Palomar Transient Factory
Overview & first results

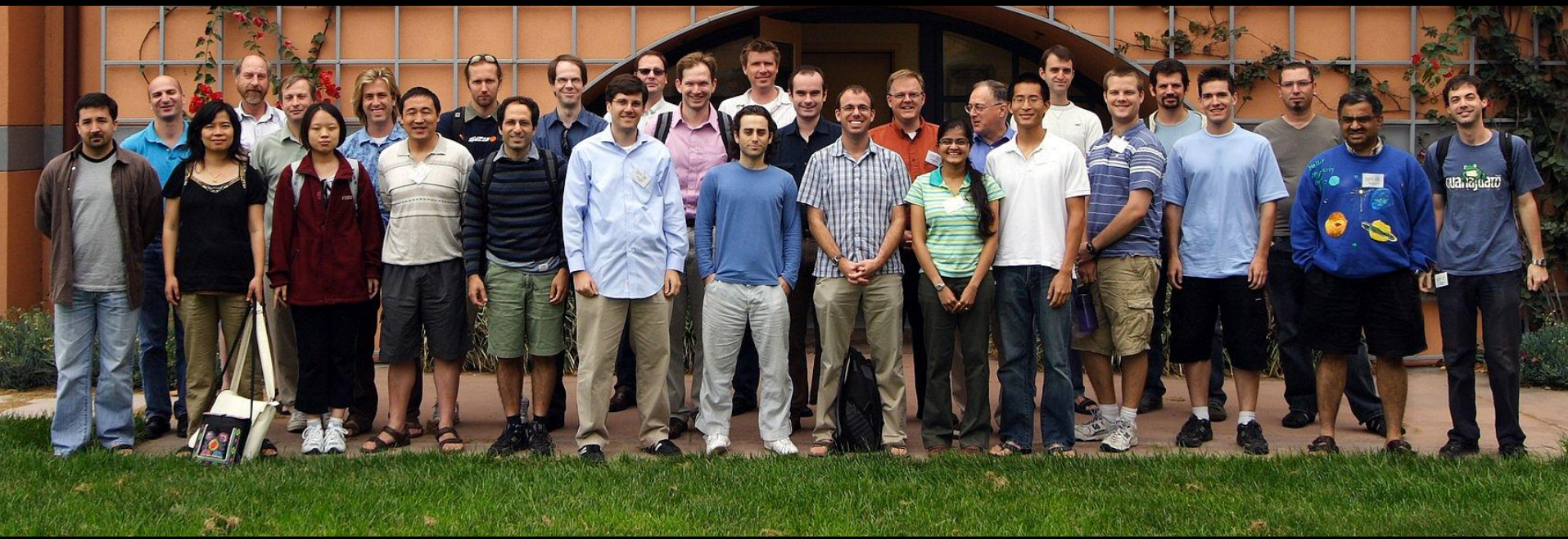
Eran Ofek
CALTECH
and the PTF collaboration

Talk Layout

- ★ PTF science (see also: Rau et al. 09)
- ★ PTF overview (see also: Law et al. 09)
- ★ PTF pipelines
- ★ Projects
- ★ First discoveries

PTF collaboration

PI: S. R. Kulkarni



Caltech, LCOGT, Berkeley, LBL, IPAC, Columbia, Oxford, Weizmann

PTF science

- ★ Explore the transient sky phase space
  - Unexplored regions of transients phase space
  - Rare events
    (maybe important for chemical evolution)
- ★ SN type-Ia calibration
- ★ SN type-Ia rapid HST/UV spec. (PI. Ellis)
- ★ CVs
- ★ Blazar variability and Tidal disruption events
- ★ Galactic structure, (SFR in) nearby galaxies,…

PTF overview

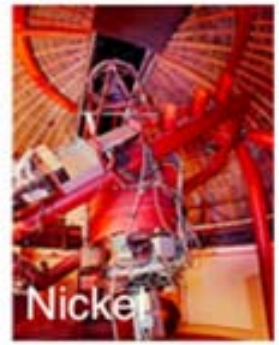
- ★ 48" Oschin Schmidt Camera (Palomar observatory)
- ★ 7.2 deg^2 FOV CCD (92 Mpix), g&R filters
- ★ Scale: 1"/pix
- ★ Robotic telescope & scheduler
  - Full automatic operation
  - Auto. Selection of science targets
    - based on
      - cadence
      - (Moon) sky brightness
      - airmass
      - …

PTF overview

- 60s exposure + 30s readout
  ~630,000 deg^2 yr^{-1}
  (currently ~410,000 deg^2 yr^{-1})

