Optimisation of the SALT schedule

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Optimising SALT

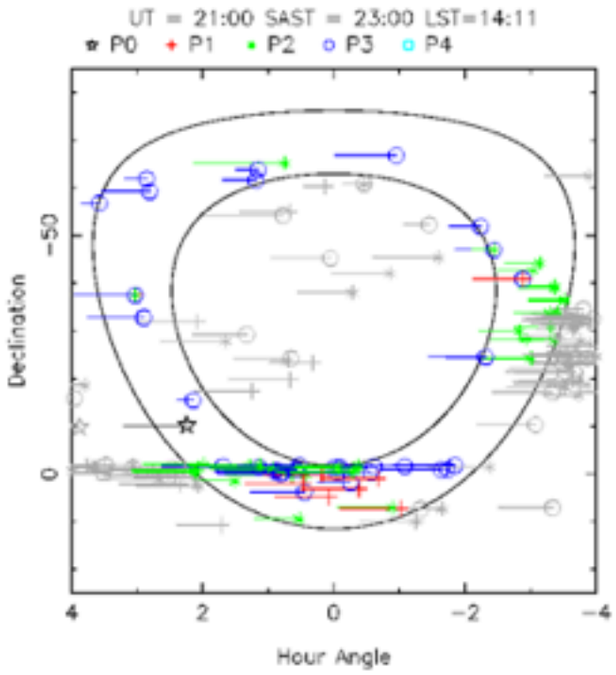
- A very complex combinatorial optimisation problem (e.g. travelling salesman)
- Five scientific priorities:
  - P0 (time critical or ToO)
  - P1 (highest), P2, P3 (lowest)
  - P4 (poor weather) - not charged
- Restricted object visibilities (some wiggle room)
- Changing observing conditions (e.g. seeing, cloud)
- Current approach: Observe best ‘now’. Cannot plan ahead easily (may miss high priority future blocks)

SALT Hour Angle Investigation Tool

Shows targets visible to SALT now

Helps SA make an informed decision

N(Targets)	585
Proposal Code	2014-1- submit
PI (surname)	submit
Moon	Any submit
Transparency	Any submit
Seeing (min)	0 submit
Seeing (max)	10 submit
Priority	0,1,2,3 submit
Manual	SAST 23.00 HA min 4 max -4 Dec min 25 max -85 REPLOT
SAST controls	-1h -0.2h +0.2h +1h
Windowing	x1 -4 x2 -4 y1 25 y2 -85 REPLOT WEST EAST EXTRAGALACTIC MAGELLANIC DEFAULT
Reset all	RESET ALL



<-----targets move to left with increasing time

block length lines include acquisition

time critical targets are in pink and time windows are *not* yet considered

Loaded MOS masks have RSS mode in GREEN, missing ones are in RED.

Objects < 25 deg from Moon are not showed (if not time critical) and MD = Moon Distance (deg).

Multiple-visit objects now have date last obs (YYYY-MM-DD) and wait time.

CCAS blocked objects now have orange boxes and **CCAS warning on this page (azimuth=54.5-65.0 deg).**

Wiki page

Moon: 20:08 09:53 (72%)

P0

Select	Proposal	PI	Instrument	WM	ObsTime	East (SAST)	West (SAST)	Target	Rank	Coords	Visits	Seeing	Moon	MD	MP	Transparency	Progress
28805	2014-1-RU-004	McCully	RSS LS PG900	28805	3487	18:01 to 19:14	22:17 to 23:30	TOO-RUSN-PSNJ1157	Hi	11:57:44.44 -10:10:15.7	3 / 5 Last: 2014-05-17 Wait: 4.6 days	3.0	Any	118.1	100.0	Scattered Clouds	P0: 59.8% [10461/17500]

P1

Select	Proposal	PI	Instrument	WM	ObsTime	East (SAST)	West (SAST)	Target	Rank	Coords	Visits	Seeing	Moon	MD	MP	Transparency	Progress
28308	2014-1-IUCAA-001	Dutta	RSS LS PG3000	28308	3168	19:58 to ----	---- to 00:16	J131938.76-004940.0	Hi	13:19:38.76 -00:49:40.0	0 / 1	2.0	Dark	101.5	14.6	Scattered Clouds	P1: 10.6% [3253/30600] P2: 0.0% [0/5400] P3: 0.0% [0/16200]
28322	2014-1-IUCAA-001	Dutta	RSS LS PG3000	28322	2668	19:58 to ----	---- to 00:16	J131938.76-004940.0	Hi	13:19:38.76 -00:49:40.0	0 / 1	2.0	Dark	101.5	14.6	Scattered Clouds	P1: 10.6% [3253/30600] P2: 0.0% [0/5400] P3: 0.0% [0/16200]
28310	2014-1-IUCAA-001	Dutta	RSS LS PG900	28310	2953	21:17 to ----	---- to 00:33	J140731.99+044949.0	Hi	14:07:31.99 +04:49:49.0	0 / 1	2.0	Dark	91.3	14.6	Scattered Clouds	P1: 10.6% [3253/30600] P2: 0.0% [0/5400] P3: 0.0% [0/16200]
28384	2014-1-IUCAA_UW-001	m	RSS LS PG900	28384	3553	20:17 to ----	---- to 00:26	J133356.02+001229.1	Hi	13:33:56.02 +00:12:29.1	0 / 1	1.5	Dark	98.3	14.6	Thin Clouds	P1: 0.0% [0/42640] P2: 0.0% [0/24160] P3: 0.0% [0/28750]
28611	2014-1-RSA_OTH-002	Vaisanen	RSS LS PG900	28611	3331	22:42 to ----	---- to 01:20	CGCG 049-057	Hi	15:13:13.10 +07:13:32.0	0 / 1	2.0	Dark	76.2	14.6	Thin Clouds	P1: 11.3% [3131/27600] P3: 0.0% [0/24000]
28676	2014-1-RSA_OTH-009	Viljoen	RSS LS PG900	28676	3173	21:34 to ----	---- to 01:11	Candidate 24726	Med	14:35:03.30 +03:06:40.0	0 / 2	2.0	Dark	84.2	14.6	Thin Clouds	P1: 0.0% [0/28800]
28673	2014-1-RSA_OTH-009	Viljoen	RSS LS PG900	28673	3173	20:36 to ----	---- to 00:27	Candidate 431	Hi	13:44:07.70 +01:56:53.7	0 / 1	2.0	Dark	96.3	14.6	Thin Clouds	P1: 0.0% [0/28800]
28678	2014-1-RSA_OTH-009	Viljoen	RSS LS PG900	28678	3173	21:39 to ----	---- to 01:41	Candidate 5680	Med	14:52:23.90 +00:57:03.3	0 / 2	2.0	Dark	79.5	14.6	Thin Clouds	P1: 0.0% [0/28800]

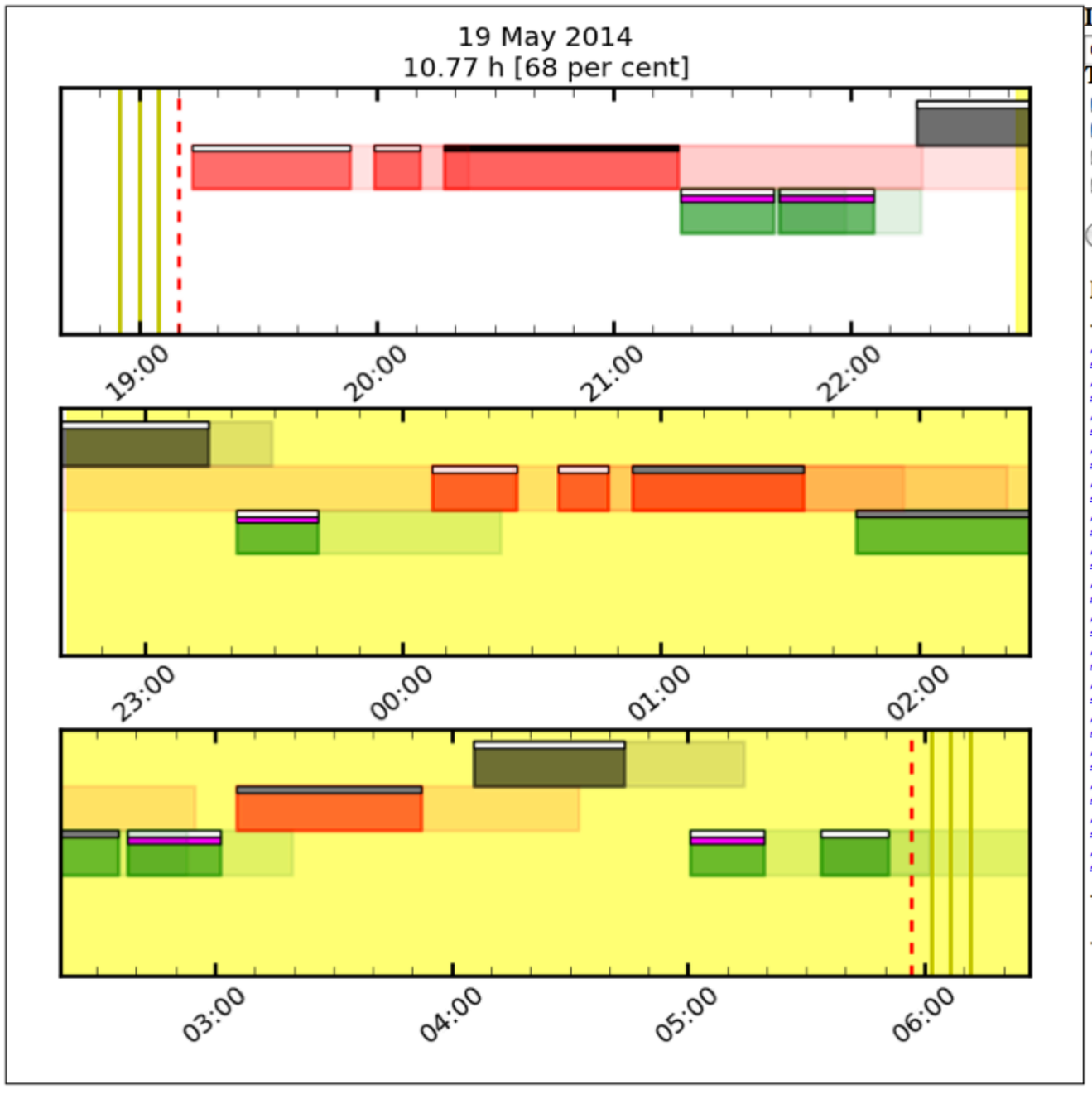
Fundamental requirement

- Queue based telescopes must deliver high completeness for top-ranked science programs
  - **Maximise completion of P1 and P2 blocks**
  - Take observations in most suitable conditions based on requirements specified by PI
- Solution: Create software to optimise the SALT queue, producing an automated schedule for the SA

