ATST(先端技術太陽望遠鏡）

・口径4m軸外しグレゴリアン太陽望遠鏡（究極の地上太陽望遠鏡）

分解能0.03“ @500nm、0.1” @1.6μ

偏光精度 10^-4 （10^-5空間分解能を少し犠牲にしても十分高分解能）

波長域： 0.3～25μ、視野： <3‘

リム・コロナの観測

・場所： ハワイ・アレヤカラ山頂（~3000m）（世界中のベスト・サイトをサーベイ）

・NSO（主）、主なUS太陽研究所、EU太陽研究所（観測装置）

・予算見積もり： 180 M$ （NSF：120-130M$、他： 55-60M$）

・予定

環境問題クリア中

2008年秋？ 着工

2014年 ファーストライト

日本との関係

・何度かメールにより所長クラスにコンタクトあったがかみ合わず

・昨年SacPeak WSの折に常田さんのSolar-Bの話に興味を持った、PIのS. Keilが日本との協力関係を打診、11月に来日して、ATST説明会

・具体的な協力関係はまだ未定。

1. SOLAR-Bの結果をまず見たい

2. サイエンスWGに参加して、ATSTを勉強しつつ、日本の協力方針を決めたい。

サイエンスWGメンバー -> 末松 （今年から）

次回、サイエンスWG 10月中旬 @ハワイ

ATSTのサイエンス、具体的に何を目指すか

提案観測装置のレビュー

ATSTへの寄与

日本に何が期待されているか？

　SOLAR-B可視光望遠鏡OTAで培った望遠鏡開発・製作技術？

ATST側からは特に具体的な希望は出ていない

　主鏡？、望遠鏡構造？、、、という話もあるが

