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Active sensing and its application to neuromorphic space imaging

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Important Points

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- **The importance of active sensing**
- **The importance of prediction in neuromorphic systems**
- **Temporal resolution makes up for spatial resolution**
- **The importance of synchronization**
- **Biologically inspired – not biologically plausible**
- **Low-power, low-bandwidth sensing and computation**

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What is space situational awareness?

Space Situational Awareness

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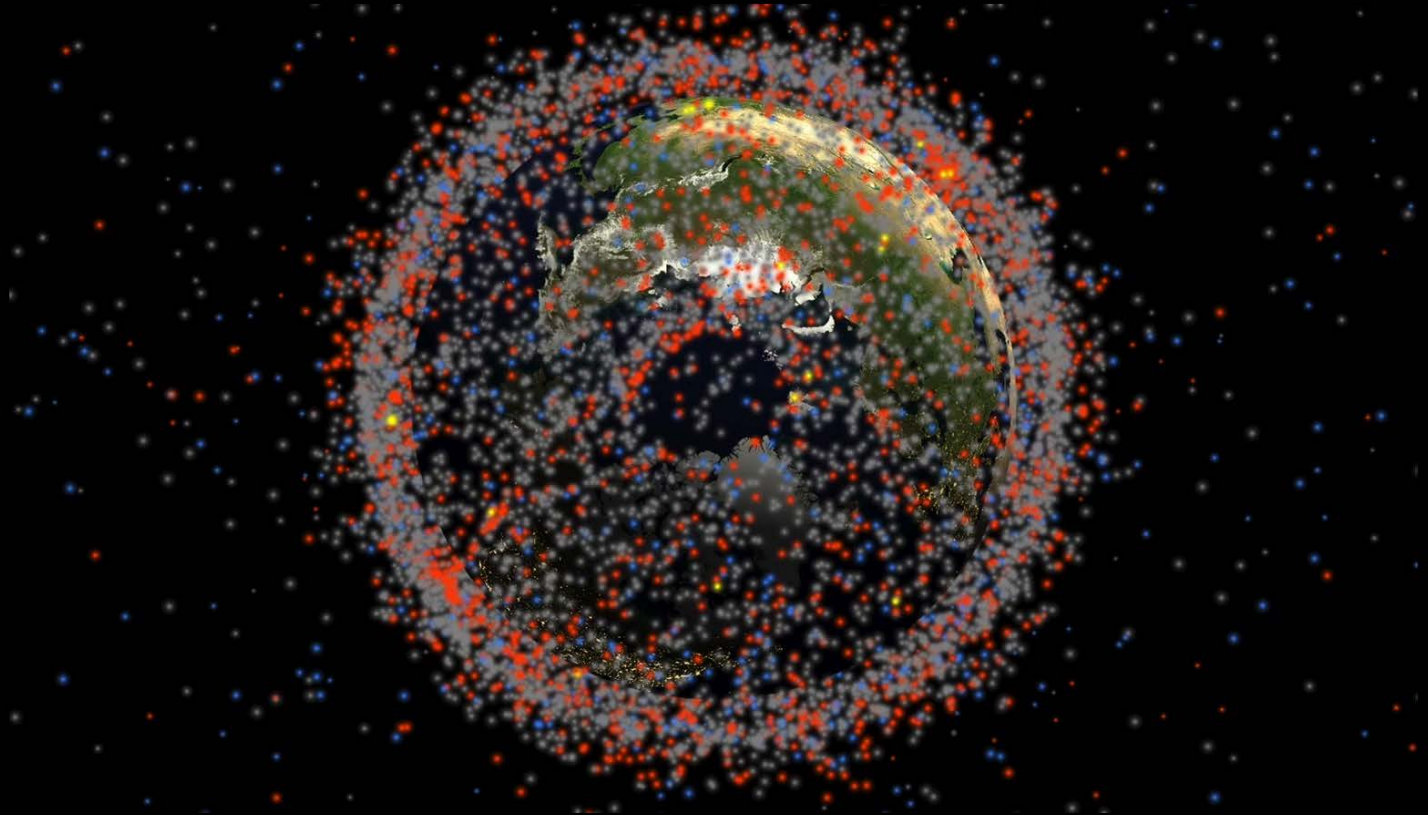
Dr Stuart Grey

