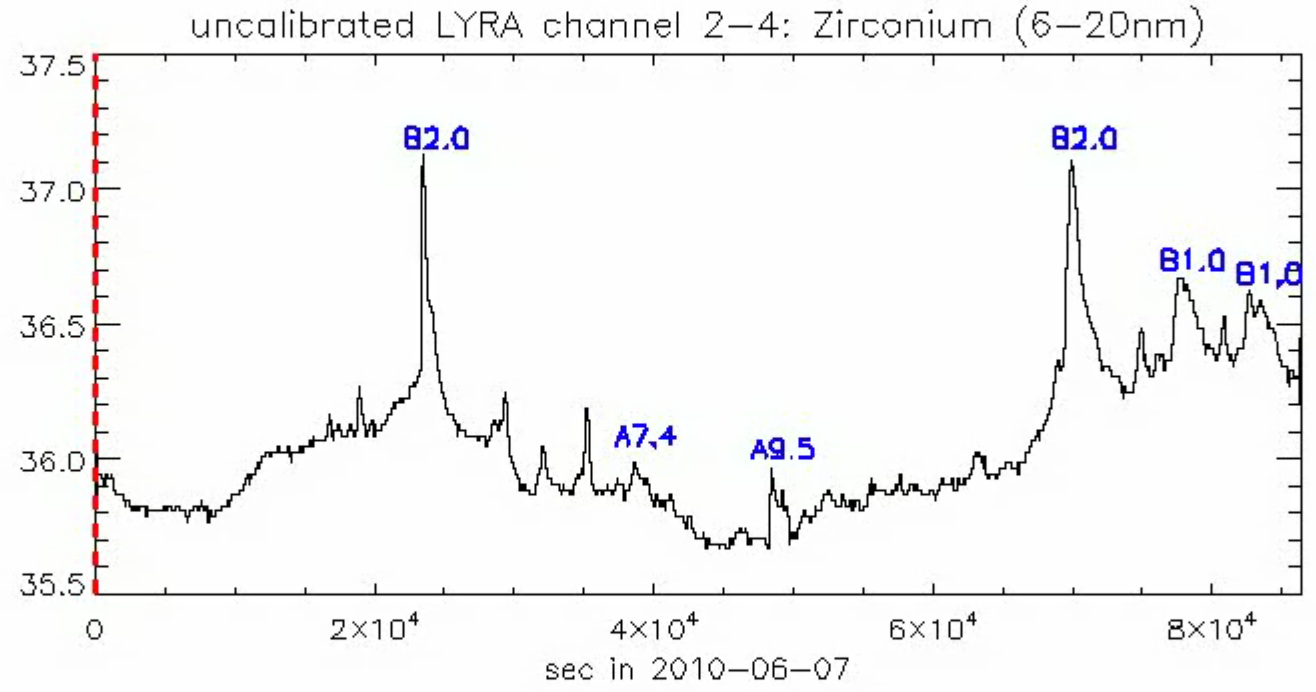
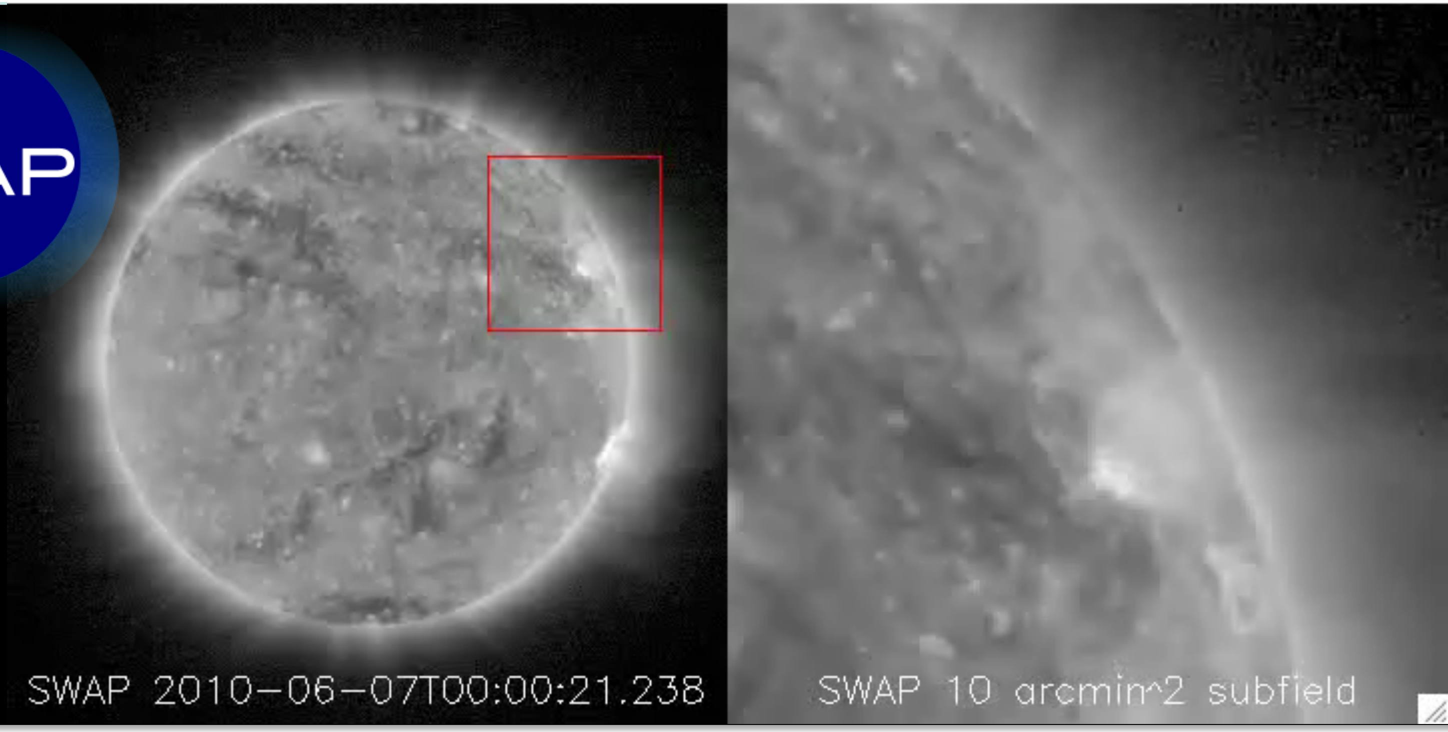
Statistical analysis of variability in SWAP image sequences

