DART

#166

3D Characterization of the Ejecta Produced by the DART Impact

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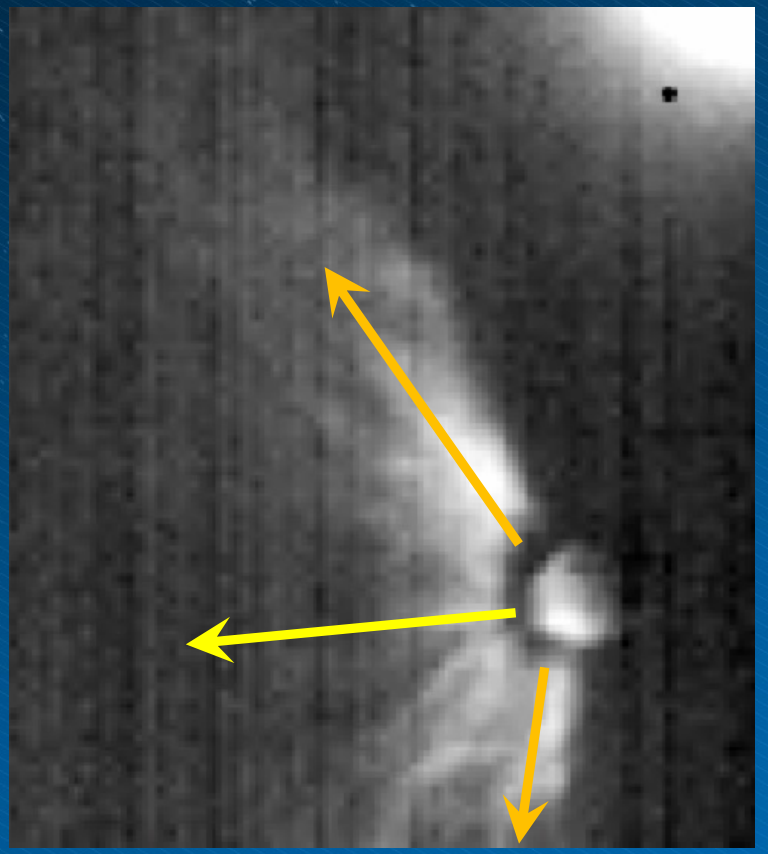
Measuring Momentum Enhancement