　望遠鏡の一部、facilityの一部を担うのは難しい（I/F、予算化）

現実的な寄与は、観測装置の1つを製作か

　日本しか開発できない装置はあるか？　多分ない

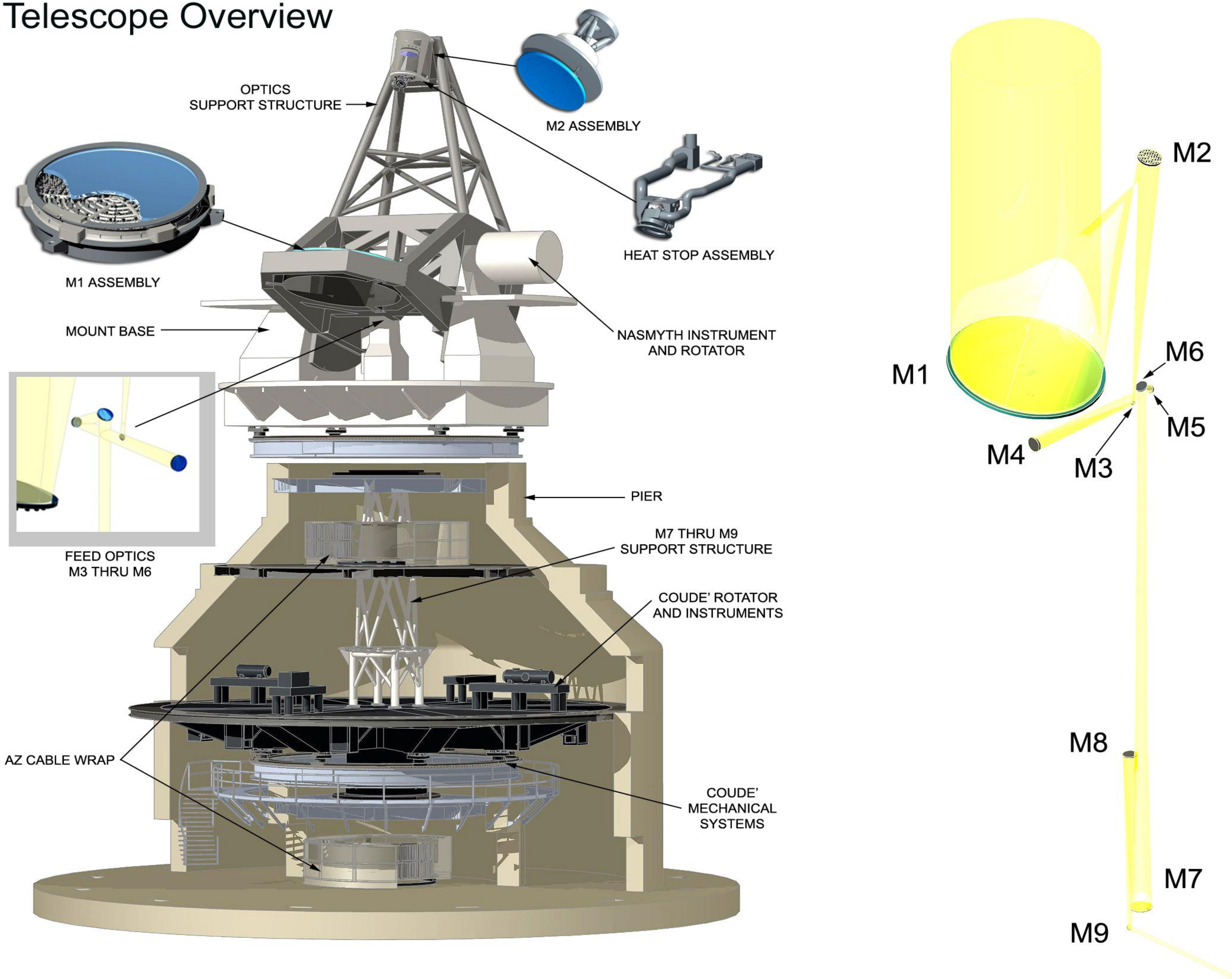
　しかし、2次元同時分光装置など特徴ある装置は提案できる。

　ただ、これによる観測時間が確実に割り当てられるかは保証されない。

参加するか？　何を？

　　Yes　->　誰が？

Telescope Overview

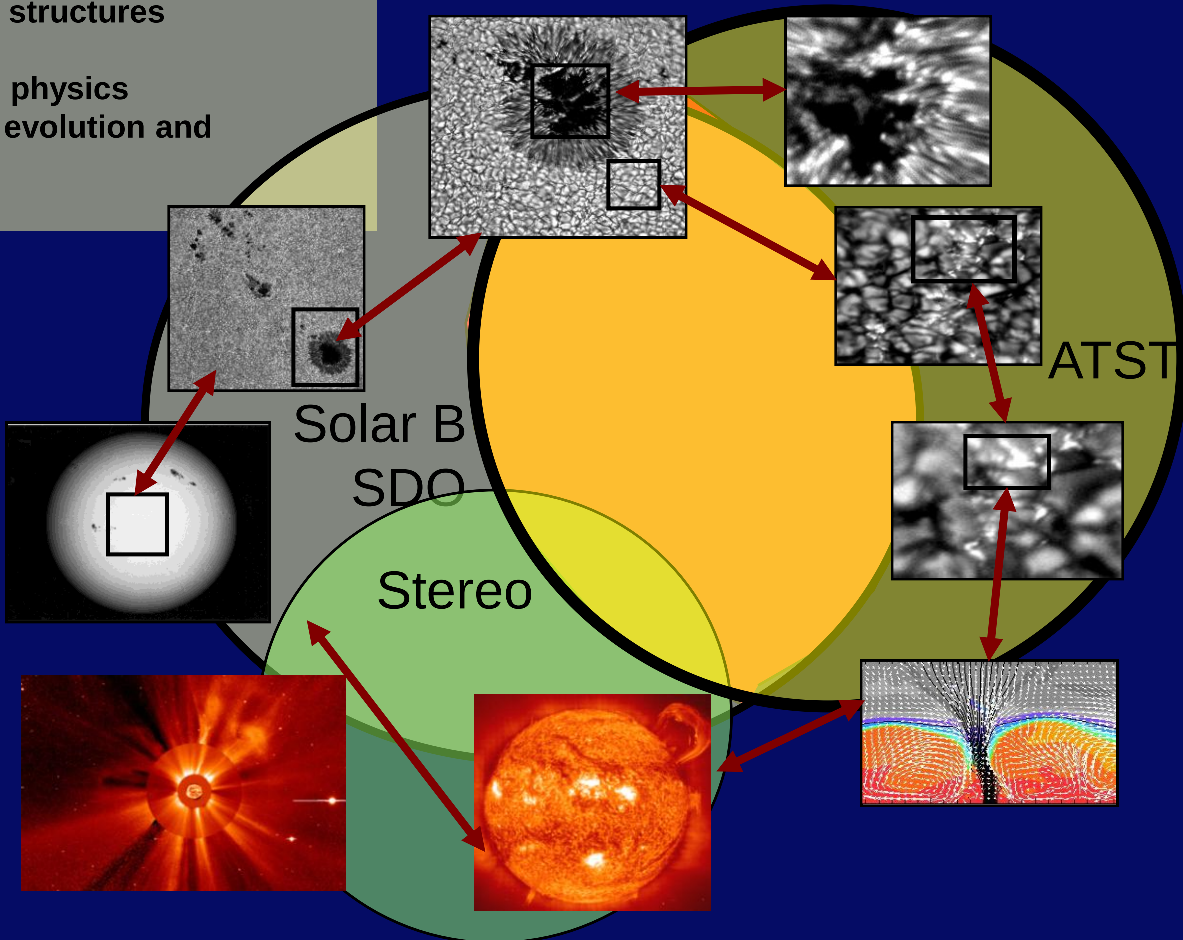


Test Energy Transport and Atmospheric Heating Models
Origins of Flares and CME's
Solar Wind Acceleration
Predictive Space Weather Models, Sun-Earth

Observe solar activity, evolution of magnetic structures, global magnetic field

Observe high-energy coronal and chromospheric structures

-Flare and CME physics
-Magnetic loop evolution and instability



Observe fundamental plasma-field interactions on there smallest scale.

