Operational Experiences with Vulcan

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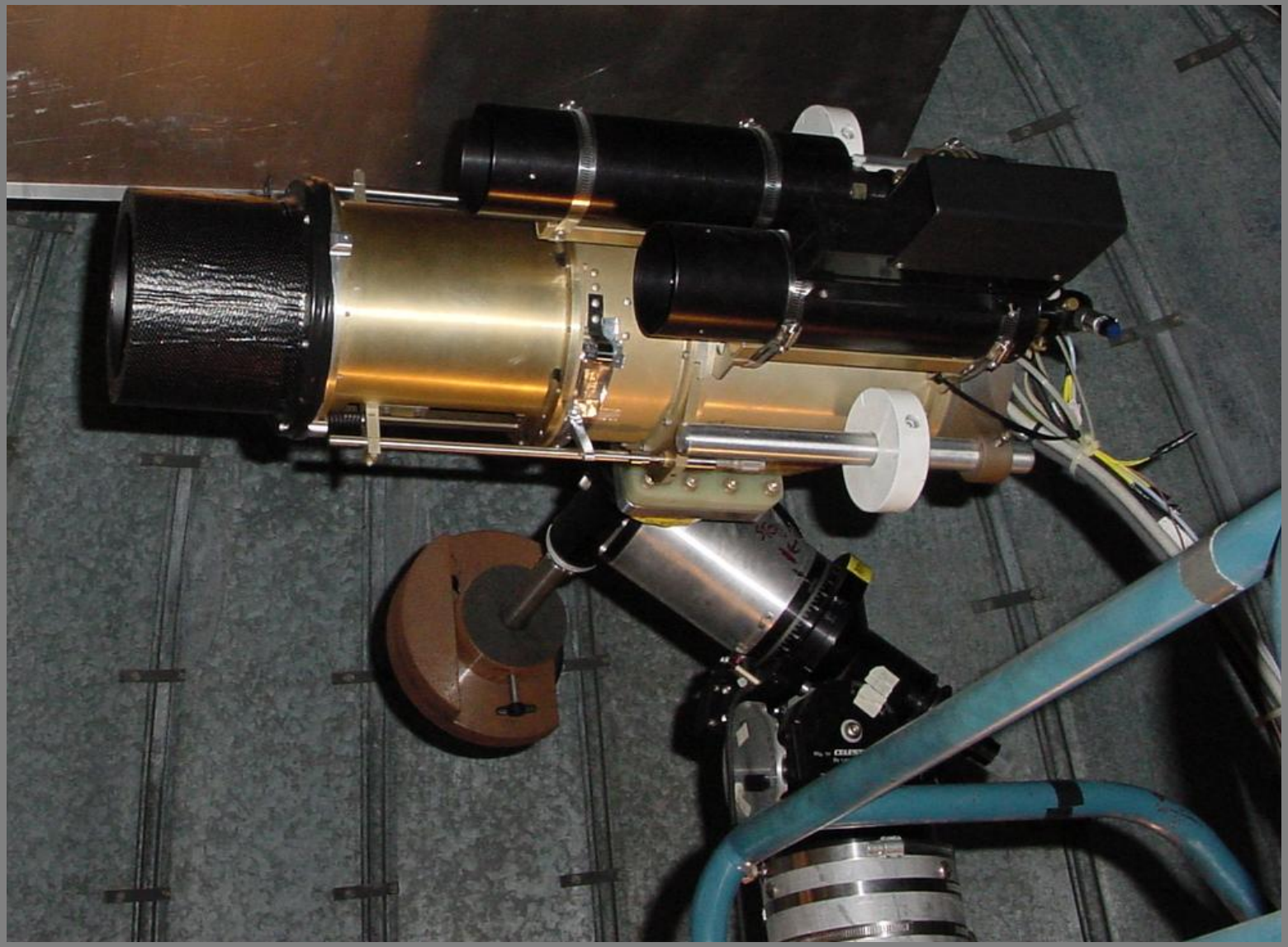
NASA Ames Research Center

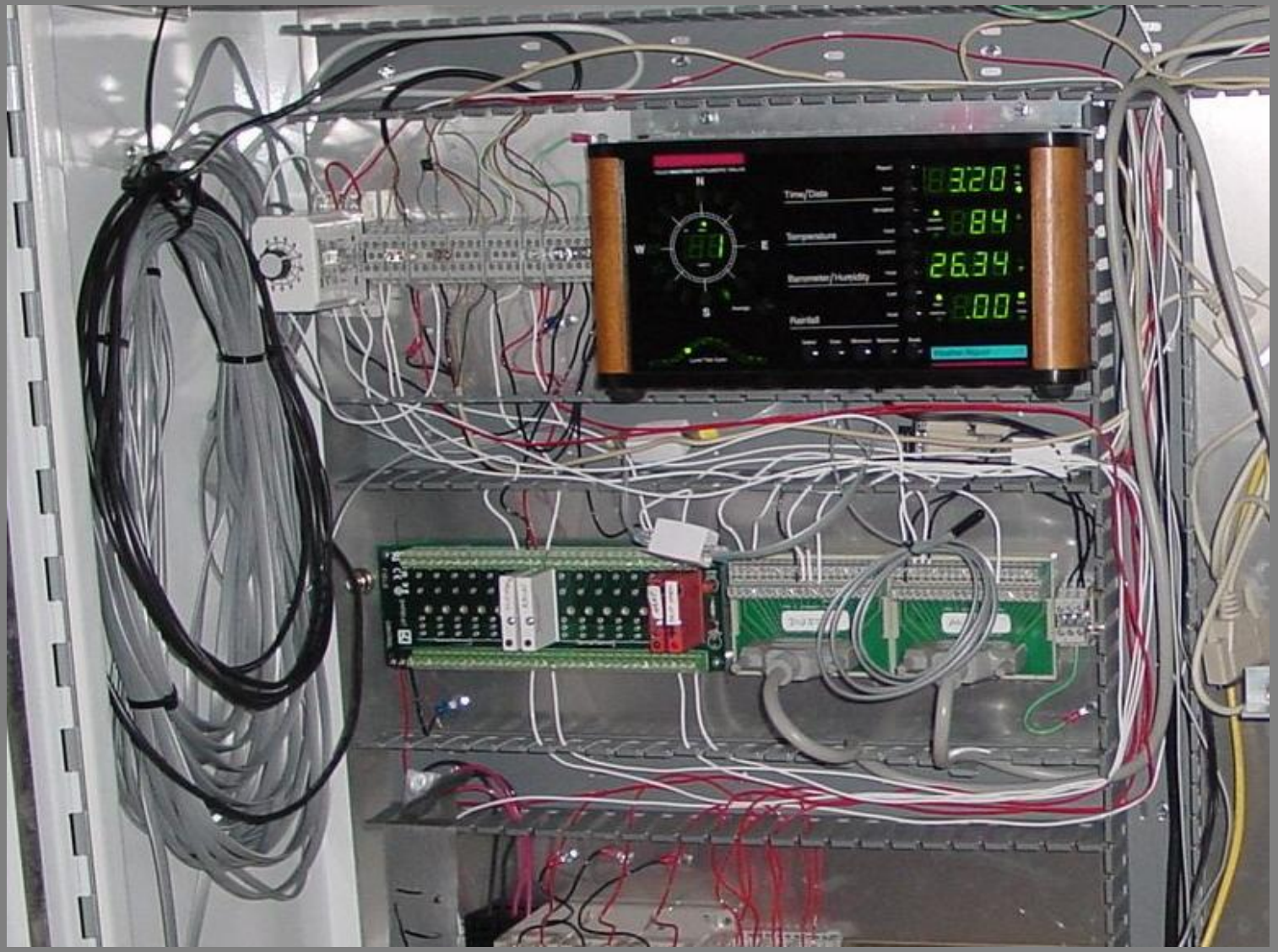
Vulcan, Roman god of fire

The Camera



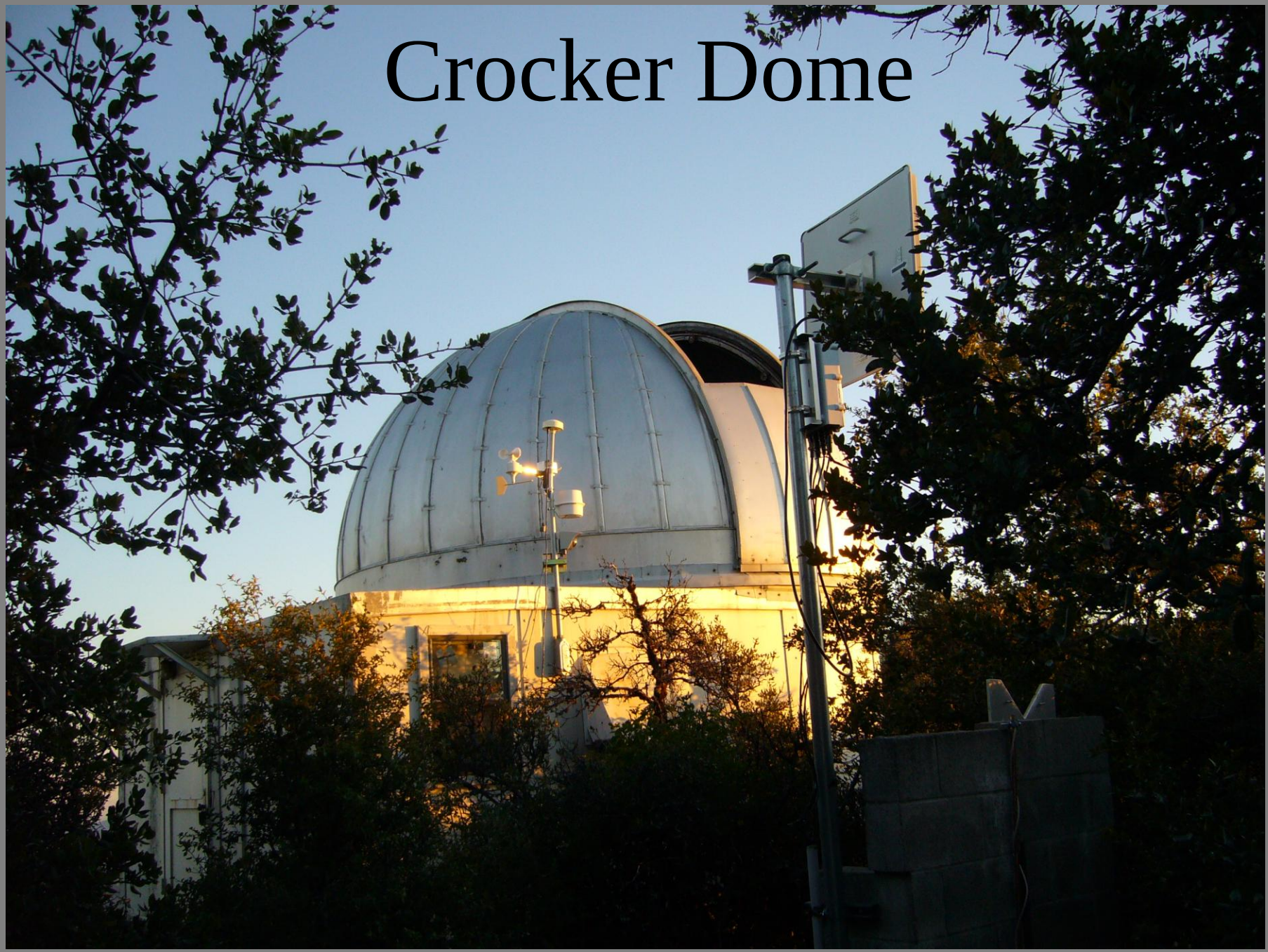
An f/2.8 Canon lens feeds a 4096x4096 Kodak CCD

