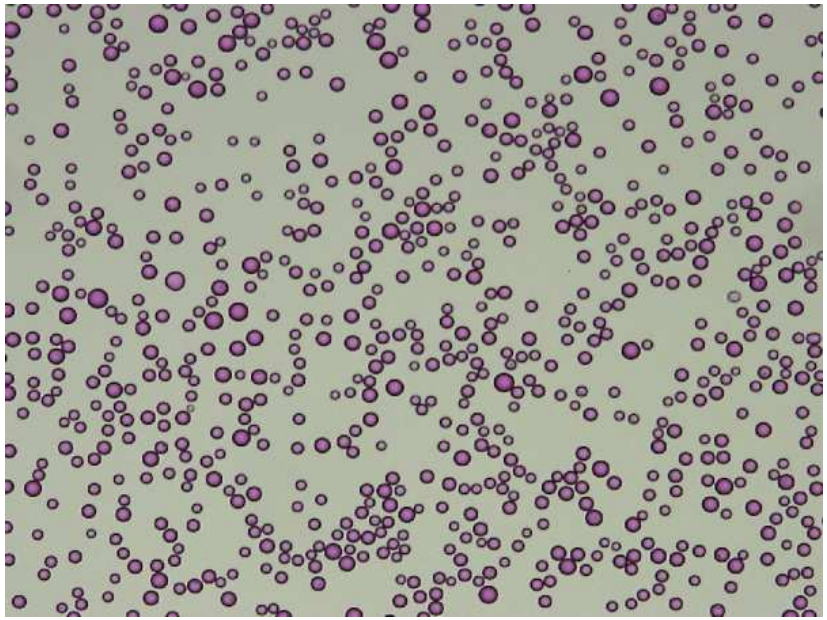


Non-fluorescent particles

FLUOSTAR® microspheres

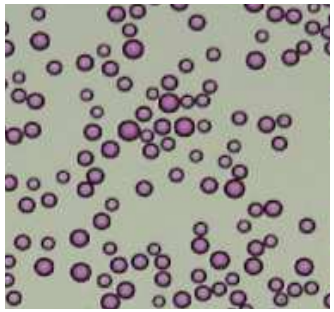
# 2) Advantage of FLUOSTAR® microsphere

| | |
|---|---|
| Shape | Sphere |
| Density | **1.1 g/cm$^3$** |
| Mean size | **15 µm** |
| Size distribution | **Less than 20% in C.V. ※1** |
| Fluorescent emission | **Excellent brightness (P6)** |
| Water dispersibility | **Excellent (P7, 8)** |
| Water stability (heating, durability) | **Excellent (P9, 10)** |
| Particle supply | Dry powder |

