Consequences of Asteroid Characterization on the State of Knowledge about Inferred Physical Properties & Impact Risk

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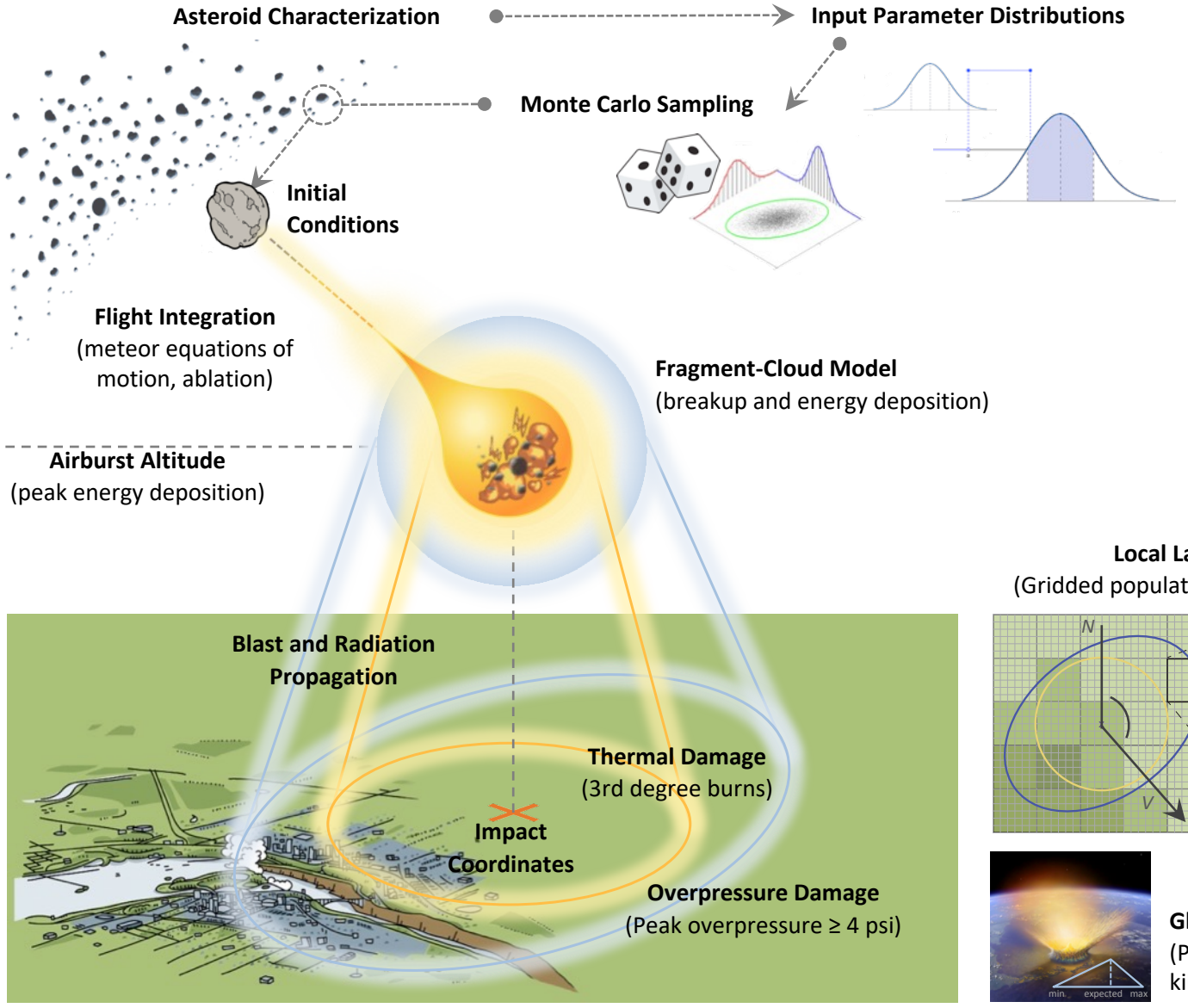
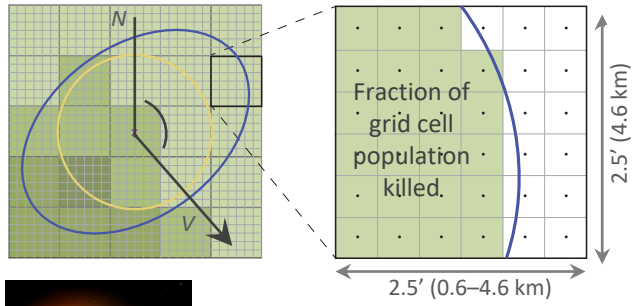
Probabilistic Asteroid Impact Risk Model



PHA Measurements
- H-magnitude
- Albedo
- Orbital trajectory
- Asteroid class
- Composition

Impact Parameters
- Diameter
- Density
- Strength
- Porosity
- Luminous efficiency
- Velocity
- Entry angle
- Azimuth angle
- Impact coordinates

Local Land Impact Casualties
(Gridded population within largest damage area)



