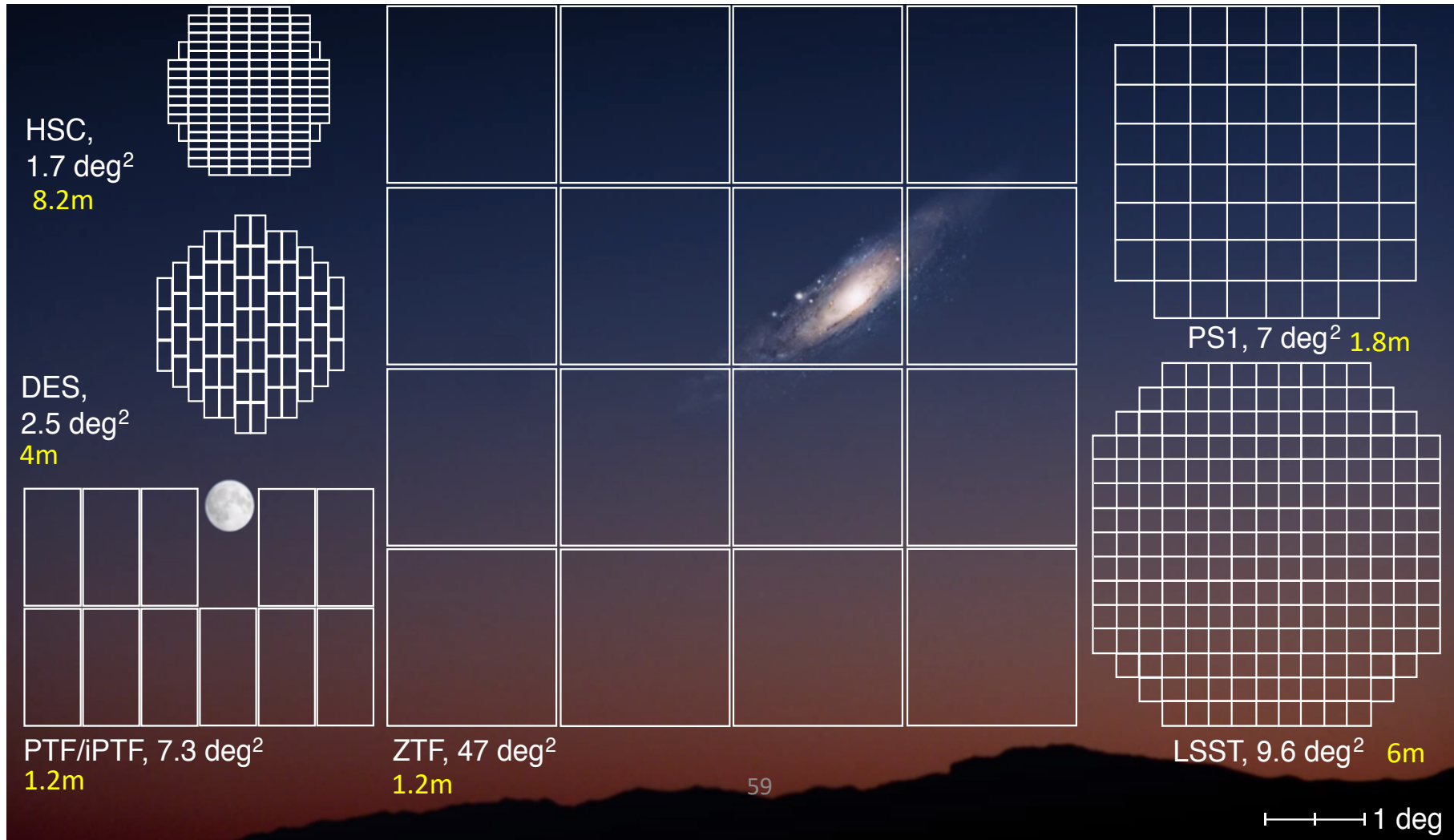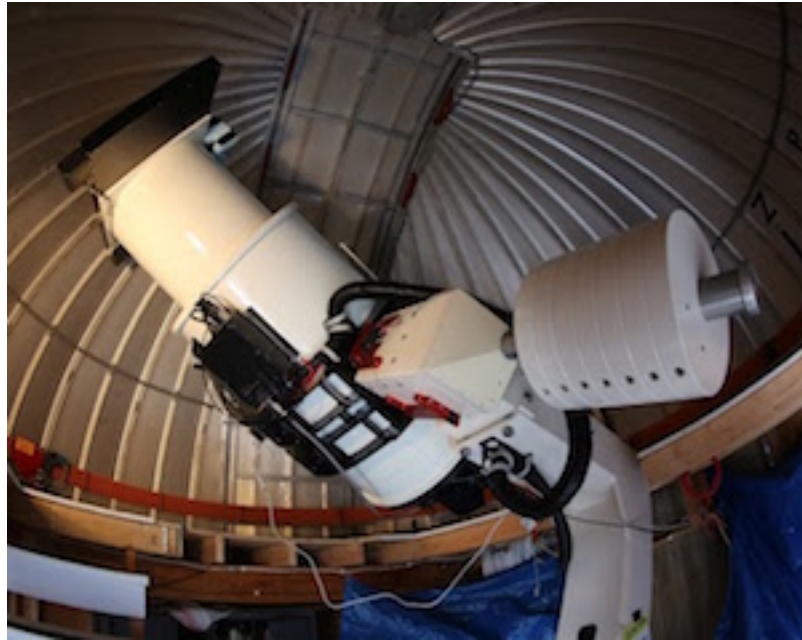# The Landscape of Time Domain Surveys

