



# Supernova Discovery in the Era of Data-Intensive Science

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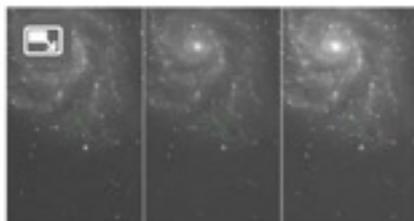
### Scientists Discover Shiny Supernova in Nearby Galaxy

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By **IB TIMES STAFF REPORTER** Subscribe to IB's [RSS feed](#)

August 26, 2011 6:44 AM EDT

Astronomers identified a bright, nearby supernova Wednesday in the Pinwheel Galaxy, which lies some 21 million light years from Earth and is located in the constellation of the Great Bear.



(Photo: Peter Nugent/LBNL and Palomar) These images show Type Ia supernova PTF 11kly, the youngest ever detected—over the past three nights. The left image taken on August 22 shows the event before it exploded supernova, approximately 1 million times fainter than the human eye can detect. The center image taken on August 23 shows the supernova at about 10,000 times fainter than the human eye can detect. The right image taken on August 24 shows that the event is 6 times brighter than the previous day. In two weeks time it should be visible with a good pair of binoculars.

The type Ia supernova, dubbed PTF11kly, is getting brighter and could be visible with good binoculars in the next 10 days.

Supernovas are exploding stars. Type Ia supernovas are the result of a binary pair of mismatched stars, the smaller, denser one feeding on material drawn off its larger companion until it can no longer take in any more material. It then explodes in a catastrophic event that outshines the brightness of its entire galaxy, Universe Today reported.

Scientists said the supernova is the closest of its type discovered in 40 years and believe they caught it within hours of its explosion-- a rare feat for events of this type.

Scientists from the University of Oxford made the

### Supernova 'of a generation': how you can see it with binoculars

A supernova in the nearby Pinwheel Galaxy is the closest supernova in 25 years. Situated near the Big Dipper, the SN 2011fe supernova can be seen with binoculars this week.

By Andrew Mach, Contributor / September 7, 2011



This Hubble Space Telescope image of the face-on spiral galaxy Messier 101, known as the Pinwheel Galaxy, was released in 2006.

Newscom/File

Enlarge

1.2k 19 11 2 and 14

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### NEWS SCIENCE & ENVIRONMENT

26 August 2011 Last updated at 07:34 ET

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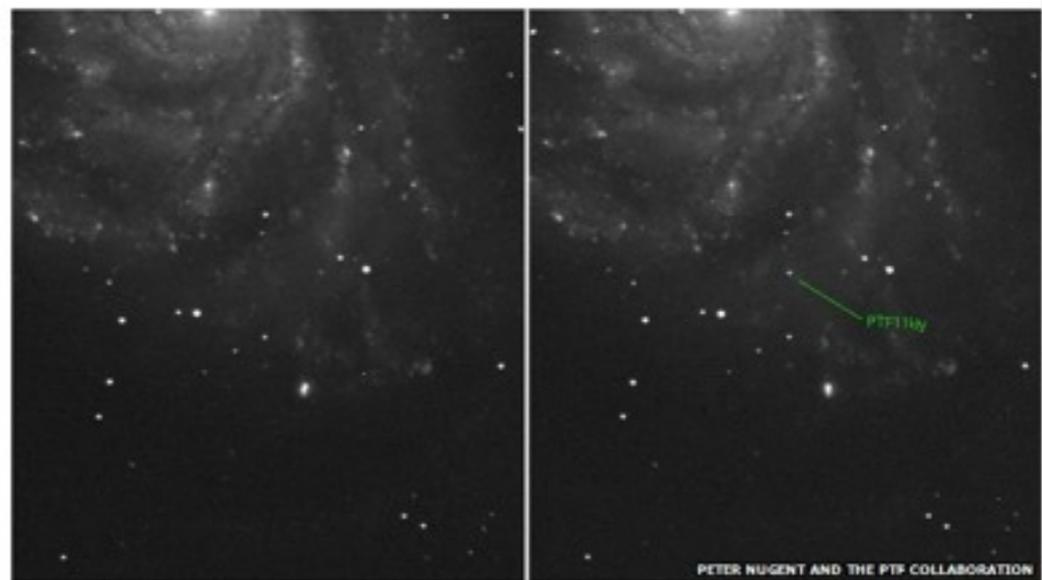
Tom Feilden

Science correspondent, Today

More from Tom



### Twinkle twinkle little new star



PETER NUGENT AND THE PTF COLLABORATION

Before and after: The image on the right shows the new supernova

### The Telegraph

HOME - SCIENCE - SPACE

### Exploding star to be visible from Earth within a fortnight

The most visible exploding star in a generation will be visible in skies above Britain within a fortnight, Oxford University astronomers have announced.

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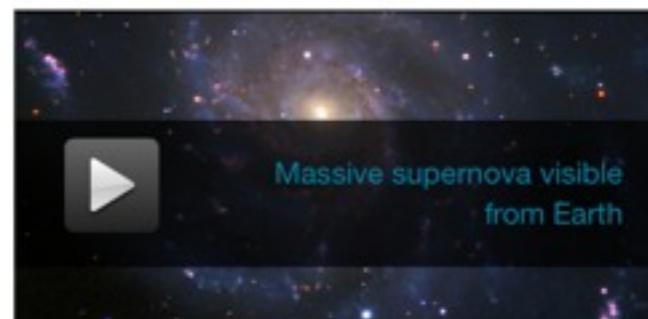
Facebook 3K

Twitter 160

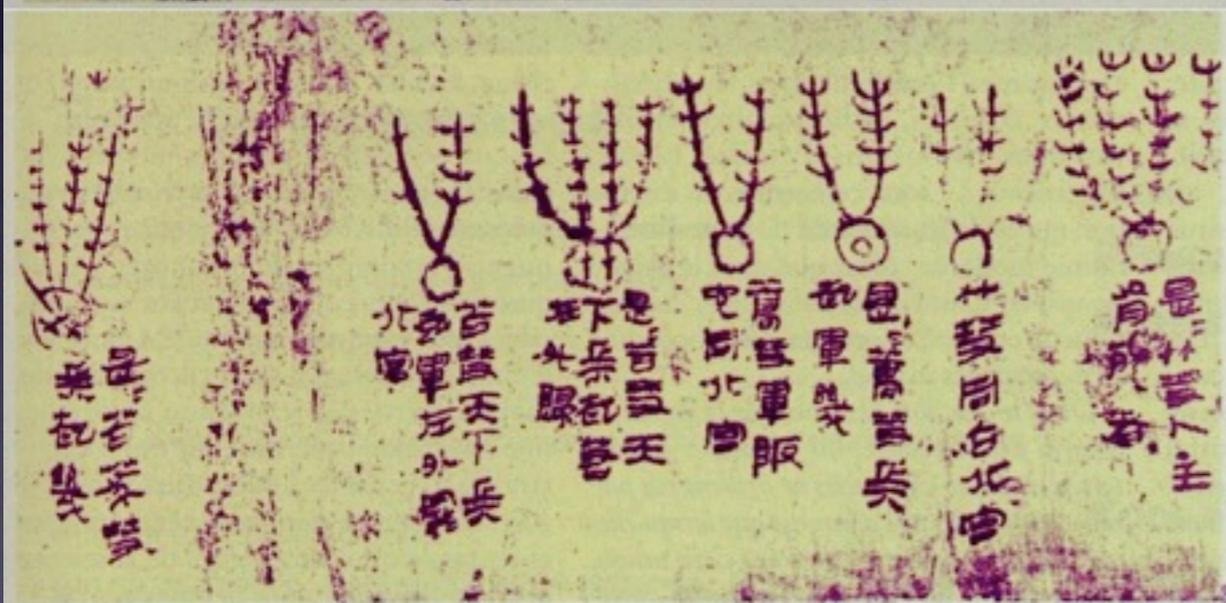
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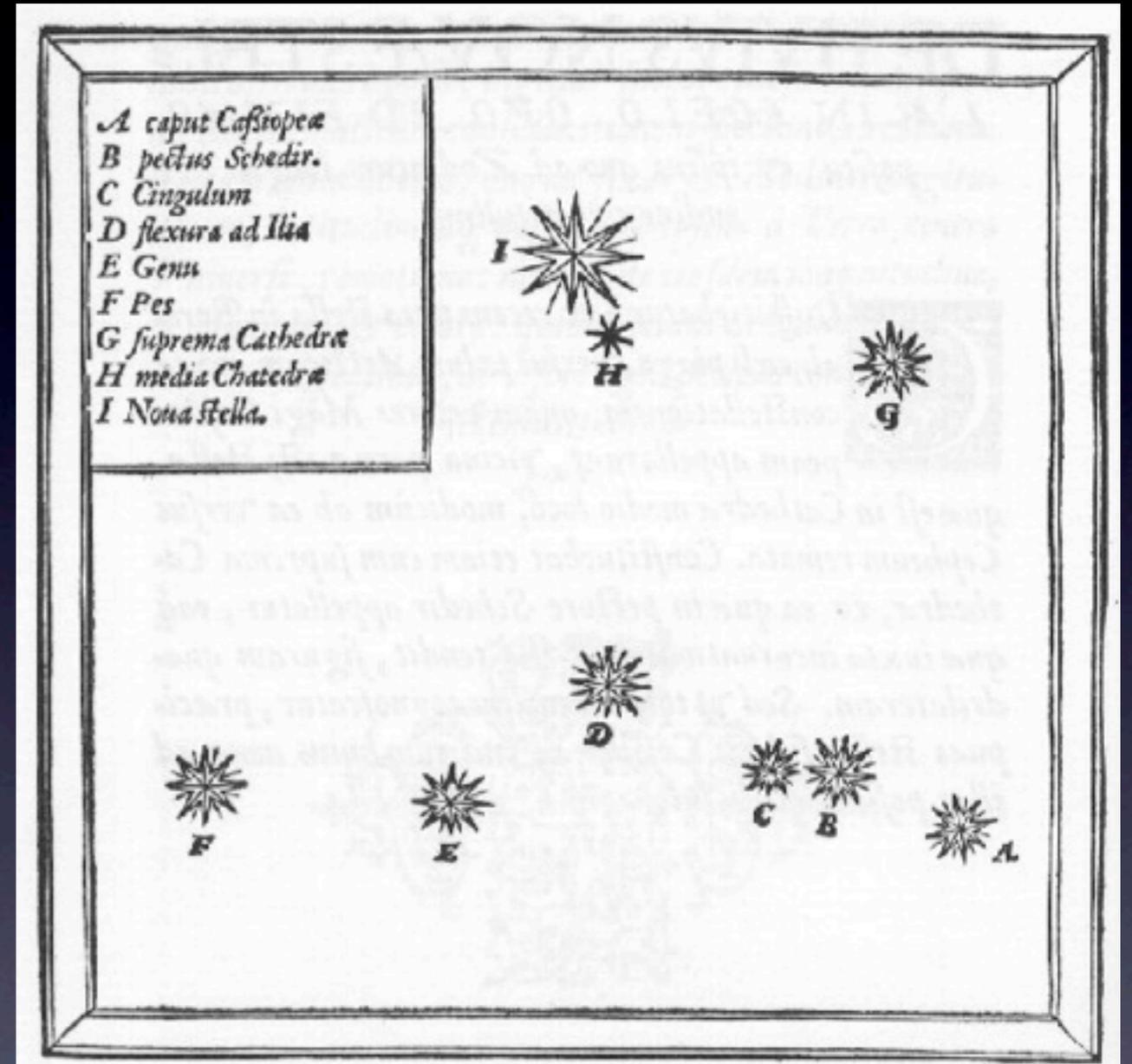
+1 55



Space



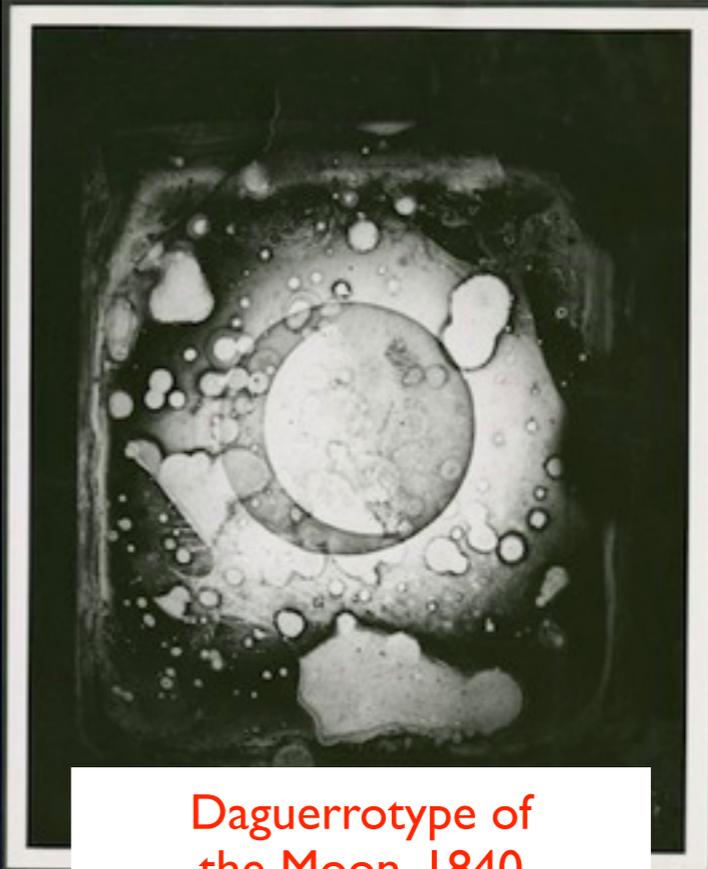
Types of Comets



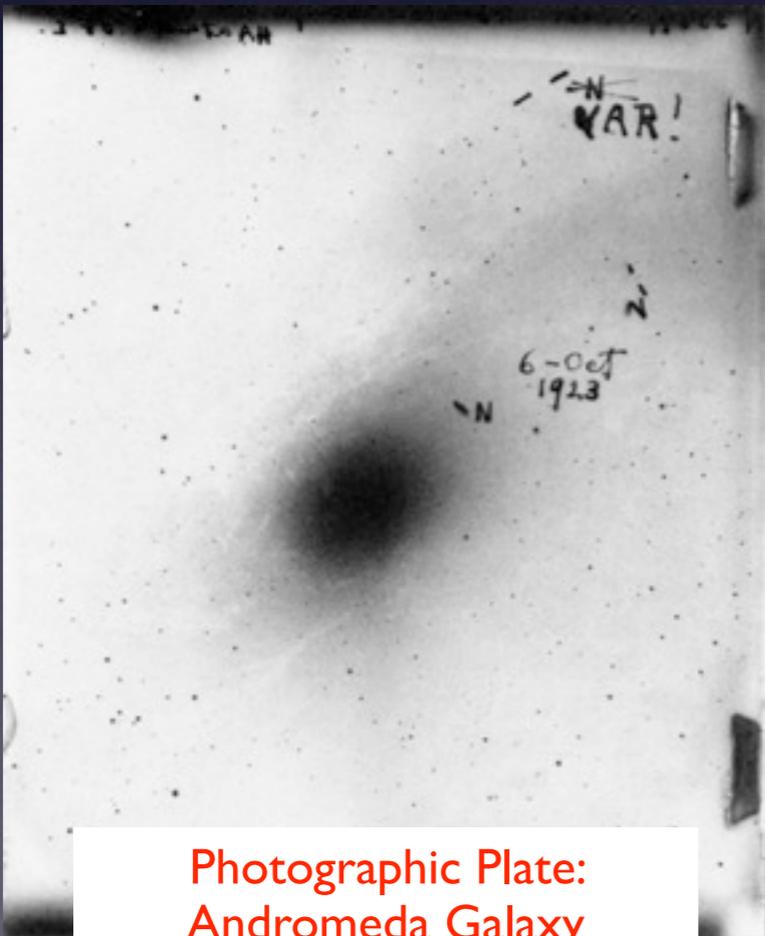
Tycho's SN 1572



First Photograph, 1826



Daguerrotype of the Moon, 1840



Photographic Plate: Andromeda Galaxy

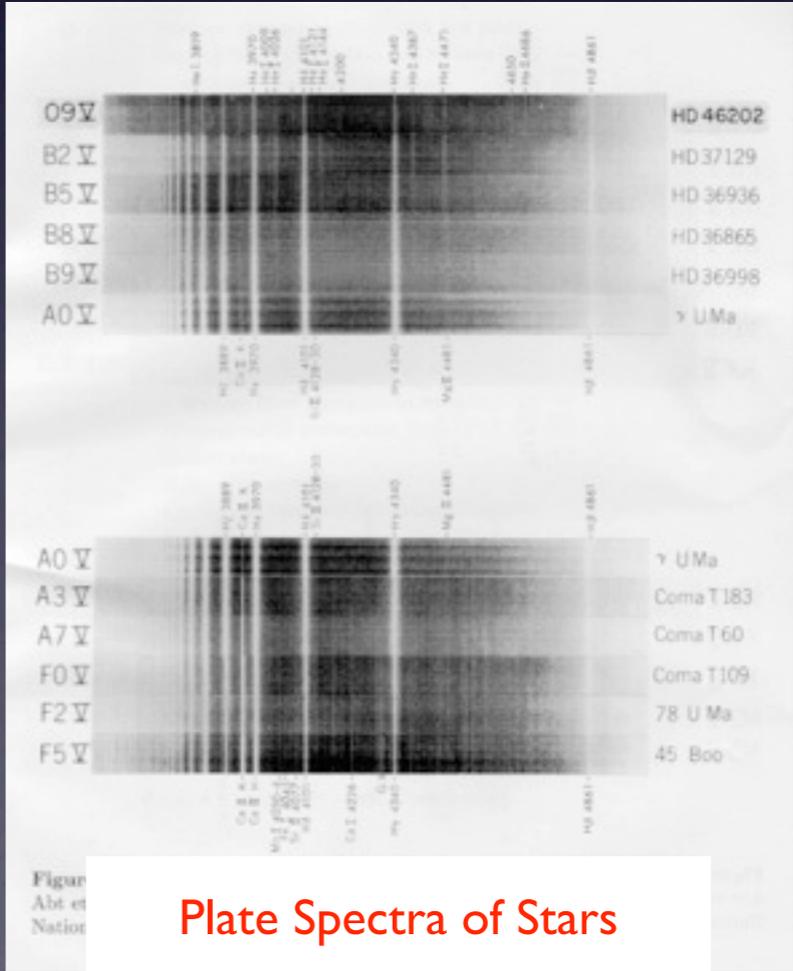
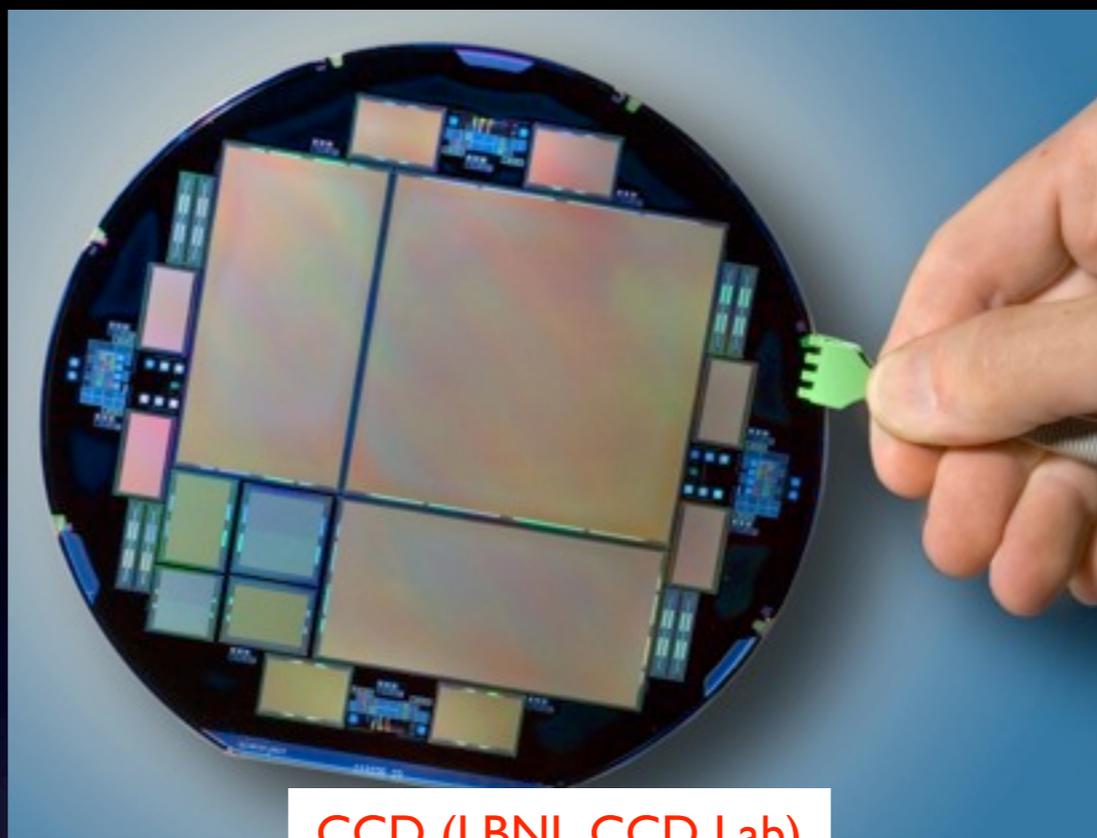