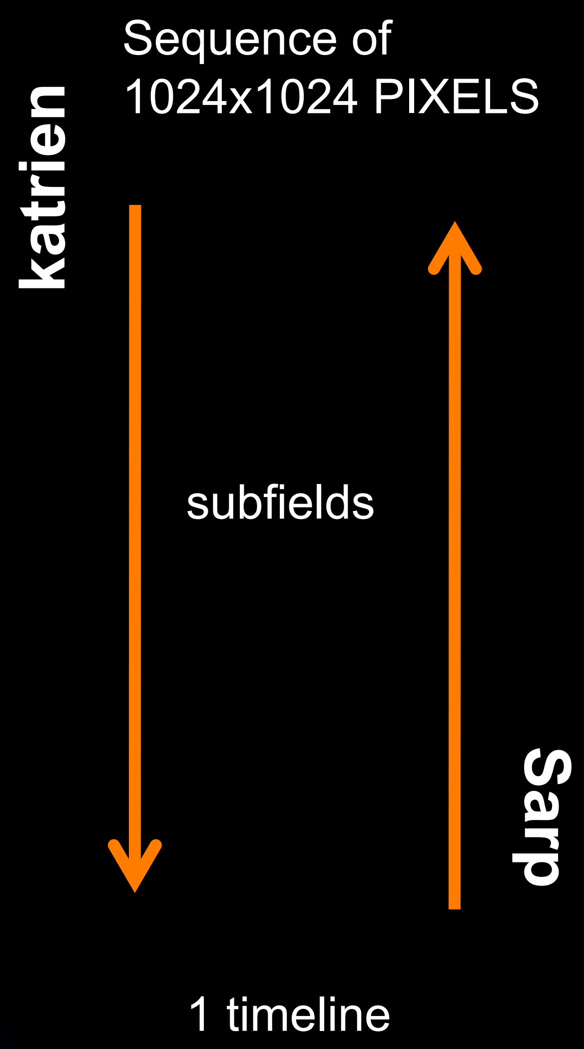
K. Bonte & Y. S. Mehmet (KULeuven)
D. Berghmans (ROB)
A. De Groof (ESA/ROB)


uncalibrated LYRA channel 2-4: Zirconium (6-20nm)
37.5
37.0
36.5
36.0
35.5
B2.0
B2.0
B1.0
B1.0
A7.4
A9.5
0
2x10^4
4x10^4
6x10^4
8x10^4
sec in 2010-06-07

