ALADDIN performance model

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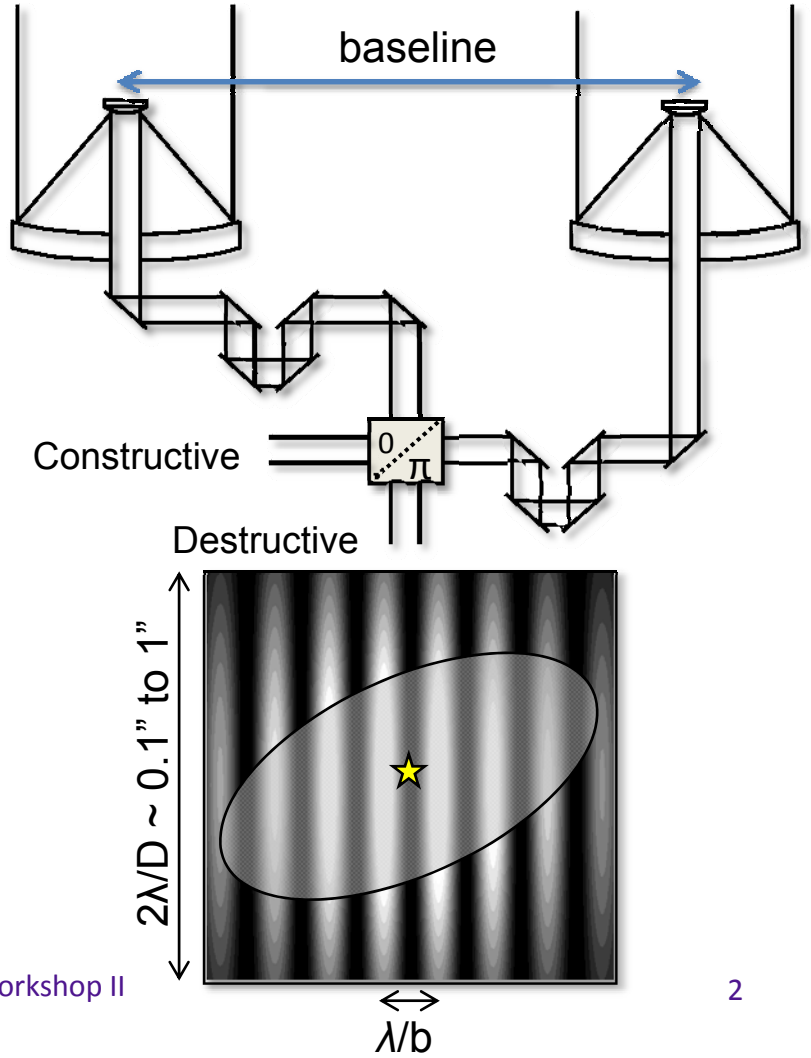
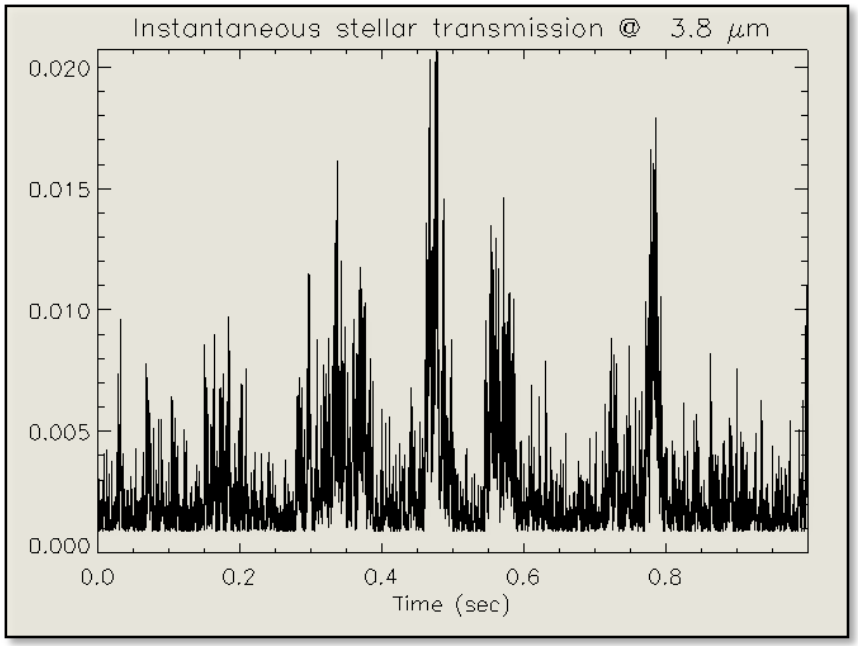
Nulling interferometry: principle

- Co-axial combination
- Interferometric response: *transmission map*
- No image
  - Flux integrated on the whole field-of-view
- Calibration and/or modulation mandatory