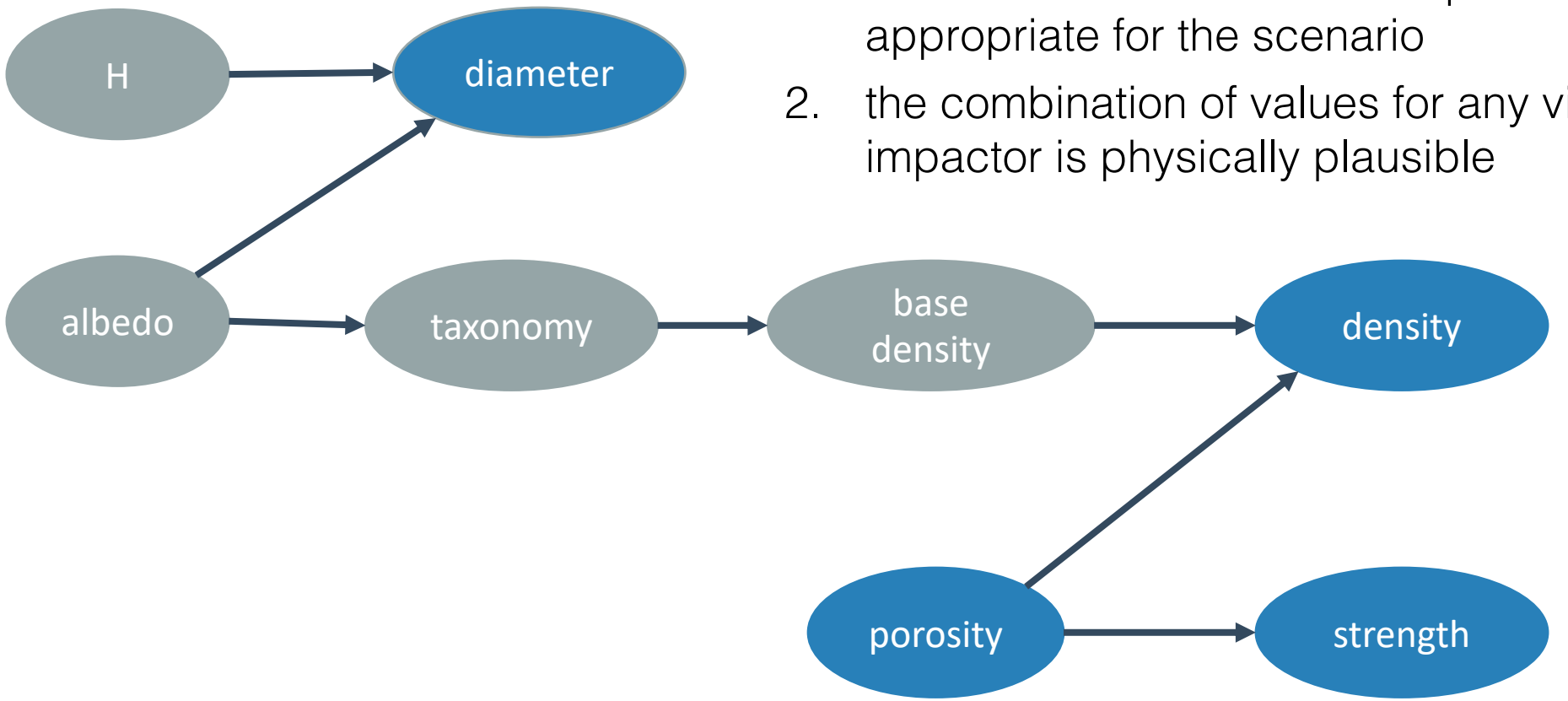
Global Effects Casualties
(Percentage world population killed by climatic effects)

Asteroid Physical Property Risk Model Inputs

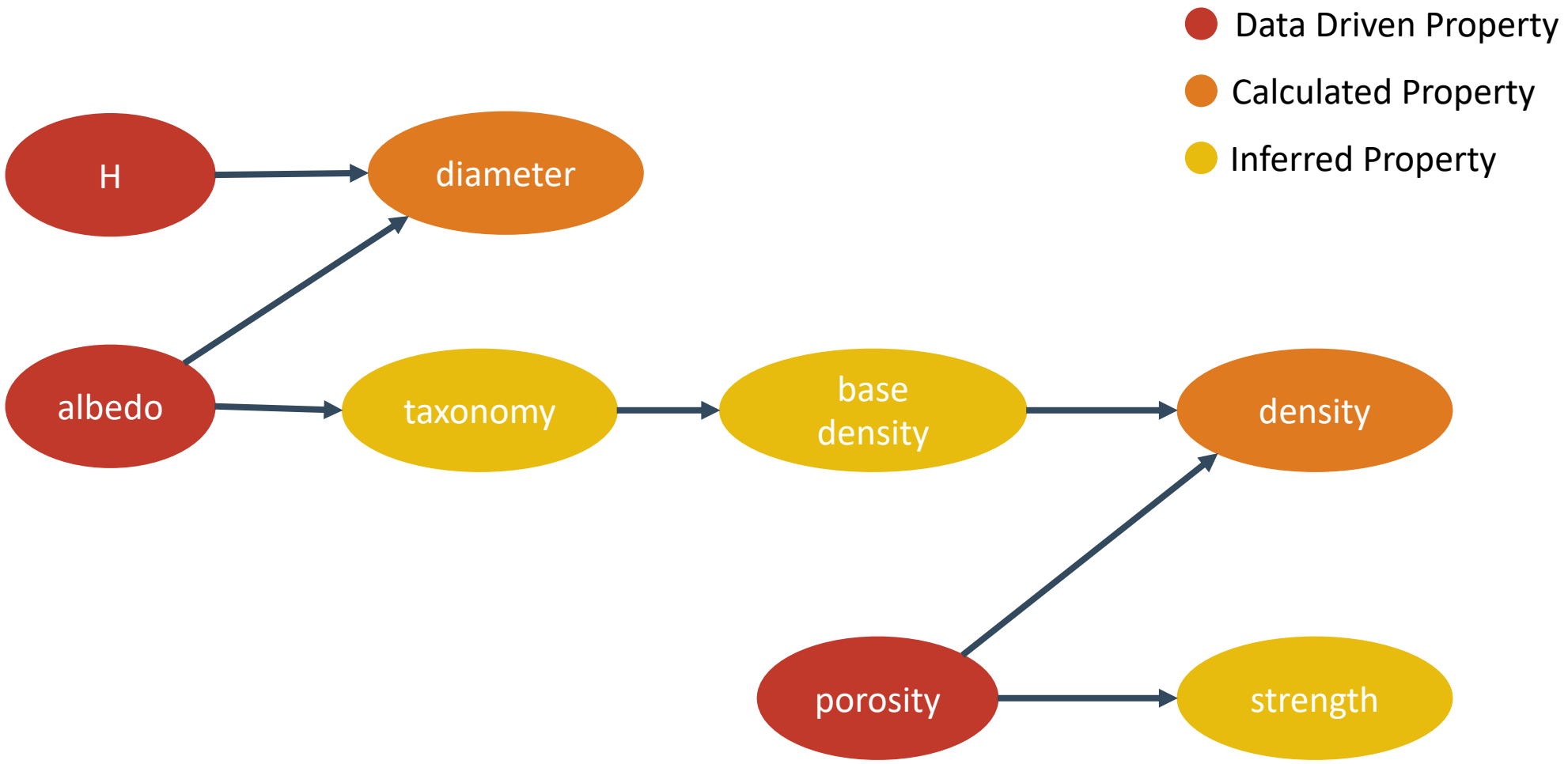
Asteroid Physical Property Inference Network

Goal: generate virtual impactors such that

1. the distribution of values are plausible and appropriate for the scenario
2. the combination of values for any virtual impactor is physically plausible