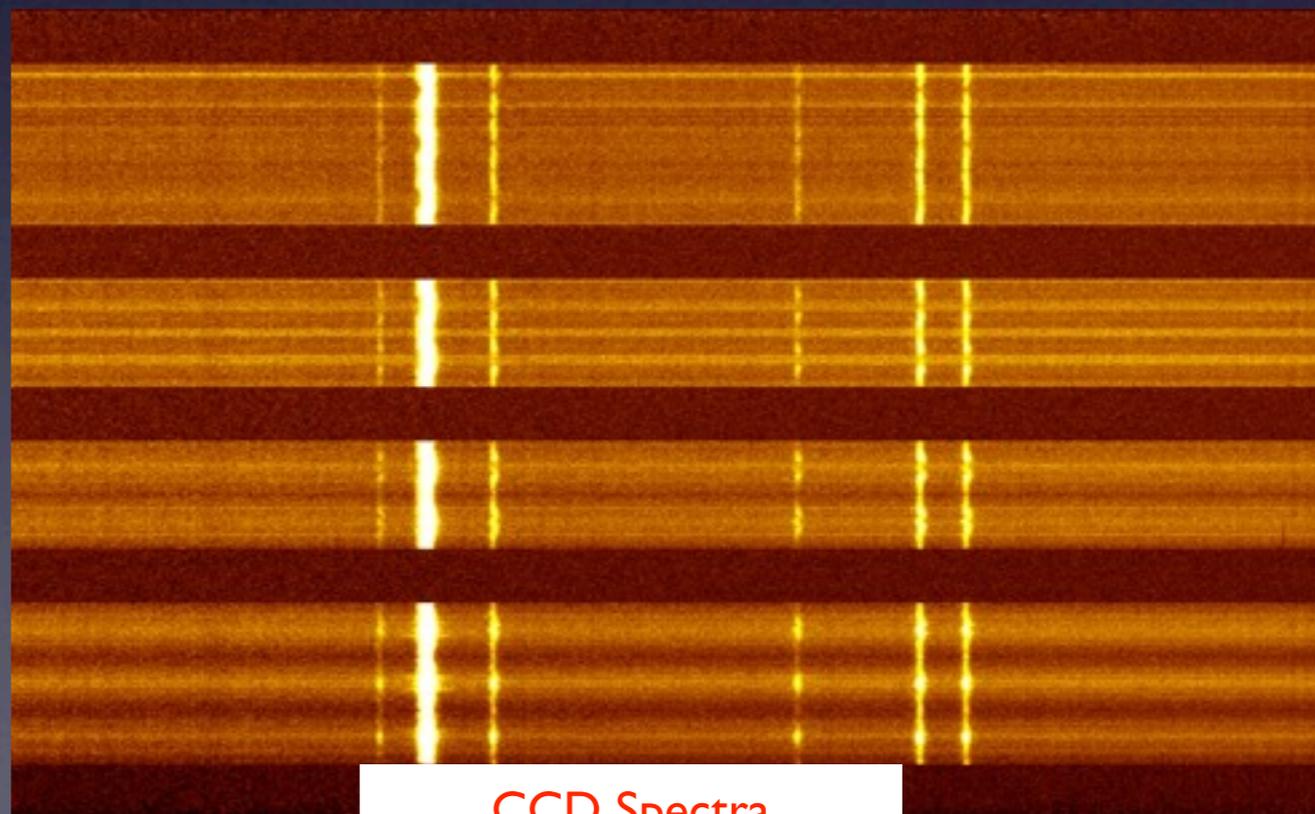
Plate Spectra of Stars



CCD (LBNL CCD Lab)

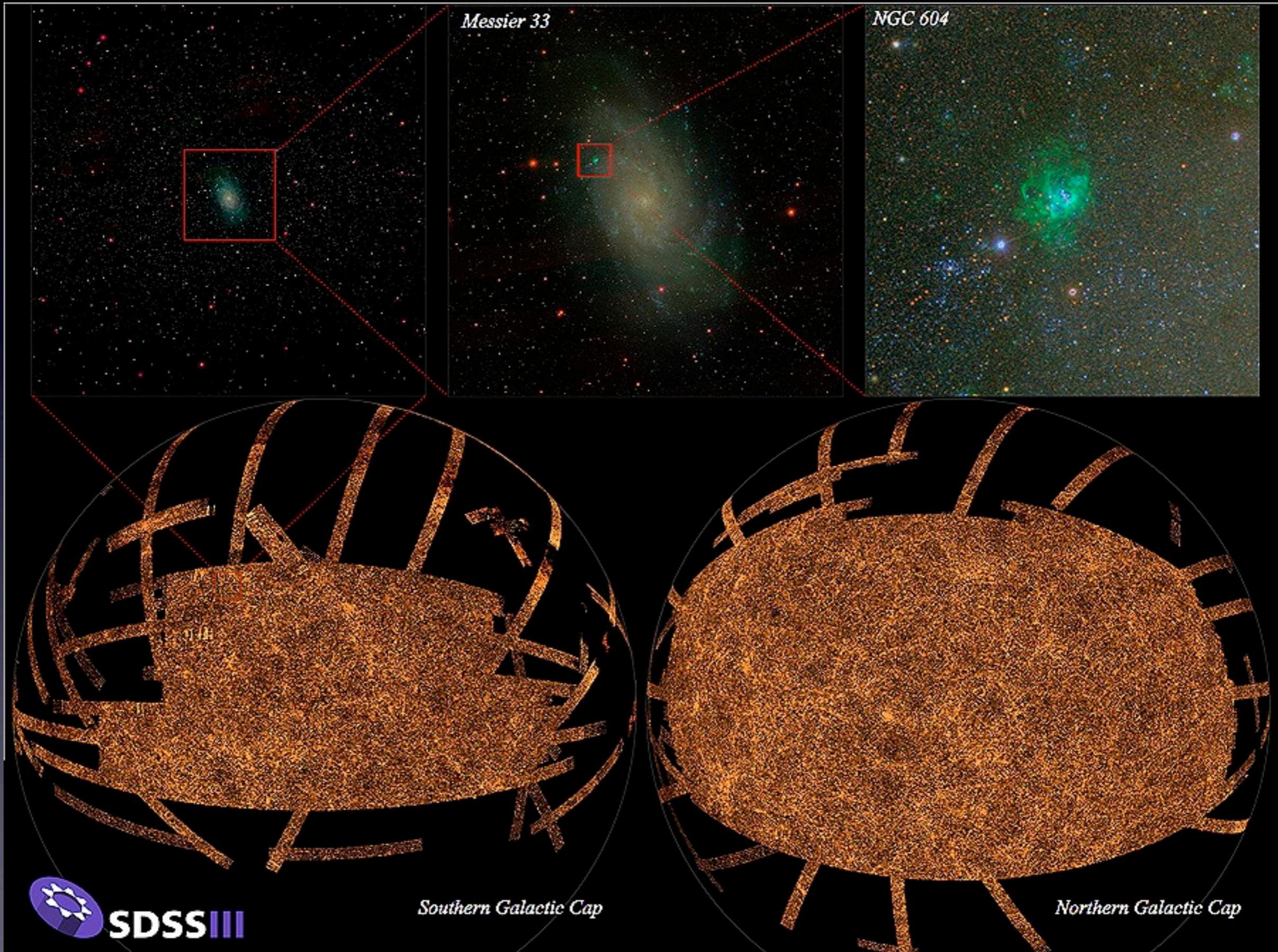


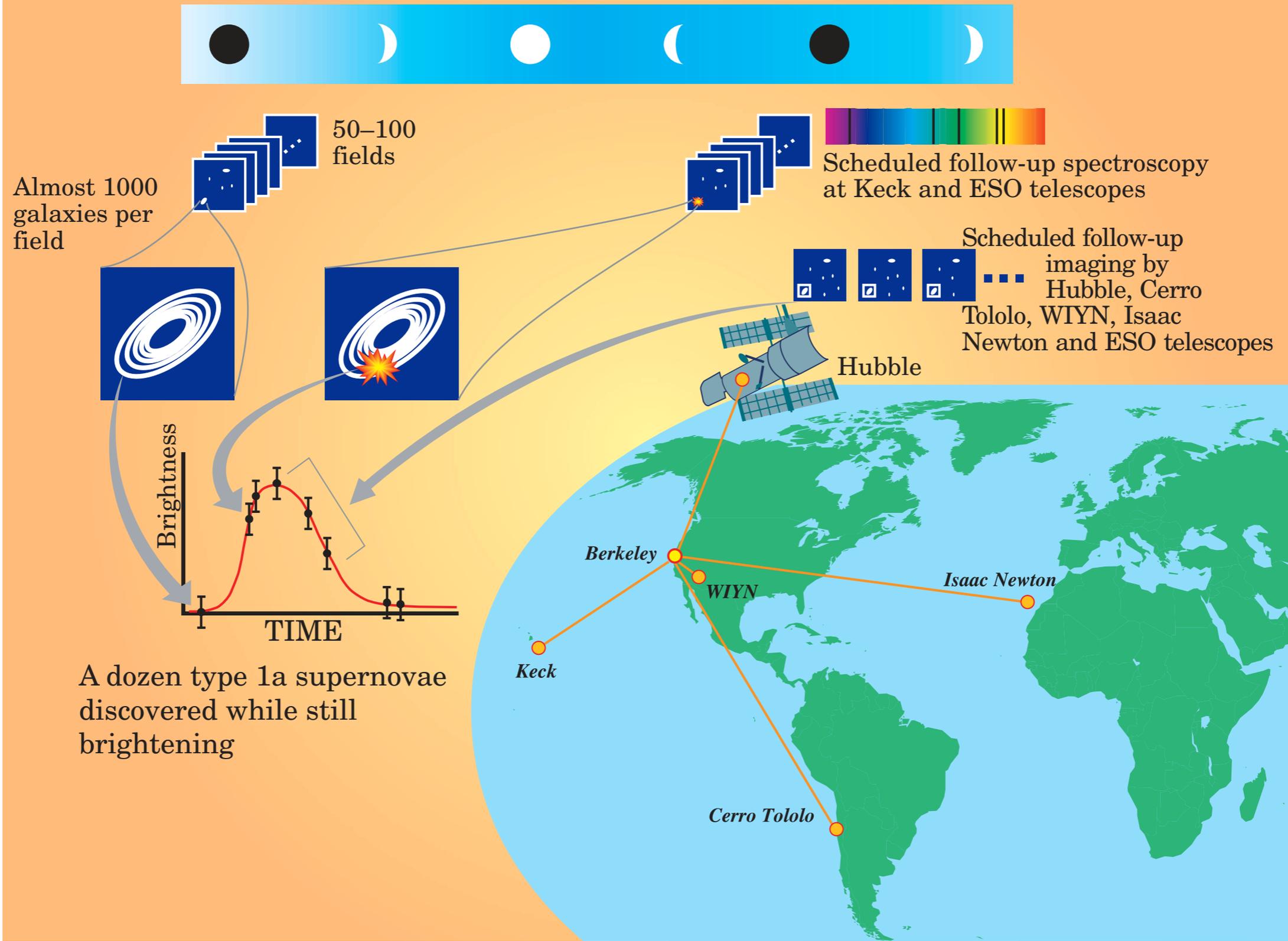
CCD Image



CCD Spectra

# CCD sky mapping



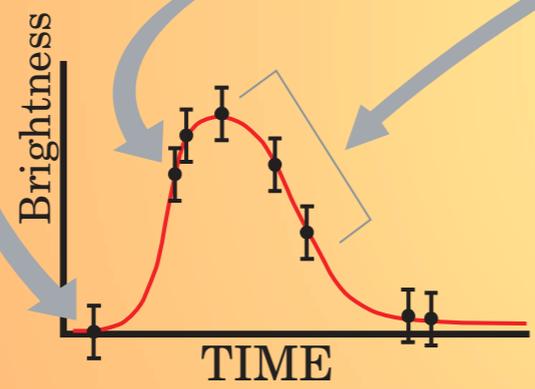


Almost 1000 galaxies per field

50-100 fields

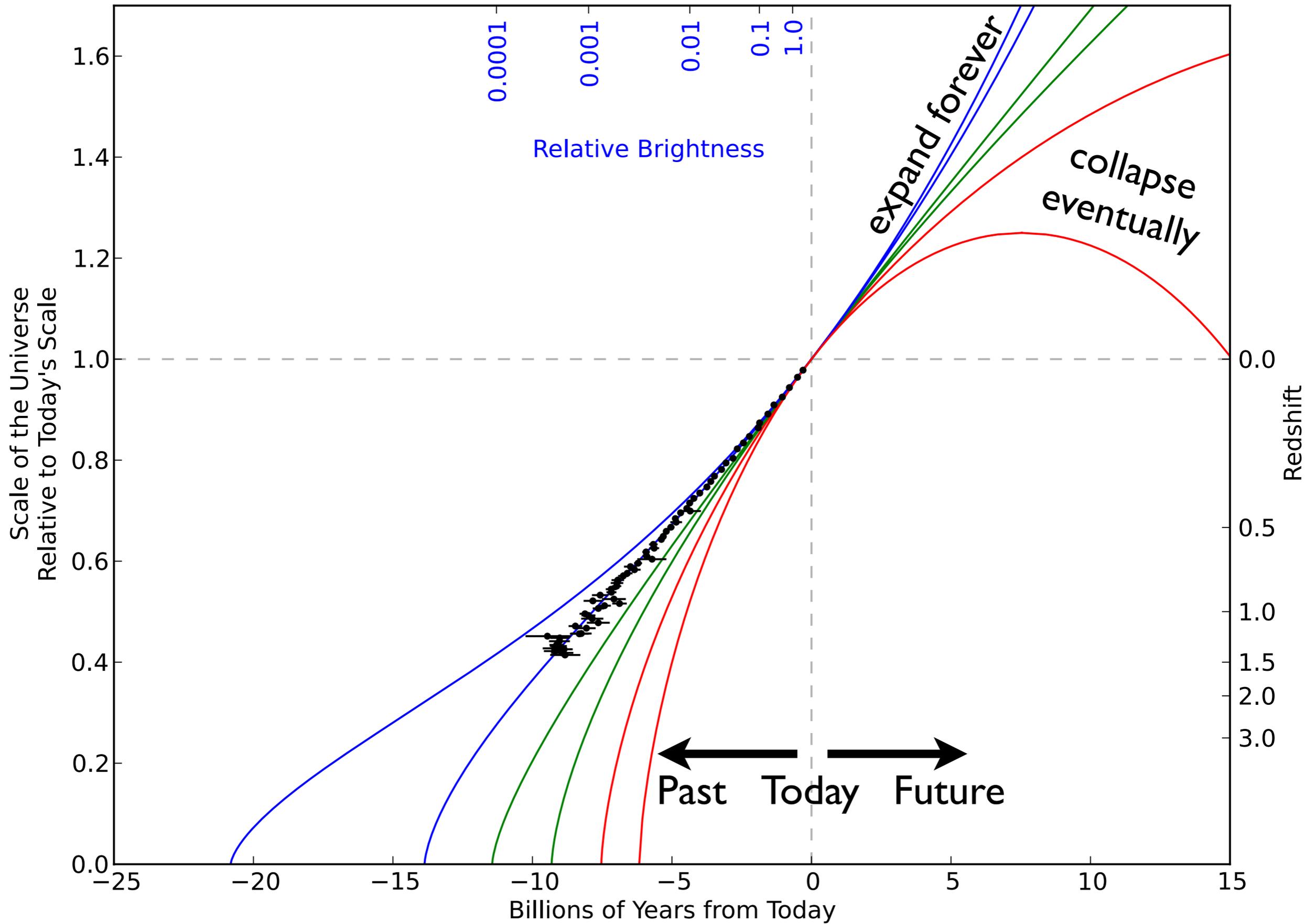
Scheduled follow-up spectroscopy at Keck and ESO telescopes

Scheduled follow-up imaging by Hubble, Cerro Tololo, WIYN, Isaac Newton and ESO telescopes



A dozen type Ia supernovae discovered while still brightening



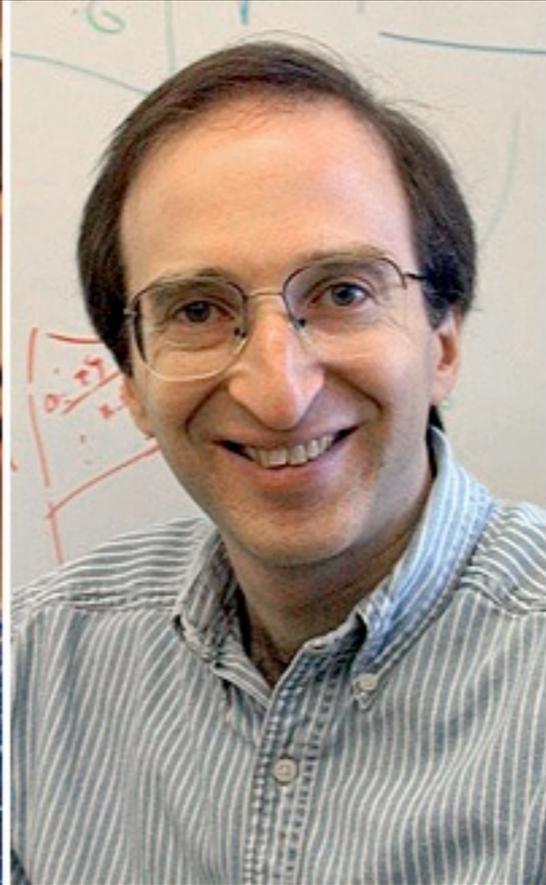


# Nobel Prize in Physics, 2011

## Dark Energy



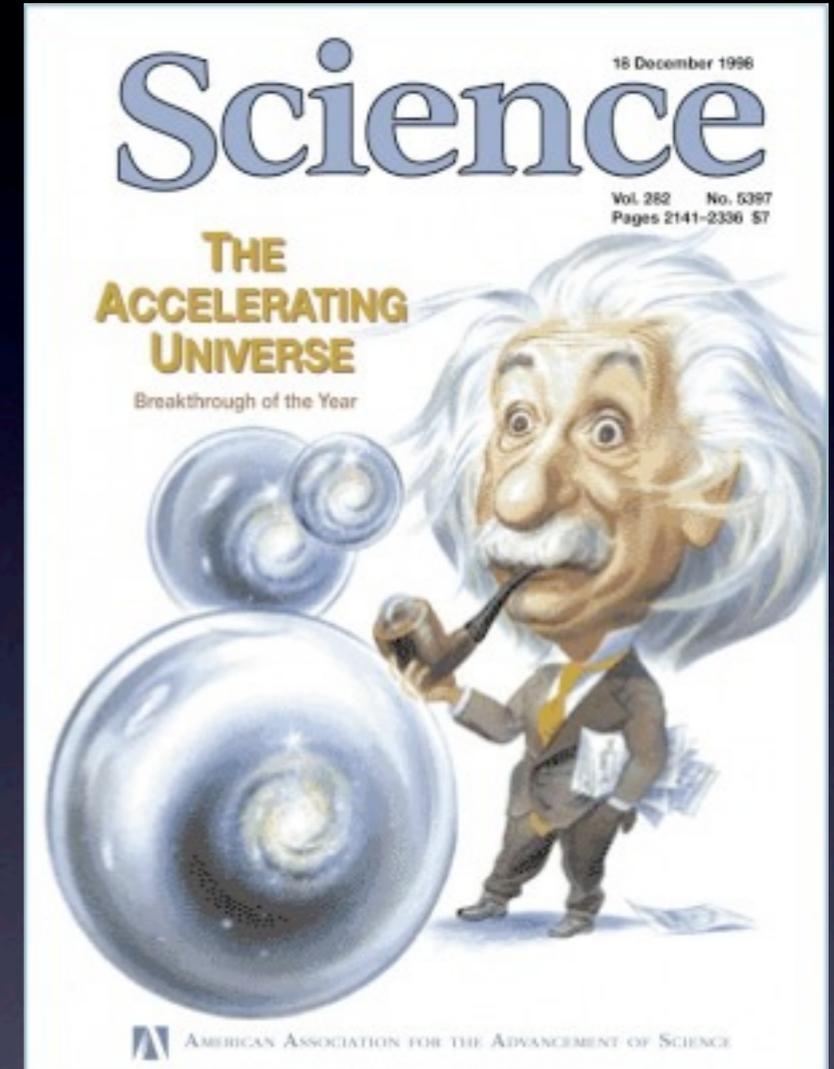
Adam  
Riess  
(STSCI/JHU)



Saul  
Perlmutter  
(LBL/UCB)



Brian  
Schmidt  
(ANU)



“for the discovery of the accelerating expansion of the Universe through observations of distant [Type Ia] supernovae”

# What ifs?

- We are now at the point where more SN observations at the same redshifts don't help constrain Dark Energy any better. **What ifs:**
- **What if** supernovae cannot be made more reliable?
- **What if** supernova brightness is different in the early Universe compared to today?
- **What if** there are different sub-populations of supernovae; can we disentangle them?
- Homework: Need a very large, very well-studied sample of "Rosetta" supernovae to answer these: **low redshift.**

# Requirements

- Need to be discovered the same way at low redshift as at high redshift: Shouldn't target individual galaxies, need **wide-field imagers**.
- Volume problem means you have to cover **as much of the sky as you can**. All if possible.
- Discover them **as early as possible**, to sample the early-time behavior, which is hard at low redshift, but easy at high redshift (time and volume).
- Once you've got them, you have to **coordinate** follow up from the ground and space, with every kind of instrument you can get your hands on.
- (Ideally you'd have a "twin" of every high-redshift supernova, at low redshift --- need hundreds, thousands.)

