Finding oscillatory regions in SDO/AIA EUV data

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Funded by a NASA ROSES 2008 HGI award.

Solar structures oscillate

- many different oscillation periods have been identified - lots of frequency space to examine.
- concentrate on 3 and 5 minute wavebands.

Scientific return

- Diagnostic potential: if you are sure that the oscillation can be identified with a predicted wave mode, then observations can be used to measure coronal properties, e.g. coronal field strength.
- Potential energy source that heats the corona.

Measurements

- Frequencies.
- Occurrence locations, longevity, recurrence rate at a given location, conditions for required for an oscillation to occur.

SDO/AIA data

- 16 Mpx/image.
- 10 wavebands.
- One image in each waveband every 12 seconds continuously. Overlapping time-ranges imply $\gtrsim$ 24 analyses per active region.
- ~ 4 x 10^9 FFTs per day.
- Identify oscillating structures.

Approach

- Look for 3 and 5 minute period oscillations only.
- Examine active regions only (smaller number of time-series examined).
- Identification of oscillating individual pixels, then segmentation into significant groups

Data

- Use SPoCA active region detections.
- Download cutouts from AIA cutout service in 171 Å and 193 Å.
- Remove solar rotation, sum 2 × 2.
- One hour duration = 300 samples.

Analysis

- Oscillation model in each pixel $d_j = A\cos(\omega t_j) + B\sin(\omega t_j)$
- Calculate (Bayesian) probability $p(\omega)$ that the time-series d_j observed at times $t_j = j.\delta t$ $(1 \leq j \leq N)$ supports a frequency ω.

$$p(\omega) \propto \left[1 - \frac{2C(\omega)}{N\overline{d^2}}\right]^{1-N/2} \qquad C(\omega) = \frac{1}{N}\left|\sum_{j=1}^{N} d_j e^{i\omega t_j}\right|^2$$

- Integrate over pre-defined frequency ranges.
- Use the Fourier frequencies $\omega_k = k.2\pi/(N.\delta t)$.

