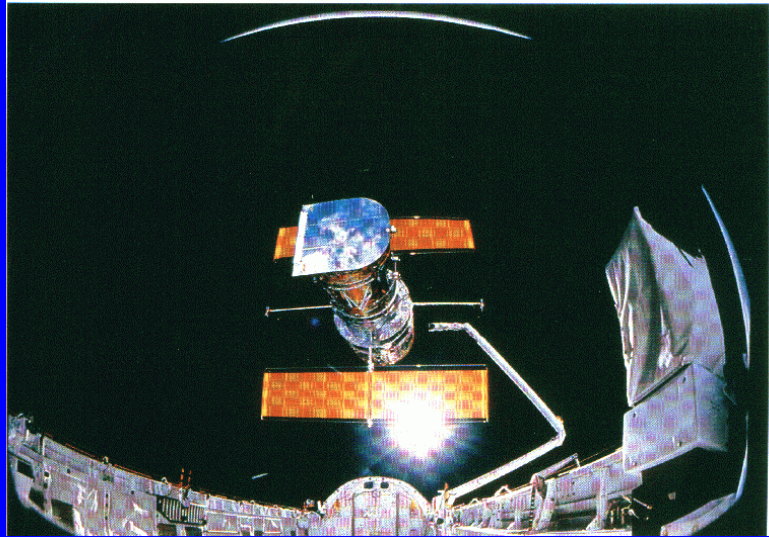


# HST++ Summary



Jeremy Mould

National Optical Astronomy Observatory

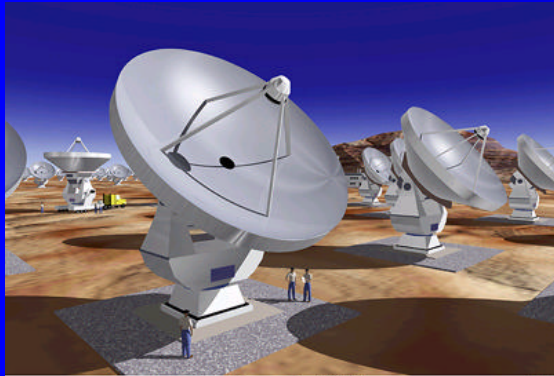
# What is the discovery space for HST++ ?

- UV 2.5 mag beyond COS
- Optical 2.5 mag beyond ACS
- Resolution a few mas
- Field larger than ACS (>1 Gpx)

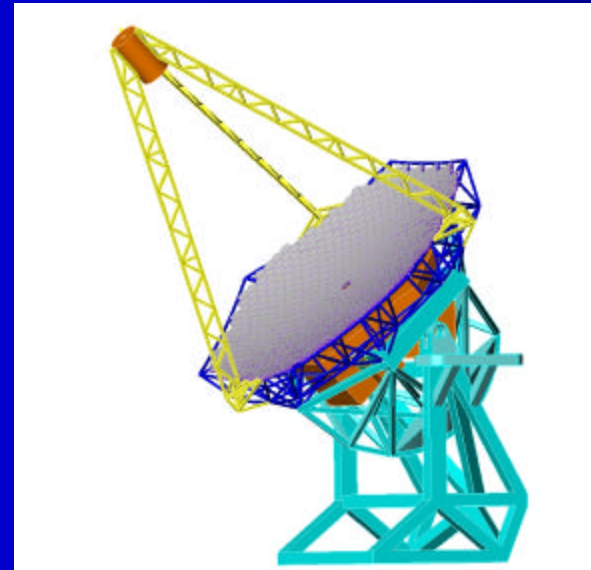
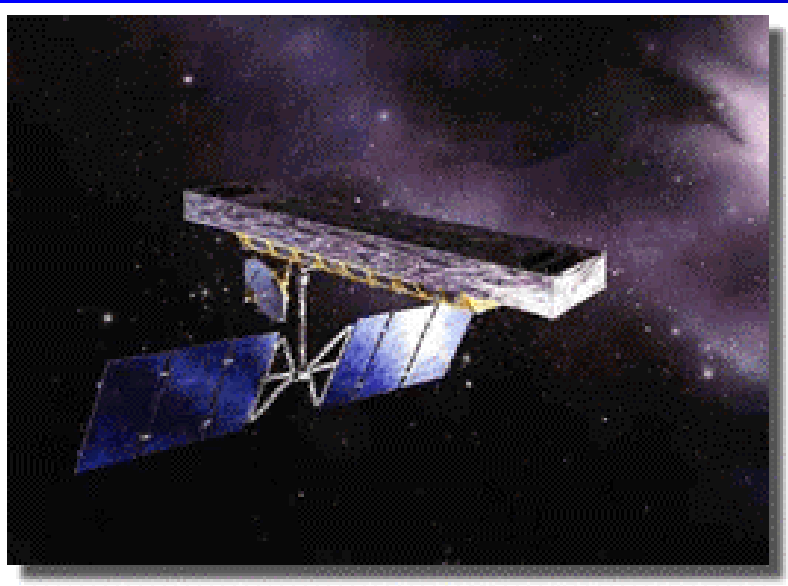
8 meter

