4MOST – 4m Multi-Object Spectroscopic Telescope

IWG4 - Selection Functions

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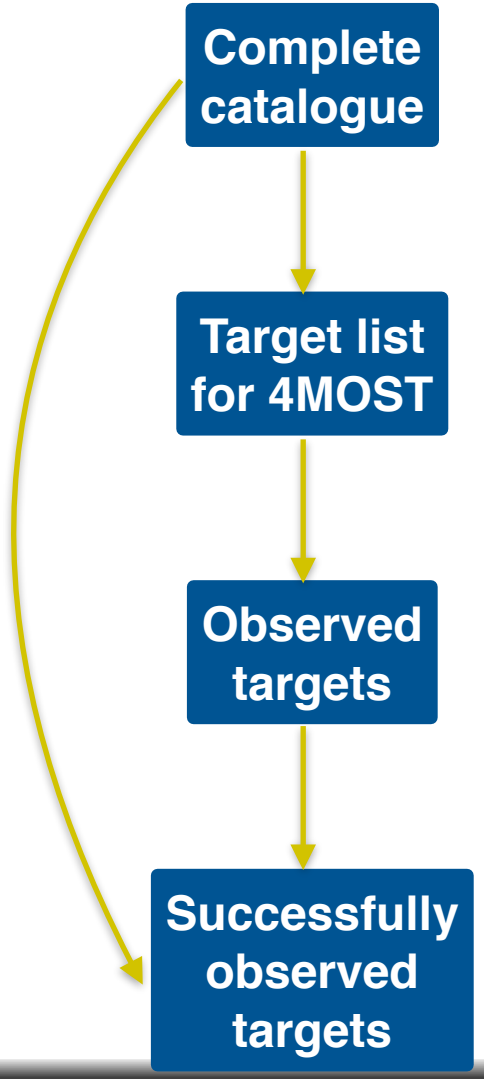
www.4MOST.eu

Why do we need Selection Functions?

- 4MOST is a statistical survey. Understanding selections is a key for unbiased statistical analysis.
- You need selection functions, if you are interested about any distribution functions (e.g. target distribution in the sky, magnitude distribution, metallicity distribution, redshift distribution, etc)
- Selection Function in 4MOST is complex and depends on all surveys — all surveys are affecting each other.

Selection Function - Big Picture

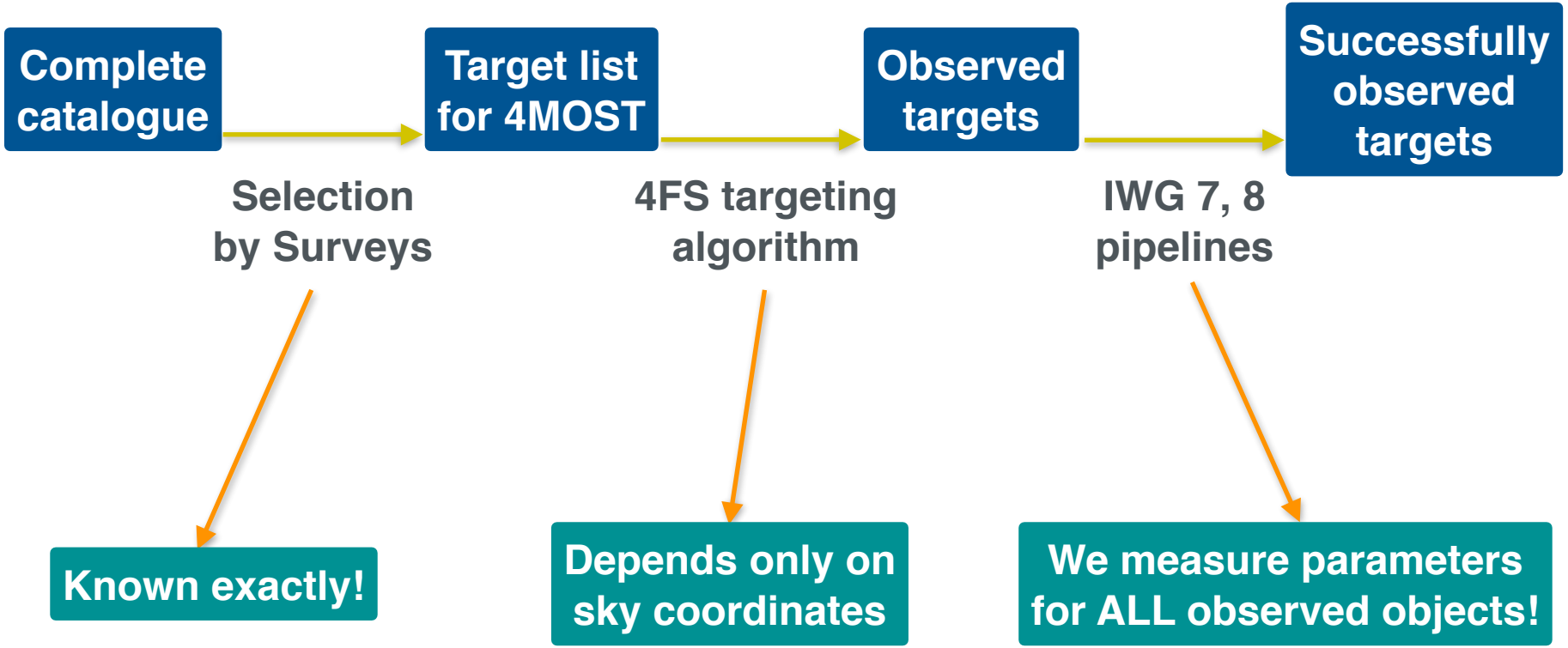


Selection by Surveys

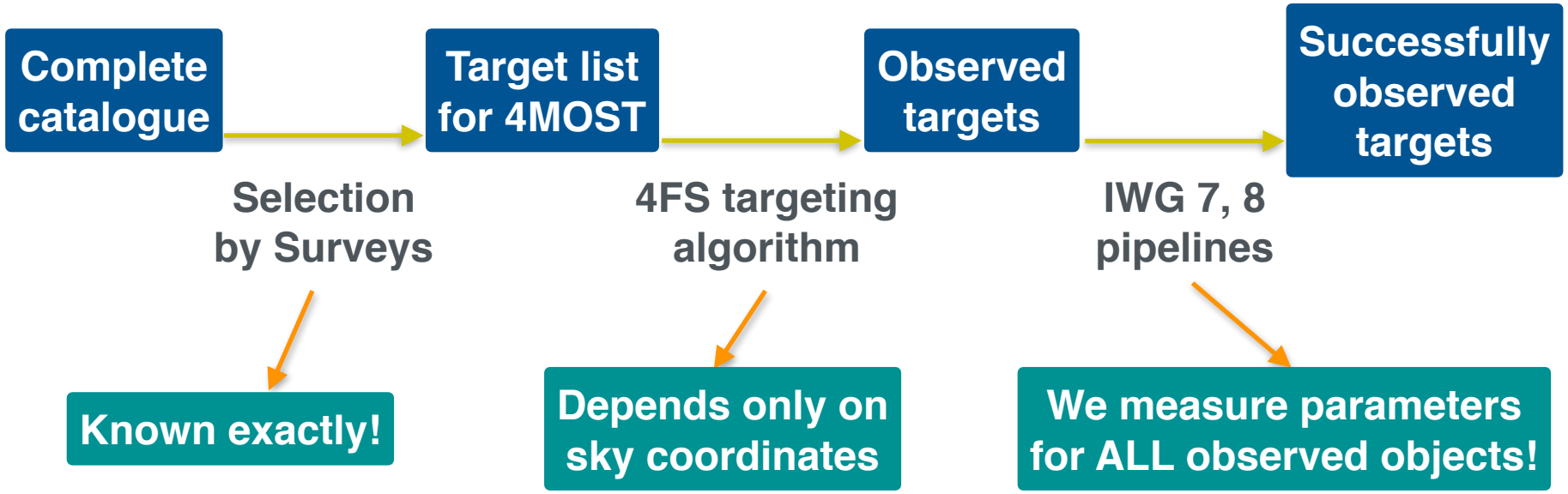
4FS targeting algorithm — Geometric Selection Function

IWG 7, 8 pipelines — Object Selection Function

Simple (ideal) Selection Function



Simple (ideal) Selection Function



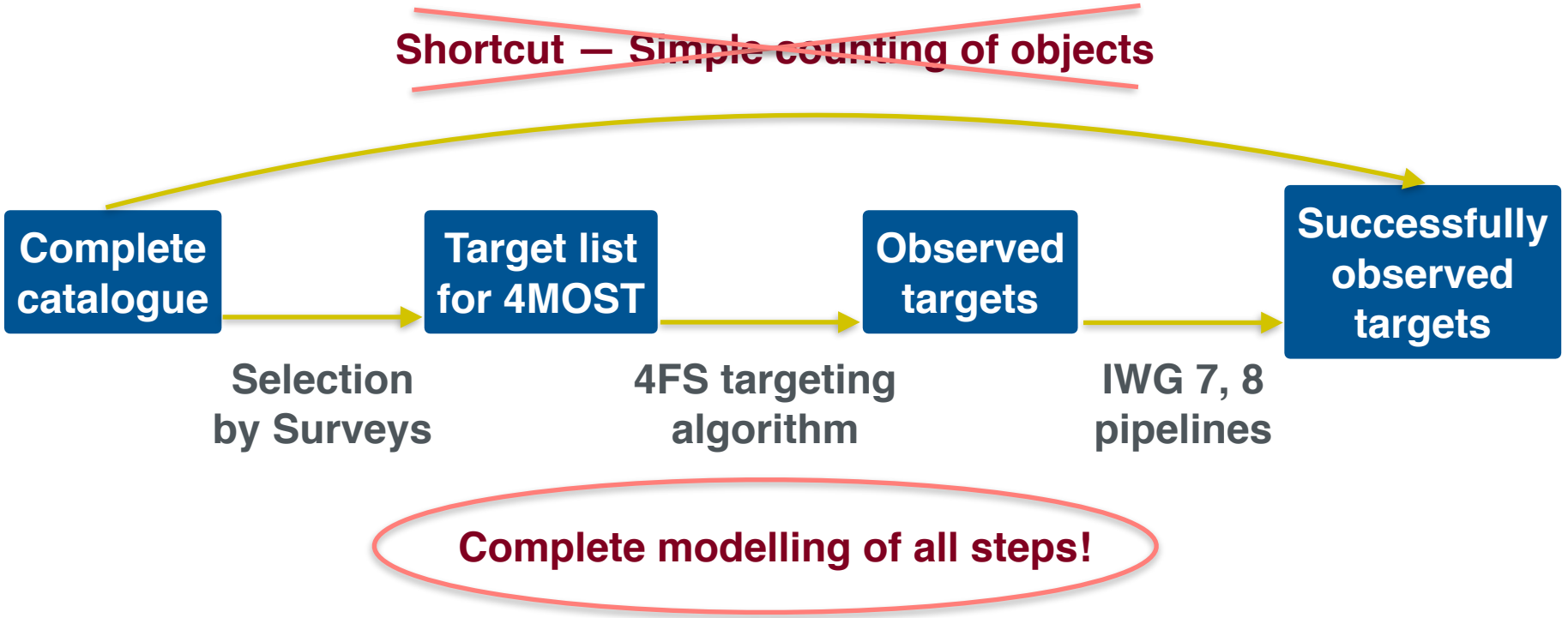
In practice (IWG4 goal):

Defined precisely

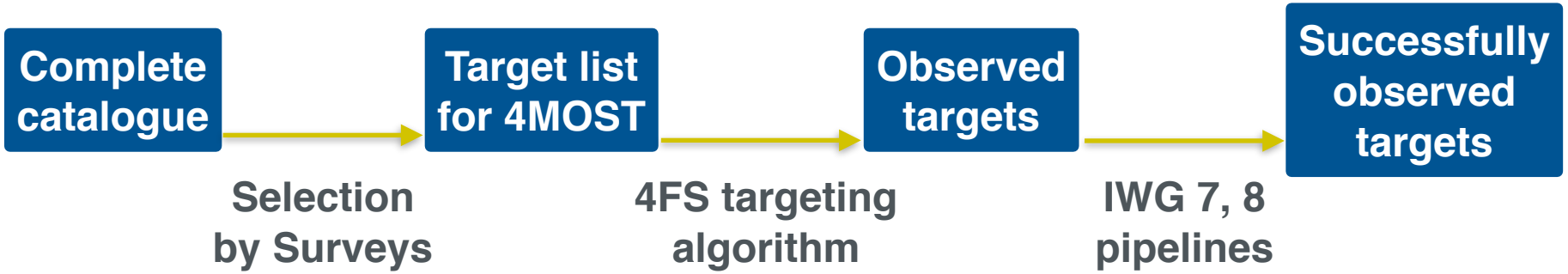
Using 4FS this can be modelled precisely

Most uncertain! Success rate of measuring object parameters should be maximized

From Complete catalogue to observed targets



From Complete catalogue to observed targets



Complete modelling of all steps!

Aims of Selection Functions:

- Complete understanding of selections
- Understanding the limitations and accuracy of selection functions
- Generation of random point catalogues
- Selection functions for mock universes
- Pre-survey selection functions

What affects the Selection Functions?

Things that we cannot change:

- Weather, seeing, Moon phase, airmass, etc
- Foreground bright stars, available imaging data
- Galactic extinction
- Minimum separation between fibres
- Fibre tilt angles, cross talk, fibre misalignment
- broken, not functional fibres
- Division between high-res and low-res fibres
- Plate scale varies across the field of view
- Additional factors…

What affects the Selection Functions?

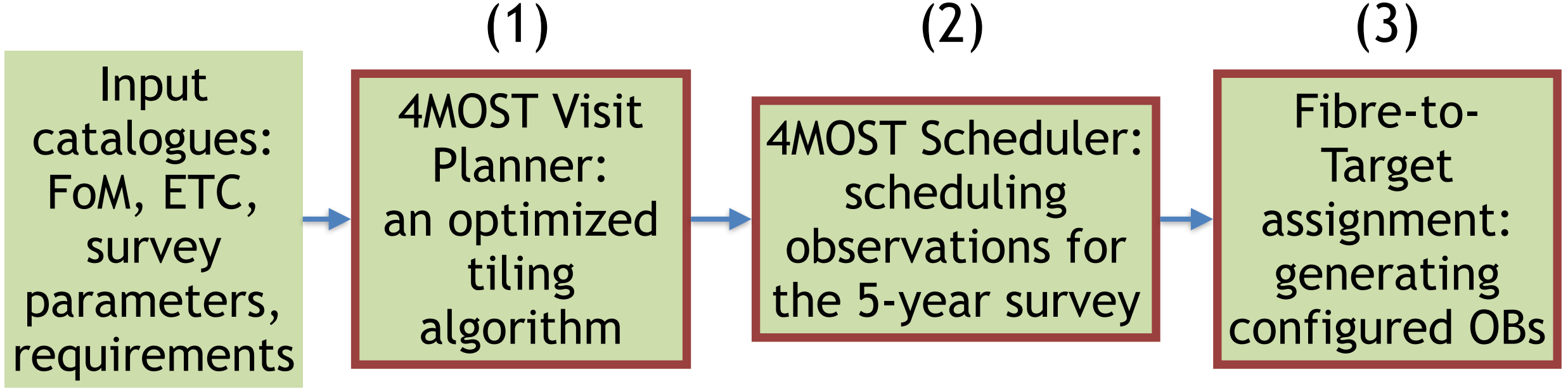
Things that are changeable:

- *Input target catalogues* — input catalogue change of one survey affects the SFs of other surveys!

