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# FLUOSTAR

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

*Technical handbook ver.1, Feb, 2010*

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- 1) Introduction of fluorescent PIV (fPIV)
- 2) Advantage of FLUOSTAR<sup>®</sup> microsphere
- 3) Application examples: 3D Stereo PIV/ Time-resolved PIV

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

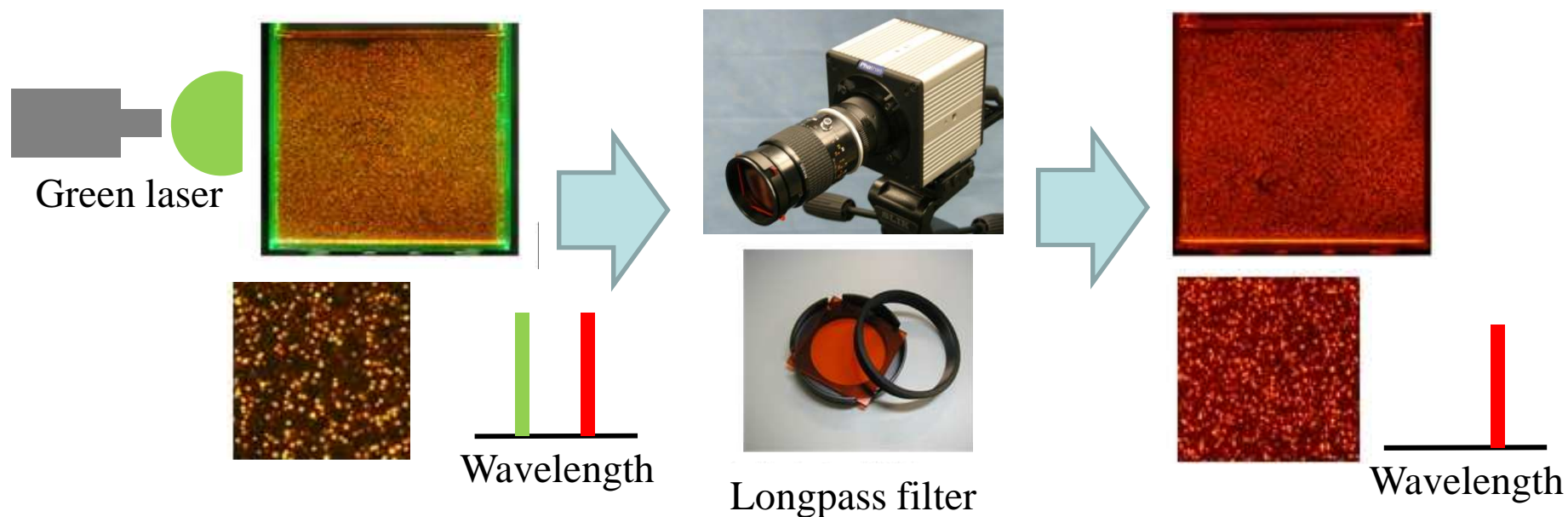
**Fluorescent PIV (fPIV)** is a hands-on advanced PIV liquid measurement using fluorescence-emitting particles rather than conventional non-fluorescent ones, such as glass spheres. When fluorescent particles are illuminated by a light source (Laser, LED etc.) , particles emits fluorescence with a different 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	<ul style="list-style-type: none"> <li>• Polystyrene</li> <li>• Glass spheres (GS)</li> <li>• Metal-coated hollow GS etc.</li> </ul>	<b>Fluorescent particles (FLUOSTAR®)</b>
Particle visibility	<b>Scattering</b> light	<b>Fluorescent emission</b>
Wavelength	Same as light source	<b>Longer than light source</b>
Light source※1	Laser / LED	<b>Laser / LED</b>
Camera	CCD (CMOS) sensor	<b>CCD (CMOS) sensor</b>
Optical filter※2	No	<b>Yes</b>

※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<sup>®</sup> images were taken by a color CCD sensor.

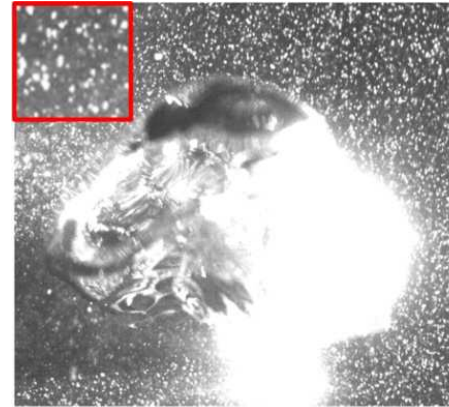
Particles were seeded in water within a Perspex-made container and illuminated by a Nd:YLF laser (527nm)

