Sizing up the Stars

Main Sequence Stellar Diameters with the CHARA Array

Tabetha Boyajian
Hal McAlister- Thesis Advisor

Outline

- Why measure stellar diameters?
- My thesis project overview
- Current status / results
- Grad student winter observing status

First of all, Size DOES Matter!!!

- If you are thirsty…

http://homebarsupplys.com/images/products_fullsize/ultimate_mug_1.jpg

Size DOES Matter!!!

- If you are clothes shopping…

www.svrc.vic.edu.au/02

Size DOES Matter!!!

- If you are choosing a guard dog…

http://www.dognet.biz/big_dog_little_dog.jpg

Size DOES Matter!!!

- If you are stuck in the mud…

http://www.humvee.net/pix/ramstkh.jpg

Size DOES Matter!!!

- If you need to park your car…

http://www.theage.com.au/ffximage/2005/01/30/car_park_wideweb__430x240.jpg

Size DOES Matter!!!

- In Stellar Astronomy, size does matter too!
  - Effective temperature
  - Absolute luminosity
  - Constraints for model stellar atmospheres and evolution
  - Single VS binary star radii (from eclipsing binaries)
  - Metallicity and age
  - Rotation
- Direct diameter measurements with long baseline optical (IR) interferometry of a large sample of stars, enables us to derive relationships (e.g., with photometry) to characterize an even larger number of stars, too far away (small) to observe with interferometry.

My Thesis

Angular Diameters of Main Sequence

A, F, and G stars with the CHARA Array

- Who:
  - Advisor: Hal McAlister
  - Committee: Doug Gies, Todd Henry, Nikolaus Dietz, Paul Wiita, Gerard van Belle

Goals

- Better than 4% accuracy in diameter
  - Establish effective temperature scale < 2% error
  - Absolute luminosity → HR diagram
  - Testing stellar evolution models
    - Metallicity and age
    - Duplicity
  - Rotation

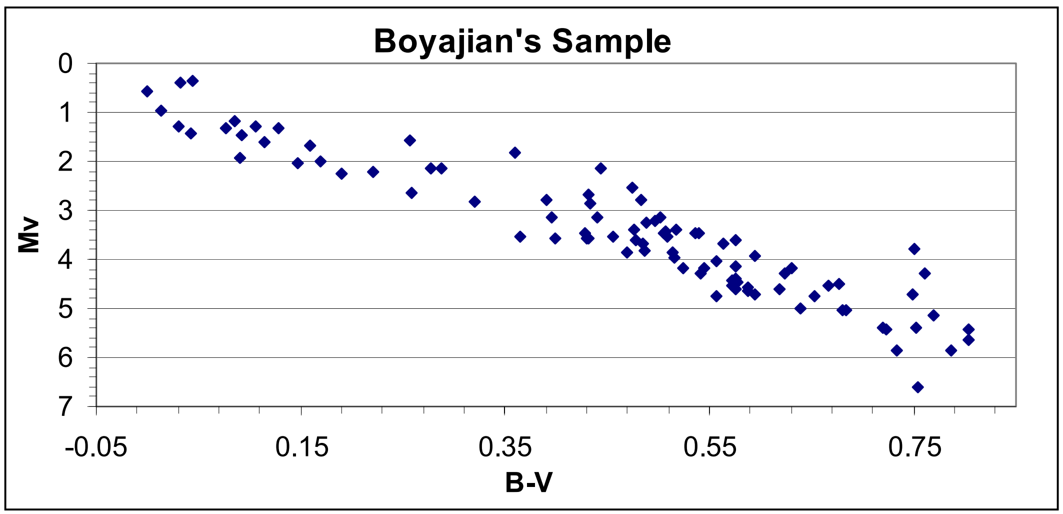
Target Selection

- Target sample was limited by:
  - Better than 4% accuracy on diameter determination from visibility curve
- A, F, and G star *Hipparcos* query

Spectral Type	V mag	B-V	Distance (pc)
A0 V – A5 V	6.0	-0.02 – 0.15	< 33
A6 V – F0 V	6.4	0.15 – 0.30	< 29
F1 V – F5 V	6.7	0.30 – 0.44	< 25
F6 V – G0 V	7.0	0.44 – 0.58	< 21
G1 V – G5 V	7.3	0.58 – 0.68	< 17
G6 V – K0 V	7.5	0.68 – 0.81	< 16

Target Selection

- Other limiting factors to qualify:
  - Duplicity (separation of 2<ρ<5 mas flagged)
  - Rotation (flagged)
  - Abnormal atmospheric activity
- Rough sample size of 92 stars

