Using Bright-Point Shapes to Constrain Wave-Heating of the Solar Corona: Opportunities for DKIST

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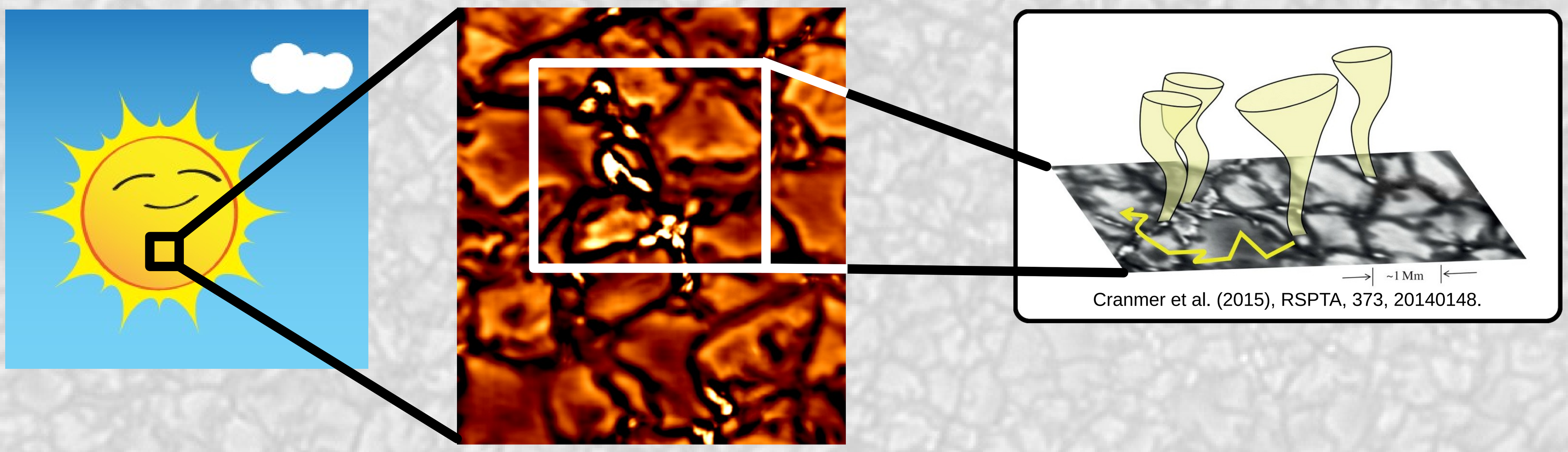
What's a bright point?

Photospheric bright points are small (~100 km) regions of concentrated (~1 kG), vertical magnetic flux. They appear in the lanes between granules on the solar surface and are shaken about by convective churning.



Cranmer et al. (2015), RSPTA, 373, 20140148.

