The Effect of Prior Knowledge on Planetary Defense Scenario Risk Assessments

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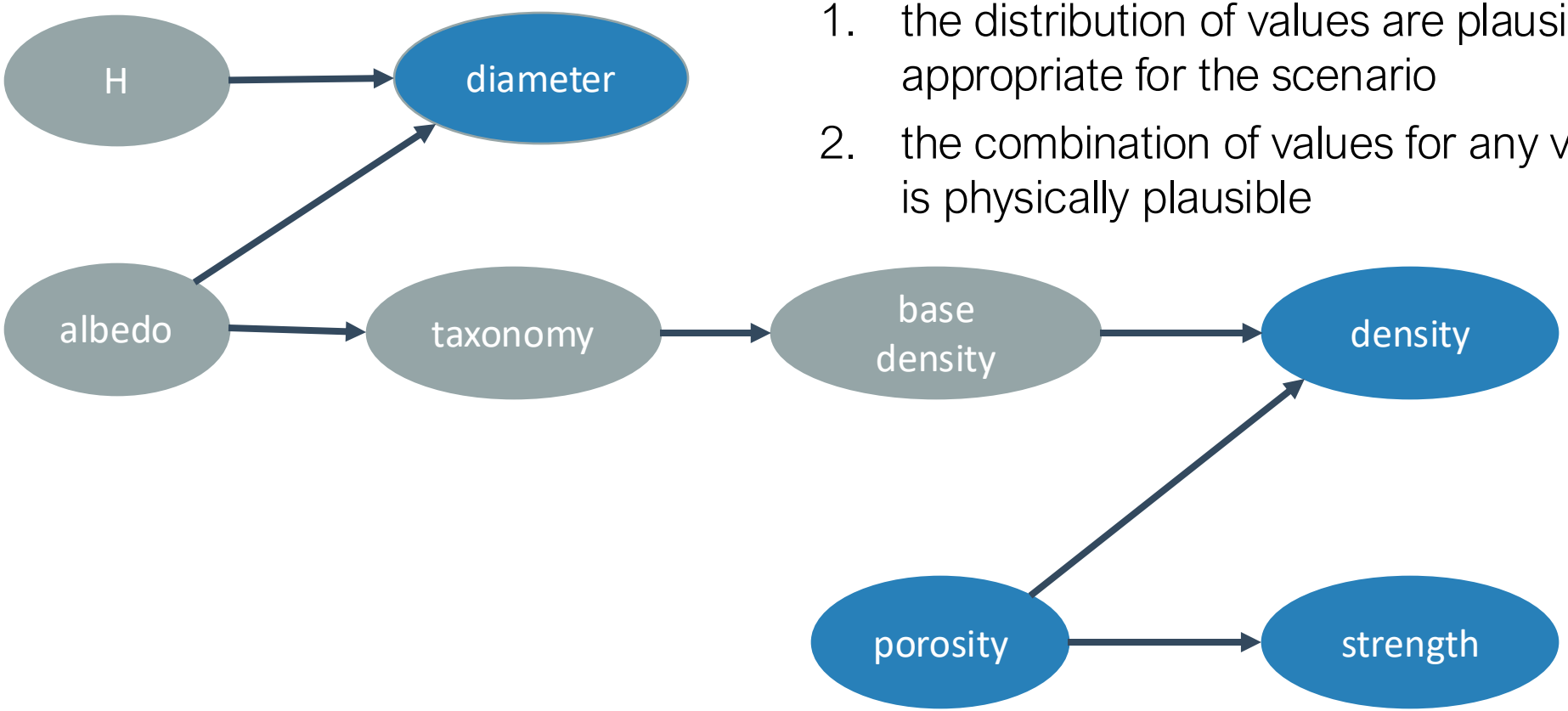
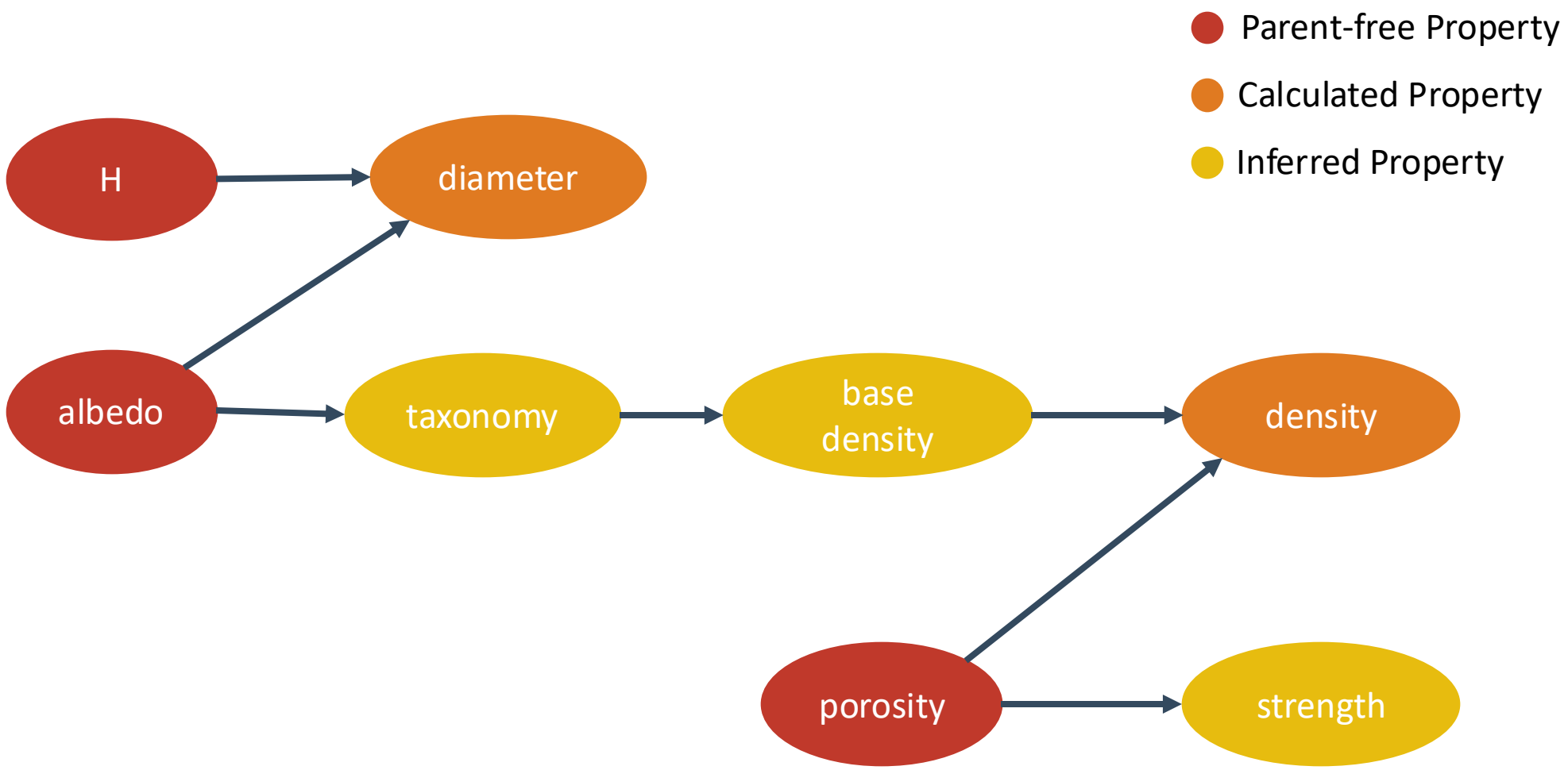
Asteroid Physical Property Inference Network