Weather Station



Dome & outside air temperature, pressure, wind speed, humidity, precipitation, cloud cover (via IR sensor)

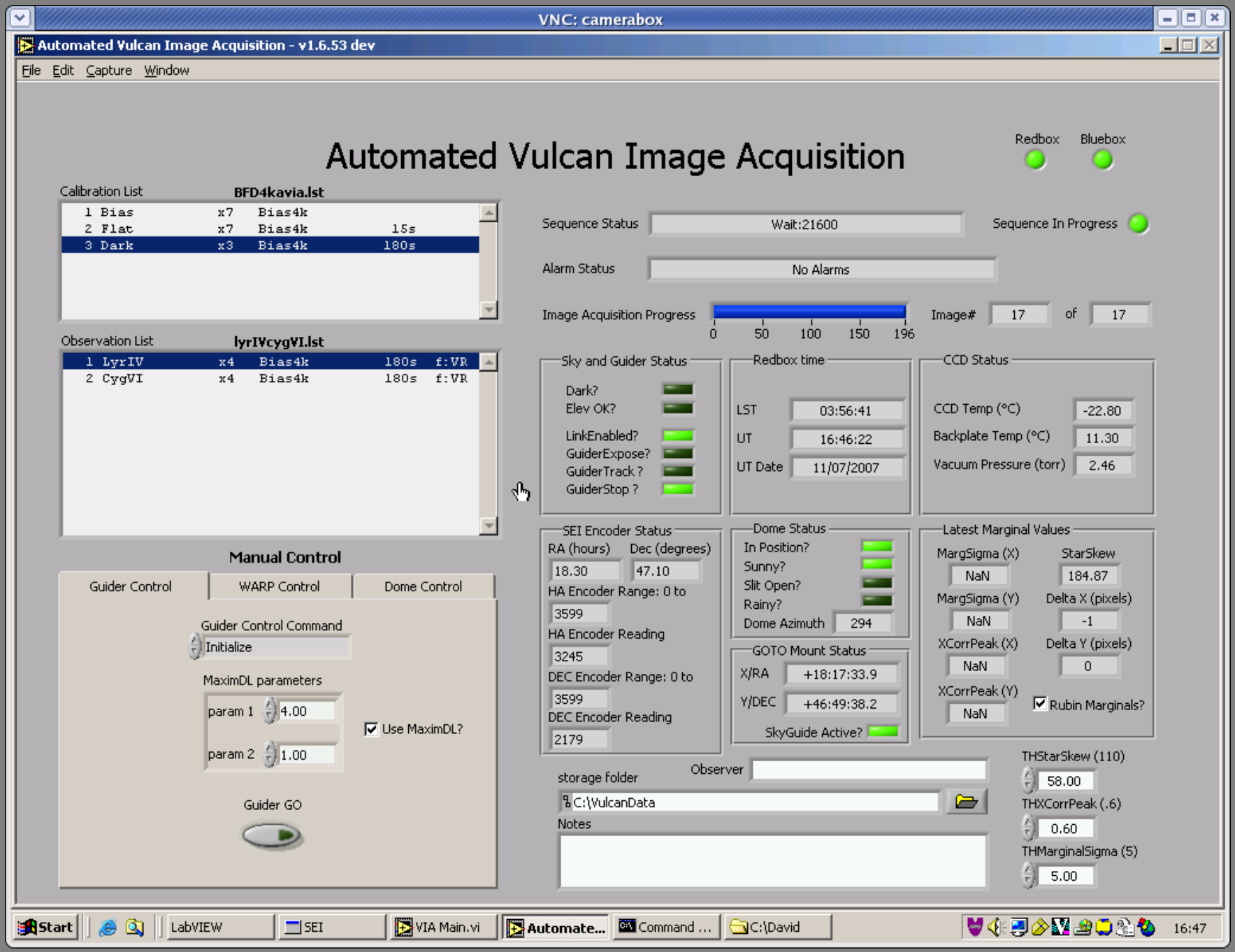
Crocker Dome

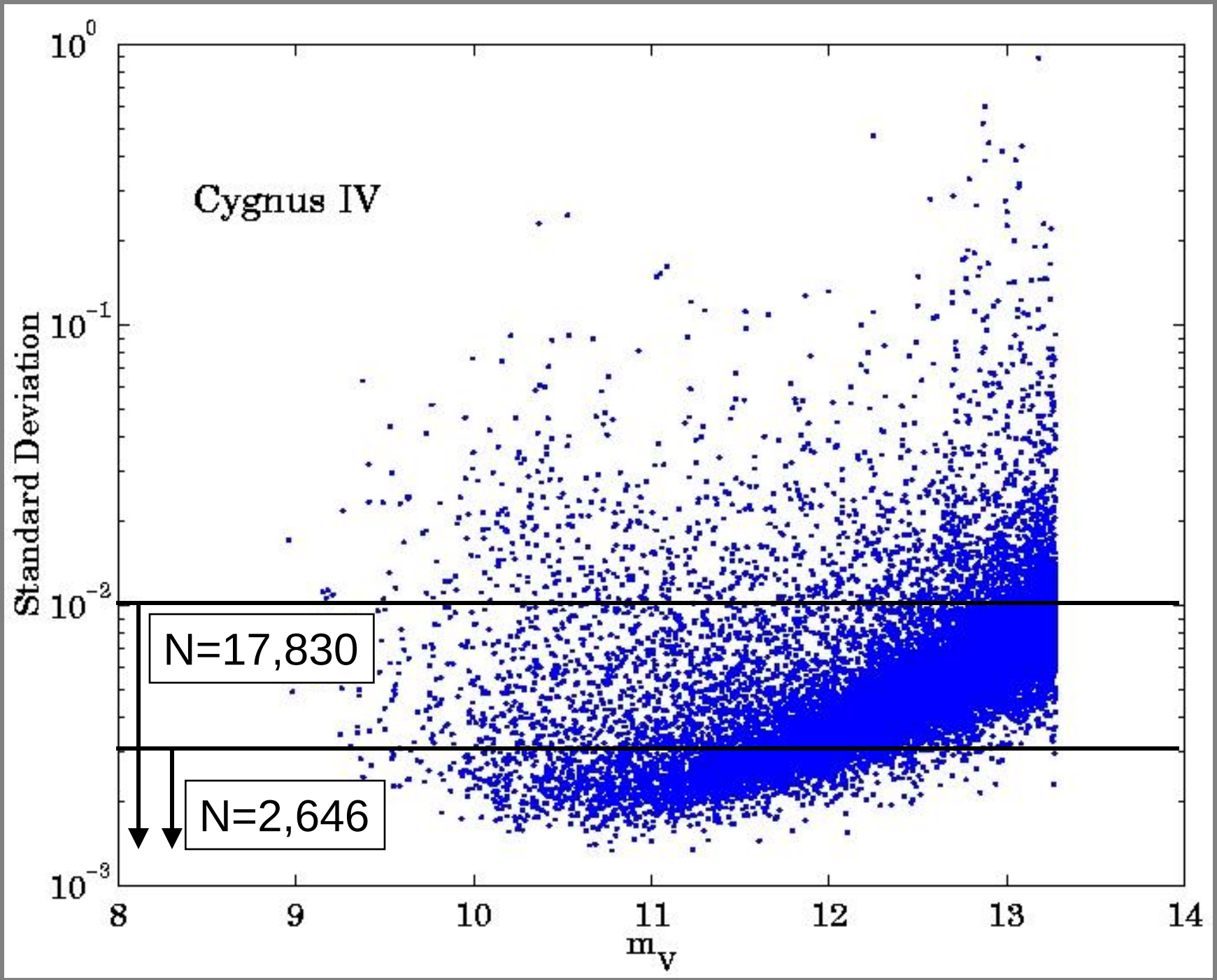


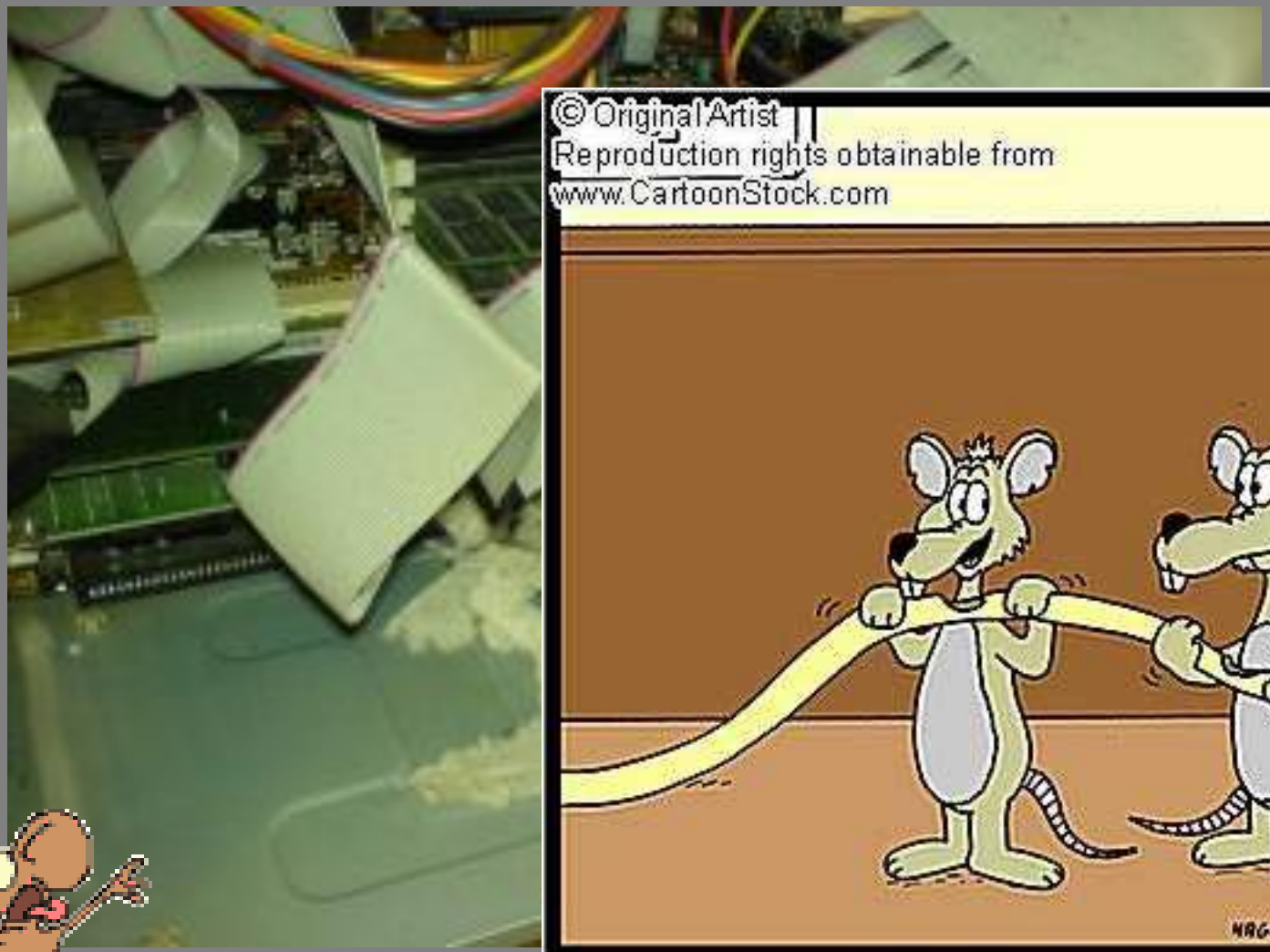
Data Transfer

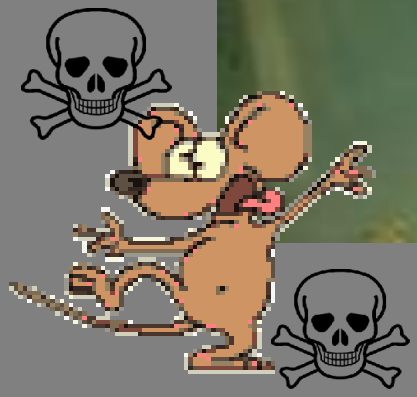
2.4 GHz Solectek MP1100E wireless bridge routers yield 500 kbytes per second.

