SDS Measurements: Previous and Latest Results

Sabatino Sofia
Yale University
and SDS Team
New Haven, CT, USA

EXISTING METHODS

Ground-based: direct

indirect

Balloon-based: SDS

Space-based: MDI-SOHO

PICARD

Differences between existing diameter measurements

- Ground-based vs. space based
- Wavelength (and spectral width) of observation
- Analysis method
- Calibration

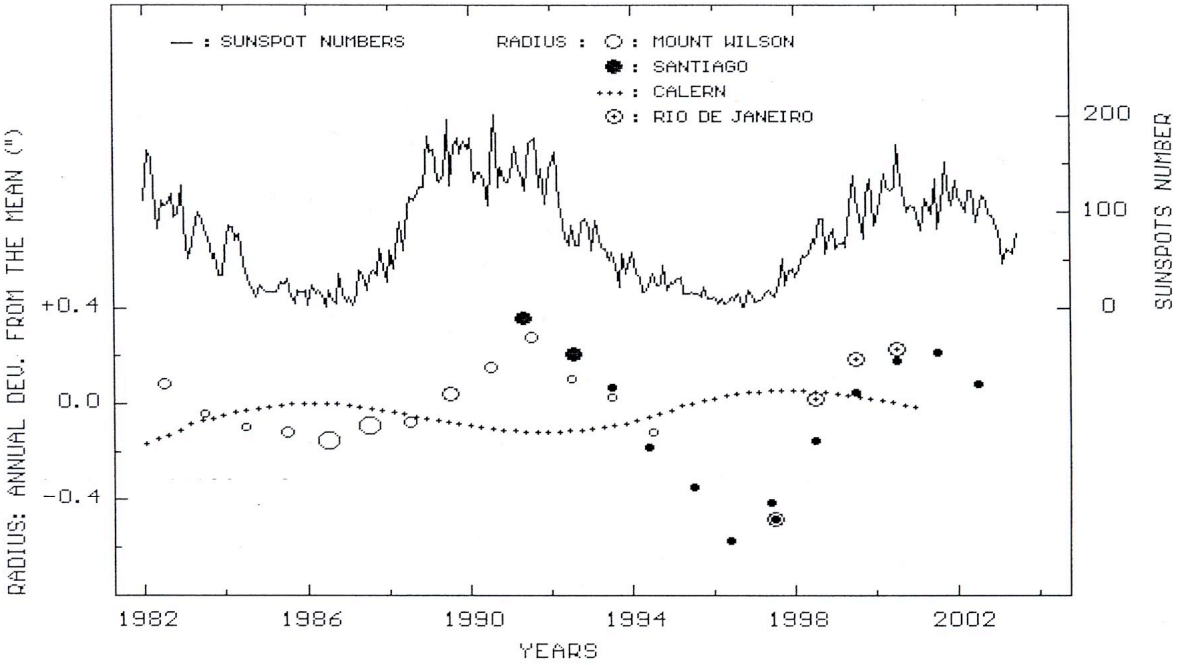
These issues are extensively described in a paper by Djafer, Thuillier and Sofia, *ApJ*, **676**, 651, 2008.

Ground-based measurements are affected by terrestrial atmosphere

Seeing is 1”-4”, and we need sensitivity of mas. This cannot be simply solved by statistics, since atmospheric turbulence is not random.

That might explain why simultaneous measurements carried out at different locations yield results that are inconsistent.

SODISM I and II *will explore whether or not atmospheric effects can be corrected*.

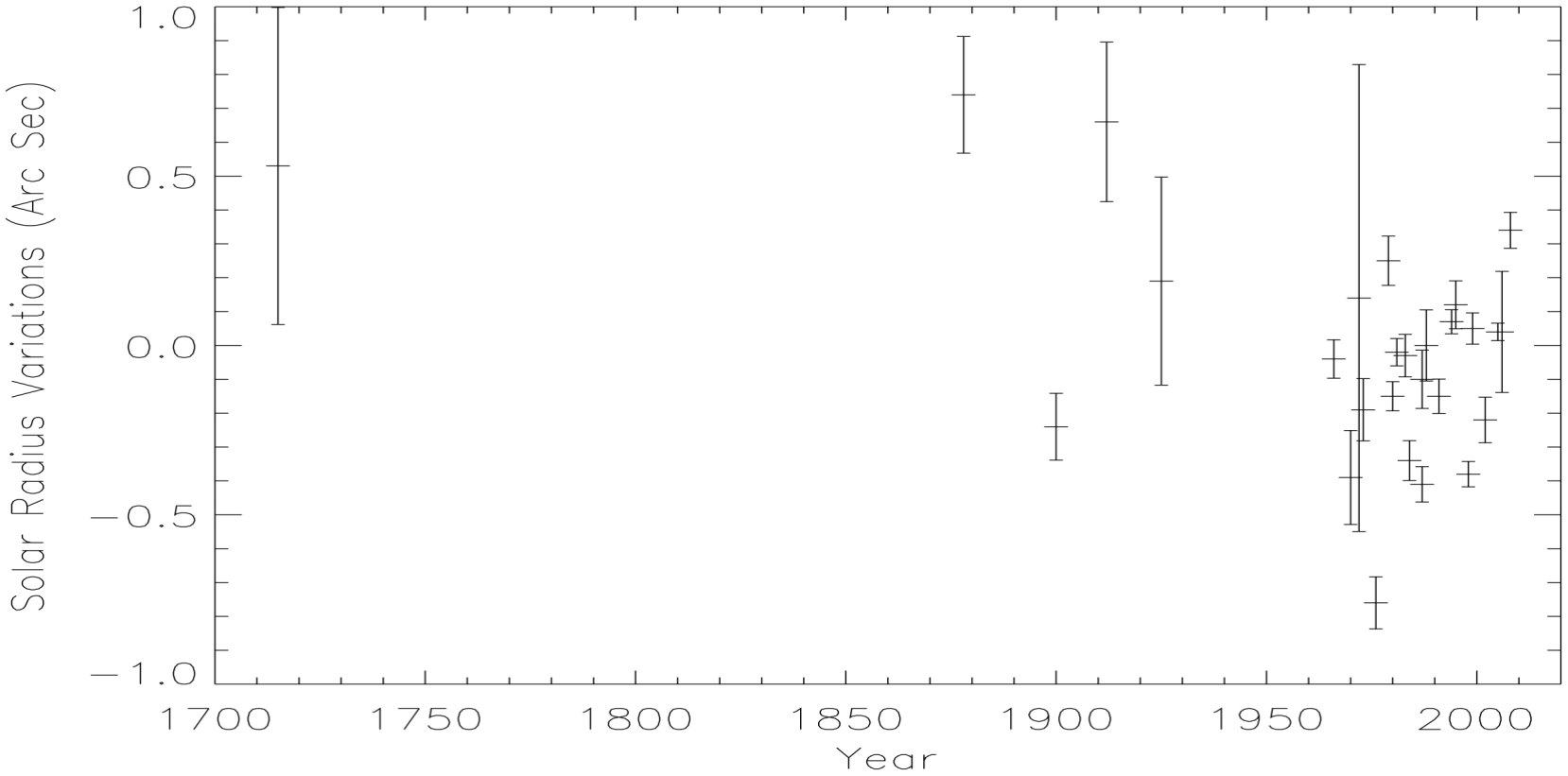

— : SUNSPOT NUMBERS
RADIUS : ○ : MOUNT WILSON
● : SANTIAGO
+++ : CALERN
⊙ : RIO DE JANEIRO
RADIUS: ANNUAL DEV. FROM THE MEAN (")
+0.4
0.0
-0.4
200
100
0
SUNSPOTS NUMBER
1982
1986
1990
1994
1998
2002
YEARS

The eclipse method and the Transits of Mercury are not affected by seeing,

However, transits of Mercury have a large error (the backdrop effect).

The eclipse methods is most sensitive for long-term trends if edge of totality observations are used.

