Survey Science Group Workshop

[A-SPEC] Survey Plan & Galaxy Science

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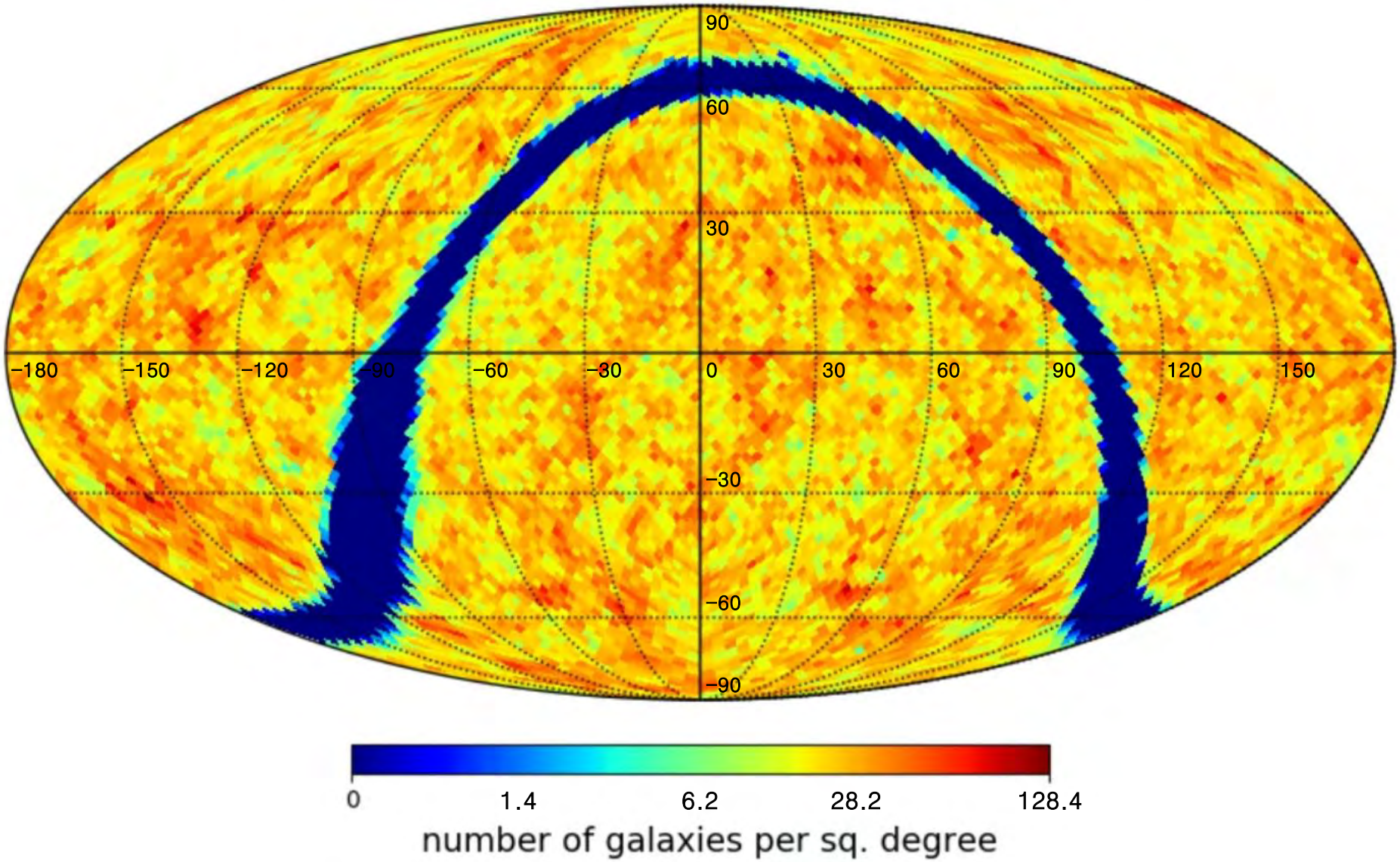
22.02.14. / Jeongseon

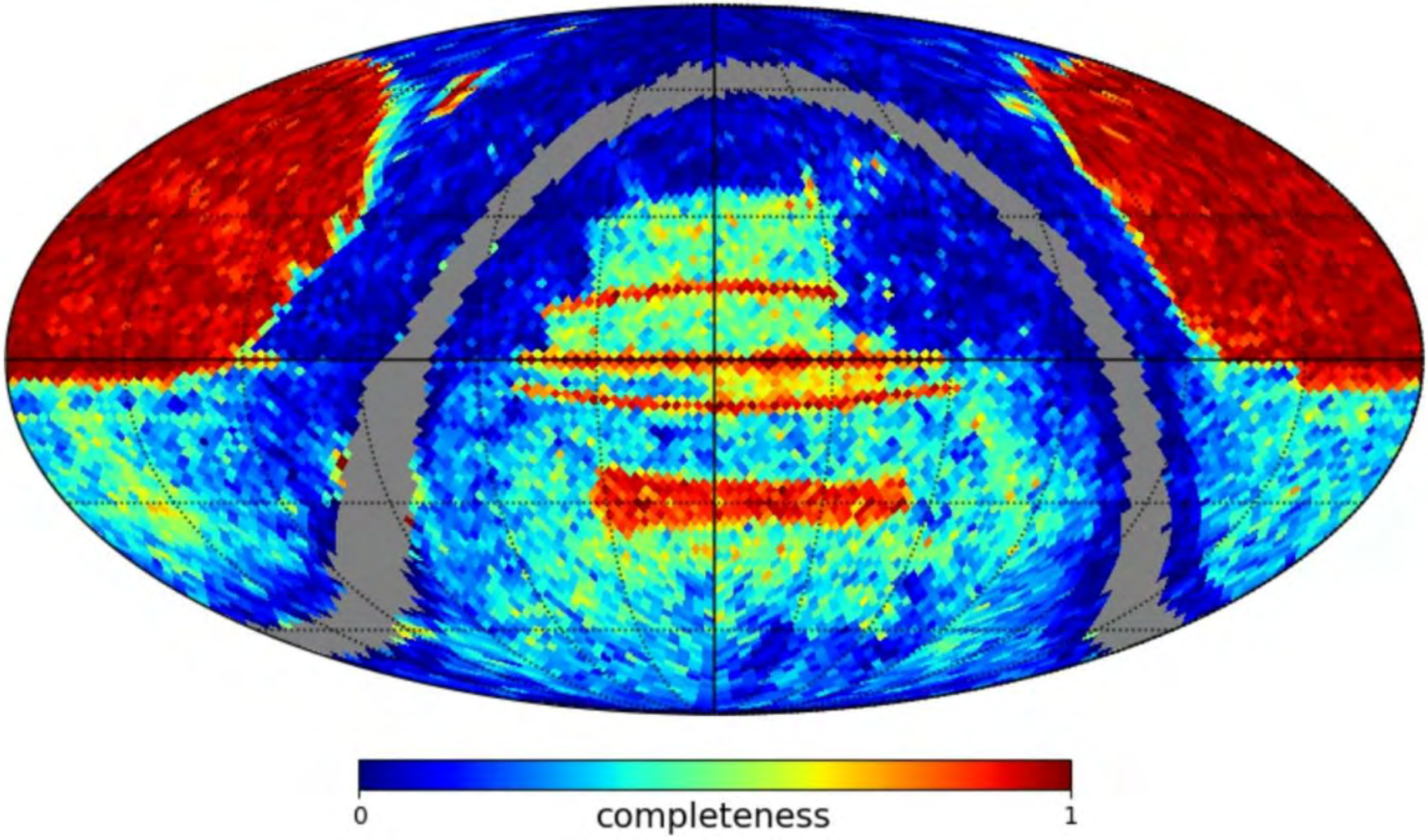
Spatial distribution of nearby galaxies

2MASS extended sources at $K_{S,0} < 13.75$ mag :
(after excluding the galactic plane region) total number = 7.8×10^5, mean density = ~20 deg^{-2}

