

# Survey Margin and Simulations

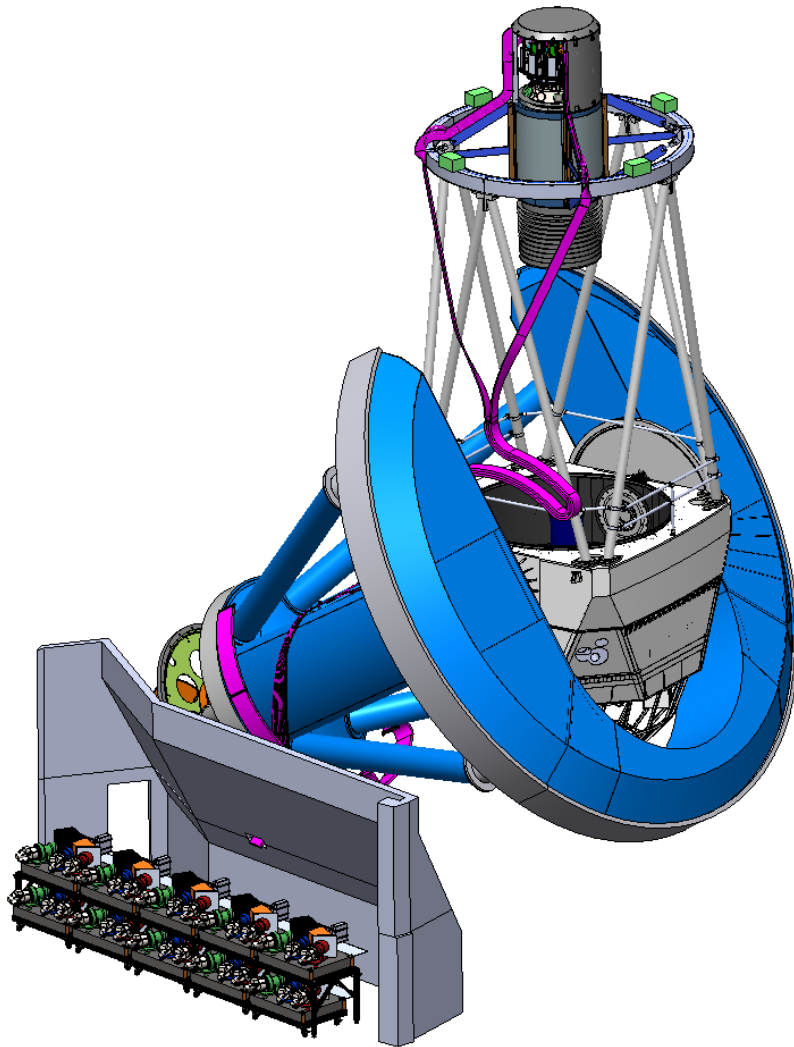
## Breakout Session B02.2

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DOE of DESI Operations

LBLN, Oct 29-31, 2018



**Dark Energy Spectroscopic Instrument**

U.S. Department of Energy Office of Science

Lawrence Berkeley National Laboratory

# Survey Completion

Operations Requirement L1.1 (from DESI-4197):

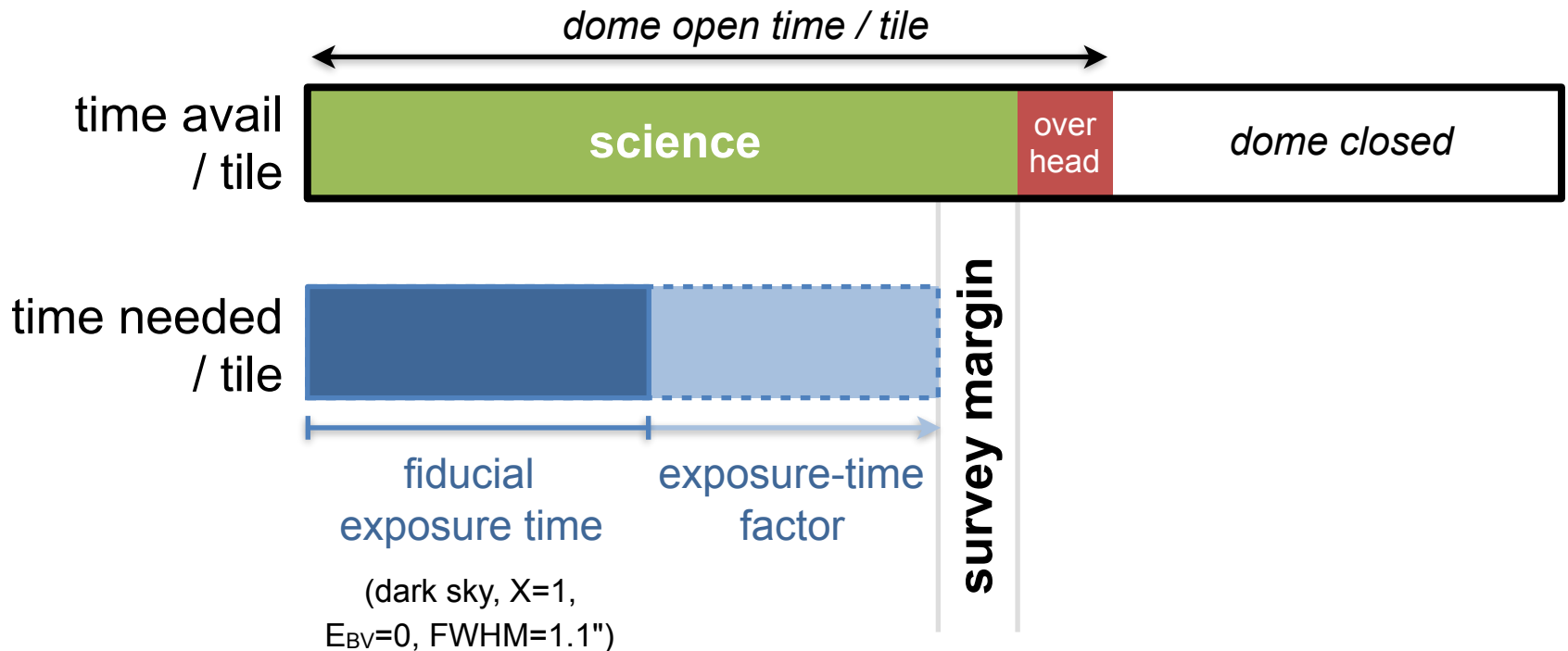
- *The 14,000 square degree survey shall complete in not more than 5 years plus time for commissioning and validation.*

Instrument downtime is estimated separately (DESI-1390).



# Survey Margin

We estimate our margin for completing on time with a ratio of exposure times:



# Dark Program Margin

FDR=Final Design Review

DESI-1611 May 2016

	FDR	Now	
Number of tiles	10043	10043	
Survey Duration	5	5 yr	
Scheduled Time	1940	2088 hr/yr	
Dome Open	0.570	0.723	
Tile Change	120	200 s	overhead
Cosmic Split	60	100 s	
Deadtime	0	30 s	
<b>Time Avail / tile</b>	<b>1801.9</b>	<b>2375.7 s</b>	

	FDR	Now	
Fiducial Exposure Time	1000	1000 s	
Exposure-time Factor	1.546	1.900	
<b>Time Required / tile</b>	<b>1546.0</b>	<b>1900.0 s</b>	

	FDR	Now	
<b>Time Avail / tile</b>	<b>1801.9</b>	<b>2375.7 s</b>	
<b>Time Required / tile</b>	<b>1546.0</b>	<b>1900.0 s</b>	
<b>Survey Margin</b>	<b>16.6%</b>	<b>25.0%</b>	



# Changes since the FDR

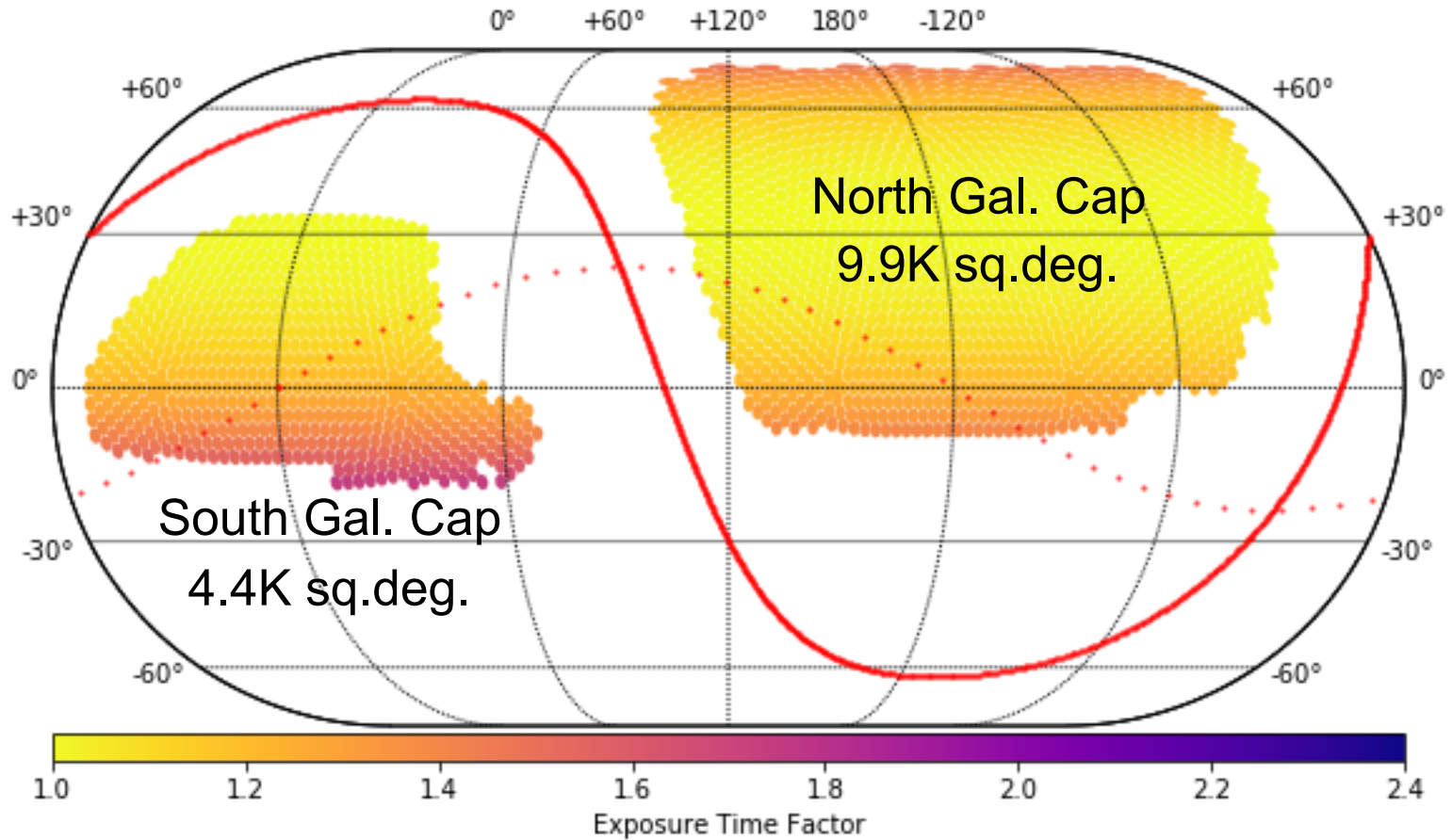
In decreasing order of importance:

- Monsoon summer shutdown reduced from 45 to 18 nights.
- More realistic weather model.
- Model exposure times with realistic seeing, transparency.
- Add operations overheads derived from survey simulations.



# Survey Footprint

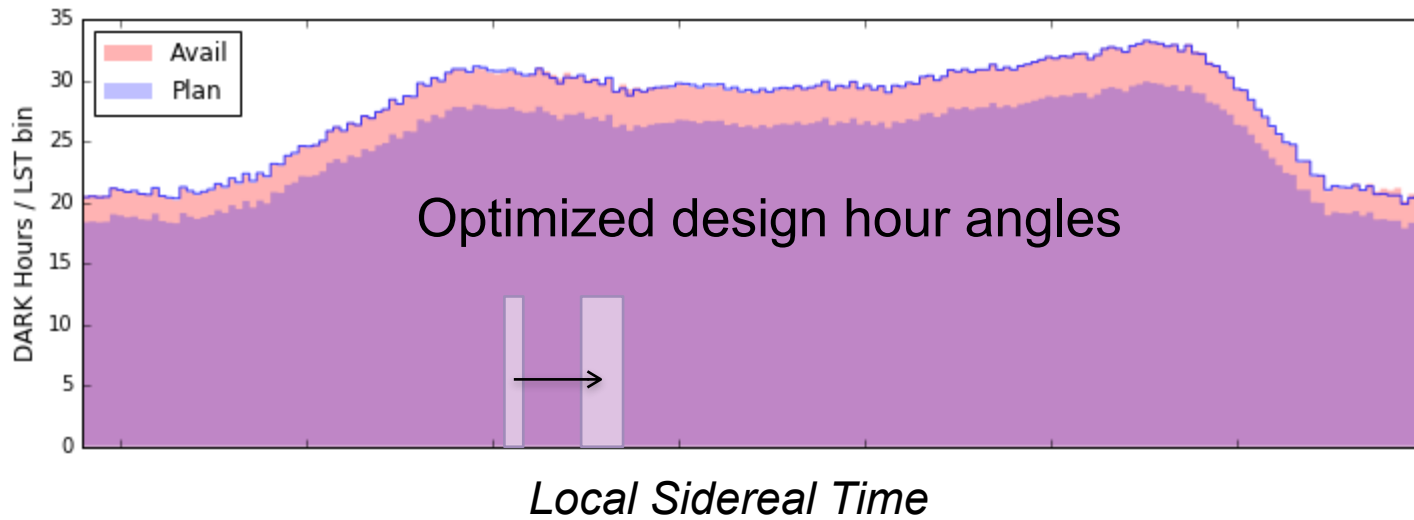
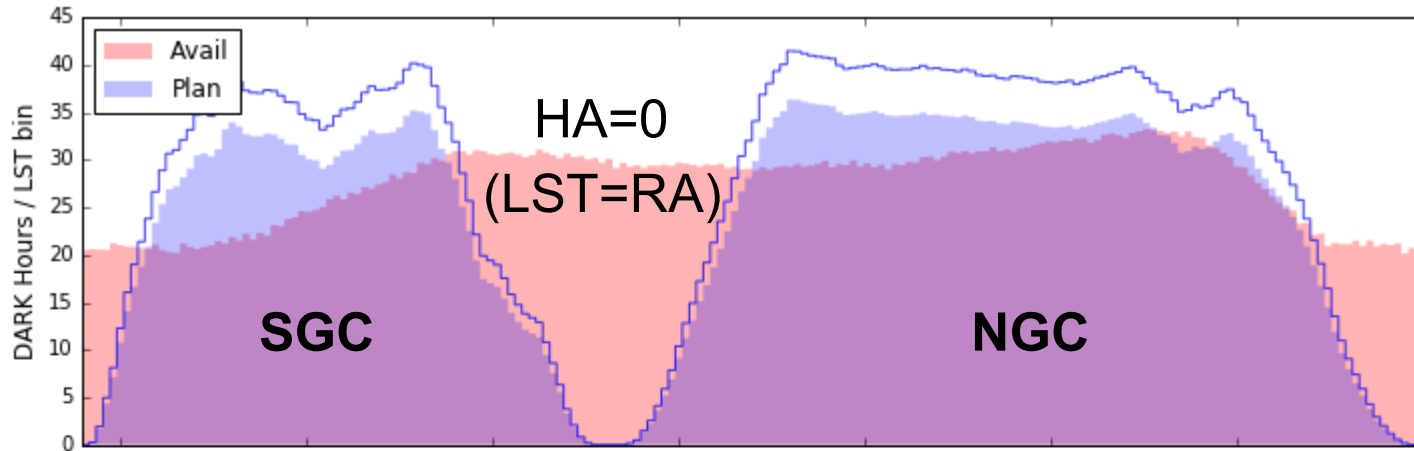
DESI-717