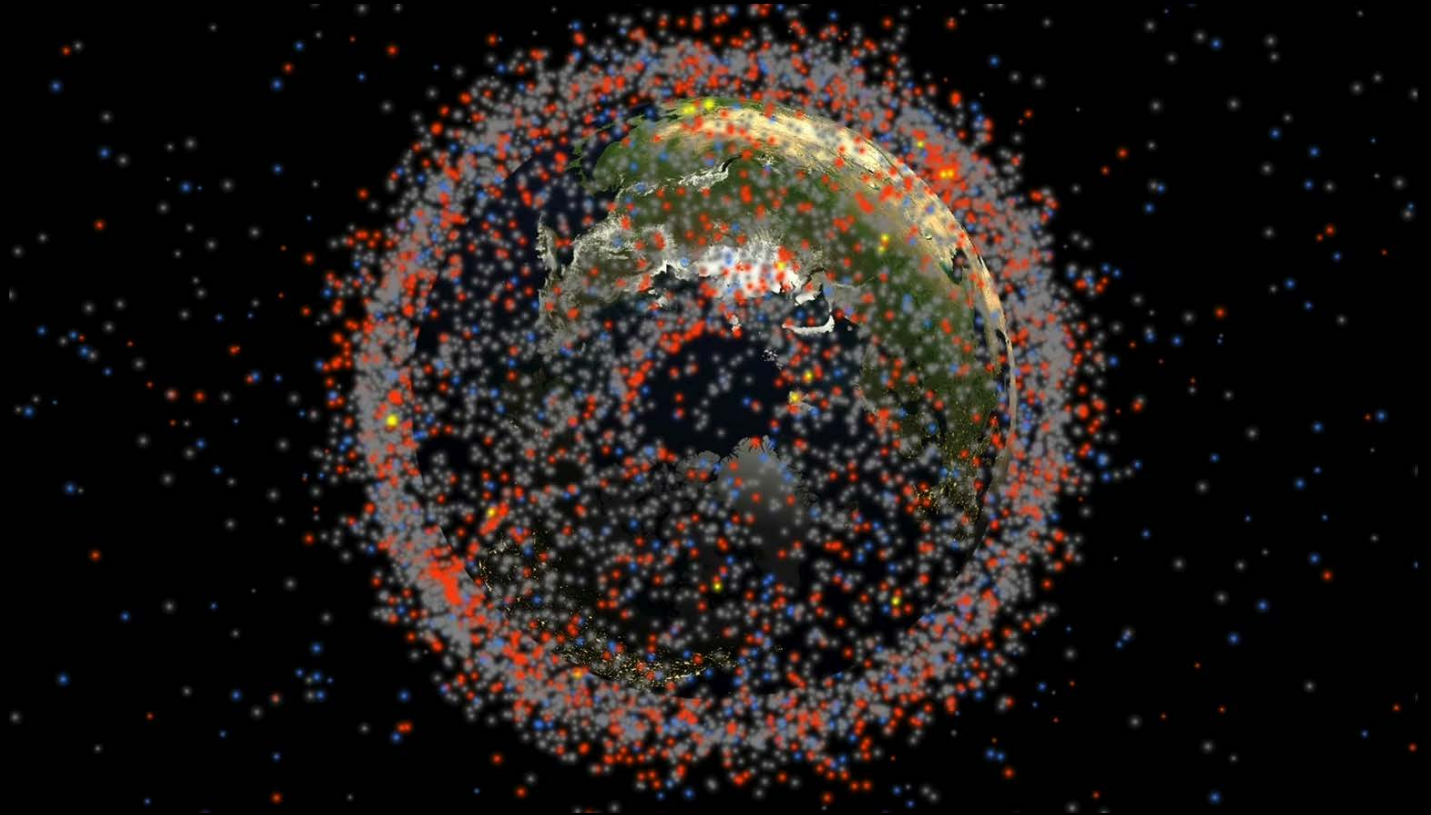
Low-Earth Orbit

Source: stuffin.space



Medium Earth Orbit

Source: stuffin.space



Geosynchronous Orbits

Source: stuffin.space

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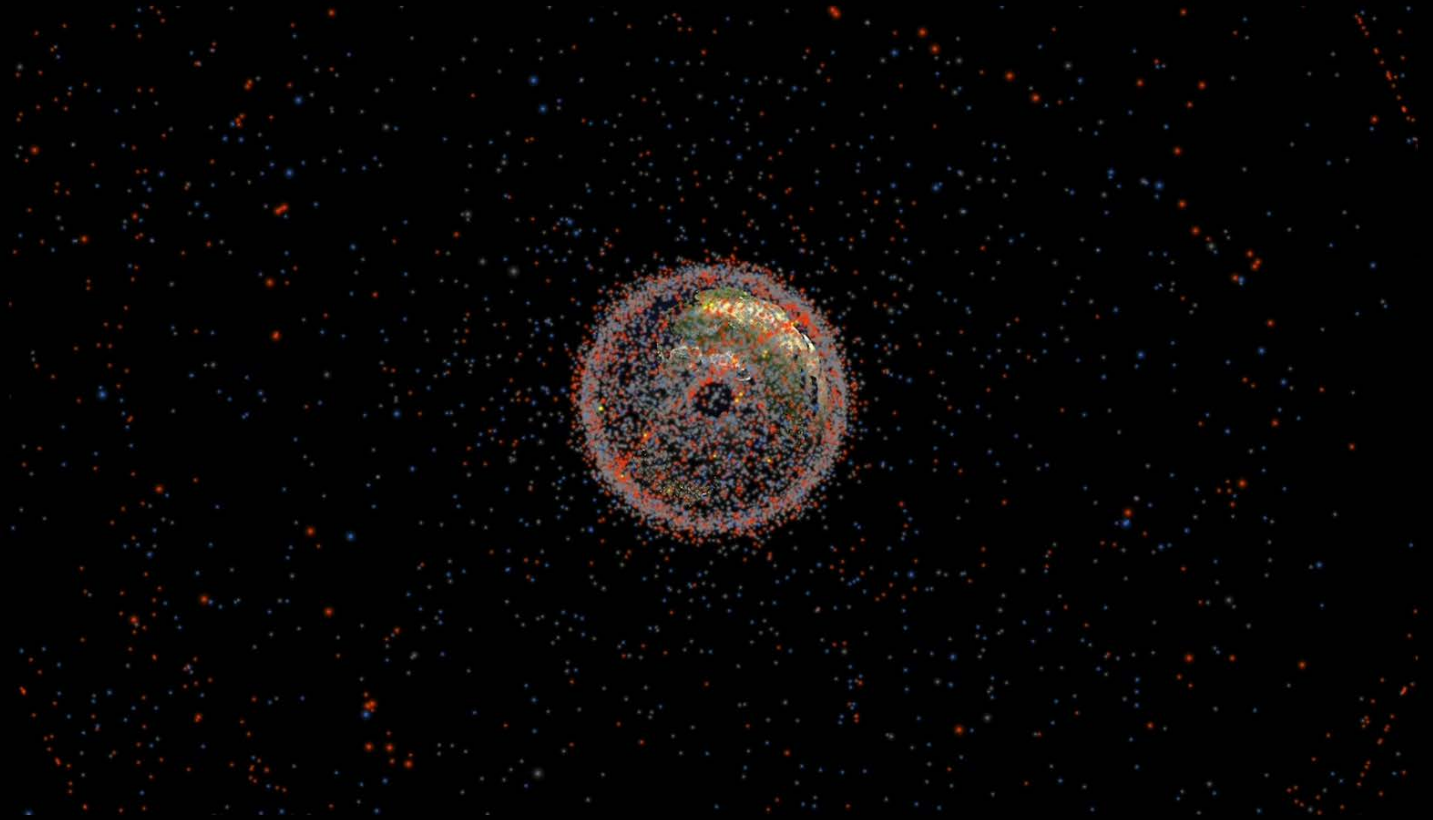

Neuromorphic Event-based Sensors

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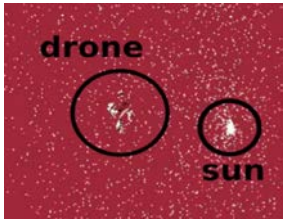
Novel imaging paradigm