Radius changes from total solar eclipses



Once you go outside the atmosphere, there are currently only 2 measurements:

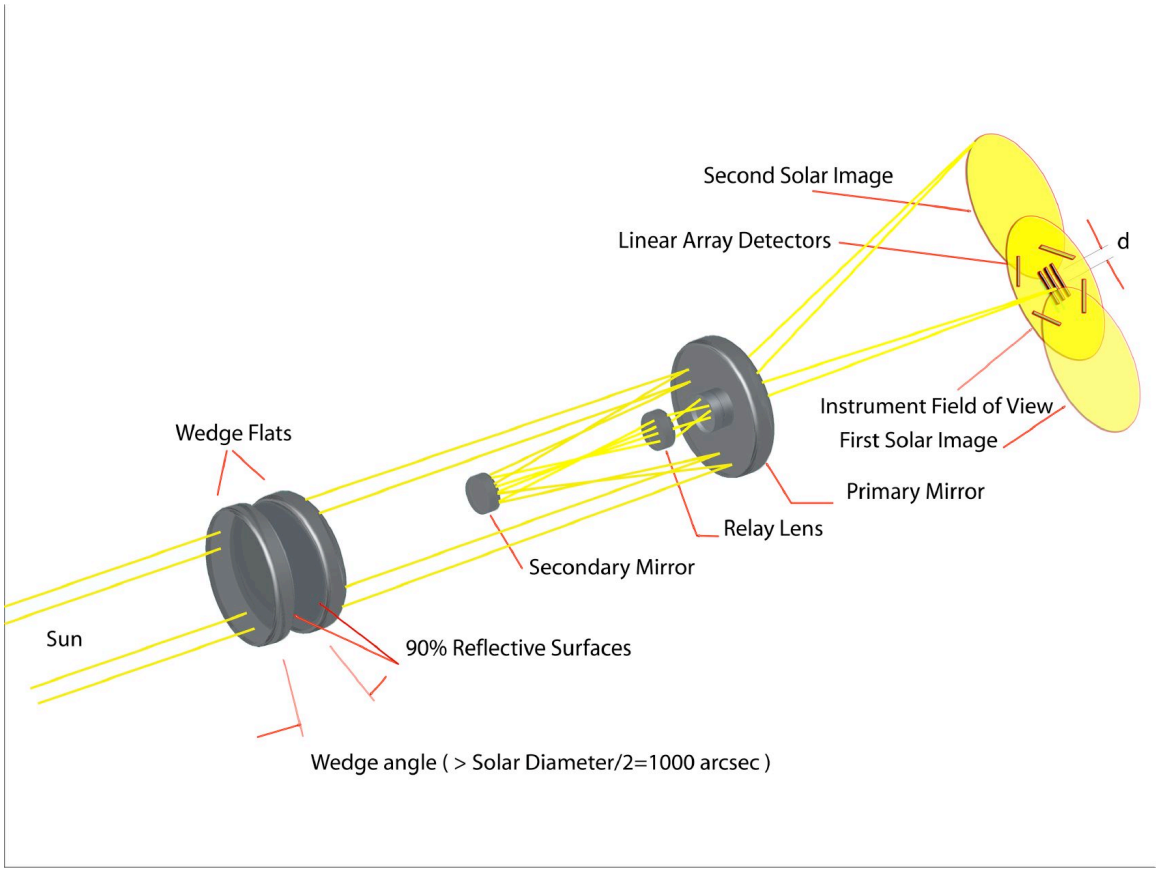
SoHO/MDI

SDS

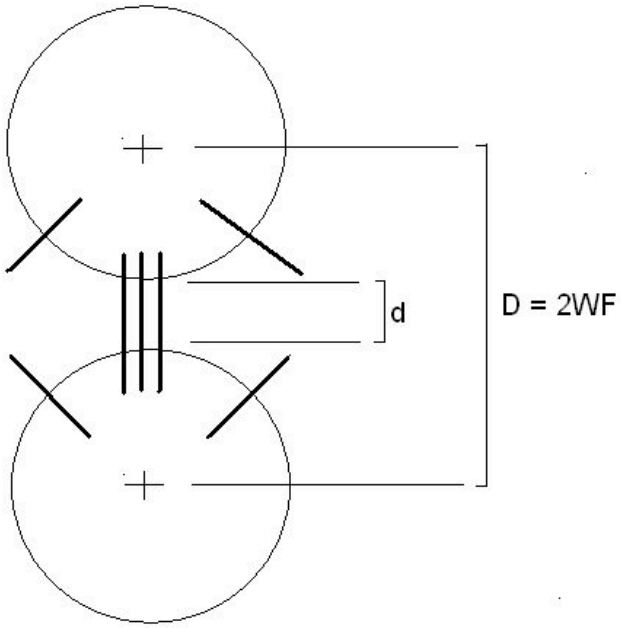
SoHO/MDI is not a metrologic instrument. It has not been calibrated before launch, and cannot be completely calibrated in space.

The only metrologic instrument to measure the solar diameter is the SDS.

