



An Introduction to the WFMOS Project



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Overview



- The original KAOS concept
- The Gemini “Aspen” Program
- The WFMOS Feasibility Study
- WFMOS and HyperSuprime Cam on Subaru
- Gemini competitive WFMOS Conceptual Design Studies now in progress
- The next steps forward

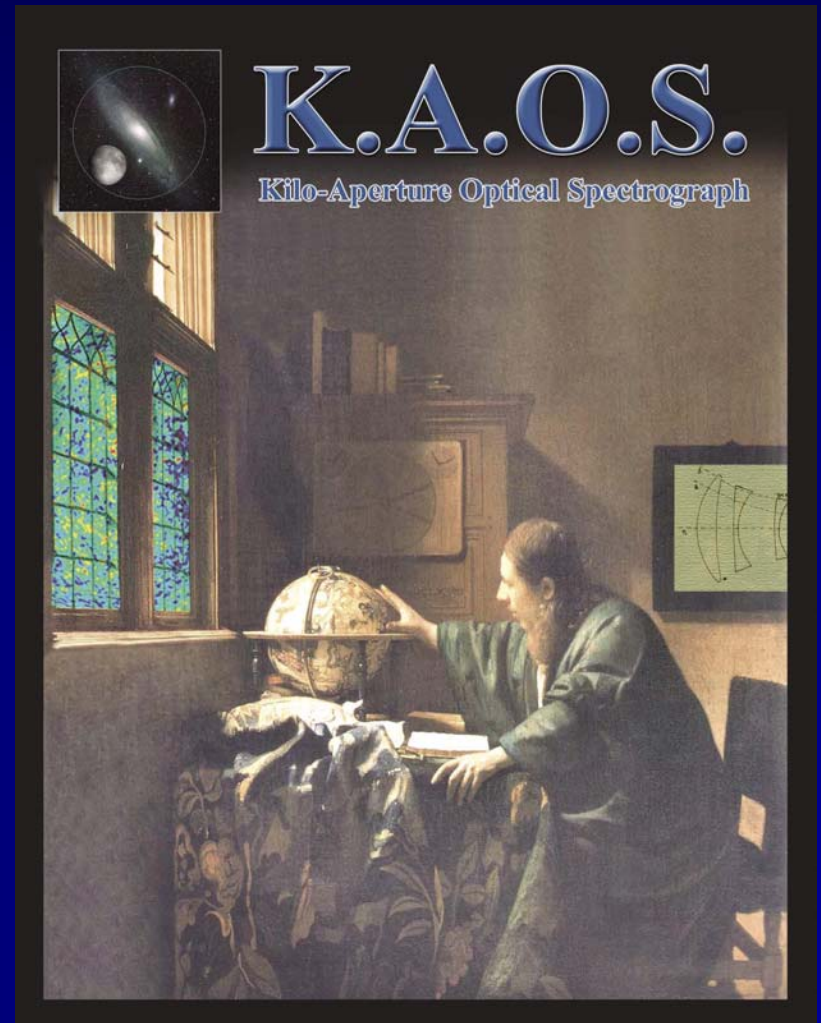


The KAOS Concept



In 2002, a team led by Sam Barden (while at NOAO) developed a proposal for a “Kilo-aperture Optical Spectrograph” (KAOS)

Many of you participated in the writing of the “KAOS Purple Book”



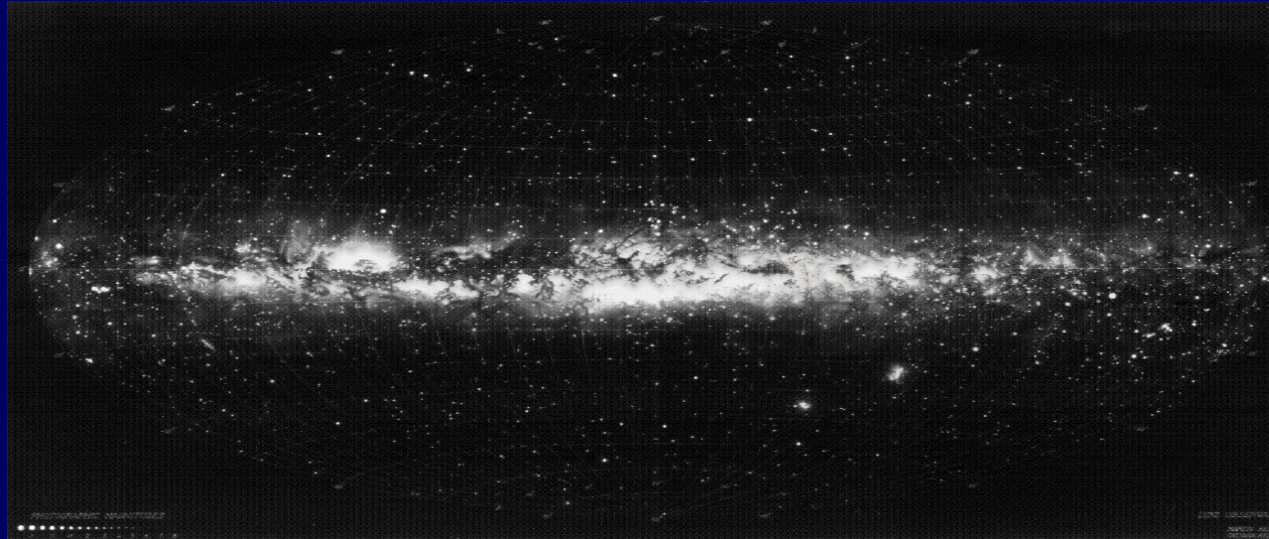
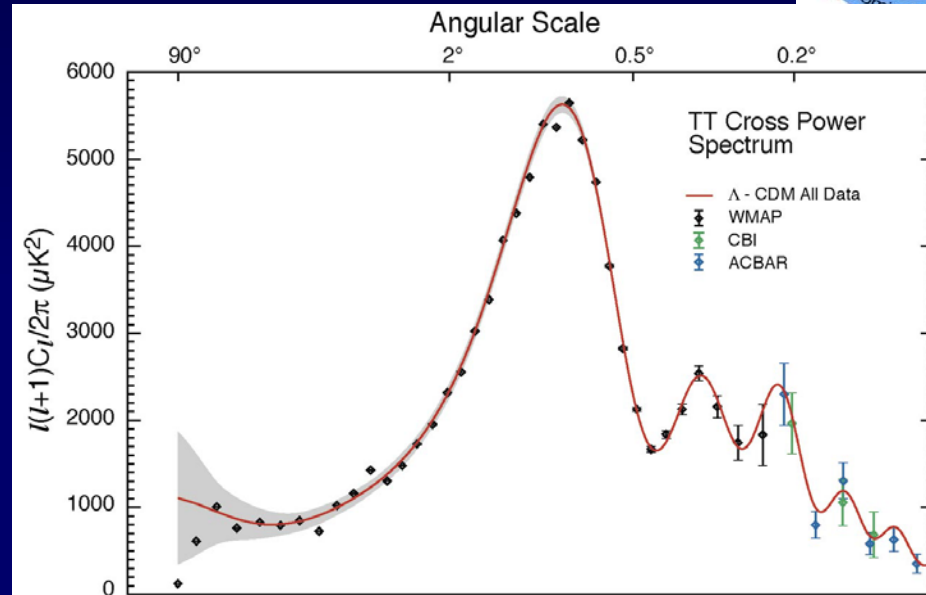


