2D online GPU correlation analysis of streamed particle images

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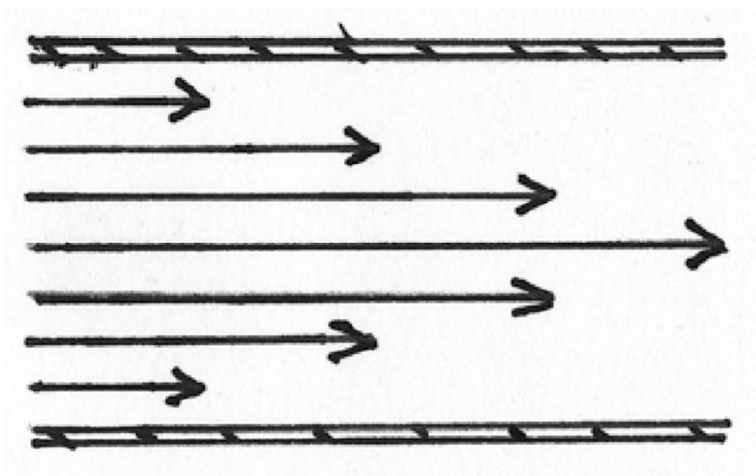
What is a flow ?

- Flow is defined as the quantity of fluid (gas, liquid or vapor) that passes a point per unit time.

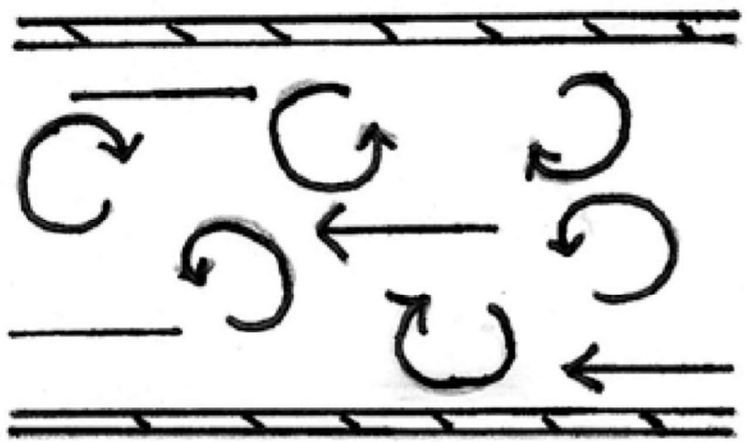
Flow (F) = Quantity (Q)/ Time (t)

What is a flow ?

Laminar Flow



Turbulent Flow

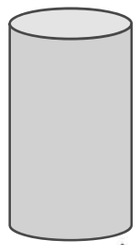


Particle Image Velocimetry

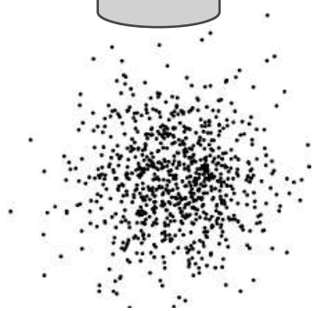
- Particle image velocimetry (PIV) is a flow visualization technique, it is not based on any simulation, we actually perform an experiment to see the flow. It also allows us to get quantitative information on flow characteristics (values of velocity components for selected points).

