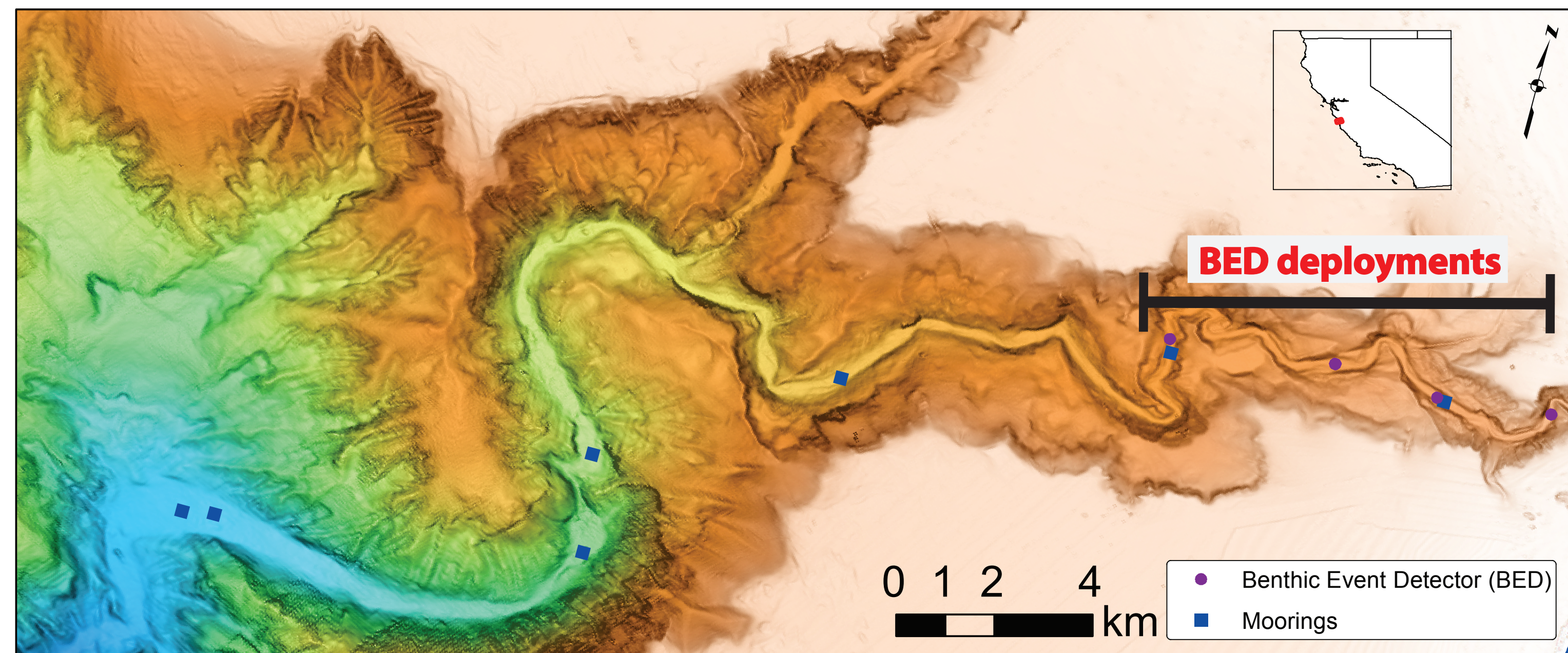


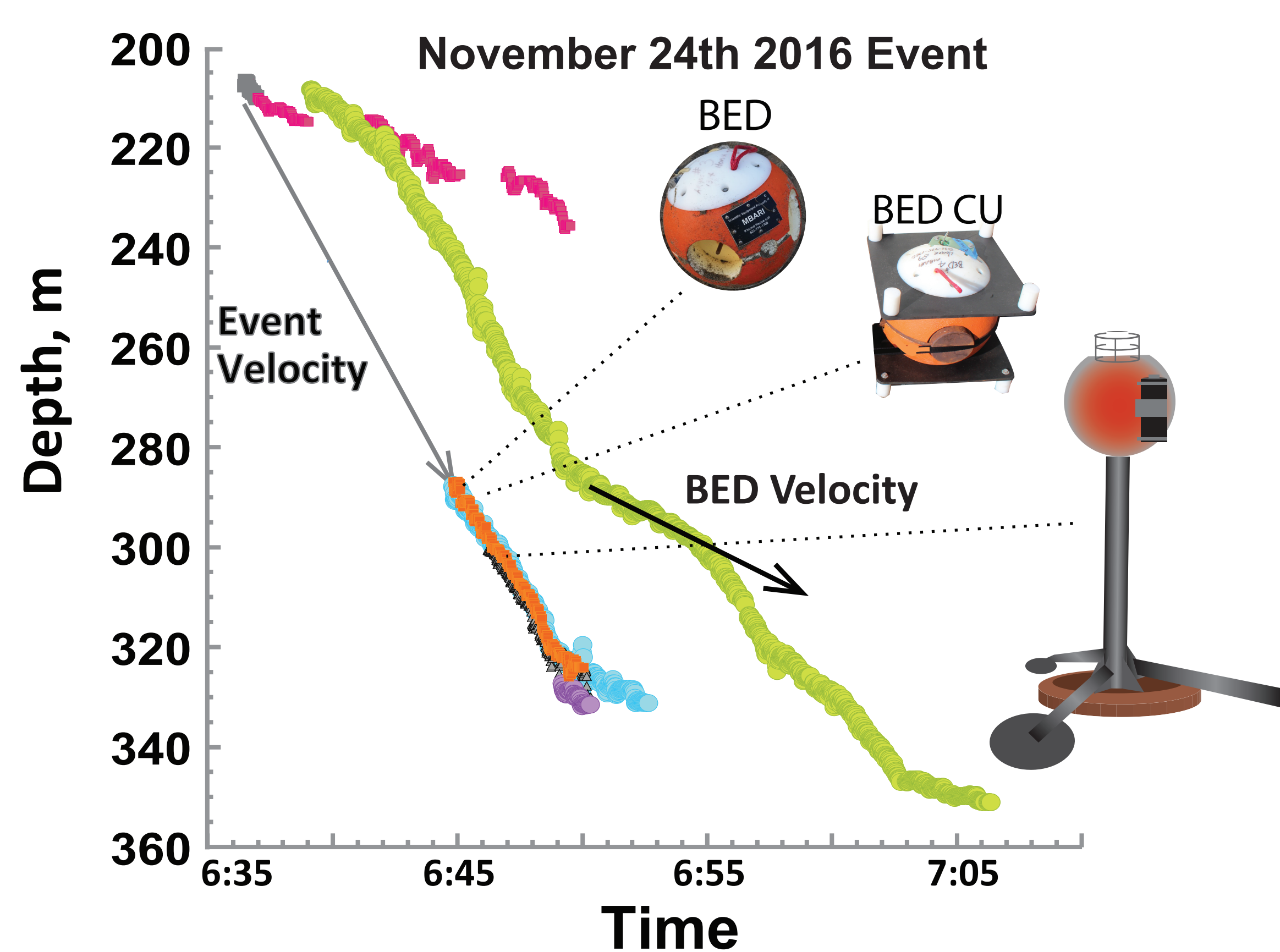
1. Introduction

The Coordinated Canyon Experiment was conducted in Monterey Canyon for 18 months to monitor the passage of sediment gravity flows over a distance of 50 km from 285 to 1,850 m water depths, using an array of instrumented moorings and sensors on the seafloor (Paull et al., 2018). A novel approach was the use of Benthic Event Detectors (BEDs), which are engineered boulders capable of recording their own motion. BEDs were designed to replicate the behavior of boulders in sediment gravity flows. **The goal was to evaluate whether sediment gravity flows involve water flows with suspended particles only or whether the flows involve displacement of a seafloor basal layer.**