*Instrumental gains beyond this  
if science drivers are  
identified*

# HST++ will complement ALMA, NGST, GSMT and SIM



Artist's Impression of ALMA  
(Atacama Large Millimetre Array) © European Southern Observatory



10  
mas  
at  
 $1.6\mu$

# SUVO

- Evolution of IGM

- equation of state of baryon
- survey hot gas
- measure its large scale structure
- how do galaxies interact with this environment ?
- chemical evolution: light elements and heavies

FUSE, COS  
Legacy

Hubble Legacy

*watch for*

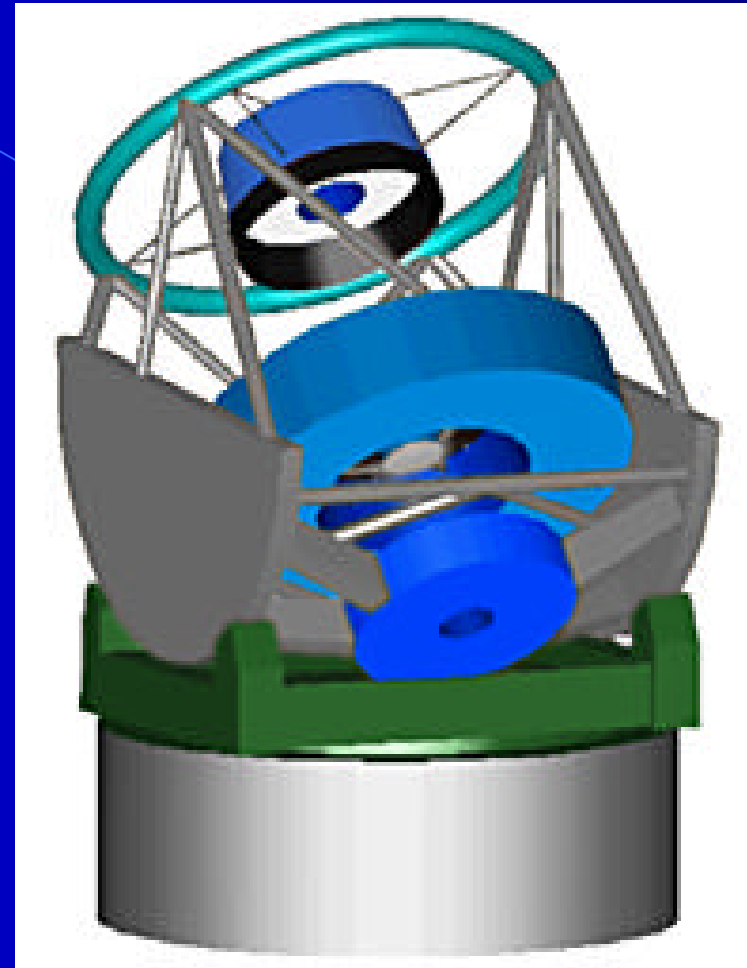
*LSST*

- Weak lensing

- Supernova cosmology

# LSST, a digital survey of the sky each week

- Weak lensing mass map of the Universe
- 100,000 supernovae per year  $z \in (1,2)$
- Earth crossing asteroids
- 10,000 primordial trans-Neptunian objects