Particle Image Velocimetry

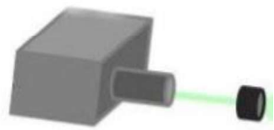
01 **Flow Domain**



02 **Particles(Seeds)**

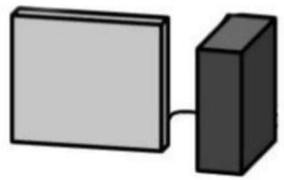


03 **Laser Illumination**



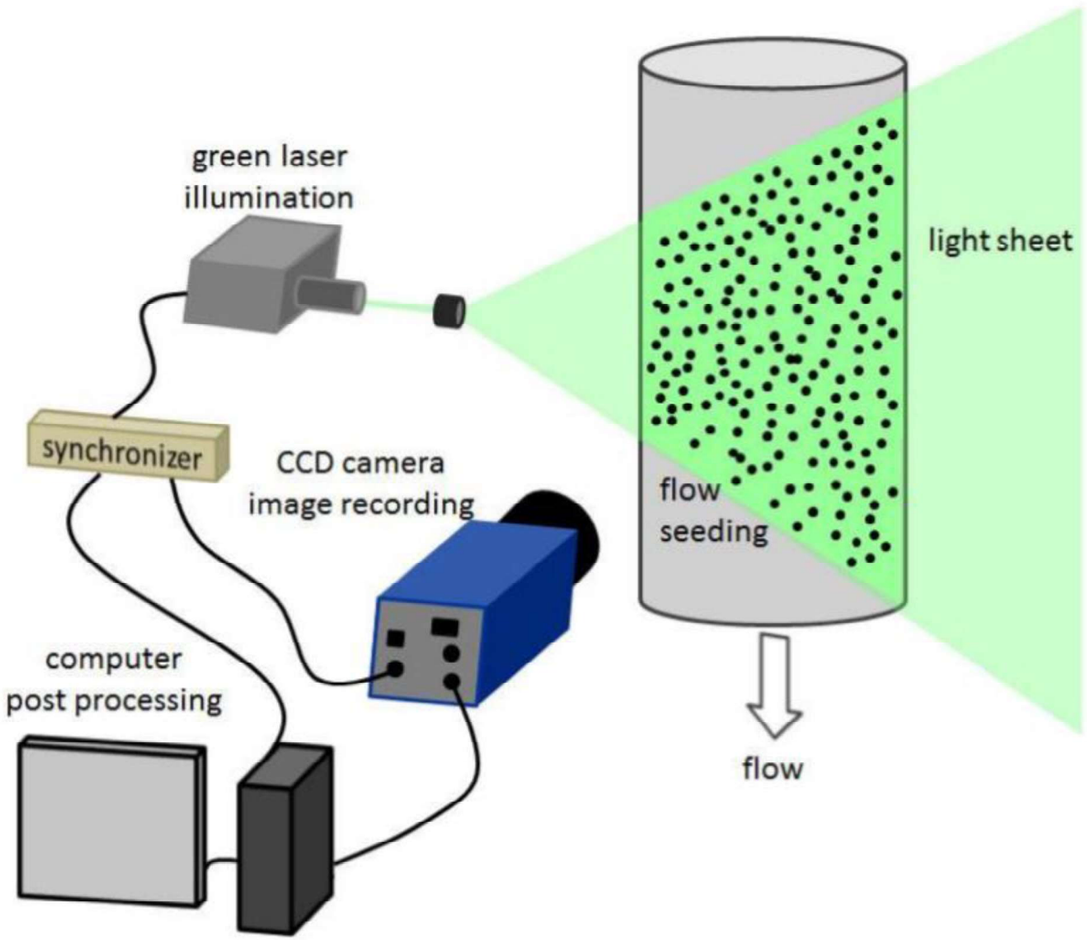
04 **CCD Camera**

05 **Computer**



