

# Overview of IRAC Gain Mapping Techniques

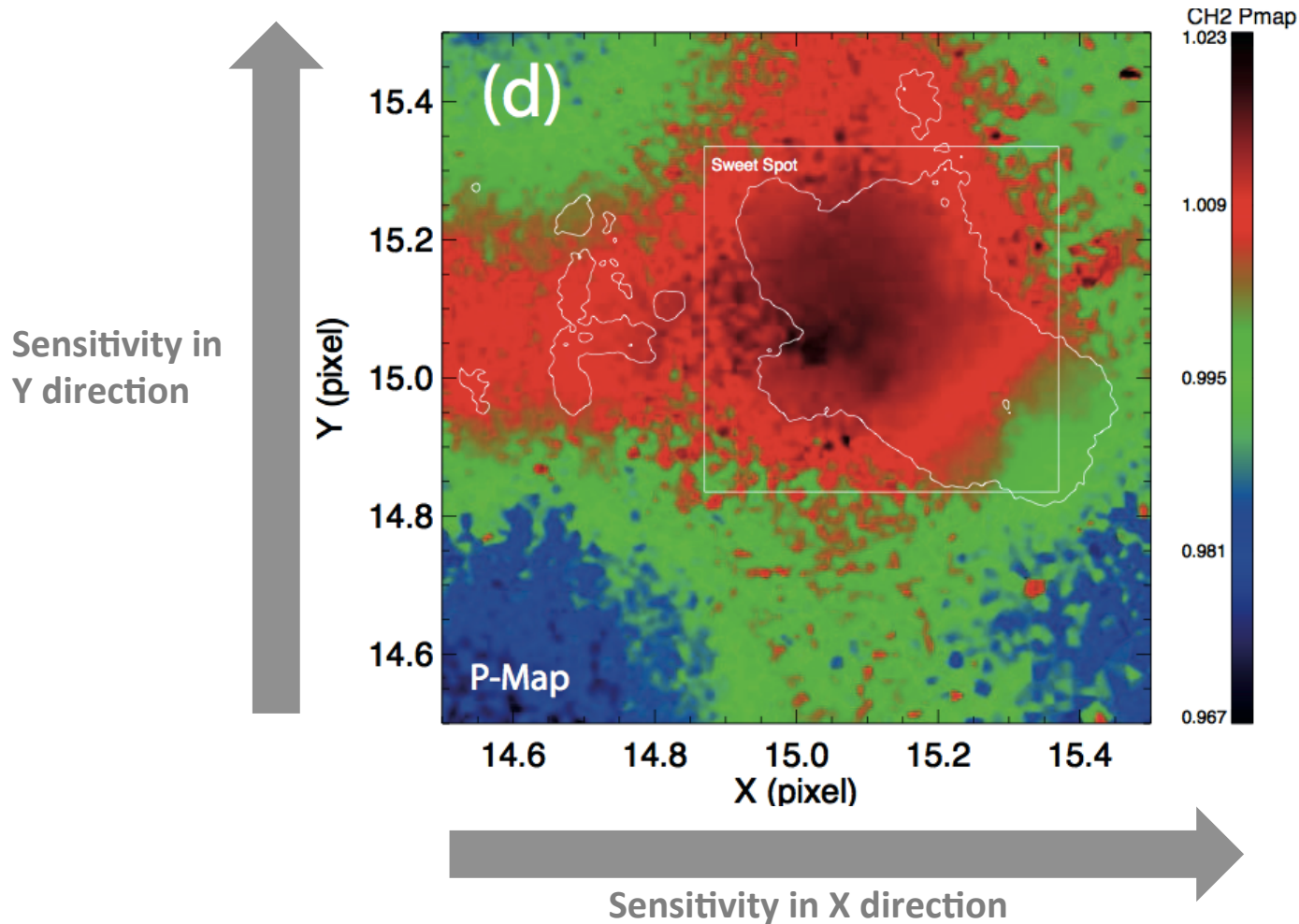
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Carl Sagan Fellow, University of Washington