- *Figure of Merit* — FoM of one survey affects the SFs of other surveys

To have predictable Selection Function,
target catalog changes should be kept minimum.
Ideally, target catalogs do not change during the survey.

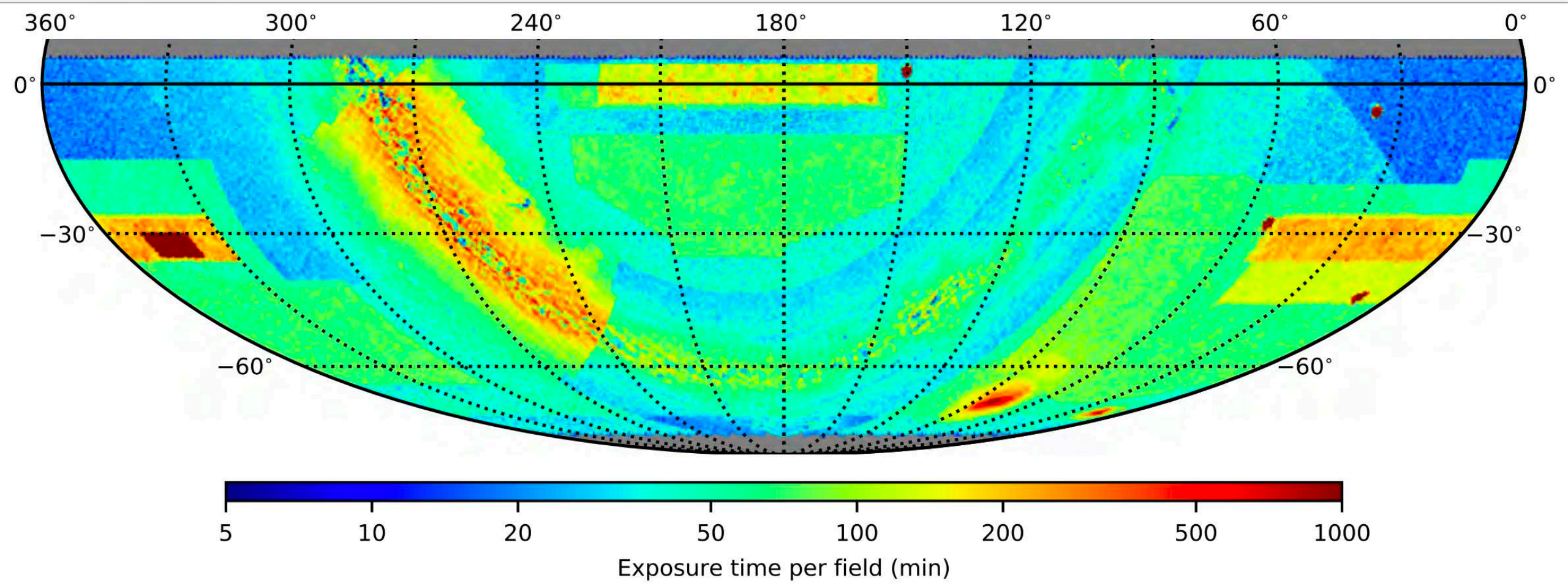
Preparing observations: a general flow-chart



(1) Tempel et al. (2020) “An optimised tiling pattern for multi-object spectroscopic surveys: application to the 4MOST survey”, MNRAS, submitted

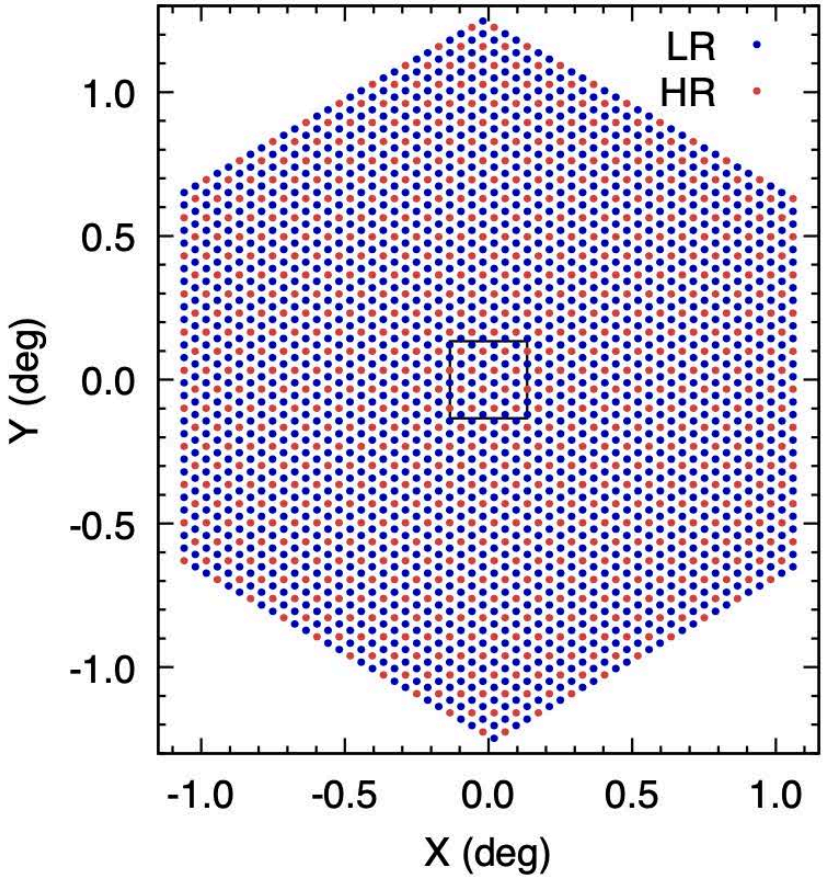
(3) Tempel et al. (2020) “Probabilistic fibre-to-target assignment algorithm for multi-object spectroscopic surveys”, A&A, 635, A101 (arXiv:2001.09348)

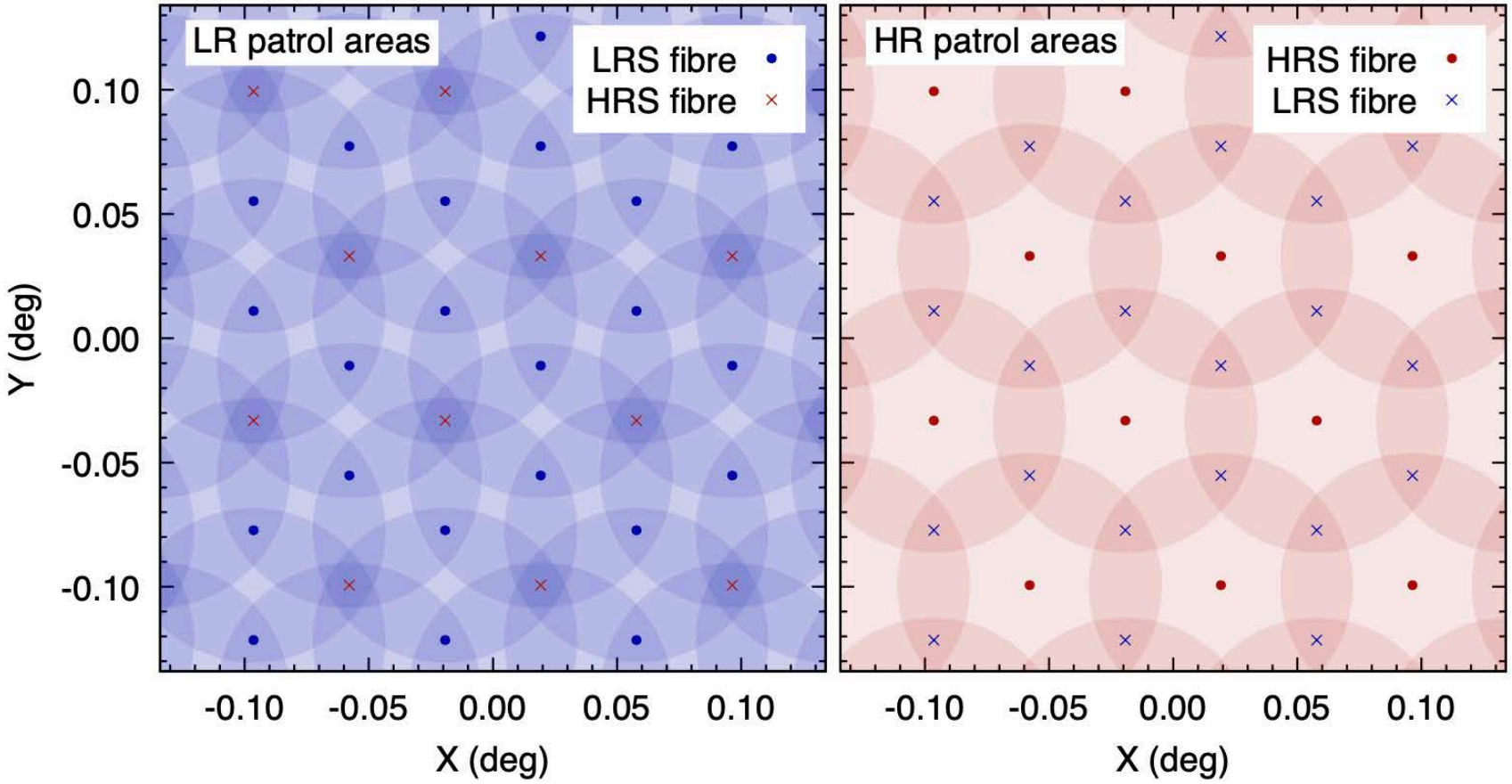
Target density in the sky



- Target density across the sky varies significantly.

