

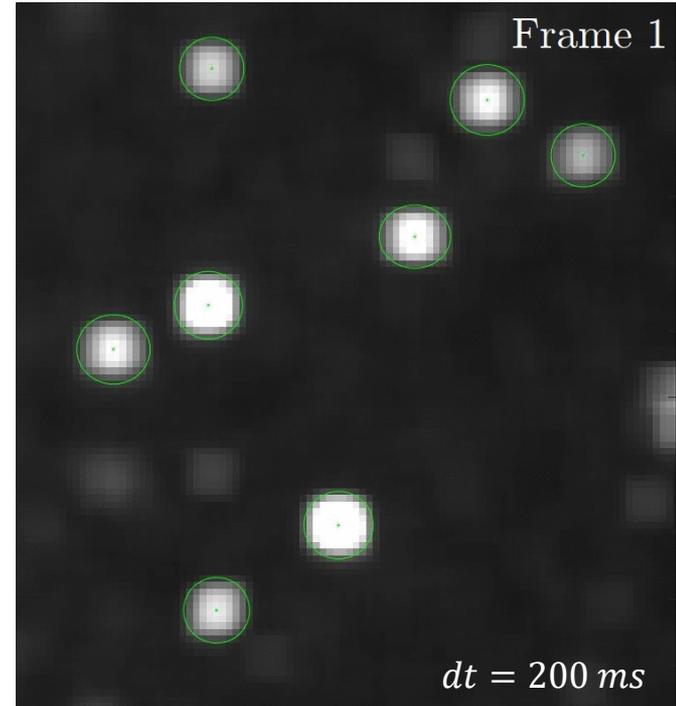
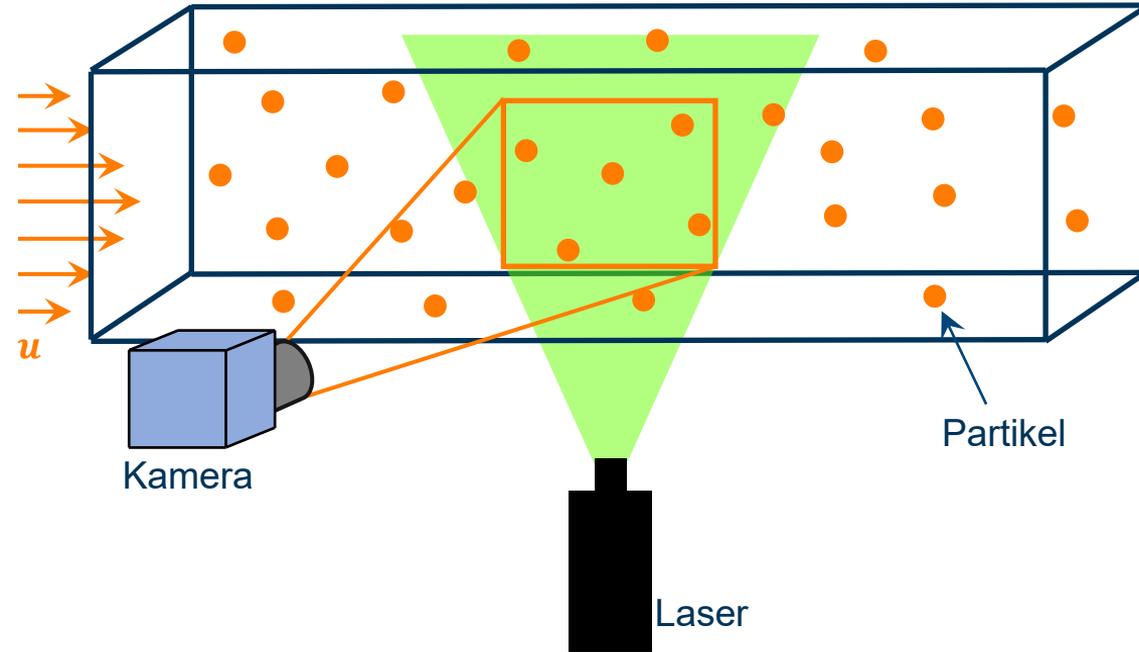
Particle tracking velocimetry using deep neural networks

Sebastian Sachs, Christian Cierpka

Institute of Thermodynamics and Fluid Mechanics
Technische Universität Ilmenau, Germany