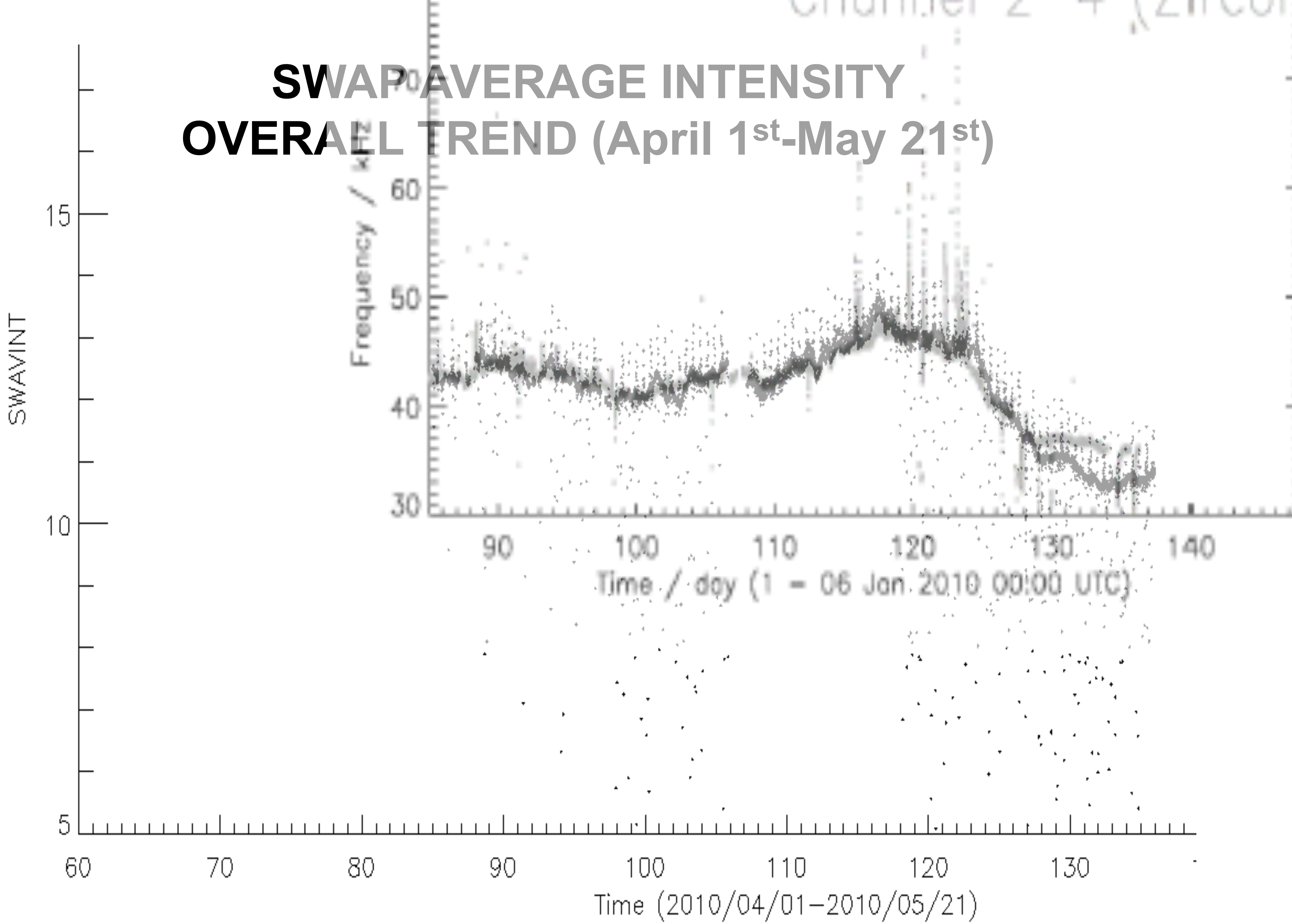

SWAP 2010-06-07T00:00:21.238
SWAP 10 arcmin^2 subfield

Understanding SWAP variability

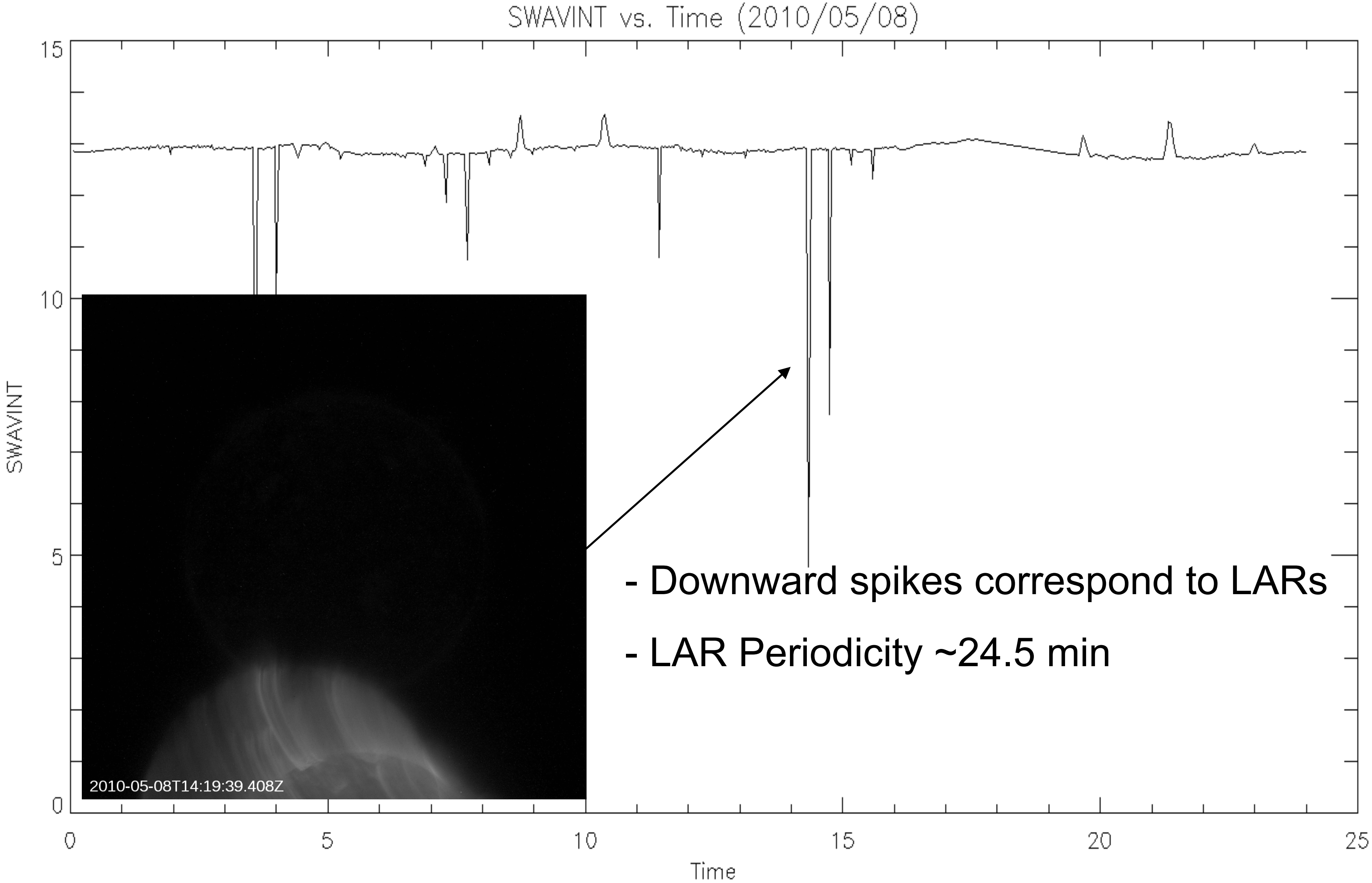
- APS: Every pixel has its own personality!
- How do we distinguish between instrumental variability and solar variability?
- Knowing each pixel's behavior, how do averages over subfields behave?
- How do we know in which subfield of SWAP the flare happens?
- How does the SWAP total intensity timeline relate to LYRA, GOES curves?



SWAP AVERAGE INTENSITY OVERALL TREND (April 1st-May 21st)

