Long baseline interferometry in the visible:
Recent progress on FRIEND project

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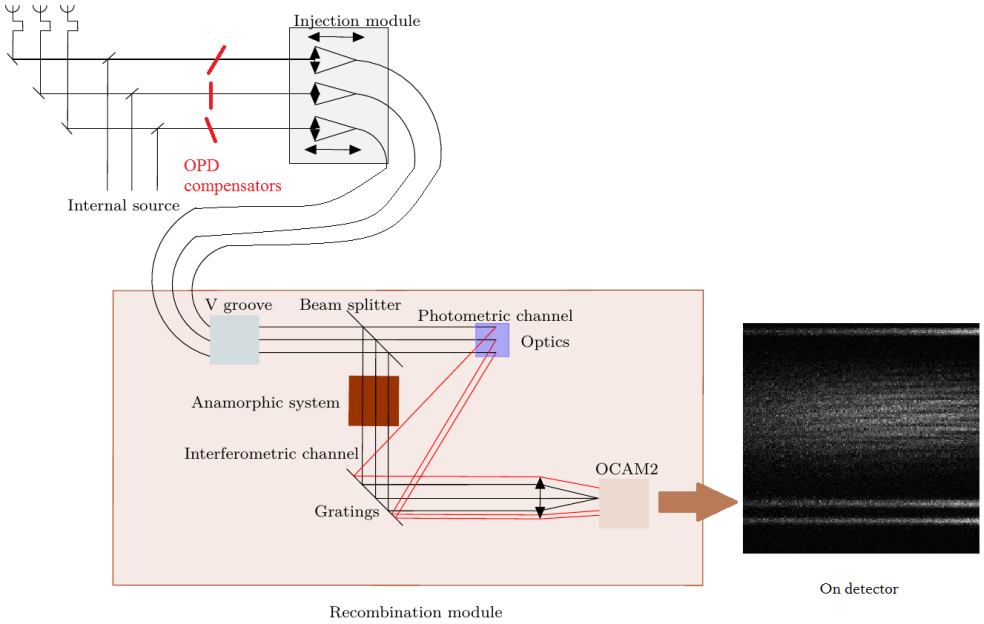
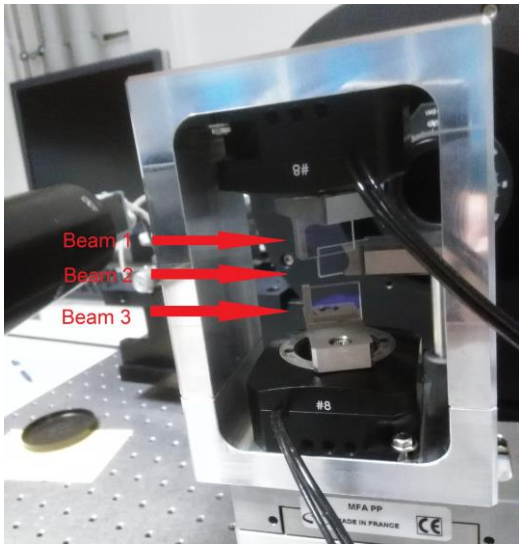
CHARA Meeting – March 2016

Outline

- Short presentation of FRIEND prototype
- Coupling efficiency and limiting magnitude
- Instrumental visibility
- Closure phase
- Adaptive optics and injection

Short presentation of FRIEND prototype





$$< |V|^2 >= \frac{< E_{HF} >}{\int_{\Delta\lambda} \kappa(\lambda) \int_{\Delta x} < P_1(\lambda, x) P_2(\lambda, x) > dx d\lambda}$$

