



STScI | SPACE TELESCOPE
SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

Toward a Grand Unified Practice of Astronomical Metadata

Joshua Peek — Space Telescope Science Institute
Principal Investigator: Mikulski Archive for Space Telescopes

07.16.2019

astronomers are
good at data*







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Filters

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Album View

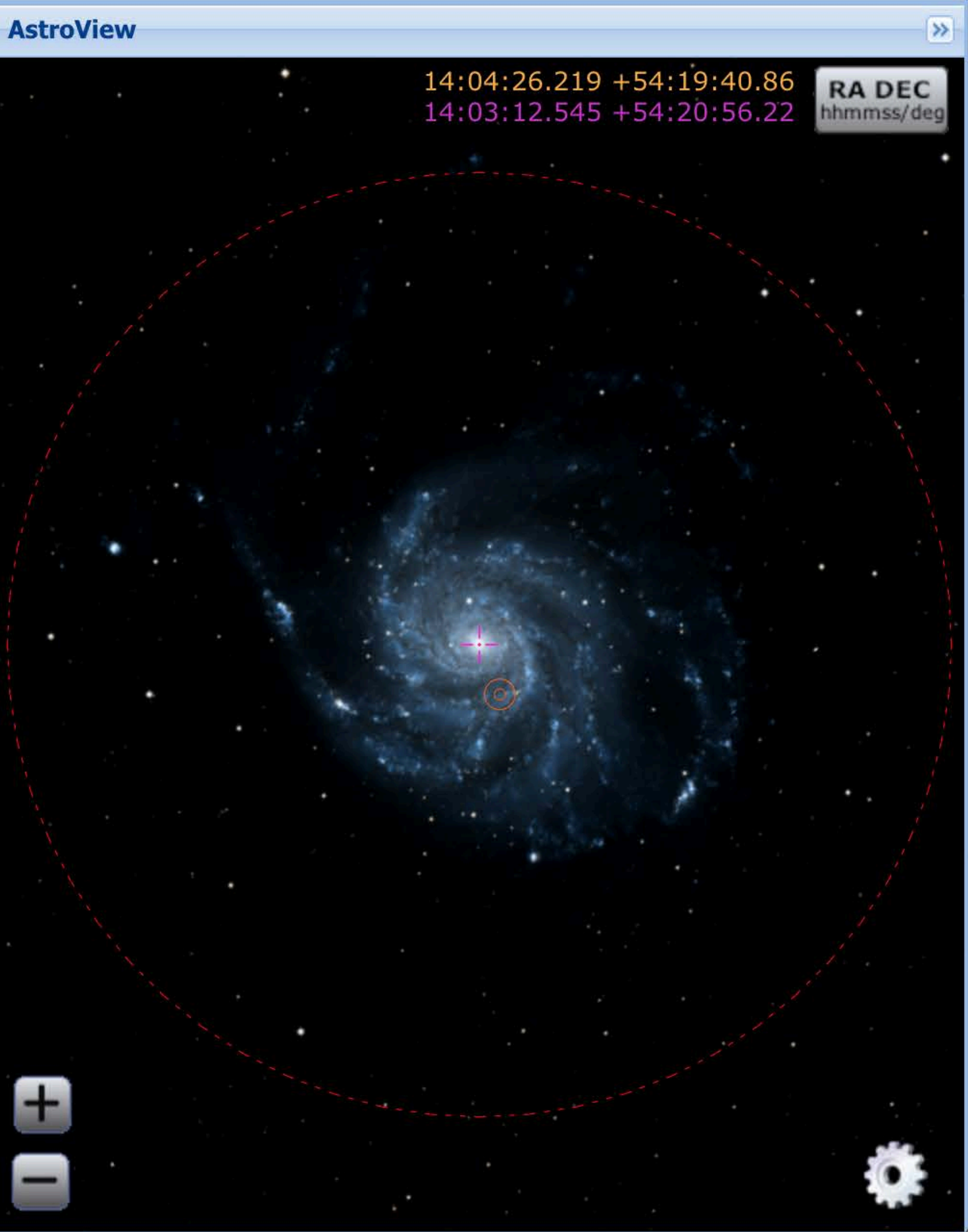
Edit Columns...

Table Display: All

Show Preview: ☐

Show Cutout: ☐

		Actions	Observation T...	Mission	Instrument	Project	Filters	Waveband	Target Name
☐	1		science	HUT	FUV			UV	M101A
☐	2		science	HUT	FUV			UV	M101A





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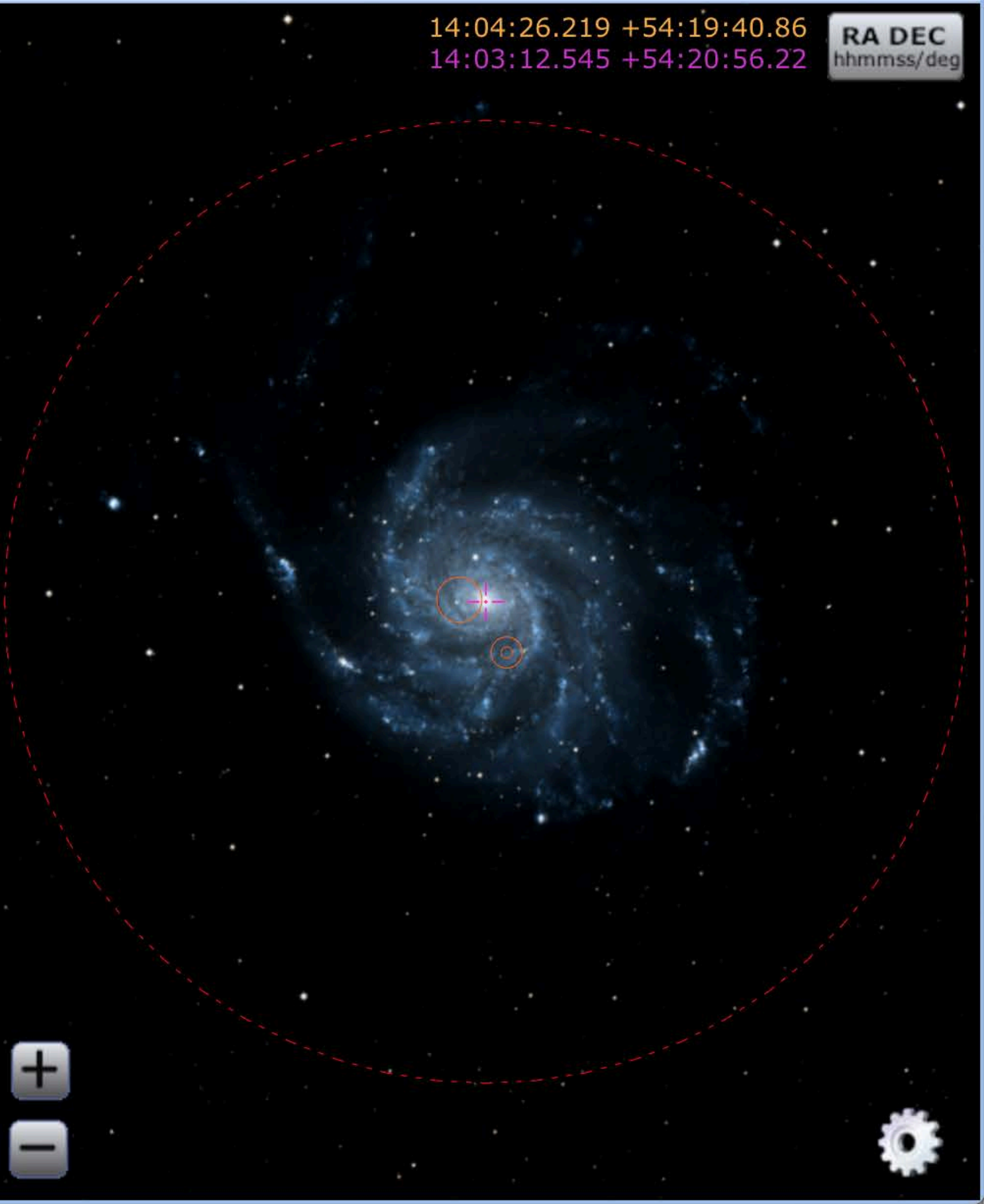
Displaying 4 of 3443 Total Rows **MESSIER 101**, radius: 0.24000° Footprints: All

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Edit Columns... Table Display: All Show Preview: Show Cutout:									
☐		Actions	Observation T...	Mission	Instrument	Project	Filters	Waveband	Target Name
☐	1		science	HUT	FUV			UV	M101A
☐	2		science	HUT	FUV			UV	M101A
☐	3		science	EUVE	DS/S	EUVE		EUV	NGC 5457
☐	4		science	EUVE	DS/S	EUVE		EUV	NGC 5457

AstroView





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Album View

Edit Columns...

Table Display:

All

Show Preview:

Show Cutout:

		Actions	Observation T...	Mission	Instrument	Project	Filters	Waveband	Target Name
☐	1		science	HUT	FUV			UV	M101A
☐	2		science	HUT	FUV			UV	M101A
☐	3		science	FUSE	FUV			UV	NGC5457-POS1
☐	4		science	FUSE	FUV			UV	M-101-D
☐	5		science	FUSE	FUV			UV	NGC5457-POS2
☐	6		science	FUSE	FUV			UV	NGC5461
☐	7		science	FUSE	FUV			UV	NGC5447
☐	8		science	FUSE	FUV			UV	NGC5471
☐	9		science	FUSE	FUV			UV	NGC5471
☐	10		science	EUVE	DS/S	EUVE		EUV	NGC 5457
☐	11		science	EUVE	DS/S	EUVE		EUV	NGC 5457

14:04:26.219 +54:19:40.86

14:03:12.545 +54:20:56.22

RA DEC
hhmmss/deg





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Footprints: All

List View

Album View

Edit Columns...

Table Display:

All

Show Preview:

Show Cutout:

		Actions	Observation T...	Mission	Instrument	Project	Filters	Waveband	Target Name
☐	1		science	HUT	FUV			UV	M101A
☐	2		science	HUT	FUV			UV	M101A
☐	3		science	GALEX	GALEX	NGS	FUV	UV	NGA_M101
☐	4		science	GALEX	GALEX	NGS	NUV	UV	NGA_M101
☐	5		science	GALEX	GALEX	GII	NUV	UV	GI3_050008_NGC54
☐	6		science	GALEX	GALEX	GII	FUV	UV	GI3_050008_NGC54
☐	7		science	GALEX	GALEX	AIS	NUV	UV	AIS_101_1_32
☐	8		science	GALEX	GALEX	AIS	FUV	UV	AIS_101_1_32
☐	9		science	GALEX	GALEX	GII	FUV	UV	GI5_028139_W3_00
☐	10		science	GALEX	GALEX	GII	NUV	UV	GI5_028139_W3_00
☐	11		science	GALEX	GALEX	AIS	NUV	UV	AIS_101_1_37
☐	12		science	GALEX	GALEX	AIS	FUV	UV	AIS_101_1_37
☐	13		science	GALEX	GALEX	NGS	FUV	UV	NGA_NGC5474

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14:04:26.219 +54:19:40.86

14:03:12.545 +54:20:56.22

RA DEC
hhmmss/deg





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Table Display:

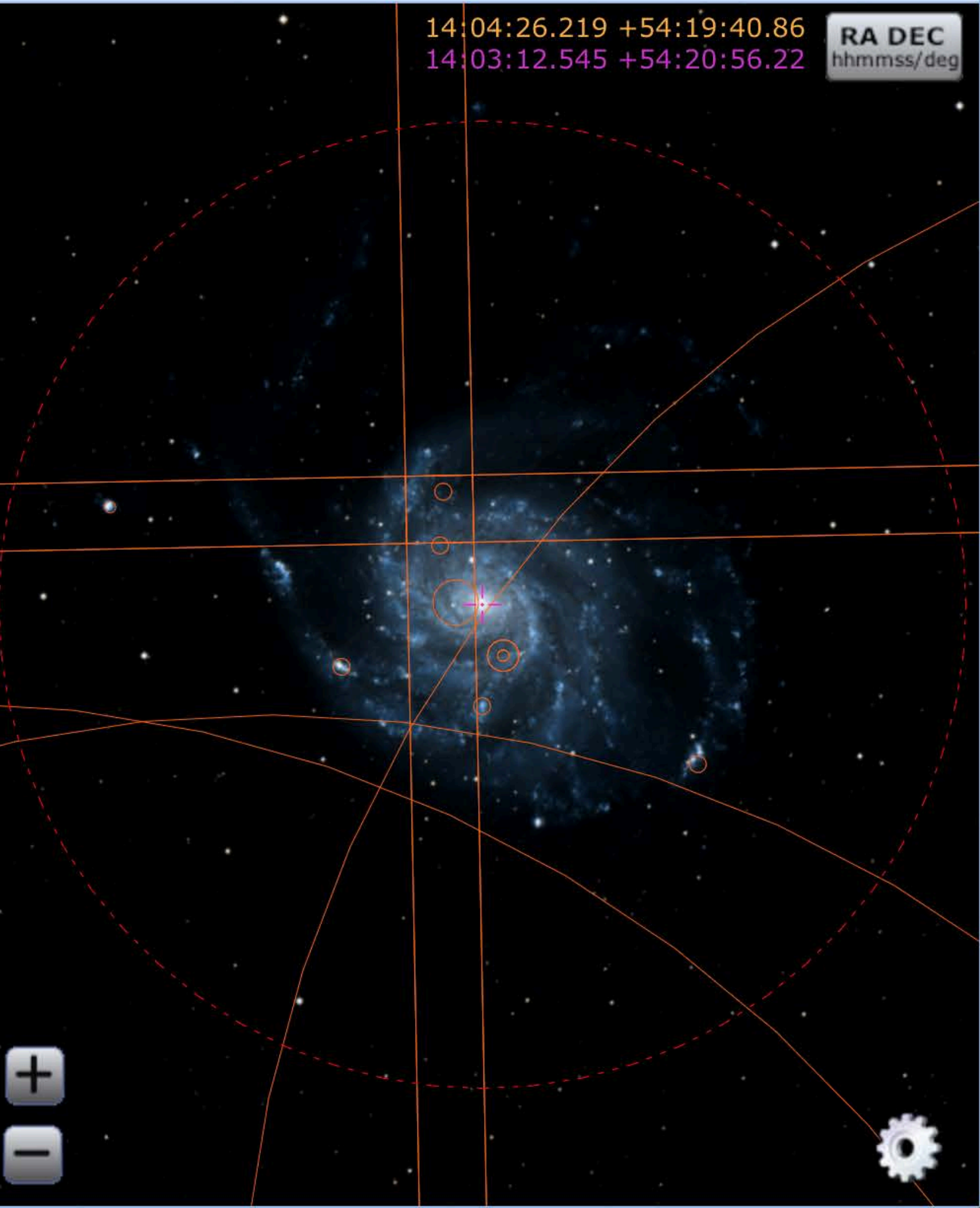
All

Show Preview:

Show Cutout:

		Actions	Observation T...	Mission	Instrument	Project	Filters	Waveband	Target Name
☐	1		science	PS1	GPC1	PS1	g	OPTICAL	2381.053
☐	2		science	PS1	GPC1	PS1	i	OPTICAL	2381.053
☐	3		science	PS1	GPC1	PS1	r	OPTICAL	2381.053
☐	4		science	PS1	GPC1	PS1	y	OPTICAL, IN...	2381.053
☐	5		science	PS1	GPC1	PS1	z	OPTICAL	2381.053
☐	6		science	PS1	GPC1	PS1	g	OPTICAL	2381.052
☐	7		science	PS1	GPC1	PS1	i	OPTICAL	2381.052
☐	8		science	PS1	GPC1	PS1	r	OPTICAL	2381.052
☐	9		science	PS1	GPC1	PS1	y	OPTICAL, IN...	2381.052
☐	10		science	PS1	GPC1	PS1	z	OPTICAL	2381.052
☐	11		science	PS1	GPC1	PS1	g	OPTICAL	2381.063
☐	12		science	PS1	GPC1	PS1	i	OPTICAL	2381.063
☐	13		science	PS1	GPC1	PS1	r	OPTICAL	2381.063

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Table Display:

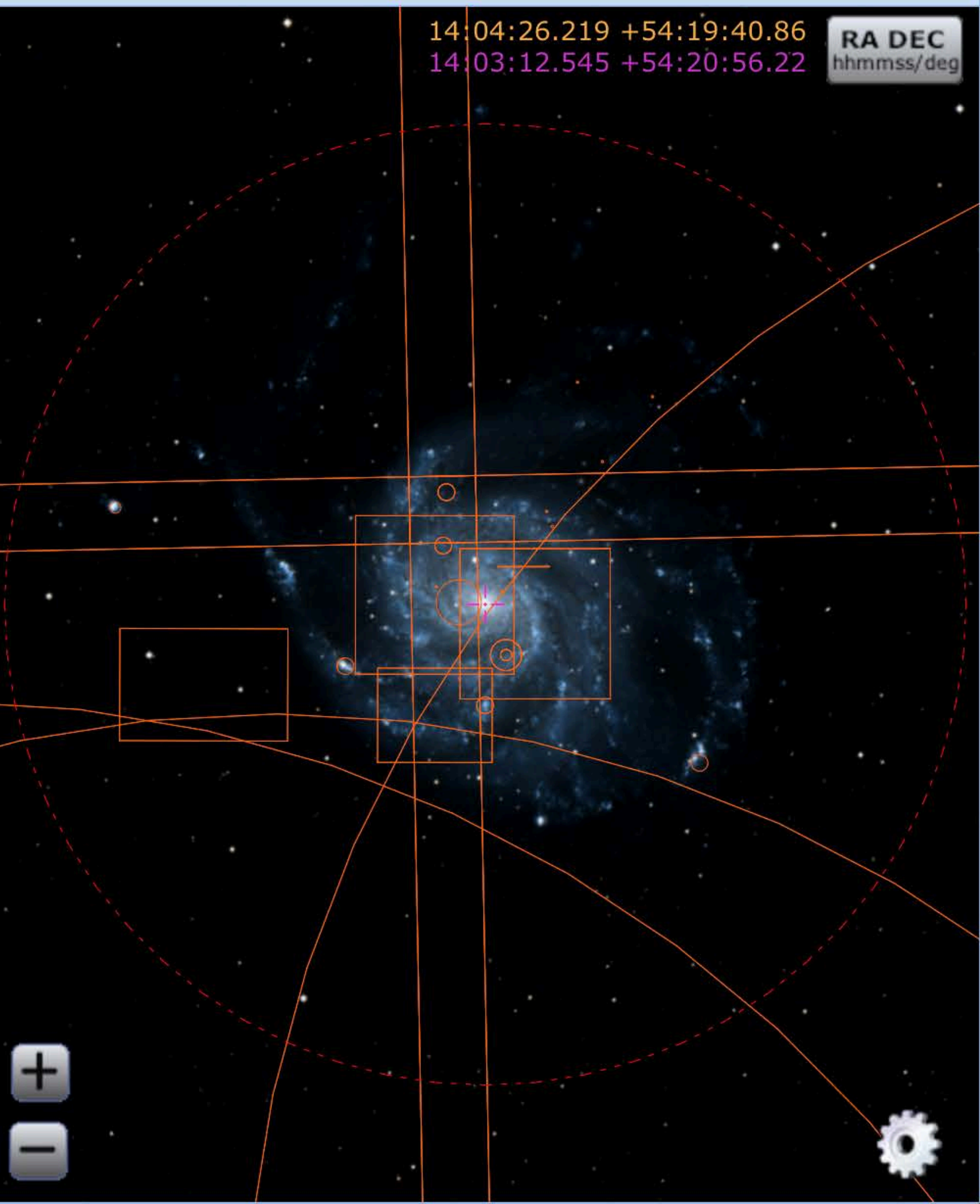
All

Show Preview:

Show Cutout:

		Actions	Observation T...	Mission	Instrument	Project	Filters	Waveband	Target Name
☐	1	...	science	PS1	GPC1	PS1	g	OPTICAL	2381.053
☐	2	...	science	PS1	GPC1	PS1	i	OPTICAL	2381.053
☐	3	...	science	PS1	GPC1	PS1	r	OPTICAL	2381.053
☐	4	...	science	PS1	GPC1	PS1	y	OPTICAL, IN...	2381.053
☐	5	...	science	PS1	GPC1	PS1	z	OPTICAL	2381.053
☐	6	...	science	PS1	GPC1	PS1	g	OPTICAL	2381.052
☐	7	...	science	PS1	GPC1	PS1	i	OPTICAL	2381.052
☐	8	...	science	PS1	GPC1	PS1	r	OPTICAL	2381.052
☐	9	...	science	PS1	GPC1	PS1	y	OPTICAL, IN...	2381.052
☐	10	...	science	PS1	GPC1	PS1	z	OPTICAL	2381.052
☐	11	...	science	PS1	GPC1	PS1	g	OPTICAL	2381.063
☐	12	...	science	PS1	GPC1	PS1	i	OPTICAL	2381.063
☐	13	...	science	PS1	GPC1	PS1	r	OPTICAL	2381.063