Asteroid Physical Property Inference Network



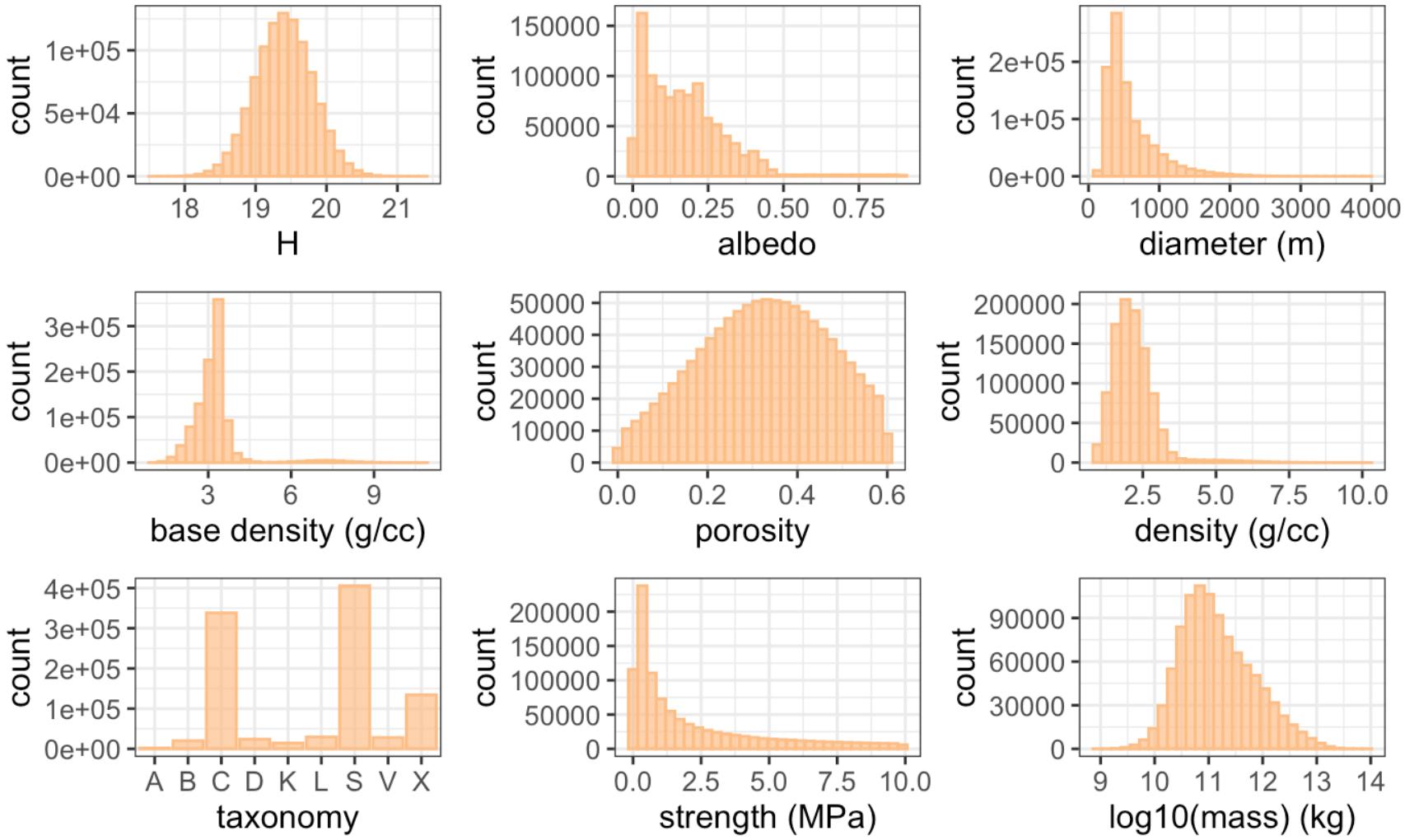
Hypothetical Scenario -- PDC 2023

Generated properties for 4 epochs

- Epoch 1: Discovery
  - H = 19.4 ± 0.4
- Epoch 2: PDC23 remains faint, ~ 22mag
  - g, r, and i band colors
  - H = 19.3 ± 0.4
- Epoch 3: Fly-by mission characterization available
  - Effective diameter = 700 ± 150m
  - C-type taxonomy
- Epoch 4: Rendezvous mission characterization
  - Effective diameter = 800 ± 0.25m
  - Mass 5.3e11 ± 0.007e11 kg