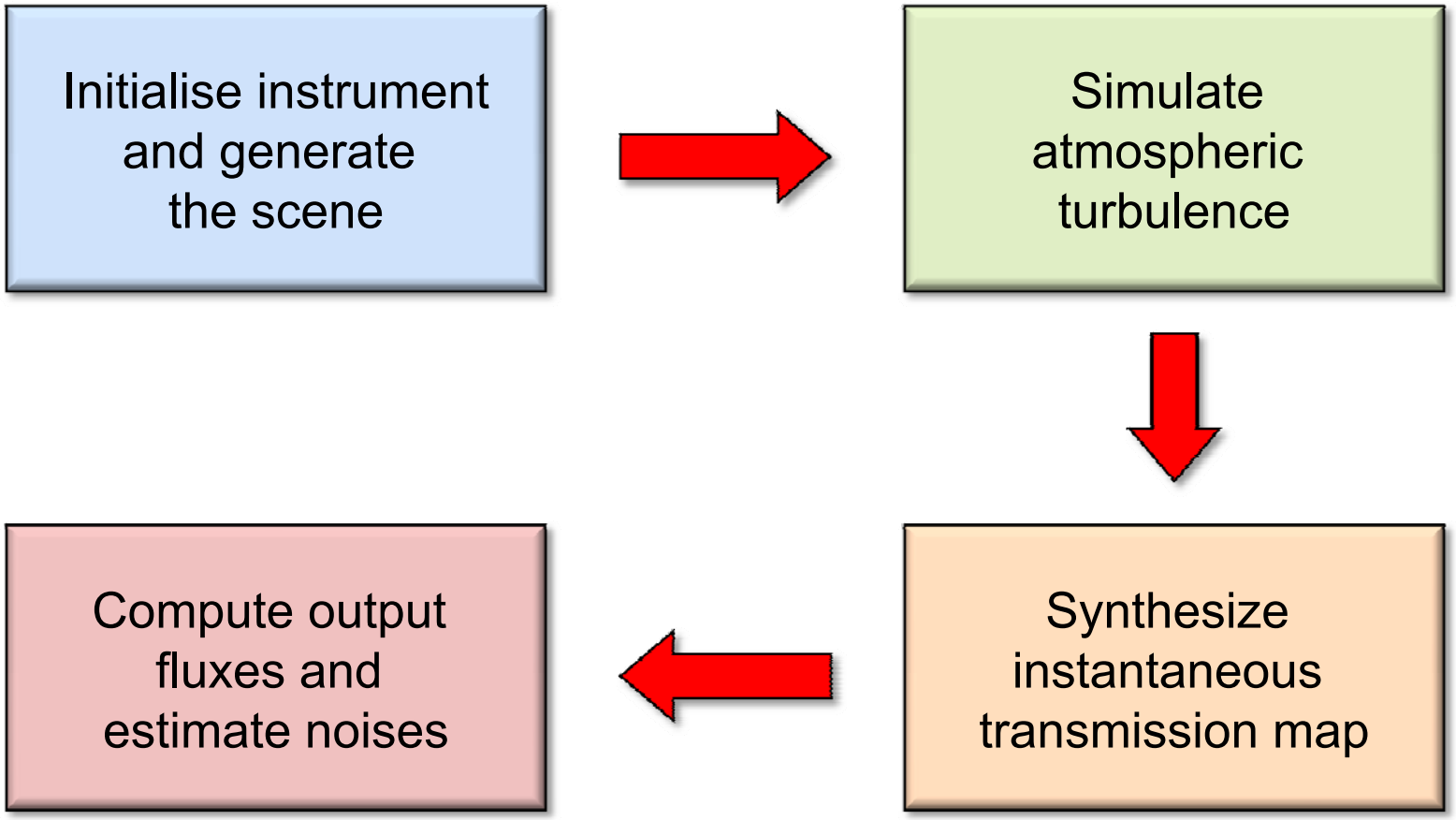
Signals and noises

- Stellar residuals
  - Geometric leakage
    - $4/\pi^2 \times (\lambda/b/\theta_\star)^2 \sim 10^{-4}$
  - Instrumental leakage
    - Due to turbulence
    - Bias + instability noise
- Thermal background
  - Sky and optical train
  - Dominant from ground
- Exozodiacal disc
  - 20 zodi: typically 10^{-4} to 10^{-5} of stellar signal (thermal IR)



