To SFP or not to SFP?

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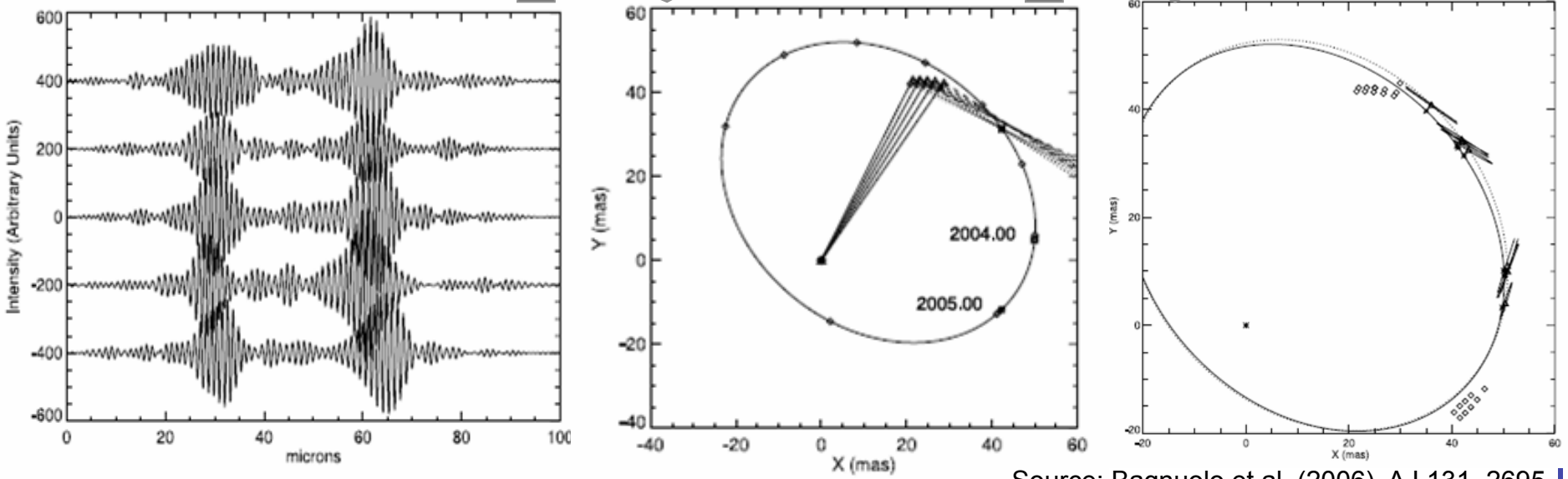
Exploring a Presumed Gap

- Radial velocity surveys go inside out
  - Periods out to low tens of years
- "Traditional" visual methods go outside in
  - Down to a few tens of mas
- Is there a gap between these two that might be ideally suited for CHARA's long baselines?
- Gap between spectroscopic and visual techniques previously seen
  - Bouvier et al. 1997, Mason et al. 1998

Separated Fringe Packets

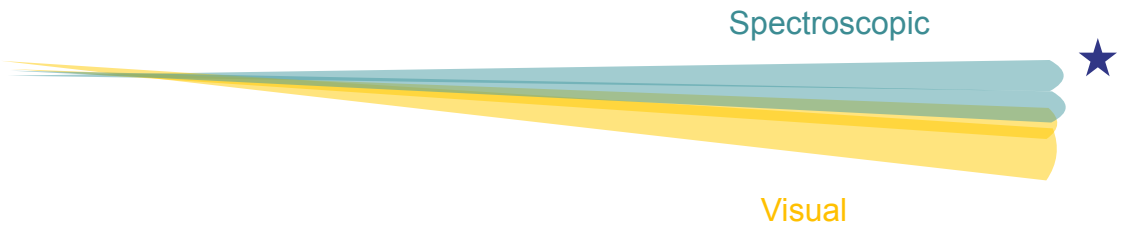


Source: Bagnuolo et al. (2006) AJ 131, 2695

- Efficient for surveys (> 20 targets per night)
  - $V \leq 9$, $K \leq 6$, Dec $\geq -10^{o}$, $\Delta K \leq 2$, separations ~ 10 – 120 mas
    - Can detect early M for G primary and mid M for K primary ($q \geq 0.5$)
- 196 targets + 92 observed by CF
- 233 null detections, 8 companions seen 0 new

Popular Stars Attract Attention!