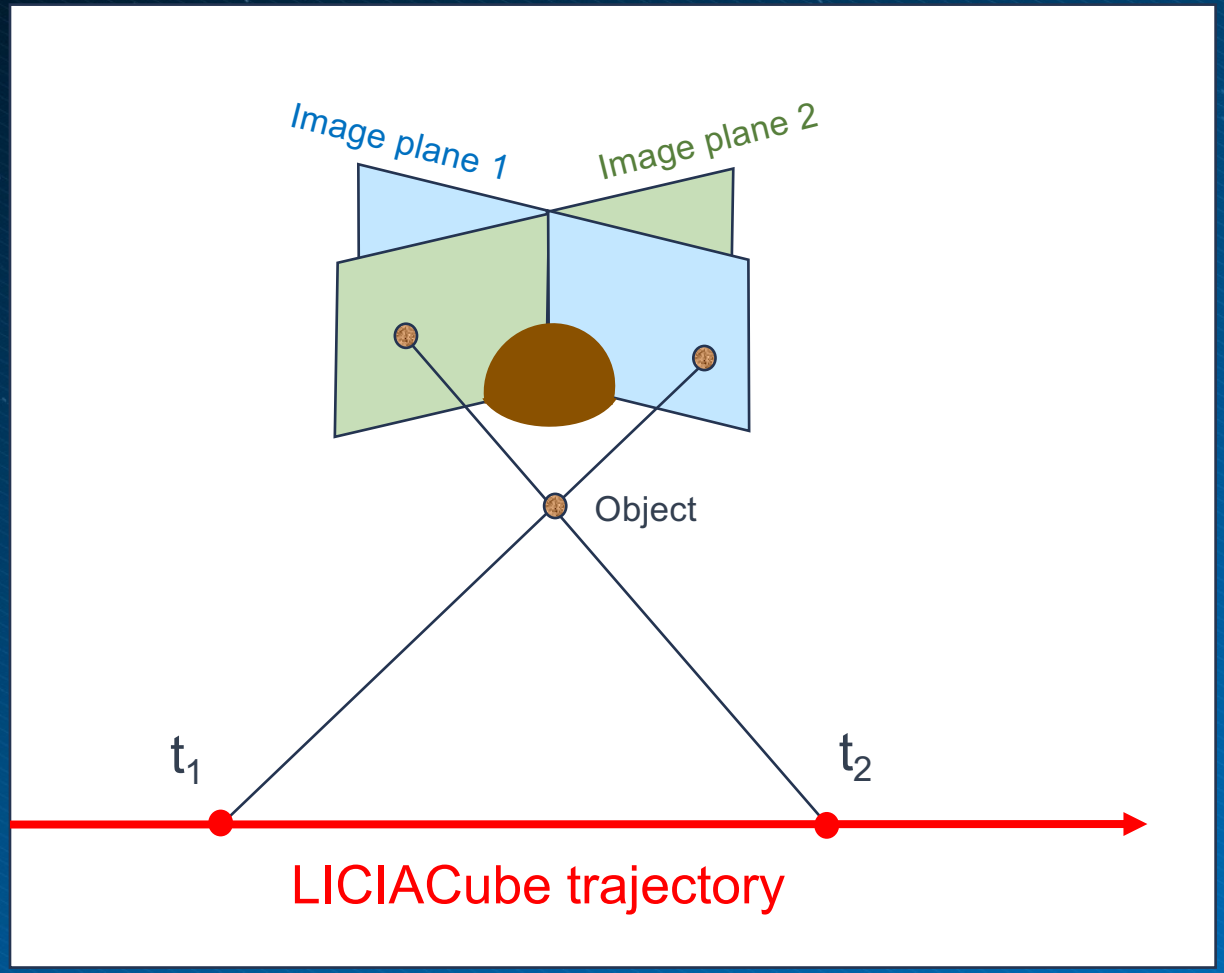
- The primary result of the DART impact: $3 < \beta < 4$
  - Measurement governed by observing changes in orbital period
  - Reflects only excess momentum parallel to the orbital velocity
- LICIACube and HST observations show significant amounts of ejecta emitted in other directions
  - How might this additional momentum affect the system?
- DART investigation team are working to characterize the ejecta field
  - Posters modeling the shape of the ejecta cone:
    - Hirabayashi et al. "DART-driven ejecta cone geometry measurement from Hubble Space Telescope and LICIACube
    - Deshapriya et al. "Constraining the ejecta cone geometry following DART impact on Dimorphos using LICIACube data"