Map of Monterey Canyon, where the Coordinated Canyon experiment took place. BEDs were deployed between 200 and 500 meters water depths.

4. BED motion velocity



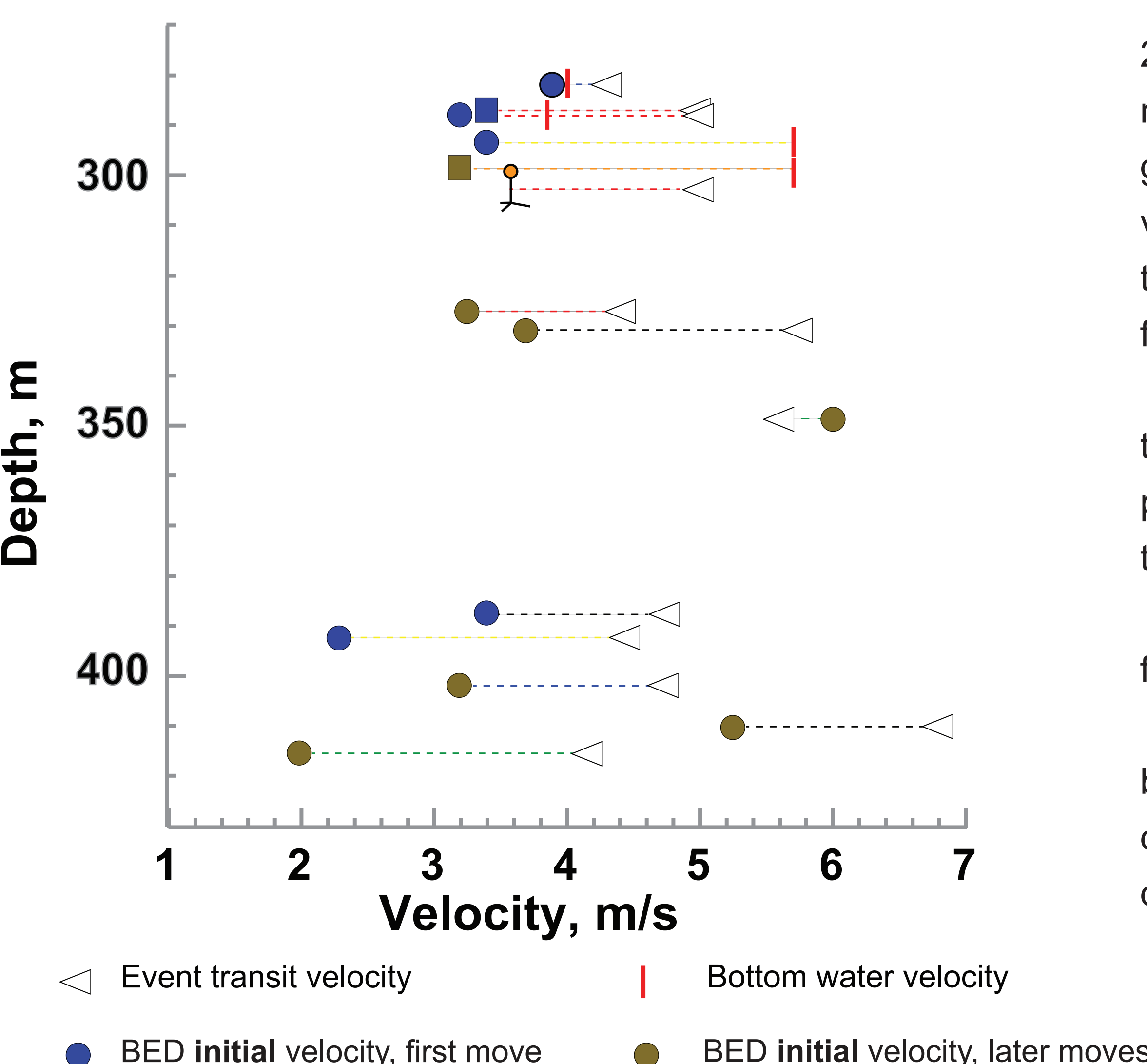
On November 24th 2016, a sediment gravity flow was recorded by 6 different BEDs, located over a >130 m water depth range. The event displaced round BEDs, cubic BEDs, and a BED-equipped 800 kg frame. BEDs spread over a downcanyon distance of 4 km moved simultaneously, and at a given location, the event lasted at least 10 minutes. The event transit velocity was faster than the BEDs initial velocities and faster than the bottom current velocity measured at 300 m water depth.