# Some Recent Low-Redshift Survey Efforts

**Lick Observatory Supernova Search.** Since 1990s.  
Targeted galaxy survey, very low-redshift.  
Automated, but not wide-field.



**Nearby Supernova Factory.** 2004-2008.  
Wide-field camera, past 400 Myr to 1 Gyr.  
Dedicated spectrophotometric follow-up.



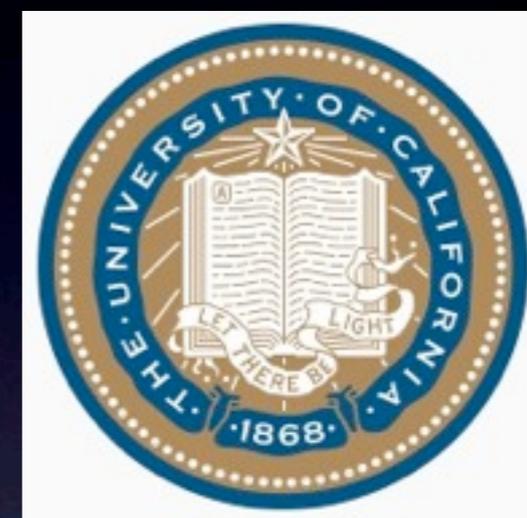
**Palomar Transient Factory.** 2009-present.  
Wide-field camera, past 2.4 Gyr.  
Additional transient science (large collaboration).



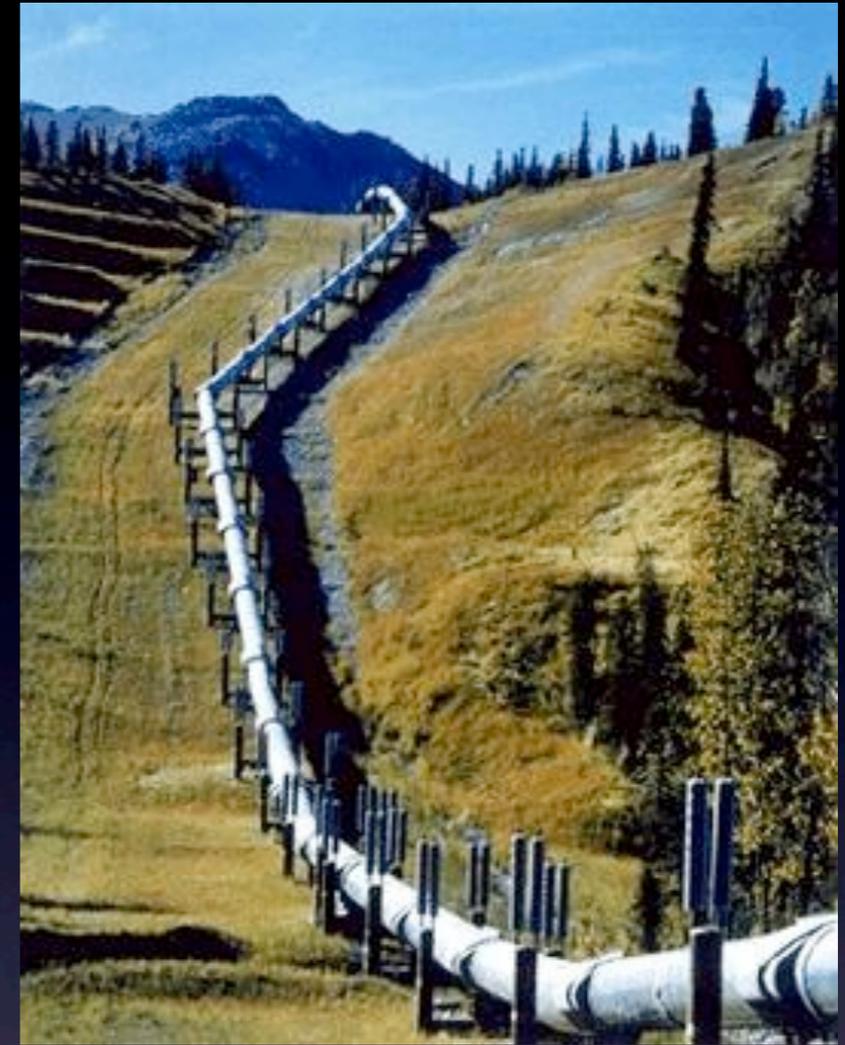
**SkyMapper** (S. hemisphere),  
**La Silla/QUEST** (S. hemisphere).



**Palomar Transient Factory.** 2009-present.  
Wide-field camera, past 2.4 Gyr.  
Additional transient science (large collaboration).

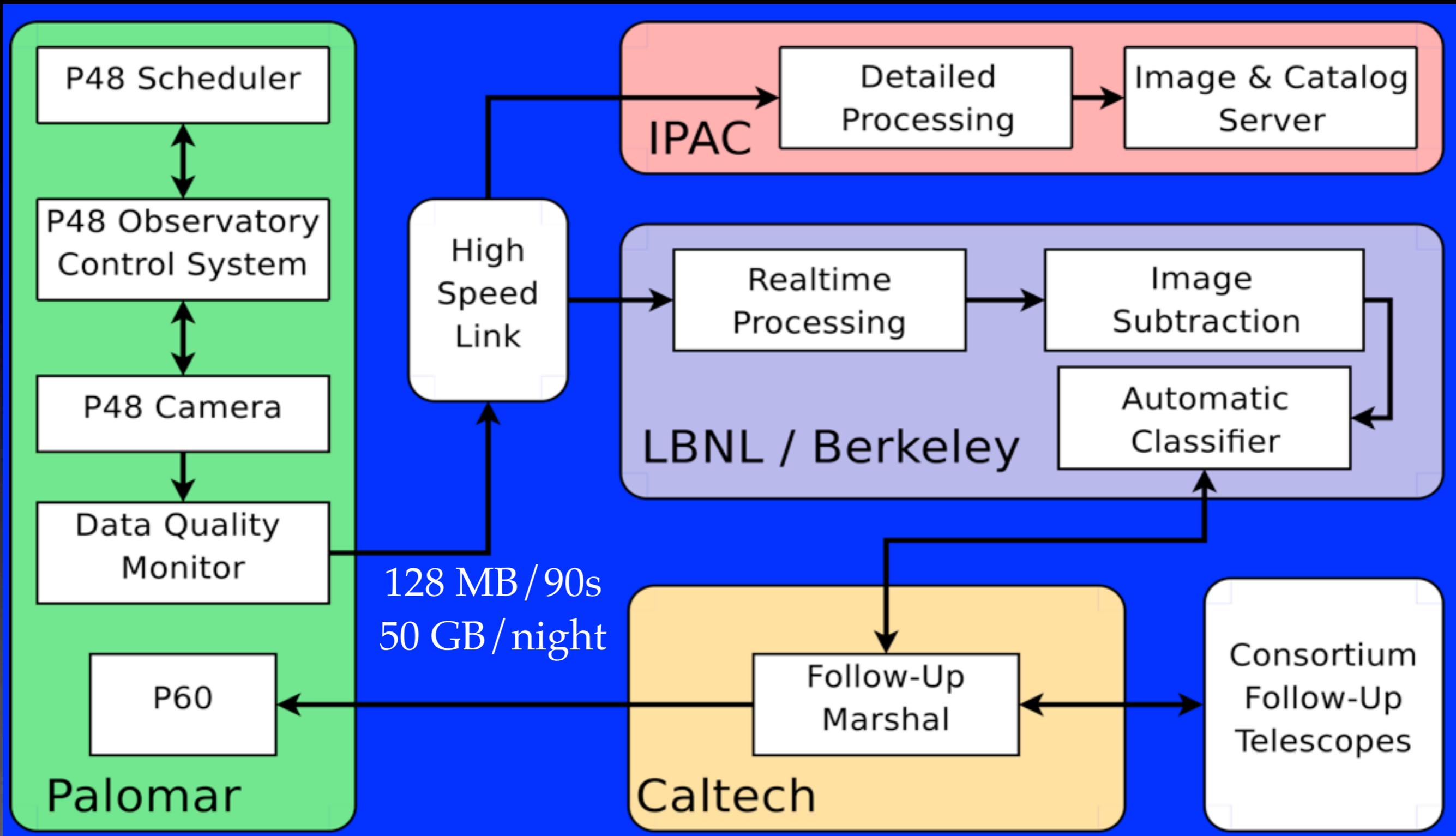


# Pipelines...!



# Pipelines...!



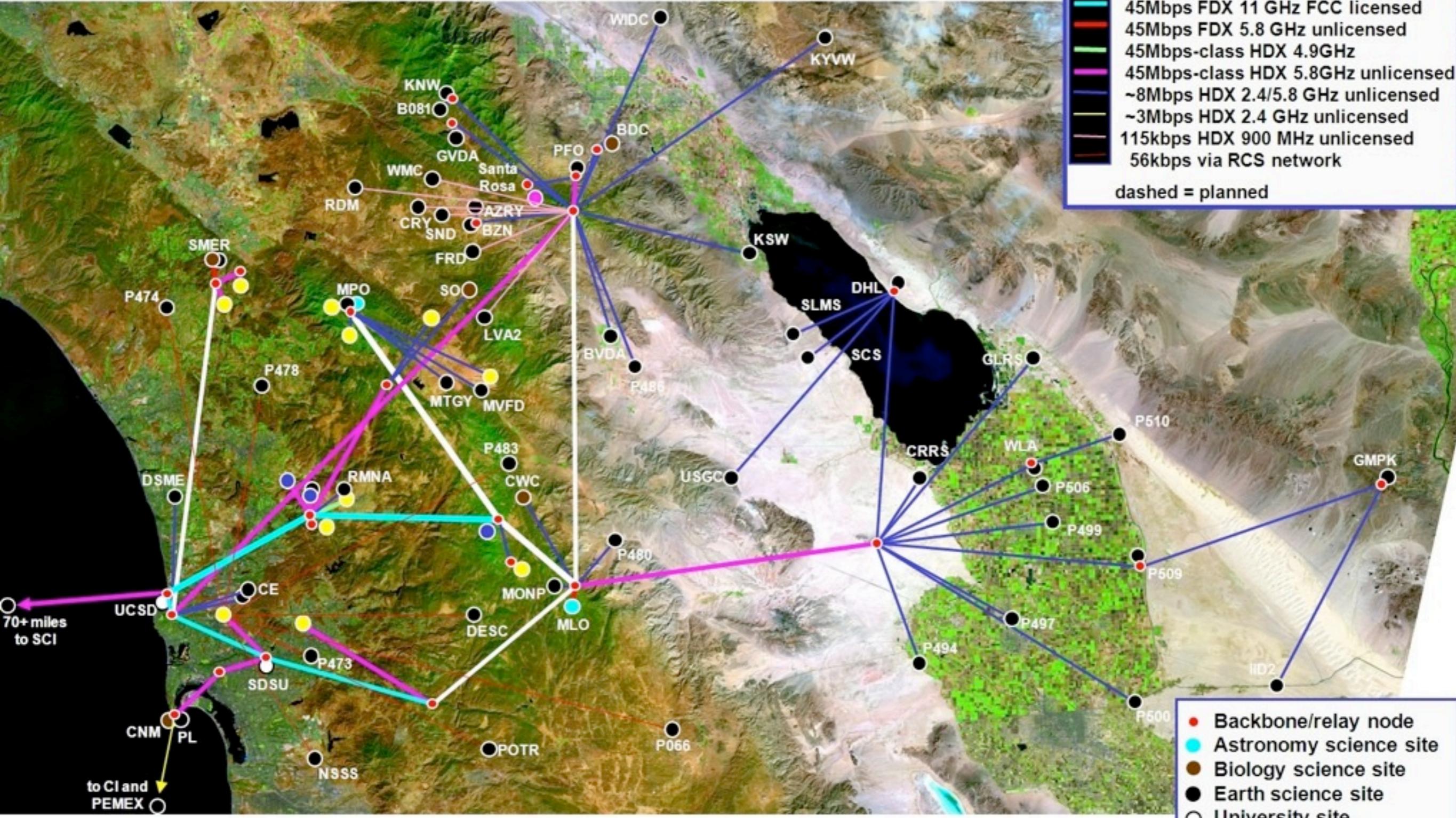


# Palomar 48'' Telescope



# HPWREN topology, December 2010

- 155Mbps FDX 6 GHz FCC licensed
  - 155Mbps FDX 11 GHz FCC licensed
  - 45Mbps FDX 6 GHz FCC licensed
  - 45Mbps FDX 11 GHz FCC licensed
  - 45Mbps FDX 5.8 GHz unlicensed
  - 45Mbps-class HDX 4.9GHz
  - 45Mbps-class HDX 5.8GHz unlicensed
  - ~8Mbps HDX 2.4/5.8 GHz unlicensed
  - ~3Mbps HDX 2.4 GHz unlicensed
  - 115kbps HDX 900 MHz unlicensed
  - 56kbps via RCS network
- dashed = planned



- Backbone/relay node
- Astronomy science site
- Biology science site
- Earth science site
- University site
- Researcher location
- Native American site
- First Responder site

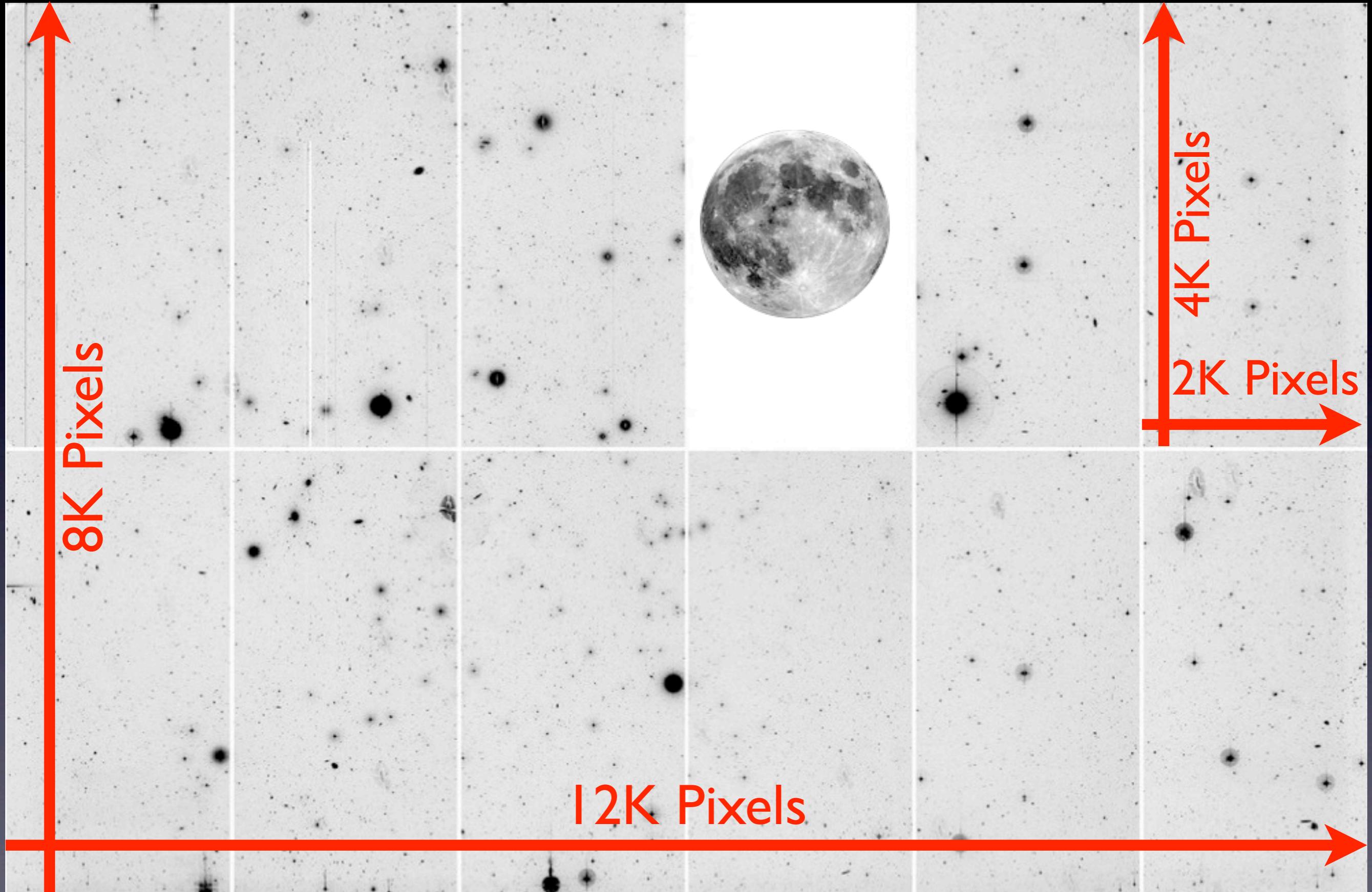
← approximately 50 miles: →

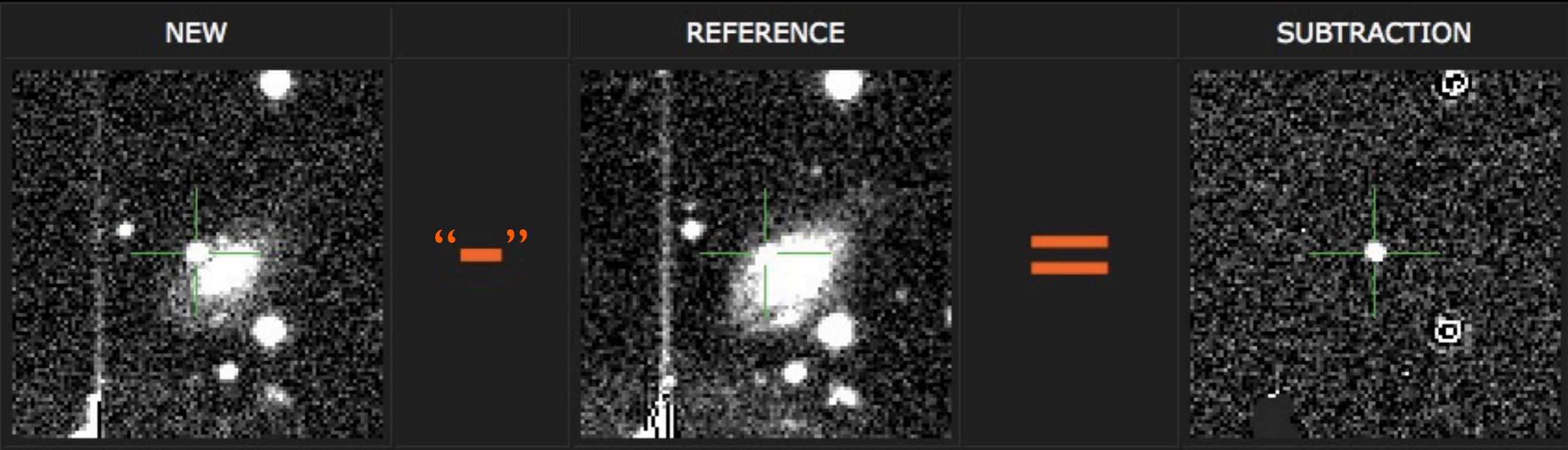
Note: locations are approximate



High Performance Wireless Research and Education Network  
<http://hpwren.ucsd.edu>