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

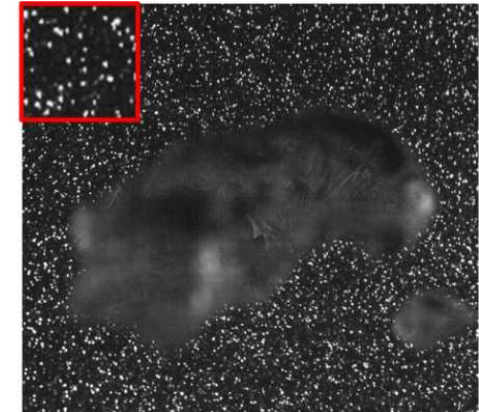
## Bubbly flow meas.

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

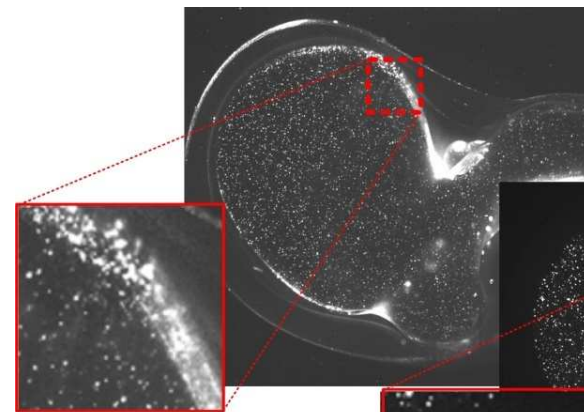


FLUOSTAR<sup>®</sup> microspheres

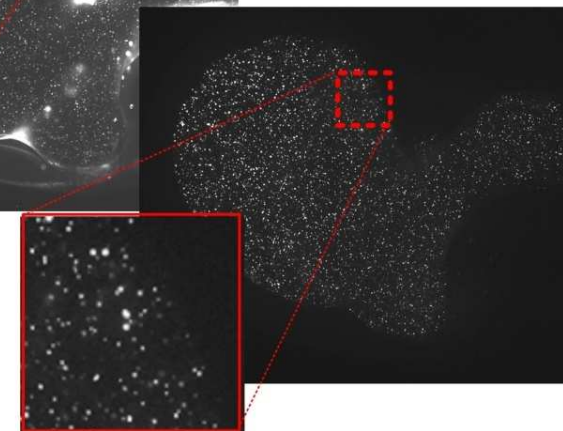
## Near-wall flow meas.

Similar as above

**Excellent particle visibility!**



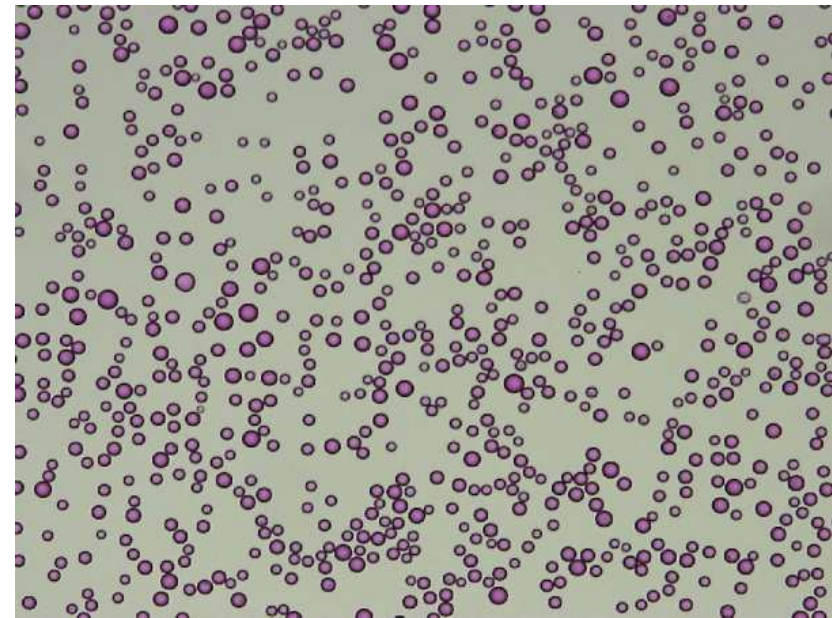
Non-fluorescent particles



FLUOSTAR<sup>®</sup> microspheres

## 2) Advantage of FLUOSTAR<sup>®</sup> microsphere

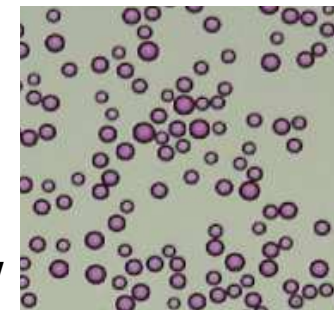
Shape	Sphere
Density	<b>1.1 g/cm<sup>3</sup></b>
Mean size	<b>15 μm</b>
Size distribution	<b>Less than 20% in C.V. ※1</b>
Fluorescent emission	<b>Excellent brightness (P6)</b>
Water dispersibility	<b>Excellent (P7, 8)</b>
Water stability (heating, durability)	<b>Excellent (P9, 10)</b>
Particle supply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



