Science Program Simulation for LUVOIR

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Key Issues	Actions
• optimize science case	• set rigorous requirements
• incorporate community input / garner support	• give them tools
• study architecture trades (aperture vs. difficulty)	• parameterize the returns
• make cross-mission comparisons	• develop effective figures of merit and DRMs.

What really bounds a mission's science impact?

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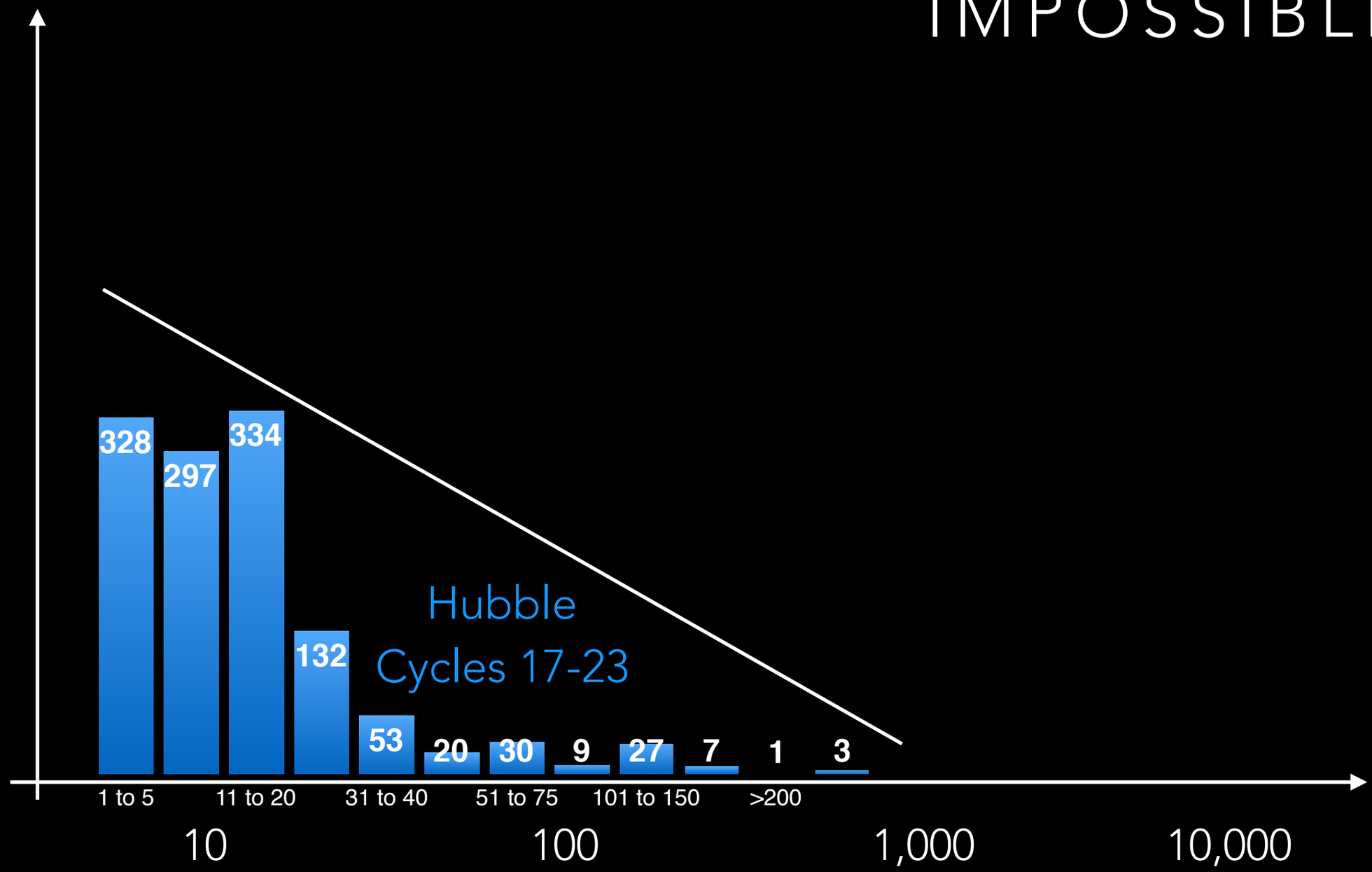
It is impossible to make sensible and reliable aperture tradeoffs without obeying this boundary condition.

WHAT DOES IT MEAN TO "DO THE IMPOSSIBLE"?



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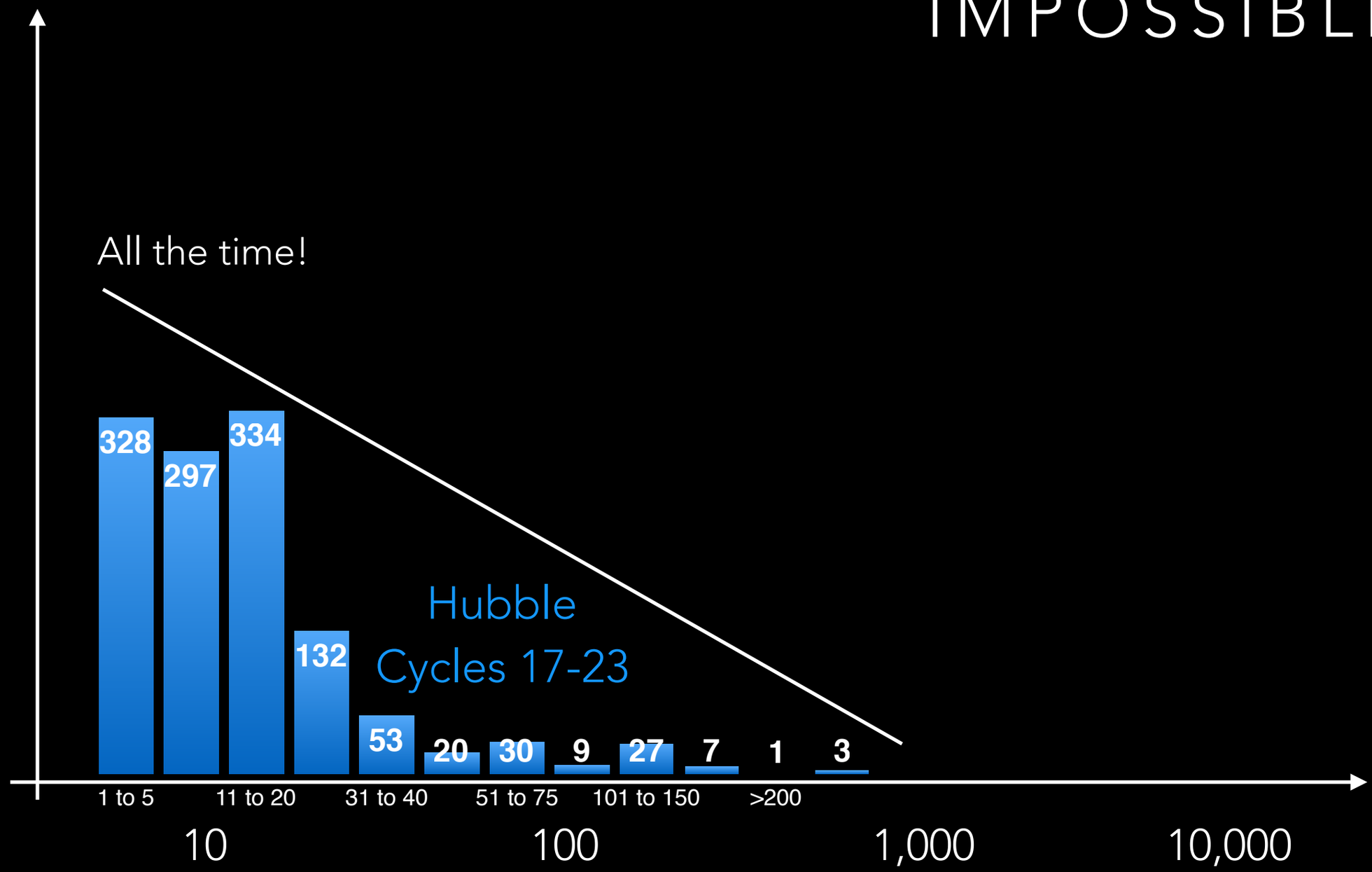

