# Status of Observing Strategy Optimized for Supernova Cosmology: White paper and more

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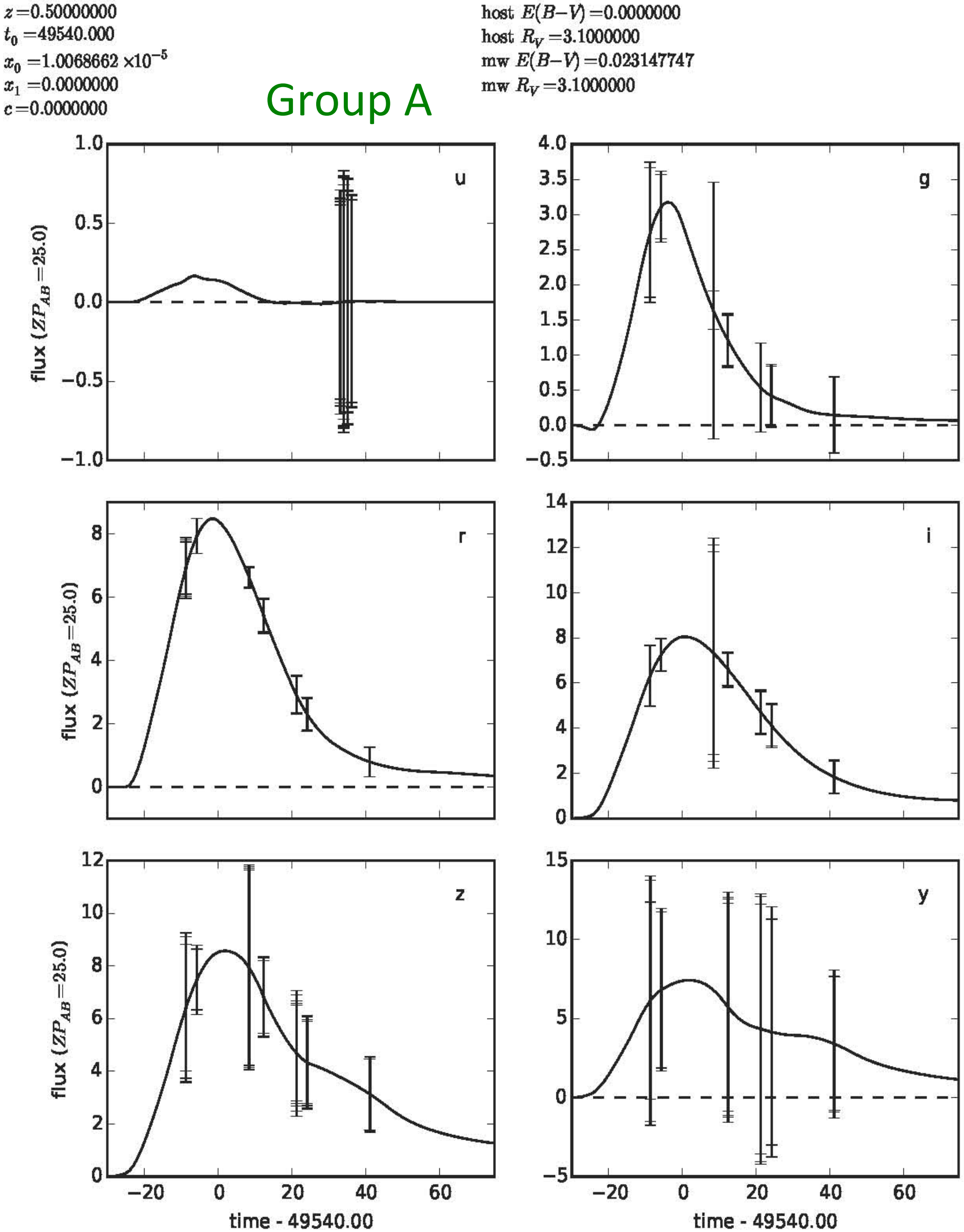
# OpSim Analysis

- Deep Drilling Survey (DDF)
- Wide field Survey (WFD)
- Light curves: assumed z = 0.5 (focus on WFC)
  May explore other z values
- Position of sky: RA, Dec → FieldID
- Y-axis: Flux (not mag)
- E(B-V) is fitting parameter (using Rv=3.1)
- MJD day Peak (time=0, explosion day) is determined based on Light curve




# Deep Drilling Field

Field ID = 290

Dec =63.321 °

RA =349.386°

Some deep fields may be better

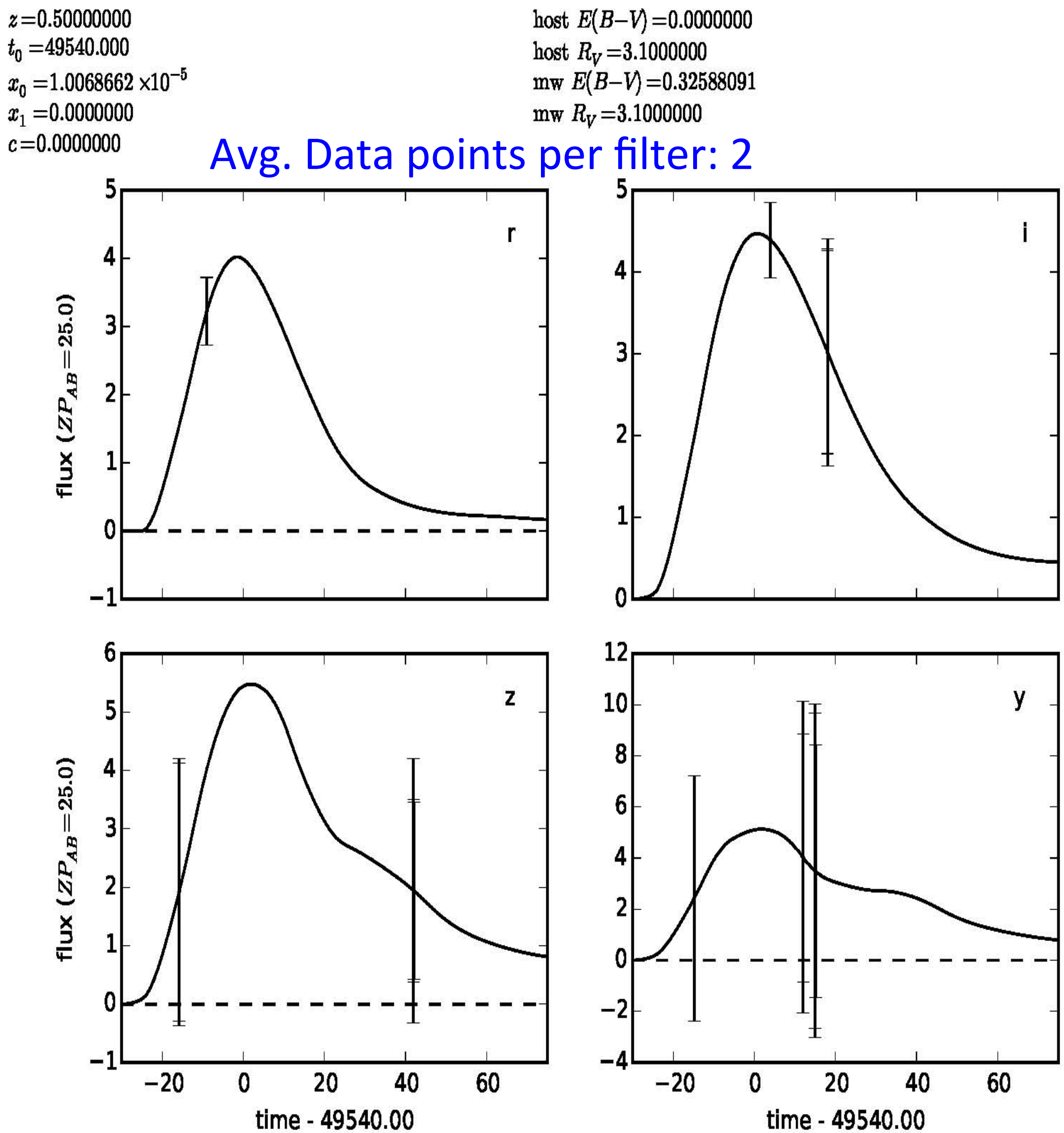
SNDM=1

SNQM=1

SNCLASS

Data have good quality: >7-9 points per filter per SNIa LC period

:




# Field ID = 309

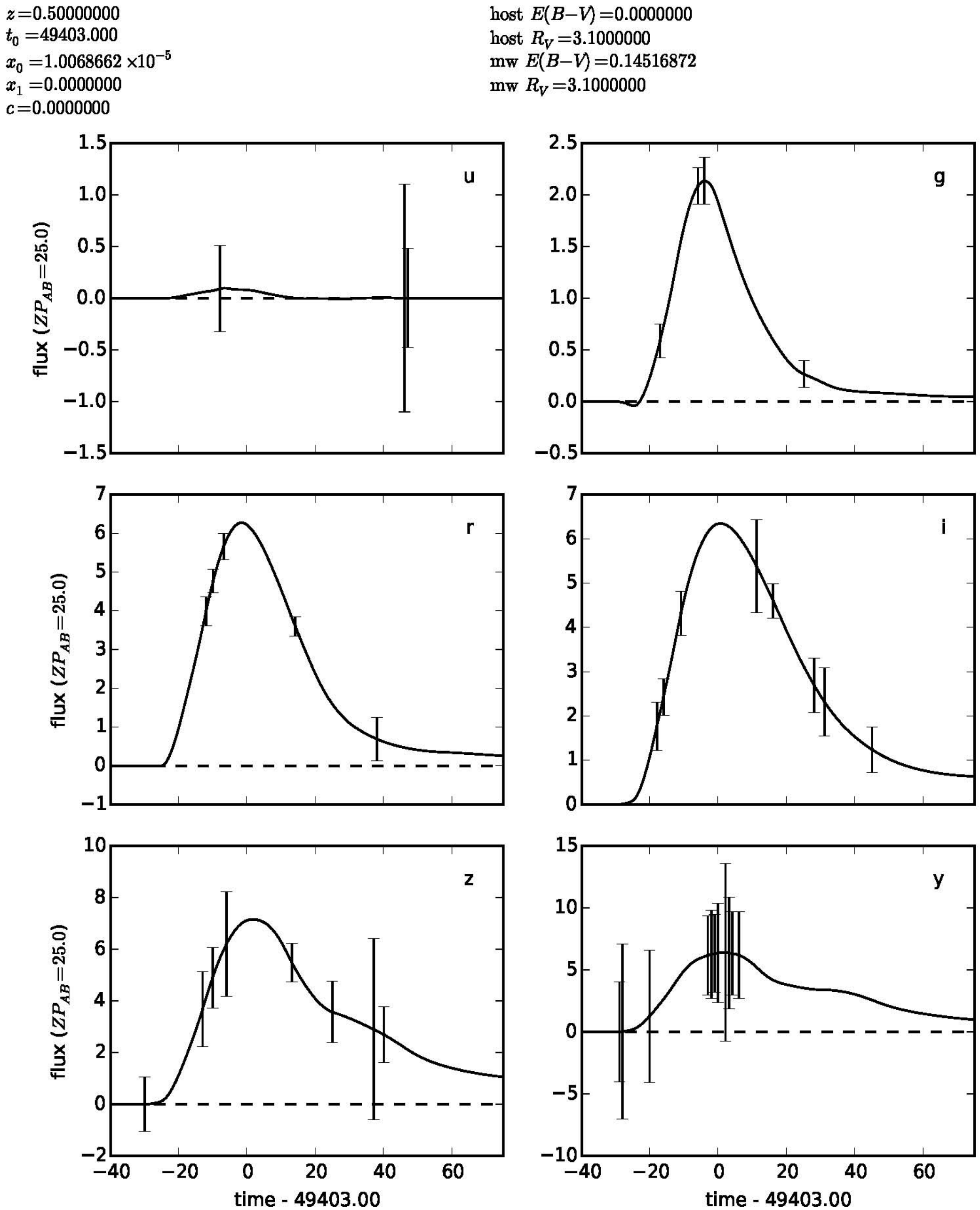
# Dec =63.321 °

# RA =349.386°

# SNDM~1

# SNQM(Ia)=0.1

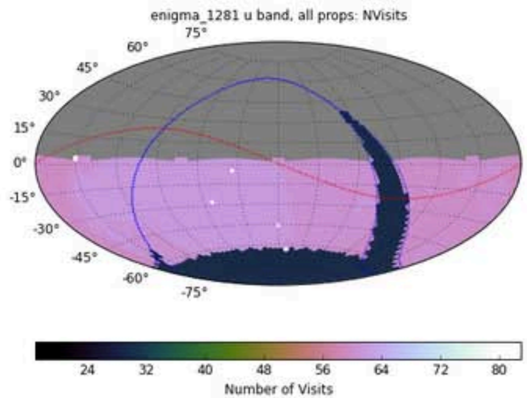
- Only 4 band detection
- total 9-14 points
- The data points are insufficient predict the LC.



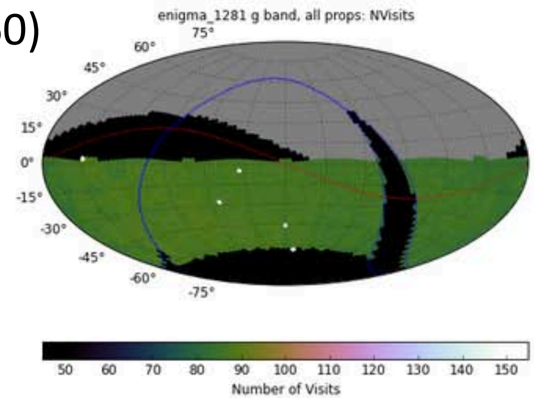
$z = 0.50000000$
$t_0 = 49403.000$
$x_0 = 1.0068662 \times 10^{-5}$
$x_1 = 0.0000000$
$c = 0.0000000$
host $E(B-V) = 0.0000000$
host $R_V = 3.1000000$
mw $E(B-V) = 0.14516872$
mw $R_V = 3.1000000$
u
g
r
i
z
y
flux ($ZP_{AB} = 25.0$)
time - 49403.00


# Dec = -66°
# RA = 115°

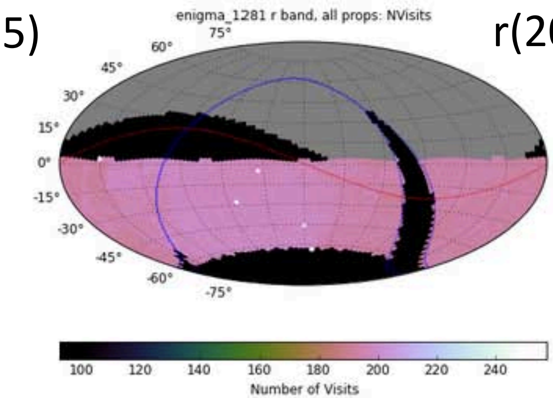
# N visits



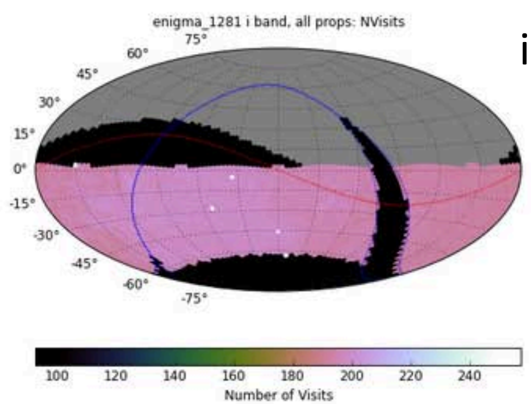

u(60)



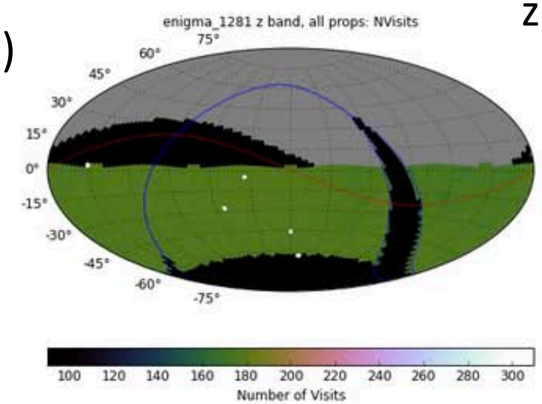

g(85)



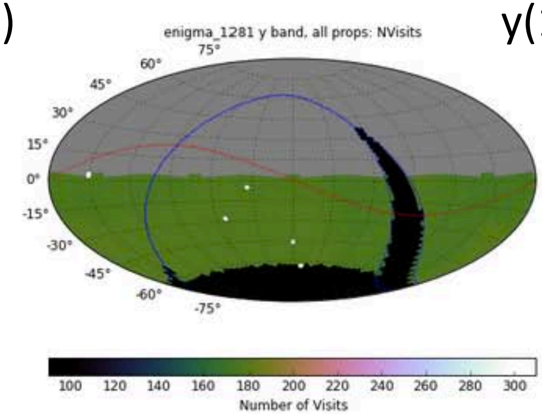

r(200)




i(200)



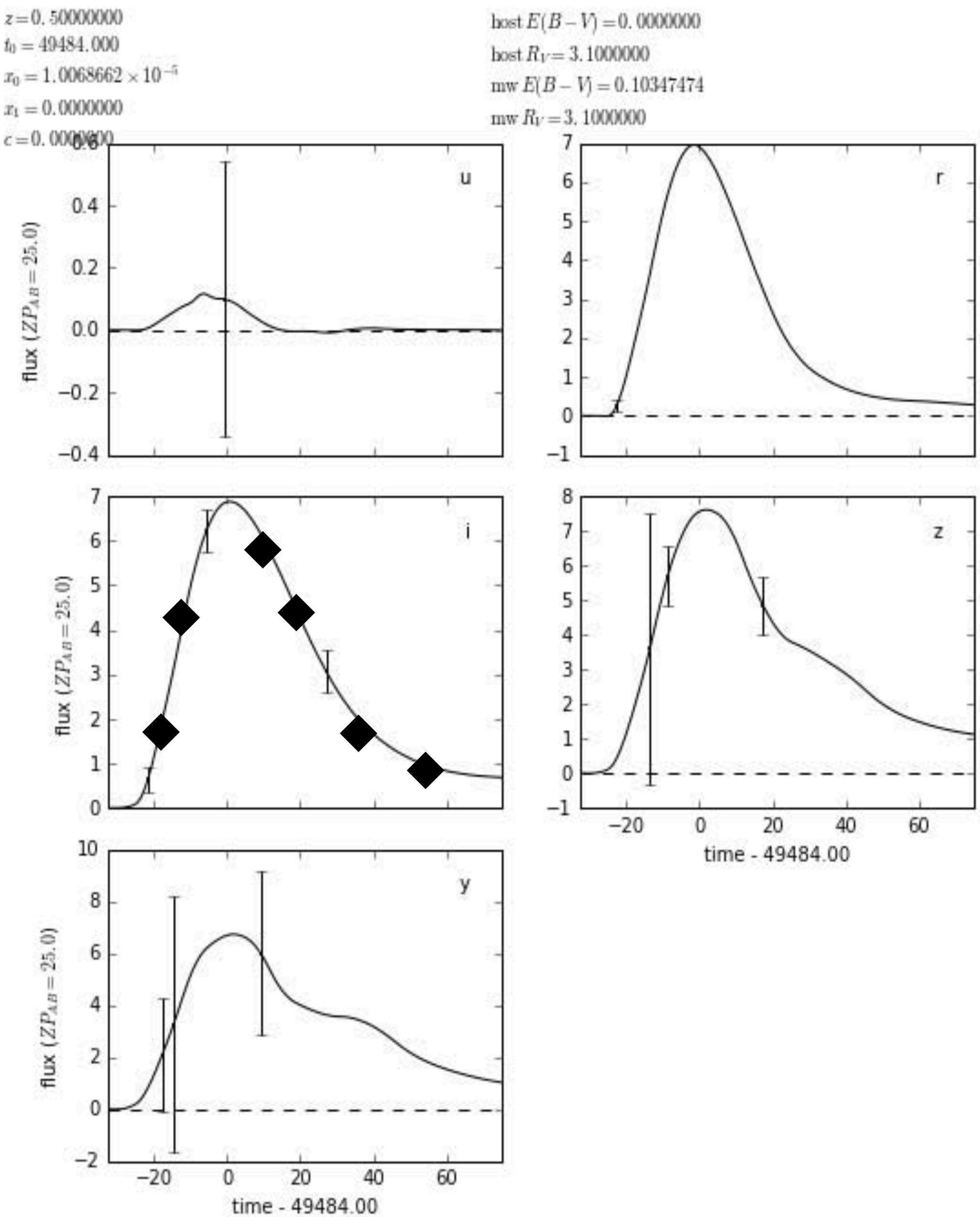

z(170)




y(170)