LICIACube LUKE image, Impact +172 s

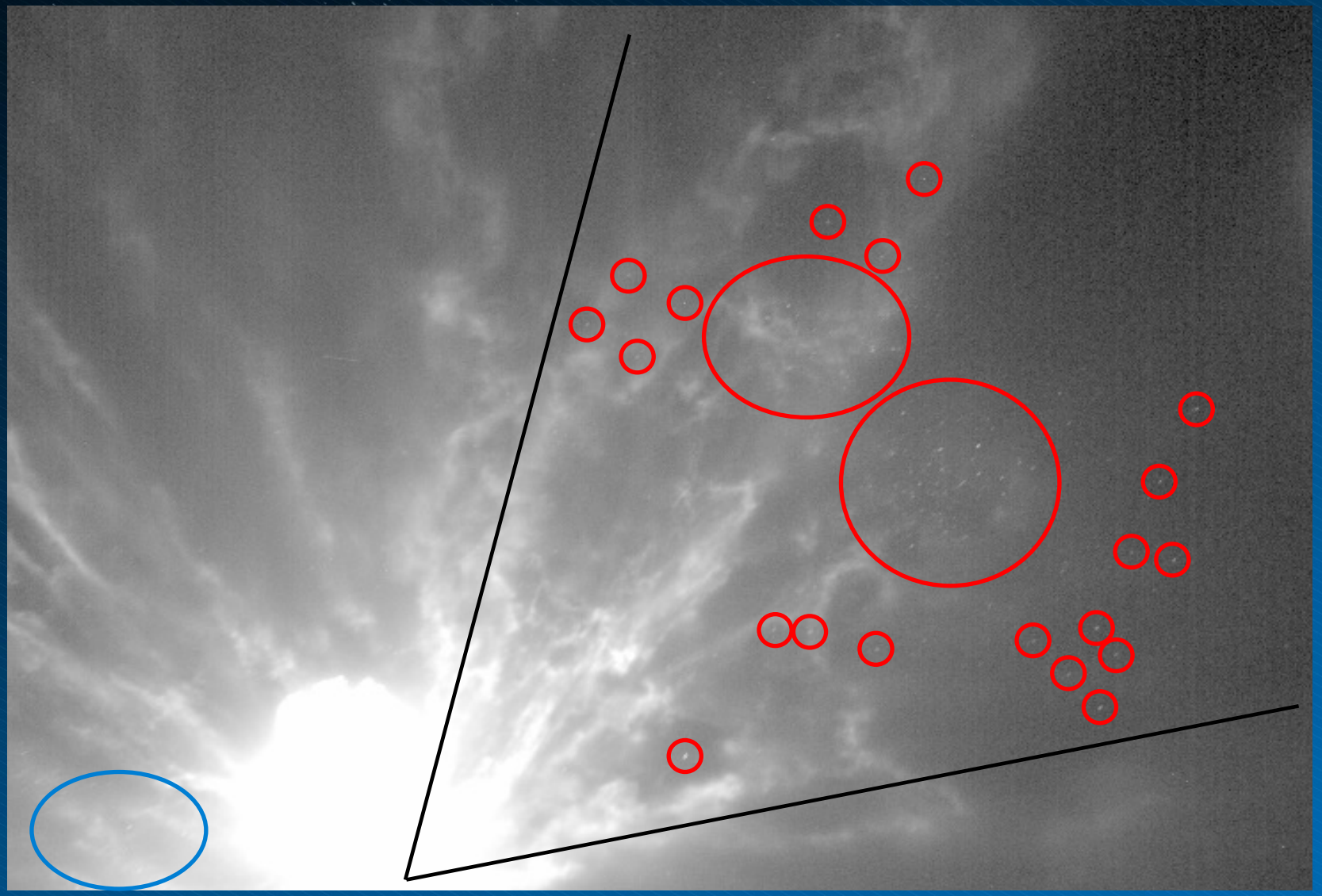
Ejecta Measurements in Three Dimensions

- Use parallax induced by LICIACube's motion to solve for positions of features in LUKE images
- Changes in the apparent position WRT Didymos define the object's location in 3-D space
- Multiple viewpoints can improve the accuracy of the position measurement and constrain the velocity



Initial Work: Individual Boulders

- 100+ “point sources”
  - Mostly clustered to the upper right direction