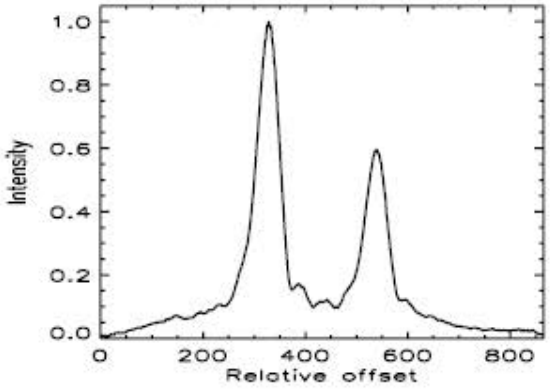
- Excellent spectroscopic coverage
  - Longstanding RV studies over 30 years, ± 0.5 km/s precision
  - High-precision measures over 12 years, ± 3 m/s precision
  - Can detect orbits of few tens of years
  - Separations out to 400 mas (P=30y, M_{sum}=1.5M_{Sun}, d= 20pc, i=45°)
- Augmented by extensive high-resolution visual coverage
  - All 453 targets observed by speckle interferometry at least once
  - Separations ≥ 30 mas

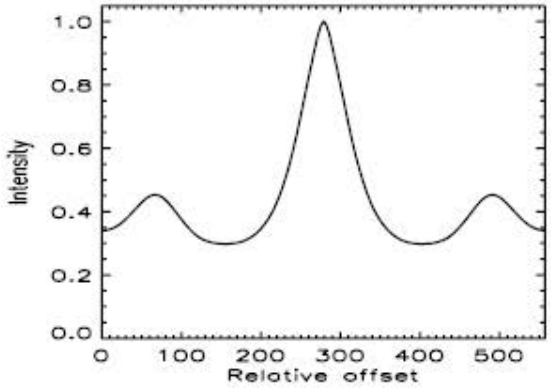


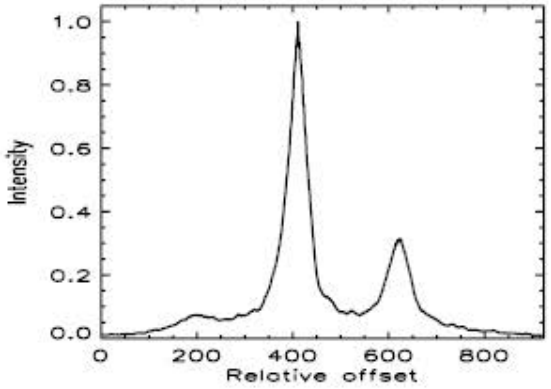
So What is One to Do?

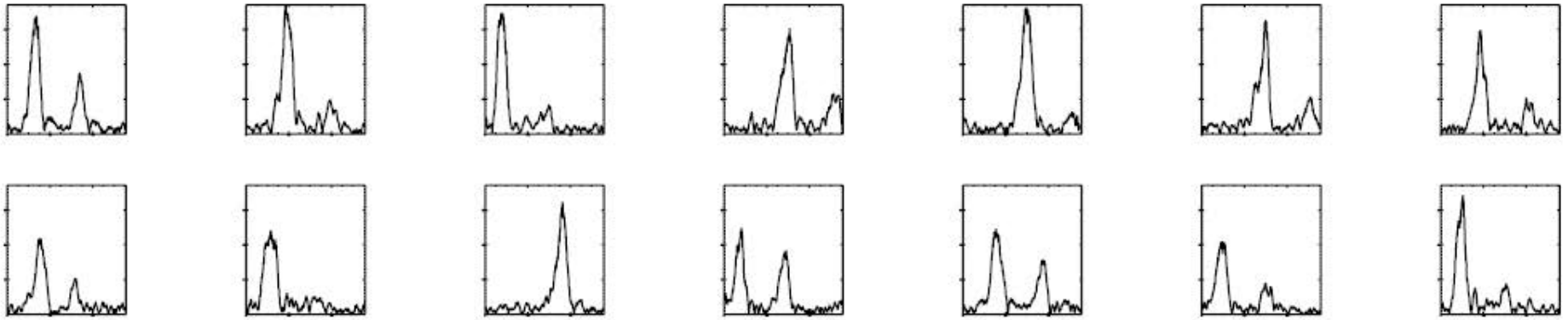
- Use null results in overall multiplicity statistics
- Publish null results and detection limits
  - CHARA paper # 67. **A Search for Separated Fringe Packet Binaries Using the CHARA Array**, D. Raghavan *et al.*, **The Astrophysical Journal**, **745**, 24, 2012.
- Help define the utility of the SFP technique for possible future companion searches at CHARA