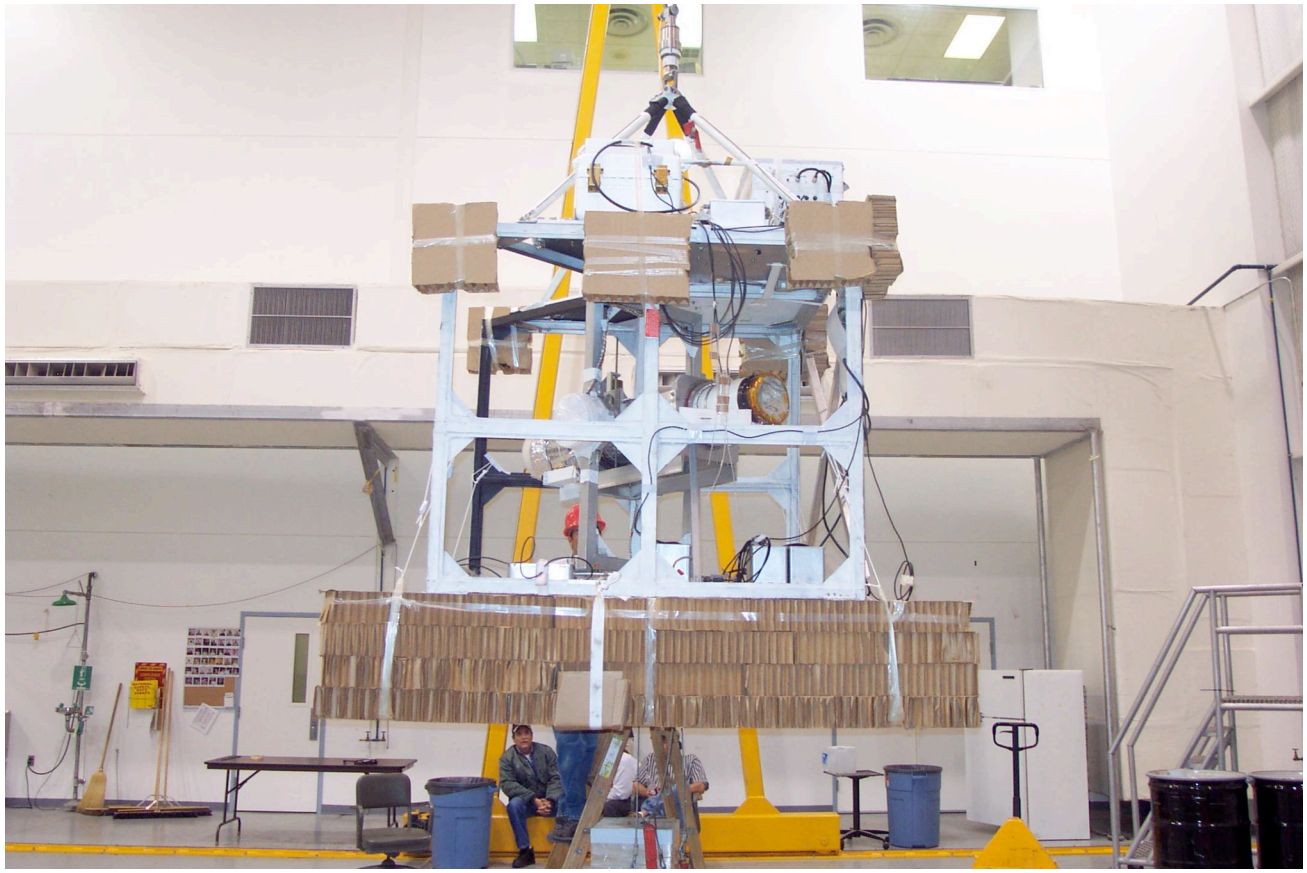
SDS Principle

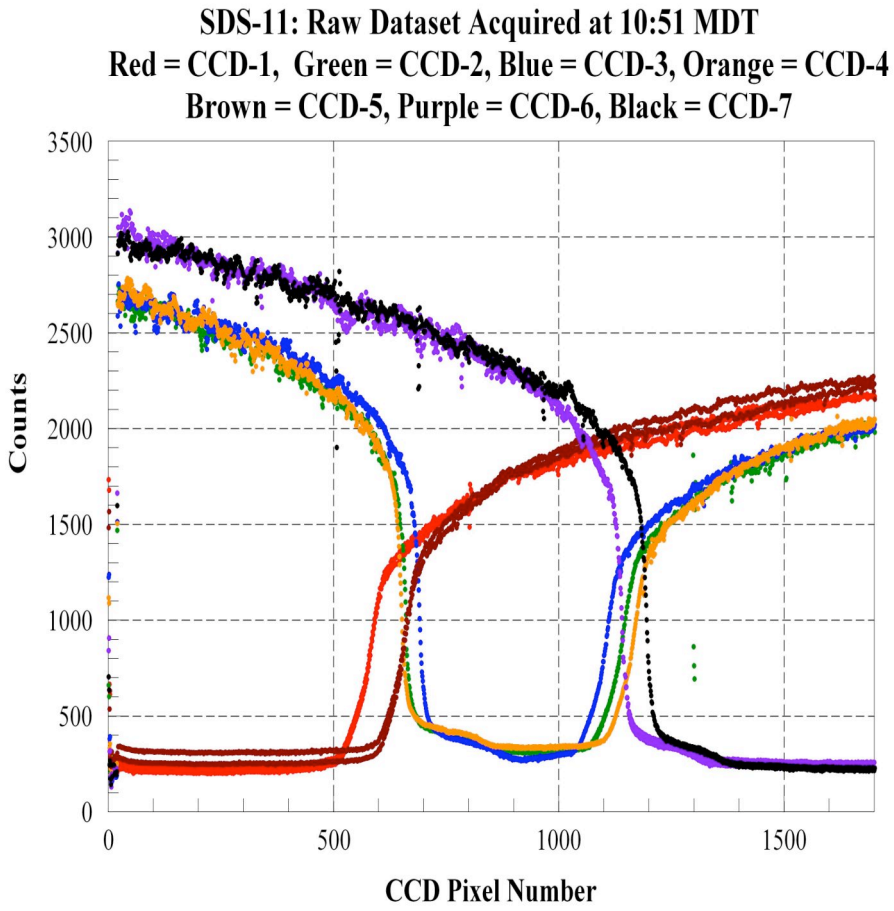


Focal Plane Schematic



SDS Payload



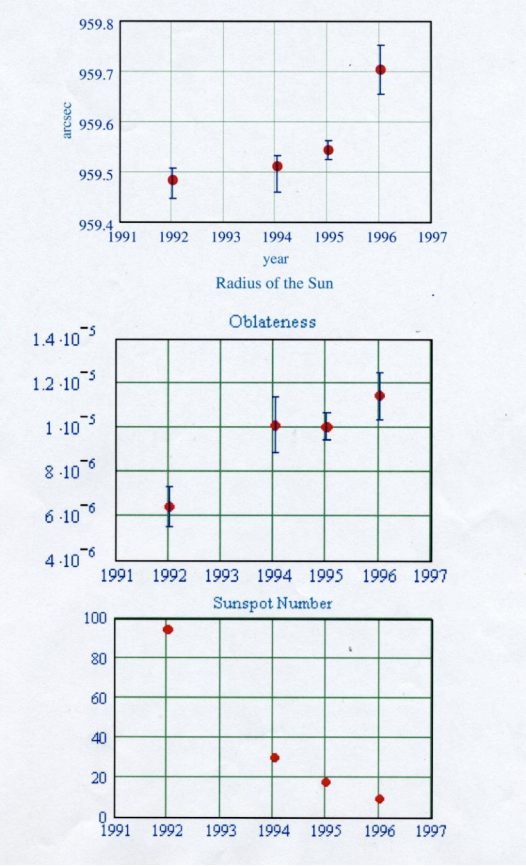

SDS-11: Raw Dataset Acquired at 10:51 MDT
Red = CCD-1, Green = CCD-2, Blue = CCD-3, Orange = CCD-4
Brown = CCD-5, Purple = CCD-6, Black = CCD-7
Counts
3500
3000
2500
2000
1500
1000
500
0
0
500
1000
1500
CCD Pixel Number

Radius Definition

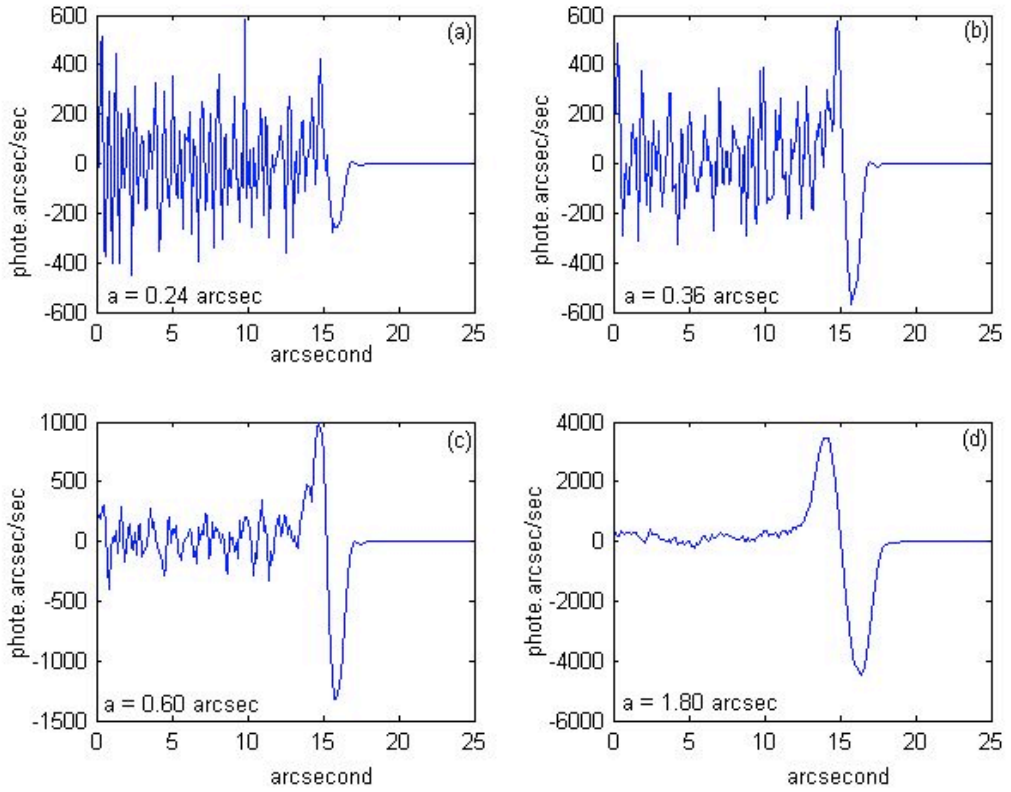
The Radius is defined as ½ the distance between the inflection points at two opposite ends of a line passing through disk center.

FFTD
Wavelet
Second derivative,
etc.