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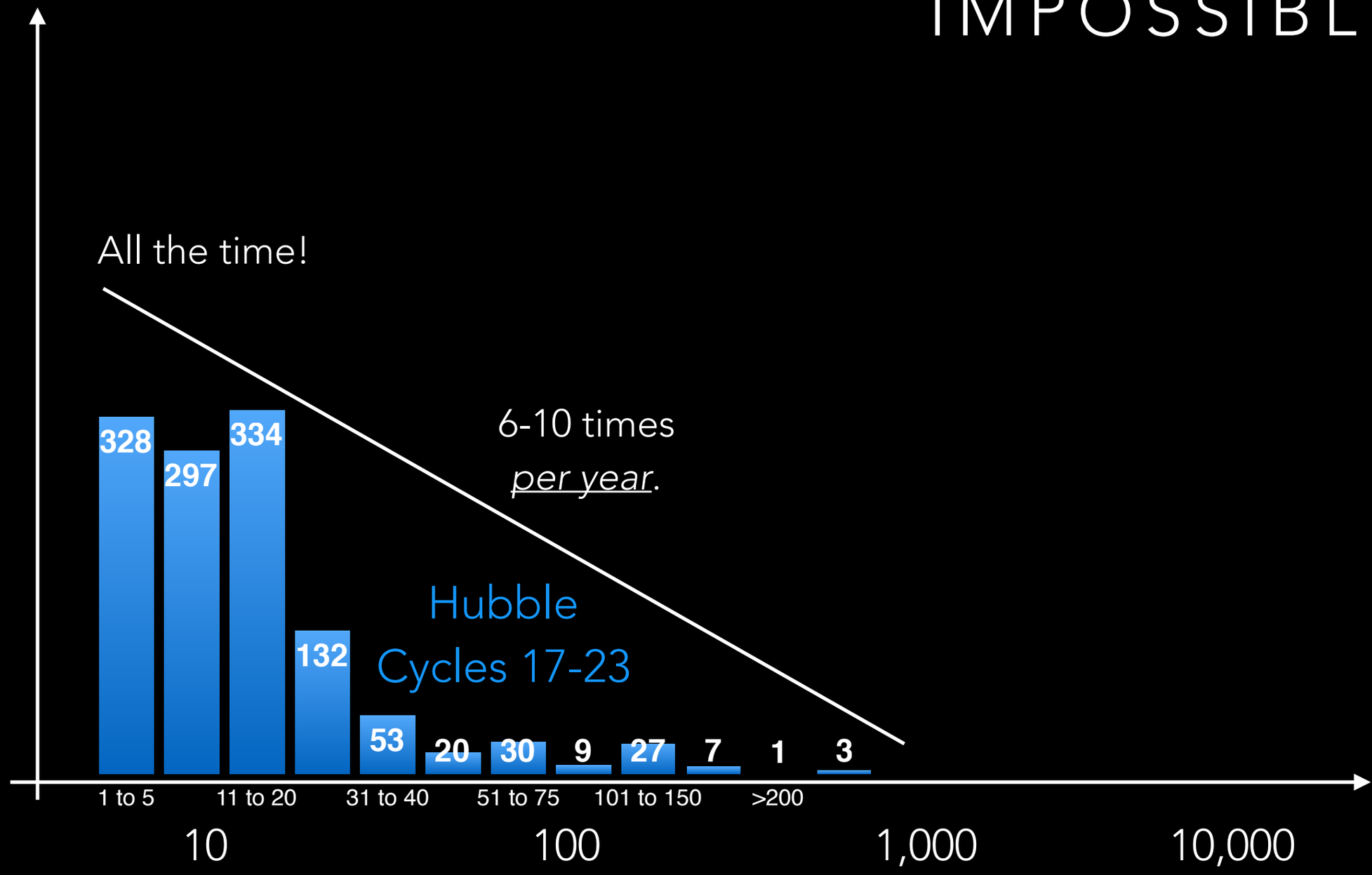

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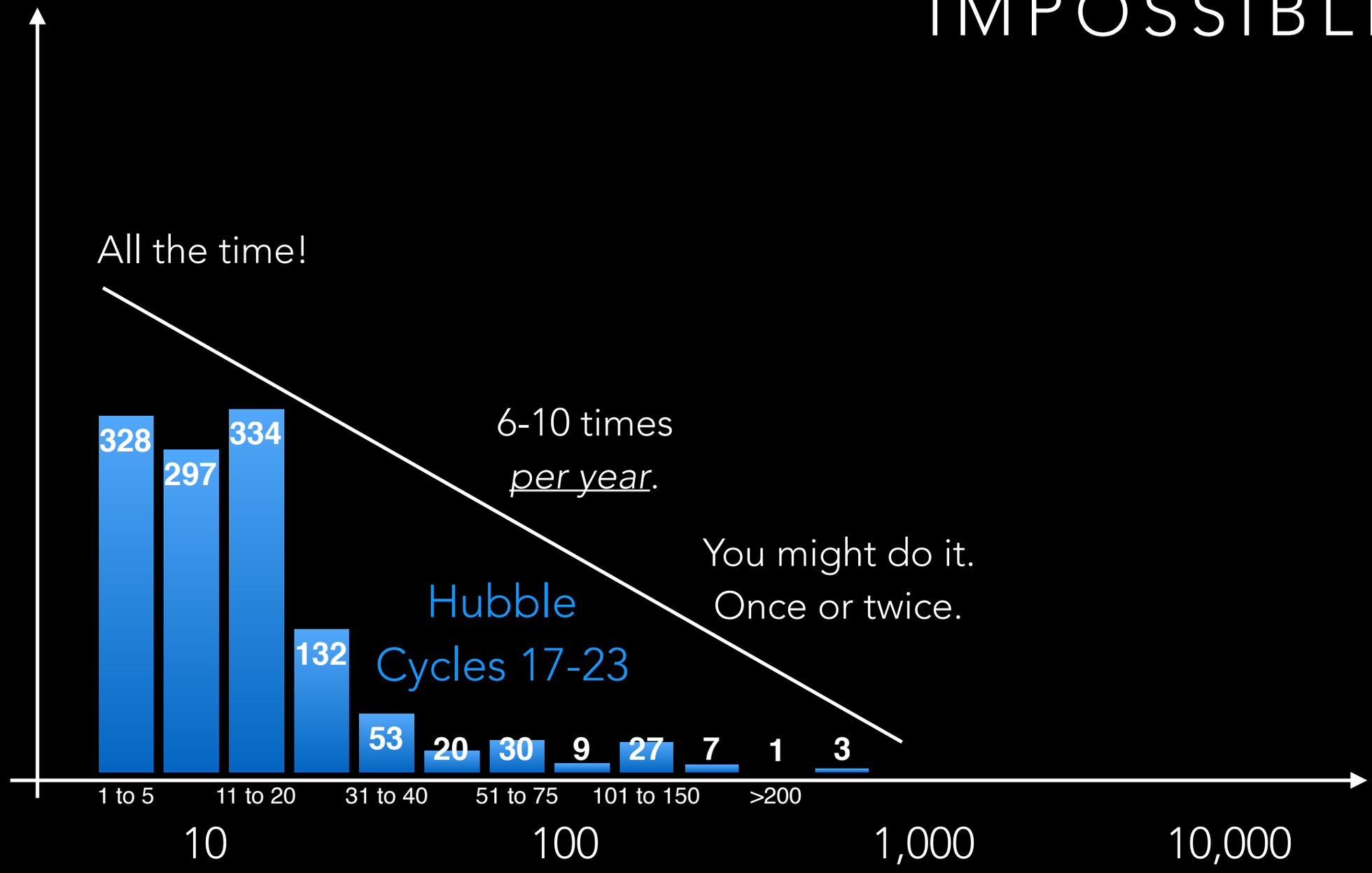

