The Wide Field Telescope (WFT)

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On behalf of the WFT Working Group @PMO:

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With Science Cases Contributed by Several Institutes in China

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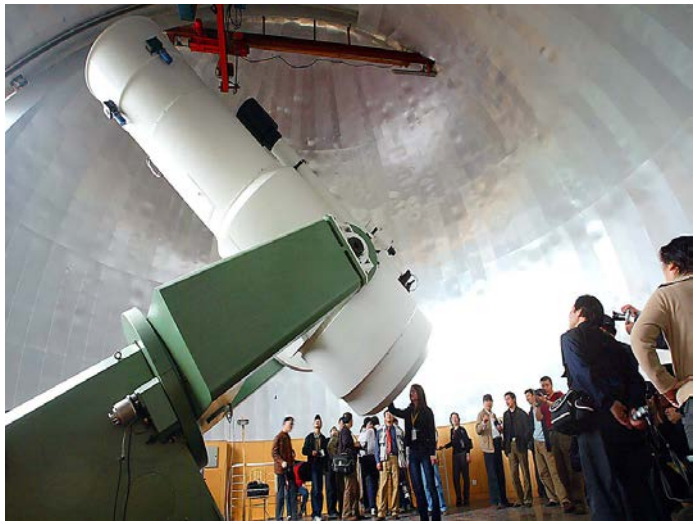
Outline

- Science Goals for the Wide-Field Telescope (WFT)?
  - Solar System Objects
  - Astrometry and Photometry for V<25mag objects
    - Parallax & Proper Motion
  - The Deep u-Band Legacy Survey
  - Galactic Bulge Timing Survey
    - X-ray Binaries (BHs); Microlensing; Exoplanets; Variables
- What is the WFT?
  - A 2.5meter Wide-Field Telescope
  - Characteristics
- Planned Roadmap

Planetary Science Research at PMO



1.04m NEO Survey Telescope

typical image taken by NEOST

- Asteroids
  - Found >1000 asteroids
  - Rank No 6 among 400 stations, best position precision
  - Light curve and shape determination
- Comets
  - Large scale morphology
  - Physical properties
- Dynamical origin of Solar system bodies
- Dynamics and impact risk assessment of NEOs
- Physical properties of asteroids

Sci Goal I: the Solar System

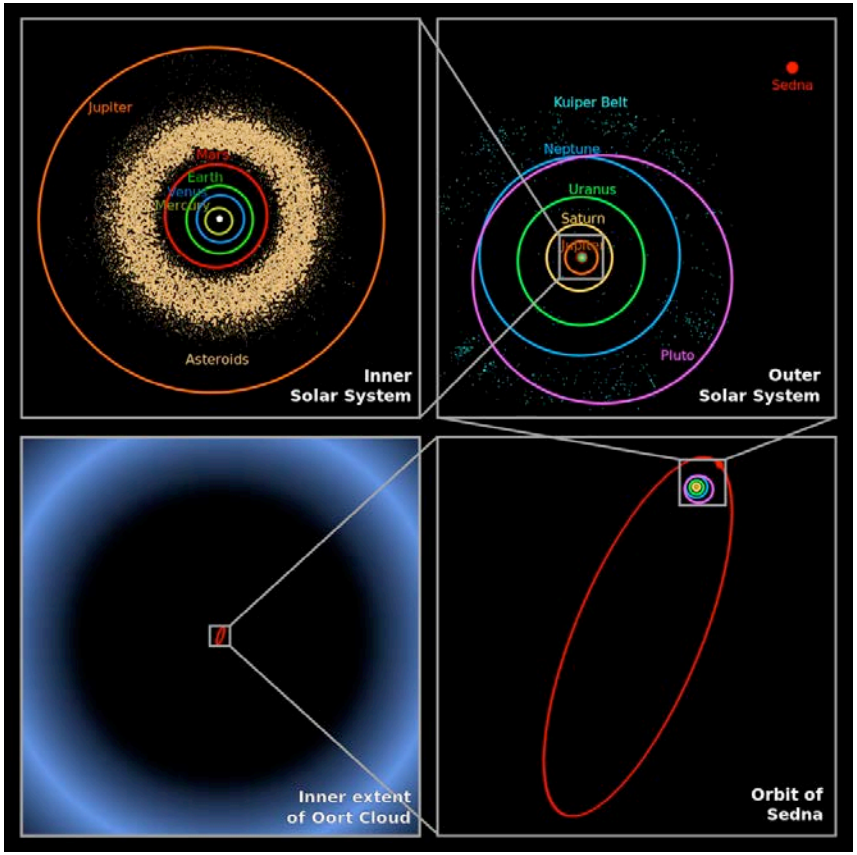
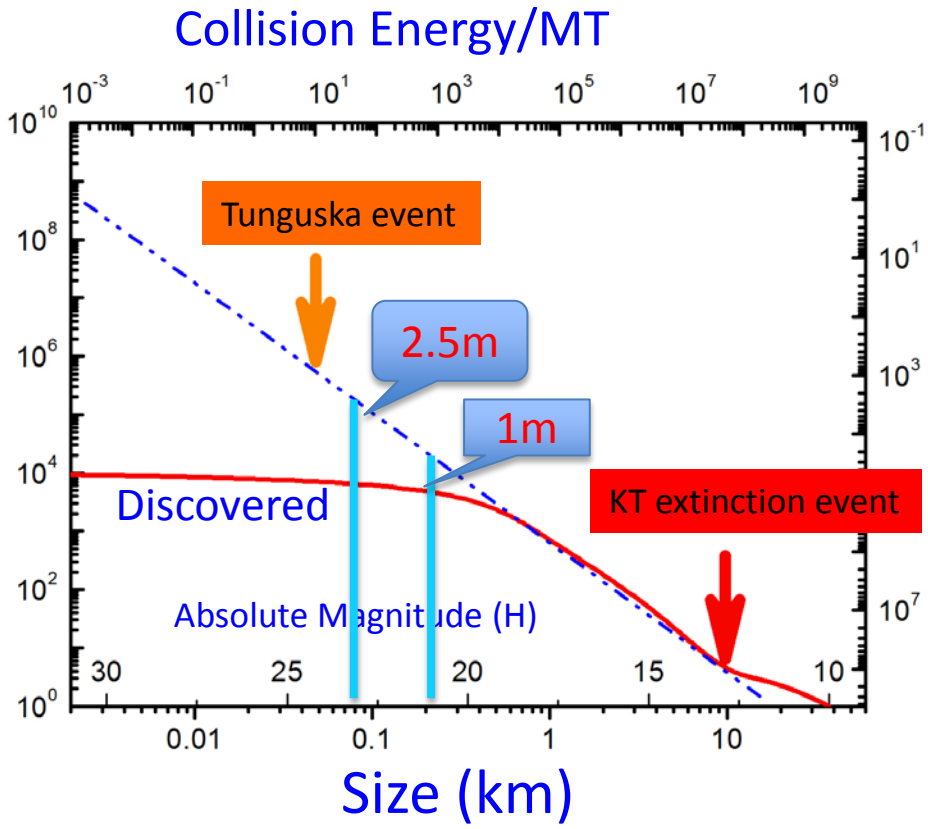