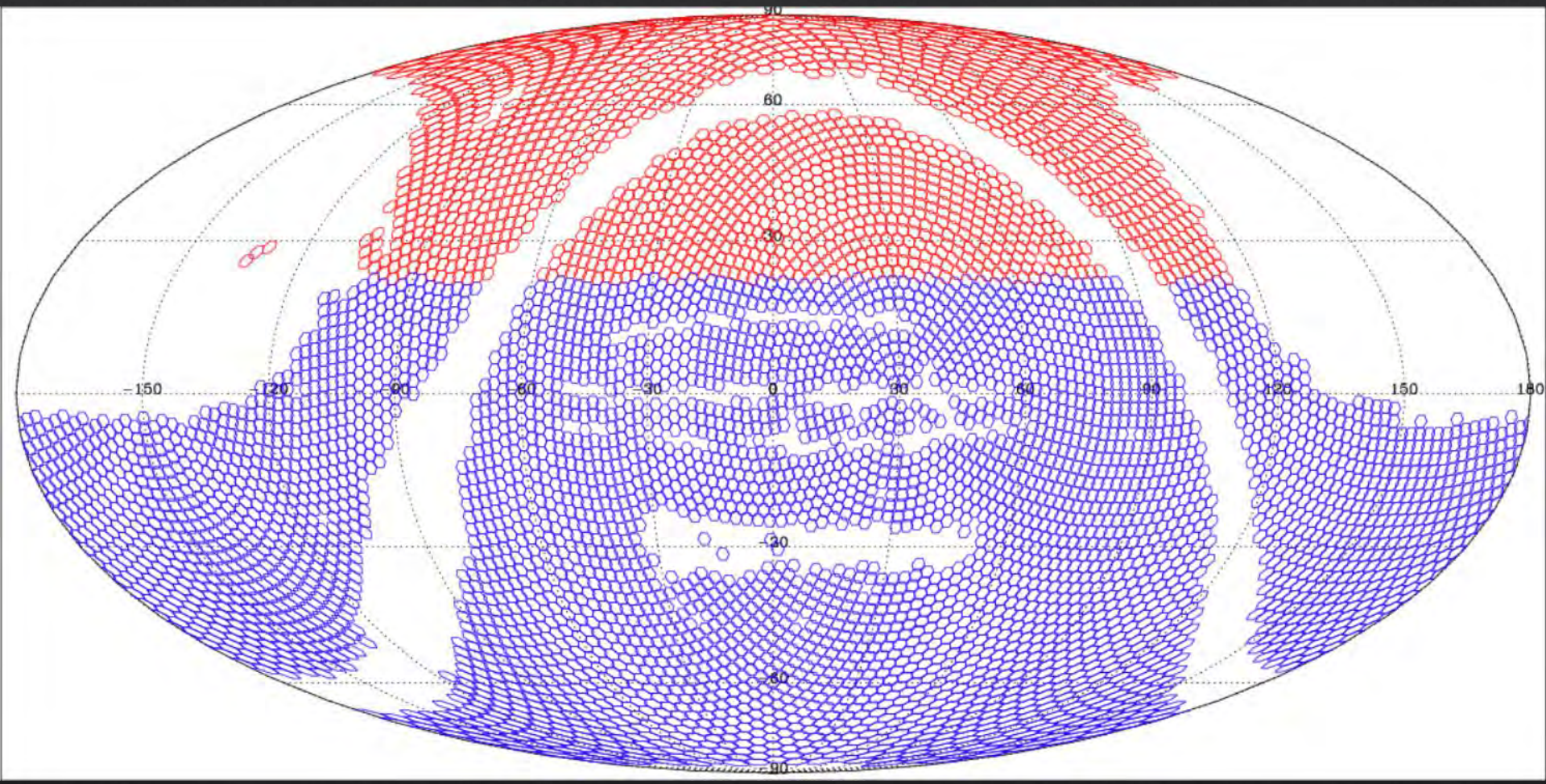


Spectroscopic completeness map

overall completeness = ~42% (redshifts from literature / nearby galaxies)
We need redshift information for 4.5×10^5 galaxies → main targets



Tiling result I



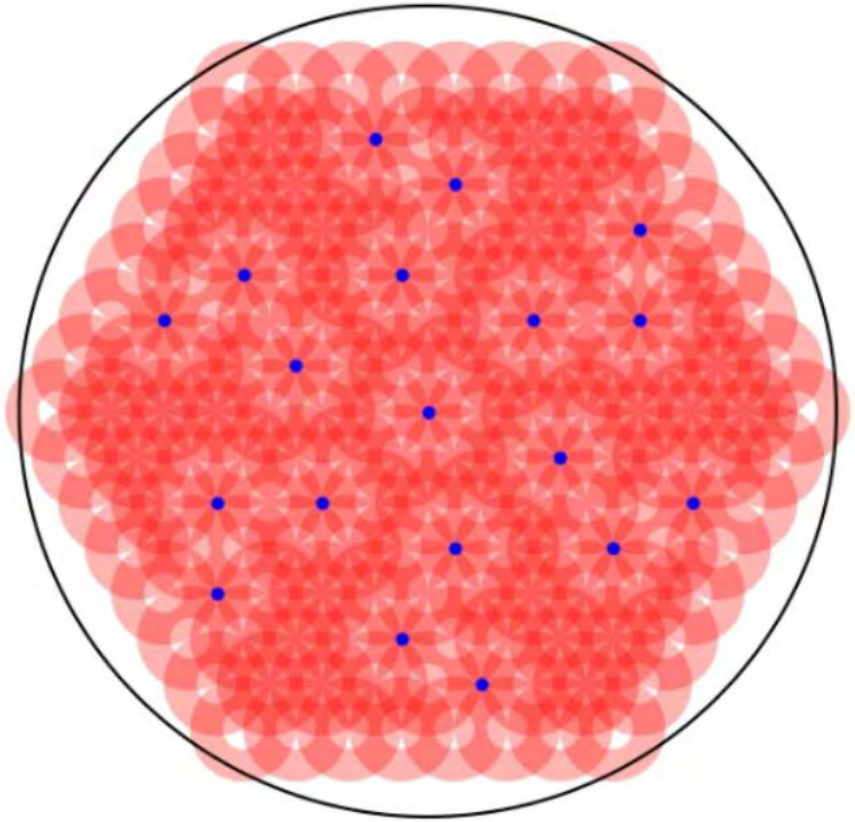
To cover the low completeness regions with the minimum number of tiles

5500 tiles (N_{target} > 25 per tile): ~4000 blue tiles for the southern sky (KMTNet SSO)
~1500 red tiles for the northern sky (to be confirmed)

KMTNet SSO: sky coverage= −84.8º < Dec. < +22.3, FoV= 6.4 deg^2 circle (5.3 deg^2 hexagon)

Tiling simulation is updated using ...