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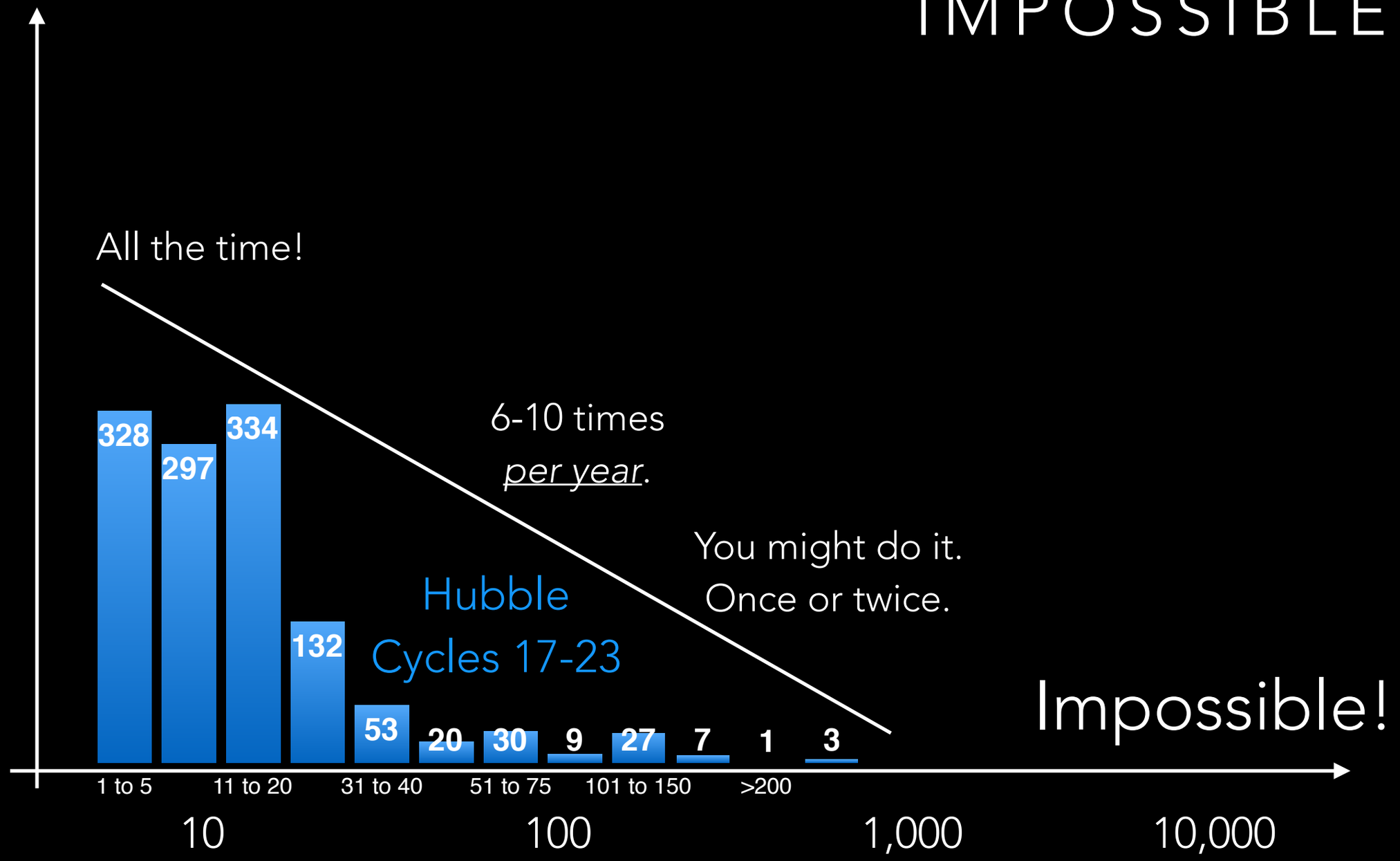

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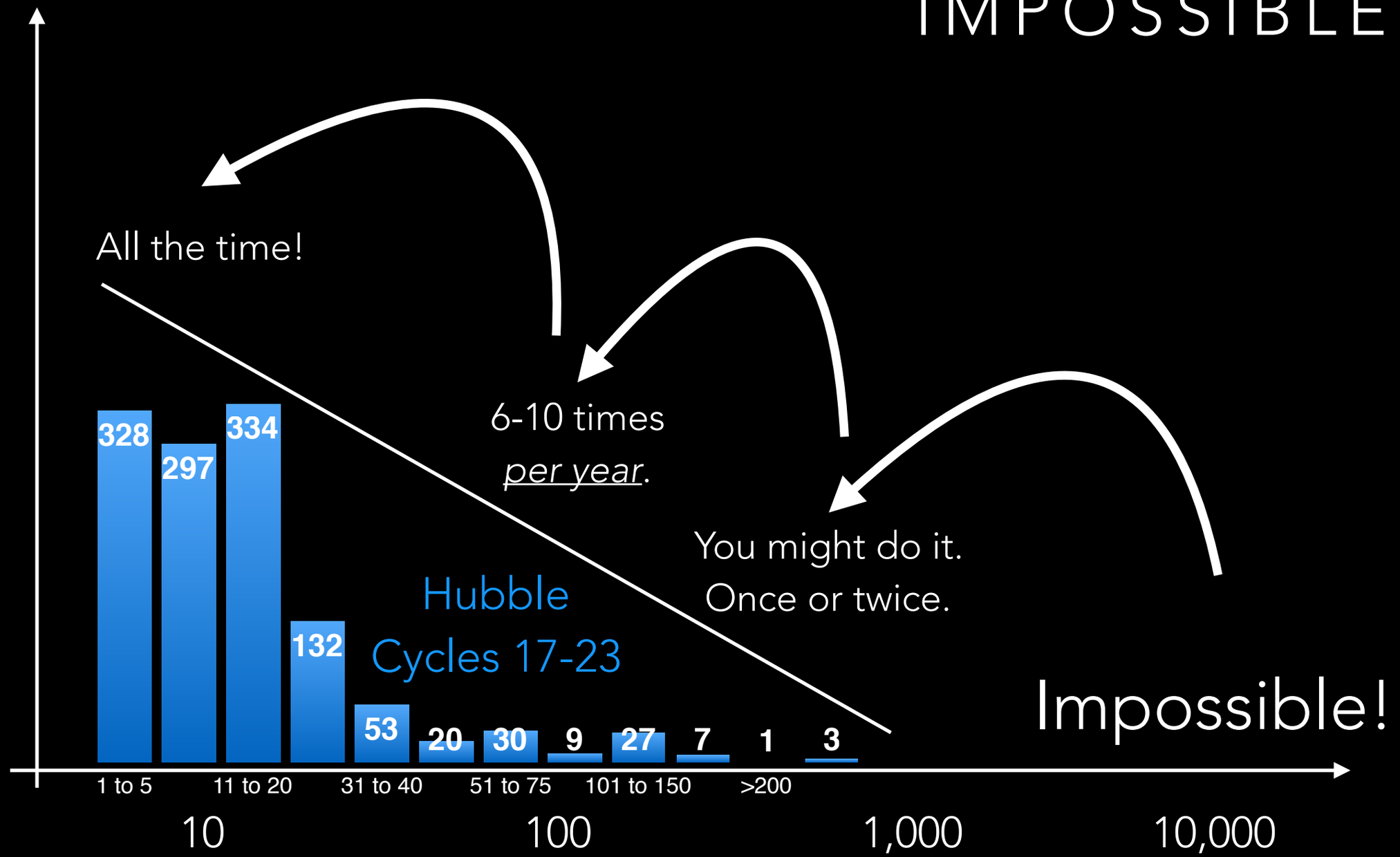
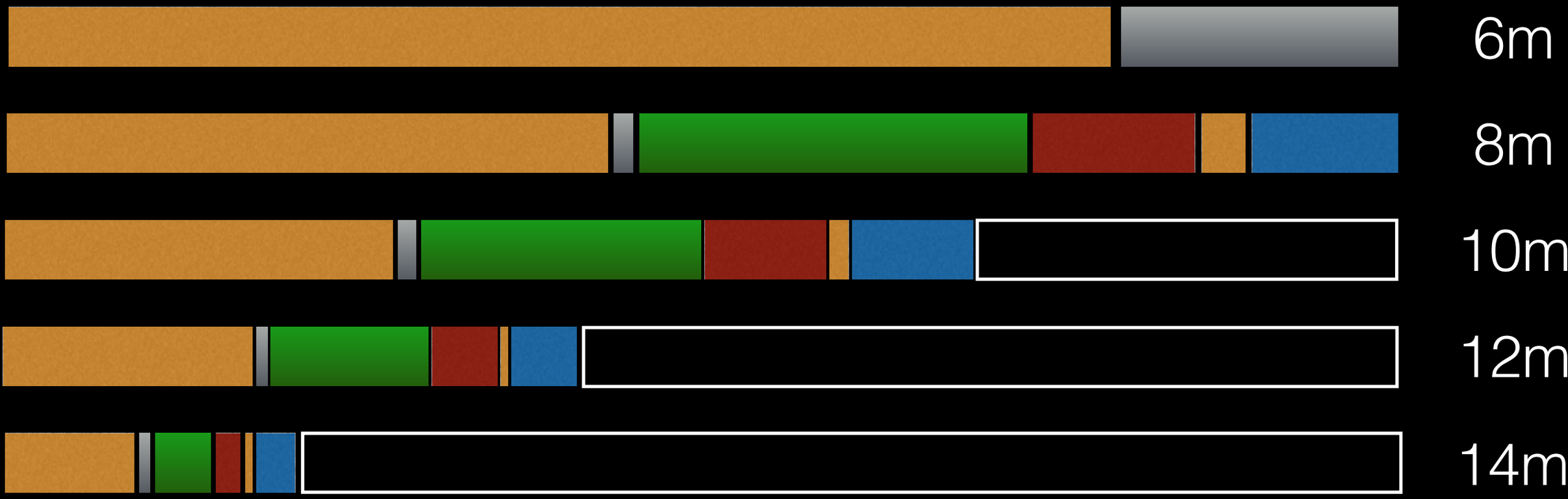


