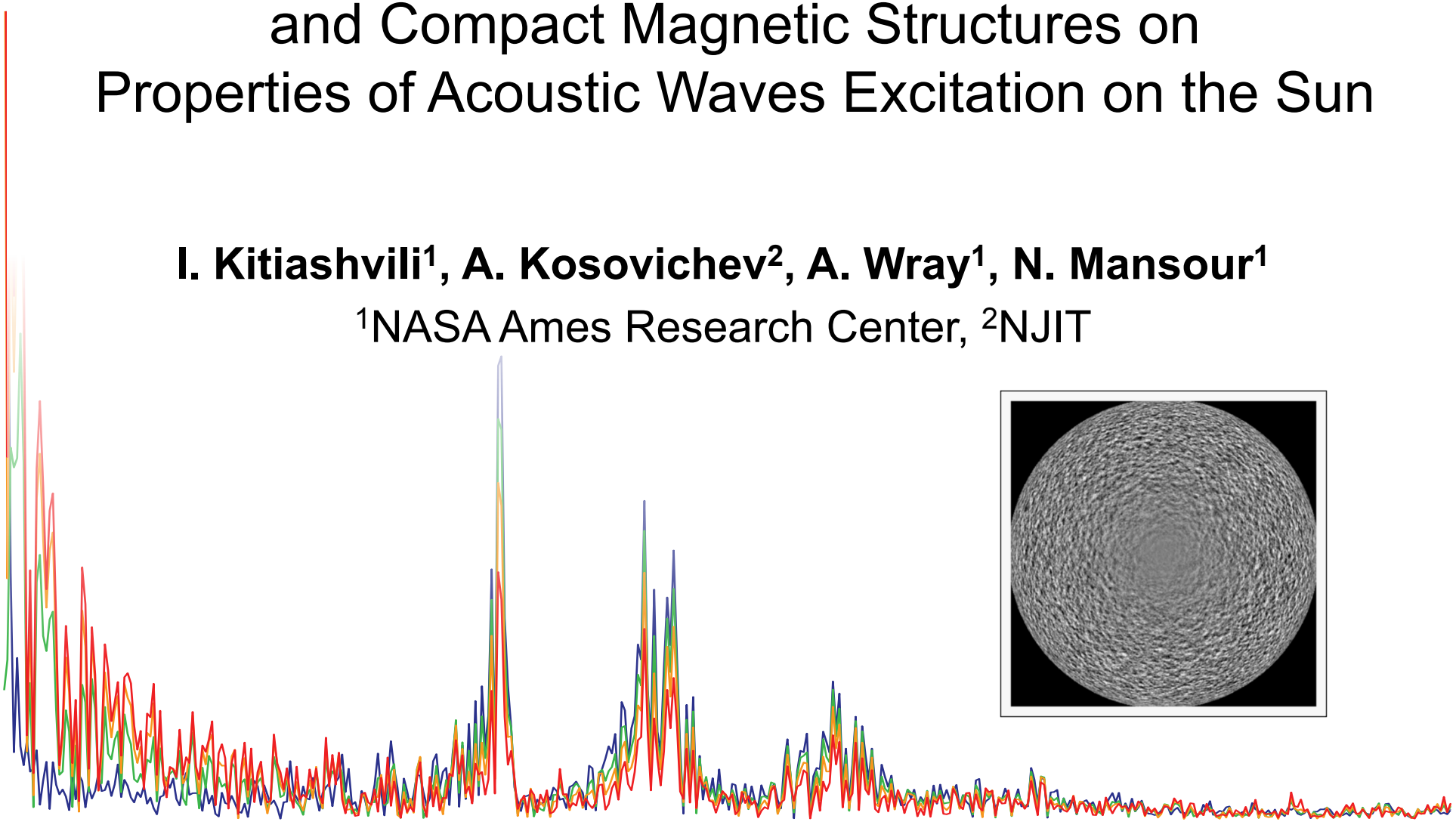
Effects of Distributed Magnetic Fields and Compact Magnetic Structures on Properties of Acoustic Waves Excitation on the Sun

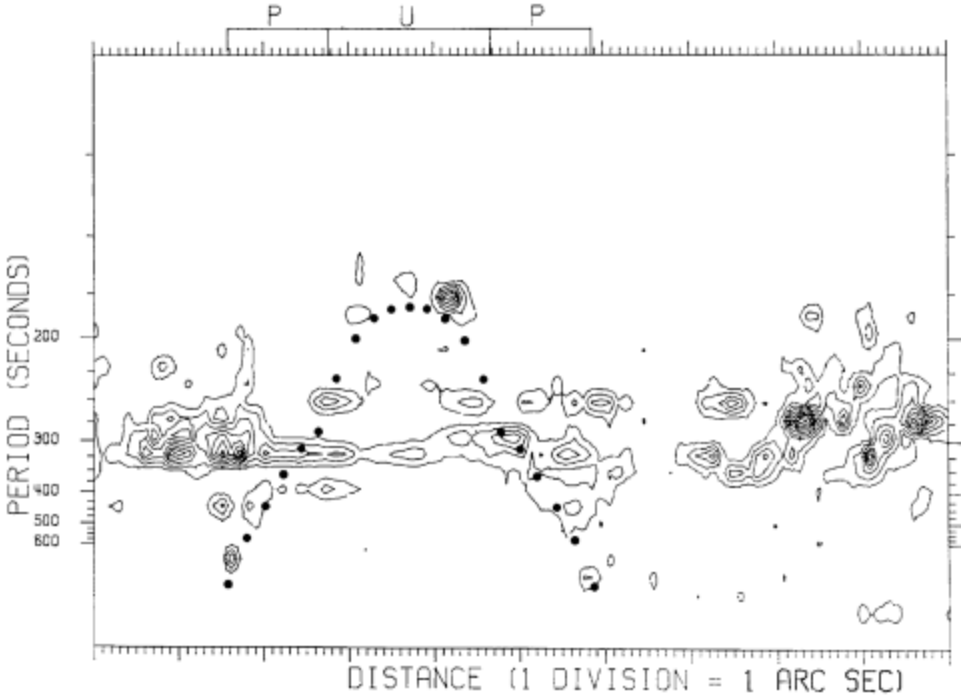
I. Kitiashvili[1], A. Kosovichev[2], A. Wray[1], N. Mansour[1]