Avg. Data No (goal > 7-9)

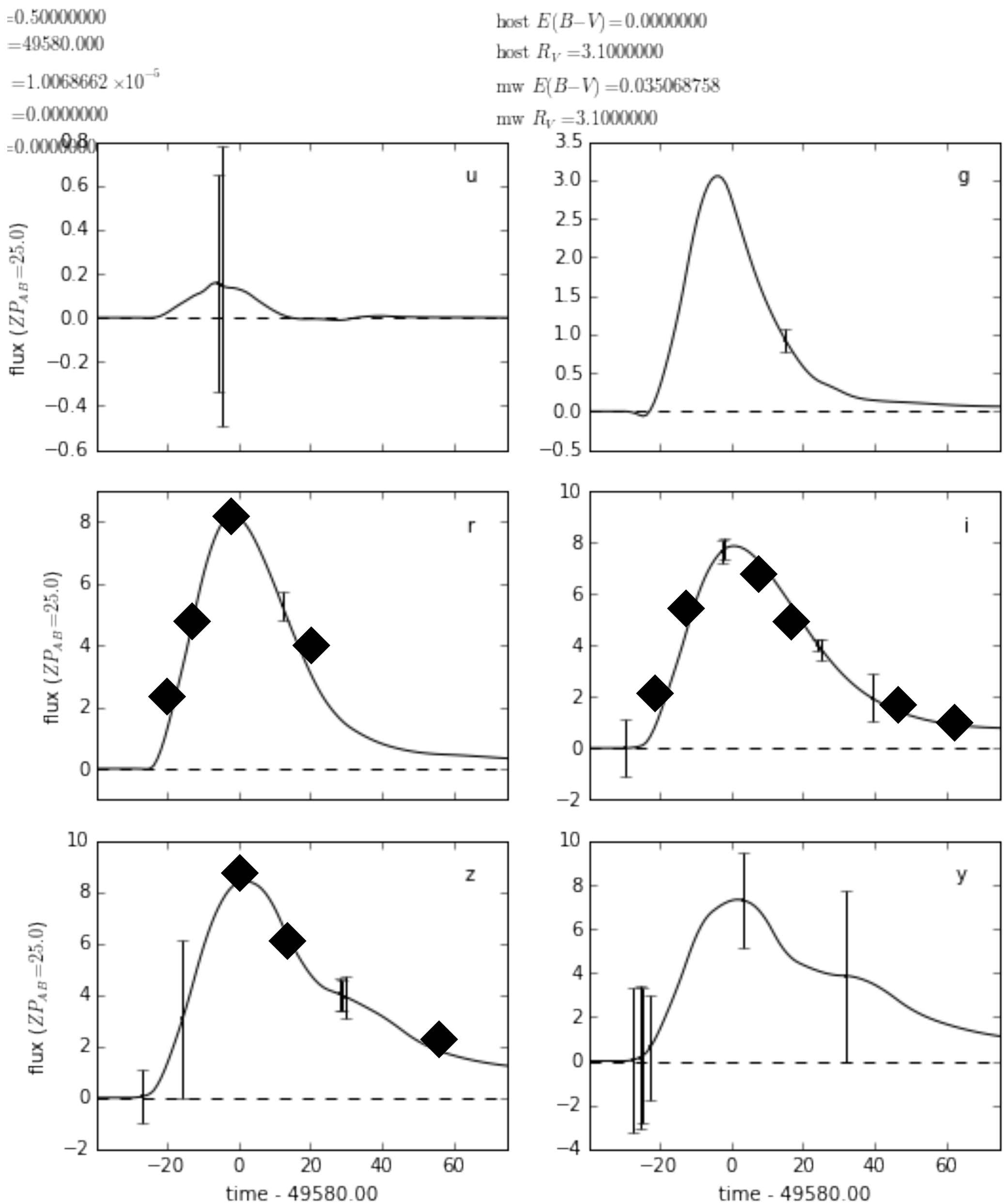
| Field or No. | (RA,Dec) | No. of LSST data per year (u,g,r,i,z,y) | Avg. No. Per filter Per 45 days | Category (TPR) | Group |
|---|---|---|---|---|---|
| 290 DDF | (349.386,-63.321) | 2363(398,229,402,414,522,396) | 53 >9 | A(1) | A: Very Good |
| 1 | (190,-83) | 239(38,41,41,44,33,42) | 5.3 | B (*0.4*) | |
| 2 | (20,-83) | 252(52,56,40,21,37,44) | 5.7 5-9 | B | B: Good |
| 3 | (116,-66) | *220(36,38,37,32,44,33)* | 5.0 | B | |
| 4 | (240.05,-62.02) | 101(2,5,11,19,19,45) | 2.2 | B | |
| 5 | (120,-50) | 80(4,7,9,18,24,18) | 1.8 | C | |
| 6 | (80,-40) | 96(5,8,15,17,27,24) | 2.2 | C | |
| 7 | (280,-40) | 86(4,2,6,4,24,18) | 2.0 1.5-5 | C | C: useful, but not good enough |
| 8 | (30,-20) | 86(3,4,10,21,27,21) | 1.96 | C | |
| 9 | (100,-20) | 58(4,2,6,4,24,18) | 1.3 | D | |
| 309 | (6.097, -1.105) | 80 (4,7,9,18,24,18) | 1.83 | C(*0.1*) | |
| 11 | (50,+1.5) | 72(3,6,10,12,22,19) | 1.64 | D | |
| 12 | (320, +5) | 7(0,0,2,0,4,0) | 0.15 | E | |
| 13 | (60,+5) | 66(0,7,11,20,28,0) | 1.5 <1.8 | D | D/E: poor |
| 14 | (60,+20) | 72(0,8,13,22,29,0) | 1.64 | D | |
| 15 | (60,+30) | 44(0,5,6,15,18,0) | 1.0 | E | |




# Dec = -40°
# RA = 280°

Rolling Cadence:
To increase the number of data points
 in the light curve to get 7-9 data point
per filter in average.

We need to experiment with SNDM
and SNQM, SNCLASS metric
About dependency of the filter.




Dec = 0.18°
RA = 358°

| Field or No. | (RA,Dec) | No. of LSST data per year (u,g,r,i,z,y) | Avg. No. Per filter Per 45 days |
|---|---|---|---|
| 290 Deep | (349.386,-63.321) | 2363(398,229,402,414,522,396) | 53 |
| 1 | (190,-83) | 239(38,41,41,44,33,42) | 5.3 |
| 2 | (20,-83) | 252(52,56,40,21,37,44) | 5.7 |
| 3 | (116,-66) | *220(36,38,37,32,44,33)* | 5.0 |
| 309 | (240.05,-62.02) | 101(2,5,11,19,19,45) | 2.2 |
| 5 | (120,-50) | 80(4,7,9,18,24,18) | 1.8 |
| 6 | (80,-40) | 96(5,8,15,17,27,24) | 2.2 |
| 7 | (280,-40) | 86(4,2,6,4,24,18) | 2.0 |
| 8 | (30,-20) | 86(3,4,10,21,27,21) | 1.96 |
| 9 | (100,-20) | 58(4,2,6,4,24,18) | 1.3 |
| 309 | (6.097, -1.105) | | |
| 11 | (50,+1.5) | 72(3,6,10,12,22,19) | 1.64 |
| 12 | (320, +5) | 7(0,0,2,0,4,0) | 0.15 |
| 13 | (60,+5) | 66(0,7,11,20,28,0) | 1.5 |
| 14 | (60,+20) | 72(0,8,13,22,29,0) | 1.64 |
| 15 | (60,+30) | 44(0,5,6,15,18,0) | 1.0 |