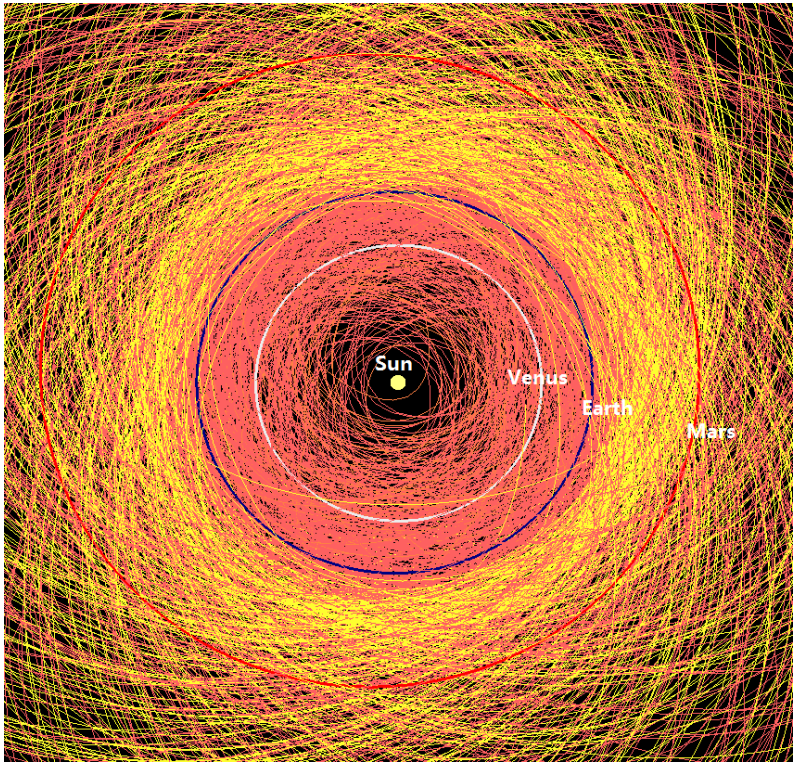
Image courtesy of NASA/JPL-Caltech/R. Hurt

- Main Belt Panoramic view
  - Characterize MBAs population in terms of their size, orbit, rotational states and shapes
  - asteroid families
- Trojans
- Kuiper Belt Objects
- Comets
  - MBCs, Extinct Comets

Hunt for Near-Earth Objects

- Found 1386 Potential Hazard Objects(PHO), only 1/3 of the total.
- About 10,000 NEOs with sizes>40m, only 3% are tracked.





Orbits for 1000 Known NEOs

To detect, track, catalogue, and characterize 90% of potentially hazardous NEOs larger than 140m (H=23 mag) in size.