V 5.076

V 5.076

Observations

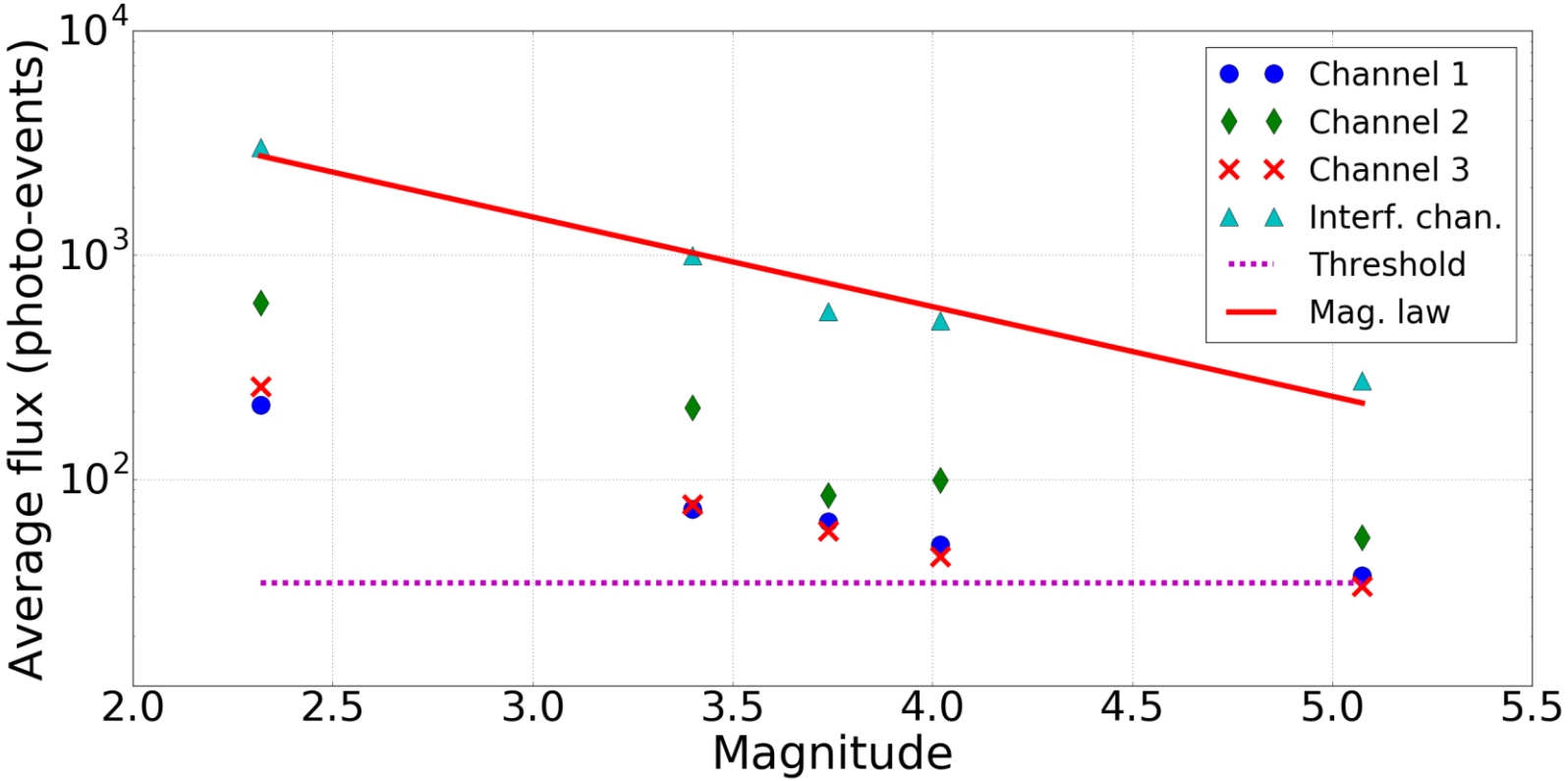
2016-09-29

- E1E2W2
- r_0 = 10 cm
- 1 Cal:
  - HD3360: mR = 3.74
- 1 Sci:
  - HD5394: mR = 2.32

2016-09-30

- E1W2W1
- r_0 = 14 cm
- 3 Cal:
  - HD3360: mR = 3.74
  - HD2905: mR = 4.02
  - HD3240: mV = 5.076
- 2 Sci:
  - HD5394: mR = 2.32
  - HD11415: mR = 3.4

Coupling efficiency and limiting magnitude



- Limiting magnitude defined by flux in photometric channels

Coupling efficiency and limit magnitude

- r_0 = 14 cm @ 550 nm => $\rho_{expected}$ = 2,6%
- Measured flux and magnitude
- t_{CHARA} = 1.7%
- $t_{FRIEND+OCAM}$ = 31.5%

=> $\boldsymbol{\rho_{estimated}}$ **= 2.8%** with *no adaptive optics*

Coupling efficiency and limiting magnitude

- Limiting mag defined by photometric channels
- For faint stars, flux at 0 or less
- Photometric sorting: $P_i > n\,\sigma_{dark}\,, n = 1{,}5$