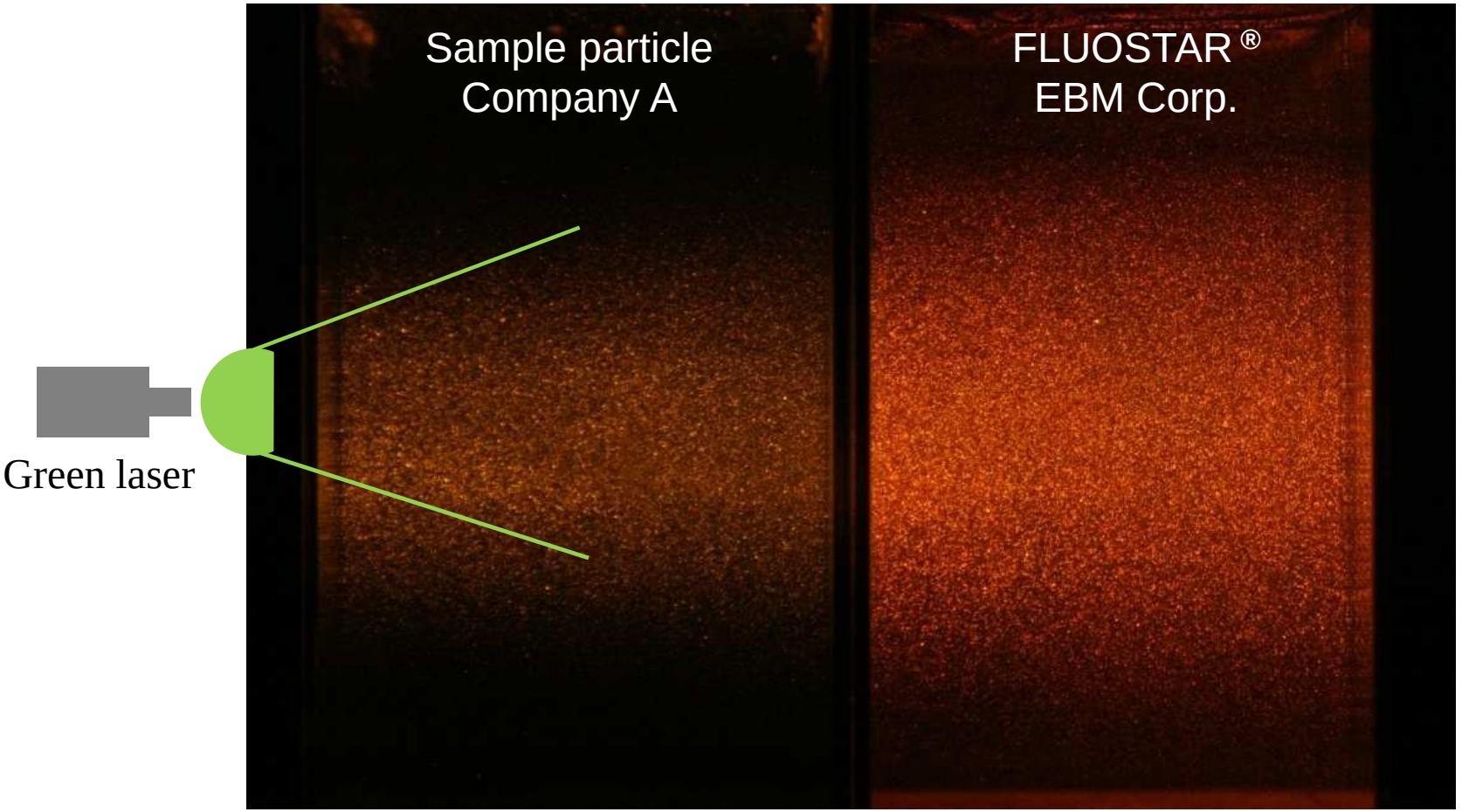


Microscope image ( ×10 )

※1 C.V. denotes coefficient of variation, (standard deviation divided by mean diameter)

Zoomed view 

# 2) FLUOSTAR® technique: excellent brightness




**Particle conditions:**

FLUOSTAR® was compared in brightness with a sample fluorescent particle commercially available. Particle concentration was **5 mg / litter** for both in fresh water. The size of each particle was similar in mean diameter (15 µm).

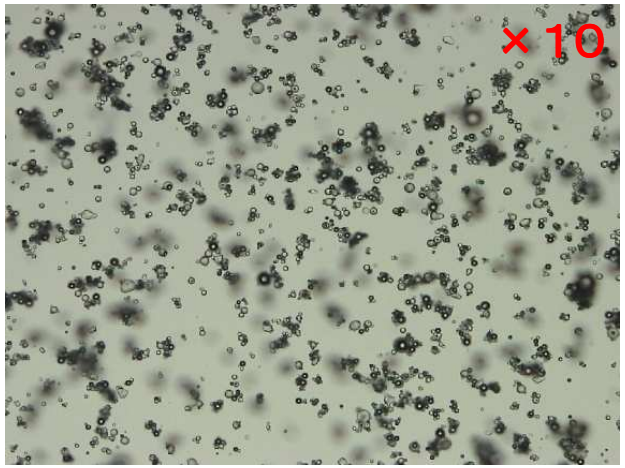
# 2) FLUOSTAR® technique : Water dispersibility

