SODISM Product levels philosophy and Instrumental corrections

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Presentation outline

1. N0, N1, N2 products
2. Instrumental corrections
3. N1 sub levels
4. From Flight calibration to CMSP processing
5. Corrections status

N0, N1, N2, etc.

1 – PRODUCT LEVELS PHILOSOPHY

Level 0 “N0”

- N0 product = FITS image
  - Raw (only reformatted from TM)
  - Header = all relevant information available at N0 creation
    - HK info (e.g. T° CCD)
    - CMSP info (e.g. version #)
    - CCC info (e.g. PICARD longitude)
  - N0P: automatically computed index in view of performance monitoring
    - Future plans: figures too
- N0 products are sorted into thematic directories
  - e.g. MDO/RS/, MNM/HL/, etc.
- A database gathers N0 header information
  - Complex SQL query ☺
- N0 production = full success ☺

Level 1 « N1 »

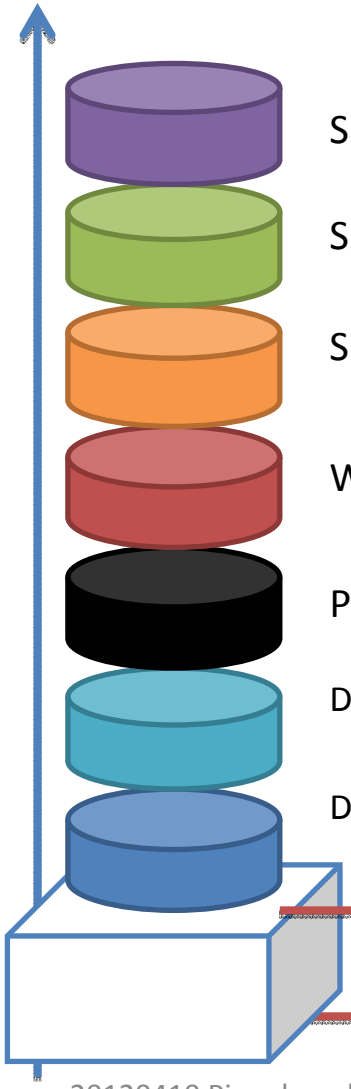
- N1 product = FITS image
  - Instrumental effects addressed at level 1 (and only at level 1)
  - N1 image = corrected N0 images
    - Directly into N1 image if univocal correction estimation 'N1X'
    - Otherwise, 'N1Z' auxiliary file available for ulterior optional correction (e.g. PSF)
      - Required correction precisions depend on exact application
  - N1 header
    - Propagation N0 info
    + Information necessary to N2 production (e.g. R_sol)
      Can be crucial to subsequent exploitation!
- N1 directory organization: idem N0
- N1 database
  - Should be *a posteriori* supplemented with analysis outcomes

Level 2 and higher

- N2 = astrophysical information
  - N2 data computed from N1 products
- Higher levels (N3, N4) could be defined
  - E.g. image files (PNG) and movie files to facilitate quick and ergonomical exploitation of PICARD archive
- N2-3-4 beyond the scope of the present talk

2 – THE REQUIRED CORRECTIONS

The additive signal in a SODISM pixel



Signal due to cosmic ray hits

Signal due to optical ghosts

Signal due to scattered light (front window, mirrors, filters…)

Wanted signal = Gain[DN/e-] * QE(x, y, t, previous image) [e-/ph_in] * Φ [ph_in]

Persistence

Dark current (CO) generated in the CCD image zone (ZI), incl. ZI ‘hot pixels’

Dark current (CO) generated in the CCD memory zone (ZM), incl. ZM ‘hot pixels’

Offset

0 DN

Required corrections sorted per type

Subtraction

- Offset
- Dark current
  - Hot pixels
- Persistence
- Ghosts
- Cosmic ray hits

Division

- Flatfield

Deconvolution

- PSF
  - Scattered light
  - Kinematic blur
  - Aberrations, defocus
- CCD CTE

Anamorphose

- Distorsion
  - Incl ‘scale factor’

N1A, N1B, N1C & N1D

3 – N1 SUB-LEVELS

N1 sublevel definition

Réf.	Title	N1 A @ CMSP	N1 B « Best effort »	N1 C « Confirmed »	N1 D « Definitive »
WP-1a	Offset	Yes	Yes		
WP-1b	Dark current	Preliminary	Target		
WP-1c	Persistence	No	If possible	Target	
WP-1d	CRH	No	Yes		
WP-2	CCD CTE	No	No	If possible	Yes
WP-3	Flatfield	Preliminary	Target		
WP-4	Point Spread Function – PSF	No	No	Target	
WP-5	Ghosts	No	Crescent ghost	Annular ghost	
WP-6	Distortion	No	No	Target	Yes
WP-7	Scale factor	No	No	If possible	Target
WP-8	QE & radiometric corrections	Preliminary	No	No	Target

Flight operations, algorithm development, validation, coding, NRT and a posteriori processings