[1]NASA Ames Research Center, [2]NJIT

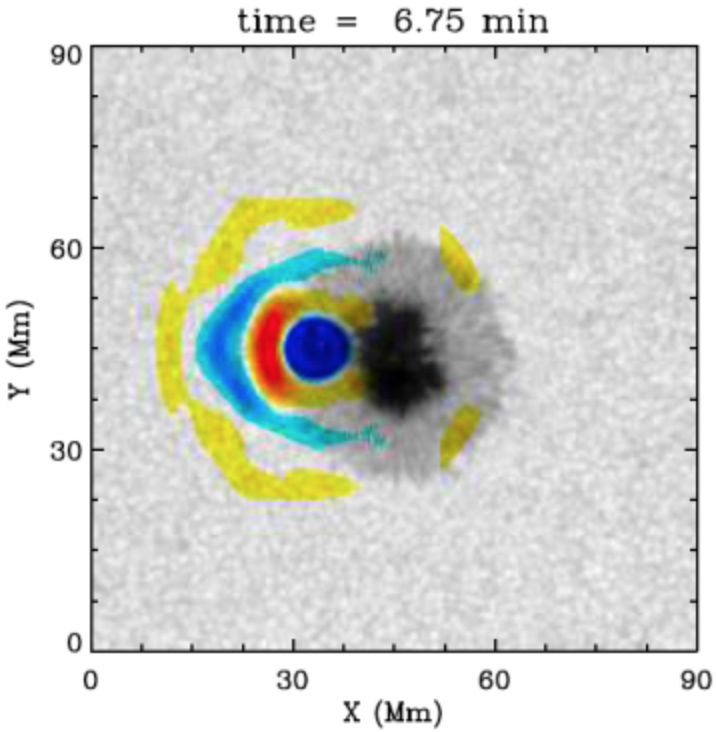


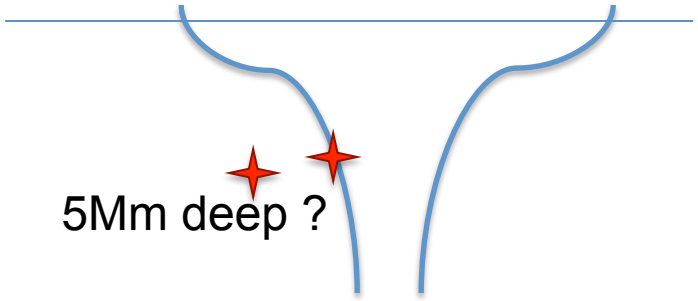
Magnetoacoustic waves in sunspots

Beckers & Schultz, 1972

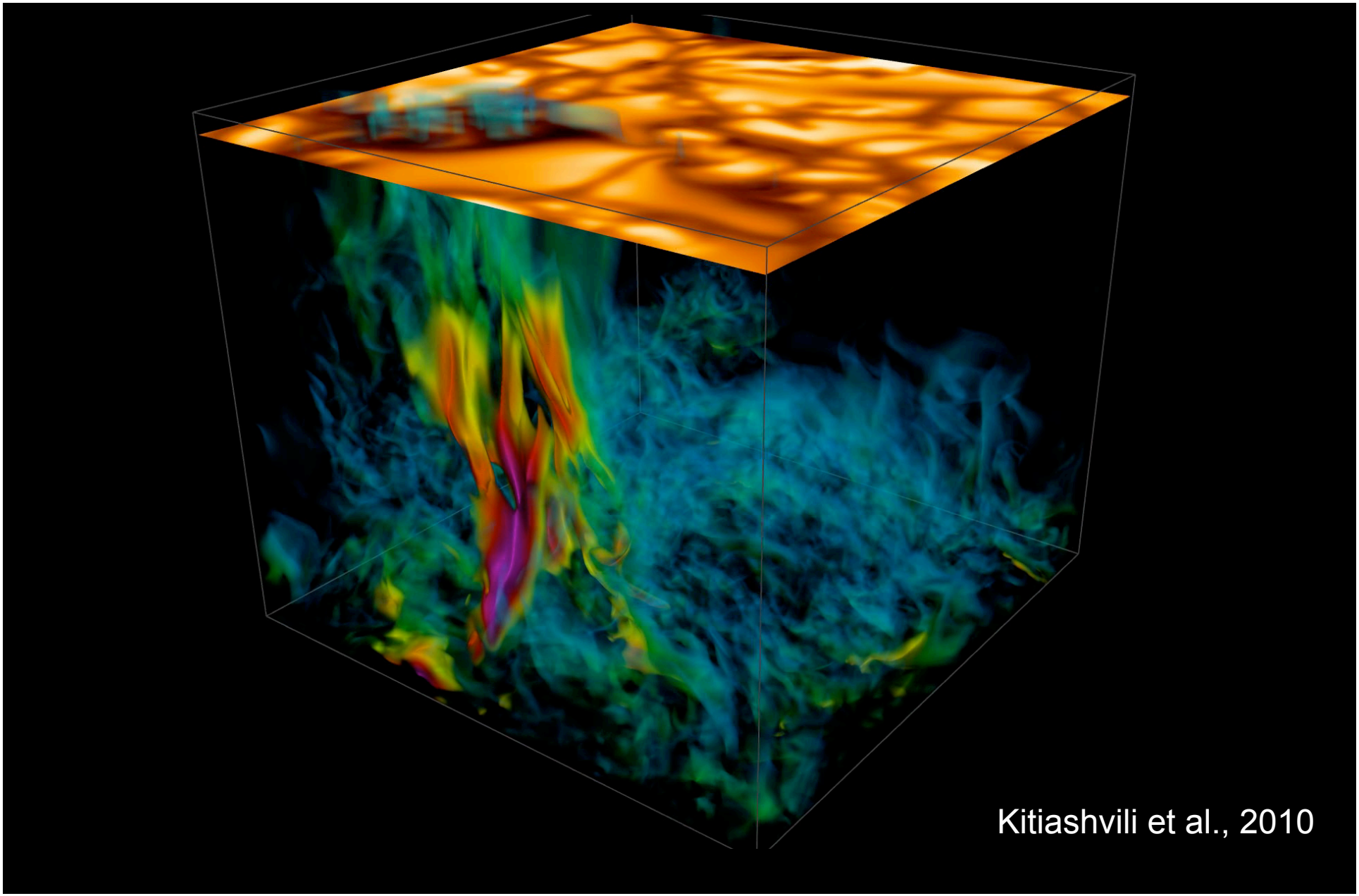


Zhao et al., 2015

