Predicting the Signal-to-Noise Ratio of VLTI Observations

Data Management & operations Division
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Introduction

Understanding the performance of VLTI instruments

Have drawn on the models and data of many others

- P. Ballester, P. Kervella, V. Coudé du Foresto, C. Leinert, I. Percheron, J. Meisner, F. Malbet

Anticipating the Signal-to-Noise Ratio (SNR) of MIDI observations

Development of an Exposure Time Calculator (ETC)

Not a straight-forward calculation!

- Atmosphere, telescope, delay line, instrument, detector
- Non-physical, or combined, parameters cause problems
- Many parameters can not be measured for testing

But we shall make things even more difficult for ourselves…

Expanding the scope

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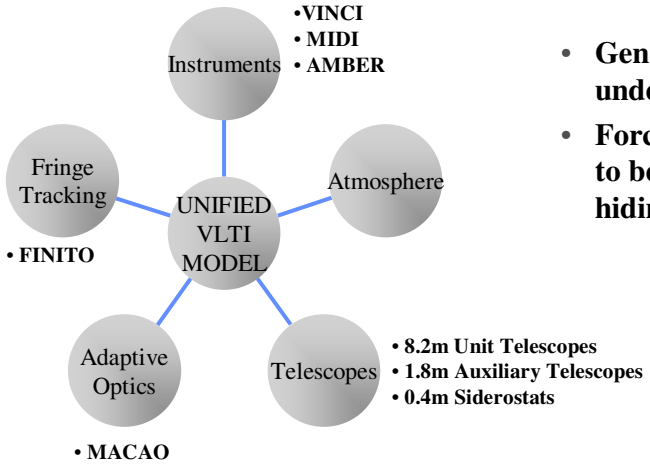
Creating a general algorithm



- **General case… helps understand the VLTI better**
- **Forces individual parameters to be explored, rather than hiding them in fudge factors!**

Creating an Exposure Time Calculator

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Provide an ETC which is generic to all of the VLTI

With a *unified model*, it is possible to have an *unified ETC*

A planning tool for astronomers

- **Test instrument performance against predictions**
- **Allows exploration of available parameter space when devising observations**
- **Plan observations to get best results for spent time**

The Challenges

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ETCs are not a new idea, nor are SNR calculations

The VLTI "standard instrument" ideal (not specialist!)

Quantifying interferometric performance

- Understandable by astronomers
- Must be physical
- Must translate to a measurable quantity in the final data (for easy comparison)

"Catch-22" problem

- Astronomers need the ETC to make useful observations
- Useful observations are needed to make a realistic model

Data Quality

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Photometric SNR & Visibility precision – dmu/mu

Model initially developed against the VINCI dataset

Simple measurement to compare against a general mag/vis term

- **Correlated magnitude** $m_c = -2.5 \log(\mu^2\ 10^{-(m/2.5)})$

Problems with data consistency

- **Noisy data**
- **Instrument still being commissioned**
- **Data acquisition problems**

Unified Model

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Model the main components limiting the measurement accuracy

- **Photometry (system transmission and object brightness)**
- **Thermal background and read-out electronics**
- **Loss of fringe contrast due to the complete telescope system**
- **Total loss of fringe contrast due to the atmosphere**

