
Funding for Adaptive Optics in the US: a key element of any "System"

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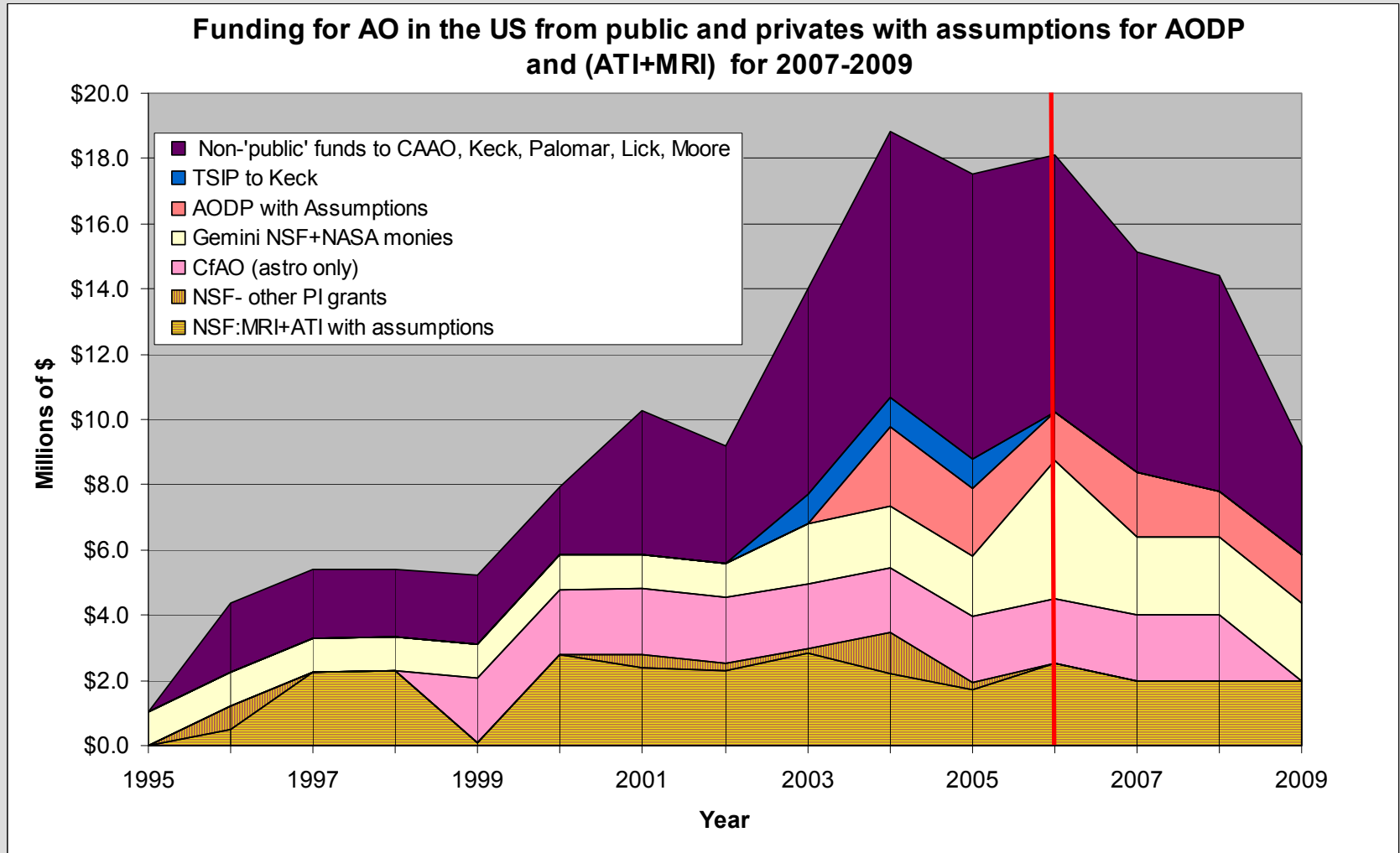
Decadal Survey Reports

- Bahcall Report (1990s)
 - “*The highest priority [moderate program for ground based astronomy] is to apply technologies collectively called adaptive optics.*”
 - The recommendation is to spend \$35M over next decade on AO.
- McKee-Taylor Report (2000):
 - *“The large size of GSMT means that substantial advances in ...adaptive optics will be required.”*
 - *“...the AO effort associated with the development of GSMT should be funded at \$5M per year for the next 10 years.”*
 - **AODP** established as a result of the recommendation above with initial emphasis on **AO R&D** for a GSMT, not instruments.
 - **TSIP** should bring **AO instruments** to private observatories to make this technique available to **all astronomers** on the largest telescopes.

