Presentation to the SAC
Survey strategy status and plans

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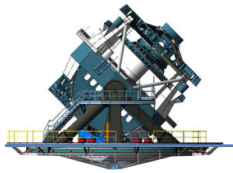
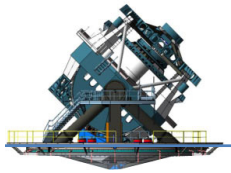
LSST2019 Project & Community Workshop
August 12, 2019



Current Status

- Starting investigation of many families
  - See July2019 update on community with more information on FBS 1.2 set of runs
  - https://community.lsst.org/t/july-2019-update/3760 (http://ls.st/xsb)
- Not complete, but getting better understanding of what metrics are telling us and what will need to go into report to the SCOC
  - Working with subsets of the community, but looking to add more community posts surrounding this
- Will be releasing more runs and also writeups describing interpretation and comparisons of various runs



FBS 1.2 runs

Runs matching SAC requests

- Pairs in same or different filters
- 1x30 or 2x15 visits
- Presto color (g+i+pause+g)
- Footprint variations (9 different ones)
- Rolling cadences (13 variations)
- Dithered DDF (spatial)
- DESC DDF
- Target of opportunity (ToO)
- Vary u-band filter loading
- 1s or 5s exposure sky coverage
- Stability tests

Bonus Experiments

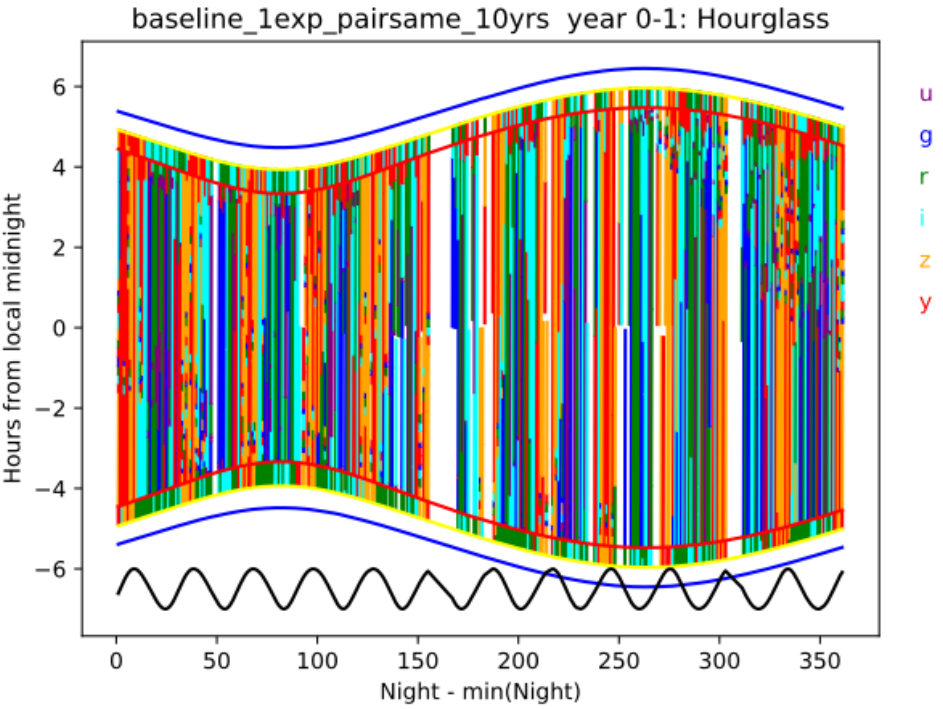
- Pathological footprint
- Variable exposure time
- AltSched like behavior
- Camera rotator dithering
- Smarter rolling cadence

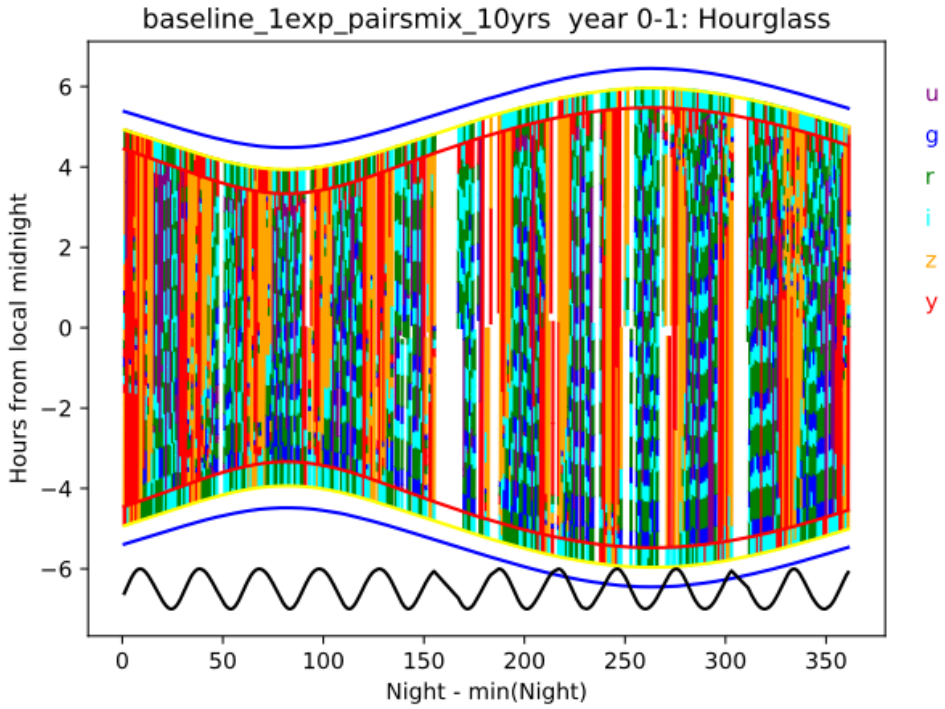
FBS 1.2 runs: pairs of visits

Baseline-like sims

- 1x30s snaps in a visit
- 2x15s snaps in a visit
- g+g, r+r, i+i pairs
- g+r, r+i, i+z pairs

1x30s snap, mixed filter pairs as the "baseline" behavior for the rest of the simulations