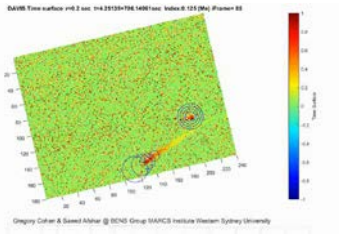
- Independent and asynchronous pixels
- Logarithmic change detection gives very high dynamic range
- Frame-free imaging with no fixed integration times
- High-speed imaging (events have 1 µs resolution)
- Greatly reduces motion blur and saturation effects

High-speed, low-power, low-bandwidth imaging

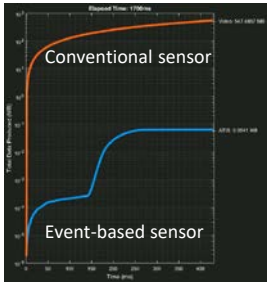
Requires a new approach to processing and computer vision



High Dynamic Range



Daytime LEO Detection



Low Data Rates
(logarithmic axis)

New Imaging Paradigm for Terrestrial Imaging

Unparalleled Orbital Applications

Experimental Setup

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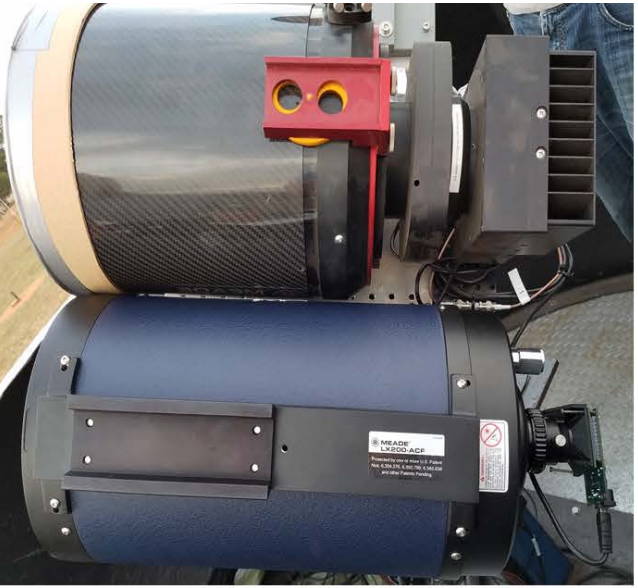

Telescope	Manufacturer and Model	Focal Length	f / ratio	Sensor
Primary telescope	Officina Stellare RH200	600 mm	f / 3	CCD Sensor
Secondary telescope	8” Meade LX200	2000mm	f / 10	ATIS Sensor

Australian Government
Department of Defence
Defence Science and Technology Group

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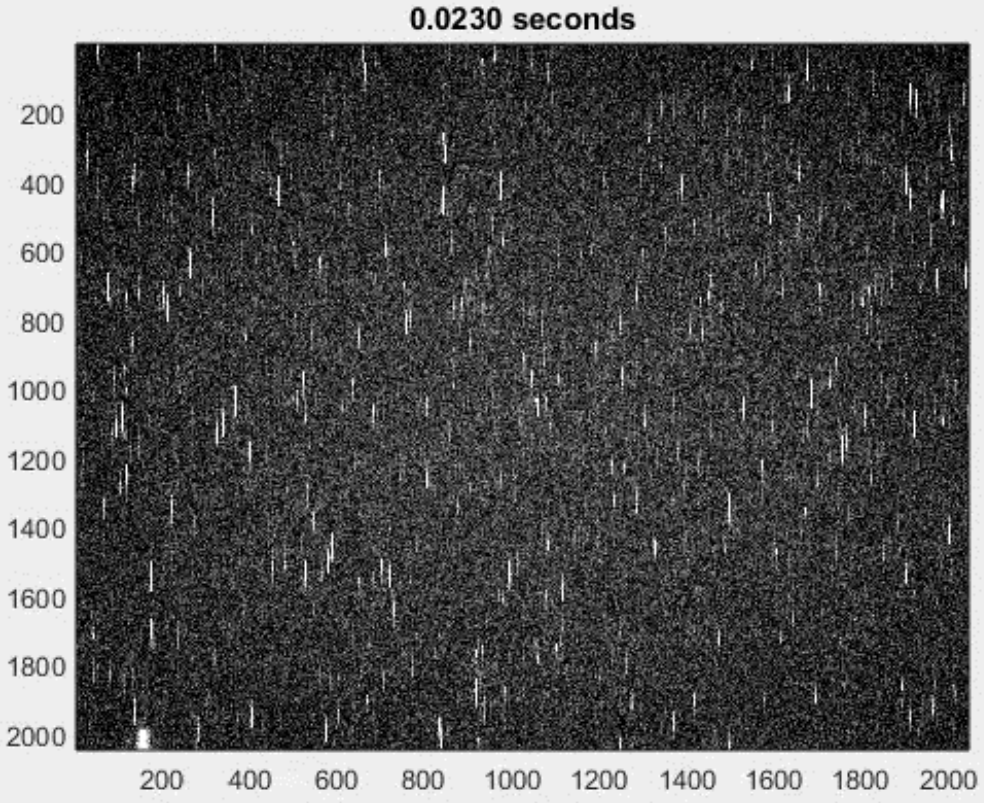
Imaging the Stars and Planets