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(on sabbatical from Caltech)
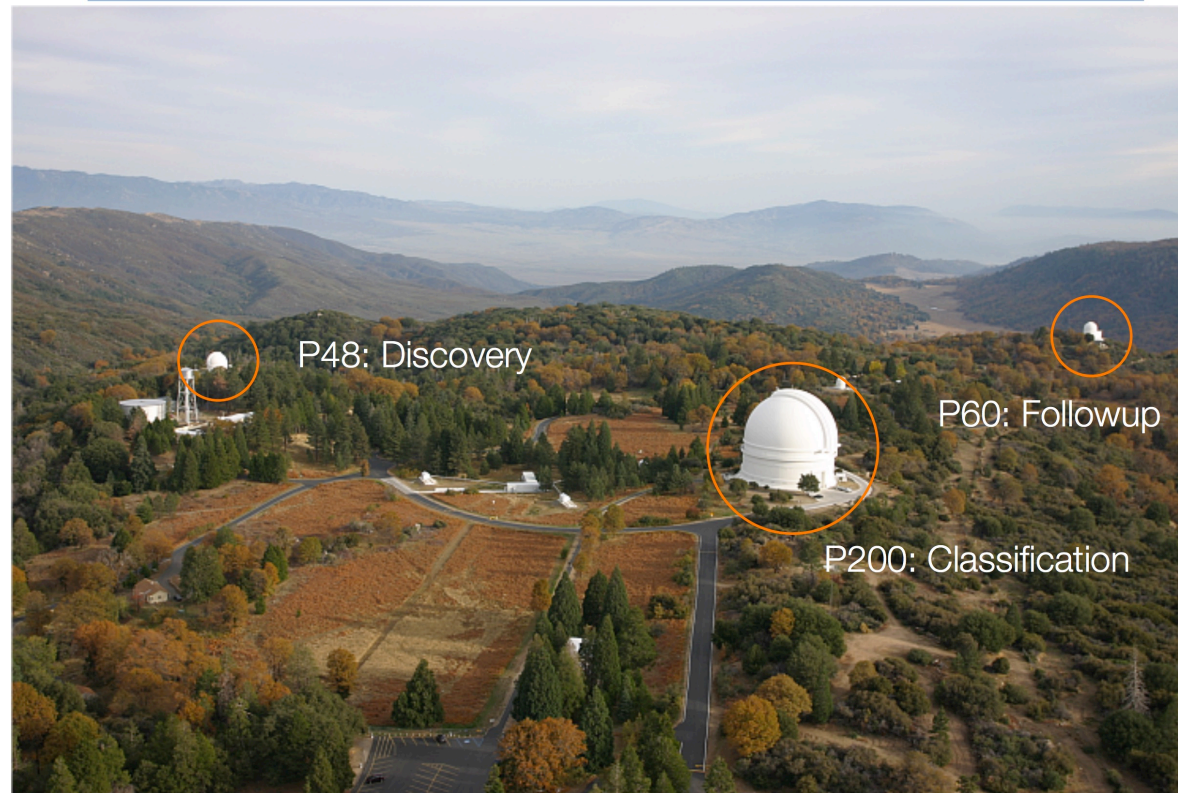
A collage of facilities

