Solar System Metrics & Survey Strategy

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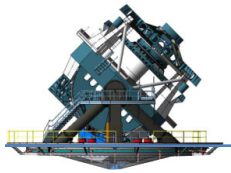
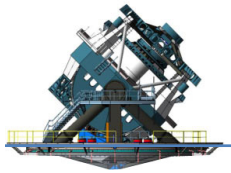
LSST2019 Project & Community Workshop
August 13, 2019



Current Status

- WP Nov 2018 / SAC guidelines May 2019 / Simulations..
- 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

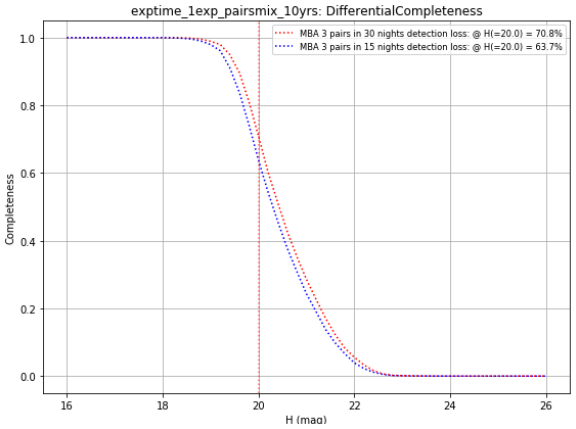


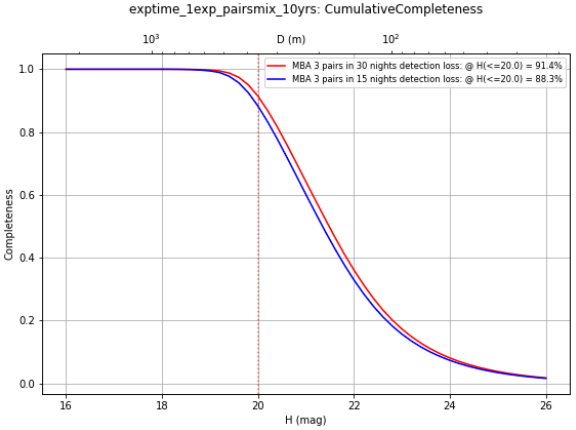
Solar system metrics

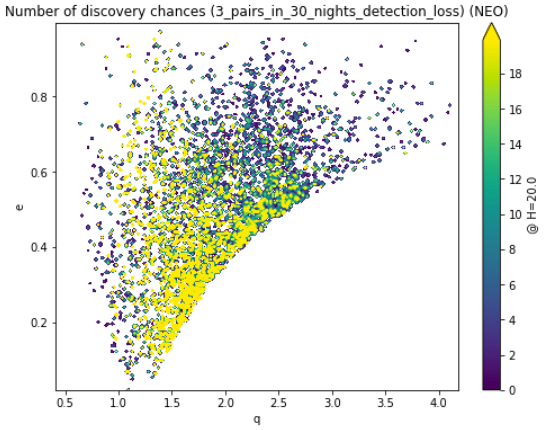
- To calculate metrics, first need to generate simulated observations of the objects
  - NEO (Granvik), MBA (S3M), Trojan (S3M), TNO (CFEPS L7)
  - + sims_movingObjects
  - https://github.com/lsst-sssc/SSSC_test_populations_gitlfs

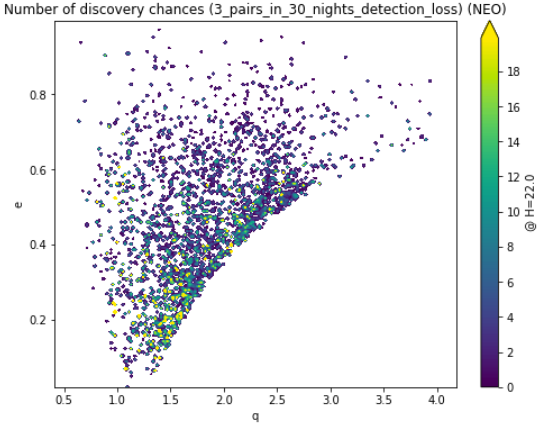
Solar system metrics

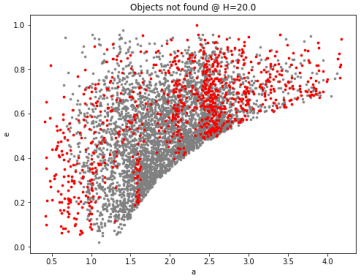
- Discovery metrics (as previously)
  - 3 pairs in 15 nights
  - 3 pairs in 30 nights
  - .. 3 pairs in 12 nights, 20 nights
  - .. 4 pairs in 20 nights, 3 triplets in 30
  - .. Single detection, single pair
  - .. 3x15 & 3x30 @ SNR=3,4,5.
  - HighVelocity (trailing) pair