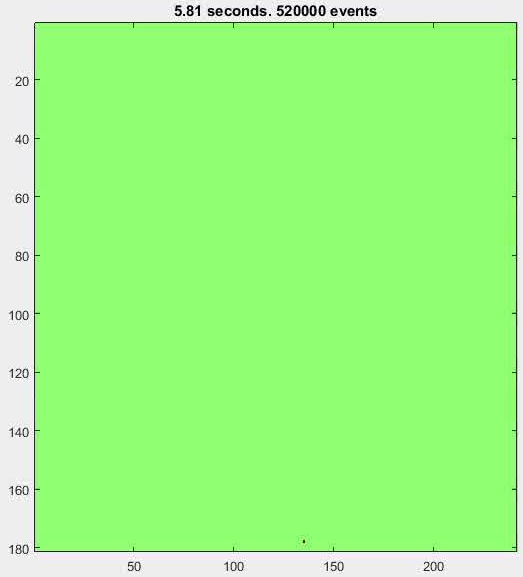
Imaging the Stars and Planets

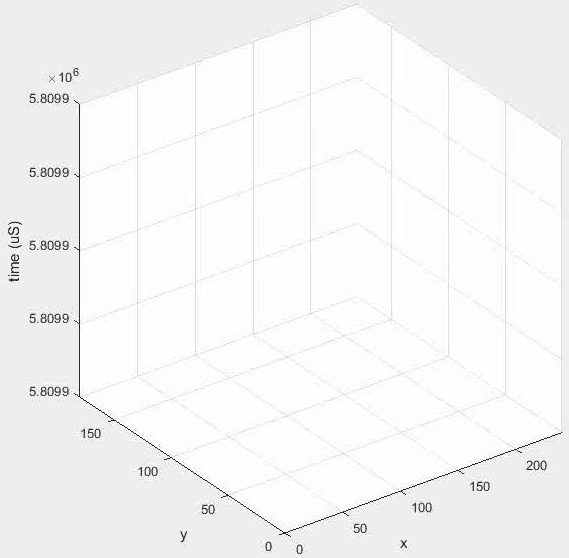
Low Earth Orbit Satellites (LEOs)

Siderally tracking the stars.



Tracking LEOs – Tracking SL8RB 21938





Low Earth Orbit Satellites (LEOs)

Siderally tracking the stars.

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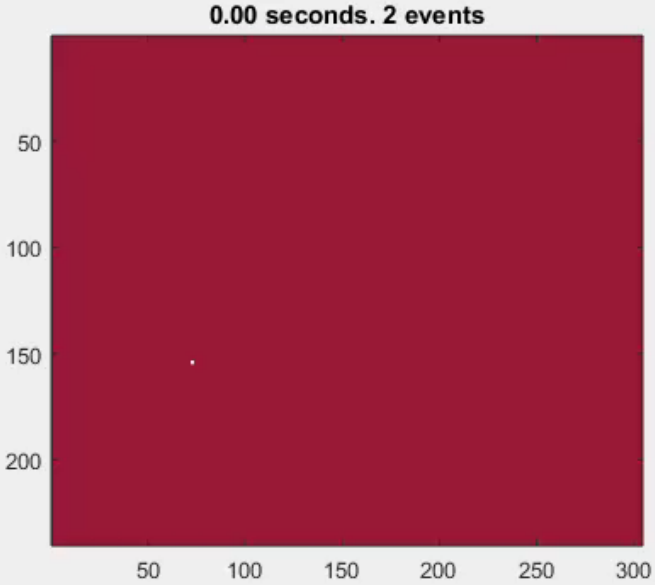
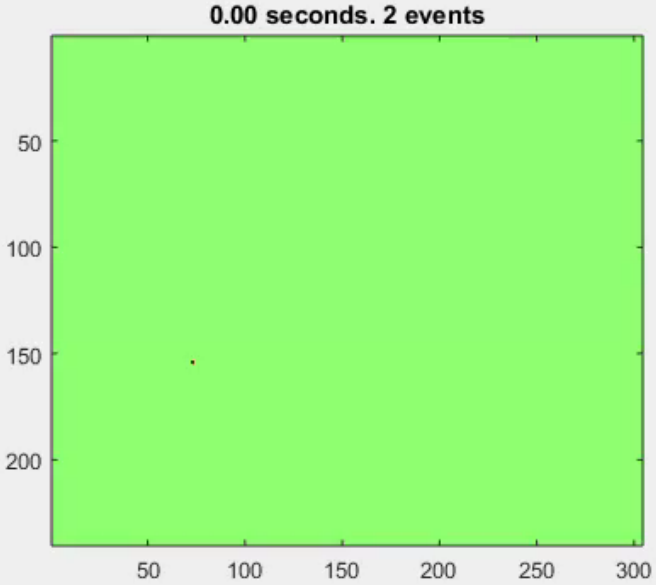
Event Frames



Visualization Surface



ABS-6 GEO Synchronous Orbit Ground Truth

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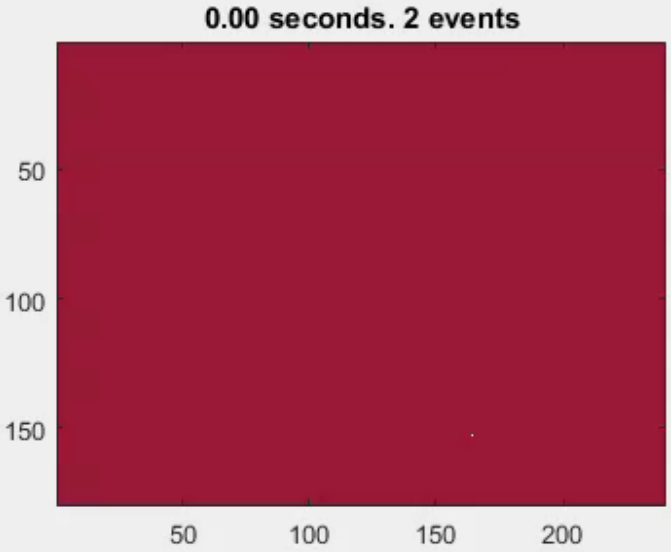
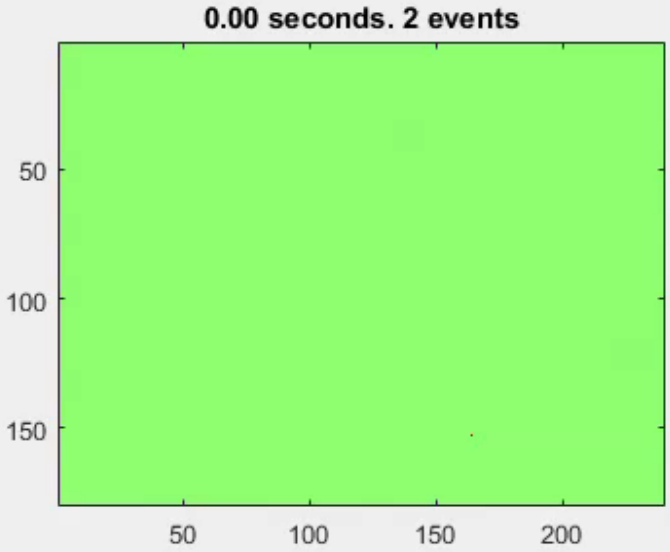
Geosynchronous Objects