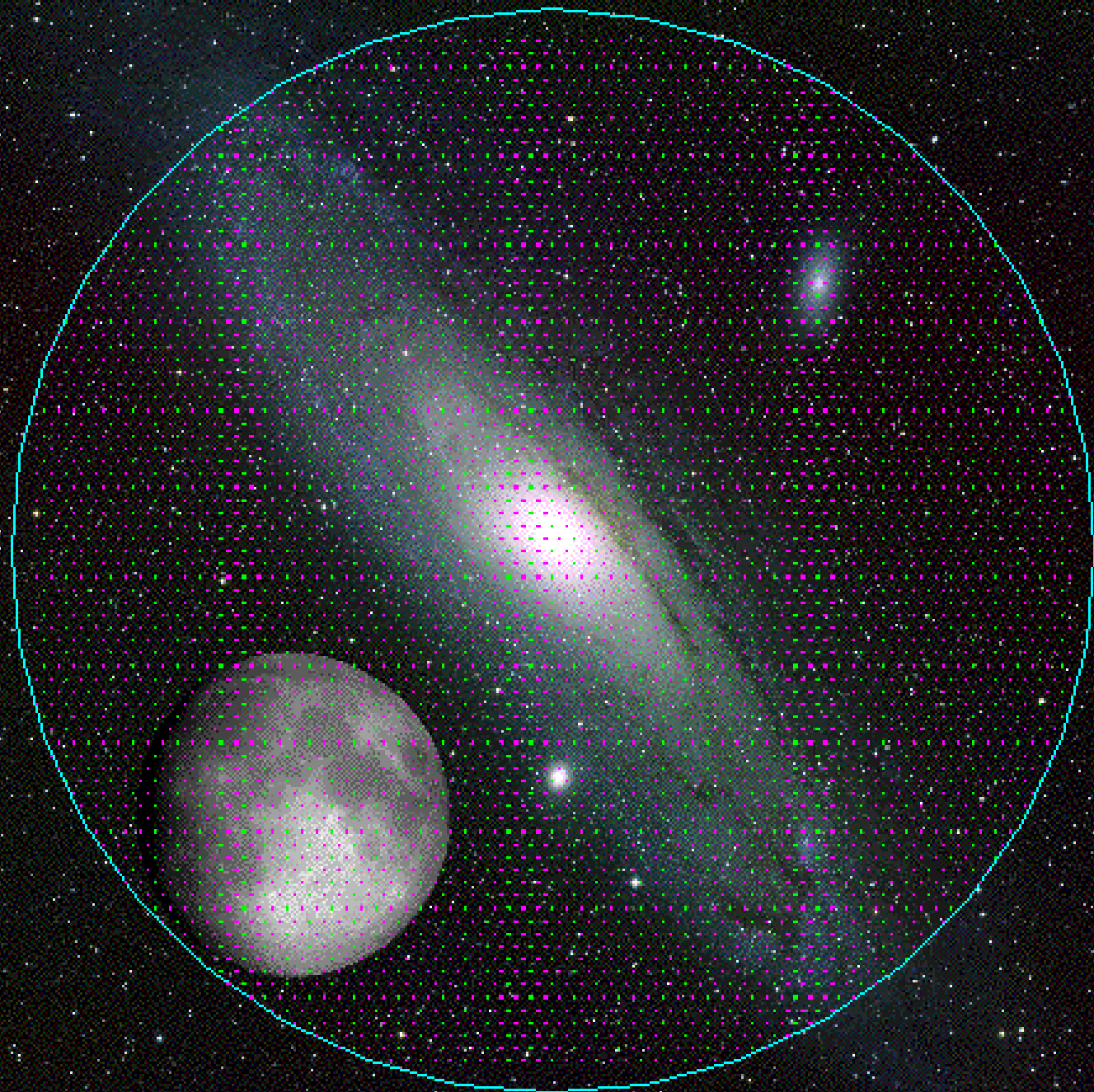
Original KAOS Science Goals



Measure the
time evolution
of Dark Energy

Map out the
assembly
history of the
Galaxy







Original KAOS concept if it were implemented on Gemini

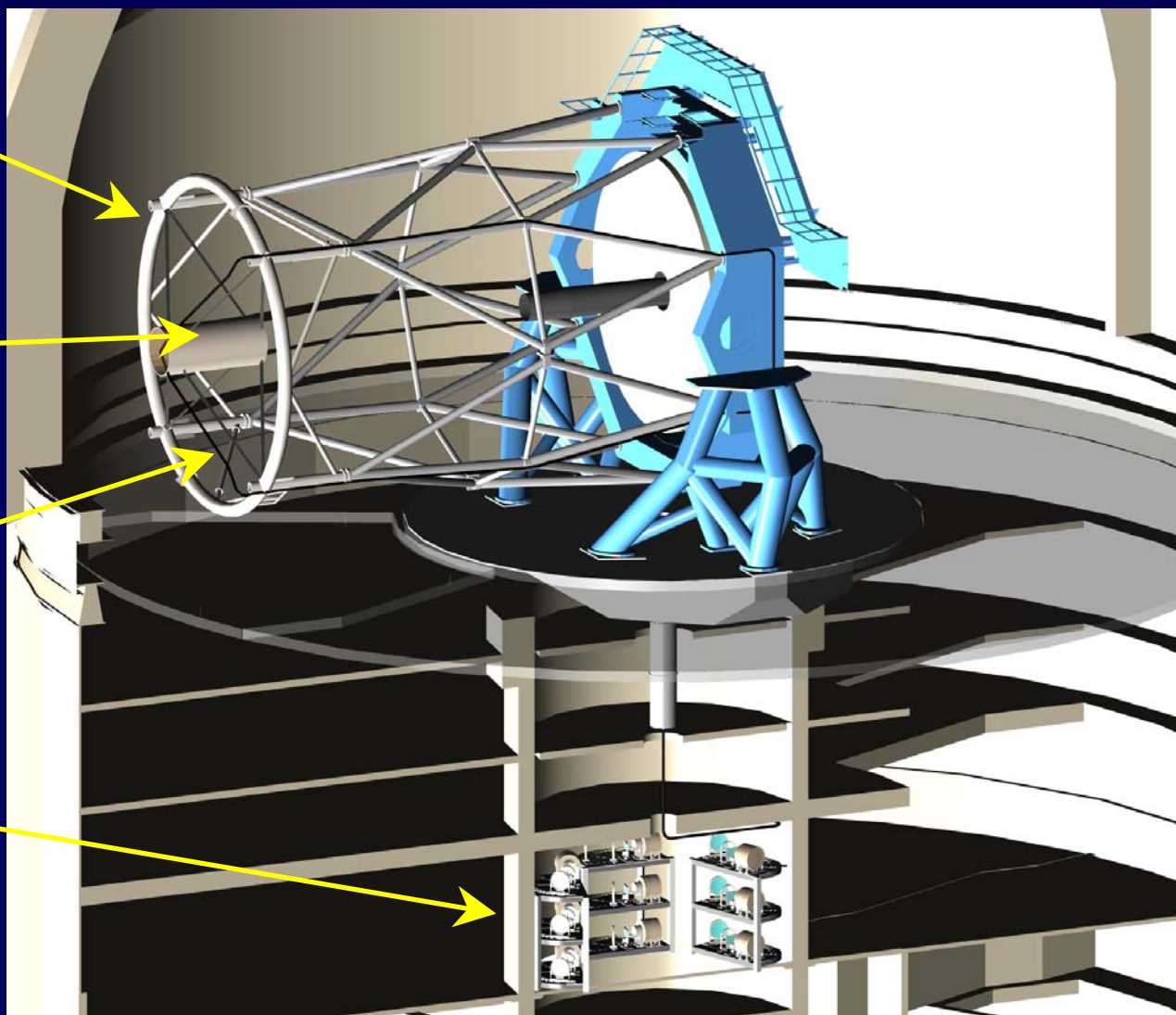


Replace entire top-end ring of one Gemini telescope

Prime focus corrector with 1.5 degree field of view

Fiber pick-offs and cable feed light off telescope

Bank of spectrographs in the pier lab





Gemini Aspen Meeting June 2003



~100 astronomers from all the Gemini partners met in Aspen to help define the instrumentation needed to meet the Gemini community's needs in the coming decade





The Aspen Science Mission





The Aspen Science Mission



1. How do galaxies form?
2. What is the nature of dark matter?
3. What is the relationship between supermassive black holes and galaxies?
4. What is dark energy?
5. How did the cosmic dark age end?
6. How common are extrasolar planets?
7. How do stars and planets form?
8. How are the elements of life formed?

MATTER

ENERGY

LIFE



The Birth of WFMOS



A wide-field, highly-multiplexed multi-object fiber spectrograph was the highest-priority instrument to emerge from the Aspen process...

WFMOS



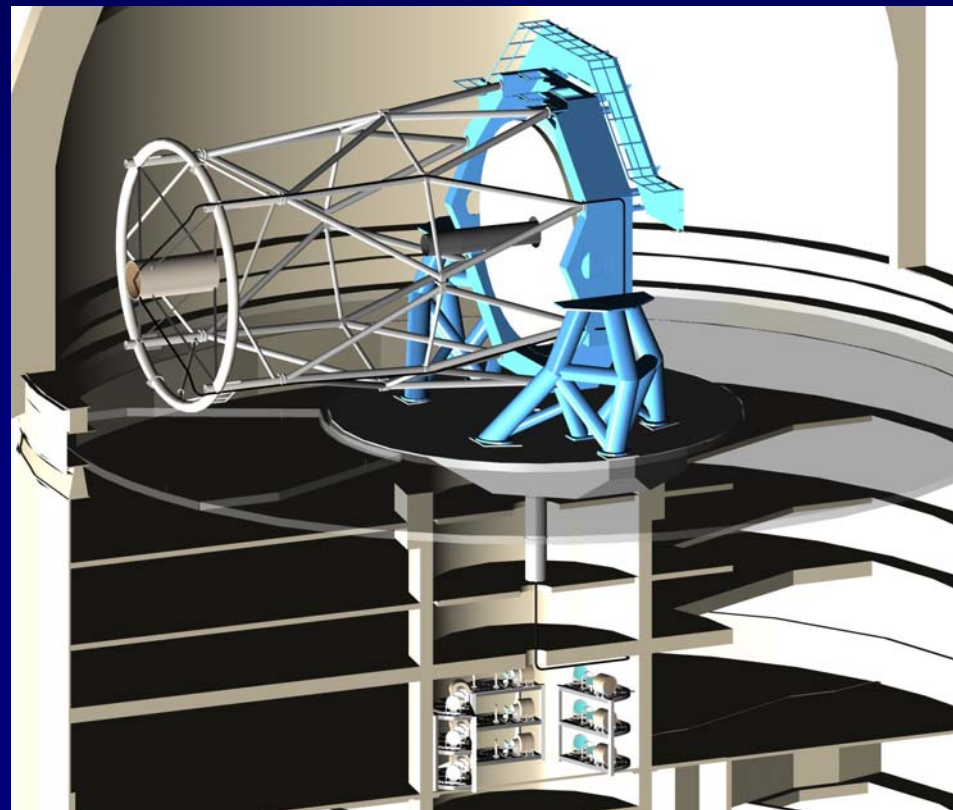
WFMOS Feasibility Study

AAO, PI Sam Barden



Baseline Design

- Wide field of view 1.5 deg
- Multiplex gain of ~4500
- Wavelength coverage 0.39 to 1.0 μm
- Spectral resolution $R \sim 3000, 40,000$ (2/3 and 1/3 fibers)
- Fiber footprint of ~ 1 arcsec
- Prime focus fiber feed to individual spectrographs
- Pipeline processing