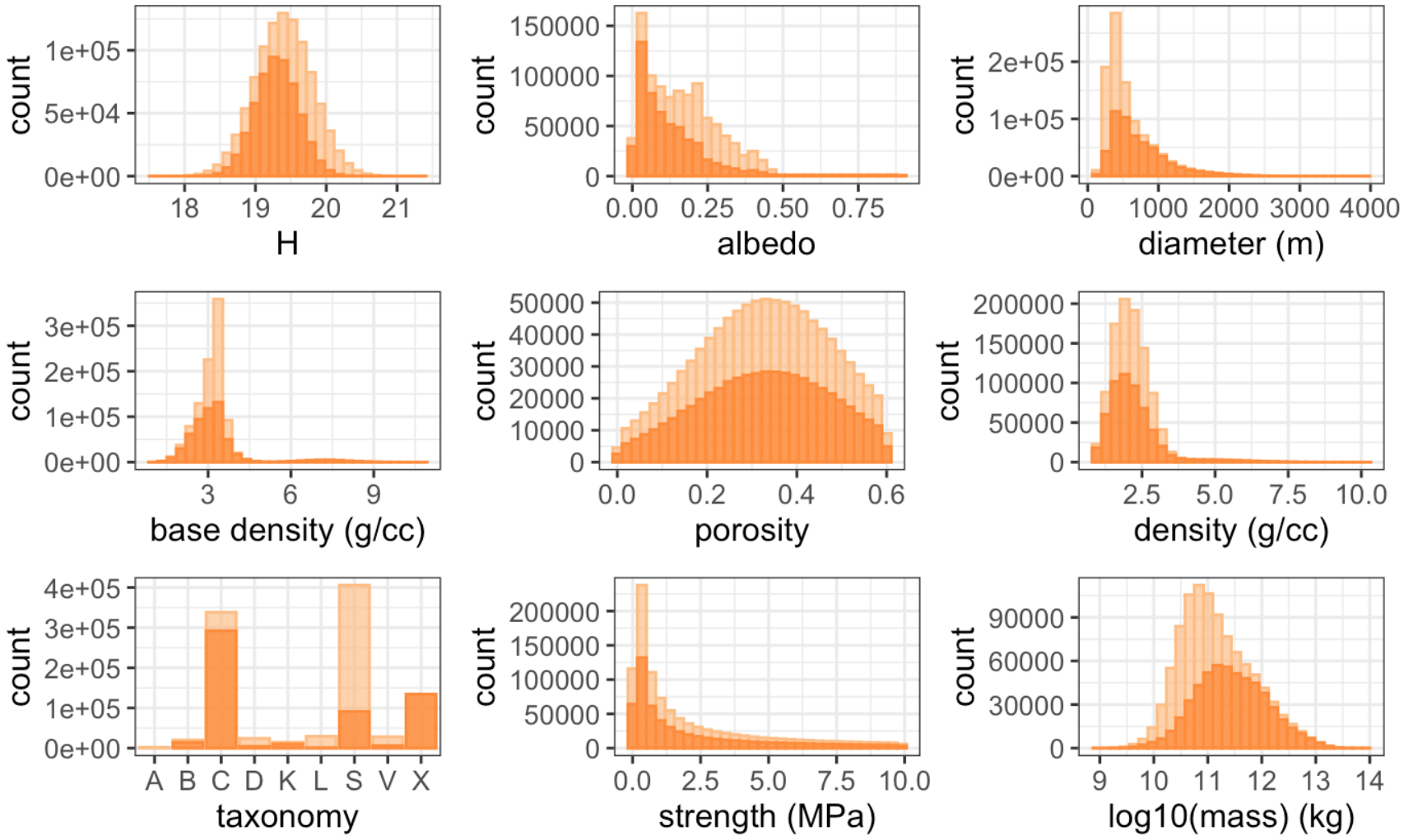
Physical Property Distributions

Epoch 1 → H magnitude



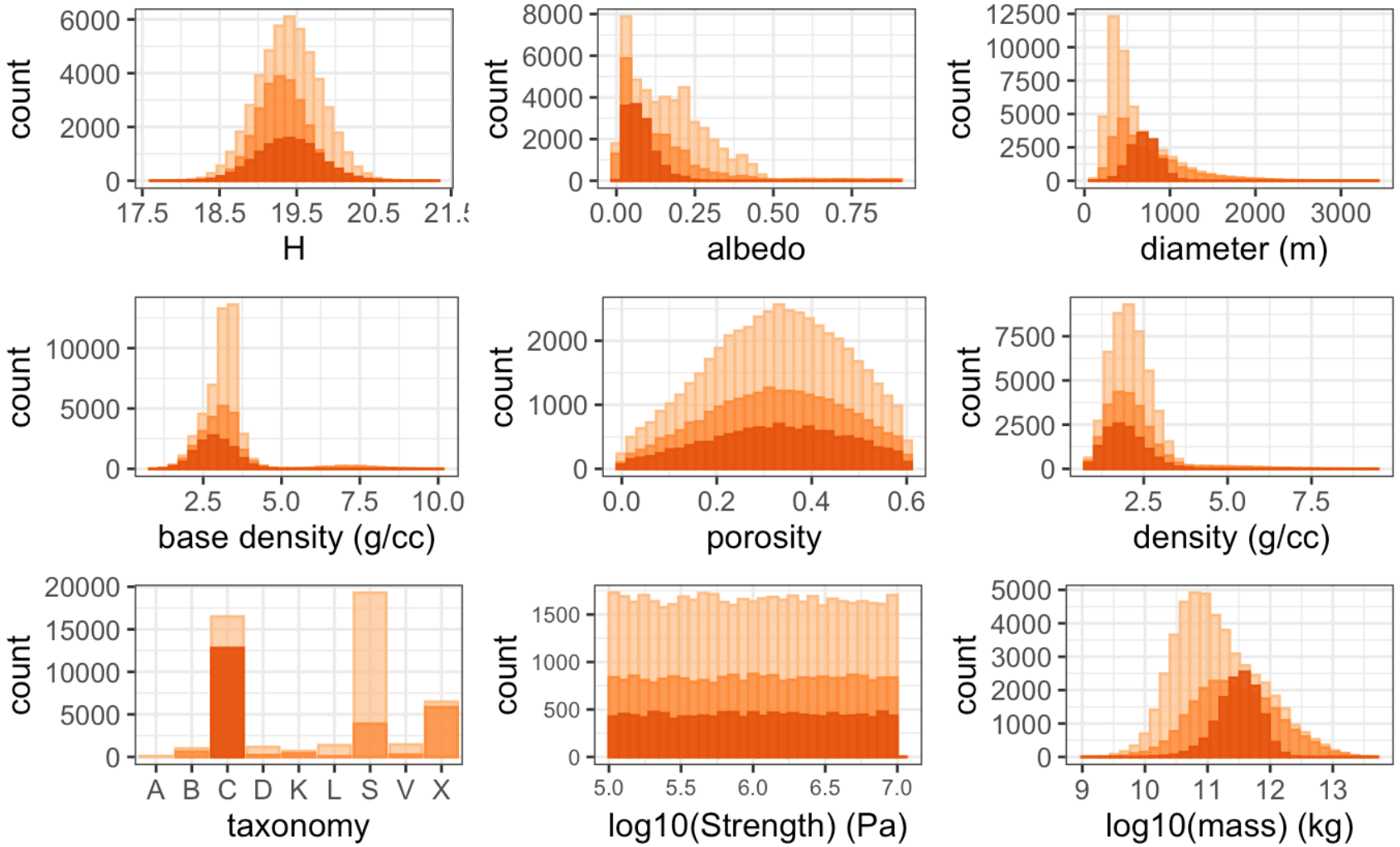
Physical Property Distributions

Epoch 2 → Photometric Colors