Goal: generate virtual impactors for risk assessment and mission design such that

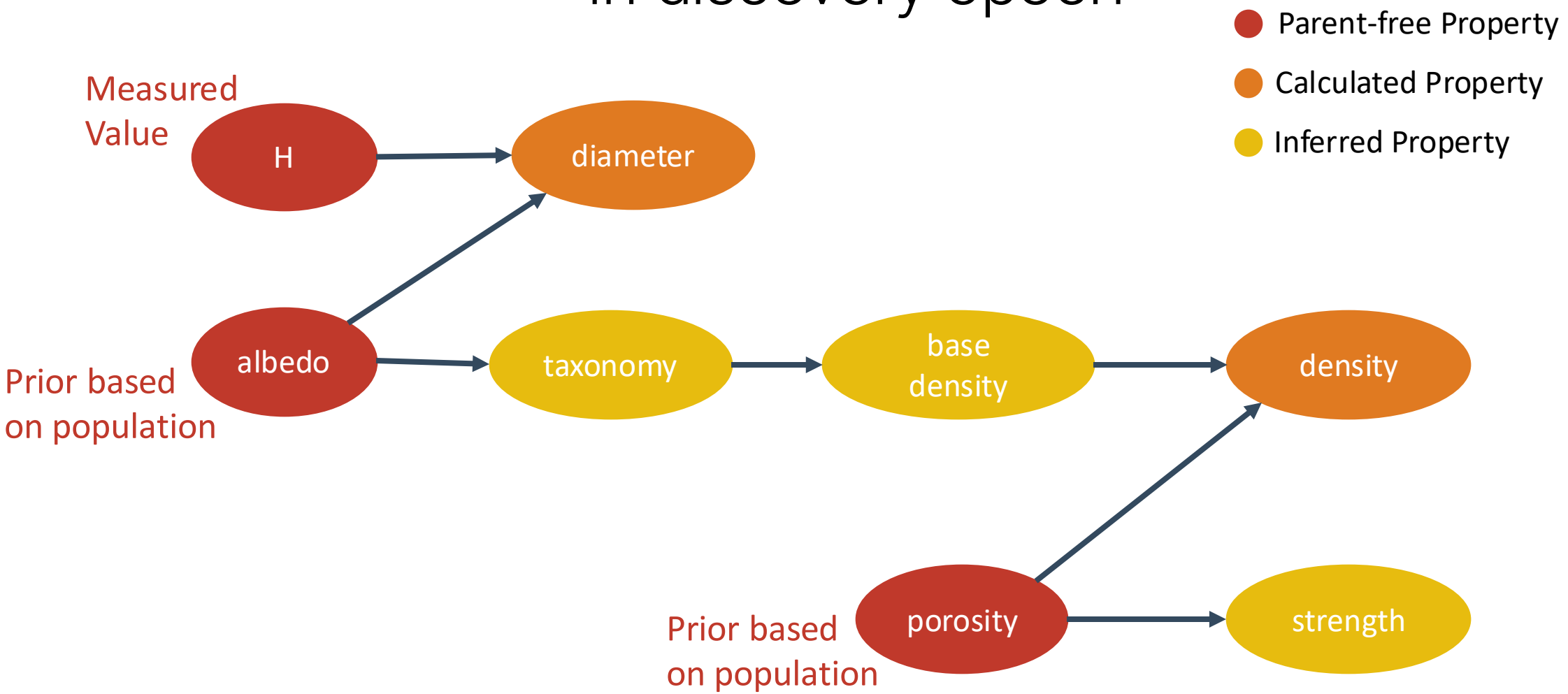
1. the distribution of values are plausible and appropriate for the scenario
2. the combination of values for any virtual impactor is physically plausible



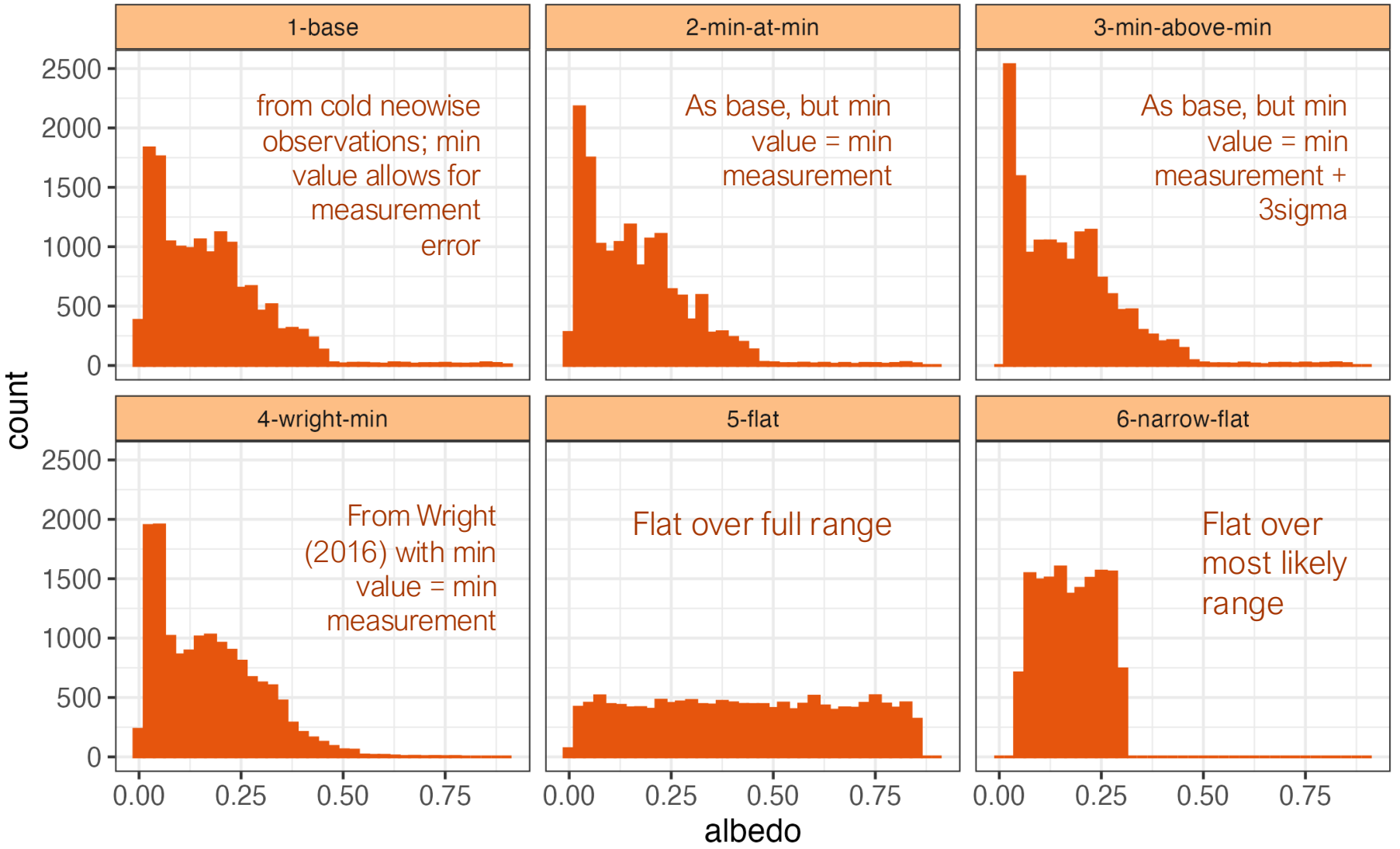
Asteroid Physical Property Inference Network