1 June 2014  
AAS 224 Spitzer Splinter Session

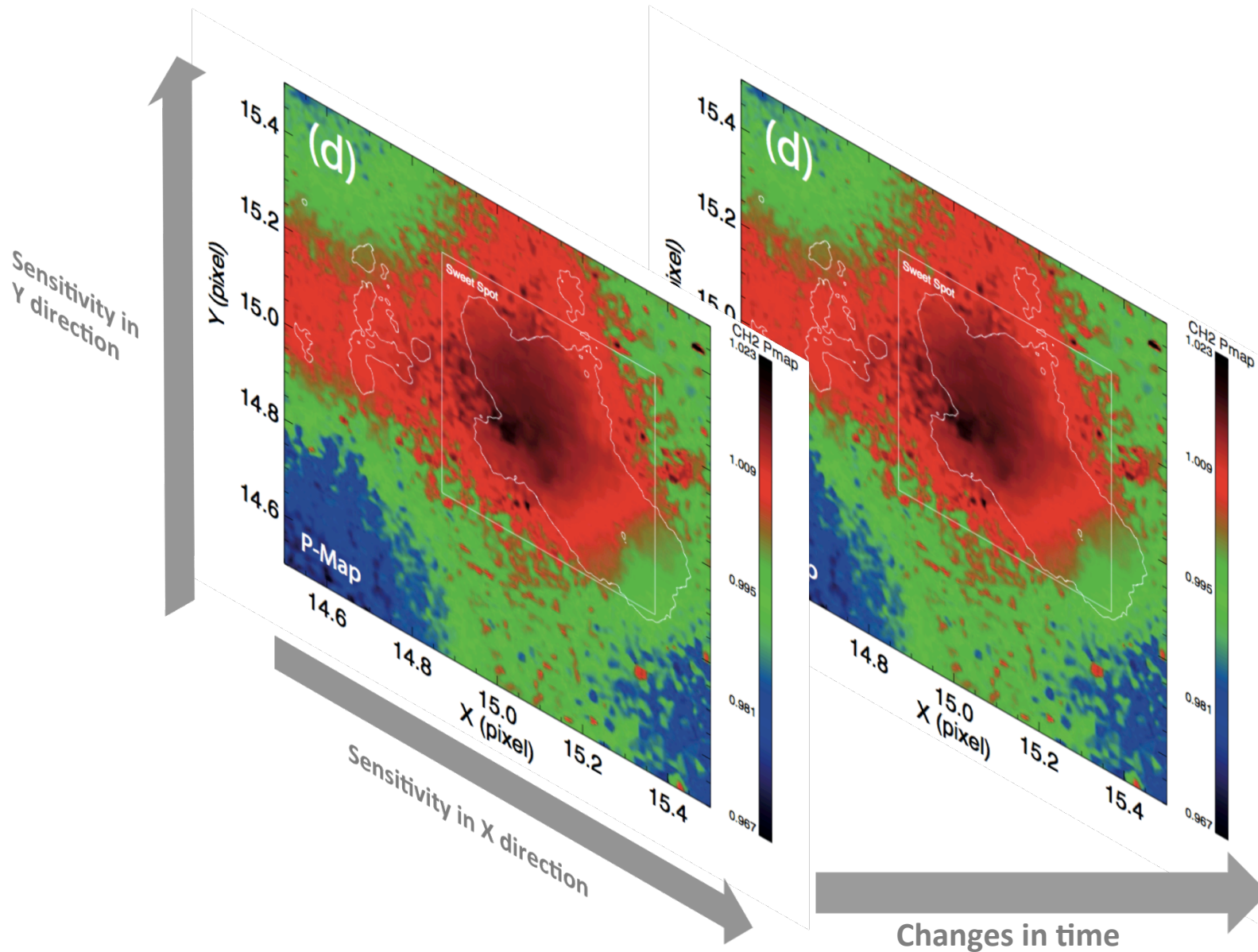
# Which parameters are considered?

Focus upon the 3.6 and 4.5  $\mu\text{m}$  bandpasses

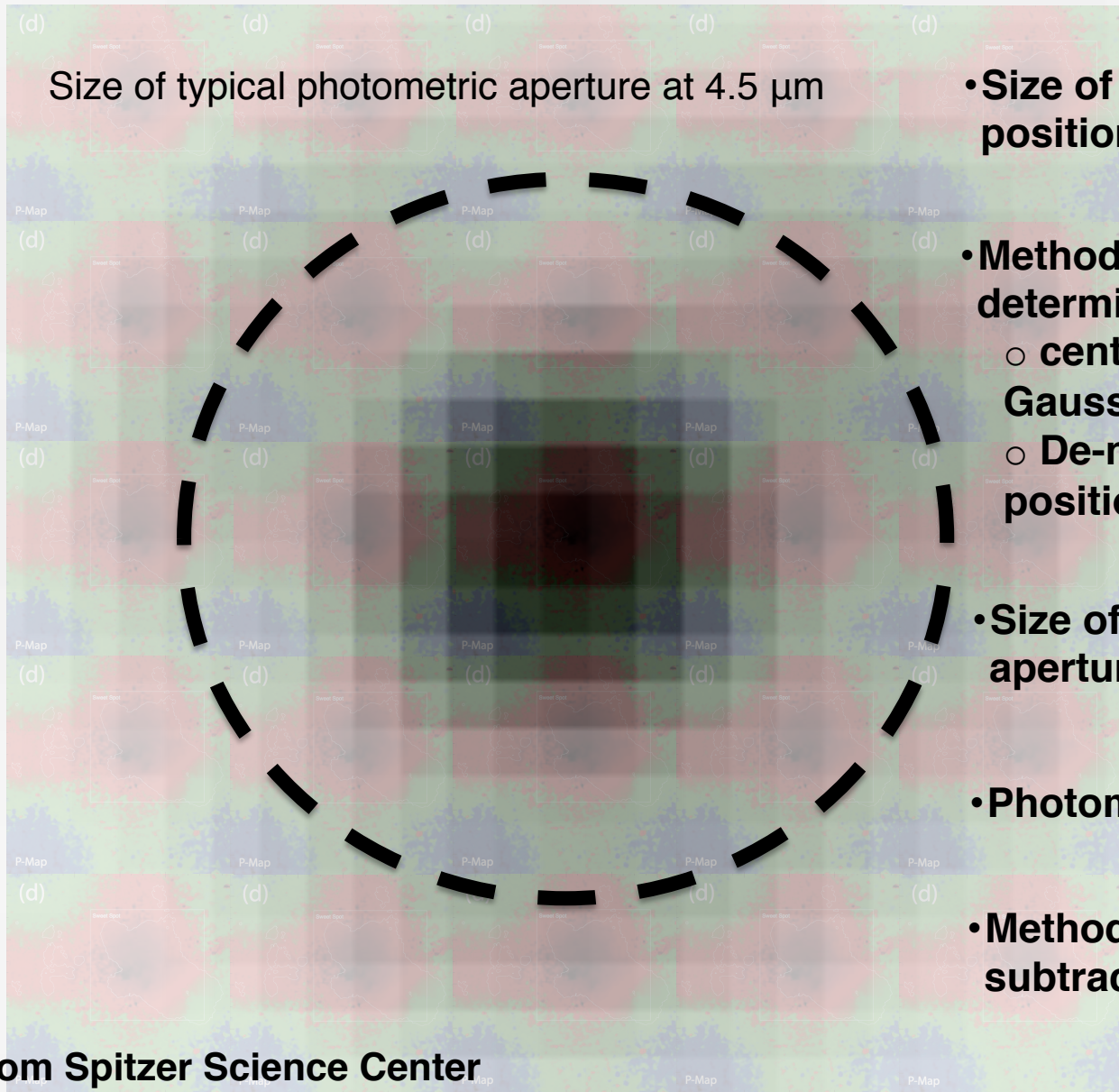
Gain map of 1 pixel at at 4.5  $\mu\text{m}$  from Ingalls et al. (2012)