350 MB per exposure





last night

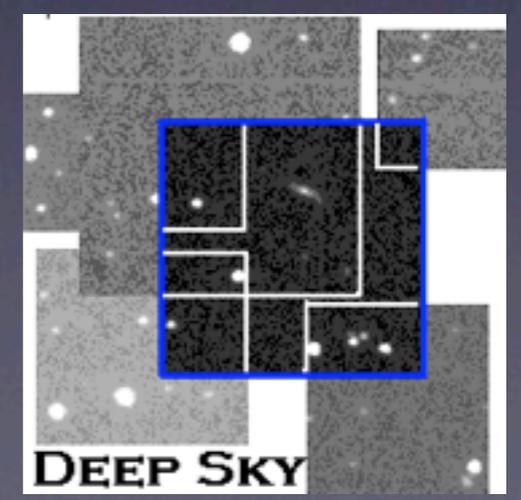
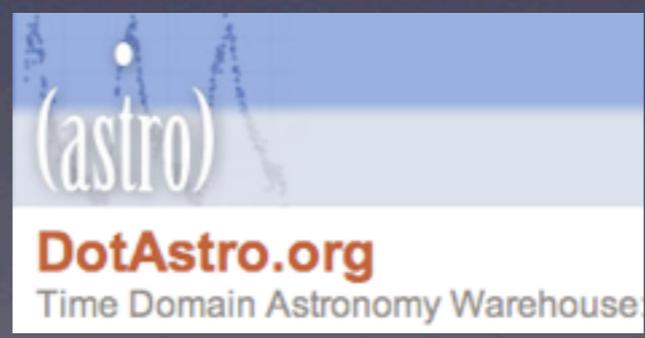
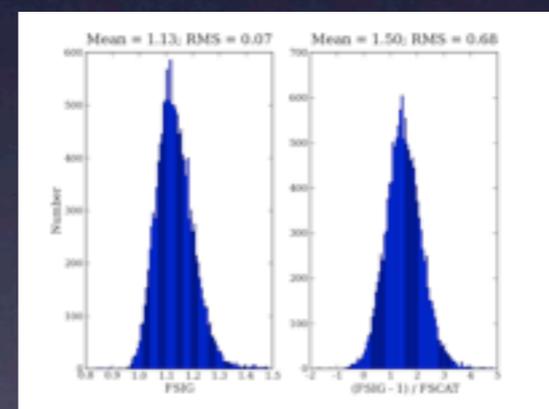
“ — ”  
↑

months ago

=

new object

(  
astrometry/registration  
flux calibration  
image convolution  
machine classification  
)

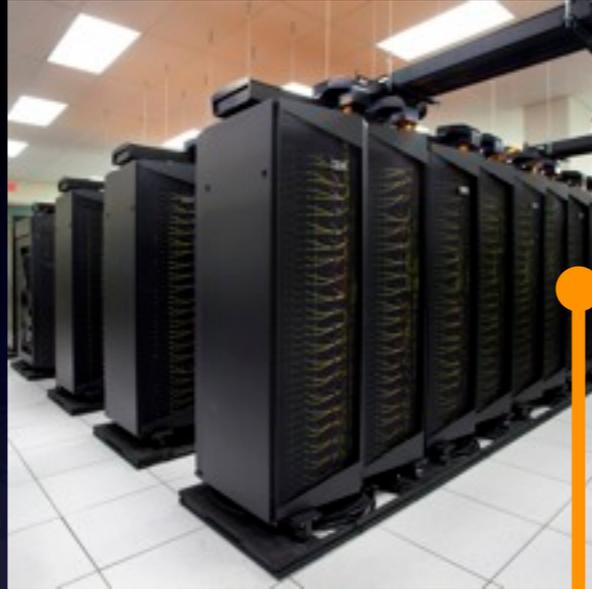


P48



PTF Collaboration

image subtraction



carver.nersc.gov

bbcp

Data Transfer Nodes

dtn01.nersc.gov  
dtn02.nersc.gov

web interface

Science Gateway Node

sgn01.nersc.gov

basic image processing

Science Gateway Node

sgn02.nersc.gov

Database Node

scidb1.nersc.gov

image/object/candidate  
metadata q3d, etc.

NERSC Global File System  
2 PB capacity, 15 GB/sec streaming I/O





~ 1 min



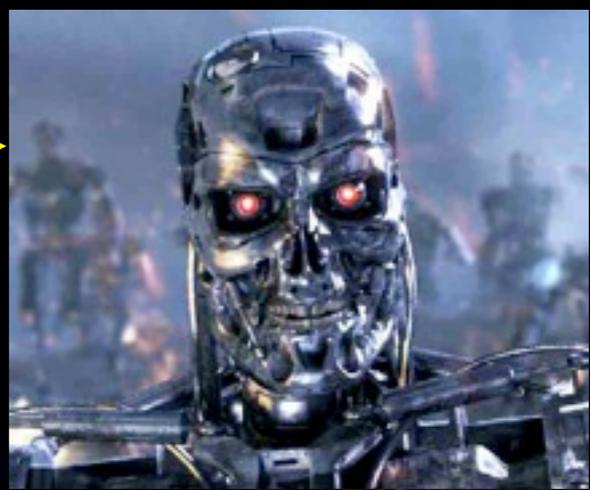
images  
(ref, new)



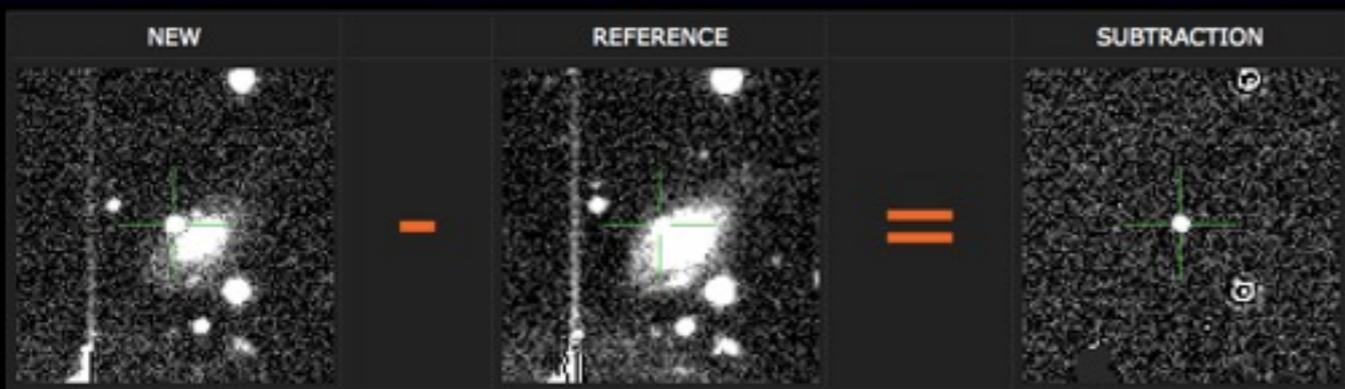
~ 1 hour



subtractions



GALAXY ZOO



last night      months ago      new object

~ hours  
candidates



followup  
marshal  
(workflow)

<a href="#">11klz</a> (433.3 d)	17:58:09.73 +51:41:43.0			$r = 18.6$ (433.3 d)	None <a href="#">no fup</a>	<ul style="list-style-type: none"> <li>ptfrobot [robotclass_conf]: 0.23</li> <li>ptfrobot [robotclass_source]: sdss</li> <li>ptfrobot [robotclass]: AGN-cnSN-TDE</li> <li>adam [type]: VarStar</li> <li>...</li> </ul>
<a href="#">11kly</a> (9.6 d)	14:03:05.83 +54:16:25.2			$r = 12.8$ (1.6 d)	SN Ia -7.3d $z=0.000804$ <a href="#">no fup</a>	<ul style="list-style-type: none"> <li>jeff_silverman [comment]: WARNING: the overlap is bad at about 6700-7000 Ang.</li> <li>rollin [comment]: prelim</li> <li>rollin [classification]: SN Ia</li> <li>jerod [classification]: SN Ia</li> <li>...</li> </ul>
<a href="#">11klx</a> (9.4 d)	17:02:58.06 +40:31:13.3			$r > 21.8$ (1.6 d)	SN Ia +24.7d $z=0.031$ <a href="#">no fup</a>	<ul style="list-style-type: none"> <li>dong [phase]: +19 days</li> <li>dong [comment]: SNID fitting result attached</li> <li>dong [redshift]: 0.031</li> <li>dong [classification]: SN Ia</li> <li>...</li> </ul>
						<ul style="list-style-type: none"> <li>ptfrobot [robotclass_conf]: 0.13</li> </ul>



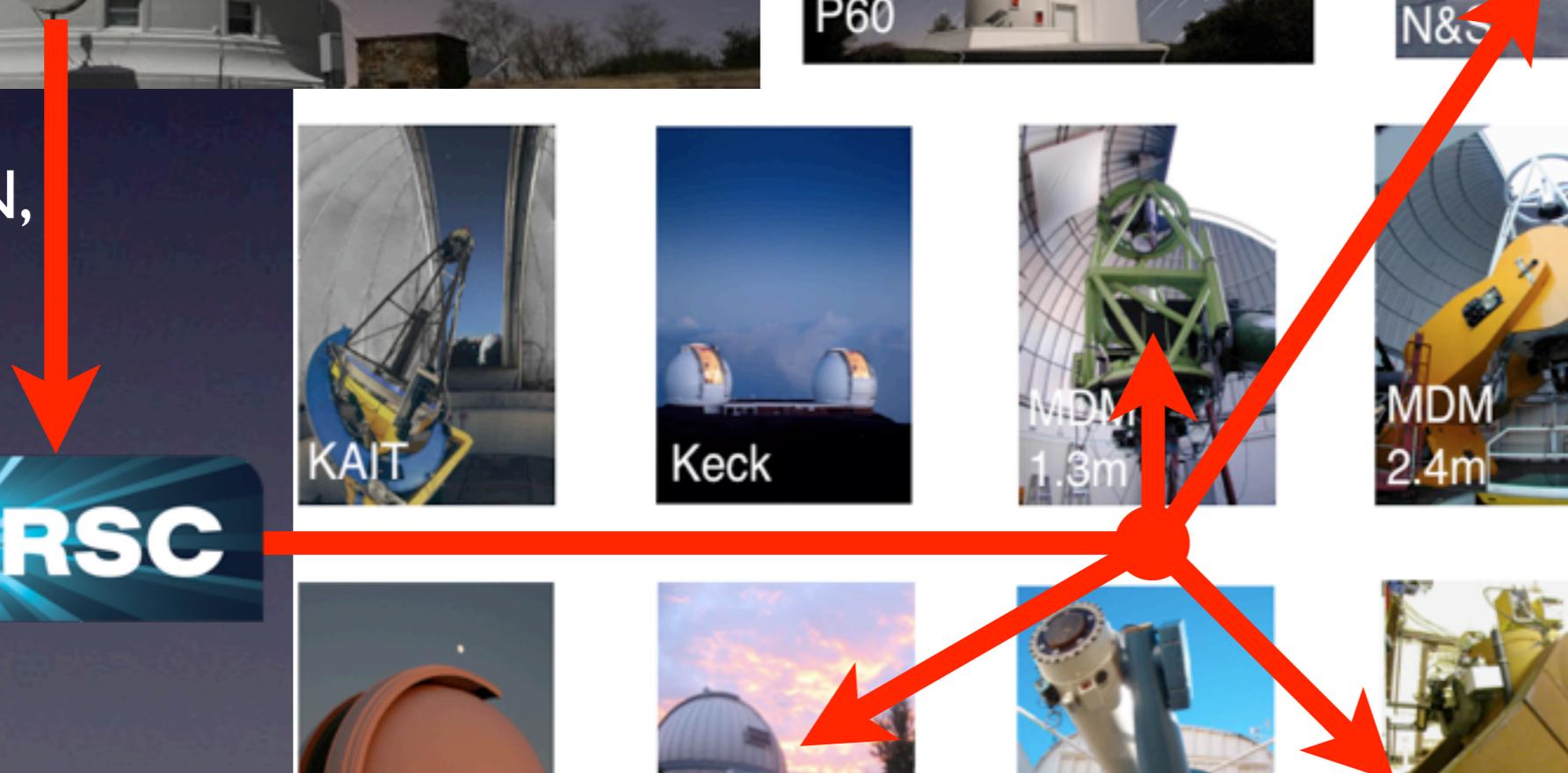
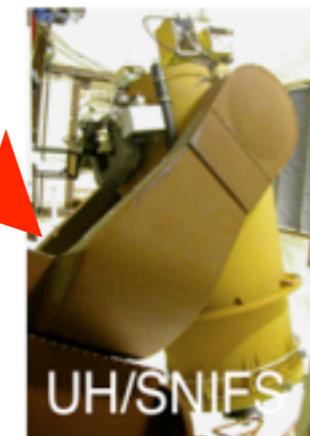
# Palomar Transient Factory

P48 (Survey)

Globally Distributed  
**Follow-up** Resources

HPWREN,  
ESNET

**NERSC**



# Palomar Transient Factory

## 2009-now

- 2.02 million images (60 TB)
- 1.48 million subtractions
- 931 million candidates identified
- 45,000 potential transients
- 1700+ supernovae of all types
- 1172 Type Ia Supernovae
- 46 publications (all transient topics) to date

# 2012 and Beyond

- PTF main survey operations will continue for one more year, “extended” survey for 2+ years after.
- Focus at LBL/NERSC: Real-time candidate discovery. Faster discovery, faster analysis, faster results: Same-night follow-up triggering.
- Migration of database onto better hardware at NERSC. Experimenting with database structure, query optimization, new hardware, flash memory devices, GPUs?

# SN2011fe: “Supernova of a generation”

Science News  
Washington Post  
SF Chronicle  
LA Times  
PBS Jim Lehrer Show  
NPR Weekend Edition  
All Things Considered  
BBC World Report  
NHK TV  
El Mundo  
California Magazine  
Daily Cal...

## How to See a Recently Discovered Supernova

BerkeleyLab

250 videos

Subscribe

Block...



**Peter Nugent**  
Astrophysicist  
Lawrence Berkeley National Laboratory

Like Add to Share

188,787

Uploaded by BerkeleyLab on Aug 31, 2011

Berkeley Lab scientist Peter Nugent discusses a recently discovered supernova that is closer to Earth — approximately 21 million light-years away — than any other of its kind in a generation. Astronomers believe they caught

Show more

324 likes, 6 dislikes

As Seen On:  
Universe Today

### Top Comments

woow supernova  
lavakafle 2 months ago 11

Really awesome!  
NocturnalRyte 2 months ago 4

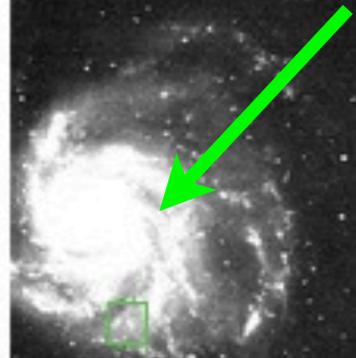
# Candidate # 61161406: Discovery Observation