*View of the LSST telescope structure in the Steward Observatory straw man design. The primary mirror is at the center, and the secondary and tertiary are almost equidistant from the primary. The detectors are just ahead of the central hole in the primary (see: <http://dmtelescope.org/design.html>).*

# IGM “killer apps” for HST++

UV

HRS

- Large scale structure of IGM @  $z < 1.65$ 
  - evolution of Ly  $\alpha$  forest and its large scale structure
  - many QSOs => many sight lines
  - damped Ly  $\alpha$  systems = baryon reservoir for all  $z$
  - chemical evolution of IGM to present day
  - relate structure to galaxies  
(*groundbased zs*)

# Stellar pops “killer apps” for HST++

- Galaxy formation

- unfilled dark halos
- first generation of stars & below a Gpc
- forming stellar halos by accretion

Don't descope  
this WF camera

- $H_0$  : Cepheids in Coma + SNIa  
zeropoint

- $\delta H/H \sim 2\%$  with SIM recalibration
- with Planck, constrain the dark energy  
“equation of state of the Universe”  $\delta w$   
 $\sim 0.01$

w is also  
an LSST  
goal

# Global parameters: the Hubble Constant

Is  $H_0 > 60$   
km/sec/Mpc ?

## *A Wager*

*John Tonry and Brian Schmidt bet Joe Silk that the Hubble constant is greater than or equal to 60 km/s/Mpc. This is the global expansion rate of the Universe in terms of the aforementioned units, free from any local anomalies in the expansion rate or questions of zero point of distance estimators.*

*This wager shall be conducted under the auspices of an arbitrator, Jim Peebles, and shall be settled by the third millenium, Jan 1, 2001, or sooner if, in the opinion of the arbiter or the contesting parties, the answer is no longer in doubt. If the arbiter decides that the answer cannot be resolved with reasonable certainty by the settlement date, the bet is null and void. The decision of the arbiter is final.*

*The loser of the wager shall present to the winner(s) one case of the Macallan, or equivalent quality, single malt Scotch whisky.*

  
John Tonry

  
Brian Schmidt

  
Joe Silk

*Witnessed this day 2 August 1995*

  
Kenneth Freeman

# Jim Peebles' ruling

RECEIVED

16 JAN 01

M.S.S.S.O.

Princeton University

DEPARTMENT OF PHYSICS: JOSEPH HENRY LABORATORIES  
JADWIN HALL  
POST OFFICE BOX 708  
PRINCETON, NEW JERSEY 08544-0708

January 15, 2001

Professor Jeremy Mould  
Mount Stromlo Observatory

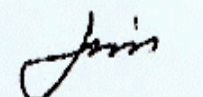
Dear Colleagues

Considering the hazards of astronomical research I don't think the Great Wager can be considered settled until  $H_0$  is five standard deviations away from  $60 \text{ km s}^{-1} \text{ Mpc}^{-1}$ , in the opinion of the more conservative members of our community. It's asking a lot, but we get to compound quite a few constraints in addition to distance scale measurements, including  $H_0 t_0$ , the thermal background radiation, and maybe even evolution ages of high redshift star populations.

I am urging the principals to extend the Great Wager for one decade.

With all best wishes,

Cheers



P. J. E. Peebles

# HST++ complementary to GSMT

- Star formation histories in Virgo  
MS Population I (to  $10^8$  years) with HST++  
AGB  $10^8$  to  $10^{10}$  years with GSMT
- $z = 6$  Universe  
molecular clouds – ALMA  
SFR from  $H\alpha$  – NGST  
kinematics of galaxy formation – GSMT  
starburst Ly  $\alpha$  emission – HST++
- Large scale structure of IGM @  $z < 1.65$