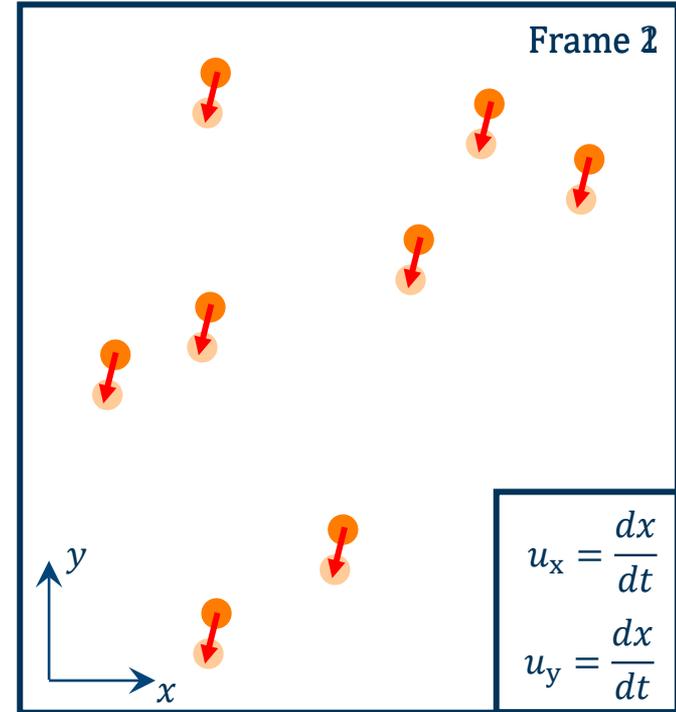
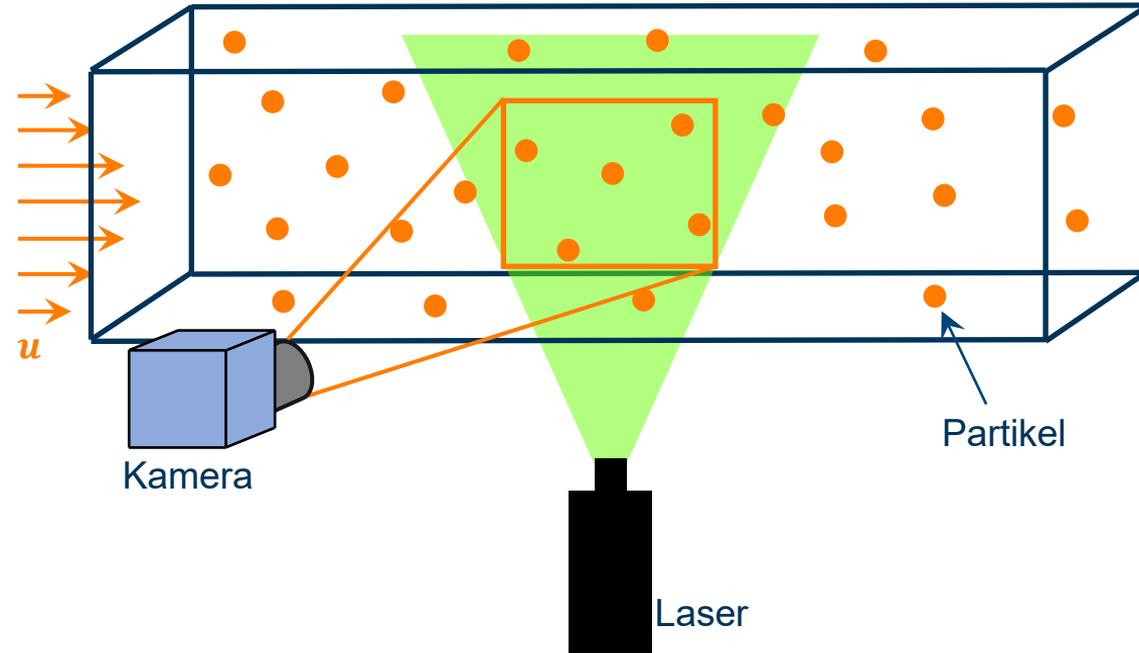
Datasets

particle tracking
velocimetry (PTV)



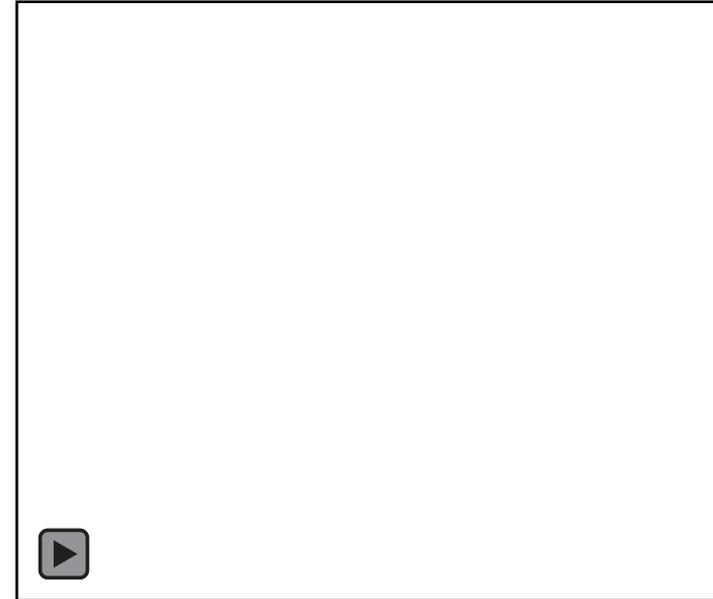
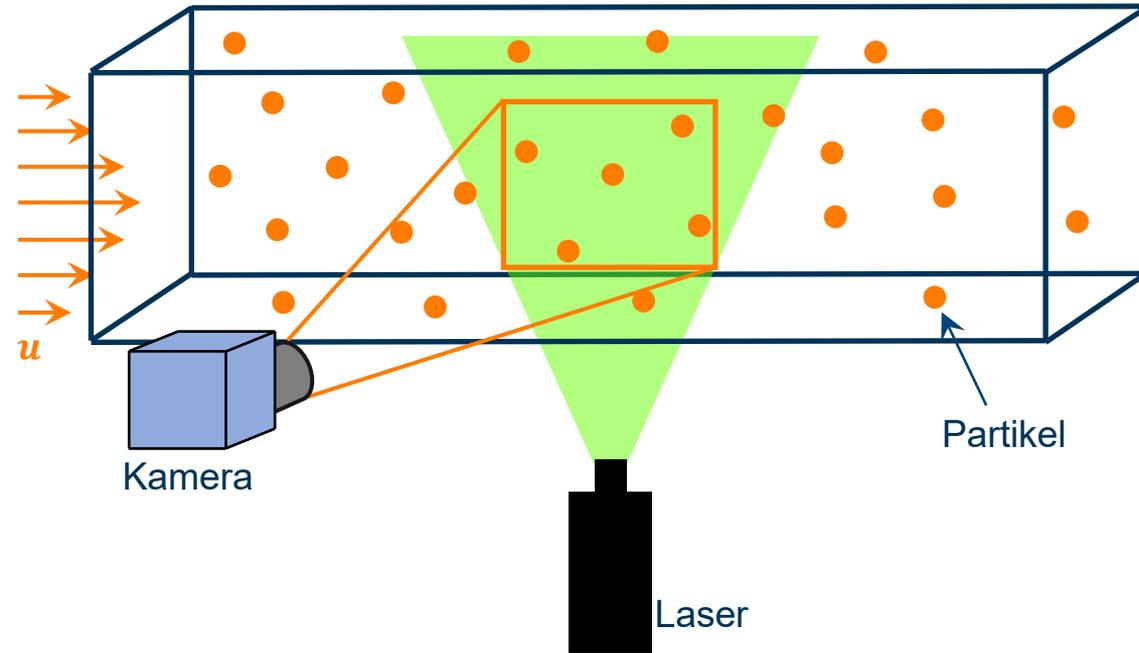
Datasets