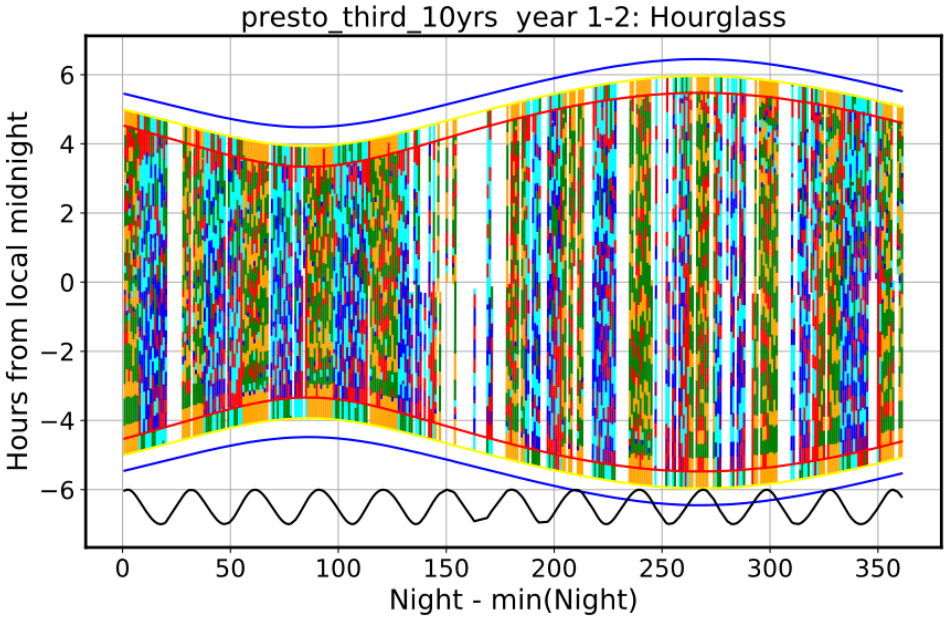


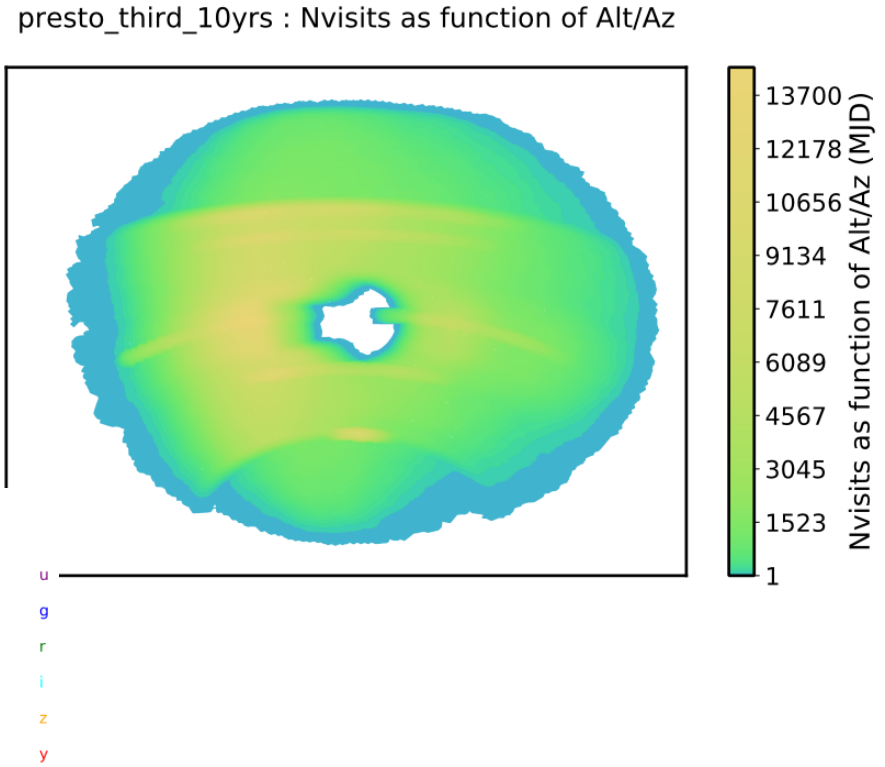


FBS 1.2 : presto-color

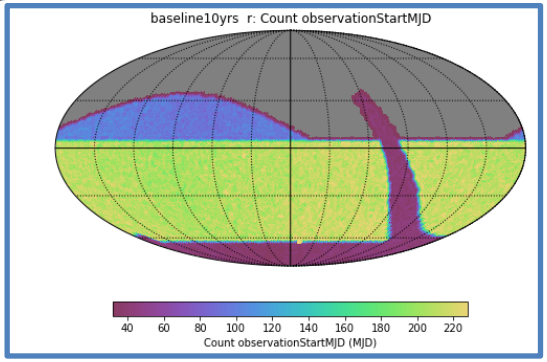
Presto color

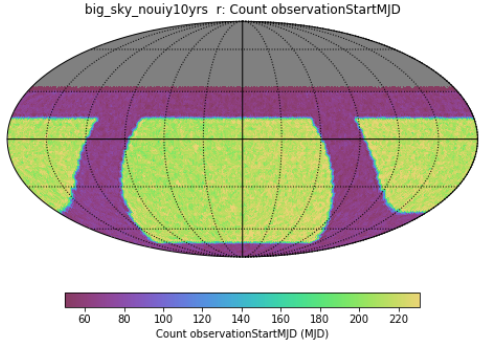
- g+i…40-120min later+g
- r+z…+r

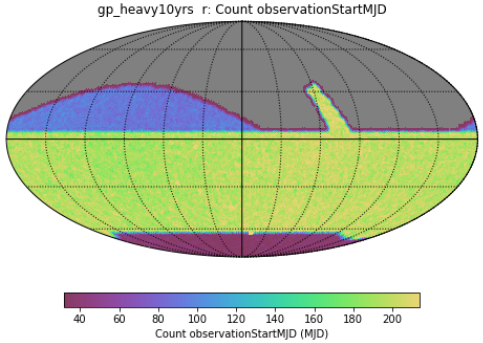


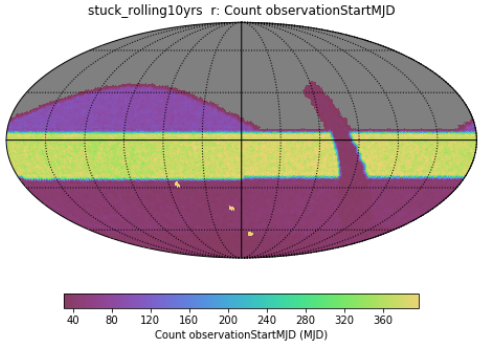


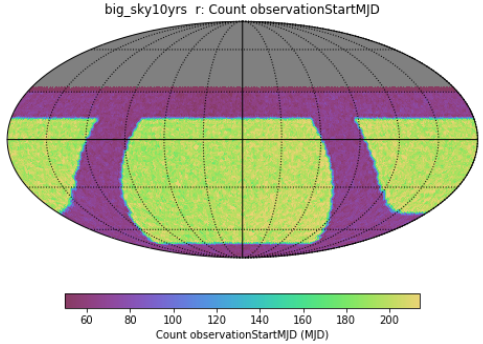
FBS 1.2 runs : footprints

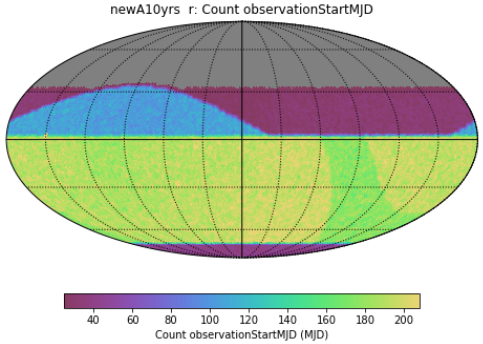


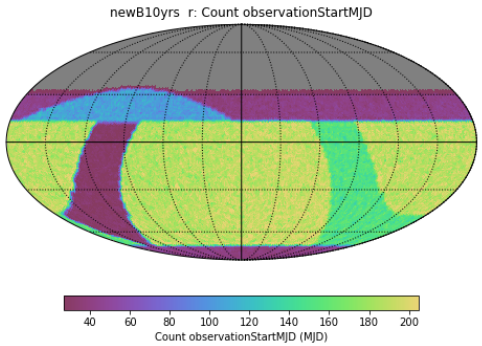


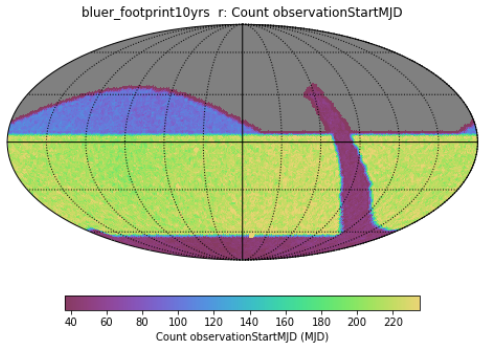


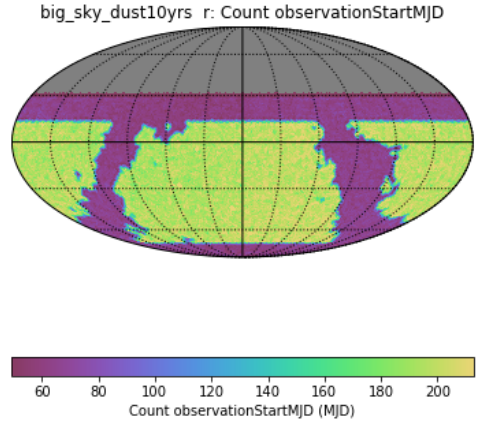










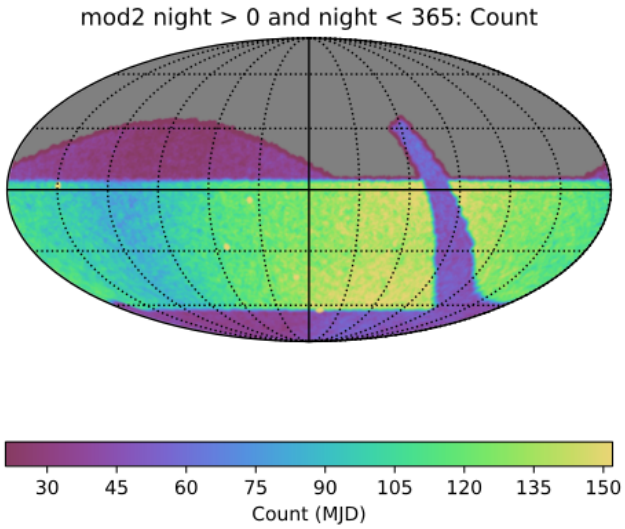


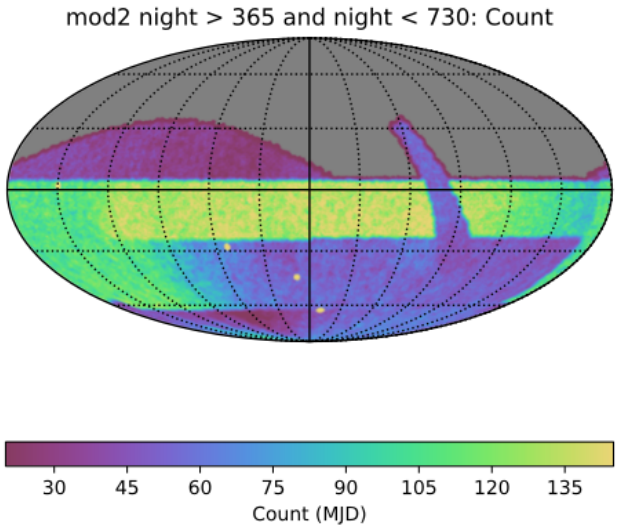
FBS 1.2 : rolling cadence

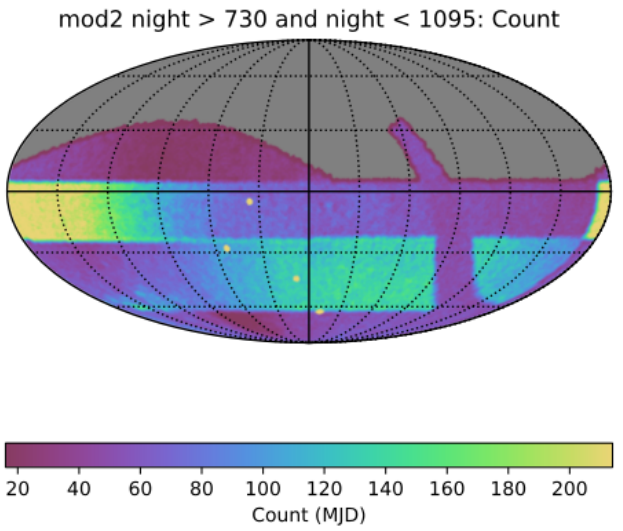
Start off normal, then divide WFD in (half) and alternate emphasis on north and south

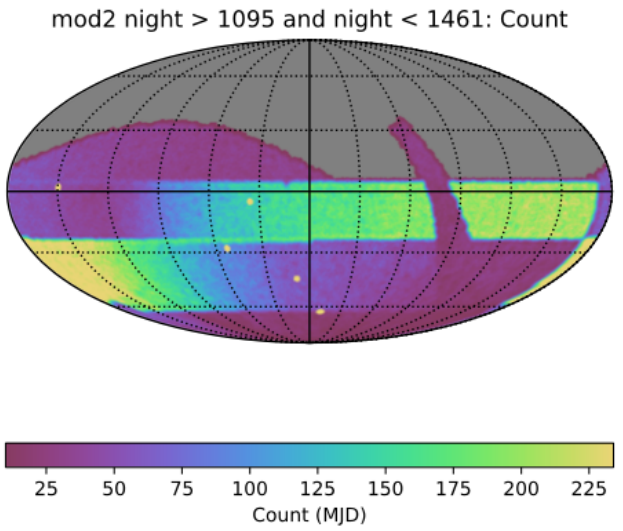
Year 1 like baseline, WFD gets 120 observations/yr

Rolling, get 25 or 215 observations per year



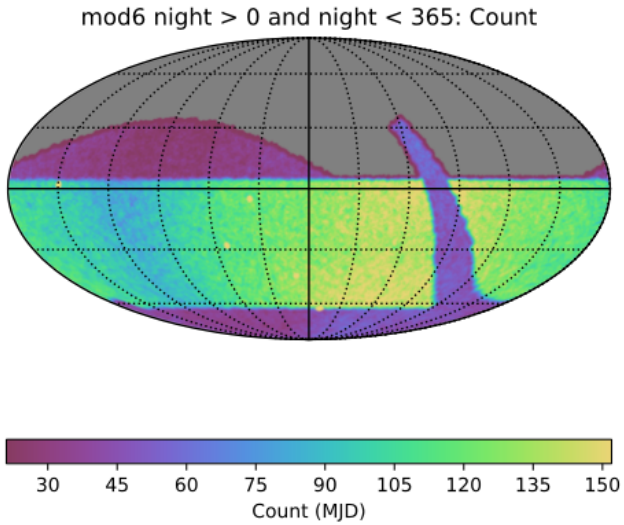


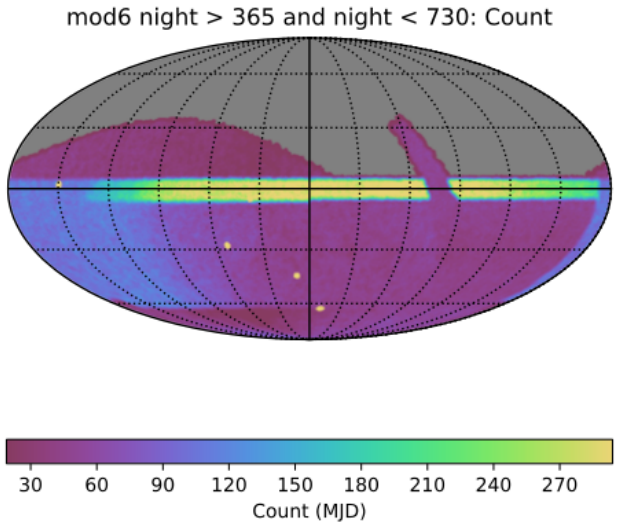


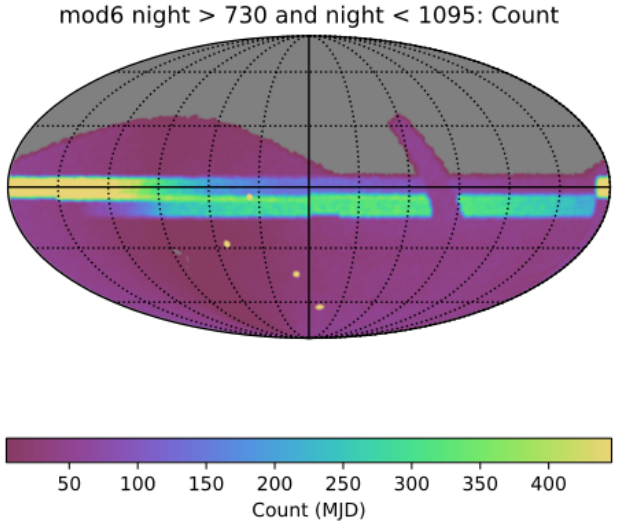


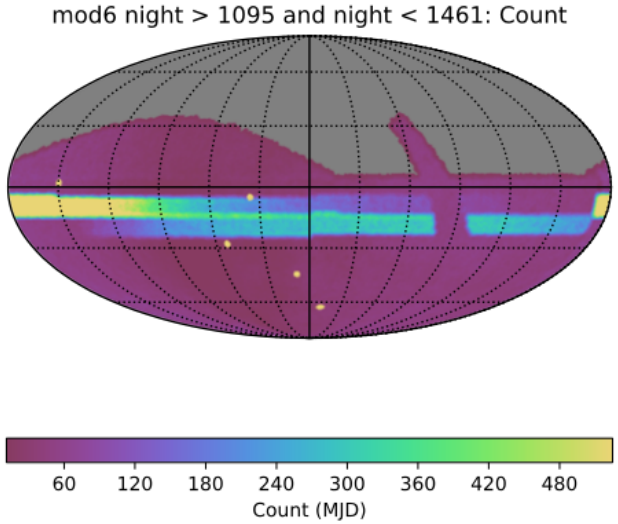
FBS 1.2 : rolling cadence

More extreme rolling: have 6 declination stripes.
Then 450+ observations in a season, with 400 more visits over remaining 9 years.





