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Constrained Signal Integration

Presented by

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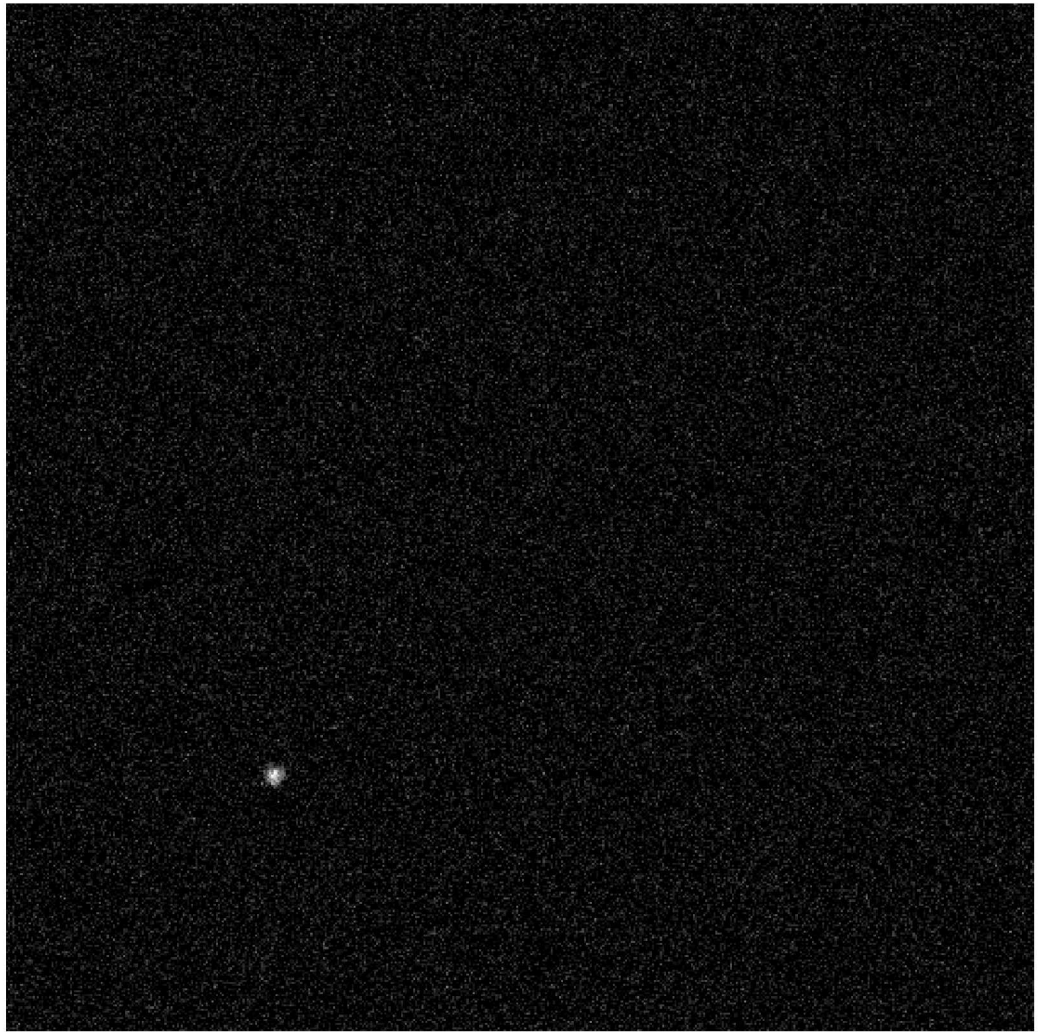
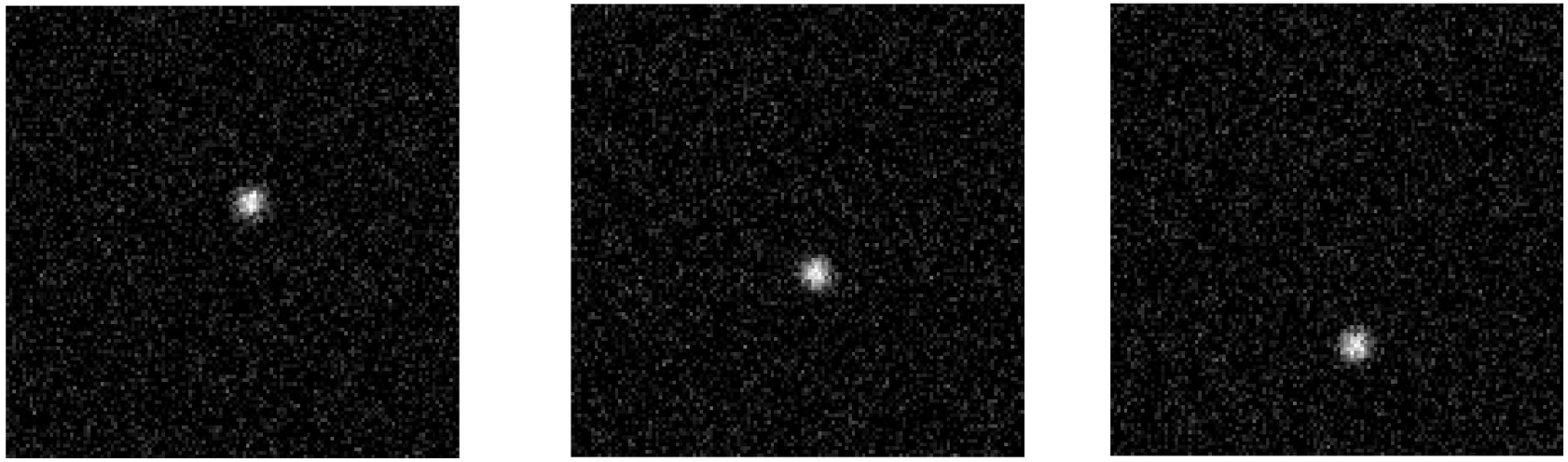
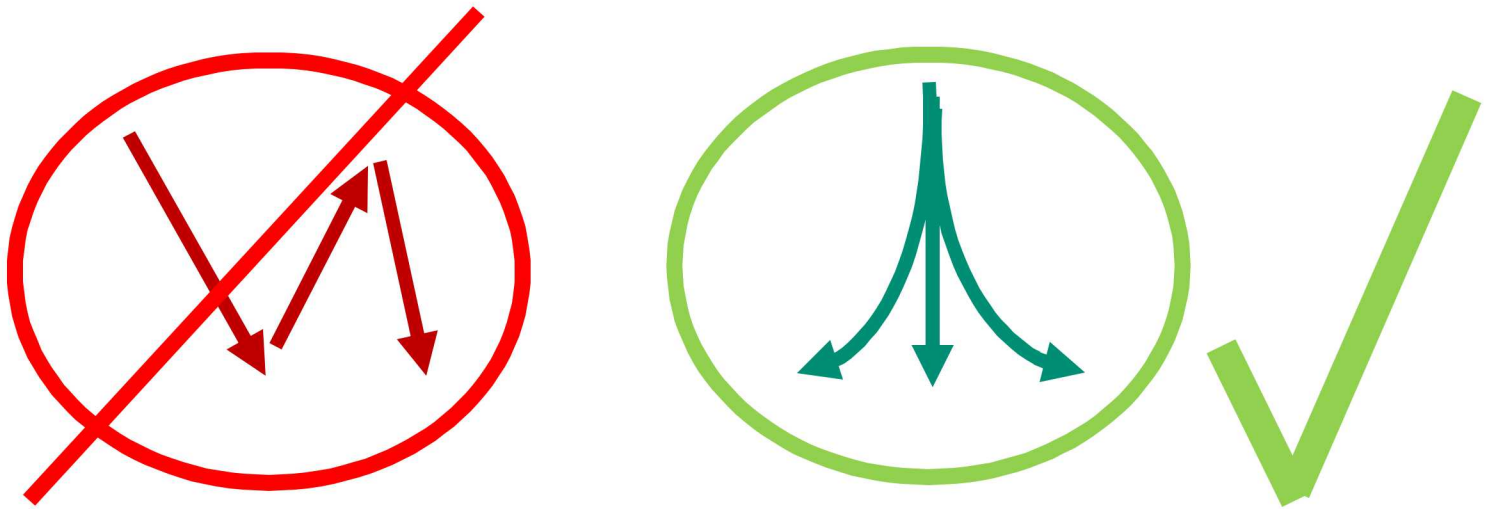
Introduction