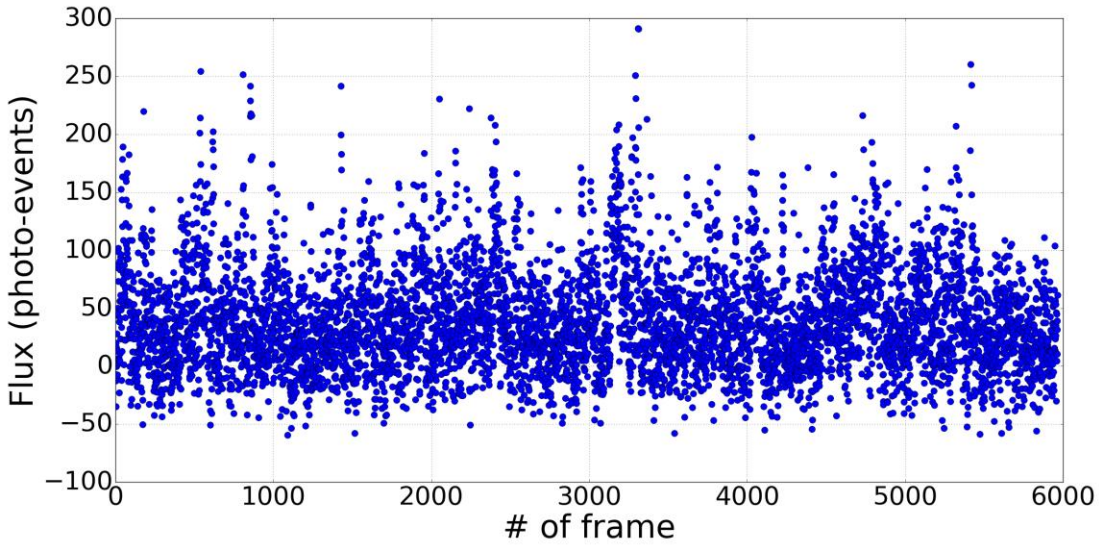
$\Rightarrow \boldsymbol{mag_{lim} = 4.1}$

->20~25% of frames

With:

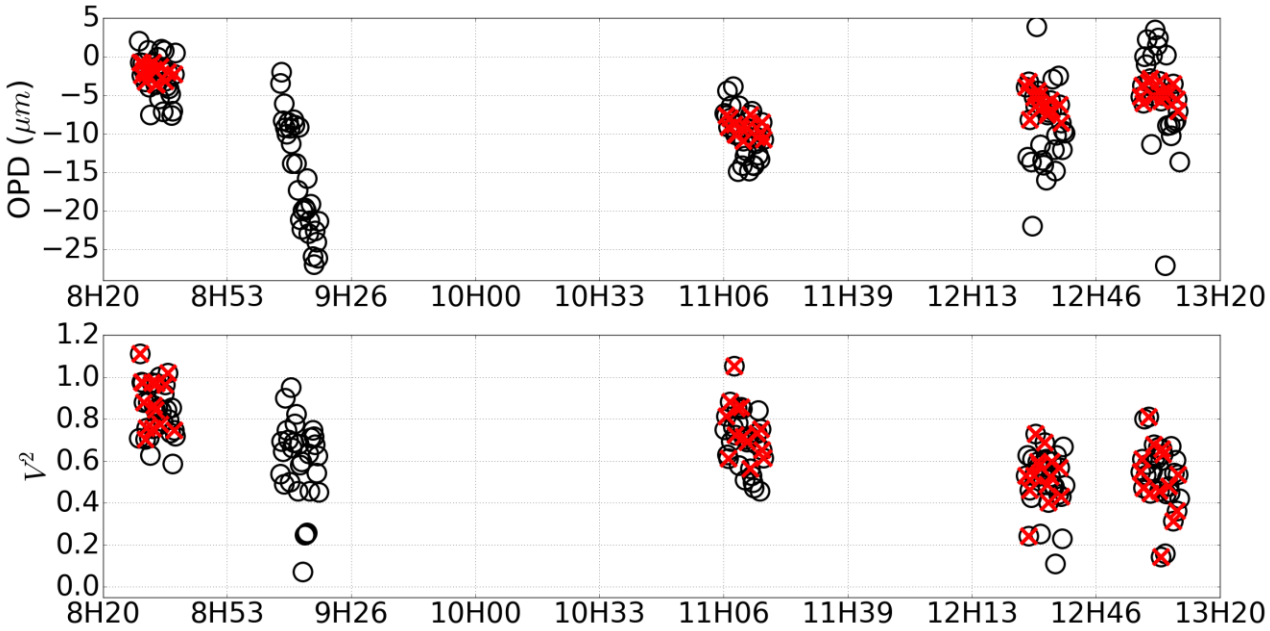
$\rho = 2.6\%$

No AO



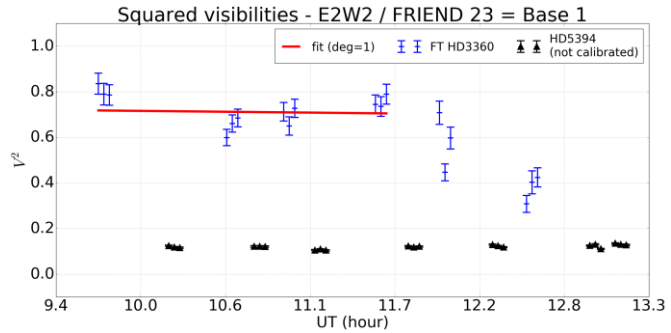
Instrumental visibility

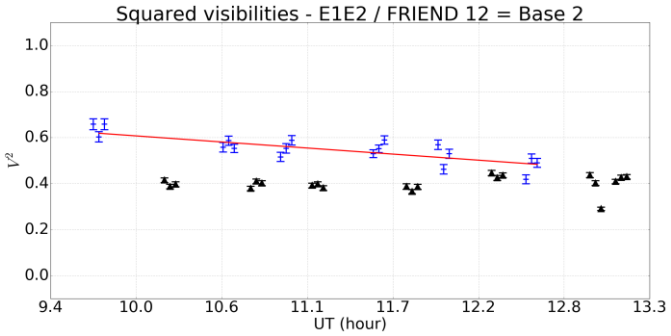
- Optimization : OPD rejection method (low spectral resolution)