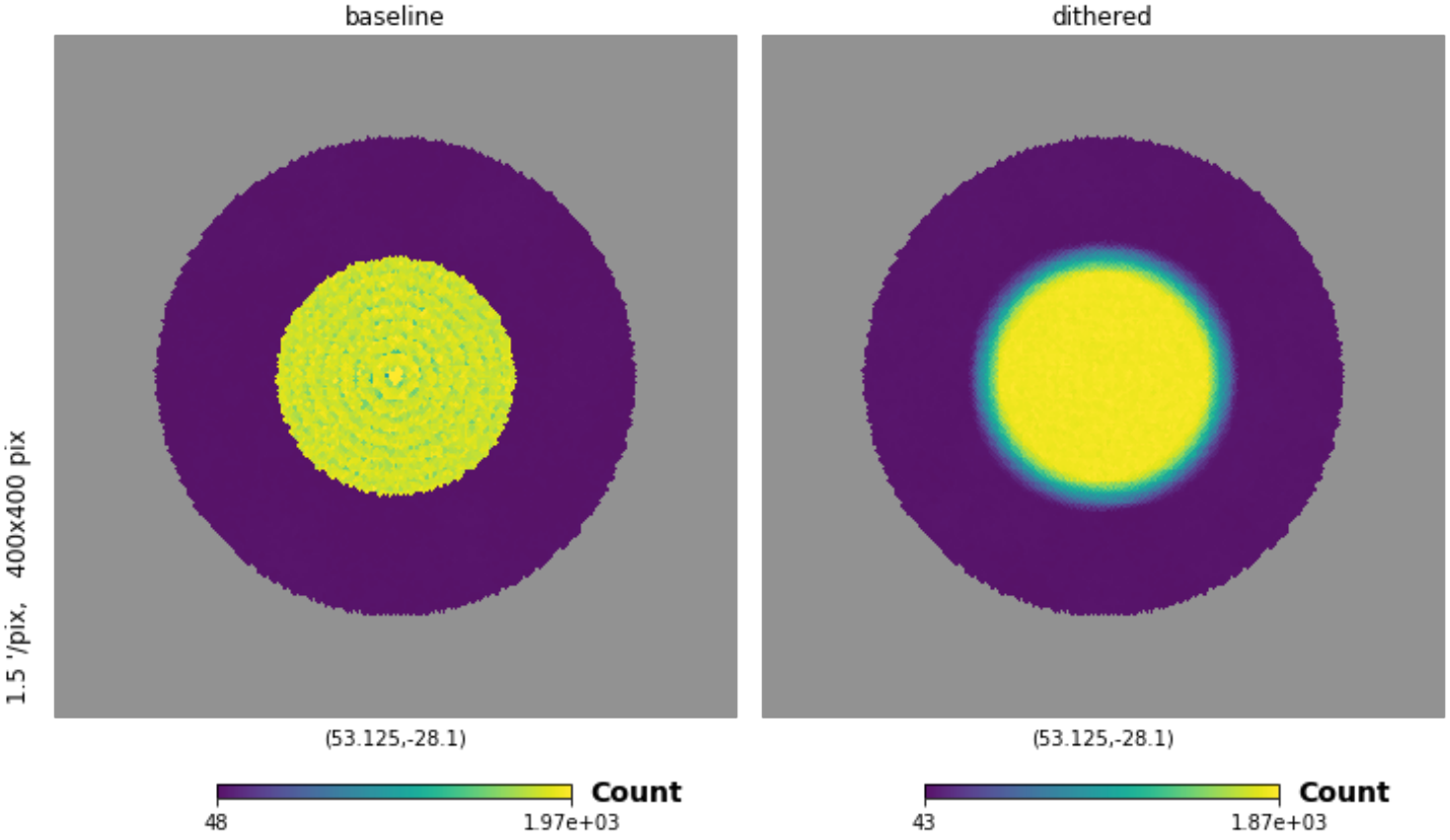




FBS 1.2 : DD dithering & sequences

DDF

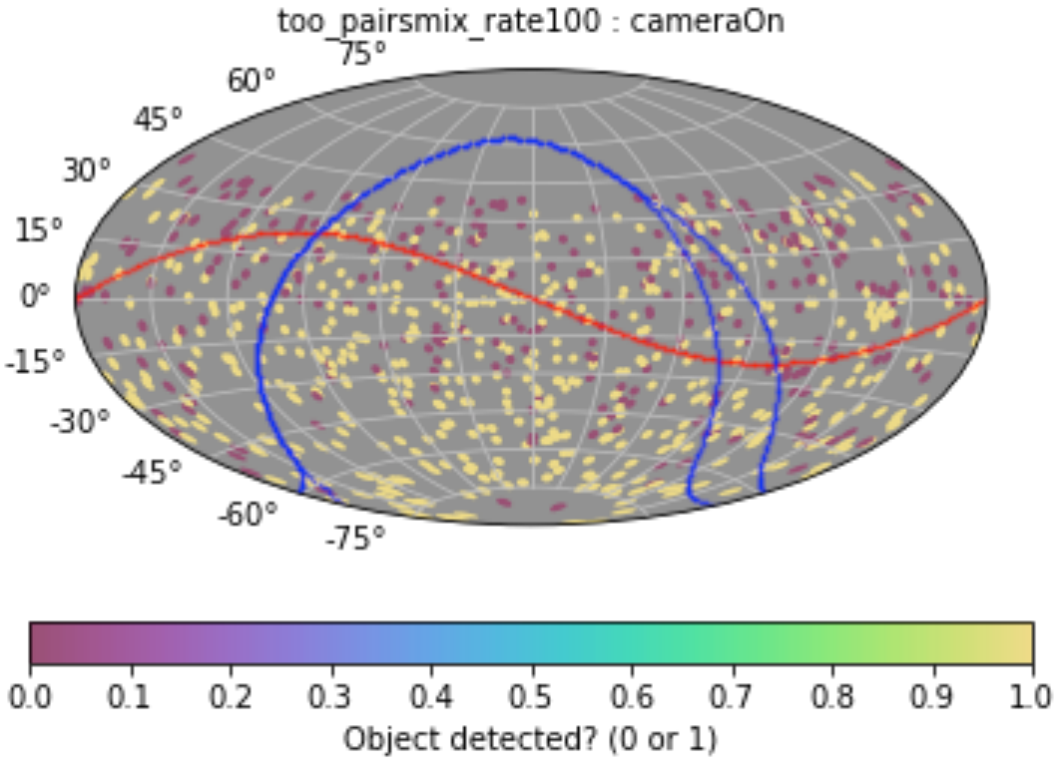
- Spatial Dithering
- DESC suggested cadence

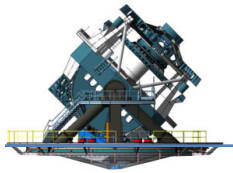


FBS 1.2 : ToOs

Target of Opportunity

- 1, 10, 50, 100 alerts per year
- Usually able to detect ~55% of ToOs





FBS 1.2 runs : More runs

Filter Loading
- Vary when u and z get swapped out of the camera

Short exposures
- Mixing in 2s or 5s exposures

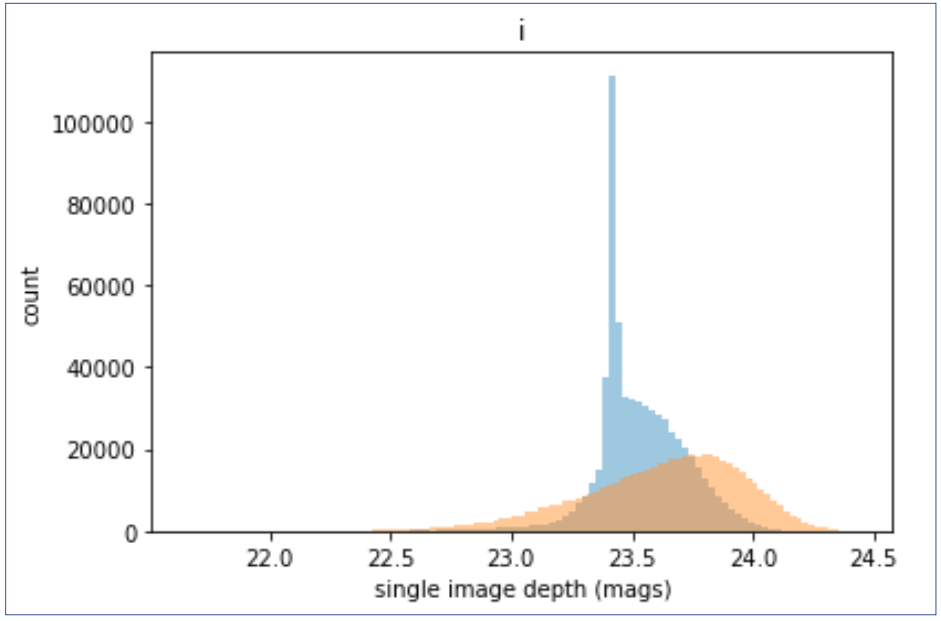
Twilight time
- Taking 1s exposures in twilight

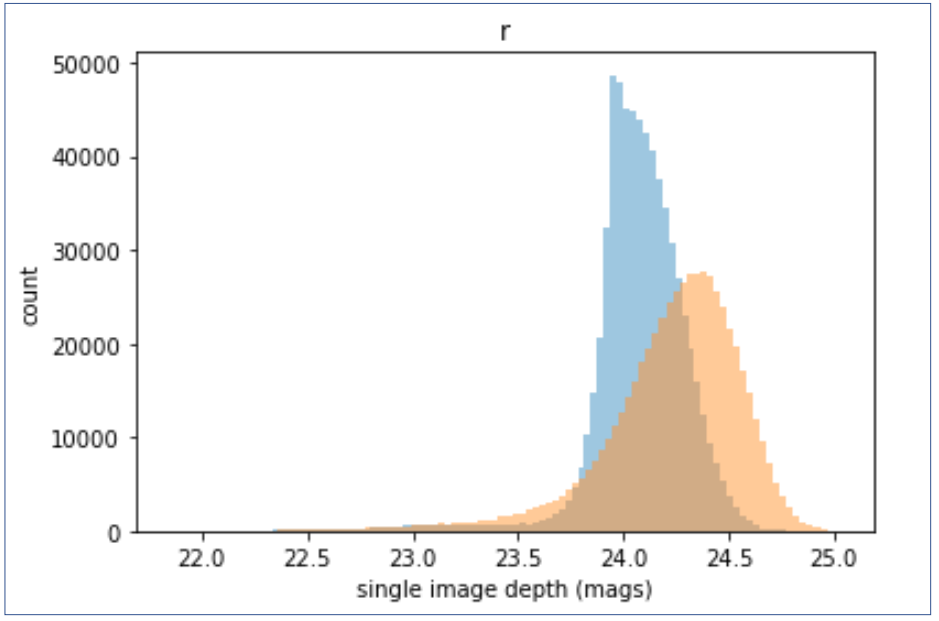
Stability tests
- Vary start date & random seeds

FBS 1.2 : variable exposure time

Adjust exposure time between 20 and 100s to get specified depth on every visit.

Images are shallower, but you get more of them. 2.9 million observations instead of 2.5, lose ~0.1 mag of final coadded depth.