PTF followup

PTF follow-up telescopes



PTF overview

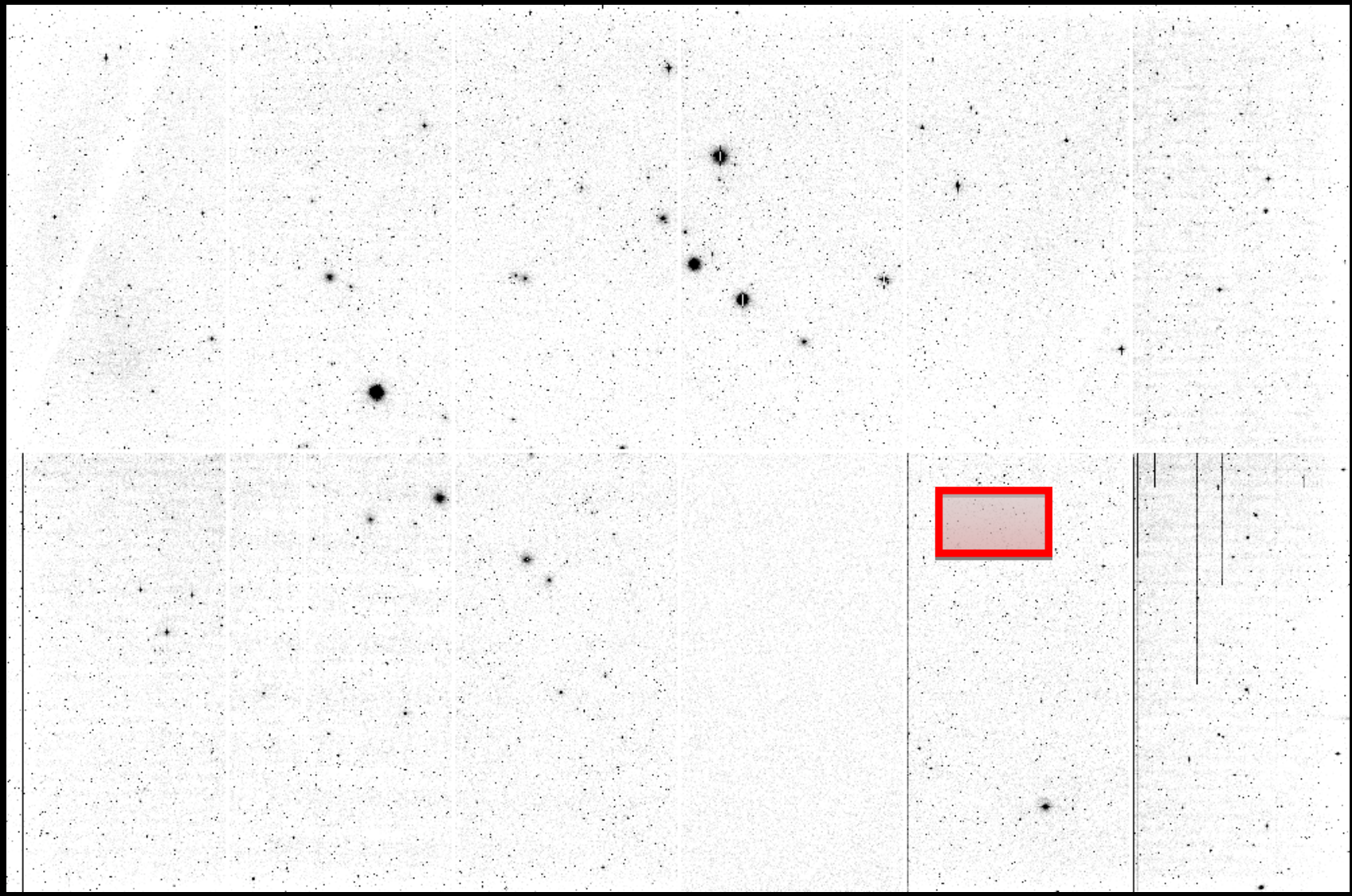
Data quality

- ★ First light: December 2008
- ★ First science run: March 2009

- ★ Typical seeing ~1.8" (best 1.4")
- ★ Lim. Mag (5σ) ~21 in g,R

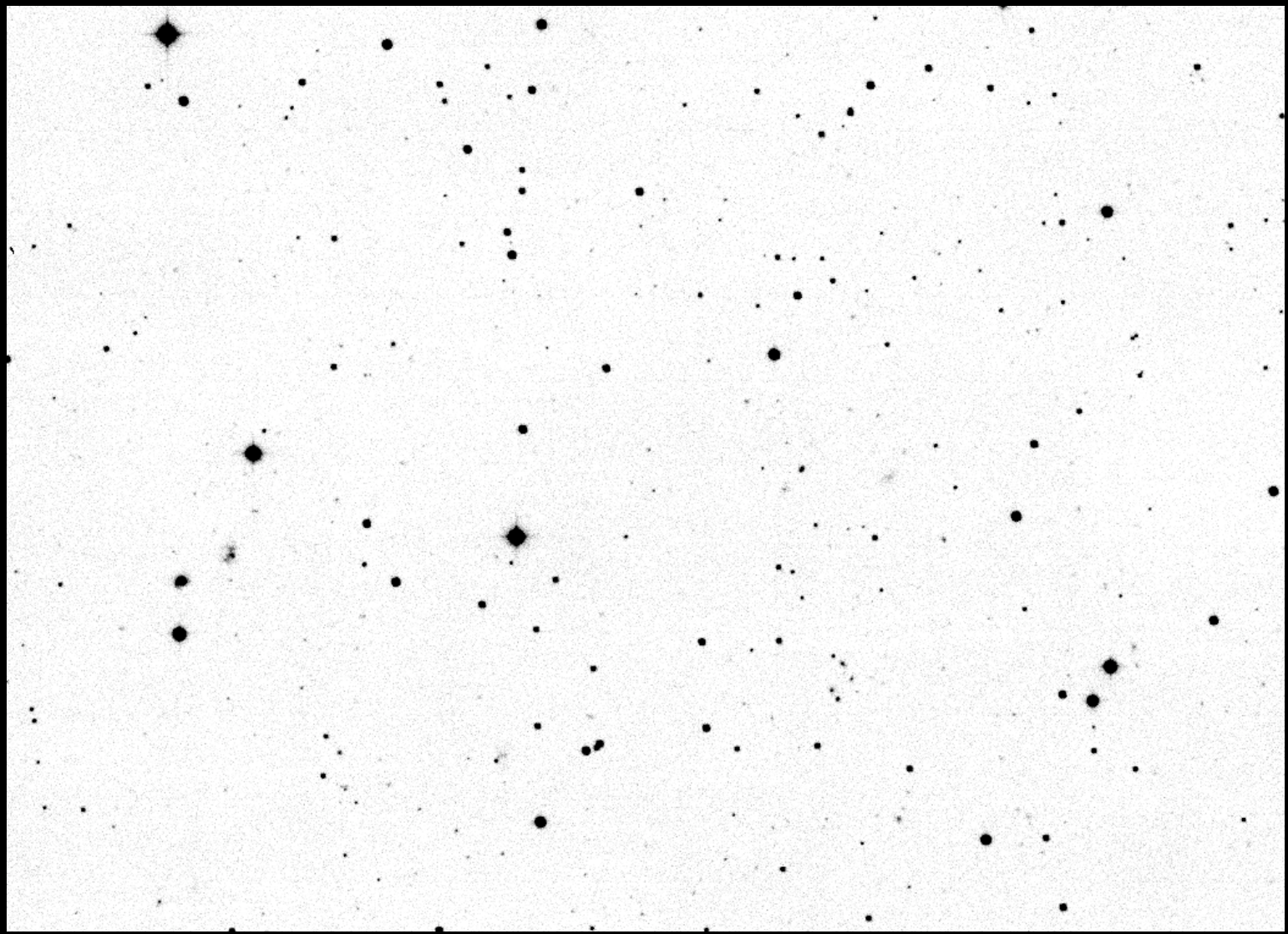
PTF overview

Data quality



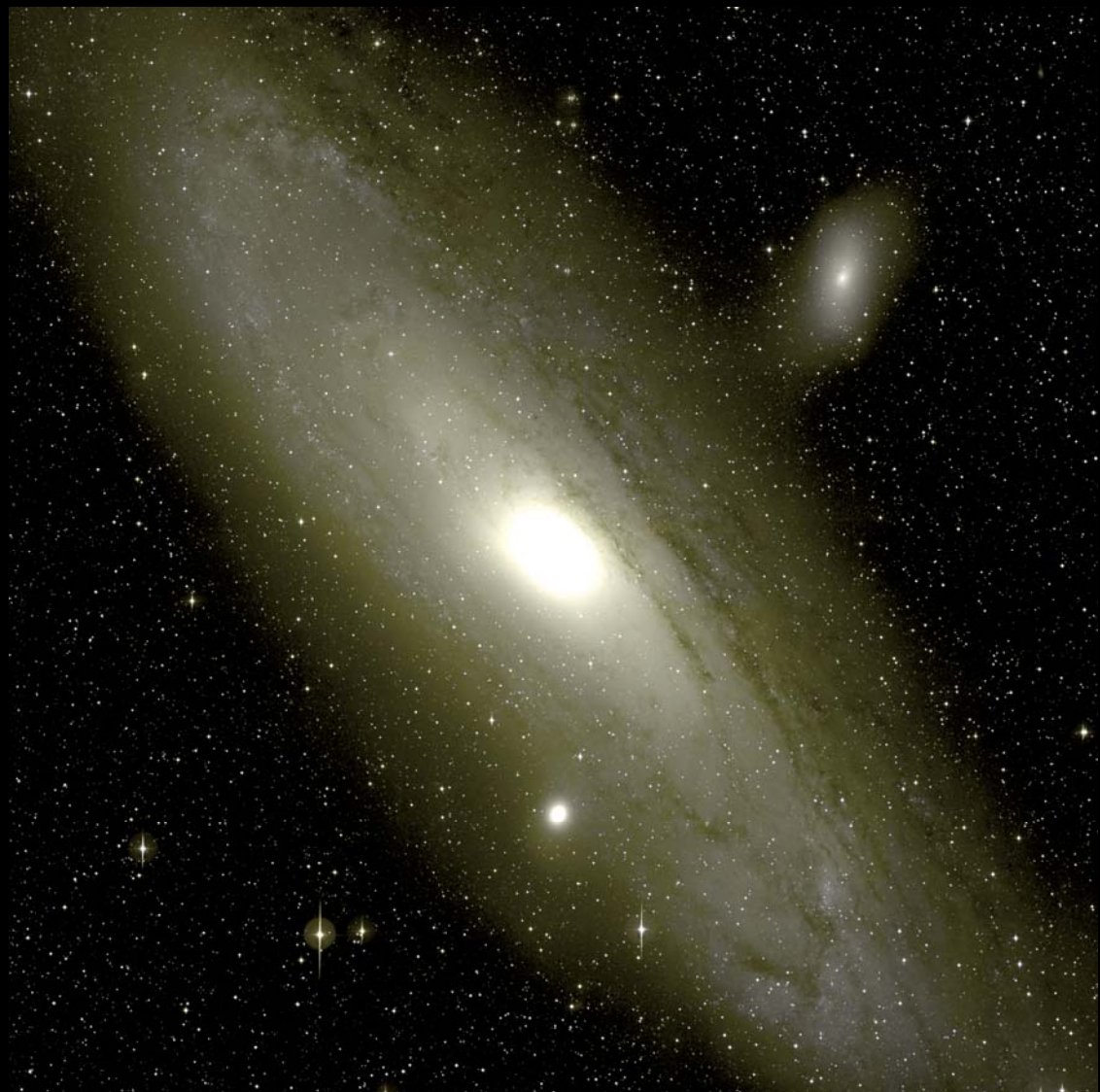
PTF overview

Data quality



PTF overview

Data quality

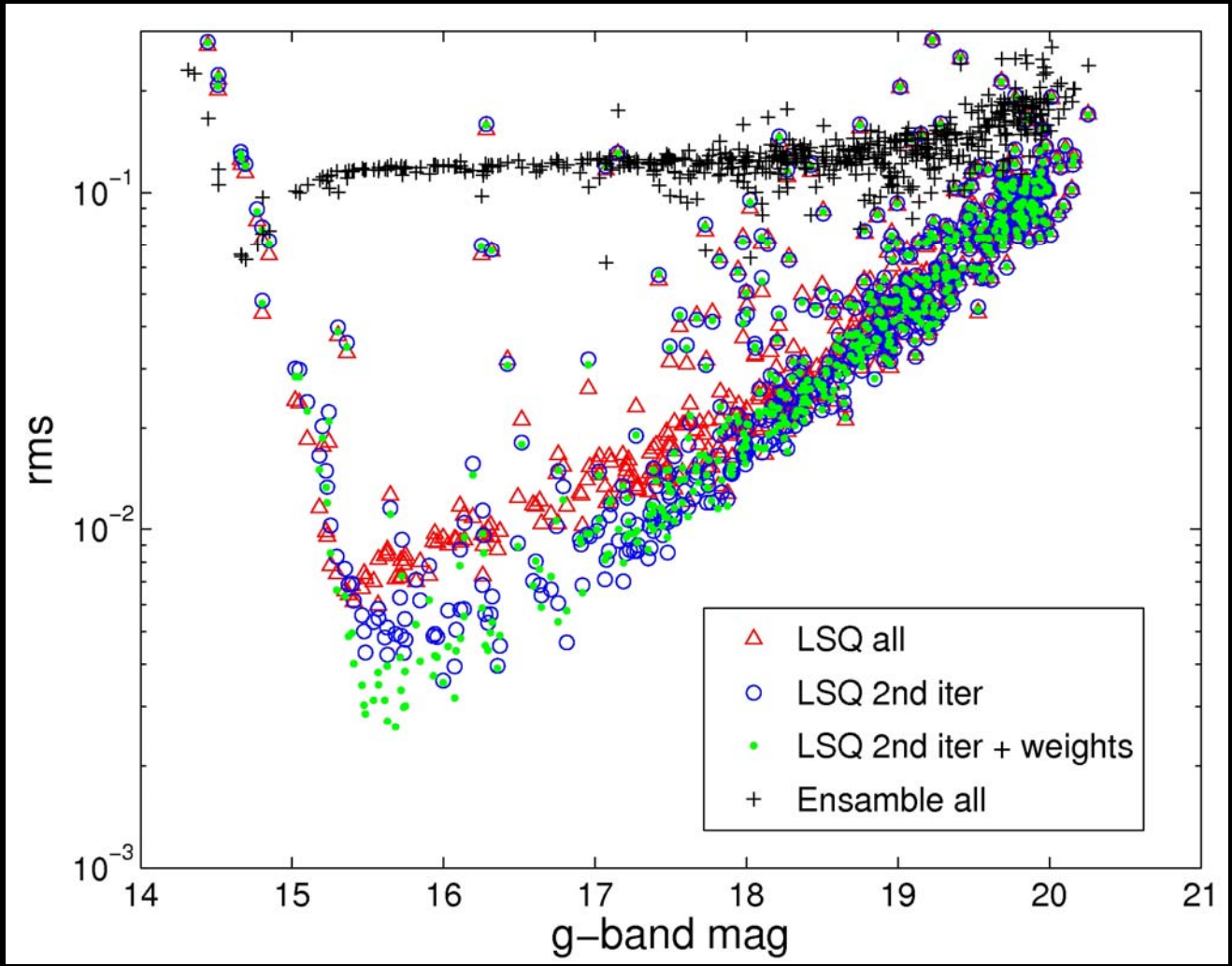


P. Nugent, D. Poznanski

PTF overview

Data quality

Relative photometry



PTF overview

- Two separate pipelines

  LBL image subtraction pipeline

  IPAC images and catalogue pipeline

Image subtraction pipeline

Lead by P. Nugent

- Main goal: efficient discovery of transients in near real time
  - Currently ~12 hr
  - near future ~1 hr