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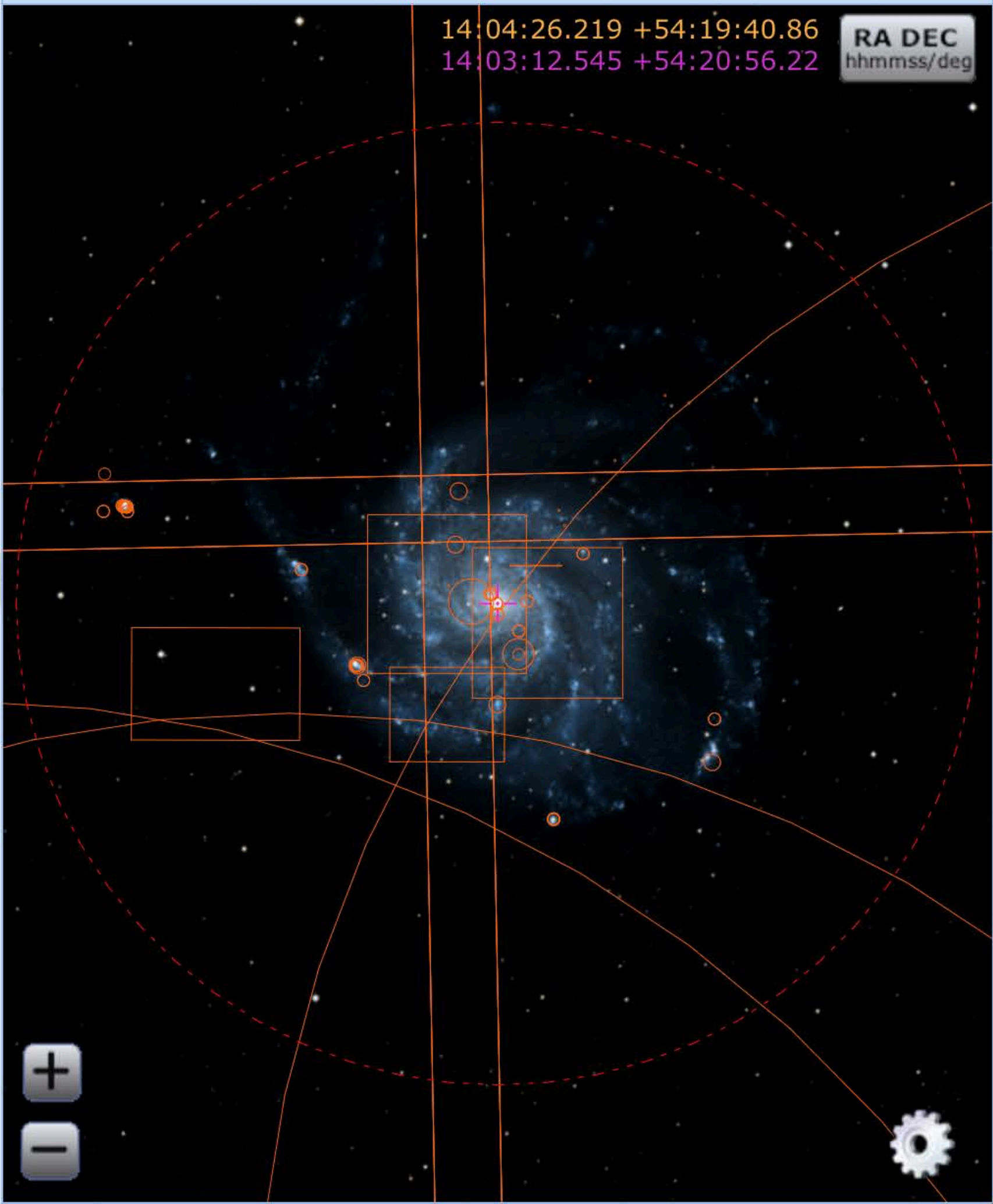
Footprints: All

List View Album View

Edit Columns... Table Display: All Show Preview: Show Cutout:

		Actions	Observation T...	Mission	Instrument	Project	Filters	Waveband	Target Name
	1		science	PS1	GPC1	PS1	g	OPTICAL	2381.053
	2		science	PS1	GPC1	PS1	i	OPTICAL	2381.053
	3		science	PS1	GPC1	PS1	r	OPTICAL	2381.053
	4		science	PS1	GPC1	PS1	y	OPTICAL, IN...	2381.053
	5		science	PS1	GPC1	PS1	z	OPTICAL	2381.053
	6		science	PS1	GPC1	PS1	g	OPTICAL	2381.052
	7		science	PS1	GPC1	PS1	i	OPTICAL	2381.052
	8		science	PS1	GPC1	PS1	r	OPTICAL	2381.052
	9		science	PS1	GPC1	PS1	y	OPTICAL, IN...	2381.052
	10		science	PS1	GPC1	PS1	z	OPTICAL	2381.052
	11		science	PS1	GPC1	PS1	g	OPTICAL	2381.063
	12		science	PS1	GPC1	PS1	i	OPTICAL	2381.063
	13		science	PS1	GPC1	PS1	r	OPTICAL	2381.063

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		Actions	Observation T...	Mission	Instrument	Project	Filters	Waveband	Target Name
☐	1	...	science	PS1	GPC1	PS1	g	OPTICAL	2381.053
☐	2	...	science	PS1	GPC1	PS1	i	OPTICAL	2381.053
☐	3	...	science	PS1	GPC1	PS1	r	OPTICAL	2381.053
☐	4	...	science	PS1	GPC1	PS1	y	OPTICAL, IN...	2381.053
☐	5	...	science	PS1	GPC1	PS1	z	OPTICAL	2381.053
☐	6	...	science	PS1	GPC1	PS1	g	OPTICAL	2381.052
☐	7	...	science	PS1	GPC1	PS1	i	OPTICAL	2381.052
☐	8	...	science	PS1	GPC1	PS1	r	OPTICAL	2381.052
☐	9	...	science	PS1	GPC1	PS1	y	OPTICAL, IN...	2381.052
☐	10	...	science	PS1	GPC1	PS1	z	OPTICAL	2381.052
☐	11	...	science	PS1	GPC1	PS1	g	OPTICAL	2381.063
☐	12	...	science	PS1	GPC1	PS1	i	OPTICAL	2381.063
☐	13	...	science	PS1	GPC1	PS1	r	OPTICAL	2381.063





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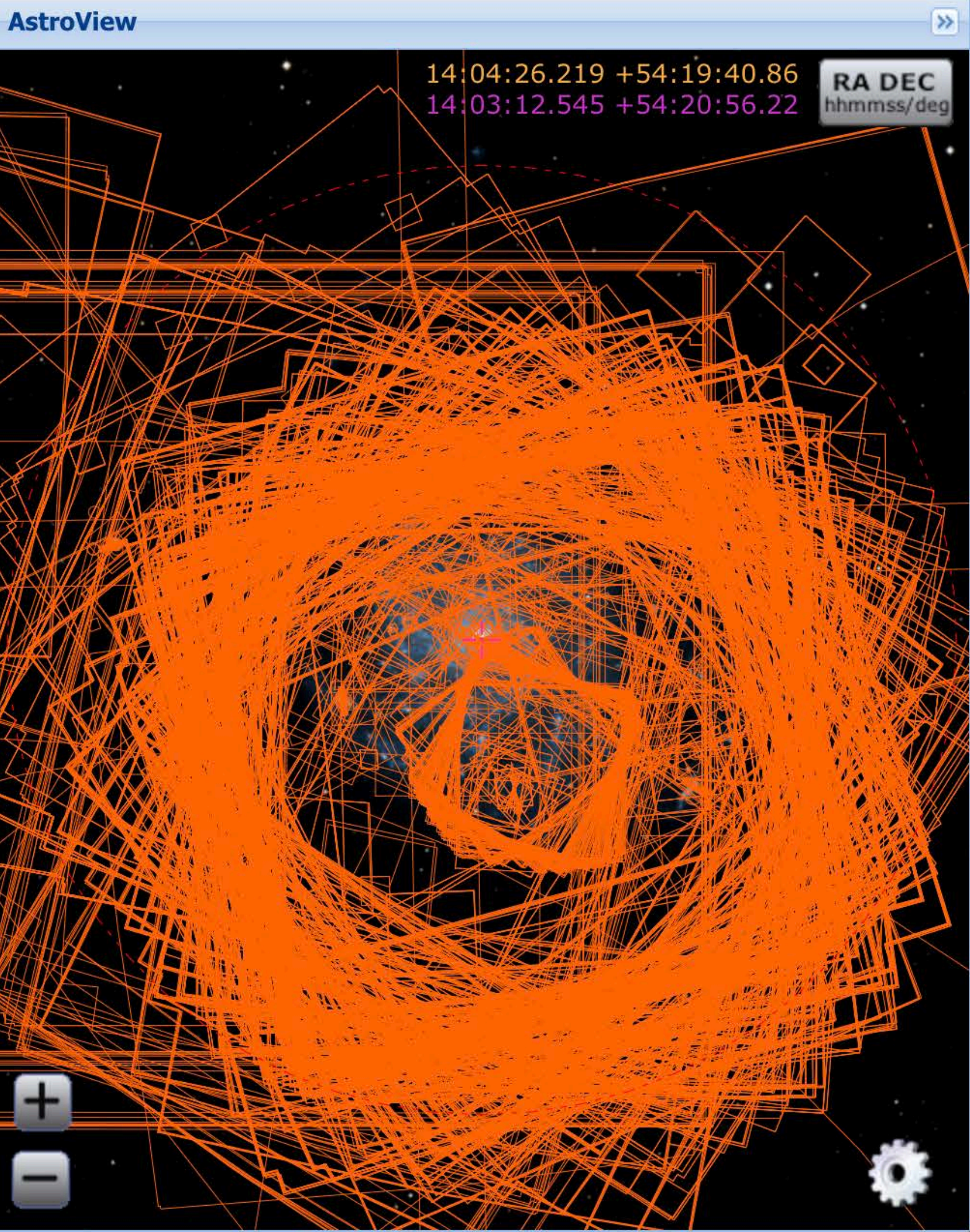


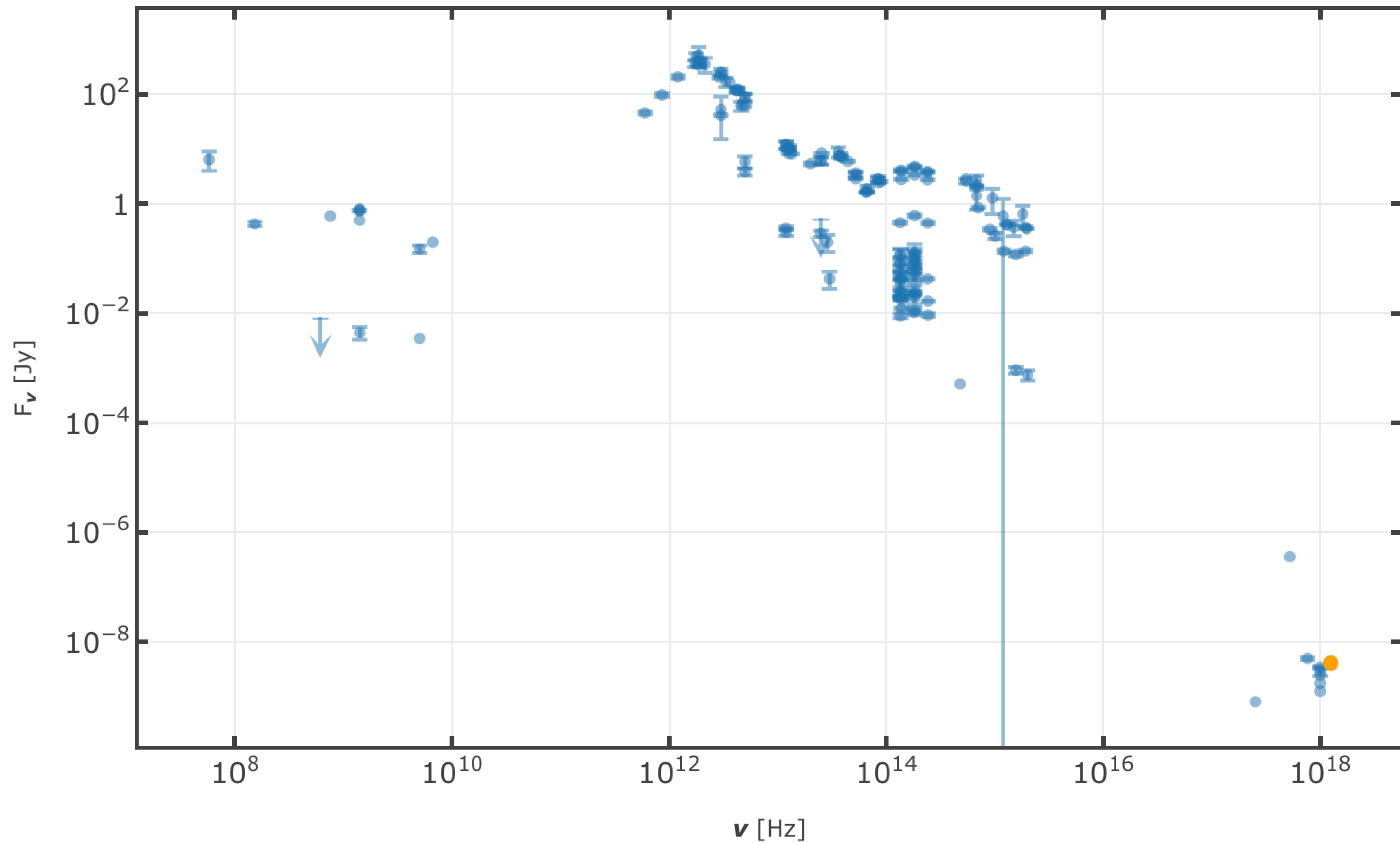
Footprints: All

[List View](#) [Album View](#)

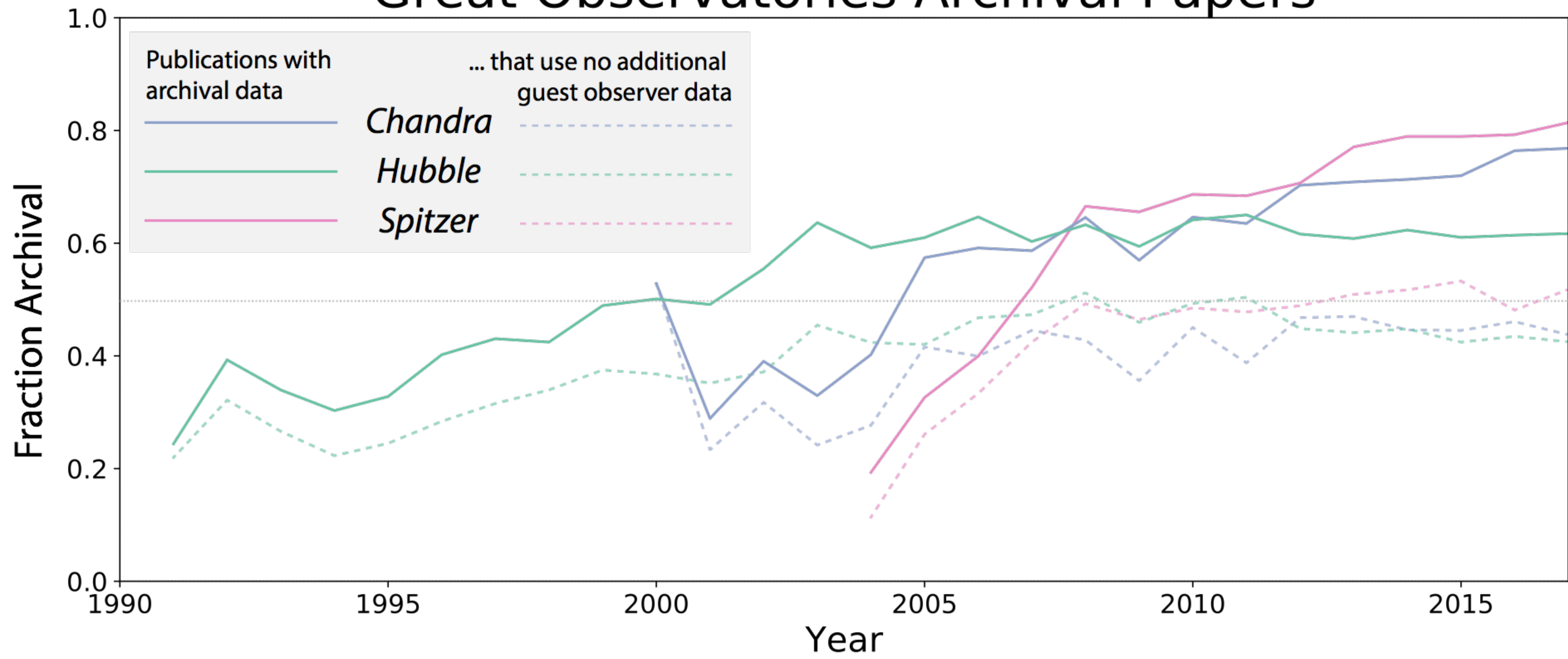
Edit Columns... Table Display: All Show Preview: Show Cutout:

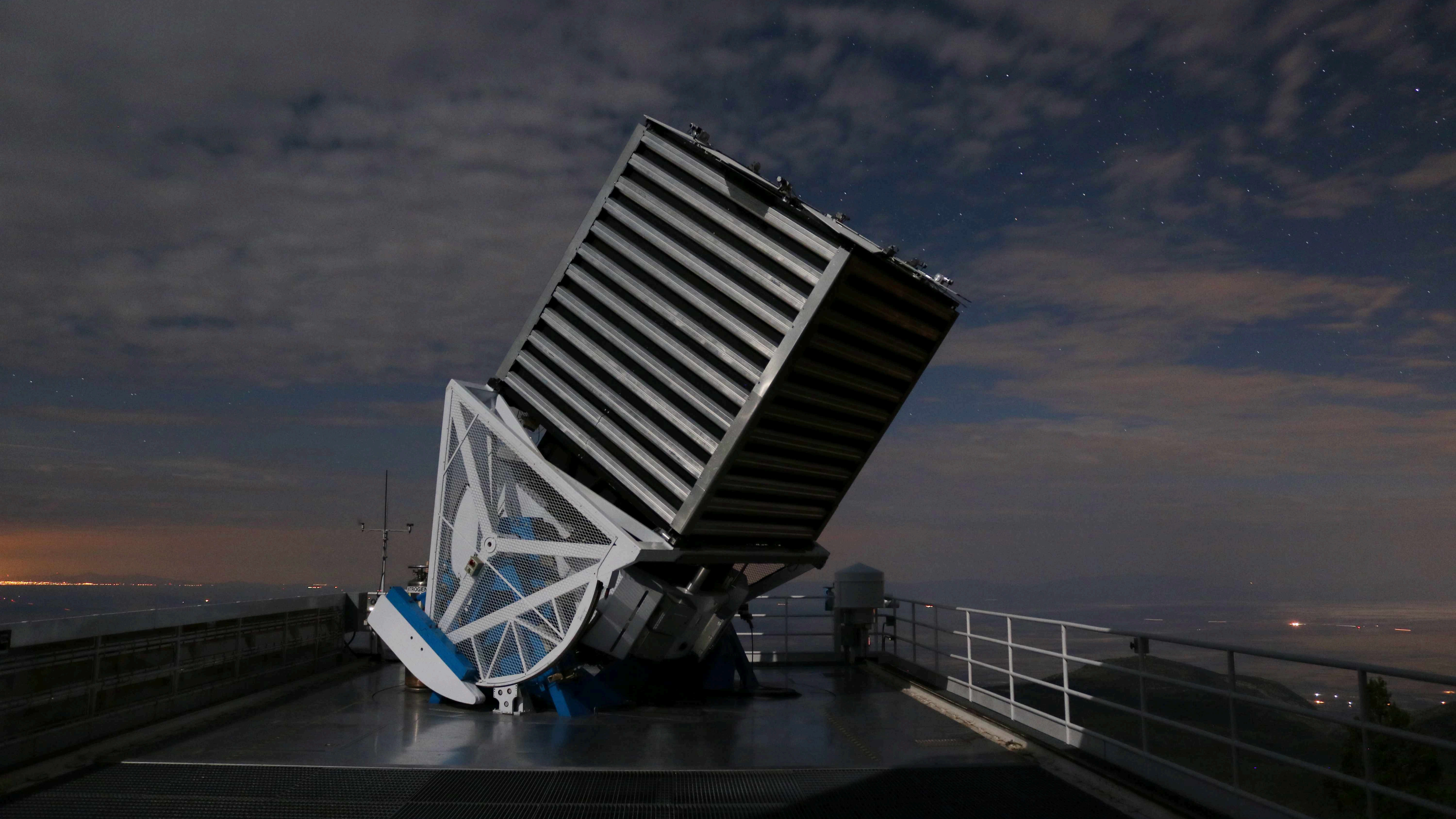
		Actions	Observation T...	Mission	Instrument	Project	Filters	Waveband	Target Name
☐	1		science	SWIFT	UVOT		V	OPTICAL	M101ULX-1
☐	2		science	SWIFT	UVOT		U	OPTICAL	M101ULX-1
☐	3		science	SWIFT	UVOT		B	OPTICAL	M101ULX-1
☐	4		science	SWIFT	UVOT		U	OPTICAL	M101ULX-1
☐	5		science	SWIFT	UVOT		V	OPTICAL	M101ULX-1
☐	6		science	SWIFT	UVOT		B	OPTICAL	M101ULX-1
☐	7		science	SWIFT	UVOT		U	OPTICAL	M101ULX-1
☐	8		science	SWIFT	UVOT		V	OPTICAL	M101ULX-1
☐	9		science	SWIFT	UVOT		B	OPTICAL	M101ULX-1
☐	10		science	SWIFT	UVOT		UVW2	UV, OPTICAL	M101ULX-1
☐	11		science	SWIFT	UVOT		U	OPTICAL	M101ULX-1
☐	12		science	SWIFT	UVOT		UVW1	UV, OPTICAL	M101ULX-1
☐	13		science	SWIFT	UVOT		UVM2	UV	M101ULX-1

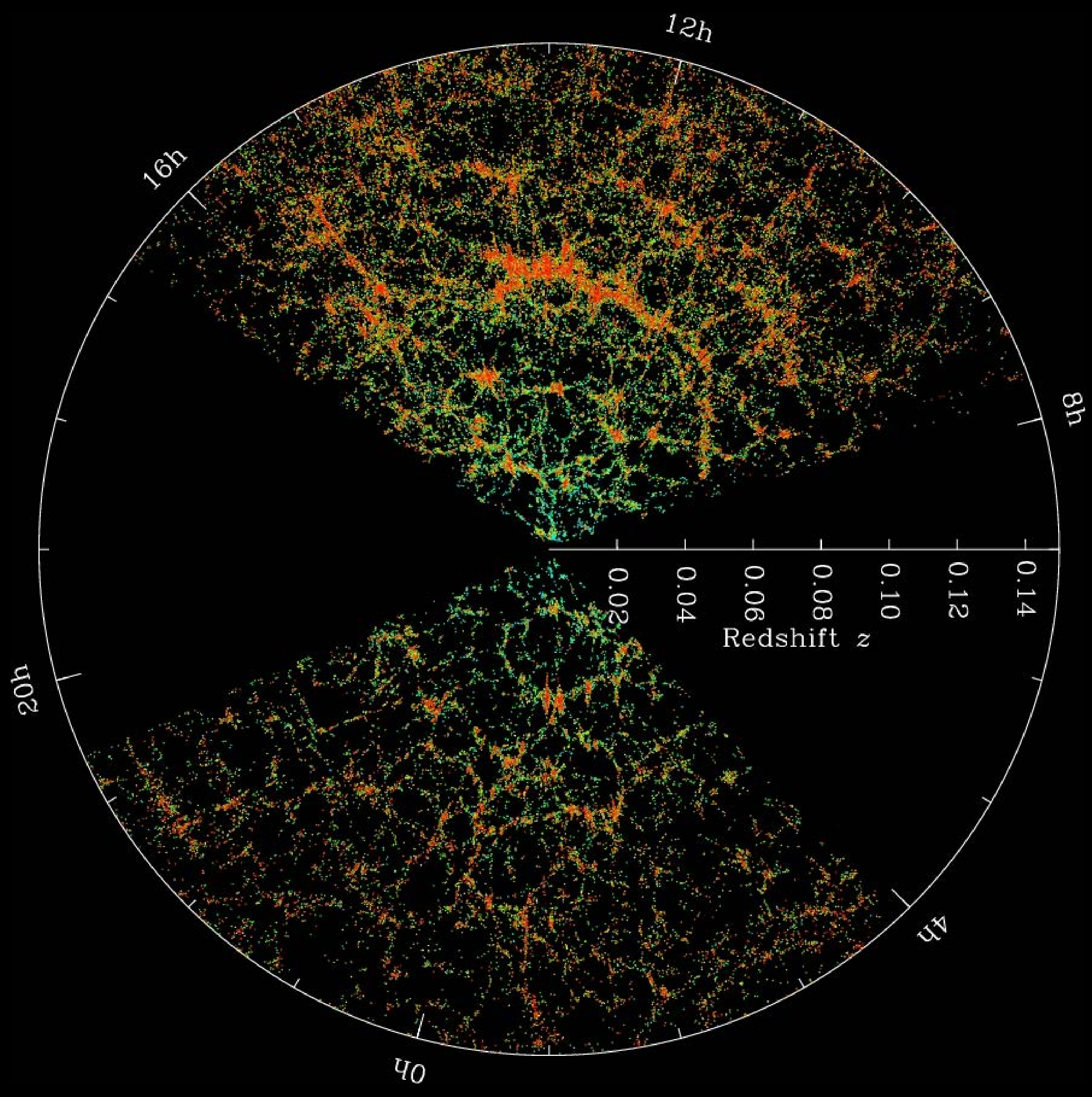




Great Observatories Archival Papers







The Virtual Observatory

Common Archive Observation Model

Unified Search



The Virtual Observatory

The Virtual Observatory (VO) is a collective term referring to an ecosystem of standards and the organizations and tools which use those standards in astronomy.