particle tracking
velocimetry (PTV)



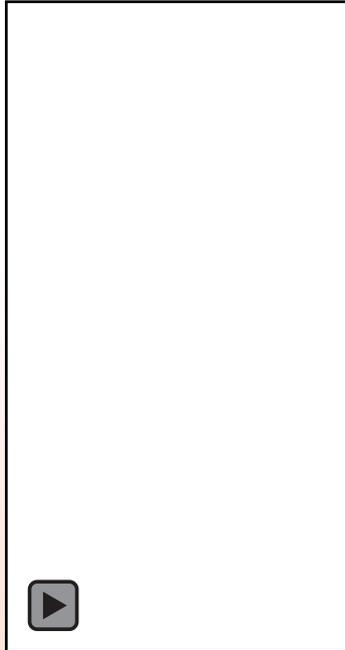
Datasets

particle tracking
velocimetry (PTV)



Datasets

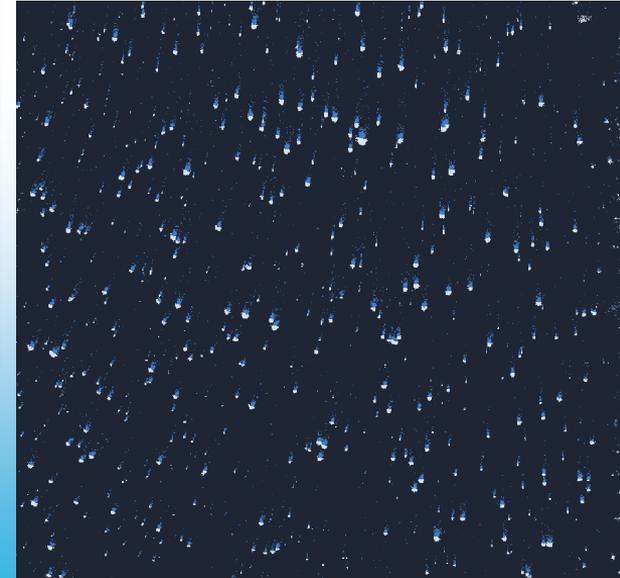
particle tracking
velocimetry (PTV)



astigmatism particle tracking
velocimetry (APTV)

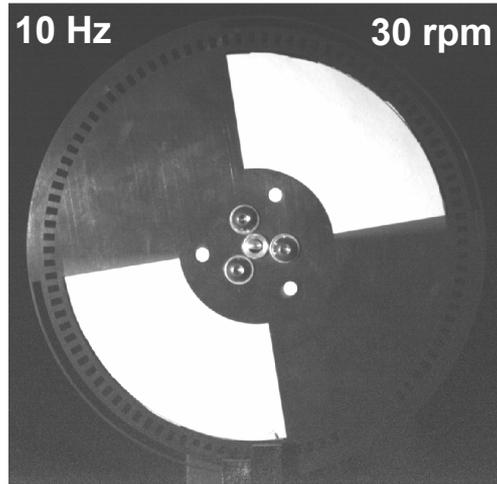


event-based vision
(EBV)