Sci Goal II: Fundamental Astronomy

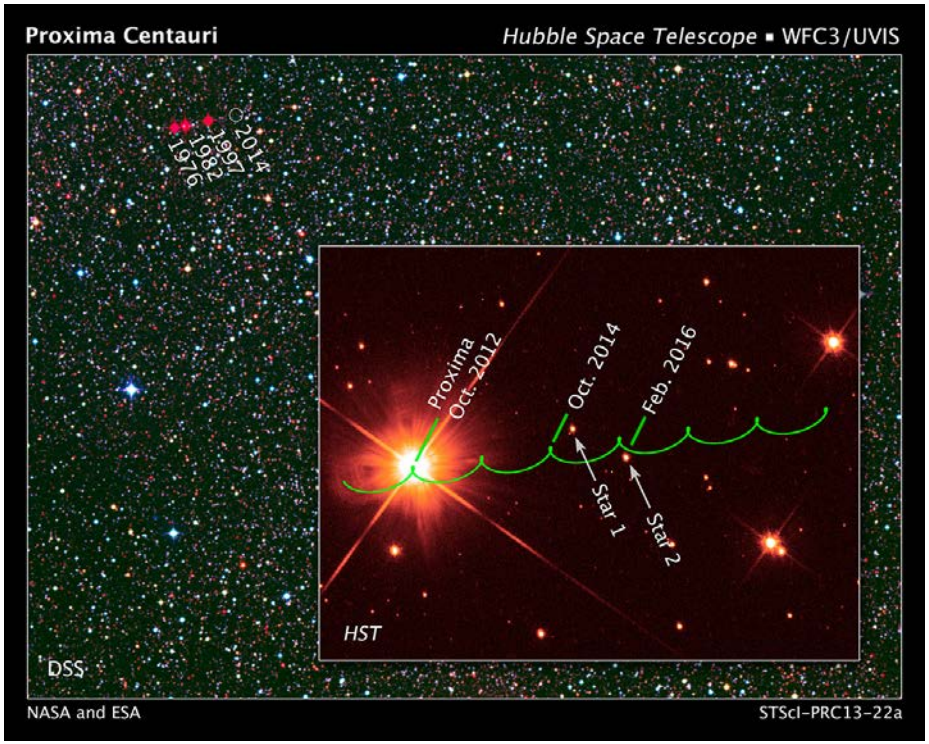
- Hipparcos & Tycho-2
  - 1mas
- Gaia
  - 0.01~0.2mas for V<20mag
- SDSS
  - 50mas for g<22mag
- Pan-STARRS1
  - 20mas for V<23mag
- LSST
  - 10mas for 15s exposure

- WFT is designed to have extremely-low distortion (<0.09% over the full FoV).
- WFT All Sky Survey will provide a catalog of billions objects (V<23mag) with precise astrometry, <10 mas @ SNR>75.
- The Imaging survey over 3-5 years will allow proper-motion 5 mas/yr per star for V=20-23mag stars.

Parallax & Proper Motion

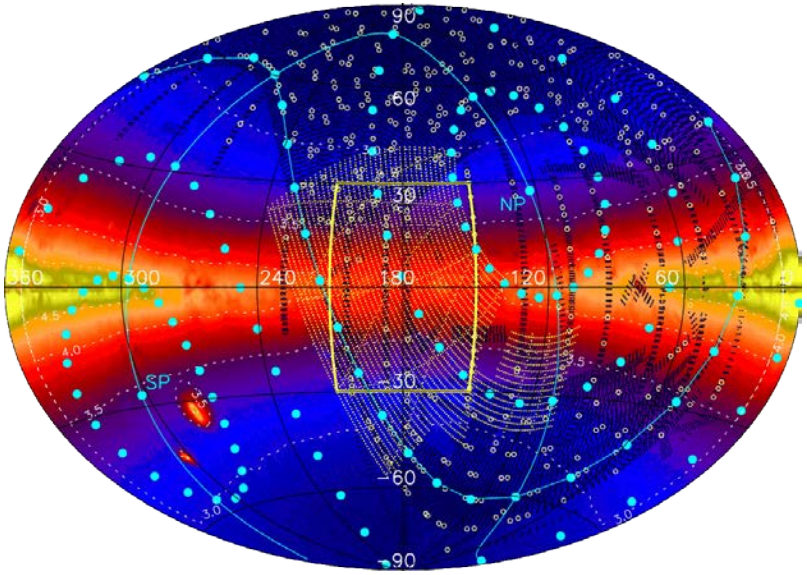
- Solar-Neighborhood Faint Stars
  - Stellar Luminosity Function
  - Environments
  - Kinematics
- Galactic Structure: Tidal Streams & star clusters
- Microlensing targets
  - exoplanets

Probing exoplanets by Microlensing



Sci Goal III: The Deep u-Band Legacy Survey

Total 20,000 deg^2, 5σ=23.5mag@45min, 215 nights over 3 years



- The Milky Way
  - Star formation
  - Extinction map
- Star formation in nearby galaxies
  - SF vs galaxy structure
  - SF vs environment
  - SF in galaxy outskirts
- Synergy with other surveys
  - Help to Identify all kinds of objects in the universe
  - Good photometric redshifts
  - X-ray, IR, Radio, etc

•XSTPS-GAC: Galactic anticenter survey during 2009-2011

• 5600 sq degs (5361+M31+LCF)