Asteroid Physical Property Inference Network in discovery epoch



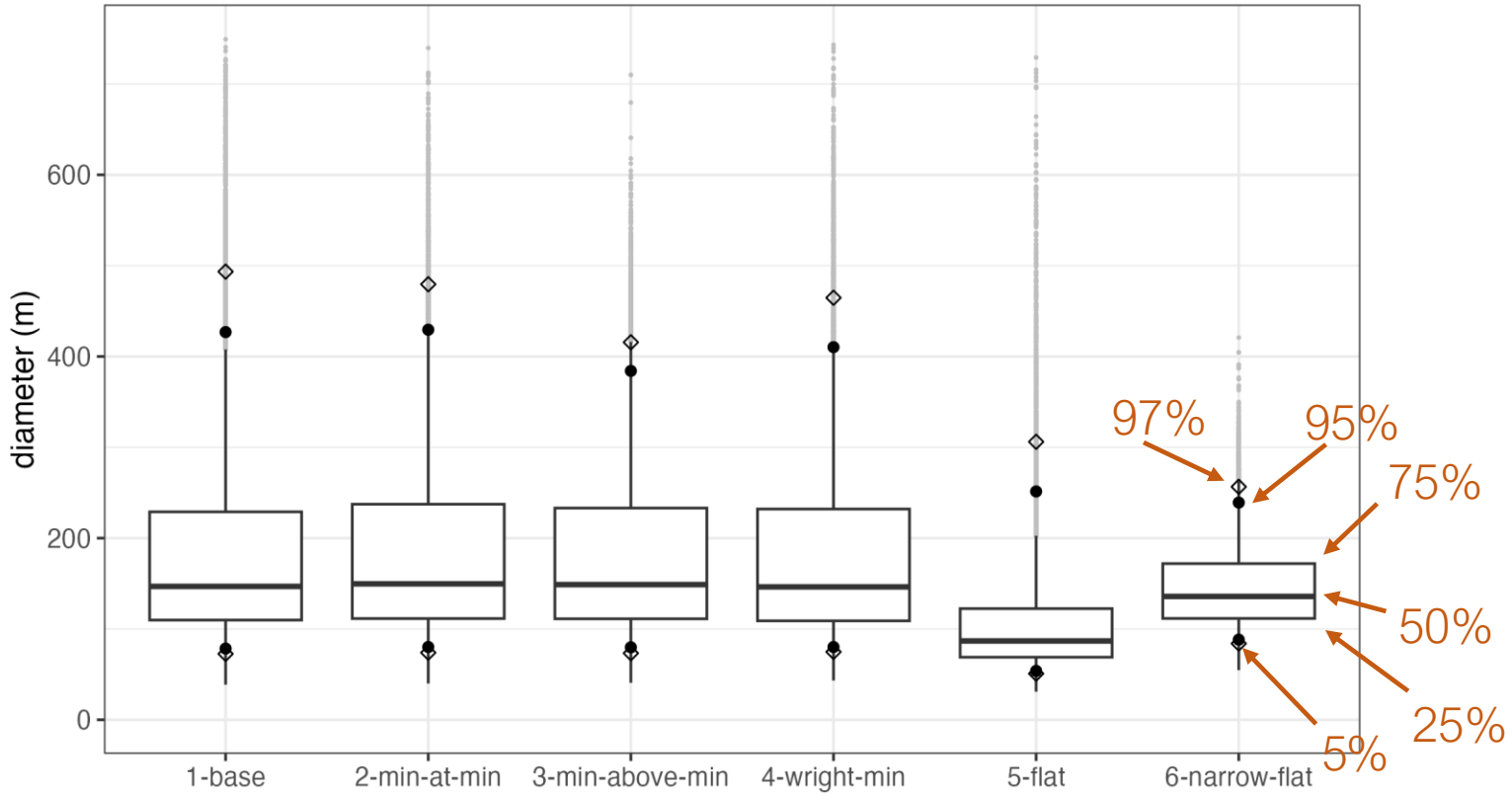
Candidate Albedo Priors



Diameter Results for Different Albedo Priors

Extremes of distribution depend on limits and shape of priors

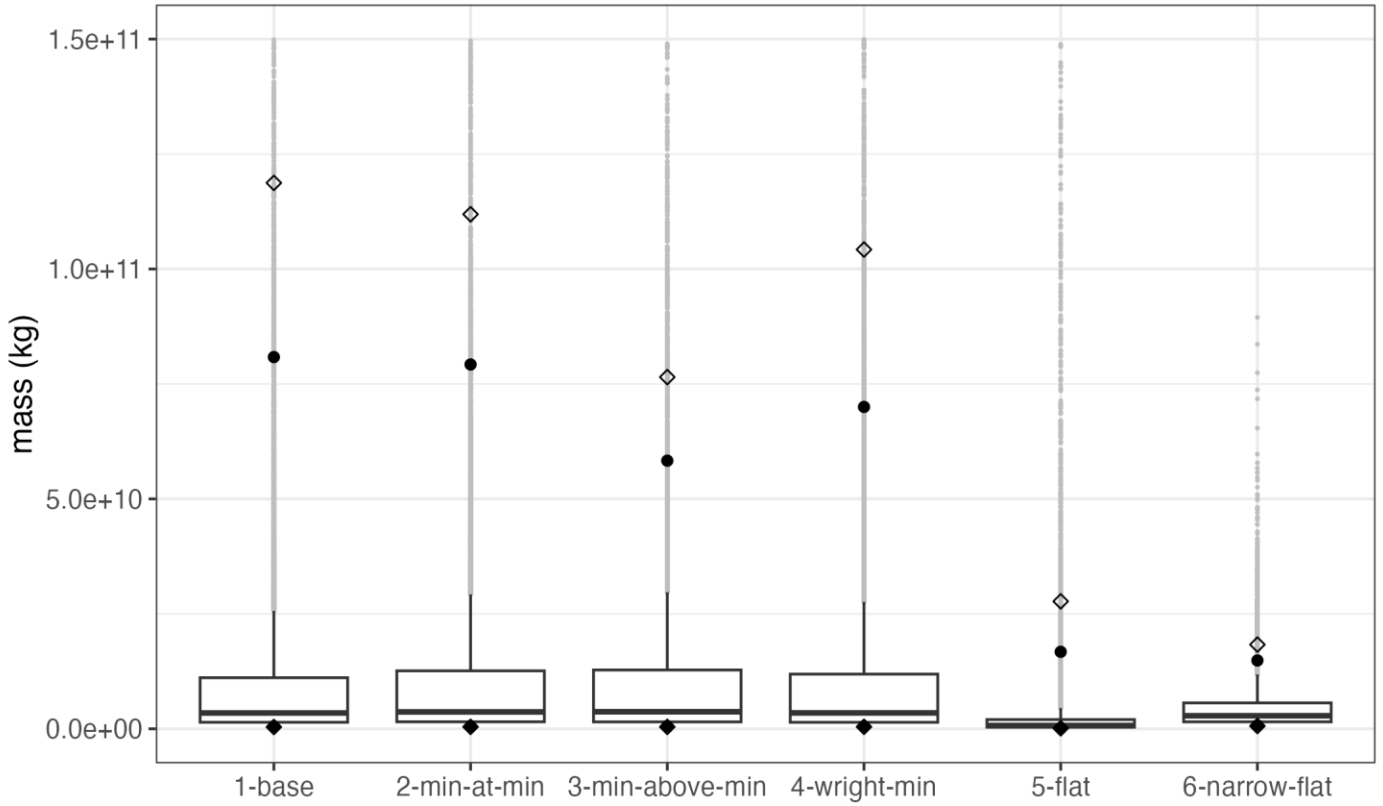
Central portion of distribution depends on shape of prior



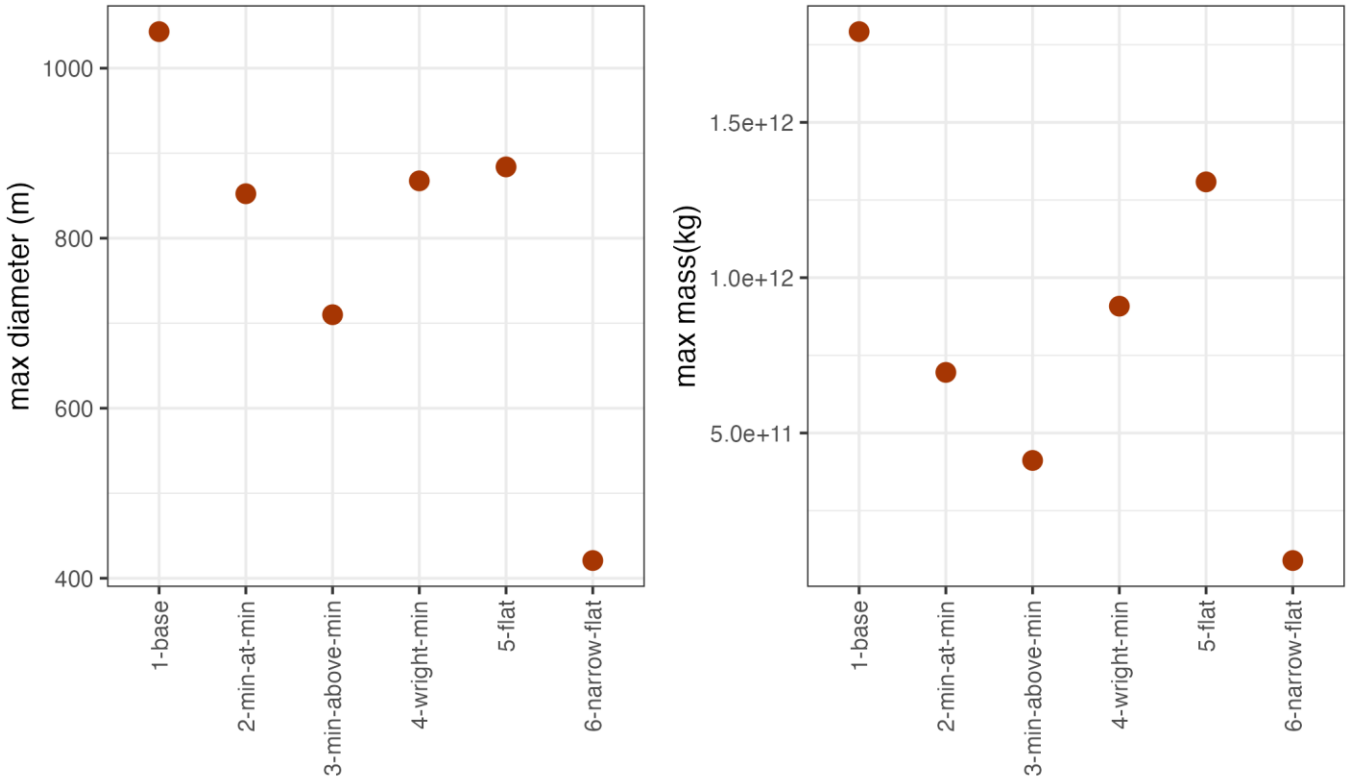
Mass Results for Different Albedo Priors

Extremes of distribution depend on limits and shape of priors

Central portion of distribution depends on shape of prior



Max Values for Different Albedo Priors



Max values depend on limits and shape of priors
(as well as sampling noise…)

What's the **correct** albedo prior in the discovery epoch?