Some HST programs  $\longrightarrow$  GSMT

*e.g.* Evolution of the fundamental plane

van Dokkum et al

- Currently,  $z = .5$  to  $1.5$

Structure from HST

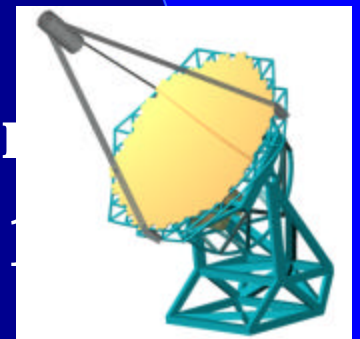
Kinematics from Keck

- Future,  $z = 2$  to  $3.5$

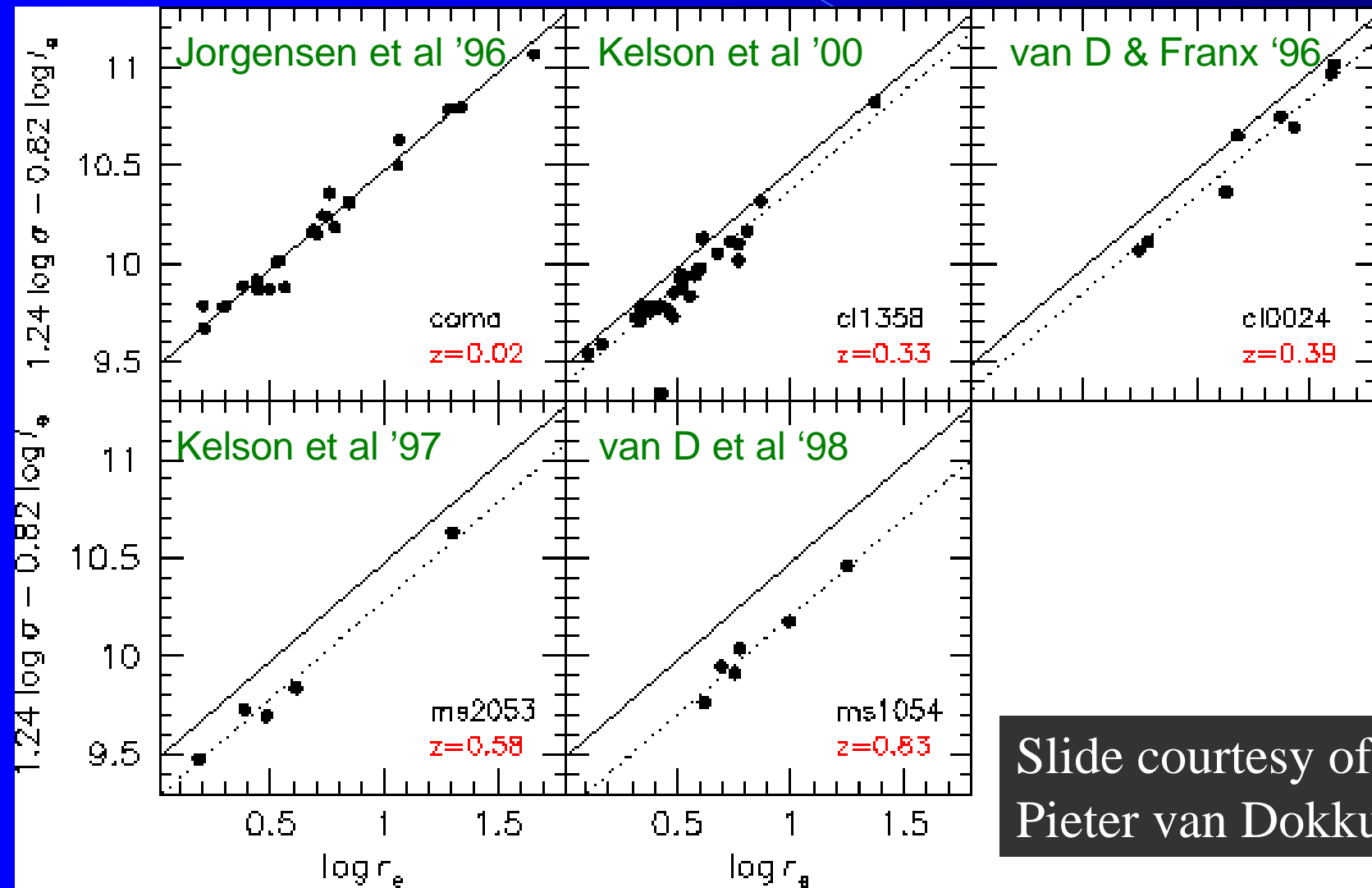
Structure and kinematics from

Mg lines 517 nm redshift to

$2.3\mu$



# The Fundamental Plane at $z > 0$



Slide courtesy of  
Pieter van Dokkum

HST programs → GSMT  
→ HST++

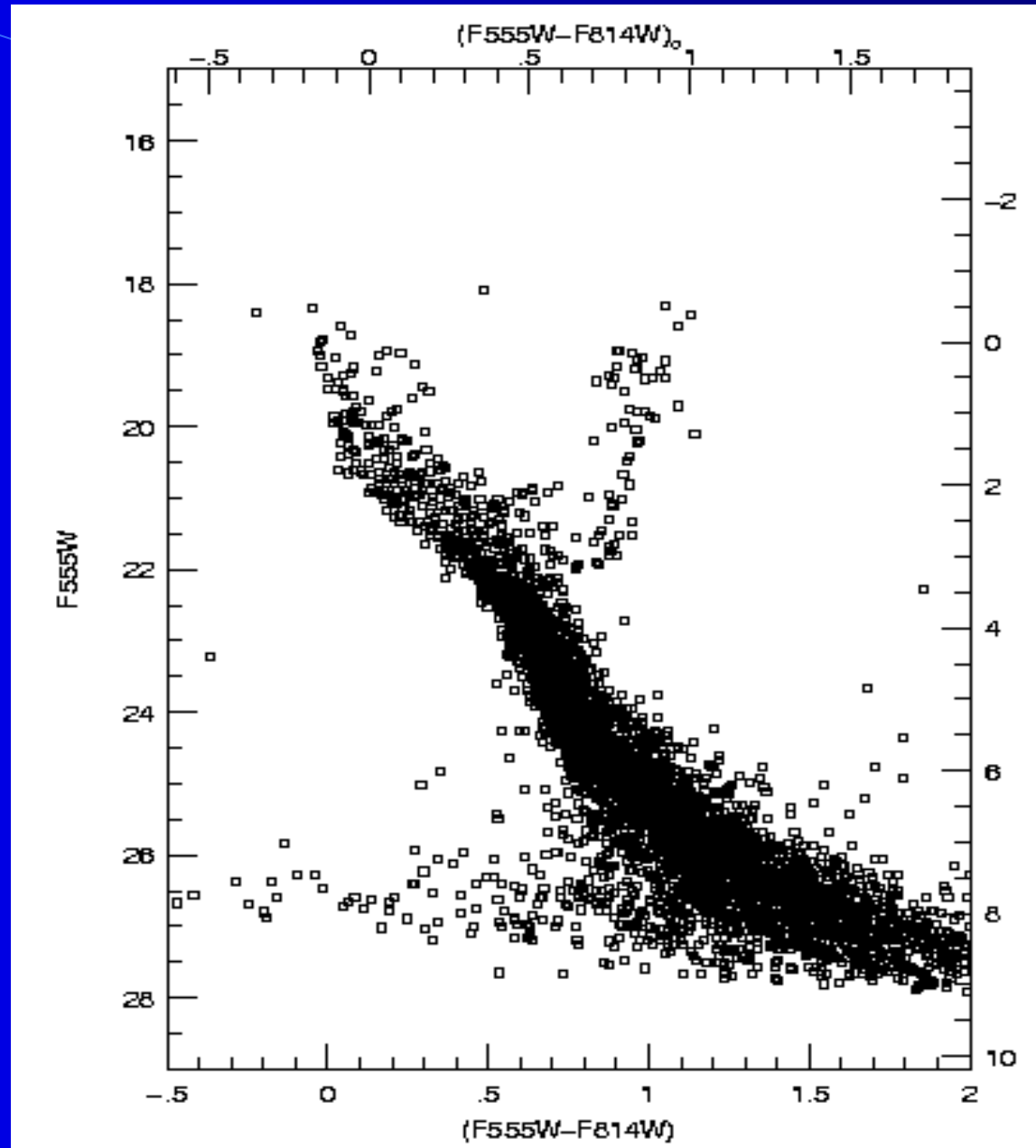
*e.g.* Extending the stellar  
populations laboratory

- Star formation histories of  
M31  
Leo ellipticals

*Projects possibly accessible from the ground  
not included here among killer applications*

# WFPC2 and SFH of LMC

Just count stars  
at base of red  
giant branch =>  
SFR(t)



# Star formation histories with GSMT or HST++

- Basic assumption: IMF is robust
  - verified by HST studies of local dwarfs
  - maybe inapplicable to Pop.III
- In all Local Group galaxies, full Star Formation History is on display
  - CMDs show number of stars formed each Gyr in the Hertzsprung gap
  - just count the stars as they cross !