4 – FROM CALIBRATION TO PRODUCTS

Process leading to an N1 product

1. Special or routine flight operation and data analysis
2. Algorithm development
3. Algorithm validation
4. Coding
5. Code verification
6. Code integration at CMS-P
7. Calibration matrix production
8. Processing or reprocessing
9. N1 & N1Z product control

Planning

- N1A available now
- N1B sub-level
  - Offering improved dark current and flatfield corrections
  - Correcting for the crescent ghost

  Should be available by the summer 2012
- N1C sub-level
  - Correcting for the PSF
  - Correcting for the persistence

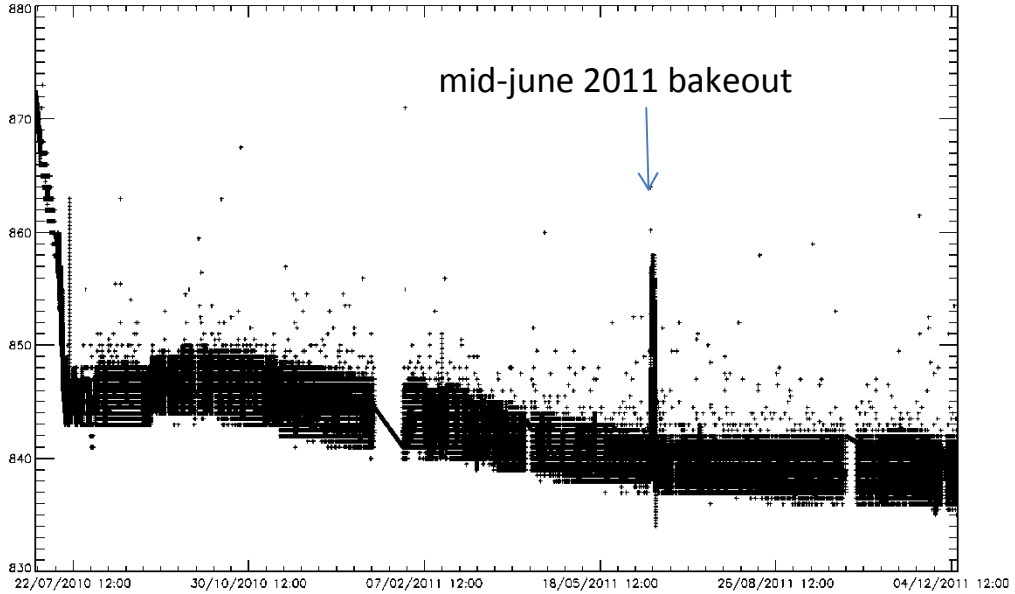
  Should be available by the fall 2012

Offset, dark signal, cosmic ray hits, ghosts, flatfield, persistence, PSF

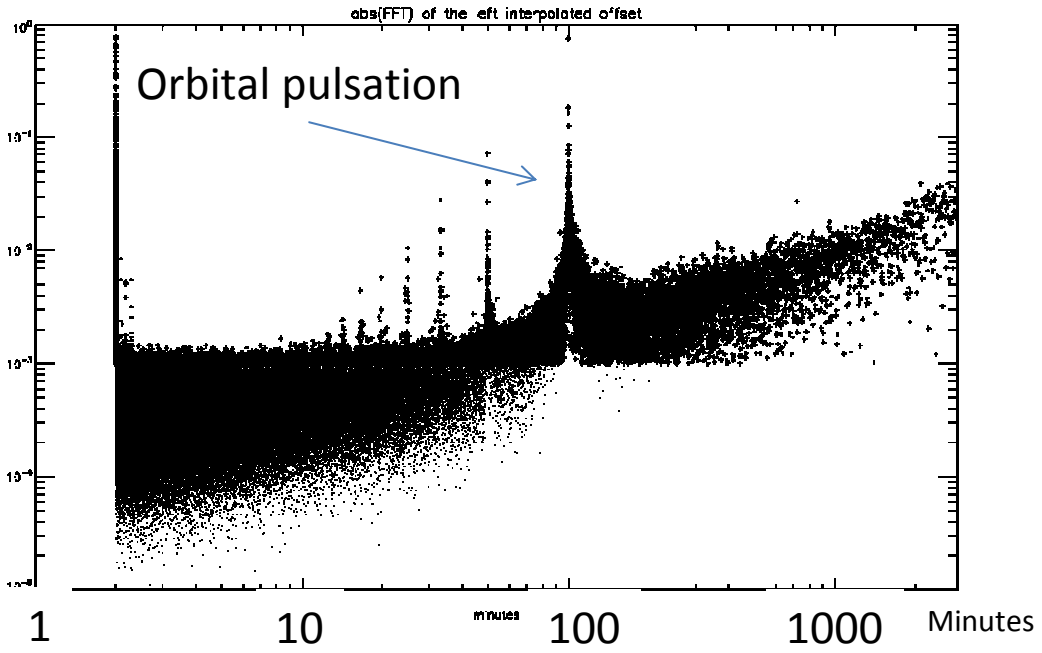
5 – CORRECTIONS STATUS

Offset

Time evolution of the left offset
(measured onboard by averaging underscans)