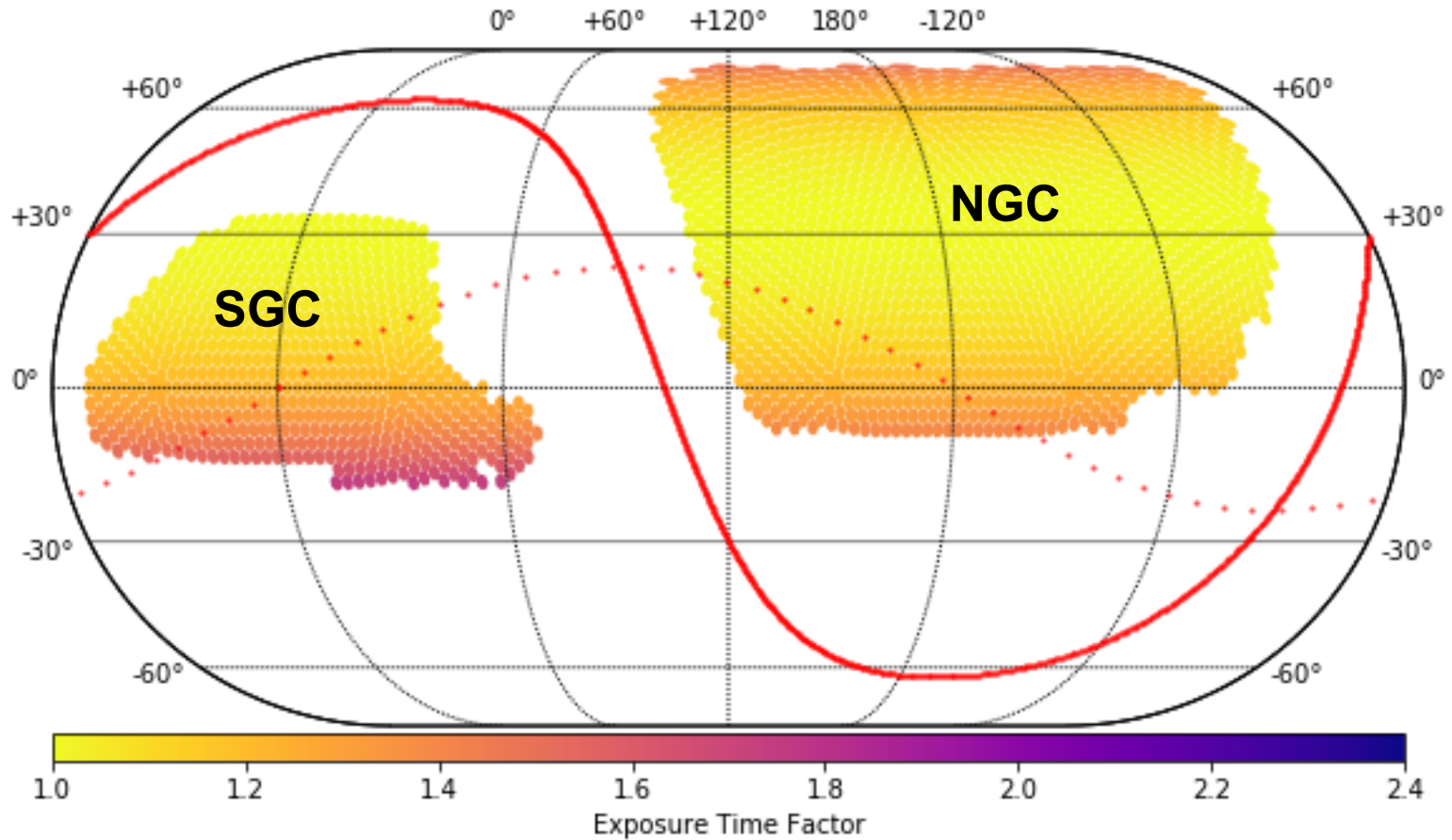
(4 + 1 + 3) passes of ~2K tiles each



# Survey Design: Global Optimization



# Survey Design: Airmass

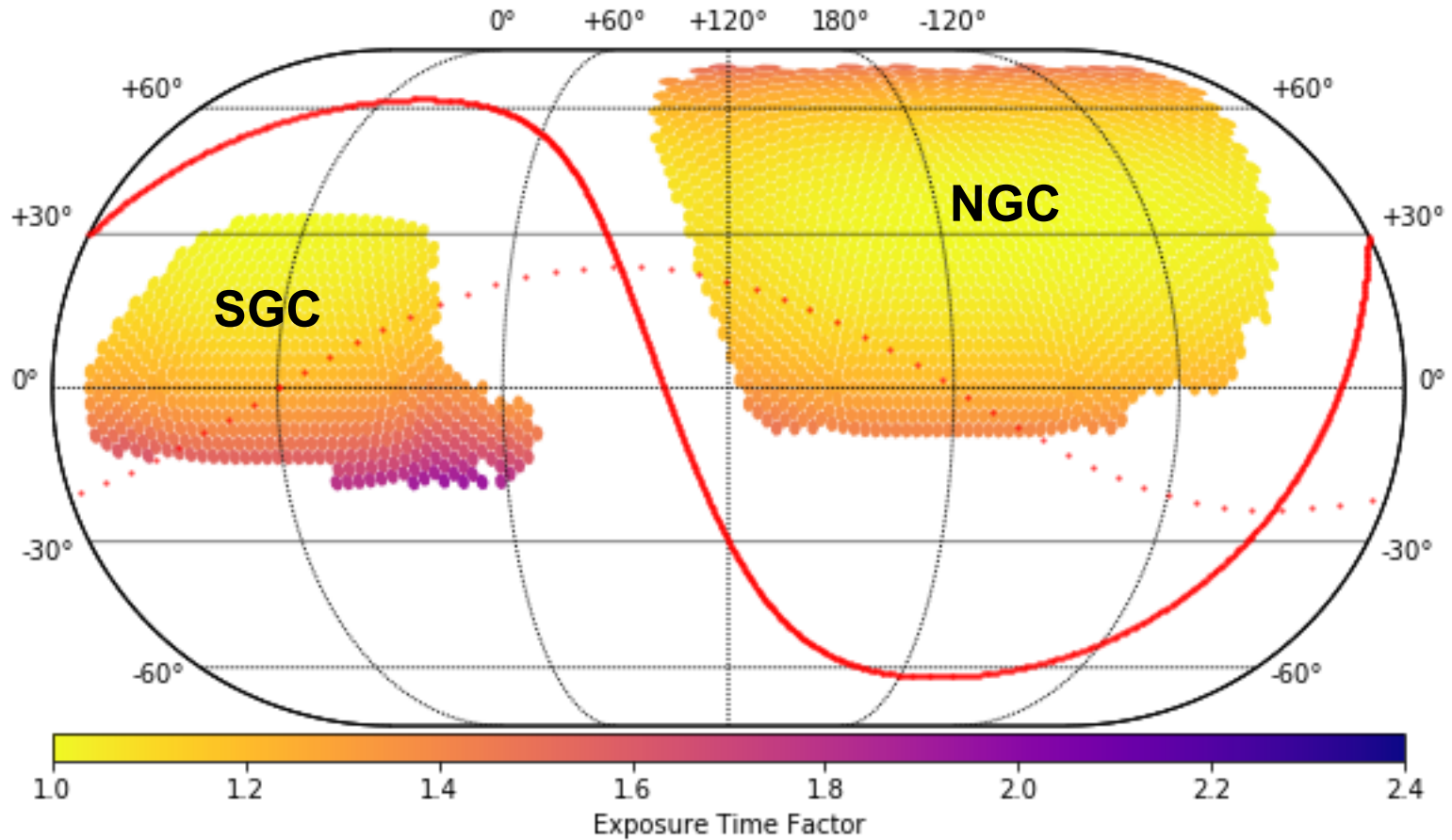


HA=0: mean exposure-time factor = 1.14





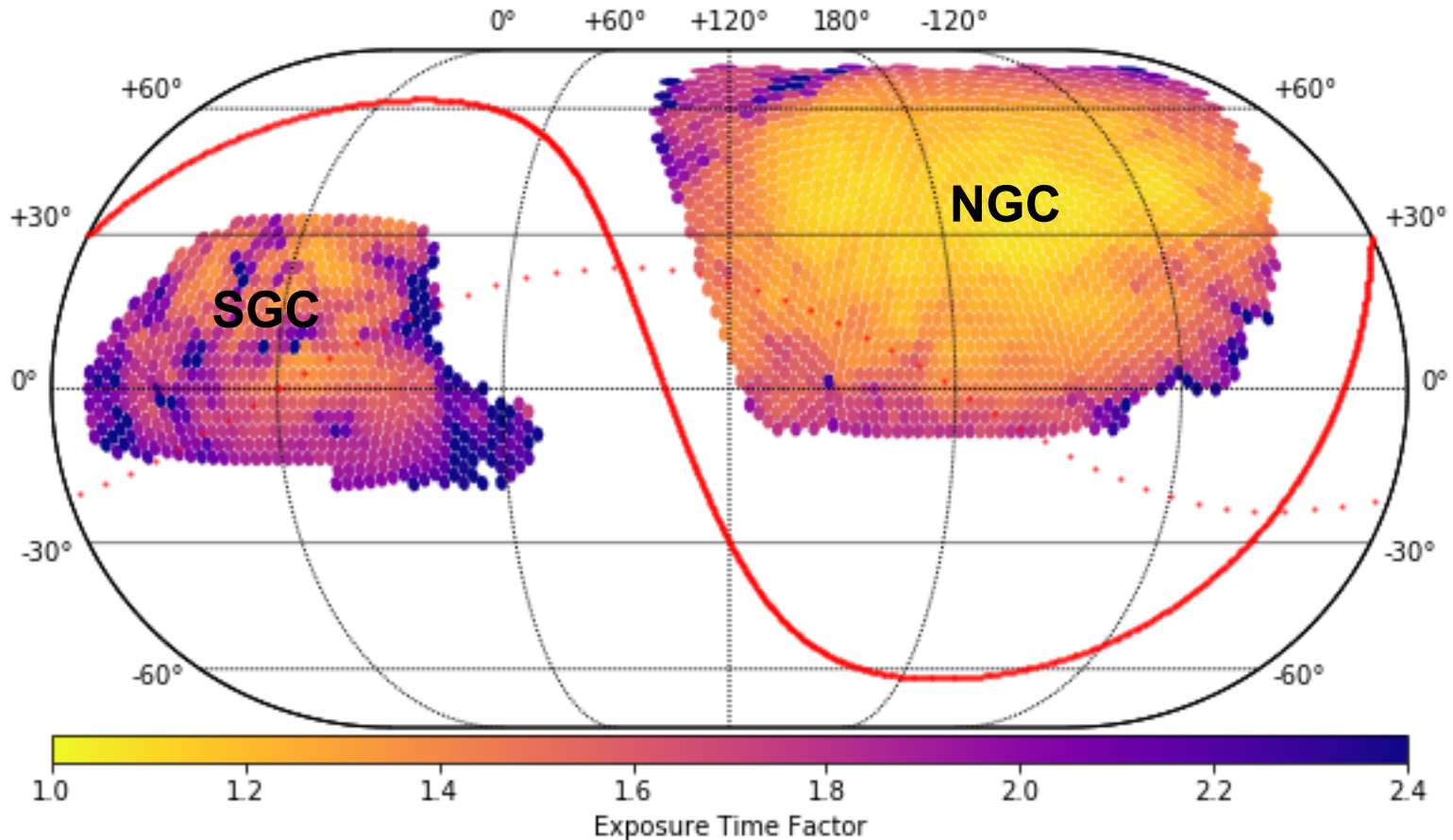
# Survey Design: Airmass



Design HA: mean exposure-time factor = 1.17



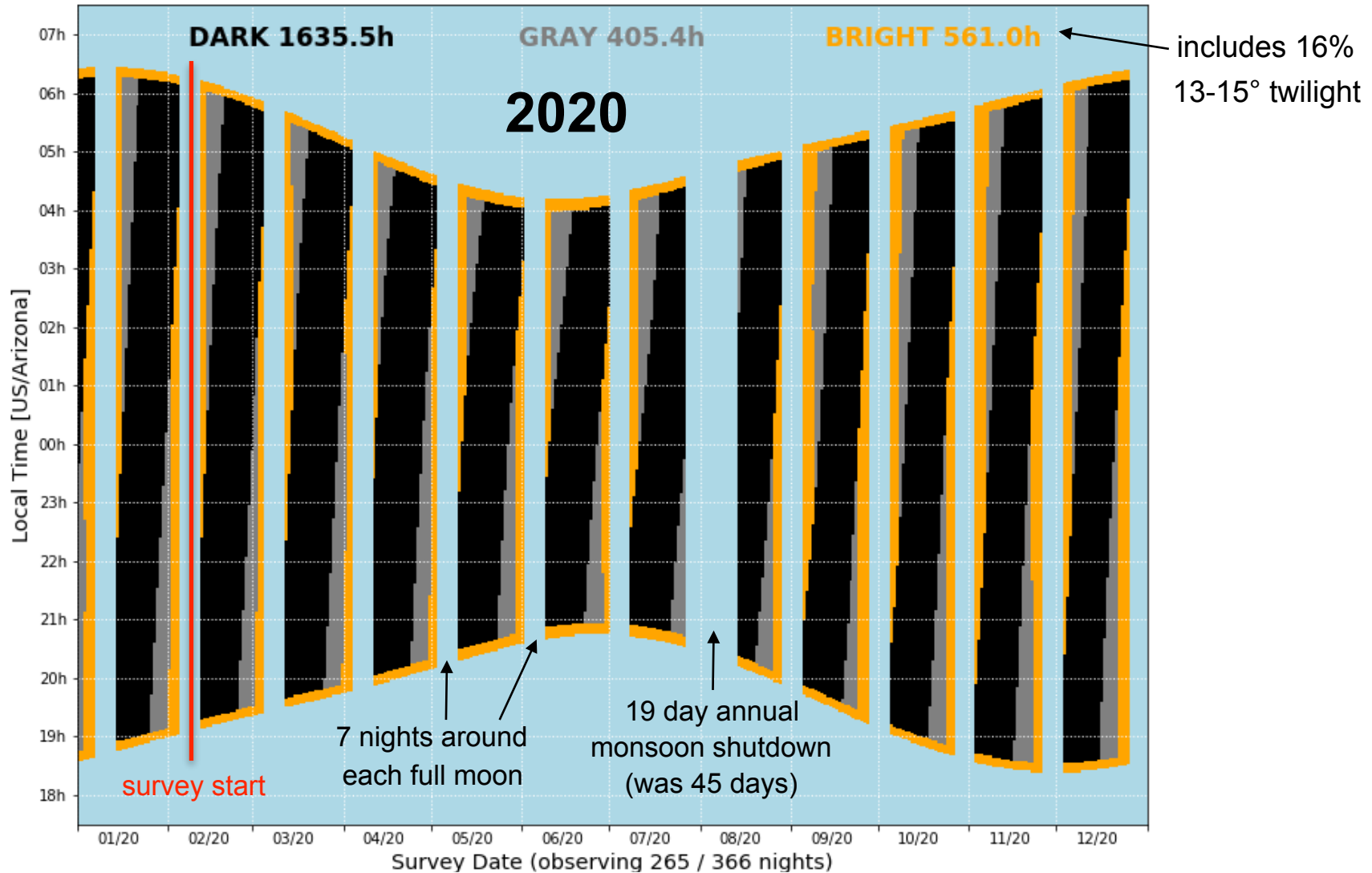
# Survey Design: Airmass & Dust



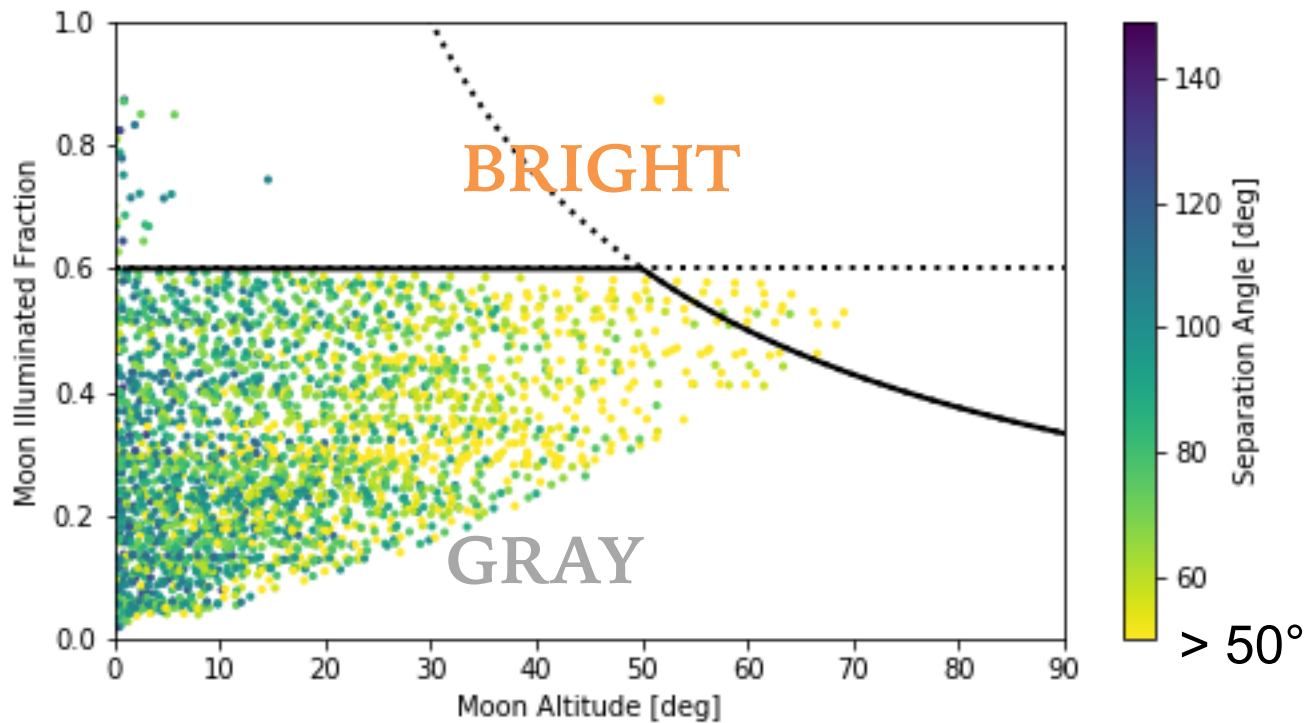