# Black hole environments

Intermediate  
mass black  
holes in  
globular  
clusters

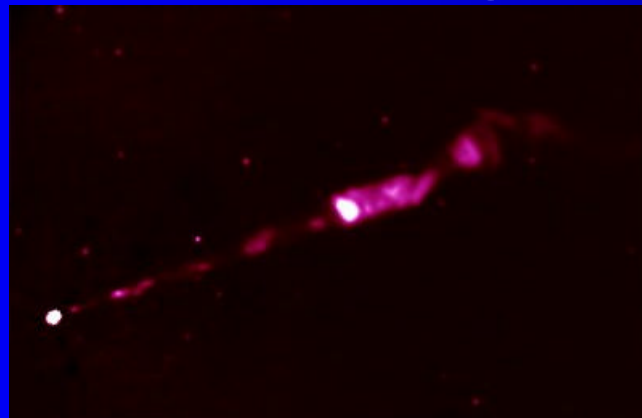
- **HST++** 10 mas 200nm 4  
meter
- **SIM** 10 mas 600nm
- **GSMT** 10 mas 1.6 $\mu$
- **NGST** 300 mas 10 $\mu$
- **ALMA** 10 mas 1mm

M87 jet

10 mas

= 1 pc

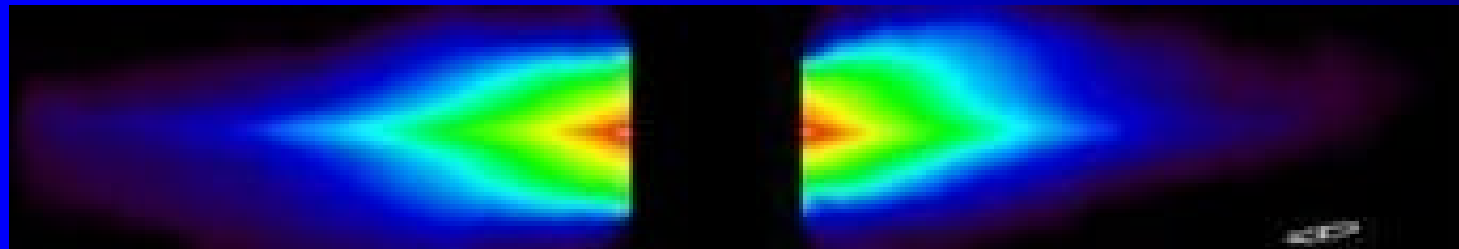
wfpc2



M31 nucleus 10  $\mu$ as  
astrometry will probe  
dynamics [Spergel]

# Resolving stars

- OVI inner disk in CVs
- Surface features of cool stars
- Globular cluster cores
- Star formation.....*summary part II*

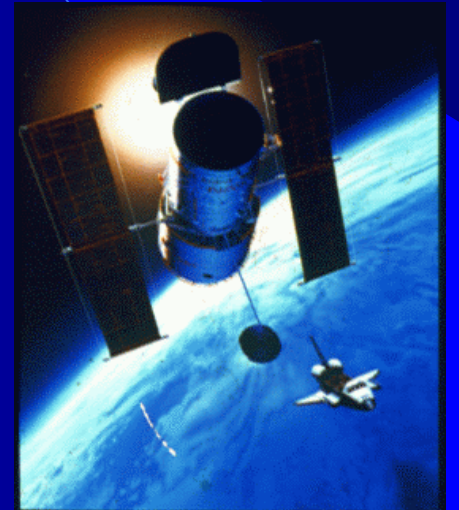


# Non-science notes

- Ground based co-program should be designed at the outset
- National Astronomy and Astrophysics Committee  
NSF/NASA cooperation
- Inter Agency Consultative Group  
NASA/ESA cooperation

# The search for identity

- SUVO
- LOST
- ALOT arbitrarily large
- Guinness
- HST++
- HST II
- NHST followed by NIST,
- TPF