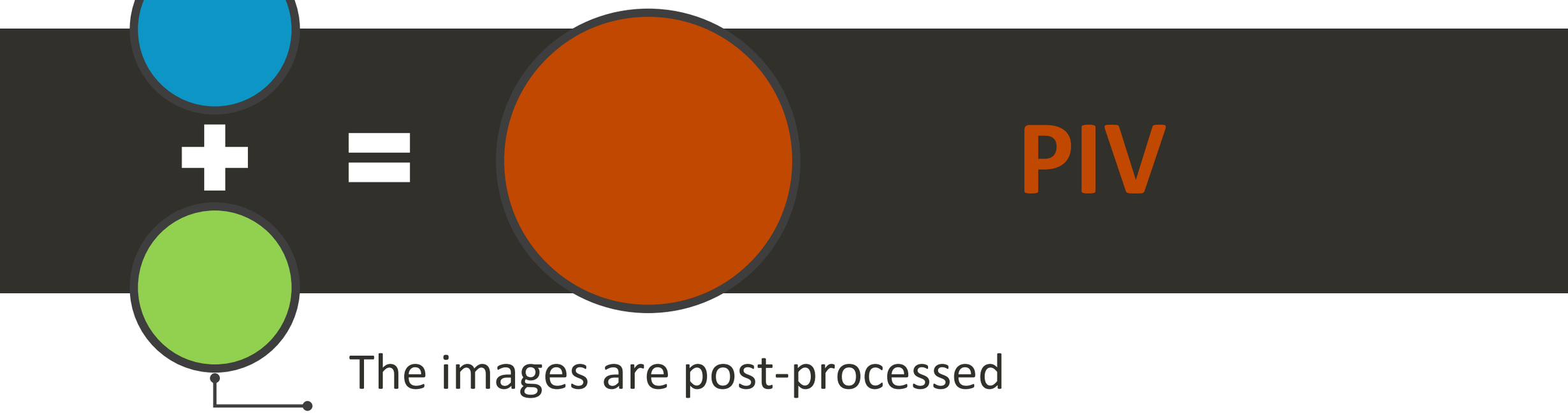
06 **Synchronizer**

Particle Image Velocimetry



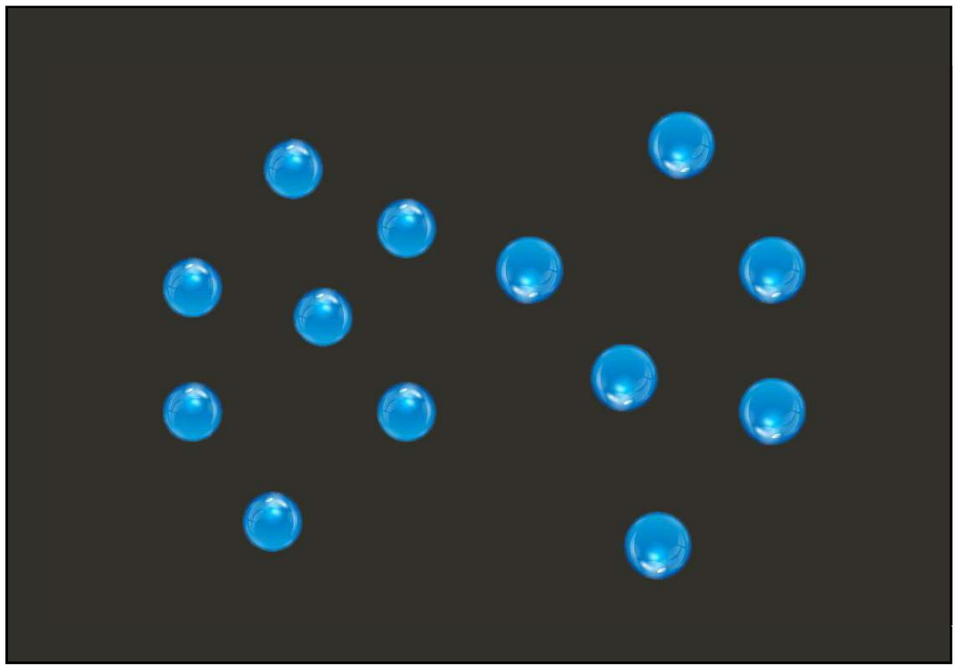
Particle Image Velocimetry

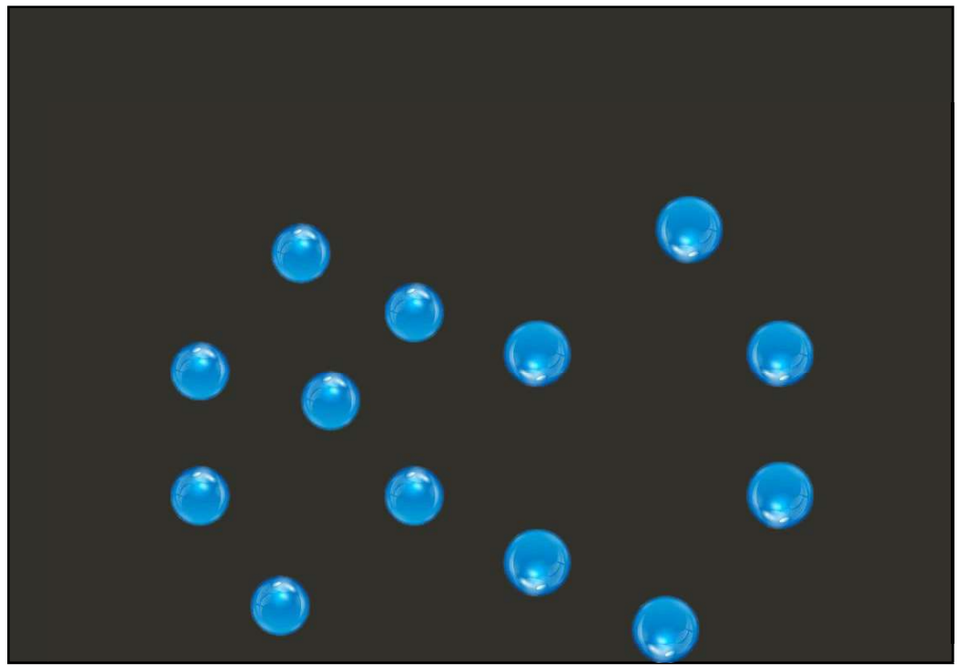
The experiment is set up and the images captured



