



# ISS nocturnal images as a scientific tool against Light Pollution: Flux calibration and colors



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SpS 17

XXVIII IAU –GA

Beijing, 29/08/2012



# Outline

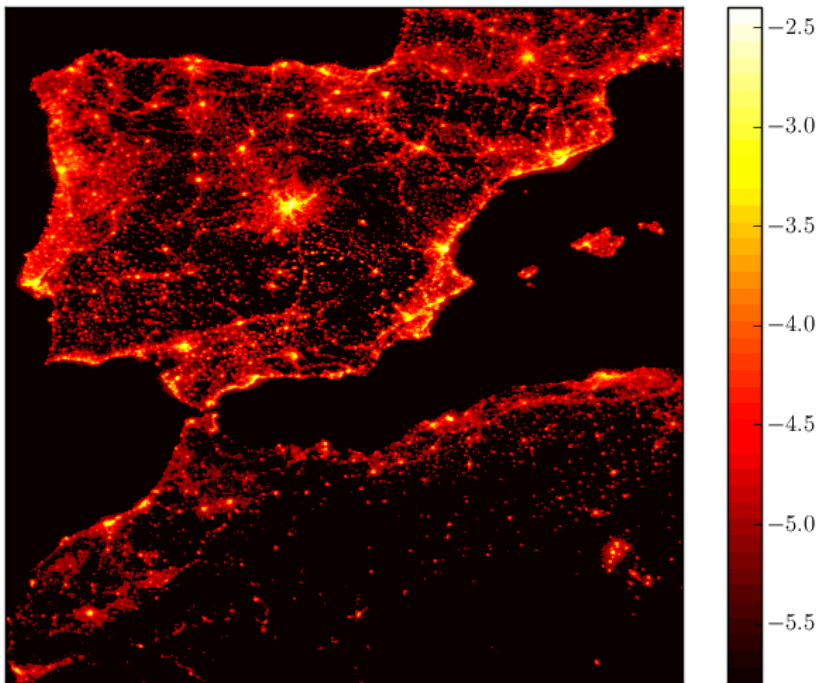


- Light Pollution studies with images of the Earth at night
- Digital pictures from ISS versus DMSP-OLS satellite data
- Absolute photometric calibration of nocturnal ISS pictures
  - Using sources at Earth
  - With standard stars (the astronomers way)
- Information extracted from colors of ISS pictures

# The Earth at night

Images of the Earth at night inform us of the light emitted to the atmosphere that is a key parameter for Light Pollution studies

Iberian Peninsula DMSP-OLS 2006



DMSP-OLS radiance calibrated image

Data from NOAA Earth Observation Group (EOG)  
National Geophysical Data Center (NGDC)

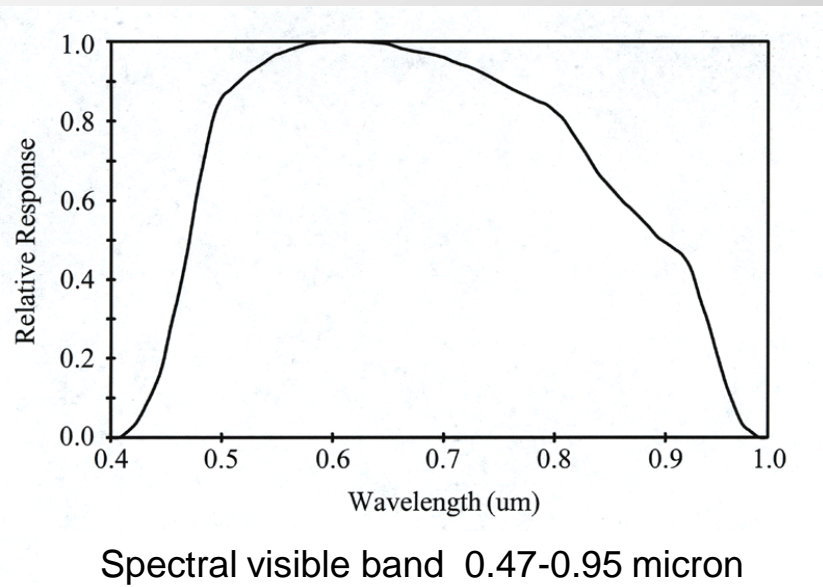
ISS030-E-192145



ISS original images provided by the  
Image Science and Analysis Laboratory  
NASA-Johnson Space Center  
“The Gateway to Astronaut Photography of Earth”

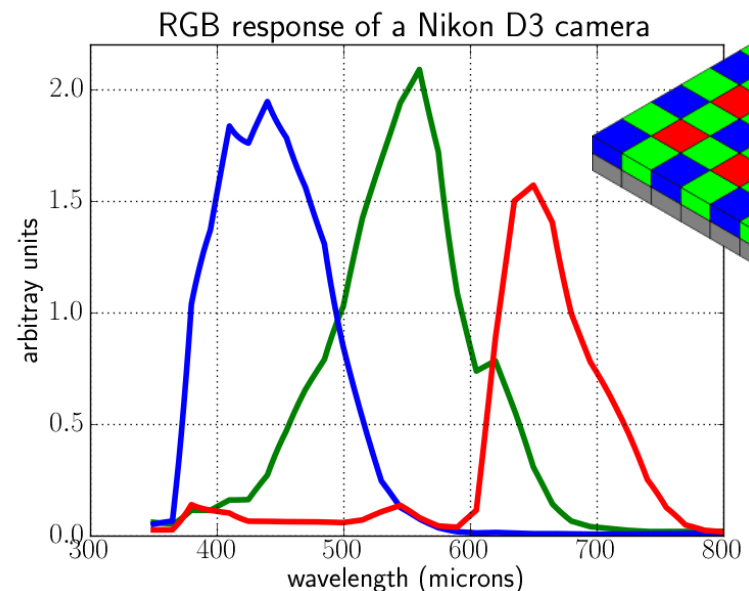
## DMSP-OLS

- Full spatial coverage of Earth
- Photo Multiplier Tube (PMT) at night
- Spatial Scale 0.55 – 2.7 km/pixel
- Calibrated in radiance
- Sensitivity  $1\text{E}-5$  –  $1\text{E}-9$  ( $\text{W}/\text{cm}^2/\text{sr}/\text{micron}$ )
- No color capability (visible band)



## ISS pictures

- Digital Single Lens Camera (DSLR) CMOS detector
- Nikon D3s operated by astronauts onboard ISS
- Scale range from 10 m to 1 km per pixel
- Bayer matrix of pixels. RGB bands
- Selectable Target, FOV, spatial resolution, sensitivity (via photographer + camera + lenses + settings)