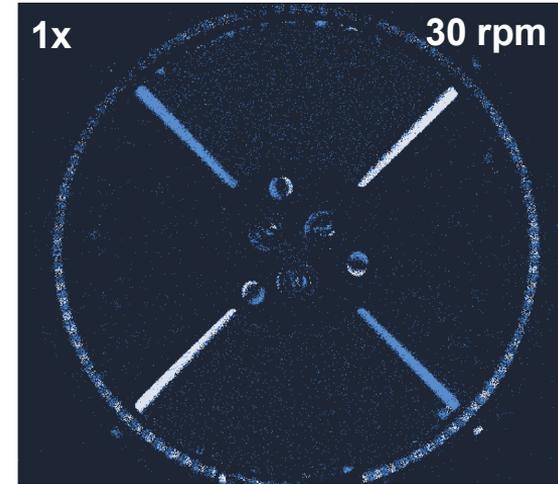


Event-based vision

frame-based

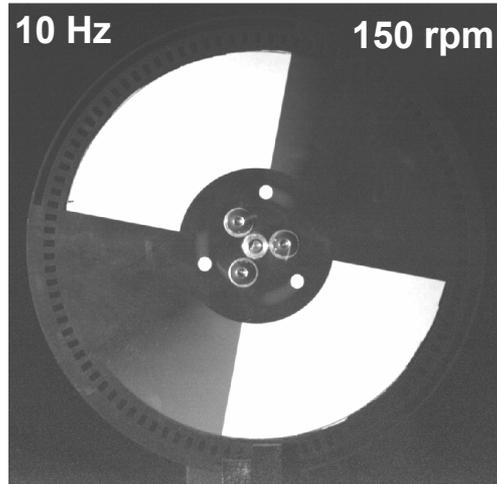


event-based

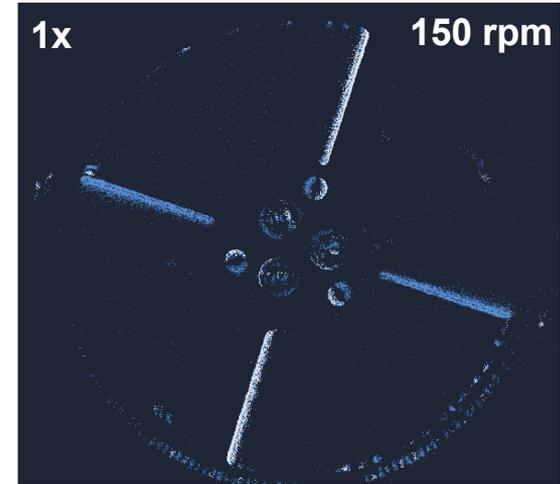


Event-based vision

frame-based

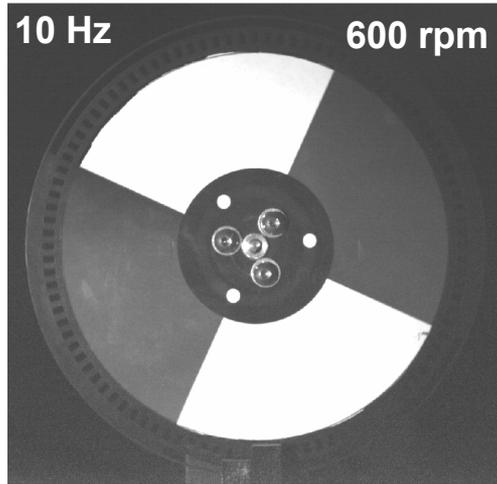


event-based

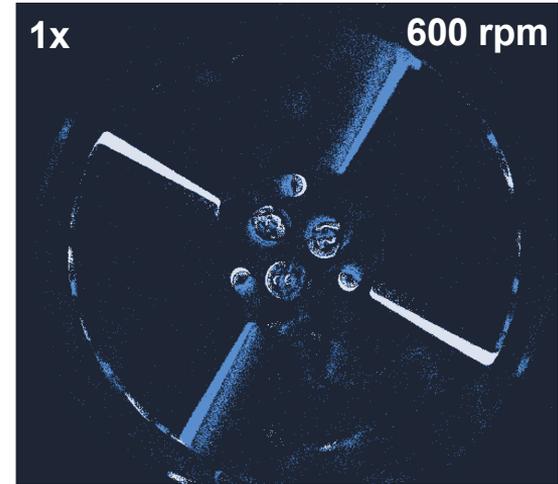


Event-based vision

frame-based