Approach: Use multiple images with motion constraints

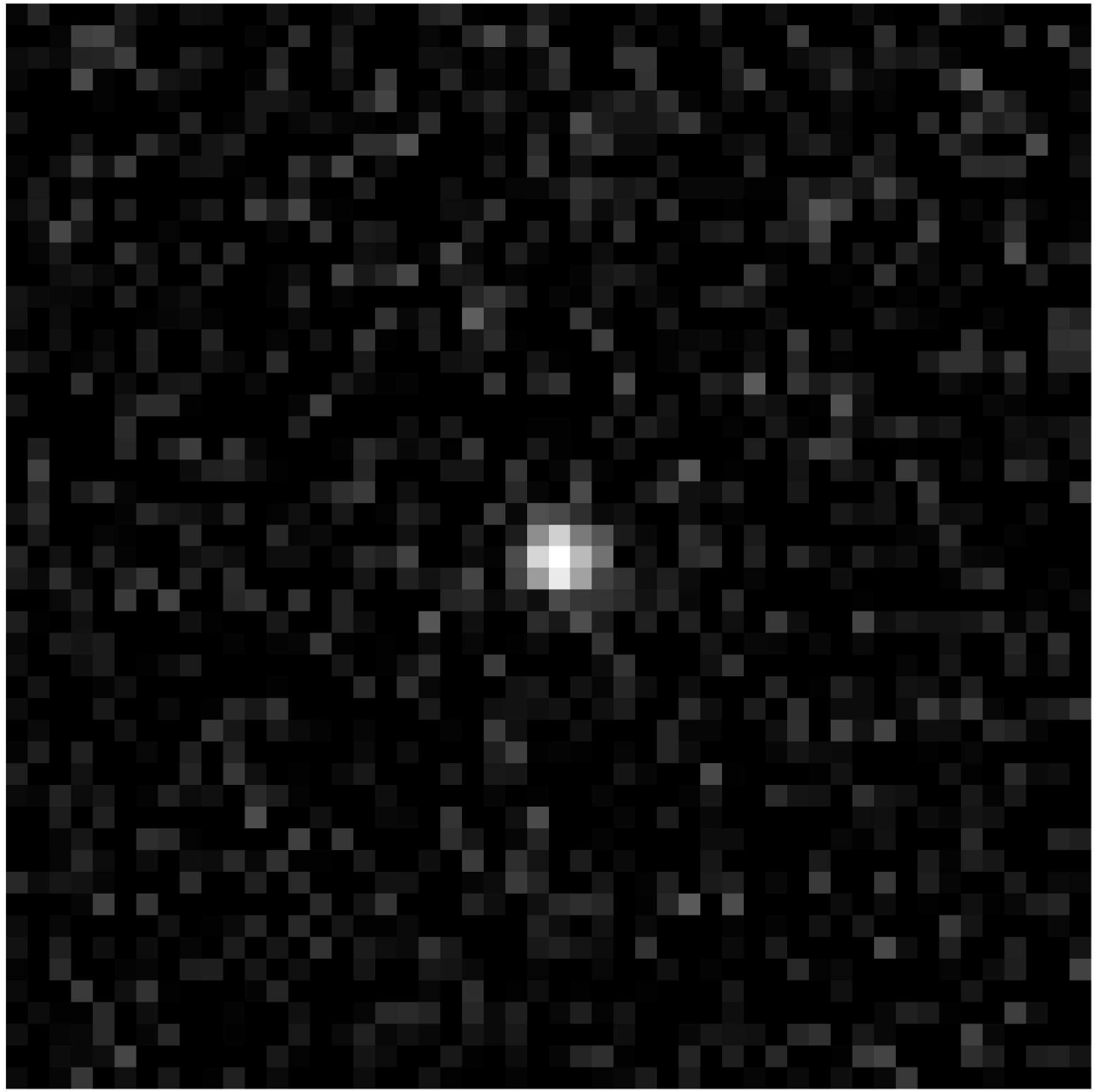




Outline

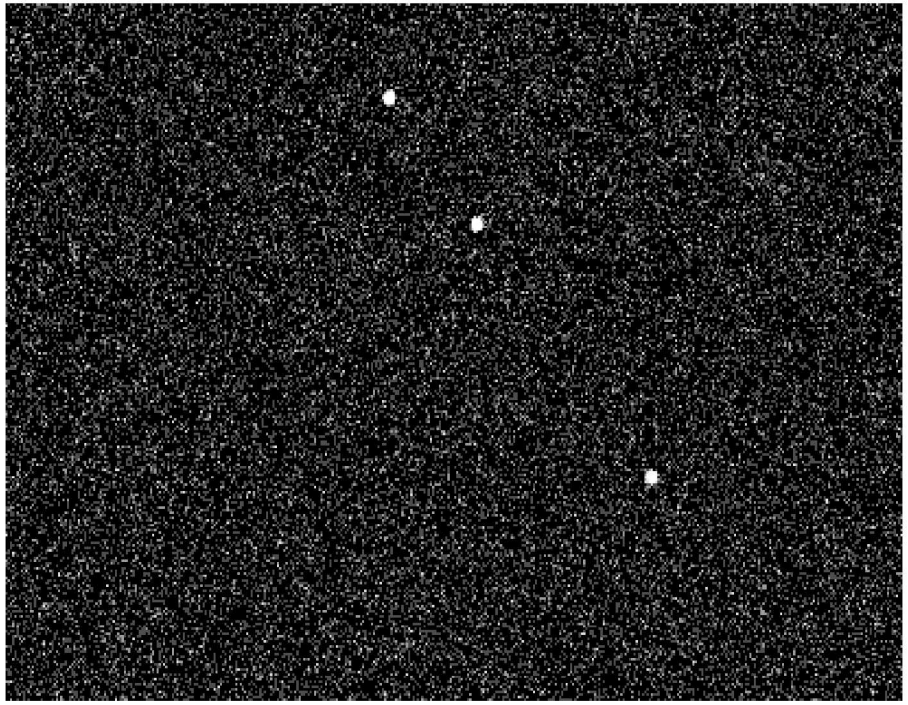
- Detection Problem
- Signal Integration
- Motion Constraints
- Examples

Detection

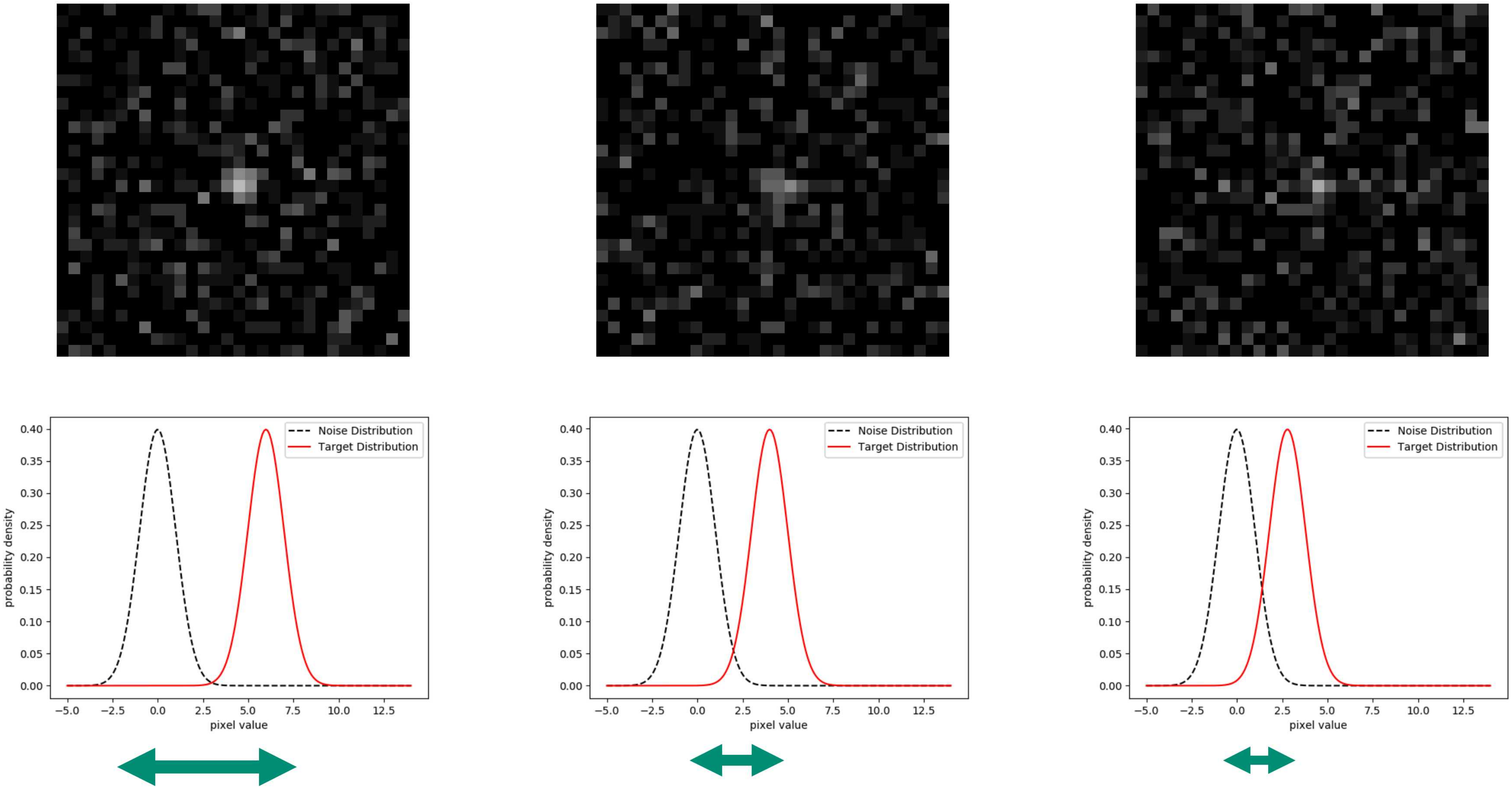


Detection preprocessing example

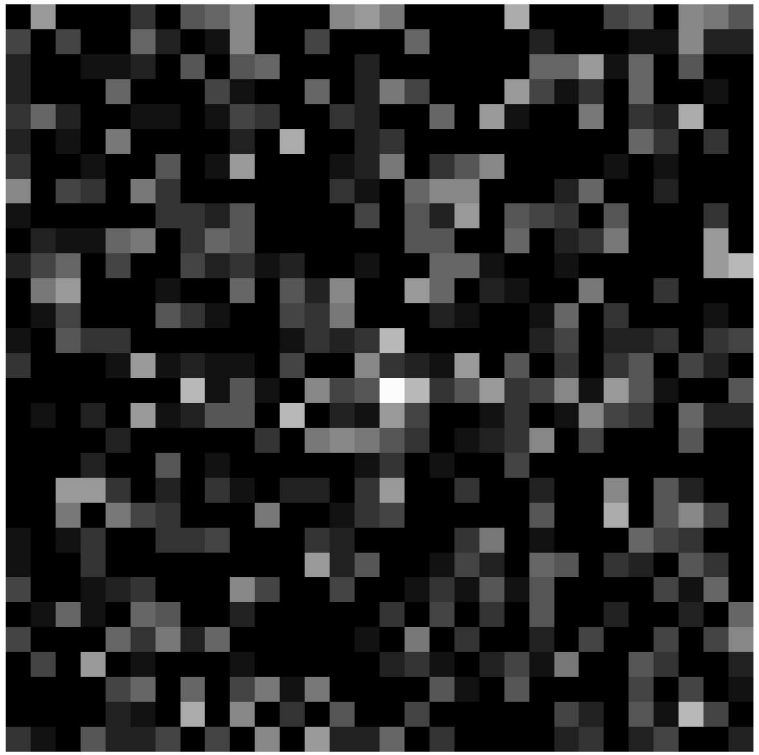
Background Subtraction to find moving objects