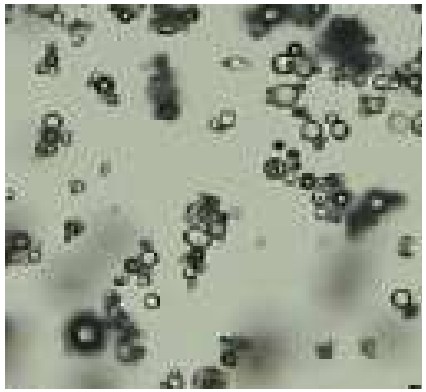

FLUOSTAR ® is **hydrophilic,** or **wettable,** particles**!!!**

Movie available
http://ebm.vc/news/107?category=info_e

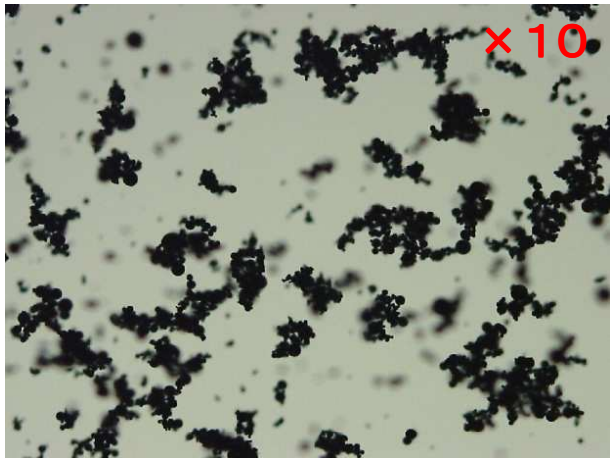
# 2) FLUOSTAR® technique : Comparison of water dispersibility