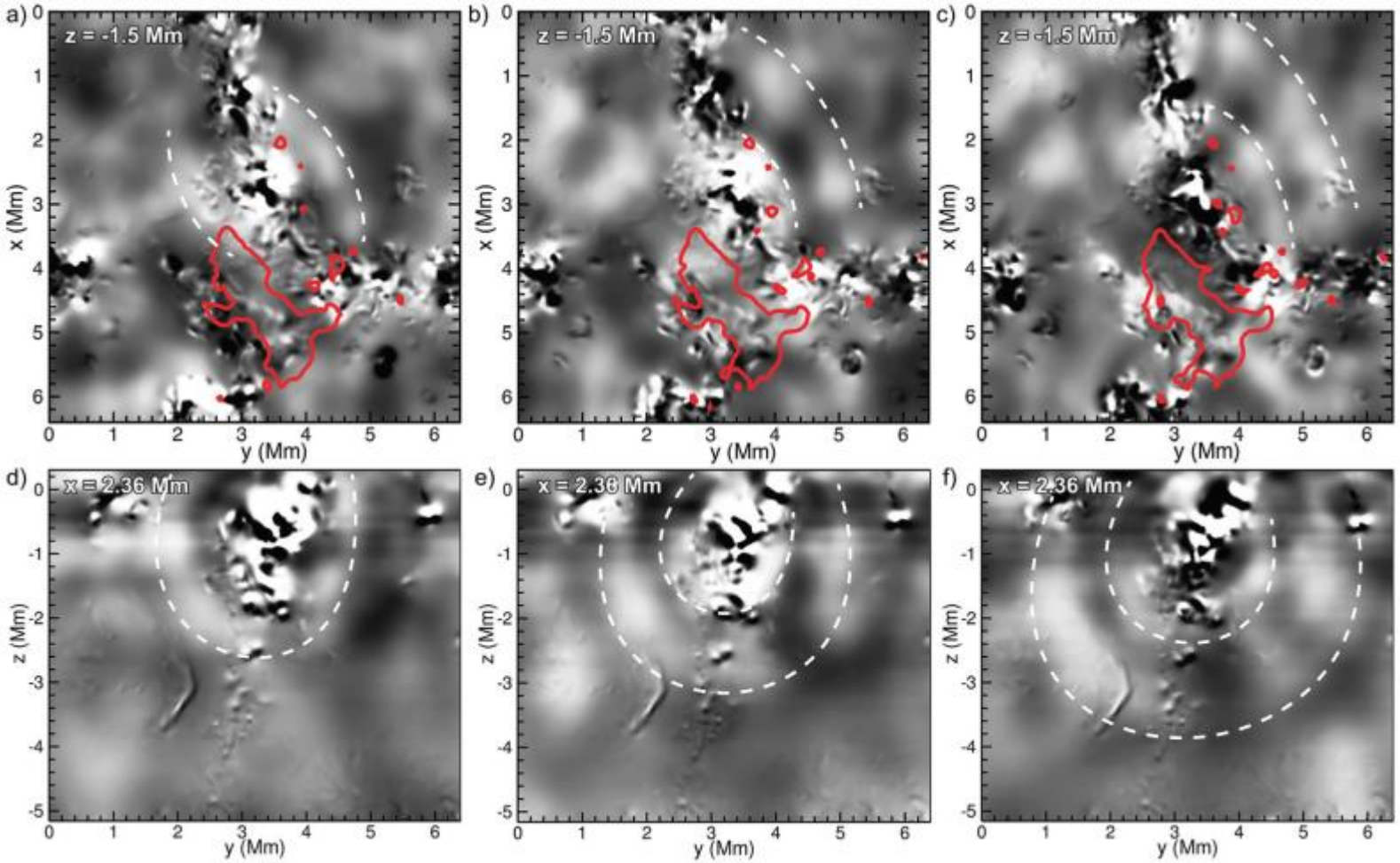




Spontaneous pore formation

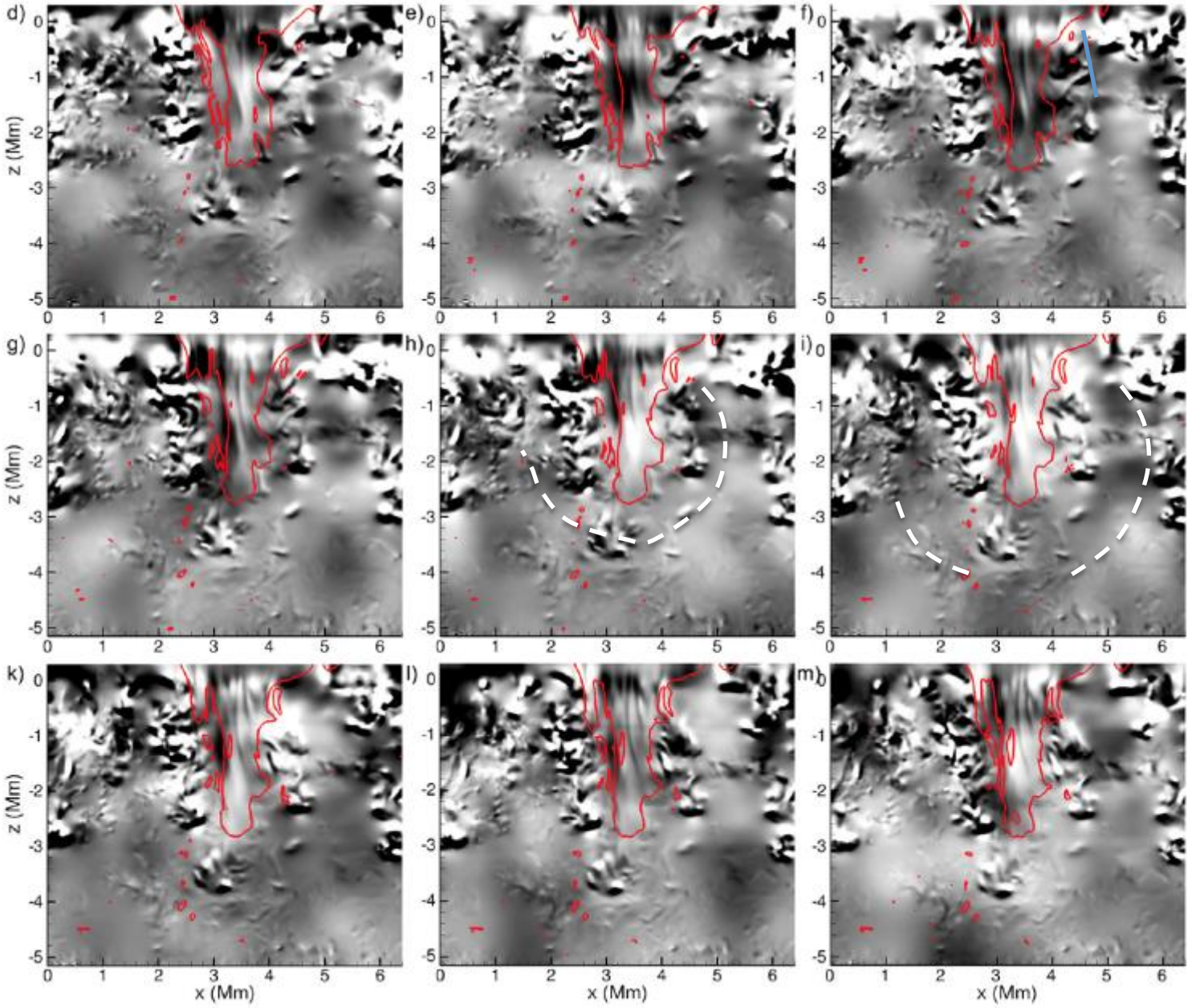


Acoustic waves in vicinity compact magnetic structure

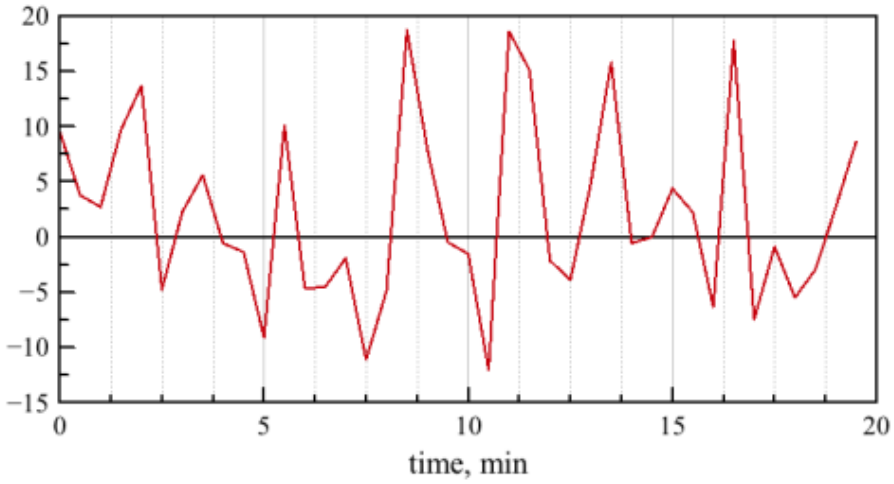


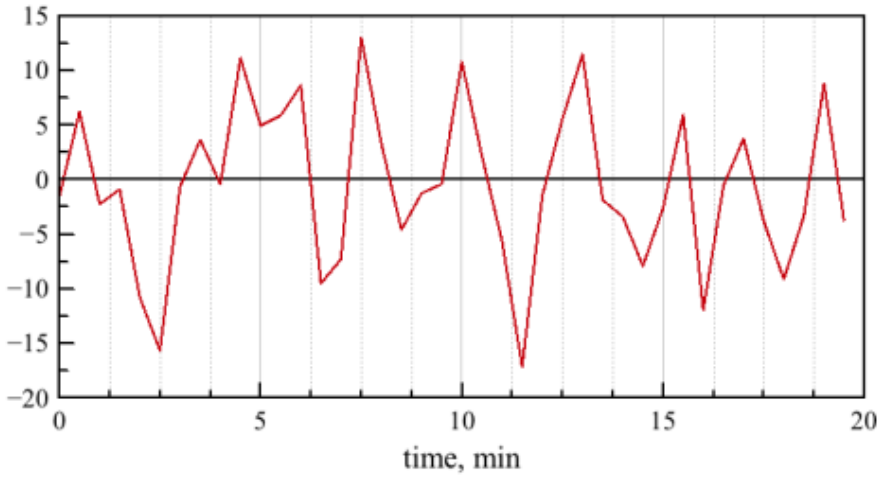