The behavior of the BEDs on the Nov 24th 2016 event was typical of the BEDs motions in other recorded sediment gravity flow events. The events transit velocities downcanyon were faster than the bottom water current velocity and faster than the BEDs initial velocities.

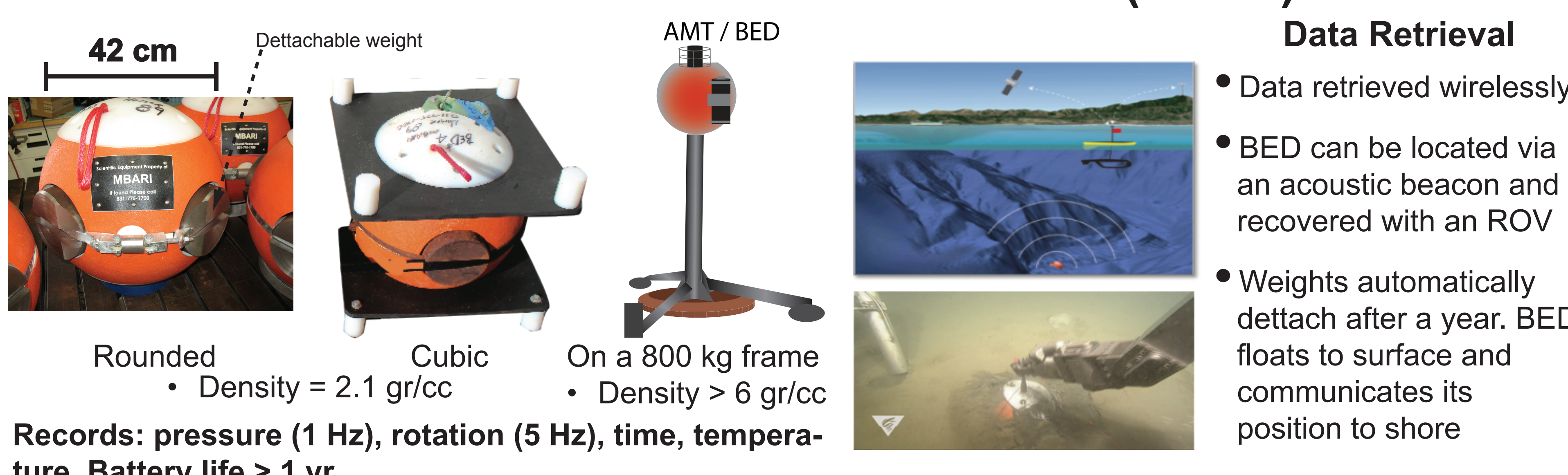
BEDs initial velocities were 75±15% of the event transit velocities, and this proportion was independent of the event transit velocity magnitude.

Events were able to move the 800 kg frame at a velocity of 3.6 m/s.

No statistical difference was observed between the BED velocities in their first displacement and in the subsequent downcanyon movements.