Ames to Crocker dome:
~25 miles


VNC: camerabox
Automated Vulcan Image Acquisition - v1.6.53 dev
File Edit Capture Window
Automated Vulcan Image Acquisition
Redbox
Bluebox
Calibration List
BFD4kavia.lst
1 Bias x7 Bias4k
2 Flat x7 Bias4k 15s
3 Dark x3 Bias4k 180s
Observation List
lyrIVcygVI.lst
1 LyrIV x4 Bias4k 180s f:VR
2 CygVI x4 Bias4k 180s f:VR
Sequence Status
Wait:21600
Sequence In Progress
Alarm Status
No Alarms
Image Acquisition Progress
0 50 100 150 196
Image#
17
of
17
Sky and Guider Status
Dark?
Elev OK?
LinkEnabled?
GuiderExpose?
GuiderTrack ?
GuiderStop ?
Redbox time
LST
03:56:41
UT
16:46:22
UT Date
11/07/2007
CCD Status
CCD Temp (°C)
-22.80
Backplate Temp (°C)
11.30
Vacuum Pressure (torr)
2.46
SEI Encoder Status
RA (hours)
Dec (degrees)
18.30
47.10
HA Encoder Range: 0 to
3599
HA Encoder Reading
3245
DEC Encoder Range: 0 to
3599
DEC Encoder Reading
2179
Dome Status
In Position?
Sunny?
Slit Open?
Rainy?
Dome Azimuth
294
GOTO Mount Status
X/RA
+18:17:33.9
Y/DEC
+46:49:38.2
SkyGuide Active?
Latest Marginal Values
MargSigma (X)
NaN
StarSkew
184.87
MargSigma (Y)
NaN
Delta X (pixels)
-1
XCorrPeak (X)
NaN
Delta Y (pixels)
0
XCorrPeak (Y)
NaN
Rubin Marginals?
Manual Control
Guider Control
WARP Control
Dome Control
Guider Control Command
Initialize
MaximDL parameters
param 1
4.00
param 2
1.00
Use MaximDL?
Guider GO
storage folder
Observer
C:\VulcanData
Notes
THStarSkew (110)
58.00
THXCorrPeak (.6)
0.60
THMarginalSigma (5)
5.00
Start
LabVIEW
SEI
VIA Main.vi
Automate...
Command ...
C:\David
16:47


Cygnus IV
Standard Deviation
10^{0}
10^{-1}
10^{-2}
10^{-3}
N=17,830
N=2,646
8
9
10
11
12
13
14
m_V





© Original Artist
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www.CartoonStock.com
HAGEN © 2005
The power is off, I've checked:
We can chew as much as we want...

The Dome Leak Diverter

Good thing it never snows in California…

AutoFocus.vi *

File Edit Operate Tools Browse Window Help

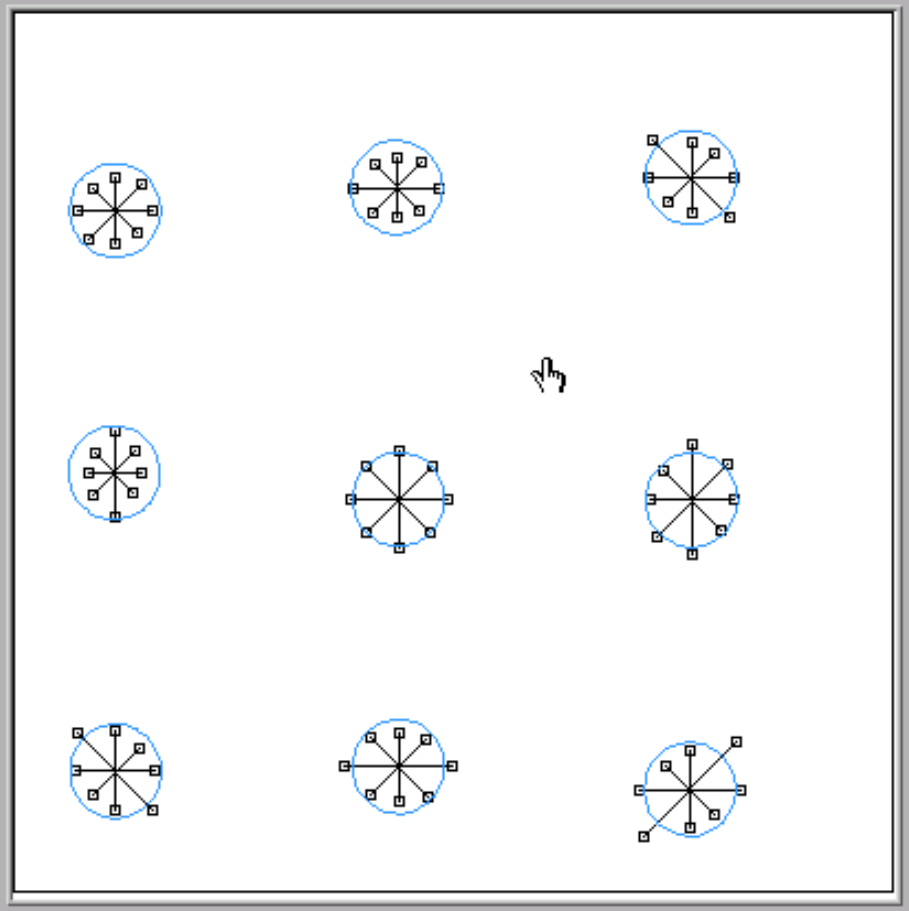
13pt Application Font

Current Image

C:\VulcanData\Data-2007-07-10\CygVI168497.fits

Finding star 9 of 9...

FWHM Plot



Ideal FWHM

3.00

Mean FWHM

2.65

SD of FWHM

0.59

Stars from Whole Image

FWHMs

2.58	2.14	2.54	3.48
3.56	2.55	2.17	2.63
3.27	4.24	2.49	2.18
1.75	1.96	2.75	1.80
3.20	3.07	3.09	3.02
2.71	3.24	3.52	2.72
2.44	2.49	2.11	1.99
2.82	2.29	1.86	2.12
2.81	2.15	2.30	3.51

AutoFocus.vi *

File Edit Operate Tools Browse Window Help

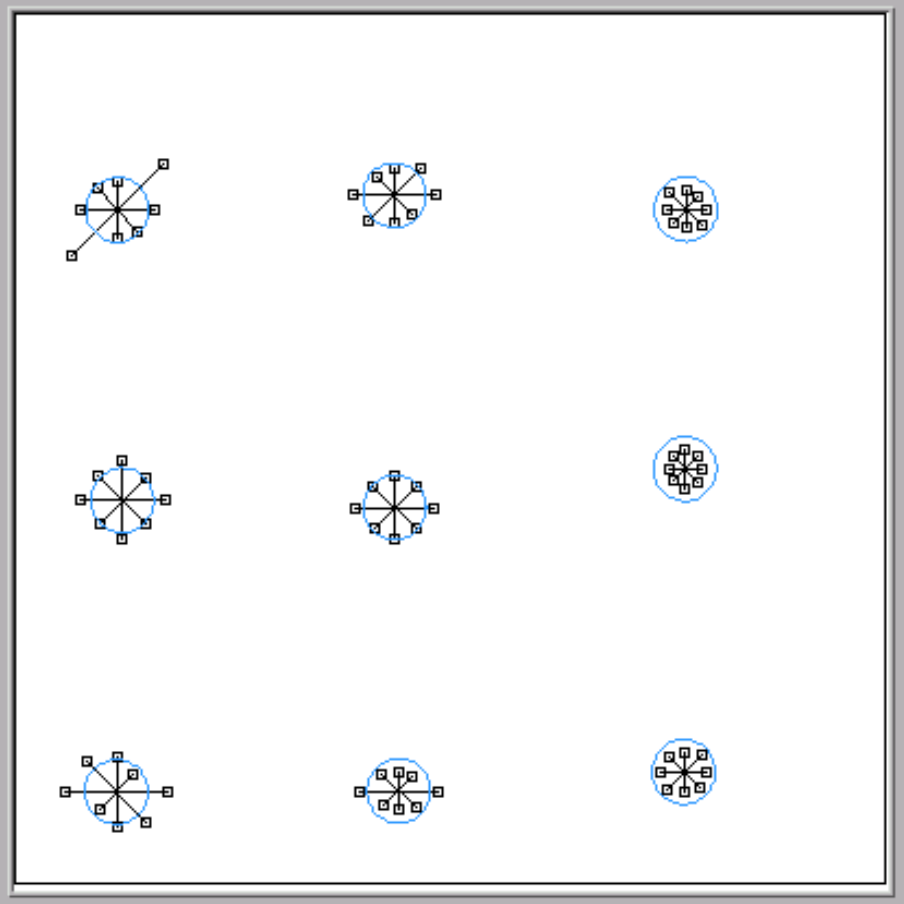
13pt Application Font

Current Image

C:\VulcanData\CygVI167305.fits

Finding star 9 of 9...

