SPICA Performance, DM-PB-NN-SL, Sep. 2019

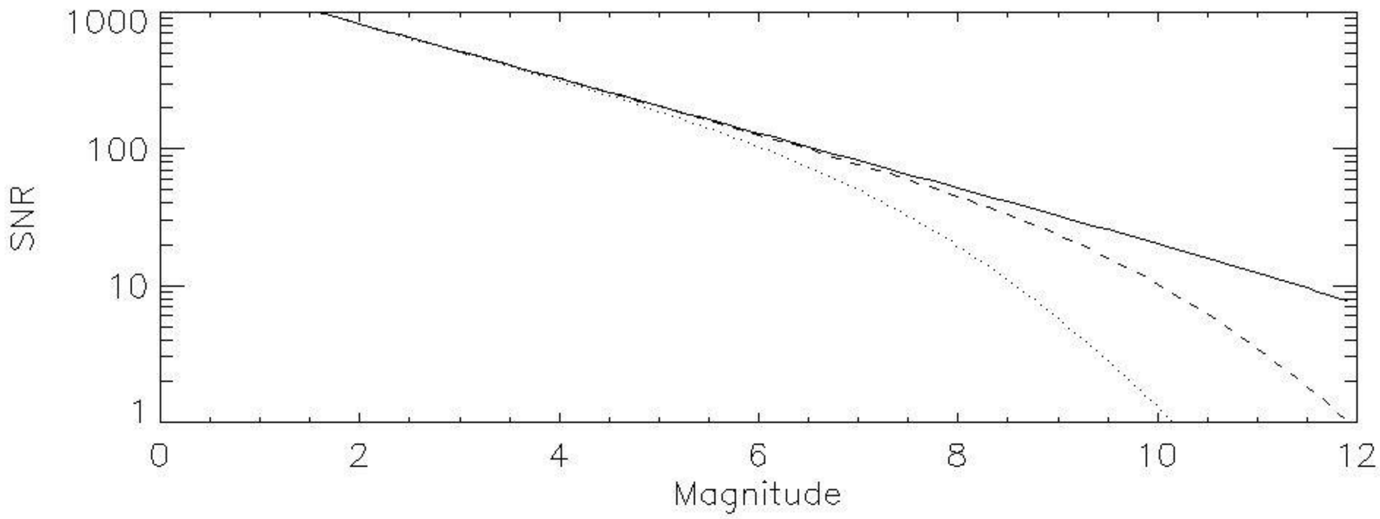
Numerical data and SNR models

1. **Main hypothesis for the spectrograph**
   a. R=140 for sensitivity and angular diameter measurements
      i. Spectral band 600-850nm; 50 spectral channels of ~5nm
      ii. for stars with θ=0.2mas, V^2>0.6
      iii. for stars with θ=0.5mas, V^2>0.02
      iv. for limb darkening (>0.8mas) V^2_{min}=0.002
   b. R=3000 for spectral imaging
      i. Spectral band of ~65nm in 600-850nm; 250 spectral channels of ~0.25nm
      ii. Differential visibility measurements V^2 =0.6 or V^2=0.1
2. **Detector parameters (Ixon897)**
   a. Without fringe tracker: DIT=0.02s (group delay tracking only)
   b. Fringe tracker specification: DIT=0.2s (goal 10s with degraded transfer function)
   c. Quantum Efficiency qe=0.9, Read Out Noise RON=0.1
   d. 1 spectral channel=600 pixels
   e. N_{CIC}=0.0018 events/pixel
   f. N_{Dark}=0.00015 events/pixel/second
3. **Transmission**
   a. CHARA transmission: 0.017. Transmission AO=0.8.
   b. Pickup optics and injection, 4 mirrors: 0.95^4
   c. Fibres + spectrograph: 0.6; Splitter for photometry: 0.8
   d. Strehl=0.25; coupling efficiency=0.8xSR
   e. Collecting area: 6x0.75m²
   f. Instrumental visibility V=0.8
4. **Model of Signal to Noise Ratio for V² (Mourard et al., 2018 JOSA-A)**
   a. $SNR = \frac{\sqrt{N_{SpCh}.N_{Fr}}.\left(\frac{N_{ph}.V_{inst}.V_{target}}{N_{Tel}}\right)^2}{\sqrt{PhotonNoise+ReadNoise+CoupledTerms}.}$
   b. $PhotonNoise = 2.\left(N_{ph} + N_{d+c}\right).\left(\frac{N_{ph}.V_{inst}.V_{target}}{N_{Tel}}\right)^2 + \left(N_{ph} + N_{d+c}\right)^2$
   c. $ReadNoise = N_{ph}.RON^2 + \left(N_{ph}.RON^2\right)^2$
   d. $CoupledTerms = 2.N_{pix}.RON^2.\left(\frac{N_{ph}.V_{inst}.V_{target}}{N_{Tel}}\right)^2 + 2.\left(N_{ph} + N_{d+c}\right).N_{pix}.RON^2$
   e. With the following notations
      i. N_{SpCh} is the number of spectral channels considered
      ii. N_{Fr} is the total number of frames
      iii. N_{ph} is the number of photons per frame
      iv. V_{inst} is the instrumental visibility
      v. V_{target} is the visibility of the target
      vi. N_{Tel} is the number of telescopes
      vii. N_{d+c} is the number of dark and CIC events per frame
      viii. RON is the Read Out Noise
      ix. N_{pix} is the number of pixels considered
5. **SNR on Differential Visibility**
   a. Differential visibility is computed from the correlation of one wide spectral channel CH1 with a narrow spectral channel CH2.
   b. The SNR on Vdiff is computed as: $SNR_{Vdiff} = \sqrt{\frac{1}{\frac{1}{SNR1^2}+\frac{1}{SNR2^2}}}$, with SNR_1 and SNR_2 the SNR on V for the two channels. We assume $SNR_V=2.SNR_{V^2}$.
   c. The uncertainty on the differential phase is given (in radian) by: $\sigma_{phi} = \frac{1}{SNR2}$