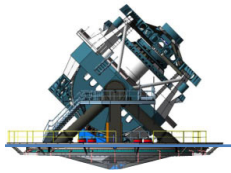








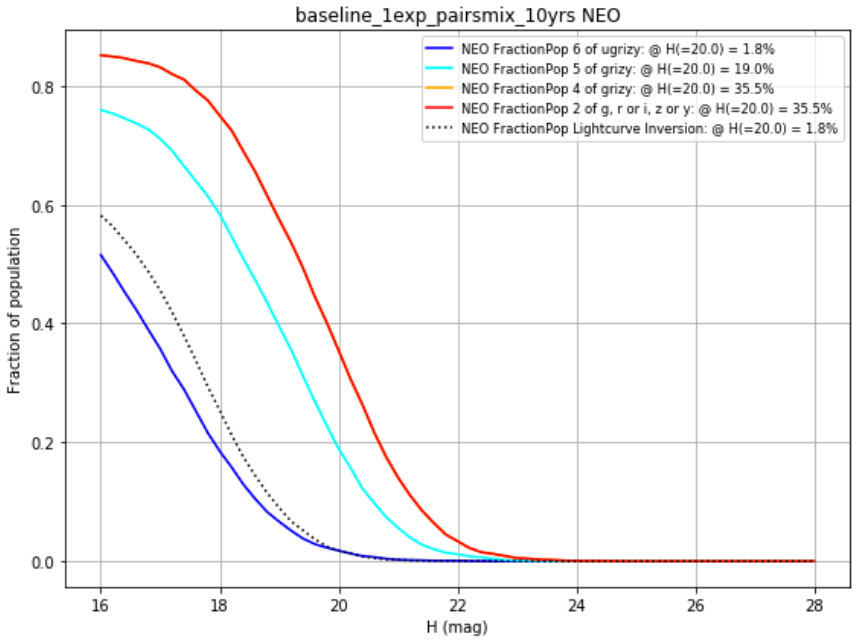


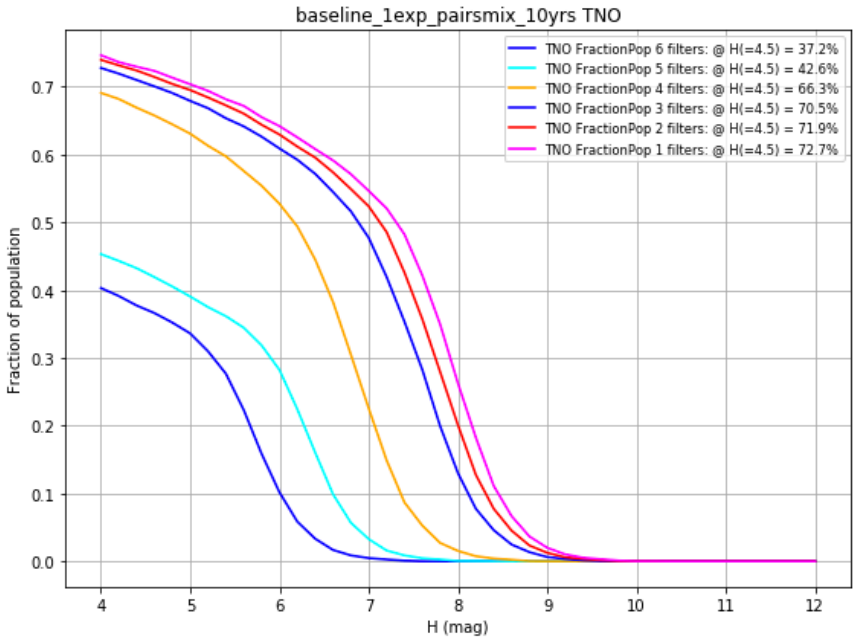


Solar system metrics

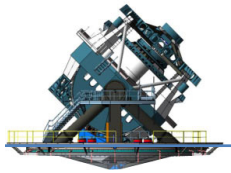
- Characterization metrics (as previously)
  - “Chance of detecting activity”
    - Bin time (or mean anomaly) over survey (or orbit) and build histogram of visits - what fraction of bins received a visit?
  - Inner solar system
    - Lightcurve inversion (updated metric)
    - Color determination (10+ SNR-weighted observations)
      - g + ([r or i] OR [z or y] (2 colors)
      - 4 of grizy
      - 5 of grizy
      - 6 of ugrizy
  - Outer solar system
    - Lightcurve/Color in 1, 2, 3, 4, 5 or 6 filters (30+ obs in first filter, 20+ in secondary)

Solar system metrics



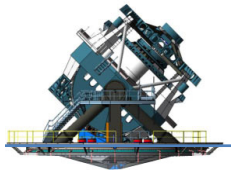


For the runs described next, these plots
for NEO, MBA, Trojan & TNO populations online at
http://astro-lsst-01.astro.washington.edu:8081
.. will also find a link for downloading full outputs if interest



Solar system metrics

Pending:
Incorporate resonant TNO populations
* Should get very red SED [Wes Fraser]
Incorporate MBC population
* Need MBC magnitude and/or updated metric [Mike Kelly]



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

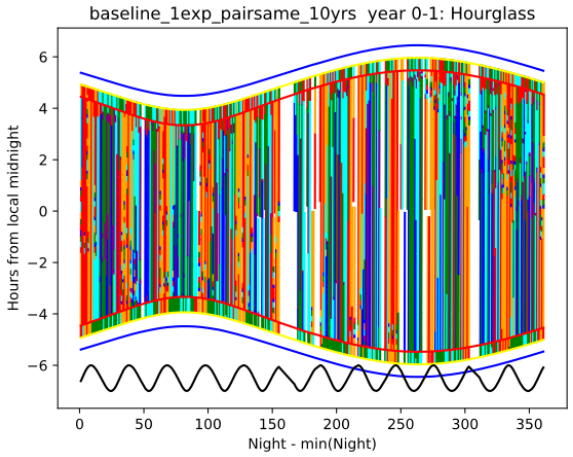
Bonus Experiments

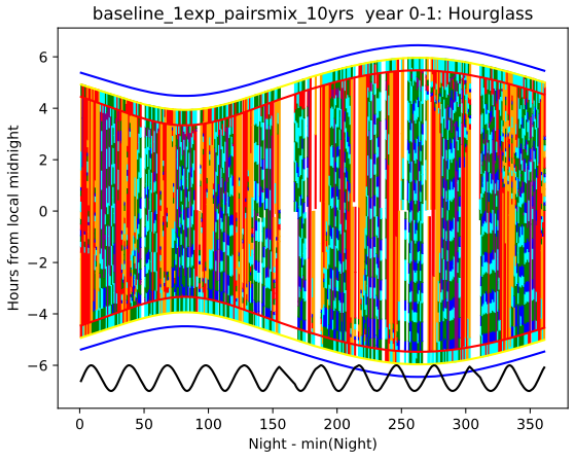
- Pathological footprint
- Variable exposure time
- AltSched like behavior
- Camera rotator dithering
- Smarter rolling cadence

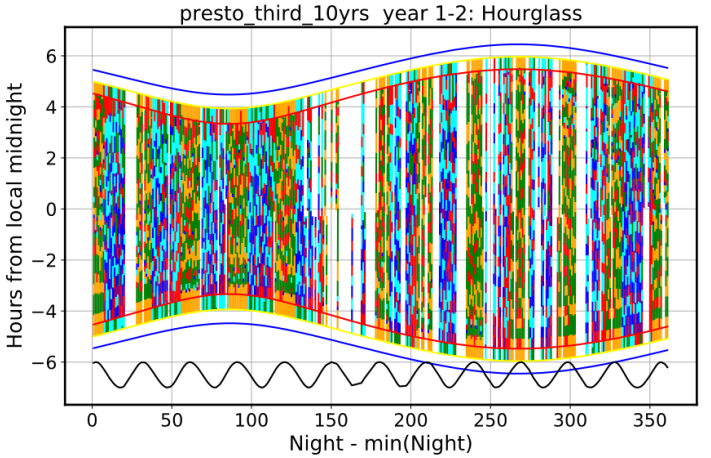
Intra-night visits FBS 1.2 runs

Baseline-like sims

- 1x30s snaps in a visit
- 2x15s snaps in a visit
- g+g, r+r, i+i pairs (u, z, y not paired) PairSame
- g+r, r+i, i+z pairs (u, some z, y not paired) PairMix
- g+i…40-120min later+g, r+z…+r Presto