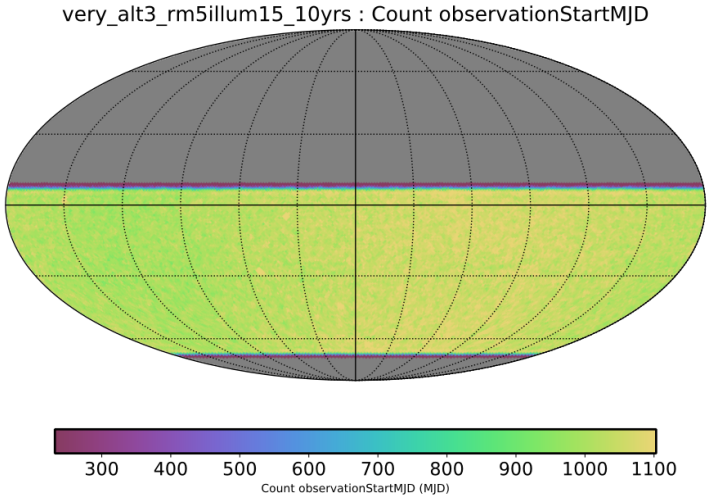


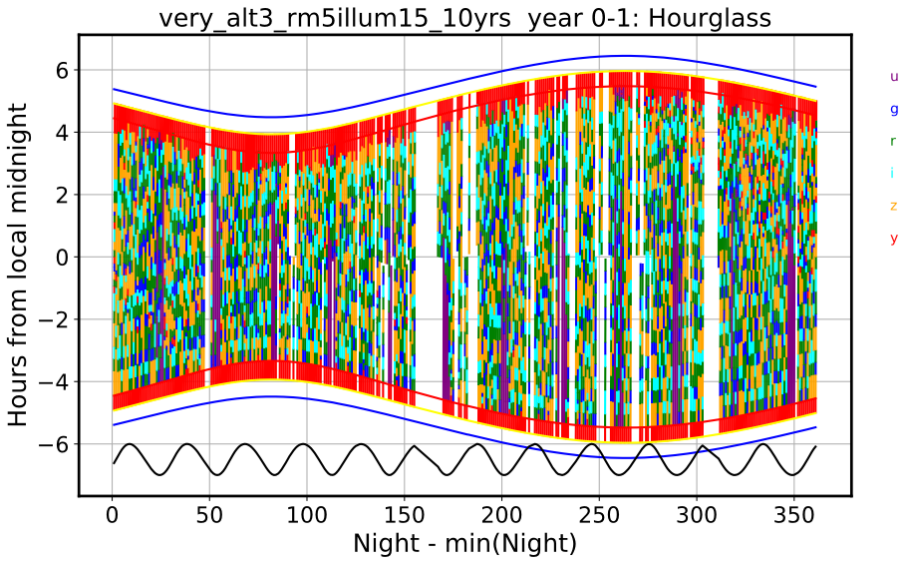


FBS 1.2 : alt_sched like

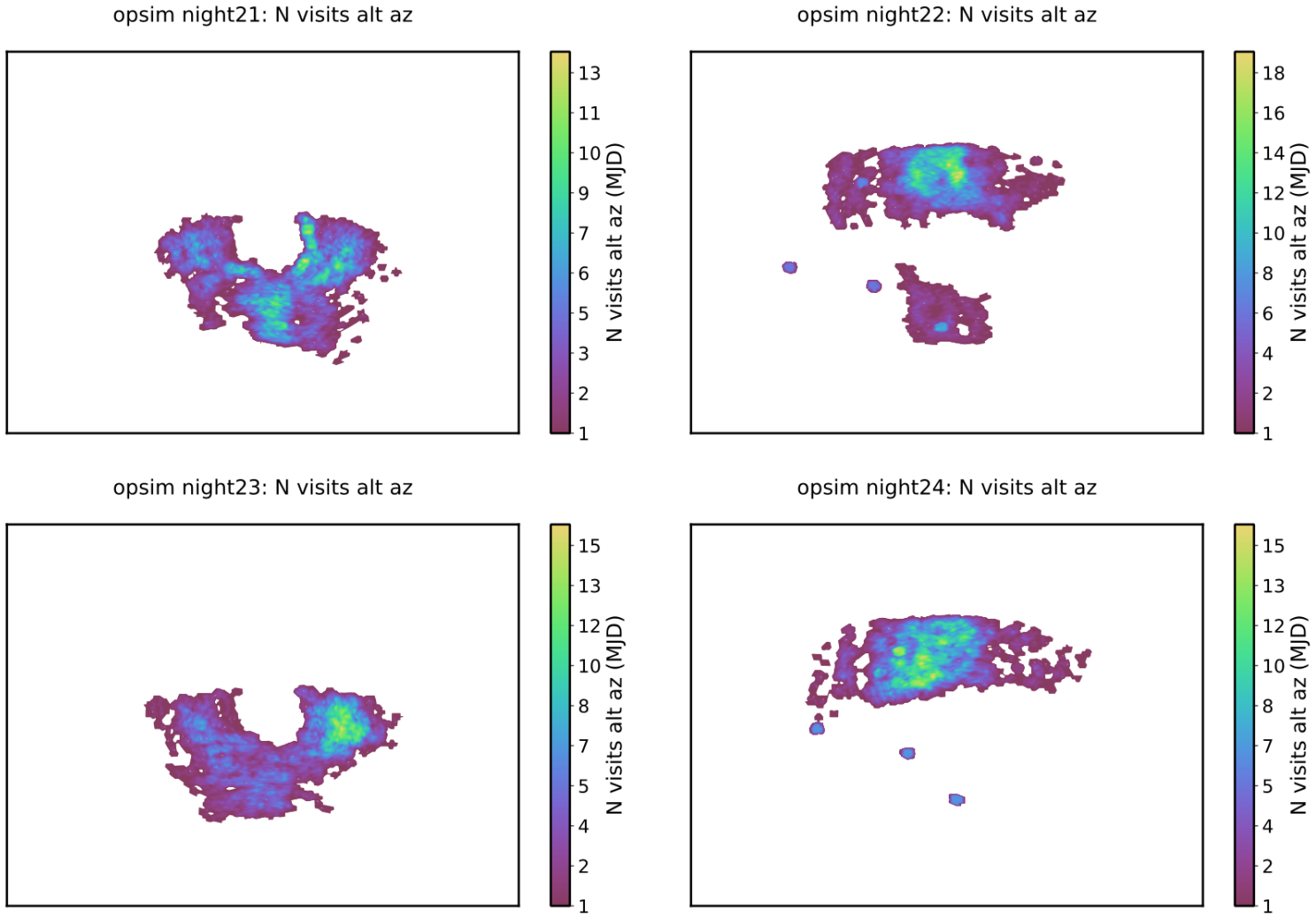
Alt-Sched like

- Y-band in twilight
- Blue filters in bright time
- Alternate north and south each night





FBS 1.2 : alt_sched

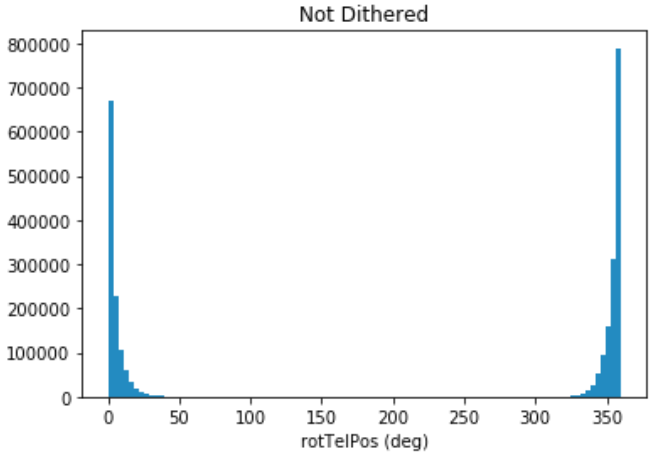


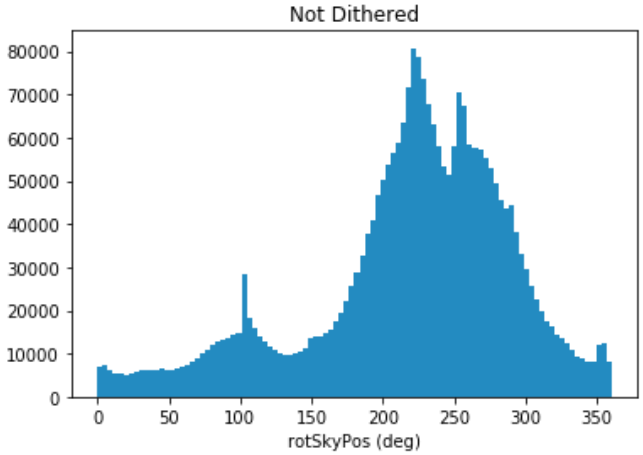
FBS 1.2 : rotator angle

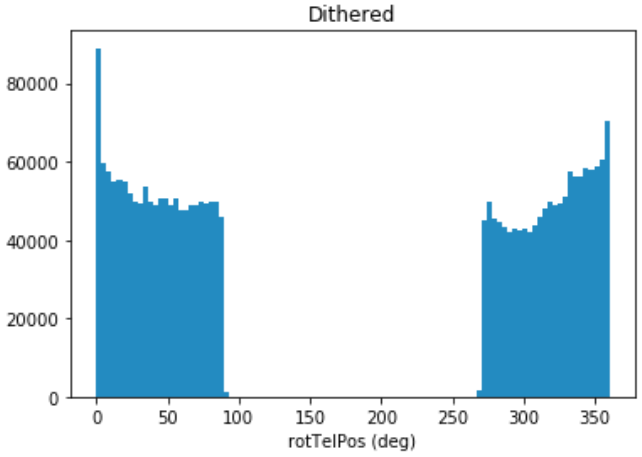
Rotator Angle

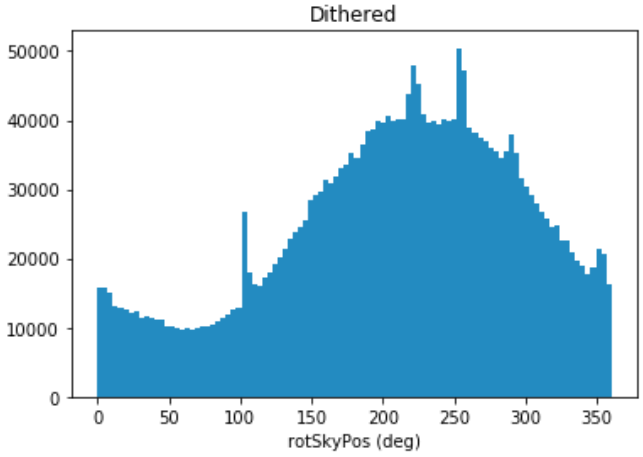
Baseline keeps the camera-telescope angle near zero.