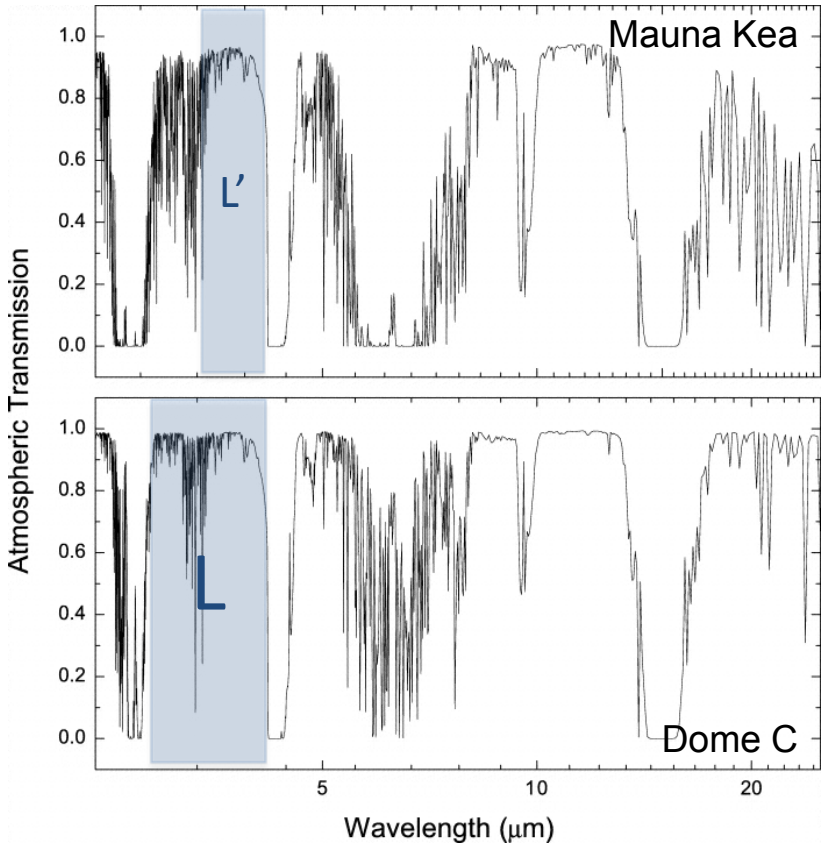
The GENIEsim software

Absil et al. 2006 (A&A 448)



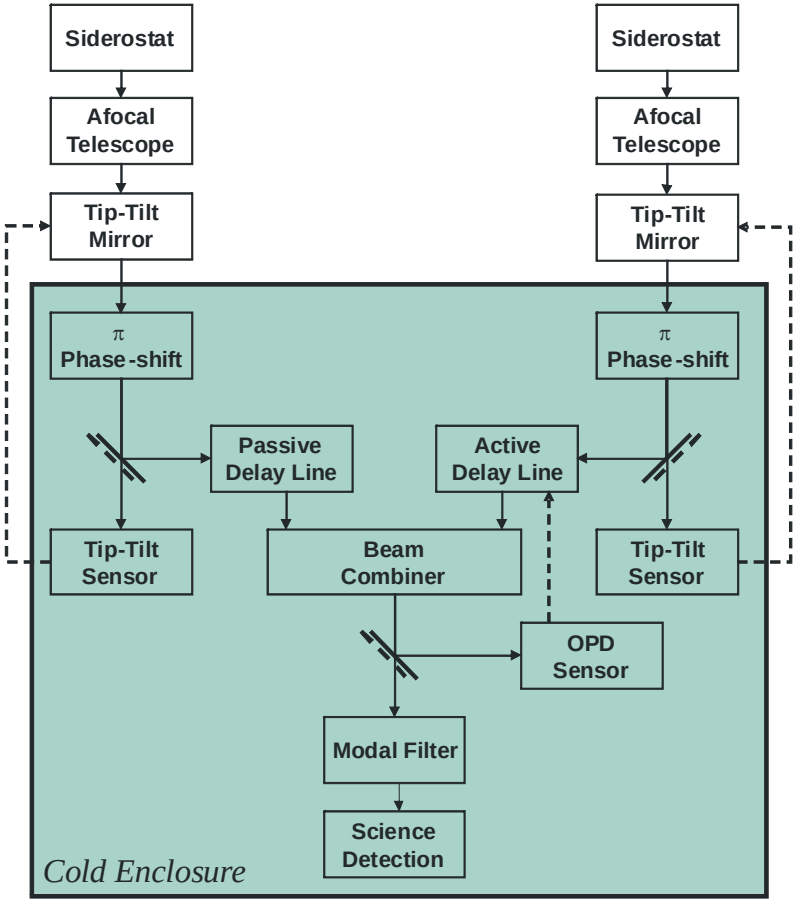
Input parameters: atmosphere

- Crude model for free air seeing
- Seeing: 0.27”
  - Equivalent r_0 = 38 cm
- Coh. time τ_0 = 7.9 msec
  - Equivalent v_{wind} = 15 m/s
- Water vapour seeing
  - ‹PWV› = 250 µm
  - σ_{PWV} = 1 µm
- T_{sky} = 230 K