The images are post-processed and analyzed using the cross-correlation approach

Capturing Images



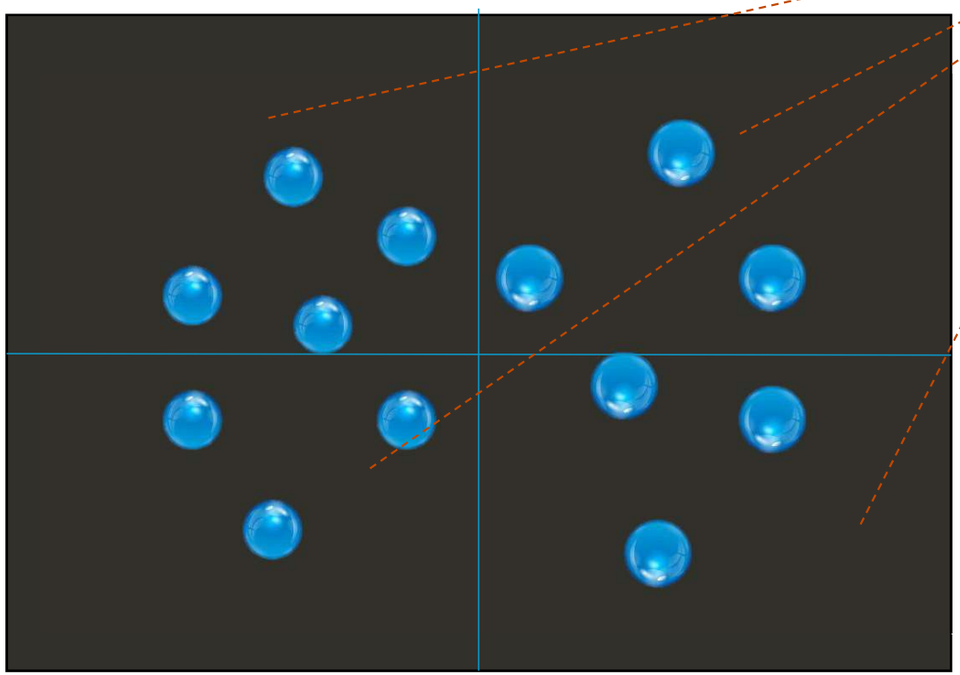


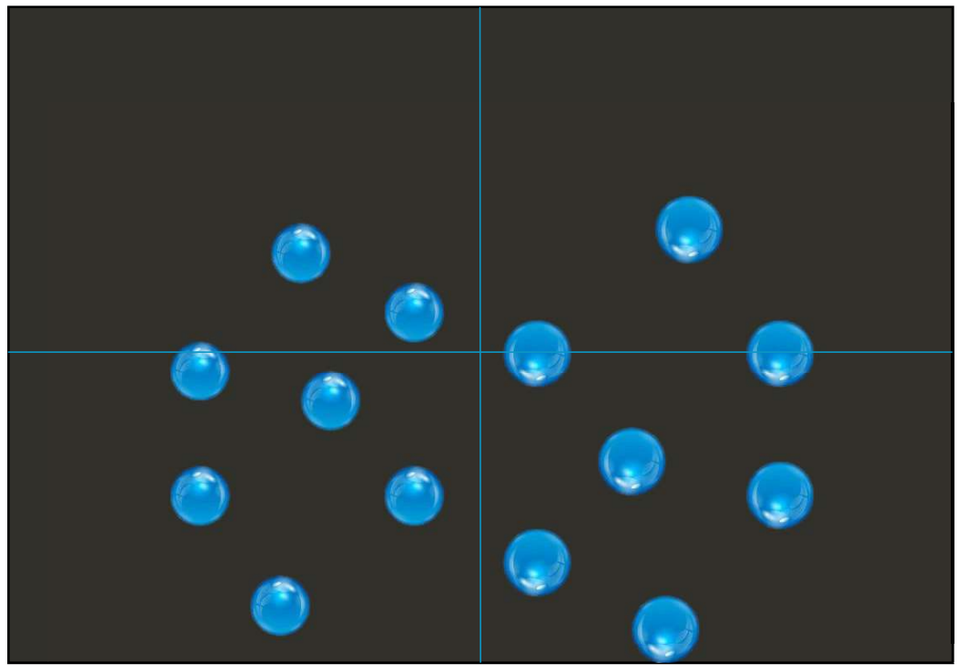
Capture A (Time : t1)

Capture B (Time : t2)

Divide and Rule

Windows

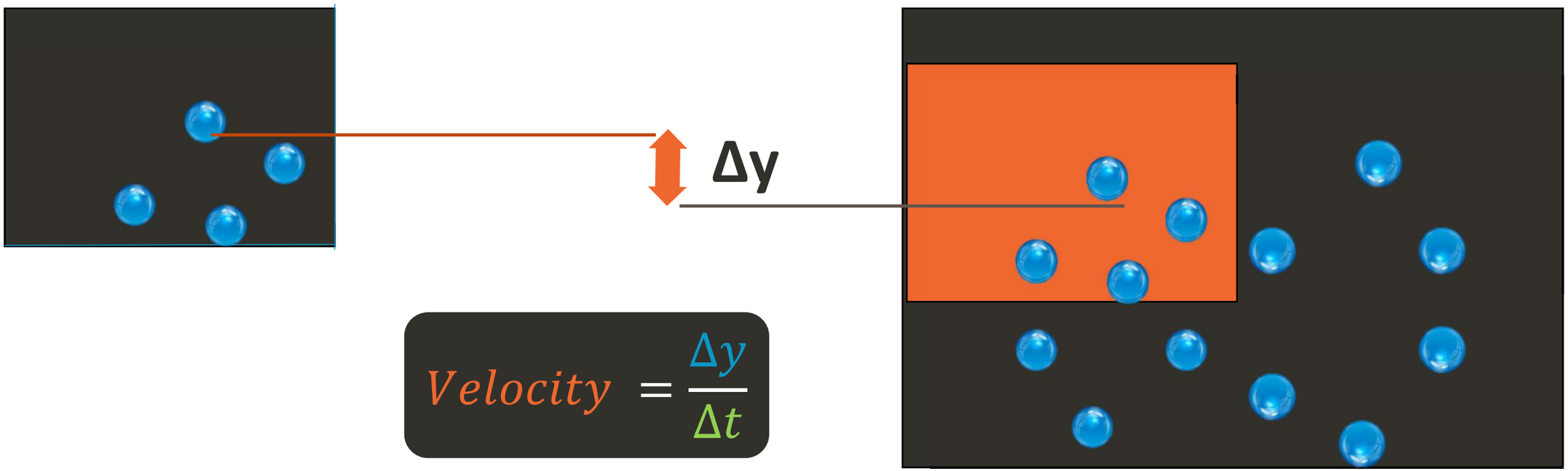




Capture A (Time : t1)

Capture B (Time : t2)