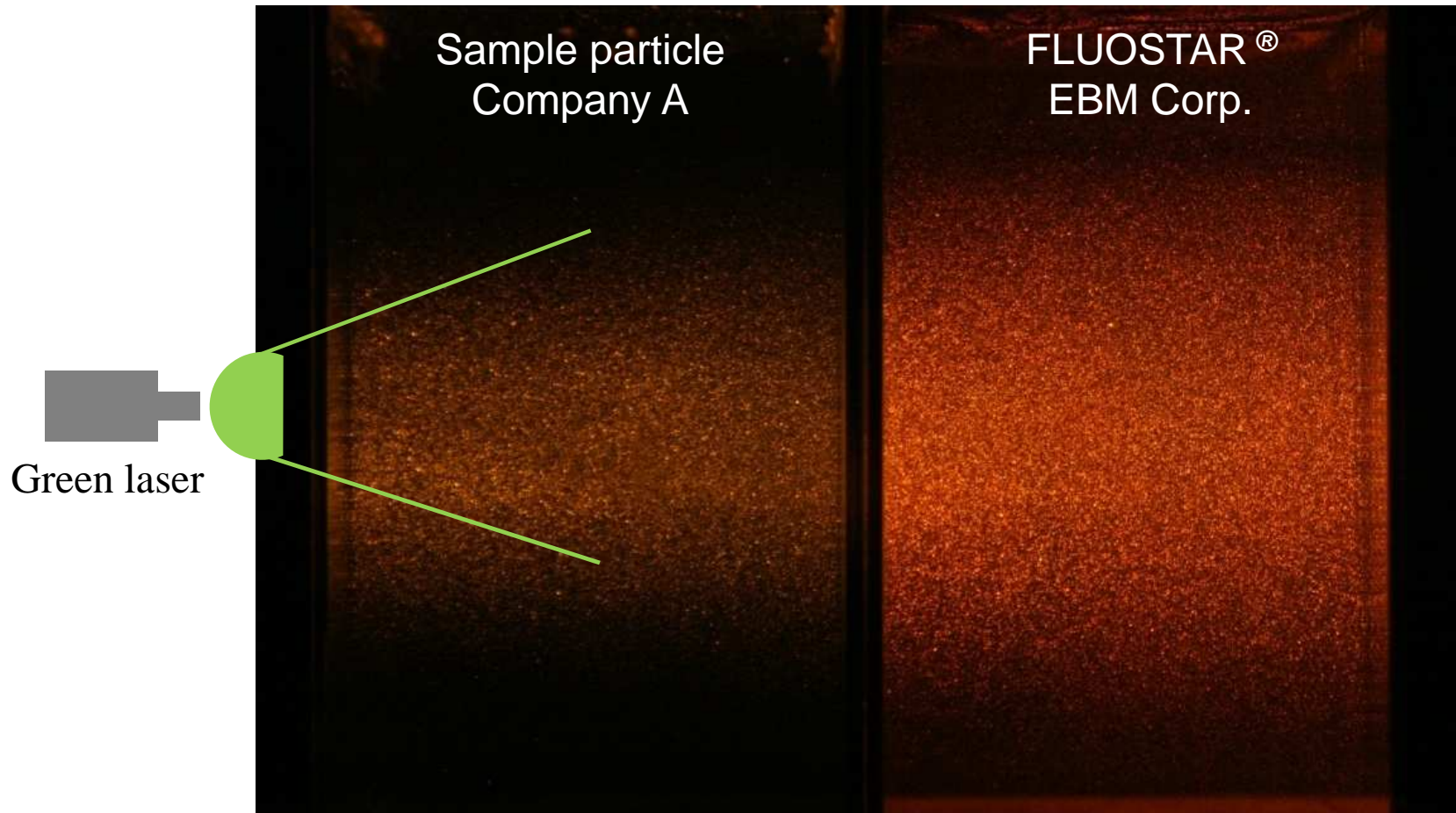
Microscope image ( ×10 )

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

Zoomed view



## 2) FLUOSTAR<sup>®</sup> technique: excellent brightness



### Particle conditions:

FLUOSTAR<sup>®</sup> was compared in brightness with a sample fluorescent particle commercially available. Particle concentration was **5 mg / liter** for both in fresh water. The size of each particle was similar in mean diameter (15  $\mu\text{m}$ ).