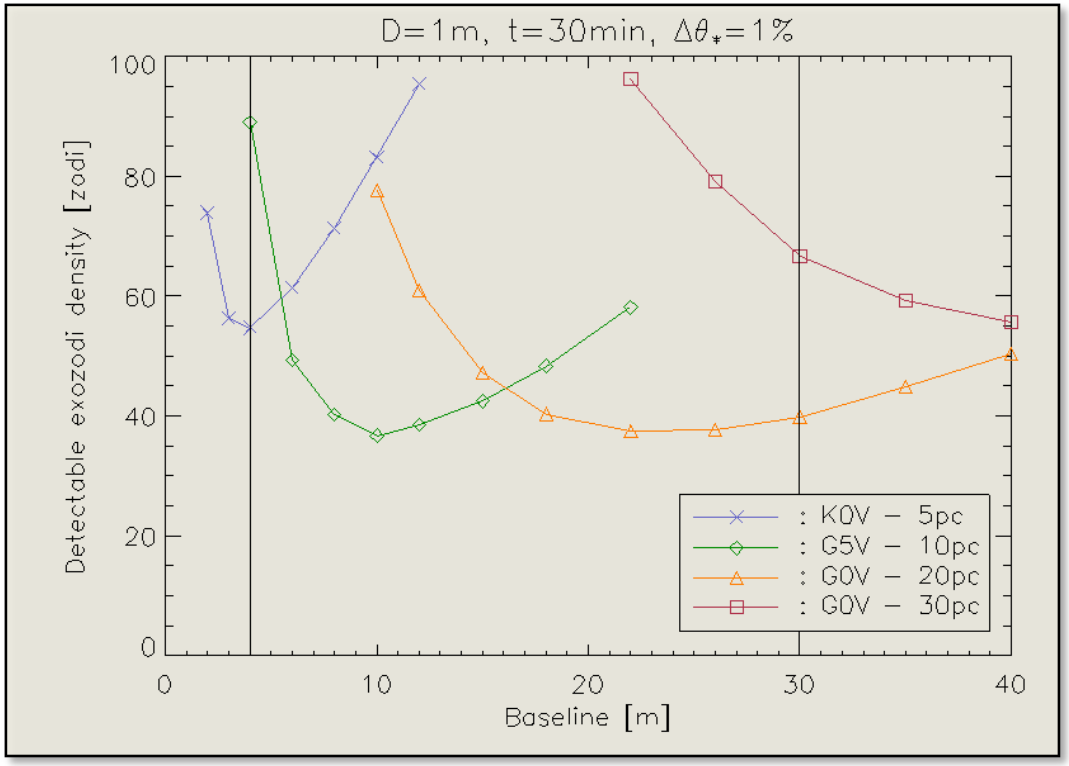
Input parameters: instrument

- Baseline range: ~4 to 30 m
- Telescope diameter: 1 m
- Warm throughput: 80%
  - 5 mirrors at 230 K
- Cold throughput: 10%
  - 15 mirrors at 150 K
- Science band: 3.1 – 4.1 µm
- Control loops
  - Fringe tracking (K band)
  - Tip-tilt control (J band)