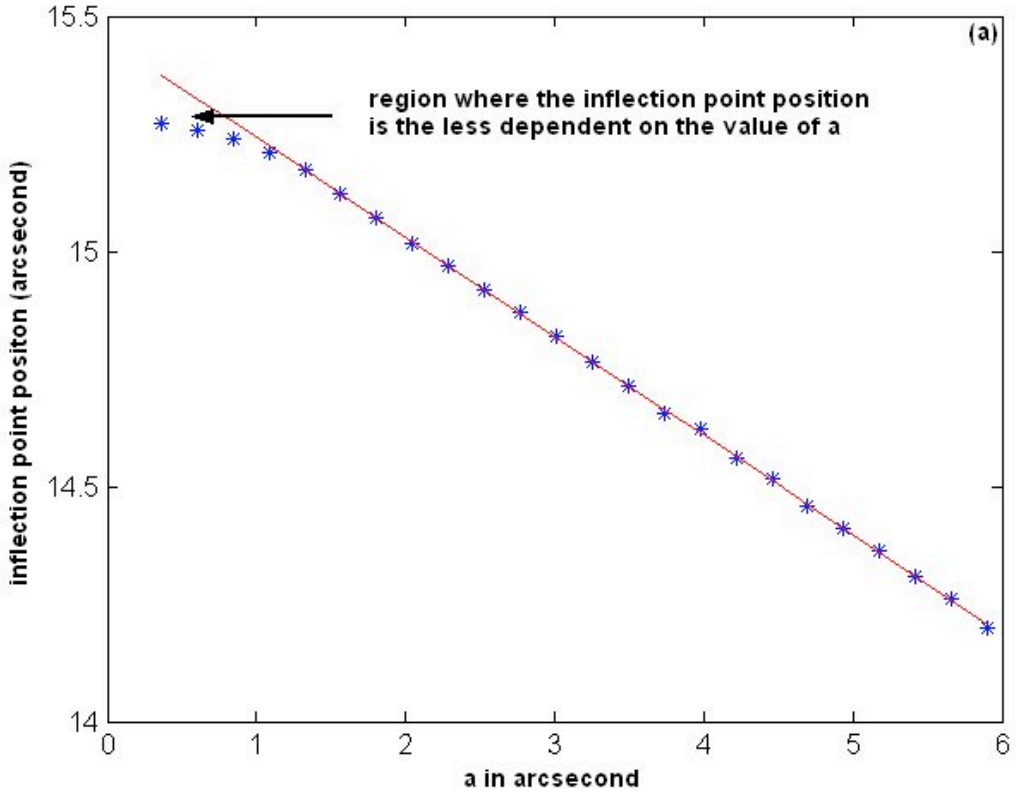
Early results



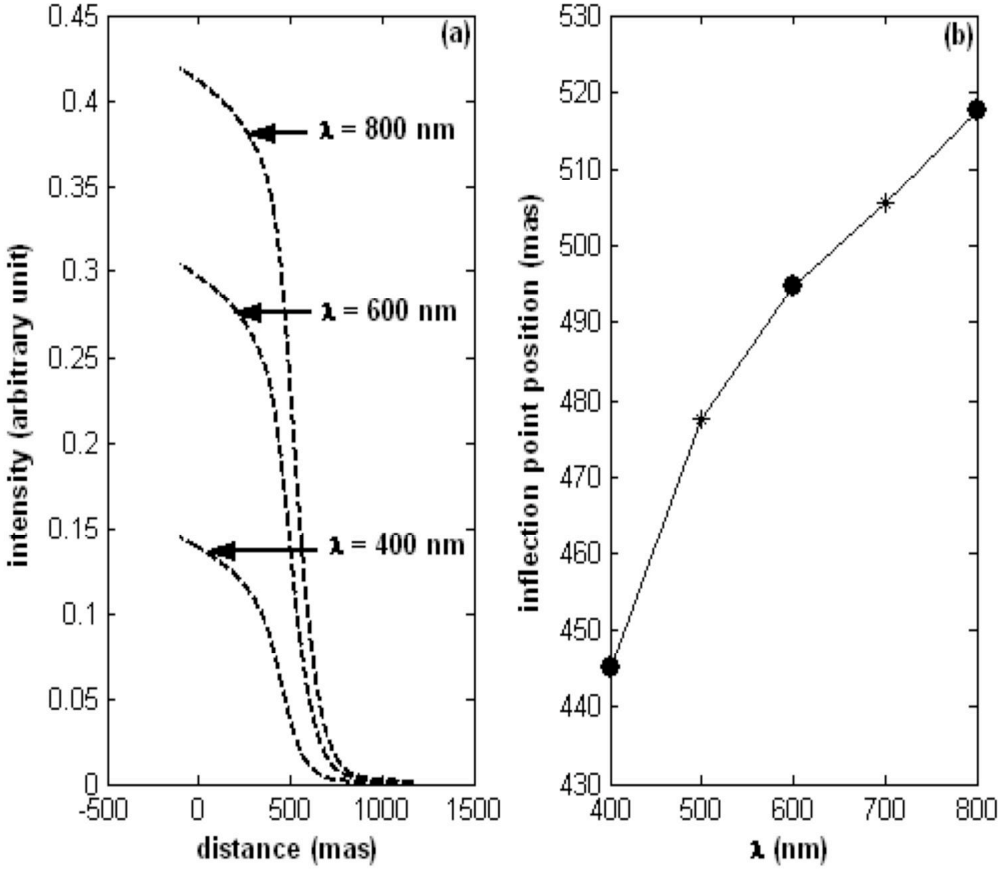
The effect of the value of *a* in noise filtering



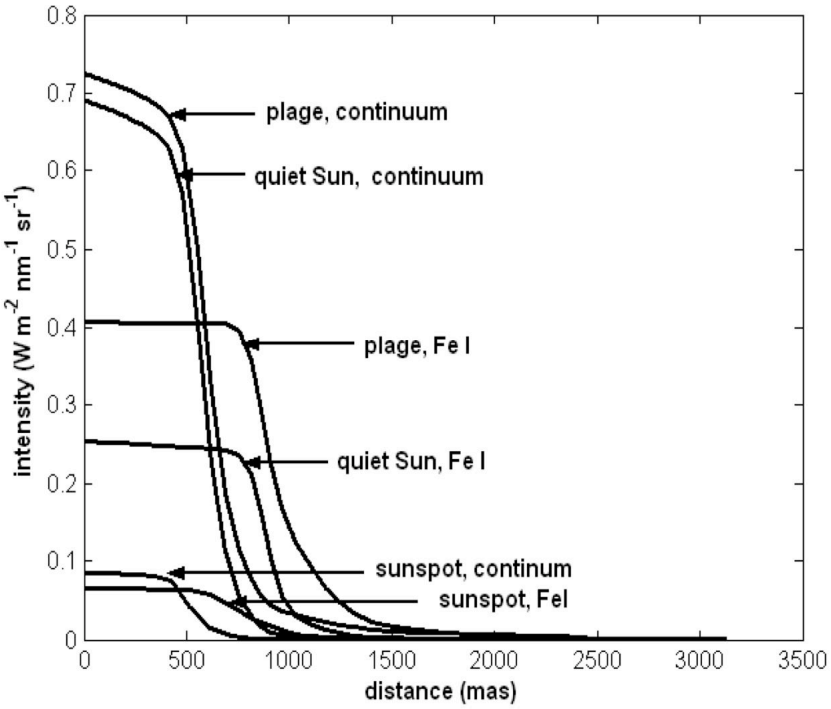
Method of analysis



Wavelength Effect



Where do you make the measurement



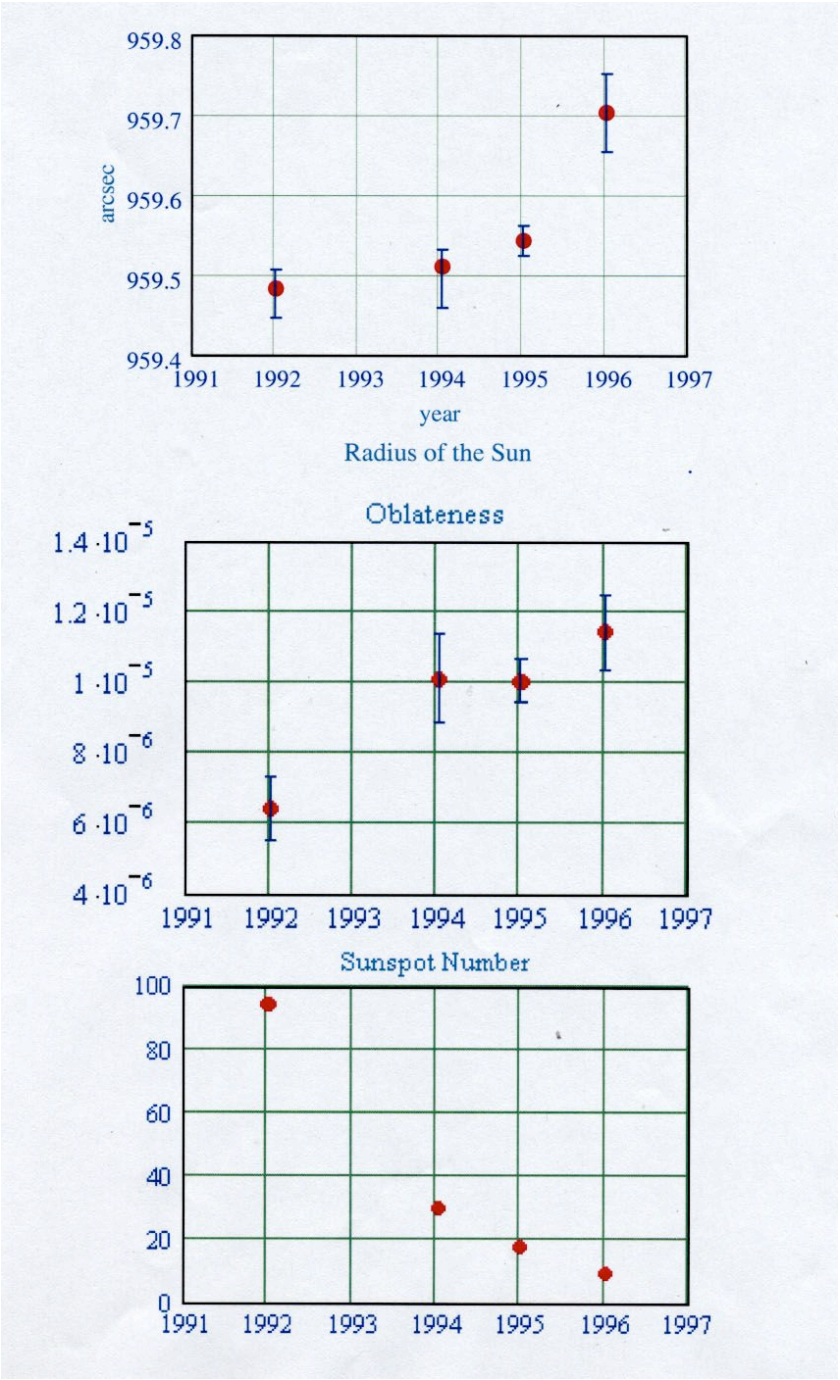
Existing Flights

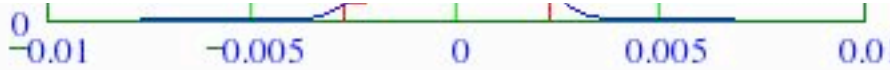
Flights with current configurations were carried out in Falls 1992,1994,1996,1996,2001,and 2009.

In 2001 we had a recorder crash, and we have just found a means of recovering a reduced number of measurements.

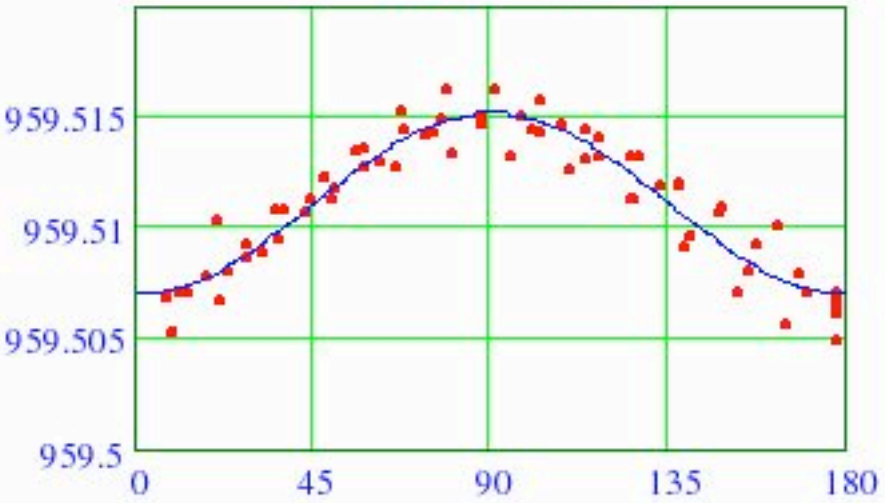
Importance: only measurement al solar maximum.