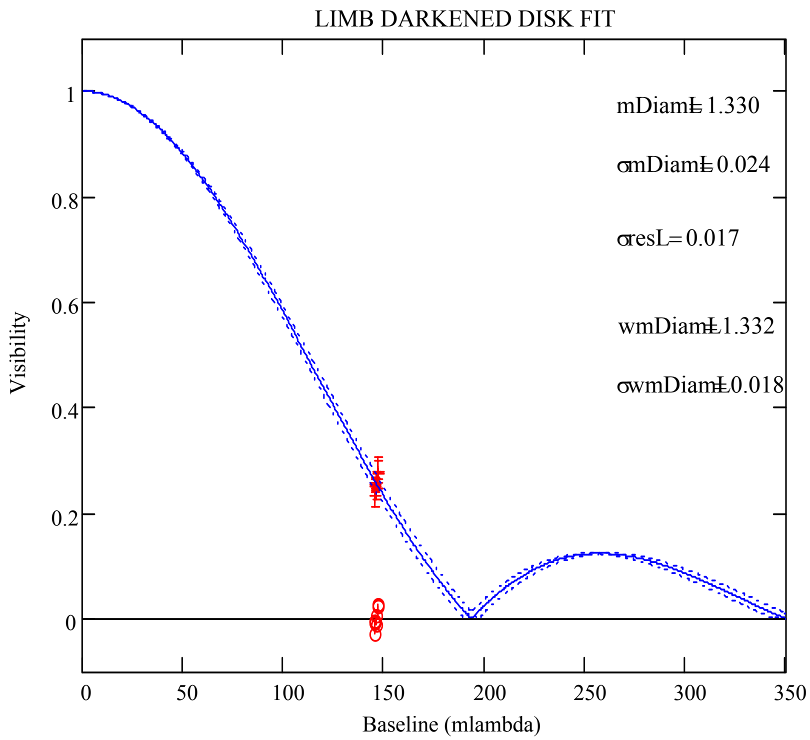


Observations

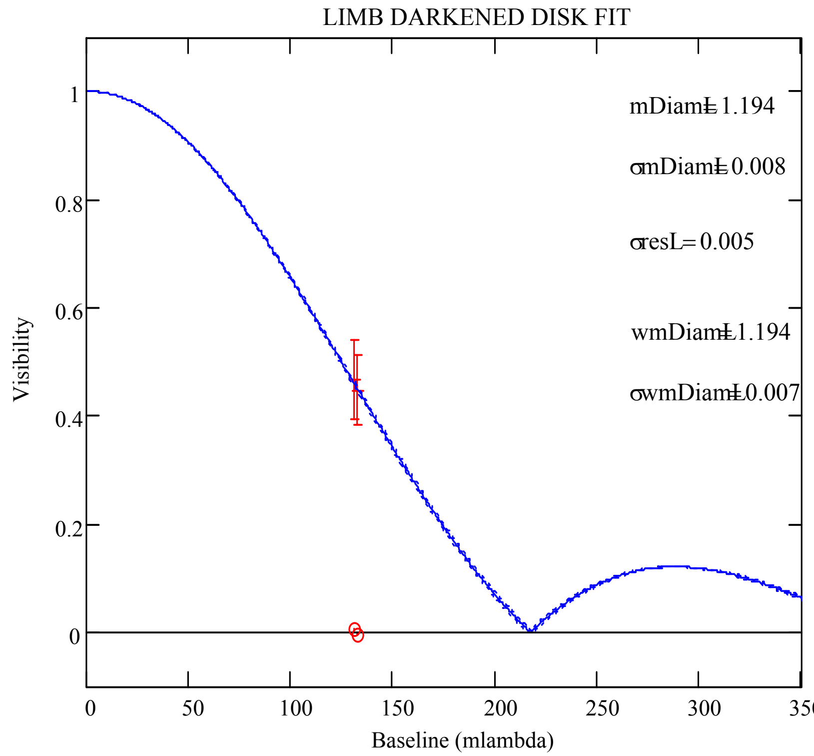
- CHARA Classic; K and H band
- Baselines; S1/E1 *and* S1/W1 or E1/W1
- SED fits for Calibrators and Targets
- Limb darkened diameter fits from visibility curve

Results so far..