Measured and Predicted

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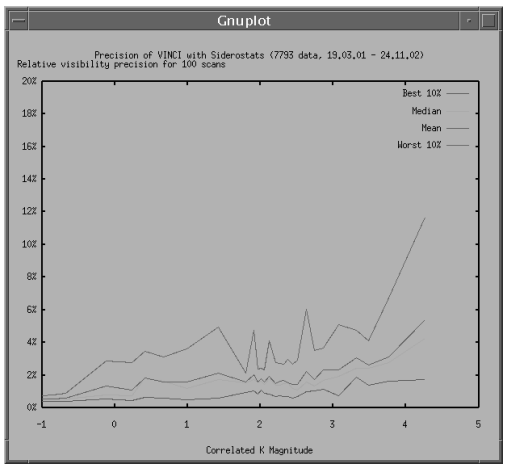
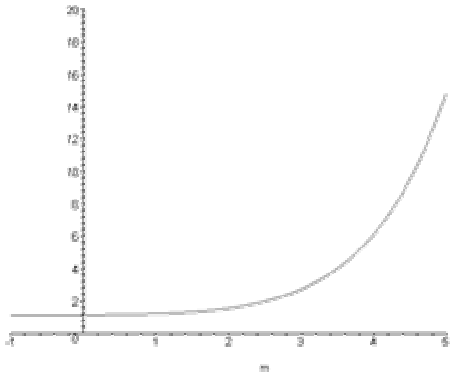
VINCI Precision vs Correlated Magnitude





Comparison to other studies

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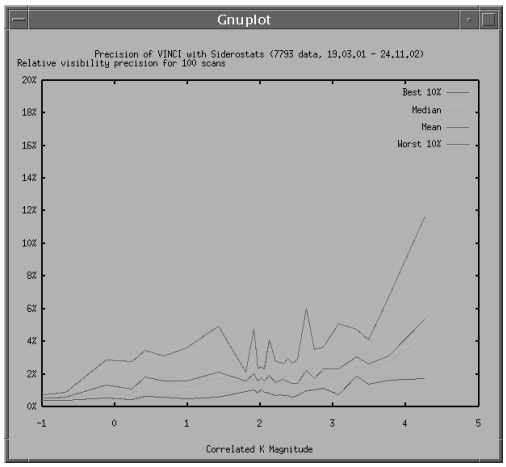
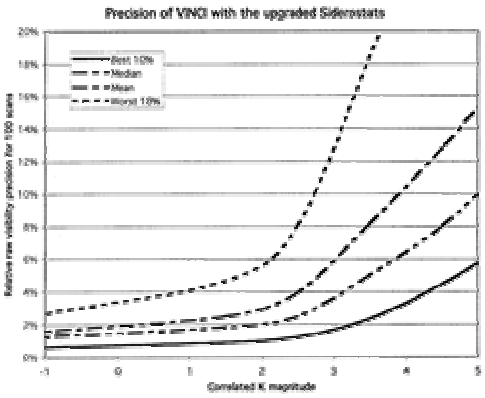
Independent study of 2001 data (Kervella)





Detailed study

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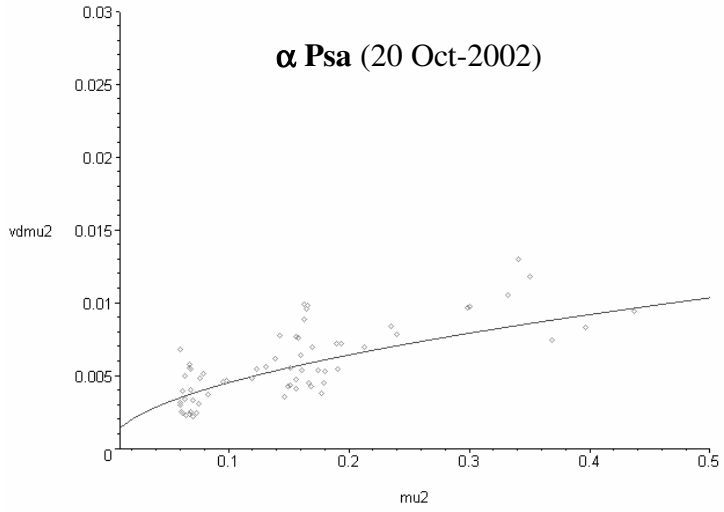

Single star

Range of baselines (due to good HA coverage)