WF MOS on Gemini

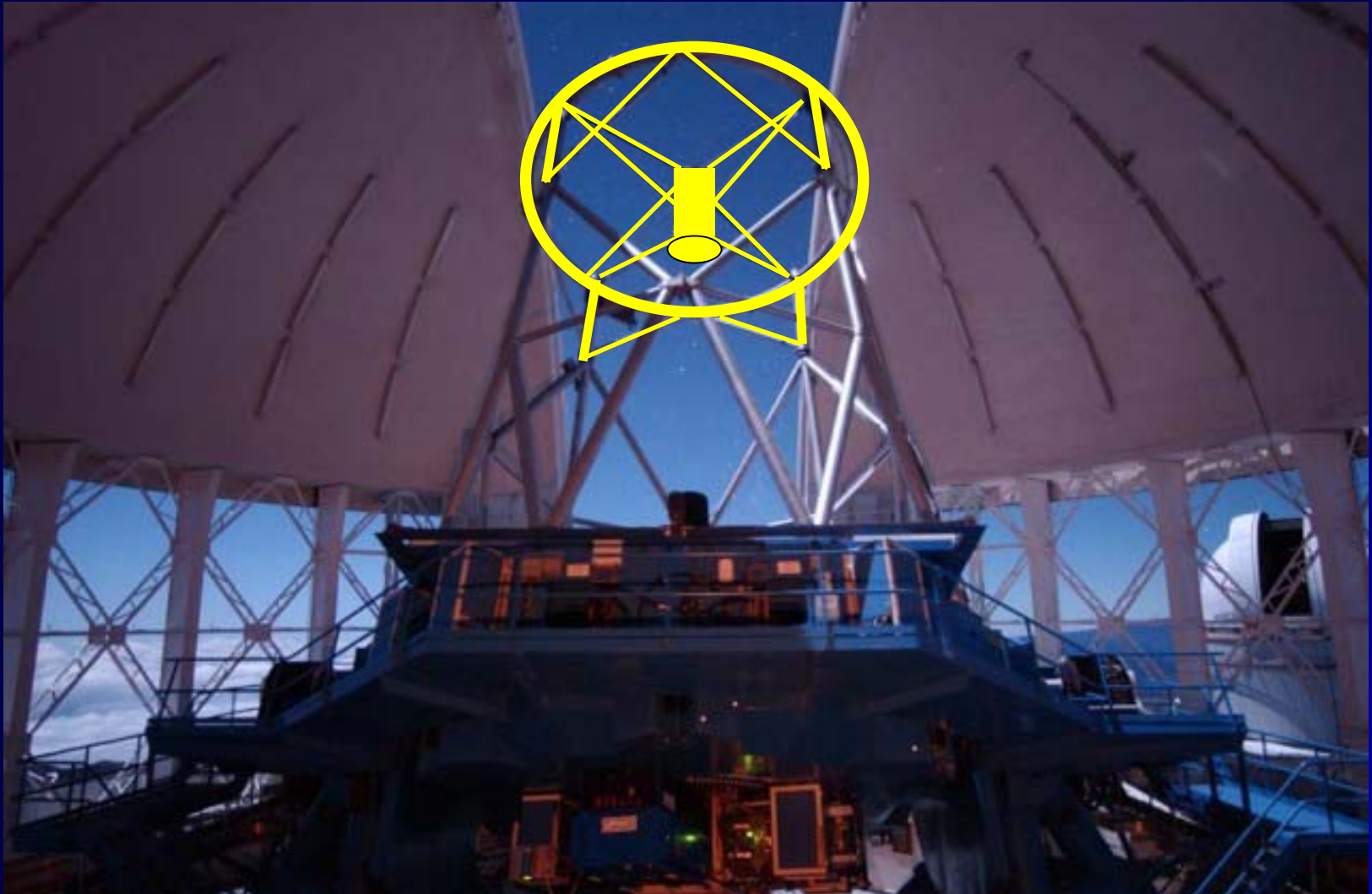


Gemini is optimized for:

- *IR sensitivity*
- *High angular resolution*
- *Flexible queue scheduling*



WF MOS on Gemini





Lunch at Hale Pohaku

March 2004



The idea of putting WFMOS on Subaru was suggested by Karoji-san over lunch with Jean-Rene Roy at Hale Pohaku.

→ *Take advantage of the strengths of each observatory while fostering international cooperation*



