

# EVO: Event-based 6-DOF Parallel Tracking and Mapping in Real-time

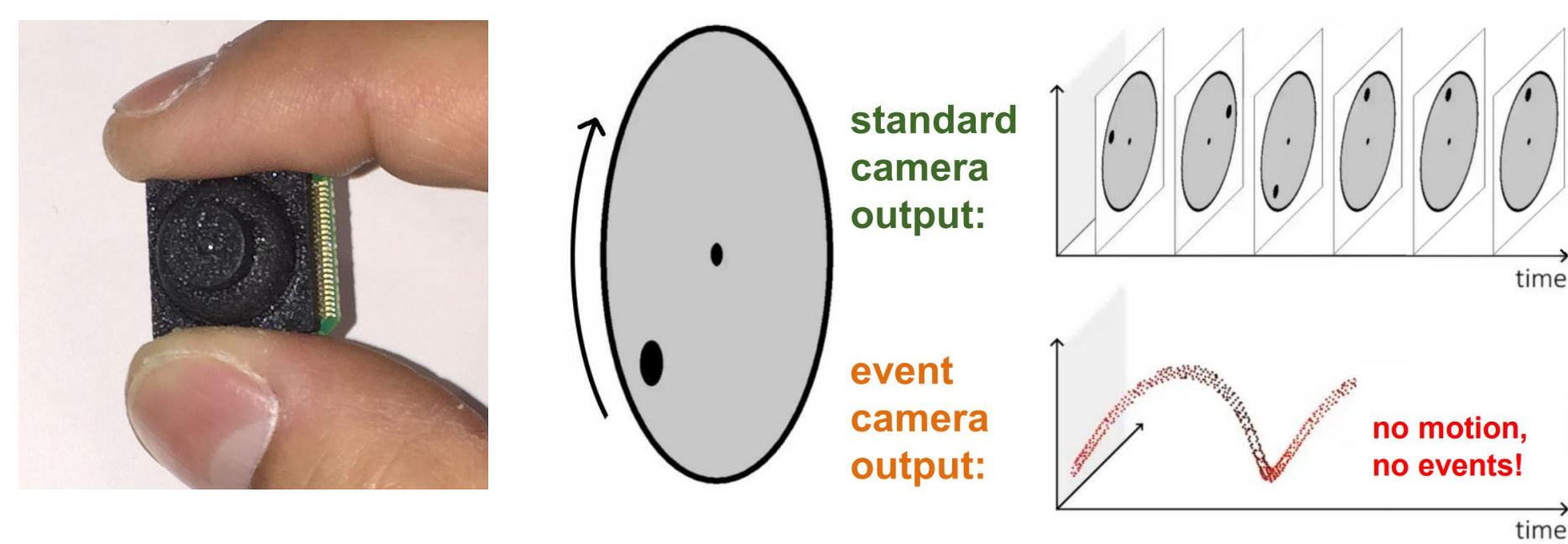
**DEMO!**

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**Motivation:** Address **challenging SLAM scenarios** (high-speed, HDR, low latency).