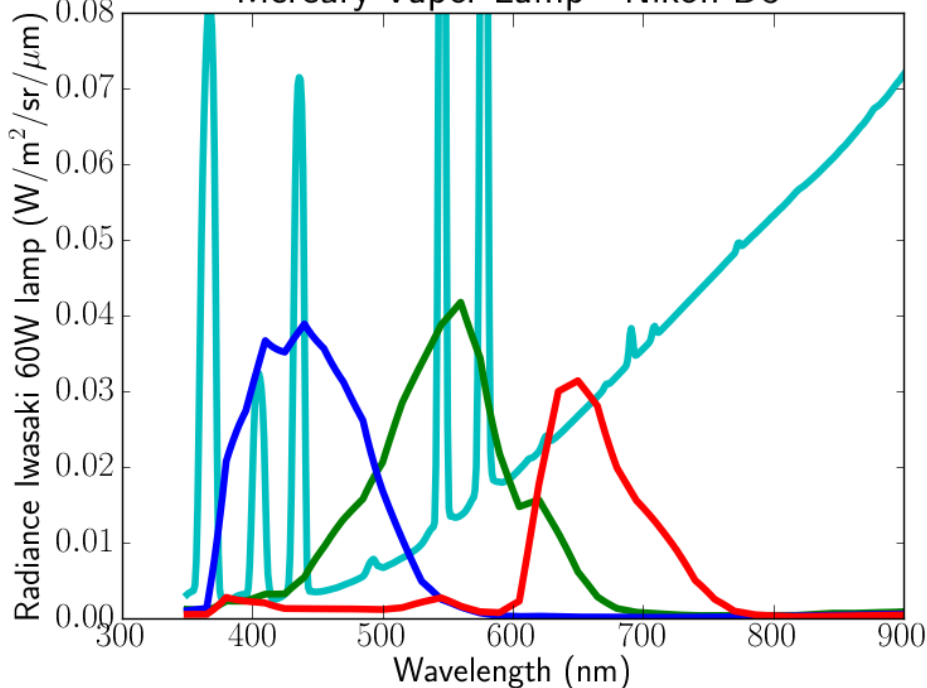


# Why color is so important ?

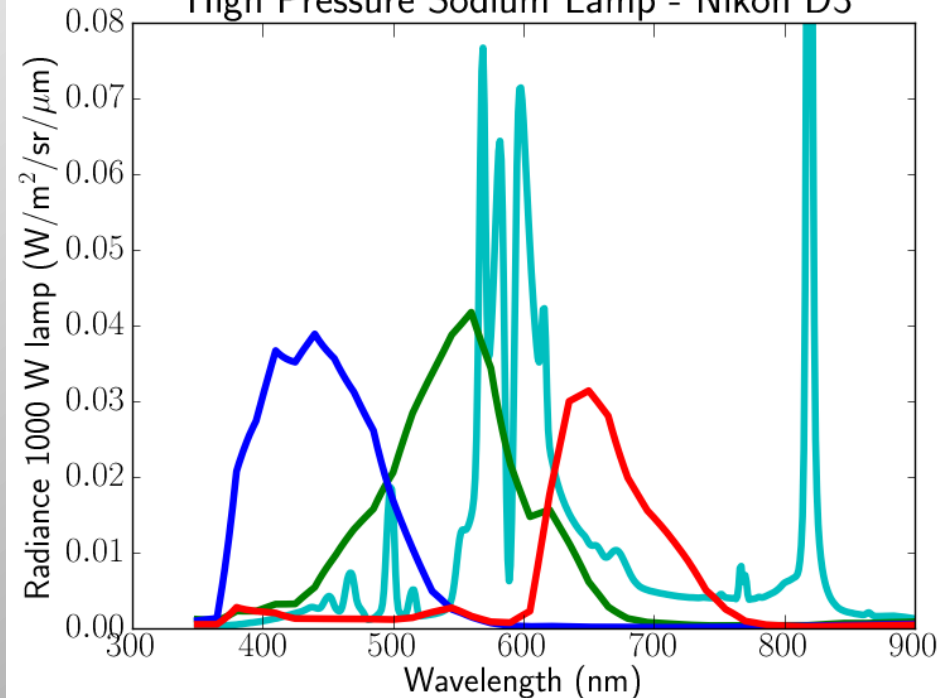


- Scattering of light in the atmosphere depends on wavelength
- Lamp type is defined by its spectrum
- Color inform about lighting type

Mercury Vapor Lamp - Nikon D3



High Pressure Sodium Lamp - Nikon D3



Elvidge & Keith (2009) *Spectral signatures of Nighttime Lights*

Elvidge, Keith, Tuttle & Baugh (2010) *Spectral Identification of Lighting Type and Character* (Sensors 2010, 10(4), 3961)

Lamp spectral radiance from <http://www.ngdc.noaa.gov/dmsp/spectra.html>

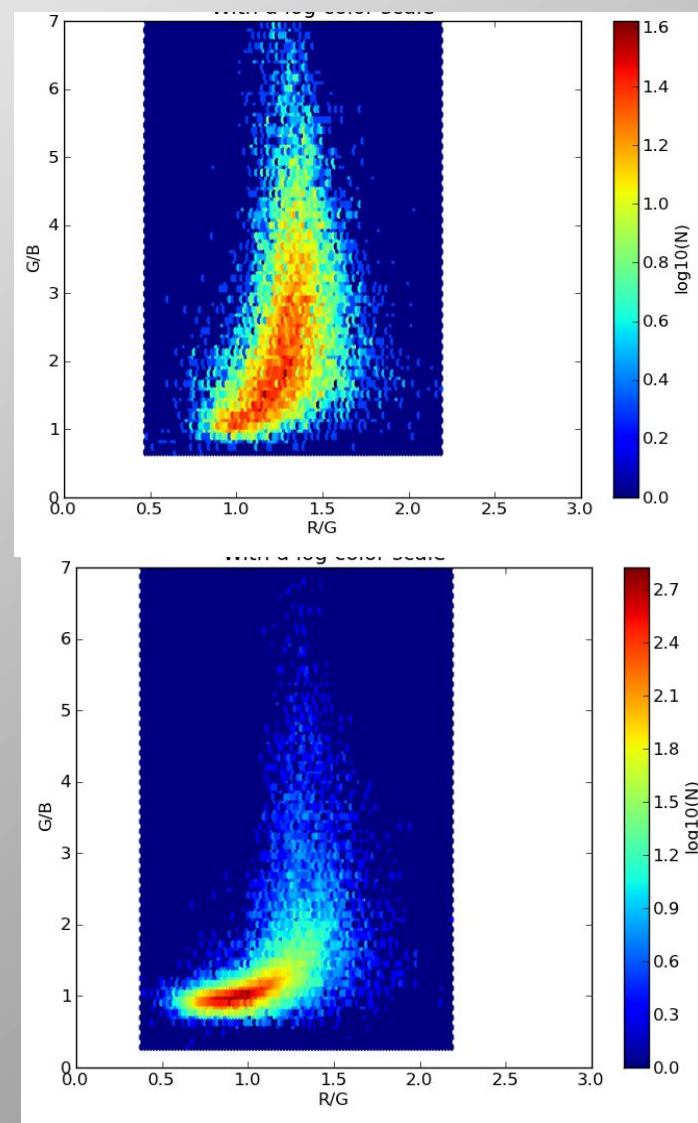




# RAW vs JPEG pictures



Color is related with lighting type but JPEG pictures lost intensity and color information