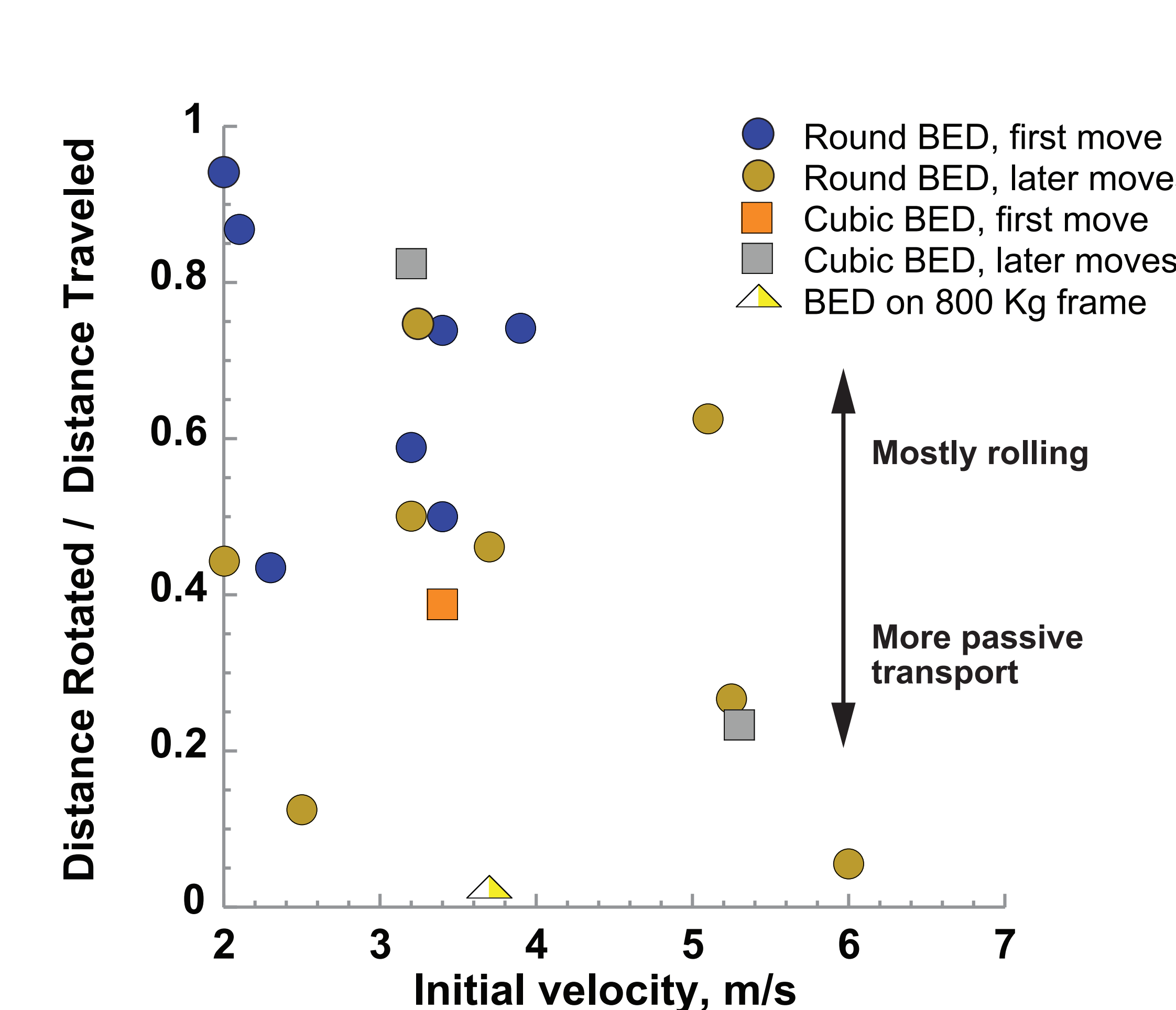