# Which parameters are considered?



# Which parameters are considered?



- **Size of aperture for position determination**

- **Method of position determination**

- centroid versus Gaussian fitting

- De-noising of positions

- **Size of photometric aperture**

- **Photometric routine**

- **Method of background subtraction**

# A Timeline from 2007 → Present

*Fit Method*

*Example result*

Polynomial  
+ ramp at longer  
wavelengths

Charbonneau+ (2005)  
Knutson+ (2008)

Polynomial+  
sinusoidal terms  
in time

Demory+ (2011)

No *a priori*  
functional form,  
weighted map

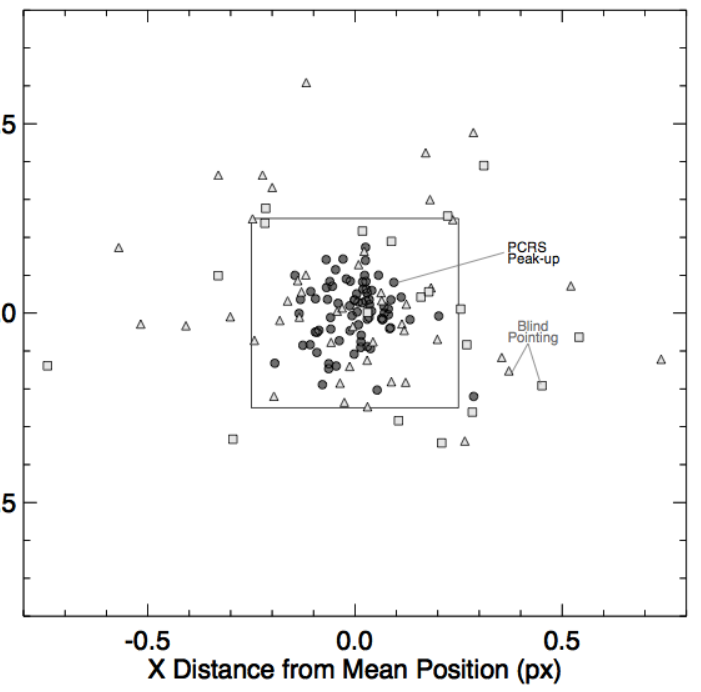
Ballard+ (2011)  
Stevenson+ (2012)  
Lewis+ (2013)

Independent  
pixel gain map

Ingalls et al. (2012)