Rolling Cadence:
X2 or X3 sampling

A: >10

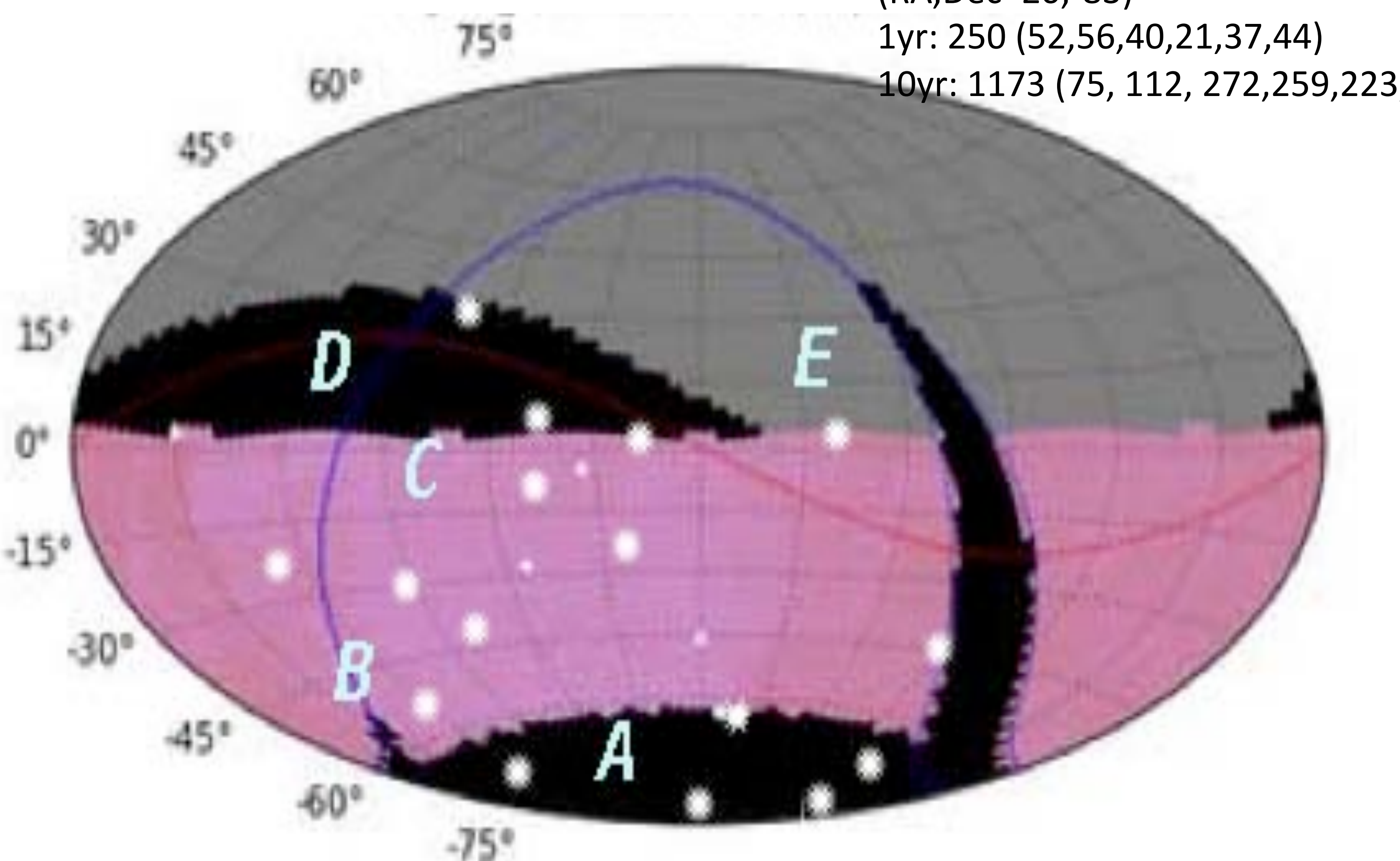
B: 10-15

C: 4-8
We focus on this region

D/E:3-5
accept

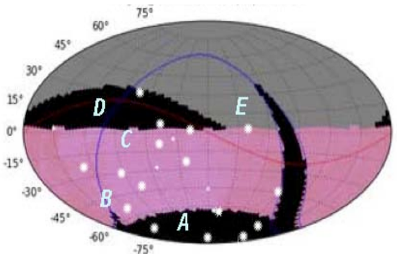
# Light Curve category with N visits

(RA,Dec=20,-83)
1yr: 250 (52,56,40,21,37,44)
10yr: 1173 (75, 112, 272,259,223,232




We will focus on B and C area: New Strategy will Impact large areas of LSST survey

# LSST Baseline observation

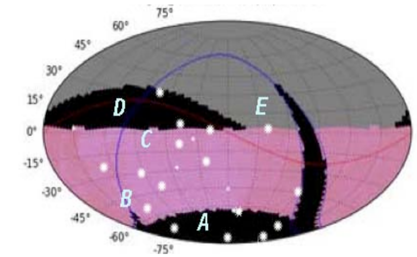



The observing strategy of WDF is defined (see Section 1.6.2 in the LSST science book) as follows.

- A revisit time of three days on average per 10,000 deg$^2$ of sky (i.e., the area visible at any given time of the year), with two visits per night (particularly useful for establishing proper motion vectors for fast moving asteroids).

We define the 10,000 deg$^2$ survey area (the visible sky for a given time of the year) simply as the "visible sky". LSST can observe 1/3 of visible sky per day for a band.

# Rolling Cadence: to increase the sampling rate x2 or x3




- Change Revisit time from 3 days to 1 day (1/3 of three days above) on average visible sky.

This means one third of the visible sky (~3300 deg$^2$) can be chosen. Preference may be given to the part of sky with low air-mass, but at the same time a uniform coverage of LSST needs to be considered.

- Observe the same part sky (3300 deg$^2$) for the period of SN Ia, 50 days using 6 filters : this will generate 8-9 data points per filter.
- After 50 days observing 1$^{st}$ part of sky, go to 2$^{nd}$ part of sky and observe for 50 days
- After 50 days, go to 2$^{nd}$ part of sky and observe for 50 days
- After 150 days observing runs, the area and the filter coverage should be the same between the baseline plan and suggested rolling cadence.

# Rolling Cadence Optimized for SN Cosmology

- Observe 1/3 available sky (compared to the current) and concentrate on this field

  assuming one data point per day

  6 filter x(7-9 data points) = 50 days

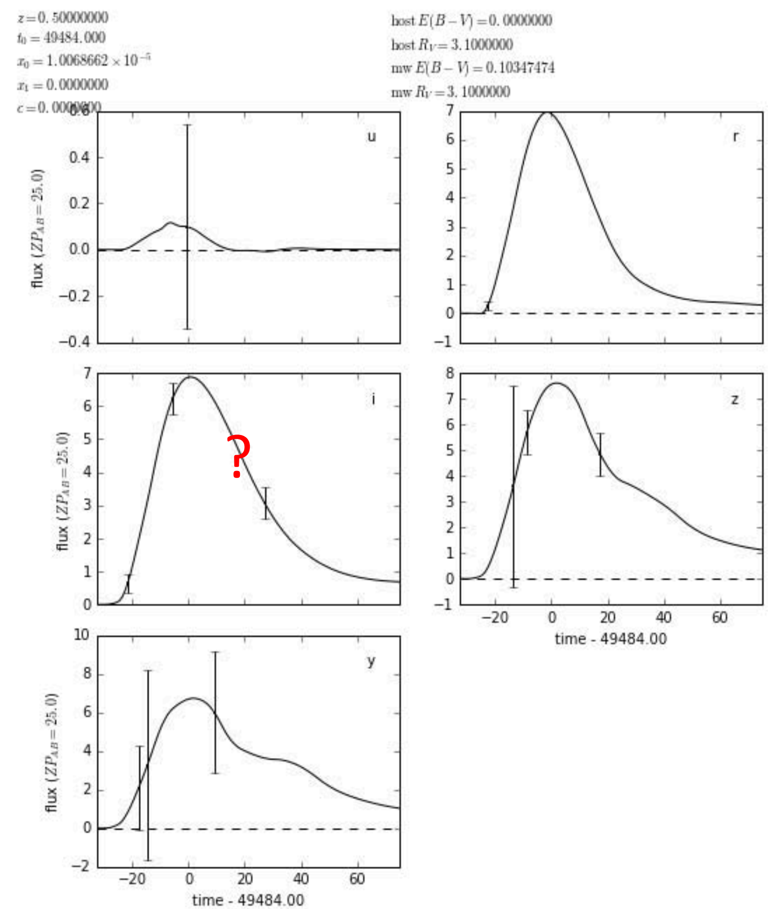
- Observe 2nd 1/3 available sky: 50 days
- Observe $3^{rd}$ 1/3 available sky: 50 days
- practically 3 filter x (7-9) + 3 filter x4= 36 days)

- Apply outside the Galactic Plane: |l| > 30°
- Improve LC quality of Group B and C area.

# What is observing strategy to make x2 or x3 factor higher sampling in light curves?

49484

- Goal: Avg data points > 7-9
- Observe a smaller area (for example 1/3) and observe 3 times frequently (compared to the current plan).