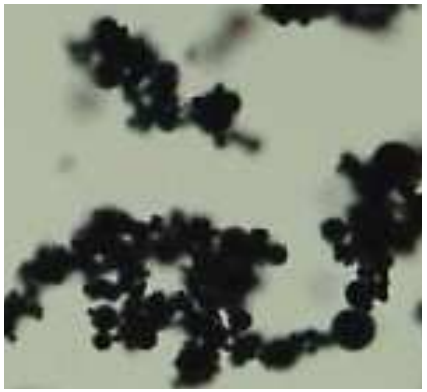
Hollow glass (HG) sphere



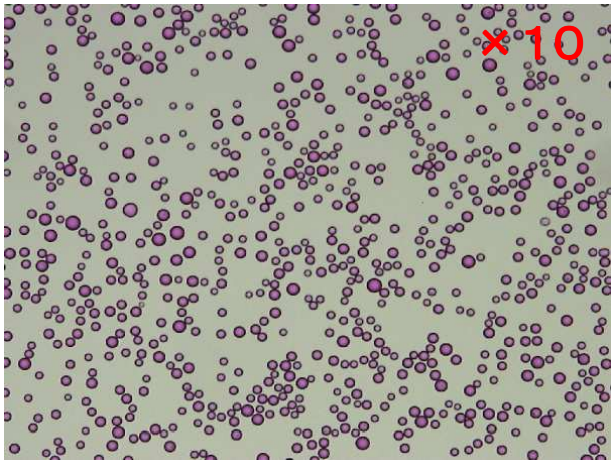



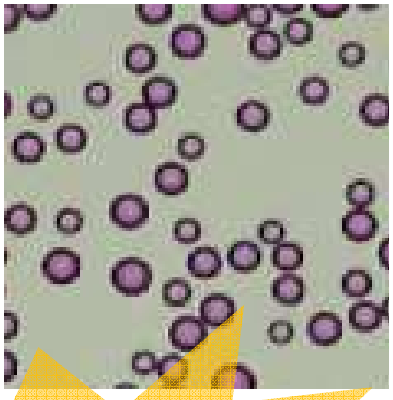
Silver-coated HG sphere



FLUOSTAR®

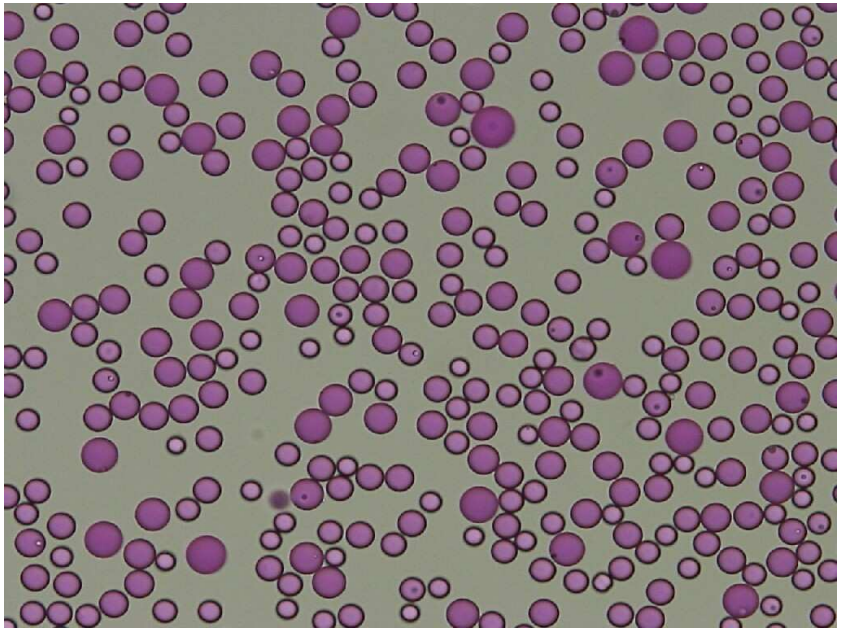


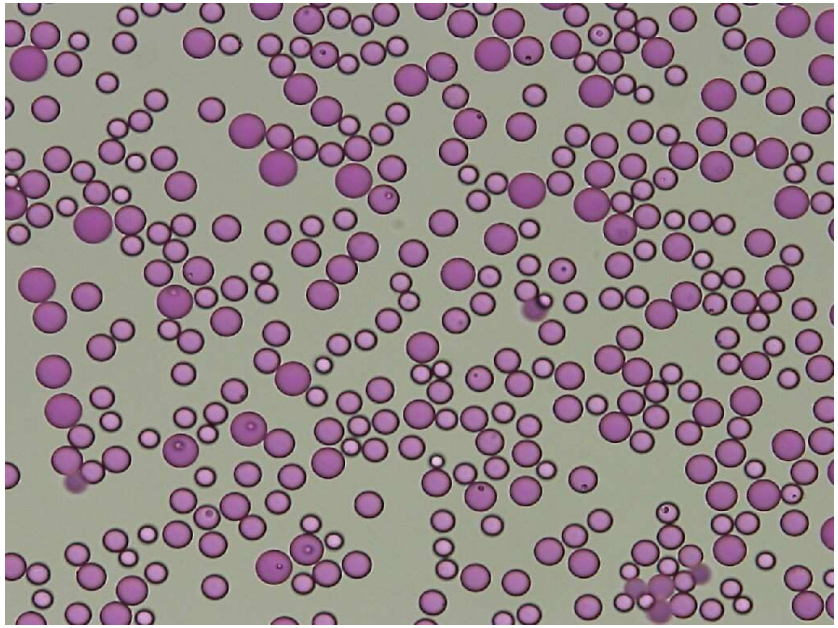
Hollow glass and silver-coated HG particles were mixed in water and then stirred in a mixing device. Despite that, these particles still formed aggregations . In contrast, Fluostar does not make aggregations even without stirring because of prominent wettability.