IMPLICATIONS FOR APERTURE

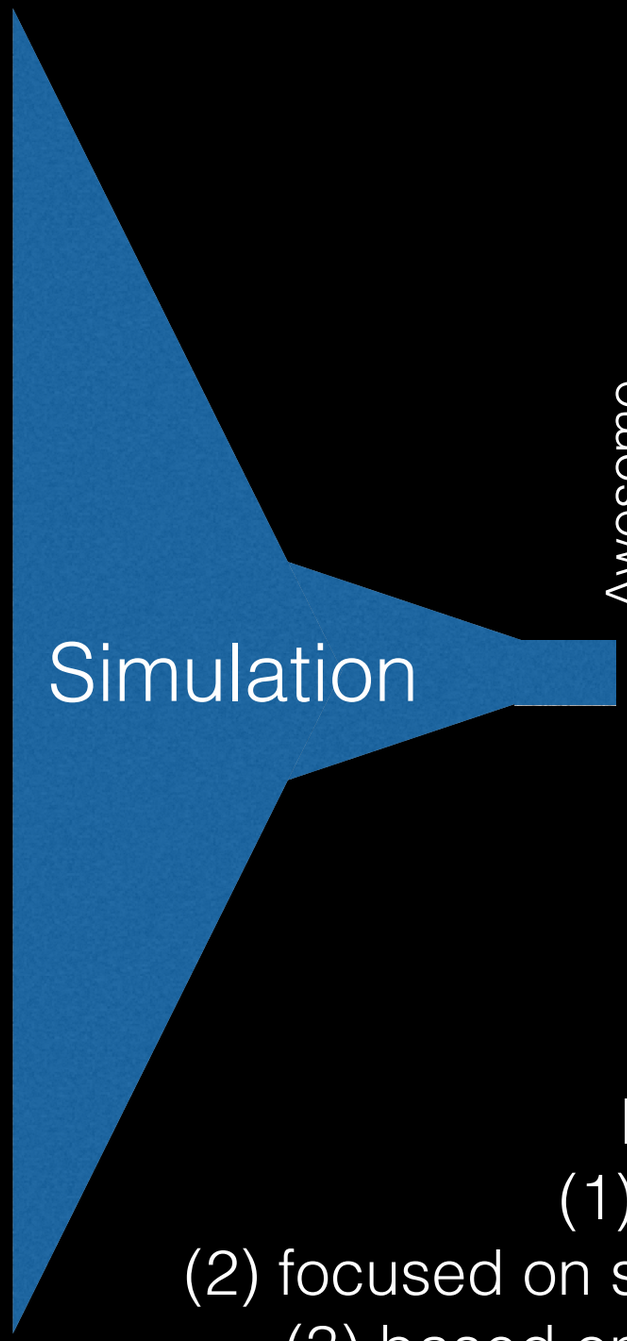
- We should not be comparing raw capacity when we compare apertures

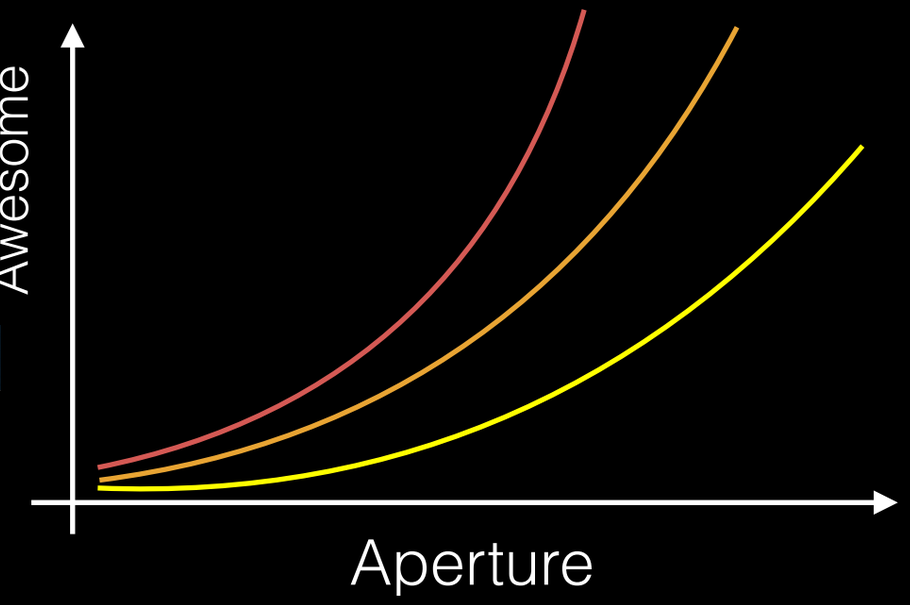
- We should compare total science programs, considered holistically, bound by the ultimate limited resource: mission lifetime

First Cycle Observing



Why do this, in one slide.





If we want:
(1) killer app plots
(2) focused on science rather than capability
(3) based on robust community input,
we have to have a healthy simulation program.

Optimzing Community Input

- crowdsource the brainstorming, leave no stone unturned.
- but, don't rely just on casual "white papers", drill down!
- but rigorous science figures of merit connected to hardware require the proper tools.
- community input to mission development will be much better when given these tools.
- can then release these tools for wide application.
- simultaneously builds community support

A hierarchy of simulations

- "Sensitivity" simulations: basically ETCs, S/N vs. time.
- "Image/spectrum" simulations: mock observations
- "Catalog" simulations: how many / what fraction of a certain kind of object can you observe. How many do you need to observe to get your result?
- "Total Yield" simulations: Pretty much the end-to-end combination of all these. Output is "figure of merit" vs. key observatory / instrument parameters.

Sensitivity Simulation

LUVOIR: Photometric ETC

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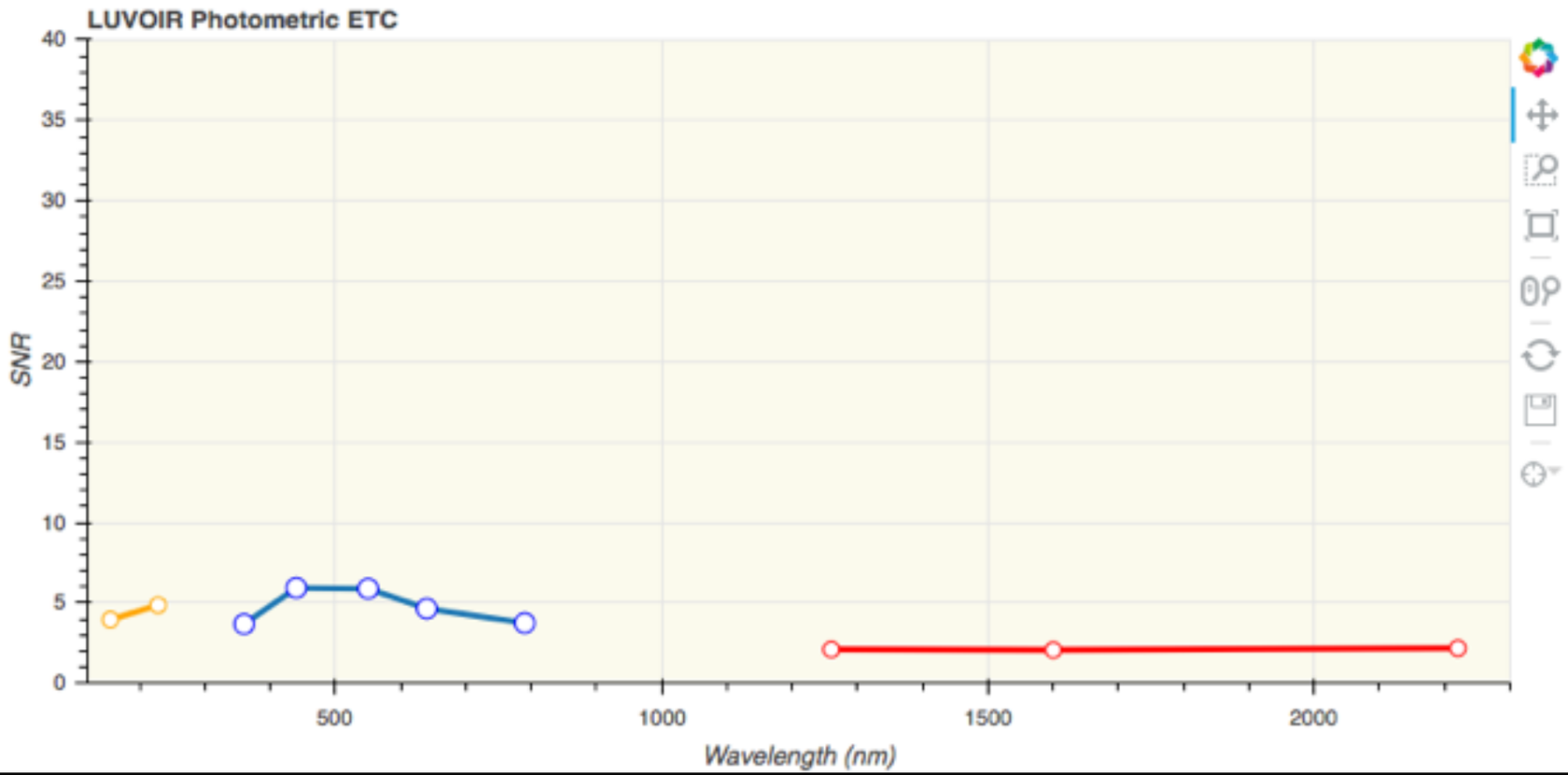
This is the basic ETC for photometry in multiband images.
Choose your telescope aperture, exposure time, and magnitude.