SALT scheduling software

- Live query to science database
- Object-oriented Python code (using datetime)
  - SubBlock class
    - A schedulable unit - west or east track
  - Queue class
    - Gathers the SubBlocks together
    - Allows a queue to be manipulated and optimised
- Web interface (installed on web.salt.saao.ac.za)
  - Choose observing conditions
  - Display queue with matplotlib and HTML

timeline



filters

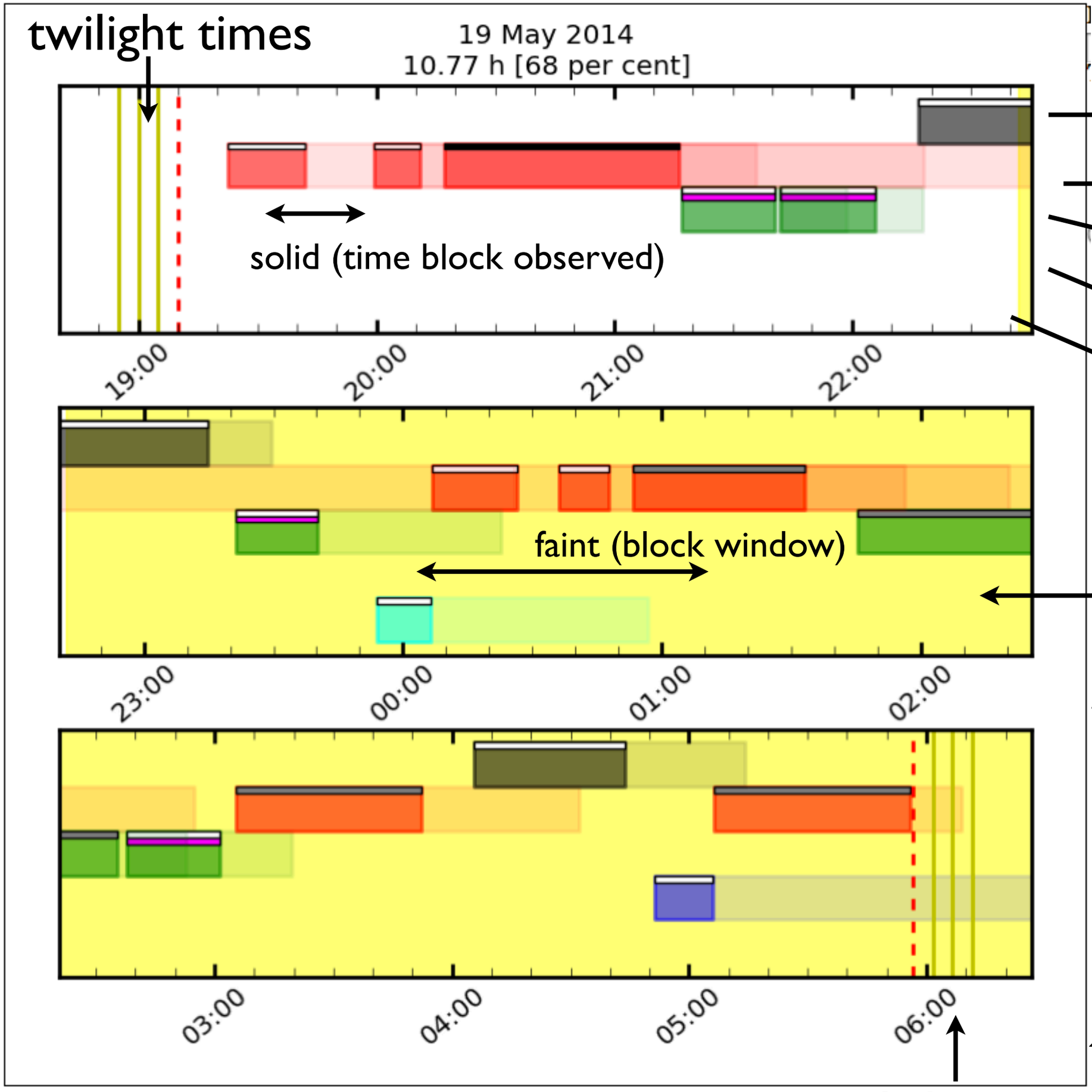
Date: 2014/05/19
0 **<= Seeing <=** 10
Transparency: Any
☑ **P0** ☑ **P1** ☑ **P2** ☐ **P3** ☐ **P4**
☑ **RSS** ☑ **SCAM** ☑ **HRS** ☑ **BVIT**
☐ **Use alternate start time** 14:38
☐ **Ignore TimeCritical Moon**

submit

ID	Priority	Proposal	PI	Instr	Clouds	OT	Seeing	Start	End	Gap
-	-	Twilight	-	-	-	-	-	-	19:10	+195
28813	P1 Hi	2014-1-UKSC-001	Holdsworth	HRS	Any	2400	4.0	19:13	19:53	366
28295	P1 Med	2014-1-HET_UC-001	Endl	HRS	Thin	690	2.0	19:59	20:10	375
28384	P1 Hi	2014-1-IUCAA_UW-001	m	RSS	Thin	3553	1.5	20:17	21:16	39
28335	P2 Hi	**2014-1-IUCAA-002**	Bhalerao	RSS	Any	1423	2.5	21:17	21:40	85
28330	P2 Hi	**2014-1-IUCAA-002**	Bhalerao	RSS	Any	1423	2.5	21:42	22:05	654
28805	P0 Hi	2014-1-RU-004	McCully	RSS	Scat	3487	3.0	22:16	23:14	385
28337	P2 Hi	**2014-1-IUCAA-003**	Bhalerao	RSS	Any	1134	2.5	23:21	23:40	1600
28299	P1 Hi	2014-1-HET_UC-001	Endl	HRS	Clear	1168	1.2	00:06	00:26	599
28295	P1 Med	2014-1-HET_UC-001	Endl	HRS	Thin	690	2.0	00:36	00:47	332
29079	P1 Hi	2014-1-UNC-002	Fuchs	HRS	Clear	2396	2.2	00:53	01:33	727
28710	P2 Hi	2014-1-RSA_OTH-020	Breytenbach	SCAM	Thin	3000	3.0	01:45	02:35	140
28330	P2 Hi	**2014-1-IUCAA-002**	Bhalerao	RSS	Any	1423	2.5	02:37	03:01	236
29134	P1 Hi	2014-1-DC-001	Wegner	RSS	Thin	2810	2.0	03:05	03:52	795
29192	P0 Hi	2014-1-DC-006	Fesen	RSS	Any	2310	3.0	04:05	04:43	987
28337	P2 Hi	**2014-1-IUCAA-003**	Bhalerao	RSS	Any	1134	2.5	05:00	05:19	860
28852	P2 Med	2014-1-UKSC_OTH-001	Haswell	RSS	Any	1037	3.0	05:33	05:50	+342
-	-	Twilight	-	-	-	-	-	05:56	-	-
-	-	Total Gaps	-	-	-	-	-	-	-	8717 (2.42 h)

block details

links to WM



a row for each priority

P0

P1

P2

P3

P4

night is subdivided into 3 parts

yellow shading moon is up

top stripe - moon

dark (black)

grey (grey)

bright (yellow)

any (white)

2nd stripe

time critical (magenta)

Date: 2014/05/19

0 <= Seeing <= 10

Transparency: Any

☑ **P0** ☑ **P1** ☑ **P2** ☑ **P3** ☑ **P4**

☑ **RSS** ☑ **SCAM** ☑ **HRS** ☑ **BVIT**

☐ **Use alternate start time** 14:38

☐ **Ignore TimeCritical Moon**

submit

Filters

alternative start time for the night

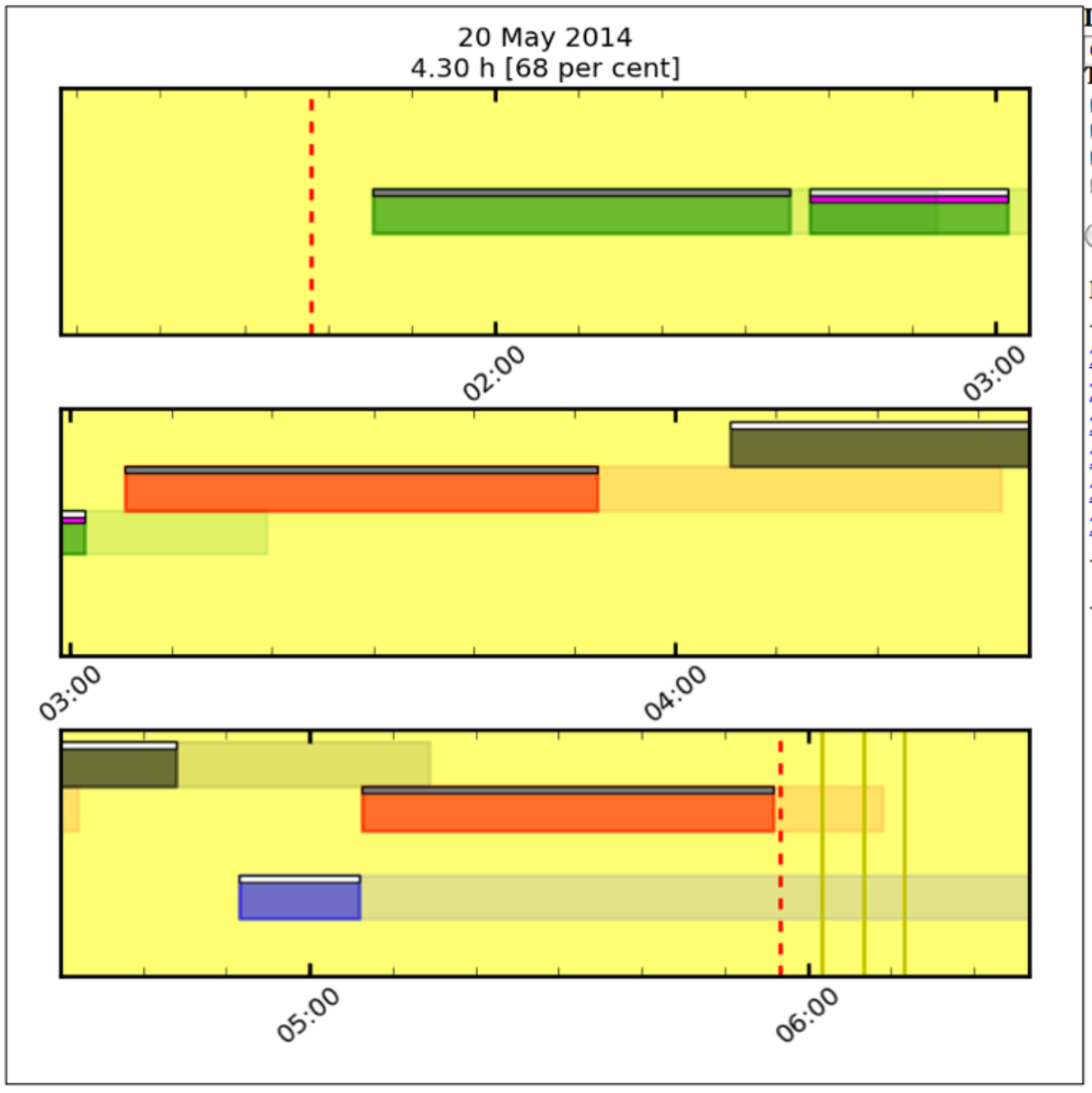
time to point to each block

Gaps time between blocks and twilight

total time not scheduled

ID	Priority	Proposal	PI	Instr	Clouds	OT	Seeing	Start	End	Gap
-	-	Twilight	-	-	-		- -	-	19:10	+750
28299	P1 Hi	2014-1-HET_UC-001	Endl	HRS	Clear	1168	1.2	19:22	19:42	1043
28295	P1 Med	2014-1-HET_UC-001	Endl	HRS	Thin	690	2.0	19:59	20:10	375
28384	P1 Hi	2014-1-IUCAA_UW-001	m	RSS	Thin	3553	1.5	20:17	21:16	39
28335	P2 Hi	**2014-1-IUCAA-002**	Bhalerao	RSS	Any	1423	2.5	21:17	21:40	85
28330	P2 Hi	**2014-1-IUCAA-002**	Bhalerao	RSS	Any	1423	2.5	21:42	22:05	654
28805	P0 Hi	2014-1-RU-004	McCully	RSS	Scat	3487	3.0	22:16	23:14	385
28337	P2 Hi	**2014-1-IUCAA-003**	Bhalerao	RSS	Any	1134	2.5	23:21	23:40	817
28145	P4 Hi	2014-1-AMNH-005	Pagnotta	SCAM	Any	758	3.0	23:53	00:06	25
28299	P1 Hi	2014-1-HET_UC-001	Endl	HRS	Clear	1168	1.2	00:06	00:26	599
28295	P1 Med	2014-1-HET_UC-001	Endl	HRS	Thin	690	2.0	00:36	00:47	332
29079	P1 Hi	2014-1-UNC-002	Fuchs	HRS	Clear	2396	2.2	00:53	01:33	727
28710	P2 Hi	2014-1-RSA_OTH-020	Breytenbach	SCAM	Thin	3000	3.0	01:45	02:35	140
28330	P2 Hi	**2014-1-IUCAA-002**	Bhalerao	RSS	Any	1423	2.5	02:37	03:01	236
29134	P1 Hi	2014-1-DC-001	Wegner	RSS	Thin	2810	2.0	03:05	03:52	795
29192	P0 Hi	2014-1-DC-006	Fesen	RSS	Any	2310	3.0	04:05	04:43	451
29287	P3 Med	2014-1-HET-004	Curtis	RSS	Any	867	3.0	04:51	05:05	22
29156	P1 Hi	2014-1-UKSC-004	Sarre	HRS	Any	2975	4.0	05:06	05:55	+45
-	-	Twilight	-	-	-	-	-	05:56	-	-
-	-	Total Gaps	-	-	-	-	-	-	-	7520 (2.09 h)