**No more aggregation and adhesion**

# 2) FLUOSTAR® technique : Water stability



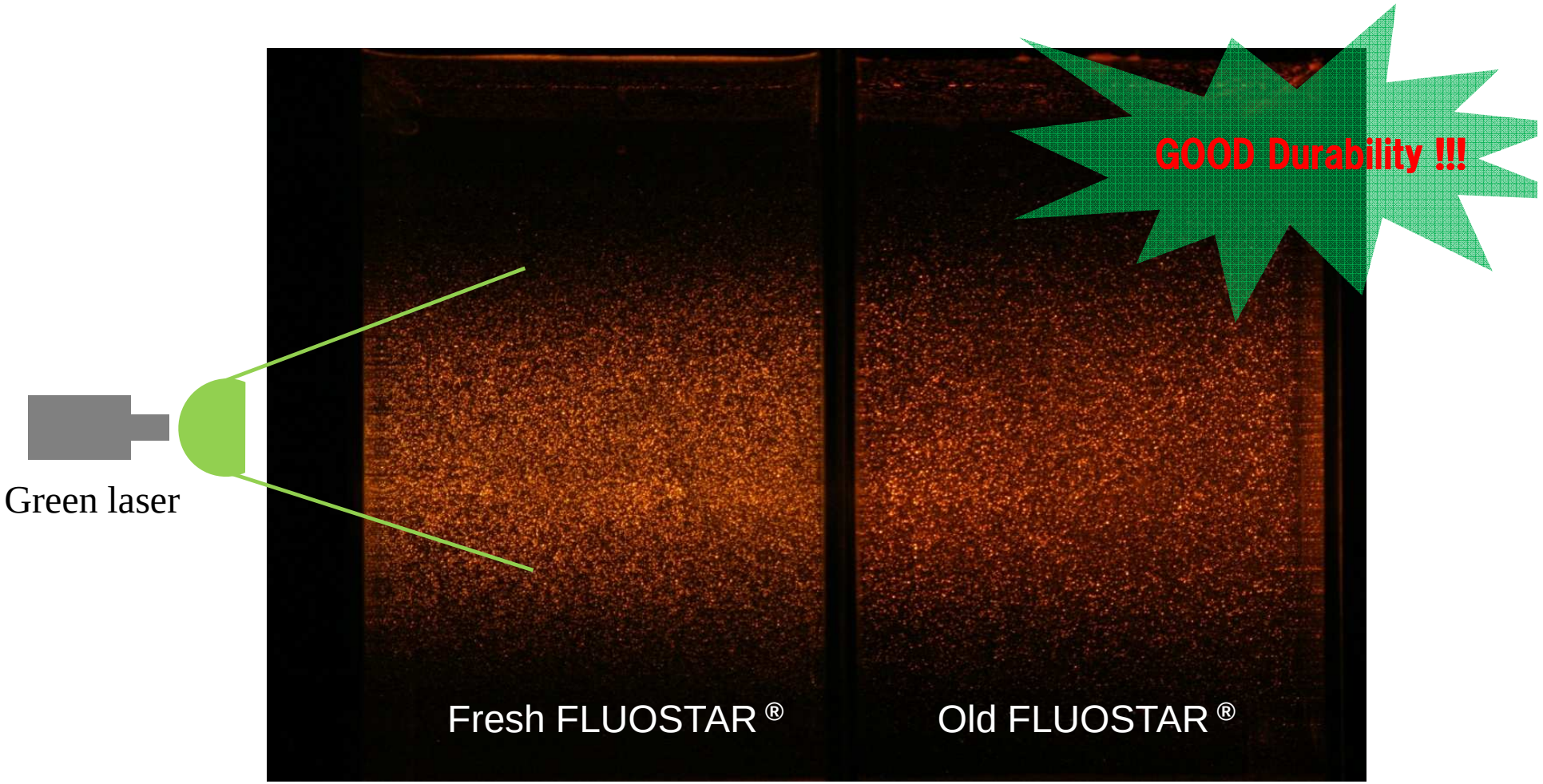
Water at 25℃



Heated in boiling water (100℃, 1 h)