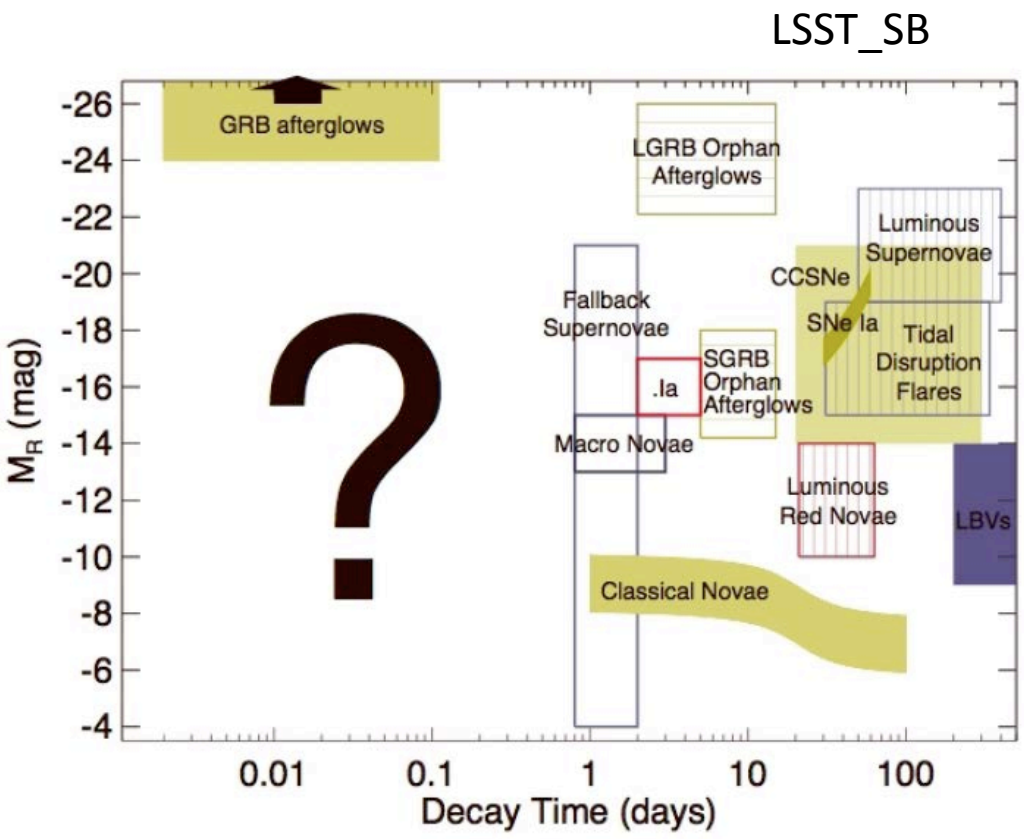
•20 mag limiting magnitude

• Photometric accuracy comparable to SDSS

Sci Goal IV: Time-Domain Astronomy

- Supernovae
  - SN physics: statistics & systematics
  - Extreme physics: Breakouts; Pop III SNe; HyperL SNe
  - SN cosmology: universe acceleration; peculiar velocity; Hubble flow;
- GRBs
- X-ray Binaries, microquasars
- Tidal disruption Flares
- Variable stars
- Asteroseismology
- AGN
  - Blazars
  - High-z QSOs
- Unknown events

Next Generation Transient Surveys



- High cadence
- High sensitivity
- All Sky
- Follow-ups

Telescope	AΩ	CCD (Gpix)
SDSS	25.3	0.12
Pan-STARRS1	13.5	1.02
LSST	308	3.2
WFT	29.3	0.9

Summary of Key Scientific Goals

Science drivers

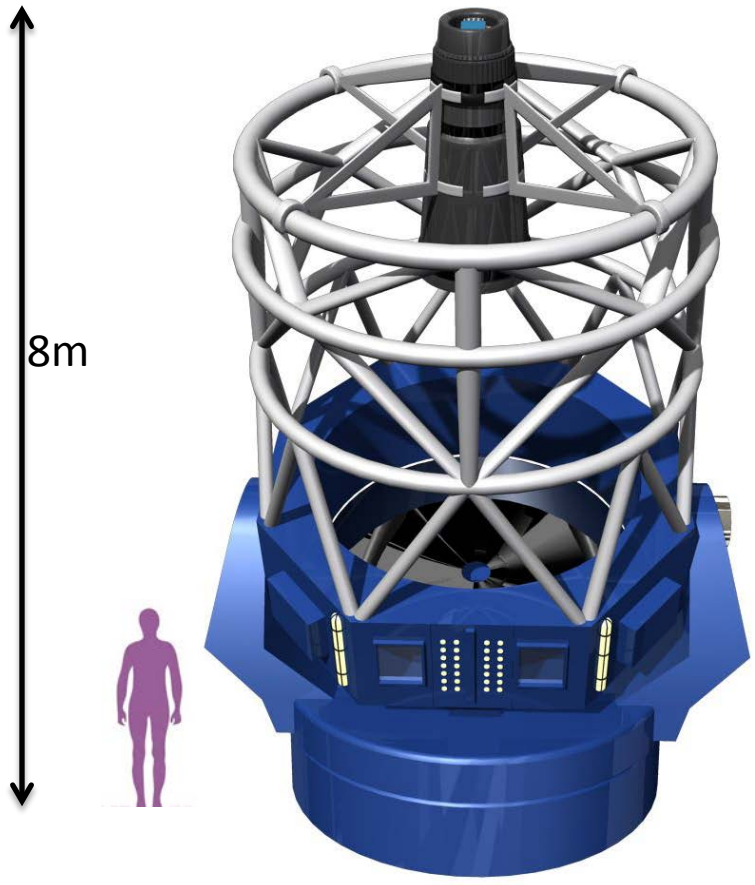
- Celestial Mechanics
  - Solar system objects
  - Stellar dynamics in Milky Way
- Extragalactic astronomy
- Time-domain Astronomy
  - Transients (SN,GRB,Flares+)
  - Binaries, Variables & AGN
  - Unknown events

Key Programs

- Northern Sky Survey
  - w (g+r+i) for solar system objects
  - Astrometric and photometric catalog for v<23mag objects
- Deep u-band 2π Legacy Survey
- Galactic Bulge Timing Surveys
  - X-ray Binaries/variables
  - Microlensing