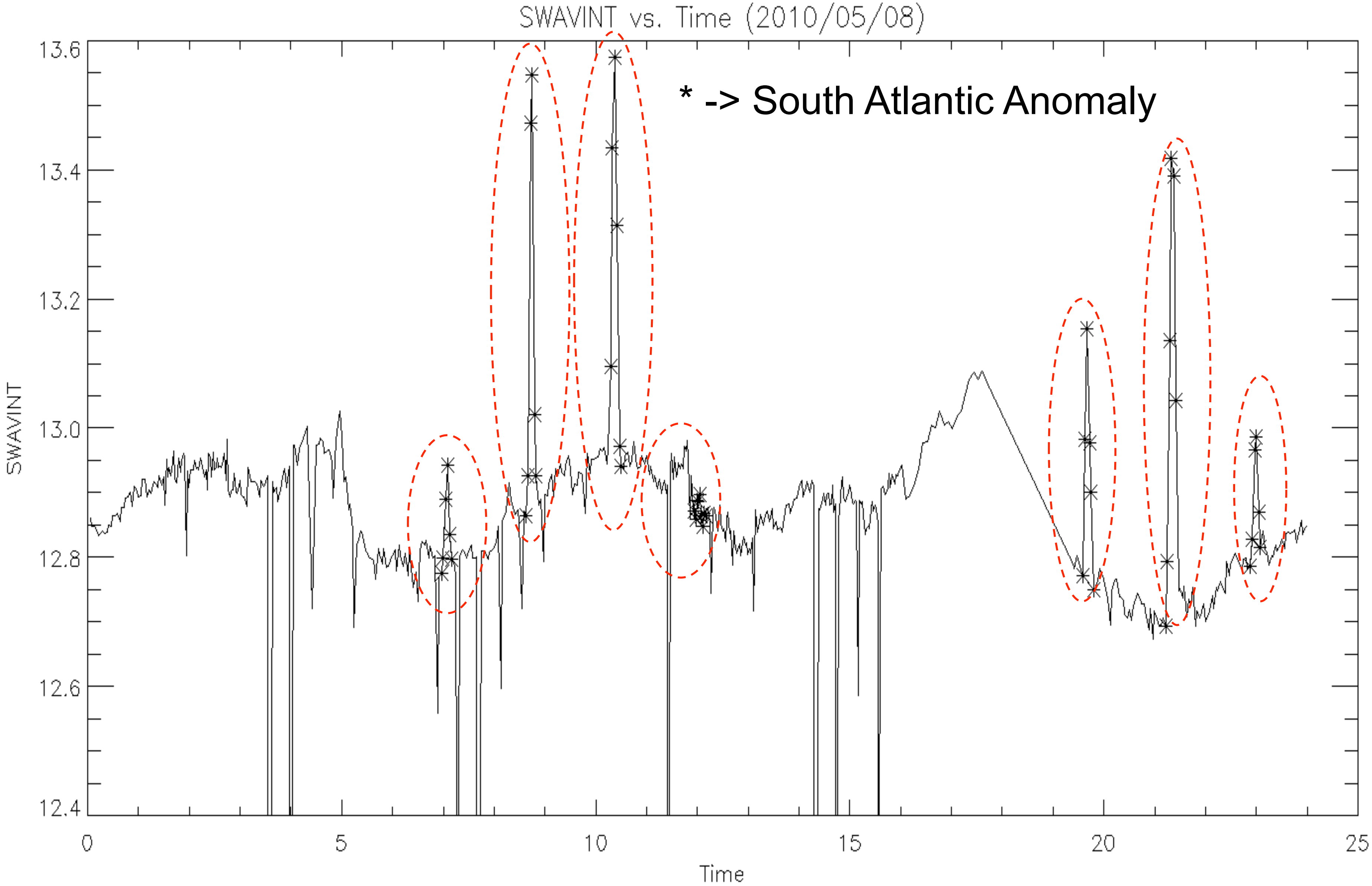


SWAP average intensity ON 2010/05/08
LARGE ANGLE ROTATIONS (LARs)