# RAW vs JPEG pictures



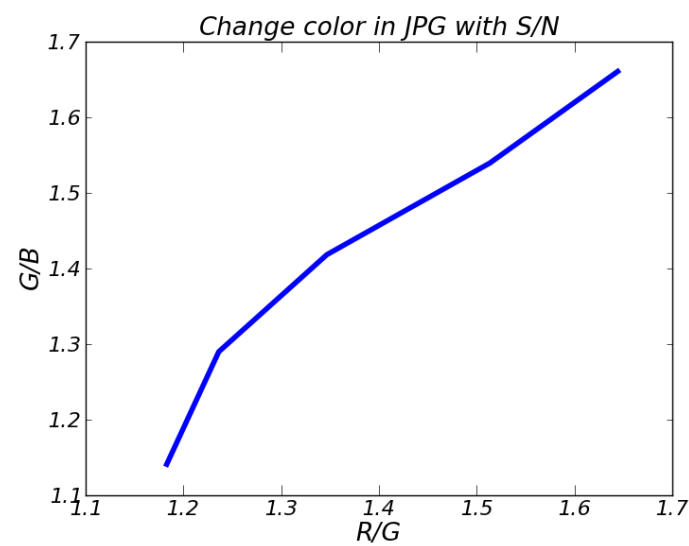
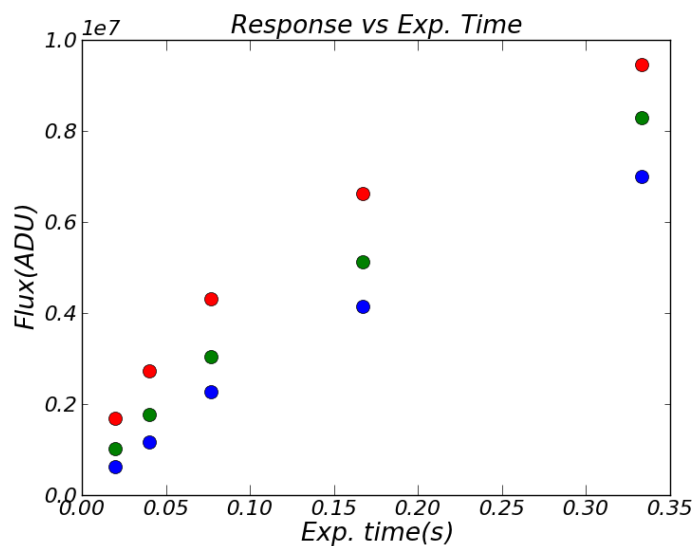
1/50 s

1/25 s

1/13 s

1/6 s

1/3 s





# Photometric calibration



## Calibration of nocturnal ISS pictures

### Available data

- RAW files of selected ISS pictures provided by NASA (JPEG images lost information on both color and intensity)
  - High resolution image over Madrid
  - Wide angle image (Iberian peninsula and stars)
- Radiance calibrated images of Madrid at Night taken with airborne spectral radiometer (ESA-DESIREX2008)