Start time = 01:38 am



Date: 2014/05/19
0 **<= Seeing <=** 10
Transparency: Any
P0 P1 P2 P3 P4
RSS SCAM HRS BVIT
Use alternate start time 01:38
Ignore TimeCritical Moon

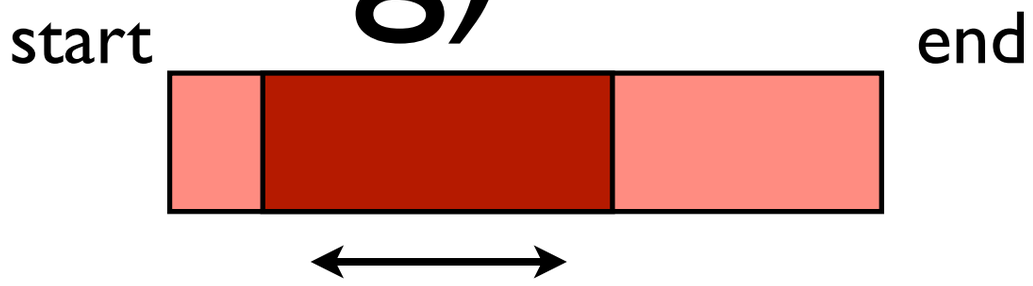
submit

ID	Priority	Proposal	PI	Instr	Clouds	OT	Seeing	Start	End	Gap
-	-	Twilight	-	-	-	-	-	-	01:38	+444
28710	P2 Hi	2014-1-RSA_OTH-020	Breytenbach	SCAM	Thin	3000	3.0	01:45	02:35	140
28330	P2 Hi	2014-1-IUCAA-002	Bhalerao	RSS	Any	1423	2.5	02:37	03:01	236
29134	P1 Hi	2014-1-DC-001	Wegner	RSS	Thin	2810	2.0	03:05	03:52	795
29192	P0 Hi	2014-1-DC-006	Fesen	RSS	Any	2310	3.0	04:05	04:43	451
29287	P3 Med	2014-1-HET-004	Curtis	RSS	Any	867	3.0	04:51	05:05	22
29156	P1 Hi	2014-1-UKSC-004	Sarre	HRS	Any	2975	4.0	05:06	05:55	+45
-	-	Twilight	-	-	-	-	-	05:56	-	-
-	-	Total Gaps	-	-	-	-	-	-	-	2133 (0.59 h)

Features (fine tuning)

- Select start time (to restart the queue in changed conditions)
- Lunar conditions
  - Blocks use rise and set times to check if observable
  - Ignore acquisition time
  - Moon distance from target (min = 30, PI limit)
    - Loosened max lunar phase from PI (e.g. grey in bright time)
- Checks for loaded MOS masks (check for slit too?)
- Checks for active time critical windows
- 5 (dark), 10 (grey) and 15 (bright) minute buffers for twilight
  - Could increase bright window for HRS targets (bright stars)

Features (fine tuning)



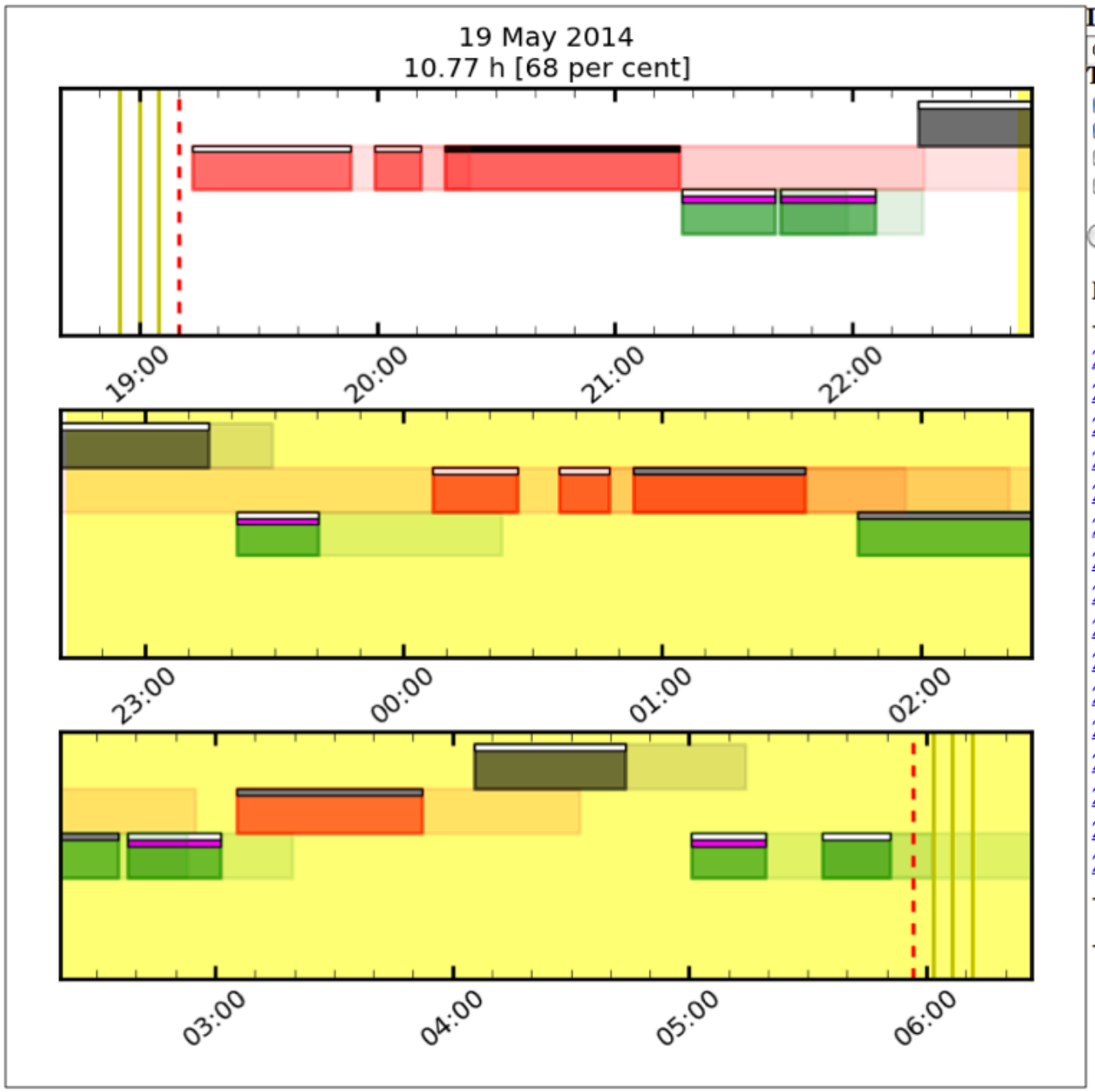
- Randomise start time of blocks
  - Checks for twilight, lunar and time critical boundaries (cannot change to an invalid start time*)
  - Essential for randomisation of the queue and squeezing in more blocks
- Still to add:
  - *Pointing windows (do not go to a block if not enough track time is left to complete the observation)
  - Support for pools (groups of targets) and blocks with multiple visits
  - Extending infrastructure to simulate a realistic semester
  - Non-sidereal target support

Optimising the queue

- Turns out to be a standard problem in computer science
  - Weighted interval scheduling problem
- Relatively fast O(n log n) divide and conquer algorithms exist to solve it
  - Already implemented in SALT scheduler software (adapted from http://farazdagi.com/blog/2013/weighted-interval-scheduling/)
- Unfortunately it does not incorporate randomisation of block start times (within their wiggle room)
- Can use as part of an algorithm that does include randomisation (still to be explored)
- Need to run simulations (simulated blocks?) to assess performance of adopted optimisation algorithm

Weighted Interval Scheduling (no randomisation)

19 May P0,P1,P2



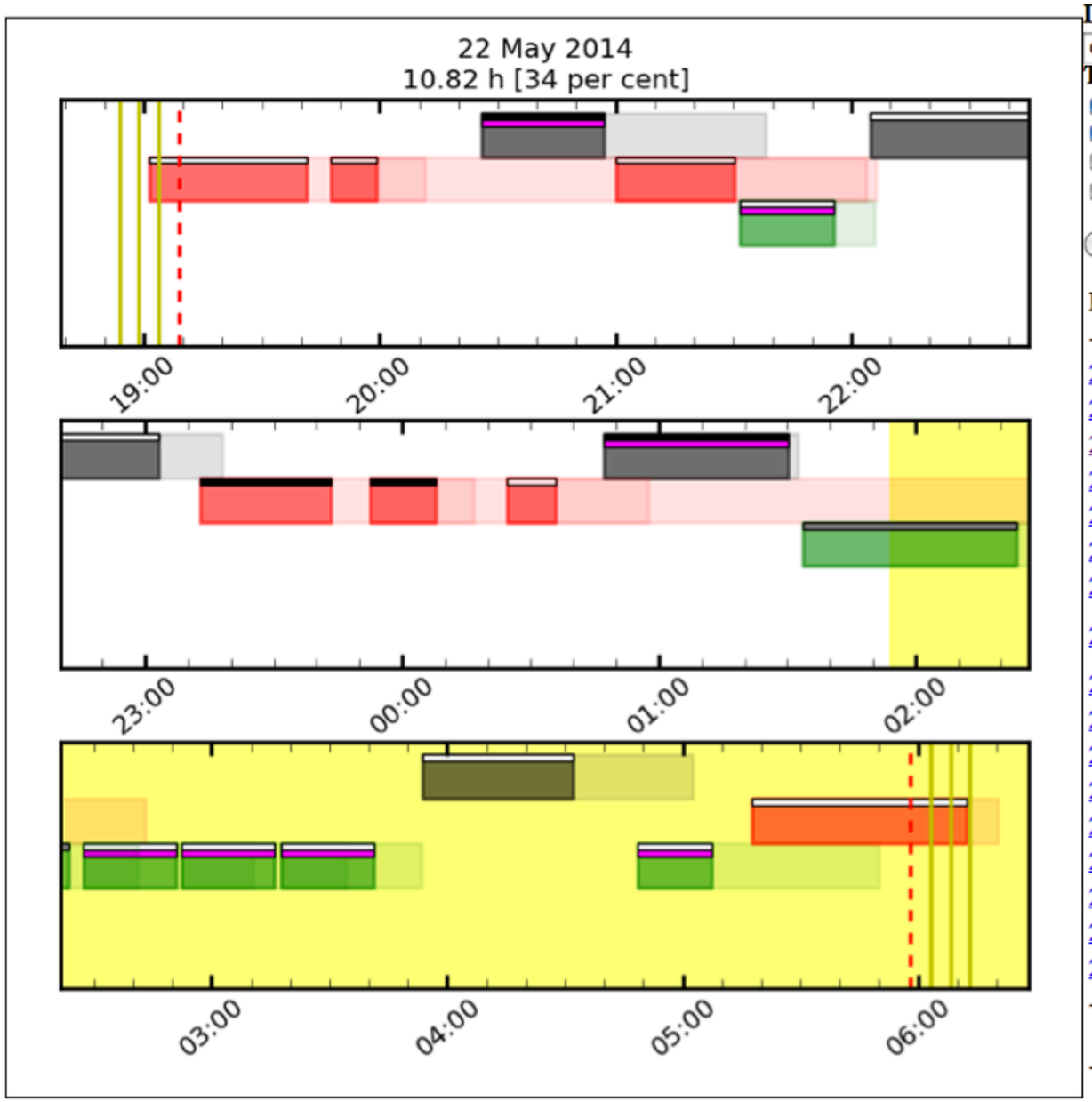
Date: 2014/05/19
0 <= Seeing <= 10
Transparency: Any
P0 P1 P2 P3 P4
RSS SCAM HRS BVIT
Use alternate start time 15:15
Ignore TimeCritical Moon
submit