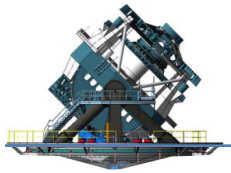
Can select a telescope angle per night to randomize orientation









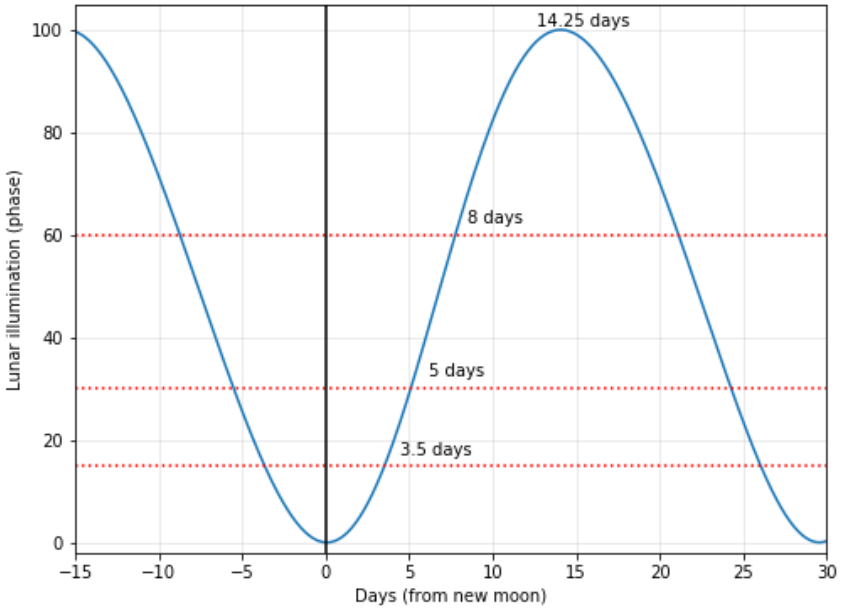


Analysis

- u band filter swap
- baseline - pairs of visits
- WFD footprint
- rolling cadence

u band filter switch FBS 1.2 runs

- Limit u band to within +/-2 nights of new moon



Effect on DD

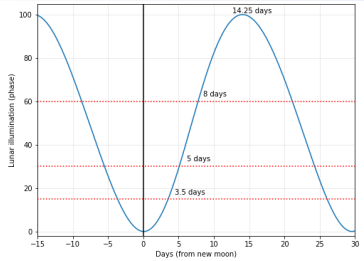
Visits

	Illum 15	Illum 30	Illum 60
DD:u,290	726	1295	2079
DD:u,COSMOS	1421	2590	3206
DD:u,ECDFS	1714	3178	3327
DD:u,ELAISS1	1092	2079	3281
DD:u,XMM-LSS	1211	2247	3265

Coadd m5

	Illum 15	Illum 30	Illum 60
DD:u,290	27.106095	27.408551	27.653017
DD:u,COSMOS	27.397545	27.724804	27.815033
DD:u,ECDFS	27.560829	27.912816	27.898625
DD:u,ELAISS1	27.434422	27.808381	28.052296
DD:u,XMM-LSS	27.383279	27.724085	27.915011

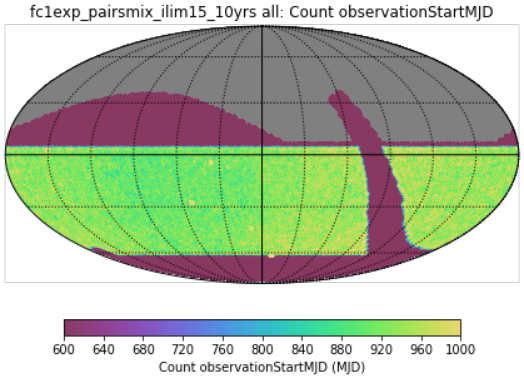
u band filter switch FBS 1.2 runs

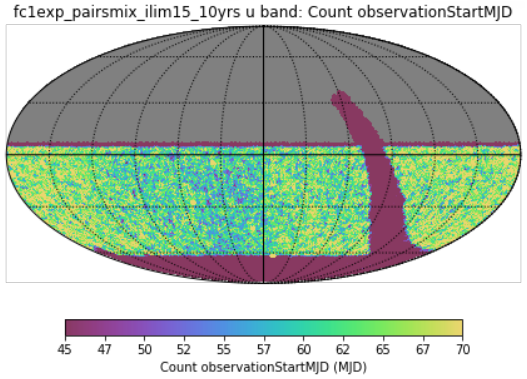


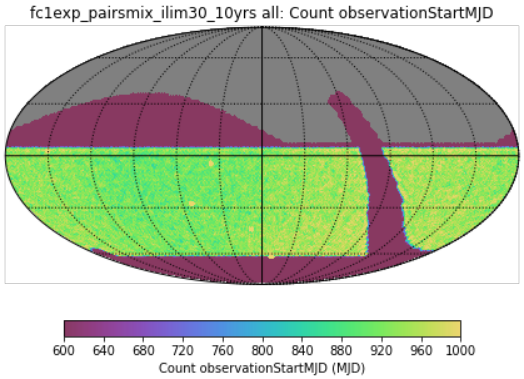
	Illum 15	Illum 30	Illum 60
Min	1.000000	1.00000	1.000000
25th%ile	307.000000	308.00000	318.000000
Mean	778.649605	777.90281	778.531494
Median	912.000000	915.00000	941.000000
75th%ile	942.000000	945.00000	971.000000
Max	43074.000000	44317.00000	34800.000000

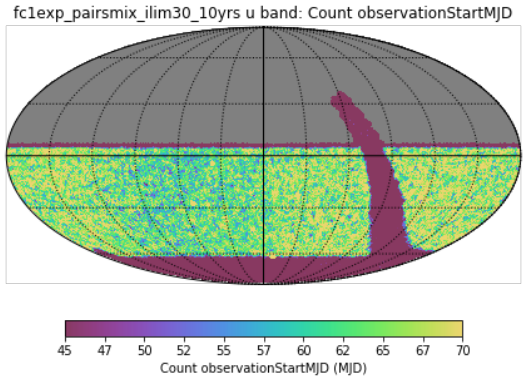
	Illum 15	Illum 30	Illum 60
Min	1.000000	1.000000	1.000000
25th%ile	54.000000	55.000000	58.000000
Mean	59.386335	62.798245	66.956338
Median	62.000000	63.000000	66.000000
75th%ile	67.000000	68.000000	71.000000
Max	1788.000000	3251.000000	3402.000000

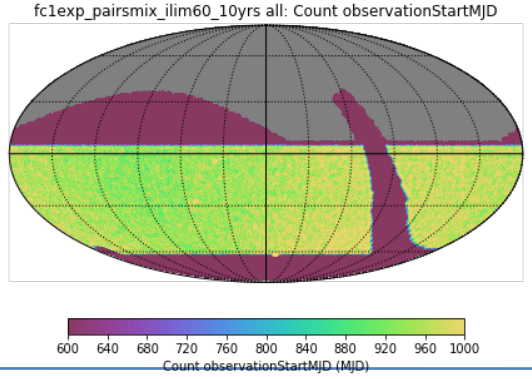
Keep u band longer

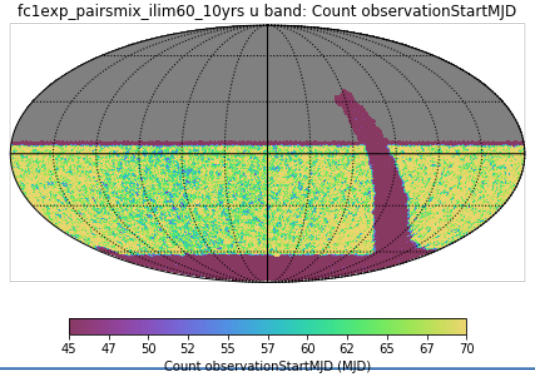


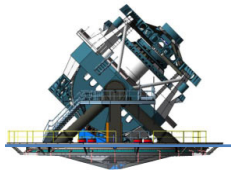












Analysis

- u band switch
- Motivation for limiting the time u band available comes from DESC/get best u band depth
- Limiting u band availability restricts potential DD u band depth and increases likelihood of not reaching requested u band visits in WFD

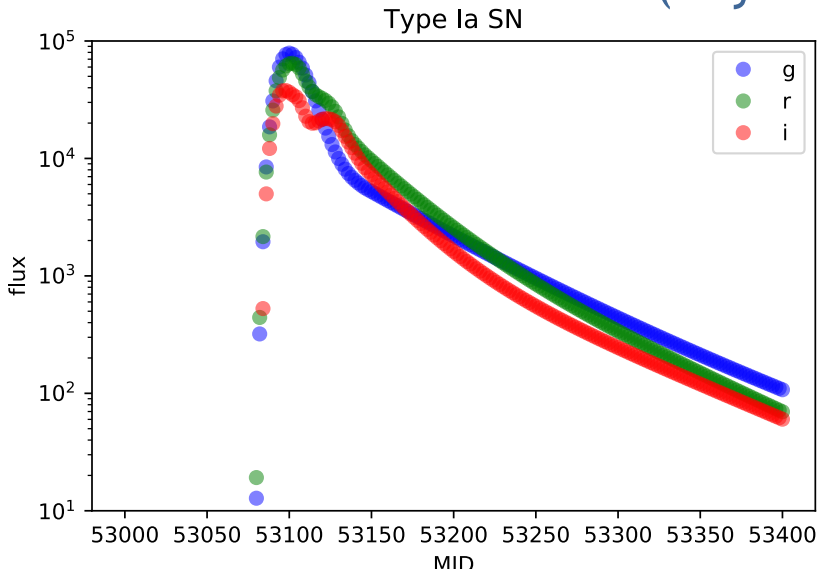
- Is the u band depth in WFD justified? Should visits be reallocated to DD and GP, allowing more time limits on u band availability?
  - Add coadded depth from SRD (photo-z requirement)
  - Look at longer exposures in u band? (& improvement with bugfix)

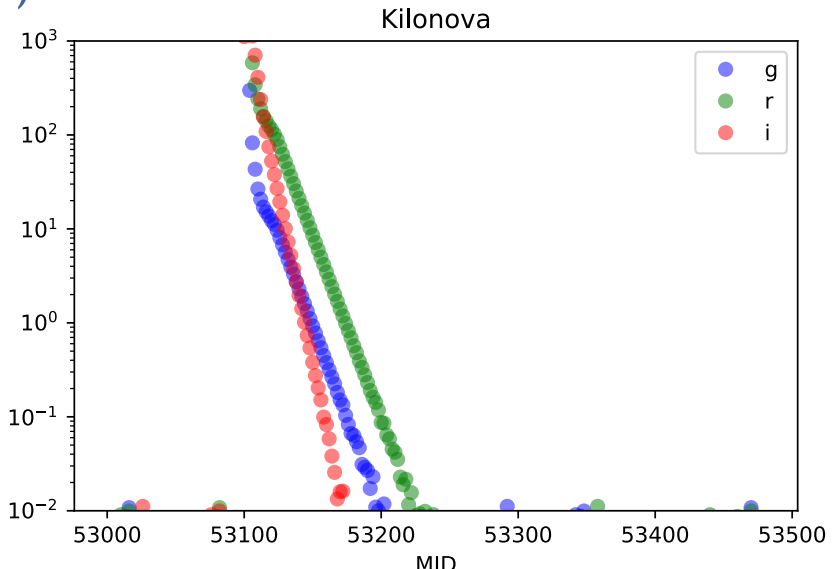
Intra-night visits FBS 1.2 runs

- Filters for pairs (same, mix, presto)

- Transient metrics: generate population of transients using (PLAsTiCC) light curves, distribute over sky & time, use MAF to test recovery rate

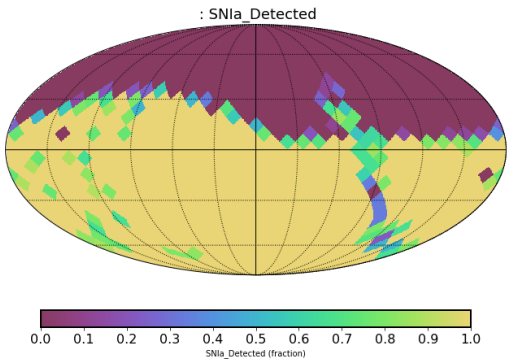
  "Pre-peak" criteria: Measure a color before peak, and a rise slope in at least 1 filter
  "Well sampled": Divide LC into 10 bins, demand 5 have observations (any filters). I would love a better criteria!