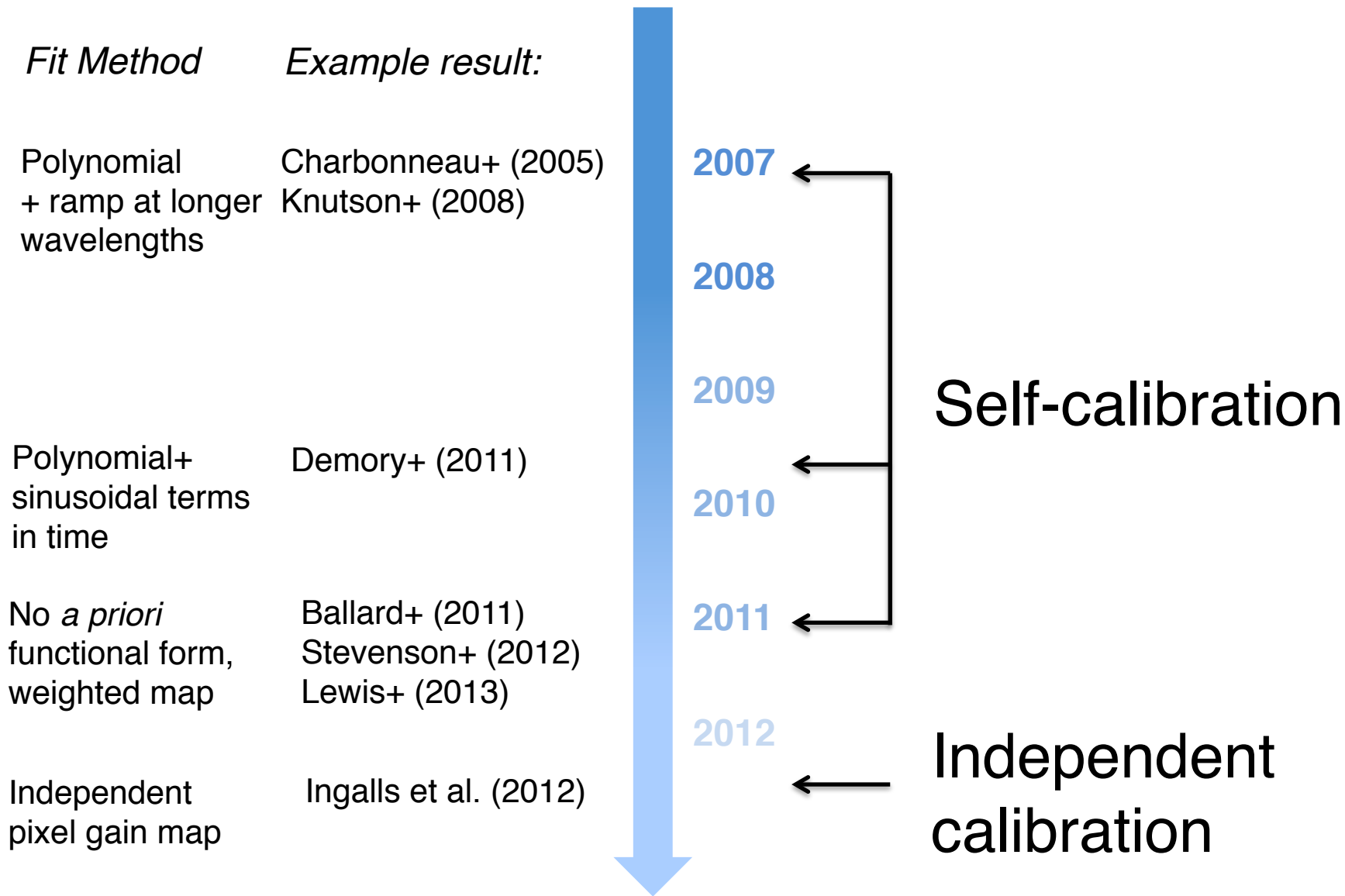


200  
200  
200  
201  
2011  
2012

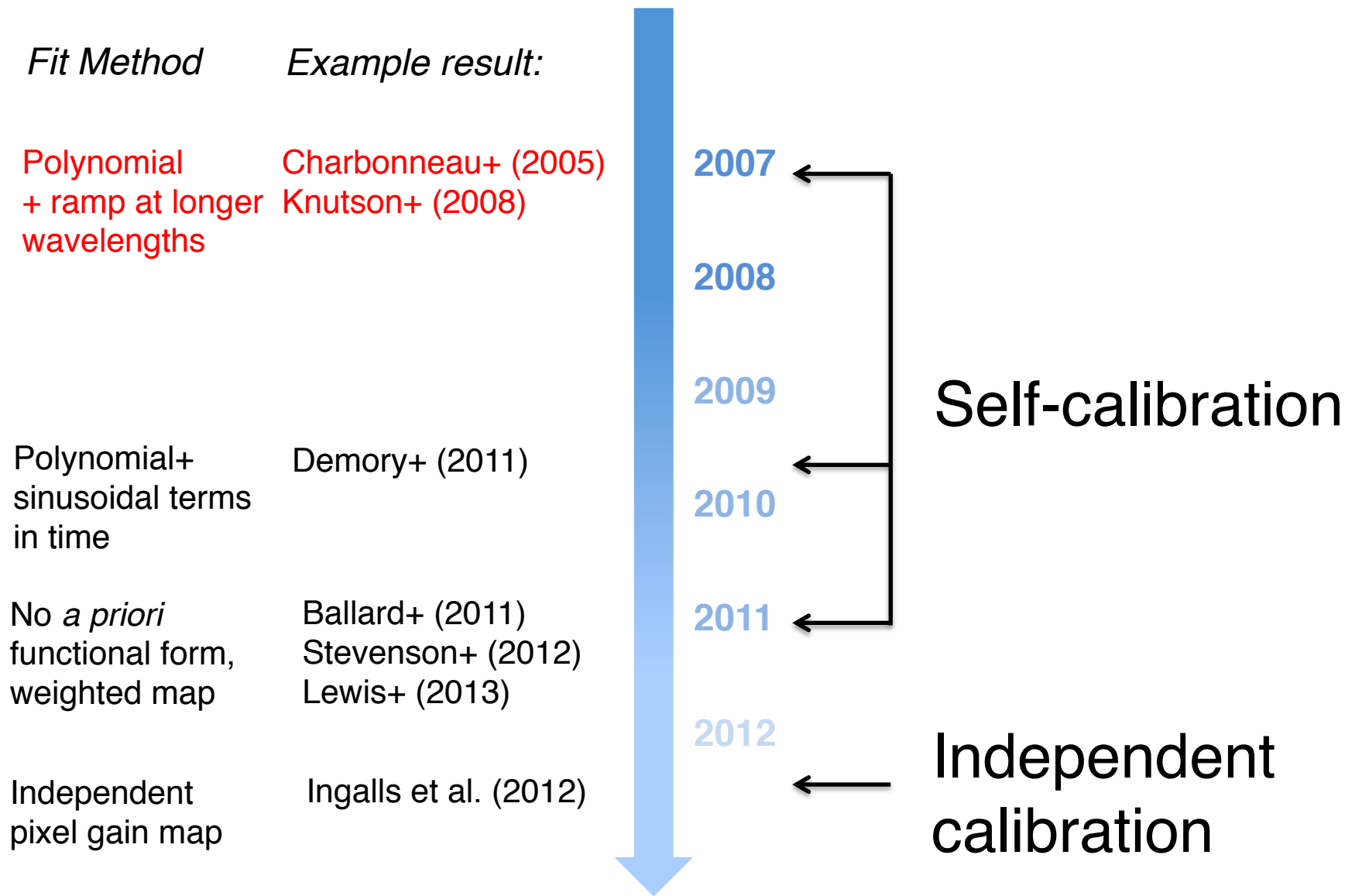


Testing of PCRS peak-up/gain mapping begins, from observations of BD+67 1044

# A Timeline from 2007 → Present



# A Timeline from 2007 → Present



# Polynomial

## DETECTION OF THERMAL EMISSION FROM AN EXTRASOLAR PLANET

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FRANCIS T. O'DONOVAN,<sup>6</sup> AND ALESSANDRO SOZZETTI<sup>1,7</sup>