**Excellent durability for heating**

# 2) FLUOSTAR® technique : Durability test




**Particle conditions:**

FLUOSTAR® was preserved in refrigerator as suspended in water for a period of **two months**. Then, the old particles were compared in brightness in contrast to fresh ones with the same particle density using fresh water for both.

# 3) FLUOSTAR® application: vascular flow modeling

Cerebral aneurysm model

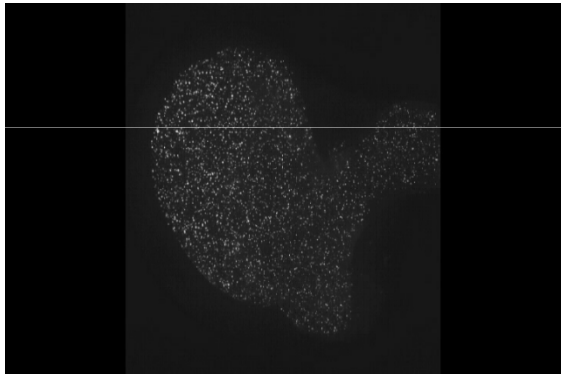
FLUOSTAR®

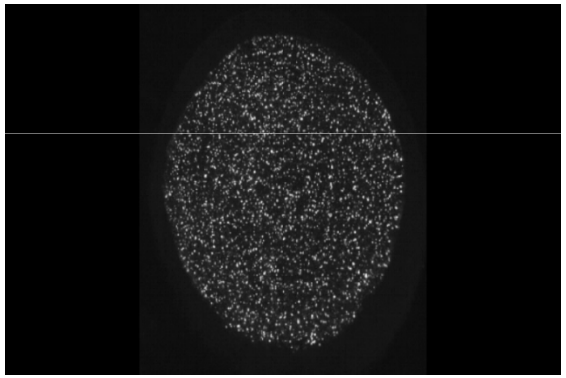
Non-fluorescent particles

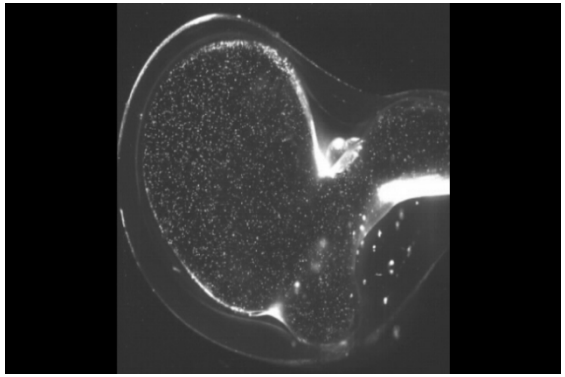
No more reflection!!!