## 2) FLUOSTAR® technique : Water dispersibility



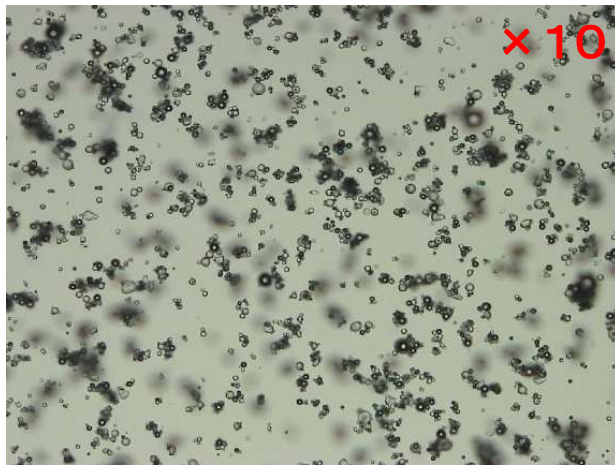
FLUOSTAR® is **hydrophilic**, or **wettable**, particles!!!

Movie available

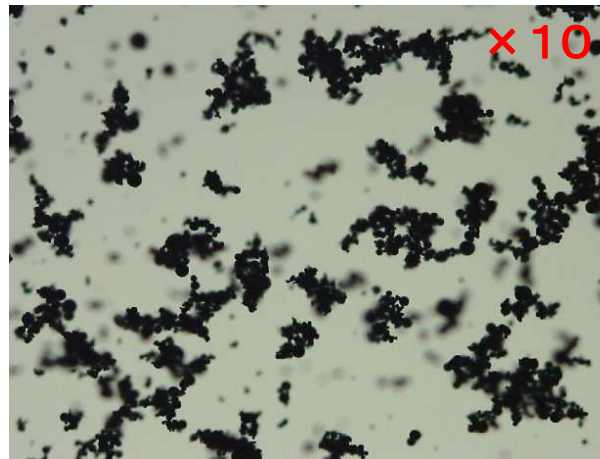
[http://ebm.vc/news/107?category=info\\_e](http://ebm.vc/news/107?category=info_e)

## 2) FLUOSTAR® technique : Comparison of water dispersibility

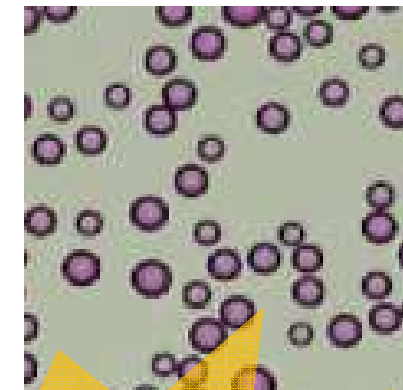
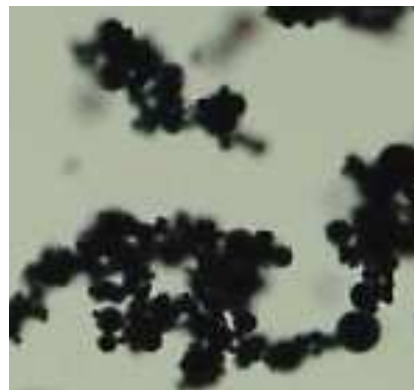
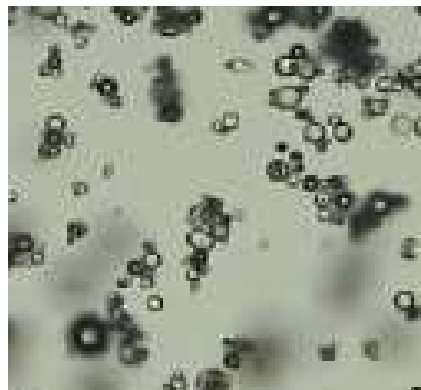
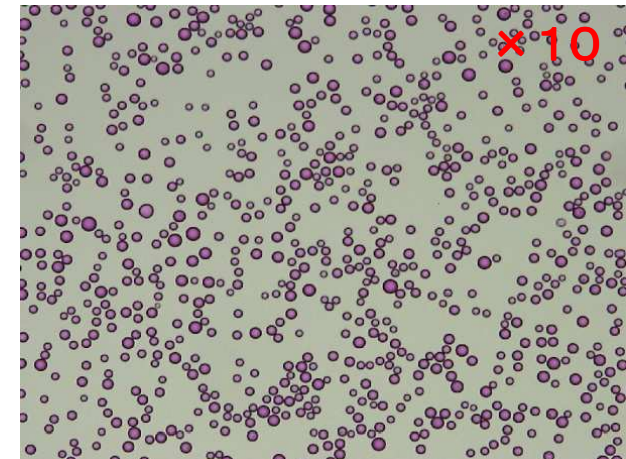
Hollow glass (HG) sphere