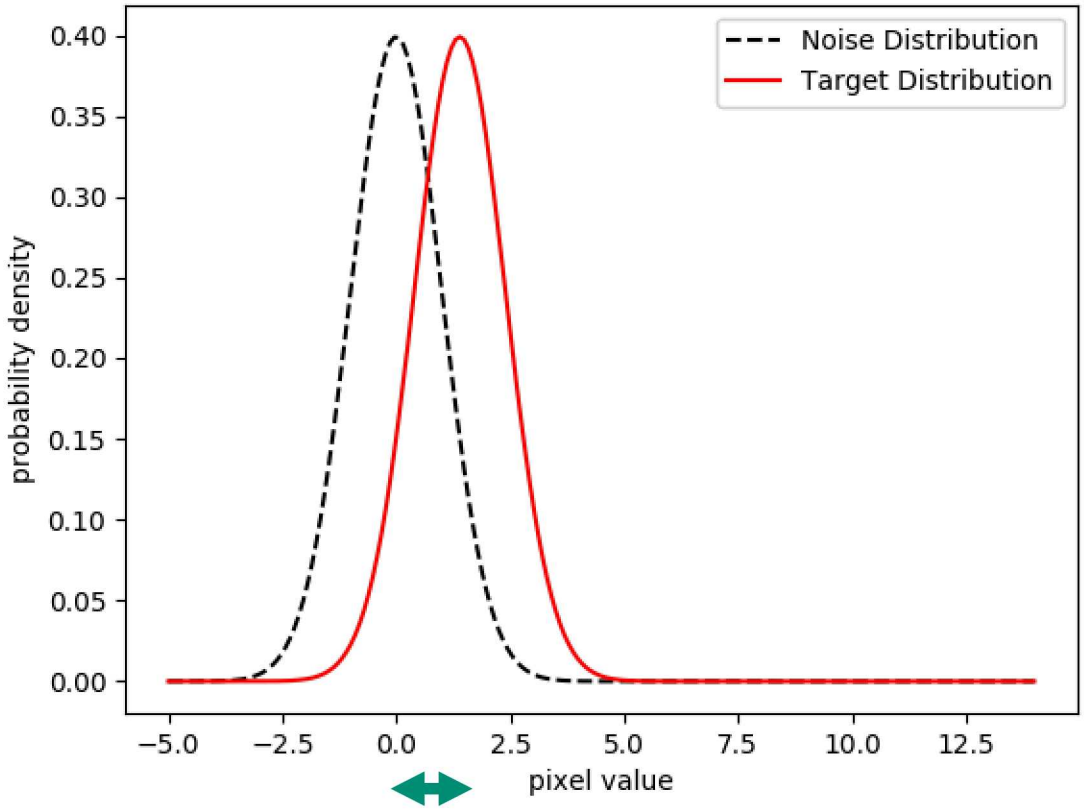


Signal-to-noise ratio

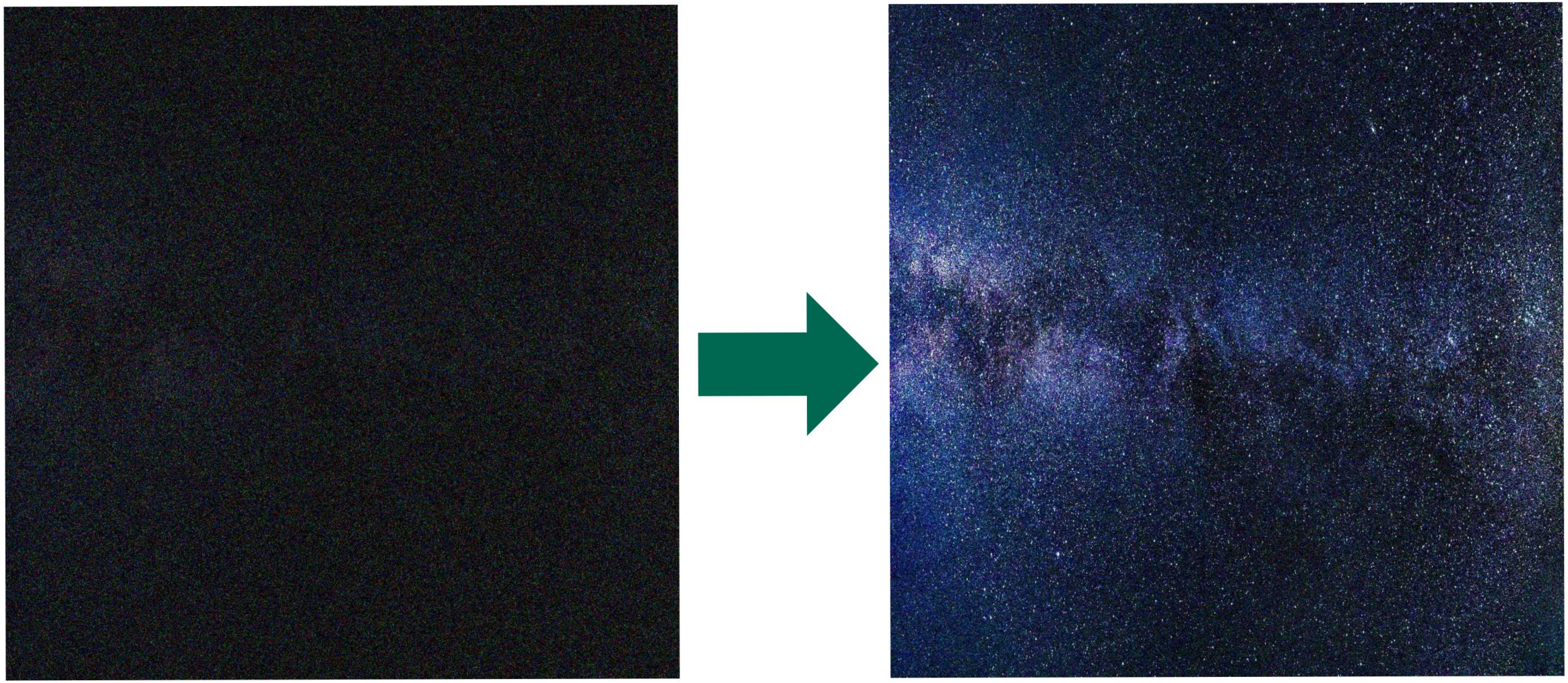


Low signal-to-noise ratio (SNR)

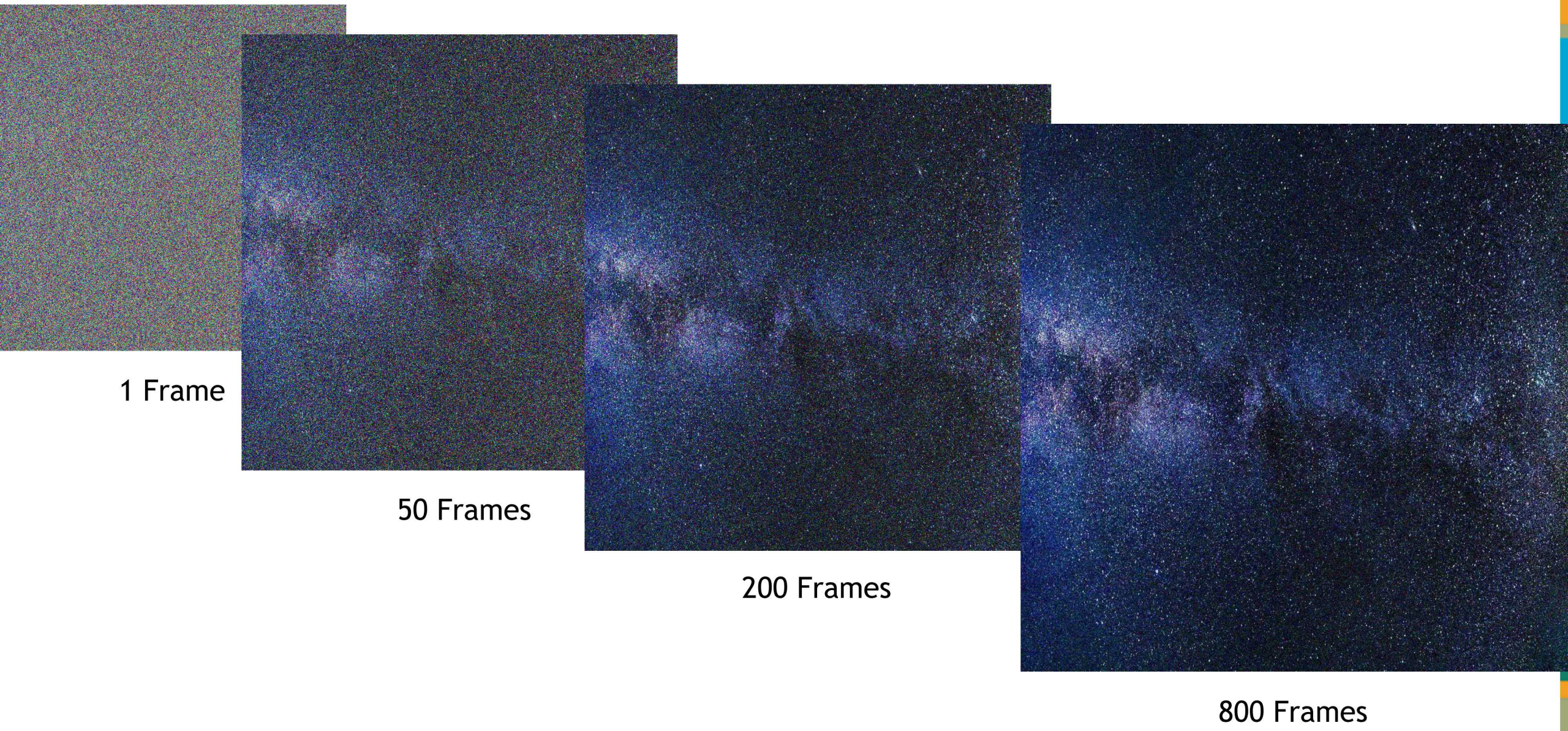




Signal Integration – Add data together to enhance signal

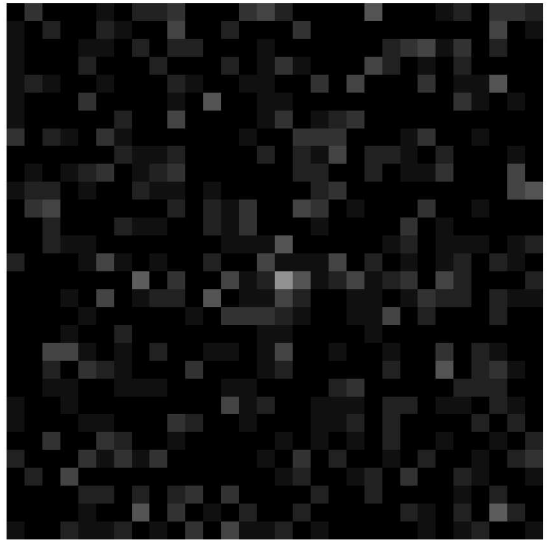


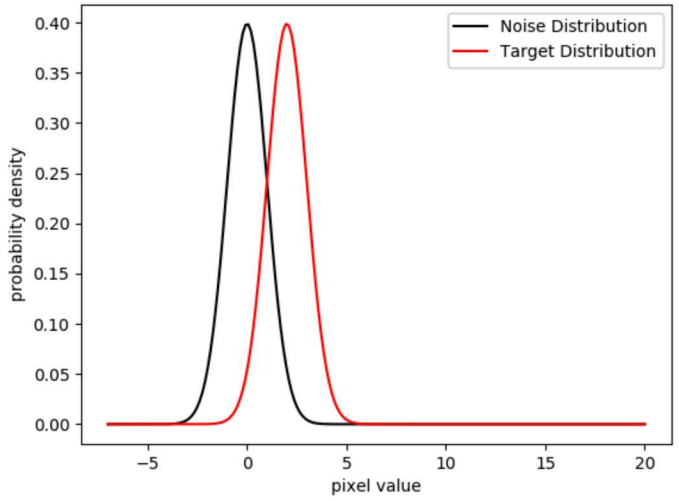
Why signal integration works – with pictures