  - A few to lower left
  - Visible in multiple frames
- Presumably these are individual boulders ejected in the impact
- Clustering suggests that the boulders were ejected in preferred directions



Boulder Analysis

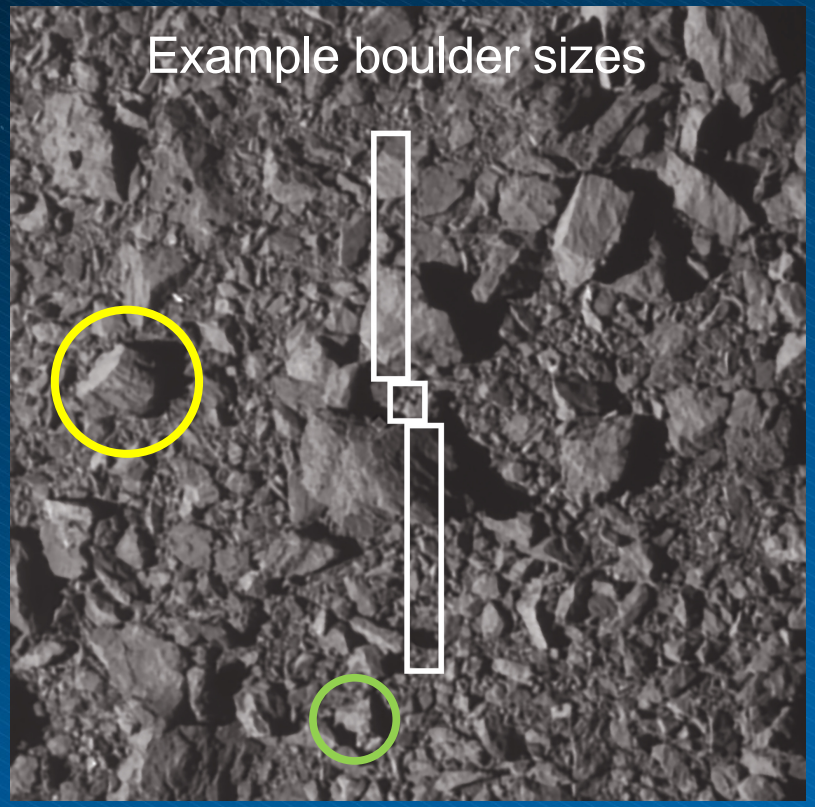
- Determine physical properties of the boulders
  - Use photometry to derive size and “shape” of the boulders
  - Use parallax to derive location in space
  - Derive ejection velocity from parallax or distance/time
- Compute their contribution to momentum enhancement