Silver-coated HG sphere



FLUOSTAR®

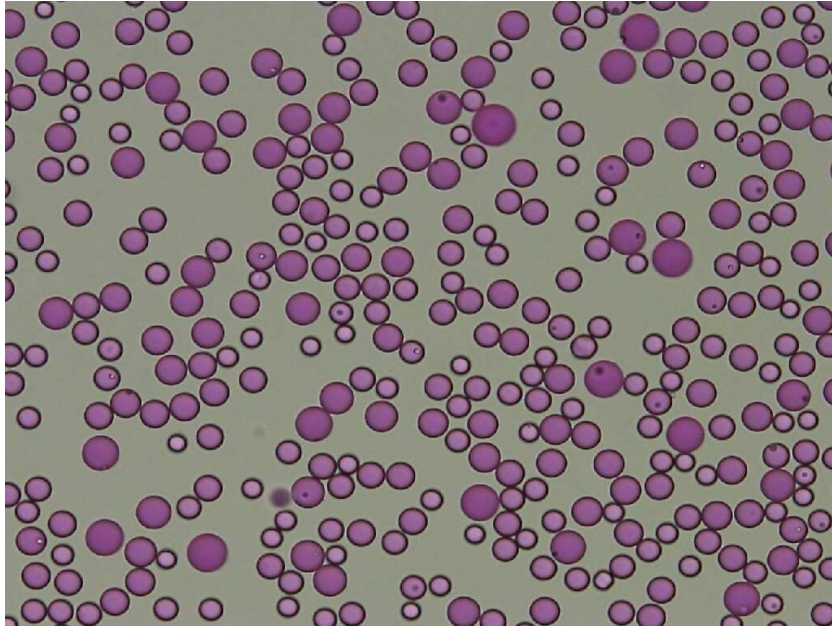


Hollow glass and silver-coated HG particles were mixed in water and then stirred in a mixing device. Despite that, these particles still formed aggregations. In contrast, Fluostar does not make aggregations even without stirring because of prominent wettability.