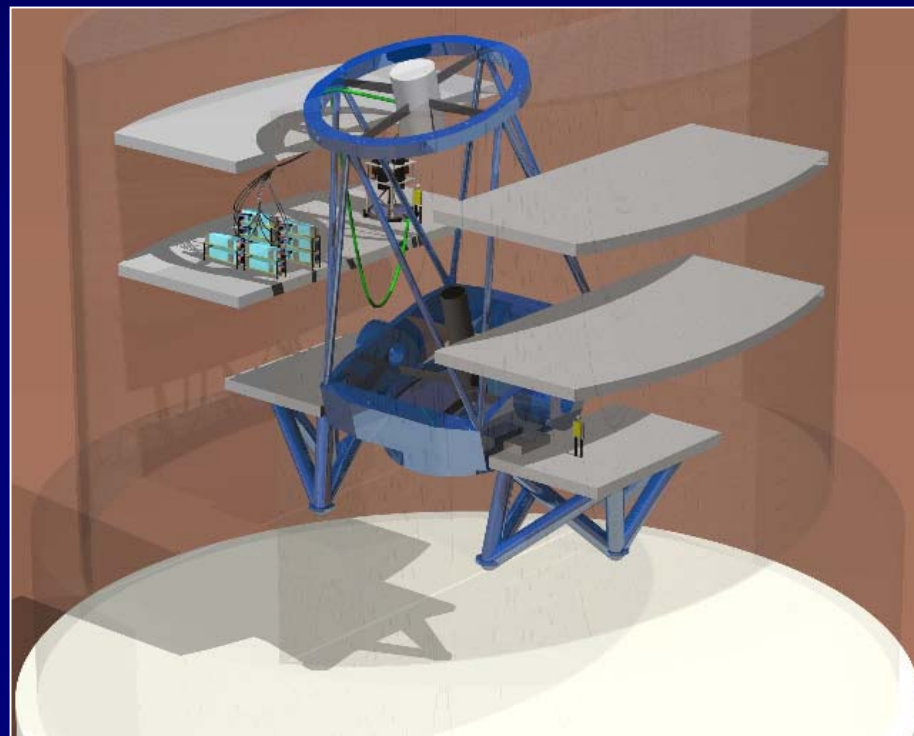
WFMOS Feasibility Study

AAO, PI Sam Barden



Baseline Design

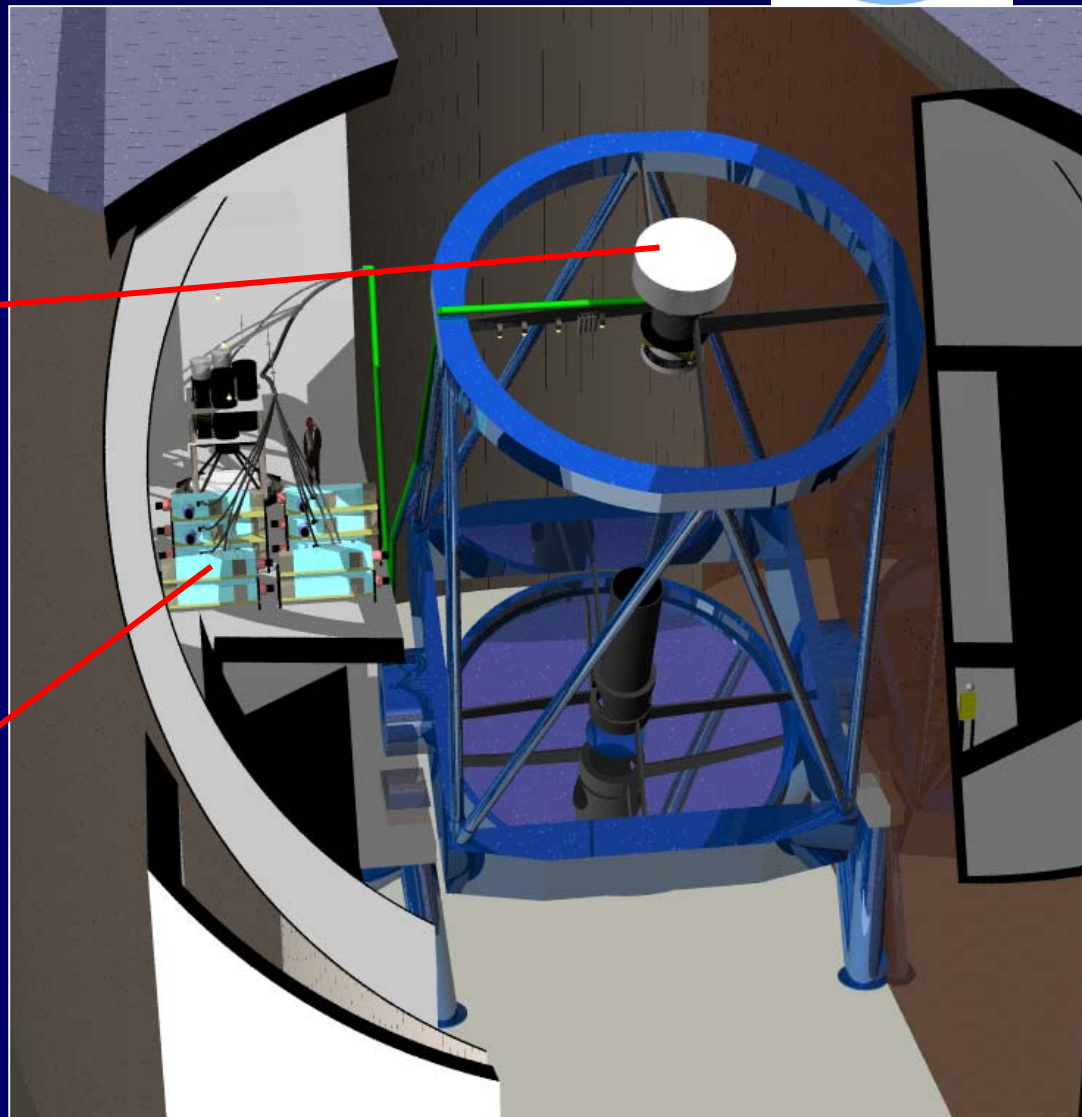
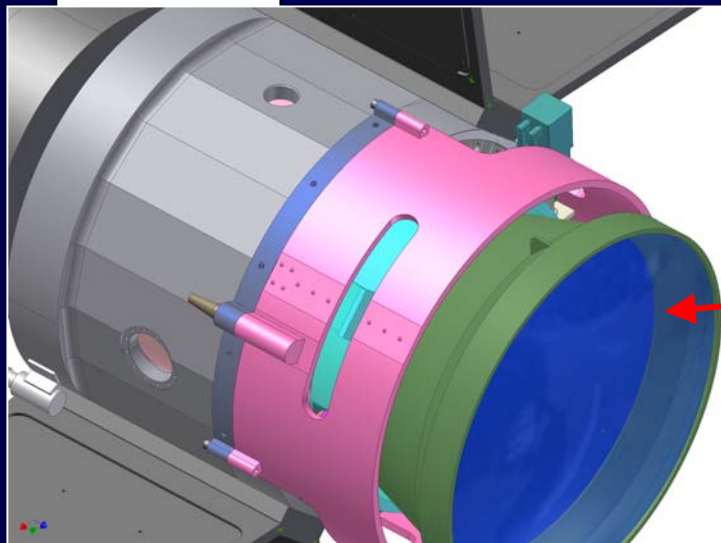