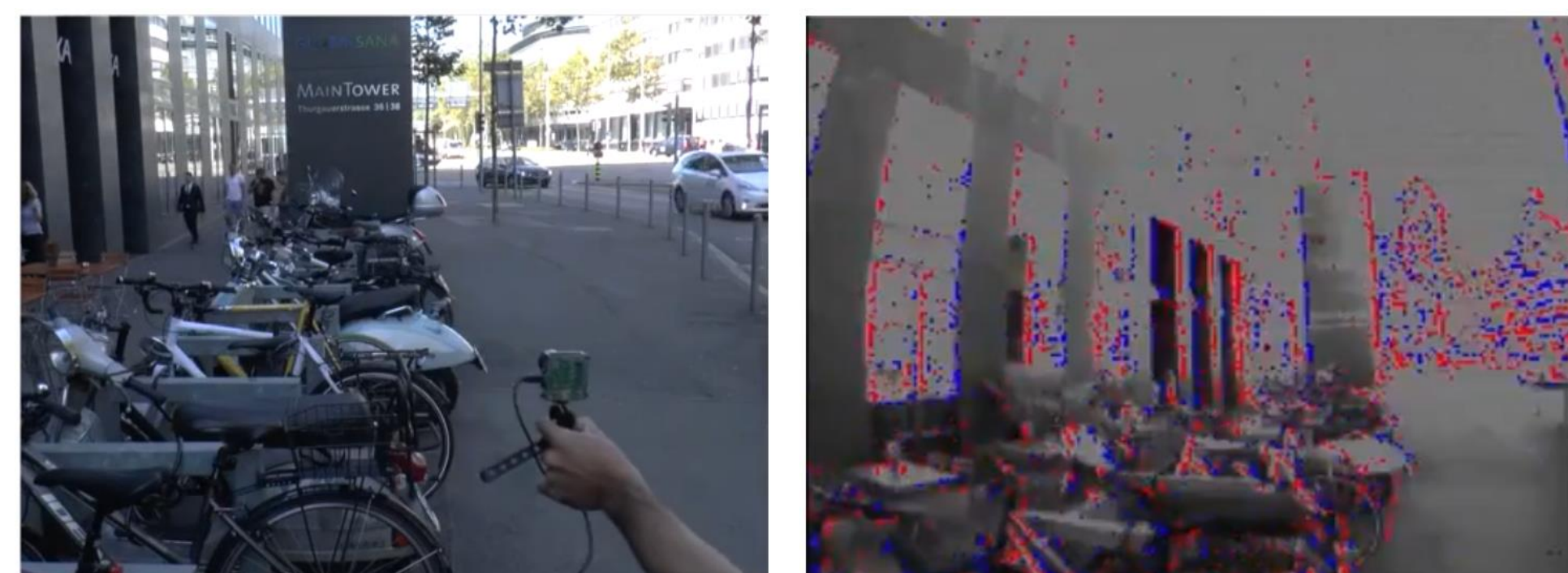
**Goal:** Semi-dense SLAM with an **event camera** in real time.

## What is an event camera?



- Only transmits **brightness changes**.
- Output is a stream of **asynchronous events**.
- **Advantages:** low latency, no motion blur, HDR.