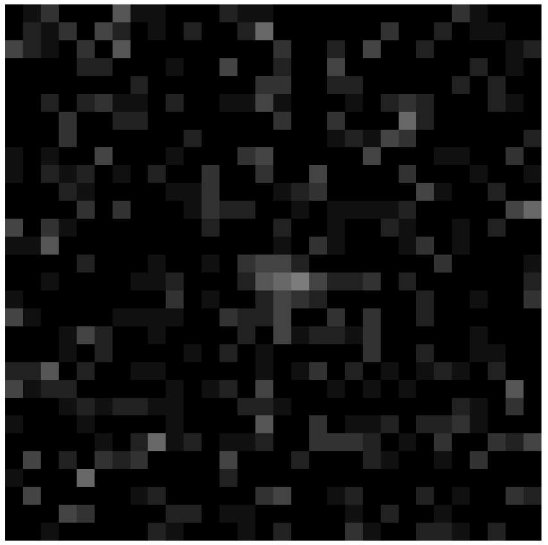
Why signal integration works – with plots

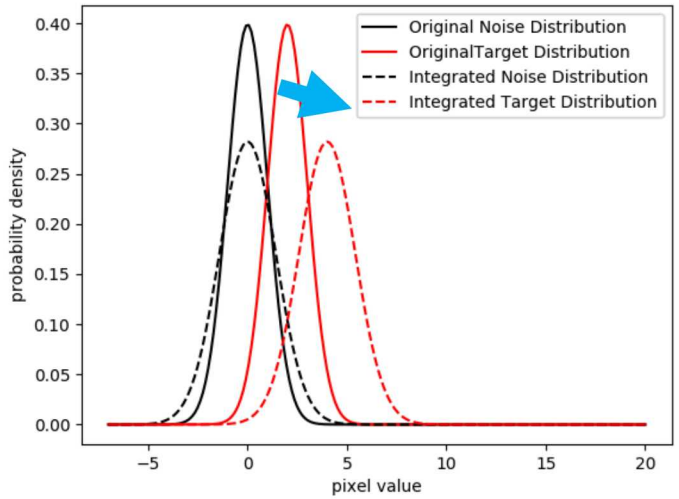
1 Frame



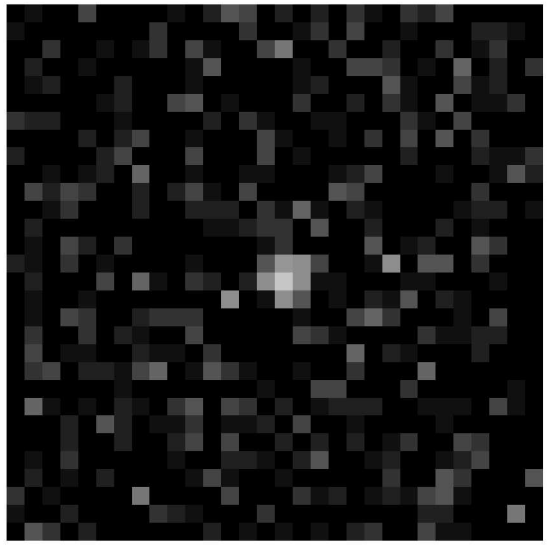


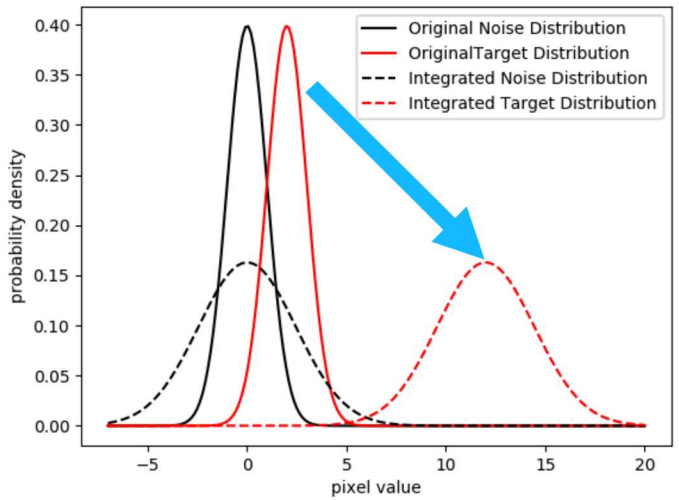
2 Frames



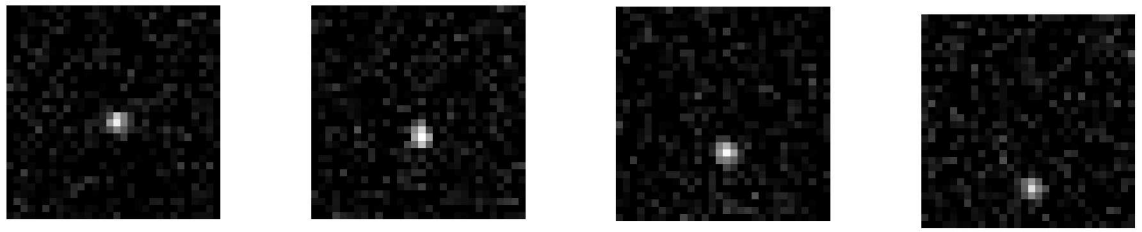


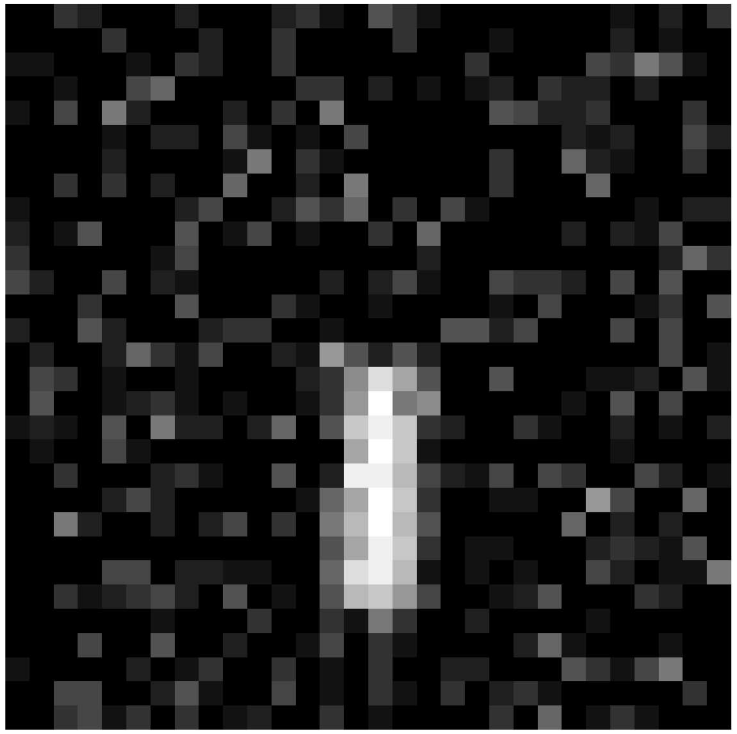
6 Frames



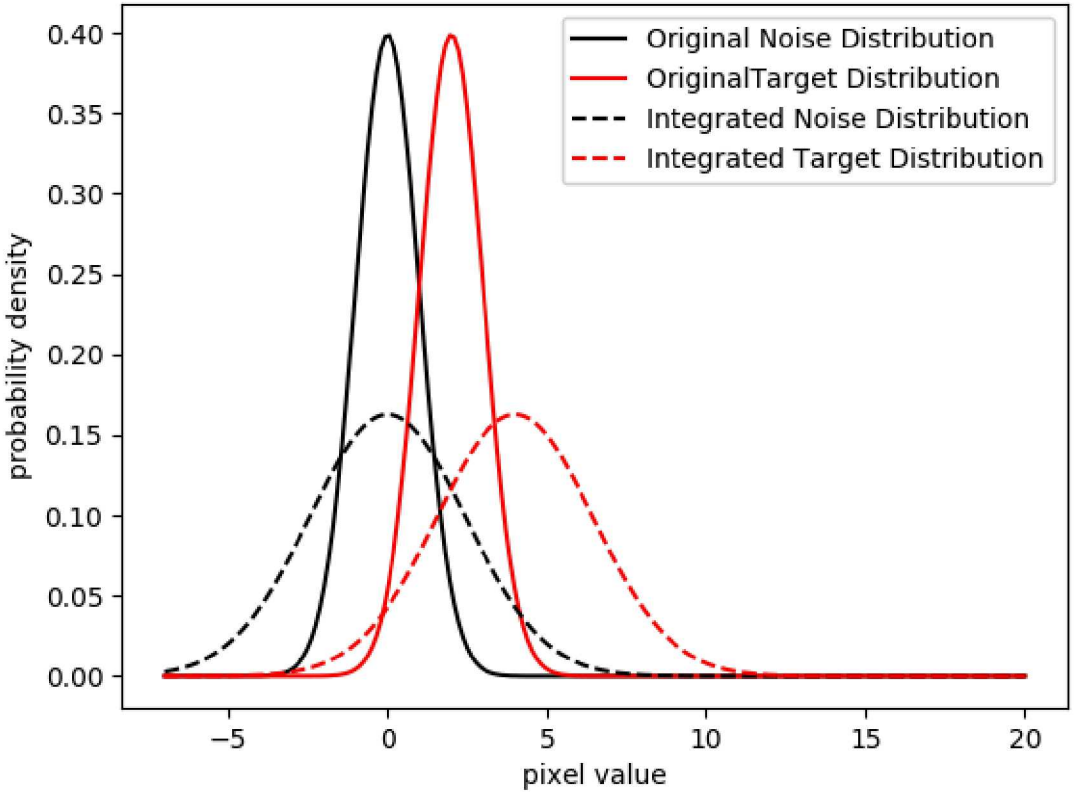


Simple image summation with moving objects



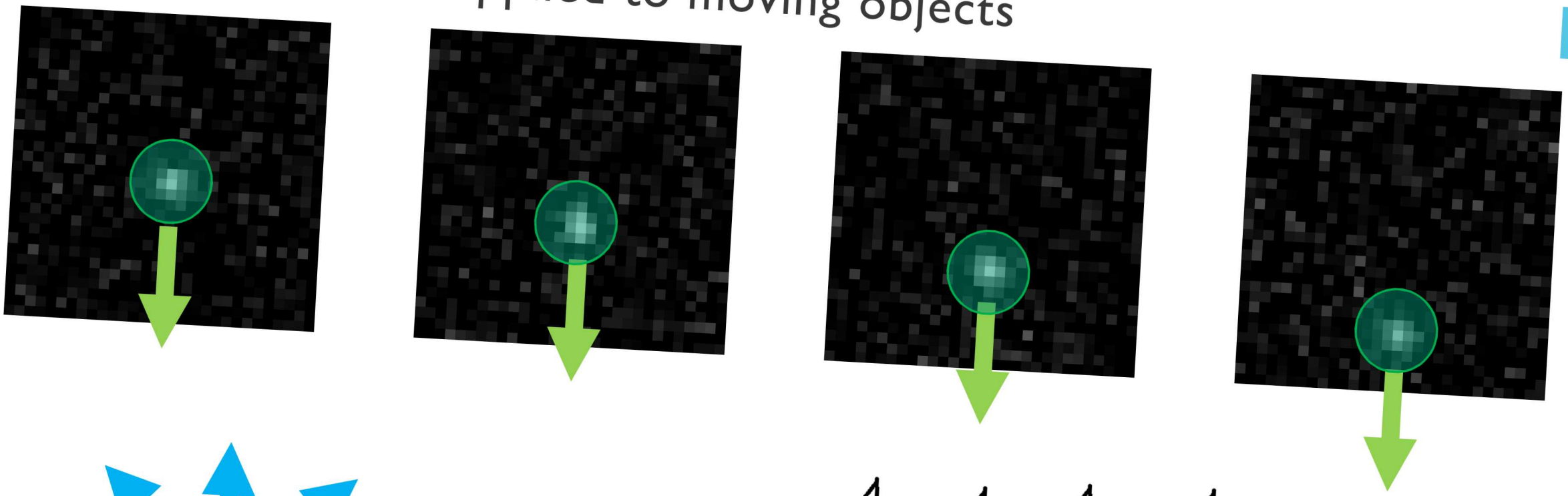


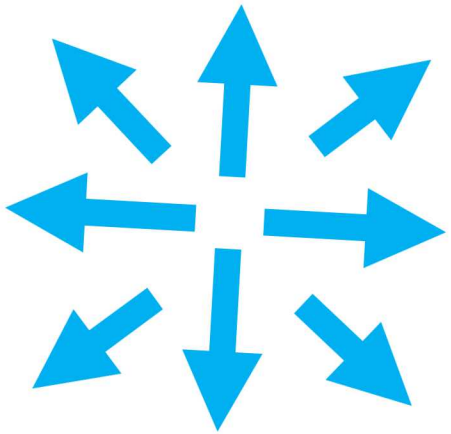
Object is smeared



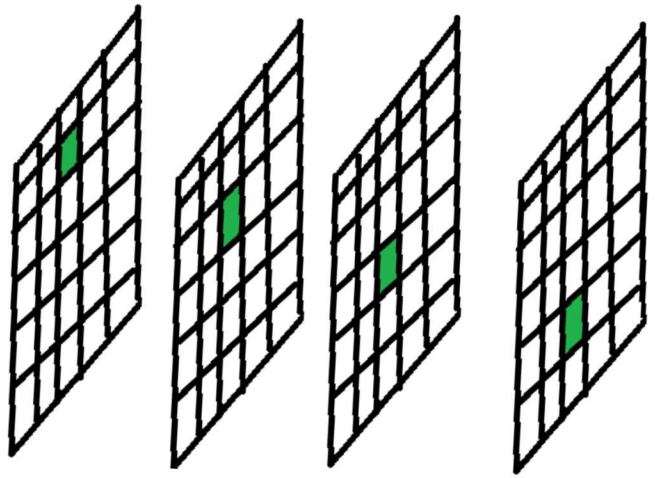
Object distribution does not separate from noise

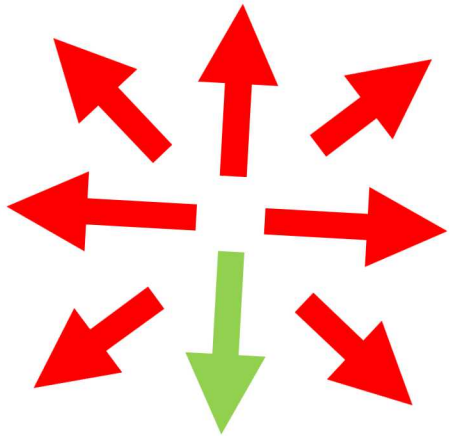
Signal integration applied to moving objects