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- *Subaru platform*



WFMOS on Subaru



WFMOS on Subaru



WFMOS

GIRAFFE

VIMOS / NIRMOS

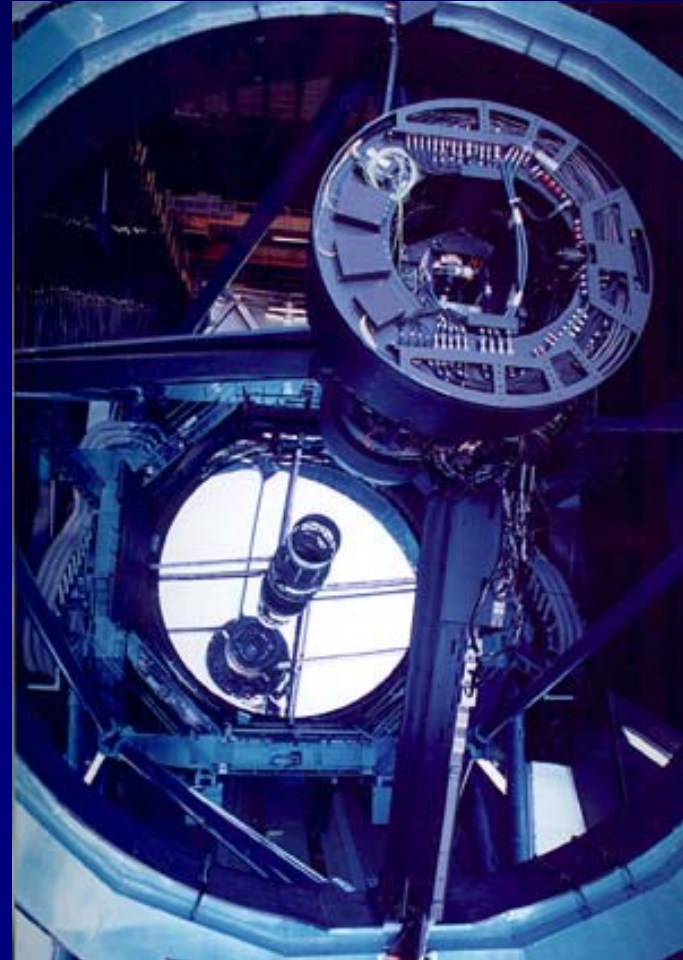
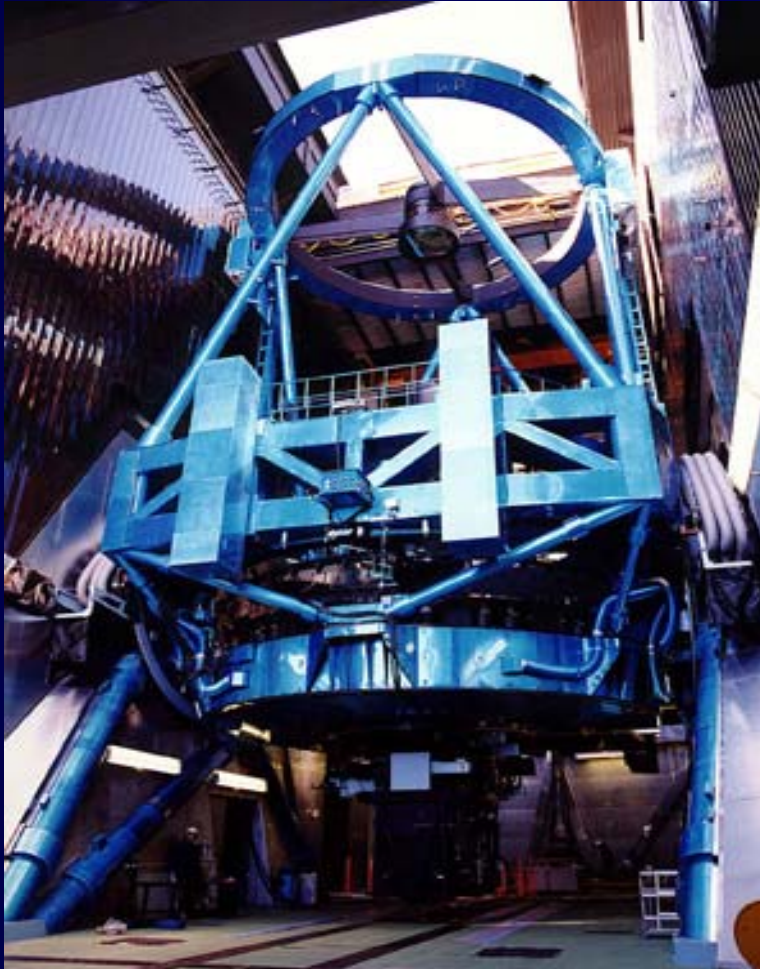
FORS 1 / 2

