The Antarctic Plateau Interferometer

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Abstract

The Antarctic Plateau Interferometer (API) is an international collaboration for an instrument concept capable of extensive ***unique discovery space science*** in a variety of areas, including exoplanets, accretion, YSO's, and AGNs. To study exoplanets in the habitable zone, API would use three 2 meter class telescopes, high dynamic range spectroscopy, and differential closure phase to achieve 1:1e5 contrast ratio measurements. API would achieve this performance ***using proven technology*** at the best accessible site on Earth for infrared interferometry. At Dome C Antarctica, the combination of low levels of atmospheric turbulence (resulting in the best seeing ever measured) and low thermal background enable an interferometer with 2 m class telescopes to exceed substantially the performance of existing instruments. API will be packaged in shipping containers so that the instrument can be demonstrated on the sky in the northern hemisphere and then shipped, with a minimum of disassemble, to Dome C. The combination of using existing interferometer technology (adapted to the Antarctic environment) and ***containerized packaging*** makes it possible to begin operation at Dome C in 5 years. In addition to delivering a high-impact science program, API could test instrument technology for space interferometry missions, such as Darwin and TPFI.

Dome C: the best seeing ever measured

Lawrence et al. 2004, Nature, 431, 281.

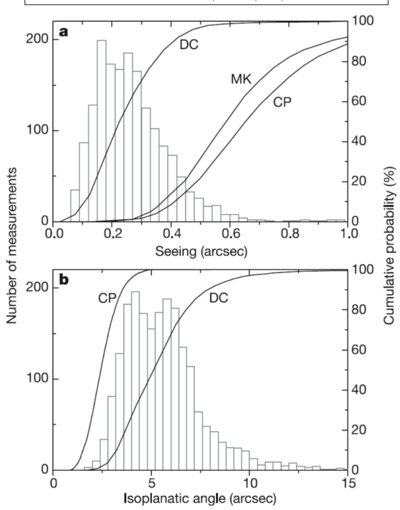
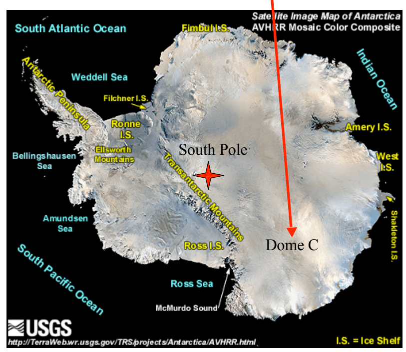


Figure 3 Histograms and cumulative distributions of the atmospheric seeing and the isoplanatic angle. **a**, Histogram of Dome C seeing above 30 m from MASS combined with SODAR, and cumulative distributions of seeing at Dome C (DC), Mauna Kea (MK) (derived from ref. 4), and Cerro Paranal (CP)[2]. **b**, Histogram of Dome C isoplanatic angle derived from the MASS instrument, and the cumulative distribution of isoplanatic angle from Dome C and Cerro Paranal[2].

Table 1 **Comparison of observatory site conditions**

Site	ϵ_0	θ_0	τ_0
Dome C	0.27	5.7	7.9
South Pole	1.8	3.2	1.6
Mauna Kea	0.5–0.7	1.9	2.7
San Pedro Martir	0.59	1.6	6.5
Cerro Paranal	0.80	2.6	3.3
La Palma	0.76	1.3	6.6