Example of acoustic wave excited in vicinity of the pore-like magnetic structure shows the time-difference of gas pressure fluctuations in the horizontal plane (z = -1.5Mm) and vertical y-z slices at x = 2.36Mm. Red contours correspond to the photospheric Bz = 500G. Time-difference between the snapshots is 30 sec.

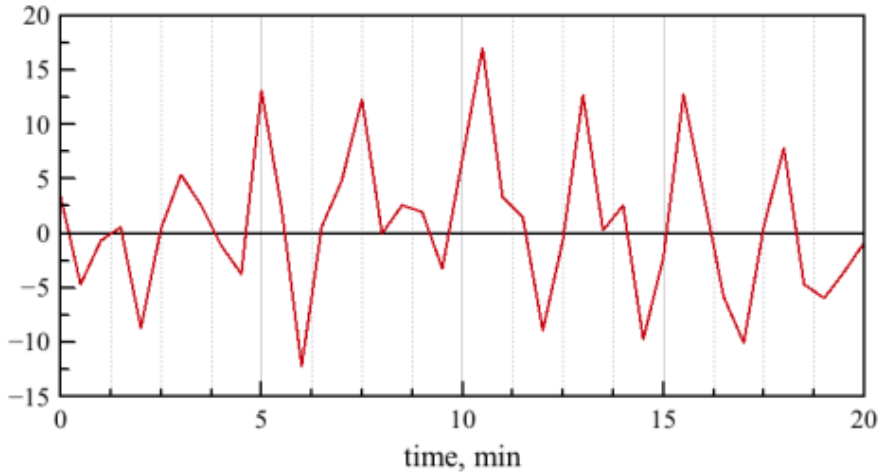
Acoustic wave inside the pore

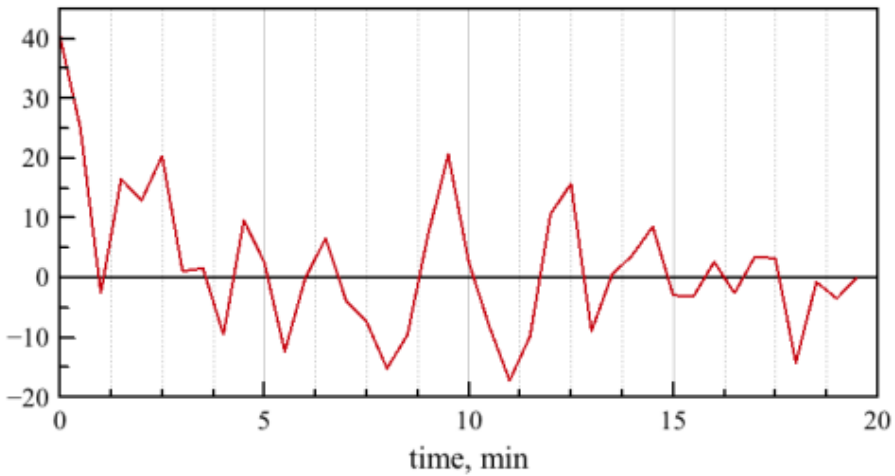


Subsurface acoustic events cause localized quasi-periodic gas pressure fluctuations with the period of 2 - 4 min