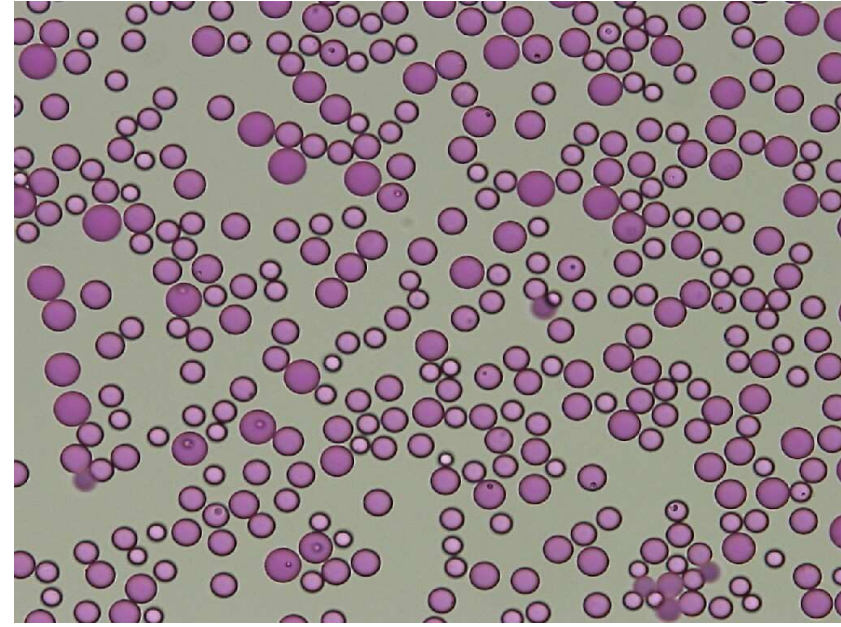
**No more aggregation and adhesion**



## 2) FLUOSTAR® technique : Water stability



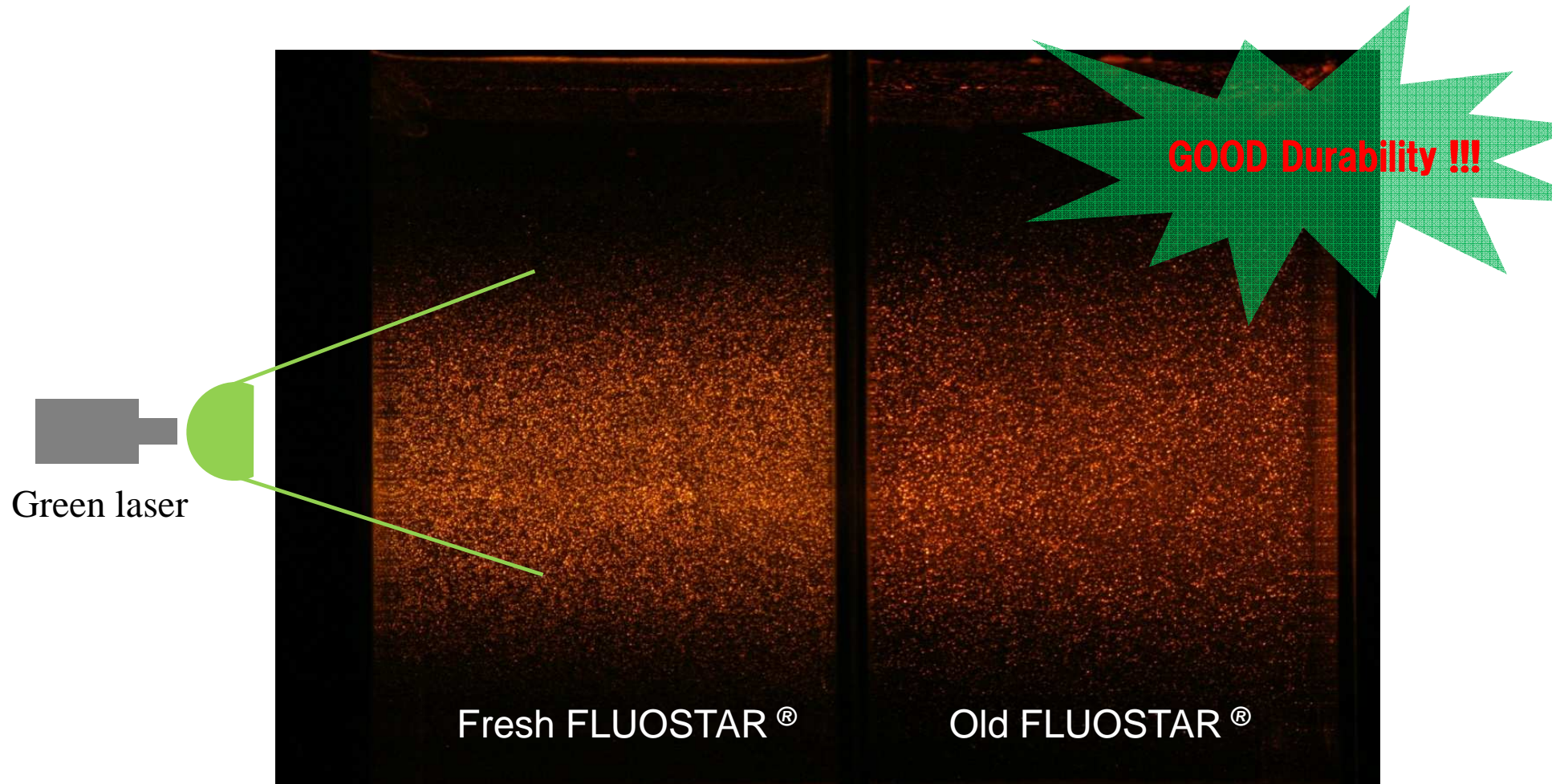
Water at 25°C



Heated in boiling water (100°C, 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<sup>®</sup> application: vascular flow modeling