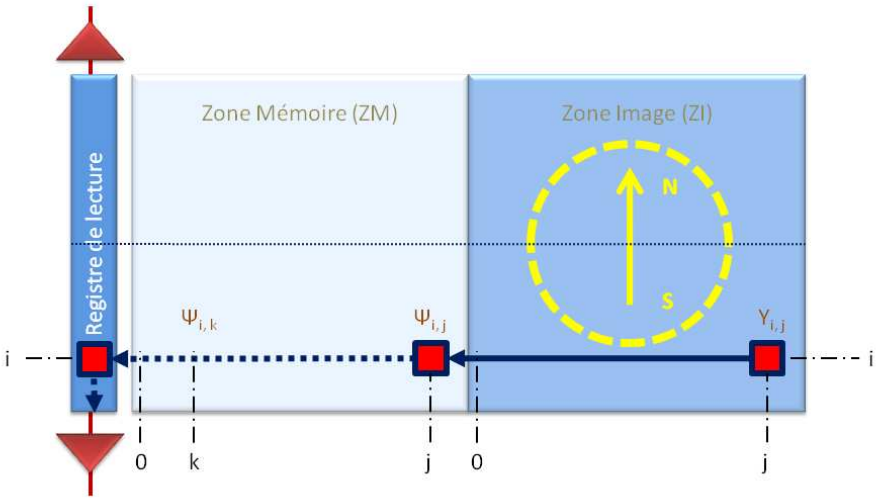


Power spectral density
of the offset time series

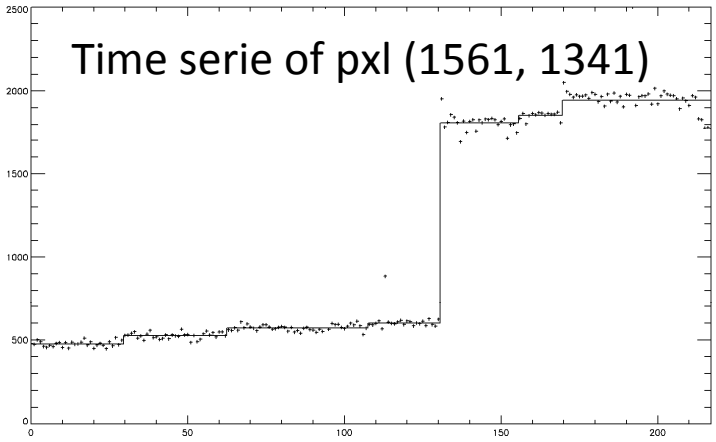


SODISM dark current

- Model produces daily pairs of ZI & ZM dark images
- Based on an analysis of the dark signal time series of every pixels
- Extracting the steps that are generated by the occurrence of a new hot pixel either in ZI or ZM

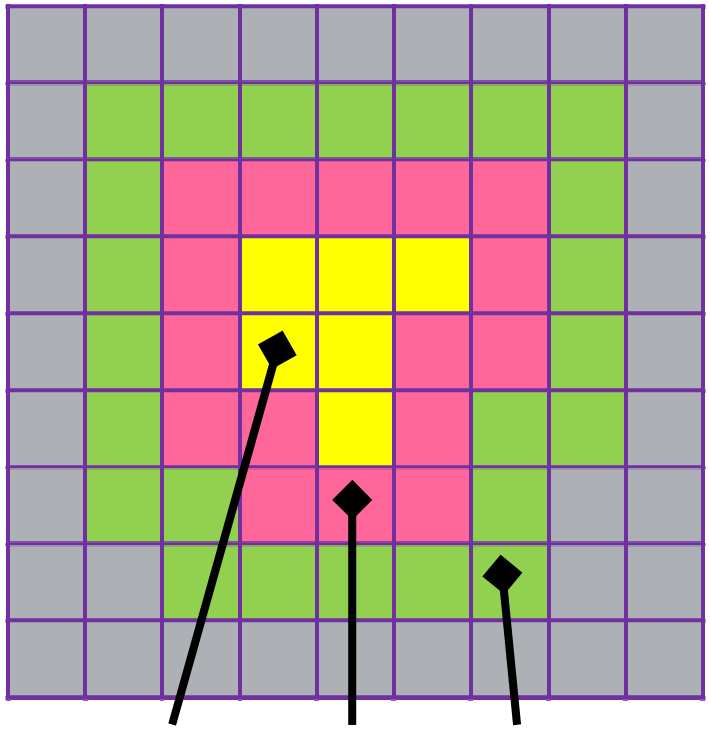


$$CO^{i\,j\,t} = O^t + G\left(T^t\,\Upsilon^{i\,j\,t} + \tau\,\psi^{ijt}\right)$$