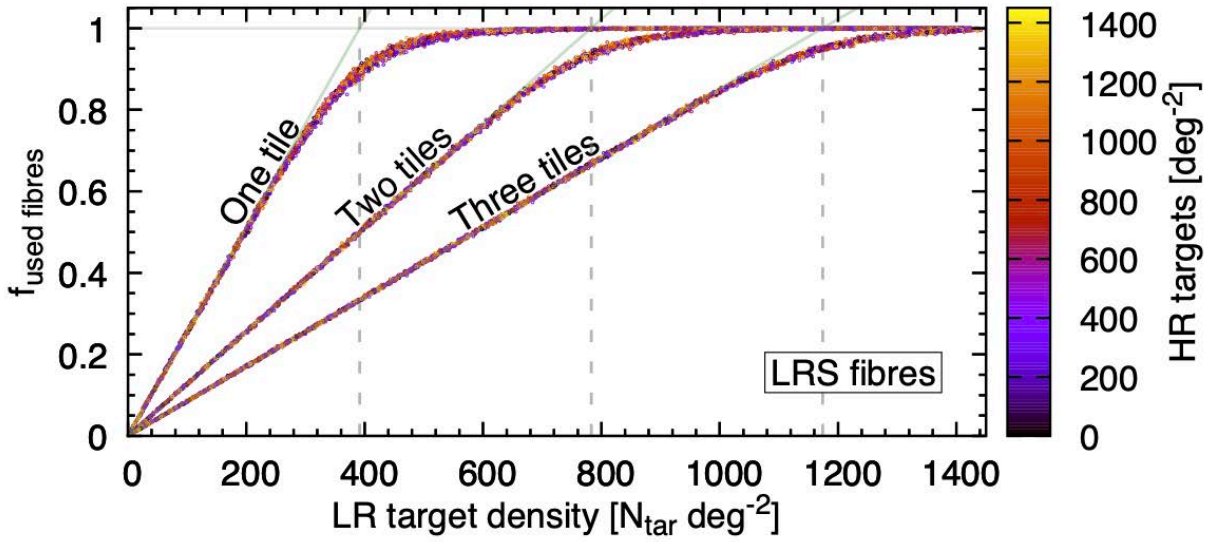
Fibre pattern in one Field of View



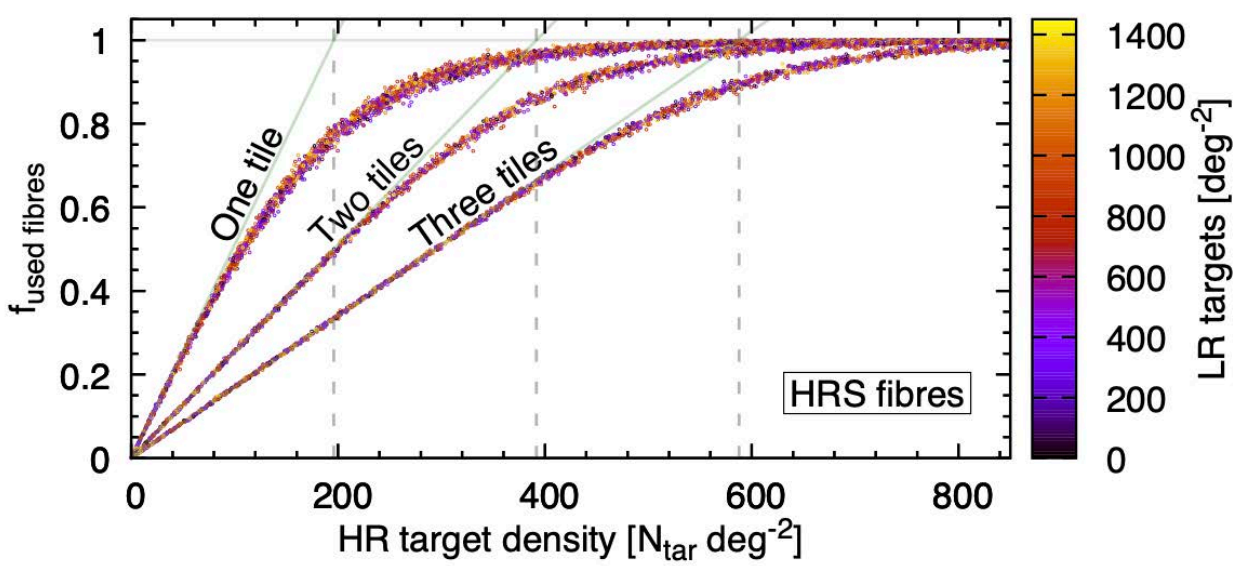


Fibre-density vs target-density

Low-resolution

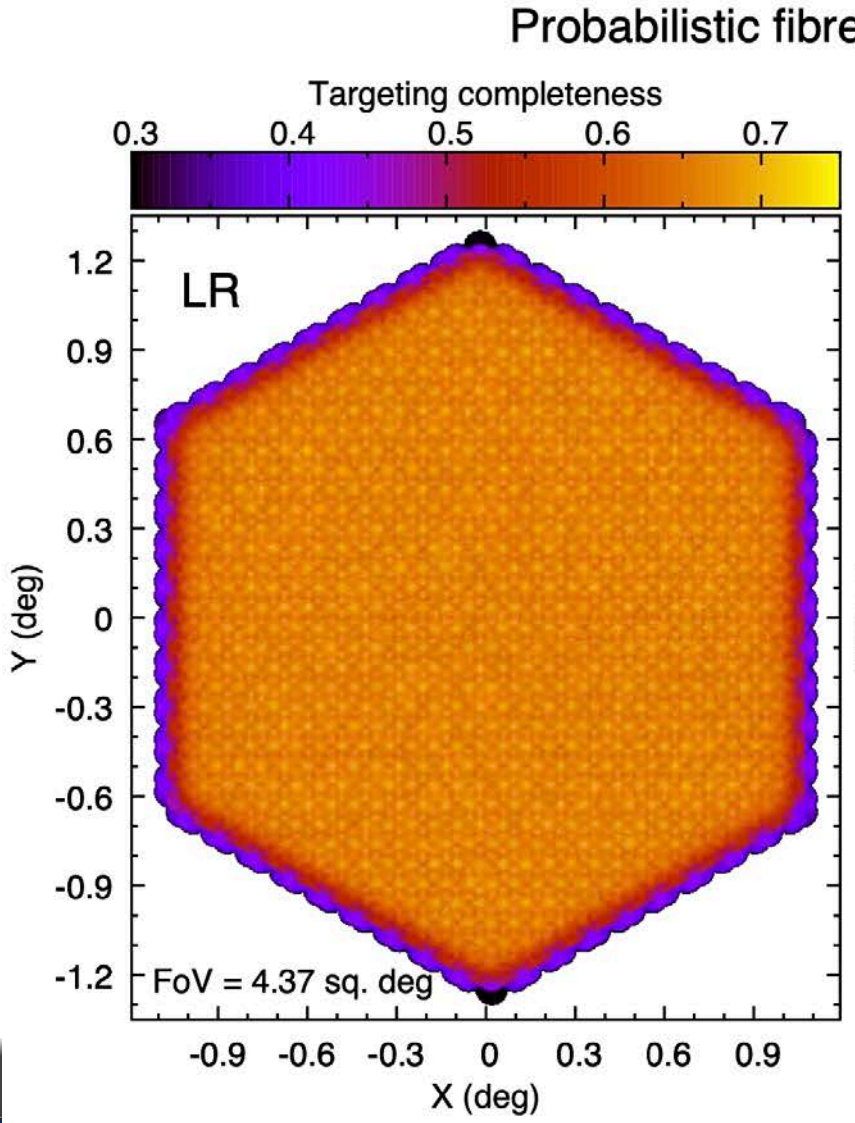


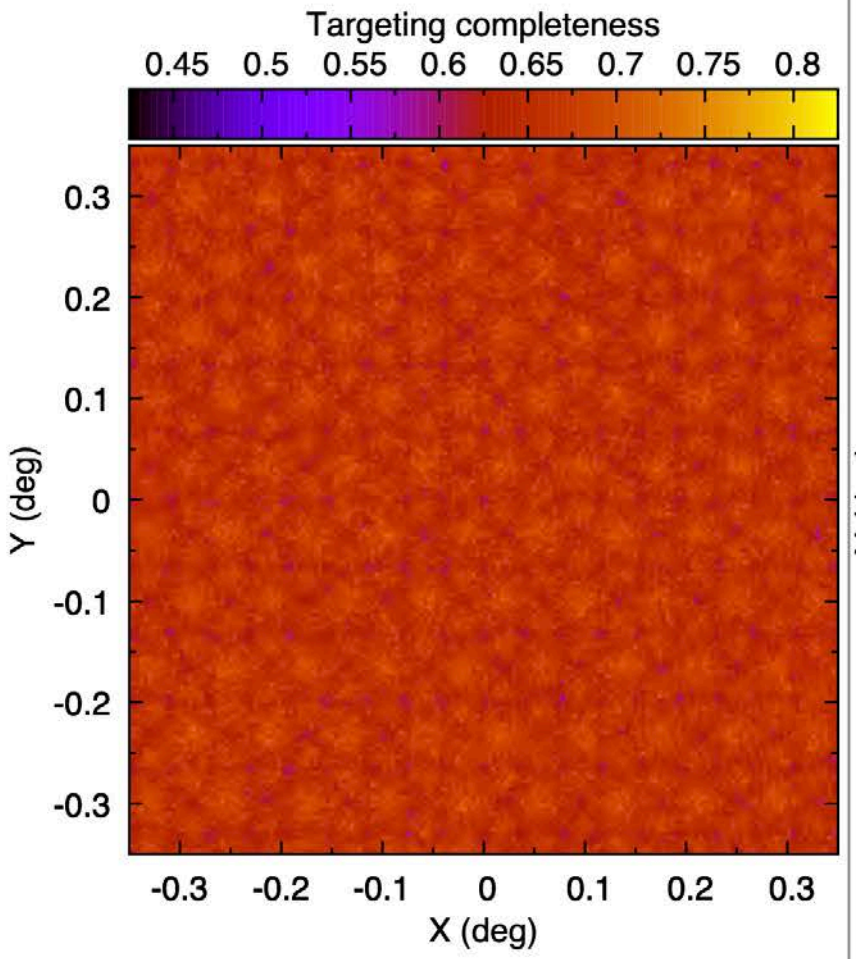
High-resolution

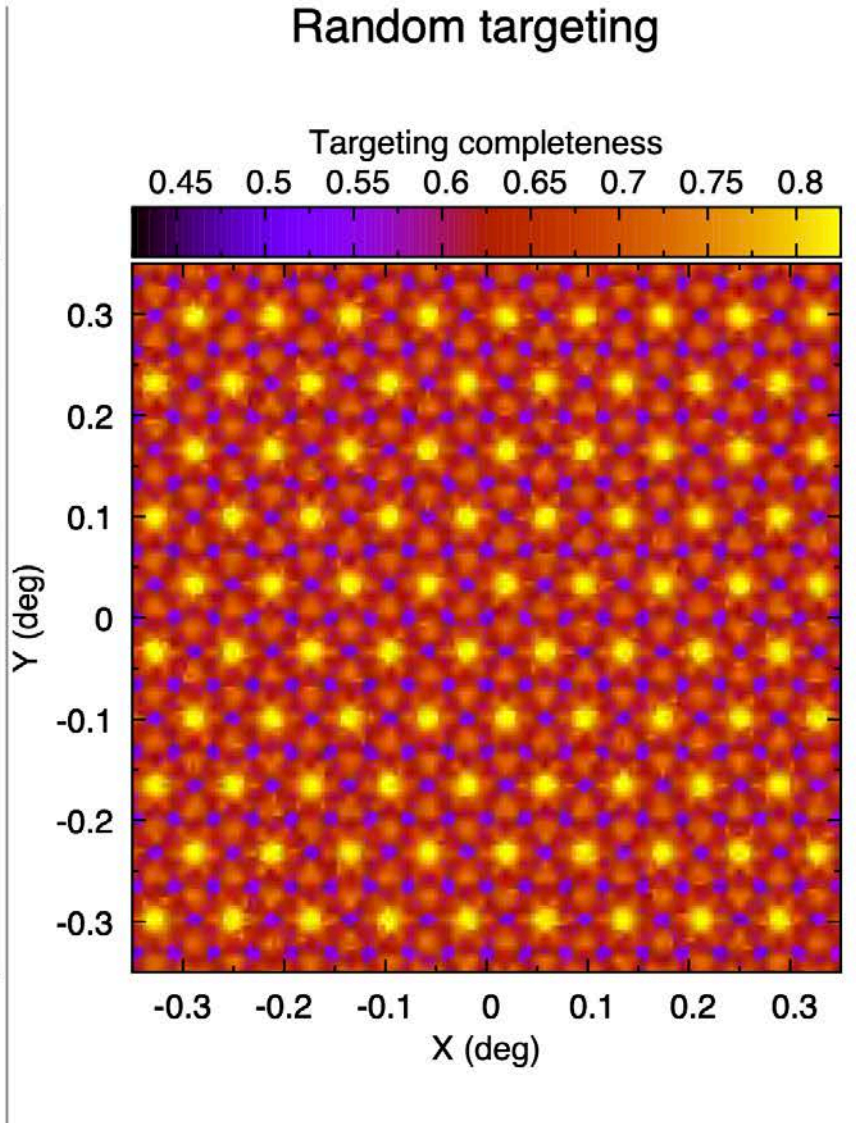


- For efficient survey, it is important to have more targets in the catalog than are required for the science goals.

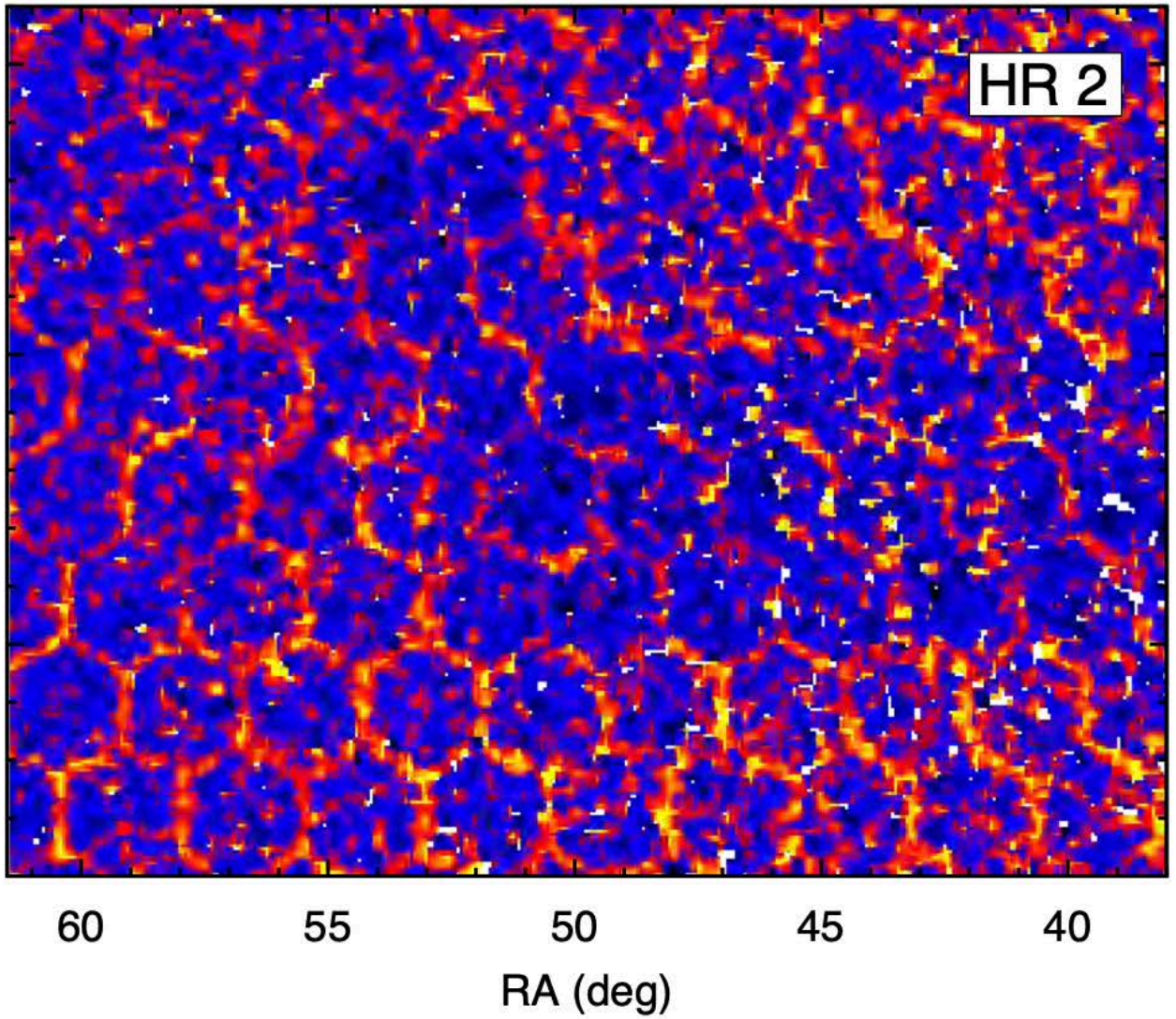
Random targeting vs probabilistic targeting