*Ask for ALOT or we may not get*

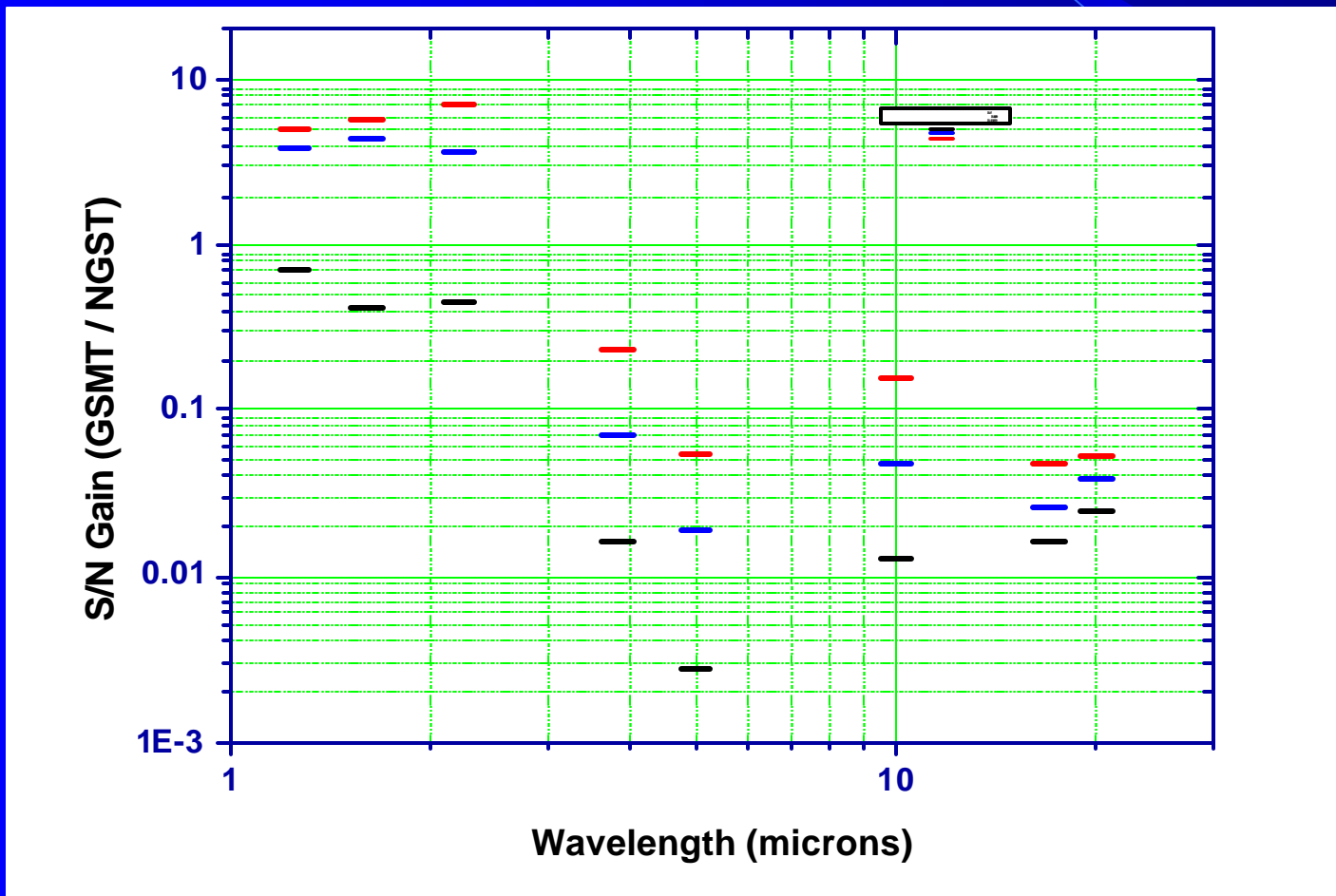
*MICHAEL*

end

# Comparative performance of a 30m GSMT with a 6.5m NGST

Assuming a detected S/N of 10 for NGST on a point source, with  $4 \times 1000s$  integration

- R = 10,000
- R = 1,000
- R = 5



GSMT advantage

NGST advantage