AO funding in the US - Summary

- Next slide: a summary of the history of funding of AO in the US for R&D and instrumentation only. No science projects are included. Note the following:
 - Essentially all “public” funds come directly or indirectly from NSF.
 - AODP money *assumes* \$1.5M in new funds yearly for 2007-2009
 - NSF MRI+ATI monies *assume* steady level of funding to 2009
 - Gemini money is leveraged by factor of 2 because of funds from other partners
 - In several cases I have used an average over time rather than actual yearly expenditures.
 - “Non-public” estimate is a lower limit as it only includes funds to Keck, Palomar, Lick, LAO, TMT, and CAAO.

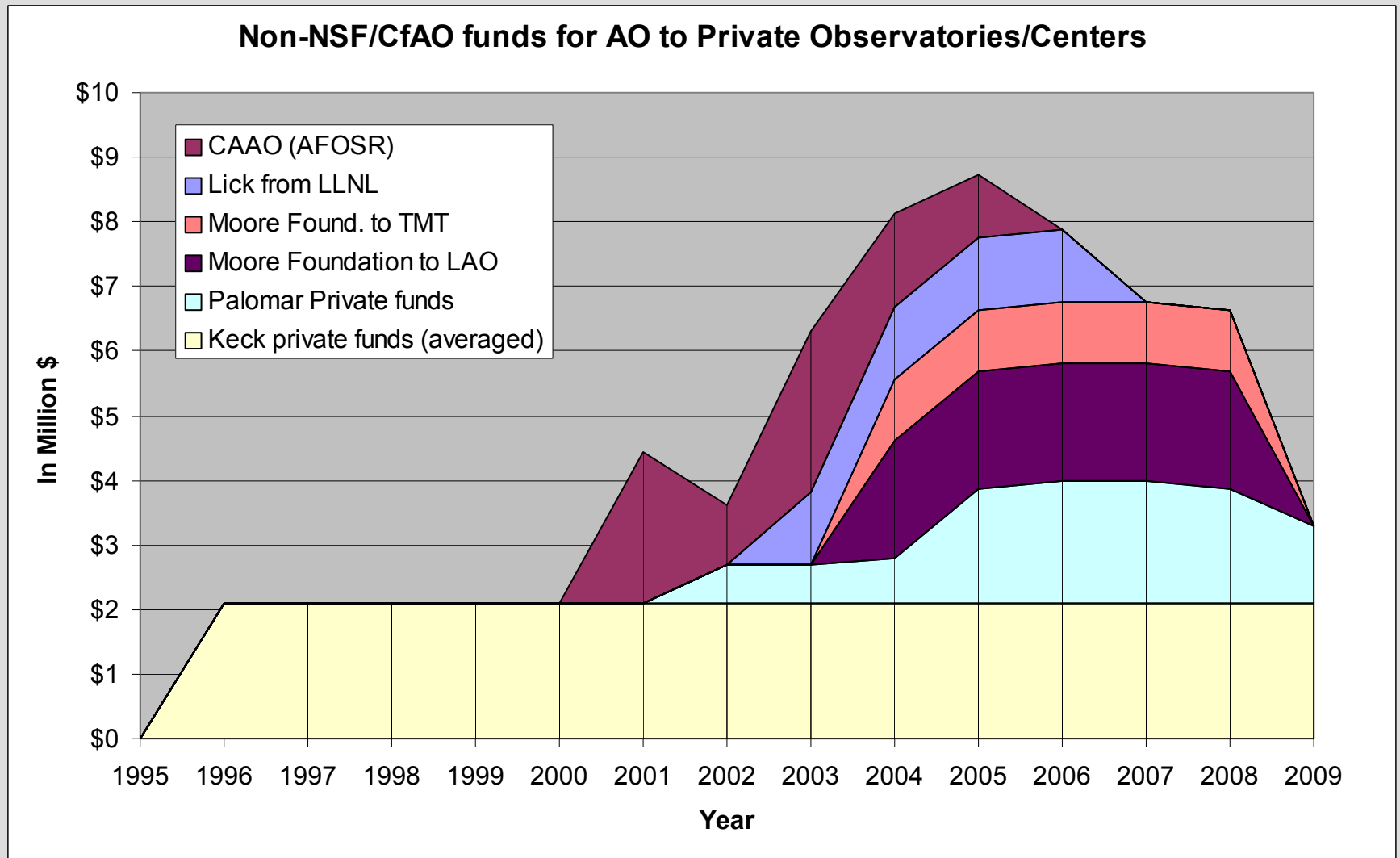
Best estimate of All AO funding in the US