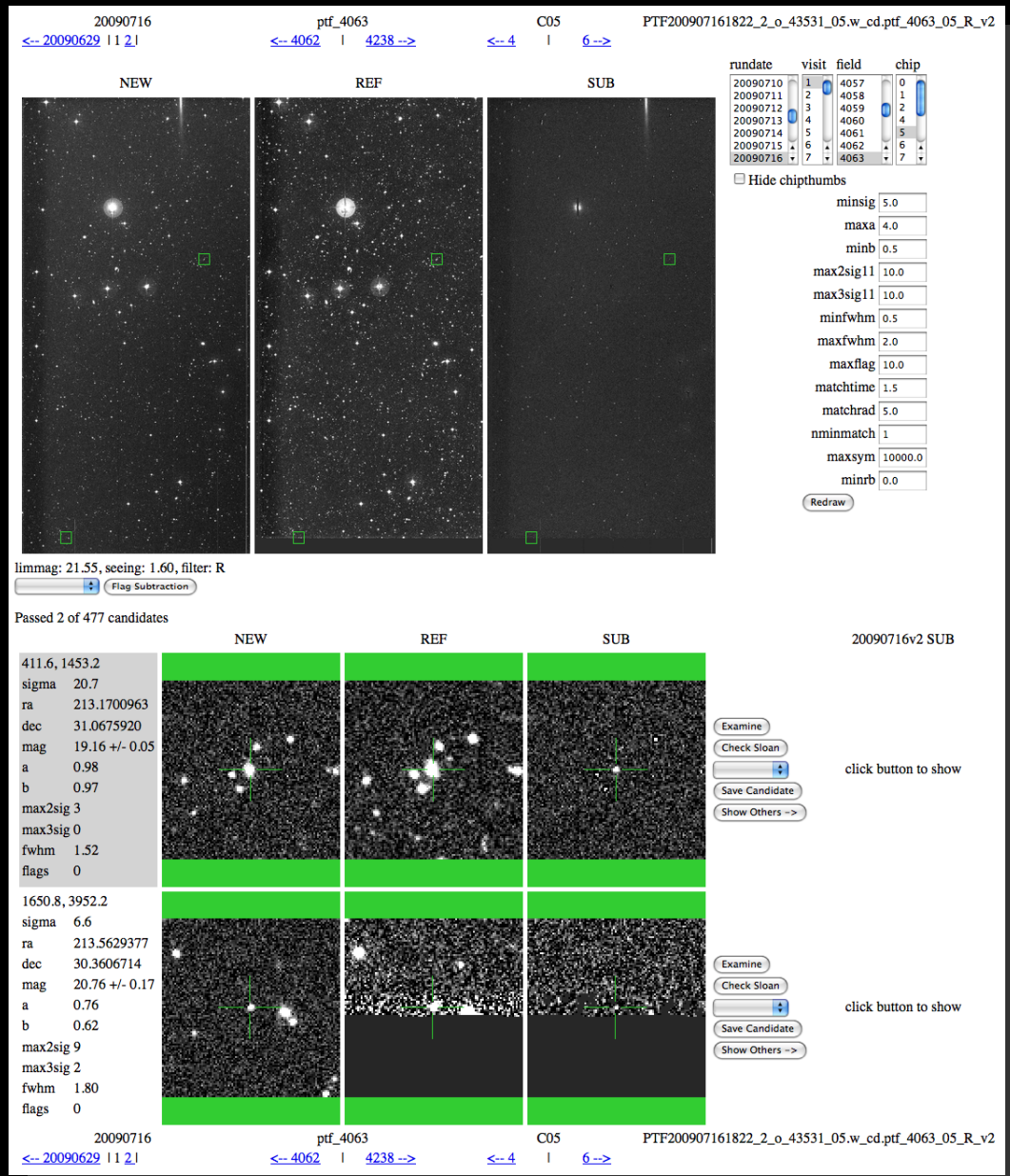


Image subtraction

LBL image subtraction pipeline

★ Challenge: 0.5-1 M sources detected in Subtracted images each night!

★ after cleaning – large number of candidates (~10%)

★ However, only a few % are real variable/transients

★ Solutions:

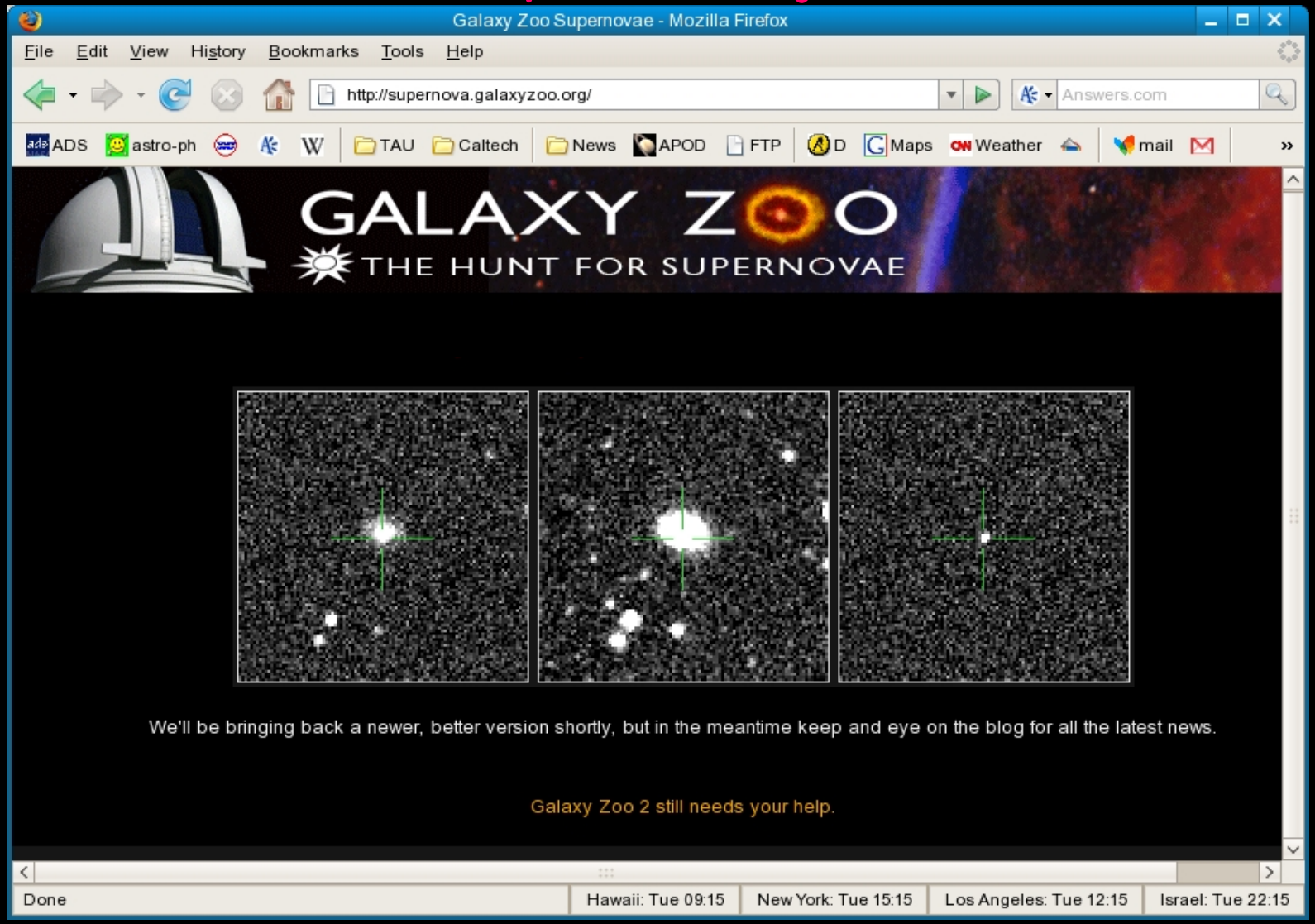
Machine vetting

Humans vetting → Scientists

Humans vetting → Public

Image Subtraction

Galaxy Zoo Project



IPAC images and catalogue pipeline

Lead by J. Surace

★ Data products:

Reduced images

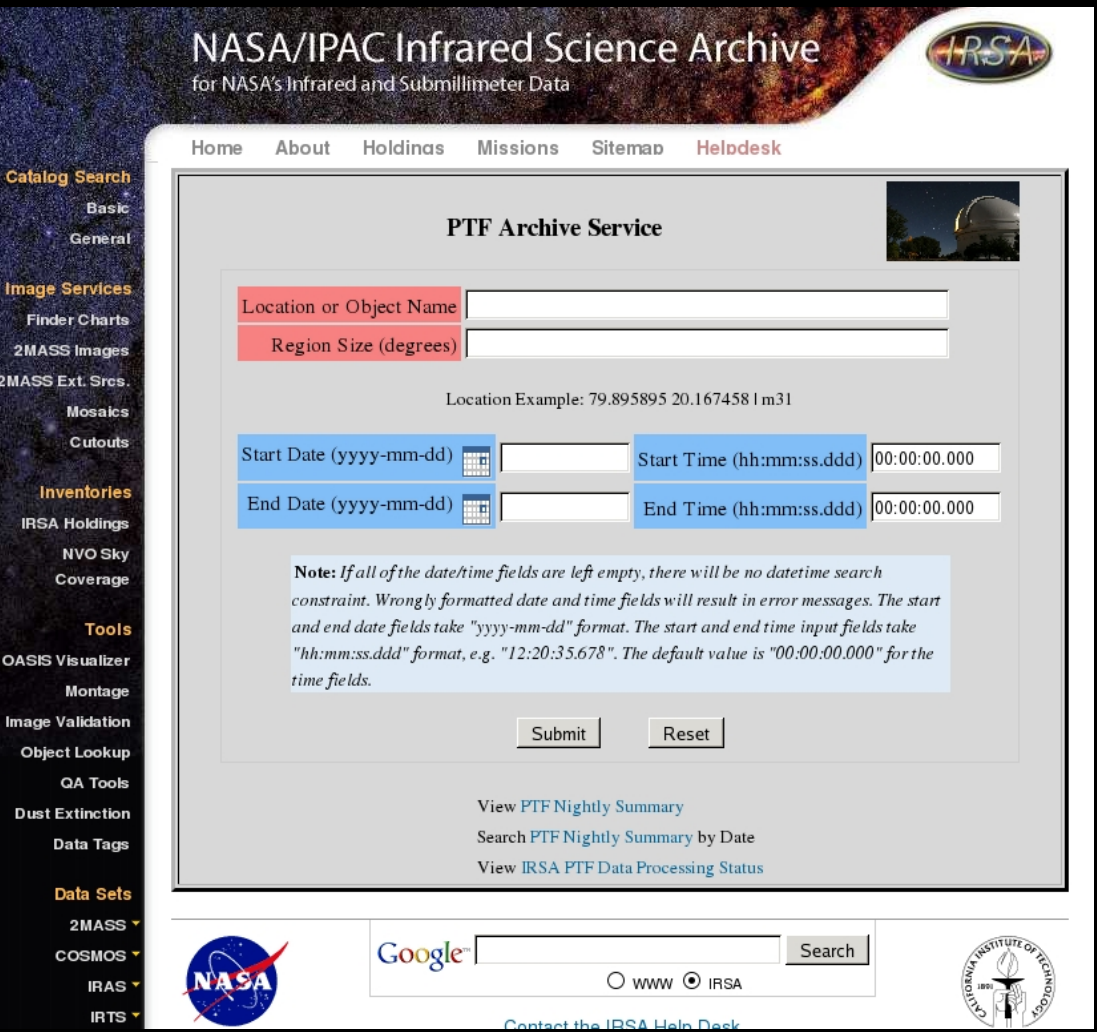
~100TB per year

Catalogue

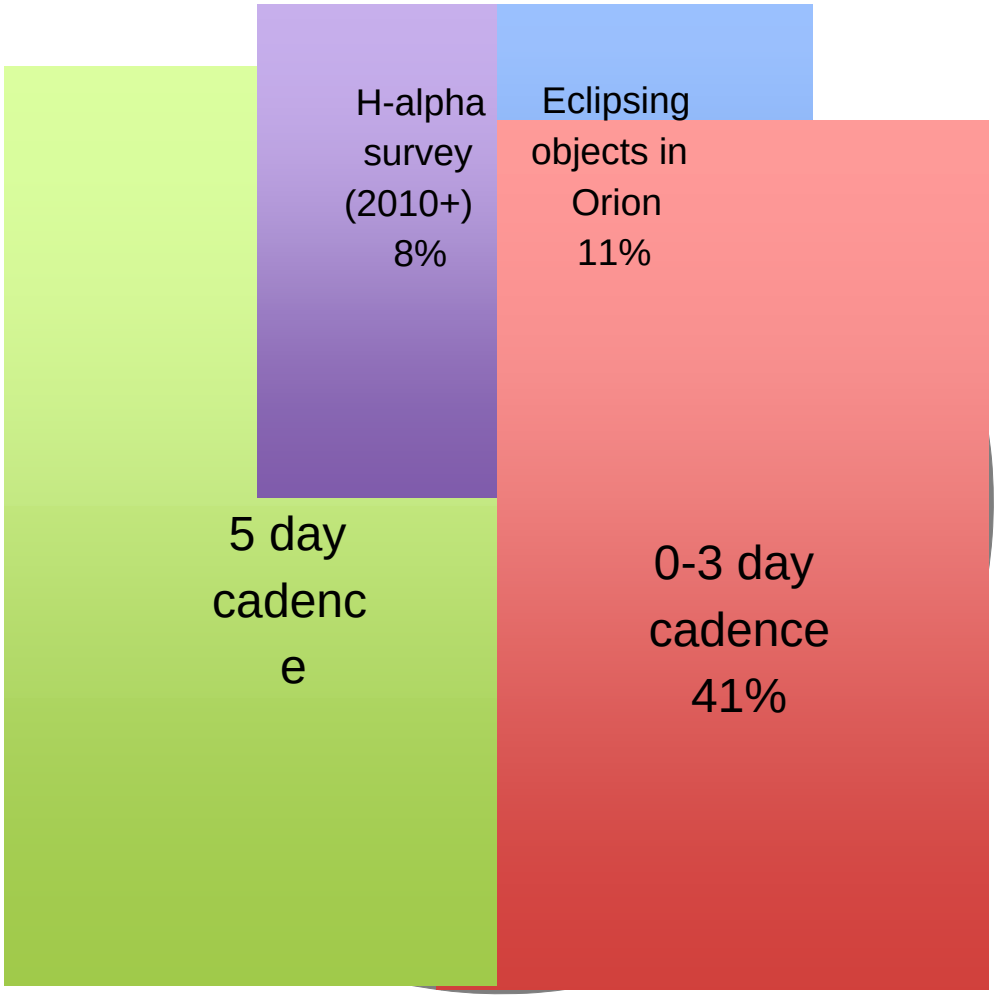
~10^{12} sources per year (10 TB)

PTF overview

IPAC image and catalog pipeline



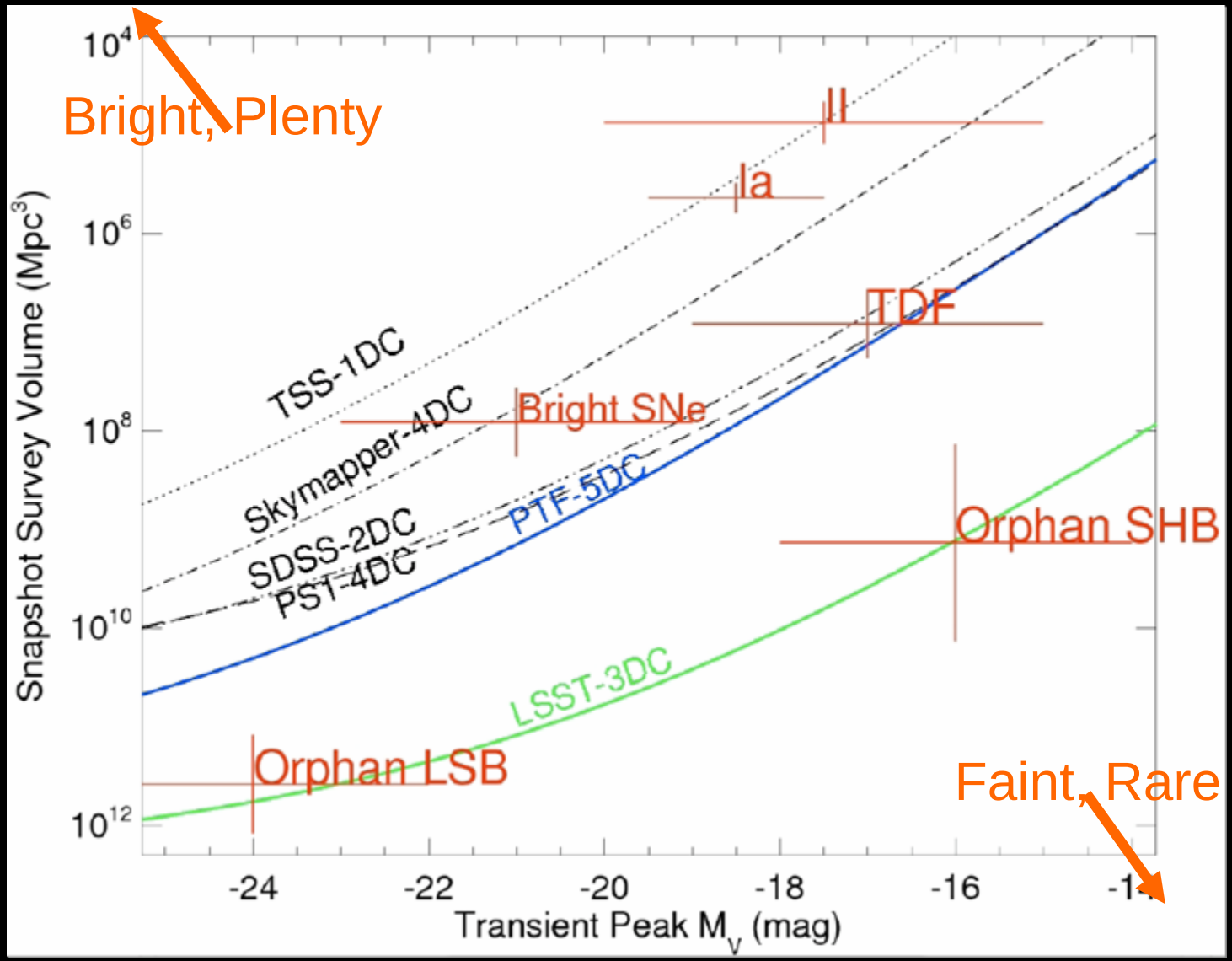
PTF projects



PTF Key Projects	
Transients in nearby galaxies	Search for eLIGO/neutrino EM counterpart
Thermonuclear SNe	Core Collapse SNe
Blazars/AGN	Tidal Disruption Flares
H-alpha Sky Survey	Orphan GRB afterglow
AM CVn	CVs
Galactic dynamics	RR Lyrae
Flare stars	Rotation in clusters
Nearby Star Kinematics	Eclipsing stars and planets
Asteroids	KBOs