HSC,
1.7 deg^2
8.2m

DES,
2.5 deg^2
4m

PTF/iPTF, 7.3 deg^2
1.2m

ZTF, 47 deg^2
1.2m

PS1, 7 deg^2 1.8m

LSST, 9.6 deg^2 6m

59

1 deg

Zwicky Transient *Facility*

PTF uses the Palomar network of telescopes.

P48: Discovery

P60: Followup

P200: Classification

Moderate aperture survey matched to followup resources.

Dedicated large area surveys

- ASAS-SN (telephoto lens)
    - North & South, several longitudes
    - Covering all night sky with limiting mag of ~18 mag
    - Transients are announced over ATELS
- ATLAS (50-cm Schmidt telescopes)
    - Tuned for NEO, limiting mag about 19 (or 19.5, depending on broad color)
    - Northern sky surveyed over 2 nights (with intra-night cadence for NEOs)
    - Transients are announced via ATELs
- ZTF (1.2-m Schmidt telescope)
    - Northern Sky, multiple surveys, 20.5 mag (5 sigma; R and g band)
    - Built-in capability for classification (SEDM)
    - Prototype for LSST: industrial approach (alerts, archives etc)
    - MSIP Northern Sky Survey (3 nights, g&R)
    - Galactic Plane Patrol (nightly survey in g&R band)
    - Moderate cadence partnership survey (2000 sq deg; 3+3 times a night)
    - 2-hour deep drilling fields

Other Dedicated Facilities

- PS-1 (1.8-m)
  - Dedicated entirely for NEO studies
  - Some TDA ("foundation survey")
- Kiso Schmidt (1-m)
  - Revolutionary CMOS camera (*)
  - 20 sq degrees behind a 1-m telescope
  - Has just been commissioned
- SkyMapper (1.35-m)
  - In Australia
  - Apparently no longer pursuing TDA
- BlackGem (65-cm telescopes)
  - In South Africa & Chile
  - 20 mag limiting mag
  - About to be commissioned

Dedicated focused projects

- Small field (Microlensing)
  - OGLE
  - MOA (*)
- Nearby SN
  - DLT40 and others (small telescopes)
  - KAIT
- SN activity has picked up a lot in China (*)
  - We will hear from XF Wang
- There are many focused projects (transits, stellar activity, GRB response)
  - Not discussed in my talk but there are opportunities here to use tens of 1-m class telescopes for transient follow up (cf. papers on AT2018cow)

Time Domain Surveys on Large telescopes (but time shared with other instruments)

- HSC on Subaru 8-m
  - 1.7 sq degrees, excellent imaging, as deep as LSST (or deeper)
  - Main focus has been large scale structure studies
  - In TDA main contribution has been fast transients (shock breakout of large stars)
- DECam on Blanco 4-m
  - 2.5 sq degrees, excellent imaging
  - Built for large scale structure & SN Ia cosmology
  - A large number of community led programs (SLSN, shock breakout, GW astronomy)

The classification bottleneck

- The local rate of SNe (core collapse & Ia) is 10^5 Gpc^{-3} yr^{-1}

- The bright surveys are capable of finding 10^4 SNe per year

- In order to classify a transient you need about 100 channels of information
  - This can be spectral (SEDM approach) or light curves (Ia cosmology approach)

- In order to determine the redshift of the transient you need 1000 channels of information
  - Low resolution spectroscopy (R=1000) is robust. Broad band colors is adequate for some purpose (but works for higher redshift)

Enter "Massively Multiplexed Spectrographs"

- A symbiotic relation between time domain astronomy surveys and massively multiplexed spectrographs

- Use the next few years to train on TDA+DESI, TDA+SDSS V and establish large SN samples
  - Use this training set to establish filters for LSST+PFS

- Then there is the entire area of stellar & solar-system astronomy

- With Gaia and other data sets and highly cadenced ZTF data new avenues for Galactic black hole searches, compact binaries and in general binaries is a rich field.