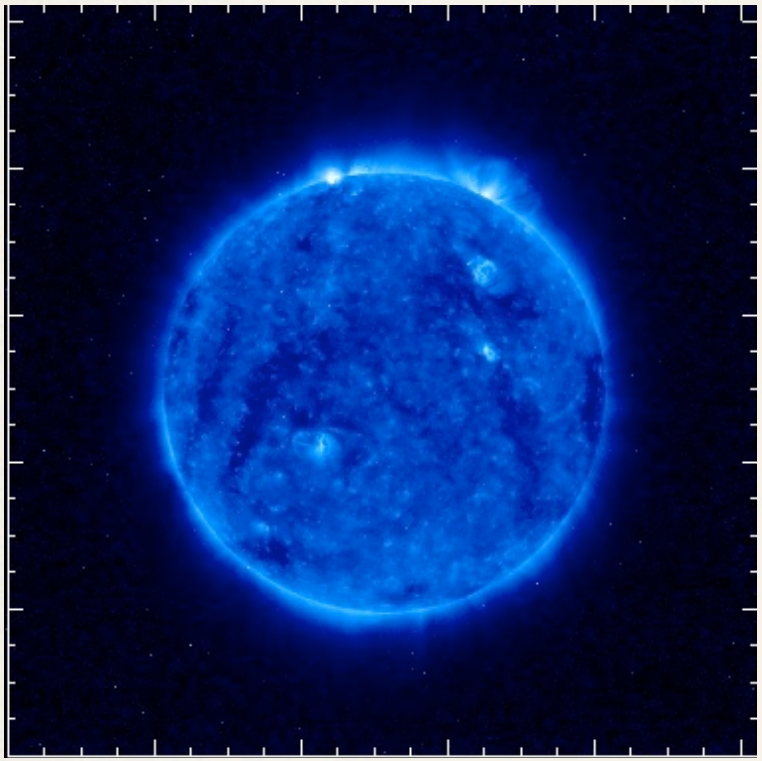
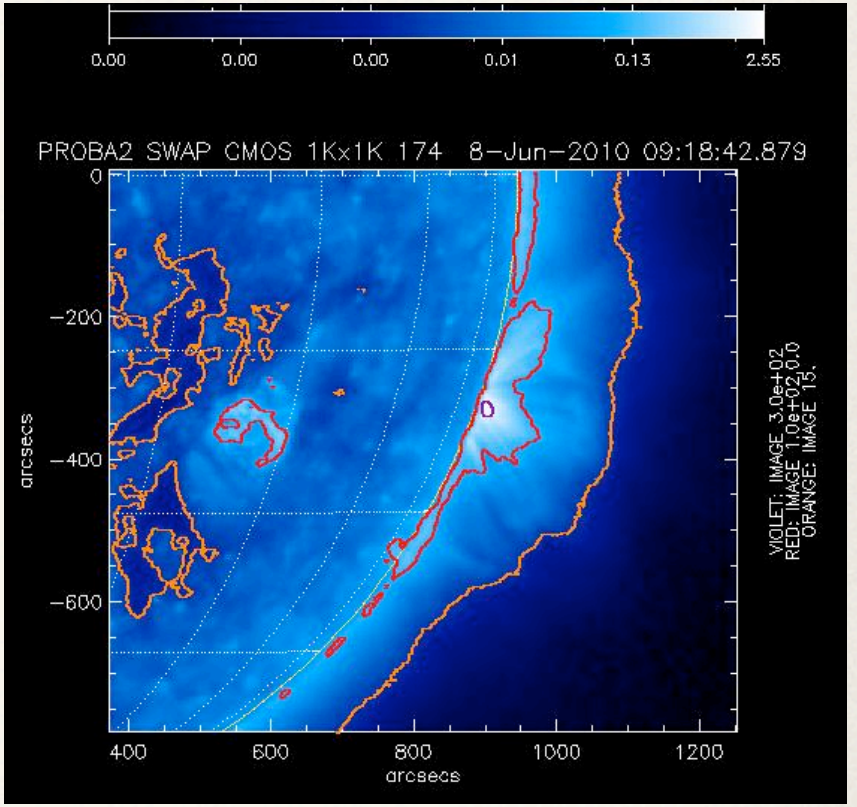




SWAP Image Calibration

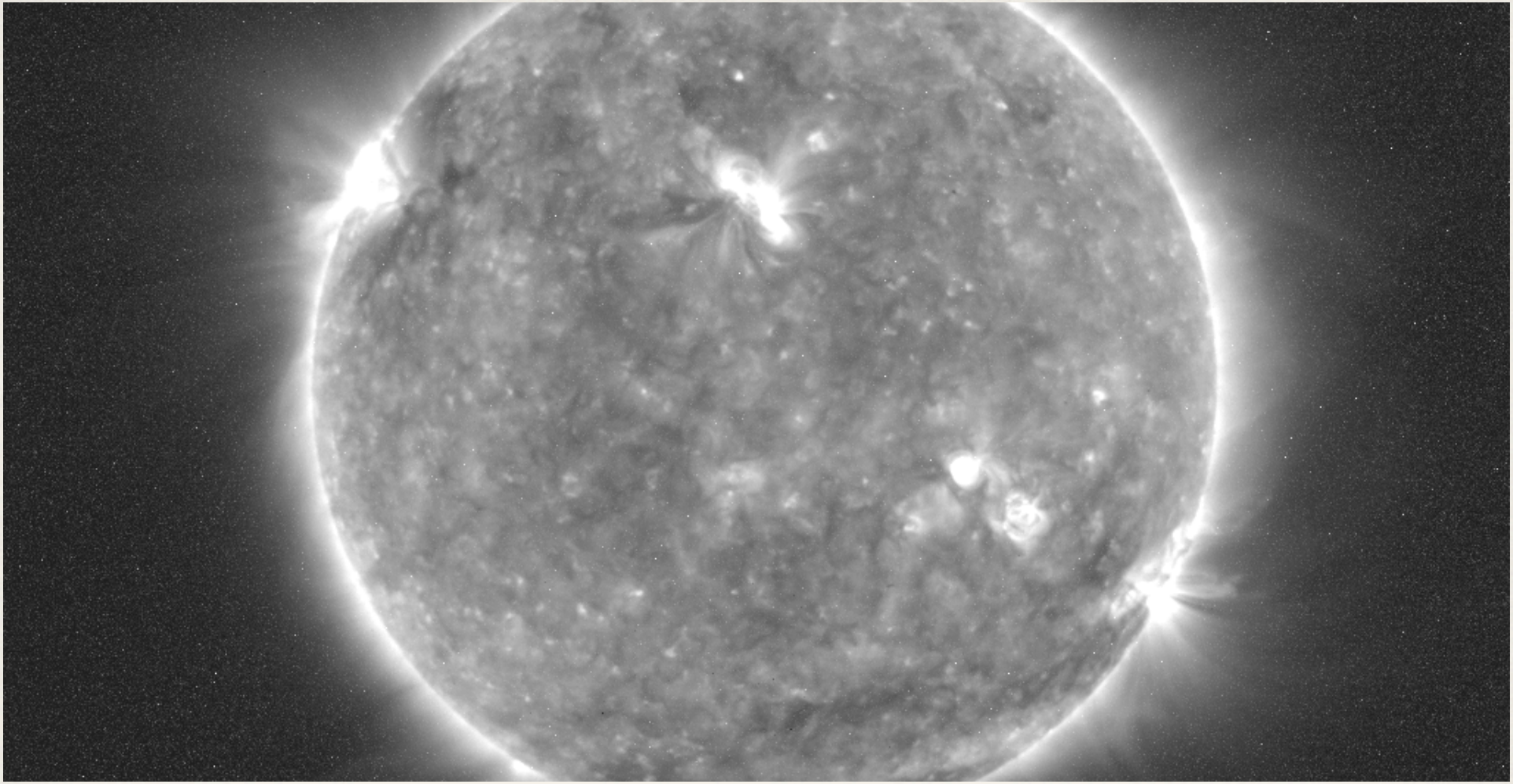
Daniel B. Seaton, D. Shaun Bloomfield, ROB & TCD SWAP Teams

Proba2 Science Working Team - 14 June 2010

Primary Image Calibration Steps

- **Implemented**
  - Dark Subtraction
  - Pixel Map Correction
  - Image Scaling, Rotation, & Centering
- **In Progress**
  - Flat Field Correction
  - Linearity

Implemented Steps



Dark Subtraction

Dark Current is the major source of noise in nominal operations

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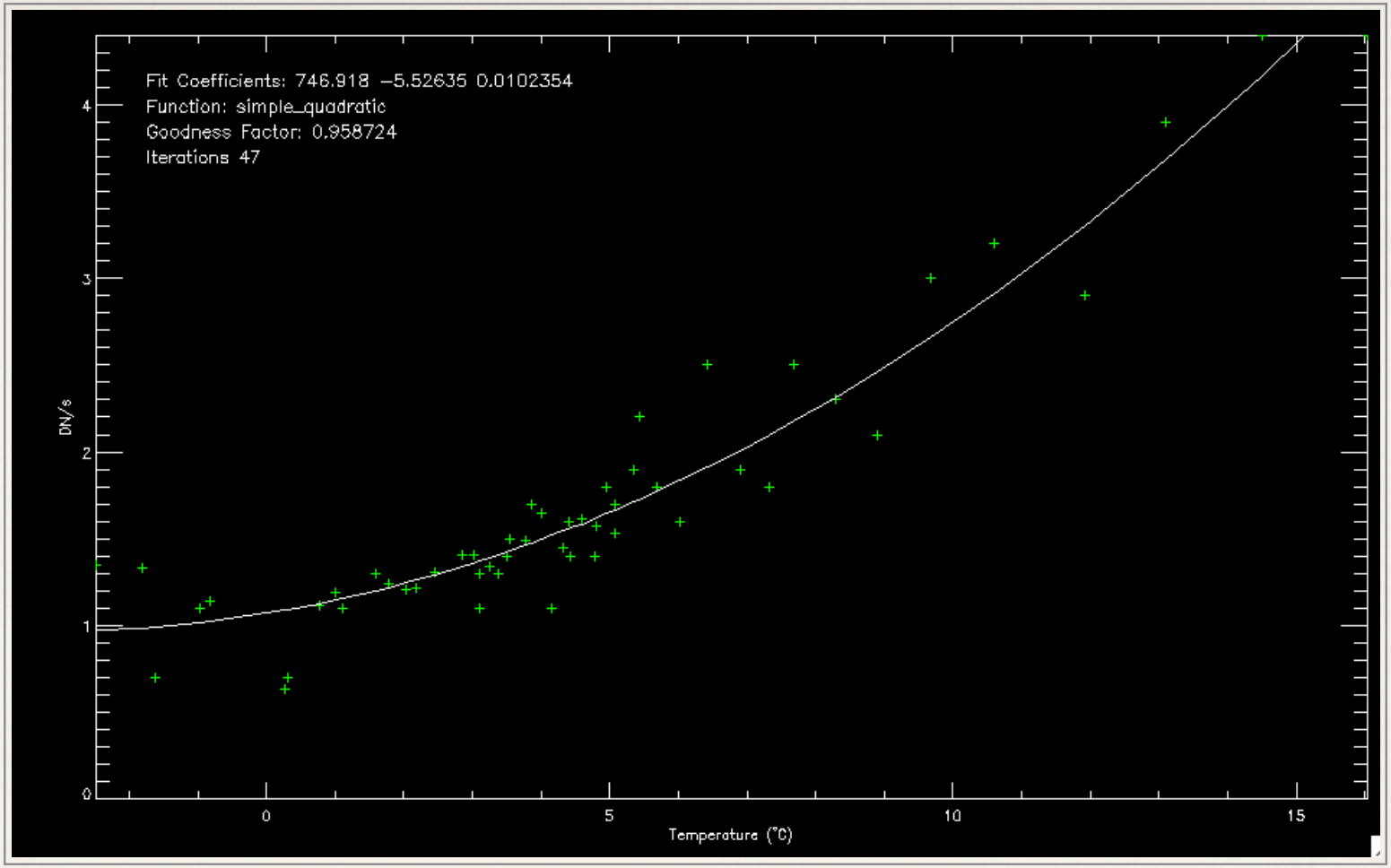