HD 97603: A4V;
LD=2.53 +/- 0.06 M⊙

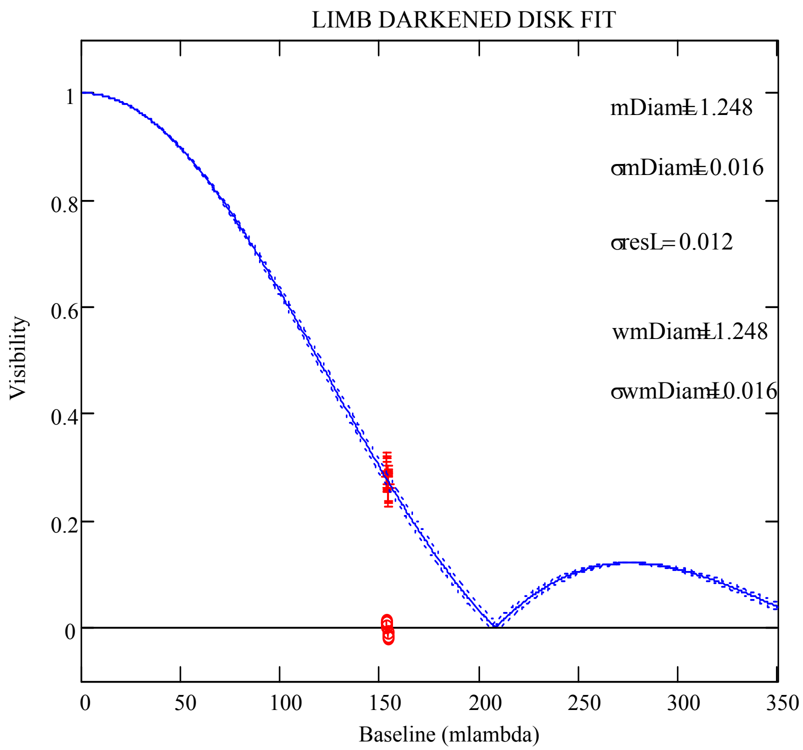


HD 222368: F7V;
LD= 1.77+/- 0.02 M⊙

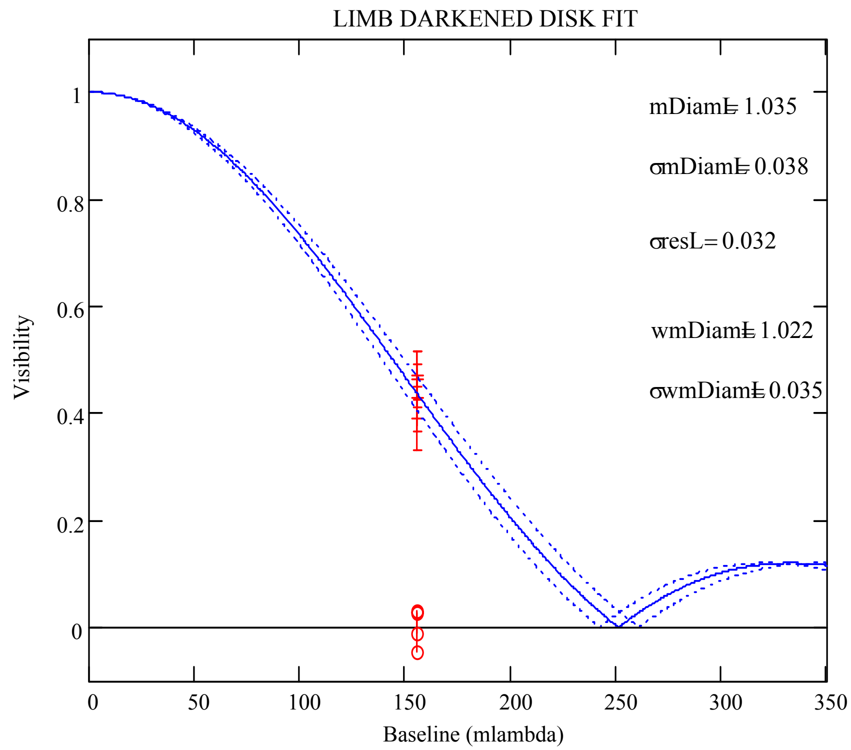


Results so far..

HD 19373: G0V;
LD=1.41 +/- 0.02 M⊙

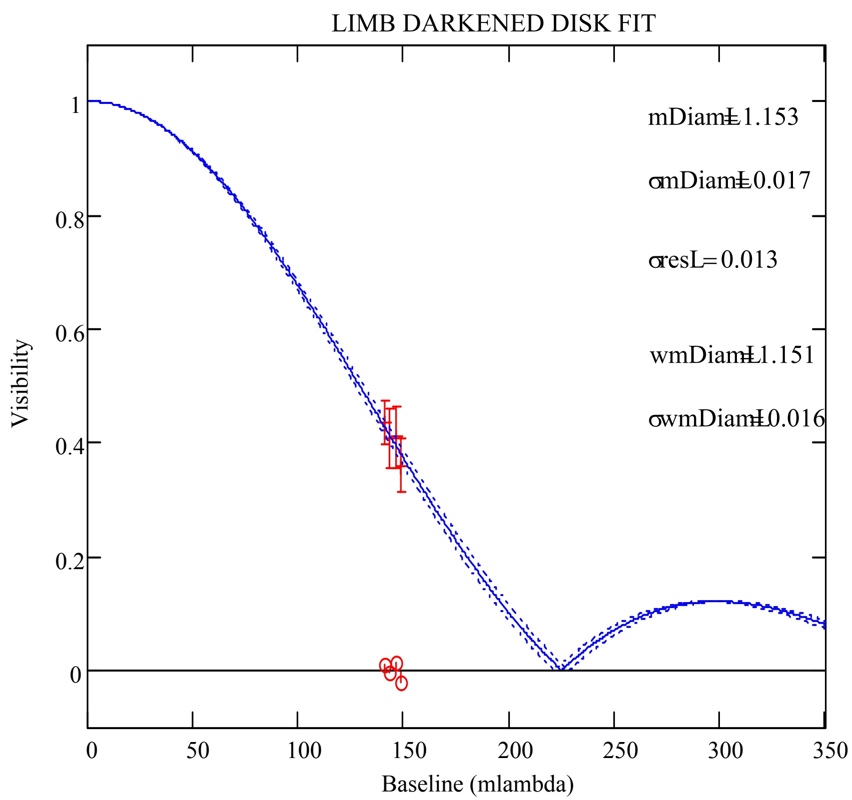


HD 34411: G0V;
LD=1.41 +/- 0.05 M⊙

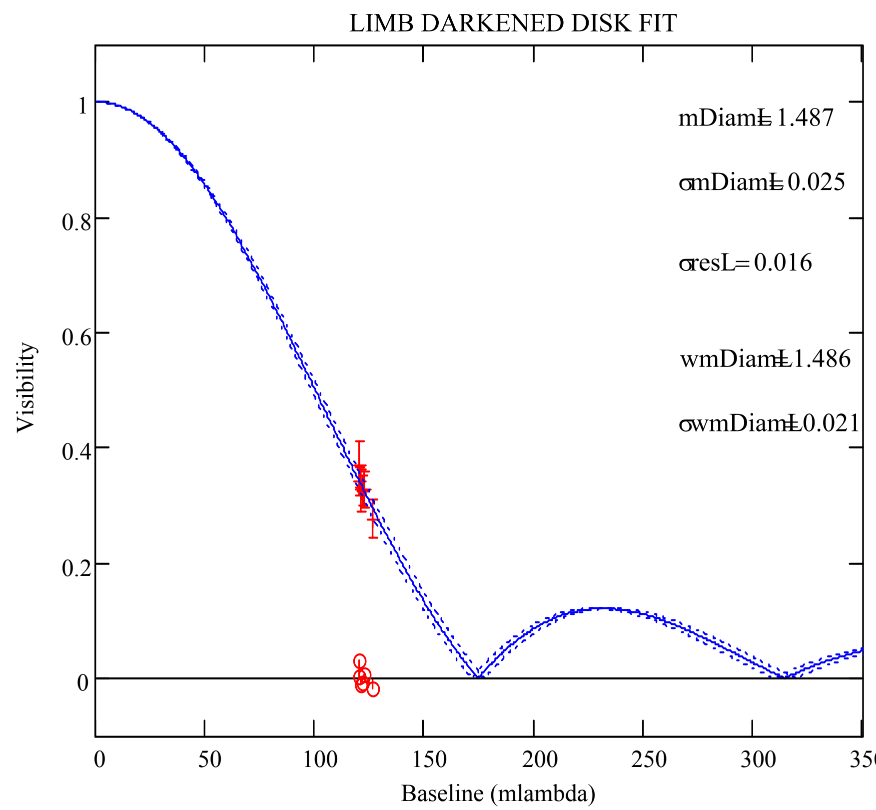


Results so far..