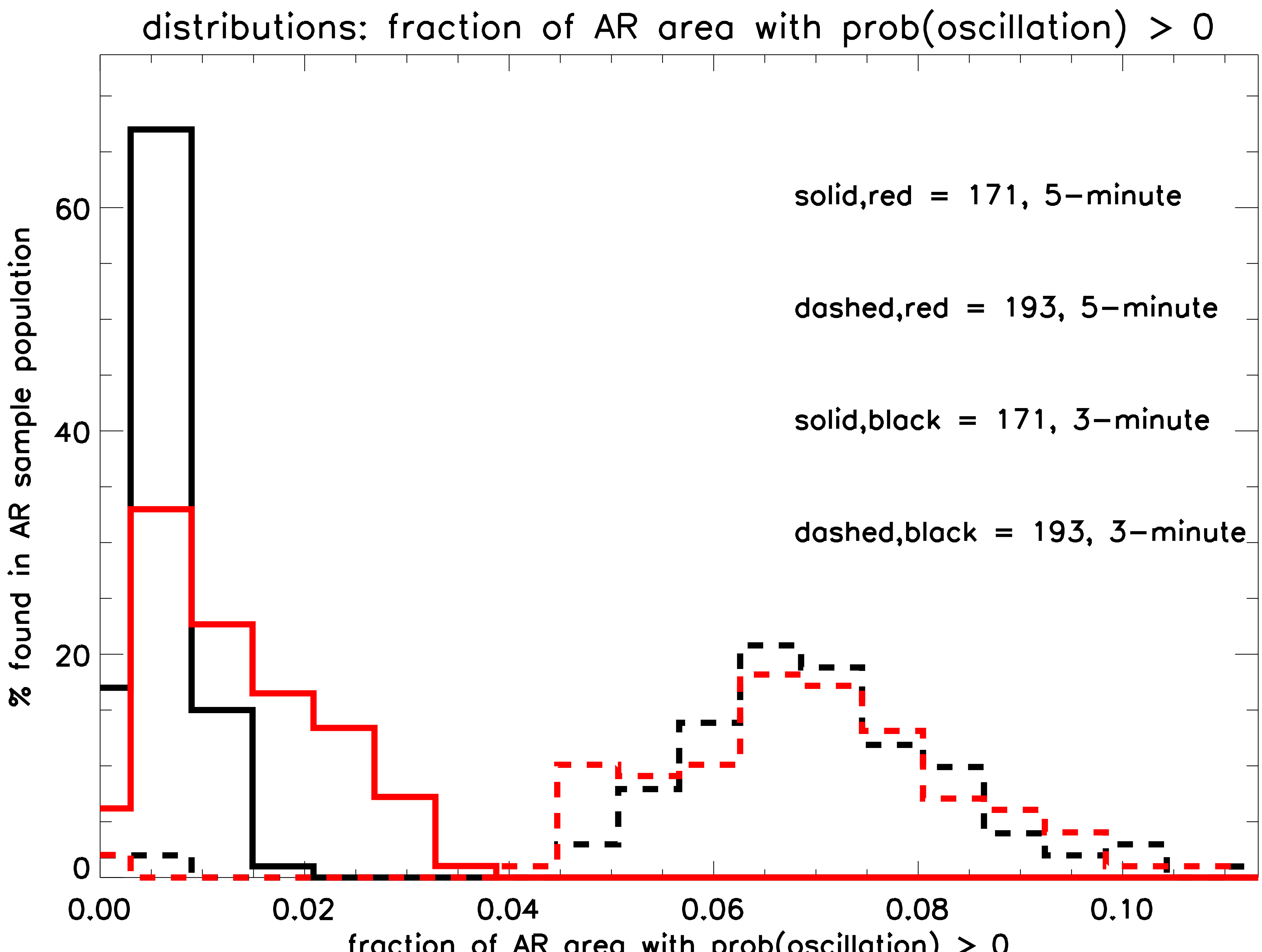
Analysis

- Group together pixels that have a high probability of oscillating within the frequency range.
- Measure local coherence properties of these groups.
- Keep groups of highly coherent pixels.