Dark Subtraction

Dark frames are created on the fly

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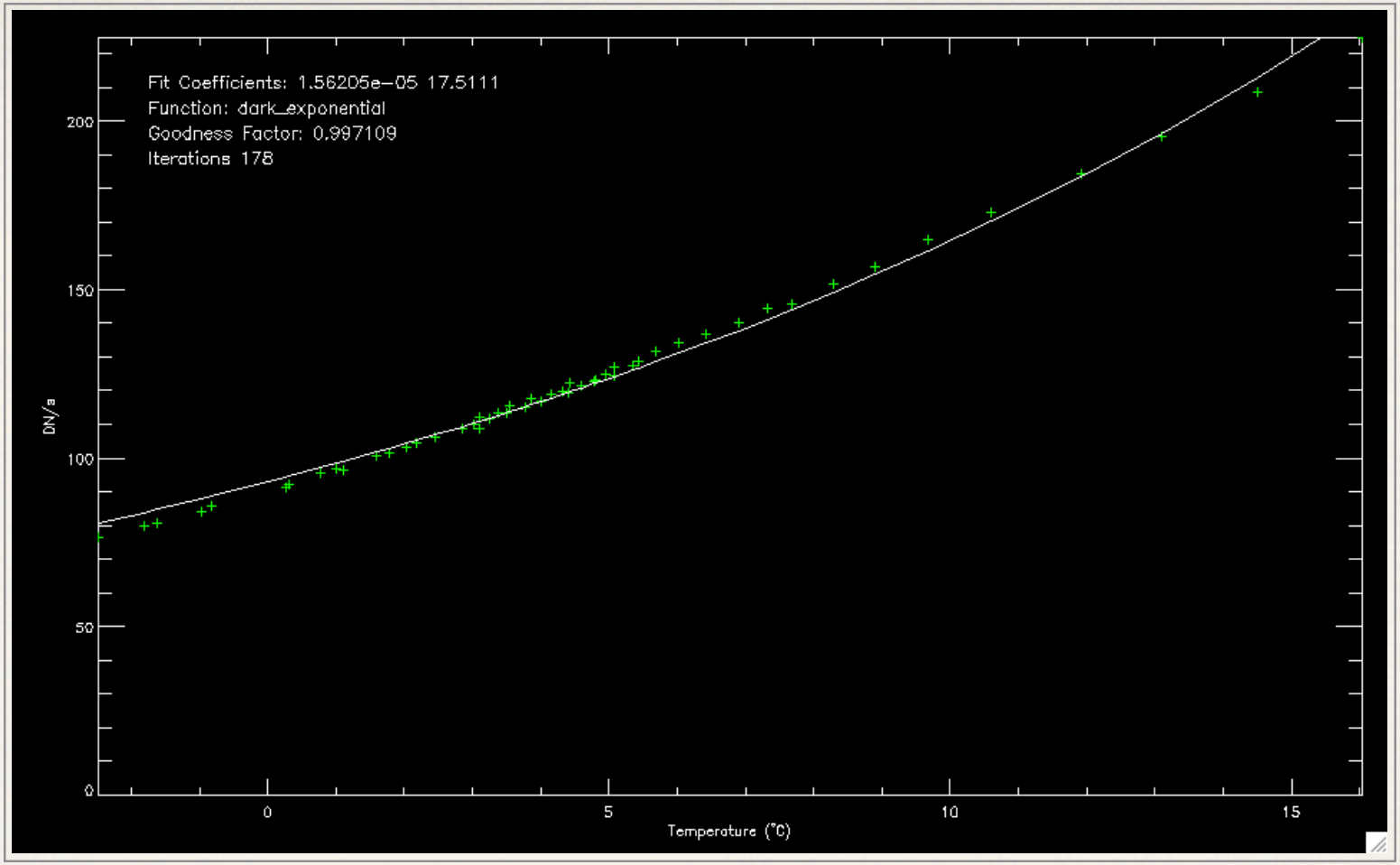

Dark Subtraction

Dark current is fit with a polynomial function

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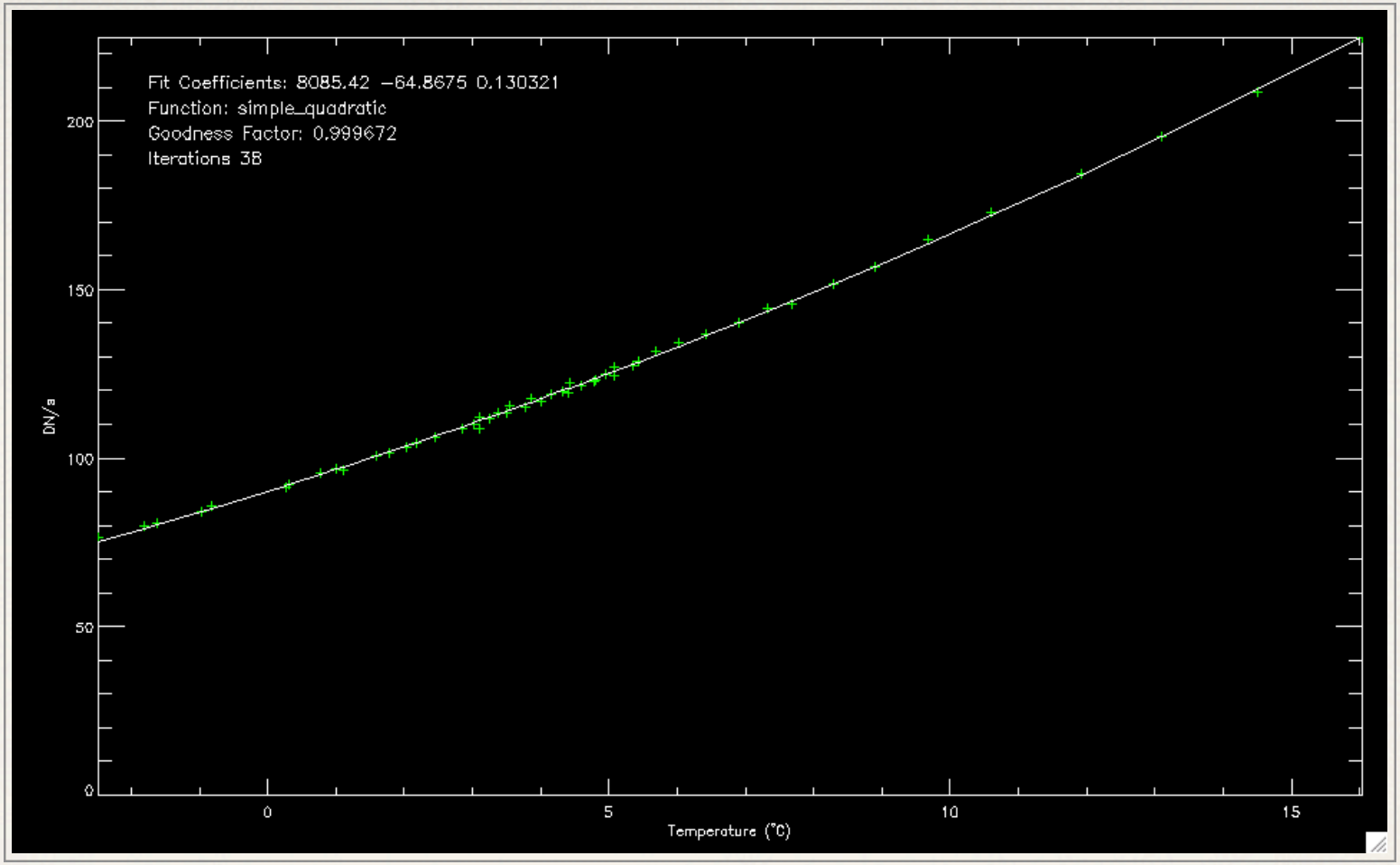
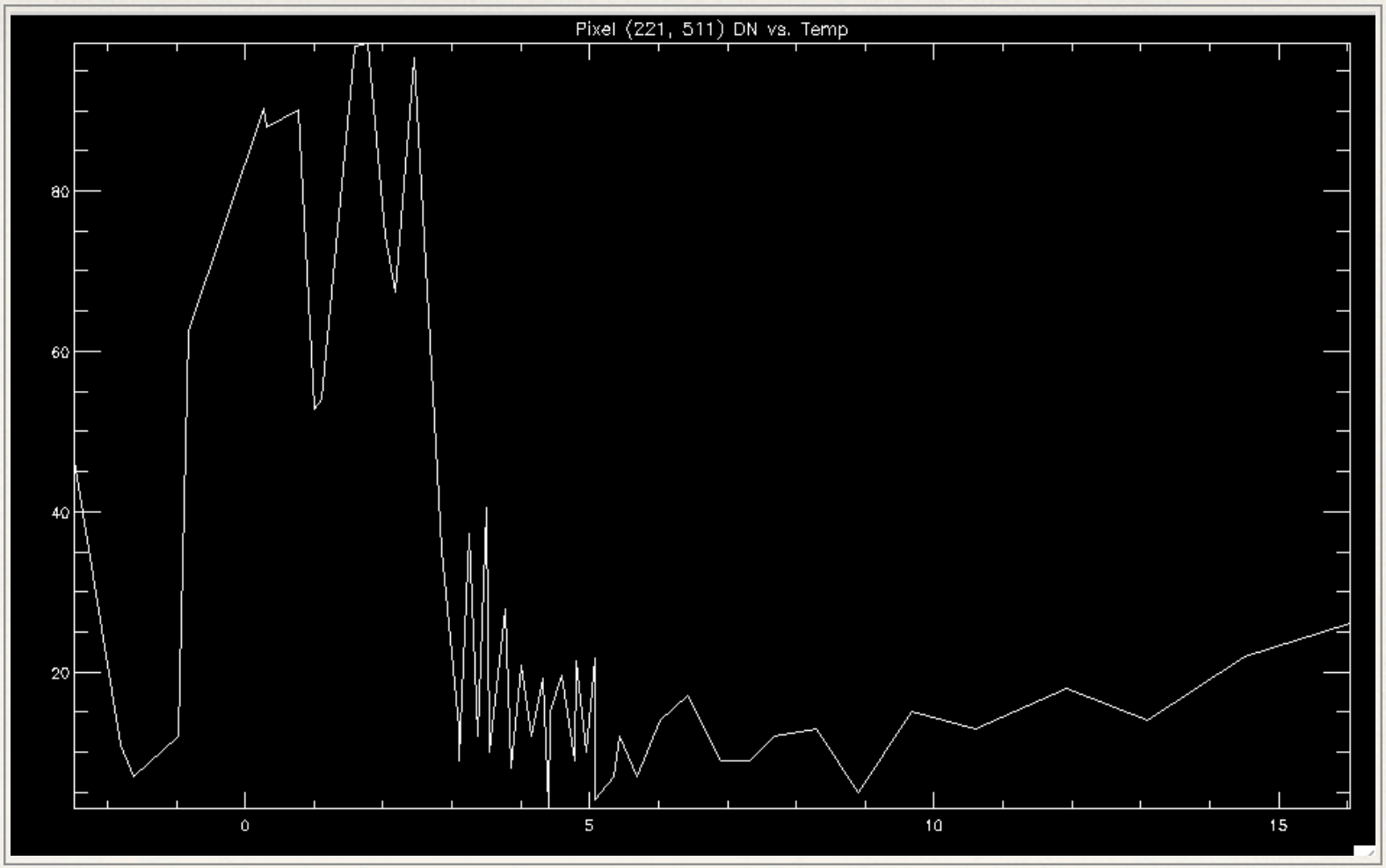


Dark Subtraction

Dark current is fit with a polynomial function

Proba2 Science Working Team - 14 June 2010



Dark Subtraction

A small number of strange pixels cannot be fit

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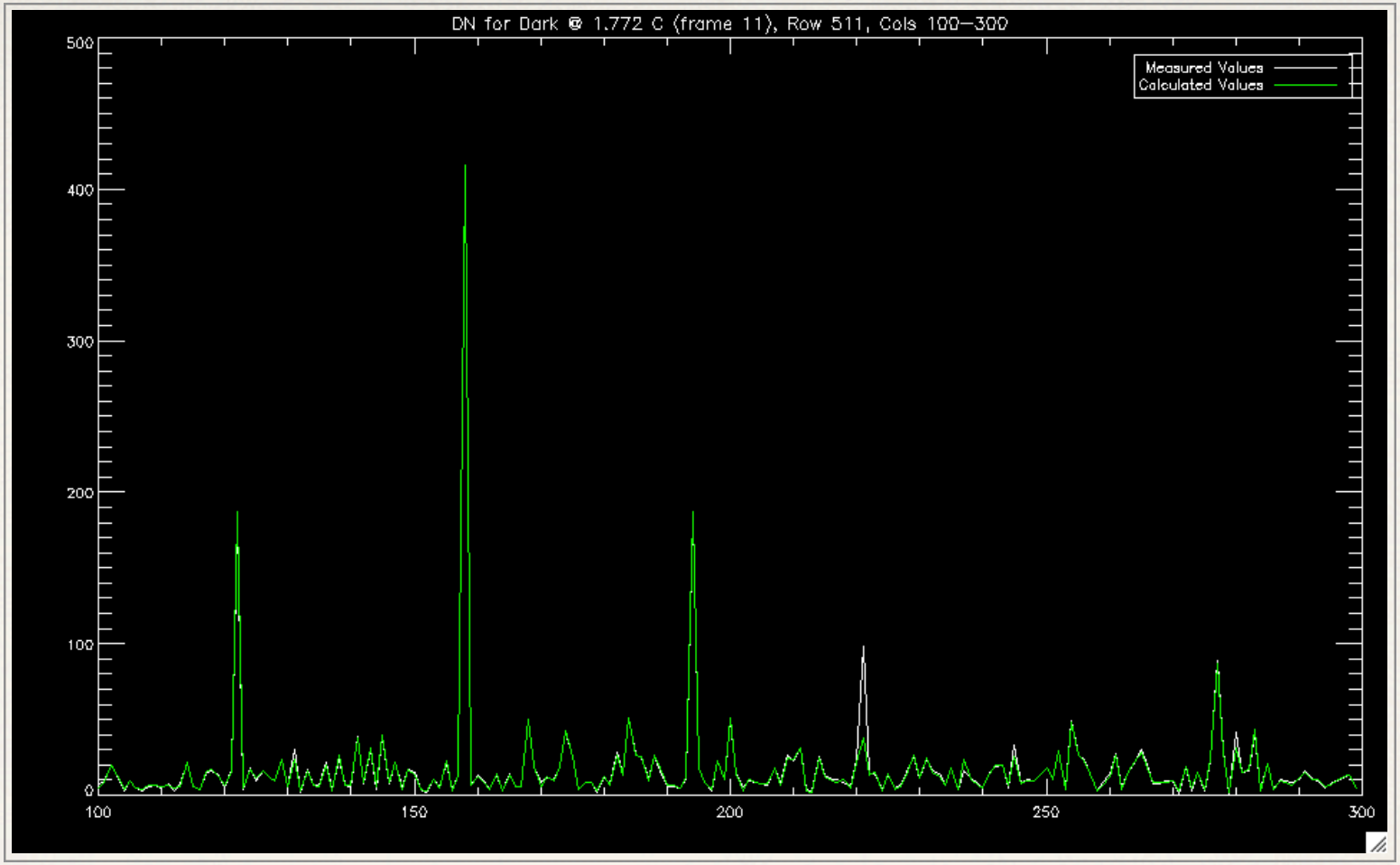