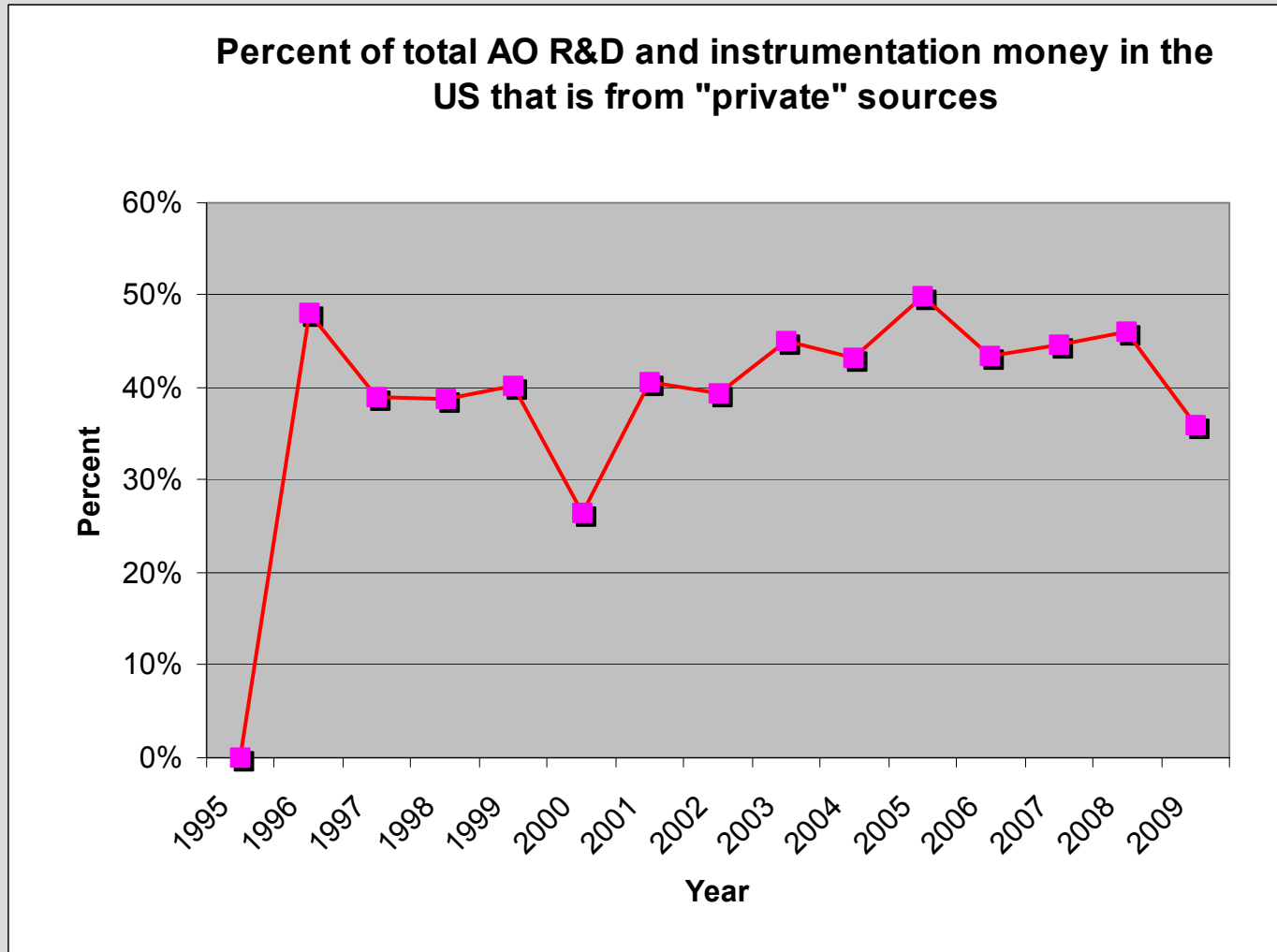
Non-NSF funds to Private Observatories

- The next slide shows *non-public* funds to the private observatories and centers for which I have data
- These funding sources by and large are unavailable to the general community, for example
 - Univ. Calif operating funds