Dust + Airmass: mean exposure-time factor = 1.53



# Survey Schedule



# Survey Schedule: GRAY vs BRIGHT



BOSS DR14 includes 2371 GRAY + 54 BRIGHT exposures



# Monsoon Shutdown

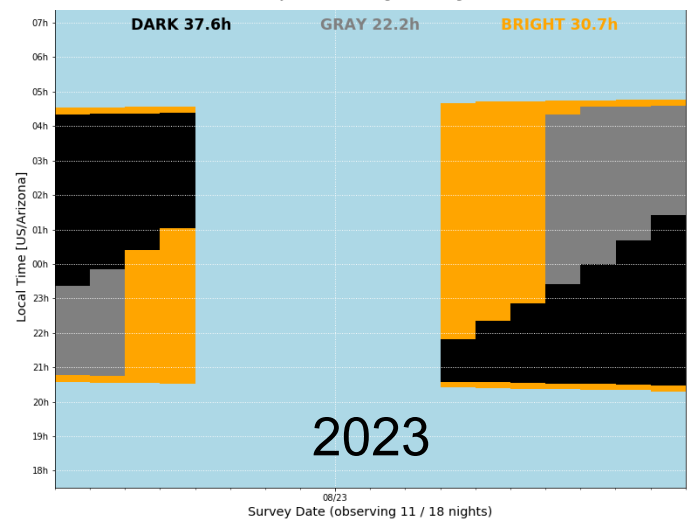
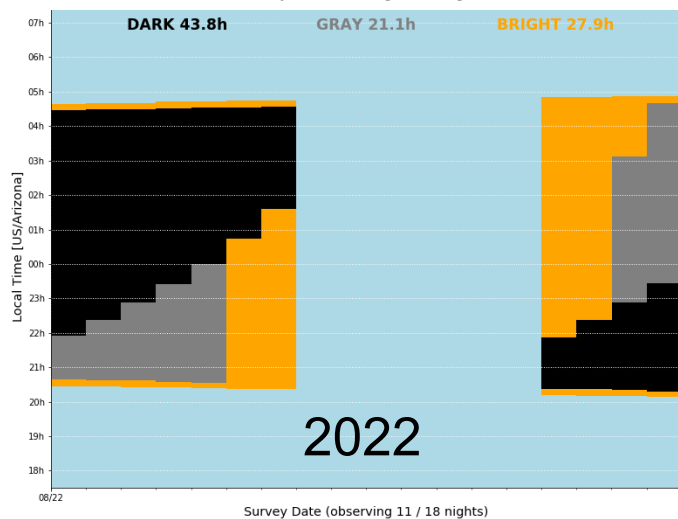
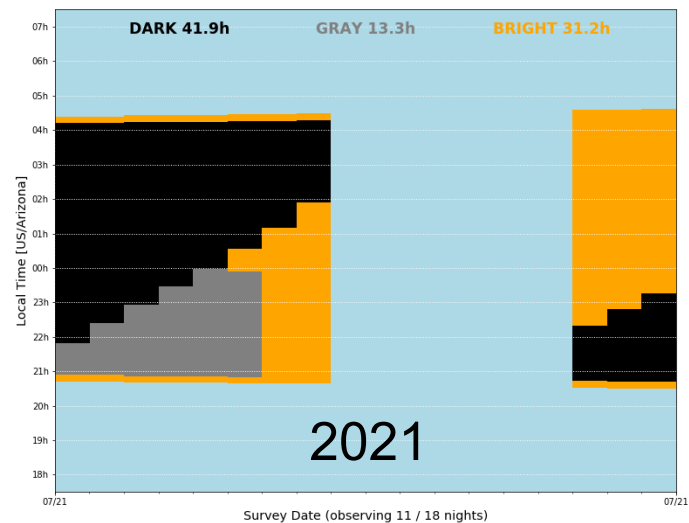
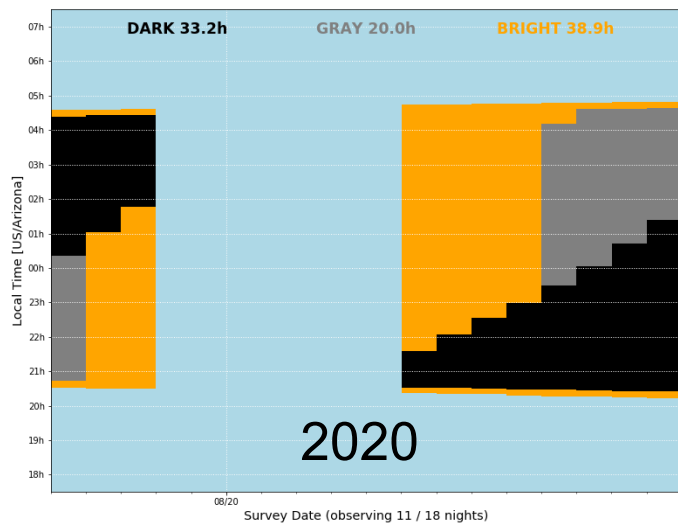
- FDR assumed a 45-night shutdown July 13 - August 27.
- Schedule instead an 18-night Mon-Fri shutdown centered on a full moon in July / August:

YEAR	Start (Mon)	Full Moon	Stop (Fri)
2020	27 July	03 August	14 August
2021	12 July	23 July	30 July
2022	01 August	11 August	19 August
2023	24 July	01 August	11 August

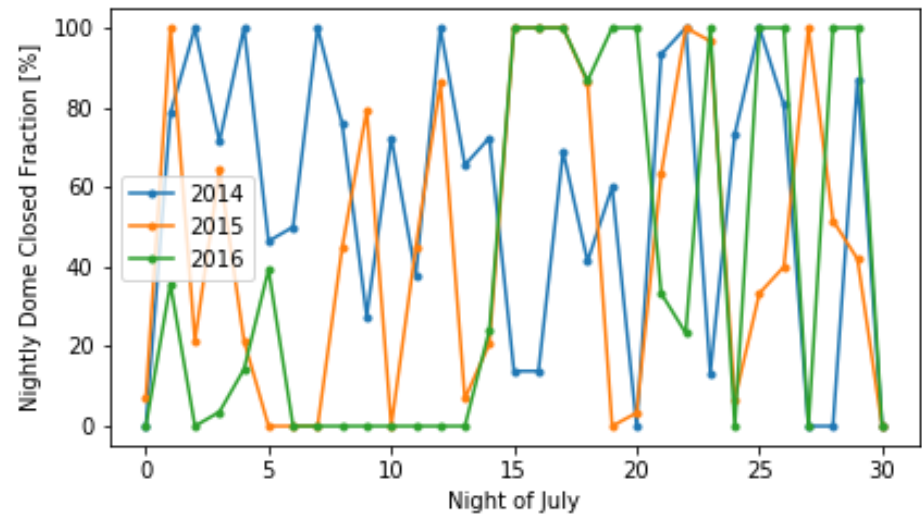
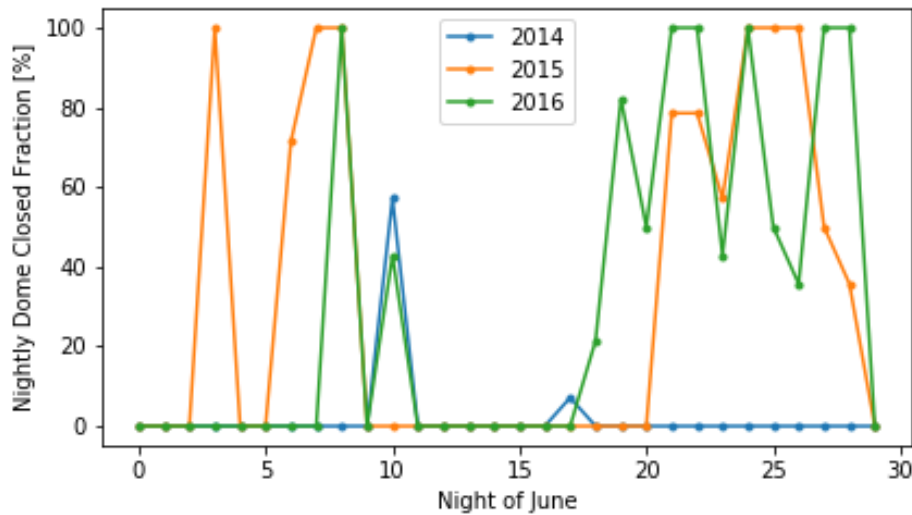
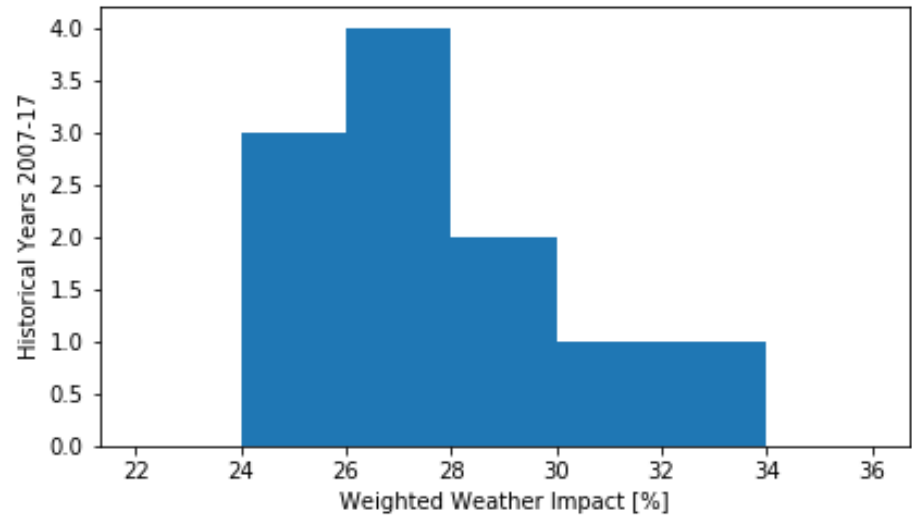
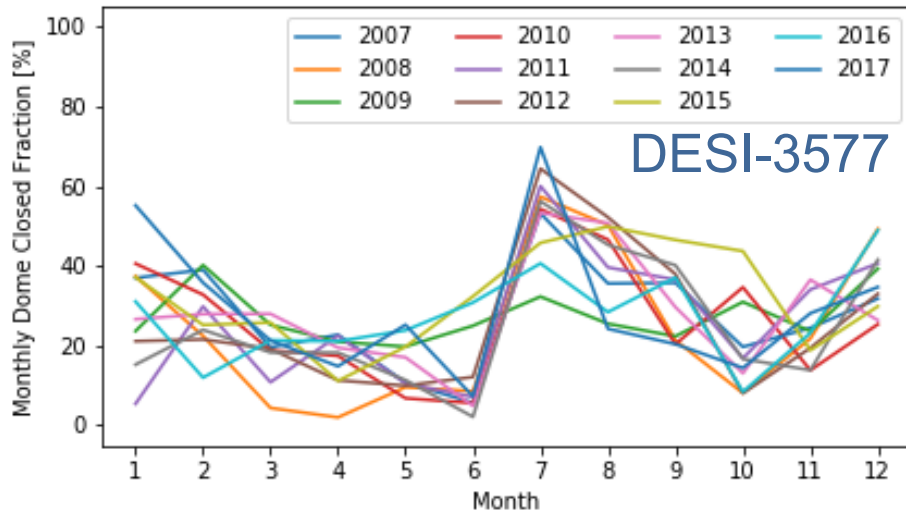
- Increases scheduled time during July & August (with short nights & bad weather).



# Monsoon Shutdown

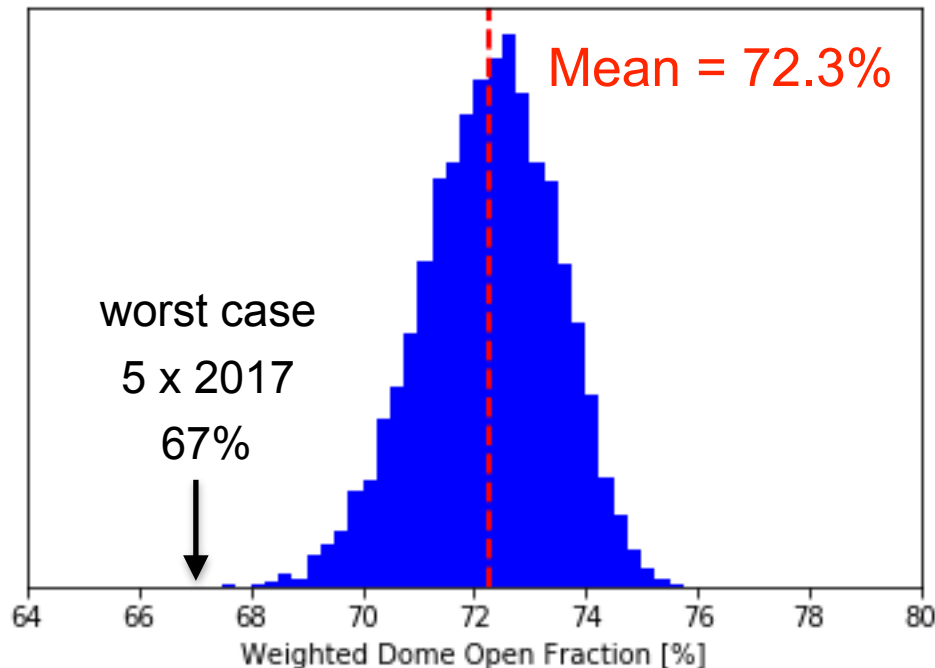


# Survey Weather



# Effects of Weather Assumptions

Use bootstrap samples of 5 years drawn from 2007-2017 to estimate distribution of expected dome open fractions:



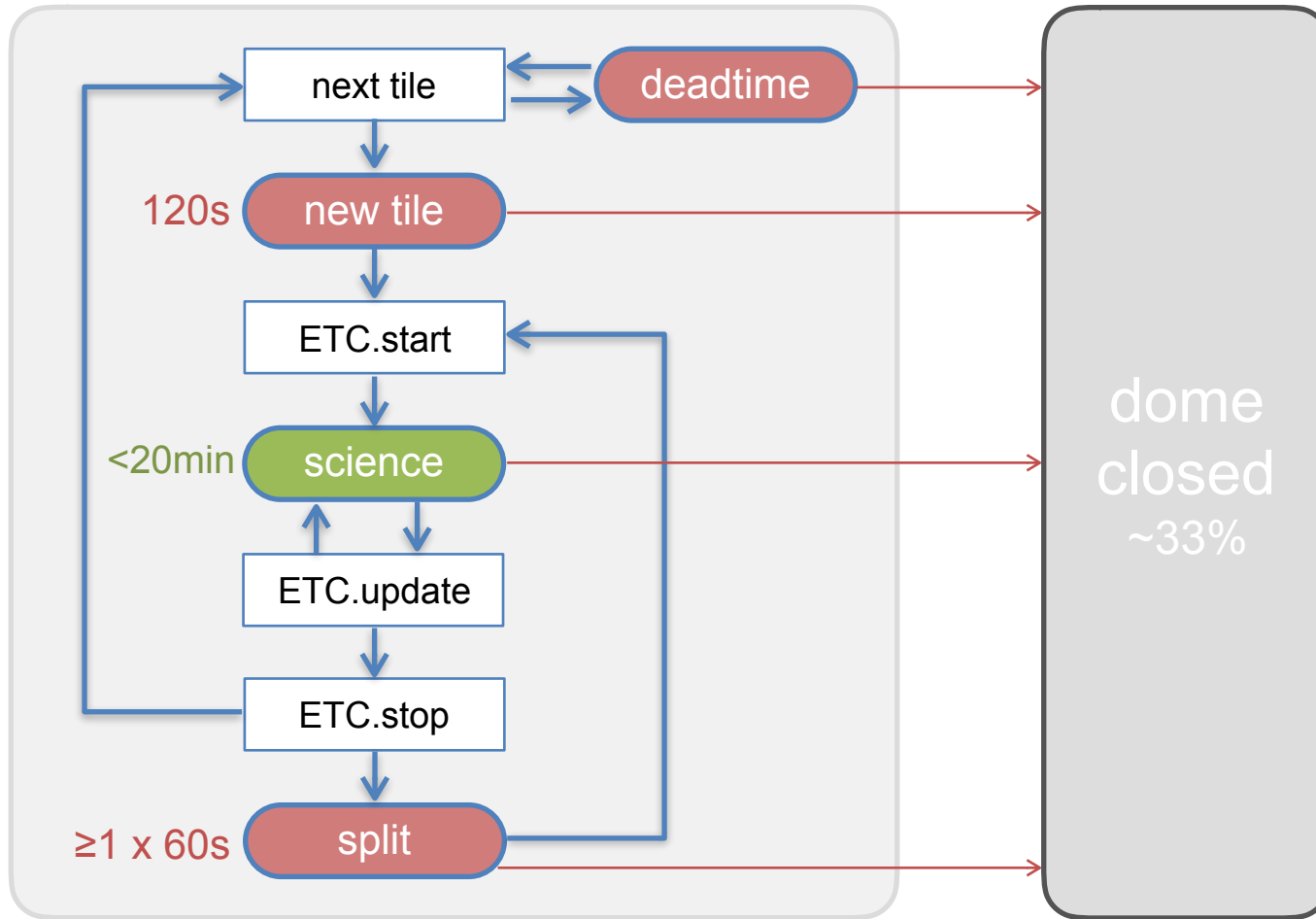
Mean margin = 25.0%

Worst case margin = 14.6%





# Survey Operations



# Overheads



	FDR	Now	
Number of tiles	10043	10043	
Survey Duration	5	5 yr	
Scheduled Time	1940	2088	hr/yr
Dome Open	0.57	0.67	
Tile Change	120	200 s	
Cosmic Split	60	100 s	
Deadtime	0	30 s	
<b>Time Avail / tile</b>	<b>1801.9</b>	<b>2177.3</b>	<b>s</b>

Overheads obtained from 5-year simulations:

- realistic observing conditions
- real scheduler and ETC
- minimal optimization (so far)

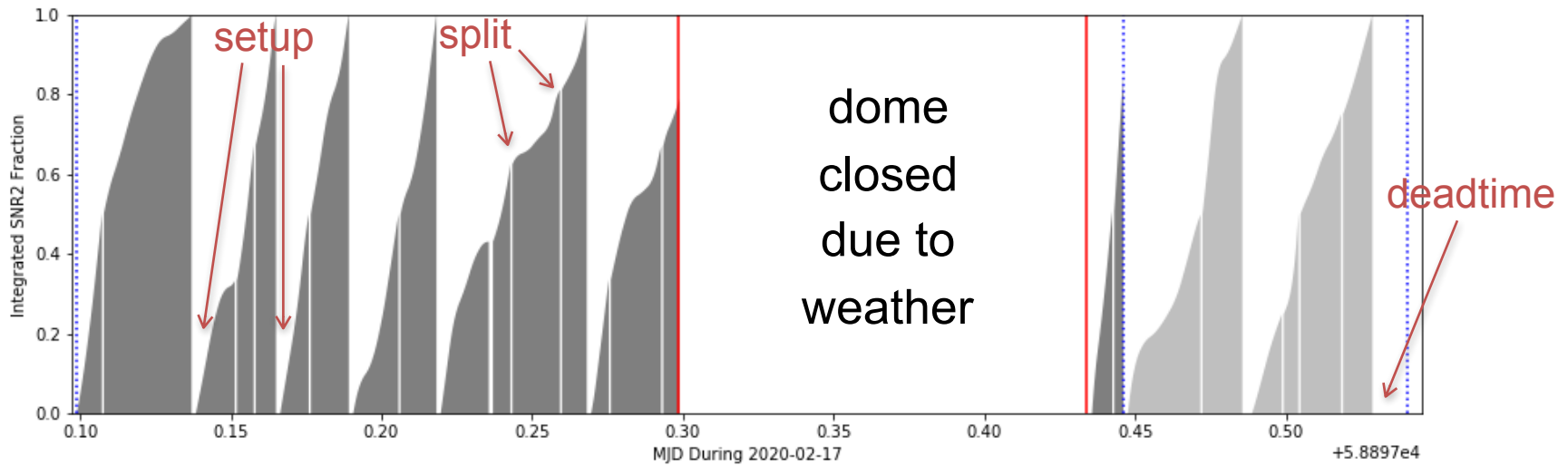
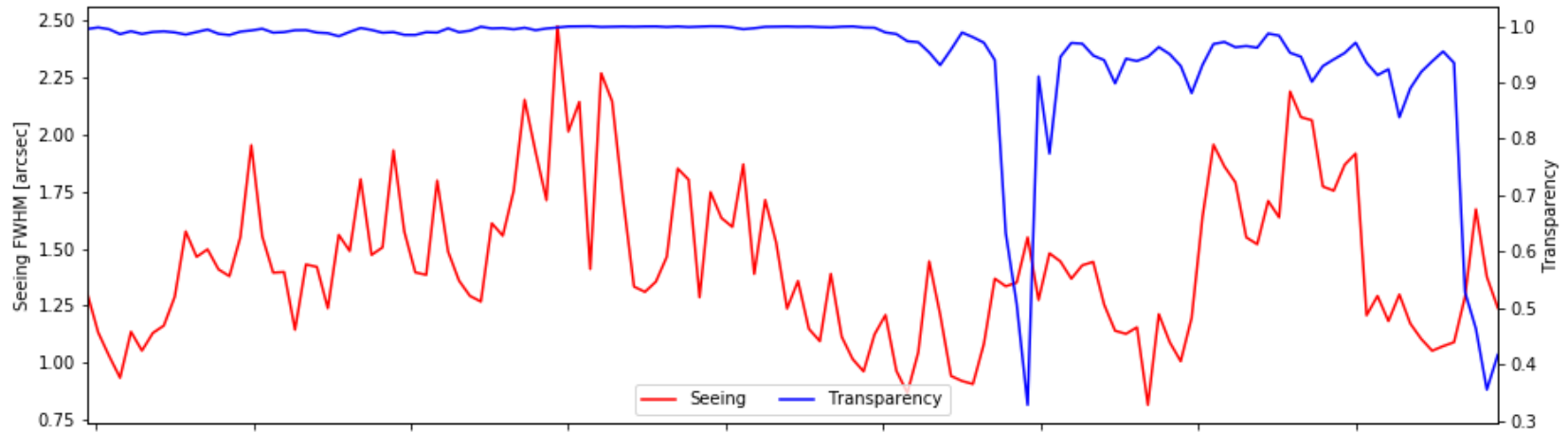
← (120 s / setup) x (1.37 setup / tile)

← (60 s / split) x (2.09 split / setup)