FWHM Plot



Ideal FWHM

3.00

Mean FWHM

2.78

SD of FWHM

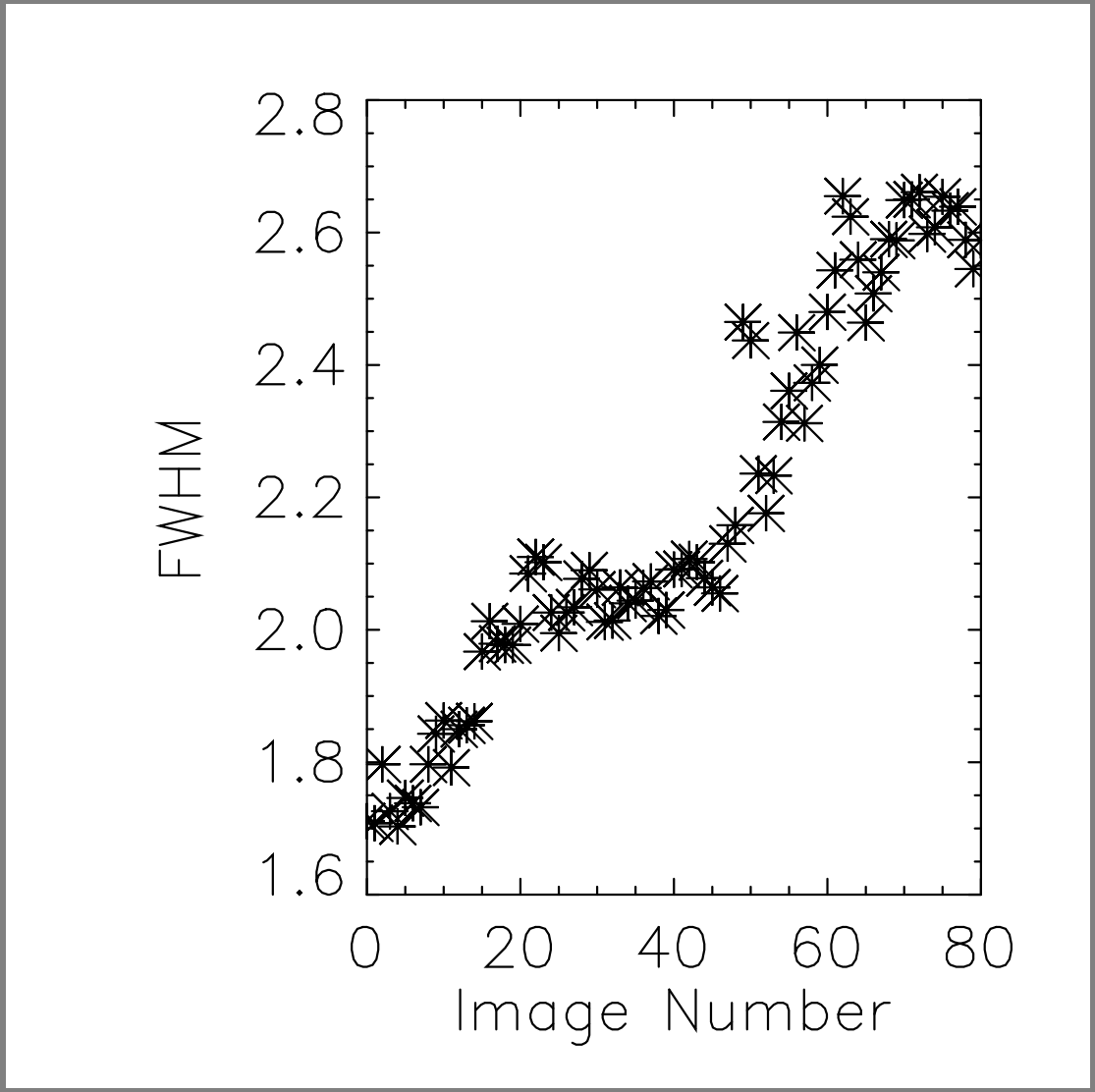
1.04

Stars from Whole Image

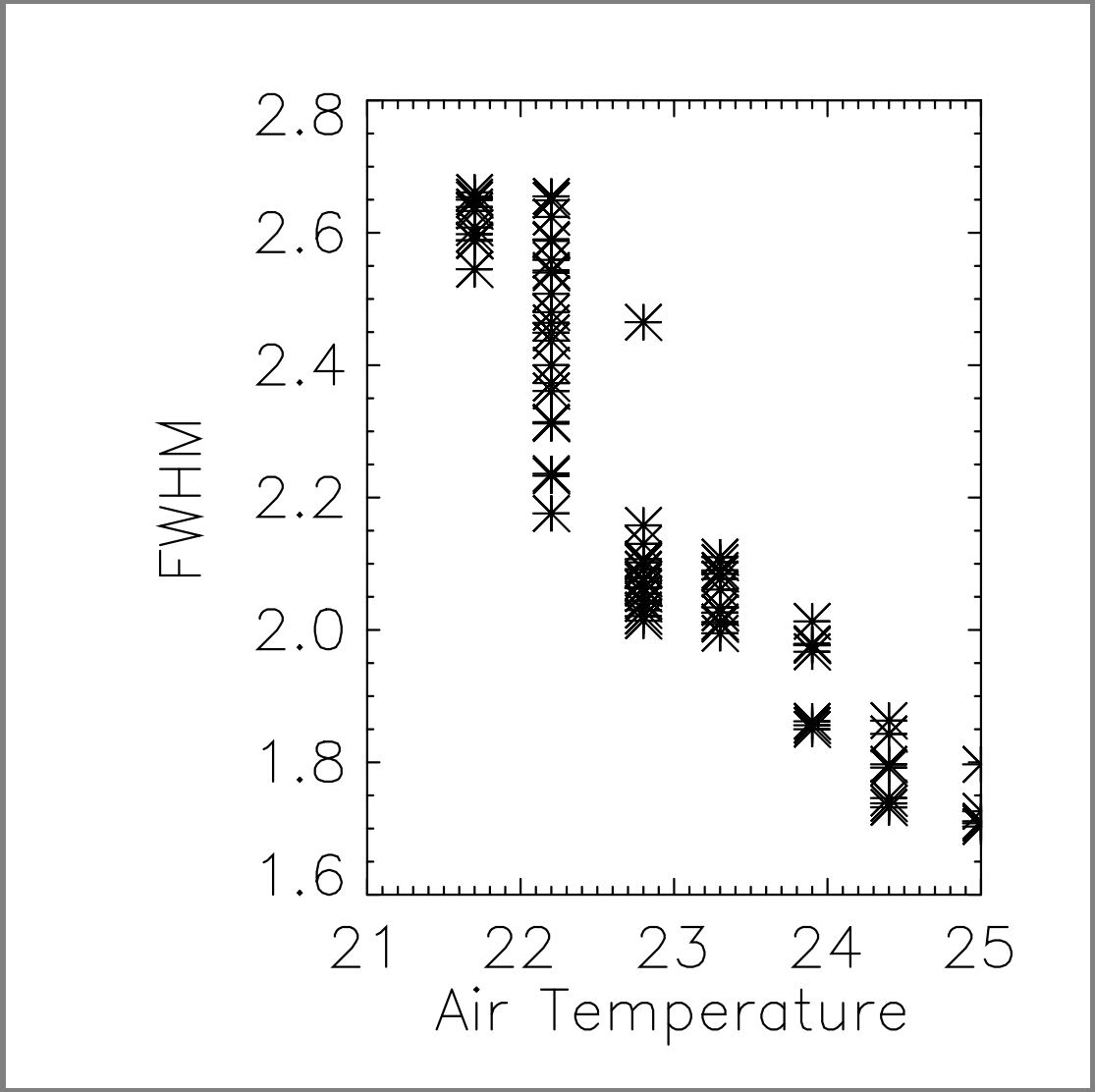
FWHMs

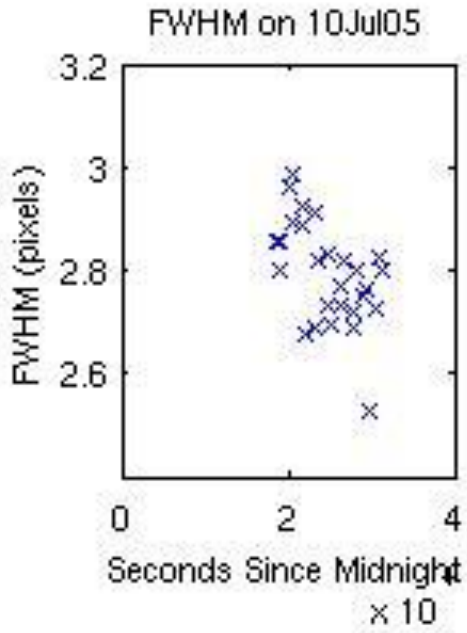
4.99	2.21	3.15	3.99
3.67	1.90	1.65	2.26
2.22	2.39	1.90	2.05
4.07	3.08	3.67	3.19
3.76	2.80	2.88	2.83
1.52	1.61	1.84	1.68
3.55	6.09	2.56	2.77
3.93	3.45	2.51	2.43
1.87	1.66	1.74	2.19

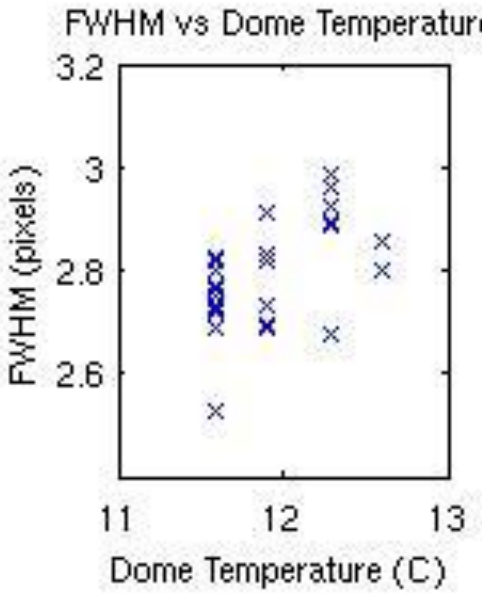
Focus Stability

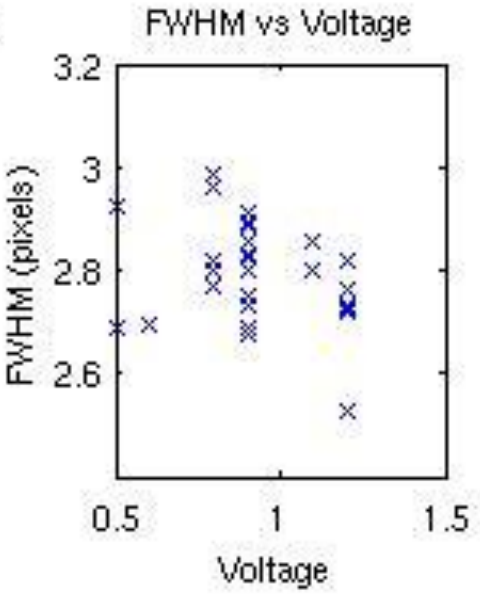


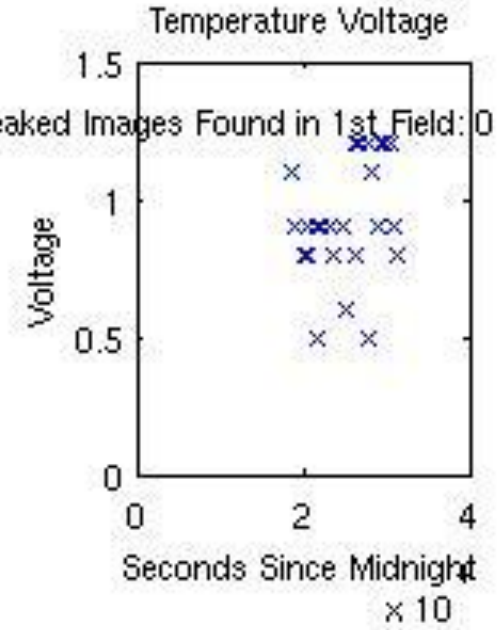
FWHM correlated with both air and CCD Temperature