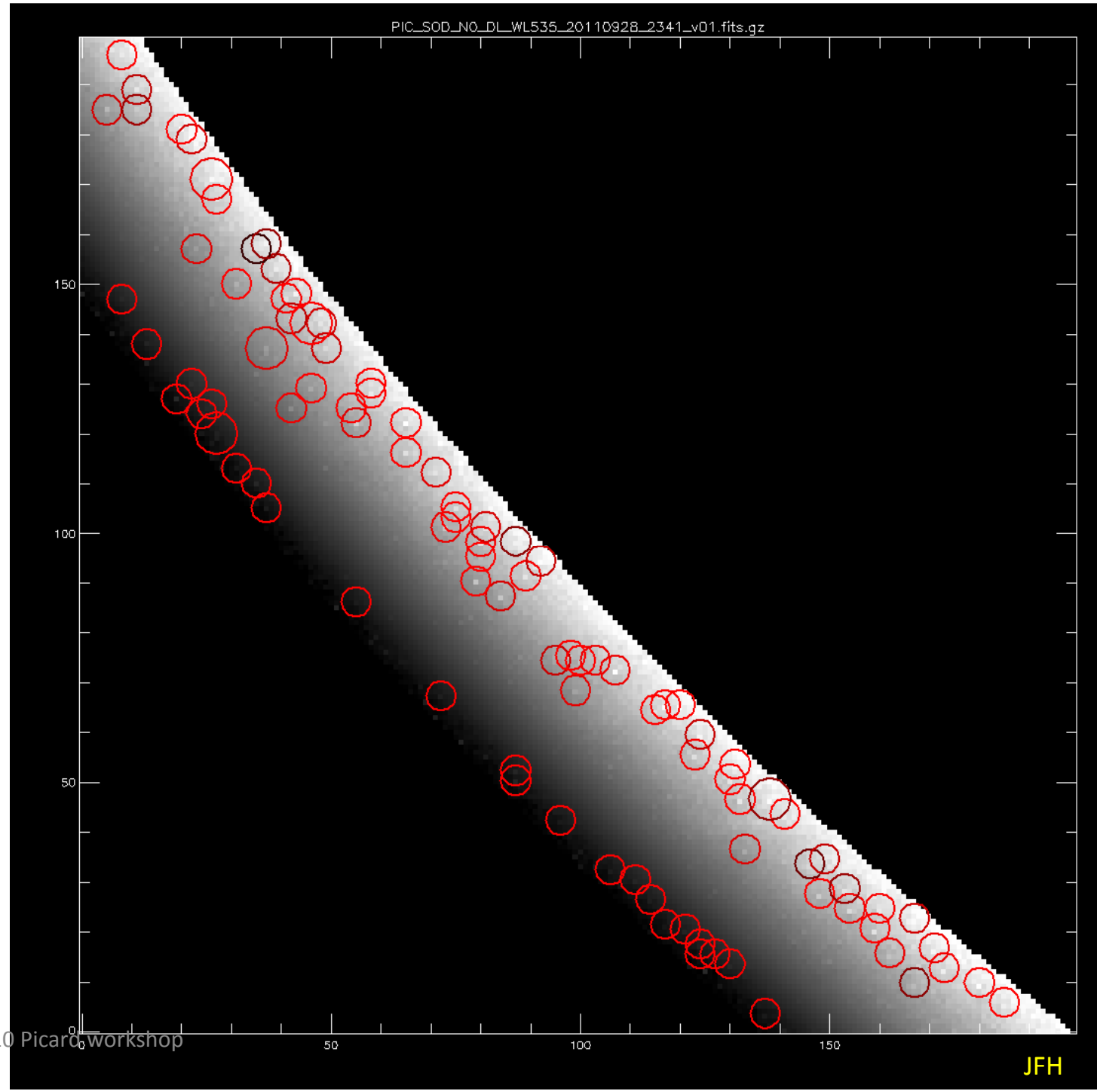


Cosmic ray hits correction

- Algorithm available
- based on local regularity
  - Hölder type criterion
- Issue related to the lossy LGV compression:
  - CRH eat up the TM budget, esp. for long exposure times