Boulder Sizes

- Use photometry from calibrated LUKE images to derive the boulder sizes
- Derive the object size from measured Irradiance

$$R = \{ 4 (I_{meas} / I_{Sun}) (r \Delta)^2 / (p f(\alpha)) \}^{1/2}$$

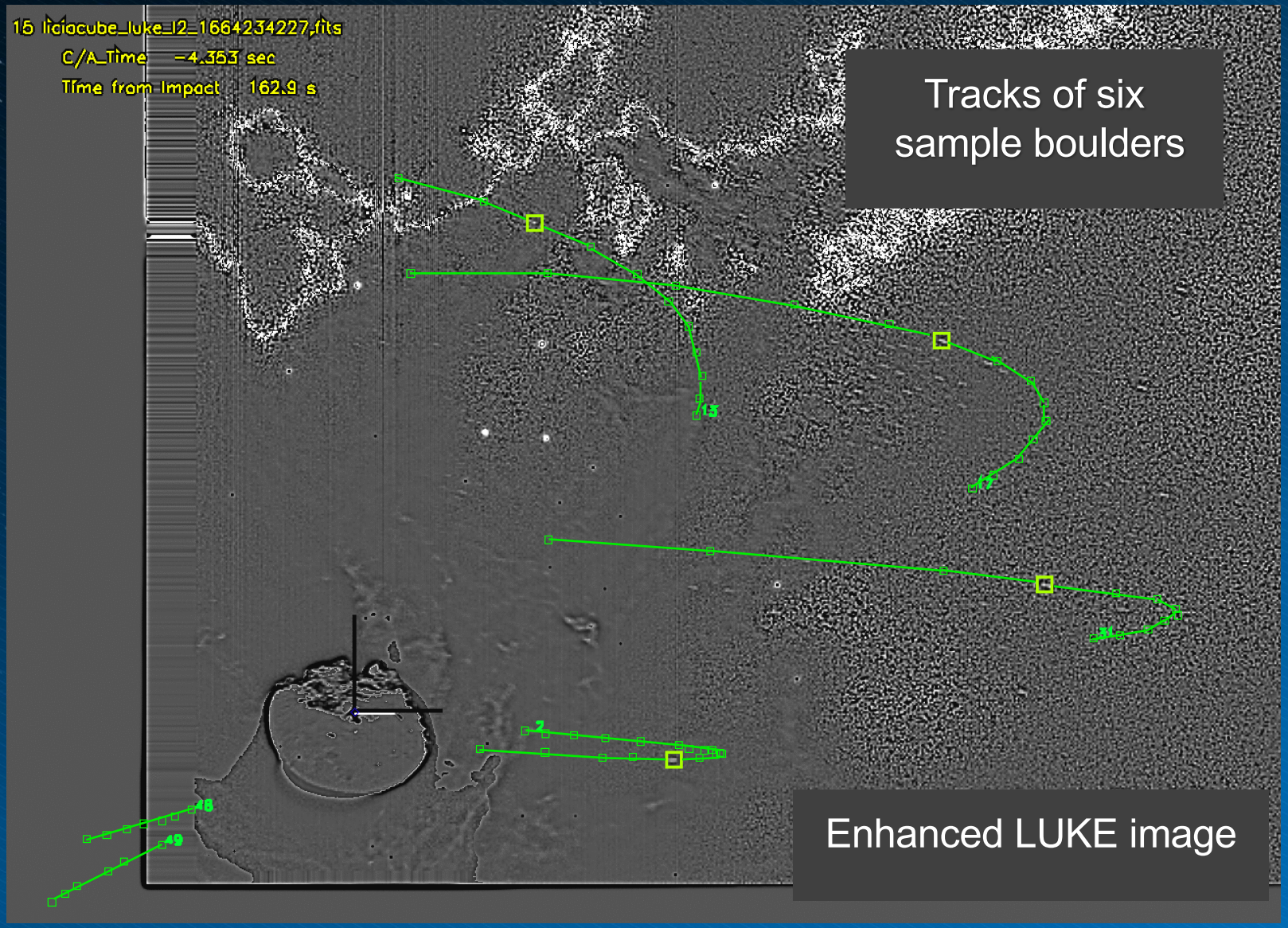
- Absolute calibration is not yet available
  - Bootstrap brightness off calibrated DRACO images of Didymos
- Brightest boulder ➔ ~2 m radius
- Brightnesses of most boulders ➔ ≤1 m radius
  - Lower limit defined by the instrument sensitivity/contrast
- Variations in lightcurves suggest boulders are irregular in shape