ID	Priority	Proposal	PI	Instr	Clouds	OT	Seeing	Start	End	Gap
-	-	Twilight	-	-	-	-	-	-	19:10	+195
28813	P1 Hi	2014-1-UKSC-001	Holdsworth	HRS	Any	2400	4.0	19:13	19:53	366
28295	P1 Med	2014-1-HET_UC-001	Endl	HRS	Thin	690	2.0	19:59	20:10	375
28384	P1 Hi	2014-1-IUCAA_UW-001	m	RSS	Thin	3553	1.5	20:17	21:16	39
28335	P2 Hi	2014-1-IUCAA-002	Bhalerao	RSS	Any	1423	2.5	21:17	21:40	85
28330	P2 Hi	2014-1-IUCAA-002	Bhalerao	RSS	Any	1423	2.5	21:42	22:05	654
28805	P0 Hi	2014-1-RU-004	McCully	RSS	Scat	3487	3.0	22:16	23:14	385
28337	P2 Hi	2014-1-IUCAA-003	Bhalerao	RSS	Any	1134	2.5	23:21	23:40	1600
28299	P1 Hi	2014-1-HET_UC-001	Endl	HRS	Clear	1168	1.2	00:06	00:26	599
28295	P1 Med	2014-1-HET_UC-001	Endl	HRS	Thin	690	2.0	00:36	00:47	332
29079	P1 Hi	2014-1-UNC-002	Fuchs	HRS	Clear	2396	2.2	00:53	01:33	727
28710	P2 Hi	2014-1-RSA_OTH-020	Breytenbach	SCAM	Thin	3000	3.0	01:45	02:35	140
28330	P2 Hi	2014-1-IUCAA-002	Bhalerao	RSS	Any	1423	2.5	02:37	03:01	236
29134	P1 Hi	2014-1-DC-001	Wegner	RSS	Thin	2810	2.0	03:05	03:52	795
29192	P0 Hi	2014-1-DC-006	Fesen	RSS	Any	2310	3.0	04:05	04:43	987
28337	P2 Hi	2014-1-IUCAA-003	Bhalerao	RSS	Any	1134	2.5	05:00	05:19	860
28852	P2 Med	2014-1-UKSC_OTH-001	Haswell	RSS	Any	1037	3.0	05:33	05:50	+342
-	-	Twilight	-	-	-	-	-	05:56	-	-
-	-	Total Gaps	-	-	-	-	-	-	-	8717 (2.42 h)

2.42h gaps

Weighted Interval Scheduling (no randomisation)

12 May P0,P1,P2



Date: 2014/05/22
0 **<= Seeing <=** 10
Transparency: Any
P0 P1 P2 P3 P4
RSS SCAM HRS BVIT
Use alternate start time 15:15
Ignore TimeCritical Moon

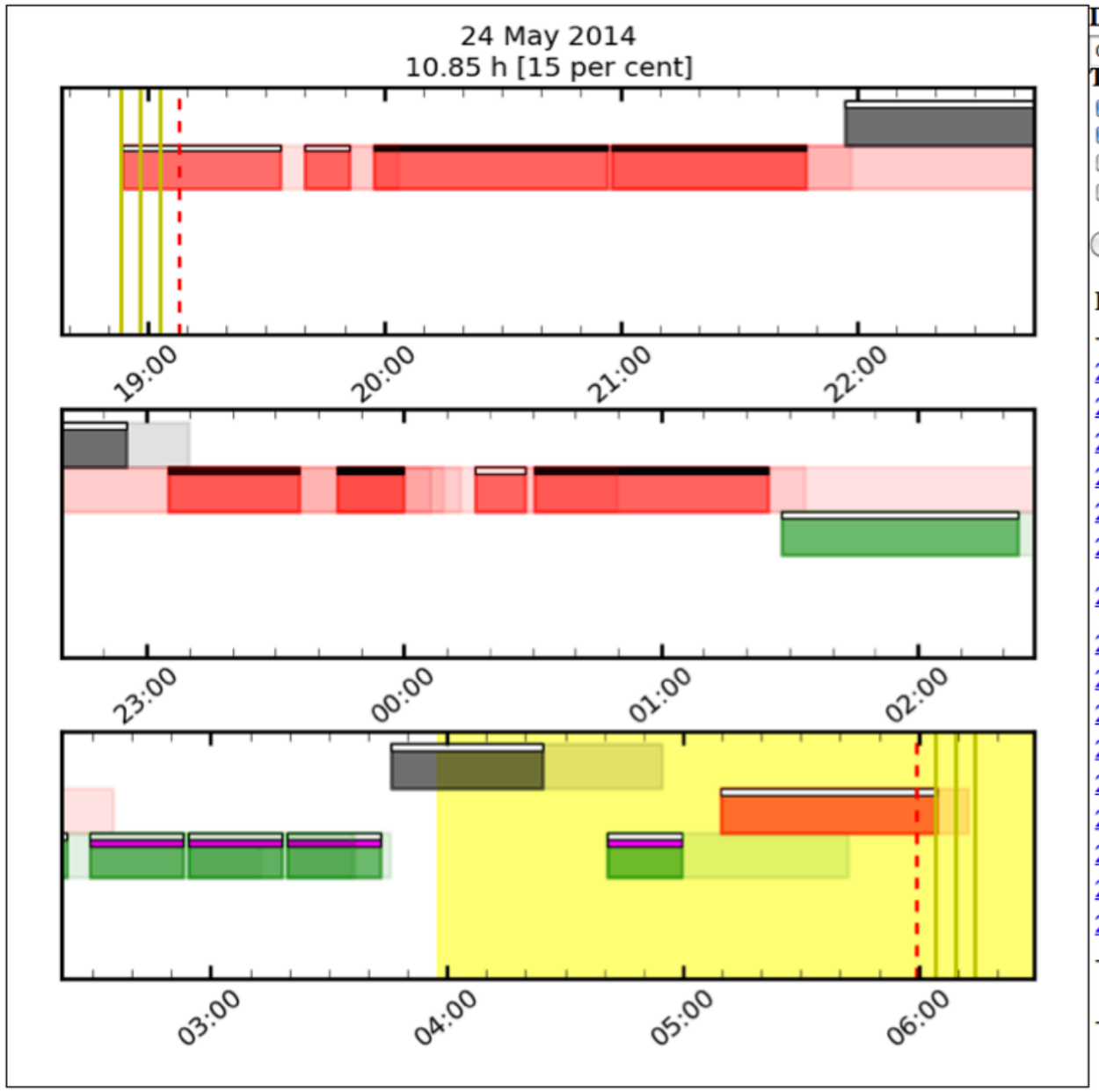
submit

ID	Priority	Proposal	PI	Instr	Clouds	OT	Seeing	Start	End	Gap
-	-	Twilight	-	-	-	-	-	-	19:08	-440
28813	P1 Hi	2014-1-UKSC-001	Holdsworth	HRS	Any	2400	4.0	19:01	19:41	365
28295	P1 Med	2014-1-HET_UC-001	Endl	HRS	Thin	690	2.0	19:47	19:59	1616
28116	P0 Hi	**2014-1-AMNH-001**	Oppenheimer	RSS	Clear	1871	2.0	20:26	20:57	179
28235	P1 Med	2014-1-GU-001	Kollatschny	RSS	Any	1809	4.0	21:00	21:30	84
28331	P2 Hi	**2014-1-IUCAA-002**	Bhalerao	RSS	Any	1423	2.5	21:31	21:55	570
28805	P0 Hi	2014-1-RU-004	McCully	RSS	Scat	3487	3.0	22:04	23:03	593
28120	P1 Hi	2014-1-AMNH-003	Pagnotta	SCAM	Thin	1825	3.0	23:12	23:43	541
28787	P1 Hi	2014-1-RSA_UKSC_OTH-002	Buckley	RSS	Thin	921	1.7	23:52	00:07	1006
28295	P1 Med	2014-1-HET_UC-001	Endl	HRS	Thin	690	2.0	00:24	00:35	664
28533	P0 Hi	**2014-1-RSA-006**	Potter	RSS	Thin	2590	2.6	00:47	01:30	202
28710	P2 Hi	2014-1-RSA_OTH-020	Breytenbach	SCAM	Thin	3000	3.0	01:33	02:23	223
28331	P2 Hi	**2014-1-IUCAA-002**	Bhalerao	RSS	Any	1423	2.5	02:27	02:51	84
28332	P2 Hi	**2014-1-IUCAA-002**	Bhalerao	RSS	Any	1423	2.5	02:52	03:16	85
28333	P2 Hi	**2014-1-IUCAA-002**	Bhalerao	RSS	Any	1423	2.5	03:17	03:41	743
29192	P0 Hi	2014-1-DC-006	Fesen	RSS	Any	2310	3.0	03:53	04:32	986
28342	P2 Hi	**2014-1-IUCAA-003**	Bhalerao	RSS	Any	1134	2.5	04:48	05:07	606
28818	P1 Hi	2014-1-UKSC-002	Elkin	HRS	Thin	3301	2.5	05:17	06:12	-863
-	-	Twilight	-	-	-	-	-	05:58	-	-
-	-	Total Gaps	-	-	-	-	-	-	-	7244 (2.01 h)

2.01h gaps

Weighted Interval Scheduling (no randomisation)

24 May P0,P1,P2



Date: 2014/05/24
0 **<= Seeing <=** 10
Transparency: Any
P0 P1 P2 P3 P4
RSS SCAM HRS BVIT
Use alternate start time 15:15
Ignore TimeCritical Moon

submit

ID	Priority	Proposal	PI	Instr	Clouds	OT	Seeing	Start	End	Gap
-	-	Twilight	-	-	-	-	-	-	19:08	-870
28813	P1 Hi	2014-1-UKSC-001	Holdsworth	HRS	Any	2400	4.0	18:53	19:33	365
28295	P1 Med	2014-1-HET_UC-001	Endl	HRS	Thin	690	2.0	19:39	19:51	376
28384	P1 Hi	2014-1-IUCAA_UW-001	m	RSS	Thin	3553	1.5	19:57	20:56	68
28310	P1 Hi	2014-1-IUCAA-001	Dutta	RSS	Scat	2953	2.0	20:57	21:47	602
28805	P0 Hi	2014-1-RU-004	McCully	RSS	Scat	3487	3.0	21:57	22:55	593
28120	P1 Hi	2014-1-AMNH-003	Pagnotta	SCAM	Thin	1825	3.0	23:05	23:35	541
28787	P1 Hi	2014-1-RSA_UKSC_OTH-002	Buckley	RSS	Thin	921	1.7	23:44	23:59	1006
28295	P1 Med	2014-1-HET_UC-001	Endl	HRS	Thin	690	2.0	00:16	00:28	141
28617	P1 Hi	2014-1-RSA_OTH-002	Vaisanen	RSS	Thin	3279	1.5	00:30	01:25	187
28850	P2 Hi	2014-1-UKSC-005	Jeffery	HRS	Any	3313	2.0	01:28	02:23	347
28334	P2 Hi	2014-1-IUCAA-002	Bhalerao	RSS	Any	1423	2.5	02:29	02:52	84
28335	P2 Hi	2014-1-IUCAA-002	Bhalerao	RSS	Any	1423	2.5	02:54	03:18	85
28330	P2 Hi	2014-1-IUCAA-002	Bhalerao	RSS	Any	1423	2.5	03:19	03:43	155
29192	P0 Hi	2014-1-DC-006	Fesen	RSS	Any	2310	3.0	03:45	04:24	988
28338	P2 Hi	2014-1-IUCAA-003	Bhalerao	RSS	Any	1134	2.5	04:40	04:59	604
28818	P1 Hi	2014-1-UKSC-002	Elkin	HRS	Thin	3301	2.5	05:09	06:04	-326
-	-	Twilight	-	-	-	-	-	05:59	-	-
-	-	Total Gaps	-	-	-	-	-	-	-	4946 (1.37 h)