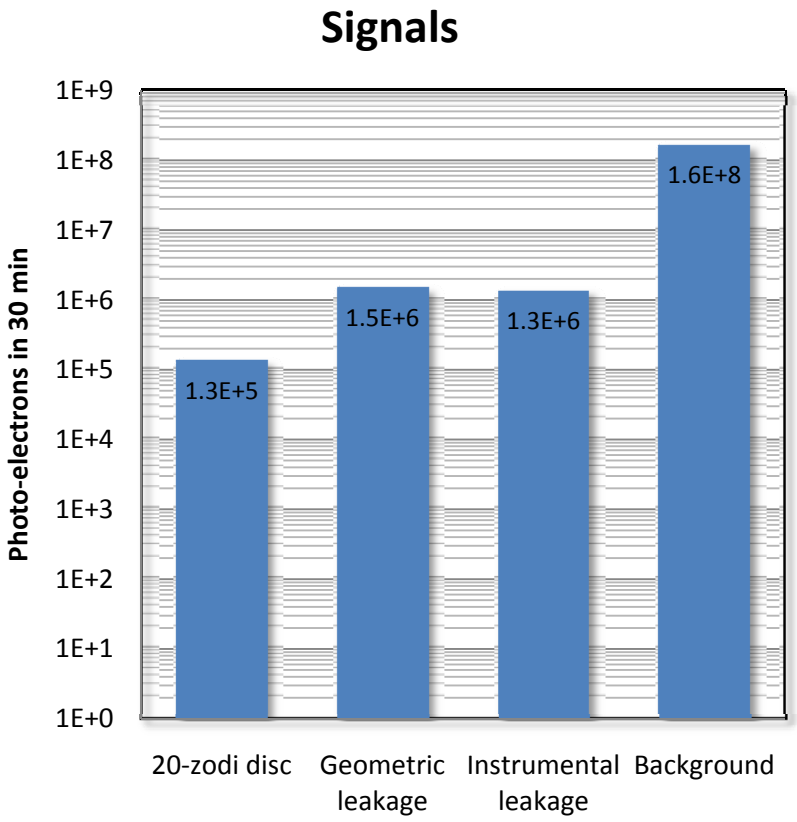
Sensitivity vs. baseline

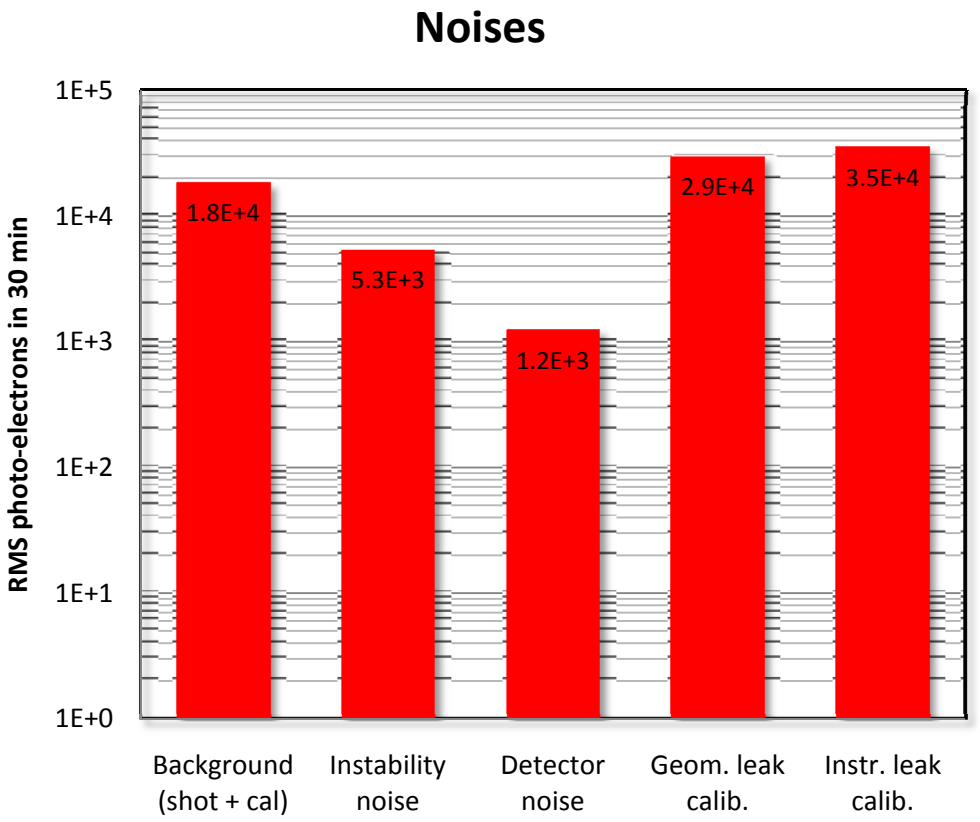
- Four representative targets
- Integration: 30 min