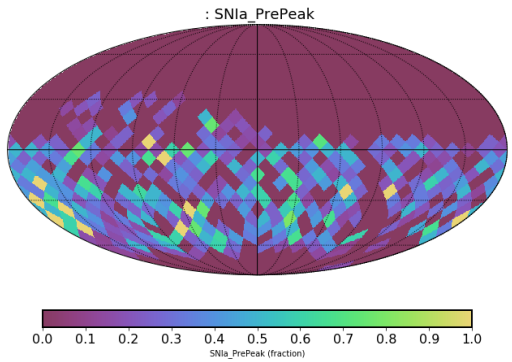


Intra-night visits FBS 1.2 runs

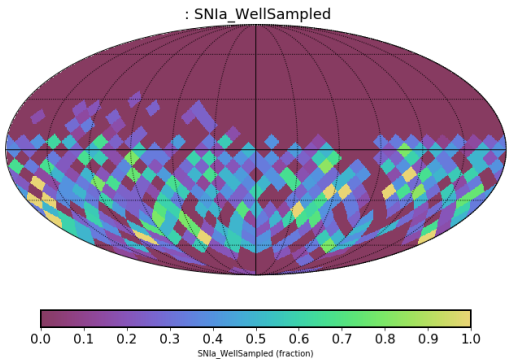
4k Type Ia SNe



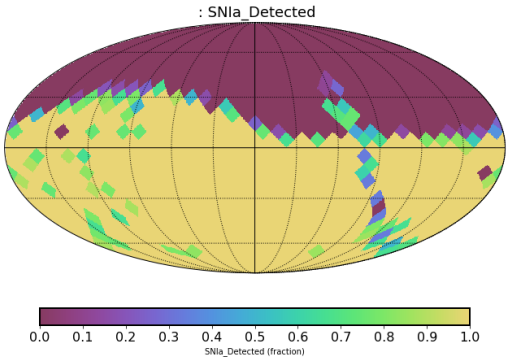
Pairs mixed 62% detected



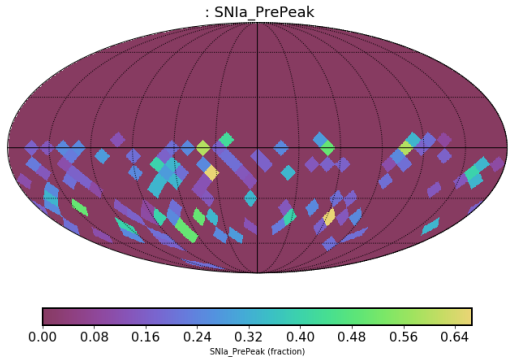
15% measured pre-peak



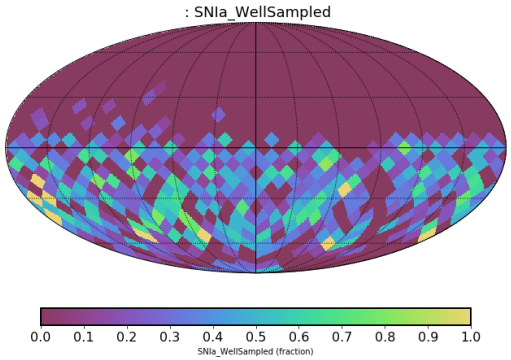
17% “well-sampled”



Pairs same 62% detected



3% measured pre-peak

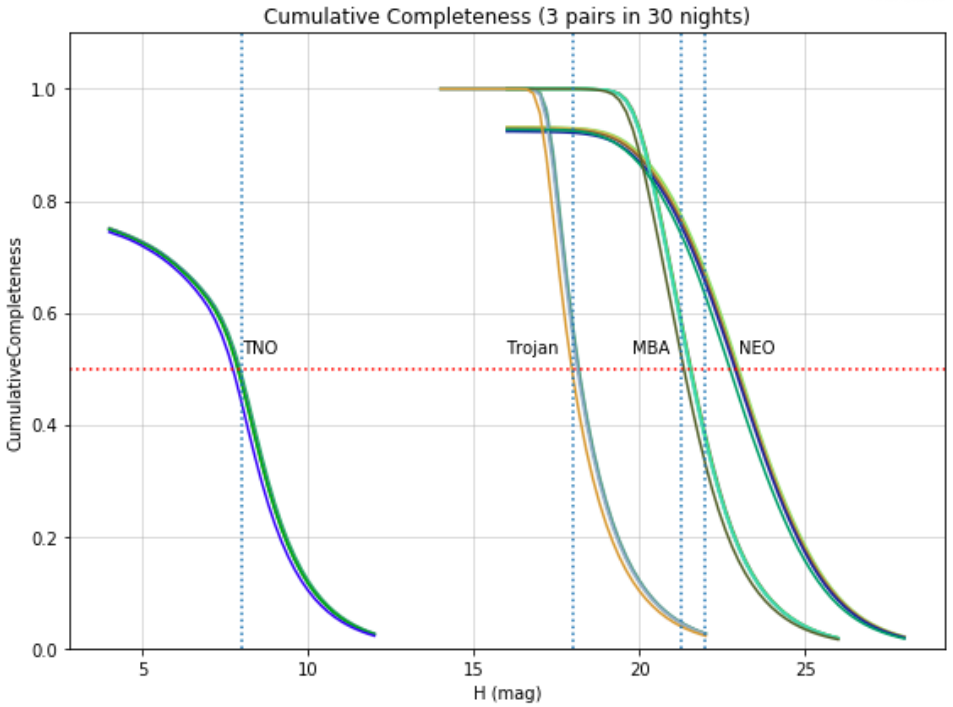


16% “well-sampled”

Intra-night visits FBS 1.2 runs

Mixing filters for pairs does have a cost to SSOs.

Set up some small % of visits to be same filters?



	NEO H=22	MBA H=21.25	Trojan H=18	TNO H=7.5
baseline_1exp_pairsame_10yrs	67.3	59.2	57.5	57.7
baseline_1exp_pairsmix_10yrs	66.5	58.7	56.6	57.0
baseline_2exp_pairsame_10yrs	66.0	58.2	56.3	56.9
baseline_2exp_pairsmix_10yrs	65.2	57.8	55.0	56.6
presto_third_10yrs	62.9	52.7	48.4	54.3

~1% mixing pairs

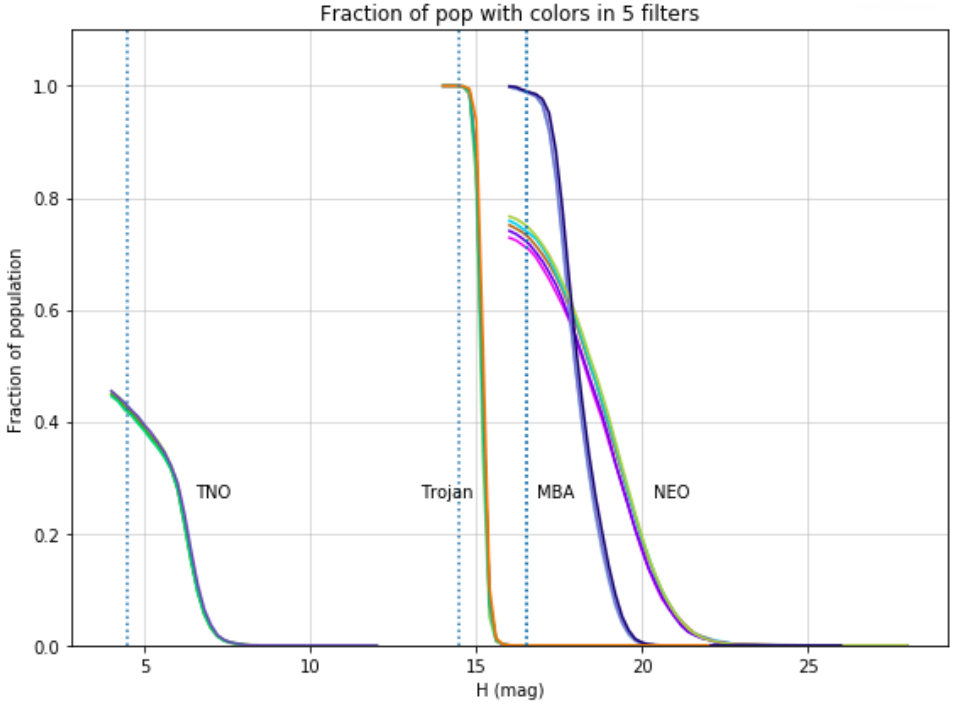
~2% mix pairs + 2x15s

~5-6% presto_third

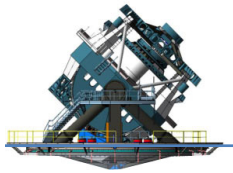
Intra-night visits FBS 1.2 runs

Characterization fairly insensitive to filters used for pairs*.

* presto_third increases NEO characterization, but has a larger cost to overall discovery



	NEO H=16.5	MBA H=16.5	Trojan H=14.5	TNO H=4.5
baseline_1exp_pairsame_10yrs	73.3	98.9	100.0	42.6
baseline_1exp_pairsmix_10yrs	74.1	99.0	100.0	42.6
baseline_2exp_pairsame_10yrs	71.1	98.8	100.0	42.1
baseline_2exp_pairsmix_10yrs	72.2	98.9	100.0	41.6
presto_third_10yrs	75.0	99.1	100.0	42.7



Analysis

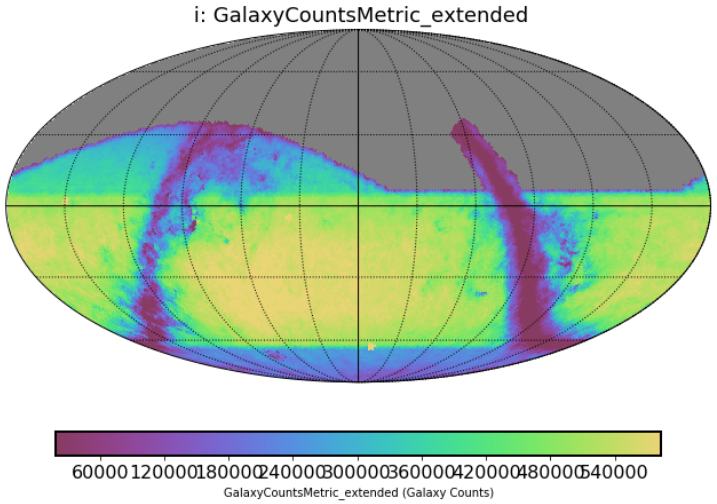
- Motivation for pairs in different filters comes from characterizing (slowly) changing transients
- Increases pre-peak sampling of SNIa (3% - 15%)
- Pushback comes from worry that SSOs will be harder to discover - there is some impact on SSO discovery, particularly with presto_third in its current form.
- Additional pushback that changing filters is less efficient - ~2% penalty
- Add some small % of visits in same-filter, try to rework presto_third

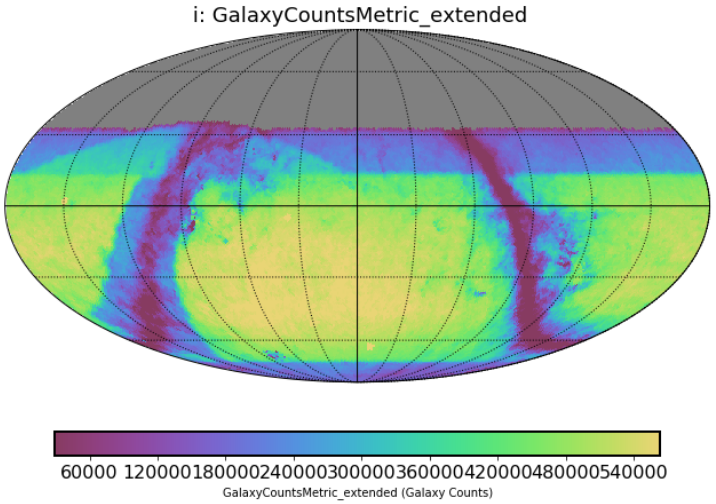
	Nvisits
baseline_1exp_nopairs_10yrs	100.8
baseline_1exp_pairsame_10yrs	100.0
baseline_1exp_pairsmix_10yrs	97.9
baseline_2exp_pairsame_10yrs	92.4
baseline_2exp_pairsmix_10yrs	90.5

WFD footprint FBS 1.2 runs

- ‘WFD footprint’

- Galaxy Count Metric (credit Humna Awan)
- Calculate number of galaxies available for LSS studies