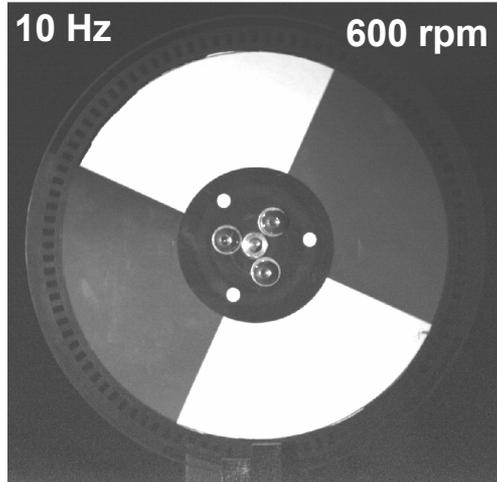


event-based

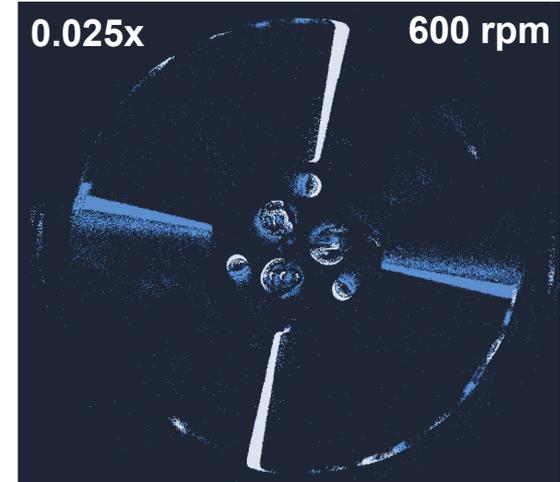


Event-based vision

frame-based

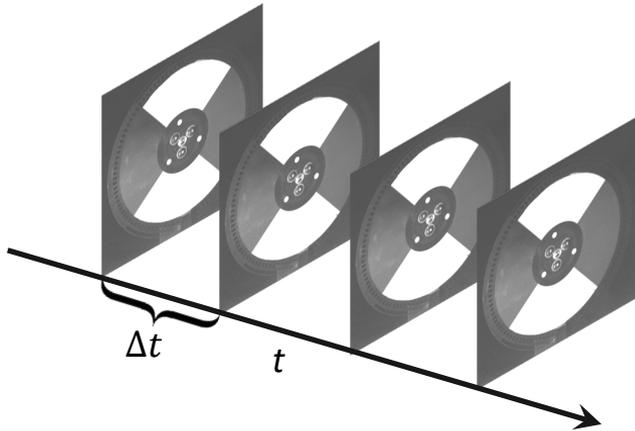


event-based



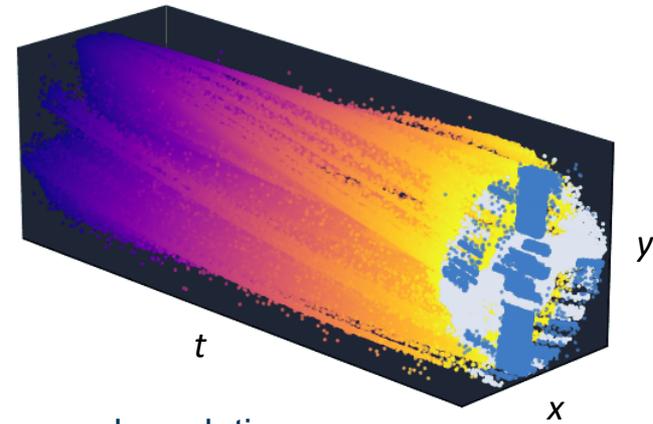
Event-based vision

frame-based



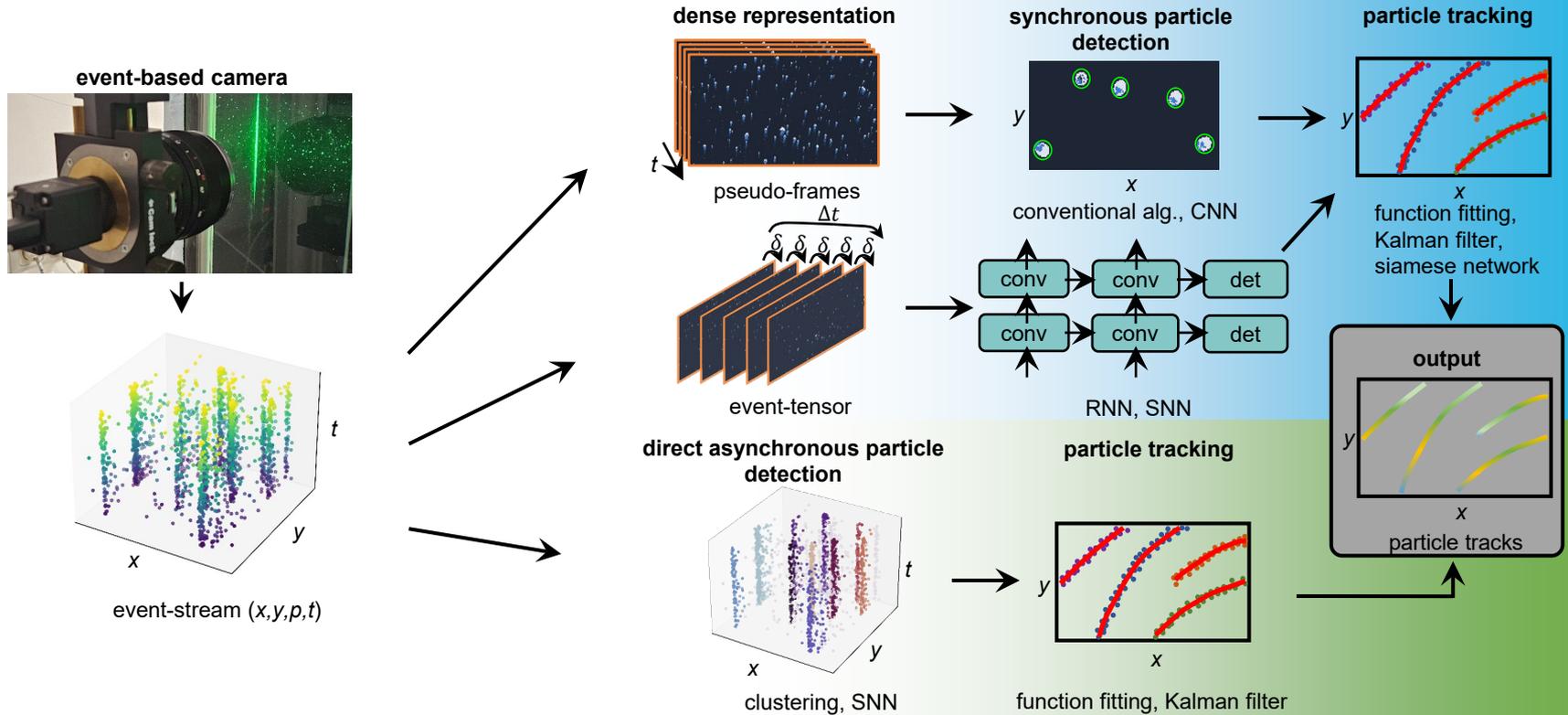
- fixed frame rate
- dense data
- rather expensive