Here is How SFPs Are Seen

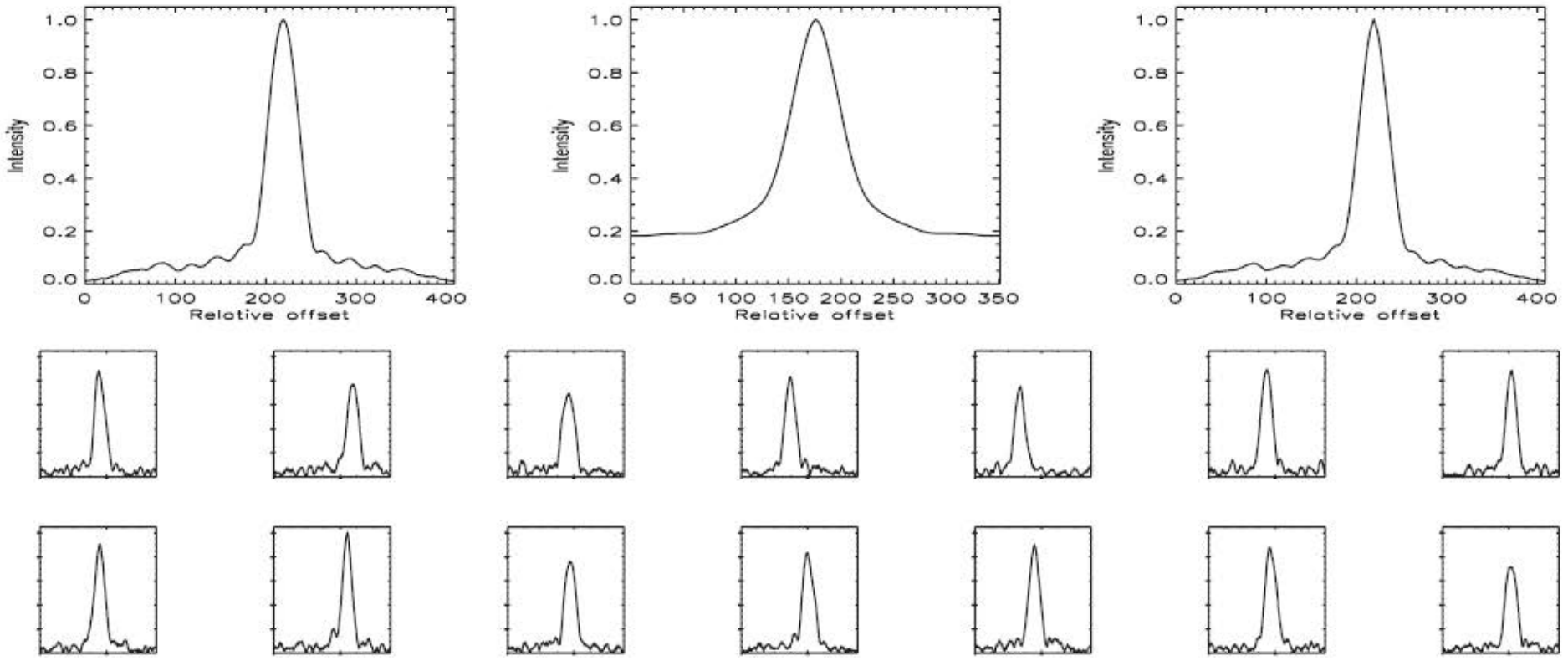








Here's How a Single Star Looks



Modeling tool: fakecc

- Generates fake fringes
- Output in FIT file just like observing software
- Can run through same reduction pipeline as real data