Given an aperture and magnitude (AB in all bands), choose the exposure time that reaches your desired S/N. To obtain limiting magnitudes given exposure time, set that time and then tune the magnitude to reach your desired limiting S/N.

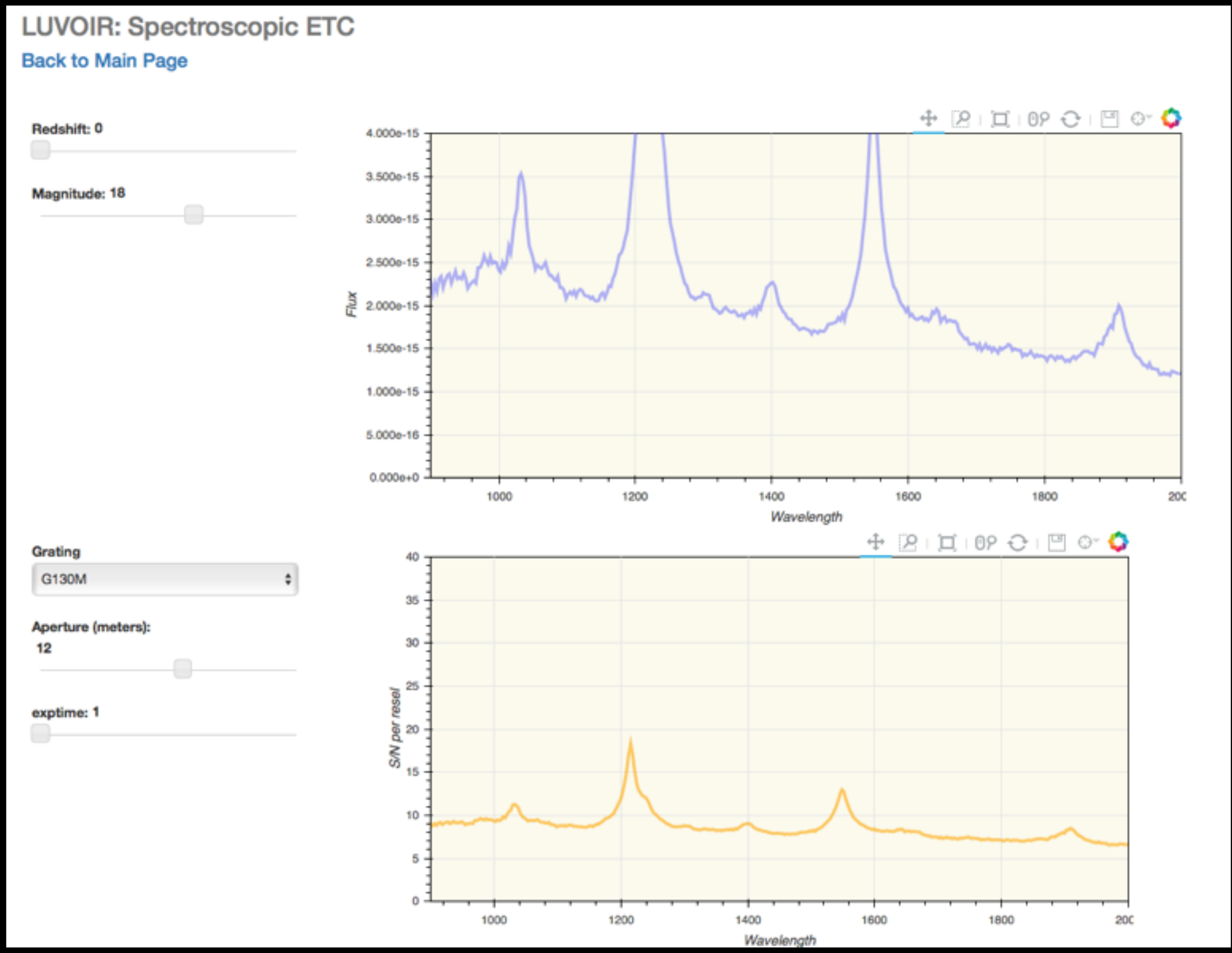
Aperture (meters):
12

Exptime (hours): 1

Magnitude (AB): 32



Observation Simulation



Observation Simulation

LUVOIR: Coronagraphic Spectra of Earth-like Planets

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This is a basic presentation of simulated spectra for Earth-like planets. Choose your exposure time, planet distance, and radius. Remember, this is a *prototype*.

The underlying model is derived from the python-based version of Tyler Robinson's coronagraphic spectrum and noise model. Python by Jacob Lustig-Yaeger, Bokeh rendering by Jason Tumlinson.