**Watch video!**



Scene

Input events



3D reconstruction

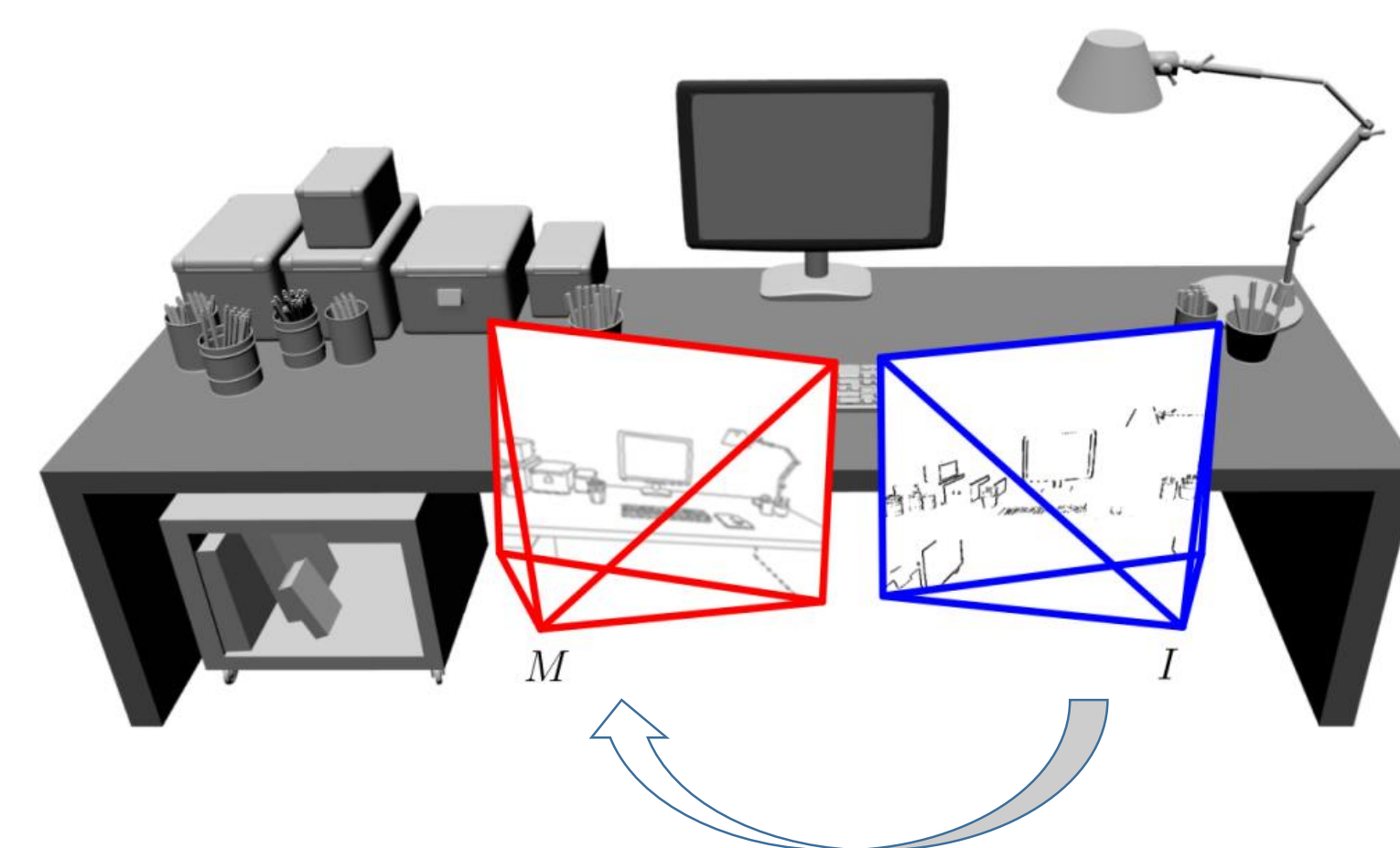
## Key properties:

- **Semi-dense 3D reconstruction** and 6-DOF tracking.
- Works even in **high-speed** and **HDR** scenes, where standard cameras fail.
- **Real-time** on a **smartphone CPU**.
- **Intensity reconstruction** not needed, but available.



Event-based Vision Research

## Tracking: edge-map alignment



I: Event Image



M: Projected Map

- **Event images** (~1000 events)
- **Minimize alignment error** between projected map and events:

$$\min_T \sum_{\mathbf{u}} \left( M(\mathbf{u}) - I(W(\mathbf{u}; T)) \right)^2$$

$$\text{6-DOF warp: } W(\mathbf{u}; T) := \pi(T \cdot \pi^{-1}(\mathbf{u}, d_u))$$