PTF discoveries

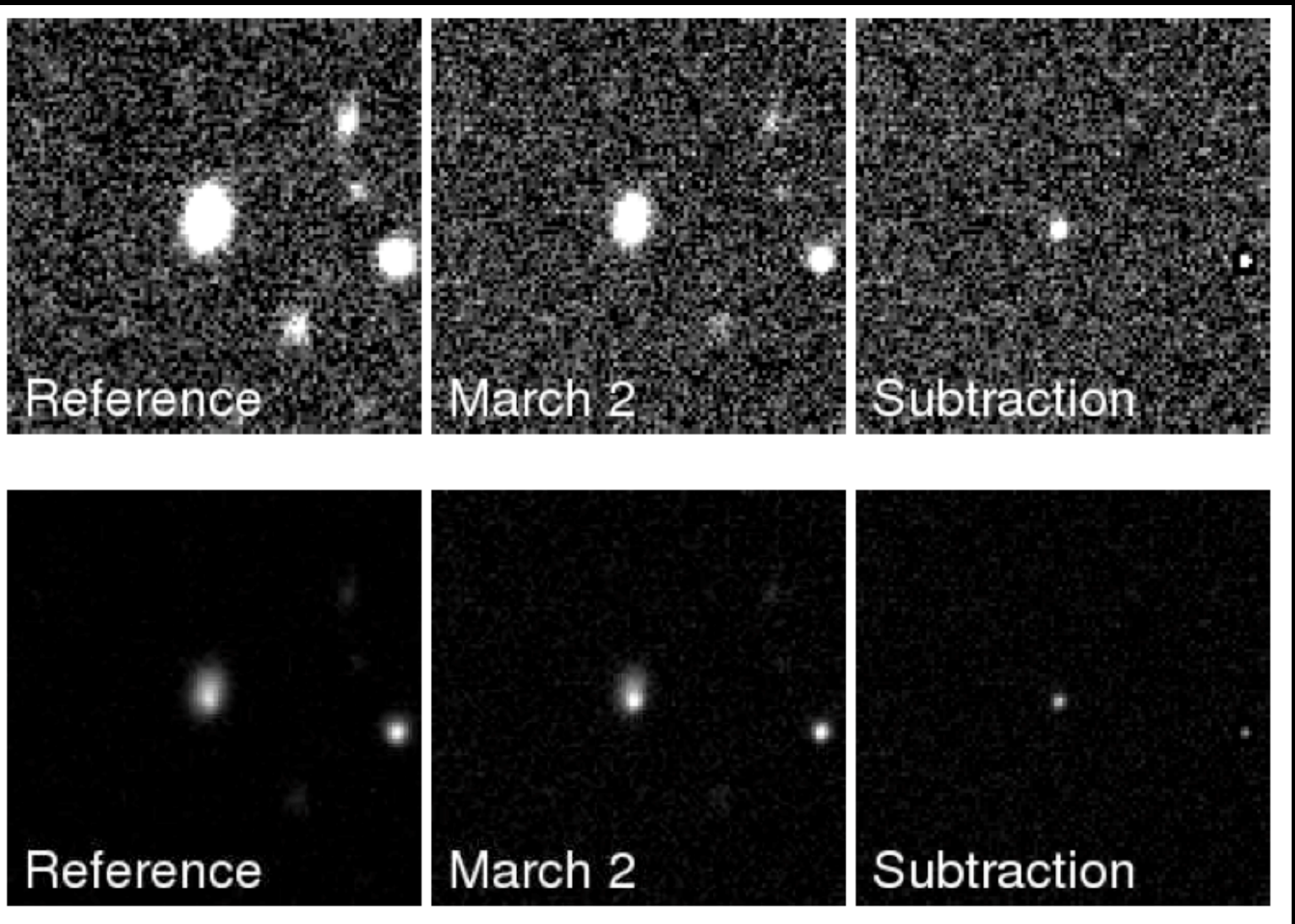
Comparison with other surveys



Courtesy: L. Bildsten

PTF discoveries

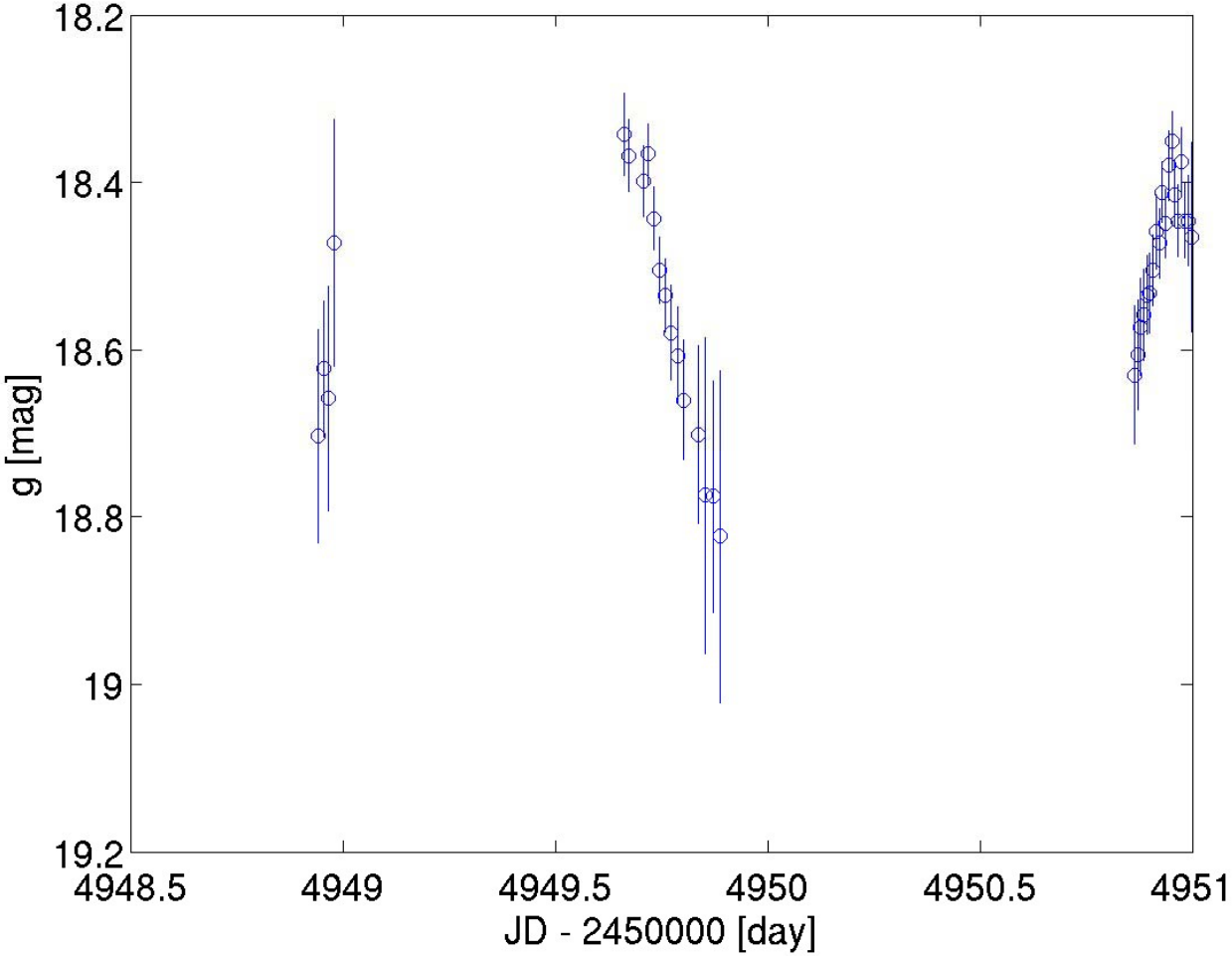
Commissioning



First SN - March 11, 2009

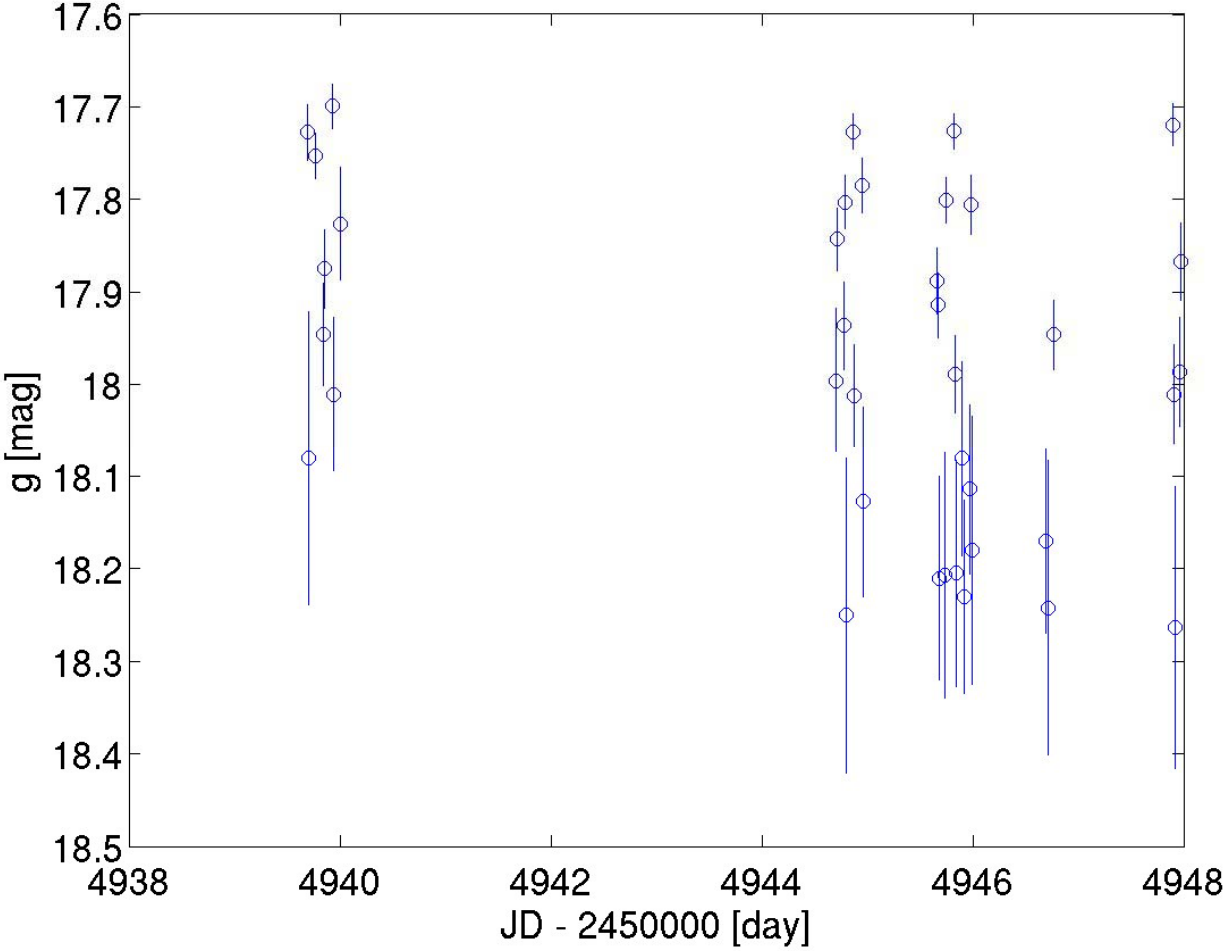
PTF discoveries

Variable stars



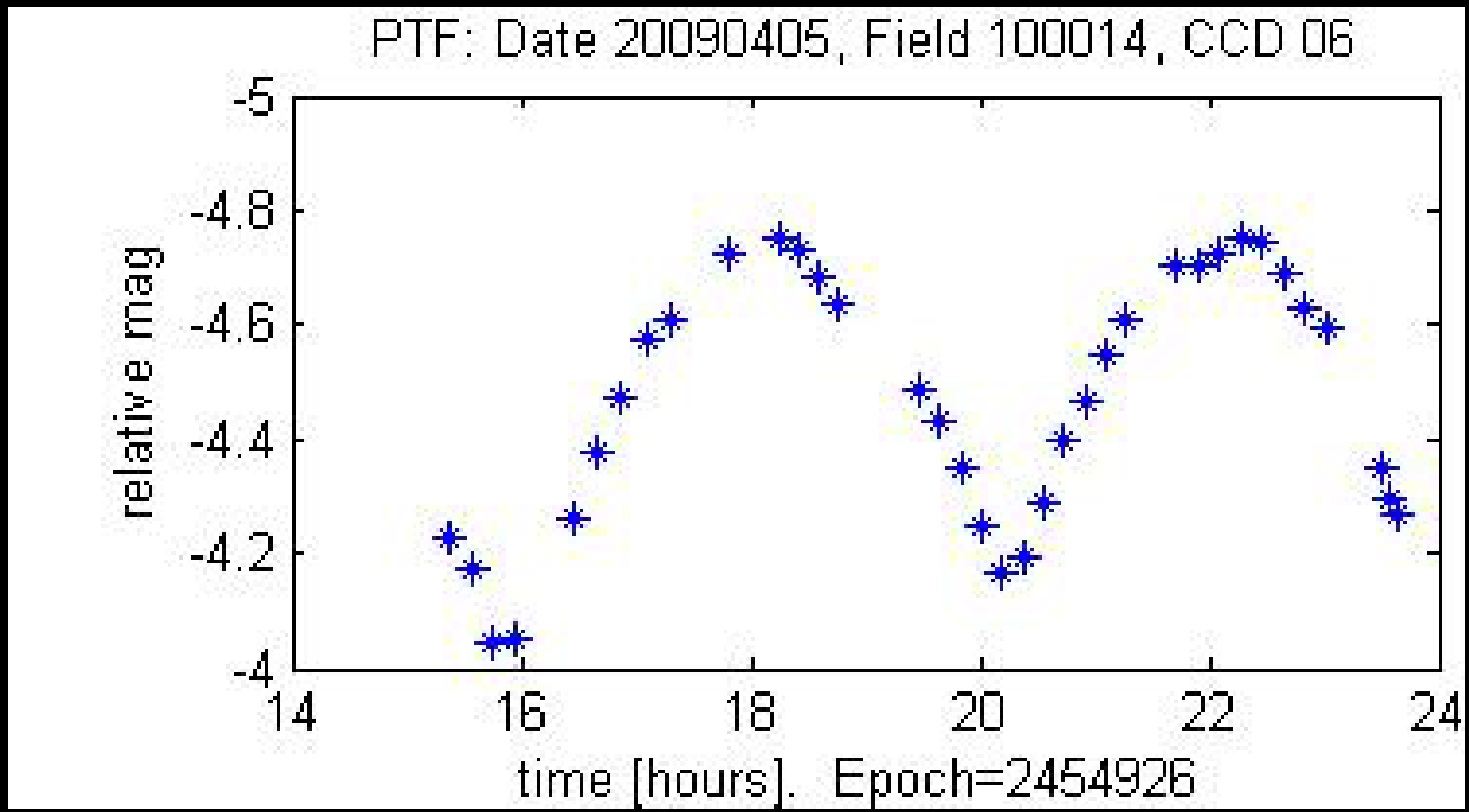
PTF discoveries

Variable stars



PTF discoveries

Variable asteroids
Prudentia (474)