Still under investigation

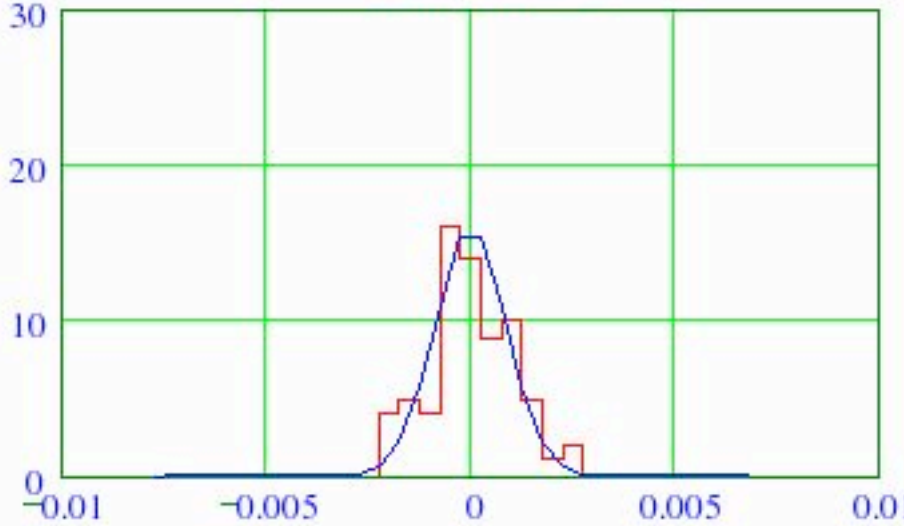

959.8
959.7
959.6
959.5
959.4
arcsec
1991
1992
1993
1994
1995
1996
1997
year
Radius of the Sun
Oblateness
1.4 ·10^-5
1.2 ·10^-5
1 ·10^-5
8 ·10^-6
6 ·10^-6
4 ·10^-6
1991
1992
1993
1994
1995
1996
1997
Sunspot Number
100
80
60
40
20
0
1991
1992
1993
1994
1995
1996
1997