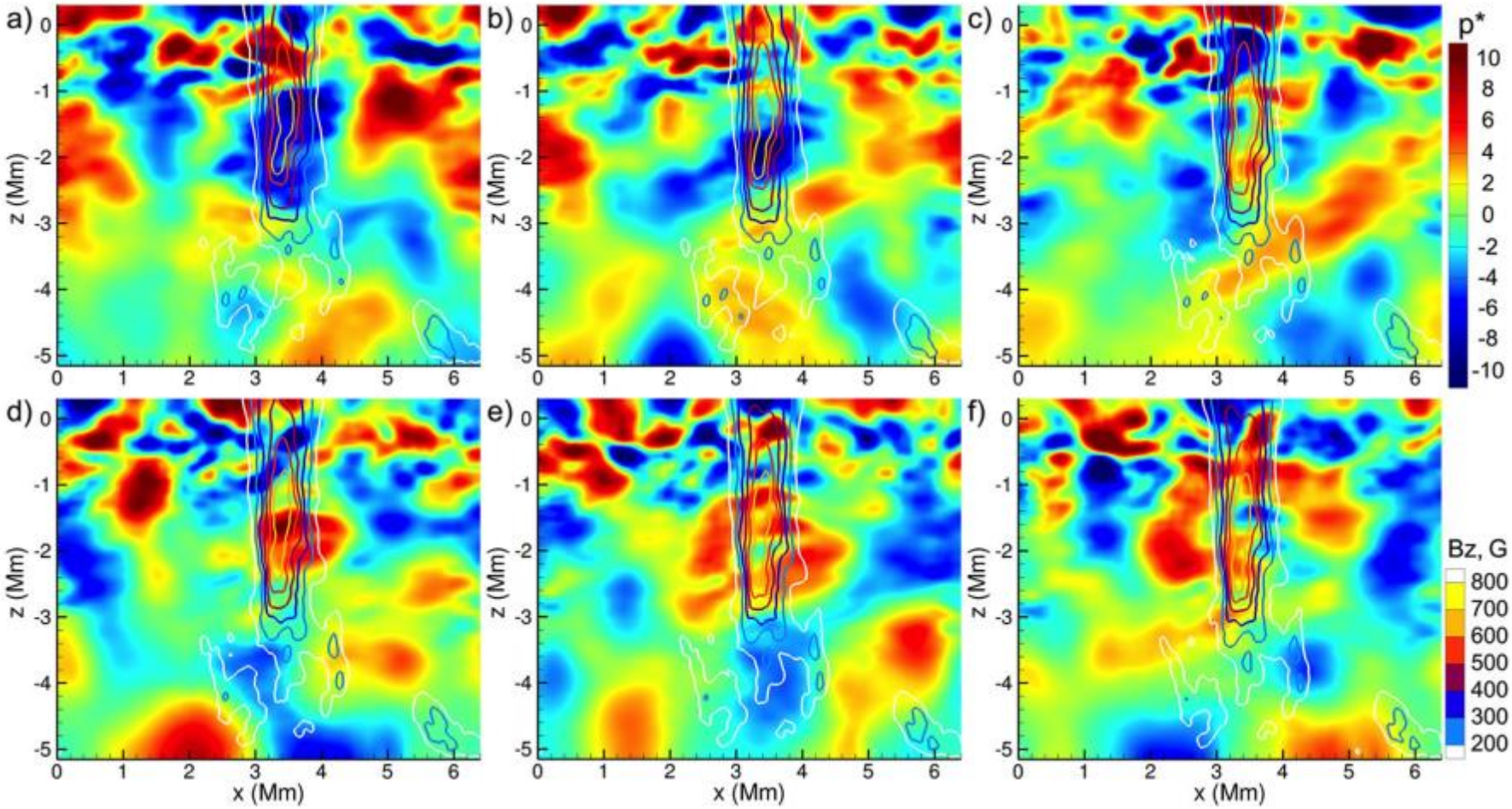






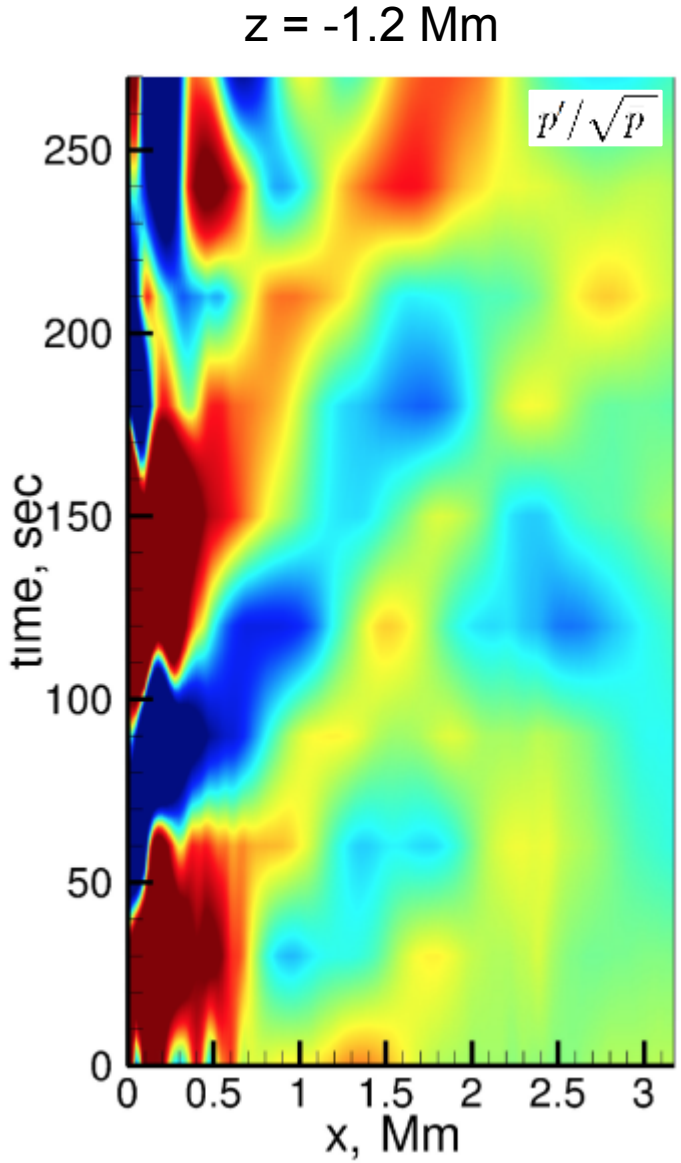


Identification of wave fronts from averaged normalized gas pressure fluctuations



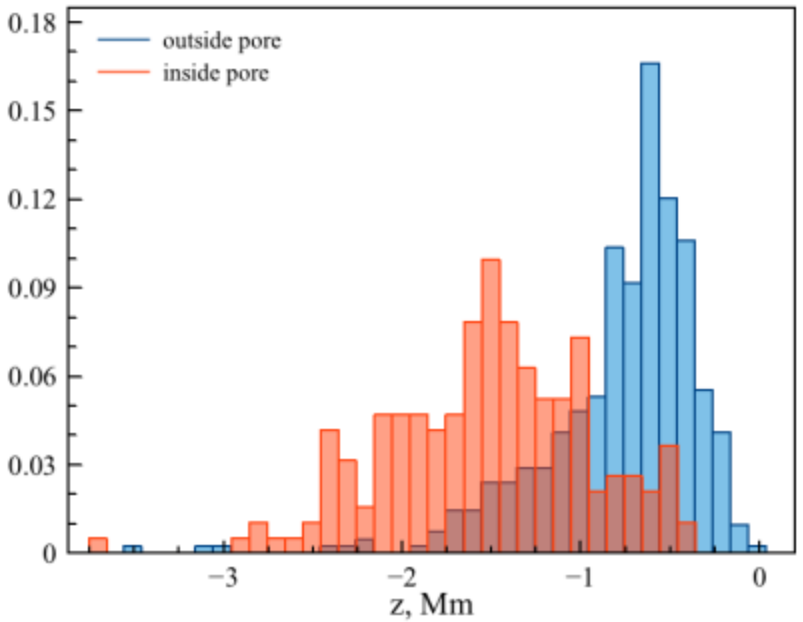
Example of acoustic wave event excited inside the pore 