FMOS





Subaru: the ideal platform





Subaru: the ideal platform



PFU

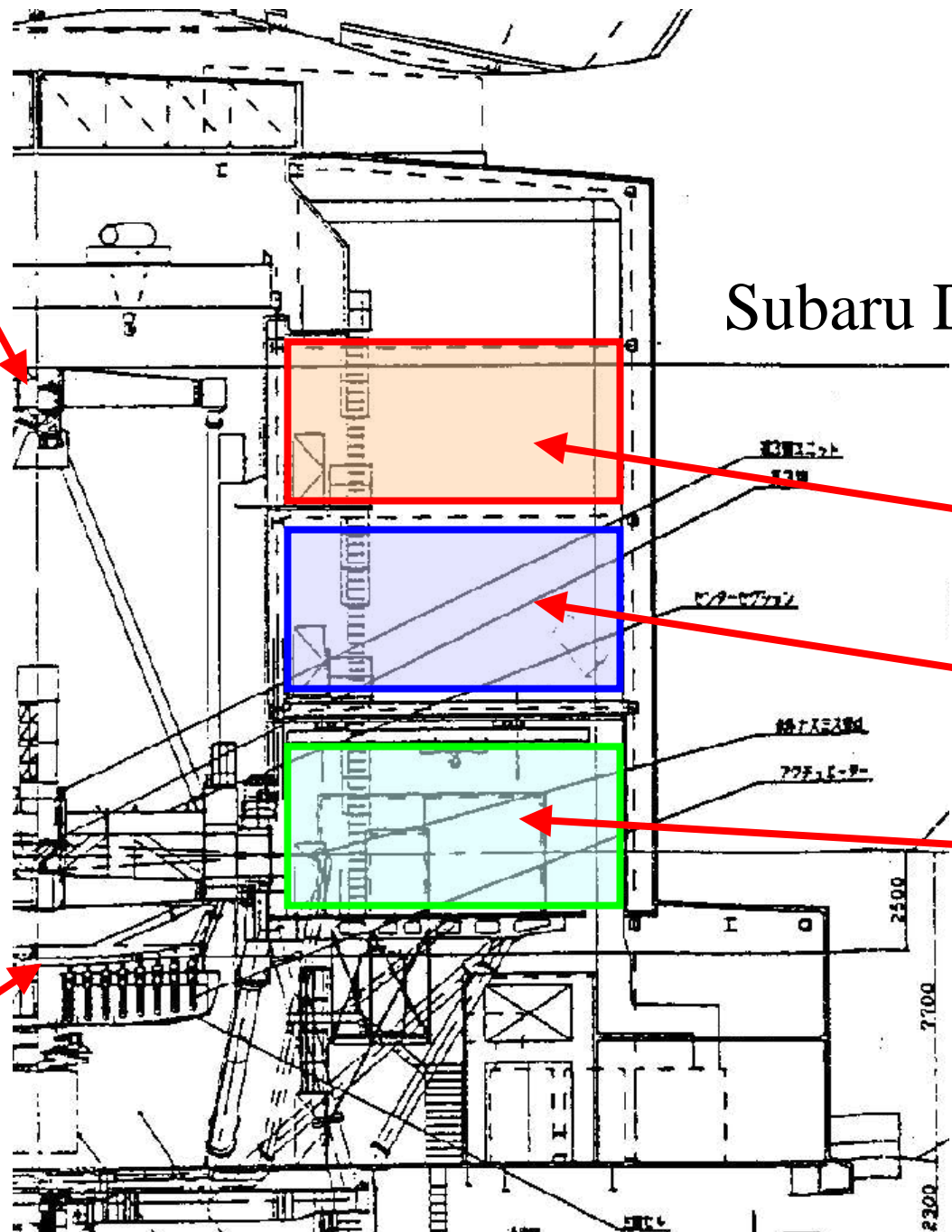
Subaru Dome IR side

TUE floor

M3 floor

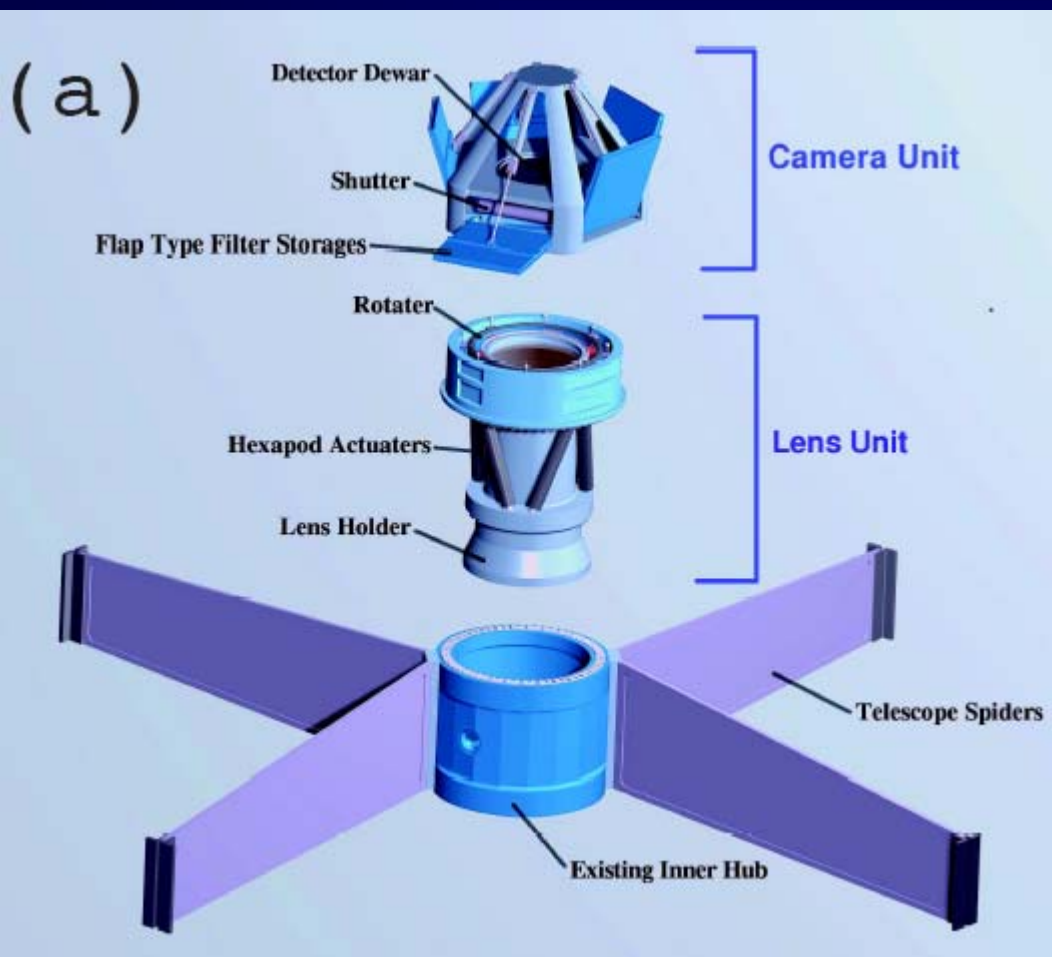
Ns floor

M1





HyperSuprime Cam



- HyperSuprime Cam and WFMOS share common infrastructure and a similar science mission
- Baseline 1.5° corrector design feeds HSC and WFMOS in existing top-end hub
- Canon and Mitsubishi working on the WFC and prime focus unit designs
- Camera unit funded!