- **configuration of fiber positioners:**
  150 science fibers + 19 fiducial fibers

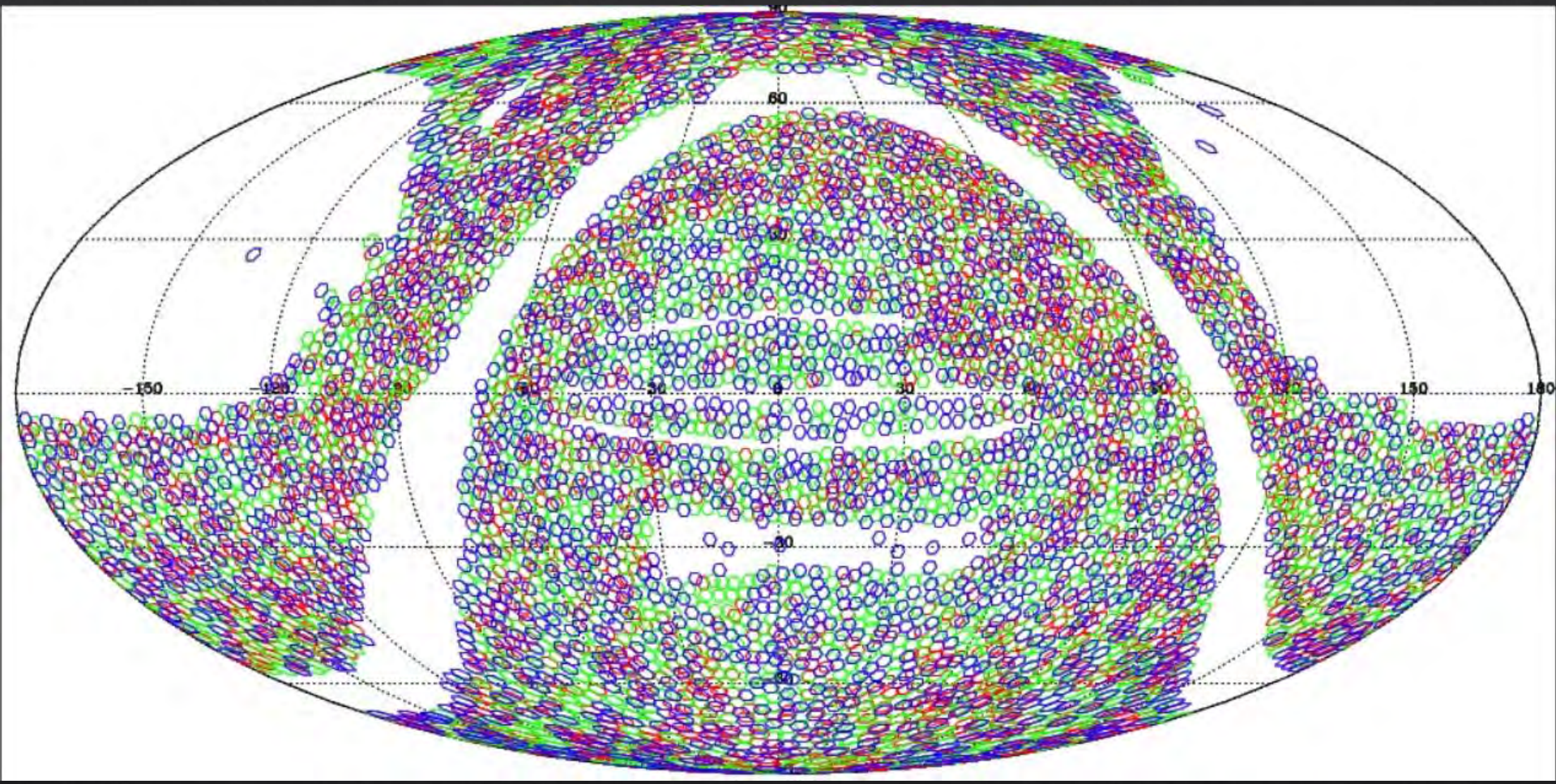


KMTNet FoV (circle): 1.44 deg radius
fiber patrol area (donut): 2.13-5.60 arcmin radius

- **simple version of fiber assignment algorithm:**

1. observe the brightest target within a fiber FoV
2. remove it from the target list
3. go to the next fiber

Tiling result II (we choose this)

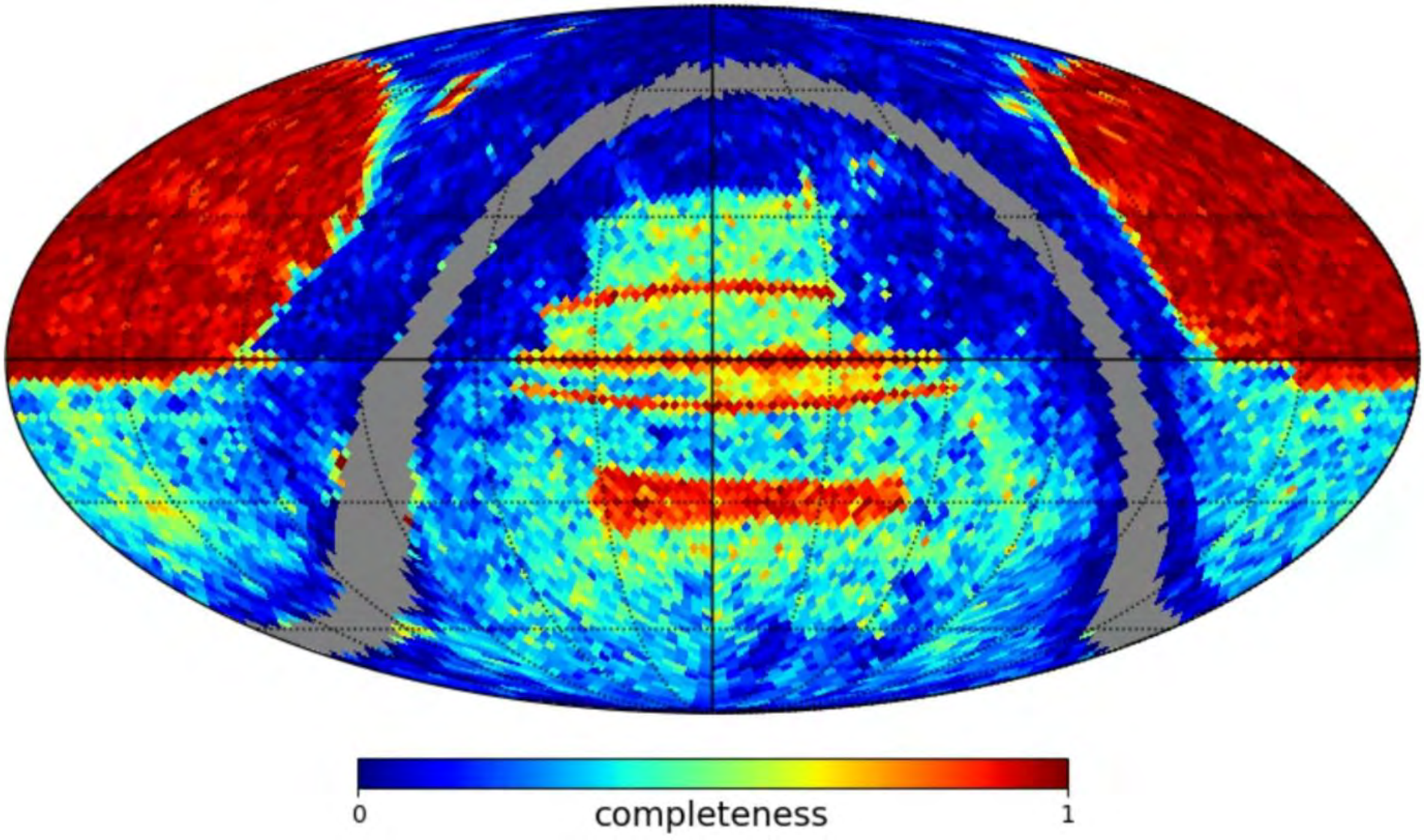


To maximize the number of targets to be observed, considering completeness weighting factors