NEW

REF

SUB

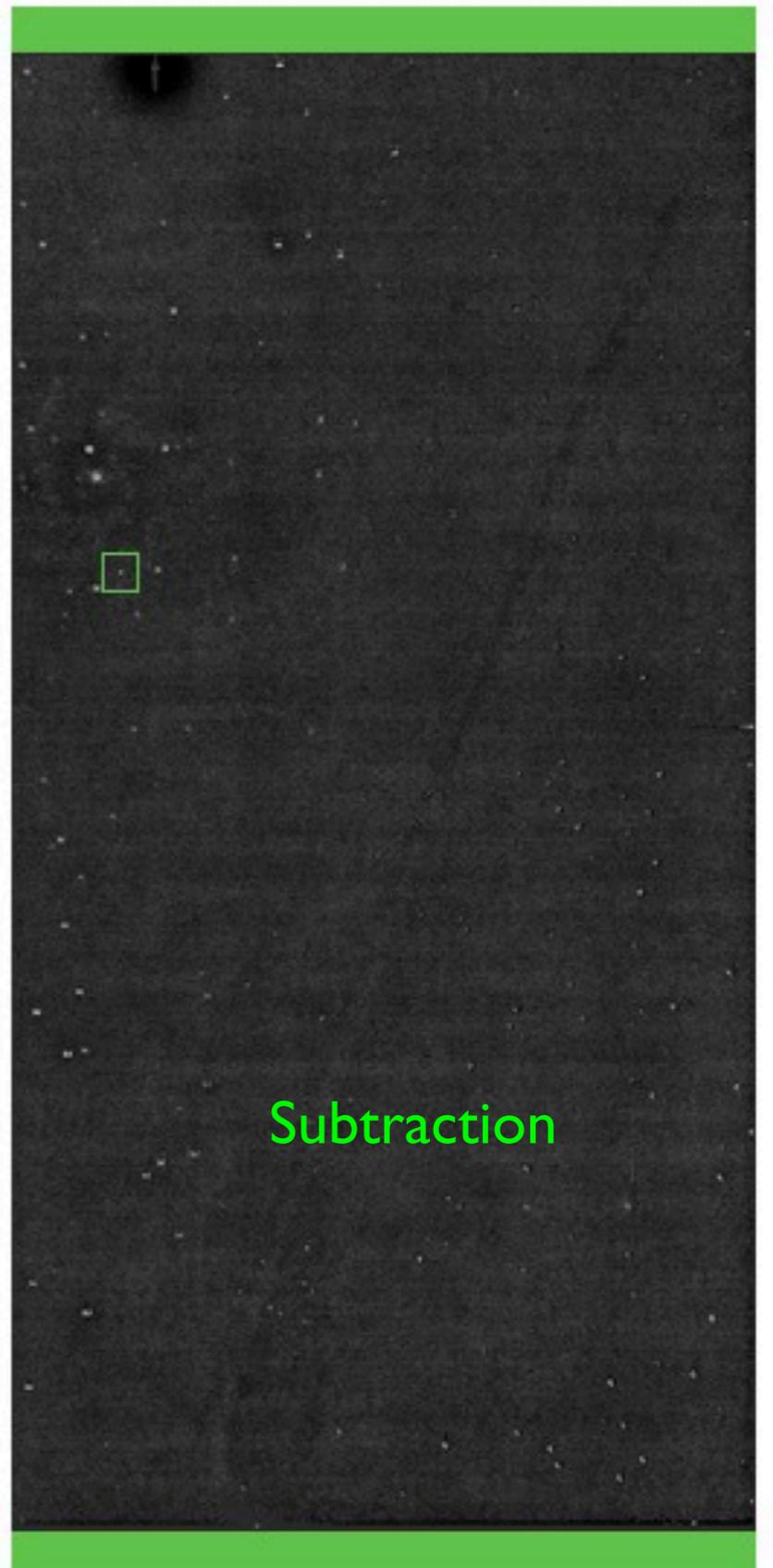
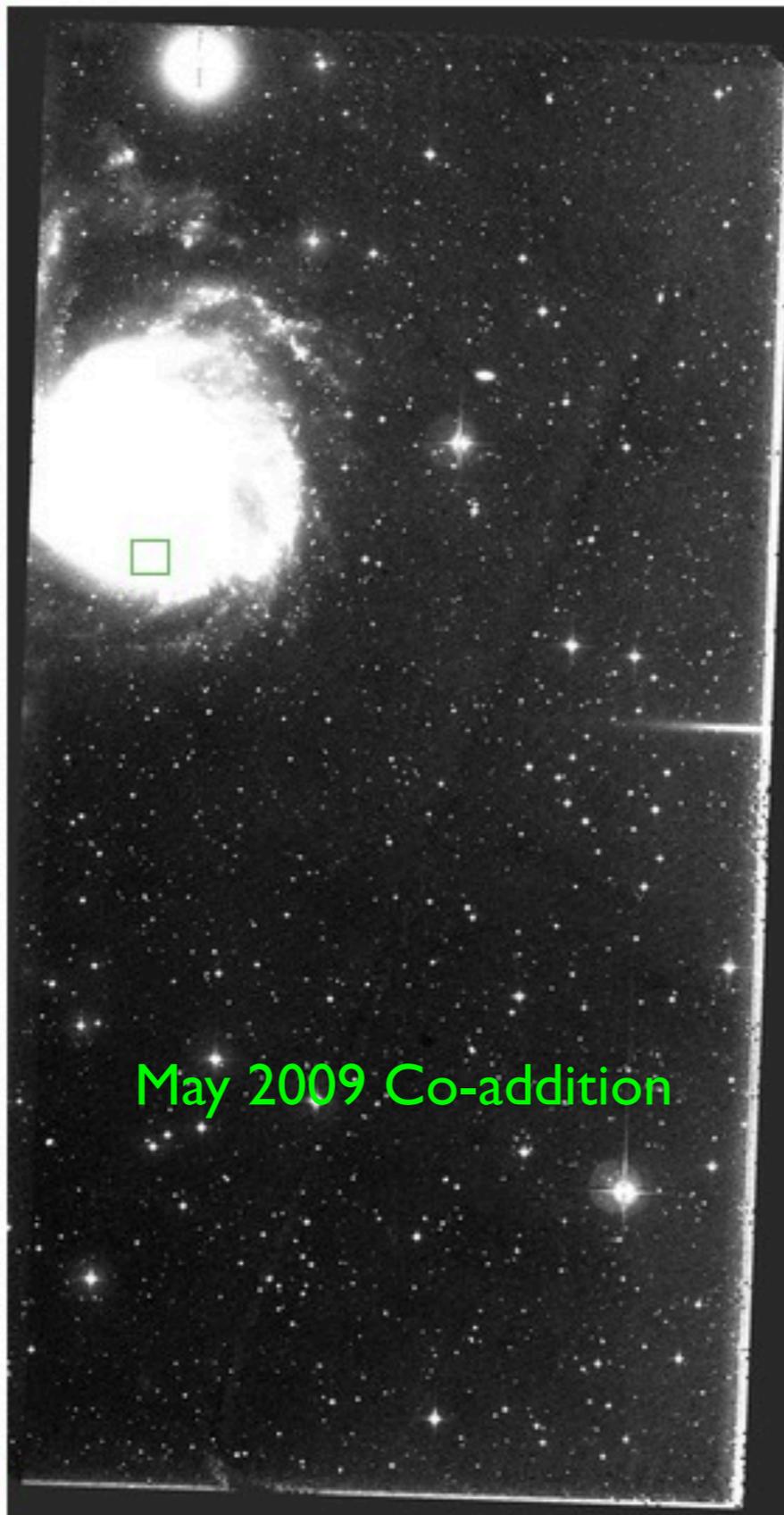
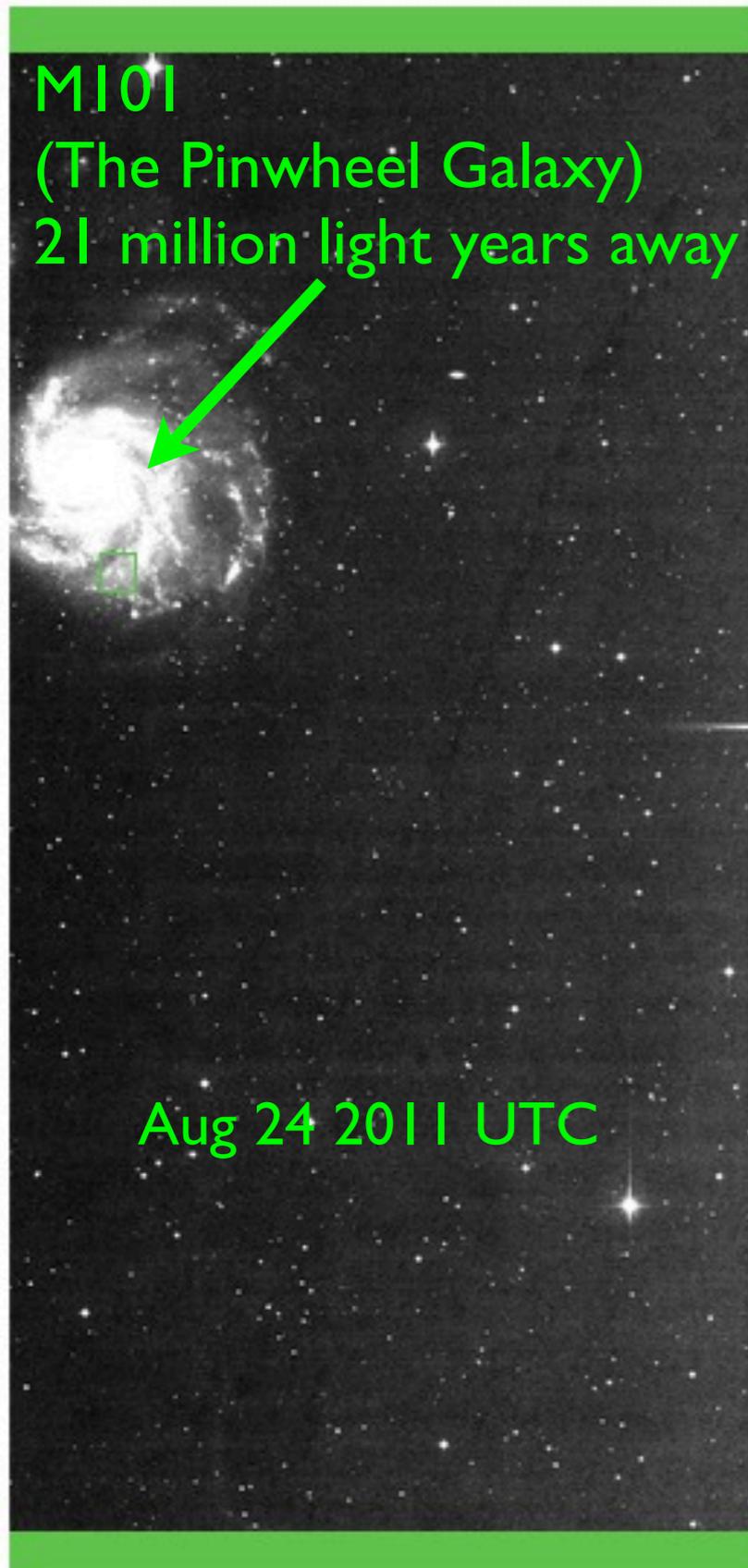
MI01  
(The Pinwheel Galaxy)  
21 million light years away



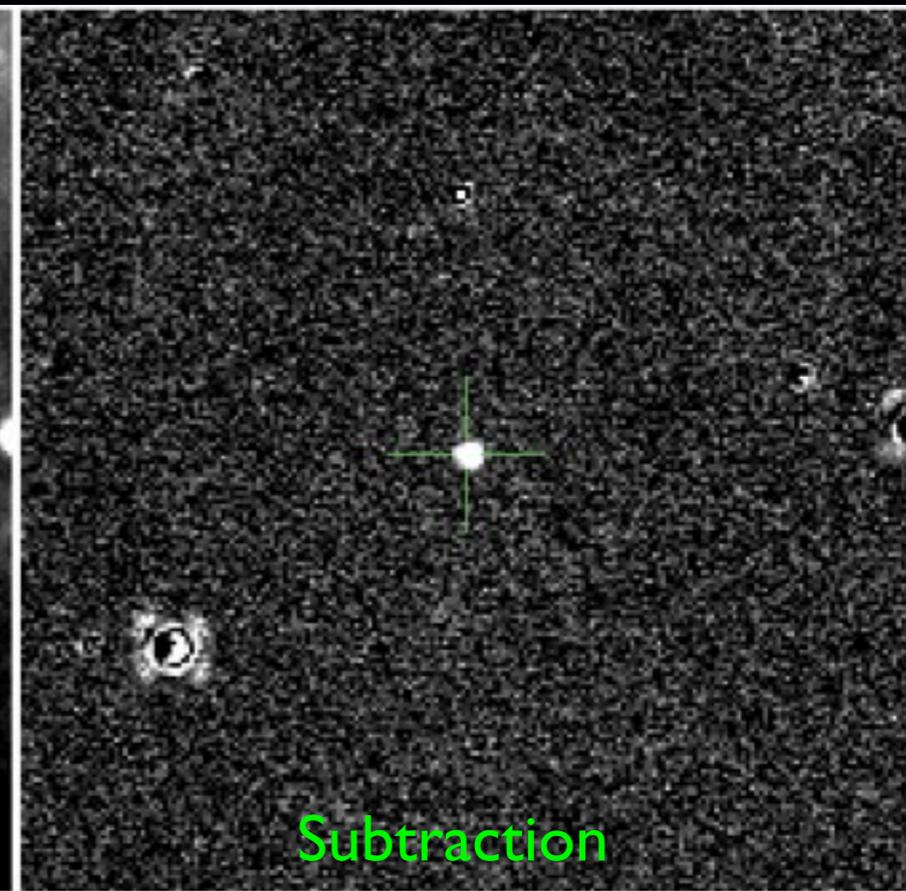
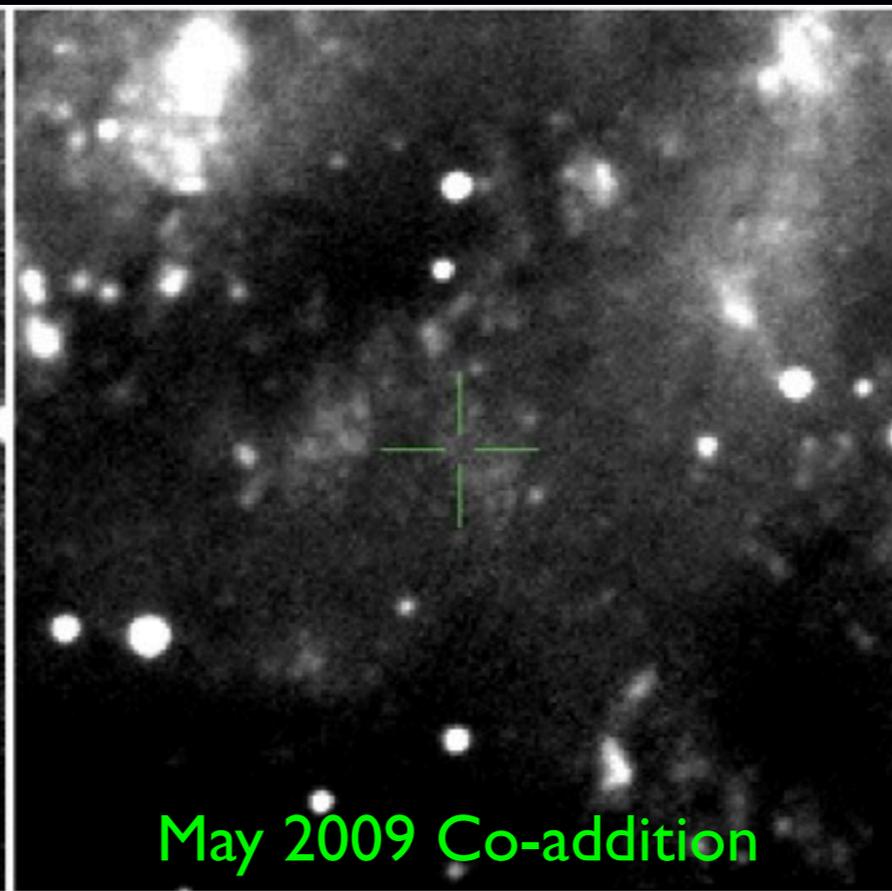
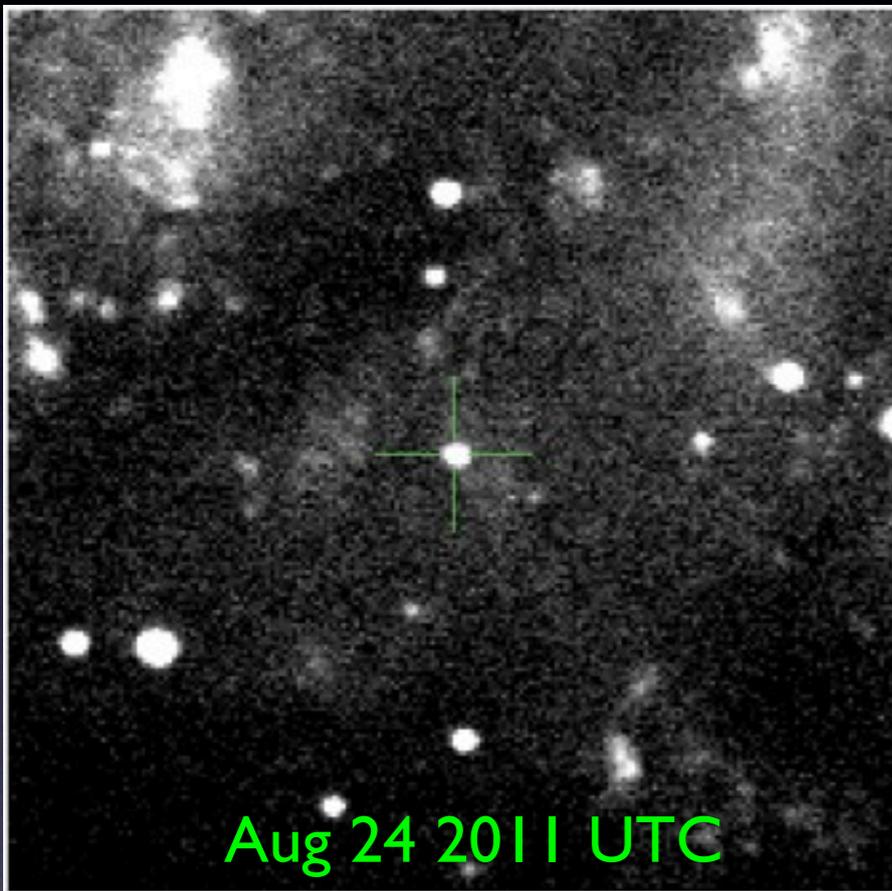
Aug 24 2011 UTC