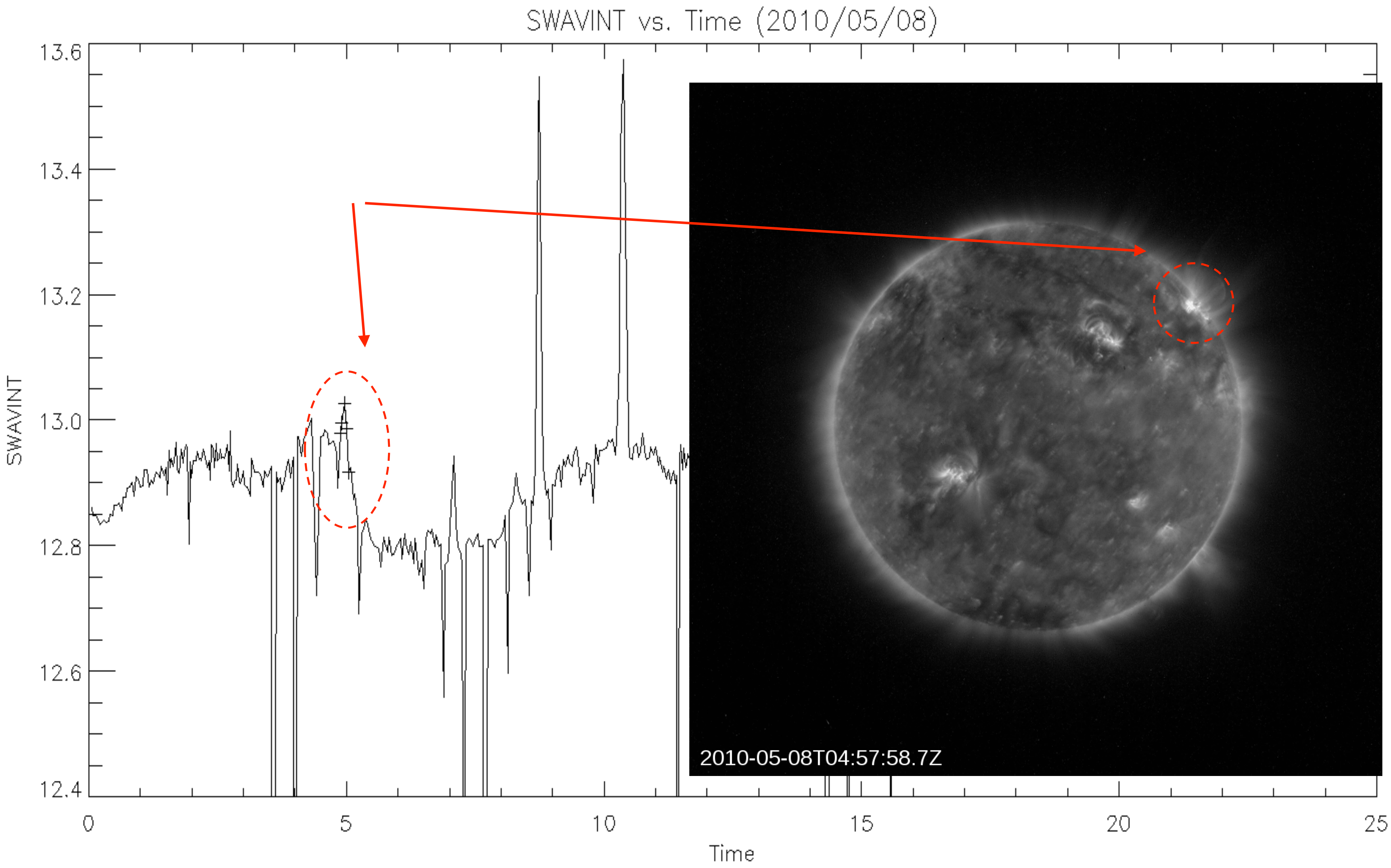


- Downward spikes correspond to LARs
- LAR Periodicity ~24.5 min

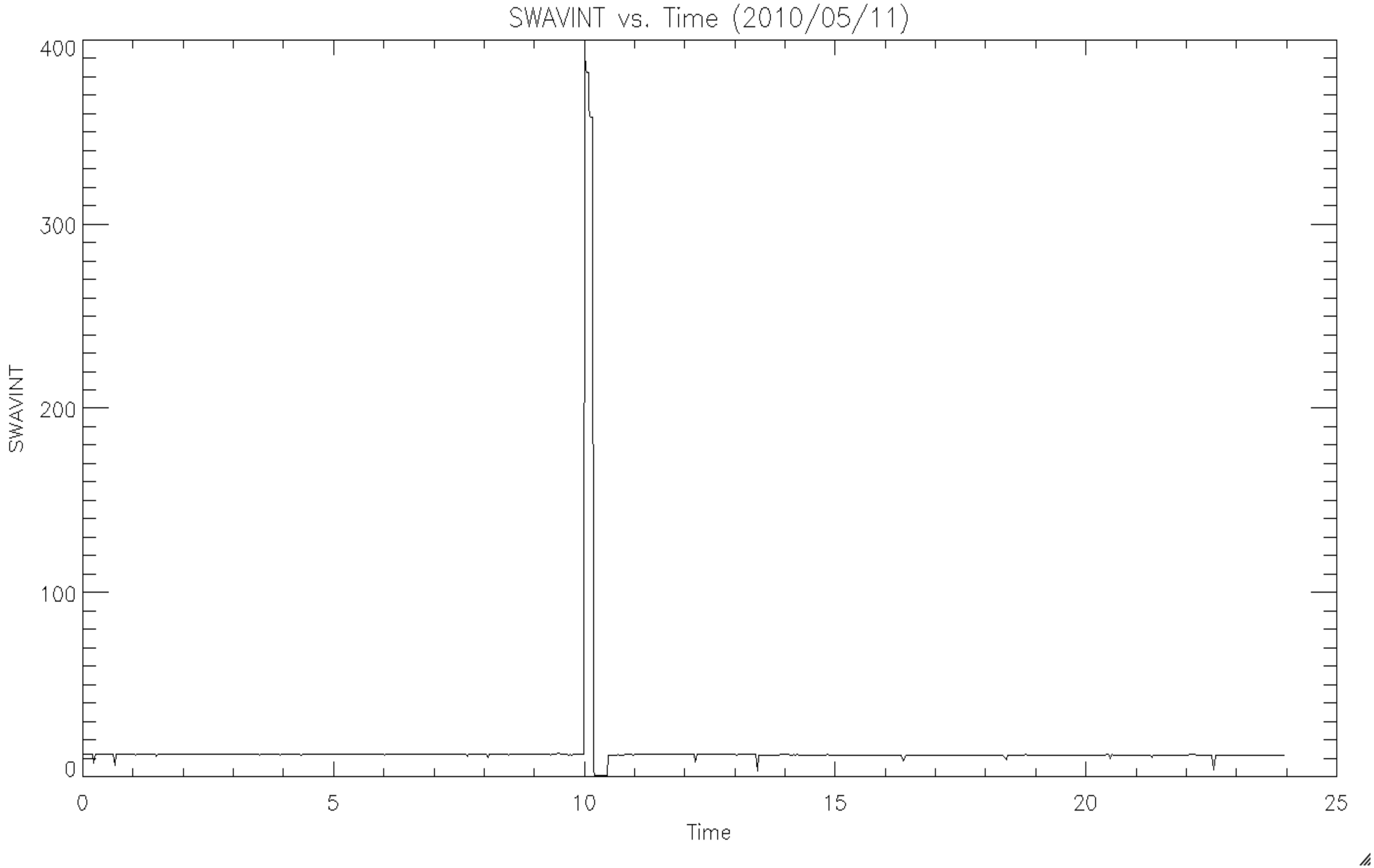
SWAVINT ON 2010/05/08
SOUTH ATLANTIC ANOMALY



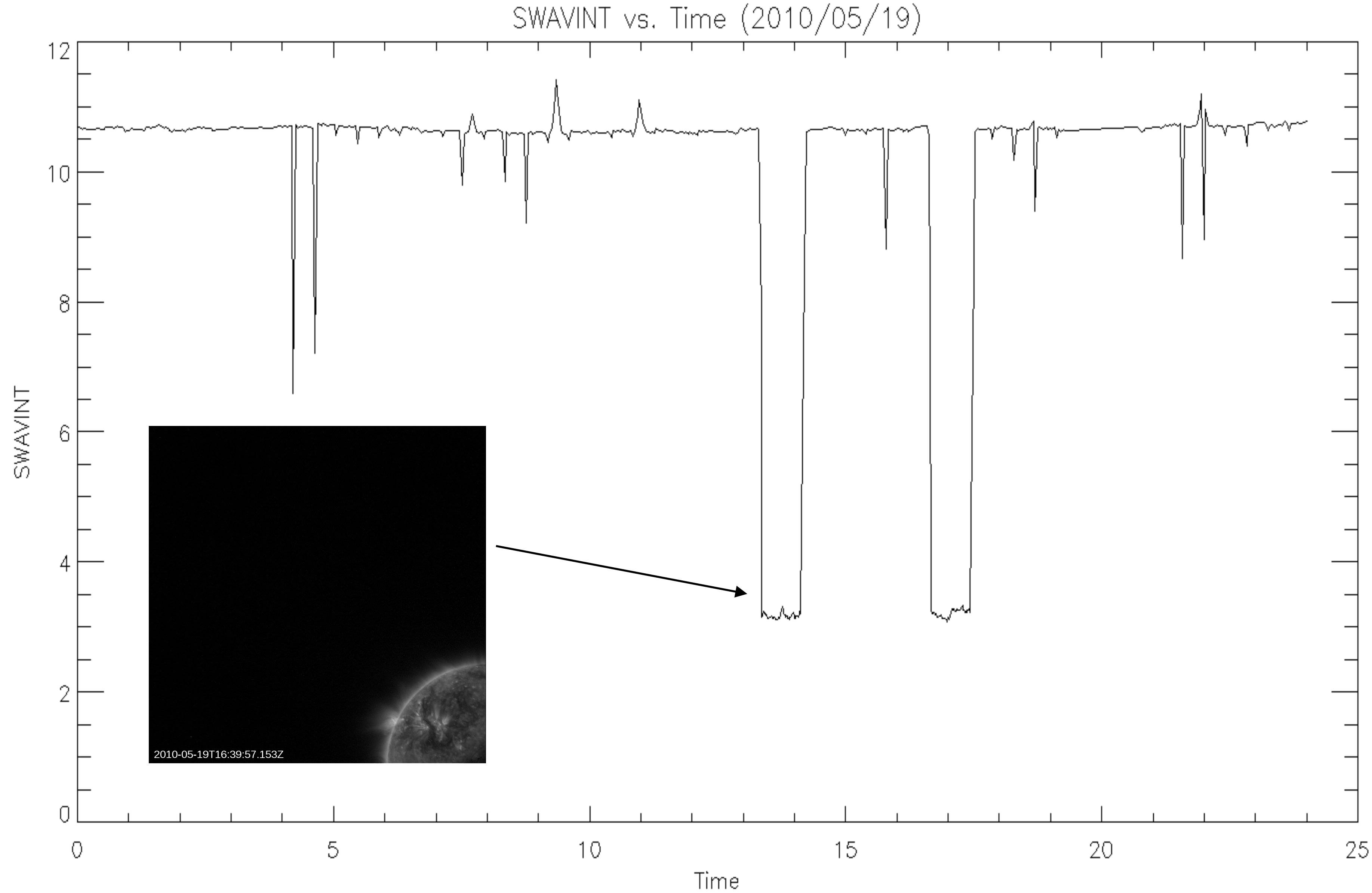
SWAVINT ON 2010/05/08
C 9.3 FLARE (GOES peak 07:42)