Measure coronal and chromospheric magnetic field strength

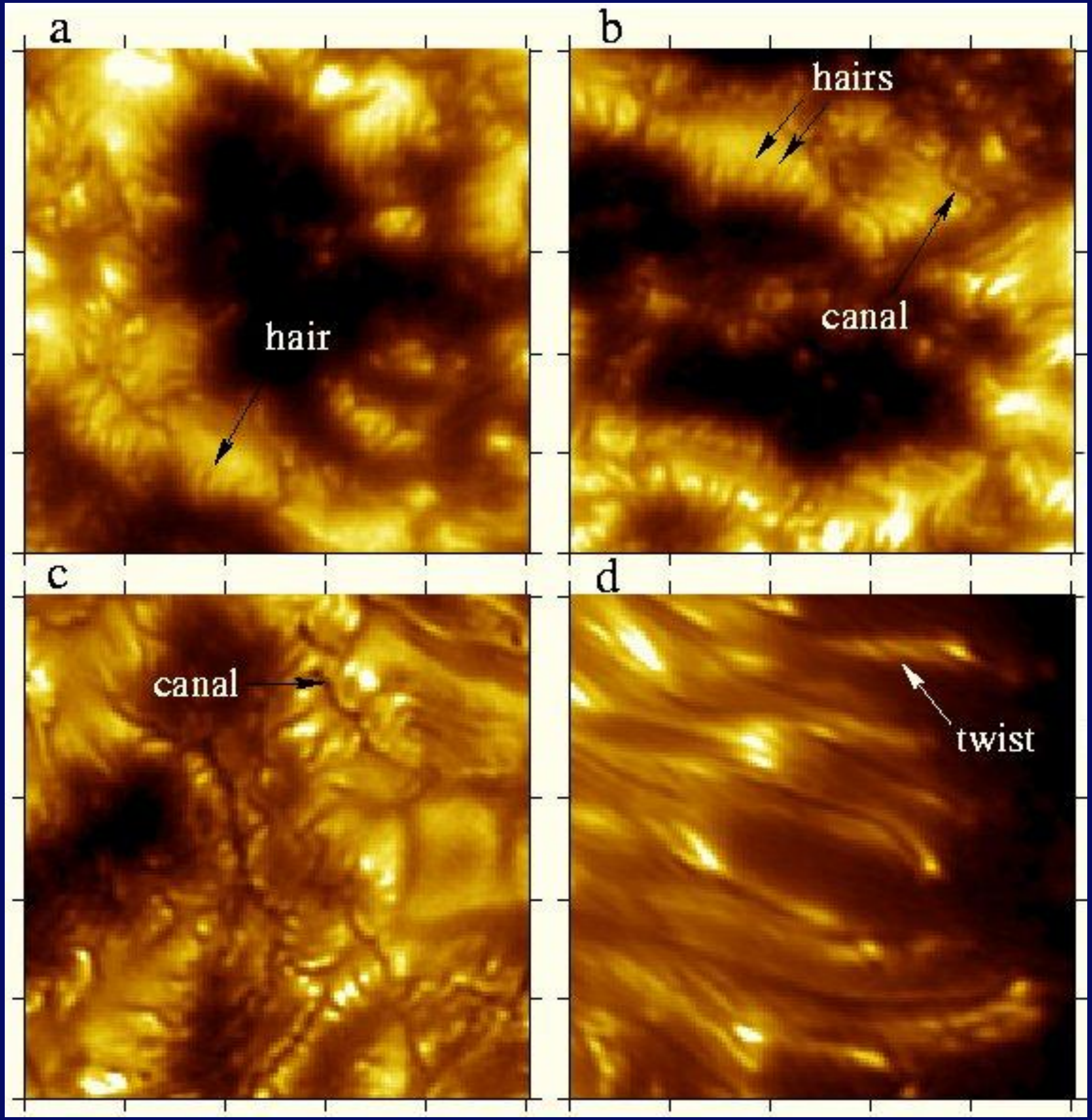
-Magnetoconvection and MHD models
-Origins of Waves and oscillations, atmospheric heating
-Drivers of magnetic instabilities

Observe 3D coronal structure
Propagation into the interplanetary medium

Instrument	Fore-Optics	Dispersing System	Detector System
Visible-Light Broadband Imager	Phase Diversity	Interference Filters	Visible
Visible Spectropolarimeter	Visible Polarization Analyzer	Medium Dispersion Spectrograph	Visible/C3PO
Near-IR disk&coronal Spectropolarimeter	Near-IR Polarization Analyzer	Medium Dispersion Spectrograph (hot and cold)	NIR Hawaii II and/or C3PO
Visible Tunable Filter	Visible Polarization Analyzer	Interference Filters Fabry-Perot	High frame rate visible and/or C3PO
Near-IR Tunable Filter	NIR Polarization Analyzer	Interference Filters Fabry-Perot	NIR Hawaii II and/or C3PO
Thermal-IR Polarimeter&Spectrometer		Medium resolution, cold grating	Thermal IR
Visible/Near-IR High-Dispersion Spectrograph			VIS/NIR
UV Polarimeter – Swiss Contribution			Zimpol