May 2009 Co-addition

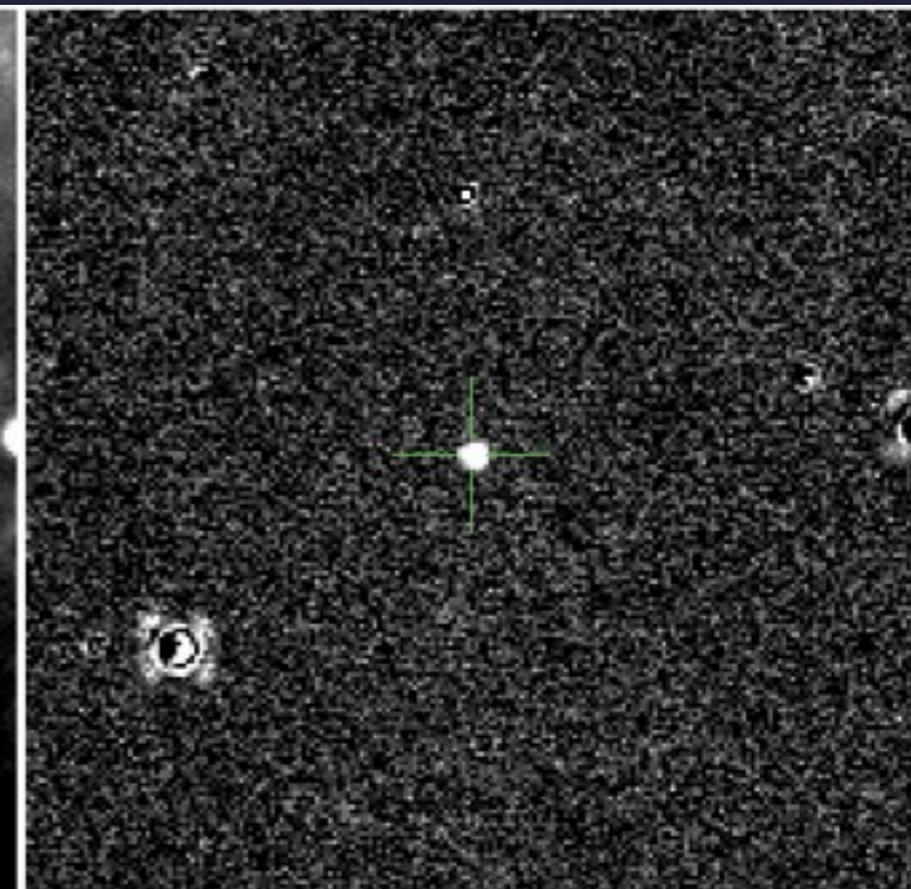
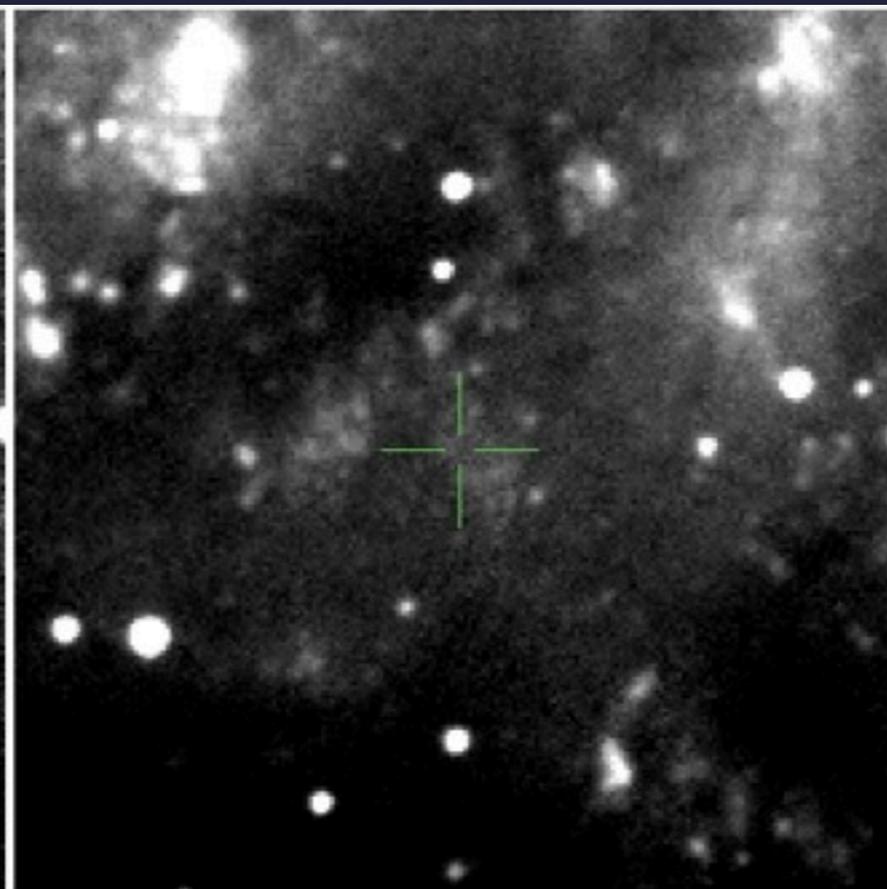
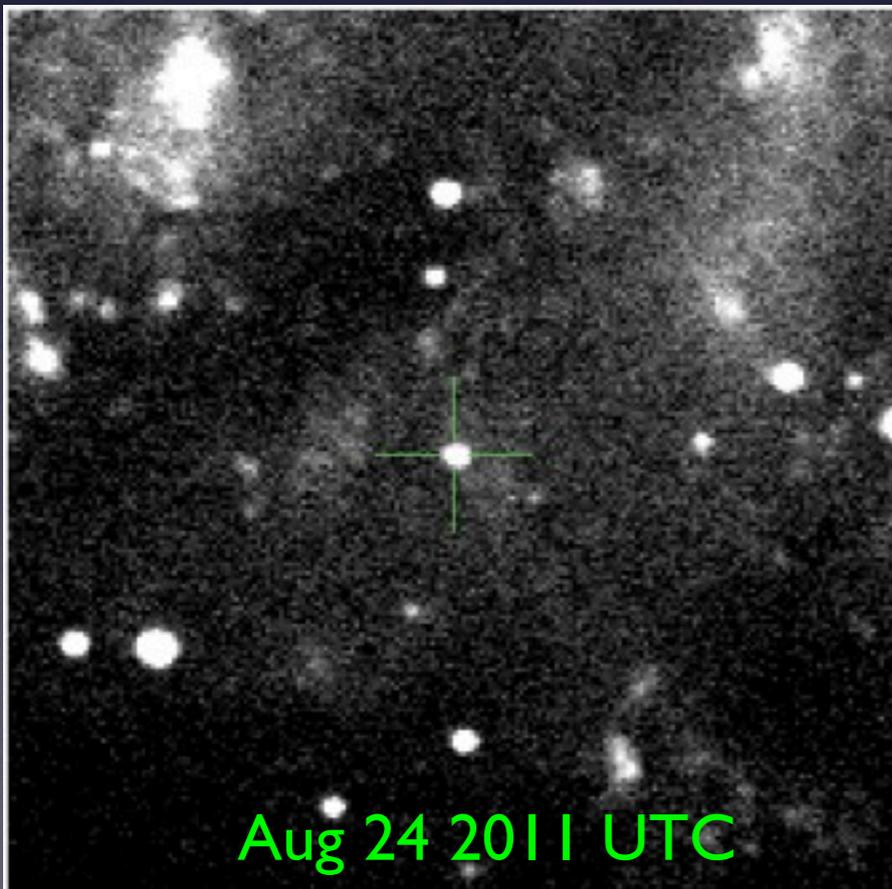
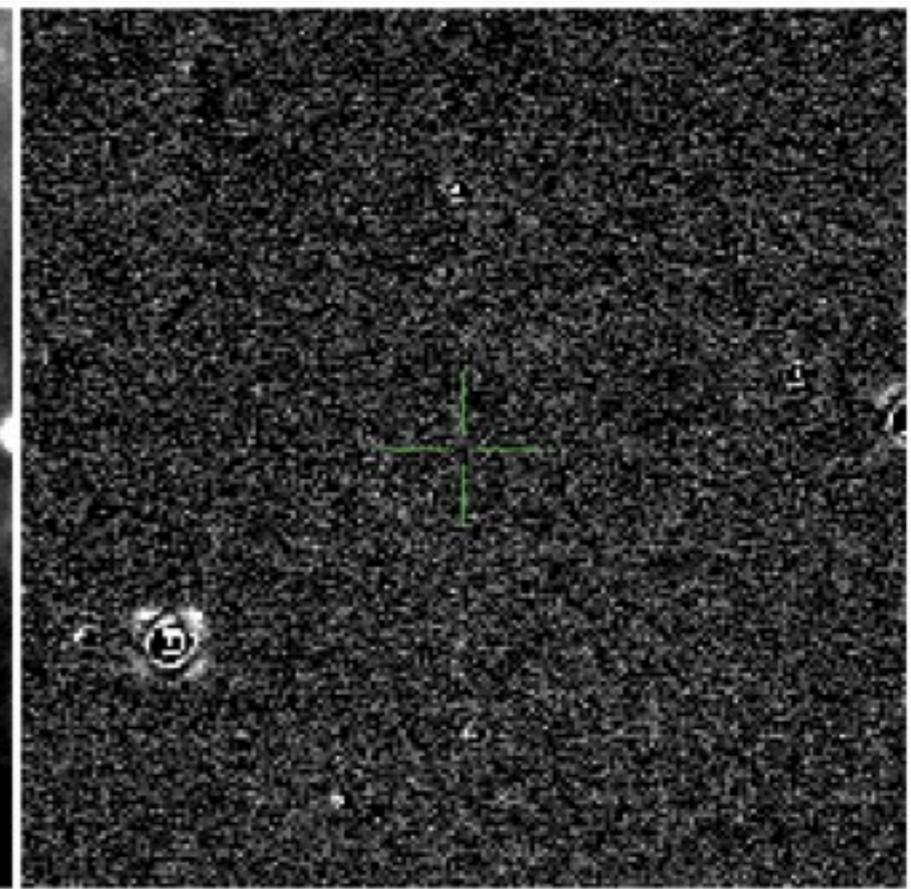
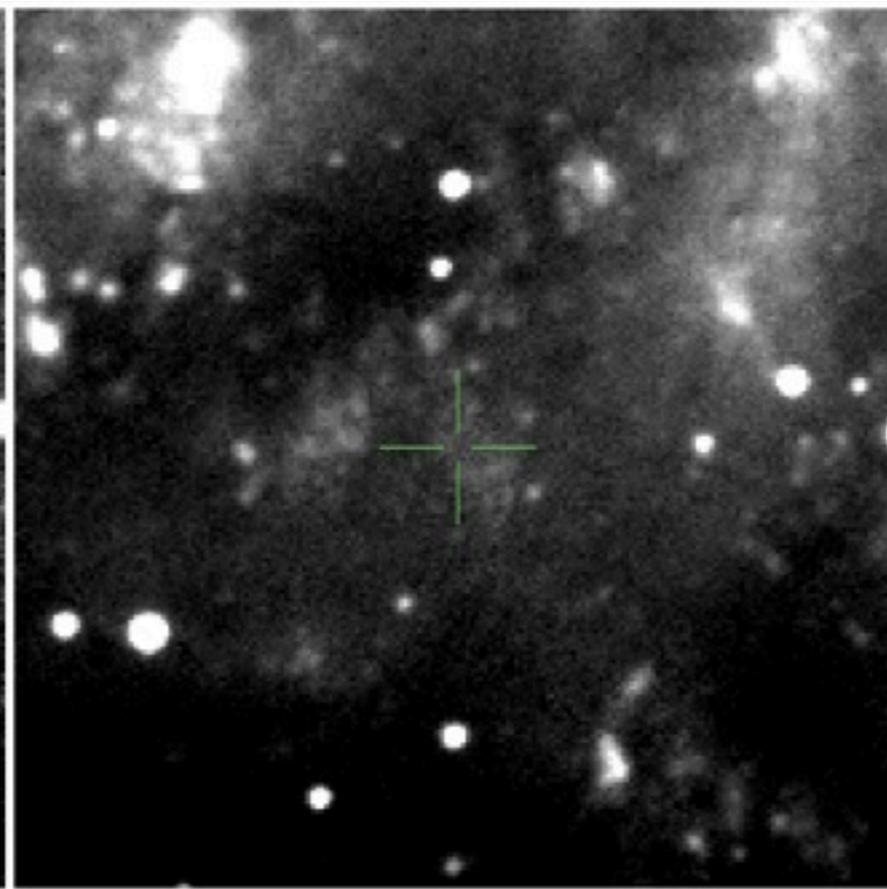
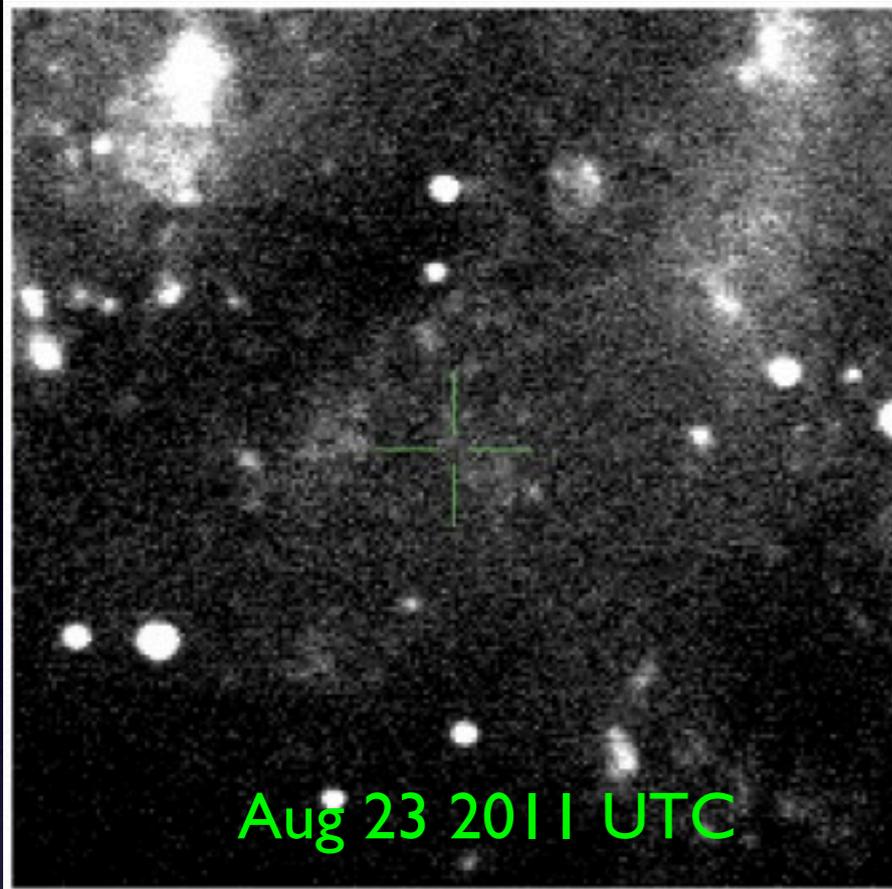
Subtraction



# Candidate # 611161406: Discovery Observation



# Candidate # 611161406: Night Previous to Discovery..



*Archival HST observations of M101 covered the position of the supernova before it exploded!*



***NOTHING*** is detected there!

This strongly constrains the nature of the progenitor.

At this point  
(lunchtime in Berkeley):

Mere hours have passed since  
the discovery image was  
obtained at Mt. Palomar.

What kind of supernova will it  
be? Will it be a Type Ia?

We need a *spectrum* to know.

The sun sets on the Canary  
Islands...



# Young Type Ia Supernova PTF11kly in M101

ATel #3581; *Peter Nugent (LBL/UCB), Mark Sullivan (Oxford), David Bersier (Liverpool John Moores), D.A. Howell (LCOGT/UCSB), Rollin Thomas (LBL), Phil James (Liverpool John Moores)*

on **24 Aug 2011; 23:47 UT**

← C.O.B. in Berkeley!

*Distributed as an Instant Email Notice Supernovae*

*Credential Certification: R. C. Thomas (rcthomas@lbl.gov)*

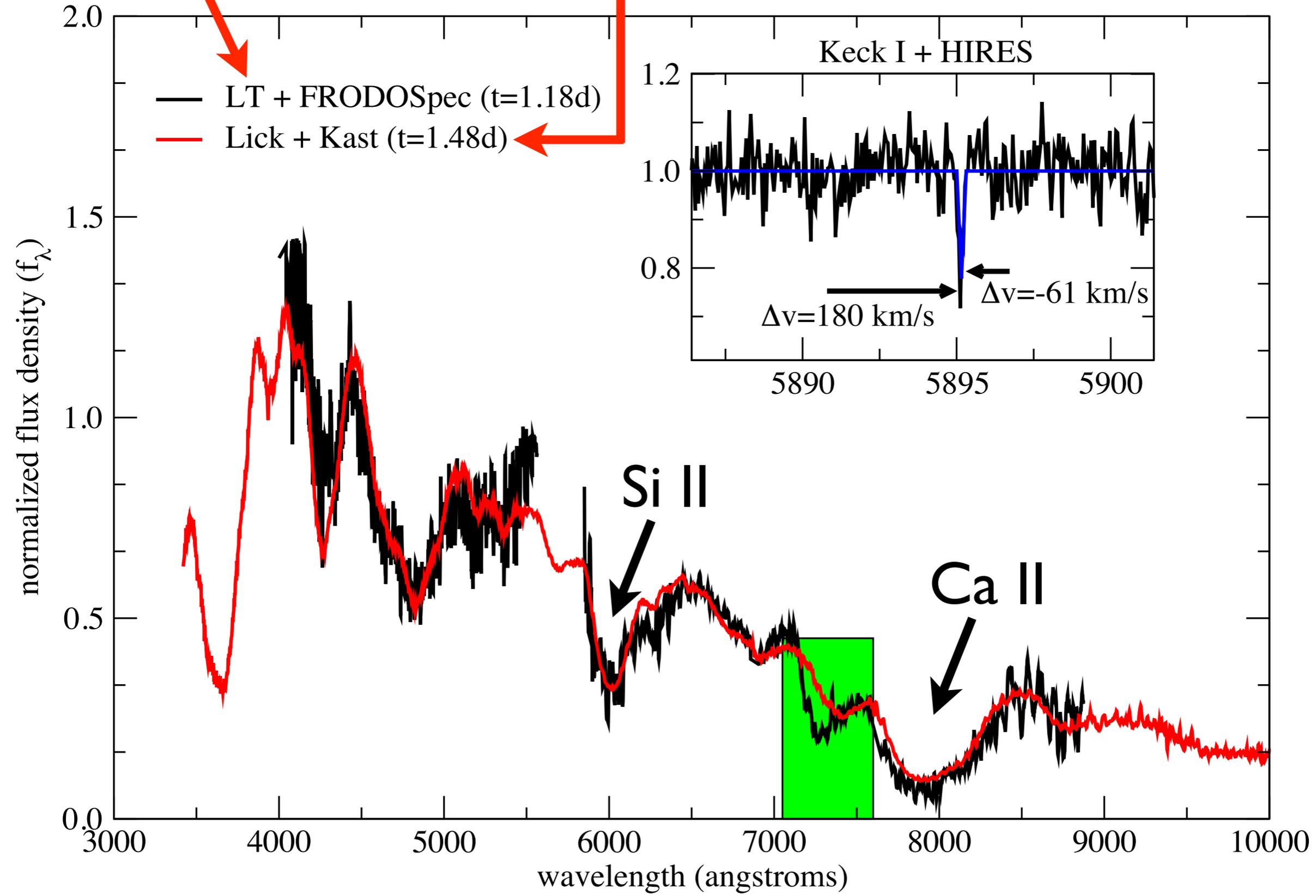
Subjects: Optical, Supernovae

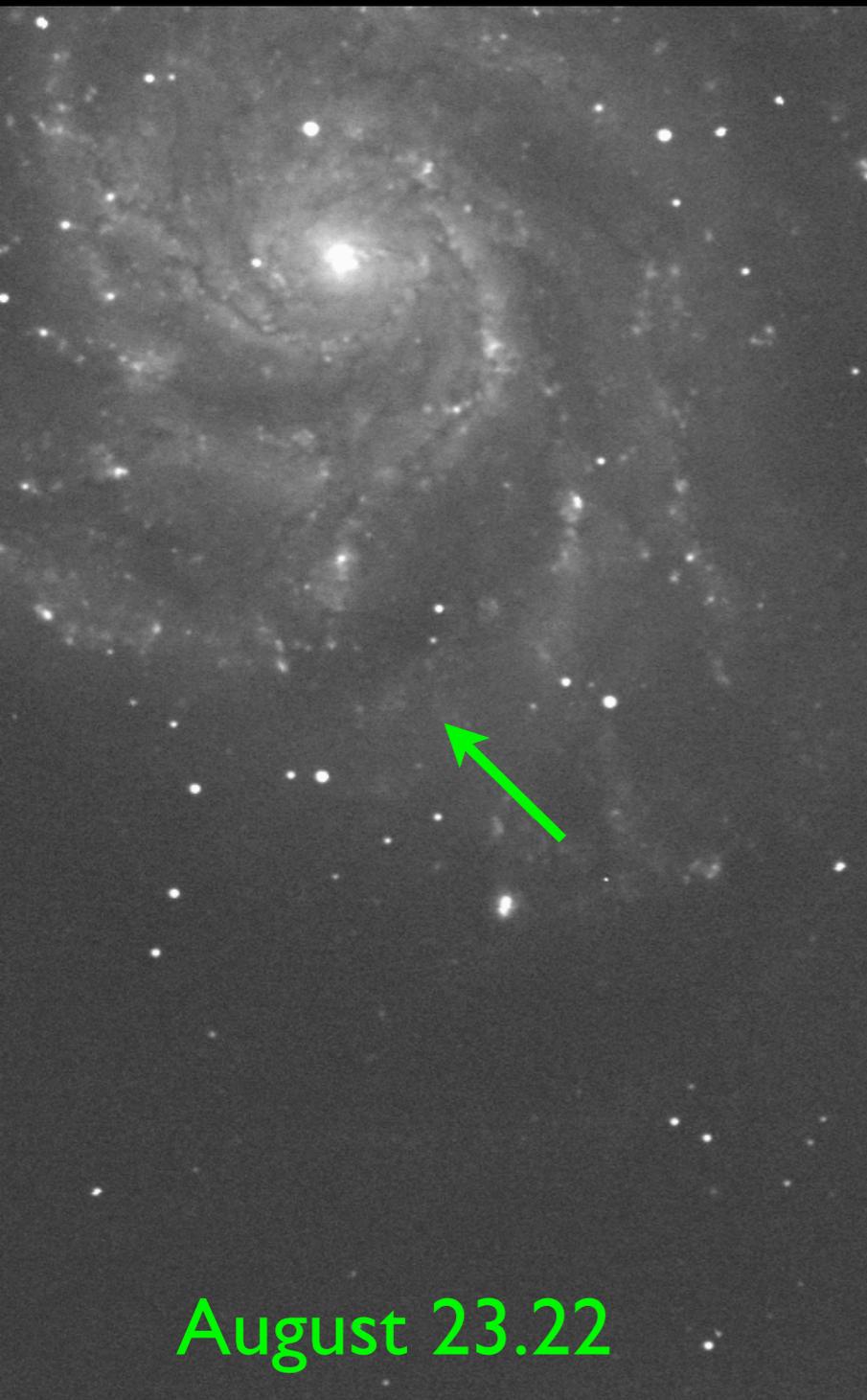
Referred to by ATel #: [3582](#), [3583](#), [3584](#), [3588](#), [3589](#), [3590](#), [3592](#), [3594](#), [3597](#), [3598](#), [3602](#), [3605](#), [3607](#), [3620](#), [3623](#), [3642](#), [3683](#), [3696](#)

The Type Ia supernova science working group of the Palomar Transient Factory (ATEL #[1964](#)) reports the discovery of the Type Ia supernova PTF11kly at RA=14:03:05.81, Dec=+54:16:25.4 (J2000) in the host galaxy M101. The supernova was discovered on Aug. 24 UT when it was at magnitude 17.2 in g-band (calibrated with respect to the USNO catalog). There was nothing at this location on Aug 23 UT to a limiting magnitude of 20.6. A preliminary spectrum obtained Aug 24 UT with FRODOSPEC on the Liverpool Telescope indicates that **PTF11kly is probably a very young Type Ia supernova**: Broad absorption lines (particularly Ca II IR triplet) are visible. The **presence of an H-alpha feature is confidently rejected**. STIS/UV spectroscopic observations on the Hubble Space Telescope are being triggered by the ToO program "Towards a Physical Understanding of the Diversity of Type Ia Supernovae" (PI: R. Ellis). Given that the supernova should brighten by 6 magnitudes, the strong age constraint, and the fact that the supernova will soon be behind the sun, we strongly encourage additional follow-up of this source at all wavelengths.