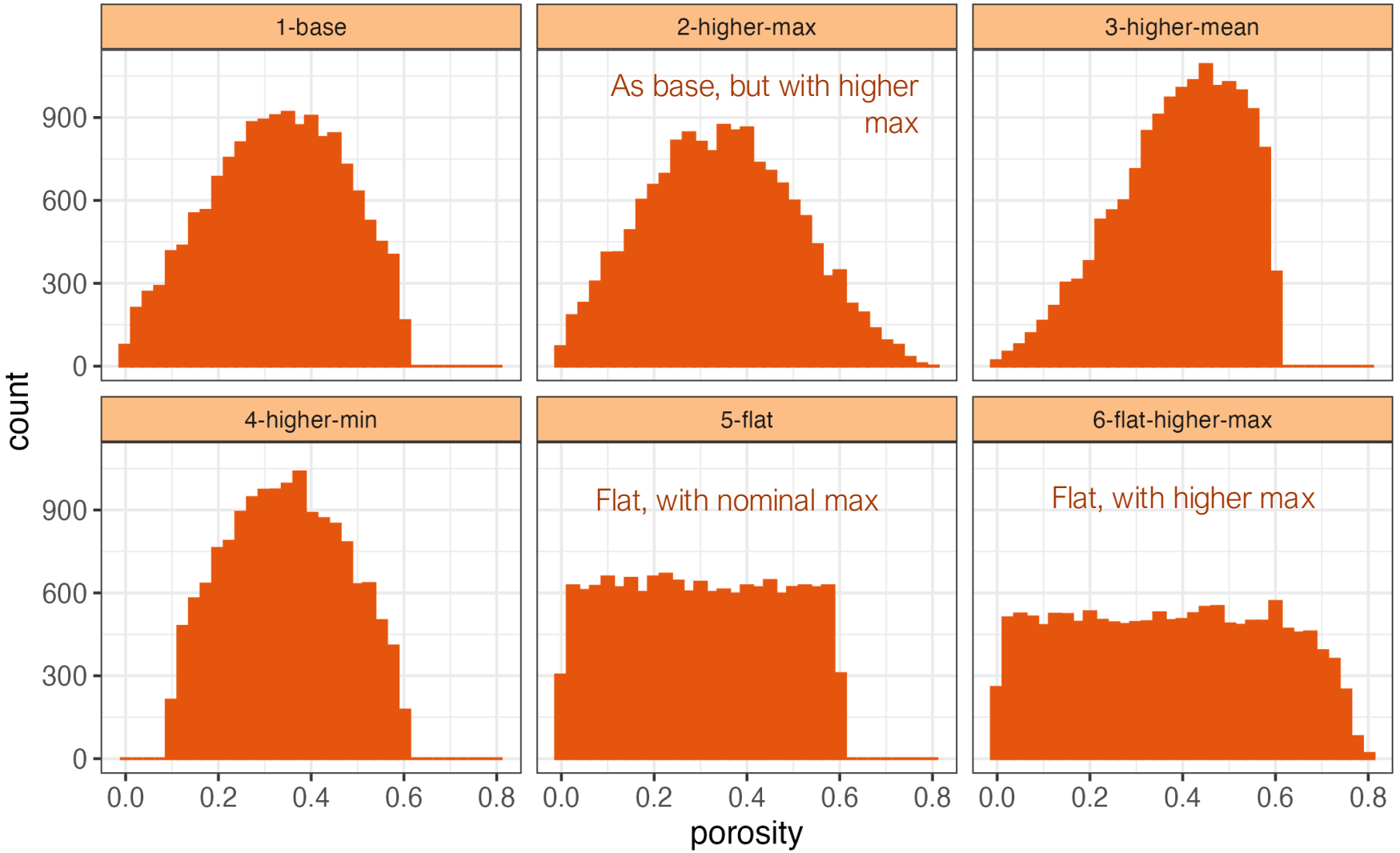
It depends on your goals and risk posture…

Main goal	Requirements on Albedo Prior	Easy to do?
Understand the central case	minimal	Yes! This is easy!
Understand the bulk of the distribution	Shape of prior is important, the limits are less important	Harder, but we have the data to do this
Understand most of the cases	Shape and limits of prior are important	Difficulty depends on extent of the range of interest
Understand the full range of possible cases	Shape and limits of prior are very important	Establishing correct limits is very difficult