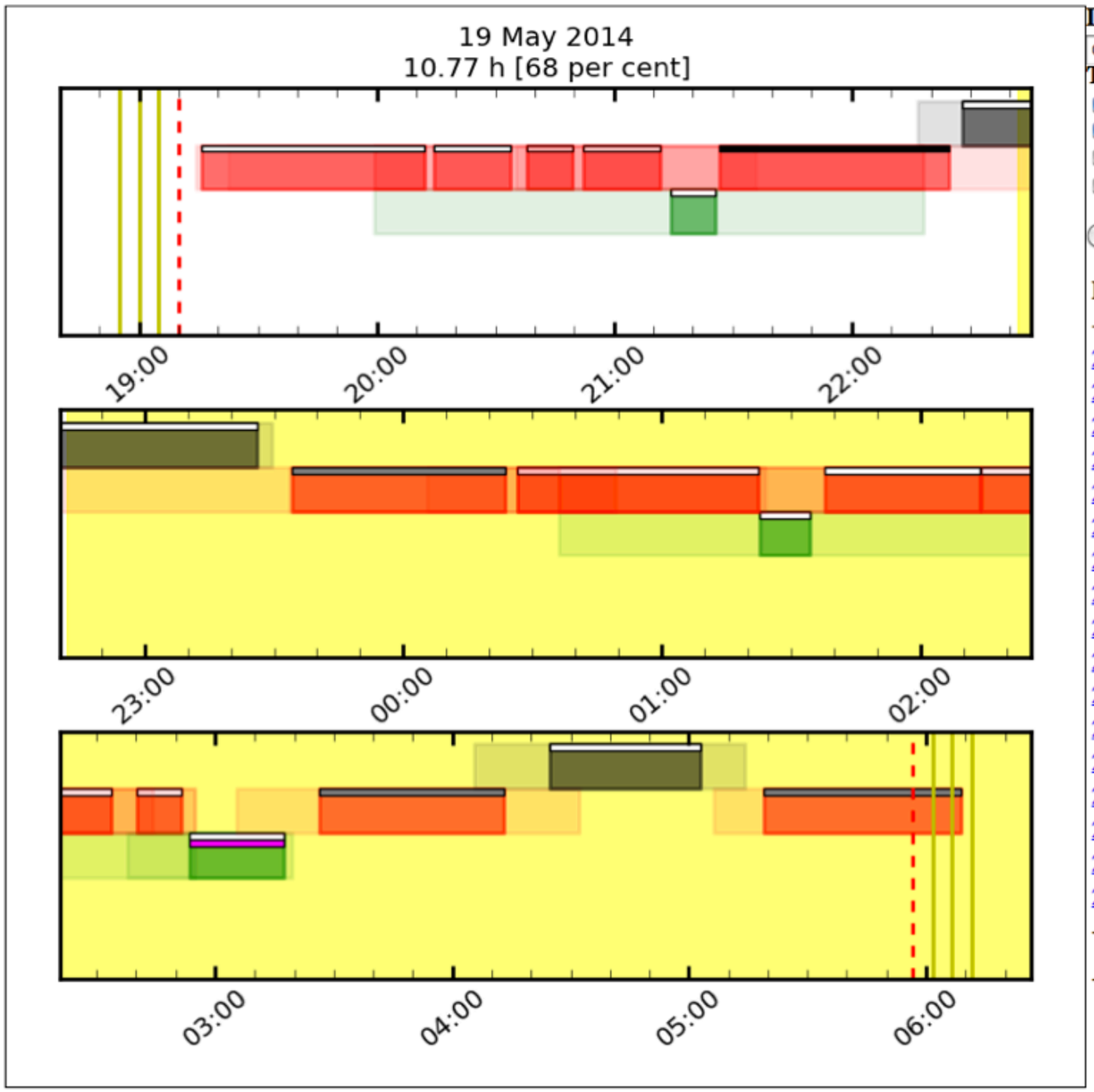
1.37h gaps

Current approach

- Aim to randomise block start times while swapping blocks around to explore the parameter space - works fairly well in filling gaps, but is a little slow and can be improved
- Current approach is to swap between blocks amongst two priority levels only (P0 and P1, P2 and P3, P3 and P4), only accepting moves that are favourable according to...
  - Weighting scheme
    - 2**(10-priority) or if time critical, 2**(10-priority-0.15)
    - i.e. two P2 blocks == one P1 block
    - Can be extended to include other effects (partner share, observing conditions, etc)
- More experimentation required once BlockPointWindows are implemented in the database (will allow for 'physical' solutions)

Randomisation (brute force)

19 May P0,P1,P2



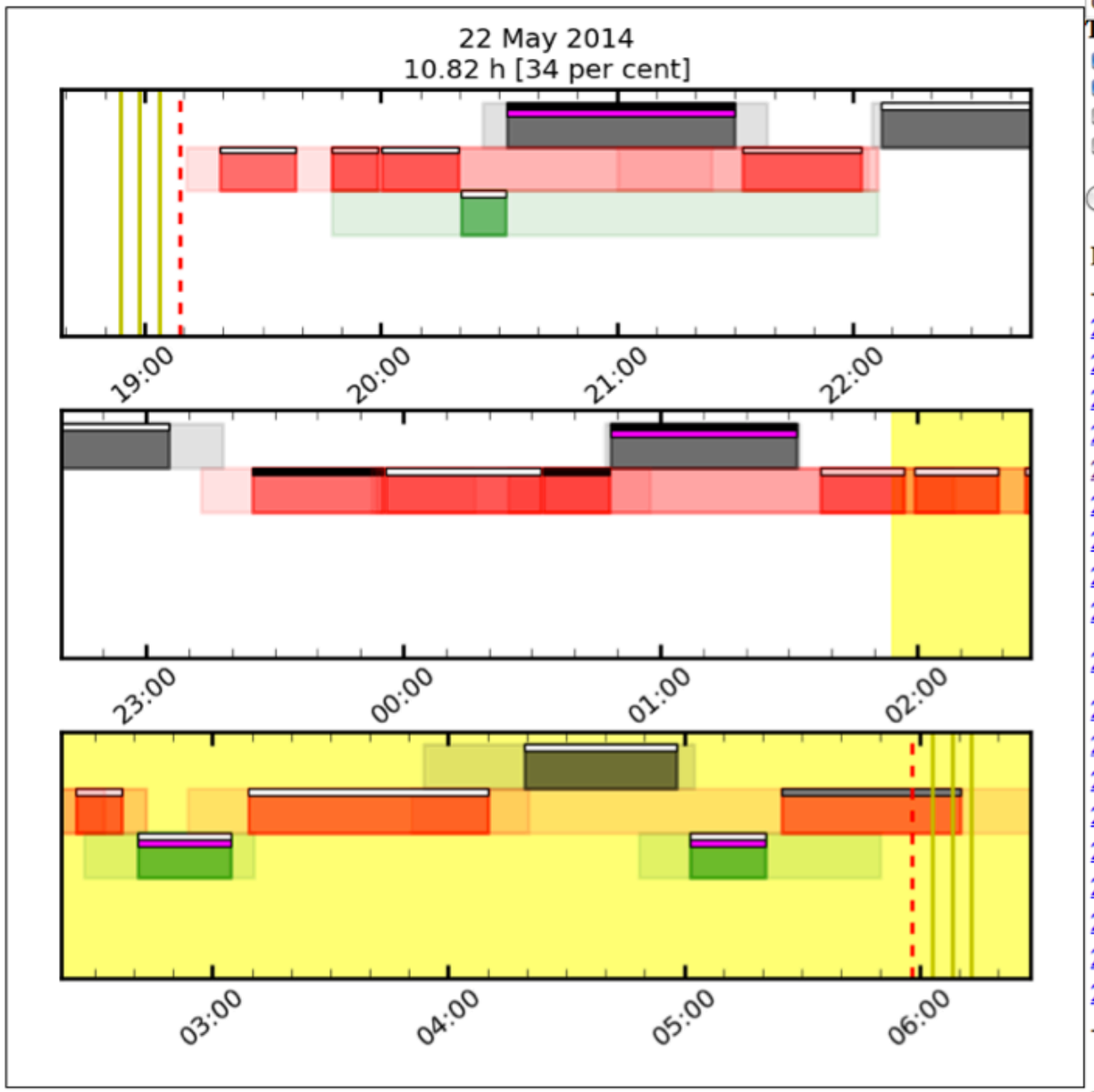
Date: 2014/05/19
0 <= Seeing <= 10
Transparency: Any
P0 P1 P2 P3 P4
RSS SCAM HRS BVIT
Use alternate start time 15:15
Ignore TimeCritical Moon
submit

ID	Priority	Proposal	PI	Instr	Clouds	OT	Seeing	Start	End	Gap
-	-	Twilight	-	-	-	-	-	-	19:10	+347
28847	P1 Hi	2014-1-UKSC-005	Jeffery	HRS	Any	3373	2.0	19:15	20:12	149
28294	P1 Hi	2014-1-HET_UC-001	Endl	HRS	Clear	1168	1.2	20:14	20:34	245
28295	P1 Med	2014-1-HET_UC-001	Endl	HRS	Thin	690	2.0	20:38	20:49	161
28299	P1 Hi	2014-1-HET_UC-001	Endl	HRS	Clear	1168	1.2	20:52	21:11	152
28297	P2 Med	2014-1-HET_UC-001	Endl	HRS	Thin	690	2.0	21:14	21:25	61
29108	P1 Hi	2014-1-DC-002	Hickox	RSS	Thin	3462	3.0	21:26	22:24	213
28805	P0 Hi	2014-1-RU-004	McCully	RSS	Scat	3487	3.0	22:28	23:26	484
29156	P1 Hi	2014-1-UKSC-004	Sarre	HRS	Any	2975	4.0	23:34	00:23	152
28847	P1 Hi	2014-1-UKSC-005	Jeffery	HRS	Any	3373	2.0	00:26	01:22	12
28297	P2 Med	2014-1-HET_UC-001	Endl	HRS	Thin	690	2.0	01:22	01:34	206
28854	P1 Hi	2014-1-UKSC_OTH-001	Haswell	RSS	Any	2169	2.2	01:37	02:13	18
28294	P1 Hi	2014-1-HET_UC-001	Endl	HRS	Clear	1168	1.2	02:14	02:33	385
28295	P1 Med	2014-1-HET_UC-001	Endl	HRS	Thin	690	2.0	02:40	02:51	126
28330	P2 Hi	**2014-1-IUCAA-002**	Bhalerao	RSS	Any	1423	2.5	02:53	03:17	536
29134	P1 Hi	2014-1-DC-001	Wegner	RSS	Thin	2810	2.0	03:26	04:13	686
29192	P0 Hi	2014-1-DC-006	Fesen	RSS	Any	2310	3.0	04:24	05:03	966
29156	P1 Hi	2014-1-UKSC-004	Sarre	HRS	Any	2975	4.0	05:19	06:08	-725
-	-	Twilight	-	-	-	-	-	05:56	-	-
-	-	Total Gaps	-	-	-	-	-	-	-	4174 (1.16 h)