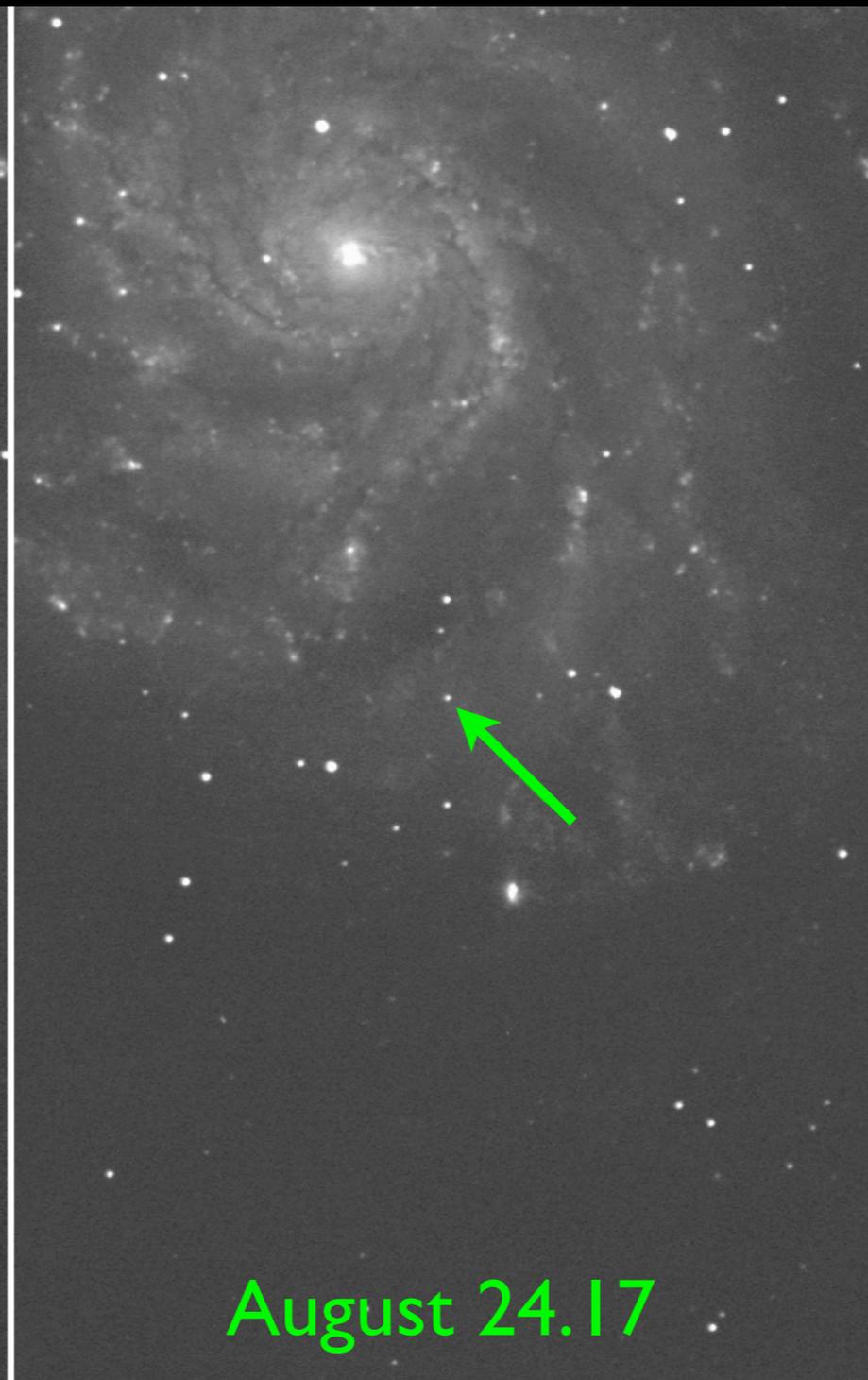
(La Palma, Canary Islands)

(Mt. Hamilton, N. California)

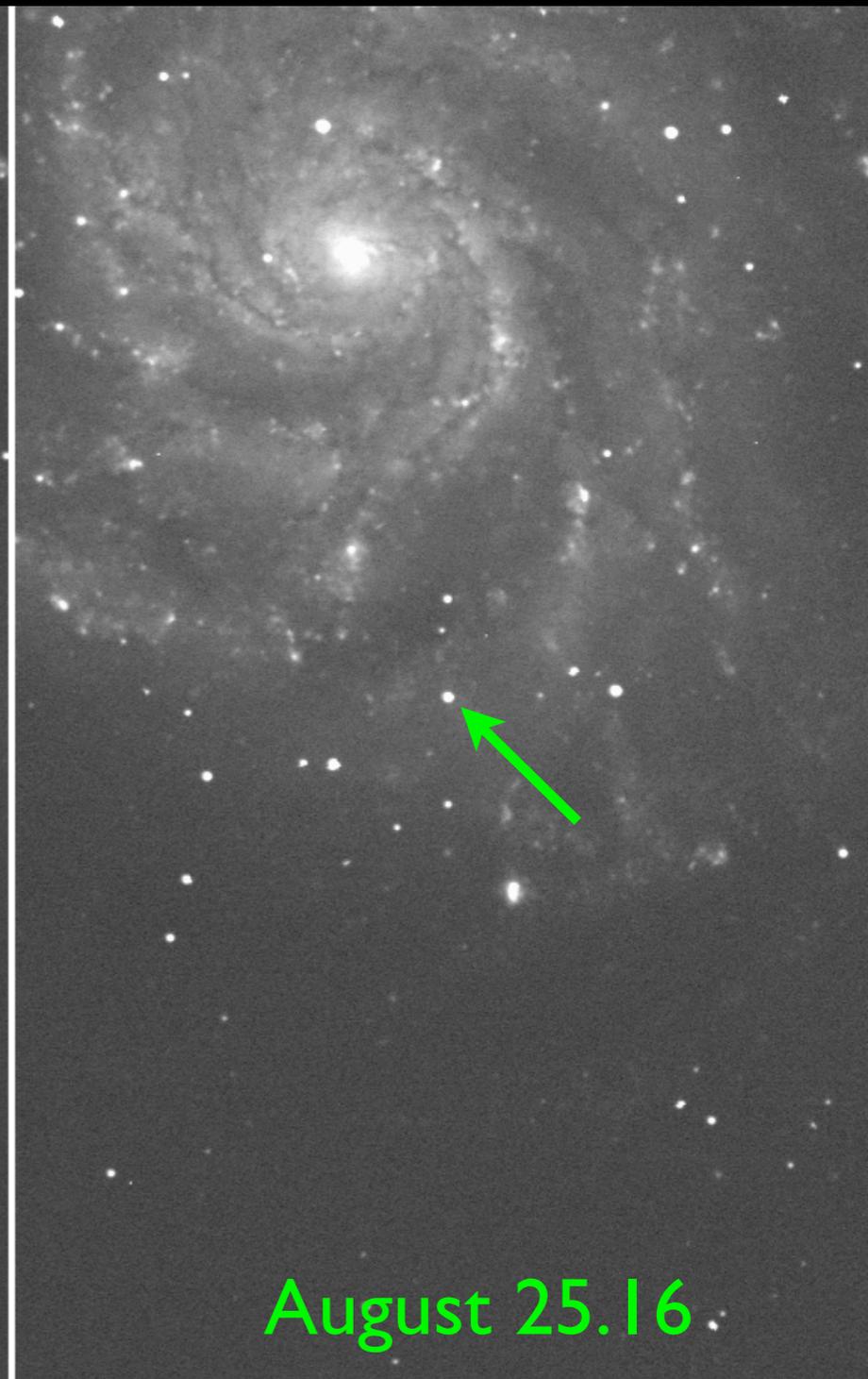




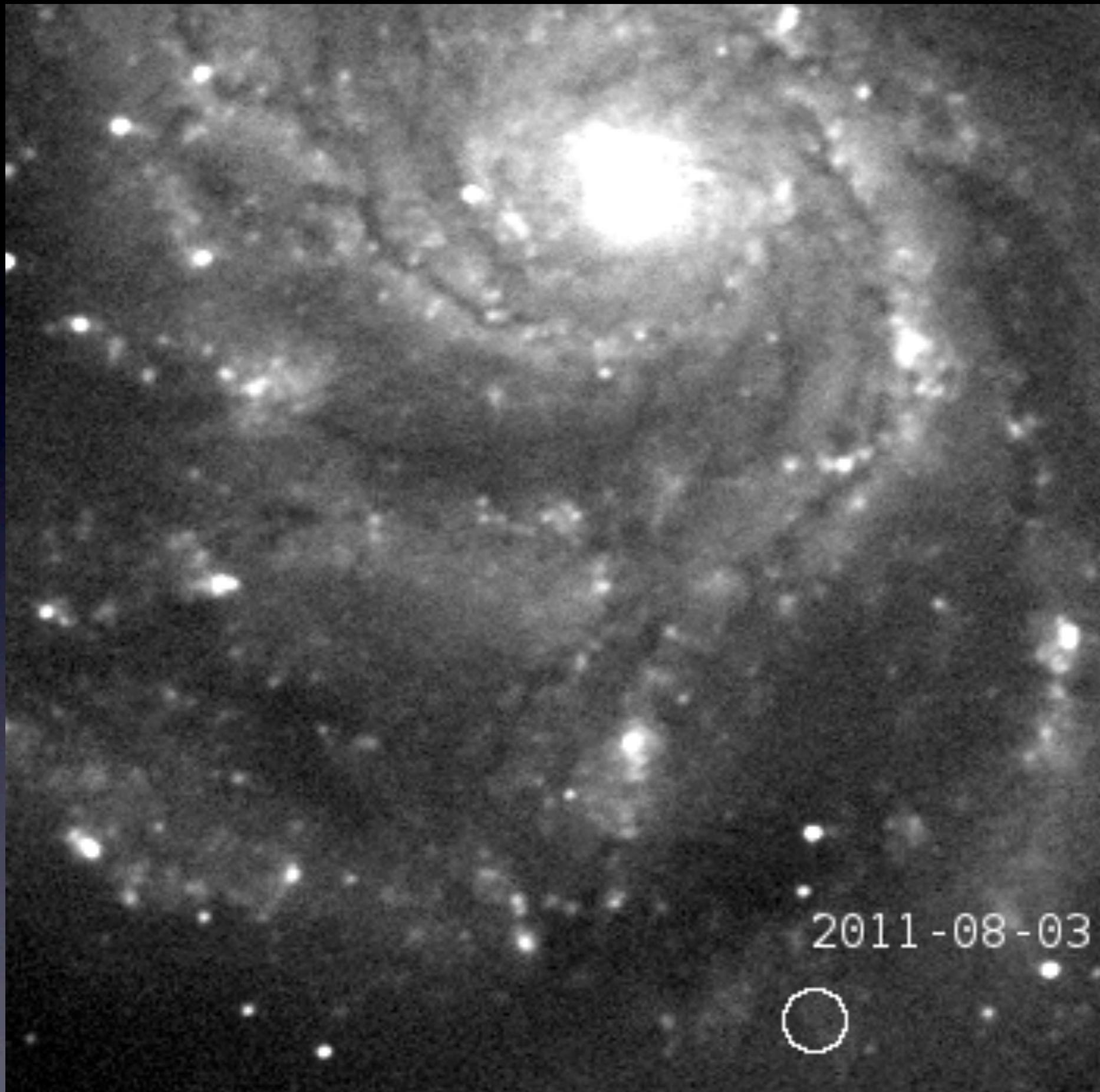
August 23.22

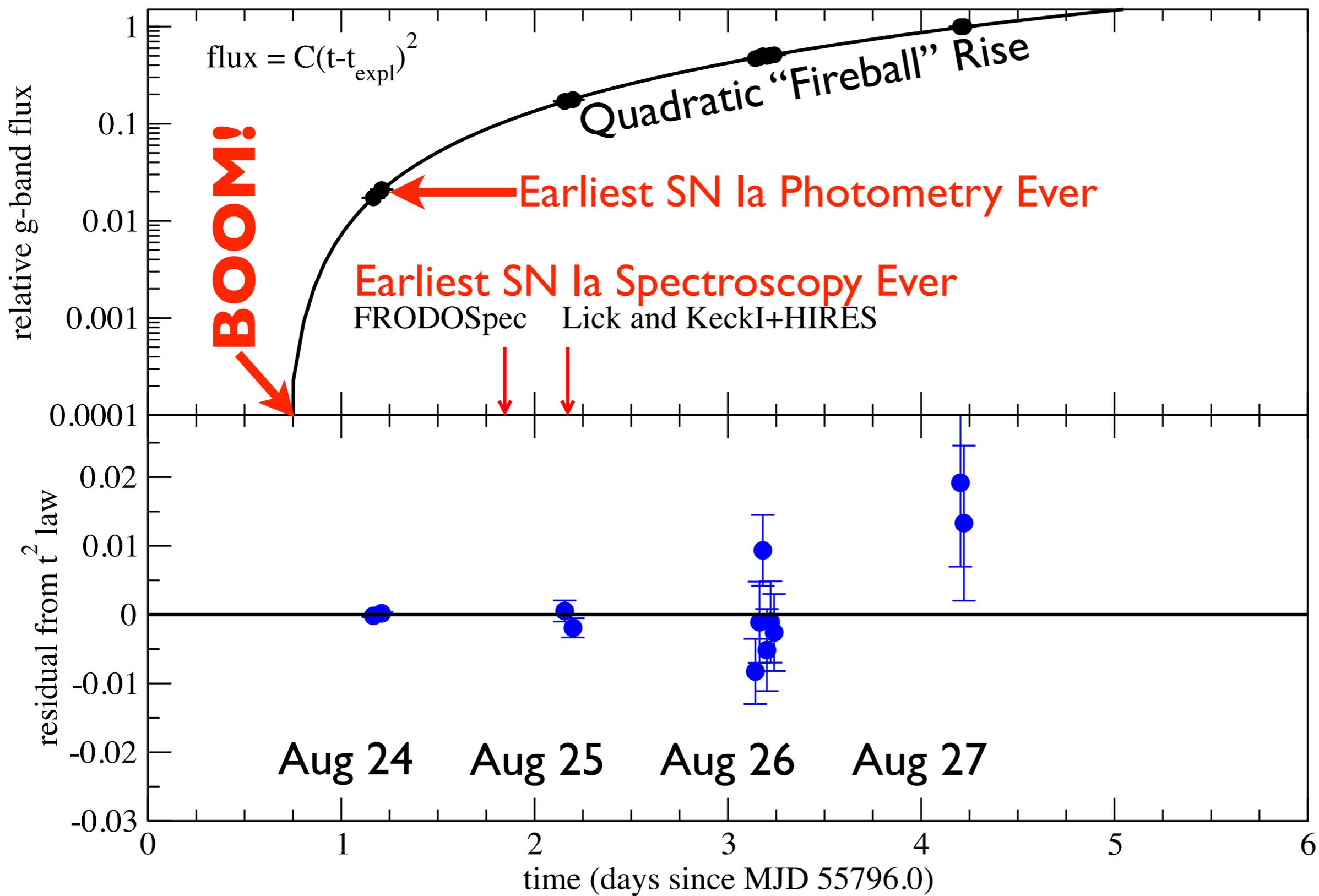


August 24.17



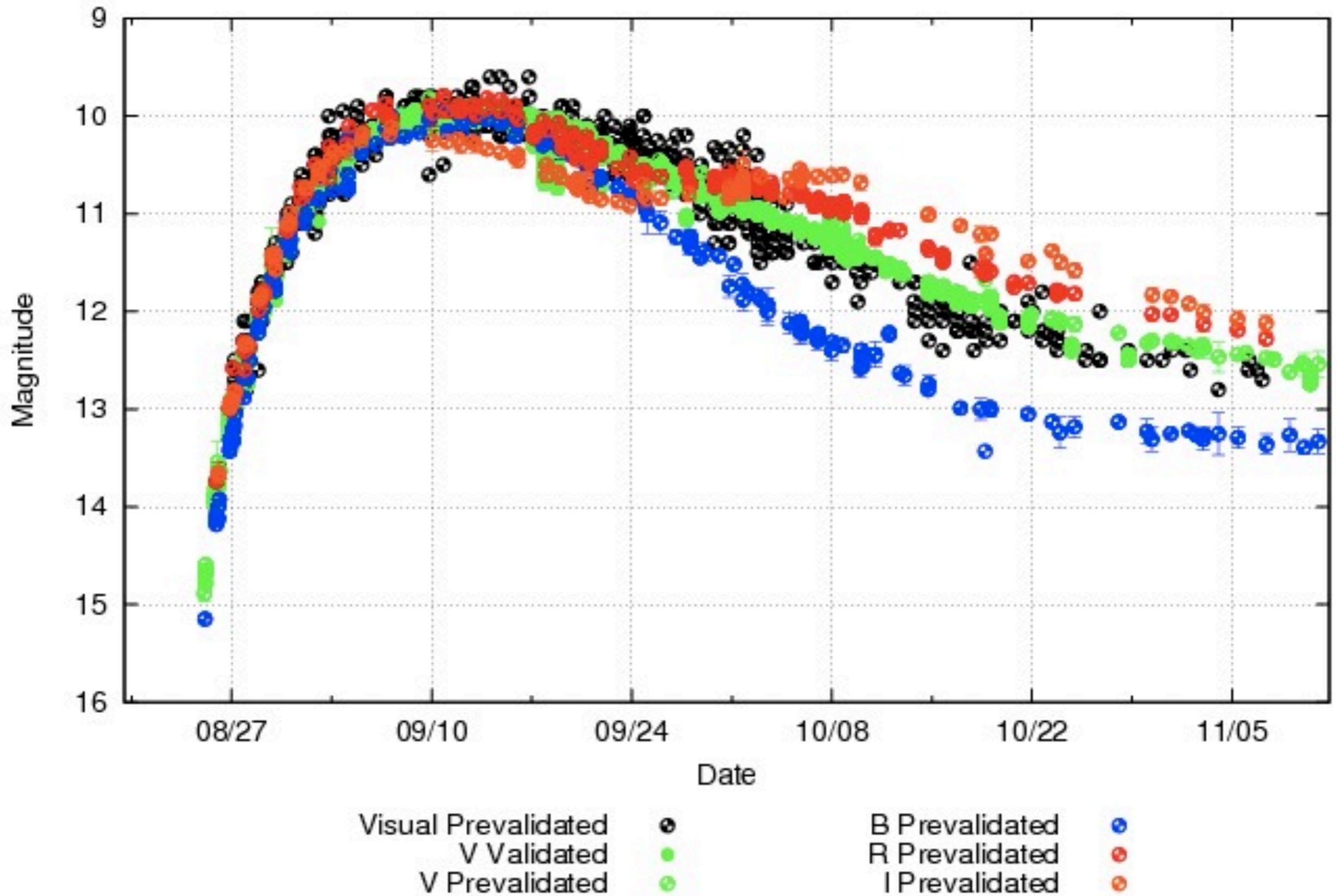
August 25.16



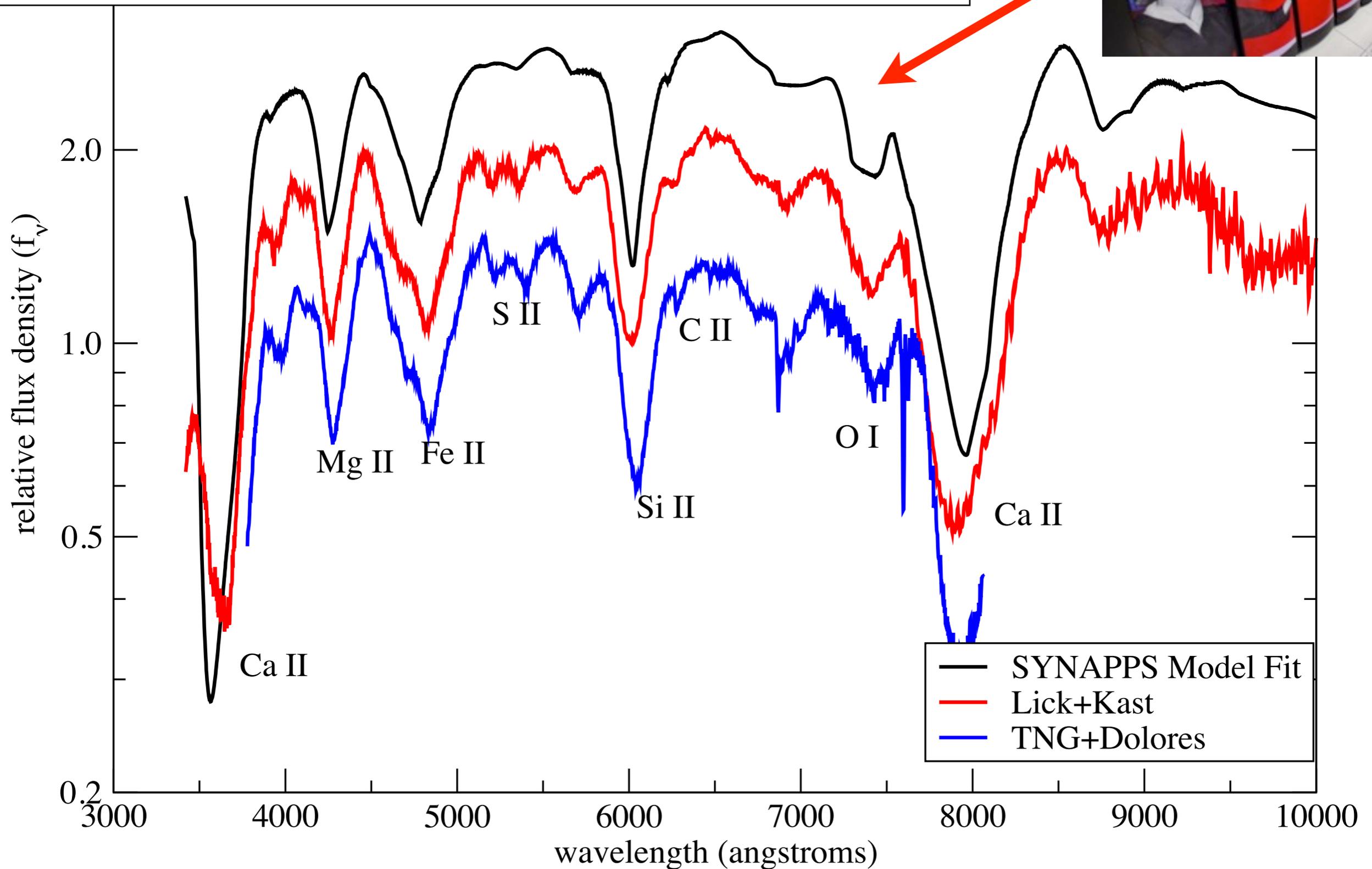
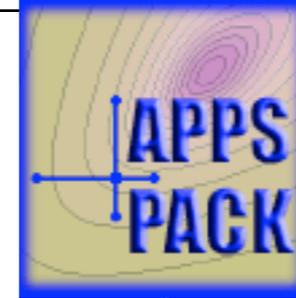