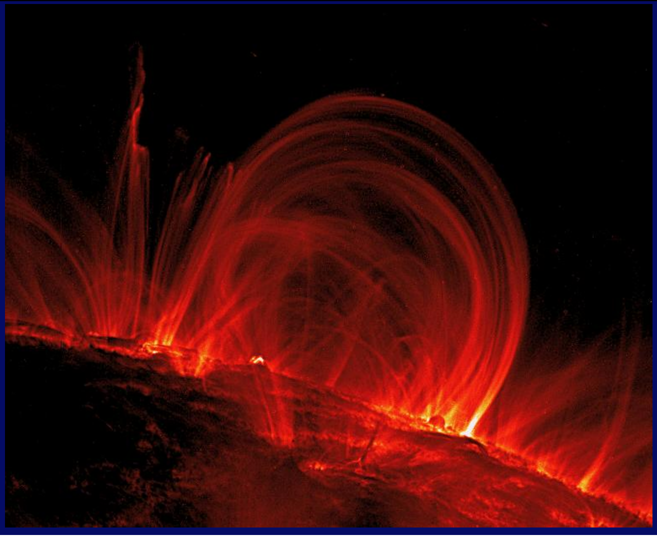
Why ATST
Magnetoconvection

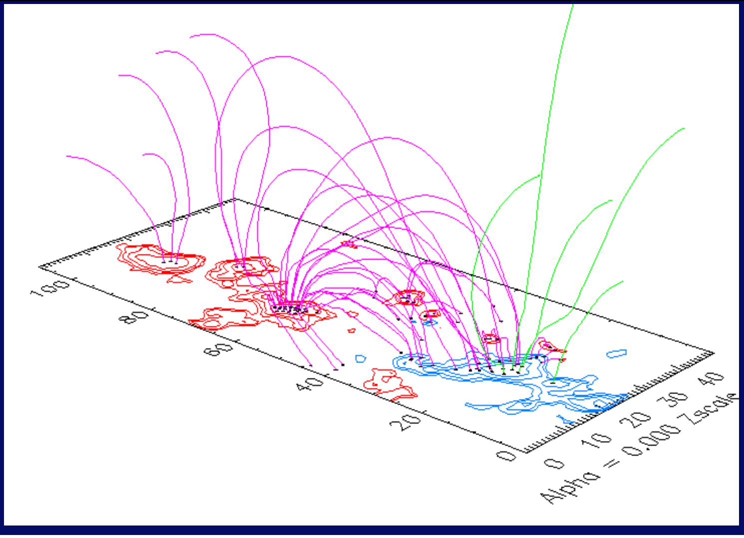
- **New Swedish Solar Telescope**
  - **A moderate increase in aperture size has already led to the discovery of a number of previously unobserved fine structure such as dark penumbral filament cores**



Courtesy of Goran Scharmer

Why an ATST
Coronal & Chromospheric Fields



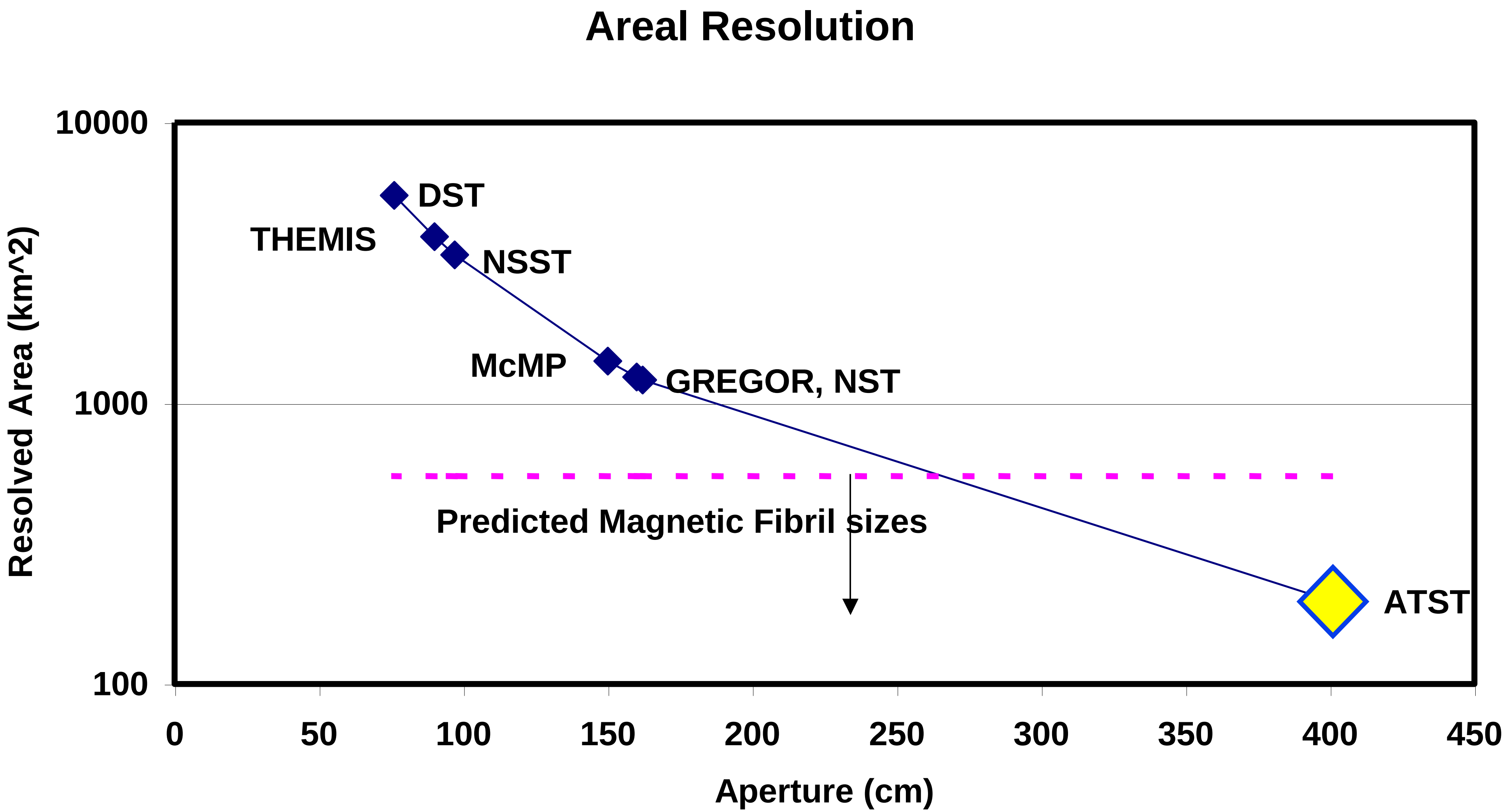


Left: TRACE image of coronal loops (courtesy of A. Title). Right: Field extrapolation from photospheric field measurements (courtesy of Meudon Observatory).