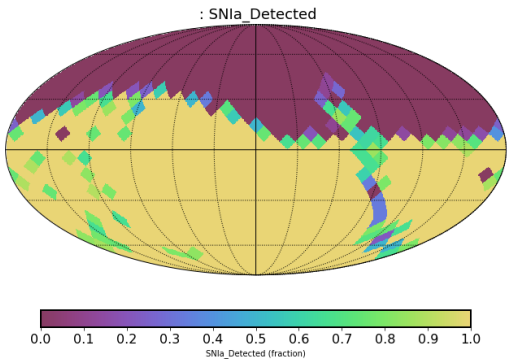




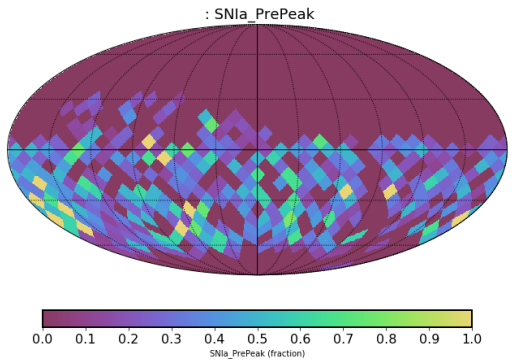


Intra-night visits FBS 1.2 runs

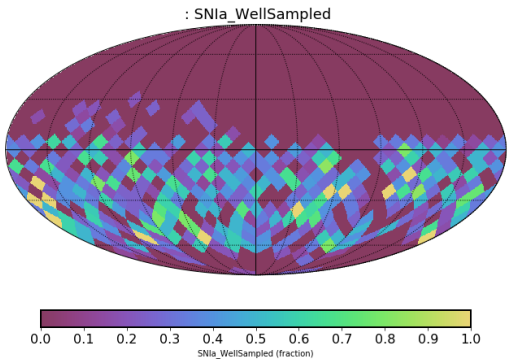
4k Type Ia SNe



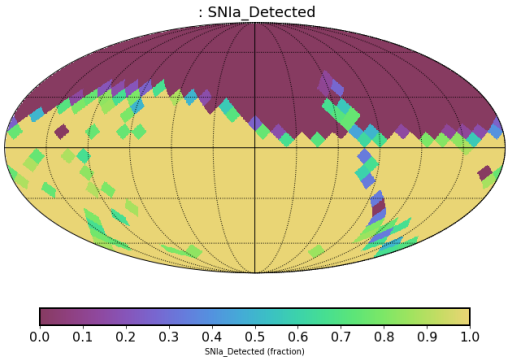
Pairs mixed 62% detected



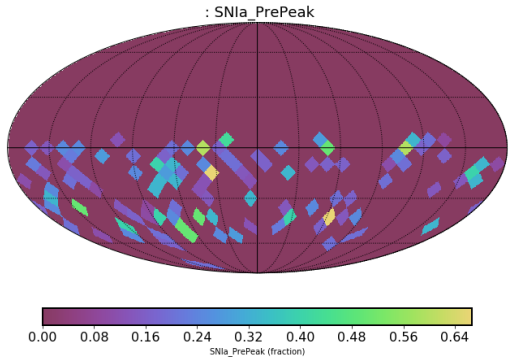
15% measured pre-peak



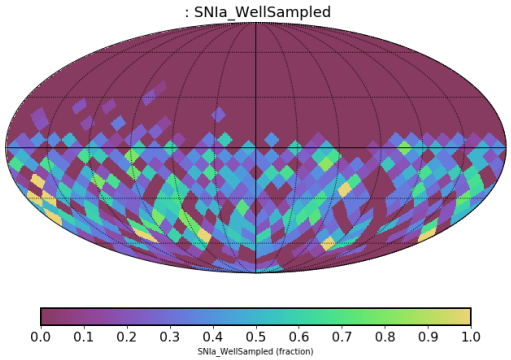
17% “well-sampled”



Pairs same 62% detected



3% measured pre-peak

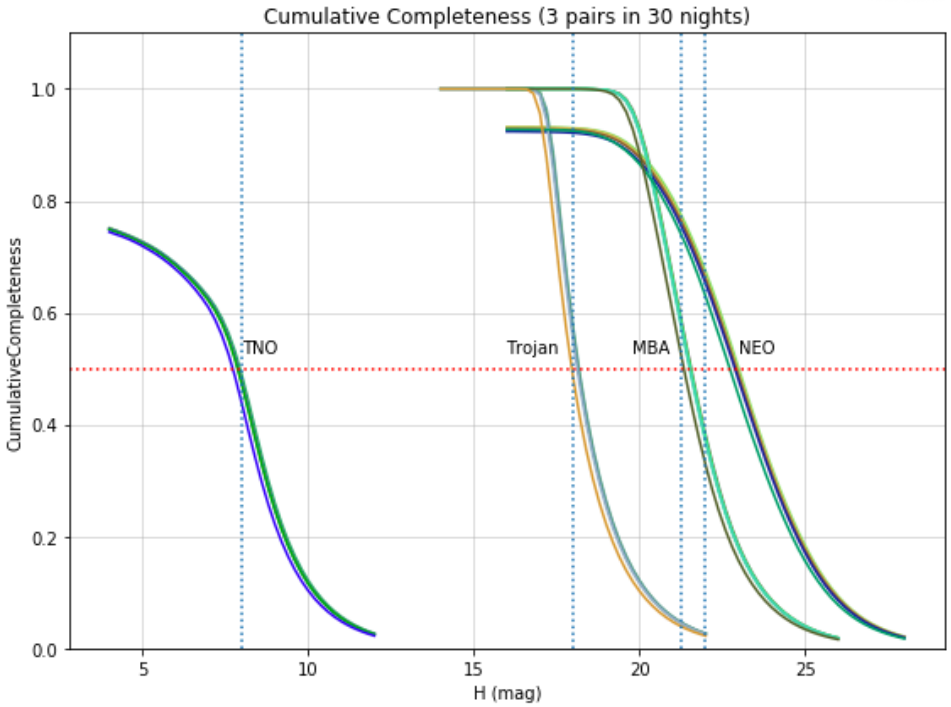


16% “well-sampled”