Dark Subtraction

Most pixels can be fit to within a few counts

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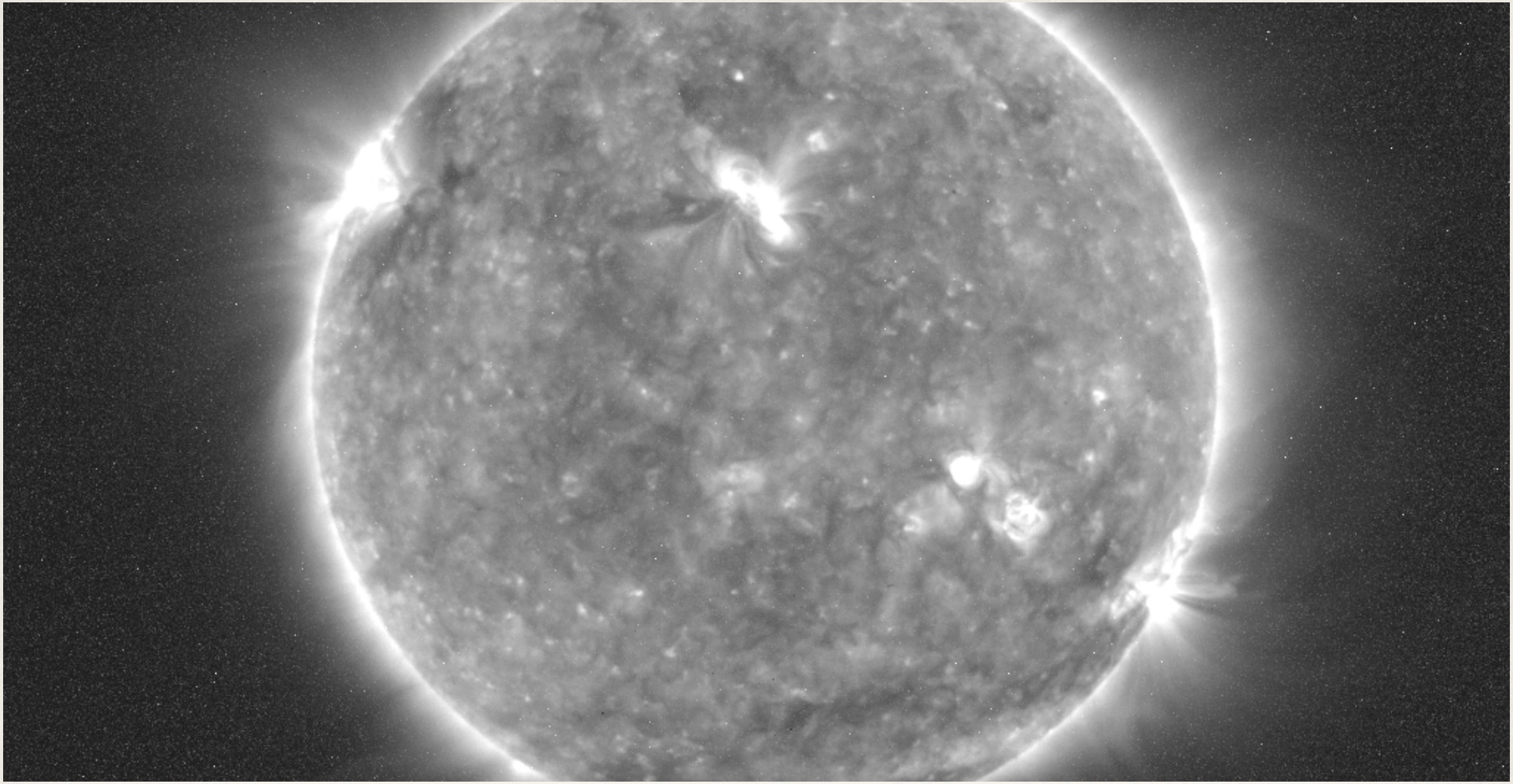

Dark Subtraction

Dark subtraction removes most image noise

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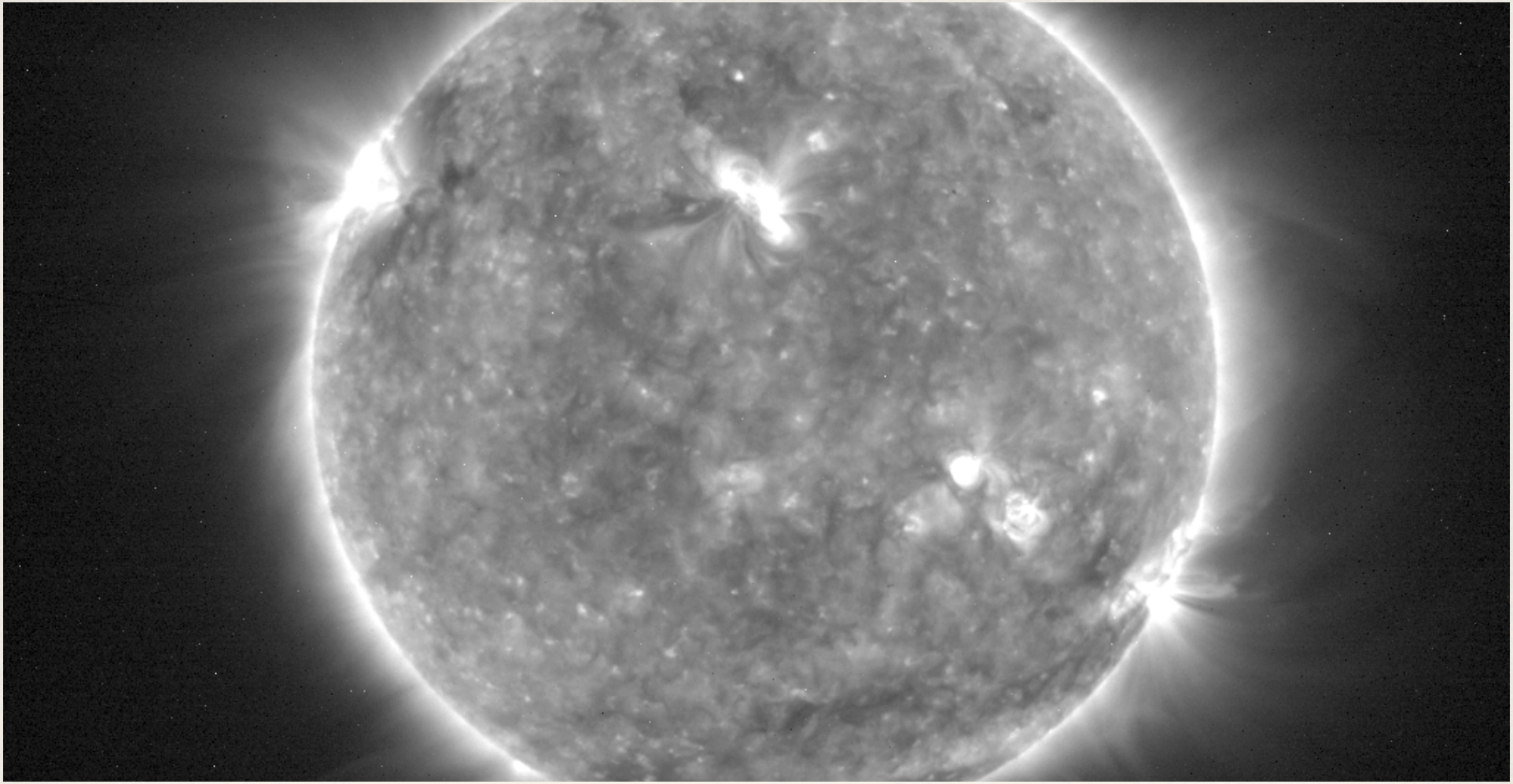

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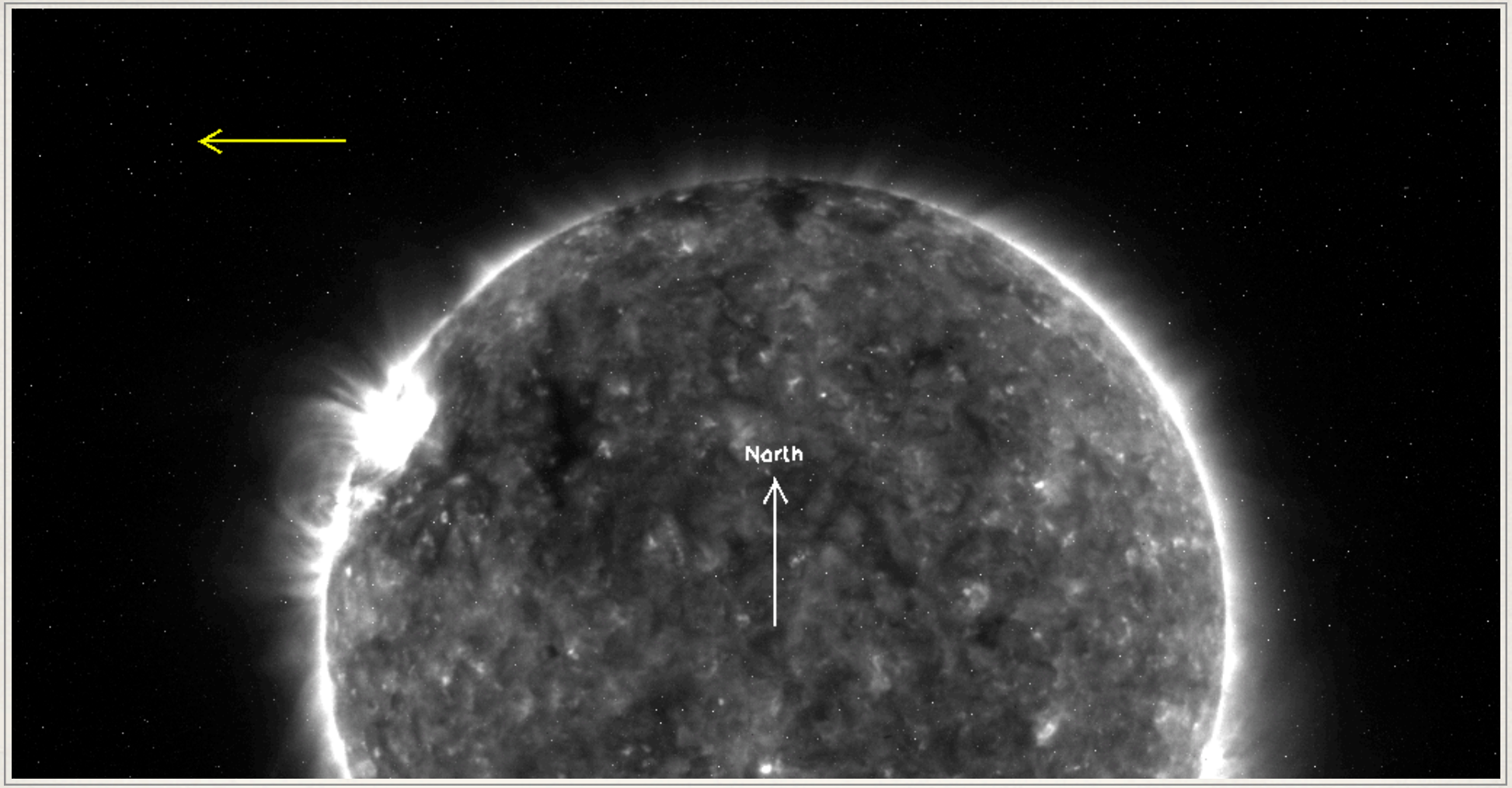
Dark subtraction removes most image noise