Cross-Correlation

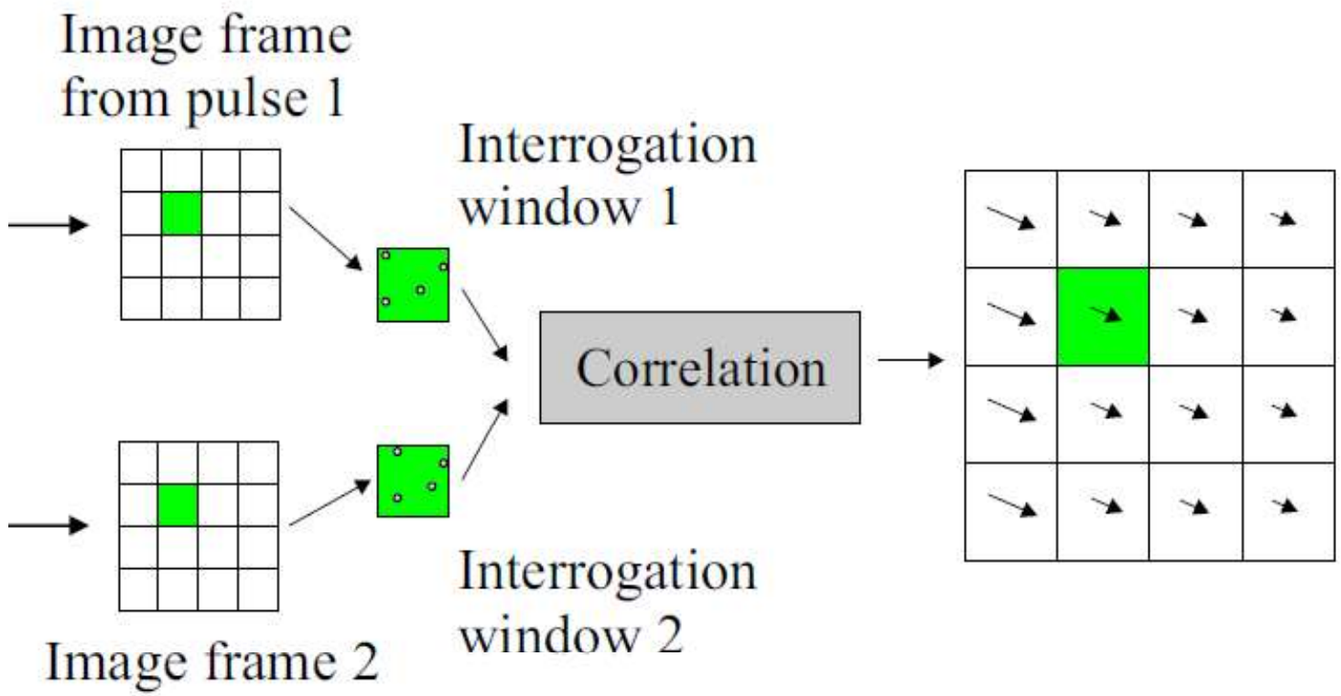


$$Velocity = \frac{\Delta y}{\Delta t}$$

Capture A (Time : t1)

Capture B (Time : t2)