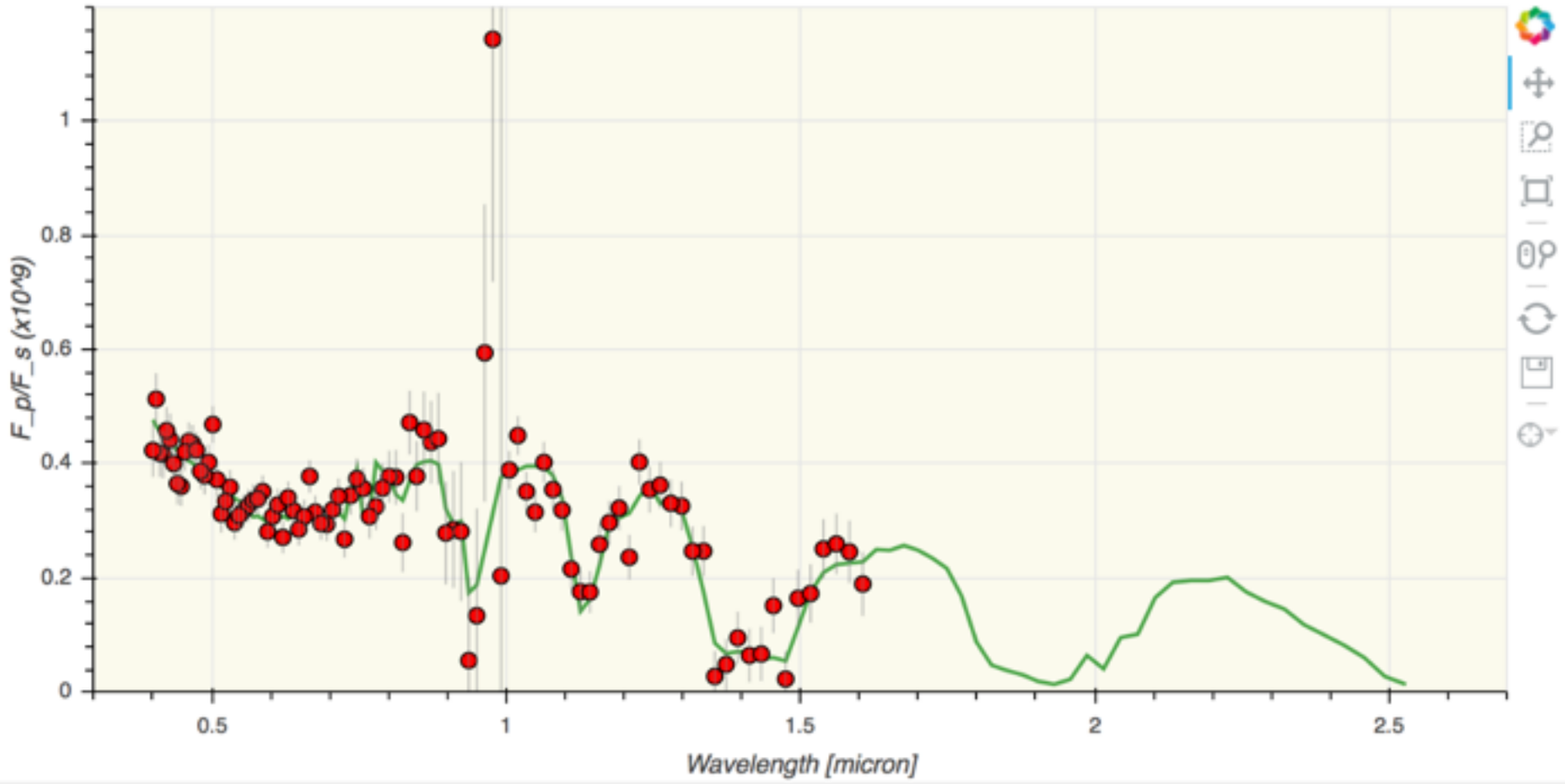
Planet | Observation

Distance (parsec):
10

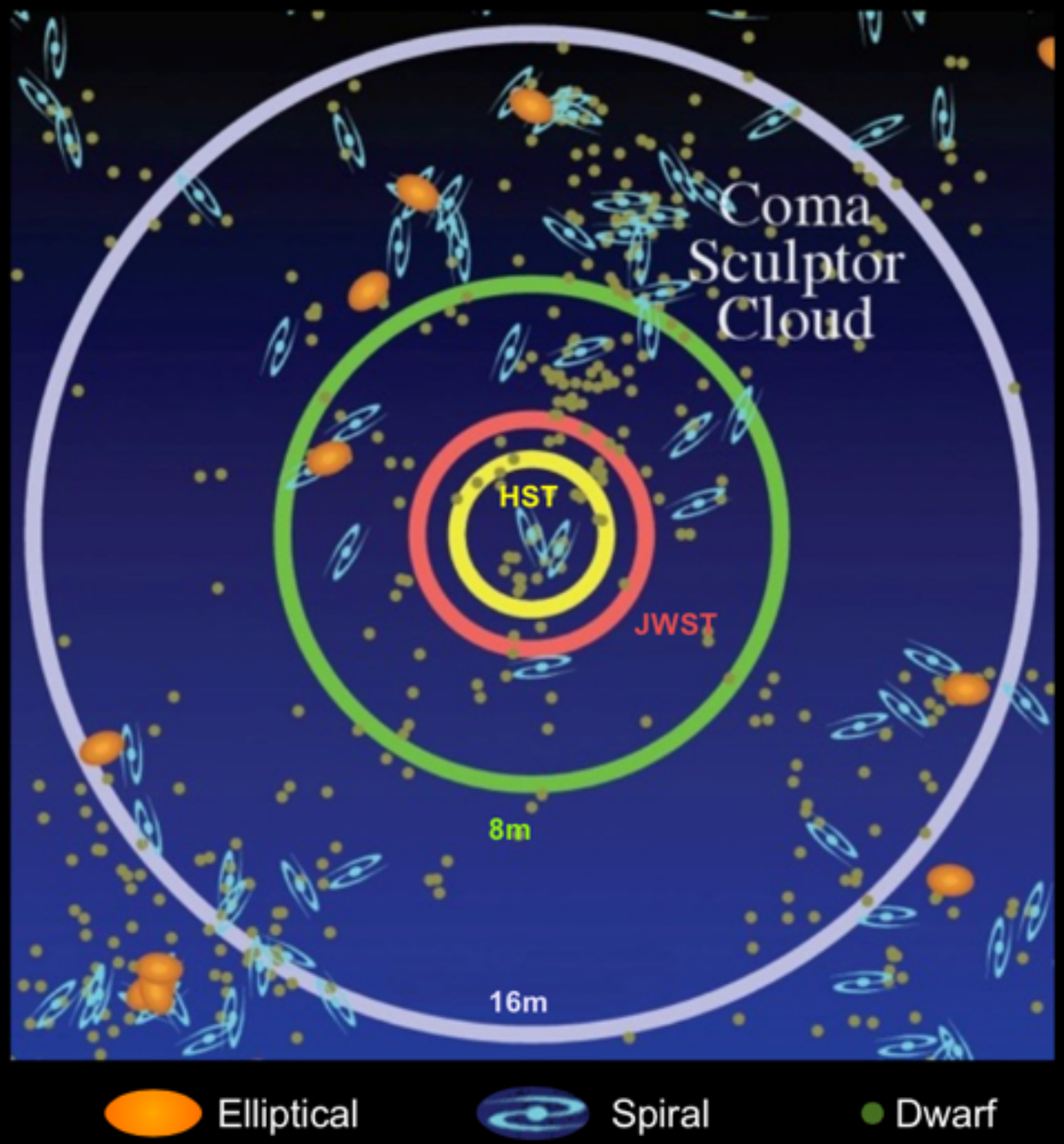
Planet Radius (R_Earth):
1

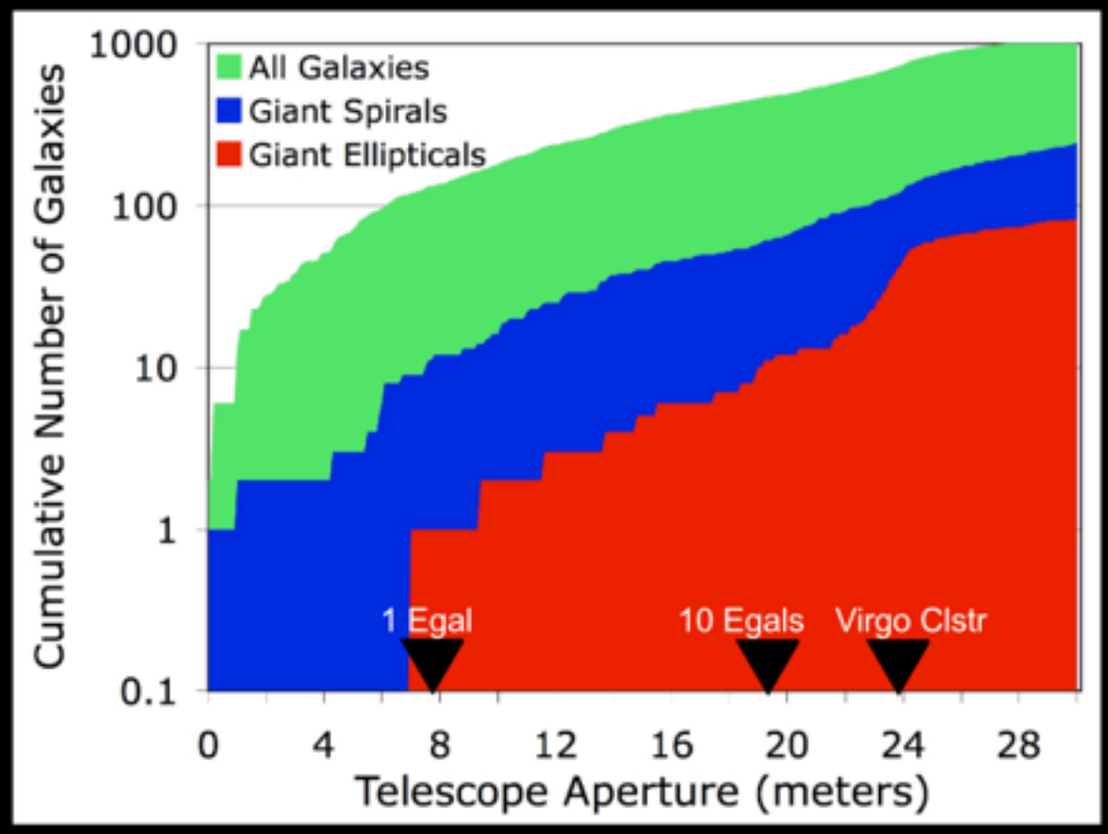
Semi-major axis of orbit (AU):
1

Number of Exozodi:
1



Catalog Simulation (Sort Of)





The Embyronic “Yield Simulations” from CB2LE

HDST 100-hour Highlights				
Epoch	Name	Observations	Science Goal	Time [hr]
$z = 1$-4	Deep/Wide Galaxy Survey	1 hour/band in *VRIJHK* to AB = 32	Statistically significant galaxy samples down to $M_V \sim -12$	120
	Ultra-Deep Field	20 hours/band in *VRIJHK* to AB = 34	Detect faintest dwarf satellites in Milky-Way-like galaxies	120
$z = 0.5$-1	Map the CGM (Emission)	R ~1000 emission in NUV over 30 square arcmin	Map H I, C IV, O VI in 300 galaxies at 1000–2000 Å	100
	Map the CGM and AGN (Absorption)	R = 20,000 spectra in FOV of emission field	Map diffuse CGM metals using background galaxies	150
<100 Mpc	Resolved Flows	100 clusters in 10 galaxies	Probe stellar cluster content and outflow dynamics	120
	The IMF at Low Metallicity (dwarf Spheroidals)	1–7 hrs in *V* and *I* bands	Measure IMF to 0.1 $M_\odot$ in six classical dSphs at [Fe/H] < –1.5	70
<100 kpc	How Stars Form at Low Metallicity	UVOIR images of Magellanic Clouds	Determine protostellar accretion rates at low metallicity	80

The Cycle 1 “Large Programs”

These are prose versions of the “yield simulations”.