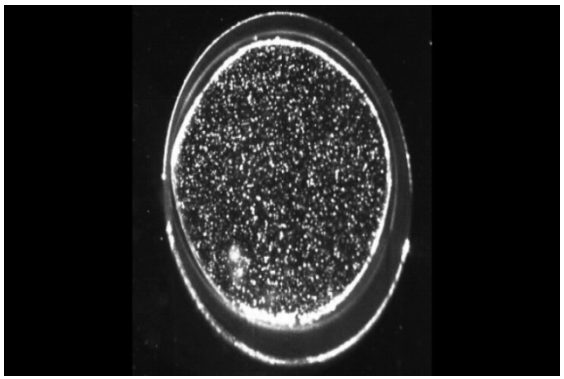
Side plane

Top plane







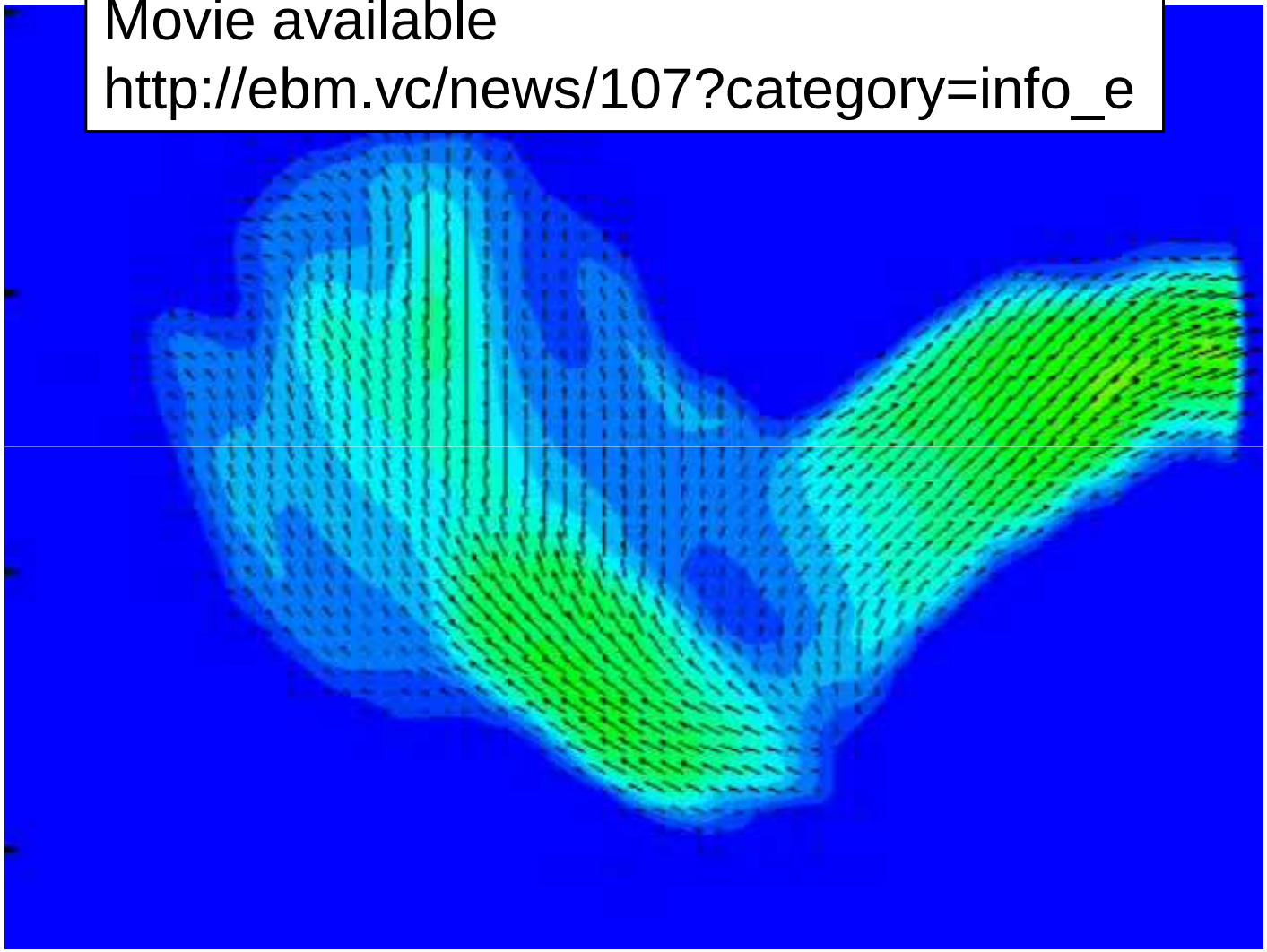


Presented by T. Yagi, at PIV09, 2009

Movie available http://ebm.vc/news/107?category=info_e

# 2) FLUOSTAR® application : 2D time-resolved PIV

Movie available
http://ebm.vc/news/107?category=info_e

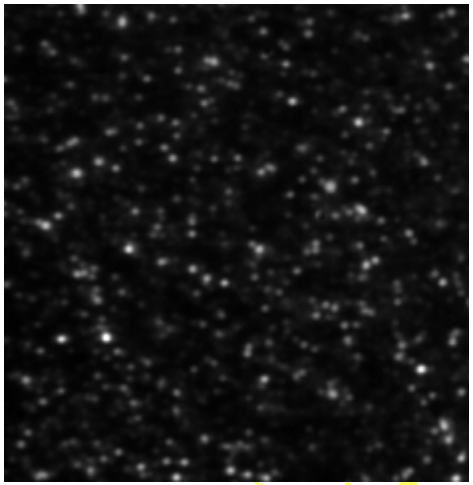


Standard PIV processing using original images (no image enhancement)



Presented by T. Yagi, at PIV09, 2009