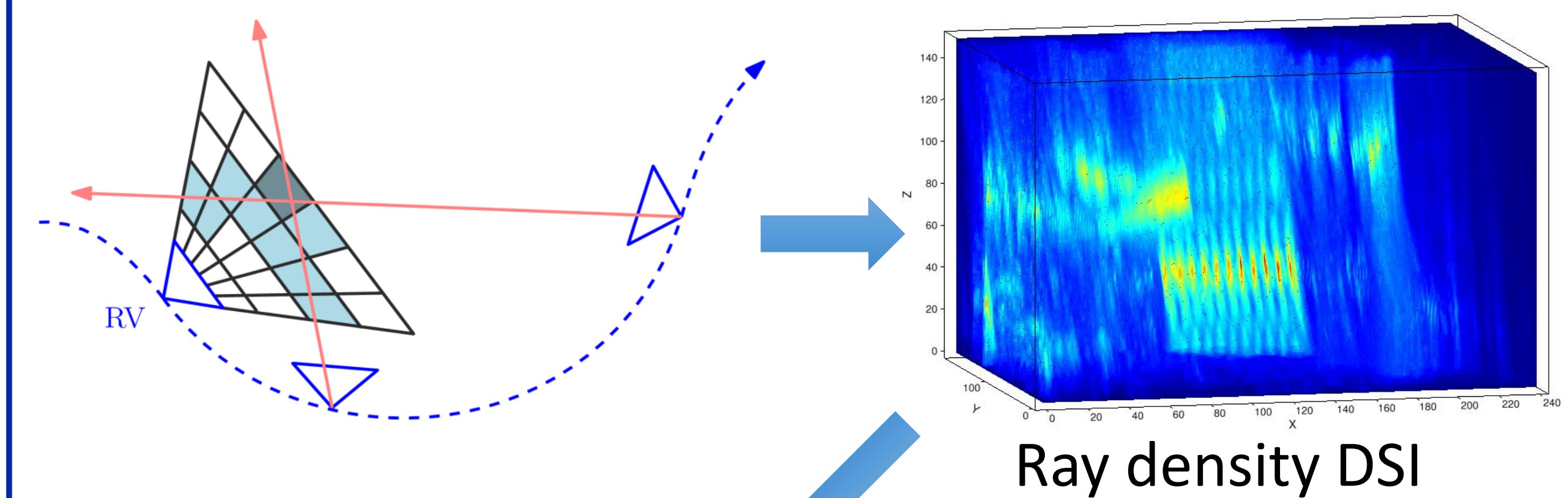
Camera pose

3D Map

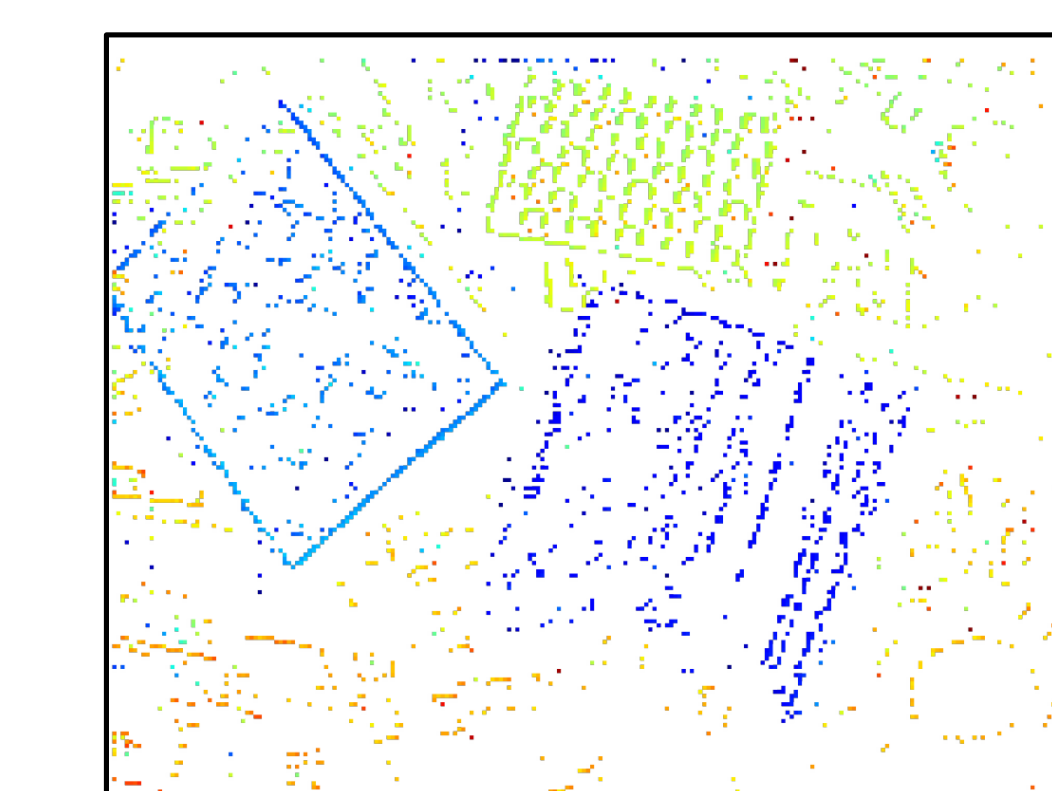
## Mapping: EMVS (IJCV'17) [2]