2000 red tiles → 67.6% completeness
4000 red+green tiles → 84.4% completeness
6000 red+green+blue tiles → 93.8% completeness

Simulated completeness map with A-SPEC 6000 tiles

overall completeness = (42% →) 94%



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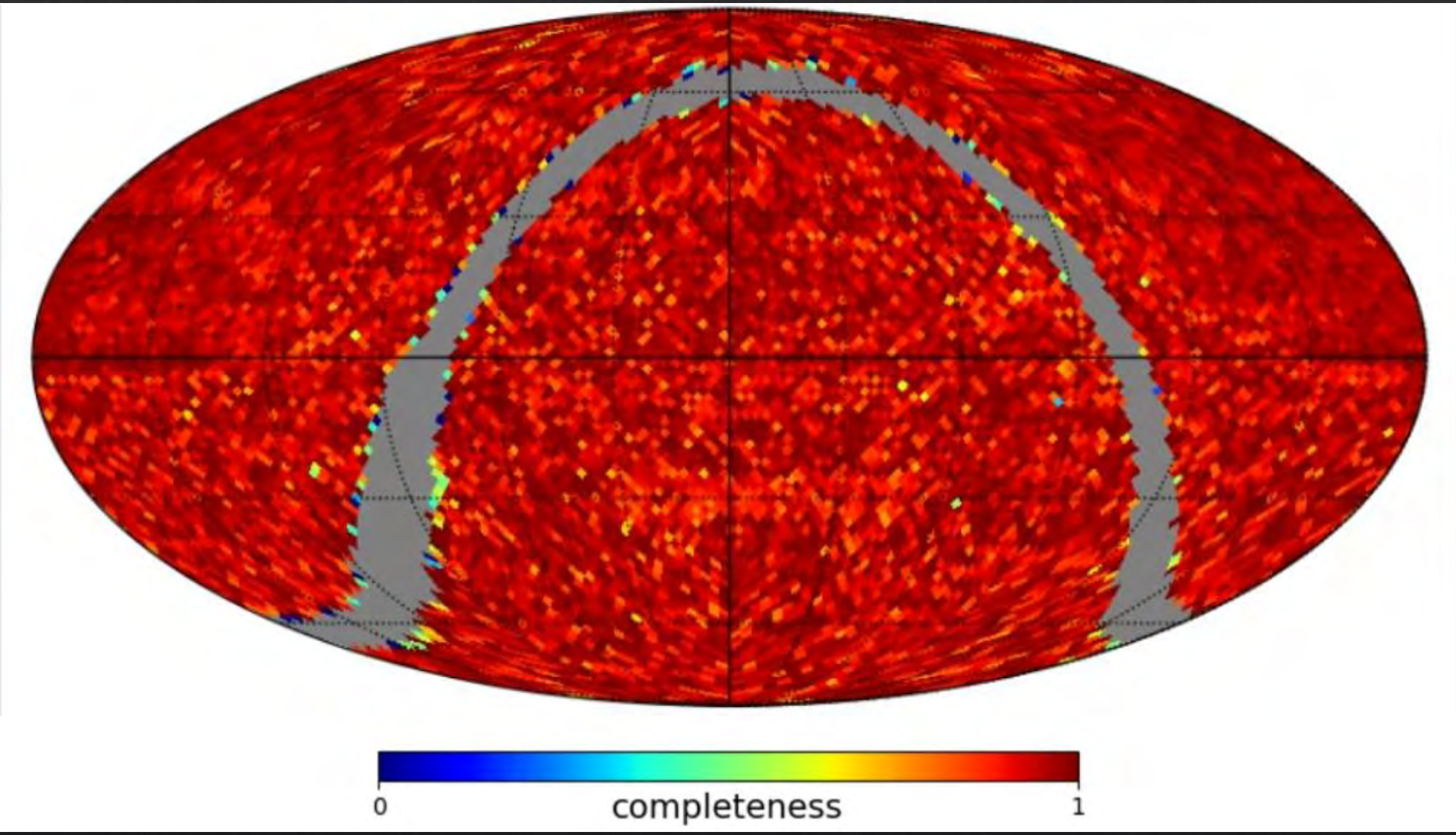
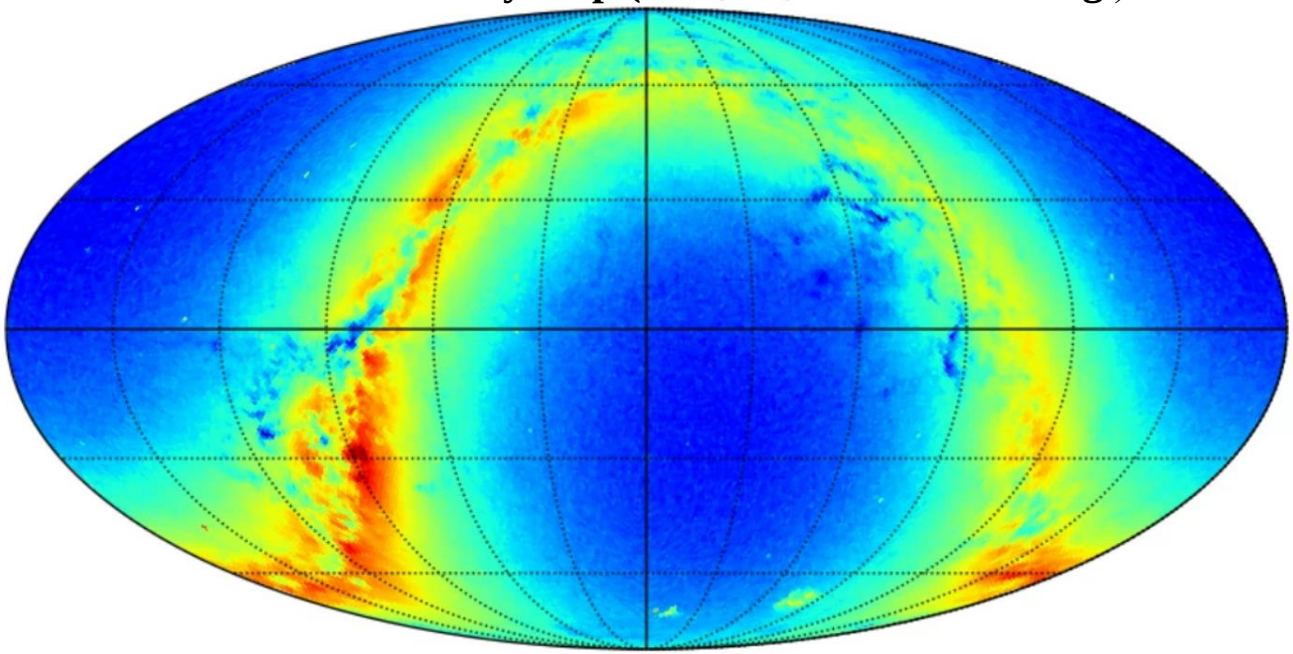


Guiding/Focusing: reference stars & tile offset

The ATLAS All-Sky Stellar Reference Catalog ("ATLAS-REFCAT2")

Tonry et al. 2018, *ApJ*, 867, 105

Stellar density map (5×10^6 stars at $r < 15$ mag.)