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% pairs same -> mix

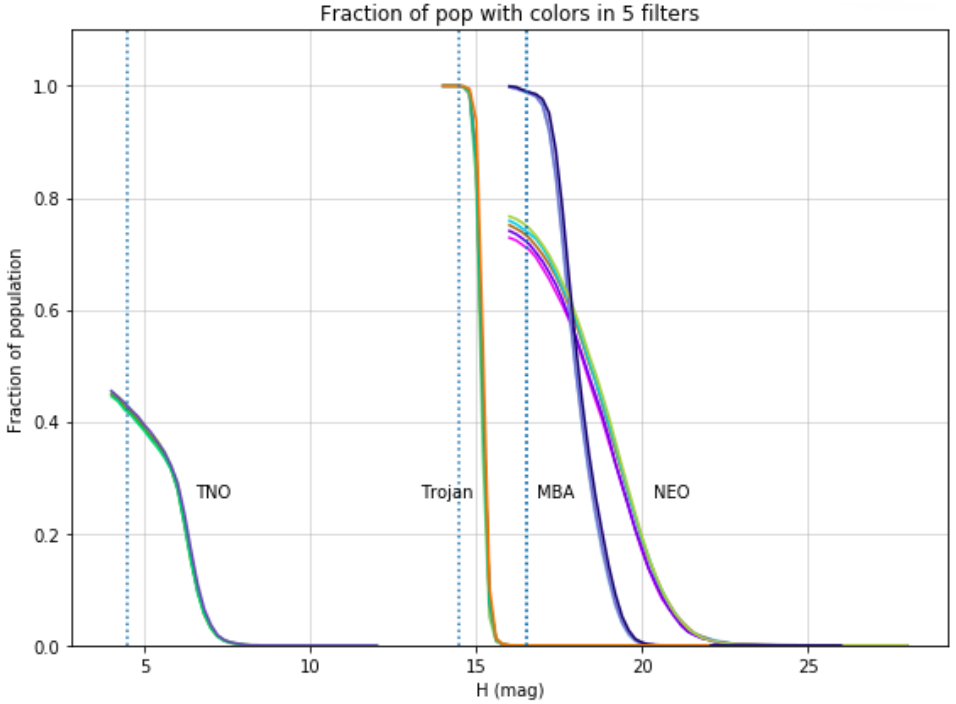
~2% mix pairs + 2x15s

~5-6% presto_third

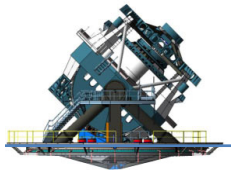
Intra-night visits FBS 1.2 runs

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

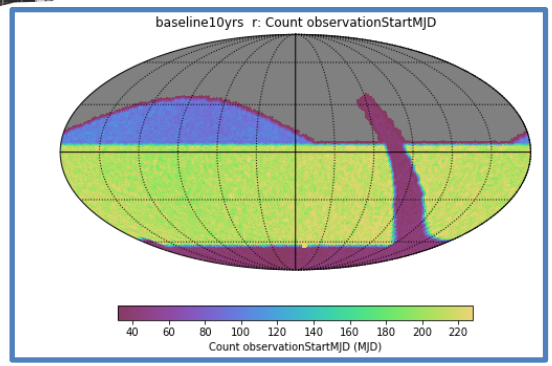


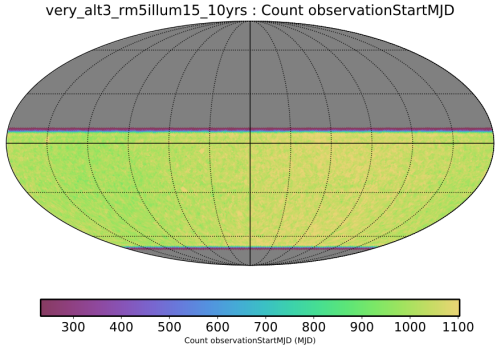
Analysis

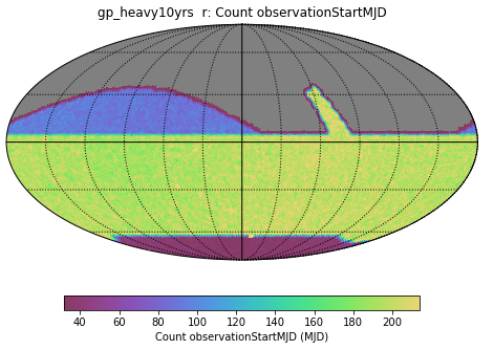
- Motivation for pairs in different filters comes from characterizing (slowly) changing transients
- Increases pre-peak sampling of SNIa (3% - 15%)
- Pushback comes from worry that SSOs will be harder to discover - there is some impact on SSO discovery, particularly with presto_third in its current form.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

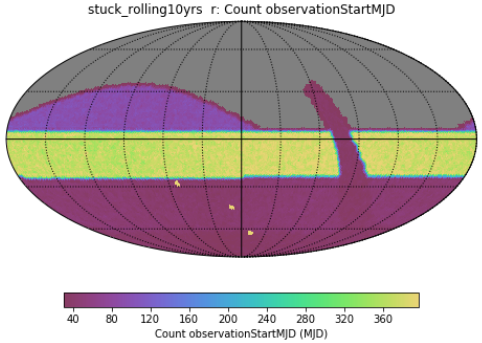
	Nvisits
baseline_1exp_nopairs_10yrs	100.8
baseline_1exp_pairsame_10yrs	100.0
baseline_1exp_pairsmix_10yrs	97.9
baseline_2exp_pairsame_10yrs	92.4
baseline_2exp_pairsmix_10yrs	90.5