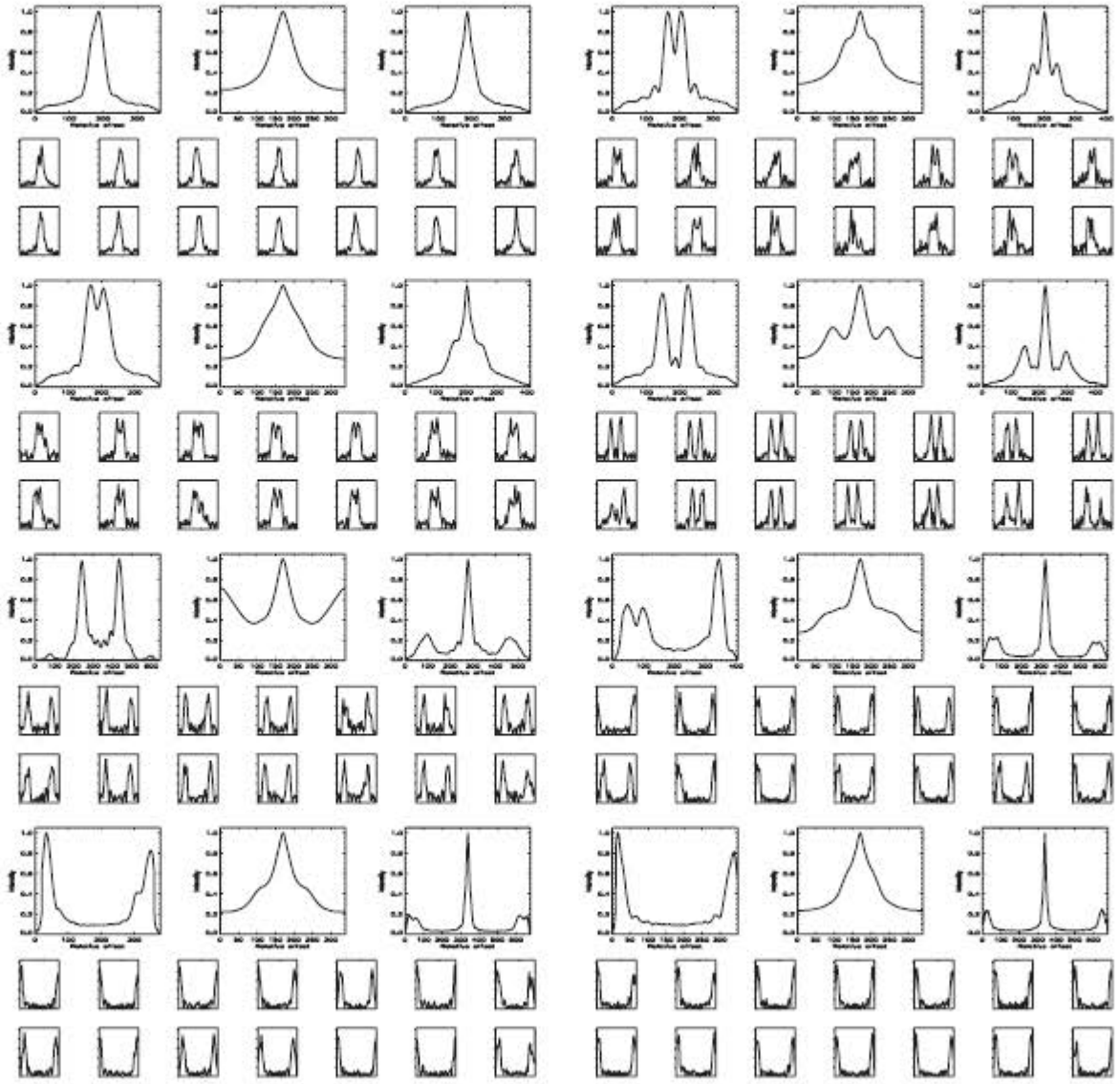
```
usage: fakecc {flags}
Flags:
-b[baseline]            Set baseline (100m)
-B[balance]             Set beam balance 0-1 (1.0)
-c                      Force CALIBRATOR (OBJECT)
-C[gain,bias,read]      Set camera parameters (1,10,9)
-f[samp,frg]            Set sample and fringe frequency (1000,200)
-F[lambda,bw]           Set filter in um (K band).
-h                      Print this message.
-H[HD#]                 Set the HD number (None)
-I[F0]                  Set scintillation f0 (0.0 - NOT WORKING!)
-n[Nph]                 Set mean photon count (500)
-p[r0(cm),vel(m/s)]     Set seeing for piston error (10,10)
-r[range]               Set dither range (200um)
-s[A,B,D]               Set shutter sequence length (10,66,200)
-S[V,pos,beta]          Set secondary star (none)
-v[V]                   Set visibility (0.5)
```