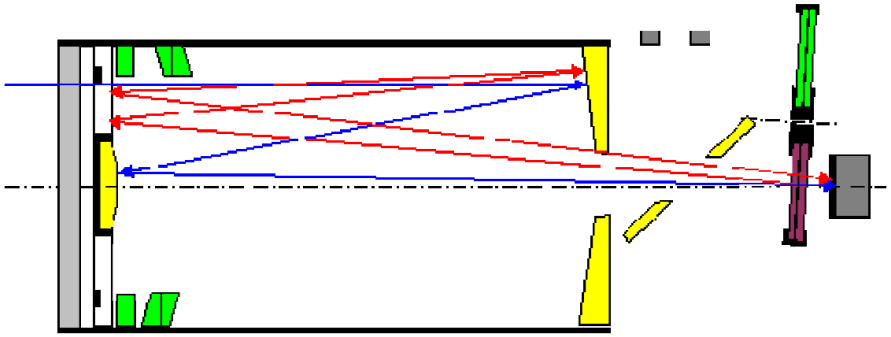
Event – Areola – Circlet


PIC_SOD_N0_DL_WL535_20110928_2341_v01.fits.gz
150
100
50
0
0
50
100
150
JFH

Crescent ghost

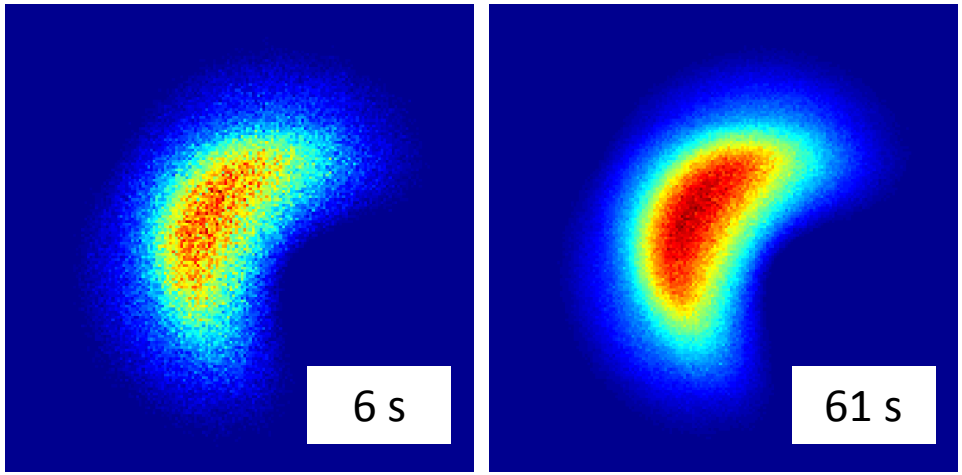
- Origin:

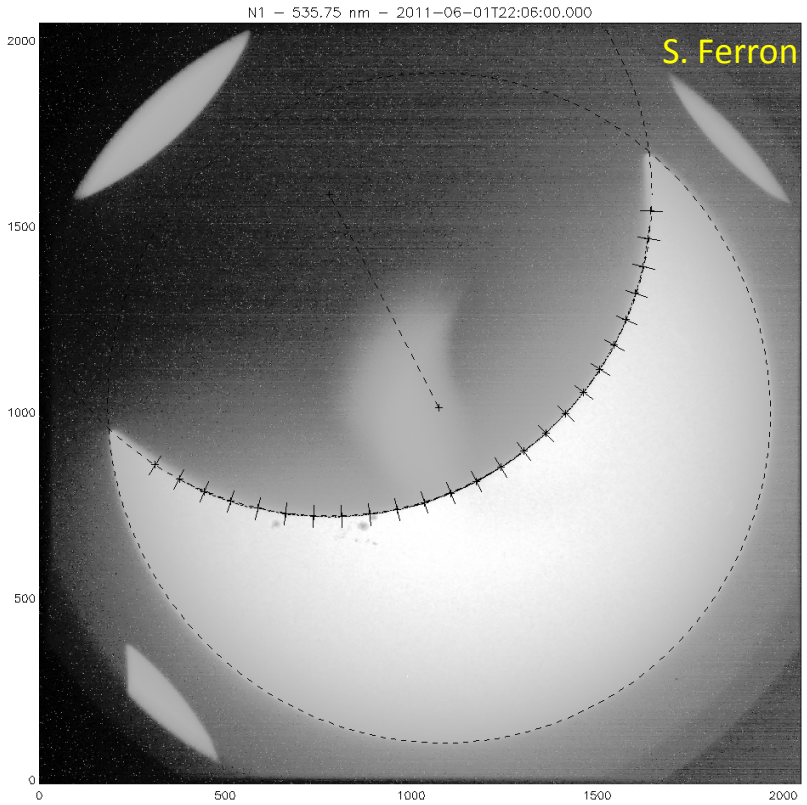
From P. Etcheto 2007



- Model:

N. Rouanet & J.-F. Hochedez 2012

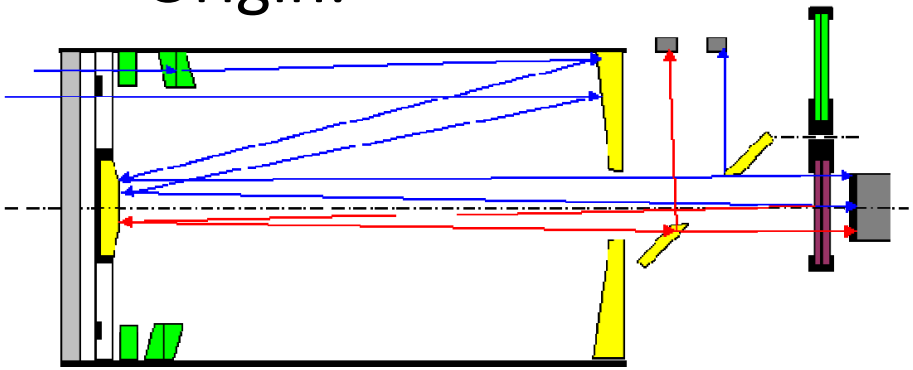




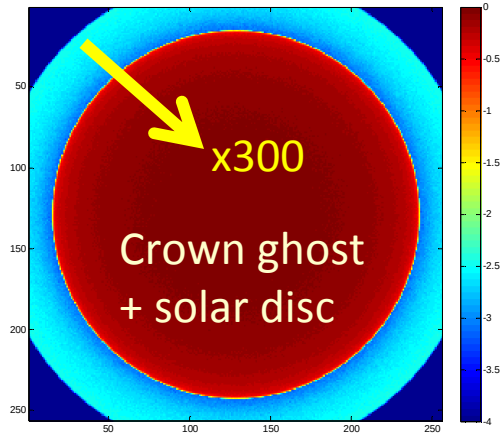
The optical configuration (filters tilt) is being inverted