SWAVINT ON TUESDAY 2010/05/11
LED IMAGES



SWAVINT ON 2010/05/19
OFF-POINTING



SWAP average intensity (SWAVINT keyword)

1. Background EUV trend well recovered. SWAP can be used as a radiometer: 5th LYRA channel
2. individual flares hardly observable. Big flares TBC. Subfields?
3. signal dominated by spacecraft rolls, SAA, instrument off-pointing and LEDS.

Statistical analysis of variability in SWAP image-sequences:

Local variability

K.Bonte – Centre for Plasma Astrophysics

Why local variability?

- Swap_average gives an idea of overall variability
  (similar to Lyra data but for narrow bandpass, centered around 17.5 nm)
- We want to zoom into regions of interest, <u>locate intresting subfields</u>
  - Active Regions
  - Events
  - Flares (possibly working towards flare-detection)
  - …
- Get an idea of how active a located Active Region really is..

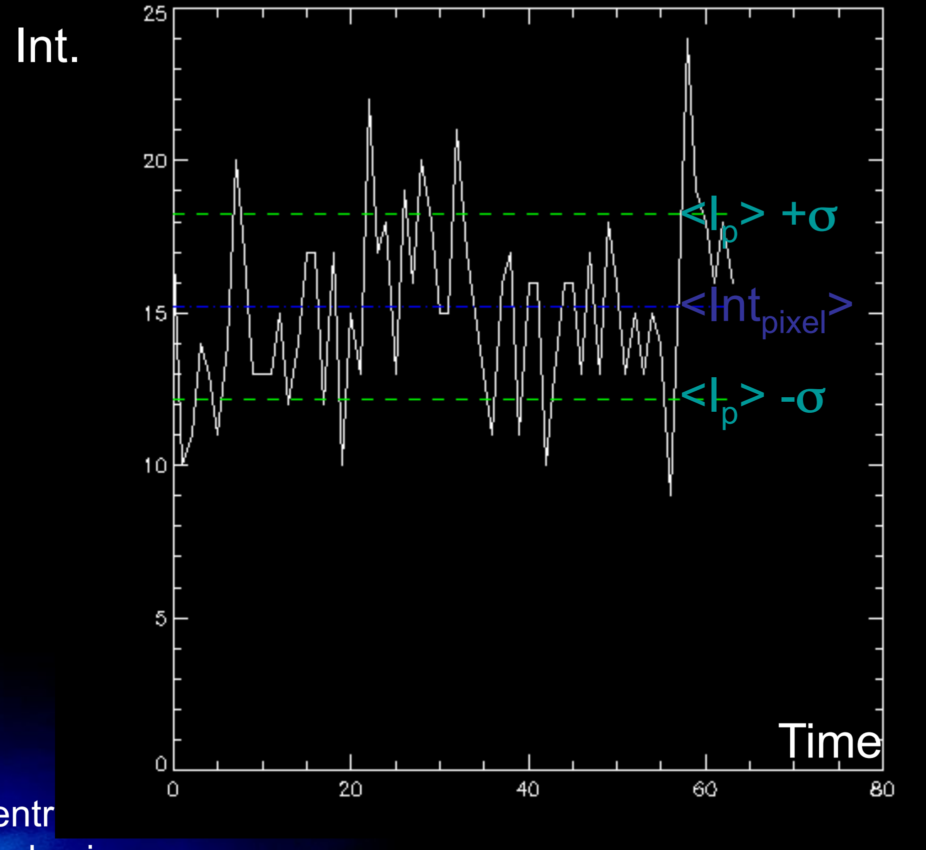
First step

- Look at <u>variability</u> of intensity in time, at <u>pixel-level</u>.
- <u>Differentiate "instrumental noise"</u> from variability in intensity due to solar activity.

- <u>INPUT</u>:
  time-sequence of SWAP images

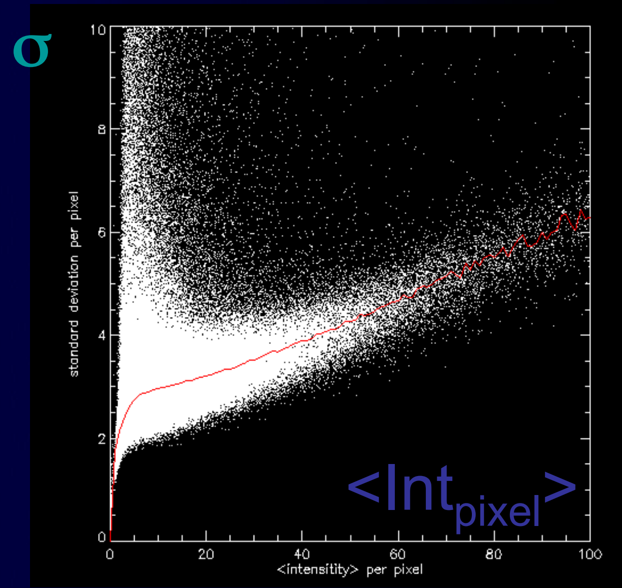
<u>OUTPUT</u>, **PER PIXEL (over time sequence)**:

- average intensity $<Int_{pixel}>$
- standard deviation σ

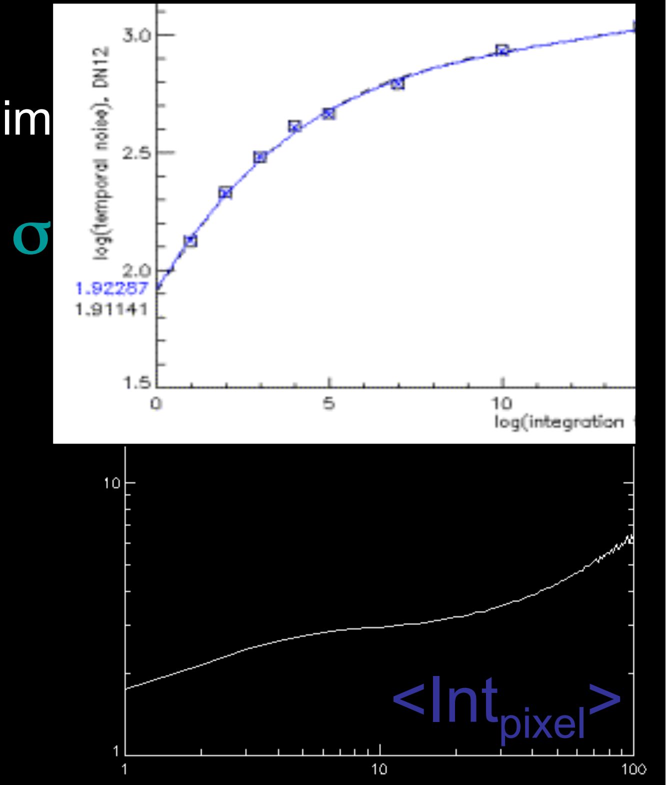


An example: Sequence of 64 dark im

a) Median st.dev.



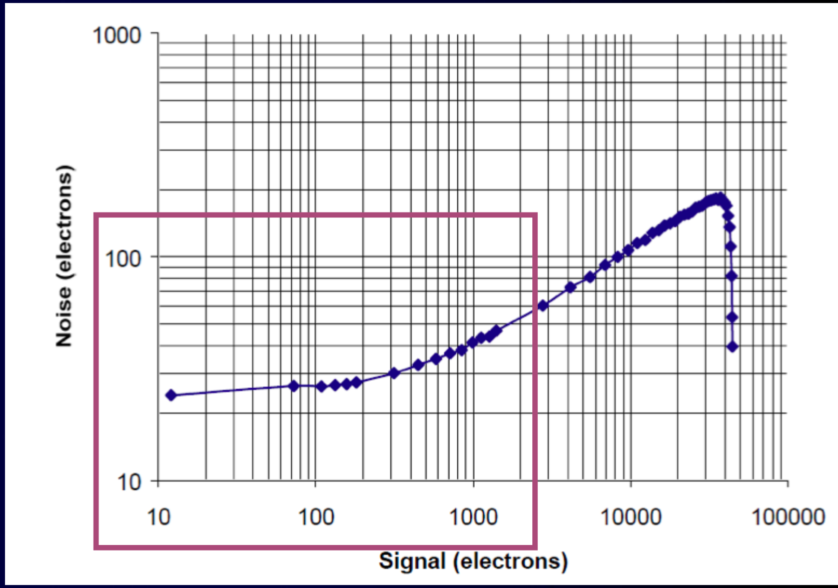
b) Logscaled median st.dev.

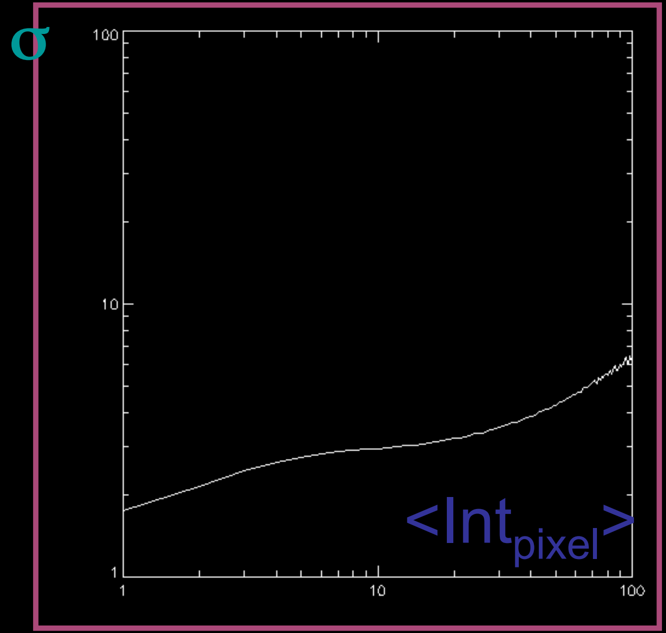


- <u>This result tells us</u>:
  - (b) Estimate for the dark noise by extrapolating the result for <Int>=0
    → +- pre-launch calibration value: 1,9 DN.
  - (a) <u>Each point</u> corresponds to (average intensity, st.dev.) of <u>1 pixel</u>.
    Each average intensity value ~ different values of st.dev. per pixel.

    Because **CMOS ≠ CCD!!**
    Every pixel of a CCD detector would show +- the same behaviour (~PTC).
    SWAP uses a CMOS detector..

CMOS ≠ CCD→ customized PTC

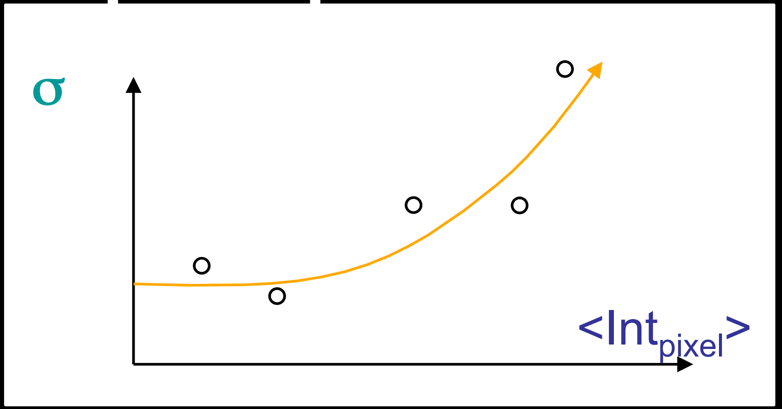




- CCD detector ~ Photon Transfer Curve
  =expected noise as function of intensity,for each pixel the same.
  - Readout_noise: slope=0
  - Photon Shot Noise: slope=0,5
  - Fixed Pattern Noise: slope=1
- CMOS detector: Every pixel suffers extra instrumental noise due to extra electronics per pixel.
  - To differentiate instrumental noise: need to understand behaviour of each pixel.
  - **First challenge: provide a "customized Photon Transfer Curve" per pixel!**

Customized PTC per pixel

- Working on pixel-level, results in 1 value (1point) per image-sequence in the [<Int> - st.deviation] diagram.