Daly, Ernst, Barnouin et al. (2023)

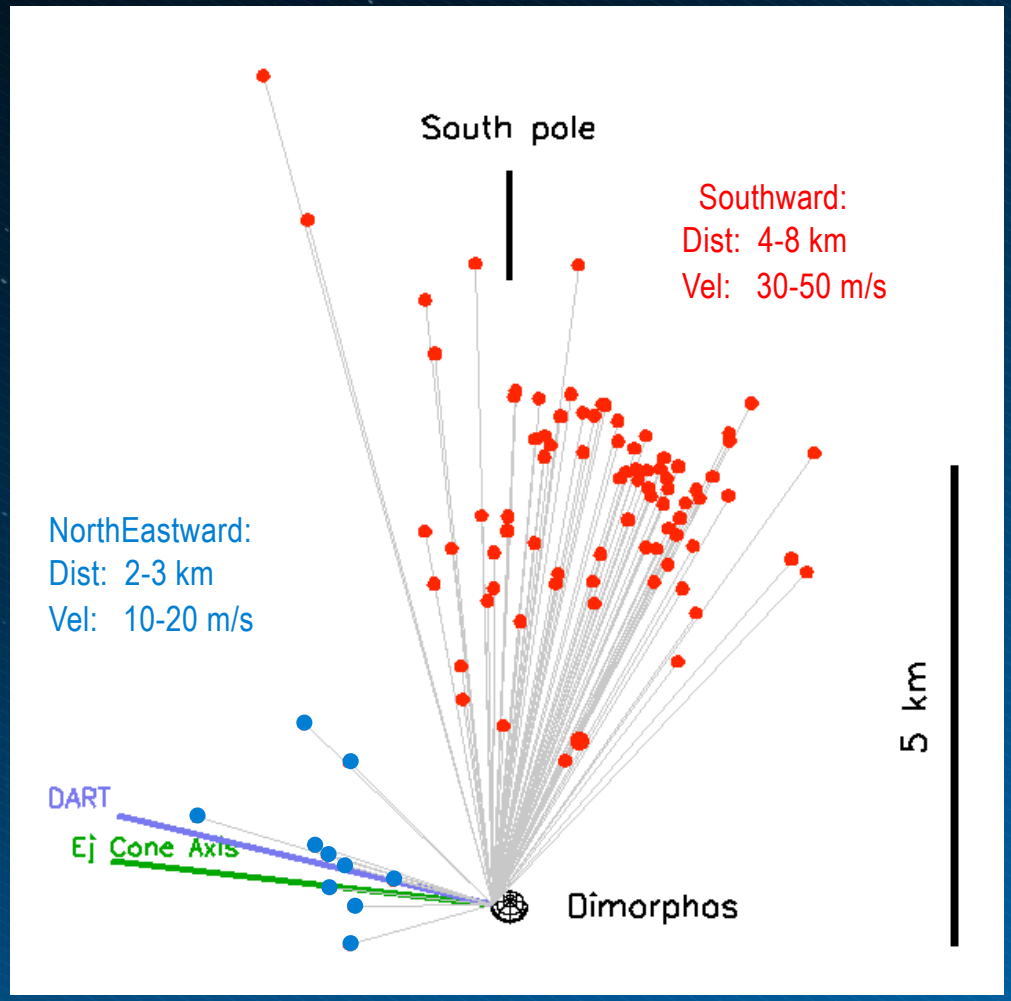
Tracking Boulders

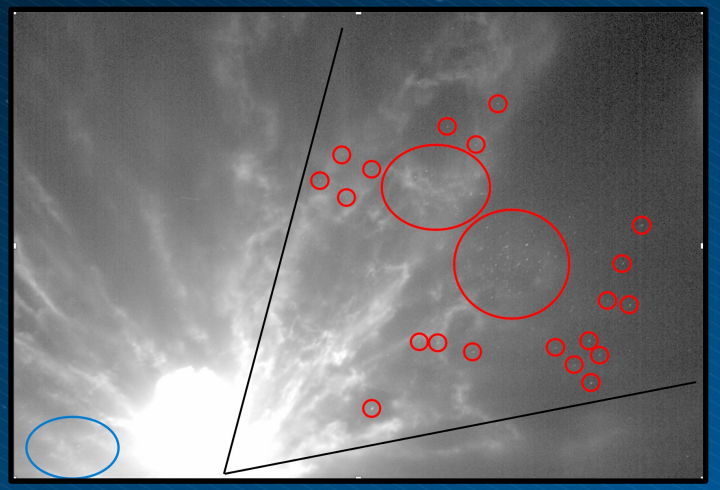
- To date, 91 boulders have been tracked
  - Another 20-30 can be seen in long exposures but are too faint to track
- Paths form characteristic horseshoe shapes

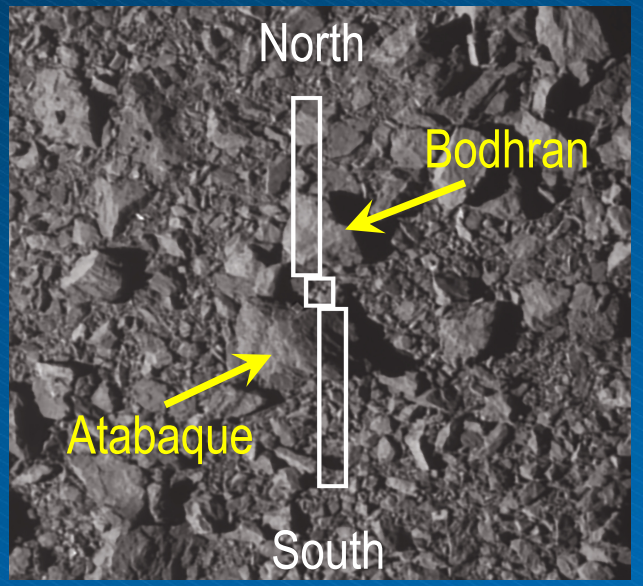


Preliminary Results – Spatial Distribution

- Two populations
  - Large cluster ejected Southward
  - Small cluster ejected NorthEastward
- High velocities for meter-sized boulders
- Preferred directions + experimental results
  - Possibly the remains of boulders Atabaque (S) and Bodhran (NE) ?