 - Keck Foundation
 - Caltech operating funds and gifts
 - AFOSR
 - LLNL
 - Moore Foundation
- Public funding (i.e. NSF) to privates for AO is also substantial

Non-NSF monies to the "Privates"



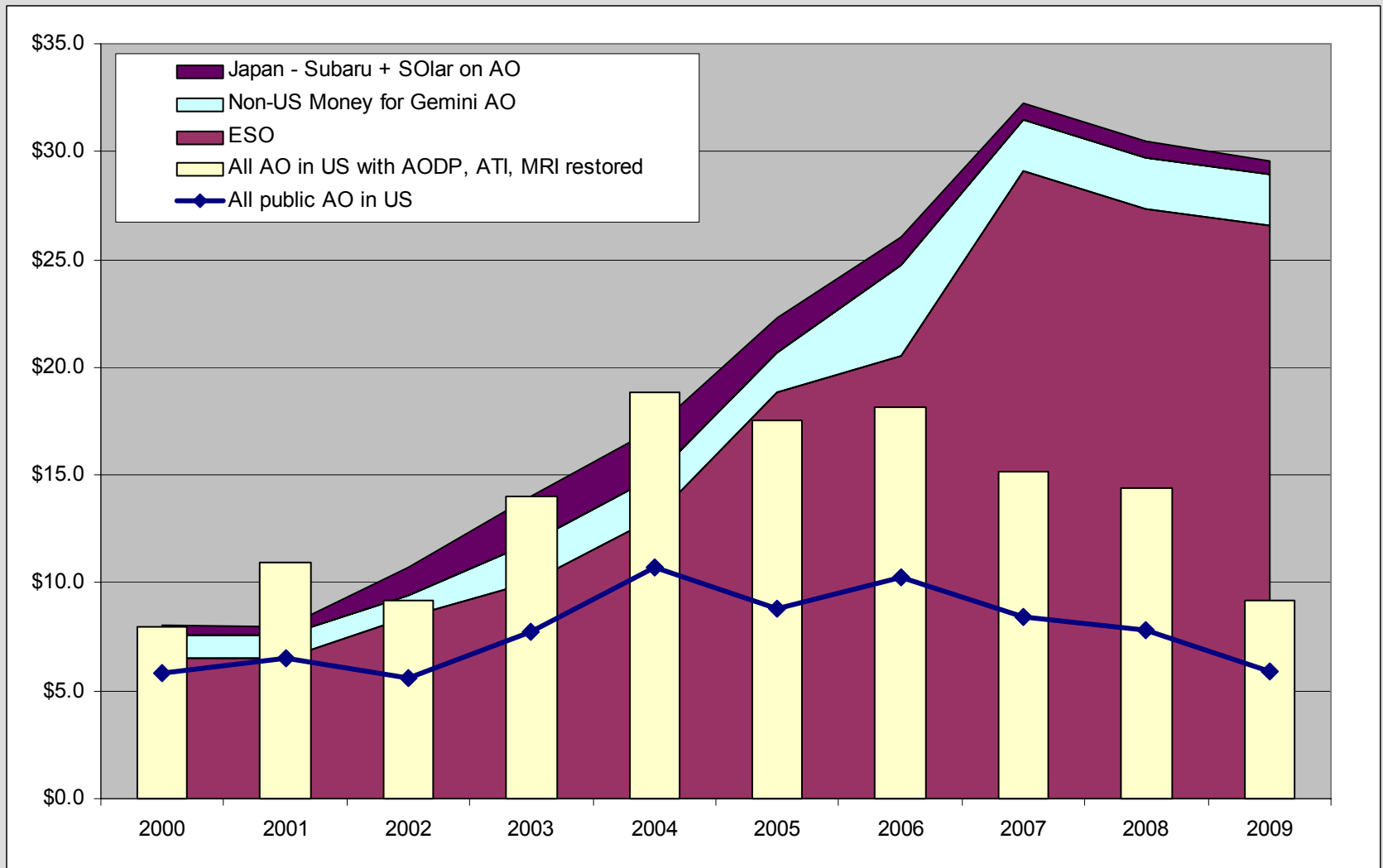
Private Funding Accounts for ~40% of all AO Funding:



NSF AO Funding for R&D (not instruments) Compared with Recommendations - Overview

- The Hope:
 - Bahcall Report: Spend \$35M on AO in the 1990s - \$3.5M/yr
 - McKee-Taylor Report: Spend \$5M/yr on AO R&D related to GSMT during 2000s.
- The Reality:
 - AO R&D public average 2004-2006: \$3.05M/yr; for 2000-2003 \$1.25M/yr.

ESO *et al.* vs. All US expenditures on AO



Addition Information

NSF AO Funding for R&D Compared with Recommendations - Details

- The Recommendations:
 - Bahcall Report: Spend \$35M on AO in the 1990s - **\$3.5M/yr**
 - McKee-Taylor Report: Spend **\$5M/yr on AO R&D** related to GSMT during 2000s.
- Reality – Public spending for AO R&D:
 - NSF PI grants for “non-science” AO:
 - \$24.9M for 1995-2006
 - \$5.4M of this for **R&D (\$0.45M/yr)**
 - \$19.5M of this for instruments to go on telescopes (\$1.6M/yr)
 - AODP - \$10.9M (2004-2009) – average of **\$1.8M/yr for R&D**
 - CfAO - \$2M/yr for astronomy themes (1999-2008) – ~41% of this is for AO R&D based on years 6 and 7 of CfAO budget, so **R&D, ~\$0.8M/yr.**
 - NSF/Gemini AO expenditures are almost all for instruments
 - AO R&D public average 2004-2006: \$3.05M/yr; for 2000-2003 \$1.25M/yr.

AO Efforts in Other Countries

- France and Canada primary support for AO at CFHT (AO Bonnette project, AOB)
- Swedish 1-m Solar Telescope (NSST) on La Palma, Spain
- Italy and Germany efforts support LBT
- UK/NL – on the WHT: move OASIS from CFHT to La Palma; LGS/GLAS facility
- Spain/Germany – LGS AO system on 3.5-m Calar Alto
- German Solar Telescopes (Tenerife, Spain):
 - On VTT: AO (KAOS), MCAO (MultiCAOS)
 - Gregor: AO and (planned) MCAO
- Probably more
- **ESO** – see next slide and my GeminiFocus article

What ESO is doing for AO

- Currently available for AO:
 - NAOS: Nasmyth AO System
 - AO for all apps in the 1-5 micron range on UT4; NGS now, LGS at end of 2006
 - Visible and IR wavefront sensors with CONICA, near IR imager and spectrograph
 - MACAO (now): Multi-Application Curvature AO for VLTI
 - At the Coude focus of all 4 UTs; NGS
 - SINFONI: Spectrograph for Integral Field Observations in the Near-IR
 - Attached AO module uses NGS or LGS
 - MAD: Multi-Conjugate AO Demonstrator
 - Nasmyth focus; part of OWL planning
- In the works for AO:
 - HAWK-I (2007): High Acuity Wide field K-band Imager
 - Near IR wide field imager for use with Adaptive Secondary
 - 4 x LGS facility (2010)
 - Planet Finder (2010?): ExAO system
 - FALCON (concept study - 2010): MOAO IFU system
 - Adaptive Secondary (2012): 1170 actuators
 - MUSE (2012): Multi Unit Spectroscopic Explorer (24 IFUs)
 - Panoramic integral field spectrograph in the visible
 - GLAO, 4 x LGS, Adaptive Secondary
- And several major non-AO instruments (KMOS, XShooter)