event-based

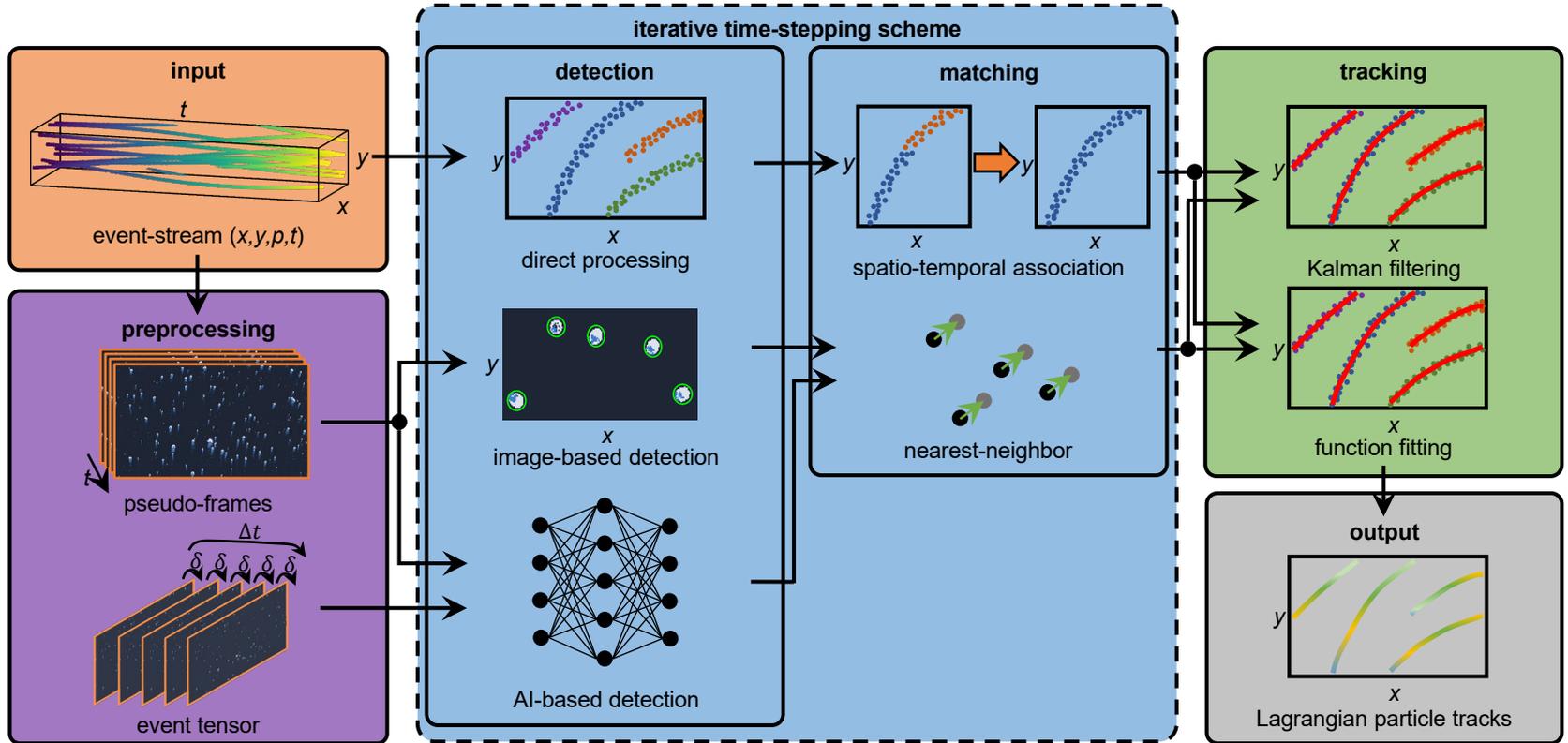


- high temporal resolution
- asynchronous, spatiotemporally sparse event-stream
- high dynamic range
- cost- and energy efficient

Data processing



Framework STELLA



Framework STELLA

The screenshot displays the STELLA framework interface, which is divided into several functional panels:

- Preprocessing:** Includes a 'DATA MANAGEMENT' section for selecting event-stream files and supported file types (e.g., .npz, .mat, .raw, .dat). It also features a 'DATA PREVIEW' section showing file details like 'Kaman_09_test.npz' and its contents (X, Y, T, P, width, height). The 'PREPROCESSING PARAMETERS' section allows users to adjust 'Accumulation time' (set to 2.000), 'ROI', 'Time range', and 'enable multirun'.
- Tracking:** Contains a 'TRACKING' section with a 'Tracking method' dropdown set to 'Kalman filtering'. It includes a 'Parameter' table with adjustable values for 'Number of workers' (100000000.000), 'q matrix', 'R', and 'Resolution factor'. A 'Test run' button is present, and the 'Tracking stats' section shows 'Number of tracks: 18313' and 'Mean track length [ms]: 27.1121'.
- Visualization:** The main display area shows a 'Pseudo-frame' visualization of event clusters and track durations. It includes 'Export / Import Results' buttons for saving and loading tracking results.
- Export / Import Results:** A section for saving and loading tracking results, with options to save as .npz or .mat and load from the same formats.