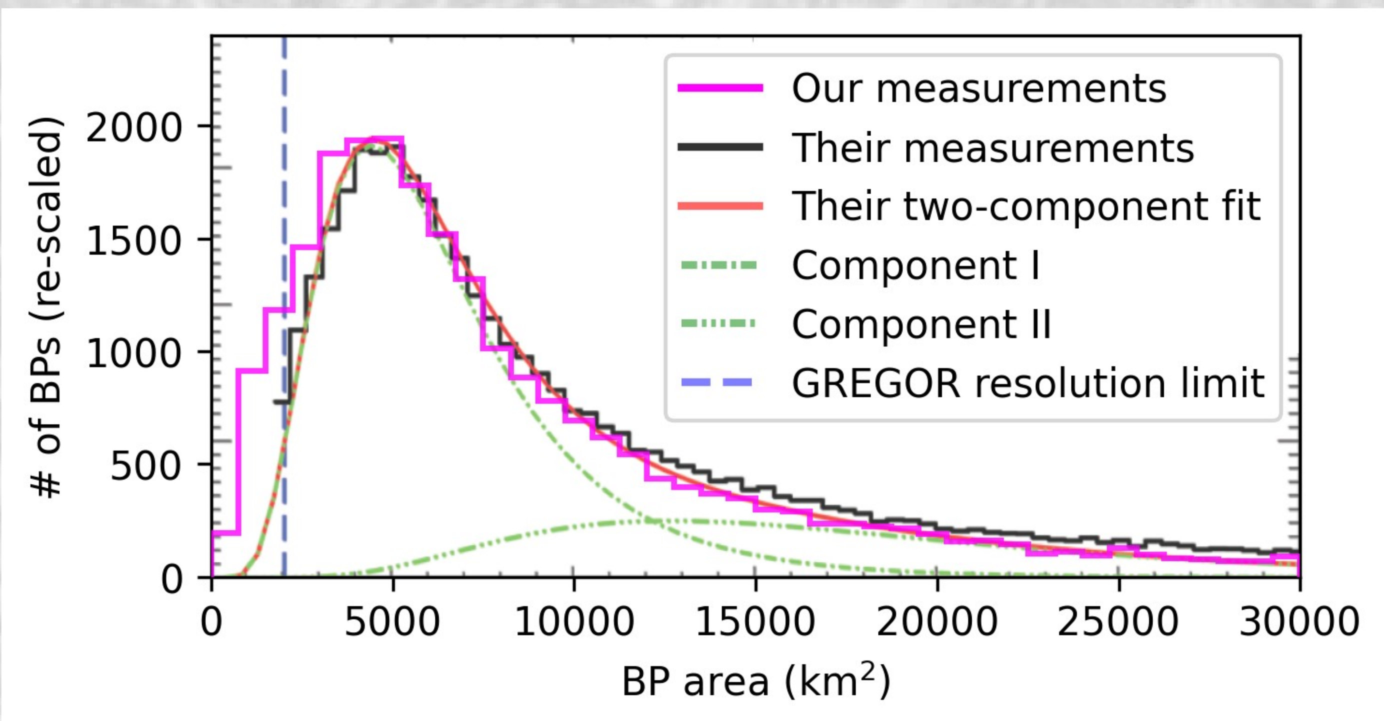
Flux tubes

Bright points are the bases ("footpoints") of magnetic flux tubes which can reach up to the corona. Illustrated above (right panel), these tubes widen as gas pressure decreases with height. The convectively-driven motions of the tube bases can cause waves to propagate up the tubes, and can twist and tangle the tubes, causing a buildup of energy. Both can contribute to coronal heating.

At the photosphere, the tubes' magnetic pressure offsets gas pressure, reducing the gas density and letting photons escape from deeper, hotter depths. This makes the footpoint look like a bright point at the tube's base, forming the most easily-observed feature of the flux tube.

Tracking bright points

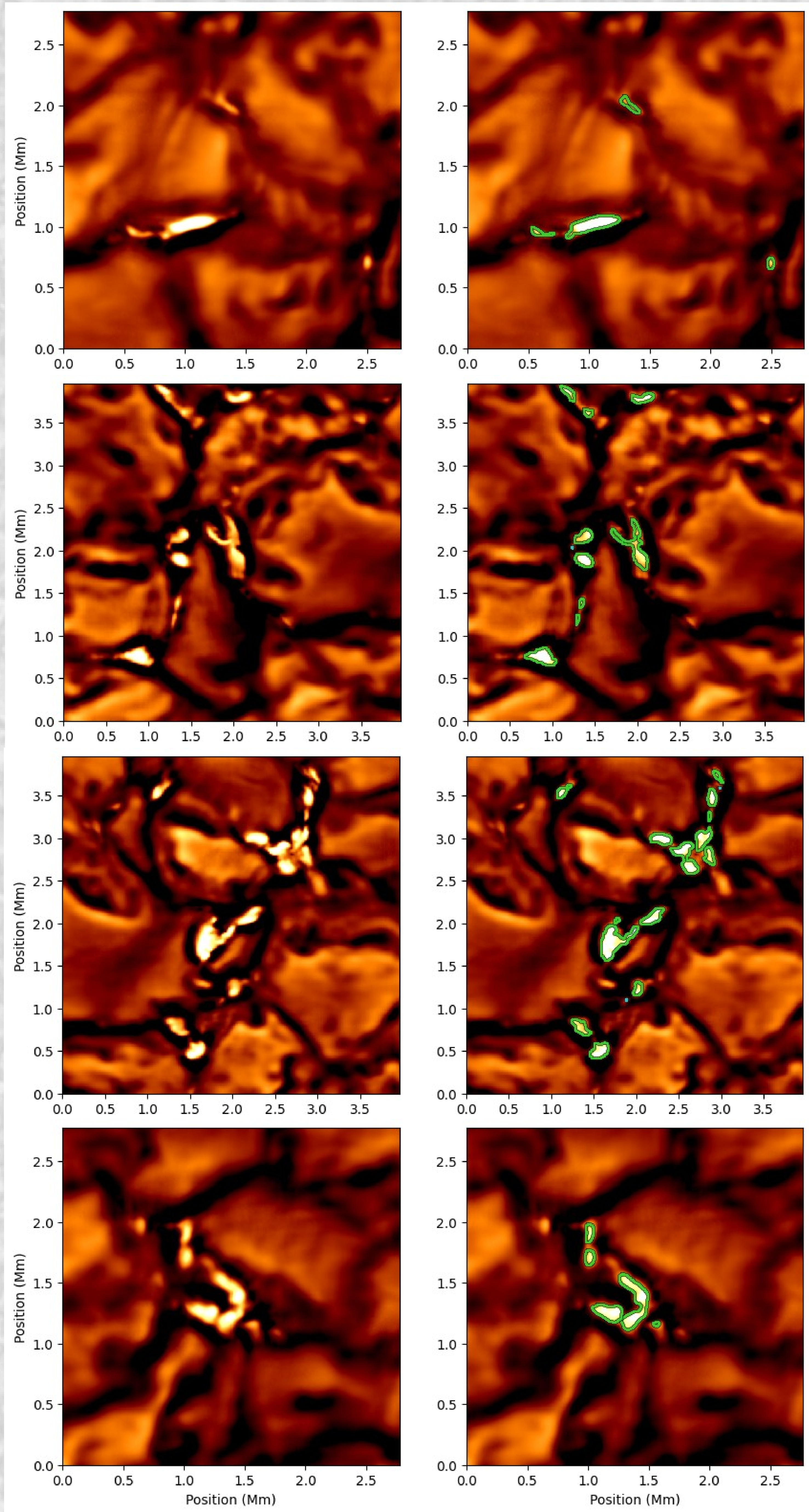
We're automatically tracking bright points in **DKIST observations, which offers more spatial resolution than any past instrument**. We plan to connect out results to both wave–turbulence models of coronal heating and to footpoint twisting and tangling (nanoflare) models. The tracking algorithm is designed with a focus on accurately measuring bright point shapes. Examples are shown to the right.