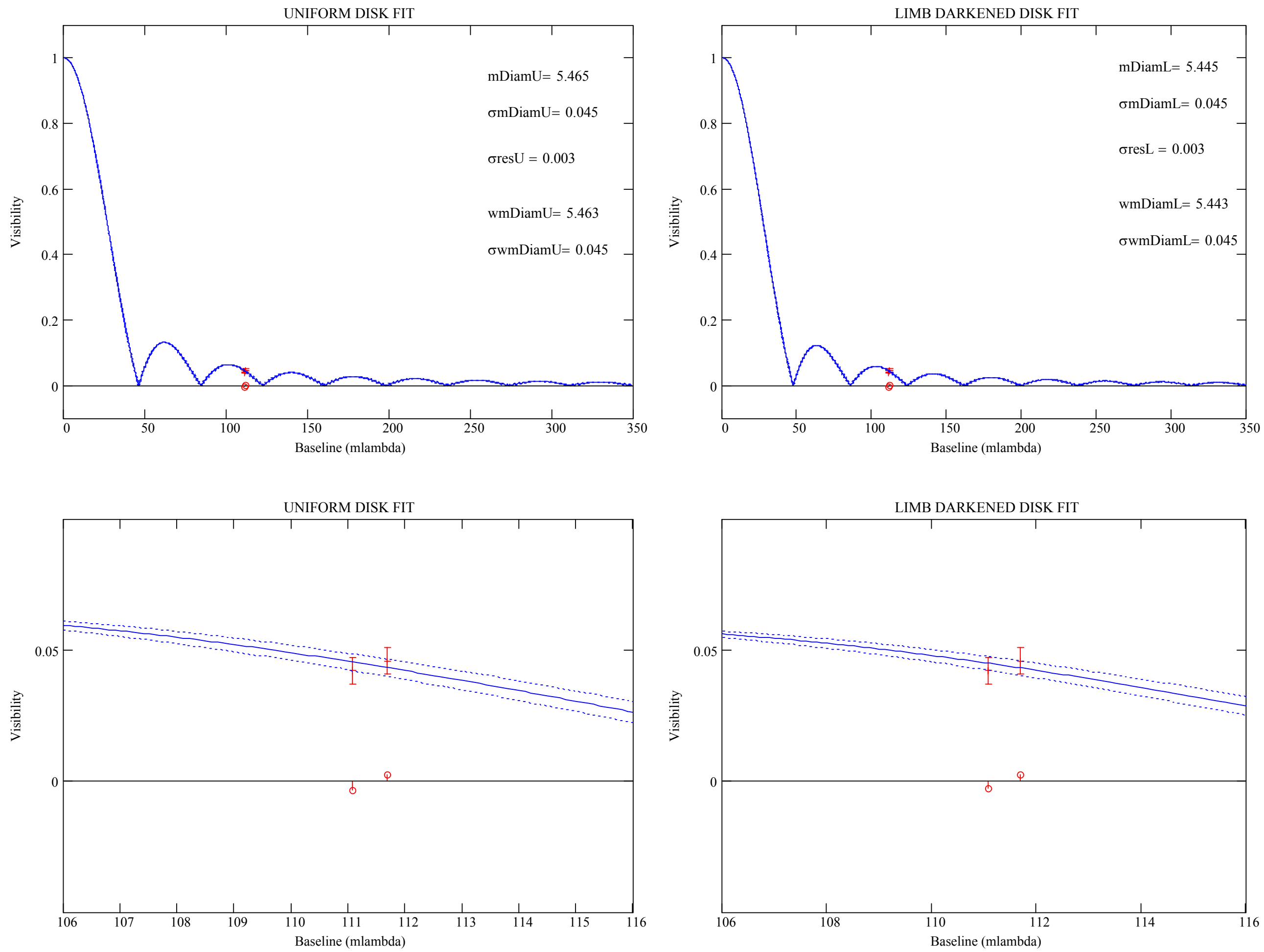
HD 22484: F9V; LD=1.70 +/- 0.03 $M_\odot$