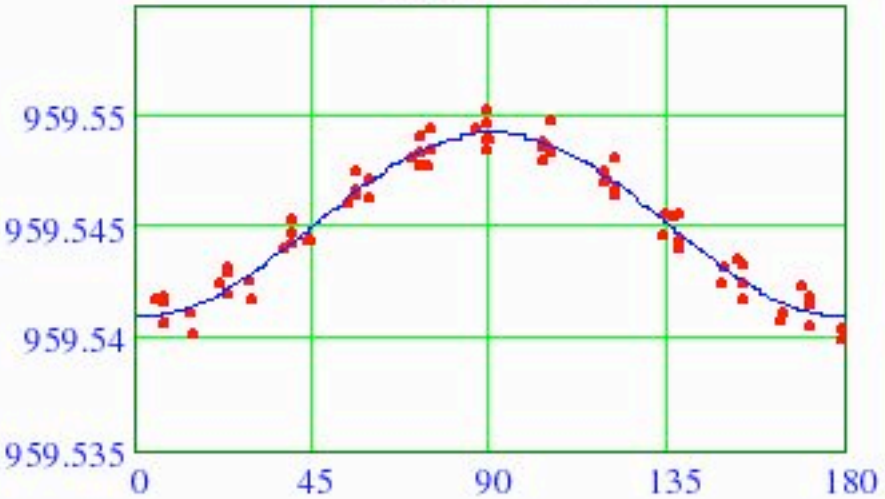
Flight 7 - 1994



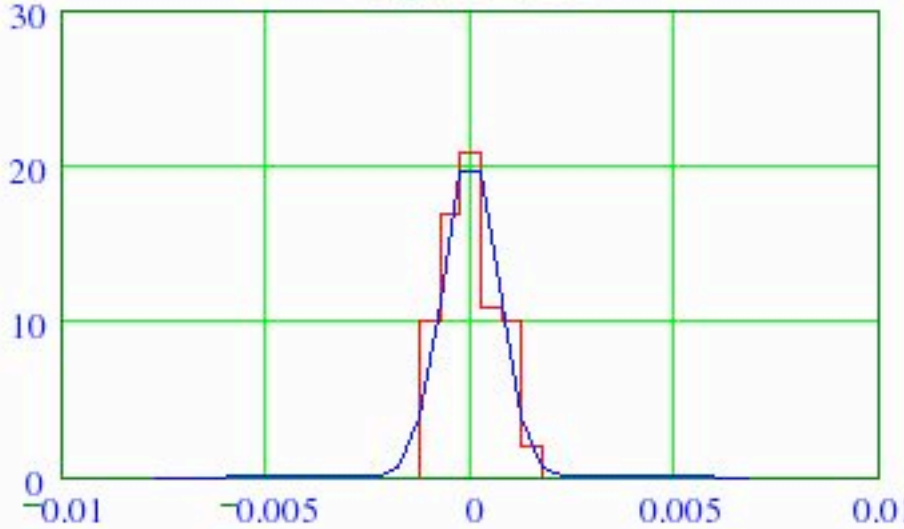
Flight 7 - 1994



Flight 8 - 1995

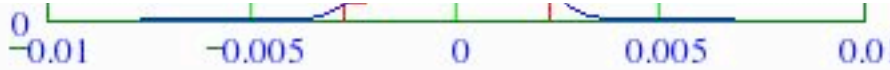


Flight 8 - 1995

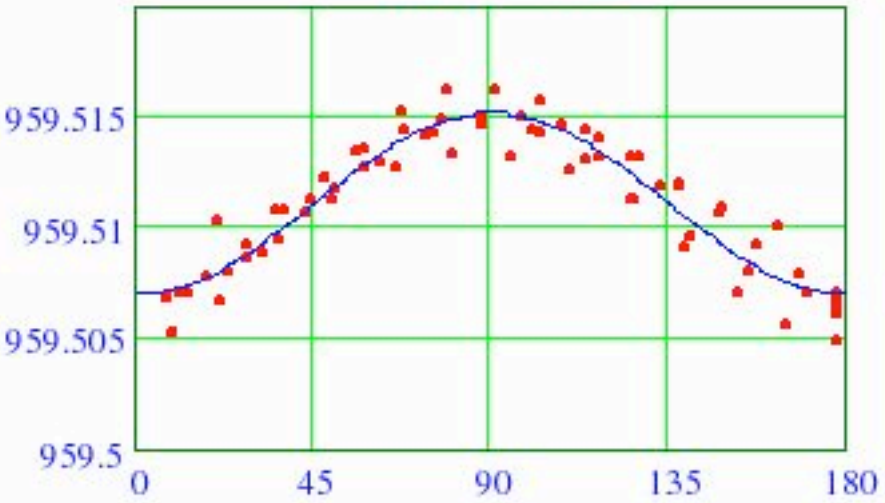


Flight 9 - 1996

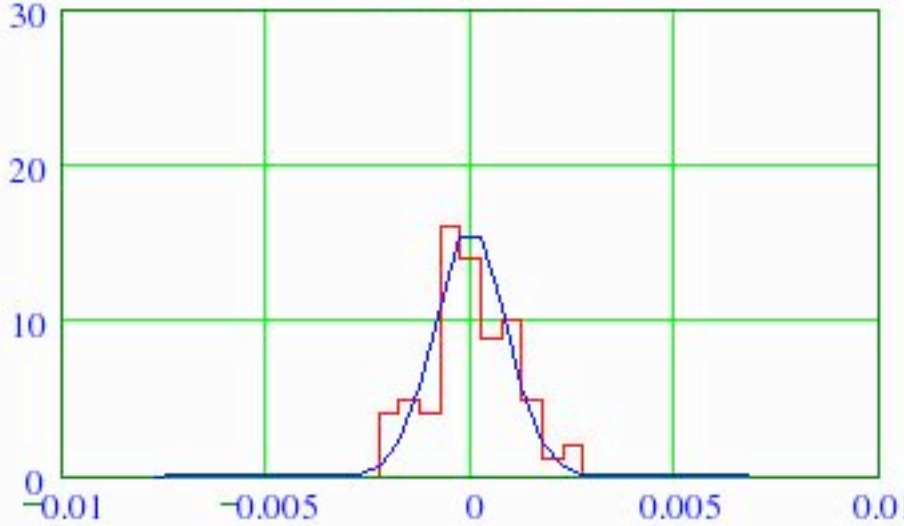
Flight 9 - 1996



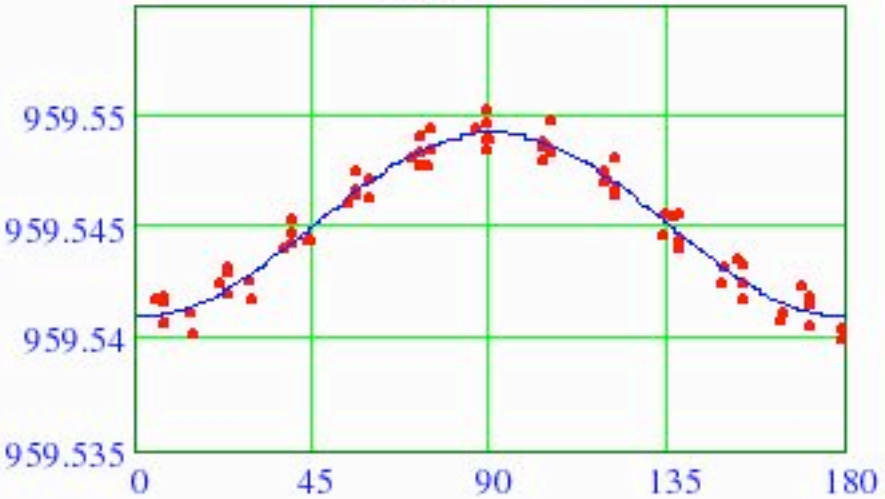
Flight 7 - 1994



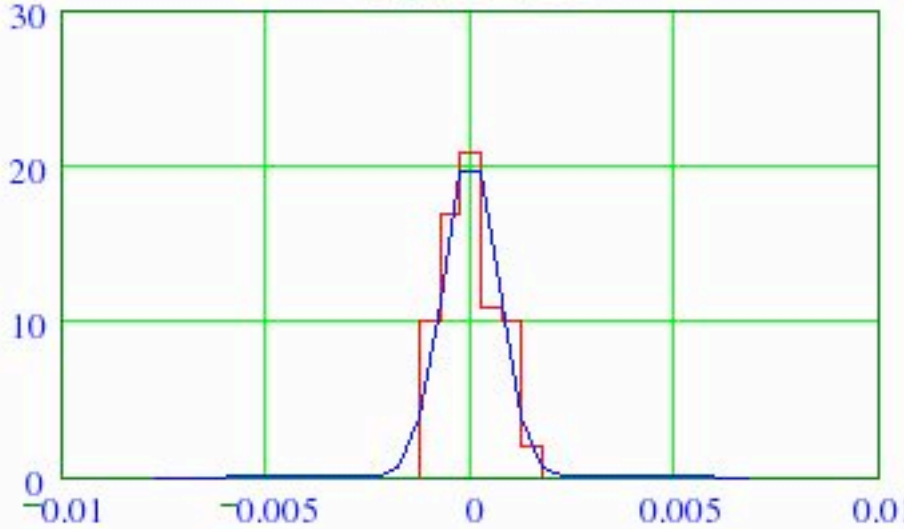
Flight 7 - 1994



Flight 8 - 1995



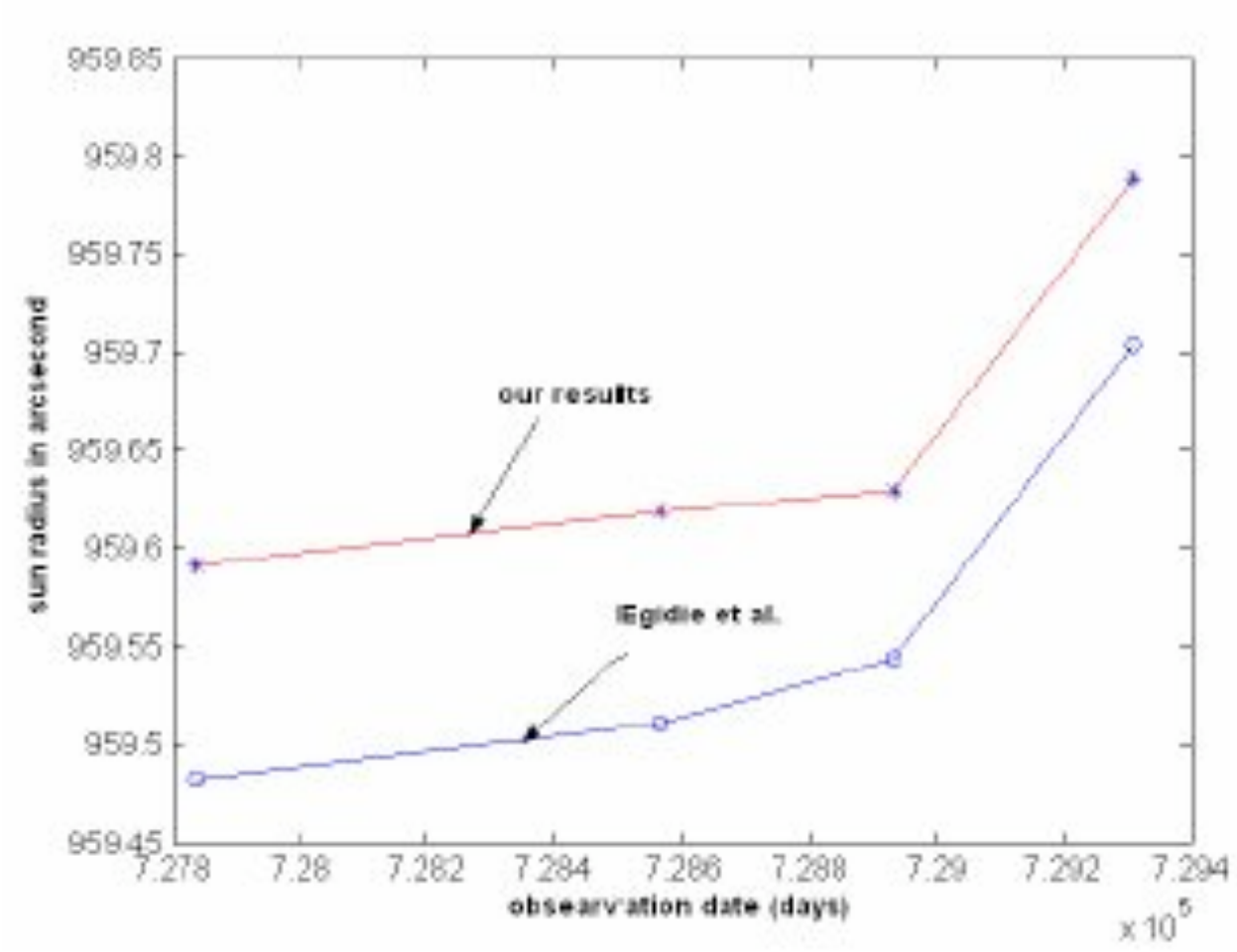
Flight 8 - 1995

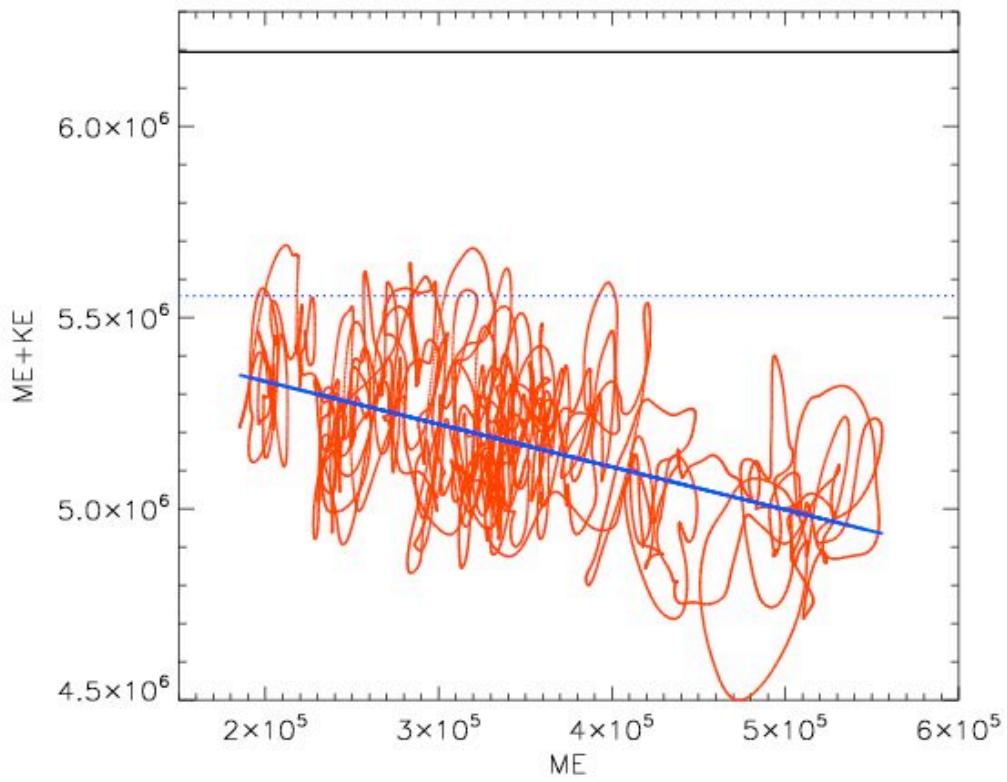


Flight 9 - 1996

Flight 9 - 1996

Results


959.85
959.8
959.75
959.7
959.65
959.6
959.55
959.5
959.45
sun radius in arcsecond
our results
Egidie et al.
7.278
7.28
7.282
7.284
7.286
7.288
7.29
7.292
7.294
obsearvation date (days)
x 10^5