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## THE 3.6–8.0 $\mu\text{m}$ BROADBAND EMISSION SPECTRUM OF HD 209458b: EVIDENCE FOR AN ATMOSPHERIC TEMPERATURE INVERSION

HEATHER A. KNUTSON, DAVID CHARBONNEAU,<sup>1</sup> AND LORI E. ALLEN

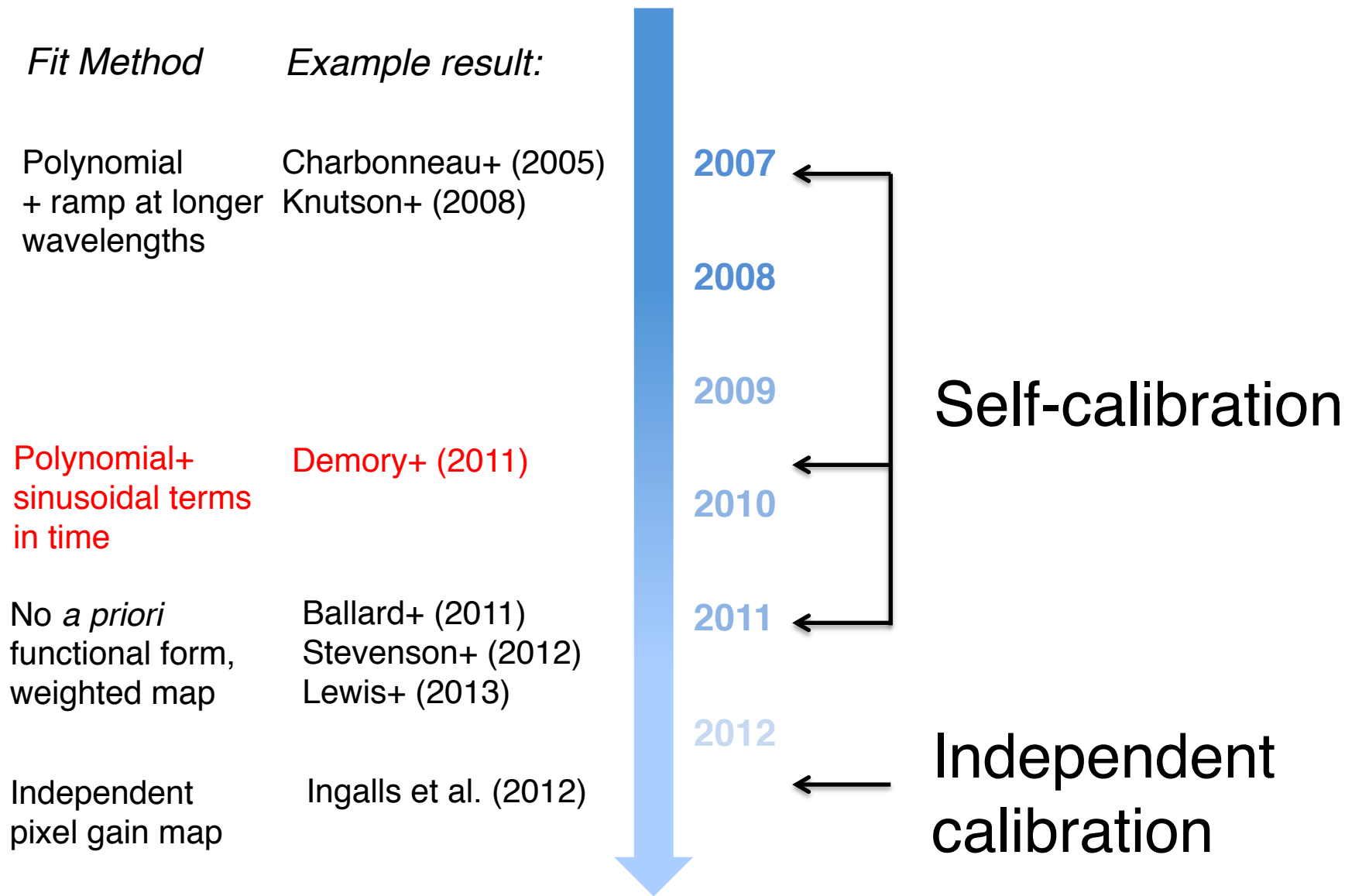
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dcharbonneau@cfa.harvard.edu, leallen@cfa.harvard.edu

$$f^1 = f[ c_1 + c_2(x - 14.5) + c_3(x - 14.5)^2 \\ + c_4(y - 14.5) + c_5(y - 14.5)^2 ],$$