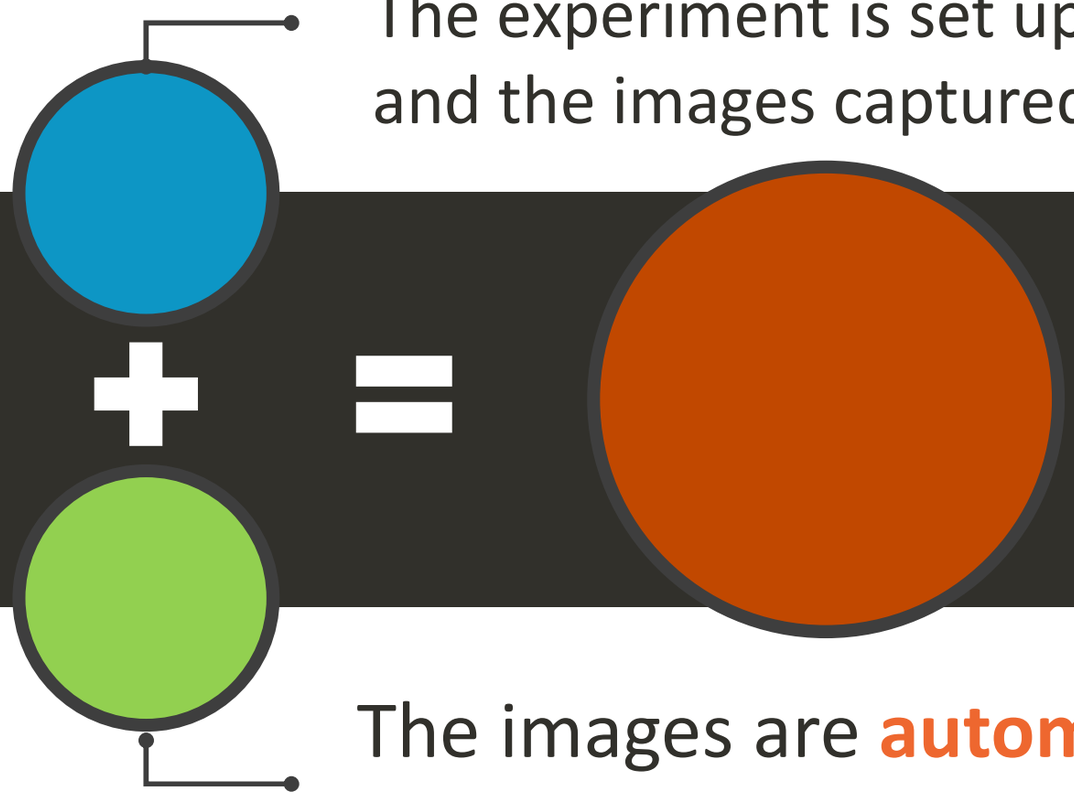
Particle Image Velocimetry



The deduced velocities are presented in a vector map

Real-Time Particle Image Velocimetry

The experiment is set up
and the images captured



RT-PIV

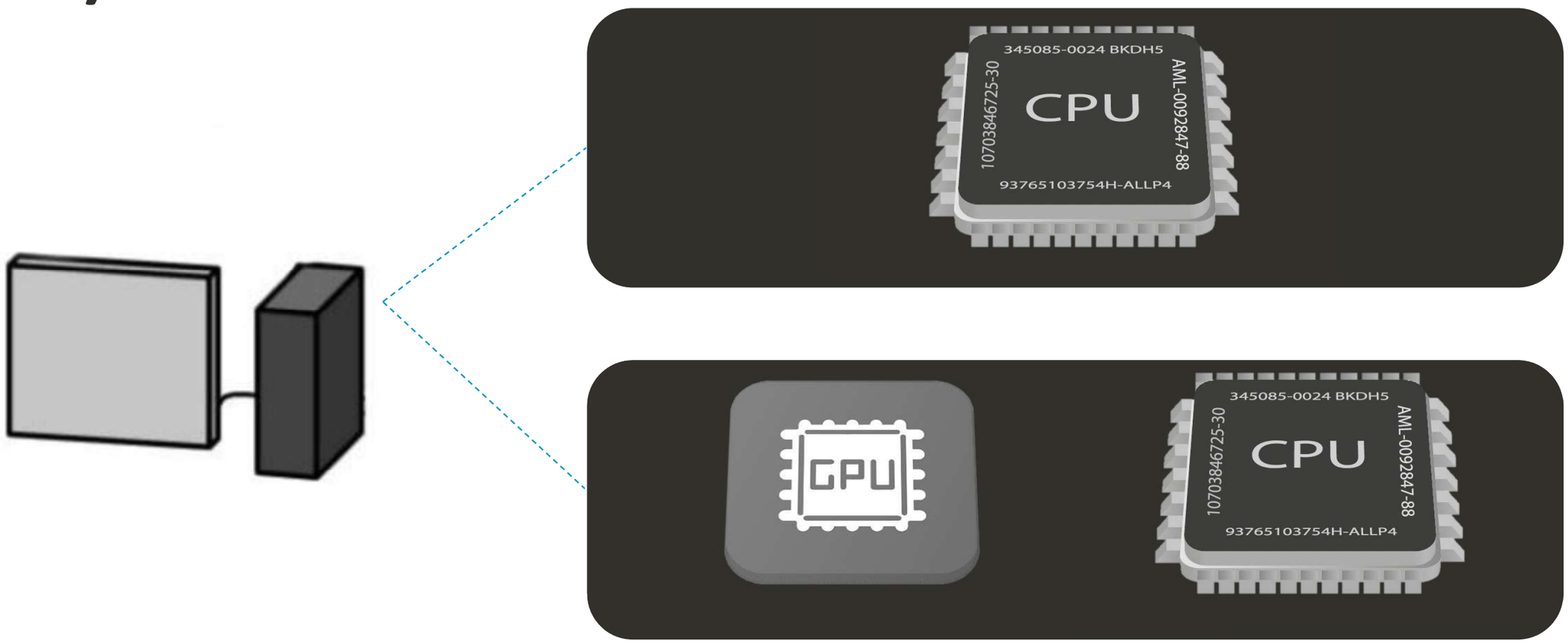
The images are **automatically** post-processed
and analyzed using the cross-correlation
approach right after the images are captured

Standard PIV VS Real-Time PIV

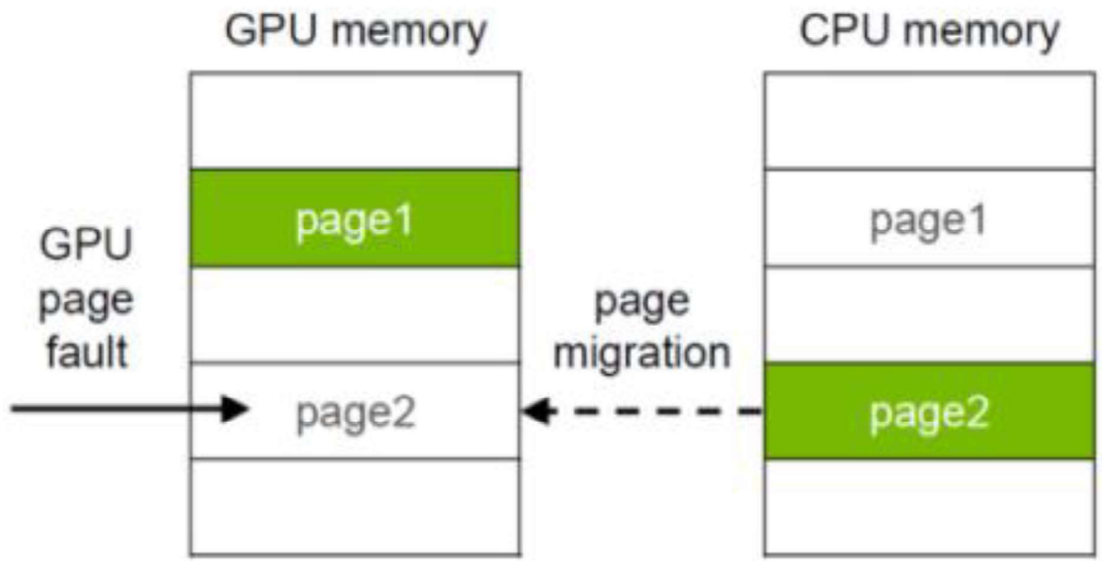
	PIV	RT-PIV
Pre-Processing	Manual	Automatic
Visualization	No real time	Real time
Time Restriction	No	Yes