Yield Simulation for Exoplanets

LUVOIR: ExoEarth Yields

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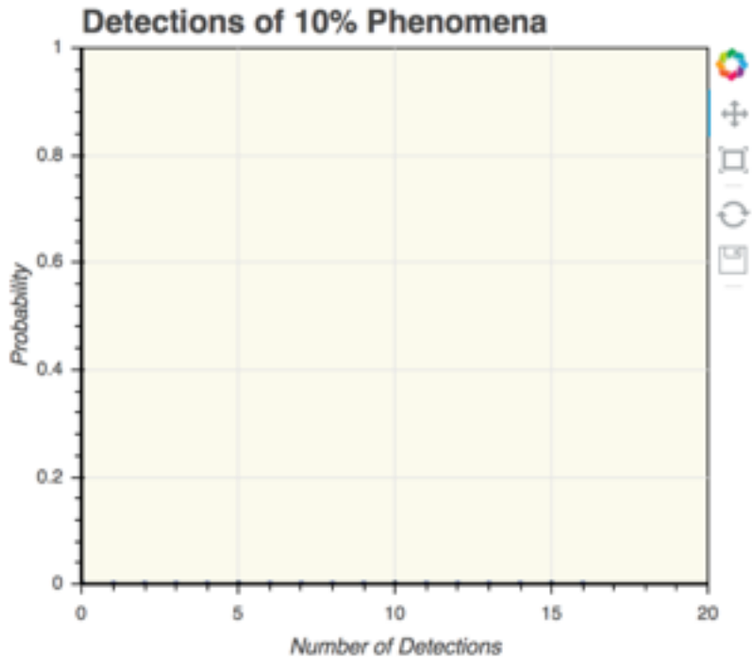
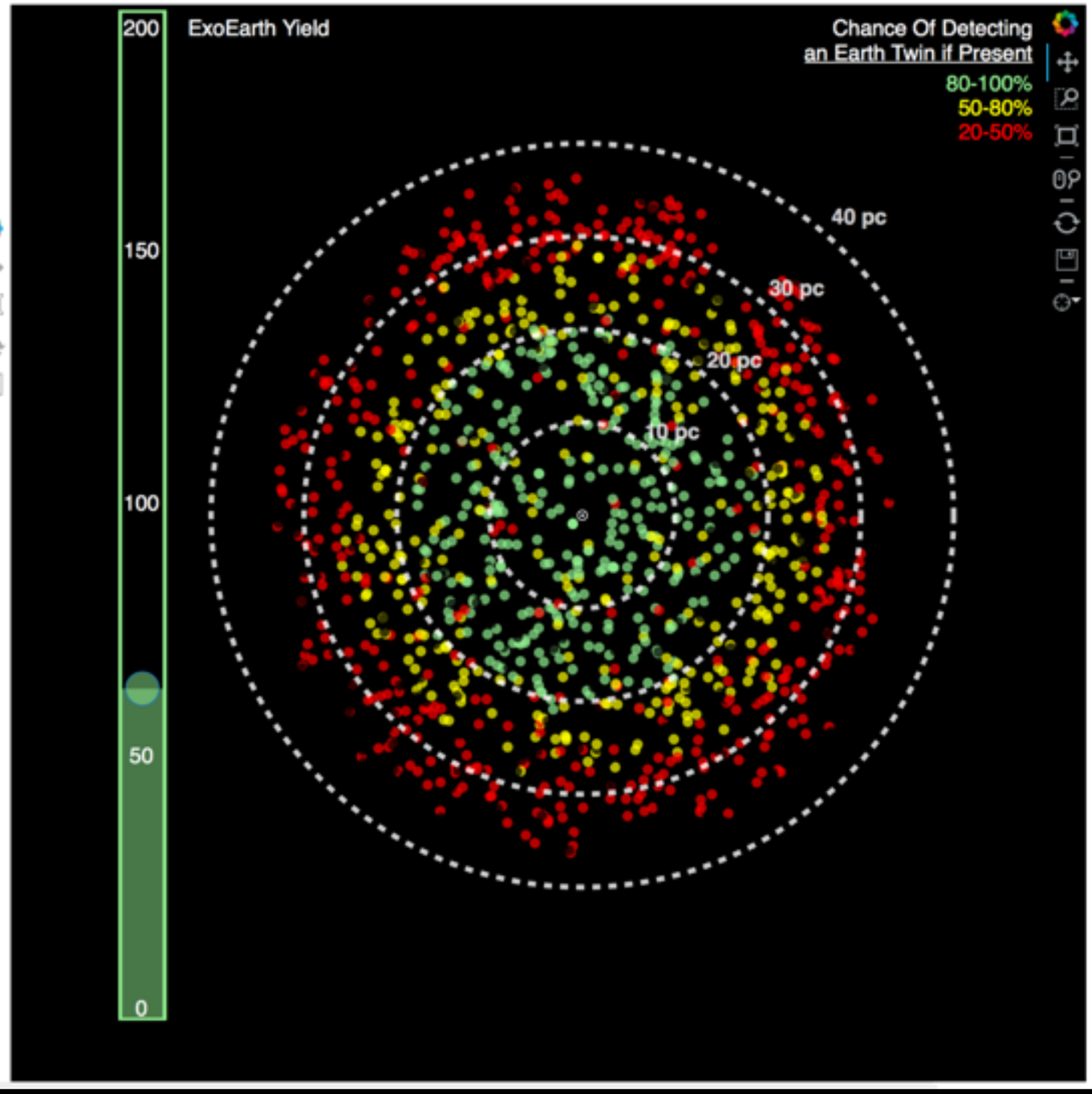
Aperture (meters): 12

Log (Contrast): -10





Yield Simulation for Astrophysics

LUVOIR: UV MOS Simulator

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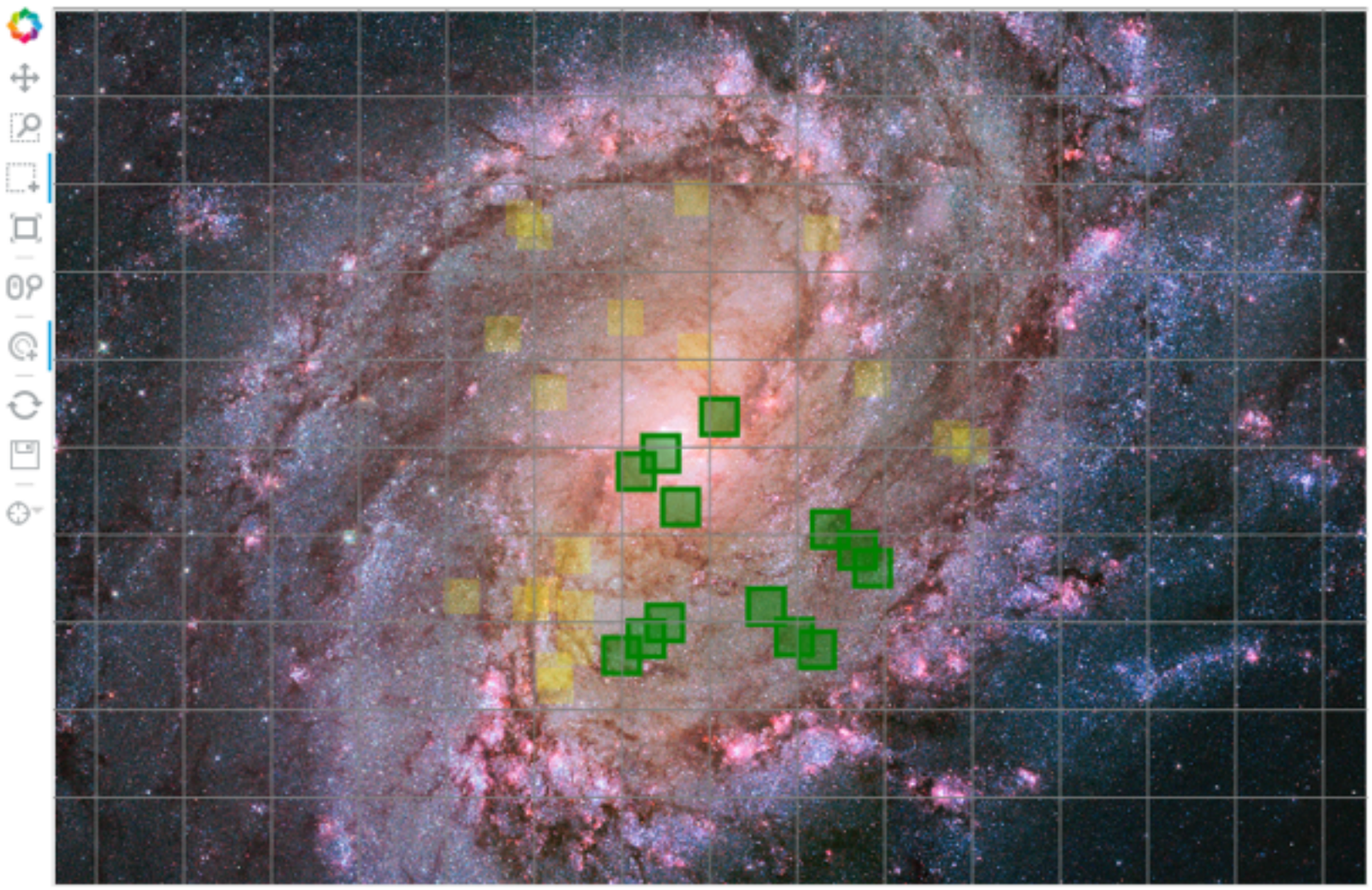
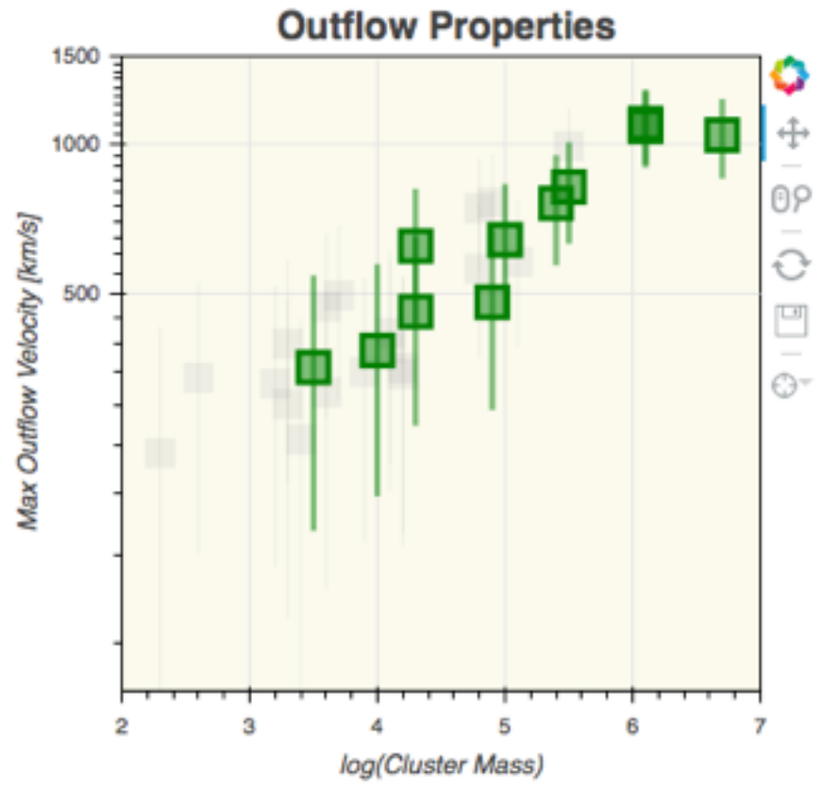
This is a prototype for playing with multiplexed UV sources.
Choose your telescope aperture, exposure time, and power law. Select sources to observe and see how well you can constrain the wind flow velocity vs. cluster mass relation.