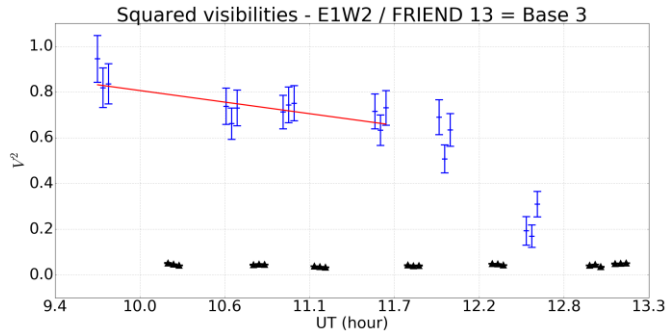


Instrumental visibility

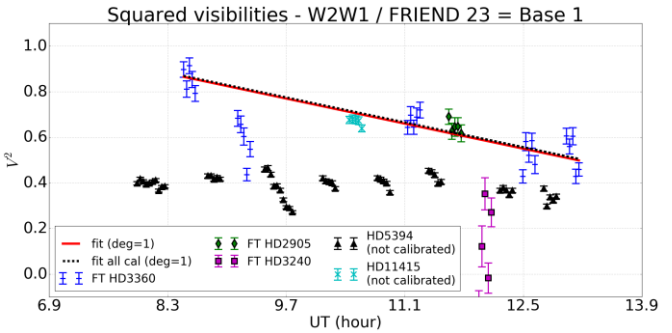
2016-09-29

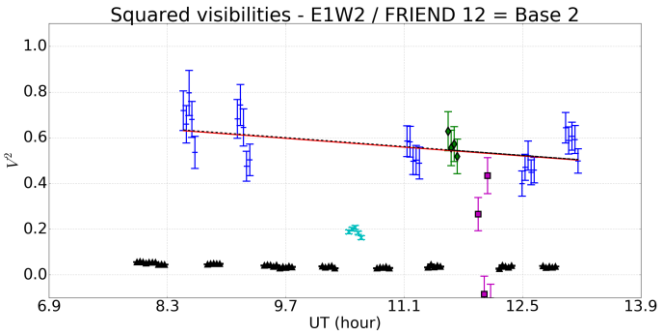


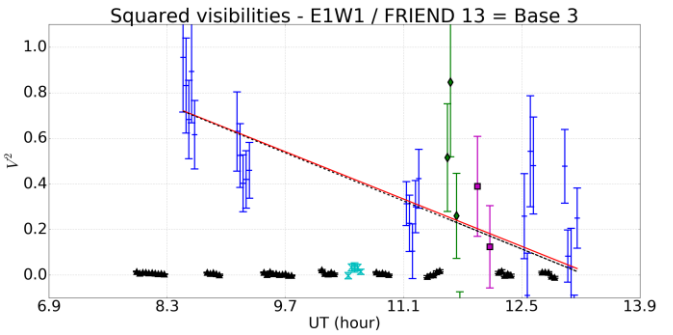




2016-09-30







Instrumental visibility

- Stability of Base 1 on 09-29
- Determination of V_{instr} stable with or without HD2905 (relative variation between fits < 1%)
- V_{instr} does not seem night-dependent

	09-29	09-30
Base 1	0.72 ± 0.05	0.82 ± 0.12
Base 2	0.62 ± 0.05	0.63 ± 0.05
Base 3	0.83 ± 0.06	0.73 ± 0.27

Table 3: Estimation of V^2_{instr} per base and per night.

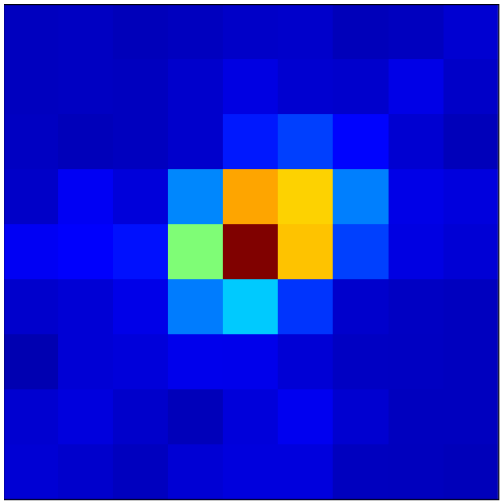
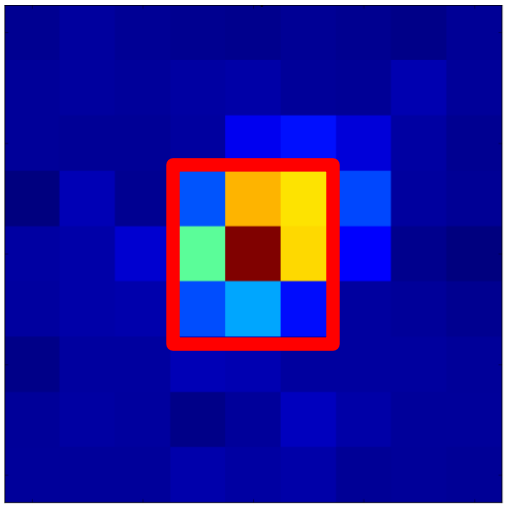
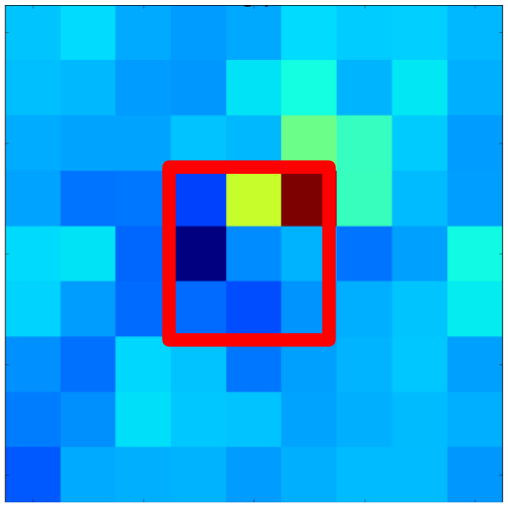
Instrumental visibility

- Decrease on other bases: due to alignment drifts of pupils ?
- Stability with respect to atmospheric condition:
  - No strong variation of the seeing during and between the nights
  - Systematic errors unseen ?
  - Keep investigating