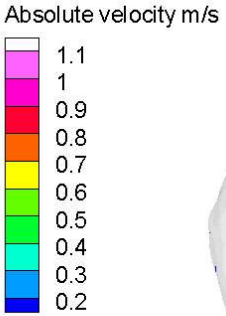
# 3) FLUOSTAR® application : 3D Stereo PIV

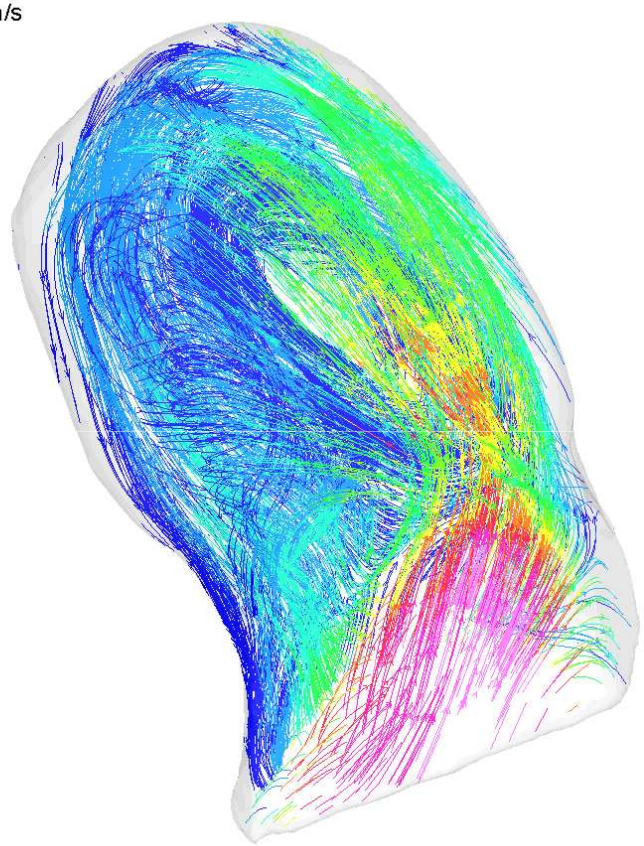


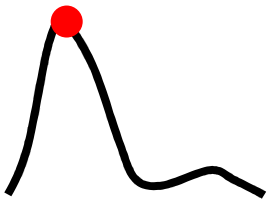
Raw image at **f#=16**

**Excellent brightness**

Movie available http://ebm.vc/news/107?category=info_e





**Interrogation size :(16×16pixel$^2$)**
**Spatial resolution: 110 μm**
**Laser light thickness: 80~100μm**
**Overlap: 50%(55μm)**
**Scanning plane: 80**

Presented by T. Yagi, at PIV09, 2009