Object: ABS-6 (25924) on 04/06/207

Real-time Frames



Visualization Surface



Sidereal tracking is used to visualize the GEO

Real-time Detection of Daytime LEOs

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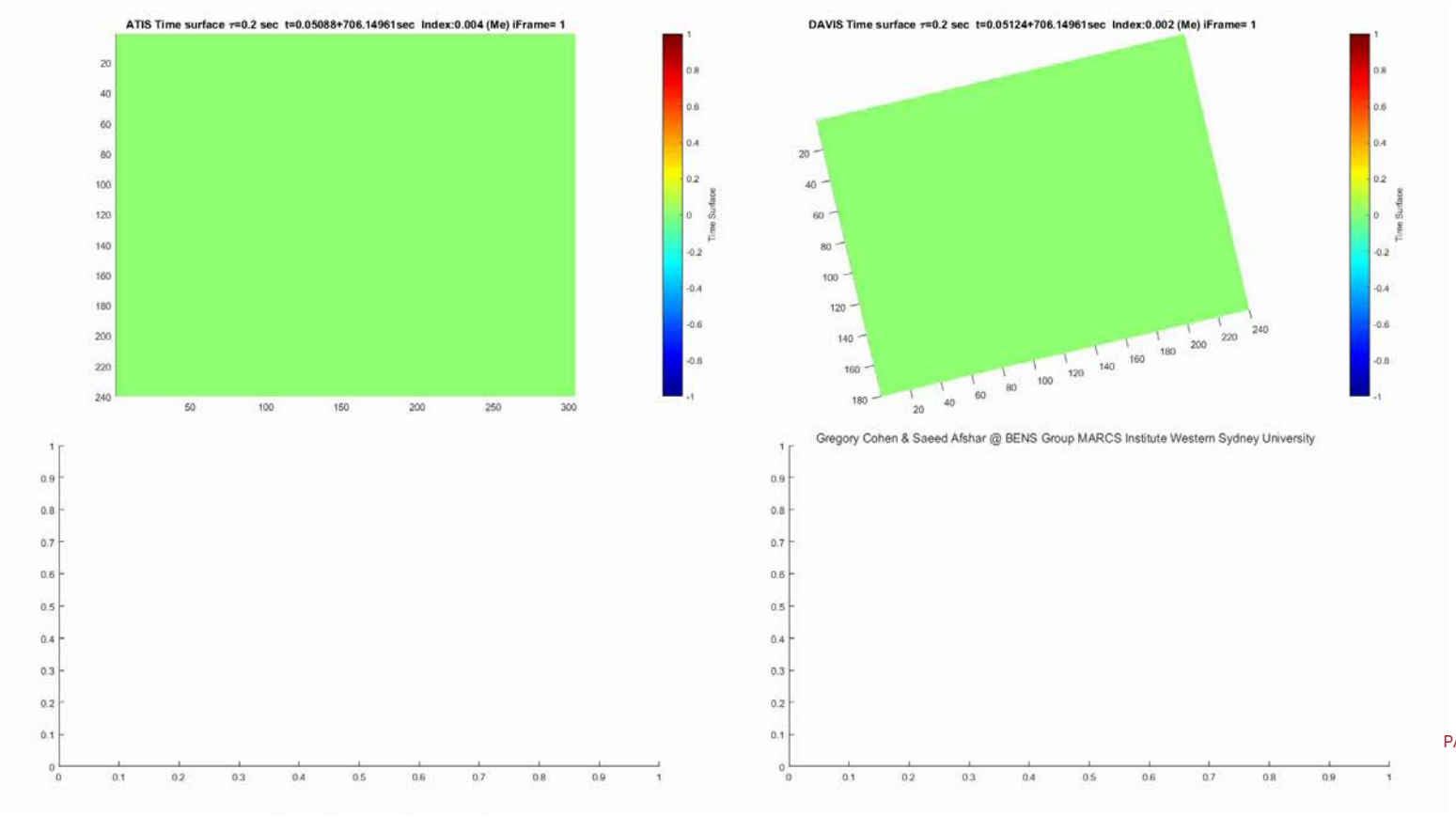
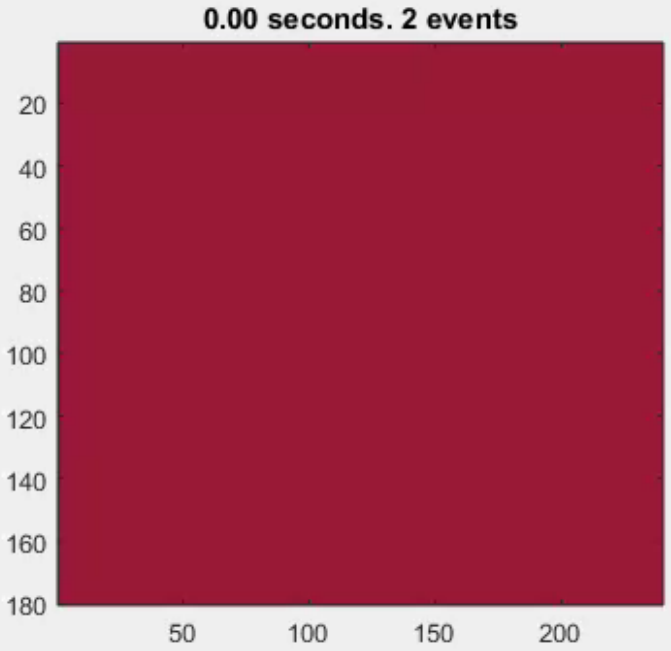
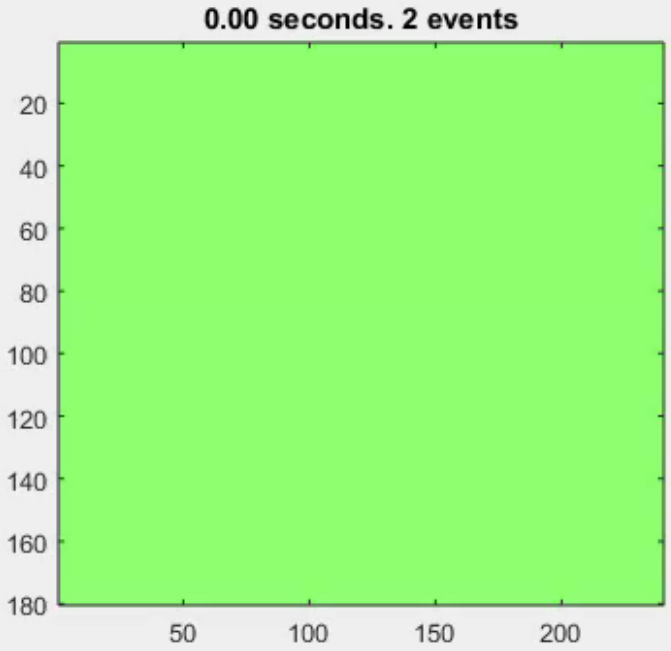


Atmospheric Effects? Jupiter from the DAVIS Camera





Atmospheric Effects?