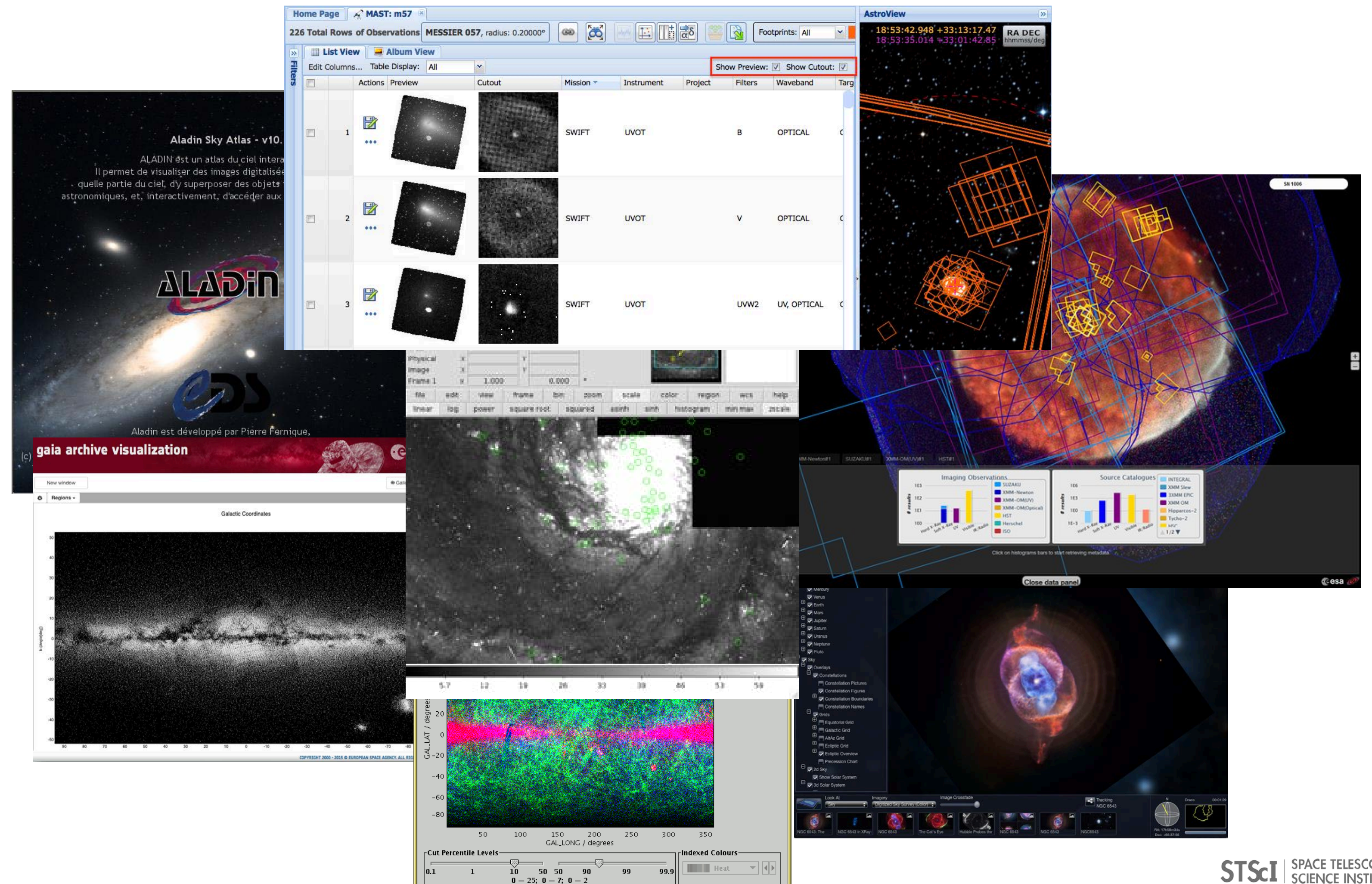
- Note: “The VO” is *not* a single application or web page.
- It is neither Virtual nor an Observatory
- The standards, organizations and tools together enable the discovery and exchange of astronomical data.
- Simple VO Standards define cone searches on catalogs (lists of eg. stars), images and spectral data collections.
- More complex standards define, for example:
 - How to register data services
 - SQL-style database queries
 - Event notification (Something goes boom in the night)
 - Image cutout services (give me a picture of the sky from this data of exactly this shape)
 - Server-side user storage



Virtual Observatory Tools

Many existing tools make use of “the VO” for data discovery and access

- MAST Discovery Portal
- ESA Sky
- WorldWide Telescope
- Gaia Archive
- Aladin
- TOPCAT
- DS9





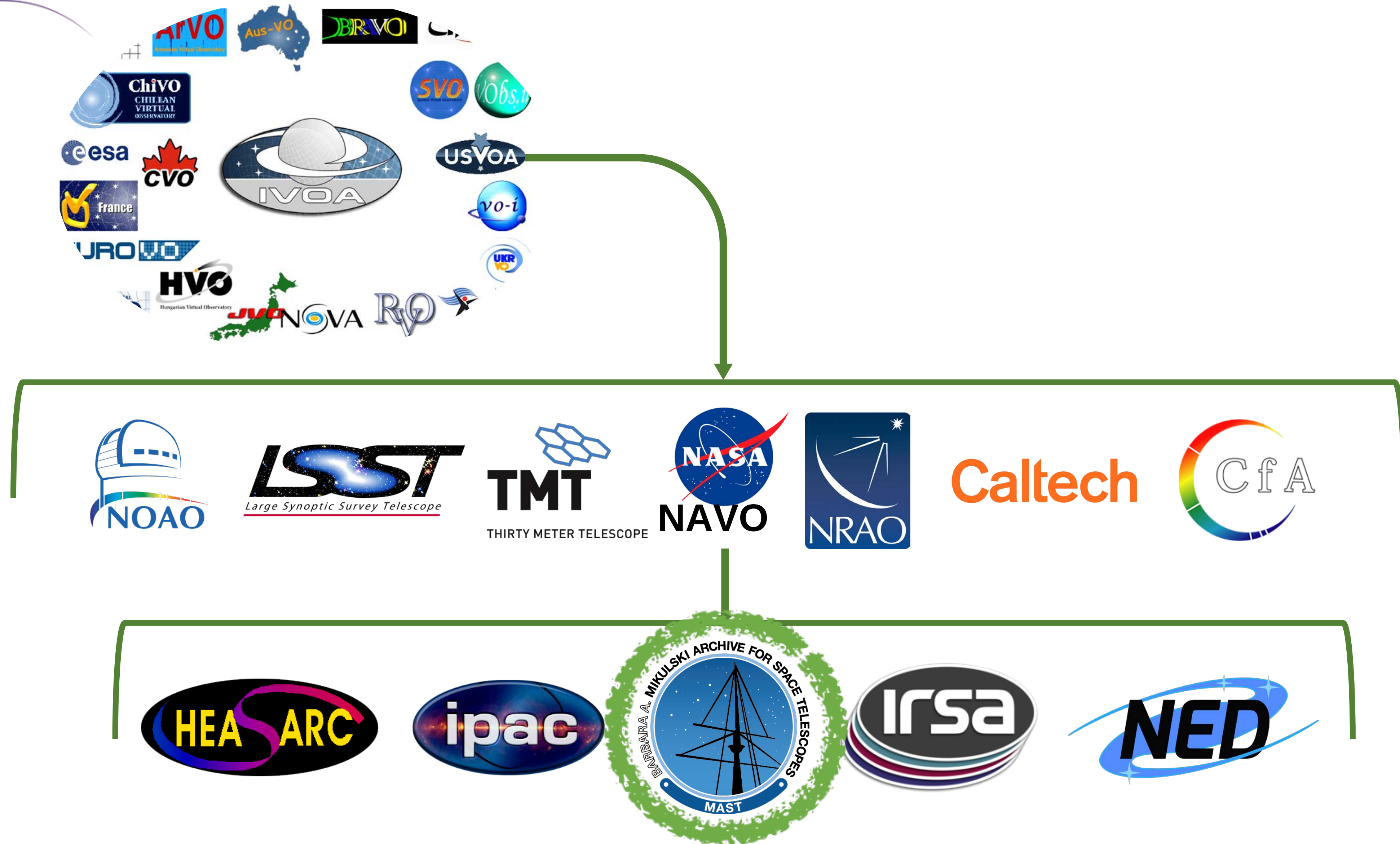
The IVOA

- IVOA defines the standards
- Composed of national-level organizations
- Astronomers and engineers in these organizations form subject matter working groups





VO Organization





VO “Dirty Laundry”

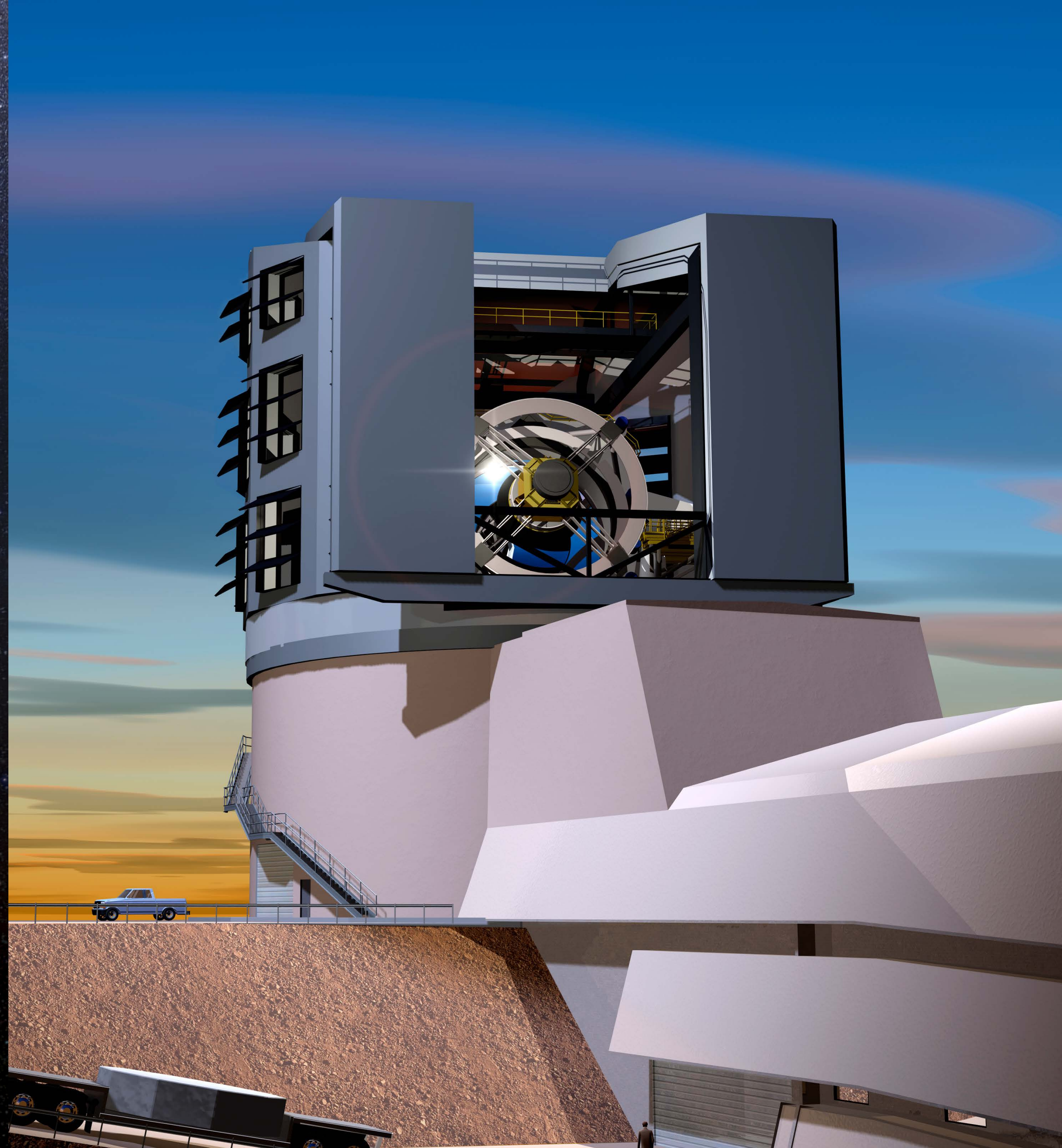
- Astronomers have very mixed feelings about “the VO”; some think it is a panacea, some think it promised much easier workflows than have been delivered (**The Atlantic Effect**)





VO “Dirty Laundry”

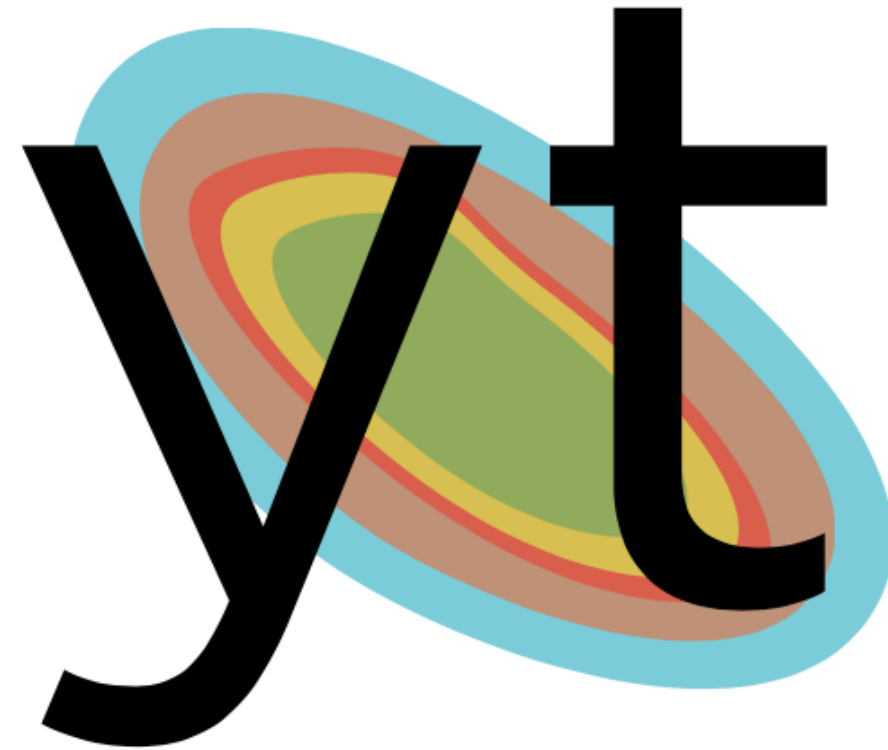
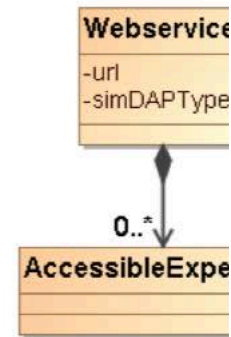
- Astronomers have very mixed feelings about “the VO”; some think it is a panacea, some think it promised much easier workflows than have been delivered (**The Atlantic Effect**)
- The success of the VO depends on technical leads of major projects spending extra effort to make technology “VO-compliant” at various levels (**The Wil Effect**)





VO “Dirty Laundry”

- Astronomers have very mixed feelings about “the VO”; some think it is a panacea, some think it promised much easier workflows than have been delivered (**The Atlantic Effect**)
- The success of the VO depends on technical leads of major projects spending extra effort to make technology “VO-compliant” at various levels (**The Wil Effect**)
- Many VO standards have failed to see any uptake in the community (**Simulation Data Model Effect**)



yt is an open-source, permissively-licensed python package for analyzing and visualizing volumetric data.

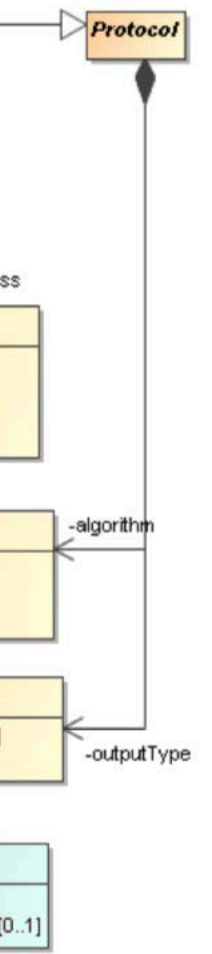
yt supports structured, variable-resolution meshes, unstructured meshes, and discrete or sampled data such as particles. Focused on driving physically-meaningful inquiry, yt has been applied in domains such as astrophysics, seismology, nuclear engineering, molecular dynamics, and oceanography. Composed of a friendly community of users and developers, we want to make it easy to use and develop — we'd love it if you got involved!



Get yt!



Try yt!