Closure phase

- Bispectrum: $B_{0,u,v} = B_{1,u,v} - \alpha\left(|C_u|^2 + |C_v|^2 + \left|C_{u,v}\right|^2\right) + \beta N$
- $\alpha = \arg\min_{\alpha}\left(Var\left(Bg(B_{1,u,v})\right)\right)$, Bg=background

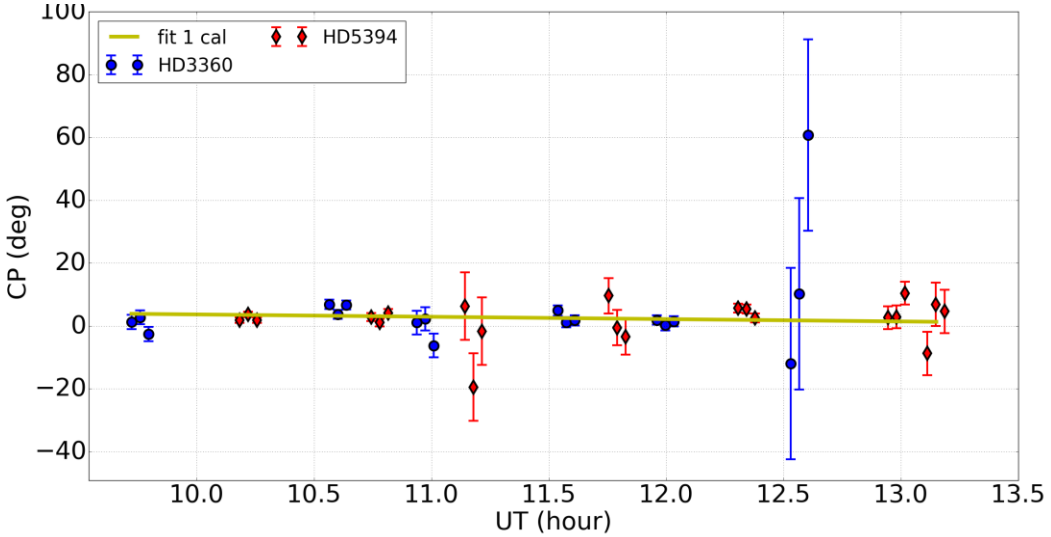
Re(B_1) Re(B_0) Re(B_0)

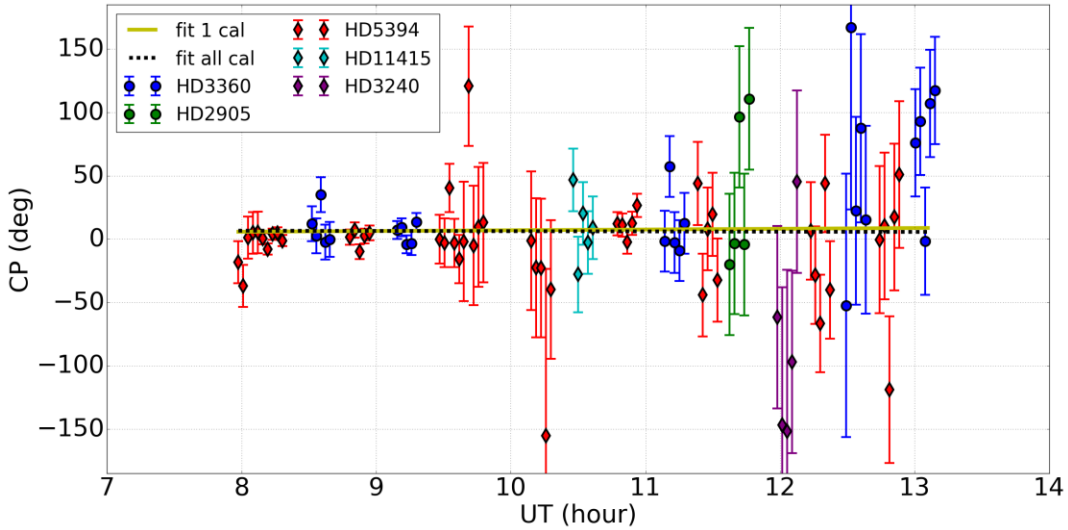




- Closure phase: $CP = \arctan\left(\frac{\Sigma_{Im}}{\Sigma_{Re}}\right)$
- $\sigma_\Sigma = \sqrt{N}\,\sigma_{bg}$, σ_{CP} determined by Monte-Carlo