Candidate Porosity Priors

Truncated gaussian based on main belt observations

As base, but with higher minimum value

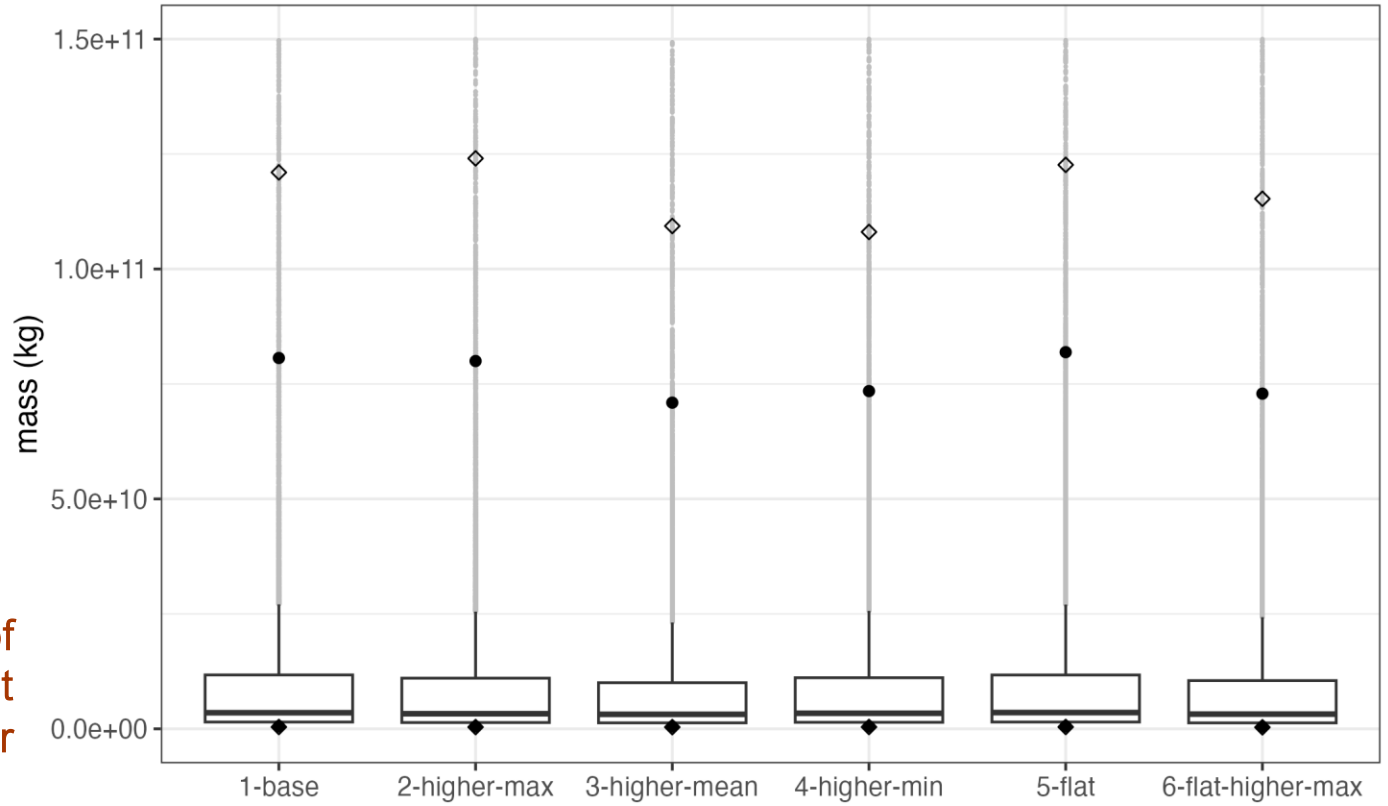


Truncated gaussian with higher mean

Mass Results for Different Porosity Priors

Extremes of distribution depend on limits and shape of priors

Central portion of distribution doesn't depend on porosity prior

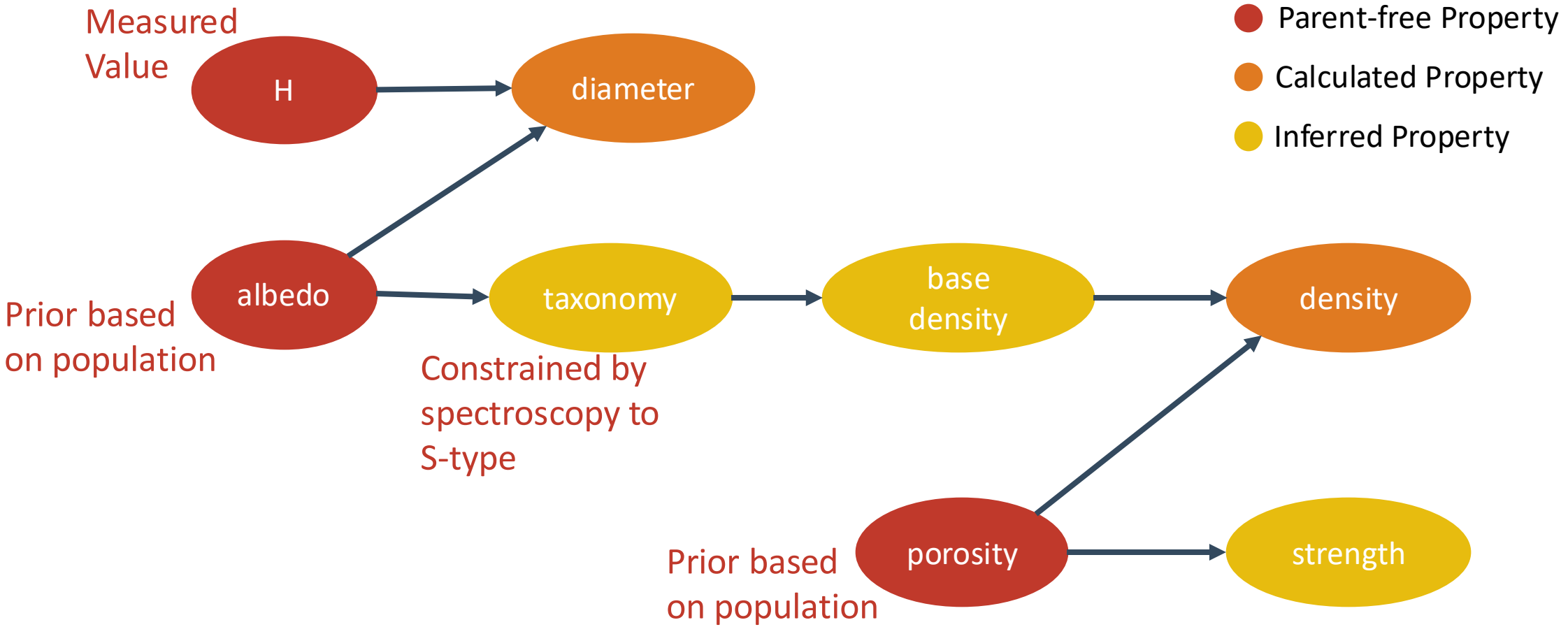


What's the **correct** porosity prior in the discovery epoch?

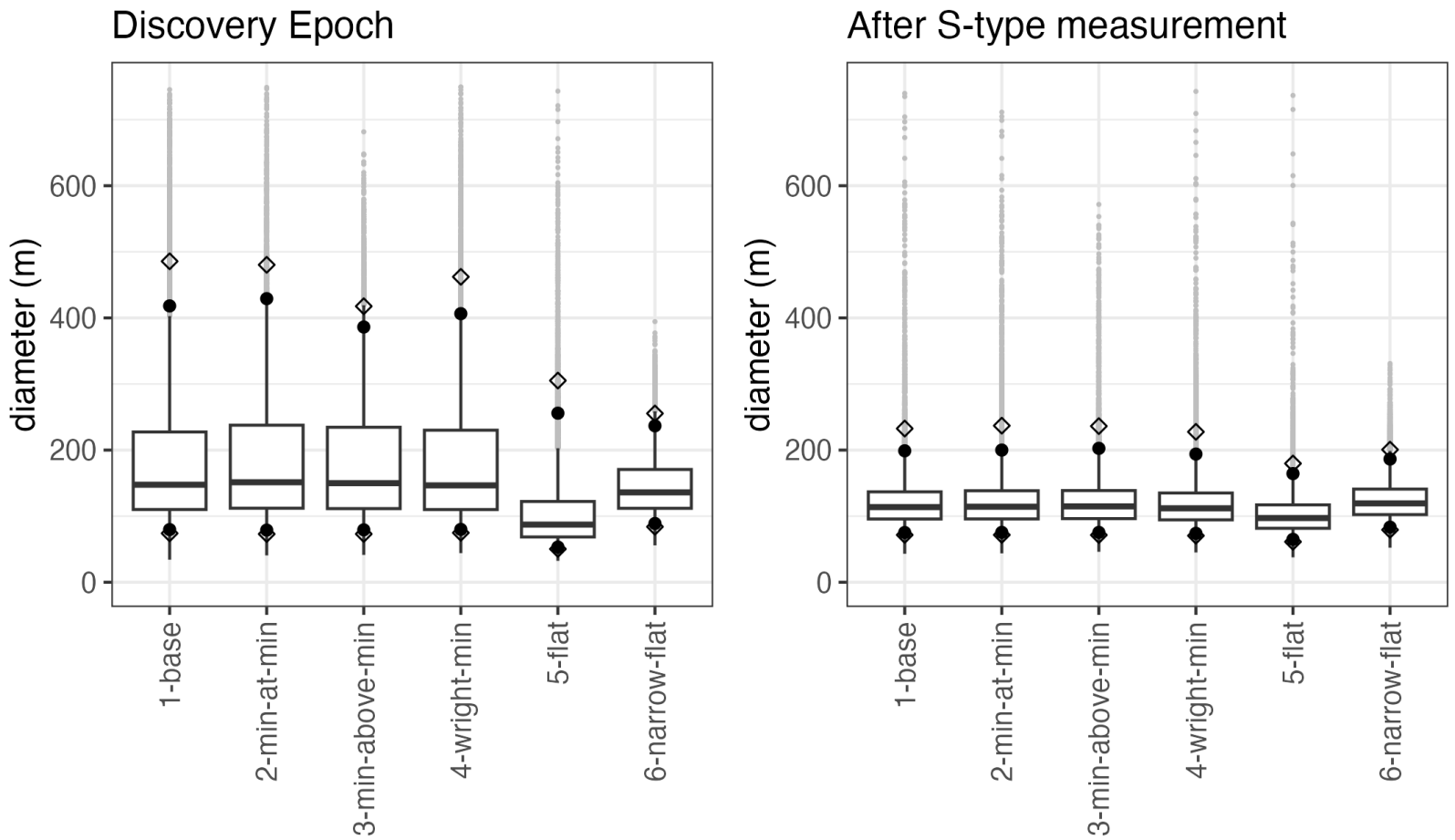
It depends on your goals and risk posture…