Science Synergies



HyperSuprime Cam

- Dark Energy via weak lensing
 - Photo-z redshifts could be calibrated using WFMOS

WFMOS

- Dark Energy via BAO
 - Imaging surveys for target selection could come from HSC

Constraints on cosmological parameters can be improved over WFMOS or HSC surveys alone because the systematics are different



WF MOS on Subaru



- There are a number of important reasons for locating WF MOS on Subaru:
 - *Cost sharing*
 - HyperSuprime Cam and WF MOS share infrastructure and science cases
 - Both communities get access to world-class facilities that would otherwise be unavailable to them, at a discount
 - *Time sharing*
 - Japanese would have access to Gemini instruments
 - Like both observatories getting another telescope
 - *Takes advantage of the inherent design strengths* of both Gemini and Subaru
 - *Fosters greater international cooperation*, which will help with future projects like TMT



Conceptual Design Study: Try and try again



In 2005, Gemini took the next step by commissioning two competing Conceptual Design Studies for WFMOS

- **Jan 2006:** AAO and Caltech teams met with Subaru engineers to establish baseline WFMOS interfaces
- **May 2006:** WFMOS Conceptual Design study work temporarily halted by Gemini Board due to funding uncertainty
- **Aug. 2006:** Gemini Board authorizes conceptual design study restart; science case developed
- **Feb. 2007:** NSF approved payments for work already performed
- **May 2007:** Started over from scratch; began “team building” work to ensure that the two teams would propose again
- **Oct. 2007:** New contract negotiated with AAO and JPL
- **Feb. 2008:** Conceptual design studies finally begin!



Two Gemini Conceptual Design Study Teams



JPL Team

- PI Richard Ellis
- Caltech
- Penn State
- ATC
- Cambridge IofA
- U. College London
- LNA Brazil

AAO Team

- PI Sam Barden
- NOAO
- U. Oxford/RAL
- U. Portsmouth
- U. Durham
- Johns Hopkins U.
- RAL

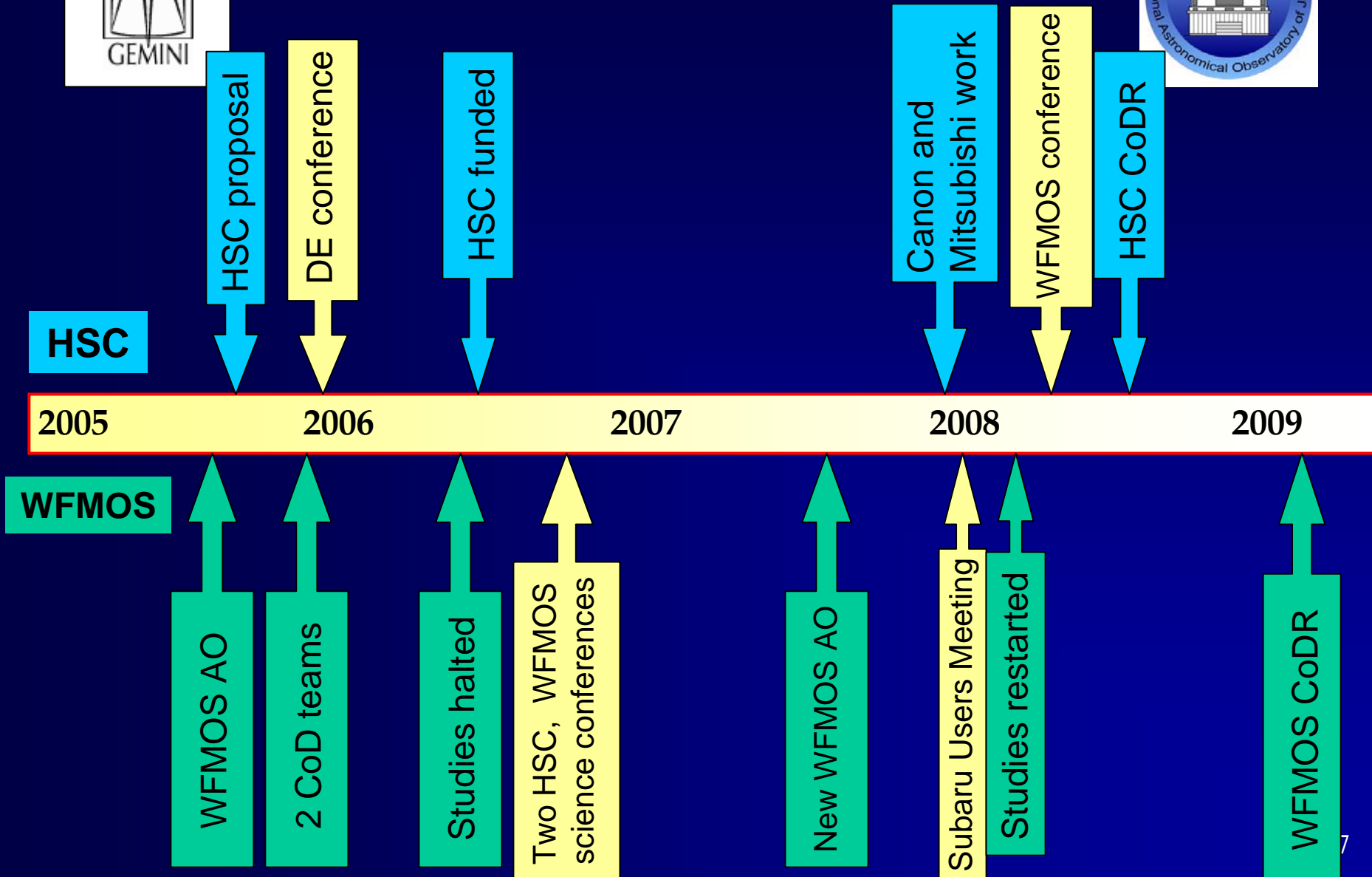
VENTILATOR B3



- Prime focus unit interfaces
 - Weight, space envelope, services
- Wide field corrector design
 - Vignetting, image quality, transmission, etc.
- Fiber routing
- Spectrograph room options
- Software interfaces
- Summit tours