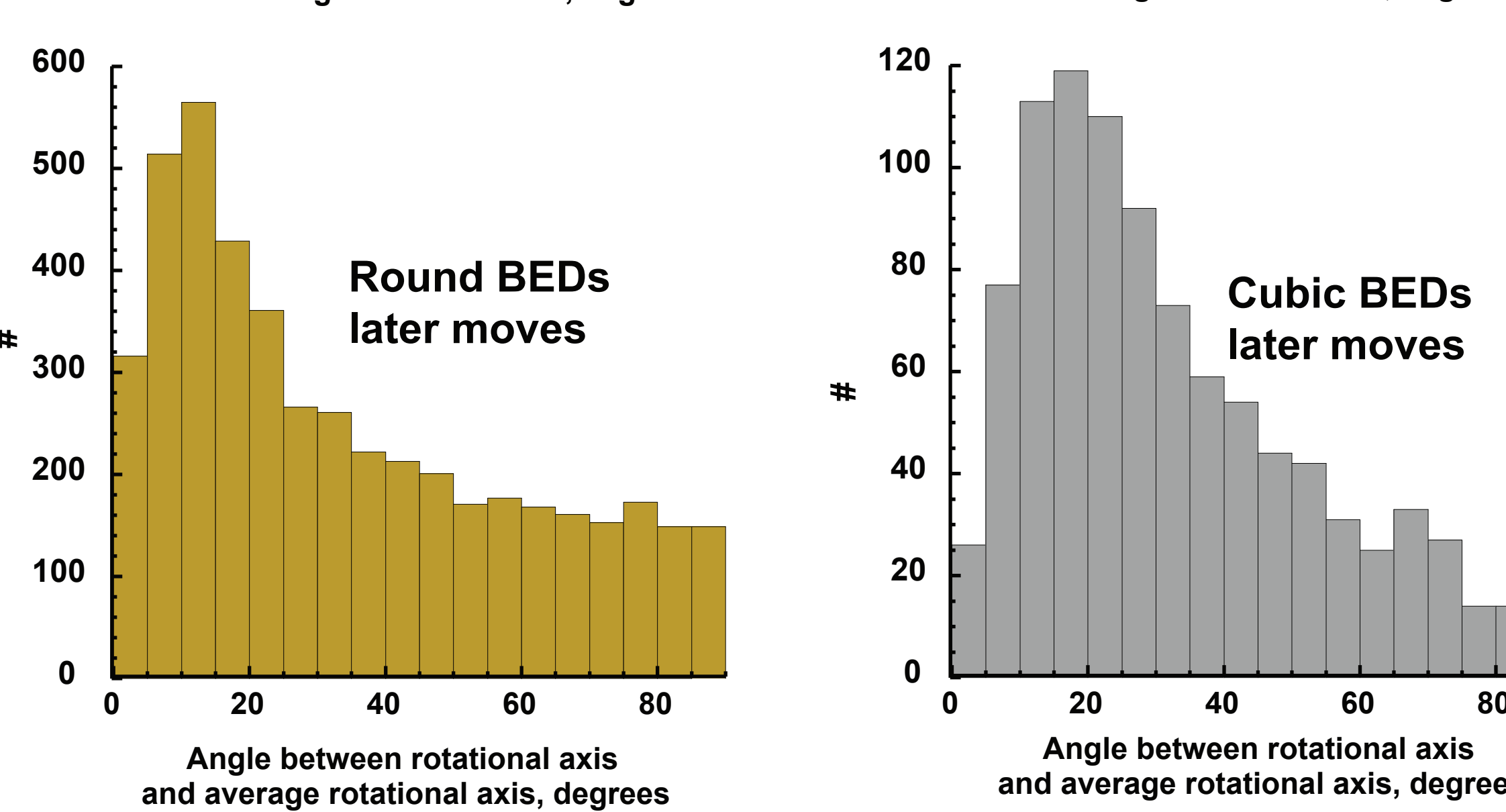
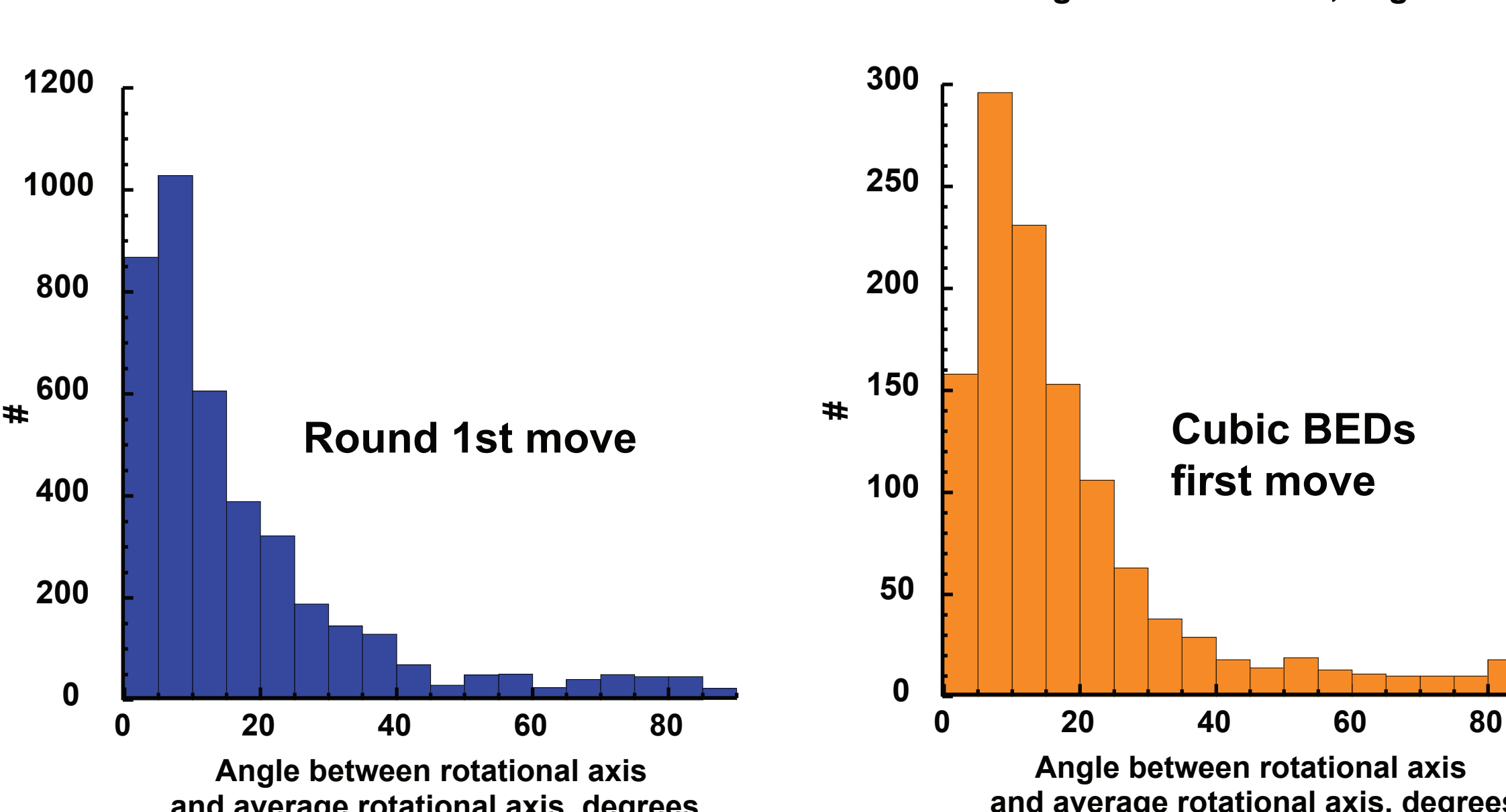