# MJD49492-49498: 6 day observing run

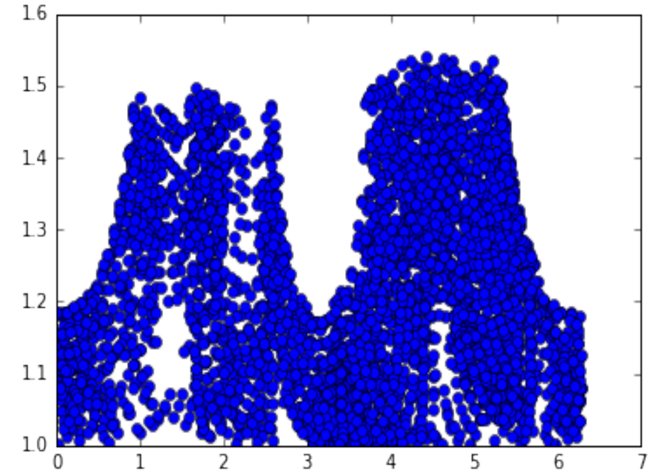
49484-49491: deep fields

Y band : 6 days

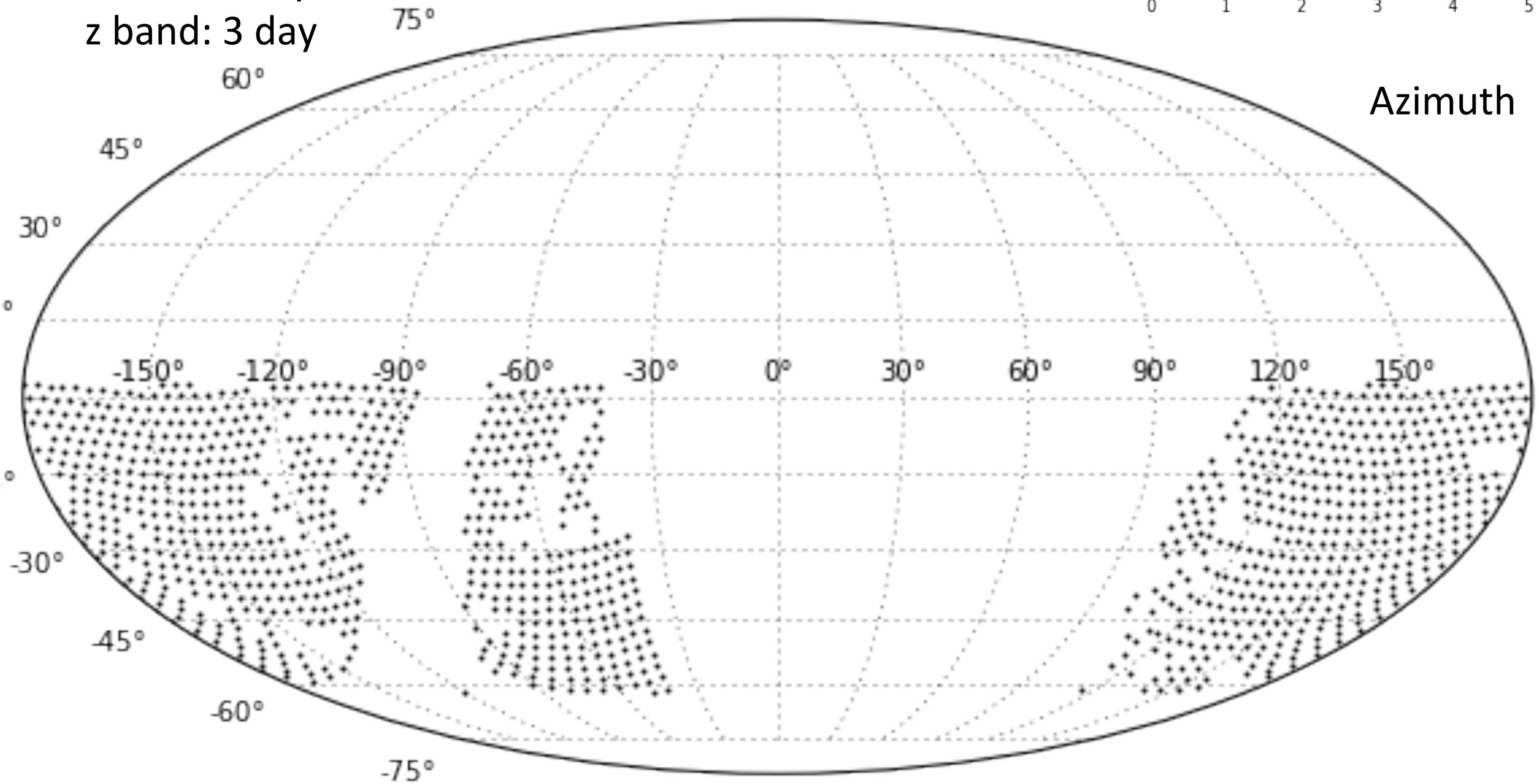
I band: 3 day

z band: 3 day

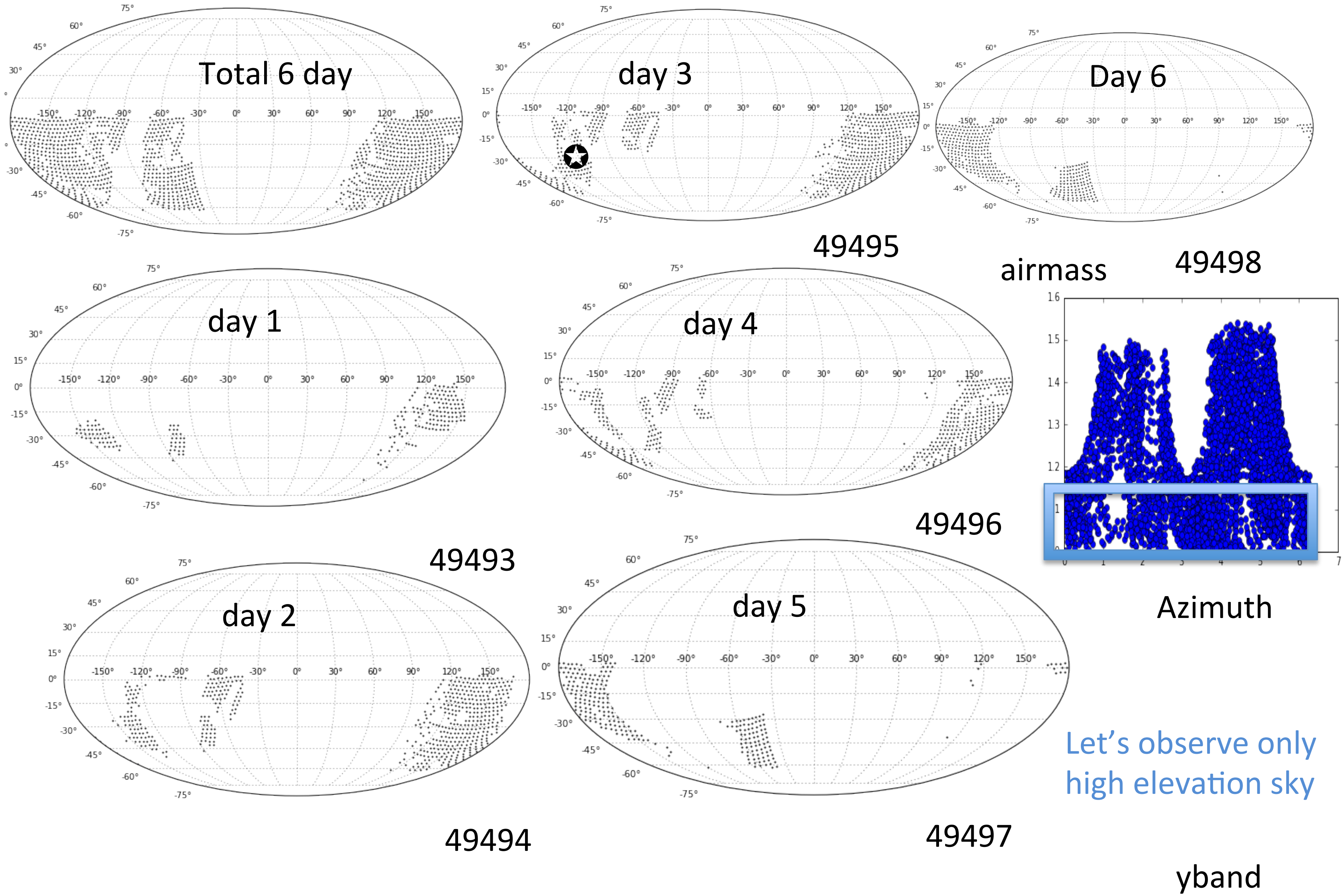
airmass

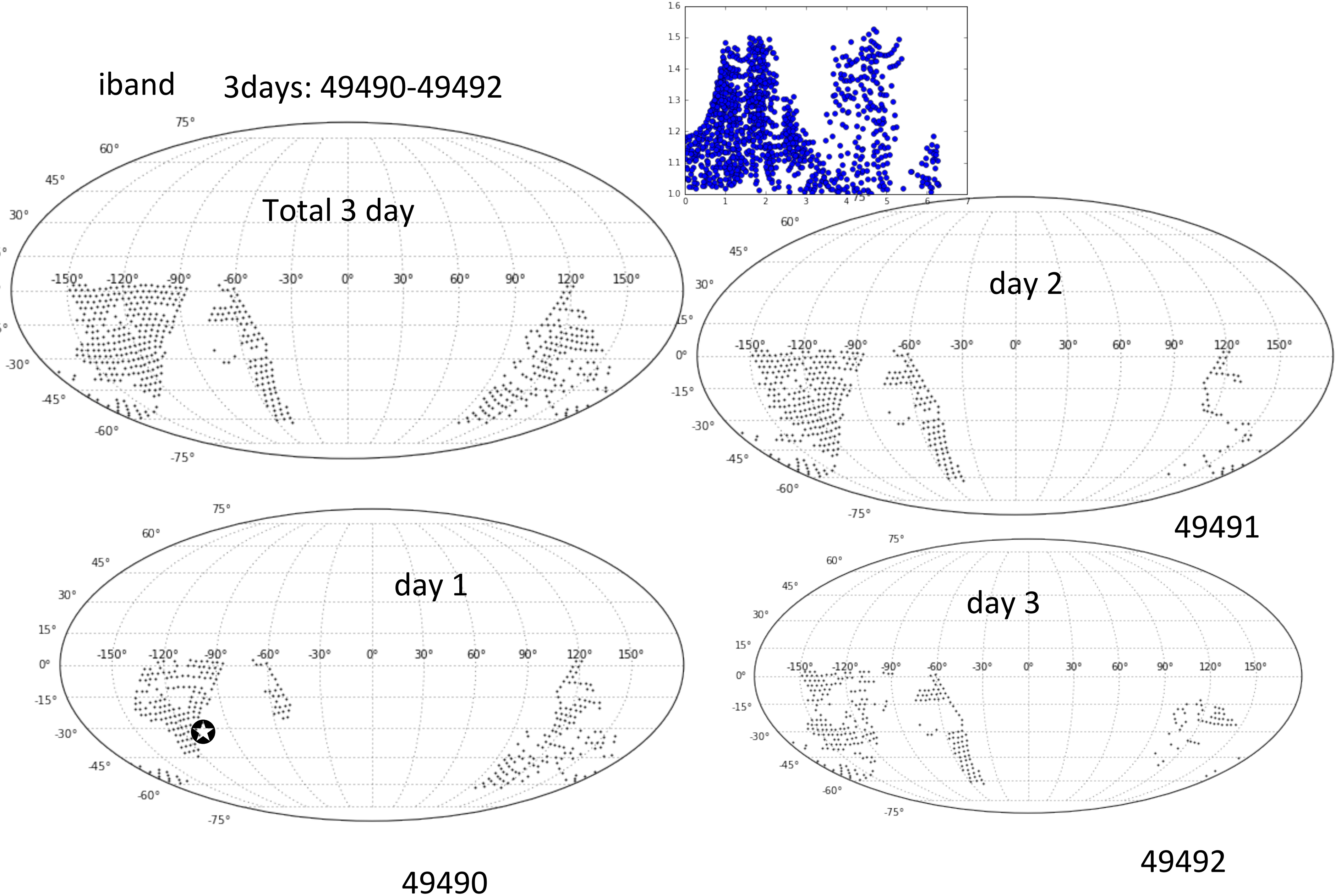



Azimuth



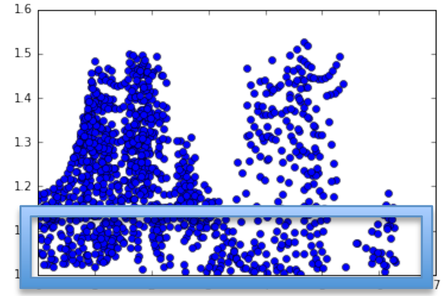
# 49492-49498 (y band)





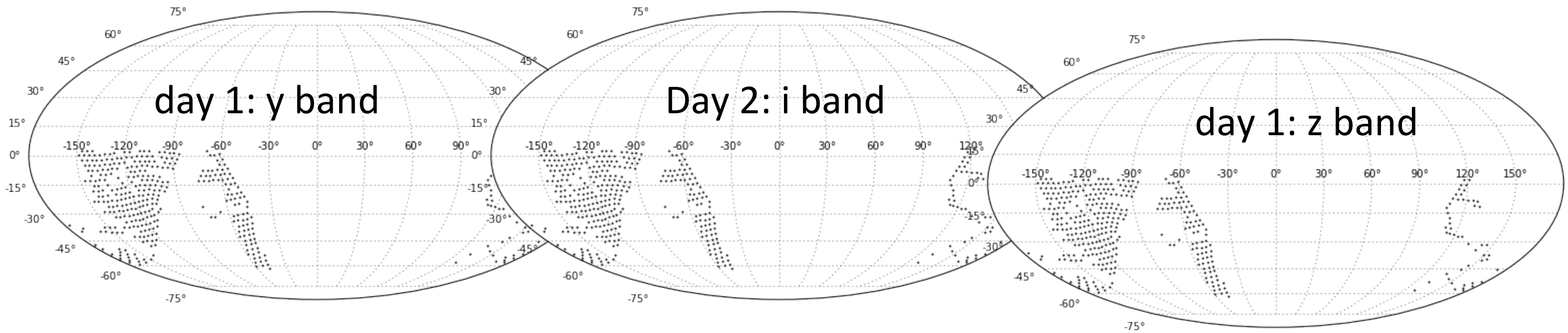
iband
3days: 49490-49492
Total 3 day
day 1
day 2
day 3
49490
49491
49492