Cerebral aneurysm model

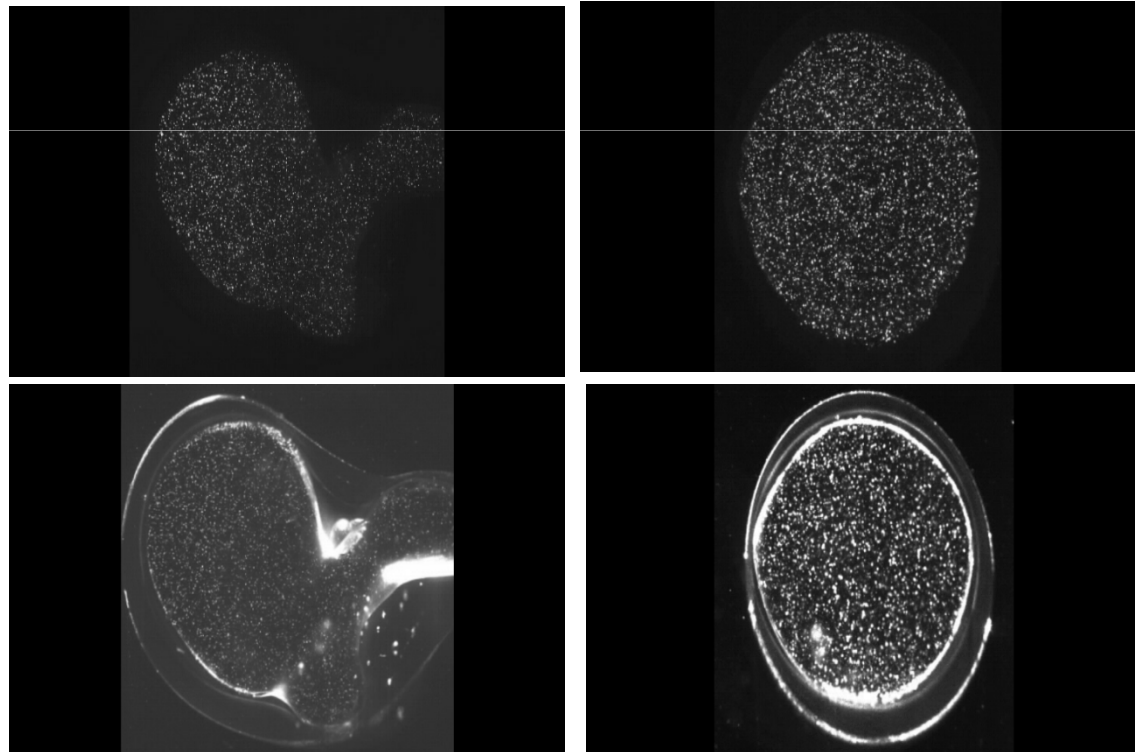
FLUOSTAR<sup>®</sup>

Non-fluorescent particles

No more reflection!!!