2 Mm beneath the surface. The images show the time-difference of the normalized gas pressure fluctuations averaged in y-direction. Time-difference between snapshots is 30 sec.

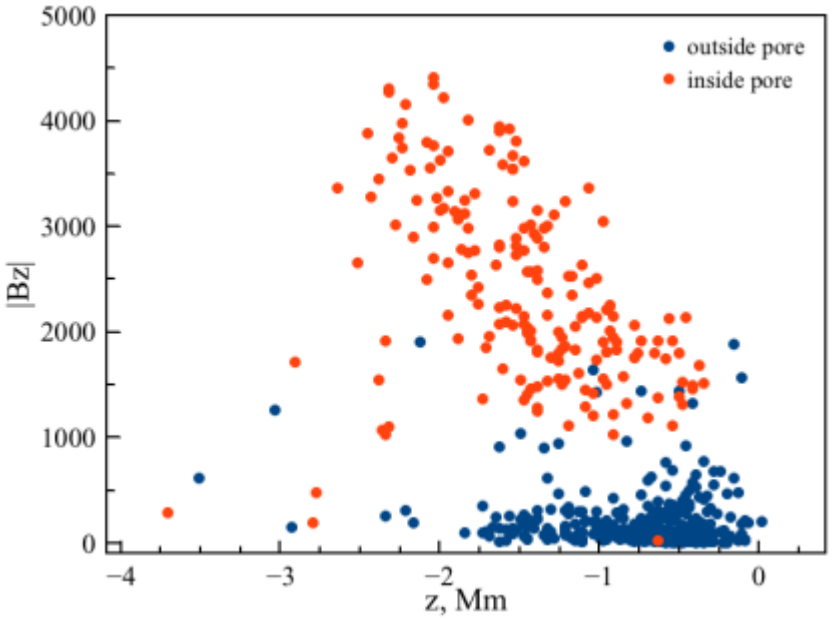
Time-distance diagram of the deep acoustic event