HD 102870: F9V; LD=1.74 +/- 0.03 $M_\odot$



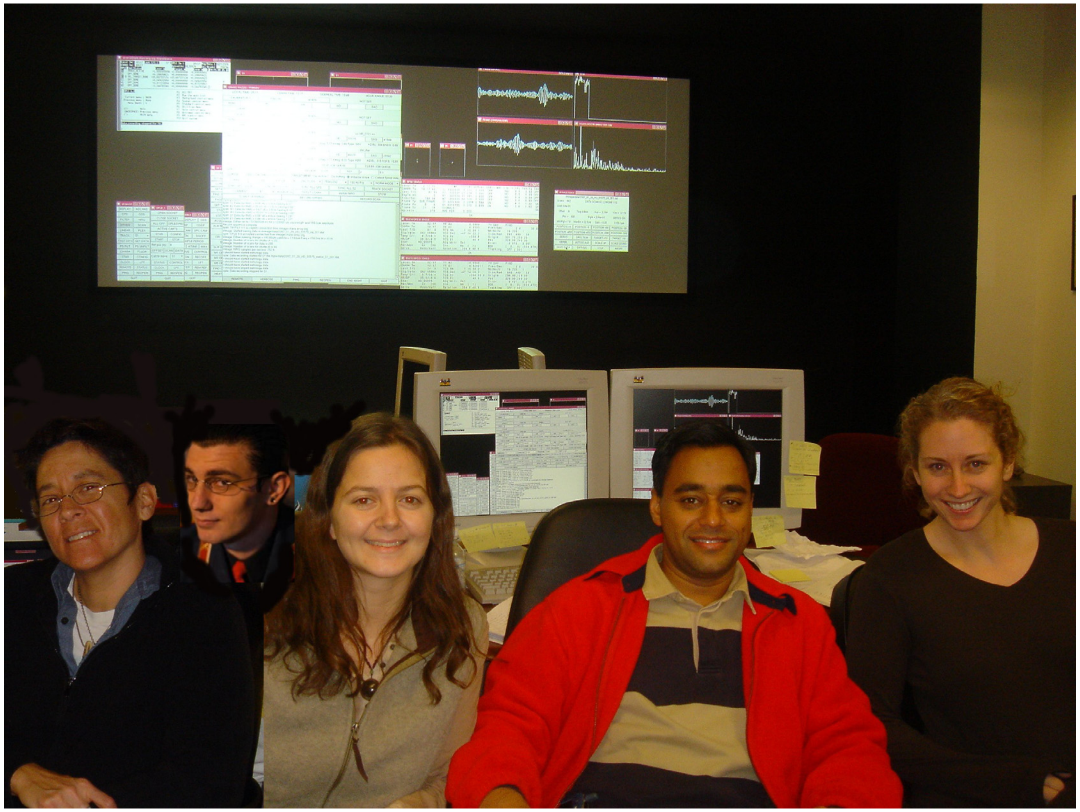
Procyon


UNIFORM DISK FIT
LIMB DARKENED DISK FIT
mDiamU= 5.465
σmDiamU= 0.045
σresU = 0.003
wmDiamU= 5.463
σwmDiamU= 0.045
mDiamL= 5.445
σmDiamL= 0.045
σresL = 0.003
wmDiamL= 5.443
σwmDiamL= 0.045
Visibility
Baseline (mlambda)
UNIFORM DISK FIT
LIMB DARKENED DISK FIT
Visibility
Baseline (mlambda)

Grad Winter Observing Progress

- 2007 January – 2007 March:

  ~16 days
- AROC Observers: Ellyn, Tabetha, and Deepak
- Mt Wilson: PJ and Chris (+ CHARA staff)



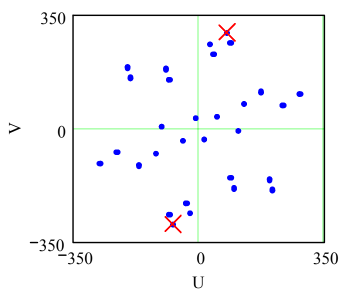
Grad Winter Observing Issues:

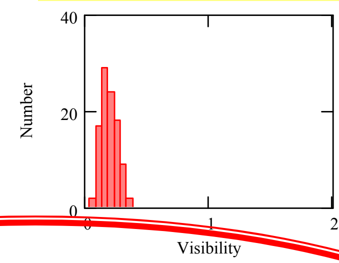
HVAC on makes tracking HARD

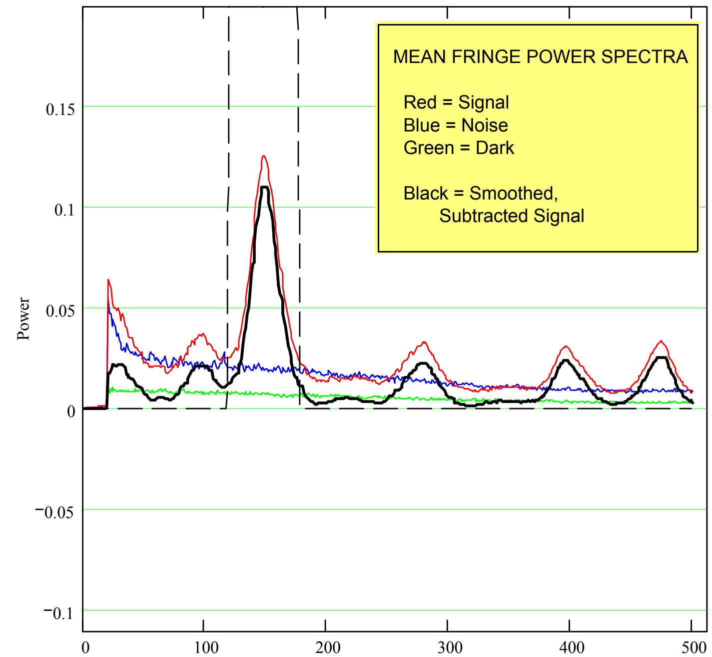
Summary of Results for: HD = 56537 UTDate = (2007 2 25) SeqNo = 1

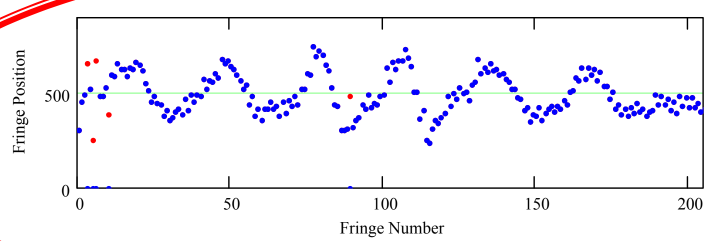
UT = (5 49 35)	RA = (7 18 6)	darkA = 61	darkB = 82
LT = (21 49 35)	Dec = (16 32 25)	avIA = 844	avIB = 714
LST = 8.3039	LSTrange = 0.0333	ΓA = 0.995	ΓB = 0.982
HA = 1.00	HArange = 0.03	avBP = 151	σBP = 6
Alt = 67.76	Altrange = 0.27	Freq0 = 155	DithStep = 0.333
Azm = 41.06	Azmrange = 1.04	avSel = 8.46	Baseline = 12
U = 75.154	Urange = 1.775		
V = 297.219	Vrange = 0.187		
Scanlength = 558	Nscans = 205		
lpass = 20	Rejects = 104		
BW = 30	cutoff = 1.00		
λ = 2.15E-006	range = 30		