Model SFP: Separation Impact

Pair of G0 V stars, r0 = 10 cm

5 mas

8 mas



12 mas

20 mas

50 mas

70 mas

80 mas

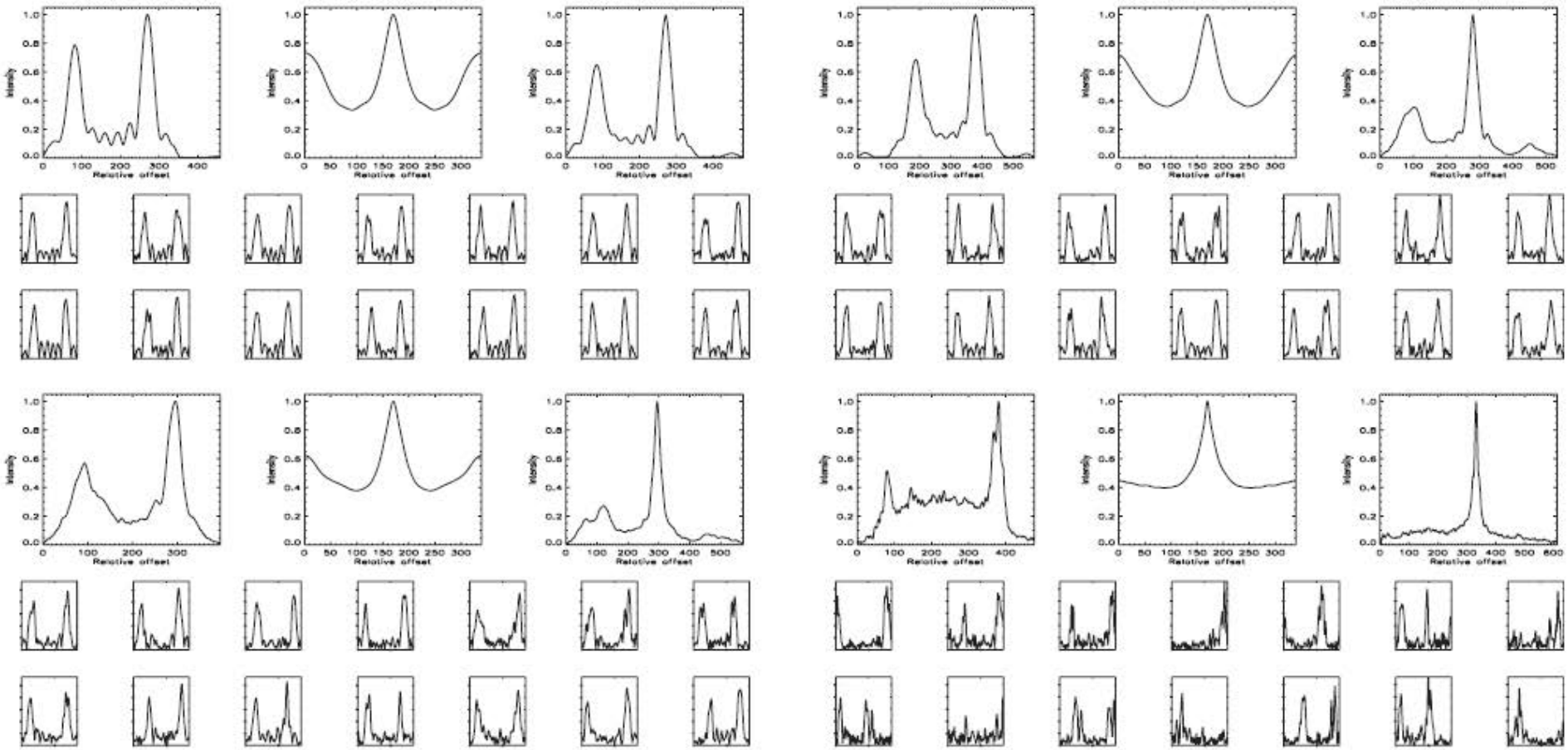
90 mas

Model SFP: Seeing Impact

G0-G5 pair, ρ = 50 mas

r0 = 20 cm

r0 = 10 cm

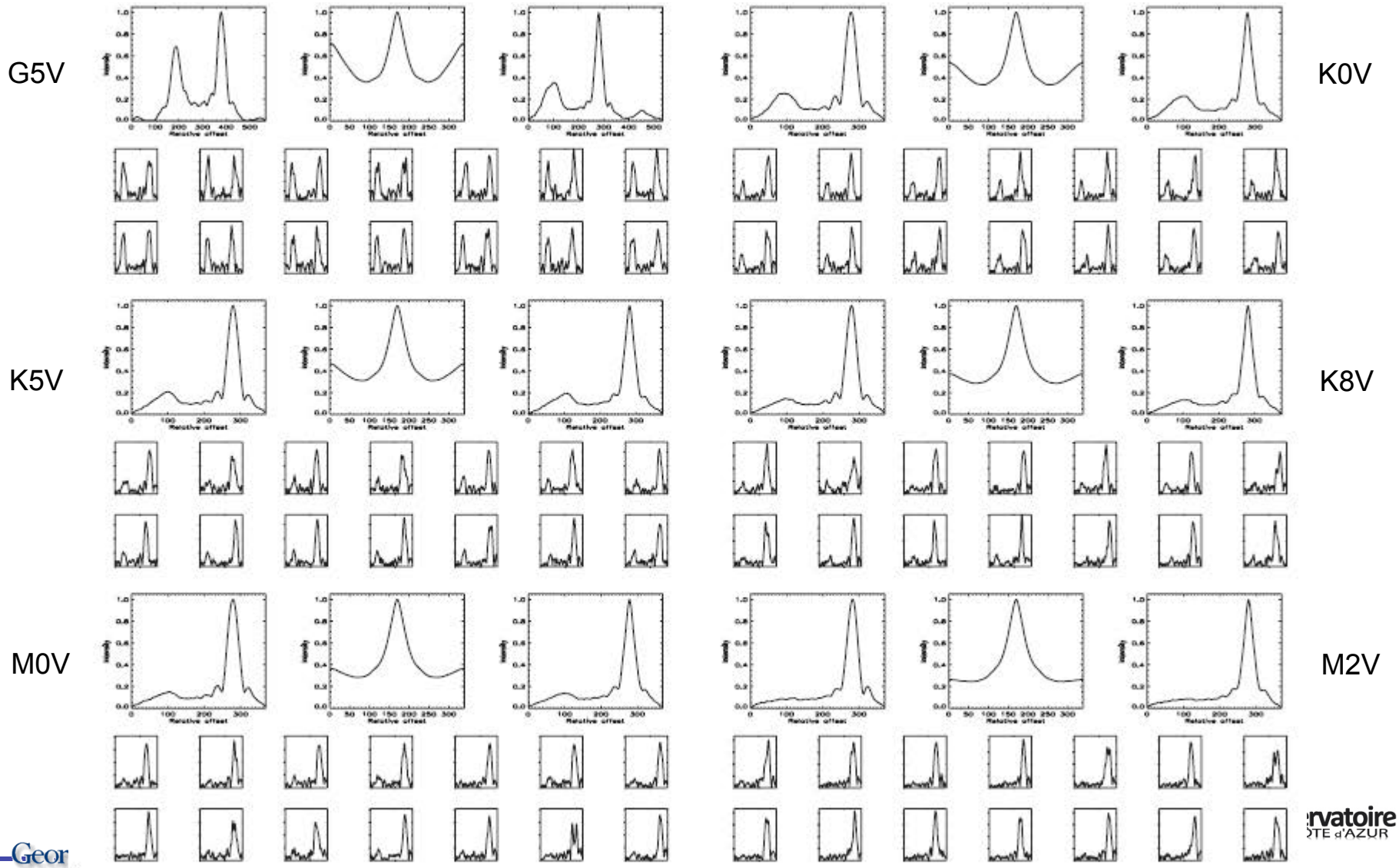


r0 = 6 cm

r0 = 3 cm

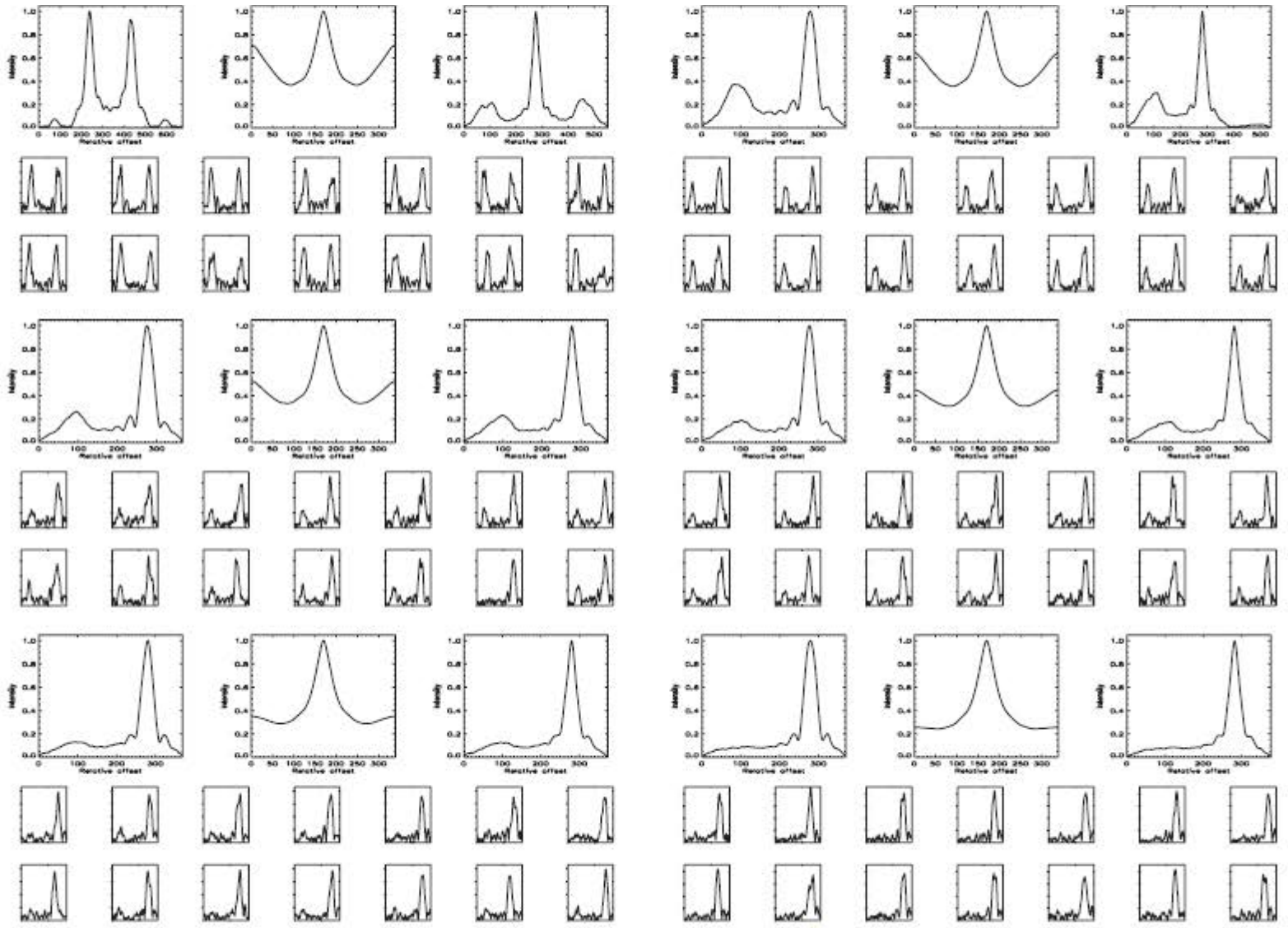
Model SFP: Contrast

G0 V primary, r0 = 10 cm, ρ = 50 mas



Model SFP: Contrast