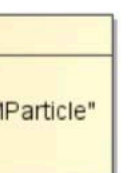
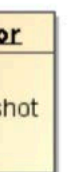
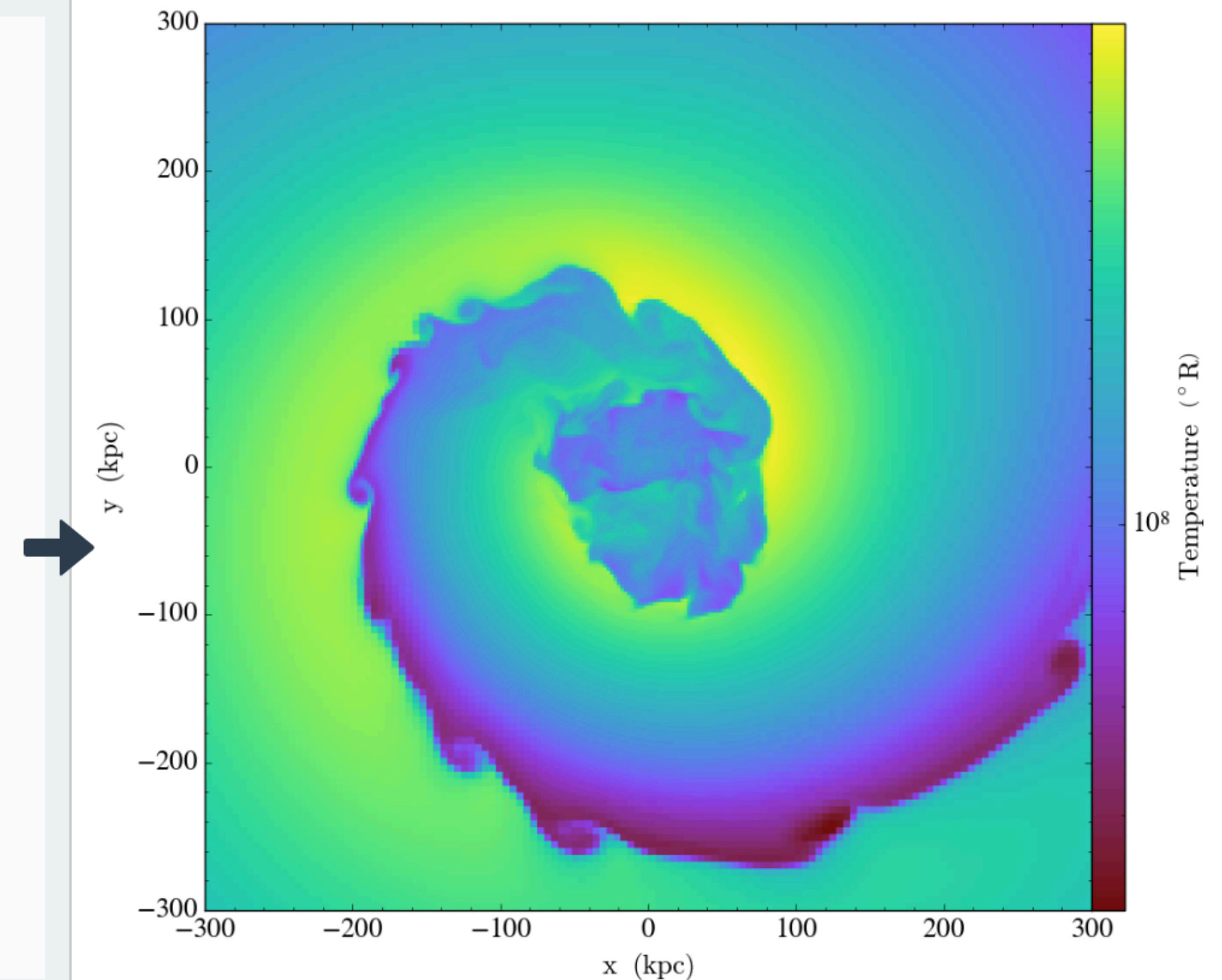


Data ▾

Viz ▾

Analysis ▾

```
import yt
ds = yt.load("GasSloshing/sloshing_nomag2_hdf5_plt_cnt_0150",
             unit_system="imperial")
slc = yt.SlicePlot(ds, 'z', "temperature", width=(600, "kpc"))
```





VO “Dirty Laundry”

- Astronomers have very mixed feelings about “the VO”; some think it is a panacea, some think it promised much easier workflows than have been delivered (**The Atlantic Effect**)
- The success of the VO depends on technical leads of major projects spending extra effort to make technology “VO-compliant” at various levels (**The Wil Effect**)
- Many VO standards have failed to see any uptake in the community (**Simulation Data Model Effect**)
- The IVOA is Slow, Formal, and Exclusive (**The ADASS/dotAstro Divide**)

Something designed to work
across many implementations

Common

At the level of a center,
not at the level of a user

Archive

For astronomy, not reinventing
something that could be adopted

Observation

A relatively generic structure,
not just for one data type

Model



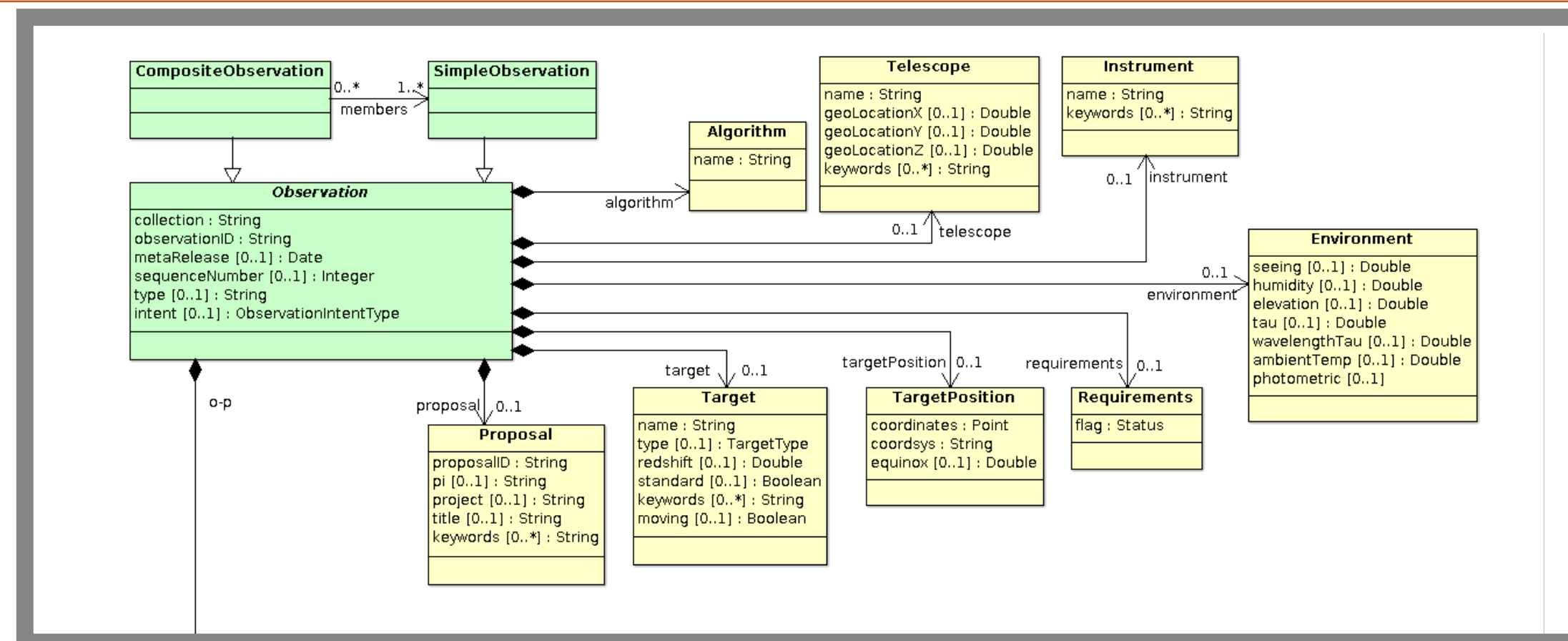
Common Archive Observation Model

CAOM is a unified model for metadata for an *observation* for any telescope:

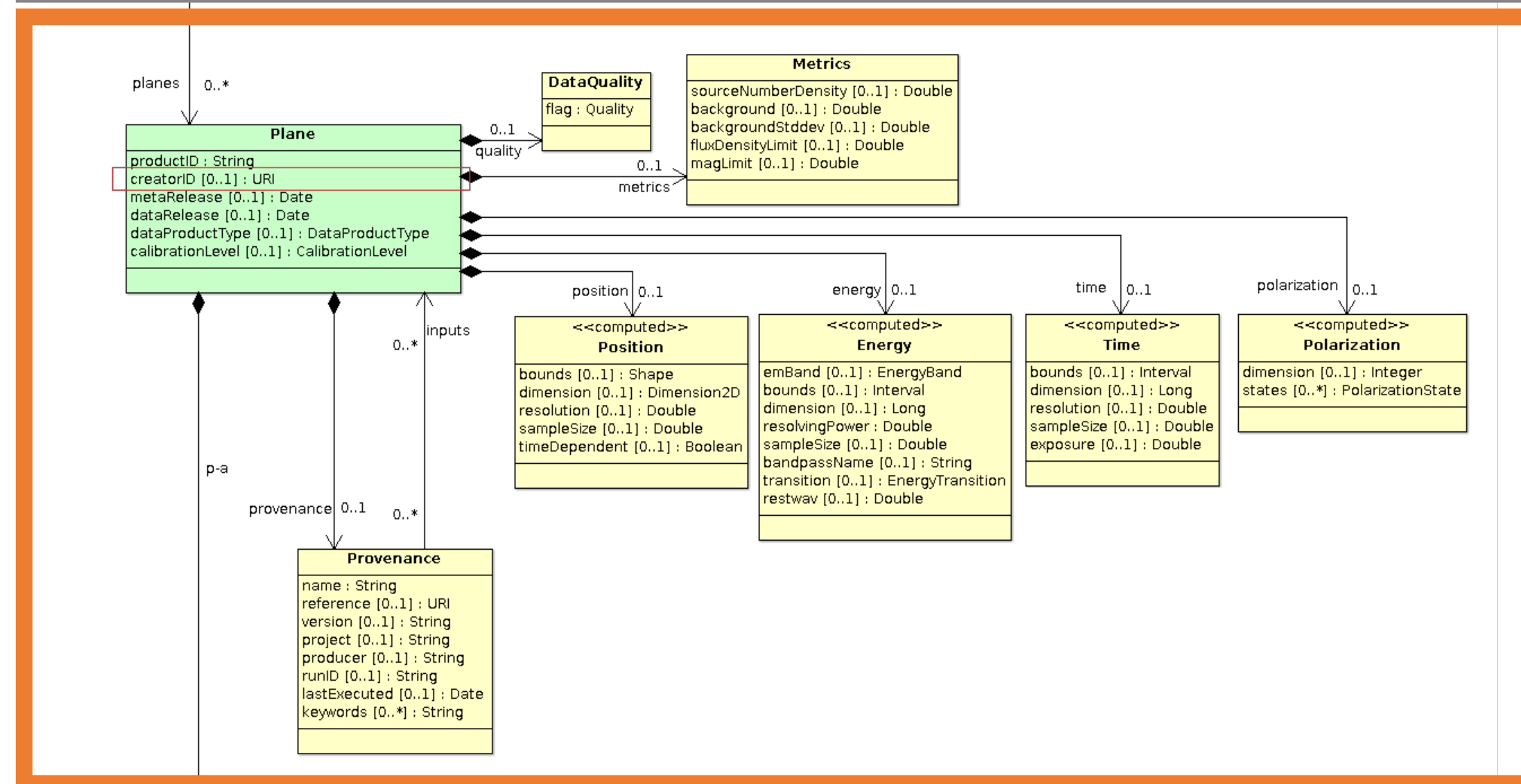
- Standardizes the core parts of an archive implementation
- Enable *cross-mission searches* and enhances scientific value
- Simplify data access with a common set of software
- Model is extensible for mission specific metadata



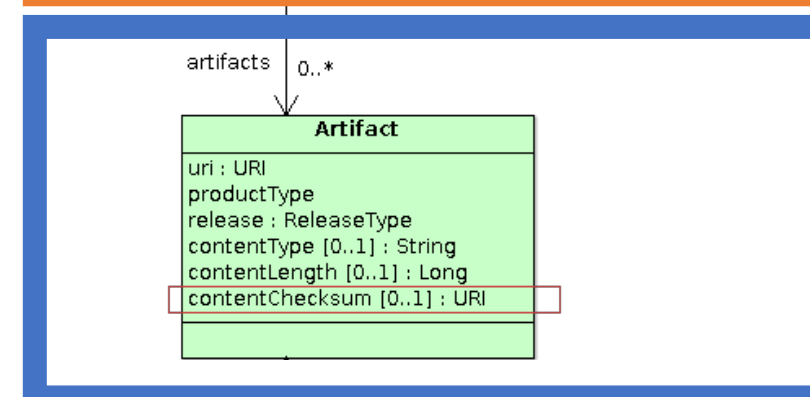
- Observation



- Plane



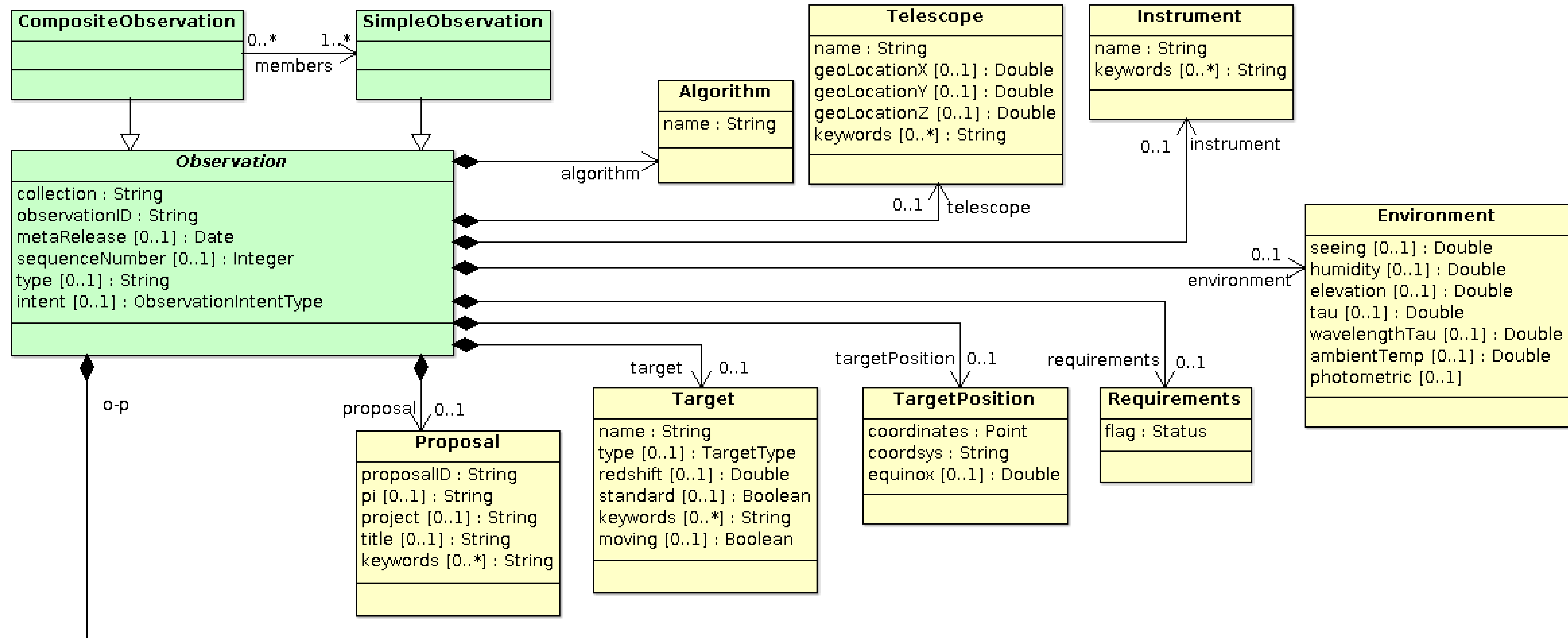
- Artifact

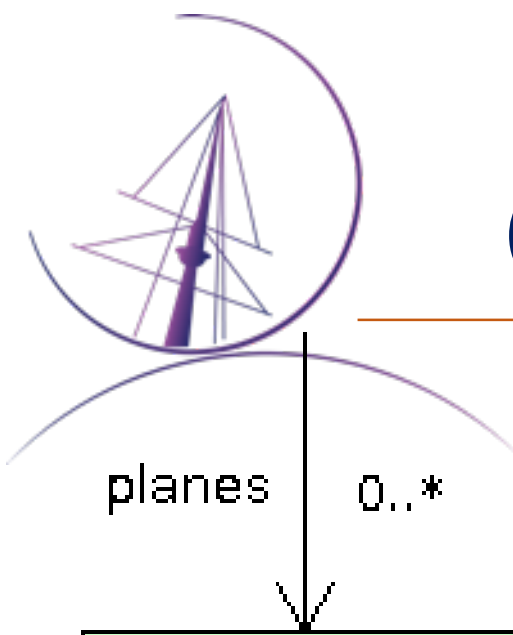




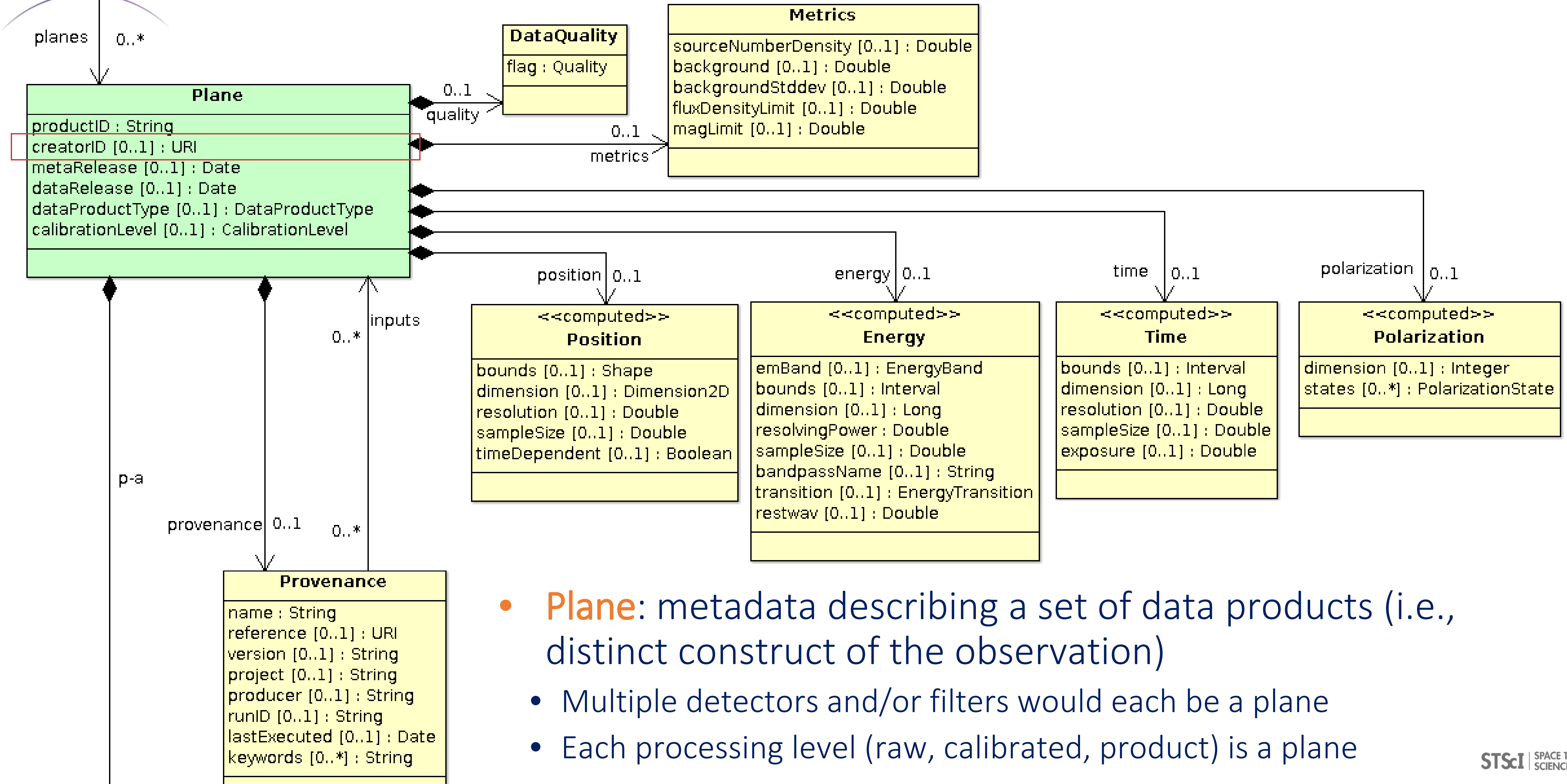
CAOM

- Observation: metadata describing characteristics of an observation





CAOM

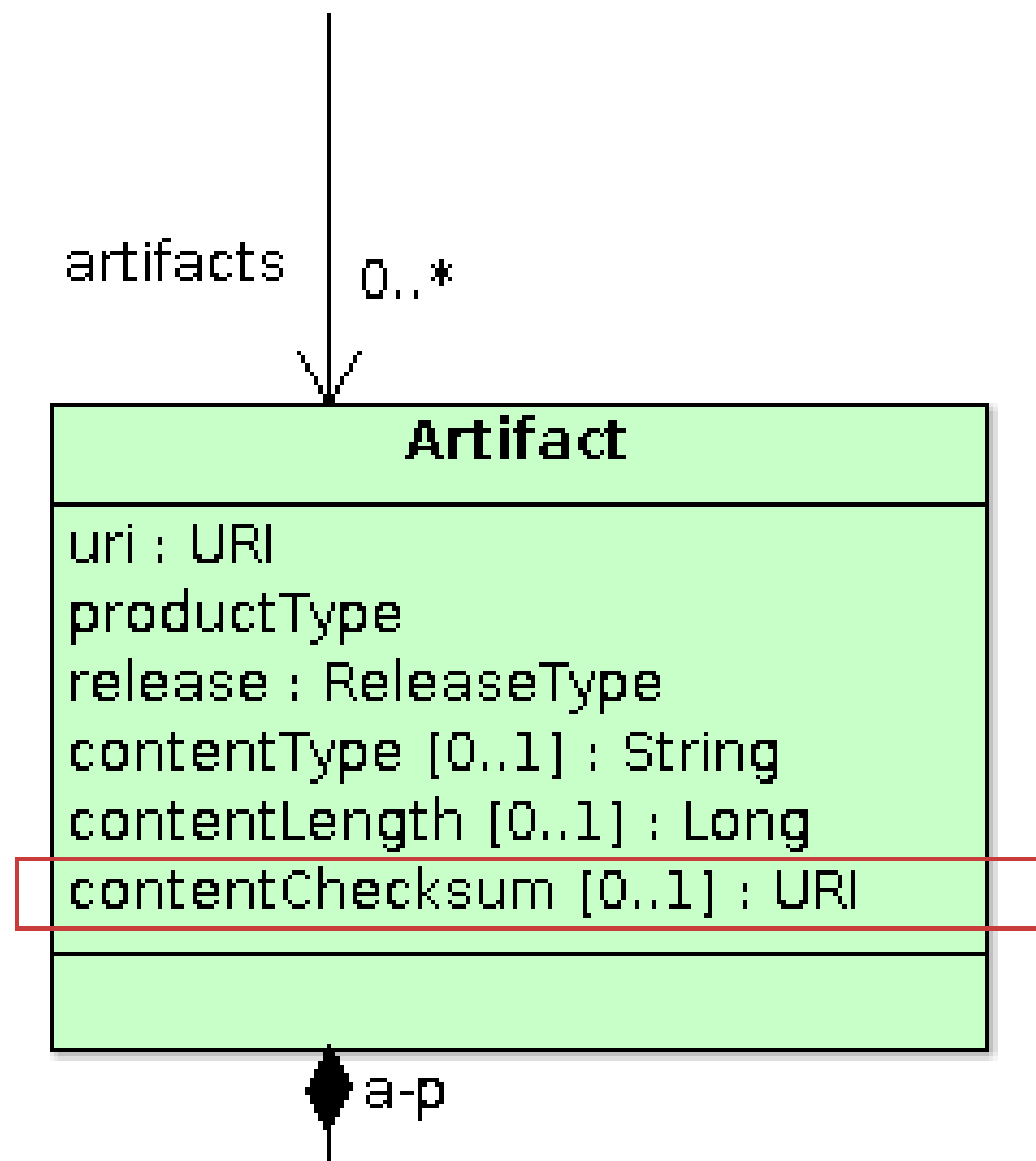


- **Plane**: metadata describing a set of data products (i.e., distinct construct of the observation)
 - Multiple detectors and/or filters would each be a plane
 - Each processing level (raw, calibrated, product) is a plane