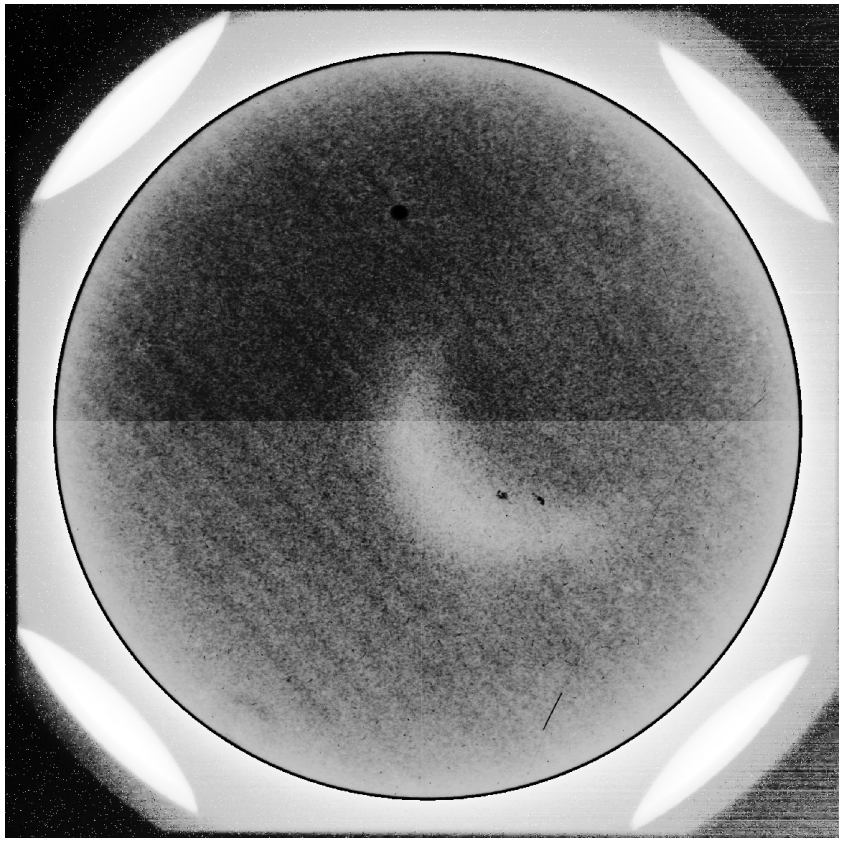
Crown ghost

- Origin: *From P. Etcheto 2007*



- Model: *N. Rouanet & J.-F. Hochedez 2012*

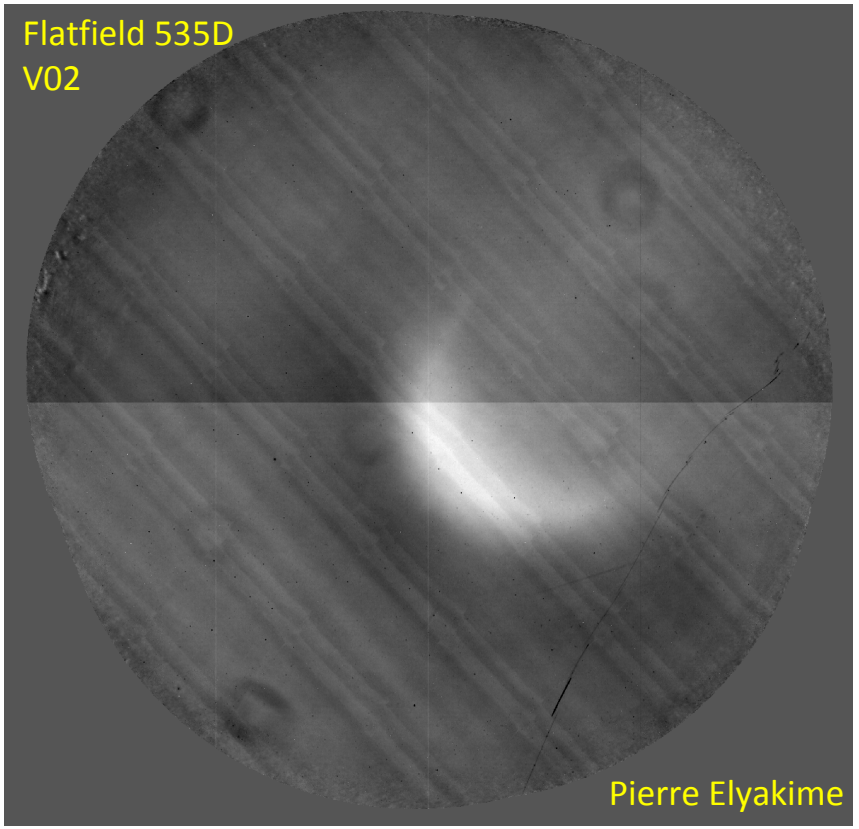




SODISM 535nm
Parameterized disc subtracted and contrast boosted

Flatfields

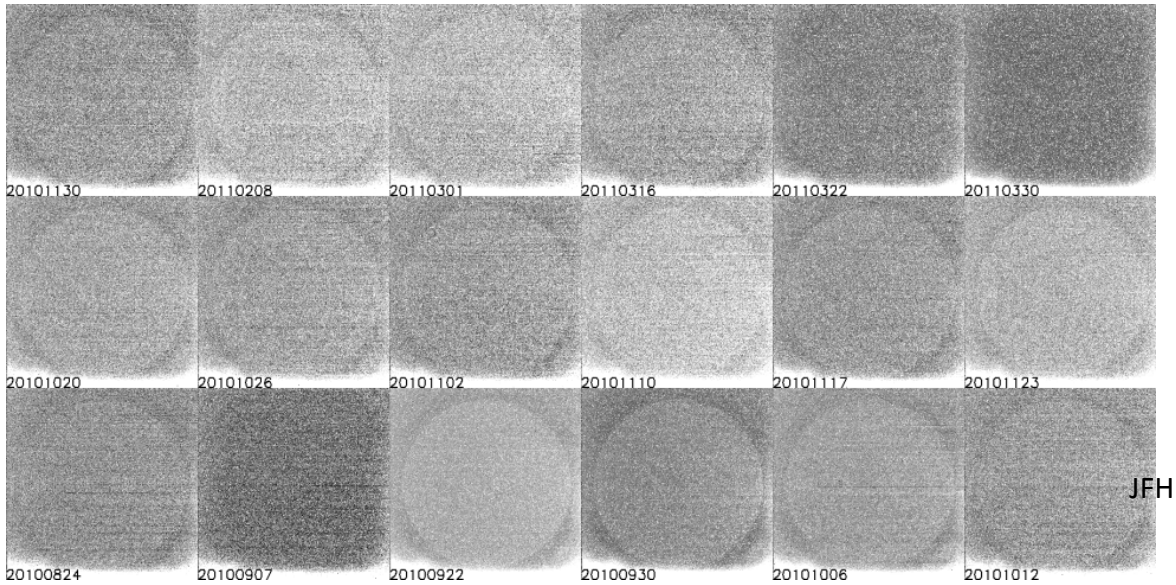
- 1 estimation concept
  - Moving a presumably still image with respect to the instrument
  - Various components!
    - CCD flatfields
    - Filter flatfields