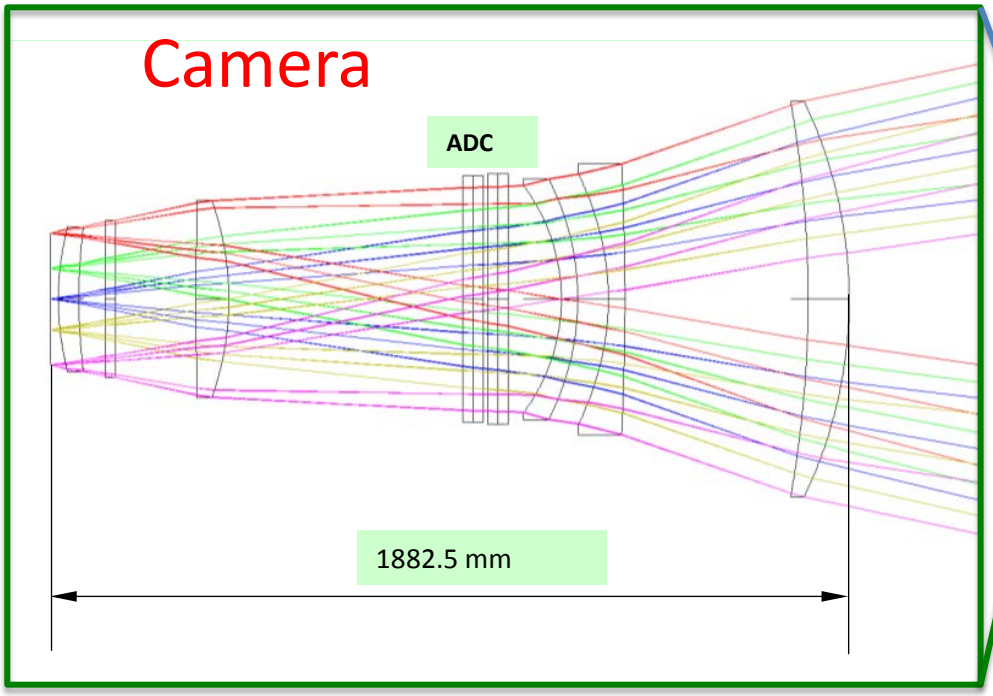
The Telescope Concept

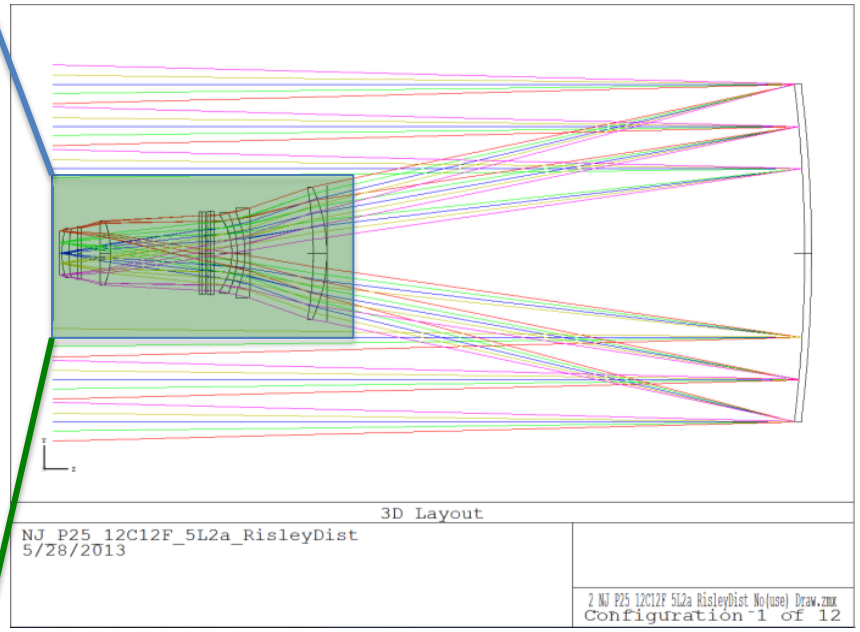
The meaning of “Wide field”: a FoV of Φ >= 3deg



- Aperture: 2.5m
- Mount: Altazimuth
- Optics: prime-focus assembly
- Focus length: 6.2m
- Field of View: Φ=3deg (7□°)
- Etendue(AΩ): 29.3
- Image Quality: 80%<0.4”
- Pixel scale: 0.3” (seeing~0.7”)
- Plate scale: 10um/pixel
- Camera: 30k×30k
- window: 320-1050nm
- Filters: u,g,r,i,z,Y,W + Narrow
- Depth: v=23m @30s

Optical Layout: A Prime-Focus System with Atmospheric Dispersion Corrector (ADC)