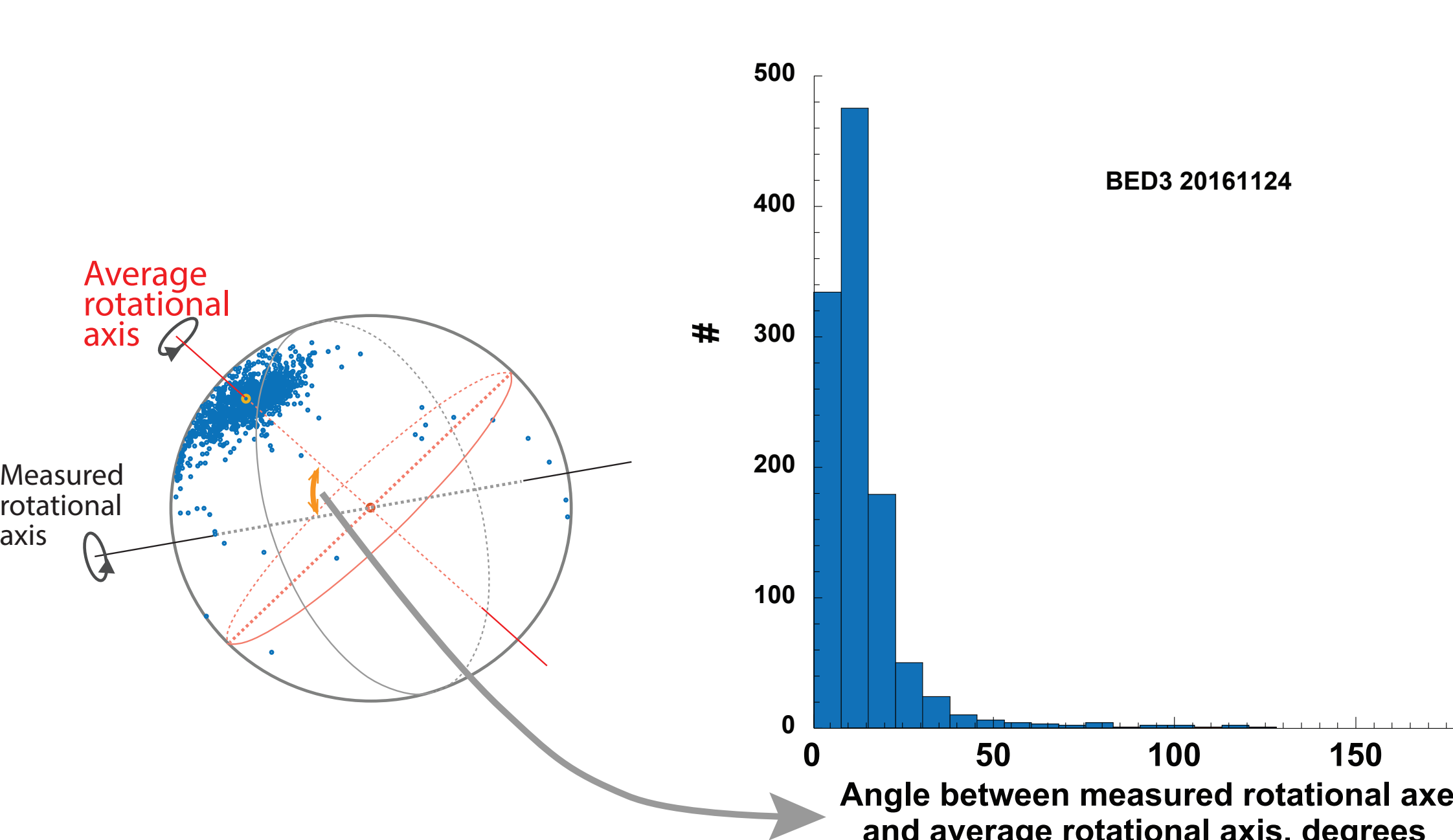