	PIV	RT-PIV
Pre-Processing Time		✖
Quality of result	✖	

(RT)PIV


345085-0024 BKDH5
CPU
10703846725-30
AML-0092847-88
93765103754H-ALLP4
GPU
345085-0024 BKDH5
CPU
10703846725-30
AML-0092847-88
93765103754H-ALLP4

RT-PIV Using GPU



1. Allocate new pages on the GPU. 2. Unmap old pages on the CPU.

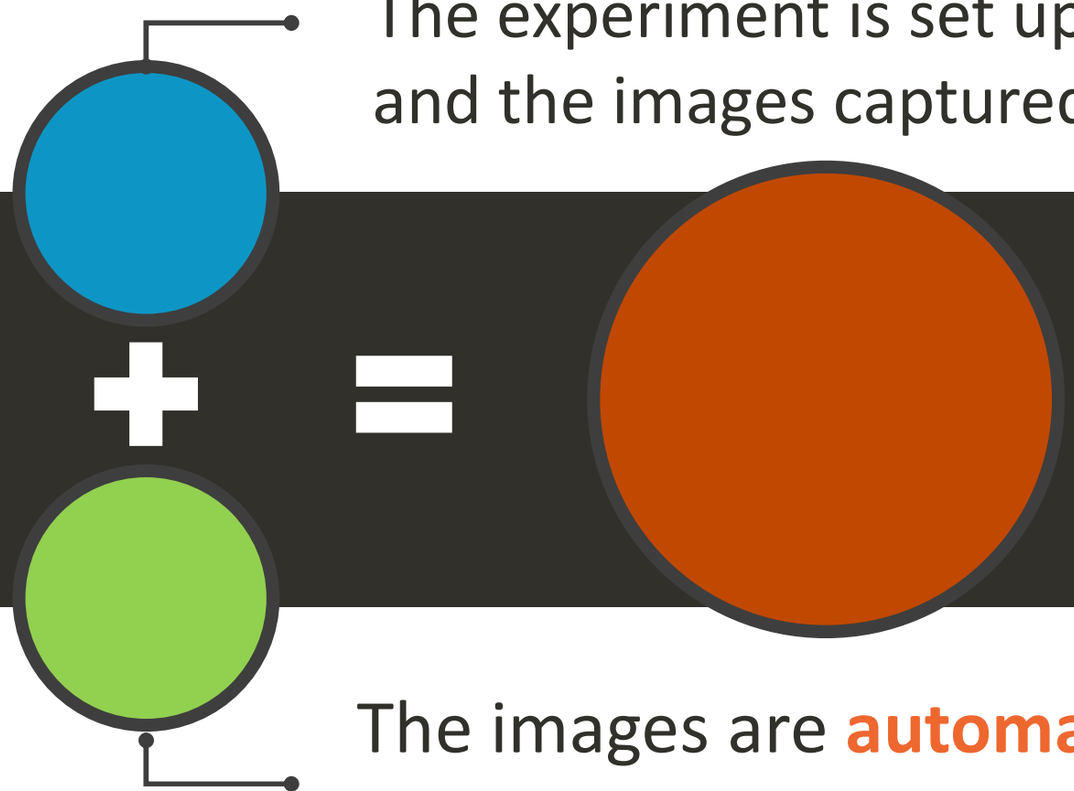
3. Copy data from the CPU to the GPU. 4. Map new pages on the GPU. 5. Free old CPU pages.

GPU (CUDA) Correlation

1. All calculations are performed in parallel, as opposed to sequentially, any calculations performed cannot depend on the results of a previous calculations.
2. The **CUDA** memory architecture is separate from that of the computer, and as such all relevant variables must be allocated in **CUDA** memory and transferred before the parallel processing step take place.

Real-Time Particle Image Velocimetry

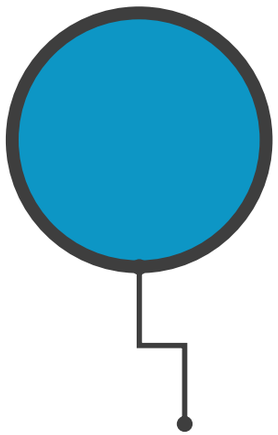
The experiment is set up
and the images captured