Closure phase

2016-09-29





2016-09-30

Closure phase

- 2016-09-29: $slope = -0.01 \pm 0.01$

- 2016-09-30: $slope = 0.16 \pm 0.06$ with 1 cal
  $slope = 0.14 \pm 0.06$ with 2 cal

=> Stability of CP_{instr} with respect to the calibrators

=> Investigating on possible instrumental effects

Adaptive optics and injection

Observations

(with T.Ten Brummelaar, M.Anderson, J.Sturmann, L.Sturmann, C.Farrington, N. Vargas, VEGA team)

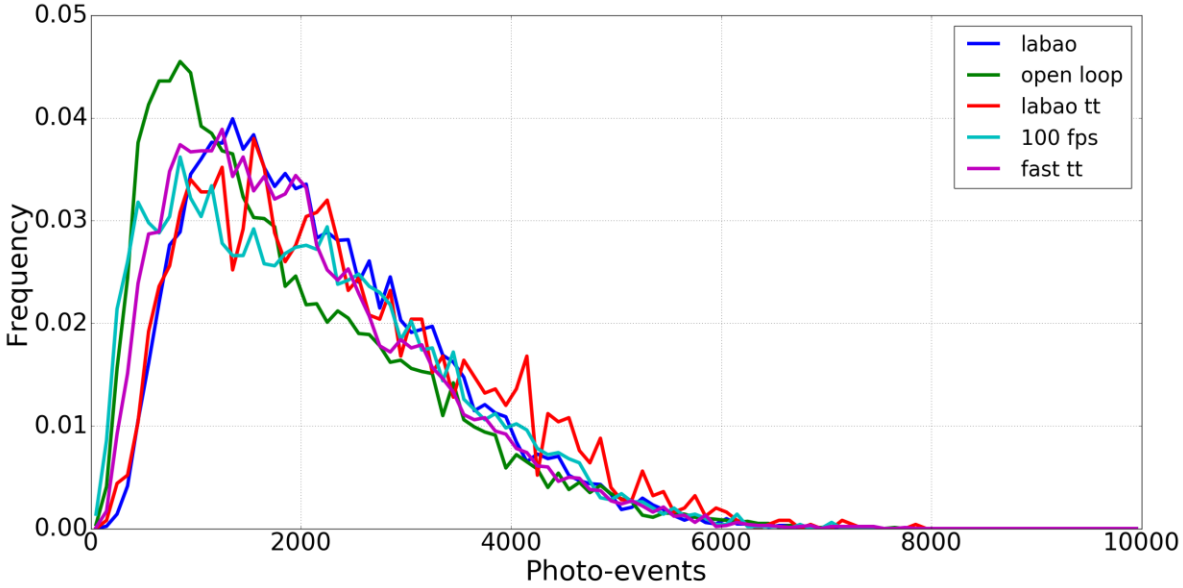
2017-03-08

- S2
- r_0 = 7 cm
- Target: Sirius
- AO modes:
  - Labao
  - Open loop
  - Labao + own TT
  - Fast TT

2017-03-10

- S1S2
- r_0 = 8 cm
- Target: Procyon
- AO modes:
  - Labao
  - Open loop

Adaptive optics and injection



2017-03-08

$$< \rho >_{open\ loop} = 0.65\%$$

$$r_0 = 7\ cm \Rightarrow \rho_{th} = 0.65\%$$

$$\rho_{labao} = 0.76\% \Rightarrow$$

$$r_{0,eq} = 7.43 cm$$

2017-03-10

$$r_0 = 8\ cm \Rightarrow \rho_{th} = 0.88\%$$

$$< \rho >_{S2,open\ loop} = 0.58\%$$

$$< \rho >_{S1,open\ loop} = 0.50\%$$

Conclusion and prospects

- Limiting magnitude: characterized and quantified
- Instrumental visiblity:
  - Stable with respect to magnitude and night-dependent
  - Very sensitive to pupil drifts?
- Closure phase:
  - First measurements of CP quite accurate
  - Keep characterizing (magnitude, AO)
- AO and Injection:
  - AO improves a bit injection in FRIEND
  - Correlate FRIEND and AO data
- *Martinod et al 2017 in prep.*