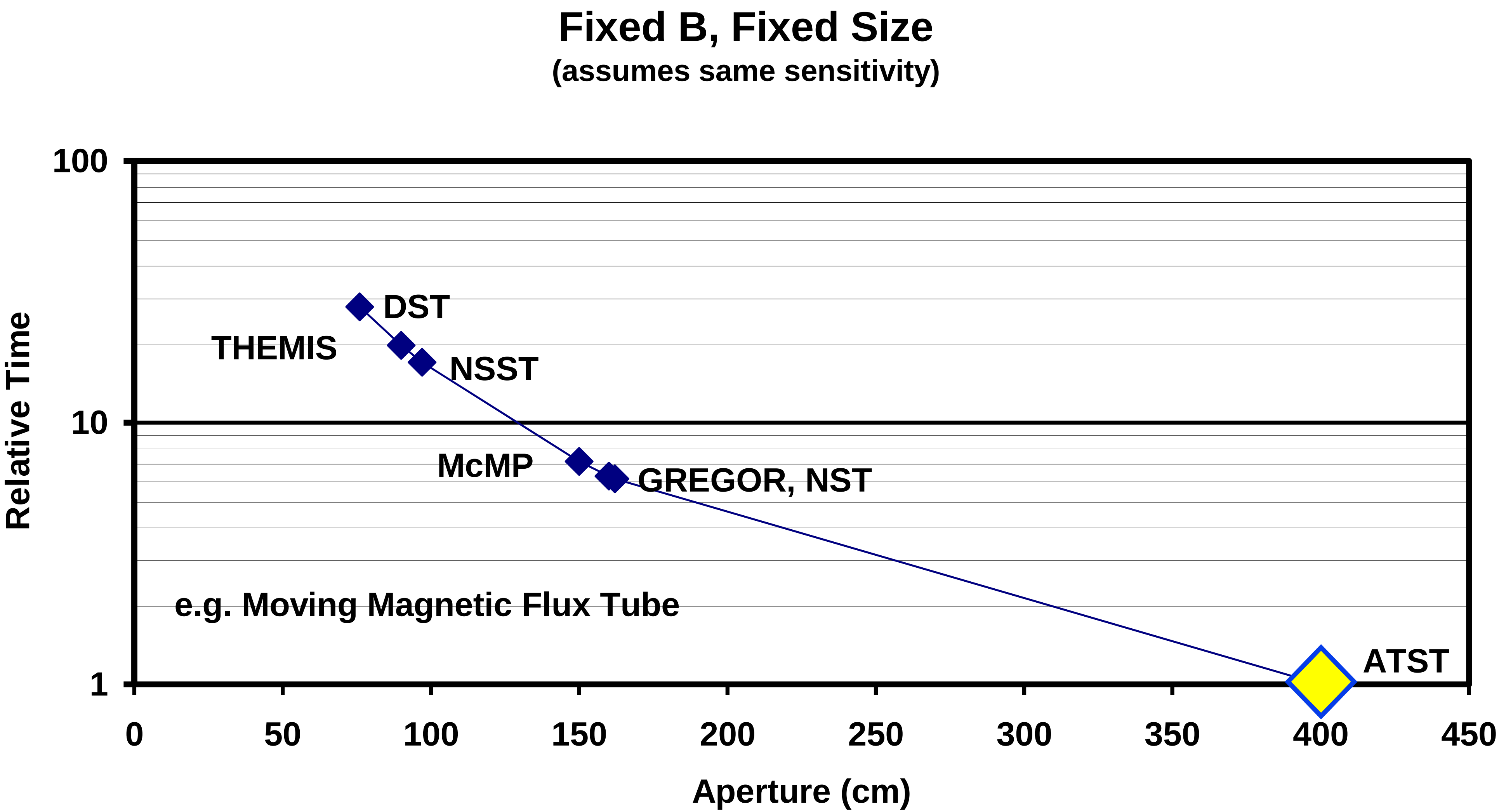
“The most striking aspect of the subject of magnetic fields in the corona is the frequency and variety of situations for which they are postulated, compared to the scarcity of any definite information concerning them.”

- from Donald E. Billings, A Guide to the Solar Corona, 1966.