CAOM v2.3

- **Artifact:** metadata describing a distinct product file
 - Includes pointer (URI) to actual data files





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Filters

List View

Album View

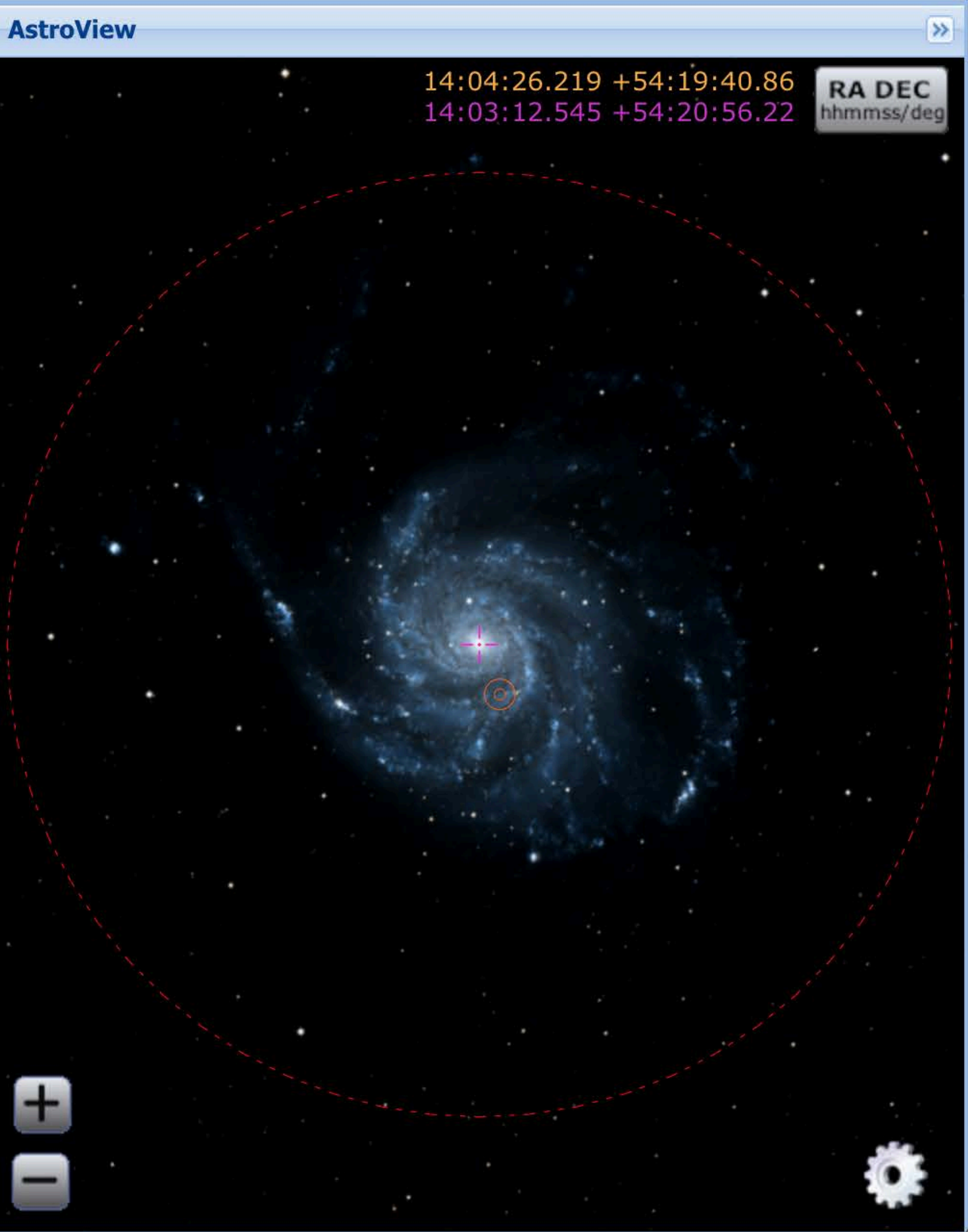
Edit Columns...

Table Display: All

Show Preview: ☐

Show Cutout: ☐

		Actions	Observation T...	Mission	Instrument	Project	Filters	Waveband	Target Name
☐	1		science	HUT	FUV			UV	M101A
☐	2		science	HUT	FUV			UV	M101A





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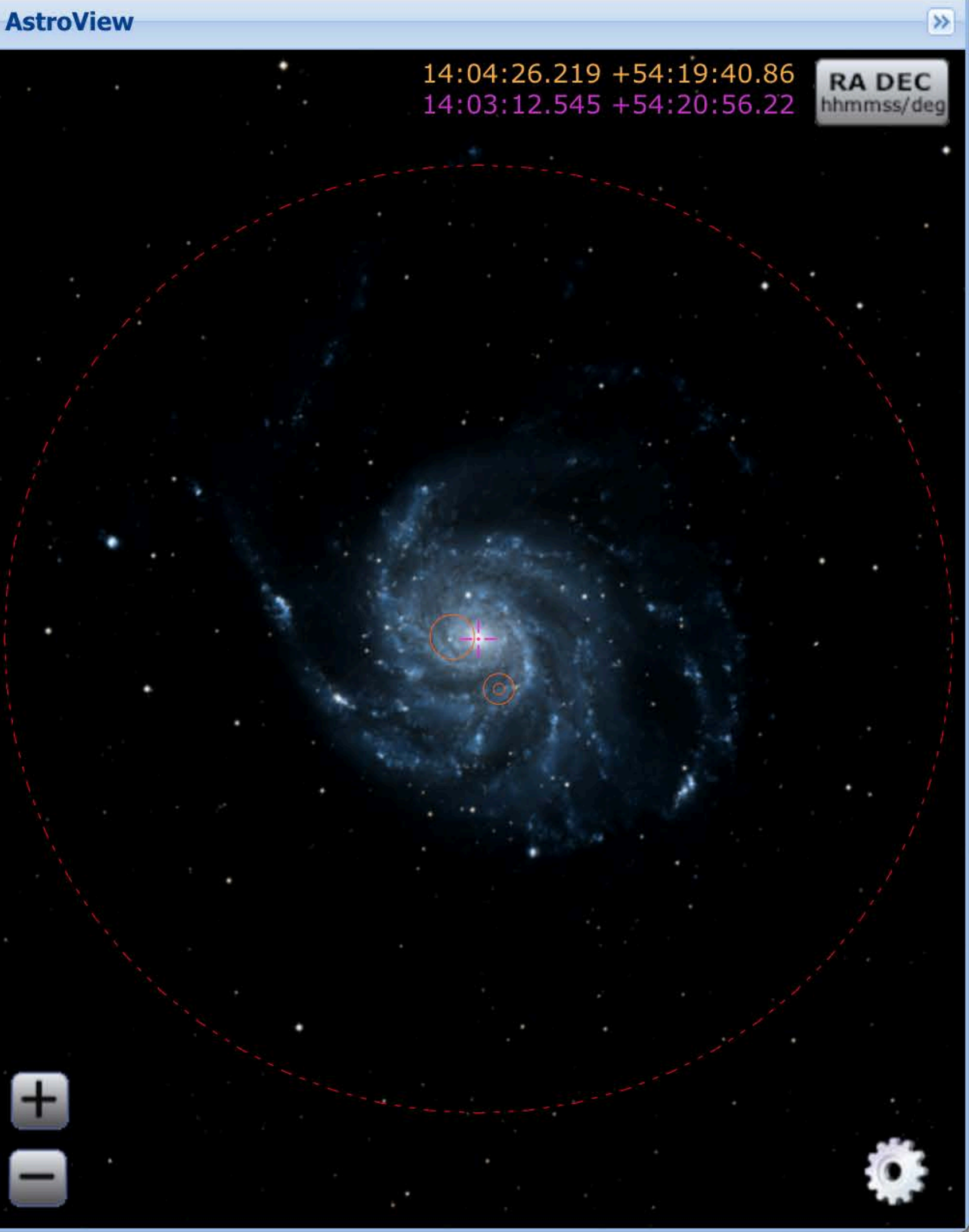
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Filters

List View		Album View	
Edit Columns...		Table Display: All	
		Show Preview: ☐ Show Cutout: ☐	
☐		Actions	Observation T... Mission Instrument Project Filters Waveband Target Name
☐	1		science HUT FUV UV M101A
☐	2		science HUT FUV UV M101A
☐	3		science EUVE DS/S EUVE EUV NGC 5457
☐	4		science EUVE DS/S EUVE EUV NGC 5457





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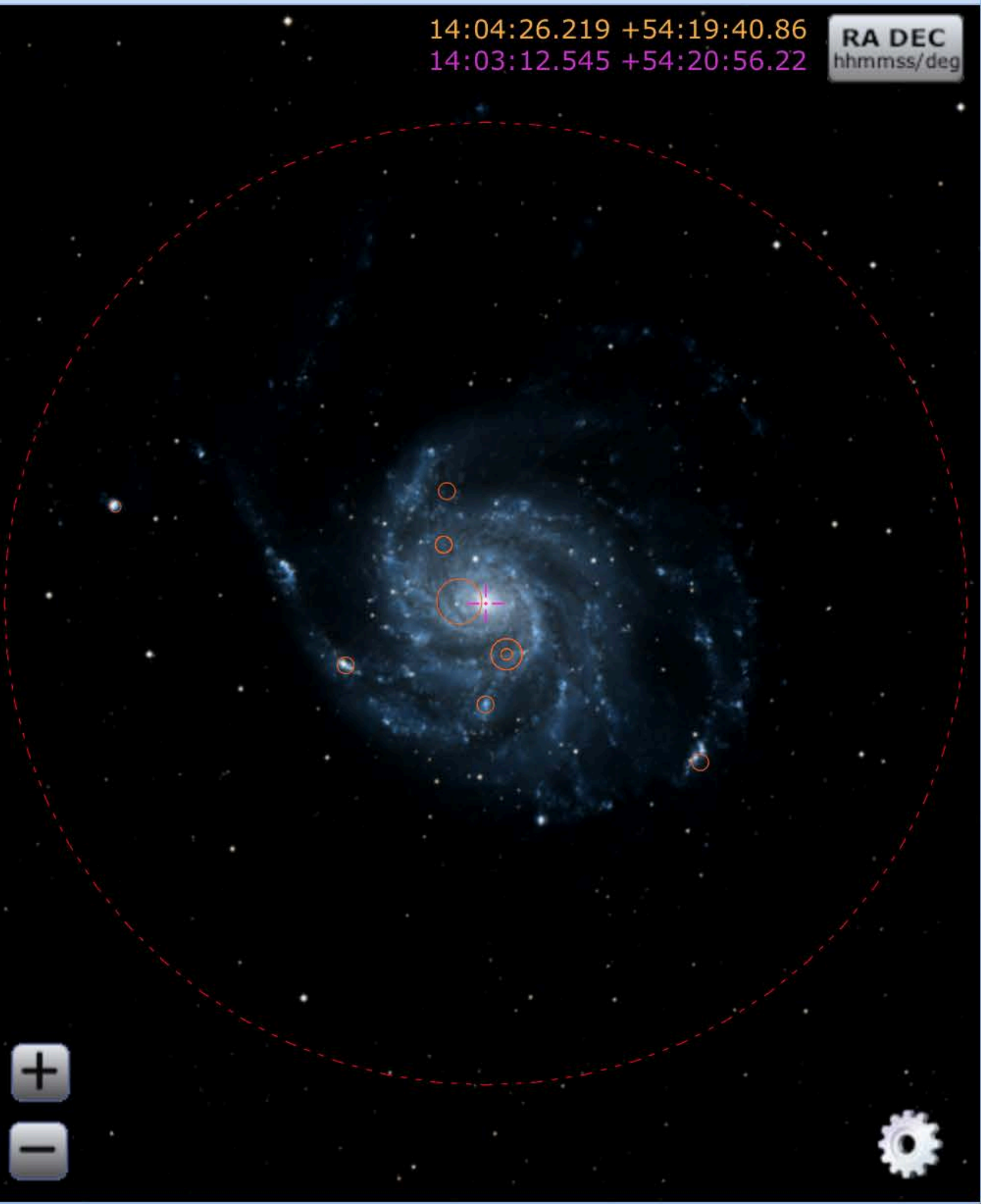
Filters

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Edit Columns... Table Display: All Show Preview: Show Cutout:

		Actions	Observation T...	Mission	Instrument	Project	Filters	Waveband	Target Name
☐	1		science	HUT	FUV			UV	M101A
☐	2		science	HUT	FUV			UV	M101A
☐	3		science	FUSE	FUV			UV	NGC5457-POS1
☐	4		science	FUSE	FUV			UV	M-101-D
☐	5		science	FUSE	FUV			UV	NGC5457-POS2
☐	6		science	FUSE	FUV			UV	NGC5461
☐	7		science	FUSE	FUV			UV	NGC5447
☐	8		science	FUSE	FUV			UV	NGC5471
☐	9		science	FUSE	FUV			UV	NGC5471
☐	10		science	EUVE	DS/S	EUVE		EUV	NGC 5457
☐	11		science	EUVE	DS/S	EUVE		EUV	NGC 5457

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MESSIER 101, radius: 0.24000°

Footprints: All

List View

Album View

Edit Columns...

Table Display:

All

Show Preview:

Show Cutout:

		Actions	Observation T...	Mission	Instrument	Project	Filters	Waveband	Target Name
☐	1		science	HUT	FUV			UV	M101A
☐	2		science	HUT	FUV			UV	M101A
☐	3		science	GALEX	GALEX	NGS	FUV	UV	NGA_M101
☐	4		science	GALEX	GALEX	NGS	NUV	UV	NGA_M101
☐	5		science	GALEX	GALEX	GII	NUV	UV	GI3_050008_NGC54
☐	6		science	GALEX	GALEX	GII	FUV	UV	GI3_050008_NGC54
☐	7		science	GALEX	GALEX	AIS	NUV	UV	AIS_101_1_32
☐	8		science	GALEX	GALEX	AIS	FUV	UV	AIS_101_1_32
☐	9		science	GALEX	GALEX	GII	FUV	UV	GI5_028139_W3_00
☐	10		science	GALEX	GALEX	GII	NUV	UV	GI5_028139_W3_00
☐	11		science	GALEX	GALEX	AIS	NUV	UV	AIS_101_1_37
☐	12		science	GALEX	GALEX	AIS	FUV	UV	AIS_101_1_37
☐	13		science	GALEX	GALEX	NGS	FUV	UV	NGA_NGC5474

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14:04:26.219 +54:19:40.86

14:03:12.545 +54:20:56.22

RA DEC
hhmmss/deg

+

-





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Filters

List View

Album View

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Table Display:

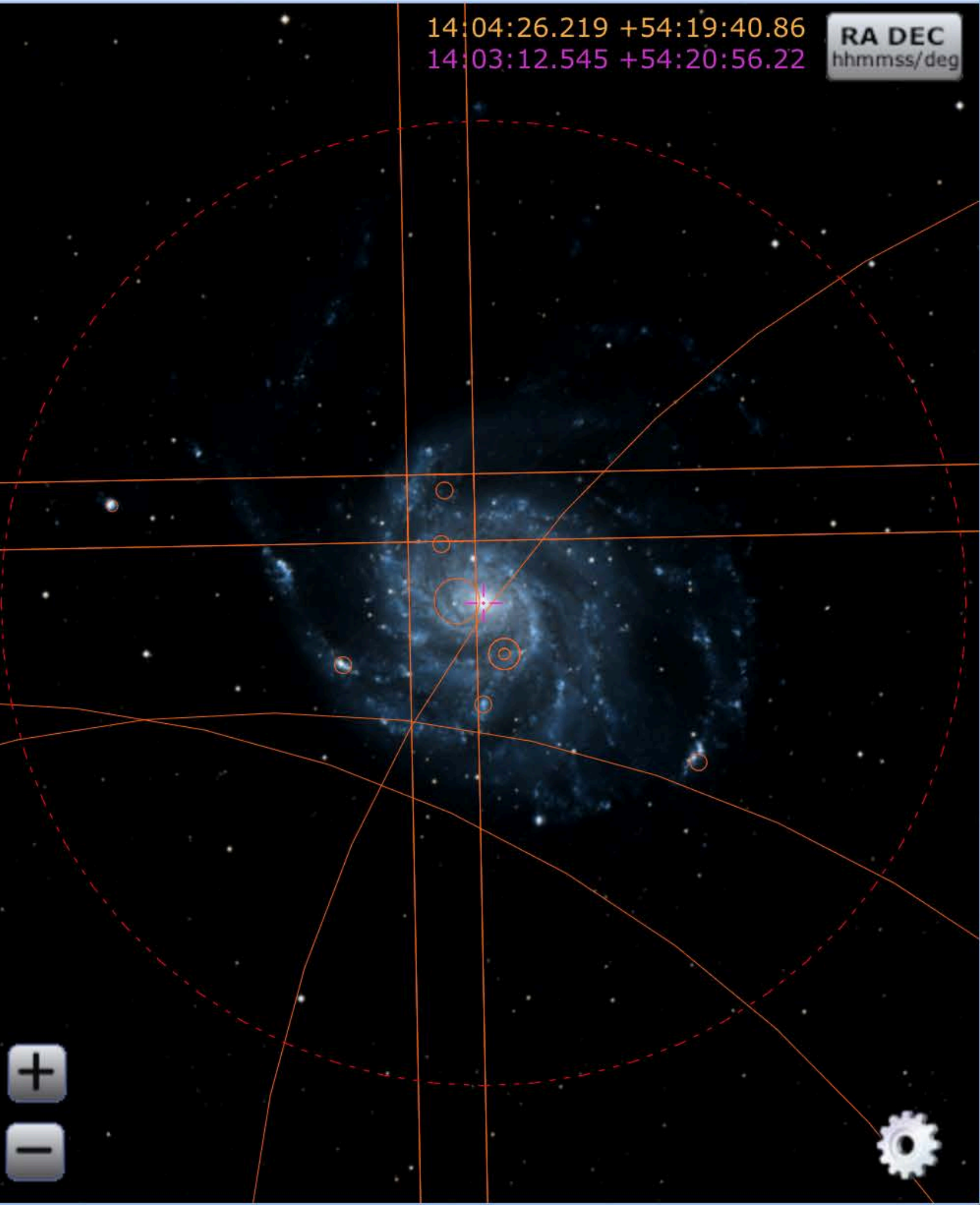
All

Show Preview:

Show Cutout:

		Actions	Observation T...	Mission	Instrument	Project	Filters	Waveband	Target Name
☐	1		science	PS1	GPC1	PS1	g	OPTICAL	2381.053
☐	2		science	PS1	GPC1	PS1	i	OPTICAL	2381.053
☐	3		science	PS1	GPC1	PS1	r	OPTICAL	2381.053
☐	4		science	PS1	GPC1	PS1	y	OPTICAL, IN...	2381.053
☐	5		science	PS1	GPC1	PS1	z	OPTICAL	2381.053
☐	6		science	PS1	GPC1	PS1	g	OPTICAL	2381.052
☐	7		science	PS1	GPC1	PS1	i	OPTICAL	2381.052
☐	8		science	PS1	GPC1	PS1	r	OPTICAL	2381.052
☐	9		science	PS1	GPC1	PS1	y	OPTICAL, IN...	2381.052
☐	10		science	PS1	GPC1	PS1	z	OPTICAL	2381.052
☐	11		science	PS1	GPC1	PS1	g	OPTICAL	2381.063
☐	12		science	PS1	GPC1	PS1	i	OPTICAL	2381.063
☐	13		science	PS1	GPC1	PS1	r	OPTICAL	2381.063

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Filters

List View

Album View

Edit Columns...