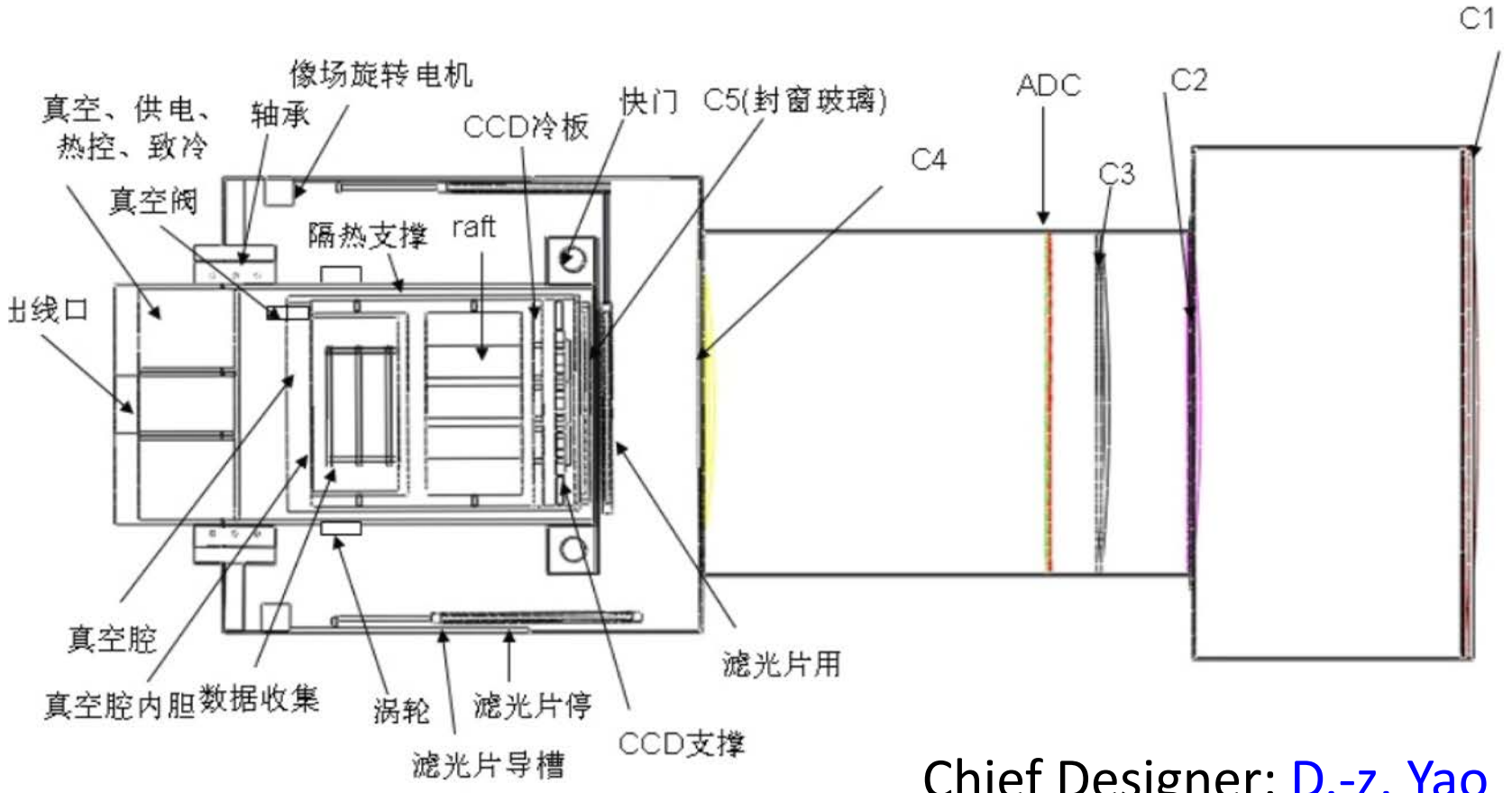




Atmospheric dispersion corrector (ADC) designed for prime focus includes two Risley prisms. Each of them is composed by silica and LLF6 (Schott).

