Systematic Exploration of the Night Sky

Eric Bellm
The PTF survey family has three phases.

**PTF yesterday**
The Palomar Transient Factory (2009-2012)
*General synoptic transient survey*

**iPTF today**
Intermediate Palomar Transient Factory (2013-2016)
*Focused mini-surveys*

**ZTF tomorrow**
The Zwicky Transient Facility (2017-2020)
*High-cadence, wide-area survey*

CFHT 12k: 7.26 deg²
new 47 deg² camera

104+ papers, 3283+ citations
PTF11kly/SN2011fe (Ia)
Nugent+11, Li+11

PTF was an extremely successful transient survey.

all PTF data now public: [http://www.ptf.caltech.edu/page/DR2](http://www.ptf.caltech.edu/page/DR2)
iPTF has prioritized discovery & followup of fast transients.

iPTF13ast/SN2013cu (IIb)
Gal-Yam+ 2014

“flash” spectroscopy finds progenitor signatures in ionized wind

first optically discovered GRB
PTF’s photometric data are increasingly valuable for variable science.

B. Sesar

RR Lyr trace Galactic Structure

WD binaries

W. Kao+ in prep
ZTF’s new camera will fill the P48 focal plane.
ZTF’s new camera will fill the P48 focal plane.
Affordable wafer-scale CCDs make ZTF possible.

<table>
<thead>
<tr>
<th></th>
<th>e2v</th>
</tr>
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<tbody>
<tr>
<td>dimension</td>
<td>9.2 x 9.2 cm</td>
</tr>
<tr>
<td>pixels</td>
<td>6.1k x 6.1k</td>
</tr>
<tr>
<td>pixel size</td>
<td>15 micron</td>
</tr>
<tr>
<td>pixel scale</td>
<td>1”/pixel</td>
</tr>
<tr>
<td>outputs</td>
<td>4</td>
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</tbody>
</table>

all 16 CCDs delivered
Moore’s Law reduces overhead.

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PTF
2000-era Leach Gen-II controller
36 second readout of 96 Mpx

ZTF
modern STA Archon controller
10 second readout of 576 Mpx

*bench testing in progress*
Fabrication has begun on the ZTF cryostat.

Zwicky Transient Facility Camera

Conceptual design: LBNL
Detailed design: Caltech

First vacuum tests Fall 2015
ZTF will survey an order of magnitude faster than PTF.

<table>
<thead>
<tr>
<th></th>
<th>PTF</th>
<th>ZTF</th>
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</thead>
<tbody>
<tr>
<td>Active Area</td>
<td>7.26 deg$^2$</td>
<td>47 deg$^2$</td>
</tr>
<tr>
<td>Overhead Time</td>
<td>46 sec</td>
<td>&lt;15 sec</td>
</tr>
<tr>
<td>Optimal Exposure</td>
<td>60 sec</td>
<td>30 sec</td>
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<tr>
<td>Survey Rate</td>
<td>1x</td>
<td>15.0x</td>
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<tr>
<td>Relative Volumetric</td>
<td>1x</td>
<td>12.3x</td>
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3750 deg$^2$/hour $\Rightarrow$ $3\pi$ survey in 8 hours

$>250$ observations/field/year for uniform survey

Existing PTF camera: MOSAIC 12k

New ZTF camera:
16 6k x 6k e2v CCDs
ZTF’s science potential is significant.

- discover a young SN every night
- discover tens of relativistic explosions each year
- search for EM/GW counterparts
- obtain hundreds of epochs in each field every year
- perform a sensitive search for NEAs

![Image of map and NEA discovery](image_url)
Modern surveys can cover the entire sky in one night.
Finite sky area influences the volume-cadence trade.
ZTF will survey spectroscopically accessible volume fastest.
ZTF will find rare events even at high cadence.
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Bellm in prep
ZTF will find rare events even at high cadence.
ZTF is coming in 2017!

wide area, high cadence survey will enable new science
observing strategies of upcoming surveys are limited by available sky