Table Display:

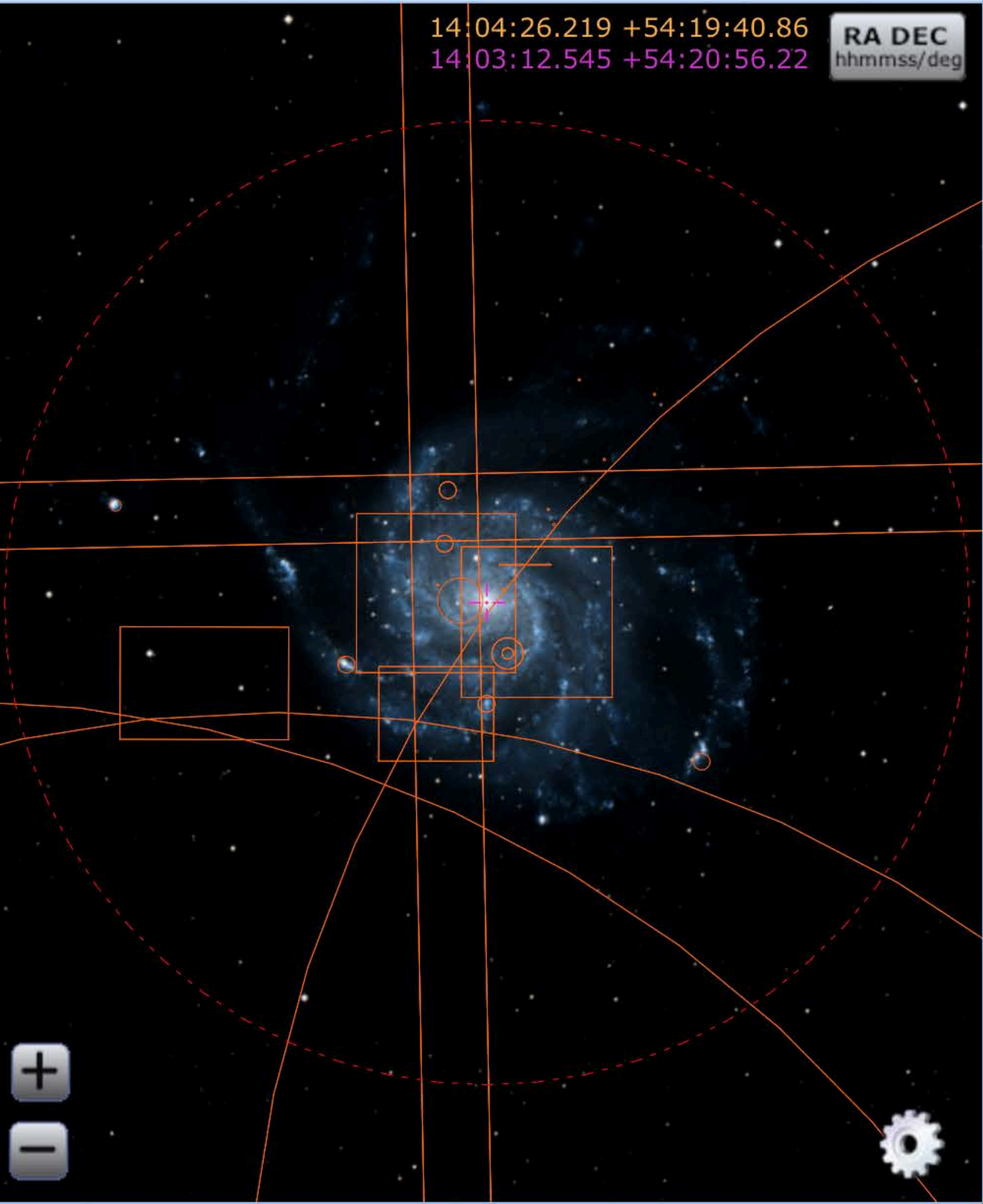
All

Show Preview:

Show Cutout:

		Actions	Observation T...	Mission	Instrument	Project	Filters	Waveband	Target Name
☐	1	...	science	PS1	GPC1	PS1	g	OPTICAL	2381.053
☐	2	...	science	PS1	GPC1	PS1	i	OPTICAL	2381.053
☐	3	...	science	PS1	GPC1	PS1	r	OPTICAL	2381.053
☐	4	...	science	PS1	GPC1	PS1	y	OPTICAL, IN...	2381.053
☐	5	...	science	PS1	GPC1	PS1	z	OPTICAL	2381.053
☐	6	...	science	PS1	GPC1	PS1	g	OPTICAL	2381.052
☐	7	...	science	PS1	GPC1	PS1	i	OPTICAL	2381.052
☐	8	...	science	PS1	GPC1	PS1	r	OPTICAL	2381.052
☐	9	...	science	PS1	GPC1	PS1	y	OPTICAL, IN...	2381.052
☐	10	...	science	PS1	GPC1	PS1	z	OPTICAL	2381.052
☐	11	...	science	PS1	GPC1	PS1	g	OPTICAL	2381.063
☐	12	...	science	PS1	GPC1	PS1	i	OPTICAL	2381.063
☐	13	...	science	PS1	GPC1	PS1	r	OPTICAL	2381.063

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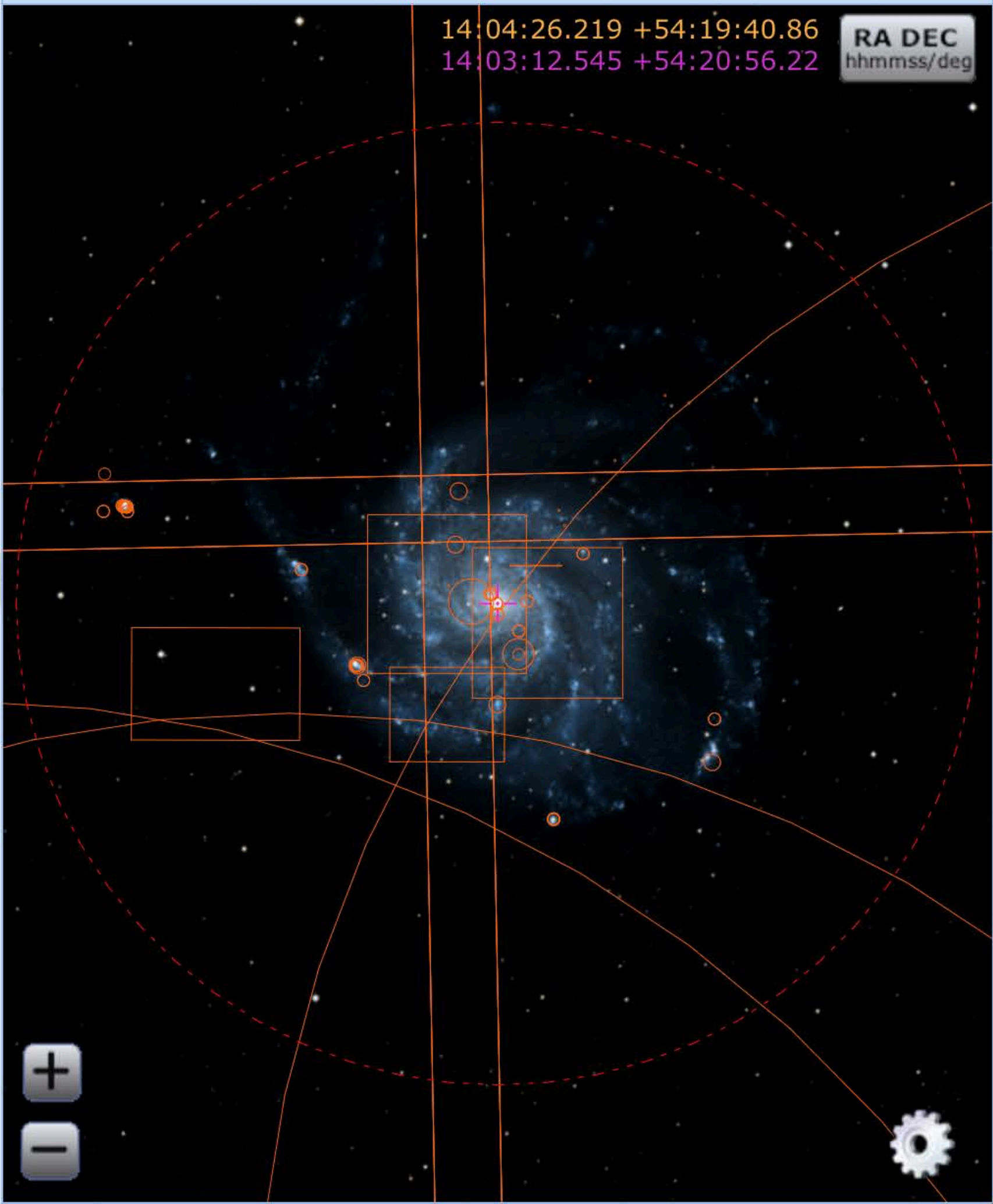
Footprints: All

List View Album View

Edit Columns... Table Display: All Show Preview: Show Cutout:

		Actions	Observation T...	Mission	Instrument	Project	Filters	Waveband	Target Name
	1		science	PS1	GPC1	PS1	g	OPTICAL	2381.053
	2		science	PS1	GPC1	PS1	i	OPTICAL	2381.053
	3		science	PS1	GPC1	PS1	r	OPTICAL	2381.053
	4		science	PS1	GPC1	PS1	y	OPTICAL, IN...	2381.053
	5		science	PS1	GPC1	PS1	z	OPTICAL	2381.053
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	7		science	PS1	GPC1	PS1	i	OPTICAL	2381.052
	8		science	PS1	GPC1	PS1	r	OPTICAL	2381.052
	9		science	PS1	GPC1	PS1	y	OPTICAL, IN...	2381.052
	10		science	PS1	GPC1	PS1	z	OPTICAL	2381.052
	11		science	PS1	GPC1	PS1	g	OPTICAL	2381.063
	12		science	PS1	GPC1	PS1	i	OPTICAL	2381.063
	13		science	PS1	GPC1	PS1	r	OPTICAL	2381.063

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Edit Columns...

Table Display: All

Show Preview: ☐

Show Cutout: ☐

		Actions	Observation T...	Mission	Instrument	Project	Filters	Waveband	Target Name
☐	1		science	PS1	GPC1	PS1	g	OPTICAL	2381.053
☐	2		science	PS1	GPC1	PS1	i	OPTICAL	2381.053
☐	3		science	PS1	GPC1	PS1	r	OPTICAL	2381.053
☐	4		science	PS1	GPC1	PS1	y	OPTICAL, IN...	2381.053
☐	5		science	PS1	GPC1	PS1	z	OPTICAL	2381.053
☐	6		science	PS1	GPC1	PS1	g	OPTICAL	2381.052
☐	7		science	PS1	GPC1	PS1	i	OPTICAL	2381.052
☐	8		science	PS1	GPC1	PS1	r	OPTICAL	2381.052
☐	9		science	PS1	GPC1	PS1	y	OPTICAL, IN...	2381.052
☐	10		science	PS1	GPC1	PS1	z	OPTICAL	2381.052
☐	11		science	PS1	GPC1	PS1	g	OPTICAL	2381.063
☐	12		science	PS1	GPC1	PS1	i	OPTICAL	2381.063
☐	13		science	PS1	GPC1	PS1	r	OPTICAL	2381.063





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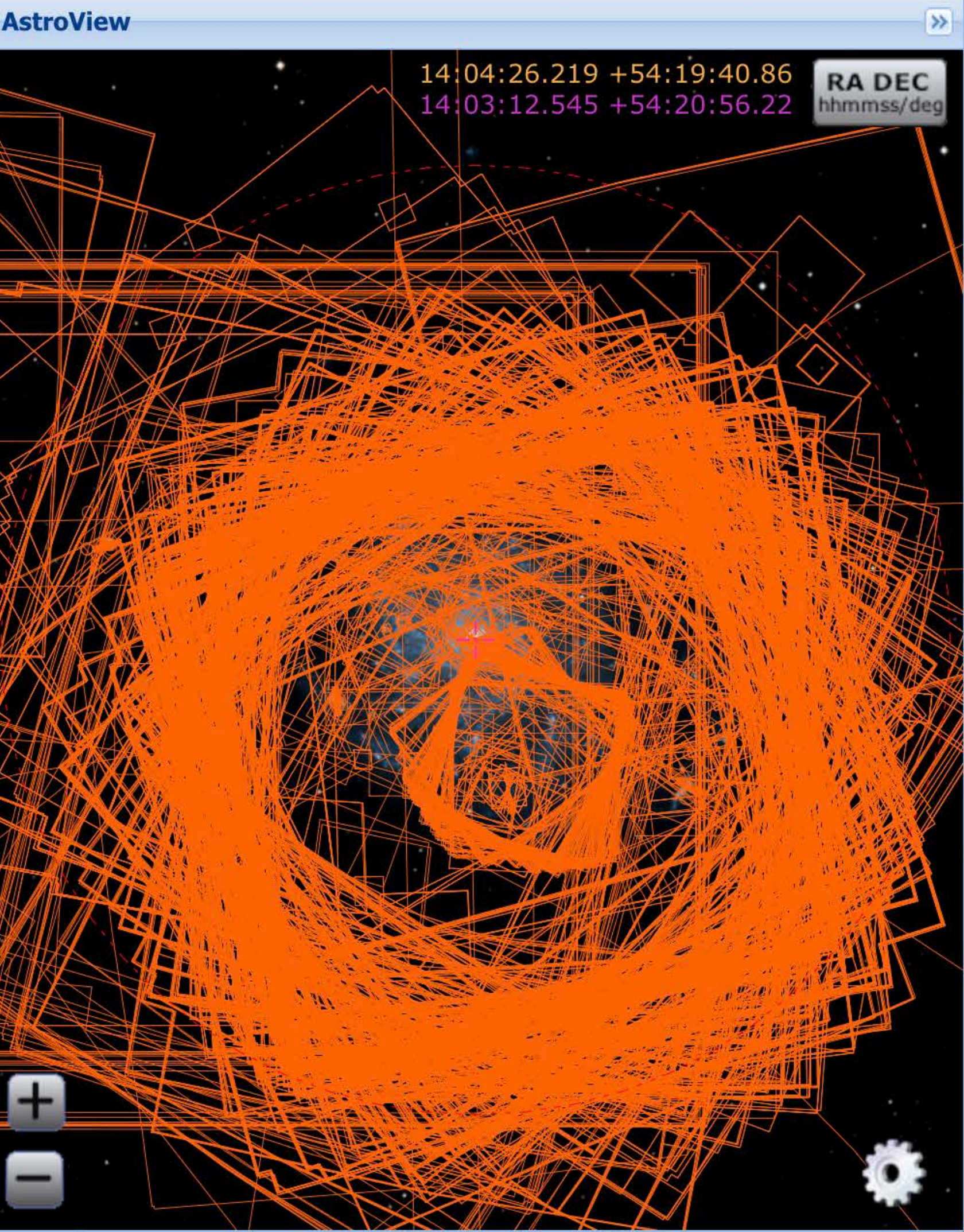


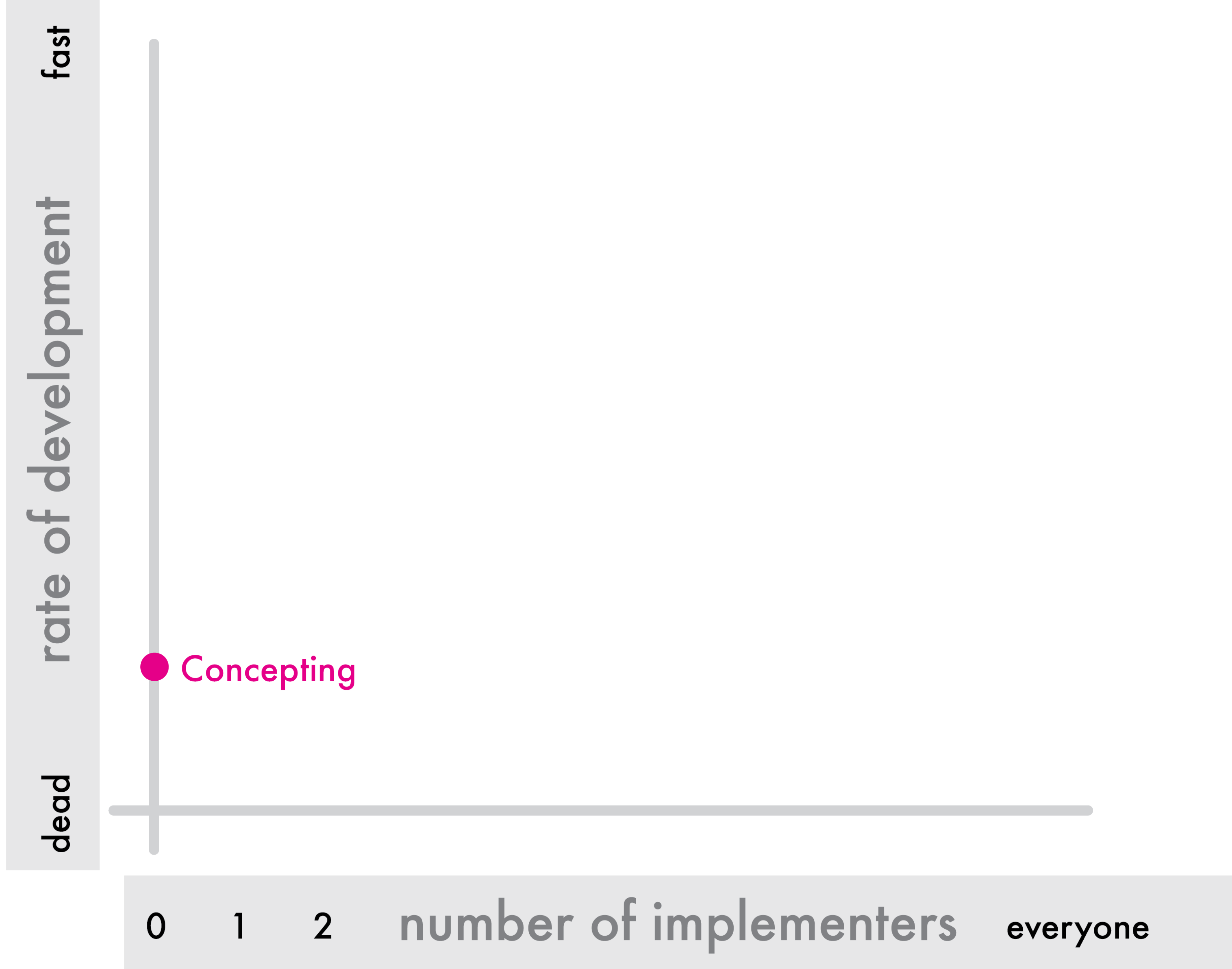
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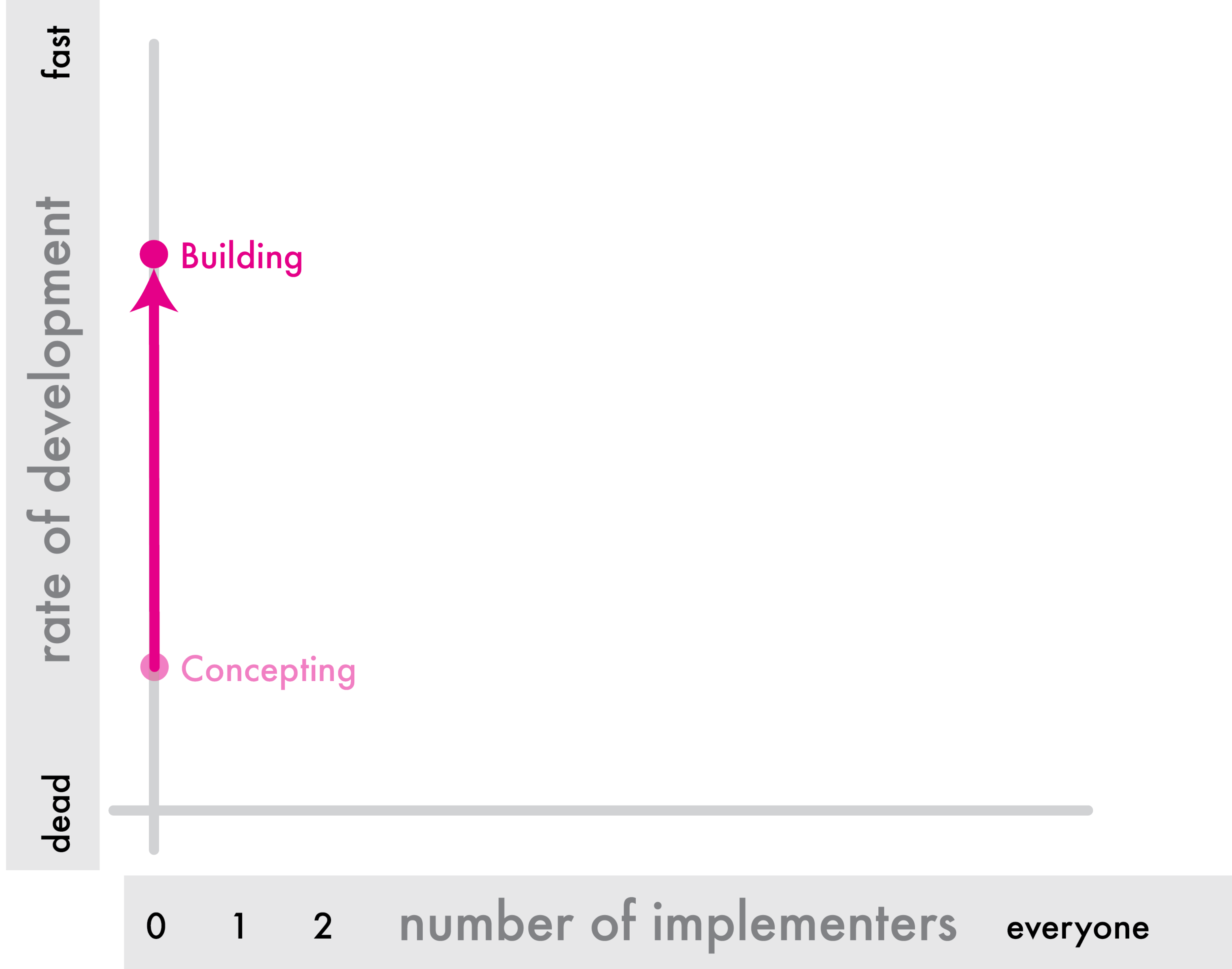
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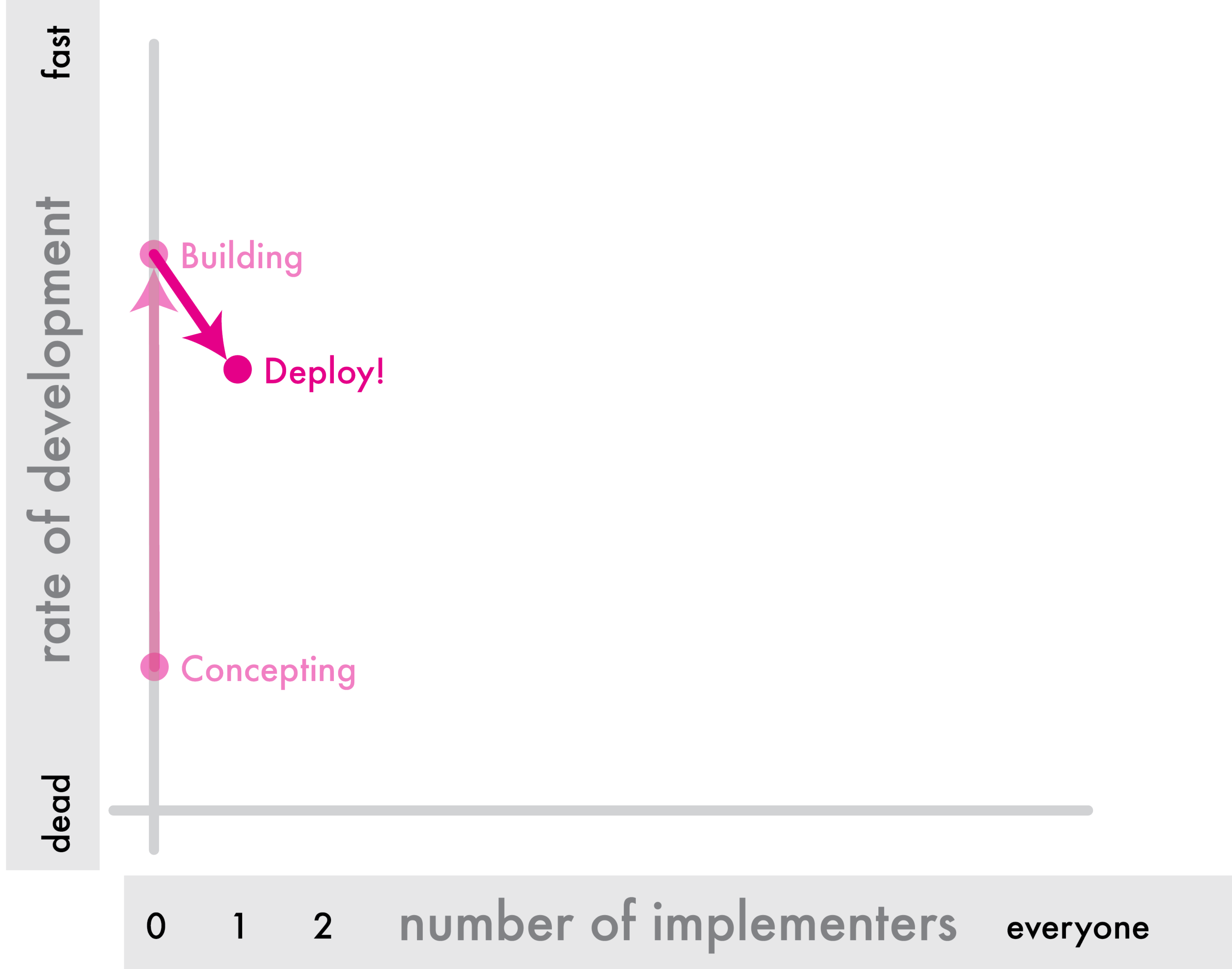
Edit Columns... Table Display: All Show Preview: Show Cutout:

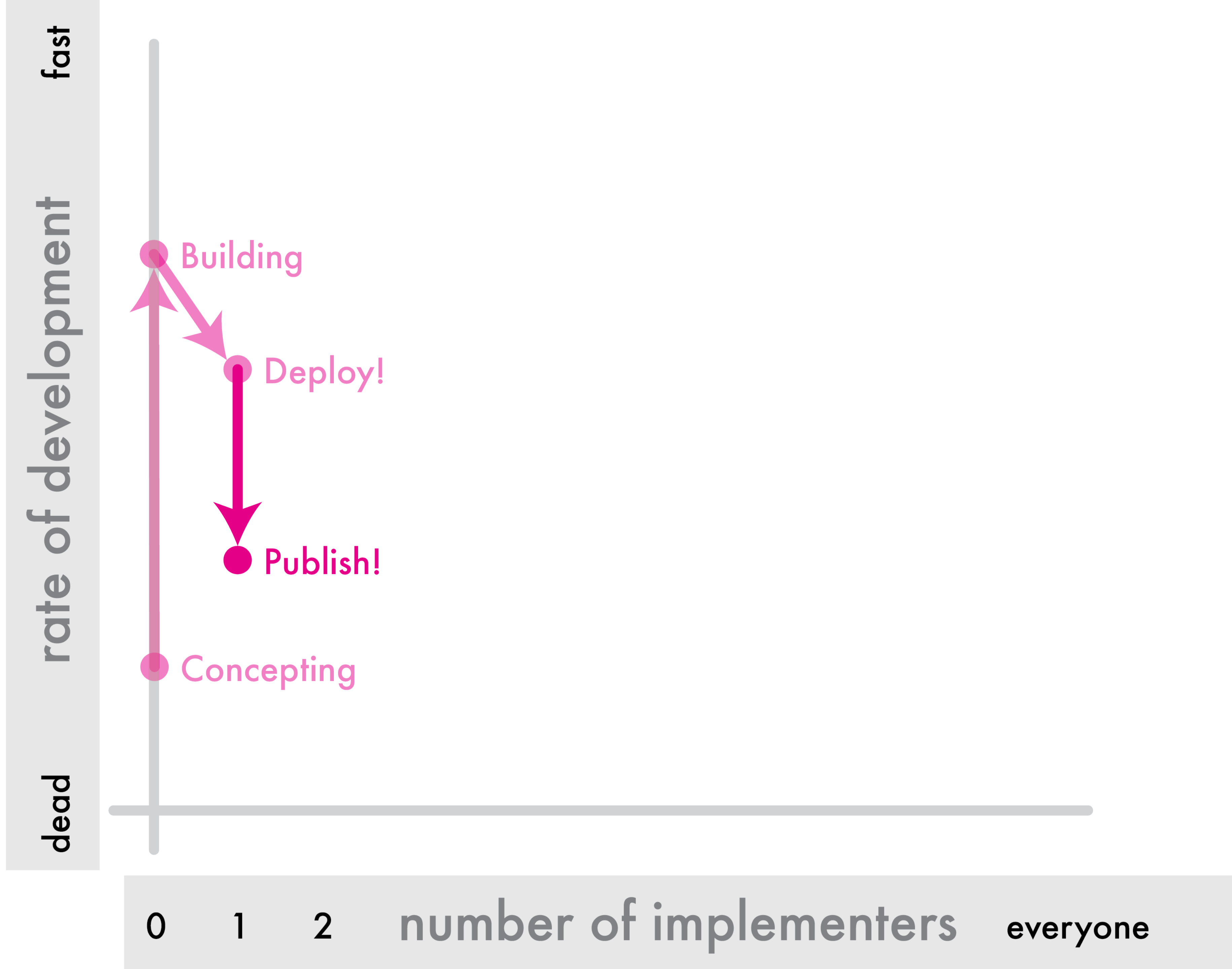
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☐	2		science	SWIFT	UVOT		U	OPTICAL	M101ULX-1
☐	3		science	SWIFT	UVOT		B	OPTICAL	M101ULX-1
☐	4		science	SWIFT	UVOT		U	OPTICAL	M101ULX-1
☐	5		science	SWIFT	UVOT		V	OPTICAL	M101ULX-1
☐	6		science	SWIFT	UVOT		B	OPTICAL	M101ULX-1
☐	7		science	SWIFT	UVOT		U	OPTICAL	M101ULX-1
☐	8		science	SWIFT	UVOT		V	OPTICAL	M101ULX-1
☐	9		science	SWIFT	UVOT		B	OPTICAL	M101ULX-1
☐	10		science	SWIFT	UVOT		UVW2	UV, OPTICAL	M101ULX-1
☐	11		science	SWIFT	UVOT		U	OPTICAL	M101ULX-1
☐	12		science	SWIFT	UVOT		UVW1	UV, OPTICAL	M101ULX-1
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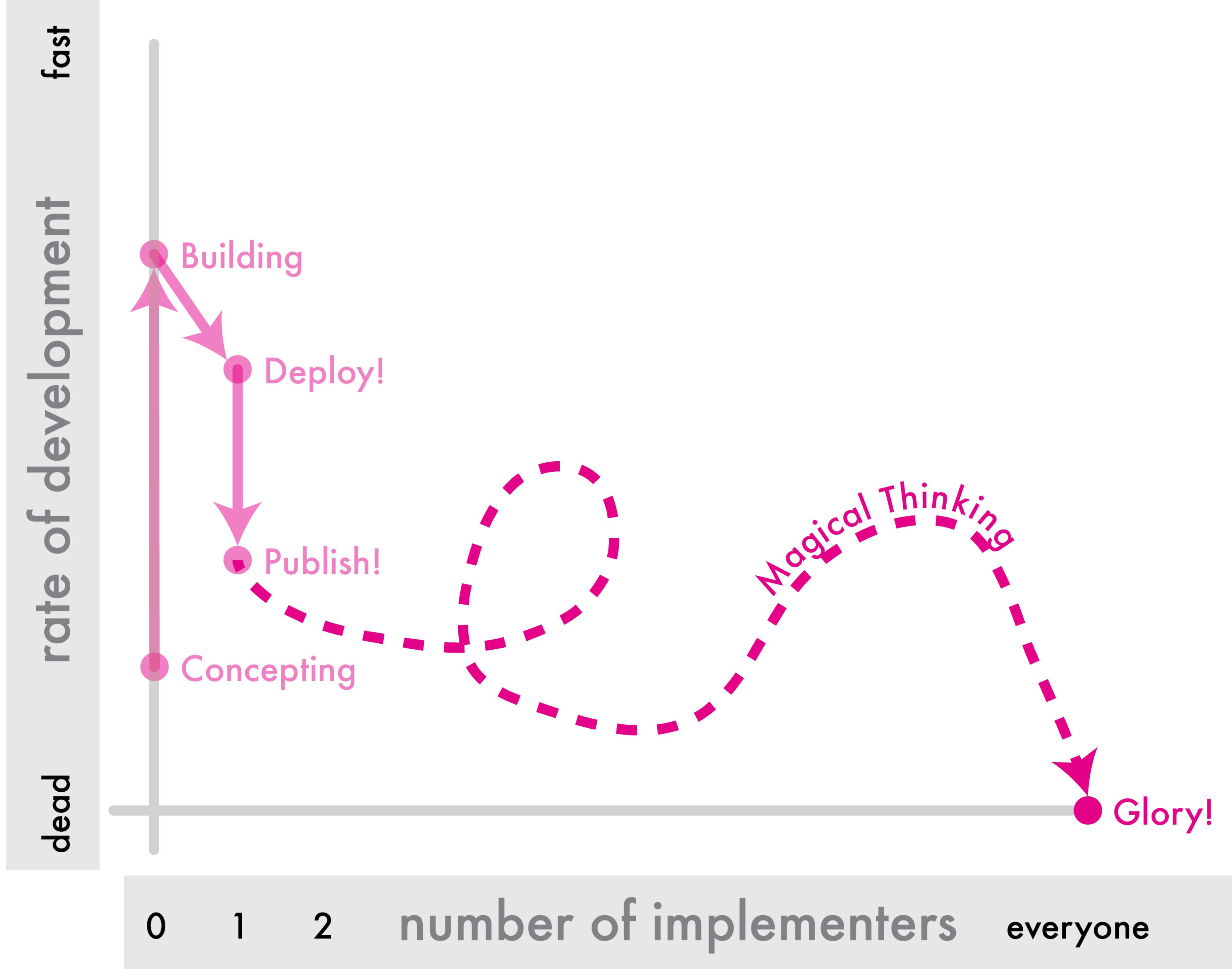