Proba2 Science Working Team - 14 June 2010



Pixel map correction

Pixels with known incorrect behavior are replaced

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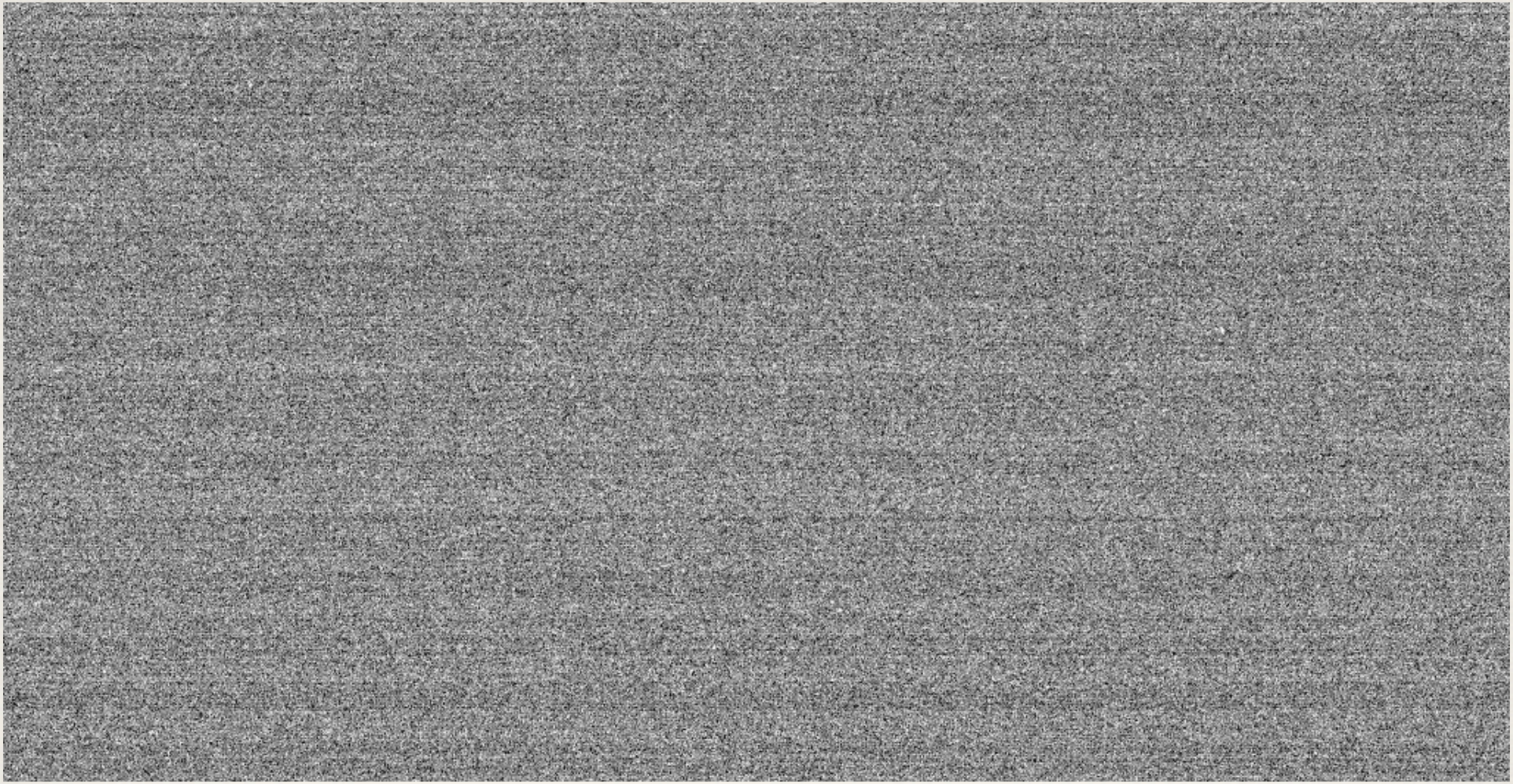
Additional Fixed-Pattern Noise

- **Correlated Double Sampling (CDS):**
  - Bias subtraction unnecessary
  - Bias automatically removed during image acquisition
- **Double Sampling (DS):**
  - Bias must be indirectly measured
  - Bias-subtraction implemented for DS images



Additional Fixed-Pattern Noise

Faint horizontal stripes remain after dark subtraction

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Image Alignment & Scaling

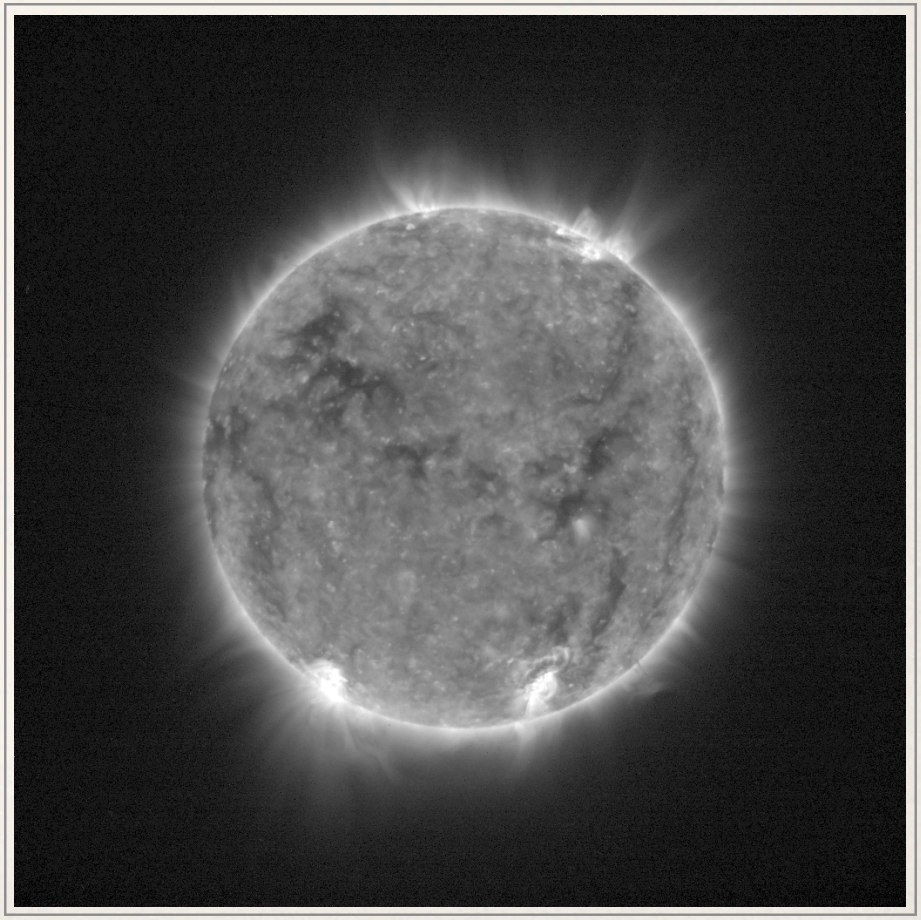
Telescope Effects

1. Spacecraft-Ecliptic Alignment

2. Sun Centering

3. Spacecraft Roll

4. Non-isotropic Pixel Scale



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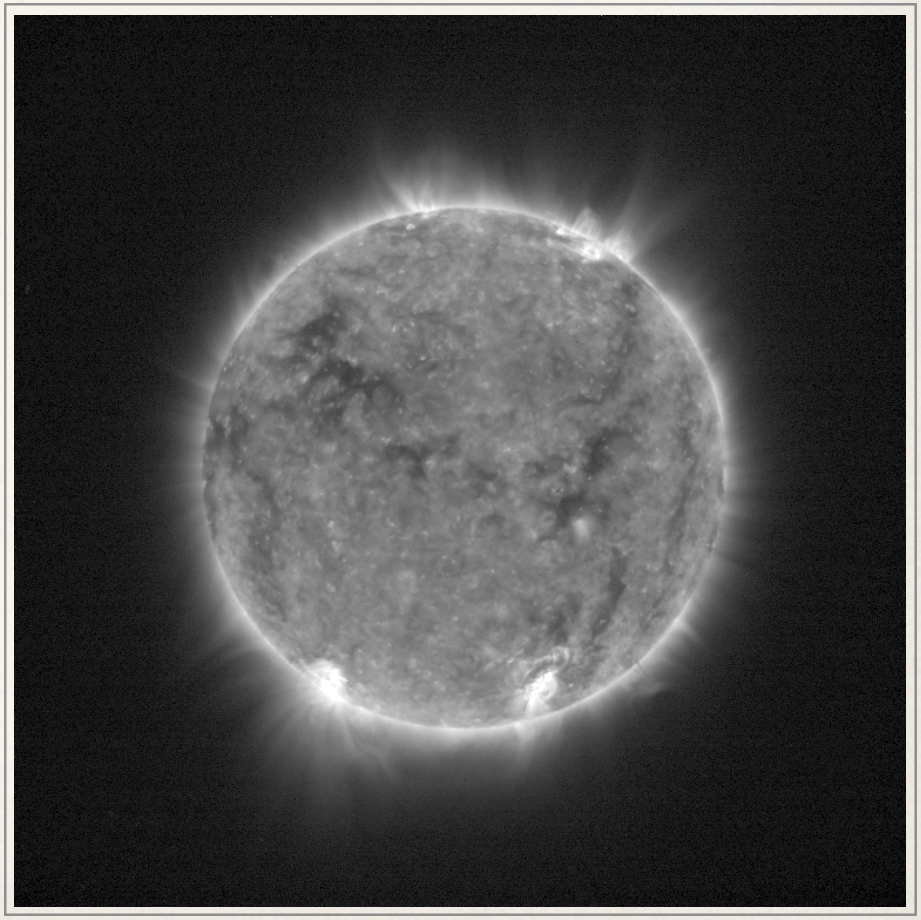

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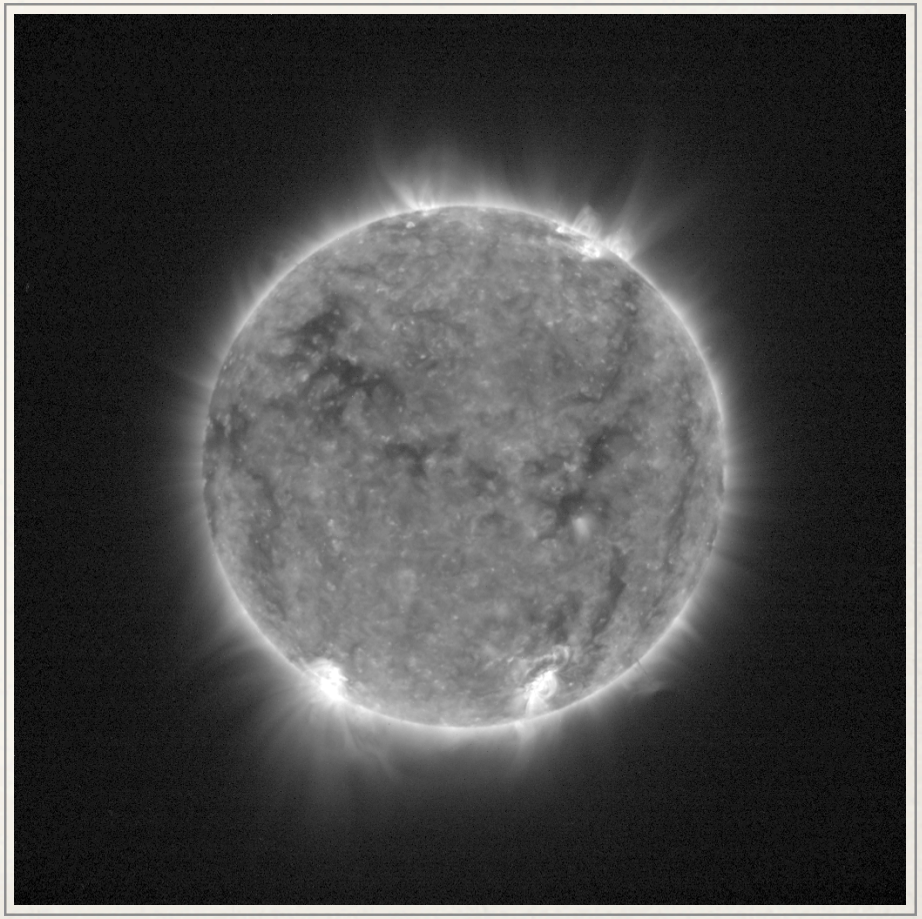

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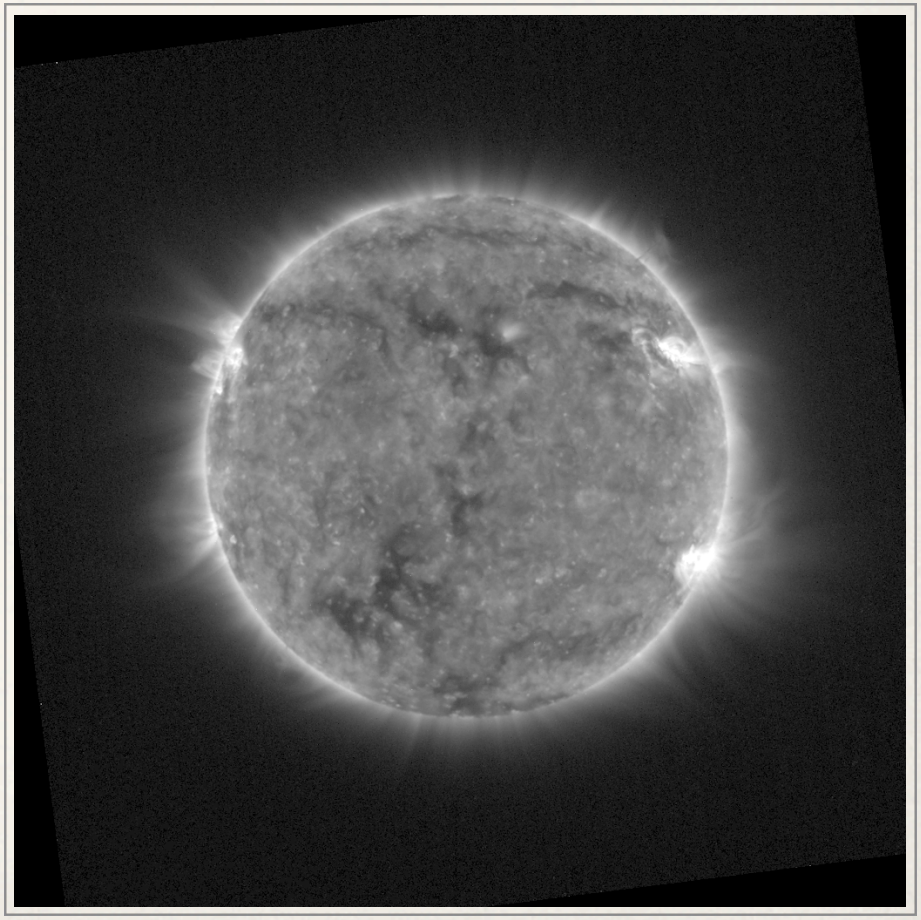