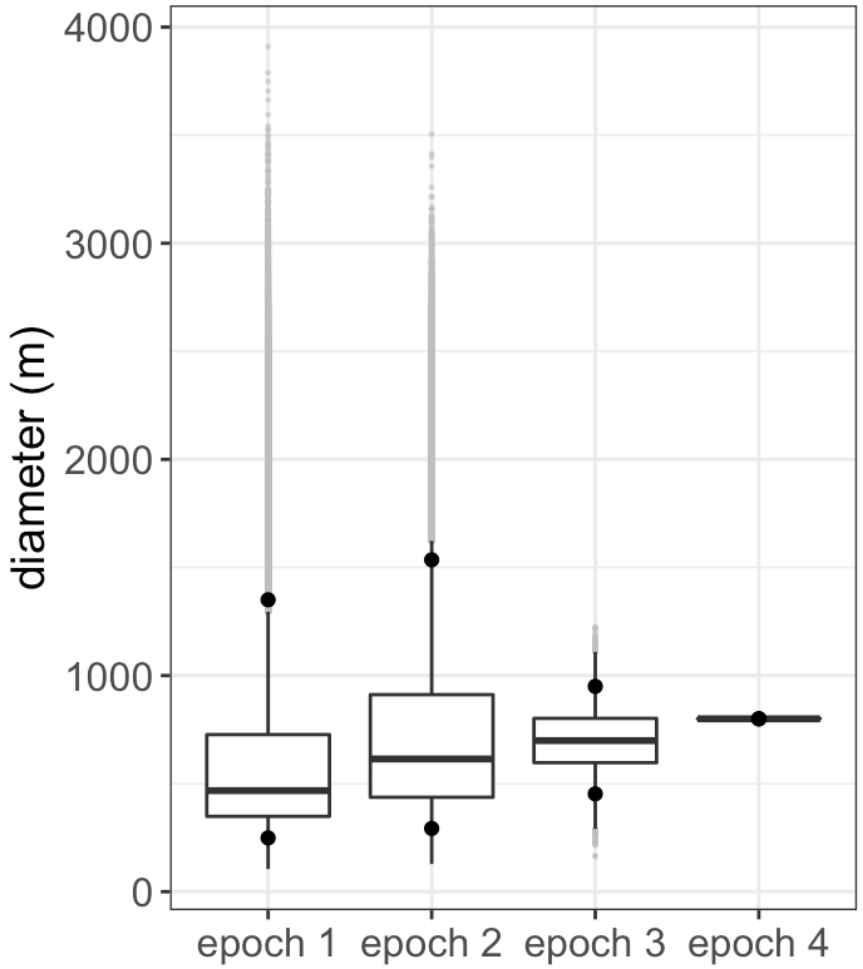


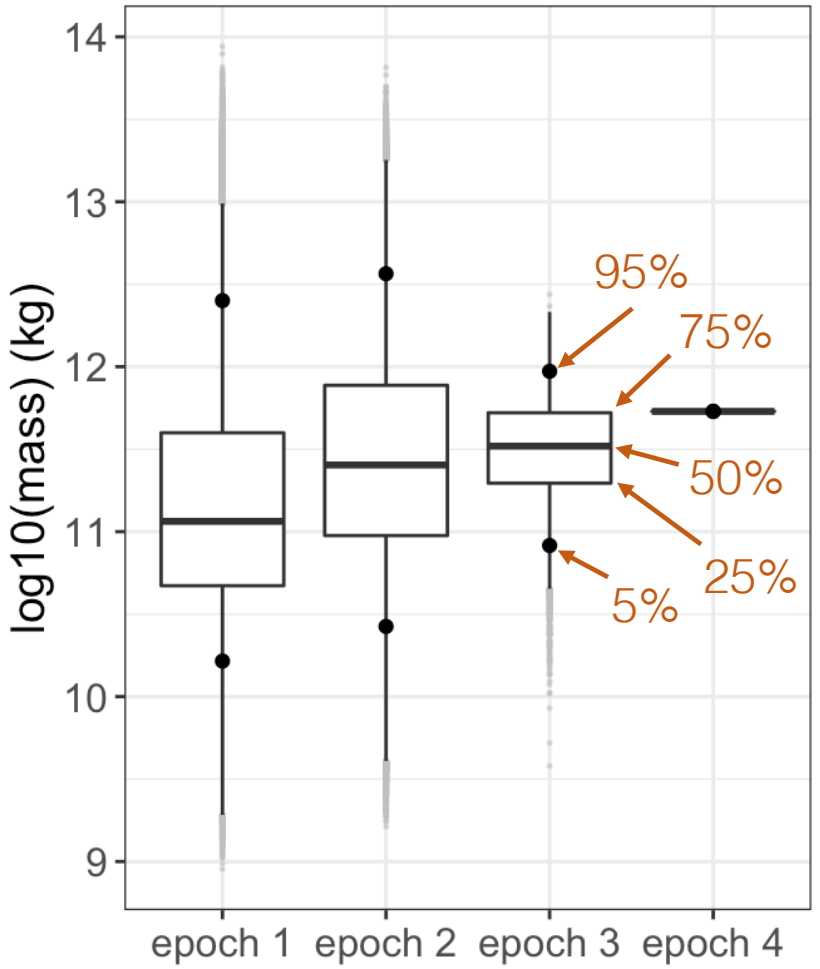
Physical Property Distributions

Epoch 3 → Fast Fly-by Mission



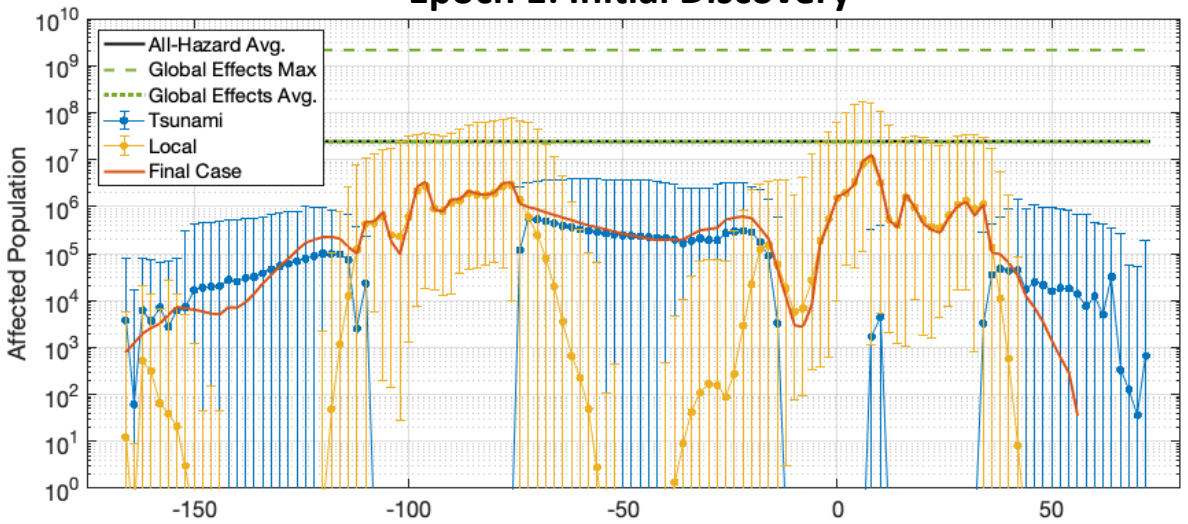