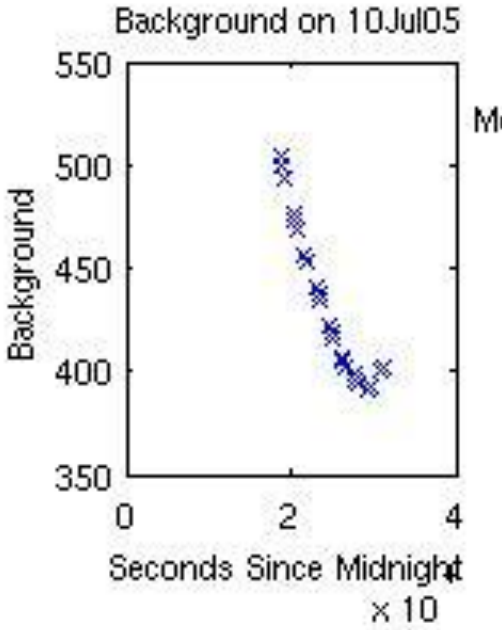


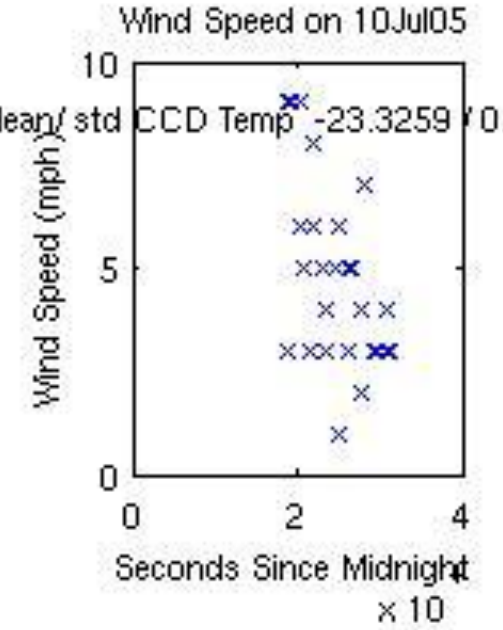

FWHM on 10Jul05
FWHM (pixels)
3.2
3
2.8
2.6
0
2
4
Seconds Since Midnight
x 10

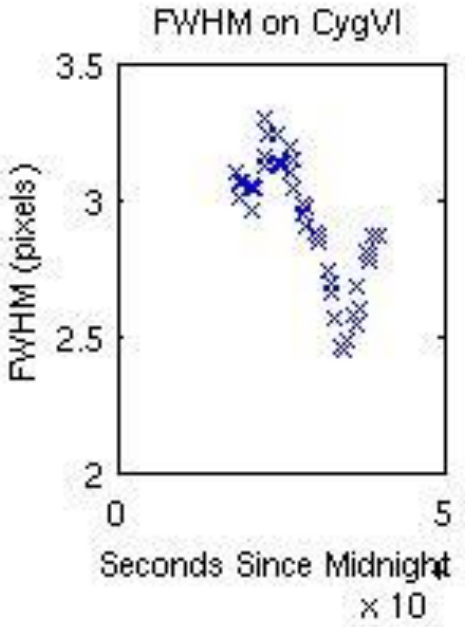

FWHM vs Dome Temperature
FWHM (pixels)
3.2
3
2.8
2.6
11
12
13
Dome Temperature (C)

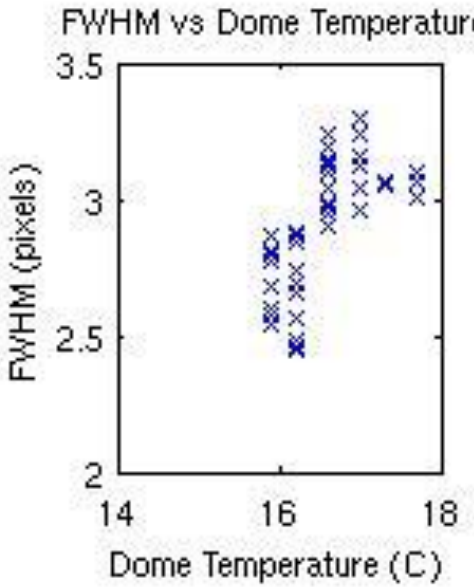

FWHM vs Voltage
FWHM (pixels)
3.2
3
2.8
2.6
0.5
1
1.5
Voltage

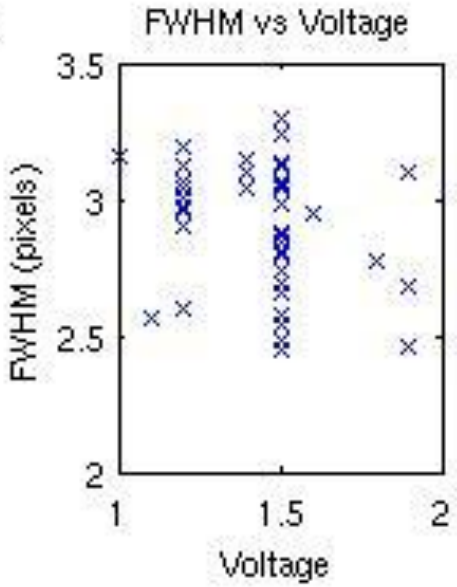

Temperature Voltage
Streaked Images Found in 1st Field: 0
Voltage
1.5
1
0.5
0
0
2
4
Seconds Since Midnight
x 10

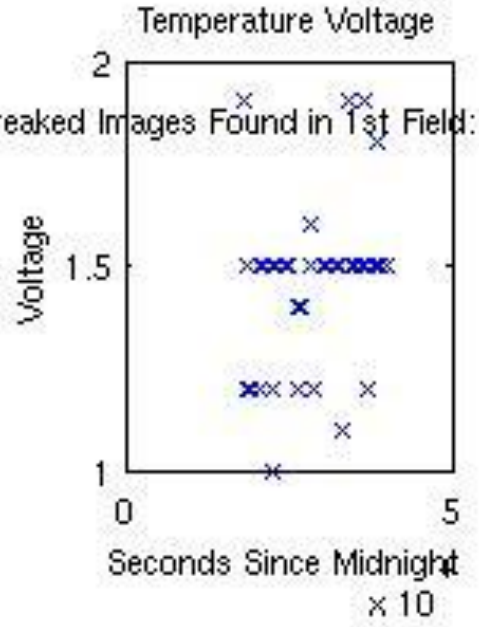

Background on 10Jul05
Background
550
500
450
400
350
0
2
4
Seconds Since Midnight
x 10

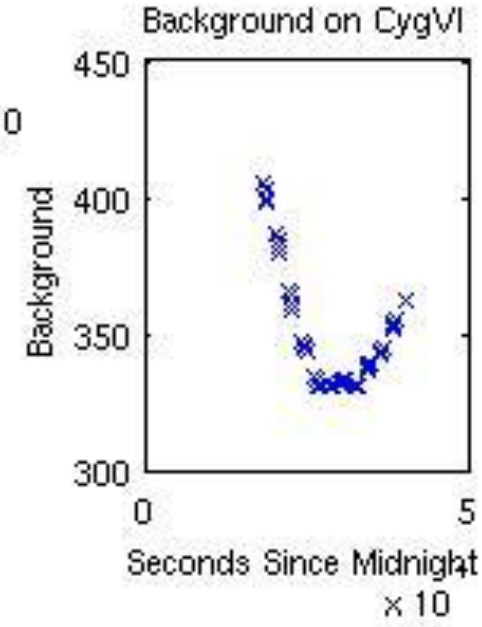

Wind Speed on 10Jul05
Mean/ std CCD Temp -23.3259 / 0.052569
Wind Speed (mph)
10
5
0
0
2
4
Seconds Since Midnight
x 10

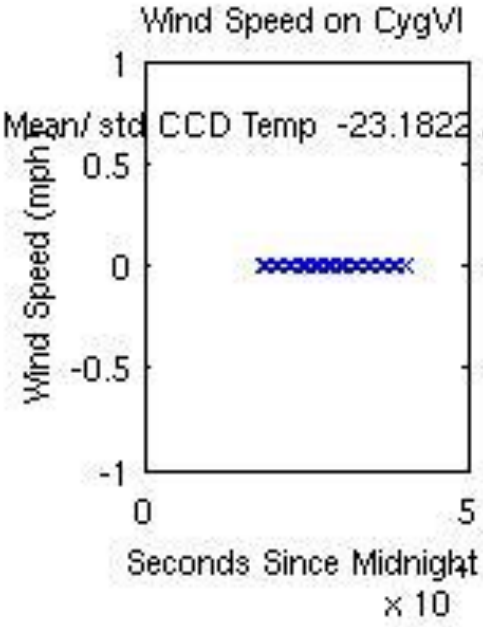

FWHM on CygVI
FWHM (pixels)
3.5
3
2.5
2
0
5
Seconds Since Midnight
x 10^4

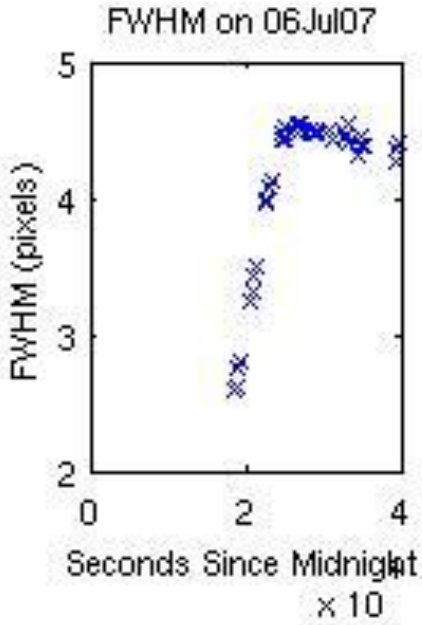

FWHM vs Dome Temperature
FWHM (pixels)
3.5
3
2.5
2
14
16
18
Dome Temperature (C)

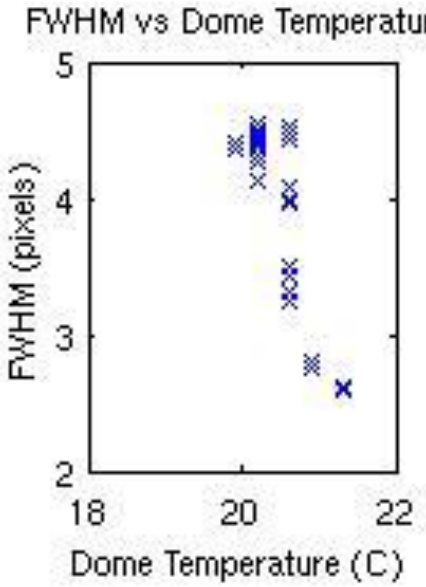

FWHM vs Voltage
FWHM (pixels)
3.5
3
2.5
2
1
1.5
2
Voltage

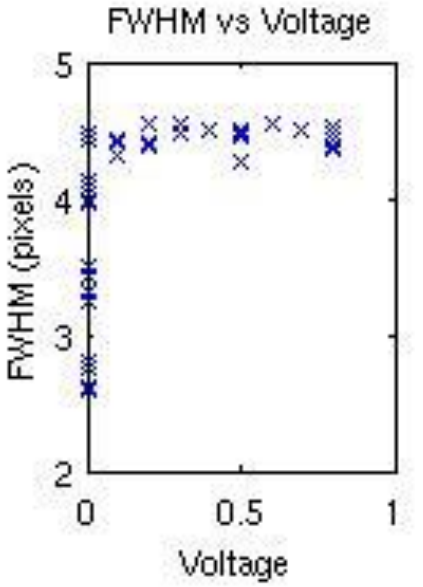

Temperature Voltage
Streaked Images Found in 1st Field: 0
Voltage
2
1.5
1
0
5
Seconds Since Midnight
x 10^4