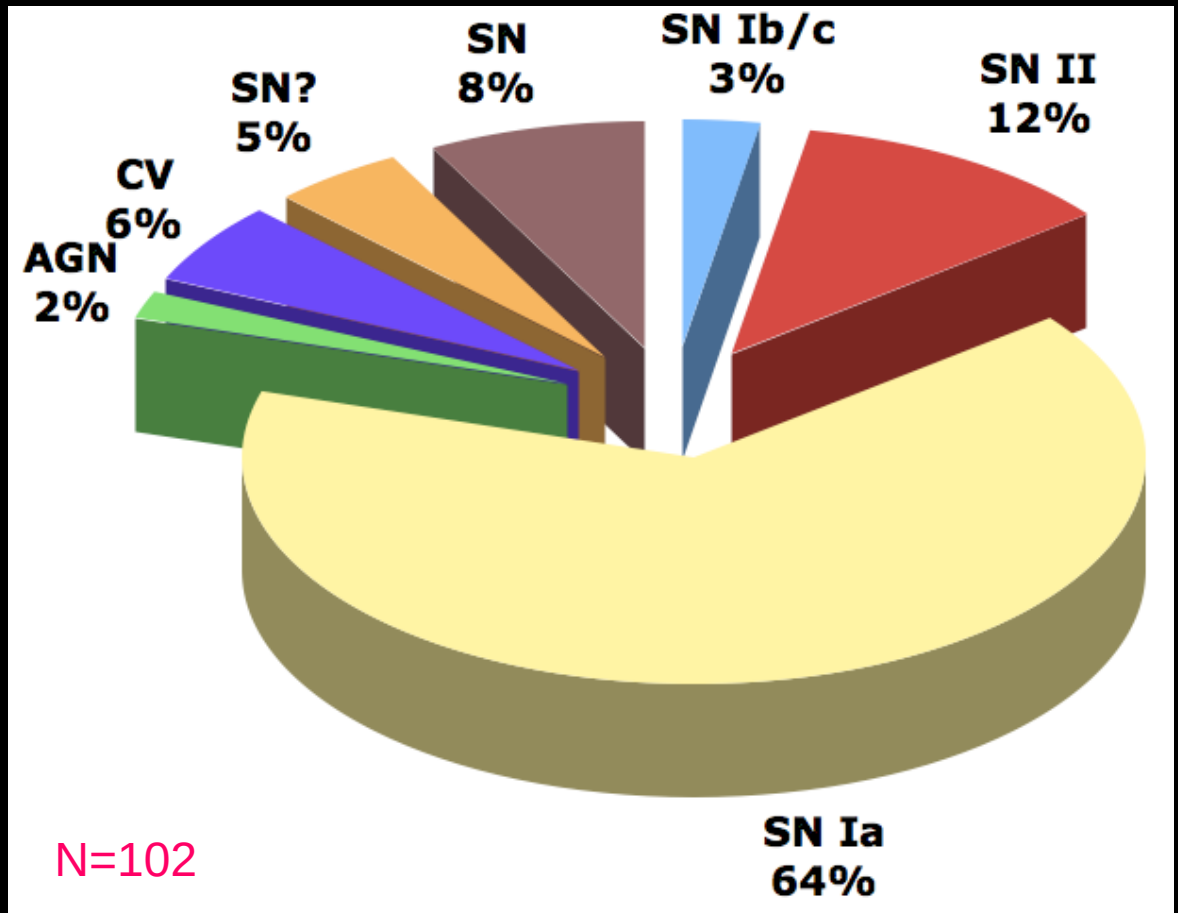
Courtesy: D. Poolishok

PTF discoveries

Till ~August 10th, 2009

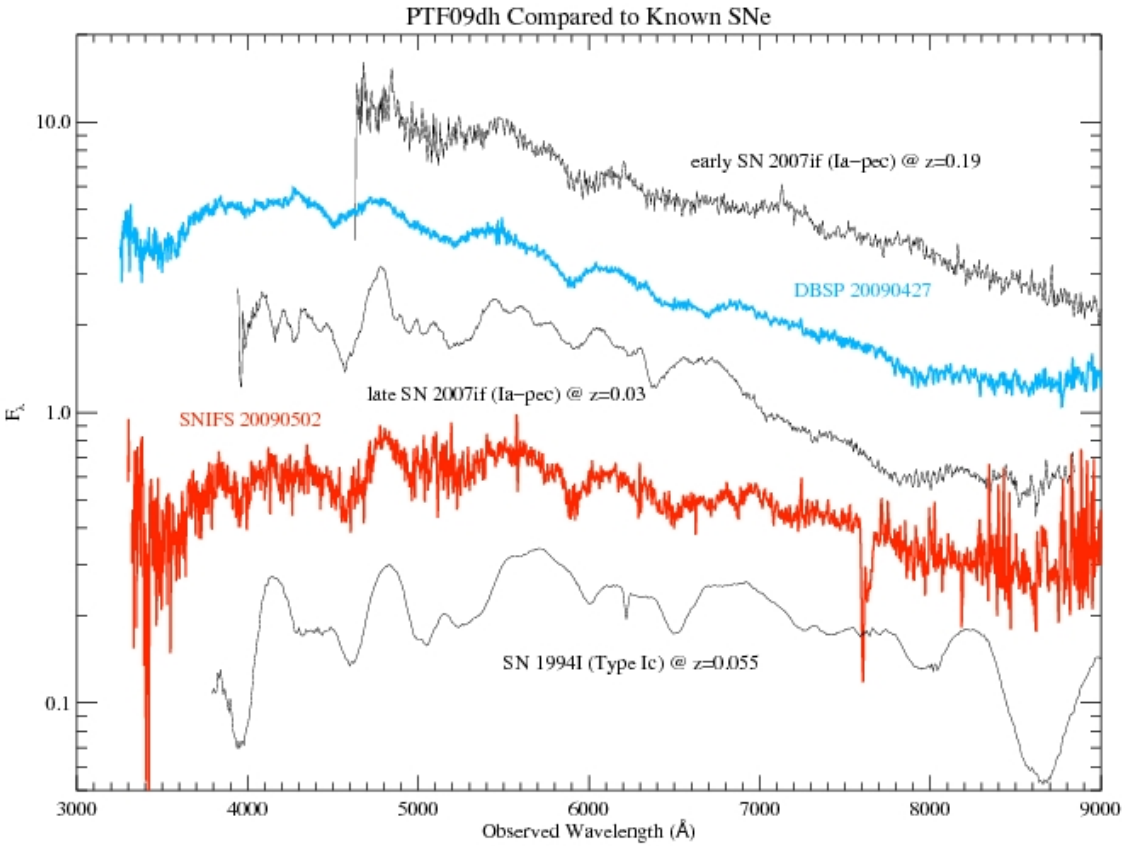
★ ~900 transient candidates

★ ~3000 variable stars



PTF discoveries

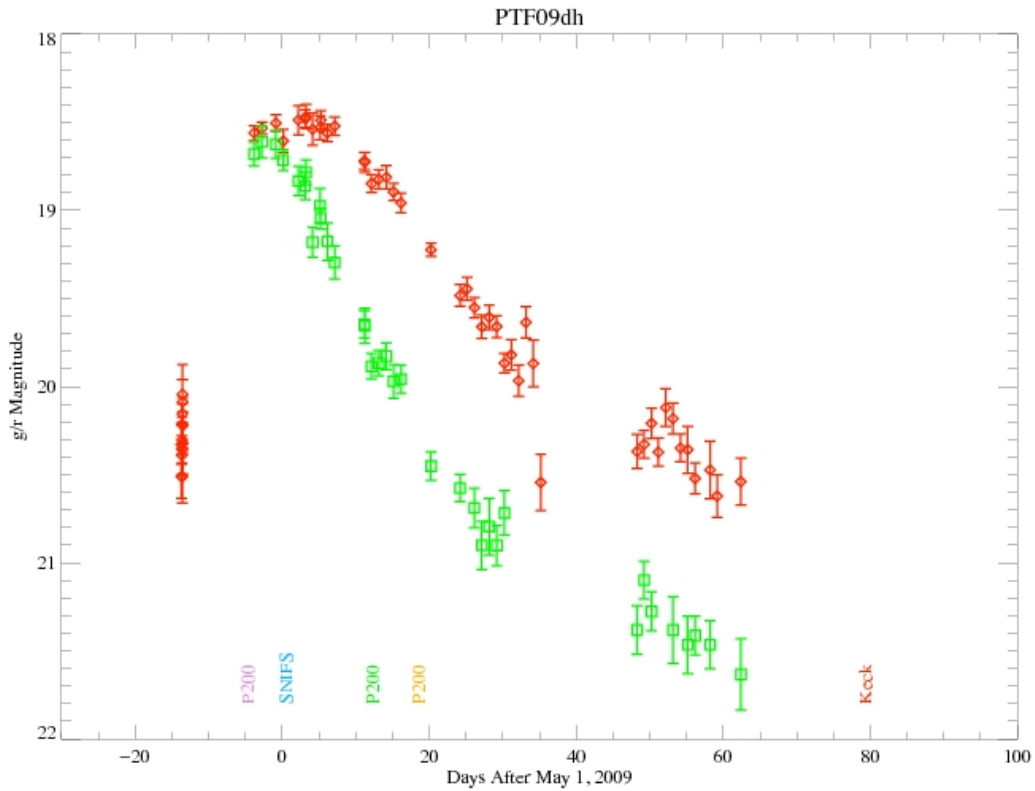
Examples for interesting SNe



PTF discoveries

Examples for interesting SNe

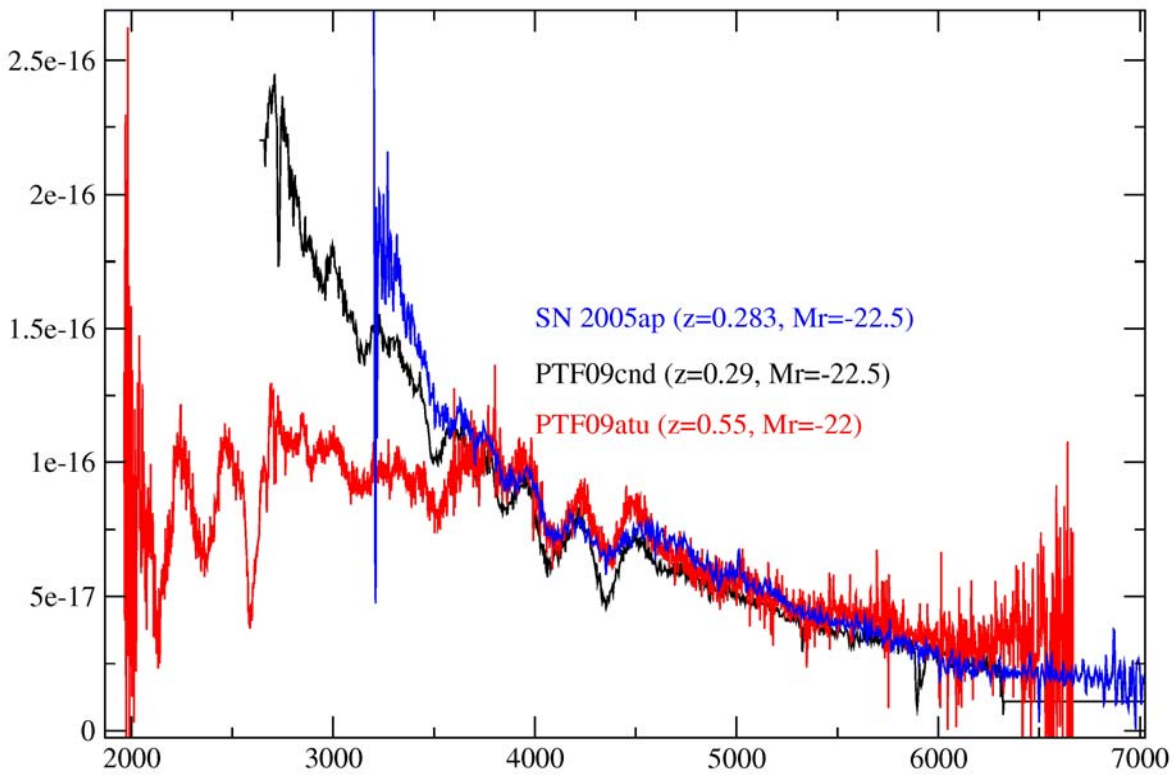
P60 light curve – generated automatically



PTF discoveries

Examples for interesting SNe

2005ap-like (quimbies) SNe