GitHub!

Datasets

synthetic

- 142 clips of 2 s (1000 fps)
- variation in magnitude, pattern, particles
- split: 70/10/20 in train/val/test



synth. particle images



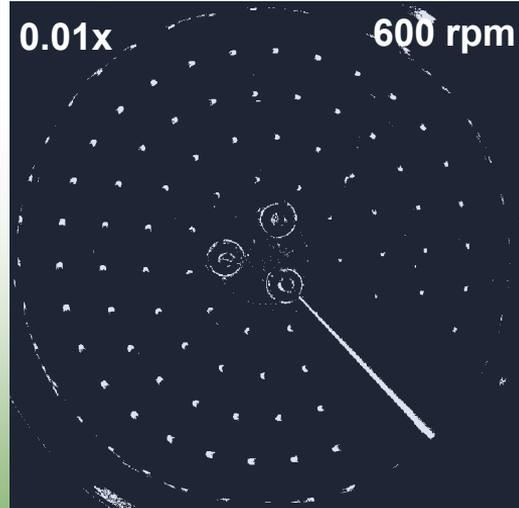
converted to event-stream using ESIM [1]

Datasets

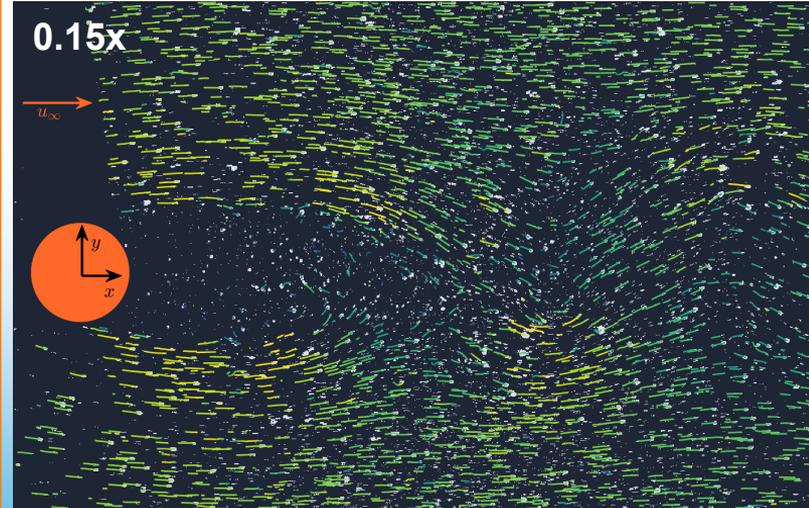
synthetic



experimental (I)

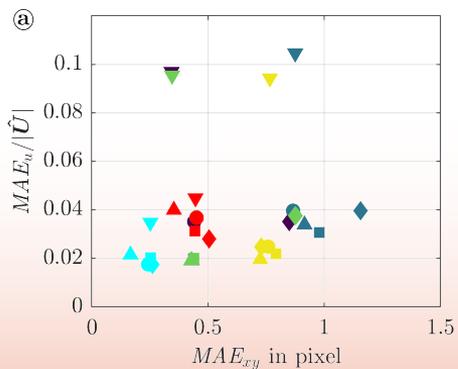


experimental (II)