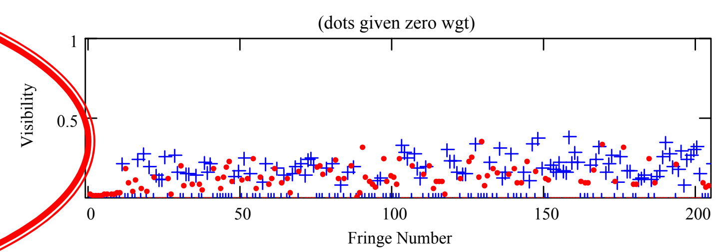
Results:
BY = 2007.15125
JD = 54156.7428
Vamp = 0.211
Vps = 0.260 σVis = 0.022
B = 306.579 Brange = 0.254
Θ = 75.810 Θrange = 0.330











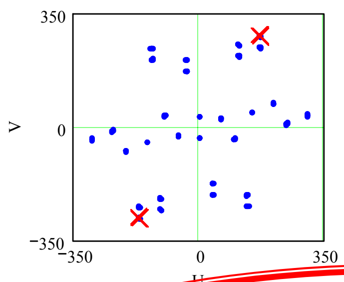
Grad Winter Observing Issues:

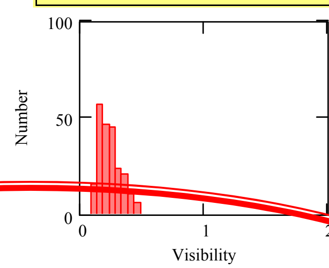
HVAC on makes tracking HARD and sometimes the Power spectrum is WEIRD!

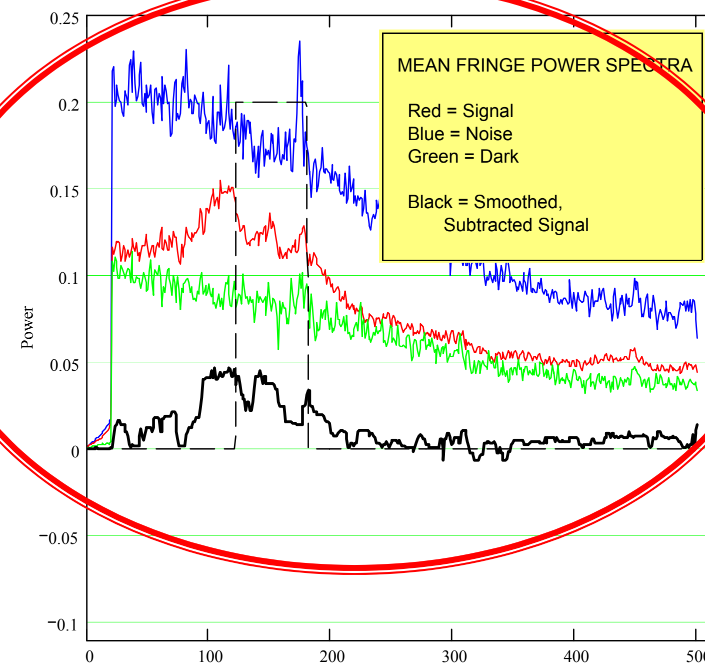
Summary of Results for: HD = 90840 UTDate = (2007 1 23) SeqNo = 3

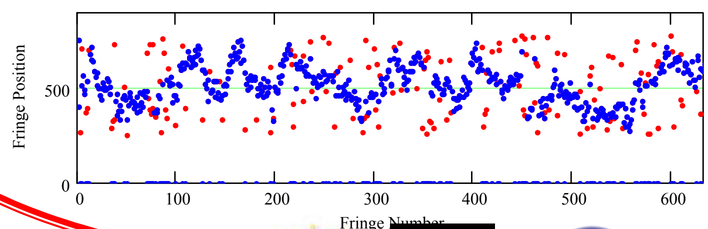
UT = (9 6 40)	RA = (10 30 6)	darkA = 65	darkB = 86
LT = (1 6 40)	Dec = (38 55 30)	avIA = 81	avIB = 62
LST = 9.4623	LSTrange = 0.0667	ΓA = 0.927	ΓB = 0.995
HA = 22.96	HArange = 0.07	avBP = 154	σBP = 7
Alt = 76.64	Altrange = 0.75	Freq0 = 155	DithStep = −0.333
Azm = 244.81	Azmrange = 0.92	avSel = 1.74	Baseline = 12
U = 168.271	Urange = 2.387		
V = 280.119	Vrange = 1.845		
Scanlength = 558	Nscans = 633		
lpass = 20	Rejects = 406		
BW = 30	cutoff = 1.00		
λ = 2.15E-006	range = 30		