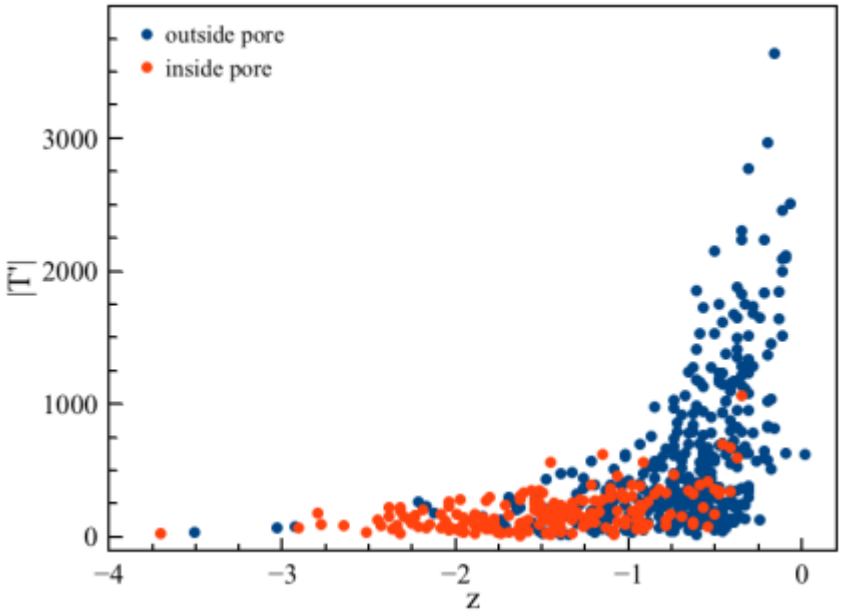


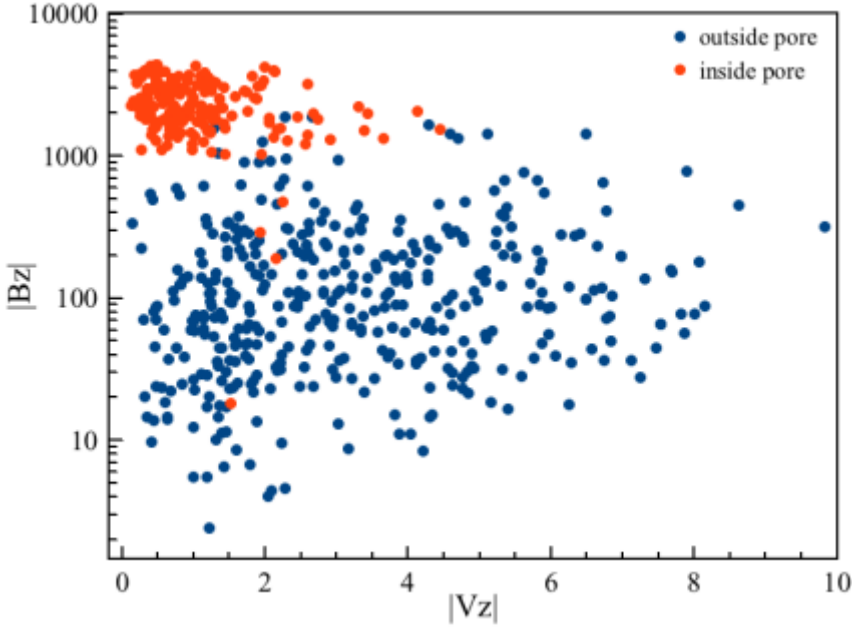
The ridges on the time-distance diagram correspond to wave propagation with the speed of ~14 km/s.

Statistical properties of acoustic events









Conclusions

- Excitation of the acoustic waves is observed everywhere on the Sun, reflecting subsurface dynamics of solar magnetoconvection. Recent helioseismology inferences have demonstrated the possibility of acoustic wave excitation in subsurface layers around sunspots much deeper than 200 km.

- Using 3D radiative MHD numerical simulations, we investigated acoustic wave excitation in the case of distributed magnetic field and spontaneously formed, highly magnetized pore-like structure, and show that, in the presence of strong magnetic field structures, acoustic waves can indeed be excited much deeper than in quiet-Sun regions.

- The distribution of acoustic events with depth depends on the magnetic field scale. In particular, in the case of small-scale magnetic patches, the acoustic events are located in a relative shallow, 0.5-1 Mm deep layer, while acoustic sources located inside a self-organized pore-like magnetic structure can be found as deep up to 3-4 Mm below the surface.

- The primary mechanisms of the deep acoustic sources are deeply penetrating downdrafts and pressure fluctuations caused by interacting magnetic flux tubes.