Summary

★ 48" Schmidt camera + 7.2 deg^2 FOV CCD
Description: Law et al. 09, Rau et al. 09

↓

Lesson: followup - limiting factor for future surveys
Lesson: lim. Mag ~21 enables long term followup with 4-10m class telescopes

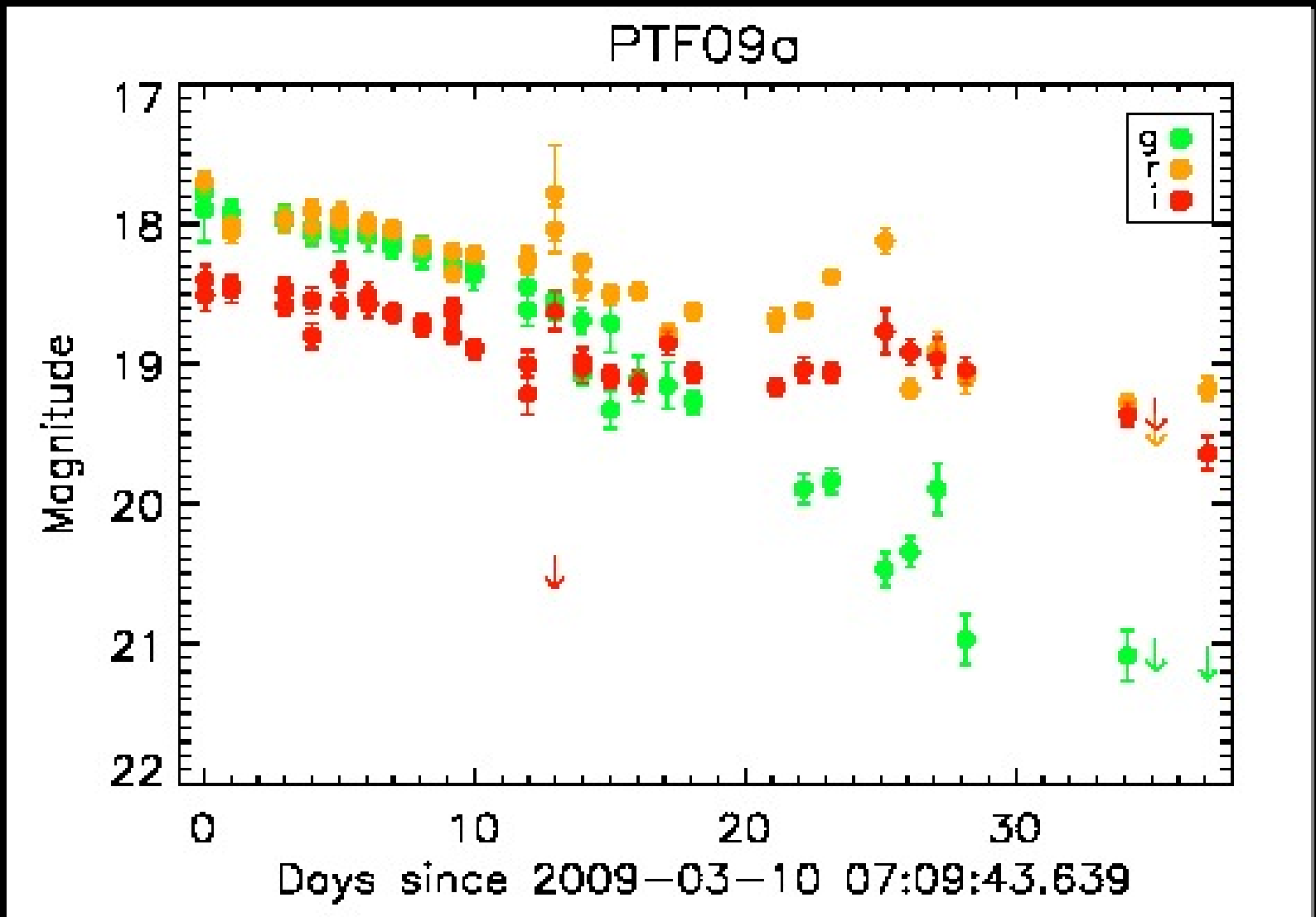
★ Data releases expected in 2010

End

Thank you!

PTF discoveries

Commissioning



First SN - March 11, 2009

PTF projects

Orion field

- ★ Eclipsing binaries and planets in the Orion star forming region
- ★ During ~1 month (November)