G5 V primary, r0 = 10 cm, ρ = 50 mas

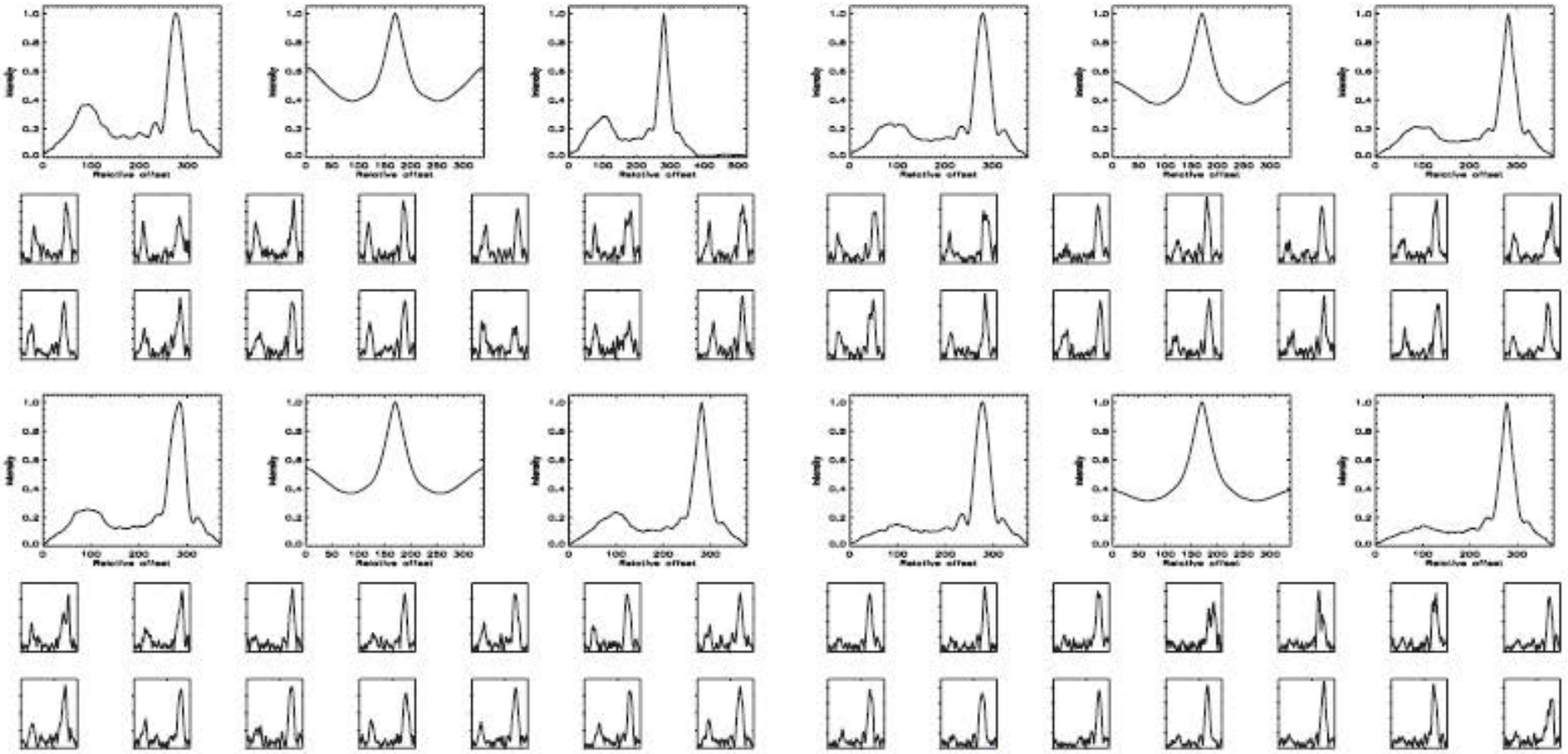


Model SFP: Contrast

K0 V primary, r0 = 10 cm, ρ = 50 mas

K5V

K8V



M0V

M2V

Back To Real Data

- Marginal SFP detections of known companions to HD 98231 and HD 137763

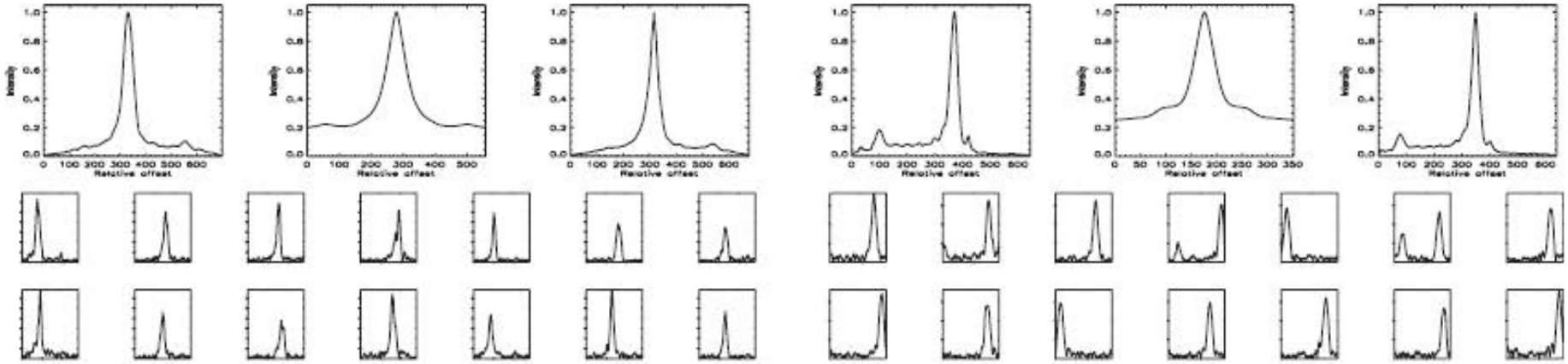


Figure 5. Marginal SFP detections for HD 98231 (left) and HD 137763 (right) in the same format as Figure 1.

Modeling Results Summary

- Projected separation range: 8 – 80 mas
  - On the Array's longest baseline
  - Using fringe scan windows 145 μm wide
- Seeing: r0 > 6 cm can readily detect SFP fringes
- Contrast:
  - $\Delta K \leq 1.1$ for clean detection (above side-lobes)
    - G0 – K5, G5 – K5, K0 – M0
  - $\Delta K \leq 1.6$ if widely enough separated to avoid side-lobes
    - G0 – M0, G5 – M0, K0 – M2

Applicability of Technique

- For companion searches
  - Choose unpopular stars, avoid the paparazzi
  - Choose distant stars
    - At 200 pc, P = 20 yr, $M_{sum} = 5\ M_{Sun}$ implies a = 60 mas
    - K < 8 for A5 V and earlier stars at 200 pc
    - Survey project for O, B, A stars?
- For visual orbit determination using SFP
  - See Chris Farrington's talk!
- CLIMB is a lot more efficient in searching for and characterizing binaries