Aperture (meters): 11

Exposure Time (hr): 3



Power Law Slope: 0.15

Let's talk about catalog simulation,
giving examples.

COSMOLOGY, LARGE SCALE STRUCTURE, AND DARK MATTER

- Greatly expand the volume for cross-calibration of standard candles (e.g. Cepheids), and bring the uncertainty in H_0 to < 1% (Scowcroft)

bright z ~ 1 galaxies: SDSS/PanSTARRS

- Direct detection of the expansion of the universe (Shiminovich, O'Meara)

bright z ~ 1 galaxies: DEEP2/HST

- The power spectrum, thermal, and ionizing history of the IGM from 0 < z < 1.5, Helium reoinization (O'Meara, McCandliss)

bright z = 1 - 2 QSOs: SDSS/GALEX

- The evolution of the escape of ionizing radiation over cosmic time (McCandliss)

z < 1 galaxies: SDSS

GALAXIES AND GALAXY EVOLUTION

- Understand structure formation and evolution in massive galaxies, and pushing into the central 1 kpc over cosmic time (Whitaker)

HST/JWST/Deep Fields

- Dynamical masses for black holes in AGN, and the SMBH mass distribution (Peterson, Matsuoka)

NGC catalog

- Map the CGM in 2-D using quasars AND galaxies as background sources (Tumlinson, Matsuoka, O'Meara)

SDSS/BOSS

- The first quasars (Matsuoka)

SDSS

- The galaxy luminosity function from -16 < M < -10 , and direct observations of the gas and dust in the first, most metal-poor galaxies (Finkelstein)
- Observing structures down to 0.0003L* (Postman)

HST Deep Fields

STARS, STELLAR EVOLUTION, AND THE LOCAL UNIVERSE

- Characterize the first stars, supernovae, and metals in the universe via UV spectra of the most metal poor stars (Roderer) HK/SDSS
- Very early/very late time observation of SNe for unique signatures of the progenitor appear (Graham) PanSTARRS/PTF
- Robust exploration of the environments where planets form (France, Pascucci, Fleming) you tell me
- Measure protostellar jet mass flux, collimation, rotation, interaction. Measure the launching and mass flux of disk winds, and mass flows in the inner disk (Schneider, Herczeg, Gómez de Castro) you tell me
- The extinction law from UV to IR in the Galaxy, Gómez de Castro)
- The white dwarf mass-radius relation (Barstow) you tell me

The Hierarchy of Simulation Again

Layer	Code(s)	Example
Yields and their visualization	new code to be developed	show local Universe with these galaxies marked, let user play with paramters to optimze.
Catalog simulation	New code for each use case (collaborative)	“Number/type of galaxies for which IMF can be measured”
Sensitivity and Data Simulation	WebbPSF, Pandeia, STIPS, MISTY	Prototype ETCs

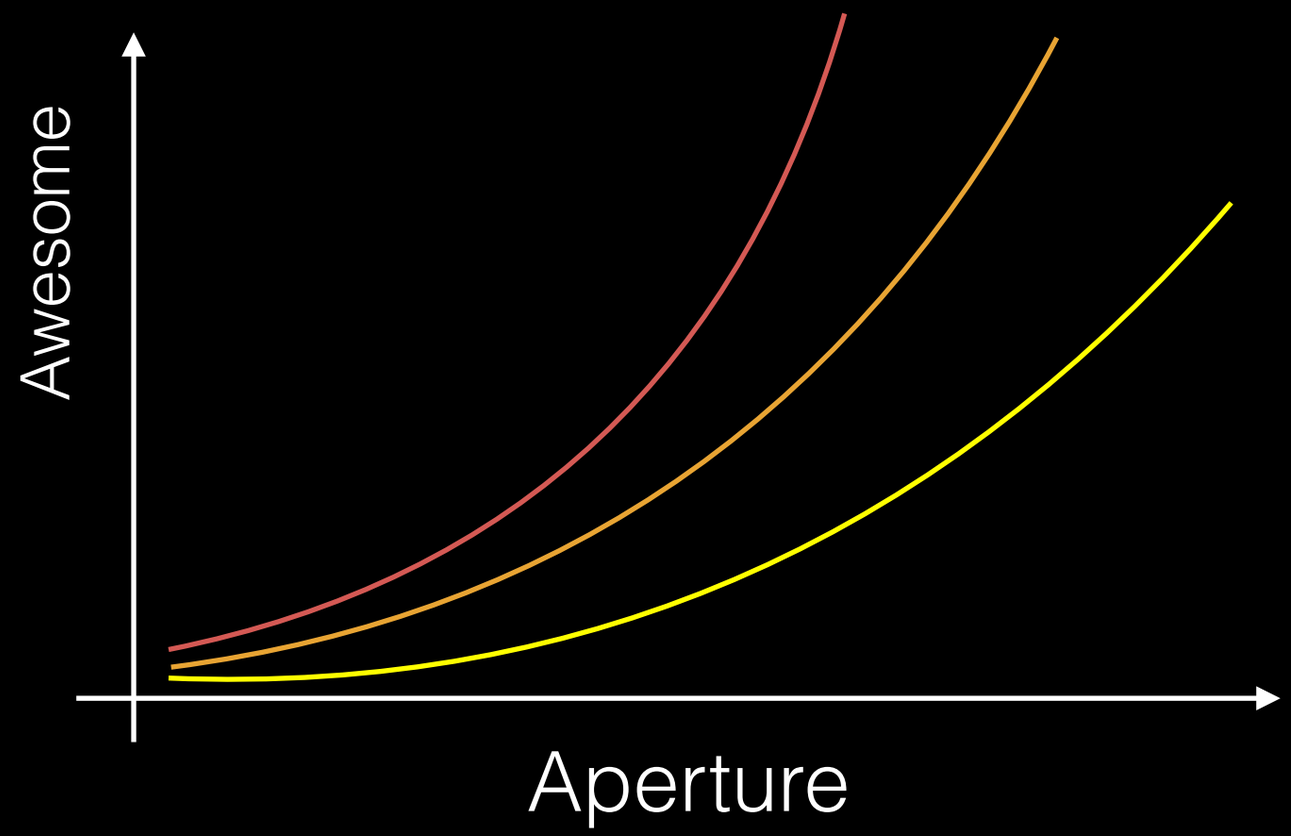
The Ultimate Goal

DRM-like simulation of all areas of LUVOIR science
as a function of aperture, time, and other key properties.

Not only a list of possible programs, but "yield simulations" of
programs that fit into the time available.

What science just can't get done with a smaller aperture?

Concrete plan for first 2 cycles of observations.



Needs

- science ideas
- catalogs
- coding to implement basic models (smart students / postdocs)
- graphics ideas
- help with integrating these into a program.

If you dream it, we can (probably) simulate it.

Please talk to me, and we'll more forward.