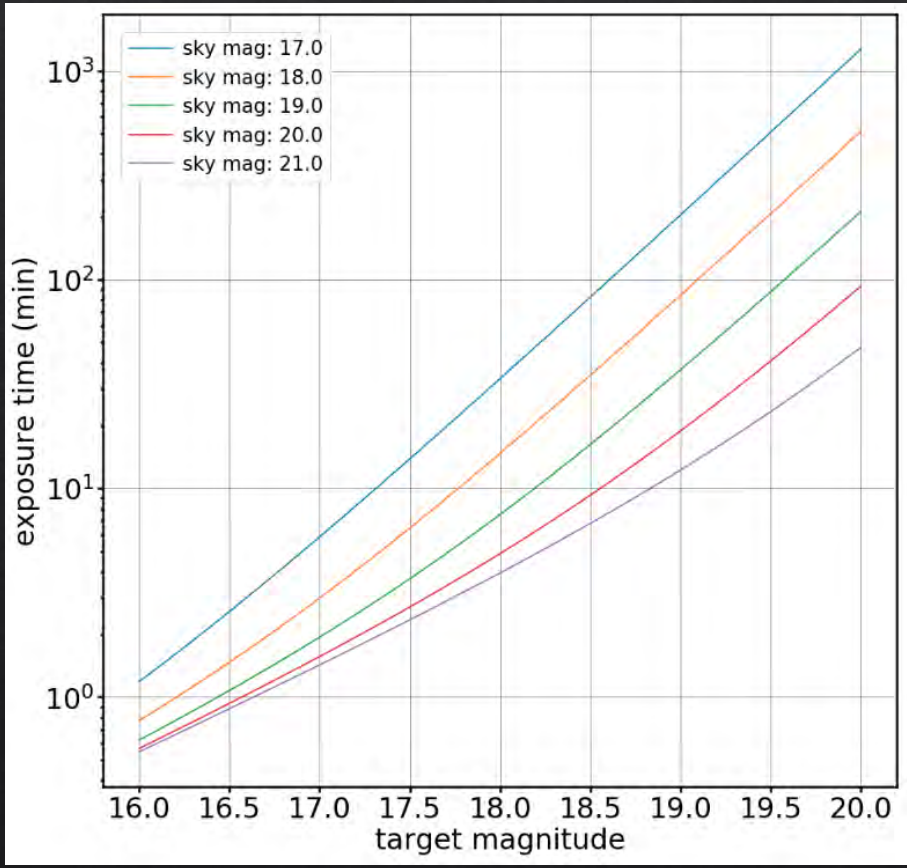


success rate	without offset	within ±2 arcmin	within ±10 arcmin
< 15 mag	99.3%	100%	100%
< 14 mag	95.7%	99.8%	100%
< 13 mag	81.4%	95.4%	100%
< 12 mag	52.9%	77.6%	99.2%
< 11 mag	20.2%	43.3%	87.9%

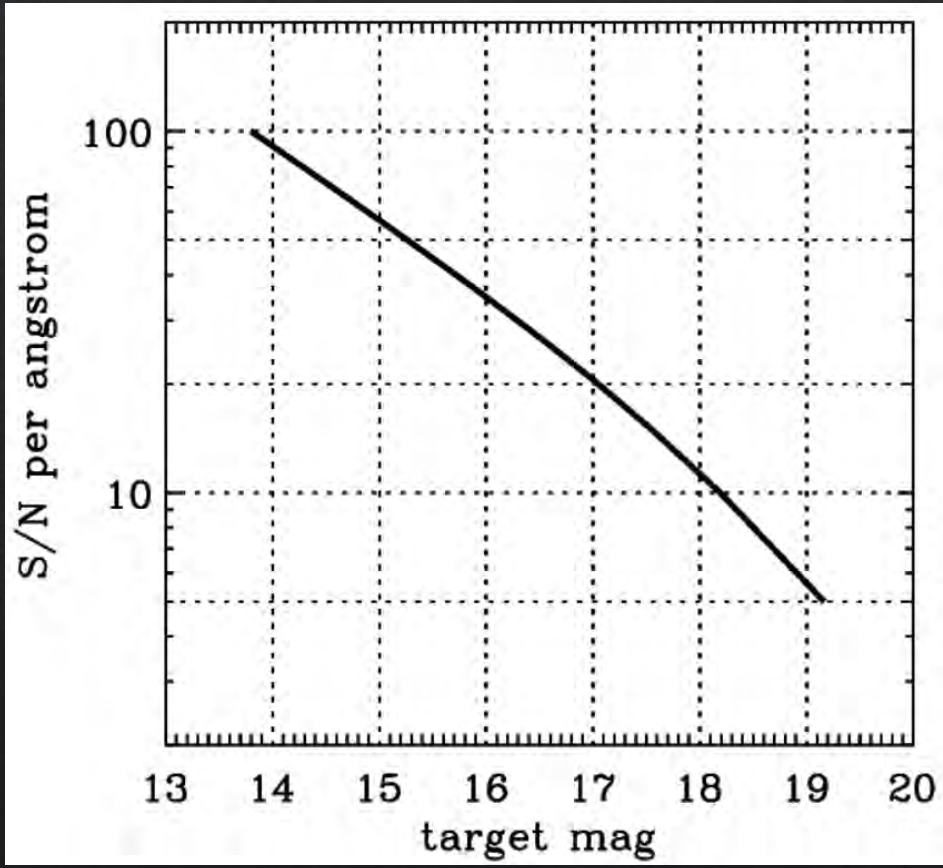
Exposure time calculator by Haeun Chung

$K_{S,0} < 13.75$
→ $r_{petro} < 17.7$ (3σ enclosure)
→ $r_{fiber} < 19.1$

20 mag/arcsec^2 isophotal mag; Vega
petrosian mag; AB (SDSS main galaxy: $r_{petro} < 17.77$)
3 arcsec diameter aperture mag; AB



dark night (sky=21.0); S/N=5; r_{fiber}=19.1
→ 13.8 min (5 min × 3)



dark night (sky=21.0); 15 min exposure
→ S/N=100, 50, 10 for r_{fiber} = 13.8, 15.3, 18.2

Moon night sky brightness model based on Krisciunas & Schaefer 91

$$X(Z) = (1 - 0.96 \sin^2 Z)^{-0.5}$$

airmass X (zenith distance Z)

$$B_0(Z) = B_{zen}\, 10^{-0.4\,k(X-1)}\, X$$

dark night sky brightness (extinction coeff. k)

$$I^* = 10^{-0.4(3.84 + 0.026\,|\alpha| + 4 \times 10^{-9}\,\alpha^4)}$$

Moon illuminance (lunar phase angle α)

$$f(\rho) = 10^{5.36}\,[1.06 + \cos^2(\rho)] + 10^{6.15-\rho/40}$$

Rayleigh & Mie scattering (moon/sky separation ρ)