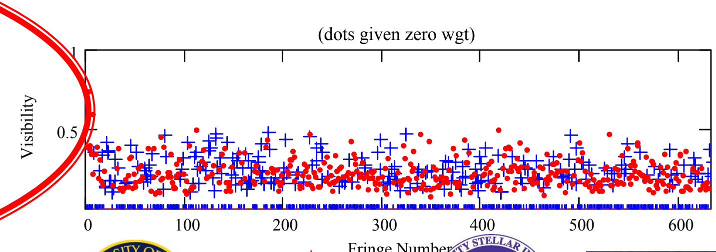
Results:
BY = 2007.061273
JD = 54123.8796
Vamp = 0.256
Vps = 0.171 σVis = 0.030
B = 326.789 Brange = 0.353
Θ = 59.006 Θrange = 0.525







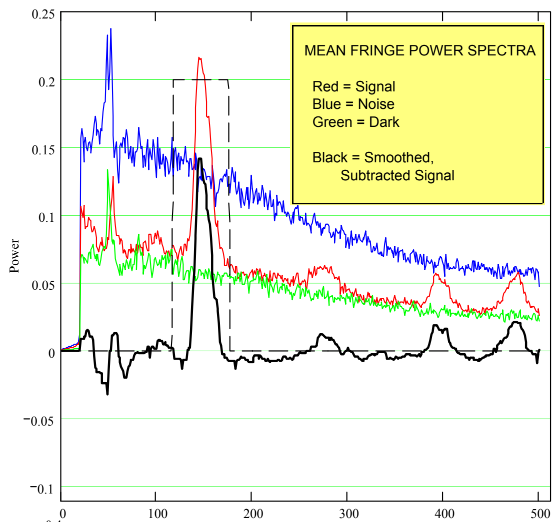


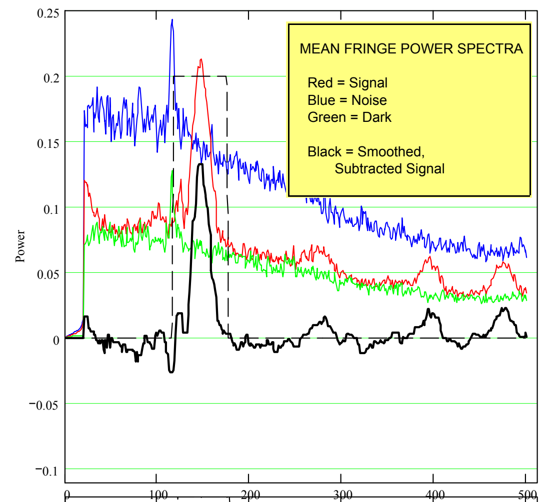


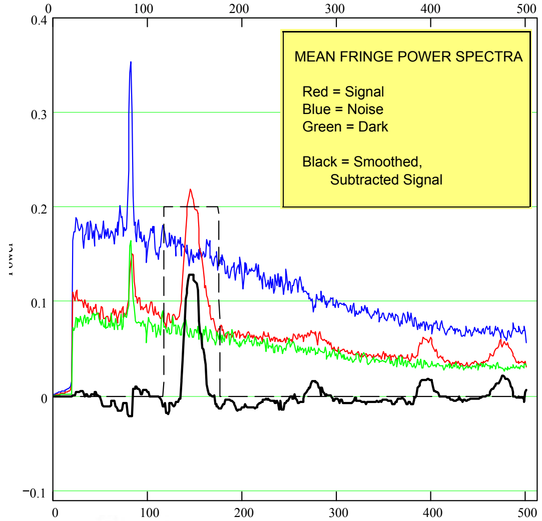
Grad Winter Observing Issues:

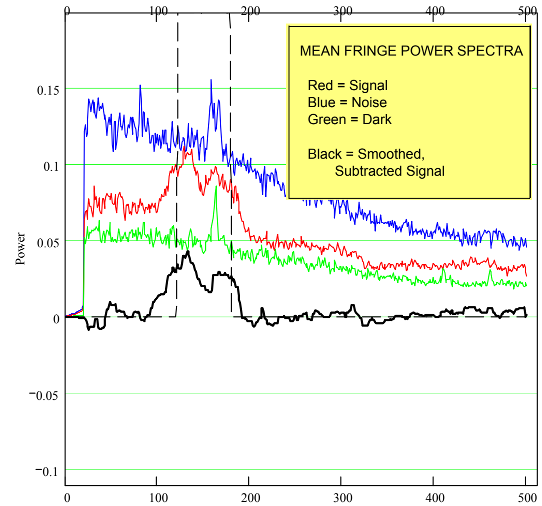
PICO box vibrations in the lab?

Not always at same frequency, same shape, or same strength.







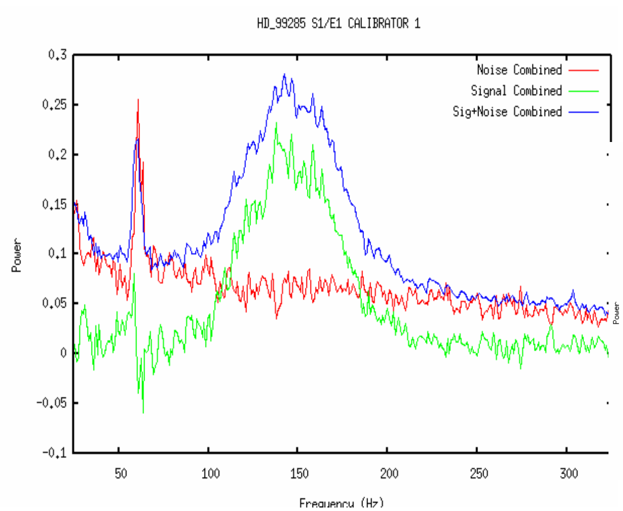


Comparing reduceIR and VisUV Calc: Tackling Noisy Data

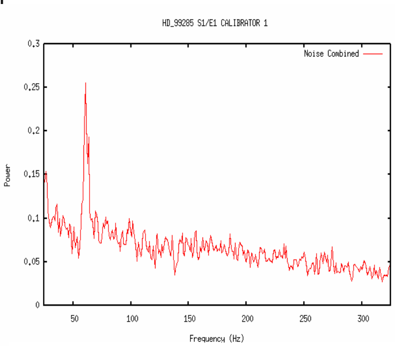
•Noise subtracted signal is not perfect in using either software package