Analysis

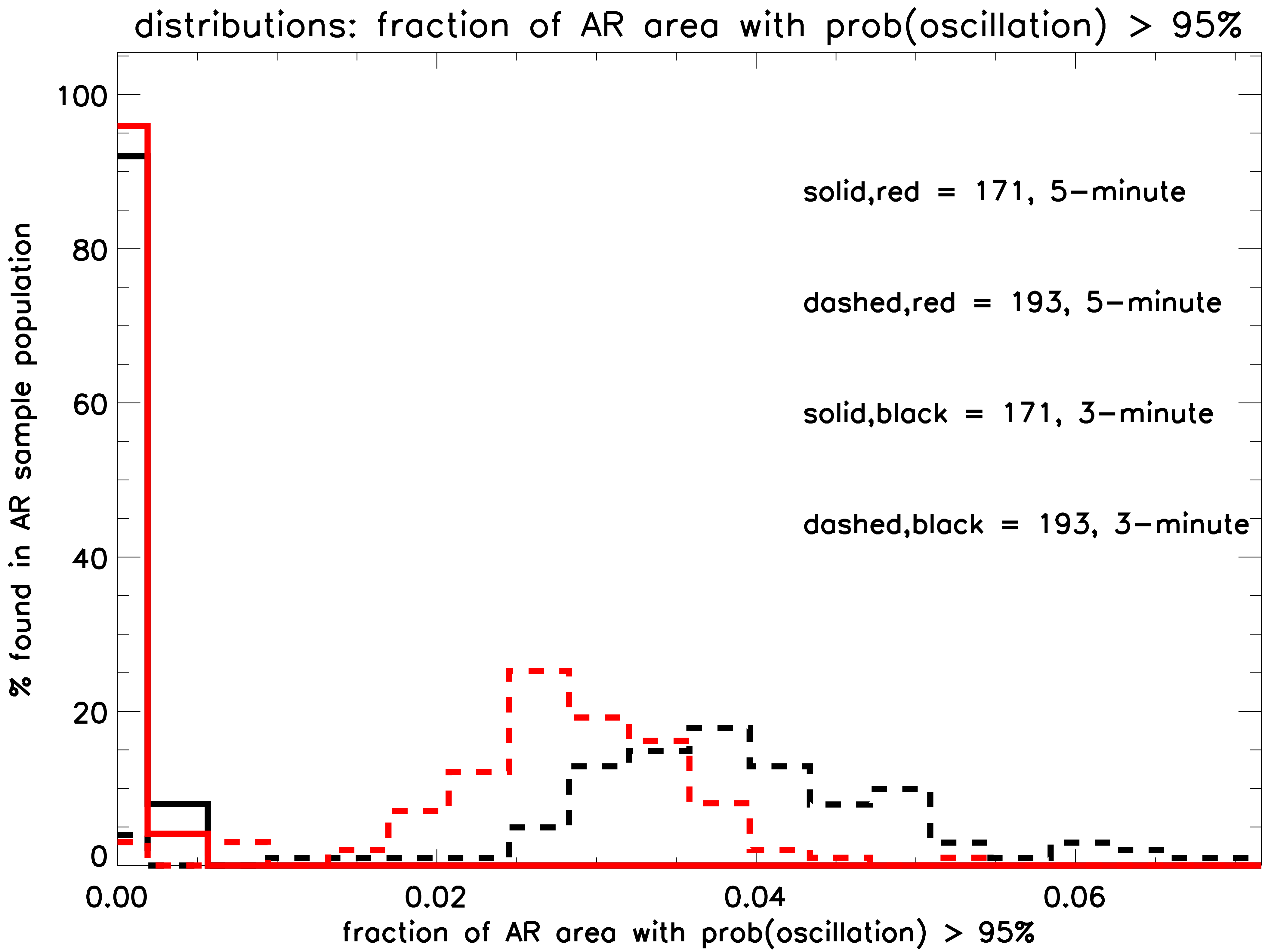
- Active region size ~ 240 x 240 arcsec^2 with 2×2 spatial summing, ~ $10^{4\text{-}5}$ px.
- Approximately 1-10 active regions per day.
- Analyze durations of 1 hour of data only.
- Two wave bands analyzed (out of a possible 6).