Left: Size distribution of bright points. Our DKIST results closely agree with the GREGOR observations of Berrios Saavedra et al. (2022) [2], while showing that the distribution extends to smaller scales.

Example bright points

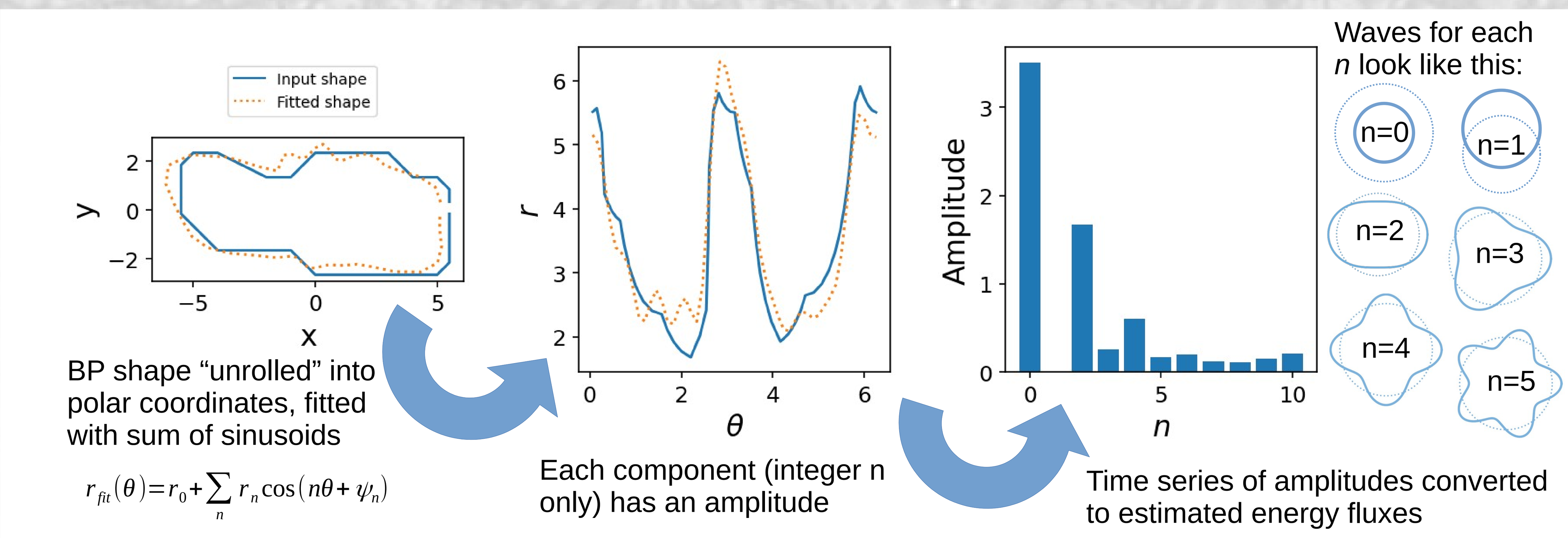
Four cutouts of a DKIST VBI G-band dataset of the quiet Sun, with unmarked views on the left and our algorithm's identified bright point boundaries marked on the right.



Interpreting bright point motions

Bright point motions can constrain many models of coronal heating, and with DKIST's extreme spatial resolution, we aim to produce better constraints.

For wave-driven models, we have developed a framework to connect changes in the shapes of bright points to a variety of MHD thin-tube wave modes [6]. As shown below, shapes are decomposed into a sum of sinusoids for various values *n*, with the time series of amplitudes of each component corresponding to a wave mode (with n=0 being the sausage mode, n=1 the kink mode, and n>1 being higher-order modes). Past work [4] with MURaM-simulated images of DKIST-like resolution [3] showed the **wave-driven energy budget could be increased by 50%** when including these many n≠1 modes, assuming they propagate and dissipate similarly to the n=1 mode. This motivates our current work, now that DKIST observations are becoming available.



For nanoflare models, involving the twisting and tangling of flux tubes, we will search for signs of rotating bright points, using the clearer bright point shapes that DKIST provides. We will explore mutual tangling of flux tubes and will be able to better detect and include the smallest bright points in our study.

References: [1] Cranmer & van Ballegooijen (2005), ApJ, 156, 265. [2] Berrios Saavedra+ (2022), A&A, 657 A79. [3] Rempel (2014) ApJ, 789, 132. [4] Van Kooten+ (2024), ApJ, 964 50.