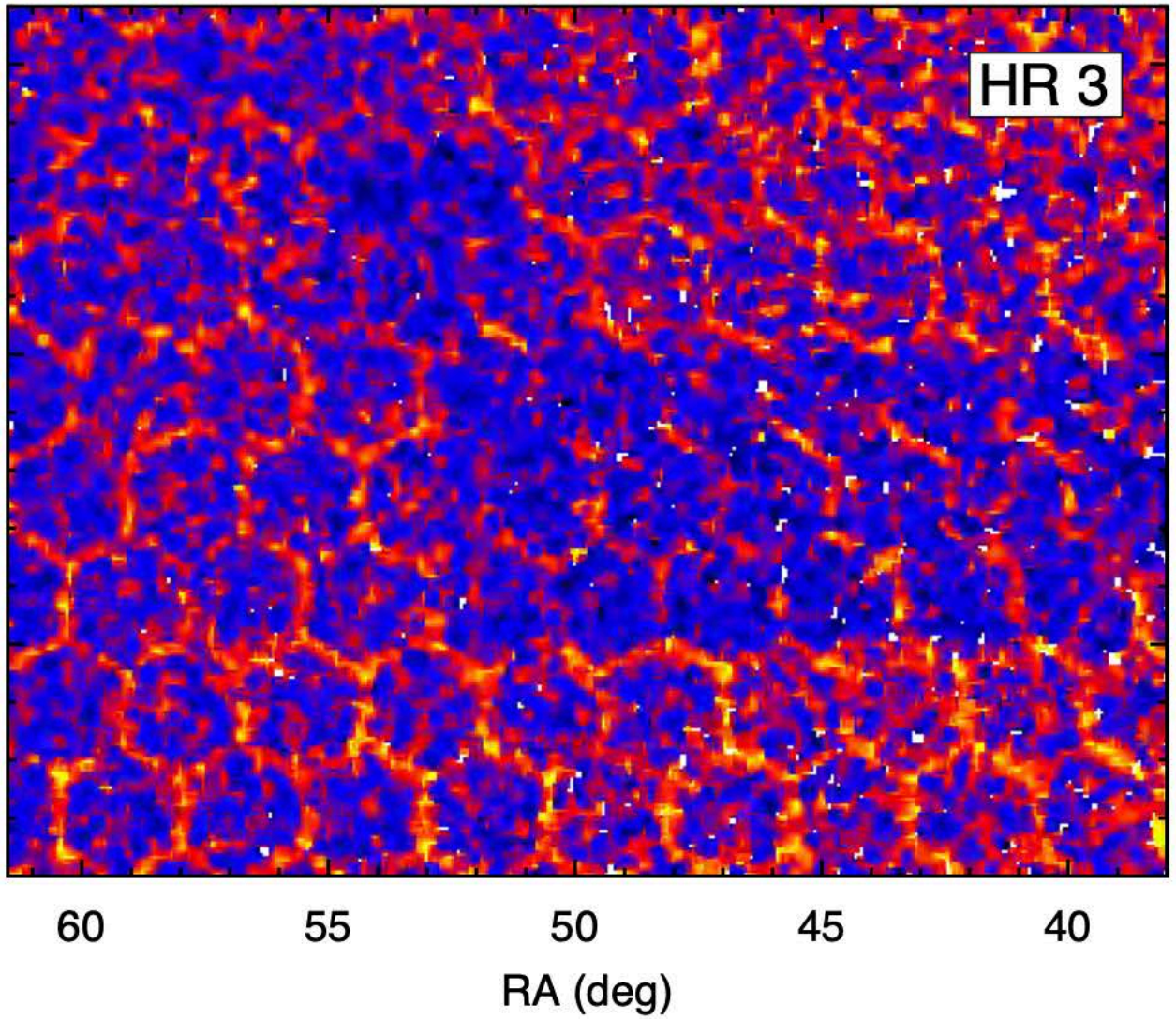




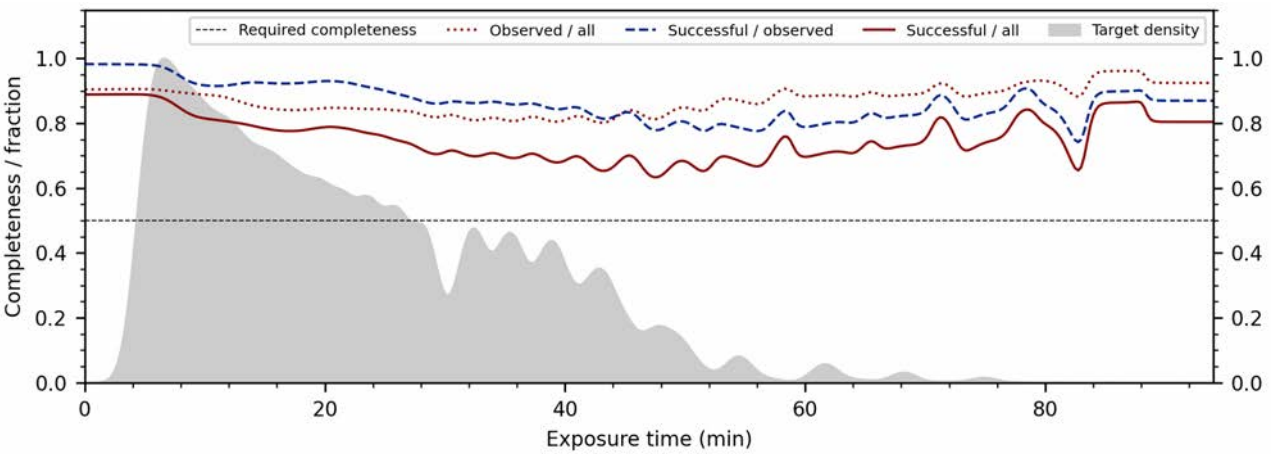


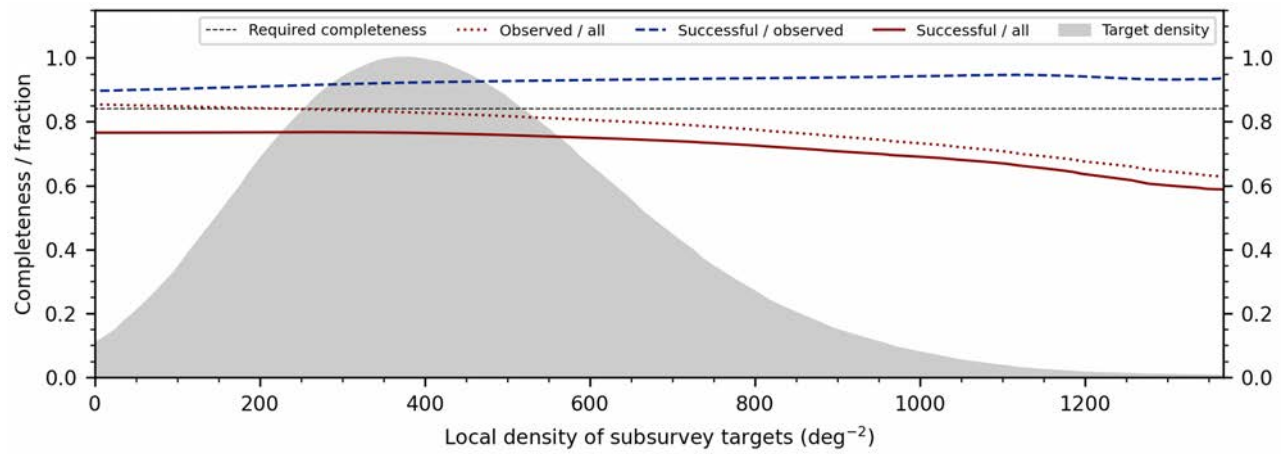
Example: tiling pattern and completeness map