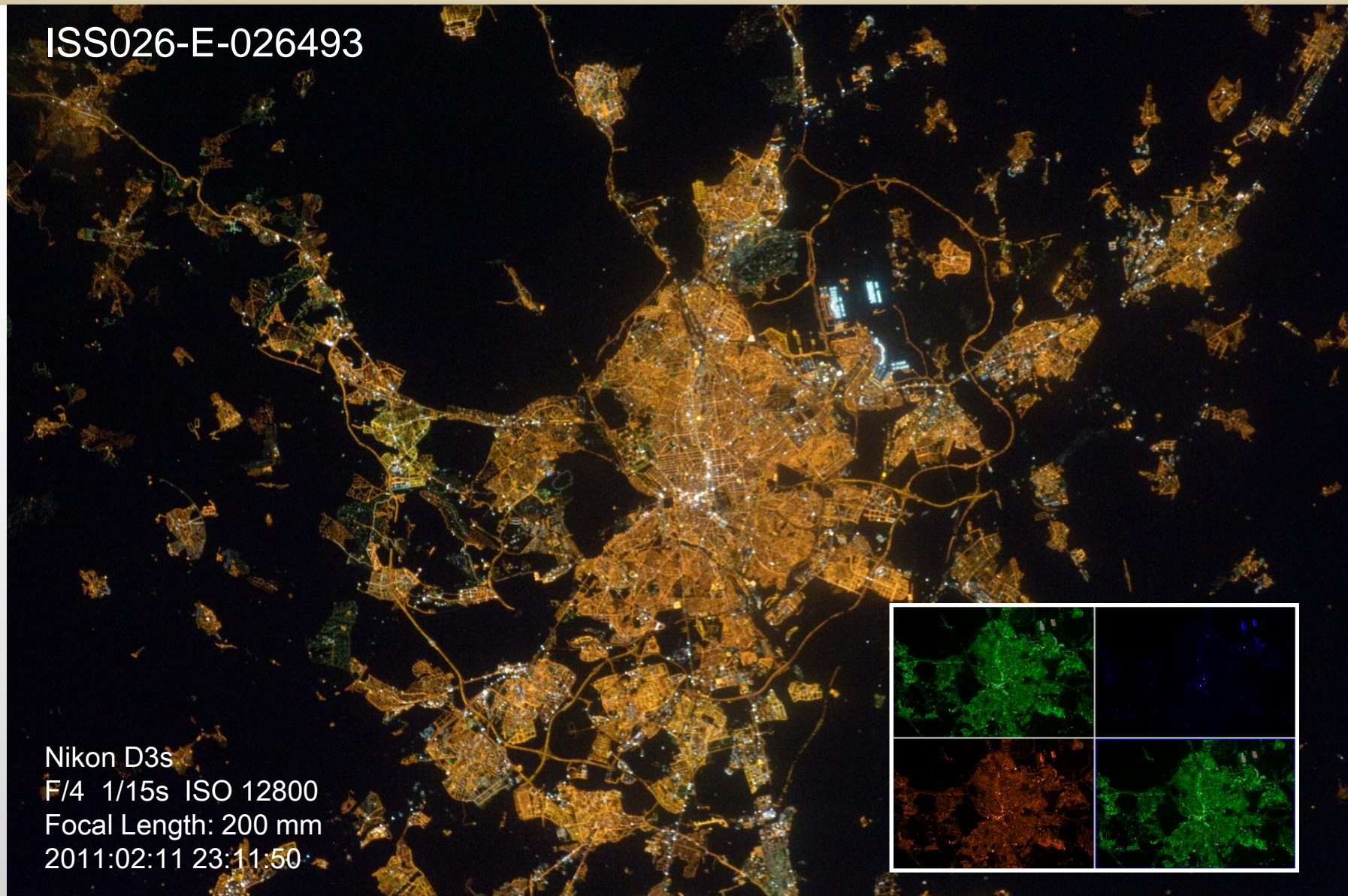




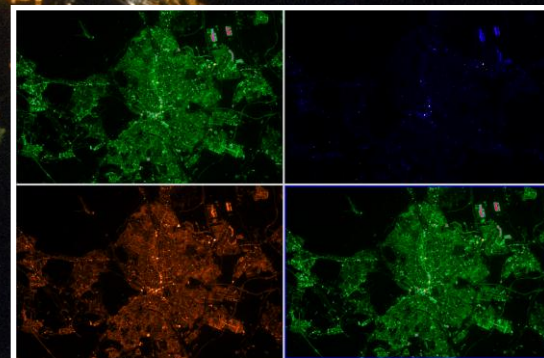
# ISS Madrid at Night



ISS026-E-026493



Nikon D3s  
F/4 1/15s ISO 12800  
Focal Length: 200 mm  
2011:02:11 23:11:50





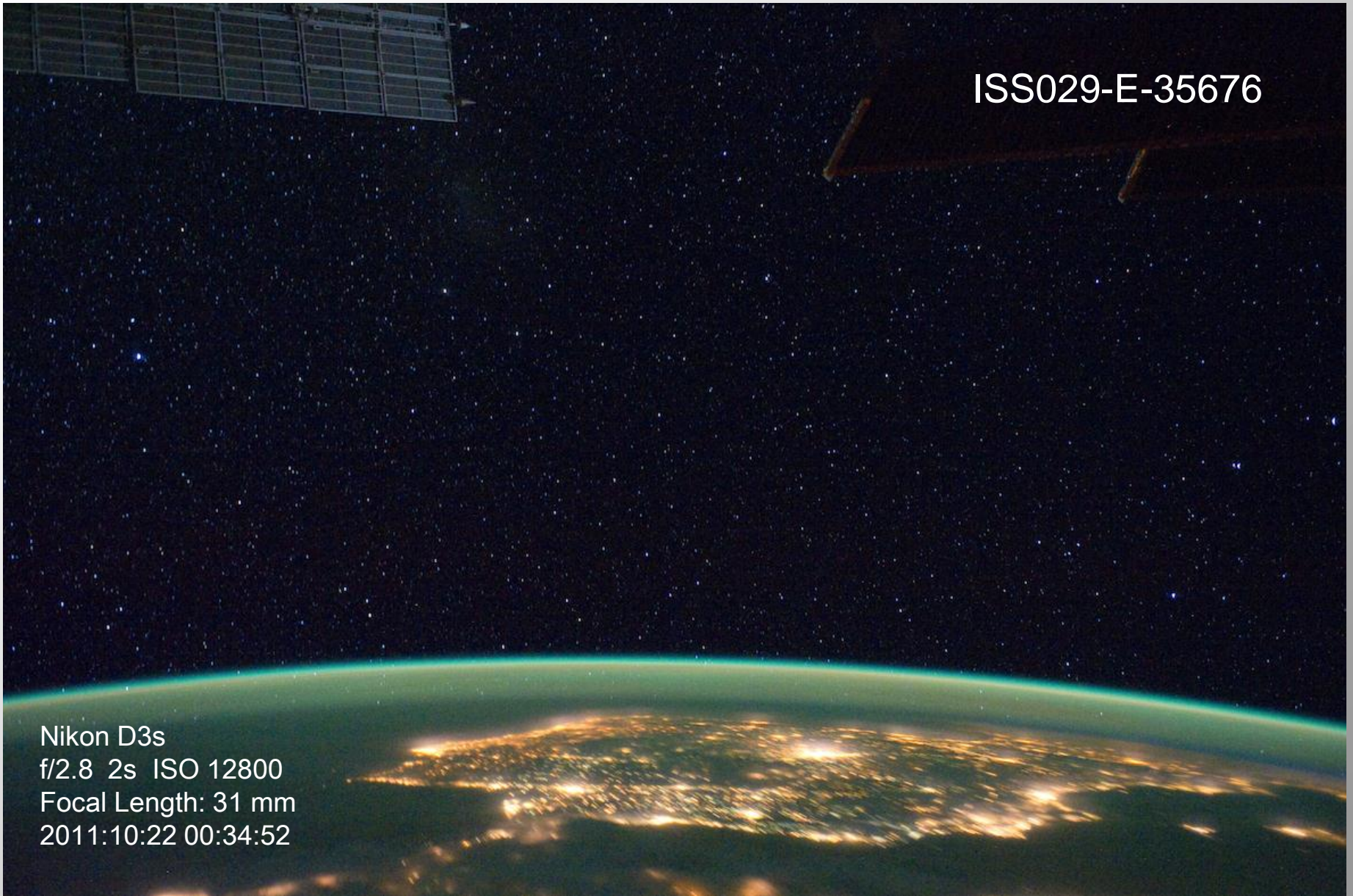


# ISS Iberian Peninsula at Night



ISS029-E-35676

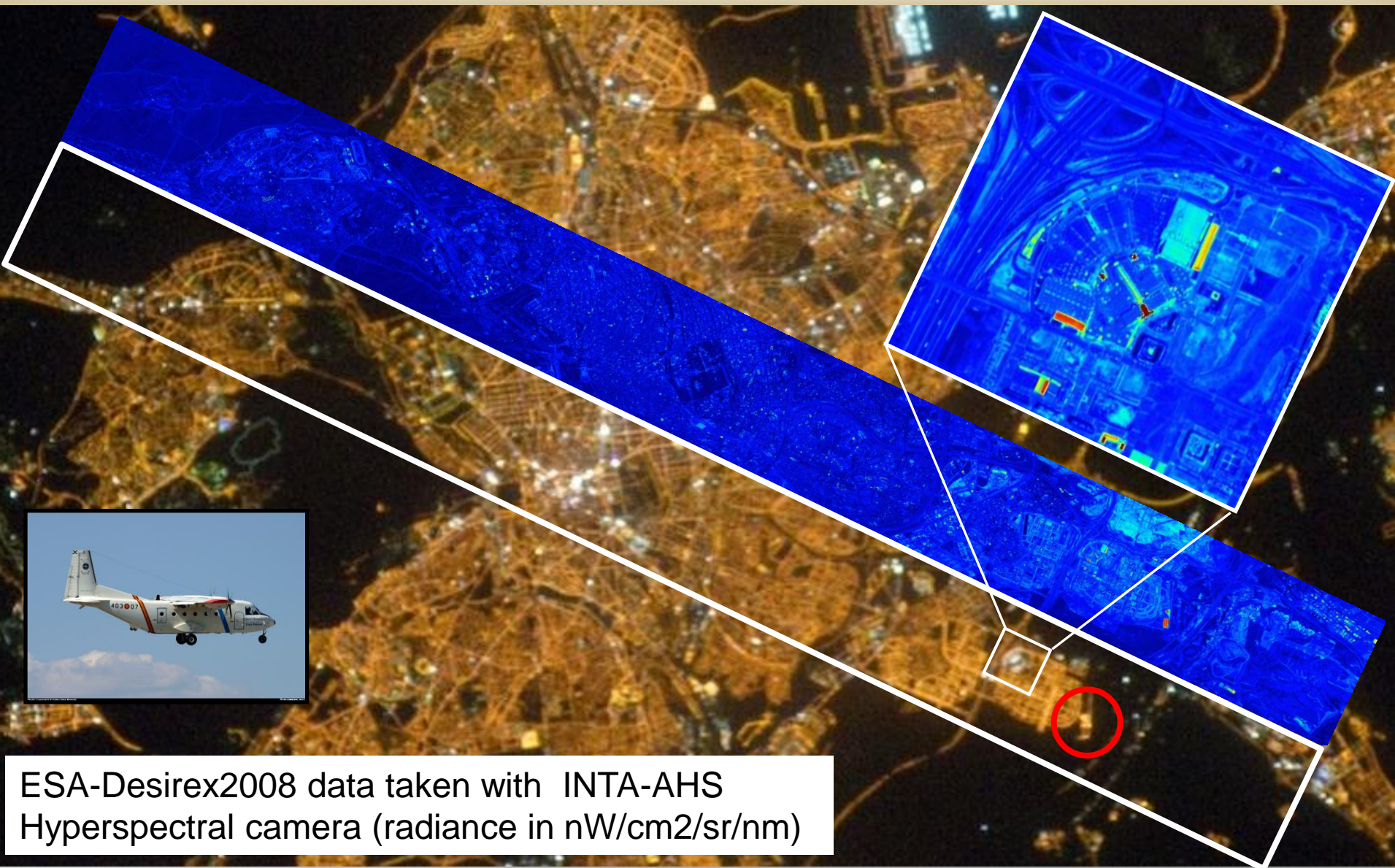