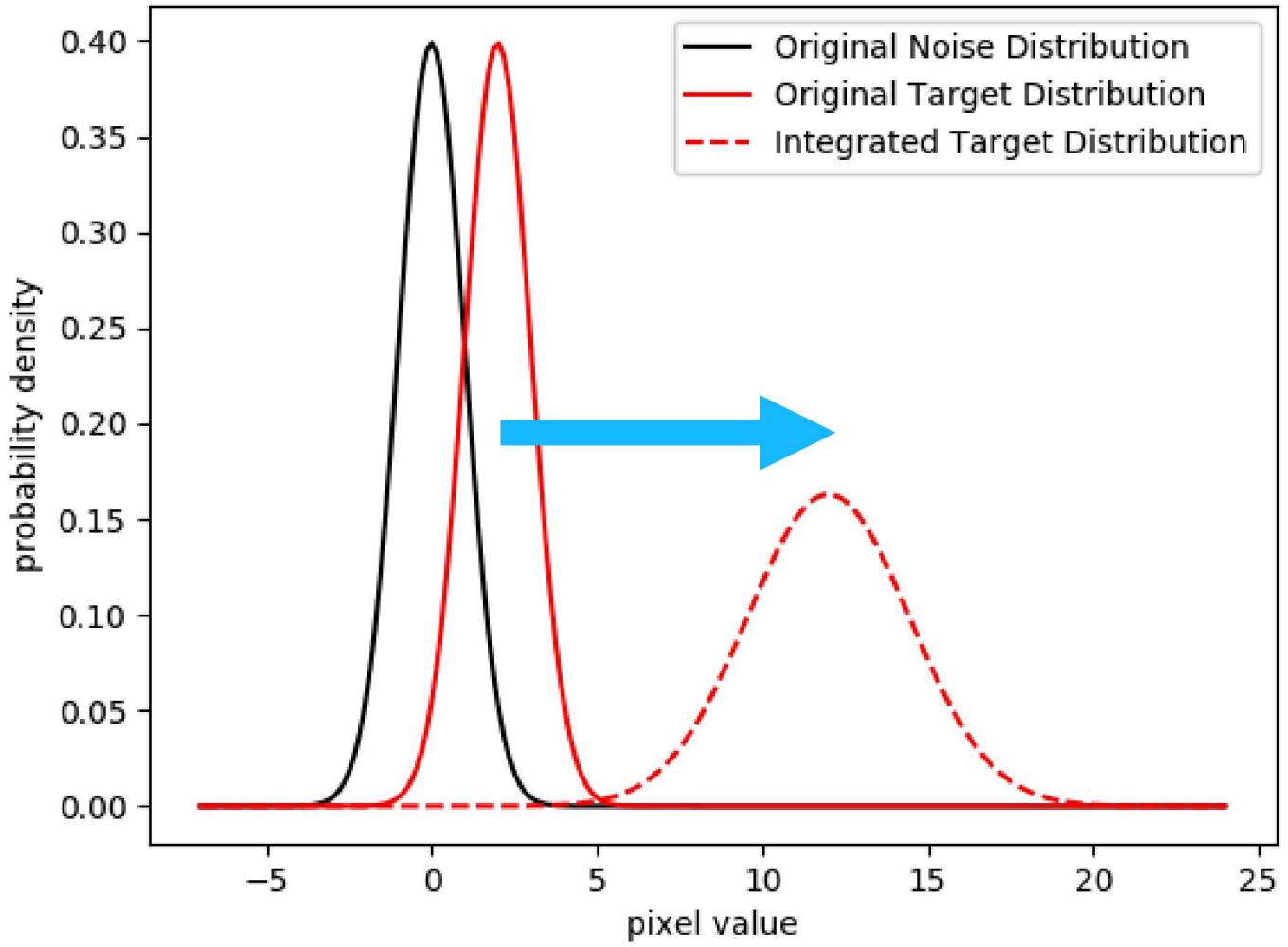
ntegrate over many object paths



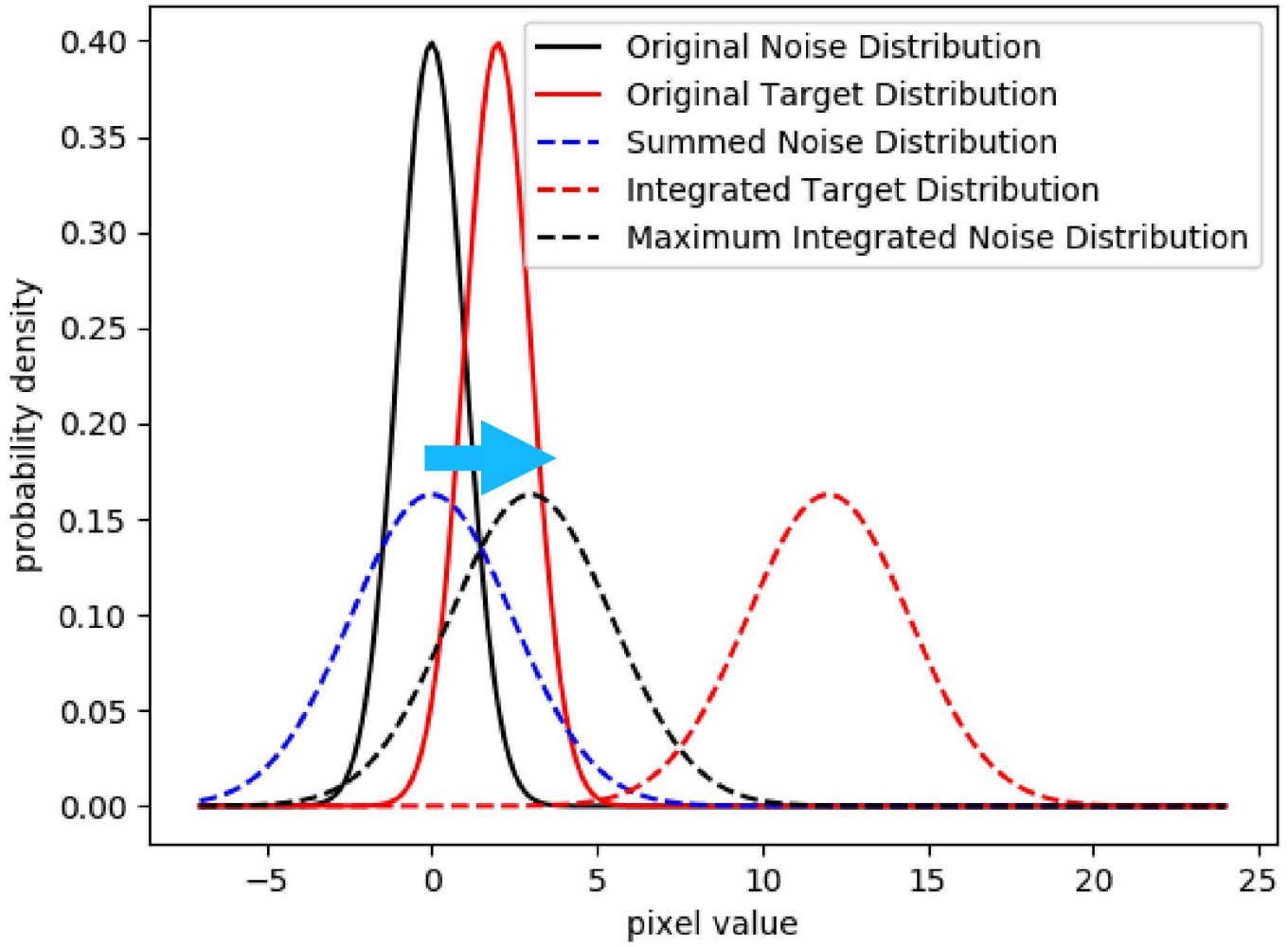


One path covers the object

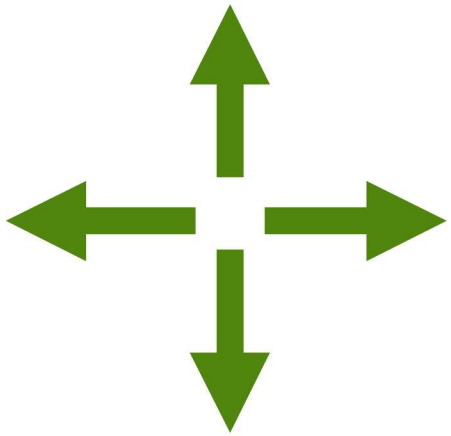
Searching over many paths enhances the signal.



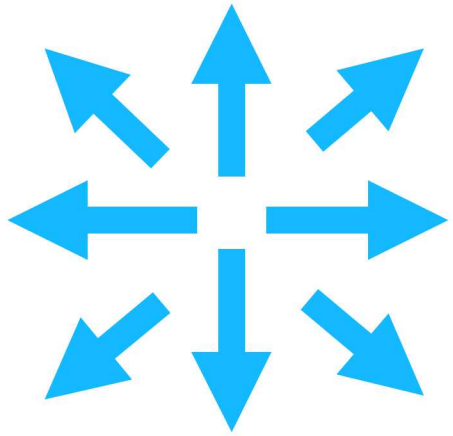
Searching over many paths also enhances the noise.



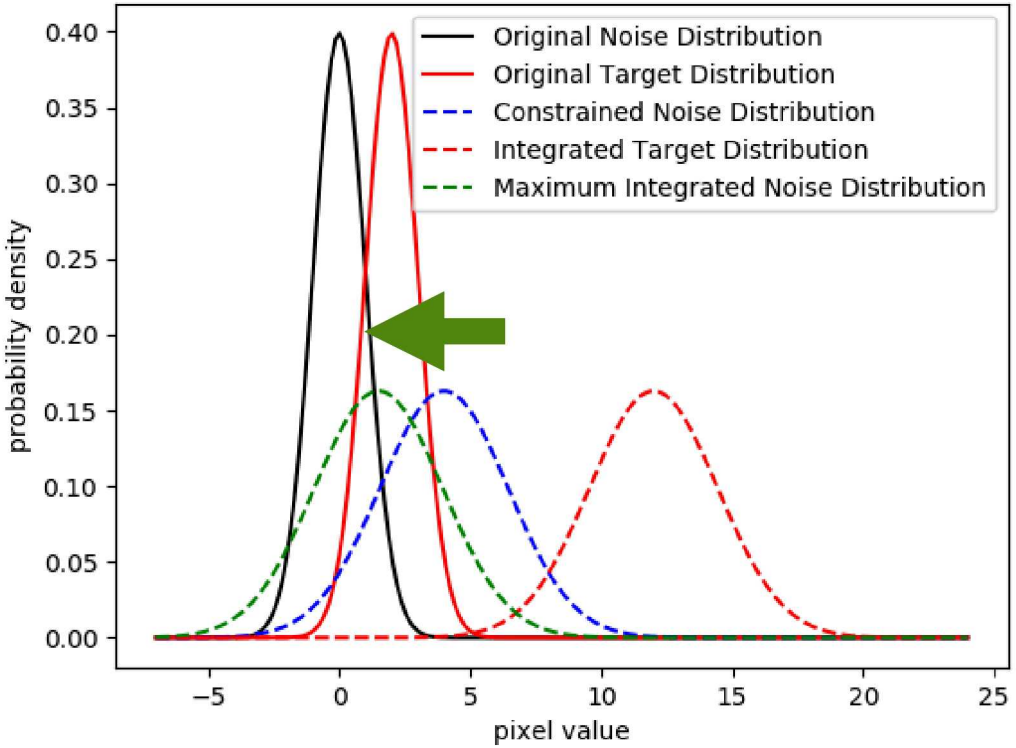
Effect of fewer paths searched:



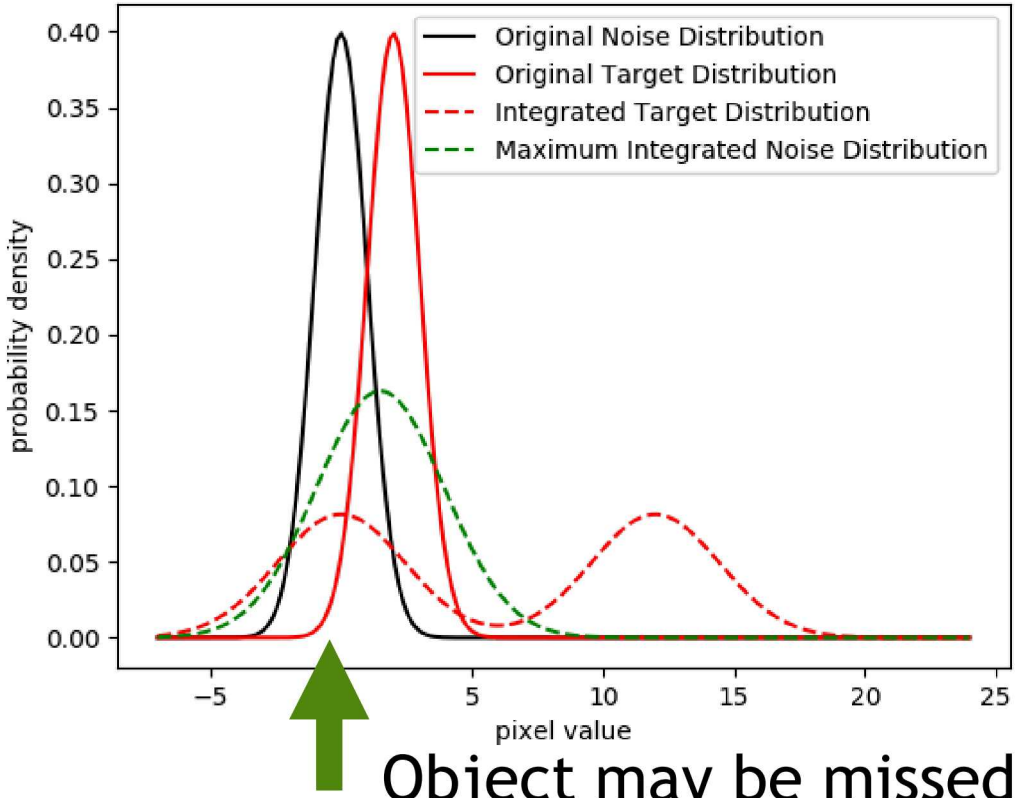
Fewer paths



More paths

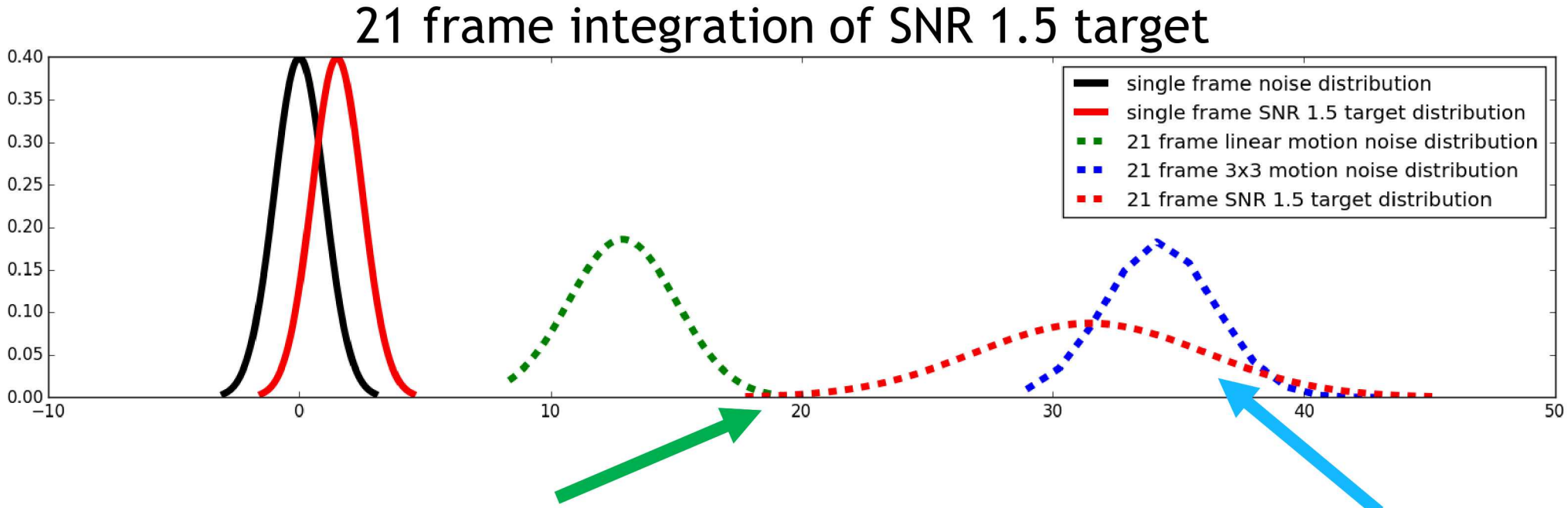


Reduced Noise Mean

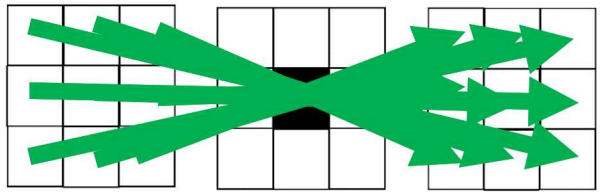


Object may be missed

Constraints needed for very low-SNR detection

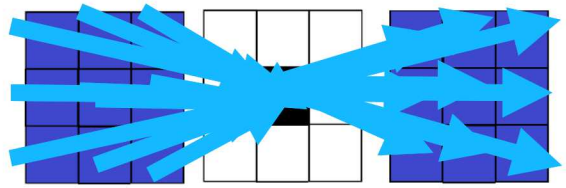


Signal separated from noise