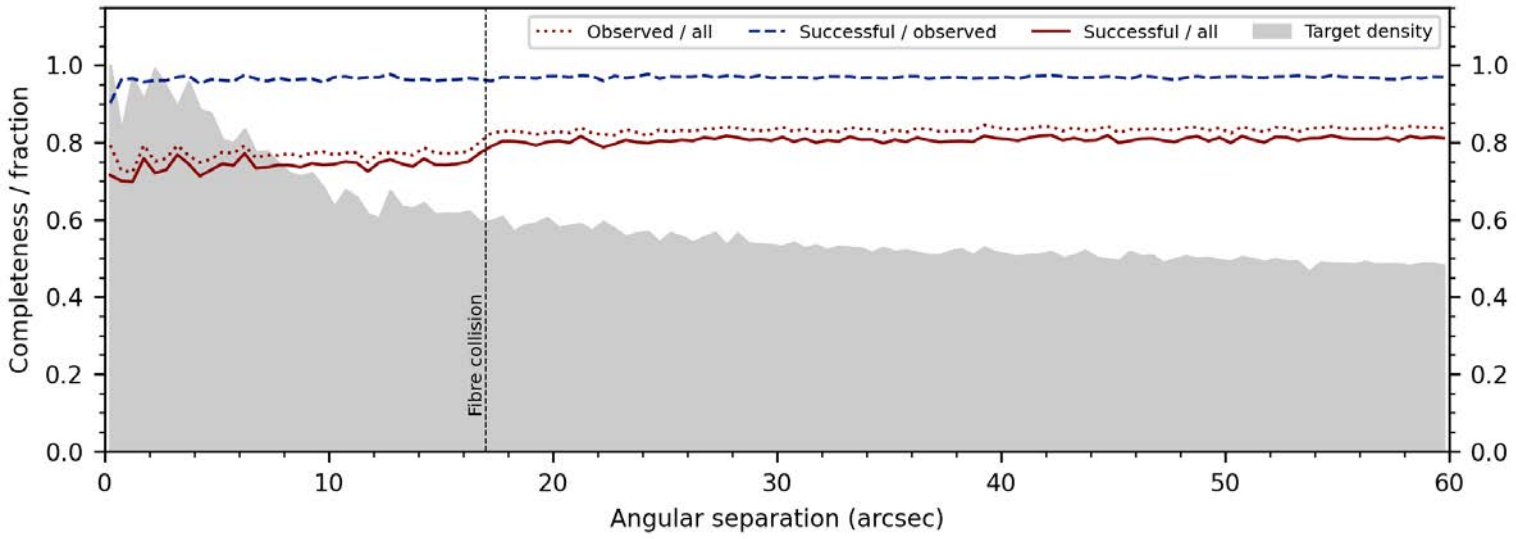




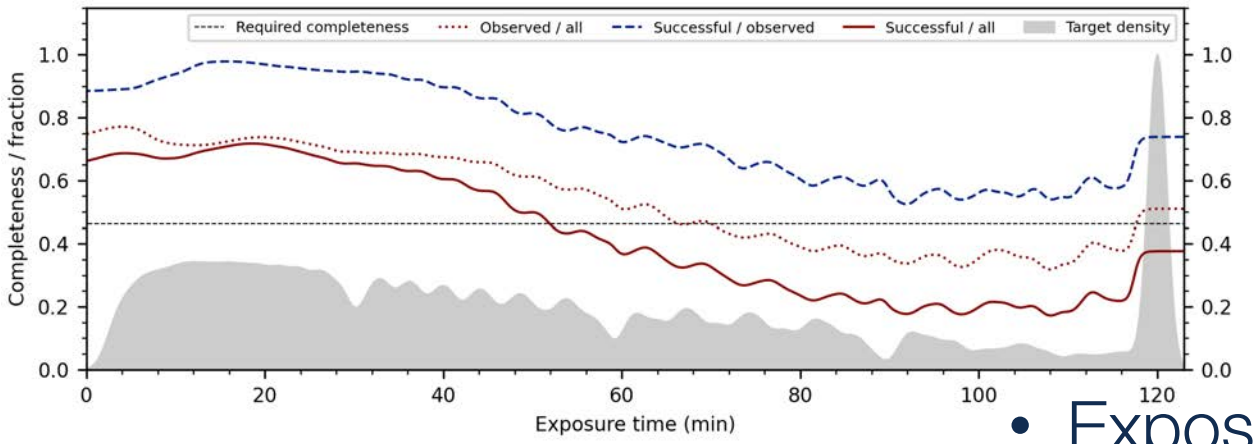
Example: 4MOST target catalogues

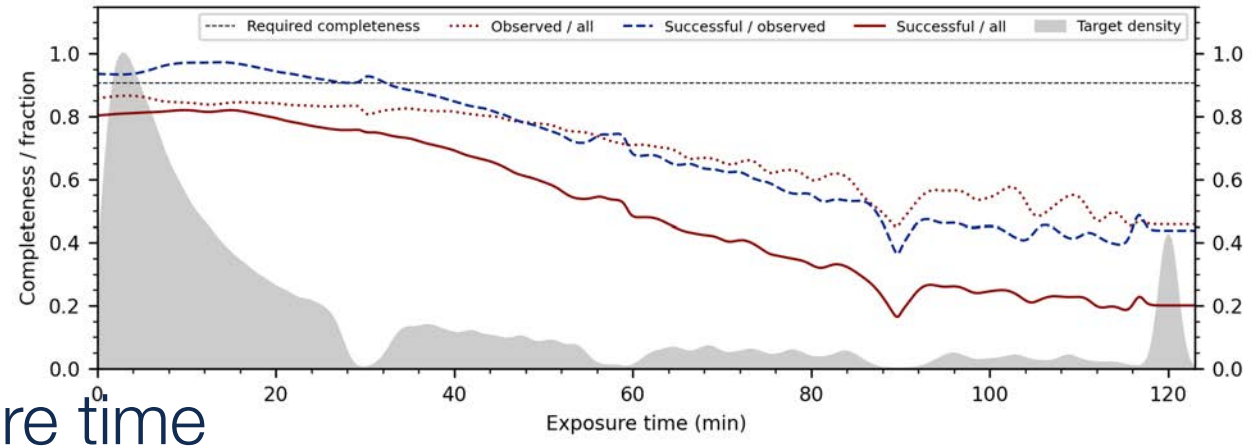




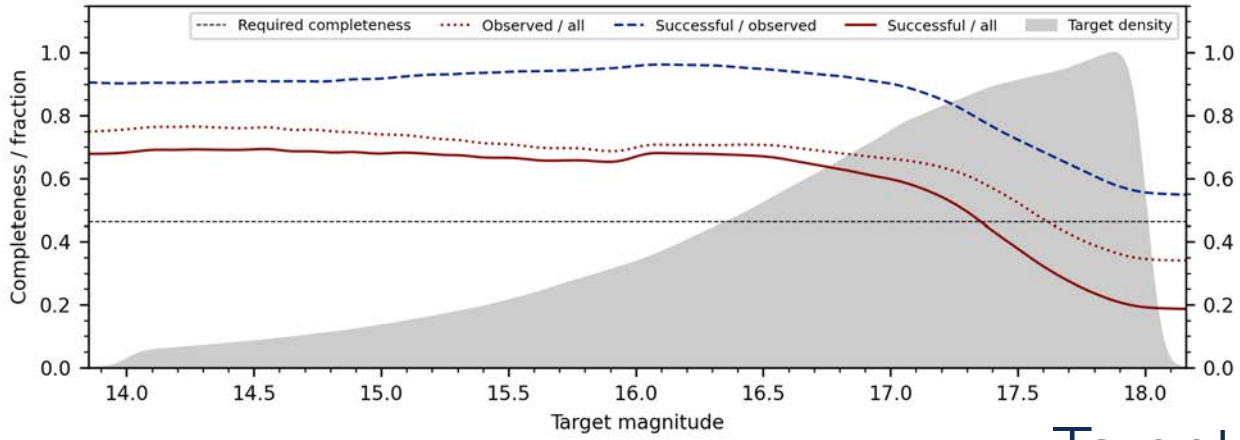


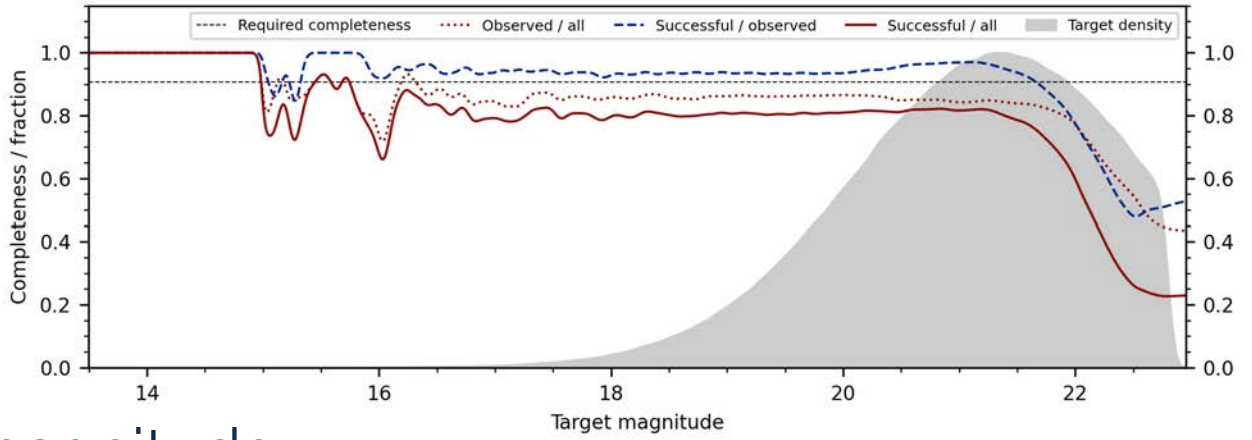
Example: 4MOST target catalogues





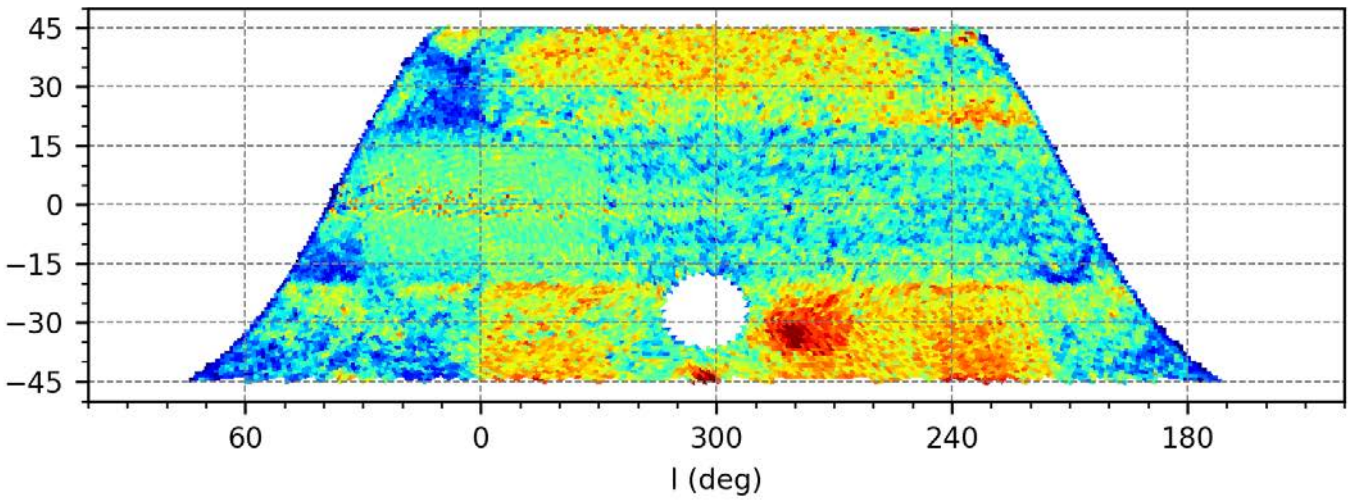
- Exposure time

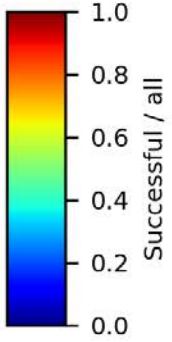


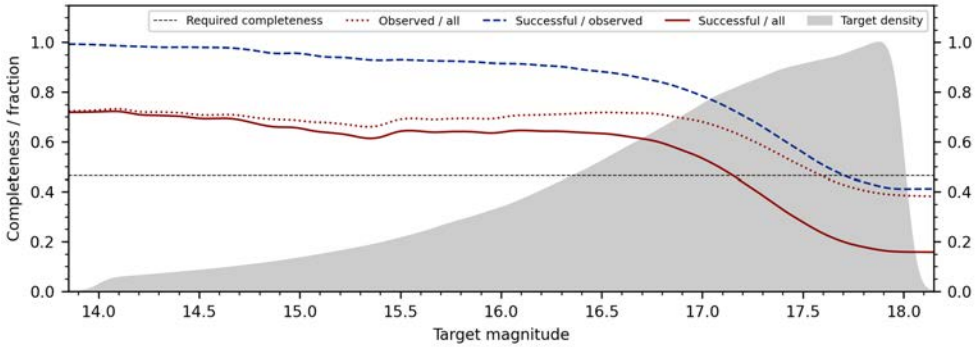


- Target magnitude

Example: Completeness for a single subsurvey







- Target magnitude

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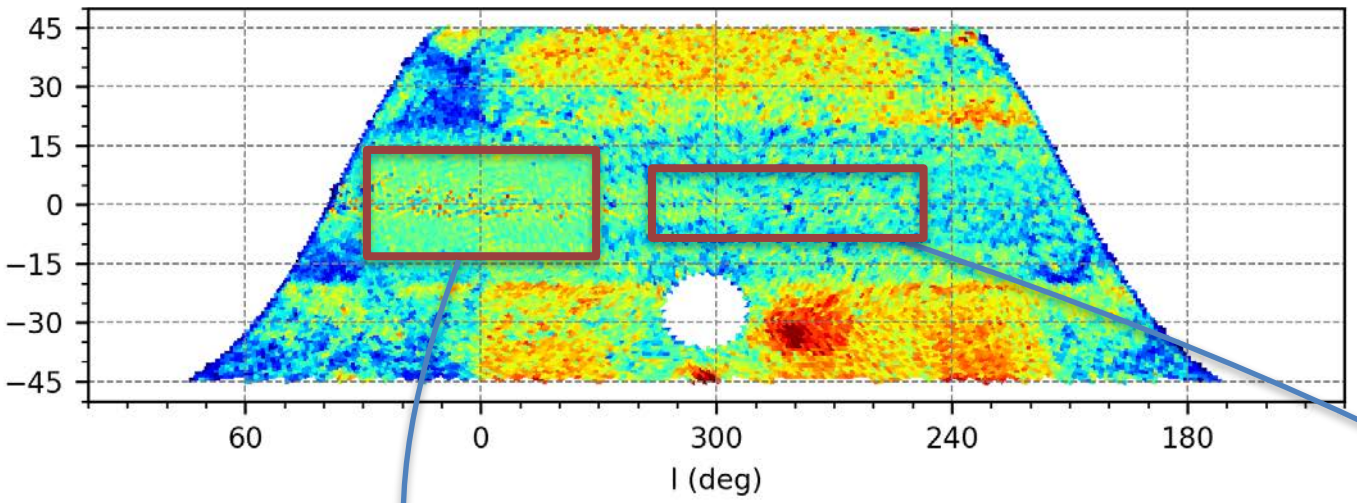
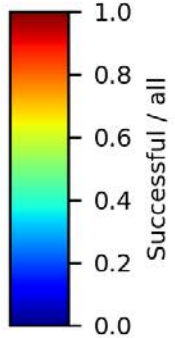
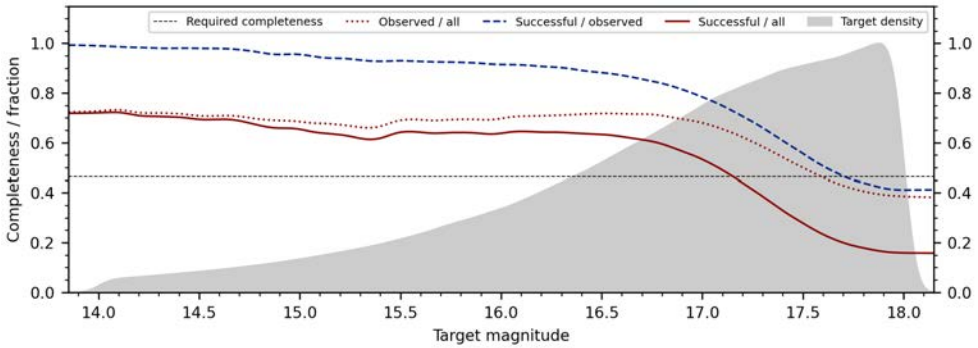
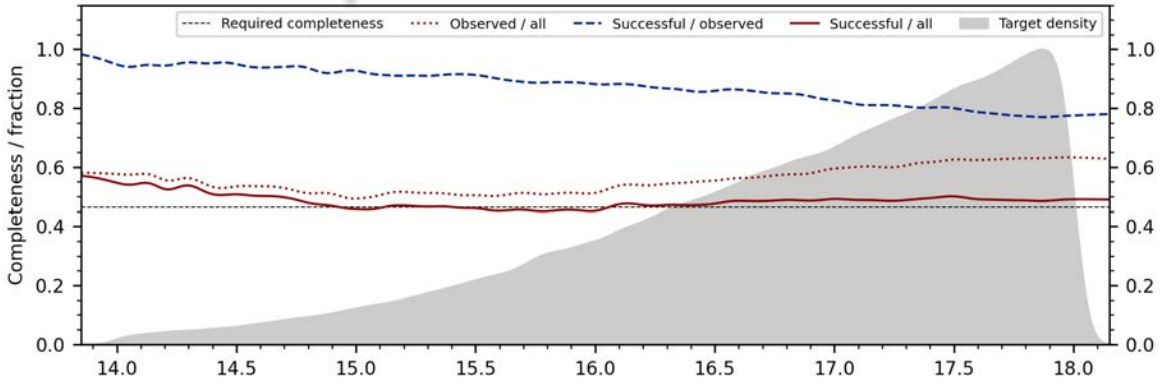




- Overall completeness



- Target magnitude



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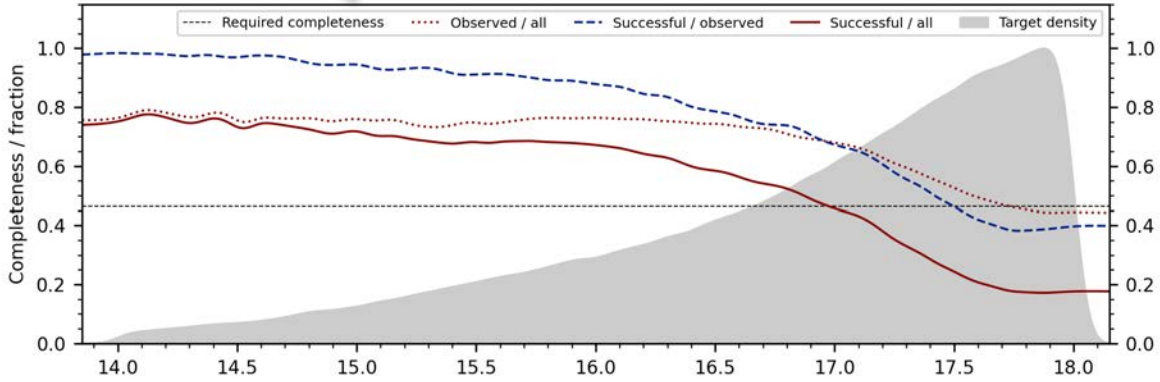
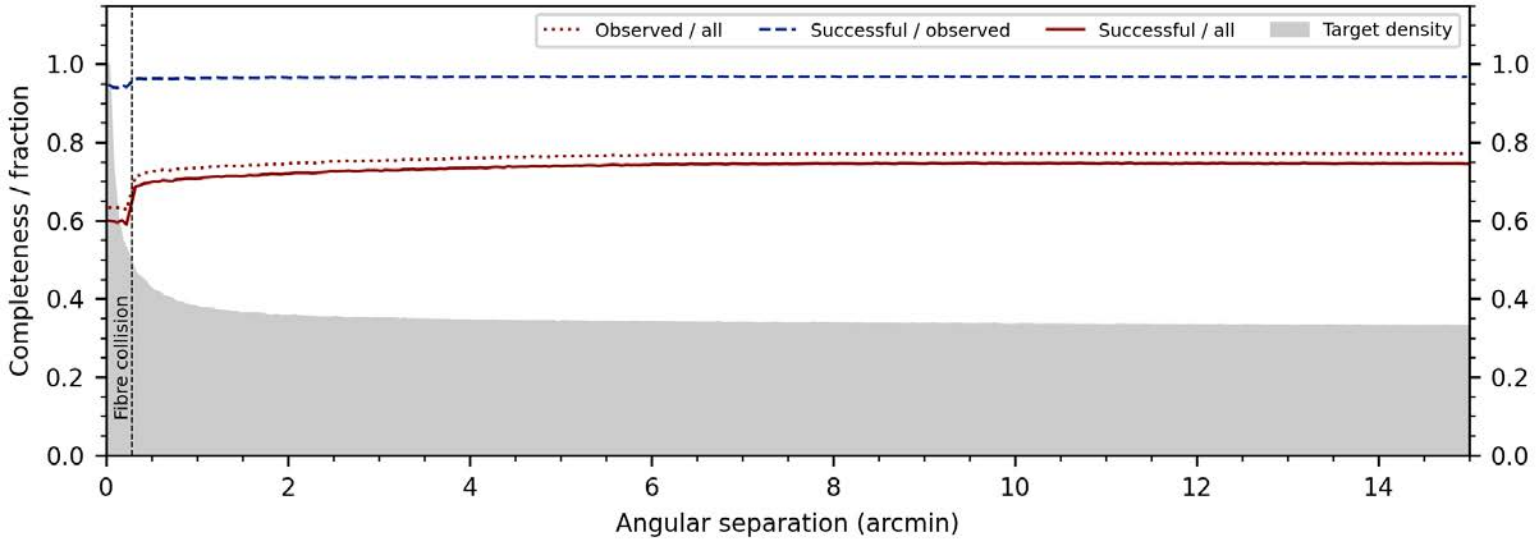