Scintillation Effects?

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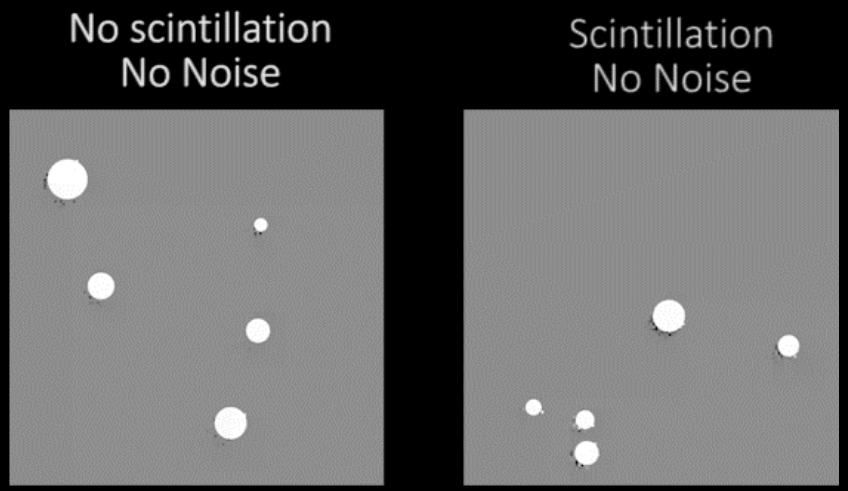
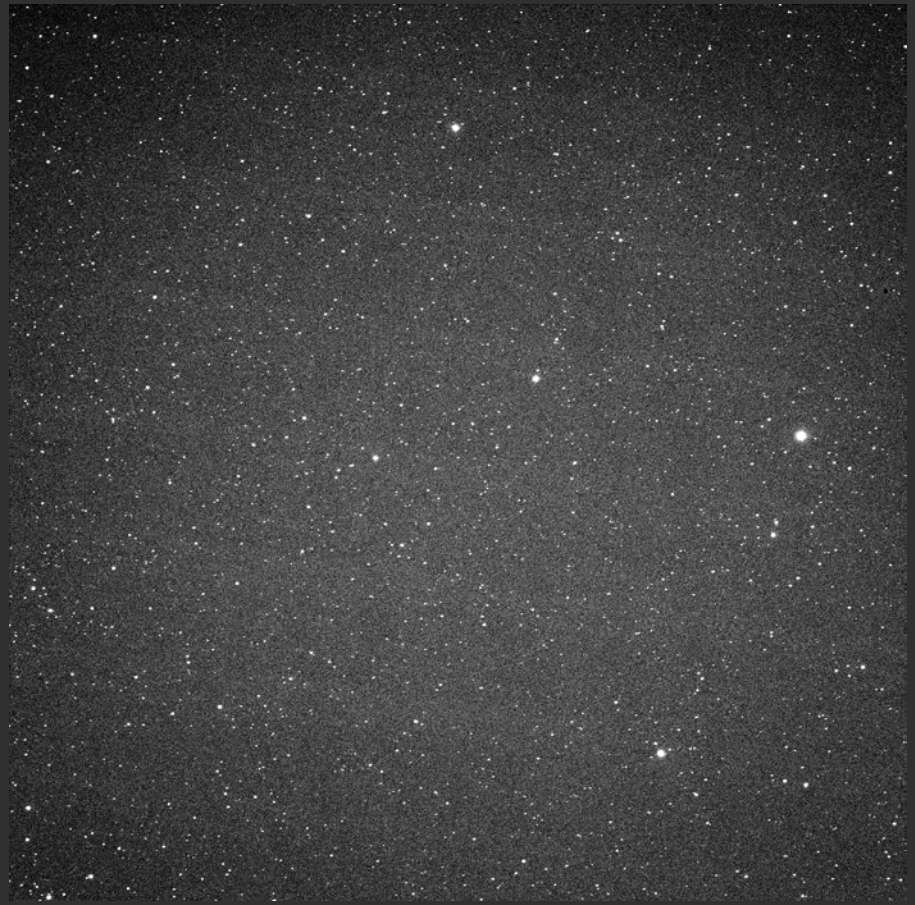
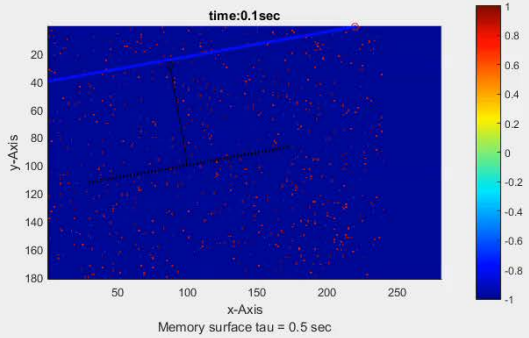
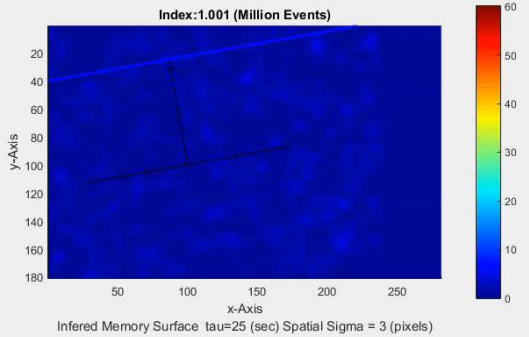