Comparison with other Telescopes



Comparison with other Telescopes



ATST Science Drivers

Transient eruptions: flares and coronal mass ejections

Origin of solar variability. Dynamo(s)

Heating of chromosphere and corona, origin of solar wind

Surface and atmosphere structure and dynamics

Exploring the unknown

High Spatial, Spectral & Temporal Resolution

High Precision Polarimetry and Spectroscopy

High Photon Flux

Near IR & Thermal Infrared

Scientific Drivers
- understand sources of space weather
- understand origin of interstellar matter
- understand stellar flares

Scientific Drivers
- understand solar input to global change
- understand irradiance variation of solar-like stars

Scientific Drivers
- understand origin and heating of upper stellar atmospheres
- understand accretion disk coronae

Scientific Drivers
- understand basic MHD processes in hot highly ionized plamsa
- understand excitation of stellar p-mode oscillations

Scientific Drivers
- open new windows
- provide best solar telescope in the world

The ATST Will:

- Clearly resolve fundamental astrophysical processes at the spatial scale needed to test models
- Provide a high photon flux for accurate and precise measurements of physical parameters throughout the solar atmosphere
  - High signal to noise spectro-polarimetry of magnetic field on its elemental scale
  - Measure magnetic strength and direction, temperature and velocity, on the short time scales of the dynamic solar atmosphere
- Directly measure coronal and chromospheric magnetic fields
- Observationally test models of:
  - Magneto-convection
  - Flux emergence and annihilation
  - Flux transport
  - Flux tube formation and evolution
  - Sunspot magnetic fields and flows
  - Atmospheric heating
  - Solar Activity
- Enable, complement and enhance planned space missions

Telescope Requirements

- **Aperture: 4 m**
- **Resolution:** diffraction limited:
  - within isoplanatic patch (conventional AO)
  - over ~2 arcmin using MCAO (upgrade)
- **Adaptive Optics:** Strehl ratio: >0.3 , goal of S > 0.6 during good seeing
- **FOV:** 3 arcmin (goal 5 arcmin)
- **Wavelength Coverage:** 300 nm - 28 micron

Unprecedented Spatial Resolution with 4m Aperture

Wavelength	Angular Resolution (1.22 λ/D)	Linear Resolution (km)
0.5 μ	0.”03	23
1.6 μ	0.”1	75
4.8 μ	0.”3	225
12 μ	0.”75	560

Q: Do we **ALWAYS** want to work at the diffraction limit?

A: NO!!

Trade-offs between: spatial, temporal spectral, resolution, S/N.

Need
Photons, Photons and more photons

Diffraction limited observations: We are quickly running out of photons!!

Example:

- Weak field 100G,
- spatially resolved, 0.”1 pixel , Moderate Spectral Resolution: R=300000
- Need S/N ~ 2000 to measure B+/-25G, direction+/- 6 deg. (Skumanich et al. 1997)
- feature moves horizontally by 0.5 pix in only 5 sec (sound speed)
- Need 4m aperture to collect enough photons within 5 sec
- Things just get worse in the Chromosphere and Corona!

Flow Down I
Science to Telescope Design

18 use cases lead to specific high-level requirements:

- **Resolution: 0.03 arcsec (25 km) at 500 nm**
  - ⇒ 4-meter aperture working at the diffraction limit
  - ⇒ High-order adaptive optics, MCAO upgrade option
  - ⇒ Minimal self-induced seeing
- **Photon flux: Integration times as short as 1 msec at spectral resolution as high as 1-2 picometers**
  - ⇒ 12 m^2 collecting area (4-meter aperture)
- **Wavelength coverage: 300 nm to 28 μm**
  - ⇒ All-reflecting optics, no windows, no evacuated column
- **Scattered light and coronagraphy: 2.5×10^{-5} of on-disk irradiance 1.1 solar radii (1.6 arcmin) above the limb**
  - ⇒ Off-axis optical design
  - ⇒ Prime-focus occulting
  - ⇒ In-situ mirror cleaning and washing
  - ⇒ Filtered air

Flow Down II
Science to Telescope Design

- **Field of view: 3 arcmin unvignetted**
  - ⇒ Gregorian optical configuration allowing heat-rejection opportunity at prime focus
- **Polarimetry: Sensitivity of 5×10^{-5} I_0**
  - ⇒ Facility-level signal modulation and analysis
  - ⇒ Specialized facility-level charge-caching detector packages
- **Operational modes: Highly flexible, multi-instrument configurations are required**
  - ⇒ Large coudé observing area
  - ⇒ High level of instrumental commonality
  - ⇒ Innovative instrument-control software
- **Lifetime: 30 to 40-year life expectancy**
  - ⇒ Flexible design with upgrade paths