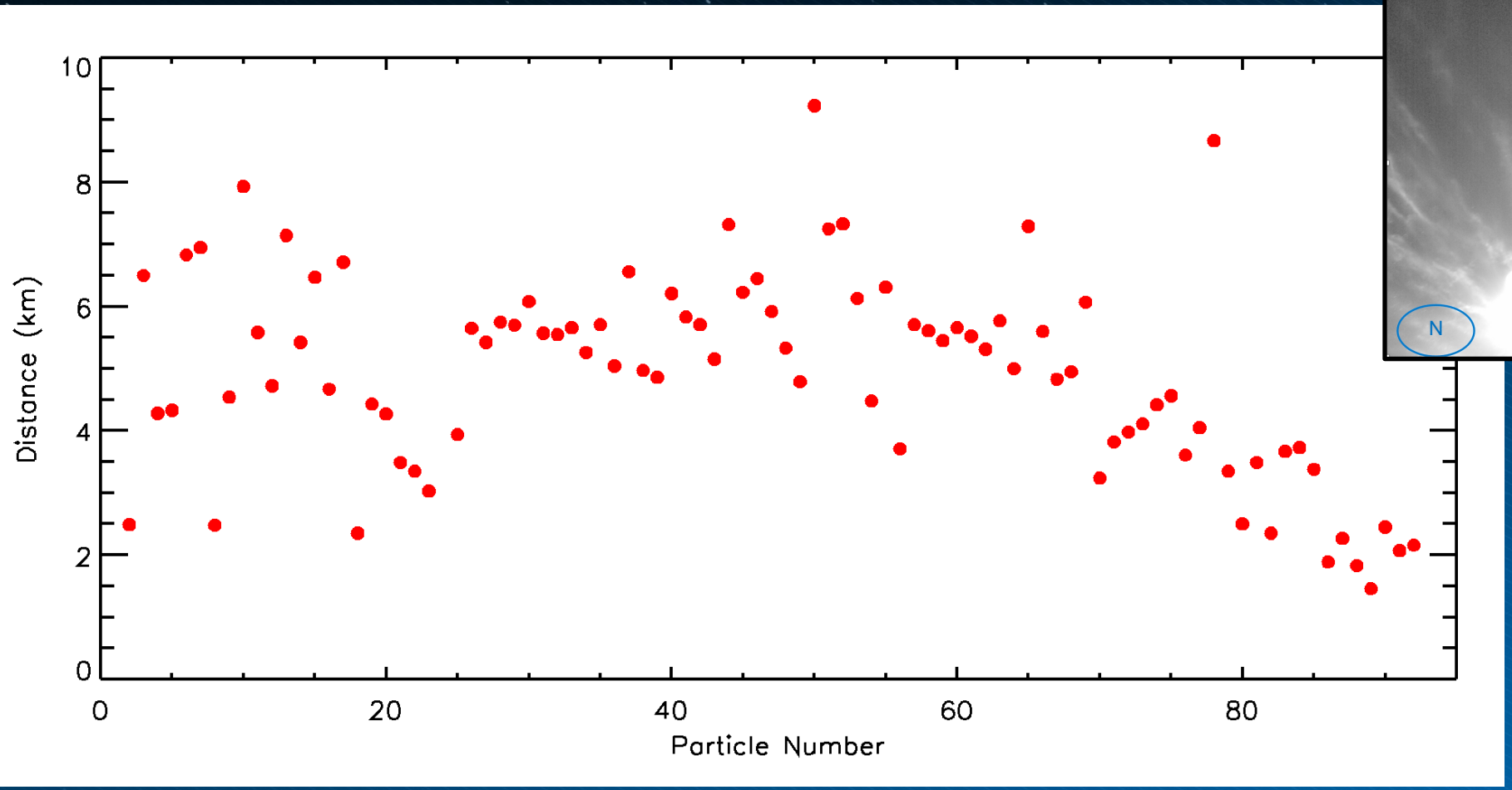


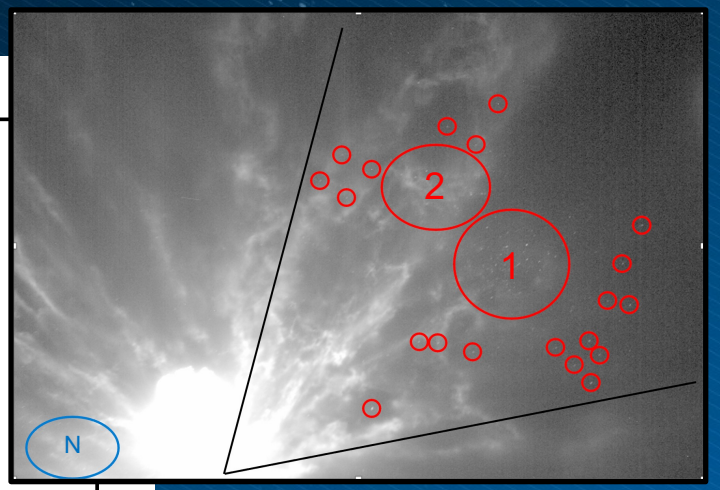
Note the different orientation

Summary

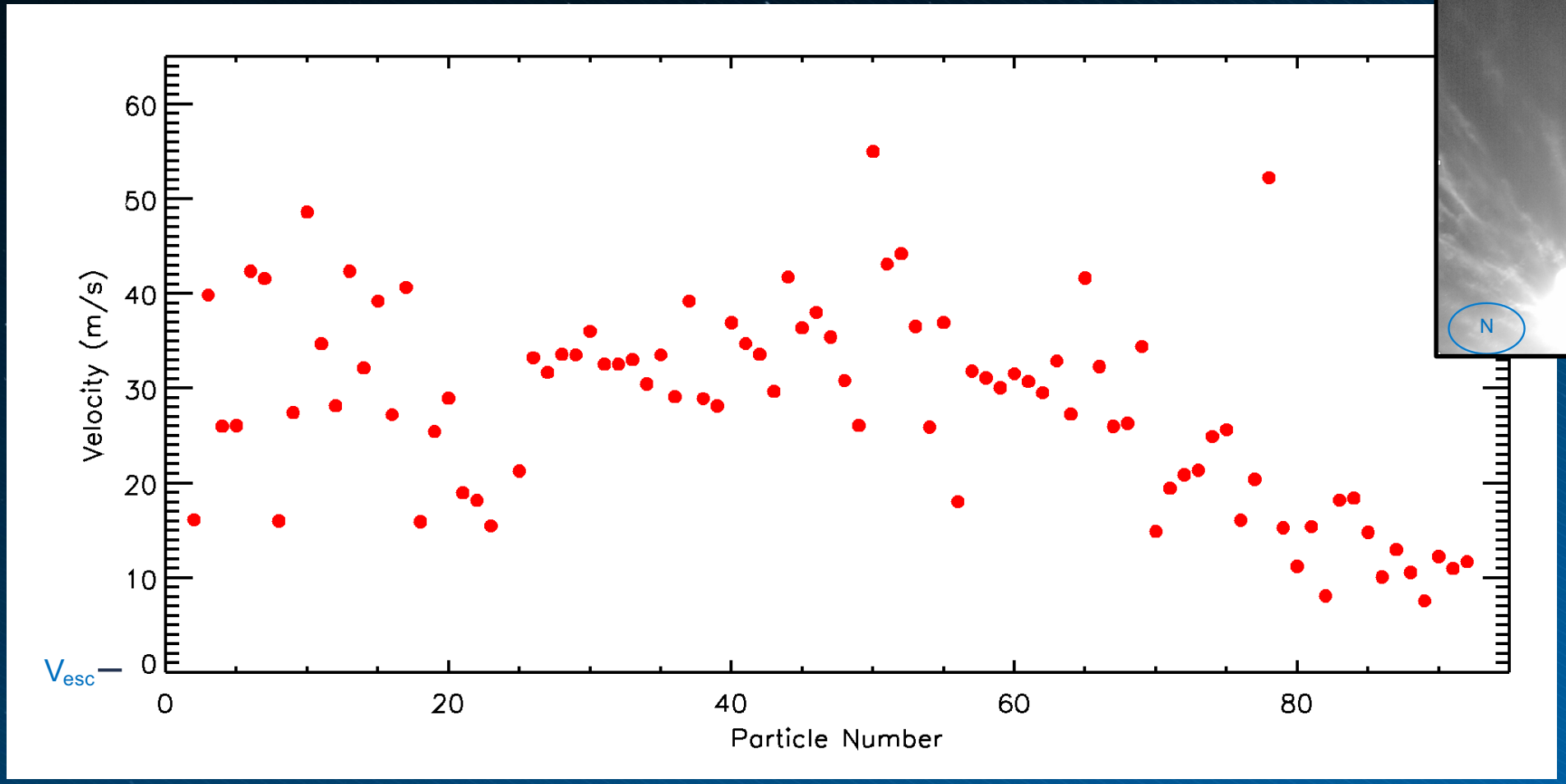
- Results based on tracking of 91 boulders
  - Boulders typically ≤1m in radius
  - Generally divided into two populations / directions
    - Most boulders clustered in Dimorphos' South polar direction
    - A few clustered to the NorthEast direction