slope = −1.1181382

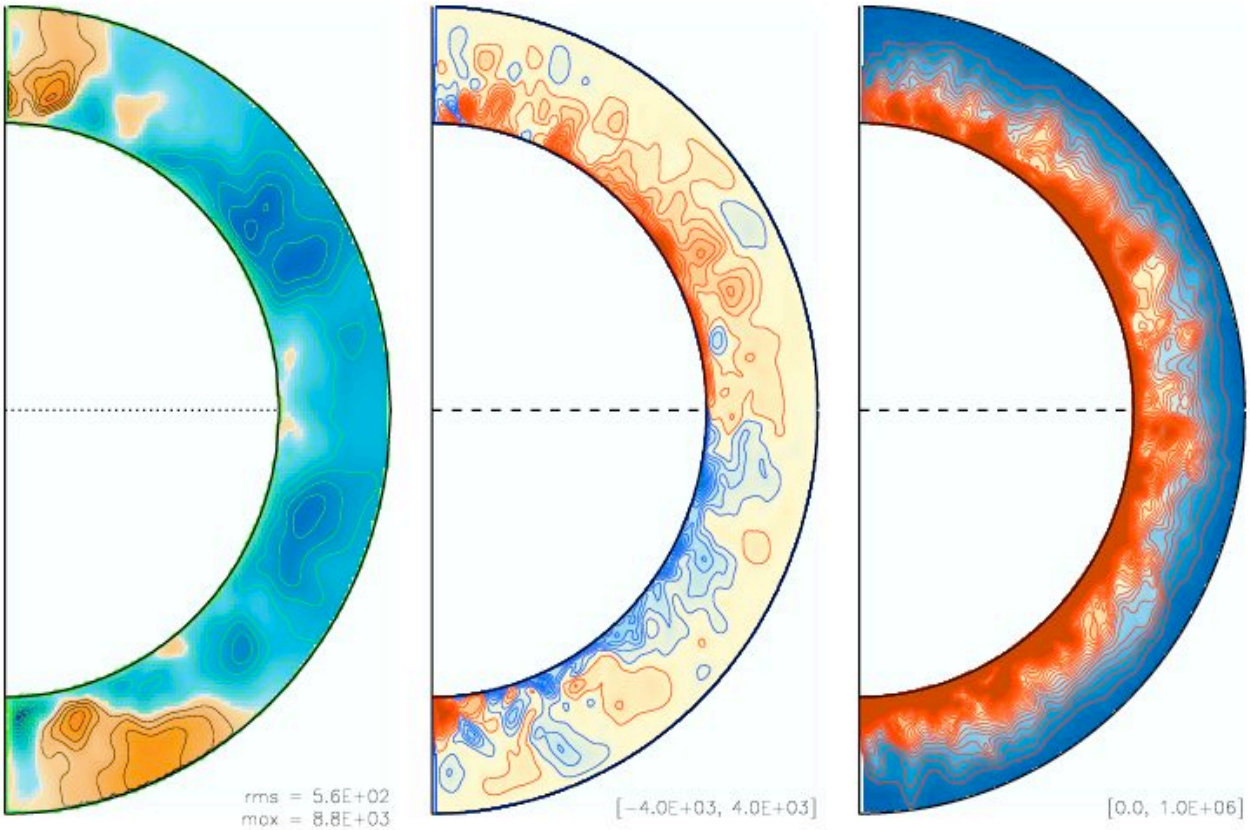
y intercept = 5557001.5

KE in hydro case = 6194495.3

KE/KE_hydro = 0.79362238

CKE/CKE_hydro = 0.90154514

DRKE/DRKE_hydro = 0.64898004



Poloidal field, toroidal field, Non-Axisymmetric ME

/Volumes/data/round/BL/vole3/AZ_Avgs/: t = 4011.23-4014.08, iteration = 7156200-7160000

monitor_Bmean.pro

Latest flight

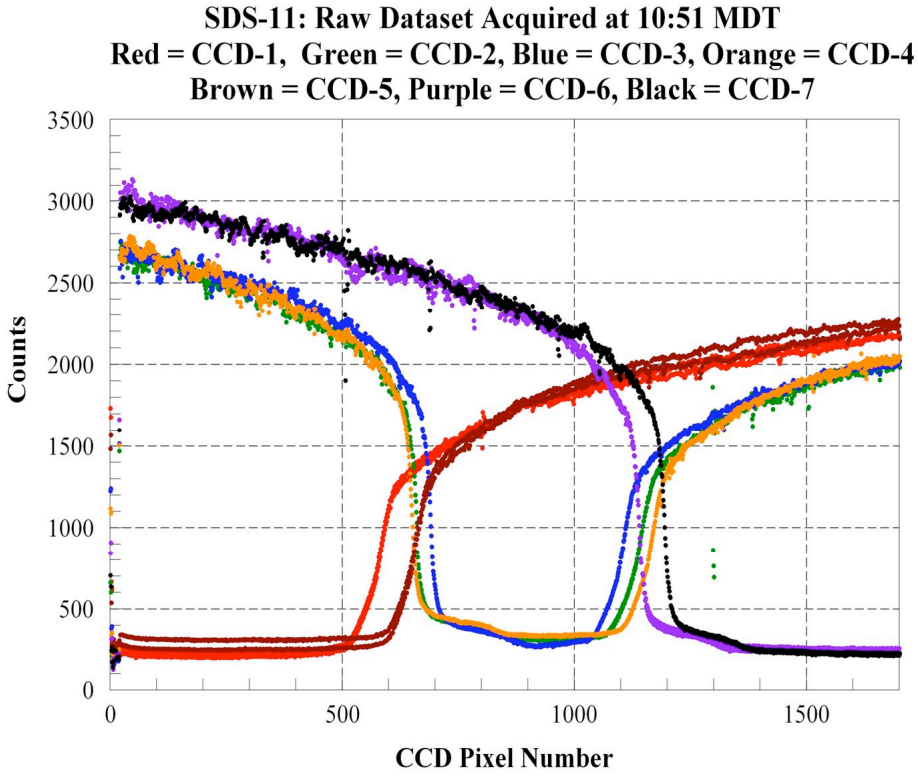
On October 17, 2009 we had a very successful flight of the SDS launched at The Columbia National Balloon Facility in Fort Sumner, NM.

The duration of the flight was of 9 hours, at a float altitude of over 145,000 ft.

The edges were sharp during the entire flight.