**Equation 1 from Knutson+ (2008)**



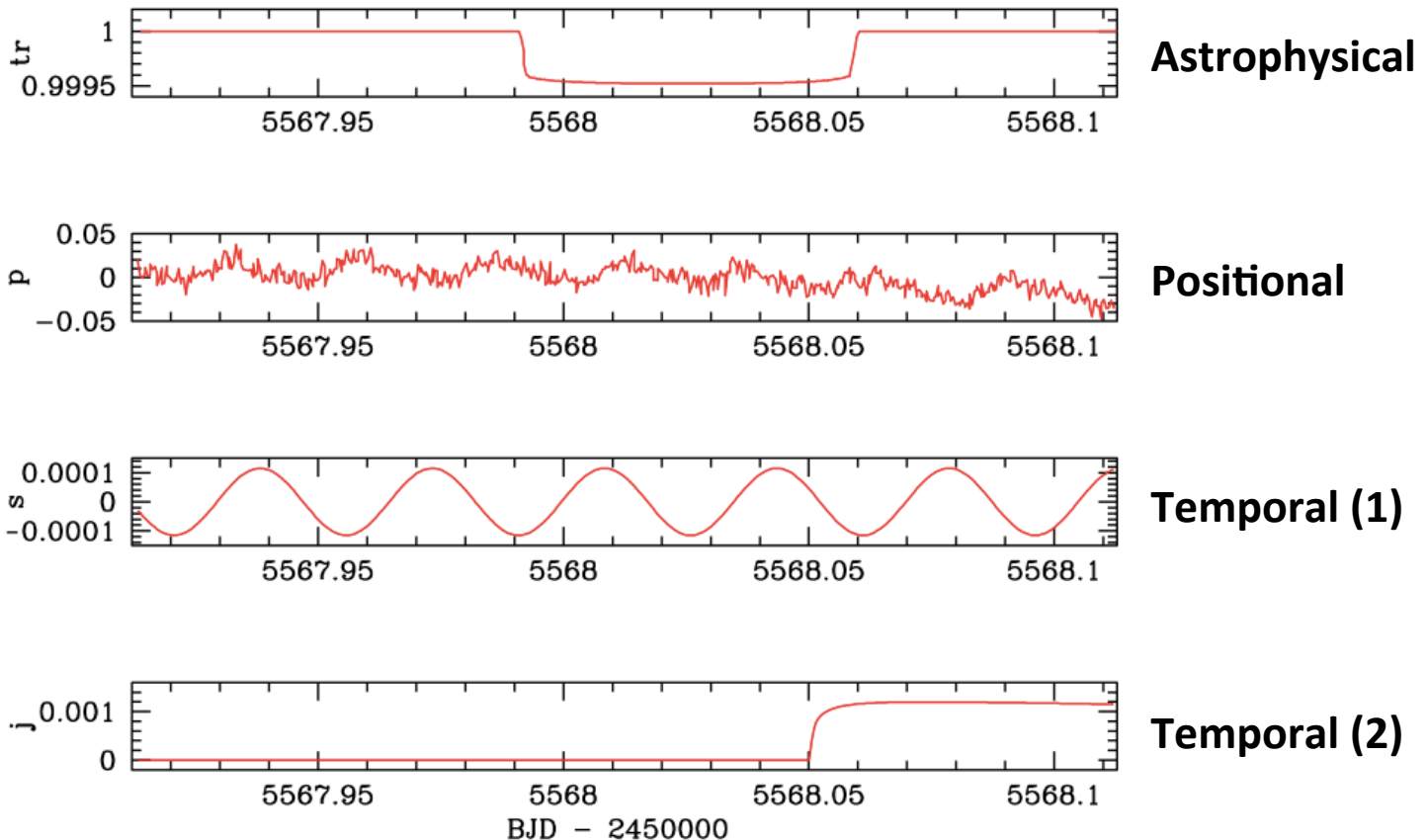
# A Timeline from 2007 → Present



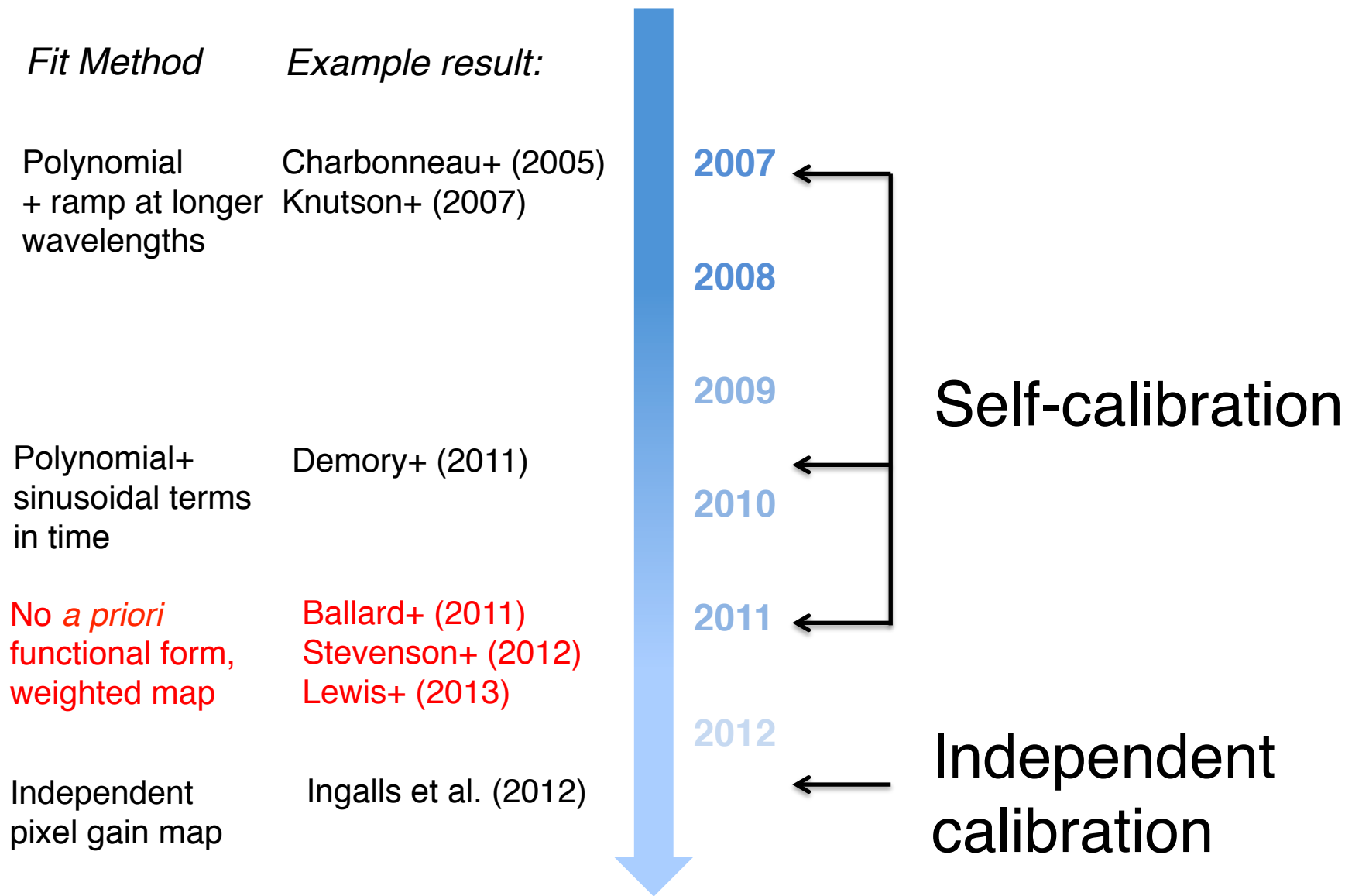
# Polynomial + Sinusoidal Terms in Time

## Detection of a transit of the super-Earth 55 Cancri e with warm *Spitzer*<sup>★</sup>

B.-O. Demory<sup>1</sup>, M. Gillon<sup>2</sup>, D. Deming<sup>3</sup>, D. Valencia<sup>1</sup>, S. Seager<sup>1</sup>, B. Benneke<sup>1</sup>, C. Lovis<sup>4</sup>, P. Cubillos<sup>5</sup>,  
J. Harrington<sup>5</sup>, K. B. Stevenson<sup>5</sup>, M. Mayor<sup>4</sup>, F. Pepe<sup>4</sup>, D. Queloz<sup>4</sup>, D. Ségransan<sup>4</sup>, and S. Udry<sup>4</sup>