  - Various spatial scales!!
- 3 algorithms
  - Kuhn et al 1991
  - Toussaint et al 2003
  - Hochedez et al 2012 (in prep)
- Many datasets
  - offpoints via piezos of the M1 mirror
  - Platform Z-axis rotation (MDO)
  - Solar rotation



- Flatfields evolve but little & slowly
- Use of the diverging lens TBD

Persistence

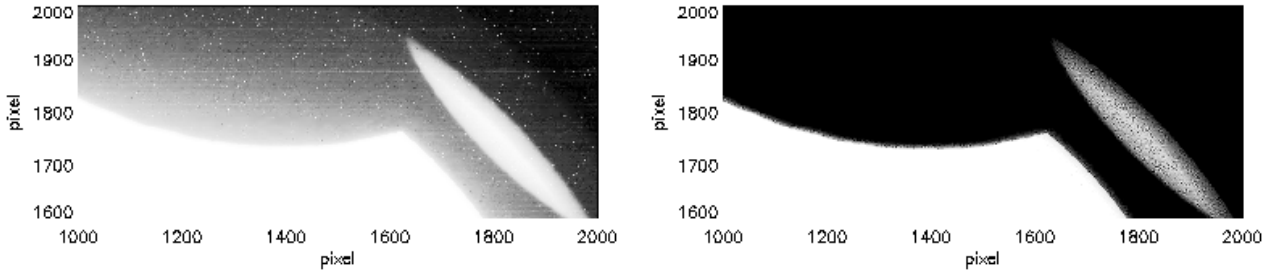
- An hysteresis is observed in dark signal images
  - ~ 0.2 ADU/pxl/sec