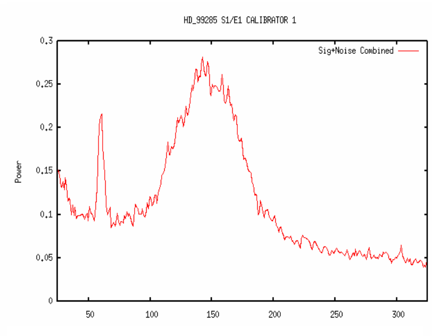
VisUV Calc:

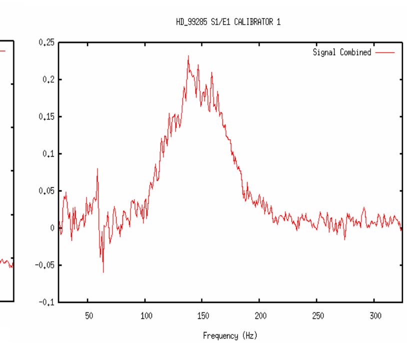
RecudeIR:



Vibrations? (HVAC, and Vacuum are OFF)

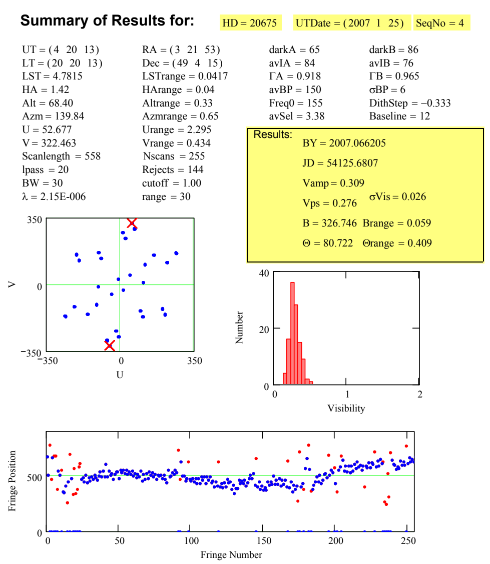


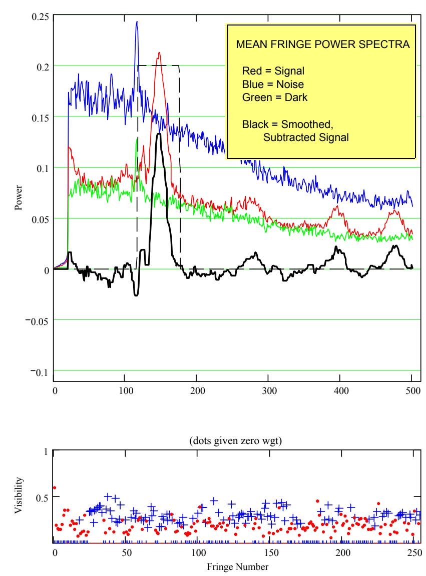


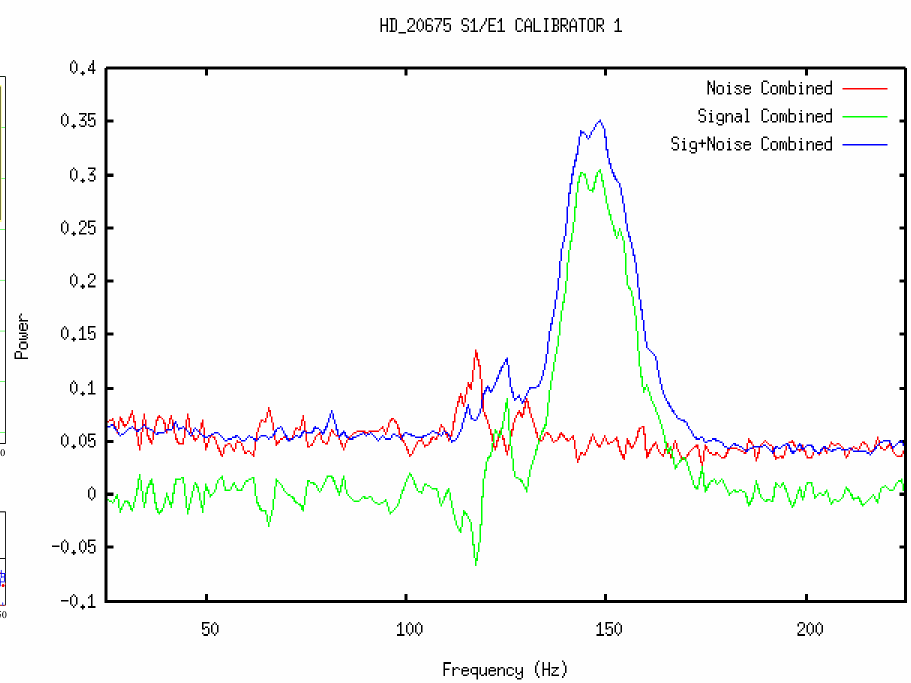


Comparing reduceIR and VisUV Calc: Tackling Noisy Data

- When is the noise too close data to make it unusable?







Discussion

- Does one continue observing if these issues arise? (ie, should you be worried, or will reducing the data properly remove all noise)
- How do we improve the removal of such noise in data reduction?
- Should we make mandatory shut-off for HVAC, PICO and Vacuum for every run?
- Possibly add switches in control room to make it easier?