- Competition between
  - Stellar leakage
  - Exozodi transmission
- Sensitivity in the 40-60 zodi range



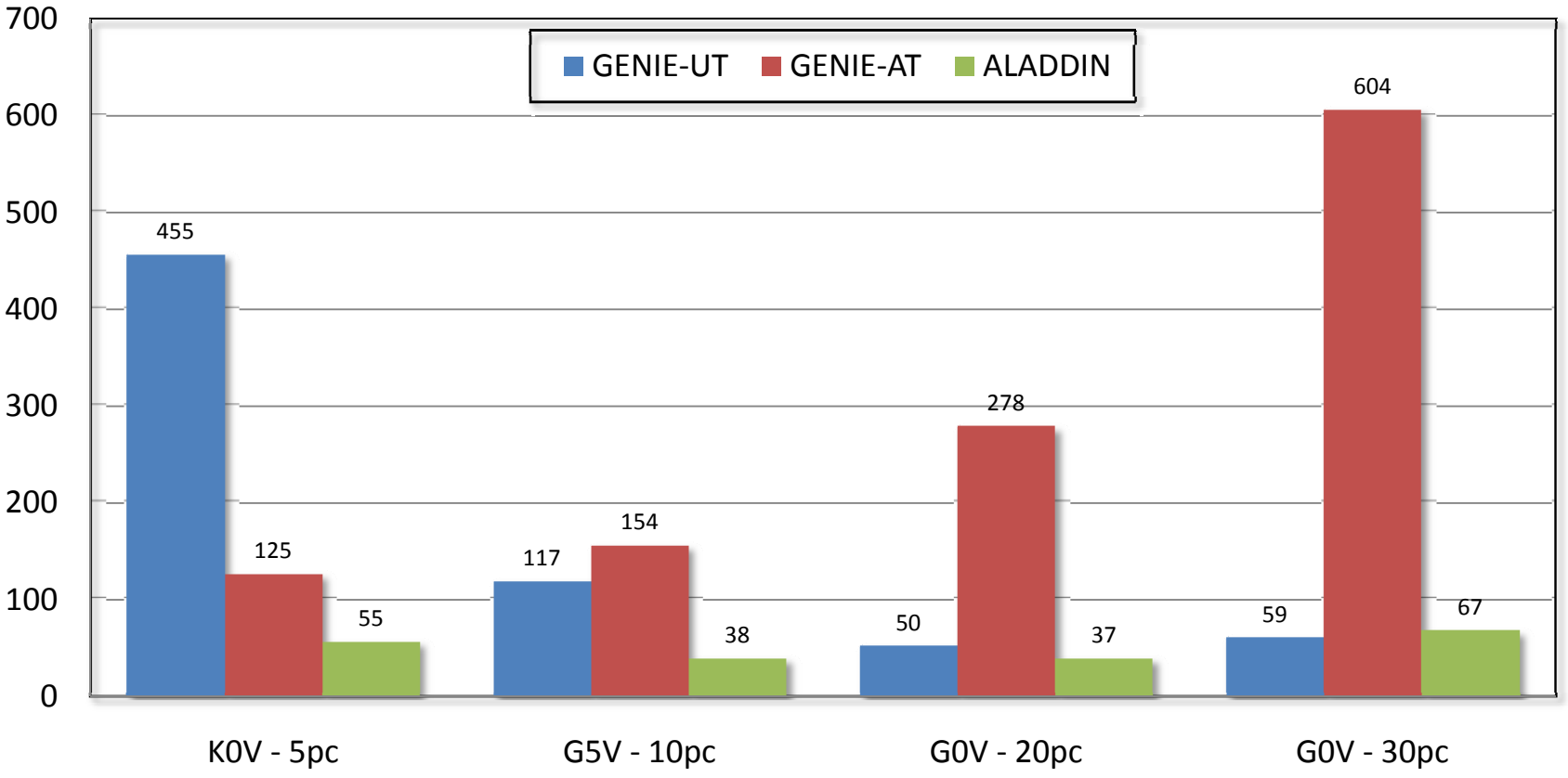
Absil et al. 2007 (A&A 475)