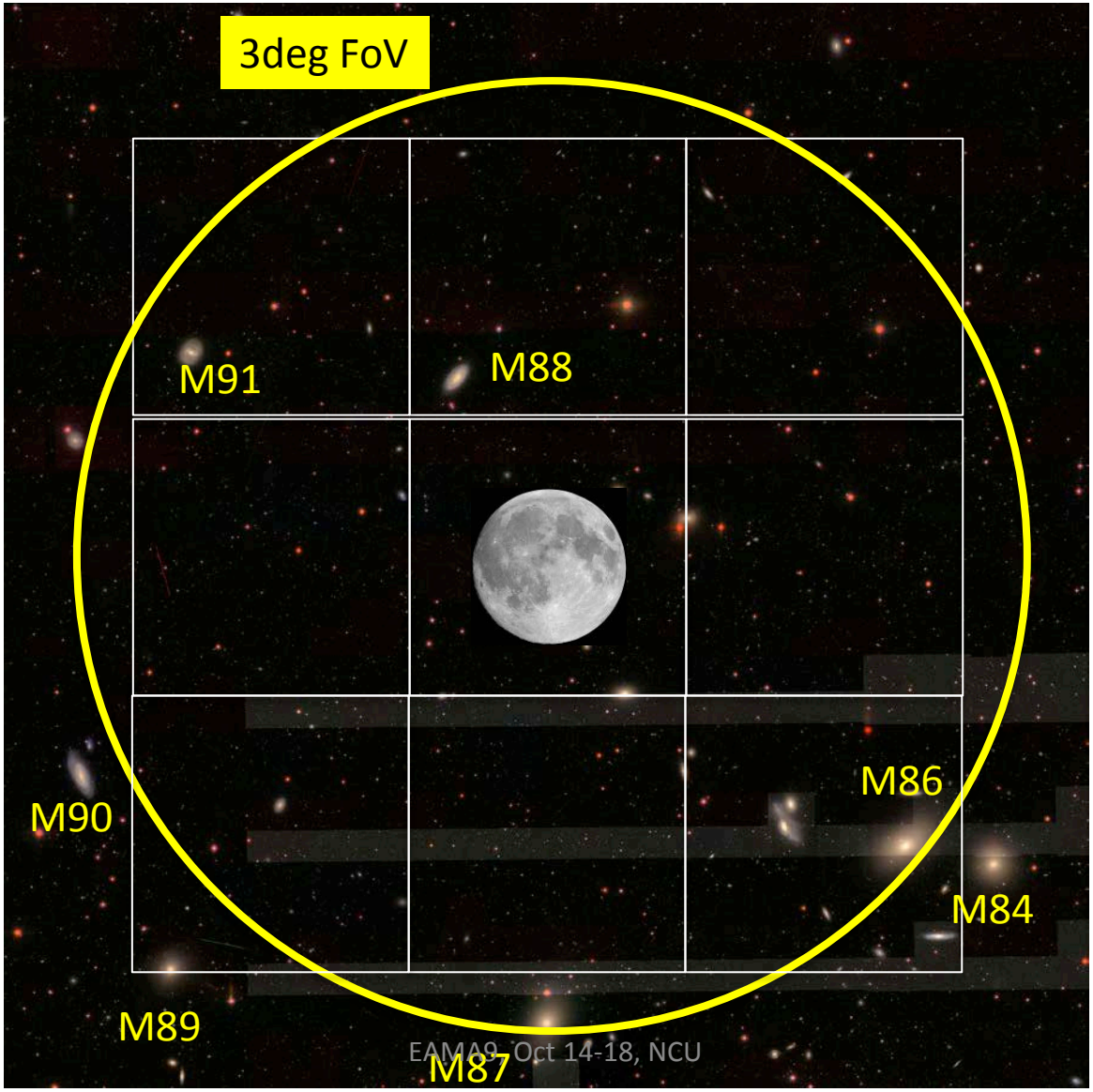
Chief Designer: Ming Liang

Camera Structure



Chief Designer: D.-z. Yao

WFT 30k×30k Mosaic CCDs



Virgo Cluster
SDSS Image

Characteristics of the WFT

- High sensitivity
  - High throughput （one mirror + 5 lens+ ADC + filter + CCD)
  - Large collection area (D=2.5m, no secondary mirror)
  - Low background light
  - High-altitude site: Ali @ 5100m (?)
- High quality imaging (seeing-limited)
  - With atmospheric dispersion corrector (ADC)
  - With distortion corrector (distortion <0.09% at edges)
  - Homogeneity of image quality (80%<0.4” & Active Optics)
  - Optics optimized from u to Y
- High Survey Power
  - AΩ=29.3 (Pan-STARRS1: 13.5, SDSS: 25.3, LSST: 307.8)
  - Survey speed 6000□° /night @ 30s exposure.

Why a size of 2.5m?

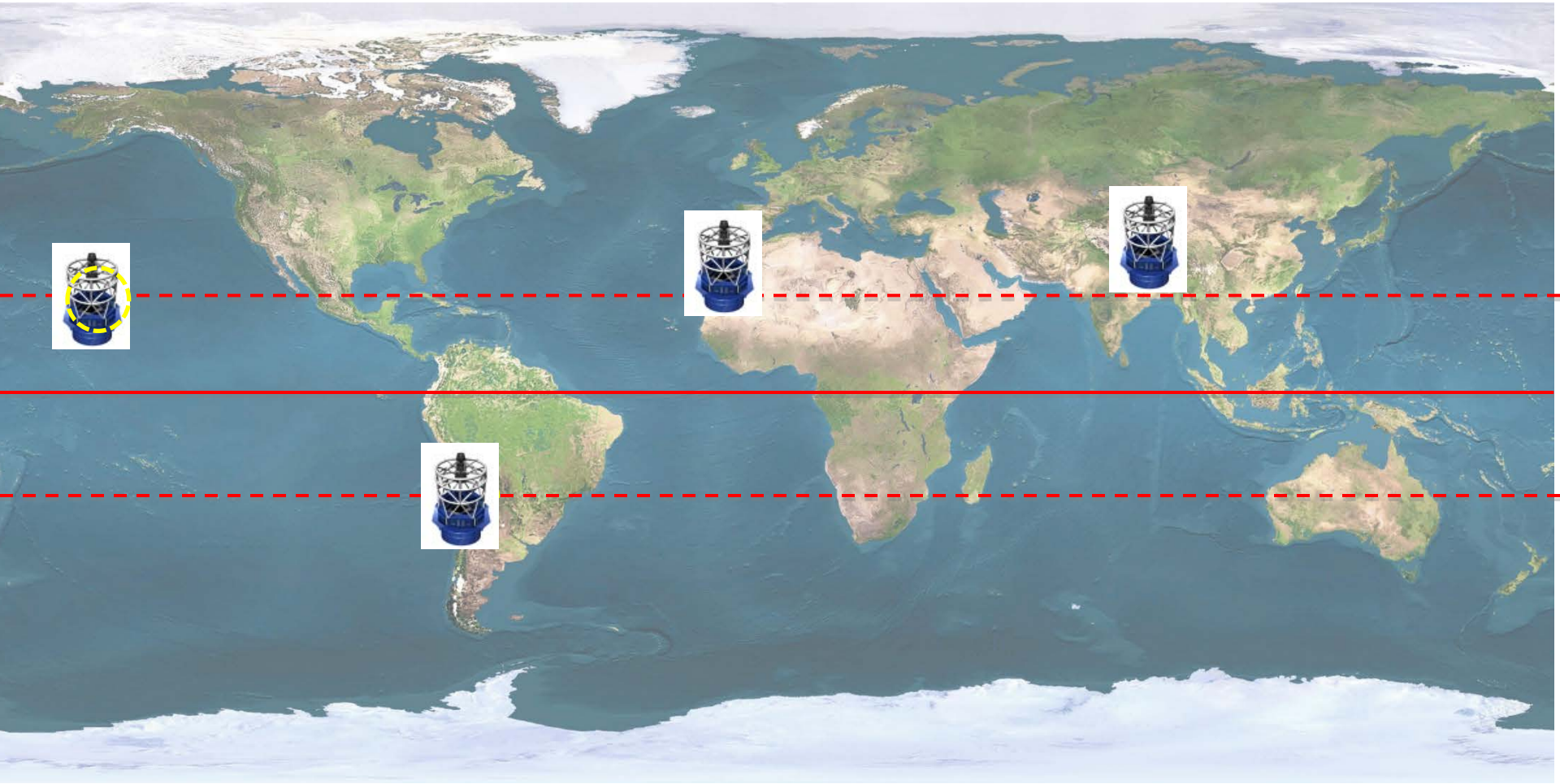
- Science Objectives - Limiting magnitude
  - 23m @short exposure (30s): spectroscopic follow-ups by 6-10m telescopes
  - 25-26m @long exposure to select targets for TMT, JWST