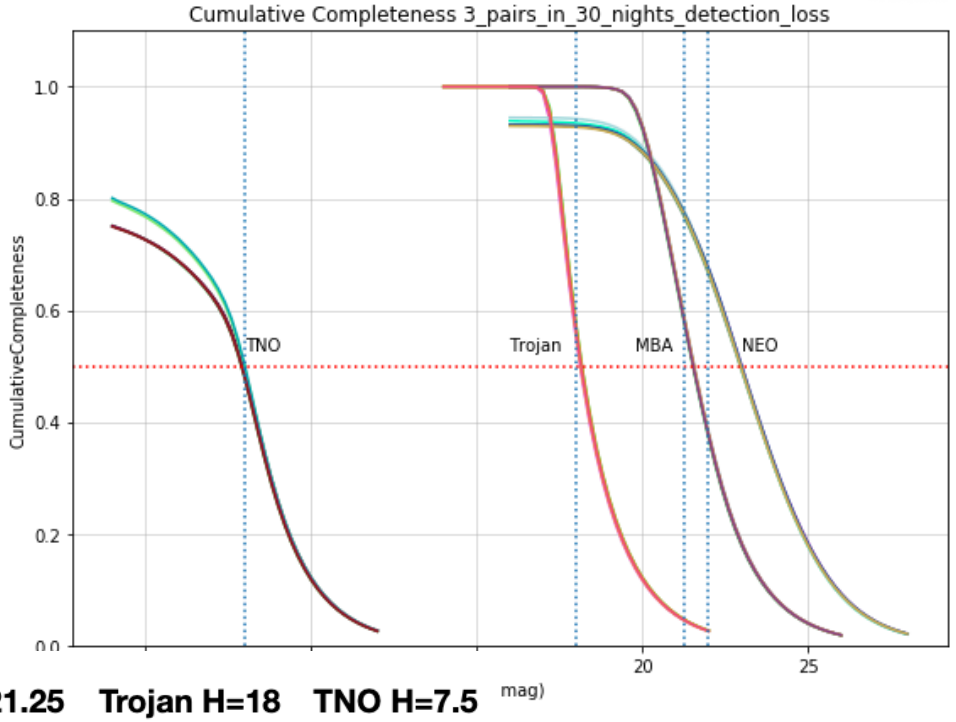
Baseline WFD:
10.8 billion galaxies

newB footprint WFD:
10.6 billion galaxies

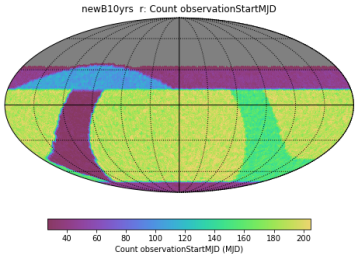
WFD footprint FBS 1.2 runs

- ‘WFD footprint’

More coverage in the north improves discovery of TNOs.



	NEO H=22	MBA H=21.25	Trojan H=18	TNO H=7.5
baseline_1exp_pairsame_10yrs	67.3	59.2	57.5	57.7
baseline_1exp_pairsmix_10yrs	66.5	58.7	56.6	57.0
newA10yrs	67.0	58.0	54.9	59.5
newB10yrs	67.1	58.6	55.9	60.0
bluer_footprint10yrs	67.5	59.0	57.5	57.2
gp_heavy10yrs	66.8	58.5	56.1	57.1

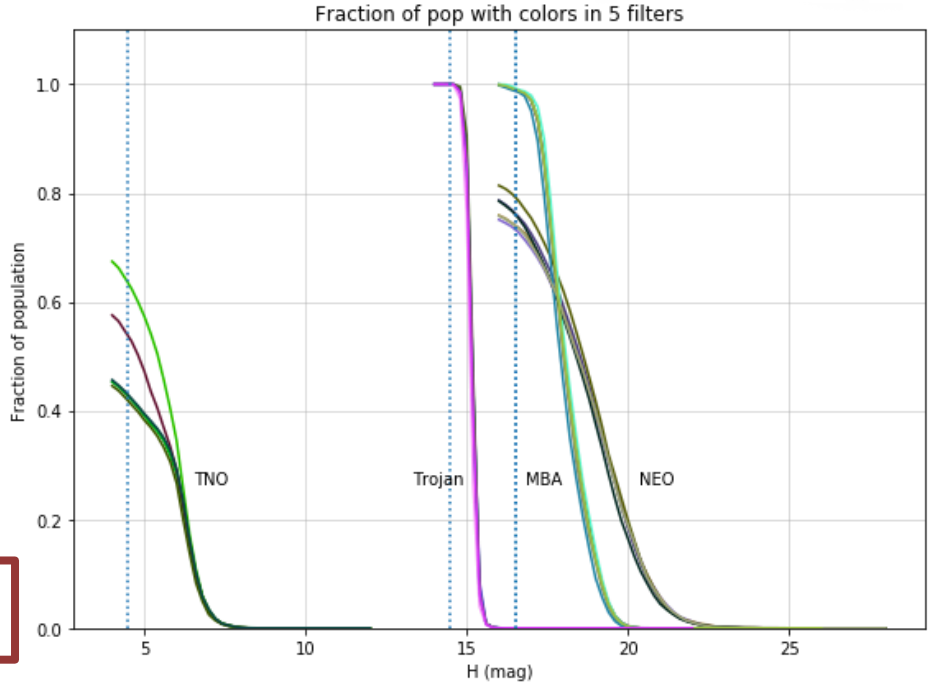


WFD footprint FBS 1.2 runs

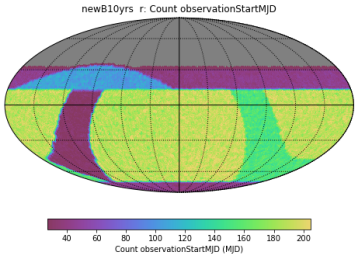
- ‘WFD footprint’

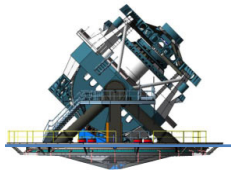
More coverage in the north improves characterization of TNOs AND NEOs.

Need to add MBC & resonant TNO



	NEO H=16.5	MBA H=16.5	Trojan H=14.5	TNO H=4.5
baseline_1exp_pairsame_10yrs	73.3	98.9	100.0	42.6
baseline_1exp_pairsmix_10yrs	74.1	99.0	100.0	42.6
newA10yrs	76.3	99.1	100.0	53.7
newB10yrs	79.3	99.3	100.0	63.4
bluer_footprint10yrs	76.1	98.8	99.9	41.8
gp_heavy10yrs	74.0	99.0	100.0	42.9





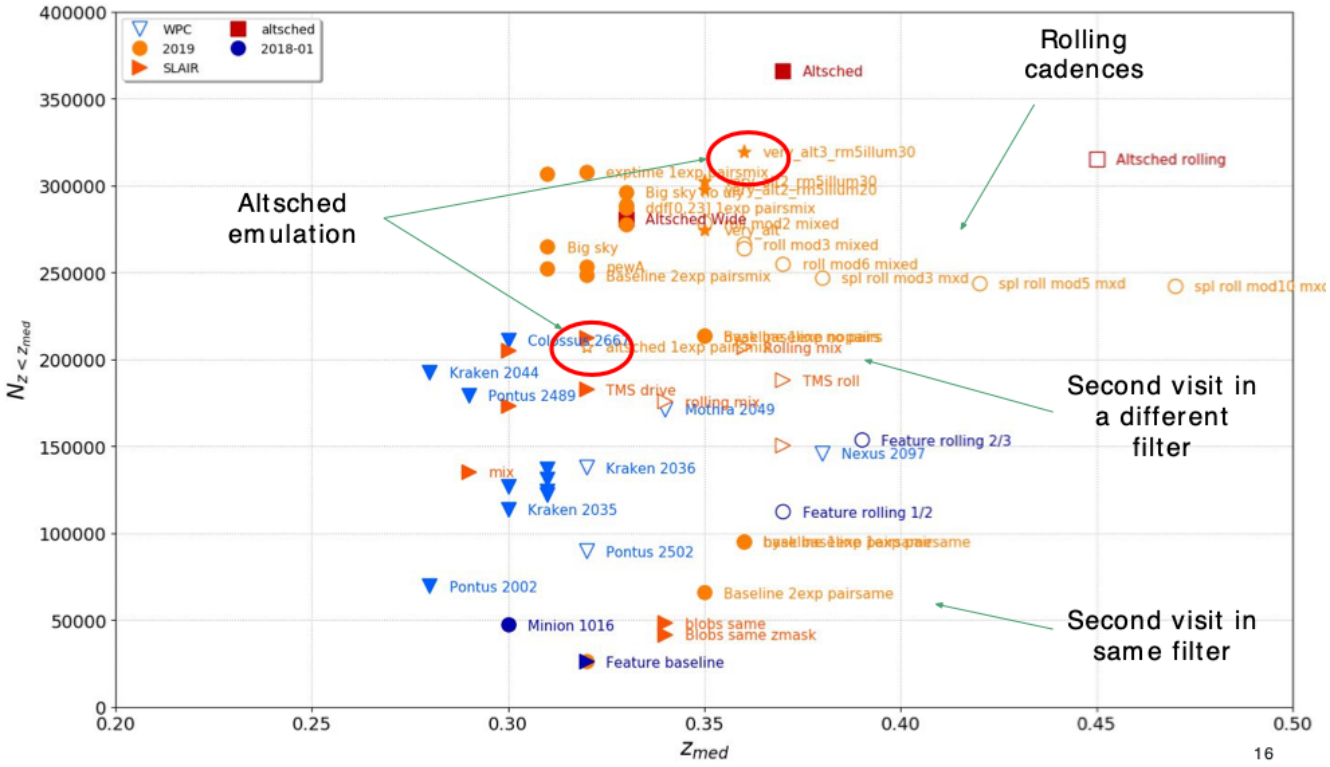
Analysis

- Footprint
- Motivated first by DESC desire for more galaxies
- Galaxy counts don’t show clear improvement
- Some motivation from mini-surveys (NES, Euclid, DESI)
- Some improvement for SSOs (discovery and characterization) if WFD footprint extended north

- Return to DESC for clarification on metrics
- Redo footprint with E(B-V) cut exactly (done)
- Redo footprint with 90% WFD and with 825 visits .. look at options to increase visits in N/S (counter poor seeing)

Rolling cadence FBS 1.2 runs

- ‘rolling cadence variations’

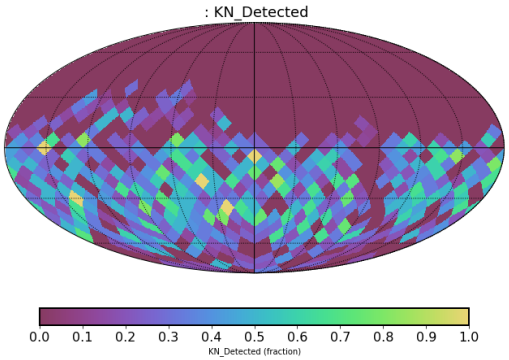


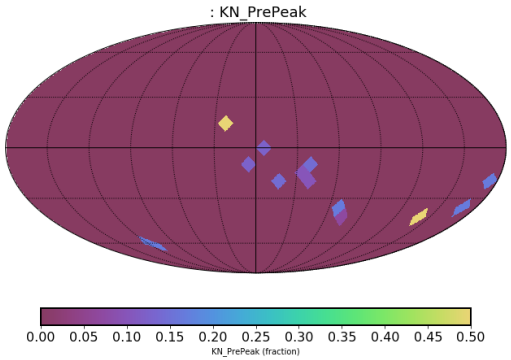
SNe group has been running more intensive analysis and giving feedback on sims