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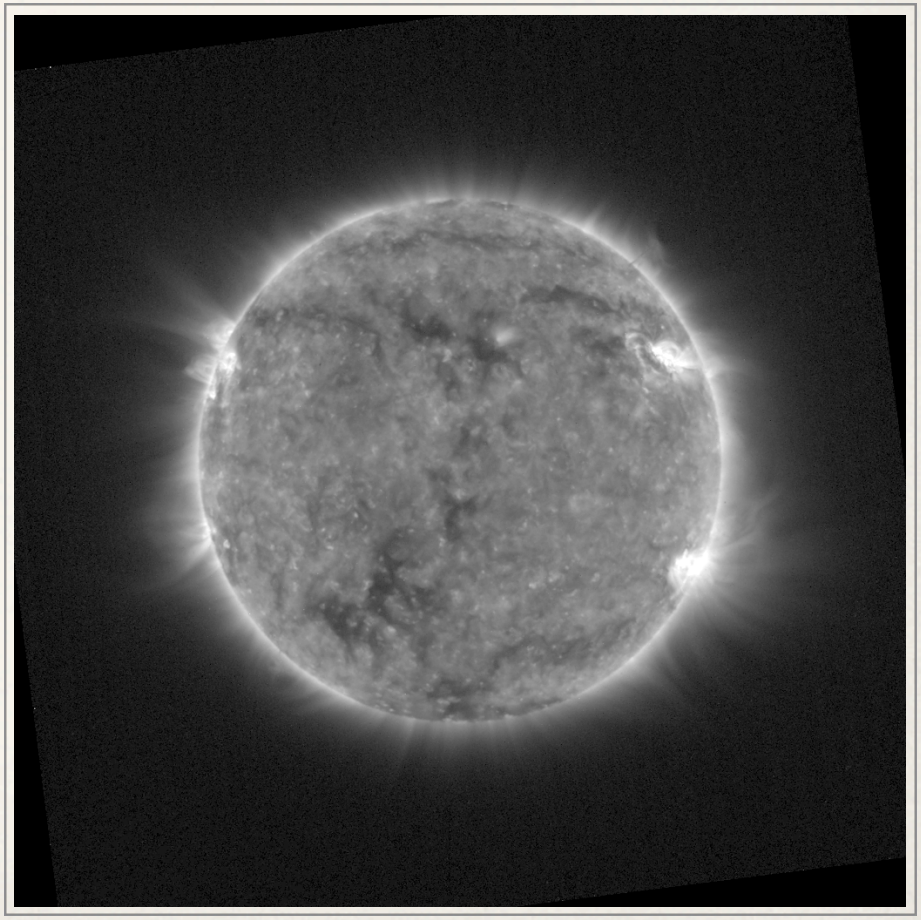
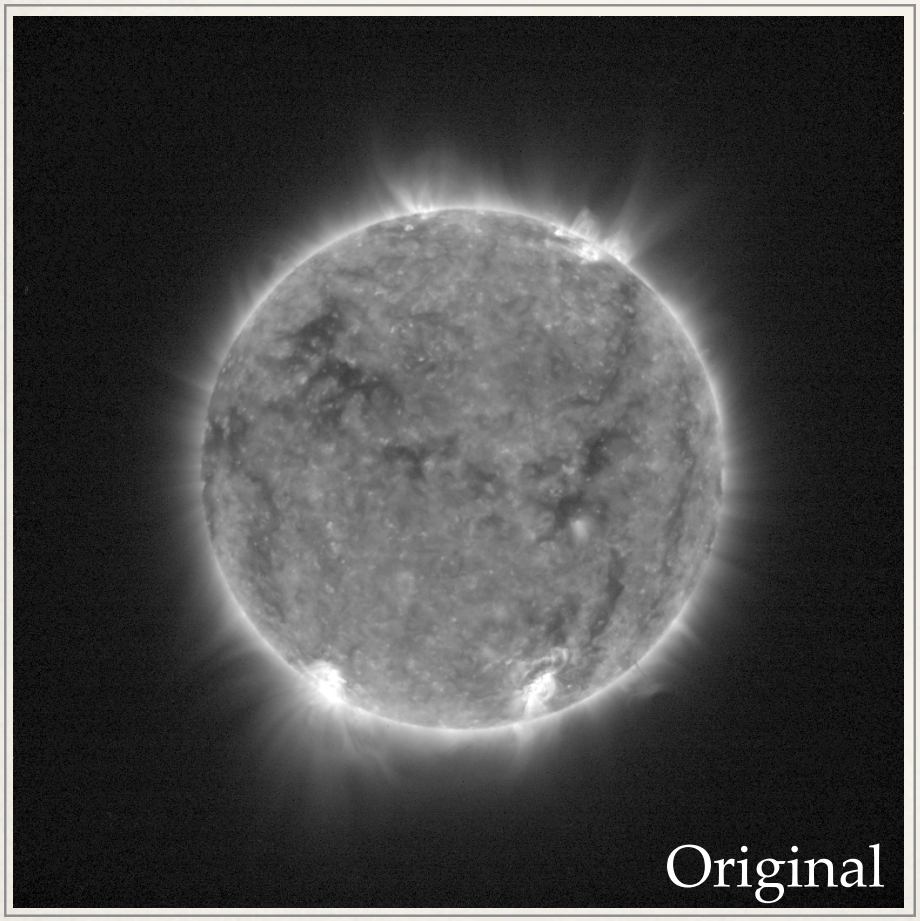
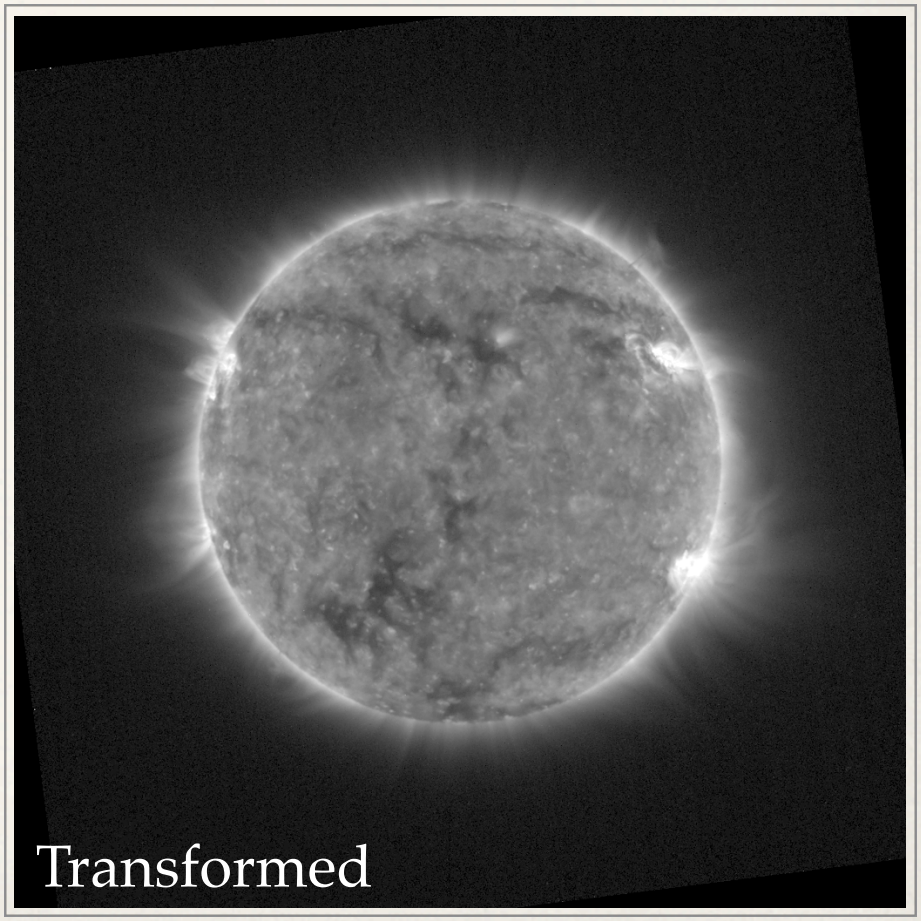


Image Alignment & Scaling



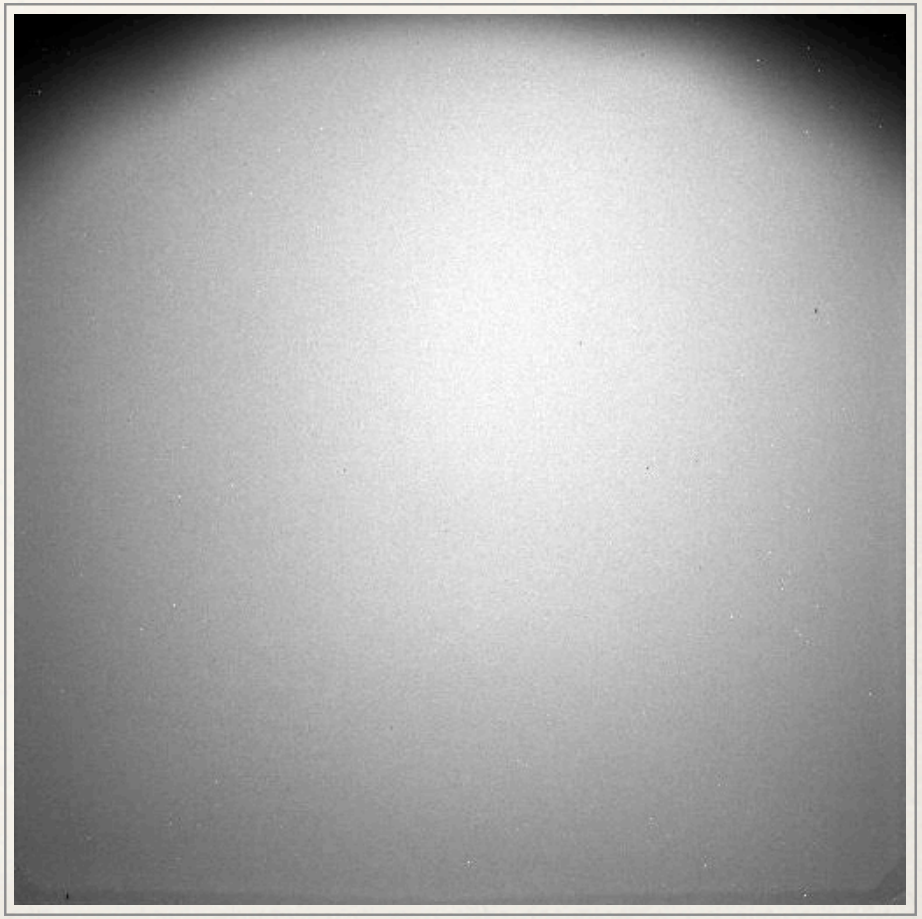


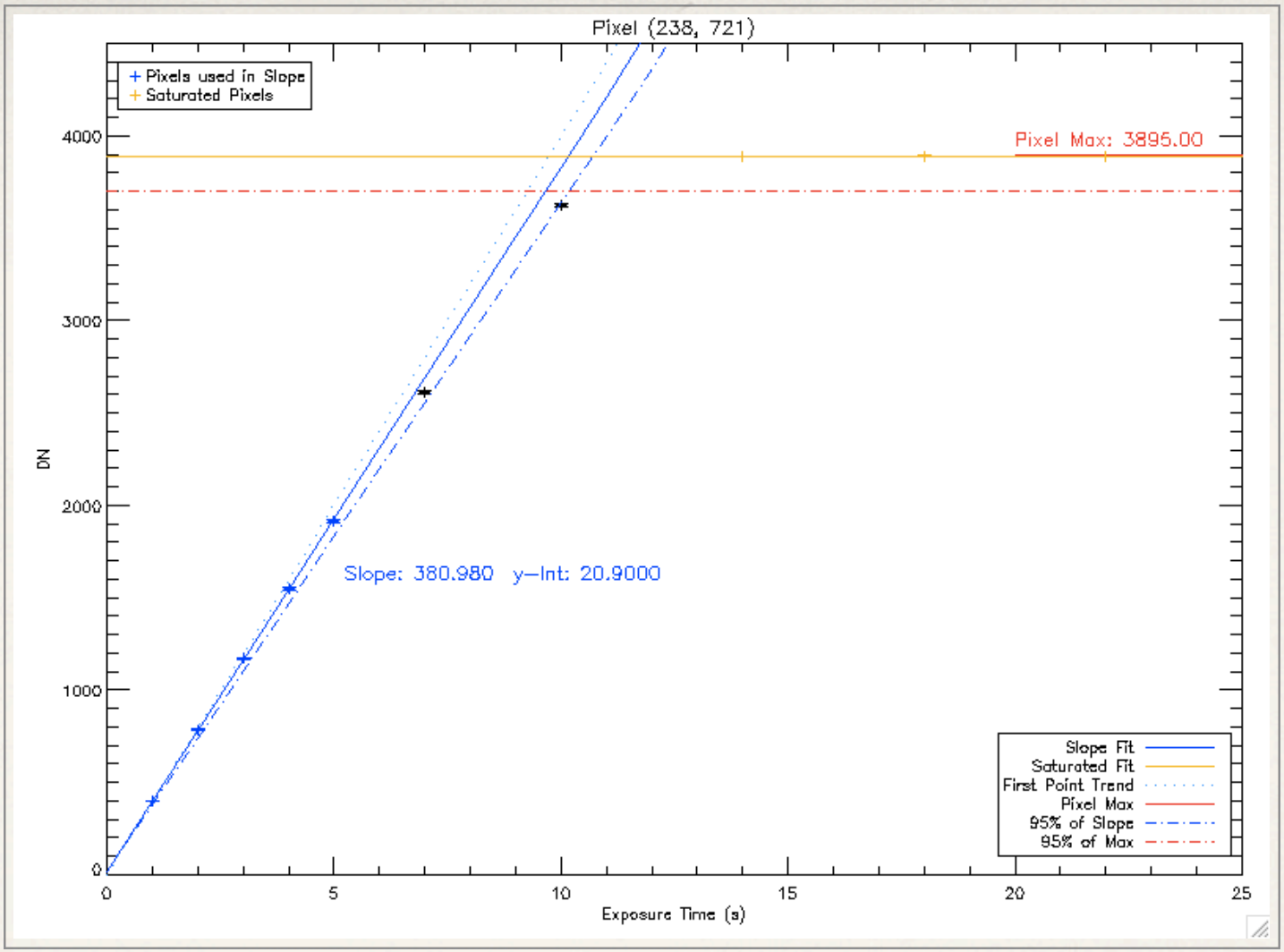
Outstanding Issues

Flat-Field Correction

Flat-field correction will address:

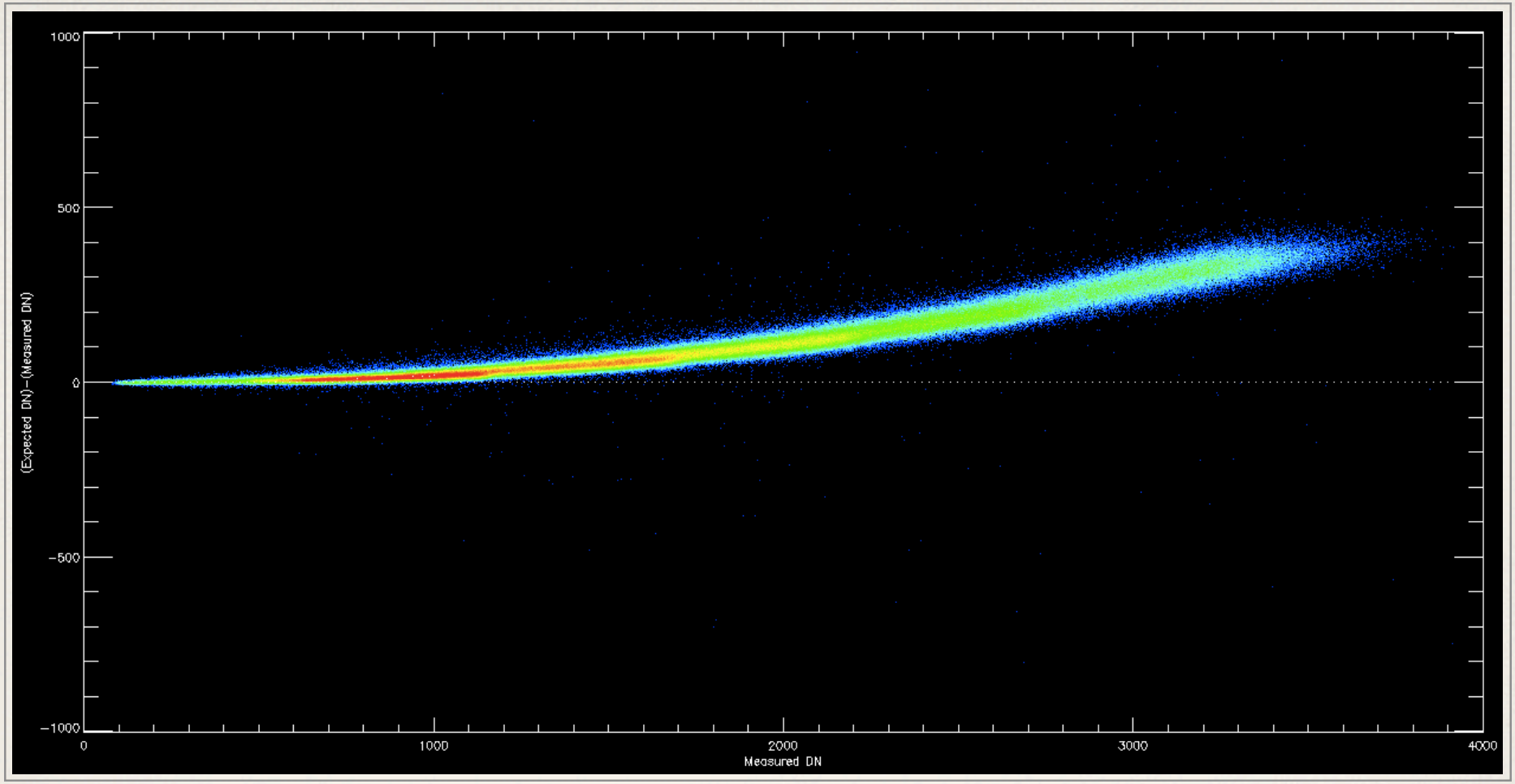
- Pixel-to-pixel variations
- Vignetting
- Other optical issues





Linearity

Detector response is linear to within 5%



Linearity

Detector response is linear to within 5%

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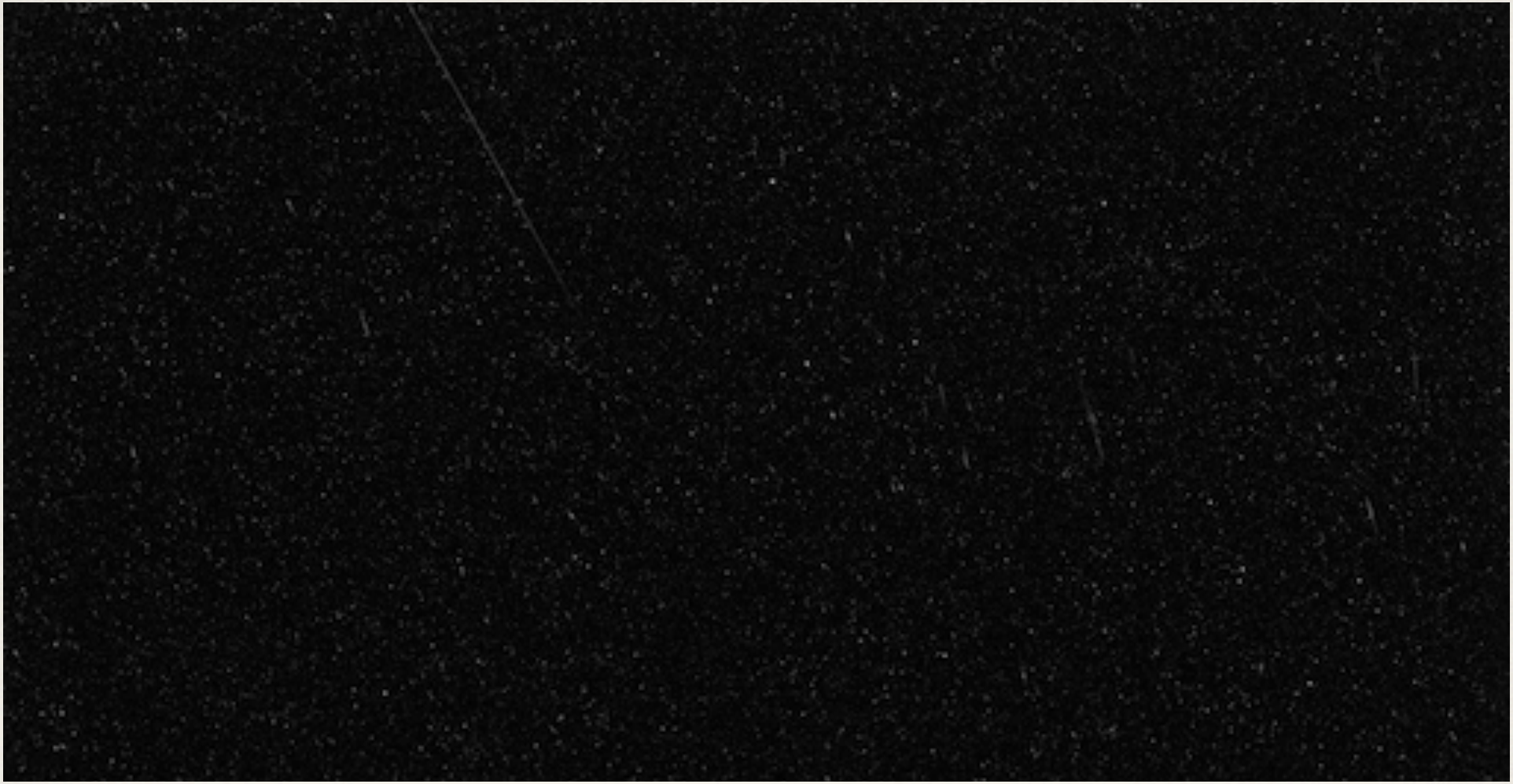
Other Image Properties



Radiation Effects

Additional noise can come from the South Atlantic Anomaly, Solar Wind & Shocks, etc.

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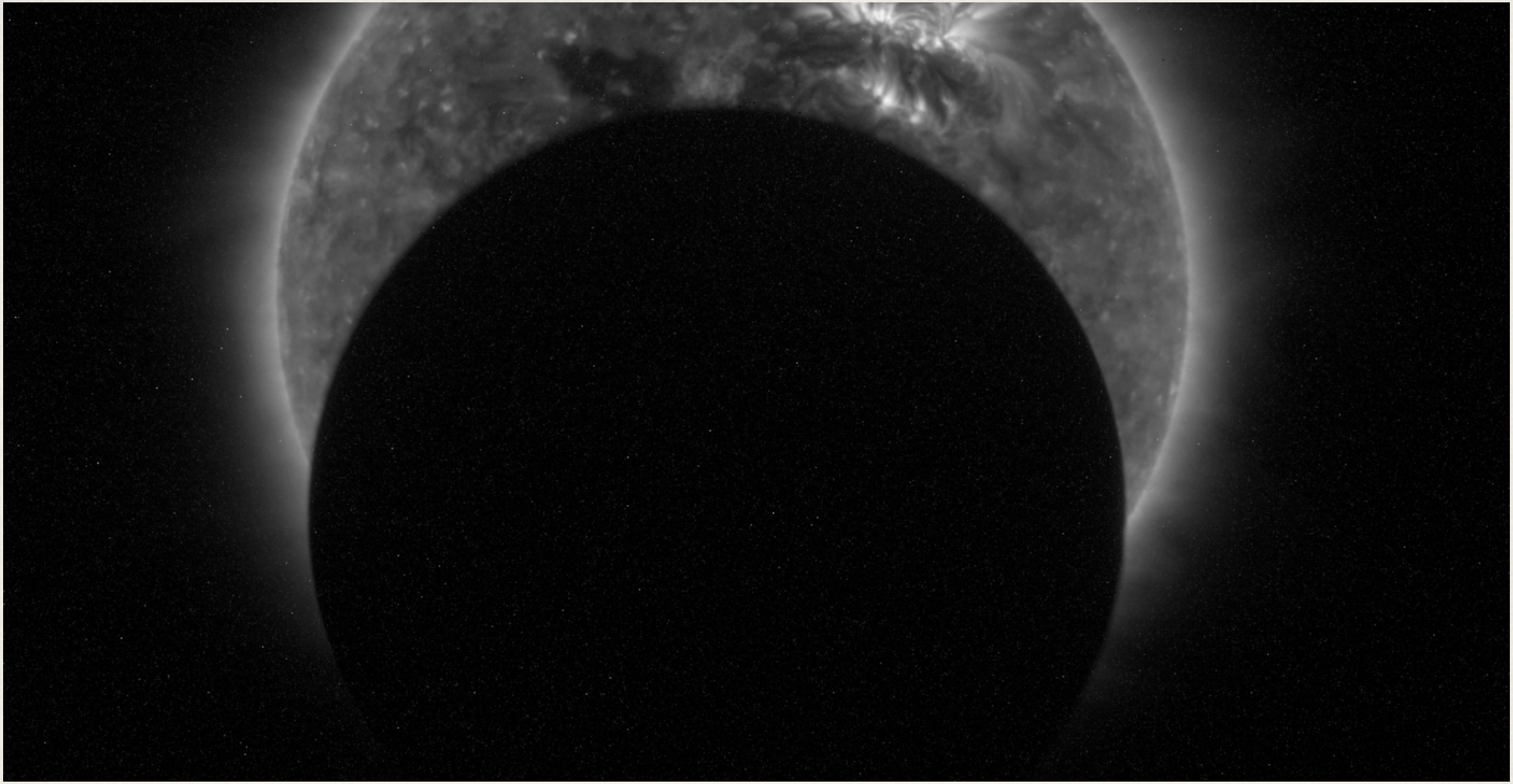