HSC+WF MOS Development Timeline





The Next Steps



- HyperSuprime Cam Design Review
 - Better interface and cost constraints for WFMOS
- Gemini and Subaru negotiate time and cost sharing agreement
- WFMOS Conceptual Design Review and team selection (March 2009)
- Funding approval
- Construction contract negotiation



Key WFMOS Challenges



- **Acceptance of the HSC and WFMOS science goals**
 - The Japanese community interest in HSC and WFMOS has increased dramatically since HSC funding was awarded
- **Acceptance of a partnership with Gemini**
 - Does gaining access to Gemini instruments, particularly at Gemini-South, justify giving up time on Subaru for WFMOS projects?
- **Long term funding**
 - *Neither Gemini nor Subaru have firm commitments to fund their portions of WFMOS*

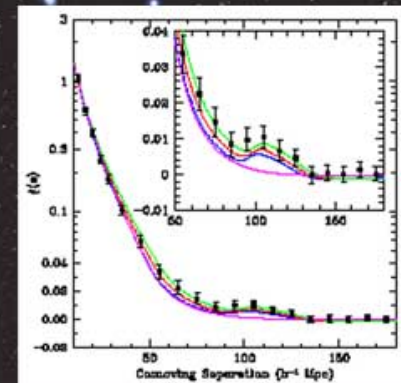
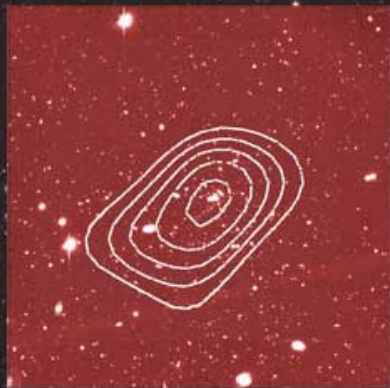


Time Sharing between Gemini and Subaru



- **Gemini and Subaru began exchanging observing time in 2006B.**
 - Up to 6 nights per semester on Subaru
 - Suprime Cam and MOIRCS
 - Classically scheduled nights
 - Up to 6 classical nights per semester on Gemini
 - Both Gemini-North and Gemini South
 - GMOS-N/S, NIRI, NIFS, T-ReCS, Altair LGS
 - Past semester exchanges also traded service observing for queue observing time

Probing the Dark Universe with Subaru and Gemini



文部科学省

Ministry of Education, Culture, Sports, Science and Technology



National Science Foundation
WHERE DISCOVERIES BEGIN

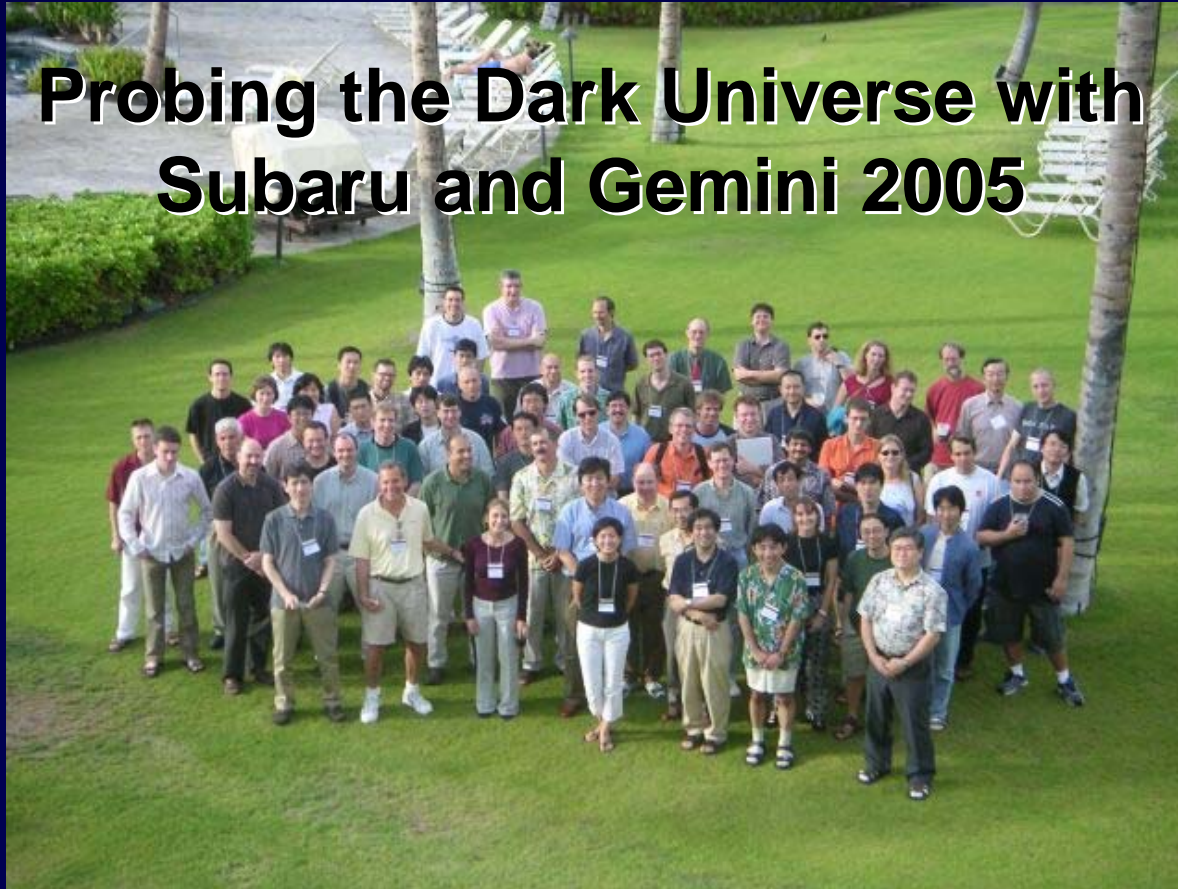


PPARC





Probing the Dark Universe with Subaru and Gemini 2005



2005 Dark Universe Workshop Purpose:

- To increase visibility of the WFMOS and HyperSuprime projects and the science they will enable
- To build relations between astronomers in the Gemini and Subaru communities.



COSMOLOGY NEAR & FAR: SCIENCE WITH WFMOS

A JOINT CONFERENCE BY SUBARU • GEMINI • JSPS • NOAO • UK STFC • AAL





The Purpose of this Meeting



- Explore the wide range of science enabled by WFMOS
- Build a strong partnership between Japanese and Gemini communities
- Competition is an essential aspect of Gemini instrument procurements
 - Explore new technological approaches
 - Reliable cost estimates
 - Because of the competition, teams cannot discuss their technical approach at this meeting.
 - Competitive design studies will be complete early next year



How were elements from iron to uranium made and distributed?



How did our Galaxy form?

Is a new theory of matter and light needed?

Enjoy the meeting!

What are the masses of the neutrinos and how have they shaped our universe?

What is Dark Energy?

How have galaxies in clusters evolved?

Did Einstein have the last word on gravity?

What is the relationship between the formation of massive black holes and the galaxies they live in?

How did the Universe begin?