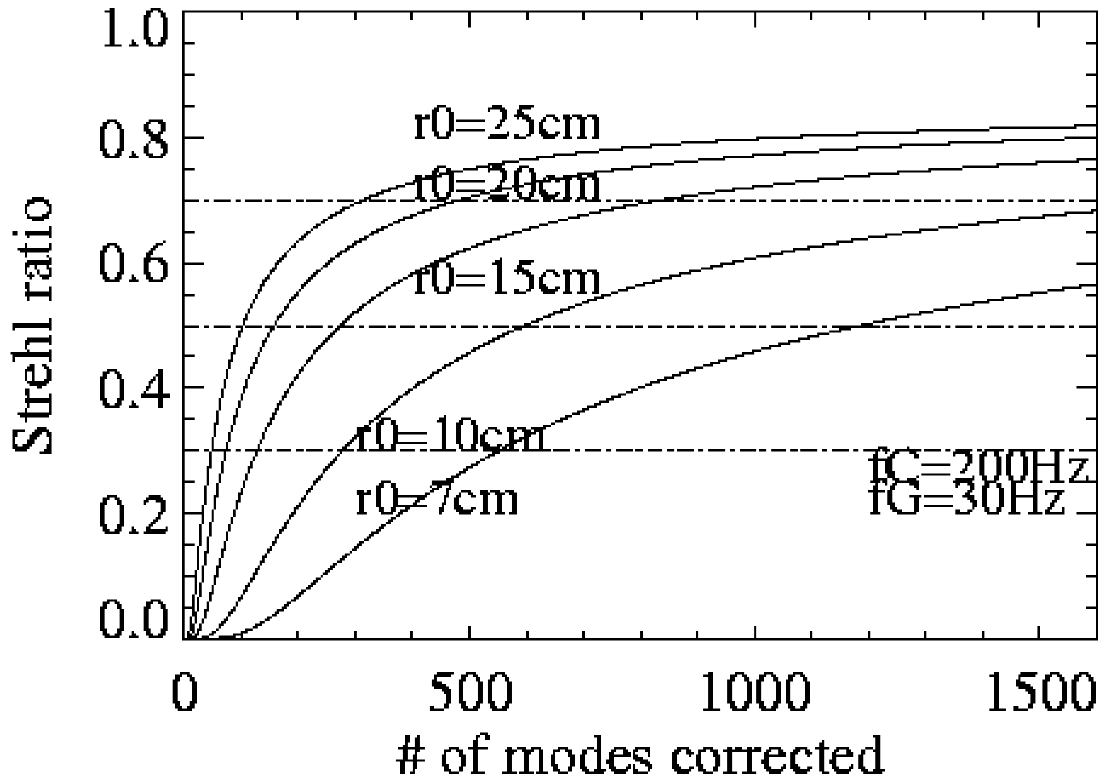
Telescope Requirements

- **Aperture:** 4 m
- **Resolution:** diffraction limited:
  - within isoplanatic patch (conventional AO)
  - over ~2 arcmin using MCAO (upgrade)
- **Adaptive Optics:** Strehl ratio: >0.3 , goal of S > 0.6 during good seeing
- **FOV:** 3 arcmin (goal 5 arcmin)
- **Wavelength Coverage:** 300 nm - 28 micron
- **Polarization Accuracy:** 10^{-4} (low instrumental polarization)
- **Polarization Sensitivity:** limited by photon statistics down to 10^{-5}
- **Low Scattered Light:** e.g. sunspots: 1% of surrounding photosphere
  Corona: $< 10^{-5}$ at $R = 1.1R_\odot$; $\lambda = 1\mu$
- **Coronagraph:** in the NIR and IR
- **Flexibility:** e.g., Combine various post-focus instruments
- **Adaptability:** e.g., try out new ideas, bring your own instrument

Adaptive Optics for the ATST

Visible (500nm)

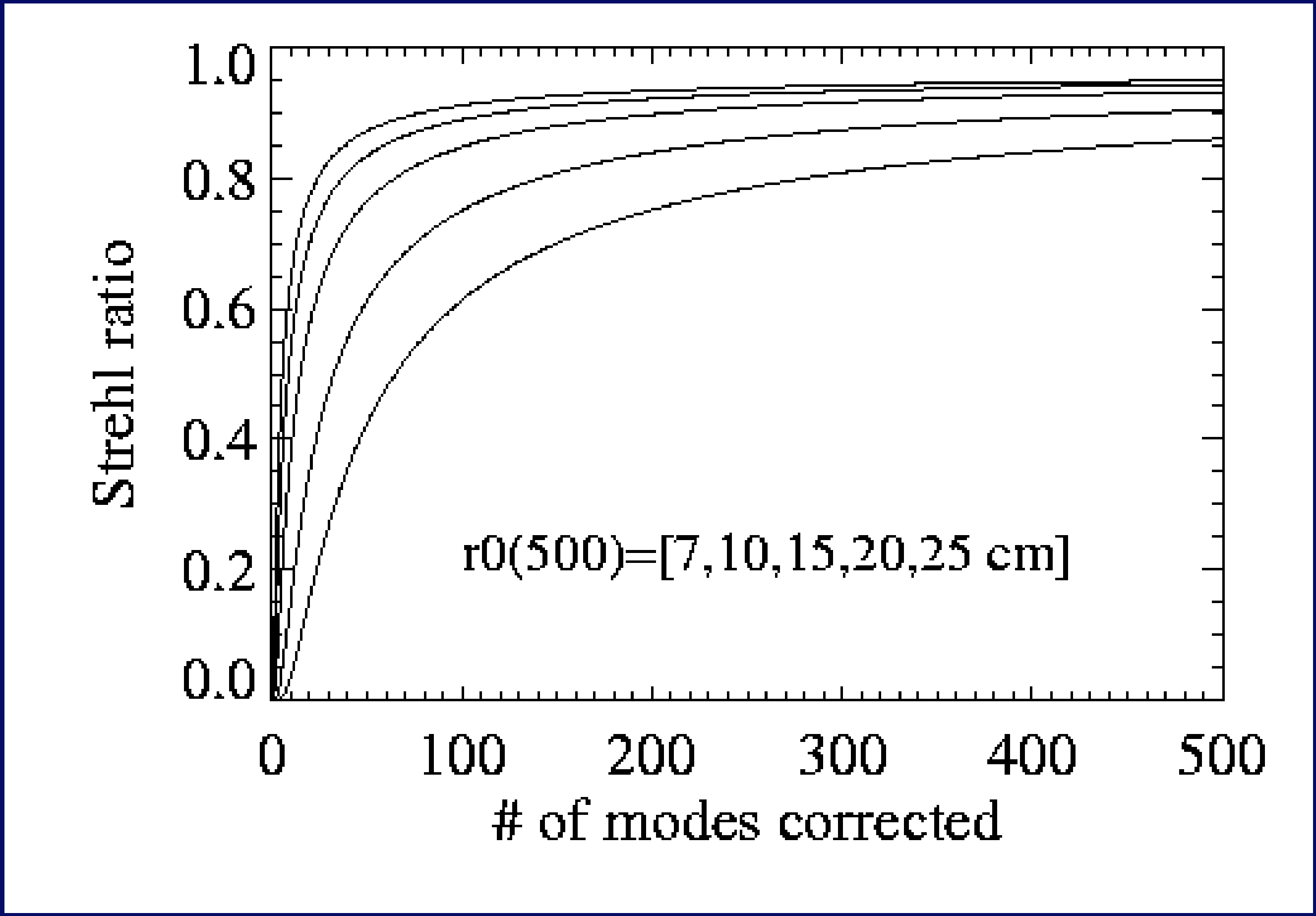
High Strehl Requirement leads to large number of DoFs