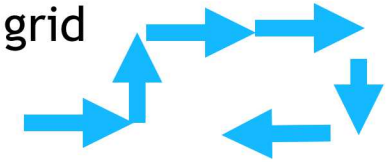


Linear motion model

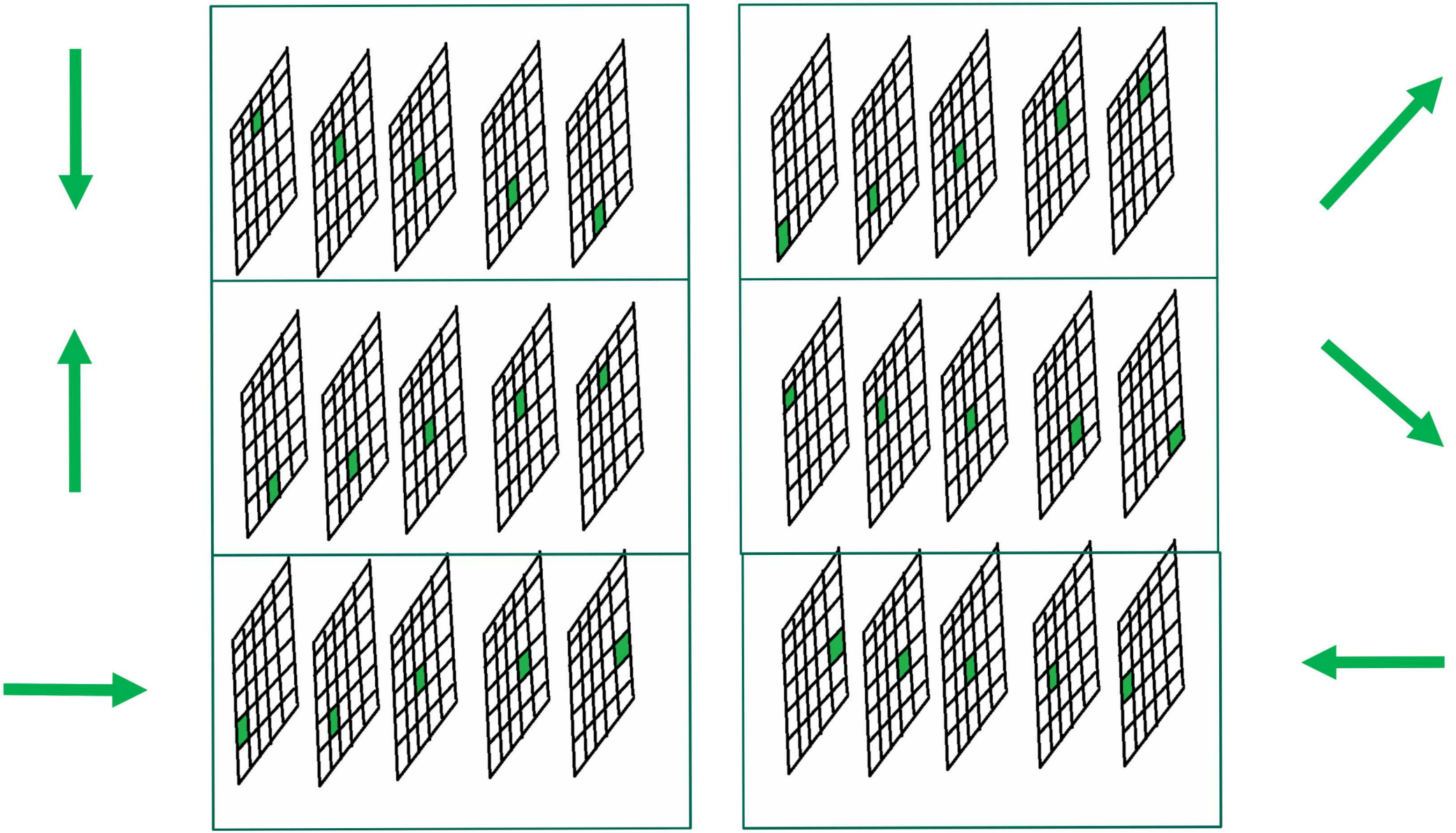
Signal confused with noise



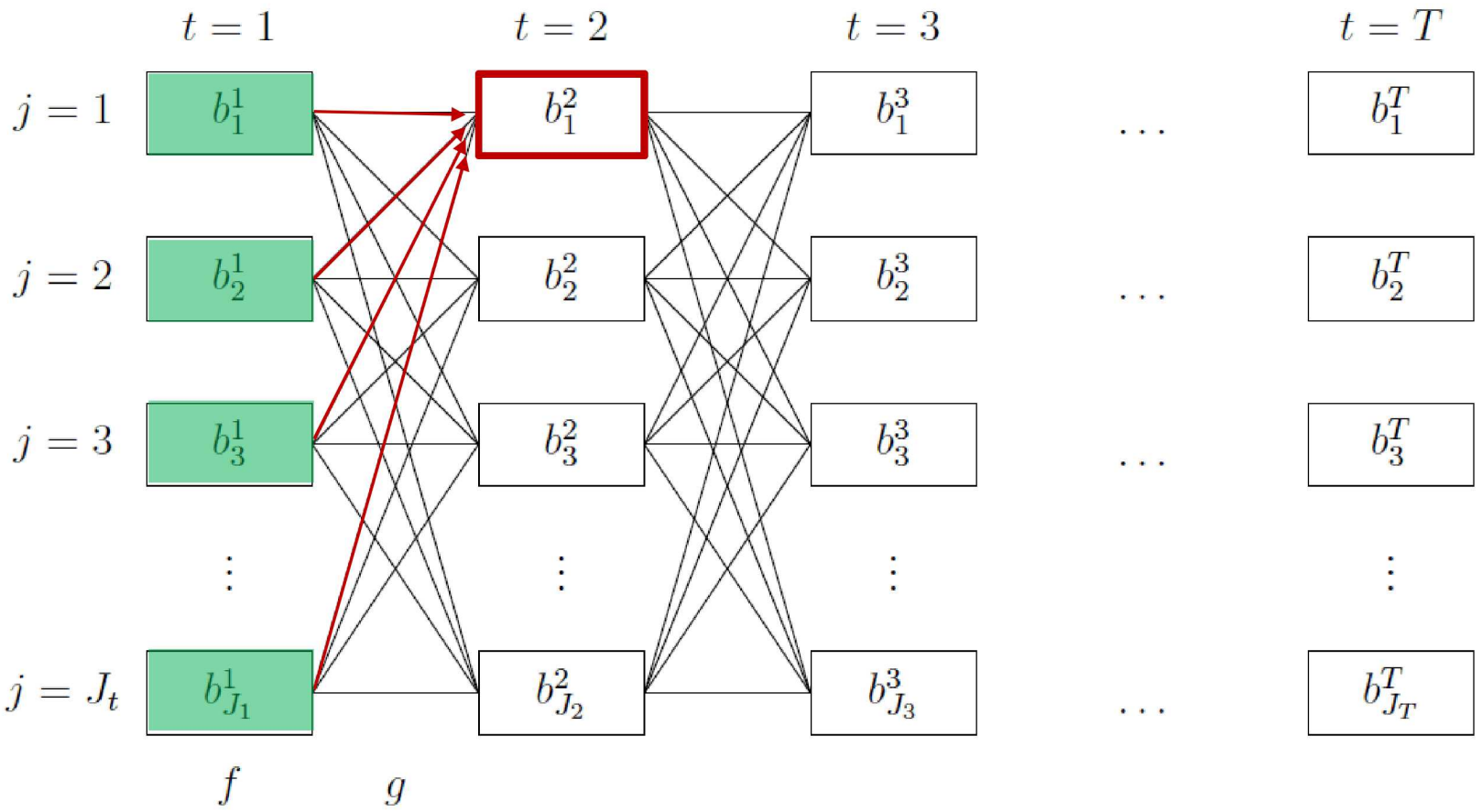
Zig-zag transitions allowed in 3x3 grid

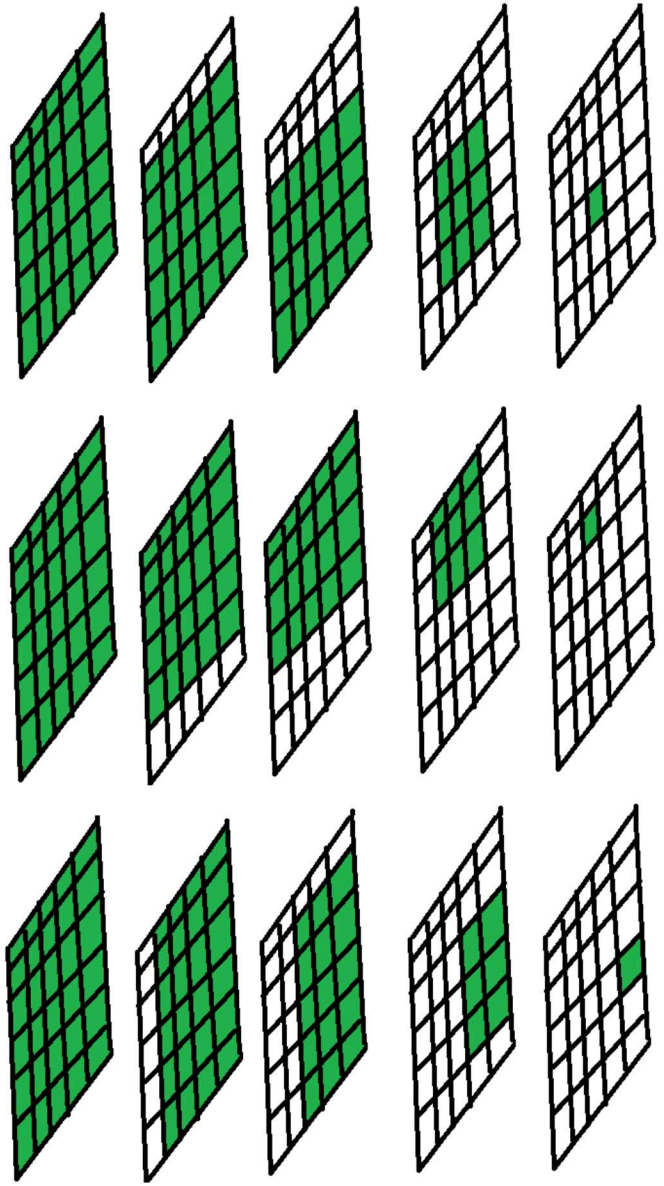


Existing methods 1: Velocity Matched Filters (VMFs)