Range of μ^2

Constant photometry

Large quantity of data - 100 measurements

Nominal 500 scans

All data > 100 scans accepted

64 measurements remain

Data then normalised to 100 scans

Comparison to MIDI data

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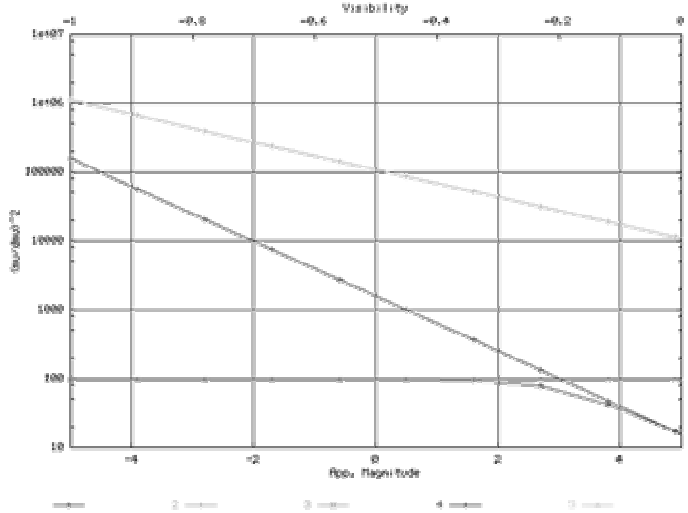

Recent observations

MIDI, August 2003

7 Psc

- $m_N = 1.82$
- $SNR^2 \approx 80$

7 Cet

- $m_N = 1.82$
- $SNR^2 \approx 80$

Exposure Time Calculator

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Development is currently underway for an exposure time calculator (ETC) which uses the unified model

Presently only available on the ESO internal web-site

Written in C/C++ and implements an HTML interface

The interface is based upon existing ESO observation preparations tools for consistency

Input page

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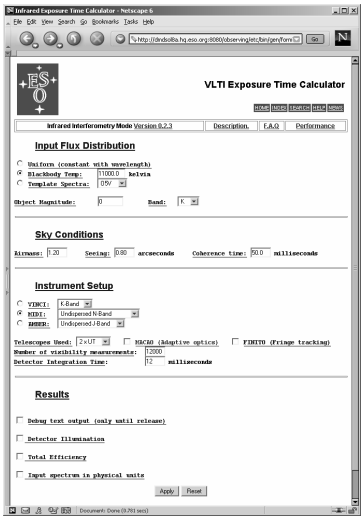

Input flux distribution

- Spectral profile
- Magnitude

Sky Conditions

- Airmass
- Seeing
- Coherence time

Instrument setup

- Instrument (MIDI, VINCI, AMBER; + Mode)
- Telescopes, Adaptive Optics, Fringe-tracking
- Exposure/scan time control

Output page

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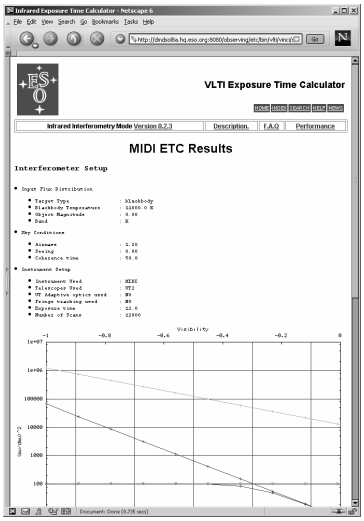

Parameters

- Listing of input parameters
- Data pertaining to specific object

Graphs

- More general case
- Better appreciation of the limiting factors

Java Applet

- Allows exploration of the data

Project status

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Current status of ETC development

- **MIDI**
  - Acquisition of more data
  - Validate model
- **VINCI**
  - Essentially complete
- **AMBER**
  - Algorithms implemented based on design documentation
  - Instrument due on-line later this year

Future development?

Summary

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Have developed a unified algorithm for VLTI performance

- **MIDI, VINCI and AMBER**
- **UTs, ATs and Siderostats**
- **UT adaptive optics (MACAO)**
- **Fringe-tracking (FINITO)**
- **Atmospheric parameters**
- **Astronomical object characteristics**

Have implemented an HTML-based ETC application