$$B_{moon} = f(\rho)\, I^*\, 10^{-0.4\,kX(Z_m)}\, [1 - 10^{-0.4\,kX(Z)}]$$

sky brightness caused by the Moon

$$\Delta V = -2.5 \log [(B_{moon} + B_0(Z))/B_0(Z)]$$

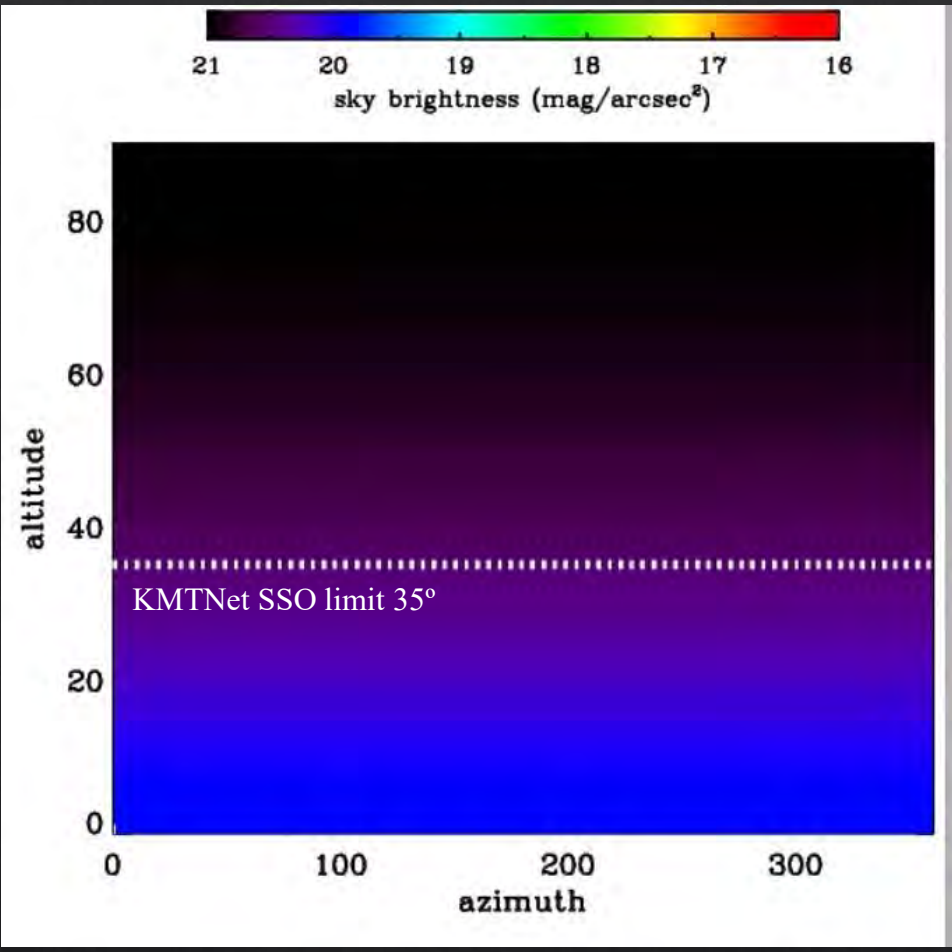
magnitude diff. bet. moon night & dark night