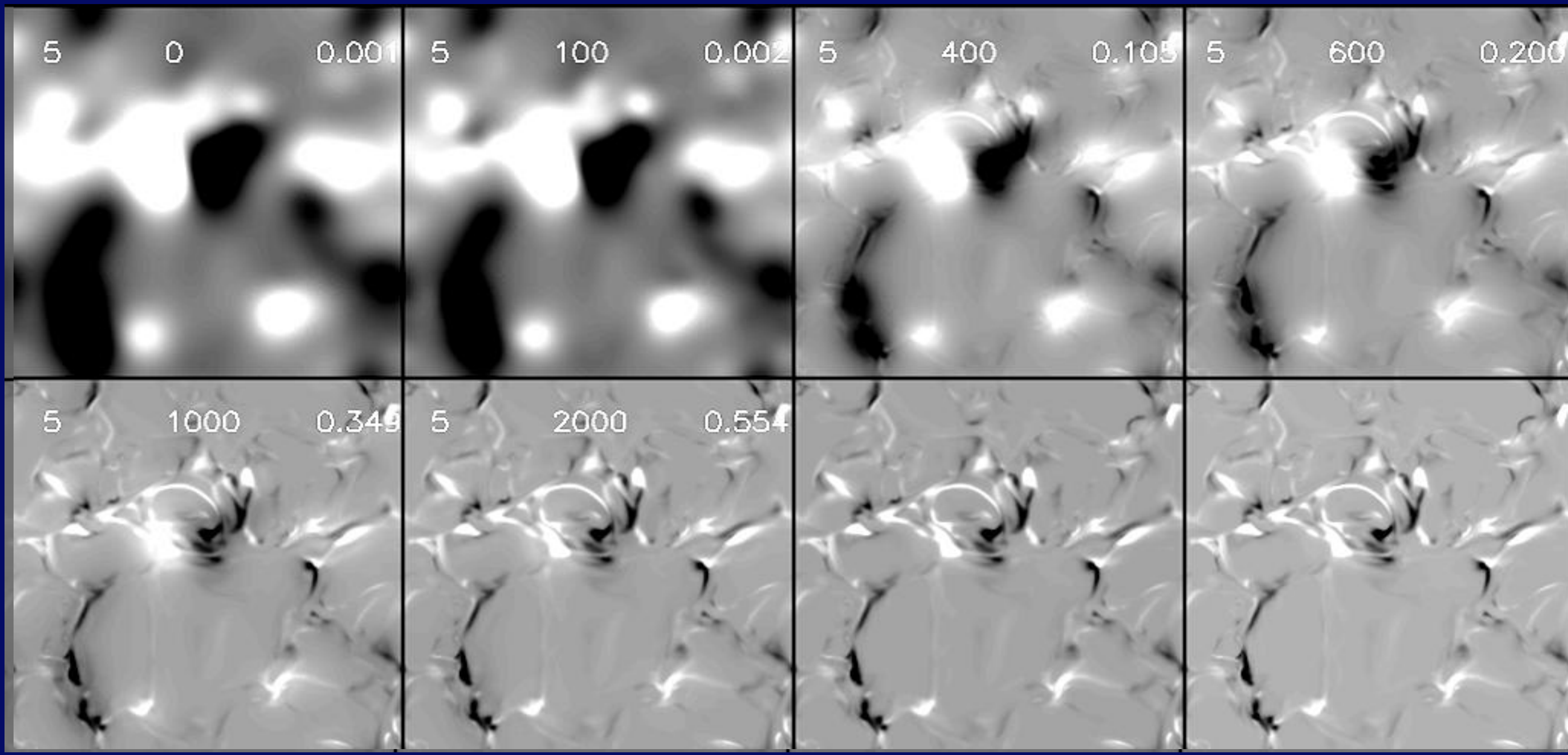
Adaptive Optics for the ATST

NIR (1.6 μ)

High Strehls are fairly easy to achieve!



Model data: Stein, Nordlund & Keller



ATST median seeing

ATST good seeing

4m in space

Input data

Space Missions with High Resolution Polarimetry Capabilities

	resolution	wavelength	Time resolution for 160" scan
Solar-B	0."26 (630nm)	630.2 nm	80 min
SDO	1" – full disk	Limited to 1 wavelength Filter based polarimeter	5 min
ATST	0."03 (630nm)	300 nm – 12 micron	few min @ 0."2 resolution