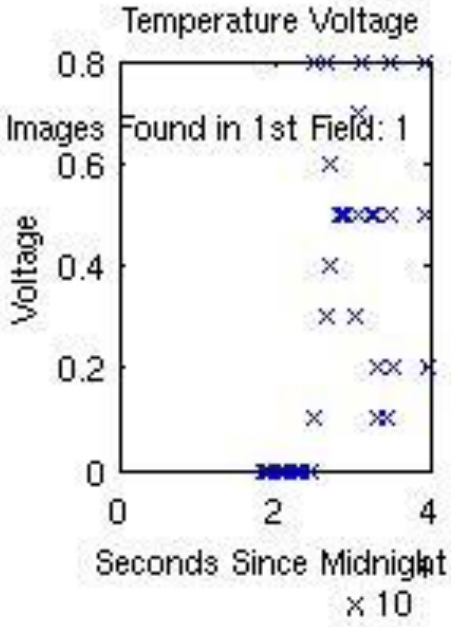

Background on CygVI
Background
450
400
350
300
0
5
Seconds Since Midnight
x 10^4

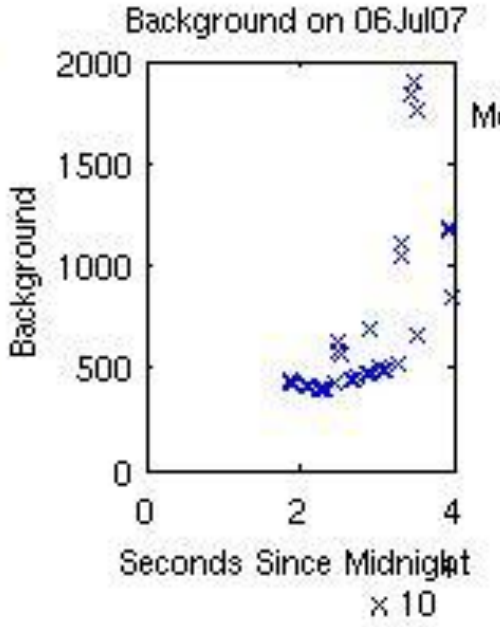

Wind Speed on CygVI
Mean/ std CCD Temp -23.1822 / 0.038665
Wind Speed (mph)
1
0.5
0
-0.5
-1
0
5
Seconds Since Midnight
x 10^4

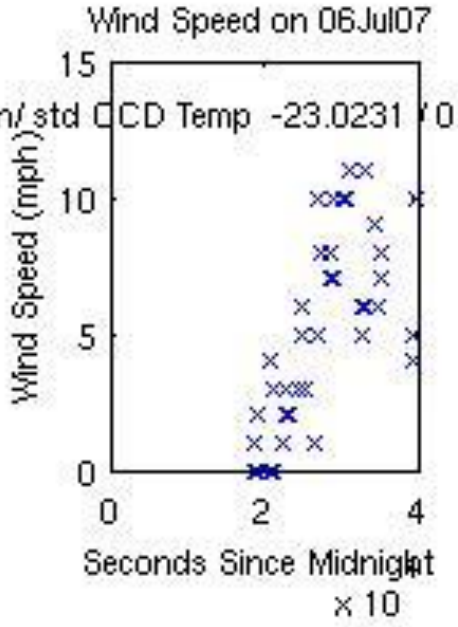

FWHM on 06Jul07
FWHM (pixels)
Seconds Since Midnight
x 10


FWHM vs Dome Temperature
FWHM (pixels)
Dome Temperature (C)


FWHM vs Voltage
FWHM (pixels)
Voltage


Temperature Voltage
Streaked Images Found in 1st Field: 1
Voltage
Seconds Since Midnight
x 10


Background on 06Jul07
Background
Seconds Since Midnight
x 10


Wind Speed on 06Jul07
Mean/ std CCD Temp -23.0231
0.087243
Wind Speed (mph)
Seconds Since Midnight
x 10

Things that can go wrong	What can help
• Mice chew cables	• Nightly diagnostics
• Mice nest in warm equipment	• Thorough observing logs
• Motors fail	• Web camera
• Circuit breakers blow	• Internet-controlled dome light
• Power fails	• Internet-controlled switches
• Domes leak	• CRON scripts to archive data
• Hard drives fill up	• Linux/Unix wherever possible
• Memory leaks cause glitches	• Absolute encoders on drive axes
• Air temperature is not stable	• Thermal control heaters

The Elephant in the Closet

Number of Expected Detections

$$N = P_d \times P_p \times P_a \times P_3 \times Nstars$$

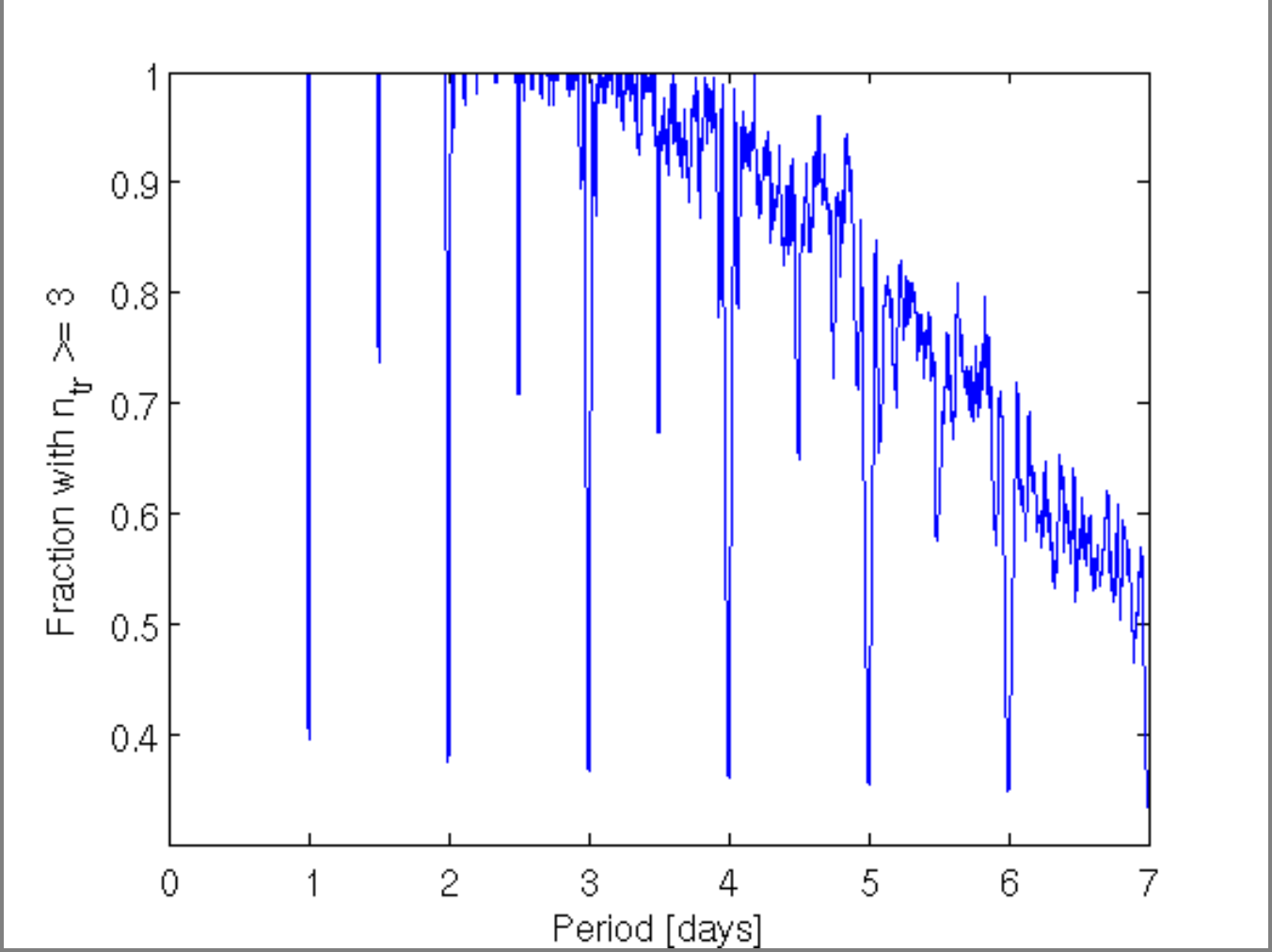
P_d = probability star is MS dwarf (50%)

P_p = probability has short – period planet (1%)

P_a = probability of alignment (10%)

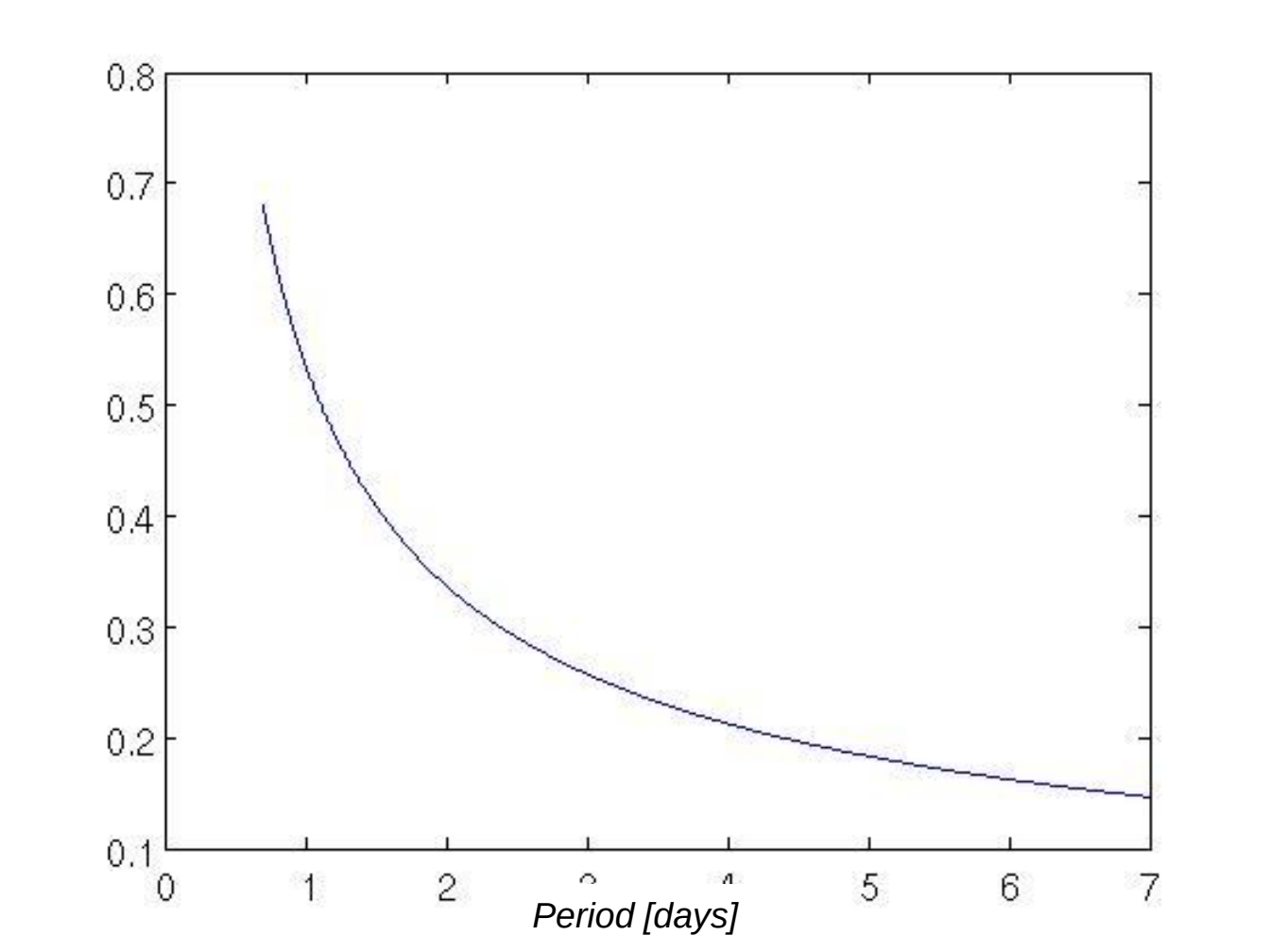
P_3 = probability of observing 3 transits (60-80%)

Assume milli-mag precision is achieved for about 3,000 stars per field. This translates to one detection per field.