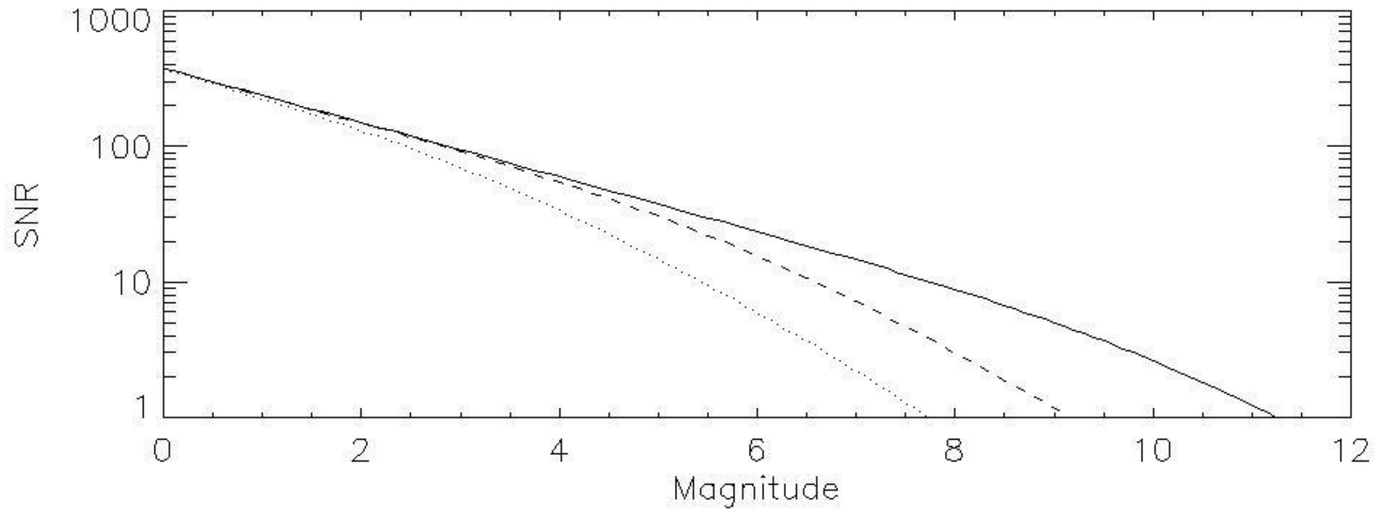
RESULTS on V^2 measurements in low resolution mode