3days: 49490-49492

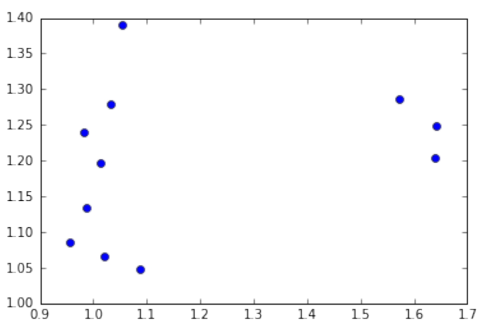


Take the sky which gives lower airmass

Method 2: modify selection of the region with lower airmass



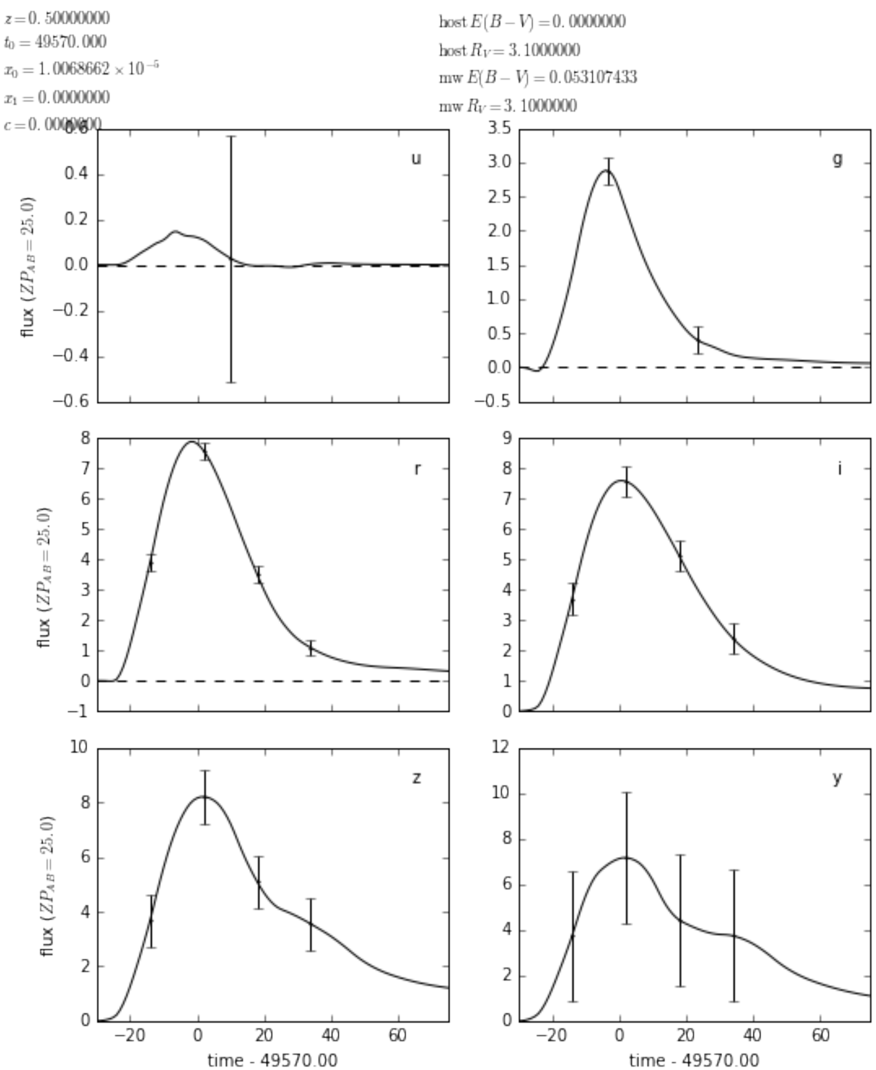

Ir, I, z band for each day



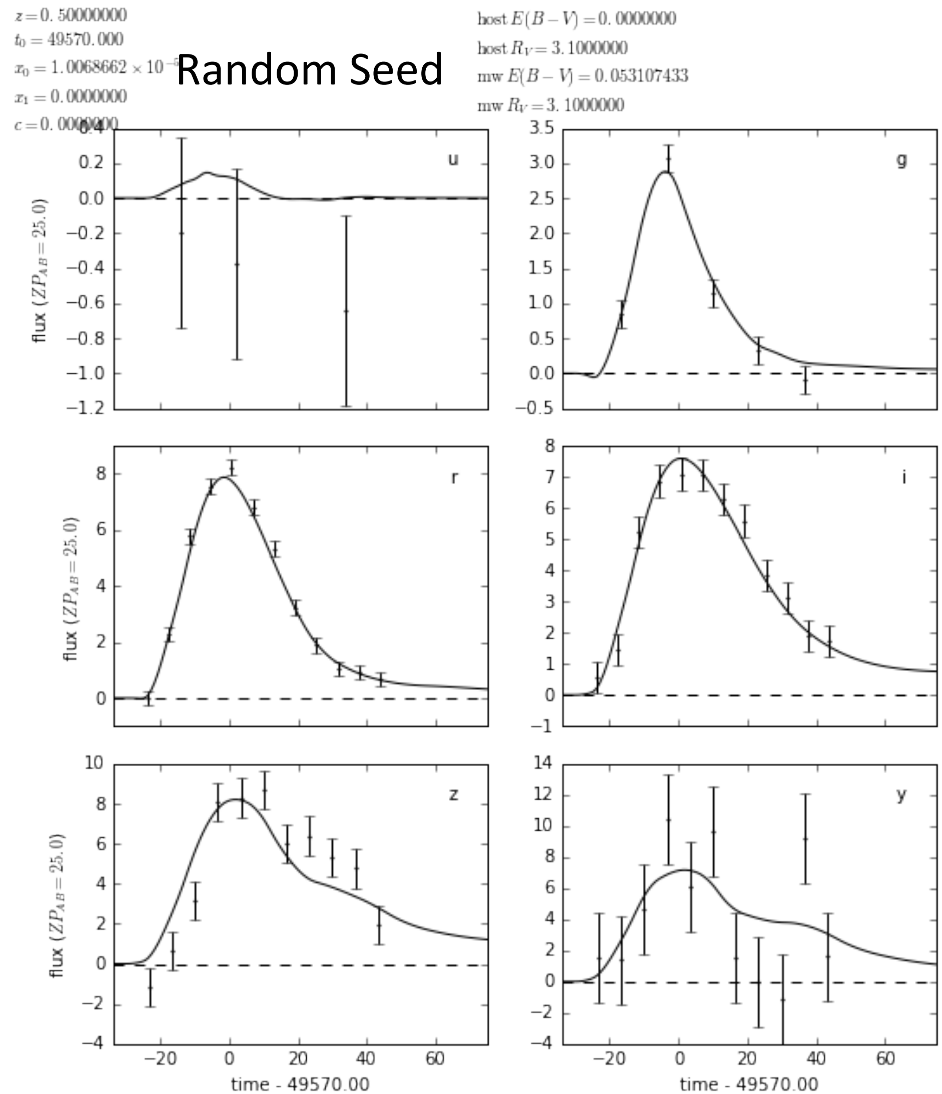
iband

- Take the 1/3 sky which gives lower airmass
- Observe more horizontally rather than vertically, which results in less variation in airmass.

# Cadence LC (x3): RA=58, Dec=-27




Random Seed




Random seed

# Status of Observing Strategy

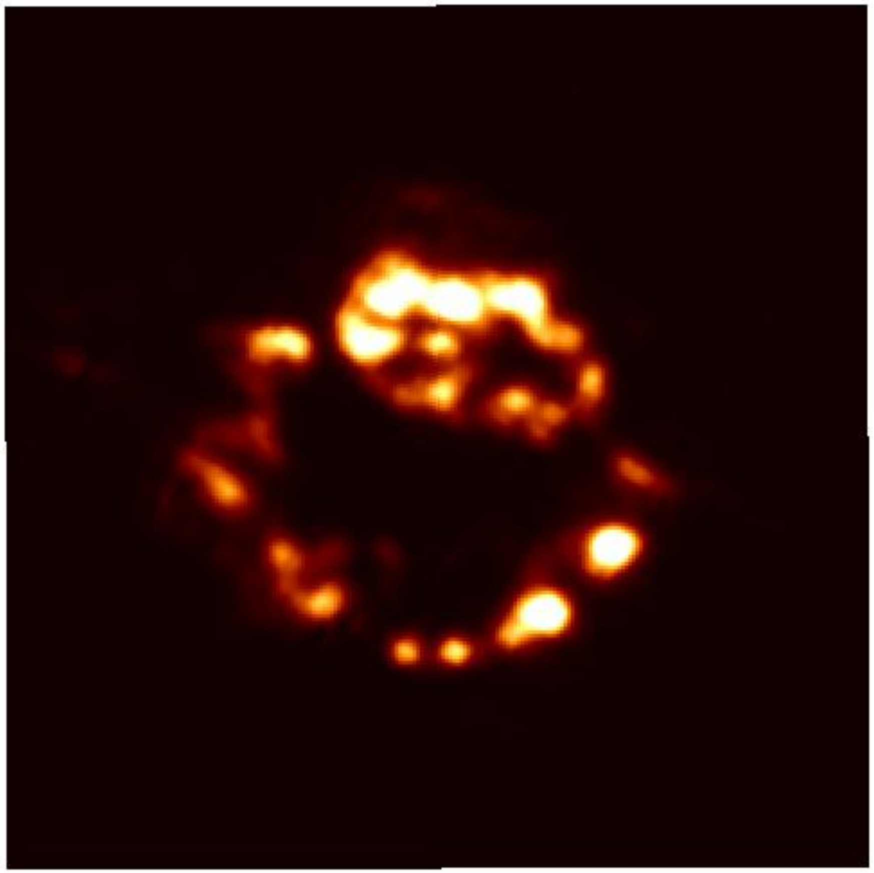
- LSST project is working on updating Opsim run for users to allow to vary these options.

New version is expected by the end of Nov.