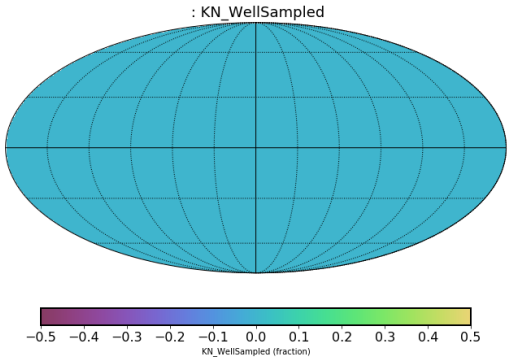
From Nicolas Regnault

Rolling cadence FBS 1.2 runs

Kilonova transient detection



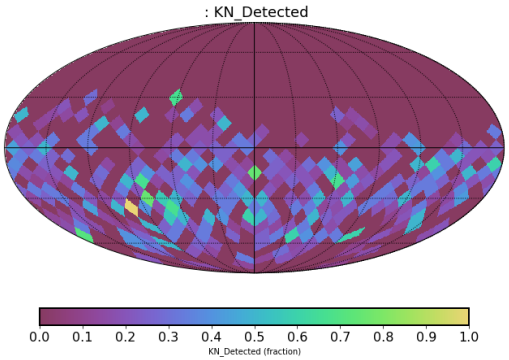


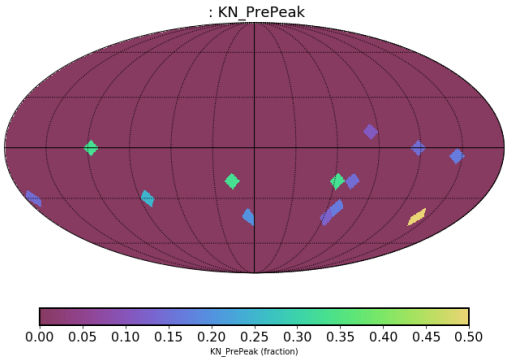


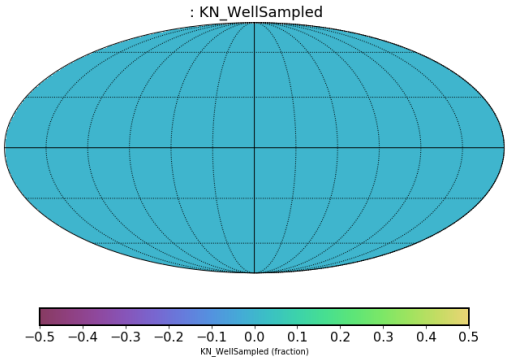
Baseline 19% detected

0.3% pre peak

0% well sampled







10-band rolling 11% detected

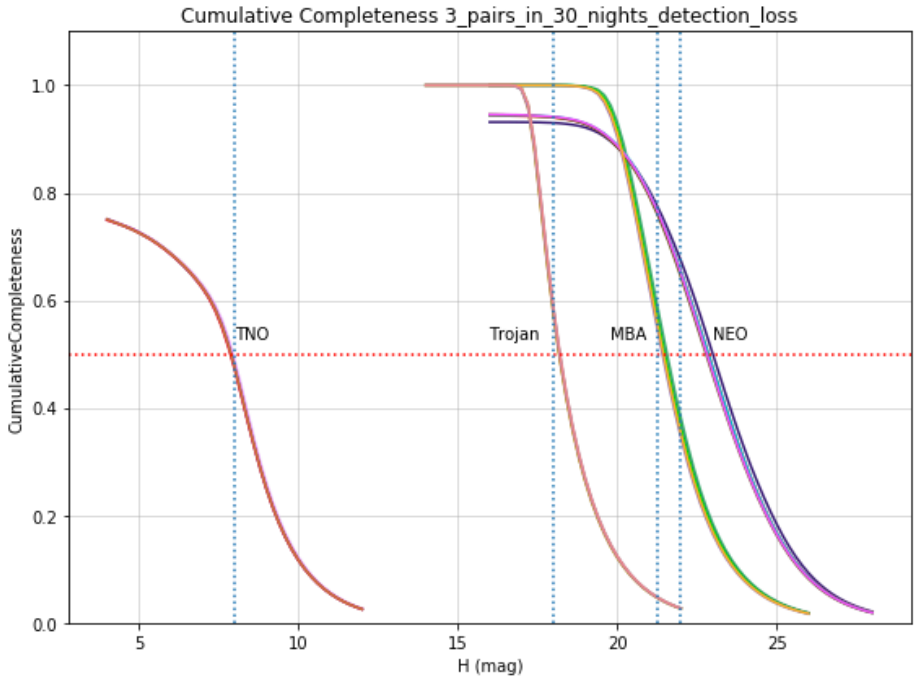
0.3% pre-peak

0% well sampled

Rolling cadence FBS 1.2 runs

- ‘rolling cadence variations’

Rolling cadence has impact on discovery of NEO and MBAs. Have not tested MBCs yet.

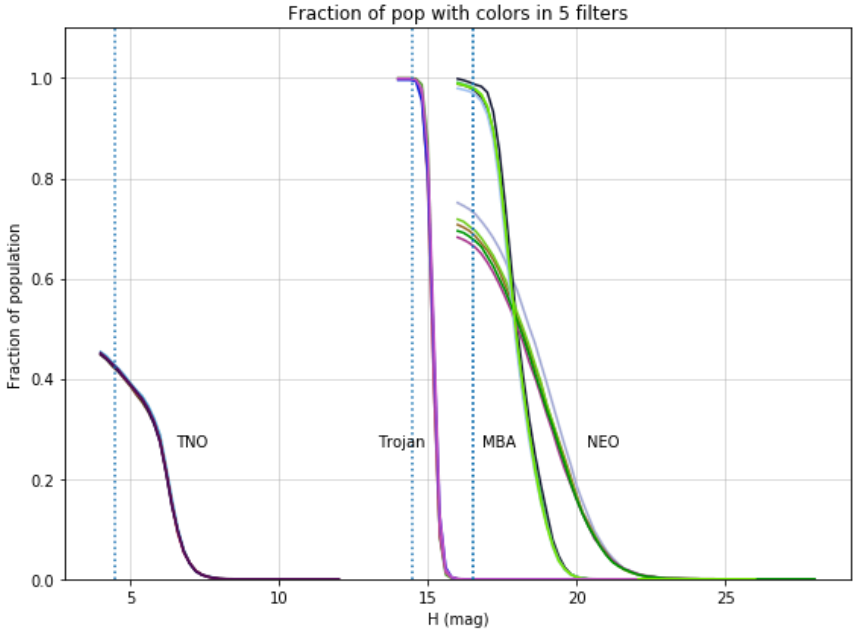


	NEO H=22	MBA H=21.25	Trojan H=18	TNO H=7.5
baseline_1exp_pairsame_10yrs	67.3	59.2	57.5	57.7
roll_mod2_sdf0.05mixed_10yrs	65.3	57.0	58.2	56.9
roll_mod2_sdf0.20mixed_10yrs	65.3	57.1	57.3	56.7
roll_mod3_sdf0.05mixed_10yrs	64.3	55.0	58.5	56.5
roll_mod3_sdf0.20mixed_10yrs	64.9	55.9	58.7	56.8

~2-3% losses for NEOs and MBAs, slightly better with higher background visits

Rolling cadence FBS 1.2 runs

- ‘rolling cadence variations’

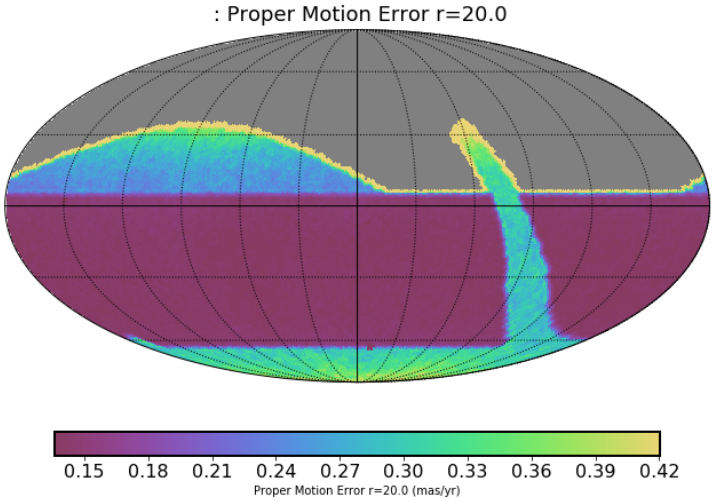


	NEO H=16.5	MBA H=16.5	Trojan H=14.5	TNO H=4.5
baseline_1exp_pairsame_10yrs	73.3	98.9	100.0	42.6
roll_mod2_sdf0.05mixed_10yrs	68.9	97.7	99.8	41.9
roll_mod2_sdf0.20mixed_10yrs	69.9	98.1	99.8	42.2
roll_mod3_sdf0.05mixed_10yrs	66.6	97.0	99.5	42.1
roll_mod3_sdf0.20mixed_10yrs	67.9	97.9	99.8	42.3

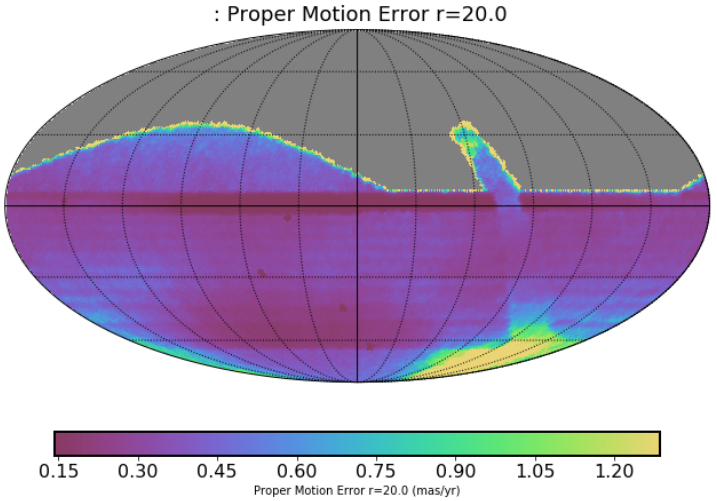
~4-7% fewer NEOs obtaining measurement of grizy colors

Rolling cadence FBS 1.2 runs

Uncertainty in the proper motion of an r=20 star

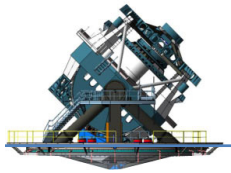


Baseline WFD median:
0.14 mas



simple_roll_mod10_sdf0.20 WFD :
0.30 mas

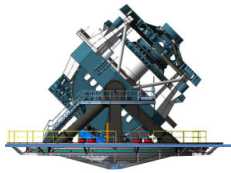
If there is no covariance, the proper motion uncertainty only depends on when observations happen and the centroiding errors.
If we do a very aggressive rolling cadence, proper motion error blows up.
Need full sky coverage in year 1 and 10 to keep proper motion errors low.



Analysis

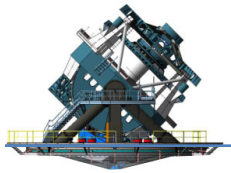
- Rolling cadence
- Motivated by desire to increase cadence for WFD observations (better discovery for transients)
  - Rolling cadence does better for SN discovery, but doing pairs in mixed filters is largest improvement
- Has some negative impact on discovery and characterization of inner solar system (NEO, MBA) objects
  - Check wider range of rolling cadence runs
  - Run simulations with higher background rate?
- Likely to need full-sky coverage each year for difference imaging templates & calibration

- Likely we're missing some metrics sensitive to rolling cadence variations



What's next? (FBS 1.3 and beyond)

- Additions
  - Fix bug in depth calculation (1x30 vs 2x15)
  - Improve DD sequences (DESC) and add AGN DD sequences
  - Add mini-survey variations (N, S, GP) to evaluate range of impacts on time requirements
  - Run footprints with WFD held at 90%, as well as held at 825 visits/pointing
- BUT need improvements in metrics as well.
  - Need to push metric development (work with Fed)
  - Solar system metrics need addition of MBC and resonant TNO populations (more sensitive)
  - Need more samples of transients (and requirements)
  - Footprint metric (galaxy counts?)



What's next? (FBS 1.3 and beyond)

- Beyond 1.3:
  - Bright planet (and satellite) avoidance
  - Add more more sophisticated sequences for WFD (specifications on filters for next-night observations)
  - Tackle remaining queue
- Run releases every other month (Sep, Nov, Jan.)
- Write ups and respond to what we're learning

Still in the queue

- AGN DDF
- Akari and WFIRST/Euclid DDF experiments
- Bulge and low galactic latitude variations
- LMC/SMC mini-surveys
- Twilight NEO survey
- Twilight DCR
- Mini-surveys in the North
- Season extension (not super well defined)
- Anti-alias timing (is it really a problem?)