Stray Light

Some measurements made, eclipse images can provide additional data

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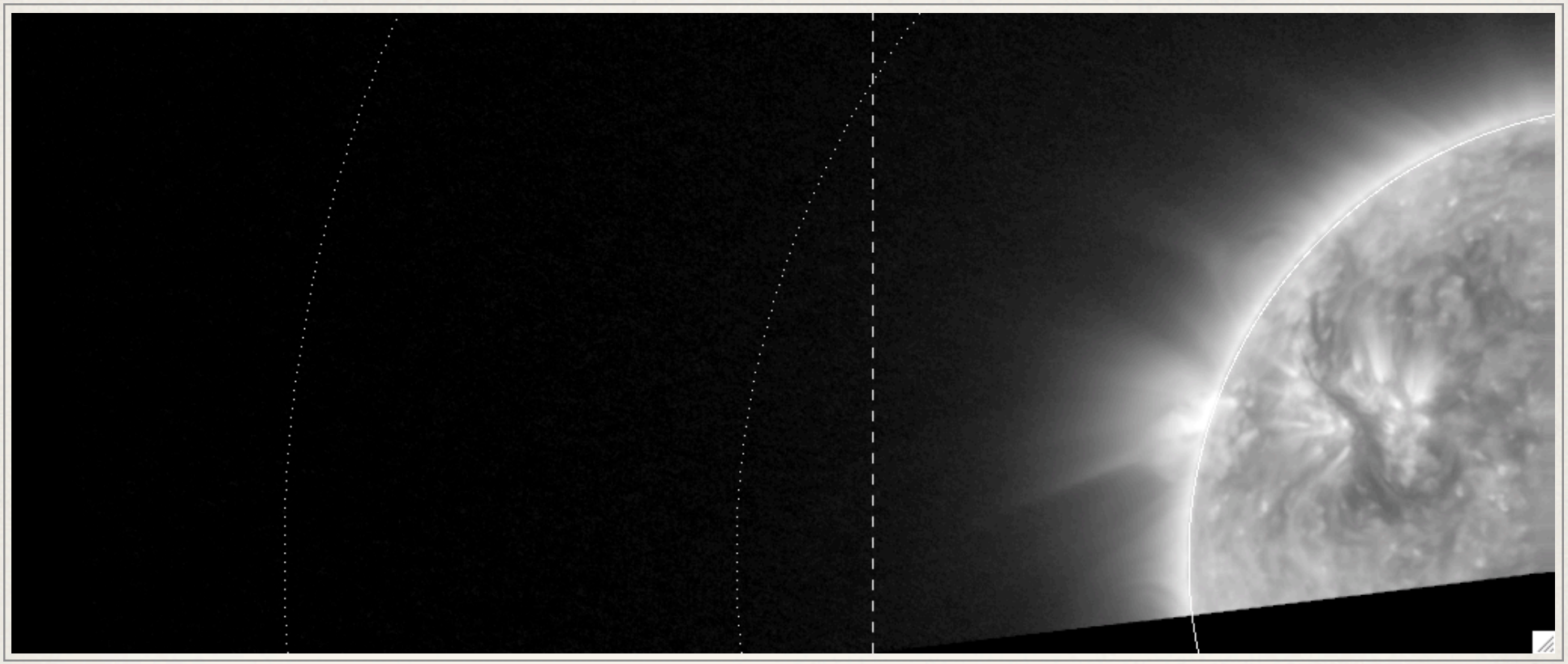
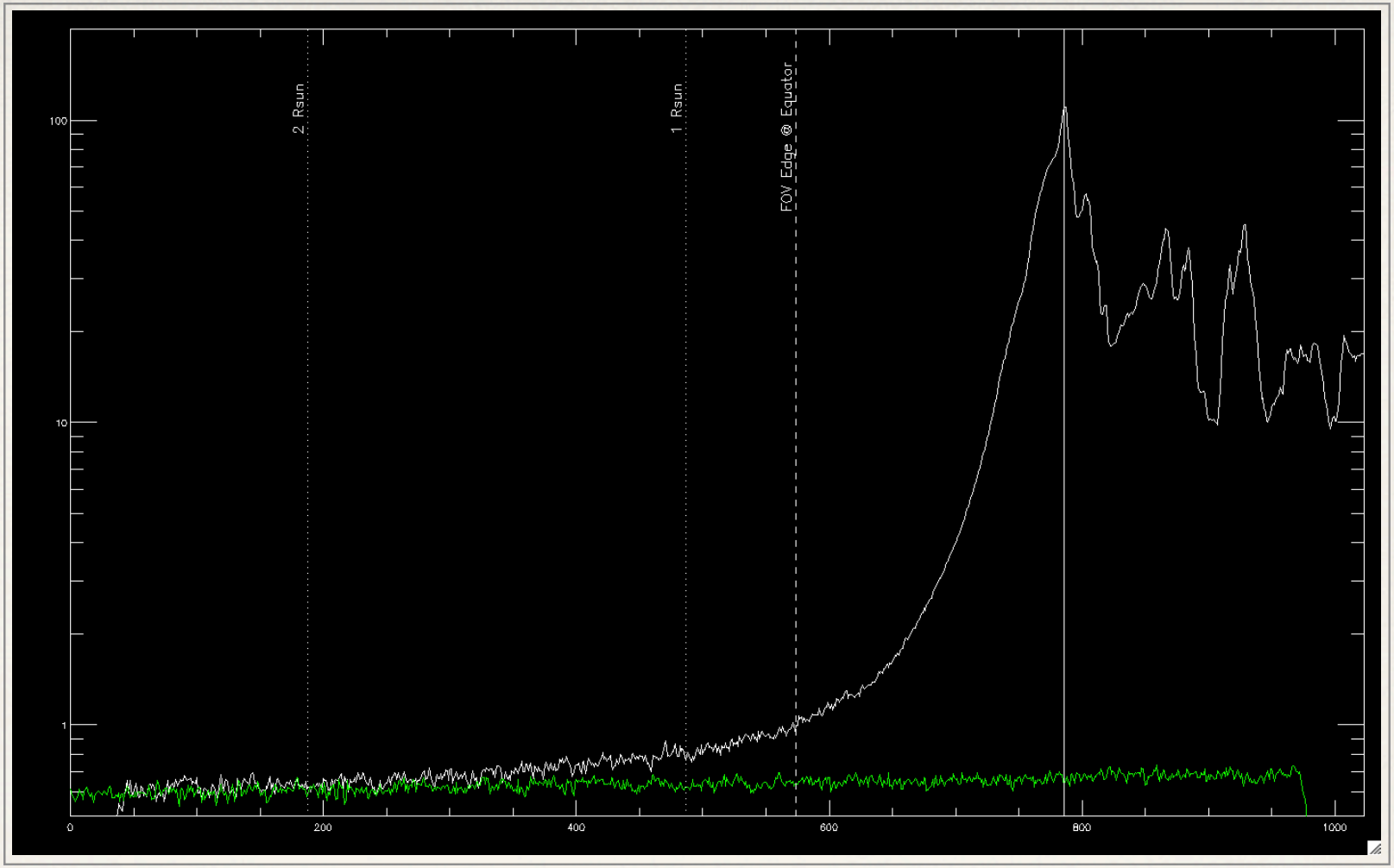


Off-pointed images

Signal is present at distances at least 1.5 R_{sun} above the limb

Proba2 Science Working Team - 14 June 2010



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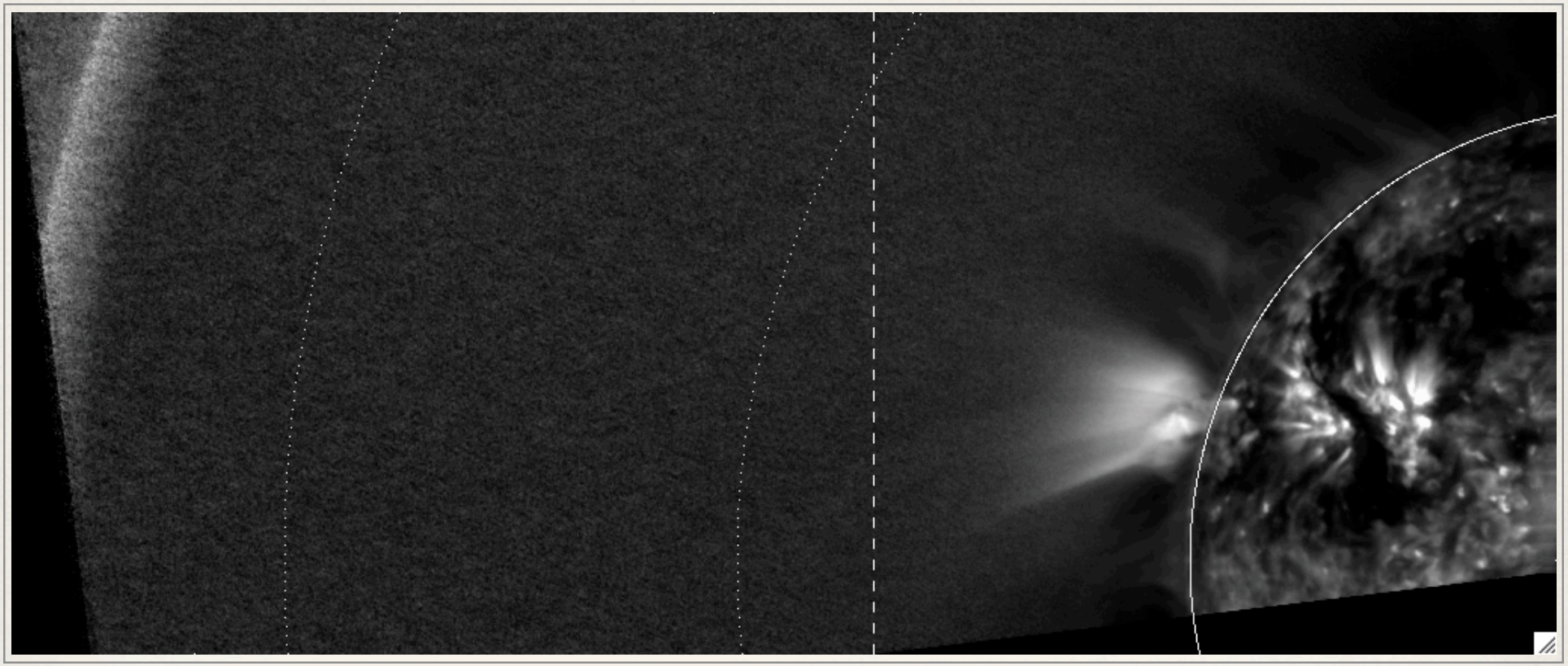