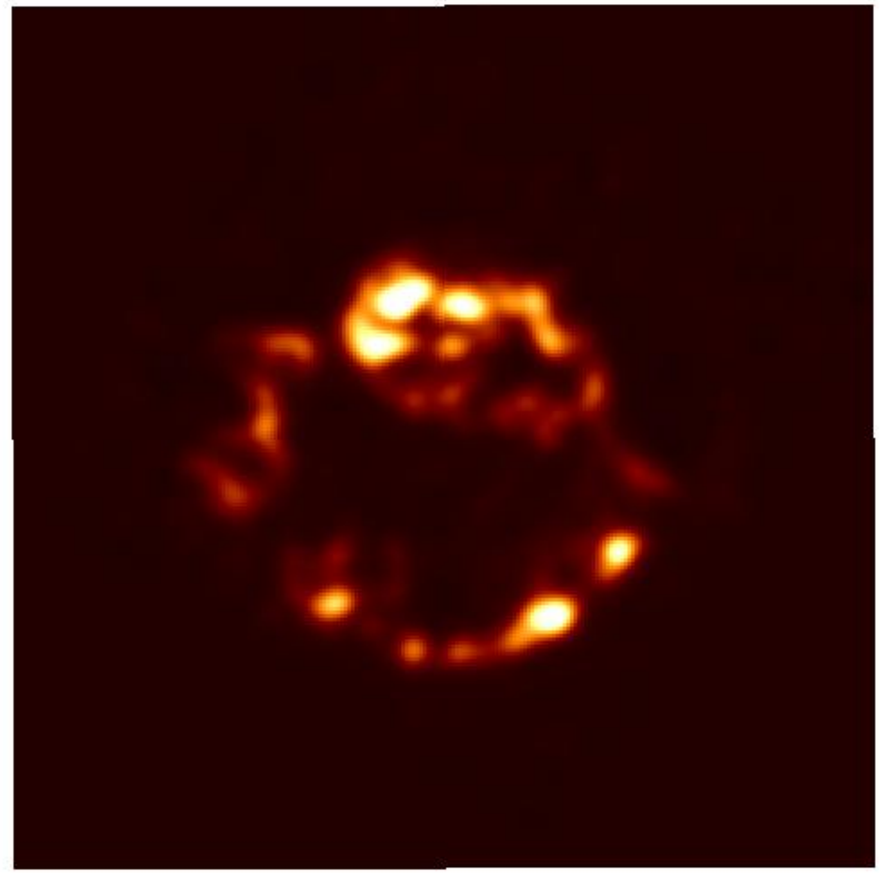
- Need to experiment various rolling cadence with new opsim.
- At the moment, it is not clear about status of white paper (it has been stopped) since the LSST team is busy with updating opsim runs etc.

# End

# Cas A: Dust formation in the SN ejecta

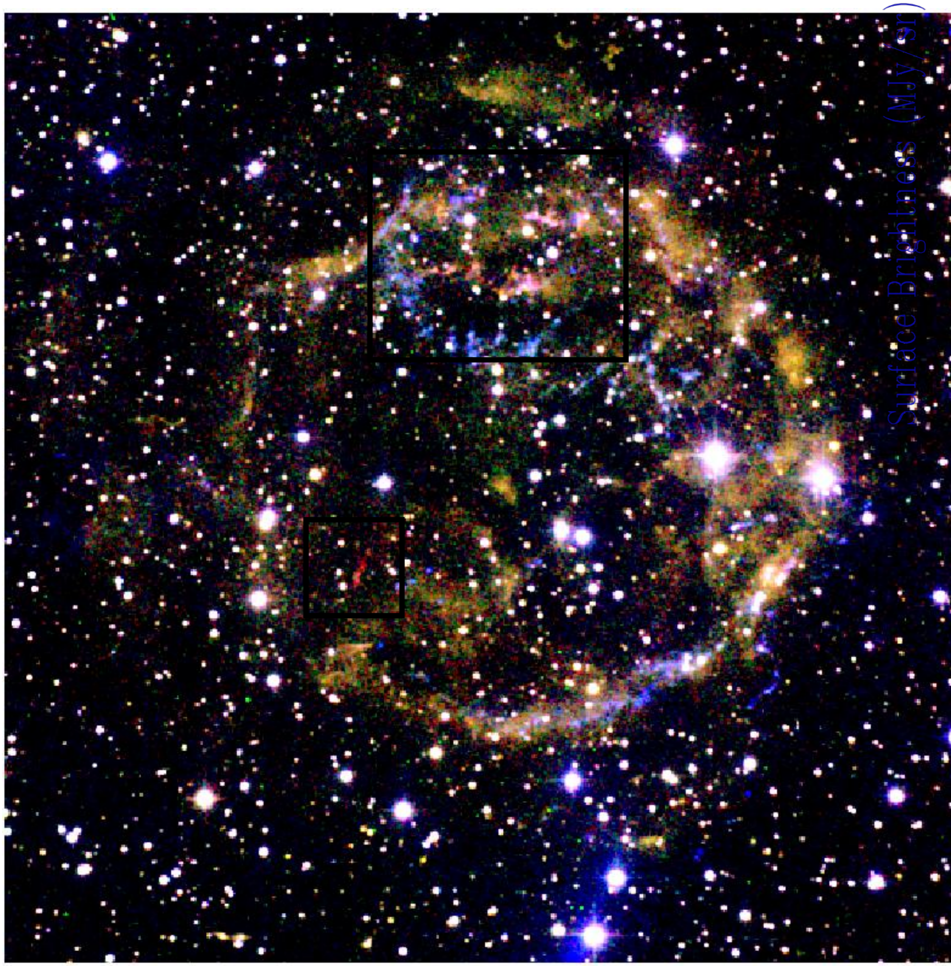


*21$\mu$m dust map which is continuum map of 19-23$\mu$m subtracted by the baselines of neighboring wavelengths.*



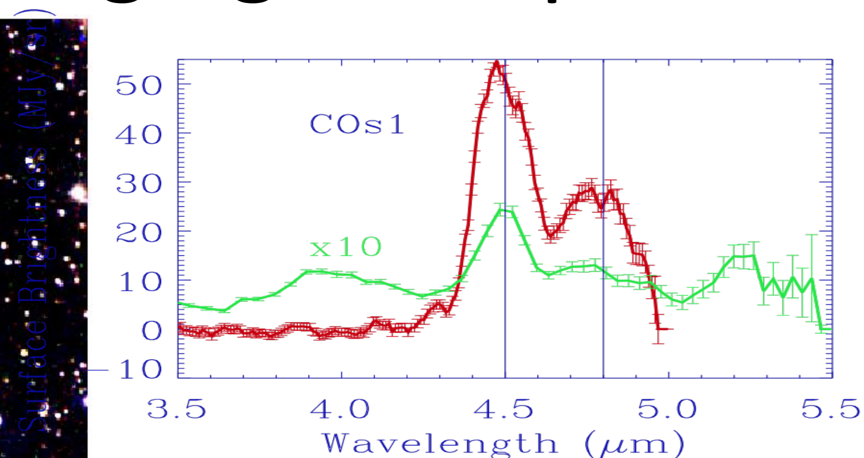
*[Ar II] 7$\mu$m map (the resolution is convolved to match): remarkably similar to the dust map.*

# CO detection in Imaging and Spectra

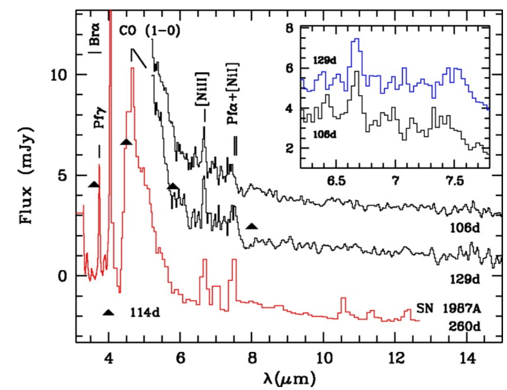


Near-IR imaging: CO filter (red): 2.294μm K-cont (green): 2.27μm P β (blue):1.182μm

First Overtone CO detection Rho et al. (2009)

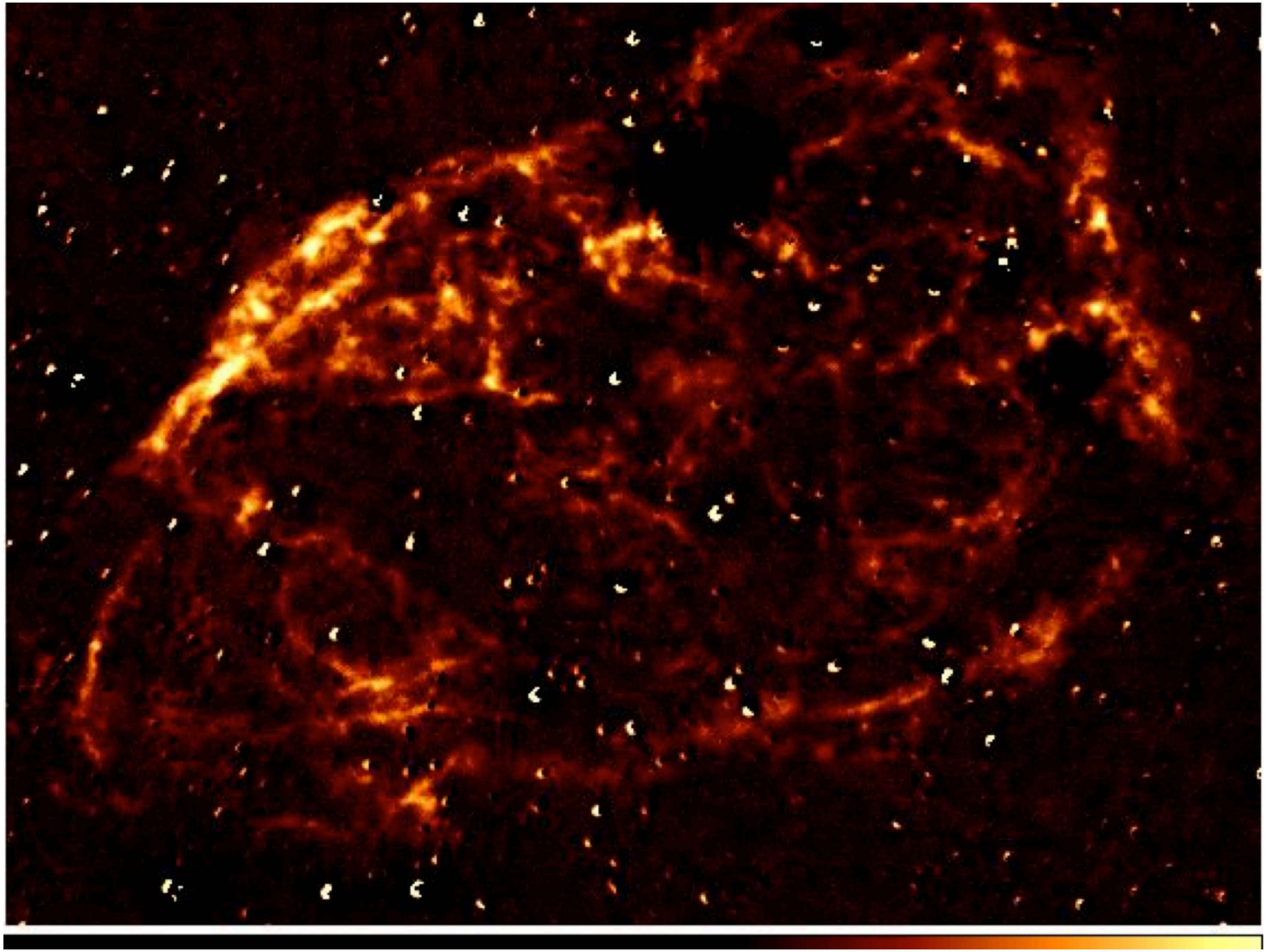



AKARI Fundamental CO lines
Rho et al. (2012)