For all plots: dotted line: DIT=0.02s, dashed line: DIT=0.2s, solid line=DIT=10s

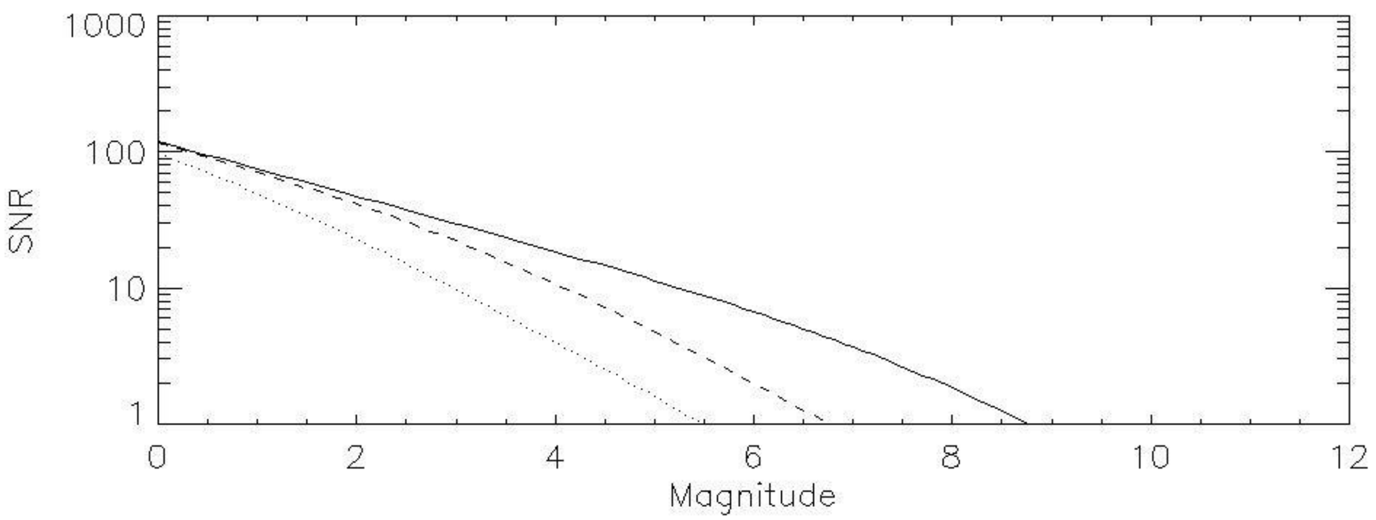
1. **SNR on V^2 for one spectral channel: V^2=0.6, 10mn of integration, R=140**



2. **SNR on V^2 for one spectral channel: V^2=0.02, 10mn of integration, R=140**

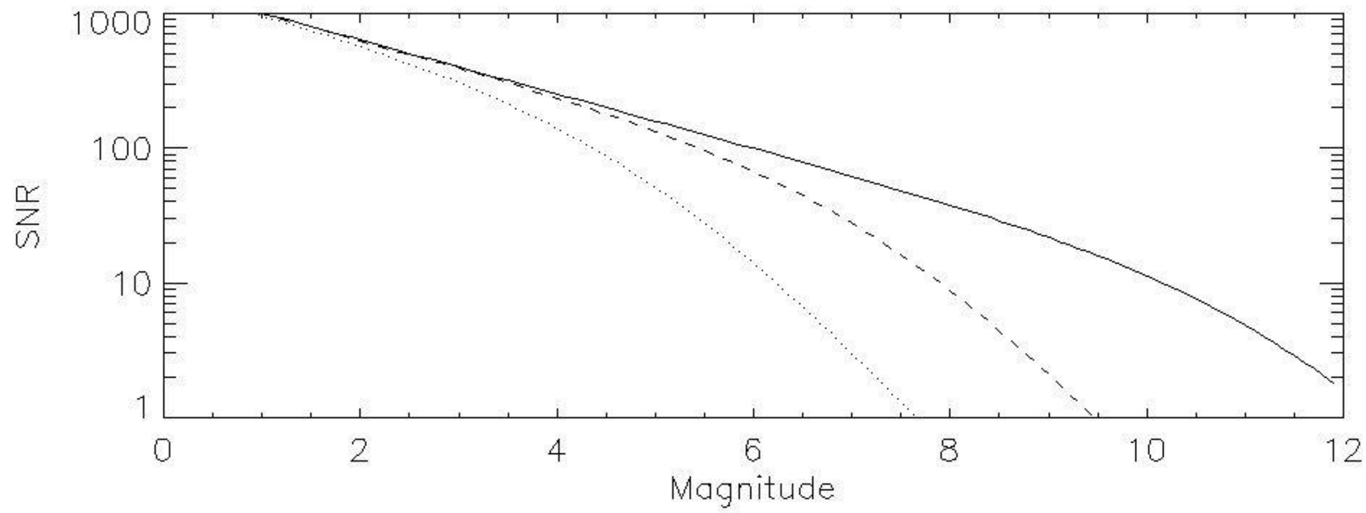


3. **SNR on V^2 for one spectral channel: V^2=0.002, 10mn of integration, R=140**