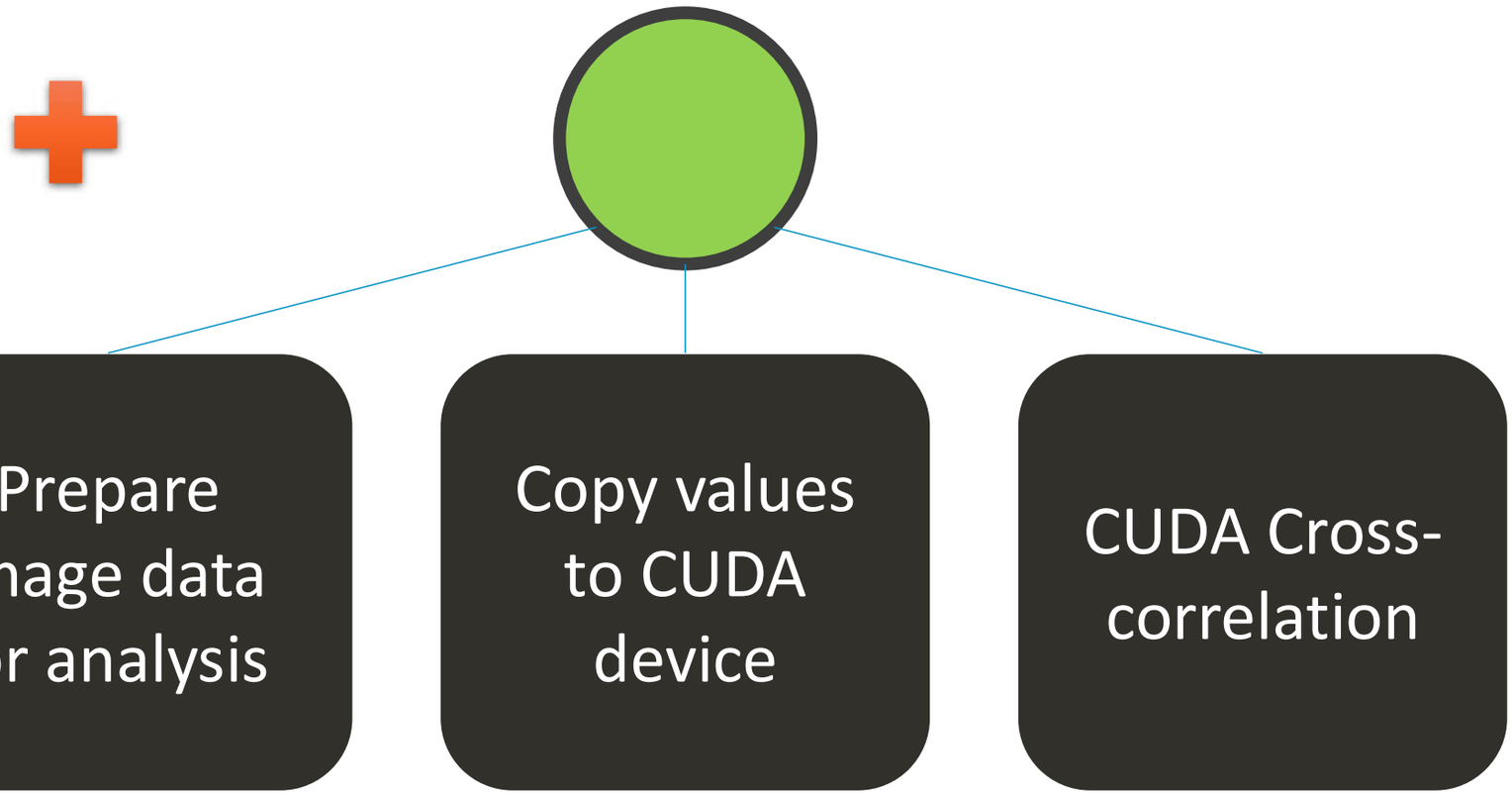
RT-PIV

The images are **automatically** post-processed and analyzed on the **GPU** using the cross-correlation in **CUDA Architecture** approach right after the images are captured

Real-Time Particle Image Velocimetry



The experiment is set up and the images captured

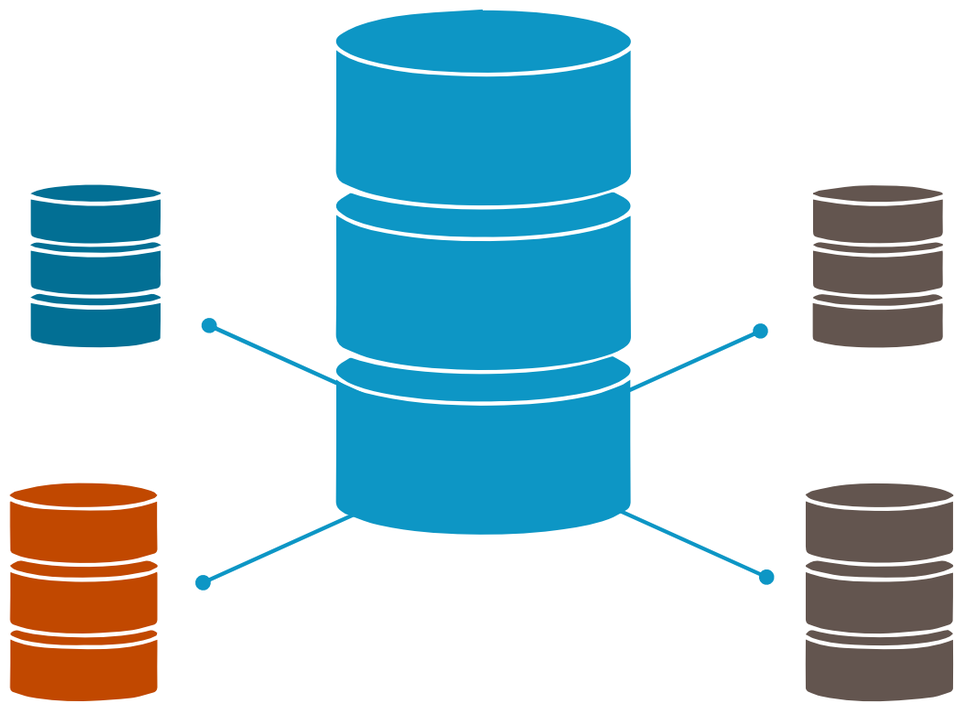


Accuracy Measurements

- A run of the algorithm with an input of a pair of images (8bit, Size : 992 x 1004), it has to give a processing time less than 0.1sec on a test PC with a test set of parameters.

Accuracy Measurements

- We'll compare our results with results collected while applying standard PIV on different types of flow.
- The datasets are already available and were collected.



THANK YOU!