- Momentum from measured boulders is likely comparable to DART momentum
  - Primarily to the South, perpendicular to DART's path
  - What are the effects of these components?
    - Dimorphos' rotation, orbital inclination and eccentricity
  - What about boulders in other directions?
- Next up: derive locations of features in the ejecta clouds

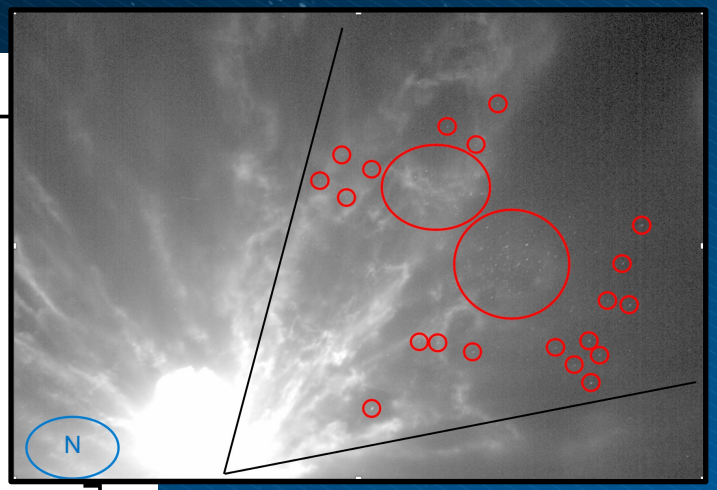
Preliminary Results - Distance





Preliminary Results - Velocity





Velocity = Distance / 167 sec