# A Timeline from 2007 → Present



# Weighted Maps

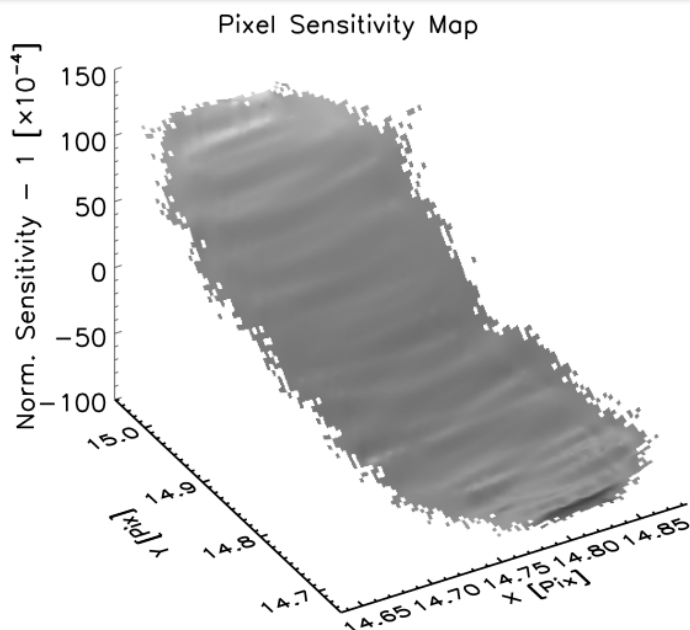
## A Search for a Sub-Earth-Sized Companion to GJ 436 and a Novel Method to Calibrate Warm *Spitzer* IRAC Observations

SARAH BALLARD,<sup>1</sup> DAVID CHARBONNEAU,<sup>1</sup> DRAKE DEMING,<sup>2</sup> HEATHER A. KNUTSON,<sup>3,4</sup> JESSIE L. CHRISTIANSEN,<sup>5</sup>  
MATTHEW J. HOLMAN,<sup>1</sup> DANIEL FABRYCKY,<sup>1,6</sup> SARA SEAGER,<sup>7</sup> AND MICHAEL F. A'HEARN<sup>8</sup>

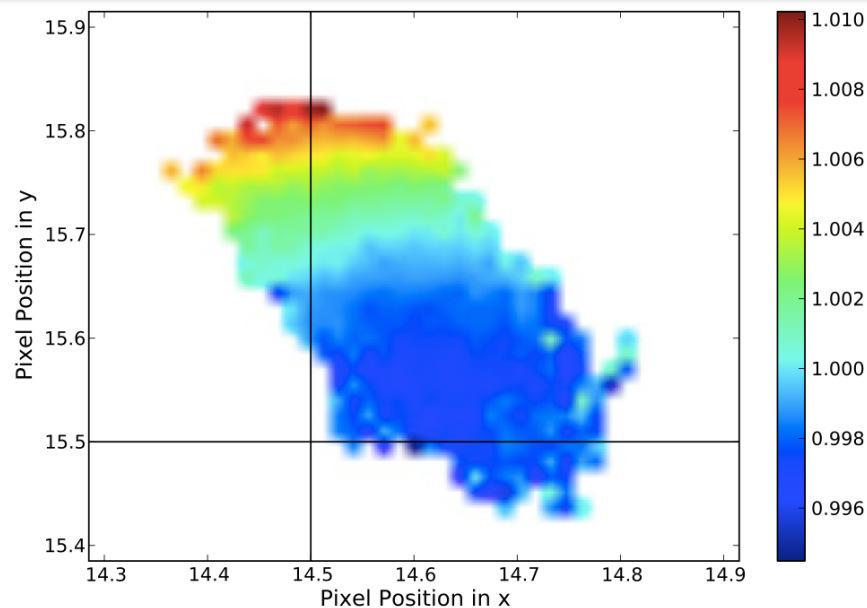
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## TRANSIT AND ECLIPSE ANALYSES OF THE EXOPLANET HD 149026b USING BLISS MAPPING