ϵ_0 is the seeing in arcseconds, θ_0 is the isoplanatic angle in arcseconds and τ_0 is the coherence time in milliseconds. All values are corrected to the zenith and at a wavelength of 500 nm. Seeing, isoplanatic angle and coherence time at South Pole are mean total atmosphere values (above ground-level) from 16 microthermal balloon launches in winter 1995 combined with microthermal tower measurements of the 0–30 m ground layer[7]. Seeing and isoplanatic angle values at Mauna Kea, Hawaii are based on 20 nights of SCIDAR observations in 1995 (seeing above ground level)[1], and FWHM measurements from the Auto Guider of the Subaru telescope during focus checks over a 12 month period from 2000 to 2001 (seeing above ~15 m)[4]. Seeing from San Pedro Martir, Mexico, is the median from 2 yr of DIMM measurements (seeing above 8 m)[3]. Isoplanatic angle and coherence time from San Pedro Martir are obtained with generalized SCIDAR (located 15 m above ground level) over 27 nights in 1997 and 2000[29]. Seeing and isoplanatic angle from Cerro Paranal, Chile, are average values from DIMM measurements (above 5 m) over 10 yr (1989–95 and 1998–2002)[2]. The coherence time at Cerro Paranal is derived (to an accuracy of 20%) from DIMM measurements combined with balloon-borne wind speed measurements[2]. Seeing from La Palma, Canary Islands, is from 9 months of DIMM measurements (seeing above 5 m)[5]. Isoplanatic angle and coherence time from La Palma are from six microthermal balloon launches[30] in 1990.



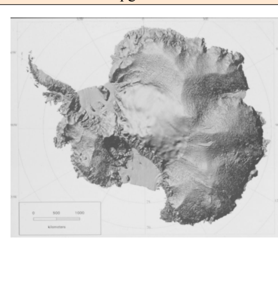
API Key Science Topics

- Spectral characterization of Jovian class planets in habitable zone
- Characterization of protoplanet signatures in YSO disks
- Observation of phase angle -dependent effects in exoplanet SED
- Measure $_{Earth}$ by detecting Venus type planets around nearby stars
- Nature of the putative inner wall in YSO disks
- Accretion processes in YSOs and compact objects
- Active Galactic Nuclei and microquasars

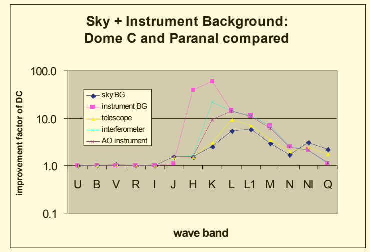
Because of the atmospheric stability and reduced infrared background, the Dome C location gives the Antarctic Plateau Interferometer ***unique discovery space capability*** enabled through very high dynamic range ($1x10^5$) and high sensitivity measurements.

The Instrument

- Three 2 meter class telescopes
- Adapt existing interferometer technology for cold operation
- Baselines of 100 to 800 m (400m in L/M)
- J-M band operation with red/blue cophasing
- Differential Closure Phase for high contrast measurements
- Double Fourier mode for high resolution spectroscopy
- 200 µm upgrade option (separately funded)
- Propose 2005, operate on ice in 2010
- On-sky testing in Northern hemisphere before deployment
- Modular design for Antarctic transport and installation
- Clear path for instrument upgrade

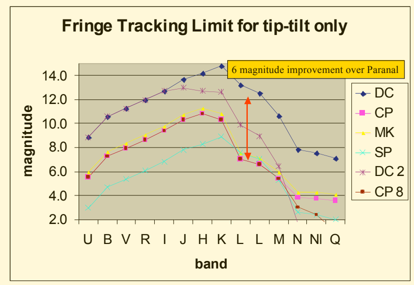


Background limited SNR improvement resulting from Antarctic location



- Sky and instrument background components differ.
- Emissivity and transmission control effective background.
- Instruments couple to background components differently.
  - Telescope: e=5%, t=95%
  - AO instrument: e=20%, t=30%
  - Interferometer: e=50%, t=5%

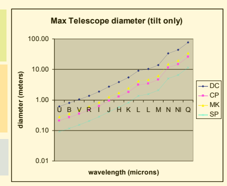
Dome C atmosphere improves interferometer sensitivity



Dome C superior to other sites but large telescopes needed to extract full potential.

Interferometer (IF) with 2 m tel. at Dome C exceeds sensitivity of IF with 8 m tel. at Mauna Kea or Paranal.

Estimates include read noise and background.



Concordia Station and traverse images by Agabi Karim.