2. Benthic Event Detectors (BEDs)



5. Rotation

The type of motion a BED experiences as it moves downcanyon (free rotation vs. transport within a dense flow) can be determined from the changes in the orientation of the axis of rotation of the BED.



BEDs were deployed on the seafloor and may have been buried after moving downcanyon for the first time. The variability in the orientation of the BED axis of rotation, as the BED moves downcanyon, indicates whether the BED rolled freely over the seafloor or whether it was carried by a dense sediment flow.

Little variability in the axis of rotation indicates predominantly free rotation around a preferred axis. Large variability in the axis of rotation is interpreted as the BED being jostled around as it is carried by the flow.

The distribution of the BEDs axes of rotation during the displacements downcanyon depended on the shape of the BED (round or cubic) and on whether the BED had moved downcanyon previously.

In their first move after deployment, the distribution in the orientation of the axes of rotation of a BED is characteristically narrow, restricted to a range mostly within 40 degrees of the orientation of the average axis of rotation. This is interpreted as an indication that during the first move after deployment they rotated freely rather than being transported in a dense medium.

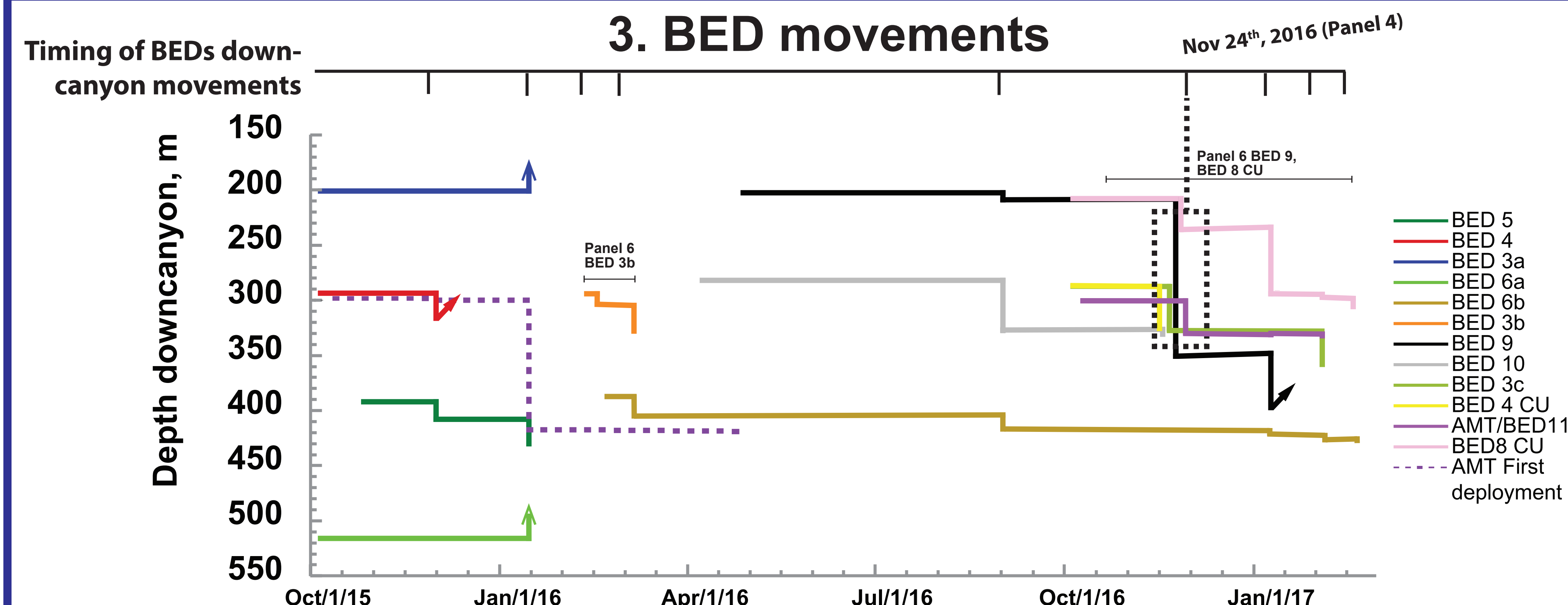
In subsequent movements downcanyon, the distribution of the orientation of the BEDs axes of rotation is broader. This is interpreted as the BED being jostled around while suspended in a thick medium that transports it downcanyon.

The distance rotated by a BEDs as it moved downcanyon was calculated from the rotational data.

As the velocity of the event increases, the ratio between the total distance rotated compared to the total distance traveled decreased. This suggests that during the faster events the BEDs were carried downcanyon by the flow as opposed to rotating freely.