← dominated by program changes

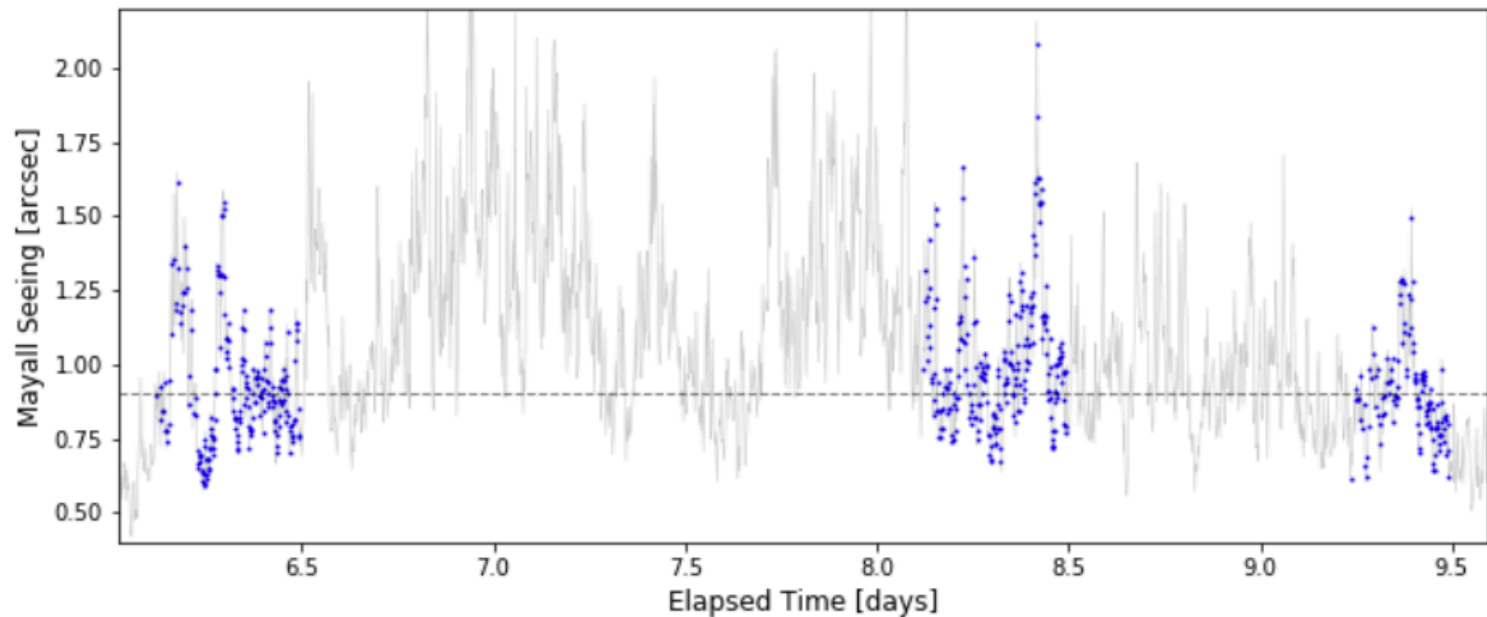


# Survey Operations: Simulated Night



# Simulated Observing Conditions

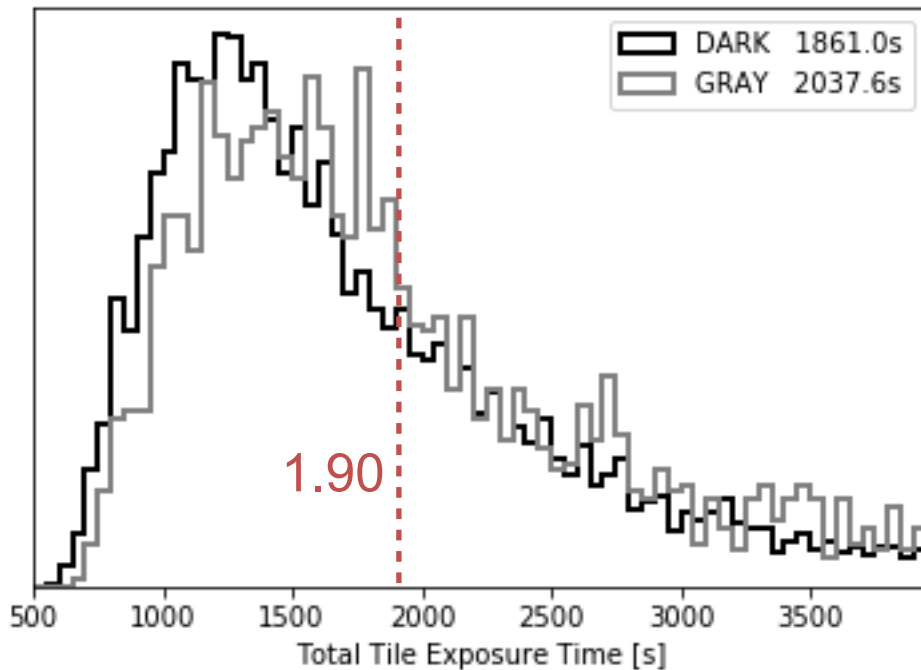
Use MzLS observing history to model distribution and auto-correlation of seeing and transparency (DESI-3087):



# Exposure Time Factor

Mean exposure-time factors:

- dust & airmass = 1.53
- seeing & transparency = 1.24



	FDR	Now	
Fiducial Exposure Time	1000	1000 s	
Exposure-time Factor	1.546	1.900	
Time Required / tile	1546.0	1900.0 s	



# Exposure Time Increase due to Moon

FDR estimate did not account for moon.

Only affects  $\text{GRAY} / (\text{DARK} + \text{GRAY}) = 20\%$  of exposure time.

Survey simulations predict mean  $\text{GRAY} / \text{DARK}$  exposure time = 1.055.

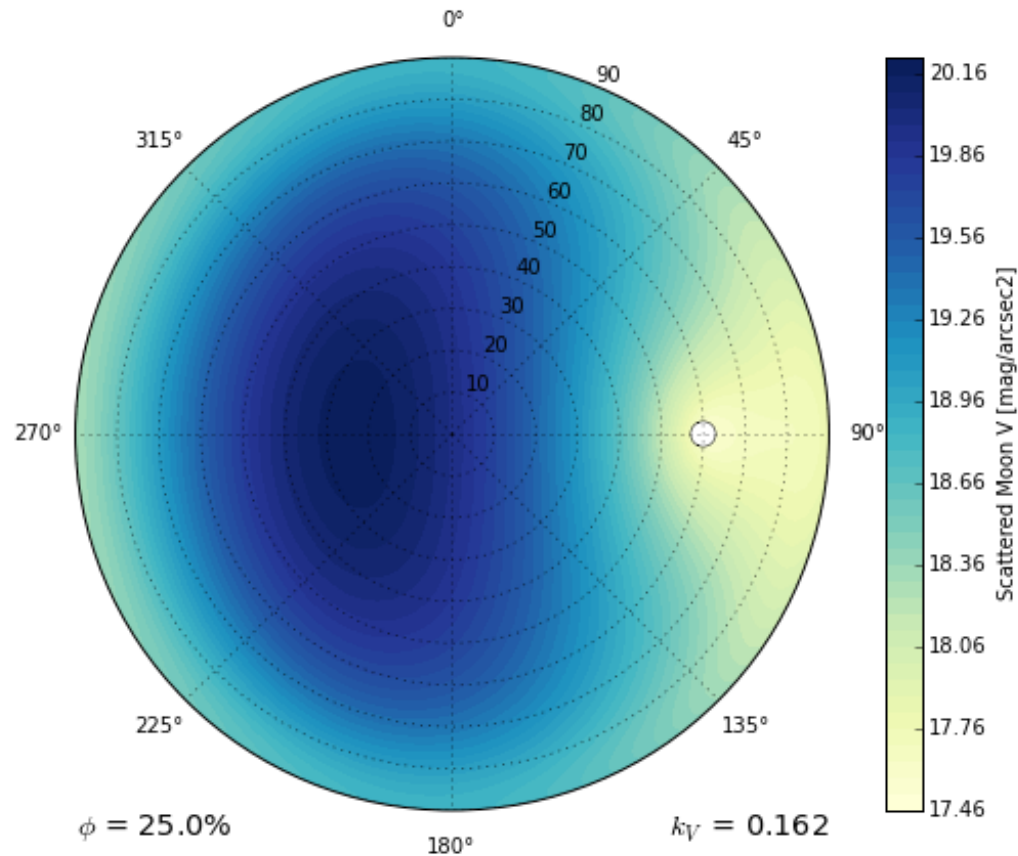
Conservative assumptions:

- **simulated sky brightness with moon up is underestimated.**
- **actual  $\text{GRAY} / \text{DARK}$  exposure time is 1.10.**
- **$\text{GRAY} + \text{DARK}$  exposure factor due to moon = 1.02.**