Off-pointed images

Under current quiet conditions, few features extend above 1 R_{sun}

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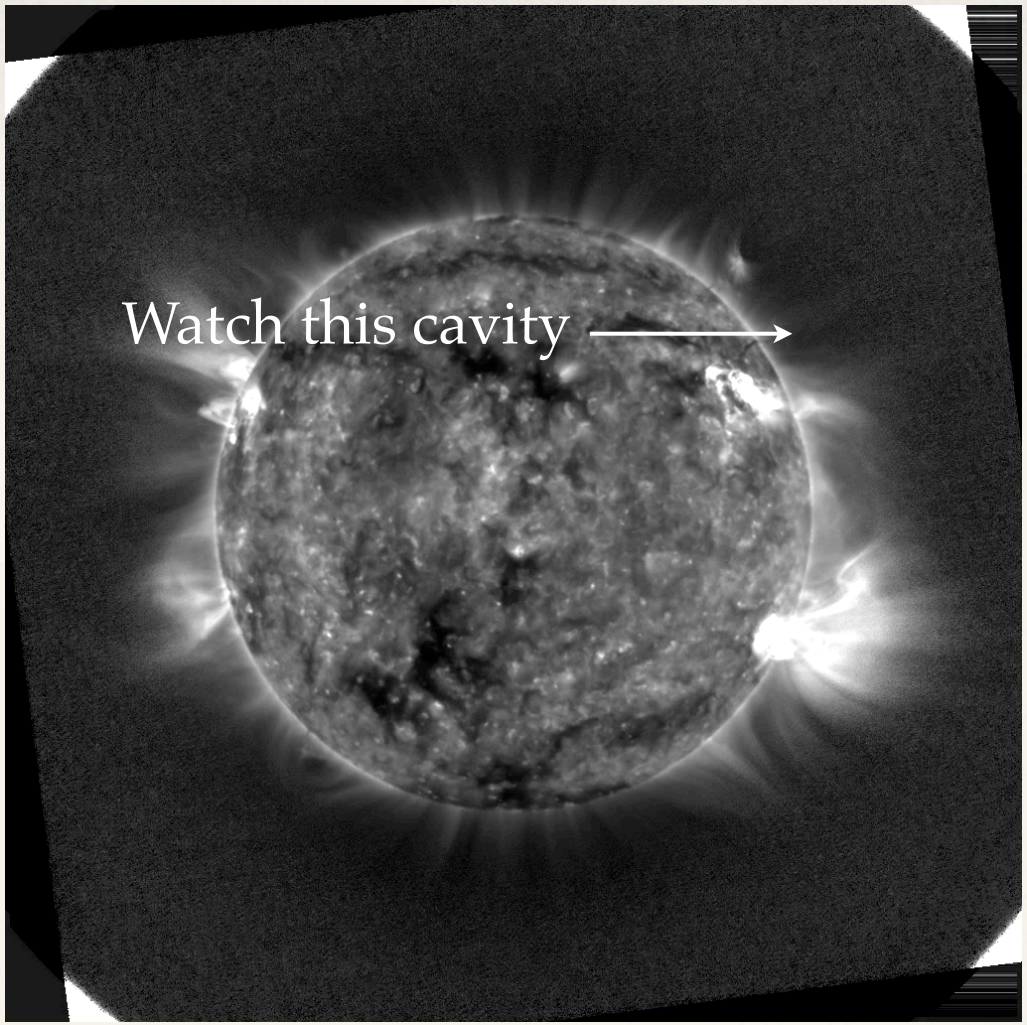
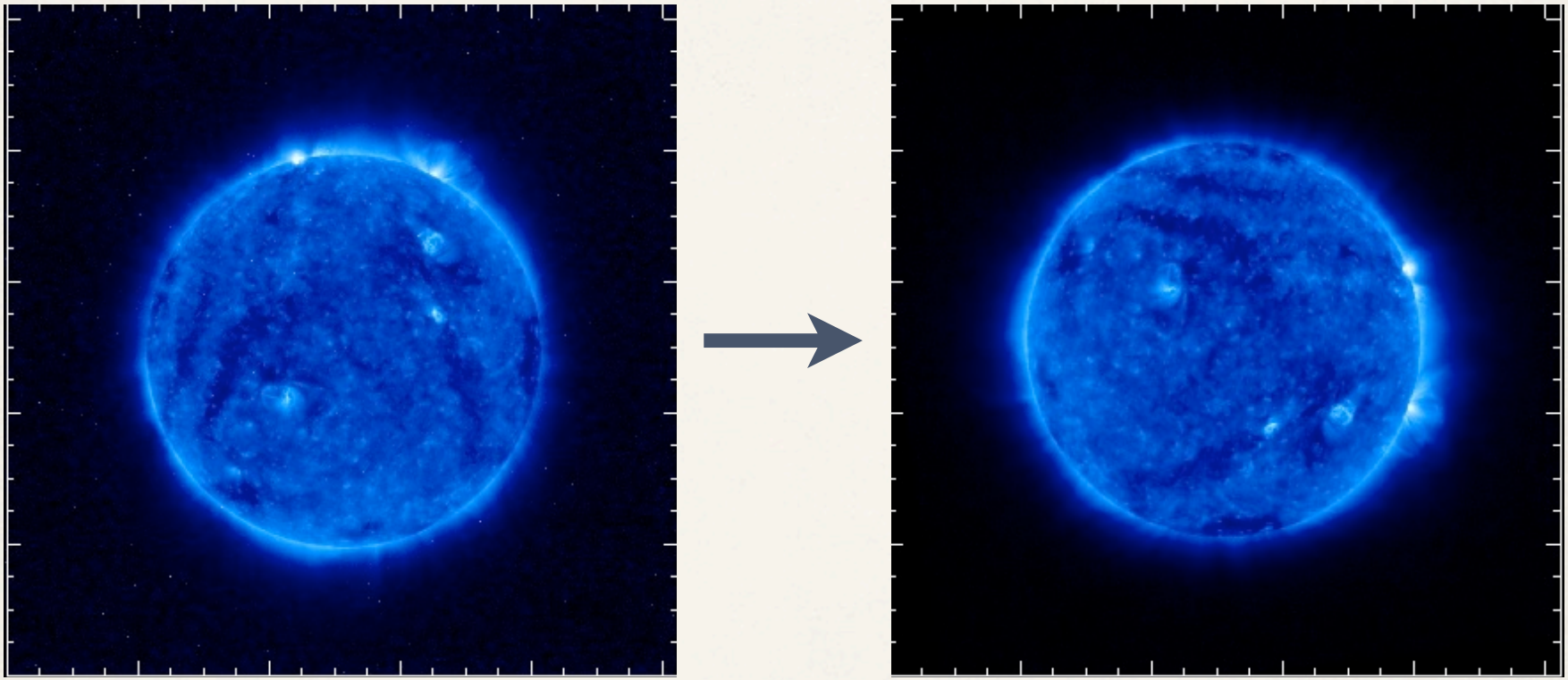


Off-limb signal

Prominence Cavity Eruption - 13 June 2010, UT 03:00:00-10:00:00

Proba2 Science Working Team - 14 June 2010



SWAP Calibration Software

D. Shaun Bloomfield, Daniel B. Seaton, TCD & ROB SWAP Teams

Proba2 Science Working Team - 14 June 2010

Getting Calibration Software

- Requires recent SSWIDL 'gen' update
  - IDL> ssw_upgrade, /swap, /spawn, /loud

- Fetches the following SSWIDL directories for SWAP
  - $SSW/proba2/swap/caldb/ (calibration database: e.g., darks, flats, pixel maps)
  - $SSW/proba2/swap/doc/ (documentation: e.g., instrument paper)
  - $SSW/proba2/swap/idl/objects/ (visualization and analysis software)
  - $SSW/proba2/swap/idl/prep/ (calibration software)
  - $SSW/proba2/swap/resp/ (instrument response data)
  - $SSW/proba2/swap/setup/ (instrument-specific IDL setup scripts)

Running Calibration Software

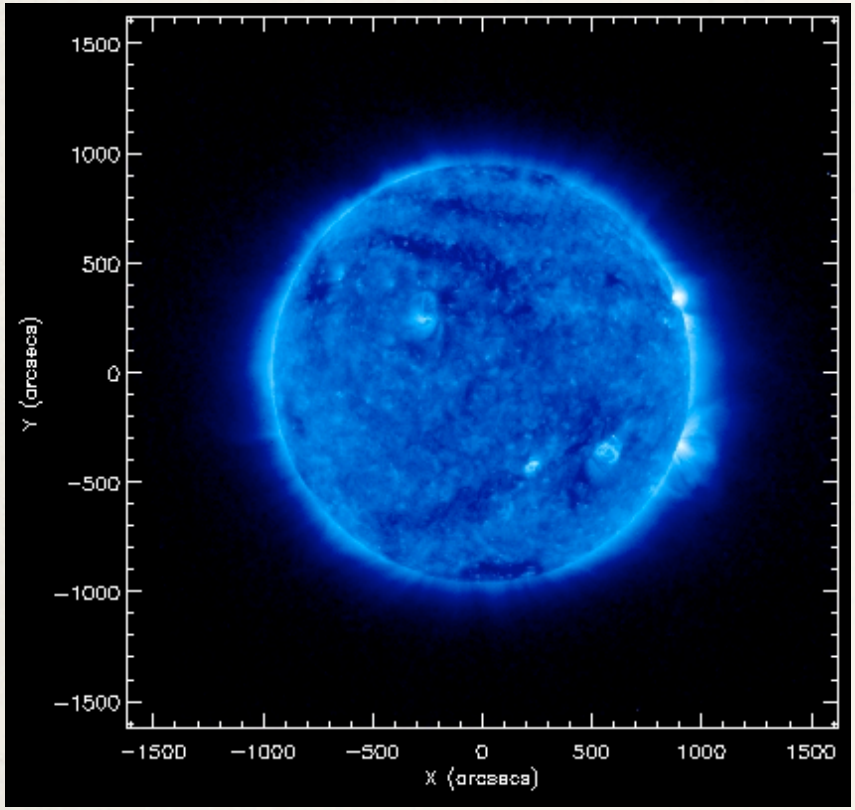
- **Dual-use code**
  - P2SC automated pipeline (high-level info- and error- status reporting)
  - end-user scientists (reduced content optional reporting)
- **Handles single files or filelists**
  - IDL> Infiles = FILE_SEARCH('~/data/swap/swap_lv0_*.fits')
  - IDL> P2SW_PREP, Infiles, Index_out, Image_out
- **Some redundant keywords for end-users**
  - all options explained in detailed IDL routine description text

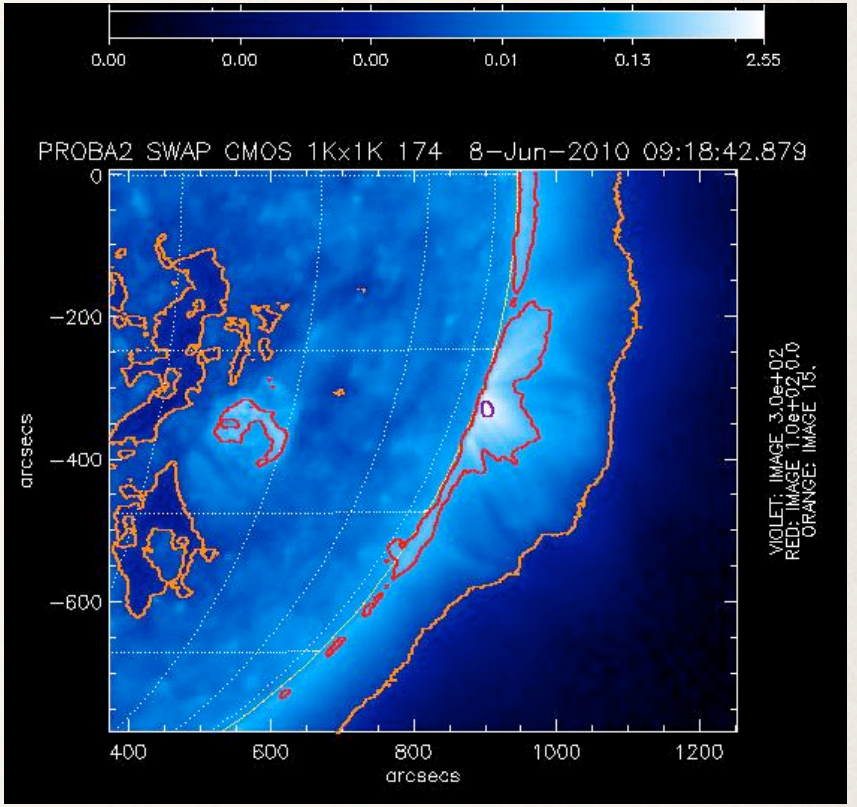
Calibration Steps and Options I

1. Information passing to terminal (optional on-switch: /VERBOSE)
2. FITS validity
3. Filename conformity (optional on-switch: /NAME_CHK)
4. FITS checksum test
5. FITS header conformity
6. Reinstate pixels x2/x4 onboard (optional off-switch: /NO_PMCDIV)
7. Reinstate pixels identified as cosmic rays onboard (optional off-switch: /NO_PIXREP)
8. Saturated pixel replacement
9. Dark current subtraction (optional off-switch: /NO_DARK)

Calibration Steps and Options II

10. Replace pixels not read out onboard (optional off-switch: /NO_PMCREP)
11. Flat-field correction (optional off-switch: /NO_FLAT)
12. Image despiking (optional on-switch and threshold level: /DESPIKE, SPIKE_SIG=6)
13. Sun centering, pixel rescaling, and rotation (optional master and individual off-switches)
14. Time normalization (optional on-switch: /NORMALIZE)
15. Retention of floating-point precision images (optional on-switch: /FLOAT)
16. Retention of all index headers and images in data cube (optional off-switch: /NO_CUBE)
17. Individual FITS writing (optional on-switch and location: /OUTFITS, OUTDIR=CURDIR())
18. Error checking procedure halt (optional on-switch: /DEBUG)





SWAP Visualization Software

Paul A. Higgins, D. Shaun Bloomfield, TCD & ROB SWAP Teams

Proba2 Science Working Team - 14 June 2010

Concept for Visualization and Analysis Software

- Object-oriented software package
  - object definition and configuration codes in $SSW/proba2/swap/idl/objects/
  - inherits framework and object functionality from $SSW/gen/
- Fully configurable
  - customized session-to-session defaults in SWAP_OBJ_CONFIG.PRO
  - specific changes within an object's lifetime are remembered
- Website tutorial for the SWAP object (http://www.solarmonitor.org/objects/swap/)

Running Visualization and Analysis Software

- Create object
  - IDL> swap = OBJ_NEW('swap')
- Set data level, prepping required, and data source
  - IDL> swap -> SET, FILTER = 'lv1', PREP = 0, LOCAL = 1 ; Level-1, no prepping, from local hard disk
  - IDL> swap -> SET, FILTER = 'lv0', PREP = 1, LOCAL = 0 ; Level-0, to be prepped, from remote server
- List full-path filenames (local = 1, filesystem path; local = 0, http address)
  - IDL> flist = swap -> LIST(TIMERANGE = ['8-Jun-2010 08:15:00', '8-Jun-2010 09:00:00'])
- Copy files, read into IDL, and plot image
  - IDL> swap -> COPY, FILELIST = flist[0:10] ; only if local = 0
  - IDL> swap -> READ, FILELIST = flist[0:10] ; includes run through P2SW_PREP if PREP = 1
  - IDL> swap -> PLOT, FILELIST = flist[0] ; or just run this line, object knows to copy and read data

P2SW_PREP Calibration Steps

- FITS files checked for suitability (checksum, header content; optional name check)
- Pixels modified onboard reinstated and corrected (optional off-switches)
- Standard calibration steps (saturation, darks, flats; optional off-switches)
- Image optionally despiked using local-pixel statistics (optional threshold level)
- Image transformed (sun centered, rescaled pixels, rotated to solar North up; optional off-switches)
- Final image options applied (integer/float, IDL data cube, FITS writing)