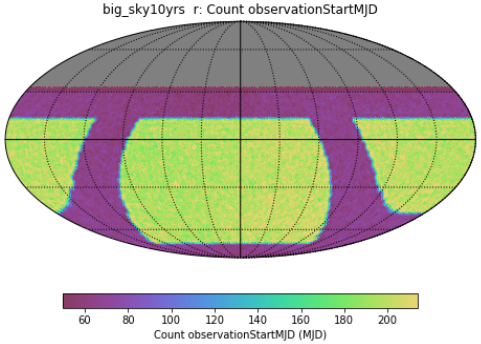
FBS 1.2 runs : footprints

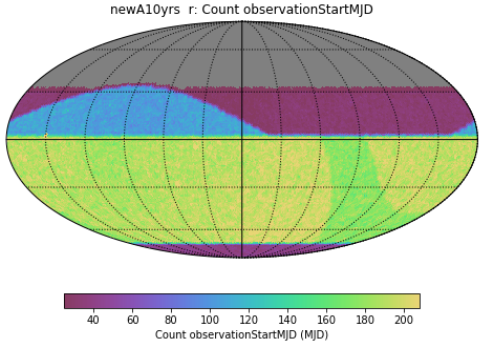


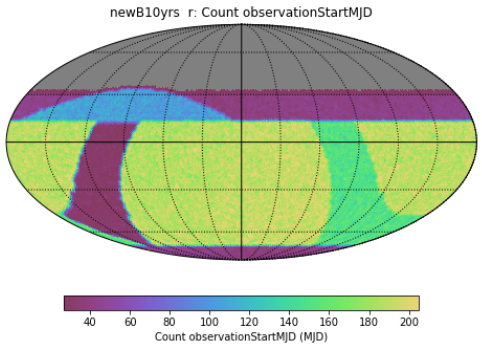


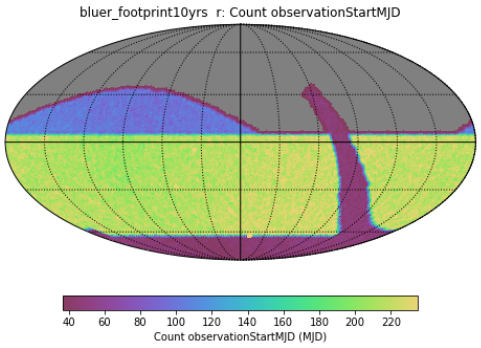


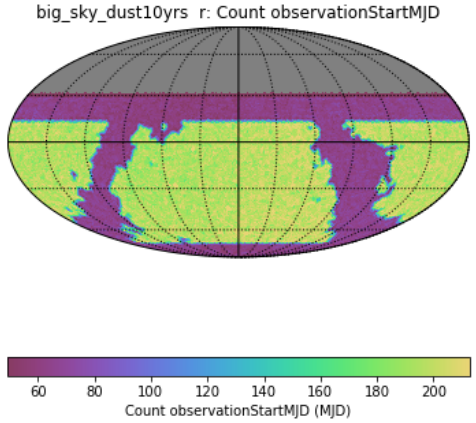








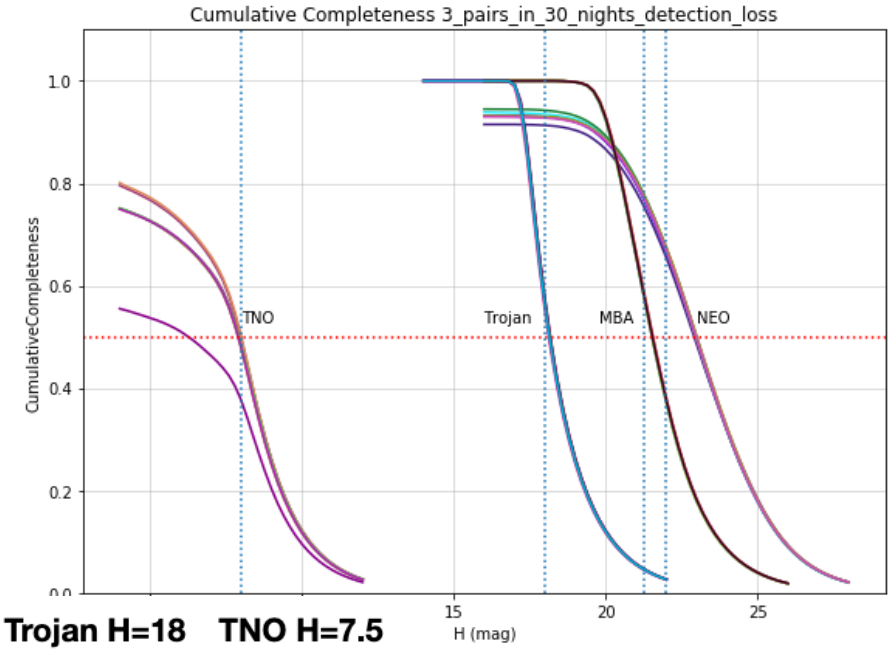




WFD footprint FBS 1.2 runs

- ‘WFD footprint’

More coverage in the north improves discovery of TNOs.



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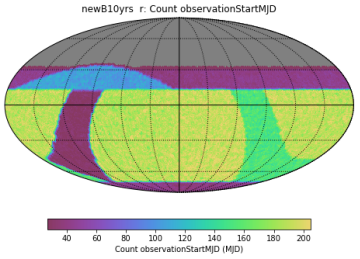
baseline_1exp_pairsame_10yrs	67.3	59.2	57.5	57.7
baseline_1exp_pairsmix_10yrs	66.5	58.7	56.6	57.0
very_alt3_rm5illum50_10yrs	65.4	58.3	57.0	43.2
newA10yrs	67.0	58.0	54.9	59.5
newB10yrs	67.1	58.6	55.9	60.0
bluer_footprint10yrs	67.5	59.0	57.5	57.2
gp_heavy10yrs	66.8	58.5	56.1	57.1

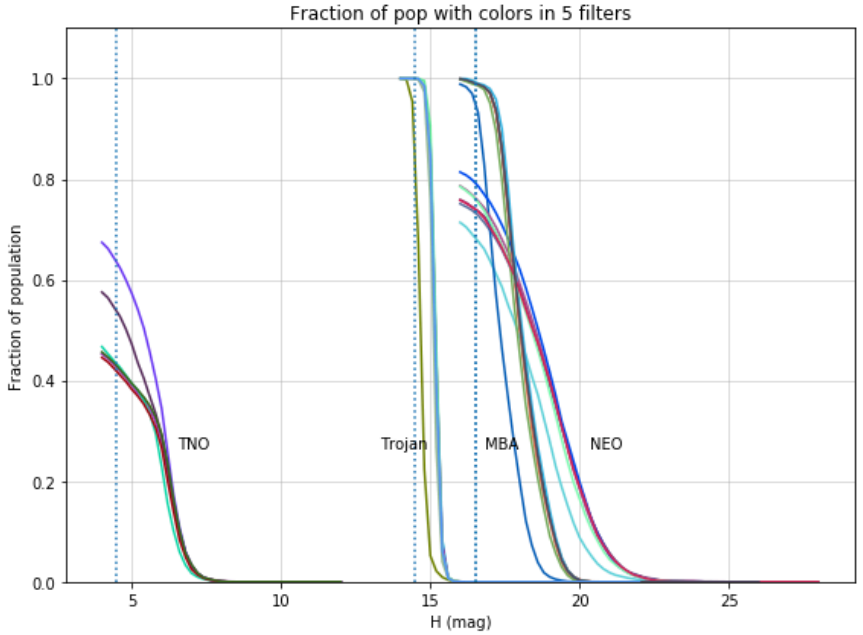


WFD footprint FBS 1.2 runs

- ‘WFD footprint’