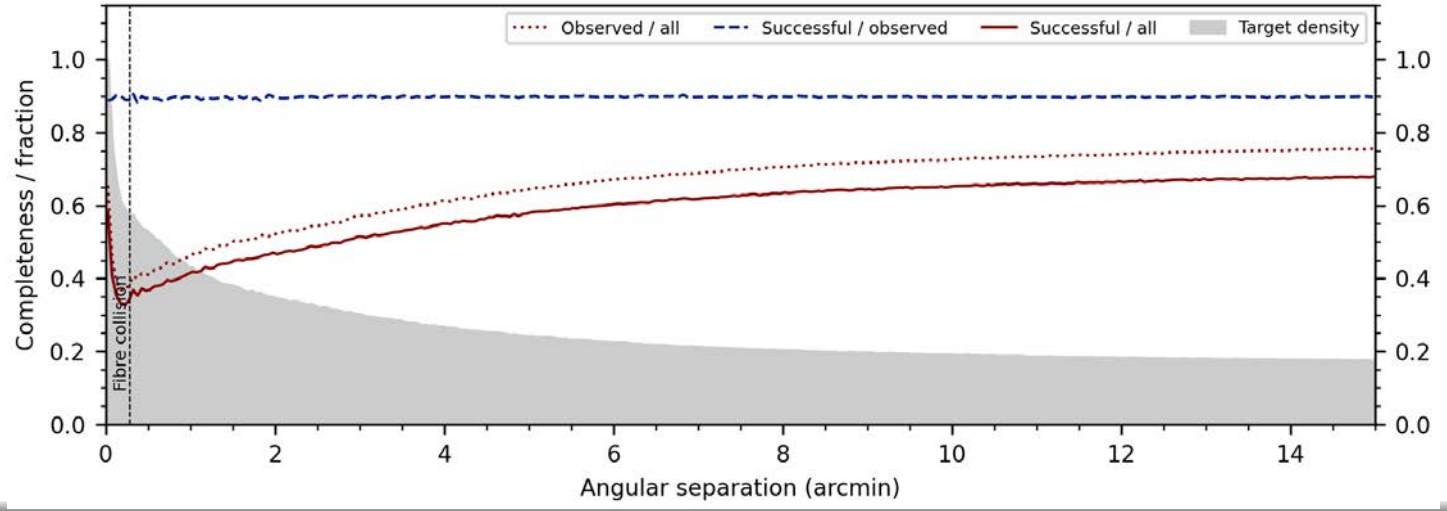
- Target magnitude

Completeness as a function of target separation

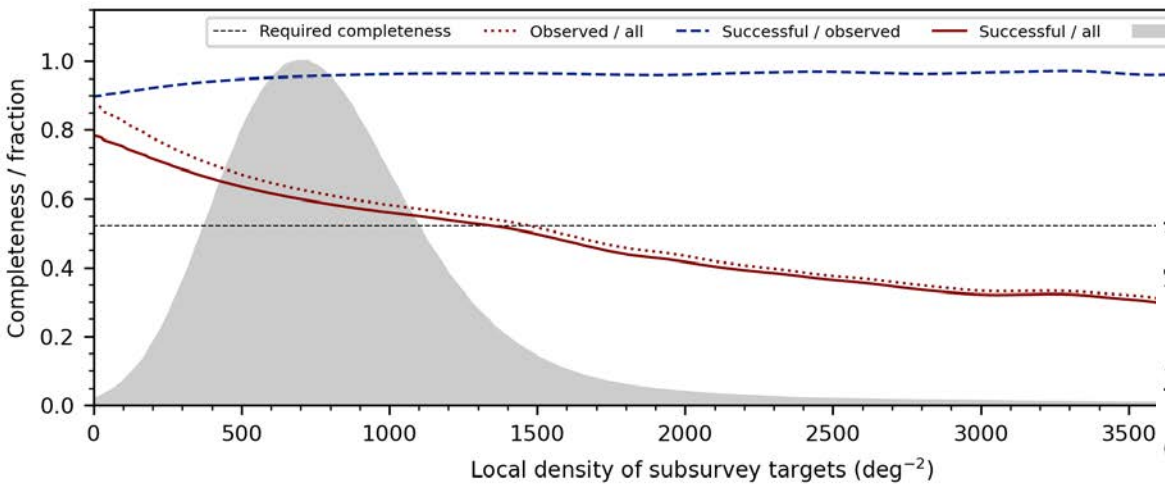


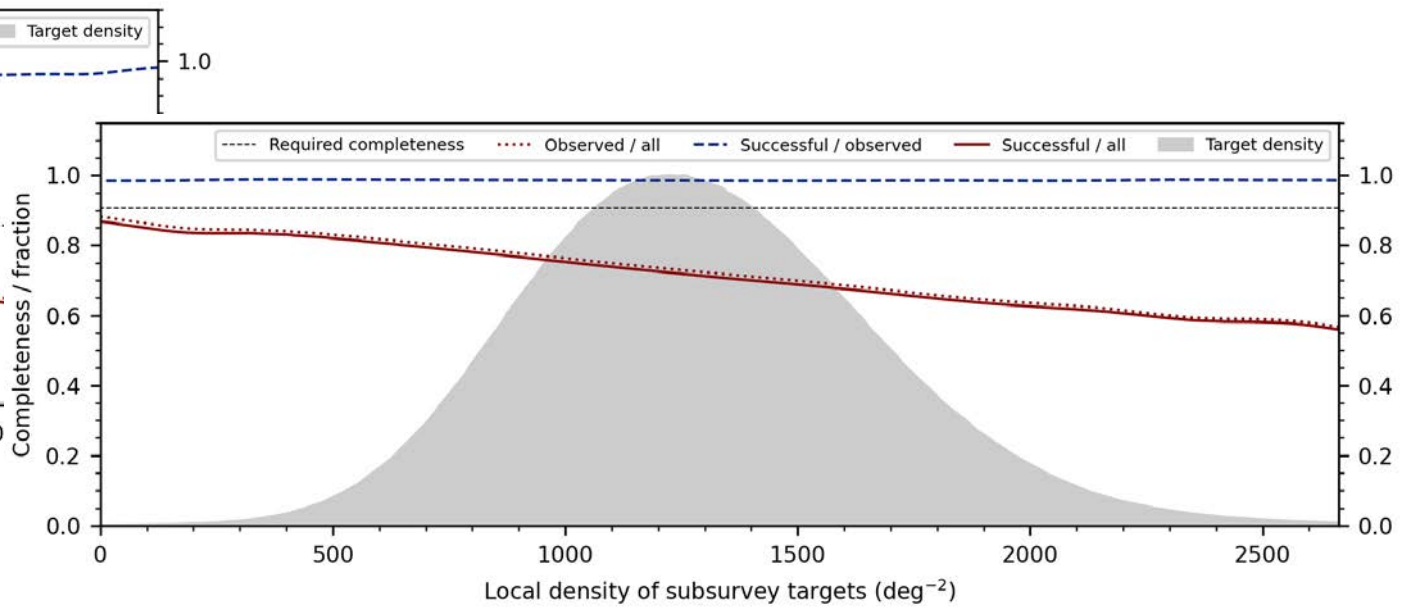
- Low-resolution survey

- High-resolution survey



Completeness as a function of target density

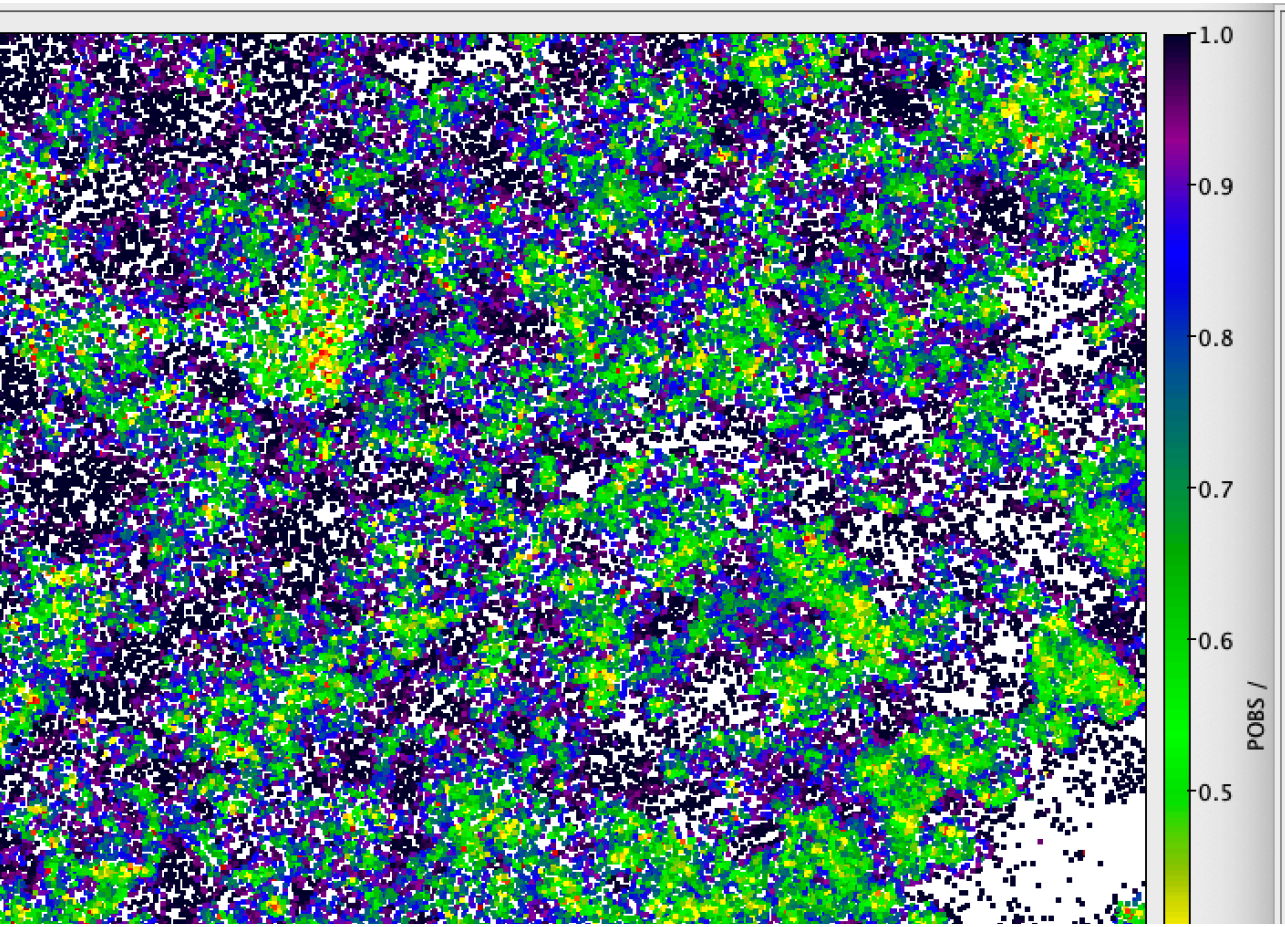


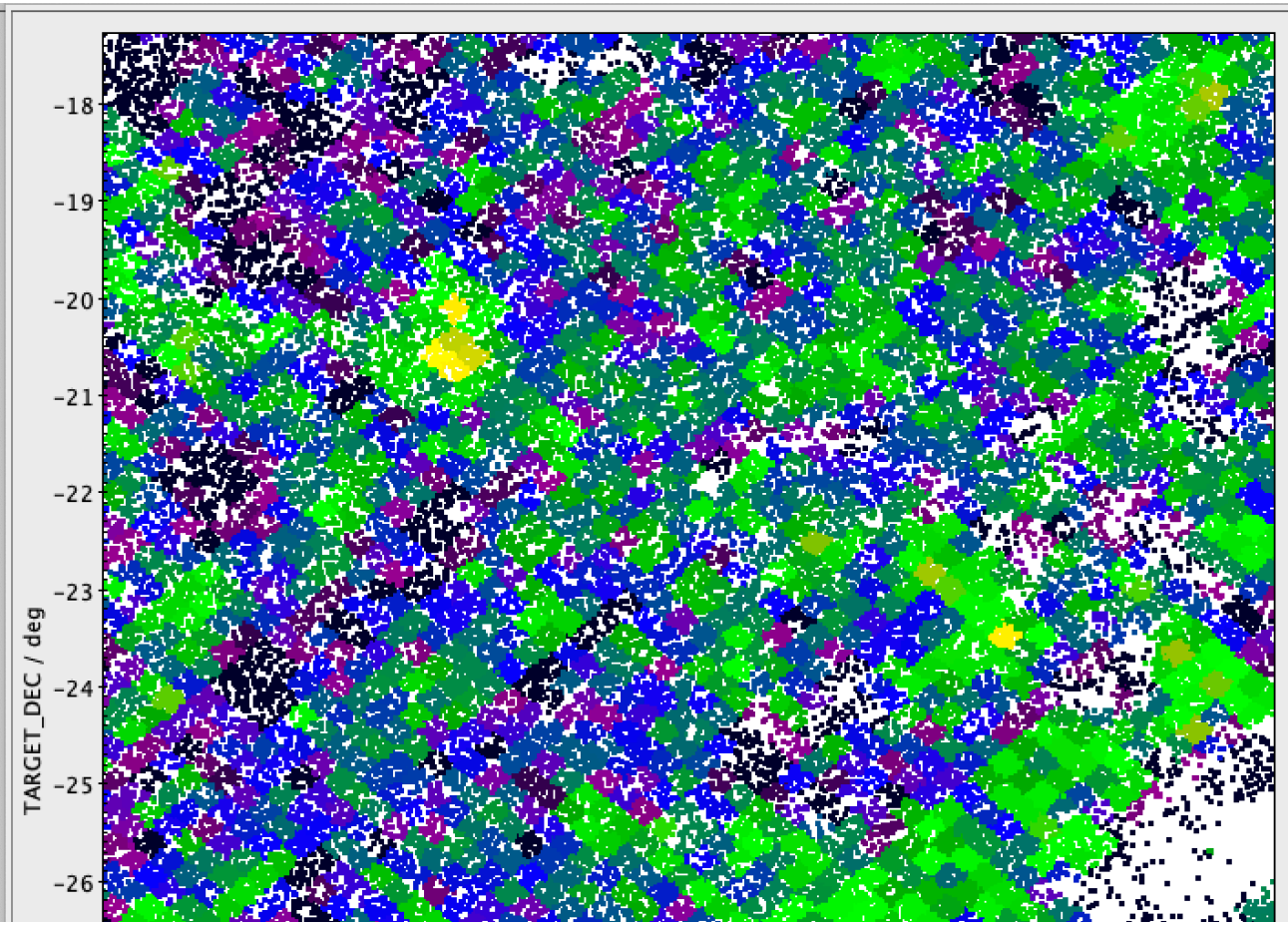


- Due to the fixed fibre density, the completeness depends on the target density