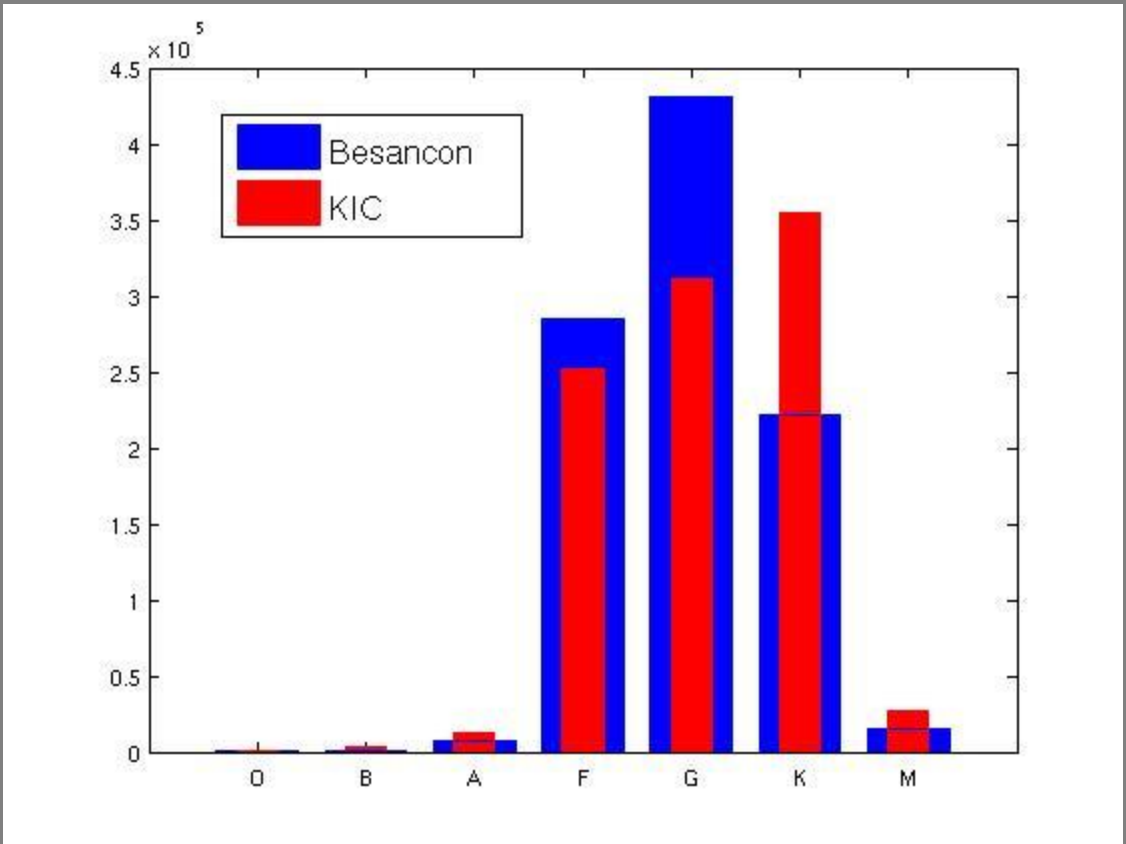
Does not imply 100% detectability probability for P < 2 days

Alignment probability also decreases with increasing period.



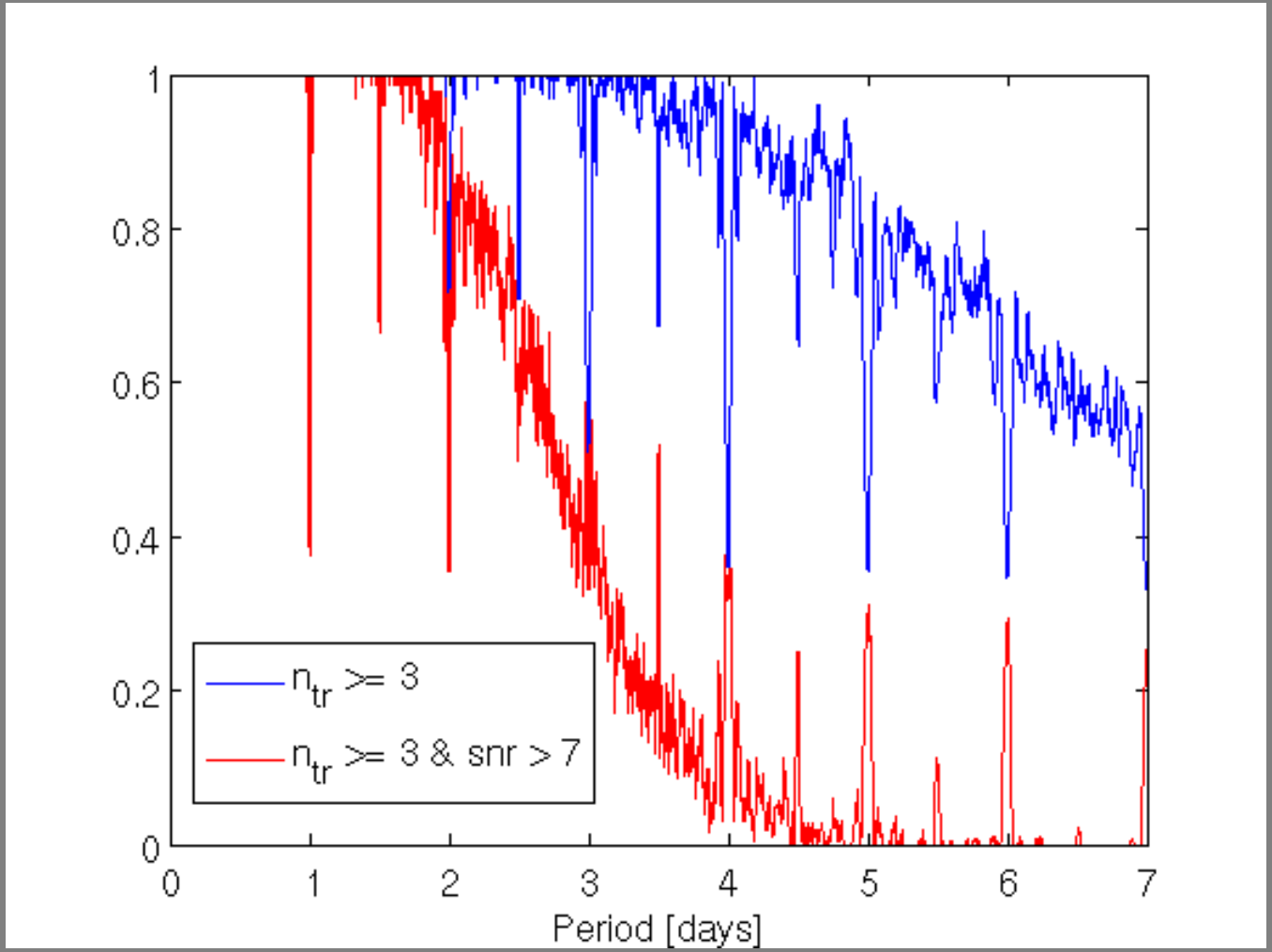
Probability depends on stellar characteristics.

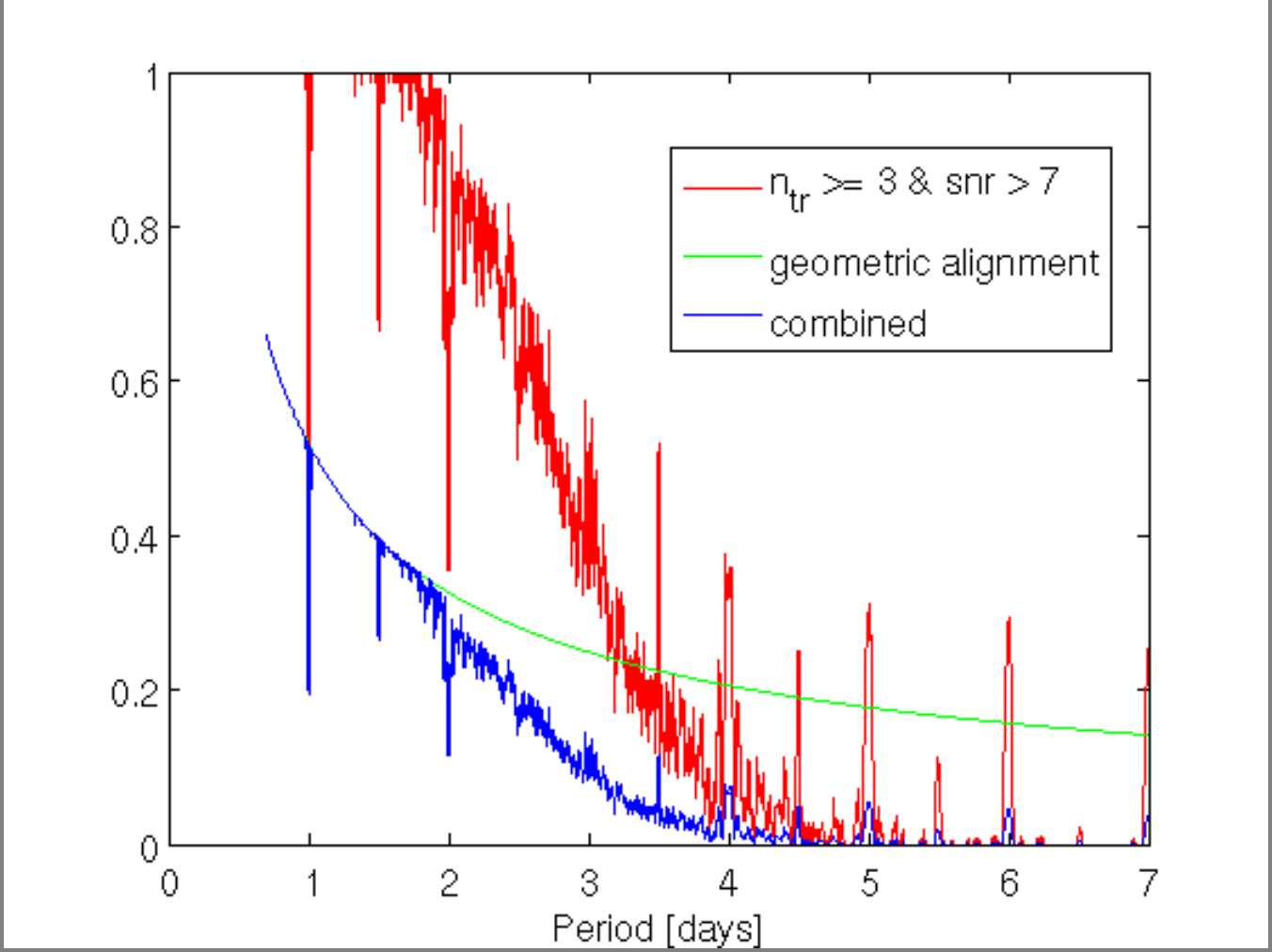
Modeled versus Observed Stellar Populations