Mass & Diameter – all Epochs



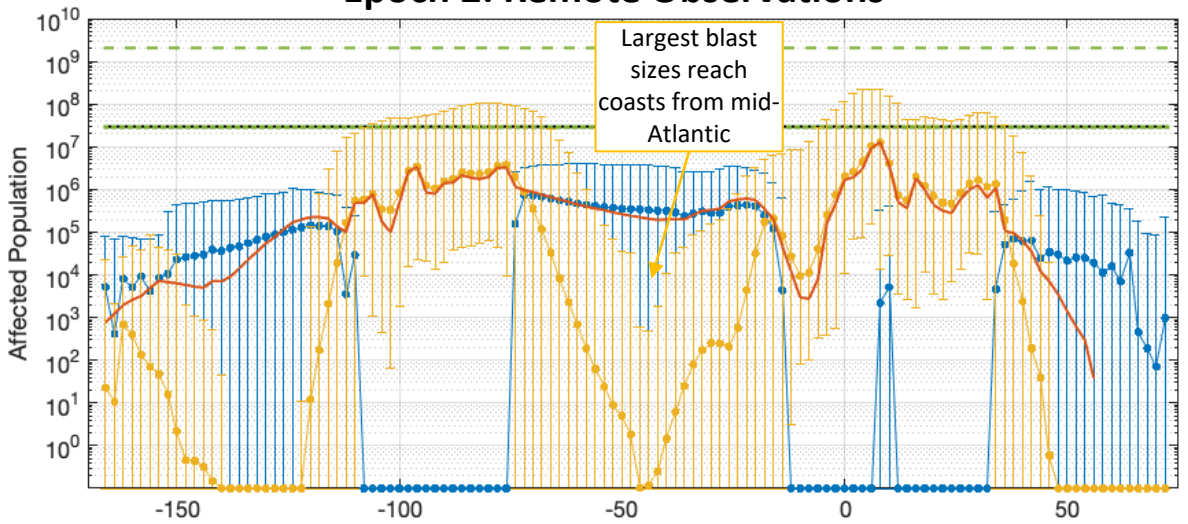


Affected Population Ranges along Impact Swath: Effects of Asteroid Property Refinements among Scenario Epochs