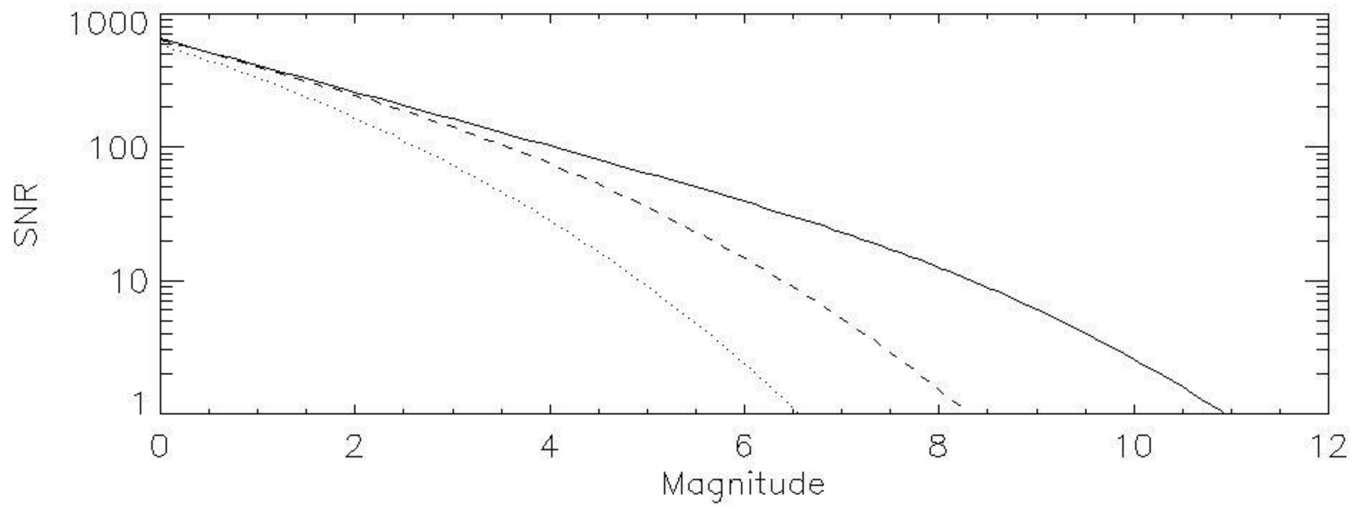


RESULTS on V diff measurements in medium resolution mode

4. SNR on Vdiff, V^2=0.6 in the reference channel, 30mn of integration, R=3000

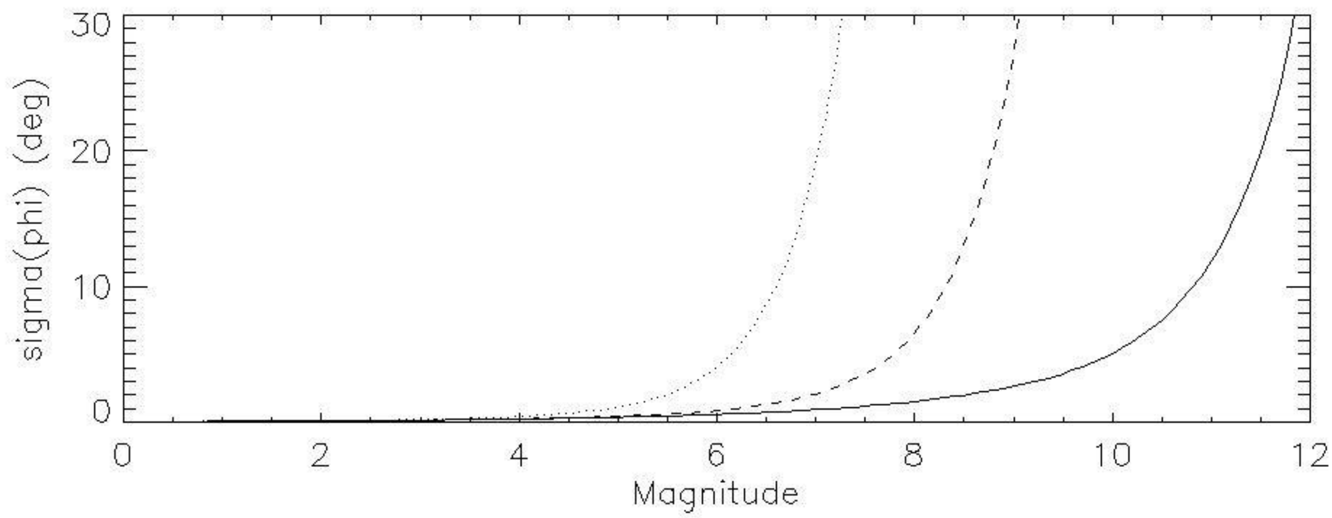


5. SNR on Vdiff, V^2=0.1 in the reference channel, 30mn of integration, R=3000



RESULTS on Differential Phase measurements in medium resolution mode

6. σ_{phi} in deg, V^2=0.6 in the reference channel, 30mn of integration, R=3000



7. σ_{phi} in deg, V^2=0.1 in the reference channel, 30mn of integration, R=3000