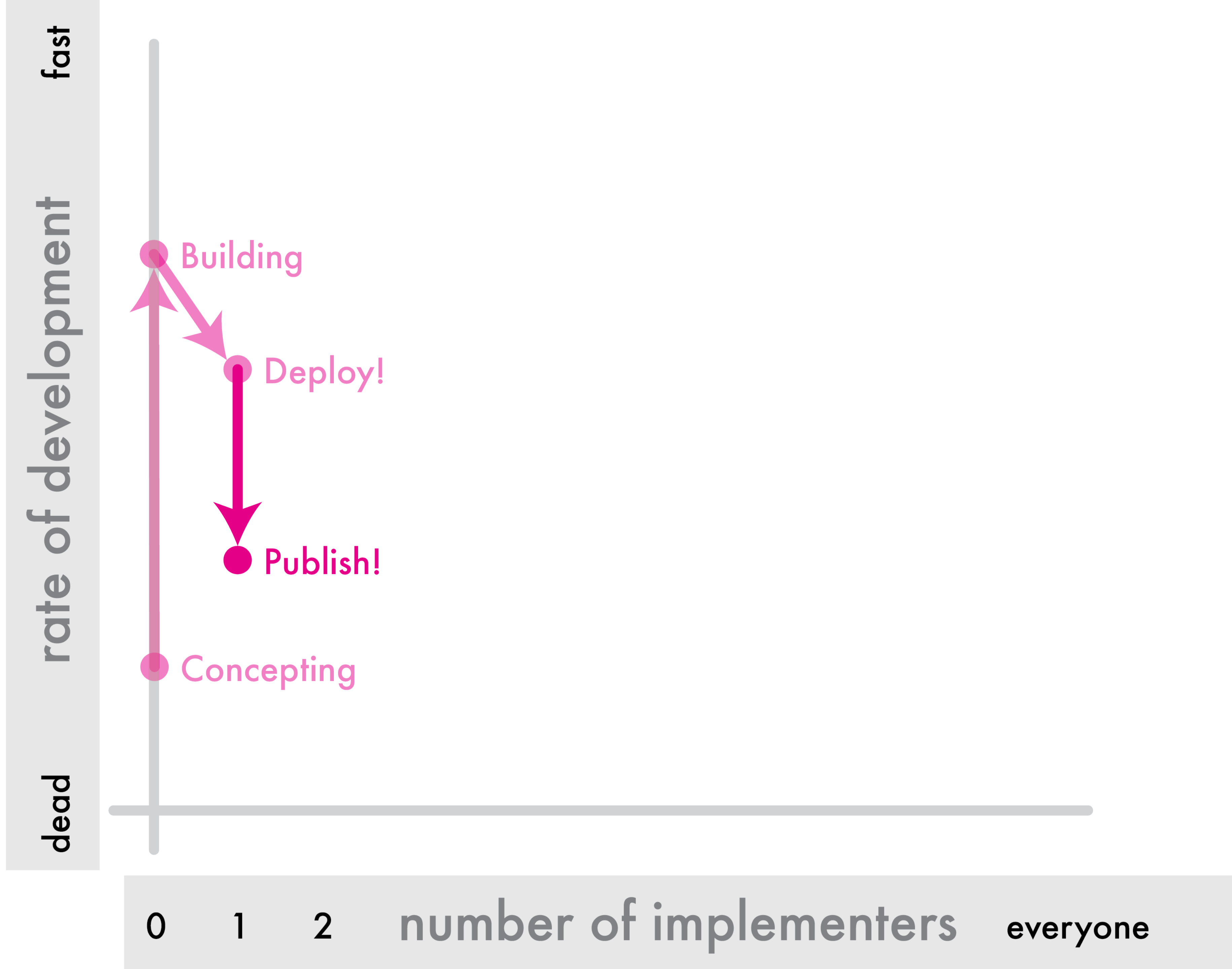


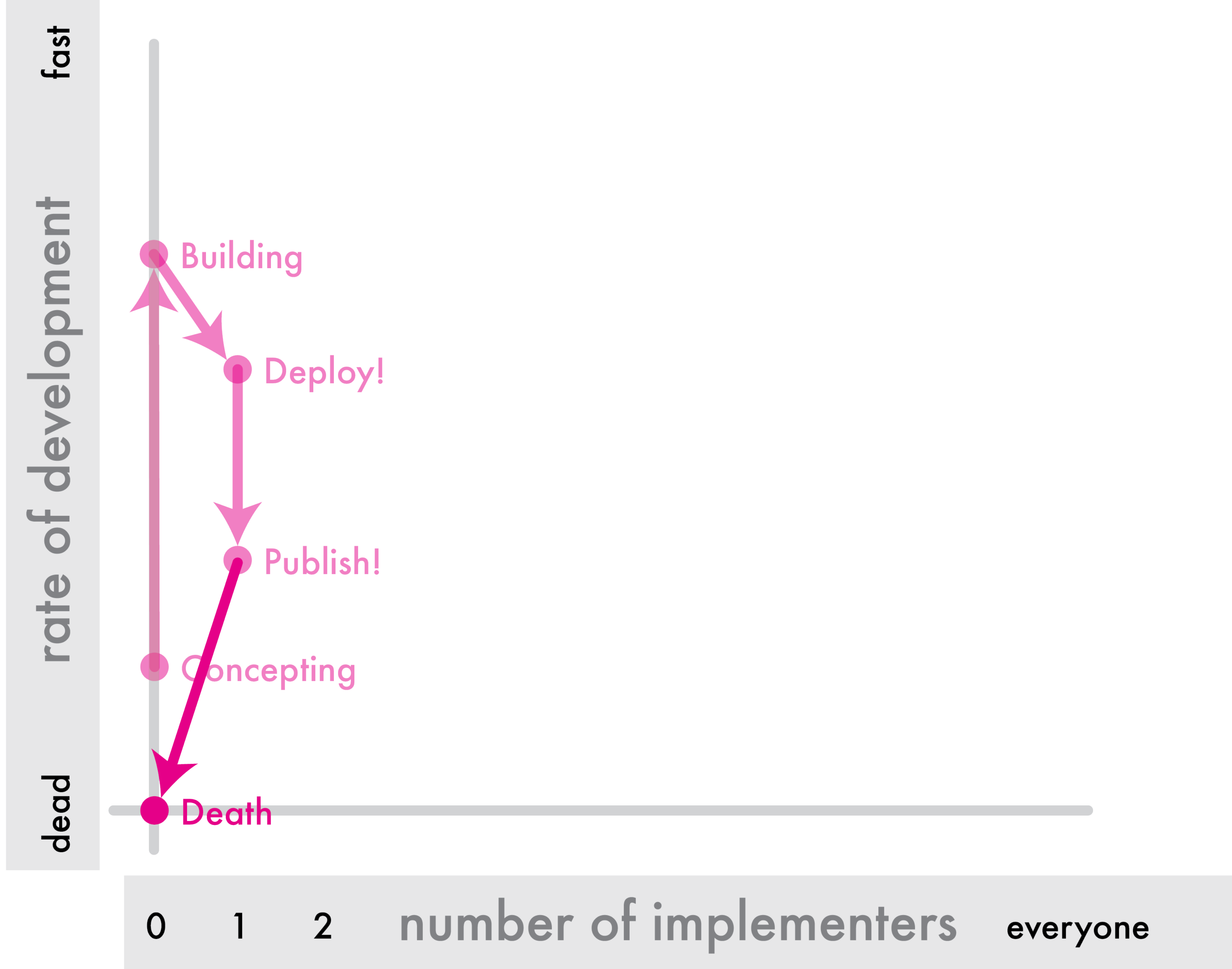


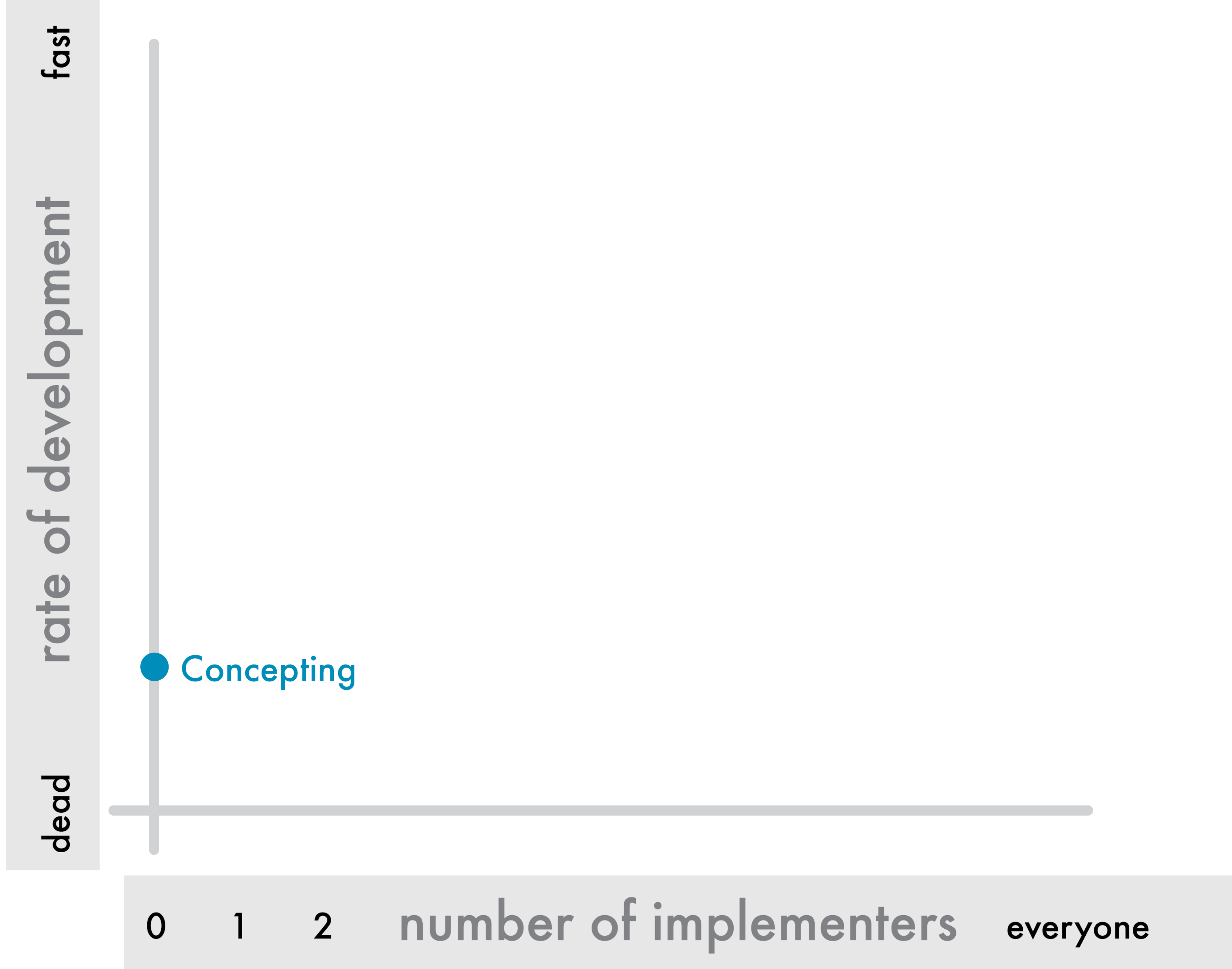


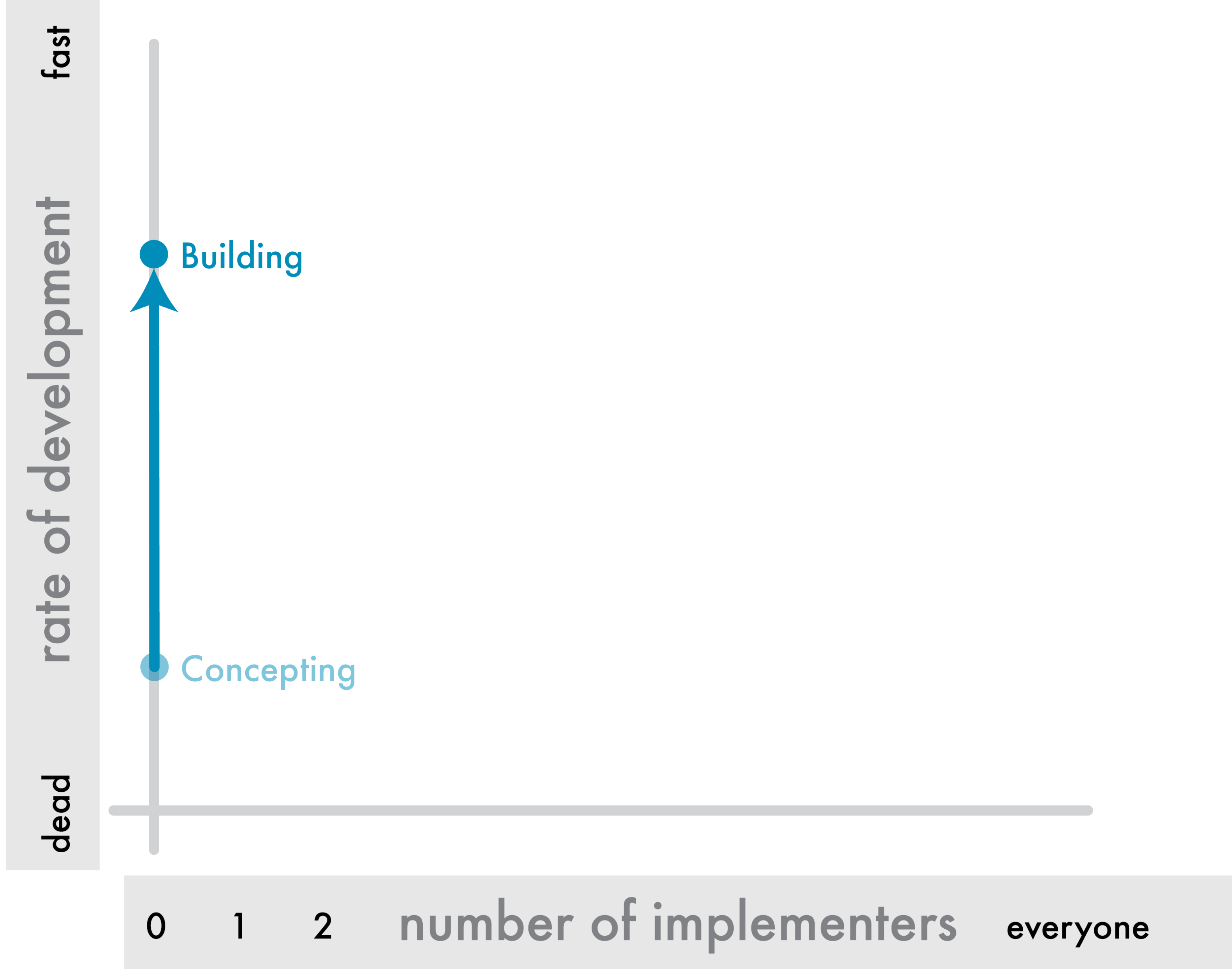


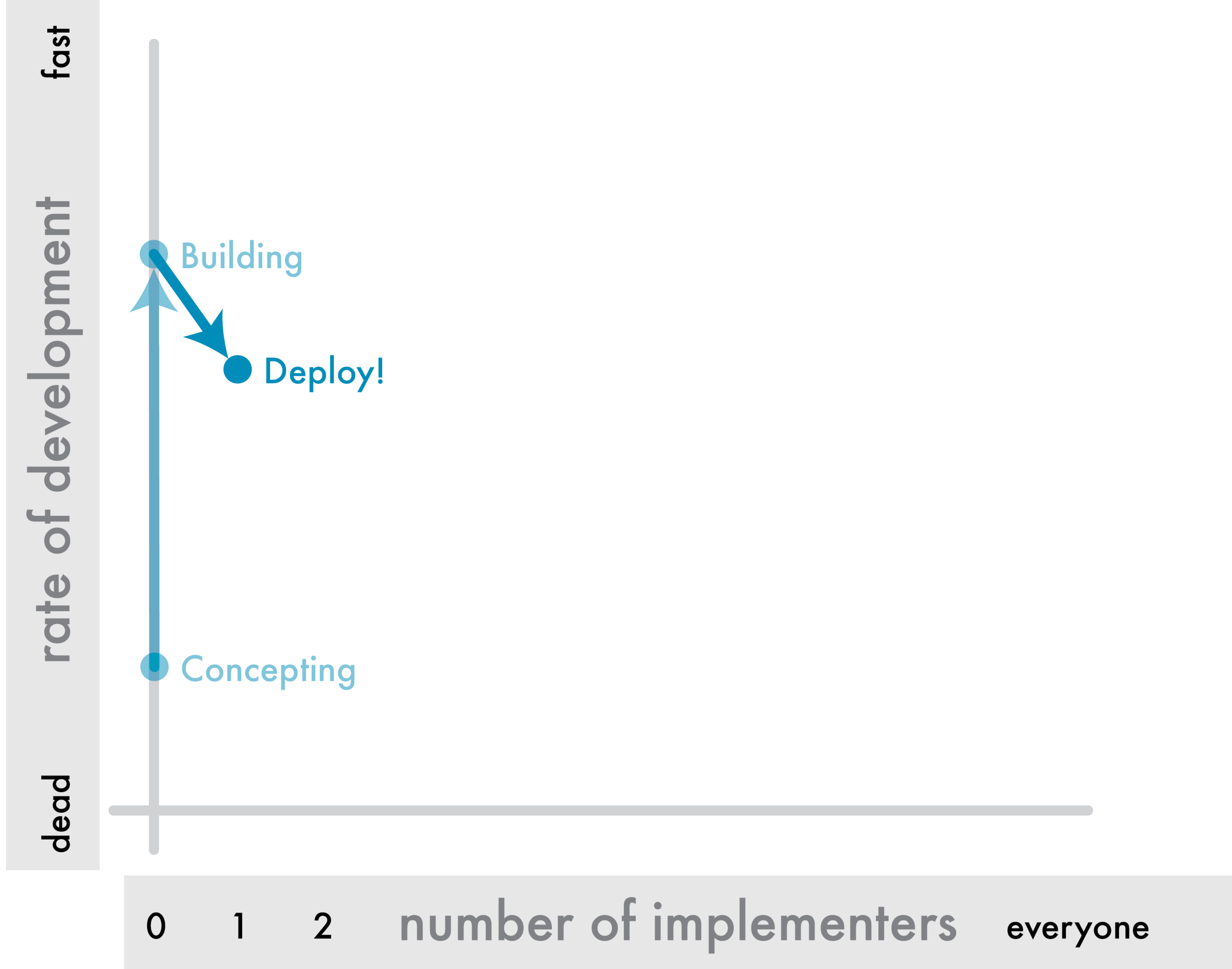


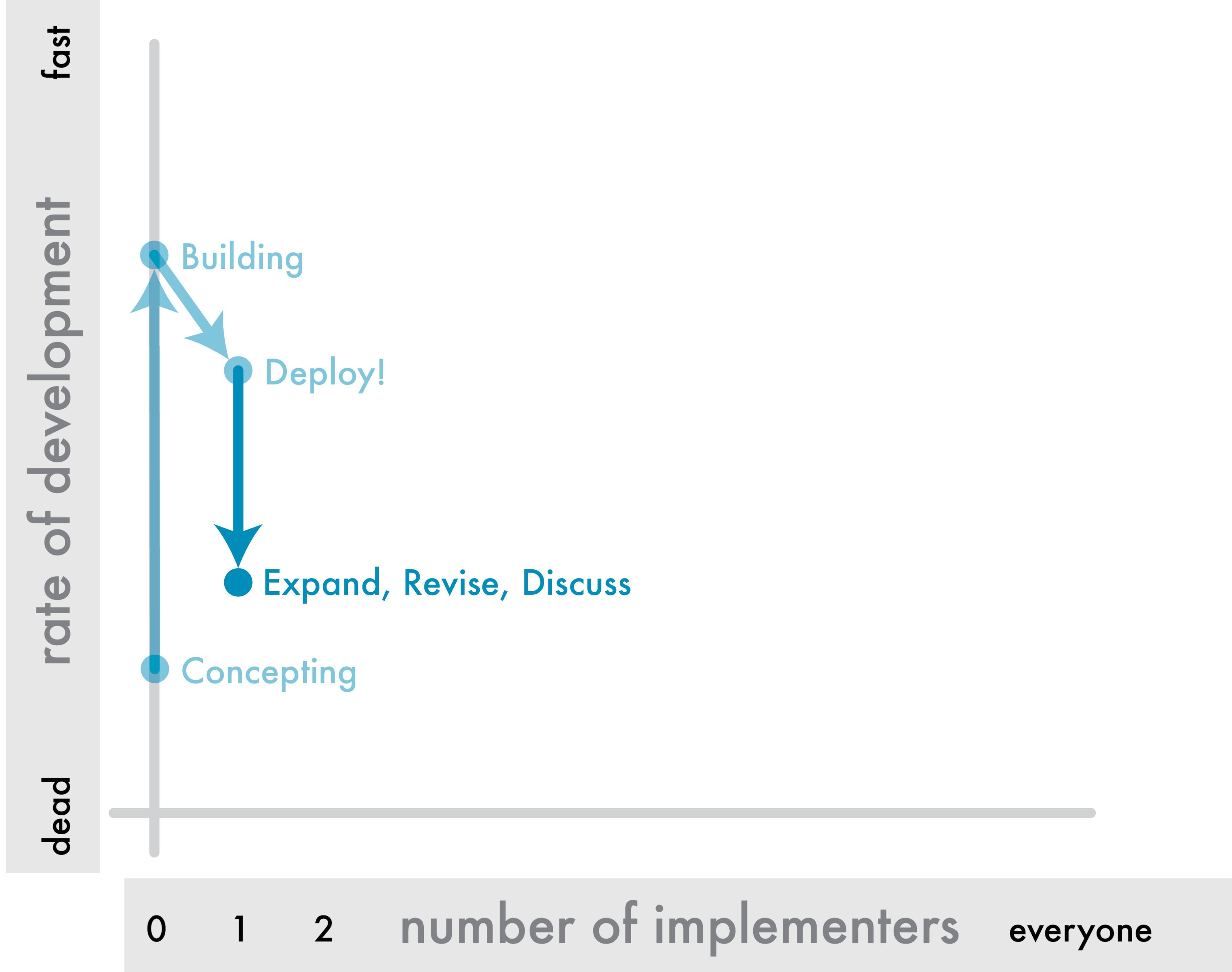


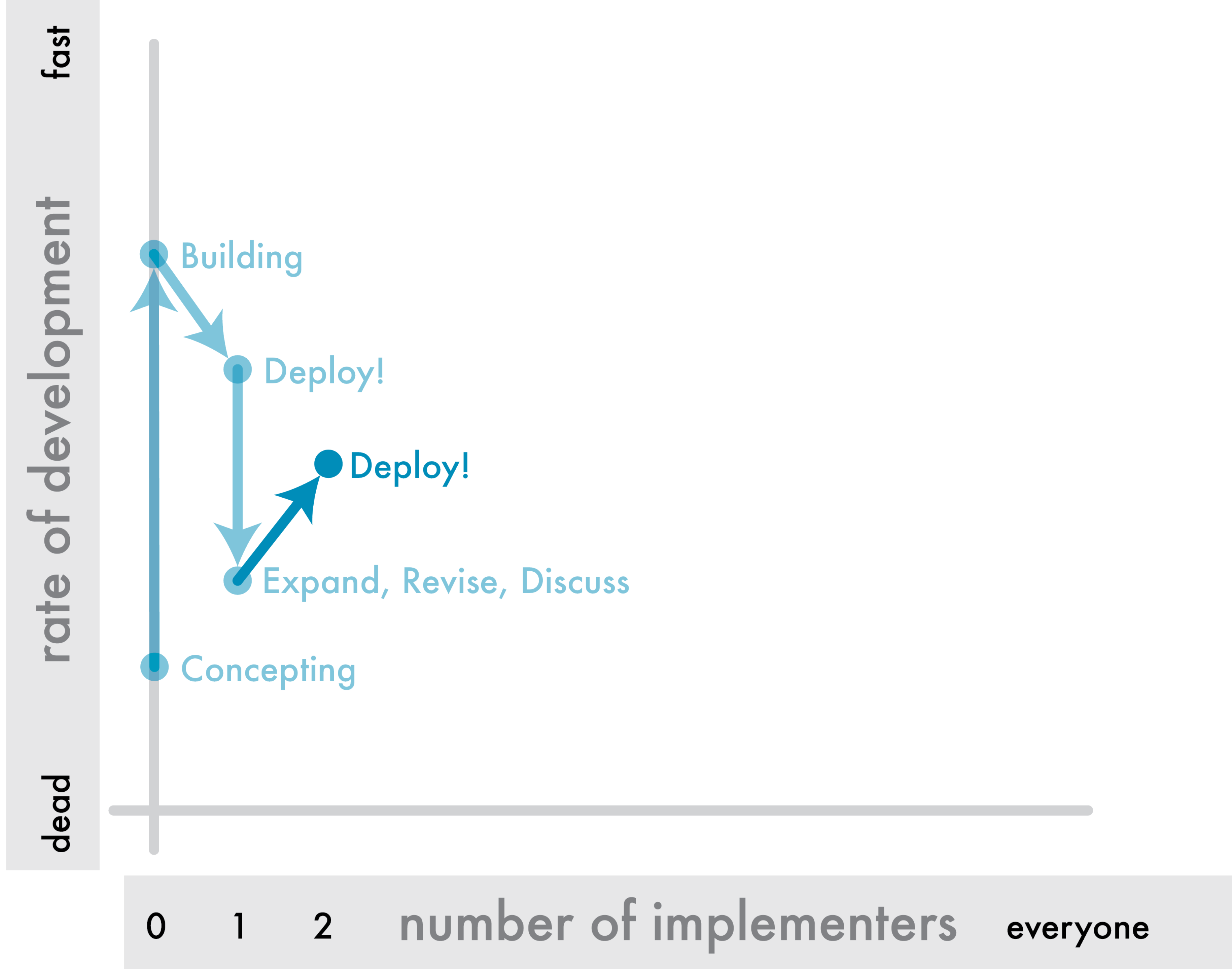


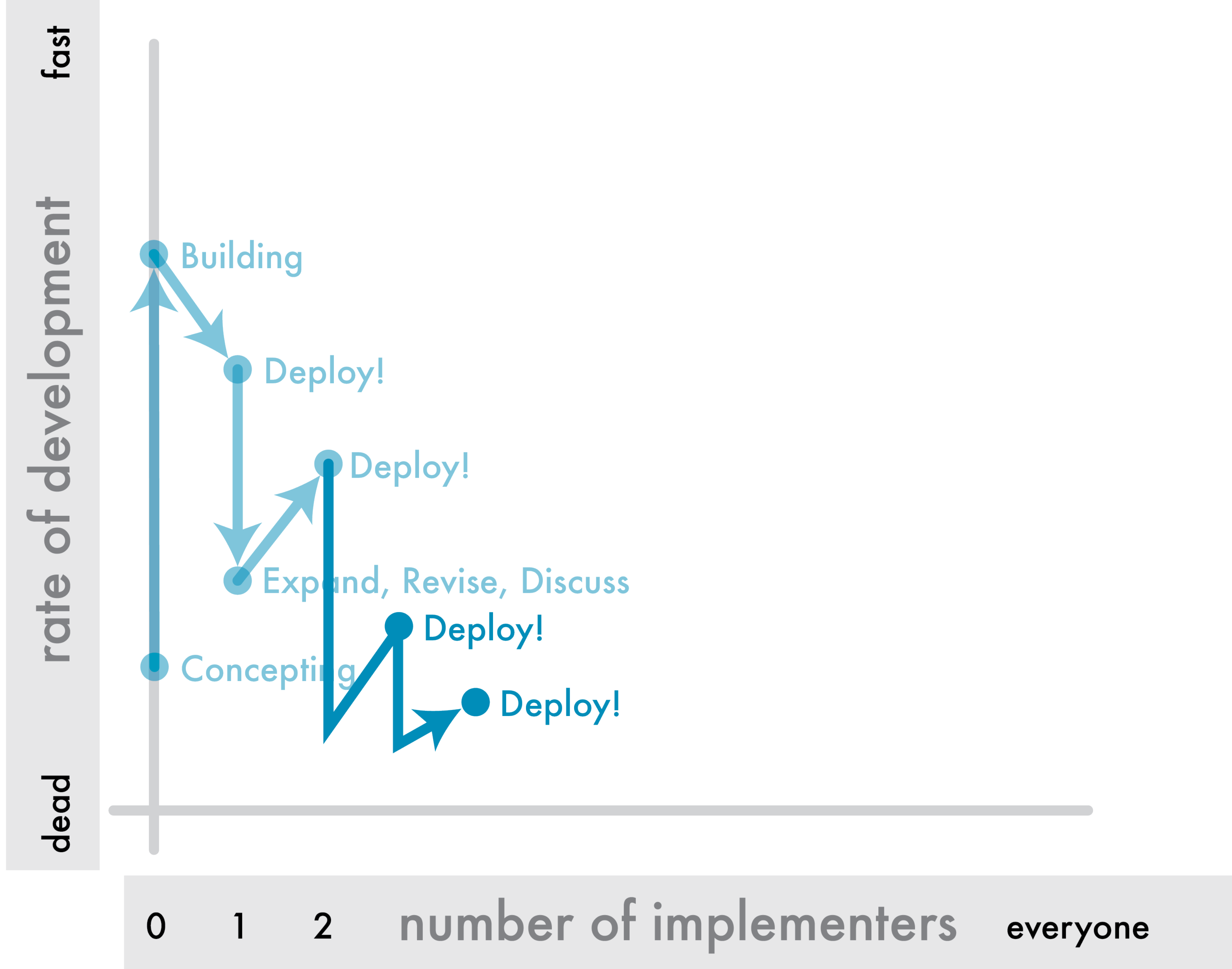


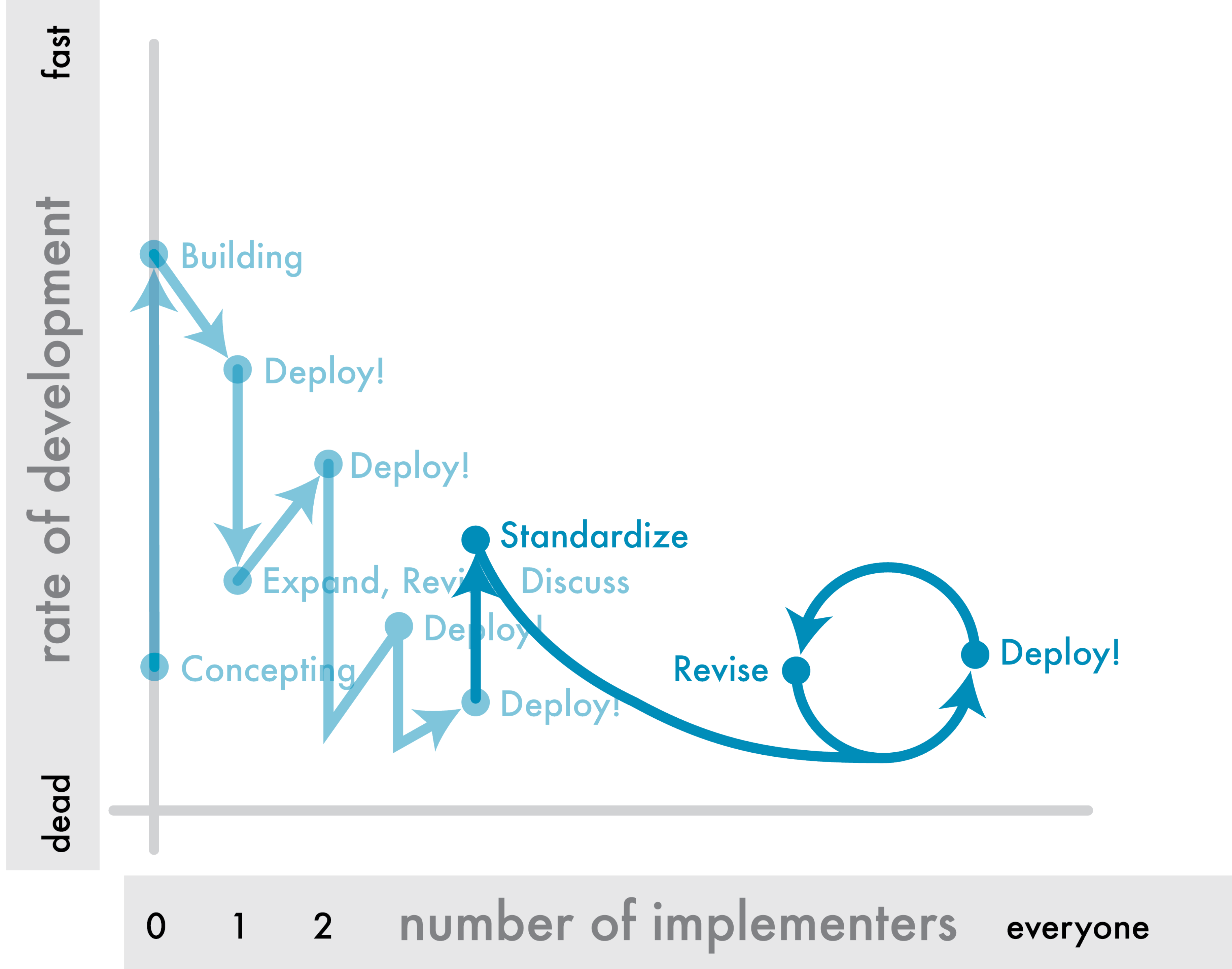












Takeaways for DMMI

- Find common conceptual “grids” defined by practitioners upon which to build
- The scientific and technical returns from data sharing can be tremendous
- Discovery and physical understanding are both enhanced by data models
- Defining common models is a messy, human process with setbacks
- Standards follow implementations before implementations follow standards
- Standards definition is often successful as a bottom-up (not top-down) process