Probabilistic Selection Function

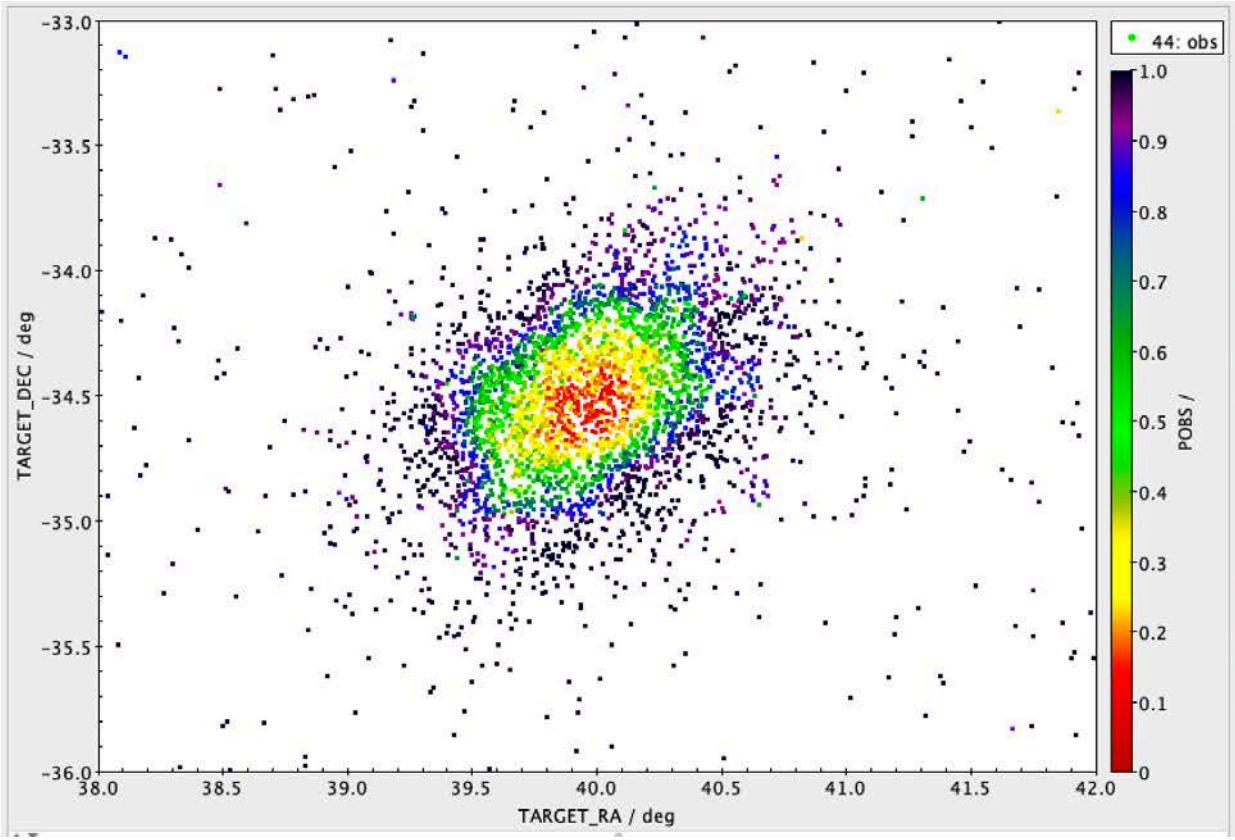
- Probabilistic SF
- Counting targets



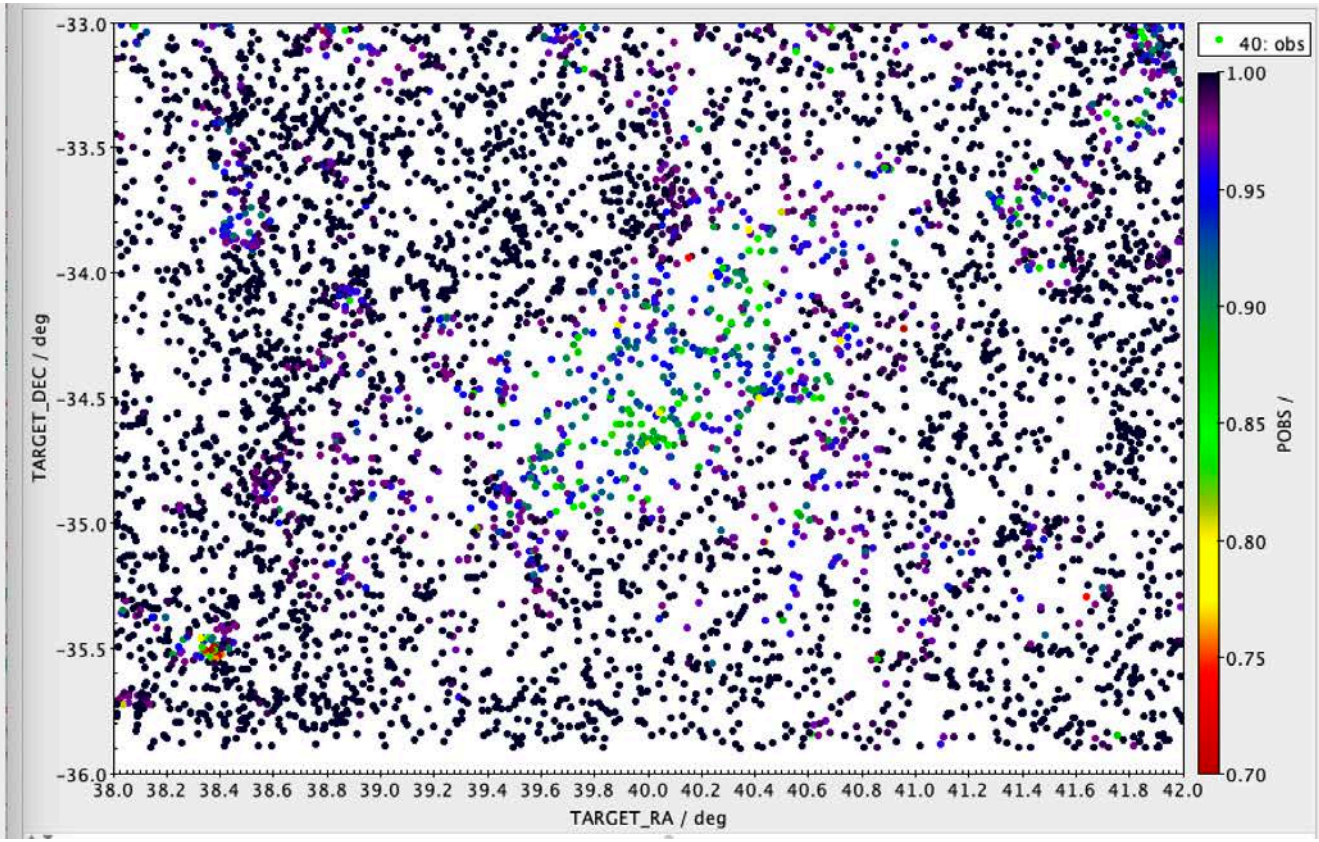


Example: Footprint of other surveys

- MW halo survey



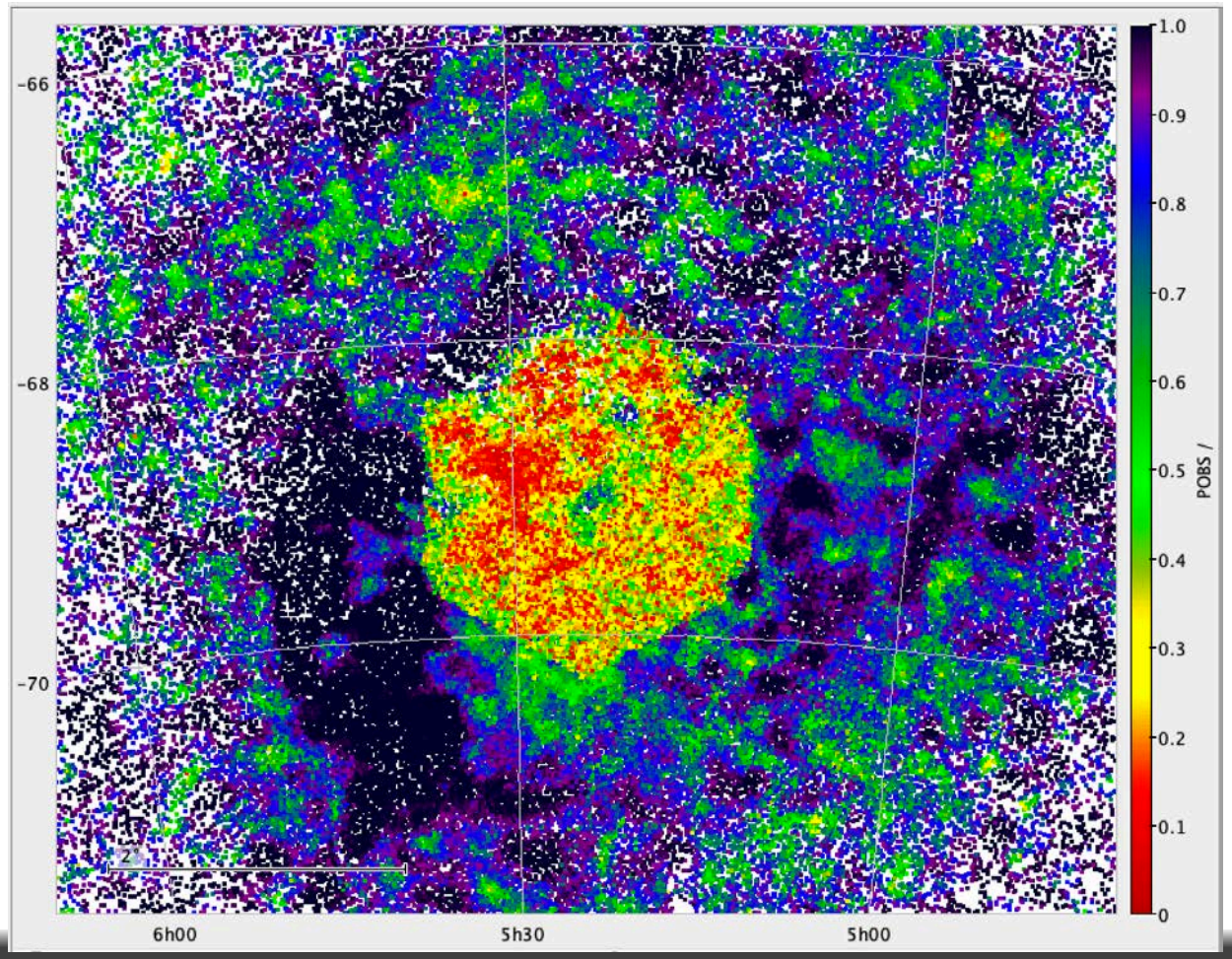
- WAVES survey



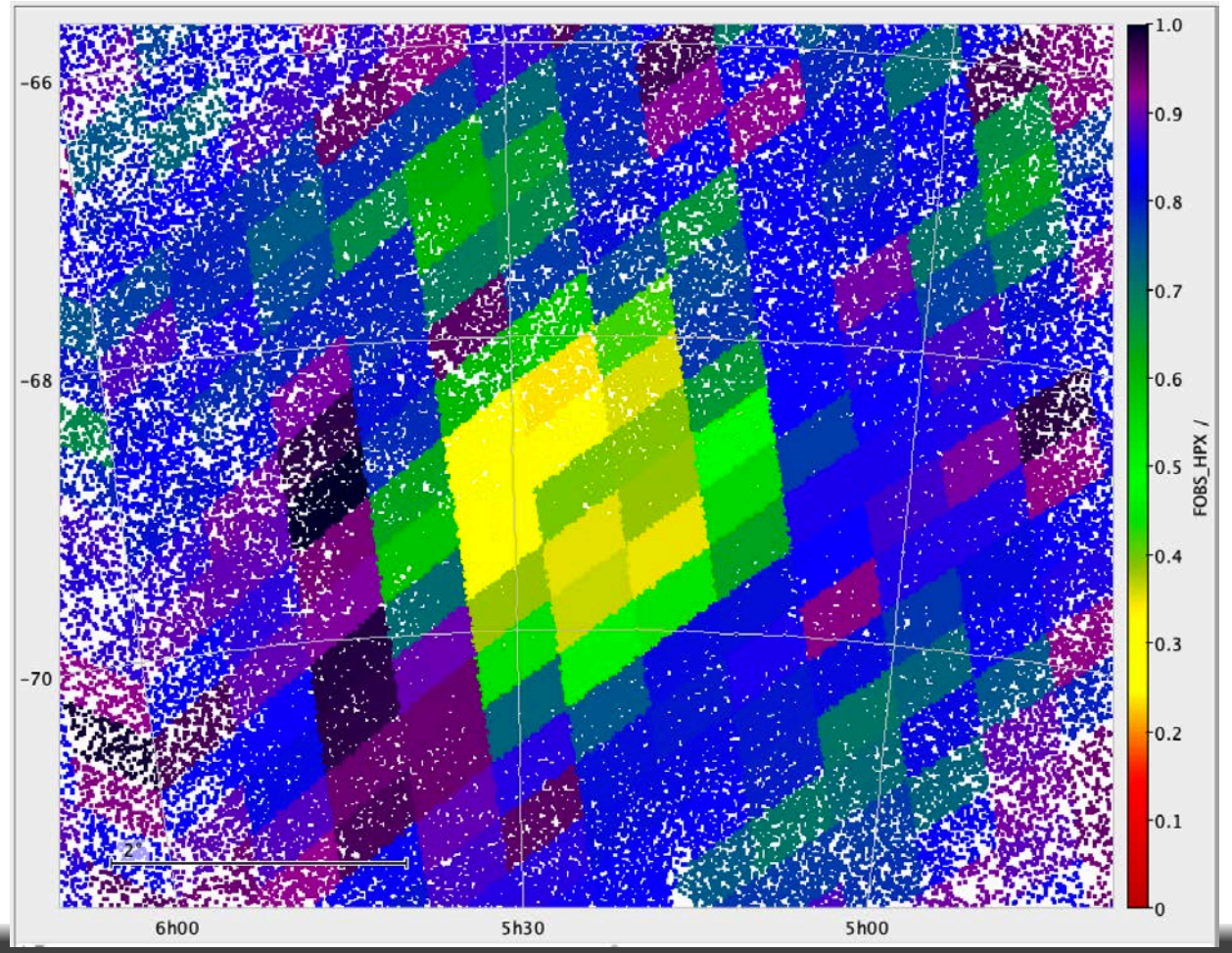
- Footprint of Sculptor dwarf irregular galaxy is clearly visible in WAVES field