1.16h gaps

Randomisation (brute force)

22 May P0,P1,P2



Date: 2014/05/22
0 **<= Seeing <=** 10
Transparency: Any
P0 P1 P2 P3 P4
RSS SCAM HRS BVIT
Use alternate start time 15:15
Ignore TimeCritical Moon

submit

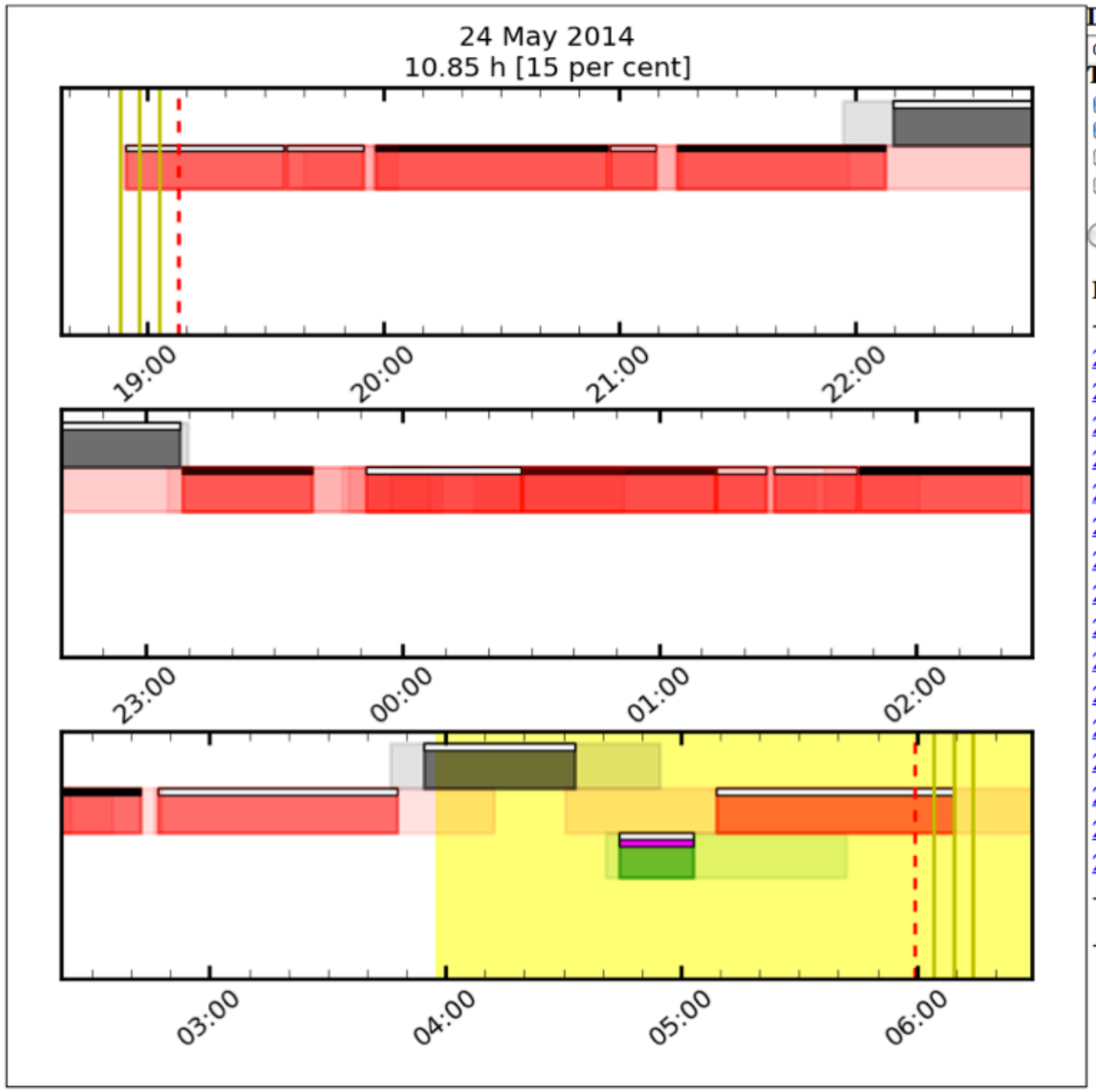
ID	Priority	Proposal	PI	Instr	Clouds	OT	Seeing	Start	End	Gap
-	-	Twilight	-	-	-	-	-	-	19:08	+613
28299	P1 Hi	2014-1-HET_UC-001	Endl	HRS	Clear	1168	1.2	19:19	19:38	544
28295	P1 Med	2014-1-HET_UC-001	Endl	HRS	Thin	690	2.0	19:47	19:59	72
28294	P1 Hi	2014-1-HET_UC-001	Endl	HRS	Clear	1168	1.2	20:00	20:19	36
28297	P2 Med	2014-1-HET_UC-001	Endl	HRS	Thin	690	2.0	20:20	20:31	19
28115	P0 Hi	2014-1-AMNH-001	Oppenheimer	RSS	Clear	3460	2.0	20:32	21:29	133
28235	P1 Med	2014-1-GU-001	Kollatschny	RSS	Any	1809	4.0	21:32	22:02	307
28805	P0 Hi	2014-1-RU-004	McCully	RSS	Scat	3487	3.0	22:07	23:05	1170
28120	P1 Hi	2014-1-AMNH-003	Pagnotta	SCAM	Thin	1825	3.0	23:24	23:55	43
28854	P1 Hi	2014-1-UKSC_OTH-001	Haswell	RSS	Any	2169	2.2	23:56	00:32	35
28787	P1 Hi	2014-1-RSA_UKSC_OTH-002	Buckley	RSS	Thin	921	1.7	00:32	00:48	21
28533	P0 Hi	2014-1-RSA-006	Potter	RSS	Thin	2590	2.6	00:48	01:31	344
28299	P1 Hi	2014-1-HET_UC-001	Endl	HRS	Clear	1168	1.2	01:37	01:56	149
28294	P1 Hi	2014-1-HET_UC-001	Endl	HRS	Clear	1168	1.2	01:59	02:18	390
28295	P1 Med	2014-1-HET_UC-001	Endl	HRS	Thin	690	2.0	02:25	02:36	244
28331	P2 Hi	2014-1-IUCAA-002	Bhalerao	RSS	Any	1423	2.5	02:40	03:04	270
29135	P1 Hi	2014-1-DC-001	Wegner	RSS	Thin	3659	2.0	03:09	04:10	565
29192	P0 Hi	2014-1-DC-006	Fesen	RSS	Any	2310	3.0	04:19	04:58	221
28342	P2 Hi	2014-1-IUCAA-003	Bhalerao	RSS	Any	1134	2.5	05:01	05:20	249
28900	P1 Med	2014-1-UW-004	Nielsen	RSS	Thin	2743	2.0	05:24	06:10	-734
-	-	Twilight	-	-	-	-	-	05:58	-	-
-	-	Total Gaps	-	-	-	-	-	-	-	4691 (1.30 h)

Notice blocks starting after their windows to allow other blocks into the queue!

1.16h gaps

Randomisation (brute force)

24 May P0,P1,P2



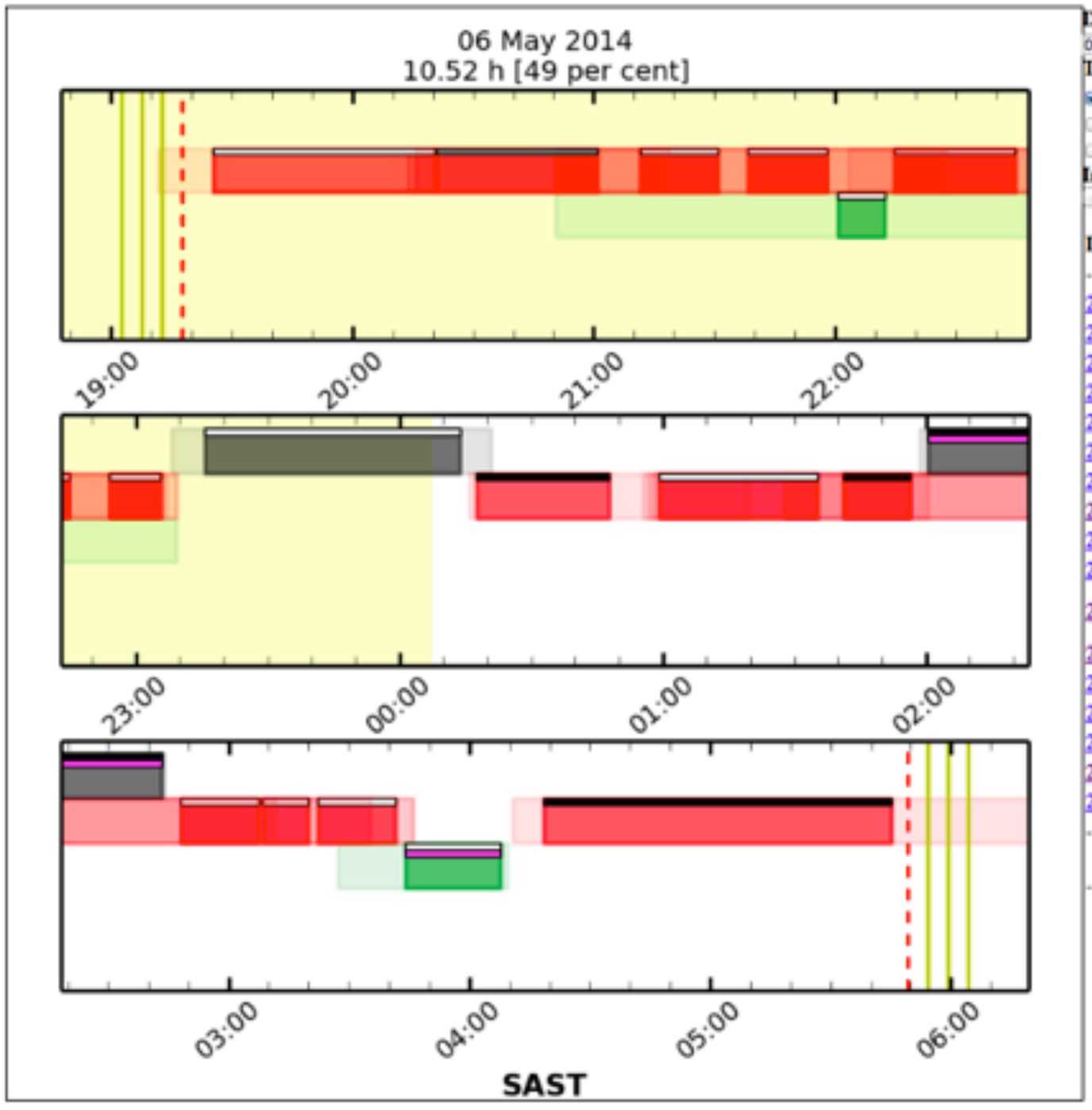
Date: 2014/05/24
0 **<= Seeing <=** 10
Transparency: Any
P0 P1 P2 P3 P4
RSS SCAM HRS BVIT
Use alternate start time 15:15
Ignore TimeCritical Moon