- We aim to fit a polynomial function through points that we retrieve from darks + led data (different sequences), simulating intensities from dark currents up to solar intensity. Function based on PTC:

$$\sigma^2 (x,y) = dark\_noise + \alpha(x,y) * Int(x,y) + \beta(x,y) * Int^2(x,y)$$

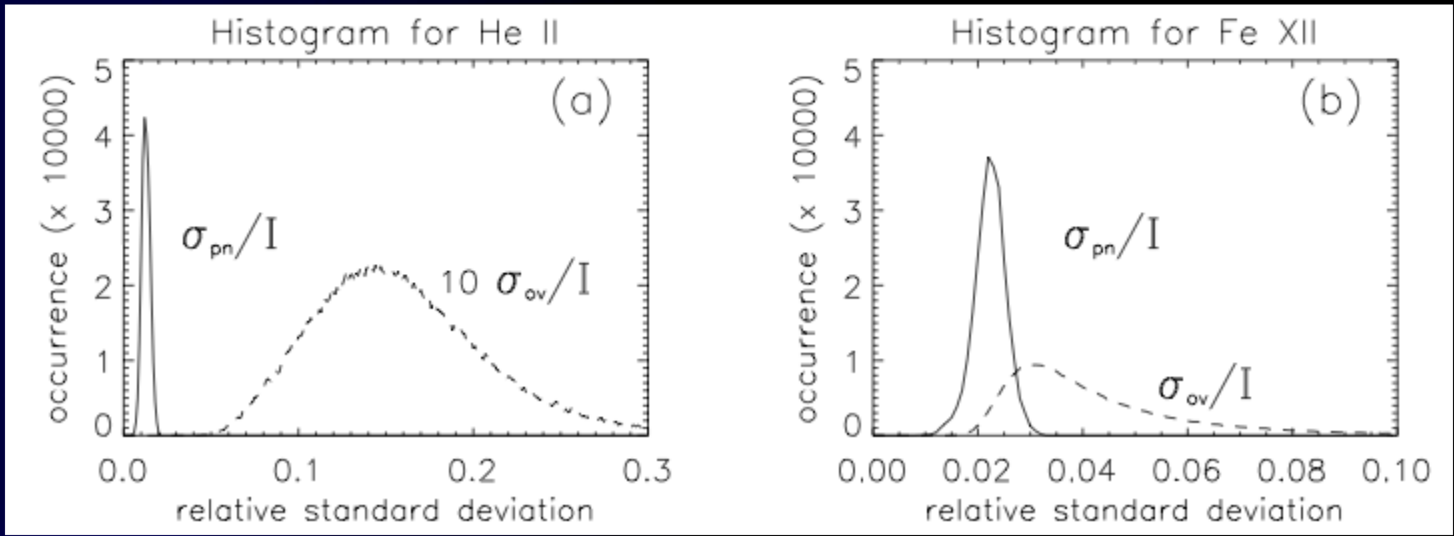
slope=0	+	slope=0,5	+	slope=1
cte	+	PSN	+	FPN

→ **relating a value of “instrumental noise” to average intensity, per pixel.**

Application

- Differentiate “instrumental noise” from intensity variability due to solar activity.
  - In histograms of standard deviation PER PIXEL (or group of pixels):

signal <--> instrumental

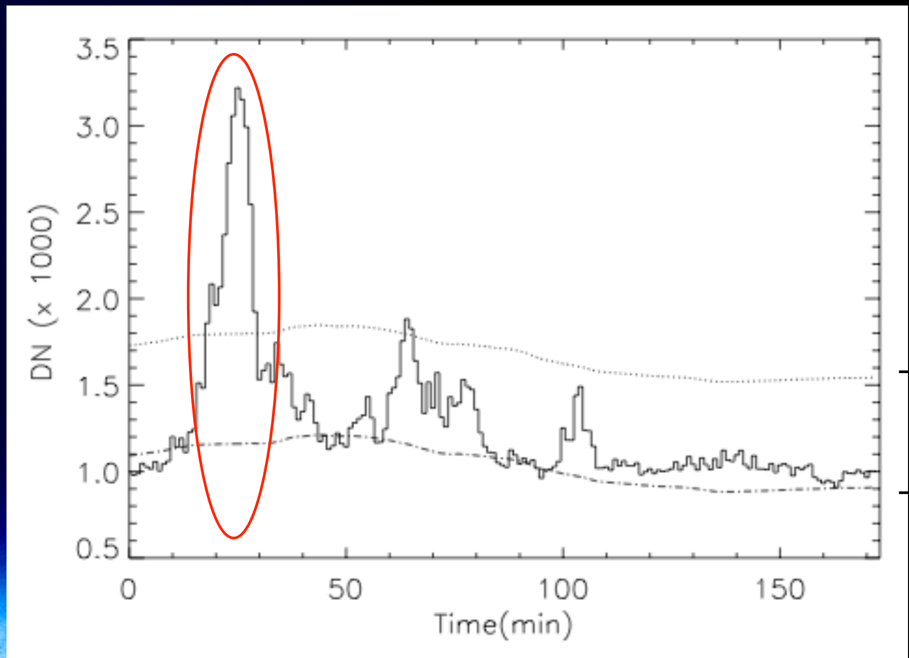


Intresting subfield Less intresting subfield

Application

- Differentiate instrumental noise from intensity variability due to solar activity.
  - In <u>time-intensity plots PER PIXEL (or group of pixels)</u>:

    Comparing per pixel peaks of intensity with instrumental noise of that pixel (value from customized PTC): locating intresting subfields



$\langle Int_{pixel} \rangle + 3*\sigma$

$\langle Int_{pixel} \rangle$

To be continued...

Thanks