Selection Function for Magellanic Clouds

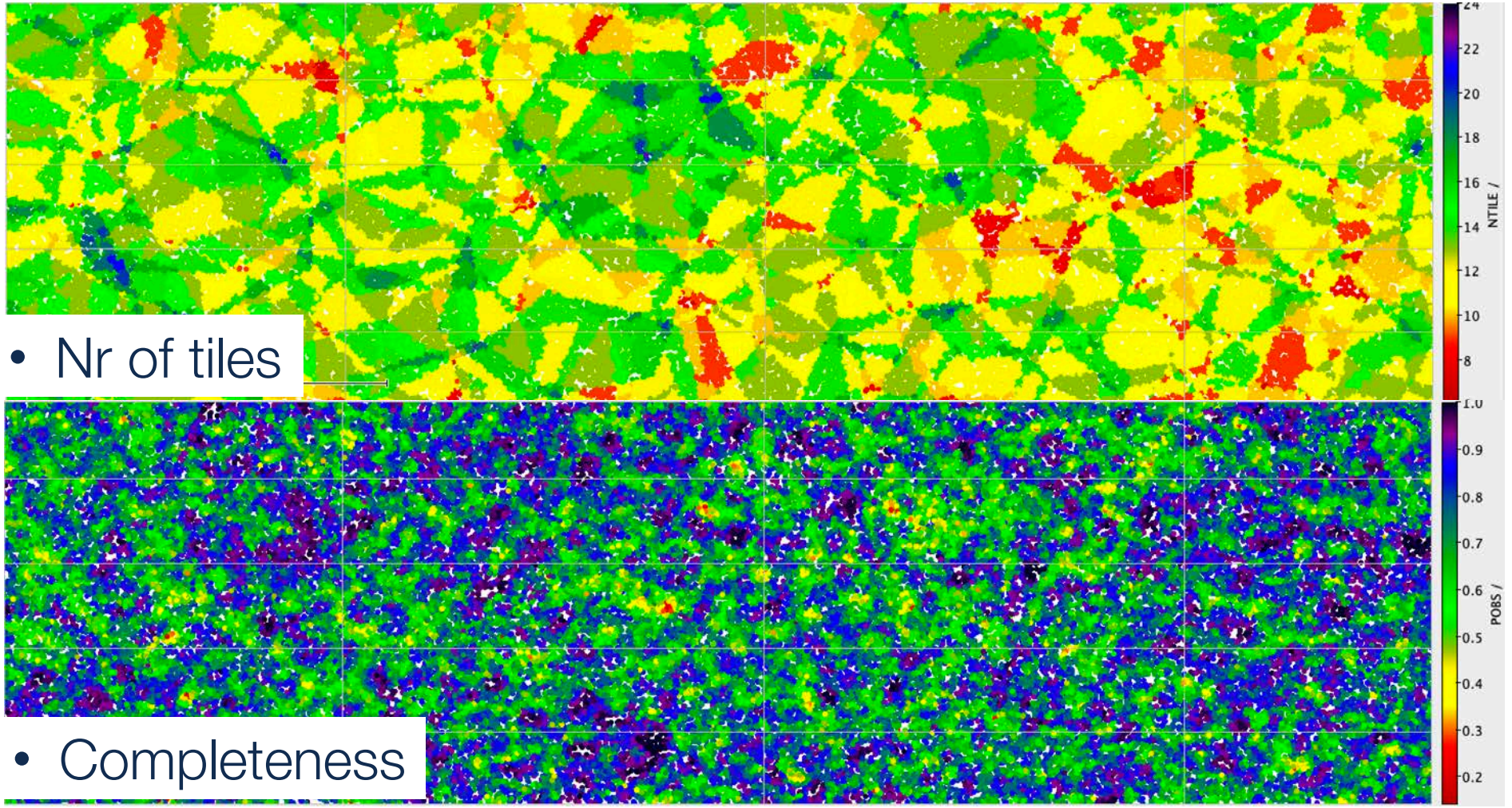
- Probabilistic SF



- Counting targets

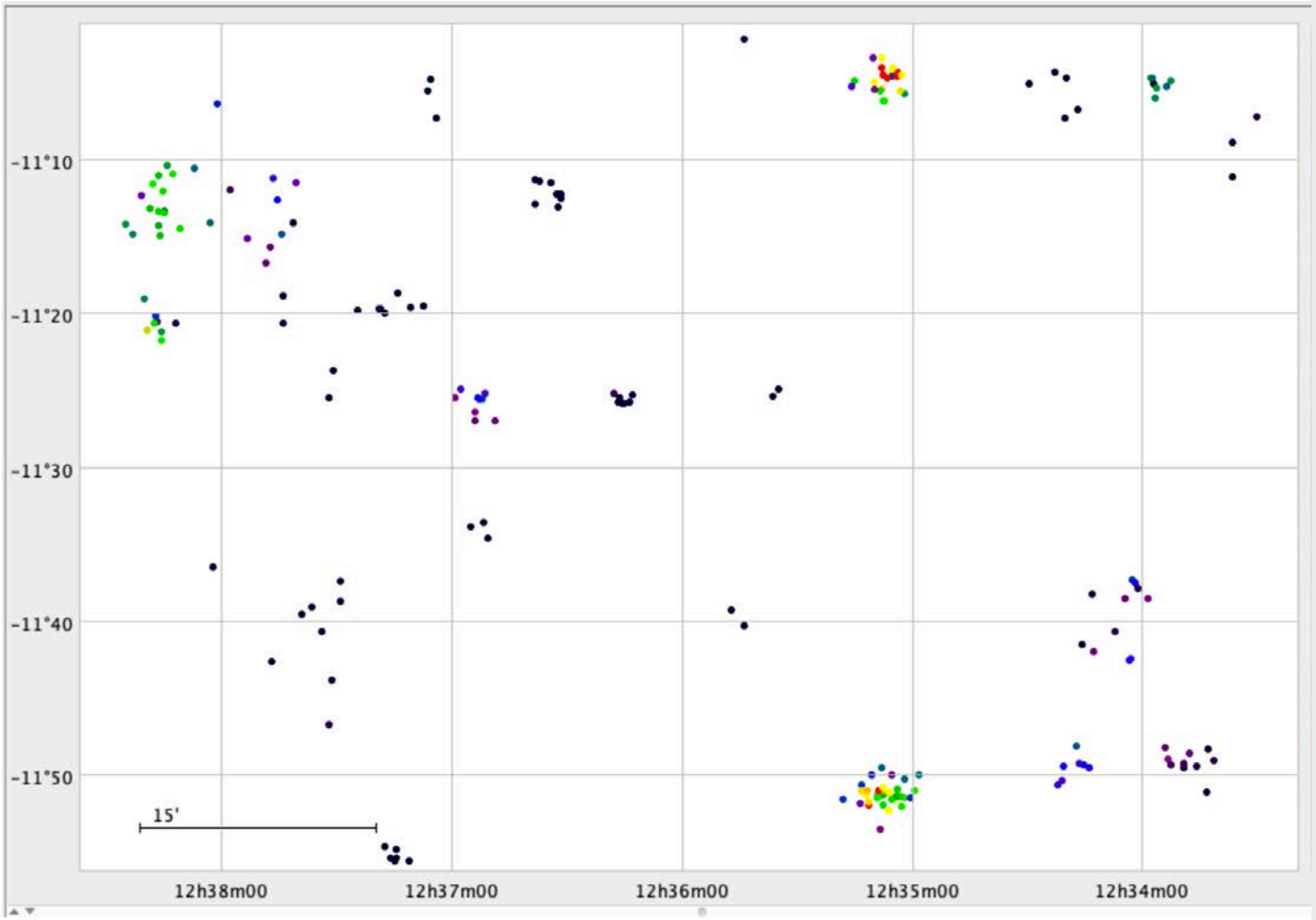


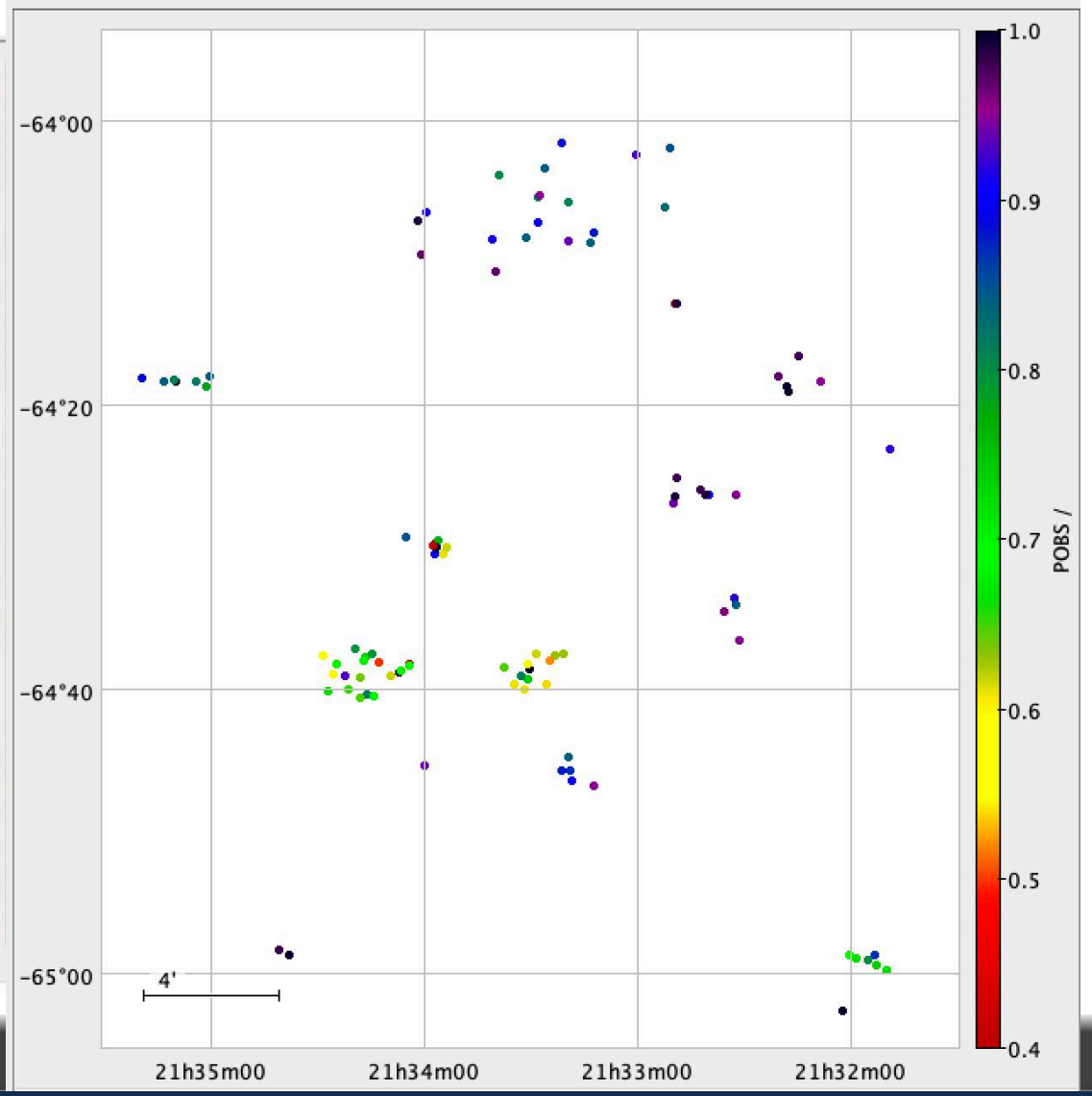
Probabilistic Selection Function



- Nr of tiles
- Completeness

Probabilistic Selection Function for clusters

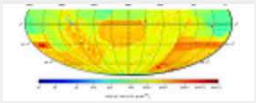
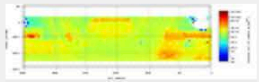
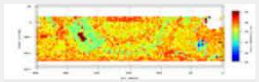
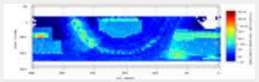
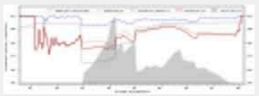
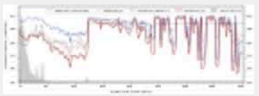
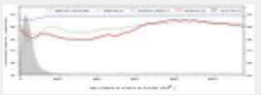
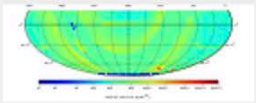
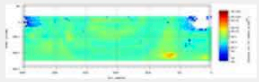
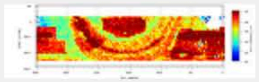
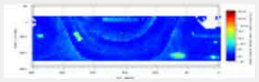
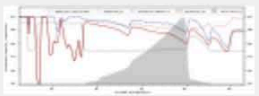
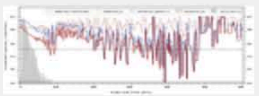
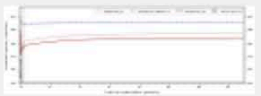
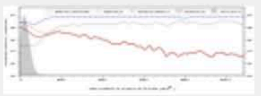
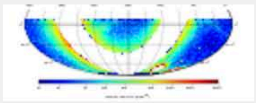
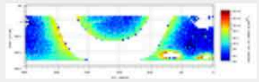
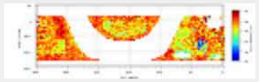
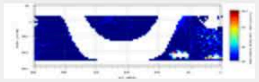
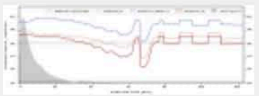
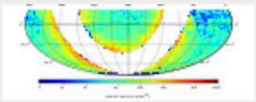
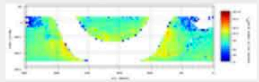
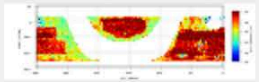
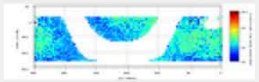
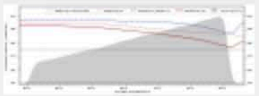
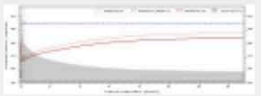
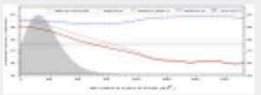
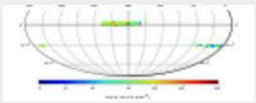
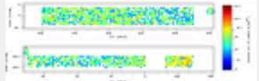
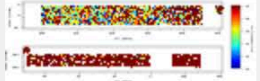
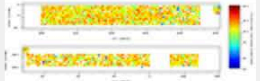
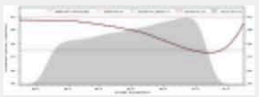
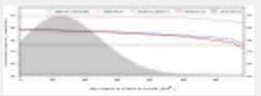




What IWG4 is providing?

- Simple selection function based on counting of objects.
- **Probabilistic selection function for every target** — statistical modelling of the 4MOST observations that allows to calculate detailed selection function.
- For each target we provide a probability that it will be targeted and successfully observed.

4MOST Selection Functions Pipeline: Plot collections

ID	Res	Collection	Count	All targets	Successful	Successful / all	Exp. time (dark)	Magnitude	Exp. time (dark)	Ang. sep. (small)	Loc. den. (512)
1	LR	All LR targets	40633868								
2	HR	All HR targets	10502491								
101	LR	S1 MW halo LR	2479224								
201	HR	S2 MW halo HR bright	1526979								
202	HR	S2 MW halo HR deep (wide view)	47929								
202	HR	S2 MW halo HR deep (deep fields)	47929								
203	HR	S2 MW halo HR faint	983503								
301	LR	S3 4MIDABLE-LR sub 1	10431215								
302	LR	S3 4MIDABLE-LR sub 2	5503684								
303	LR	S3 4MIDABLE-	3233310								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