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

Need to add MBC & resonant TNO



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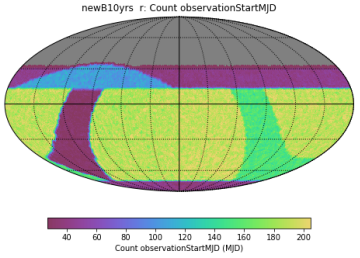
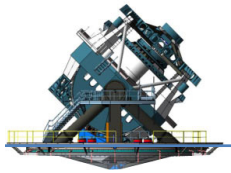
baseline_1exp_pairsame_10yrs	67.3	59.2	57.5	57.7
baseline_1exp_pairsmix_10yrs	66.5	58.7	56.6	57.0
very_alt3_rm5illum50_10yrs	65.4	58.3	57.0	43.2
newA10yrs	67.0	58.0	54.9	59.5
newB10yrs	67.1	58.6	55.9	60.0
bluer_footprint10yrs	67.5	59.0	57.5	57.2
gp_heavy10yrs	66.8	58.5	56.1	57.1





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

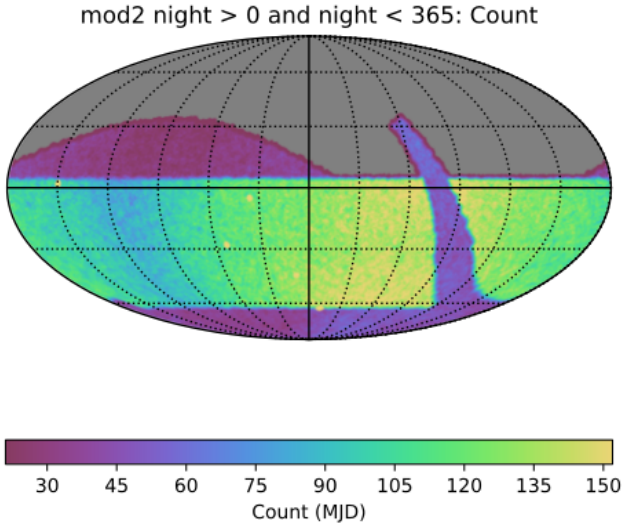
- Return to DESC for clarification on metrics
- Redo footprint with E(B-V) cut exactly (done)
- Redo footprint with 90% WFD and with 825 visits .. look at options to increase visits in N/S (counter poor seeing)

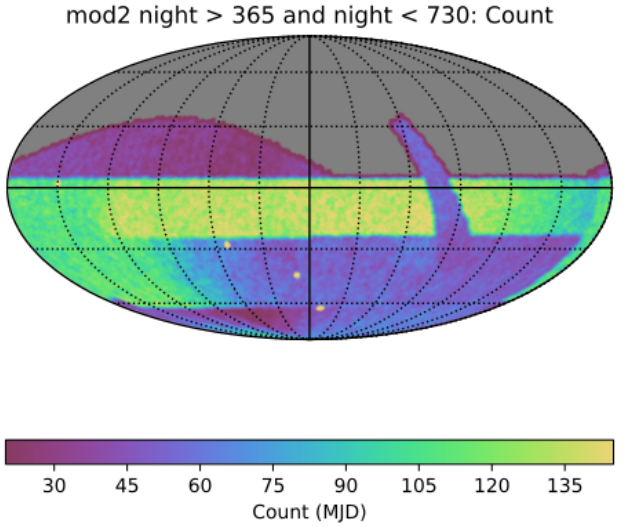
FBS 1.2 : rolling cadence

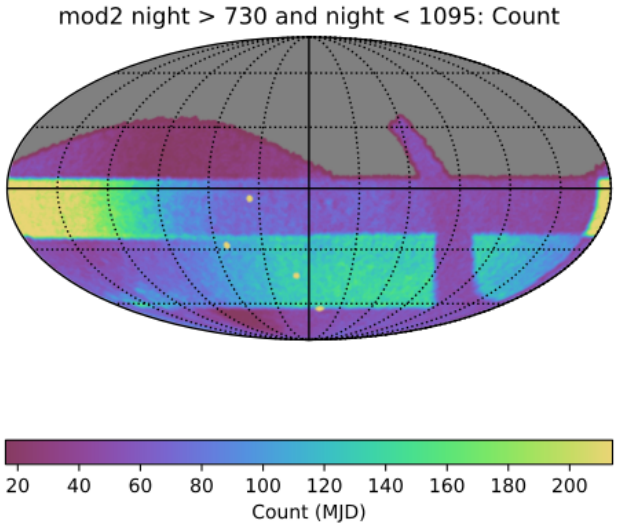
Start off normal, then divide WFD in (half) and alternate emphasis on north and south

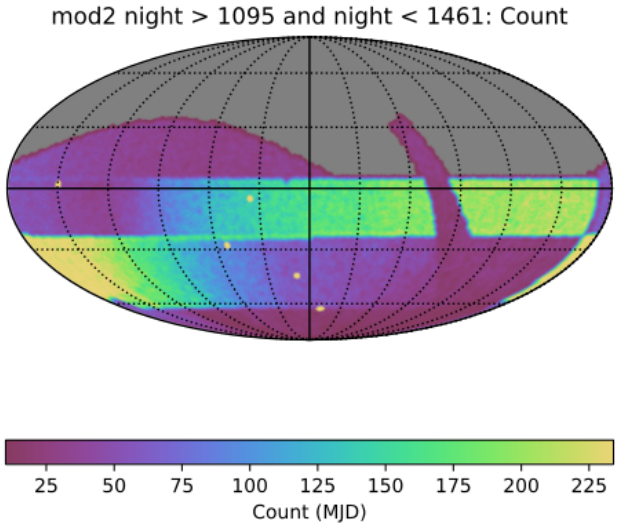
Year 1 like baseline, WFD gets 120 observations/yr