Main goal	Requirements on Porosity Prior	Easy to do?
Understand the central case	minimal	Yes! This is easy!
Understand the bulk of the distribution	minimal	Yes! This is easy!
Understand most of the cases	Shape and limits of prior are important	Difficulty depends on extent of the range of interest
Understand the full range of possible cases	Shape and limits of prior are important	This is hard…. Insufficient data exists

Asteroid Physical Property Inference Network After Taxonomy Measurement



Diameter Results for Different Albedo Priors with Spectroscopy (S-type)



Characterization measurements significantly reduce importance of priors

Priors matter…

More:

- For albedo. (It depends on the property)
- When you're concerned about understanding the full range of possibilities
- When characterization measurements aren't available

Less:

- For porosity (It depends on the property)
- When focusing on the bulk of the cases
- When characterization measurements become available

Forward Work:

- Thoughtfully identify the range of possibilities that need to be considered for the task at hand
- Assess if priors are sufficient for desired use and update as necessary
- Investigate effect of other priors currently in the network
- Investigate if additional priors (e.g., size distribution, orbital parameters) would be informative

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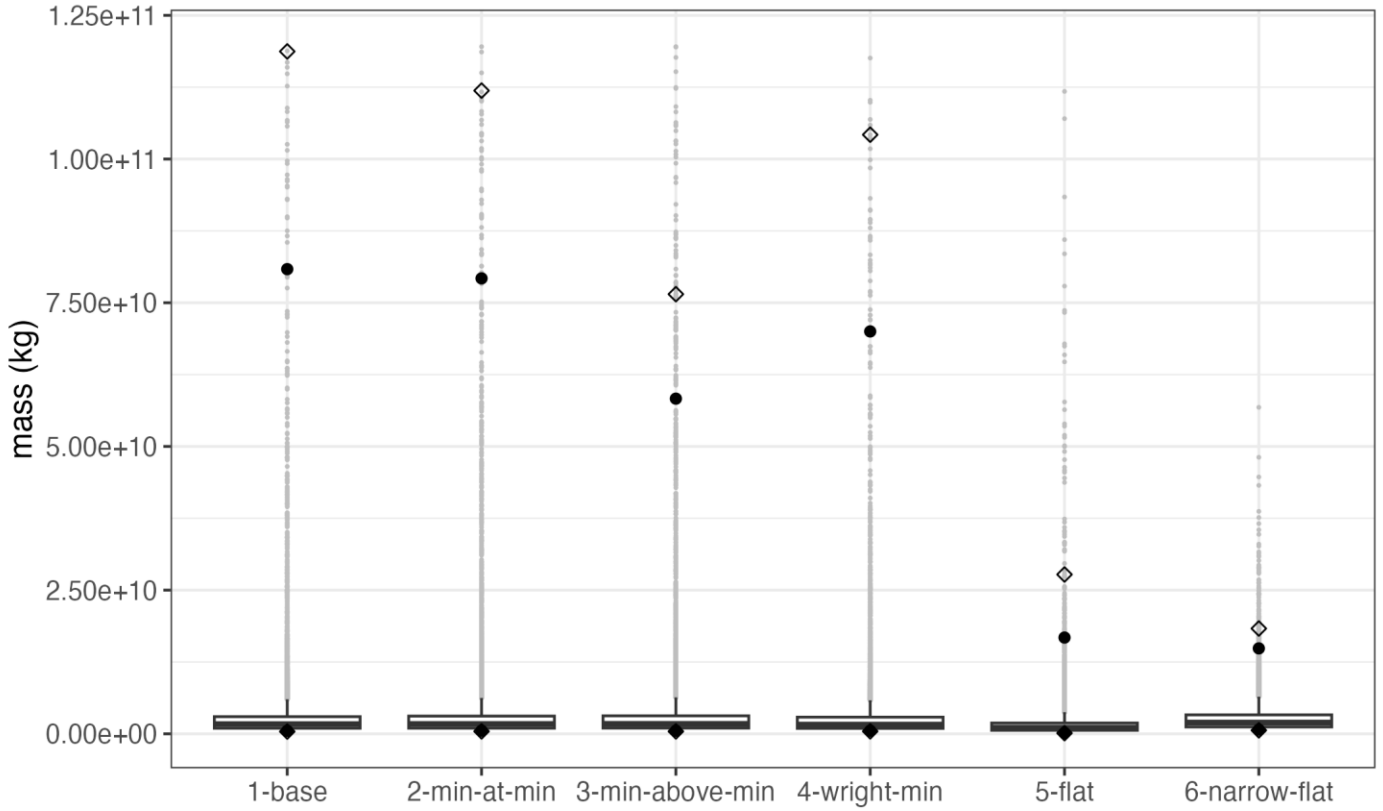
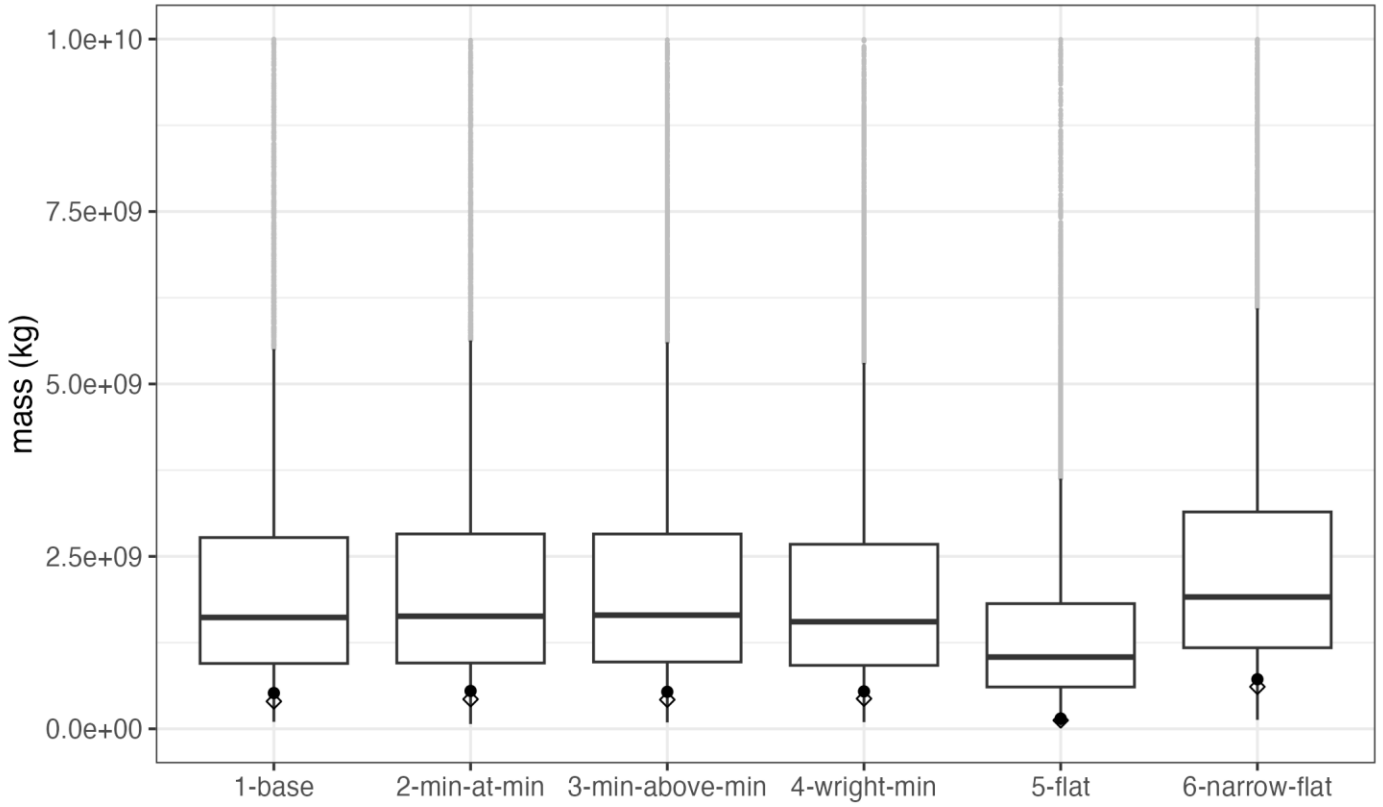
Backup