- Practical Issues – Cost vs Performance
  - collecting area ~D^2: $(4m/2.5m)^2 = 2.5$ (1mag)
  - cost ~ D^{3-4}: $(4m/2.5m)^{3.5} = 5.2$
  - Total cost: < ~20M USD

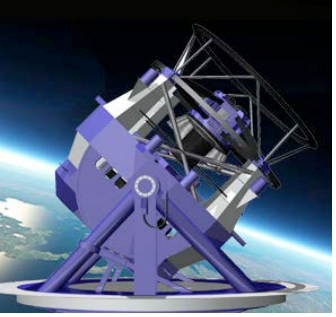
Planned Roadmap

- 2011 – 2012: collecting science requirements
- 2012 – 2013: conceptual design
- **2014 – 2015: critical design/Funding**
- **2016 – 2018: construction**
- **2019 – 2020: commissioning**

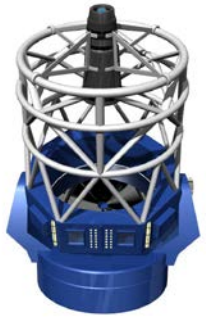
An EA/World Network of WFT?



- A candidate project for East-Asia Collaboration
  - Discussed in the EACOA workshop (Kunming, June 21-25, 2013)



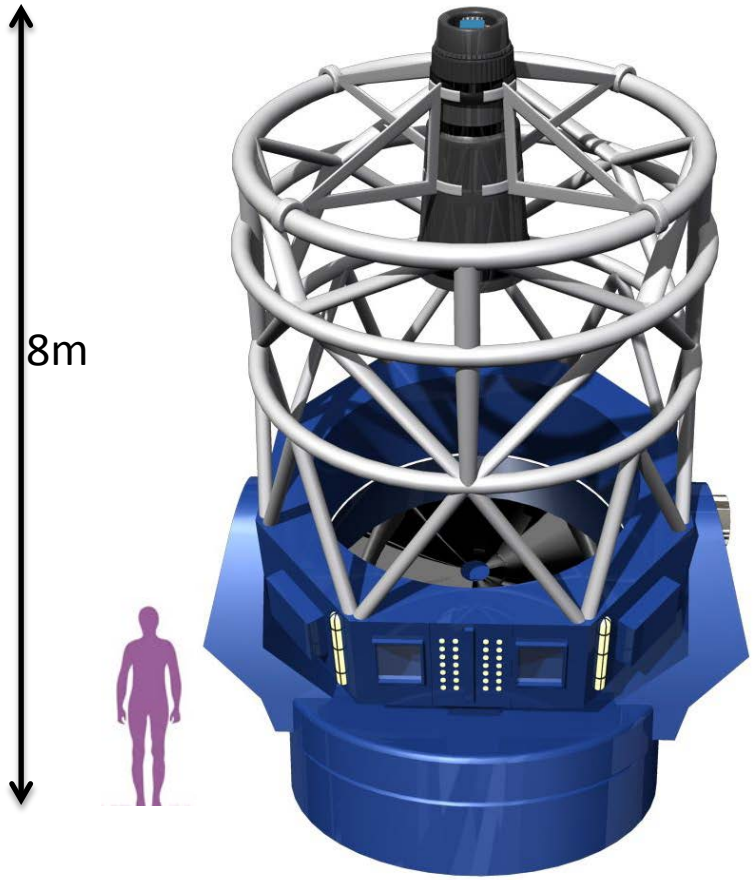
In the Era of LSST (2020 --)



- LSST is a flagship facility for time-domain astronomy, but NOT a terminator to other wide-field telescopes. Huge discovery space is available for the other telescopes.
- The network of 2.5m Wide-Field Telescopes is complementary to LSST in sky accessibility and science.
  - The solar system objects & the Milky Way
  - Dedicated surveys include
  1. Semi-simultaneous multi-band survey
  2. 24 hour global monitoring observation
  3. **High-cadence survey**
- With your own "LSST", you build up key technologies in mining big data.
- Get ready for big surprise in time-domain astronomy.

Summary

- In upcoming decades, there are still many excellent scientific objectives to pursue with a medium-size telescope having a large field of view.
- It is a matter of telescope time to raise your own flags in the era of time-domain astronomy!
- The 2.5m wide-field telescope is optimized for wide-field imaging surveys, and holds promise for its exciting science goals.



Cordially invite EA collaborations!