# Citizen Science

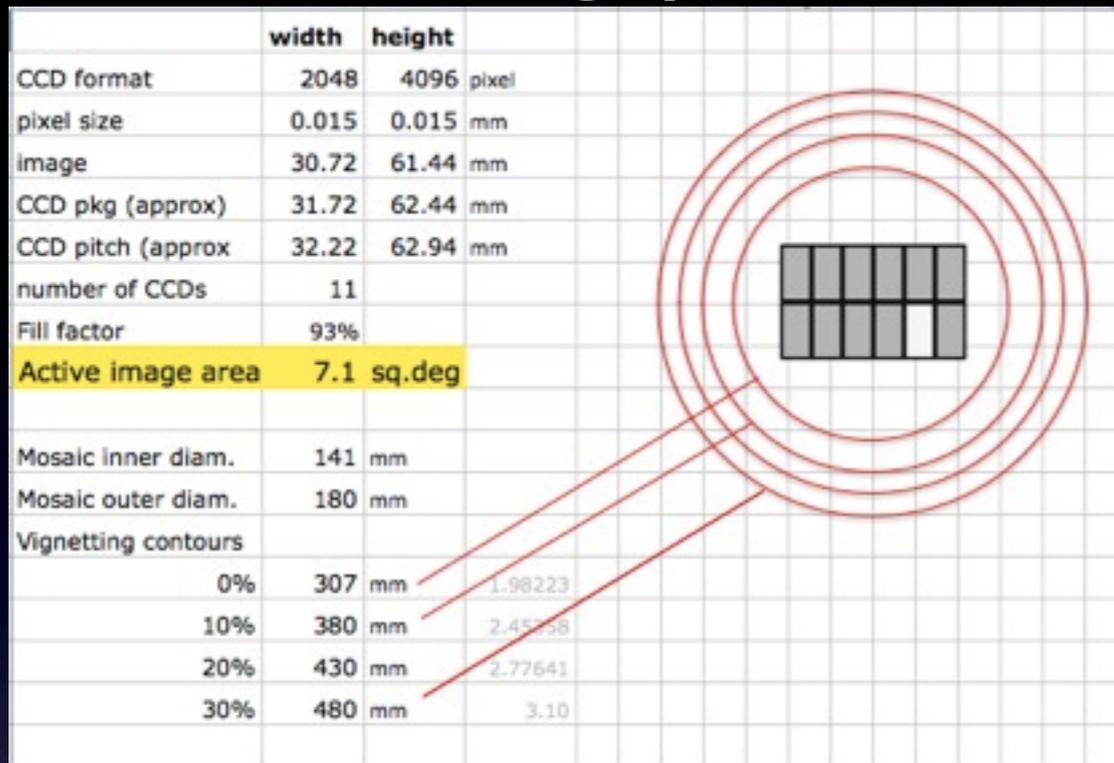
AAVSO DATA FOR SN 2011FE - WWW.AAVSO.ORG



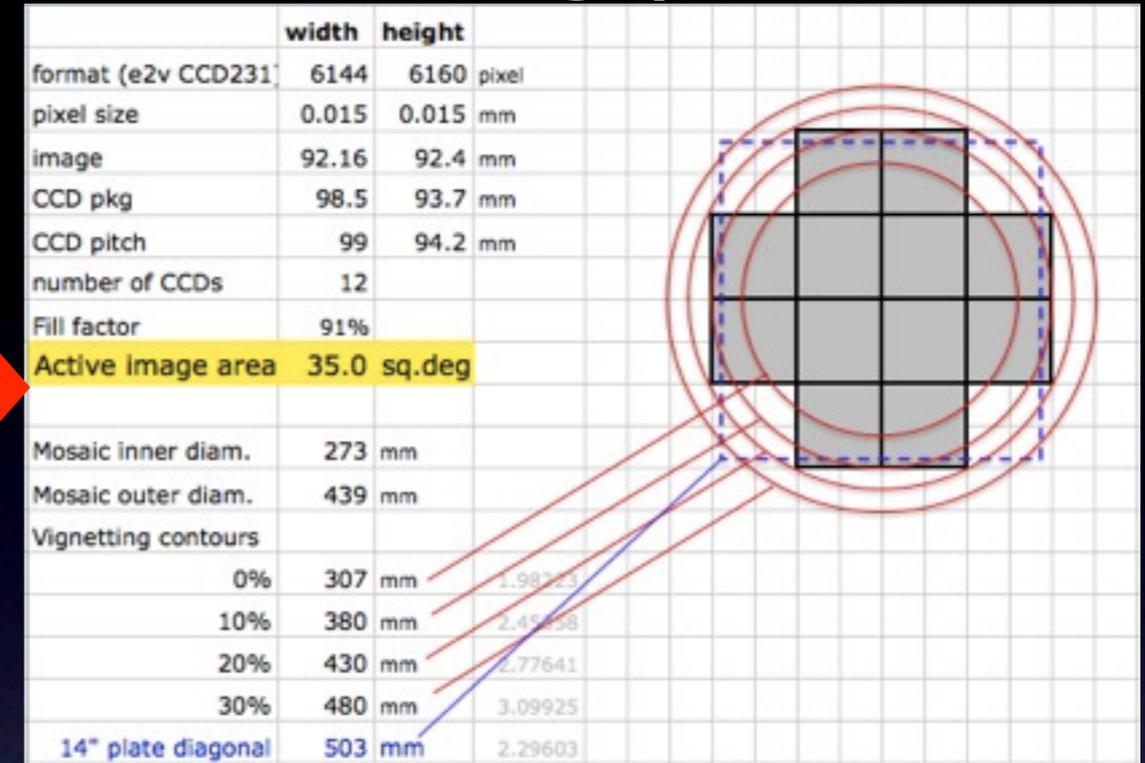
# Hybrid-parallel, forward modeling over SN atmosphere parameters to fit the spectrum. (APPSPACK)



# PTF 88 megapixels

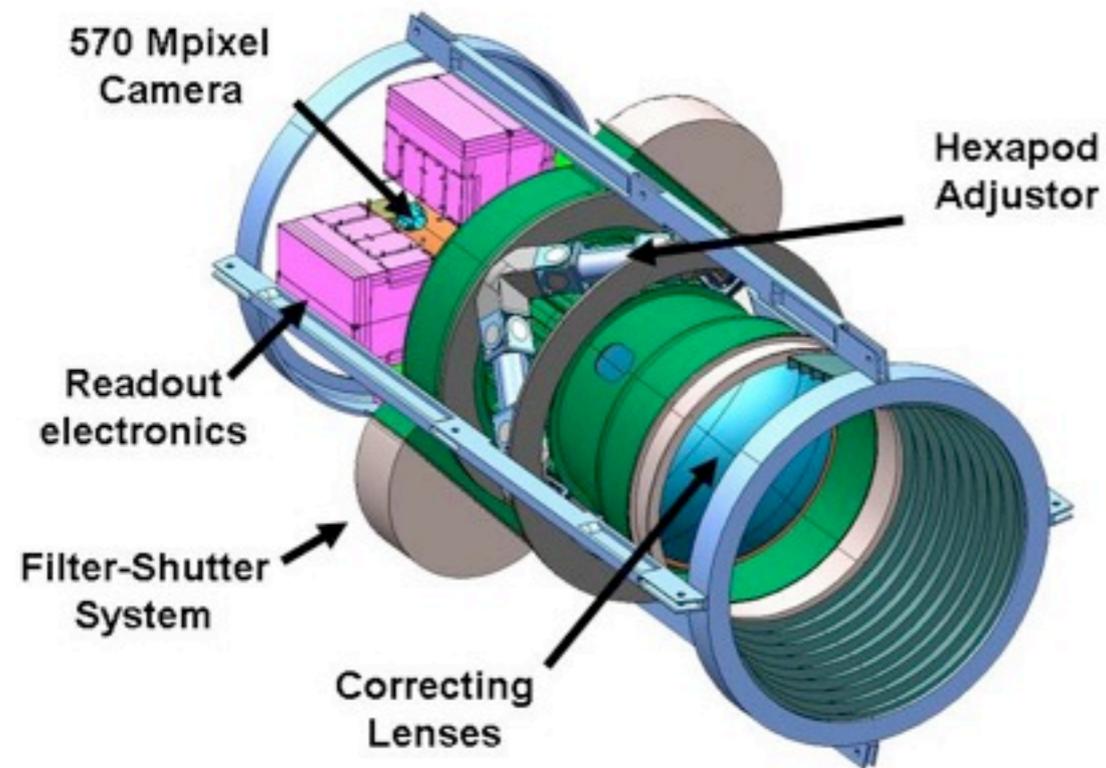


# ZTF 450 megapixels

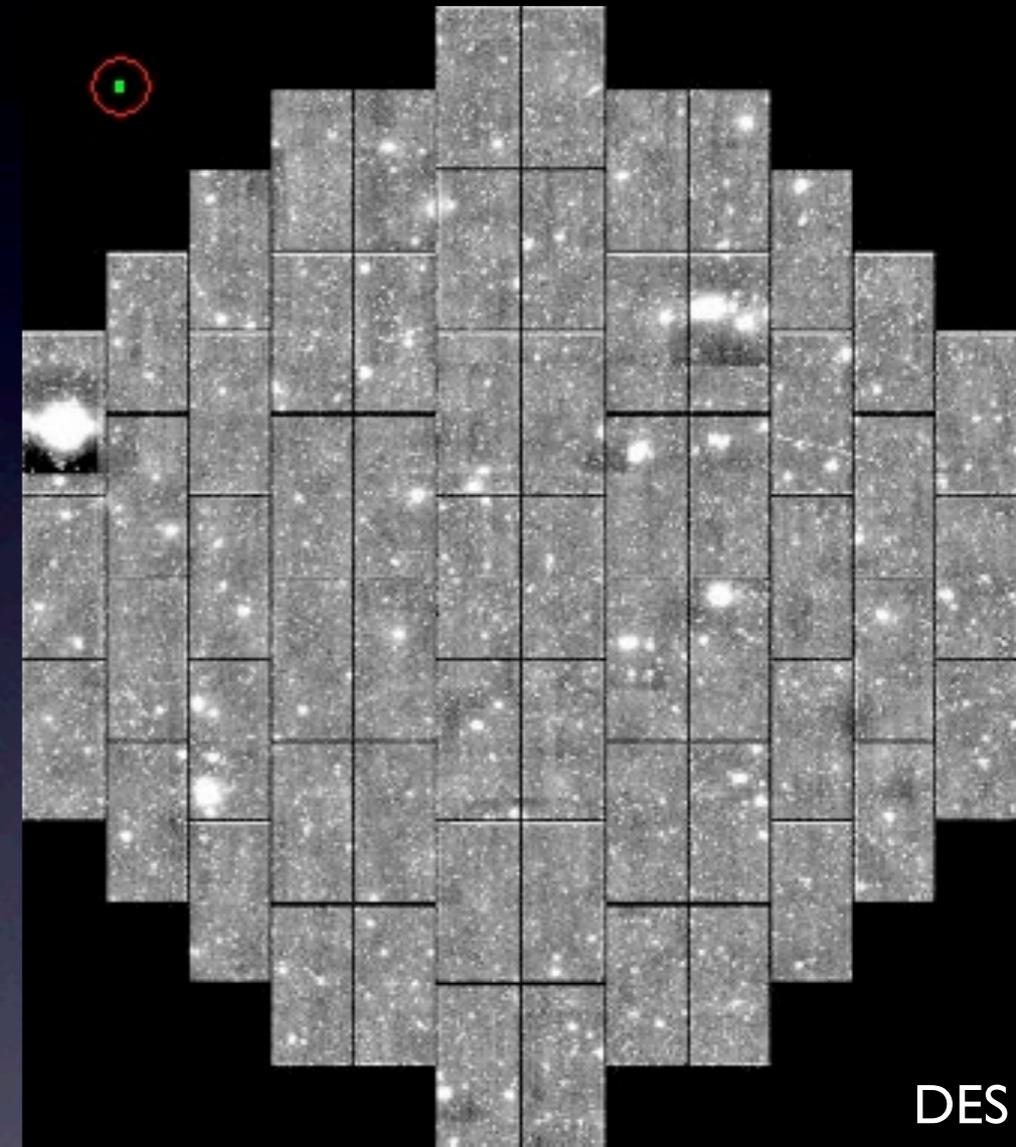


	PTF	ZTF	
QE		10% improvement?	Depends on passband
Fill factor	93%	91%	Some loss due to 4 side butting
<i>Active image area</i>	7.1	<b>35</b> (unweighted by vignetting)	Sq.deg
Duty cycle (60s exposure)	70%	<b>85%</b>	
Readout	25	<10	s
Repointing time	<25	10	s
Shutter time	<1	0.5	s
Beam obstruction	15%	18%	
Average data rate	7.9	46.7	GB/hr
<b>Relative survey rate</b>	<b>1</b>	<b>5.8</b>	

# Dark Energy Survey Camera



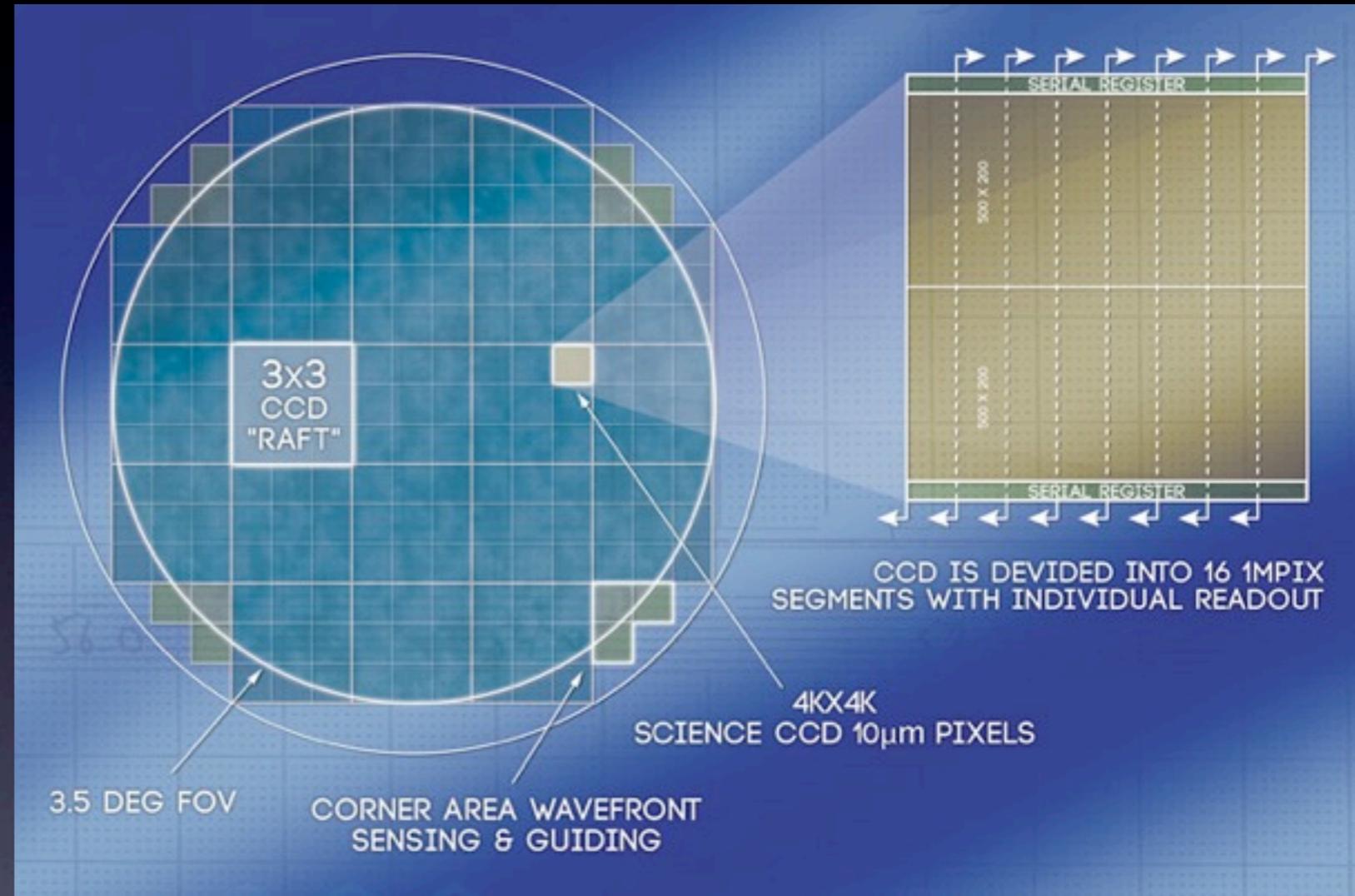
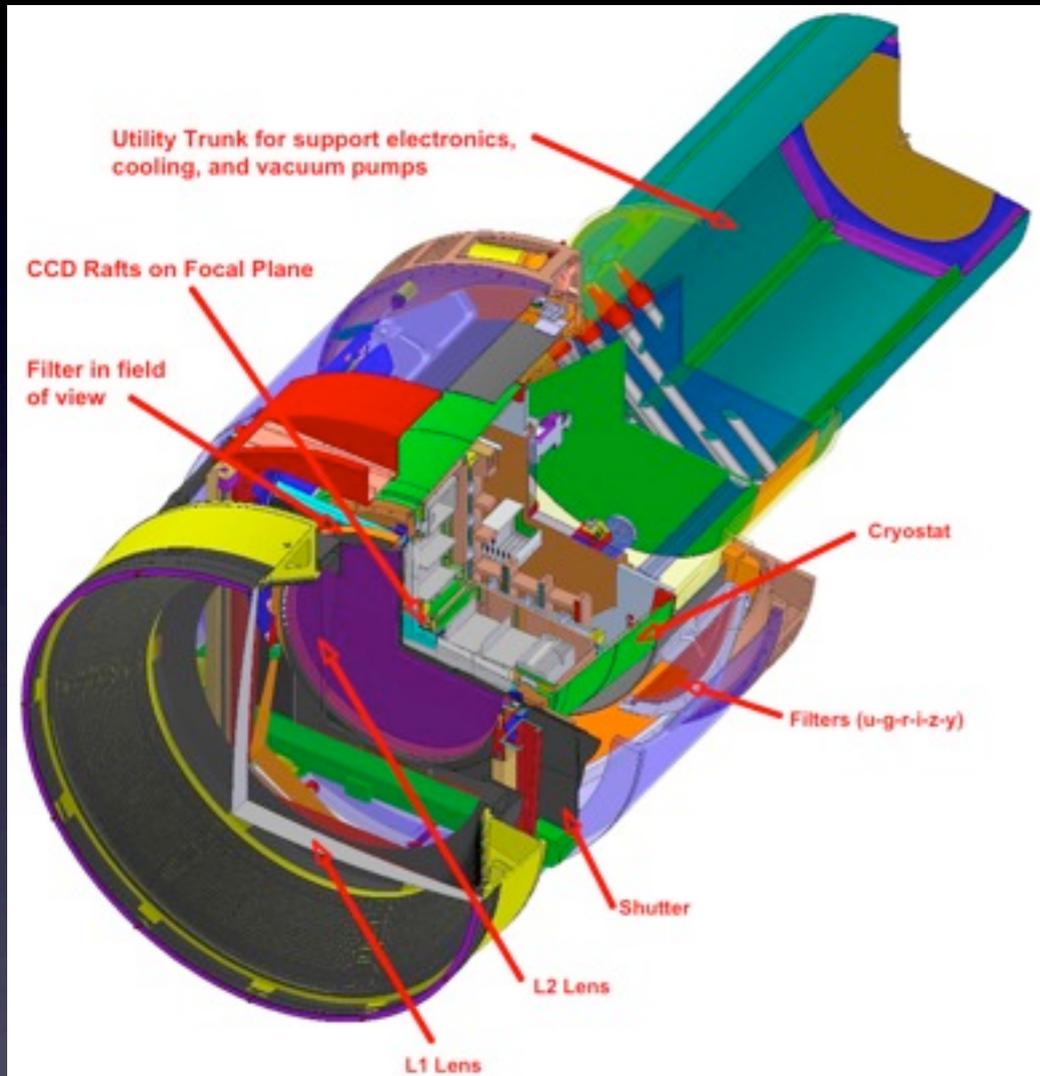
DES



DES

570 megapixels

# Large Synoptic Survey Telescope Camera



3.2 gigapixels