KEVIN B. STEVENSON<sup>1</sup>, JOSEPH HARRINGTON<sup>1</sup>, JONATHAN J. FORTNEY<sup>2</sup>, THOMAS J. LOREDO<sup>3</sup>, RYAN A. HARDY<sup>1</sup>,  
SARAH NYMEYER<sup>1</sup>, WILLIAM C. BOWMAN<sup>1</sup>, PATRICIO CUBILLOS<sup>1</sup>, M. OLIVER BOWMAN<sup>1</sup>, AND MATTHEW HARDIN<sup>1</sup>

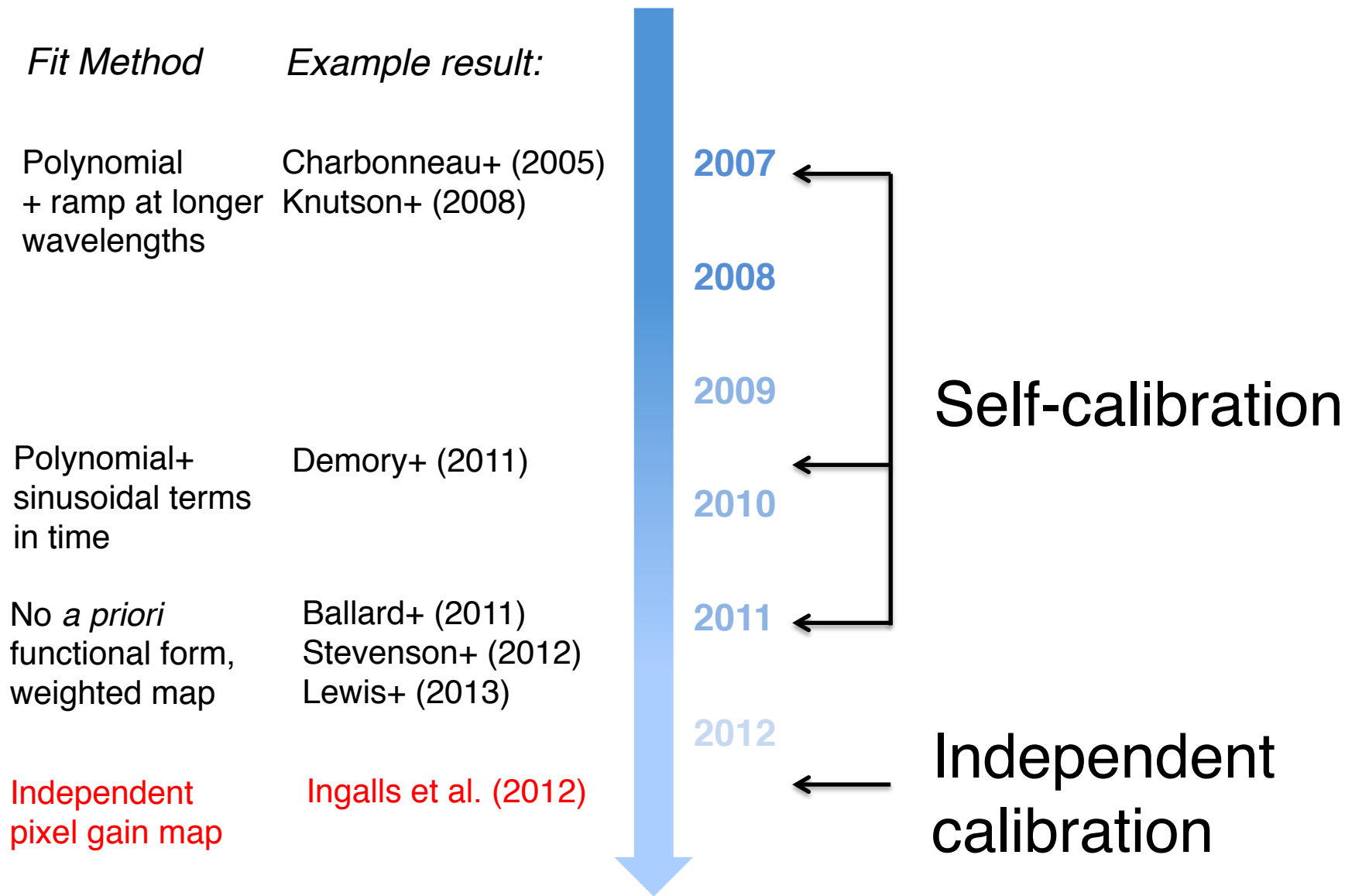


From Ballard+ (2011), each point corrected individually from weighted flux of nearest neighbors (improvements from Lewis+ 2013)



From Stevenson+ (2012), with optimized resolution  
Individuals points corrected by interpolating onto map

# A Timeline from 2007 → Present



# Independent Pixel Gain Map

## Intra-Pixel Gain Variations and High-Precision Photometry with the Infrared Array Camera (IRAC)

James G. Ingalls, Jessica E. Krick, Sean J. Carey, Seppo Laine, Jason A. Surace, William J. Glaccum, Carl C. Grillmair, and Patrick J. Lowrance