THIS WILL BE A BASIC RESULT OBTAINED AT SOLAR MINIMUM

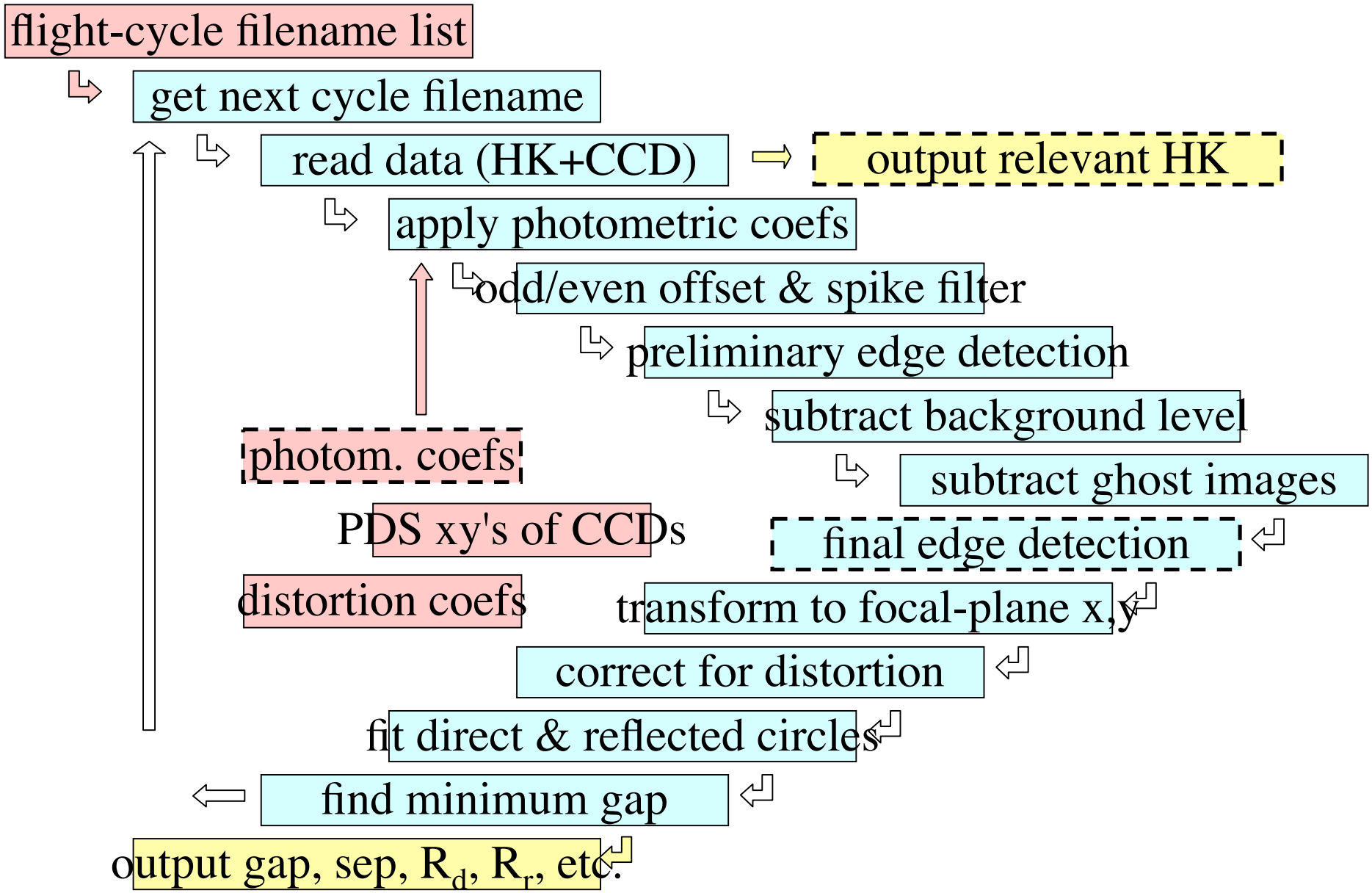
One measurement



Improved Analysis

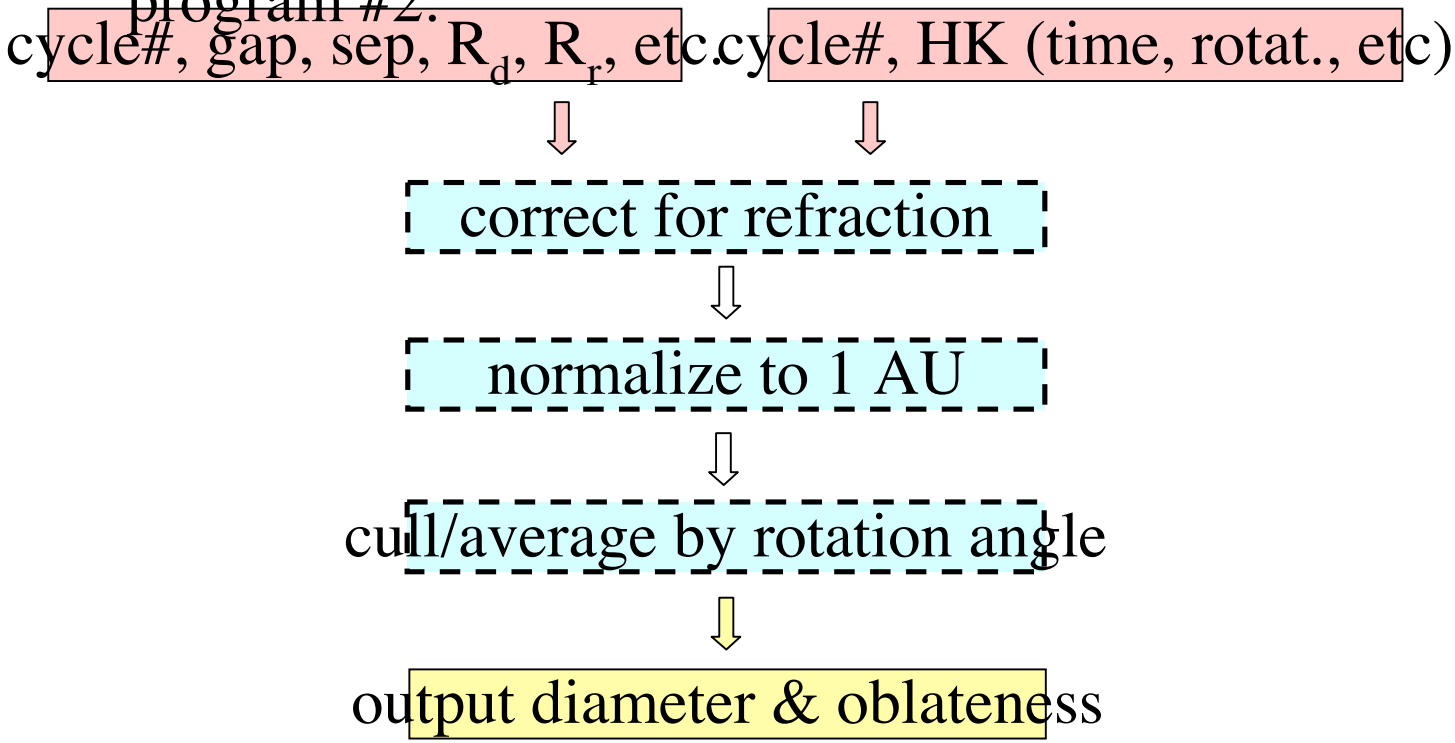
Because of the new importance of the SDS results vis-à-vis PICARD, we are refining the SDS pipeline

"New" Yale SDS Flight Data Reduction Pipeline

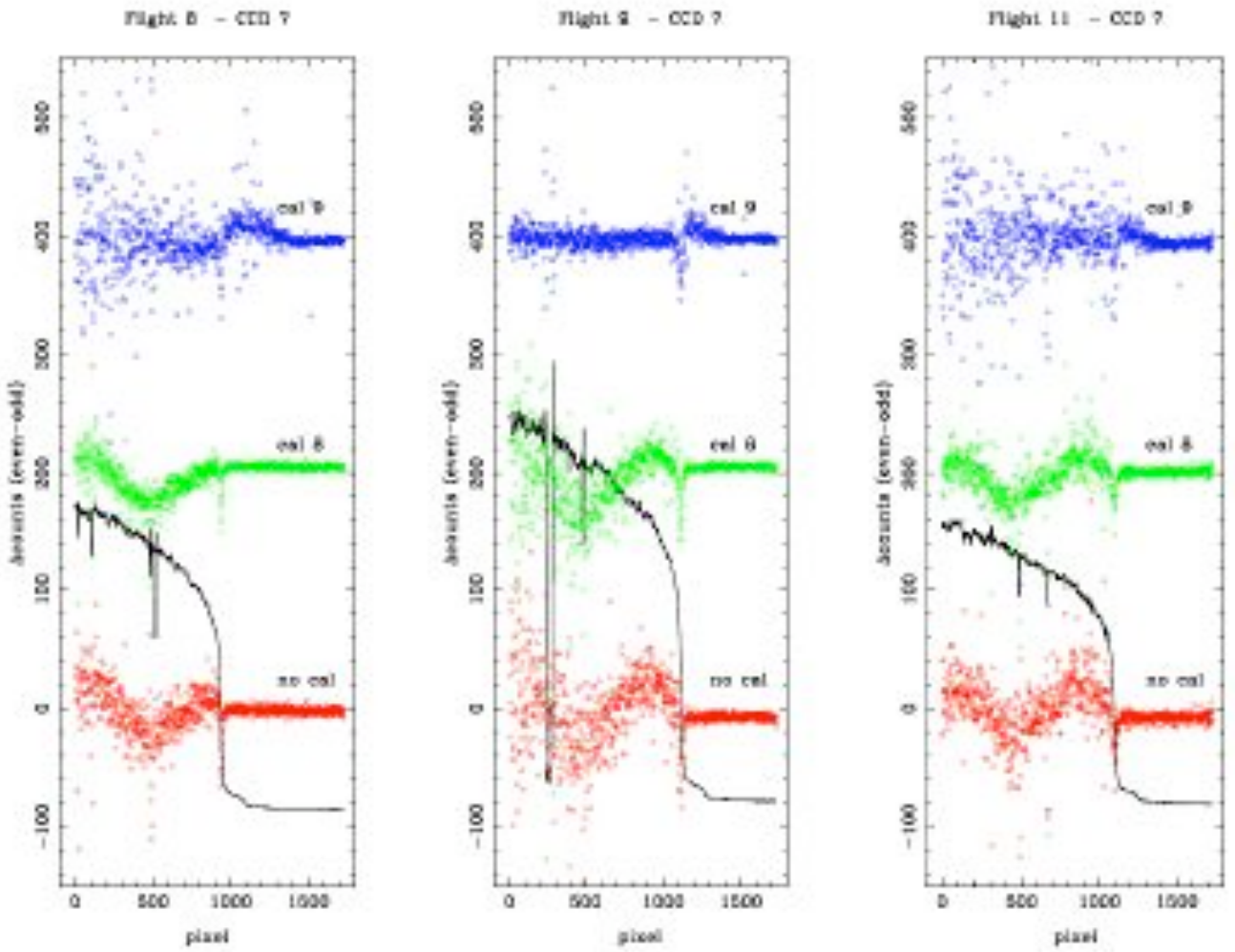


"New" Yale SDS Flight Data Reduction Pipeline *(cont.)*

Output from program #1 becomes input for program #2:



Need for New Photometric Calibration Coefficients



Delta counts (even - odd pixels) for sample CCD 7 profiles from Flights 8, 9 and 11.

Top (blue) - photometric calibration using coefficients designated for Flight 9