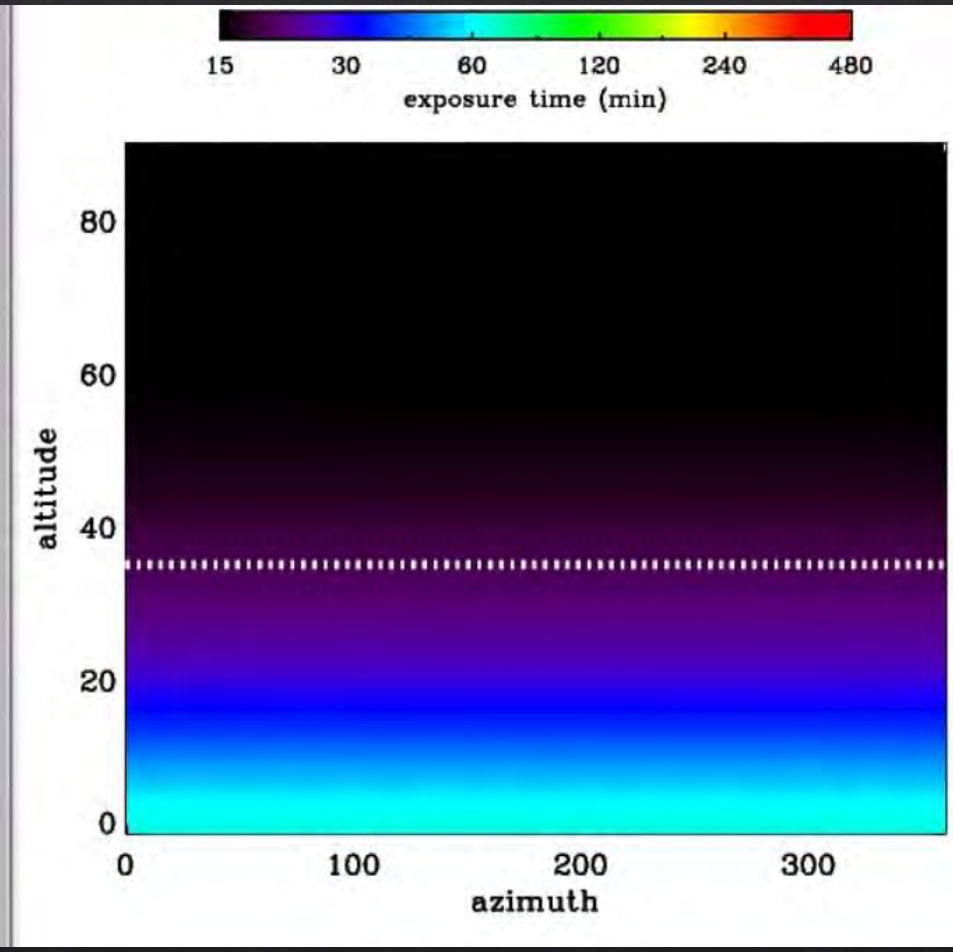
KMTNet SSO in *r*-band,

We assume dark zenith brightness = 21.0 mag/arcsec^2

extinction coefficient = 0.15

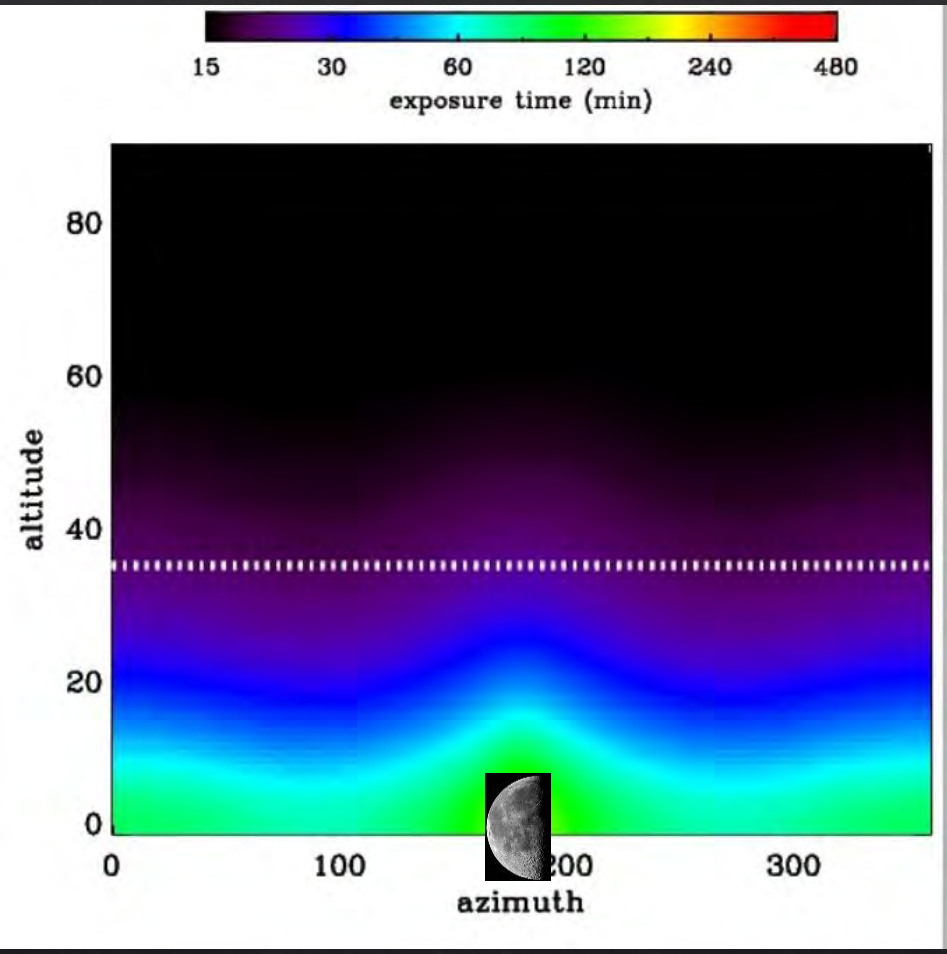
Exposure time variation: dark night

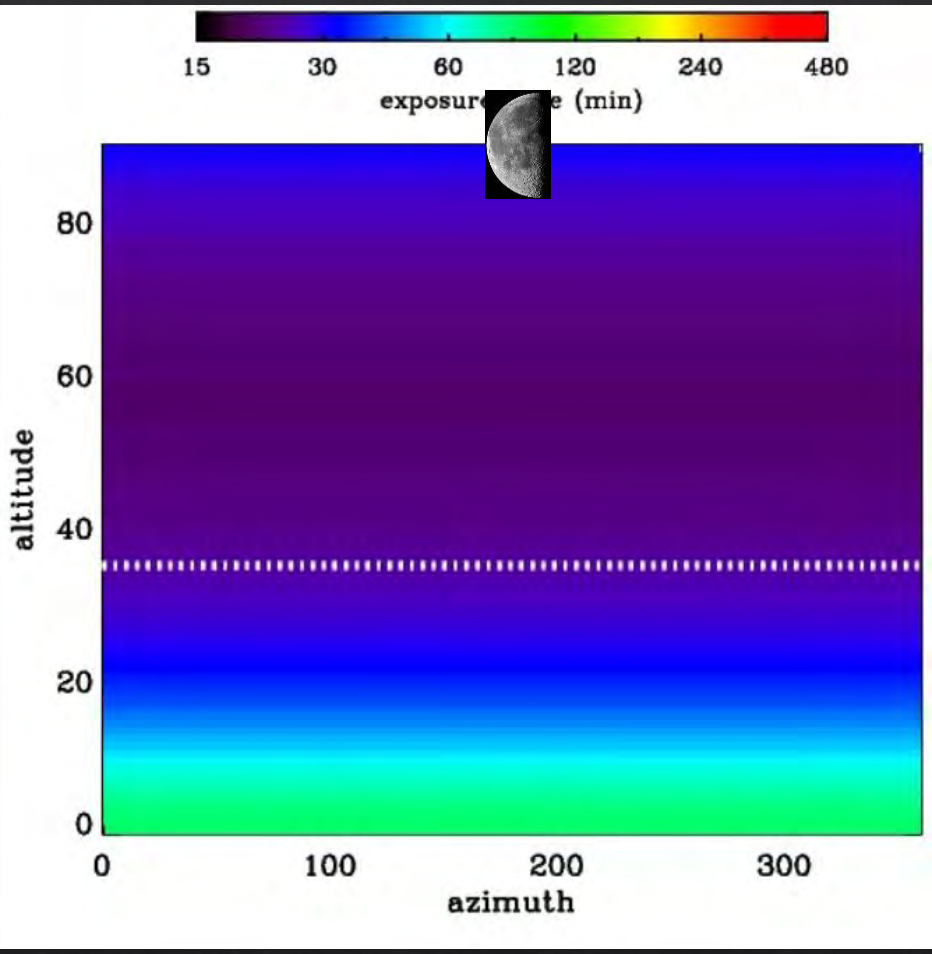




We need 19 min exposure (5 min × 4) even at altitude=35°

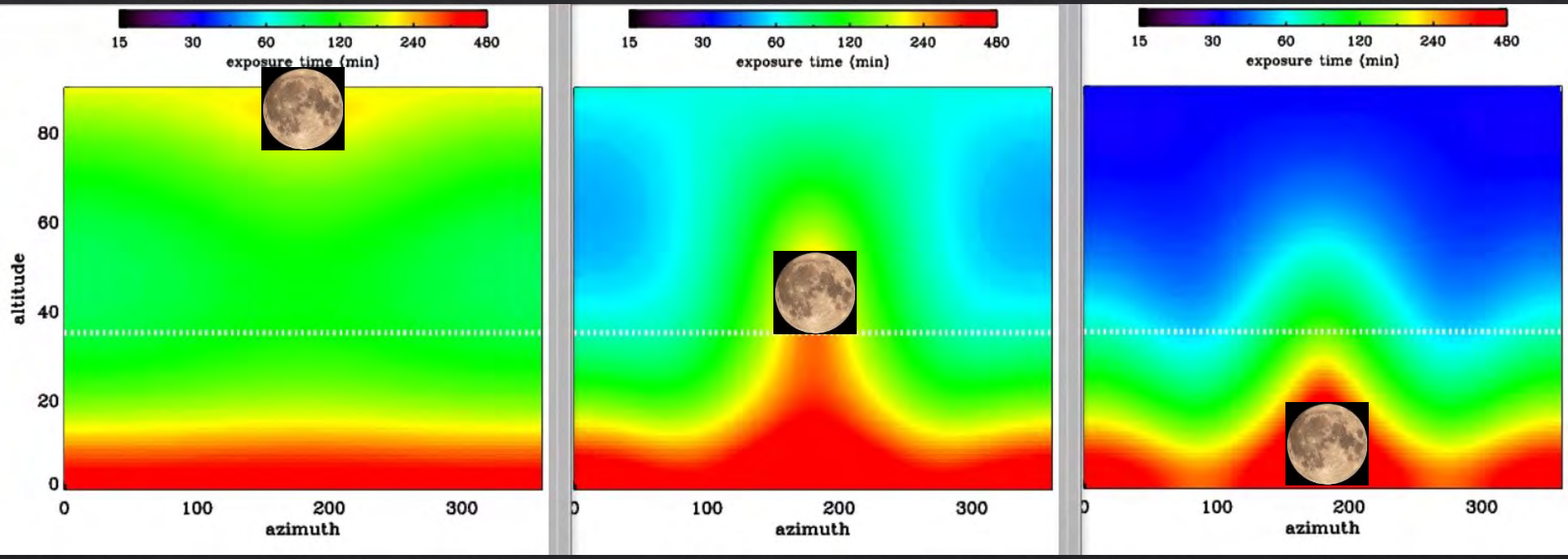
Exposure time variation: half moon





At half moon nights, we can perform observations with ~20 min exposure.

Exposure time variation: full moon



meridian altitude of full moon at KMTNet SSO:

during bulge season (02/20~10/22) = 45~85º (85º; left panel)

during A-SPEC season (e.g., 09/08~04/03) = 30~60º (45º; middle panel)

moon altitude at astronomical twilight = ~10º (right panel)

At full moon nights, the exposure time should be increased to 30~60 min.