Nikon D3s  
f/2.8 2s ISO 12800  
Focal Length: 31 mm  
2011:10:22 00:34:52







# INTA-AHS (Airborne observations)



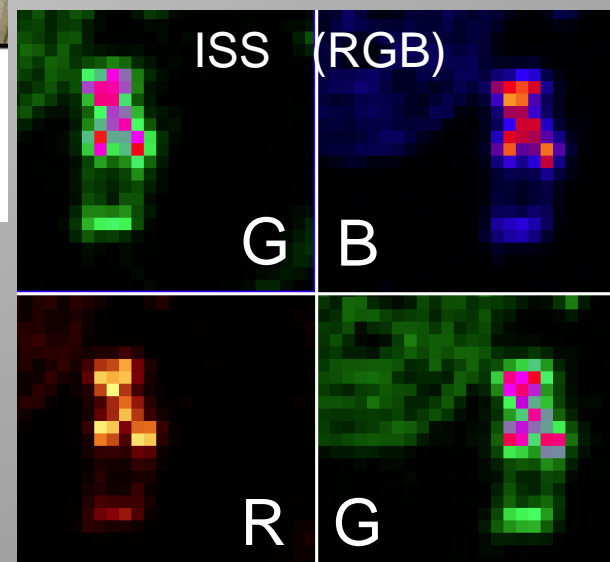
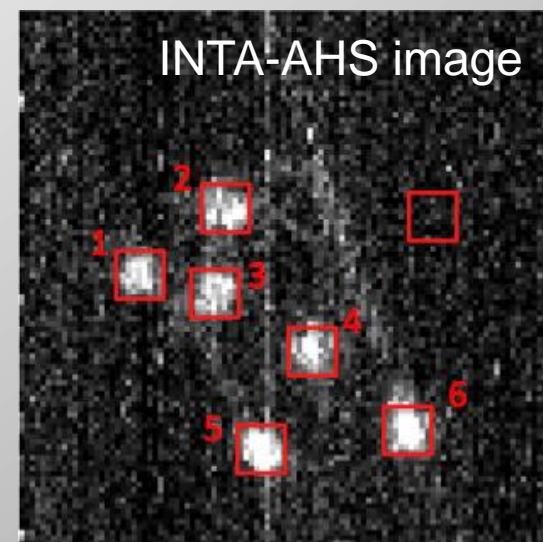
ESA-Desirex2008 data taken with INTA-AHS  
Hyperspectral camera (radiance in  $\text{nW/cm}^2/\text{sr/nm}$ )