Star Tracking with CCD Imaging



Star Mapping with an Event-based Sensor





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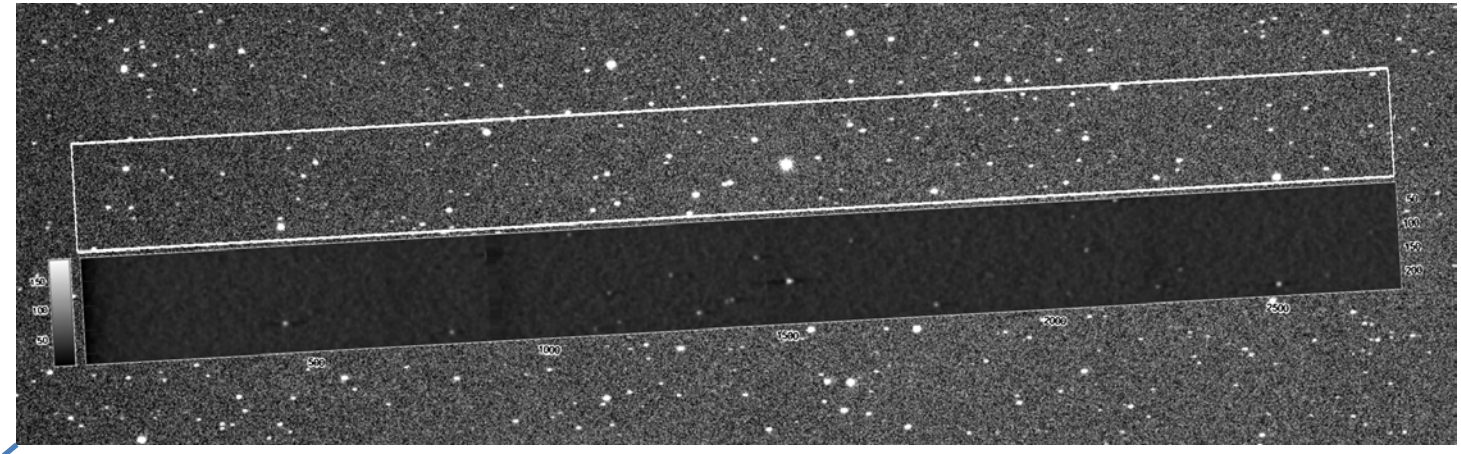
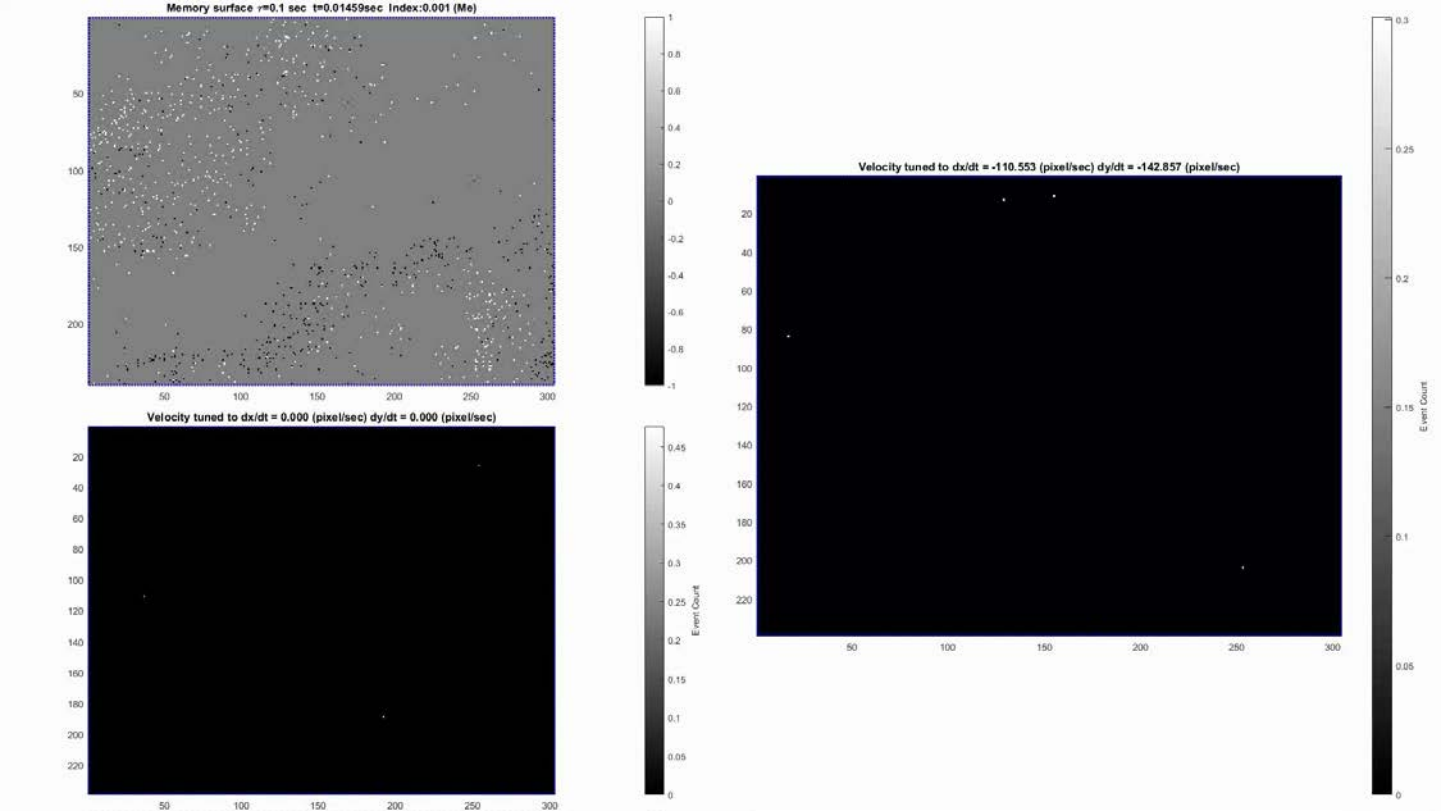
Star Mapping with an Event-based Sensor