submit

ID	Priority	Proposal	PI	Instr	Clouds	OT	Seeing	Start	End	Gap
-	-	Twilight	-	-	-	-	-	-	19:08	-813
28813	P1 Hi	2014-1-UKSC-001	Holdsworth	HRS	Any	2400	4.0	18:54	19:34	46
28299	P1 Hi	2014-1-HET_UC-001	Endl	HRS	Clear	1168	1.2	19:35	19:54	188
28384	P1 Hi	2014-1-IUCAA_UW-001	m	RSS	Thin	3553	1.5	19:57	20:57	37
28295	P1 Med	2014-1-HET_UC-001	Endl	HRS	Thin	690	2.0	20:57	21:09	329
28676	P1 Med	2014-1-RSA_OTH-009	Viljoen	RSS	Thin	3173	2.0	21:14	22:07	123
28805	P0 Hi	2014-1-RU-004	McCully	RSS	Scat	3487	3.0	22:09	23:07	37
28120	P1 Hi	2014-1-AMNH-003	Pagnotta	SCAM	Thin	1825	3.0	23:08	23:38	756
28855	P1 Hi	2014-1-UKSC_OTH-001	Haswell	RSS	Any	2169	2.2	23:51	00:27	17
28117	P1 Hi	2014-1-AMNH-002	Pagnotta	SCAM	Thin	2708	3.0	00:27	01:12	22
28295	P1 Med	2014-1-HET_UC-001	Endl	HRS	Thin	690	2.0	01:13	01:24	114
28299	P1 Hi	2014-1-HET_UC-001	Endl	HRS	Clear	1168	1.2	01:26	01:46	28
29285	P1 Hi	2014-1-UW-001	Morsony	RSS	Thin	3330	2.0	01:46	02:42	269
29135	P1 Hi	2014-1-DC-001	Wegner	RSS	Thin	3659	2.0	02:46	03:47	412
29192	P0 Hi	2014-1-DC-006	Fesen	RSS	Any	2310	3.0	03:54	04:33	679
28338	P2 Hi	2014-1-IUCAA-003	Bhalerao	RSS	Any	1134	2.5	04:44	05:03	351
28812	P1 Hi	2014-1-UKSC-001	Holdsworth	HRS	Any	3611	4.0	05:09	06:09	-600
-	-	Twilight	-	-	-	-	-	05:59	-	-
-	-	Total Gaps	-	-	-	-	-	-	-	1995 (0.55 h)

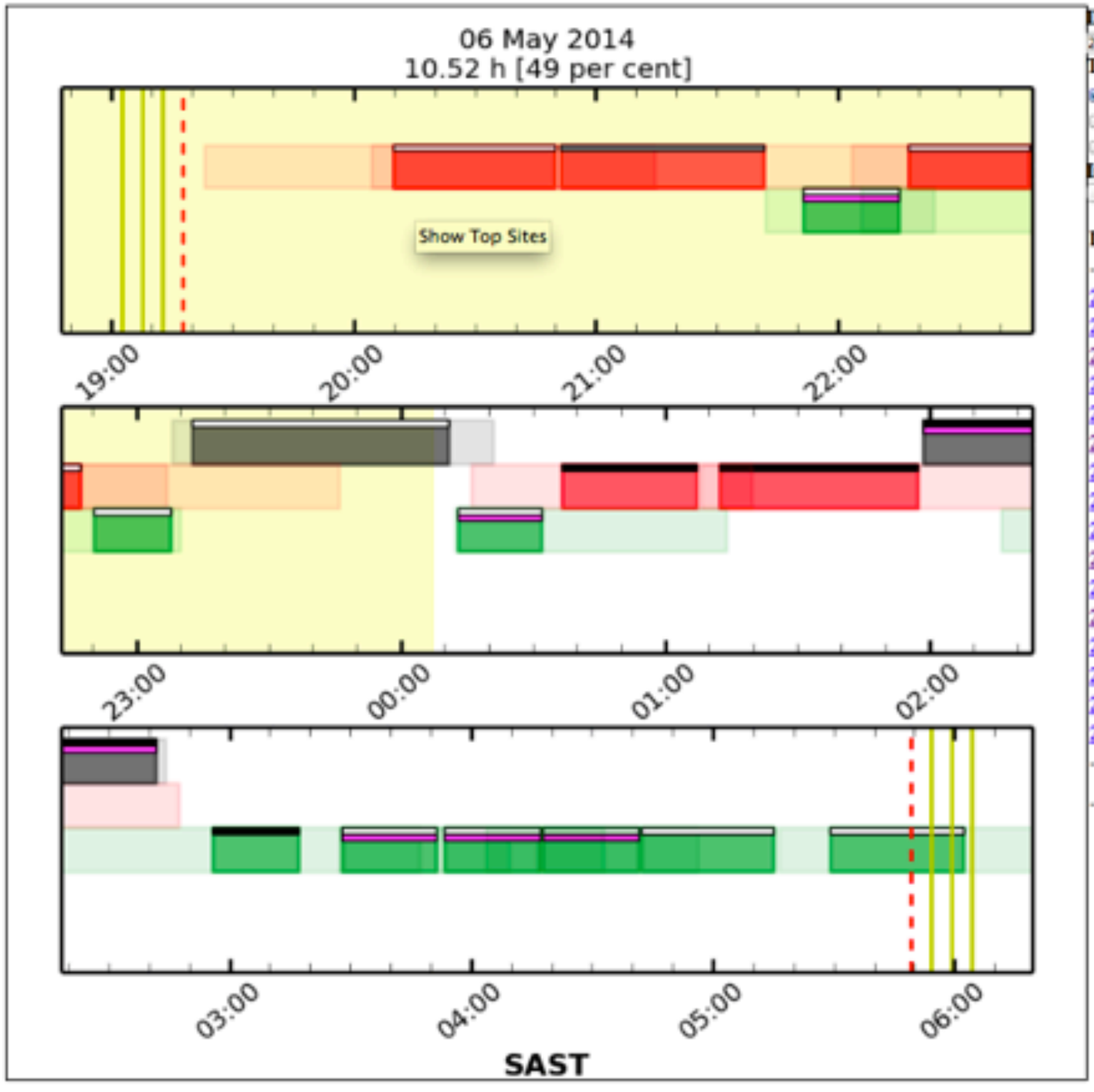
0.55h gaps

More brute force randomisation examples



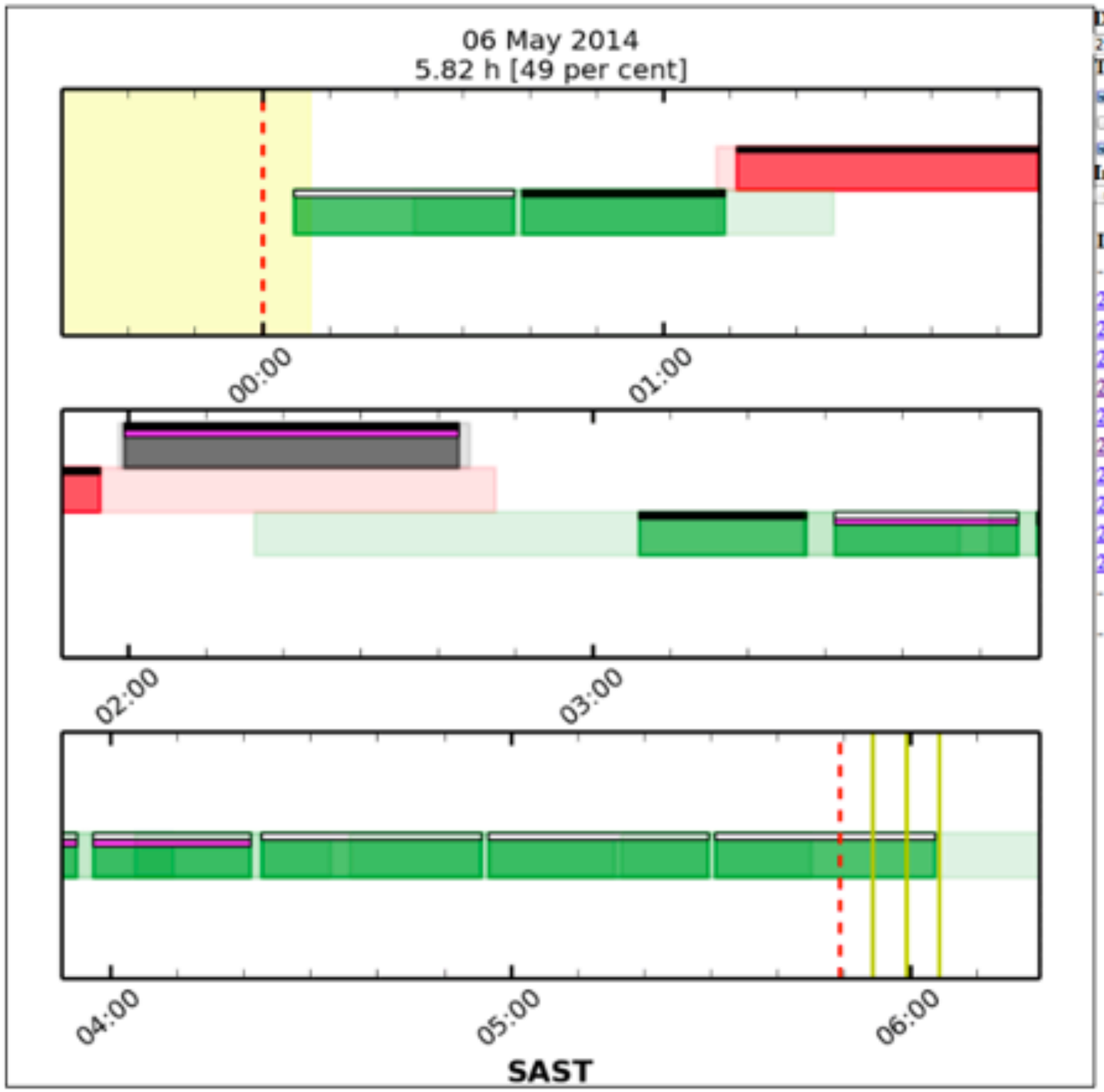
Date: 2014/05/06
0 <= **Seeing** <= 10
Transparency: Any
P0 **P1** **P2** **P3** **P4**
Ignore TimeCritical Moon
Use alternate start time 23:18
Instrument: Radio (use either CT or SALT - db and wm):
submit

ID	Priority	Proposal	PI	Instrument	OT	Seeing	Start	End	Gap
-	-	Twilight	-	-	-	-	-	19:17	+455
28848	P1	2014-1-UKSC-005	Jeffery	HRS	3313	2.0	19:25	20:20	26
29079	P1	2014-1-UNC-002	Fuchs	HRS	2396	2.2	20:20	21:00	634
28294	P1	2014-1-HET_UC-001	Endl	HRS	1168	1.2	21:11	21:30	447
28299	P1	2014-1-HET_UC-001	Endl	HRS	1168	1.2	21:38	21:57	178
28297	P2	2014-1-HET_UC-001	Endl	HRS	690	2.0	22:00	22:12	142
28235	P1	2014-1-GU-001	Kollatschny	RSS	1809	4.0	22:14	22:44	560
28295	P1	2014-1-HET_UC-001	Endl	HRS	690	2.0	22:54	23:05	609
28805	P0	2014-1-RU-004	McCully	RSS	3487	3.0	23:15	00:13	215
28120	P1	2014-1-AMNH-003	Pagnotta	SCAM	1825	3.0	00:17	00:47	676
28854	P1	2014-1-UKSC_OTH-001	Haswell	RSS	2169	2.2	00:59	01:35	351
28787	P1	2014-1-RSA_UKSC_OTH-002	Buckley	RSS	921	1.7	01:41	01:56	233
28532	P0	2014-1-RSA-006	Potter	RSS	2590	2.6	02:00	02:43	271
28299	P1	2014-1-HET_UC-001	Endl	HRS	1168	1.2	02:48	03:07	52
28295	P1	2014-1-HET_UC-001	Endl	HRS	690	2.0	03:08	03:19	148
28294	P1	2014-1-HET_UC-001	Endl	HRS	1168	1.2	03:22	03:41	124
28334	P2	2014-1-IUCAA-002	Bhalerao	RSS	1423	2.5	03:43	04:07	661
28687	P1	2014-1-RSA_OTH-018	Jauzac	RSS	5197	1.5	04:18	05:45	+243
-	-	Twilight	-	-	-	-	05:49	-	-
-	-	Total Gaps	-	-	-	-	-	-	6025 (1.67 h)