### Event-Based Space-Sweep Method:

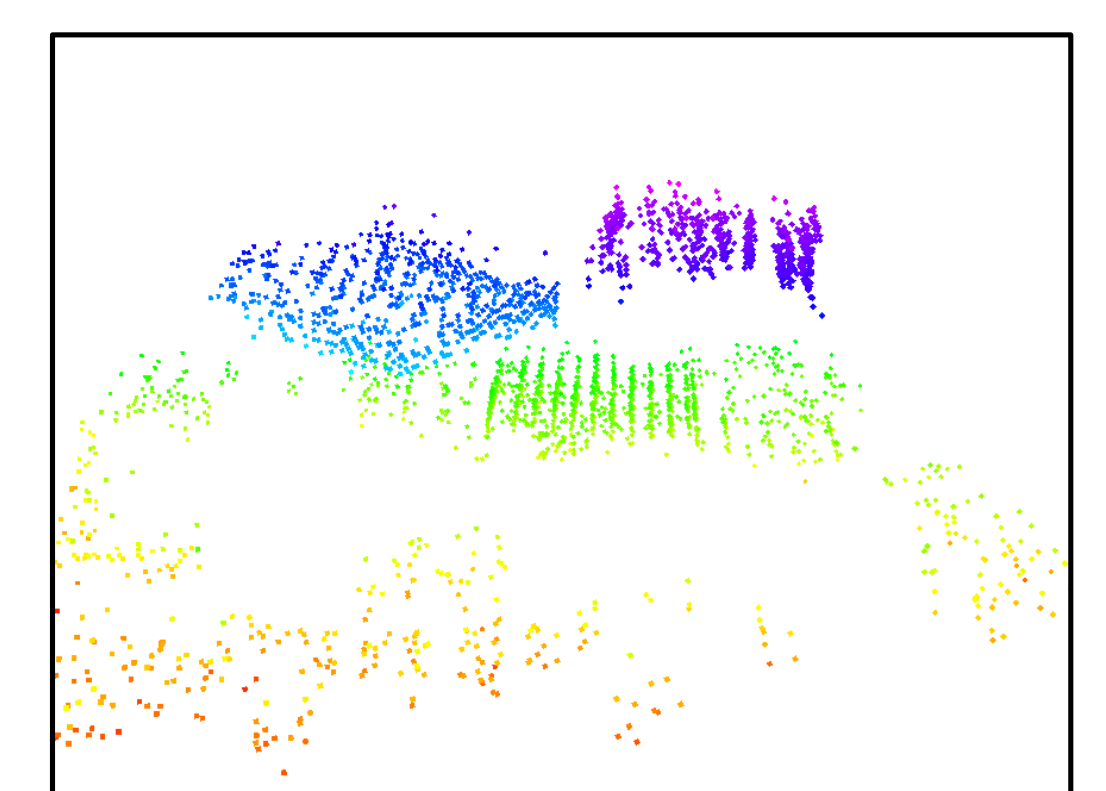
- **Back-project events** into space.
- Disparity Space Image (DSI) with **ray density**.
- Projective sampling of DSI + Adaptive thresholding.



Ray density DSI



Semi-dense depth map



3D point cloud

**References:** [1] Rebecq et al, **EVO**. IEEE Robot. and Autom. Letters, 2017

[2] Rebecq et al, **EMVS: Event-based MultiView Stereo**. IJCV'17.