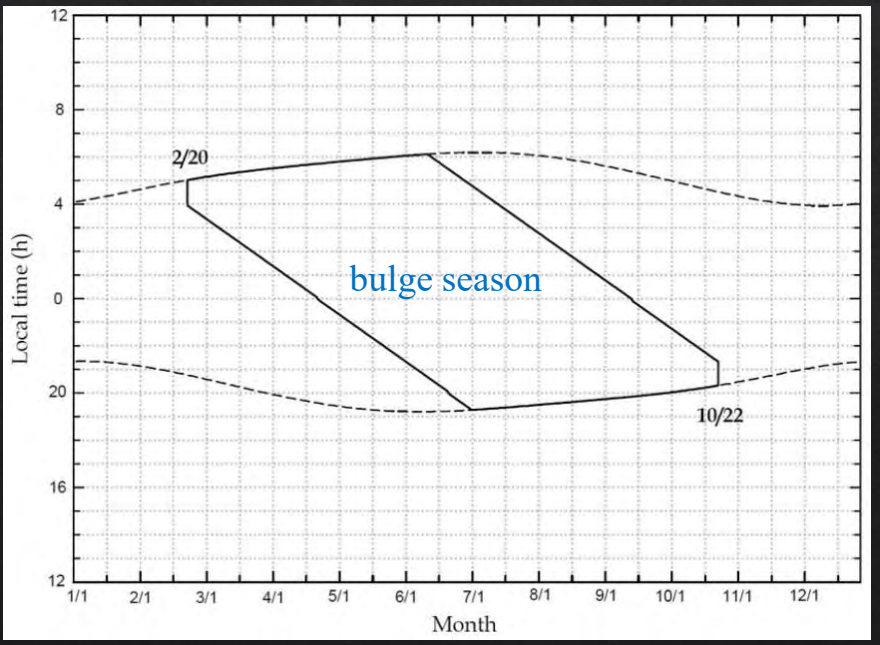
Observation time

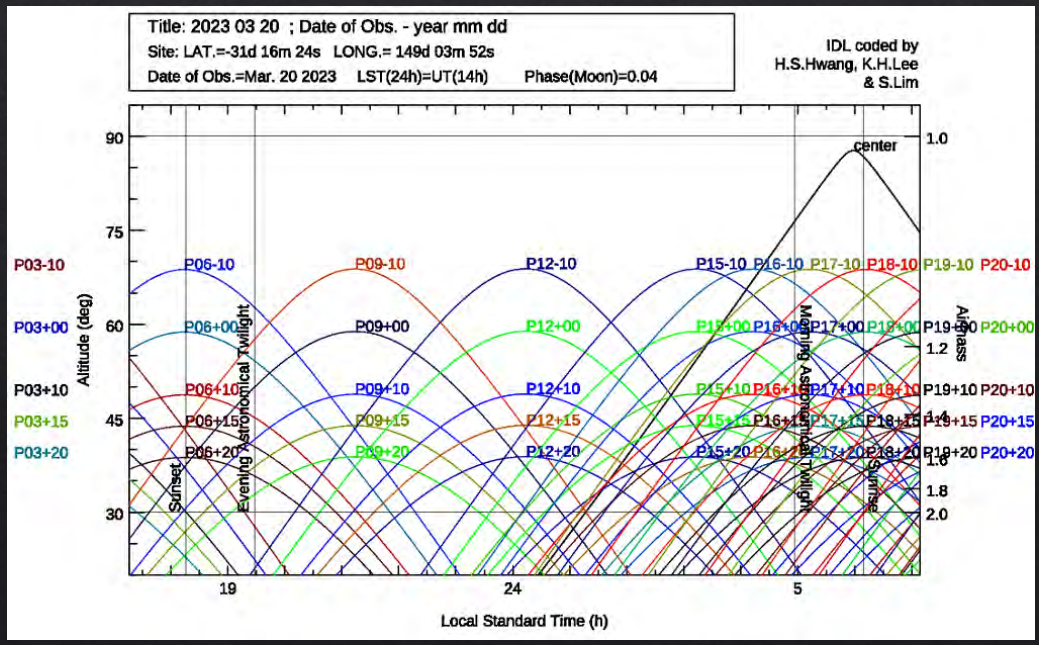
4300 KMTNet tiles (for 94% completeness) ×

[15 min exposure × 1.5 airmass & moon factor + 5 min overhead] ×

1.4 weather factor / 8 hour per night

→ **We need 345 nights (11.5 months) for the southern sky survey.**





→ **We need 7-month span (e.g., 09/08~04/03) to fully cover the KMTNet sky.**

Scheduling (to be performed)

Exposure time table (tile position & observation time)

	173.824, -52.196	186.702, -55.358	184.169, -70.990	182.813, -54.674
24/01/15/23:50	18.76			20.25
24/01/15/23:55	18.59		20.10	20.03
24/01/15/24:00	18.42		20.00	19.82
24/01/15/24:05	18.27	20.29	19.86	19.61

1. at a given time, select the tile with the shortest exposure time (considering its urgency)
2. observe the tile and remove it from the tile list (if its spectral quality is good enough)
3. repeat the steps 1 and 2

Before the observation start, determine the order of tiles for each night.
Real-time exposure updates (caused by weather condition) are required?

Future works

Back-up target list:

40~50% fibers will not be assigned to the main targets
candidates: bright quasars, faint-blue galaxies,
photometrically selected metal-poor stars…

Calibration strategy:

(flux) standard star observation
number & distribution of sky fibers
…

Science proposals (internal)

<Note> 1: main targets 2: back-up targets 3: special program

Changbom Park: 1. 가까운 우주 탐사 자료를 활용한 우주팽창역사 복원과 암흑에너지 연구

Ho Seong Hwang: 1. Accurate measurement of local density to resolve the Hubble parameter discrepancy

Donghui Jeong: 1. Cosmological study with local galaxies

Sungwook Hong: 1. Reconstruction of the local dark matter distribution

Junsup Shim: 1. All-sky survey for testing isotropy in the local Universe

Hyunmi Song: 1. Construction of a highly complete catalog of galaxy groups/clusters from an all-sky spectroscopic survey in the local universe

Jong Chul Lee: 1. Connection between brightest cluster galaxies and their host clusters
2. All-sky bright quasar survey
2. MIR-excess galaxy survey
3. Wide area spectroscopic survey for a local supercluster of galaxies

Jae-Woo Kim: 2. Revealing the bright variable sources with K-SPEC
3. Evolutionary stage of galaxy clusters based on their environment

Yongmin Yoon: 1. Investigating effects of cluster-cluster interactions on galaxy properties such as bar structure and star formation activity

Ho-Gyu Lee: 2. K-SPEC spectroscopic survey for stars: nearby stars, halo stars & SPHEREx ice sources

Sang-Hyun Chun: 2. Chemical linking of dynamical substructures and stellar stream in the Milky Way
3. Spectral survey for red supergiant stars in LMC and SMC

Galaxy science: galaxy cluster studies using main targets

- local galaxy group/cluster identification for a complete census
  led by Hyunmi Song

- connection between brightest cluster galaxies and their host clusters
  led by Jong Chul Lee

- cluster-cluster interaction effects on galaxy properties
  led by Yongmin Yoon

Galaxy science: galaxy cluster studies using special programs

- wide area (500 deg^2) survey for a local supercluster of galaxies
  led by Jong Chul Lee (collaboration with the KI-DSS team)

- deep (1~2 hr exposure per tile) survey for 30 X-ray selected clusters
  led by Jae-Woo Kim

Galaxy science: for back-up targets

- All-sky bright quasar survey:
  a substantial fraction of bright quasars is still missing
  due to the magnitude limit ($r > 17.5$) of large surveys such as SDSS and DESI.

- MIR-excess galaxy survey:
  There are a lot of *Ks*-faint but WISE 12 micron-bright galaxies (probably star-forming or AGN). We expect to observe their emission lines with A-SPEC.