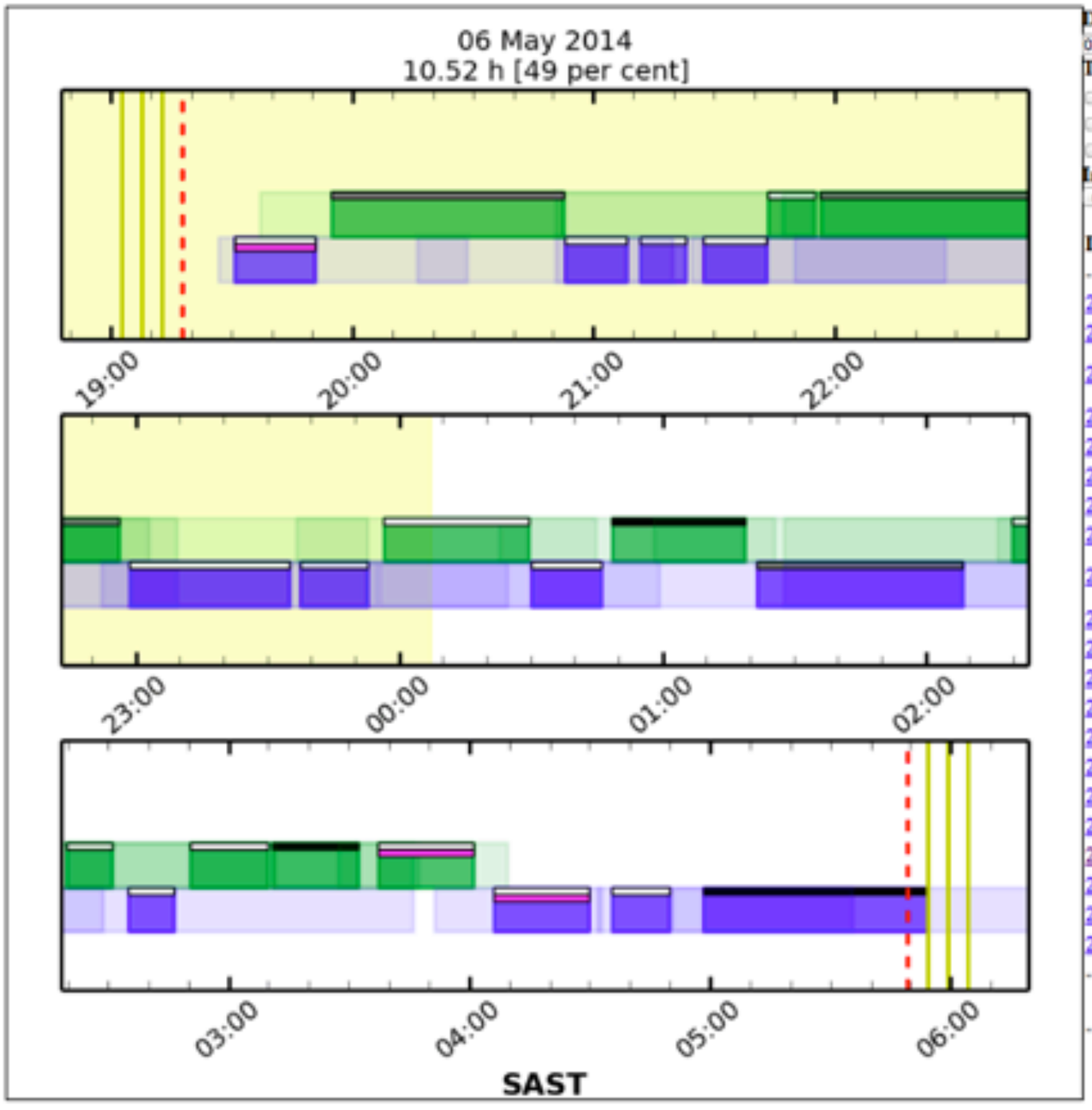
Date: 2014/05/06
2.5 <= Seeing <= 10
Transparency: Any
P0 P1 P2 P3 P4
Ignore TimeCritical Moon
Use alternate start time 23:18
Instrument: Radio (use either CT or SALT - db and wm):
submit

ID	Priority	Proposal	PI	Instrument	OT	Seeing	Start	End	Gap
-	-	Twilight	-	-	-	-	-	19:17	+3124
28813	P1	2014-1-UKSC-001	Holdsworth	HRS	2400	4.0	20:09	20:49	96
29089	P1	2014-1-DC-002	Hickox	RSS	3012	3.0	20:51	21:41	592
28332	P2	2014-1-IUCAA-002	Bhalerao	RSS	1423	2.5	21:51	22:15	123
28235	P1	2014-1-GU-001	Kollatschny	RSS	1809	4.0	22:17	22:47	190
29131	P2	2014-1-DC-001	Wegner	HRS	1035	2.5	22:50	23:07	303
28805	P0	2014-1-RU-004	McCully	RSS	3487	3.0	23:12	00:10	120
28340	P2	2014-1-IUCAA-003	Bhalerao	RSS	1134	2.5	00:12	00:31	292
28120	P1	2014-1-AMNH-003	Pagnotta	SCAM	1825	3.0	00:36	01:07	308
28117	P1	2014-1-AMNH-002	Pagnotta	SCAM	2708	3.0	01:12	01:57	79
28532	P0	2014-1-RSA-006	Potter	RSS	2590	2.6	01:58	02:41	838
28124	P2	2014-1-AMNH-003	Pagnotta	SCAM	1290	3.0	02:55	03:17	630
28334	P2	2014-1-IUCAA-002	Bhalerao	RSS	1423	2.5	03:27	03:51	105
28335	P2	2014-1-IUCAA-002	Bhalerao	RSS	1423	2.5	03:53	04:16	55
28330	P2	2014-1-IUCAA-002	Bhalerao	RSS	1423	2.5	04:17	04:41	28
28934	P2	2014-1-RSA_POL-001	Miszalski	RSS	1981	3.0	04:42	05:15	845
28956	P2	2014-1-RSA_POL-001	Miszalski	RSS	1981	3.0	05:29	06:02	-775
-	-	Twilight	-	-	-	-	05:49	-	-
-	-	Total Gaps	-	-	-	-	-	-	6953 (1.93 h)



Date: 2014/05/06
2.5 <= **Seeing** <= 10
Transparency: Any
P0 **P1** **P2** **P3** **P4**
Ignore TimeCritical Moon
Use alternate start time 00:00
Instrument: Radio (use either CT or SALT - db and wm):
submit

ID	Priority	Proposal	PI	Instrument	OT	Seeing	Start	End	Gap
-	-	Twilight	-	-	-	-	-	23:59	+282
28925	P2	2014-1-RSA_POL-001	Miszalski	RSS	1981	3.0	00:04	00:37	68
28118	P2	2014-1-AMNH-003	Pagnotta	SCAM	1825	3.0	00:38	01:09	107
28117	P1	2014-1-AMNH-002	Pagnotta	SCAM	2708	3.0	01:11	01:56	194
28532	P0	2014-1-RSA-006	Potter	RSS	2590	2.6	01:59	02:42	1402
28124	P2	2014-1-AMNH-003	Pagnotta	SCAM	1290	3.0	03:05	03:27	220
28334	P2	2014-1-IUCAA-002	Bhalerao	RSS	1423	2.5	03:31	03:54	151
28335	P2	2014-1-IUCAA-002	Bhalerao	RSS	1423	2.5	03:57	04:21	92
28934	P2	2014-1-RSA_POL-001	Miszalski	RSS	1981	3.0	04:22	04:55	57
28935	P2	2014-1-RSA_POL-001	Miszalski	RSS	1981	3.0	04:56	05:29	57
28956	P2	2014-1-RSA_POL-001	Miszalski	RSS	1981	3.0	05:30	06:03	-855
-	-	Twilight	-	-	-	-	05:49	-	-
-	-	Total Gaps	-	-	-	-	-	-	1775 (0.49 h)



Date: 2014/05/06
0 <= **Seeing** <= 10
Transparency: Any
P0 **P1** **P2** **P3** **P4**
Ignore TimeCritical Moon
Use alternate start time 00:00
Instrument: Radio (use either CT or SALT - db and wm):
submit

ID	Priority	Proposal	PI	Instrument	OT	Seeing	Start	End	Gap
-	-	Twilight	-	-		- -	-	19:17	+775
28553	P3	2014-1-RSA_HET-002	Townsend	HRS	1211	2.0	19:30	19:50	234
29090	P2	2014-1-DC-002	Hickox	RSS	3462	3.0	19:54	20:52	21
28717	P3	2014-1-RSA_OTH_UKSC-001	McBride	RSS	922	5.0	20:52	21:08	207
28298	P3	2014-1-HET_UC-001	Endl	HRS	690	2.0	21:11	21:23	244
29049	P3	2014-1-HET-004	Curtis	RSS	957	2.0	21:27	21:43	16
28297	P2	2014-1-HET_UC-001	Endl	HRS	690	2.0	21:43	21:54	87
28707	P2	2014-1-RSA_OTH-020	Breytenbach	SCAM	3600	3.0	21:56	22:56	147
28906	P3	2014-1-UW-005	Mathieu	HRS	2184	3.0	22:58	23:35	146
28718	P3	2014-1-RSA_OTH_UKSC-001	McBride	RSS	922	5.0	23:37	23:52	206
28947	P2	2014-1-RSA_POL-001	Miszalski	RSS	1981	3.0	23:56	00:29	36
29048	P3	2014-1-HET-004	Curtis	RSS	957	3.0	00:29	00:45	151
28118	P2	2014-1-AMNH-003	Pagnotta	SCAM	1825	3.0	00:48	01:18	156
28174	P3	2014-1-AMNH_OTH-001	Graur	RSS	2807	2.5	01:21	02:08	687
28297	P2	2014-1-HET_UC-001	Endl	HRS	690	2.0	02:19	02:31	232
28298	P3	2014-1-HET_UC-001	Endl	HRS	690	2.0	02:35	02:46	229
28300	P2	2014-1-HET_UC-001	Endl	HRS	1172	1.2	02:50	03:09	56
28124	P2	2014-1-AMNH-003	Pagnotta	SCAM	1290	3.0	03:10	03:32	296
28334	P2	2014-1-IUCAA-002	Bhalerao	RSS	1423	2.5	03:37	04:01	314
28329	P3	2014-1-IUCAA-002	Bhalerao	RSS	1423	2.5	04:06	04:29	337
29045	P3	2014-1-HET-004	Curtis	RSS	867	3.0	04:35	04:50	499
28517	P3	2014-1-RSA-005	Skelton	RSS	3353	2.0	04:58	05:54	-296
-	-	Twilight	-	-		- -	05:49	-	-
-	-	Total Gaps	-	-		- -	-	-	4780 (1.33 h)

Resources on interval scheduling problem

- In graph theory, equivalent to finding the weighted maximum independent set
  - http://en.wikipedia.org/wiki/Independent_set_(graph_theory) and
  - http://en.wikipedia.org/wiki/Interval_scheduling.
- http://farazdagi.com/blog/2013/weighted-interval-scheduling/
- http://pages.cs.wisc.edu/~shuchi/courses/787-F09/scribe-notes/lec3.pdf
- http://www.cs.uiuc.edu/class/sp08/cs473/Lectures/lec10.pdf