Typical noise budget



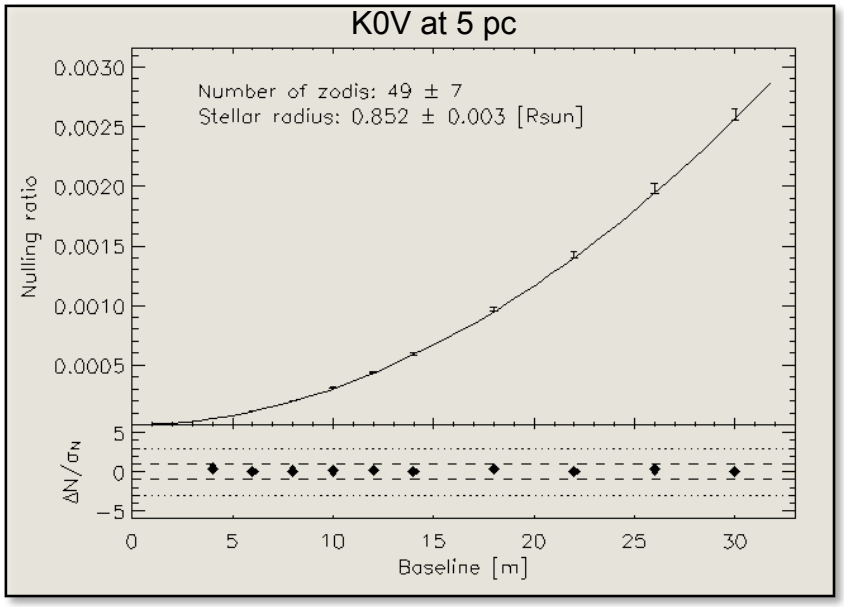


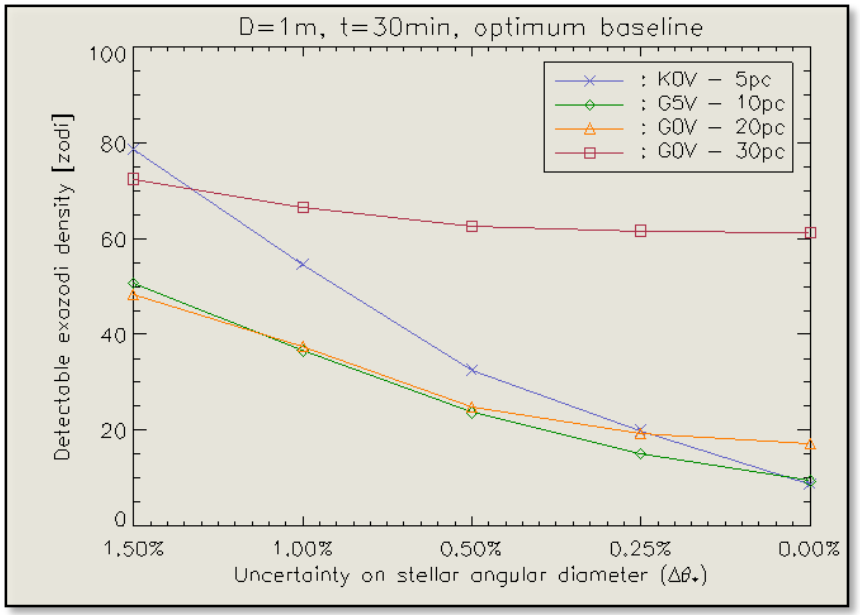
Comparison with GENIE



Stellar leakage calibration

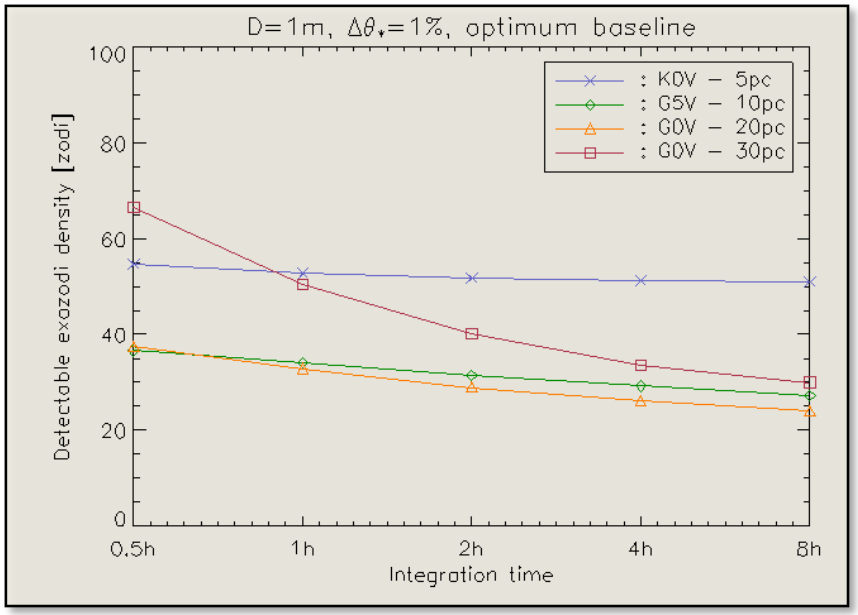
- Imperfect knowledge of stellar diameter
  - $\Delta\theta_\star$~1%
  - Self-calibration possible

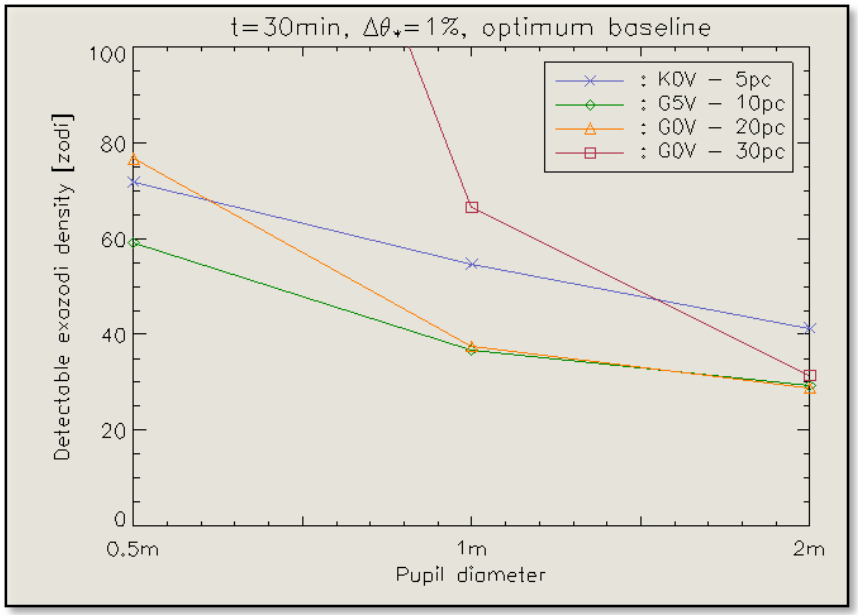




Integr. time / telescope diam.