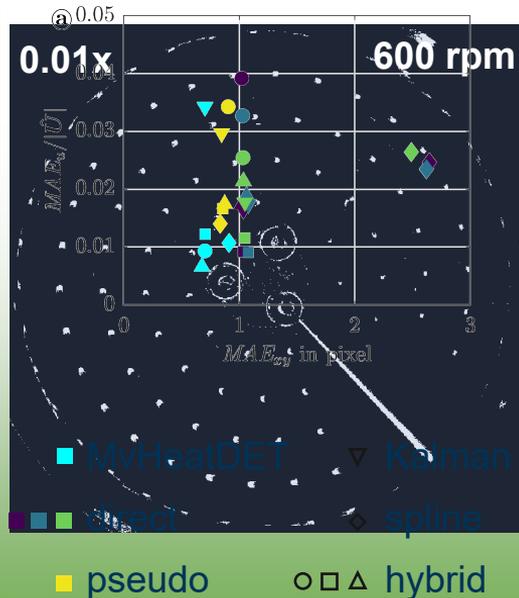
Datasets

synthetic



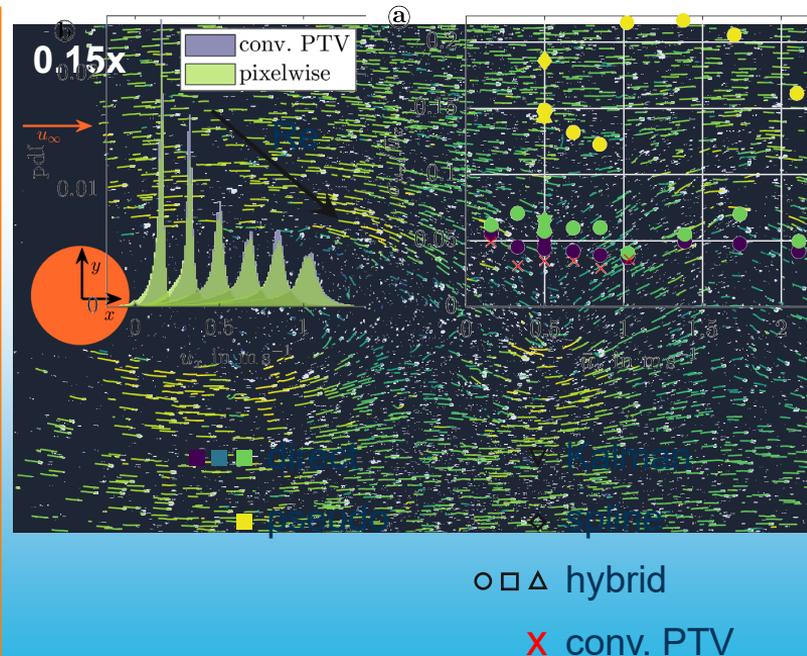
- MvHeatDET ▼ Kalman
- RVT ◇ spline
- direct ○ □ △ hybrid
- pseudo

experimental (I)



- MvHeatDET ▼ Kalman
- RVT ◇ spline
- direct ○ □ △ hybrid
- pseudo

experimental (II)



- □ △ hybrid
- X conv. PTV

Datasets

particle tracking
velocimetry (PTV)



astigmatism particle tracking
velocimetry (APTV)

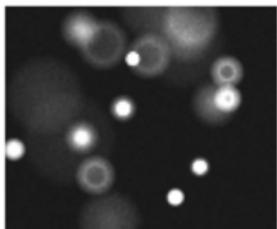


event-based vision
(EBV)

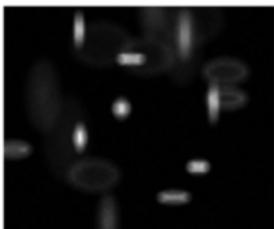


Defocus Challenge

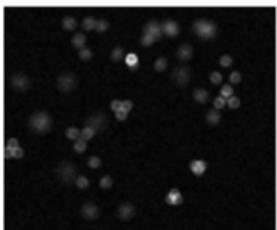
Mutli-flavor datasets



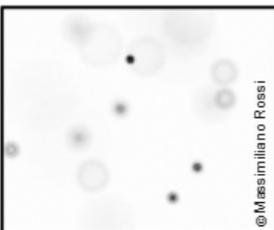
Defocusing



Astigmatism



3-Pinholes

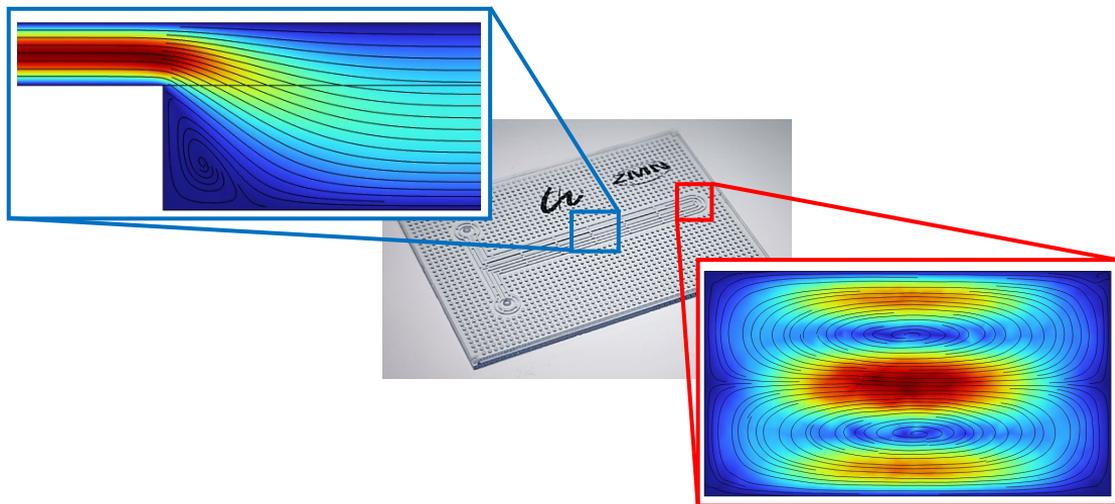


Shadowgraphy

@Massimiliano Rossi



Chip-in-the-Box (ChiB)



Conclusion

- collected synthetic and experimental **datasets** of multiple flavors
- developed modular **framework** for particle tracking using event-based cameras
- **presented** at „ISPIV2025“ and „Fachtagung Experimentelle Strömungsmechanik“
- **journal publication** submitted
- initiated **Defocus Challenge**

Outlook:

- working on applying trained networks to experimental data
- tailored neural network architecture in strong collaboration with Prof. Margret Keuper