http://bison.obs-besancon.fr/modele

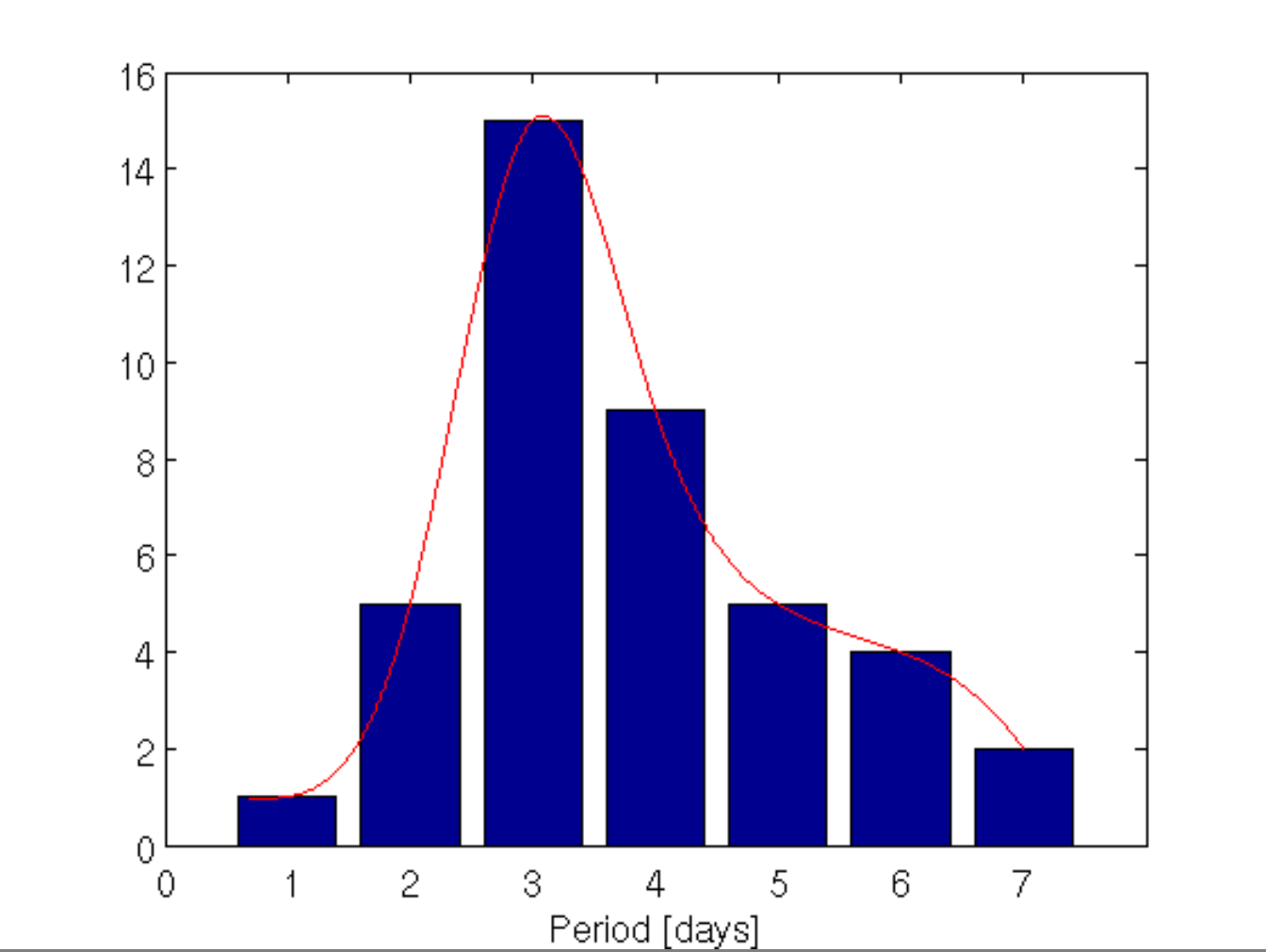
Robin, Reyle, Derriere, Picaud, 2003, AA 409 523

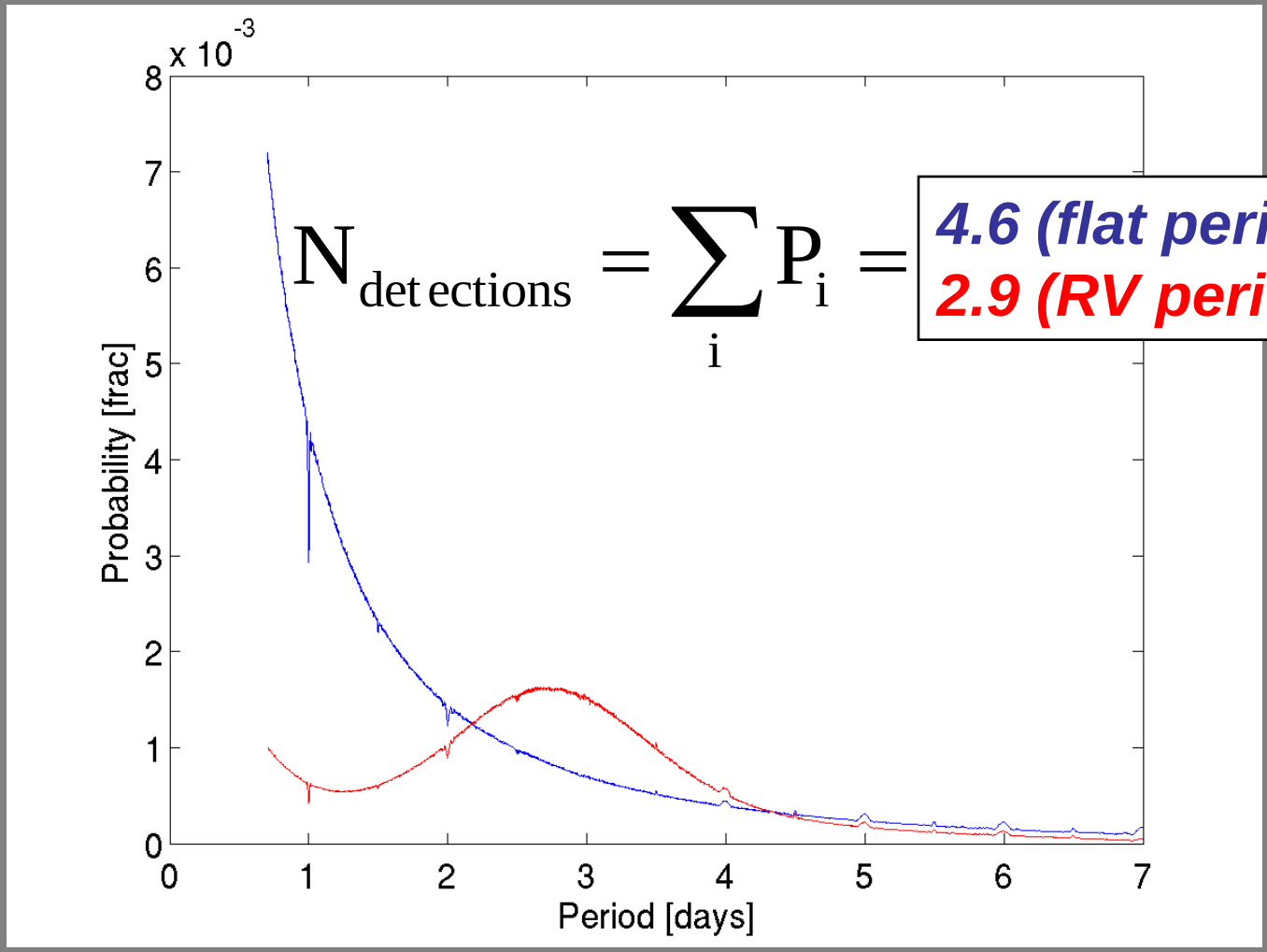

1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
7
Period [days]
n_tr >= 3
n_tr >= 3 & snr > 7



Note: blue and green traces applicable to one specific star

RV Period Distribution





Does not consider binarity or dilution effects due to crowding.

More cameras, more fields, more telescopes…

$$N_{detections} = \sum_i P_i =$$

One camera, one field, one telescope:

4.6 (flat period distr)
2.9 (RV period distr)

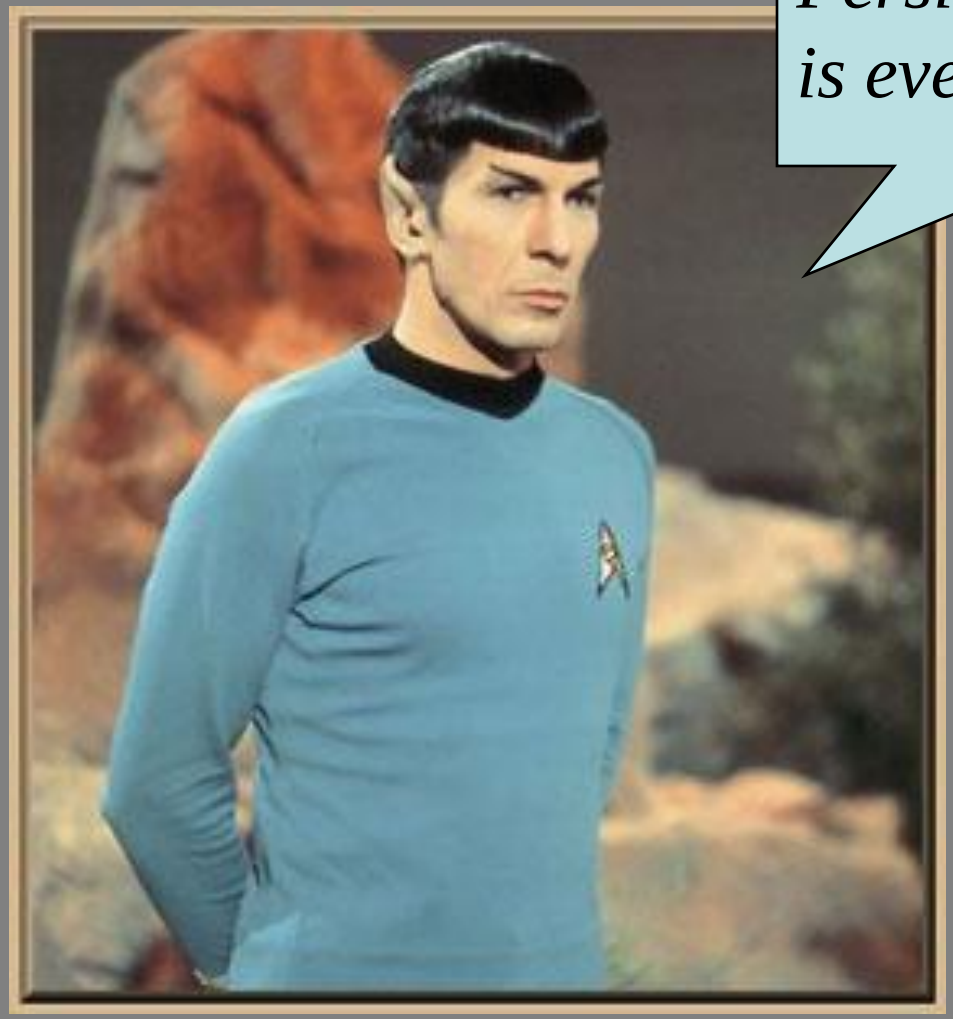
One camera, two fields, one telescope:

Per field:

4.3 (flat period distr)
2.6 (RV period distr)

Total:

8.6 (flat period distr)
5.2 (RV period distr)



Persistence, Captain, is everything.