Comparison of the inferred star map and the ground truth from the CCD sensor



Seeing Through Gaps in Clouds

Seeing Through Gaps in Clouds



Active Sensing and Occlusion-invariant Sensing

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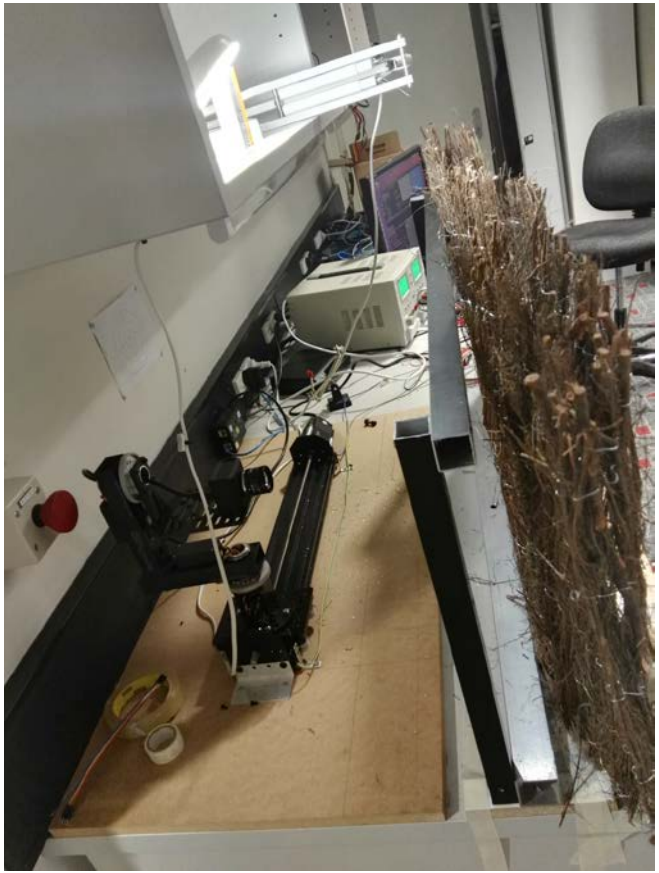

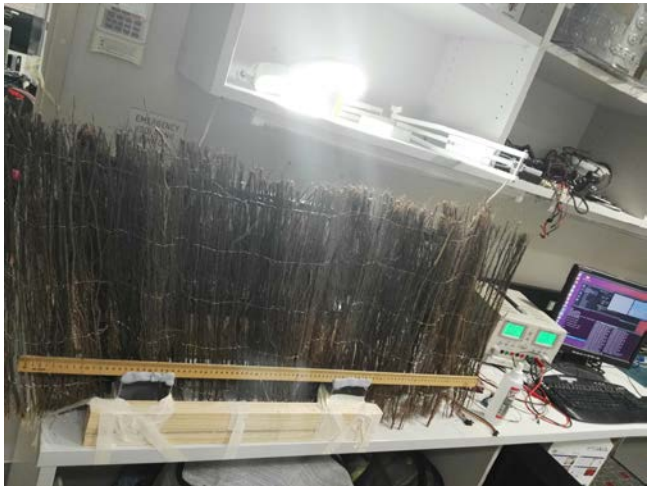

Seeing through the bushes

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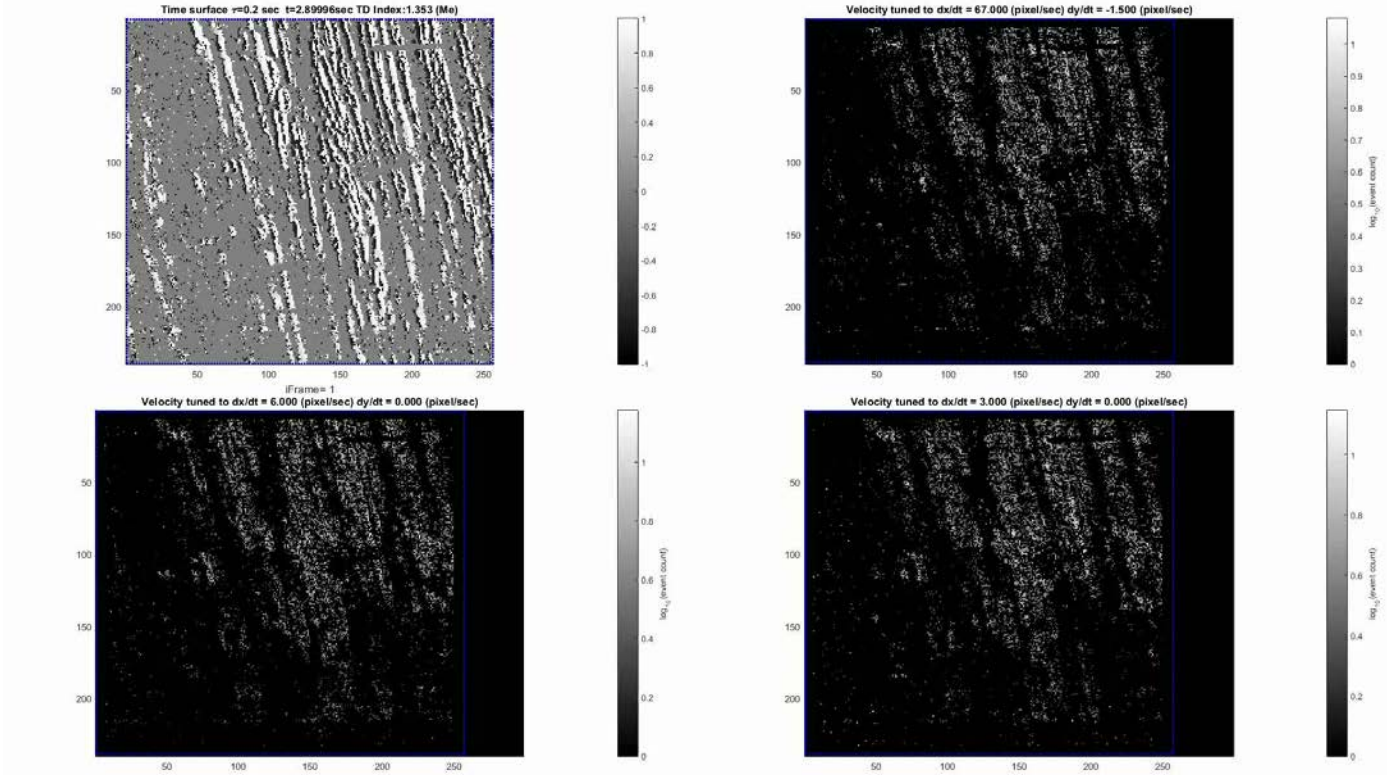
Seeing through the bushes



Questions