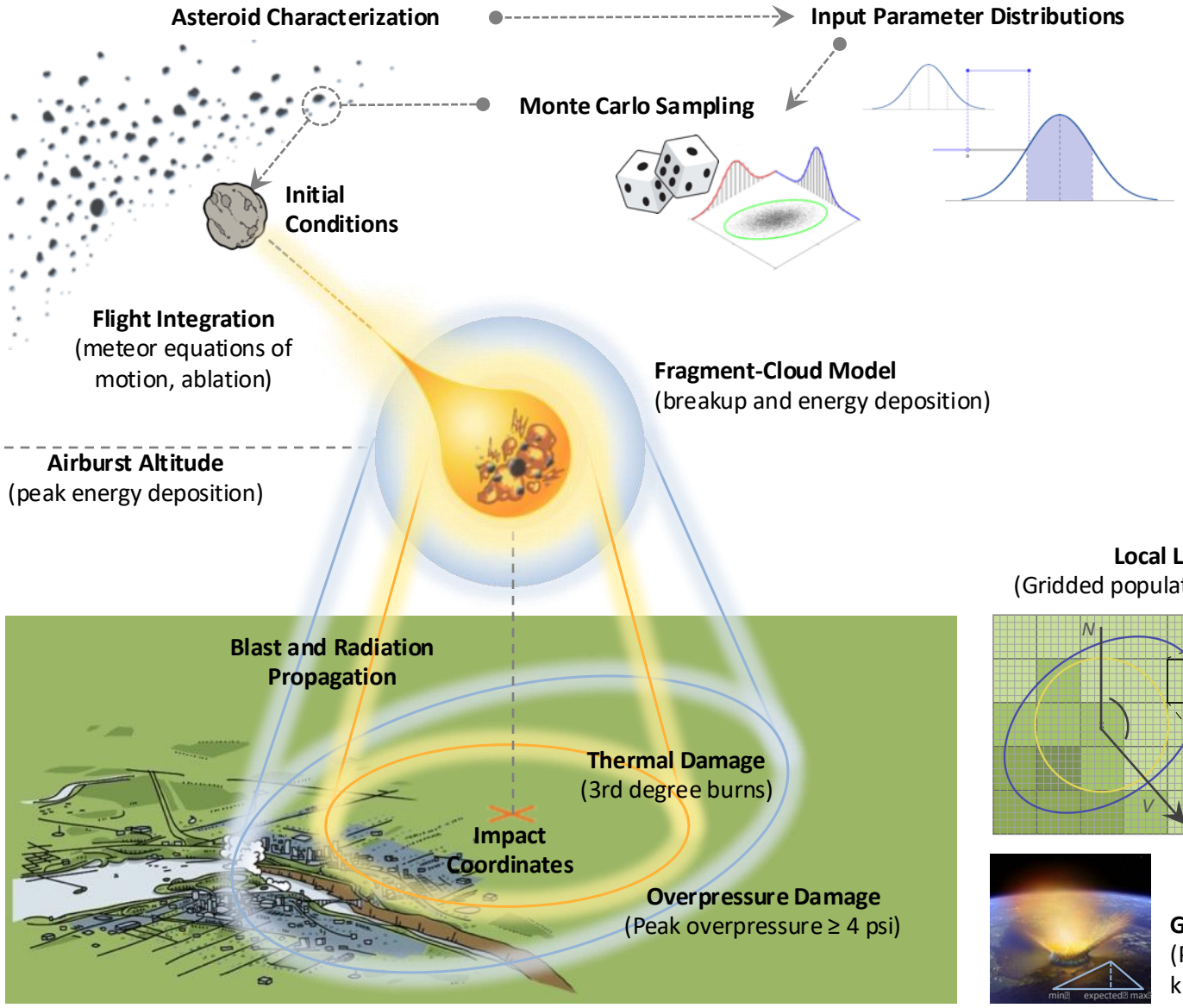
Mass Results for Different Albedo Priors with Spectroscopy (S-type)



Mass Results for Different Albedo Priors with Spectroscopy (S-type)



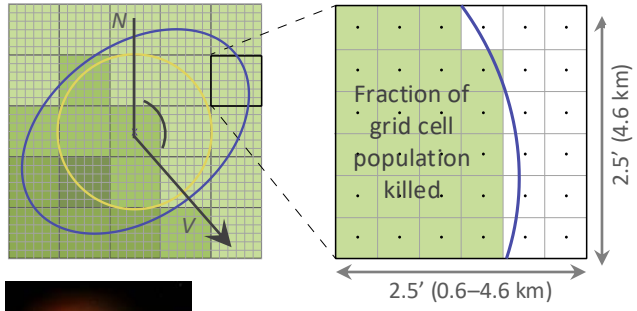
Probabilistic Asteroid Impact Risk Model



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)