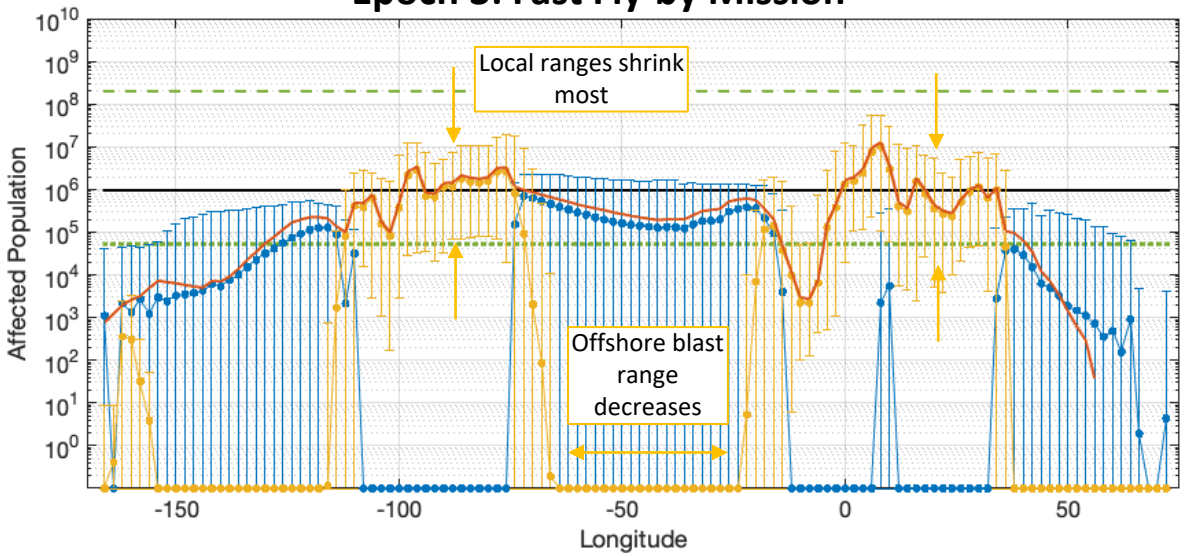
Epoch 1: Initial Discovery



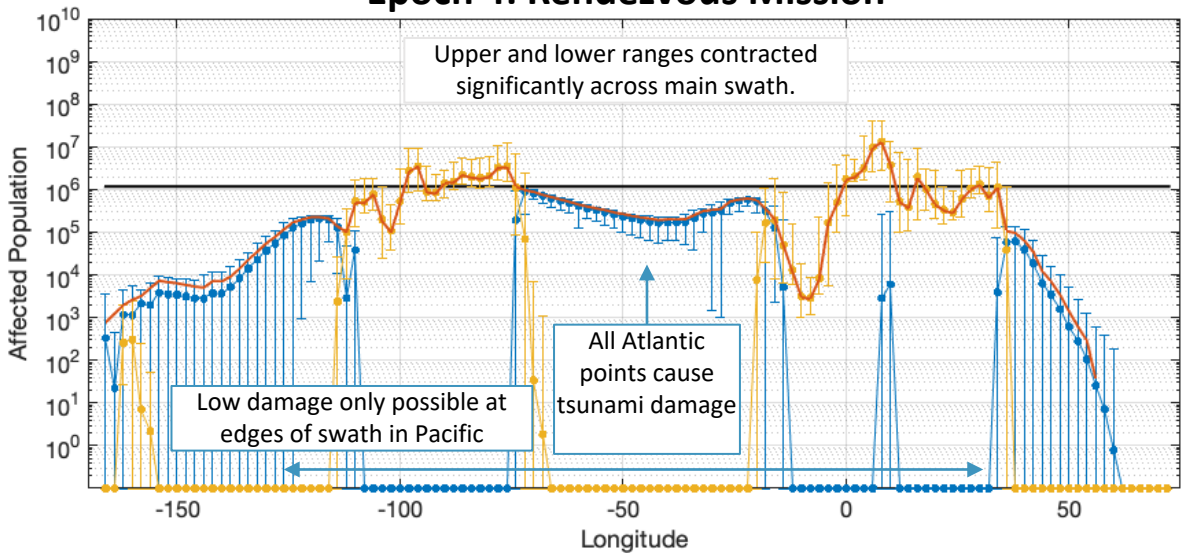
Epoch 2: Remote Observations



Epoch 3: Fast Fly-by Mission



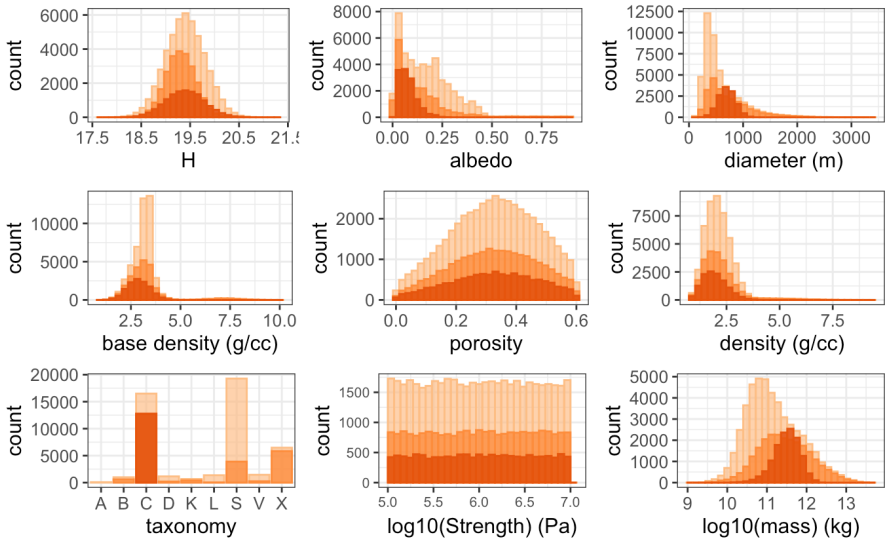
Epoch 4: Rendezvous Mission

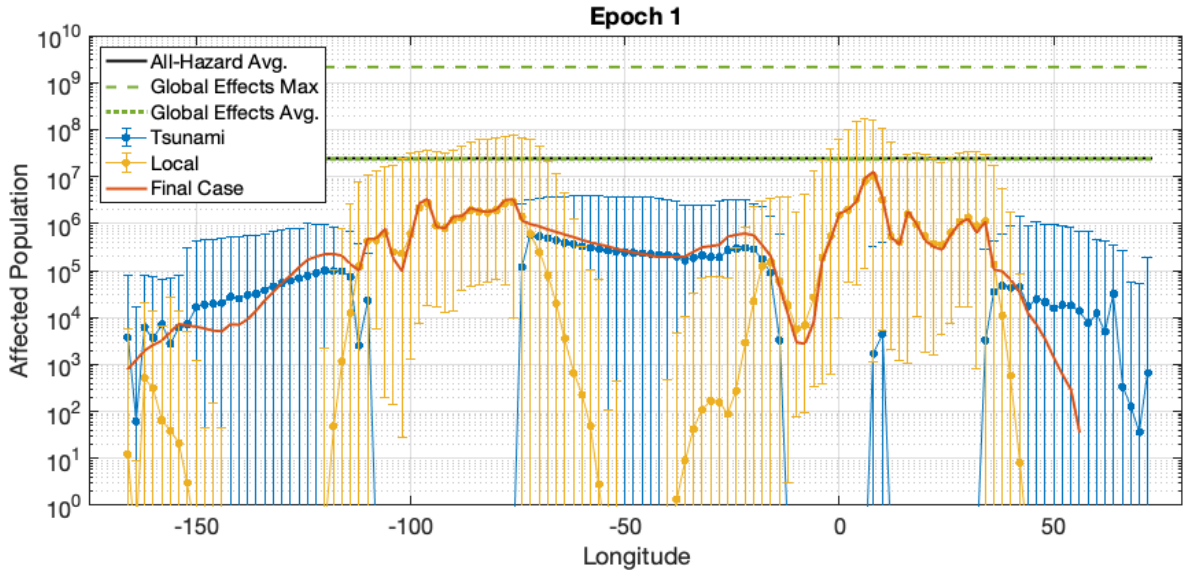


HYPOTHETICAL EXERCISE

Asteroid Physical Property Generation

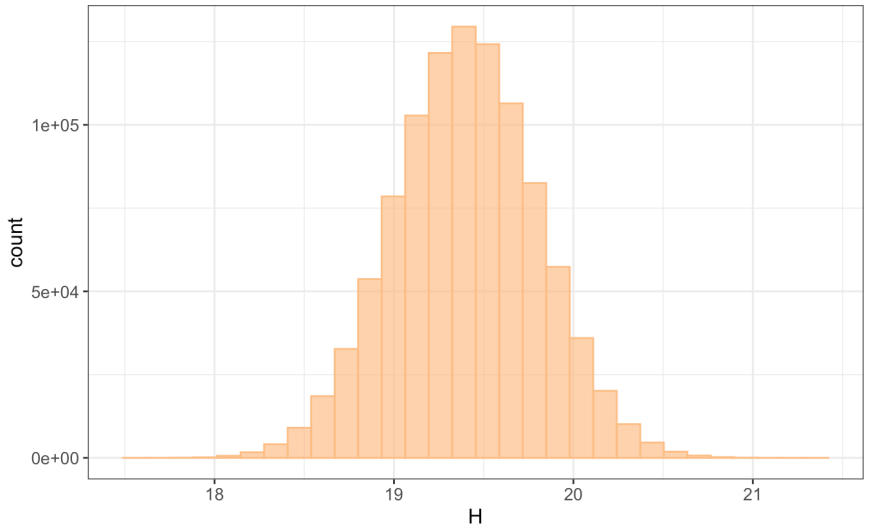
- Generates virtual impactors such that the distribution of their physical properties and the combination of values for any impactor are physically plausible using a combination of data driven nodes, calculated nodes, and inferred nodes.
- Population's properties can be adjusted as new measurements become available, reflecting the change in state of knowledge while maintaining physically plausible combinations of parameters.
- Inference network produces physical properties needed for risk modeling.