Existing methods 2: Dynamic Programming Algorithm (DPA)

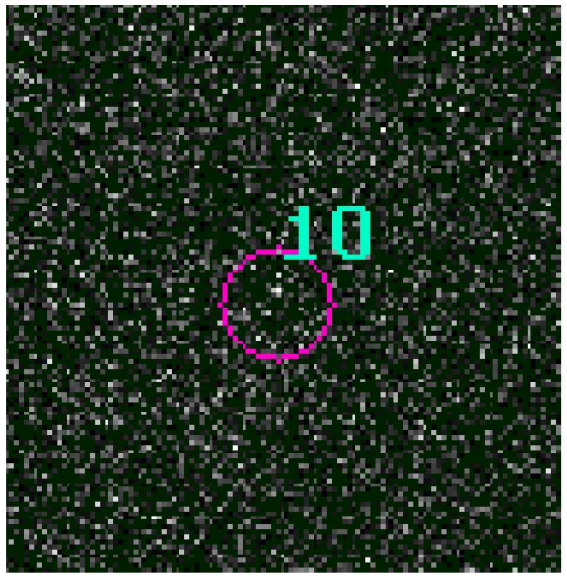




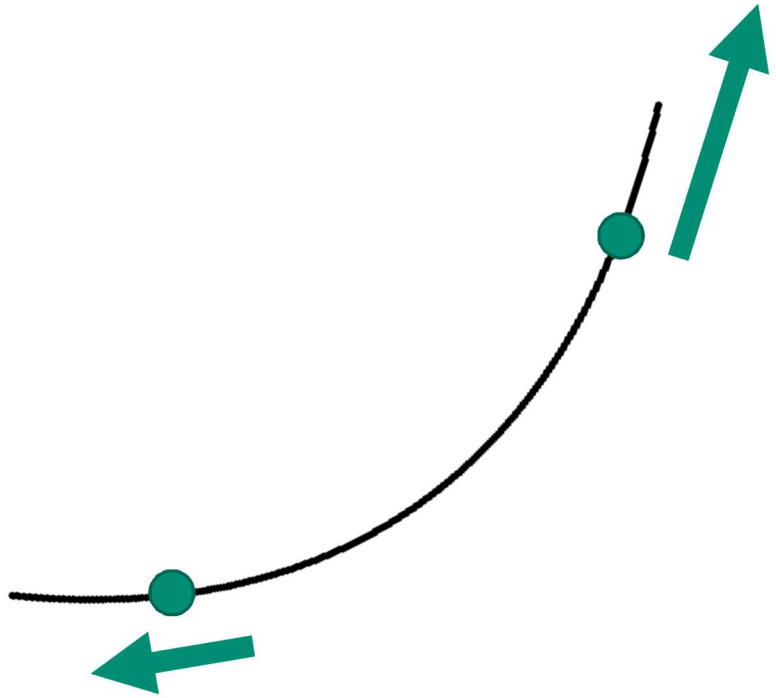
Research Hypothesis

A method that uses **stronger valid constraints** to integrate the signal will perform better at detecting very low SNR objects.

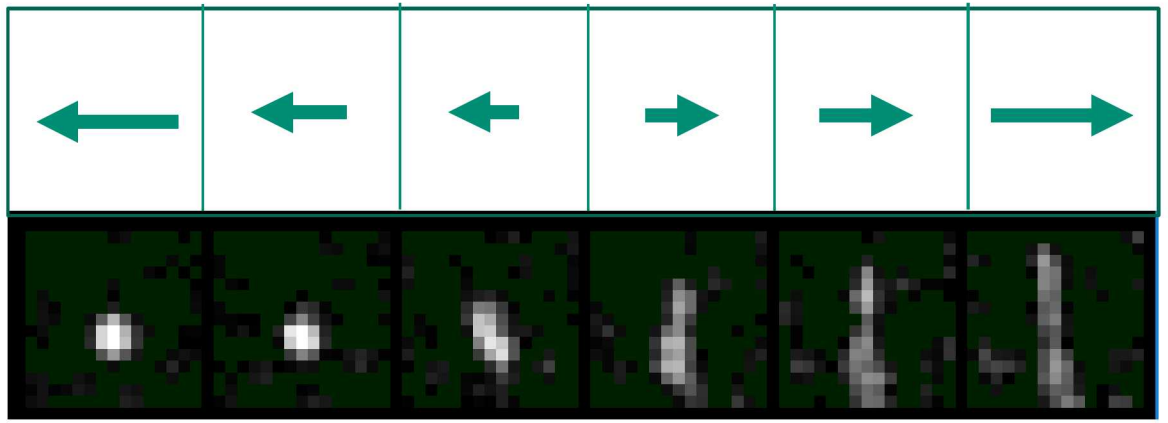
Example Application 1: Objects travelling on known curve.



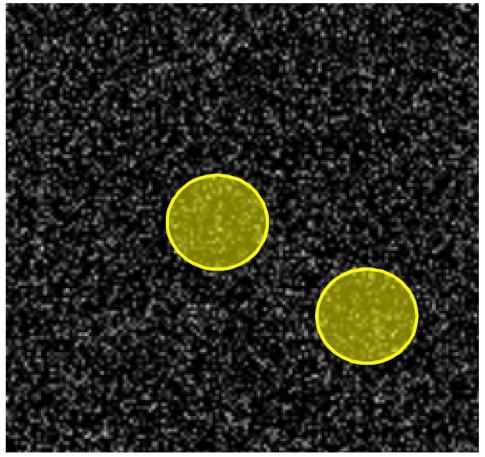
Input Image



Search a range of speeds

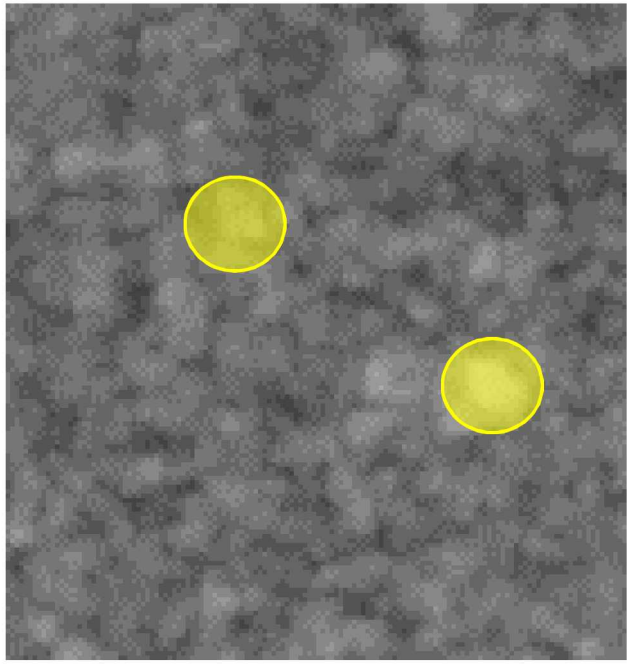


Example Application 2: Maneuvering Objects

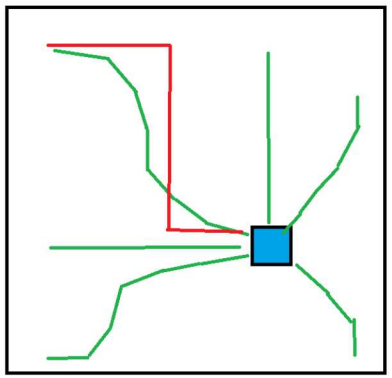


Input Image

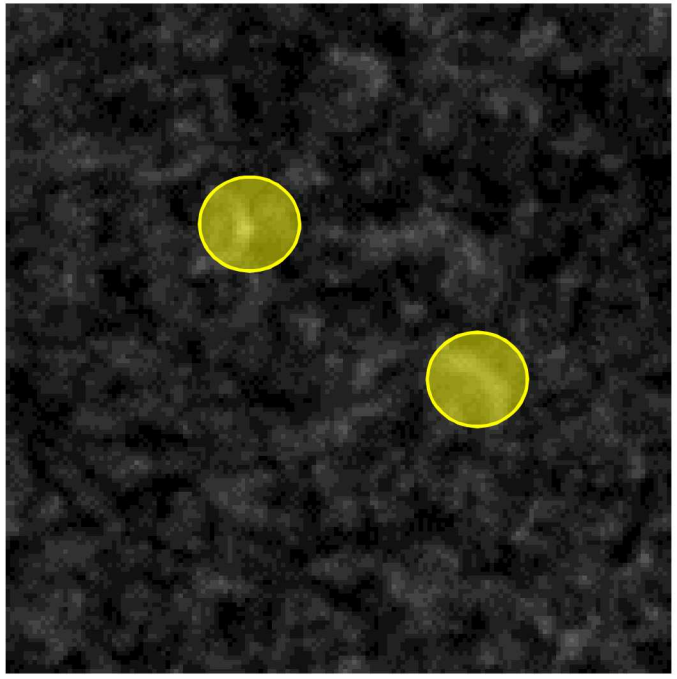
Allow arbitrary zig-zags



Under-constrained



Allow smooth acceleration but no zig-zags



Constrained

Conclusion

Very Low SNR detection requires constraints

Use a priori knowledge about object motion

Challenge to design constraints that:
- don’t exclude real objects
- suppress enough noise
- allow fast computation