Side plane

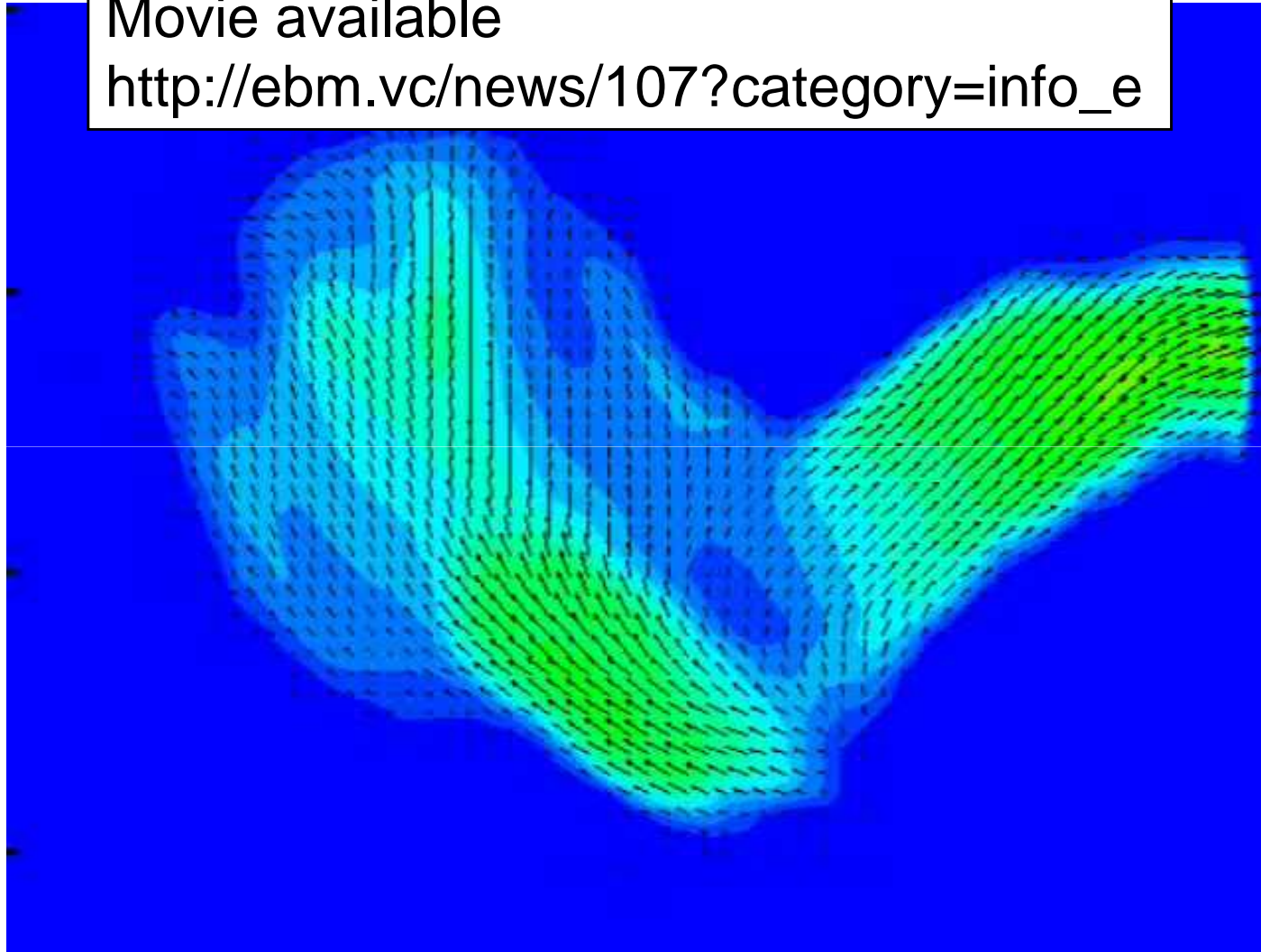
Top plane



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

Movie available

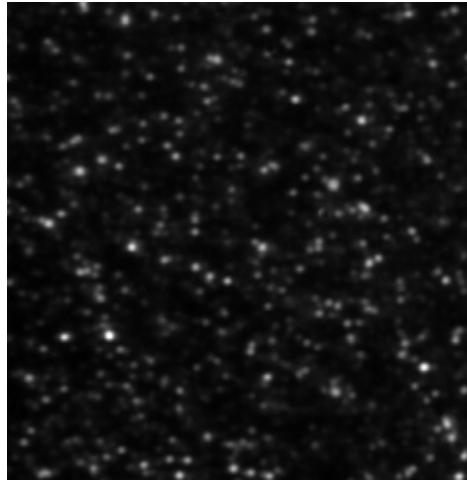
[http://ebm.vc/news/107?category=info\\_e](http://ebm.vc/news/107?category=info_e)



Standard PIV processing using original images (no image enhancement)

### 3) FLUOSTAR<sup>®</sup> application : 3D Stereo PIV

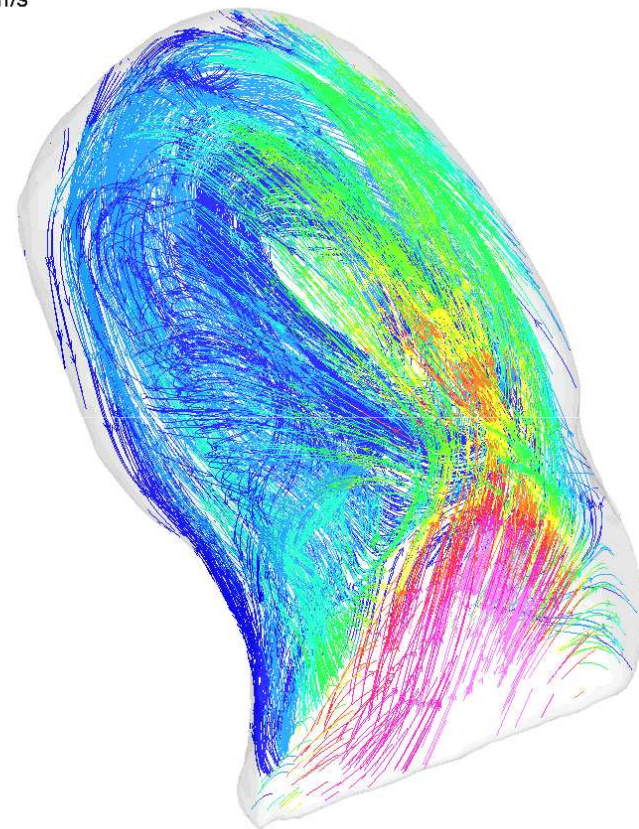
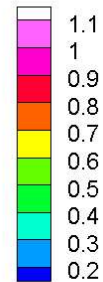
Movie available [http://ebm.vc/news/107?category=info\\_e](http://ebm.vc/news/107?category=info_e)



Raw image at **f#=16**

**Excellent brightness**

Absolute velocity m/s



Interrogation size : (16×16pixel<sup>2</sup>)  
Spatial resolution: 110 μm  
Laser light thickness: 80~100μm  
Overlap: 50%(55μm)  
Scanning plane: 80