- No large improvement
  - 30min integration on 1m telescopes is appropriate





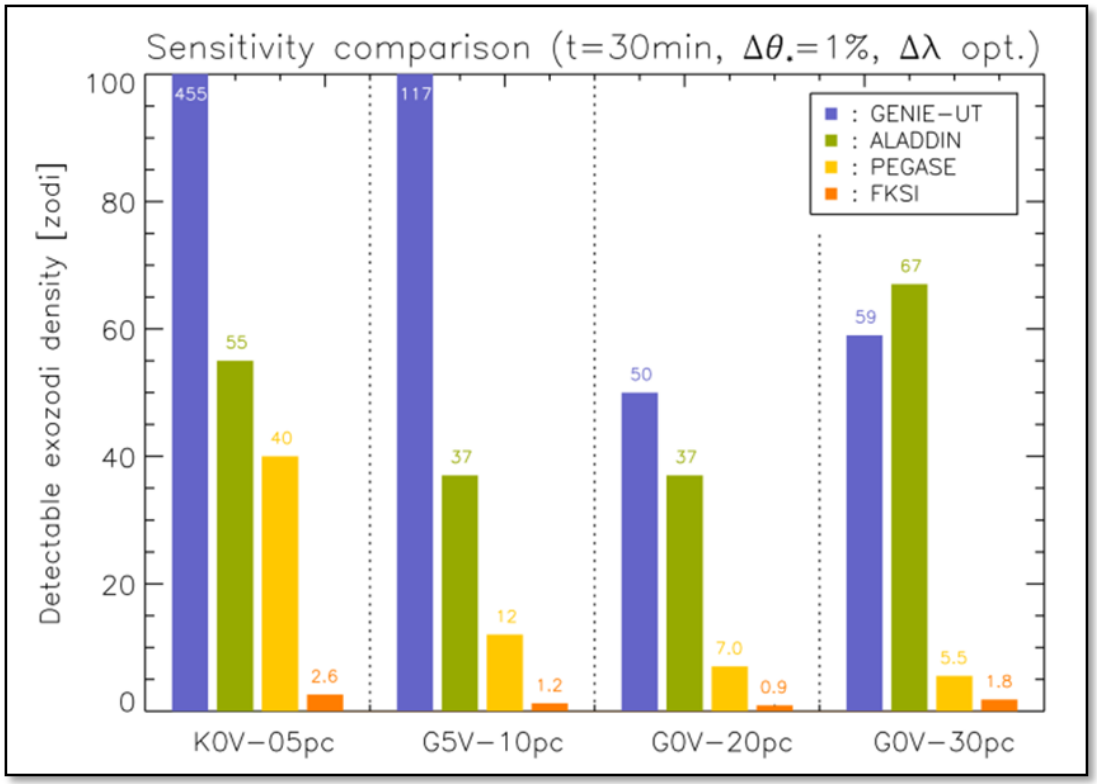
Influence of boundary layer

- At ground level: seeing 1.9", τ_0 ~ 2.9 msec
  - 1st problem: wave front quality
    - Multi-speckle → adaptive optics (20×20 actuators, 1 kHz)
  - 2nd problem: piston
    - Residual OPD ~25 nm @ 10 kHz (instead of 10 nm @ 4 kHz)
    - Dispersion control might be required (TBC)
  - Estimated sensitivity (G0V at 20 pc)
    - ~50 / ~200 zodi with / without AO (instead of 37 zodi)
- Maximum tolerable seeing
  - Around 0.8" before significant performance decrease
  - Calibration may become difficult

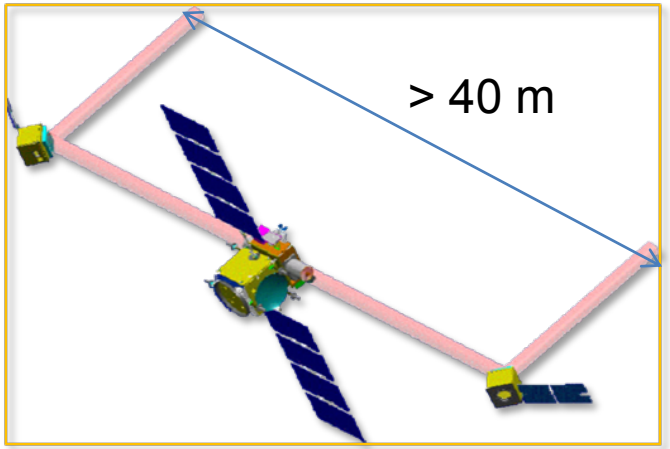
ALADDIN at Paranal?

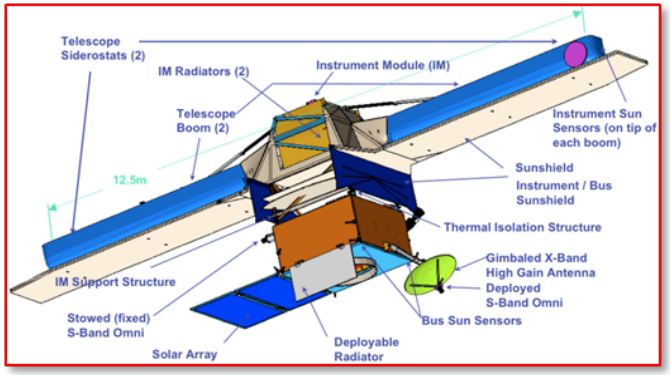
- Atmosphere: seeing 0.9”, τ_0 ~ 3 msec
- 1st problem: background
  - 8-m class telescopes would be required
- 2nd problem: water vapour seeing
  - Dispersion control mandatory (fluctuation ~ 1 rad)
- 3rd problem: wave front quality
  - A few speckles → intensity control (or AO)
    - Tip-tilt control (1 kHz) → intensity variation of 7%
- Estimated sensitivity (G0V at 20 pc)
  - ~250 / ~3000 zodi with / without dispersion control

Final benchmark: space missions



Defrère et al. 2008 (A&A 490)





Best performance with FKSI, but compare price (~700M$)