PTF projects

Hα all-sky survey

★ Lim. Mag. $2X10^{-17}$ erg cm^{-2} s^{-1} ~ 0.6R

★ Galactic ionized hydrogen contributes to CMB background

★ Detection of faint nearby galaxies

★ Estimate the SFR in galaxies within 70Mpc

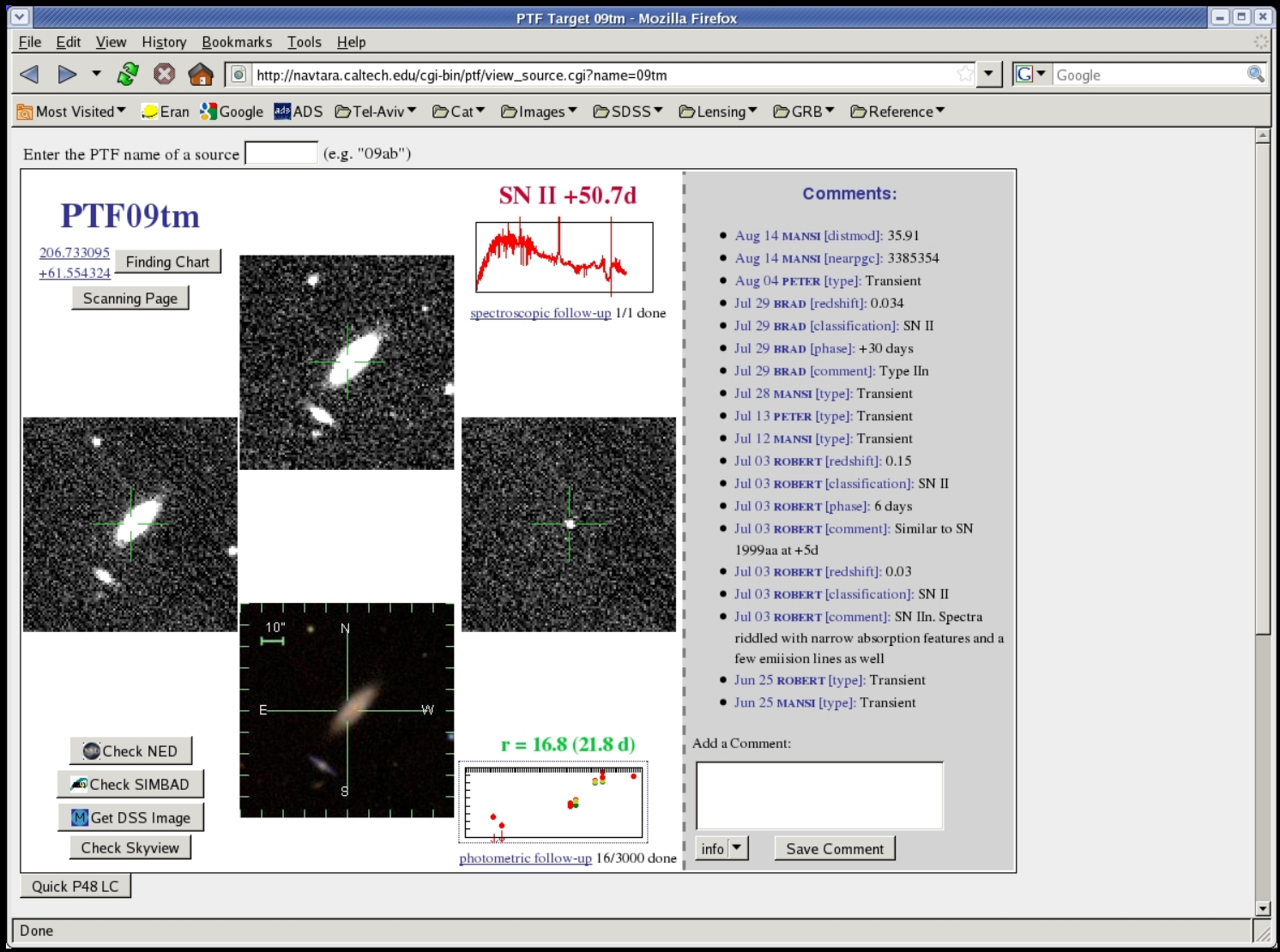
★ All sky search for PN

★ Galactic structure

★ Shells around old novae

Candidates

Marshal



PTF science
H alpha – all sky survey

- ★ Galactic ionized hydrogen contributes to CMB background
- ★ Detection of faint nearby galaxies
- ★ Estimate the SFR in galaxies within 70Mpc
- ★ All sky search for PN
- ★ Galactic structure
- ★ Shells around old novae

PTF projects

5 day cadence SNe search

★ Scan ~2700 deg^2 every 5 days in R-band
Total footprint ~9000 deg^2

Motivation:

★ SN type-Ia

e.g., Cosmology
HST UV spectroscopy project

★ Exploring the core collapse zoo

e.g., IIp cosmology project
Bright SNe (Quimbies)

PTF projects

<1 day cadence transients search

- ★ New kind of (fast) transients
- ★ Transients in the local Universe (<200Mpc)

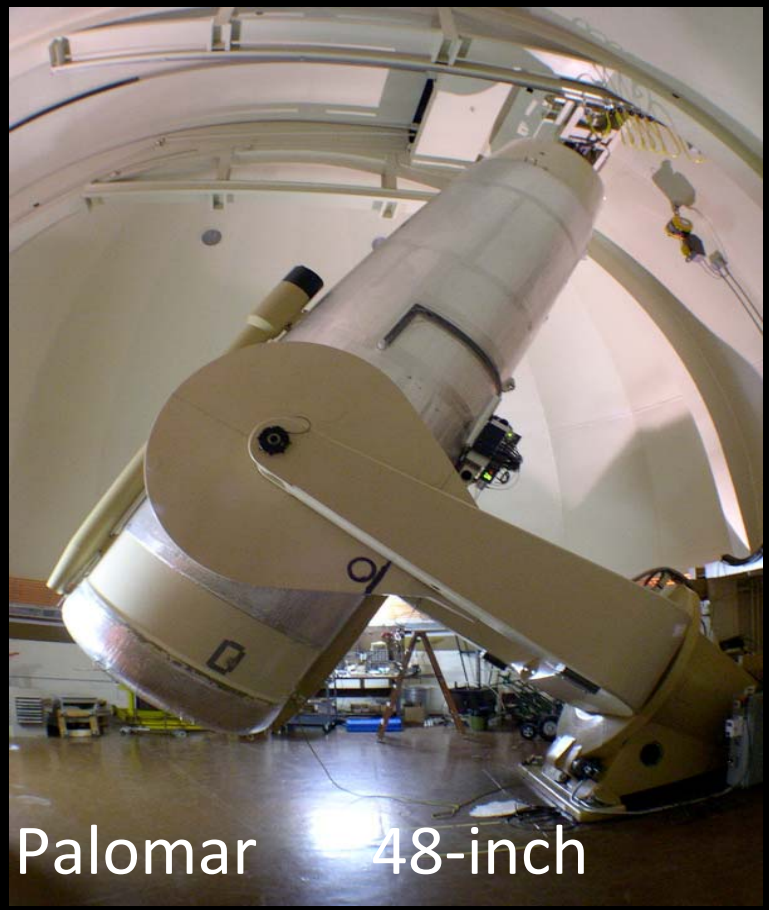
PTF discoveries

Commissioning

- PTF first light: December 2008
  (less than 2 years after project started)

- Started test observing: January 2009
  Complete telescope robotization: March 2009

PTF followup



PTF projects

5 day cadence SNe search

★ Scan ~2700 deg^2 every 5 days in R-band
Total footprint ~9000 deg^2

<1 day cadence transients search

★ New kind of (fast) transients

★ Transients in the local Universe (<200Mpc)

The PTF H alpha survey

- H alpha survey of 3pi sr (dec>-20^{o})
- Lim. Mag. 2X10^{-17} erg cm^{-2} s^{-1} ~ 0.6R
- With 3 nights per month:
  ~1 year for 2 images per pointing
  (dithering to fill the gaps)
  ~2 years to complete the H alpha survey

Other surveys

★ IPHAS — Drew et al. (2005)

Galactic lat<5 deg ~1800 deg^2

sensitivity ~0.3 R

★ WHAM — Tufte et al. (1998)

dec>-30^o

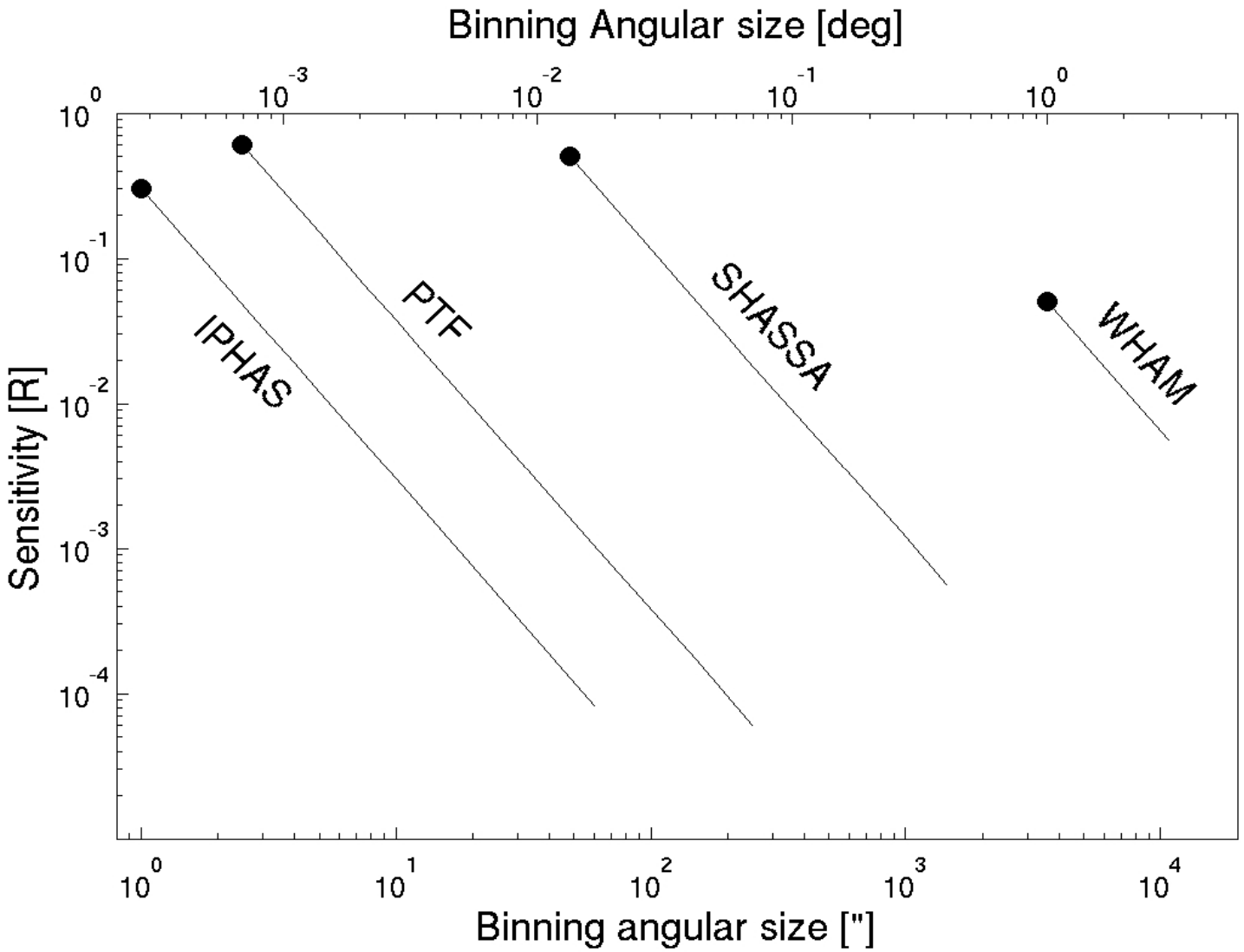
Resolution: 1 deg Sensitivity: ~0.05R

★ SHASSA — Gaustad et al. (2001)

dec<+15^o

Resolution: 0.8' Sensitivity: 0.5R

Other surveys



Calibration

★ Constructing a list of H alpha calibration stars

★ Synthetic photometry of SDSS stellar spectra

★ Estimated 1s accuracy ~0.06 mag

~0.03 mag using 10 stars

★ ~25,000 stars with reliable H alpha flux

Decisions

- ★ How many filters: 2, 3?, 4?
- ★ Calibration outside the SDSS footprint?
- ★ Get filters from CFHT? Or buy it?

End