Results



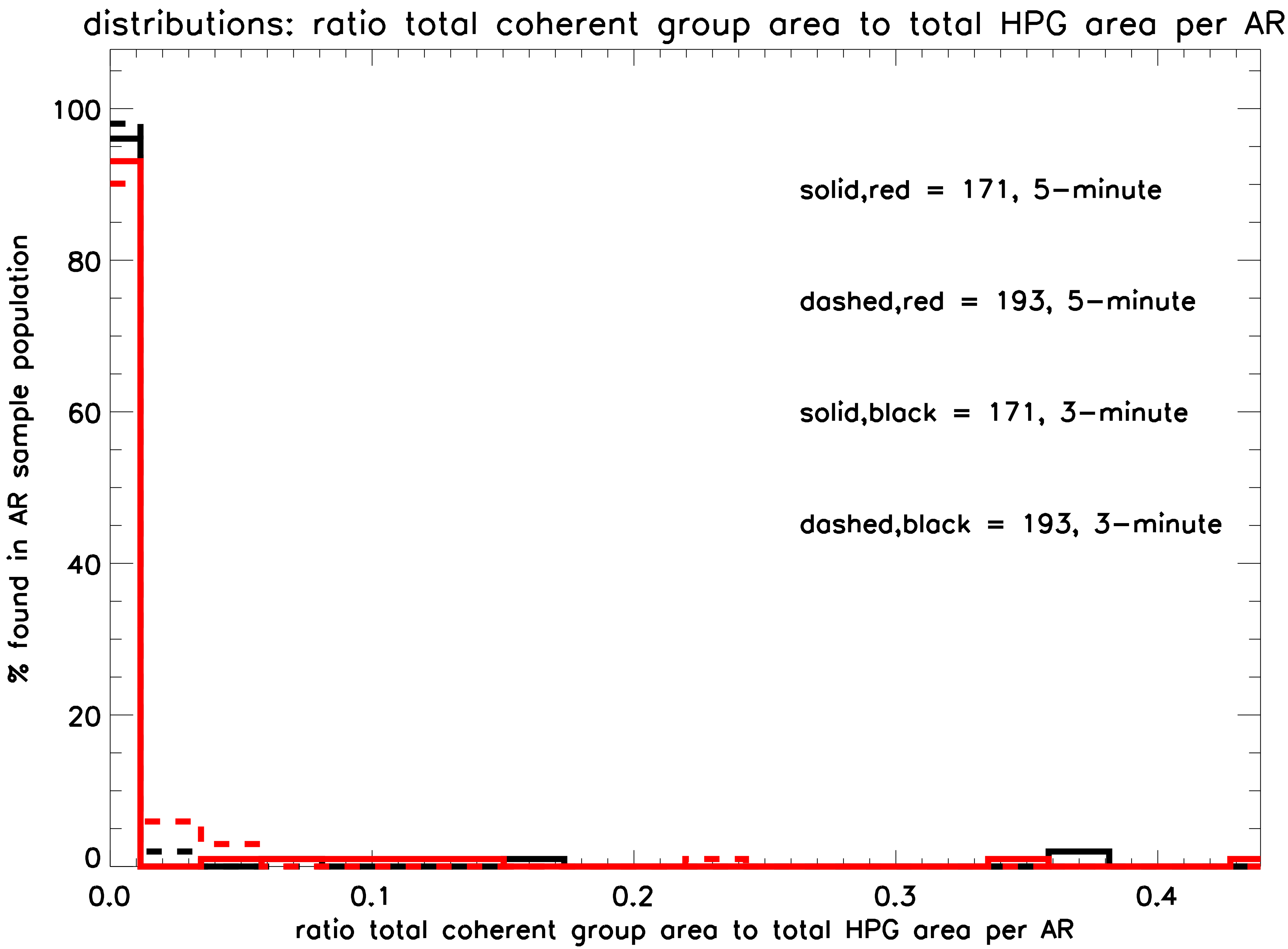
distributions: fraction of AR area with prob(oscillation) > 0
solid,red = 171, 5–minute
dashed,red = 193, 5–minute
solid,black = 171, 3–minute
dashed,black = 193, 3–minute
% found in AR sample population
0
20
40
60
0.00
0.02
0.04
0.06
0.08
0.10
fraction of AR area with prob(oscillation) > 0

Results



distributions: fraction of AR area with prob(oscillation) > 95%
100
80
60
40
20
0
% found in AR sample population
0.00
0.02
0.04
0.06
fraction of AR area with prob(oscillation) > 95%
solid,red = 171, 5−minute
dashed,red = 193, 5−minute
solid,black = 171, 3−minute
dashed,black = 193, 3−minute

Results



distributions: ratio total coherent group area to total HPG area per AR
100
80
60
40
20
0
0.0
0.1
0.2
0.3
0.4
% found in AR sample population
ratio total coherent group area to total HPG area per AR
solid,red = 171, 5–minute
dashed,red = 193, 5–minute
solid,black = 171, 3–minute
dashed,black = 193, 3–minute

Conclusions

- Not many coherently oscillating groups of pixels in171 Å and 193 Å.
- Consistent with the suggestion most oscillatory signals are not wave-like.
- But....
  - need knowledge of the underlying physical structure (where are the loops? where is the moss?) to give a definitive answer.