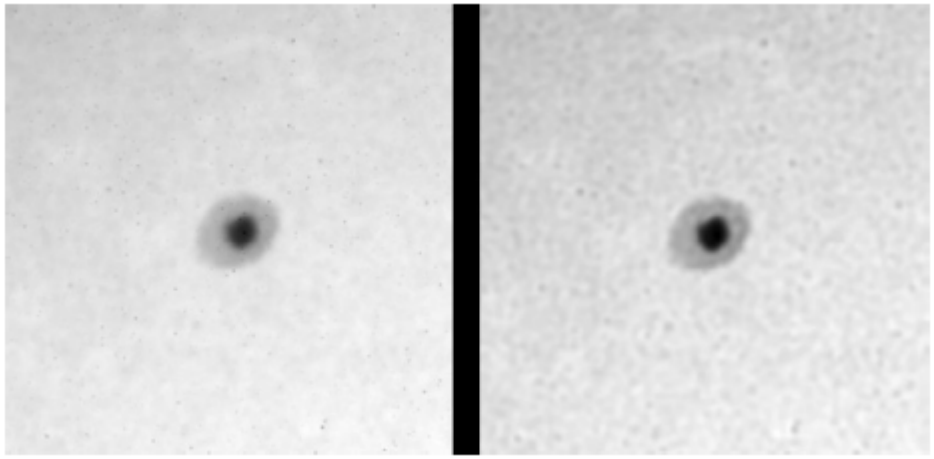
JFH

- Another persistence has been noticed in illuminated images
  - Of different origin
  - Under investigation

PSF

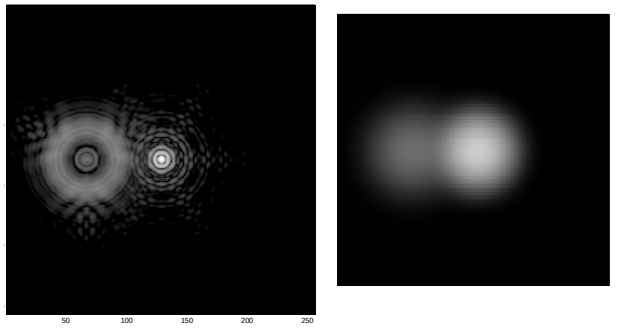


- The PSF accounts for
  - diffraction
  - Kinematic blurring
  - Scattered light (wings)
  - Defocus and other aberrations



Without PSF deconvolution After PSF deconvolution

- The PSF is unknown
  - non axisymetric
  - non shift-invariant
  - Evolutive
- We have no choice but implement a "blind deconvolution" supported by instrumental priors
- Currently some success using a parametrical PSF made of two Gaussians:



Four tracks to estimate the PSF

1. Eclipse exploitation
   - Sharp lunar limb ☺
   - Lunar limb can reach the center of the FOV ☺
   - 1D degeneracy ☹
   - 2 - 4 eclipses per year ☹
   - Pointing off ☹

     → Non representative

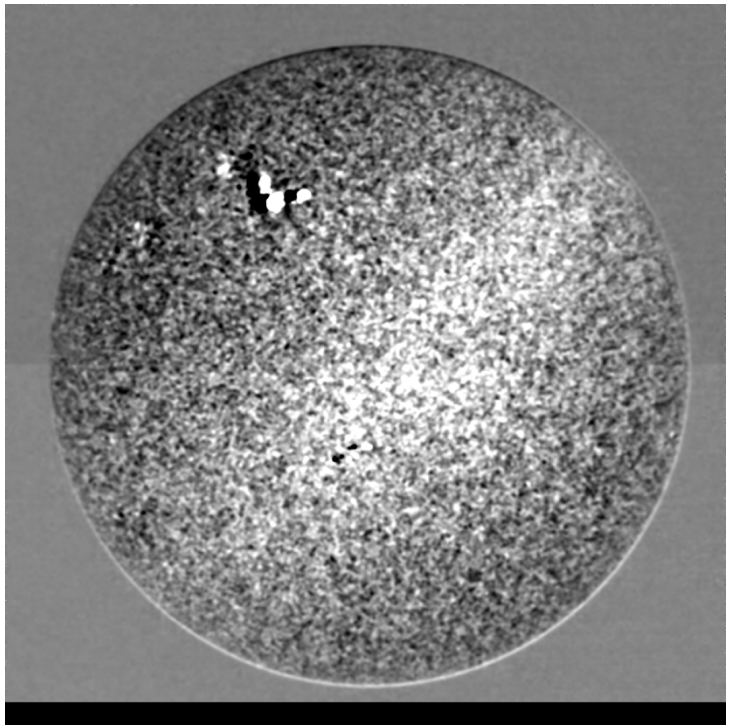
2. Solar limb inversion
   - Radial profile not well known
   - 1D degeneracy ☹
   - Continuous monitoring ☺

3. Stellar observation
   - *Direct* PSF measurement if bright star ☺
   - Unrepresentative thermal configuration ☹
     - Thermal model needed to bridge

4. Optical modelization
   - Match model and observations
   - To be articulated with other approaches!

Other corrections

- CCD charge transfer efficiency
- Optical distorsion
- Signal at T_exp=0 ➔



Conclusions

- Elaborating corrections takes:
  - Time and effort to understand the data and the instrument
  - Special measurement campaigns
- Precision will improve in cycles
  - Best at proximity of special observation
  - ➔ Setup flight operations accordingly
- Correction requirements depend on science goal