Rolling, get 25 or 215 observations per year



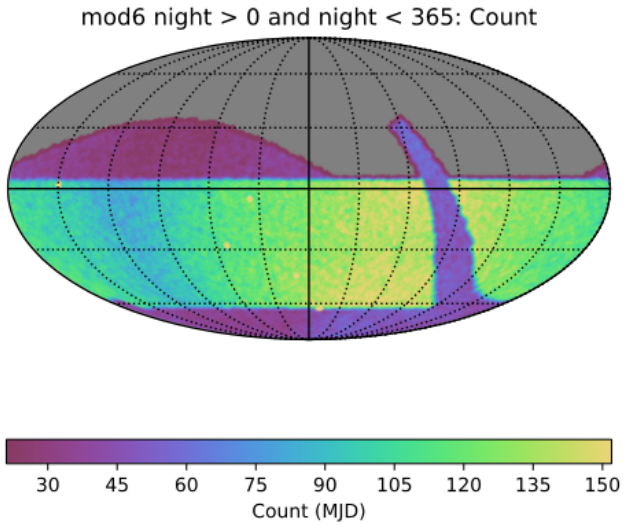


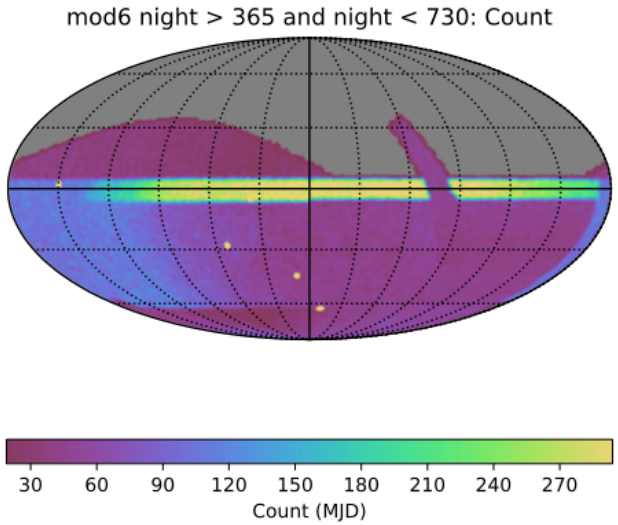


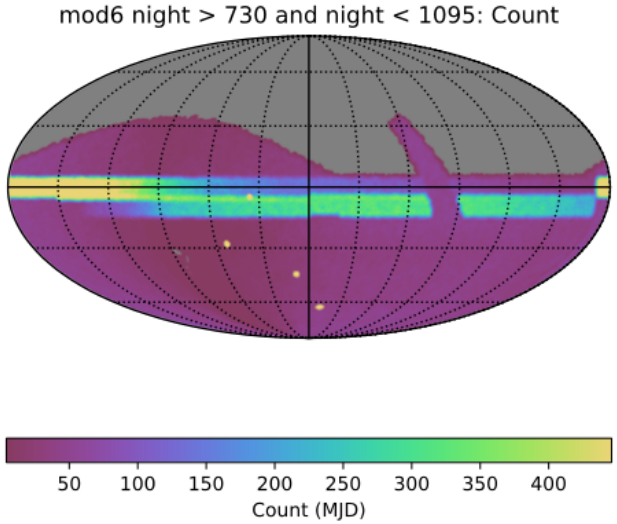


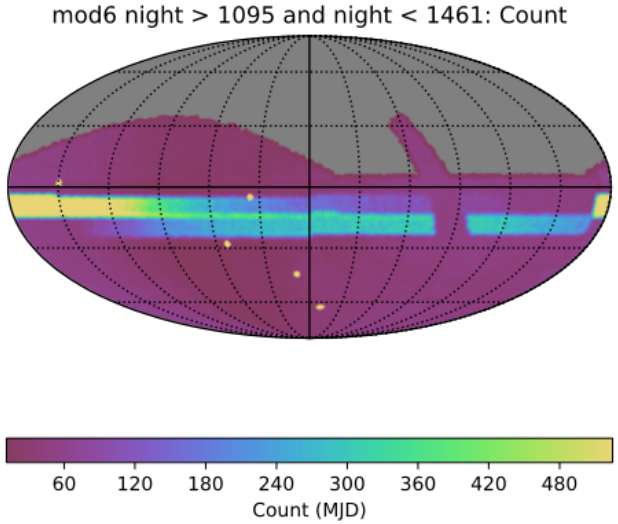
FBS 1.2 : rolling cadence

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



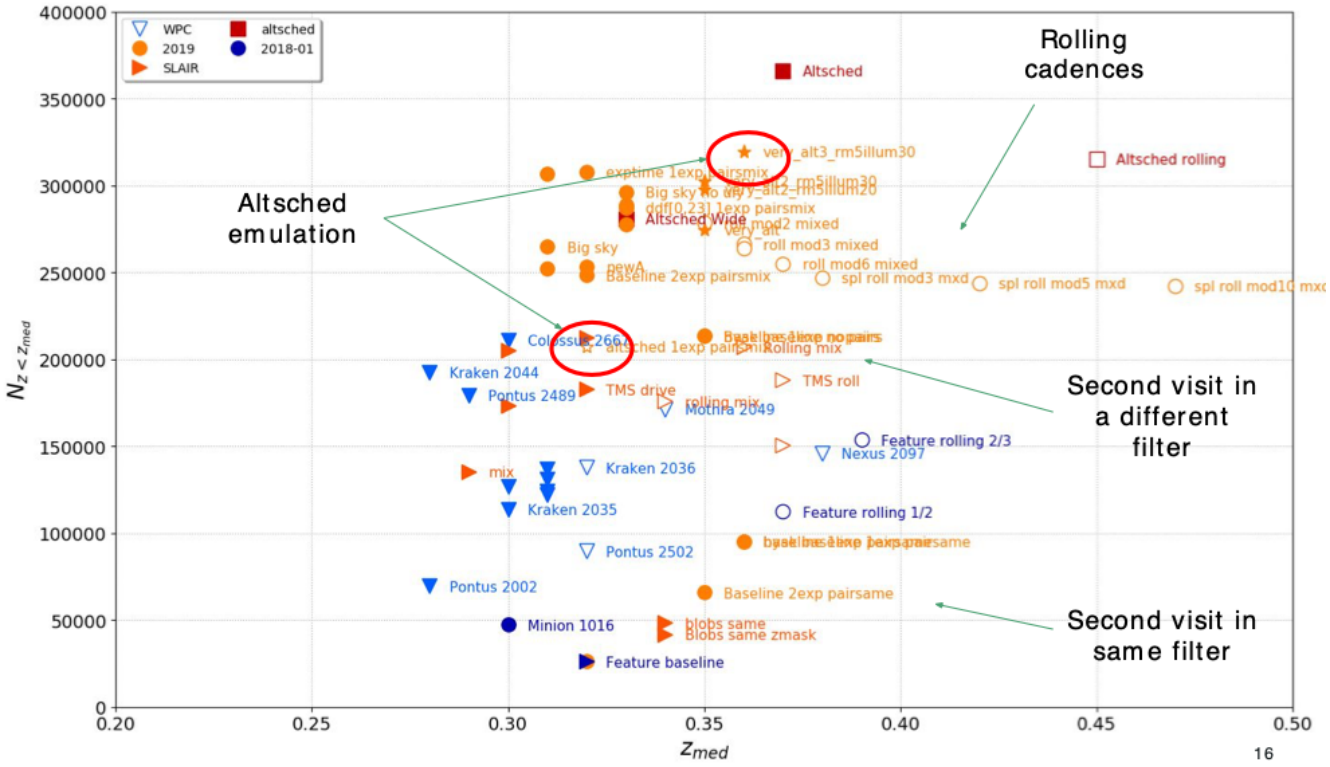






Rolling cadence FBS 1.2 runs

- ‘rolling cadence variations’



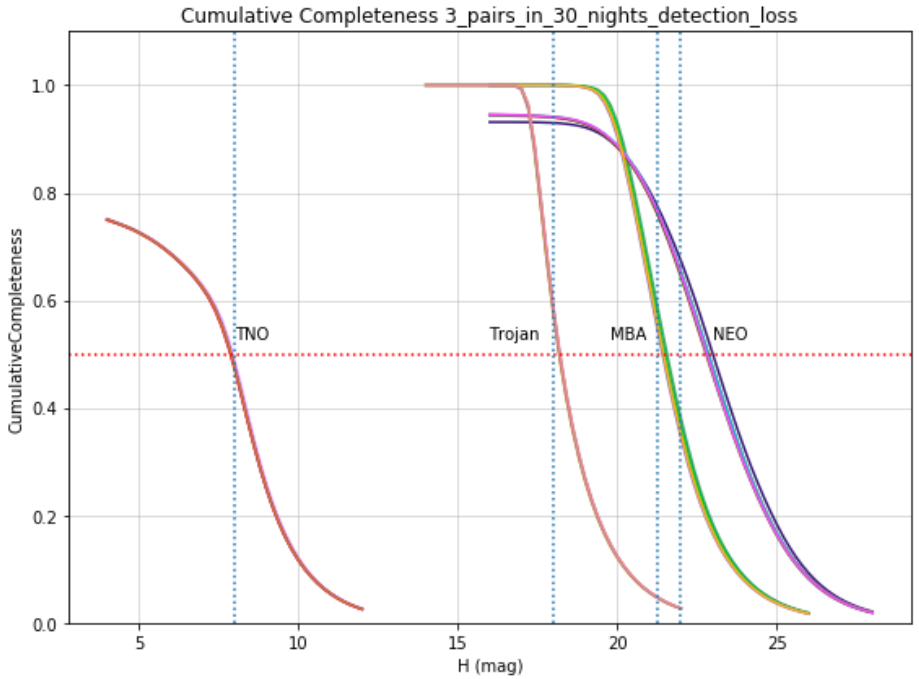
SNe group has been running more intensive analysis and giving feedback on sims

From Nicolas Regnault

Rolling cadence FBS 1.2 runs

- ‘rolling cadence variations’

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

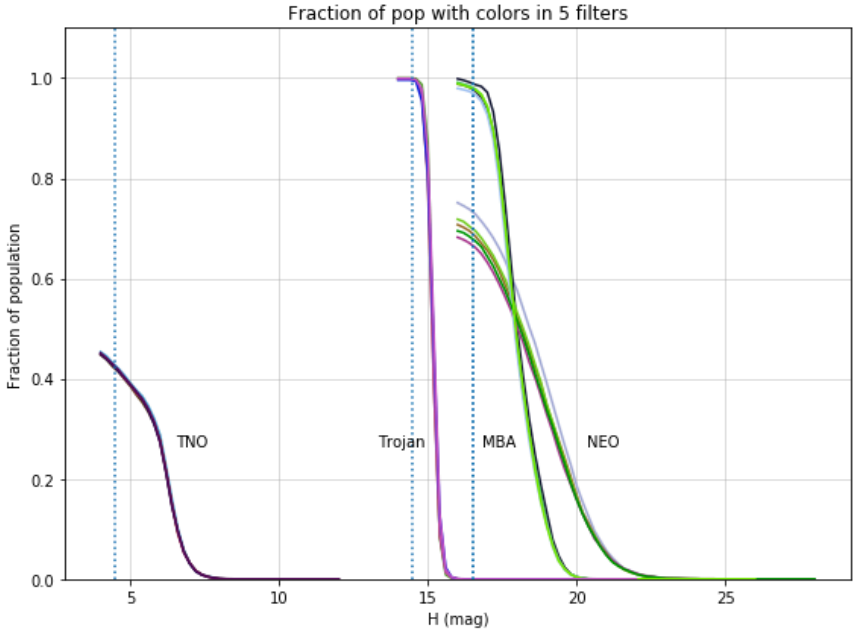


	NEO H=22	MBA H=21.25	Trojan H=18	TNO H=7.5
baseline_1exp_pairsame_10yrs	67.3	59.2	57.5	57.7
roll_mod2_sdf0.05mixed_10yrs	65.3	57.0	58.2	56.9
roll_mod2_sdf0.20mixed_10yrs	65.3	57.1	57.3	56.7
roll_mod3_sdf0.05mixed_10yrs	64.3	55.0	58.5	56.5
roll_mod3_sdf0.20mixed_10yrs	64.9	55.9	58.7	56.8

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

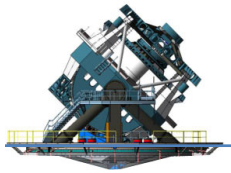
Rolling cadence FBS 1.2 runs

- ‘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

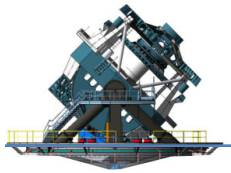
~4-7% fewer NEOs obtaining measurement of grizy colors



Analysis

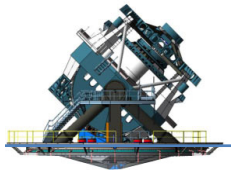
- Rolling cadence
- Motivated by desire to increase cadence for WFD observations (better discovery for transients)
  - Rolling cadence does better for SN discovery, but doing pairs in mixed filters is largest improvement
- Has some negative impact on discovery and characterization of inner solar system (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?)