# Calibration using sources at Earth



40 21 18 N  
03 35 01 W

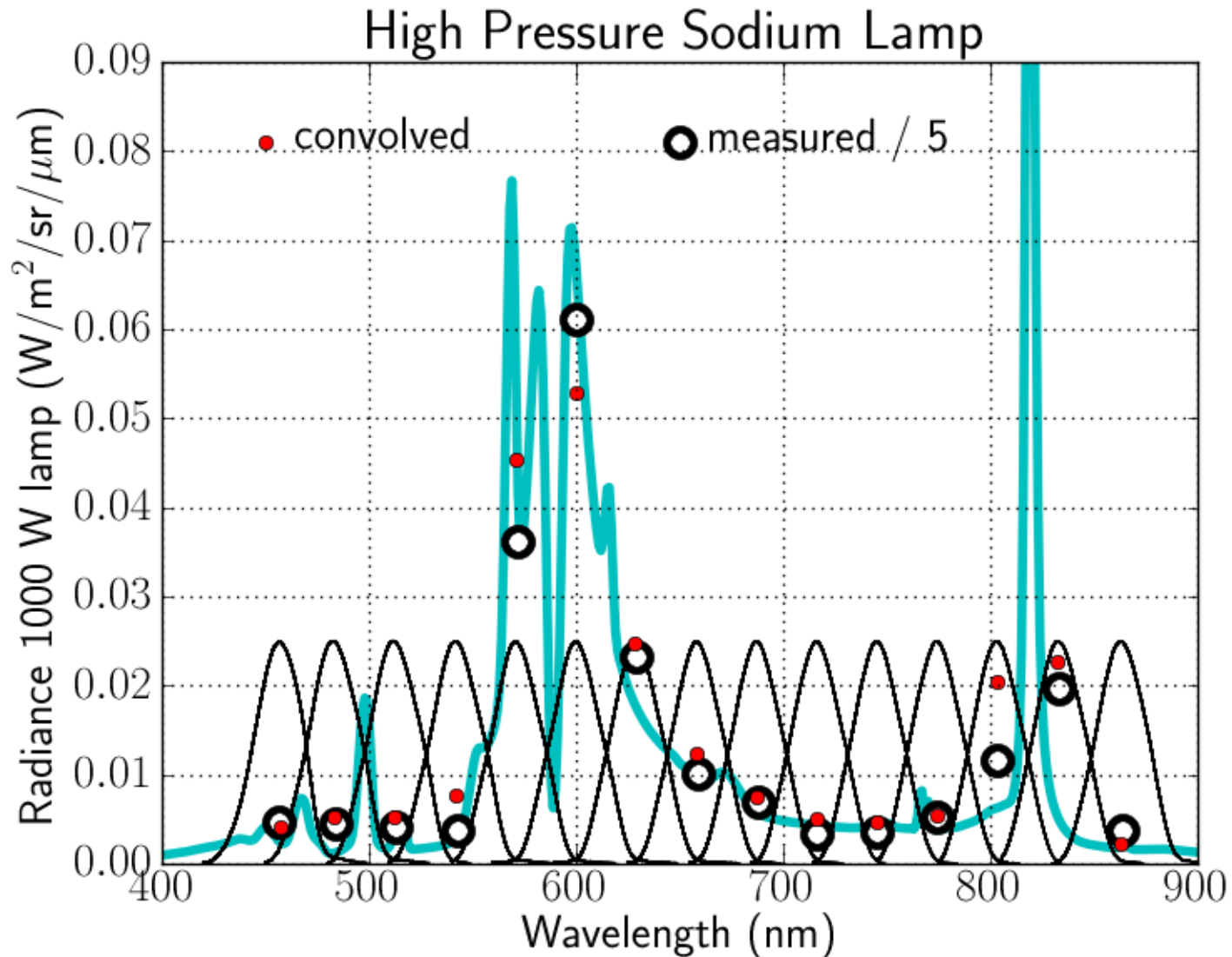


Selected calibration area: Valdecarros Railway Station

- 6 posts with 6 HPS lamps (1000 W)
- Illuminated surface of concrete

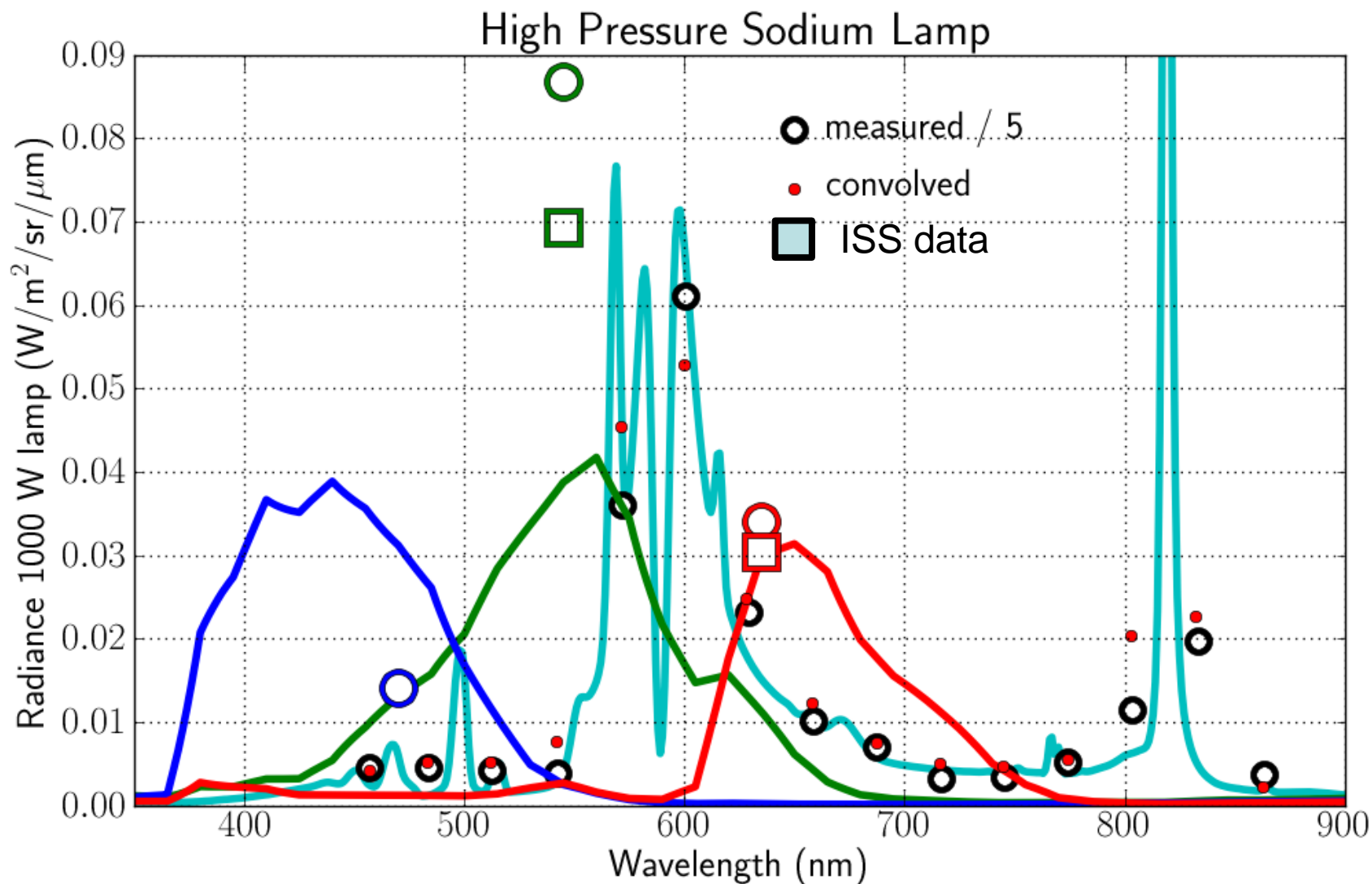