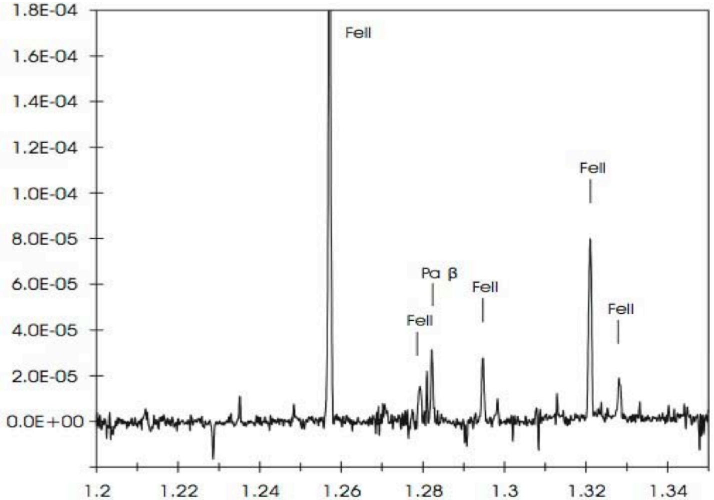


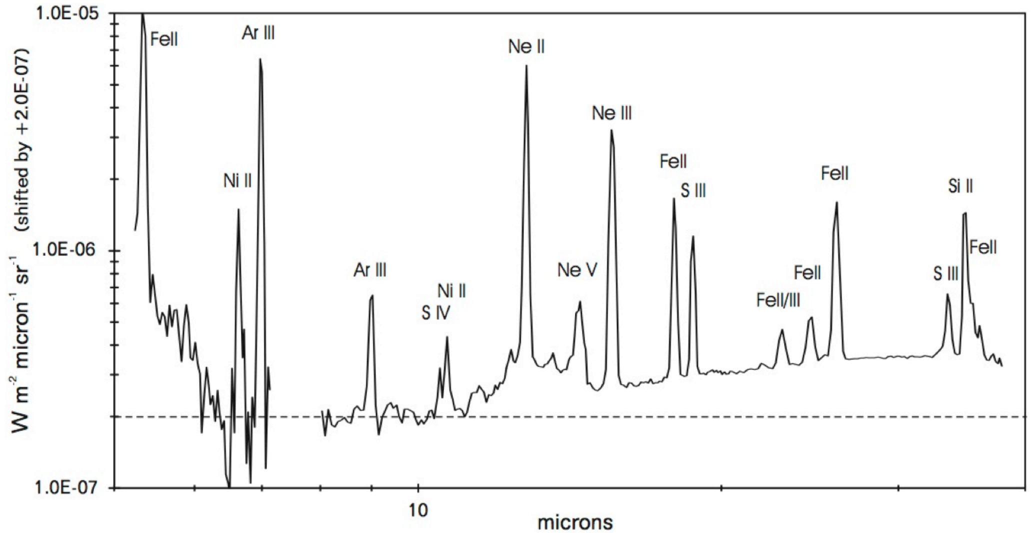

CO from SNe (Kotak et al. 2006)

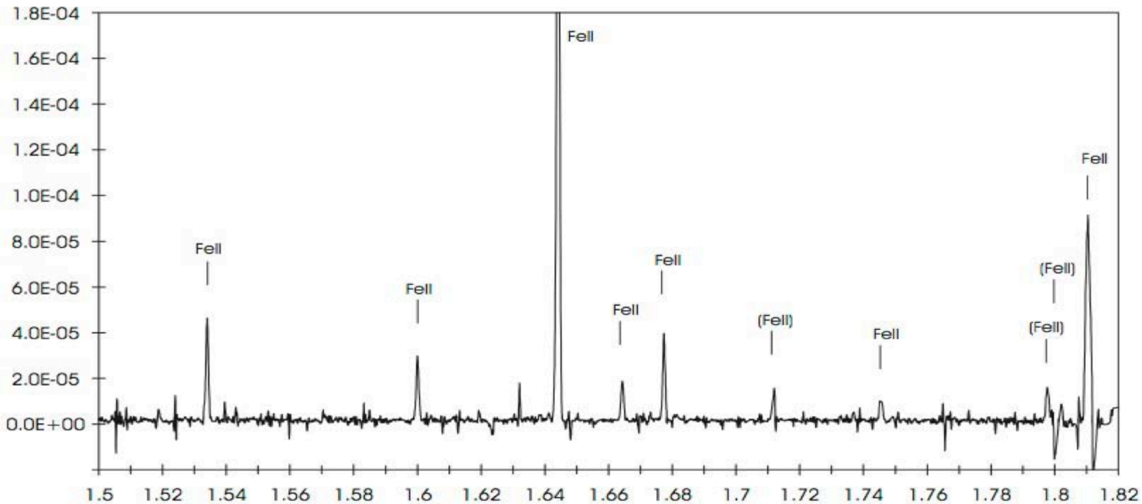
# SN Ia progenitor: 3C397



Near-IR Fe image: Higher Fe abudance in SN Ia (Rho et al., in prep)



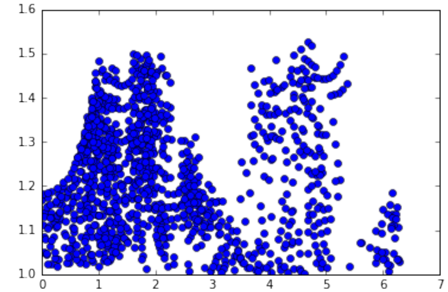




The best-fit parameters of Fe model
are T = 7000 K and $n_e$ = 8200 (5000-1.2x$10^4$) $cm^{-3}$.

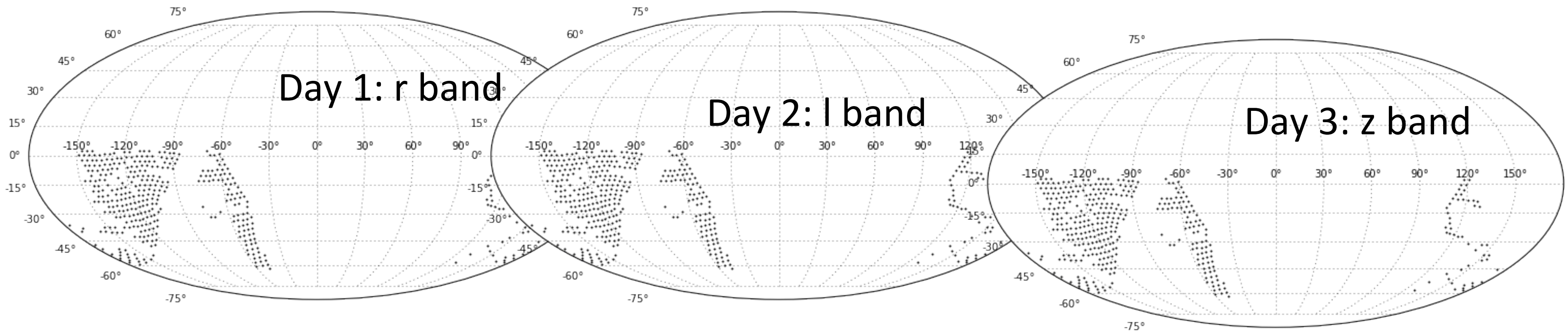
Near-IR and Spitzer Spectroscopy

iband

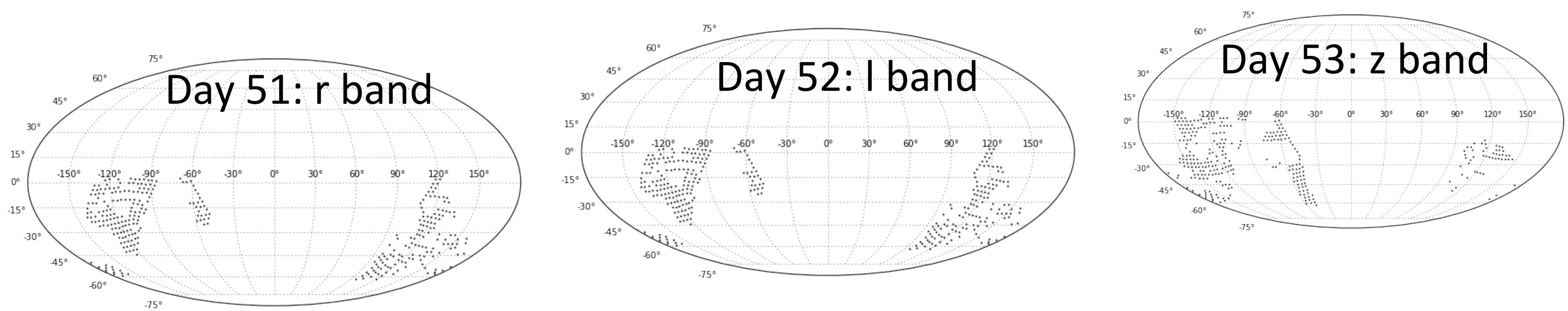
3days: 49490-49492



Method 1




r, I, z band for each day for the same field



# Hard Questions?

- What bands do we want to increase (priority)?

  r, I and z band if we focus on SNe at z=0.5
- What is optimal fudge factor to stay at the same field (f) to maximize detection of the number of SN Ia?

  $(38+f_{add})$[or 48]x fudge factor (f)

  We can regenerate LC eventually with OpSim output
- What are fast, simple way to add the data points?

  - Add with random function
  - merge two light curves
  - Any suggestion?

Eventually New OpSim run is needed (at least 4-5 months and possible 1 year according to Zeljko (OpSim team plans to work on this).

But in the meantime, what test can we do?