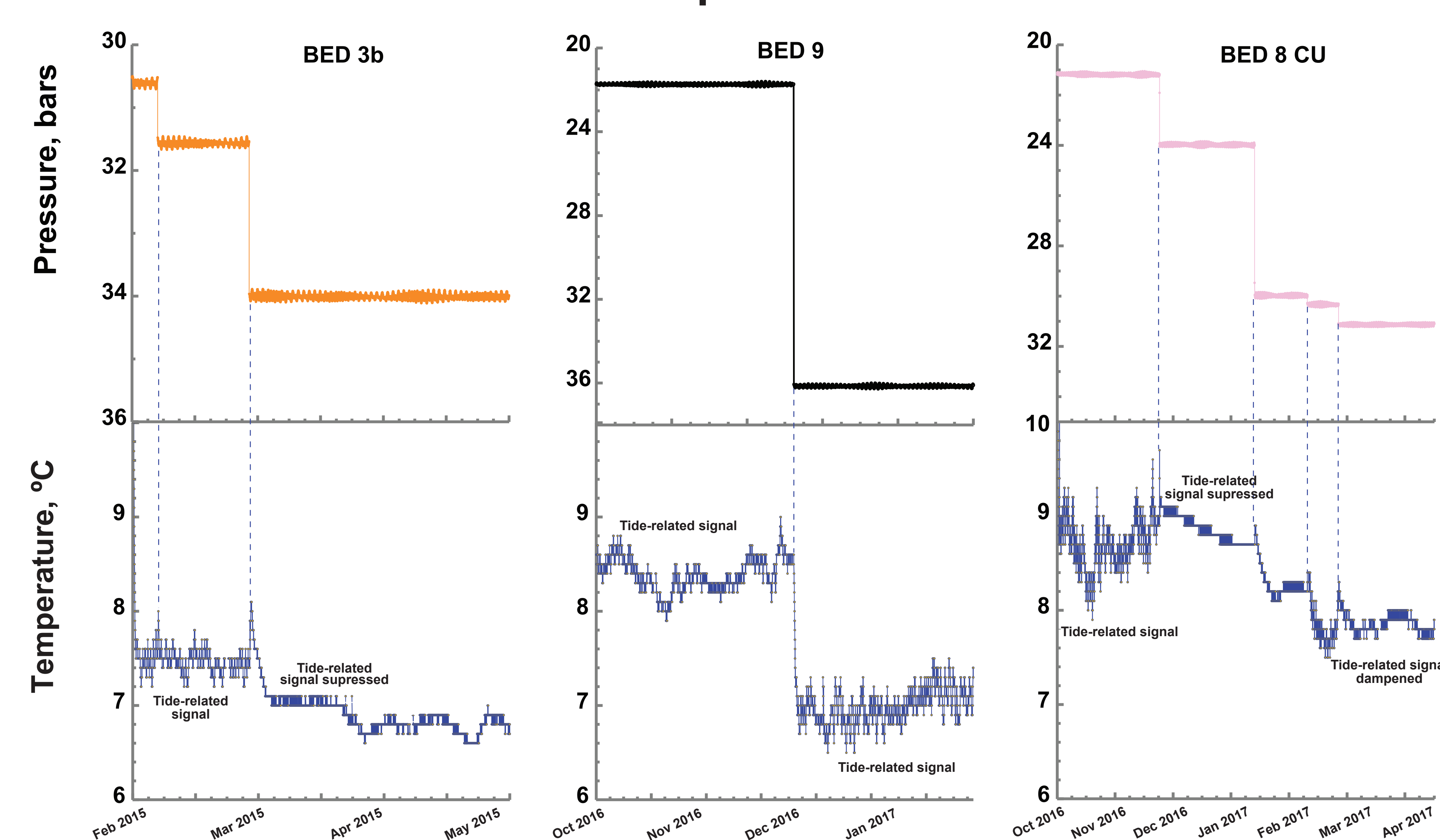
On average, BEDs rotated a larger proportion of the distance traveled in their first move after deployment than in subsequent movements. This suggests a more restricted motion in the subsequent events where free rotation was inhibited.

3. BED movements



During the course of the study BEDs moved downcanyon in 9 events, which were also recorded in moored current meters. Most BEDs recorded multiple events. Some lost their weights and surfaced (arrows) and some were recovered. For some BEDs, data were retrieved wirelessly but the BED was buried too deeply for recovery.

6. Temperature



- Initially BEDs recorded a tide-related temperature signal.
- Once the BED moved, the tide-related temperature variability decreased or dissappeared. This is interpreted as periods when BEDs were buried. Even when buried, BEDs moved in subsequent events. In some instances the temperature variability after an event remained unchanged, interpreted as the BED resting at or close to the seafloor.

7. Summary and Conclusions

- BEDs moved during nine sediment gravity flows in Monterey Canyon and recorded pressure, rotation and temperature data during their downcanyon movements.
- When reached by a sediment gravity flow BEDs initial velocities were on average 75% of the transit velocity of the event. This percentage was independent of the magnitude of the event transit velocity.
- The characteristics of the BEDs movements in their first trip downcanyon were compared with their characteristics in subsequent movements: In their first move the orientation of the axis of rotation of the BED was within a narrow angle, but in subsequent movements the orientation of the axis of rotation was more dispersed.
- In their first move BEDs rotated proportionally a longer distance than in subsequent moves.
- Initially BEDs detected a tide-related temperature signal, but after moving downcanyon the tidal signal was dampened or suppressed in some BEDs.
- The rotational and temperature data are consistent with the BEDs being buried after moving downcanyon with the first sediment gravity flow and carried within a seafloor basal layer in subsequent events.
- Sediment gravity flows in Monterey Canyon appear to involve a dense basal seafloor layer.**

References

Paull CK, Talling PJ, Maier KL, Parsons D, Xu J., Caress DW. et al., 2018, Powerful turbidity currents driven by dense basal layers, *Nature Communications*, 9:4114.