# INTA-AHS and HPS spectrum



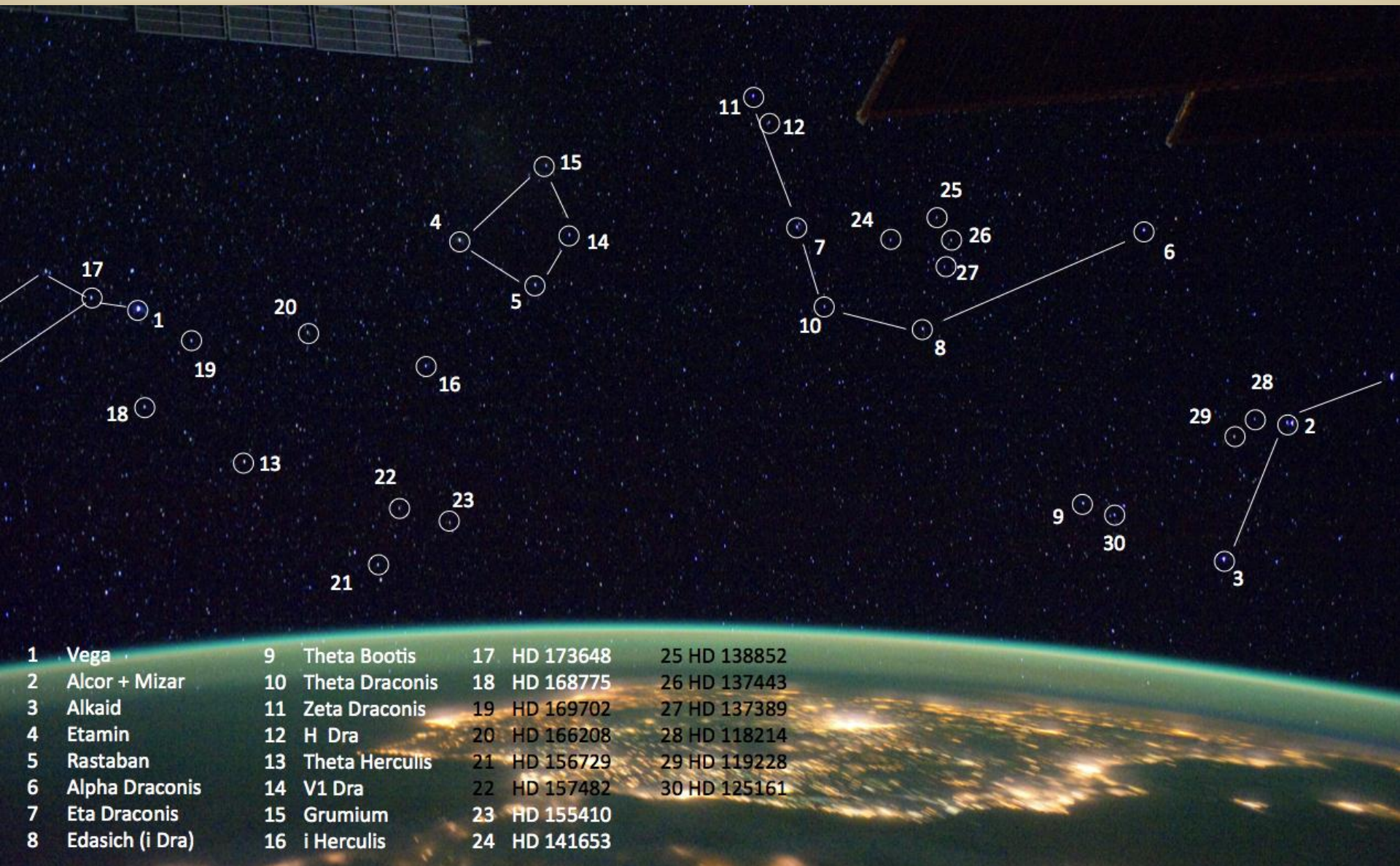


# INTA-AHS vs ISS data





# Calibration using star fluxes



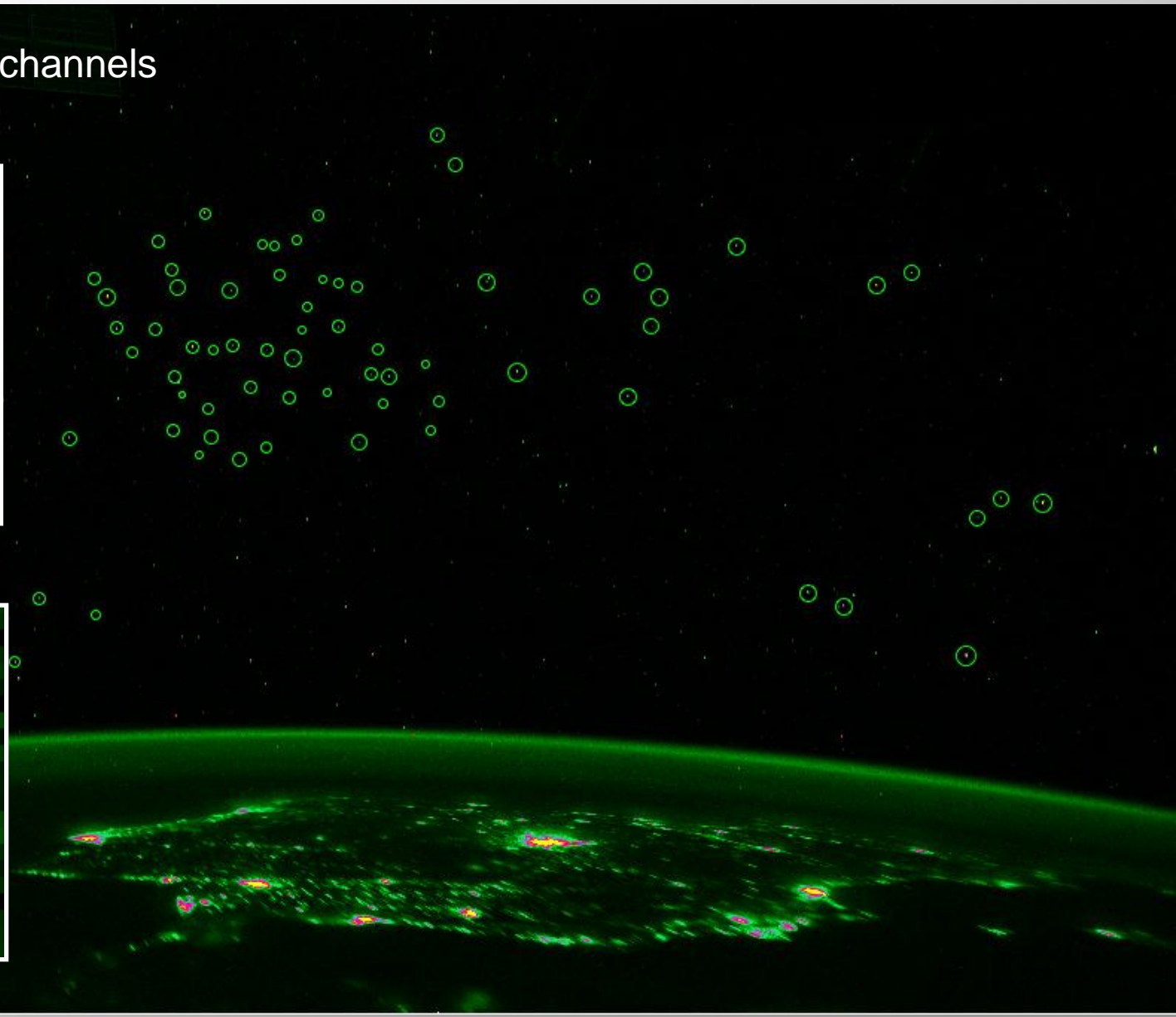
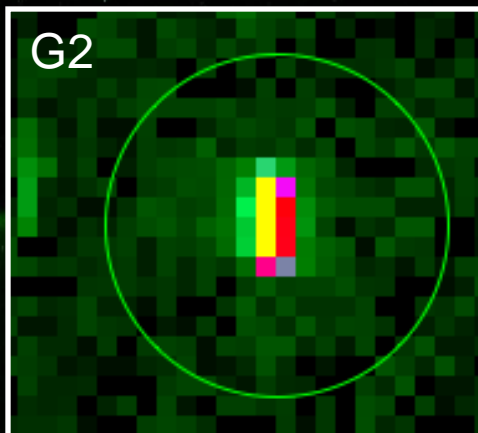
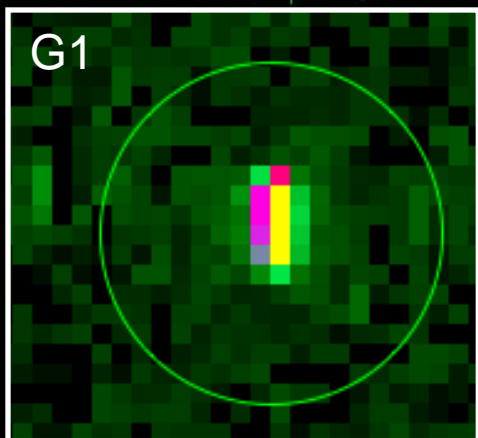