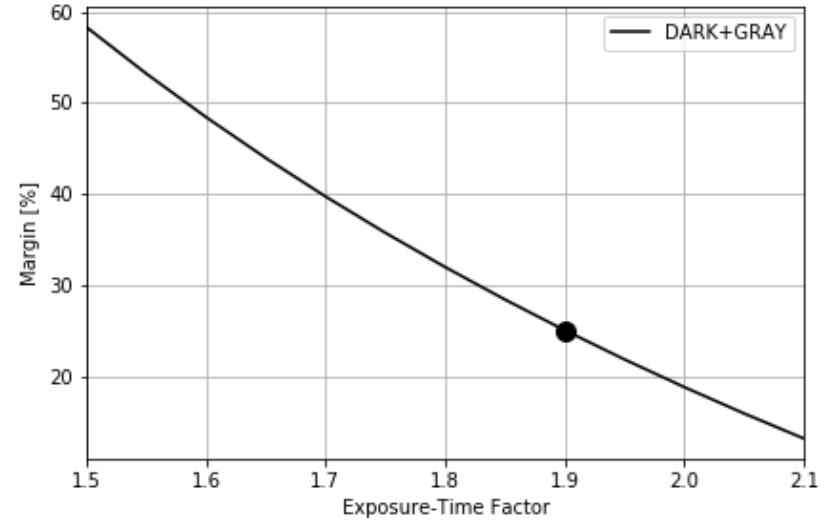
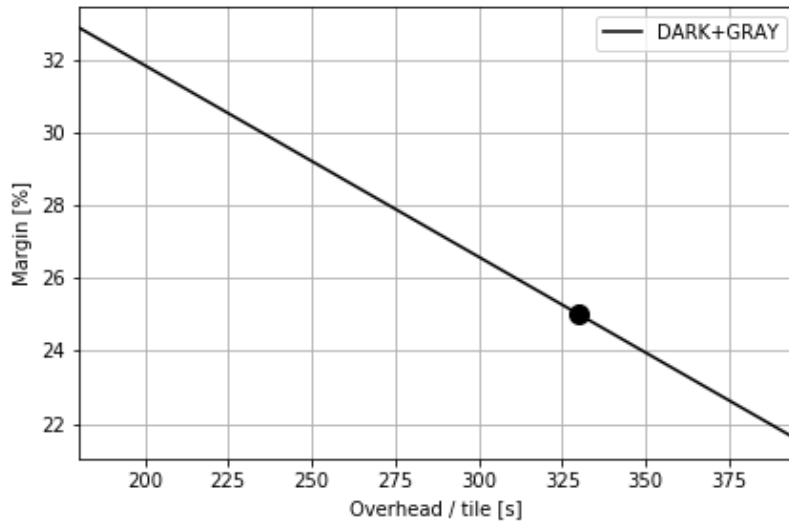
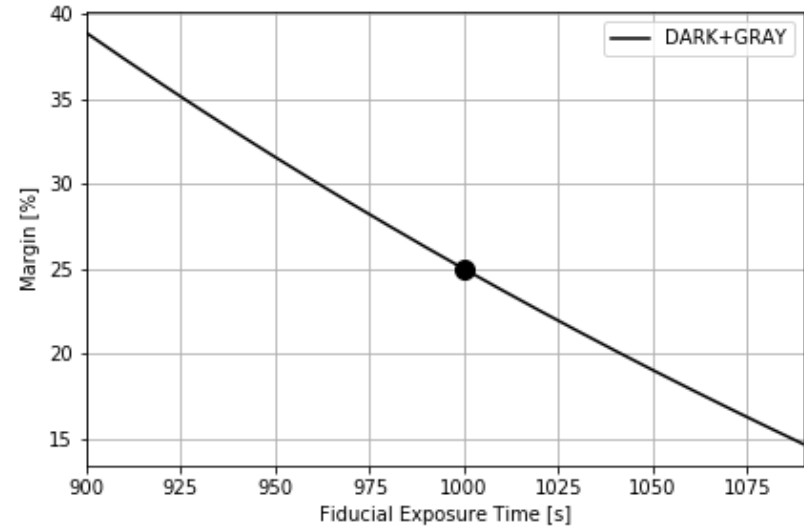
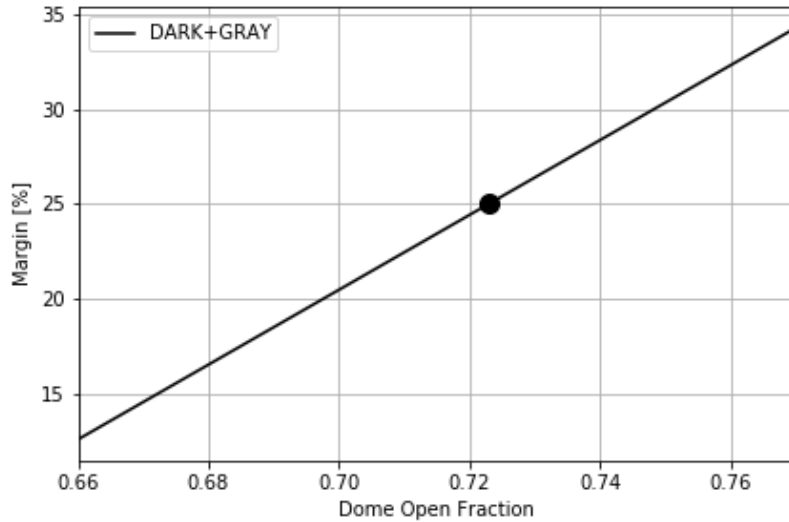


# Exposure Time Increase due to Moon

Moon impact depends on real-time scheduler performance:



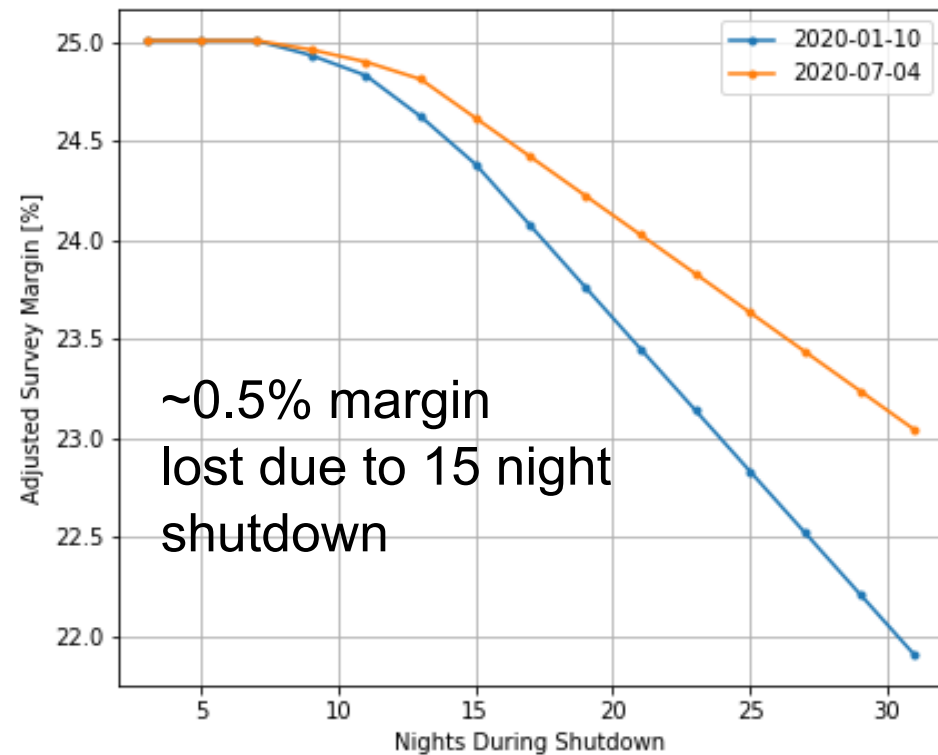
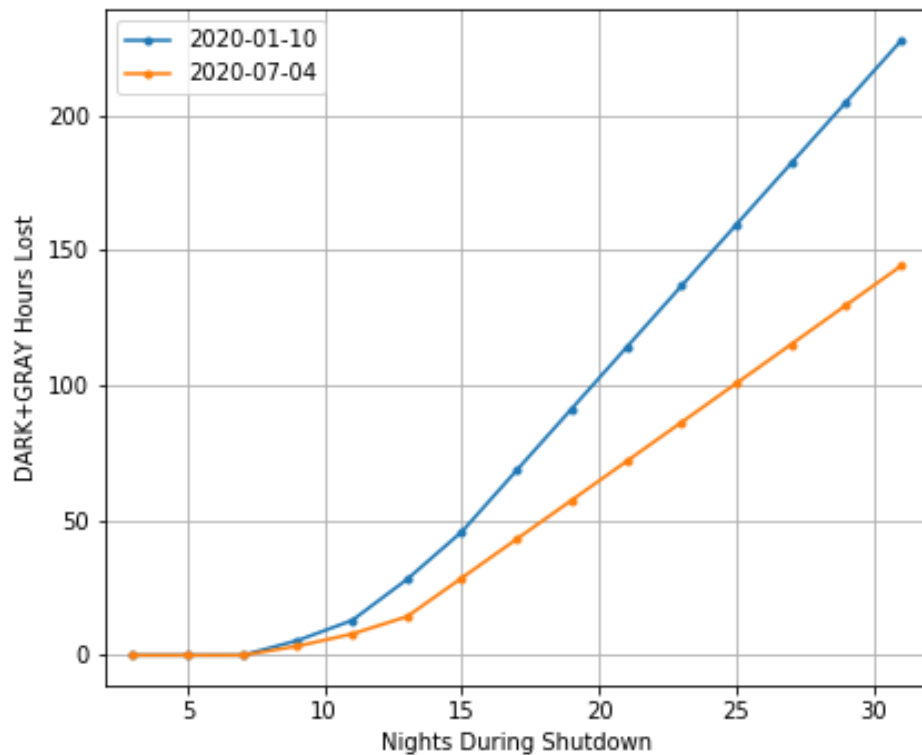
# Margin Sensitivity to Input Parameters





# Shutdown Impact on Schedule

Assume that a shutdown to replace a GFA (14 nights) or petal (30 nights) is centered on a full-moon:



~0.5% margin  
lost due to 15 night  
shutdown



# Summary

**Estimated margin to complete baseline program is 25.0%.**

\*baseline is 14K sq. deg. DARK+GRAY

Models of expected weather and observing conditions based on historical site data.

Detailed survey simulations used to:

- Exercise on-sky scheduler and online-ETC algorithms.
- Estimate operations overheads.
- Estimate impact of any downtime and plan repair schedule.



# References

DESI-717: DESI footprint and tile centers.

DESI-1767: baseline survey strategy.

DESI-4041: details on survey margin estimates.

DESI-3087: seeing and transparency models.

DESI-3577: nightly weather records for 2007-17.

DESI-3977: SNR for as-built instrument.

DESI-3060: design hour angle calculations.