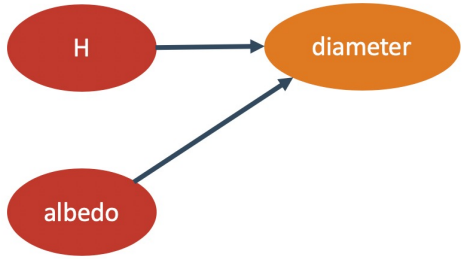




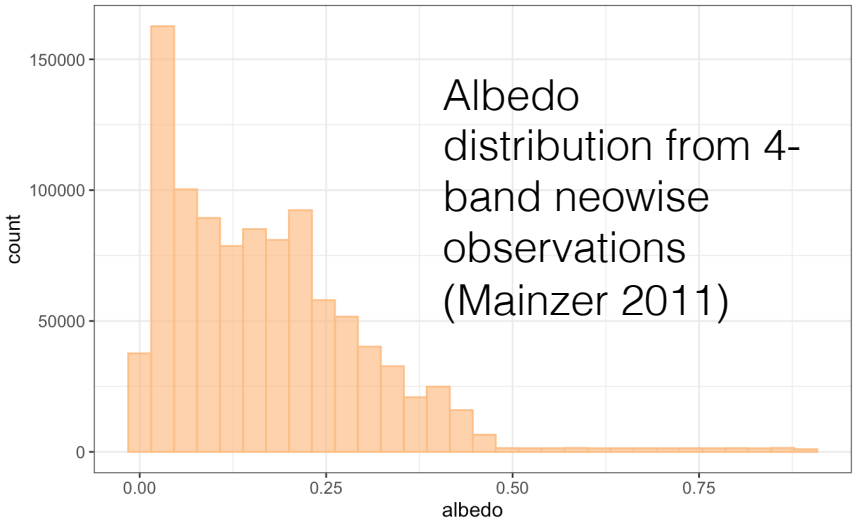
Backup

Diameter

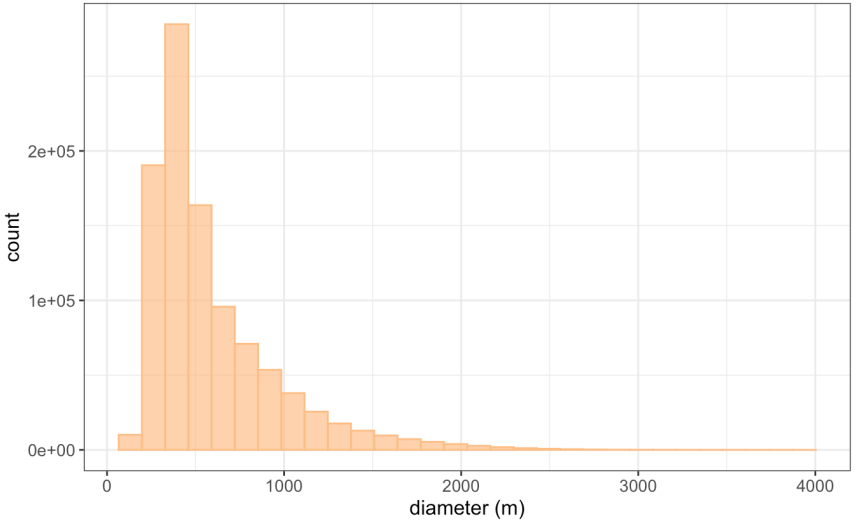




$$D\ (km) = 1329\ * 10^{-0.2H/\sqrt{albedo}}$$



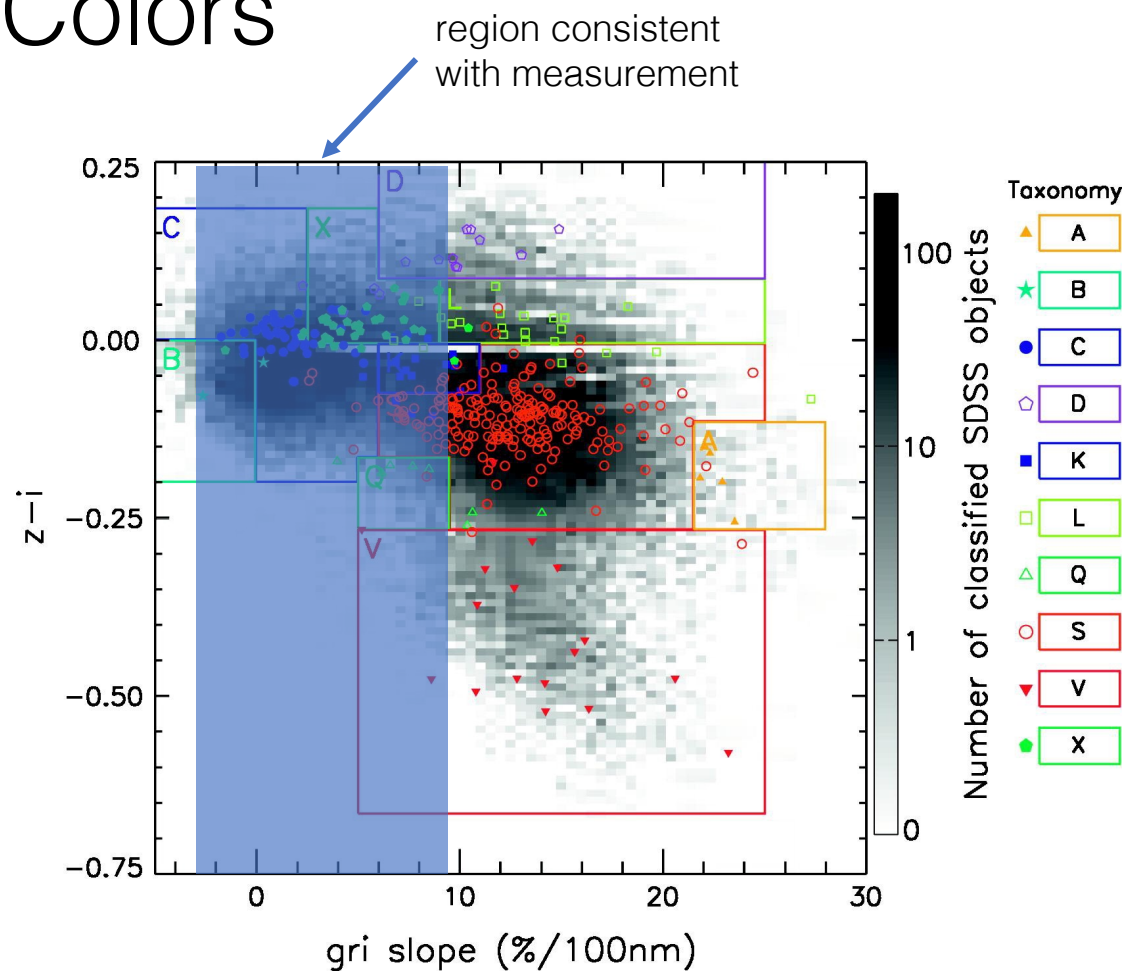
Albedo distribution from 4-band neowise observations (Mainzer 2011)



Epoch 2 measurement – Asteroid Colors

PDC23's visible magnitude is ~ 22mag or fainter

- Spectra would be challenging, but color photometry is accessible with a ~5m (or larger) telescope
- The color measurements don't specify a single taxonomy, but does rule out some completely, and make others less likely.



Color to Taxonomy mapping from DeMeo & Carry 2013