# Calibration using star fluxes

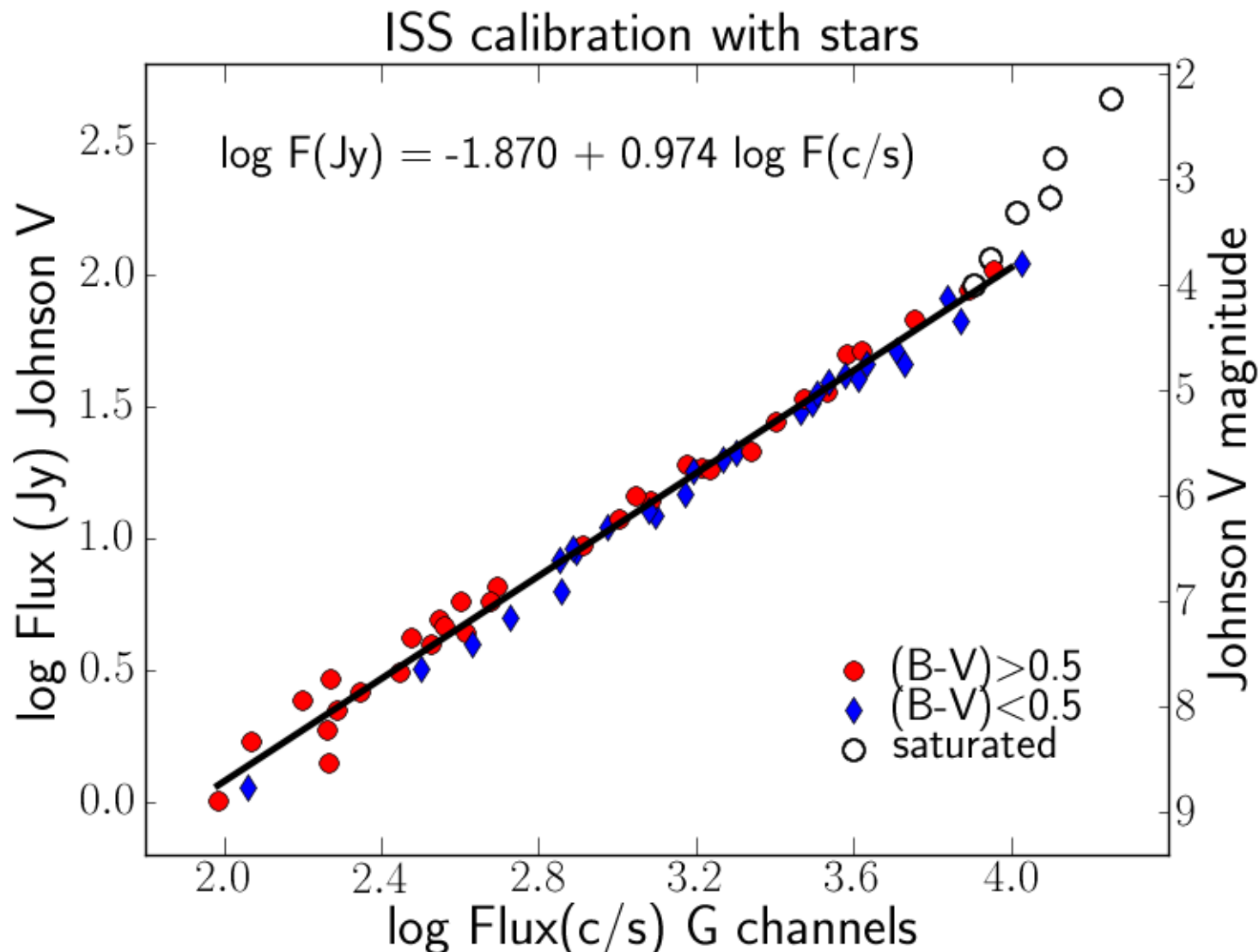


ISS RGB with twh G channels





# Calibration using star fluxes





# Conclusions



- So with the calibrated ISS images we will be able to determine the flux emitted in a large range of resolutions.
- Will be able to determine the effective temperature of color of a city or a region.
  - This will be useful to determine epidemiologic effects of lighting.
  - Also will be useful to determine the full effect of light pollution in air pollution.
- And we will determine the energy efficacy and more accuracy power consumption and compliance with lighting standards.